Decadal predictability and signal-to-noise

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Some issues for decadal predictability

- WGCM has suggested the next CMIP experiment provide simulations to be analysed for IPCC AR5 will included decadal prediction runs for 2000-2030
- These runs will likely include
  - changes in anthropogenic forcing ie ghgs and aerosols
  - specified ocean initial conditions to represent the observed climate state at the start of the simulation
  - multi-member ensemble with varying atmospheric initial conditions

Some issues for decadal predictability

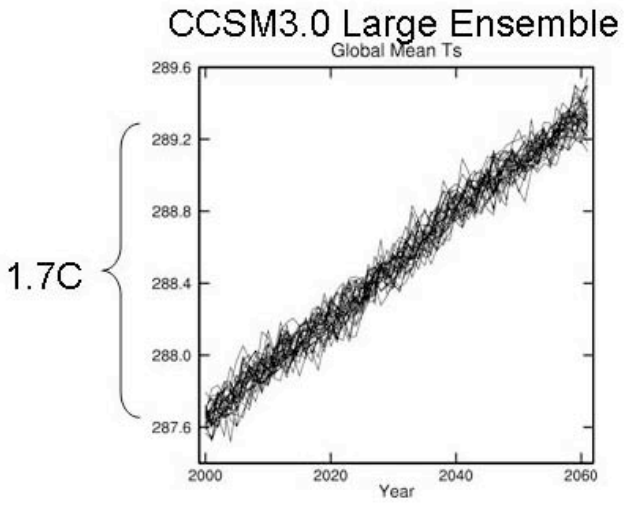
- Estimating noise - can internal climate variability be estimated if long control runs do no exist?
  - Can ensemble spread reliably estimate internal variability?
- Forced climate change signals - can signals due to increasing anthropogenic forcing be identified and, if so, when?
  - When is the forced signal in an individual realization likely larger than noise?
- Initial condition signals - can signals associated with specified ocean initial conditions be identified and, if so, for how long?
  - How long will any signal due to initial conditions remain large reltive to noise and the increasing forced signals?

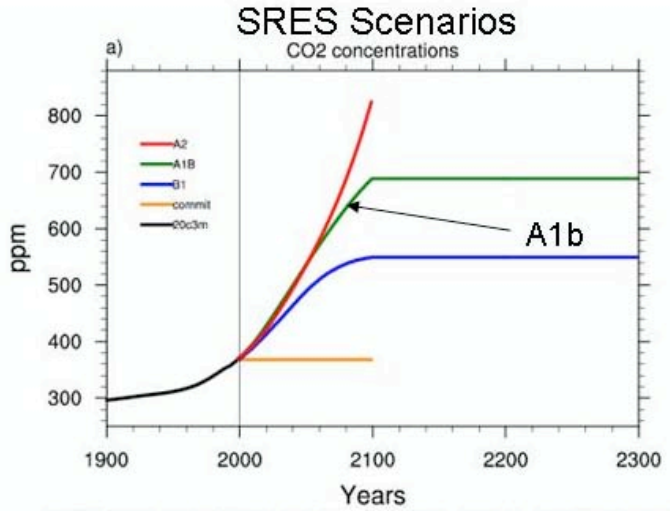
CCSM3 Large Ensemble Experiment

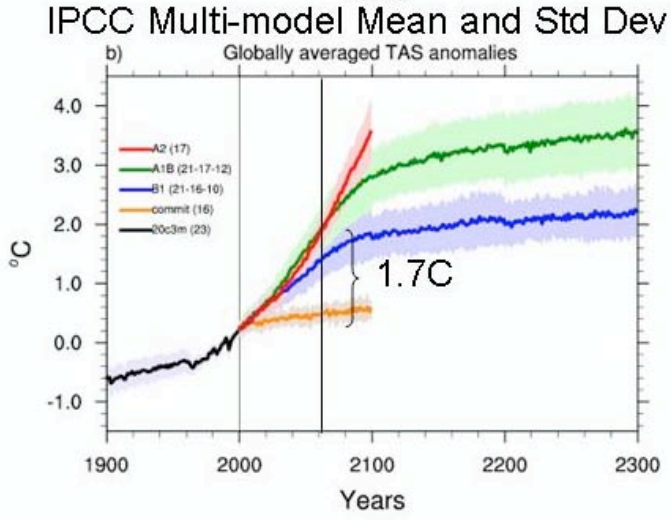
The 30-member ensemble allows statistical analysis of emerging signals ie. the point at which the forced signal exceeds the noise

CVWG/CCWG Large Ensemble Experiment

- SRES A1b
- CCSM3.0 T42 1x
- 30 members
- 2000-2061
- Only vary initial atmospheric state







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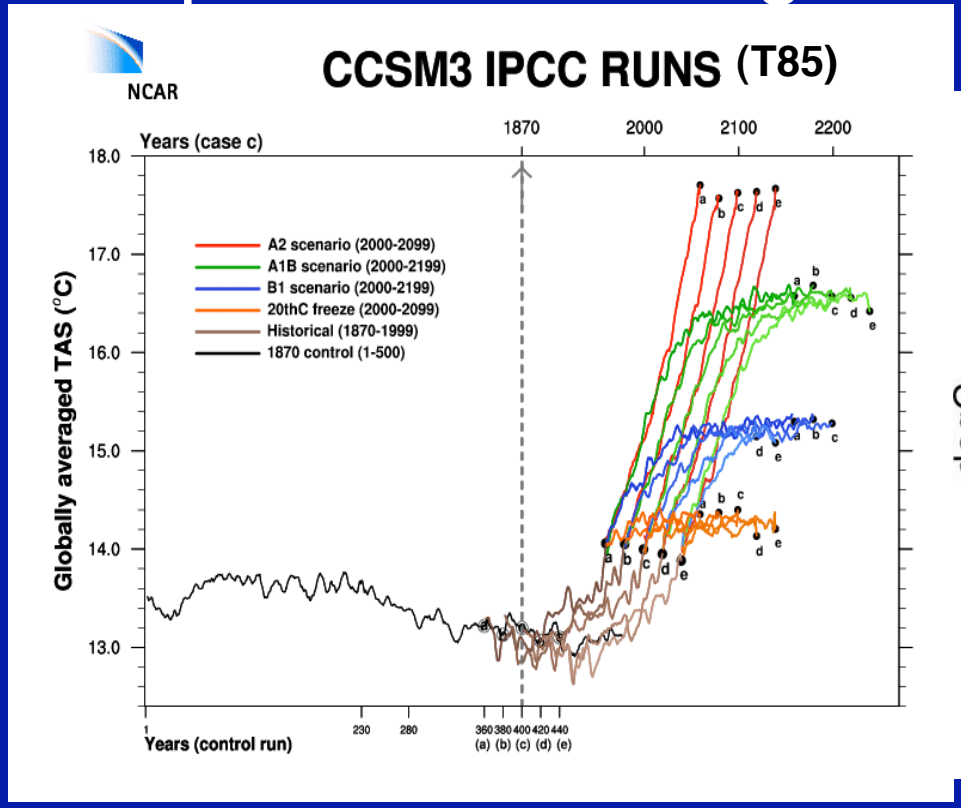
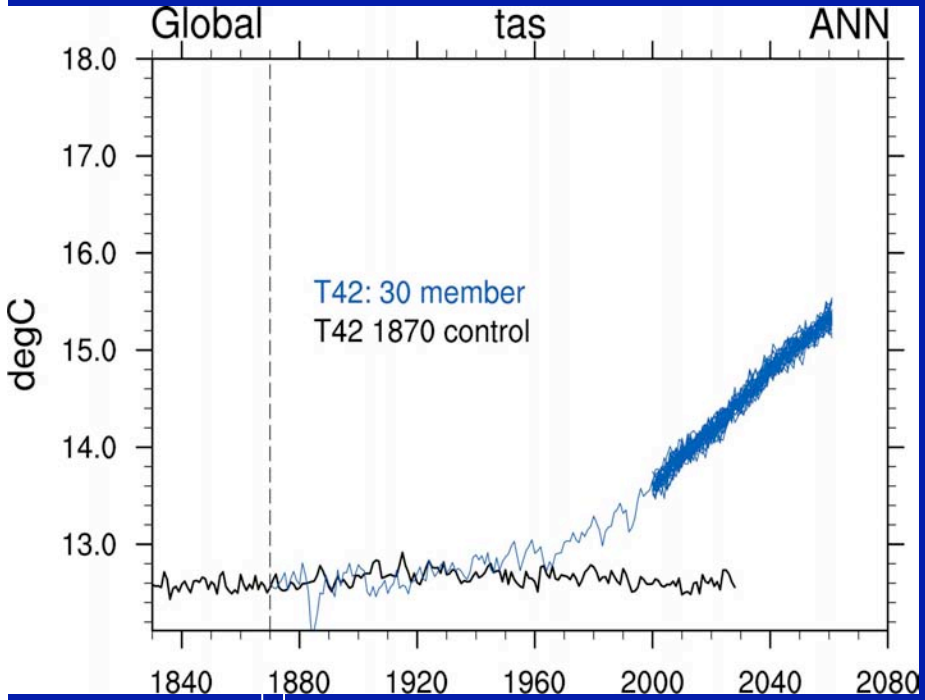
Experimental design: compared to IPCC runs



