ScenarioMIP:
the three other tasks

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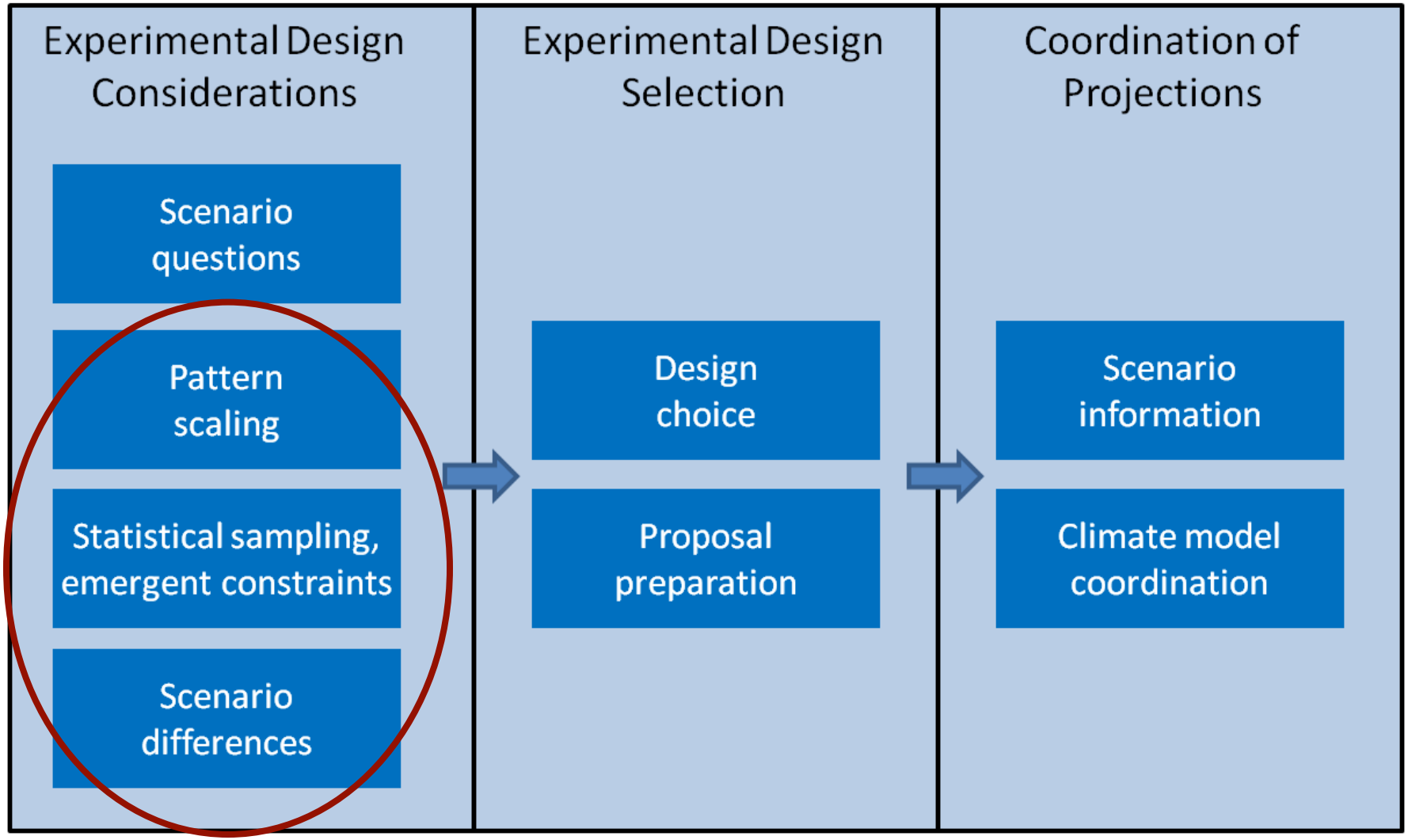
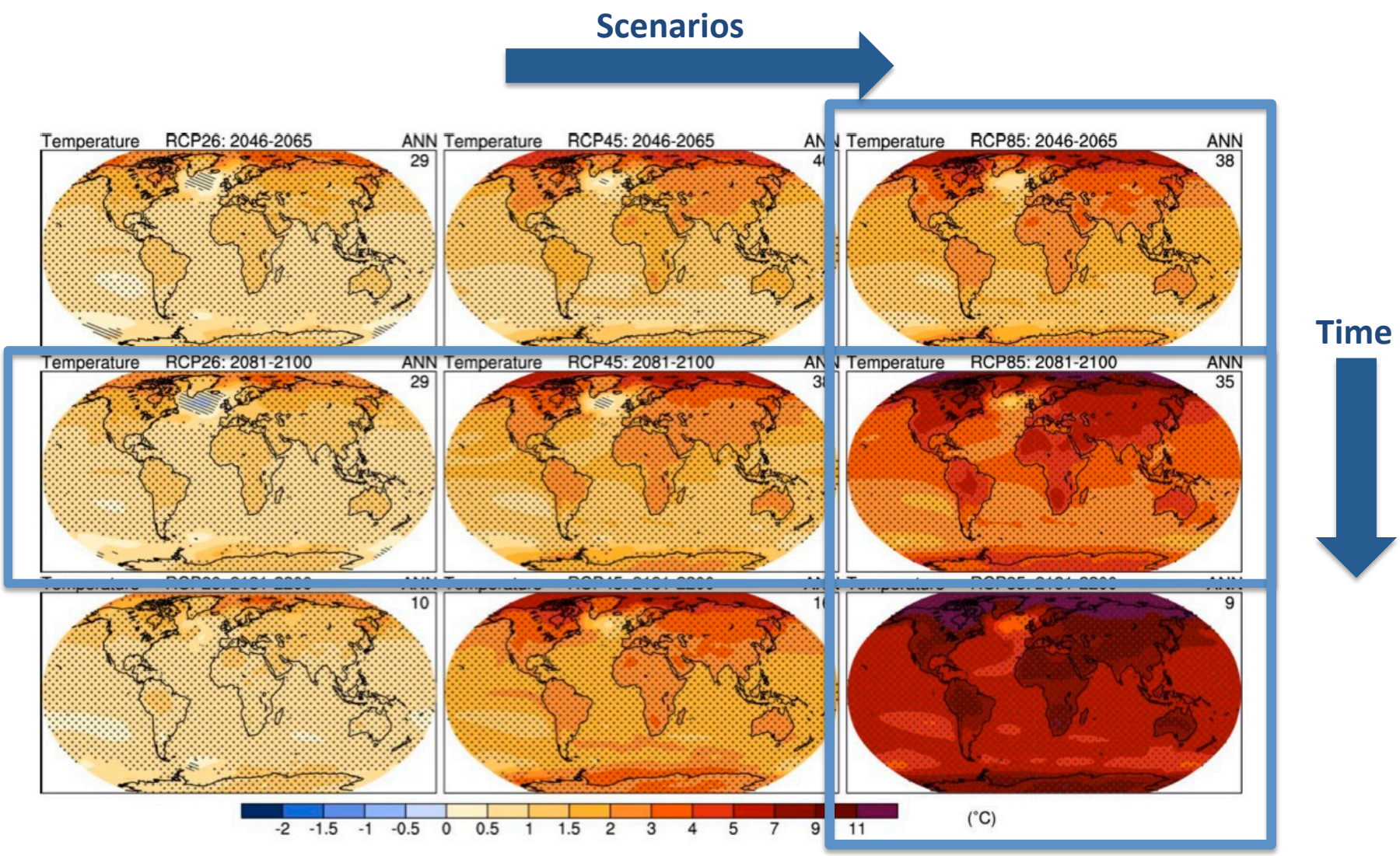
EMF
Snowmass, August 1, 2014

