Variability and Change in Our Water: Some Results from Climate Model Ensembles

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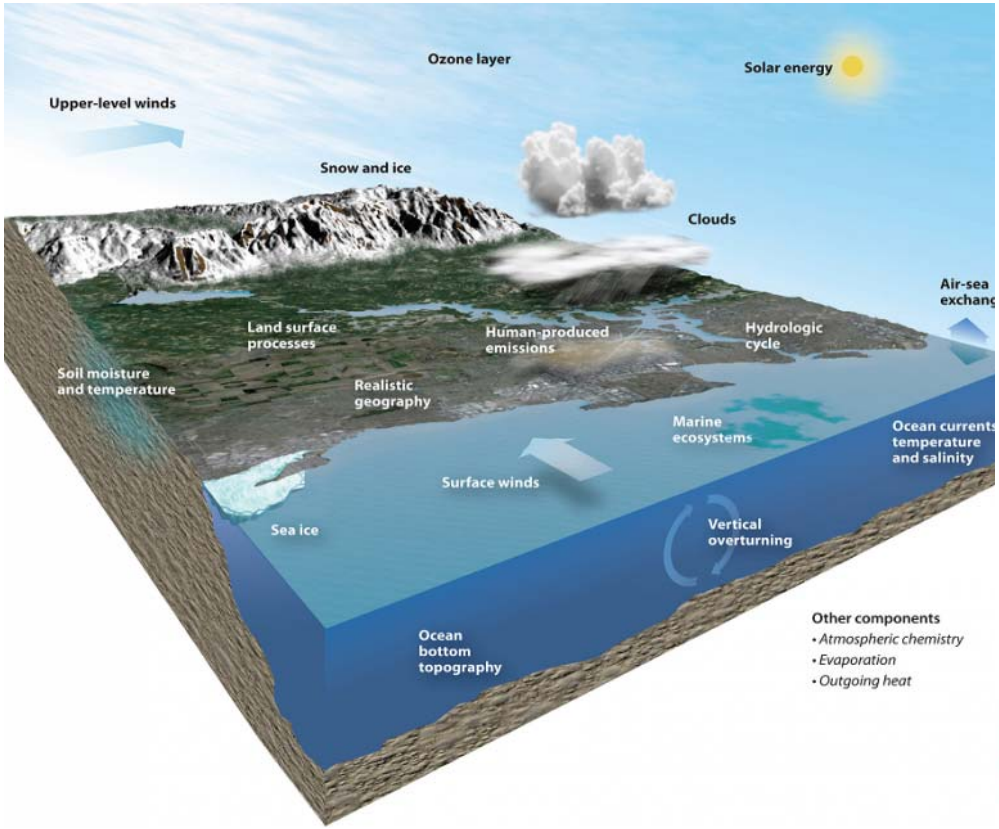
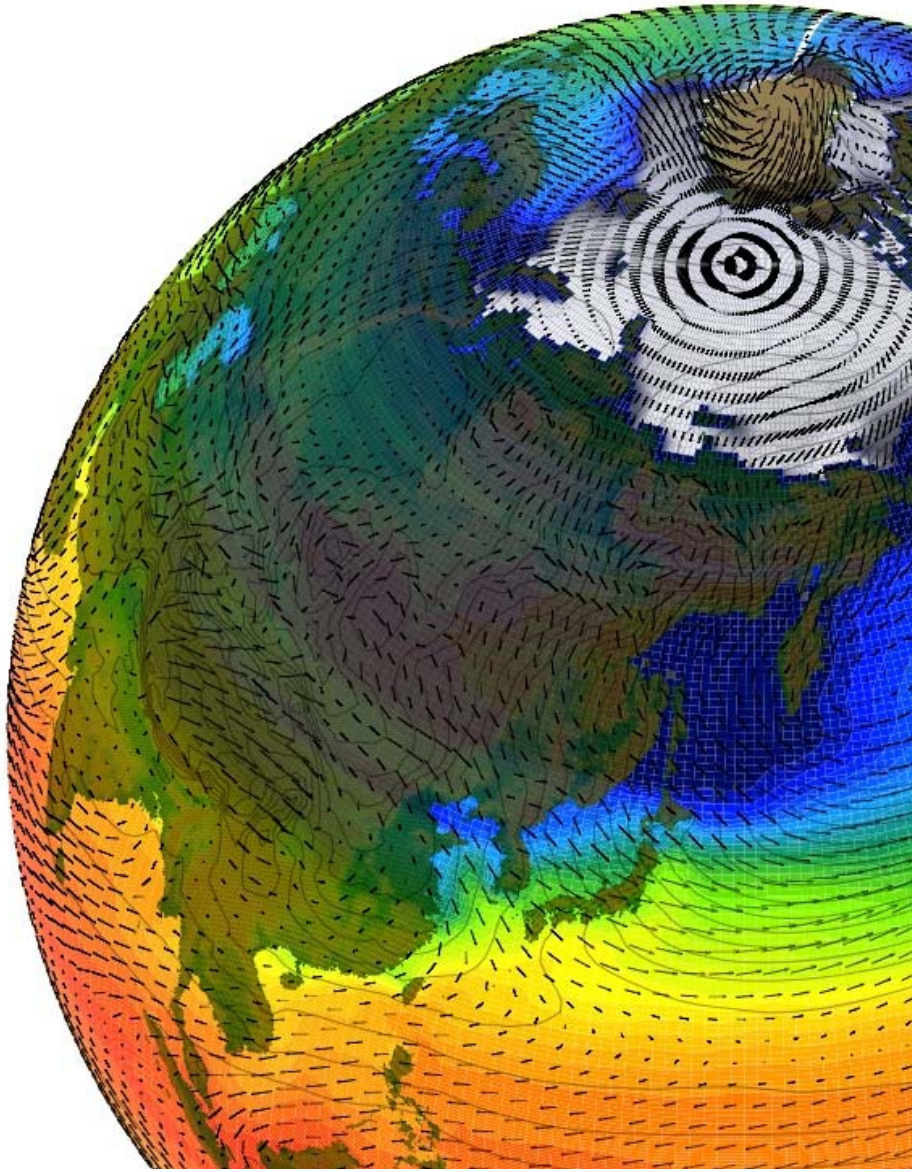
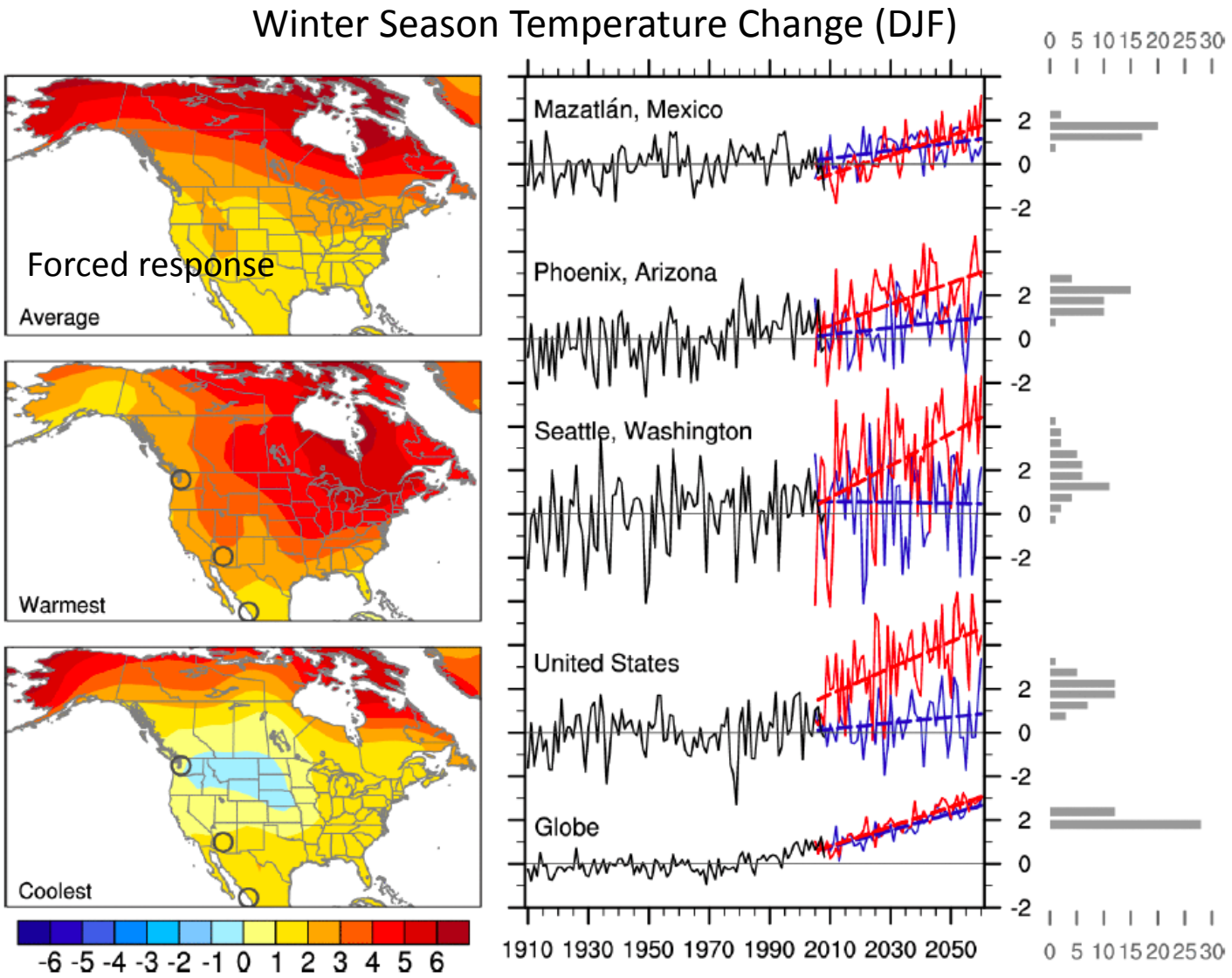
How Variable is the Local Climate?





