Effects of phosphorus limitation and temperature changes on the life history of *Daphnia magna*

Marte K. Rosnes

Master of Science thesis,
Department of Biology
Integrative Biology Group

University of Oslo
2012

Preface

This study was conducted at the University of Oslo, Norway, as part of my master thesis. My friend, mentor and hero Marcin Wojewodzic is the reason why I became interested in ecological stoichiometry, without him I would never have had the persistence, skills or interest to finish this master thesis. Hans P. Leinaas has also both helped and instructed me through my bachelor and master. My main supervisor Tom Andersen has been the most patient man I have ever met, with regards to all aspects of my education. I am really happy that you did not take an arrow to the knee, but stood by me to the end.

Thanks to the comity of the IXth International Symposium of Cladocera for granting me a stipend to travel to and present my thesis at the Cladocera conference. The inspiration, knowledge and experience of such a great conference will stay with me forever.

Thanks to Anders Aak, who believed in me, and read through my thesis countless times with the most ferocious red pen I have ever seen. Your insight and wisdom was of enormous importance to me and this thesis. Elianne Sirnæs Egge, thank you for your interest and insight, both in modeling and life history theory. My lab partner, conference assistant and Daphnia-friend Nita Shala, you are immensely awesome. Both you and Marwa Jalal have been of great help and comfort when chemostats crash, autoclaves break and beakers need to be washed. Thanks to the rest of the 4th floor, fellow students and dungeon inmates, your coffee, rat sitting and cakes have been of much help and encouragement.

Special thanks to family, friends and girlfriend who have kept your cool when I have not, and reminded me that there are more important things than *Daphnia.* Thank you for support and patience, especially when days become nights and the time and space continuum cannot be breached.

Martek
Blindern, May 1st 2012

Master thesis summary

The elements carbon (C), nitrogen (N) and phosphorus (P) are the most important constituents of essential biomolecules. P is a crucial element in ribosomal ribonucleic acid (RNA) is indirectly responsible for protein biosynthesis, and thus growth. According to the growth rate hypothesis coined by Elser (1992), we can predict that faster growth must be associated with higher requirement for P, due to allocation of this element into P rich ribosomes. Temperature in turn can further modulate C:P ratio of an organisms, and hence animals requirements. This can potentially be manifested in alterations of life histories whenever temperature changes. The C:P ratio is easier to alter in autrophic organisms than herbivores (Andersen and Hessen 1991; Sterner and Hessen 1994). This increase in C:P ratio reduce zooplankton growth (Elser et al. 2001), which might affect the ecosystem due to a mismatch in elemental requirements of algal- herbivore interactions (Winder and Schindler 2004).Recently, an increase in temperature has been shown to promote P limitation in *Daphnia magna*, as manifested by changes in somatic growth rate (Persson et al. 2011). However, we still do not know which consequences this might have for life histories and in turn population growth. Unfortunately, we still lack the basic understanding of how temperature and food elemental composition interact with each other in such a scenario, and if trade-offs for P allocation are mirrored in changes of life histories, once temperature changes. This thesis is an effort to assess effects of different diet and temperature regimes from a life history perspective.

Ecological stoichiometry (ES) was used as a framework to assess life history changes of the cladoceran *D. magna* kept on different diets (with respect to C:N:P ratio) and temperatures. Prior to the experiment, animals were acclimatized to 10, 15, 20, and 25 ˚C for several generations. They were fed *ad libitum* with the same quality of green algae *Selenastrum capricornutum*. In the experiment, less than 24-hours old juveniles were picked from the second brood of their mothers, and were followed individually throughout their entire life. Animals were transferred to a new glass vial every second day, and time at first reproduction, moult counts, reproductive success, and time of death was recorded. Stage transition matrices were used to further explore this complex dataset, especially the impact of independent variables on different life stages.

I demonstrate that temperature is significant for the survival probability of *D. magna*. P limitation affects survival negatively at low temperatures, but not when temperature increase. P limited animals have significantly smaller probability of maturation and lower fecundity in general compared to animals kept on P rich food. Matrix modelling reveals that intrinsic rate of increase (λ) is more sensitive to changes in survival until first reproduction than changes in fecundity. This finding might indicate a trade- off for animals in cold temperatures. The trade-off promotes high survival in longer periods when food quality is diminished, but delaying or stalling reproduction. Such strategies can for instance be used to survive winter in ice covered lakes, when temperatures and food quantity is low. The main finding of this study is that individual body growth rate is not always best predictor for stoichiometric effects on population intrinsic rate of increase. My finding are important to better understand the implications of stoichiometry and temperature change on the overall fitness of *D. magna* throughout their life.

Table of content

1 How do P- limitation and temperature affect the life history of *Daphnia magna*?

1.1 Ecological stoichiometry

Ecological stoichiometry (ES) is “the balance of multiple chemical substances in ecological interactions and processes, or the study of this balance, sometimes refers to the balance of energy in materials” (Sterner and Elser 2002). ES uses the chemical laws of matter conservation in biological systems to describe the rates and yields between reactants and reaction products in ecological production dynamics (Sterner and Hessen 1994).

All animals require the macro-elements H, C, N, O, Na, Mg, P, S, Cl, K, Ca, and some of the 19 trace elements to survive and reproduce (Sterner and Hessen 1994). Ecological stoichiometry creates the framework to explain the balance and interactions of nutrients in the environment, and how this effects the organisms, but also how the organisms in turn influence the environment as reflected by the regularity in the proportions of carbon (C), nitrogen (N), and phosphorus (P) in living matter (C:N:P = 106:16:1; Redfield 1958). These three elements are considered to be, directly and indirectly, the most important elements for structural growth. Although consumers can be constrained by the quality and quantity limiting supply of dietary P and N (Hessen 1992; White 1993; Hessen et al. 2002; Sterner and Elser 2002), their content are often shown more homeostatic than those of their diet. However, the ratio of these elements can vary in different organism groups (Sterner and Hessen 1994), but also between different species of the same genus, such as *Daphnia* (Cowgill and Burns 1928; Hessen et al. 2002). However, the elemental ratios in *D. magna* resemble those of other species (Hessen 1990), which are known to show somatic growth rate retardation under P limited conditions (Hessen et al. 2002). Stoichiometry is therefore useful in understanding not only how nutrients flow and dissipate between different trophic levels, but also to explain the efficiency of transforming food into new body mass (Elser et al. 1996).

1.2 Temperature

Temperature is a parameter that directly effects the physiology of ectoderms through their biologic rate processes (Hochachka and Somero 2002), as well as indirectly through abiotic stressors, like food quality (Sokolova and Lannig 2008). *D. magna,* for instance, has been shown to increase the filtering rate at higher temperatures (Burns 2012).
Daphnia experiences major fluctuations in temperature, as well as in food quality in its natural habitat (Sterner and Schwalbach 2001). Temperature can also change dramatically through the seasons in temperate regions. Overwintering *Daphnia* in can experience close to 0°C during winter ice cover, but up to 30°C during summer time.

Temperature can shift the N and P content of poikilothermic organisms (Woods et al. 2003), compensating for reduced enzyme activity at low temperatures by increasing the enzyme concentration (Woods et al. 2003; Allen and Gillooly 2009). Temperature has also been shown to effect somatic growth more than food composition when temperature is low (Persson et al. 2011). This indicated that temperature can effect an animal's response to P limitation, which might have cascading effects on the whole ecosystem. With the effect of global warming imminently changing the environment, it is important to understand how temperature change effects the trophic interactions in an ecosystem, both seasonally and over time. Such changes can lead to a mismatch in the stoichiometric conditions of the algal-herbivore interplay (Winder and Schindler 2004).

1.3 Phosphorus as a limiting nutrient

Consumer-driven nutrient recycling in lakes might be ~ 5 times higher than in marine systems, with the consequence that zooplankton-phytoplankton interactions in freshwater seem to be more vulnerable to P limitation than in marine systems (Elser and Hassett 1994). Both N and P shortage can be limiting for growth, but P limitation is more disruptive and relevant than N limitation for *Daphnia* (Hessen 1992; Urabe et al. 1997; Sterner and Elser 2002). P is an essential mineral of all organisms, and has a central role in transfer and storage of energy and information, as well as for membrane integrity (P-lipids). P is important in the synthesis of ribosomal RNA and thus indirectly for protein biosynthesis (Elser et al. 1996). RNA makes up a major part of P in most cells, and can constitute up to 15% of the biomass in some metazoa (Sterner and Elser 2002). This leads to the growth rate hypothesis (GRH) which propose that faster growth requires more phosphorus to maintain a higher protein biosynthesis (Main et al. 1997; Elser et al. 2002, 2003; Hessen et al. 2002; Vrede et al. 2002). Different zooplankton taxa also differ in body N:P ratios (Andersen and Hessen 1991), such that organisms with low N:P ratio and fast growth might have higher P demand than slower growing organisms (Stearns 1992; Sterner and Hessen 1994; Main et al. 1997).

Growing algae with high C:P content could also effect the C:N ratio. Furthermore, subjecting algae to P limitation can decrease their content of polyunsaturated fatty acids (PUFAs) (Piorreck et al. 1984; Harrison et al. 1990). PUFAs have been pointed to as a good descriptor for high quality food for pelagic grazers (Brett and Müller-Navarra 1997; Müller-Navarra et al. 2004). The controversy between PUFA and nutrient limitation started with Ahlgren et al. (1990), pointing out that the poor quality of cyanobacteria, and the high quality of flagellates and diatoms, could be accounted for by differences in fatty acid composition. This in turn led to the conflict of the interpretation and opinions regarding N and P as a limiting nutrients (Brett 1993). Nutrient limitation of algae might results in an increase in total fatty acids but a decline in polyunsaturated ones, which means that interplay between the fatty acids and nutrient limitation can occur. PUFA deficiency have been claimed to be responsible for the poor quality of a P limited green alga compared with a P limited diatom (Müller-Navarra 1995a). Fatty acid composition has been shown to be closely related to growth in *Daphnia* in a seston diet, and that P was not (Müller-Navarra 1995b). Later studies have found that only egg production is effected by PUFA concentration, and that sterols are limiting to growth (Martin-Creuzburg and Elert 2009).When growing algae with high C:P ratio, it is therefore important to take into account; that this change in nutrient composition can effect PUFA and N content too, and should therefore be controlled for.

1.4 The water flea (*Daphnia*)

Daphnia spp. are relatively small aquatic planktonic crustaceans (0.3 - 5 mm) (Taylor and Gabriel 1993). They are members of the order Cladocera, and are commonly called water fleas because of their saltatory swimming style (although fleas are insects and thus only very distantly related). They are often abundant in lakes and ponds, and are present over a broad range of temperatures (Hebert 1978). Most *Daphnia* require at least 2 ppm of oxygen, and can tolerate temperatures between 0 and 35 °C (Dodson 2005). Present in a variety of environments, from acidic swamps to freshwater lakes, ponds and rivers, they have a wide distribution over several continents, and hence experience an extensive genotypic variance and phenotypic plasticity.

Many species show tropism, which is attraction or avoidance to light, temperature and perhaps also food concentration (Dodson 2005). This means that they actively can swim to or from an area in the water column to better light, temperature or food conditions, or to avoid predation.

Daphnia are unselective filter feeders, and can consume algae, fungi, protozoa and organic debris (Hebert 1978). They are regarded as a keystone species, that can control the phytoplankton biomass and restructure the phytoplankton community when their abundance is high (Sarnelle and Knapp 2005). In turn, they can also be prey to small fish and other carnivorous aquatic animals. *Cladocerans,* and zooplankton in general, are nutrient demanding organisms with low body C:P ratio that often feed on a diet with high C:P ratio (Elser and Hassett 1994). The elemental ratio in the food relative to the herbivores, suggests that they must concentrate N and P relative to C in their body tissue in order to grow and reproduce (Sterner 1990).This makes them highly susceptible to growth or reproductive limitations when nutrient levels are low.

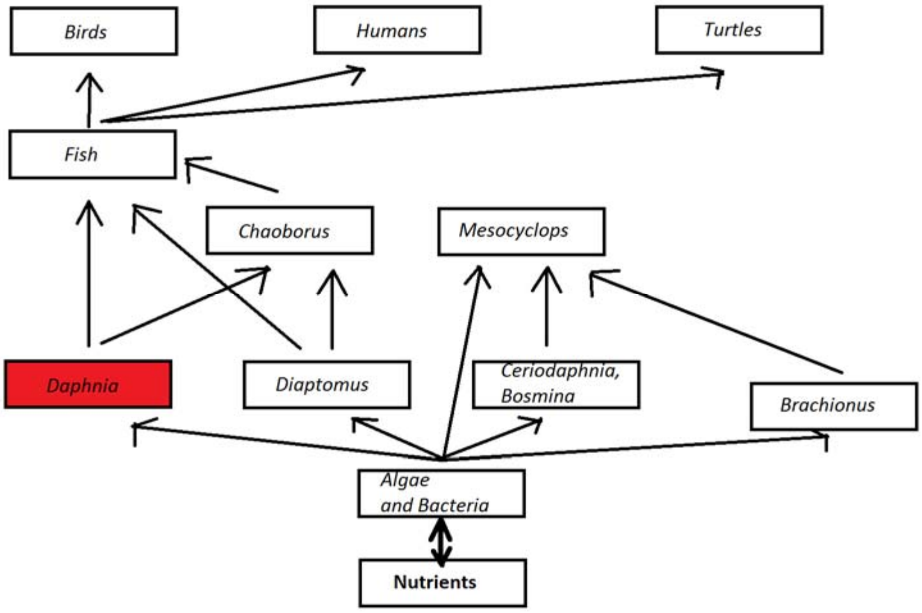


Figure 1: Position of *Daphnia* in a generalized food web model of a lake. The boxes are labeled with names of common aquatic taxa; the arrows point from prey to predator. The model is artistically reconstructed from figure 1.13 p.17 in Dodson (2005).

Daphnia grow relatively fast and can reproduce many times during a season. The life span from the release of the egg into the brood chamber until the death of the adult can vary depending on the species and environmental conditions (Pennak 1978), but the lifespan generally increases with decreasing temperature. *Daphnia* reproduce by parthenogenesis when conditions are good; in such clonal reproduction mode there is no need to account for sex- ratio. However, sexually reproduction can occur when conditions change, and sexual reproduction result in resting eggs (ephippia). The diapause stage can last for days or decades, until the ephitium receives the right environmental signal (Dodson 2005). During the turnover in early spring, the resting eggs hatch, and a new population of sexually produced *Daphnia* start growing. Hatching ephippia usually produce females (Dodson 2005). Sexual reproduction is often associated with stress such as unfavorable food and temperature conditions or increased population density, which stimulates the production of males.

Juvenile *Daphnia* are born resembling the adult form, and grow in size by regularly replacing their exoskeleton by a new and larger one (moulting) (Dodson 2005). The developmental stages between moults are called instars.

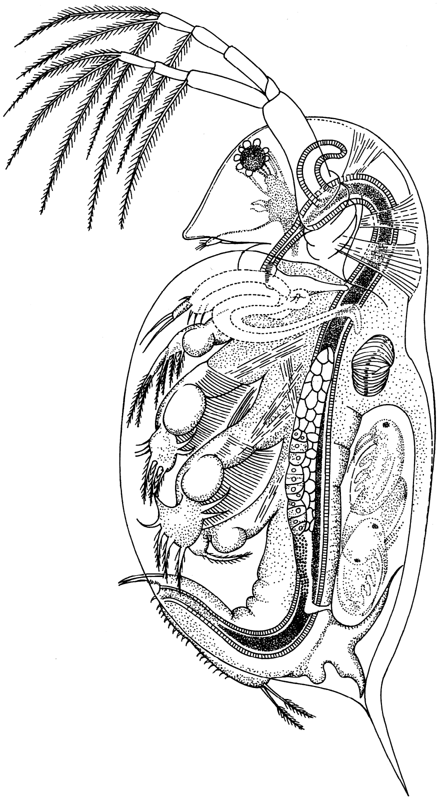


Figure 2: Reconstruction of *Daphnia pulex* by Prof. C. M. Laane (UiO) from old drawing by Prof. C. Claus (Zur Kenntniss der Organisation und des feineren Baues der Daphniden und verwandter Cladoceren. Pp.362-402. Zeitschrift für Wissenschaftliche Zoologie, Siebenundzwandzigster Band, Leipzig, Verl. Wilhelm Engelmann. Tafel XXV. Fig.1,1876

Daphnia is a good model organism, much because they can reproduce both sexually and clonally, which make it ideal for experimental genetics. Its clones are commonly used in ecotoxicology, and can be a good indicator species. *Daphnia* is a highly ecoresponsive organism, and the genome of *Daphnia pulex* has recently been sequenced (Colbourne et al. 2011). Because they are relatively transparent and have a complete set of organs similar to the parts found in larger crustaceans, such as lobster and crabs, it is also easy to use them for live specimen internal organ studies (Dodson 2005). *D. magna,* which has been traditionally used in European research since XVIII century, is a laboratory model organism that represents this genus. Techniques such as microsatellites, microarray analysis and even HTS become more common while studying this species. Outside the lab, *Daphnia* are also often used as live food for fish, tadpoles, or small amphibians.

1.5 Life history traits

Life history traits are a set of rules to allocate time and energy between growth, reproduction and survival. Such life history traits are principally size at birth, growth pattern, age at maturity, size at maturity, number and size of offspring (in clonal reproduction we don't have to account for sex-ratio), age and size specific mortality schedules, and life-span (Stearns 1992). All traits are intertwined and may interfere with each other negatively, such that there can be trade- offs between them. Trade- offs often occur between reproduction and survival, current reproduction, and future reproduction or number and size of offspring. Such trade- offs are thus an organism's life history. These trade- offs can be better understood when dynamic energy budget theory (DEB) is implemented (Kooijman 1993; Nisbet et al. 2000) , or life history approach is used.

Life history modeling assumes unlimited availability of resources for an organism to allocate towards maintenance and reproduction. Under natural conditions however, this is not the case. Such limited resources can be linked to food quality or quantity, population density (which increase competition for all resources), time or temperature. All of these limiting resources can effect fitness, which often translates to the individual growth and reproduction rate. However, growth is not the only important parameter when concerning fitness. When under resource limited conditions, increased allocations for reproduction are expected to reduce the resources available for maintenance, which will effect survival (Snell and King 1977). In general, living long and reproducing late is only a good strategy if survival probability is high. For animals like *Daphnia*, fast growth and early maturation are believed to be the optimal strategy (Lampert 1993), at least in populations with predation, but several trade- offs might be made to facilitate maximum population growth rate. It has been shown that water fleas in populations were small individuals was removed, grew rapidly and reproduced when large, but in populations were large individuals was harvested, they grew more slowly and reproduced at a smaller size (Enserink et al. 1995). Experimental studies of *Daphnia* suggest that in poor feeding conditions, low somatic growth rate is compensated by an increased number of pre-adult instars (Porter et al. 1983). Although age and size at reproduction are among the most commonly measured life history traits in *Daphnia*, only a few authors have investigated the maturation process itself (Enserink et al. 1995).

Size of offspring and clutch size can also be a trade- off, and for *D. magna* clutch size has been shown to decrease with food level (Enserink et al. 1995). Limiting supply of nutrients can thus not only delay age at first reproduction, but put constraints on clutch size. Growth is often linked directly to fitness, because organisms must grow before they reproduce (Elser et al. 2002). Specific population growth rate is a central integrating parameter of overall life histories (Arendt 2012). A thorough investigation of the different life history traits and the trade- offs among them is important to understand how and if a population will grow or decline under different temperature and food levels. In a population with constant high birth and low death rate, the growth of the population will be exponential and at a constant rate, although this kind of population growth is not something one would expect in nature. As a group of individuals grow and reproduce, the stage distribution in the population will change. In the beginning there will be only juvenile individuals, and as they grow the stage distribution will change with them. When constant growth rate is reached, the population will grow with a constant stage distribution, normally with a big part made up by juveniles. "A population with a constant birth and death schedule will attain a stable age distribution and then grow exponentially at a constant rate" (Stearns 1992). How much the population grows is called the intrinsic rate of increase, and reflects the animal fitness. The population intrinsic rate of increase can be calculated from data related to age at maturity, last reproduction, probability of survival to a given age, and number of expected offspring given by a specific age class. Intrinsic growth rate can be iterated from the Euler- Lotka equation with rate of growth in a population (r), or by dominant eigenvalue lambda (λ) in a population matrix for the population present in a stable age classes. Such calculated values can give information about whether a population decline or how fast it will grow under certain conditions. Additionally, it might access the variation present between different populations characterized by different life histories and under a variety of conditions.

1.6 Matrix modeling

Life history parameters, recorded individually, may serve to predict the differences between treatments at the population level, and this can be done using the matrix modeling technique (Caswell 2001). Looking at the data this way, gives a powerful view of the life cycle and allows us to extract the essential elements of population growth or demise. It is possible to stage the population in many different ways, most commonly by age, size, or stage, each fitting the data differently. The goal is to project the population from time *t* to time $t + 1$, which in this case exclude the age based model on the basis that we cannot assume that the unit of time is the same as the age class width. The size based model would be appropriate if there was sufficient data on size, especially when compared to the stage based model, however this cannot yet be done for these data.

The stage based model assumes that age-specific survival and fertility rates are sufficient to determine the population dynamics. In this case, what is most interesting is the survival probability until reproductive age (adult stage), and the variation in the distribution of stages and the fertilities among the different diet treatments and temperatures. With a stage based model, time is relative, and the model only gives transition probability within or to another stage. The time spent in each time step can thus vary, and give no information of time, but hopefully it explains the demanding task that growth and reproduction is in a sufficient way. The dominant eigenvalue (λ) is the intrinsic growth rate, which give an estimation of population growth or decay. If the dominant eigenvalue is larger than 1, then the population grows exponentially. The population decays exponentially if λ is smaller than 1. In addition damped oscilliations with a period equal to 2 will occur with λ bigger than -1 and smaller than 0. Diverging oscilliations occur with $\lambda < -1$ (Caswell 2001). Sensitivity analyses measure how sensitive λ is to an absolute change in each life history compartment. The elasticity of λ quantifies the proportional change resulting from a proportional change in a life history compartment, thus the relative importance of transitions in the life cycle to the population growth rate (de Kroon et al. 1986). Furthermore, it is possible to analyze the different matrices according to one reference matrix. Life- table response experiment (LTRE) analyses, gives the opportunity to observe differences between the different treatments and temperatures by comparing them to each other (Levin et al. 1996). LTRE quantifies the contribution of different matrix elements to the difference in λ between the transition matrixes (Caswell 2001).

2 Materials and method

2.1 *Daphnia magna* in cultures

Laboratory stock culture of *Daphnia magna* was collected from a pond in Northern Germany (Pulkkinen and Ebert 2004). This clone was successfully kept for many generations at the University of Oslo, climate room U112, at 20 °C. The animals were kept in N and P- free COMBO medium (Kilham et al. 1998), and fed P- sufficient algae *ad libitum* (C:P ratio < 100). The cultures were always kept at low density to minimize stress and ensure clonal reproduction. Equipment used in the study was soda and acid washed, to prevent contamination with P or the appearance of bacterial films. Plastic transfer-pipettes (Sarsted, cat.no 86.1171.000) where used to manually transfer animals to new beakers. The edge of the pipette was cut to avoid any harm to the animals.

Figure 3: Stock cultures of Daphnia magna were kept in glass beakers at 10, 15, 20 and 25 °C in N and P- free medium, and fed P- sufficient algae *ad libitum*.

To avoid any interference from maternal effects due to temperature, animals were randomly distributed to 4 different beakers and kept at 10, 15, 20 and 25 °C to acclimate to the experimental treatment temperatures over the next 3 generations. Such established cultures where followed up over time. Animals were transferred to new beakers with COMBO once a week.. The experiment was started when the animals reached second brood and were less than 24 hours old. The temperature in the climate rooms were recorded with tiny tag loggers, to assure constant temperature conditions. Animals were not acclimatized to the different food quality treatments in this study since I was interested in knowing the immediate response to changes in diet.

2.2 Green algae (*Selenastrum capricornutum)*

As food source for *D.* magna in the experiment and in the stock cultures I used the green algae *Selenastrum capricornutum* that were grown in a continuous culture (chemostat). The chemostat set up was inspired by Hessen et al. (2002). Four two liter glass tubes were closed with silicone stoppers, filled with sterile COMBO medium (Kilham et al. 1998), and inoculated with *S. capricornum*. The chemostats were continuously diluted with COMBO at a rate of 0.2 day $^{-1}$ by peristaltic pumps (SCHEGO, M2K3, 5W) with cycle 36/360 second on-off. Light levels were at 70 µmol quanta m^{-2} s^{-1} using 25 W blue-white fluorescent tubes (OSRAM FQ 24W/960). The chemostats were run in a room with constant temperature of 20 °C. Sterile filtered air (0.2 µm) was supplied through sinters to ensure sufficient CO_2 supply for algal photosynthesis. In addition to air bubbling, circulation increased with magnetic stirrers to avoid sedimentation and aggregation of algae at the bottom. In addition to the four running chemostats, there was always kept backups.

The algal outflow was collected in glass beakers and used as food for *Daphnia* when the cultured reached a stable density as measured by optical density at 633 nm. Algal biomass was also measured with carbon and phosphorus analysis, using pre-combusted (3 h, 500°C) GF/F filters (Kilham et al. 1998).

The algae C:P ratio in the chemostats was manipulated by adding COMBO with either **full** formula, P content of 50 µM (Figure 4; the two bottles on the left), or **P limited** formula (Figure 4; the two bottles on the right). The P limited formula had reduced P to 2 µM, with an addition of 48 µM KCl to maintain the same ionic strength as in the full medium. COMBO media were adjusted to pH 7.8 with 1 M HCl (Kilham et al. 1998) before use.

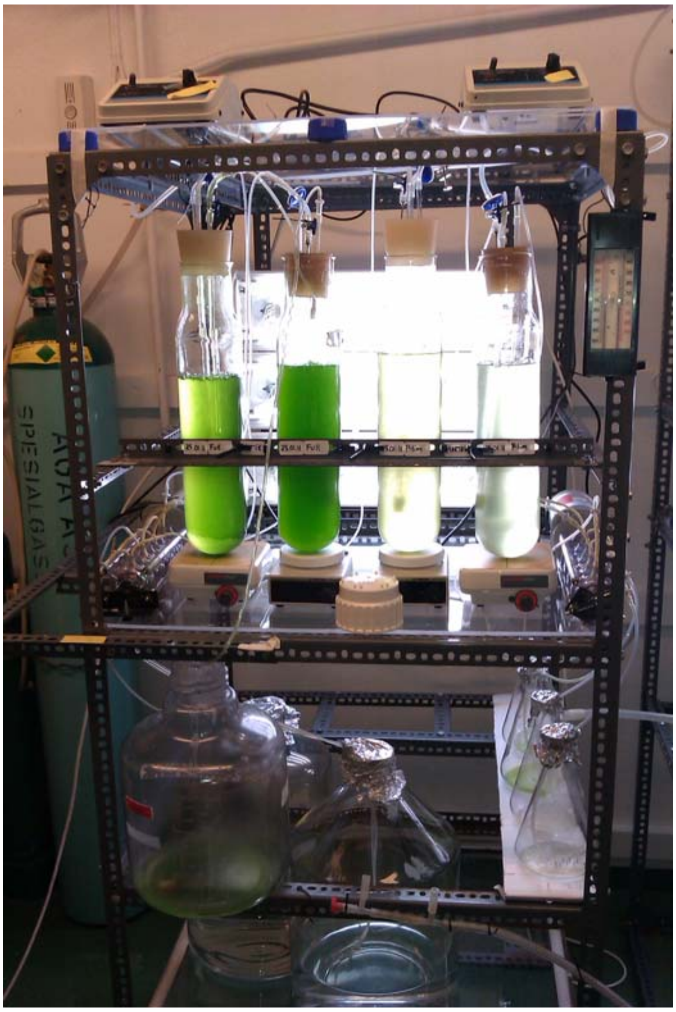


Figure 4: Chemostats system with four glass tubes that were used throughout all experiments, two with full medium (left) and two with P limited (right). Full chemostats characterize with higher algal density and dark green color while less dense P limited algae have a yellowish green color. This results in different extinction coefficient for different chemostats.

The food regimes for *D. magna* in the experiment was **full** (C:P ~ 100) which was considered as the best diet in respect of N and P content and **P limited** (C:P > 600) which was considered as the worst in terms of stoichiometric N and P quality. Algae was collected directly from the chemostat. The third diet was **P limited spiked** (C:P ~ 100) which was to act as an intermediate diet, with possible low N content but enough P, like mentioned in 2.2. This was done to lower the C:P ratio of the P limited algae, while keeping the other food quality parameters constant (e.g, N, sterols and fatty acids). The spiking procedure was based on the observation that P limited phytoplankton assimilate inorganic P within a few minutes, and thus lowering the C:P ratio without changing the biomass. Spiking the algae with inorganic P was done accordingly to Rothhaupt (1995), Plath and Boersma (2001) to separate the effects of P and fatty acids, N and sterols. P limited algae spiked with inorganic P was thus a control, and any difference between full and spiked diet would indicate that the P limited algae had molecular changes other than P content. With spiked and full treatment proving equally good, changes in life history traits and trade- offs could thus be attributed to P limitation alone.

The method for analyzing, diluting and spiking algae to make the different diets was done accordingly to Persson et al. 2011. The algae collected from the chemostat were measured from the optical density (OD) at 633 nm, using a previously established calibration curve between OD and measured particulate organic C concentration. Algae for C and P analysis were collected on pre-combusted (530 °C, 3h) GF/F filters (Whatman, Kent, UK). C content was analyzed on a Thermo Finnigan FlashEA 1112 elemental analyzer. Samples for particulate P were analyzed using a modified molybdate blue method (Menzel and Corwin 1965) after persulphate digestion.

After C concentration was measured, the algae were diluted to 2 mg C L^{-1} using N- and P free COMBO, and divided into **full**, **P limited**, and P limited algae that was to become **spiked** diet. The diluted mix of P limited algae was added P, and then incubated for 20 minutes before it was offered to the Daphnia. All diets were acclimatized to their respective temperature before used in the animal transfer.

2.3 Life history experiment

The experimental setup was designed to use an ecological stoichiometry framework to assess life history changes of the cladoceran *D. magna* fed different quality diets (with respect to C:N:P ratio) at different temperatures. Four temperatures (10, 15, 20 and 25 °C) and three different diet treatments following the method mentioned in 2.2. There were 20 animals for each temperature and food treatment, a total of 240 animals in the beginning of the experiment. Each animal was held individually in a glass vial, filled with 25 mL of one of the three treatments. The animals were held individually to exclude for density dependence processes, but also to keep track of individual moulting and reproduction records. By keeping the animals separately, population feedback processes to counteract P limitation were also avoided (Andersen et al. 2007).

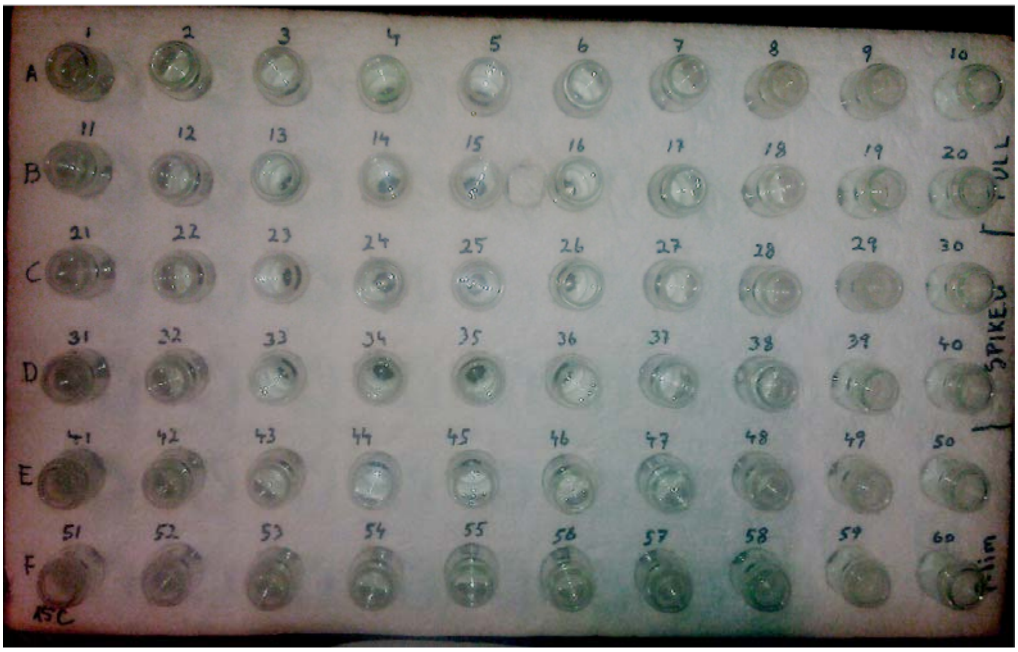


Figure 5: The experimental setup, 60 x 25 mL glass vials were filled with the three diets full, Spiked and P limited and less than 24 h old individuals were randomly distributed (20 indicindividuals per treatment in each temperature) in a tray and placed in shade in the four different climate rooms; 10, 15, 20 and 25 °C. Animals were transferred to a new vial with fresh diet each second day.

The experiment was held in four different temperature monitored climate rooms with temperatures 10, 15, 20 and 25 °C.

Prior to the main experiment, I conducted a 2 month pilot experiment (2010) to assess the method. I observed that the animals were fragile for handling, and should not be measured or photographed while the experiment was running. Transferring the animals every second day was preferable to minimize stress, but also to make sure that moults did not disintegrate at higher temperatures before the next transfer. The animals were transferred to clean glass vials by picking them up with 3.5 mL transfer-pipettes (Sarsted, cat. No 86.1171.000). This method is quick and non-intrusive. After the animals were transferred to the new glass vial, the old vials were examined for moults and juveniles, and these were counted.

To initiate the experiment, the biggest animals in each stock culture were isolated, and the offspring they produced within 24 hours randomly assigned to treatments. Animals were then transferred every second day, and at each transfer the different life history traits were recorded. To estimate fecundity, all live juvenile offspring born was counted and removed when mothers where transferred to new medium. The stage-class was recorded and estimated by the count of moults observed in the vial. An animal grew one stage class per moult, and the moults were easy to spot and count. Residual debris in the glass vials was sometimes visible as very small round objects, variable in size and color. They were clearly not part of the moult, or any form of ephippia, they were therefore identified as aborted eggs. Since size and color varied, and I could not be certain that they were always noticed, had disintegrated or for some other reason where not counted, they are not included in the data. An animal was recorded as dead when there was no movement of any sort. This included checking for movement of filtering apparatus and antlers, and as disintegration starts rapidly after death, any sign of decomposition was also used as additional proof before concluding that the animal was in fact dead.

2.4 Statistical analysis

All statistical analyses were conducted in R version 2.14.1. (R Development Core Team 2011-12-22). The survival curves of the different treatments and temperatures were estimated by the Kaplan-Meier method. I used the Cox proportional hazard model to test and quantify the differences in mortality between the temperatures and treatments.

The probability of surviving to maturity was analyzed by logistic regression with the logit link function, which fits a linear combination of explanatory variables to a binary response variable by the maximum likelihood method (McCullagh and J.A. Nelder 1989). The binary response variable represented whether an individual reached maturity before dying, or not, and the explanatory variables were treatment and temperature.

2.5 Matrix modeling

The life cycle of *Daphnia* can be divided into stages defined by moulting events (Gorokhova and Kyle 2002). All animals collected from the brood of their mothers were categorized as stage **juvenile 0** (J0), and progressed by moulting to **juvenile 1** (J1). Each moulting thus resulted in one stage transition, and more than one moult in one time step equal to a stage transition over more than one stage. When the animals reproduced for the first time, they progressed to **adult 0** (A0), if they also moulted A1 accordingly (Figure 6).

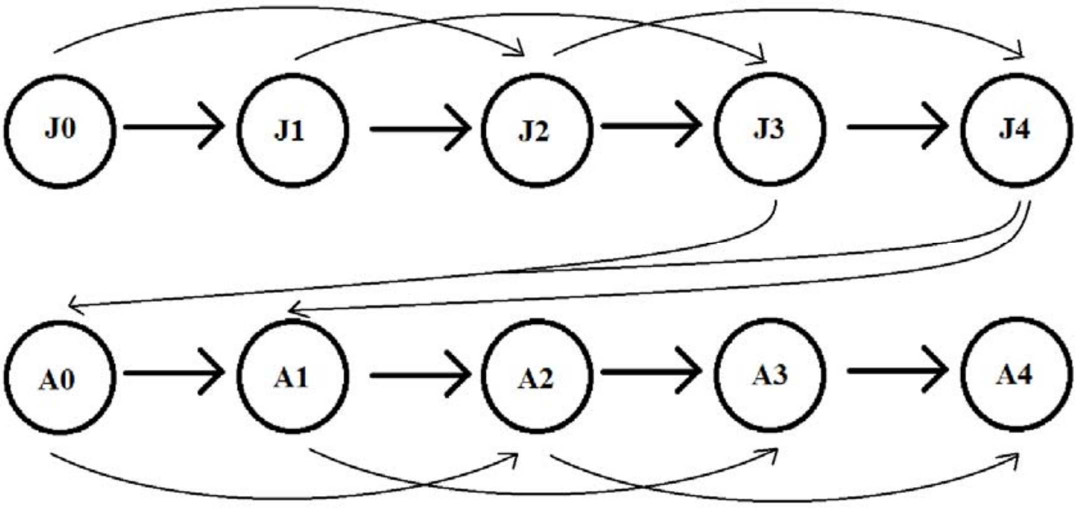


Figure 6: An example of a life cycle graph of *Daphnia magna*. Juvenile stages in the upper row, and adult stages in the lower. Individuals can grow more than one stage in a time step (census interval), and they can also stay in the same stage over several time steps.

Within the time step between state and state observations (the census interval, which was 2 days in all experiments), animals could do a variety of transitions, and the relative number of transitions made equals the transition probability. A matrix with transition probabilities of an average animal links an individual's fate from one census to the next.

All transitions were classified as belonging to one of four life history events (Jongejans and De Kroon 2005): **fecundity** (F), expressed as the mean number of juveniles produced per animal in each stage, **growth** (G), one moult notes one growth step, defined as the transition to a larger stage, **stasis** (S), survival in the same life stage class, and **hopping** (H), moulting more than one time during one time step, and skipping one growth step.

The population projection equation in matrix form is n(t+1) = A n(t) where A is the transition matrix and n(t) is the stage distribution vector at time t. Each life history compartment (F, G, S and H) represent the transition probability, or the contribution to stage J0 (Fecundity).
In the end I constructed 12 stage-based transition matrices, one for every diet treatment in each temperature. The dominant eigenvalue (λ) was calculated for each matrix, and sensitivity and elasticity of the matrices was analyzed. To further analyze the data, Life-table response experiment (LTRE) analyses gives the opportunity to observe differences between the different food regimes and temperatures by comparing them to each other. Full diet at 20 °C was chosen as reference matrix, and the LTRE quantifies the contribution of the different matrix elements to the difference in λ between the transition matrixes (Caswell 2001).
The matrixes and the analyses done on them can be found in the Appendix.

	J0	J1	J2	J3	J4	A0	A1	A2	A3	A4
J0	S0									
J1	G1	S1								
J2	H2	G2	S2							
J3		H3	G3	S3						
J4			H4	G4	S4					
A0				H5	G5	S5				
A1					H6	G6	S6			
A2						H7	G7	S7		
A3							H8	G8	S8	
A4								H9	G9	S9

Table 1: An example of a life table of *Daphnia magna* based on figure 6. Note that transitions not shown in the table are not necessarily impossible, but the probability of making such a transition is unlikely. Most animals in the experiments also had far more stages than this, thus this is a crude and simplified life table.

3 Results

3.1 Descriptive statistics

3.1.1 Survival

As expected, the maximal lifespan for the clone of *D. magna* used in this study was 178 days at 10 °C. The same clone lived a maximum of 75 days at 25 °C. The other temperatures showed intermediate survivals. Animals fed spiked diet had the lowest mortality at 10 °C, but the highest at 25°C (Figure 7), meaning there was an interaction between this food quality and temperature.

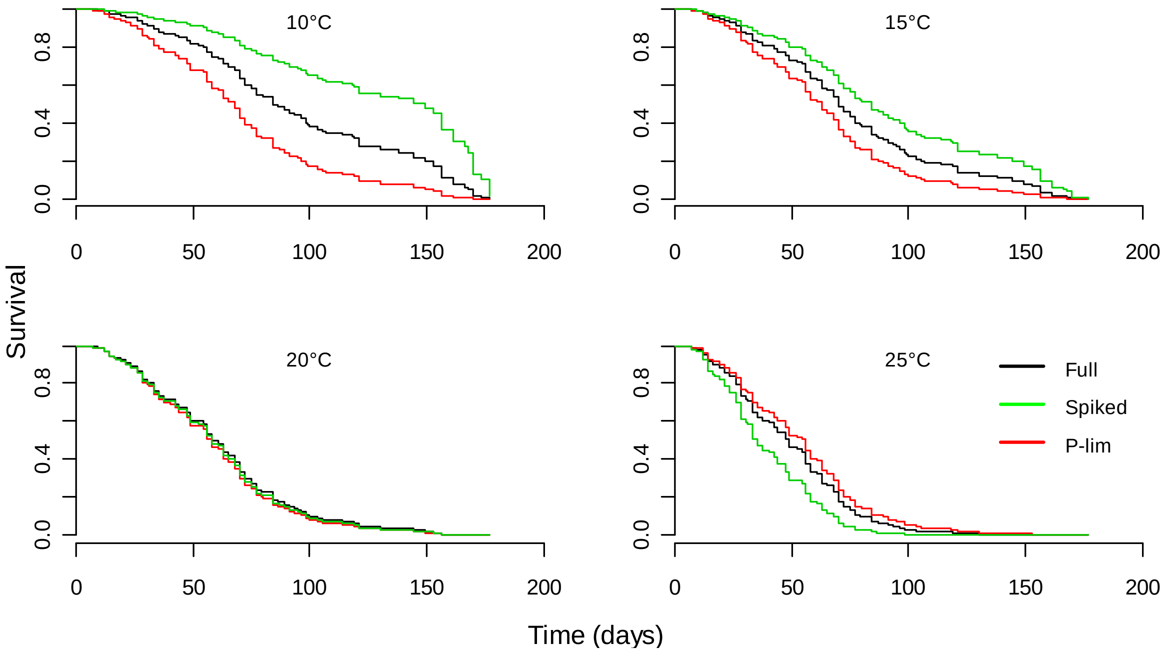


Figure 7: Survival curves for animals at 10, 15, 20 and 25 ˚C fed three different food quality diets. Black lines represent **full** diet, green are **spiked,** while red line stands for **P limited** diet. The y- axis is survival and the x-axis represents time in days. Note that animals at lower temperature survive significantly longer than those kept at higher temperatures. Moreover, note the interaction between the different food qualities and temperatures.

ANOVA of the additive effect of temperature and diet treatment on survival, show that the effects of both diet and temperature are significant ($p = 0.021$ and $p << 0.001$, respectively). The ANOVA for the interaction, show that the interaction between temperature and diet has a large effect ($p = << 0.001$).The best model for survival included temperature, diet, as well as the interaction component among these independent variables (See Appendix).

	Log (HR)	Hazard Ratio (HR)	p- value
P lim	1.1597	3.189	0.03300
Spiked	-1.6192	0.198	0.00620
Temperature	0.0884	1.092	0.00016
P lim:Temperature	-0.0537	0.948	0.07200
Spiked:Temperature	0.0832	1.087	0.00770
Likelihood ratio test=68.4	**on 5 df,**	**p=2.22e-13**	**n= 240**

Table 2: Survival of animals fed **full**, **spiked** and **P limited** food in four different temperatures analysed by Cox' proportional hazard regression. The parameter Hazard Ratio (HR) is the hazard ratio: HR > 1 means that the parameter has a negative effect on survival, 0 < HR < 1 means that the parameter has a positive effect on survival.

The Cox analysis of the best ANOVA (Table 2) gave Hazard Ratio (HR) bigger than 1 for P limited diet when temperature was low, which means that P limitation had a negative effect on survival at low temperatures. Spiked diet alone had no negative effect on survival at low temperatures, but did so when temperature increased.

When temperature was analyzed alone, it also had a negative effect on survival with increasing temperatures (Figure 7). In addition there was hardly any effect of diet treatment on survival at 20 °C, and the relative effect of diet treatment crossed at this temperature (Figure 8). The effect of temperature and diet can be easily visualized by presenting time (in days) when 50% reduction in population size (RP50) was recorded (Figure 8). Interestingly, spiked diet had better survival than P limited diet at lower temperatures (144 days for spiked, 66 for P limited) but as temperature increased, this was reversed. The trend was similar at 75% survival (See Appendix). Also with 50 and 75 % survival, 20°C had the least variation between diet treatments. The 50% survival times were almost identical (58, 56 and 57 days for full, P limited and spiked diet, respectively) (See Appendix).

Full diet treatment had no negative effect on survival (Table 2), and days until 50% survival show a decrease from 84 to 47 days, and decline in a straight line (Figure 8). P limited diet, which had a negative effect on survival at low temperatures (Table 2), also showed a linear decrease in 50% survival time from 66 to 54 days (Figure 8). Spiked treatment, with negative effect on 50 % survival at high temperature (Table 2), did not decline linearly, and varied from 144 to 33 days. Variation in 50% survival time was thus biggest in spiked treatment and smallest in P limited, whereas full diet was intermediate (Figure 8). The difference in survival for full, spiked and P limited diet is visualized in figure 9. The shape of the survival curve for P limited treatment is uniform over all temperatures, whereas the shapes of survival for spiked animals are distinctive for each temperature. Rate of mortality is generally uniform, and the survival curve can almost be fitted to a straight line. However, spiked treatment at 10 °C has low mortality in the early stages in life and show a sudden drop in survival after ca 150 days. Survival curves for full treatment is an intermediate between P limited and spiked.

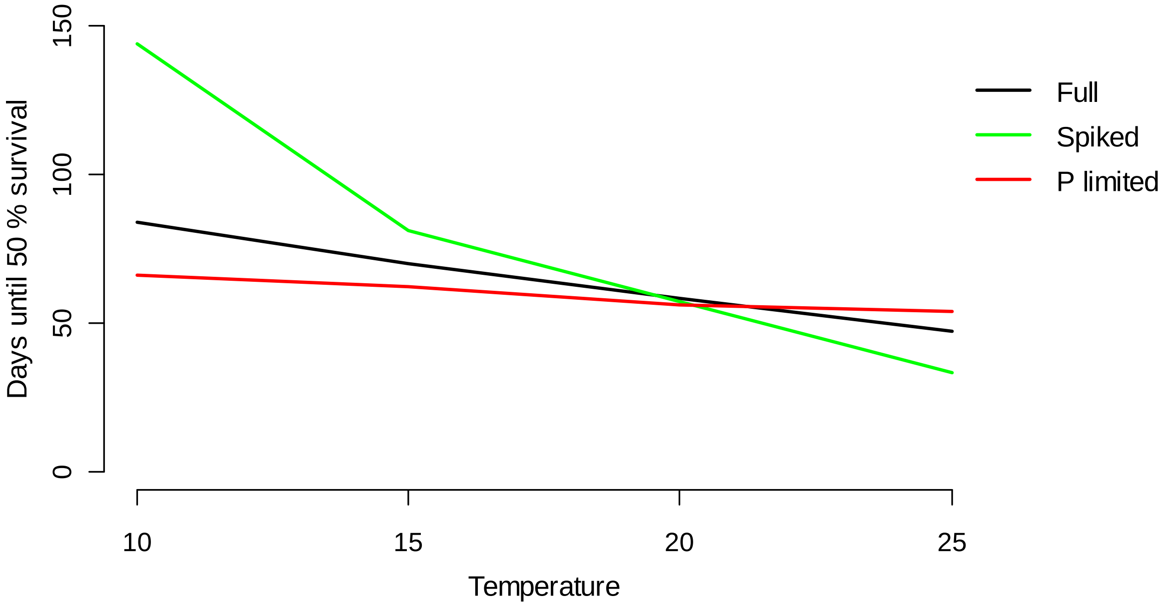


Figure 8: The effect of temperature on time when 50 % of the reduction in population size (RP50) of *D. magna* was recorded for different food quality. Y-axis is time in days and x-axis is temperatures. Black line represents **full** diet, green line **spiked** and red **P limited** respectively.

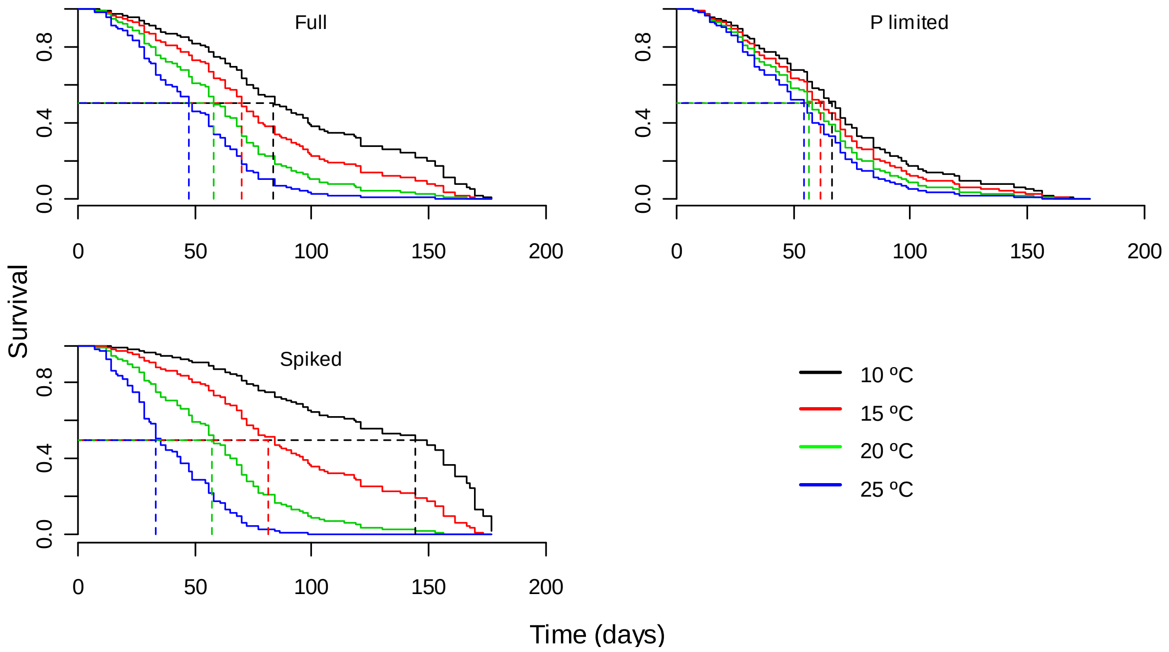


Figure 9: Individual survival curves for **full**, **P limited** and **spiked** treatment. Black represents 10 °C, red line 15 °C, green line 20 °C and blue line 25 °C. The Y- axis denotes survival and the X- axis time as days. The dotted lines denotes days at 50 % survival in each diet treatment. The accurate number of days can be found in appendix Table 1.

3.1.2 Growth and maturity

I used a generalized linear model (GLM; McCullagh and J.A. Nelder 1989) for predicting the probability of transition from juvenile to adult before death. Adult stage was defined as the first stage where an individual produces offspring, while all the moulting stages prior to reproduction were juvenile stages. The additive ANOVA show significant effect of temperature ($p << 0.001$) and P limited treatment ($p << 0.001$) with residual deviance of 16.34 on 8 degrees of freedom. There was no difference between spiked and full treatment ($p = 0.07$). When ANOVA with interaction was run, neither effect of temperature ($p = 0.31$), nor interactional were found for P limited ($p = 0.17$) or spiked diet ($p = 0.71$). However there was still a significant effect of P limited treatment alone ($p = 0.01$) (14 residual deviance and 6 degrees of freedom).

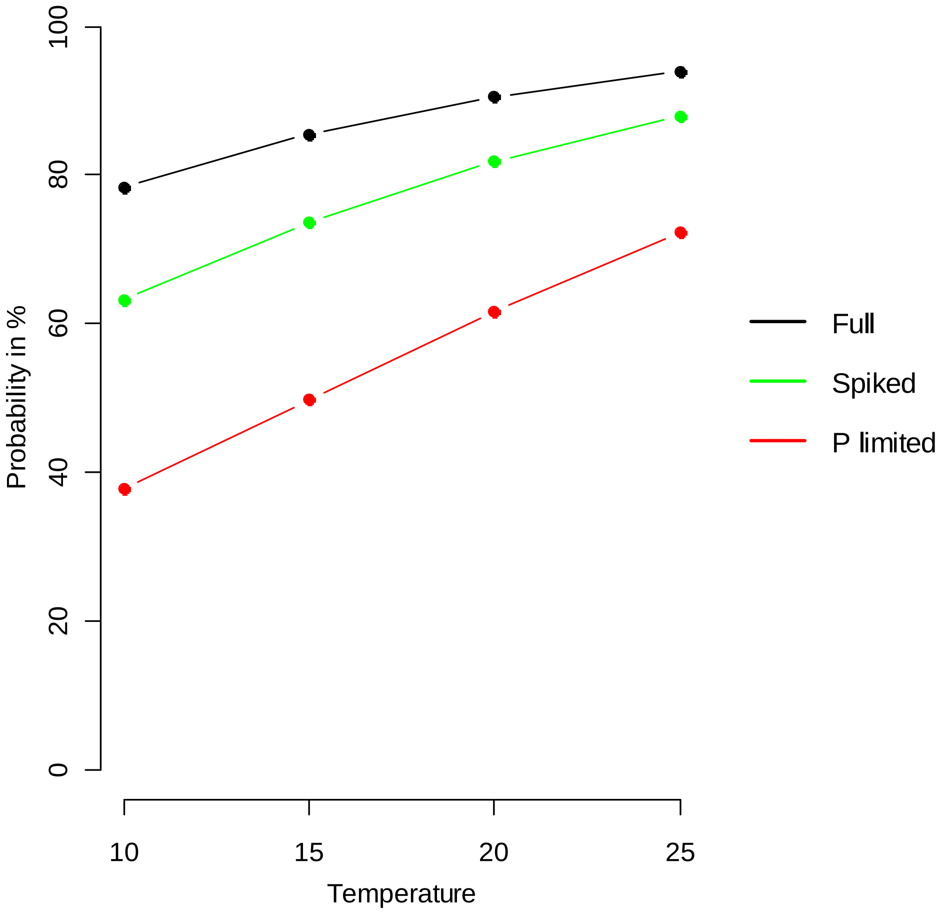


Figure 10: Effect of temperature and diet (explanatory variables) on the probability of maturity (binary response variable). Full diet is shown with a black line, spiked with green and P limited red. Each dot denotes the probability of maturity for each respective diet and temperature. The X- axis shows temperature, and the Y-axis probability in percentage of total population.

The highest probability of maturation found was for full diet, followed by spiked and P limited respectively (Figure 10). Probability of maturation for the full and spiked diets increased with ≈ 25 % from 10 to 25 °C. P limited diet had a similar increase, but the overall probability was ≈ 20% lower than the full and spiked diets.

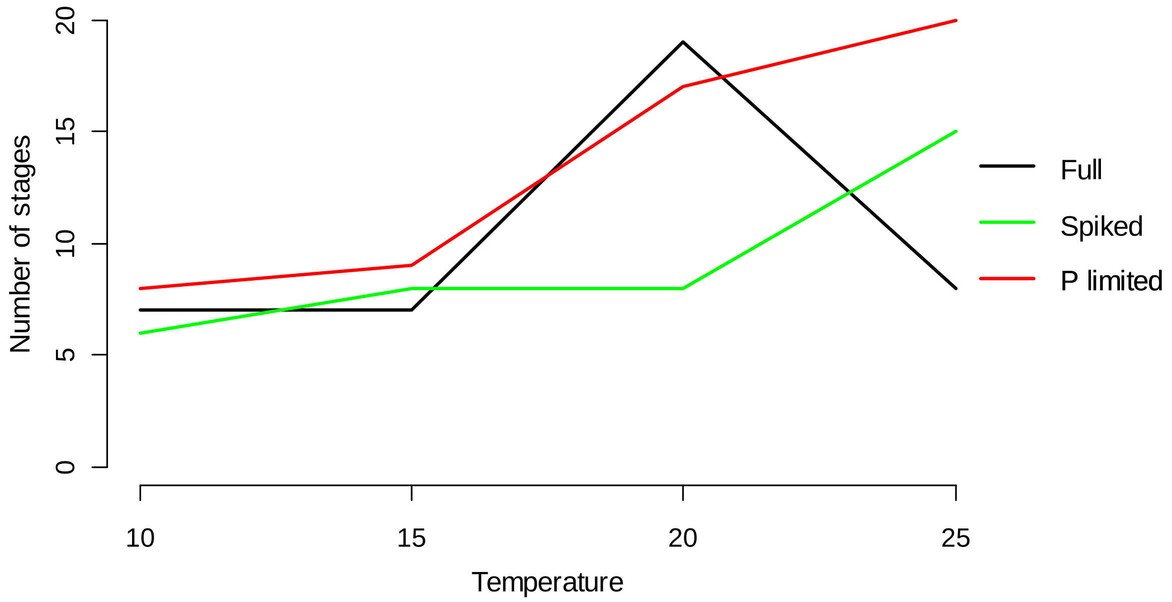


Figure 11: The maximum number of juvenile stages (G and H) an animal can have before death or maturation on **full**, **spiked** and **P limited** diet in the different temperatures (10, 15, 20 and 25 °C respectively). **Full** diet is shown with a black line, **spiked** green and **P limited** red. The X- axis shows temperature and the Y- axis maximum number of juvenile transitions made for the respective temperatures and diets.

Animals fed P rich diets transitioned maximum 7 and 6 times before maturing at 10 °C, and 8 and 15 times at 25 °C (Figure 11). The variation was small at lower temperatures (between 6 and 8 for all diets in 10°C), and large at higher temperatures (between 8 and 20 for all diets in 25 °C). Temperature had significant additive effect on maximum number of juvenile stages before maturation (Table 3 and figure 12). Neither temperature nor diet treatment has a negative additive or interactional effect on maximum number of adult stages before death (Table 3 and figure 12). There was also no interaction between maximum total stages in a lifetime and diet treatment, temperature or an interaction of the two (Table 3 and figure 12).

	ANOVA Total life span			ANOVA Juvenil			ANOVA Adult		
	Df	*F value*	*Pr(>F)*	*Df*	*F value*	*Pr(>F)*	*Df*	*F value*	*Pr(>F)*
Temperature	1	4.768	0.061	1	7.514	0.025	1	0.878	0.376
Diet	2	0.137	0.874	2	1.204	0.349	2	0.350	0.715
Temperature	1	4.304	0.083	1	6.724	0.0411	1	0.741	0.422
Diet	2	0.124	0.886	2	1.077	0.3983	2	0.295	0.755
Temperature:Diet	2	0.611	0.574	2	0.579	0.5889	2	0.376	0.703

Table 3: ANOVA of the maximum number of stages for juveniles, adult and in total for **full**, **spiked** and **P limited** diet at the different temperatures (10, 15, 20 and 25 °C respectively).

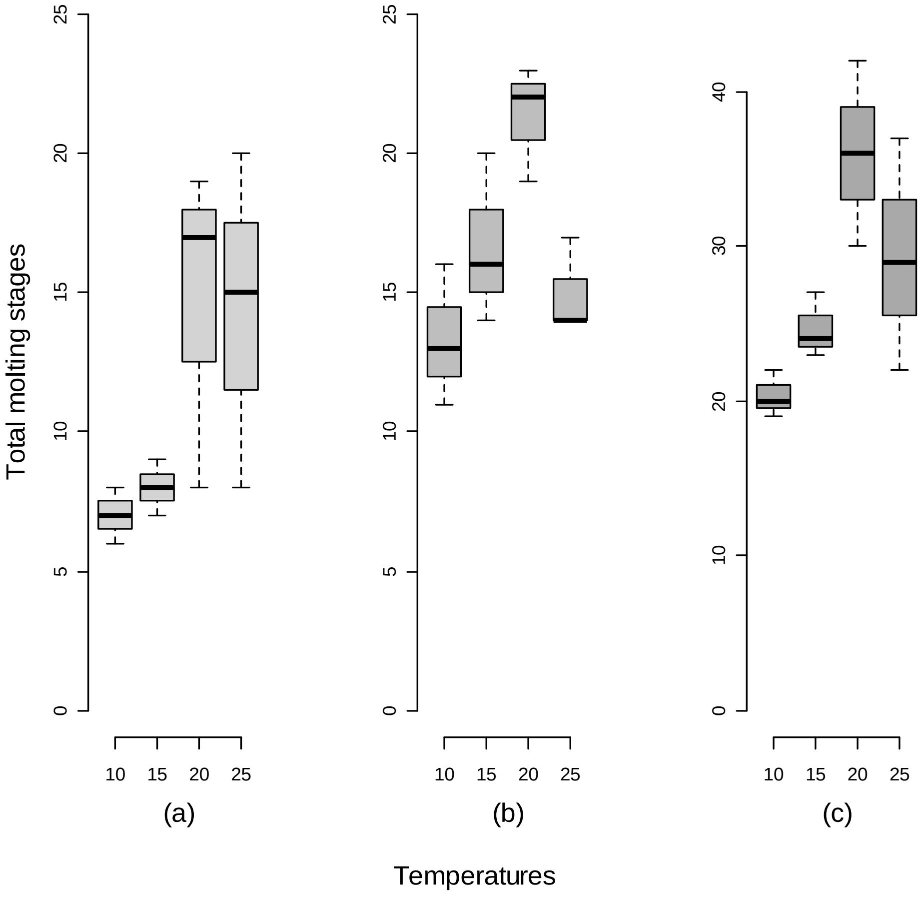


Figure 12: Maximum number of stages for juveniles (a), adults (b) and juvenile and adult together (c), for the different temperatures (10, 15, 20 and 25 °C respectively). The X- axis show temperature, and the Y axis give number of moulting stages.

3.2 Fecundity

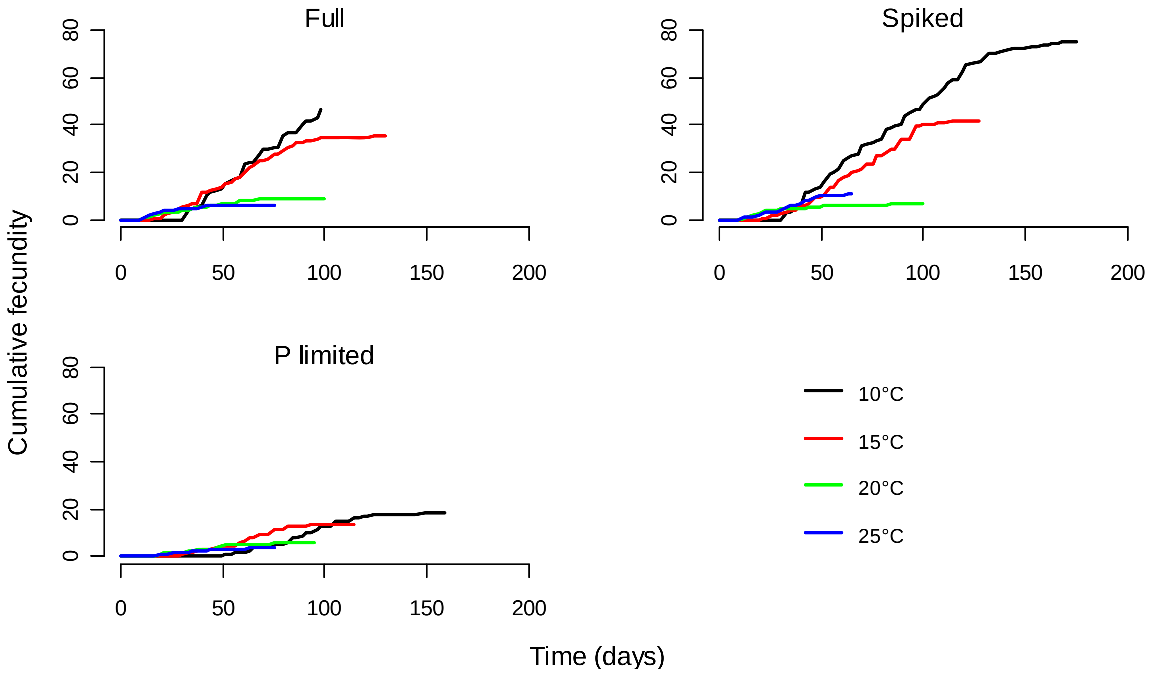


Figure 13: Average cumulative fecundity for animals in the different diet treatments and temperatures.

The average cumulative fecundity varies over temperatures (Figure 13), but also among diet treatments (Figure 14). An ANOVA of additive effect on average fecundity per animal in a lifetime is significantly effected by both temperature and diet treatment ($p << 0.001$ and $<< 0.001$). The interaction among them are also significant ($p << 0.001$). At 20 days, animals in 10 °C have not yet started reproduction, and thus have the lowest cumulative fecundity per animal, while 20 and 25 °C have the highest (Table 4). At 50 days, this is reversed for full and spiked diet.

	Full		**P limited**		**Spiked**	
	20 days	*50 days*	*20 days*	*50 days*	*20 days*	*50 days*
10°C	0	14.0	0	0.5	0	14.7
15°C	1.2	14.3	0	4.3	0.2	10.1
20°C	3.1	6.8	1.0	4.5	2.8	5.7
25°C	3.6	5.9	0.7	3.1	2.2	10.1

Table 4: Cumulative fecundity at 20 and 50 days for **full**, **spiked** and **P limited** diet at 10, 15, 20 and 25 °C.

