An Analysis of Forced and Internal Variability under Increasing CO_2 in CCSM3

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Main Results

- **Increase of GHG concentration changes the mean states significantly, but the internal variability does not change much**
- **Superimposed on a warming trend, amplitude of internal variability of ENSO is slightly suppressed in the A1B runs**
- **Predictability (or signal-to-noise ratio) of the response to increase of GHG concentration depends on variable, forcing intensity, and geographical location**

1: Questions

Q1: What are the responses in the mean states and internal variability (noise) to increase in GHG concentrations?

Q2: Is there any change for internal variability (noise) patterns in global warming scenario?

Q3: What is the response of ENSO to increase in GHG concentrations?

Q4: What are differences in predictability in global warming scenario for different variables?

2: Model and Data

A: Model, CCSM3: T42L26 CAM fully coupled with ocean, land and sea ice (Collins et al. 2006). The ocean model is POP with a horizontal resolution of 1° (down to 1/2° latitude in the equatorial tropics) and L40. No flux adjustments are used in CCSM3.

B: A1B Runs: forced by the SRES A1B scenario for the period Jan2000-Dec2061 with initial condition (IC) from a single simulation of 20th century climate (forced by a combination of anthropogenic and natural forcings in 20th century). The perturbations only in atmosphere from different days around Jan. 1, 2000 generate 30 ICs (see Teng and Branstator, 2010, Meehl et al. 2006, 2010 for more details).

C: Control Runs: also called commit runs, forced by the forcing fixed in the year 2000 level (Meehl et al. 2006). Others are similar to the A1B runs.

D: Available Data: Monthly mean surface temperature (TS), precipitation, and geopotential height at 200 hPa (H200) for period Jan2000-Dec2061. 30 members of A1B runs and 28 members of Control runs

3: SUMMARY

A. **Increase in GHG concentrations changes the mean states significantly, especially for TS and H200, but the internal variability (noise) does not change much in extra-tropics, and** the leading modes of internal variability are almost identical for Control and A1B runs.

B. Significant warming in the tropical Oceans. Superimposed on a warming trend, amplitude of internal variability in the Nino3.4 region is slightly suppressed in the A1B runs.

C. Predictability (or signal-to-noise ratio) of the response to increase in GHG concentrations depends on variable, period, and location: The predictability increases with time for all variables, especially for H200. The predictability is the highest for H200, the lowest for precipitation, in between for TS, and it is higher in lower latitudes than in higher latitudes, particularly for H200 and TS. The predictability for precipitation does not vary much with latitudes. In addition, the TS response to the increase in GHG concentrations is largely linear, even for regional scale.