ScenarioMIP



Co-chairs: B. O'Neill, D. vanVuuren, C. Tebaldi

Scientific Steering Committee: P. Friedlingstein, G. Hurtt, R. Knutti, JF Lamarque, J. Lowe, J. Meehl, R. Moss, B. Sanderson.



CMIP5 multi-model ensemble means (for different time horizons and RCPs).
No pattern scaling here, but still, the similarity of patterns across time and scenarios is obvious, at least from this bird-eye view.

Pattern Scaling

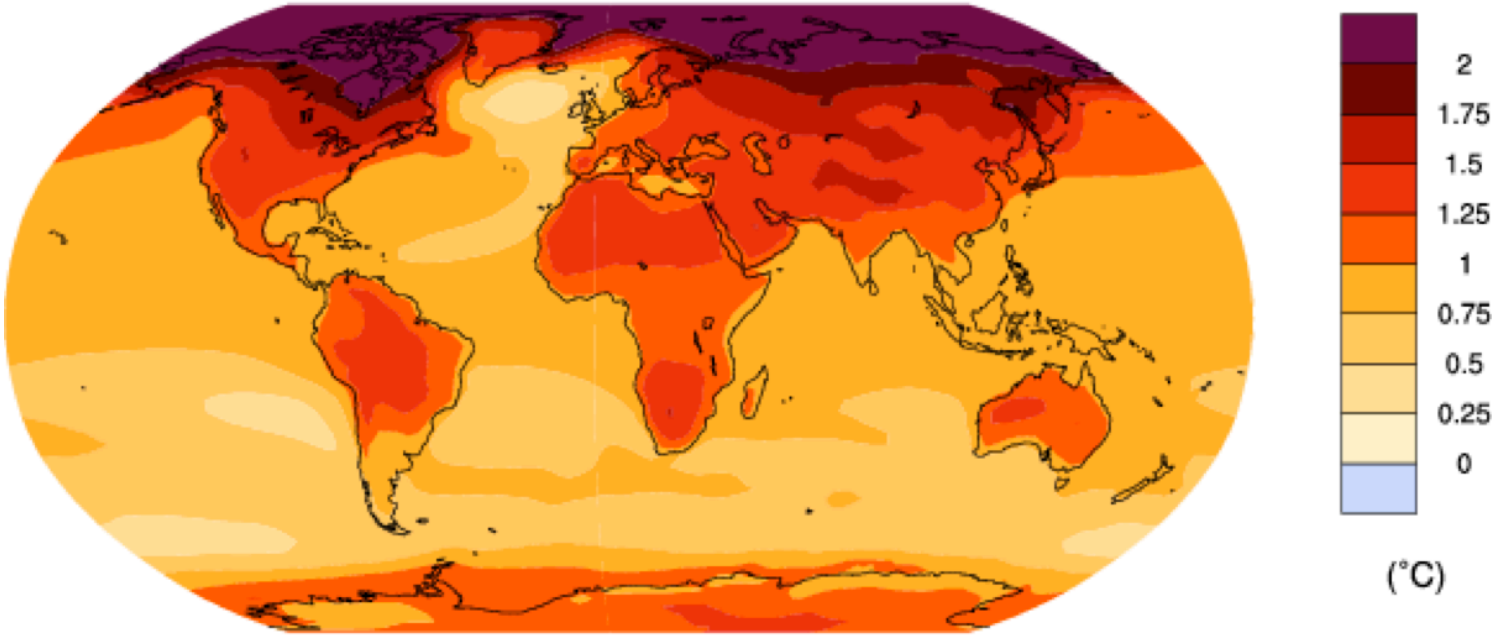
- Has been developed, tested and applied for more than twenty years now (*Santer et al. , 1990*; MAGICC-SCENGEN)

- Relies on the notion that a **robust constant geographic pattern of change** emerges as the forced response through a transient simulation, independent of the actual scenario **as long as WMGHGs are the main driving force of change**