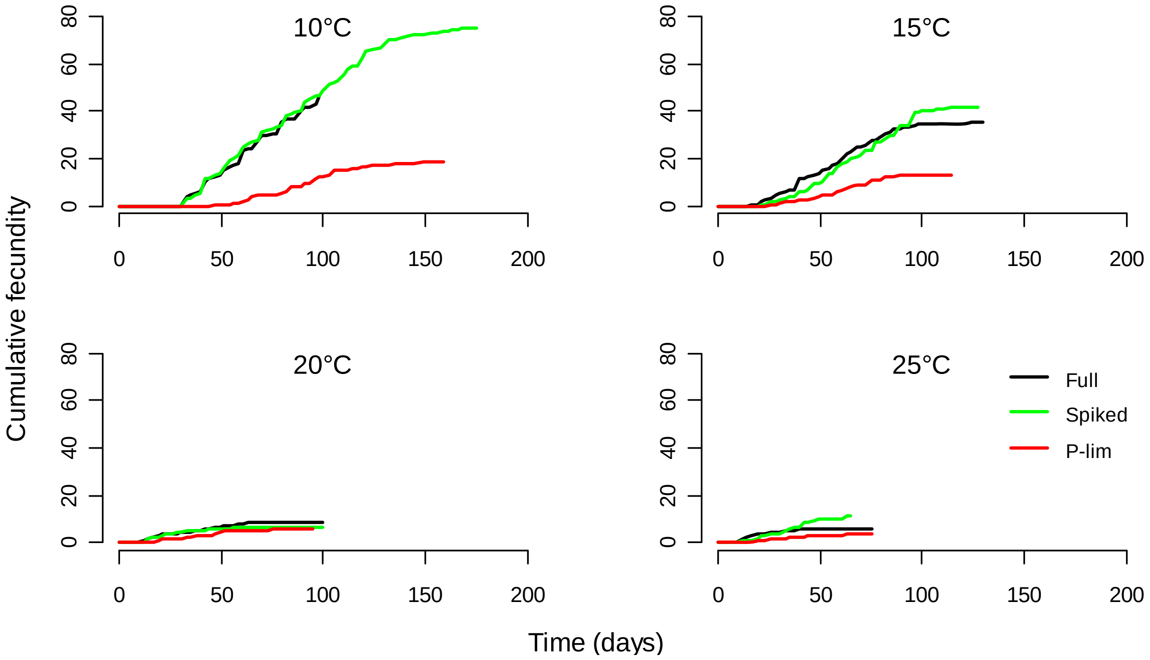
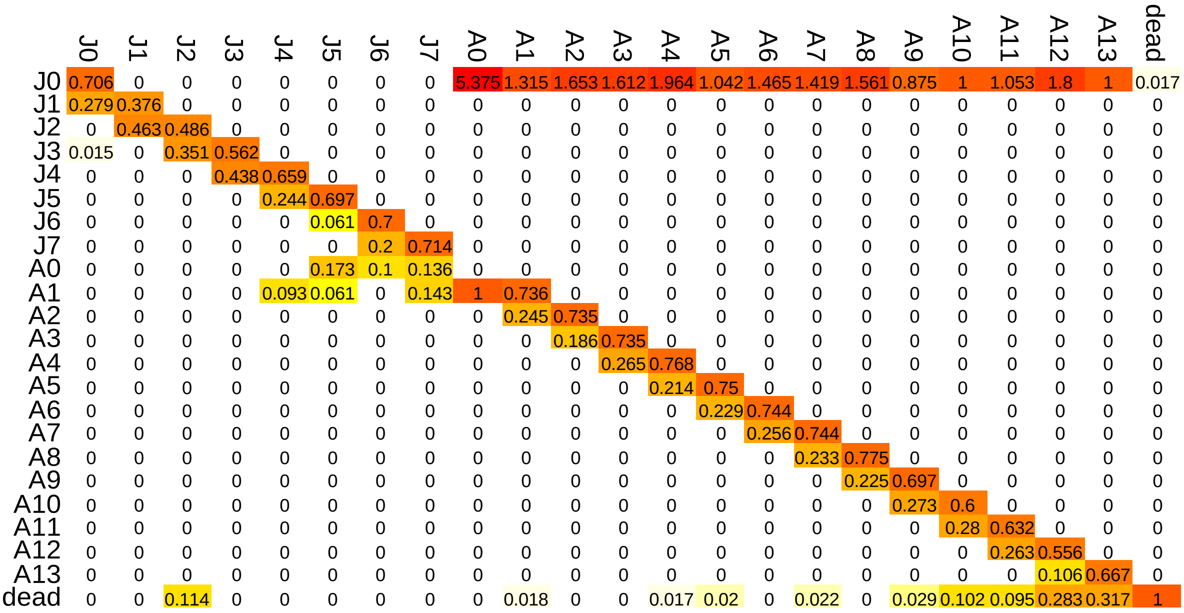


Figure 14: The average cumulative fecundity for 10, 15, 20 and 25 °C. Black line is full, green spiked and red P limited treatment. X-axis show time in days, and Y- axis changes in cumulative fecundity.

Differences in cumulative fecundity decline as temperatures increases (Figure 14), with lowest between-treatment variation at 20°C. Effects of spiked diet on cumulative fecundity was not significantly different from full diet without interaction with temperature ($p = 0.14$). Spiked diet with the interaction of temperature was significantly different from full diet ($p \ll 0.001$). Spiked treatment has much higher fecundity than full when temperature is low (Figure 14). P limited diet was significantly different from full diet ($p \ll 0.001$), and the interaction of P limited diet and temperature was also significantly different from full treatment ($p \ll 0.001$). The difference between full and P limited treatment is low at 20 and 25 °C, but very large at 10 and 15 °C. Total cumulative fecundity of animals fed spiked diet is intertwined with full diet, but at 10 °C it became more than 10 times higher than in 20 °C due to an increase in survival compared to full diet.

3.3 Matrix analysis result



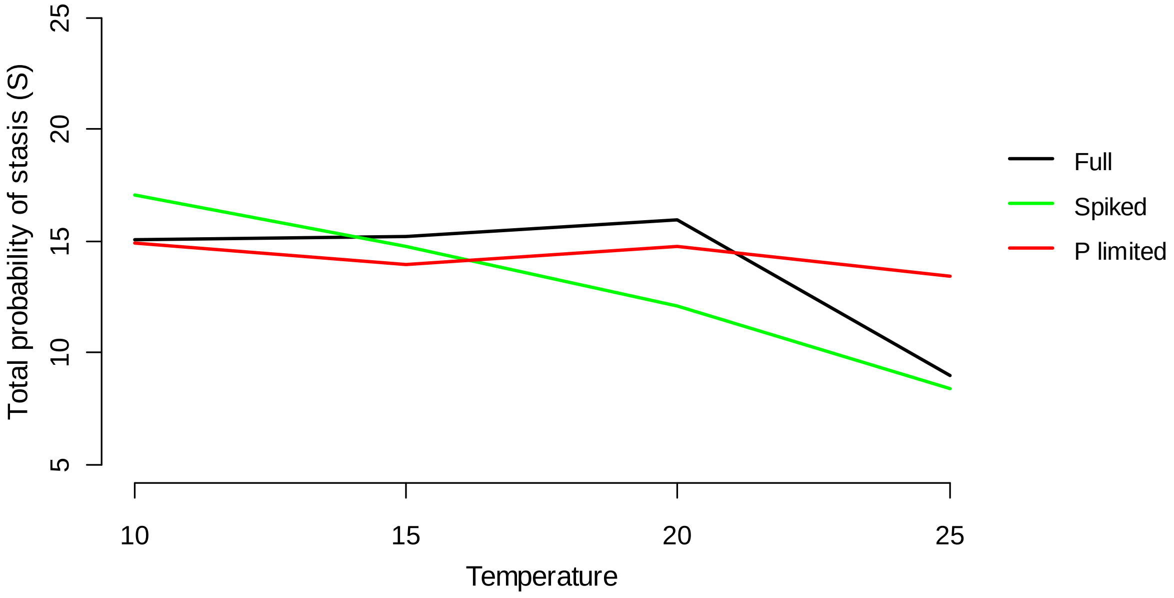
	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	dead
J0	0.706	0	0	0	0	0	0	0	5.375	1.315	1.653	1.612	1.964	1.042	1.465	1.419	1.561	0.875	1	1.053	1.8	1	0.017
J1	0.279	0.376	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.463	0.486	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0.015	0	0.351	0.562	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.438	0.659	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.244	0.697	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.061	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.2	0.714	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0.173	0.1	0.136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0.093	0.061	0	0.143	1	0.736	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0.245	0.735	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0.186	0.735	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0.265	0.768	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0.214	0.75	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0.229	0.744	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.256	0.744	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.233	0.775	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.225	0.697	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.273	0.6	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0.632	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.263	0.556	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.106	0.667	0
dead	0	0	0.114	0	0	0	0	0	0	0.018	0	0	0.017	0.02	0	0.022	0	0.029	0.102	0.095	0.283	0.317	1

Table 5: Transition matrix for full treatment 10 °C (For other diet treatments and temperatures see appendix). The colours denote the probabililty of making a transition. Numbers close to or higher than 1 is red in colour, and the colour gets stronger as the number increas. Small numbers are yellow, and thus for the transition stages high probability is more red and lower probability of transitioning yellow. See table 1.

3.3.1 Survival and growth

Transition matrixes (Figure 15) give probability of dying (transitioning to stage dead) in the bottom column. All other transitions denote as survival in one time step. For 10 °C full treatment, animals only survived to juvenile stage 2 (J2), before they mature (Table 5). The probability of transition to dead in J2 is 11.4 %. Spiked diet in 10 °C has in total 9.6 %, while P limited treatment had totally 33.4 % chance of transition to death before maturation. In 15 °C the chance of transitioning to dead is only 4.5 % for full treatment, 90.2 % for P limited and 32.9 % for spiked treatment. Death for all diet treatments and temperatures did mostly occur in early juvenile stages J1 or J2, when animals transition to mature stage A, and remain high after second reproduction. J0 has no mortality in any of the diet treatments or temperatures.

Stasis (S), the transition probability within a stage in a time step for 10 °C, was high (Figure 15). The probability of S decrease with temperature, bit has big variation among the diet treatments. The probability of growth (G) increases with temperature.



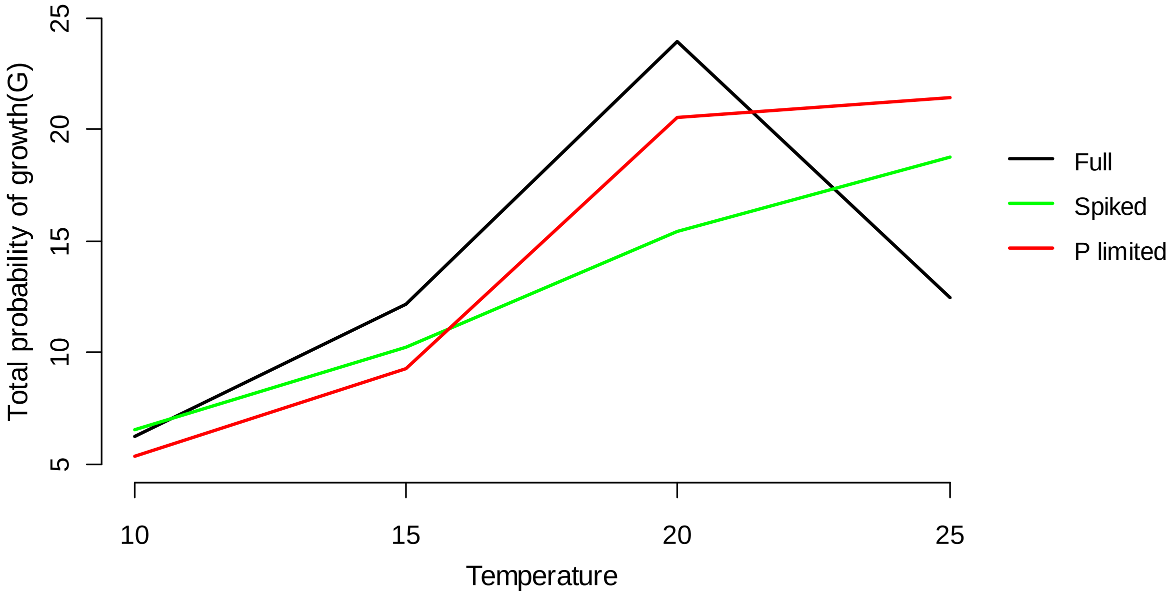


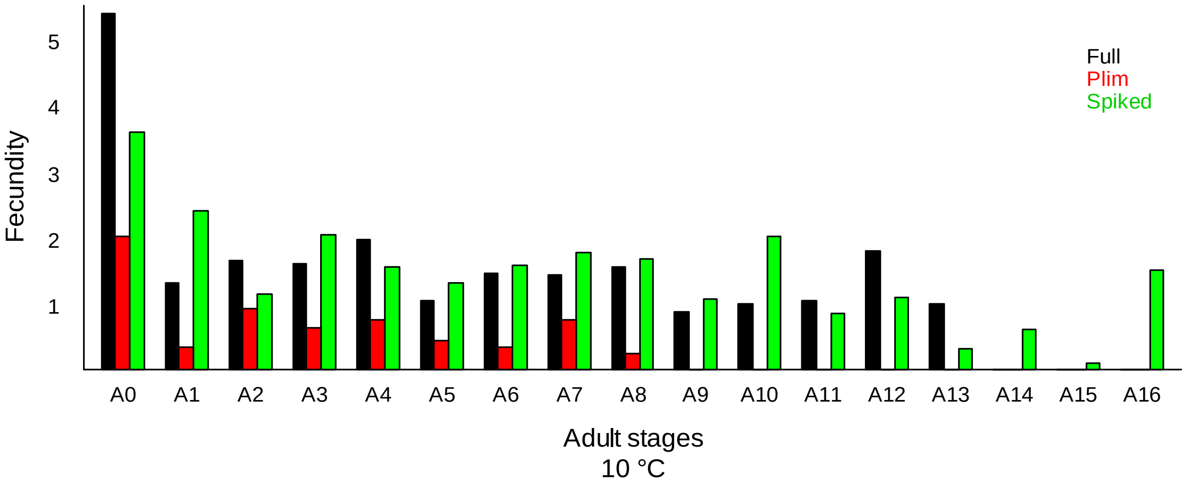
Figure 15: The diagonal of the transition matrix denotes the probabilities of stasis, and the sub- diagonal the probability of growth for each stage. Here we show the sum of the diagonal and sub-diagonal respectively, to give the total probability of stasis (S) or growth (G) in 10, 15, 20 and 25 °C for **full**, **spiked** and **P limited** treatment. X-axis is temperature. Black line is full, green line is spiked and red line is P limited treatment.

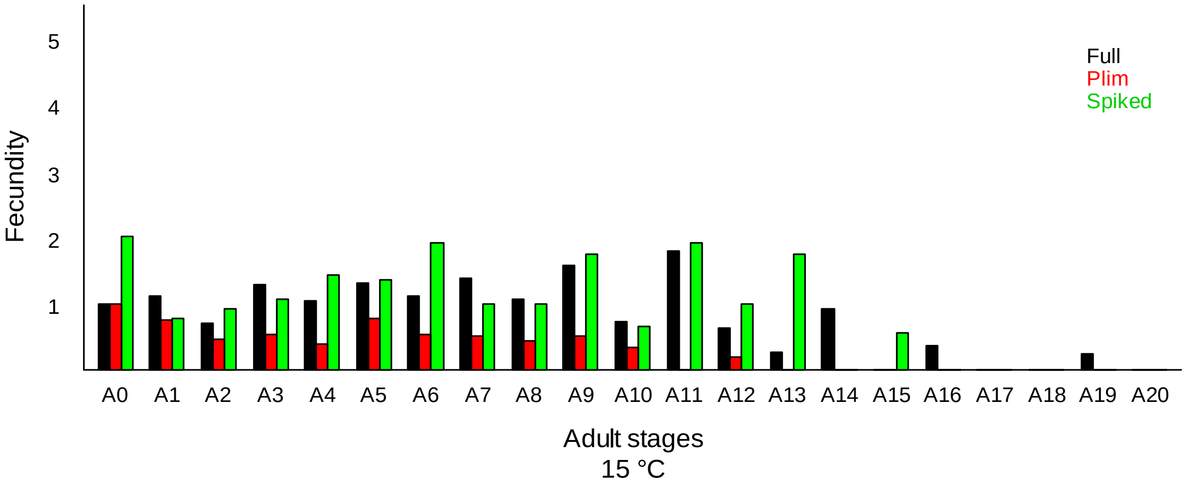
All 10 °C diets had between 6 to 8 juvenile stages before they were dead or become adult, but high probability of S within a time step. The probability of S is highest in J0, lower in the intermediate stages before maturation, and increase again in the stages where animals transition to A0 and A1. Stasis is stable in all adult stages relative to its temperature. S is not more likely for P limited treatment then P rich (Figure 16).

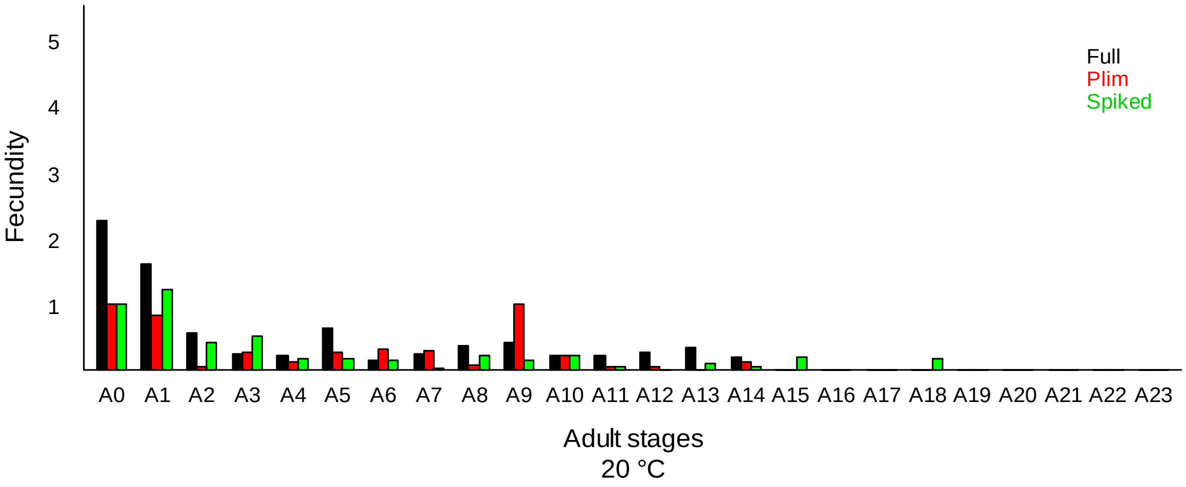
The P limited treatments had on average the highest amounts of moulting stages for juveniles, although variation here was large. In 25 °C, there are 20 juvenile stages and 17 adult stages for P limited animals, compared to only 8 juvenile stages and 14 adult stages for the full treatment. The biggest difference between diets and temperatures was the high mortality before reaching the adult stages in P limited compared to the P rich treatments.

P limited animals had on average fewer adult stages than P rich animals. Mortality in A0 to A1 stage is 0 for all diet treatments and temperatures. And mortality increase with each adult stage transition, this is true for all diet treatments and temperatures.

3.3.2 Fecundity







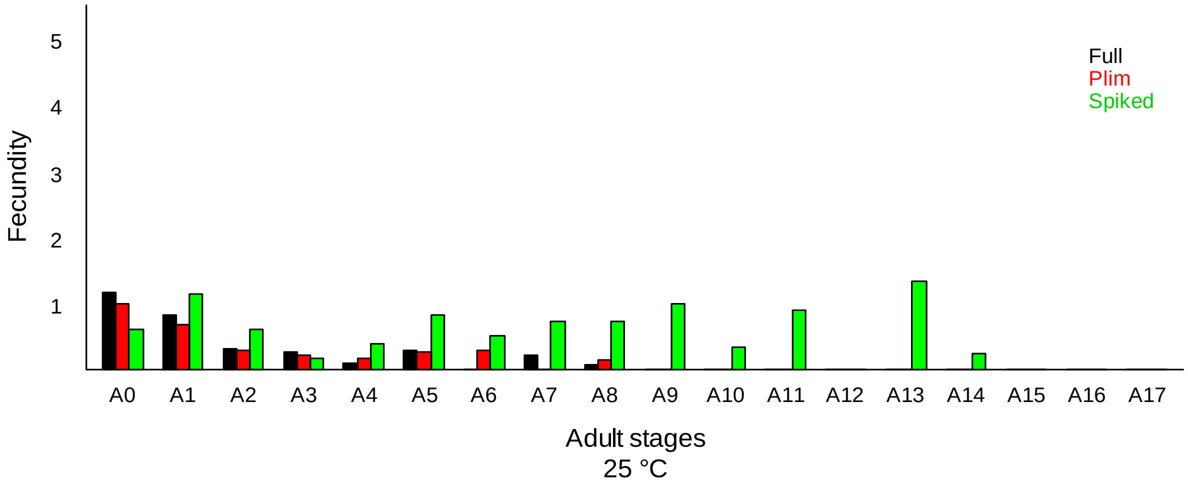


Figure 16: The stage specific fecundity per animal alive in each stage for full, spiked and P limited treatment at 10, 15, 20 and 25 °C. The X- axis show the possible adult stages in each temperature, and the Y- axis average number of juveniles produced in each time step for one animal (Fecundity).

Fecundity, the average amount of juveniles produced per animal in each stage in one time step, was highest in the early adult stages for all diet treatments at low temperatures. This peak in reproductive output was very distinct for all diets at 10°C. Stage specific fecundity at A0 stage noted in the transition matrix at 10°C was 5.375 (full), 3.571 (spiked) and 2.00 (P limited). Fecundity at 10 °C was also in general higher than in 15, 20, and 25°C (Figure 16). The P limited animals have smaller peaks than the P rich treatments, but they also had lower fecundity in general. After the burst in fecundity at first reproduction, fecundity remained stable for the rest of the reproductive stages. For animals fed spiked diet, the early adult fecundity was somehow shifted towards, or divided between the two first adult stages, whereas in full and P limited, the peak was only recorded in A0. 20 and 25°C had no stages with notably higher fecundity, and there are several stages with no reproductive output. *Daphnia* that were still alive after A16 rarely reproduced, but could stay alive until A20. Reproductive output per animal was highest at 10°C in general (close to 2 juveniles produced per animal in each stage for P rich treatment in one time step), and lowest in 25 °C (less than 1 juvenile produced per stage per animal in one time step).

3.3.3 Population growth

The relative intrinsic growth rate of the population (λ) per time step, varied from 1.01 (15°C P limited) to 1.18 (15°C full), hence all λ > 1 (Table 6 and figure 17).

Temperature	Full	P limited	Spiked
10 °C	1,14	1,01	1,15
15 °C	1,18	1,01	1,10
20 °C	1,14	1,08	1,14
25 °C	1,14	1,06	1,15

Table 6: The lambda values for **full**, **spiked** and **P limited** diet at 10, 15, 20 and 25 °C.

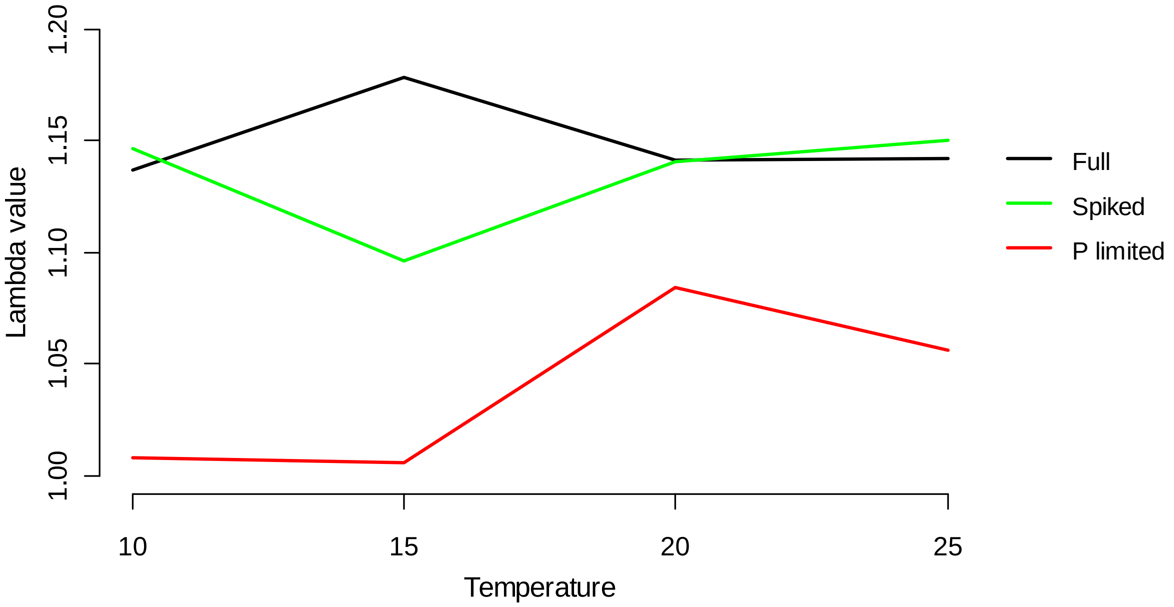


Figure 17: The lambda (λ) values of **full**, **spiked** and **P limited** diet at the four temperatures (10, 15, 20 and 25 °C respectively). λ denotes the long-term intrinsic growth rate of a population and is the dominant eigenvalue of a transition matrix for one time step.

Lambda for the full treatment was highest in 15°C, but both P limited and spiked did worse here than in any other temperature (Figure 17). The lambda for the P rich diets is in general were very similar over the four temperatures, and varies between 14 and 15, except for in 15 ° (Table 6). The three diets have the most uniform lambda in 20°C. P limited treatment also have its highest lambda in 20°C (1.08), doing a little better than in 25° C (1.06).

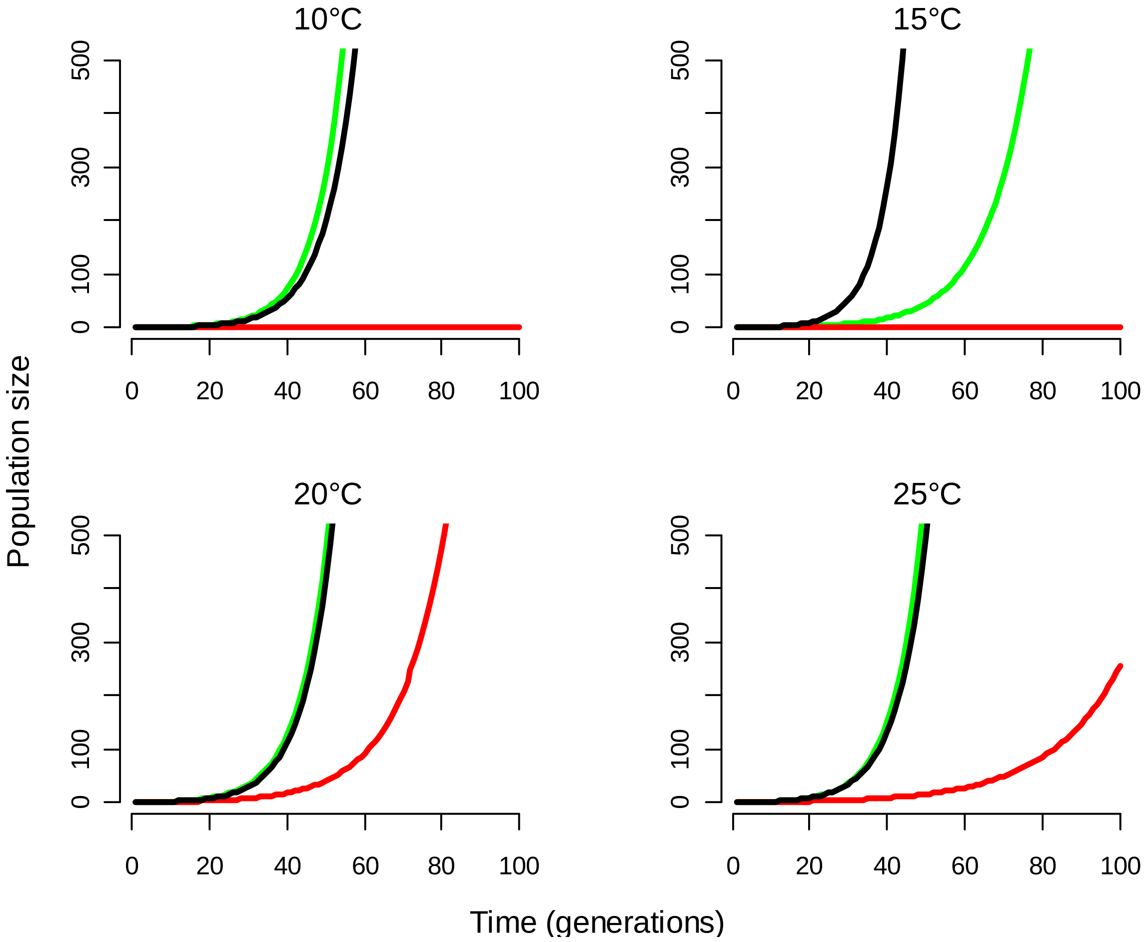


Figure18: Population growth projection of the given intrinsic growth rate (λ) values in table 6 for 10, 15, 20 and 25 °C. Black line is full, green line is spiked and red line is P limited treatment. Y-axis is population size, and x-axis time in generations.

Population projection show that the P rich diets are very similar in all temperatures except 15°C, and the lambda values are almost identical and lie between 14 and 15 (Table 17). P limited treatment has almost no population growth in 10 and 15 °C compared to the P rich diets (Figure 18). Population stage distribution stabilize after 20 generations in 10 °C for P rich diets, but more than 40 generation for P limited treatment (Figure 19), 15 °C population stage distribution is almost identical (Appendix). P limited stage distribution has a much smaller domination of juvenile individuals then P rich diets in 10 and 15 °C when population growth is small, but in 20 and 25 °C P limited treatments stable stage distribution becomes stable at 20 generations similar to P rich diets (Appendix).

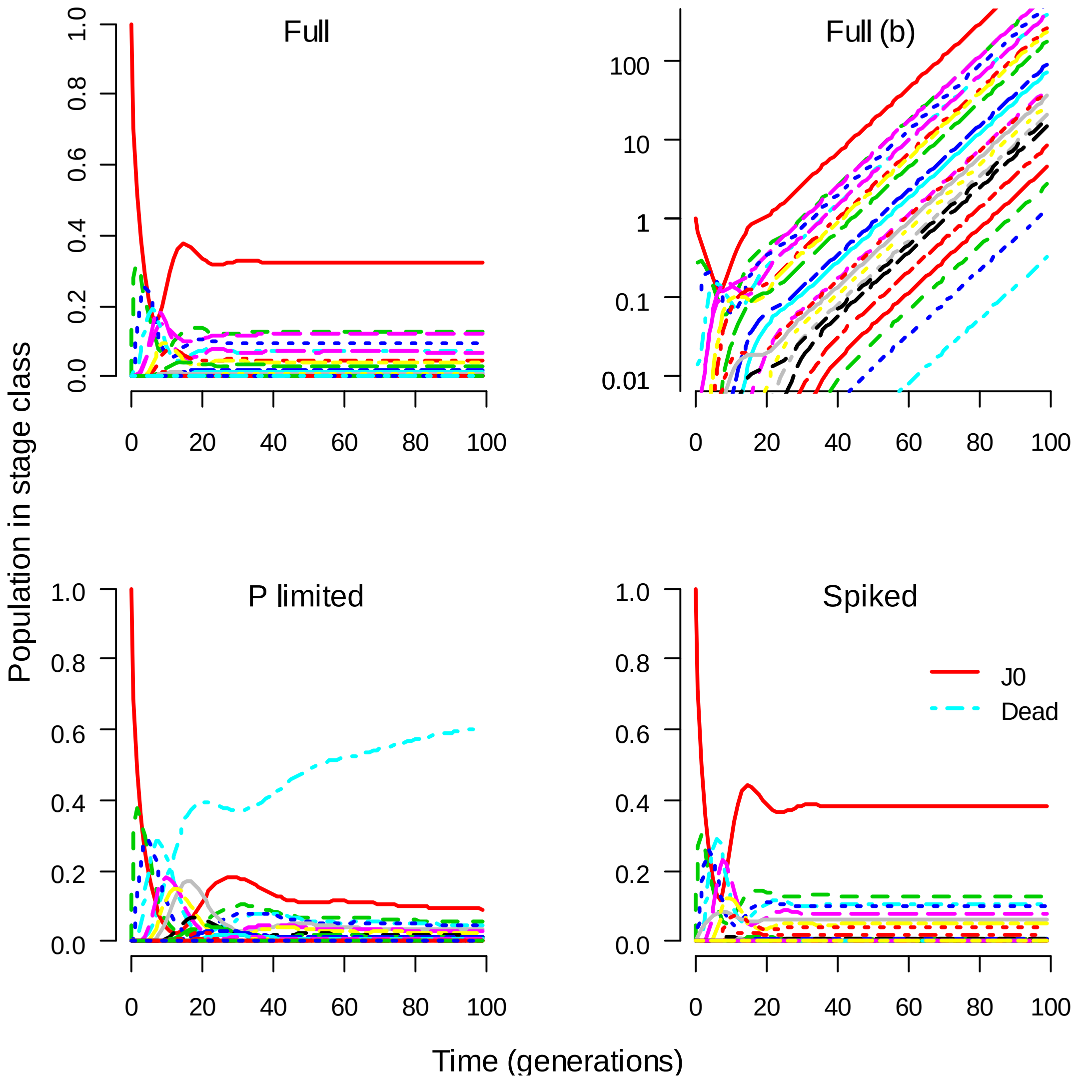


Figure 19: Population stage vector distribution for 10 °C. Full top left, P limited bottom left and spiked treatment bottom right. Top right is a stage vector plot for full treatment. The red line is proportion of population in stage class juvenile 0 (J0), cyan dotted line is proportion of population in stage class dead.

There is no stable stage distribution before ca 20 generations for P rich diets in 10 and 15 °C, this decreases a to 10 generations in 20 and 25 °C. P limited treatment does not reach stage distribution is not stable in 10 °C before more than 40 generations, and 30 in 15 °C. The amount of animals in J0 is dominant in all stable stage distributions, but less so for the P limited treatments.

Sensitivity analysis show high sensitivity to changes in growth until first reproduction, and high sensitivity in first reproduction, but low sensitivity in fecundity (Figure 18). *Daphnia* in spiked treatment in 25 °C do not transition to adult stages after J8, and sensitivity in these stages to population growth is low (low sensitivity shown with yellow color in Figure 18, high sensitivity is red). Elasticity in fecundity is ca 8 times higher in A2 then A7 and 31 times higher than in A8. Elastisity in transition from juvenile to adult stage in spiked 25°C is also ca 8 times higher, than transition after J8. This is a general trend for P rich matrixes in all temperatures (see appendix). P limited *Daphnia* shows both lower sensitivity and elasticity in general, but not at 10°C temperatures, where lambda was low.

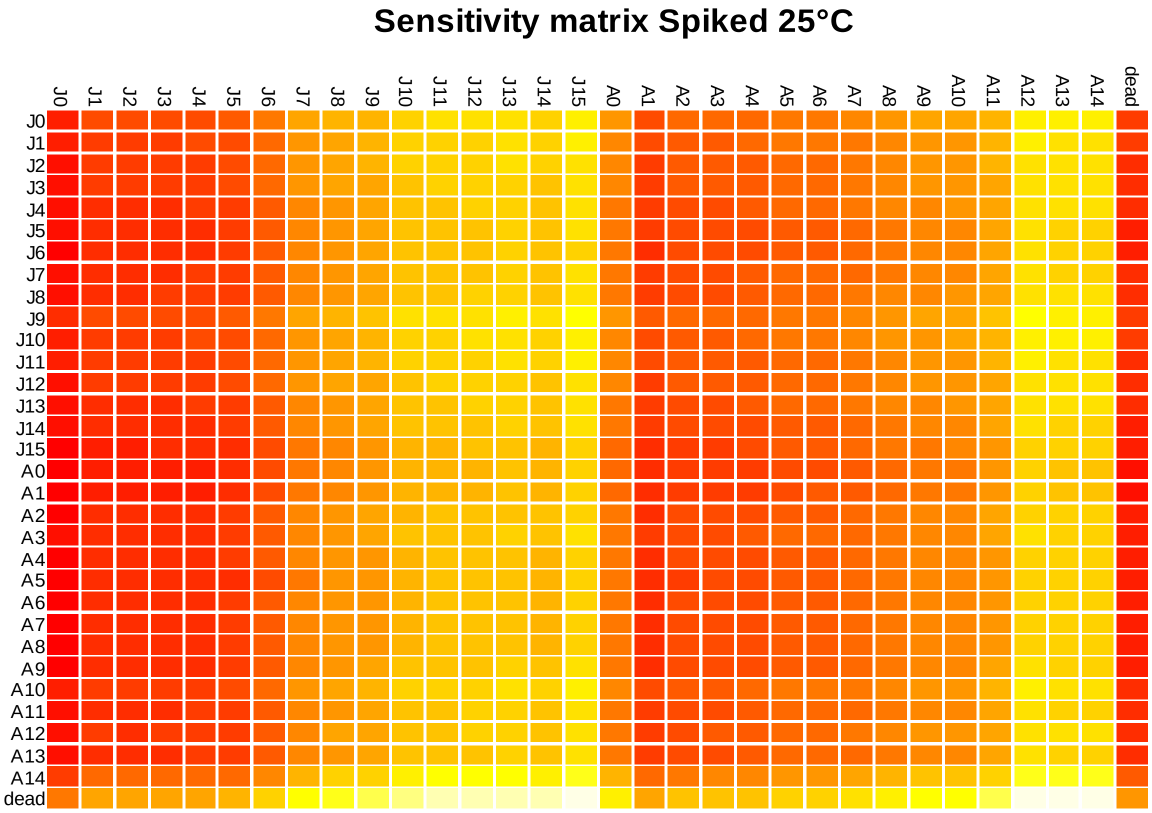


Figure 20: Sensitivity analysis for spiked treatment 25°C.

LTRE analysis was measured with reference matrix as 20 °C full treatment. LTRE analysis on full treatment in 10 and 15°C show that the main differences are between probabilities in growth versus stasis. The LTRE also show that fecundity contributes little to differences between the two matrices. There is an opposite difference in probabilities between stasis and growth between full treatment in 20 and 25 °C. LTRE between full and spiked treatment show that the differences between full and spiked are minimal. In 20 °C, P limited *Daphnia* has a smaller probability of growth, and higher probability of stasis than full treatment animals. Also here the differences in fecundity are not significantly different (Appendix).

4 Discussion

4.1 Experimental setup

4.1.1 Algae and nutrient concentration

I successfully maintained chemostats and produced a stable source of the different food quality treatments for the life history experiment of *D. magna*. The advantage of using a chemostat, was the possibility of having concentrated algae with well defined stoichiometry in respect to C:P:N ratios. The C and P levels of the produced algae were monitored by daily measurements of the optical density (OD), while P levels were controlled with chemistry analysis of the collected algae. The chemostats were stable throughout the experiment, however because they can be fragile for long lasting runs, I also kept backups throughout the whole experiment. To account for other molecular changes than C:P:N that might occur in the P limited algae (Brett and Müller-Navarra 1997; Müller-Navarra et al. 2004), the spiked diet worked as a control for possible negative effects not related to P content such as N and PUFA (Persson et al. 2011). Although I have not measured the fatty acid composition of the different diets, the P limited versus spiked algae controlled for it. Moreover, the spiked diet did not show any signs of being a lesser alternative food source then the full diet, and the P limited treatment can thus be assumed to be only limiting with respect to P. It is also important to notice that there were differences in full and spiked diet in the respect of P source, which was organic versus inorganic. Because animals were not limited by food quantity throughout the experiment; the observed differences on life history were caused by the food quality offered to the animals, which was the object of my study.

4.1.2 The experiment

The main goal of my experiment was to further elaborate on the data of Persson et al. (2010), therefore my experimental setup was similar to their work. First, to investigate if the method was suitable for a life history experiment, I conducted a short-term pilot experiment (May 2010) that I stopped after 2 months (data not shown in this thesis). Here I concluded that animals should be acclimatized to their respective temperatures for several generations, to exclude the stress of sudden temperature changes prior to the experiment, as this proved to have negative effects on survival. This observation aligns well with Frost et al. (2011), whom found that maternal effects can indeed have serious impacts on *Daphnia*. The pilot study also showed that all animal handling should be as little intrusive as possible, as this also showed to have negative effects on immediate survival. It would have been preferable to have a size estimate of the animals, but with the constraints of limited handling time, this was not possible for this experiment. Although using a flow-through system (Lampert et al. 1988) might have offered such a possibility, my experiment was focused on individual based responses to temperature and dietary changes, the individual based setup without size was thus seen as preferable. The animals used in the experiment were from the second brood of their mothers, because neonates hatched from the first clutch are smaller, grow slower and mature earlier than those from later broods (Ebert 1991; Lampert 1993; Lampert and Trubetskova 1996). Moulting was chosen as an estimator for growth (Ebert 1991; Gorokhova and Kyle 2002) as it is a good stage estimator, which also incorporates stage specific fecundity. Survival was recorded in order to estimate intrinsic growth rate (Stearns 1992). The temperature range (10-25 °C) was chosen accordingly to Persson et al. (2010). However, as *Daphnia* can tolerate temperatures from 0 to 35 °C, and this temperature range also occurs in natural habitats (Dodson 2005), a wider range of temperatures would possibly broaden the understanding of temperature constraints.

4.2 Growth and survival

Not surprisingly, survival of *D. magna* was significantly effected by temperature, such that the life spans varied from 178 days at 10 °C to 75 days at 25 °C. Accordingly, the intermediate temperatures had intermediate life spans. Moreover, temperature, diet and the interaction of the two had a dramatic effect on survival. The life span of *D. magna* increased as temperature decreased, but survival was only negatively correlated with diet for animals fed P limited food at lower temperatures. There were found no negative effects of P limited diet at higher temperatures. This significant interaction found in survival means; that *Daphnia* are more sensitive to P limitation at lower temperatures. This observation is supported by the opposite effect found for animals fed the spiked diet, who survived better at low temperatures. The effect of too much good food (Boersma and Elser 2006) was already reported for survival for *Daphnia* fed diets with low C:P ratios and could also be the case in my study. The idea is that animals have a maximum limit in nutrient uptake, and all excess nutrients ingested must be discarded of through some mechanism. In Daphnia P is excreted (Olsen et al. 1986; Elser and Urabe 1999; Boersma and Elser 2006) but regulation mechanisms of this excretion are still not well understood (Wojewodzic 2010). I propose, based on the survival data, that too much P in the diet decreases the survival of *Daphnia*, but only if P is not excreted relatively fast, as with inorganic origin. This could be mediated via pH changes related to inorganic P source in the diet offered and is supported by good survival data for animals fed full algae where P is kept in organic sources as RNA, DNA. My data also suggest that the phenomenon of too much good food exists, and that it is temperature-dependent.

The variation in survival was highest in spiked and lowest in P limited diet, while full diet were an intermediate. The effect of P limitation on survival was somehow opposite of what was expected. Animals fed spiked diet had a significant increase in survival compared to the full diet at lower temperatures, which suggest that there may be some advantage of having C:P ratio lowered shortly prior to ingestion. This difference is possibly correlated with the difference between inorganic and organic P. We know that *D. magna* at 10 °C have higher expressed levels of alkaline phosphatase (AP) at lower temperatures when fed an organic sourced P (Wojewodzic et al. 2011). This higher expression of AP is more effective on organic than inorganic P sources, but algae spiked with inorganic P might be a better food source (availability) than algae with natural organic levels of P (investment in processing the food).

Alternatively, the opposite effects of P limited and spiked diet on survival can be related to differences in their PUFA or N content, which might result in a positive effect on survival at lower temperatures (Bec et al. 2011). To keep membrane stability at different temperatures, different fatty acid compositions (or their ratios), might be required (Hazel and Williams 1990).This advantage is P dependent, which means that P limited animals experience the opposite effect.

The difference between the three diets was lowest at 20 °C, suggesting that whatever advantages, or disadvantages this might have on survival, it is not present at this temperature. Prior to the acclimation to their respective temperatures (10, 15, 20 and 25 °C), this clone of *D. magna* was held at 20 °C for several years (Pulkkinen and Ebert 2004). It is possible that this acclimation to a stable 20 °C for so many years caused some adaptation to this temperature, which became a disadvantage when temperature again changed. An acclimation for three generations only removed the immediate stress response of temperature change, and neonate survival, but an overall increase in stress remain constant for theentire life span. Variation in survival was greatest at 10 °C, and is quite similar at 15 and 25 °C, which indicates that the variation will increase as temperature increase or changes from 20 °C. It is also worth noting that the algae *S. capricornutum* was cultivated at 20 °C, and that temperature alone might have implications on P and fatty acid composition of algae (Personal communication Sikora, A. IXth International Symposium on Cladocera). Thus, algae grown at 20 °C have a fatty acid composition that accommodates *Daphnia* growth at the same temperature, but not higher or lower temperatures, not meeting requirements. Algae grown at 10 °C would thus have a different fatty acid composition, which would be best suited for growth at 10 °C. The effect of spiking P limited algae has only been measured at 20 °C (Rothhaupt 1995; Plath and Boersma 2001), and could also possibly therefore have a positive effect of spiking with inorganic P at 10 °C. Algae with naturally high C:P ratio spiked with inorganic P thus has an advantage at lower temperatures, which disappear at 20 and 25 °C where metabolism also is higher (Boersma and Elser 2006).

4.3 Fecundity

Fecundity is a life history trait tightly coupled with growth (Stearns 1992), and reproduction thus starts earlier at higher temperatures than lower. Probability of maturation increased with temperature and P. The reproductive period was longer for animals at lower temperatures (slower allocation into reproduction), and cumulative fecundity was more than 7 fold from 10 to 25 °C for animals fed spiked diet. The length of rotifer reproductive period has been coupled with reproductive output, short lived animals reproduce large, and long lived individuals reproduce at smaller rates over a longer period (Snell and King 1977). In this experiment, the average number of juveniles produced was highest in the first and second adult stages (A0 and A1), meaning disproportional investment in fecundity throughout the whole reproduction period, and maximization of reproduction output for newly matured individuals. Interestingly, the highest stage specific fecundity was found for animals at 10 °C, which also had the longest reproductive period. It is however possible that animals in a natural population would be outcompeted by their juveniles after first reproduction, because juveniles are more effective feeders than adults (Nilsson et al. 2010). If this is the case, there will be no possibility of an elongated reproduction period when competition for resources is strong. In such a scenario, pressure to maximize reproductive output in the first reproductive stages would be favored at lower temperatures, where survival to maturity and growth is low, and the elongated reproductive period observed in the lab is not a naturally occurring phenomenon.

It has been proposed that animals fed P limited diet can excrete excess C by respiration, egestion and moulting (Andersen et al. 2007). One possible life history strategy would be to acquire sufficient levels of P, N and fatty acids, by simply eating more, and excreting excess C. This can be mediated simply via increase of the respiration or the rate of moulting. I found no correlation between diets and moulting, thus P limited *Daphnia* did not moult significantly more than animals fed sufficient P. Animals that experienced increased moulting might have done so because they allocated more energy towards growth, and moulting is related to the way *Daphnia* grow. However, *Daphnia* with exaggerated growth normally failed to reproduce, which indicates that moulting is a poor way of ridding of excess C simply because it is too energy consuming. P limitation reduces clutch size significantly compared to spiked and full diet. This reduction in clutch size might be a result of abortions, which was not recorded in this study. Urabe and Sterner (2001), found that 15 to 30 % of eggs where aborted in *Daphnia obtuse* when fed P limited food. This high abortion rate might be a way to rid of excess C, or simply a result of failed reproduction due to lack of recourses. Delay in first reproduction relative to full and spiked diet was only present at lower temperatures. *Daphnia* size and time at first reproduction has been found to correlate strongly (Ebert 1991), which suggests that P limitation reduce growth only at lower temperatures. Persson et al. 2011 found that P limitation only reduce growth at higher temperatures, which either means that there is no correlation between growth and time of first reproduction, or that P limitation do not reduce growth at higher temperatures. If growth is reduced at lower temperatures, it would indicate a trade-off between allocation for growth and reproduction, and could account for the disproportional reproduction found for P limited animals, which occur only at lower temperatures.

Starvation experiments suggest that there is a trade- off between growth and maintenance, and reproduction (Bradley et al. 1991). The results of animals fed P limited diet suggests that *Daphnia* indeed allocate more energy to growth and maintenance then reproduction. It would therefore be interesting to see if animals fed P limited diet until maturation would change reproductive output once they were changed to full diet. This is of great relevance as *Daphnia* can experience great fluctuations in food quality and quantity in nature (Dodson 2005), which would favor a strategy of growth and maintenance until resources are available for reproduction without reduction in survival. This strategy would also favor resource allocation towards an early adult reproduction only when nutrients are available. Delayed maturation, and possibly heightened abortion rate observed in animals kept on P limited diet, is thus a way for *Daphnia* to wait until there is sufficient recourses available for reproduction. This is supported by the fact temperature is the main driving factor in interannual variability in *Daphnia* population dynamics in spring (Schalau et al. 2008). This will mean that the growth of zooplankton not necessarily overlaps with algae blooms, and the possibility of delayed maturity would indeed be a good survival strategy. It is plausible that animals grown on P limited diet, if switched to a diet with low C:P ratio, develop and hatch normally and without an increase in abortion rates and mortality. In the starvation experiments by Bradley et al. 1991, *Daphnia* had a recovery period with reduced reproduction. This was probably a strategy to build up storage nutrients for growth and maintenance in case of further nutrient limitation. It is possible that if switched to full food, there would be a recovery period also for animals grown on P limitation algae. This would mean no immediate positive effect of the change in C:P ratio, and a negative effect of a possible mismatch in zooplankton and algae blooms due to global warming. However it is possible that this is a response to starvation only, and that a C:P > 600 is sufficient for growth and maintenance, as my results indicate. In that case I would expect the delayed maturation to be a strategy to maximize fitness in situations with delayed algae blooms.

The variation in cumulative fecundity between the different diets was lowest at 20 °C. P limited diet had the lowest variation in cumulative fecundity over the different temperatures, whereas spiked diet had the highest (Figure 9). This variation among the diets are similar to the variation found in survival, again suggesting that the there might be an optimal temperature for this clone of *D. magna,* which lies around 20 °C. As mentioned before, there might be other mechanisms in the dietary algae, correlated with inorganic versus organic P and fatty acid compositions, which are not well understood.

4.4 Matrices and the intrinsic rate of increase

By analyzing survival and fecundity as separate events, differences in important life history traits are easily visualized. However, when constructing a stage based transition model, it becomes obvious that even though temperature changes the time aspects of the life history events, the overall life history stays the same (Appendix). The stage transition pattern of *D. magna* is the same at all temperatures with no effect of P limitation, but with great variation over all temperatures and diet treatments. This basically means that *Daphnia* follow the same population growth pattern, also if they are P limited, but that even within one clone, temperature and diet, there is a great possibility of phenotypic plasticity. This means that a stage based model is a good way of analyzing the life history data of *Daphnia*. LTRE analysis is one way of statistically comparing the different matrices with a reference matrix of choice. With this approach it is possible to see if the matrixes and transition patterns that look the same, actually are statistically similar. LTRE analysis was conducted with 20 °C full treatment as reference matrix. This matrix was chosen because 20 °C was the temperature with lowest variation, and thus seems the optimal temperature for this clone of *D. magna* fed on *S. capricornutum*. Full treatment was considered the best diet treatment, and spiked the control. There LTRE show that there are small differences between the matrixes in general. The biggest differences are between the probability of stasis and growth in the different temperatures. There are also some differences in fecundity among the temperatures. This lack in difference among the matrixes supports the fact that *Daphnia* grow and reproduce in the same way, over all temperatures and diet treatments, with only small variations in fecundity and time spend in each stage step. This makes it possible to examine growth without the time difference that temperature imposes on the life history trait analysis. Time is however not ignored with a stage based model, because time spent in one life stage (probability of stasis versus growth), changes along temperatures.

When a *Daphnia* sheds its exoskeleton, it absorbs water through the soft intergument, which rapidly increases the animals size before a new exoskeleton forms (Dodson 2005). The moult is therefore thought to be a good indicator of growth, and was therefore used as a growth parameter. The probability of moulting at low temperatures during one time step declines with temperature, which correlates well with the notion that *Daphnia* grows slower at low temperatures. The variation in number of juvenile moulting stages was small at low temperatures, and increased with increasing temperature. There were thus no fixed number of moulting stages for *Daphnia,* and there was no interaction from diet on moulting. Within 15 °C, animals moulted between 3~8 times. Ebert (1991) conducted a similar study in 15 °C, and found a strong correlation between length and time at maturation, with variation of ± 1 moult. This suggests that there were big differences in juvenile size at the beginning of my experiment, which could account for some of the variation in juvenile stages before maturation. However it is also a possibility that species and clones vary greatly in moulting, and that my clone of *D. magna* has great potential for phenotypic plasticity. Another factor not taken into account in my study is density dependence. Natural populations with high density dependence exhibit equal short term birth and death rates, with high genetic variance in spring and low genetic variance by late summer (Tessier et al. 1992). The clone used in my experiment had most likely not undergone any genetic selection, as individuals in stock cultures were kept at low density and selected at random. Furthermore, the animals in the experiment were kept separately, all factors that naturally increase variation.

Even if there was a difference in size of newborn juveniles at the beginning of the experiment, this cannot explain the variance of up to 19 juvenile stages in 20 °C, which in all other respects has the lowest variation in all life history traits for the different temperatures. Such variance only occurs in 20 and 25 °C, and the animals that moult more than 8 times rarely mature. The occurrence of such a threshold size of maturation, suggests that there is a possibility of overinvestment of energy allocated towards growth, and that this is temperature dependent. Animals that allocate too much of their energy per time towards growth, will thus have a much smaller probability of maturation.

Probability of stasis was greatest in the first juvenile stage J0, and in the stages where *Daphnia* transition to adult. This means that for the first days, and before animals gave birth for the first time, growth stopped for a period of time. Fecundity was highest in the first adult stages, which are the only stages with delayed growth. This is a general trait for animals in all temperatures and diets, further implying that there is indeed a trade-off between growth and reproduction. P limitation has a great impact on both probability of maturity, and fecundity. For all temperatures and diet treatments juvenile death is not random, but occurs at critical stages associated with maturation. Such maturation related deaths are more common for P limited *Daphnia* than those kept on full and spiked diet, thus the increased mortality observed for P limited animals seem to be a result of failed maturation. Those P limited animals that do mature, have much lower fecundity than animals on full and spiked food.

Many studies have successfully recorded the relationship between growth rate and stoichiometry (Main et al. 1997; Elser et al. 2002, 2003; Hessen et al. 2002; Vrede et al. 2002) while overall fitness measurements has received little attention in comparison (Stearns 1992) , probably due to experimental labor involved. Age at maturity, probability of survival and number of offspring in a given class gives the opportunity to specify rate of growth of the population (Stearns 1992). The dominant eigenvector (λ) for the transition matrixes (Caswell 2001), show that although survival and fecundity vary among the temperatures, intrinsic growth rate are stable for animals fed full and spiked diet. Because of the high cumulative and stage specific fecundity at lower temperatures, I expected λ to be accordingly high, which was not the case. With the exception of 15 °C, λ lies between 1.14 and 1.15 for full and spiked diet. The LTRE analysis shows that the differences among the temperatures are small, and the intrinsic rate of increase confirms this.

The correlation between fecundity and growth can be investigated with sensitivity and elasticity analysis of the different transition matrices, to see how sensitive the intrinsic growth of increase is to changes in each stage transition (Caswell 2001). Probability of maturity increase with temperature, but stage specific survival is relatively stable. The stable survival is the reason why λ does not change much. Sensitivity and elasticity show that changes in survival for stages prior to maturation and the first adult stages will have the greatest impact on λ. Probability of maturation was reduced with 20 % for *Daphnia* fed P limited diet compared to full and spiked. This 20 % reduction in survival to maturation at 10 °C, changes the λ from 1.14 to 1.01 which equals the difference between population growth and no growth. This change in λ is most likely caused by survival, because fecundity has a far smaller impact on population growth when survival to mature age is low. This is further confirmed by the fact that fecundity is higher at 10 and 15 °C than at 20 and 25 °C, which seem to have no impact on λ. Thus, even if other clones of *Daphnia* have higher fecundity than what I found in my study (Pietrzak et al. 2010), fitness will not change notably if survival to mature age does not improve.

Survival and probability of maturation increase with temperature, and as survival to maturity reaches 60 %, λ increase to 1.08 for P limited *Daphnia*. Survival has thus a far bigger impact on λ than fecundity, because fecundity for P limited diet is higher at lower temperatures than higher, meaning that even small changes in survival to maturity will impact λ more than big changes in fecundity. Furthermore, it implies that for positive population growth to occur, survival to mature age needs to be higher than 60 %. This finding suggests that within the variation, there may be an overall optimal growth and moulting pattern, conserved over all temperatures. This pattern is not as fixed as the one Ebert (1991) found, but maturing before J8 seems optimal for population growth. Furthermore, continued reproduction after A0 and A1 is of contributes little to λ. This supports the notion that *Daphnia* are outcompeted by their offspring after reproducing (Nilsson et al. 2010), and therefore must allocate as much resources to first reproduction as possible.

The fact that there are differences in spiked and full treatments in survival and fecundity seems to be cancelled out when taken to the population level. This can be explained by the fact that the differences found, was in the life cycle stages of less importance to population growth, which was shown by the sensitivity and elasticity analysis. The positive effect of spiked diet on *Daphnia* was higher survival at later adult stages, stages that even with reproduction contributes little to the overall population size. Changes in reproduction is also of less importance, especially when any later than A2, and thus the positive effect of spiked diet on cumulative fecundity and survival only contributes + 0.01 to λ. This means that full and spiked diets are not significantly different, at least not in life history traits that are important to λ. It is therefore safe to assume that the low λ for animals fed P limited diet is caused by P limitation, and that juvenile survival and probability of survival to maturity is the main reasons why P limitation will decrease λ of *D. magna* to a level where the population stops growing at 10 °C.

Under ice cover in winter, population intrinsic rate of increase has been observed to be negative (Winder et al. 2003). This indicates that the λ observed in 10 °C for P limited *Daphnia,* will further decrease with temperature. The small λ is caused by a low probability of maturity, and thus at temperatures close to 0 °C, there would be no maturation which will make λ negative. However, animals can survive for long periods with only small reduction in survival, because the trade- off in P allocation is between maturation and growth, and maturation is not an option. *Daphnia* can in fact survive for 6 weeks with less than 0.1 mg CL^{-1} and almost 2 weeks with no food at all at 5 °C (Rellstab and Spaak 2009). Overall survival was significantly reduced by temperature and P limitation, but survival before maturation was only slightly reduced. This indicates that juvenile survival under temperatures lower than 10 °C also can stay high, which will make overwintering a valid alternative to sexual reproduction and epphibia. When temperature and nutrients increase in spring, juveniles that survived the winter can start reproduction immediately, which will give them an advantage in the competition against hatching epphibia, if one assumes that the two methods of overwintering strategies are competitive. It is however some indications, that at least some species have a mixed strategy (Lampert 2010), which suggests that individual females produce resting eggs, and then tries to survive the winter. However my data suggests that it would be most profitable for survival, to delay maturity until after winter, and that the overwintering females are indeed juveniles and not females in later adult stages, at least for my clone. However the winter ice cover in the study lake of Lampert et al. 2010 is variable, as climate on the west coast of Norway is relatively mild. Thus temperatures and nutrients might be higher than in a lake with thick ice for the entire winter period. In a fish free lake in the Tatra mountains, two lineages of *Daphnia pulex* coexists with different overwintering strategies, and thus also big differences in longlivity and size (Pietrzak, B. IXth International Symposium on Cladocera).

4.5 Conclusion

The experimental setup successfully observed the effect of food quality and temperature on the life history of *D. magna*. I show that the results are caused by the food quality offered to the animals, which was what I wanted to measure in my study.
There were a significant effect of temperature and C:P ratio on the survival of *D. magna*. The observed effect was negatively correlated with P limitation at low, but not at high temperatures. The opposite effect was found for spiked diet, indicating that there are some underlying mechanisms correlated with nutrients and fatty acids that effect the life history of *D. magna*. Whatever mechanisms this might be, the phenomenon is likely to be temperature-dependent.

There was found both temperature and diet effects on fecundity. *Daphnia* invest disproportional amounts of energy into reproduction, and fecundity in the first adult stages. Abortion of eggs might be a way to get rid of excess C, although it might also just be a sign of failed reproduction and thus an energy sink and not a way of conserving energy. Excess C is not likely to be excreted through moults, as this seems to be highly energy consuming.

Matrix analysis emphasizes the fact that *Daphnia* moulting and growth, all though different in time spent in each transition stage, is equal over all temperatures. Furthermore, stage based matrix models is a good way of investigating the life history of *Daphnia*. This can be used in many aspects of biology; from toxicology and ecological stoichiometry to the optimal temperature and feeding regime for animals kept in cultures.

I found clear indications that there is a trade- off between allocation for growth and reproduction for the clone of *D. magna* in my study. My data show that there is a possibility of allocating too much energy per time towards growth, which results in failed maturation and reproduction. My results also show that population growth is reduced at low but not at higher temperatures, contrary to the findings of Persson et al. 2010, using somatic growth as a proxy for population growth. Therefore I conclude that growth rate in general is a poor estimator for fitness. Fecundity is also a poor indicator of fitness, because only the first adult stages contribute to intrinsic rate of increase. Thus stage specific fecundity for first and second reproduction is a much better indicator for fitness. When looking at intrinsic rate of increase, there is no difference between full and spiked diet.

The high survival of individuals at low temperatures, indicate that overwintering is a good alternative strategy to dormant stage through the production of epphibia. This might lead to a mixed strategy, or two competing strategies. As growth of *Daphnia* is strongly temperature dependent, delaying reproduction might be a way to counteract negative effects of a mismatch between zooplankton growth period and algae blooms.

4.6 Future prospects

Investigating the life history of more than one clone of *Daphnia*, would further increase the power of my study, especially when it comes to better understanding the dynamic mechanisms between trade- offs in growth, survival and reproduction, especially in the genetic context. It would indeed be interesting to see if the results gathered from this clone of *D. magna* are similar in other clones of the same species, and other species. Anderson, 1932; Anderson & Jenkins, 1942; Green, 1956; Vuorinen, Ketola, & Walls, 1989; Mari Walls & Ketola, 1989 showed that differential juvenile growth or small size differences at birth in *Daphnia* can lead to variation in the number of juvenile stages, this in turn causes variation in other life history traits. My experiments required a lot of logistics and labor, and having more clones would be impossible to handle, however following Ebert (1991); observing and understanding the variation in one clone in one environment can help us understand the cause of variation to life history traits of *Daphnia.* This experiment is a good example that even one clone can increase our understanding of the life history of cladocera, however I would be very interesting in doing a follow up study with another clone, to further investigate the findings in this thesis.

As size at birth is important for growth and time of first reproduction (Ebert 1991; Lampert 1993; Lampert and Trubetskova 1996), it would also be very interesting to investigate if the results are similar in this clone of *D. magna* after several generations on the different food and temperature regimes, to investigate possible molecular changes and maternal effects. Stress from P limitation can have effects on the phenotype of the offspring, and the environment the offspring is born into will in turn also effect the response of this variation (Frost et al. 2009). As size in juvenile offspring can vary even within a growth season (Tessier et al. 1992),

Daphnia spp.is a key species in freshwater ecosystems and considered a good model organism. Knowing the underlying mechanisms of the life history traits and trade- offs in freshwater crustacea, may allow a greater understanding of the population dynamics at several trophic levels. As temperature is changing, inter- specific interactions become of greater importance, and the possibility of predicting cascading ecological effects will be of common interest for the ecosystem as a whole. Matrix modeling offers an elegant opportunity to approach, and combine the tools of ecological stoichiometry and modern genetics to predict future scenarios of global warming effects and its consequences.

5 References

Allen, A. P., and J. F. Gillooly. 2009. Towards an integration of ecological stoichiometry and the metabolic theory of ecology to better understand nutrient cycling. Ecology letters **12**: 369-84, doi:10.1111/j.1461-0248.2009.01302.x

Andersen, T., P. J. Færøvig, and D. O. Hessen. 2007. Growth rate versus biomass accumulation : Different roles of food quality and quantity for consumers. Limnology and Oceanography **52**: 2128-2134.

Andersen, T., and D. . Hessen. 1991. Carbon, nitrogen and phosphorus content freshwater zooplankton. Limnology **36**: 807-814.

Anderson, B. G. 1932. The Number of Pre- Adult Instars, Growth, Relative Growth, and Cariation in Daphnia Magna. Biological Bulletin **63**: 81-98.

Anderson, B. G., and J. C. Jenkins. 1942. A Time Study of Events in the Life Span of Daphnia Magna. Biological Bulletin **83**: 260-272.

Arendt, J. D. 2012. Adaptive Intrinsic Growth Rates: An Integration Across Taxa. The Quarterly Review of Biology **72**: 149-177.

Bec, A., M.-E. Perga, A. Koussoroplis, G. Bardoux, C. Desvilettes, G. Bourdier, and A. Mariotti. 2011. Assessing the reliability of fatty acid-specific stable isotope analysis for trophic studies. Methods in Ecology and Evolution **2**: 651-659, doi:10.1111/j.2041-210X.2011.00111.x

Boersma, M., and J. J. Elser. 2006. Too much of a good thing: on stoichiometrically balanced diets and maximal growth. Ecology **87**: 1325-1330.

Bradley, M. C., N. Perrin, and P. Calow. 1991. Energy allocation in the cladoceran Daphnia magna Straus, under starvation and refeeding. Oecologia **86**: 414-418, doi:10.1007/BF00317610

Brett, M. T. 1993. Comment on " Possibility of N or P limitation for planktonic cladocerans : An experimental test " (Urabe and Watanabe) and " Nutrient element limitation of zooplankton production " (Hessen) l. Limnology and oceanography **38**: 1333-1337.

Brett, M. T., and D. C. Müller-Navarra. 1997. The role of highly unsaturated fatty acids in aquatic foodweb processes. Freshwater Biology 483-499.

Burns, C. W. 2012. RELATION BETWEEN FILTERING RATE , TEMPERATURE , AND BODY SIZE IN FOUR SPECIES OF DAPHNIA. Limnology **14**: 693-700.

Caswell, H. 2001. Matrix Population Models, construction, analysis and interpretation, Second edi.

