Multi-Decadal Climate Variability in the Observed and Modeled Surface Temperatures

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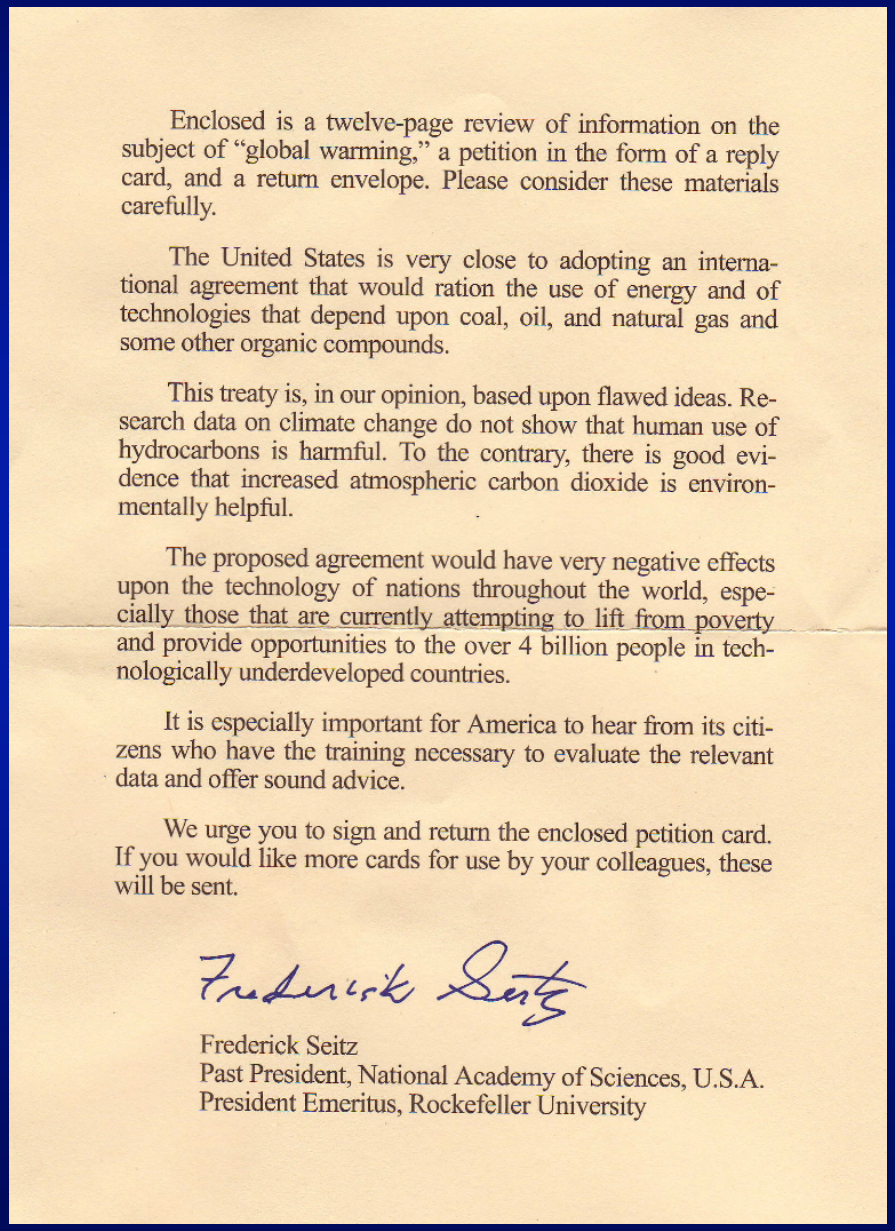
Global Warming – I



Enclosed is a twelve-page review of information on the subject of "global warming," a petition in the form of a reply card, and a return envelope. Please consider these materials carefully.

The United States is very close to adopting an international agreement that would ration the use of energy and of technologies that depend upon coal, oil, and natural gas and some other organic compounds.

This treaty is, in our opinion, based upon flawed ideas. Research data on climate change do not show that human use of hydrocarbons is harmful. To the contrary, there is good evidence that increased atmospheric carbon dioxide is environmentally helpful.

The proposed agreement would have very negative effects upon the technology of nations throughout the world, especially those that are currently attempting to lift from poverty and provide opportunities to the over 4 billion people in technologically underdeveloped countries.

It is especially important for America to hear from its citizens who have the training necessary to evaluate the relevant data and offer sound advice.

We urge you to sign and return the enclosed petition card. If you would like more cards for use by your colleagues, these will be sent.

Frederick Seitz

Frederick Seitz
Past President, National Academy of Sciences, U.S.A.
President Emeritus, Rockefeller University

" The (Kyoto) treaty is … based upon flawed ideas."

"Increased atmospheric carbon dioxide is environmentally helpful…"

" It is … important for America to hear from its citizens who have the training necessary to offer sound advice."

Global Warming – II

Petition

We urge the United States government to reject the global warming agreement that was written in Kyoto, Japan in December, 1997, and any other similar proposals. The proposed limits on greenhouse gases would harm the environment, hinder the advance of science and technology, and damage the health and welfare of mankind.

There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the Earth.

_____ ❒ Please send more petition cards for me to distribute.

Please sign here

My academic degree is B.S. ❒ M.S. ❒ Ph.D. ❒ in the field of _____

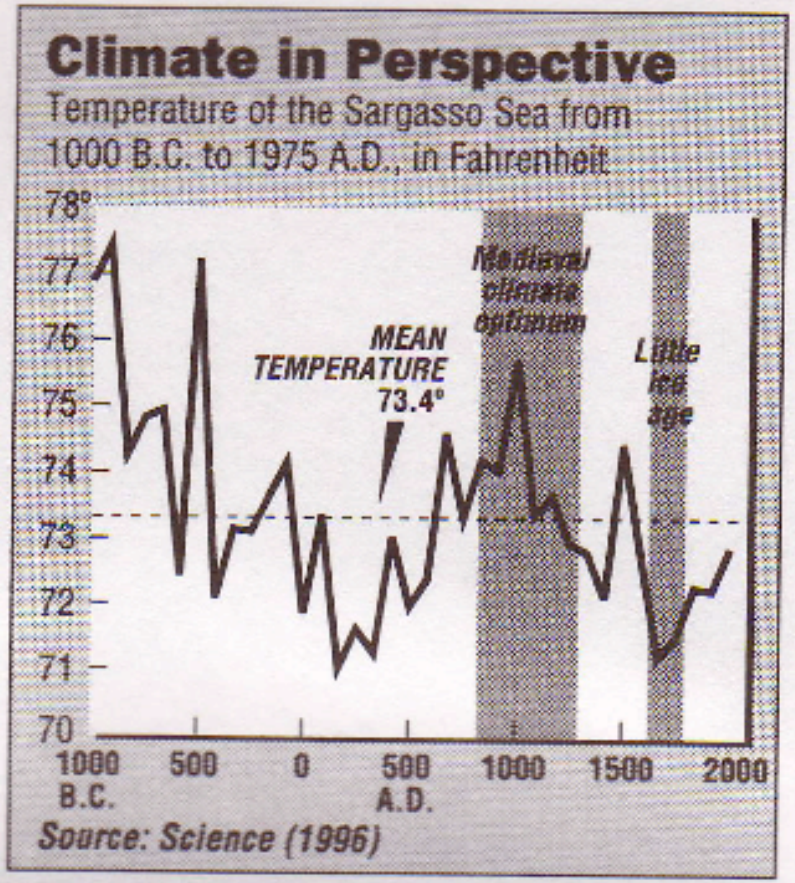
Global Warming – III

Kyoto supporters cheer new findings that the Earth's surface temperature is probably rising. But this trend isn't recent and isn't man-made.

