

More accurate quantification of model-to-model agreement in externally forced climatic responses over the coming century

Nicola Maher
Scott Power and Jochem Marotzke

18/02/2020



Quantifying uncertainty

- ▶ Important to understand why our model projections differ
- ▶ Projections can differ for three reasons:
 - ▶ Structural model differences
 - ▶ Internal variability
 - ▶ Scenario choices
- ▶ Magnitude of each type of uncertainty depends on the variable, timescale and location (e.g Hawkins and Sutton, 2009)
- ▶ Quantifying uncertainty is complicated by the fact that models are not independent - share components and code

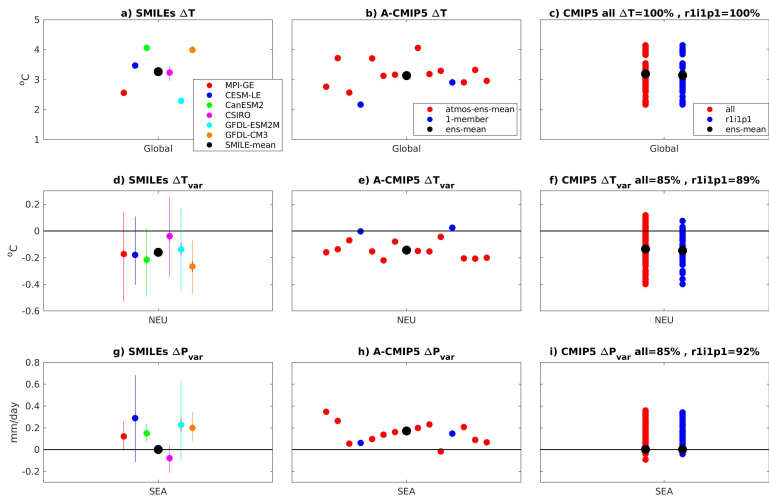
Outline

1. Introduce the method
2. Quantify the relative magnitude of internal variability and model-to-model differences in causing uncertainty in long-term projections of temperature, precipitation, and their temporal variability
3. Assess model-to-model agreement over the tropical Pacific

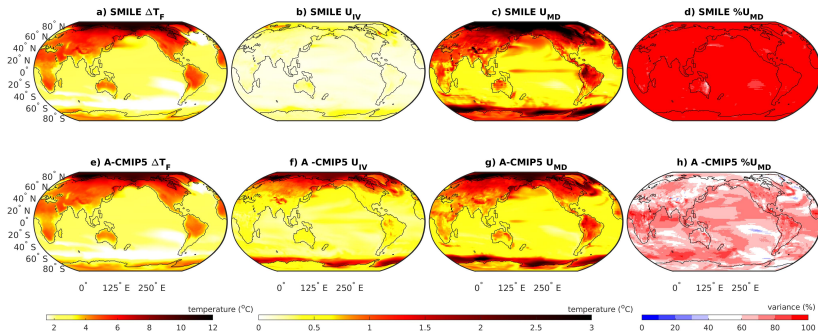
Methods

- ▶ Look at projections from 2050-2099 (RCP8.5) as compared to 1950-1999 (historical)
- ▶ 6 Single Model Initial-Condition Large Ensembles (SMILEs; Deser et al, 2020)
- ▶ CMIP5 sub-ensembles - share the atmospheric component
- ▶ Uncertainty due to internal variability = average of internal variability from each ensemble
- ▶ Uncertainty due to model differences = spread of ensemble means
- ▶ Forced response in each SMILE = ensemble mean

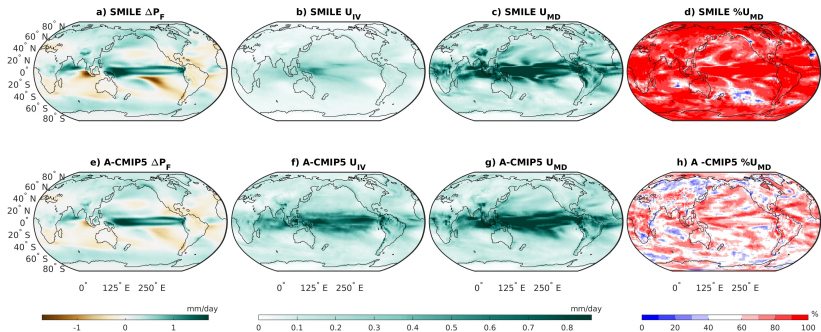
Method - what do we gain?