Colbourne, J. K., M. E. Pfrender, D. Gilbert, W. K. Thomas, A. Tucker, T. H. Oakley, S. Tokishita, A. Aerts, G. J. Arnold, M. K. Basu, D. J. Bauer, C. E. Cáceres, L. Carmel, C. Casola, J. Choi, J. C. Detter, Q. Dong, S. Dusheyko, B. D. Eads, T. Fröhlich, K. a. Geiler-Samerotte, D. Gerlach, P. Hatcher, S. Jogdeo, J. Krijgsveld, E. V. Kriventseva, D. Kültz, C. Laforsch, E. Lindquist, J. Lopez, J. R. Manak, J. Muller, J. Pangilinan, R. P. Patwardhan, S. Pitluck, E. J. Pritham, A. Rechtsteiner, M. Rho, I. B. Rogozin, O. Sakarya, A. Salamov, S. Schaack, H. Shapiro, Y. Shiga, C. Skalitzky, Z. Smith, A. Souvorov, W. Sung, Z. Tang, D. Tsuchiya, H. Tu, H. Vos, M. Wang, Y. I. Wolf, H. Yamagata, T. Yamada, Y. Ye, J. R. Shaw, J. Andrews, T. J. Crease, H. Tang, S. M. Lucas, H. M. Robertson, P. Bork, E. V. Koonin, E. M. Zdobnov, I. V. Grigoriev, M. Lynch, and J. L. Boore. 2011. The ecoresponsive genome of Daphnia pulex. Science (New York, N.Y.) **331**: 555-61, doi:10.1126/science.1197761

Cowgill, U. ., and C. W. Burns. 1928. Differences in chemical composition and some freshwater algae cultured between two species of Daphnia in the laboratory1. Notes.

Dodson, S. I. 2005. Introduction to limnology, 1st ed. McGraw- Hill.

Ebert, D. 1991. The effect of size at birth, maturation treshold and genetic differences on the life-history of Daphnia magna. Oecologia 243-250.

Elser, J. J., K. Acharya, M. Kyle, J. Cotner, W. Makino, T. Markow, T. Watts, S. Hobbie, W. Fagan, J. Schade, J. Hood, and R. W. Sterner. 2003. Growth rate-stoichiometry couplings in diverse biota. Ecology Letters **6**: 936-943, doi:10.1046/j.1461-0248.2003.00518.x

Elser, J. J., D. R. Dobberfuhl, N. A. Mackay, and J. H. Schampel. 1996. Organism Size, Life History, and N:P Stoichiometry. American Institute of Biological sciences **46**: 674-684.

Elser, J. J., P. Frost, M. Kyle, J. Urabe, and T. Andersen. 2002. Effects of light and nutrients on plankton stoichiometry and biomass in a P-limited lake. Hydrobiologia 101-112.

Elser, J. J., K. Hayakawa, and J. Urabe. 2001. Nutrient Limitation Reduces Food Quality for Zooplankton: Daphnia Response To Seston Phosphorus Enrichment. Ecology **82**: 898-903, doi:10.1890/0012-9658(2001)082[0898:NLRFQF]2.0.CO;2

Elser, J. J., and P. Hassett. 1994. A stoichiometric analysis of the zooplankton-phytoplankton interaction in marine and freshwater ecosystem. Nature **370**: 211-213.

Elser, J. J., and J. Urabe. 1999. The stoichiometry of consumer- driven nutrient recycling: theory, observations, and consequences. ecology **80**: 735-751.

Enserink, E. L., M. J. J. Kerkhofs, C. A. M. Baltus, and J. H. Koeman. 1995. Influence of food quantity and lead exposure on in Daphnia magna ; evidence maturation for a trade-off mechanism. Functional Ecology **9**: 175-185.

Frost, P. C., D. Ebert, J. H. Larson, M. a Marcus, N. D. Wagner, and A. Zalewski. 2009. Transgenerational effects of poor elemental food quality on Daphnia magna. Oecologia **162**: 865-72, doi:10.1007/s00442-009-1517-4

Gorokhova, E., and M. Kyle. 2002. Analysis of nucleic acids in Daphnia : development of methods and ontogenetic variations in RNA-DNA content. Journal of Plankton Research **24**: 511-522.

Green, J. 1956. Variation in the Haemoglobin Content of Daphnia. Proceedings of the Royal Society of London. Series B. Biological sciences. **145**: 214-232.

Harrison, P. J., P. A. Thompson, and G. S. Calderwood. 1990. Effects of nutrient and light limitation on the biochemical composition of phytoplankton *. Journal of Applied Phycology 45-56.

Hazel, J. R., and E. E. Williams. 1990. The role of alterations in membrane lipid composition in enabling physiological adaptation of organisms to their physical environment. Progress in lipid research **29**: 167-227.

Hebert, P. D. N. 1978. The population biology of Daphnia (Crustacea, daphnidae). Biological review **53**: 387-426.

Hessen, D. O. 1990. Carbon, nitrogen and phosphorus status in Daphnia at varying food conditions. Journal of Plankton Research **12**: 1239-1249, doi:10.1093/plankt/12.6.1239

Hessen, D. O. 1992. Nutrient Element Limitation of Zooplankton Production. The American Naturalist **140**: 799-814.

Hessen, D. O., P. J. Færøvig, and T. Andersen. 2002. LIGHT , NUTRIENTS , AND P : C RATIOS IN ALGAE : GRAZER PERFORMANCE RELATED TO FOOD QUALITY AND QUANTITY. Ecology **83**: 1886-1898.

Hochachka, P. W., and G. N. Somero. 2002. Biochemicsm adaptation: mechanism and process in physiological evolution, Oxford University Press.

Jongejans, E., and H. De Kroon. 2005. Space versus time variation in the population dynamics of three co-occurring perennial herbs. Journal of Ecology **93**: 681-692, doi:10.1111/j.1365-2745.2005.01003.x

Kilham, S. S., D. A. Kreeger, S. G. Lynn, C. E. Goulden, and L. Herrera. 1998. COMBO : a defined freshwater culture medium for algae and zooplankton. Methods 147-159.

Kooijman, S. A. L. M. 1993. Dynamic Energy Budgets in Biological Systems: Theory and Applications in Ecotoxicology, Cambridge University Press (Jan 28 1994).

de Kroon, H., A. Plaisier, J. van Groenendael, and H. Caswell. 1986. Elasticity : The Relative Contribution of Demographic Parameters to Population Growth Rate. Ecology **67**: 1427-1431.

Lampert, W. 1993. Phenotypic Plasticity of the Size at First Reproduction in Daphnia : The Importance of Maternal. Ecology **74**: 1455-1466.

Lampert, W., R. D. Schmitt, and P. Muck. 1988. VERTICAL MIGRATION OF FRESHWATER ZOOPLANKTON: TEST OF SOME HYPOTHESES. Bulletin of marine science **43**: 620-640.

Lampert, W., and I. Trubetskova. 1996. Juvenile Growth Rate as a Measure of Fitness in Daphnia. Functional Ecology **10**: 631-635.

Levin, L., H. Caswell, T. Bridges, C. DiBacco, D. Cabrera, and G. Plaia. 1996. Demographic Responses of Estuarine Polychaetes to Pollutants : Life Table Response Experiments. Ecological Applications **6**: 1295-1313.

Main, T. M., D. R. Dobberfuhl, and J. J. Elser. 1997. zooplankton : of crustacean and ontogeny N : P stoichiometry rate hypothesis A test of the growth. Limnology **42**: 1474-1478.

Martin-Creuzburg, D., and E. Elert. 2009. Good food versus bad food: the role of sterols and polyunsaturated fatty acids in determining growth and reproduction of Daphnia magna. Aquatic Ecology **43**: 943-950, doi:10.1007/s10452-009-9239-6

McCullagh, P., and J.A. Nelder. 1989. Generalized Linear Models, 2nd ed. Chapman & Hall/CRC, Boca Raton, Florida.

Müller-Navarra, D. C. 1995a. Biochemical versus mineral limitation in Daphnia. Limnology **40**: 1209-1214.

Müller-Navarra, D. C. 1995b. Evidence that a highly unsaturated fatty acid limits Daphnia growth in nature. Archiv für Hydrobiologie **132**: 297-307.

Müller-Navarra, D. C., M. T. Brett, S. Park, S. Chandra, A. P. Ballantyne, E. Zorita, and C. R. Goldman. 2004. Unsaturated fatty acid content in seston and tropho-dynamic coupling in lakes. Nature **427**: 69-72, doi:10.1038/nature02210

Nilsson, K. a, L. Persson, and T. van Kooten. 2010. Complete compensation in Daphnia fecundity and stage-specific biomass in response to size-independent mortality. The Journal of animal ecology **79**: 871-8, doi:10.1111/j.1365-2656.2010.01679.x

Nisbet, R. M., E. B. Muller, K. Lika, and S. A. L. M. Kooijman. 2000. From Molecules to Ecosystems through Dynamic Energy Budget Models. Journal of Animal Ecology **69**: 913-926.

Olsen, Y., A. Jensen, H. Reinertsen, K. Y. Borsheim, M. Heldal, and A. Langeland. 1986. Dependence of the rate of release of phosphorus by on the P : C ratio in the food supply , as calculated by a recycling model. Limnology and Oceanography **31**: 34-44.

Pennak, R. W. 1978. Fresh-water invertebrates of the United States, 2nd ed. Wiley (New York).

Persson, J., M. W. Wojewodzic, D. O. Hessen, and T. Andersen. 2011. Increased risk of phosphorus limitation at higher temperatures for Daphnia magna. Oecologia **165**: 123-9, doi:10.1007/s00442-010-1756-4

Pietrzak, B., M. Grzesiuk, and A. Bednarska. 2010. Food quantity shapes life history and survival strategies in Daphnia magna (Cladocera). Hydrobiologia **643**: 51-54, doi:10.1007/s10750-010-0135-9

Piorreck, M., K. H. Baasch, and P. Pohl. 1984. Biomass production, total protein, chlorophylls, lipids and fatty acids of freshwater green and blue-green algae under different nitrogen regimes. Phytochemistry **23**: 207-216, doi:10.1016/S0031-9422(00)80304-0

Plath, K., and M. Boersma. 2001. MINERAL LIMITATION OF ZOOPLANKTON : STOICHIOMETRIC CONSTRAINTS AND OPTIMAL FORAGING. Ecology **82**: 1260-1269.

Porter, K. G., J. D. J. Orcutt, and J. Gerritsen. 1983. Functional Response and Fitness in a Generalist Filter Feeder , Daphnia Magna (Cladocera :Crustacea). Ecology **64**: 735-742.

Pulkkinen, K., and D. Ebert. 2004. HOST STARVATION DECREASES PARASITE LOAD AND MEAN HOST SIZE IN EXPERIMENTAL POPULATIONS. Ecology **85**: 823-833.

Redfield, A. C. 1958. THE BIOLOGICAL CONTROL OF CHEMICAL FACTORS IN THE ENVIRONMENT. American scientist **46**: 205-221.

Rellstab, C., and P. Spaak. 2009. Lake origin determines Daphnia population growth under winter conditions. Journal of Plankton Research **31**: 261-271, doi:10.1093/plankt/fbn120

Rothhaupt, K. O. 1995. Algal nutrient limitation affects rotifer growth rate but not ingestion rate. Limnology and Oceanography **40**: 1201-1208.

Sarnelle, O., and R. A. Knapp. 2005. Nutrient recycling by fish versus zooplankton grazing as drivers of the trophic cascade in alpine lakes. Limnology and oceanography **50**: 2032-2042.

Schalau, K., K. Rinke, D. Straile, and F. Peeters. 2008. Temperature is the key factor explaining interannual variability of Daphnia development in spring: a modelling study. Oecologia **157**: 531-43, doi:10.1007/s00442-008-1081-3

Snell, T. W., and C. E. King. 1977. Lifespan and Fecundity Patterns in Rotifers : The Cost of Reproduction. Evolution **31**: 882-890.

Sokolova, I. M., and G. Lannig. 2008. Interactive effects of metal pollution and temperature on metabolism in aquatic ectotherms: implications of global climate change. Climate Research **37**: 181-201, doi:10.3354/cr00764

Stearns, S. C. 1992. The evolution of life histories, Oxford University Press.

Sterner, R. W. 1990. The Ratio of Nitrogen to Phosphorus Resupplied by Herbivores: Zooplankton and the Algal Competitive Arena. The American Naturalist **136**: 209-229.

Sterner, R. W., and J. J. Elser. 2002. Ecological stoichiometry: the biology of elements from molecules to the biosphere, Princeton University Press.

Sterner, R. W., and D. O. Hessen. 1994. Algal Nutrient Limitation and the Nutrition of Aquatic Herbivores. Annual Review of Ecology and Systematics **25**: 1-29, doi:10.1146/annurev.ecolsys.25.1.1

Sterner, R. W., and M. S. Schwalbach. 2001. Diel integration of food quality by Daphnia: Luxury consumption by a freshwater planktonic herbivore. Limnology and Oceanography **46**: 410-416, doi:10.4319/lo.2001.46.2.0410

Taylor, B. E., and W. Gabriel. 1993. Adult Growth of Daphnia in a Seasonal Environment. Functional Ecology 513-521.

Tessier, A. J., A. Young, and M. Leibold. 1992. Population Dynamics and Body- Size Selection in Daphnia. Limnology and Oceanography **37**: 1-13.

Urabe, J., J. Clasen, and R. W. Sterner. 1997. Is it real ? Phosphorus limitation of Daphnia growth : Limnology and Oceanography **42**: 1436-1443.

Vrede, T., J. Persson, and G. Aronsen. 2002. The influence of food quality (P : C ratio) on RNA : DNA ratio and somatic growth rate of Daphnia. Limnology **47**: 487-494.

Vuorinen, I., M. Ketola, and M. Walls. 1989. Defensive Spine formation in Daphnia pulex Leydig and induction by Chaoborus crystallinus. Limnology and Oceanography **34**: 245-248.

Walls, M., and M. Ketola. 1989. Effects of predator-induced spines on Individual fitness in Daphnia pulex. Limnology and Oceanography **34**: 390-396.

White, T. C. R. 1993. The Inadequate Environment: Nitrogen and the Abundance of Animals, Springer-Verlag, USA.

Winder, M., H. R. Bürgi, and P. Spaak. 2003. Mechanisms regulating zooplankton populations in a high-mountain lake. Freshwater Biology **48**: 795-809.

Winder, M., and D. E. Schindler. 2004. CLIMATE CHANGE UNCOUPLES TROPHIC INTERACTIONS IN AN AQUATIC ECOSYSTEM. Ecology **85**: 2100-2106.

Wojewodzic, M. W. 2010. Somatic growth in invertebrates: physiological effects of temperature and foor stoichiometry. University of Oslo.

Wojewodzic, M. W., M. Kyle, J. J. Elser, D. O. Hessen, and T. Andersen. 2011. Joint effect of phosphorus limitation and temperature on alkaline phosphatase activity and somatic growth in Daphnia magna. Oecologia **165**: 837-46, doi:10.1007/s00442-010-1863-2

Woods, H. a., W. Makino, J. B. Cotner, S. E. Hobbie, J. F. Harrison, K. Acharya, and J. J. Elser. 2003. Temperature and the chemical composition of poikilothermic organisms. Functional Ecology **17**: 237-245, doi:10.1046/j.1365-2435.2003.00724.x

6 Appendix

	Df	*Chisq*	*p*
Temperature	2	7.6943	0.02134
Treatment	1	38.9734	4.296e-10
Temperature	2	7.6943	0.02134
Treatment	1	38.9734	4.296e-10
Temperature: Treatment	2	21.7195	1.922e-05
ANOVA 1	8		
ANOVA 2	9	21.720	1.922e-05

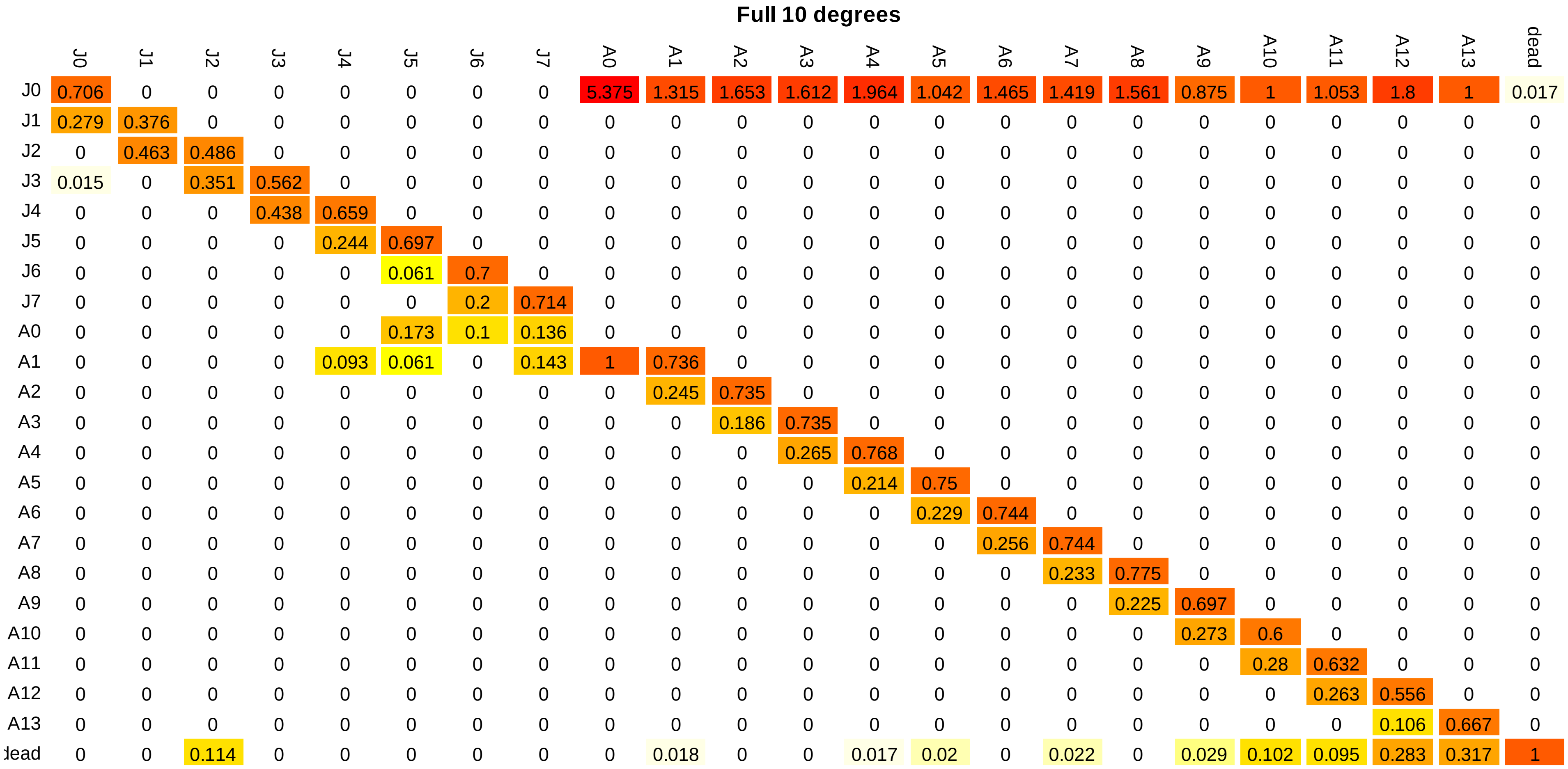
Appendix Tabel 1: ANOVA for survival, additive and with interaction.

Temperature	**Full**		**P-lim**		**Spiked**	
	50%	75%	50%	75%	50%	75%
10 °C	84	58	66	43	144	81
15 °C	70	47	62	36	81	57
20 °C	58	34	56	33	57	33
25 °C	47	28	54	31	33	21

Appendix Table 2: Days until 50 and 75% survival for the different temperatures and diets. See also figure .

	Df	*Chisq*	*P*
Temperature	2	7.6943	0.02134
Treatment	1	38.9734	4.296e-10
Temperature	2	7.6943	0.02134
Treatment	1	38.9734	4.296e-10
Temperature: Treatment	2	21.7195	1.922e-05
ANOVA 1	8		
ANOVA 2	9	21.720	1.922e-05

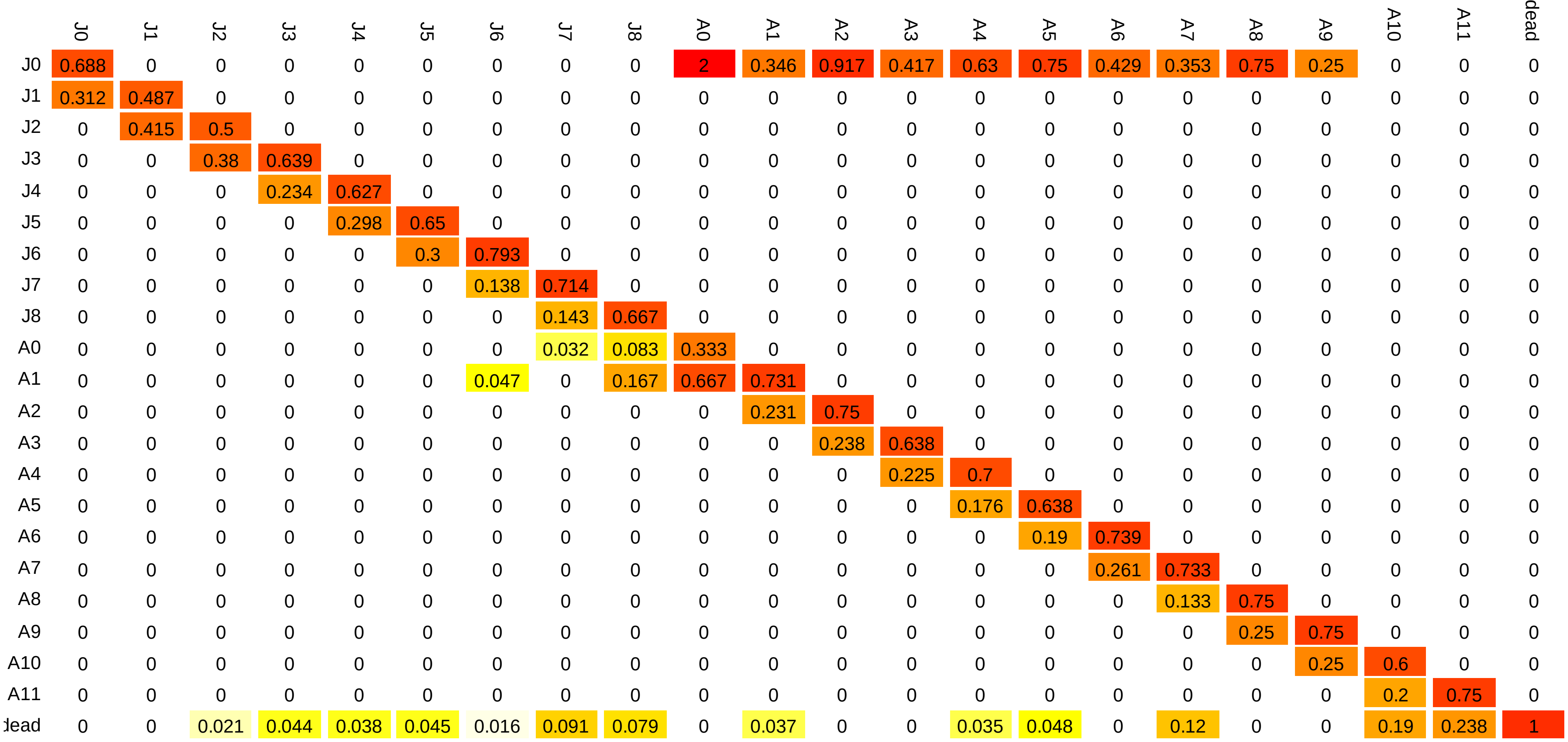
Appendix Table 3: ANOVA of the probability of transitioning to maturity.



Full 10 degrees

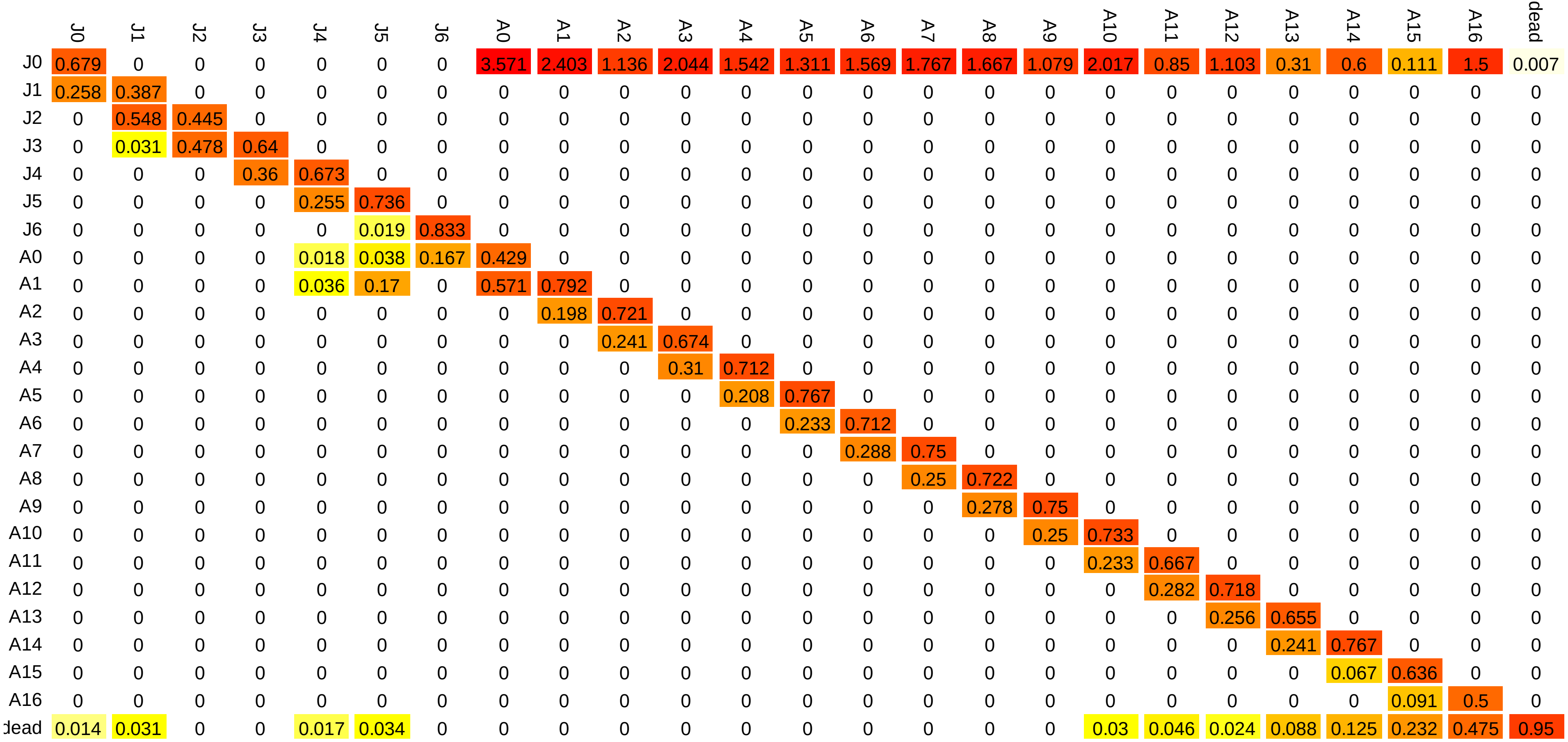
	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	dead
J0	0.706	0	0	0	0	0	0	0	5.375	1.315	1.653	1.612	1.964	1.042	1.465	1.419	1.561	0.875	1	1.053	1.8	1	0.017
J1	0.279	0.376	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.463	0.486	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0.015	0	0.351	0.562	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.438	0.659	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.244	0.697	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.061	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.2	0.714	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0.173	0.1	0.136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0.093	0.061	0	0.143	1	0.736	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0.245	0.735	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0.186	0.735	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0.265	0.768	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0.214	0.75	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0.229	0.744	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.256	0.744	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.233	0.775	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.225	0.697	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.273	0.6	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.28	0.632	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.263	0.556	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.106	0.667	0
dead	0	0	0.114	0	0	0	0	0	0	0.018	0	0	0.017	0.02	0	0.022	0	0.029	0.102	0.095	0.283	0.317	1

P-lim 10 degrees

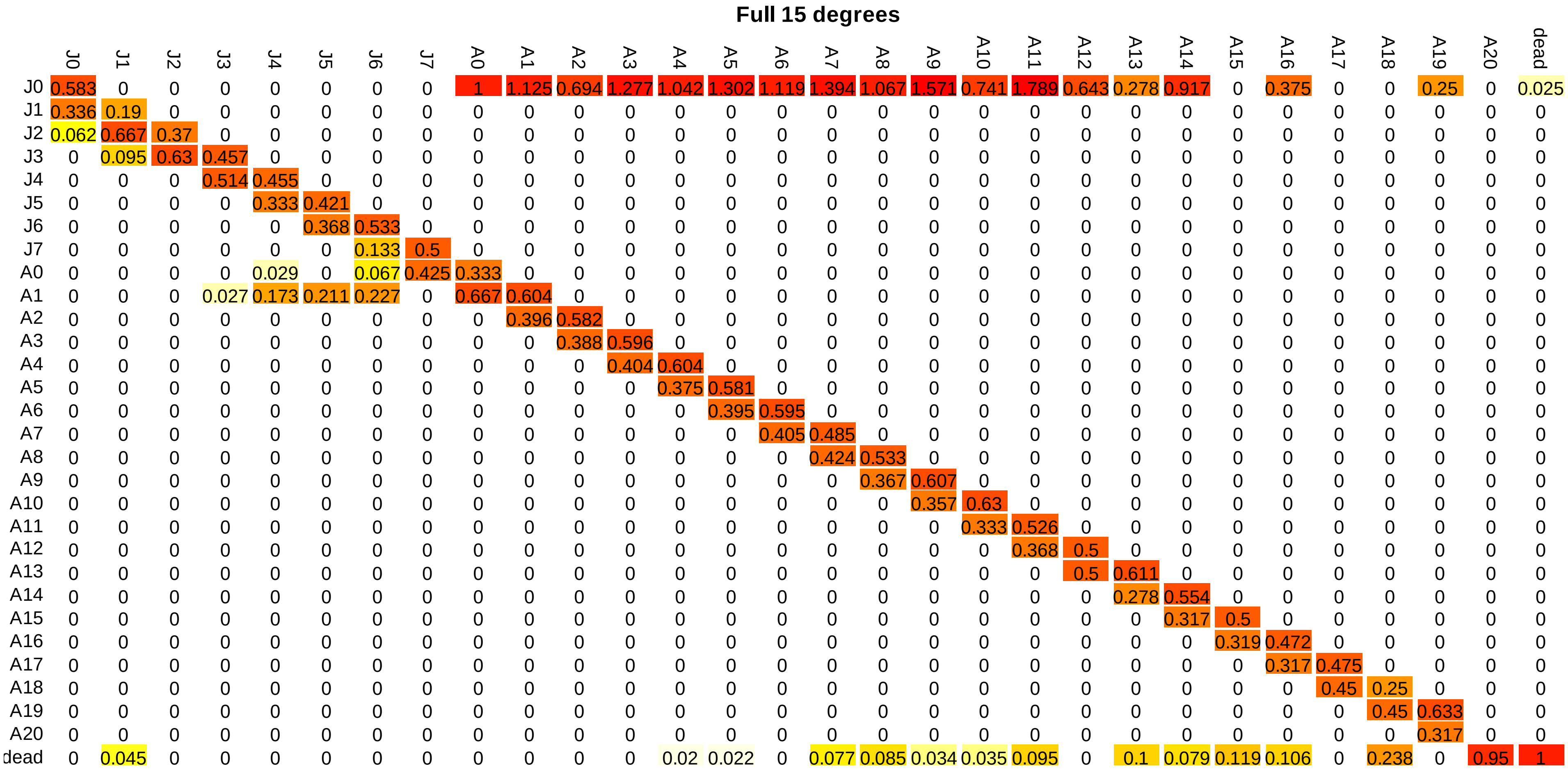


	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	dead
J0	0.688	0	0	0	0	0	0	0	0	2	0.346	0.917	0.417	0.63	0.75	0.429	0.353	0.75	0.25	0	0	0
J1	0.312	0.487	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.415	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0	0.38	0.639	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.234	0.627	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.298	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.3	0.793	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.138	0.714	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.143	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0	0	0.032	0.083	0.333	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0	0.047	0	0.167	0.667	0.731	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0.231	0.75	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0.238	0.638	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0.225	0.7	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.176	0.638	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.19	0.739	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.261	0.733	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.133	0.75	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.75	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.6	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.75	0
dead	0	0	0.021	0.044	0.038	0.045	0.016	0.091	0.079	0	0.037	0	0	0.035	0.048	0	0.12	0	0	0.19	0.238	1

Spiked 10 degrees



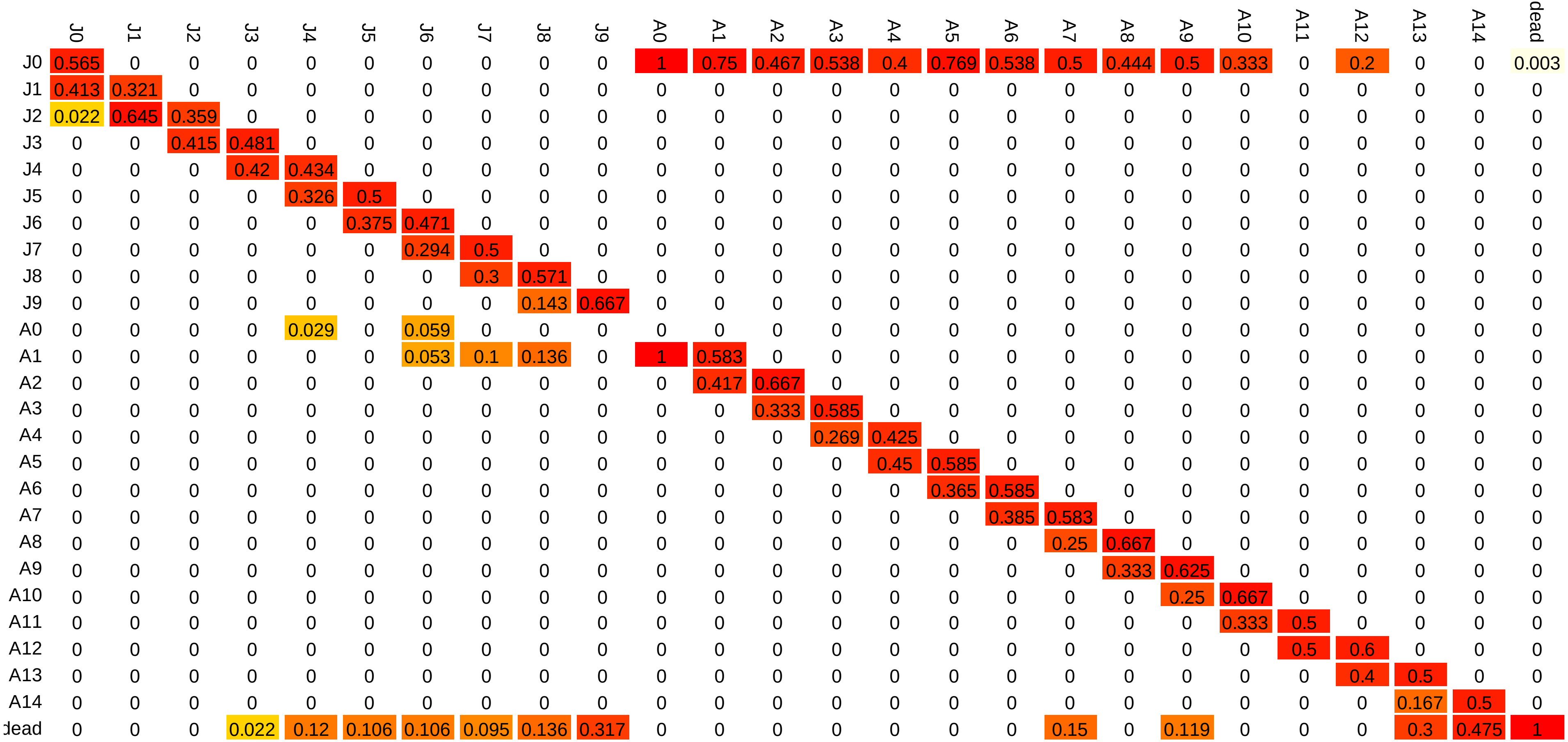
	J0	J1	J2	J3	J4	J5	J6	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	dead
J0	0.679	0	0	0	0	0	0	3.571	2.403	1.136	2.044	1.542	1.311	1.569	1.767	1.667	1.079	2.017	0.85	1.103	0.31	0.6	0.111	1.5	0.007
J1	0.258	0.387	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.548	0.445	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.031	0.478	0.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.36	0.673	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.255	0.736	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.019	0.833	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0.018	0.038	0.167	0.429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0.036	0.17	0	0.571	0.792	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0.198	0.721	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0.241	0.674	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0.31	0.712	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0.208	0.767	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0.233	0.712	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0.288	0.75	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.722	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.278	0.75	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.733	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.233	0.667	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.282	0.718	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.256	0.655	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.241	0.767	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.067	0.636	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.091	0.5	0
dead	0.014	0.031	0	0	0.017	0.034	0	0	0	0	0	0	0	0	0	0	0	0.03	0.046	0.024	0.088	0.125	0.232	0.475	0.95



Full 15 degrees

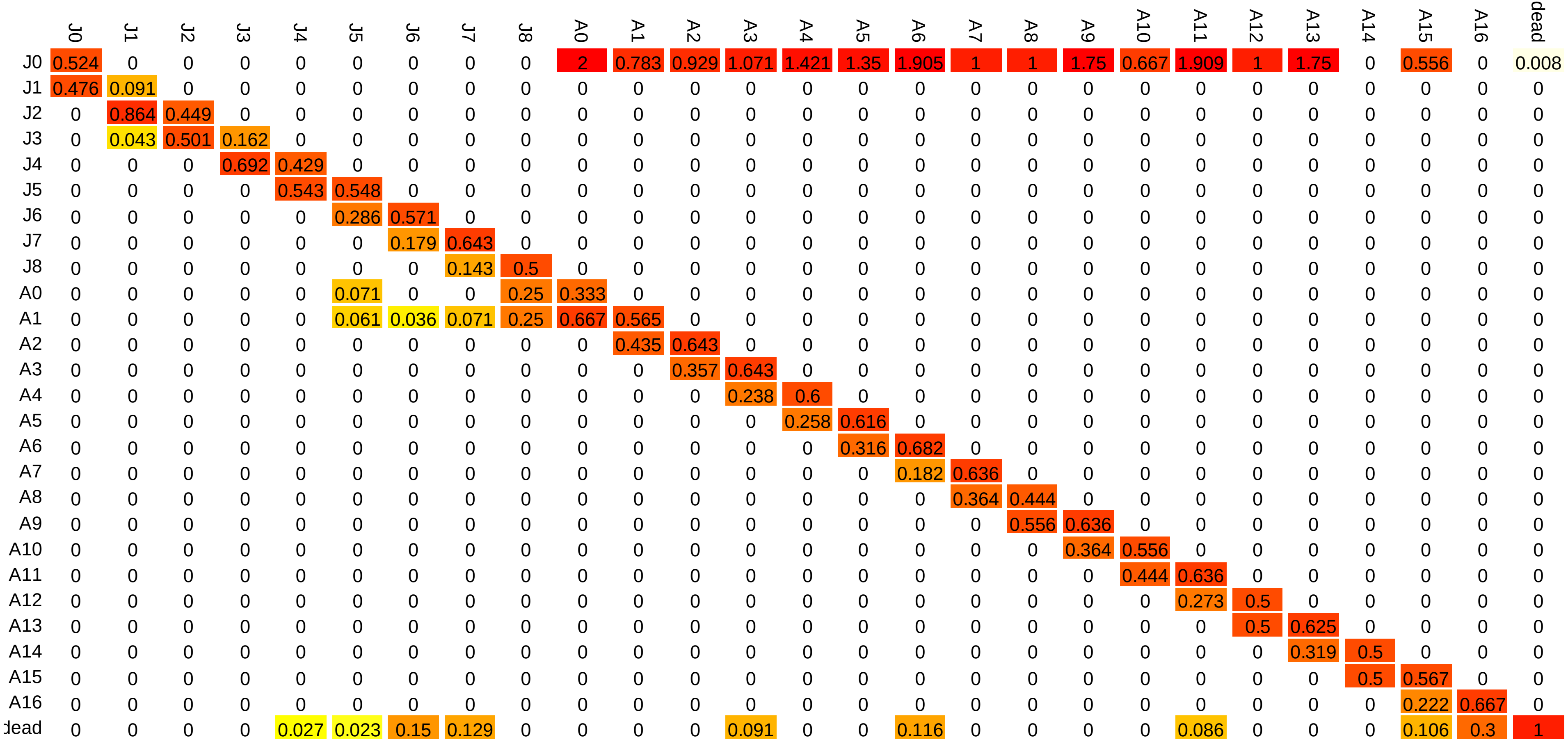
	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	dead
J0	0.583	0	0	0	0	0	0	0	1	1.125	0.694	1.277	1.042	1.302	1.119	1.394	1.067	1.571	0.741	1.789	0.643	0.278	0.917	0	0.375	0	0	0.25	0	0.025
J1	0.336	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.062	0.667	0.37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.095	0.63	0.457	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.514	0.455	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.333	0.421	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.368	0.533	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.133	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0.029	0	0.067	0.425	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.027	0.173	0.211	0.227	0	0.667	0.604	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0.396	0.582	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0.388	0.596	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0.404	0.604	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0.375	0.581	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0.395	0.595	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.405	0.485	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.424	0.533	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.367	0.607	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.357	0.63	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0.526	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.368	0.5	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.611	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.278	0.554	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.317	0.5	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.319	0.472	0	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.317	0.475	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0.25	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0.633	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.317	0	0
dead	0	0.045	0	0	0	0	0	0	0	0	0	0	0.02	0.022	0	0.077	0.085	0.034	0.035	0.095	0	0.1	0.079	0.119	0.106	0	0.238	0	0.95	1

P-lim 15 degrees

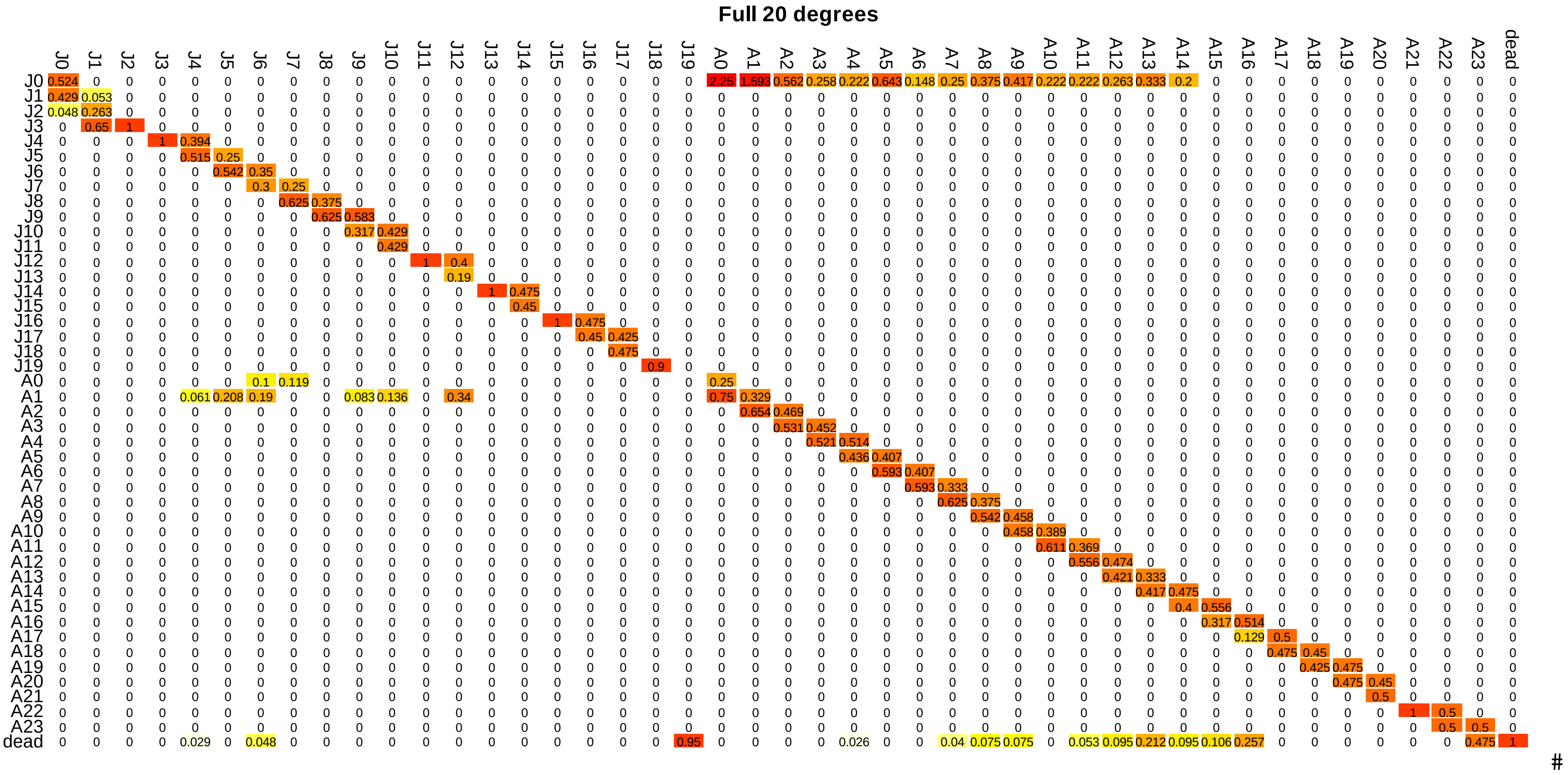


	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	0.565	0	0	0	0	0	0	0	0	0	1	0.75	0.467	0.538	0.4	0.769	0.538	0.5	0.444	0.5	0.333	0	0.2	0	0	0.003
J1	0.413	0.321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.022	0.645	0.359	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0	0.415	0.481	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.42	0.434	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.326	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.375	0.471	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.294	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.3	0.571	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.143	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0.029	0	0.059	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0	0.053	0.1	0.136	0	1	0.583	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0.417	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0.585	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.269	0.425	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0.585	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.365	0.585	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.385	0.583	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.667	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0.625	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0.667	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0.5	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.6	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.5	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.167	0.5	0
dead	0	0	0	0.022	0.12	0.106	0.106	0.095	0.136	0.317	0	0	0	0	0	0	0	0.15	0	0.119	0	0	0	0.3	0.475	1

Spiked 15 degrees



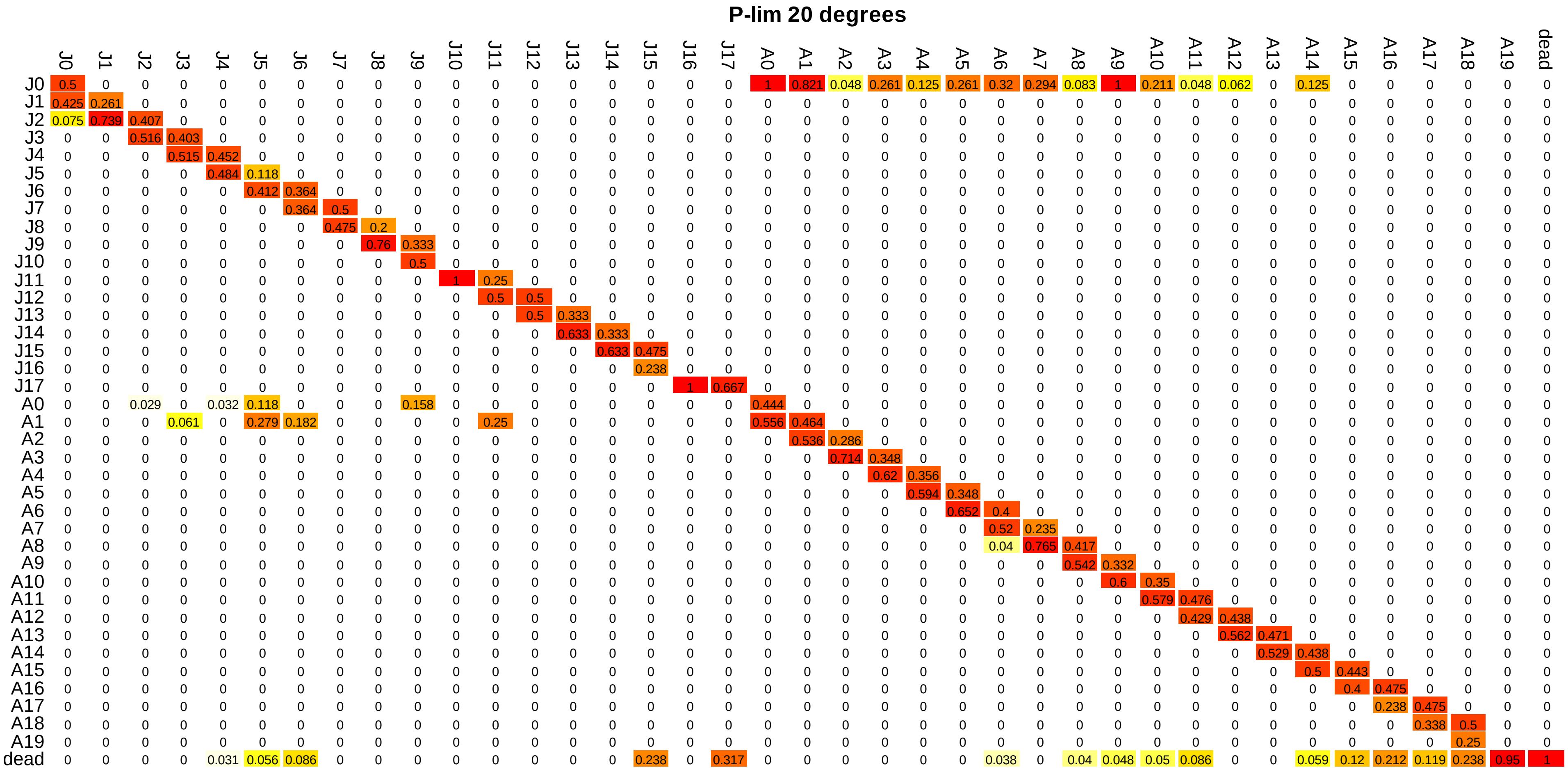
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	dead
J0	0.524	0	0	0	0	0	0	0	0	2	0.783	0.929	1.071	1.421	1.35	1.905	1	1	1.75	0.667	1.909	1	1.75	0	0.556	0	0.008
J1	0.476	0.091	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.864	0.449	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.043	0.501	0.162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.692	0.429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.543	0.548	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.286	0.571	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.179	0.643	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.143	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0.071	0	0	0.25	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0.061	0.036	0.071	0.25	0.667	0.565	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0.435	0.643	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0.357	0.643	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0.238	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.258	0.616	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.316	0.682	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.182	0.636	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.364	0.444	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.556	0.636	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.364	0.556	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.444	0.636	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.273	0.5	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.625	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.319	0.5	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.567	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.222	0.667	0
dead	0	0	0	0	0.027	0.023	0.15	0.129	0	0	0	0	0.091	0	0	0.116	0	0	0	0	0.086	0	0	0	0.106	0.3	1



Full 20 degrees

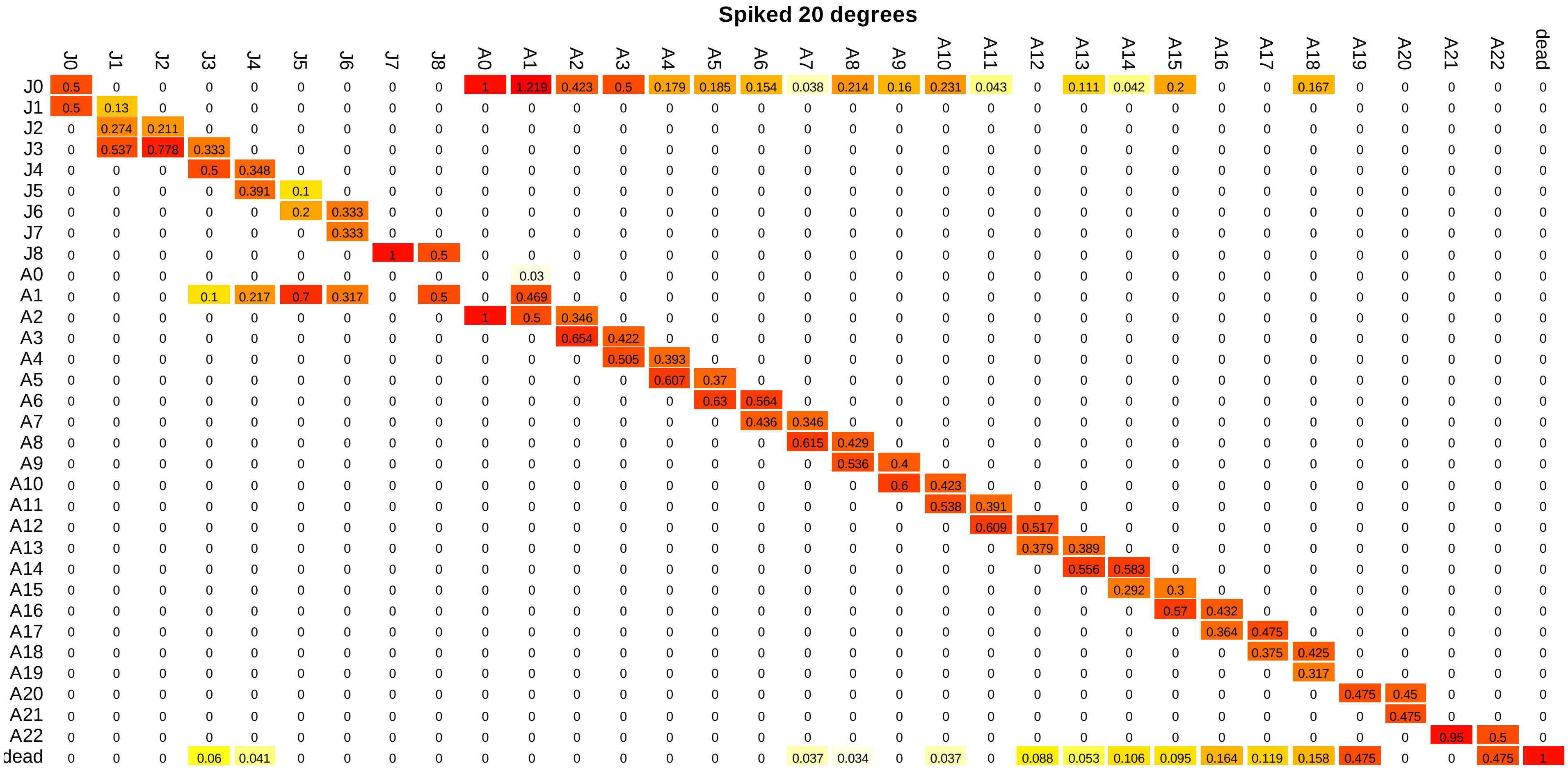
	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	dead
J0	0.524	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.25	1.593	0.562	0.258	0.222	0.643	0.148	0.25	0.375	0.417	0.222	0.222	0.263	0.333	0.2	0	0	0	0	0	0	0	0	0	0
J1	0.429	0.053	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.048	0.263	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.65	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	1	0.394	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.515	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.542	0.35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.3	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.625	0.375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.625	0.583	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	0.317	0.429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	0.429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	1	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0.425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0	0.1	0.119	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0.061	0.208	0.19	0	0	0.083	0.136	0	0.34	0	0	0	0	0	0	0	0.75	0.329	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.654	0.469	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.531	0.452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.521	0.514	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.436	0.407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.593	0.407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.593	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.625	0.375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.542	0.458	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.458	0.389	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.611	0.369	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.556	0.474	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.421	0.333	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.417	0.475	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.556	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.317	0.514	0	0	0	0	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.129	0.5	0	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0.45	0	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.425	0.475	0	0	0	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0.45	0	0	0	0
A21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
A22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.5	0	0
A23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0
dead	0	0	0	0	0.029	0	0.048	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0	0	0	0	0.026	0	0	0.04	0.075	0.075	0	0.053	0.095	0.212	0.095	0.106	0.257	0	0	0	0	0	0	0.475	1

#



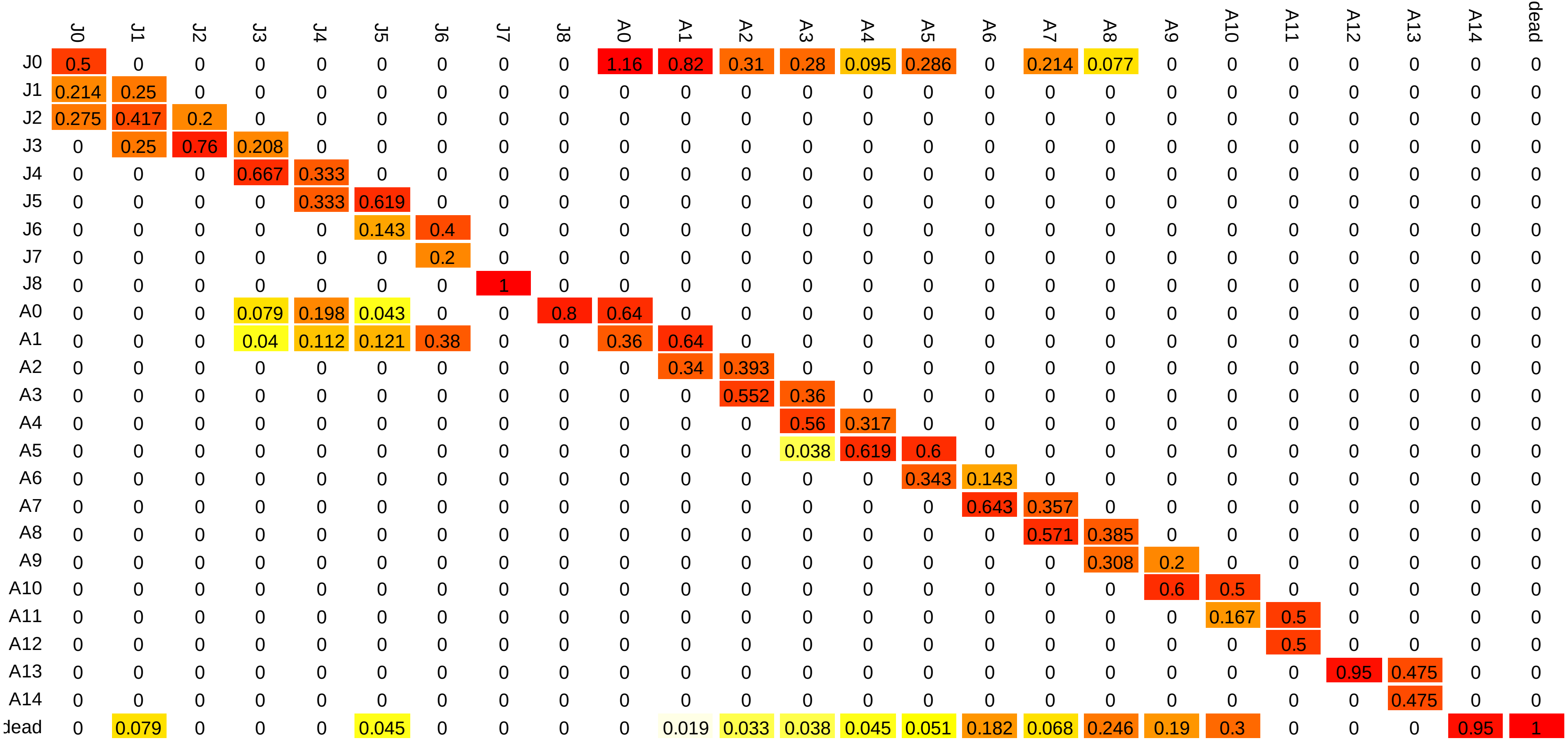
P-lim 20 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	dead
J0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.821	0.048	0.261	0.125	0.261	0.32	0.294	0.083	1	0.211	0.048	0.062	0	0.125	0	0	0	0	0	0
J1	0.425	0.261	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.075	0.739	0.407	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0	0.516	0.403	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.515	0.452	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.484	0.118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.412	0.364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.364	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.475	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.76	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	1	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	0.633	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.633	0.475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.238	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0.029	0	0.032	0.118	0	0	0	0.158	0	0	0	0	0	0	0	0	0.444	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.061	0	0.279	0.182	0	0	0	0	0.25	0	0	0	0	0	0	0.556	0.464	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.536	0.286	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.714	0.348	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.62	0.356	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.594	0.348	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.652	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.52	0.235	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.765	0.417	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.542	0.332	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.35	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.579	0.476	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.429	0.438	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.562	0.471	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.529	0.438	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.443	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.475	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.238	0.475	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.338	0.5	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0
dead	0	0	0	0	0.031	0.056	0.086	0	0	0	0	0	0	0	0	0.238	0	0.317	0	0	0	0	0	0	0.038	0	0.04	0.048	0.05	0.086	0	0	0.059	0.12	0.212	0.119	0.238	0.95	1



Spiked 20 degrees

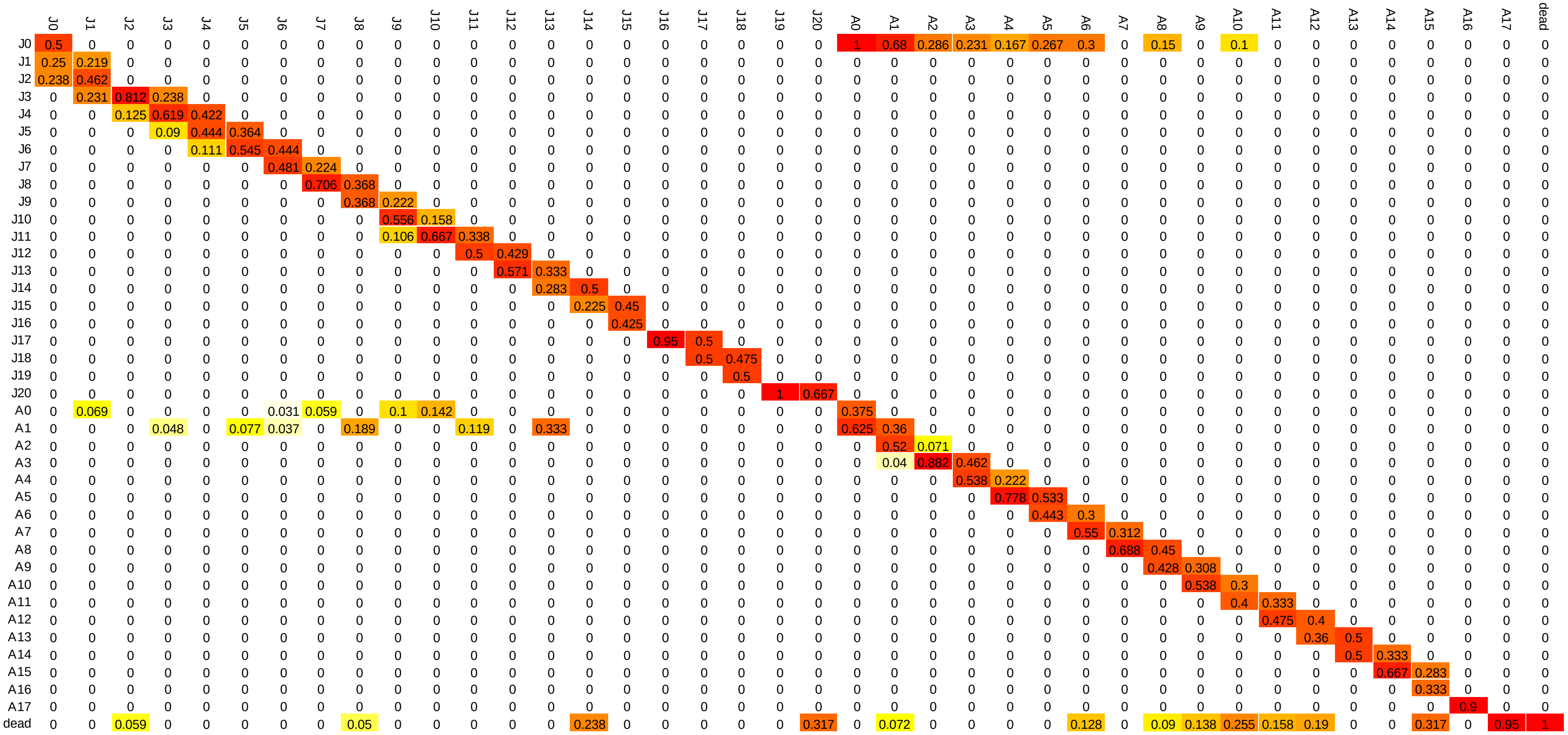
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	dead
J0	0.5	0	0	0	0	0	0	0	0	1	1.219	0.423	0.5	0.179	0.185	0.154	0.038	0.214	0.16	0.231	0.043	0	0.111	0.042	0.2	0	0	0.167	0	0	0	0	0
J1	0.5	0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.274	0.211	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.537	0.778	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.5	0.348	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.391	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.2	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	1	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.1	0.217	0.7	0.317	0	0.5	0	0.469	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	1	0.5	0.346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0.654	0.422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0.505	0.393	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.607	0.37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.63	0.564	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.436	0.346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.615	0.429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.536	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.423	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.538	0.391	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.609	0.517	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.379	0.389	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.556	0.583	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.292	0.3	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.57	0.432	0	0	0	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.364	0.475	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.375	0.425	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.317	0	0	0	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0.45	0	0	0
A21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0	0	0
A22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.5	0
dead	0	0	0	0.06	0.041	0	0	0	0	0	0	0	0	0	0	0	0.037	0.034	0	0.037	0	0.088	0.053	0.106	0.095	0.164	0.119	0.158	0.475	0	0	0.475	1