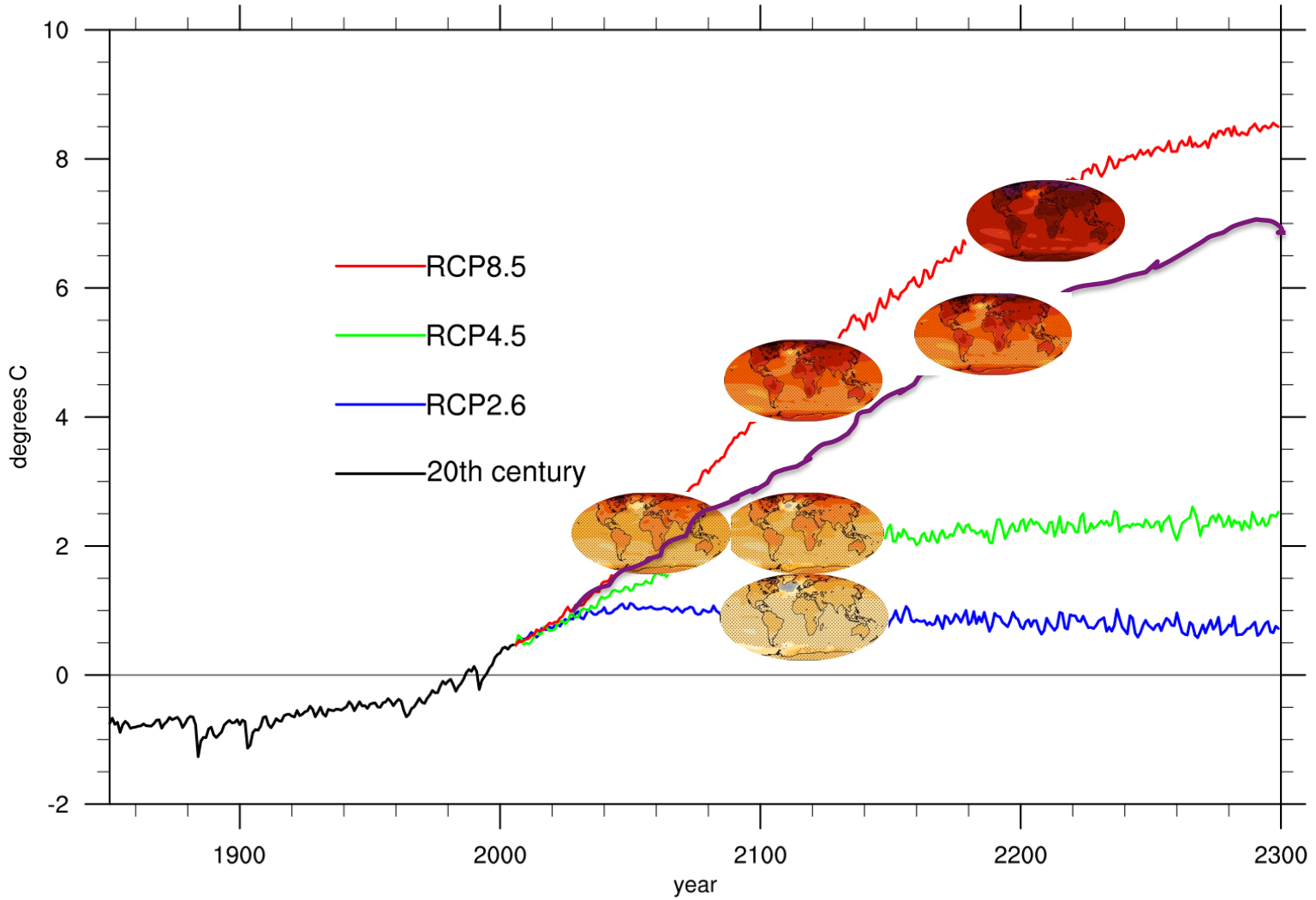
  The most significant difference, as time goes by and GHGs increase, is the **intensity of the change**, which can be well approximated as **proportional** (as in location-specific proportional) **to global average temperature increase**.

- Given the need for information under **a new scenario** the constant pattern can be rescaled by global average temperature changes under the new scenario obtained through a **simple model.**

Temperature change per 1C of global warming



Overall (ensemble mean) pattern from CMIP5



CCSM4 temperature series plot courtesy of G. Strand

Challenges

- Some variables do not vary linearly with global average temperature: e.g. sea level rise, but also precipitation in some areas.

- WMGHG are not the whole story, of course, spatially heterogeneous forcing agents complicate the picture.

- Natural variability and near-term changes.

- Workshop in Boulder April 23-25, 2014: "*Pattern scaling, climate model emulators and their application to the new scenario process*" (Brian O'Neill, James Murphy, Tim Carter and yours truly as co-chairs)

- About 60 participants from climate, statistical, integrated assessment and impact modeling areas of research.

Driving question

Can pattern scaling help us in the new scenario process by complementing ESM runs, providing the necessary information for IAV/IAM research needs?

Summary/Main Outcomes

- Pattern scaling is widely used, in particular for average temperature and precipitation inputs to impact models but hasn't been systematically validated/evaluated and falls short for variables other than those.

- Spatial and temporal scales other than "large averages"; temporal coherence; joint variable emulation; extremes remain problematic.

- Alternative emulation methods are being developed but in an ad-hoc fashion for specific variables/scales/applications, and their validation is also ad hoc. There is no easily accessible available software out there that offers emulated model output other than pattern scaling packages.

Summary/Main Outcomes

- Preliminary *survey of user needs* in terms of variables, time and spatial scales of interest was undertaken – a more comprehensive survey is under way;
- There is a *hierarchy of needs*; for some, PS/Es may suffice, but it is clear that *they cannot satisfy the whole gamut of user needs* and therefore cannot be relied upon as substitutes for climate model runs at this time.
- A systematic *review of the methodologies*, and rigorous standardized *benchmarks* for their validation are needed and we plan to undertake some of it.
- A meeting report is being finalized; a session at AGU (Fall 2014) is planned.

Statistical sampling

Addressing the design of climate model experiments with respect to both *multi-model ensemble choices* and *initial condition ensemble size*.

The multi-model ensemble

- For a while we entertained the idea of a "NARCCAP-esque" design, by which a 4 dimensional space (IAM/ SSP/RF targets/ESMs combinations) could be sparsely sampled by the participating ESMs.
- Considerations of modeling sociology and politics and – more seriously – the realization that we would not have the necessary information a priori to intelligently assign ESMs across this space made us go back to the usual design where a limited set of scenarios is recommended for all ESMs to run.

Initial condition ensemble size (sampling internal variability)

- Leave it to the modeling centers, as usual, or

- Large Ensemble Proposal: *focus large ensembles on a single scenario* (or two at most, high and low) while intermediate could be run by only one IC member.

  (Possible synergies with other MIP focusing on Large Ensembles?)