State of the art AOGCM; NCAR CCSM
One 40 member ensemble at T42 (1.5°x1.5°), run for 2000-2050. Each run has identical land, ocean, and sea ice but begins with slightly different atmosphere, from different days in Dec-Jan, 2000.

Advancing predictability and adaptation



Repeated runs of a state of the art AOGCM (40 realizations).

Averaging over a decade, or over the whole contiguous US, doesn't reduce noise much – it is intrinsic, esp in winter

But: some single grid points are less variable than continental U.S.

Implications for adaptation

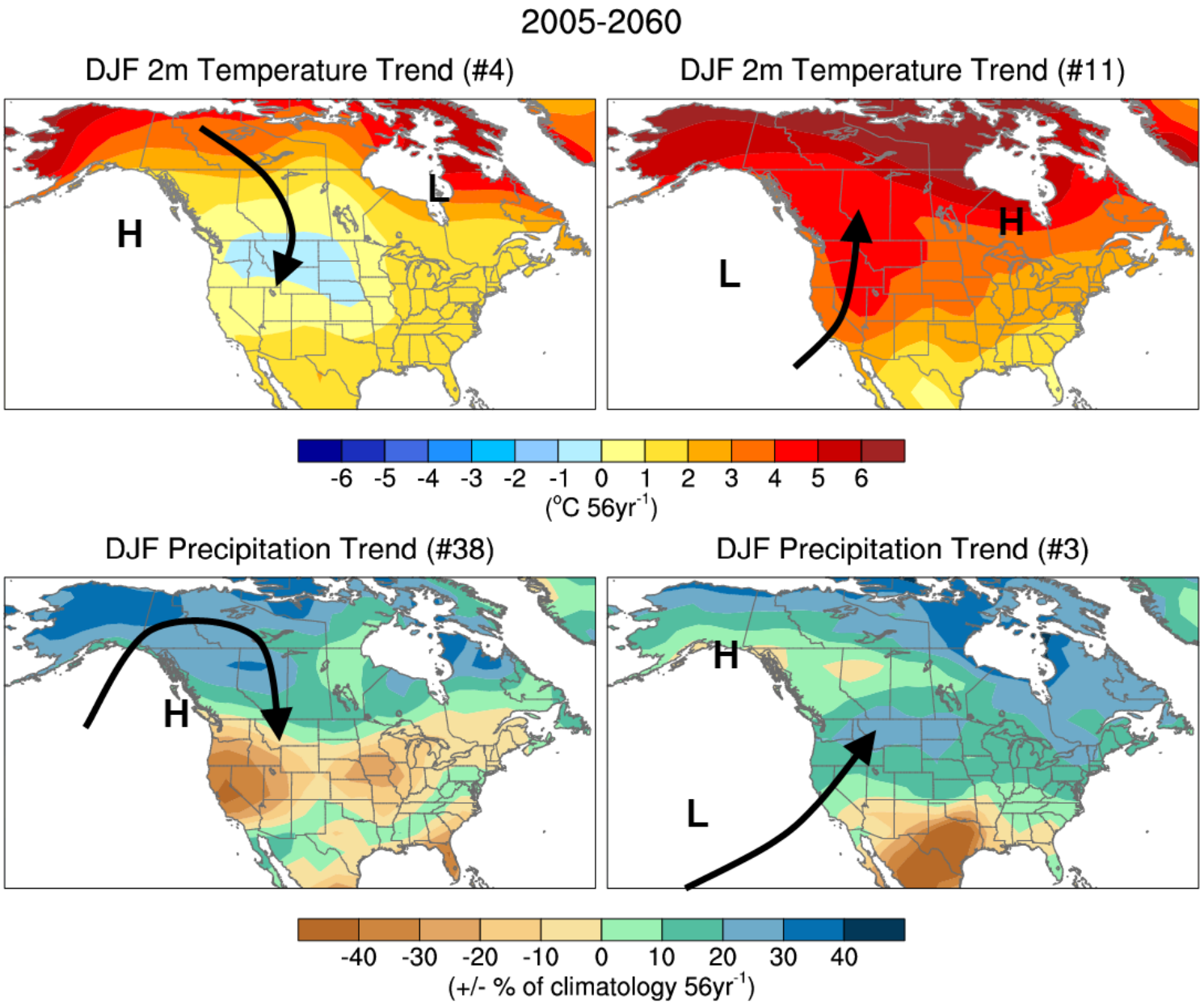
Deser, Knutti, Solomon, Phillips, Nat. Clim. Chg, 2012.