CCSM3 Large Ensemble (T42)



branch from year 541 of T42 1870 control

In the Large Ensemble, the initial state is identical except for atmosphere which varies from December 1, 1999 to January 15, 2000 from the 20th Century experiment

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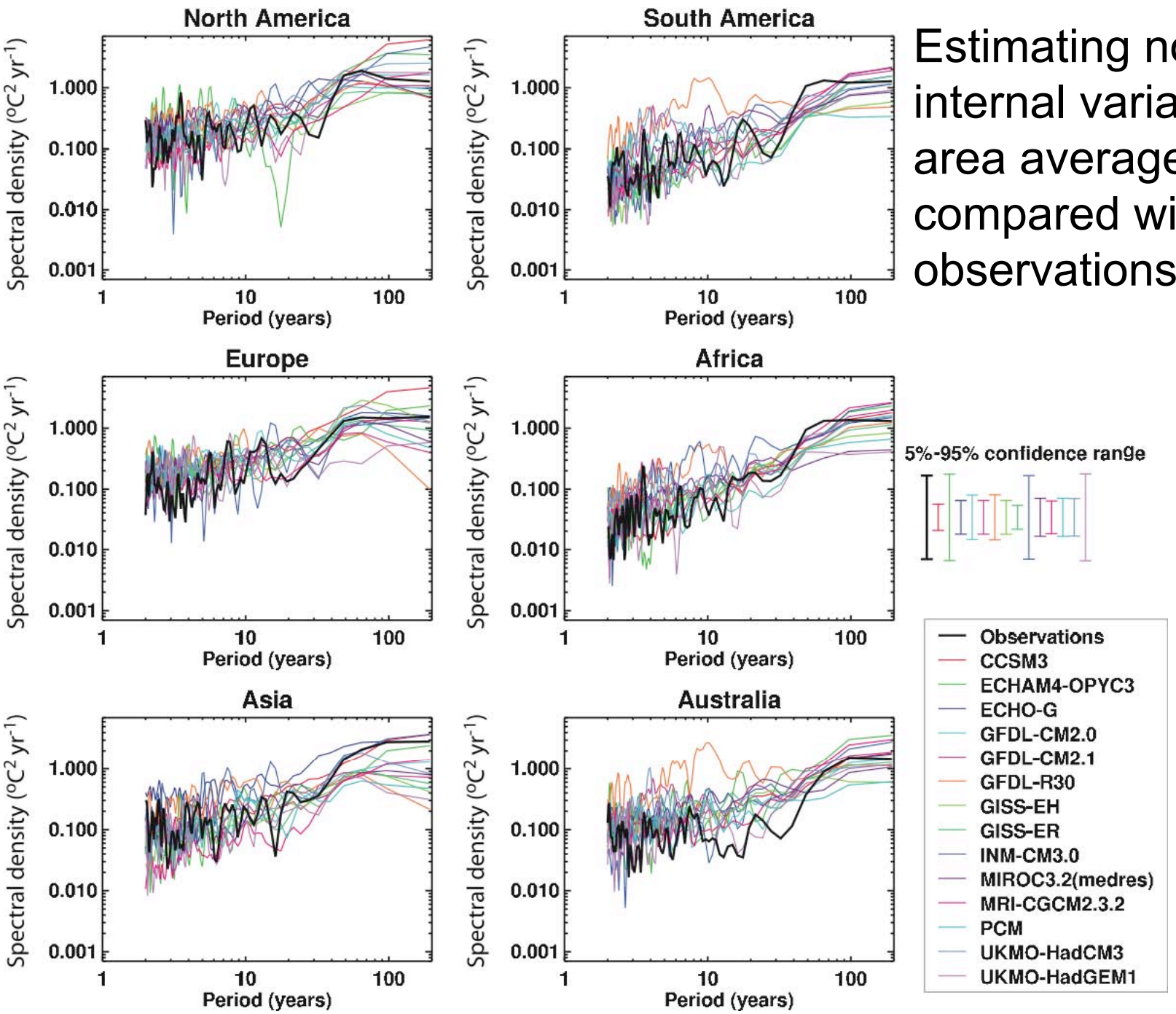
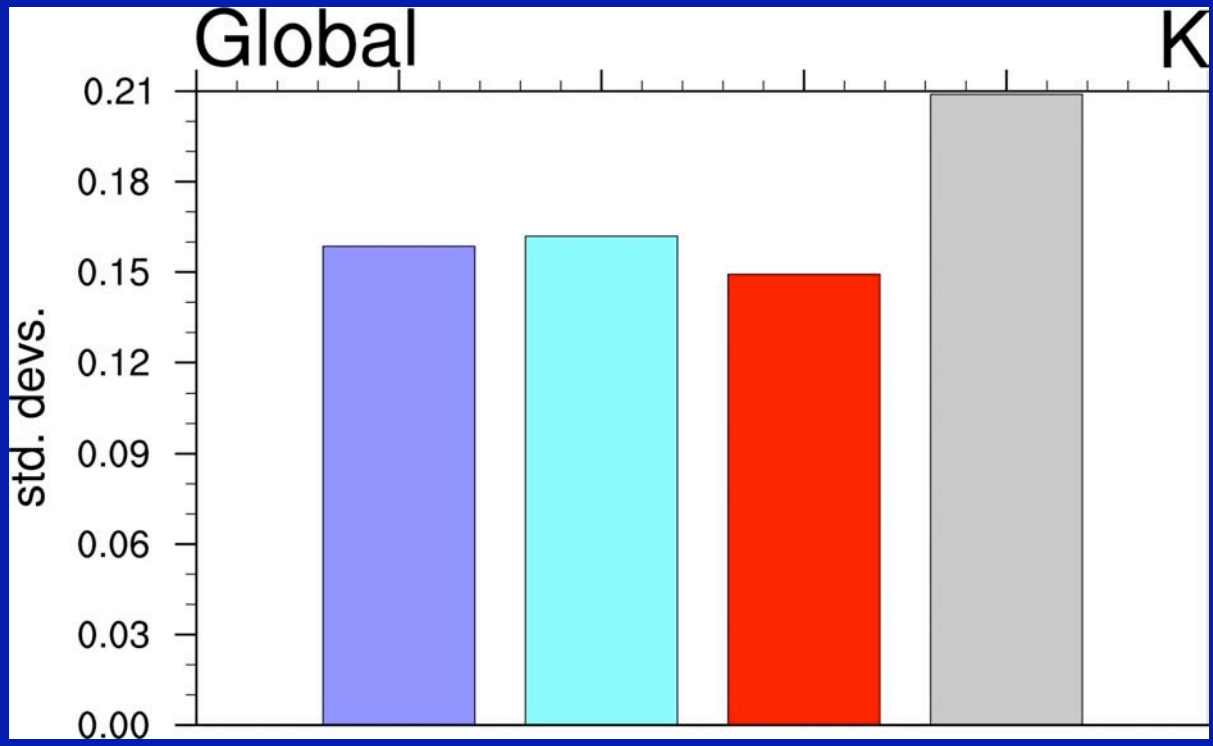


Estimating noise: internal variability of area average Temp compared with observations

