COMMUNICATING GLOBAL CLIMATE CHANGE USING SIMPLE INDICES: AN UPDATE

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INTRODUCTION

The most common indicator of global-scale climate change is the global mean surface air temperature (**GM**). There are several additional indices of global-scale temperature variations that are useful for distinguishing natural internal climate variations from anthropogenic climate change (Karoly and Braganza 2001, Braganza et al. 2003). These include:

LO - the contrast between average temperature over land and oceans
MTG - the meridional temperature gradient in the Northern Hemisphere
NS - temperature contrast between Northern and Southern Hemispheres
AC - magnitude of the annual cycle of average temperature over land.

They are nearly independent of the global mean temperature for natural internal climate variations at decadal time scales and represent different aspects of the climate system, yet they show common responses to anthropogenic climate change (Braganza et al, 2004). In addition, physical arguments suggest that the ratio of average temperature changes over land to those over the oceans (**RLO**) should be nearly constant for transient climate change, determined by evaporative limits over land and the rate of ocean heat uptake (e.g. Sutton et al. 2007). Hence, these indices are helpful in evaluating model "quality" in large multi-model ensembles.

This study extends previous analysis to include the last ten years of observational data and the CMIP3 climate model simulations analysed for the IPCC AR4.

DATA

The climate indices were computed from monthly mean global surface temperature data from 3 different observational datasets and data from simulations with 8 CMIP3 coupled atmosphere-ocean-sea-ice climate models. We use data from models that had at least one simulation for the Pre-Industrial Control and multiple simulations for the 20th century and future emission scenario A1B.

All data were masked to eliminate observationally sparse regions, including polar regions and much of the Southern Ocean.

NR	MODEL	PICNTRL	20C3M	A1B
1	cccma_cgcm3_1	1	5	5
2	miub_echo_g	1	5	3
3	miroc3_2_medres	1	3	3
4	mpi_echam5	1	4	4
5	mri_cgcm2_3_2a	1	5	5
6	ncar_ccsm3_0	2	9	9
7	ncar_pcm1	1	4	4
8	csiro_mk3_0	2	3	1

An overview of the models, scenarios and the number of simulations used in this analysis. The numbers in the first column correspond to the numbers along the x-axis used in Figures 1, 2 and 4.