Scenario Differences

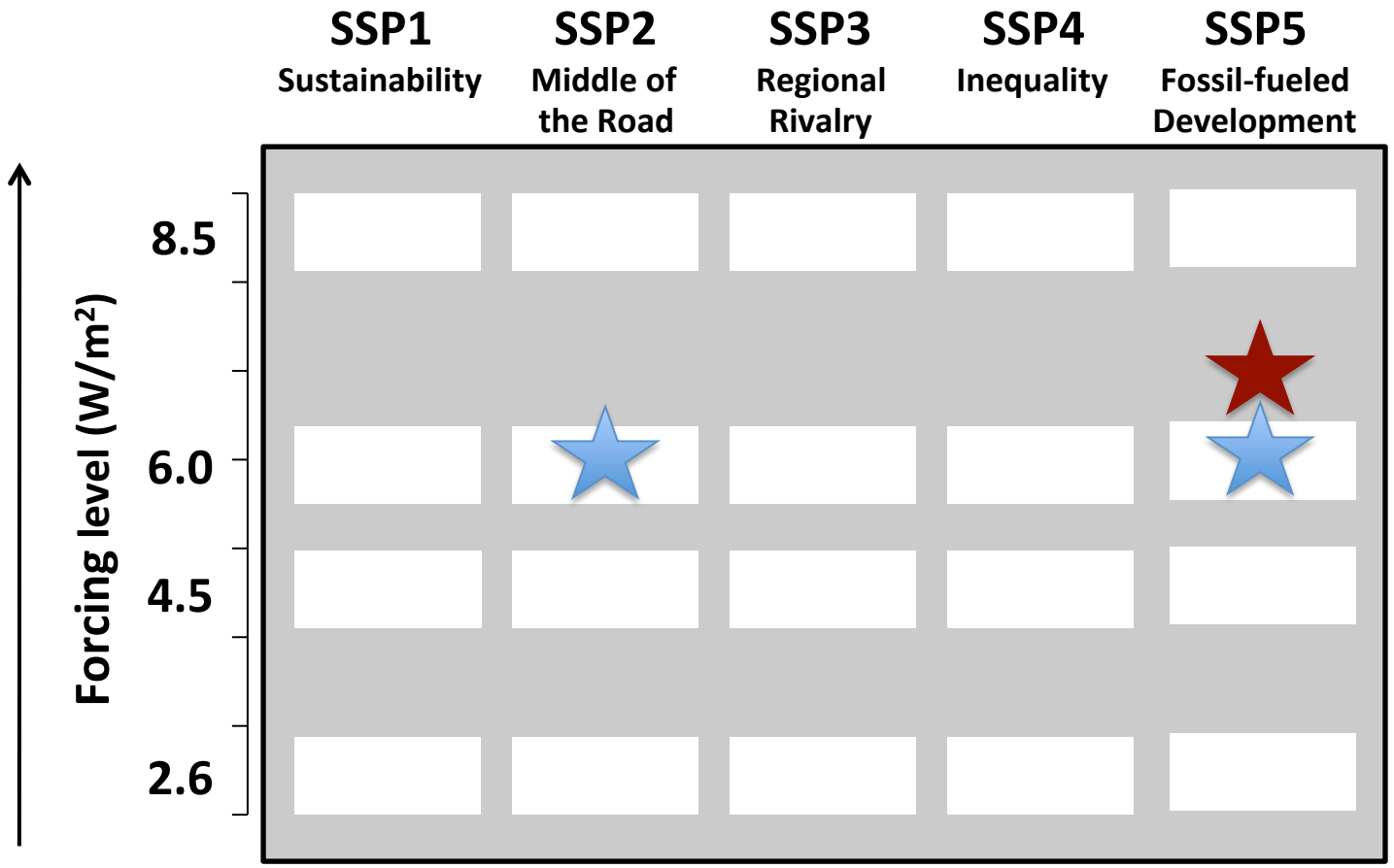
How far apart do scenarios need to be to justify running them through ESMs?

Or

When are two scenarios close enough that climate information from one can be used in place of that from the other?

- We can answer by focusing only on differences between scenarios in terms of *global characteristics* (RF, GAT).

- We should also address other relevant but thornier questions, having to do with *differences in regional forcings* (LUC, Aerosols) even under the same level of global forcing.


SSP1
Sustainability
SSP2
Middle of the Road
SSP3
Regional Rivalry
SSP4
Inequality
SSP5
Fossil-fueled Development
Forcing level (W/m²)
8.5
6.0
4.5
2.6

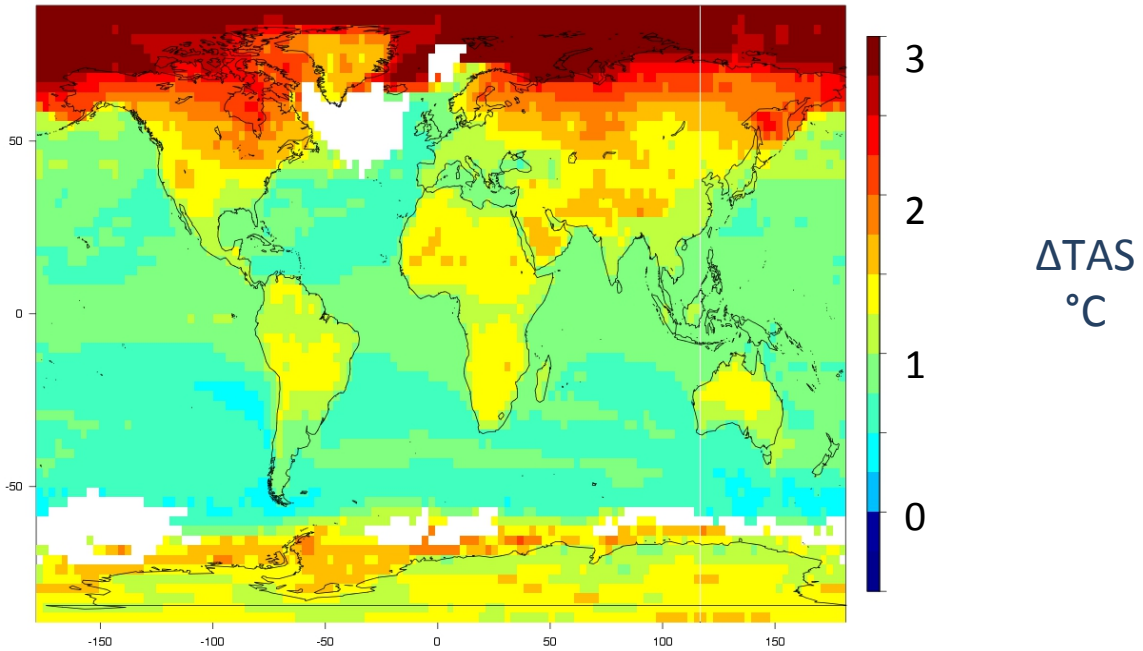
Differences in climate outcomes from differences in global characteristics

At what magnitude of change in **Global Average Temperature** or **Radiative Forcing** do we start experiencing *significant* change "on the ground"?

We have talked a lot about RFs here but actually we think that looking at GAT is more telling

What happens when ΔGAT= 1.0°C?