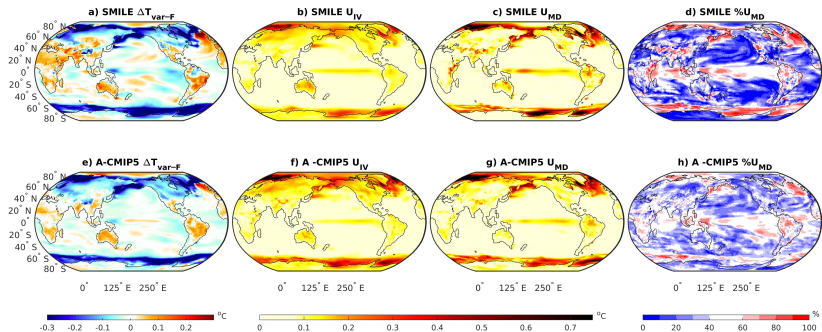
Mean-state temperature projections



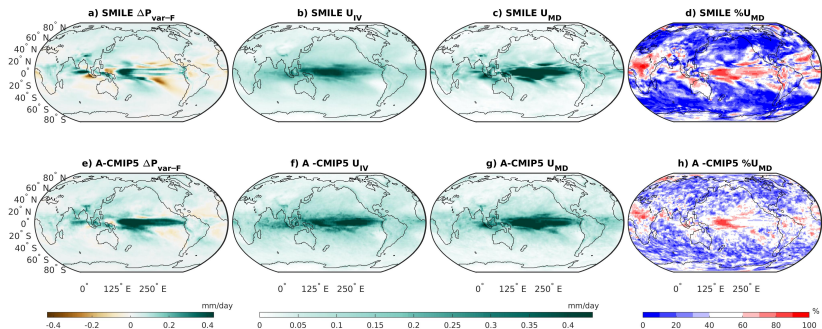
Mean-state precipitation projections



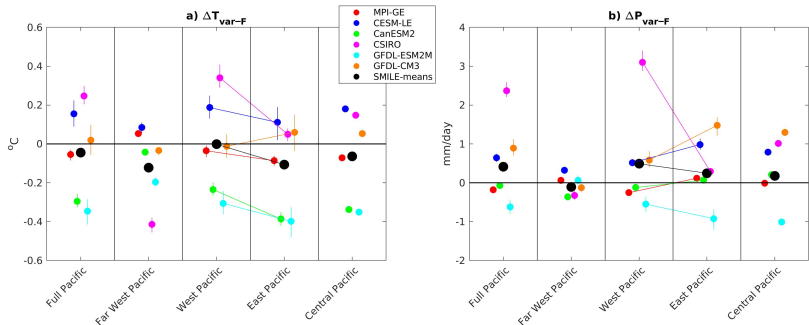
Temporal temperature variability projections



Temporal precipitation variability projections



Agreement in the tropical Pacific - DJF



Conclusions

- ▶ Grouping CMIP5 models that share an atmospheric component provides a reasonable estimate of SMILE results
- ▶ Model-to-model differences are larger than internal variability globally for temperature and precipitation
- ▶ For both temporal temperature and precipitation variability internal variability is larger than model-to-model differences in the extratropics
- ▶ Tropical Pacific still shows large model-to-model disagreement in projections of temporal temperature variability and western Pacific temporal precipitation variability

Implications

- ▶ SMILEs are powerful tools for quantifying internal variability and investigating model-to-model agreement
- ▶ Where model differences dominate improving our understanding we can decrease spread of projections
- ▶ Where internal variability is larger than model differences improving the models may not decrease the spread of projections
- ▶ More work is needed in understanding tropical Pacific projections
- ▶ Just because the models agree on the sign of the change does not mean that they will agree on the magnitude of the change

Publication:

- ▶ *Maher, N., Power, S.B. Marotzke, J. More accurate quantification of model-to-model agreement in externally forced climatic responses over the coming century. Nat Commun 12, 788 (2021). <https://doi.org/10.1038/s41467-020-20635-w>*

What now? - Investigating how Pacific Decadal Variability modulates ENSO teleconnections in SMILEs

Contact: nicola.maher@colorado.edu

