2007 Tripartite Symposium

April 23 2007

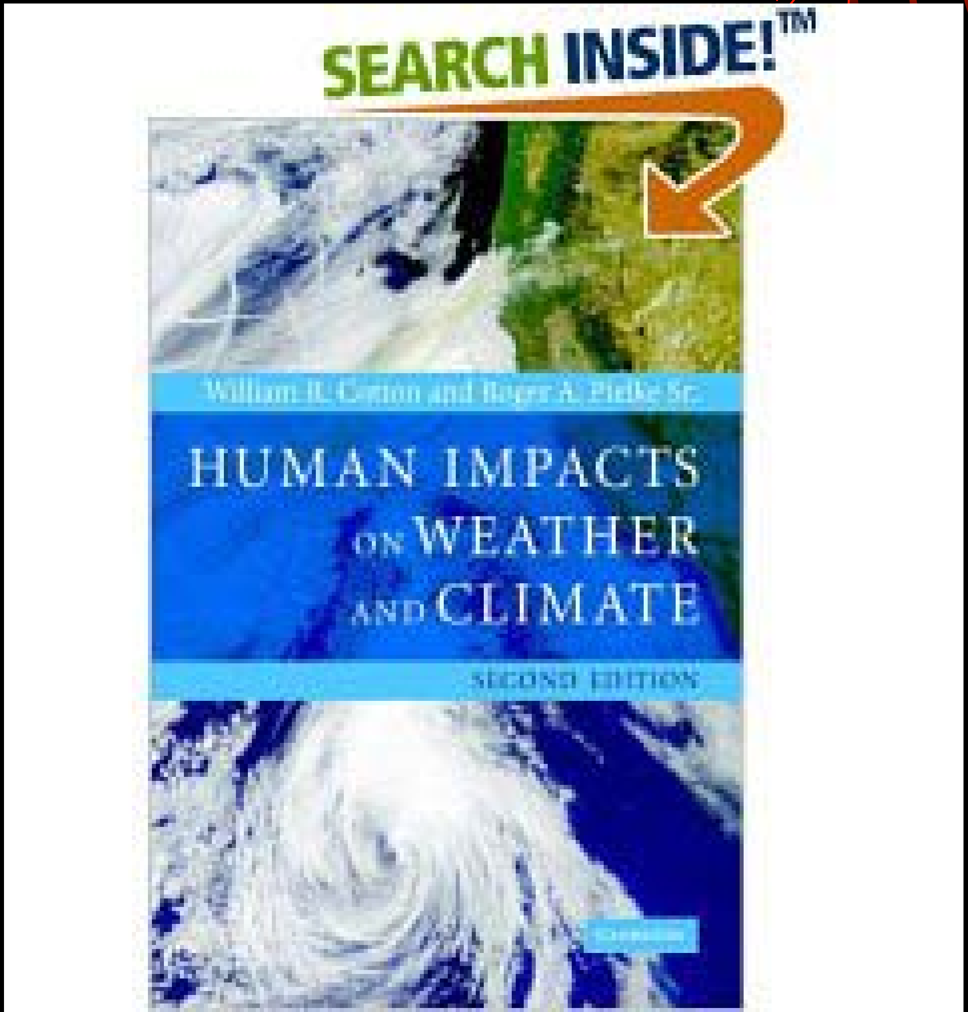
The Human Impact on the Weather and Climate

By Roger A. Pielke Sr.
University of Colorado at Boulder
CIRES/ATOC

Human Impacts on Weather and Climate
2nd Edition

William R. Cotton
Colorado State University
Roger A. Pielke, Sr.
University of Colorado, Boulder

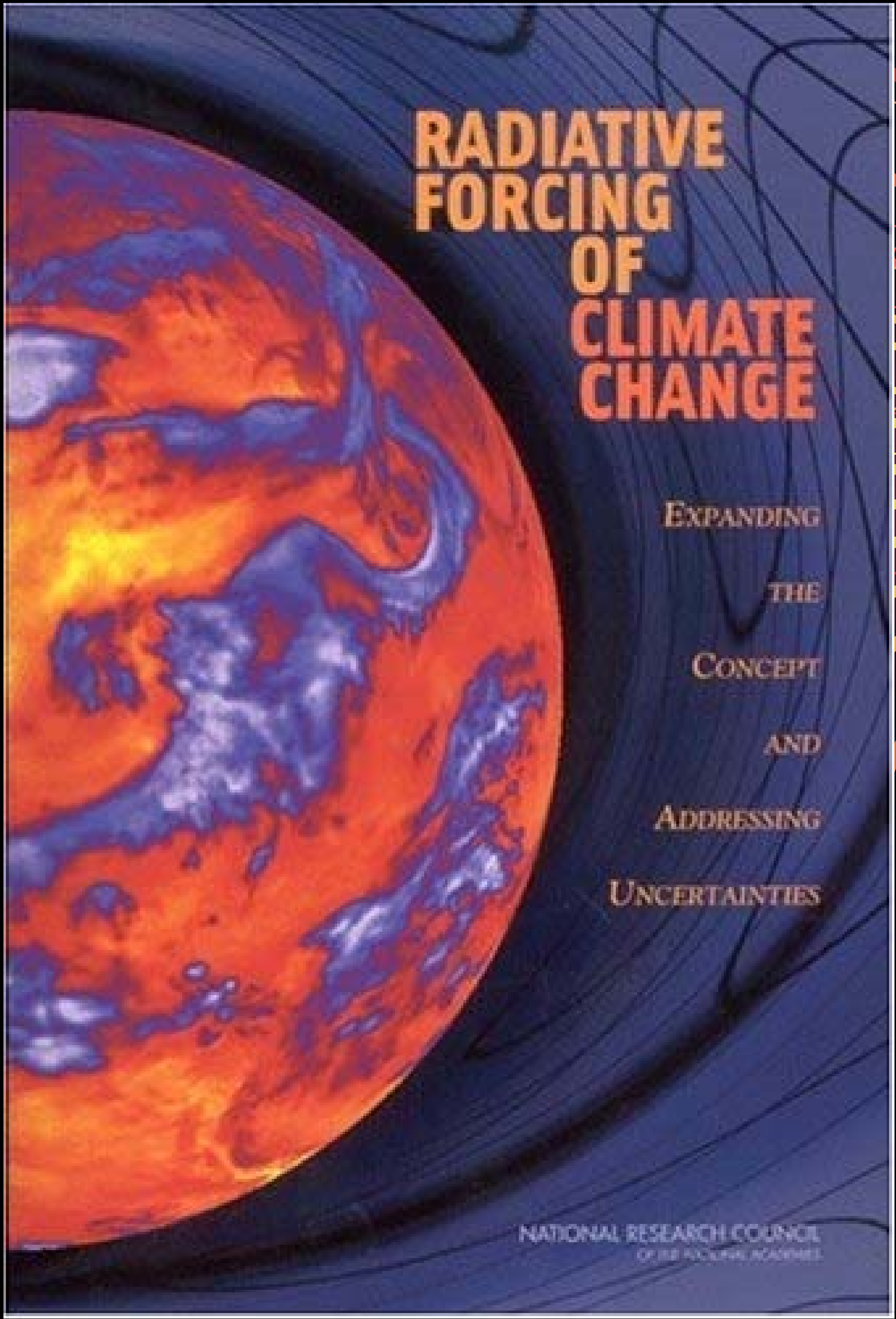
Cambridge University Press, 2007



Politicalization of Climate Science

- The current focus is on carbon dioxide emissions from fossil fuel combustion (the IPCC view)
- Since the climate forcing of CO_2 is only one of a diverse set of first order human climate forcings, and global warming is only a subset of climate change (NRC,2005; IGBP-BAHC, 2004), the current IPCC focus is an ineffective climate policy
- The current IPCC focus is to use the focus on CO_2 to promote changes in energy policy.
- The use of carbon dioxide as the instrument to promote energy policy changes, however, is an inappropriately blunt instrument for this purpose, and can lead to poor energy policy decisions,

- The Climate System is much more than long- term weather statistics.
- Climate is not a boundary value problem but an initial value problem.
- Skillful multi-decadal climate predictions on the global, zonally-averaged and regional scales have not been achieved.
- The global-averaged surface temperature trends assessment is an inadequate climate change metric.
- Human caused global warming is just a subset of human caused climate change