Full 25 degrees

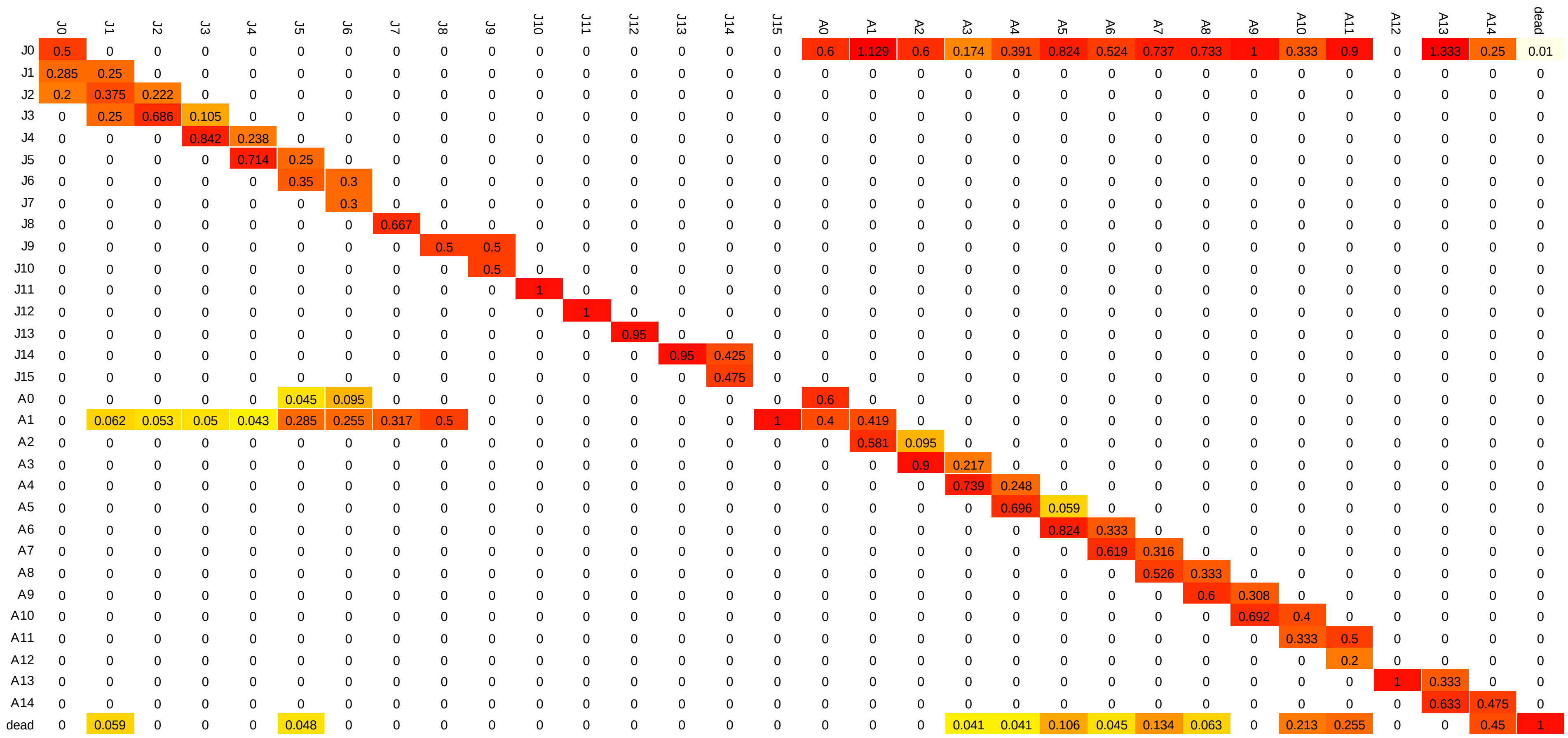
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	0.5	0	0	0	0	0	0	0	0	1.16	0.82	0.31	0.28	0.095	0.286	0	0.214	0.077	0	0	0	0	0	0	0
J1	0.214	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.275	0.417	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.25	0.76	0.208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.667	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.333	0.619	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.143	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0.079	0.198	0.043	0	0	0.8	0.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.04	0.112	0.121	0.38	0	0	0.36	0.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0.34	0.393	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0.552	0.36	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0.56	0.317	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0.038	0.619	0.6	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.343	0.143	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.643	0.357	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.571	0.385	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.308	0.2	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.5	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.167	0.5	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.475	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0	0
dead	0	0.079	0	0	0	0.045	0	0	0	0	0.019	0.033	0.038	0.045	0.051	0.182	0.068	0.246	0.19	0.3	0	0	0	0.95	1

P-lim 25 degrees



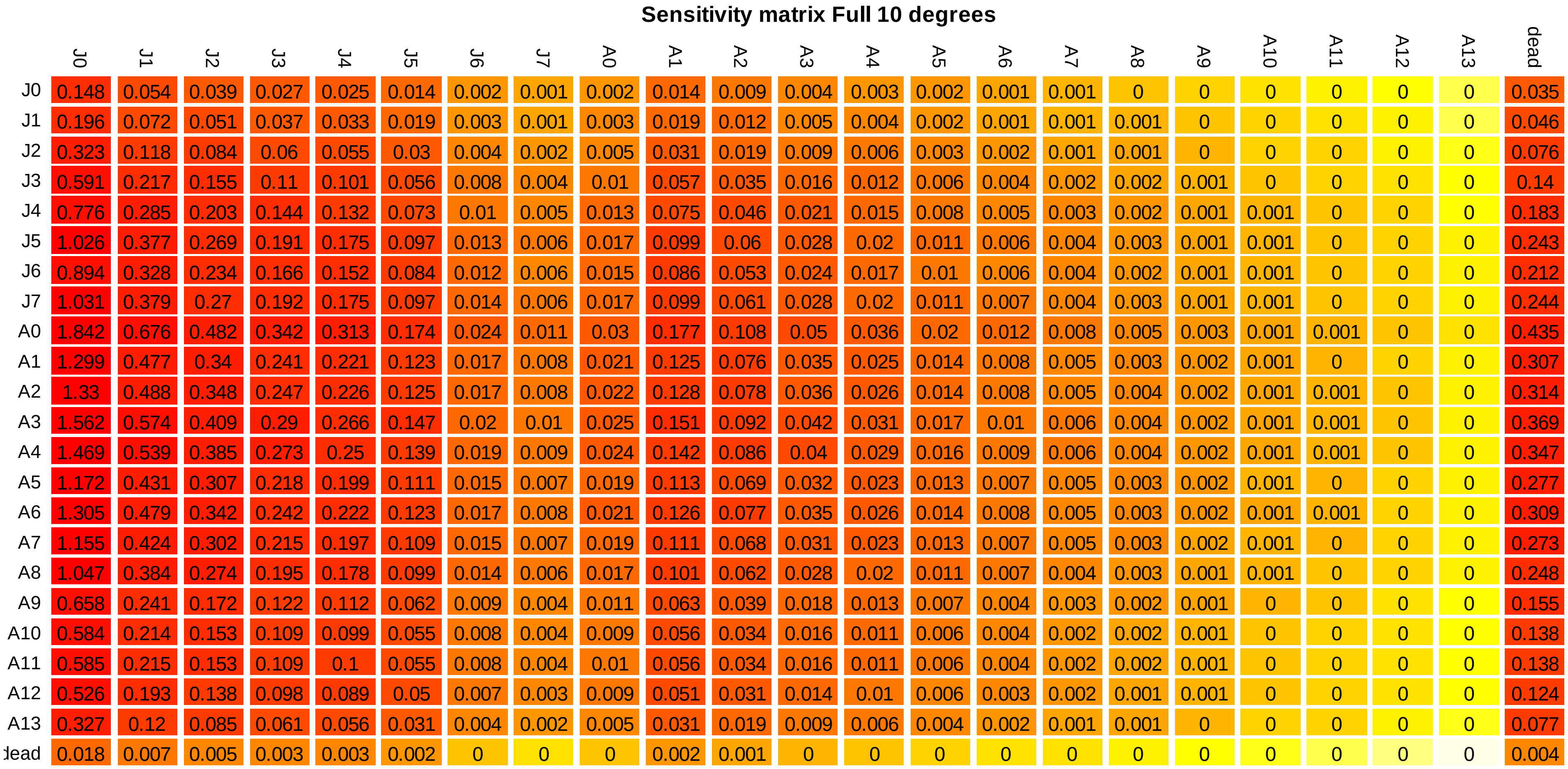
	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	J20	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	dead
J0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.68	0.286	0.231	0.167	0.267	0.3	0	0.15	0	0.1	0	0	0	0	0	0	0	0
J1	0.25	0.219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.238	0.462	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.231	0.812	0.238	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0.125	0.619	0.422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0.09	0.444	0.364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0.111	0.545	0.444	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.481	0.224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.706	0.368	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.368	0.222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	0.556	0.158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0.106	0.667	0.338	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	0.5	0.429	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0.571	0.333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	0.283	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.225	0.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0.069	0	0	0	0	0.031	0.059	0	0.1	0.142	0	0	0	0	0	0	0	0	0	0	0.375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.048	0	0.077	0.037	0	0.189	0	0	0.119	0	0.333	0	0	0	0	0	0	0	0.625	0.36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.52	0.071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.882	0.462	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.538	0.222	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.778	0.533	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.443	0.3	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.55	0.312	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.688	0.45	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.428	0.308	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.538	0.3	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.333	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0.4	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.36	0.5	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0.333	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.667	0.283	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0
dead	0	0	0.059	0	0	0	0	0	0.05	0	0	0	0	0	0.238	0	0	0	0	0	0.317	0	0.072	0	0	0	0	0.128	0	0.09	0.138	0.255	0.158	0.19	0	0	0.317	0	0.95	1

#



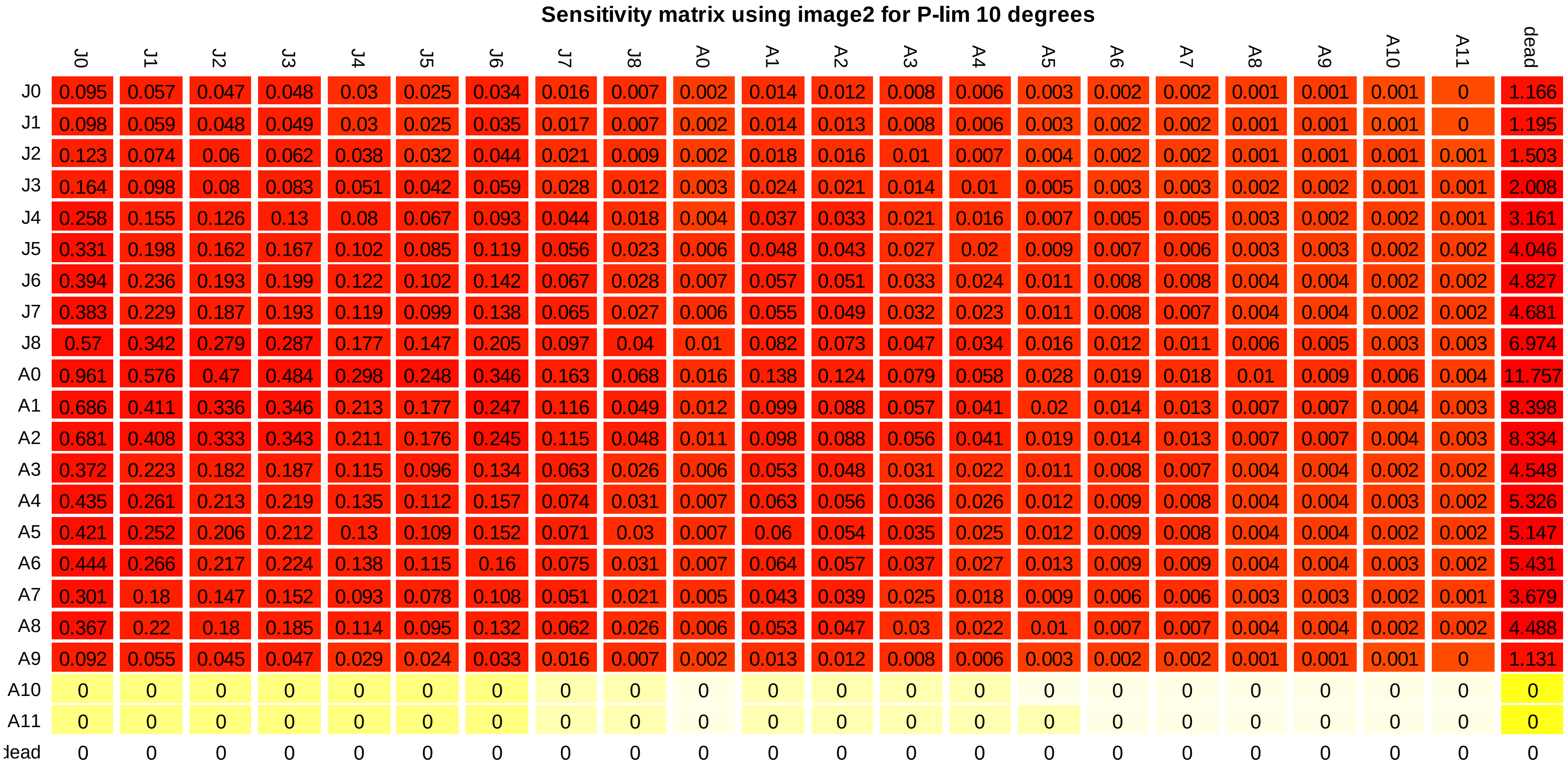
Spiked 25 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	1.129	0.6	0.174	0.391	0.824	0.524	0.737	0.733	1	0.333	0.9	0	1.333	0.25	0.01
J1	0.285	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.2	0.375	0.222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.25	0.686	0.105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.842	0.238	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.714	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.35	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.667	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.425	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.475	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0.045	0.095	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0.062	0.053	0.05	0.043	0.285	0.255	0.317	0.5	0	0	0	0	0	0	1	0.4	0.419	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.581	0.095	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0.217	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.739	0.248	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.696	0.059	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.824	0.333	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.619	0.316	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.526	0.333	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.308	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.692	0.4	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.333	0.5	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.333	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.633	0.475	0
dead	0	0.059	0	0	0	0.048	0	0	0	0	0	0	0	0	0	0	0	0	0	0.041	0.041	0.106	0.045	0.134	0.063	0	0.213	0.255	0	0	0.45	1



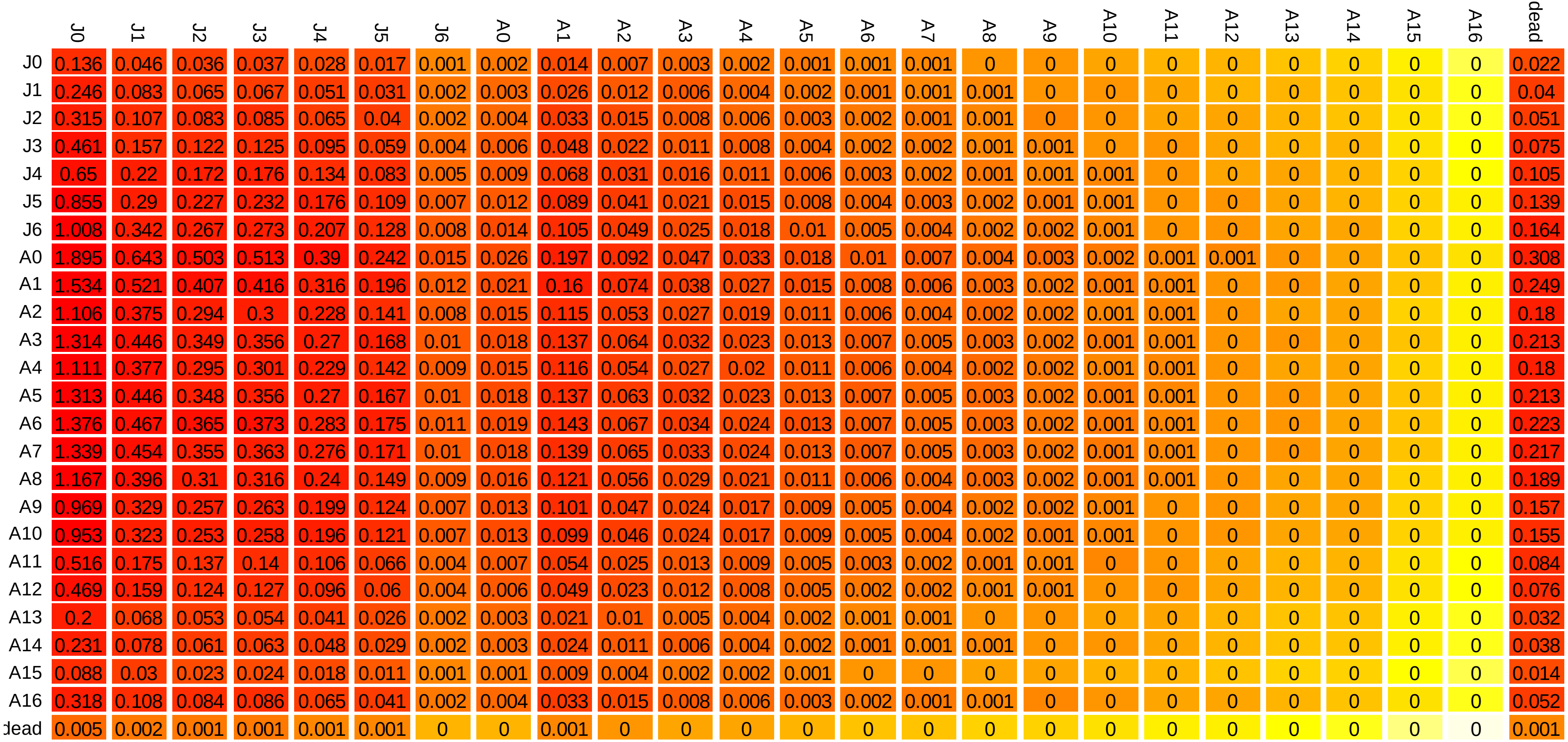
Sensitivity matrix Full 10 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	dead
J0	0.148	0.054	0.039	0.027	0.025	0.014	0.002	0.001	0.002	0.014	0.009	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0.035
J1	0.196	0.072	0.051	0.037	0.033	0.019	0.003	0.001	0.003	0.019	0.012	0.005	0.004	0.002	0.001	0.001	0.001	0	0	0	0	0	0.046
J2	0.323	0.118	0.084	0.06	0.055	0.03	0.004	0.002	0.005	0.031	0.019	0.009	0.006	0.003	0.002	0.001	0.001	0	0	0	0	0	0.076
J3	0.591	0.217	0.155	0.11	0.101	0.056	0.008	0.004	0.01	0.057	0.035	0.016	0.012	0.006	0.004	0.002	0.002	0.001	0	0	0	0	0.14
J4	0.776	0.285	0.203	0.144	0.132	0.073	0.01	0.005	0.013	0.075	0.046	0.021	0.015	0.008	0.005	0.003	0.002	0.001	0.001	0	0	0	0.183
J5	1.026	0.377	0.269	0.191	0.175	0.097	0.013	0.006	0.017	0.099	0.06	0.028	0.02	0.011	0.006	0.004	0.003	0.001	0.001	0	0	0	0.243
J6	0.894	0.328	0.234	0.166	0.152	0.084	0.012	0.006	0.015	0.086	0.053	0.024	0.017	0.01	0.006	0.004	0.002	0.001	0.001	0	0	0	0.212
J7	1.031	0.379	0.27	0.192	0.175	0.097	0.014	0.006	0.017	0.099	0.061	0.028	0.02	0.011	0.007	0.004	0.003	0.001	0.001	0	0	0	0.244
A0	1.842	0.676	0.482	0.342	0.313	0.174	0.024	0.011	0.03	0.177	0.108	0.05	0.036	0.02	0.012	0.008	0.005	0.003	0.001	0.001	0	0	0.435
A1	1.299	0.477	0.34	0.241	0.221	0.123	0.017	0.008	0.021	0.125	0.076	0.035	0.025	0.014	0.008	0.005	0.003	0.002	0.001	0	0	0	0.307
A2	1.33	0.488	0.348	0.247	0.226	0.125	0.017	0.008	0.022	0.128	0.078	0.036	0.026	0.014	0.008	0.005	0.004	0.002	0.001	0.001	0	0	0.314
A3	1.562	0.574	0.409	0.29	0.266	0.147	0.02	0.01	0.025	0.151	0.092	0.042	0.031	0.017	0.01	0.006	0.004	0.002	0.001	0.001	0	0	0.369
A4	1.469	0.539	0.385	0.273	0.25	0.139	0.019	0.009	0.024	0.142	0.086	0.04	0.029	0.016	0.009	0.006	0.004	0.002	0.001	0.001	0	0	0.347
A5	1.172	0.431	0.307	0.218	0.199	0.111	0.015	0.007	0.019	0.113	0.069	0.032	0.023	0.013	0.007	0.005	0.003	0.002	0.001	0	0	0	0.277
A6	1.305	0.479	0.342	0.242	0.222	0.123	0.017	0.008	0.021	0.126	0.077	0.035	0.026	0.014	0.008	0.005	0.003	0.002	0.001	0.001	0	0	0.309
A7	1.155	0.424	0.302	0.215	0.197	0.109	0.015	0.007	0.019	0.111	0.068	0.031	0.023	0.013	0.007	0.005	0.003	0.002	0.001	0	0	0	0.273
A8	1.047	0.384	0.274	0.195	0.178	0.099	0.014	0.006	0.017	0.101	0.062	0.028	0.02	0.011	0.007	0.004	0.003	0.001	0.001	0	0	0	0.248
A9	0.658	0.241	0.172	0.122	0.112	0.062	0.009	0.004	0.011	0.063	0.039	0.018	0.013	0.007	0.004	0.003	0.002	0.001	0	0	0	0	0.155
A10	0.584	0.214	0.153	0.109	0.099	0.055	0.008	0.004	0.009	0.056	0.034	0.016	0.011	0.006	0.004	0.002	0.002	0.001	0	0	0	0	0.138
A11	0.585	0.215	0.153	0.109	0.1	0.055	0.008	0.004	0.01	0.056	0.034	0.016	0.011	0.006	0.004	0.002	0.002	0.001	0	0	0	0	0.138
A12	0.526	0.193	0.138	0.098	0.089	0.05	0.007	0.003	0.009	0.051	0.031	0.014	0.01	0.006	0.003	0.002	0.001	0.001	0	0	0	0	0.124
A13	0.327	0.12	0.085	0.061	0.056	0.031	0.004	0.002	0.005	0.031	0.019	0.009	0.006	0.004	0.002	0.001	0.001	0	0	0	0	0	0.077
dead	0.018	0.007	0.005	0.003	0.003	0.002	0	0	0	0.002	0.001	0	0	0	0	0	0	0	0	0	0	0	0.004



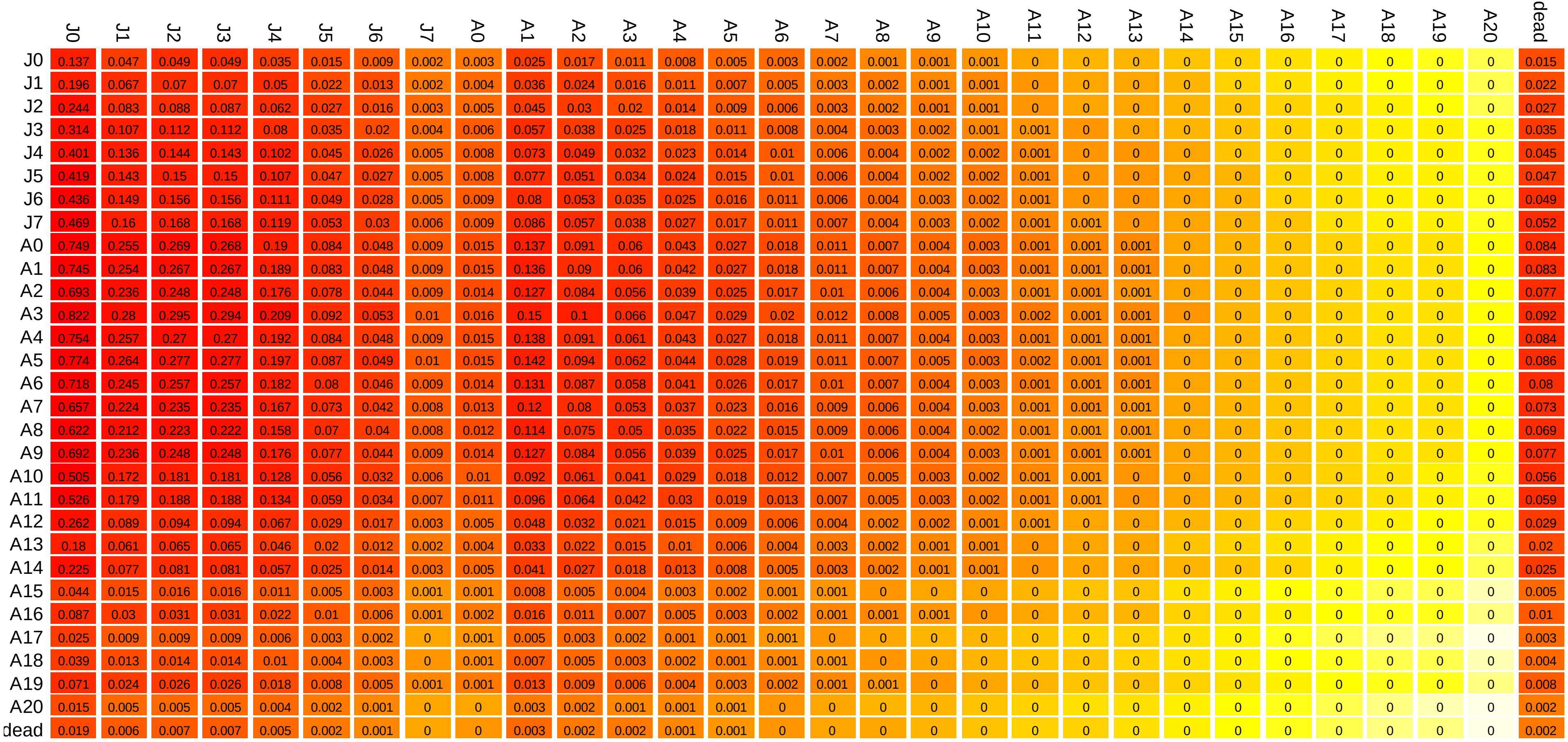
Sensitivity matrix using image2 for P-lim 10 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	dead
J0	0.095	0.057	0.047	0.048	0.03	0.025	0.034	0.016	0.007	0.002	0.014	0.012	0.008	0.006	0.003	0.002	0.002	0.001	0.001	0.001	0	1.166
J1	0.098	0.059	0.048	0.049	0.03	0.025	0.035	0.017	0.007	0.002	0.014	0.013	0.008	0.006	0.003	0.002	0.002	0.001	0.001	0.001	0	1.195
J2	0.123	0.074	0.06	0.062	0.038	0.032	0.044	0.021	0.009	0.002	0.018	0.016	0.01	0.007	0.004	0.002	0.002	0.001	0.001	0.001	0.001	1.503
J3	0.164	0.098	0.08	0.083	0.051	0.042	0.059	0.028	0.012	0.003	0.024	0.021	0.014	0.01	0.005	0.003	0.003	0.002	0.002	0.001	0.001	2.008
J4	0.258	0.155	0.126	0.13	0.08	0.067	0.093	0.044	0.018	0.004	0.037	0.033	0.021	0.016	0.007	0.005	0.005	0.003	0.002	0.002	0.001	3.161
J5	0.331	0.198	0.162	0.167	0.102	0.085	0.119	0.056	0.023	0.006	0.048	0.043	0.027	0.02	0.009	0.007	0.006	0.003	0.003	0.002	0.002	4.046
J6	0.394	0.236	0.193	0.199	0.122	0.102	0.142	0.067	0.028	0.007	0.057	0.051	0.033	0.024	0.011	0.008	0.008	0.004	0.004	0.002	0.002	4.827
J7	0.383	0.229	0.187	0.193	0.119	0.099	0.138	0.065	0.027	0.006	0.055	0.049	0.032	0.023	0.011	0.008	0.007	0.004	0.004	0.002	0.002	4.681
J8	0.57	0.342	0.279	0.287	0.177	0.147	0.205	0.097	0.04	0.01	0.082	0.073	0.047	0.034	0.016	0.012	0.011	0.006	0.005	0.003	0.003	6.974
A0	0.961	0.576	0.47	0.484	0.298	0.248	0.346	0.163	0.068	0.016	0.138	0.124	0.079	0.058	0.028	0.019	0.018	0.01	0.009	0.006	0.004	11.757
A1	0.686	0.411	0.336	0.346	0.213	0.177	0.247	0.116	0.049	0.012	0.099	0.088	0.057	0.041	0.02	0.014	0.013	0.007	0.007	0.004	0.003	8.398
A2	0.681	0.408	0.333	0.343	0.211	0.176	0.245	0.115	0.048	0.011	0.098	0.088	0.056	0.041	0.019	0.014	0.013	0.007	0.007	0.004	0.003	8.334
A3	0.372	0.223	0.182	0.187	0.115	0.096	0.134	0.063	0.026	0.006	0.053	0.048	0.031	0.022	0.011	0.008	0.007	0.004	0.004	0.002	0.002	4.548
A4	0.435	0.261	0.213	0.219	0.135	0.112	0.157	0.074	0.031	0.007	0.063	0.056	0.036	0.026	0.012	0.009	0.008	0.004	0.004	0.003	0.002	5.326
A5	0.421	0.252	0.206	0.212	0.13	0.109	0.152	0.071	0.03	0.007	0.06	0.054	0.035	0.025	0.012	0.009	0.008	0.004	0.004	0.002	0.002	5.147
A6	0.444	0.266	0.217	0.224	0.138	0.115	0.16	0.075	0.031	0.007	0.064	0.057	0.037	0.027	0.013	0.009	0.009	0.004	0.004	0.003	0.002	5.431
A7	0.301	0.18	0.147	0.152	0.093	0.078	0.108	0.051	0.021	0.005	0.043	0.039	0.025	0.018	0.009	0.006	0.006	0.003	0.003	0.002	0.001	3.679
A8	0.367	0.22	0.18	0.185	0.114	0.095	0.132	0.062	0.026	0.006	0.053	0.047	0.03	0.022	0.01	0.007	0.007	0.004	0.004	0.002	0.002	4.488
A9	0.092	0.055	0.045	0.047	0.029	0.024	0.033	0.016	0.007	0.002	0.013	0.012	0.008	0.006	0.003	0.002	0.002	0.001	0.001	0.001	0	1.131
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



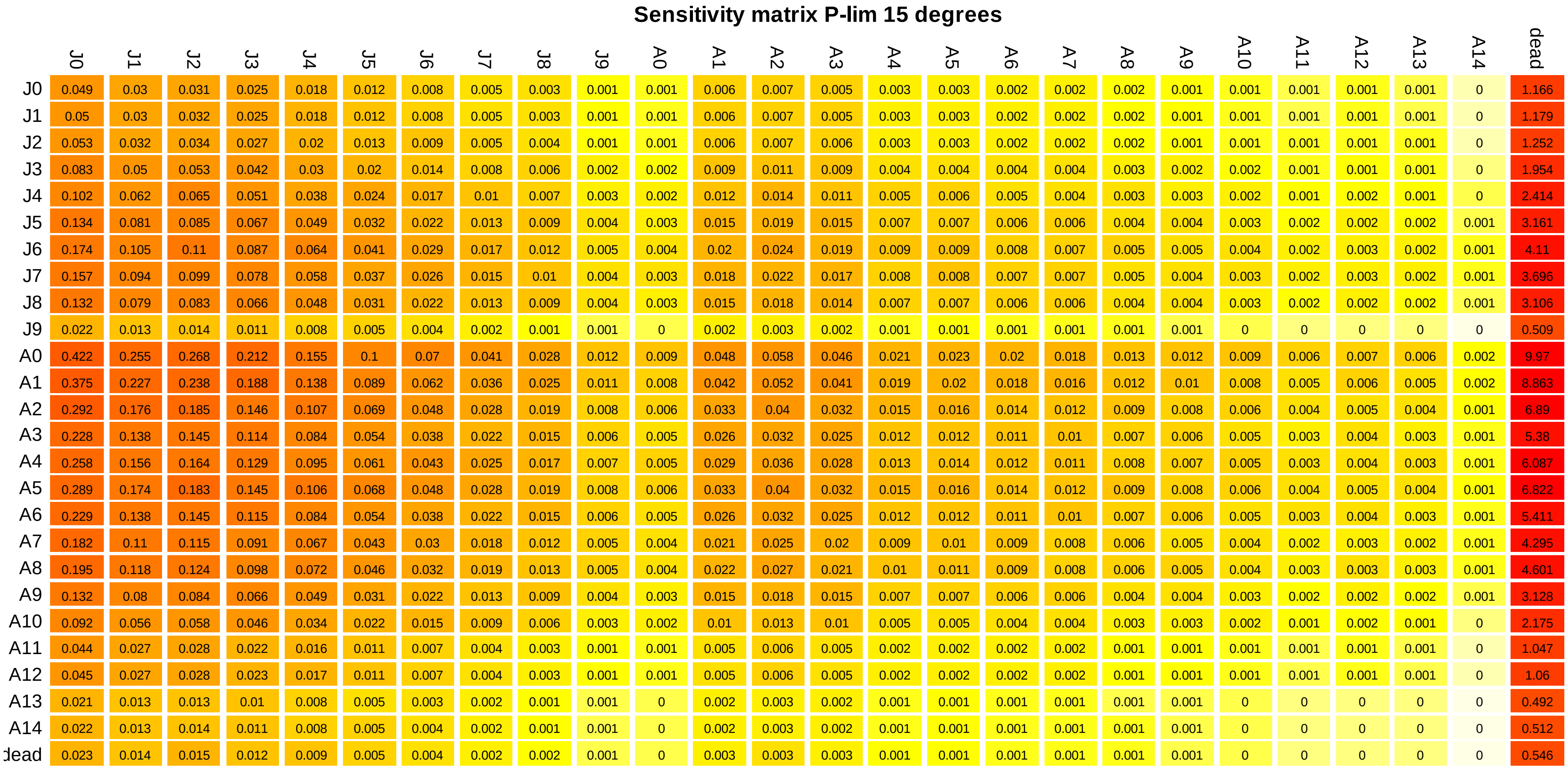
Sensitivity matrix Spiked 10 degrees

	J0	J1	J2	J3	J4	J5	J6	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	dead
J0	0.136	0.046	0.036	0.037	0.028	0.017	0.001	0.002	0.014	0.007	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0.022
J1	0.246	0.083	0.065	0.067	0.051	0.031	0.002	0.003	0.026	0.012	0.006	0.004	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0.04
J2	0.315	0.107	0.083	0.085	0.065	0.04	0.002	0.004	0.033	0.015	0.008	0.006	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0.051
J3	0.461	0.157	0.122	0.125	0.095	0.059	0.004	0.006	0.048	0.022	0.011	0.008	0.004	0.002	0.002	0.001	0.001	0	0	0	0	0	0	0	0.075
J4	0.65	0.22	0.172	0.176	0.134	0.083	0.005	0.009	0.068	0.031	0.016	0.011	0.006	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0.105
J5	0.855	0.29	0.227	0.232	0.176	0.109	0.007	0.012	0.089	0.041	0.021	0.015	0.008	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0.139
J6	1.008	0.342	0.267	0.273	0.207	0.128	0.008	0.014	0.105	0.049	0.025	0.018	0.01	0.005	0.004	0.002	0.002	0.001	0	0	0	0	0	0	0.164
A0	1.895	0.643	0.503	0.513	0.39	0.242	0.015	0.026	0.197	0.092	0.047	0.033	0.018	0.01	0.007	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0.308
A1	1.534	0.521	0.407	0.416	0.316	0.196	0.012	0.021	0.16	0.074	0.038	0.027	0.015	0.008	0.006	0.003	0.002	0.001	0.001	0	0	0	0	0	0.249
A2	1.106	0.375	0.294	0.3	0.228	0.141	0.008	0.015	0.115	0.053	0.027	0.019	0.011	0.006	0.004	0.002	0.002	0.001	0.001	0	0	0	0	0	0.18
A3	1.314	0.446	0.349	0.356	0.27	0.168	0.01	0.018	0.137	0.064	0.032	0.023	0.013	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0.213
A4	1.111	0.377	0.295	0.301	0.229	0.142	0.009	0.015	0.116	0.054	0.027	0.02	0.011	0.006	0.004	0.002	0.002	0.001	0.001	0	0	0	0	0	0.18
A5	1.313	0.446	0.348	0.356	0.27	0.167	0.01	0.018	0.137	0.063	0.032	0.023	0.013	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0.213
A6	1.376	0.467	0.365	0.373	0.283	0.175	0.011	0.019	0.143	0.067	0.034	0.024	0.013	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0.223
A7	1.339	0.454	0.355	0.363	0.276	0.171	0.01	0.018	0.139	0.065	0.033	0.024	0.013	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0.217
A8	1.167	0.396	0.31	0.316	0.24	0.149	0.009	0.016	0.121	0.056	0.029	0.021	0.011	0.006	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0.189
A9	0.969	0.329	0.257	0.263	0.199	0.124	0.007	0.013	0.101	0.047	0.024	0.017	0.009	0.005	0.004	0.002	0.002	0.001	0	0	0	0	0	0	0.157
A10	0.953	0.323	0.253	0.258	0.196	0.121	0.007	0.013	0.099	0.046	0.024	0.017	0.009	0.005	0.004	0.002	0.001	0.001	0	0	0	0	0	0	0.155
A11	0.516	0.175	0.137	0.14	0.106	0.066	0.004	0.007	0.054	0.025	0.013	0.009	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0.084
A12	0.469	0.159	0.124	0.127	0.096	0.06	0.004	0.006	0.049	0.023	0.012	0.008	0.005	0.002	0.002	0.001	0.001	0	0	0	0	0	0	0	0.076
A13	0.2	0.068	0.053	0.054	0.041	0.026	0.002	0.003	0.021	0.01	0.005	0.004	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0.032
A14	0.231	0.078	0.061	0.063	0.048	0.029	0.002	0.003	0.024	0.011	0.006	0.004	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0.038
A15	0.088	0.03	0.023	0.024	0.018	0.011	0.001	0.001	0.009	0.004	0.002	0.002	0.001	0	0	0	0	0	0	0	0	0	0	0	0.014
A16	0.318	0.108	0.084	0.086	0.065	0.041	0.002	0.004	0.033	0.015	0.008	0.006	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0.052
dead	0.005	0.002	0.001	0.001	0.001	0.001	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001



Sensitivity matrix Full 15 degrees

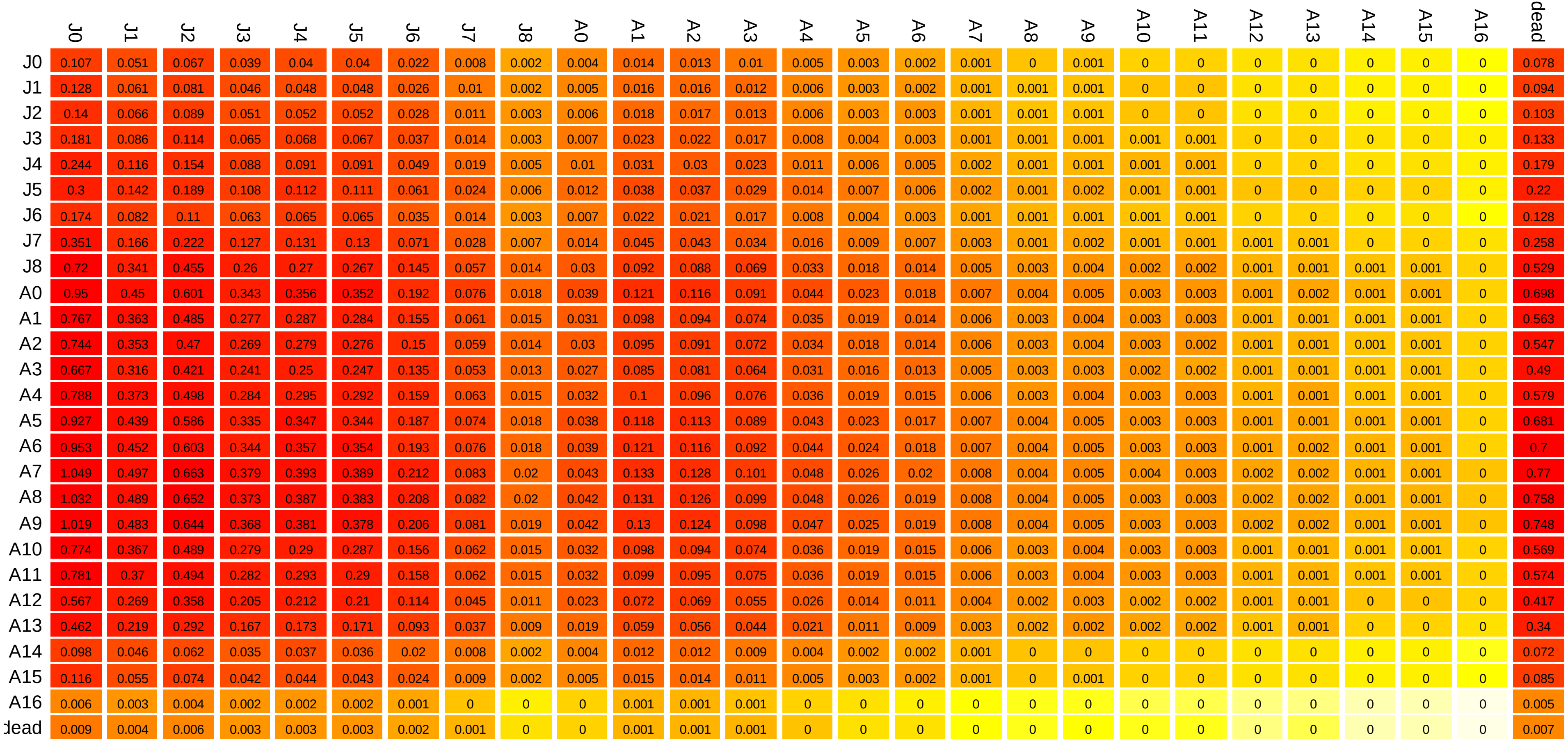
	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	dead
J0	0.137	0.047	0.049	0.049	0.035	0.015	0.009	0.002	0.003	0.025	0.017	0.011	0.008	0.005	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0.015
J1	0.196	0.067	0.07	0.07	0.05	0.022	0.013	0.002	0.004	0.036	0.024	0.016	0.011	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0.022
J2	0.244	0.083	0.088	0.087	0.062	0.027	0.016	0.003	0.005	0.045	0.03	0.02	0.014	0.009	0.006	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0.027
J3	0.314	0.107	0.112	0.112	0.08	0.035	0.02	0.004	0.006	0.057	0.038	0.025	0.018	0.011	0.008	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0.035
J4	0.401	0.136	0.144	0.143	0.102	0.045	0.026	0.005	0.008	0.073	0.049	0.032	0.023	0.014	0.01	0.006	0.004	0.002	0.002	0.001	0	0	0	0	0	0	0	0	0	0.045
J5	0.419	0.143	0.15	0.15	0.107	0.047	0.027	0.005	0.008	0.077	0.051	0.034	0.024	0.015	0.01	0.006	0.004	0.002	0.002	0.001	0	0	0	0	0	0	0	0	0	0.047
J6	0.436	0.149	0.156	0.156	0.111	0.049	0.028	0.005	0.009	0.08	0.053	0.035	0.025	0.016	0.011	0.006	0.004	0.003	0.002	0.001	0	0	0	0	0	0	0	0	0	0.049
J7	0.469	0.16	0.168	0.168	0.119	0.053	0.03	0.006	0.009	0.086	0.057	0.038	0.027	0.017	0.011	0.007	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0.052
A0	0.749	0.255	0.269	0.268	0.19	0.084	0.048	0.009	0.015	0.137	0.091	0.06	0.043	0.027	0.018	0.011	0.007	0.004	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.084
A1	0.745	0.254	0.267	0.267	0.189	0.083	0.048	0.009	0.015	0.136	0.09	0.06	0.042	0.027	0.018	0.011	0.007	0.004	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.083
A2	0.693	0.236	0.248	0.248	0.176	0.078	0.044	0.009	0.014	0.127	0.084	0.056	0.039	0.025	0.017	0.01	0.006	0.004	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.077
A3	0.822	0.28	0.295	0.294	0.209	0.092	0.053	0.01	0.016	0.15	0.1	0.066	0.047	0.029	0.02	0.012	0.008	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0.092
A4	0.754	0.257	0.27	0.27	0.192	0.084	0.048	0.009	0.015	0.138	0.091	0.061	0.043	0.027	0.018	0.011	0.007	0.004	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.084
A5	0.774	0.264	0.277	0.277	0.197	0.087	0.049	0.01	0.015	0.142	0.094	0.062	0.044	0.028	0.019	0.011	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0.086
A6	0.718	0.245	0.257	0.257	0.182	0.08	0.046	0.009	0.014	0.131	0.087	0.058	0.041	0.026	0.017	0.01	0.007	0.004	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.08
A7	0.657	0.224	0.235	0.235	0.167	0.073	0.042	0.008	0.013	0.12	0.08	0.053	0.037	0.023	0.016	0.009	0.006	0.004	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.073
A8	0.622	0.212	0.223	0.222	0.158	0.07	0.04	0.008	0.012	0.114	0.075	0.05	0.035	0.022	0.015	0.009	0.006	0.004	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0.069
A9	0.692	0.236	0.248	0.248	0.176	0.077	0.044	0.009	0.014	0.127	0.084	0.056	0.039	0.025	0.017	0.01	0.006	0.004	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.077
A10	0.505	0.172	0.181	0.181	0.128	0.056	0.032	0.006	0.01	0.092	0.061	0.041	0.029	0.018	0.012	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0.056
A11	0.526	0.179	0.188	0.188	0.134	0.059	0.034	0.007	0.011	0.096	0.064	0.042	0.03	0.019	0.013	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0.059
A12	0.262	0.089	0.094	0.094	0.067	0.029	0.017	0.003	0.005	0.048	0.032	0.021	0.015	0.009	0.006	0.004	0.002	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0.029
A13	0.18	0.061	0.065	0.065	0.046	0.02	0.012	0.002	0.004	0.033	0.022	0.015	0.01	0.006	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0.02
A14	0.225	0.077	0.081	0.081	0.057	0.025	0.014	0.003	0.005	0.041	0.027	0.018	0.013	0.008	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0.025
A15	0.044	0.015	0.016	0.016	0.011	0.005	0.003	0.001	0.001	0.008	0.005	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0.005
A16	0.087	0.03	0.031	0.031	0.022	0.01	0.006	0.001	0.002	0.016	0.011	0.007	0.005	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0.01
A17	0.025	0.009	0.009	0.009	0.006	0.003	0.002	0	0.001	0.005	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003
A18	0.039	0.013	0.014	0.014	0.01	0.004	0.003	0	0.001	0.007	0.005	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0.004
A19	0.071	0.024	0.026	0.026	0.018	0.008	0.005	0.001	0.001	0.013	0.009	0.006	0.004	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0.008
A20	0.015	0.005	0.005	0.005	0.004	0.002	0.001	0	0	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002
dead	0.019	0.006	0.007	0.007	0.005	0.002	0.001	0	0	0.003	0.002	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002



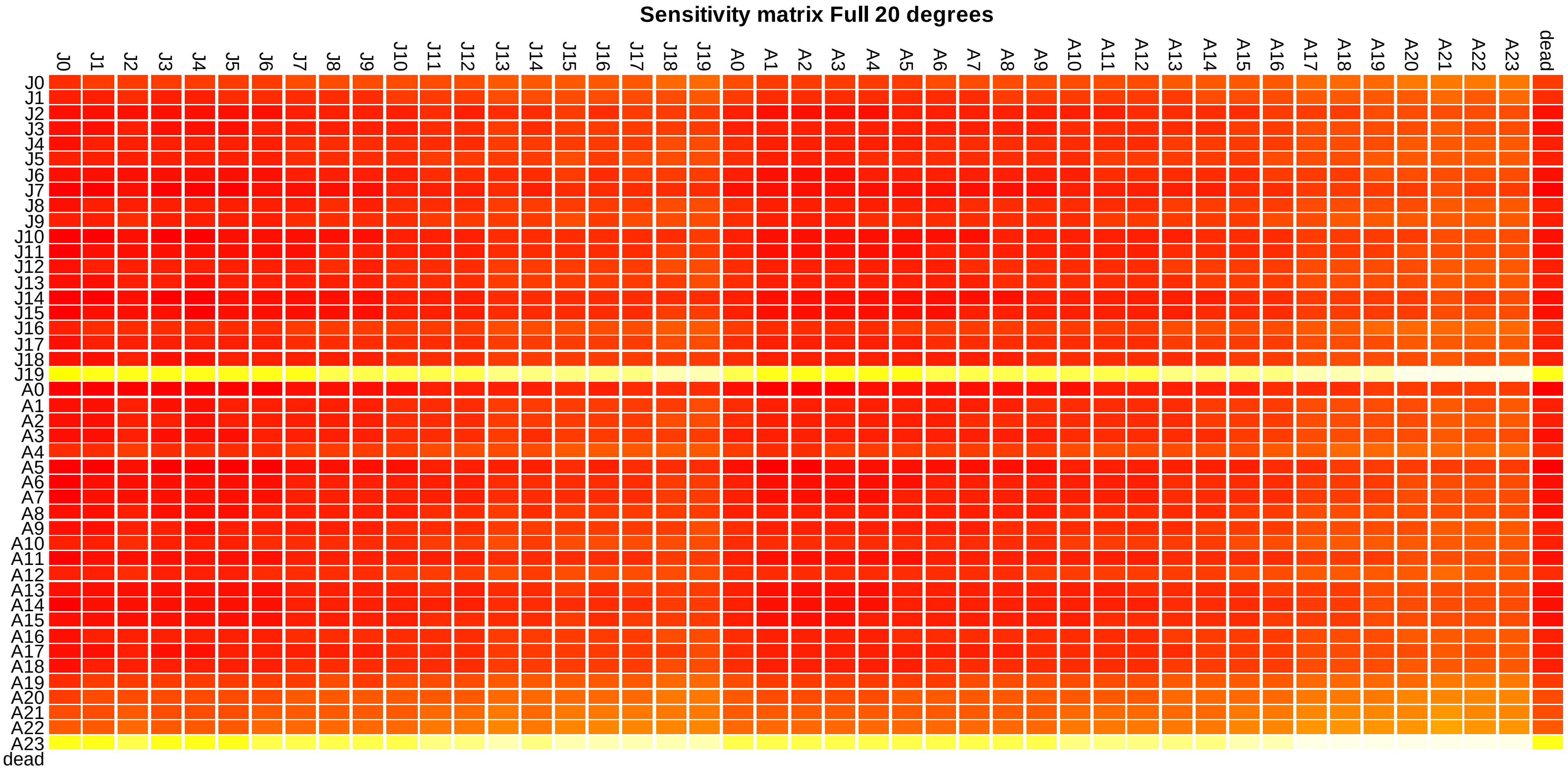
Sensitivity matrix P-lim 15 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	0.049	0.03	0.031	0.025	0.018	0.012	0.008	0.005	0.003	0.001	0.001	0.006	0.007	0.005	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0	1.166
J1	0.05	0.03	0.032	0.025	0.018	0.012	0.008	0.005	0.003	0.001	0.001	0.006	0.007	0.005	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0	1.179
J2	0.053	0.032	0.034	0.027	0.02	0.013	0.009	0.005	0.004	0.001	0.001	0.006	0.007	0.006	0.003	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0	1.252
J3	0.083	0.05	0.053	0.042	0.03	0.02	0.014	0.008	0.006	0.002	0.002	0.009	0.011	0.009	0.004	0.004	0.004	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0	1.954
J4	0.102	0.062	0.065	0.051	0.038	0.024	0.017	0.01	0.007	0.003	0.002	0.012	0.014	0.011	0.005	0.006	0.005	0.004	0.003	0.003	0.002	0.001	0.002	0.001	0	2.414
J5	0.134	0.081	0.085	0.067	0.049	0.032	0.022	0.013	0.009	0.004	0.003	0.015	0.019	0.015	0.007	0.007	0.006	0.006	0.004	0.004	0.003	0.002	0.002	0.002	0.001	3.161
J6	0.174	0.105	0.11	0.087	0.064	0.041	0.029	0.017	0.012	0.005	0.004	0.02	0.024	0.019	0.009	0.009	0.008	0.007	0.005	0.005	0.004	0.002	0.003	0.002	0.001	4.11
J7	0.157	0.094	0.099	0.078	0.058	0.037	0.026	0.015	0.01	0.004	0.003	0.018	0.022	0.017	0.008	0.008	0.007	0.007	0.005	0.004	0.003	0.002	0.003	0.002	0.001	3.696
J8	0.132	0.079	0.083	0.066	0.048	0.031	0.022	0.013	0.009	0.004	0.003	0.015	0.018	0.014	0.007	0.007	0.006	0.006	0.004	0.004	0.003	0.002	0.002	0.002	0.001	3.106
J9	0.022	0.013	0.014	0.011	0.008	0.005	0.004	0.002	0.001	0.001	0	0.002	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0.509
A0	0.422	0.255	0.268	0.212	0.155	0.1	0.07	0.041	0.028	0.012	0.009	0.048	0.058	0.046	0.021	0.023	0.02	0.018	0.013	0.012	0.009	0.006	0.007	0.006	0.002	9.97
A1	0.375	0.227	0.238	0.188	0.138	0.089	0.062	0.036	0.025	0.011	0.008	0.042	0.052	0.041	0.019	0.02	0.018	0.016	0.012	0.01	0.008	0.005	0.006	0.005	0.002	8.863
A2	0.292	0.176	0.185	0.146	0.107	0.069	0.048	0.028	0.019	0.008	0.006	0.033	0.04	0.032	0.015	0.016	0.014	0.012	0.009	0.008	0.006	0.004	0.005	0.004	0.001	6.89
A3	0.228	0.138	0.145	0.114	0.084	0.054	0.038	0.022	0.015	0.006	0.005	0.026	0.032	0.025	0.012	0.012	0.011	0.01	0.007	0.006	0.005	0.003	0.004	0.003	0.001	5.38
A4	0.258	0.156	0.164	0.129	0.095	0.061	0.043	0.025	0.017	0.007	0.005	0.029	0.036	0.028	0.013	0.014	0.012	0.011	0.008	0.007	0.005	0.003	0.004	0.003	0.001	6.087
A5	0.289	0.174	0.183	0.145	0.106	0.068	0.048	0.028	0.019	0.008	0.006	0.033	0.04	0.032	0.015	0.016	0.014	0.012	0.009	0.008	0.006	0.004	0.005	0.004	0.001	6.822
A6	0.229	0.138	0.145	0.115	0.084	0.054	0.038	0.022	0.015	0.006	0.005	0.026	0.032	0.025	0.012	0.012	0.011	0.01	0.007	0.006	0.005	0.003	0.004	0.003	0.001	5.411
A7	0.182	0.11	0.115	0.091	0.067	0.043	0.03	0.018	0.012	0.005	0.004	0.021	0.025	0.02	0.009	0.01	0.009	0.008	0.006	0.005	0.004	0.002	0.003	0.002	0.001	4.295
A8	0.195	0.118	0.124	0.098	0.072	0.046	0.032	0.019	0.013	0.005	0.004	0.022	0.027	0.021	0.01	0.011	0.009	0.008	0.006	0.005	0.004	0.003	0.003	0.003	0.001	4.601
A9	0.132	0.08	0.084	0.066	0.049	0.031	0.022	0.013	0.009	0.004	0.003	0.015	0.018	0.015	0.007	0.007	0.006	0.006	0.004	0.004	0.003	0.002	0.002	0.002	0.001	3.128
A10	0.092	0.056	0.058	0.046	0.034	0.022	0.015	0.009	0.006	0.003	0.002	0.01	0.013	0.01	0.005	0.005	0.004	0.004	0.003	0.003	0.002	0.001	0.002	0.001	0	2.175
A11	0.044	0.027	0.028	0.022	0.016	0.011	0.007	0.004	0.003	0.001	0.001	0.005	0.006	0.005	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0	1.047
A12	0.045	0.027	0.028	0.023	0.017	0.011	0.007	0.004	0.003	0.001	0.001	0.005	0.006	0.005	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0	1.06
A13	0.021	0.013	0.013	0.01	0.008	0.005	0.003	0.002	0.001	0.001	0	0.002	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0.492
A14	0.022	0.013	0.014	0.011	0.008	0.005	0.004	0.002	0.001	0.001	0	0.002	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0.512
dead	0.023	0.014	0.015	0.012	0.009	0.005	0.004	0.002	0.002	0.001	0	0.003	0.003	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0.546

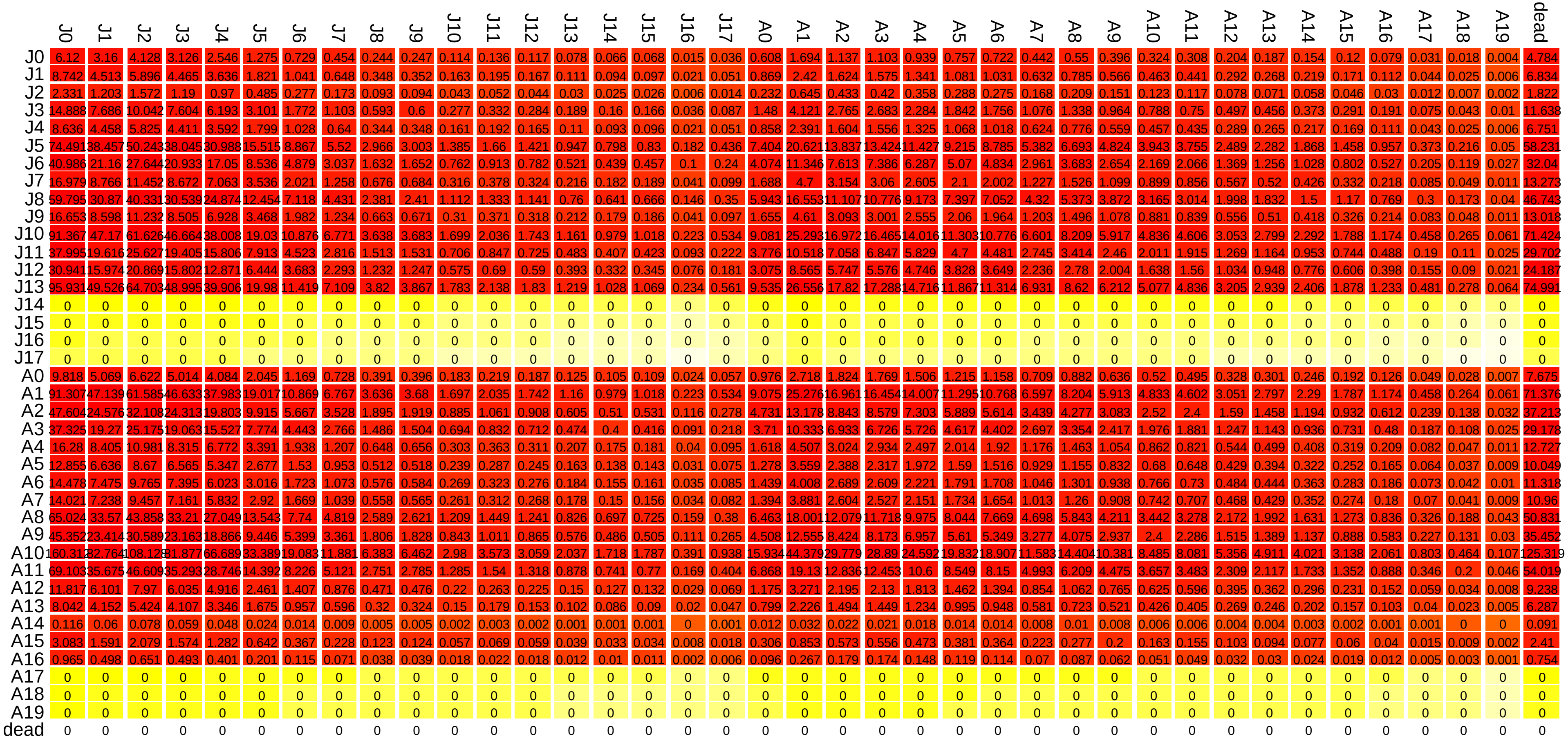
Sensitivity matrix Spiked 15 degrees



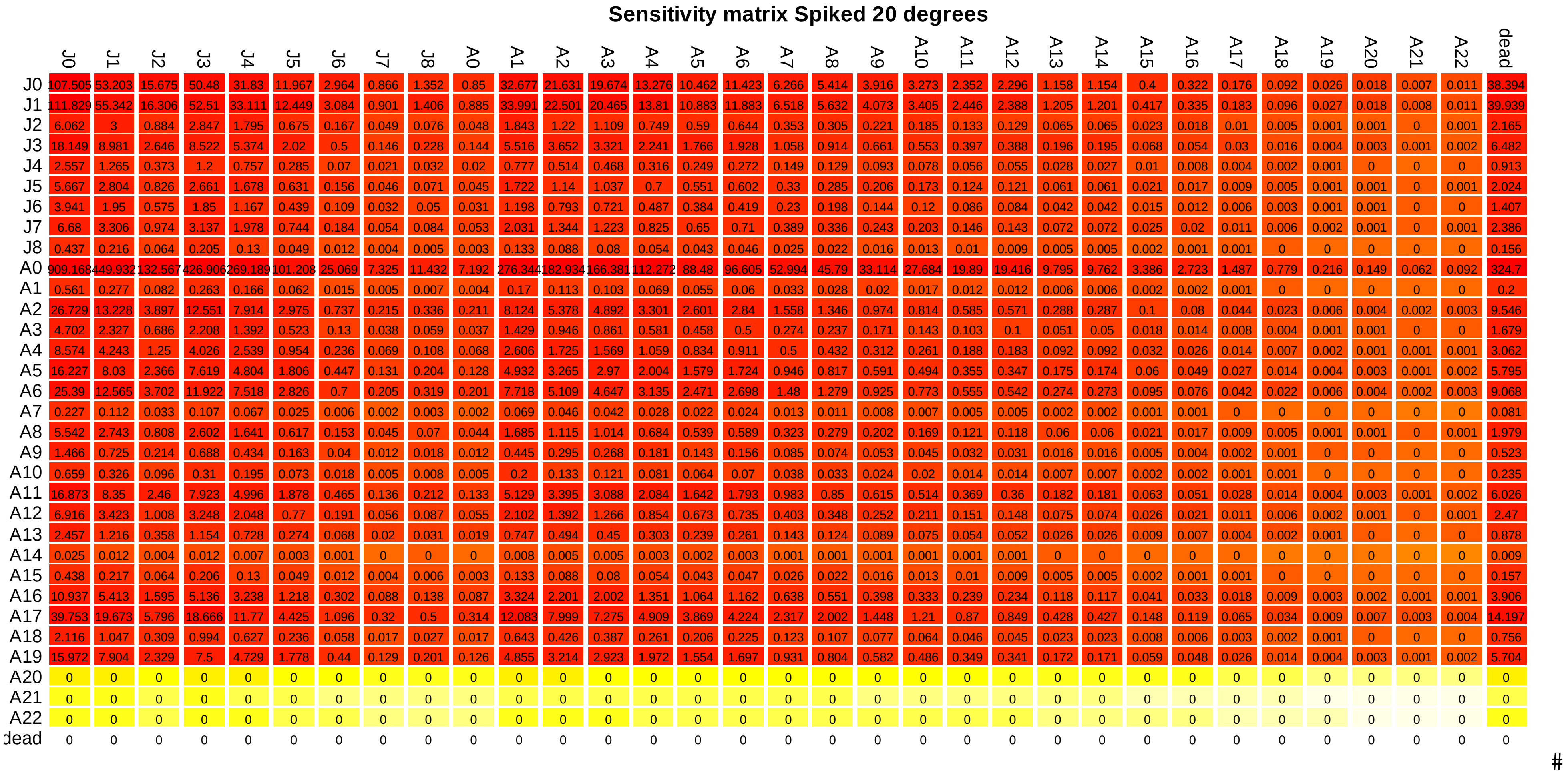
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	dead
J0	0.107	0.051	0.067	0.039	0.04	0.04	0.022	0.008	0.002	0.004	0.014	0.013	0.01	0.005	0.003	0.002	0.001	0	0.001	0	0	0	0	0	0	0	0.078
J1	0.128	0.061	0.081	0.046	0.048	0.048	0.026	0.01	0.002	0.005	0.016	0.016	0.012	0.006	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0.094
J2	0.14	0.066	0.089	0.051	0.052	0.052	0.028	0.011	0.003	0.006	0.018	0.017	0.013	0.006	0.003	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0.103
J3	0.181	0.086	0.114	0.065	0.068	0.067	0.037	0.014	0.003	0.007	0.023	0.022	0.017	0.008	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0.133
J4	0.244	0.116	0.154	0.088	0.091	0.091	0.049	0.019	0.005	0.01	0.031	0.03	0.023	0.011	0.006	0.005	0.002	0.001	0.001	0.001	0.001	0	0	0	0	0	0.179
J5	0.3	0.142	0.189	0.108	0.112	0.111	0.061	0.024	0.006	0.012	0.038	0.037	0.029	0.014	0.007	0.006	0.002	0.001	0.002	0.001	0.001	0	0	0	0	0	0.22
J6	0.174	0.082	0.11	0.063	0.065	0.065	0.035	0.014	0.003	0.007	0.022	0.021	0.017	0.008	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0.128
J7	0.351	0.166	0.222	0.127	0.131	0.13	0.071	0.028	0.007	0.014	0.045	0.043	0.034	0.016	0.009	0.007	0.003	0.001	0.002	0.001	0.001	0.001	0.001	0	0	0	0.258
J8	0.72	0.341	0.455	0.26	0.27	0.267	0.145	0.057	0.014	0.03	0.092	0.088	0.069	0.033	0.018	0.014	0.005	0.003	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0	0.529
A0	0.95	0.45	0.601	0.343	0.356	0.352	0.192	0.076	0.018	0.039	0.121	0.116	0.091	0.044	0.023	0.018	0.007	0.004	0.005	0.003	0.003	0.001	0.002	0.001	0.001	0	0.698
A1	0.767	0.363	0.485	0.277	0.287	0.284	0.155	0.061	0.015	0.031	0.098	0.094	0.074	0.035	0.019	0.014	0.006	0.003	0.004	0.003	0.003	0.001	0.001	0.001	0.001	0	0.563
A2	0.744	0.353	0.47	0.269	0.279	0.276	0.15	0.059	0.014	0.03	0.095	0.091	0.072	0.034	0.018	0.014	0.006	0.003	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0	0.547
A3	0.667	0.316	0.421	0.241	0.25	0.247	0.135	0.053	0.013	0.027	0.085	0.081	0.064	0.031	0.016	0.013	0.005	0.003	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0	0.49
A4	0.788	0.373	0.498	0.284	0.295	0.292	0.159	0.063	0.015	0.032	0.1	0.096	0.076	0.036	0.019	0.015	0.006	0.003	0.004	0.003	0.003	0.001	0.001	0.001	0.001	0	0.579
A5	0.927	0.439	0.586	0.335	0.347	0.344	0.187	0.074	0.018	0.038	0.118	0.113	0.089	0.043	0.023	0.017	0.007	0.004	0.005	0.003	0.003	0.001	0.001	0.001	0.001	0	0.681
A6	0.953	0.452	0.603	0.344	0.357	0.354	0.193	0.076	0.018	0.039	0.121	0.116	0.092	0.044	0.024	0.018	0.007	0.004	0.005	0.003	0.003	0.001	0.002	0.001	0.001	0	0.7
A7	1.049	0.497	0.663	0.379	0.393	0.389	0.212	0.083	0.02	0.043	0.133	0.128	0.101	0.048	0.026	0.02	0.008	0.004	0.005	0.004	0.003	0.002	0.002	0.001	0.001	0	0.77
A8	1.032	0.489	0.652	0.373	0.387	0.383	0.208	0.082	0.02	0.042	0.131	0.126	0.099	0.048	0.026	0.019	0.008	0.004	0.005	0.003	0.003	0.002	0.002	0.001	0.001	0	0.758
A9	1.019	0.483	0.644	0.368	0.381	0.378	0.206	0.081	0.019	0.042	0.13	0.124	0.098	0.047	0.025	0.019	0.008	0.004	0.005	0.003	0.003	0.002	0.002	0.001	0.001	0	0.748
A10	0.774	0.367	0.489	0.279	0.29	0.287	0.156	0.062	0.015	0.032	0.098	0.094	0.074	0.036	0.019	0.015	0.006	0.003	0.004	0.003	0.003	0.001	0.001	0.001	0.001	0	0.569
A11	0.781	0.37	0.494	0.282	0.293	0.29	0.158	0.062	0.015	0.032	0.099	0.095	0.075	0.036	0.019	0.015	0.006	0.003	0.004	0.003	0.003	0.001	0.001	0.001	0.001	0	0.574
A12	0.567	0.269	0.358	0.205	0.212	0.21	0.114	0.045	0.011	0.023	0.072	0.069	0.055	0.026	0.014	0.011	0.004	0.002	0.003	0.002	0.002	0.001	0.001	0	0	0	0.417
A13	0.462	0.219	0.292	0.167	0.173	0.171	0.093	0.037	0.009	0.019	0.059	0.056	0.044	0.021	0.011	0.009	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0	0	0	0.34
A14	0.098	0.046	0.062	0.035	0.037	0.036	0.02	0.008	0.002	0.004	0.012	0.012	0.009	0.004	0.002	0.002	0.001	0	0	0	0	0	0	0	0	0	0.072
A15	0.116	0.055	0.074	0.042	0.044	0.043	0.024	0.009	0.002	0.005	0.015	0.014	0.011	0.005	0.003	0.002	0.001	0	0.001	0	0	0	0	0	0	0	0.085
A16	0.006	0.003	0.004	0.002	0.002	0.002	0.001	0	0	0	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0.005
dead	0.009	0.004	0.006	0.003	0.003	0.003	0.002	0.001	0	0	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0.007


