

Human Impacts on Weather and Climate - Recent Research Results Require That We Adopt A Broader Assessment

Dr. Roger A. Pielke Sr.
Senior Research Scientist
University of Colorado, Boulder
Professor Emeritus, Colorado State University
Marshall Climate Science Meeting
September 14-16, 2008, Washington, DC

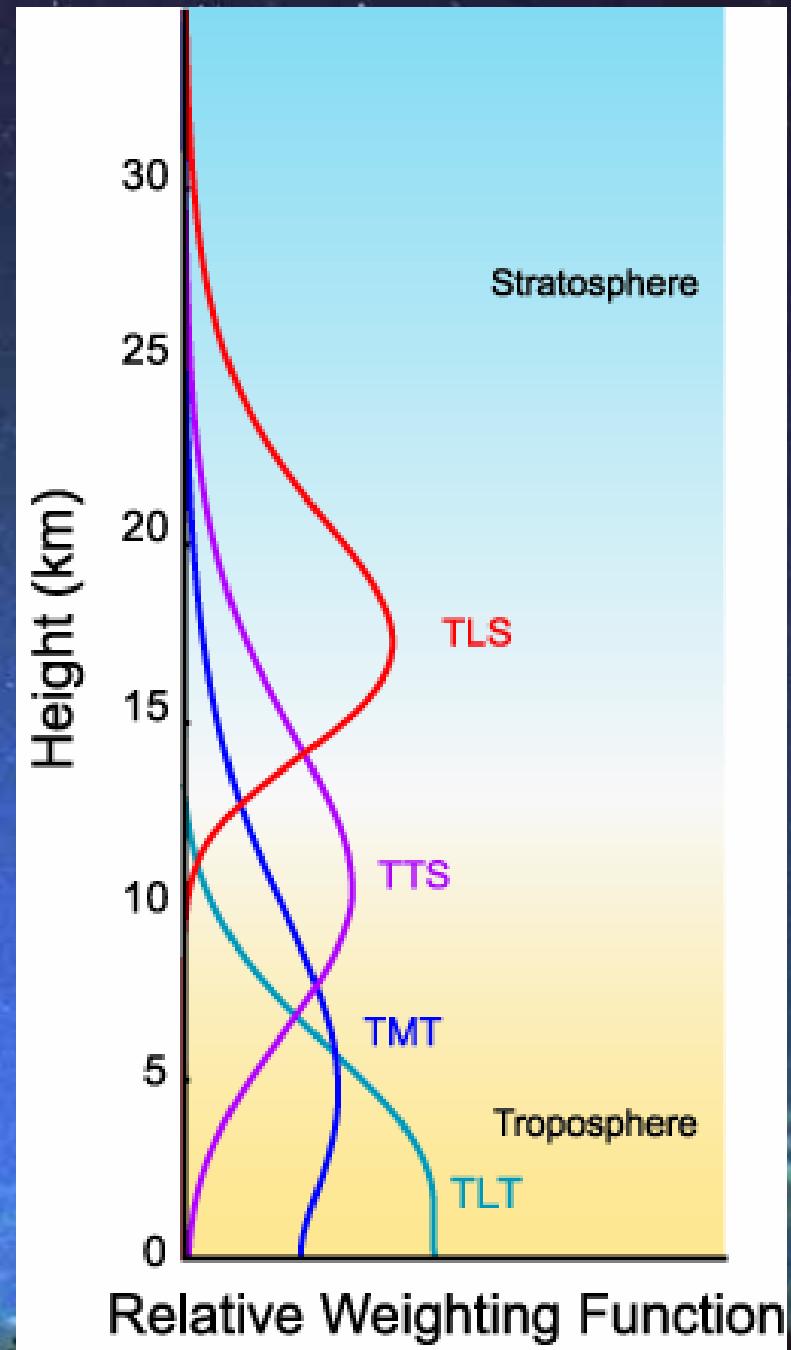
The background of the slide is a photograph of a dark blue night sky filled with numerous small white stars. At the bottom of the frame, the dark silhouettes of several trees are visible against the starry background.

What Does The Data Tell Us?

Vertical relative weighting functions for each of the channels discussed on this website. The vertical weighting function describes the relative contribution that microwave radiation emitted by a layer in the atmosphere makes to the total intensity measured above the atmosphere by the satellite.

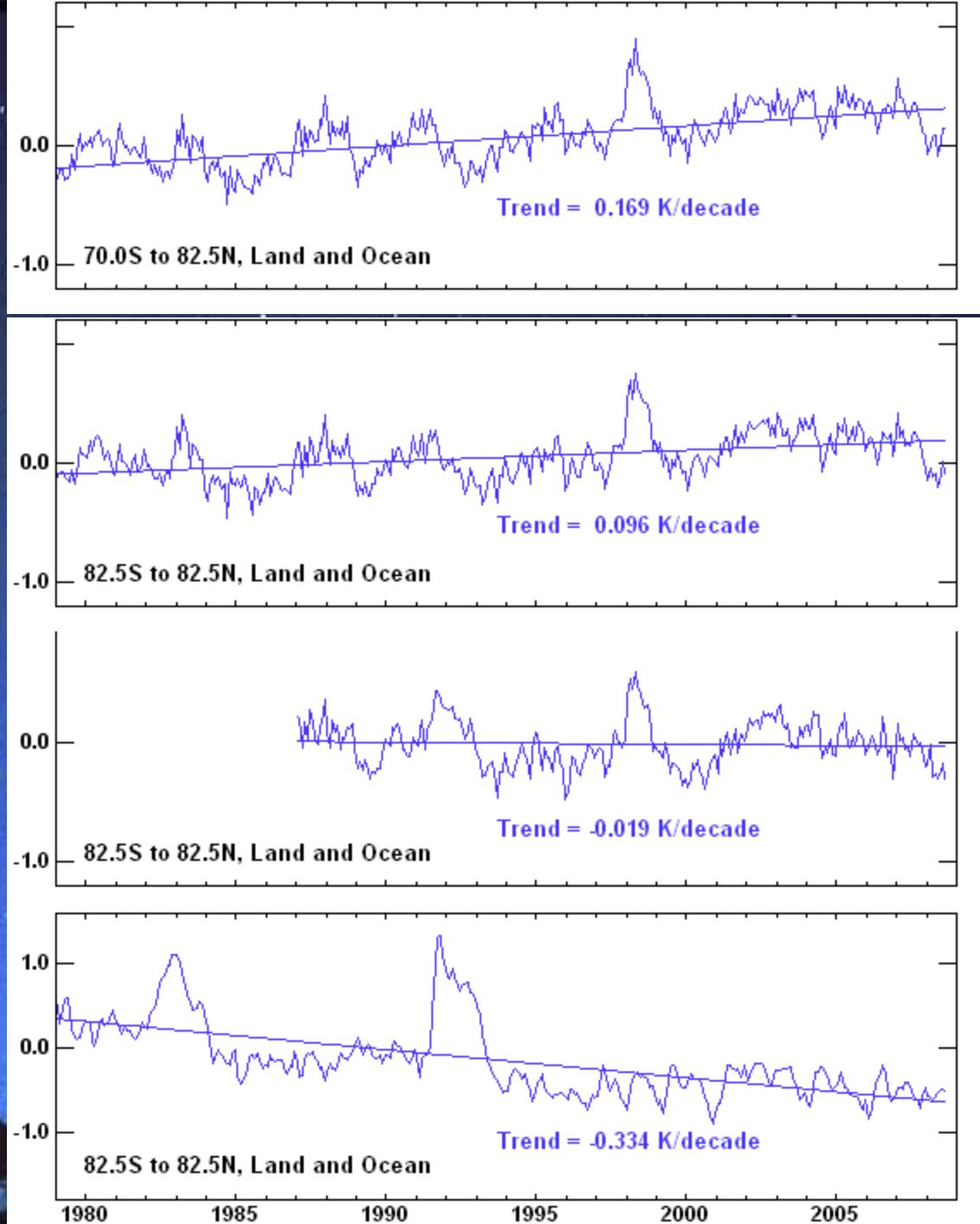
The weighting functions are available at
ftp://ssmi.com/msu/weighting_functions

From:
http://www.remss.com/msu/msu_data_description.html



Global, monthly time series of brightness temperature anomaly for channels TLT, TMT, TTS, and TLS (from top to bottom). For Channel TLT (Lower Troposphere) and Channel TMT (Middle Troposphere), the anomaly time series is dominated by ENSO events and slow tropospheric warming. The three primary El Niños during the past 20 years are clearly evident as peaks in the time series occurring during 1982-83, 1987-88, and 1997-98, with the most recent one being the largest. Channel TLS (Lower Stratosphere) is dominated by stratospheric cooling, punctuated by dramatic warming events caused by the eruptions of El Chichon (1982) and Mt Pinatubo (1991). Channel TTS (Troposphere / Stratosphere) appears to be a mixture of both effects. From:

http://www.remss.com/msu/msu_data_description.htm

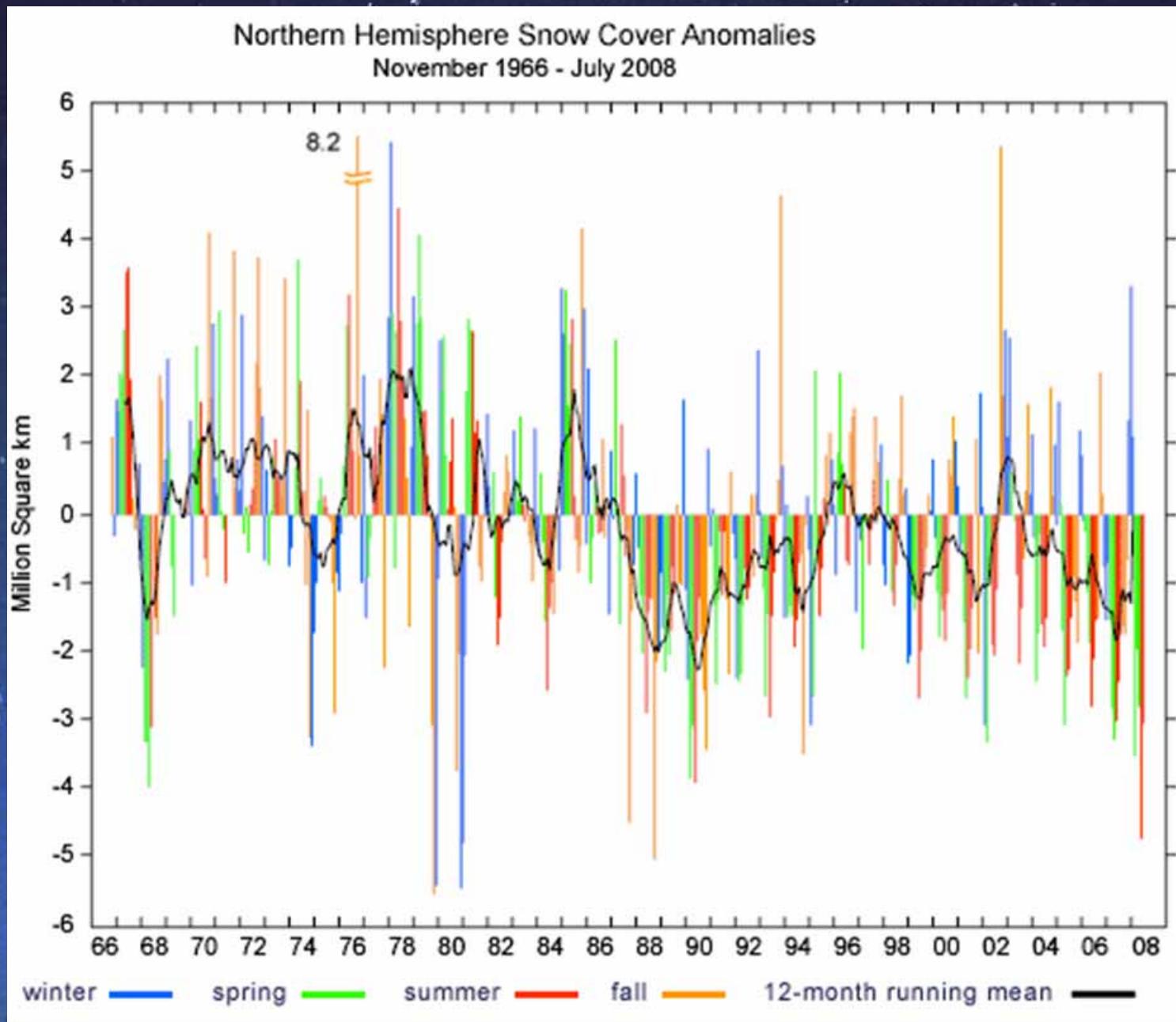


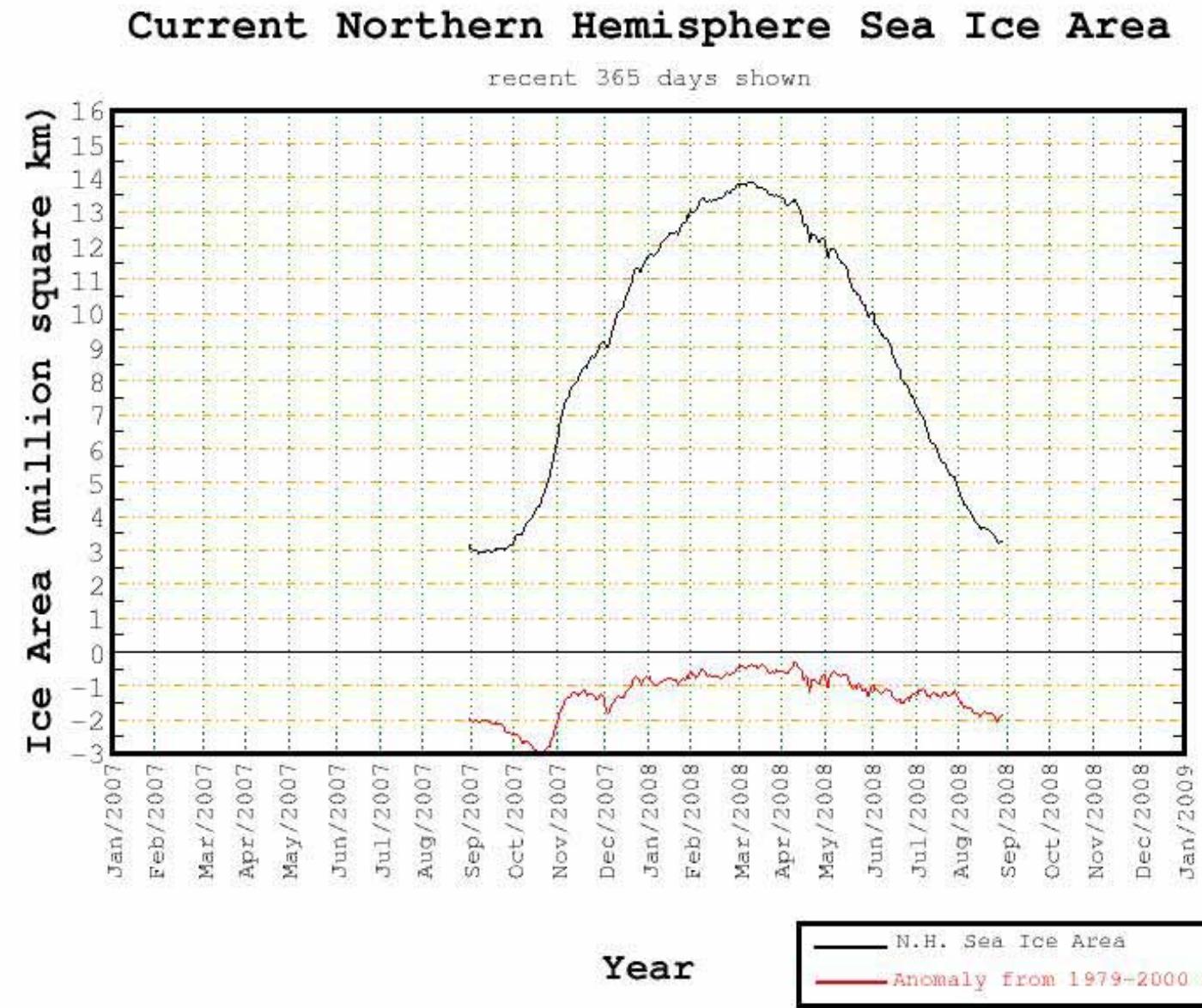
TLT

TMT

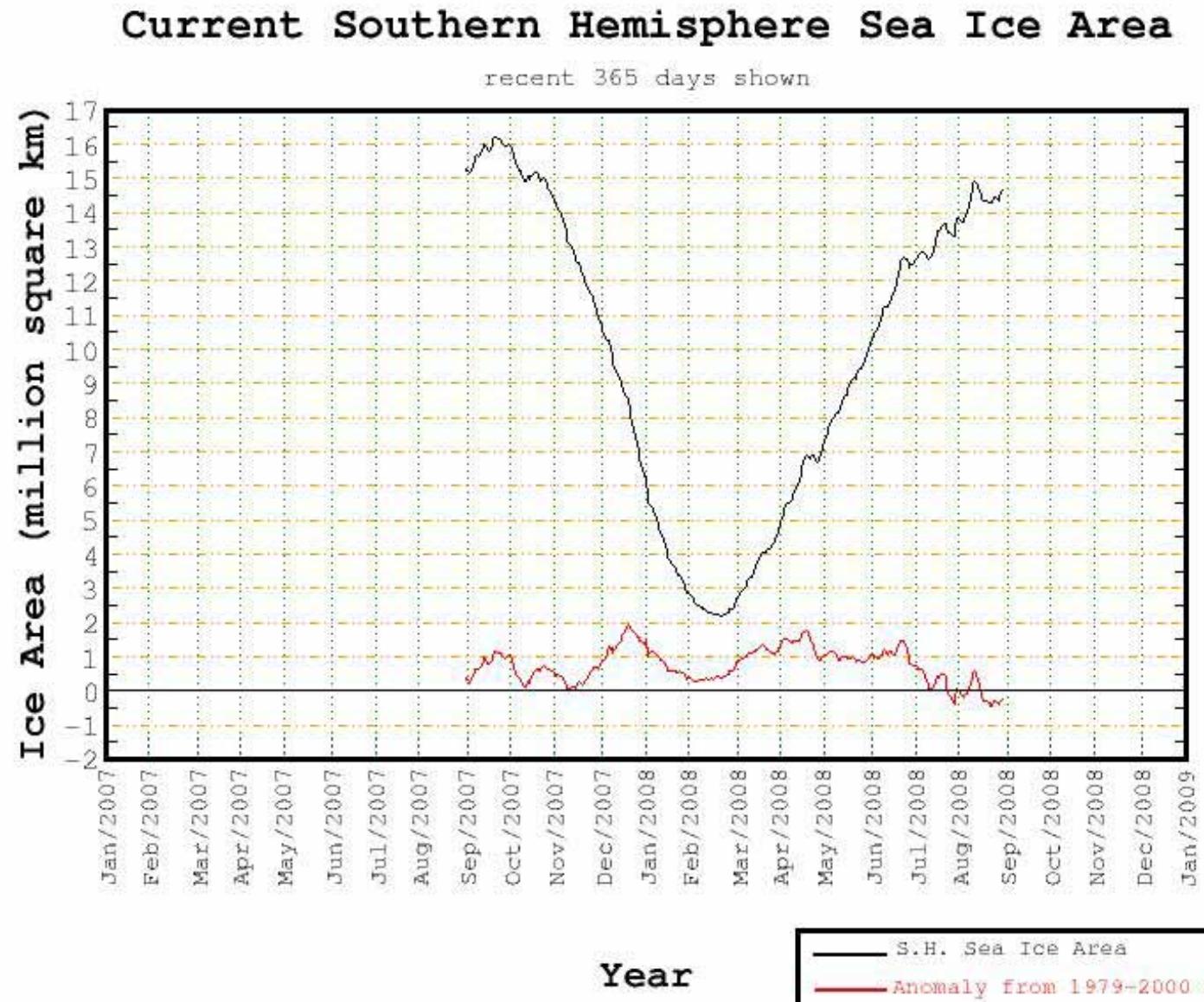
TTS

TLS

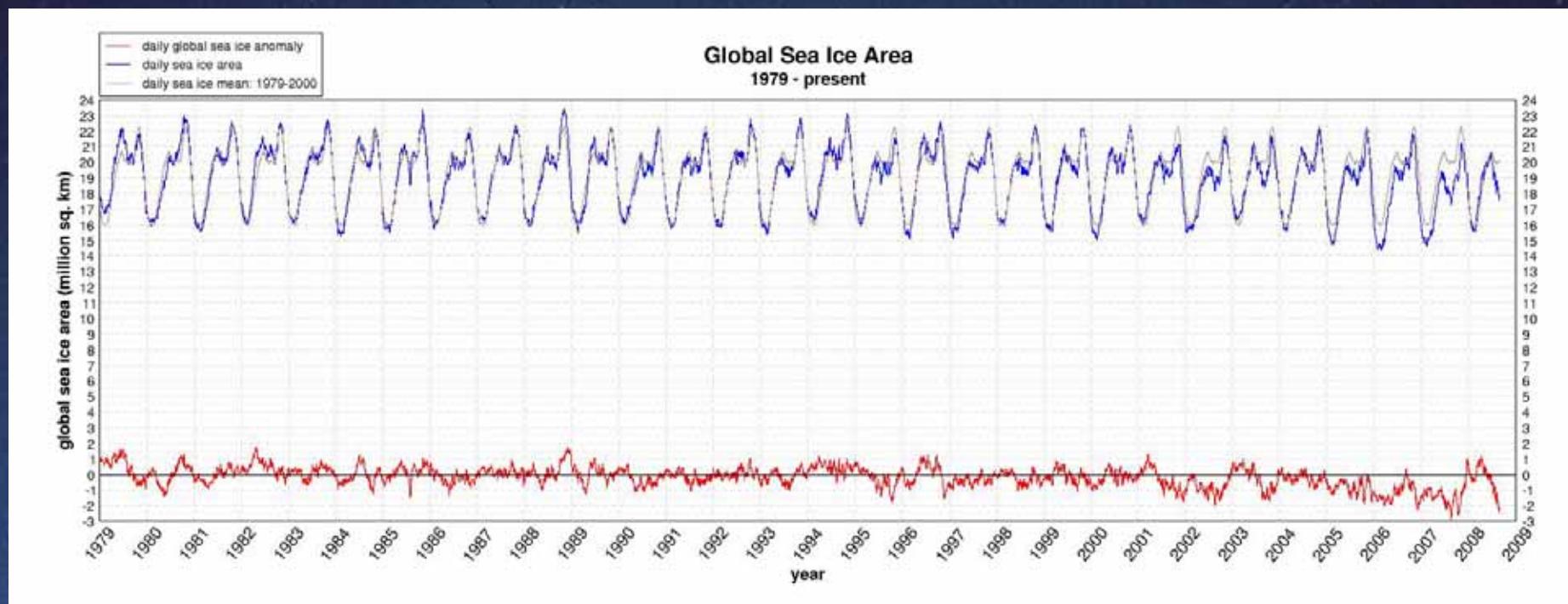




<http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/current.365.south.jpg>