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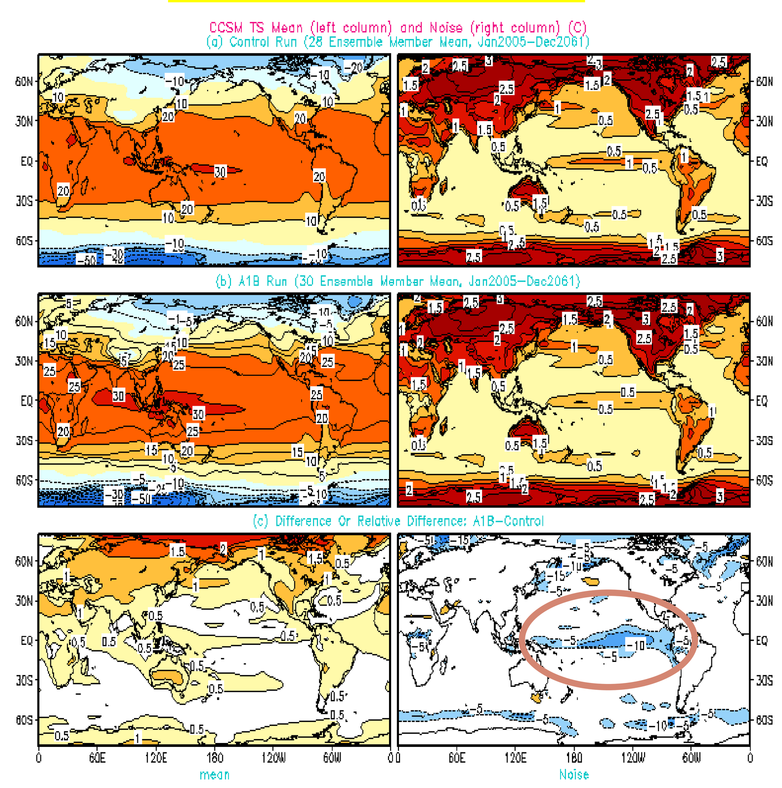
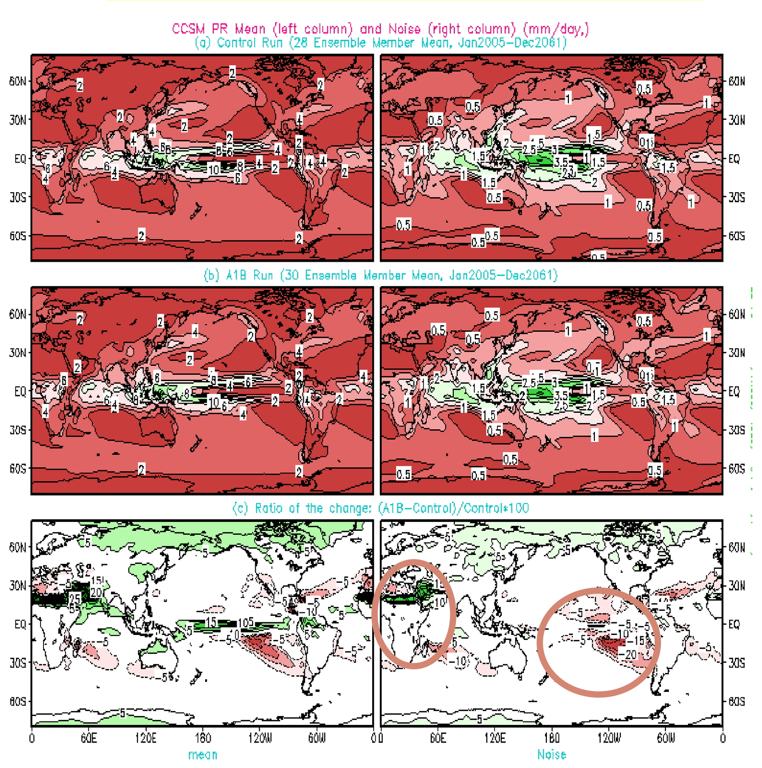
4: Changes of Mean State and Internal Variability (Noise)