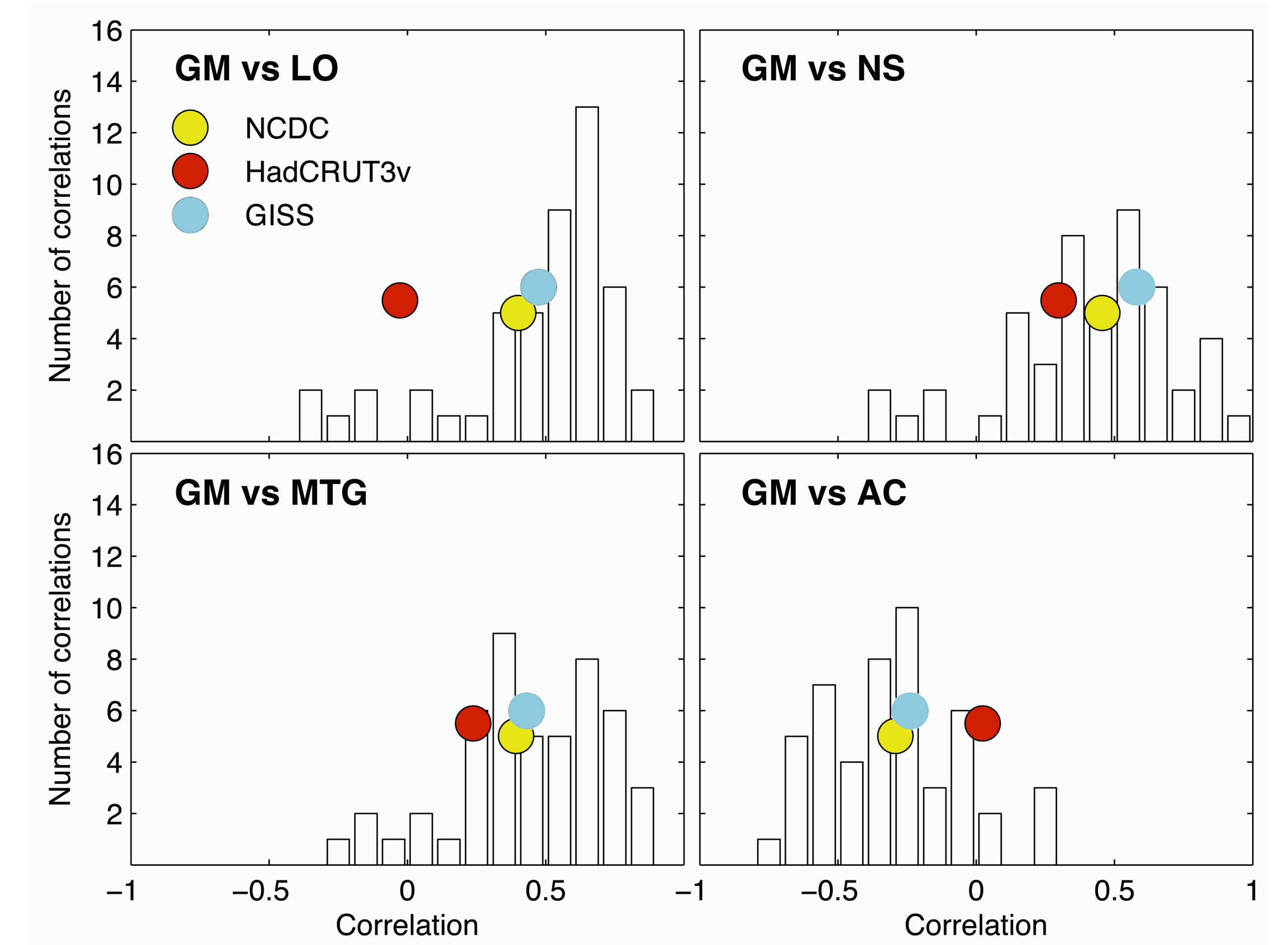

Figure 1. Histograms of correlations of decadal variations of the indices with global-mean temperature GM for various 120-year periods from control model simulations. Superimposed onto this distribution are the correlation values for the observational data.
This shows that the correlations for the observational and simulated data are similar.