Warmest/coolest ;
driest/wettest from among 40 different runs of the same model

Strong effects of changes in circulation esp in winter (linked to NAM, SAM changes-polar vortex)

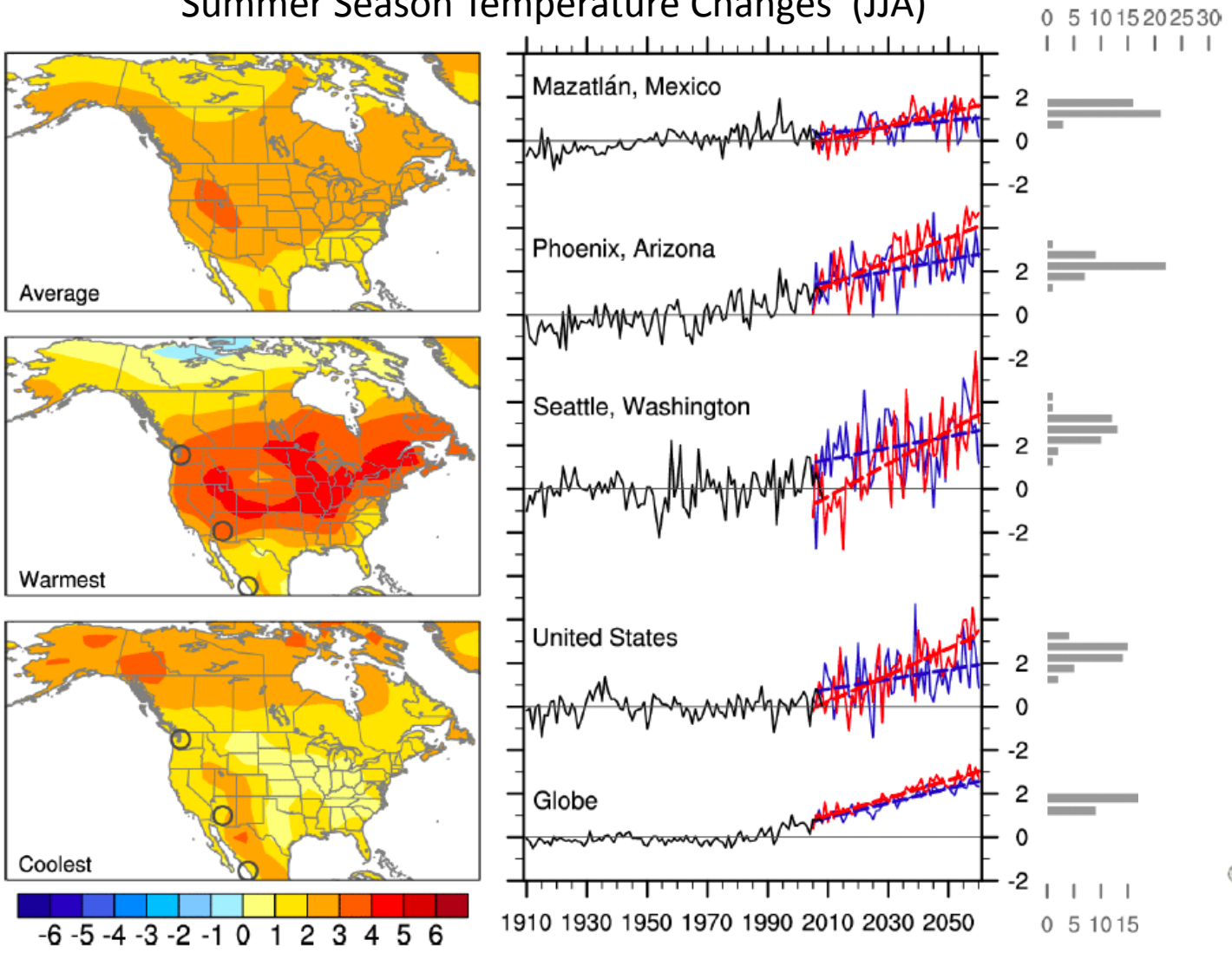
But lower latitudes are less affected

See Deser et al., in press, J. Clim., 2014.



Advancing predictability and adaptation

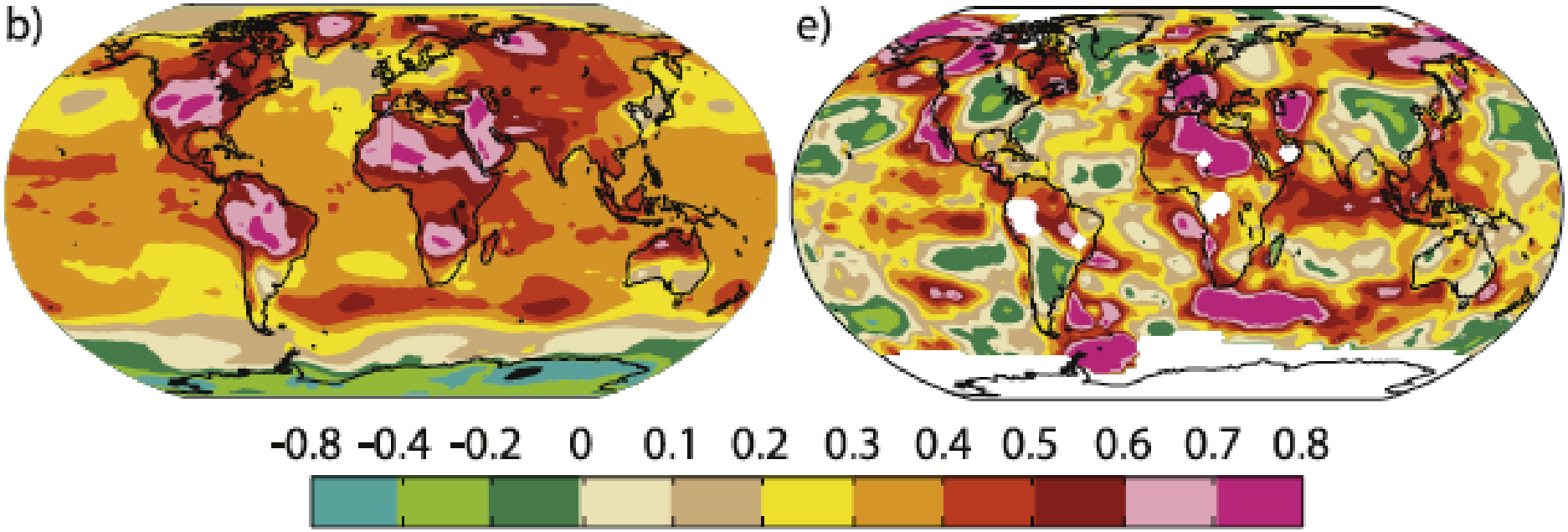
Summer Season Temperature Changes (JJA)



Repeated runs of a state of the art AOGCM (40 realizations).

Deser, Knutti, Solomon, Phillips, Nat. Clim. Chg, 2012.