Figure 9.8

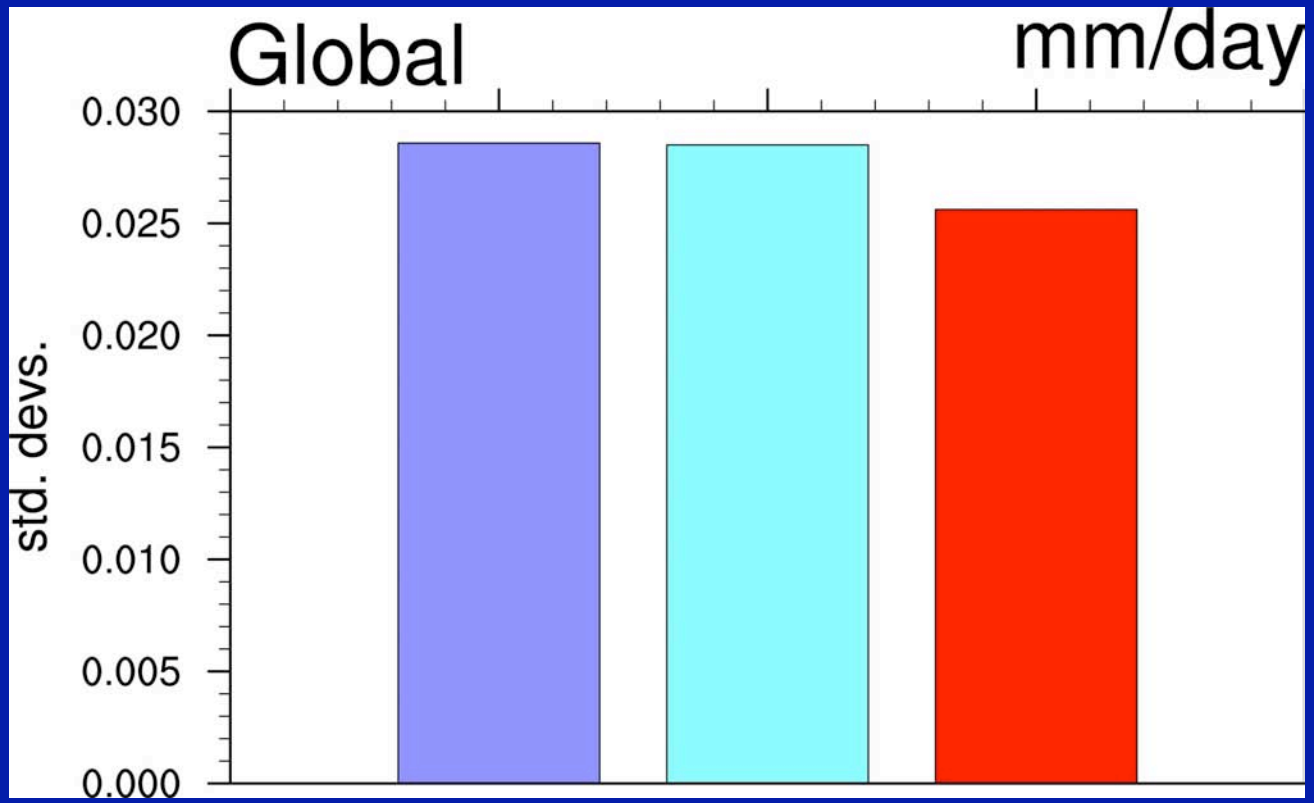
Estimating noise: global av temperature

Interannual standard deviations of global mean surface air temperature indicate that the internal variability can be mostly represented by the ensemble spread



Estimating noise: global av precipitation

Standard deviations of global av precipitation also indicate that the internal variability can be mostly represented by the ensemble spread



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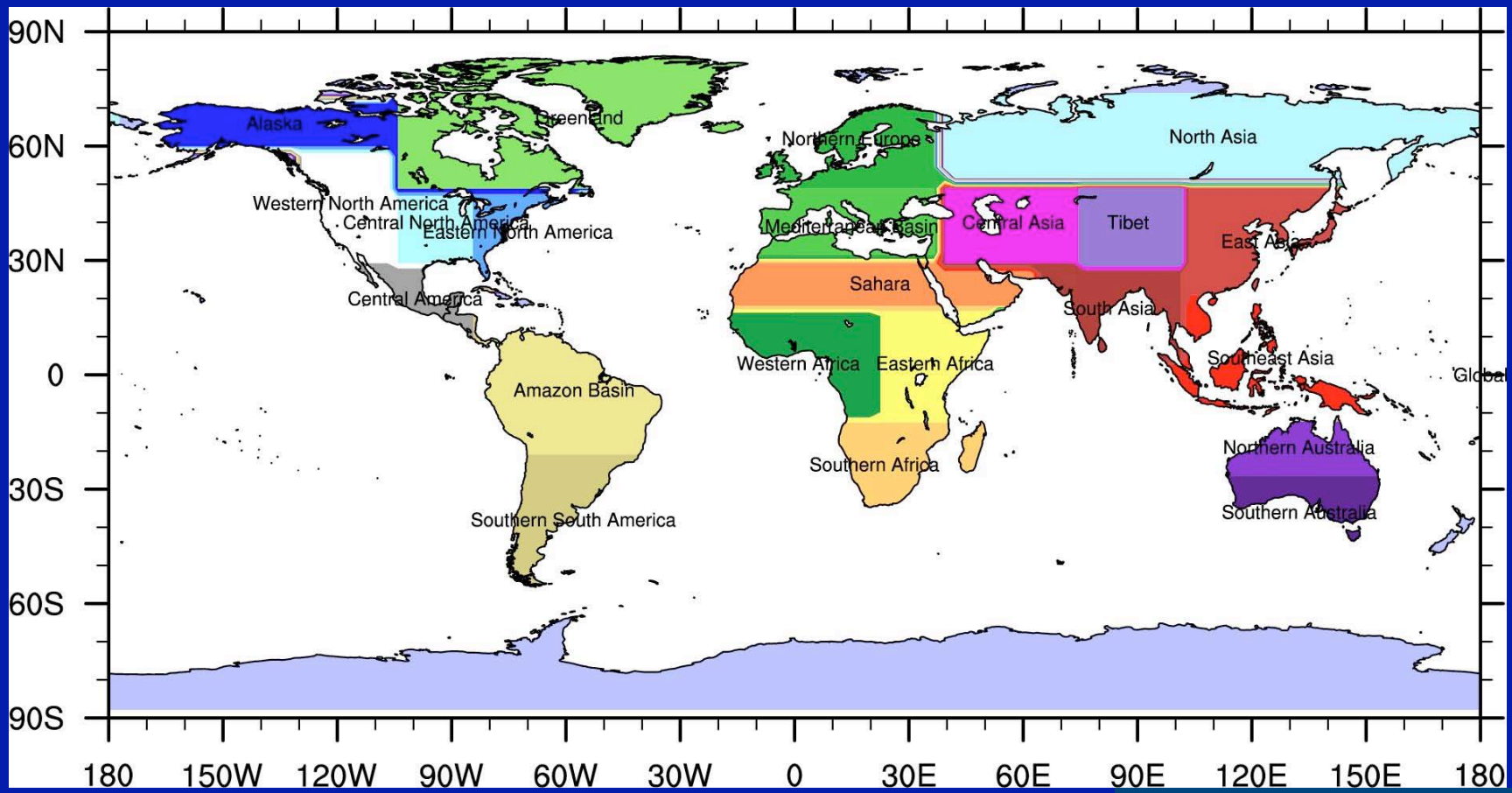
Estimates of internal variability

Land points split into 22 regions, based on Giorgi (2000)