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

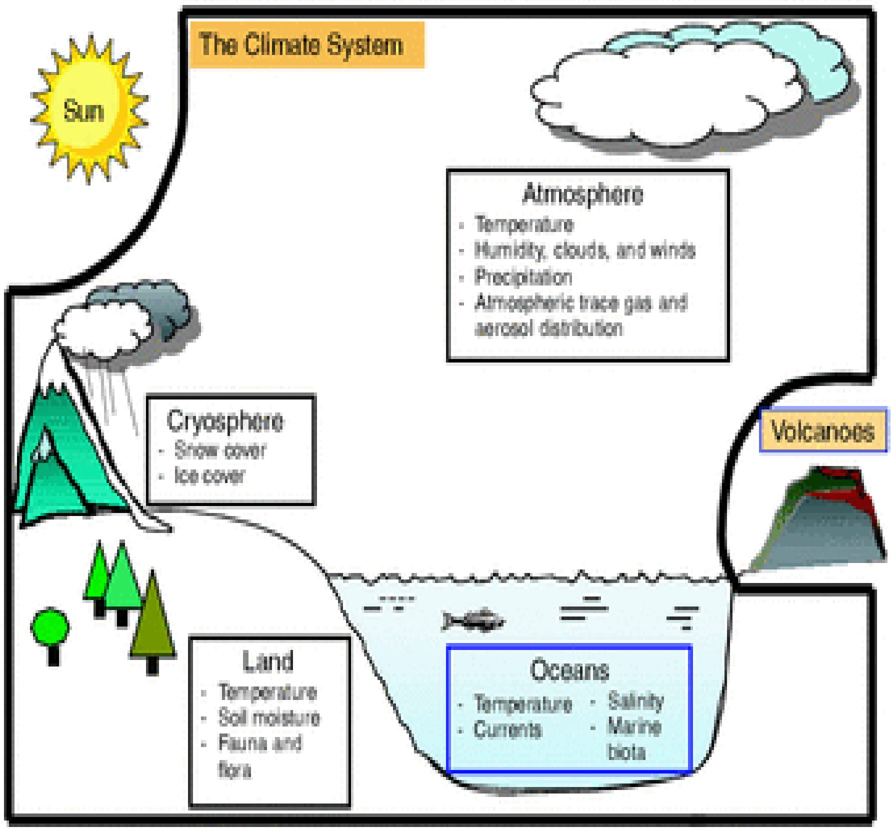


FIGURE 1-1 The climate system, consisting of the atmosphere, oceans, land, and cryosphere. Important state variables for each sphere of the climate system are listed in the boxes. For the purposes of this report, the Sun, volcanic emissions, and human-caused emissions of greenhouse gases and changes to the land surface are considered external to the climate system.

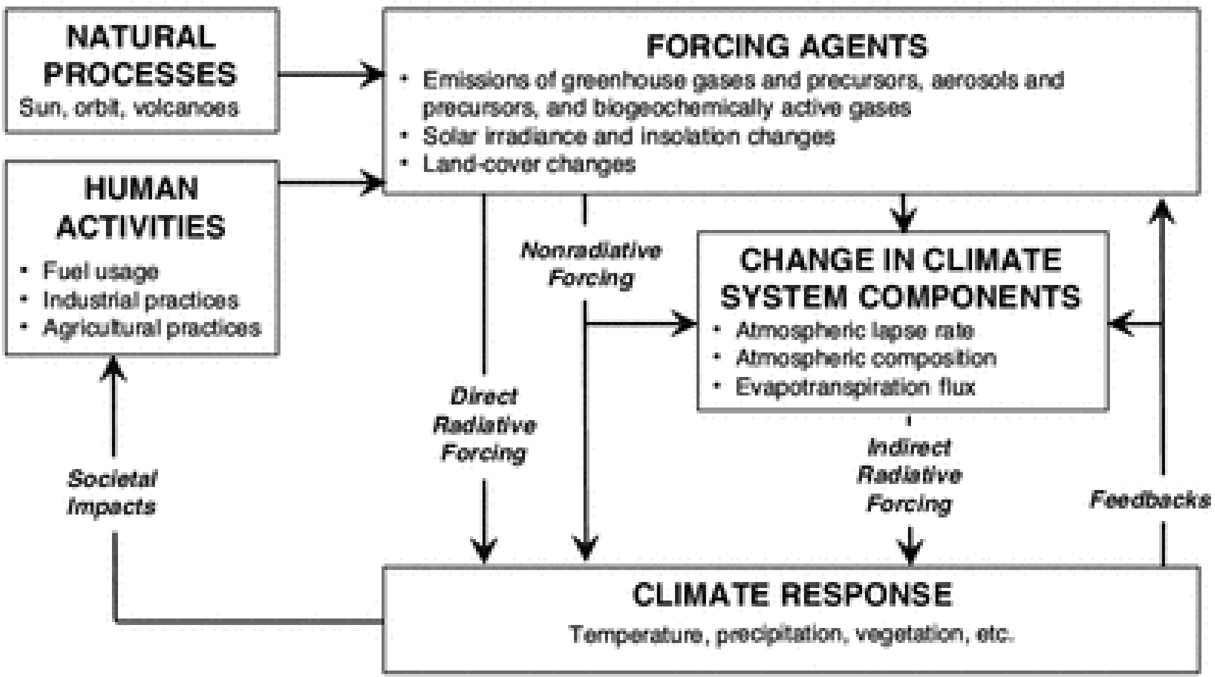


FIGURE 1-2 Conceptual framework of climate forcing, response, and feedbacks under present-day climate conditions. Examples of human activities, forcing agents, climate system components, and variables that can be involved in climate response are provided in the lists in each box.

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

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

Account for the Vertical Structure of Radiative Forcing

National Research Council Report PRIORITY RECOMMENDATIONS

- → Test and improve the ability of climate models to reproduce the observed vertical structure of forcing for a variety of locations and forcing conditions.
- → Undertake research to characterize the dependence of climate response on the vertical structure of radiative forcing.
- → Report global mean radiative forcing at both the surface and the top of the atmosphere in climate change assessments.

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.

- → 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.

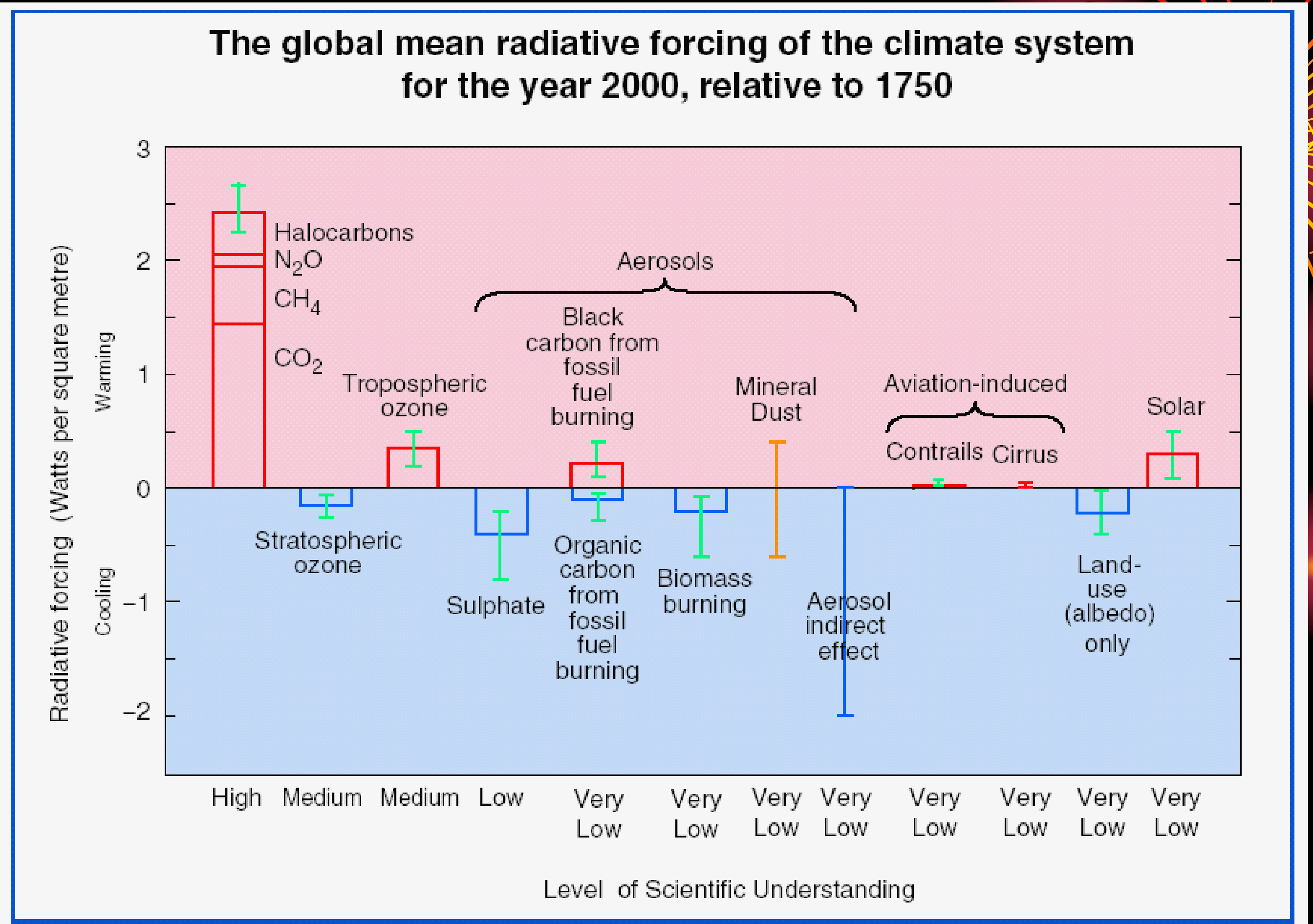
- → Develop improved land-use and land-cover classifications at high resolution for the past and present, as well as scenarios for the future.