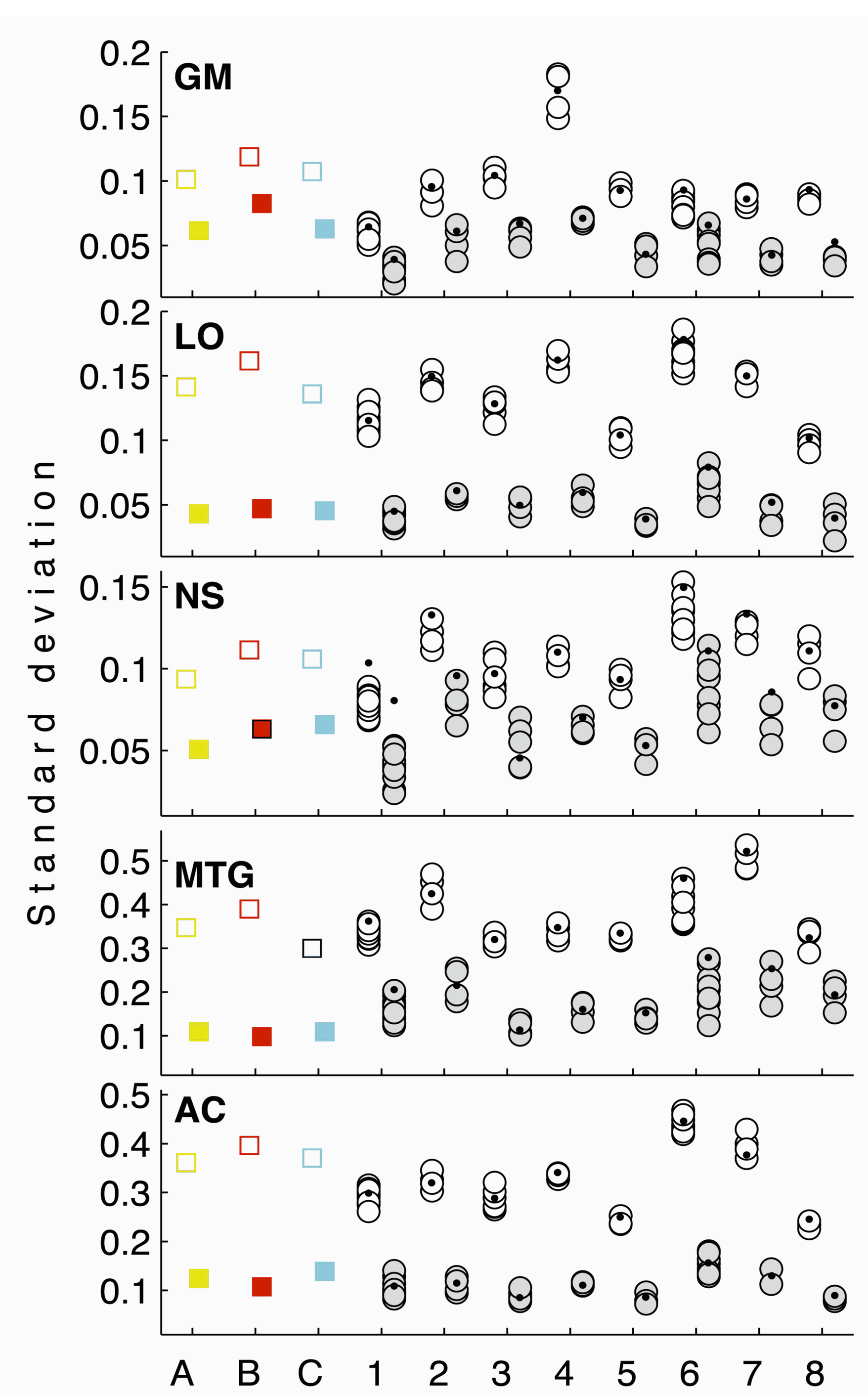

Figure 2. Standard deviation of the indices from detrended observations (A, B, C) and model PICNTRL data (1-8) at annual (open symbols) and decadal time scales (filled in symbols) over 120-years intervals.
Along the x-axis: Observations: A = NCDC, B = HadCRUT3v, C = GISS. Models: The numbers refer to the models as listed in the table. The black dots indicate the standard deviation determined over the full length of the PICNTRL simulation.

The simulated variability in the indices at annual and decadal timescales is similar to that observed.