Sensitivity matrix Full 20 degrees
J0
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
J15
J16
J17
J18
J19
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
A22
A23
dead

Sensitivity matrix P-lim 20 degrees



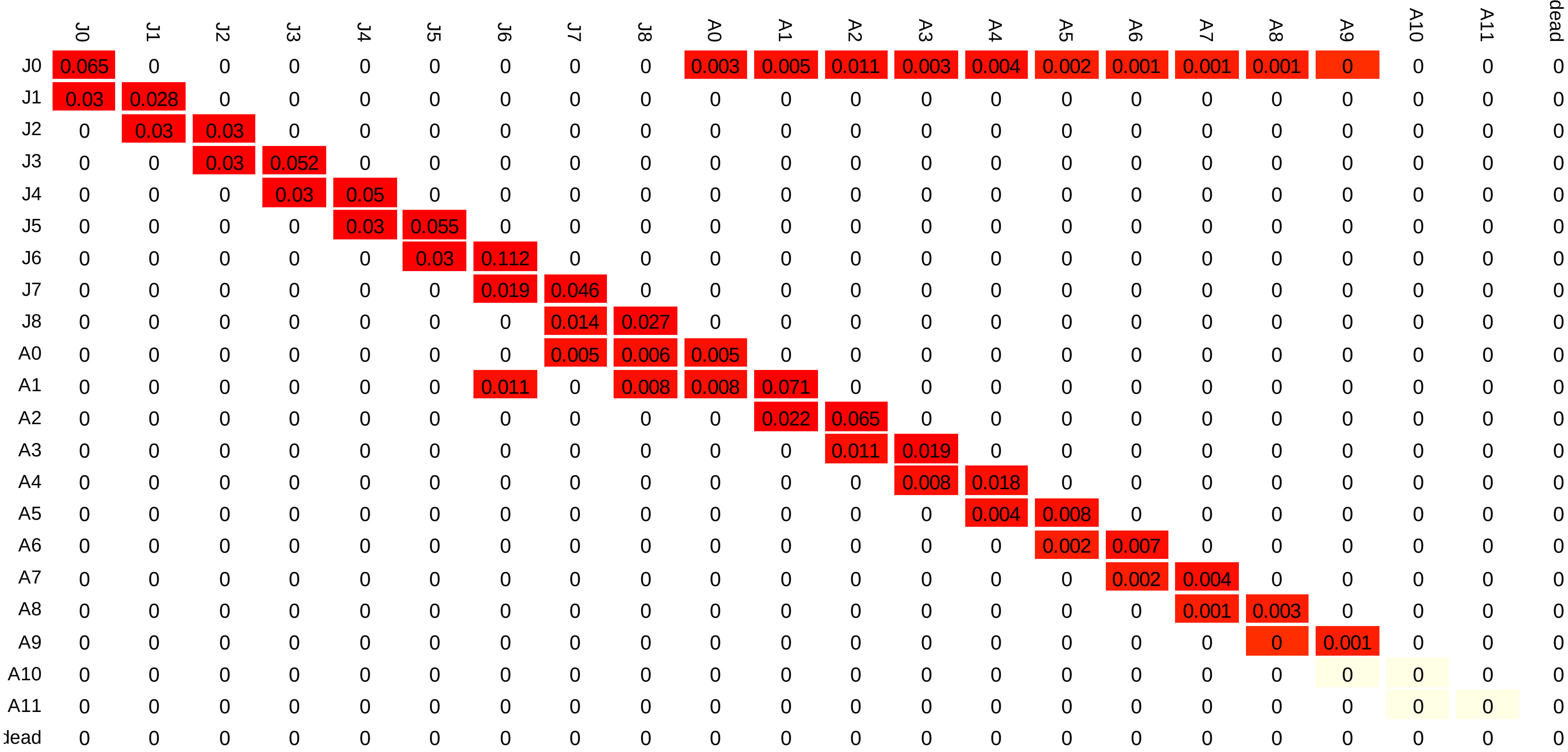
	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	dead
J0	6.12	3.16	4.128	3.126	2.546	1.275	0.729	0.454	0.244	0.247	0.114	0.136	0.117	0.078	0.066	0.068	0.015	0.036	0.608	1.694	1.137	1.103	0.939	0.757	0.722	0.442	0.55	0.396	0.324	0.308	0.204	0.187	0.154	0.12	0.079	0.031	0.018	0.004	4.784
J1	8.742	4.513	5.896	4.465	3.636	1.821	1.041	0.648	0.348	0.352	0.163	0.195	0.167	0.111	0.094	0.097	0.021	0.051	0.869	2.42	1.624	1.575	1.341	1.081	1.031	0.632	0.785	0.566	0.463	0.441	0.292	0.268	0.219	0.171	0.112	0.044	0.025	0.006	6.834
J2	2.331	1.203	1.572	1.19	0.97	0.485	0.277	0.173	0.093	0.094	0.043	0.052	0.044	0.03	0.025	0.026	0.006	0.014	0.232	0.645	0.433	0.42	0.358	0.288	0.275	0.168	0.209	0.151	0.123	0.117	0.078	0.071	0.058	0.046	0.03	0.012	0.007	0.002	1.822
J3	14.888	7.686	10.042	7.604	6.193	3.101	1.772	1.103	0.593	0.6	0.277	0.332	0.284	0.189	0.16	0.166	0.036	0.087	1.48	4.121	2.765	2.683	2.284	1.842	1.756	1.076	1.338	0.964	0.788	0.75	0.497	0.456	0.373	0.291	0.191	0.075	0.043	0.01	11.638
J4	8.636	4.458	5.825	4.411	3.592	1.799	1.028	0.64	0.344	0.348	0.161	0.192	0.165	0.11	0.093	0.096	0.021	0.051	0.858	2.391	1.604	1.556	1.325	1.068	1.018	0.624	0.776	0.559	0.457	0.435	0.289	0.265	0.217	0.169	0.111	0.043	0.025	0.006	6.751
J5	74.491	38.457	50.243	38.045	30.988	15.515	8.867	5.52	2.966	3.003	1.385	1.66	1.421	0.947	0.798	0.83	0.182	0.436	7.404	20.621	13.837	13.424	11.427	9.215	8.785	5.382	6.693	4.824	3.943	3.755	2.489	2.282	1.868	1.458	0.957	0.373	0.216	0.05	58.231
J6	40.986	21.16	27.644	20.933	17.05	8.536	4.879	3.037	1.632	1.652	0.762	0.913	0.782	0.521	0.439	0.457	0.1	0.24	4.074	11.346	7.613	7.386	6.287	5.07	4.834	2.961	3.683	2.654	2.169	2.066	1.369	1.256	1.028	0.802	0.527	0.205	0.119	0.027	32.04
J7	16.979	8.766	11.452	8.672	7.063	3.536	2.021	1.258	0.676	0.684	0.316	0.378	0.324	0.216	0.182	0.189	0.041	0.099	1.688	4.7	3.154	3.06	2.605	2.1	2.002	1.227	1.526	1.099	0.899	0.856	0.567	0.52	0.426	0.332	0.218	0.085	0.049	0.011	13.273
J8	59.795	30.87	40.331	30.539	24.874	12.454	7.118	4.431	2.381	2.41	1.112	1.333	1.141	0.76	0.641	0.666	0.146	0.35	5.943	16.553	11.107	10.776	9.173	7.397	7.052	4.32	5.373	3.872	3.165	3.014	1.998	1.832	1.5	1.17	0.769	0.3	0.173	0.04	46.743
J9	16.653	8.598	11.232	8.505	6.928	3.468	1.982	1.234	0.663	0.671	0.31	0.371	0.318	0.212	0.179	0.186	0.041	0.097	1.655	4.61	3.093	3.001	2.555	2.06	1.964	1.203	1.496	1.078	0.881	0.839	0.556	0.51	0.418	0.326	0.214	0.083	0.048	0.011	13.018
J10	91.367	47.17	61.626	46.664	38.008	19.03	10.876	6.771	3.638	3.683	1.699	2.036	1.743	1.161	0.979	1.018	0.223	0.534	9.081	25.293	16.972	16.465	14.016	11.303	10.776	6.601	8.209	5.917	4.836	4.606	3.053	2.799	2.292	1.788	1.174	0.458	0.265	0.061	71.424
J11	37.995	19.616	25.627	19.405	15.806	7.913	4.523	2.816	1.513	1.531	0.706	0.847	0.725	0.483	0.407	0.423	0.093	0.222	3.776	10.518	7.058	6.847	5.829	4.7	4.481	2.745	3.414	2.46	2.011	1.915	1.269	1.164	0.953	0.744	0.488	0.19	0.11	0.025	29.702
J12	30.941	15.974	20.869	15.802	12.871	6.444	3.683	2.293	1.232	1.247	0.575	0.69	0.59	0.393	0.332	0.345	0.076	0.181	3.075	8.565	5.747	5.576	4.746	3.828	3.649	2.236	2.78	2.004	1.638	1.56	1.034	0.948	0.776	0.606	0.398	0.155	0.09	0.021	24.187
J13	95.931	49.526	64.703	48.995	39.906	19.98	11.419	7.109	3.82	3.867	1.783	2.138	1.83	1.219	1.028	1.069	0.234	0.561	9.535	26.556	17.82	17.288	14.716	11.867	11.314	6.931	8.62	6.212	5.077	4.836	3.205	2.939	2.406	1.878	1.233	0.481	0.278	0.064	74.991
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	9.818	5.069	6.622	5.014	4.084	2.045	1.169	0.728	0.391	0.396	0.183	0.219	0.187	0.125	0.105	0.109	0.024	0.057	0.976	2.718	1.824	1.769	1.506	1.215	1.158	0.709	0.882	0.636	0.52	0.495	0.328	0.301	0.246	0.192	0.126	0.049	0.028	0.007	7.675
A1	91.307	47.139	61.585	46.633	37.983	19.017	10.869	6.767	3.636	3.68	1.697	2.035	1.742	1.16	0.979	1.018	0.223	0.534	9.075	25.276	16.961	16.454	14.007	11.295	10.768	6.597	8.204	5.913	4.833	4.602	3.051	2.797	2.29	1.787	1.174	0.458	0.264	0.061	71.376
A2	47.604	24.576	32.108	24.313	19.803	9.915	5.667	3.528	1.895	1.919	0.885	1.061	0.908	0.605	0.51	0.531	0.116	0.278	4.731	13.178	8.843	8.579	7.303	5.889	5.614	3.439	4.277	3.083	2.52	2.4	1.59	1.458	1.194	0.932	0.612	0.239	0.138	0.032	37.213
A3	37.325	19.27	25.175	19.063	15.527	7.774	4.443	2.766	1.486	1.504	0.694	0.832	0.712	0.474	0.4	0.416	0.091	0.218	3.71	10.333	6.933	6.726	5.726	4.617	4.402	2.697	3.354	2.417	1.976	1.881	1.247	1.143	0.936	0.731	0.48	0.187	0.108	0.025	29.178
A4	16.28	8.405	10.981	8.315	6.772	3.391	1.938	1.207	0.648	0.656	0.303	0.363	0.311	0.207	0.175	0.181	0.04	0.095	1.618	4.507	3.024	2.934	2.497	2.014	1.92	1.176	1.463	1.054	0.862	0.821	0.544	0.499	0.408	0.319	0.209	0.082	0.047	0.011	12.727
A5	12.855	6.636	8.67	6.565	5.347	2.677	1.53	0.953	0.512	0.518	0.239	0.287	0.245	0.163	0.138	0.143	0.031	0.075	1.278	3.559	2.388	2.317	1.972	1.59	1.516	0.929	1.155	0.832	0.68	0.648	0.429	0.394	0.322	0.252	0.165	0.064	0.037	0.009	10.049
A6	14.478	7.475	9.765	7.395	6.023	3.016	1.723	1.073	0.576	0.584	0.269	0.323	0.276	0.184	0.155	0.161	0.035	0.085	1.439	4.008	2.689	2.609	2.221	1.791	1.708	1.046	1.301	0.938	0.766	0.73	0.484	0.444	0.363	0.283	0.186	0.073	0.042	0.01	11.318
A7	14.021	7.238	9.457	7.161	5.832	2.92	1.669	1.039	0.558	0.565	0.261	0.312	0.268	0.178	0.15	0.156	0.034	0.082	1.394	3.881	2.604	2.527	2.151	1.734	1.654	1.013	1.26	0.908	0.742	0.707	0.468	0.429	0.352	0.274	0.18	0.07	0.041	0.009	10.96
A8	65.024	33.57	43.858	33.21	27.049	13.543	7.74	4.819	2.589	2.621	1.209	1.449	1.241	0.826	0.697	0.725	0.159	0.38	6.463	18.001	12.079	11.718	9.975	8.044	7.669	4.698	5.843	4.211	3.442	3.278	2.172	1.992	1.631	1.273	0.836	0.326	0.188	0.043	50.831
A9	45.352	23.414	30.589	23.163	18.866	9.446	5.399	3.361	1.806	1.828	0.843	1.011	0.865	0.576	0.486	0.505	0.111	0.265	4.508	12.555	8.424	8.173	6.957	5.61	5.349	3.277	4.075	2.937	2.4	2.286	1.515	1.389	1.137	0.888	0.583	0.227	0.131	0.03	35.452
A10	160.312	82.764	108.128	81.877	66.689	33.389	19.083	11.881	6.383	6.462	2.98	3.573	3.059	2.037	1.718	1.787	0.391	0.938	15.934	44.379	29.779	28.89	24.592	19.832	18.907	11.583	14.404	10.381	8.485	8.081	5.356	4.911	4.021	3.138	2.061	0.803	0.464	0.107	125.319
A11	69.103	35.675	46.609	35.293	28.746	14.392	8.226	5.121	2.751	2.785	1.285	1.54	1.318	0.878	0.741	0.77	0.169	0.404	6.868	19.13	12.836	12.453	10.6	8.549	8.15	4.993	6.209	4.475	3.657	3.483	2.309	2.117	1.733	1.352	0.888	0.346	0.2	0.046	54.019
A12	11.817	6.101	7.97	6.035	4.916	2.461	1.407	0.876	0.471	0.476	0.22	0.263	0.225	0.15	0.127	0.132	0.029	0.069	1.175	3.271	2.195	2.13	1.813	1.462	1.394	0.854	1.062	0.765	0.625	0.596	0.395	0.362	0.296	0.231	0.152	0.059	0.034	0.008	9.238
A13	8.042	4.152	5.424	4.107	3.346	1.675	0.957	0.596	0.32	0.324	0.15	0.179	0.153	0.102	0.086	0.09	0.02	0.047	0.799	2.226	1.494	1.449	1.234	0.995	0.948	0.581	0.723	0.521	0.426	0.405	0.269	0.246	0.202	0.157	0.103	0.04	0.023	0.005	6.287
A14	0.116	0.06	0.078	0.059	0.048	0.024	0.014	0.009	0.005	0.005	0.002	0.003	0.002	0.001	0.001	0.001	0	0.001	0.012	0.032	0.022	0.021	0.018	0.014	0.014	0.008	0.01	0.008	0.006	0.006	0.004	0.004	0.003	0.002	0.001	0.001	0	0	0.091
A15	3.083	1.591	2.079	1.574	1.282	0.642	0.367	0.228	0.123	0.124	0.057	0.069	0.059	0.039	0.033	0.034	0.008	0.018	0.306	0.853	0.573	0.556	0.473	0.381	0.364	0.223	0.277	0.2	0.163	0.155	0.103	0.094	0.077	0.06	0.04	0.015	0.009	0.002	2.41
A16	0.965	0.498	0.651	0.493	0.401	0.201	0.115	0.071	0.038	0.039	0.018	0.022	0.018	0.012	0.01	0.011	0.002	0.006	0.096	0.267	0.179	0.174	0.148	0.119	0.114	0.07	0.087	0.062	0.051	0.049	0.032	0.03	0.024	0.019	0.012	0.005	0.003	0.001	0.754
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Sensitivity matrix Spiked 20 degrees

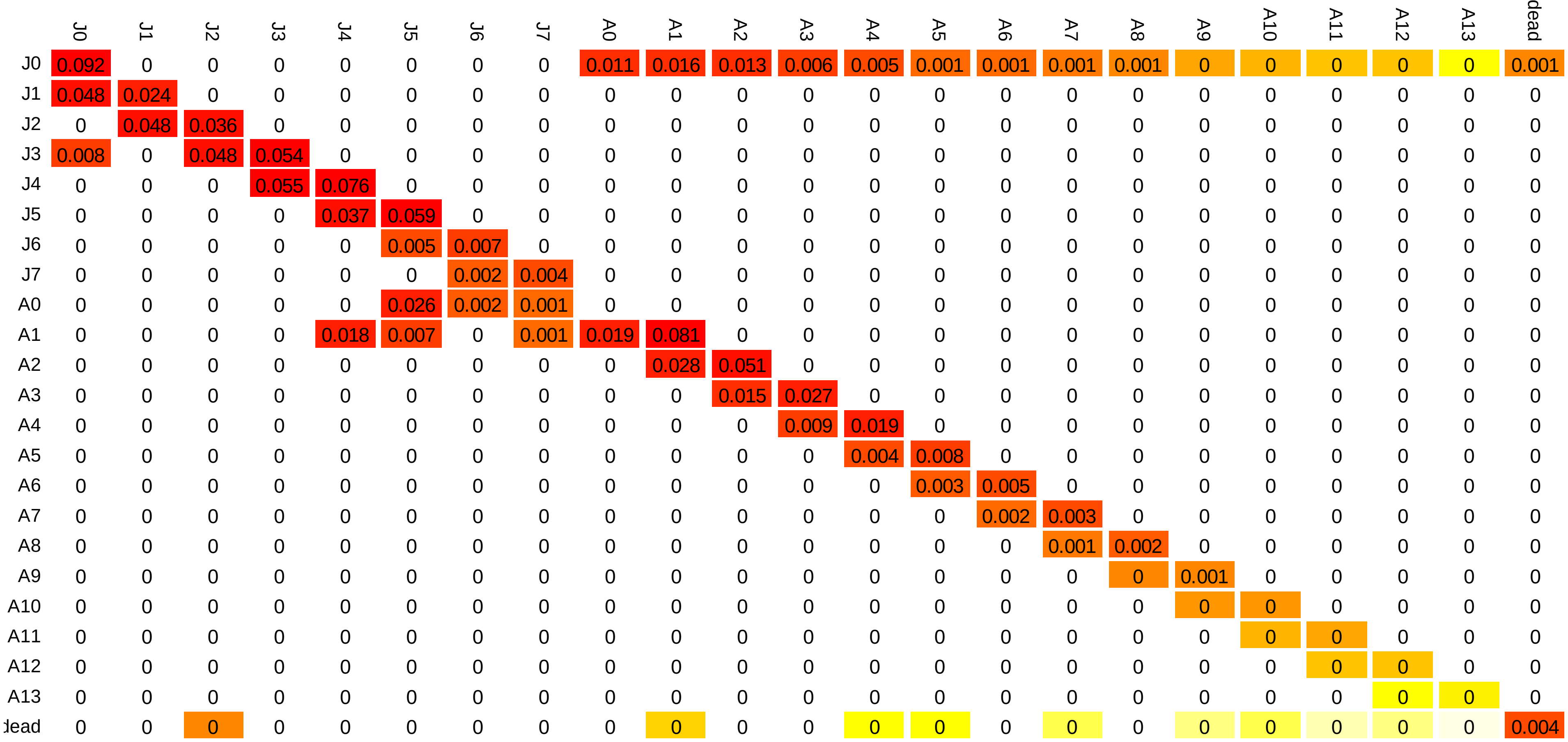
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	dead
J0	107.505	53.203	15.675	50.48	31.83	11.967	2.964	0.866	1.352	0.85	32.677	21.631	19.674	13.276	10.462	11.423	6.266	5.414	3.916	3.273	2.352	2.296	1.158	1.154	0.4	0.322	0.176	0.092	0.026	0.018	0.007	0.011	38.394
J1	111.829	55.342	16.306	52.51	33.111	12.449	3.084	0.901	1.406	0.885	33.991	22.501	20.465	13.81	10.883	11.883	6.518	5.632	4.073	3.405	2.446	2.388	1.205	1.201	0.417	0.335	0.183	0.096	0.027	0.018	0.008	0.011	39.939
J2	6.062	3	0.884	2.847	1.795	0.675	0.167	0.049	0.076	0.048	1.843	1.22	1.109	0.749	0.59	0.644	0.353	0.305	0.221	0.185	0.133	0.129	0.065	0.065	0.023	0.018	0.01	0.005	0.001	0.001	0	0.001	2.165
J3	18.149	8.981	2.646	8.522	5.374	2.02	0.5	0.146	0.228	0.144	5.516	3.652	3.321	2.241	1.766	1.928	1.058	0.914	0.661	0.553	0.397	0.388	0.196	0.195	0.068	0.054	0.03	0.016	0.004	0.003	0.001	0.002	6.482
J4	2.557	1.265	0.373	1.2	0.757	0.285	0.07	0.021	0.032	0.02	0.777	0.514	0.468	0.316	0.249	0.272	0.149	0.129	0.093	0.078	0.056	0.055	0.028	0.027	0.01	0.008	0.004	0.002	0.001	0	0	0	0.913
J5	5.667	2.804	0.826	2.661	1.678	0.631	0.156	0.046	0.071	0.045	1.722	1.14	1.037	0.7	0.551	0.602	0.33	0.285	0.206	0.173	0.124	0.121	0.061	0.061	0.021	0.017	0.009	0.005	0.001	0.001	0	0.001	2.024
J6	3.941	1.95	0.575	1.85	1.167	0.439	0.109	0.032	0.05	0.031	1.198	0.793	0.721	0.487	0.384	0.419	0.23	0.198	0.144	0.12	0.086	0.084	0.042	0.042	0.015	0.012	0.006	0.003	0.001	0.001	0	0	1.407
J7	6.68	3.306	0.974	3.137	1.978	0.744	0.184	0.054	0.084	0.053	2.031	1.344	1.223	0.825	0.65	0.71	0.389	0.336	0.243	0.203	0.146	0.143	0.072	0.072	0.025	0.02	0.011	0.006	0.002	0.001	0	0.001	2.386
J8	0.437	0.216	0.064	0.205	0.13	0.049	0.012	0.004	0.005	0.003	0.133	0.088	0.08	0.054	0.043	0.046	0.025	0.022	0.016	0.013	0.01	0.009	0.005	0.005	0.002	0.001	0.001	0	0	0	0	0	0.156
A0	909.168	449.932	132.567	426.906	269.189	101.208	25.069	7.325	11.432	7.192	276.344	182.934	166.381	112.272	88.48	96.605	52.994	45.79	33.114	27.684	19.89	19.416	9.795	9.762	3.386	2.723	1.487	0.779	0.216	0.149	0.062	0.092	324.7
A1	0.561	0.277	0.082	0.263	0.166	0.062	0.015	0.005	0.007	0.004	0.17	0.113	0.103	0.069	0.055	0.06	0.033	0.028	0.02	0.017	0.012	0.012	0.006	0.006	0.002	0.002	0.001	0	0	0	0	0	0.2
A2	26.729	13.228	3.897	12.551	7.914	2.975	0.737	0.215	0.336	0.211	8.124	5.378	4.892	3.301	2.601	2.84	1.558	1.346	0.974	0.814	0.585	0.571	0.288	0.287	0.1	0.08	0.044	0.023	0.006	0.004	0.002	0.003	9.546
A3	4.702	2.327	0.686	2.208	1.392	0.523	0.13	0.038	0.059	0.037	1.429	0.946	0.861	0.581	0.458	0.5	0.274	0.237	0.171	0.143	0.103	0.1	0.051	0.05	0.018	0.014	0.008	0.004	0.001	0.001	0	0	1.679
A4	8.574	4.243	1.25	4.026	2.539	0.954	0.236	0.069	0.108	0.068	2.606	1.725	1.569	1.059	0.834	0.911	0.5	0.432	0.312	0.261	0.188	0.183	0.092	0.092	0.032	0.026	0.014	0.007	0.002	0.001	0.001	0.001	3.062
A5	16.227	8.03	2.366	7.619	4.804	1.806	0.447	0.131	0.204	0.128	4.932	3.265	2.97	2.004	1.579	1.724	0.946	0.817	0.591	0.494	0.355	0.347	0.175	0.174	0.06	0.049	0.027	0.014	0.004	0.003	0.001	0.002	5.795
A6	25.39	12.565	3.702	11.922	7.518	2.826	0.7	0.205	0.319	0.201	7.718	5.109	4.647	3.135	2.471	2.698	1.48	1.279	0.925	0.773	0.555	0.542	0.274	0.273	0.095	0.076	0.042	0.022	0.006	0.004	0.002	0.003	9.068
A7	0.227	0.112	0.033	0.107	0.067	0.025	0.006	0.002	0.003	0.002	0.069	0.046	0.042	0.028	0.022	0.024	0.013	0.011	0.008	0.007	0.005	0.005	0.002	0.002	0.001	0.001	0	0	0	0	0	0	0.081
A8	5.542	2.743	0.808	2.602	1.641	0.617	0.153	0.045	0.07	0.044	1.685	1.115	1.014	0.684	0.539	0.589	0.323	0.279	0.202	0.169	0.121	0.118	0.06	0.06	0.021	0.017	0.009	0.005	0.001	0.001	0	0.001	1.979
A9	1.466	0.725	0.214	0.688	0.434	0.163	0.04	0.012	0.018	0.012	0.445	0.295	0.268	0.181	0.143	0.156	0.085	0.074	0.053	0.045	0.032	0.031	0.016	0.016	0.005	0.004	0.002	0.001	0	0	0	0	0.523
A10	0.659	0.326	0.096	0.31	0.195	0.073	0.018	0.005	0.008	0.005	0.2	0.133	0.121	0.081	0.064	0.07	0.038	0.033	0.024	0.02	0.014	0.014	0.007	0.007	0.002	0.002	0.001	0.001	0	0	0	0	0.235
A11	16.873	8.35	2.46	7.923	4.996	1.878	0.465	0.136	0.212	0.133	5.129	3.395	3.088	2.084	1.642	1.793	0.983	0.85	0.615	0.514	0.369	0.36	0.182	0.181	0.063	0.051	0.028	0.014	0.004	0.003	0.001	0.002	6.026
A12	6.916	3.423	1.008	3.248	2.048	0.77	0.191	0.056	0.087	0.055	2.102	1.392	1.266	0.854	0.673	0.735	0.403	0.348	0.252	0.211	0.151	0.148	0.075	0.074	0.026	0.021	0.011	0.006	0.002	0.001	0	0.001	2.47
A13	2.457	1.216	0.358	1.154	0.728	0.274	0.068	0.02	0.031	0.019	0.747	0.494	0.45	0.303	0.239	0.261	0.143	0.124	0.089	0.075	0.054	0.052	0.026	0.026	0.009	0.007	0.004	0.002	0.001	0	0	0	0.878
A14	0.025	0.012	0.004	0.012	0.007	0.003	0.001	0	0	0	0.008	0.005	0.005	0.003	0.002	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0.009
A15	0.438	0.217	0.064	0.206	0.13	0.049	0.012	0.004	0.006	0.003	0.133	0.088	0.08	0.054	0.043	0.047	0.026	0.022	0.016	0.013	0.01	0.009	0.005	0.005	0.002	0.001	0.001	0	0	0	0	0	0.157
A16	10.937	5.413	1.595	5.136	3.238	1.218	0.302	0.088	0.138	0.087	3.324	2.201	2.002	1.351	1.064	1.162	0.638	0.551	0.398	0.333	0.239	0.234	0.118	0.117	0.041	0.033	0.018	0.009	0.003	0.002	0.001	0.001	3.906
A17	39.753	19.673	5.796	18.666	11.77	4.425	1.096	0.32	0.5	0.314	12.083	7.999	7.275	4.909	3.869	4.224	2.317	2.002	1.448	1.21	0.87	0.849	0.428	0.427	0.148	0.119	0.065	0.034	0.009	0.007	0.003	0.004	14.197
A18	2.116	1.047	0.309	0.994	0.627	0.236	0.058	0.017	0.027	0.017	0.643	0.426	0.387	0.261	0.206	0.225	0.123	0.107	0.077	0.064	0.046	0.045	0.023	0.023	0.008	0.006	0.003	0.002	0.001	0	0	0	0.756
A19	15.972	7.904	2.329	7.5	4.729	1.778	0.44	0.129	0.201	0.126	4.855	3.214	2.923	1.972	1.554	1.697	0.931	0.804	0.582	0.486	0.349	0.341	0.172	0.171	0.059	0.048	0.026	0.014	0.004	0.003	0.001	0.002	5.704
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Elasticity matrix using image2 for P-lim 10 degrees



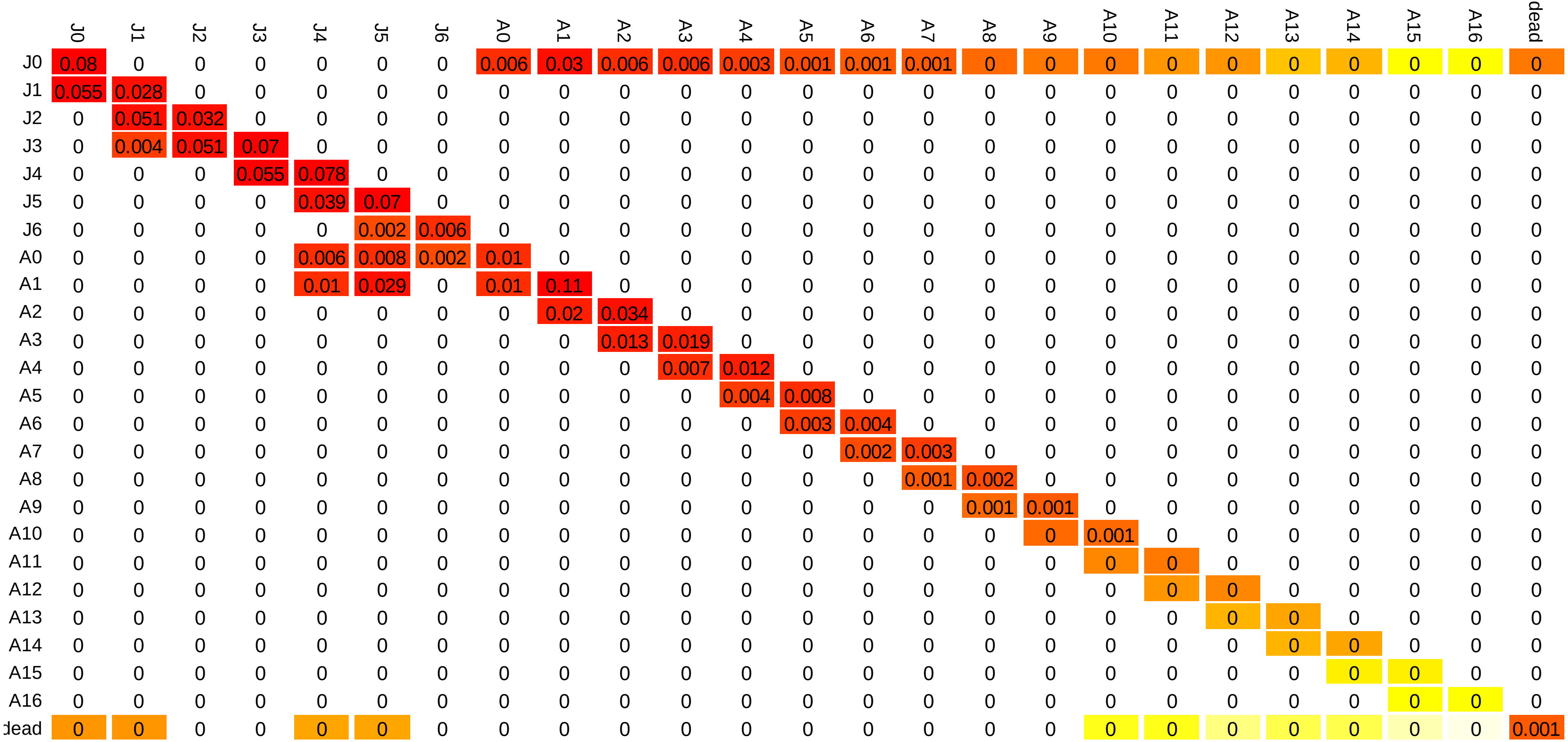
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	dead
J0	0.065	0	0	0	0	0	0	0	0	0.003	0.005	0.011	0.003	0.004	0.002	0.001	0.001	0.001	0	0	0	0
J1	0.03	0.028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.03	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0	0.03	0.052	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.03	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.03	0.055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.03	0.112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.019	0.046	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.014	0.027	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0	0	0.005	0.006	0.005	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0	0.011	0	0.008	0.008	0.071	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0.022	0.065	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0.011	0.019	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0.008	0.018	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.004	0.008	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.007	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.004	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.003	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Elasticity matrix Full 10 degrees

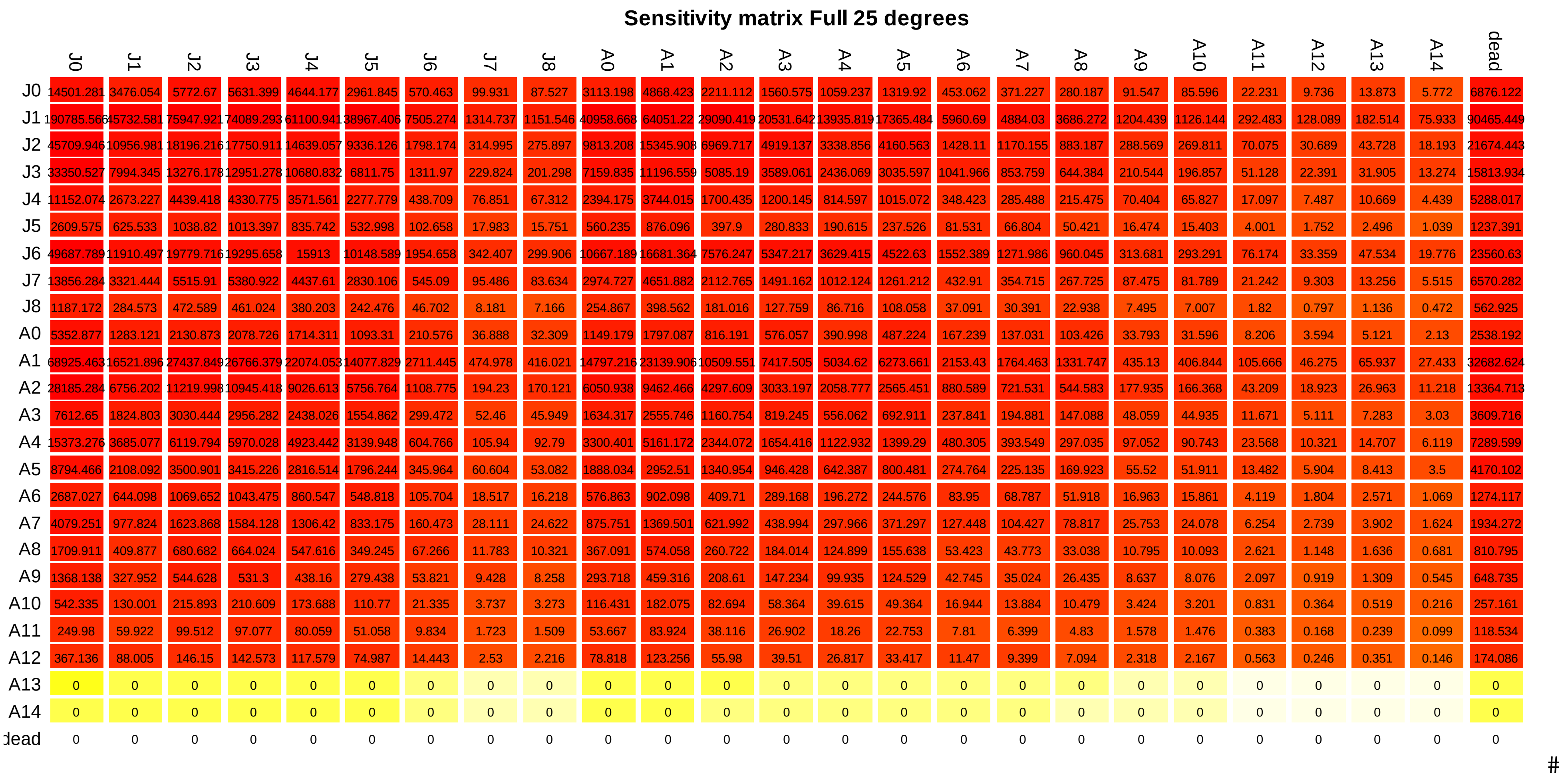


	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	dead
J0	0.092	0	0	0	0	0	0	0	0.011	0.016	0.013	0.006	0.005	0.001	0.001	0.001	0.001	0	0	0	0	0	0.001
J1	0.048	0.024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.048	0.036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0.008	0	0.048	0.054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.055	0.076	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.037	0.059	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.005	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.002	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0.026	0.002	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0.018	0.007	0	0.001	0.019	0.081	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0.028	0.051	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0.015	0.027	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0.009	0.019	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0.004	0.008	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.005	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.003	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.002	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.004

Elasticity matrix Spiked 10 degrees

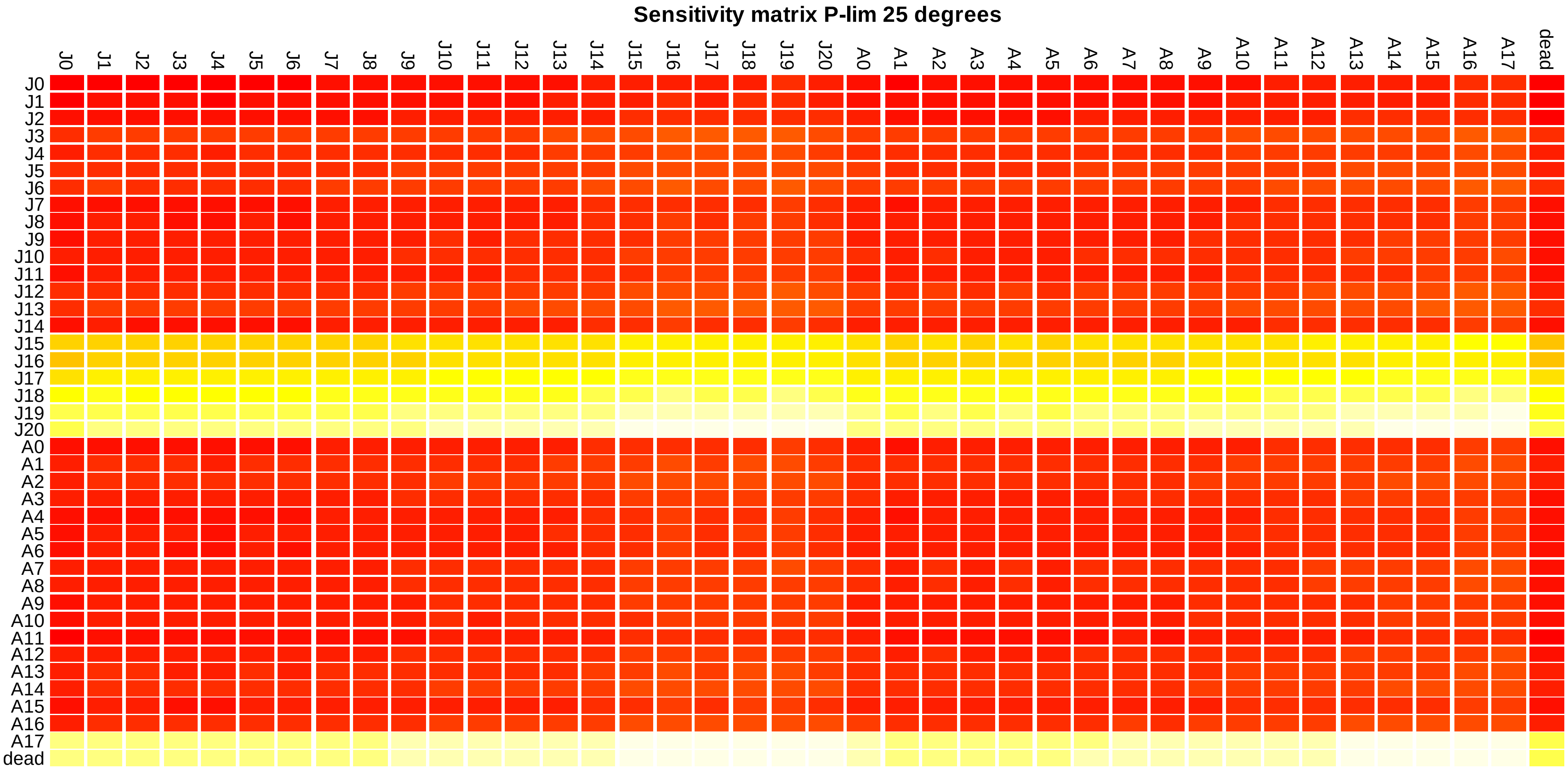


	J0	J1	J2	J3	J4	J5	J6	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	dead
J0	0.08	0	0	0	0	0	0	0.006	0.03	0.006	0.006	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0	0
J1	0.055	0.028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.051	0.032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.004	0.051	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.055	0.078	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.039	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.002	0.006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0.006	0.008	0.002	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0.01	0.029	0	0.01	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0.02	0.034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0.013	0.019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0.007	0.012	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0.004	0.008	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.004	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.003	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.002	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001

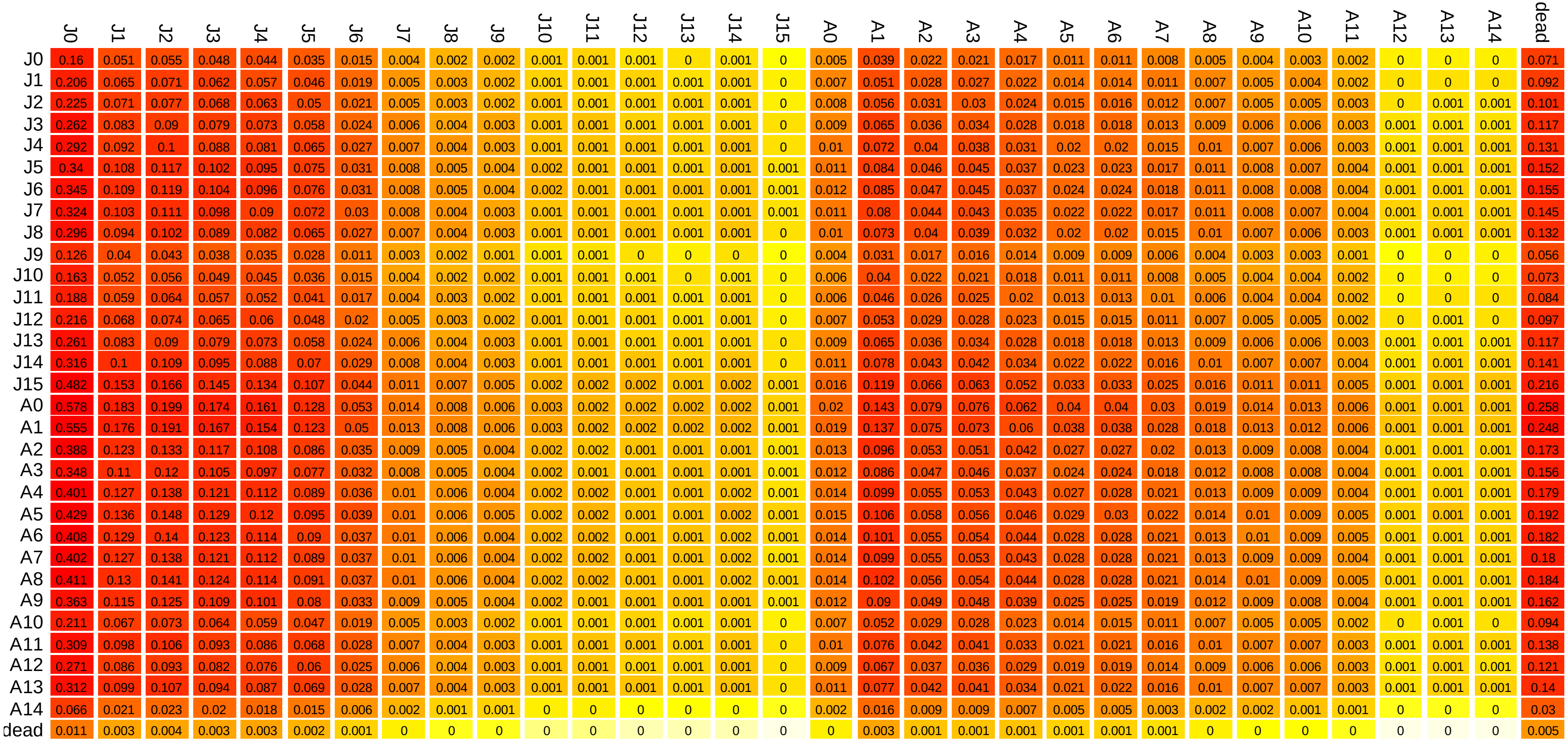


Sensitivity matrix Full 25 degrees

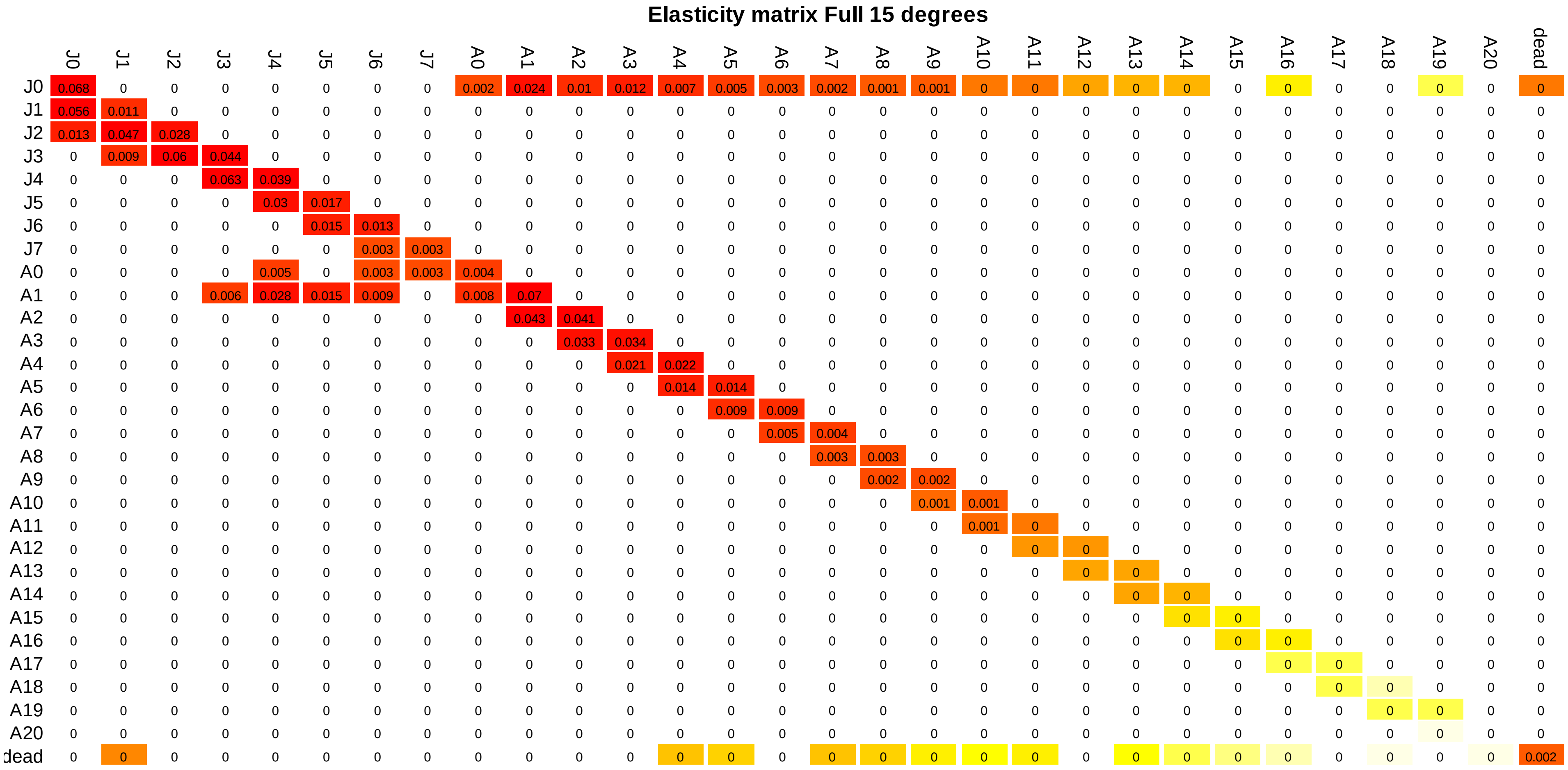
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	14501.281	3476.054	5772.67	5631.399	4644.177	2961.845	570.463	99.931	87.527	3113.198	4868.423	2211.112	1560.575	1059.237	1319.92	453.062	371.227	280.187	91.547	85.596	22.231	9.736	13.873	5.772	6876.122
J1	190785.566	45732.581	75947.921	74089.293	61100.941	38967.406	7505.274	1314.737	1151.546	40958.668	64051.22	29090.419	20531.642	13935.819	17365.484	5960.69	4884.03	3686.272	1204.439	1126.144	292.483	128.089	182.514	75.933	90465.449
J2	45709.946	10956.981	18196.216	17750.911	14639.057	9336.126	1798.174	314.995	275.897	9813.208	15345.908	6969.717	4919.137	3338.856	4160.563	1428.11	1170.155	883.187	288.569	269.811	70.075	30.689	43.728	18.193	21674.443
J3	33350.527	7994.345	13276.178	12951.278	10680.832	6811.75	1311.97	229.824	201.298	7159.835	11196.559	5085.19	3589.061	2436.069	3035.597	1041.966	853.759	644.384	210.544	196.857	51.128	22.391	31.905	13.274	15813.934
J4	11152.074	2673.227	4439.418	4330.775	3571.561	2277.779	438.709	76.851	67.312	2394.175	3744.015	1700.435	1200.145	814.597	1015.072	348.423	285.488	215.475	70.404	65.827	17.097	7.487	10.669	4.439	5288.017
J5	2609.575	625.533	1038.82	1013.397	835.742	532.998	102.658	17.983	15.751	560.235	876.096	397.9	280.833	190.615	237.526	81.531	66.804	50.421	16.474	15.403	4.001	1.752	2.496	1.039	1237.391
J6	49687.789	11910.497	19779.716	19295.658	15913	10148.589	1954.658	342.407	299.906	10667.189	16681.364	7576.247	5347.217	3629.415	4522.63	1552.389	1271.986	960.045	313.681	293.291	76.174	33.359	47.534	19.776	23560.63
J7	13856.284	3321.444	5515.91	5380.922	4437.61	2830.106	545.09	95.486	83.634	2974.727	4651.882	2112.765	1491.162	1012.124	1261.212	432.91	354.715	267.725	87.475	81.789	21.242	9.303	13.256	5.515	6570.282
J8	1187.172	284.573	472.589	461.024	380.203	242.476	46.702	8.181	7.166	254.867	398.562	181.016	127.759	86.716	108.058	37.091	30.391	22.938	7.495	7.007	1.82	0.797	1.136	0.472	562.925
A0	5352.877	1283.121	2130.873	2078.726	1714.311	1093.31	210.576	36.888	32.309	1149.179	1797.087	816.191	576.057	390.998	487.224	167.239	137.031	103.426	33.793	31.596	8.206	3.594	5.121	2.13	2538.192
A1	68925.463	16521.896	27437.849	26766.379	22074.053	14077.829	2711.445	474.978	416.021	14797.216	23139.906	10509.551	7417.505	5034.62	6273.661	2153.43	1764.463	1331.747	435.13	406.844	105.666	46.275	65.937	27.433	32682.624
A2	28185.284	6756.202	11219.998	10945.418	9026.613	5756.764	1108.775	194.23	170.121	6050.938	9462.466	4297.609	3033.197	2058.777	2565.451	880.589	721.531	544.583	177.935	166.368	43.209	18.923	26.963	11.218	13364.713
A3	7612.65	1824.803	3030.444	2956.282	2438.026	1554.862	299.472	52.46	45.949	1634.317	2555.746	1160.754	819.245	556.062	692.911	237.841	194.881	147.088	48.059	44.935	11.671	5.111	7.283	3.03	3609.716
A4	15373.276	3685.077	6119.794	5970.028	4923.442	3139.948	604.766	105.94	92.79	3300.401	5161.172	2344.072	1654.416	1122.932	1399.29	480.305	393.549	297.035	97.052	90.743	23.568	10.321	14.707	6.119	7289.599
A5	8794.466	2108.092	3500.901	3415.226	2816.514	1796.244	345.964	60.604	53.082	1888.034	2952.51	1340.954	946.428	642.387	800.481	274.764	225.135	169.923	55.52	51.911	13.482	5.904	8.413	3.5	4170.102
A6	2687.027	644.098	1069.652	1043.475	860.547	548.818	105.704	18.517	16.218	576.863	902.098	409.71	289.168	196.272	244.576	83.95	68.787	51.918	16.963	15.861	4.119	1.804	2.571	1.069	1274.117
A7	4079.251	977.824	1623.868	1584.128	1306.42	833.175	160.473	28.111	24.622	875.751	1369.501	621.992	438.994	297.966	371.297	127.448	104.427	78.817	25.753	24.078	6.254	2.739	3.902	1.624	1934.272
A8	1709.911	409.877	680.682	664.024	547.616	349.245	67.266	11.783	10.321	367.091	574.058	260.722	184.014	124.899	155.638	53.423	43.773	33.038	10.795	10.093	2.621	1.148	1.636	0.681	810.795
A9	1368.138	327.952	544.628	531.3	438.16	279.438	53.821	9.428	8.258	293.718	459.316	208.61	147.234	99.935	124.529	42.745	35.024	26.435	8.637	8.076	2.097	0.919	1.309	0.545	648.735
A10	542.335	130.001	215.893	210.609	173.688	110.77	21.335	3.737	3.273	116.431	182.075	82.694	58.364	39.615	49.364	16.944	13.884	10.479	3.424	3.201	0.831	0.364	0.519	0.216	257.161
A11	249.98	59.922	99.512	97.077	80.059	51.058	9.834	1.723	1.509	53.667	83.924	38.116	26.902	18.26	22.753	7.81	6.399	4.83	1.578	1.476	0.383	0.168	0.239	0.099	118.534
A12	367.136	88.005	146.15	142.573	117.579	74.987	14.443	2.53	2.216	78.818	123.256	55.98	39.51	26.817	33.417	11.47	9.399	7.094	2.318	2.167	0.563	0.246	0.351	0.146	174.086
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0


Sensitivity matrix P-lim 25 degrees
J0
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
J15
J16
J17
J18
J19
J20
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
dead

Sensitivity matrix Spiked 25 degrees

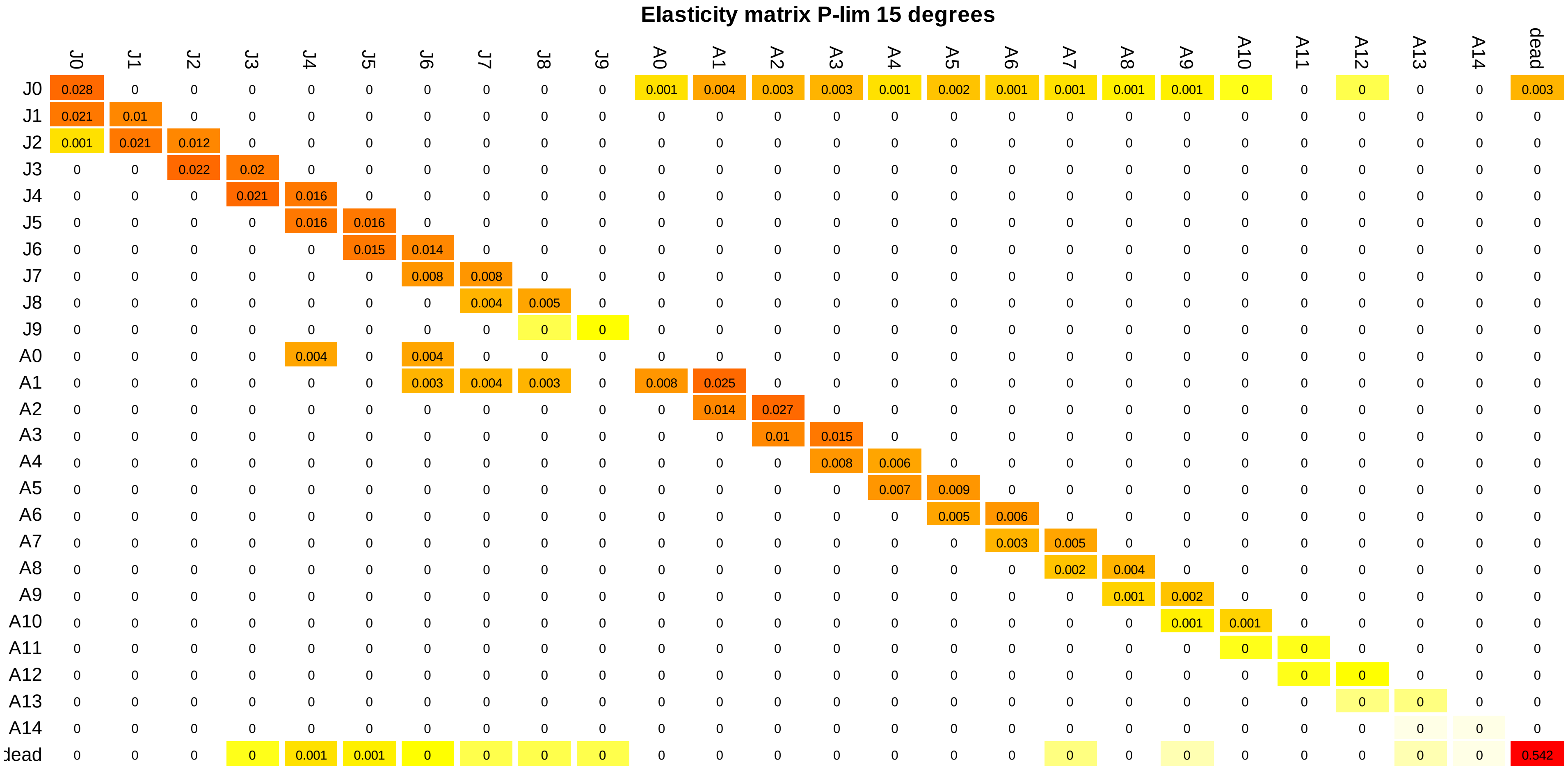


	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	0.16	0.051	0.055	0.048	0.044	0.035	0.015	0.004	0.002	0.002	0.001	0.001	0.001	0	0.001	0	0.005	0.039	0.022	0.021	0.017	0.011	0.011	0.008	0.005	0.004	0.003	0.002	0	0	0	0.071
J1	0.206	0.065	0.071	0.062	0.057	0.046	0.019	0.005	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0	0.007	0.051	0.028	0.027	0.022	0.014	0.014	0.011	0.007	0.005	0.004	0.002	0	0	0	0.092
J2	0.225	0.071	0.077	0.068	0.063	0.05	0.021	0.005	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0	0.008	0.056	0.031	0.03	0.024	0.015	0.016	0.012	0.007	0.005	0.005	0.003	0	0.001	0.001	0.101
J3	0.262	0.083	0.09	0.079	0.073	0.058	0.024	0.006	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.009	0.065	0.036	0.034	0.028	0.018	0.018	0.013	0.009	0.006	0.006	0.003	0.001	0.001	0.001	0.117
J4	0.292	0.092	0.1	0.088	0.081	0.065	0.027	0.007	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.01	0.072	0.04	0.038	0.031	0.02	0.02	0.015	0.01	0.007	0.006	0.003	0.001	0.001	0.001	0.131
J5	0.34	0.108	0.117	0.102	0.095	0.075	0.031	0.008	0.005	0.004	0.002	0.001	0.001	0.001	0.001	0.001	0.011	0.084	0.046	0.045	0.037	0.023	0.023	0.017	0.011	0.008	0.007	0.004	0.001	0.001	0.001	0.152
J6	0.345	0.109	0.119	0.104	0.096	0.076	0.031	0.008	0.005	0.004	0.002	0.001	0.001	0.001	0.001	0.001	0.012	0.085	0.047	0.045	0.037	0.024	0.024	0.018	0.011	0.008	0.008	0.004	0.001	0.001	0.001	0.155
J7	0.324	0.103	0.111	0.098	0.09	0.072	0.03	0.008	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.011	0.08	0.044	0.043	0.035	0.022	0.022	0.017	0.011	0.008	0.007	0.004	0.001	0.001	0.001	0.145
J8	0.296	0.094	0.102	0.089	0.082	0.065	0.027	0.007	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.01	0.073	0.04	0.039	0.032	0.02	0.02	0.015	0.01	0.007	0.006	0.003	0.001	0.001	0.001	0.132
J9	0.126	0.04	0.043	0.038	0.035	0.028	0.011	0.003	0.002	0.001	0.001	0.001	0	0	0	0	0.004	0.031	0.017	0.016	0.014	0.009	0.009	0.006	0.004	0.003	0.003	0.001	0	0	0	0.056
J10	0.163	0.052	0.056	0.049	0.045	0.036	0.015	0.004	0.002	0.002	0.001	0.001	0.001	0	0.001	0	0.006	0.04	0.022	0.021	0.018	0.011	0.011	0.008	0.005	0.004	0.004	0.002	0	0	0	0.073
J11	0.188	0.059	0.064	0.057	0.052	0.041	0.017	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0	0.006	0.046	0.026	0.025	0.02	0.013	0.013	0.01	0.006	0.004	0.004	0.002	0	0	0	0.084
J12	0.216	0.068	0.074	0.065	0.06	0.048	0.02	0.005	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0	0.007	0.053	0.029	0.028	0.023	0.015	0.015	0.011	0.007	0.005	0.005	0.002	0	0.001	0	0.097
J13	0.261	0.083	0.09	0.079	0.073	0.058	0.024	0.006	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.009	0.065	0.036	0.034	0.028	0.018	0.018	0.013	0.009	0.006	0.006	0.003	0.001	0.001	0.001	0.117
J14	0.316	0.1	0.109	0.095	0.088	0.07	0.029	0.008	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.011	0.078	0.043	0.042	0.034	0.022	0.022	0.016	0.01	0.007	0.007	0.004	0.001	0.001	0.001	0.141
J15	0.482	0.153	0.166	0.145	0.134	0.107	0.044	0.011	0.007	0.005	0.002	0.002	0.002	0.001	0.002	0.001	0.016	0.119	0.066	0.063	0.052	0.033	0.033	0.025	0.016	0.011	0.011	0.005	0.001	0.001	0.001	0.216
A0	0.578	0.183	0.199	0.174	0.161	0.128	0.053	0.014	0.008	0.006	0.003	0.002	0.002	0.002	0.002	0.001	0.02	0.143	0.079	0.076	0.062	0.04	0.04	0.03	0.019	0.014	0.013	0.006	0.001	0.001	0.001	0.258
A1	0.555	0.176	0.191	0.167	0.154	0.123	0.05	0.013	0.008	0.006	0.003	0.002	0.002	0.002	0.002	0.001	0.019	0.137	0.075	0.073	0.06	0.038	0.038	0.028	0.018	0.013	0.012	0.006	0.001	0.001	0.001	0.248
A2	0.388	0.123	0.133	0.117	0.108	0.086	0.035	0.009	0.005	0.004	0.002	0.002	0.001	0.001	0.001	0.001	0.013	0.096	0.053	0.051	0.042	0.027	0.027	0.02	0.013	0.009	0.008	0.004	0.001	0.001	0.001	0.173
A3	0.348	0.11	0.12	0.105	0.097	0.077	0.032	0.008	0.005	0.004	0.002	0.001	0.001	0.001	0.001	0.001	0.012	0.086	0.047	0.046	0.037	0.024	0.024	0.018	0.012	0.008	0.008	0.004	0.001	0.001	0.001	0.156
A4	0.401	0.127	0.138	0.121	0.112	0.089	0.036	0.01	0.006	0.004	0.002	0.002	0.001	0.001	0.002	0.001	0.014	0.099	0.055	0.053	0.043	0.027	0.028	0.021	0.013	0.009	0.009	0.004	0.001	0.001	0.001	0.179
A5	0.429	0.136	0.148	0.129	0.12	0.095	0.039	0.01	0.006	0.005	0.002	0.002	0.001	0.001	0.002	0.001	0.015	0.106	0.058	0.056	0.046	0.029	0.03	0.022	0.014	0.01	0.009	0.005	0.001	0.001	0.001	0.192
A6	0.408	0.129	0.14	0.123	0.114	0.09	0.037	0.01	0.006	0.004	0.002	0.002	0.001	0.001	0.002	0.001	0.014	0.101	0.055	0.054	0.044	0.028	0.028	0.021	0.013	0.01	0.009	0.005	0.001	0.001	0.001	0.182
A7	0.402	0.127	0.138	0.121	0.112	0.089	0.037	0.01	0.006	0.004	0.002	0.002	0.001	0.001	0.002	0.001	0.014	0.099	0.055	0.053	0.043	0.028	0.028	0.021	0.013	0.009	0.009	0.004	0.001	0.001	0.001	0.18
A8	0.411	0.13	0.141	0.124	0.114	0.091	0.037	0.01	0.006	0.004	0.002	0.002	0.001	0.001	0.002	0.001	0.014	0.102	0.056	0.054	0.044	0.028	0.028	0.021	0.014	0.01	0.009	0.005	0.001	0.001	0.001	0.184
A9	0.363	0.115	0.125	0.109	0.101	0.08	0.033	0.009	0.005	0.004	0.002	0.001	0.001	0.001	0.001	0.001	0.012	0.09	0.049	0.048	0.039	0.025	0.025	0.019	0.012	0.009	0.008	0.004	0.001	0.001	0.001	0.162
A10	0.211	0.067	0.073	0.064	0.059	0.047	0.019	0.005	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0	0.007	0.052	0.029	0.028	0.023	0.014	0.015	0.011	0.007	0.005	0.005	0.002	0	0.001	0	0.094
A11	0.309	0.098	0.106	0.093	0.086	0.068	0.028	0.007	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.01	0.076	0.042	0.041	0.033	0.021	0.021	0.016	0.01	0.007	0.007	0.003	0.001	0.001	0.001	0.138
A12	0.271	0.086	0.093	0.082	0.076	0.06	0.025	0.006	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.009	0.067	0.037	0.036	0.029	0.019	0.019	0.014	0.009	0.006	0.006	0.003	0.001	0.001	0.001	0.121
A13	0.312	0.099	0.107	0.094	0.087	0.069	0.028	0.007	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0	0.011	0.077	0.042	0.041	0.034	0.021	0.022	0.016	0.01	0.007	0.007	0.003	0.001	0.001	0.001	0.14
A14	0.066	0.021	0.023	0.02	0.018	0.015	0.006	0.002	0.001	0.001	0	0	0	0	0	0	0.002	0.016	0.009	0.009	0.007	0.005	0.005	0.003	0.002	0.002	0.001	0.001	0	0	0	0.03
dead	0.011	0.003	0.004	0.003	0.003	0.002	0.001	0	0	0	0	0	0	0	0	0	0	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0	0	0	0	0	0.005