Provide Improved Guidance to the Policy Community

National Research Council Report PRIORITY RECOMMENDATIONS

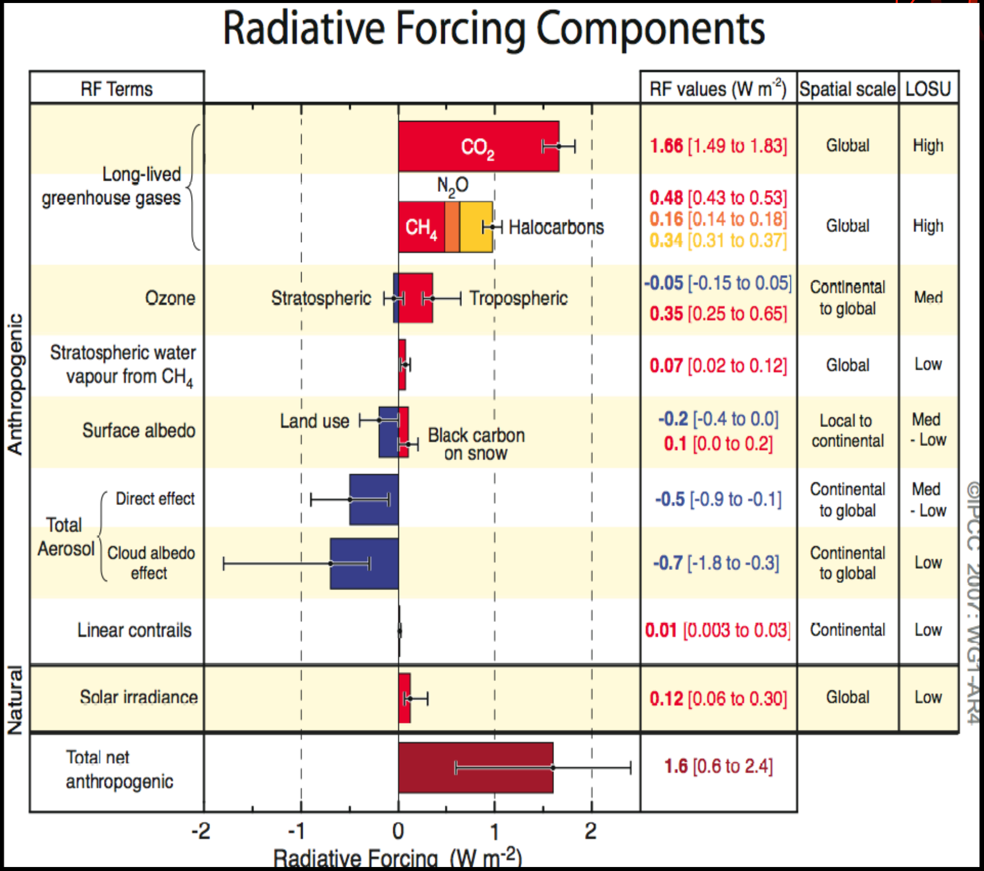
→ Encourage policy analysts and integrated assessment modelers to move beyond simple climate models based entirely on global mean TOA radiative forcing and incorporate new global and regional radiative and nonradiative forcing metrics as they become available.

The Narrow Focus of the IPCC Assessment



Estimated radiative forcings since preindustrial times for the Earth and Troposphere system (TOA) radiative forcing with adjusted stratospheric temperatures). The height of the rectangular bar denotes a central or best estimate of the forcing, while each vertical line is an estimate of the uncertainty range associated with the forcing guided by the spread in the published record and physical understanding, and with no statistical connotation. Each forcing agent is associated with a level of scientific understanding, which is based on an assessment of the nature of assumptions involved, the uncertainties prevailing about the processes that govern the forcing, and the resulting confidence in the numerical values of the estimate. On the vertical axis, the direction of expected surface temperature change due to each radiative forcing is indicated by the labels "warming" and "cooling." From: IPCC 2001: Summary for Policymakers. A Report of the Working Group 1 of the Intergovernmental Panel on Climate Change.
http://www.ipcc.ch/pub/spm22-01.pdf

2007 IPCC SPM View



- **Did The IPCC Adequately Consider All Significant Positive Radiative Forcings?**

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.

Estimates of Positive Radiative Forcing

[In Watts per meter squared]

- Methane +0.8
- Short-wave albedo change +0.5
- Tropospheric ozone +0.3
- Aerosol black carbon +0.2
- Black carbon on snow and ice +0.3
- Semi-direct aerosol effect +0.1
- Glaciation effect +0.1
- Solar influences +0.25
- Dust ?

The CO_2 contribution to the radiative warming decreases to 30% or less using the IPCC framework given in the 2001 IPCC

Are The Multi-Decadal Land Surface Air Temperature Trends A Robust Measure Of Global Warming and Cooling?

USHCN station exposure at Greensburg, Kentucky. From: Pielke Sr. et al., 2006: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Research, accepted.

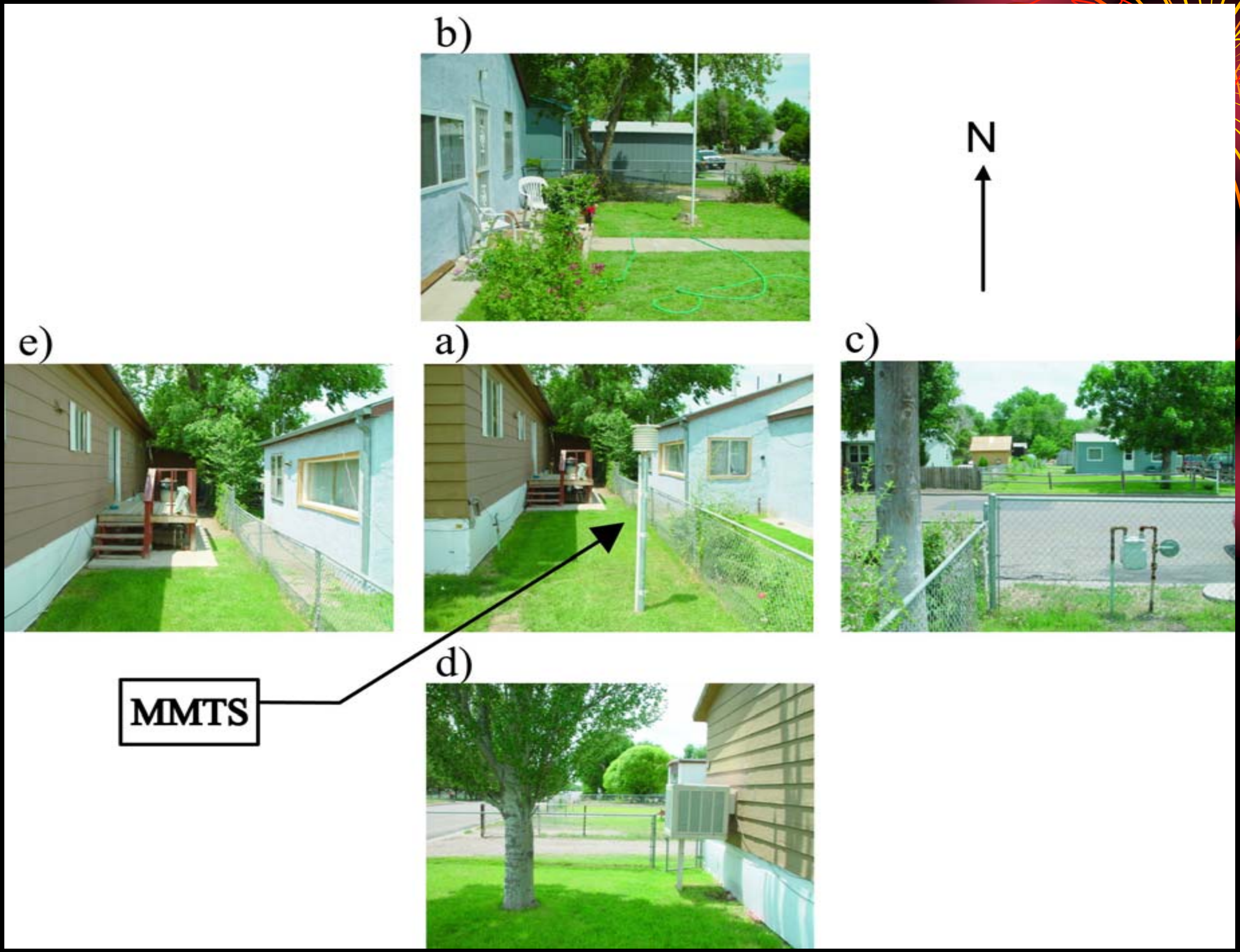
http://blue.atmos.colostate.edu/publications/pdf/R-321.pdf