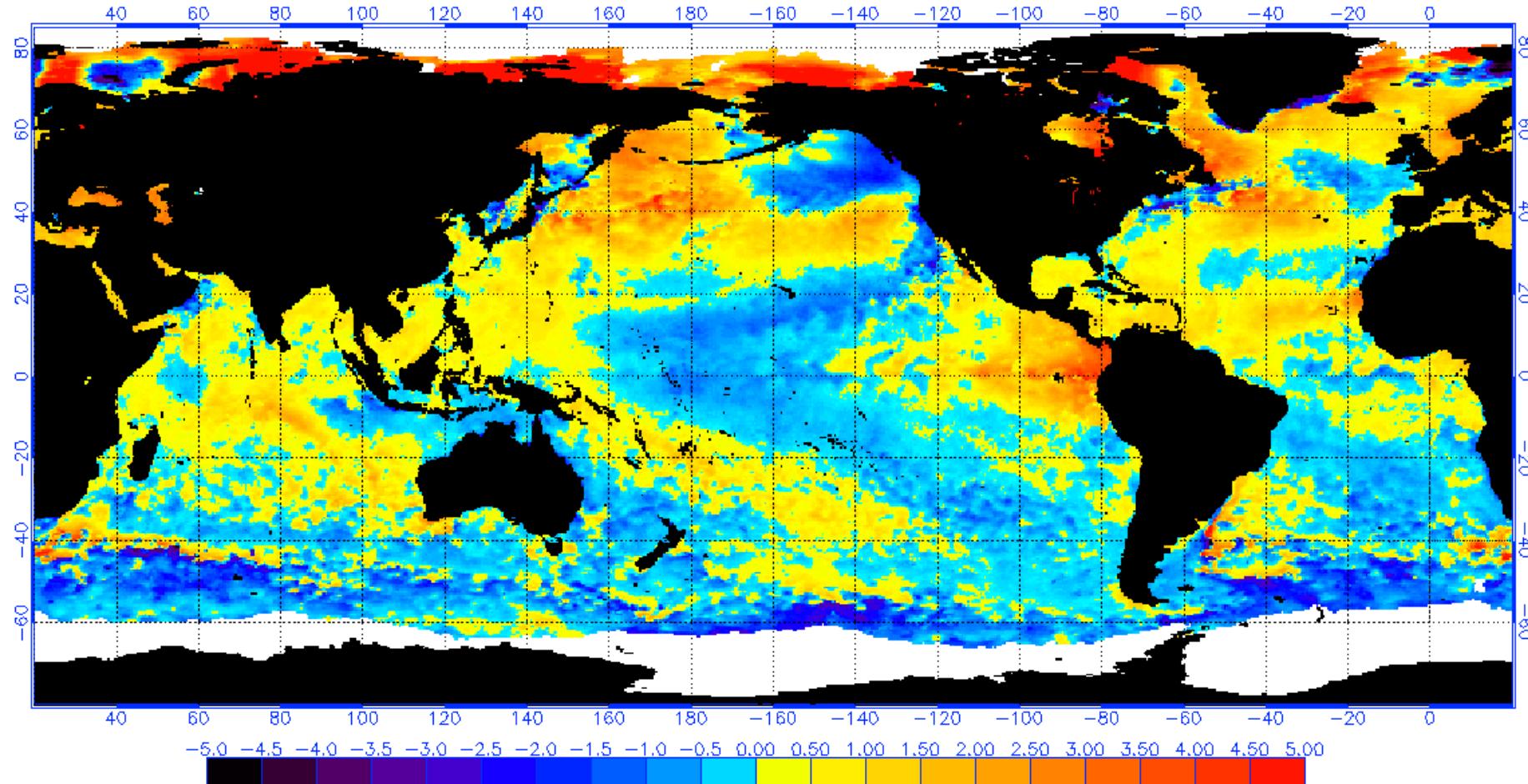


<http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/global.daily.ice.area.withtrend.jpg>

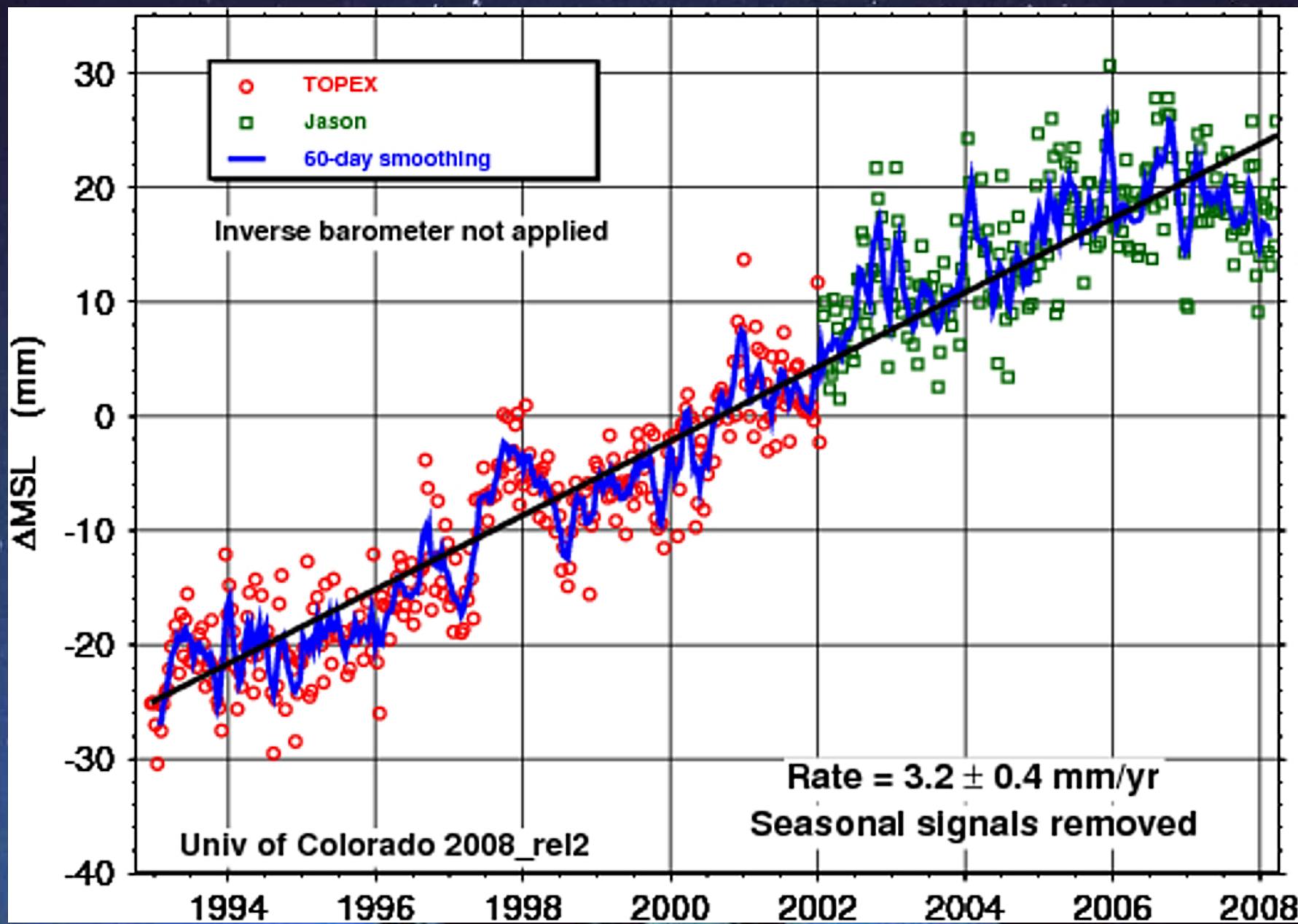


<http://www.osdpd.noaa.gov/PSB/EPS/SST/data/anomnight.9.1.2008.gif>

NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 9/1/2008
(white regions indicate sea-ice)



http://sealevel.colorado.edu/current/sl_noib_ns_global.jpg

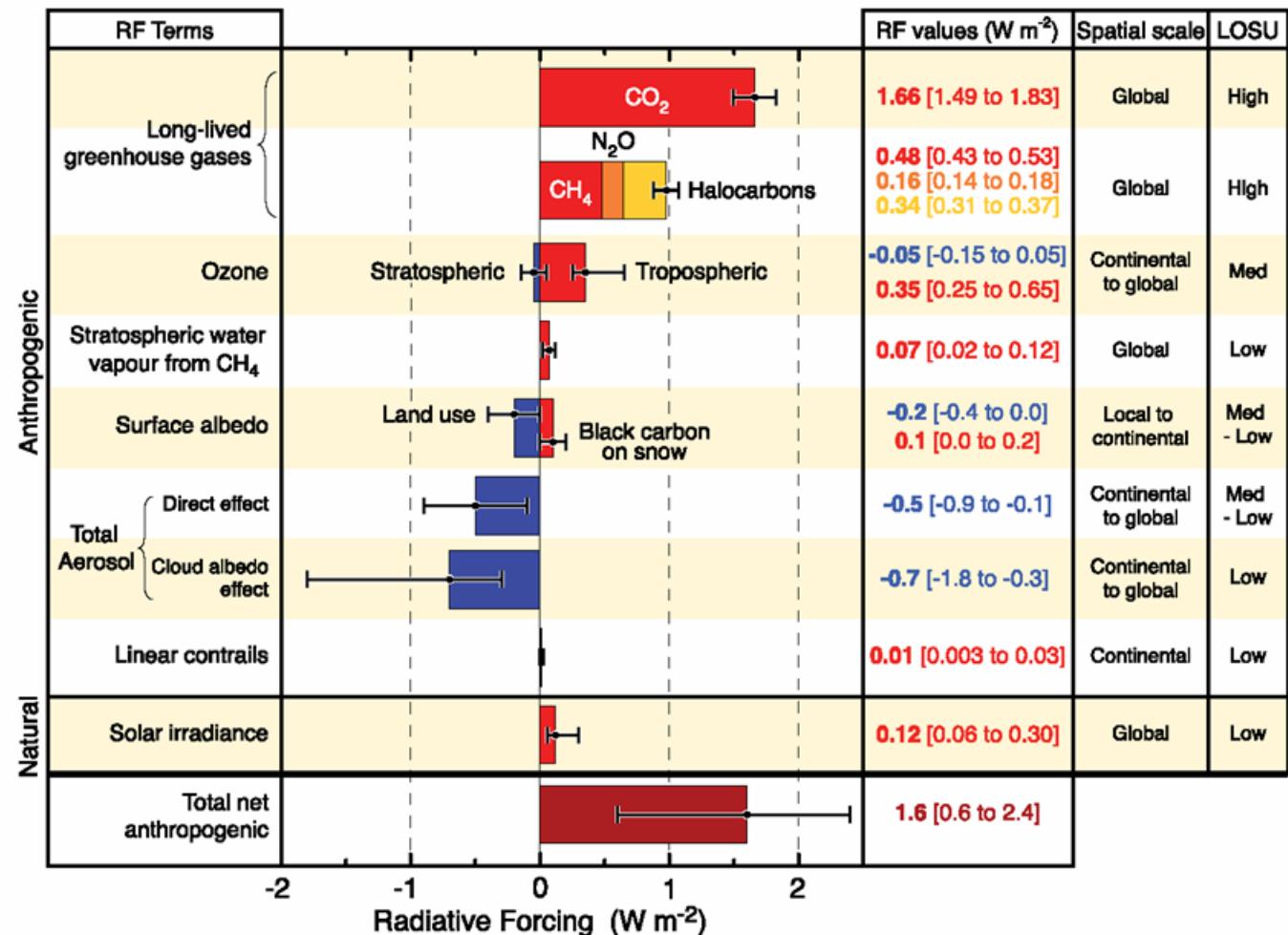


The Data Presents A Complex Variation In Time That Is Not Accurately Simulated By The Global Models

The IPCC View

2007 IPCC SPM View

RADIATIVE FORCING COMPONENTS

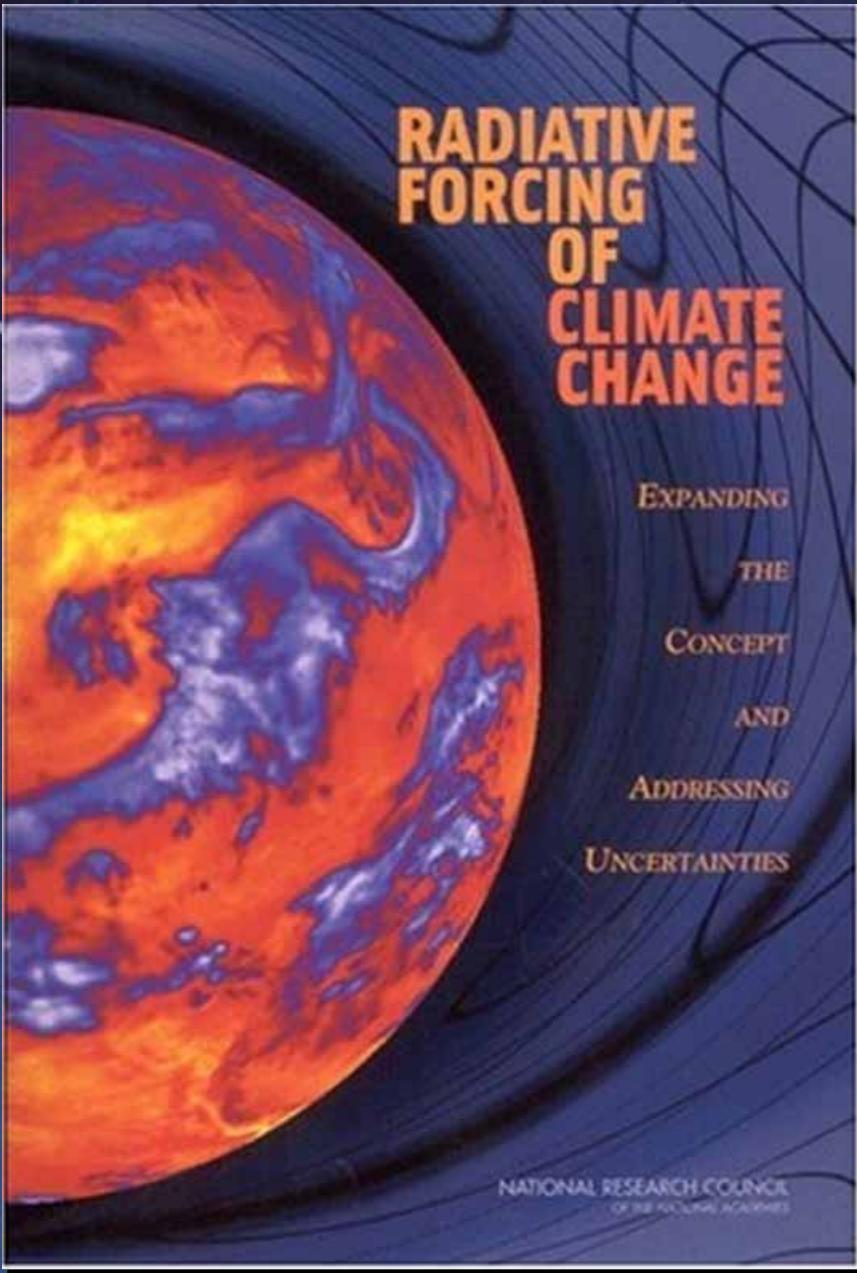


©IPCC 2007: WG1-AR4

Figure SPM.2. Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. {2.9, Figure 2.20}

FIGURE SPM-2. Global-average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. Range for linear contrails does not include other possible effects of aviation on cloudiness.

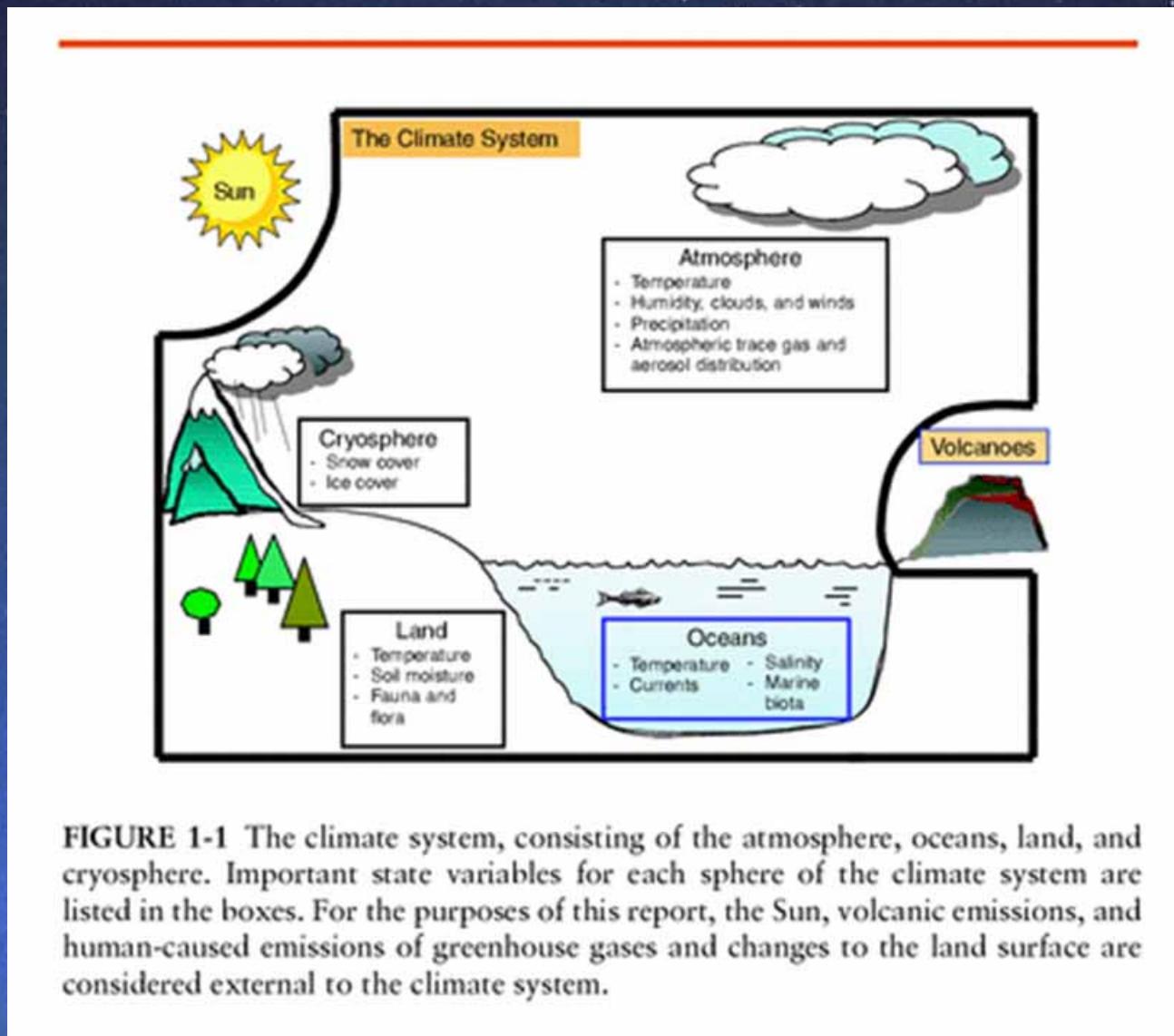
- The role of humans within the climate system must be one of the following three possibilities.
- The human influence is minimal and natural variations dominate climate variations on all time scales.
- While natural variations are important, the human influence is significant and involves a diverse range of first-order climate forcings, including, but not limited to the human input of CO₂.
- The human influence is dominated by the emissions into the atmosphere of greenhouse gases, particularly carbon dioxide.