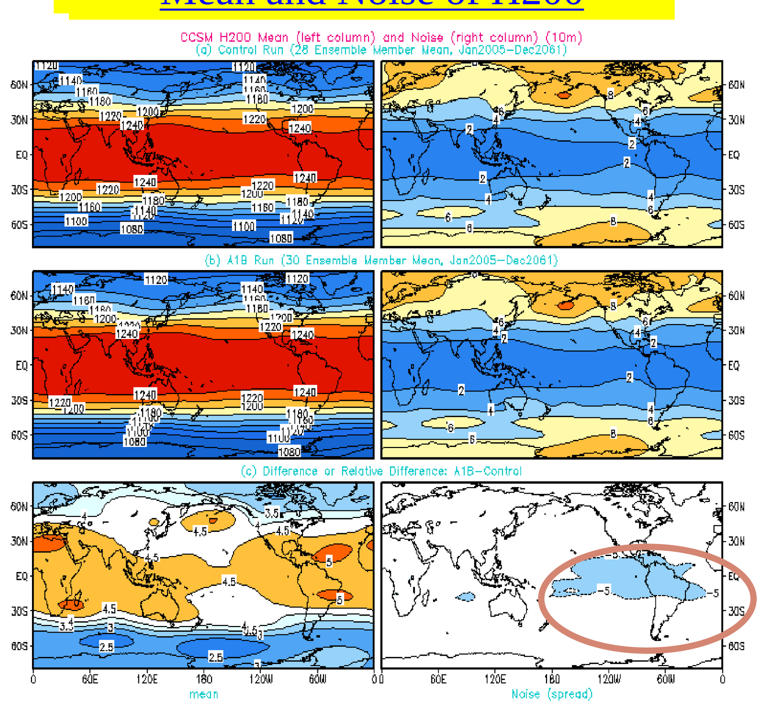
Mean and Noise of TS



Mean and Noise of Precipitation



Mean and Noise of H200



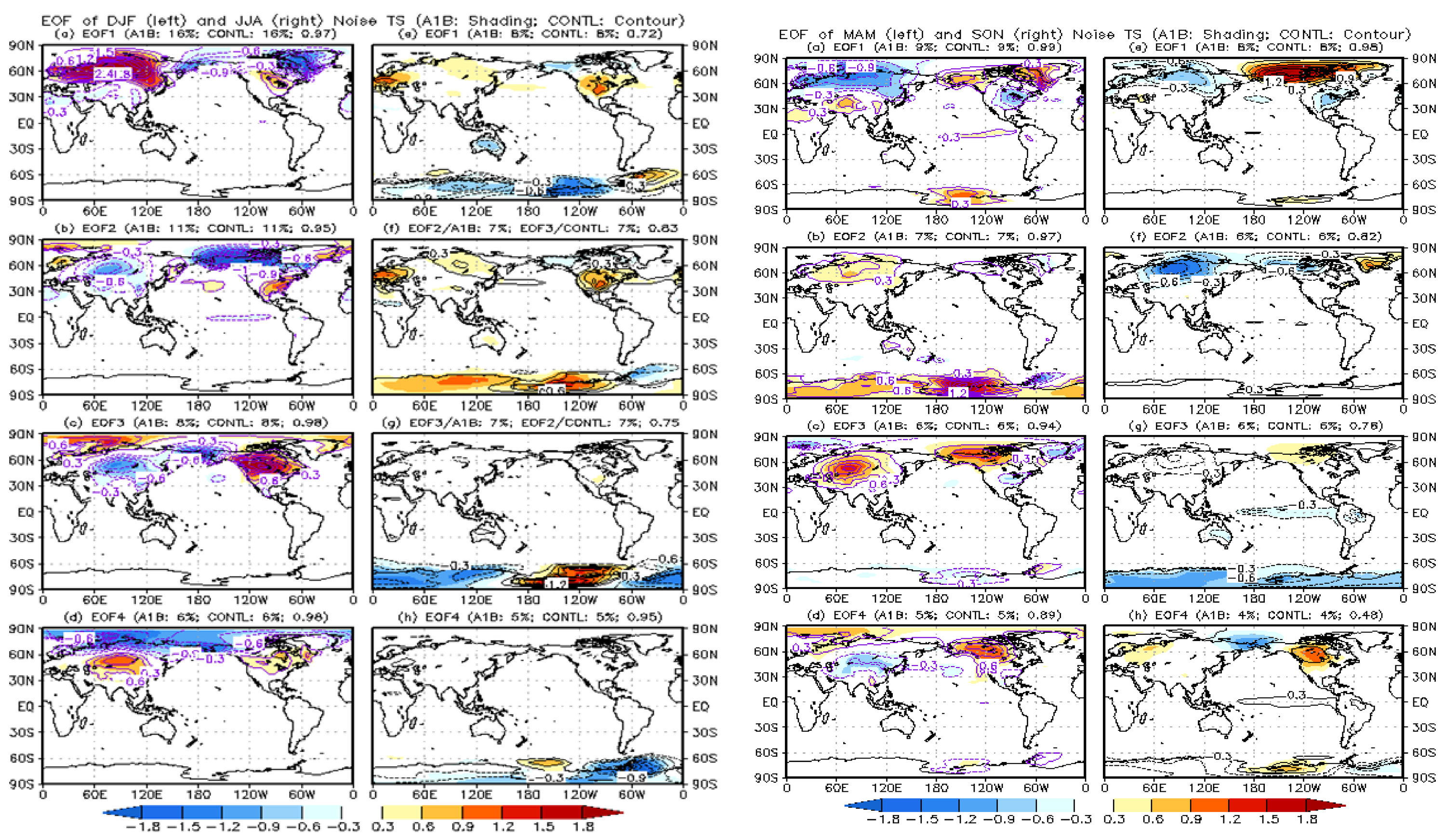
Increase in GHG concentrations changes the mean states significantly, particularly for TS and H200