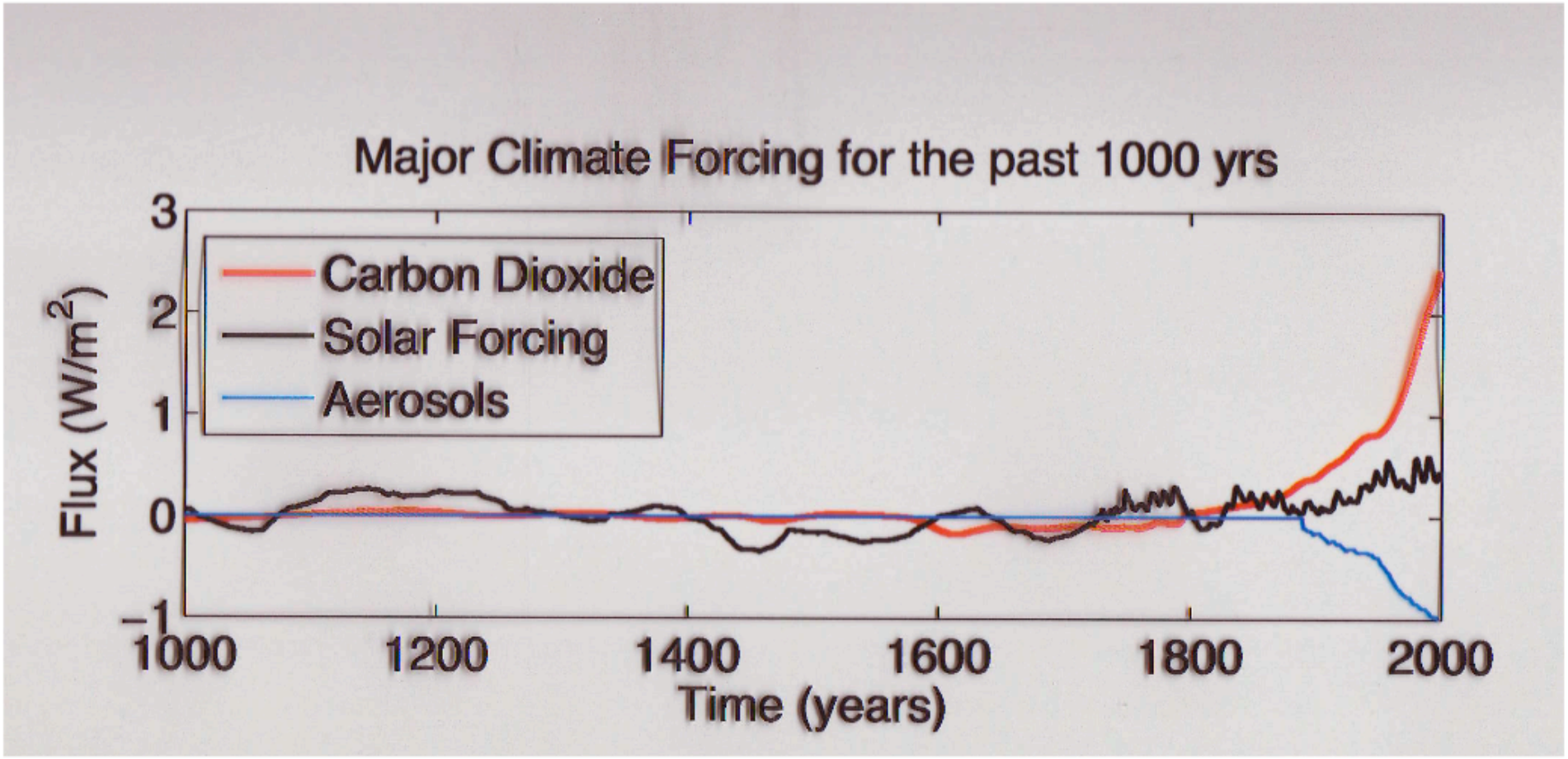
due to arrive with the new millennium. Now, in the absence of more solid proof, opposition to their global plans will continue to grow. Already, more than 17,000 American scientists have signed a petition opposing the Kyoto treaty. Treaty supporters, meanwhile, are increasingly relying on their multimillion-dollar media campaign promoting a perception of human-caused global warming.

That the Earth is warming is, of course, very old news. The current warming trend began about 300 years

years ago known as the Medieval Climate Optimum, so named because the climate was unusually benign. Earth tem-



Causes of Warming – I



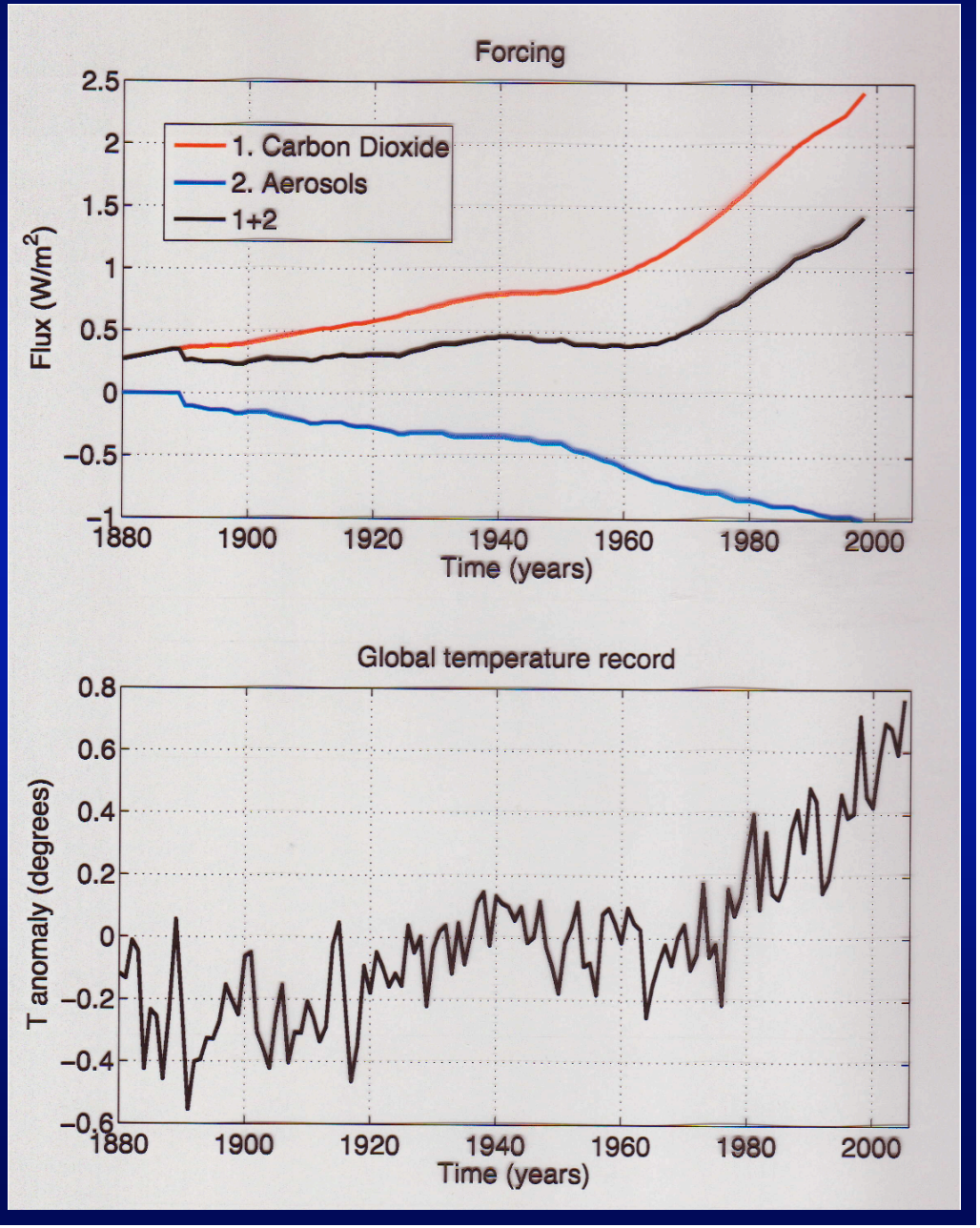
Causes of Warming – II

- If the atmosphere is in radiative equilibrium, then global temperature follows changes in forcing:

$$\Delta A + B\Delta T + T\Delta B = 0;$$

$$\Delta T = -(\Delta A + T\Delta B)/B.$$

- Climate GCMs reproduce the warming trend reasonably well



Causes of Warming – III

$$\tilde{T}(t) = T(t) - \kappa_1 t - \kappa_3$$

$$\dot{\tilde{T}} = \kappa_2 \tilde{T}(t-\tau),$$

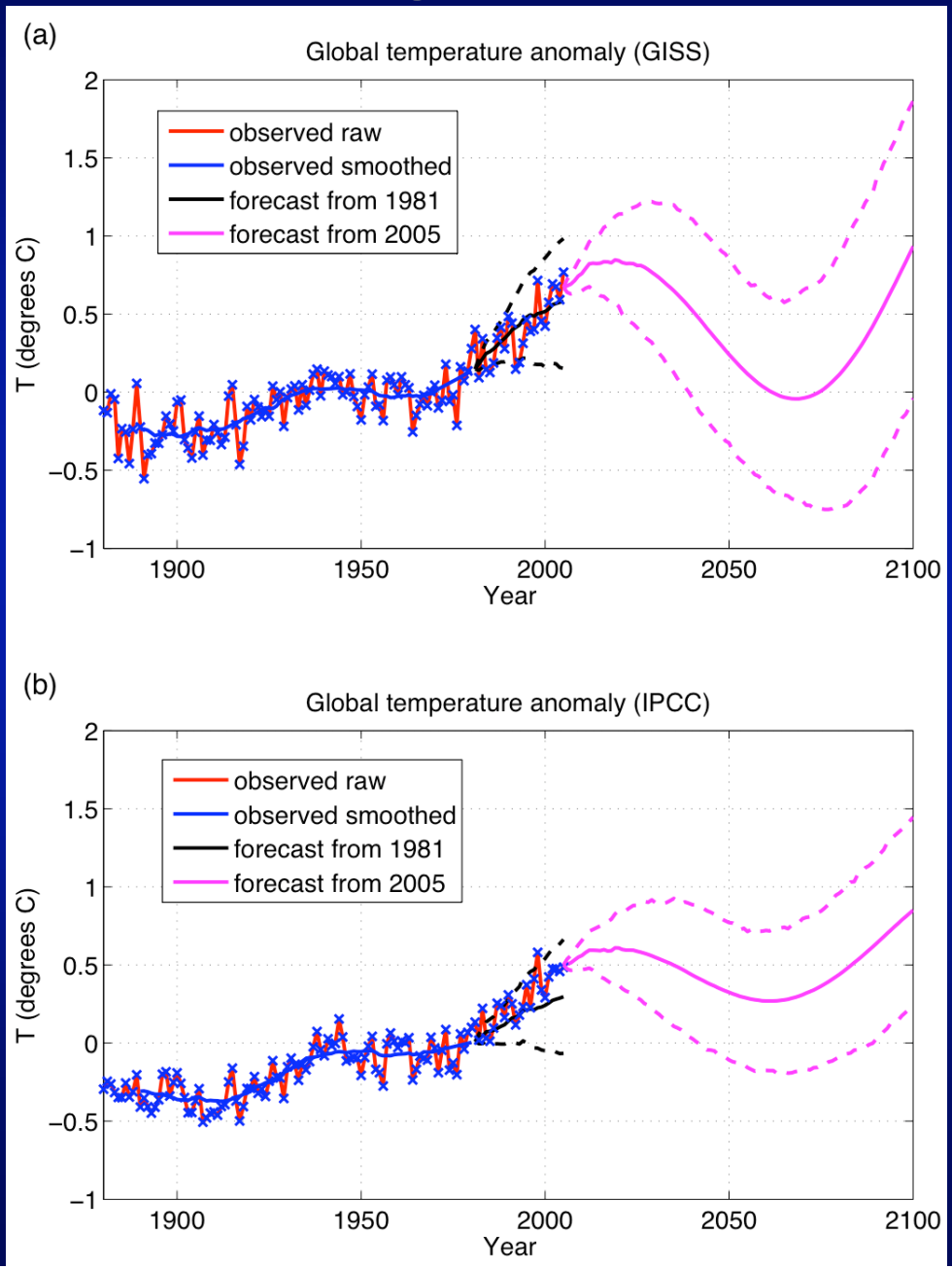
$$\kappa_2(\kappa_1\tau + \kappa_3) \rightarrow \kappa_3$$

$$\dot{T} = \kappa_1 + \kappa_2[T(t-\tau) - \kappa_1 t] - \kappa_3.$$

Causes of Warming – IV

- RESULTS FROM THE STATISTICAL MODEL:

Warming would be maximal by 2020, at which point half of the temperature increase (~0.4°/century) will be due to natural variability



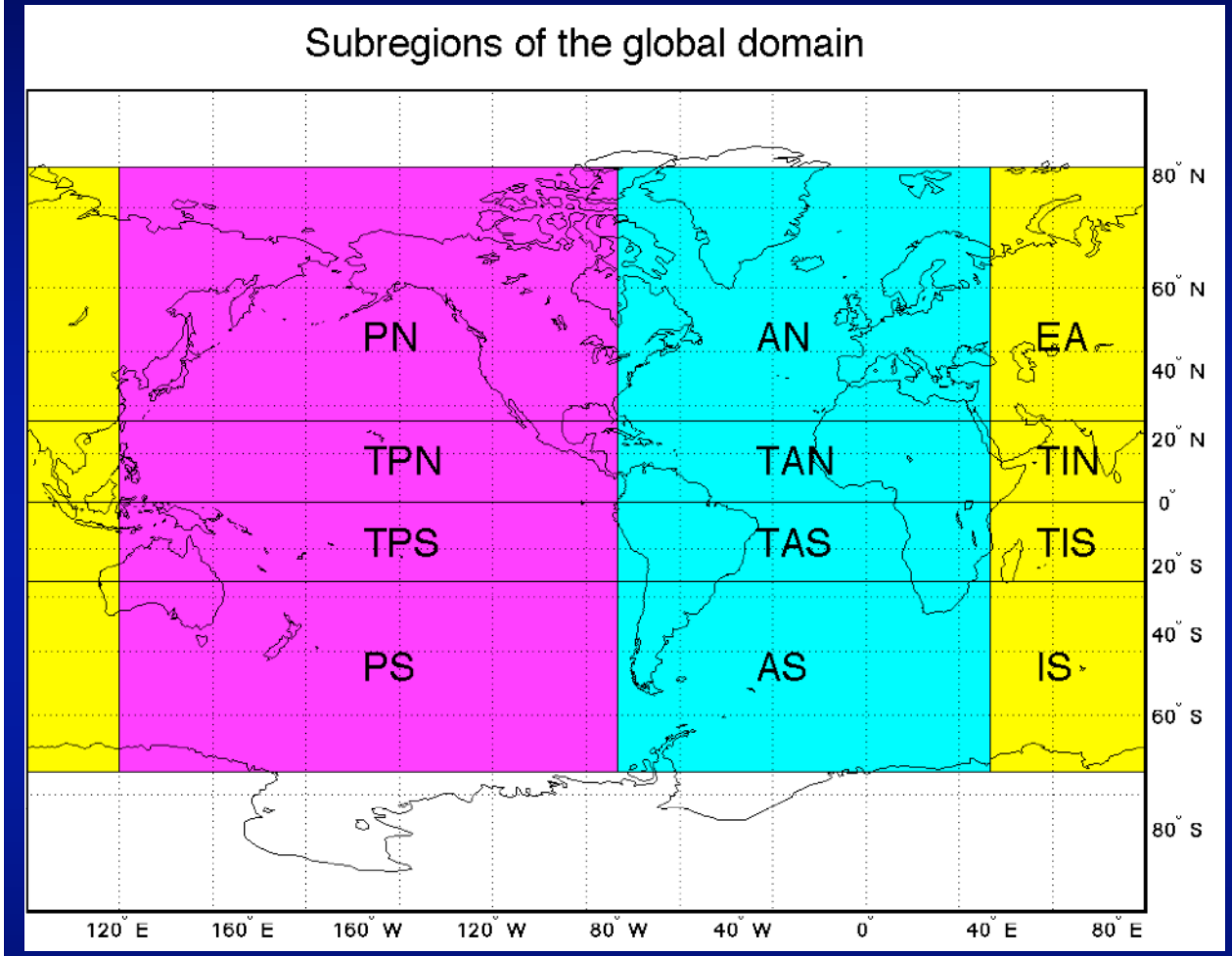
Natural or Anthropogenic?

- Idea: Use the multi-model ensemble average of the 20-century simulations as an estimate of human-induced signal

- Issues: differences between models include those in resolved physics, external forcings used, as well as initial conditions

We assume that all of these uncertainties are reduced via ensemble averaging

Analysis domain and smoothing



<u>To reduce errors</u>:

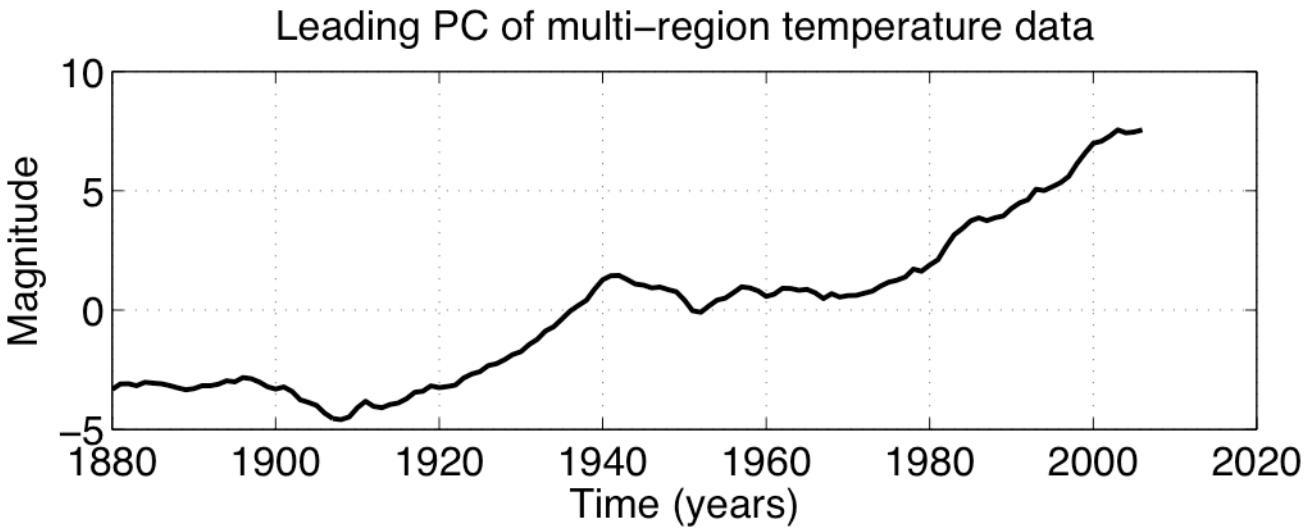
- Average surface T data within 12 sub-regions
- Apply decadal smoothing and concentrate on inter-decadal T anomalies