National Research Council,
2005: Radiative Forcing of
Climate Change:
Expanding the Concept
and Addressing
Uncertainties, Committee
on Radiative Forcing
Effects on Climate, Climate
Research Committee, 224
pp.

<http://www.nap.edu/catalog/11175.html>

From: National Research Council, 2005: Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties, Committee on Radiative Forcing Effects on Climate, Climate Research Committee, 224 pp. <http://www.nap.edu/catalog/11175.html>



From: National Research Council, 2005: Radiative Forcing of Climate Change: Expanding the Concept and Addressing Uncertainties, Committee on Radiative Forcing Effects on Climate, Climate Research Committee, 224 pp. <http://www.nap.edu/catalog/11175.html>

INTRODUCTION

13

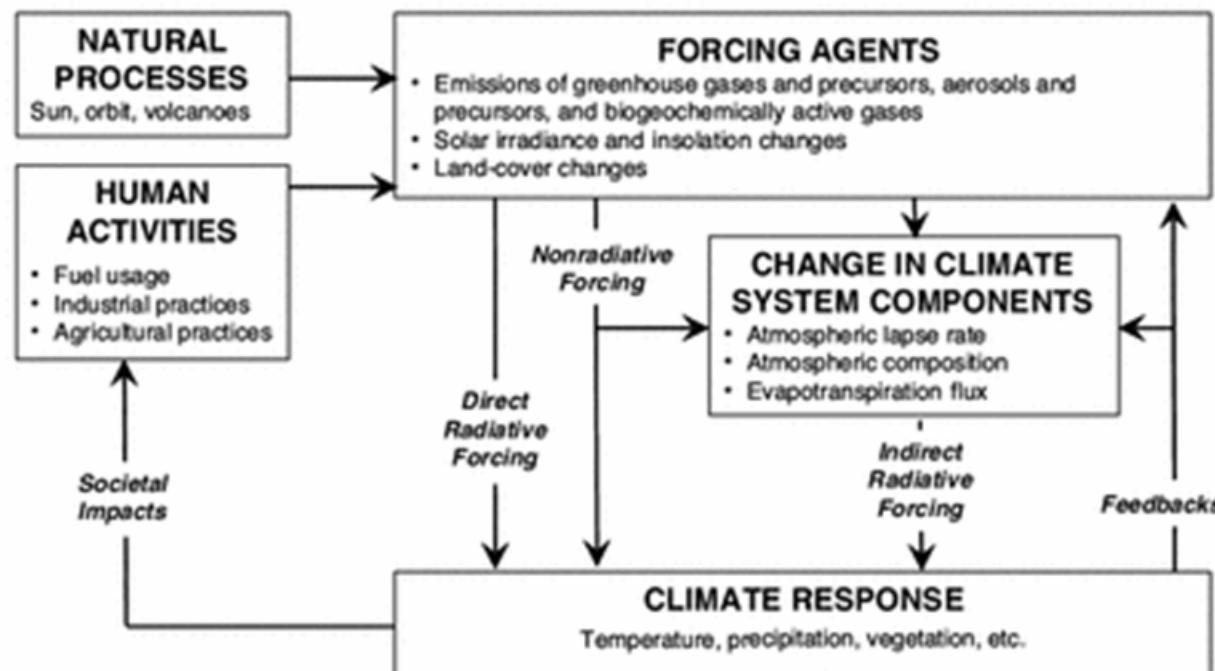


FIGURE 1-2 Conceptual framework of climate forcing, response, and feedbacks under present-day climate conditions. Examples of human activities, forcing agents, climate system components, and variables that can be involved in climate response are provided in the lists in each box.

EXPANDING THE RADIATIVE FORCING CONCEPT

(NRC 2005 Recommendations)

- Account for the Vertical Structure of Radiative Forcing
- Determine the Importance of Regional Variation in Radiative Forcing
- Determine the Importance of Nonradiative Forcings
- Provide Improved Guidance to the Policy Community

Determine the Importance of Regional Variation in Radiative Forcing

National Research Council Report

PRIORITY RECOMMENDATIONS

Use climate records to investigate relationships between regional radiative forcing (e.g., land use or aerosol changes) and climate response in the same region, other regions, and globally.

Determine the Importance of Regional Variation in Radiative Forcing

National Research Council Report PRIORITY RECOMMENDATIONS

Quantify and compare climate responses from regional radiative forcings in different climate models and on different timescales (e.g., seasonal, interannual), and report results in climate change assessments.

Determine the Importance of Nonradiative Forcings

National Research Council Report

PRIORITY RECOMMENDATIONS

Improve understanding and parameterizations of aerosol-cloud thermodynamic interactions and land-atmosphere interactions in climate models in order to quantify the impacts of these nonradiative forcings on both regional and global scales.

Determine the Importance of Nonradiative Forcings

National Research Council Report PRIORITY RECOMMENDATIONS

Develop improved land-use and land-cover classifications at high resolution for the past and present, as well as scenarios for the future.

Provide Improved Guidance to the Policy Community

National Research Council Report

PRIORITY RECOMMENDATIONS

Encourage policy analysts and integrated assessment modelers to move beyond simple climate models based entirely on global mean TOA radiative forcing and incorporate new global and regional radiative and nonradiative forcing metrics as they become available.

The Assessment of The Global Radiative Imbalance From Changes In Ocean Heat Content

Global Radiative Imbalance

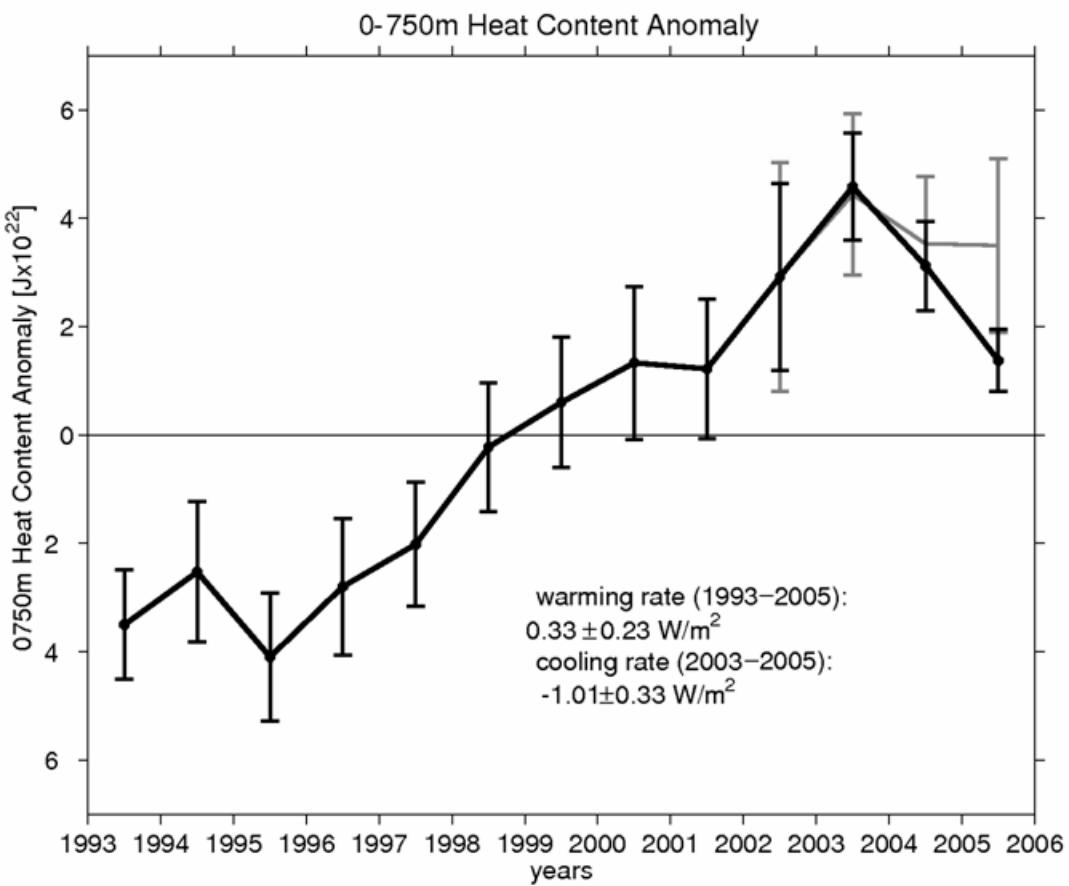


Figure 1. Globally averaged annual OHCA [10^{22} J] in the upper 750 m estimated using in situ data alone from 1993 through 2005 (black line) and using in situ data excluding profiling floats (gray line). Error bars (from Figure 3) reflect the standard error estimates discussed in Section 3. Linear trends are computed from a weighted least square fit [Wunsch, 1996] and reflect the OHCA estimate made using all available profile data. Errors for inset linear trend estimates are quoted at the 95% confidence interval.

From Lyman, J.M., J. Willis, and G. Johnson, 2006: Recent cooling of the upper ocean. Geophys Res. Lett., 33, L18604, doi:10.1029/2006GL027033. Correction completed April 2007 which eliminates cooling but finds no warming in recent years.

Global Radiative Forcing

©IPCC 2007: WG1-AR4

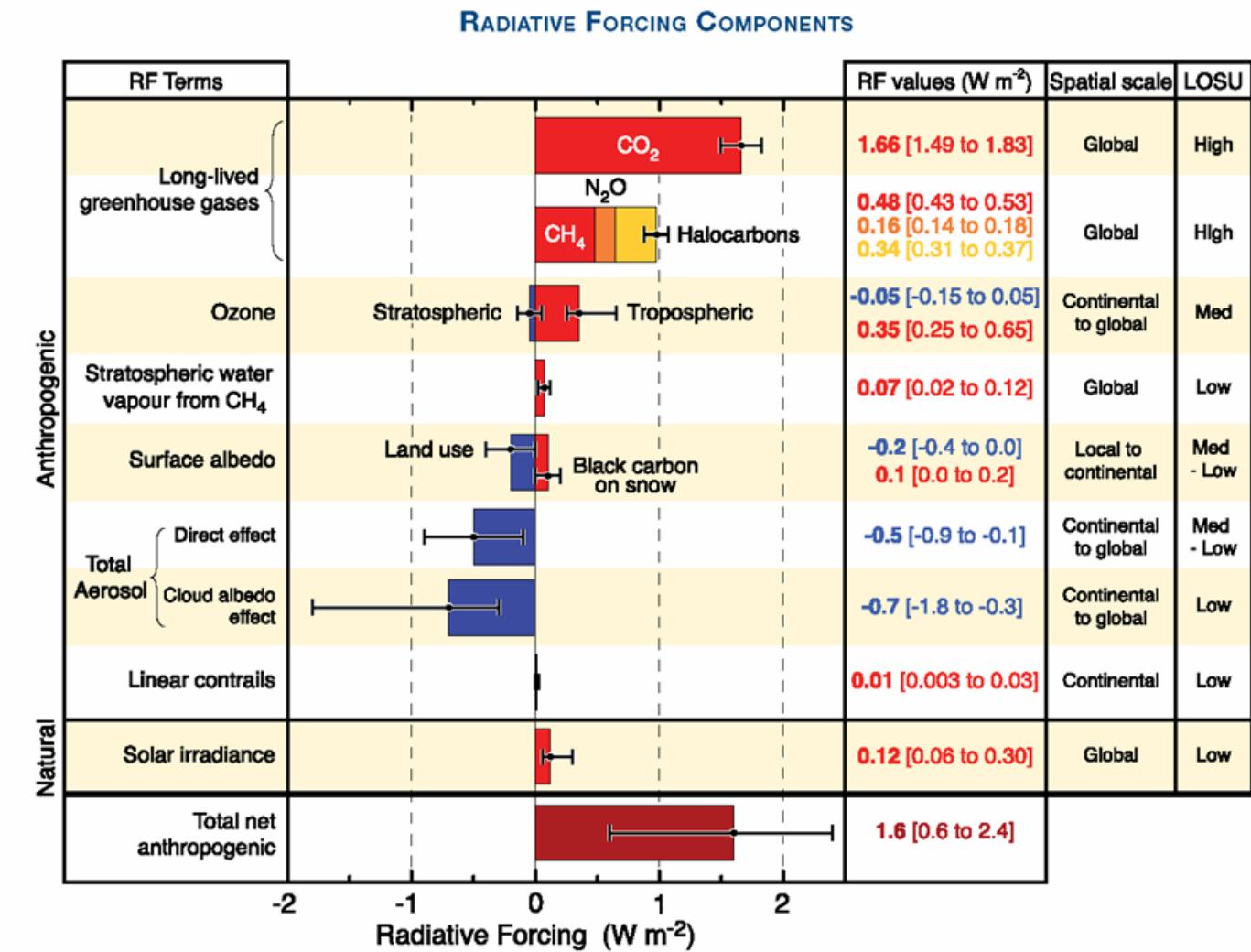


Figure SPM.2. Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. These require summing asymmetric uncertainty estimates from the component terms, and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure due to their episodic nature. The range for linear contrails does not include other possible effects of aviation on cloudiness. (2.9, Figure 2.20)

**2007 IPCC Total
Radiative Forcing =
1.72 (0.66 to 2.7)
Watts per meter
squared**

**Best Estimate of
Total Radiative
Imbalance
(1993-2005) =
0.33 (0.10
to 0.56) Watts
per meter
squared**

**If the IPCC
Forcing is
accepted as the
current forcing,
then the net
global radiative
feedbacks are
negative!**

Definition Of The Global Average Radiative Temperature

$$dH/dt = f - T'\Lambda$$

Poor Microclimate Exposure At Many Climate Observing Sites

[**http://wattsupwiththat.wordpress.com/**](http://wattsupwiththat.wordpress.com/)

Davey, C.A., and R.A. Pielke Sr., 2005: Microclimate exposures of surface-based weather stations - implications for the assessment of long-term temperature trends. Bull. Amer. Meteor. Soc., Vol. 86, No. 4, 497–504.
<http://climatesci.colorado.edu/publications/pdf/R-274.pdf>

Fort Morgan site showing images of the cardinal directions from the sensor (from Hanamean et al. 2003)

N
↑



Northeast view



Close up of sensor location

http://wattsupwiththat.wordpress.com/category/weather_stations/



Santa Ana, Orange County CA site situated on the rooftop of the local fire department. See related article and photos at:

<http://wattsupwiththat.wordpress.com/> and

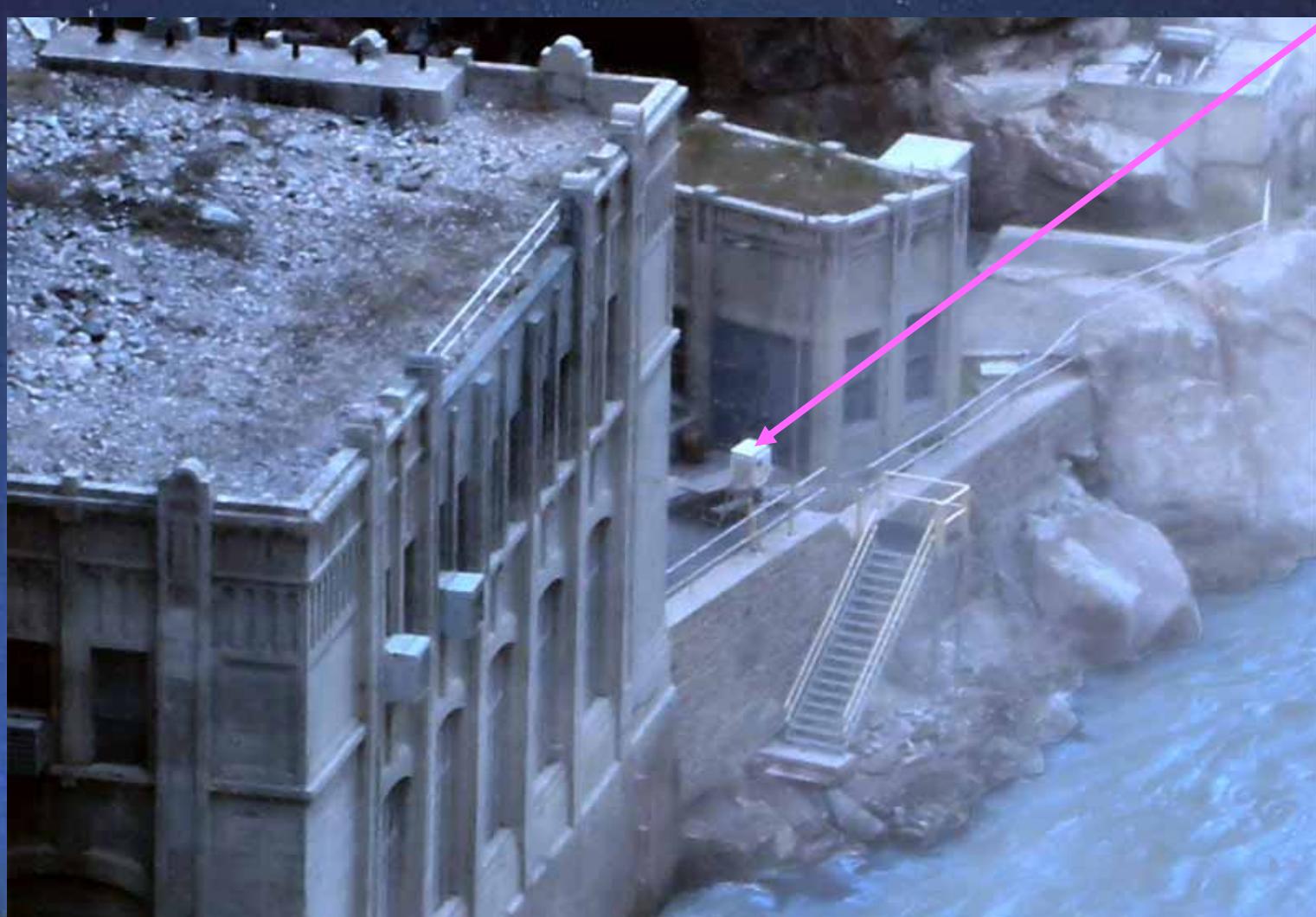
<http://sciedude.freedomblogging.com/2008/08/07/urbanization-raises-the-heat-in-oc/>



Photo taken at Roseburg, OR (MMTS shelter on roof, near a/c exhaust)
http://www.surfacestations.org/images/Roseburg_OR_USHCN.jpg



Buffalo Bill Dam, Cody WY shelter on top of a stone wall at the edge of the river. It is surrounded by stone building heat sinks except on the river side. On the river it is exposed to waters of varying temperatures, cold in spring and winter, warm in summer and fall as the river flows vary with the season. The level of spray also varies, depending on river flow. <http://wattsupwiththat.wordpress.com/2008/07/15/how-not-to-measure-temperature-part-67/>



Lampasas, TX, February 10, 2008

[http://gallery.surfacestations.org/main.php?g2\(itemId=34296](http://gallery.surfacestations.org/main.php?g2(itemId=34296)