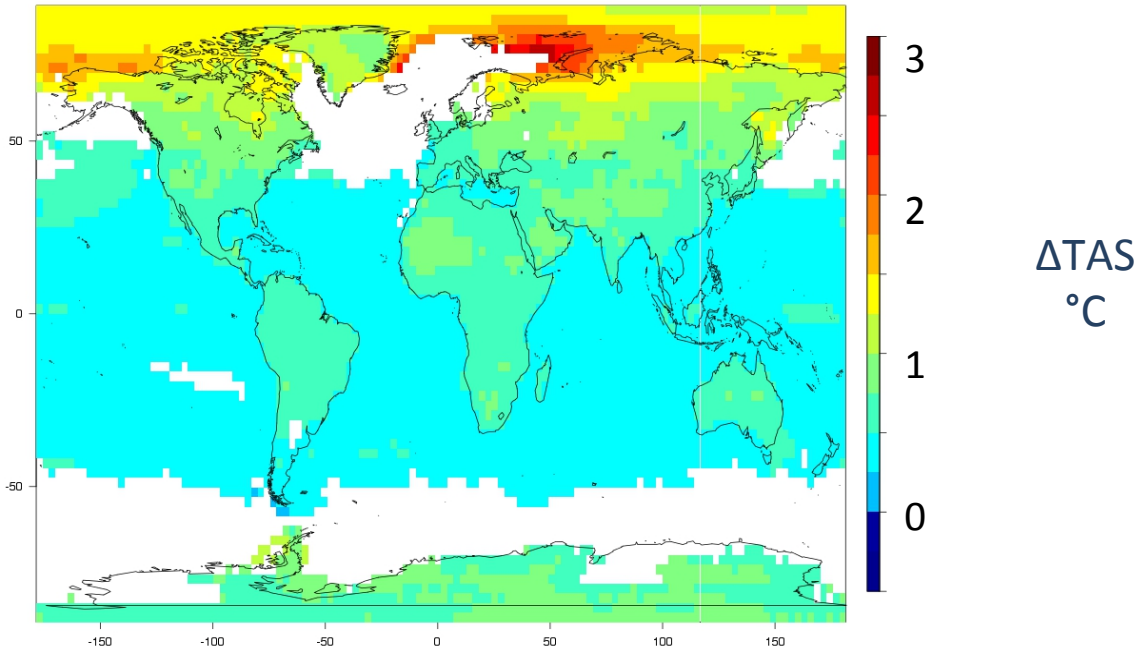
1%CO2 Experiments
Multimodel median change



Color: at least 1/2 of models say it is significant

What happens when ΔGAT= 0.5°C?

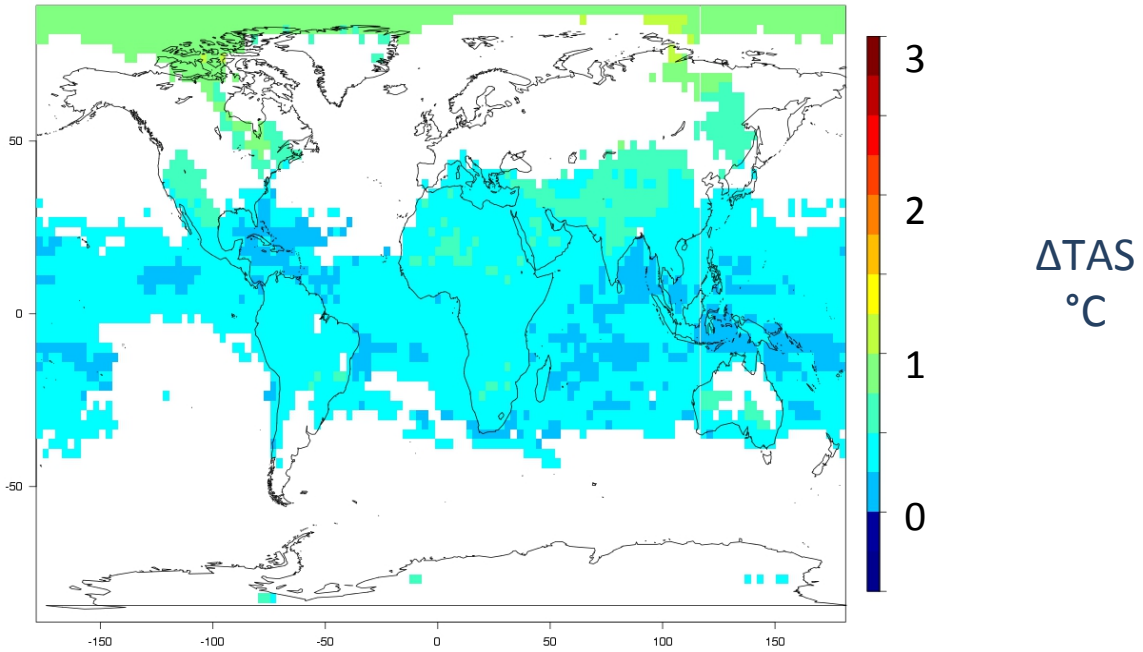
1%CO2 Experiments
Multimodel median change