Elasticity matrix Full 15 degrees

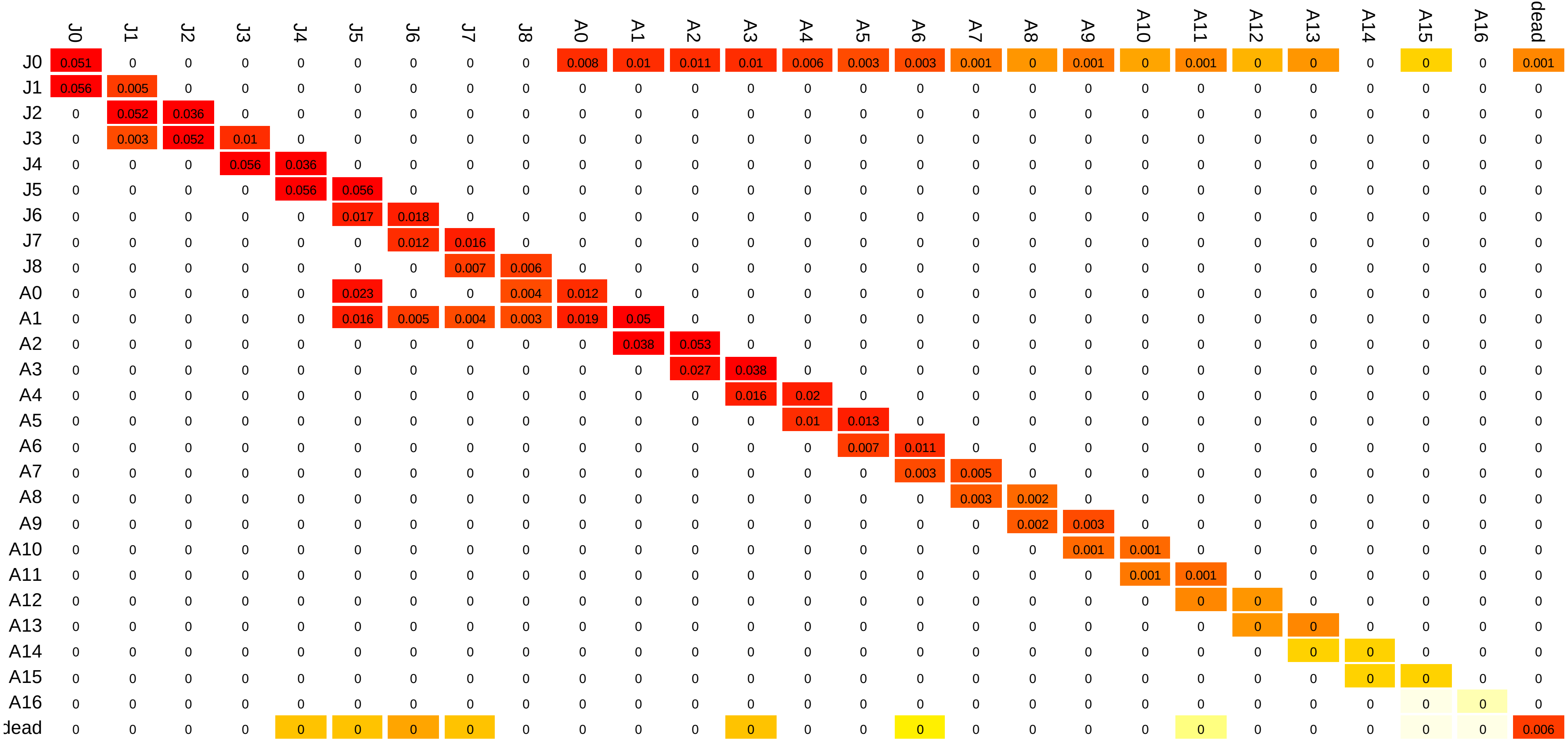
	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	dead
J0	0.068	0	0	0	0	0	0	0	0.002	0.024	0.01	0.012	0.007	0.005	0.003	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0
J1	0.056	0.011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.013	0.047	0.028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.009	0.06	0.044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.063	0.039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.03	0.017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.015	0.013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.003	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0.005	0	0.003	0.003	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.006	0.028	0.015	0.009	0	0.008	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0.043	0.041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0.033	0.034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0.021	0.022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0.014	0.014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0.009	0.009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.005	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.002	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002



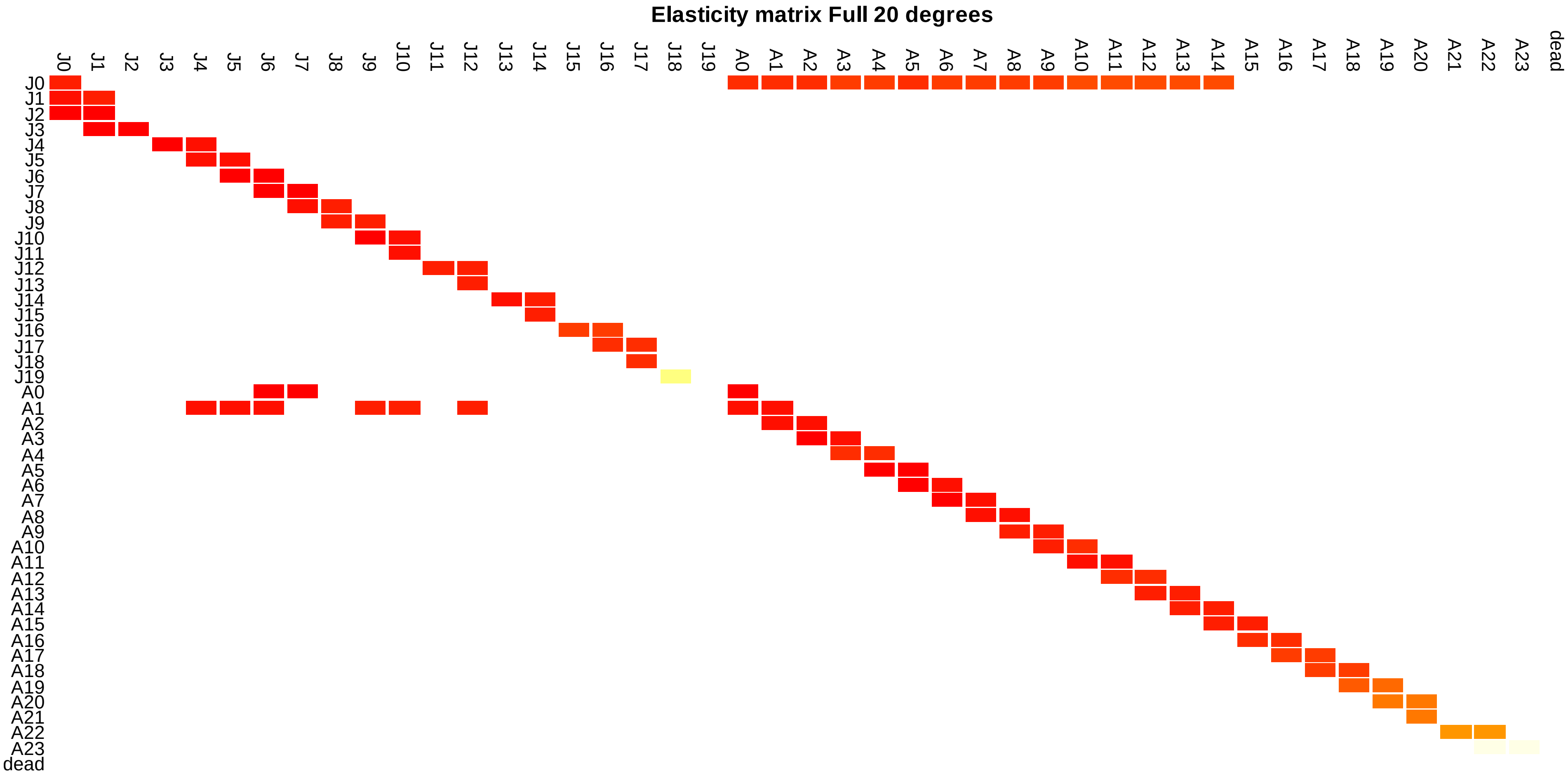
Elasticity matrix P-lim 15 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	0.028	0	0	0	0	0	0	0	0	0	0.001	0.004	0.003	0.003	0.001	0.002	0.001	0.001	0.001	0.001	0	0	0	0	0	0.003
J1	0.021	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.001	0.021	0.012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0	0.022	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.021	0.016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.016	0.016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.015	0.014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.008	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.004	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0.004	0	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0	0.003	0.004	0.003	0	0.008	0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0.014	0.027	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.015	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.008	0.006	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.007	0.009	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.005	0.006	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.005	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.004	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.002	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.542

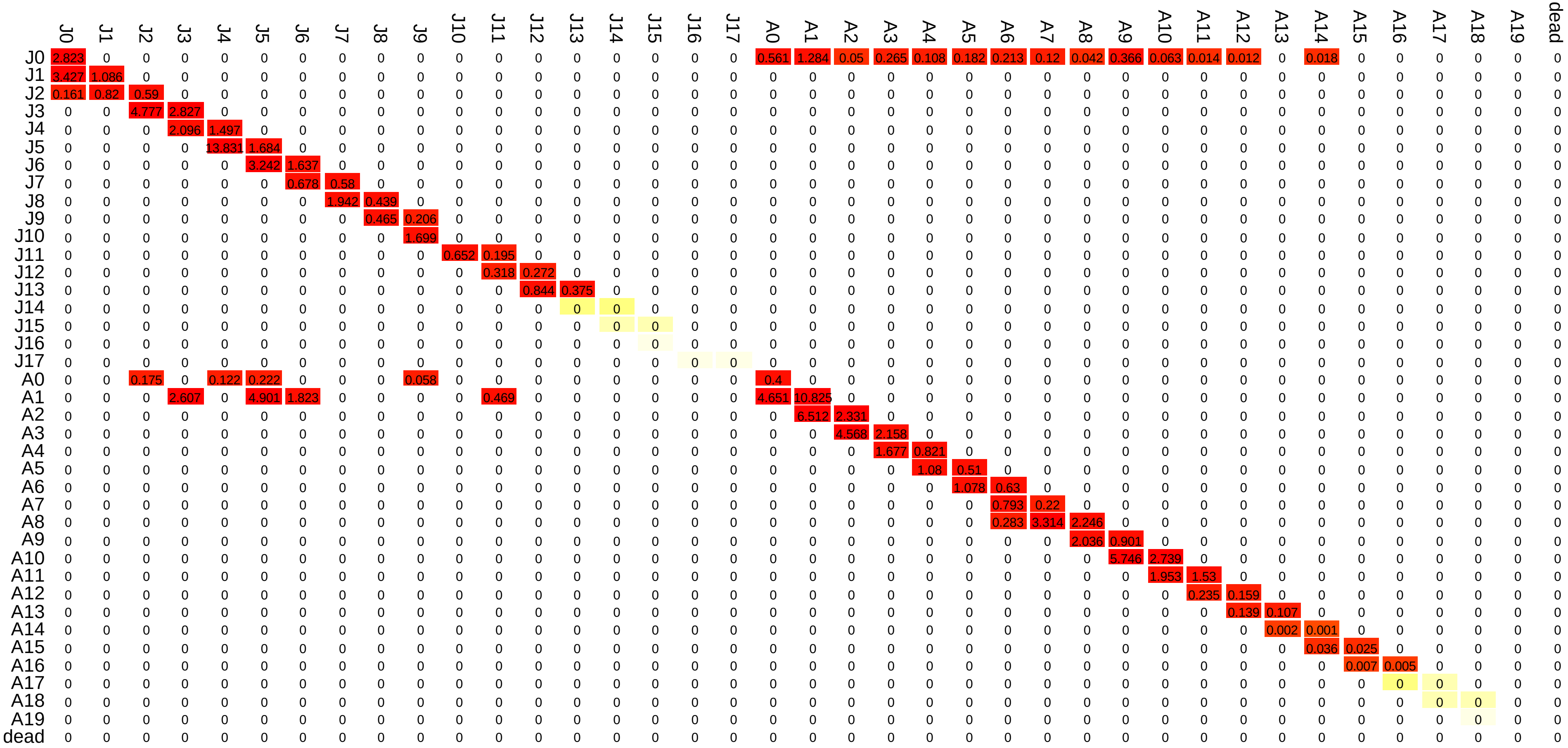
Elasticity matrix Spiked 15 degrees



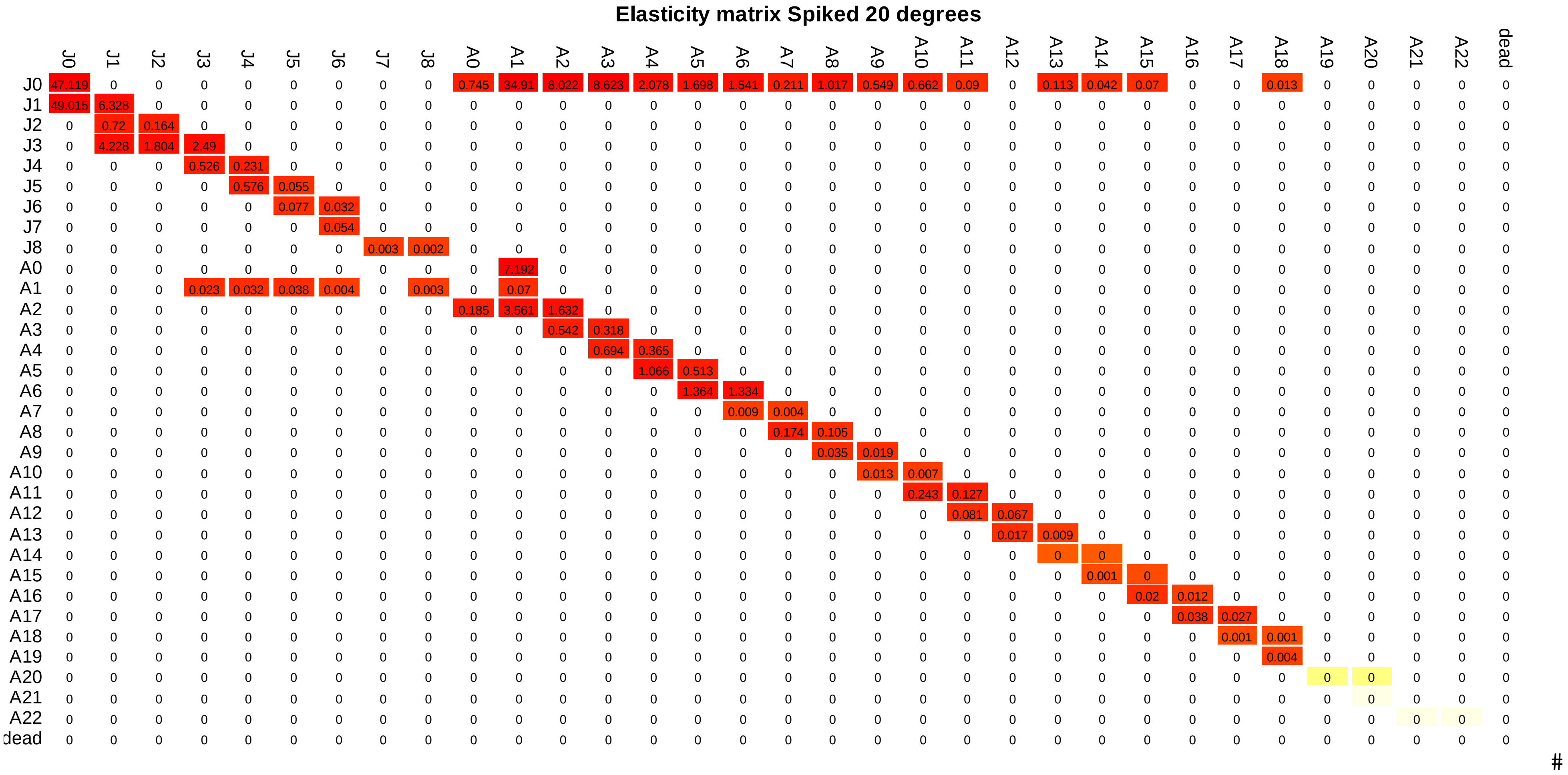
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	dead
J0	0.051	0	0	0	0	0	0	0	0	0.008	0.01	0.011	0.01	0.006	0.003	0.003	0.001	0	0.001	0	0.001	0	0	0	0	0	0.001
J1	0.056	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.052	0.036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.003	0.052	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.056	0.036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.056	0.056	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.017	0.018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.012	0.016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.007	0.006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0.023	0	0	0.004	0.012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0.016	0.005	0.004	0.003	0.019	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0.038	0.053	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0.027	0.038	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0.016	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.013	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.007	0.011	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.005	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.002	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.003	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.006


Elasticity matrix Full 20 degrees
J0
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
J15
J16
J17
J18
J19
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
A22
A23
dead

Elasticity matrix P-lim 20 degrees



	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	dead
J0	2.823	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.561	1.284	0.05	0.265	0.108	0.182	0.213	0.12	0.042	0.366	0.063	0.014	0.012	0	0.018	0	0	0	0	0	0
J1	3.427	1.086	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.161	0.82	0.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0	4.777	2.827	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	2.096	1.497	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	13.831	1.684	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	3.242	1.637	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.678	0.58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	1.942	0.439	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.465	0.206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	1.699	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	0.652	0.195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	0.318	0.272	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0.844	0.375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0.175	0	0.122	0.222	0	0	0	0.058	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	2.607	0	4.901	1.823	0	0	0	0	0.469	0	0	0	0	0	0	4.651	10.825	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.512	2.331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.568	2.158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.677	0.821	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.08	0.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.078	0.63	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.793	0.22	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.283	3.314	2.246	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.036	0.901	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.746	2.739	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.953	1.53	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.235	0.159	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.139	0.107	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.001	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.036	0.025	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.007	0.005	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

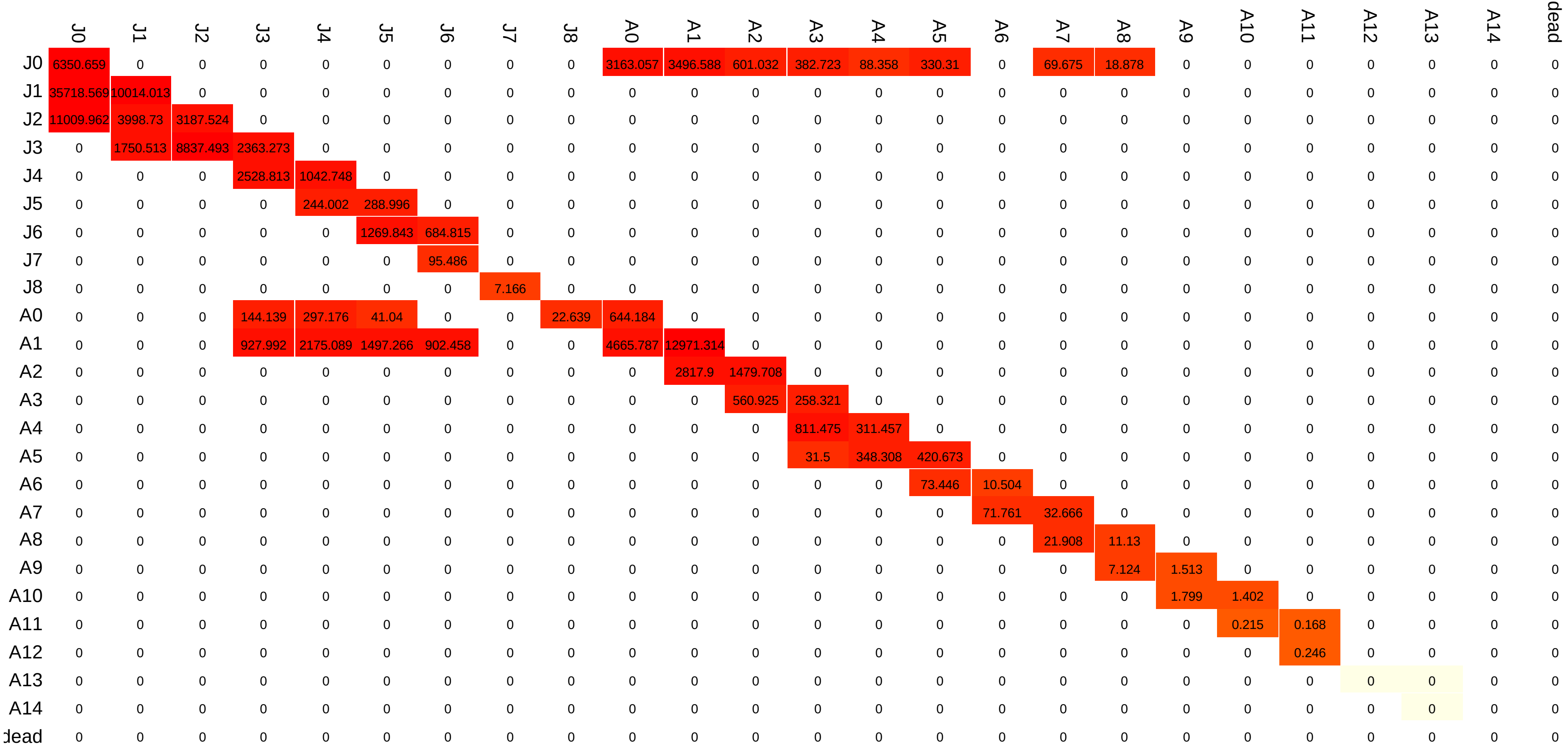


Elasticity matrix Spiked 20 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	dead
J0	47.119	0	0	0	0	0	0	0	0	0.745	34.91	8.022	8.623	2.078	1.698	1.541	0.211	1.017	0.549	0.662	0.09	0	0.113	0.042	0.07	0	0	0.013	0	0	0	0	0
J1	49.015	6.328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0	0.72	0.164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	4.228	1.804	2.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.526	0.231	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.576	0.055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.077	0.032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.003	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0	0	0	0	0	7.192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.023	0.032	0.038	0.004	0	0.003	0	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0.185	3.561	1.632	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0.542	0.318	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0.694	0.365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	1.066	0.513	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.364	1.334	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.009	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.174	0.105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.035	0.019	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.013	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.243	0.127	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.081	0.067	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.017	0.009	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.012	0	0	0	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.038	0.027	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.004	0	0	0	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

#

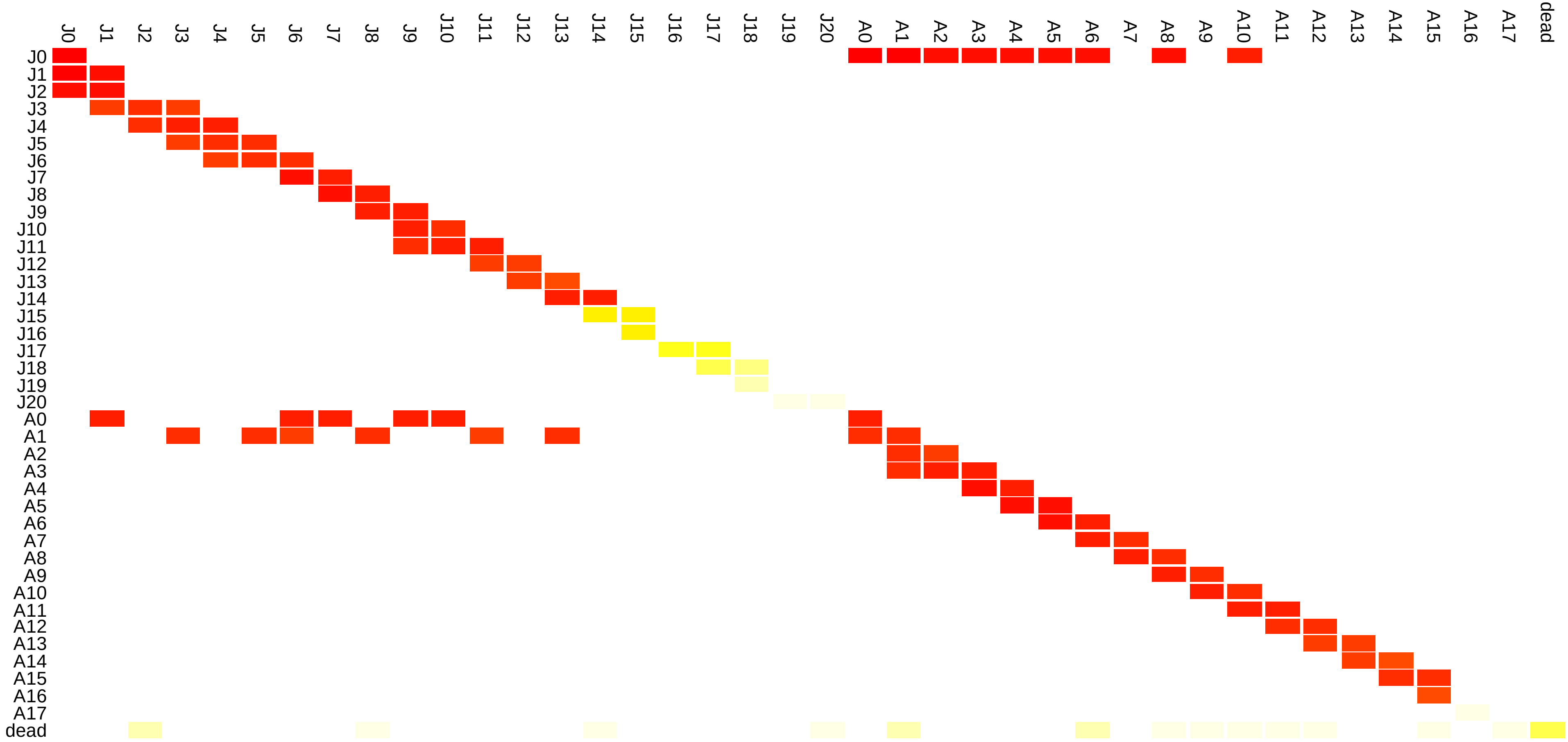
Elasticity matrix Full 25 degrees

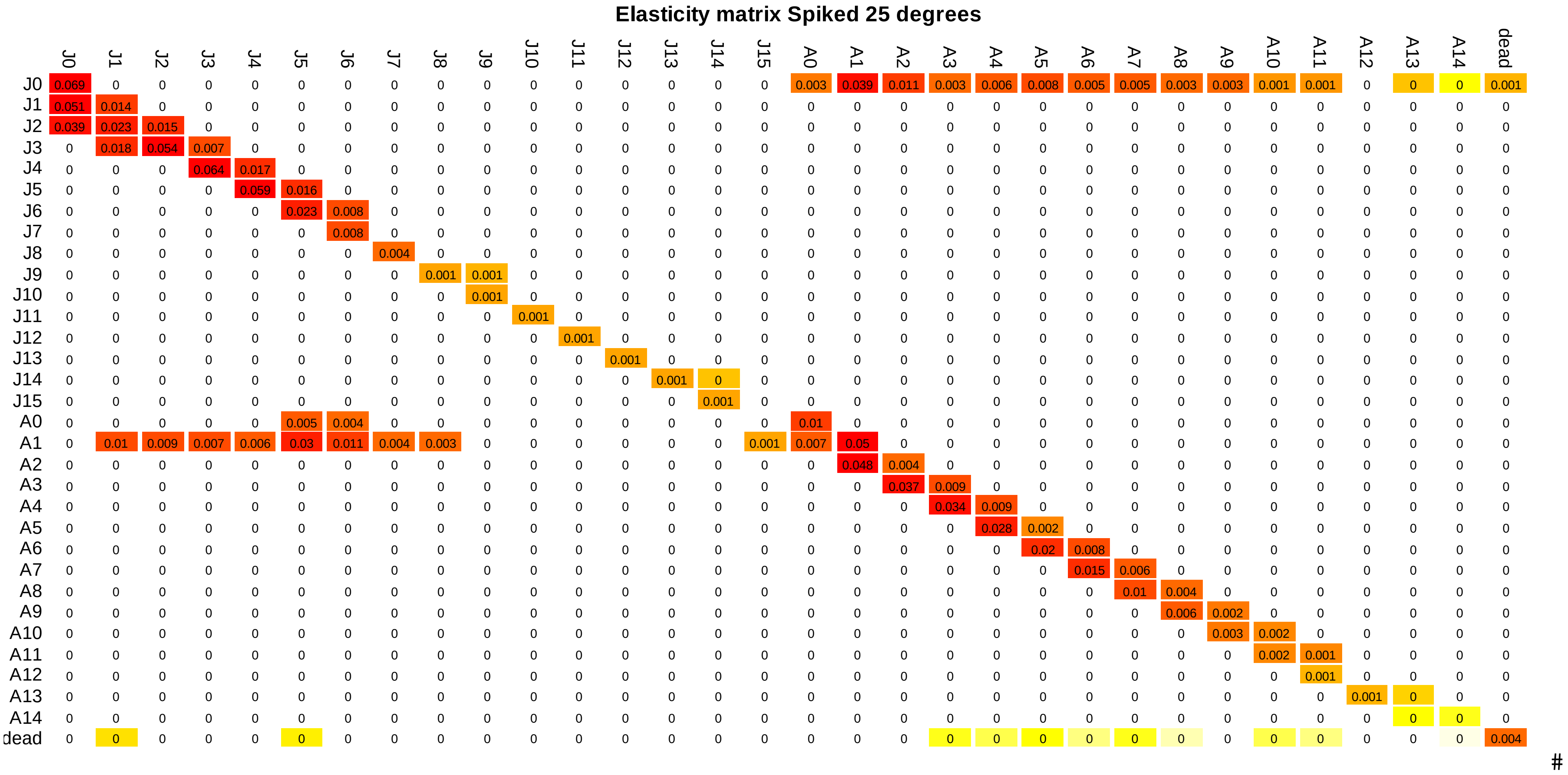


	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	6350.659	0	0	0	0	0	0	0	0	3163.057	3496.588	601.032	382.723	88.358	330.31	0	69.675	18.878	0	0	0	0	0	0	0
J1	35718.569	10014.013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	11009.962	3998.73	3187.524	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	1750.513	8837.493	2363.273	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	2528.813	1042.748	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	244.002	288.996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	1269.843	684.815	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	95.486	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	7.166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	144.139	297.176	41.04	0	0	22.639	644.184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	927.992	2175.089	1497.266	902.458	0	0	4665.787	12971.314	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	2817.9	1479.708	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	560.925	258.321	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	811.475	311.457	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	31.5	348.308	420.673	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	73.446	10.504	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71.761	32.666	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21.908	11.13	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.124	1.513	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.799	1.402	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.215	0.168	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.246	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

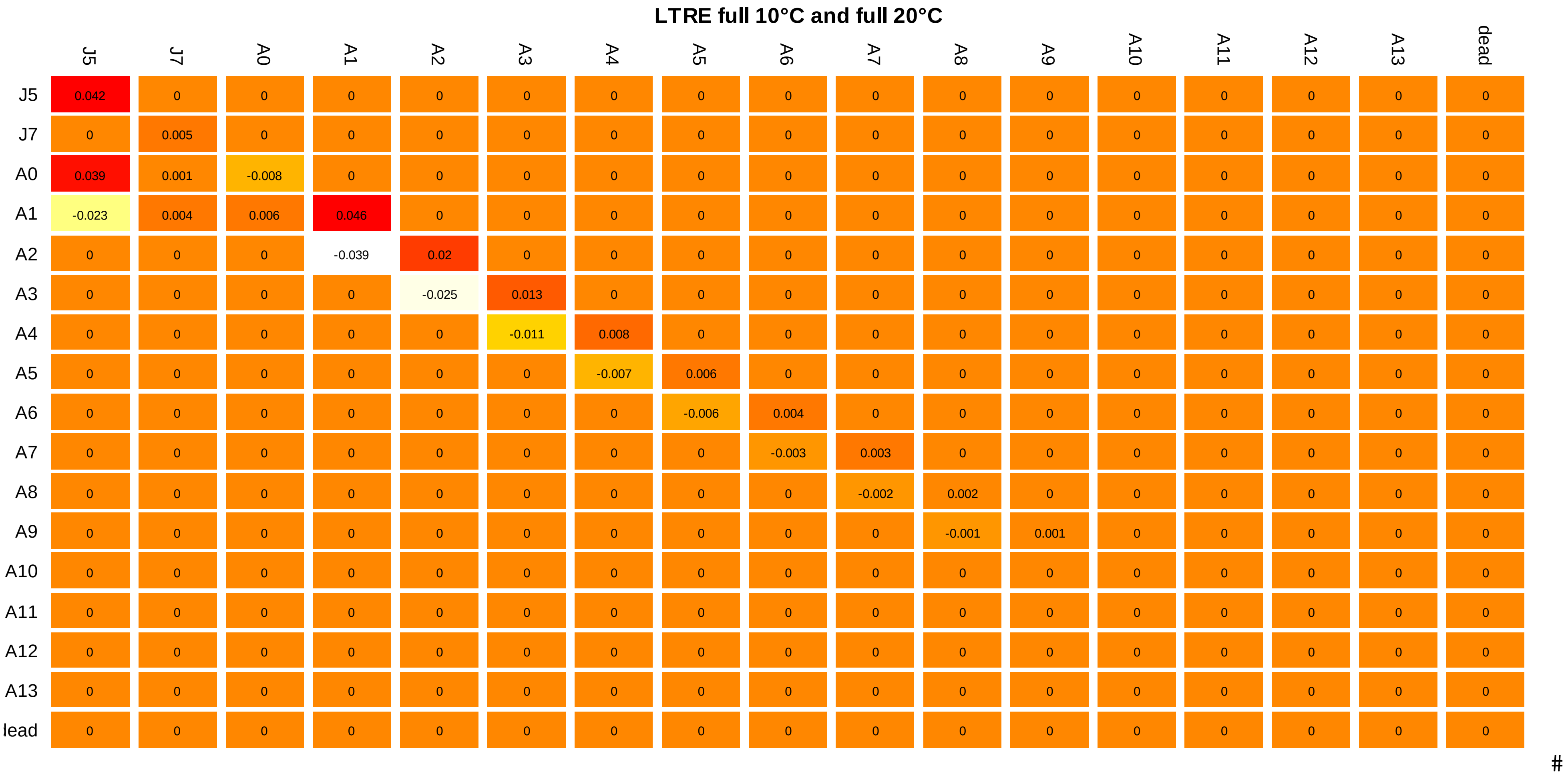
#

Elasticity matrix P-lim 25 degrees




Elasticity matrix Spiked 25 degrees

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
J0	0.069	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.039	0.011	0.003	0.006	0.008	0.005	0.005	0.003	0.003	0.001	0.001	0	0	0	0.001
J1	0.051	0.014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.039	0.023	0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	0.018	0.054	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	0.064	0.017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	0.059	0.016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	0.023	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0	0.005	0.004	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0.01	0.009	0.007	0.006	0.03	0.011	0.004	0.003	0	0	0	0	0	0	0.001	0.007	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.048	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.037	0.009	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.034	0.009	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.028	0.002	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.008	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.015	0.006	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.004	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.006	0.002	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	0.002	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0.001	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.004

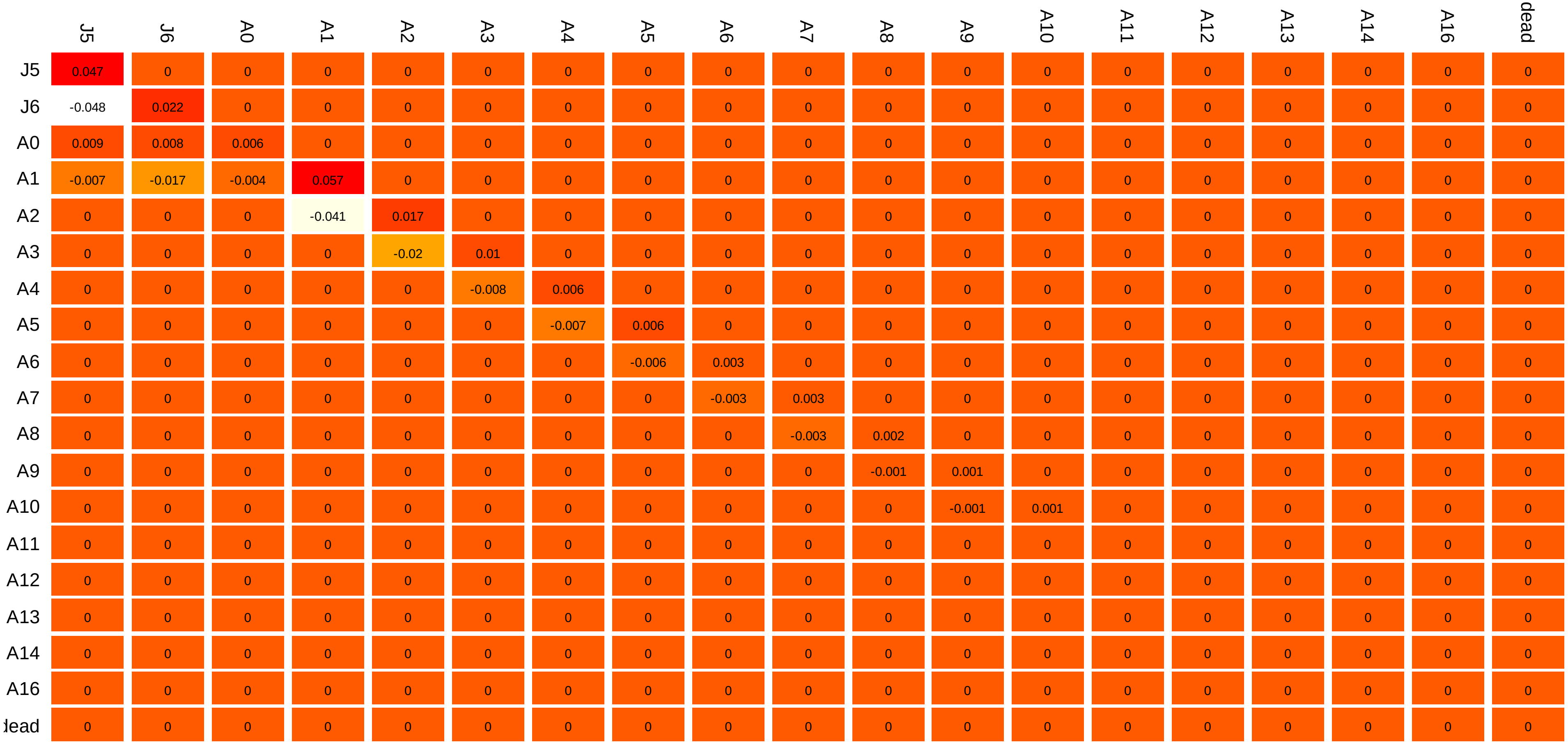


LTRE full 10°C and full 20°C

	J5	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	dead
J5	0.042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0.039	0.001	-0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	-0.023	0.004	0.006	0.046	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	-0.039	0.02	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	-0.025	0.013	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	-0.011	0.008	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	-0.007	0.006	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	-0.006	0.004	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	-0.003	0.003	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	-0.002	0.002	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

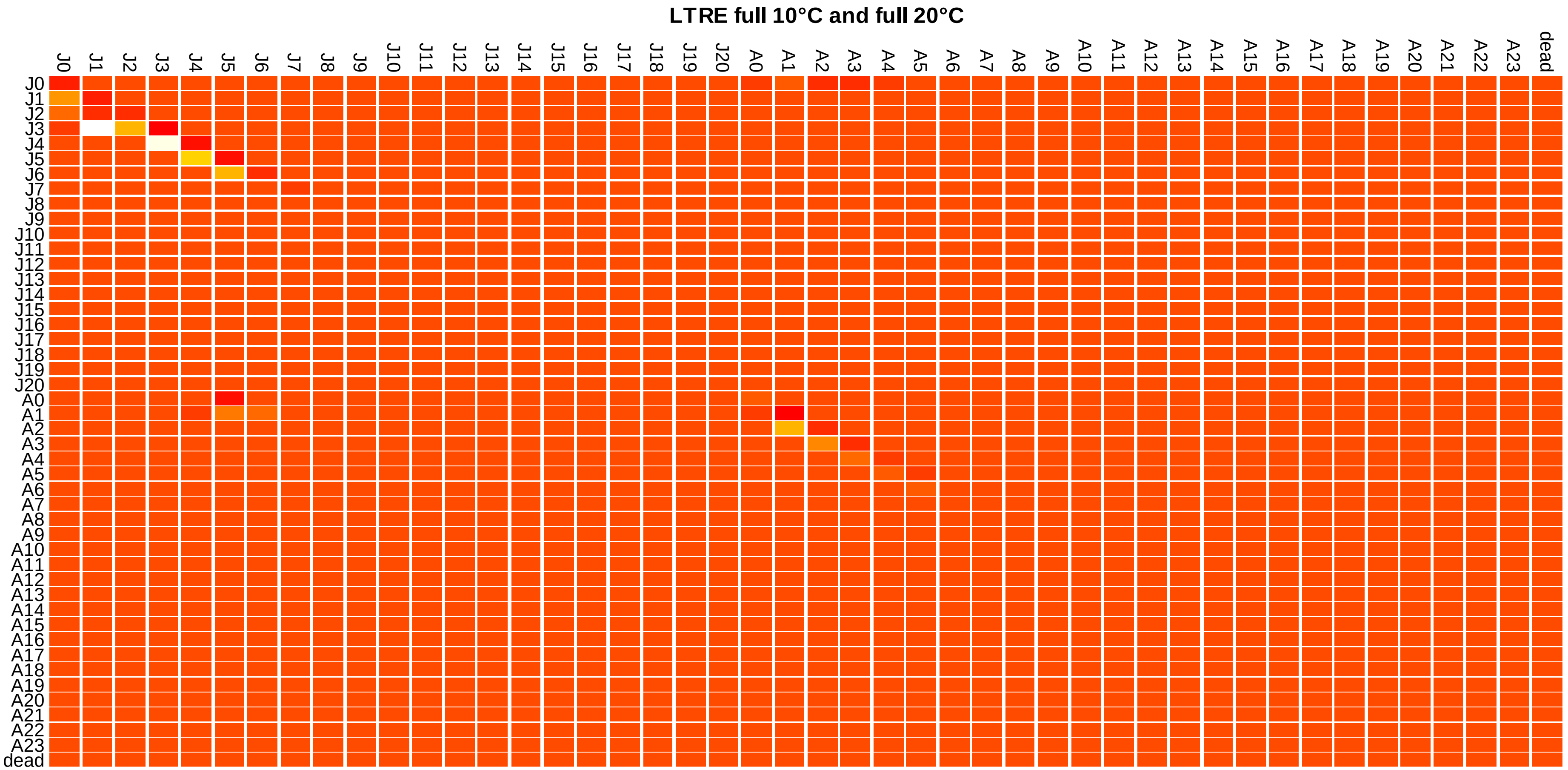
#

LTRE full 10°C and full 20°C

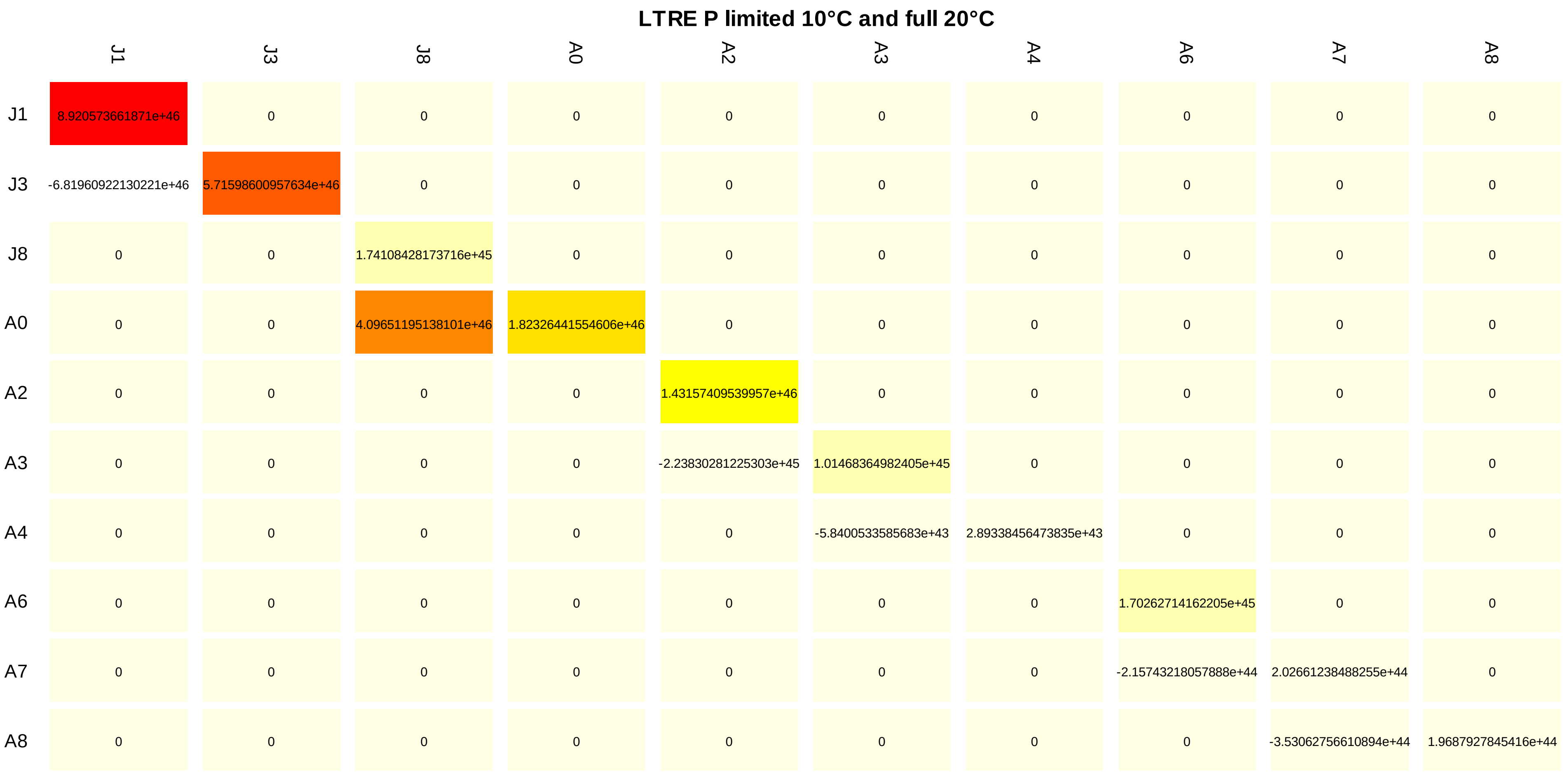


	J5	J6	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A16	dead
J5	0.047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	-0.048	0.022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0.009	0.008	0.006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	-0.007	-0.017	-0.004	0.057	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	-0.041	0.017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	-0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	-0.008	0.006	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	-0.007	0.006	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	-0.006	0.003	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	-0.003	0.003	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	-0.003	0.002	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

#


LTRE full 10°C and full 20°C
J0
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
J15
J16
J17
J18
J19
J20
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
A22
A23
dead
J0
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
J11
J12
J13
J14
J15
J16
J17
J18
J19
J20
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
A18
A19
A20
A21
A22
A23
dead

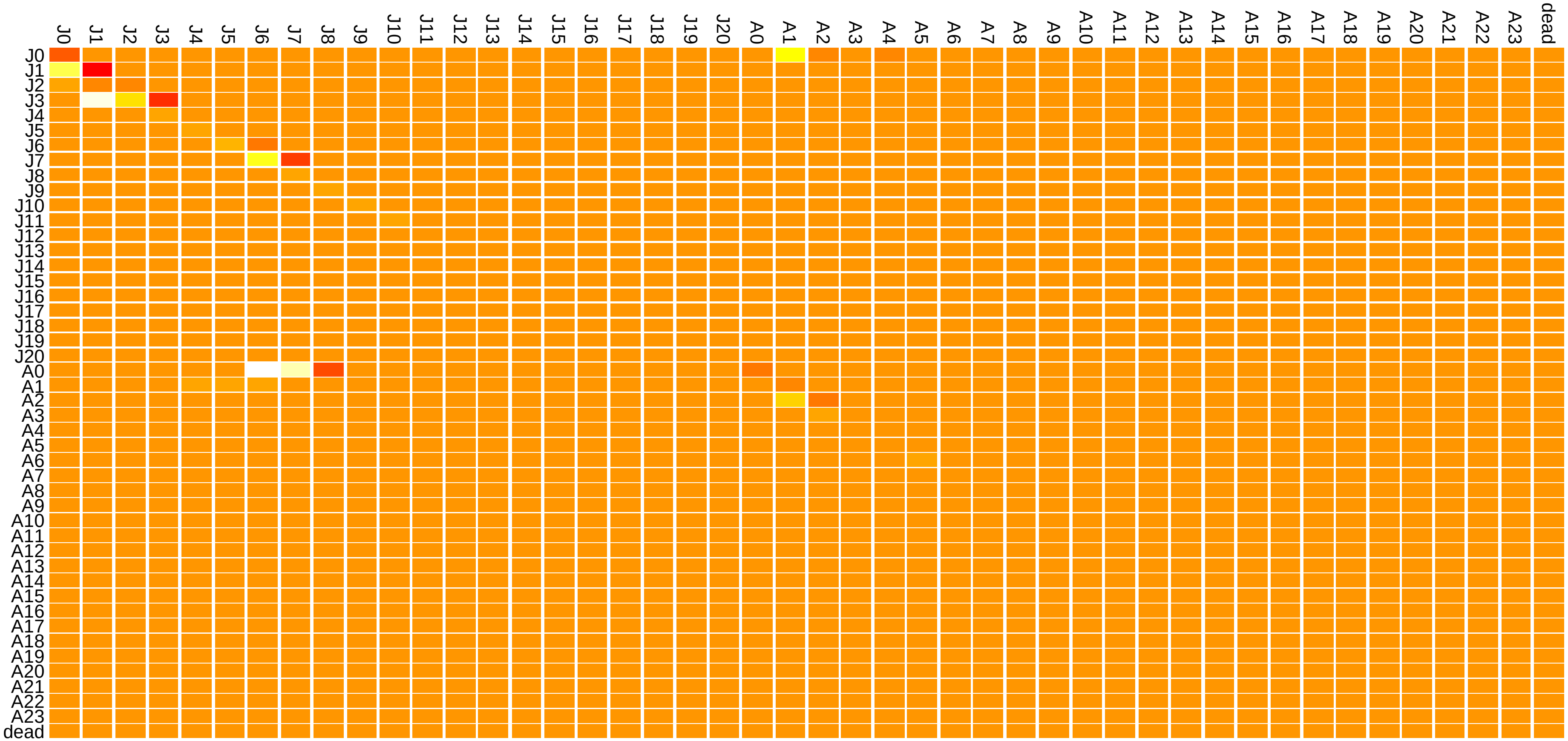
#

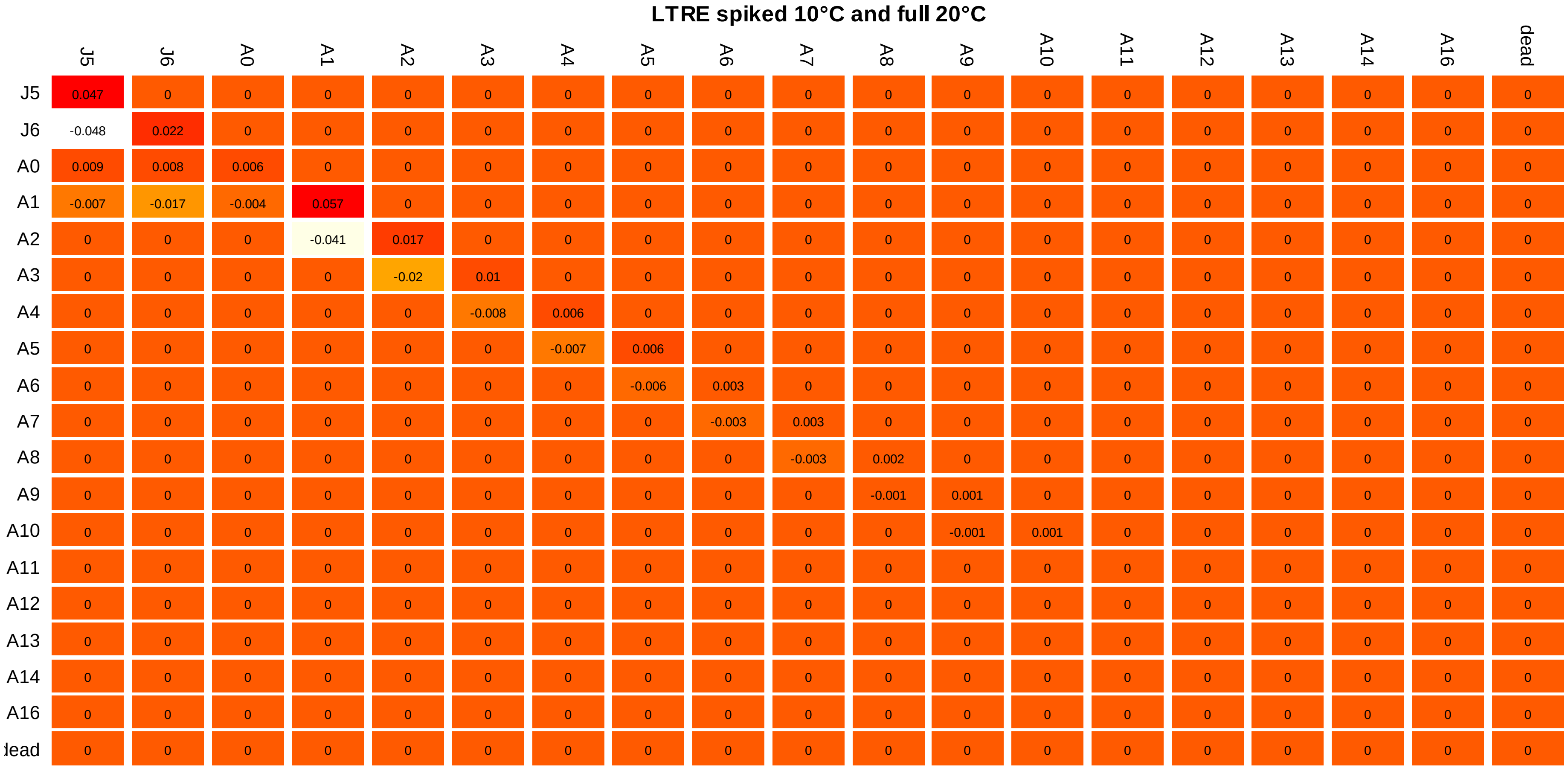


LTRE P limited 10°C and full 20°C

	J1	J3	J8	A0	A2	A3	A4	A6	A7	A8
J1	8.920573661871e+46	0	0	0	0	0	0	0	0	0
J3	-6.81960922130221e+46	5.71598600957634e+46	0	0	0	0	0	0	0	0
J8	0	0	1.74108428173716e+45	0	0	0	0	0	0	0
A0	0	0	4.09651195138101e+46	1.82326441554606e+46	0	0	0	0	0	0
A2	0	0	0	0	1.43157409539957e+46	0	0	0	0	0
A3	0	0	0	0	-2.23830281225303e+45	1.01468364982405e+45	0	0	0	0
A4	0	0	0	0	0	-5.8400533585683e+43	2.89338456473835e+43	0	0	0
A6	0	0	0	0	0	0	0	1.70262714162205e+45	0	0
A7	0	0	0	0	0	0	0	-2.15743218057888e+44	2.02661238488255e+44	0
A8	0	0	0	0	0	0	0	0	-3.53062756610894e+44	1.9687927845416e+44

LTRE P limited 10°C and full 20°C

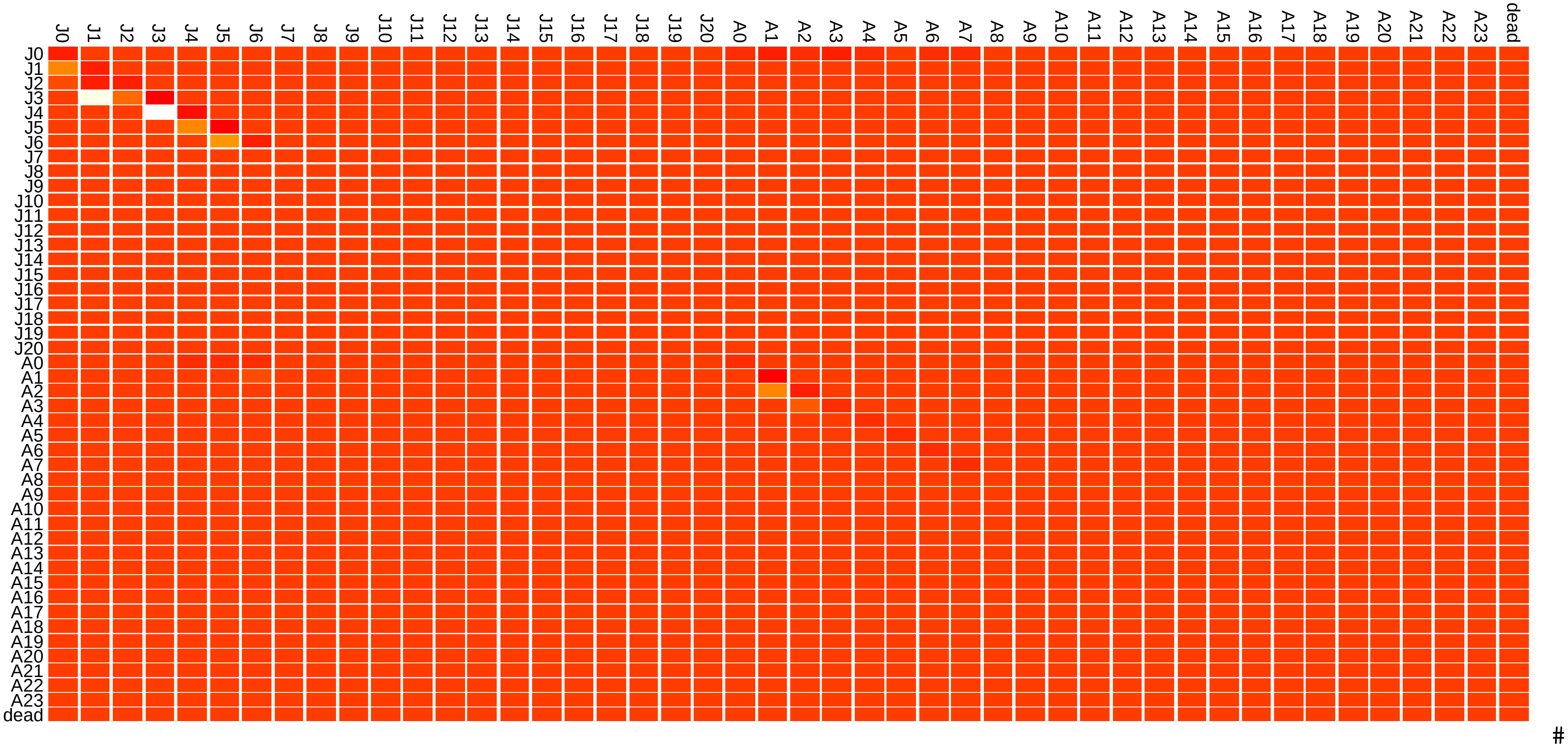




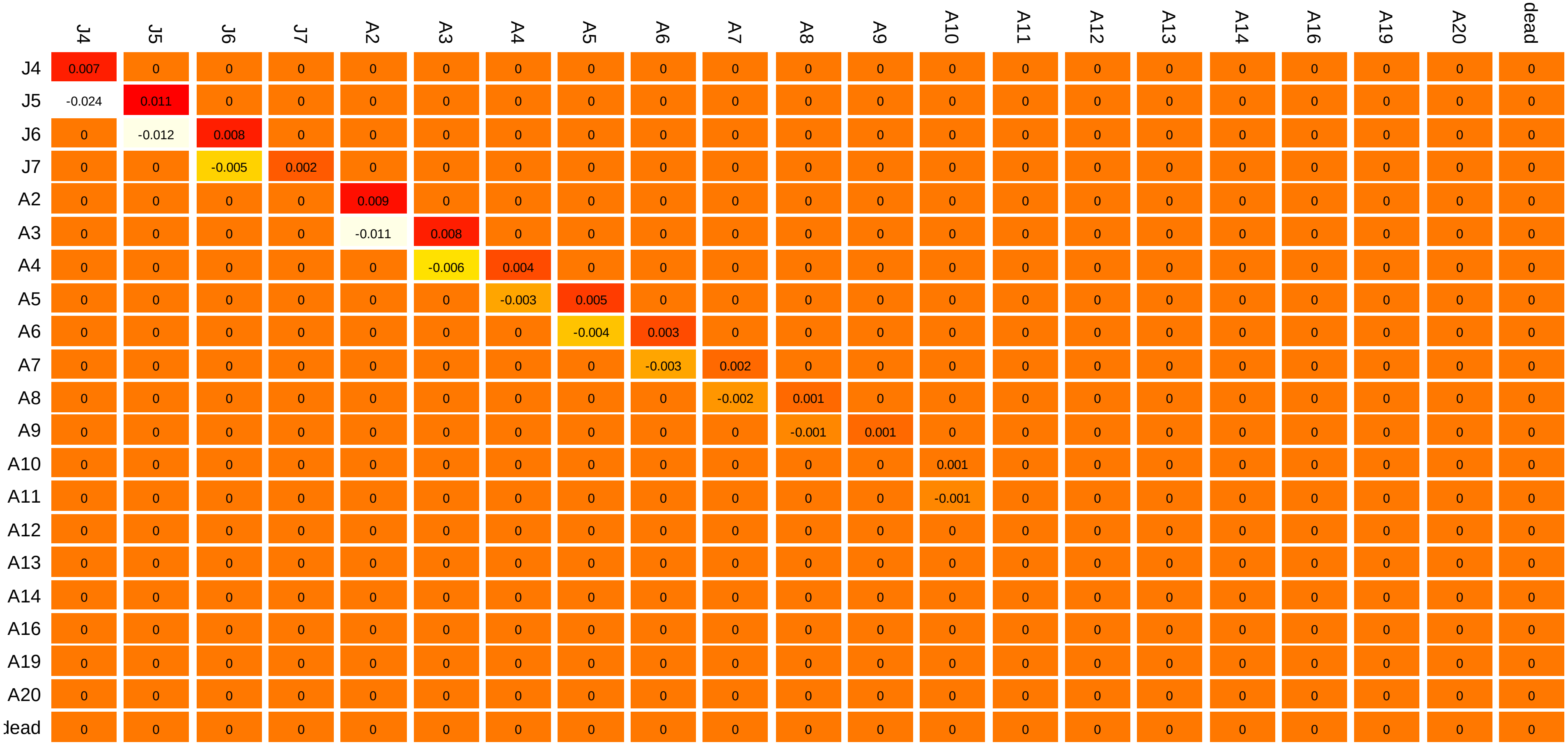
LTRE spiked 10°C and full 20°C

	J5	J6	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A16	dead
J5	0.047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	-0.048	0.022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0.009	0.008	0.006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	-0.007	-0.017	-0.004	0.057	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	-0.041	0.017	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	-0.02	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	-0.008	0.006	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	-0.007	0.006	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	-0.006	0.003	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	-0.003	0.003	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	-0.003	0.002	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