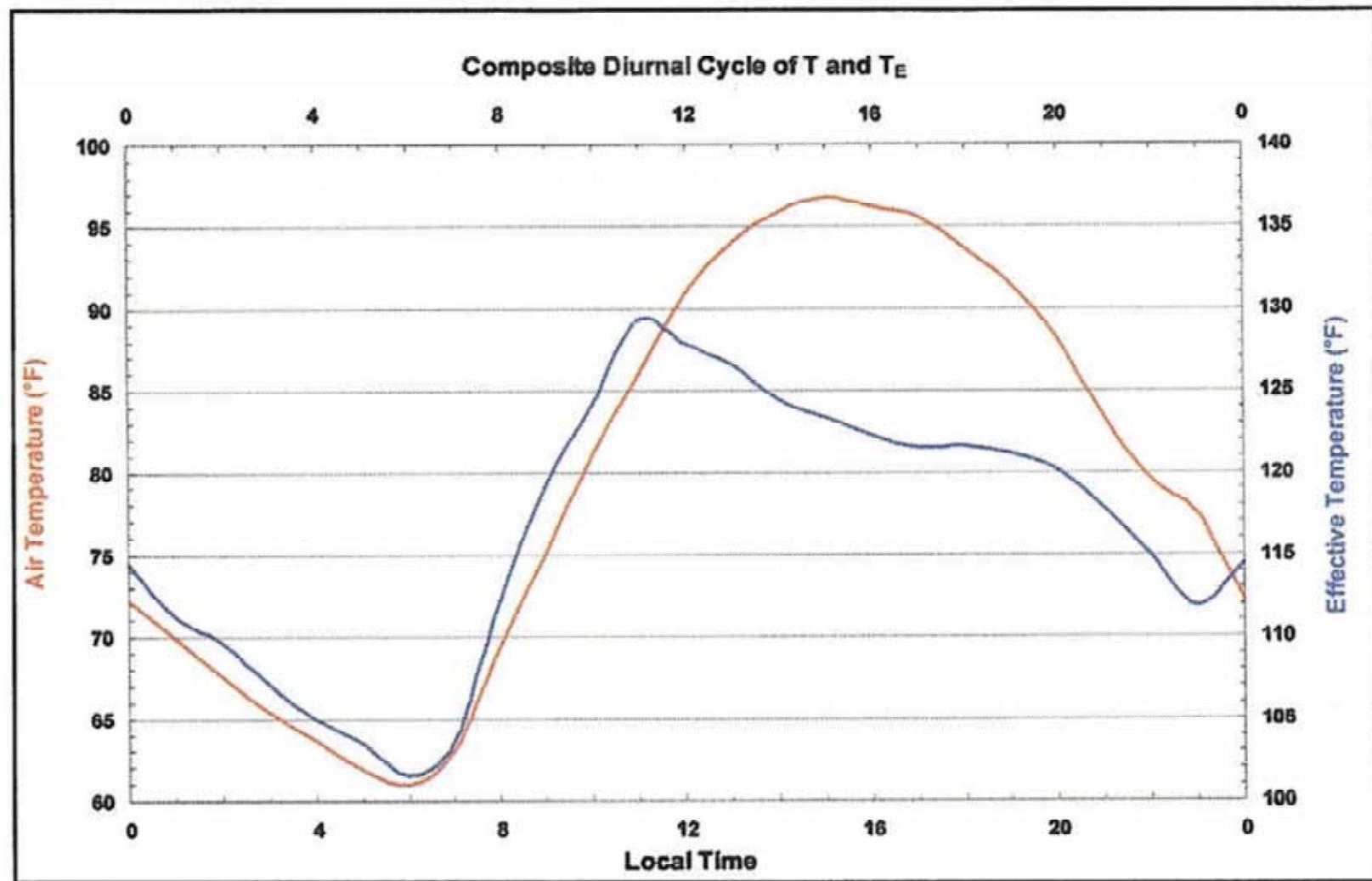
As shown in *Pielke et al. [2004]*, the heat content of surface air is given by

$$H = C_p T + Lq$$

where H is the heat in Joules, C_p is the heat capacity of air at constant pressure, T is the air temperature, L is the latent heat of vaporization and q is the specific humidity. This equation can be rewritten as

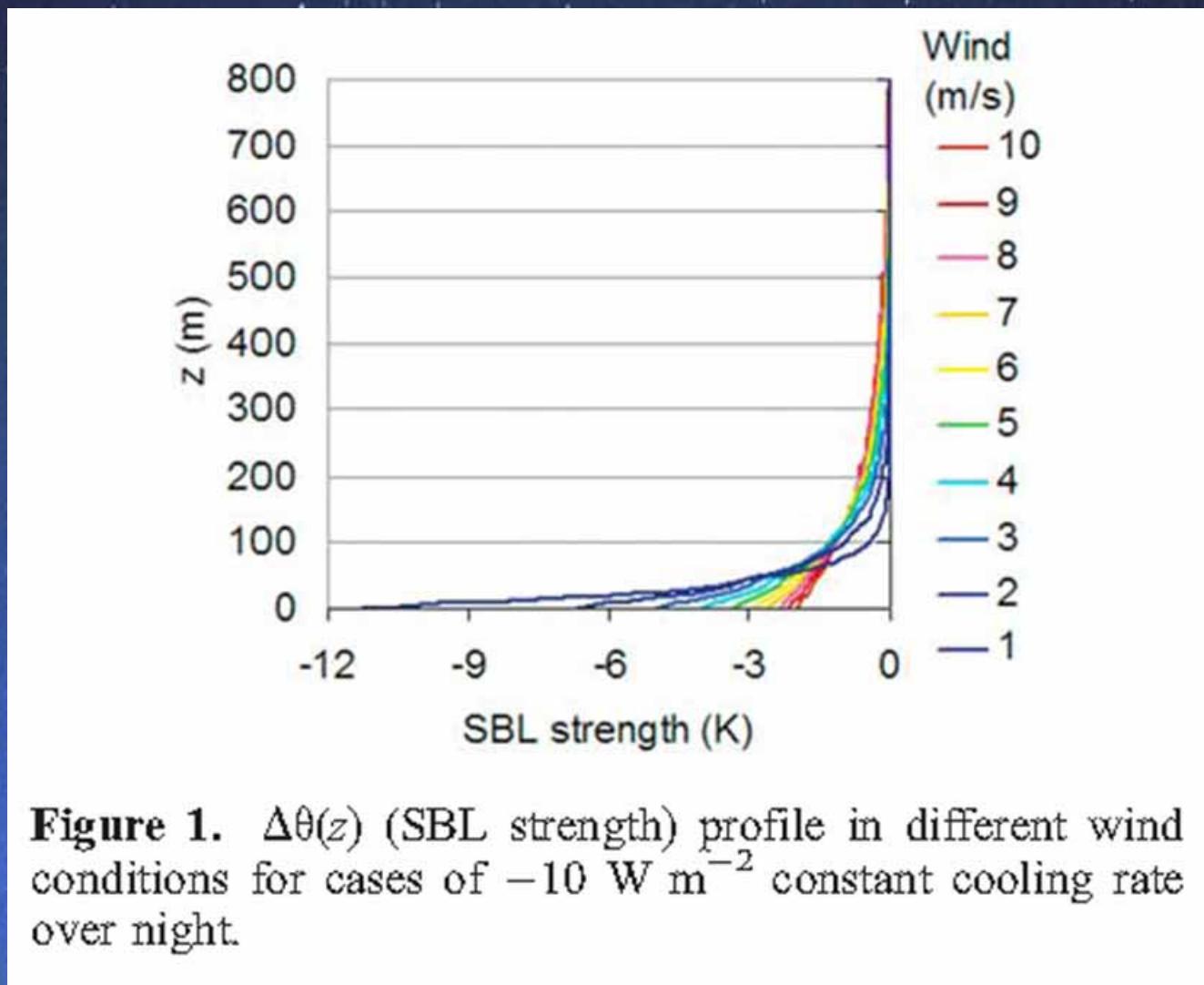
$$\frac{H}{C_p} = T_E = T + \frac{L_v q}{C_p}$$

Pielke, R.A. Sr., K. Wolter, O. Bliss, N. Doesken, and B. McNoldy, 2006: The July 2005 Denver heat wave: How unusual was it? Nat. Wea. Dig., 31, 24-35.
<http://climatesci.colorado.edu/publications/pdf/R-313.pdf>



Documentation Of A Significant Warm Bias In Long-Term Trends of Minimum Temperatures

From: Pielke Sr., R.A., and T. Matsui, 2005: Should light wind and windy nights have the same temperature trends at individual levels even if the boundary layer averaged heat content change is the same? Geophys. Res. Letts., 32, No. 21, L21813, 10.1029/2005GL024407. <http://climatesci.colorado.edu/publications/pdf/R-302.pdf>



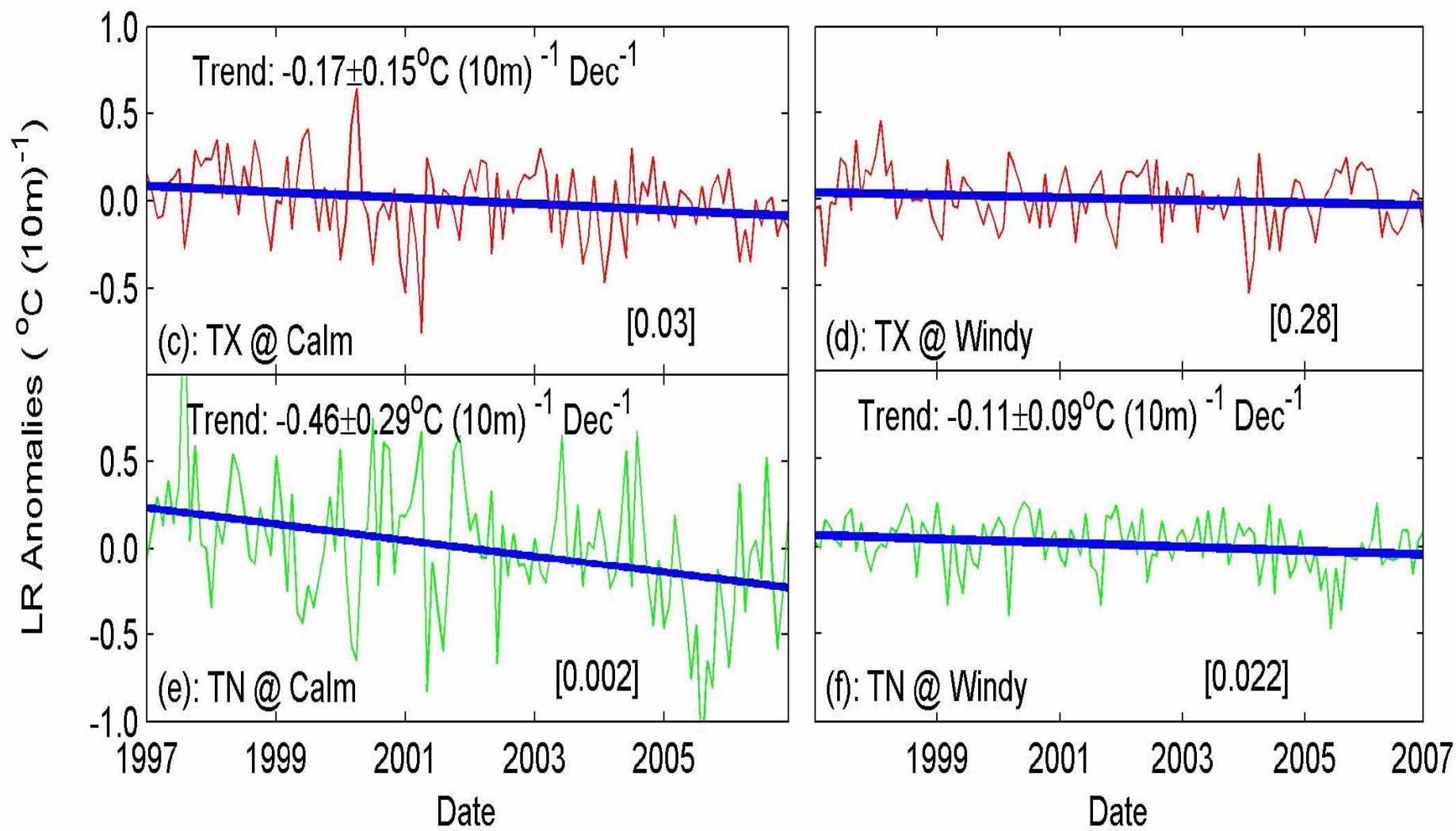
From: Pielke Sr., R.A., and T. Matsui, 2005: Should light wind and windy nights have the same temperature trends at individual levels even if the boundary layer averaged heat content change is the same? Geophys. Res. Letts., 32, No. 21, L21813, 10.1029/2005GL024407.

<http://climatesci.colorado.edu/publications/pdf/R-302.pdf>

Table 1. Tabulated Version of Figure 3^a

Z, m	Wind Speed, m s^{-1}									
	10	9	8	7	6	5	4	3	2	1
10	0.28	0.30	0.33	0.36	0.40	0.45	0.52	0.63	0.81	1.20
9	0.28	0.30	0.33	0.36	0.40	0.45	0.53	0.64	0.83	1.24
8	0.28	0.30	0.33	0.36	0.40	0.46	0.53	0.65	0.85	1.28
7	0.28	0.31	0.33	0.37	0.41	0.46	0.54	0.66	0.86	1.32
6	0.28	0.31	0.33	0.37	0.41	0.47	0.55	0.67	0.88	1.37
5	0.29	0.31	0.34	0.37	0.41	0.47	0.55	0.68	0.89	1.41
4	0.29	0.31	0.34	0.37	0.42	0.48	0.56	0.69	0.91	1.46
3	0.29	0.31	0.34	0.38	0.42	0.48	0.57	0.70	0.93	1.50
2	0.29	0.31	0.34	0.38	0.42	0.49	0.57	0.71	0.95	1.55
1	0.29	0.32	0.35	0.38	0.43	0.49	0.58	0.72	0.97	1.60
0	0.29	0.32	0.35	0.38	0.43	0.50	0.59	0.73	0.98	1.66

^aPotential temperature increase at different levels from the experiment with -49 W m^{-2} cooling to the experiment with -50 W m^{-2} cooling.

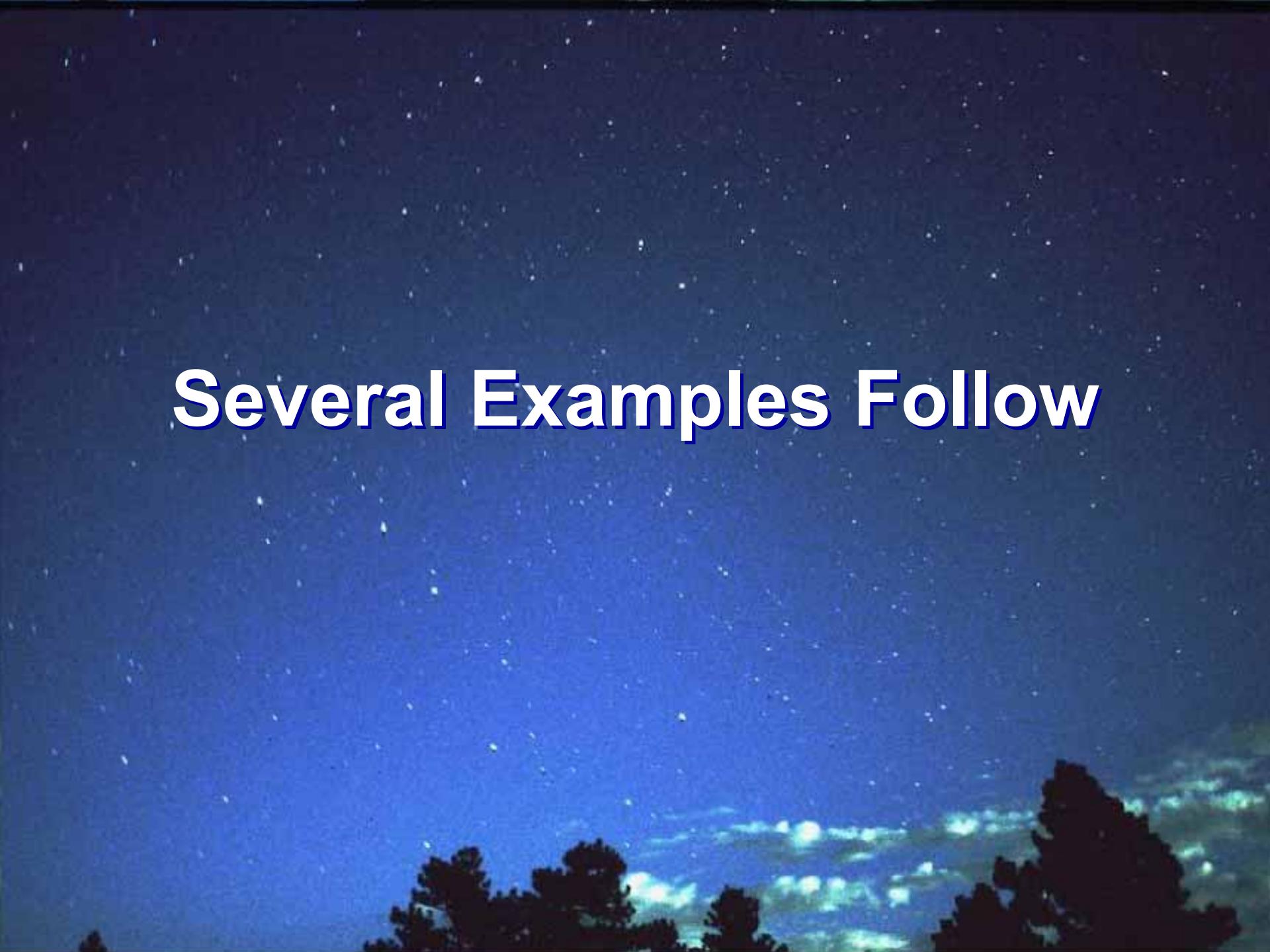


A conservative estimate of the warm bias resulting from measuring the temperature near the ground is around 0.21°C per decade (with the nighttime minimum temperature contributing a large part of this bias). Since land covers about 29% of the Earth's surface, the warm bias due to this influence explains about 30% of the IPCC estimate of global warming. In other words, consideration of the bias in temperature would reduce the IPCC trend to about 0.14°C per decade; still a warming, but not as large as indicated by the IPCC.

[From <http://climatesci.colorado.edu/publications/pdf/Testimony-written.pdf>].

Human Climate Forcings Ignored or Underreported in the 2007 IPCC Report

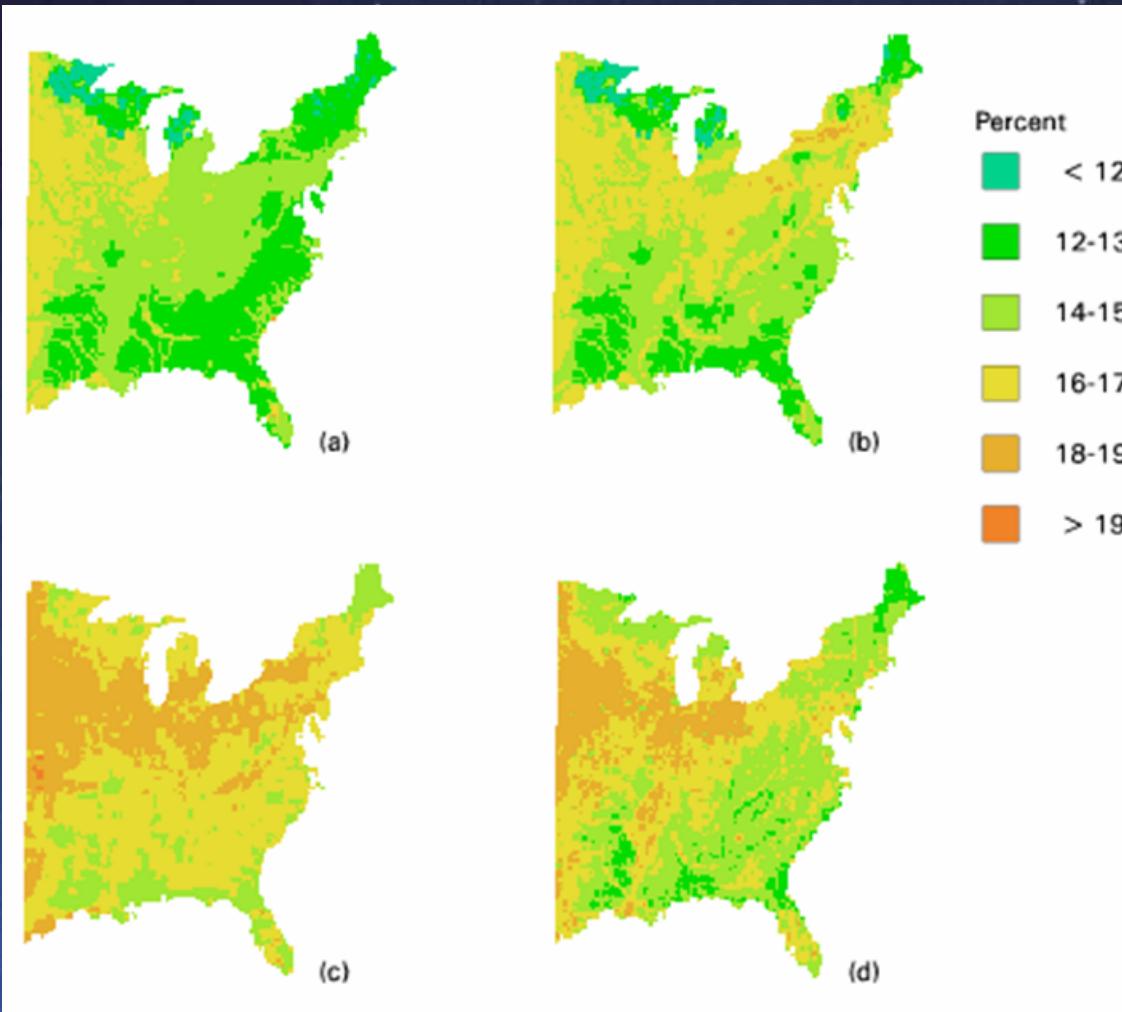
- Land Use/Land Cover Change
- Nitrogen Deposition
- Black Carbon Deposition
- Dust Deposition
- Biogeochemical Effect of Added CO₂
- Methane Outgassing
- Ozone Effects On Vegetation

The background of the image is a dark blue night sky filled with numerous small white stars of varying brightness. At the bottom of the frame, the dark silhouettes of several trees are visible against the starry sky. The overall atmosphere is peaceful and suggests a clear, dark night.