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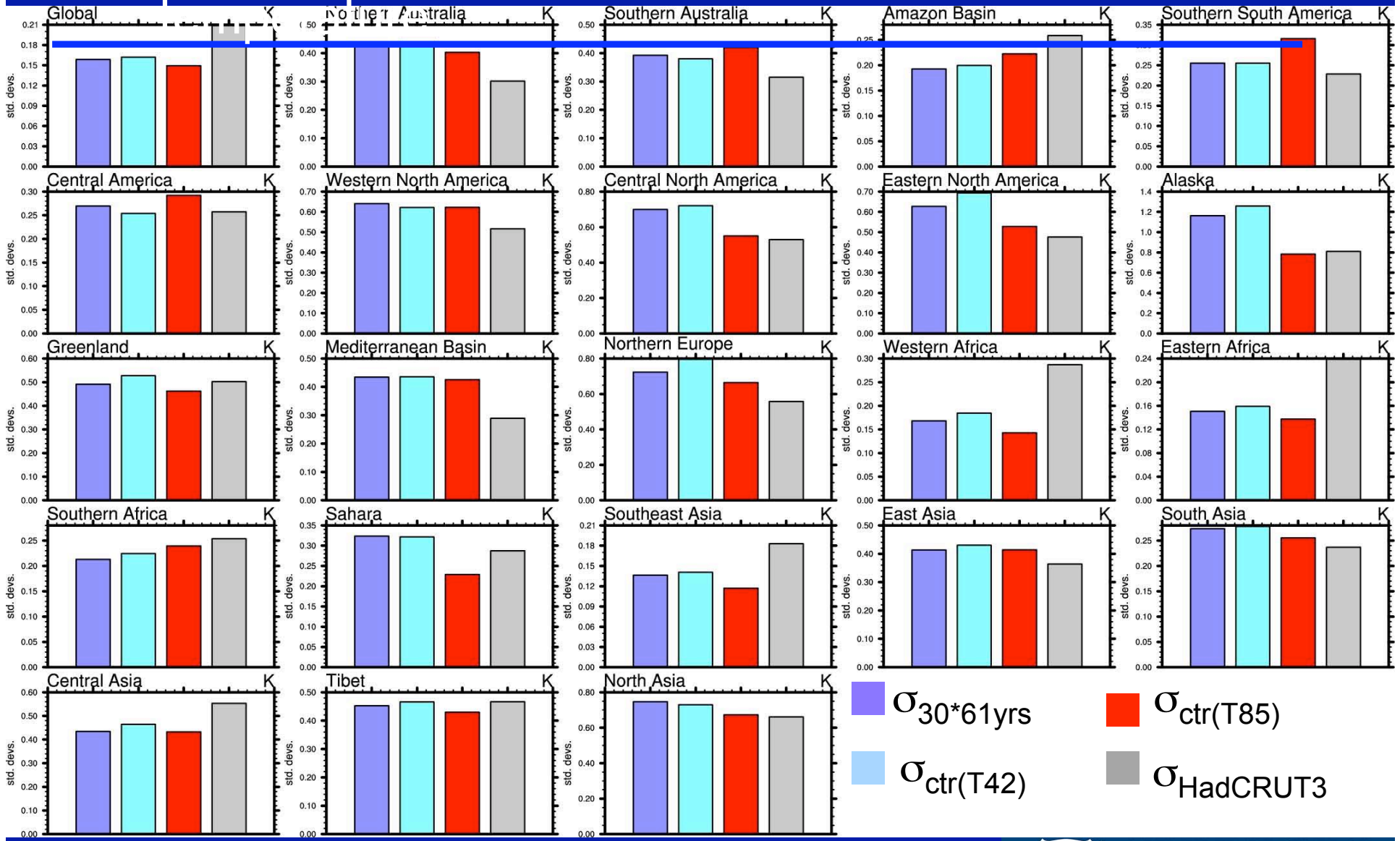
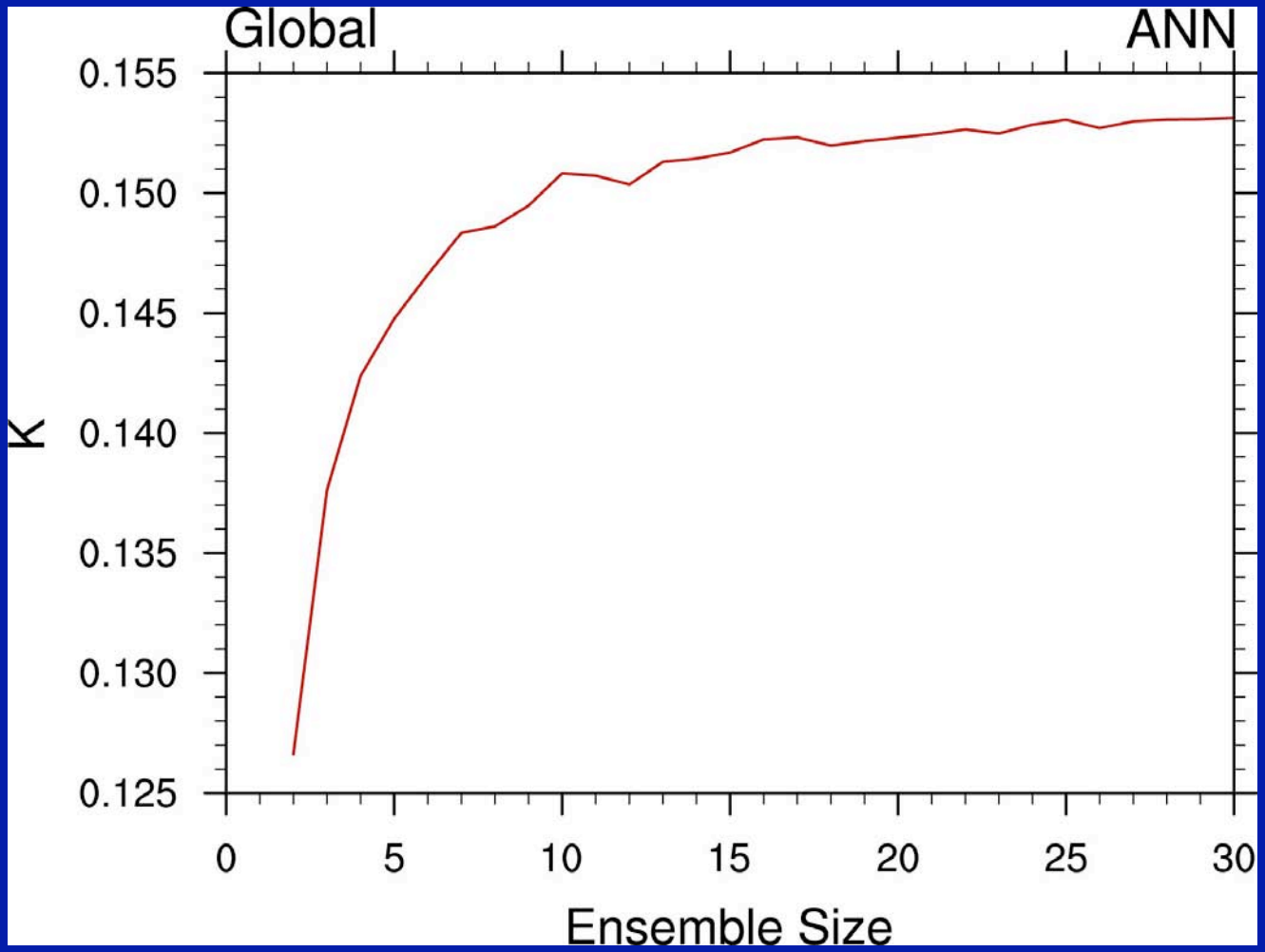
Estimates of internal variability: regional



Ensemble size dependence of noise estimate

Standard deviations of global surface air temperature across ***N*** randomly sampled members of the large ensemble



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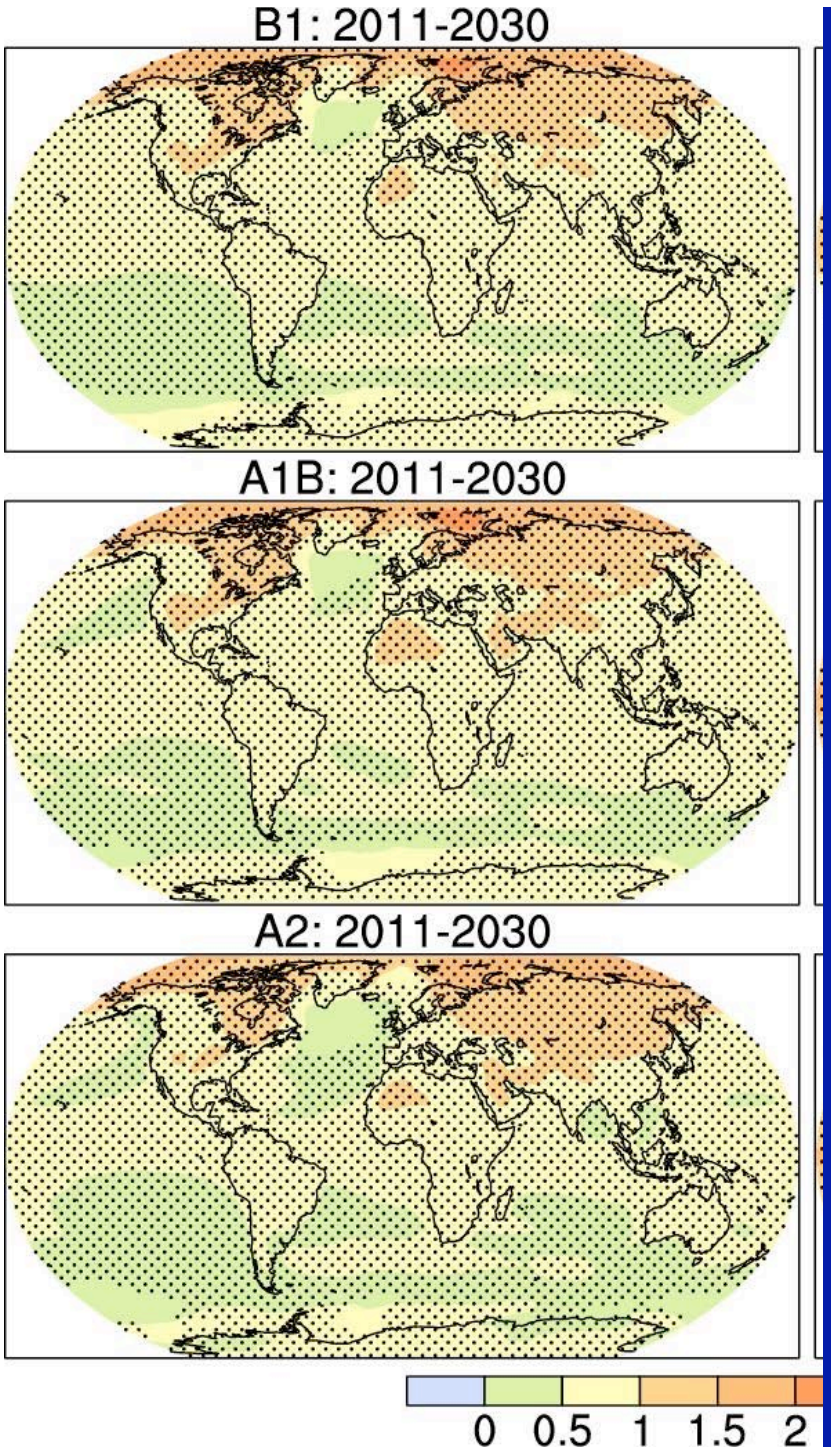

Detection of emerging regional warming

Projections of mean surface temperature change for 2011-2030 relative to 1980-99 from the CMIP3 multi-model ensemble. Stippling shows the regions with significant warming at the individual grid cells. Based on IPCC AR4 WGI fig 10.8

There is significant warming almost everywhere in the ensemble mean.

But when could such an emerging warming signal be detected at the regional scale? Are 20-yr averages needed to enhance signal to noise?

