A Statistical Analysis of Model Simulated Extreme Temperature and Precipitation Indices

Investigation of Minimum Number of Ensemble Members

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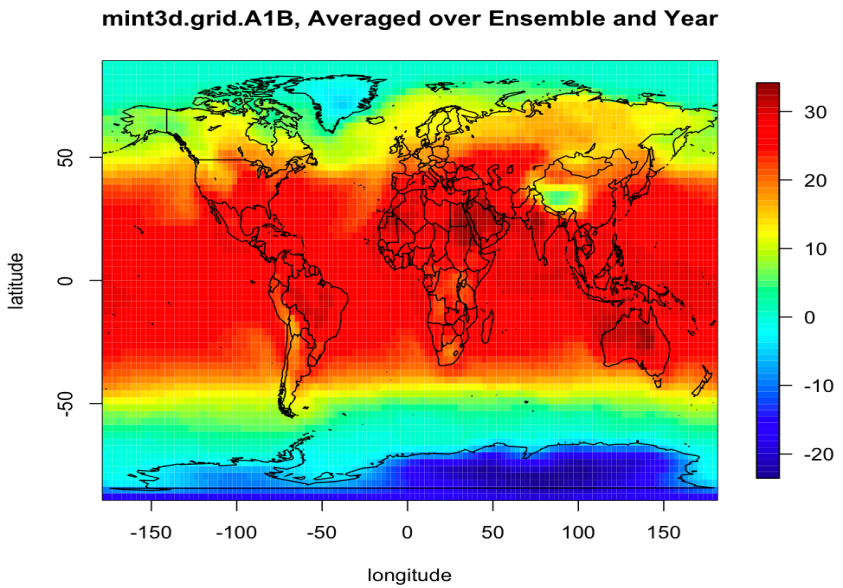
Getting to know the Data...

The Indices

- What do you mean "extreme"?
  - "It's very hot/cold"
  - "It rained a lot/very little"
- Analyzed across the globe
- 40 ensemble members
  - Different initial conditions
- Years: 2000-2060
- 2 emission scenarios
  - A1B and Commit

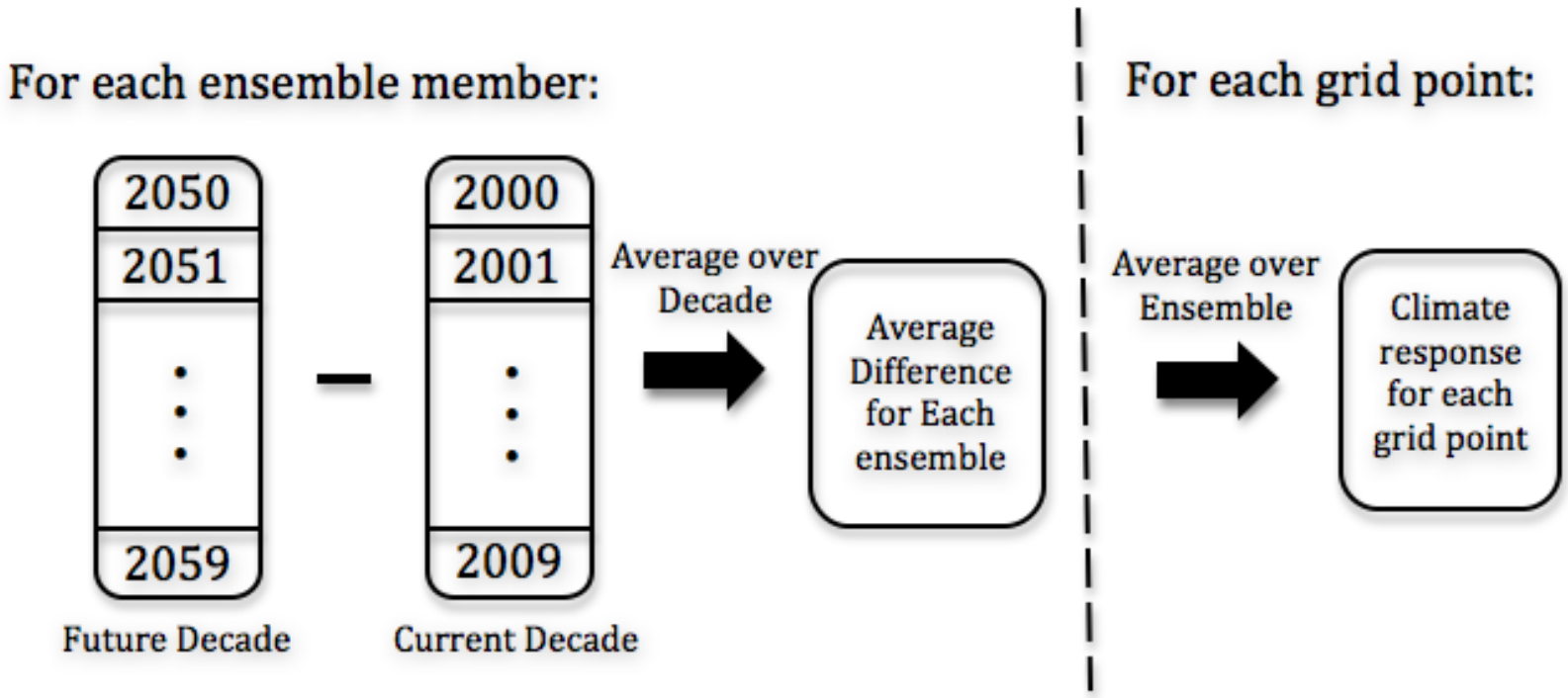


Indice	Type	Definition	Units
mint3d	Temp	Hottest min. temp., three day	°C
hwdi	Temp	Heat wave duration index	Days
sdii	Precip	Simple daily intensity index	$\frac{mm}{day}$
cdd	Precip	Consecutive dry days	Days

Getting to know the Data...