Signal of Change: 1990-1999 vs 1900-1999 (warm season at each pt)

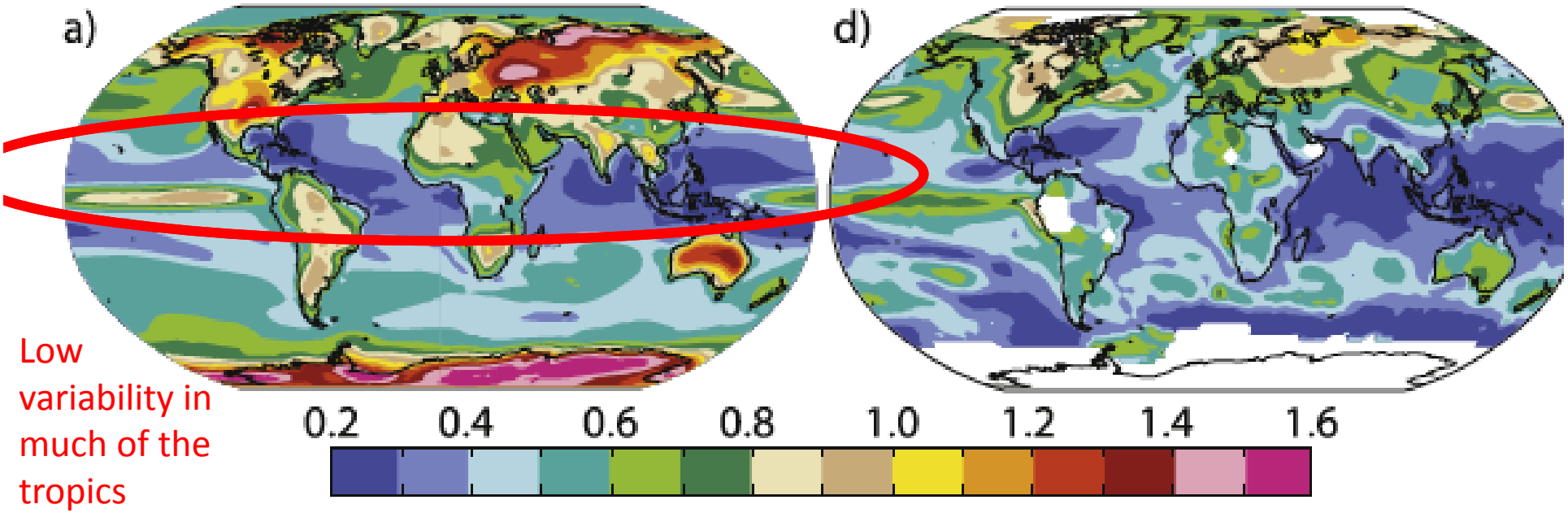


CMIP3 model average

GISS Observations: one realization

Mahlstein, Knutti, Solomon, Portmann, Env. Res. Lett., 2011

Noise: Variability (interannual, warm season)



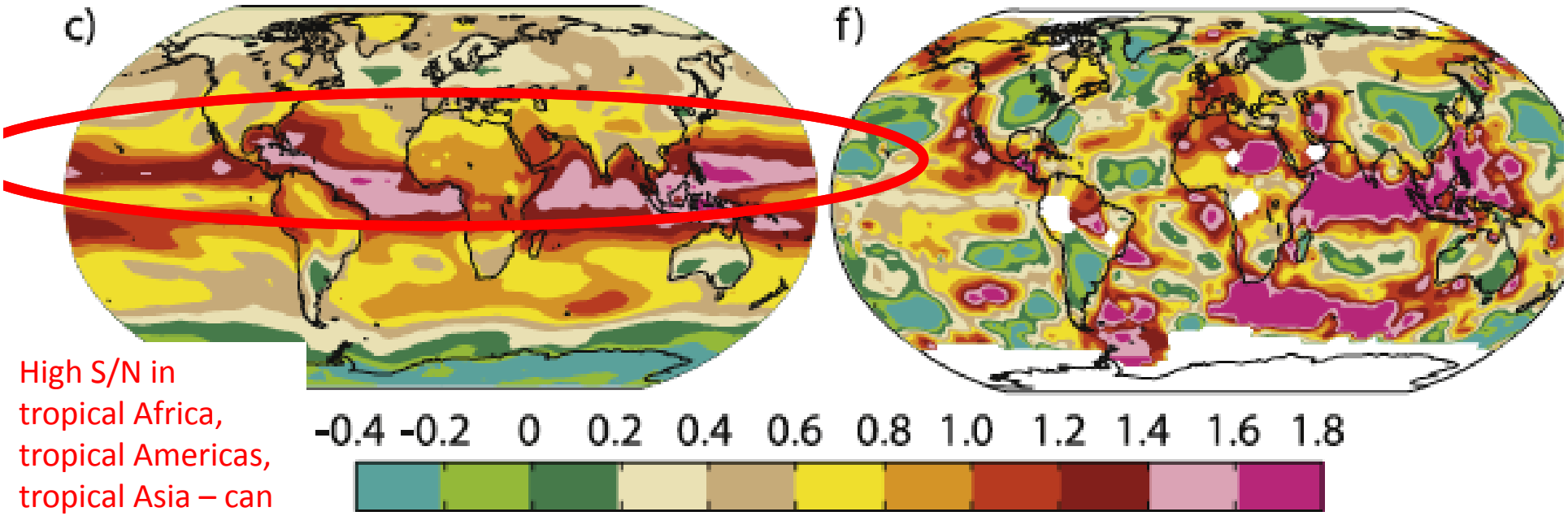
Low variability in much of the tropics

Models

GISS Observations: one realization

Mahlstein, Knutti, Solomon, Portmann, Env. Res. Lett., 2011

S/N 1990-1999 vs 1900-1999 (warm season)

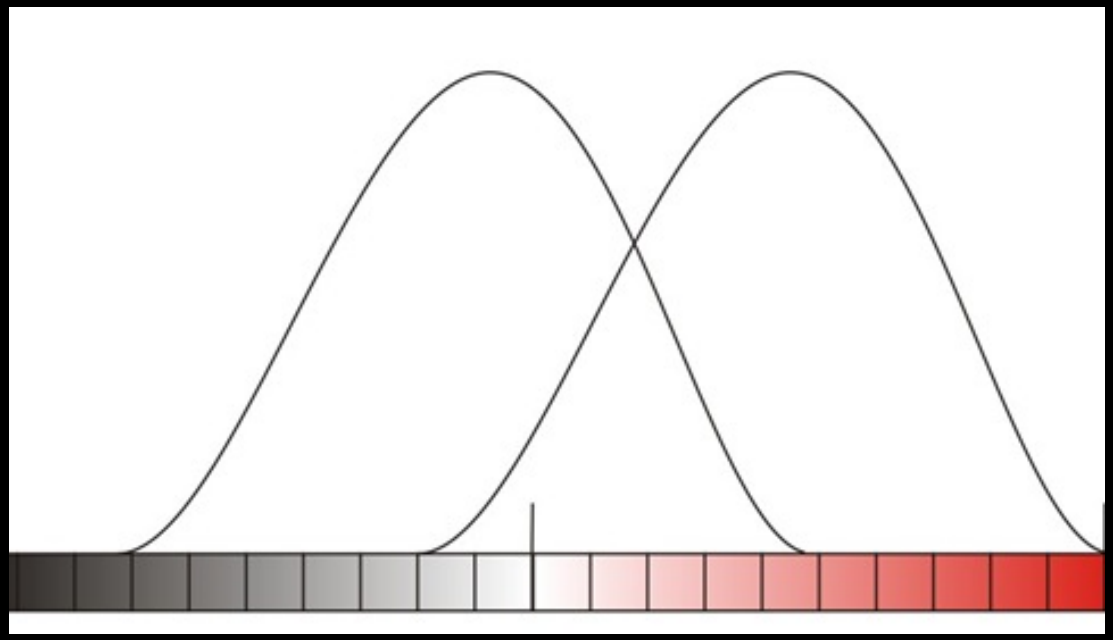


High S/N in tropical Africa, tropical Americas, tropical Asia – can these regions adapt? Are they adapting already?