USHCN station exposure at Leitchfield_2_N, Kentucky. From: Pielke Sr. et al., 2006: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Research, accepted.
http://blue.atmos.colostate.edu/publications/pdf/R-321.pdf

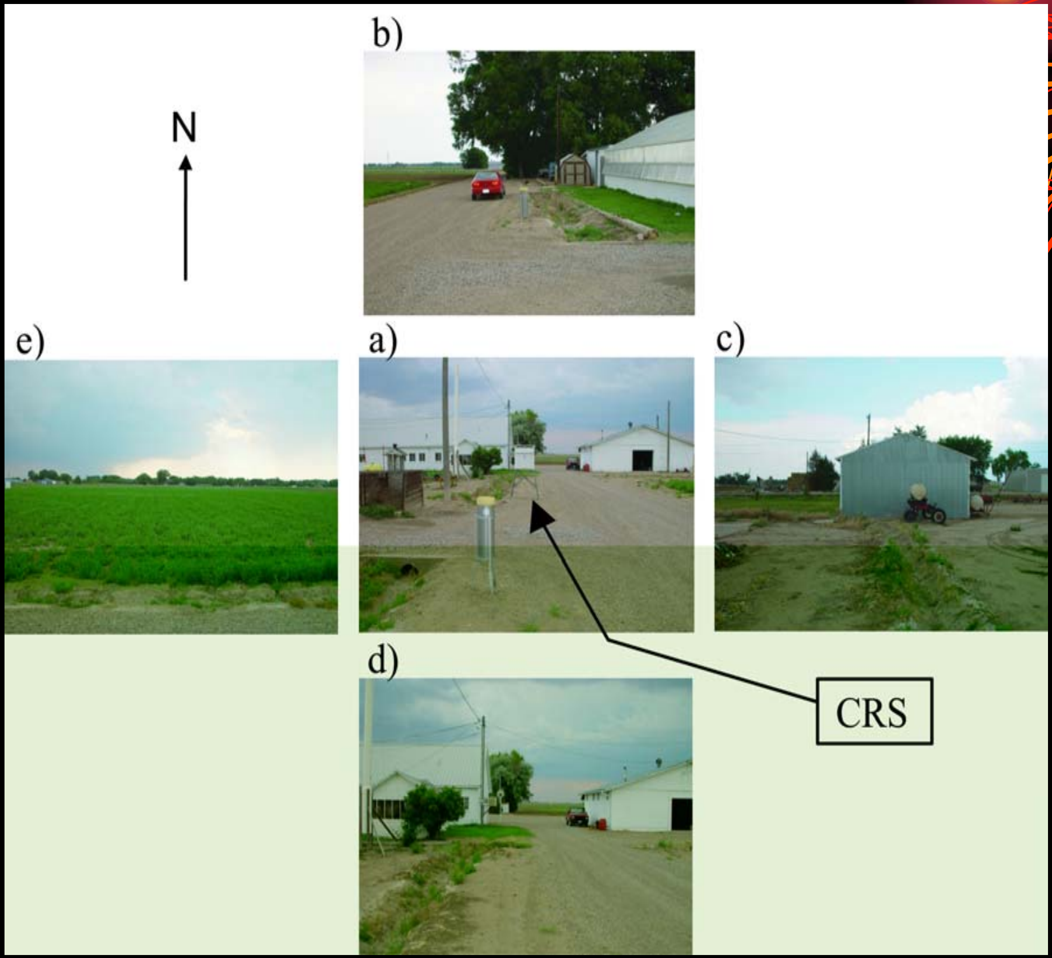
USHCN station exposure at Leitchfield_2_N, Kentucky. From: Pielke Sr. et al., 2006: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Research, accepted.

http://blue.atmos.colostate.edu/publications/pdf/R-321.pdf

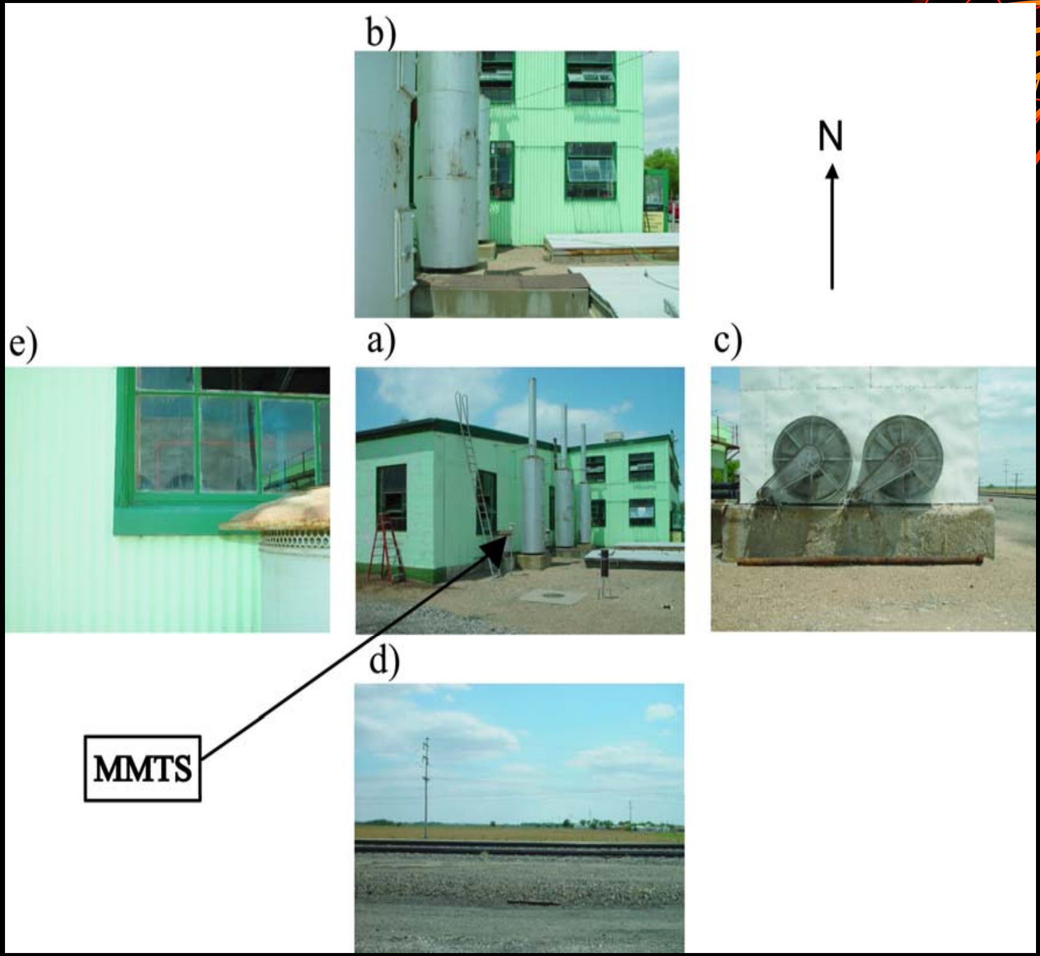
USHCN station exposure at Hopkinsville, Kentucky. From: Pielke Sr. et al., 2006: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Research, accepted.
http://blue.atmos.colostate.edu/publications/pdf/R-321.pdf



http://blue.atmos.colostate.edu/publications/pdf/R-274.pdf



http://blue.atmos.colostate.edu/publications/pdf/R-274.pdf



http://blue.atmos.colostate.edu/publications/pdf/R-274.pdf

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

What is the most appropriate metric to assess global warming and cooling?