Several Examples Follow

Regional Land-Use Change Effects On Climate In The Eastern United States in June

Albedo: 1650, 1850, 1920, 1992



Historical Patterns of Broadband Solar Albedo:

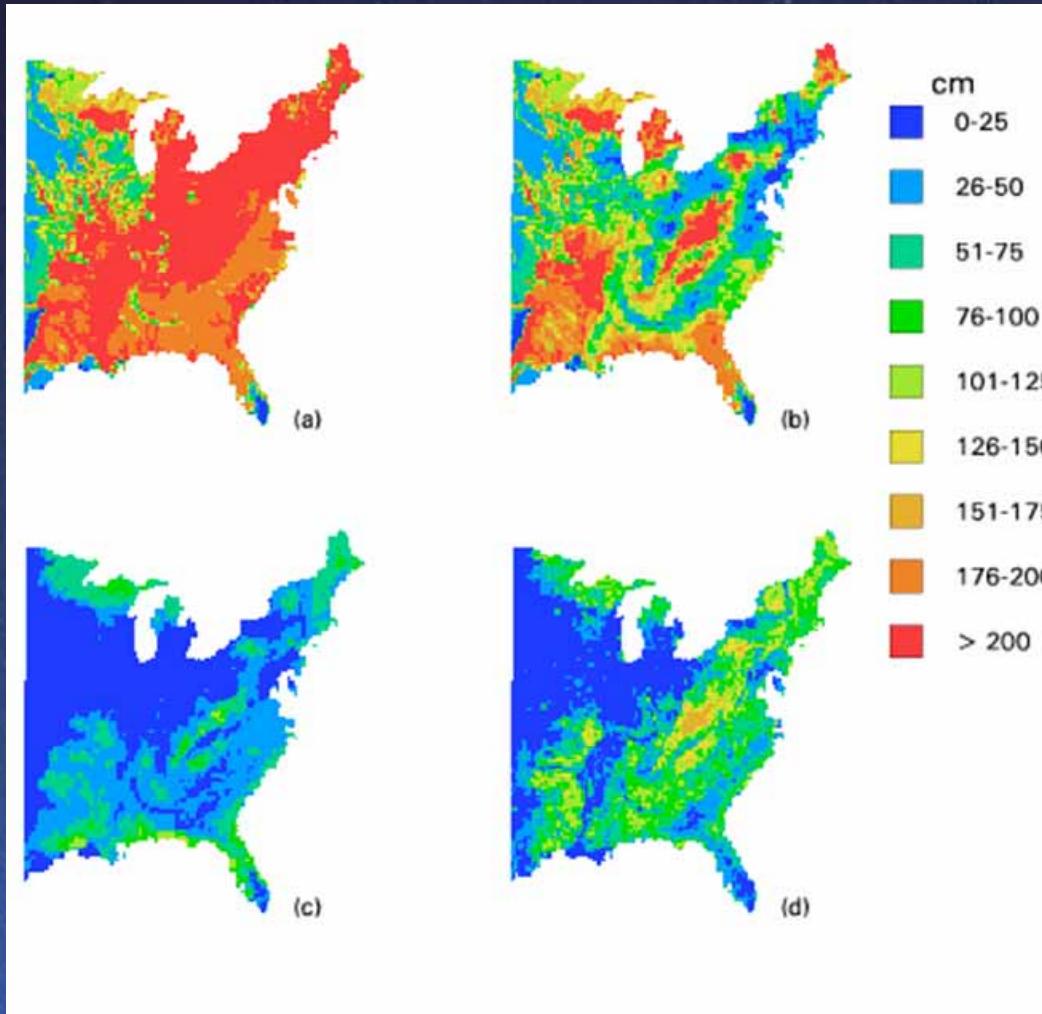
- (a) 1650
- (b) 1850
- (c) 1920
- (d) 1992

Source: Steyaert, L. T., and R. G. Knox, 2008: Reconstructed historical land cover and biophysical parameters for studies of land-atmosphere interactions within the eastern United States, *J. Geophys. Res.*, 113, D02101, doi:10.1029/2006JD008277



NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

Surface Roughness Length: 1650, 1850, 1920, 1992



**Historical
Patterns of
Surface
Roughness
Length (cm):**

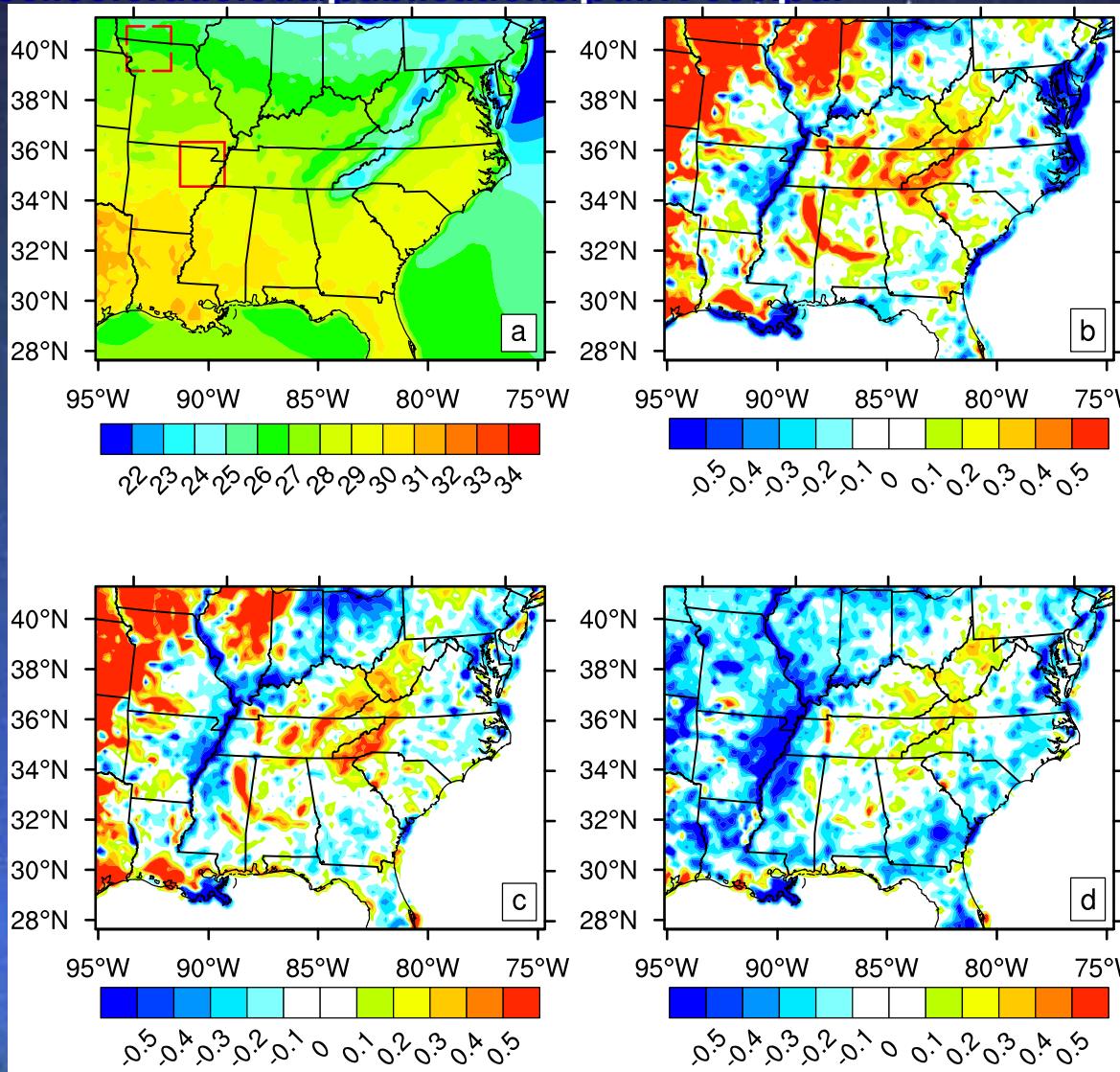
- (a) 1650
- (b) 1850
- (c) 1920
- (d) 1992

Source: Steyaert, L. T., and R. G. Knox, 2008: Reconstructed historical land cover and biophysical parameters for studies of land-atmosphere interactions within the eastern United States, *J. Geophys. Res.*, 113, D02101, doi:10.1029/2006JD008277



NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

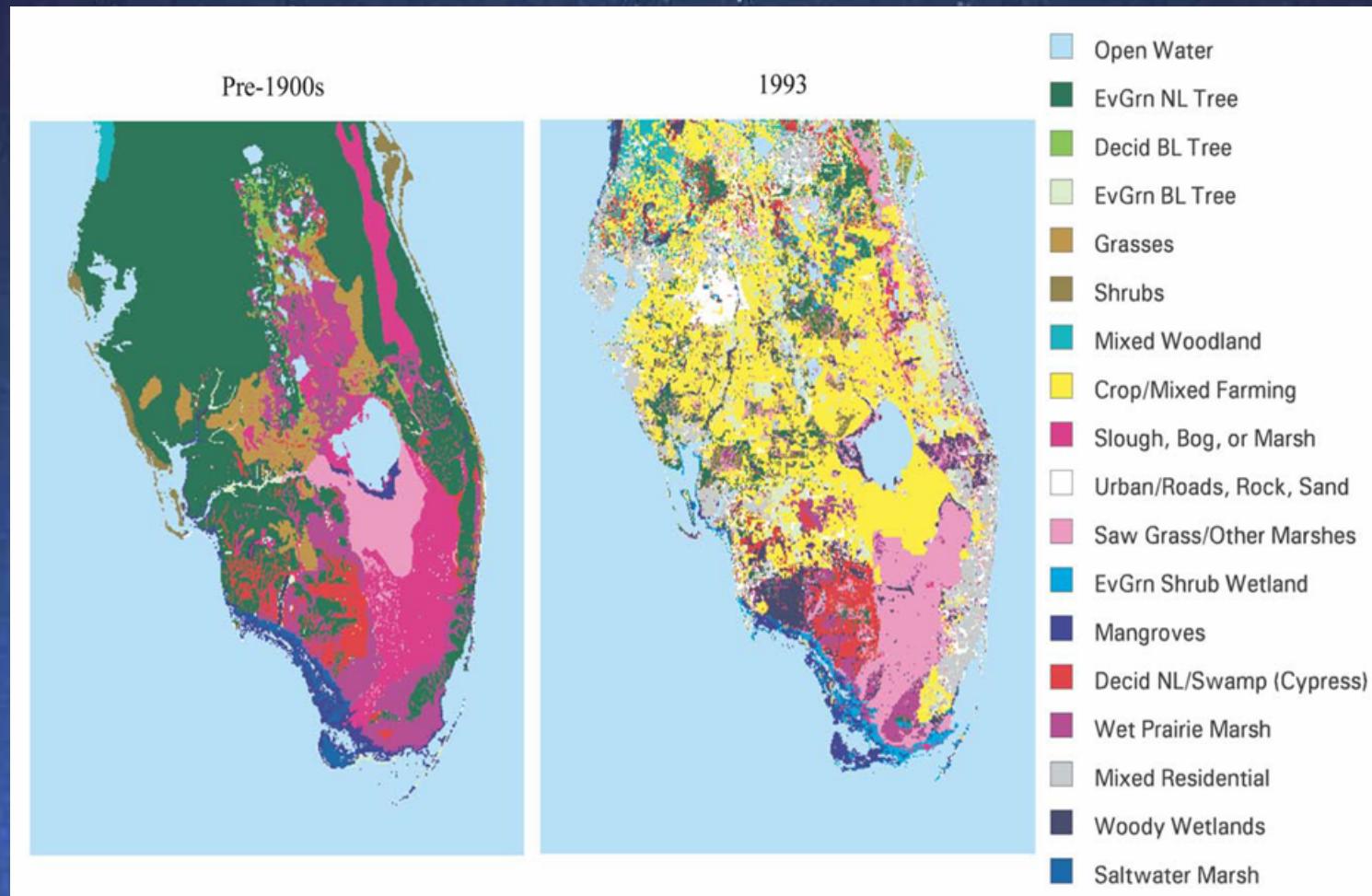
a.) Maximum temperature ($^{\circ}\text{C}$) with 1992 land cover. Dashed box shows area of region 1 and solid box shows area of region 2. Difference in maximum temperature between 1992 and b.) 1650, c.) 1850, d.) 1920. From Strack et al. 2008: Sensitivity of Summer Near-Surface Temperatures and Precipitation in the Eastern United States to Historical Land Cover Changes Since European Settlement, Water Resources Research, submitted. <http://climatesci.colorado.edu/publications/pdf/R-330.pdf>



REGIONAL LAND-USE CHANGE EFFECTS ON CLIMATE IN FLORIDA IN THE SUMMER



U.S. Geological Survey land-cover classes for pre-1900's natural conditions (left) and 1993 land-use patterns (right). From Marshall, C.H. Jr., R.A. Pielke Sr., L.T. Steyaert, and D.A. Willard, 2004: The impact of anthropogenic land-cover change on the Florida peninsula sea breezes and warm season sensible weather. Mon. Wea. Rev., 132, 28-52.
<http://climatesci.colorado.edu/publications/pdf/R-272.pdf>



From Marshall, C.H. Jr., R.A. Pielke Sr., L.T. Steyaert, and D.A. Willard, 2004: The impact of anthropogenic land-cover change on the Florida peninsula sea breezes and warm season sensible weather. *Mon. Wea. Rev.*, 132, 28–52. <http://climatesci.colorado.edu/publications/pdf/R-272.pdf>

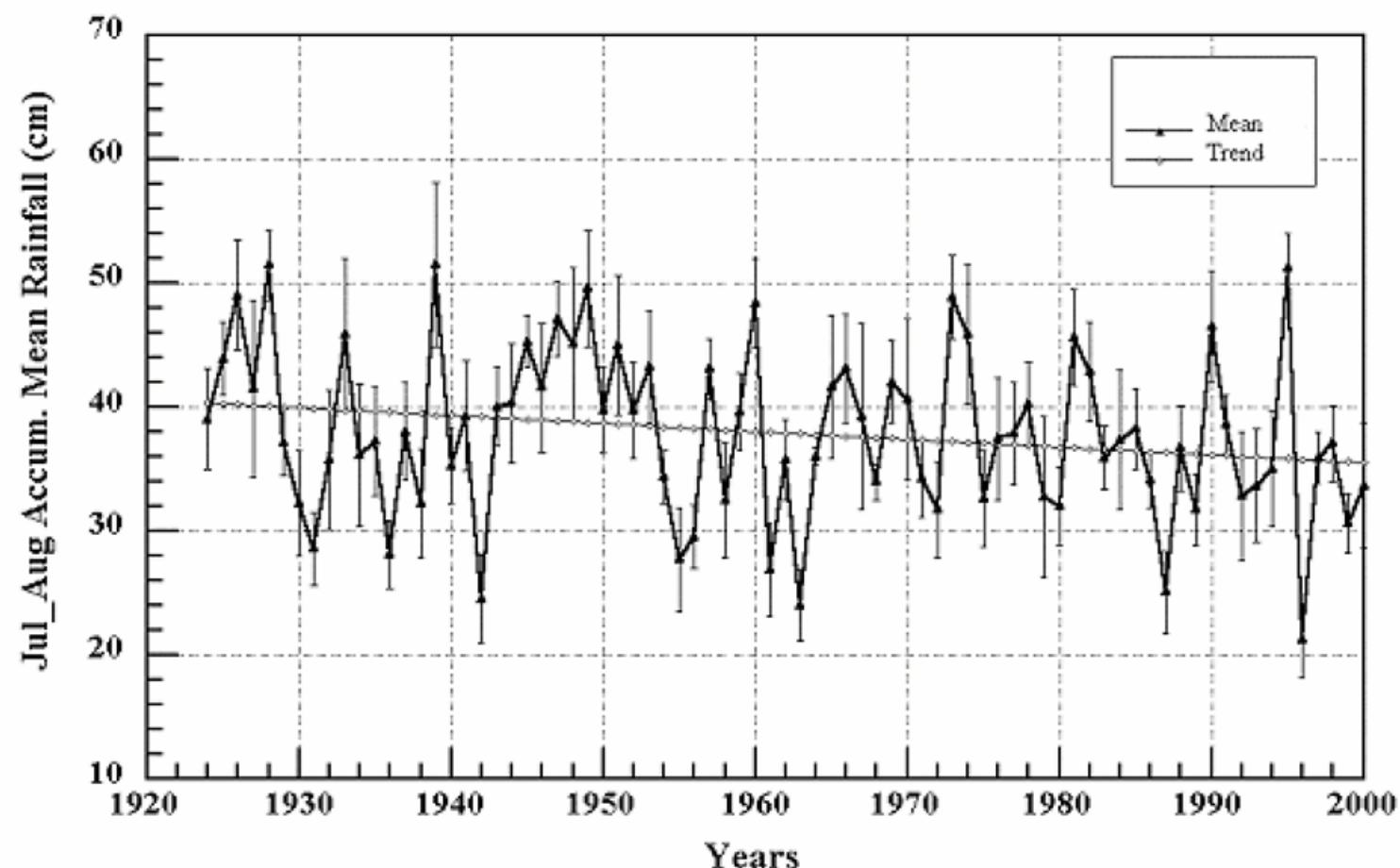
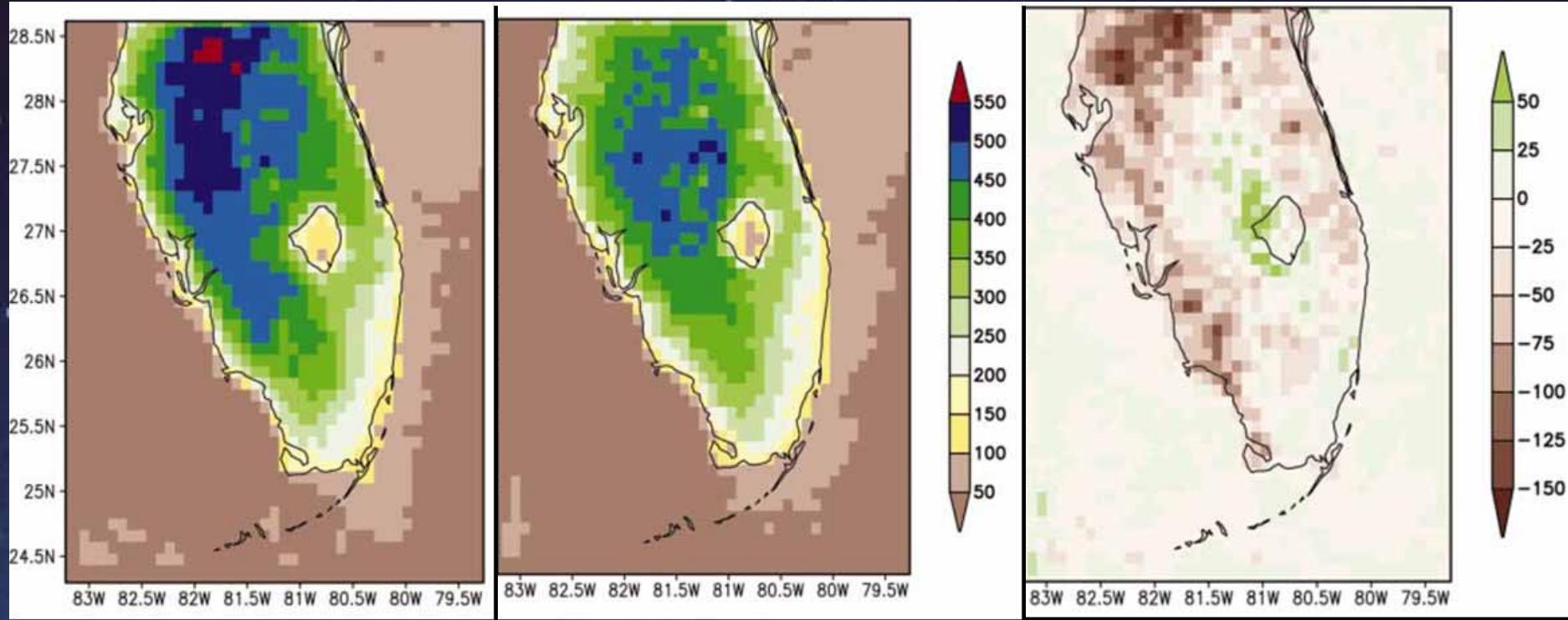
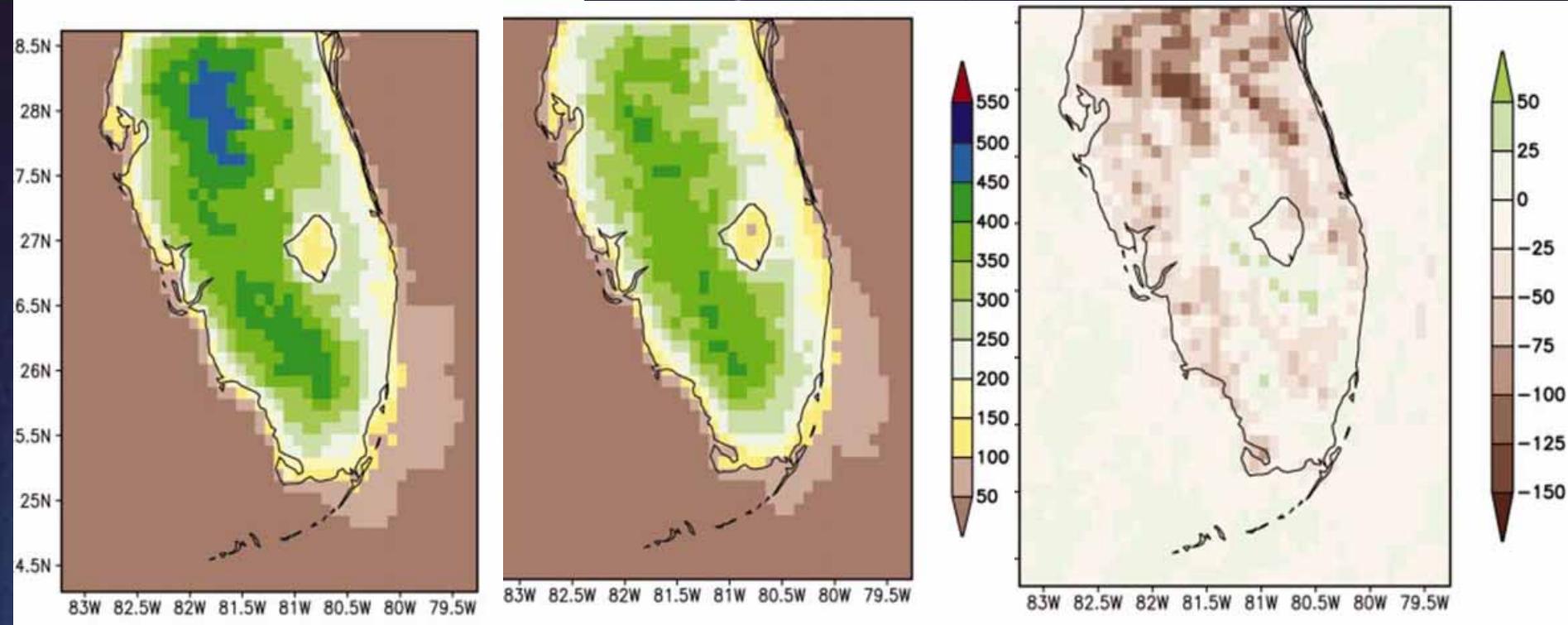


FIG. 25. Regional average time series of accumulated convective rainfall (cm) from 1924 to 2000, with corresponding trend based on linear regression of all July-August amounts. The vertical bars overlain on the raw time series indicate the value of the standard error of the July-August regional mean.