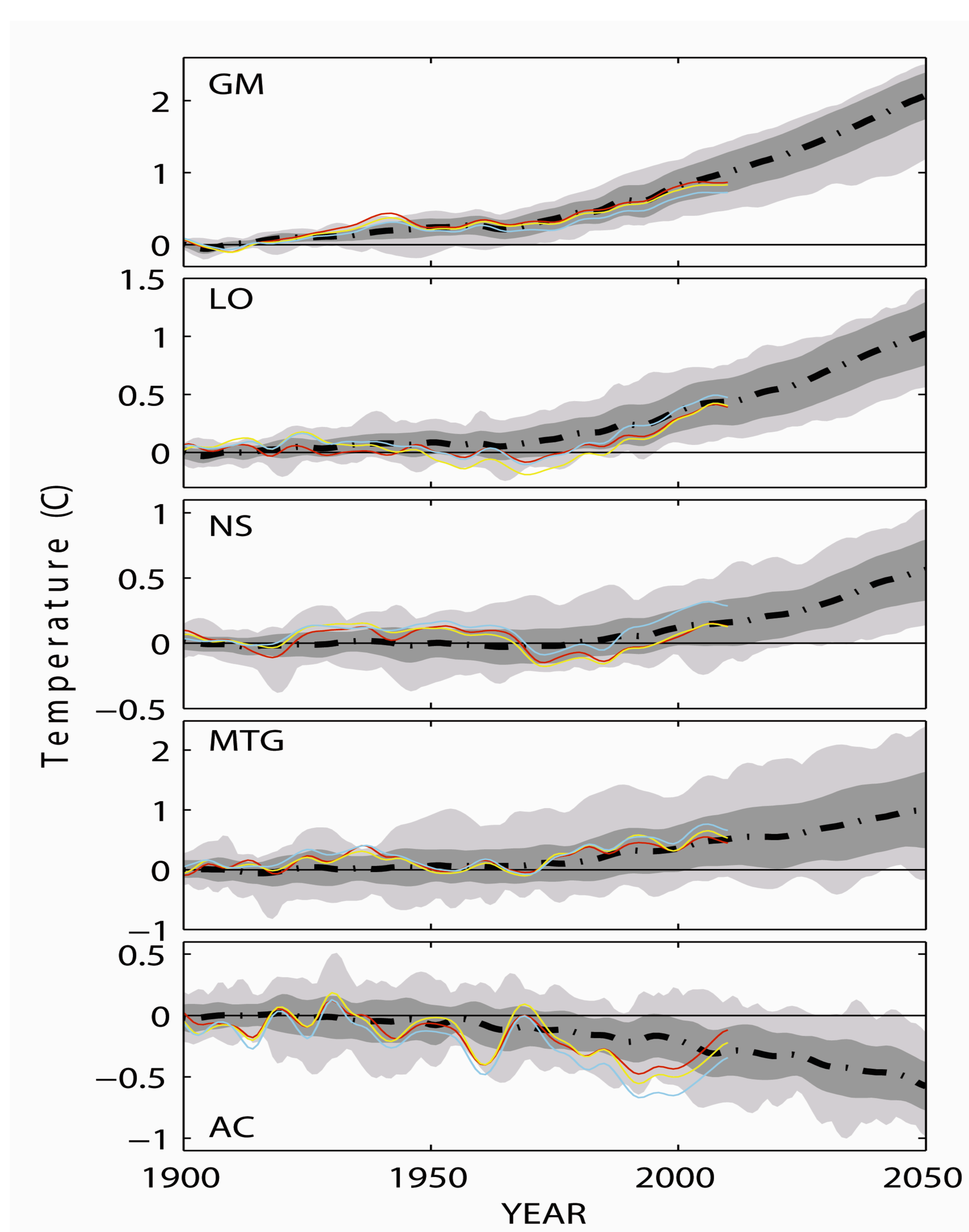

Figure 3: Evolution of the indices from all simulations with the 8 models. Shown are the mean (dash-dot line), one standard deviation (dark grey shaded area), and the minimum and maximum range (light grey shaded area). The 3 thin colored lines in each graph are the indices from the observational datasets used in this study (with color coding the same as in the other graphs). The twentieth century simulation data were extended with data from the A1B simulations.