The internal variability (noise) does not change much in extra-tropics

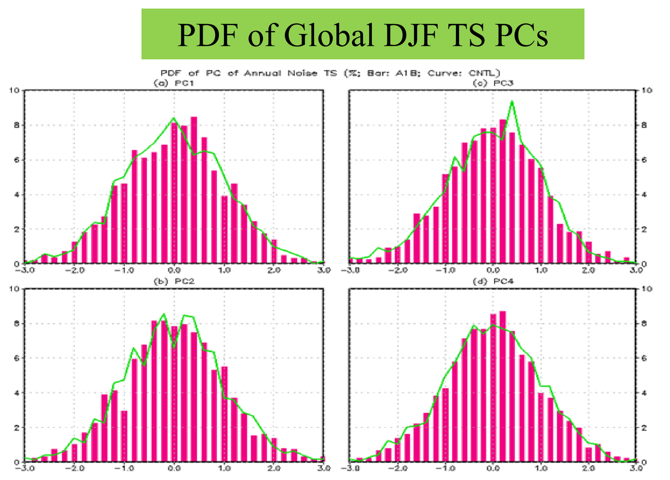
In A1B run, internal variability (noise) decreases in equatorial Pacific and in high latitudes of both hemispheres for TS; enhances in high latitudes and in Middle East and weakens in tropical Pacific and Atlantic Oceans for precipitation; slightly decreases over the regions from the tropical eastern Pacific to the western tropical Atlantic Ocean for H200