LTRE spiked 10°C and full 20°C

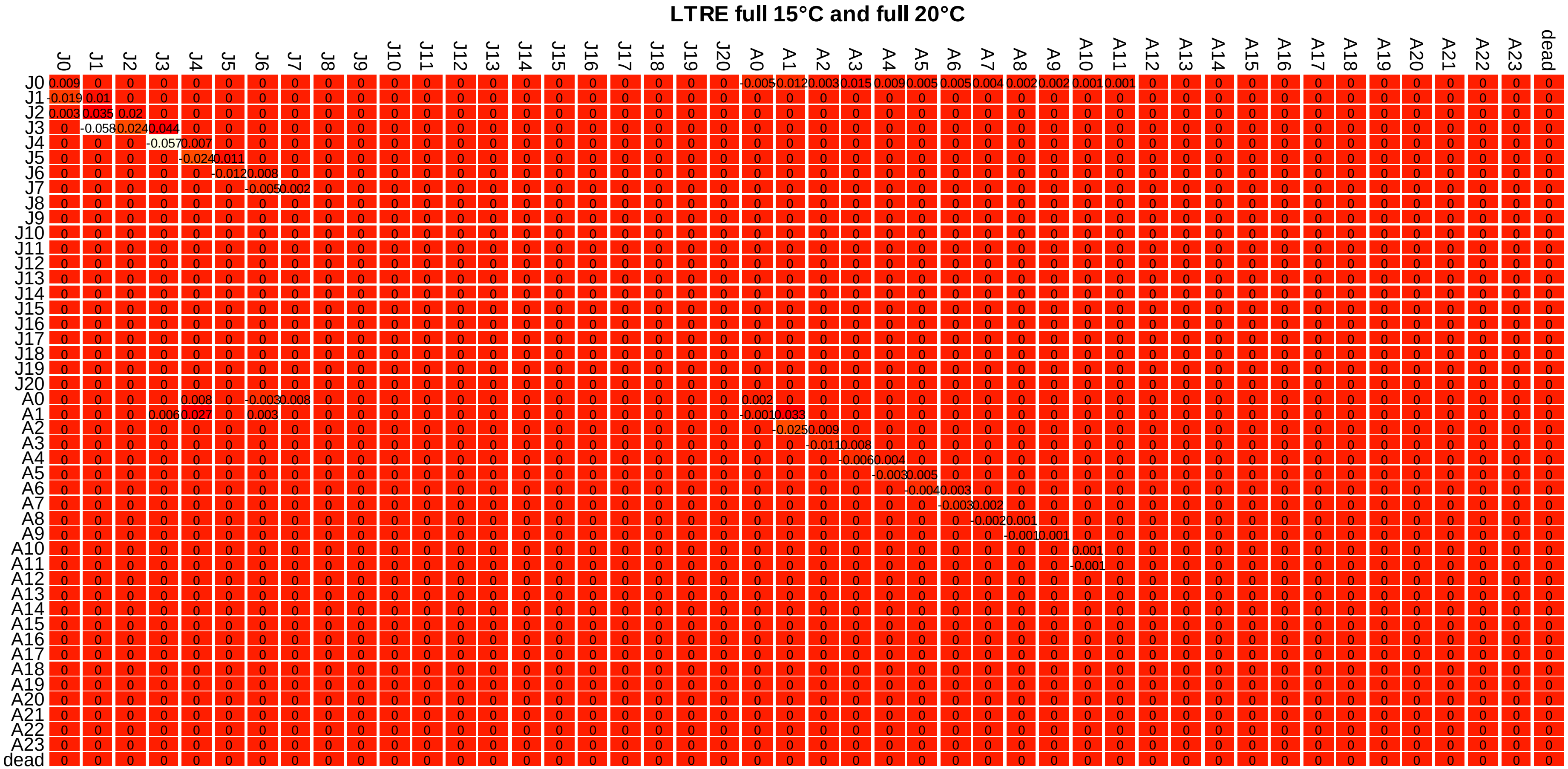


LTRE full 15°C and full 20°C



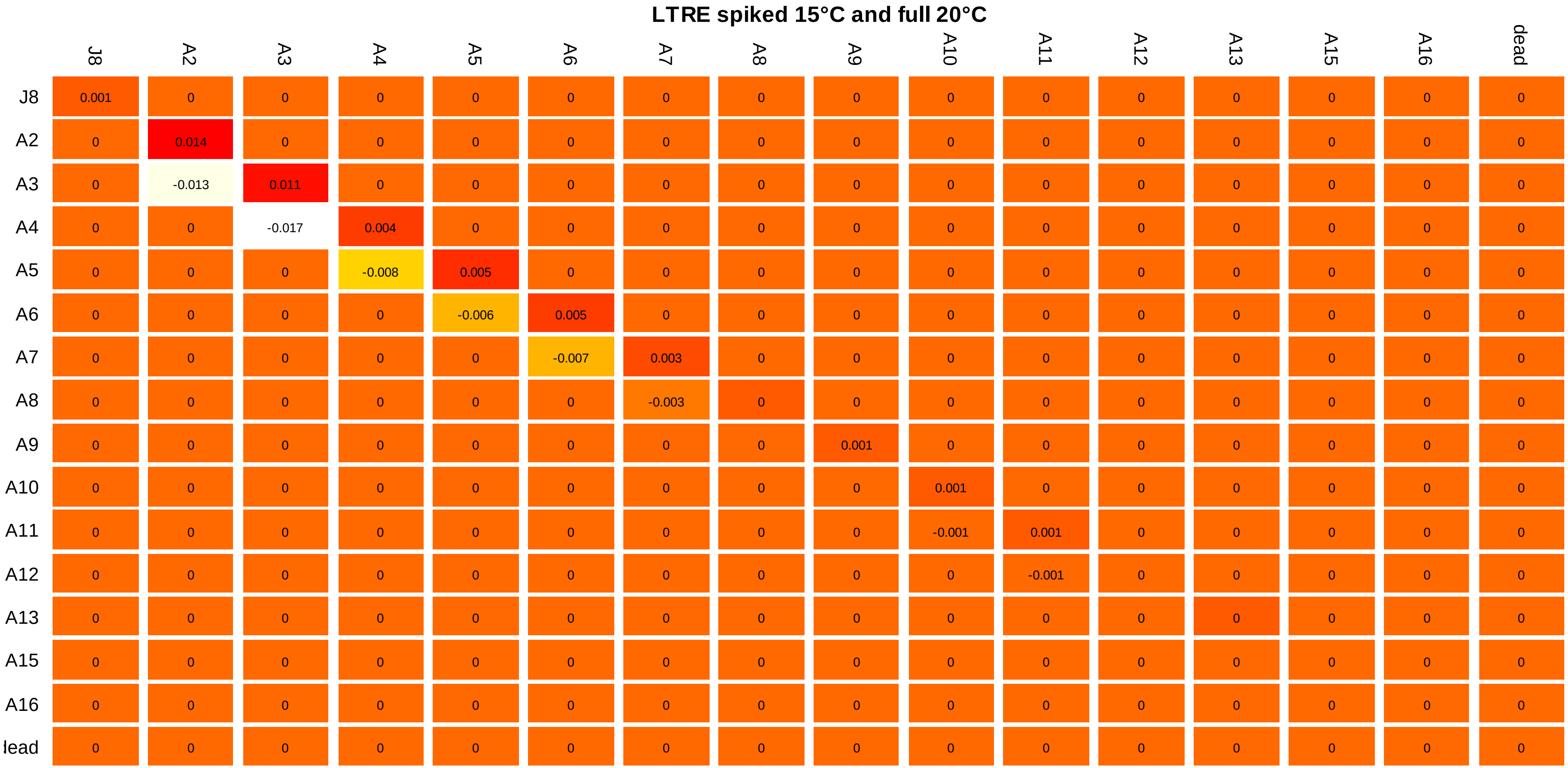
	J4	J5	J6	J7	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A16	A19	A20	dead
J4	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	-0.024	0.011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	-0.012	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	-0.005	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0.009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	-0.011	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	-0.006	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	-0.003	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	-0.004	0.003	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	-0.003	0.002	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	-0.002	0.001	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	-0.001	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

#



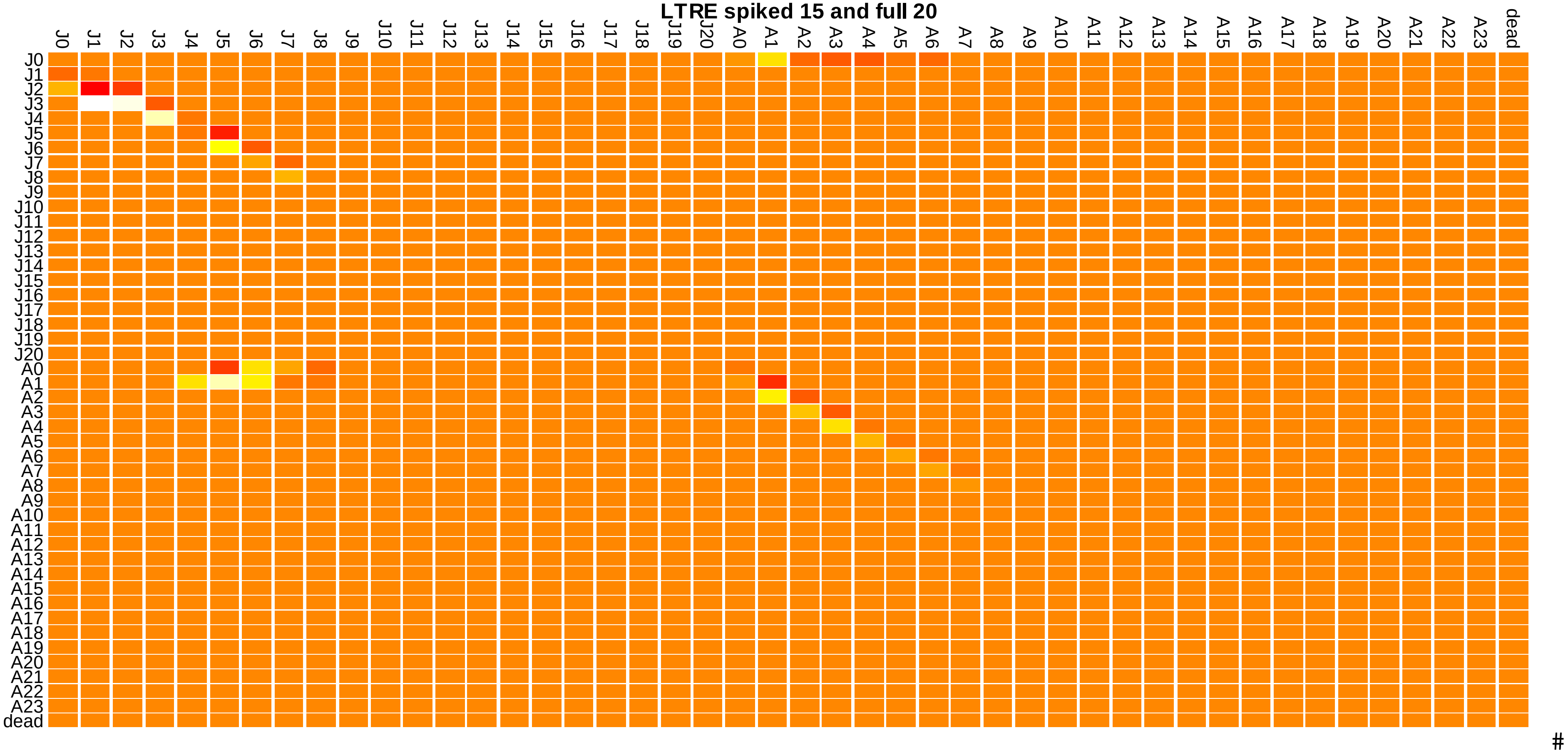
LTRE full 15°C and full 20°C

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	J20	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	dead
J0	0.009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.005	0.012	0.003	0.015	0.009	0.005	0.005	0.004	0.002	0.002	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0
J1	-0.019	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.003	0.035	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	-0.058	-0.024	0.044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	-0.057	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	-0.024	0.011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	-0.012	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	-0.005	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0	0	0.008	0	-0.003	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.006	0.027	0	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.001	0.033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.025	0.009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.011	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.006	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.003	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.004	0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.003	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.002	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

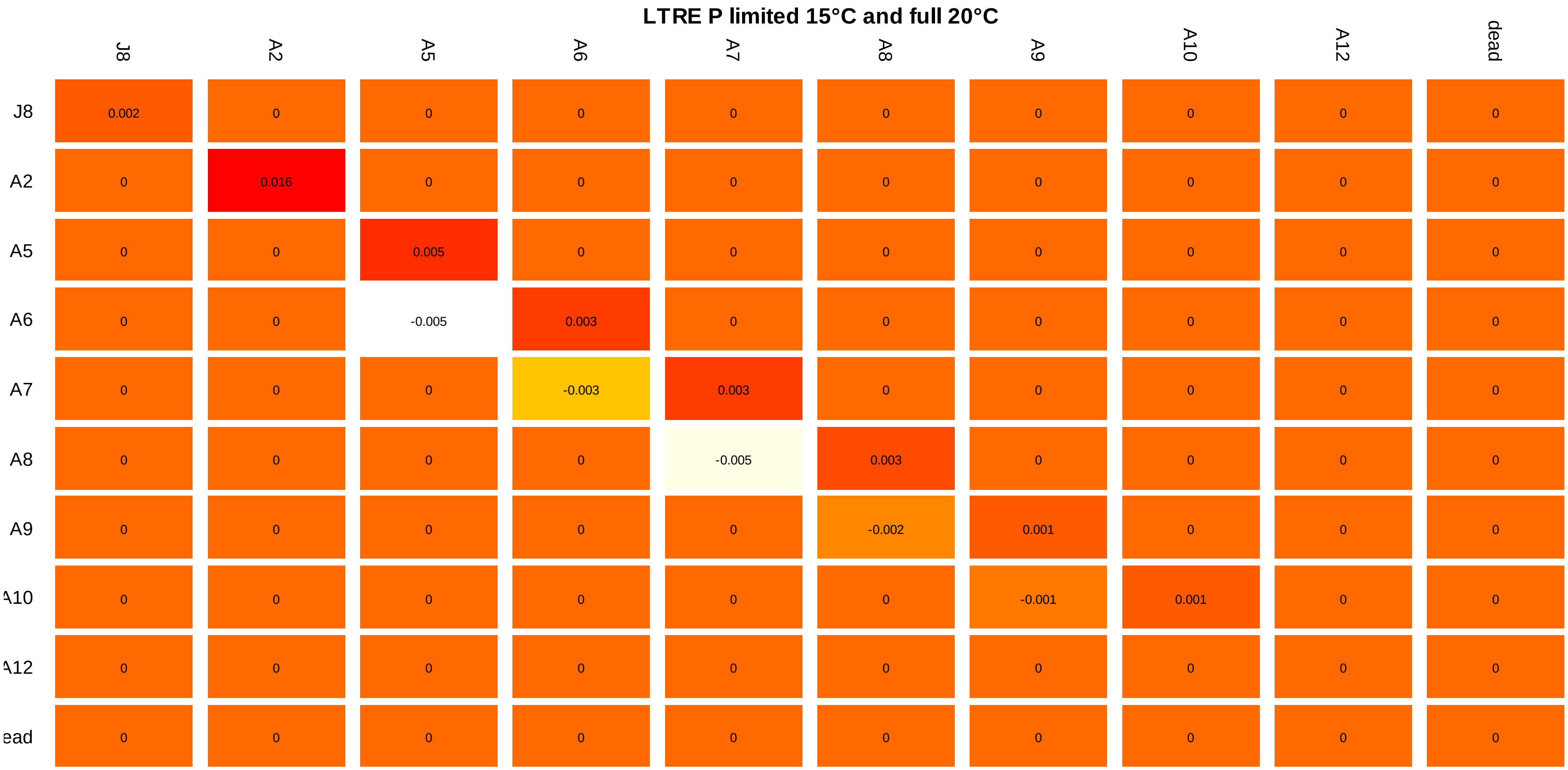


LTRE spiked 15°C and full 20°C

	J8	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A15	A16	dead
J8	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0.014	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	-0.013	0.011	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	-0.017	0.004	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	-0.008	0.005	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	-0.006	0.005	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	-0.007	0.003	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	-0.003	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	-0.001	0.001	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	-0.001	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

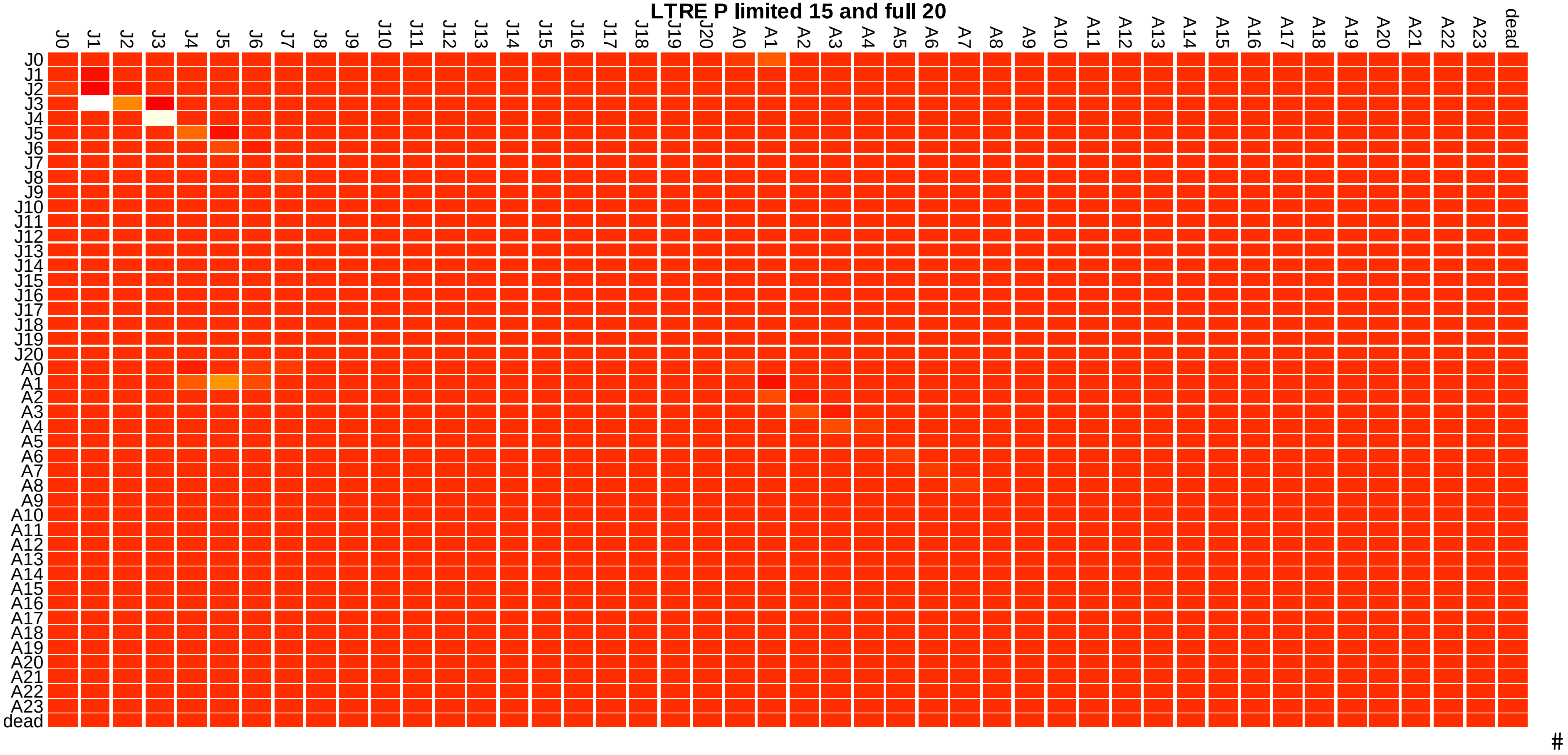


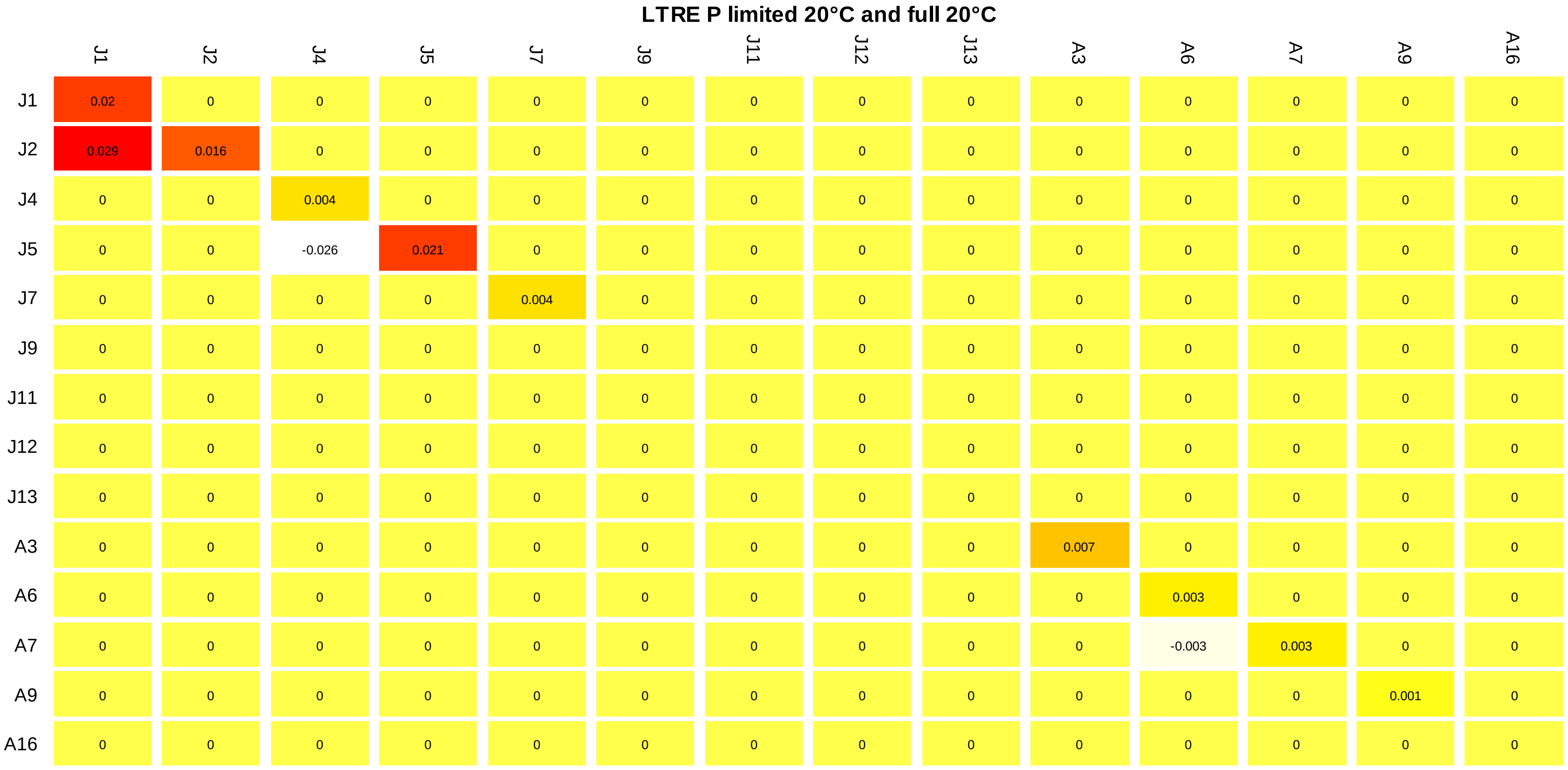
LTRE spiked 15 and full 20



LTRE P limited 15°C and full 20°C

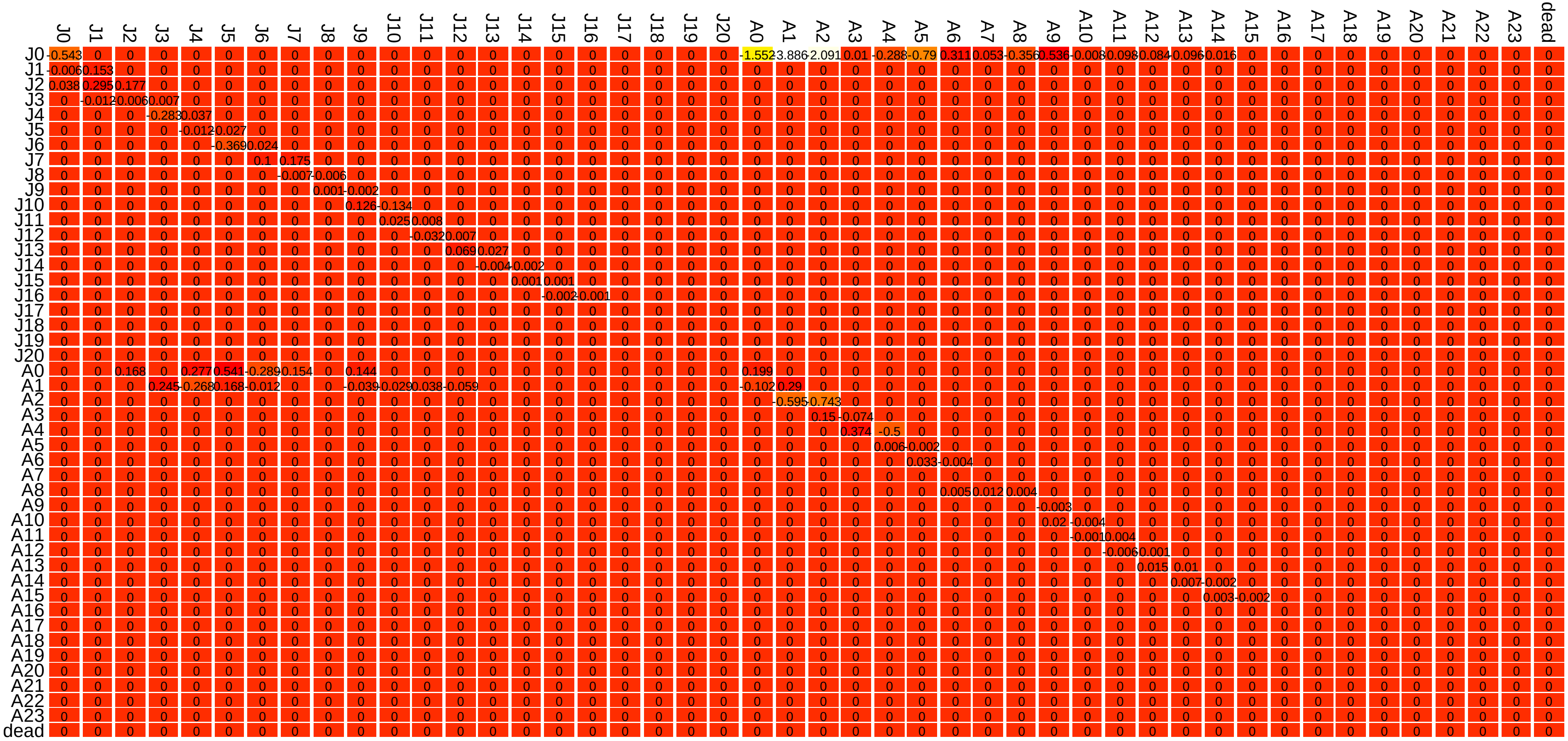
	J8	A2	A5	A6	A7	A8	A9	A10	A12	dead
J8	0.002	0	0	0	0	0	0	0	0	0
A2	0	0.016	0	0	0	0	0	0	0	0
A5	0	0	0.005	0	0	0	0	0	0	0
A6	0	0	-0.005	0.003	0	0	0	0	0	0
A7	0	0	0	-0.003	0.003	0	0	0	0	0
A8	0	0	0	0	-0.005	0.003	0	0	0	0
A9	0	0	0	0	0	-0.002	0.001	0	0	0
A10	0	0	0	0	0	0	-0.001	0.001	0	0
A12	0	0	0	0	0	0	0	0	0	0
ead	0	0	0	0	0	0	0	0	0	0


LTRE P limited 15 and full 20

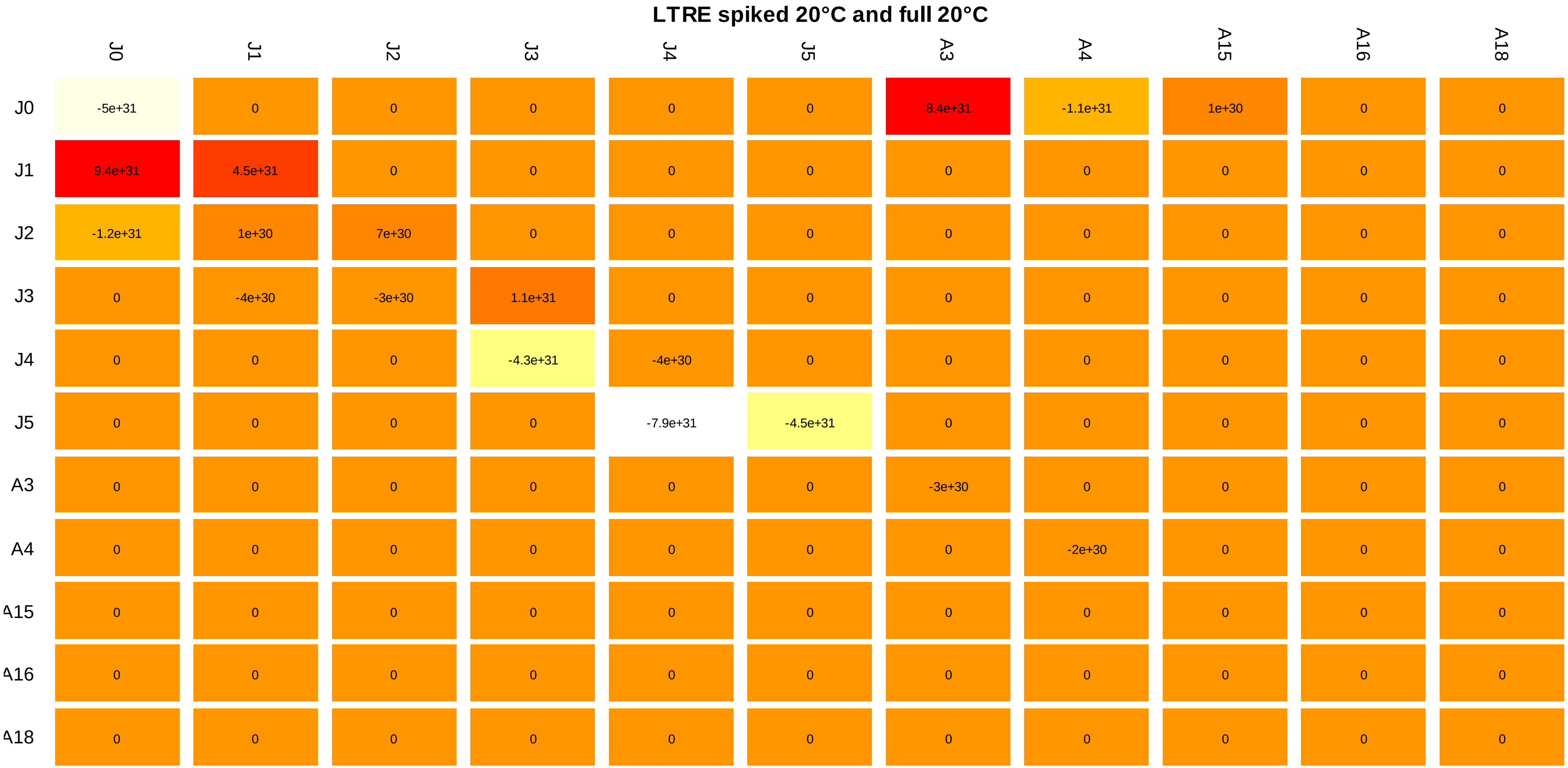


LTRE P limited 20°C and full 20°C

	J1	J2	J4	J5	J7	J9	J11	J12	J13	A3	A6	A7	A9	A16
J1	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.029	0.016	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0.004	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	-0.026	0.021	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0.004	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0.007	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0.003	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	-0.003	0.003	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0

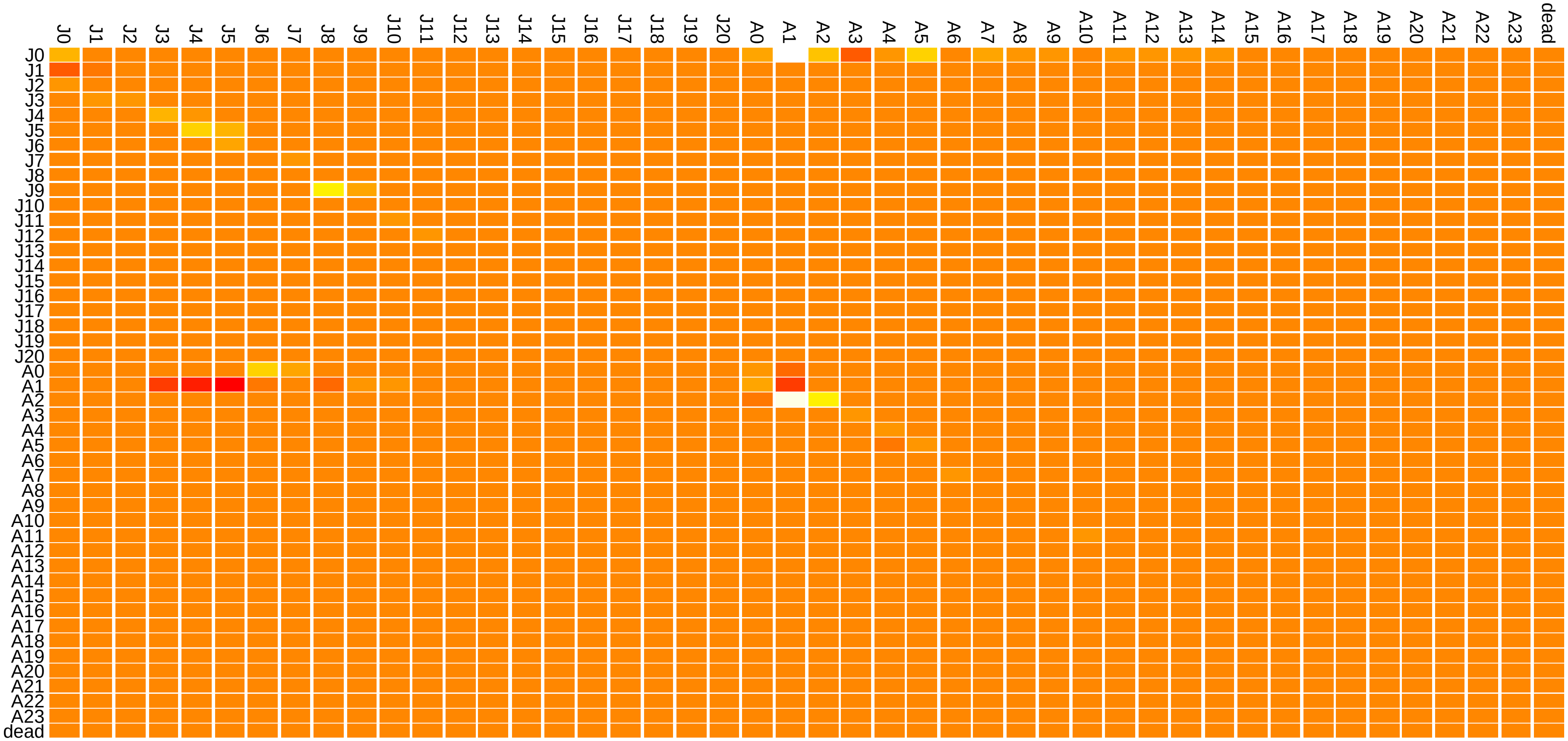


	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	J20	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	dead
J0	-0.543	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1.552	-3.886	-2.091	0.01	-0.288	-0.79	0.311	0.053	-0.356	0.536	-0.008	-0.098	-0.084	-0.096	-0.016	0	0	0	0	0	0	0	0	0	0
J1	-0.006	0.153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J2	0.038	0.295	0.177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J3	0	-0.012	-0.006	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	0	0	-0.283	0.037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0	0	-0.012	-0.027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	0	0	-0.369	0.024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0.1	0.175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	0	-0.007	-0.006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J9	0	0	0	0	0	0	0	0	0.001	-0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	0	0	0	0	0	0	0.126	-0.134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	0	0	0	0	0	0	0	0.025	0.008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	0	0	0	0	0	0	0	-0.032	0.007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J13	0	0	0	0	0	0	0	0	0	0	0	0	0.069	0.027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J14	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.004	-0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.002	-0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A0	0	0	0.168	0	0.277	0.541	-0.289	0.154	0	0.144	0	0	0	0	0	0	0	0	0	0	0	0.199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0.245	-0.268	0.168	-0.012	0	0	-0.039	-0.029	0.038	-0.059	0	0	0	0	0	0	0	0	-0.102	0.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.595	-0.743	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.15	-0.074	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.374	-0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.006	-0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.033	-0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.005	0.012	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	-0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.001	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.006	-0.001	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.015	0.01	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.007	-0.002	0	0	0	0	0	0	0	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003	-0.002	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
dead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



LTRE spiked 20°C and full 20°C

	J0	J1	J2	J3	J4	J5	A3	A4	A15	A16	A18
J0	-5e+31	0	0	0	0	0	8.4e+31	-1.1e+31	1e+30	0	0
J1	9.4e+31	4.5e+31	0	0	0	0	0	0	0	0	0
J2	-1.2e+31	1e+30	7e+30	0	0	0	0	0	0	0	0
J3	0	-4e+30	-3e+30	1.1e+31	0	0	0	0	0	0	0
J4	0	0	0	-4.3e+31	-4e+30	0	0	0	0	0	0
J5	0	0	0	0	-7.9e+31	-4.5e+31	0	0	0	0	0
A3	0	0	0	0	0	0	-3e+30	0	0	0	0
A4	0	0	0	0	0	0	0	-2e+30	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0
A16	0	0	0	0	0	0	0	0	0	0	0
A18	0	0	0	0	0	0	0	0	0	0	0

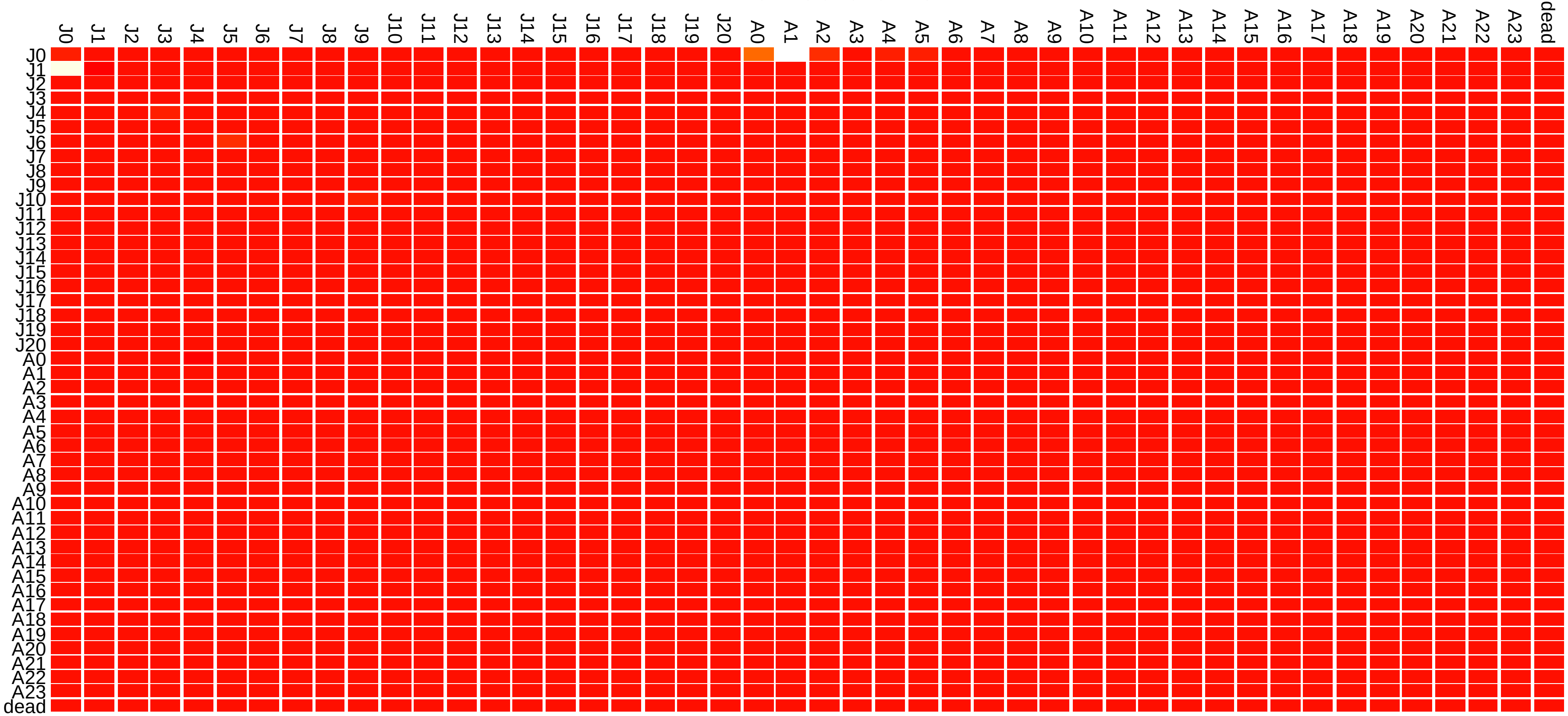


LTRE spiked 20°C and full 20°C

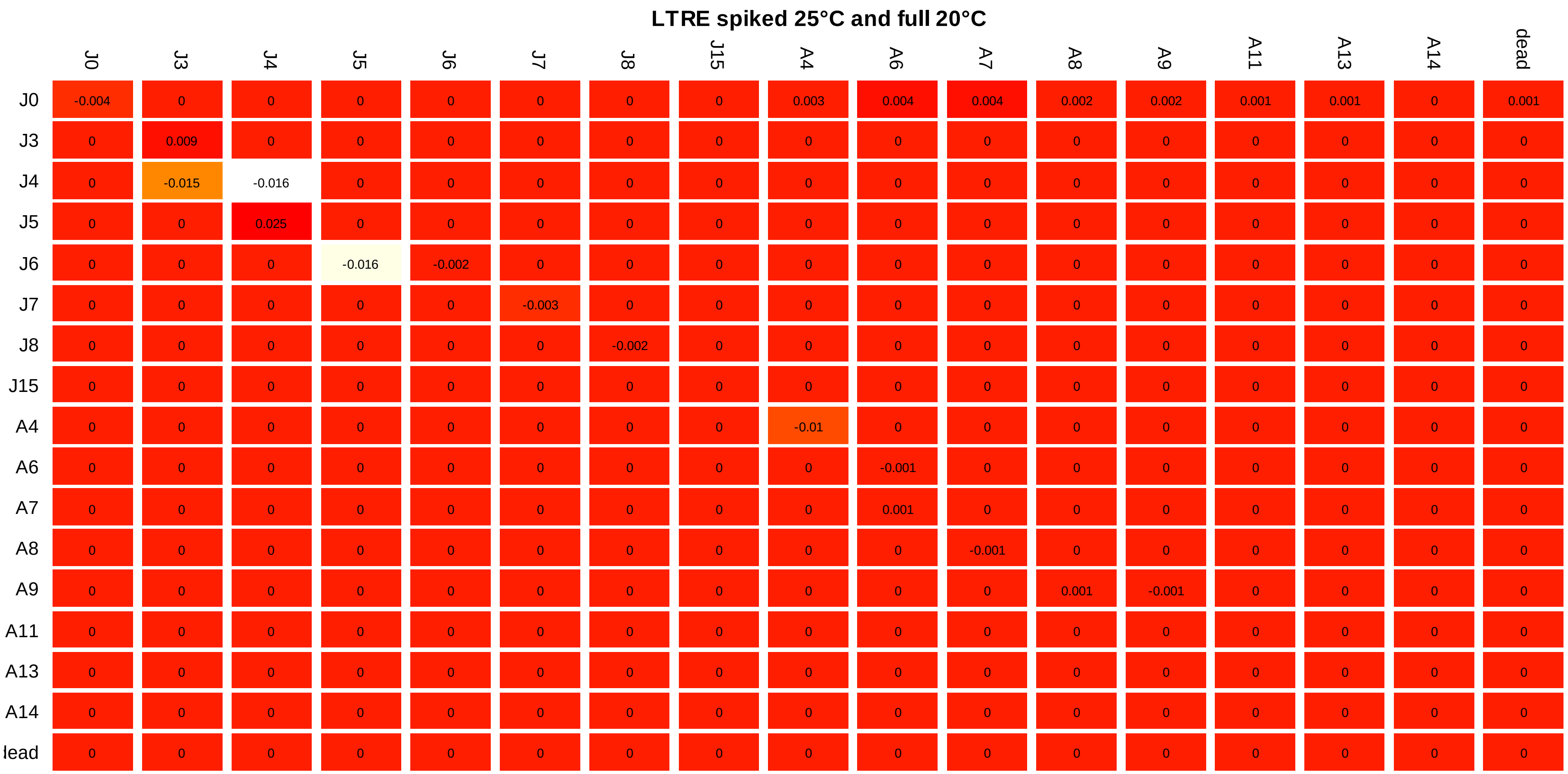
#

LTRE full 25°C and full 20°C

	J1	J4	J7	A3
J1	1.10698529460174e+50	0	0	0
J4	0	-6.71390583661472e+48	0	0
J7	0	0	-5.23158273649734e+48	0
A3	0	0	0	-8.74037759712672e+48

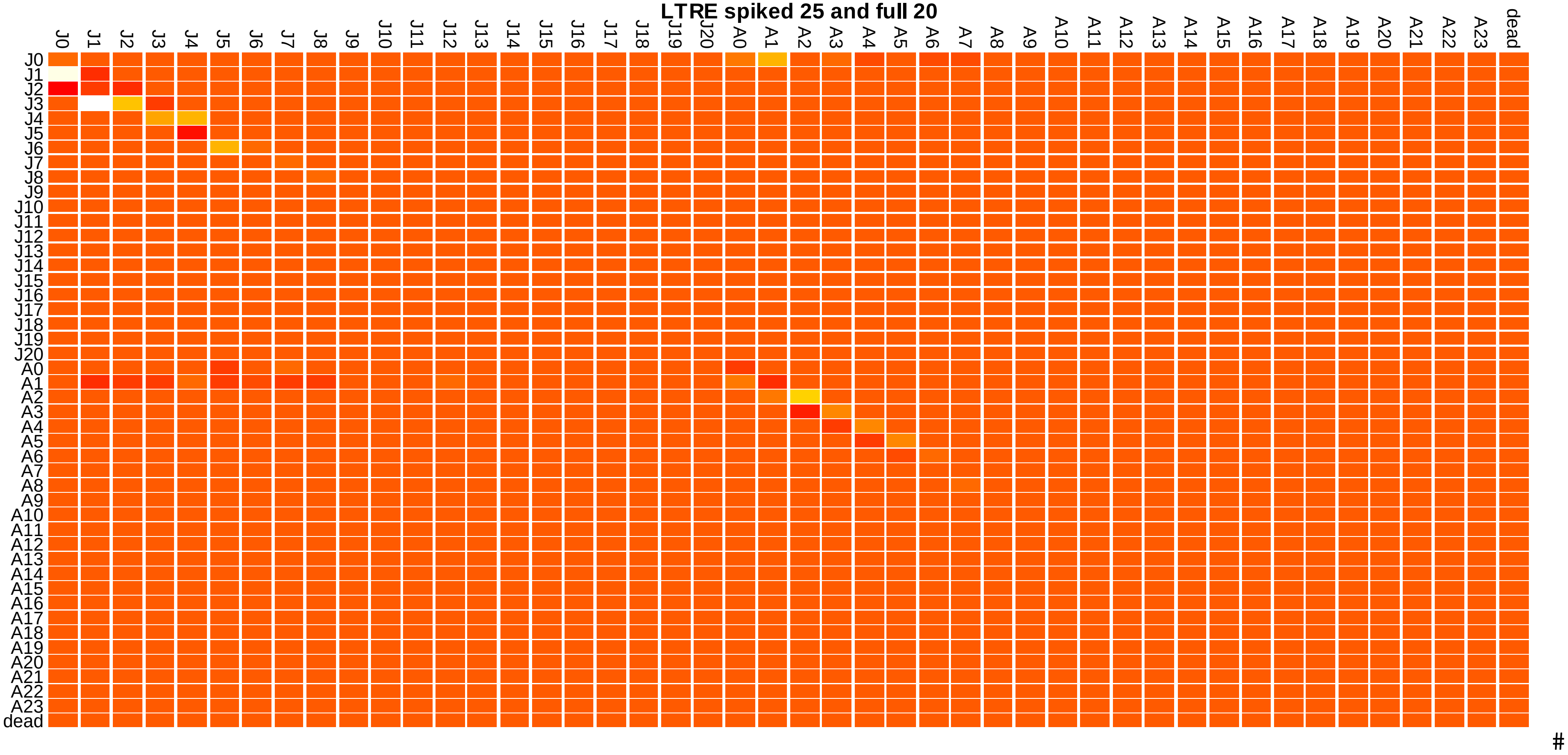

LTRE full 25 and full 20

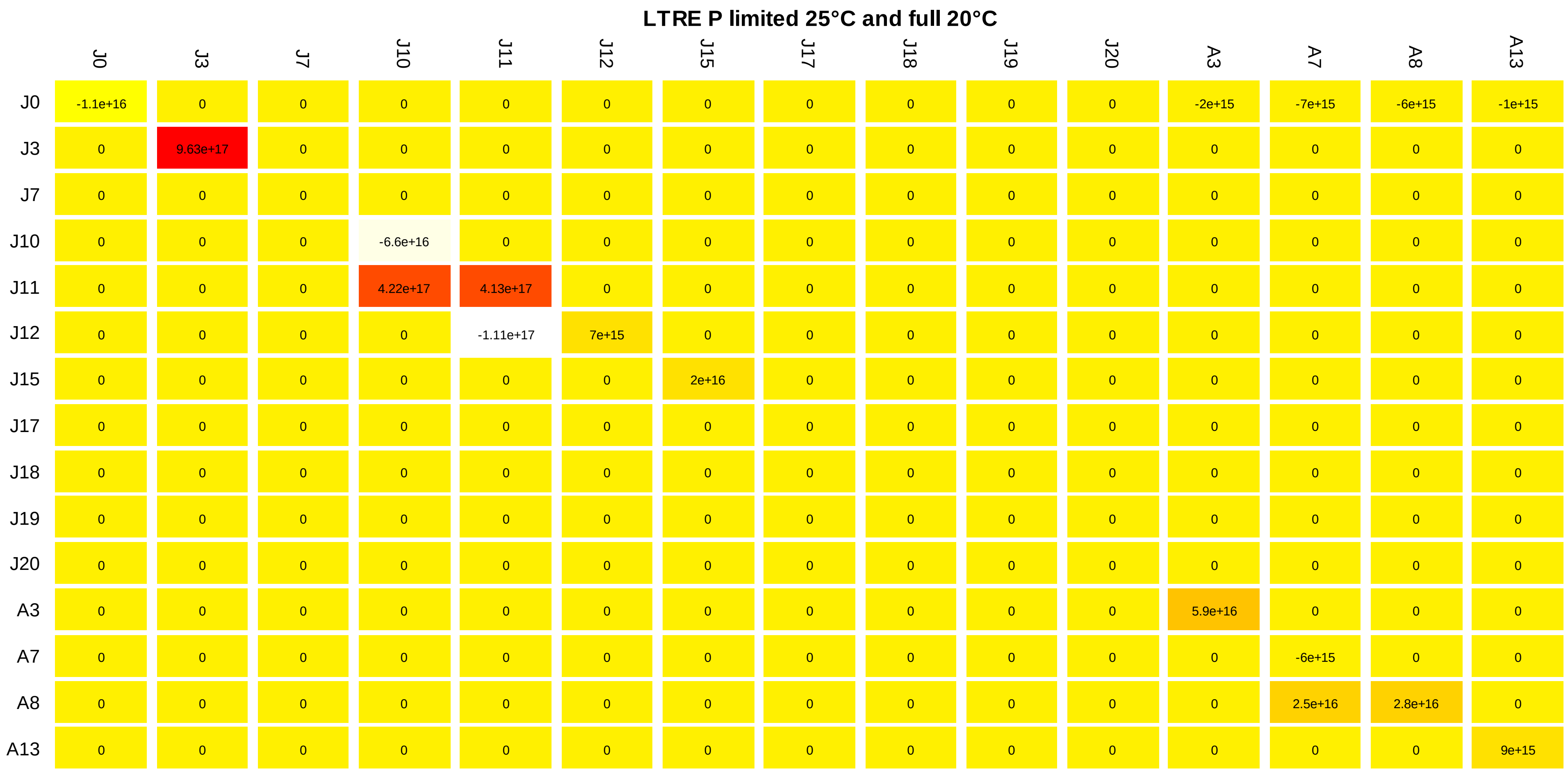
#



LTRE spiked 25°C and full 20°C

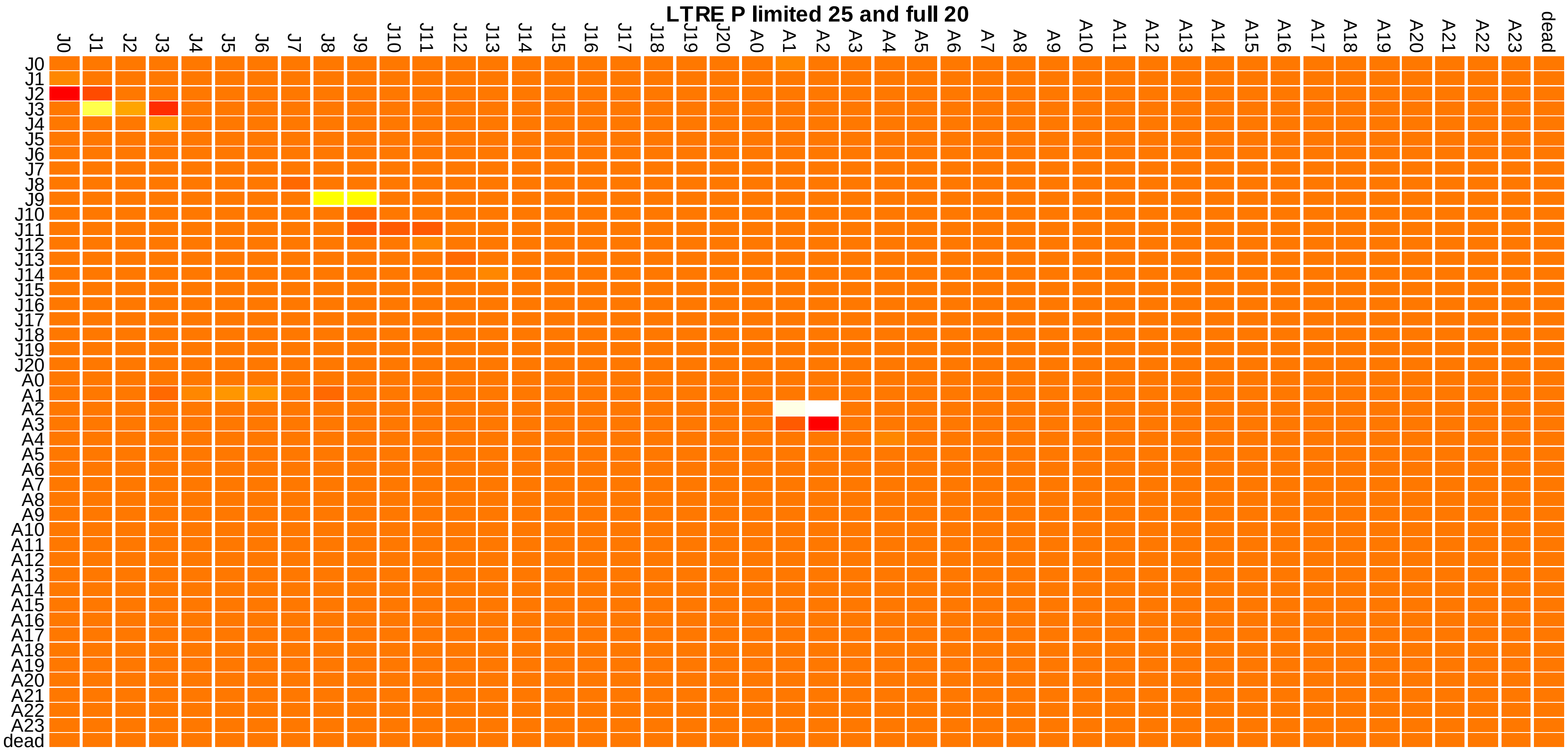
	J0	J3	J4	J5	J6	J7	J8	J15	A4	A6	A7	A8	A9	A11	A13	A14	dead
J0	-0.004	0	0	0	0	0	0	0	0.003	0.004	0.004	0.002	0.002	0.001	0.001	0	0.001
J3	0	0.009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J4	0	-0.015	-0.016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J5	0	0	0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J6	0	0	0	-0.016	-0.002	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	-0.003	0	0	0	0	0	0	0	0	0	0	0
J8	0	0	0	0	0	0	-0.002	0	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0	0	-0.01	0	0	0	0	0	0	0	0
A6	0	0	0	0	0	0	0	0	0	-0.001	0	0	0	0	0	0	0
A7	0	0	0	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0
A8	0	0	0	0	0	0	0	0	0	0	-0.001	0	0	0	0	0	0
A9	0	0	0	0	0	0	0	0	0	0	0	0.001	-0.001	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0


LTRE spiked 25 and full 20
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21 A22 A23 dead
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21 A22 A23 dead
#

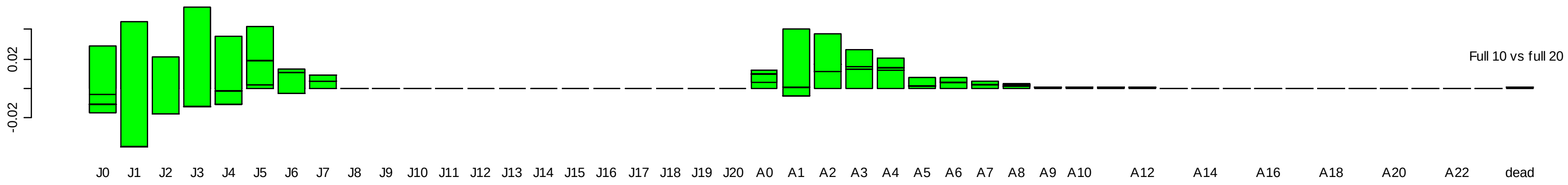


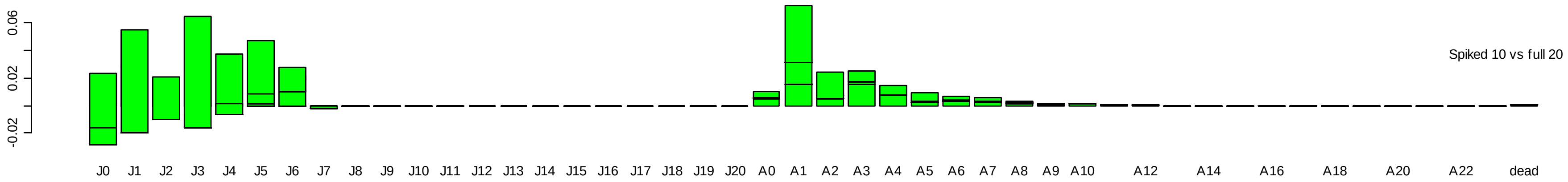
LTRE P limited 25°C and full 20°C

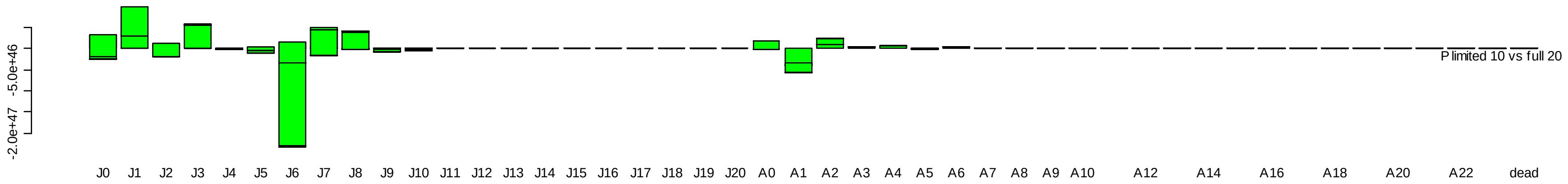
	J0	J3	J7	J10	J11	J12	J15	J17	J18	J19	J20	A3	A7	A8	A13
J0	-1.1e+16	0	0	0	0	0	0	0	0	0	0	-2e+15	-7e+15	-6e+15	-1e+15
J3	0	9.63e+17	0	0	0	0	0	0	0	0	0	0	0	0	0
J7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J10	0	0	0	-6.6e+16	0	0	0	0	0	0	0	0	0	0	0
J11	0	0	0	4.22e+17	4.13e+17	0	0	0	0	0	0	0	0	0	0
J12	0	0	0	0	-1.11e+17	7e+15	0	0	0	0	0	0	0	0	0
J15	0	0	0	0	0	0	2e+16	0	0	0	0	0	0	0	0
J17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
J20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	5.9e+16	0	0	0
A7	0	0	0	0	0	0	0	0	0	0	0	0	-6e+15	0	0
A8	0	0	0	0	0	0	0	0	0	0	0	0	2.5e+16	2.8e+16	0
A13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9e+15

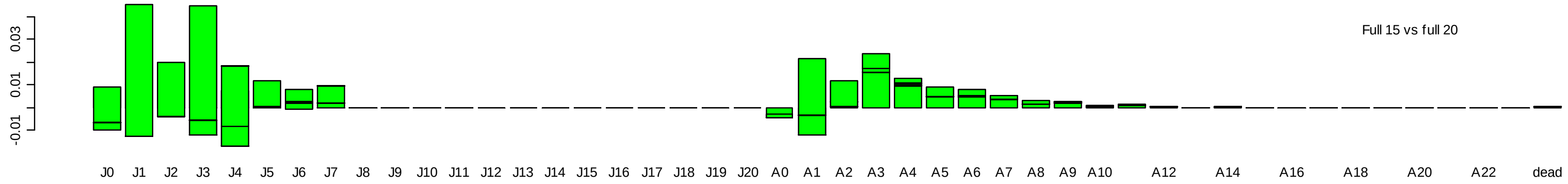


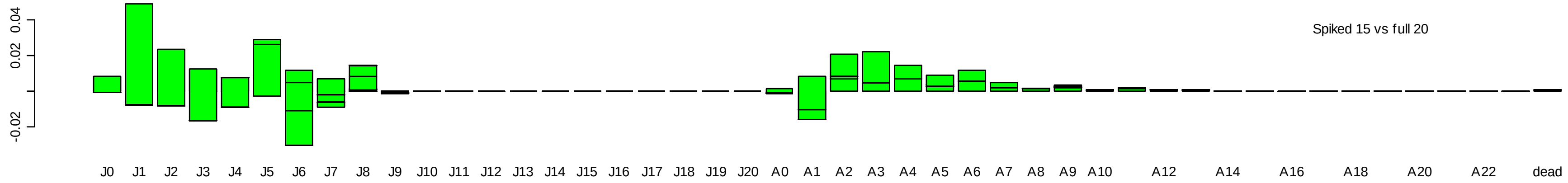
LTRE P limited 25 and full 20

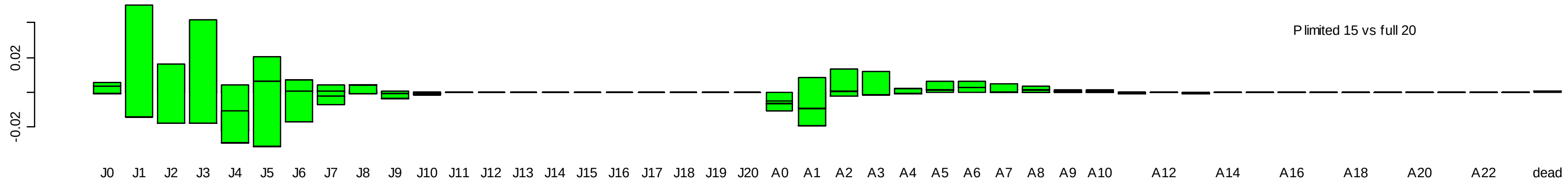

0.02
-0.02
Full 10 vs full 20
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A12 A14 A16 A18 A20 A22 dead

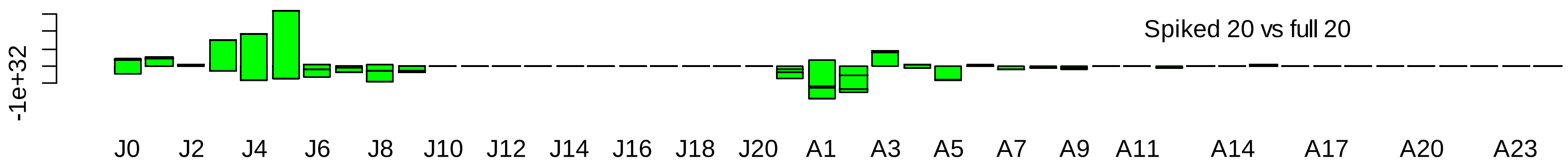

0.06
0.02
-0.02
Spiked 10 vs full 20
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A12 A14 A16 A18 A20 A22 dead

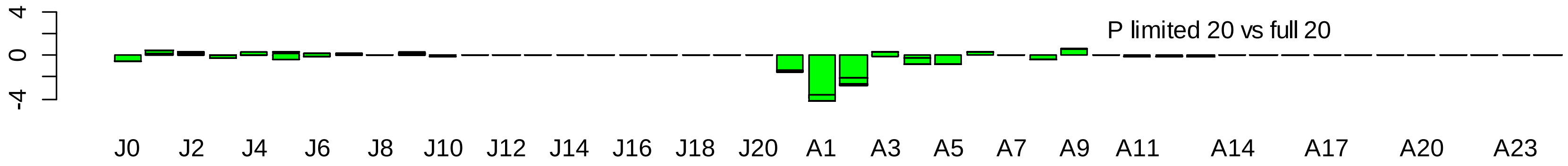

-5.0e+46
-2.0e+47
P limited 10 vs full 20
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A12 A14 A16 A18 A20 A22 dead