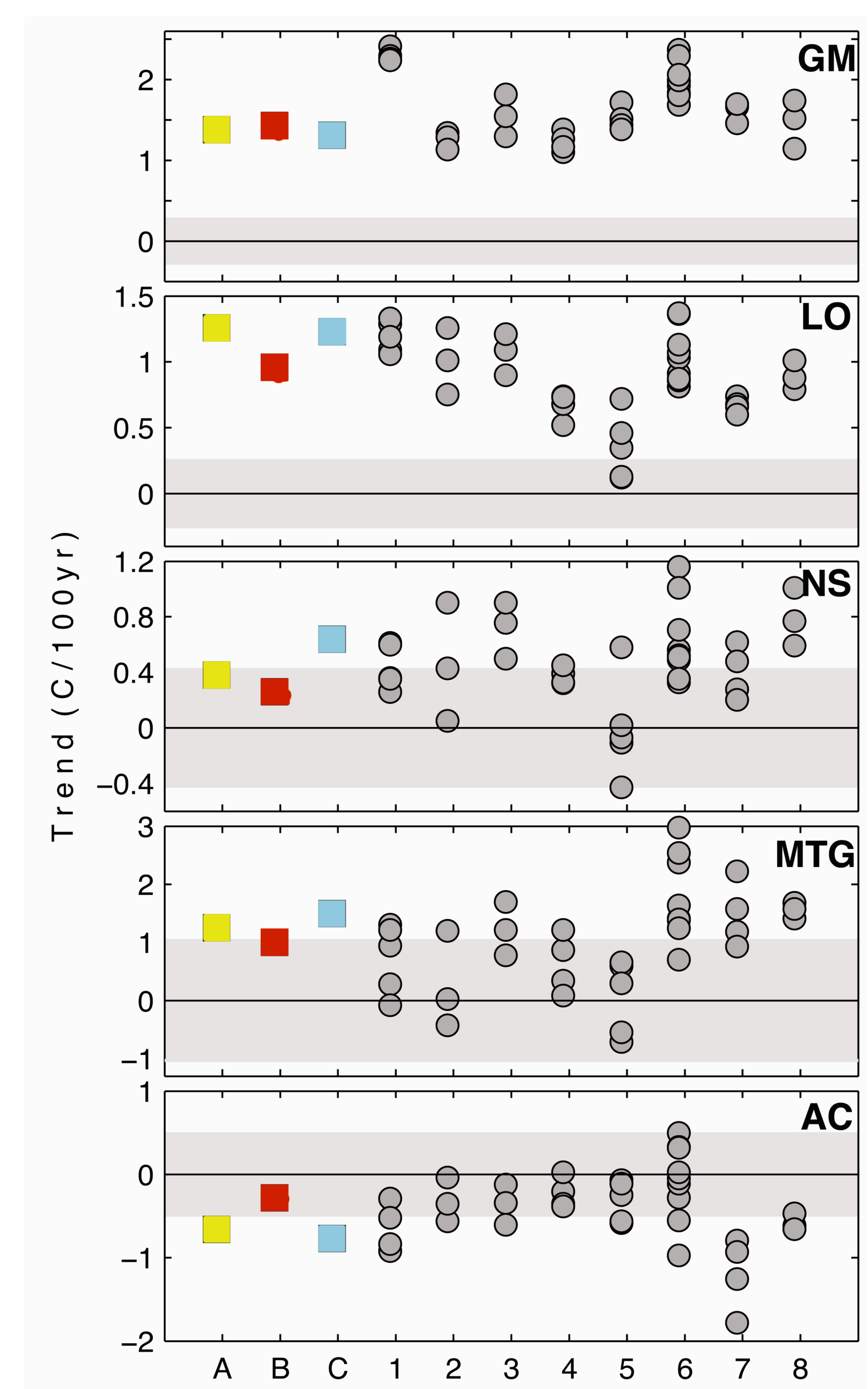

Figure 4: Trends in the indices in the observations (A, B, C) and the model simulations (1-8) for the period 1961-2010.
Along the x-axis: Observations: A = NCDC, B = HadCRUT3v, C = GISS.
Models (grey circles): The numbers refer to the models listed in the table.
The shaded area marks the 5% to 95% confidence interval for no trend in each index, estimated from 50-year trends from the control runs.