Associated convective rainfall (mm) from the model simulations of July-August 1973 with pre-1900s land cover (top), 1993 land use (middle), and the difference field for the two (bottom; 1993 minus pre-1900s case). From Marshall, C.H. Jr., R.A. Pielke Sr., L.T. Steyaert, and D.A. Willard, 2004: The impact of anthropogenic land-cover change on the Florida peninsula sea breezes and warm season sensible weather. Mon. Wea. Rev., 132, 28-52. <http://climatesci.colorado.edu/publications/pdf/R-272.pdf>



Same as previous figure except for July and August, 1989. From Marshall, C.H. Jr., R.A. Pielke Sr., L.T. Steyaert, and D.A. Willard, 2004: The impact of anthropogenic land-cover change on the Florida peninsula sea breezes and warm season sensible weather. Mon. Wea. Rev., 132, 28-52.

<http://climatesci.colorado.edu/publications/pdf/R-272.pdf>

Max and Min Temp Trends

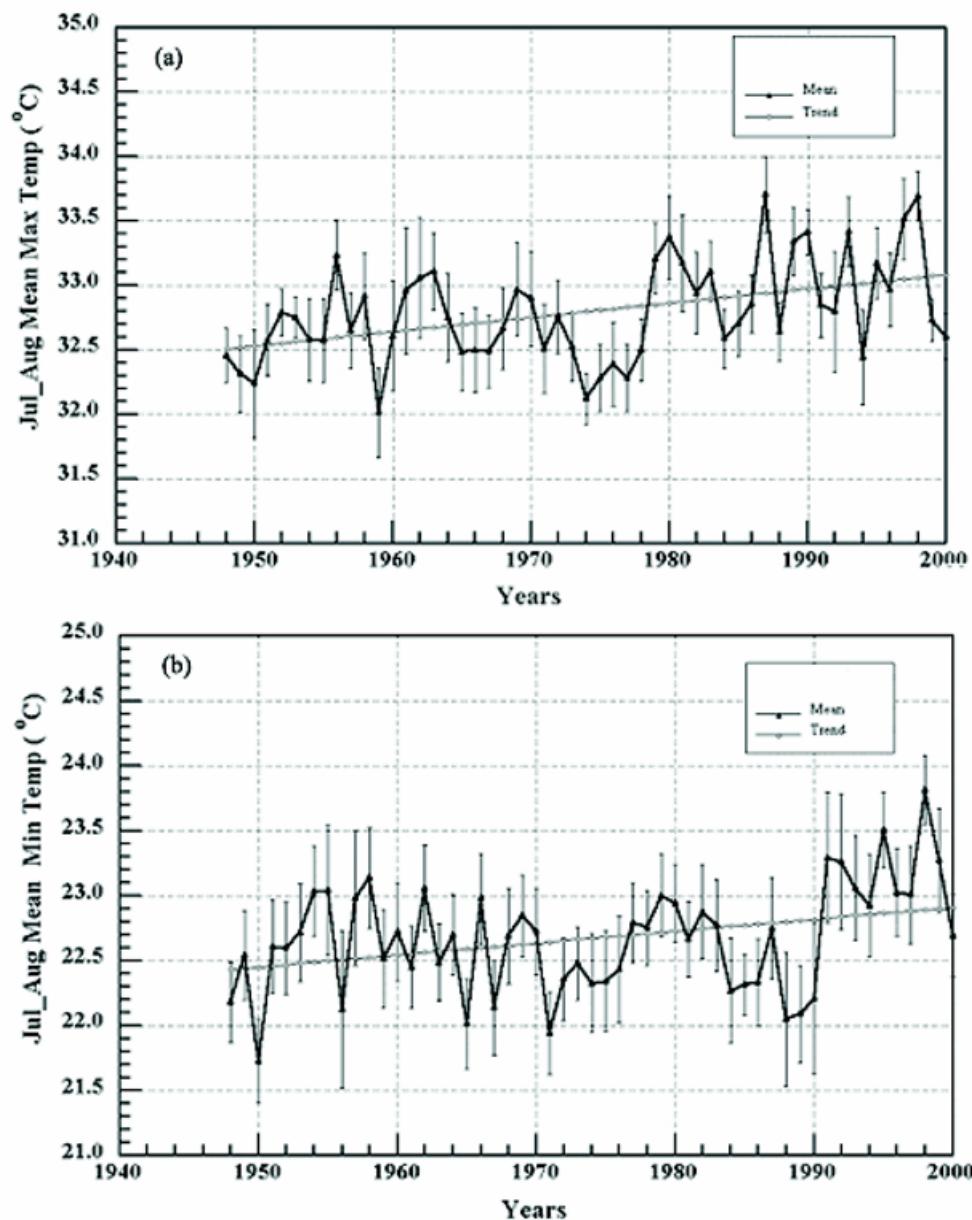
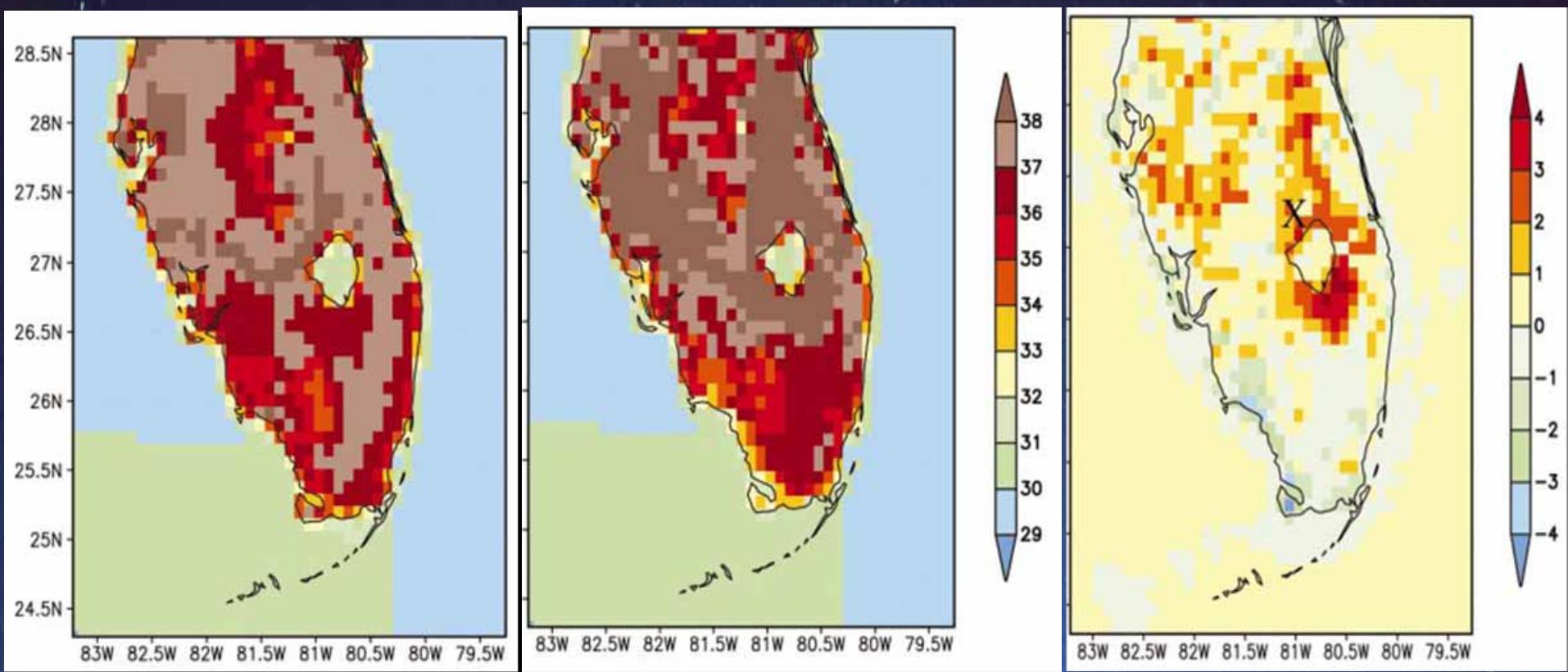
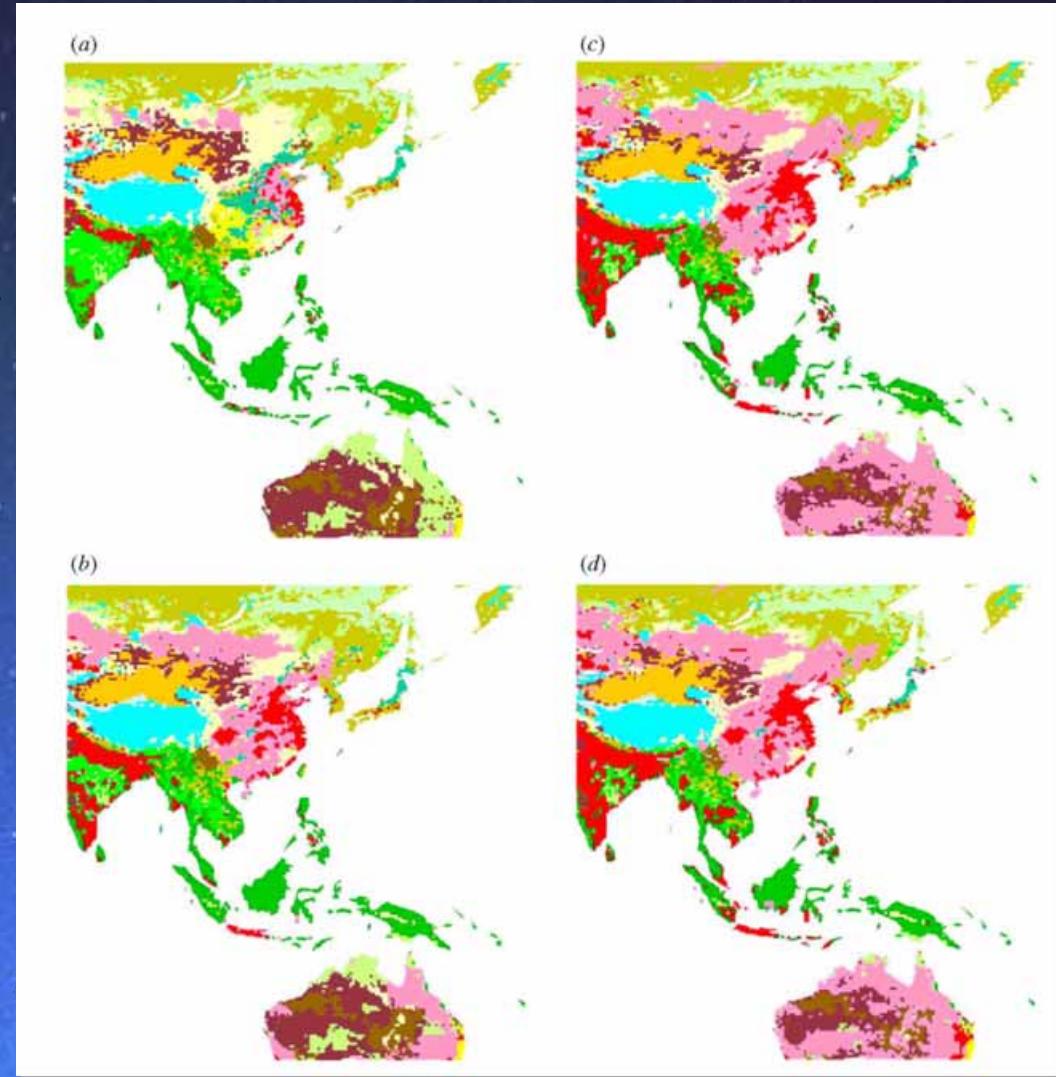


FIG. 26. Same as in Figure 25, except for daily (a) maximum and (b) minimum shelter-level temperature (°C)

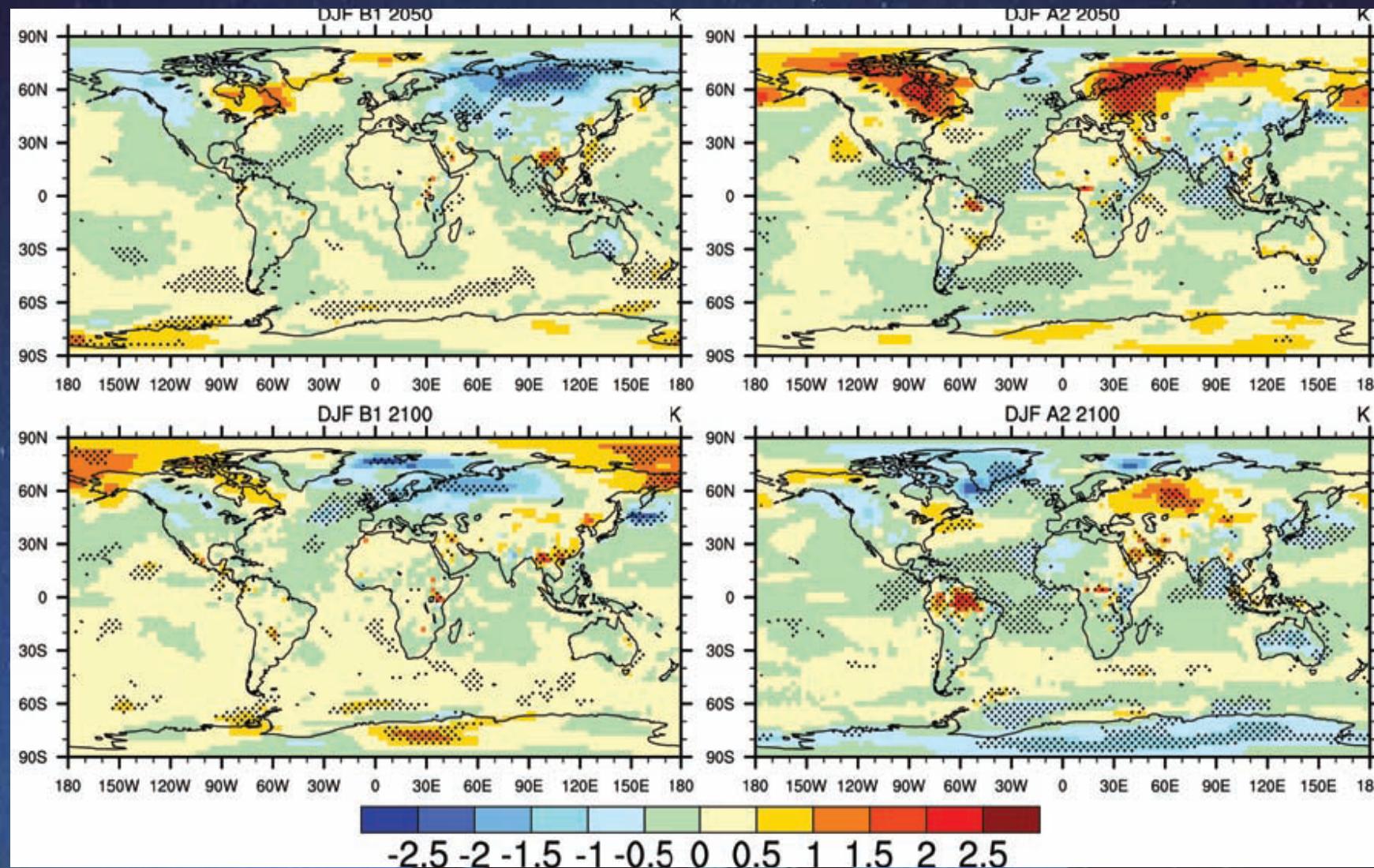


Two-month average of the daily maximum shelter-level temperature ($^{\circ}\text{C}$) from the model simulations of Jul-Aug 1989 with (top) natural land cover, (middle) current land cover. From Marshall et al. 2004: The impact of anthropogenic land-cover change on the Florida peninsula sea breezes and warm season sensible weather. Mon. Wea. Rev., 132, 28-52.
<http://climatesci.colorado.edu/publications/pdf/R-272.pdf>

Examples of land-use change from (a) 1700, (b) 1900, (c) 1970, and (d) 1990. The human-disturbed landscape includes intensive cropland (red) and marginal cropland used for grazing (pink). Other landscape includes tropical evergreen forest and deciduous forest (dark green), savannah (light green), grassland and steppe (yellow), open shrubland (maroon), temperate deciduous forest (blue), temperate needleleaf evergreen forest (light yellow) and hot desert (orange). Note the expansion of cropland and grazed land between 1700 and 1900. (Reproduced with permission from Klein Goldewijk 2001.)



DJF temperature differences due to land-cover change in each of the scenarios. Values were calculated by subtracting the greenhouse gas-only forcing scenarios from a simulation including land-cover and greenhouse gas forcings. Feddema et al. 2005: The importance of land-cover change in simulating future climates, Science 310, 1674-1678.