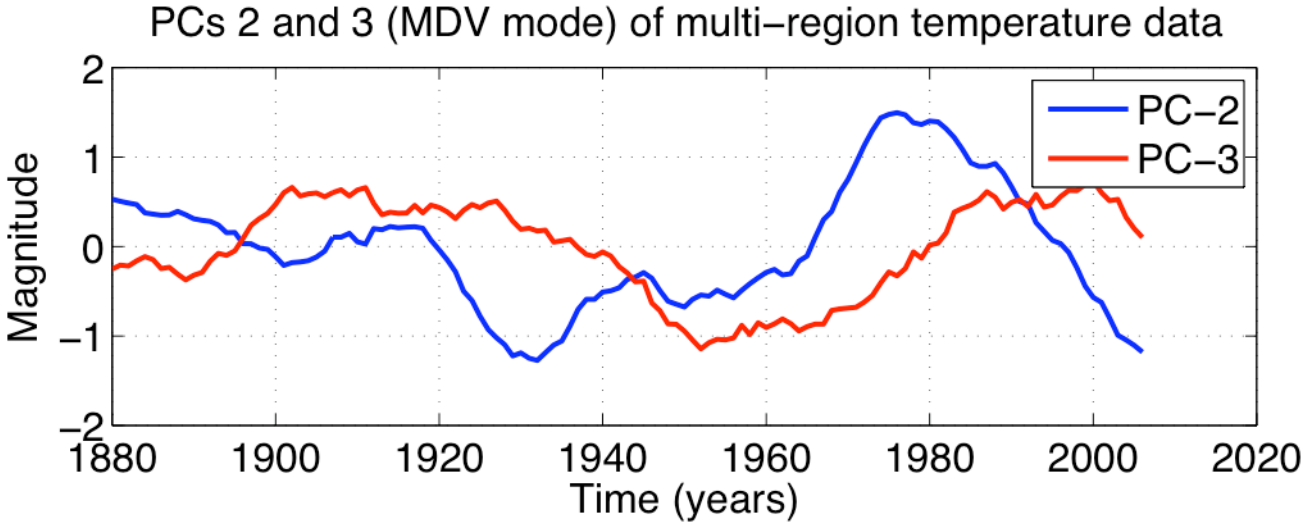
Surface temperature data sets

- Observational:
  (1) GISS (http://data.giss.nasa.gov.gistemp)
  (2) HadCRUT3 (http://www.hadobs.org)
  (3) Kaplan data set

- Simulated: WCRP's CMIP3 — 16 models, with the total of 52 simulations

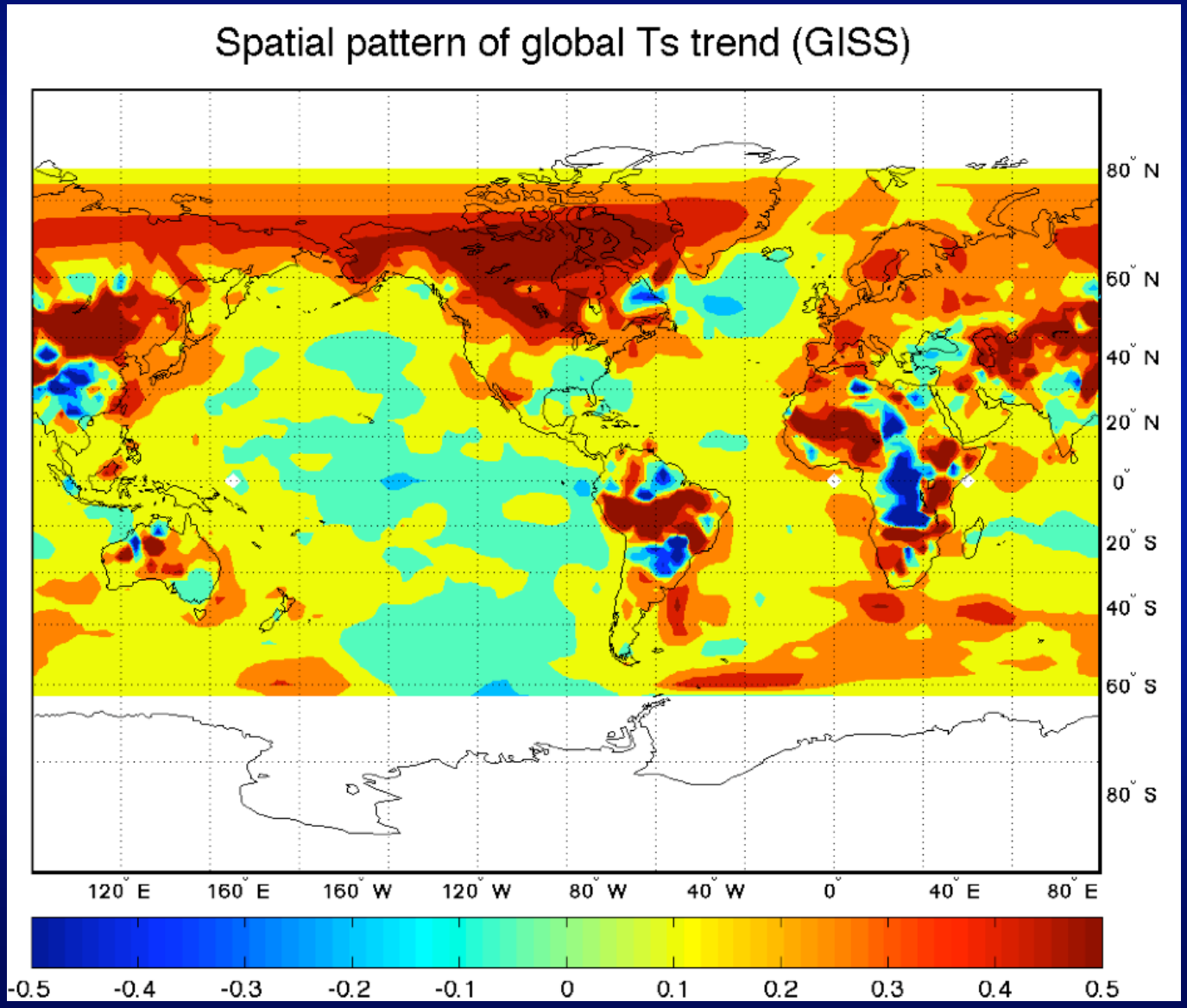
Leading modes of the observed secular variability