Ocean Heat Content Changes Over Time Provides An Effective Metric To Diagnose The Radiative Imbalance of the Climate System

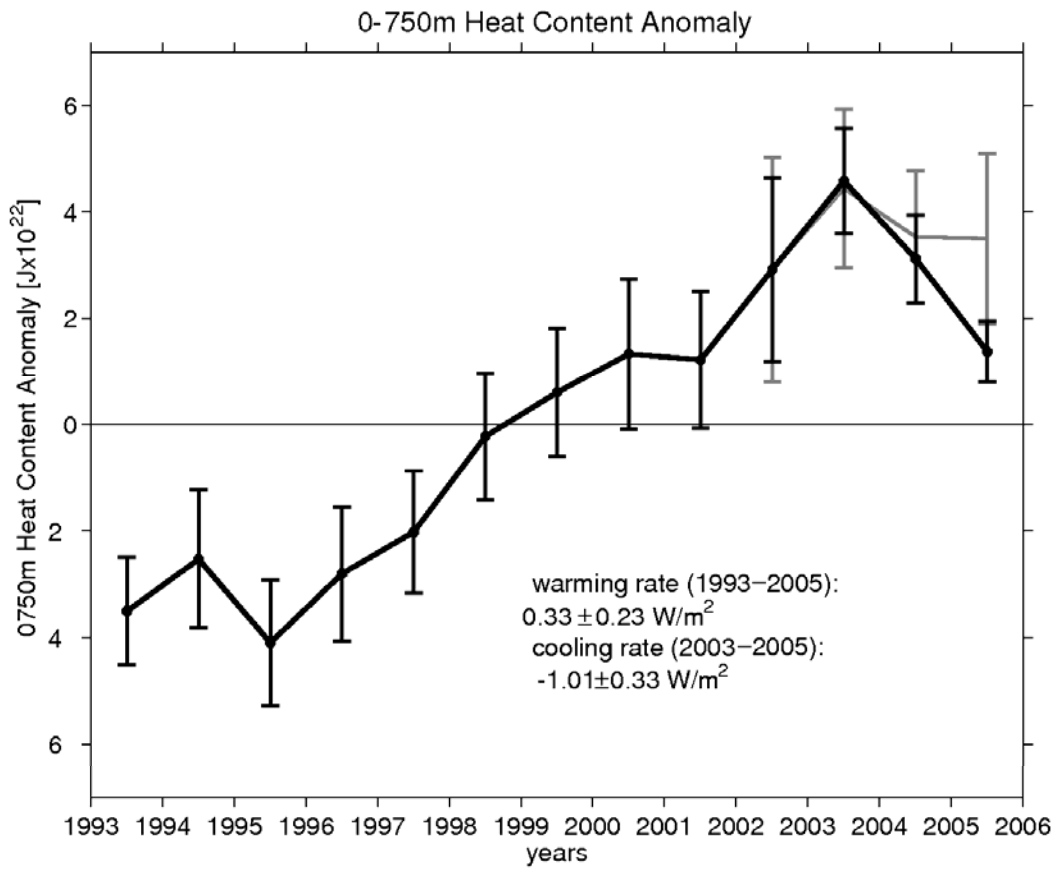


Figure 1. Globally averaged annual OHCA [10^{22} J] in the upper 750 m estimated using in situ data alone from 1993 through 2005 (black line) and using in situ data excluding profiling floats (gray line). Error bars (from Figure 3) reflect the standard error estimates discussed in Section 3. Linear trends 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 A correction to this paper has just been submitted for publication that removes this

A Litmus Test For Global Warming

Joules must accumulate in the ocean each year at a more or less monotonic rate of about 10**22 Joules per year

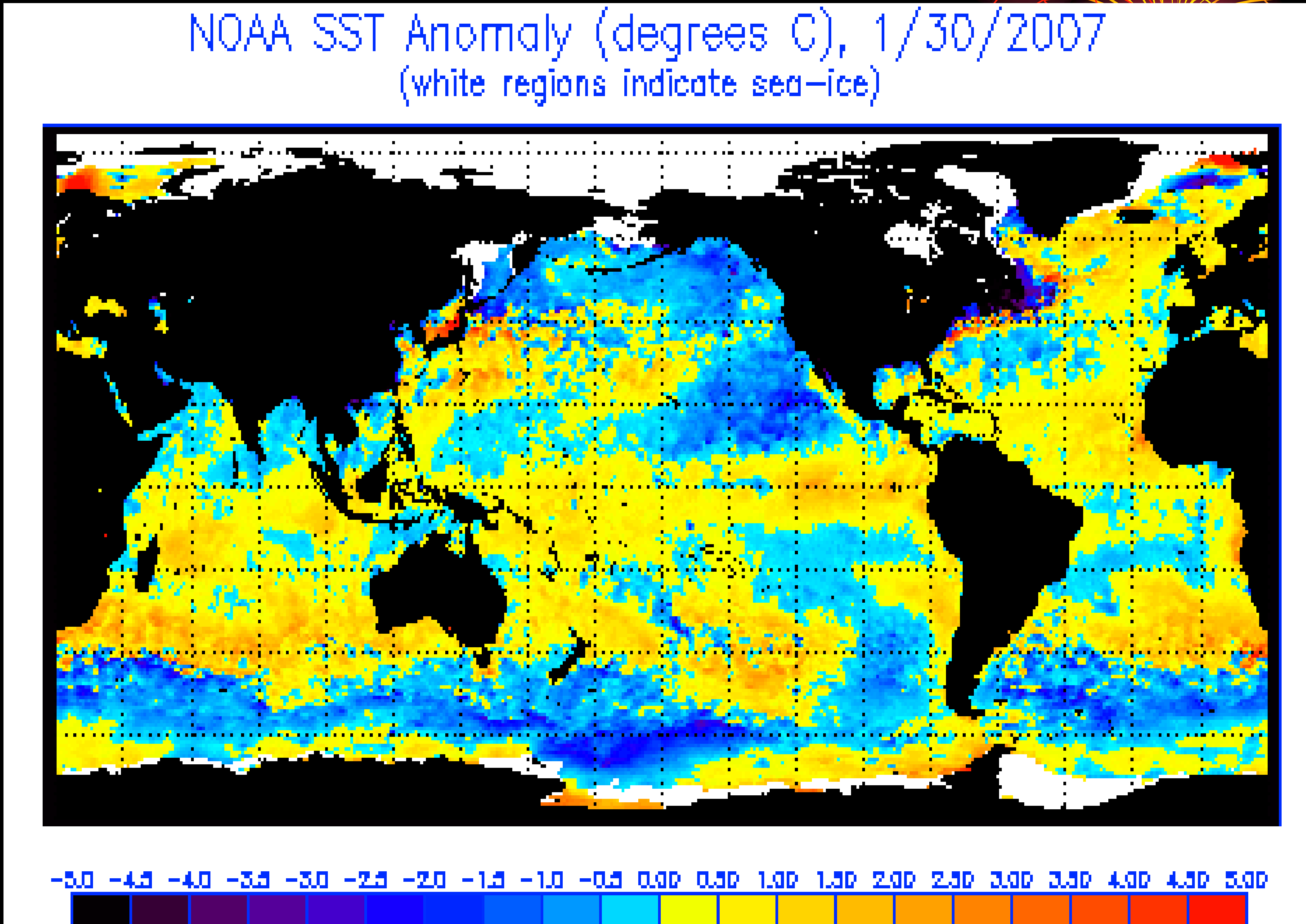
2003 8*10**22 Joules
2004 9*10**22 Joules
2005 10*10**22 Joules
2006 11*10**22 Joules
2007 12*10**22 Joules
2008 13*10**22 Joules
2009 14*10**22 Joules
2010 15*10**22 Joules
2011 16*10**22 Joules
2012 17*10**22 Joules

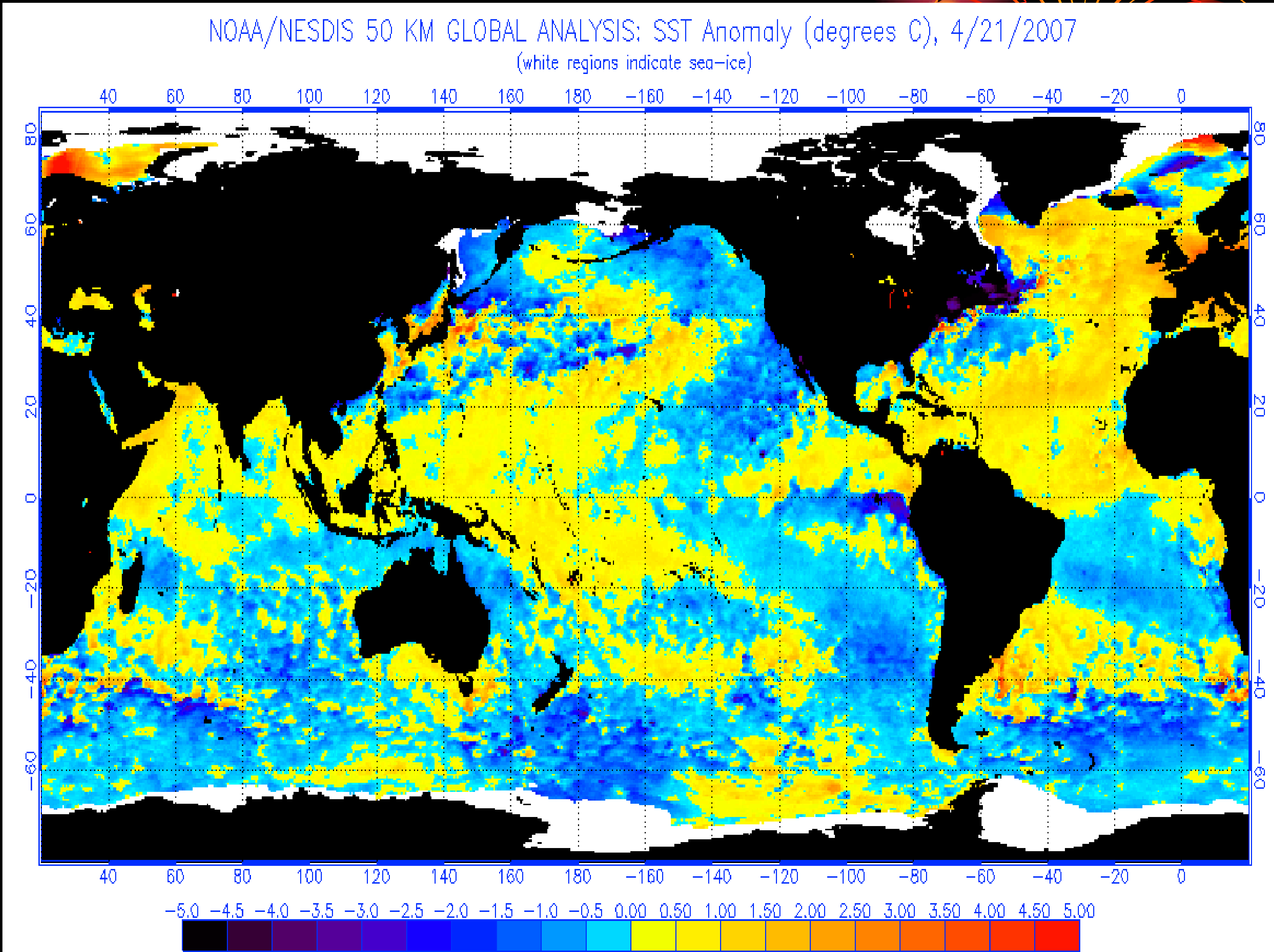
Correction to the Lyman et al paper removes recent cooling but also does not show warning