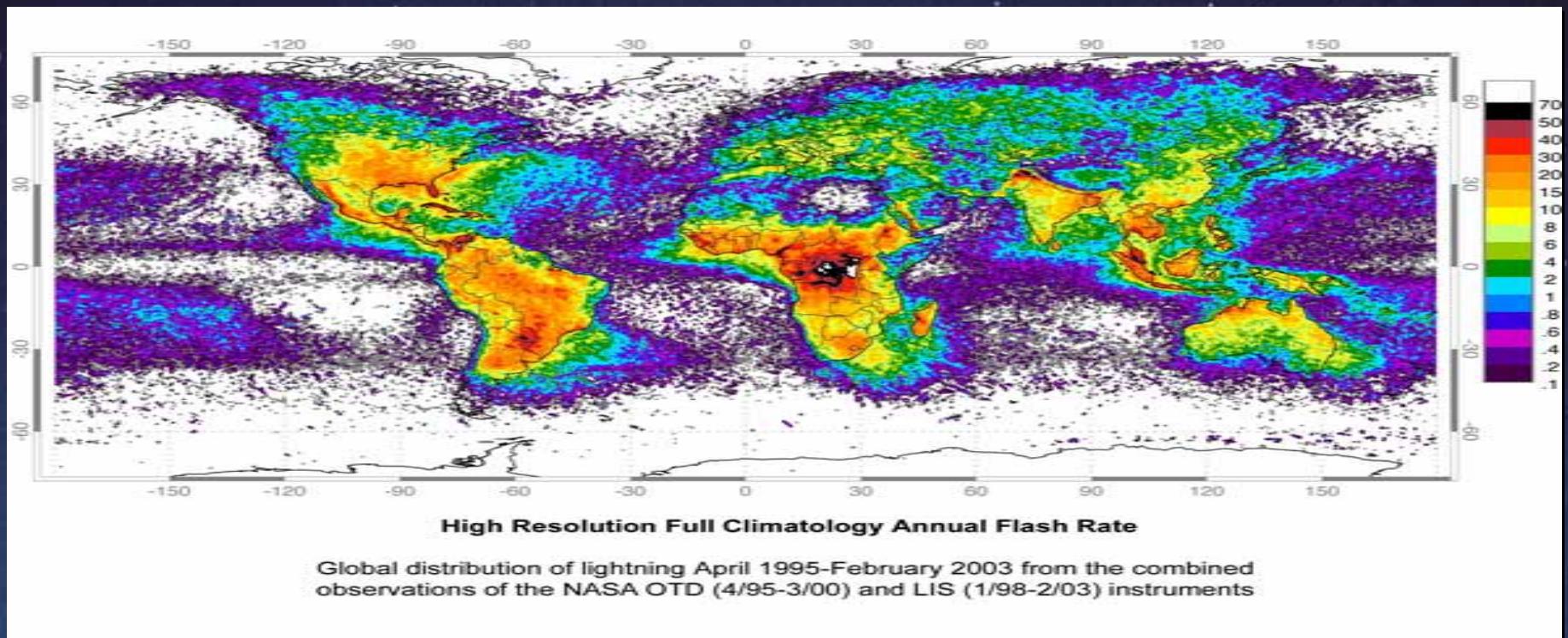
**Why Should Landscape
Effects, Which Cover Only a
Fraction of the Earth's
Surface, Have Global
Circulation Effects?**

“HOT TOWERS”

“As shown in the pioneering study by Riehl and Malkus (1958) and by Riehl and Simpson (1979), 1500-5000 thunderstorms (which they refer to as ‘hot towers’) are the conduit to transport this heat, moisture, and wind energy to higher latitudes. Since thunderstorms occur only in a relatively small percentage of the area of the tropics, a change in their spatial patterns would be expected to have global consequences.”

From Pielke Sr., R.A., 2001: Influence of the spatial distribution of vegetation and soils on the prediction of cumulus convective rainfall. Rev. Geophys., 39, 151-177.

<http://climatesci.colorado.edu/publications/pdf/R-231.pdf>



Most thunderstorms (about 10 to 1) occur over land.
From: http://thunder.nsstc.nasa.gov/images/HRFC_AnnualFlashRate_cap.jpg

Global Climate Effects occur with ENSOs for the Following Reasons:

- 1. Large Magnitude**
- 2. Long Persistence**
- 3. Spatial Coherence**

**Wu, Z. - X., and Newell, R. E. 1998 Influence of sea surface temperature
of air temperature in the tropic. *Climate Dynamics* 14, 275-290.**

**We Should, Therefore Expect
Global Climate Effects With
Landscape Changes!**

**The Regional Alteration in
Tropospheric Diabatic Heating
has a Greater Influence on the
Climate System than a Change
in the Globally-Averaged
Surface and Tropospheric
Temperatures**

**WHAT IS THE IMPORTANCE OF
MORE HETEROGENEOUS
CLIMATE FORCINGS RELATIVE
TO MORE HOMOGENEOUS
CLIMATE FORCING
SUCH AS THE RADIATIVE
FORCING OF CO₂?**

AN EXAMPLE FOR AEROSOL CLIMATE FORCING

Figure 1. Shortwave aerosol direct radiative forcing (ADRF) for top-of atmosphere (TOA), surface, and atmosphere. From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. Geophys. Res. Letts., 33, L11813, doi:10.1029/2006GL025974. <http://climatesci.colorado.edu/publications/pdf/R-312.pdf>

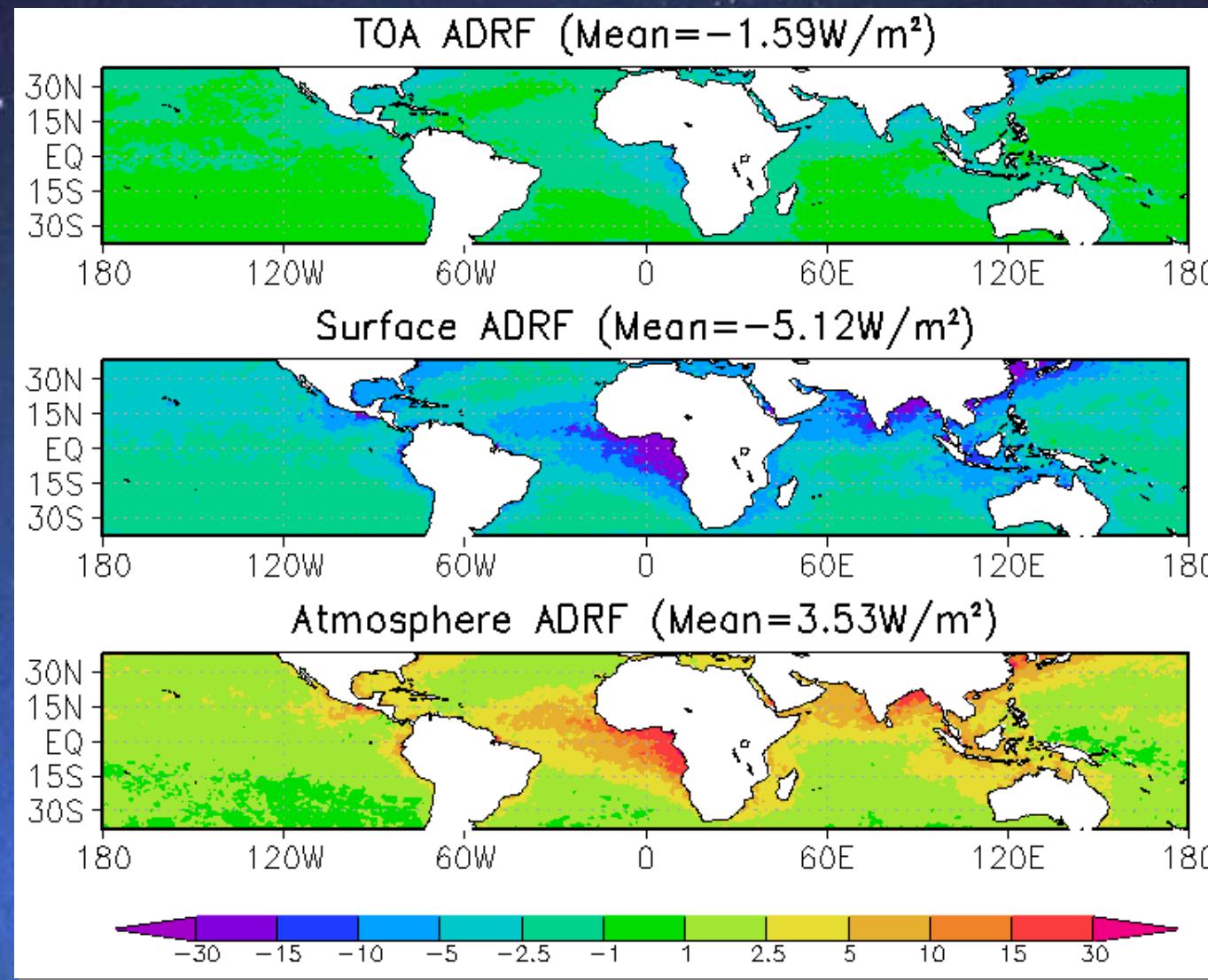


Figure 2. Vertical profile of atmospheric heating rate (K day^{-1}) due to shortwave ADRF.
Vertical coordinate is pressure level (mb). From: Matsui, T., and R.A. Pielke Sr., 2006:
Measurement-based estimation of the spatial gradient of aerosol radiative forcing.
Geophys. Res. Letts., 33, L11813, doi:10.1029/2006GL025974.
<http://climatesci.colorado.edu/publications/pdf/R-312.pdf>

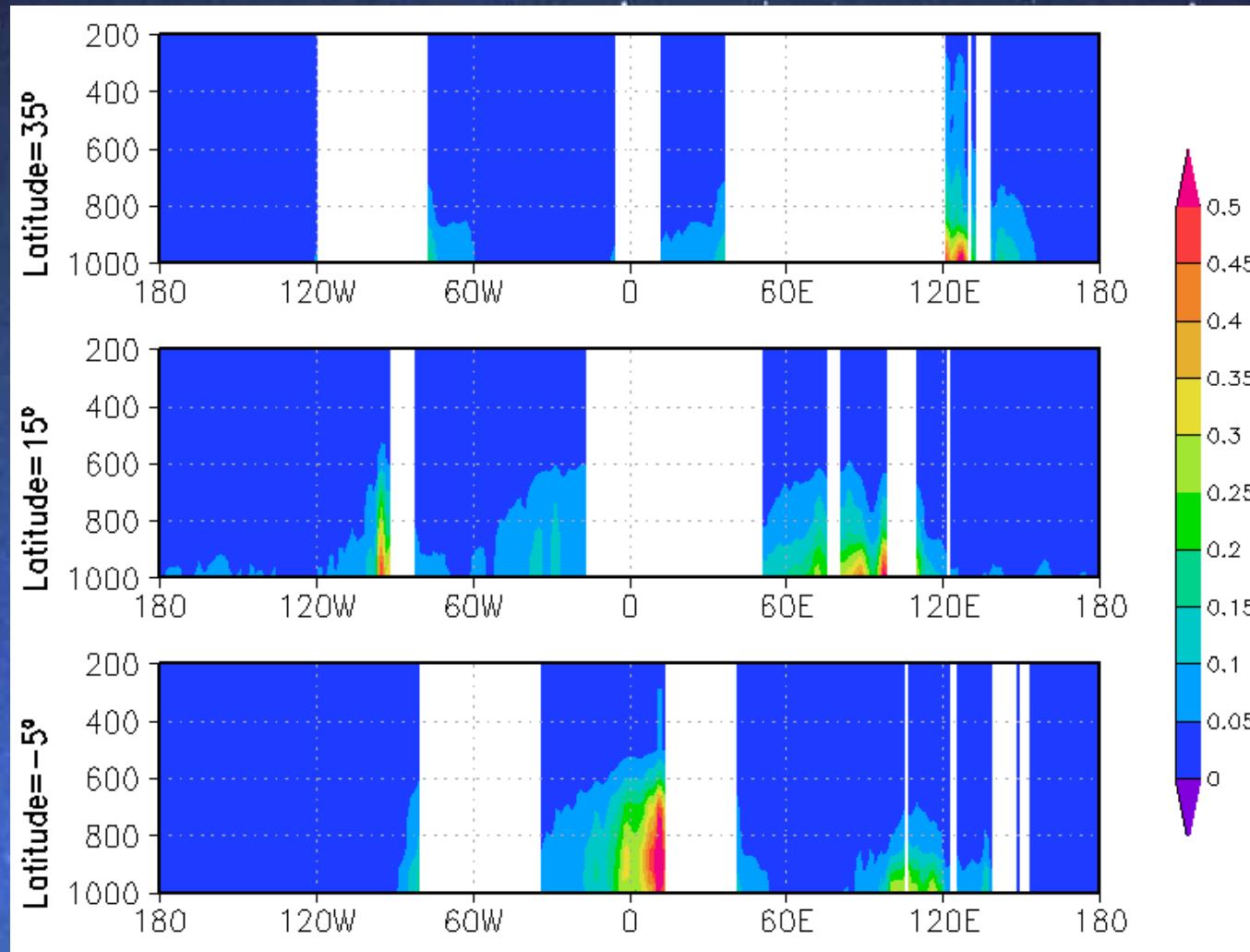


Figure 3. Shortwave aerosol indirect radiative forcing (AIRF) for top-of atmosphere (TOA), surface, and atmosphere. From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. Geophys. Res. Letts., 33, L11813, doi:10.1029/2006GL025974.

<http://climatesci.colorado.edu/publications/pdf/R-312.pdf>

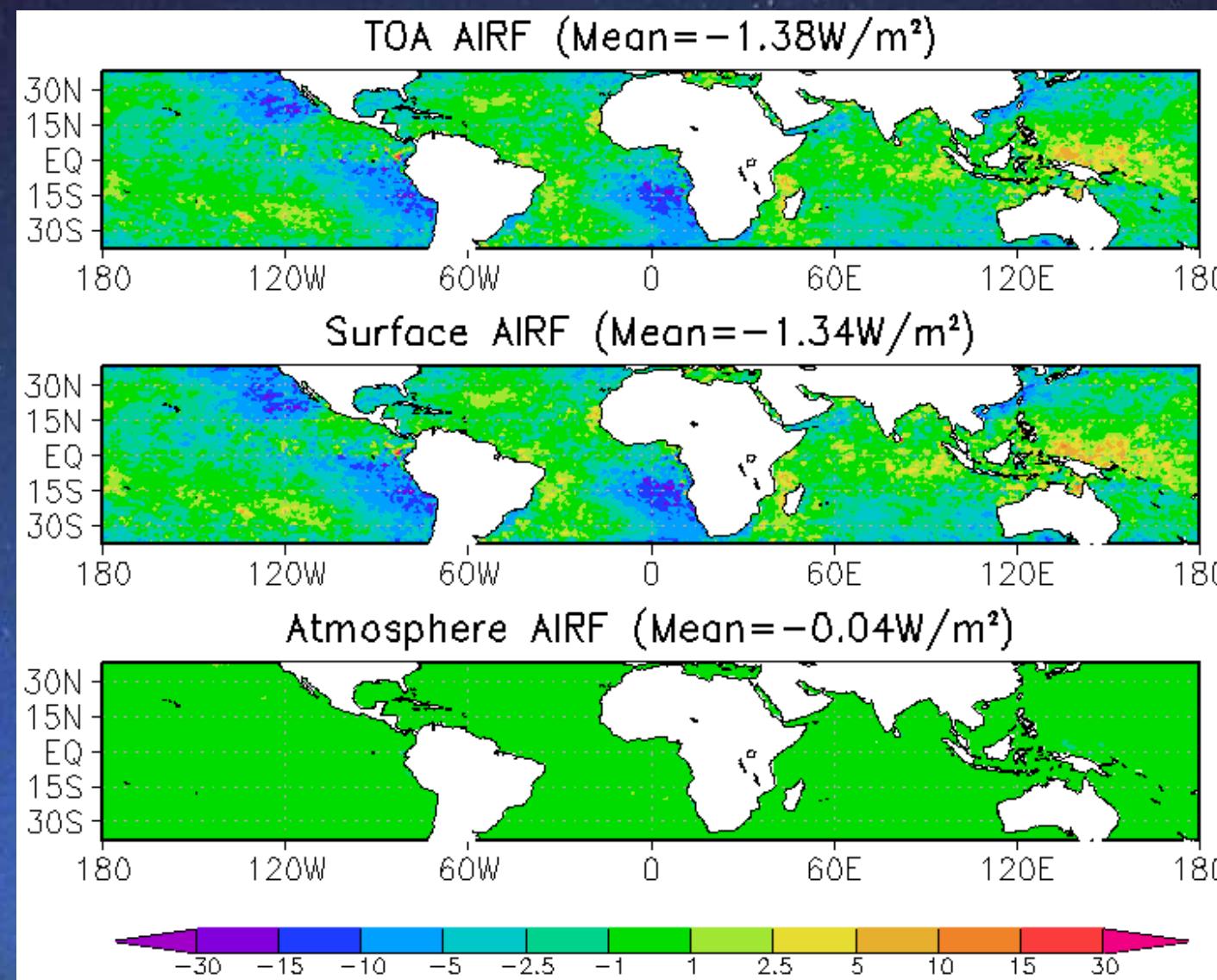
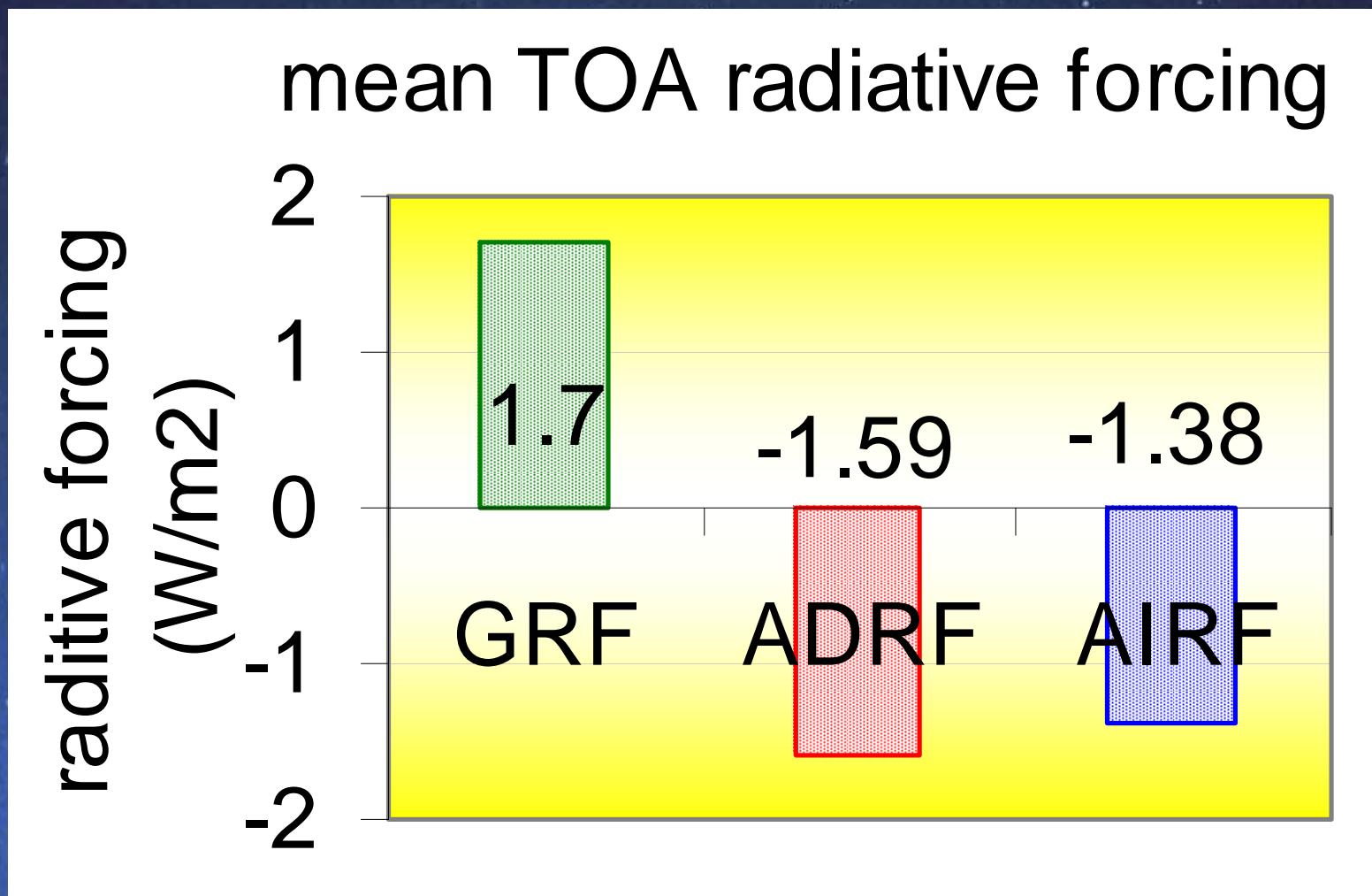


Figure 4. Comparison of Mean TOA radiative forcing between infrared GRF, shortwave ADRF, and shortwave AIRF. From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. *Geophys. Res. Letts.*, 33, L11813, doi:10.1029/2006GL025974.