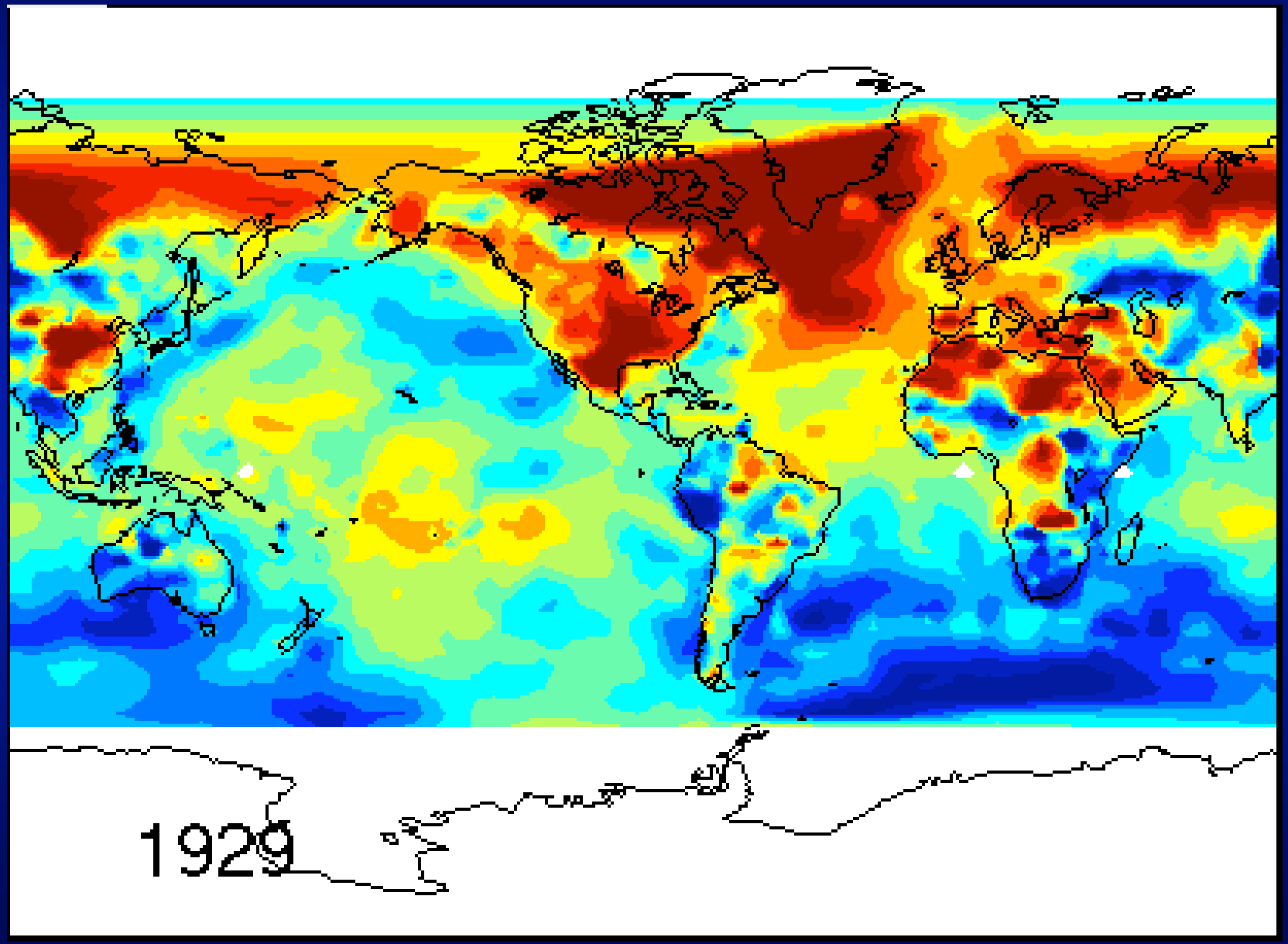


- The first mode is well correlated with global T
- Multi-decadal pair has a time-scale of 60–80 yr

“Global Warming” pattern



Multi-decadal variability (AMO)



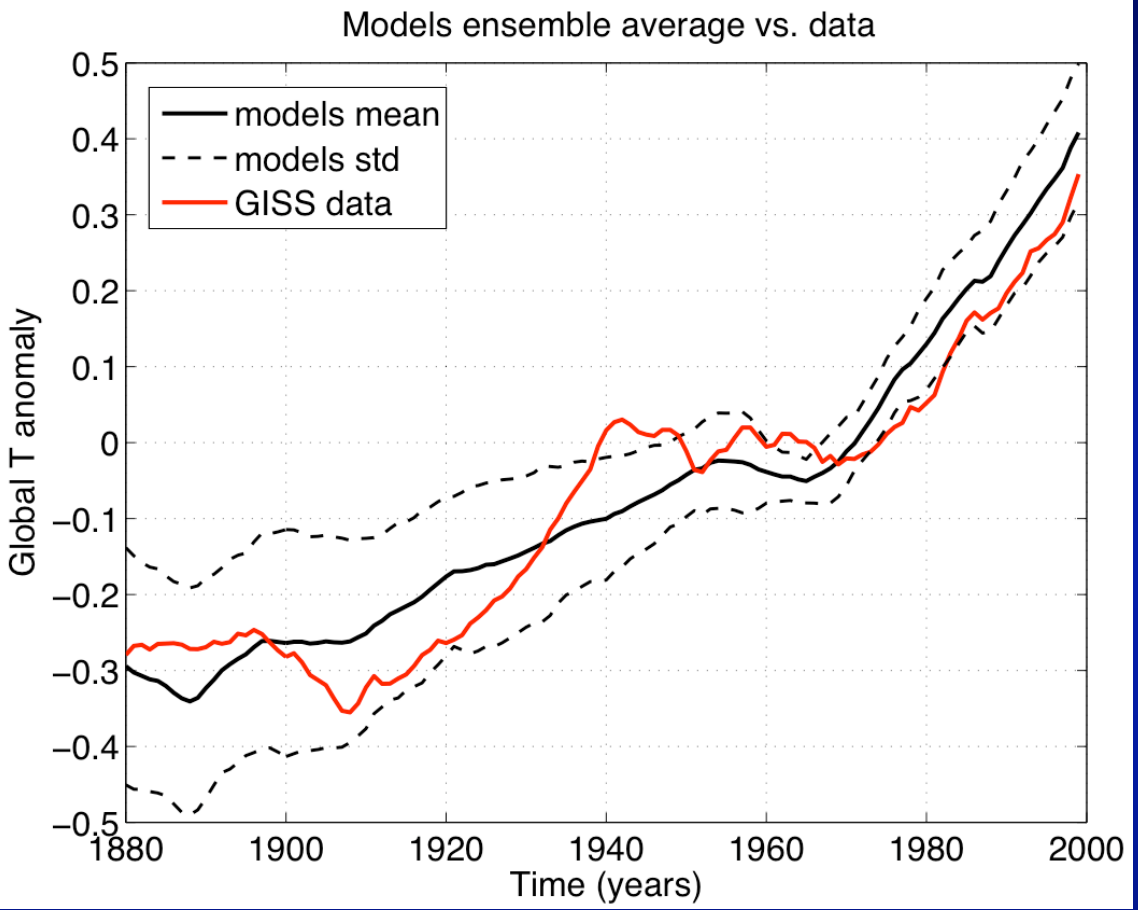
Key points (observed data)

- While the global warming pattern (GWP) and MDV patterns are spatially uncorrelated over the whole globe by construction, substantial correlation exist between GWP and certain phases of MDV patterns

- Non-uniform GW time series, when linearly de-trended, exhibits a 70-yr time scale, consistent with that of MDV

Indirect effect of AMO on global warming?
(*Zhang and Delworth (2007) argue for a substantial direct influence as well)