- **Other data also show little if any global warming since 2002**

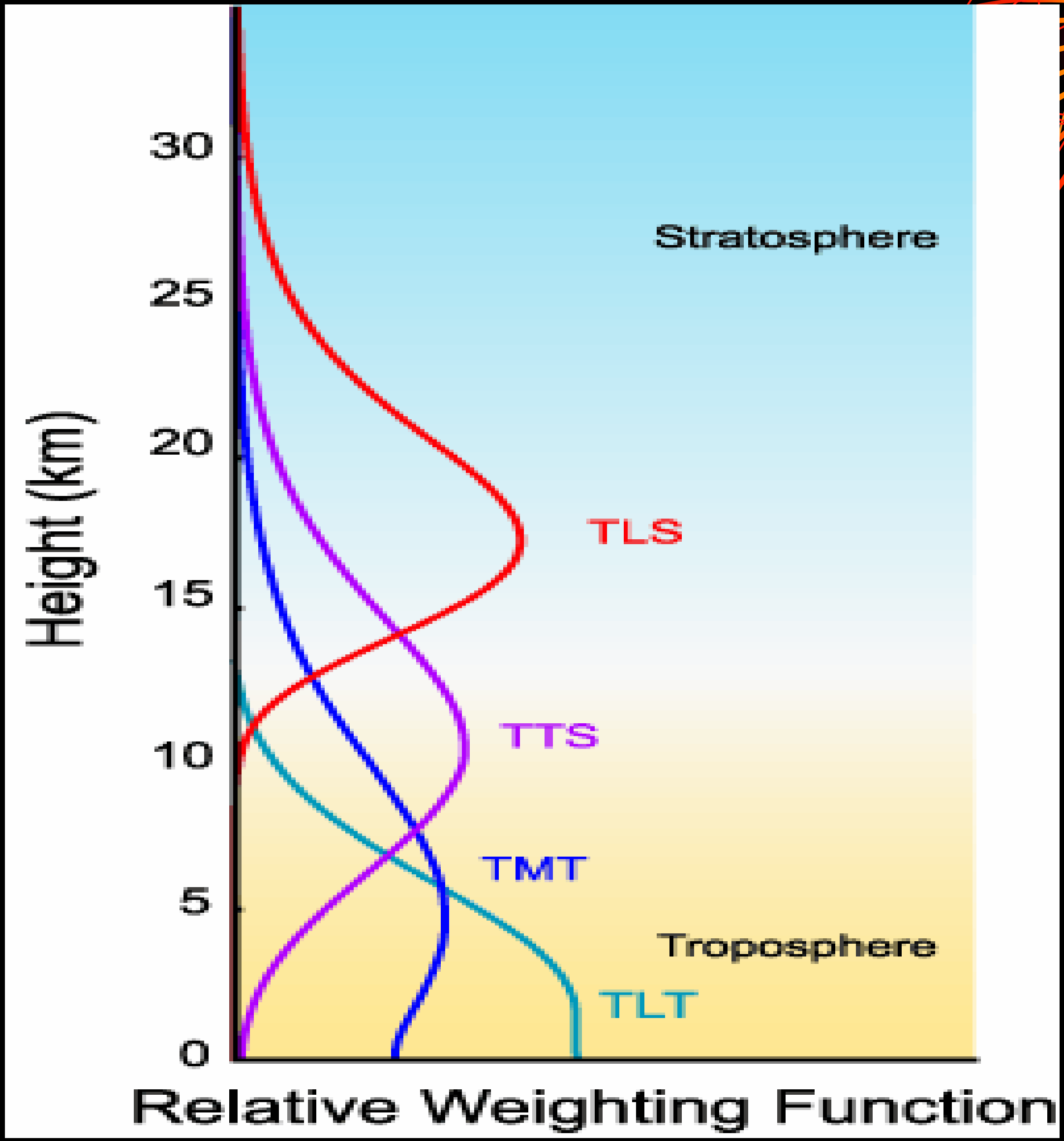
  SSTs

  tropospheric temperatures [RSS and UAH MSU data]

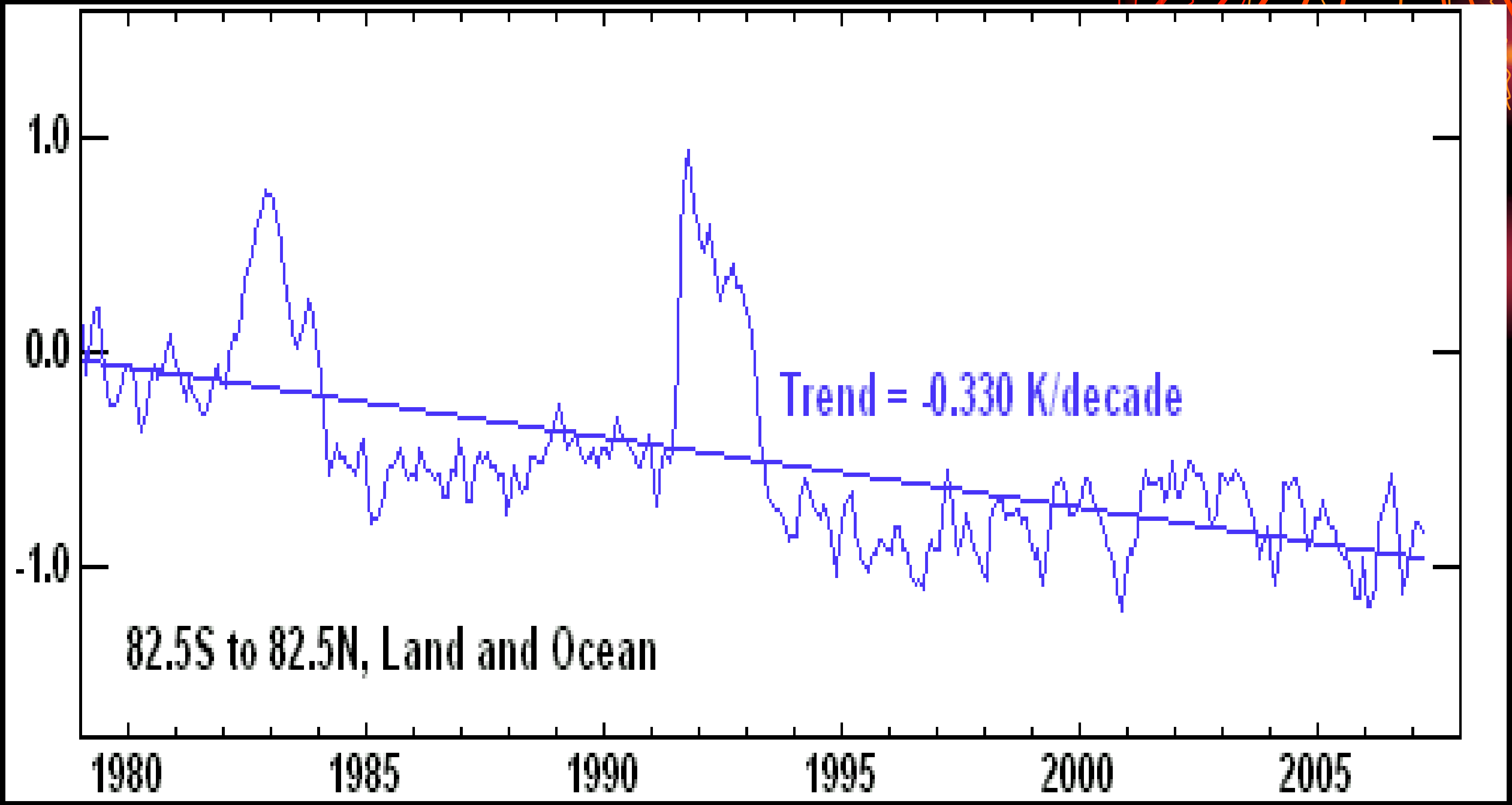

NOAA SST Anomaly (degrees C), 1/30/2007
(white regions indicate sea-ice)
-5.0 -4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00