Models GISS Observations: one realization

Mahlstein, Knutti, Solomon, Portmann, Env. Res. Lett., 2011

Evaluating When Local Warming Emerges in models….



Range of statistical tests used in Mahlstein et al include student-t, Kolmogorov-Smirnov)

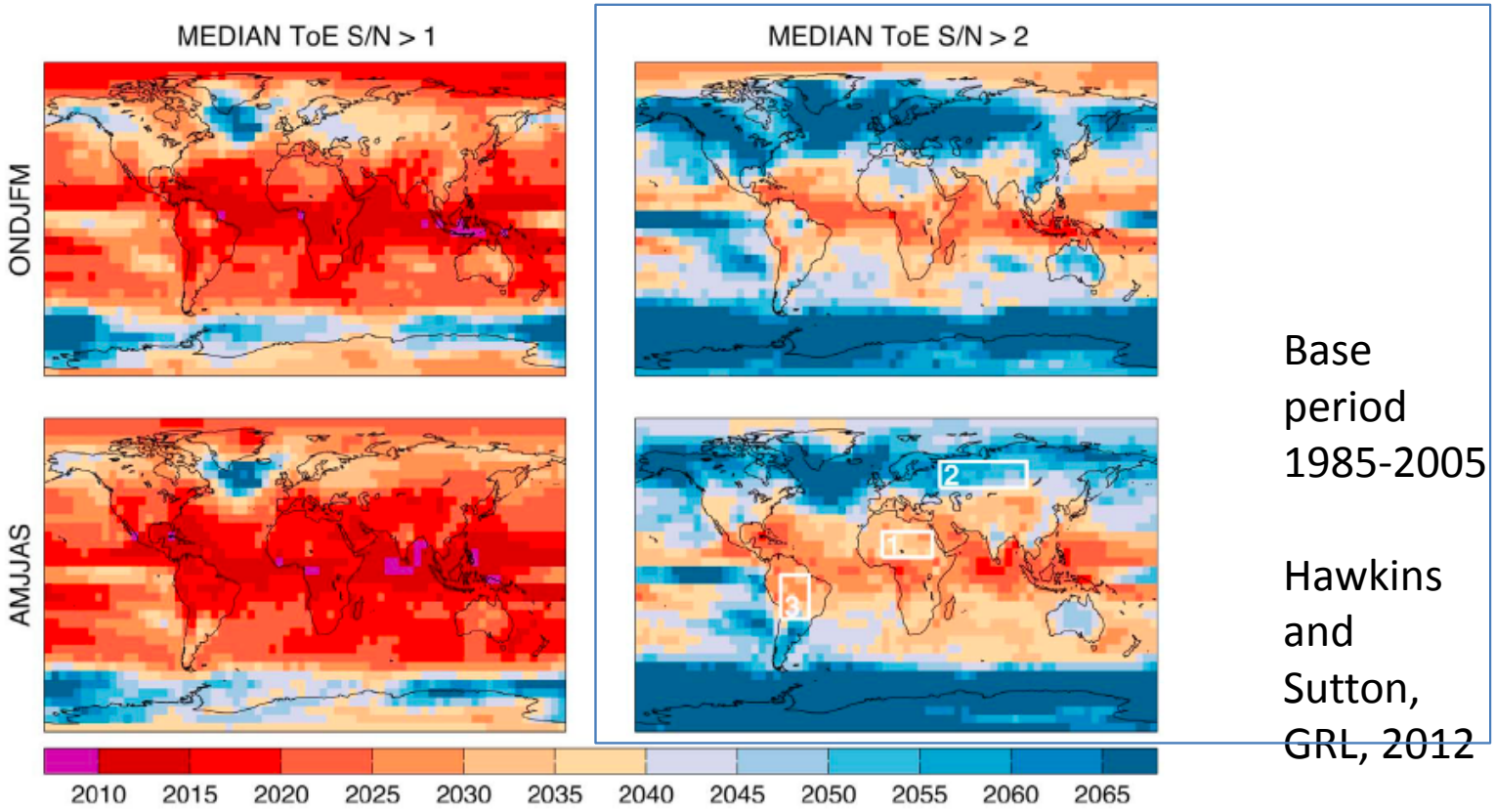
30yr base period

30yr test period

(??different or not)

Time (or temperature) when signal emerges

When Could We Expect A Significantly Different Summer?