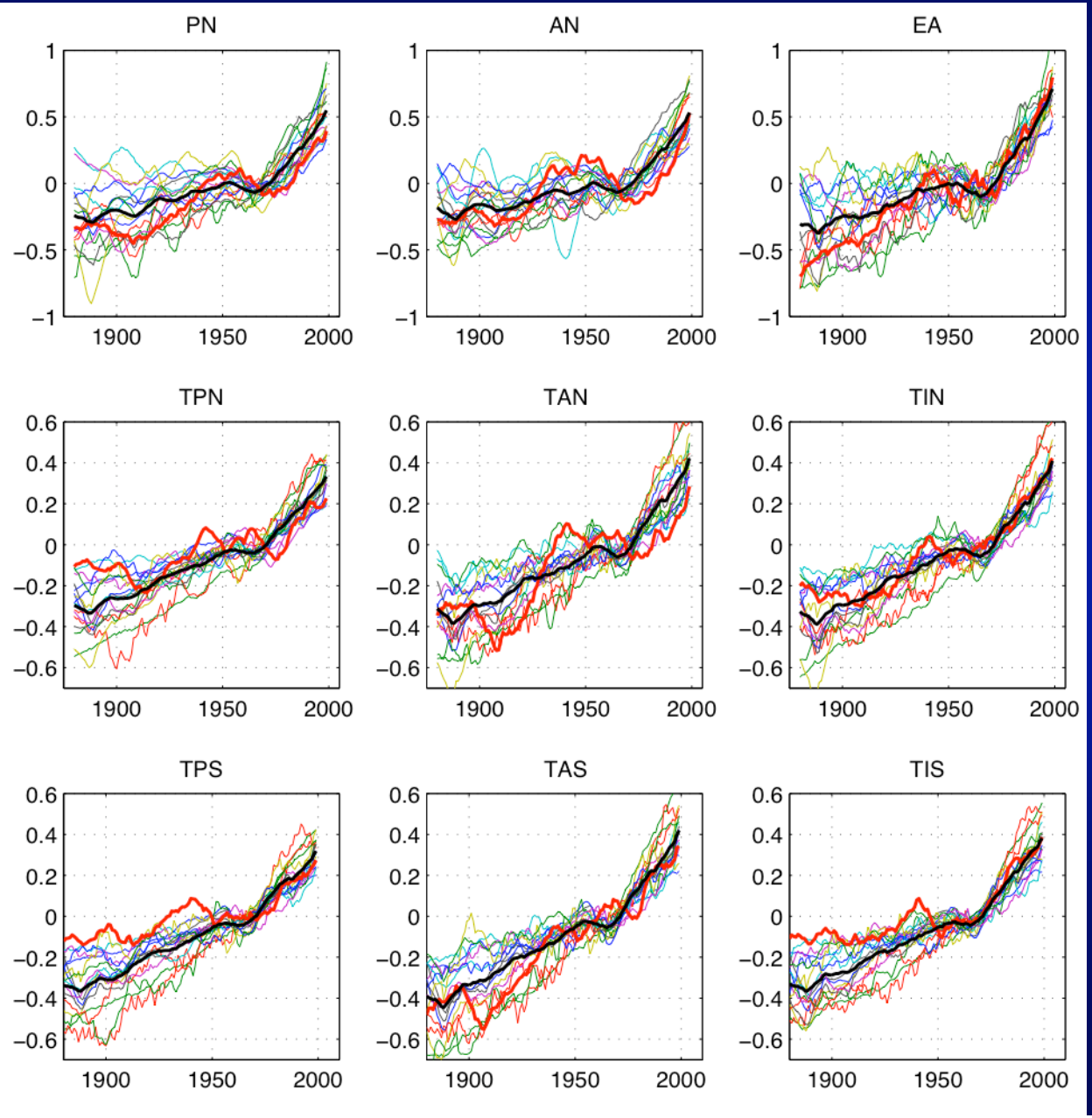
Model–data comparison – I



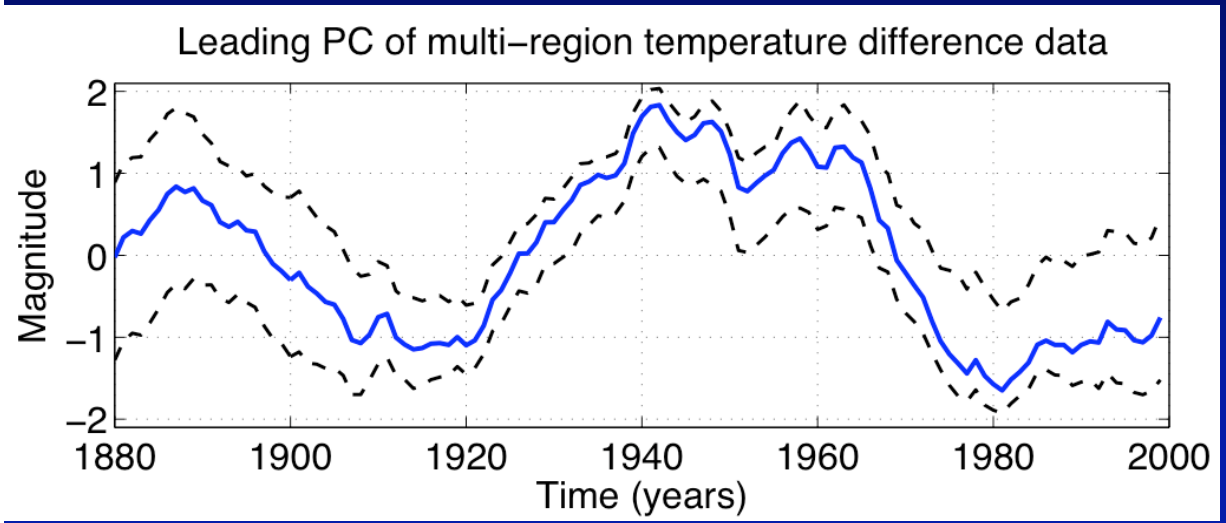
- General agreement between models and data, but…
- Consistent structural deviation of all models from observed multi-decadal "wiggles" (direct AMO effect?)

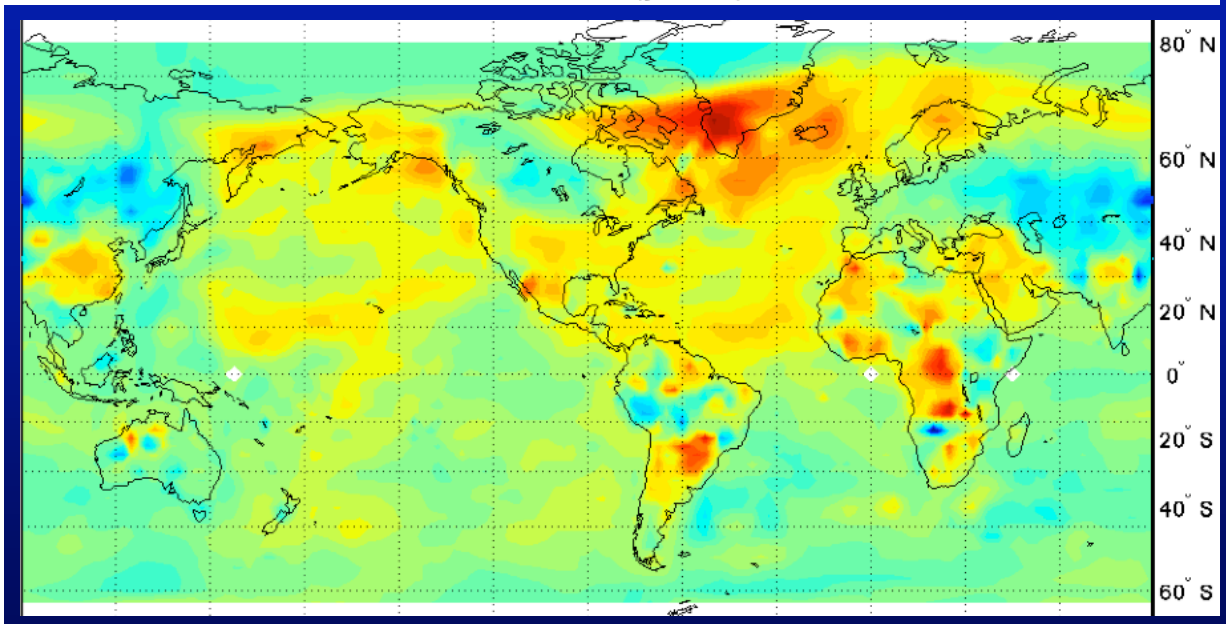
Note: Models use "observed" forcing, which may itself be due, in part, to natural variability…

Model–data comparison – II



Dominant model–data differences





- This time series is well correlated with "classical" AMO index (but no linear detrending was used!)