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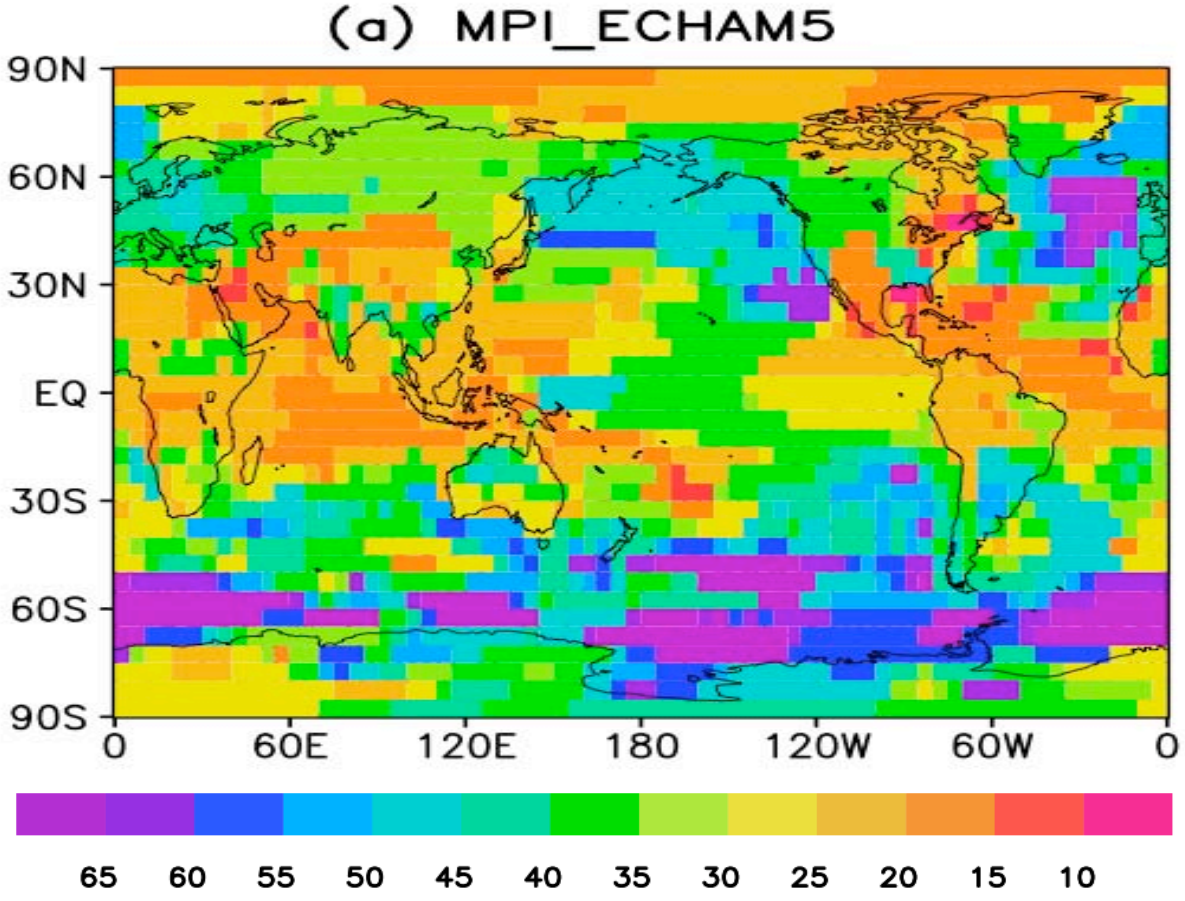
Detection of emerging regional warming

Consider low frequency variations of surface temperature in an individual grid cell in climate model simulations with anthropogenic forcing. When is the low frequency warming relative to 1980-99 locally significant relative to natural variability?



Latest year in which the low frequency warming signal is first significant in each grid cell, $\Delta T/\sigma_T$ large, across all members in ensemble

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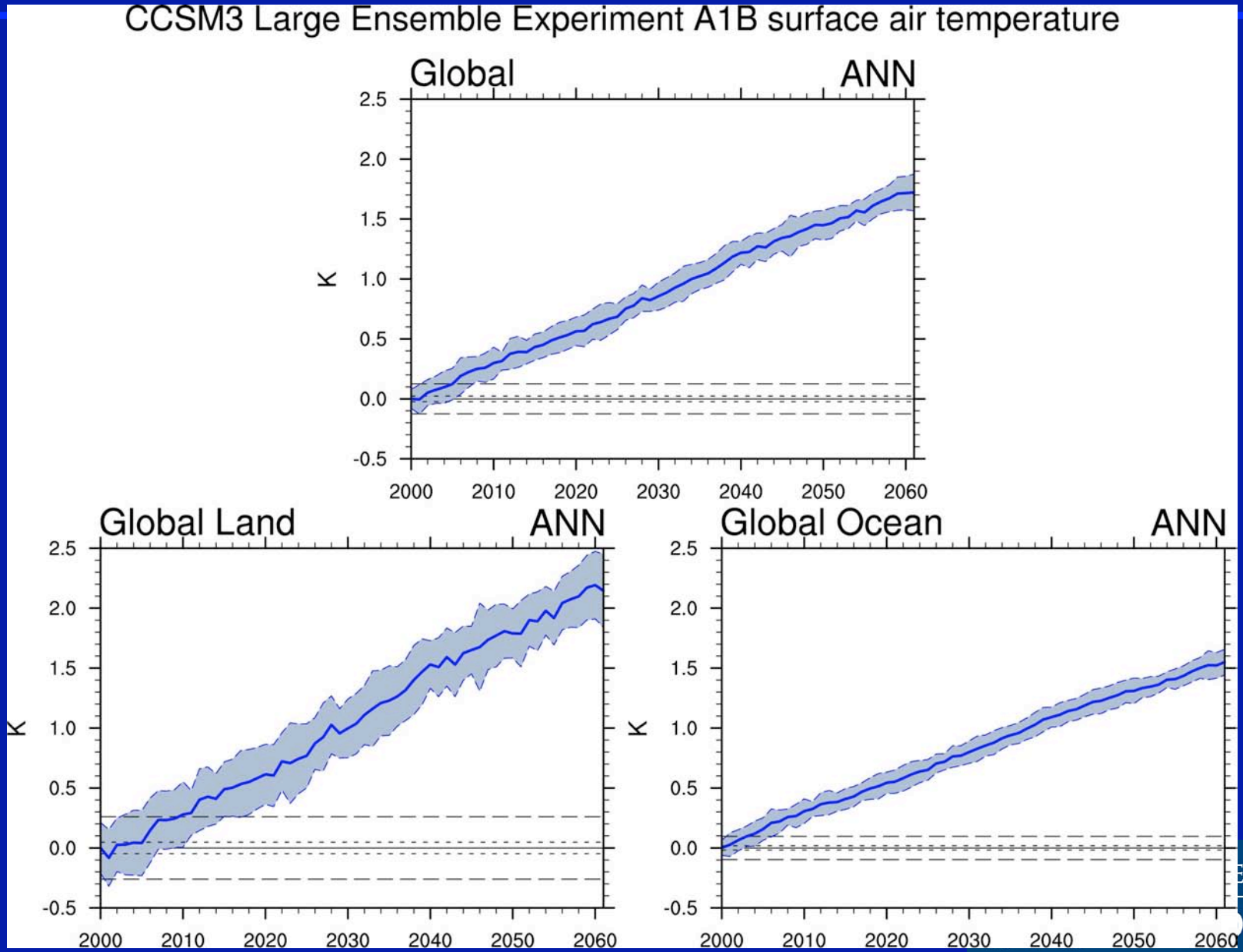
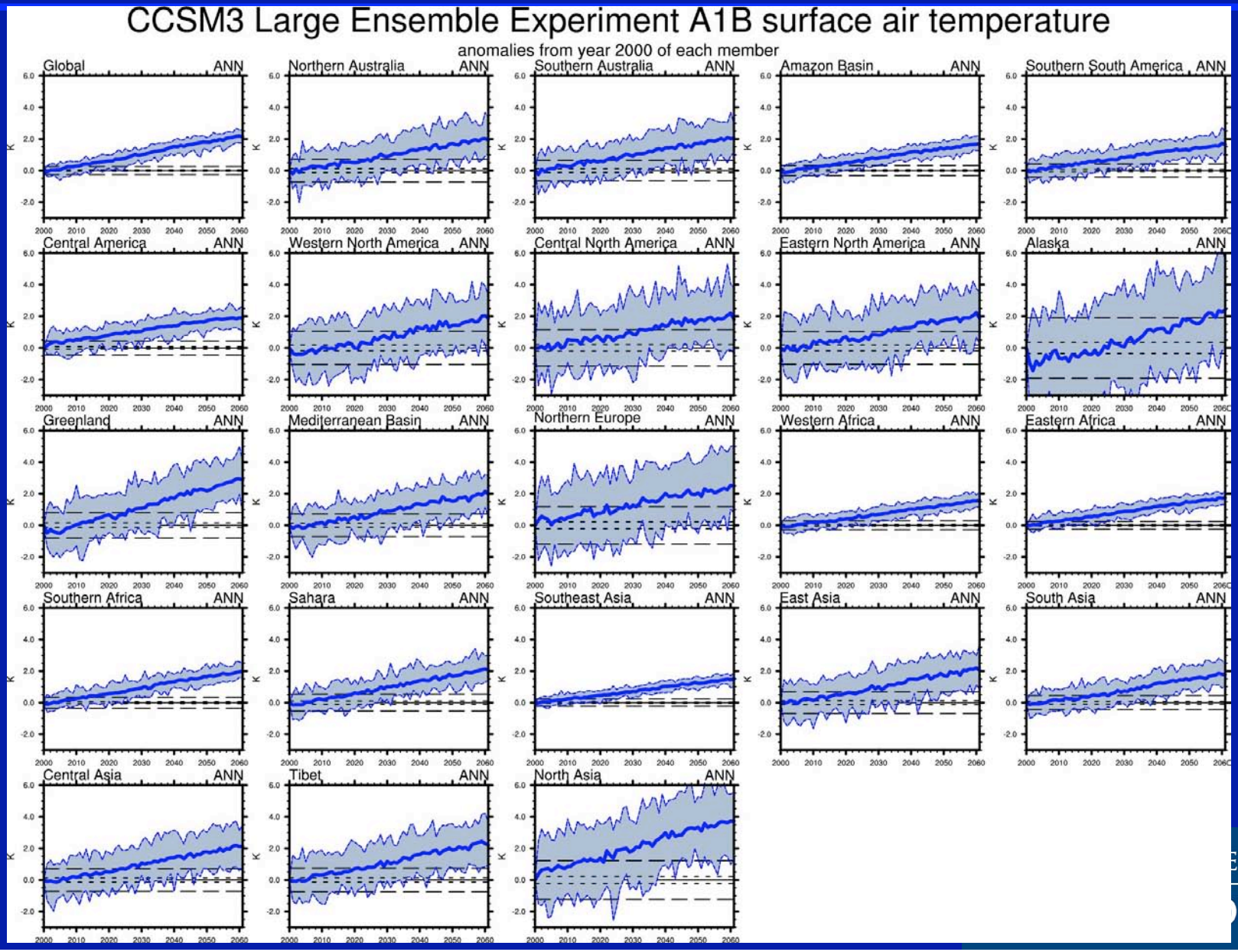
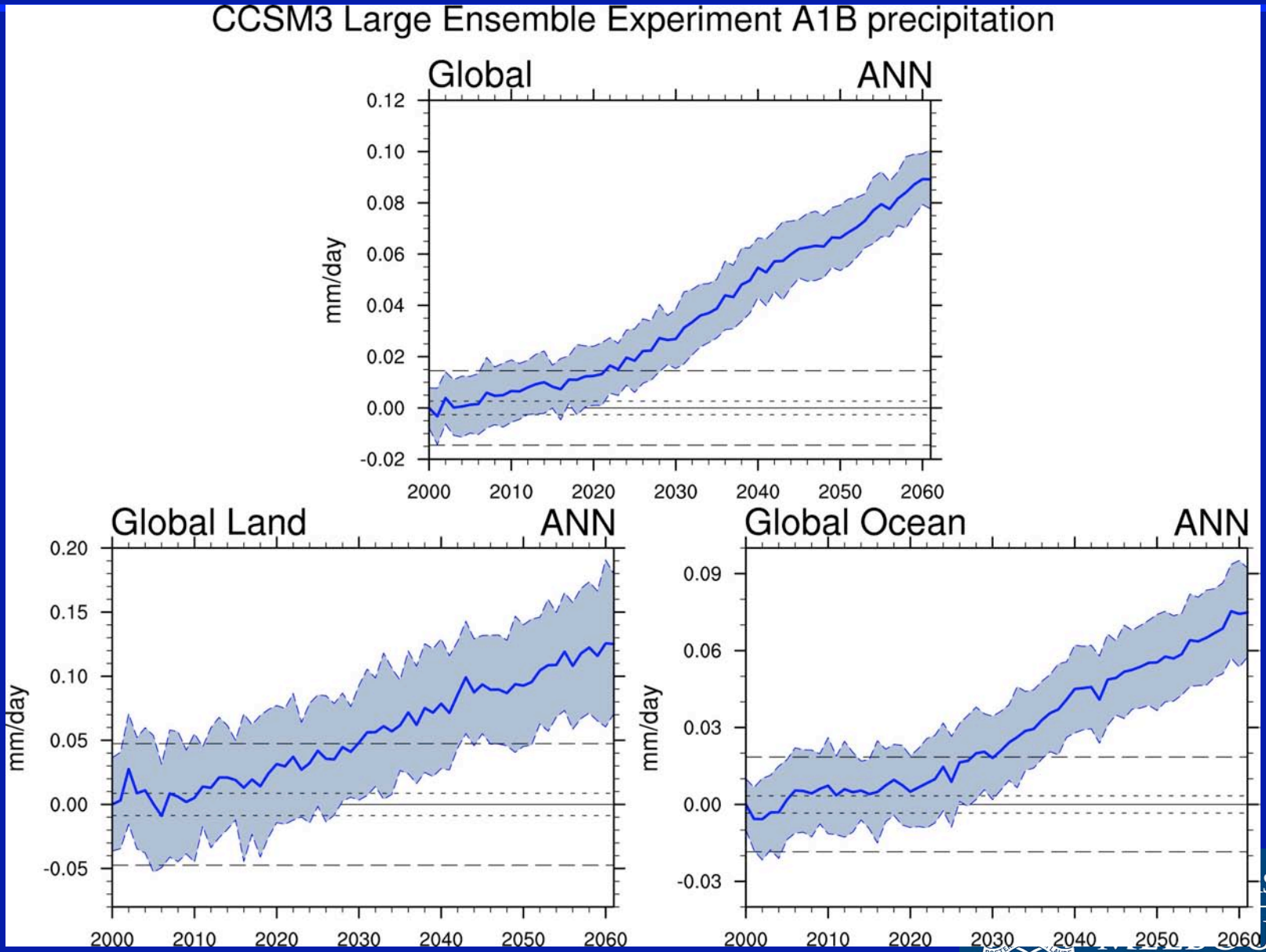
Emerging forced signal: annual temperature