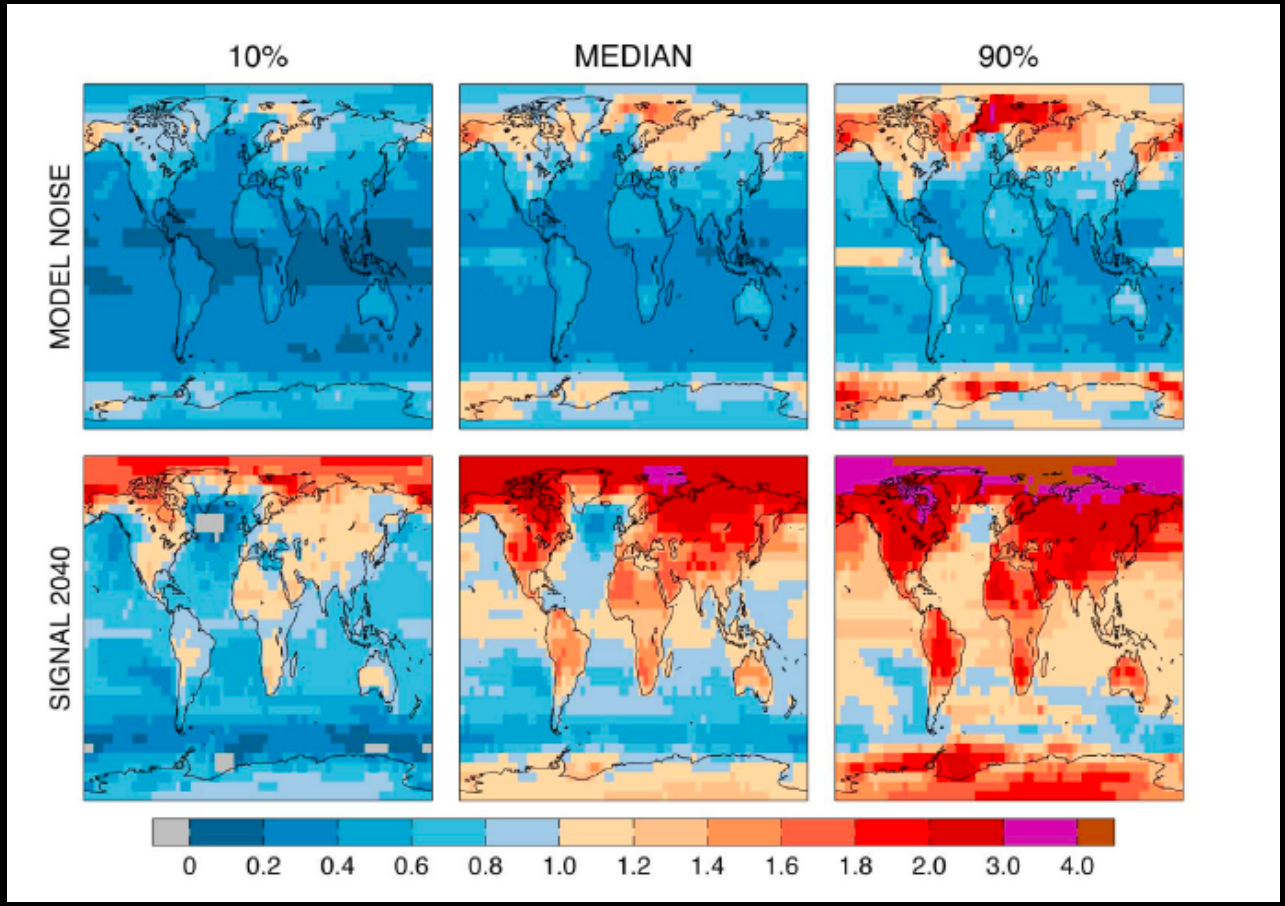


Base period 1985-2005

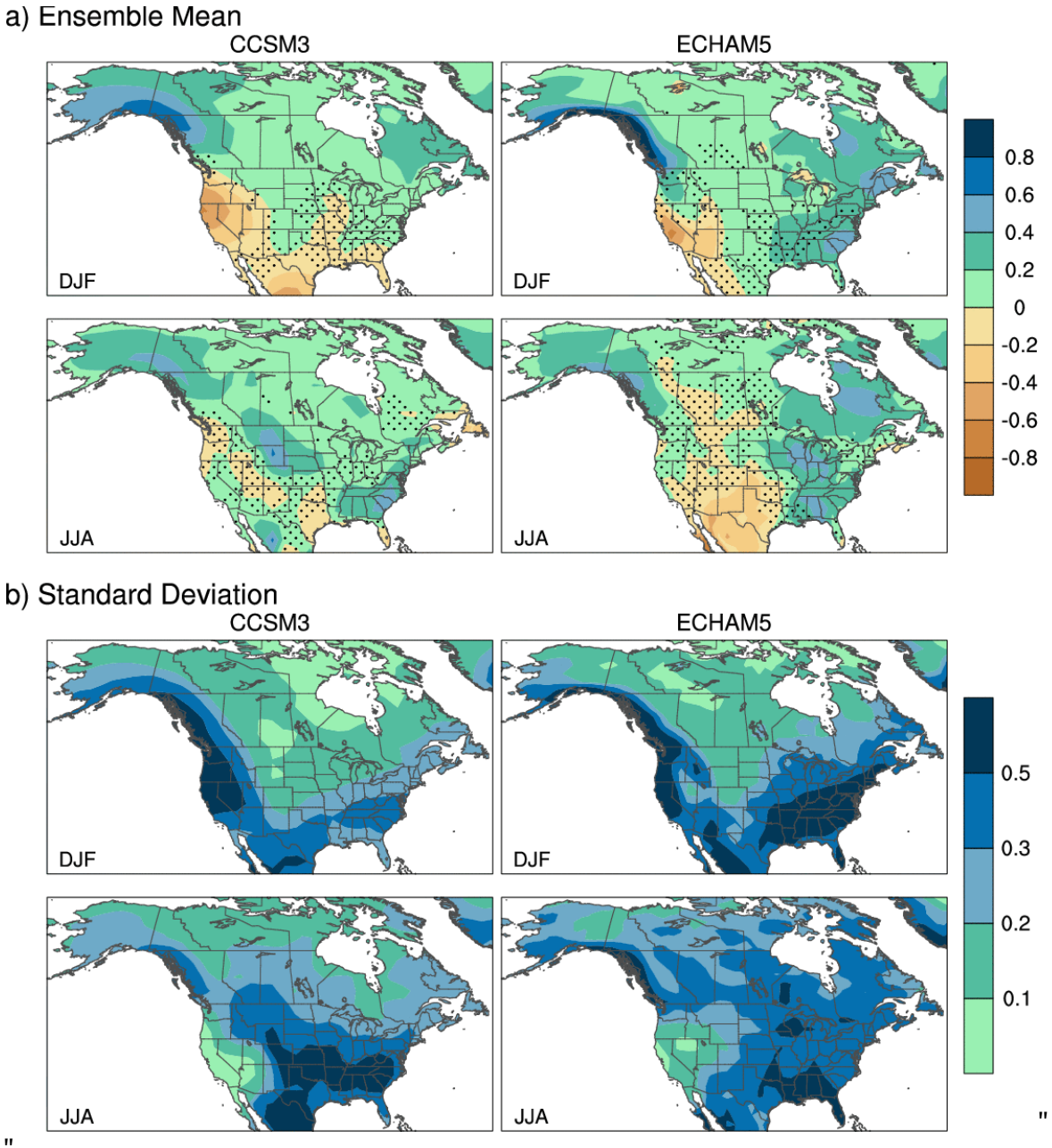
Hawkins and Sutton, GRL, 2012

Figure 3. Median Time of Emergence for surface air temperatures for (top) October-March and (bottom) April-September. First year when temperature has expected (left) $S/N > 1$ and (right) $S/N > 2$. The regions indicated by the white boxes are used in Figures 4, 5.

Hawkins and Sutton: Differences in model noise across CMIP3



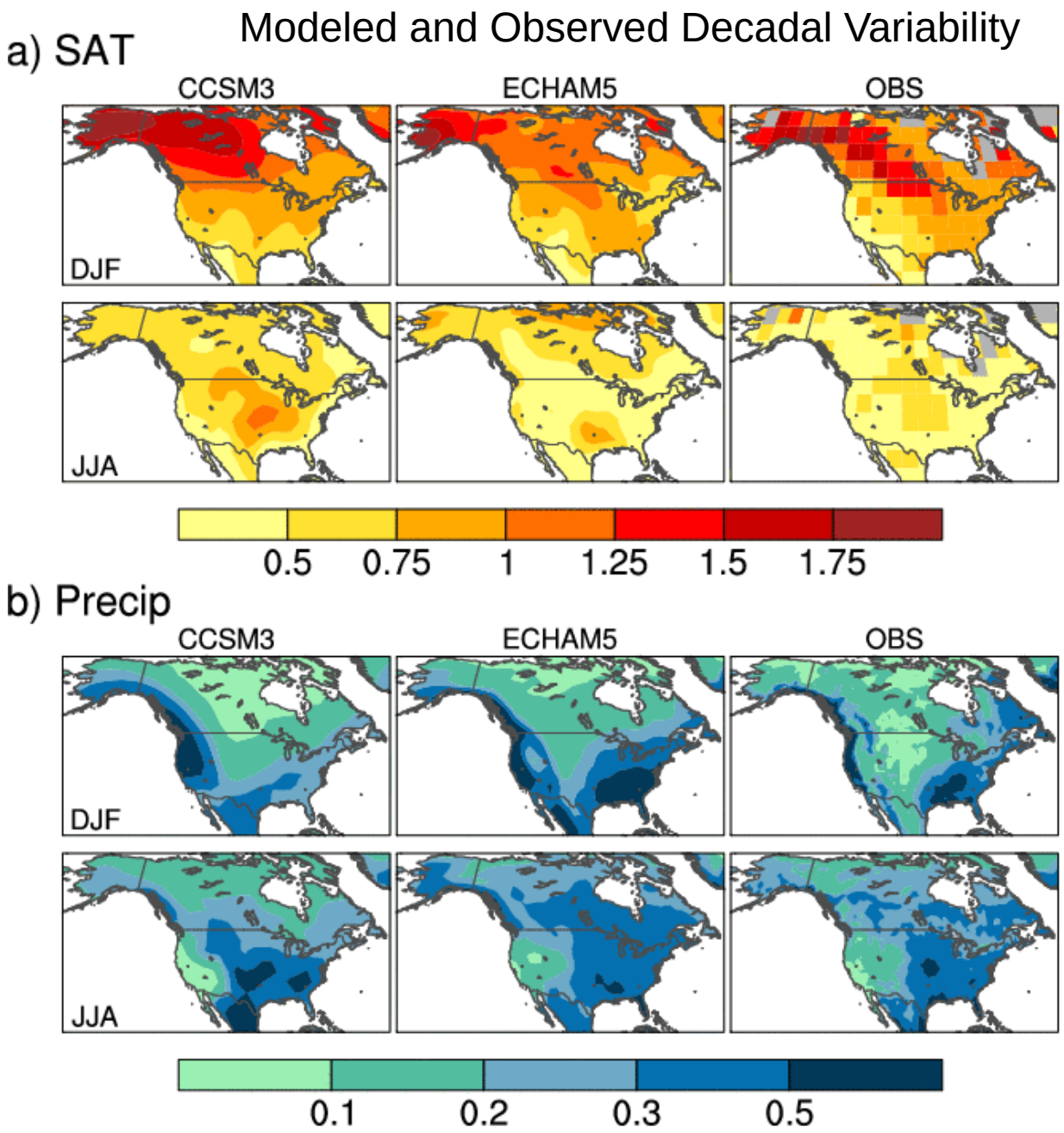
"….the range (10–90% quantiles) of the GCM estimates of the interannual variability can be up to a factor of 3 in standard deviation. Much previous work has focussed on the large range of climate sensitivity, but the ranges in variability are arguably as important across the GCMs considered, contributing to uncertainty in S/N**."**