5: Identical Internal Variability (Noise) Patterns

EOF Patterns of Global Seasonal Mean TS



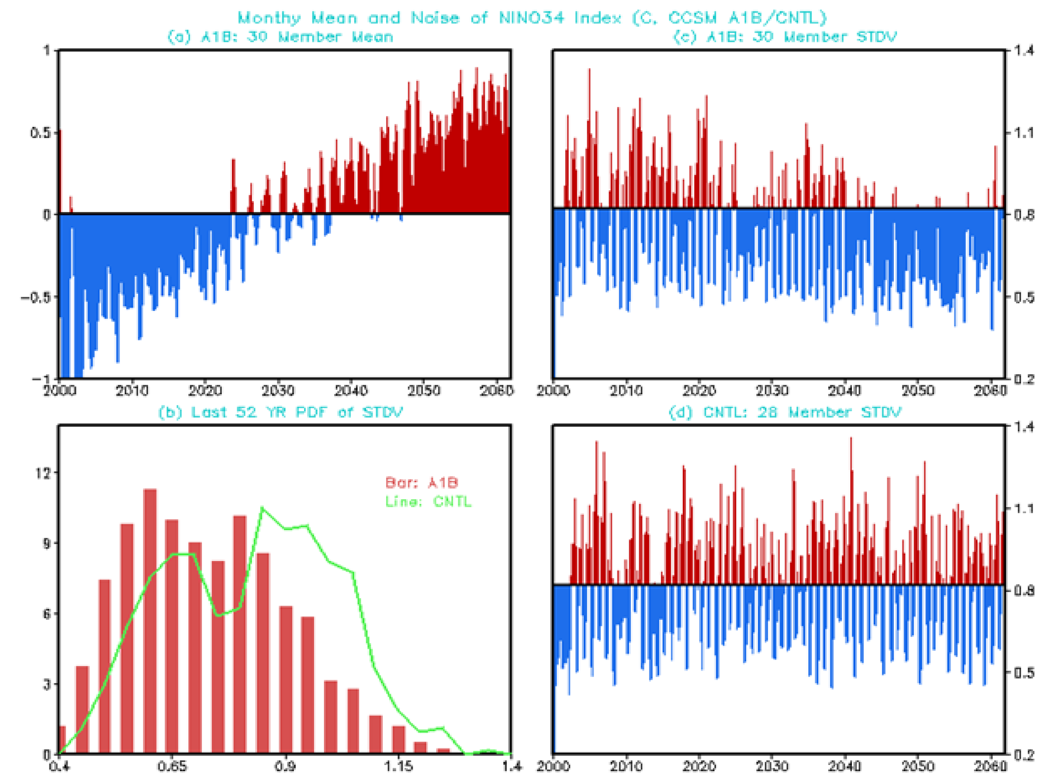
PDF of Global DJF TS PCs



The leading modes of internal variability (noise) of seasonal mean TS, H200 and Precipitation are almost identical for the Control and A1B runs, suggesting that the leading modes are less affected by the increase in GHG and aerosol concentrations than the mean states do.
However, the similarity of these spatial patterns between the two runs slightly depends on the variable and season.

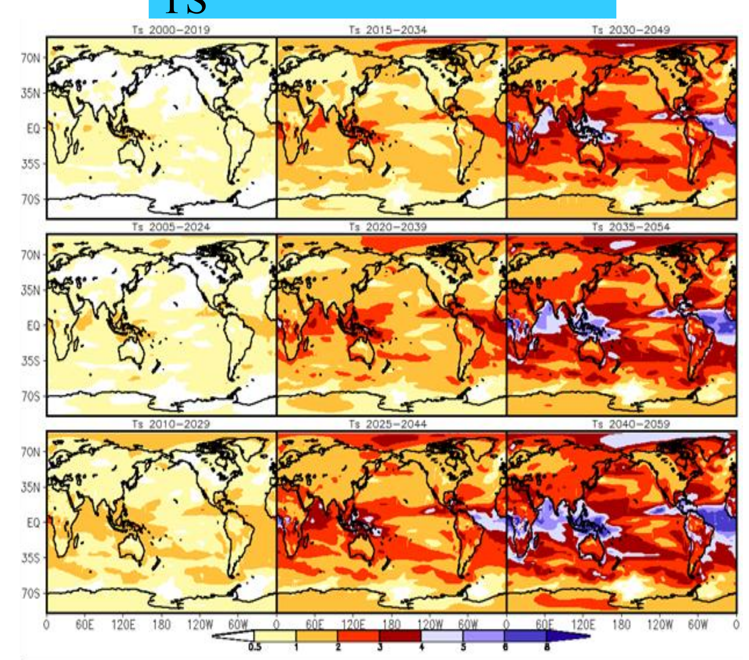
6: Response of ENSO

Superimposed on a warming trend, amplitude of internal variability in the Nino3.4 region is slightly suppressed in the A1B runs.