Color: at least 1/2 of models say it is significant

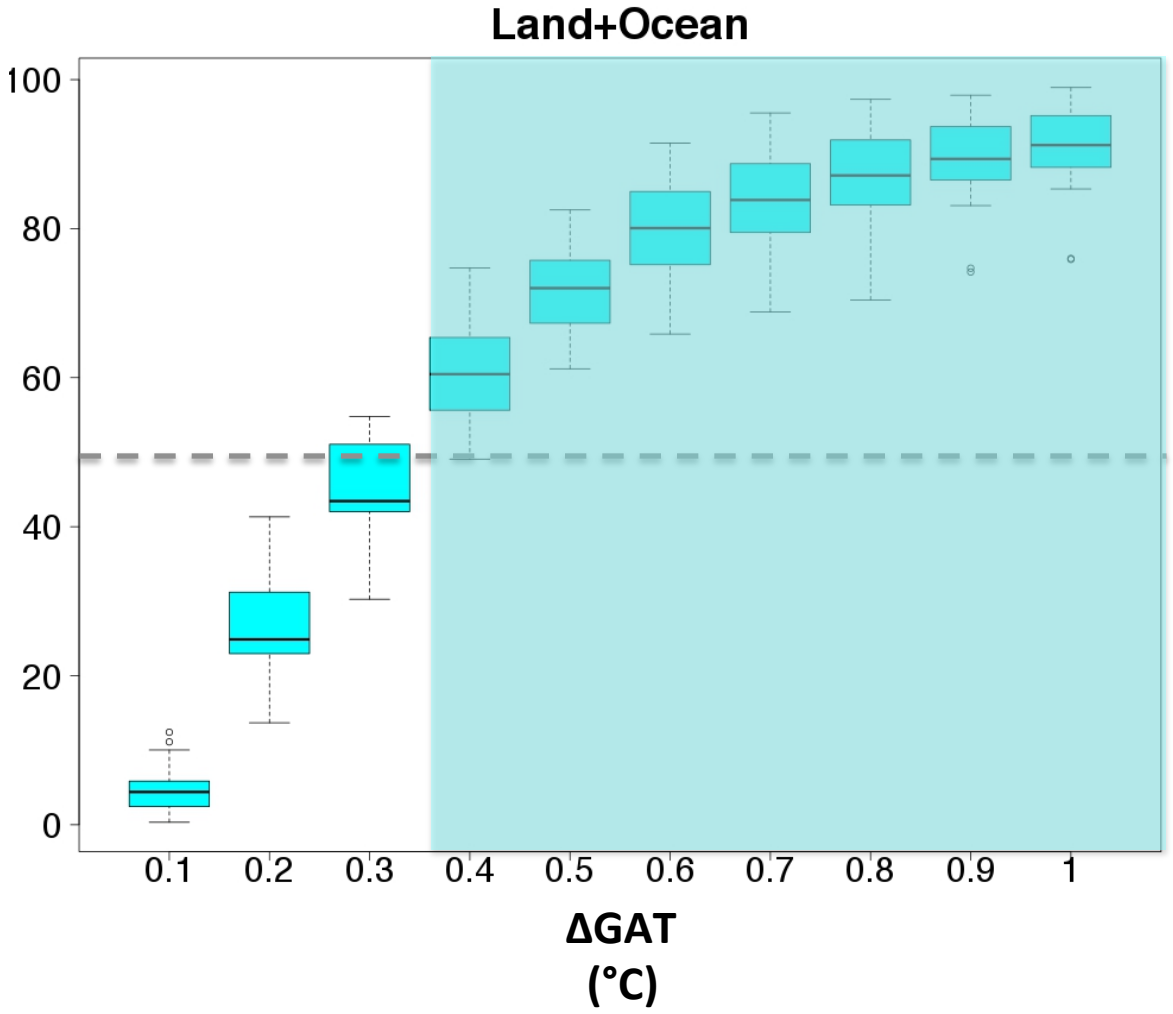
What happens when ΔGAT= 0.3°C?

1%CO2 Experiments
Multimodel median change



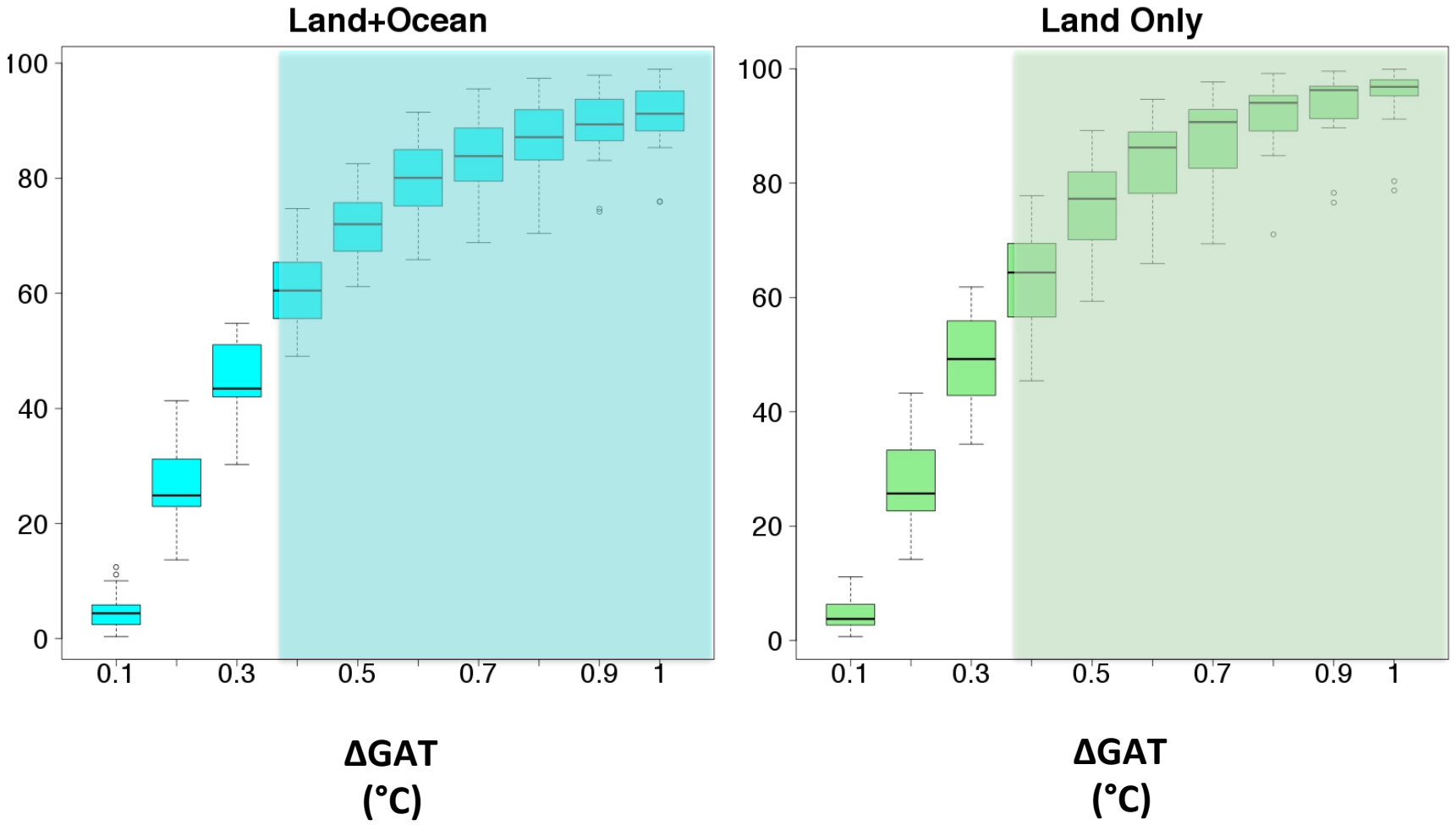
Color: at least 1/2 of models say it is significant

Percentage of grid-points showing significant change in TAS for different values of ΔGAT