Measuring a Climate Response

- Climate response: Decadal difference
  - (future decade response) - (current decade response)
  - averaged over decade and ensemble members



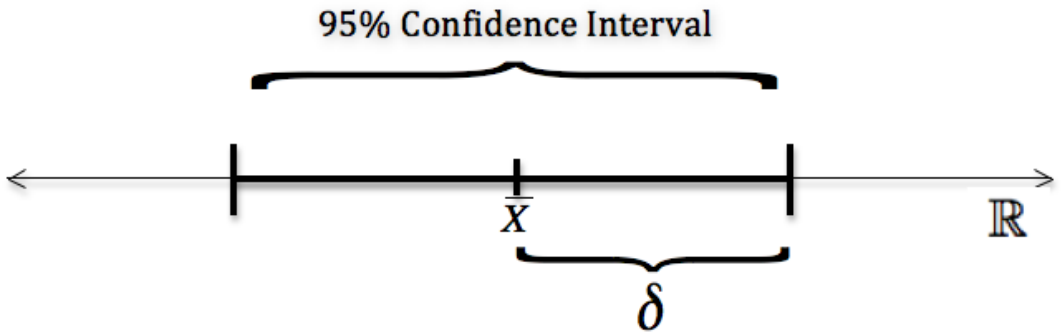
Minimum Number of Ensemble Members

The Idea: Confidence Intervals

- Question: How many ensemble members do we need to show a certain statistical significant difference?
  - Ensemble members are computationally expensive

- The Approach:
  - Confidence Interval Definition:
    - Approximate 95% confidence interval

$$\underbrace{\overline{X}}_{\text{Average Decadal Difference}} \pm \underbrace{2\sigma/\sqrt{n}}_{\text{Margin of error, } \delta}$$



Minimum Number of Ensemble Members

Definition

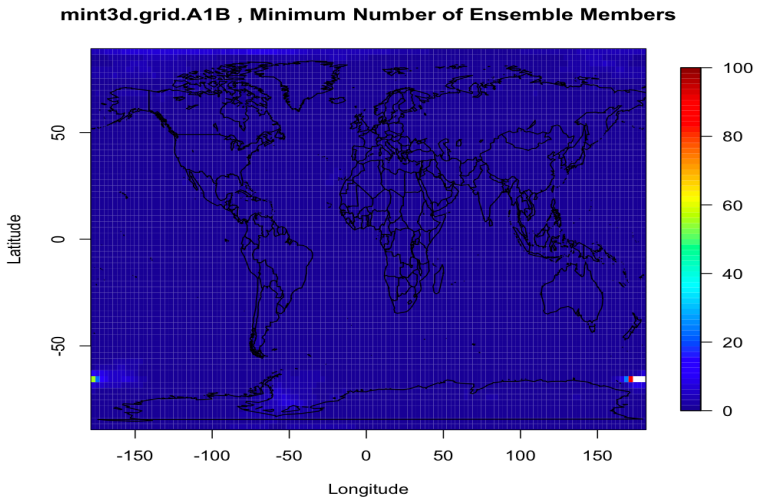
$$\delta = \frac{2\sigma}{\sqrt{n}} \Rightarrow n_{\min} = \frac{4\sigma^2}{\delta^2}$$

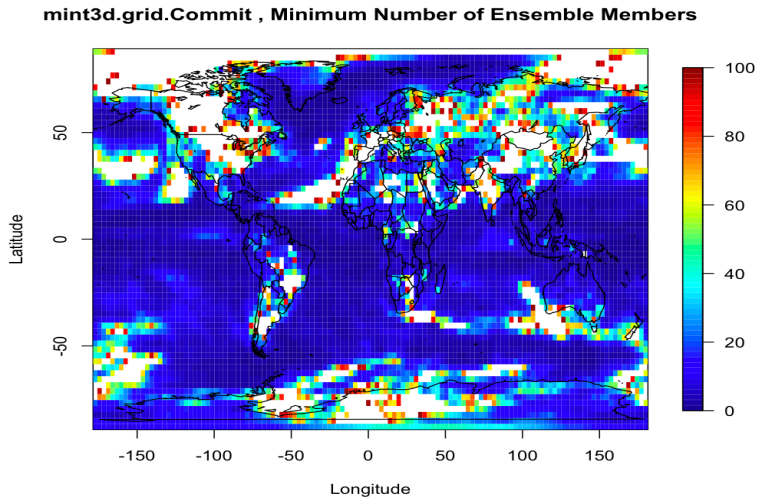
Two methods for choosing δ:

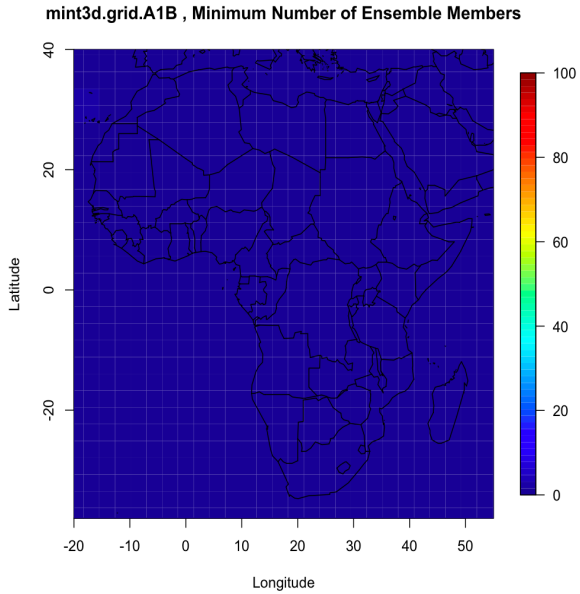
1. Let δ be the observed average decadal difference
2. Let δ be a chosen constant value

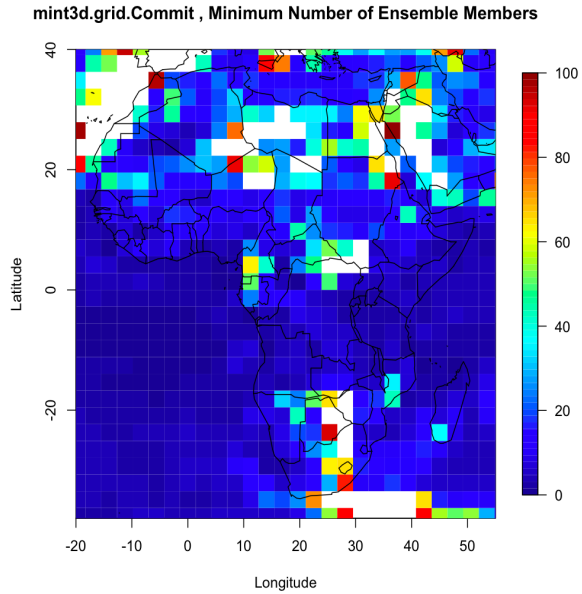
Minimum Number of Ensemble Members: Temperature