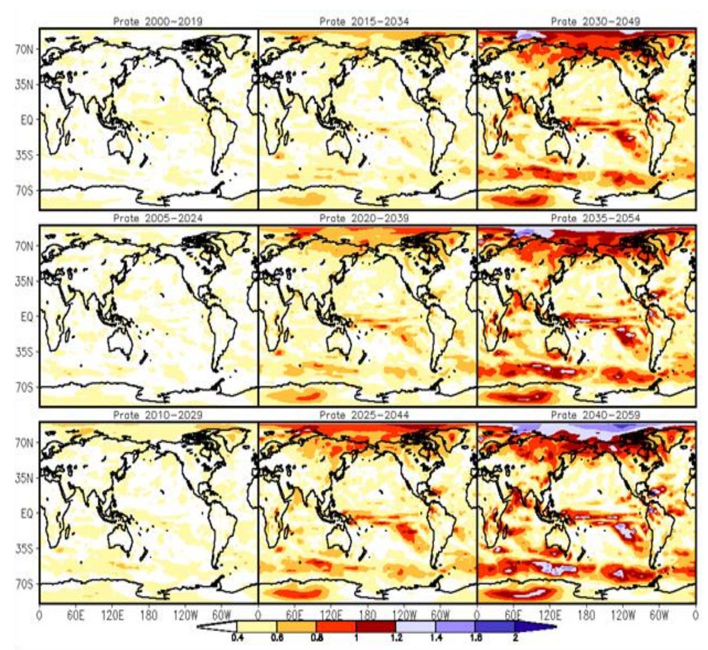


7: Dependence of Predictability

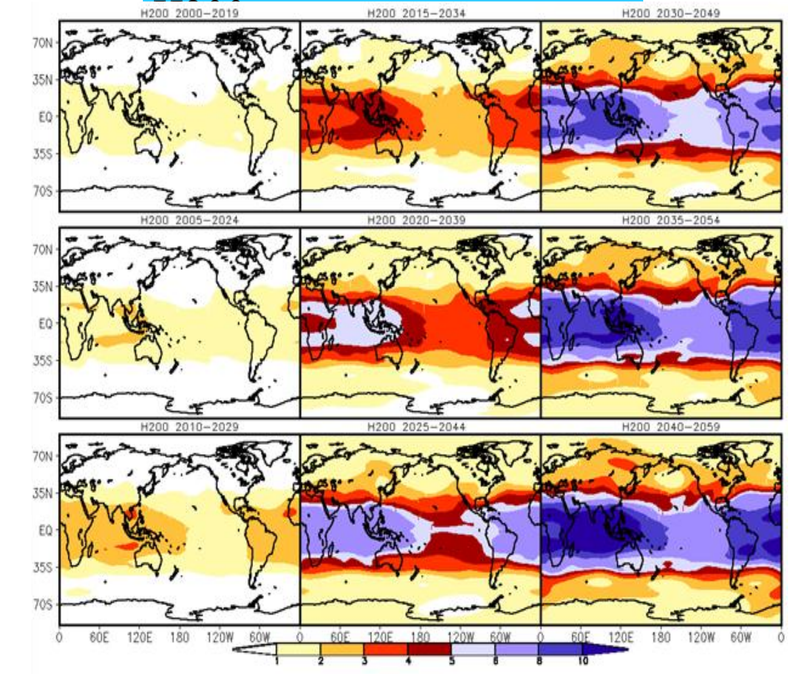
Signal-to-noise Ratio of TS



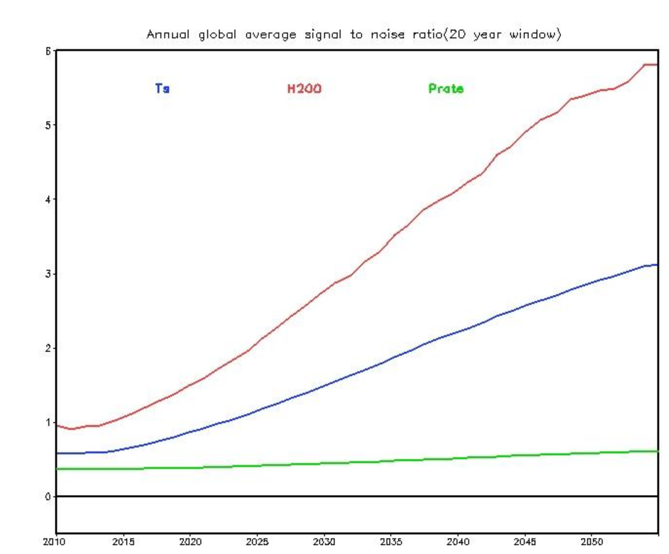
Signal-to-noise Ratio of Precipitation



Signal-to-noise Ratio of



Signal-to-noise Ratio of Global Average



Predictability of the response due to increase in GHG concentrations depends on variable, period, and location:
- The predictability increases with time for all variables, especially for H200.
- The predictability is the highest for H200, the lowest for precipitation, in between for TS.
- H200 & TS: The predictability is higher in lower latitudes than in higher latitudes, and higher in the tropical Indian and Atlantic Oceans than elsewhere.
- Precipitation: The predictability does not vary much with latitudes. However, it seems relative higher in high latitude oceans and tropical southern Pacific than elsewhere.
- The response of TS to the increase in GHG concentrations is largely linear, even for regional scale.