Are Some Climate Models Outliers?

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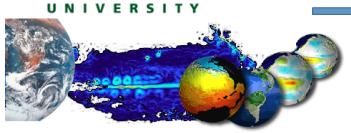


DATA

- CMIP3, Interpolated to 72x36 grid
- 99-years of Temperature data
- 3-month mean (JFM, AMJ, JAS, OND)
- Pre-industrial (PICNTRL, 24 models) and 20C (19 models) runs
- Observation dataset from CRU

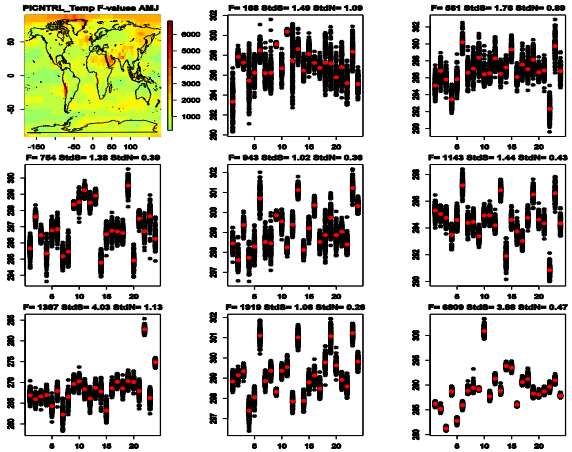
MOTIVATION

- Model data is often pooled to detect and attribute signals of natural variability and anthropogenic forcing
- When pooling model data, we want to pool models that come from the same distribution
- Knowing a model is an outlier is helpful for understanding model differences
- ***Are some models "grossly" inconsistent with other models?***

METHOD 1: ANOVA

- ***Do models simulate the same climatology?***
- Test Hypothesis:
- $\mu_1 = \mu_2 .... \mu_m$
- where μ_i is the 99-yr mean of model *i*
- ANOVA: $F = Y \frac{\hat{\sigma}_S^2}{\hat{\sigma}_N^2}$
- where $\hat{\sigma}_S^2$ and $\hat{\sigma}_N^2$ are unbiased estimators of the variance of seasonal means and the variance about those seasonal means, respectively
- Y = 99 and M = 19 (20C) or 24 (PICNTRL)
- The probability that F > 100 at least once out of 72x36=2592 gridpoints under the null distribution is less than $1x10^{-254}$: virtually impossible!

RESULTS: ANOVA



This figure provides a typical result of the ANOVA method for AMJ in the PICNTRL run (first panel). The hypothesis of equal means is rejected at every gridpoint and every season.

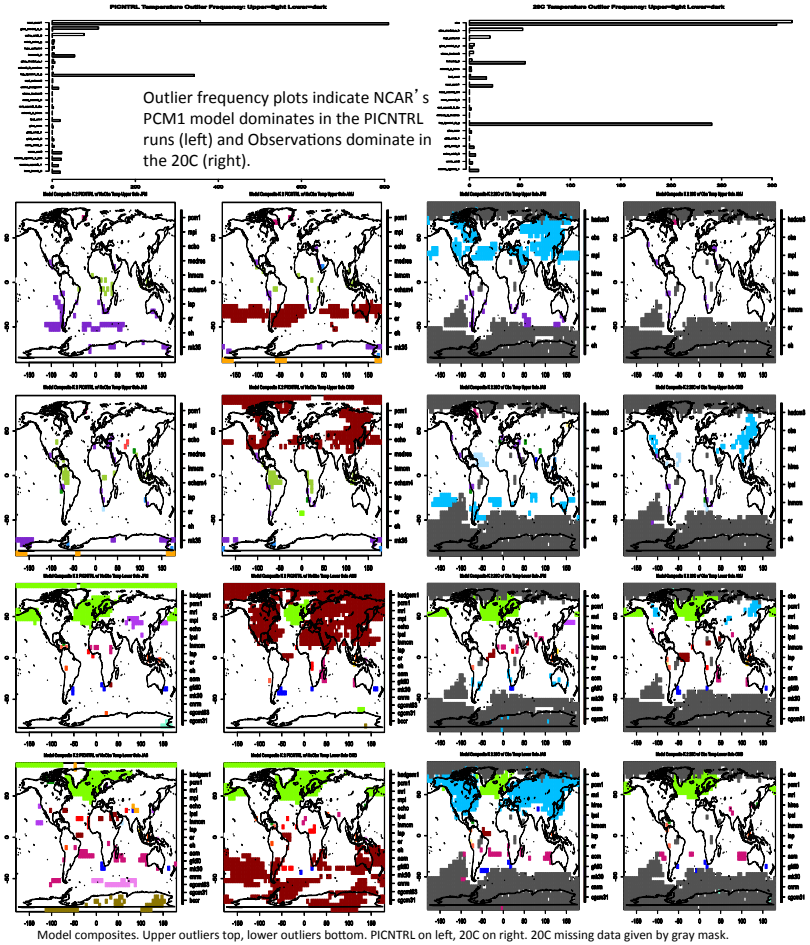
SUMMARY: ANOVA

The hypothesis of equal means is rejected at every gridpoint for every season at the 'impossible' significance level. It is clear from the scatter plots that some models are 'gross' outliers, that is, their 99-yr range of temperature values are well beyond every other models' 99-yr ranges.

METHOD 2: OUTLIERS

- ***Are some models consistent outliers?***
  - Outlier is defined as a model whose 99-yr mean differs from all other model means by 4 or more (pooled) standard deviations
  - For reference, the probability that two 99-year means differ from each other by 4 standard deviations, when samples are drawn independently from the same normal distributions, is less than $1x10^{-174}$

RESULTS: OUTLIERS



Outlier frequency plots indicate NCAR's PCM1 model dominates in the PICNTRL runs (left) and Observations dominate in the 20C (right).

Model composites. Upper outliers top, lower outliers bottom. PICNTRL on left, 20C on right. 20C missing data given by gray mask.

SUMMARY: OUTLIERS

PICNTRL: IAP is a frequent lower outlier for all seasons in the N. Atlantic Ocean near deep-water formation sites. PCM1 has frequent upper and lower outliers in the transition seasons. **20C:** results indicate observations are a frequent outlier in the JFM upper case-study and JAS lower case-study. These results imply that models are in stark disagreement with the observed seasonal cycle. As in PICNTRL, IAP remains a lower outlier in the N. Atlantic Ocean.