- The pattern is very much like 1930–40 phase of observed MDV

Summary thus far

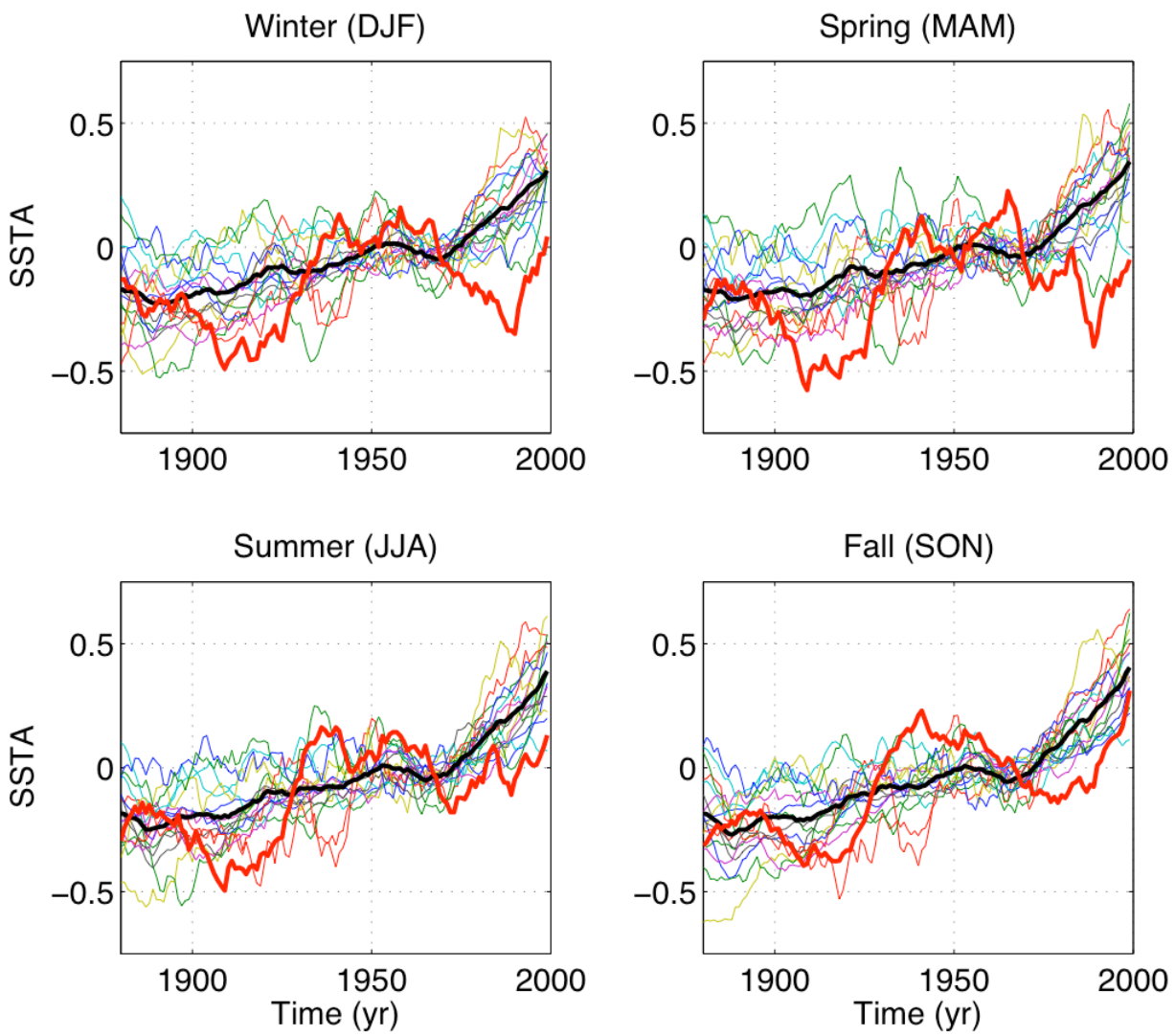
- The leading mode of observed-minus-simulated surface temperatures resembles, in its apparent time scale and spatial pattern, the so-called Atlantic Multi-Decadal Oscillation (AMO)
- The AMO defined above contributes somewhat to non-uniform global temperature trend; it also has large projection on certain phases of the leading “stationary” multi-decadal variability (MDV) found in the observed temperatures
- The AMO pattern is characterized, in part, by fairly large SST anomalies in the tropical Atlantic

Discussion

- Various definitions of AMO:
  (1) linearly detrended SSTAs in the North Atlantic;
  (2) remove quadratic trend (Enfield and Cid-Cerrano);
  (3) remove global T trend (Trenberth and Shea, Mann and Emanuel);
  (4) leading mode of multi-region model–data differences

- Observed forcing (e.g., CO_2, or aerosols) may have a component due to natural variability, in which case even more of the non-uniform global warming trend may be attributed to natural, rather than anthropogenic causes

AMO and Hurricanes



- SST anomalies <u>in the main development region</u>
- The peak-to-peak amplitude of AMO-related SST anomalies is similar to forced SST rise in the 20-th century
- Methodological differences with Mann and Emanuel

AMO and CO_2

Idea: enhanced THC brings CO_2-depleted water to the surface and increases atmospheric uptake of CO_2, with an advective lag of about

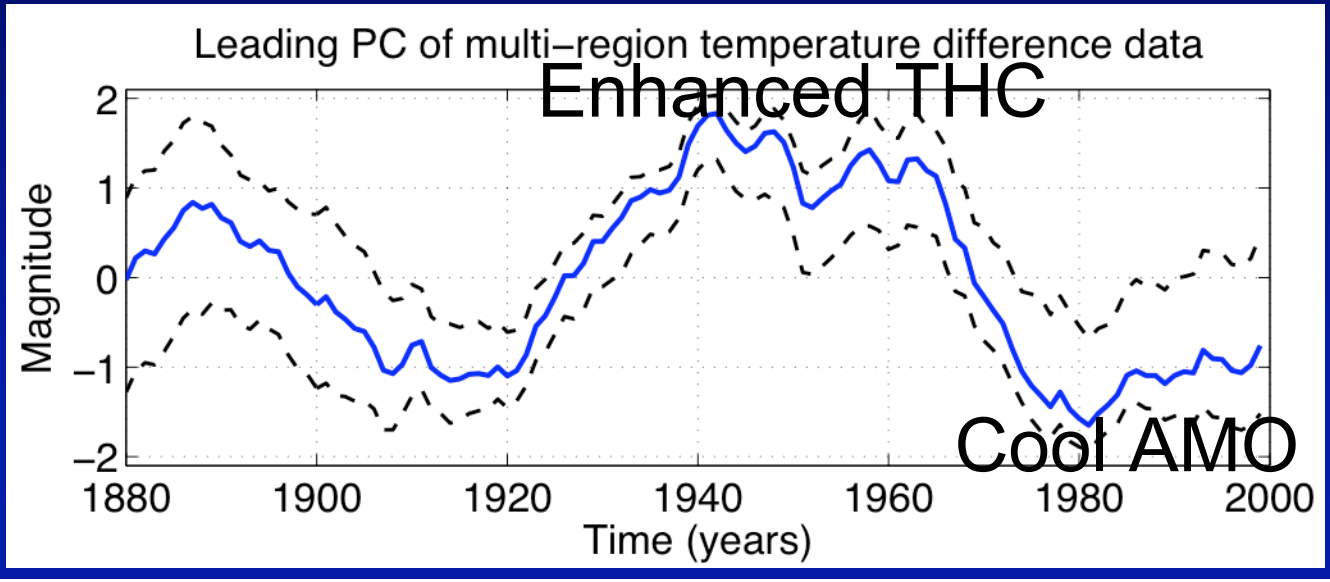
$$\tau \approx H/w = 1000m/10^{-6}ms^{-1} \approx 30yr$$

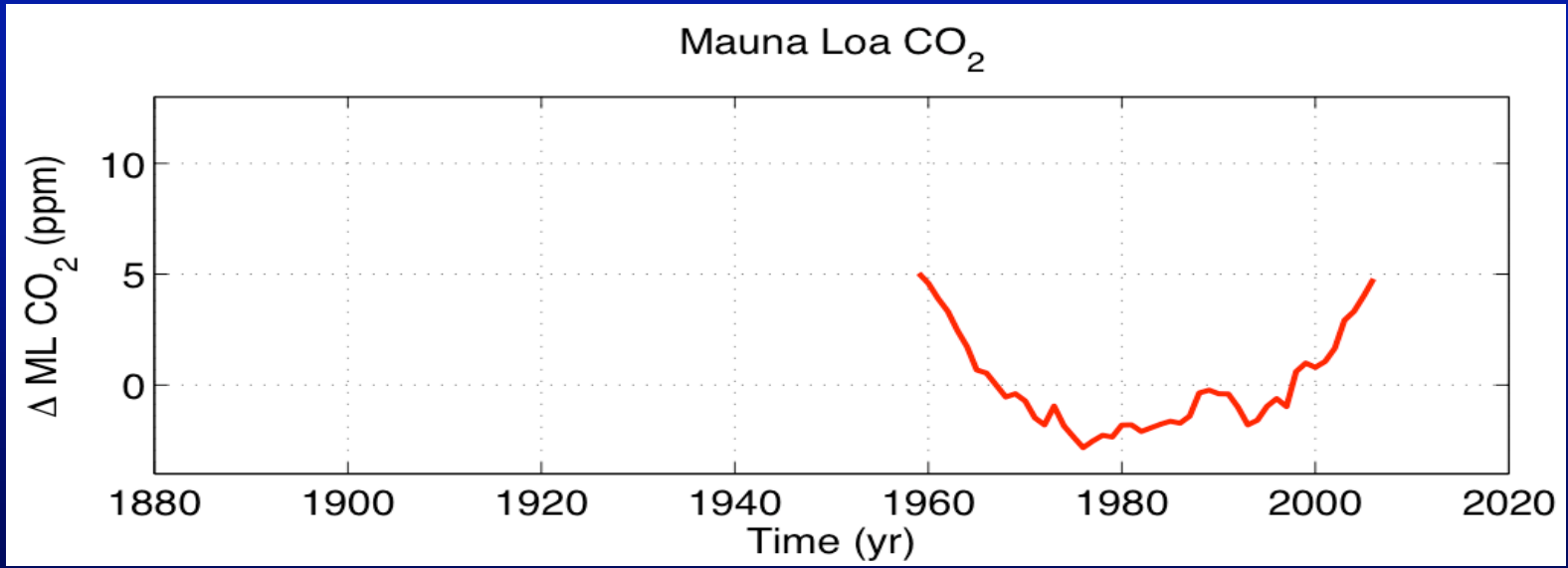
Other possibilities of the same kind:

(1) solubility pump — in phase relation with AMO
[cold phase of AMO – less CO_2]