NOAA/NESDIS 50 KM GLOBAL ANALYSIS: SST Anomaly (degrees C), 4/21/2007
(white regions indicate sea-ice)
40 60 80 100 120 140 160 180 -160 -140 -120 -100 -80 -60 -40 -20 0
80 60 40 20 0 -20 -40 -60
-5.0 -4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00

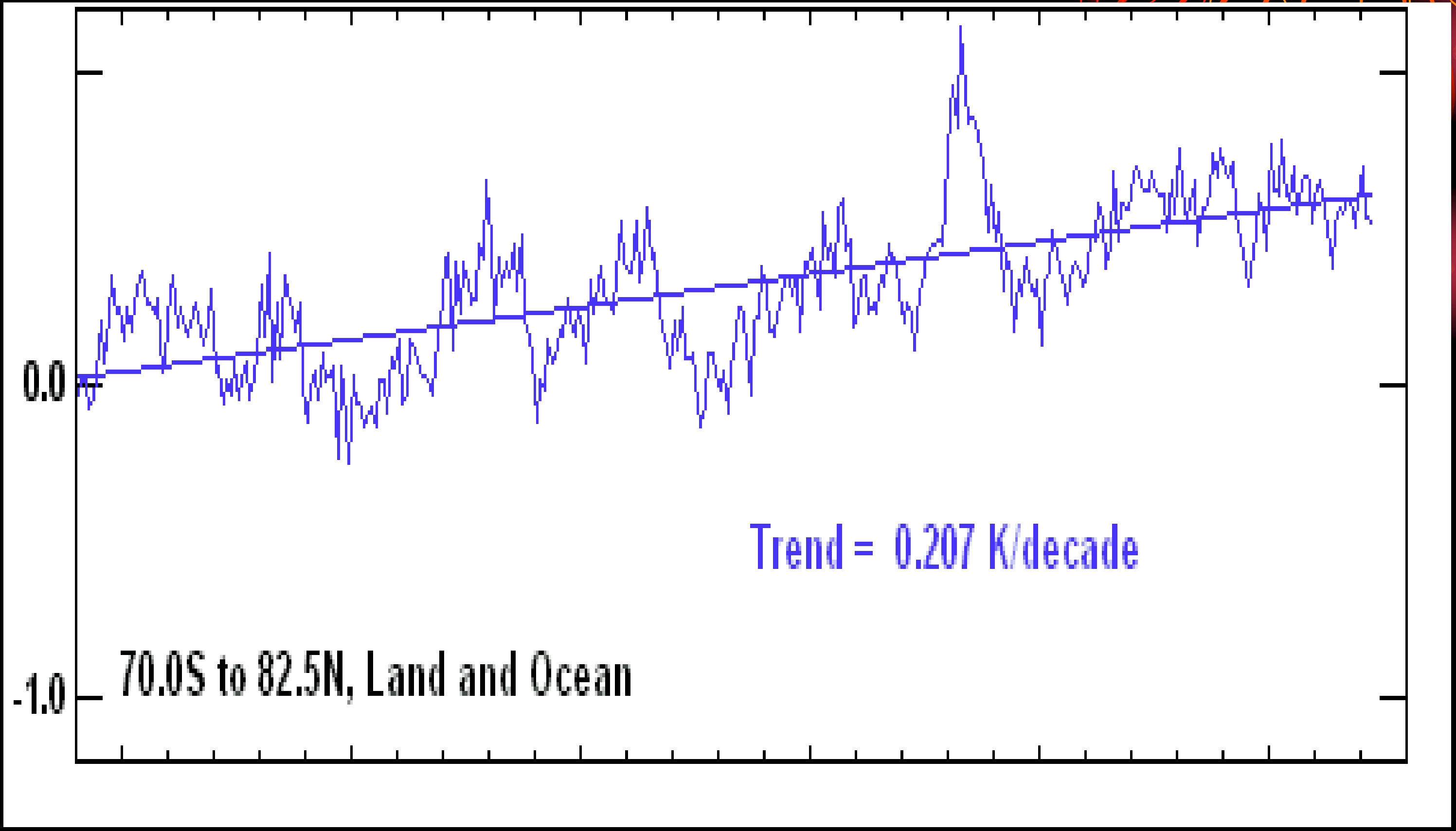
http://www.remss.com/msu/msu_data_description.html#msu_decadal_trends



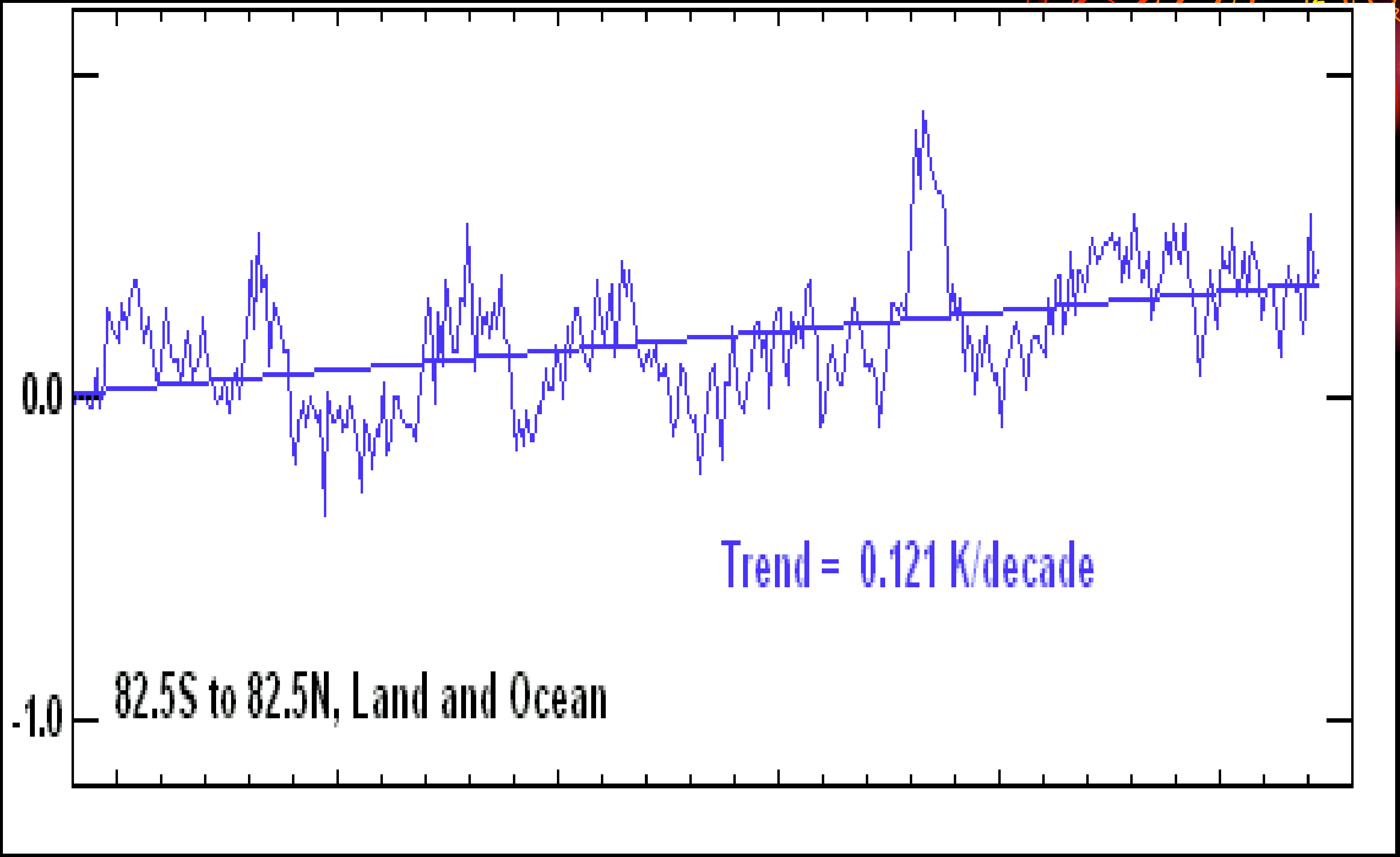
RSS TLS


1.0
0.0
-1.0
Trend = -0.330 K/decade
82.5S to 82.5N, Land and Ocean
1980
1985
1990
1995
2000
2005

RSS TLT



RSS TMT



Are There Climate Forcings That Are Ignored Or Understated In The IPCC SPM?