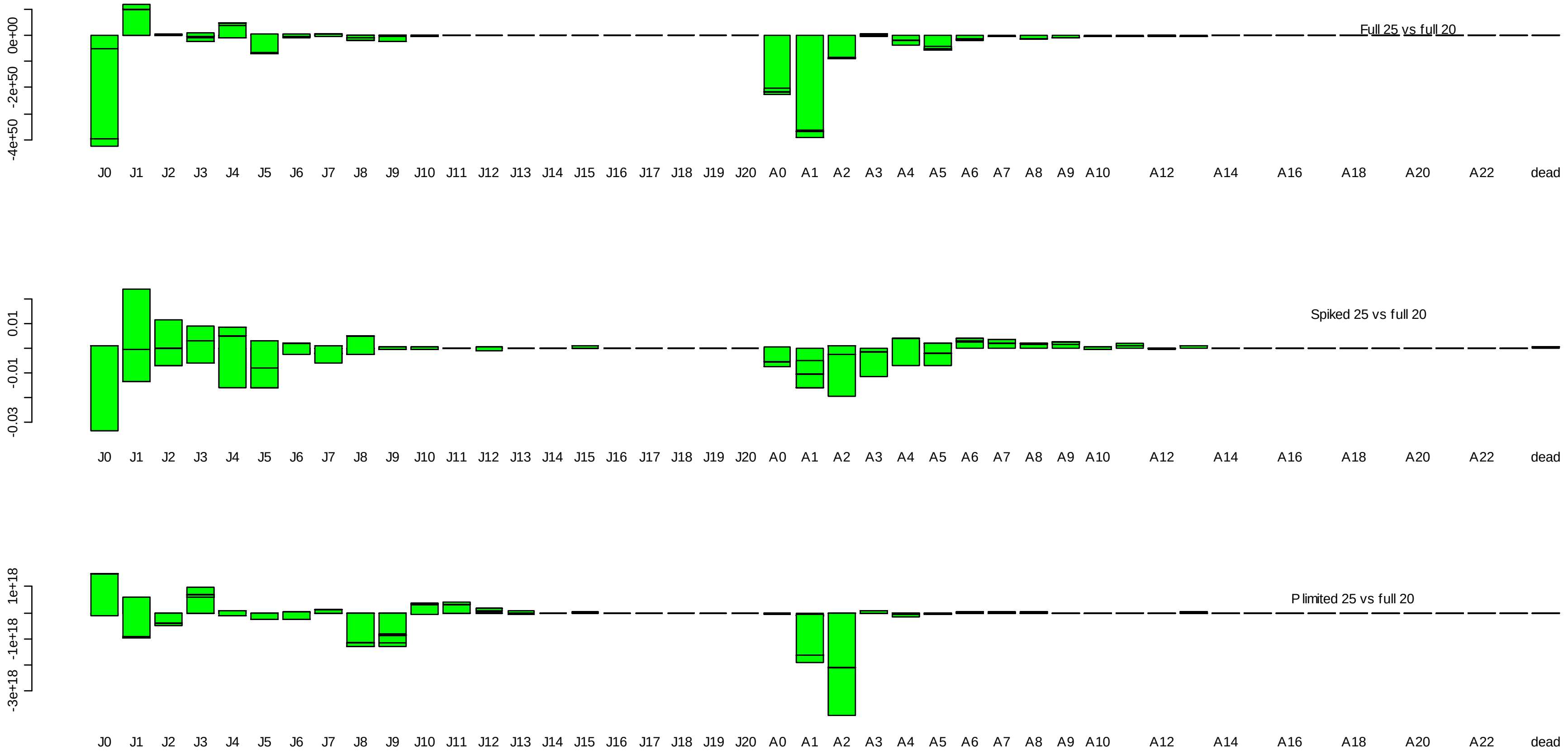

Full 15 vs full 20
-0.01
0.01
0.03
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A12 A14 A16 A18 A20 A22 dead


Spiked 15 vs full 20
-0.02
0.02
0.04
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A12 A14 A16 A18 A20 A22 dead

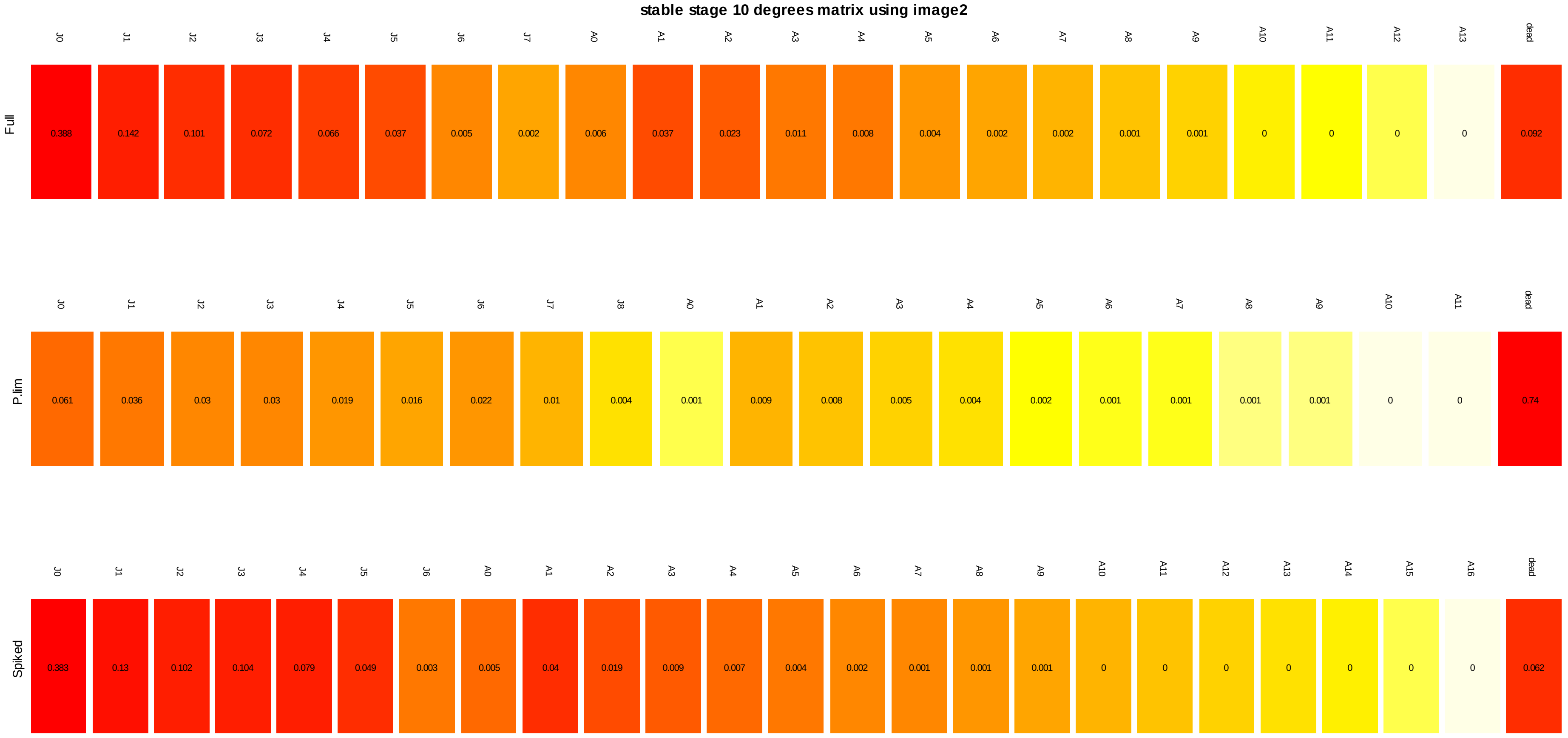

P limited 15 vs full 20
-0.02
0.02
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A12 A14 A16 A18 A20 A22 dead


Spiked 20 vs full 20
-1e+32
J0
J2
J4
J6
J8
J10
J12
J14
J16
J18
J20
A1
A3
A5
A7
A9
A11
A14
A17
A20
A23


P limited 20 vs full 20
4
0
-4
J0
J2
J4
J6
J8
J10
J12
J14
J16
J18
J20
A1
A3
A5
A7
A9
A11
A14
A17
A20
A23


Full 25 vs full 20
-4e+50
-2e+50
0e+00
Spiked 25 vs full 20
-0.03
-0.01
0.01
P limited 25 vs full 20
-3e+18
-1e+18
1e+18
J0 J1 J2 J3 J4 J5 J6 J7 J8 J9 J10 J11 J12 J13 J14 J15 J16 J17 J18 J19 J20 A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A12 A14 A16 A18 A20 A22 dead

#

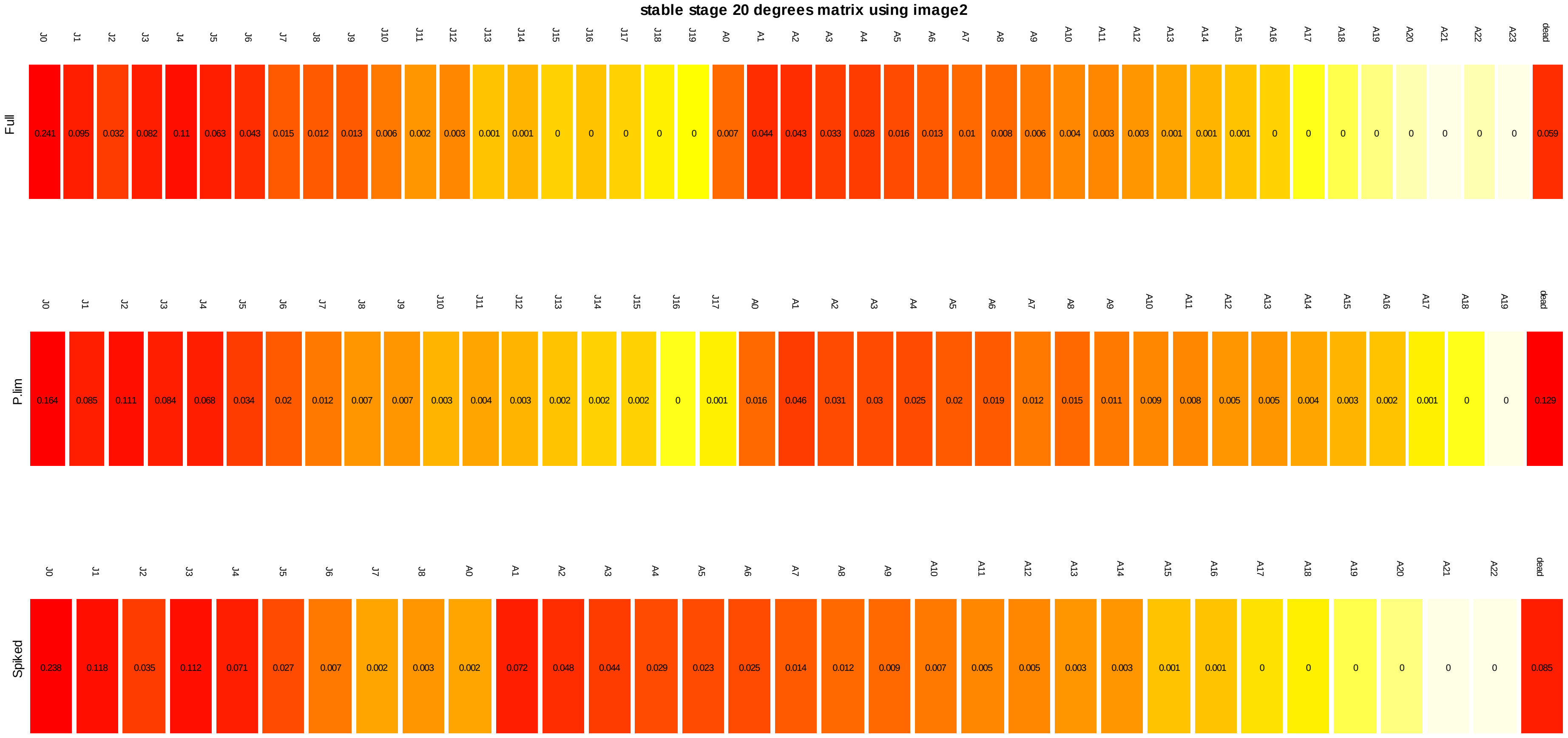


stable stage 10 degrees matrix using image2

	J0	J1	J2	J3	J4	J5	J6	J7	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	dead
Full	0.388	0.142	0.101	0.072	0.066	0.037	0.005	0.002	0.006	0.037	0.023	0.011	0.008	0.004	0.002	0.002	0.001	0.001	0	0	0	0	0.092

	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	dead
P.lim	0.061	0.036	0.03	0.03	0.019	0.016	0.022	0.01	0.004	0.001	0.009	0.008	0.005	0.004	0.002	0.001	0.001	0.001	0.001	0	0	0.74

	J0	J1	J2	J3	J4	J5	J6	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	dead
Spiked	0.383	0.13	0.102	0.104	0.079	0.049	0.003	0.005	0.04	0.019	0.009	0.007	0.004	0.002	0.001	0.001	0.001	0	0	0	0	0	0	0	0.062



stable stage 20 degrees matrix using image2

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19
Full	0.241	0.095	0.032	0.082	0.11	0.063	0.043	0.015	0.012	0.013	0.006	0.002	0.003	0.001	0.001	0	0	0	0	0

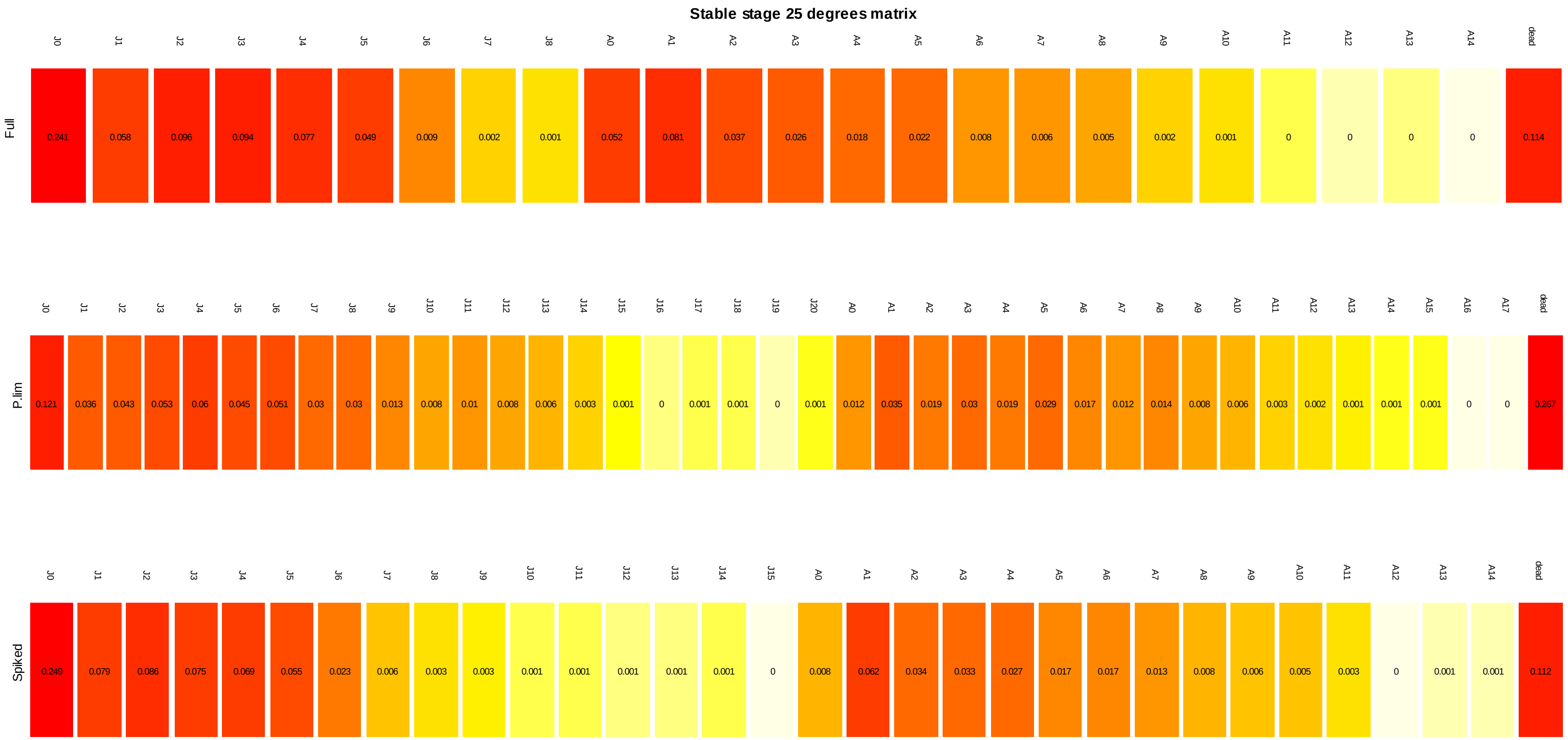
	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	dead
Full	0.007	0.044	0.043	0.033	0.028	0.016	0.013	0.01	0.008	0.006	0.004	0.003	0.003	0.001	0.001	0.001	0	0	0	0	0	0	0	0	0.059

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17
P.lim	0.164	0.085	0.111	0.084	0.068	0.034	0.02	0.012	0.007	0.007	0.003	0.004	0.003	0.002	0.002	0.002	0	0.001

	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	dead
P.lim	0.016	0.046	0.031	0.03	0.025	0.02	0.019	0.012	0.015	0.011	0.009	0.008	0.005	0.005	0.004	0.003	0.002	0.001	0	0	0.129

	J0	J1	J2	J3	J4	J5	J6	J7	J8
Spiked	0.238	0.118	0.035	0.112	0.071	0.027	0.007	0.002	0.003

	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	dead
Spiked	0.002	0.072	0.048	0.044	0.029	0.023	0.025	0.014	0.012	0.009	0.007	0.005	0.005	0.003	0.003	0.001	0.001	0	0	0	0	0	0	0.085



Stable stage 25 degrees matrix

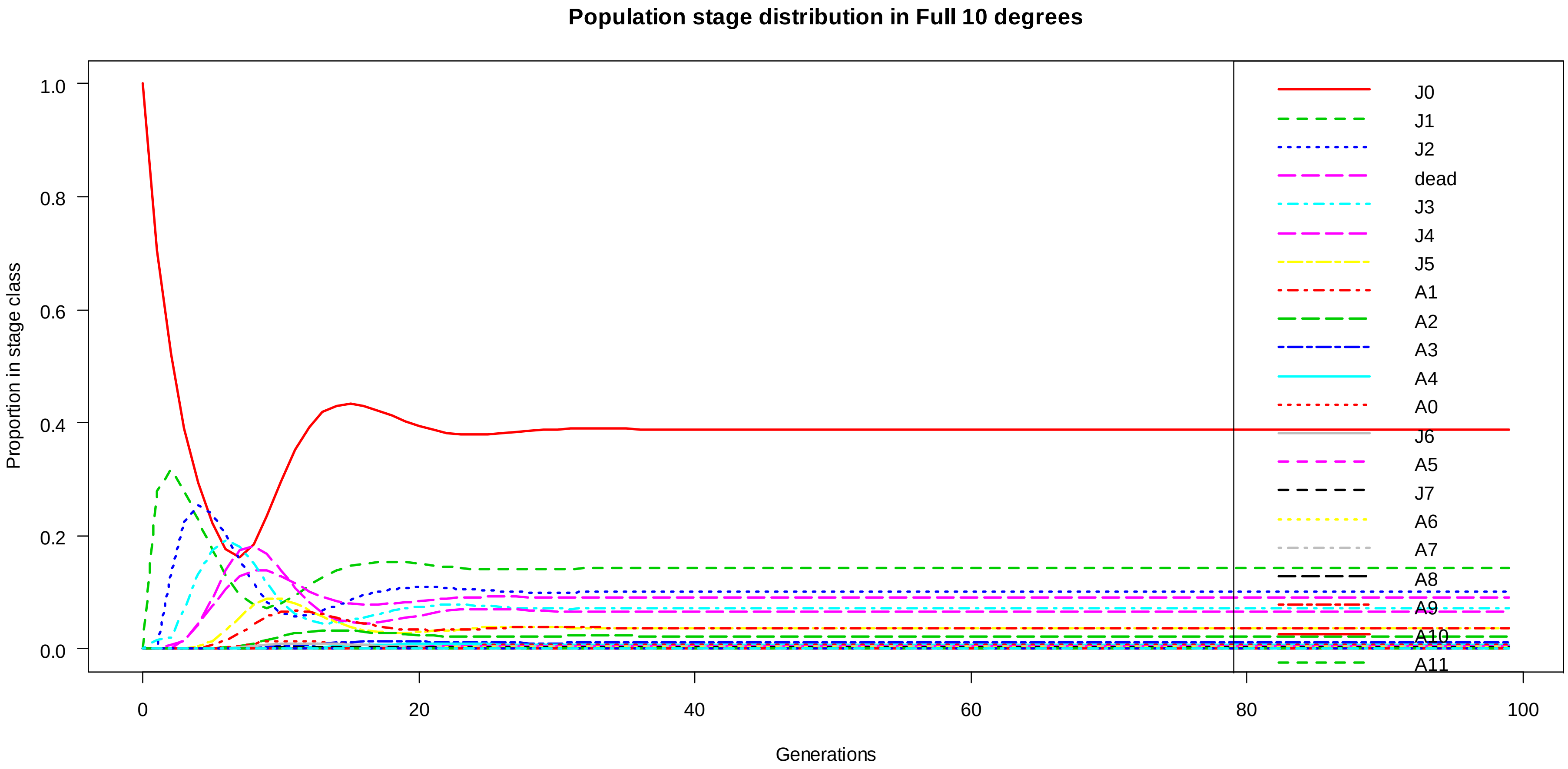
	J0	J1	J2	J3	J4	J5	J6	J7	J8	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
Full	0.241	0.058	0.096	0.094	0.077	0.049	0.009	0.002	0.001	0.052	0.081	0.037	0.026	0.018	0.022	0.008	0.006	0.005	0.002	0.001	0	0	0	0	0.114

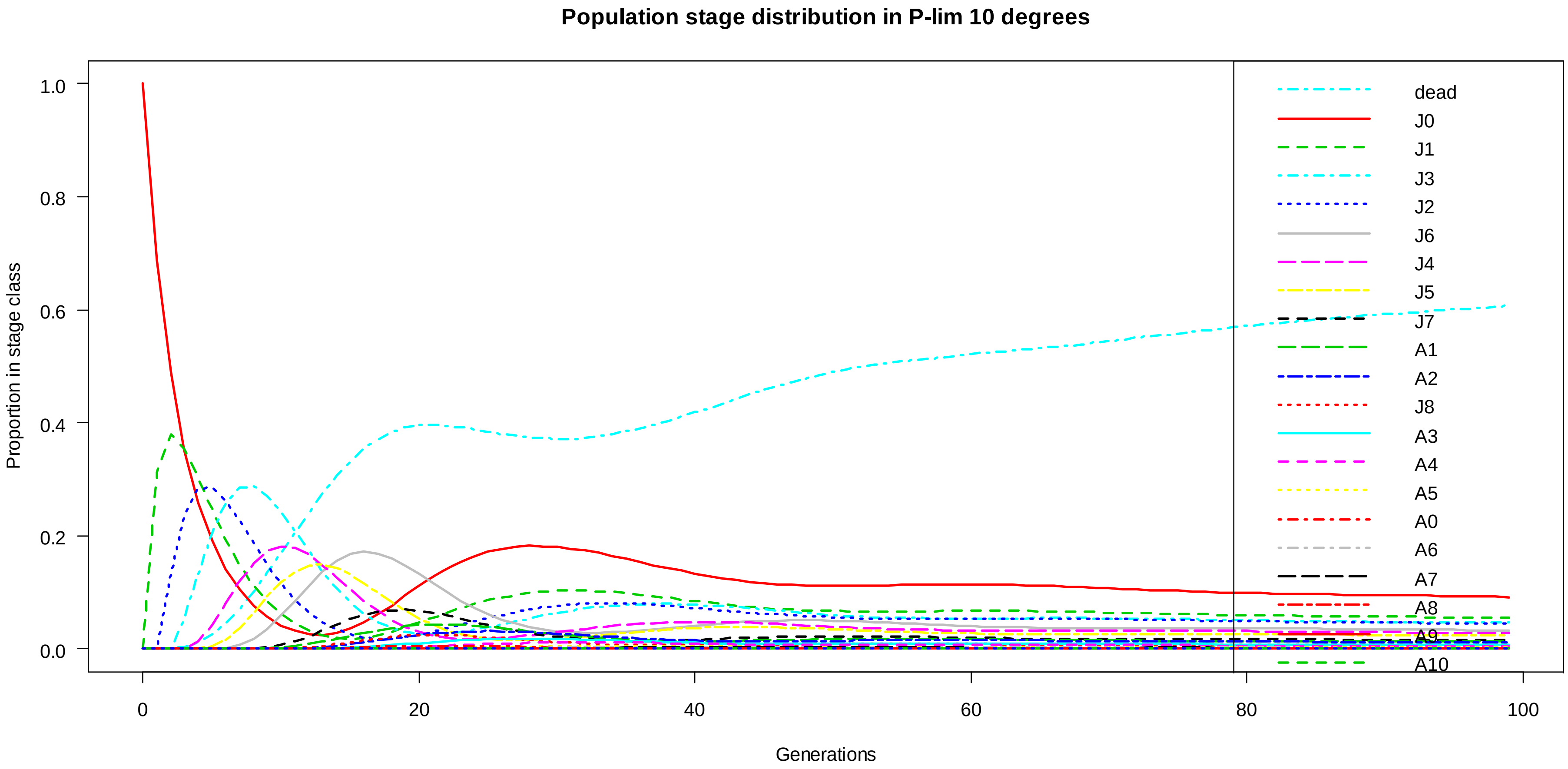
	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	J20
P.lim	0.121	0.036	0.043	0.053	0.06	0.045	0.051	0.03	0.03	0.013	0.008	0.01	0.008	0.006	0.003	0.001	0	0.001	0.001	0	0.001

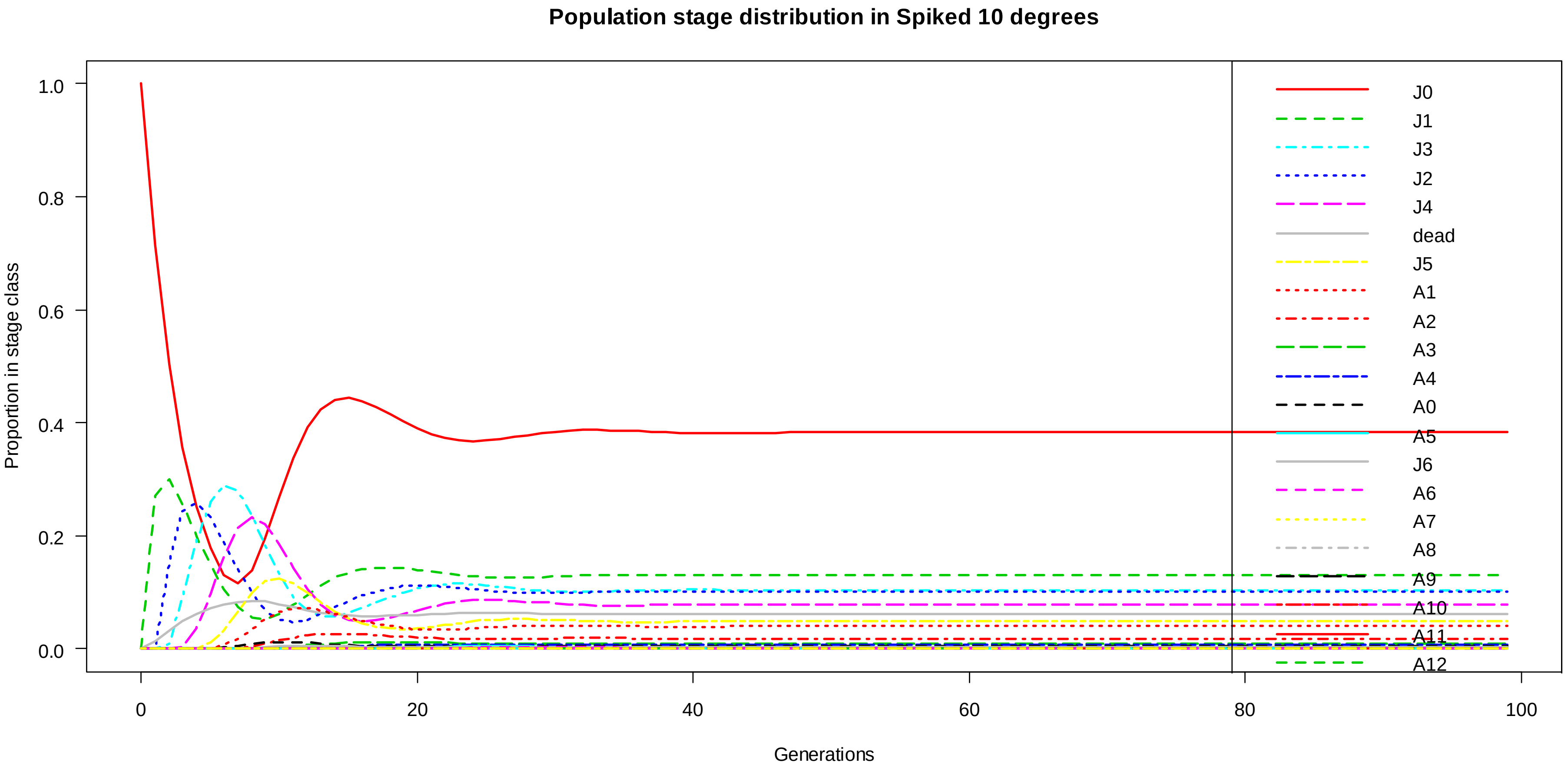
	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	dead
P.lim	0.012	0.035	0.019	0.03	0.019	0.029	0.017	0.012	0.014	0.008	0.006	0.003	0.002	0.001	0.001	0.001	0	0	0.267

	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15
Spiked	0.249	0.079	0.086	0.075	0.069	0.055	0.023	0.006	0.003	0.003	0.001	0.001	0.001	0.001	0.001	0

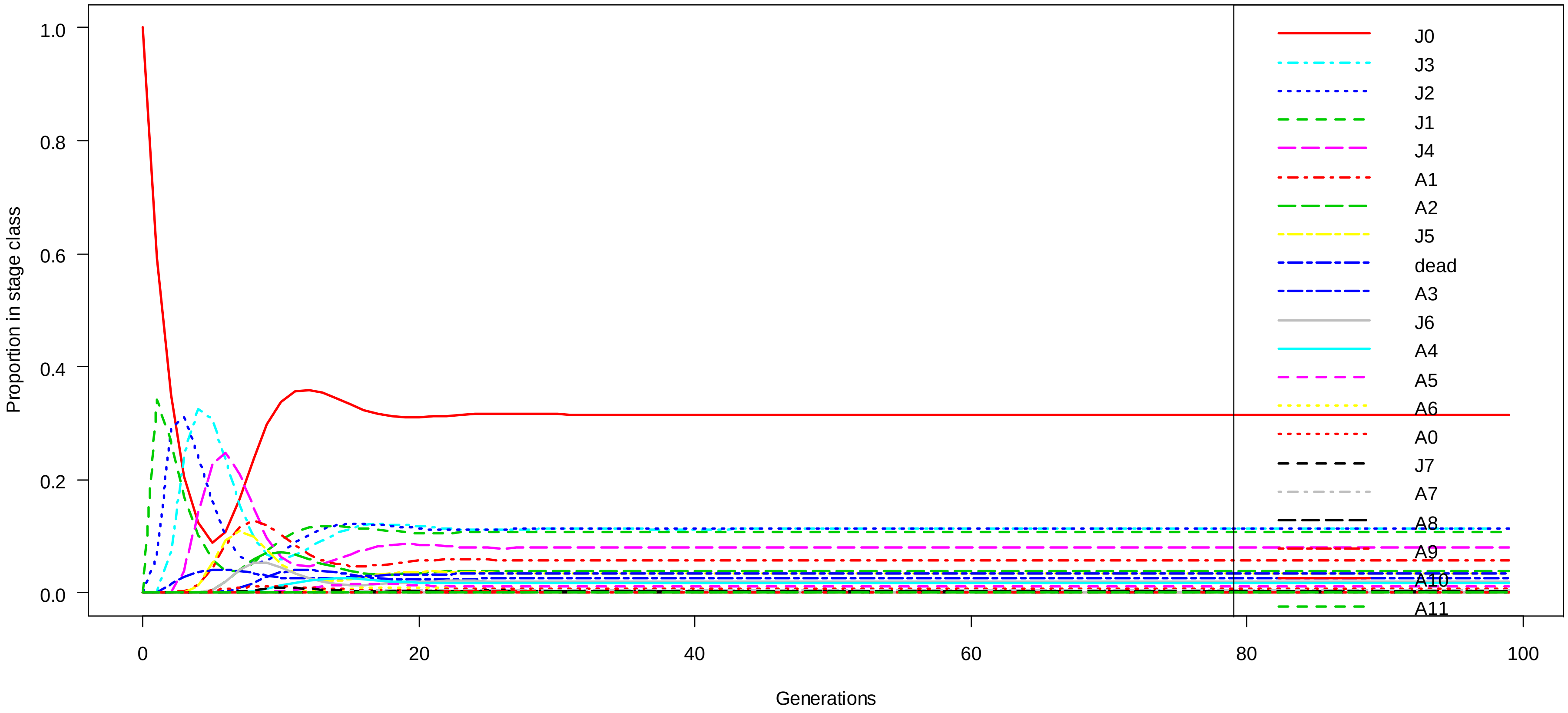
	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	dead
Spiked	0.008	0.062	0.034	0.033	0.027	0.017	0.017	0.013	0.008	0.006	0.005	0.003	0	0.001	0.001	0.112


Population stage distribution in Full 10 degrees
Proportion in stage class
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Generations
J0
J1
J2
dead
J3
J4
J5
A1
A2
A3
A4
A0
J6
A5
J7
A6
A7
A8
A9
A10
A11

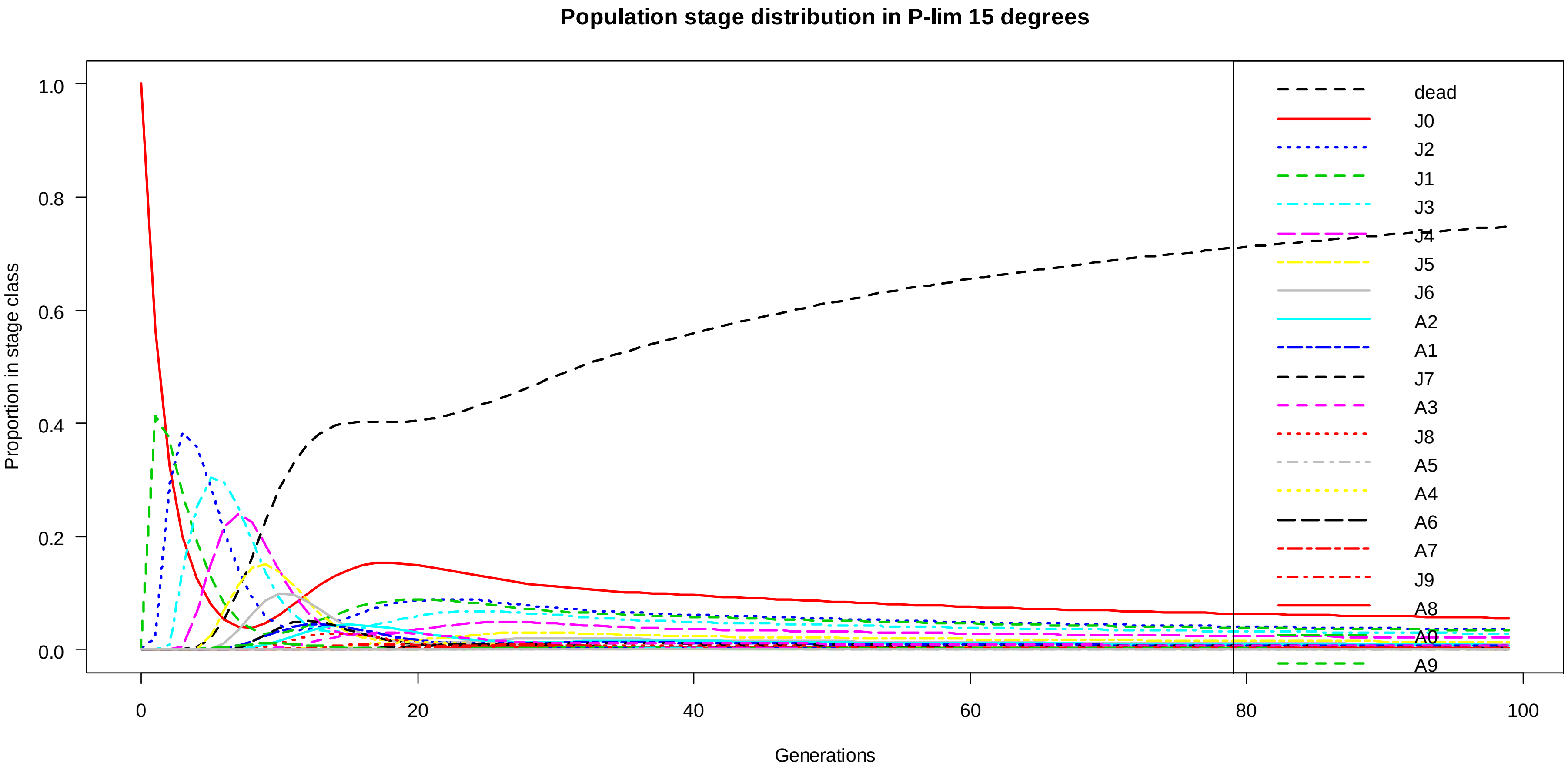

Population stage distribution in P-lim 10 degrees
Proportion in stage class
0.0
0.2
0.4
0.6
0.8
1.0
Generations
0
20
40
60
80
100
dead
J0
J1
J3
J2
J6
J4
J5
J7
A1
A2
J8
A3
A4
A5
A0
A6
A7
A8
A9
A10

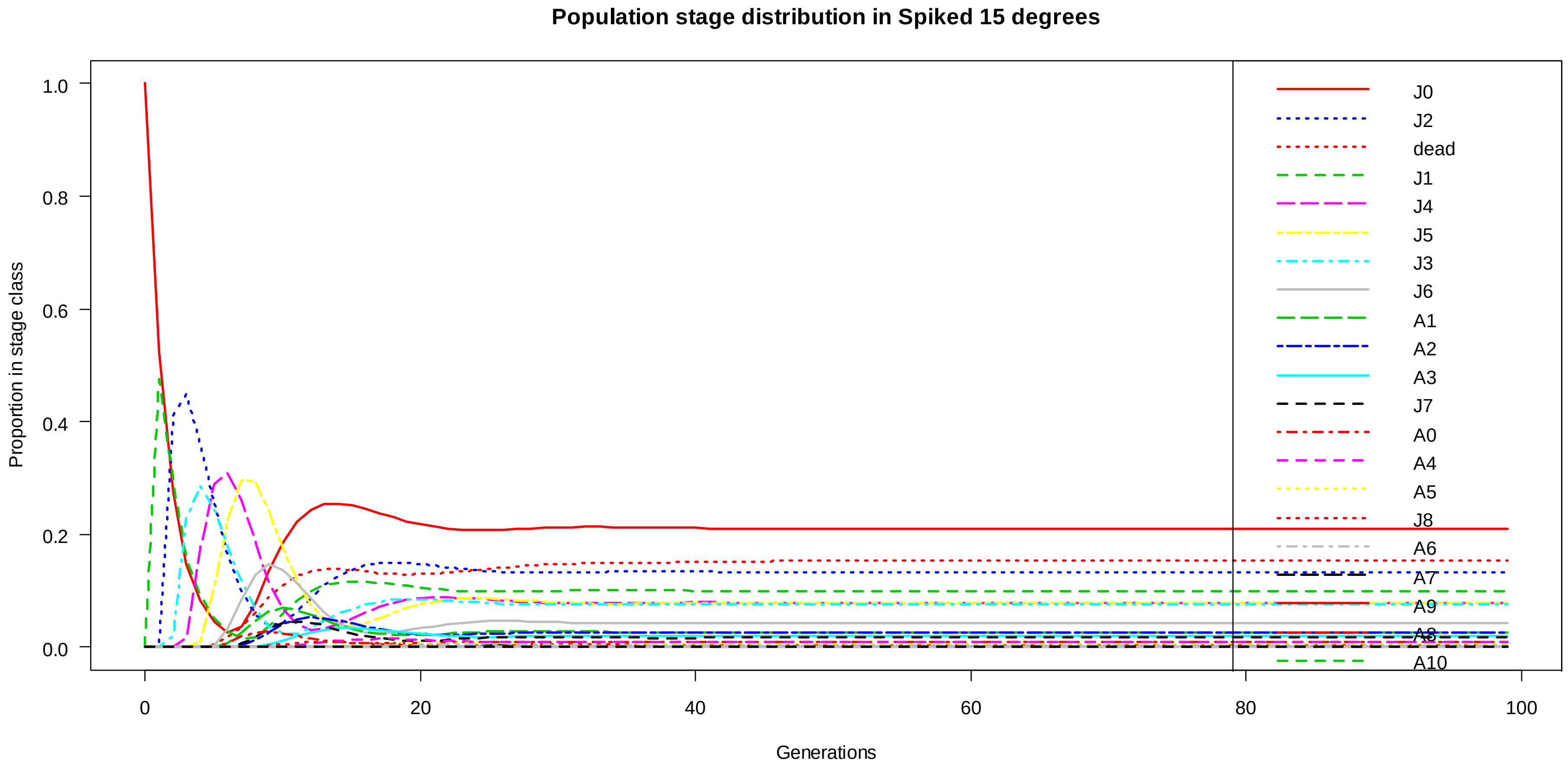


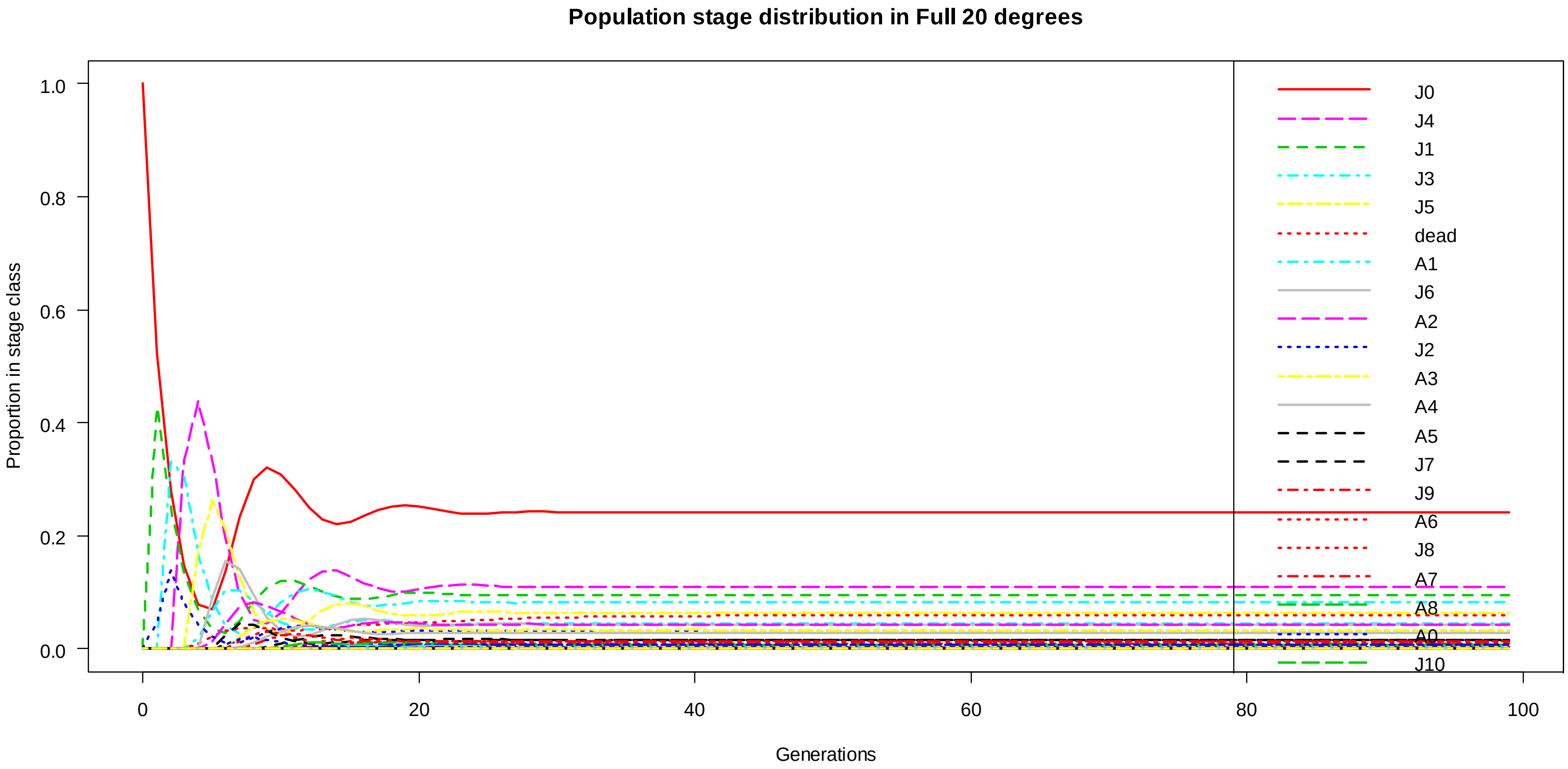
Population stage distribution in Spiked 10 degrees

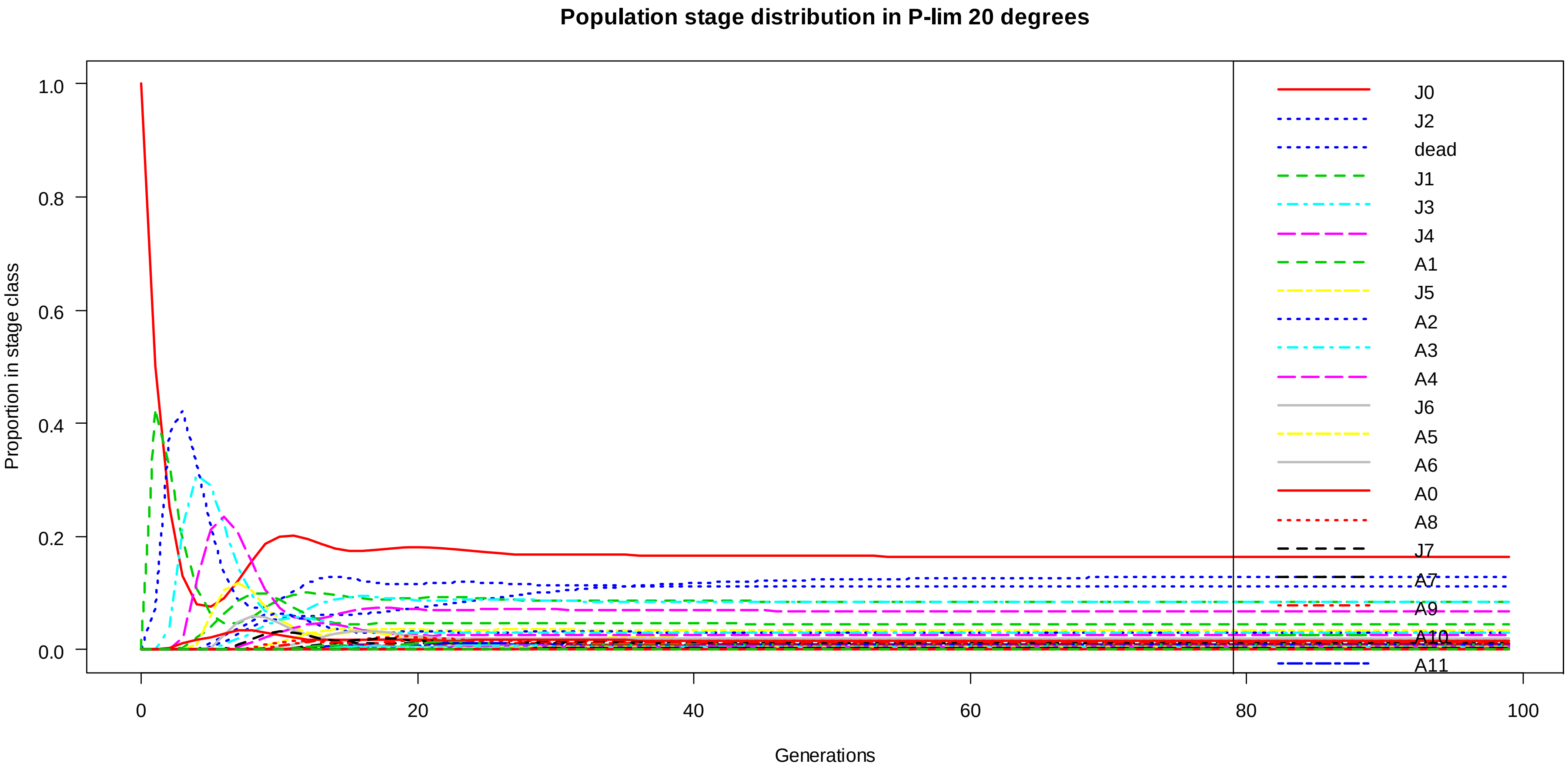


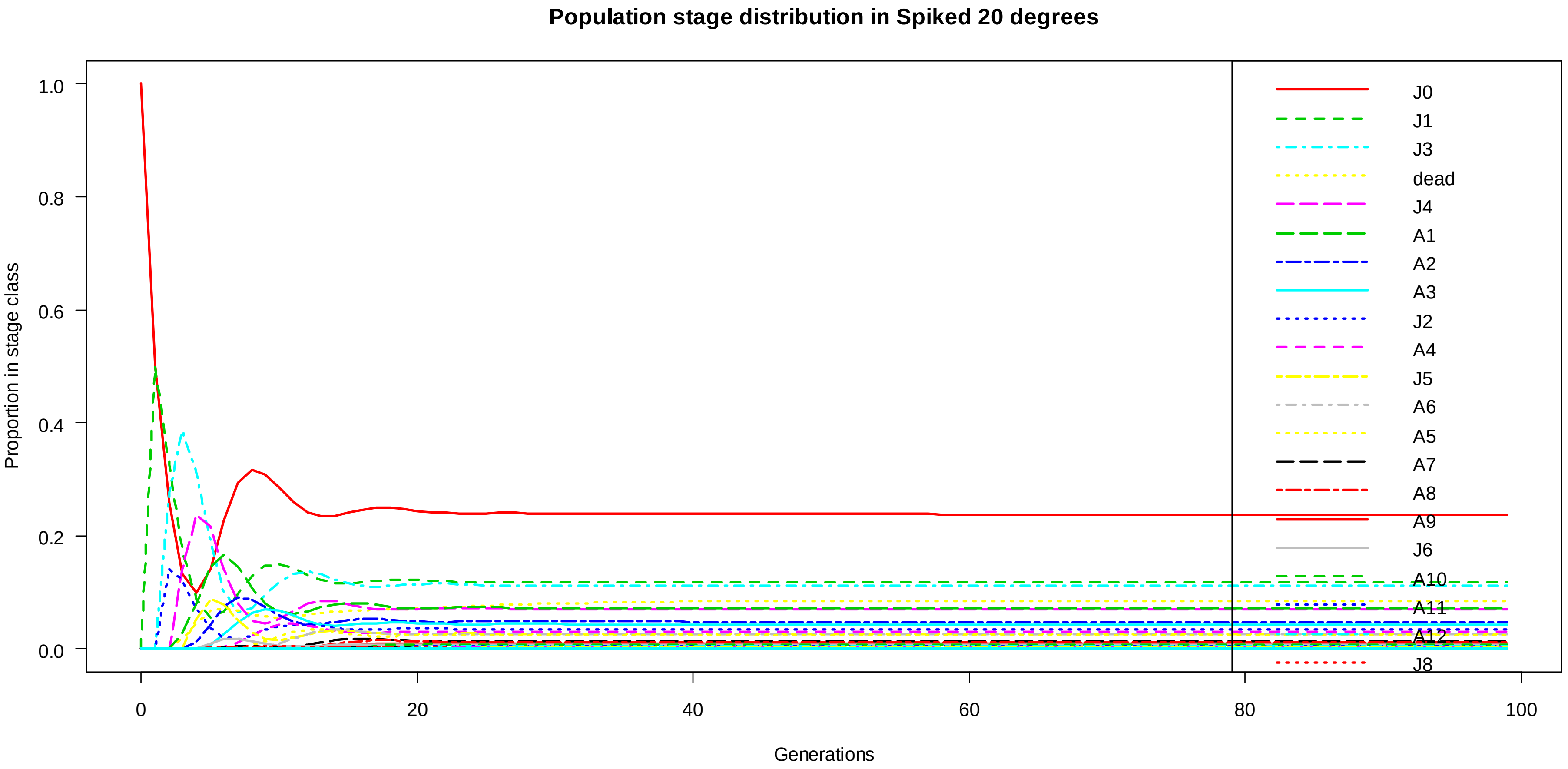
Population stage distribution in Full 15 degrees

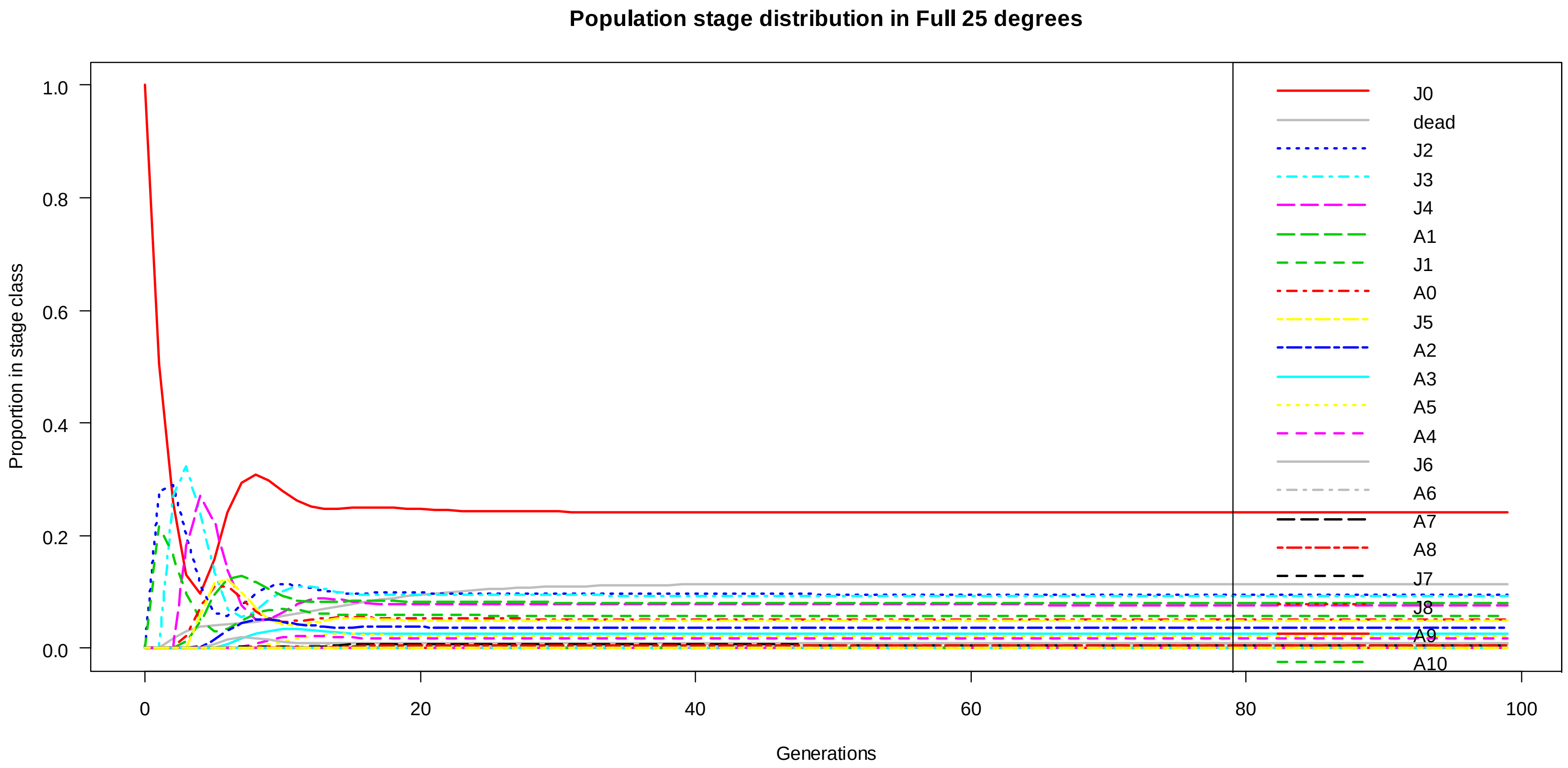

Population stage distribution in P-lim 15 degrees
Proportion in stage class
Generations
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
dead
J0
J2
J1
J3
J4
J5
J6
A2
A1
J7
A3
J8
A5
A4
A6
A7
J9
A8
A0
A9

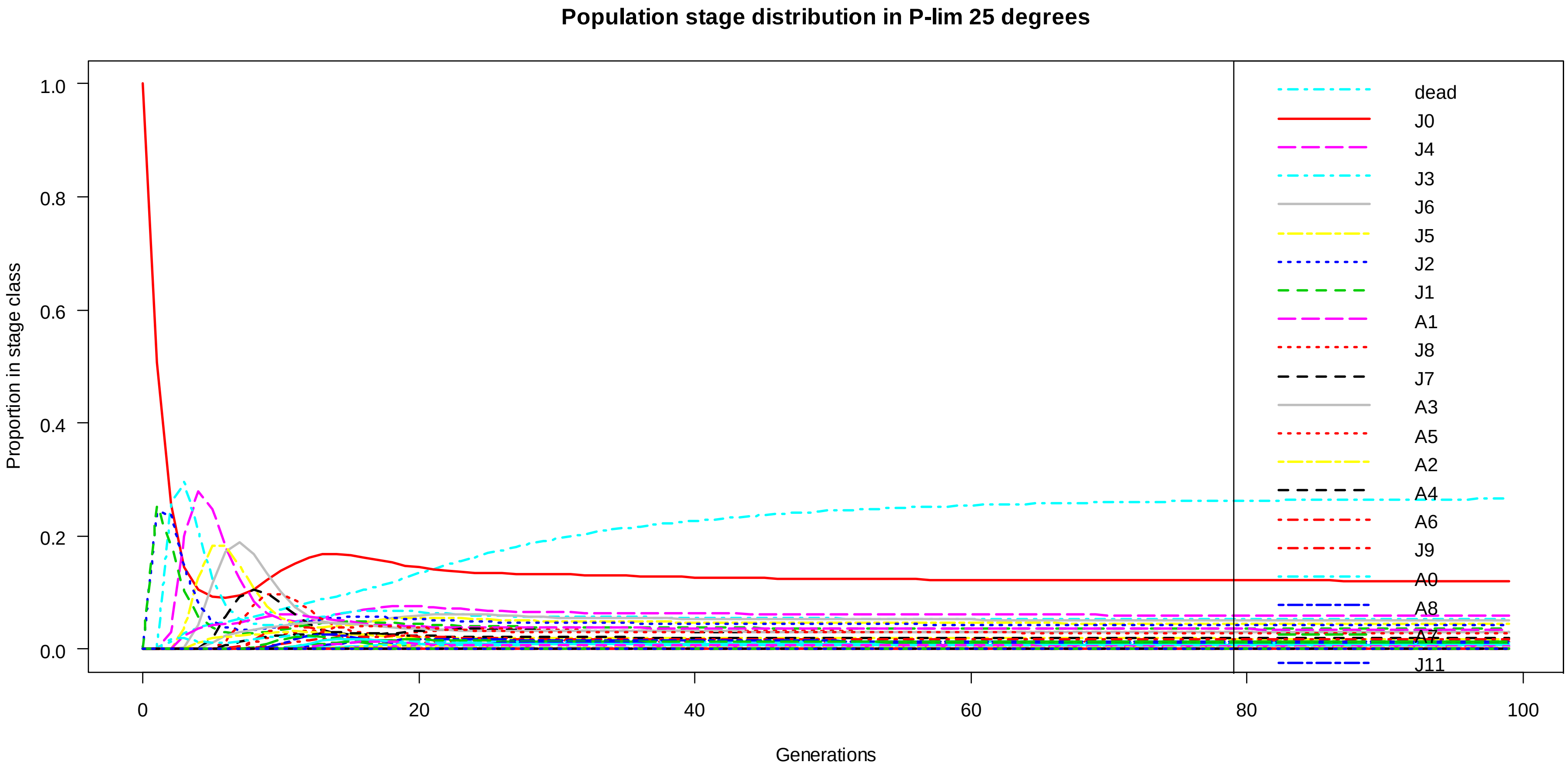

Population stage distribution in Spiked 15 degrees
Proportion in stage class
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100
Generations
J0
J2
dead
J1
J4
J5
J3
J6
A1
A2
A3
J7
A0
A4
A5
J8
A6
A7
A9
A8
A10

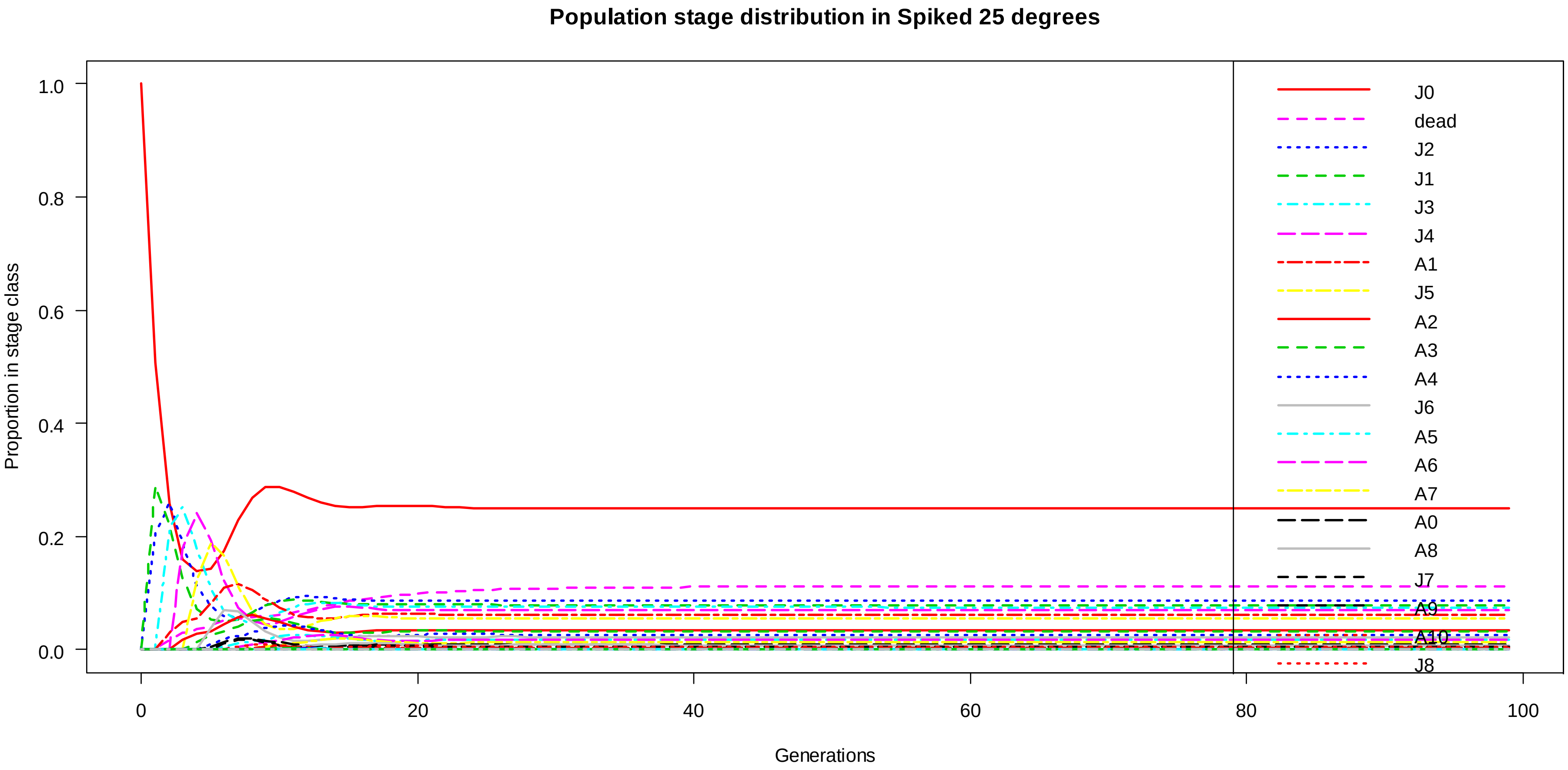

Population stage distribution in Full 20 degrees
Proportion in stage class
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Generations
J0
J4
J1
J3
J5
dead
A1
J6
A2
J2
A3
A4
A5
J7
J9
A6
J8
A7
A8
A0
J10


Population stage distribution in P-lim 20 degrees
Proportion in stage class
0.0
0.2
0.4
0.6
0.8
1.0
Generations
0
20
40
60
80
100
J0
J2
dead
J1
J3
J4
A1
J5
A2
A3
A4
J6
A5
A6
A0
A8
J7
A7
A9
A10
A11


Population stage distribution in Spiked 20 degrees
Proportion in stage class
0.0
0.2
0.4
0.6
0.8
1.0
Generations
0
20
40
60
80
100
J0
J1
J3
dead
J4
A1
A2
A3
J2
A4
J5
A6
A5
A7
A8
A9
J6
A10
A11
A12
J8


Population stage distribution in Full 25 degrees
Proportion in stage class
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Generations
J0
dead
J2
J3
J4
A1
J1
A0
J5
A2
A3
A5
A4
J6
A6
A7
A8
J7
J8
A9
A10


Population stage distribution in P-lim 25 degrees
Proportion in stage class
0.0
0.2
0.4
0.6
0.8
1.0
Generations
0
20
40
60
80
100
dead
J0
J4
J3
J6
J5
J2
J1
A1
J8
J7
A3
A5
A2
A4
A6
J9
A0
A8
A7
J11


Population stage distribution in Spiked 25 degrees