Method 1



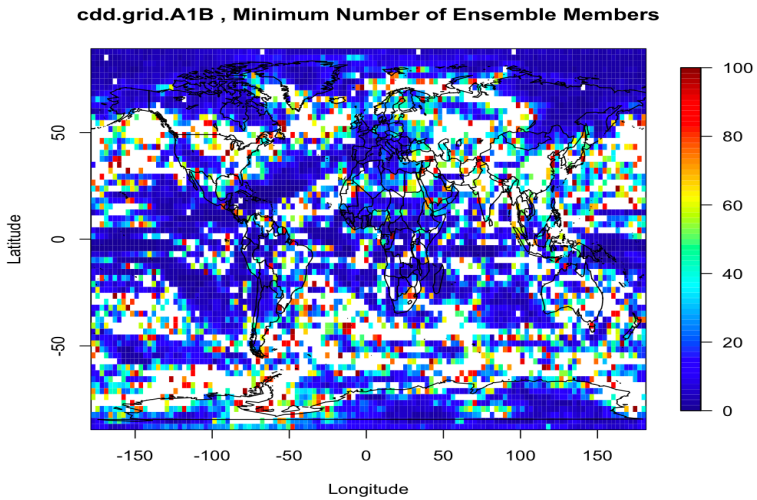


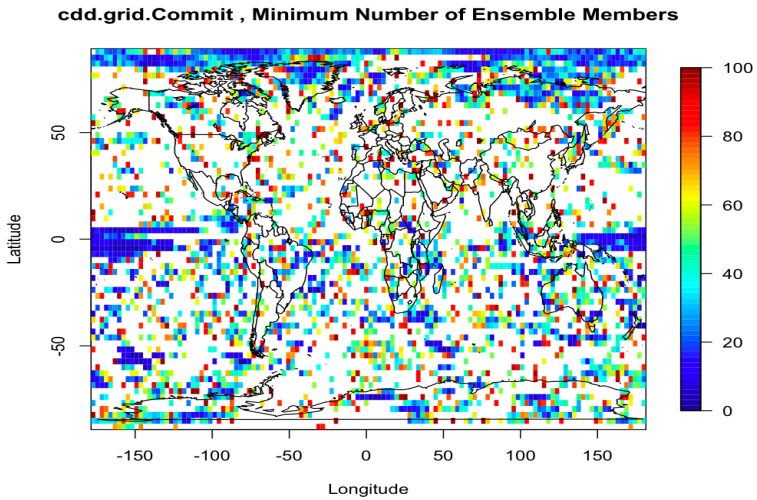


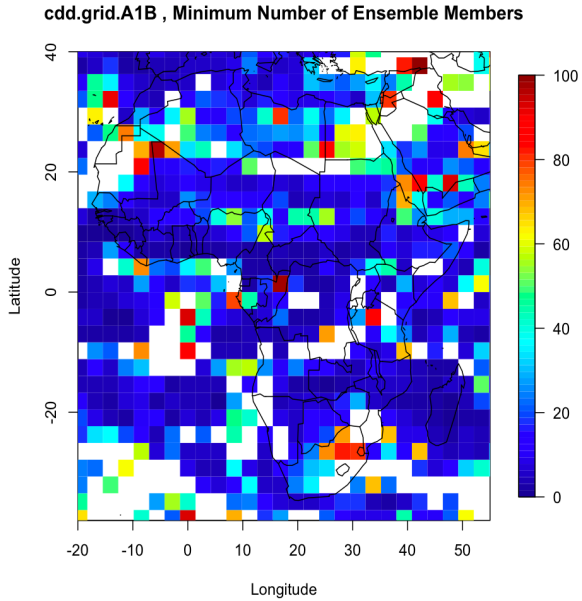


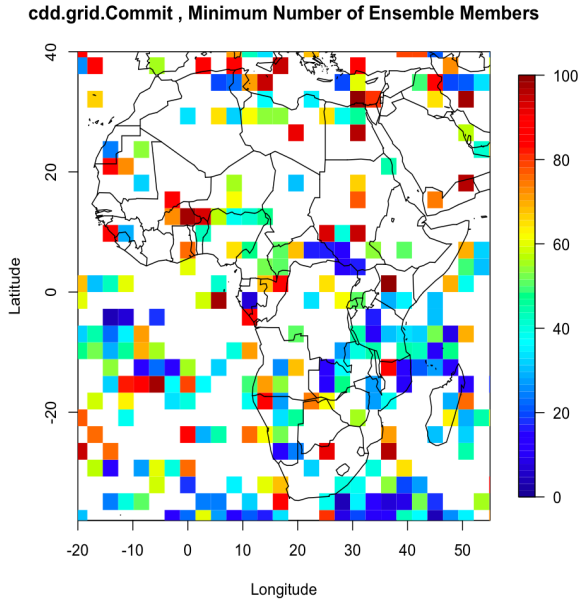
Minimum Number of Ensemble Members: Precipitation

Method 1









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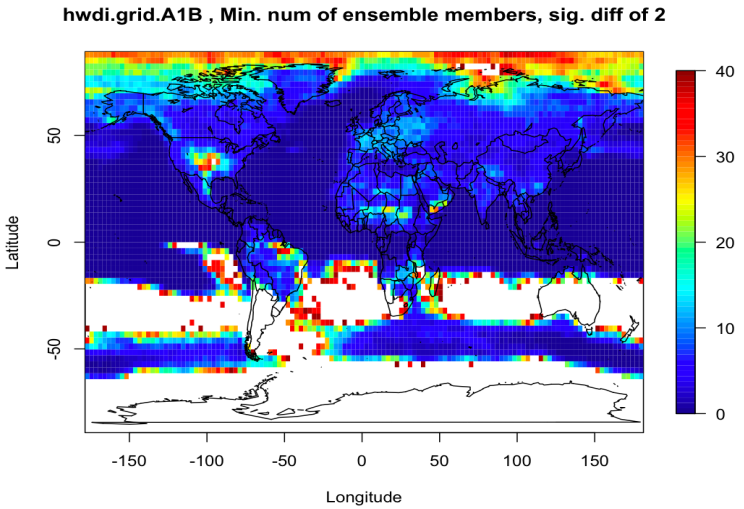
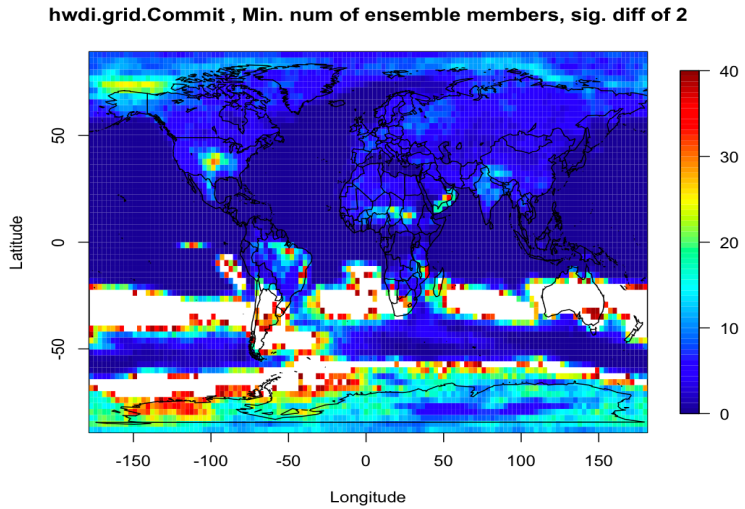
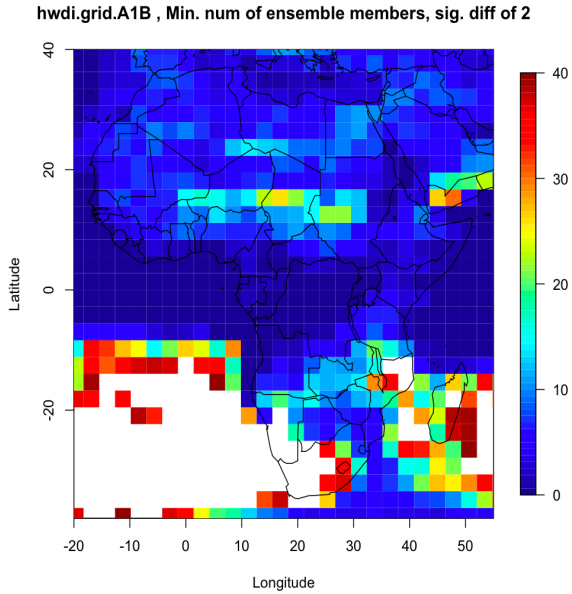
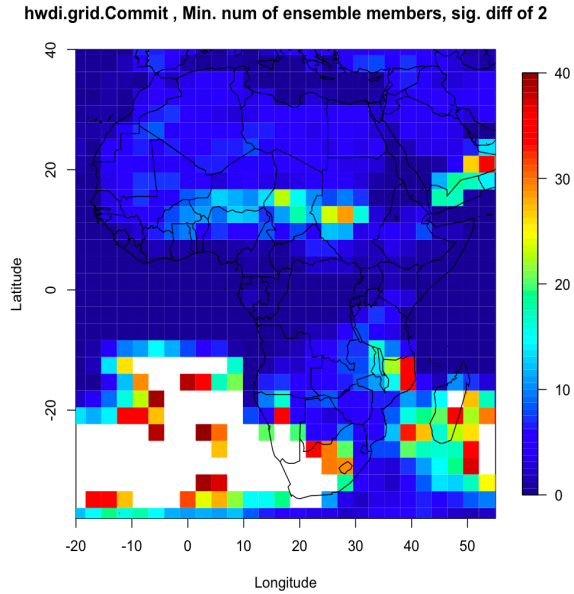
Minimum Number of Ensemble Members: Temperature