<http://climatesci.colorado.edu/publications/pdf/R-312.pdf>



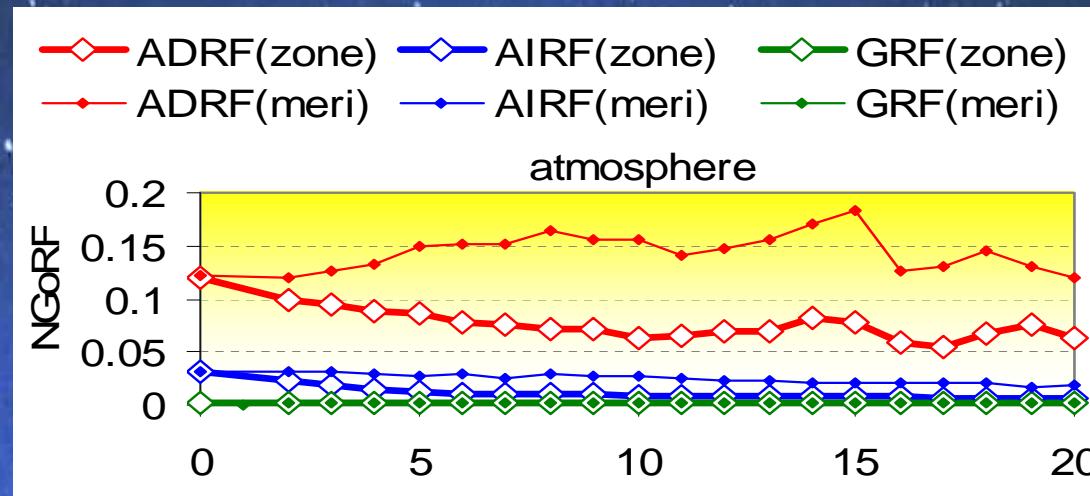
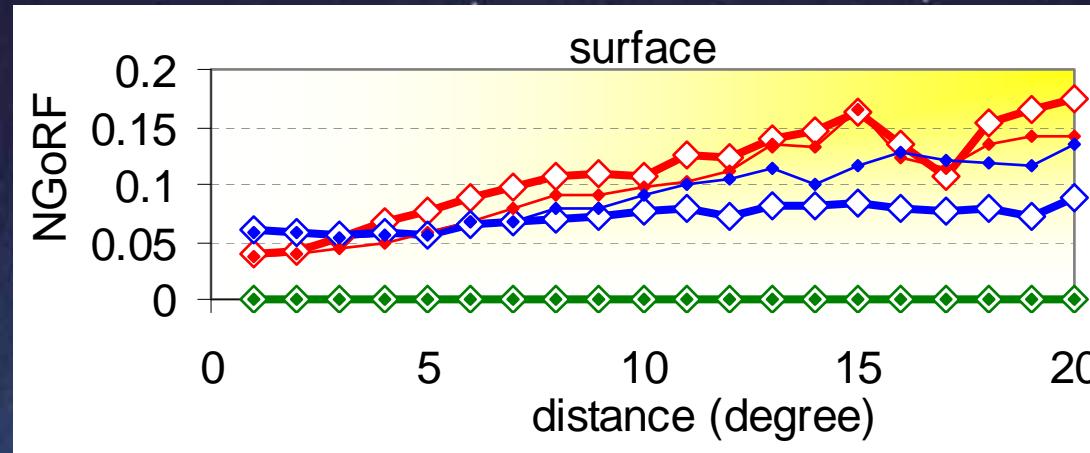


Figure 5. Comparison of the meridional and the zonal component of NGoRF between infrared GRF, shortwave ADRF, and shortwave AIRF for atmosphere and surface. From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. *Geophys. Res. Letts.*, 33, L11813, doi:10.1029/2006GL025974. <http://climatesci.colorado.edu/publications/pdf/R-312.pdf>

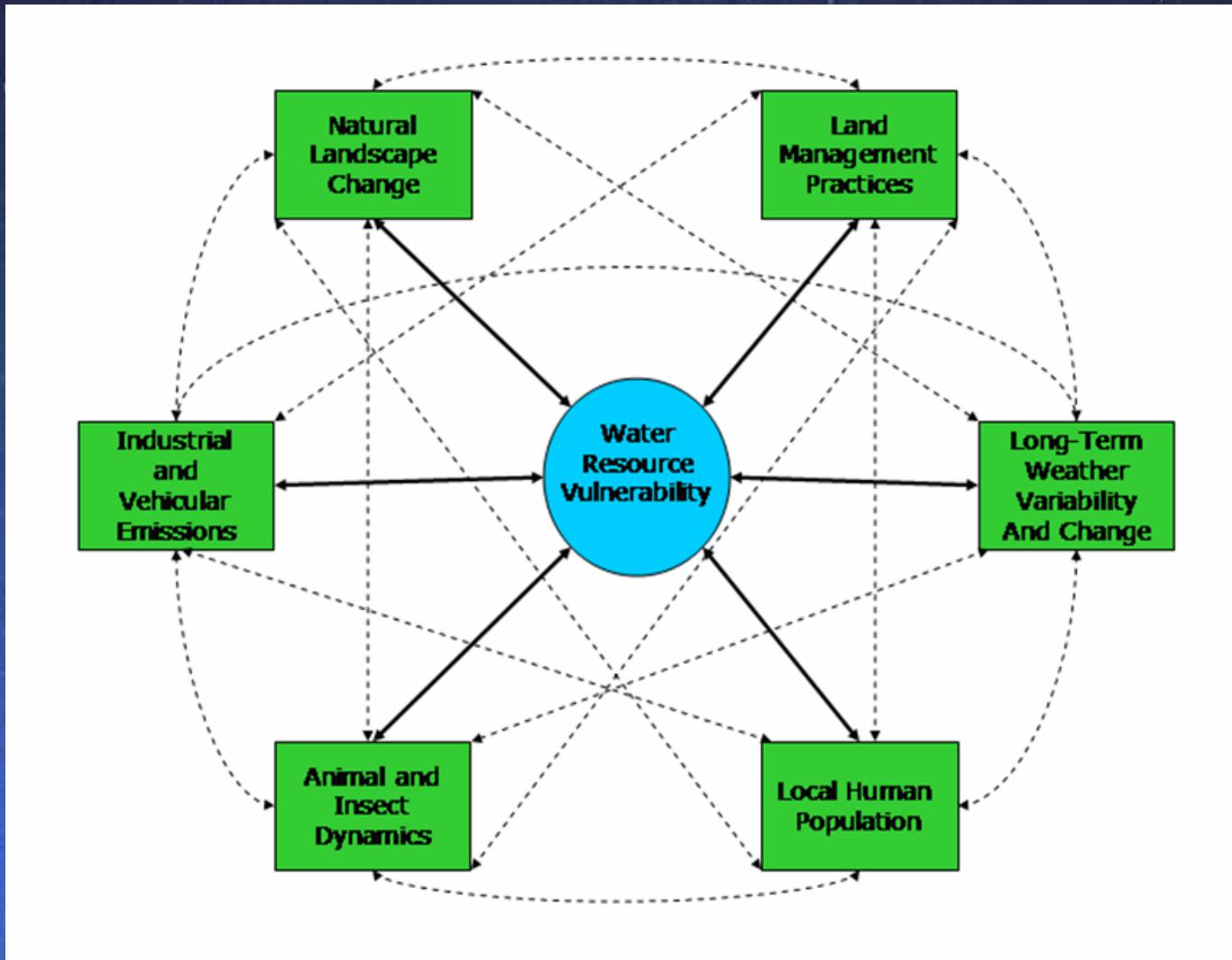
In Matsui and Pielke Sr. (2006), it was found from observations of the spatial distribution of aerosols in the atmosphere in the lower latitudes, that the aerosol effect on atmospheric circulations, as a result of their alteration in the heating of regions of the atmosphere, is **60 times greater** than due to the heating effect of the human addition of well-mixed greenhouse gases.

Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. *Geophys. Res. Letts.*, 33, L11813, doi:10.1029/2006GL025974.

**WE NEED A NEW
PERSPECTIVE ON THE ROLE OF
ENVIRONMENTAL VARIABILITY
AND CHANGE ON SOCIETY
AND THE ENVIRONMENT**

**A FOCUS ON
VULNERABILITY**

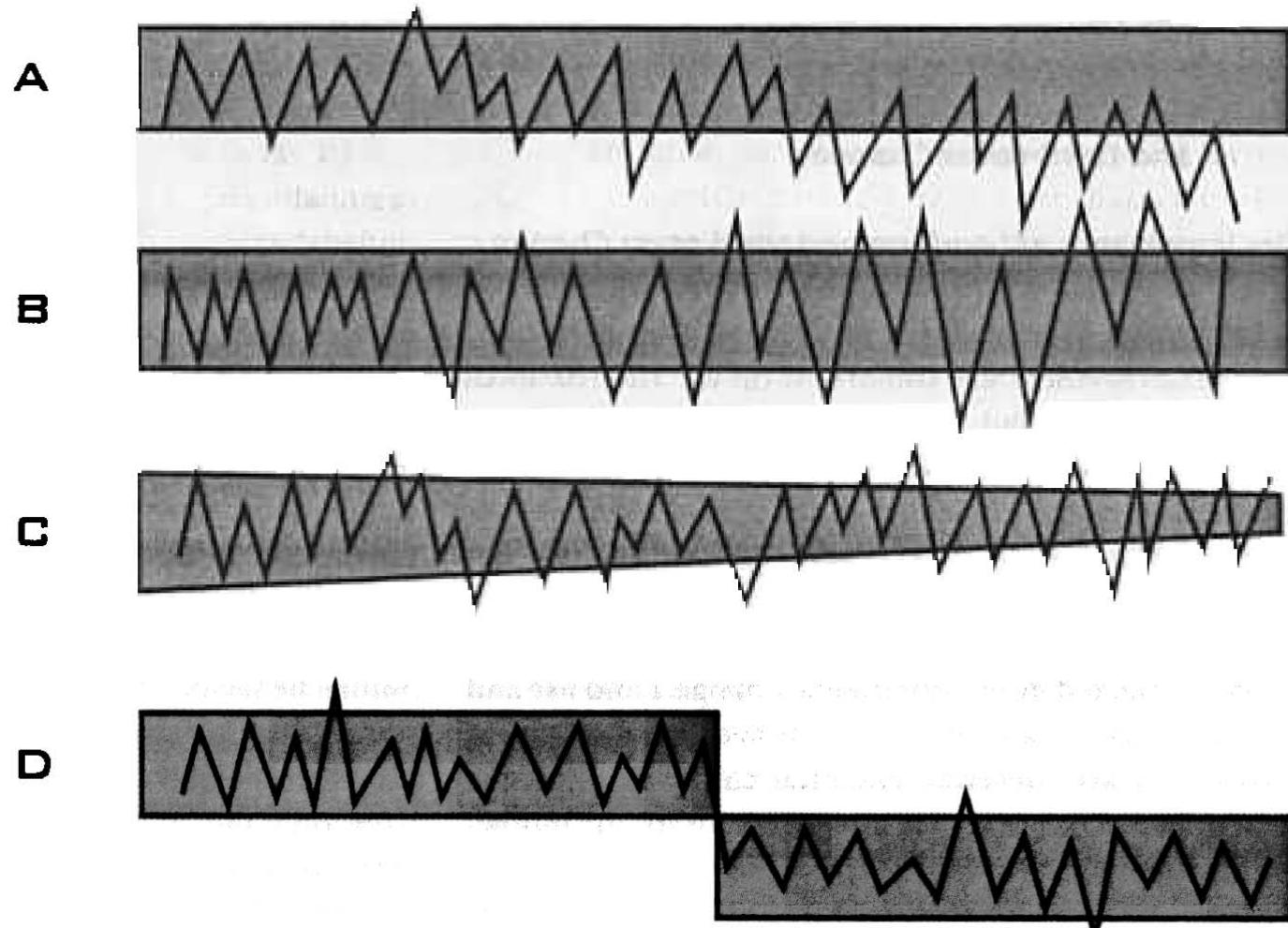
Schematic of the relation of water resource vulnerability to the spectrum of the environmental forcings and feedbacks (adapted from [3]). The arrows denote nonlinear interactions between and within natural and human forcings. From: Pielke, R.A. Sr., 2004: Discussion Forum: A broader perspective on climate change is needed. IGBP Newsletter, 59, 16-19. <http://climatesci.colorado.edu/publications/pdf/NR-139.pdf>



From: Bravo de Guenni, L., R.E. Schulze, R.A. Pielke Sr., and M.F. Hutchinson, 2004: The vulnerability approach. Chapter E.5 In: Vegetation, Water, Humans and the Climate: A New Perspective on an Interactive System. Global Change - The IGBP Series, P. Kabat et al., Eds., Springer, 499-514.
<http://climatesci.colorado.edu/publications/pdf/CB-40.pdf>

Fig. E.5.

A schematic illustration in which risk changes due to variations in the physical system and the socio-economic system. In all the cases risk increases over time (with modifications after Smith 1996)



Time series plot of 25-year running mean of reconstructed flows of the Colorado River at Lee Ferry . Flows are plotted as percentage of the 1906–2004 mean of observed natural flows (18.53 billion cubic meters, or 15.03 million acre-ft). Confidence interval derived from 0.10 and 0.90 probability points of ensemble of 1000 noise-added reconstructions. Horizontal dashed line is lowest 25-year running mean of observed flows (1953–1977). From Meko, D., C. A. Woodhouse, C. A. Baisan, T. Knight, J. J. Lukas, M. K. Hughes, and M. W. Salzer (2007), Medieval drought in the upper Colorado River Basin, *Geophys. Res. Lett.*, 34, L10705, doi:10.1029/2007GL029988.

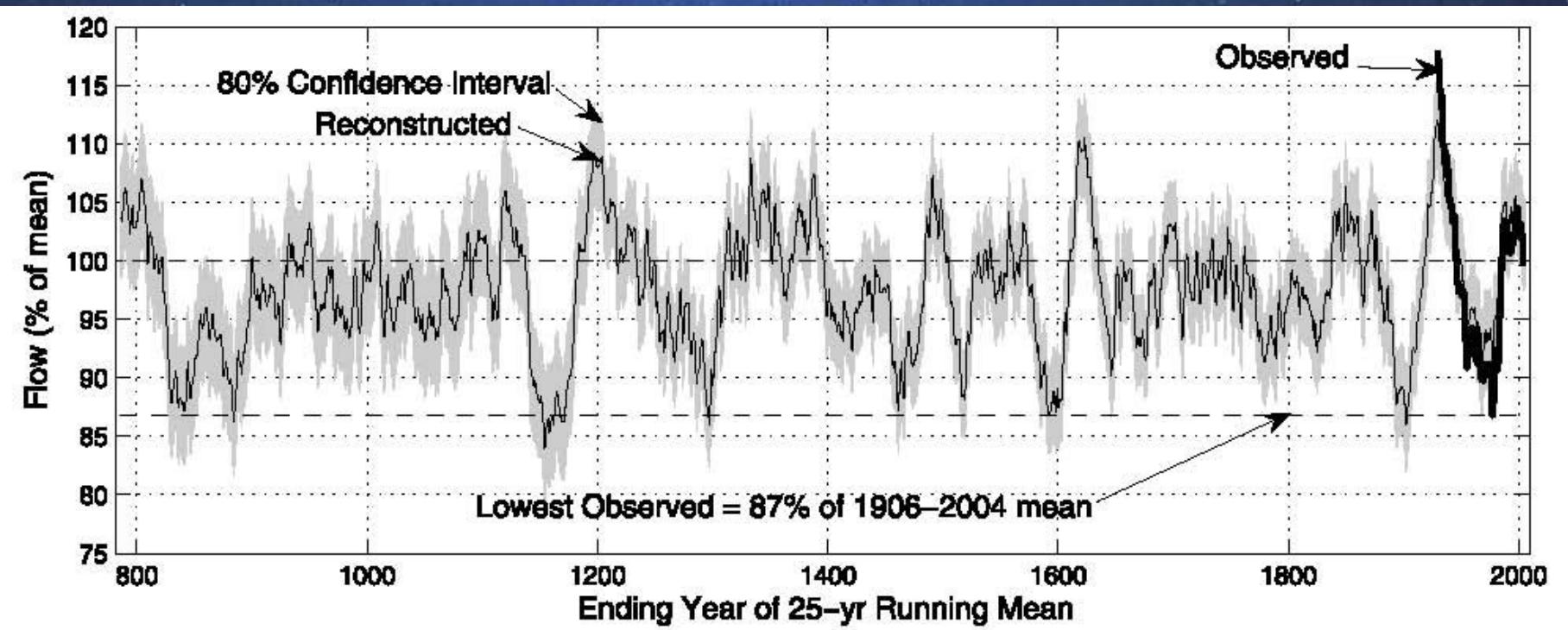


Table E.7. General characteristics of the scenario and vulnerability approaches as typically used

Approach	Scenario	Vulnerability
Assumed dominant stress	Climate, recent greenhouse gas emissions to the atmosphere, ocean temperatures, aerosols, etc.	Multiple stresses: climate (historical climate variability), land use and water use, altered disturbance regimes, invasive species, contaminants/pollutants, habitat loss, etc.
Usual timeframe of concern	Long-term, doubled CO ₂ , 30 to 100 years in the future	Short-term (0 to 30 years) and long-term research.
Usual scale of concern	Global, sometimes regional. Local scale needs downscaling techniques. However, there is little evidence to suggest that present models provide realistic, accurate, or precise climate scenarios at local or regional scales.	Local, regional, national and global scales.
Major parameters of concern	Spatially averaged changes in mean temperatures and precipitation in fairly large grid cells with some regional scenarios for drought.	Potential extreme values in multiple parameters (temperature, precipitation, frost-free days) and additional focus on extreme events (floods, fires, droughts, etc.); measures of uncertainty.
Major limitations for developing coping strategies	<p>Focus on single stress limits preparedness for other stresses.</p> <p>Results often show gradual ramping of climate change-limiting preparedness for extreme events.</p> <p>Results represent only a limited subset of all likely future outcomes – usually unidirectional trends.</p> <p>Results are accepted by many scientists, the media, and the public as actual “predictions”.</p> <p>Lost in the translation of results is that all models of the distant future have unstated (presently unknowable) levels of certainty or probability.</p>	<p>Approach requires detailed data on multiple stresses and their interactions at local, regional, national and global scales – and many areas lack adequate information.</p> <p>Emphasis on short-term issues may limit preparedness for abrupt “threshold” changes in climate some time in the short- or long-term.</p> <p>Requires preparedness for a far greater variation of possible futures, including abrupt changes in any direction – this is probably more realistic yet difficult.</p>

From: Pielke, R.A. Sr., and L. Bravo de Guenni, 2004: Conclusions. Chapter E.7
In: Vegetation, Water, Humans and the Climate: A New Perspective on an Interactive System. Global Change - The IGBP Series, P. Kabat et al., Eds., Springer, 537-538. <http://climatesci.colorado.edu/publications/pdf/CB-42.pdf>

CONCLUSIONS



- ❖ The needed focus for the study of climate change and variability is on the regional and local scales. Global and zonally-averaged climate metrics would only be important to the extent that they provide useful information on these space scales.
- ❖ Global and zonally-averaged surface temperature trend assessments, besides having major difficulties in terms of how this metric is diagnosed and analyzed, do not provide significant information on climate change and variability on the regional and local scales.
- ❖ Global warming is not equivalent to climate change. Significant, societally important climate change, due to both natural- and human- climate forcings, can occur without any global warming or cooling.
- ❖ The spatial pattern of ocean heat content change is the appropriate metric to assess climate system heat changes including global warming.

- ❖ In terms of climate change and variability on the regional and local scale, the IPCC Reports, the CCSP Report on surface and tropospheric temperature trends, and the U.S. National Assessment have overstated the role of the radiative effect of the anthropogenic increase of CO₂ relative to the role of the diversity of other human climate forcings on global warming, and more generally, on climate variability and change.
- ❖ Global and regional climate models have not demonstrated skill at predicting regional and local climate change and variability on multi-decadal time scales.
- ❖ Attempts to significantly influence regional and local-scale climate based on controlling CO₂ emissions alone is an inadequate policy for this purpose.
- ❖ A vulnerability paradigm, focused on regional and local societal and environmental resources of importance, is a more inclusive, useful, and scientifically robust framework to interact with policymakers, than is the focus on global multi-decadal climate predictions which are downscaled to the regional and local scales. The vulnerability paradigm permits the evaluation of the entire spectrum of risks associated with different social and environmental threats, including climate variability and change.

- ❖ Climate policy in the past has been, with the limited exception of deliberate weather modification focused on adaptation. Dams, zoning so as to limit habitation in flood plains, etc. are examples of this adaptation.
- ❖ For the coming decades, adaptation still needs to be the primary approach. As reported in the 2005 National Research Council report (Radiative forcing of climate change: Expanding the concept and addressing uncertainties) the human influence on the climate system involves a diverse range of forcings. Thus, a focus on controlling the emissions of carbon dioxide by itself (i.e., mitigation) is an inadequate approach for an effective climate policy.
- ❖ Energy policy, however, clearly must emphasize an active management policy since a vibrant economy and society requires energy. However, all energy sources are not the same in terms of how they affect the environment and their availability. For example, the dependence of the United States, Europe and other countries on oil from politically unstable regions of the world needs to be eliminated.
- ❖ The current focus of the IPCC and others on climate change with their emphasis on global warming, as a guise to promote energy policy, therefore, is an erroneous and dishonest approach to communicate energy policy to policymakers and the public. The optimal energy policy requires expertise and assessments that involves a much broader community than the climate science profession.

RECOMMENDATIONS

- It is essential to publish in ISI-cited peer-reviewed literature.
- The creation of climate assessment committees without conflict of interest should be a requirement.
- The communication of results in weblogs is an effective way to disseminate broader scientific viewpoints.

Roger A. Pielke Sr. Weblog

<http://climatesci.org>

Roger A. Pielke Sr. Website

<http://cires.colorado.edu/science/groups/pielke>

**Background Photograph Courtesy
of Mike Hollingshead**

<http://www.extremeinstability.com/index.htm>

**PowerPoint Presentation Prepared by
Dallas Jean Staley
Research Assistant and Webmaster
University of Colorado
Boulder, Colorado 80309
dallas@cires.colorado.edu**