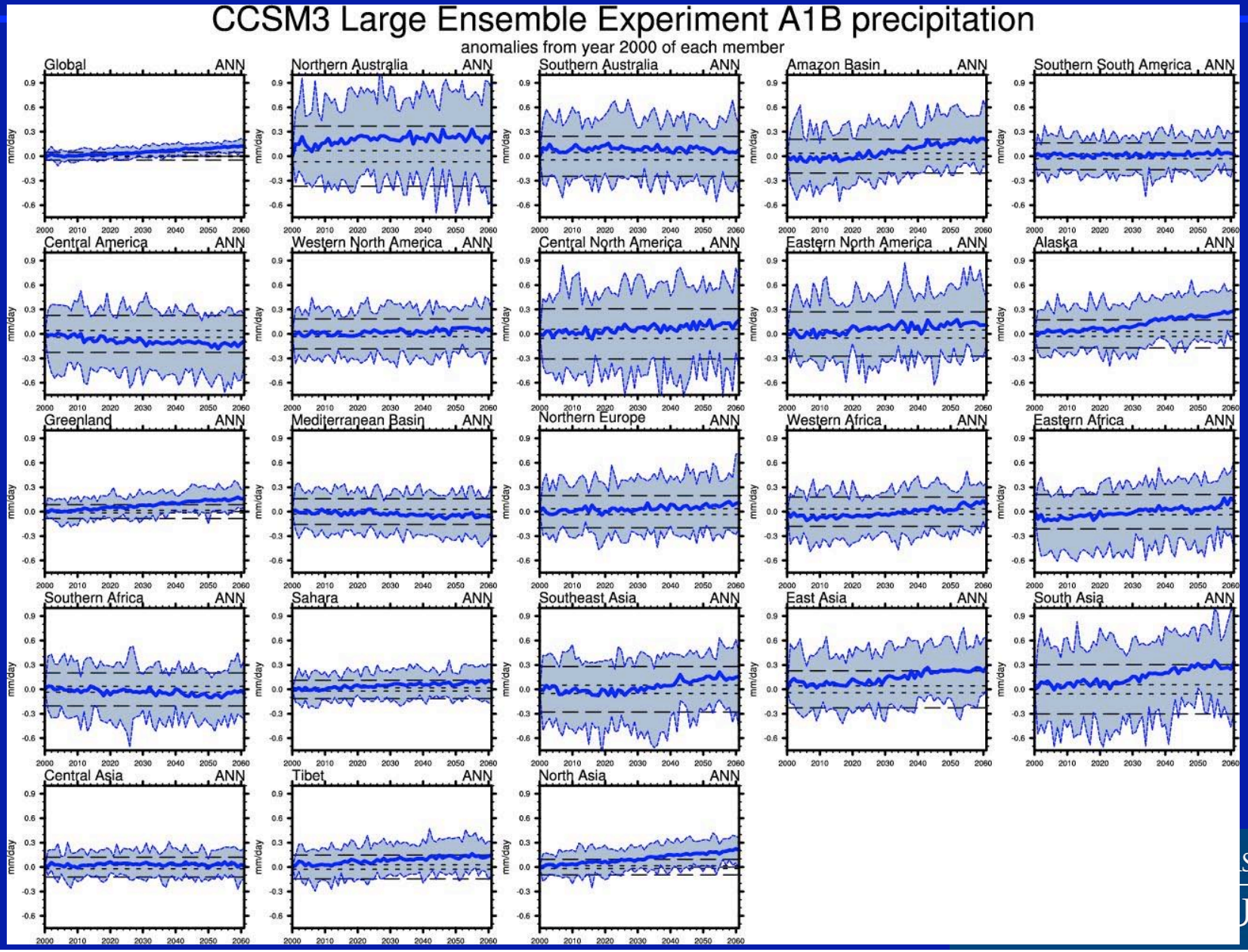
Emerging forced signal: regional av temp