Method 2



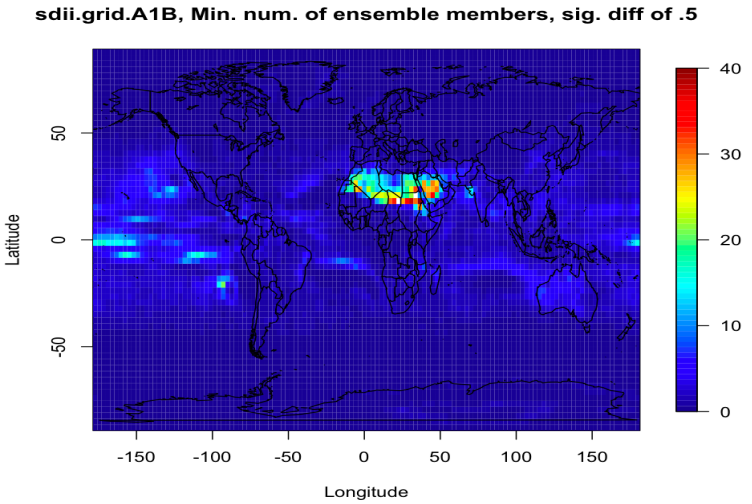


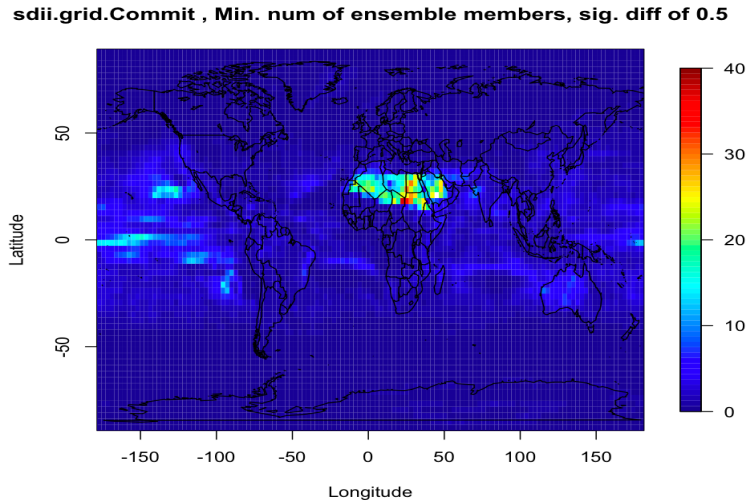


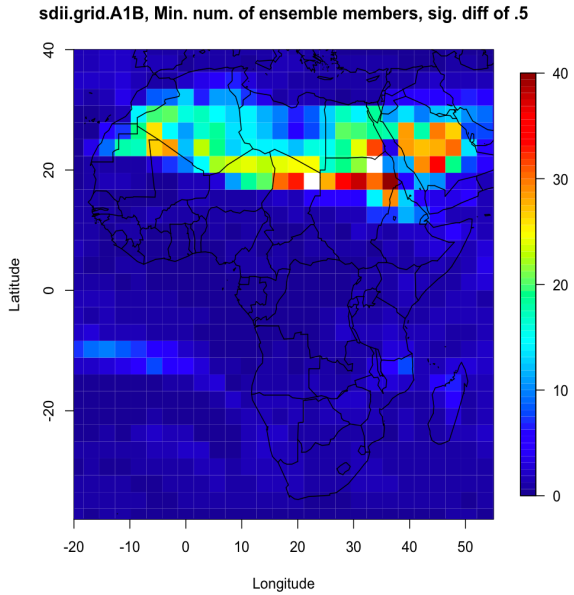


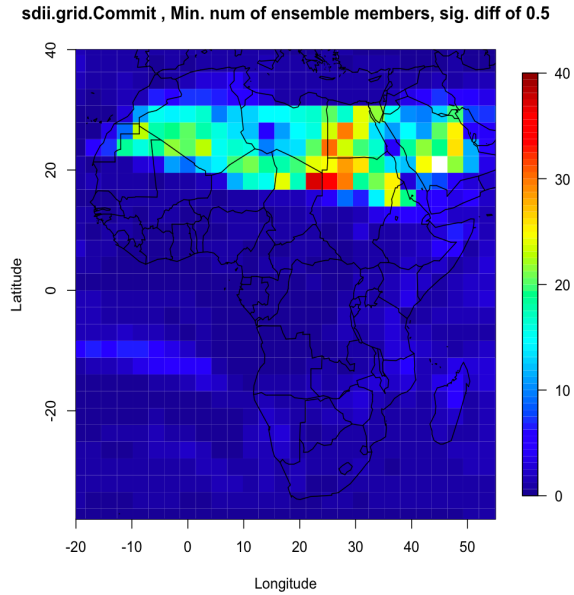
Minimum Number of Ensemble Members: Precipitation