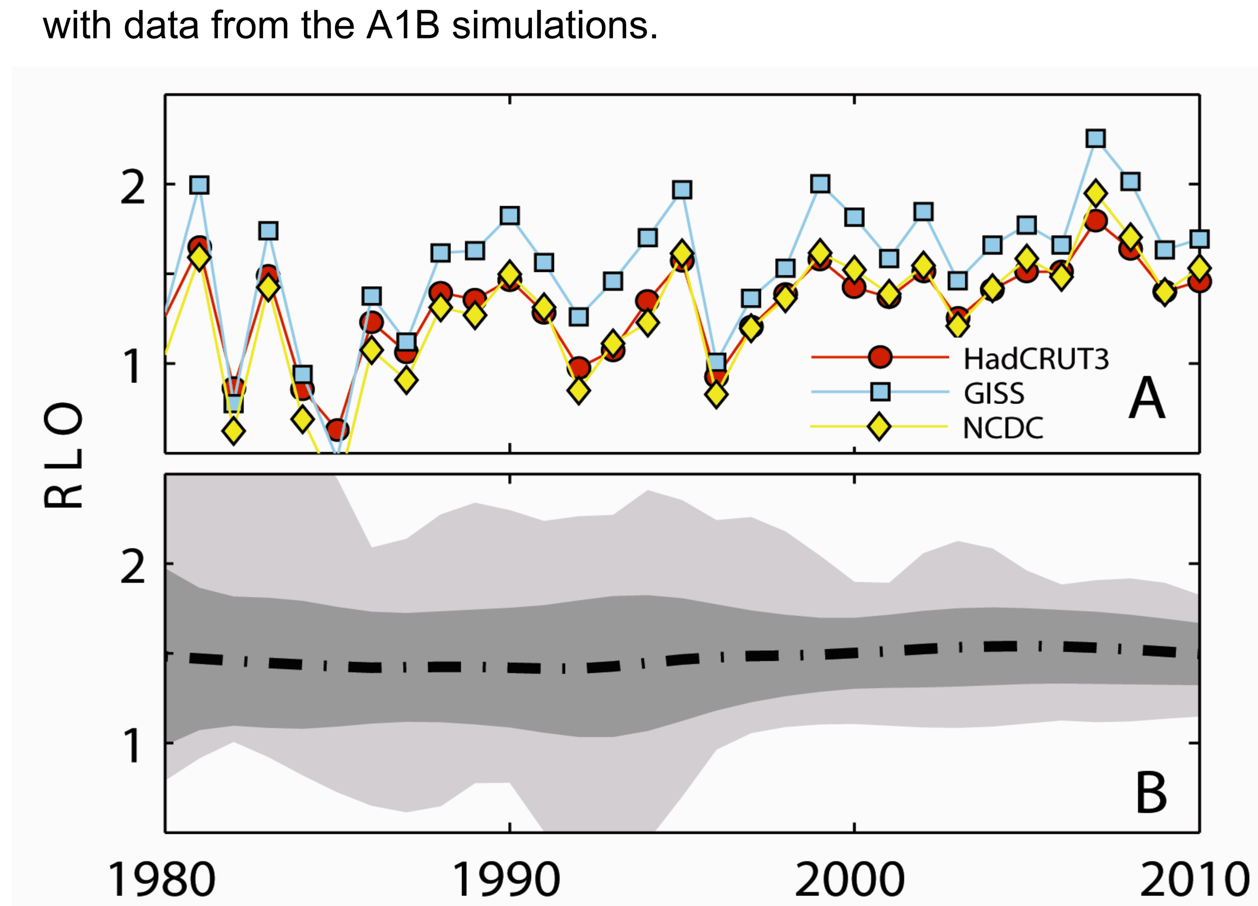

Figure 5: A: Evolution of annual-mean RLO for 1980-2010 relative to 1890-1920 from the observational datasets.
B: Evolution of annual-mean RLO for 1980-2010 from all simulations. Dashed line is the mean; dark grey shaded area is one standard deviation; light grey shaded area is the full range across all simulations.

CONCLUSIONS

This study has shown that the evidence for anthropogenic climate change has increased since a similar study by Braganza et al. (2004):

1) The mean observational trends in the indices GM, LO, MTG, and AC are all outside the 5%-95% confidence interval for natural variability of 50-year trends. The fact that the trends in these observational indices have higher significance than in Braganza et al. (2004) reflects increased evidence for anthropogenic climate change.

2) The multi-model ensemble mean trends in GM, LO and NS are outside the 5%-95% confidence interval for natural variability. The 95% multi-model mean trends for MTG and AC are not significant.

3)The ratio of warming over land and oceans appears to be converging towards a constant value of about 1.5, consistent with the model simulations (Figure 5), as expected during periods of transient radiative forcing (Sutton et al. 2007).

Evaluating these results together has increased our confidence that observed changes in these climate indices are statistically significant, cannot be explained by natural variability, and that they are very likely caused by anthropogenic gas emissions.

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