Emerging forced signal: annual precipitation



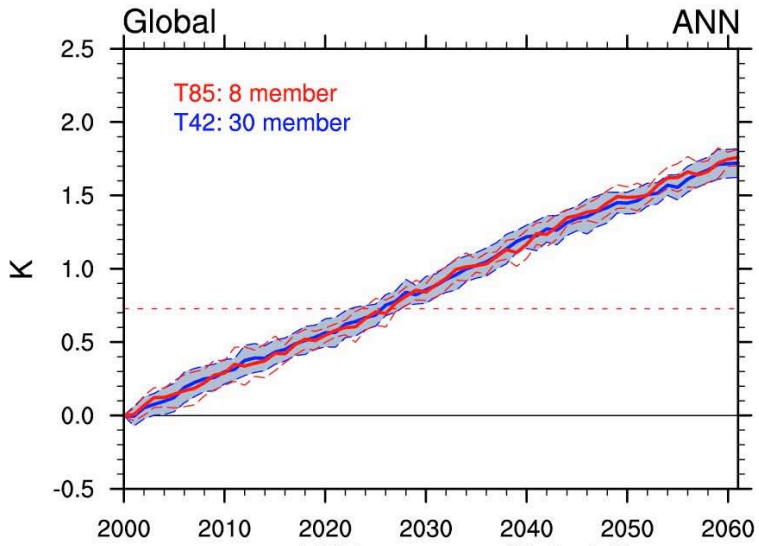
Emerging forced signal: regional av precip

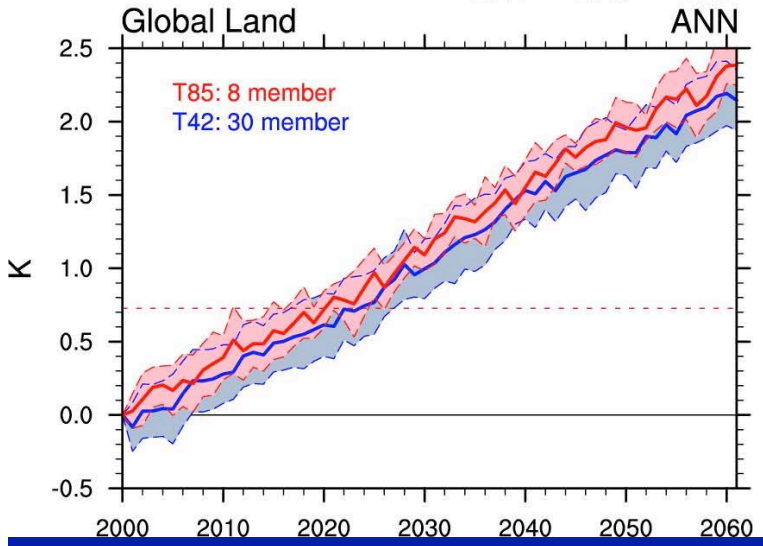


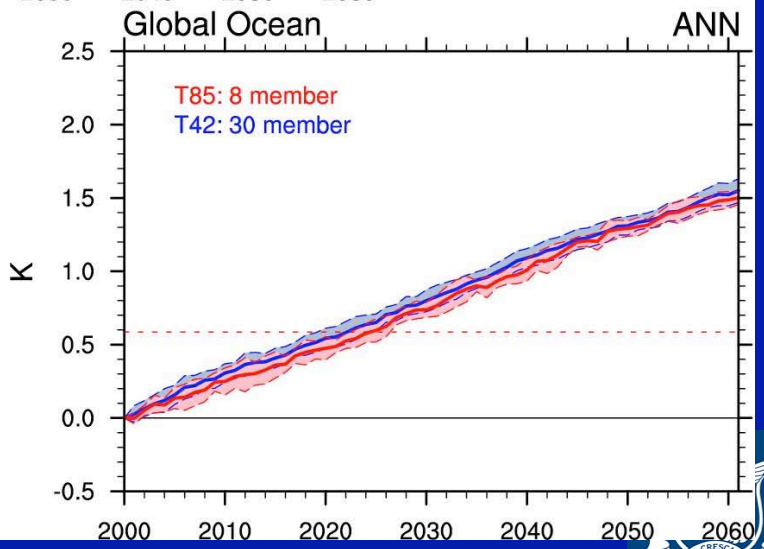
Initial condition signal: annual temperature

CCSM3 Large Ensemble Experiment A1B surface air temperature

Annual av temps







Don't have a predictability expt with ocean init conditions.

Compare ens spread from T42 ens (same ocean conds) with T85 ens (diff ocean cond)

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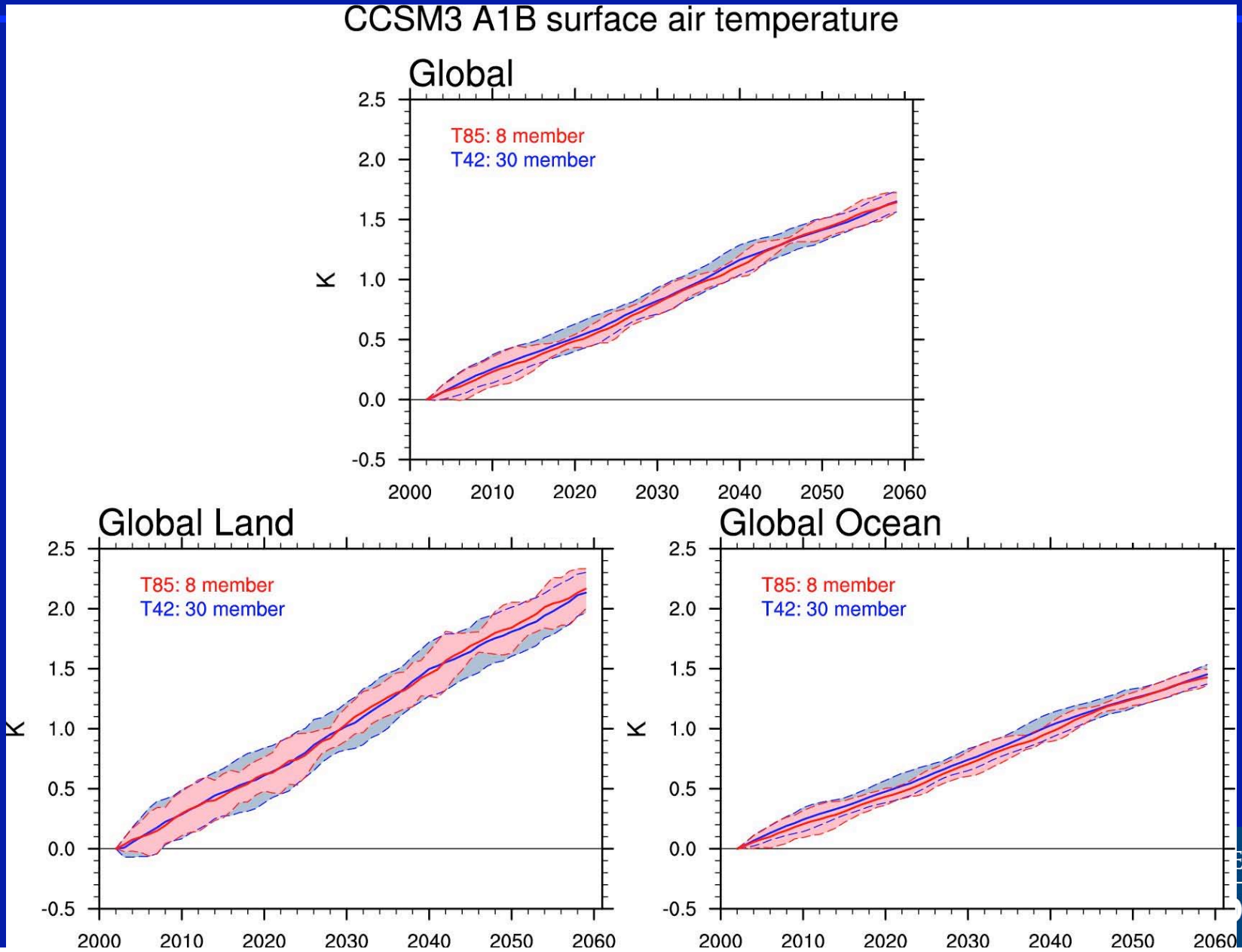
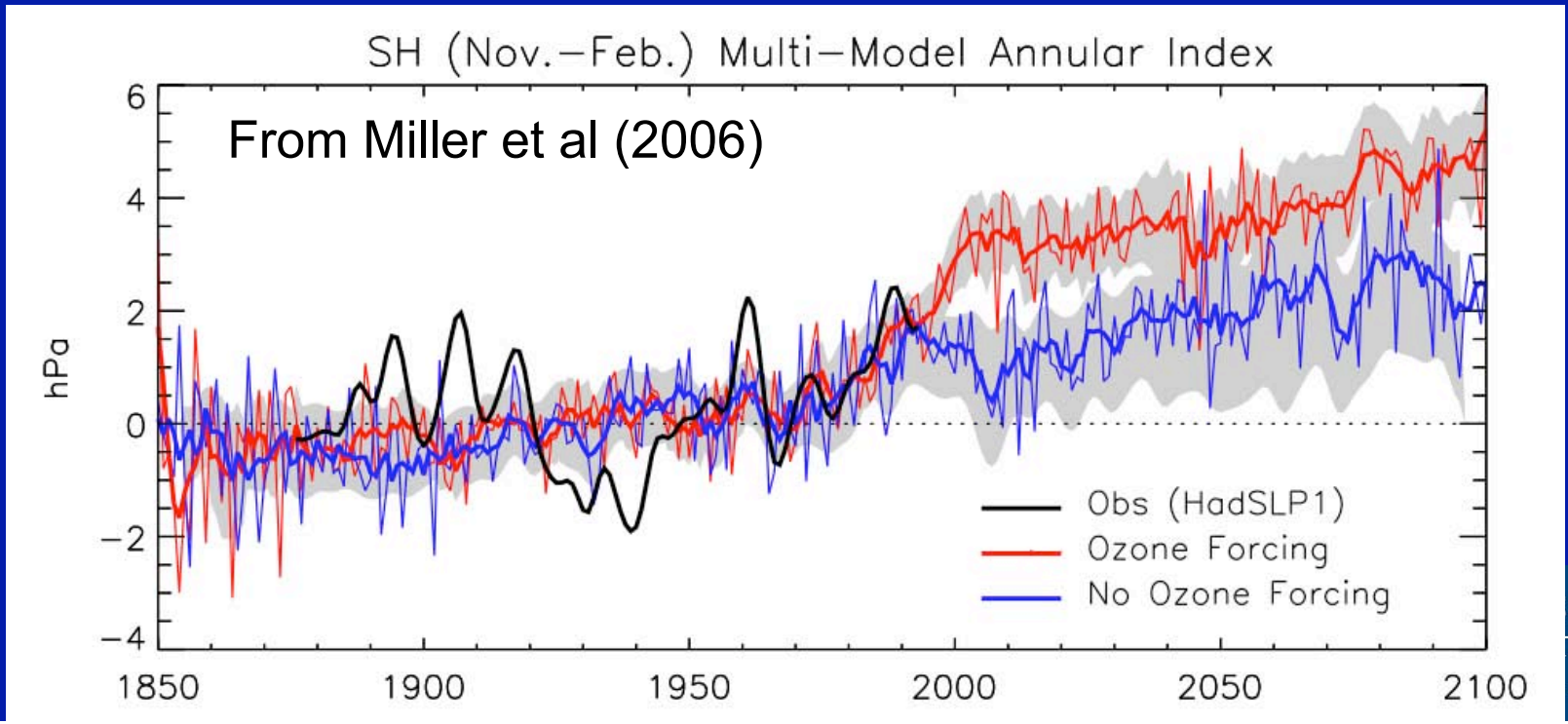
Initial condition signal: 5-yr av temperature