Method 2 *







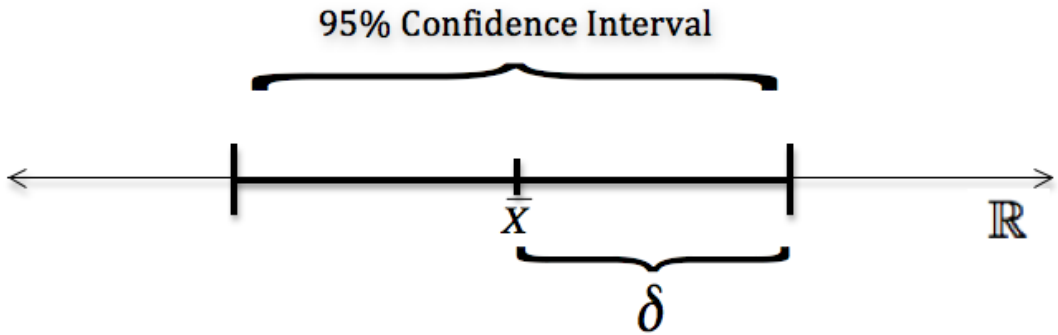


*Ensemble 23 excluded

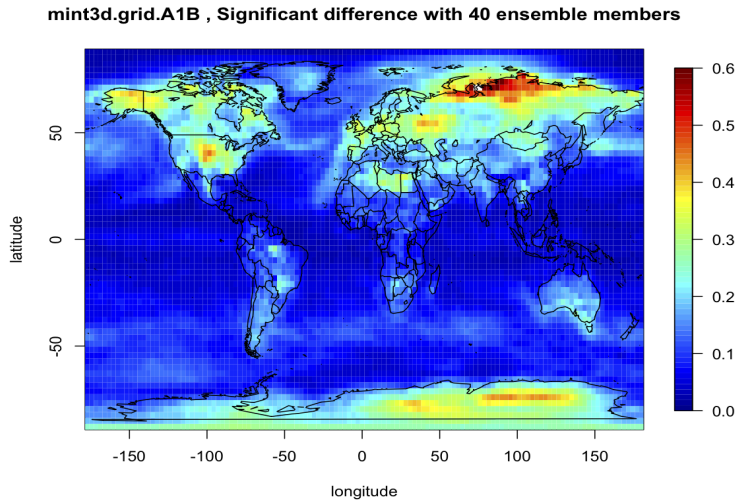
Minimum Significant Difference

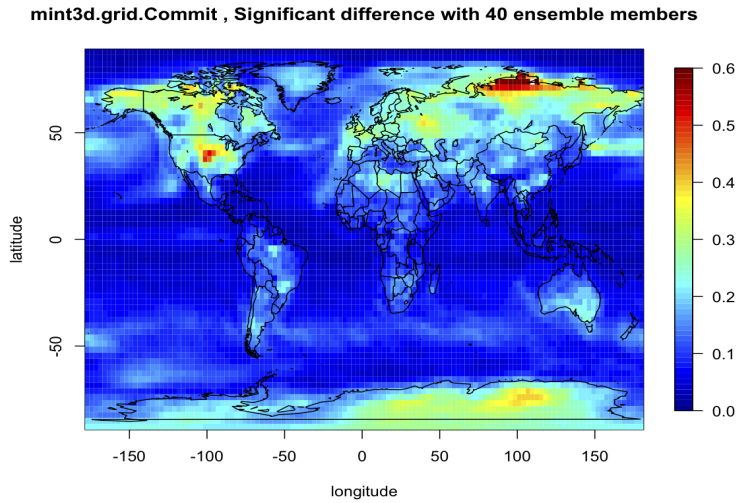
New Question... Same Idea

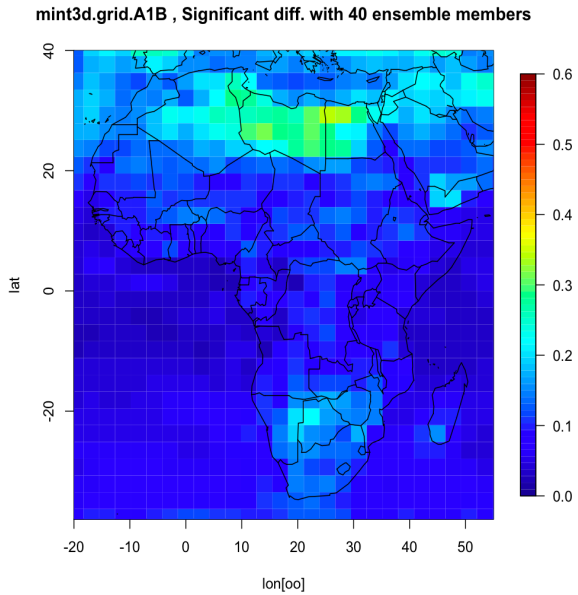
- Same idea, different question
  - Recall that, $$\delta = \frac{2\sigma}{\sqrt{n}}$$
  - Given that we have 40 ensemble members (n), what is the minimum significant difference (δ) that can be shown?