Comparing model to model precipitation projections

Areas of agreement, (and some disagreement) in 40 member NCAR and 17 member ECHAM ensembles

Deser, Phillips, Alexander and Smoliak, in press, J. Clim., 2014



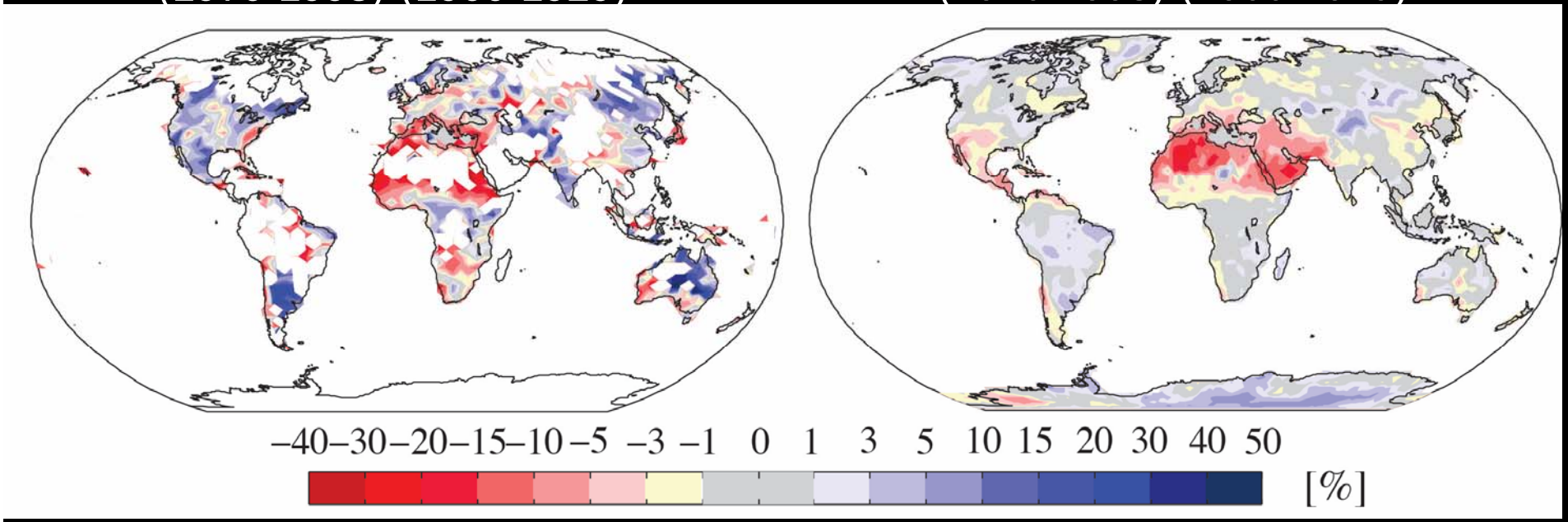
Amplitude of decadal variability in segments of detrended 56 year future projections

Compare to past 110 years of observations

From Deser

Hulme Dataset
(1970-1998)-(1900-1929)

CMIP3 multi model mean
(1970-1998)-(1900-1929)

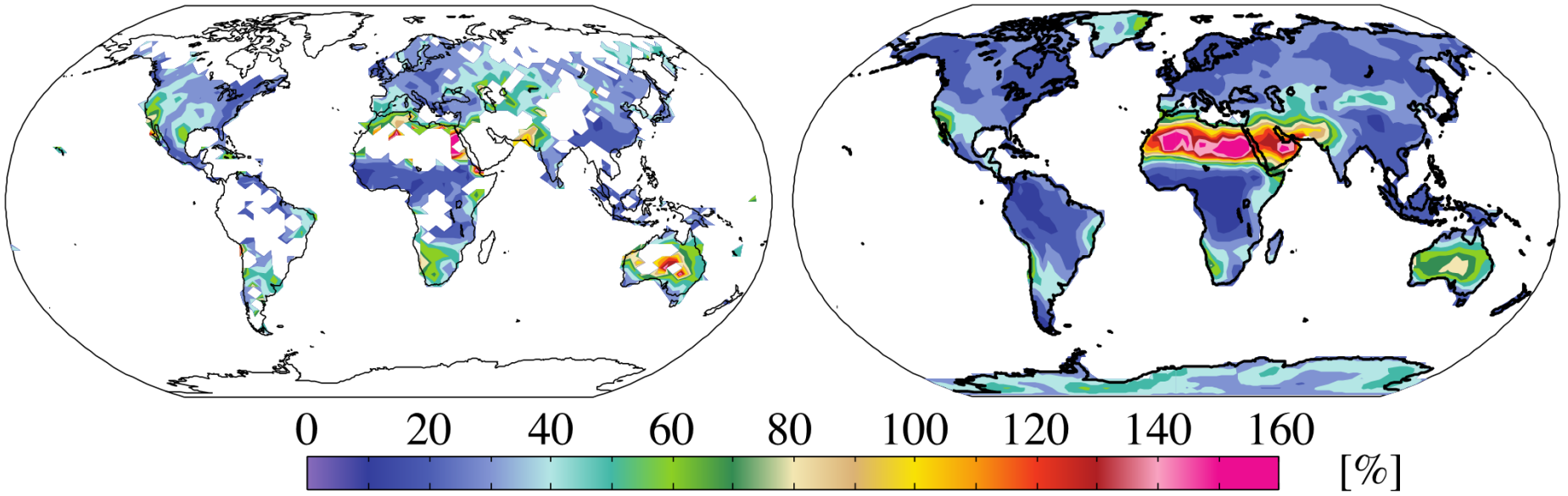


Mahlstein et al., GRL, 2012

Precipitation signal in wet season

Hulme Dataset
(1900-1998)