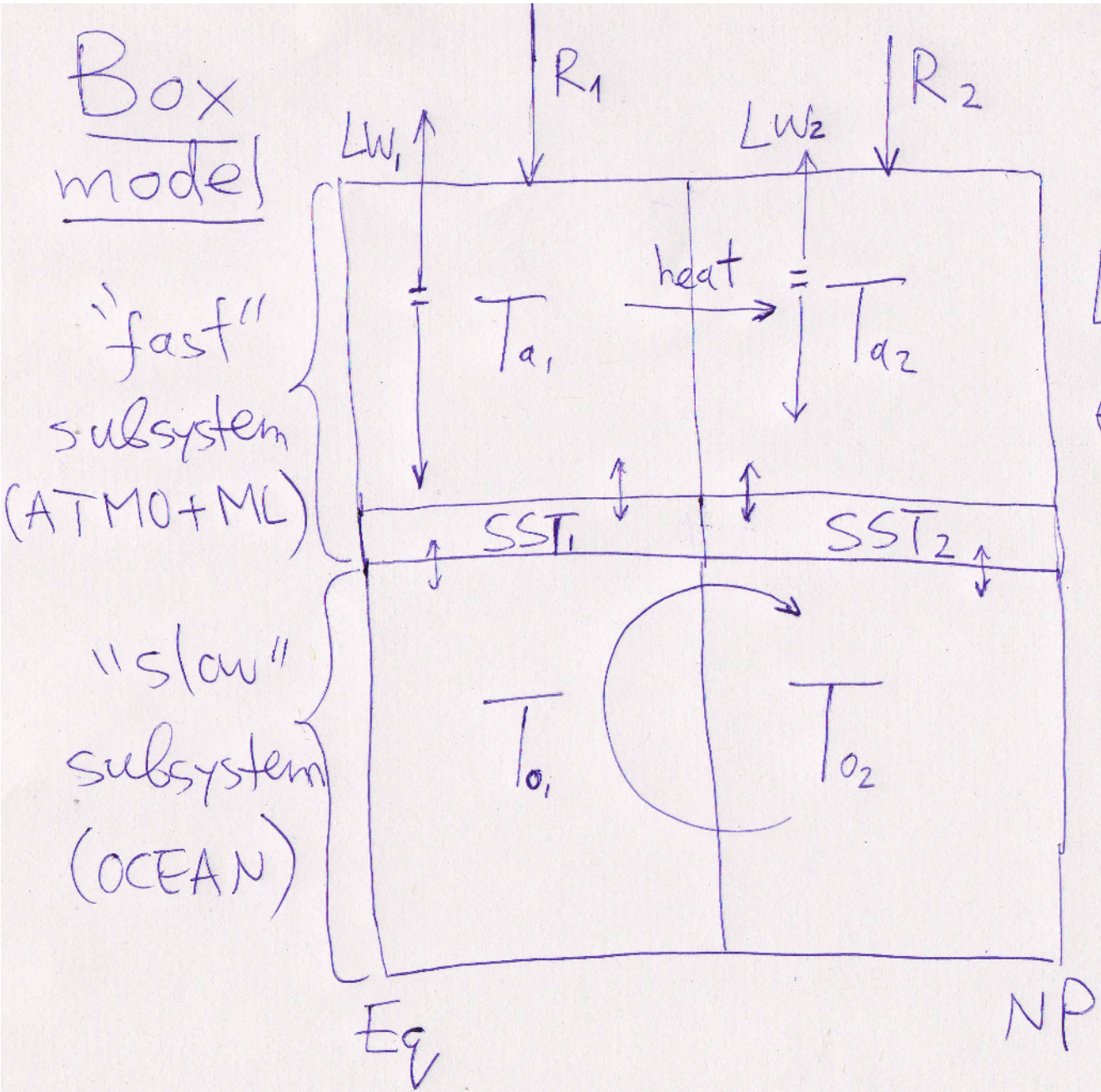
(2) aerosol-related scenarios — when AMO is cool, NW Africa is drier and produces more aerosol, thus reducing global temperature

AMO and CO_2 (cont'd)





Box model



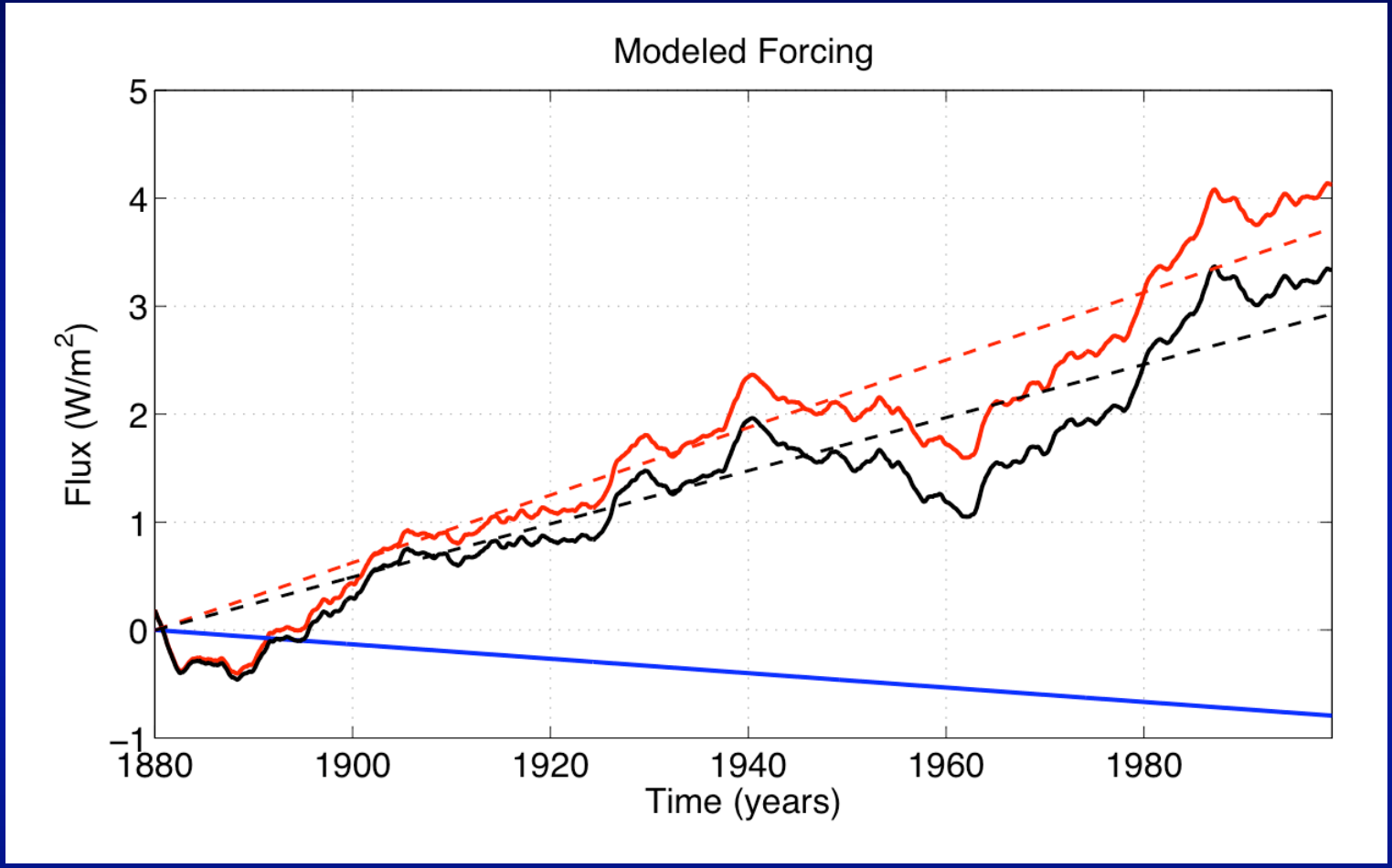
emissivity

$$LW = f(\epsilon)$$

$$\epsilon = \underbrace{\epsilon_0 + \Delta\epsilon(t)}_{\text{ANTHRO}} + \underbrace{f(q(t-J_i}_{\text{NATURAL}}$$

$$\Delta\dot{T}_o = -K\,\Delta T_o(t-J)$$

Box model results



Shown are simulated CO_2 (red), aerosol (blue) and total (black) forcing. Natural variability is a substantial part of interdecadal sub-trends

Conclusions

- We defined natural climate variability over the past century by subtracting multi-model ensemble average from the observed surface temperature data
- The leading mode of this variability (AMO) may have a dominant time scale of 60–80 yrs, and has a pattern characterized by pronounced teleconnections throughout the globe, including apparent large influence on the tropical Atlantic SST
- AMO may influence global temperature trend directly, via SST forcing, and indirectly, by affecting CO_2 and/or aerosol concentrations