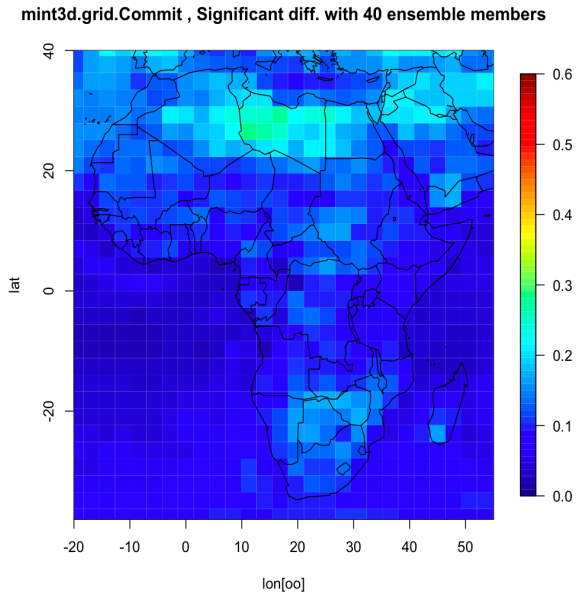


Minimum Significant Difference: Temperature

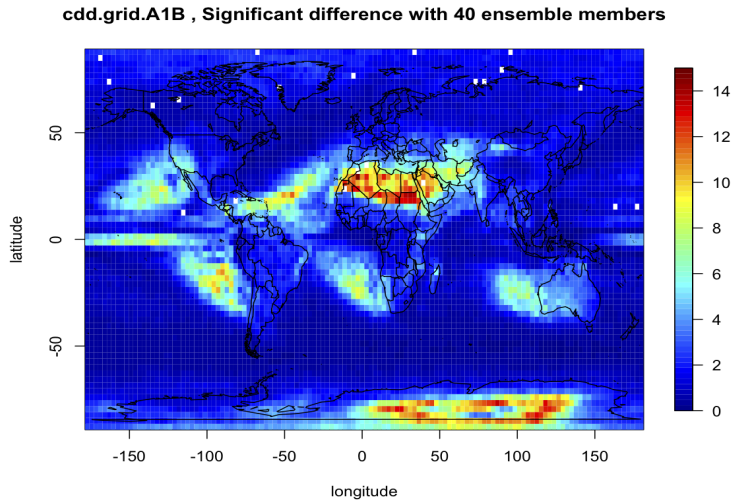


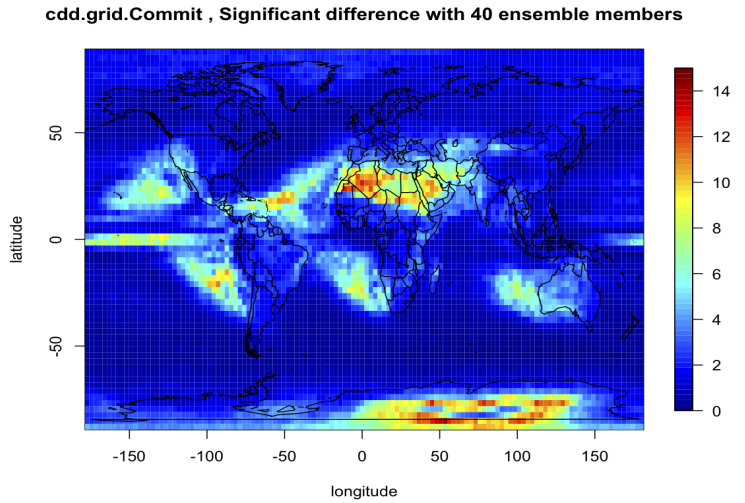


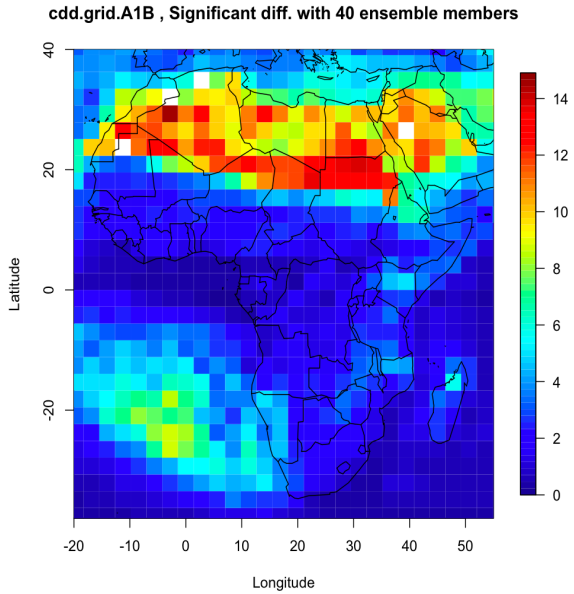


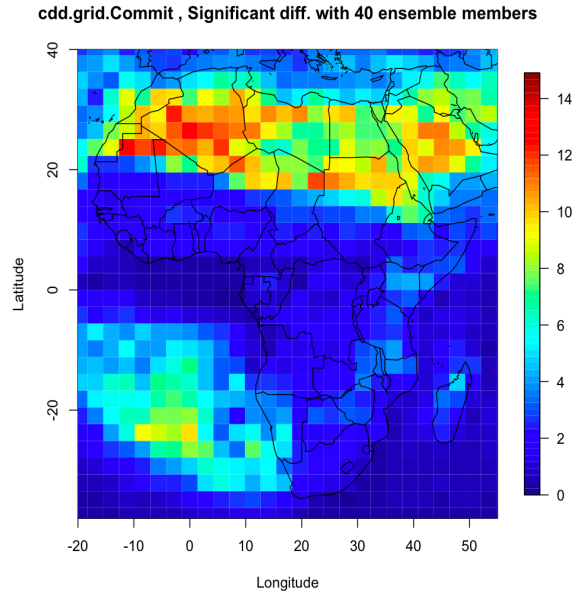


Minimum Significant Difference: Precipitation









Results

Minimum Number of Ensemble Members

- Precipitation indices generally require more ensemble members than temperature indices
  - cdd requires most ensemble members
- The Commit emission scenario generally requires more ensemble members than A1B
  - The Commit uses emission levels equal to those of the year 2000
- Method 1 requires more ensemble members in areas of high ensemble variance and/or small observed average decadal difference
- Method 2 requires more climate knowledge to determine δ, the specified significant difference

Future Work