CMIP3 multi model mean
(1900-1998)

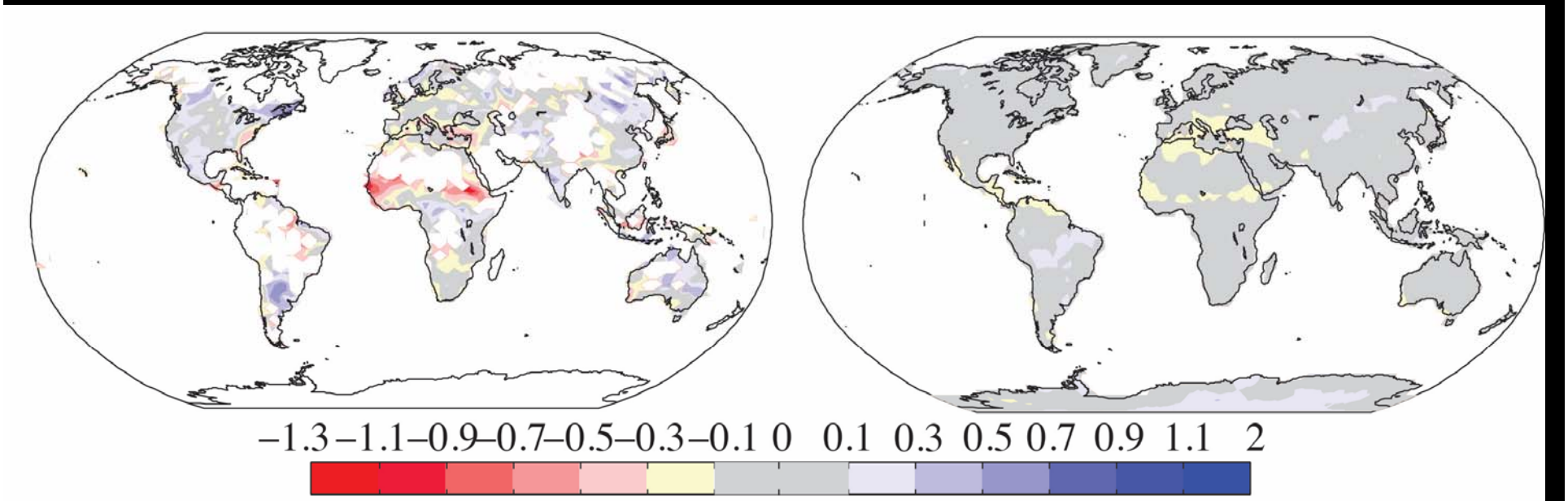


Mahlstein et al., GRL, 2012

Natural variability (noise) in wet season

Hulme Dataset

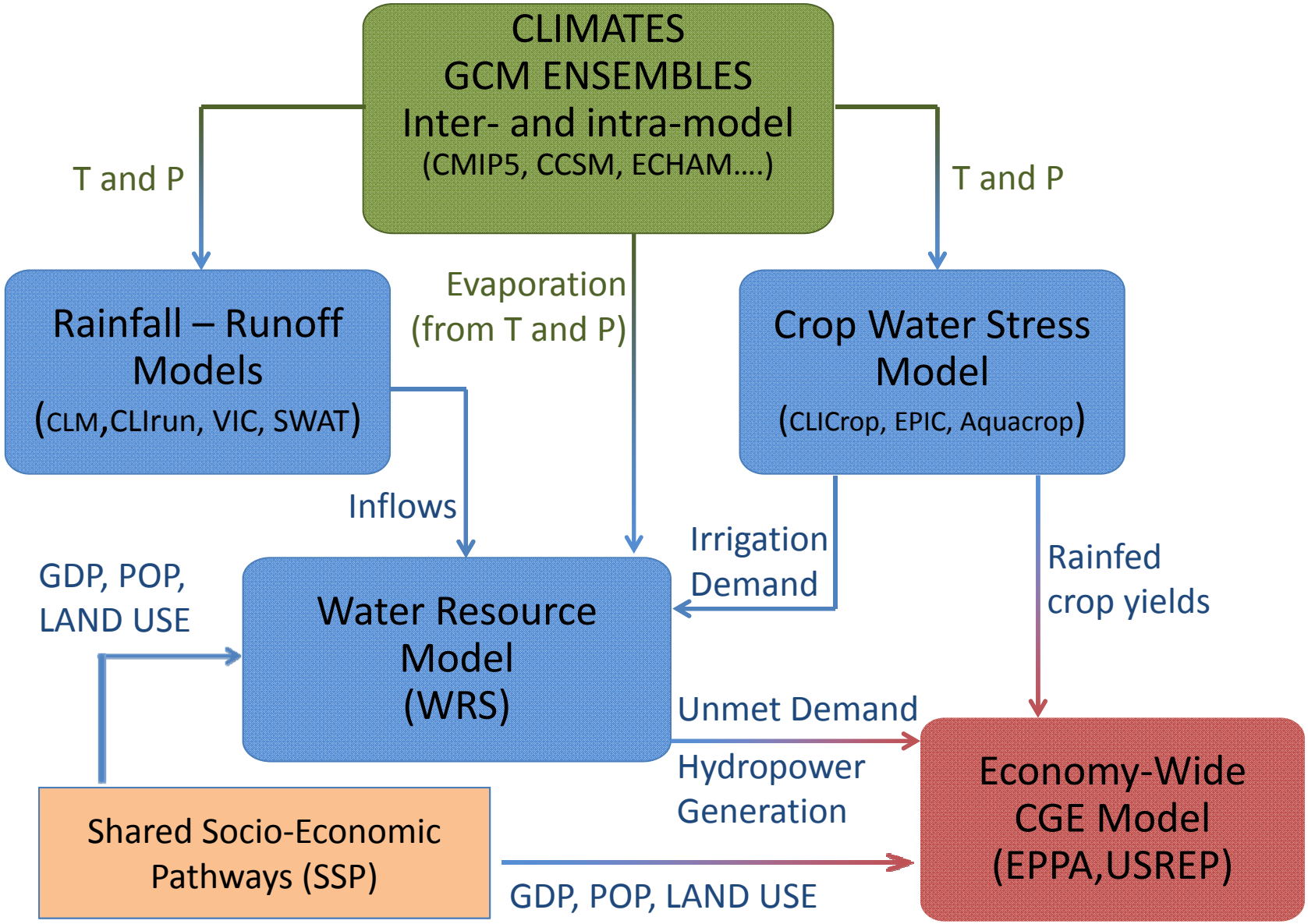
CMIP3 multi model mean



Mahlstein et al., GRL, 2012

Signal to noise in anthropogenic precipitation change: has not emerged at grid point level. Look at river runoff?

MODELING FRAMEWORK



Some Points to Ponder

- The world is warming *on average*, mainly due to anthropogenic carbon dioxide emissions
- Averaging over space and/or time doesn't overcome fundamentals of predictability at local scales (Lorenz).
- Largest *local* warming = Arctic, but largest S/N = parts of the deep tropics! (Manabe, personal communication)
- Many low latitude countries that contribute the least to warming happen to be on the front lines.
- Ensemble modelling offers new approach to quantifying climate changes and related variability.
- Implications for impacts, adaptation, water and agriculture.