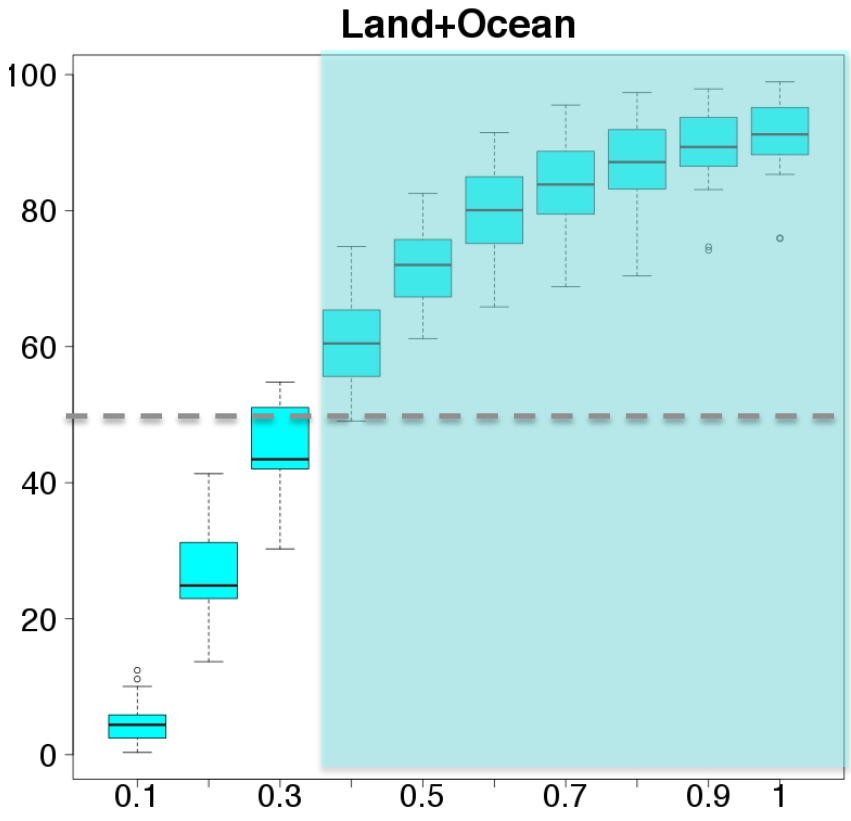


Looks like between 0.3 and 0.5C things start to get interesting

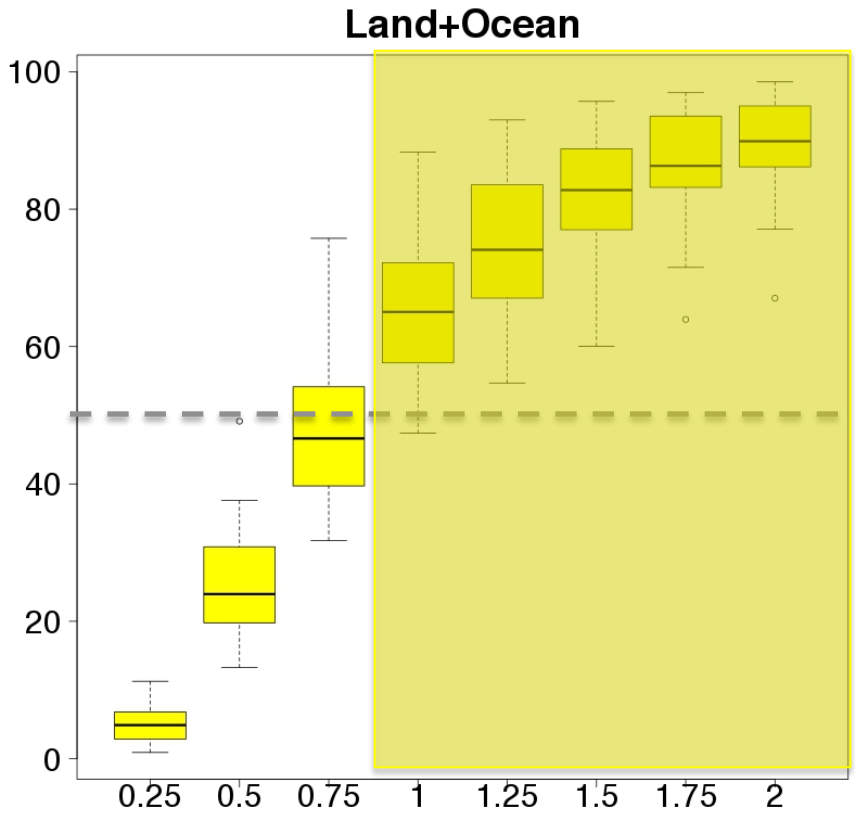
Percentage of grid-points showing significant change in TAS for different values of ΔGAT



Percentage of grid-points showing significant change in TAS for different values of ΔGAT or RF