Ozone forcing and projections of climate change

The observed increasing trend in the SAM is simulated better in models that include both increasing greenhouse gases and stratospheric ozone depletion.

The largest differences in SAM variations are from 1990 to 2010, the period of lowest Antarctic ozone.



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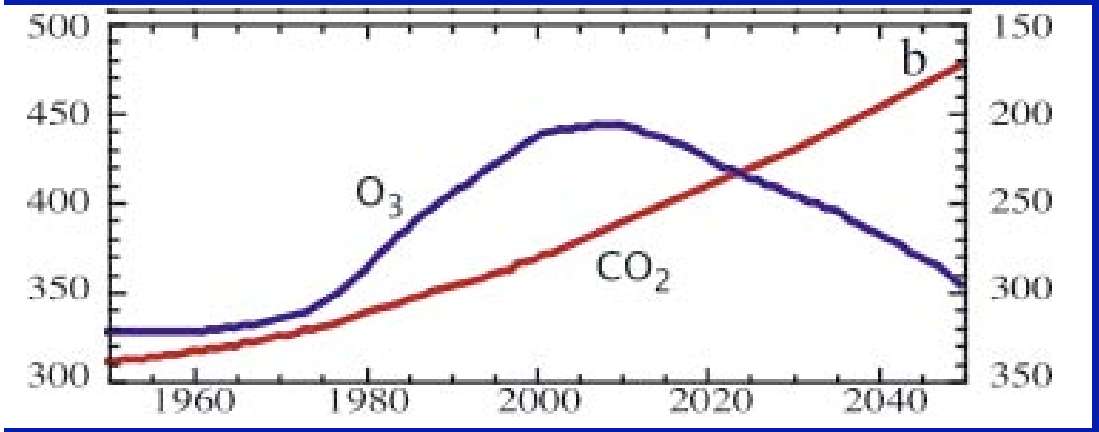
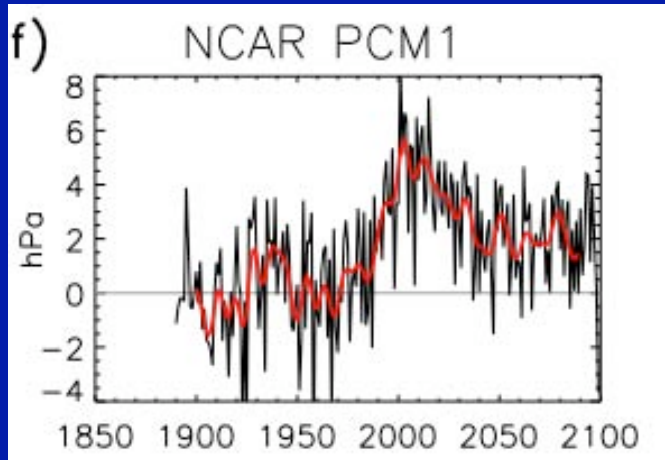
Competing influences: increasing ghgs and ozone recovery

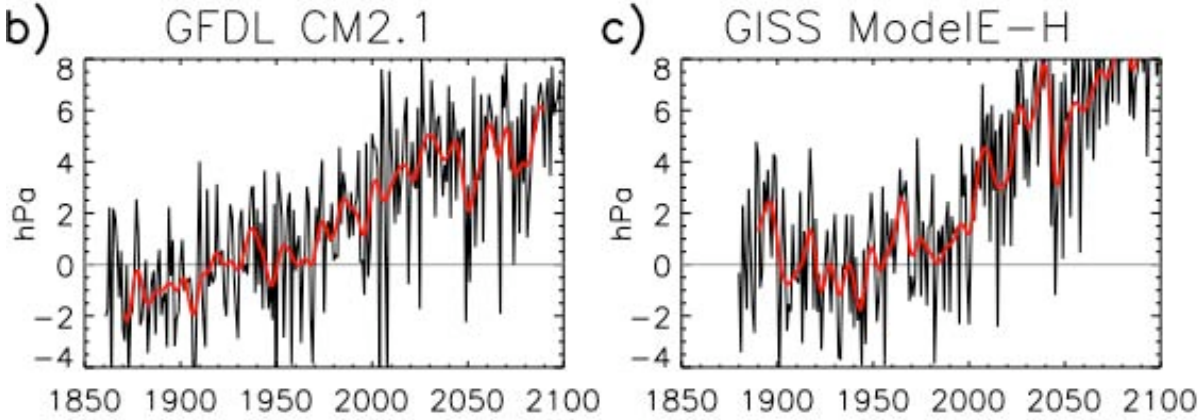
Future greenhouse gases and ozone

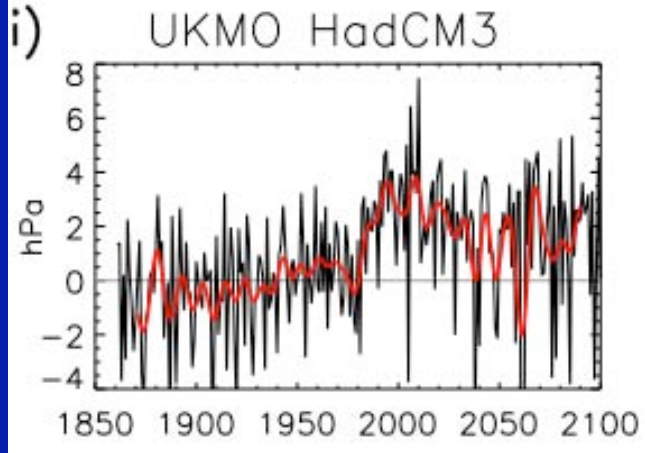


Model SAM for increasing ghgs and ozone depletion and recovery



Model SAM for increasing ghgs and ozone depletion but no recovery





Summary

Estimates of noise due to interannual variability

- Departure from ensemble mean gives a good estimate of unforced internal variability for global and regionally averaged temperature and precipitation
- preliminary results suggest internal variability is significantly underestimated for ensemble size less than ~5

Emerging forced signal

- Emergence of signal depends on spatial and time averaging; global av ann and reg low freq T signal apart by 2020
- cooling is possible for first decade
- Signal depends on forcing, so need to get forcing right

Initial condition signal

- Difficult to identify and only apart for first period of runs