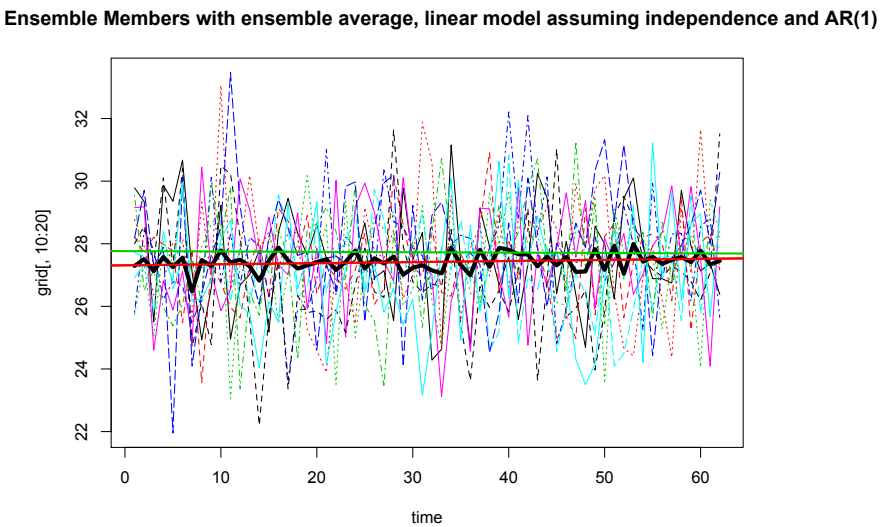
Minimum Number of Ensemble Members

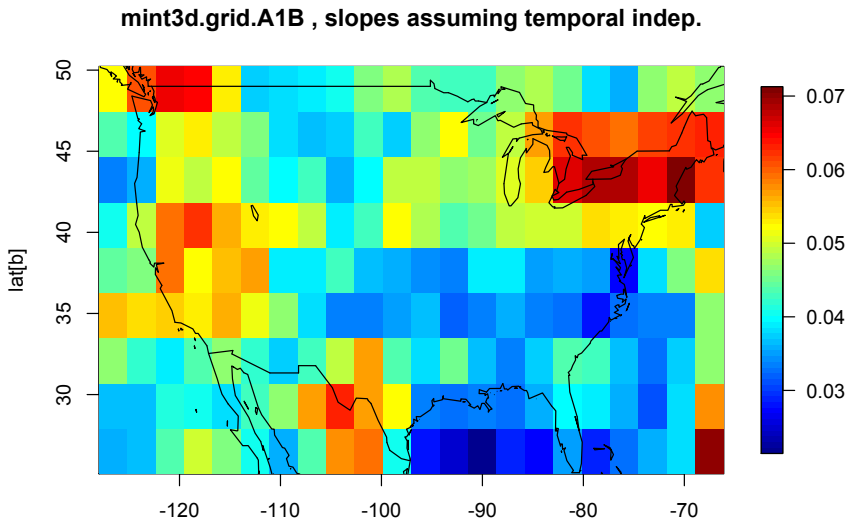
- Type I error correction for multiple comparison
  - false positives
- Investigate temporal correlation structures
- Investigate spatial correlation structures
- Method 1: Investigate areas with a high number of minimum ensemble members when observed average decadal difference is used
- Method 2: Discuss nature and human system implications for specified changes in indices

Future Work

A Second Project

- Modeling linear regression slopes for each index
  - Assume two temporal error structures:
    - ★ Independent
    - ★ Autoregressive model (AR)
  - Investigate spatial dependence structures





Acknowledgments

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- Mentor: Steve Sain
- Claudia Tebaldi
- Clara Deser
- Doug Nychka
- SIParCS Admin
- NCAR/UCAR
- NSF

Questions?