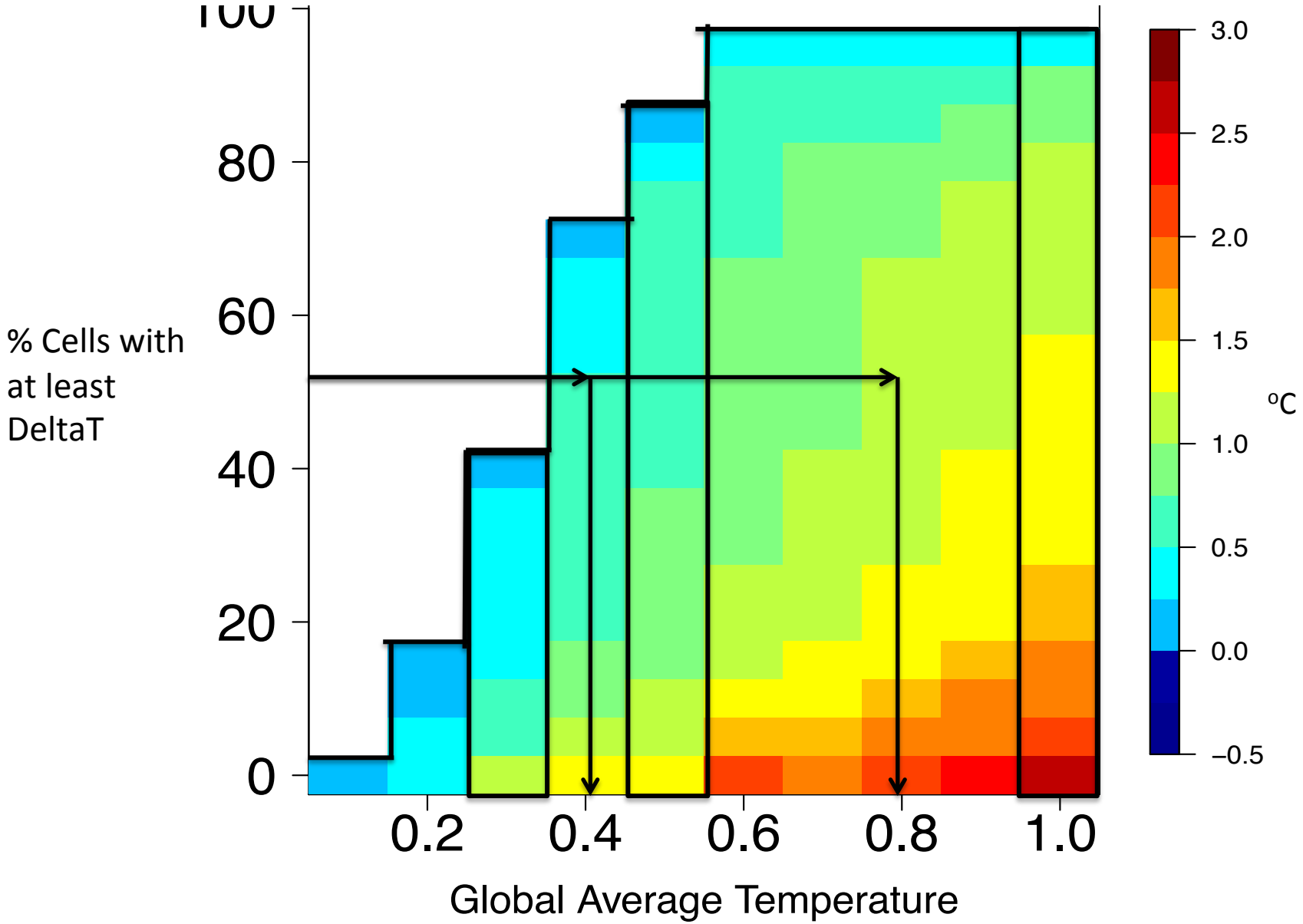


ΔGAT
(°C)

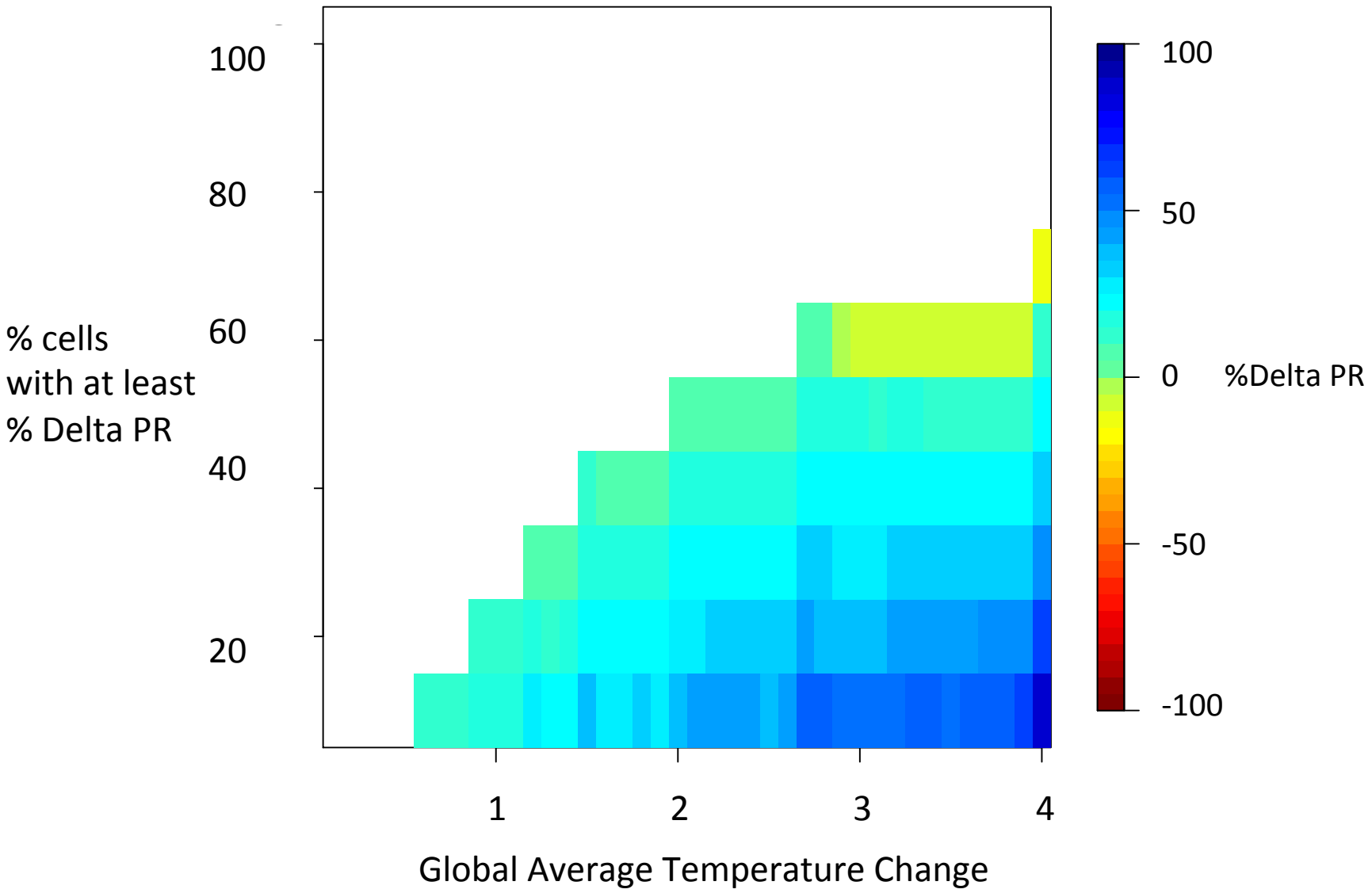


RF
(W/m²)

Temperature Changes (land-only)



Percent Precipitation changes (land-only)



Implications

Above 1°C of ΔGAT or 2 W/m^2 of ΔRF more than 80% of the surface experiences statistically significant change in temperatures.

Above 0.3°C of ΔGAT or 1 W/m^2 of ΔRF more than 50% of the surface experiences statistically significant change in temperatures.

Above 0.8°C of ΔGAT more than 50% of the surface experiences a statistically significant change in temperature of more than 1°C.

Results based on RF differences are more uncertain due to the effect of climate sensitivity and path-dependency.

Variables affected by higher noise from internal variability will show less sensitivity to ΔGAT. E.g., Precipitation changes are significant over only about 30% of cells for a change of 1°C.

Differences in climate outcomes from differences in regional forcings

- Lack of experiments available to systematically address the question
- We plan to collaborate with AerChemMIP and LUMIP to identify useful idealized experiments in order to explore these sensitivities

  (AGCI session next week, stay tuned!)