Not to be trusted? Climate models care too little about the oceans!

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Introduction

Aim

Evaluation of overestimation of global warming in two ways:

- Are modelled global mean temperatures significantly higher than observed?
- Is there a trend difference between models and observations?

Anomalies

Departure from the average temperature of a reference period used for comparison and combination of different temperature patterns

Global mean temperature

- Ensemble of 45 climate models with four scenarios each
- GISS3: land-based data
- HadCRUT4: land-and-ocean based data

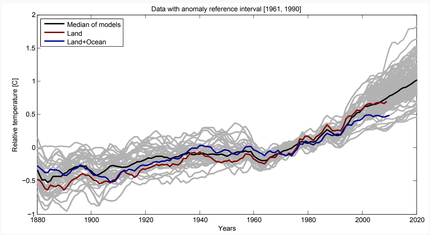

Figure 1: Modelled and observed global mean temperature anomalies from 1880 to 2020. Observations from land data (GISS3) and land-and-ocean data (HadCRUT4) .

Analysis

Temperature overestimation study

- No unusual overestimation for land data (GISS3)
- Definite overestimation for land-and-ocean data (HadCRUT4)

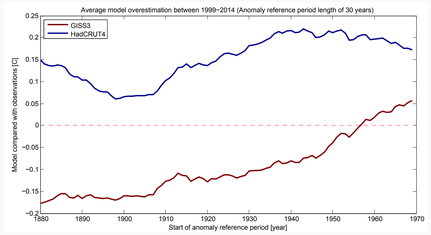

Figure 2: Mean overestimation of models median compared to observations during the time period 1999-2014 as a function of reference period.

Model uncertainty

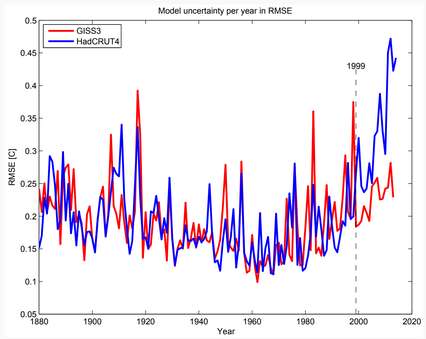

Figure 3: Model uncertainty in RMSE for land data (GISS3) and land-and-ocean data (HadCRUT4) using anomalies based on a 1951-1980 reference period.

- Based on RMSE, the models are more uncertain for land-and-ocean based data (HadCRUT4) than for land data (GISS3) for the past 15 years

Conclusion

- **For the past 15 years, climate models overestimate global warming.**
- **On the contrary, models fit land-based global mean temperature well.**
- **Better understanding of oceans needed!**

Historical trend analysis

- For the past 15 years, the overestimation is twice as high for land-and-ocean data (HadCRUT4) than for land data (GISS3)

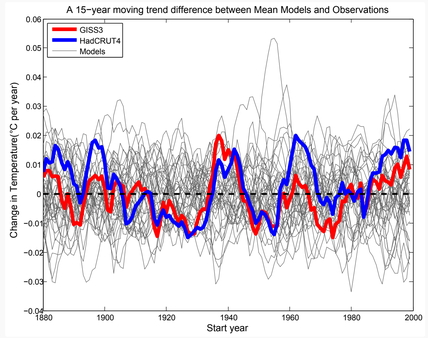

Figure 4: Global mean surface temperature 15-year running trends difference between mean model and two observation datasets.

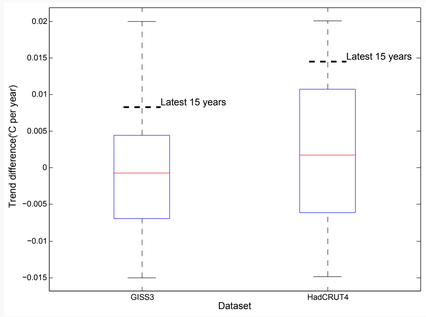

Figure 5: The increasing trend difference between the mean climate projection and two observation datasets.

- The overestimation is unusual for both, the land and the land-and-ocean data

Comparing distributions of data and models

- Two-sample Kolmogorov-Smirnov tests: No evidence that the land data (GISS3) and most models come from different distributions, but for the land-and-ocean data (HadCRUT4)

Figure 6: Empirical cumulative distribution functions of the two observation datasets (black lines) and of the models (green lines).

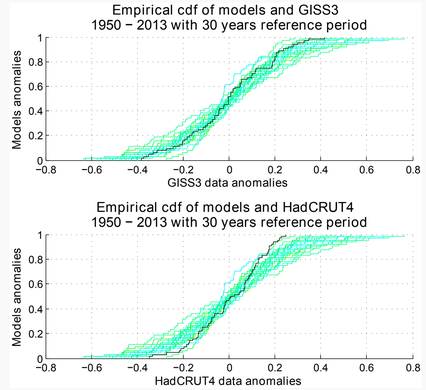

Table 1: Non-rejection ratio (1950 - 2013)

data\ ref. period (years)	15	30	45	75	100
GISS3	100%	100%	92%	96%	92%
HadCRUT4	96%	88%	85%	73%	62%

Discussion

- Analyses were conducted for several reference periods and three land-and-ocean datasets leading to same conclusions
- Model uncertainty results depend on the reference period
- Conclusions are in line with findings in the literature e.g. below

Important reference:
J.S. Risbey et al. (2014). *Well-estimated global surface warming in climate projections selected for ENSO phase*. Nature Climate Change, 4, 835–840

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