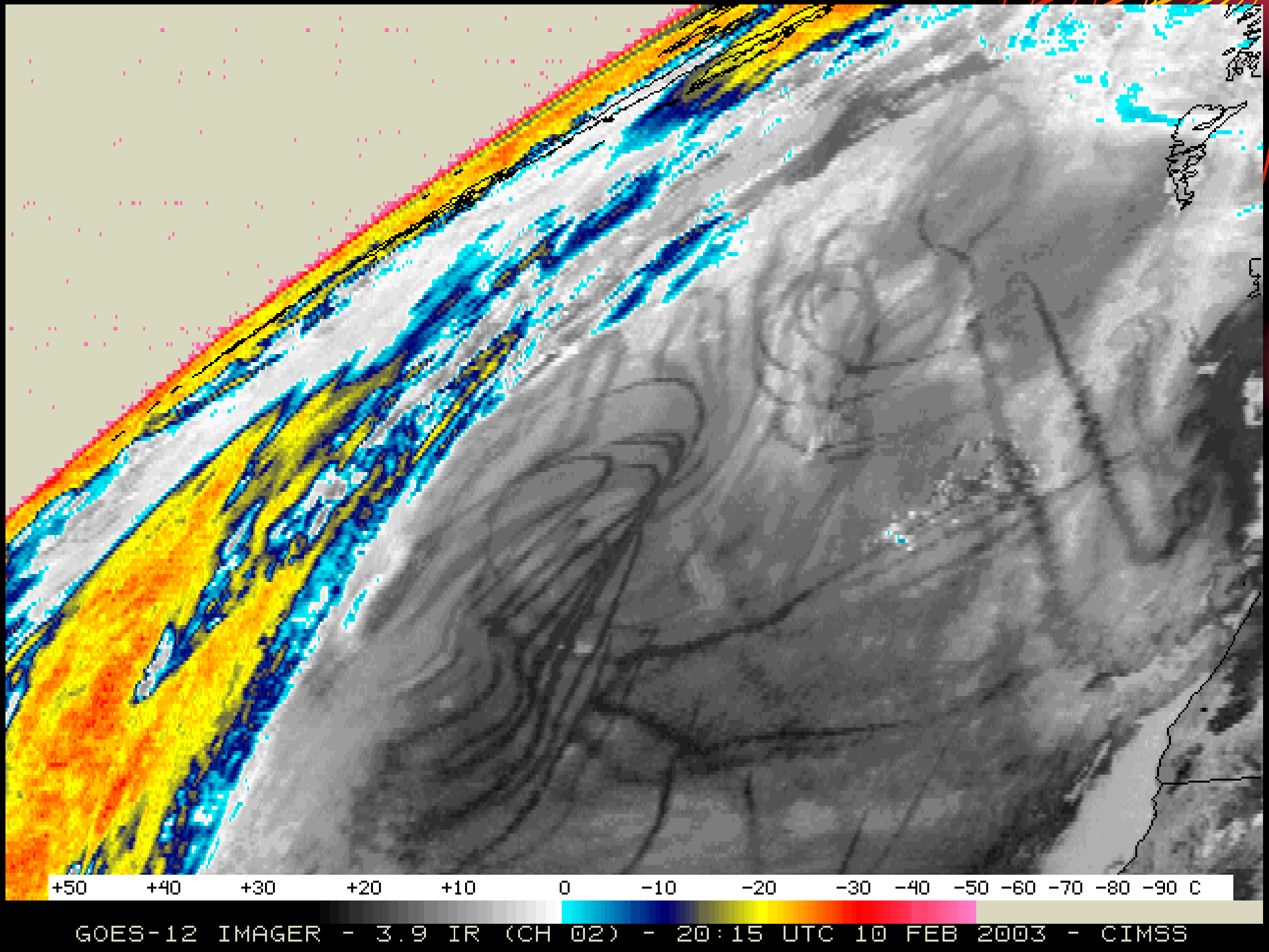
New or Under-Recognized Human Climate Forcings

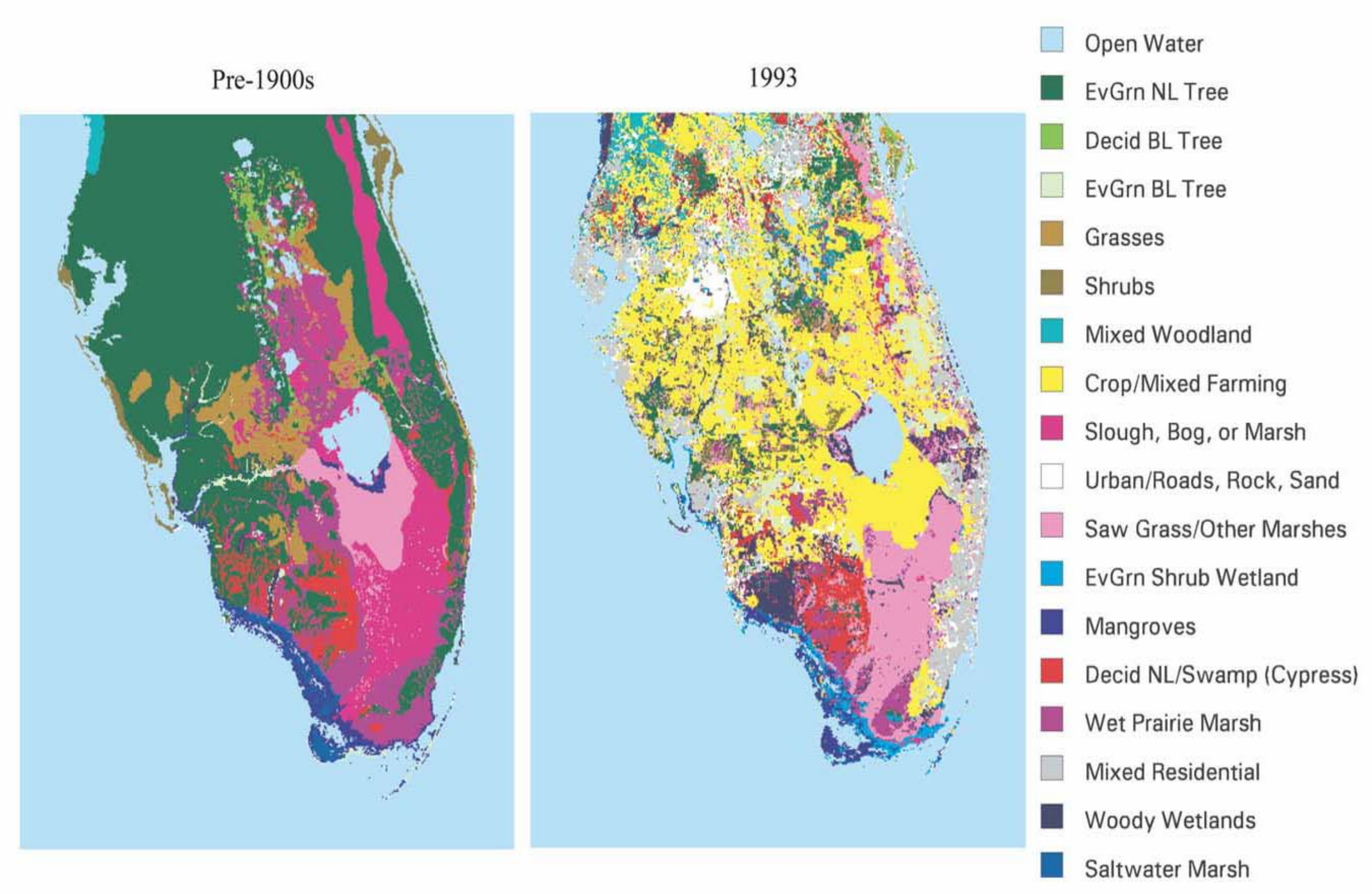
- →Biogeochemical Effect of CO_2
- →Nitrogen Deposition
- →Land-Use/Land-Cover Change
- →Glaciation Effect of Aerosols
- →Thermodynamic Effect of Aerosols
- →Surface Energy Budget Effect

Example of a pyrocumulus cloud (copyright 2001, Axel Thielmann).

Example of industrial emissions from a smokestack

From http://earthobservatory.nasa.gov/Laboratory/Aerosol/Images/anthro_smokestack.jpg


+50 +40 +30 +20 +10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 C
GOES-12 IMAGER - 3.9 IR (CH 02) - 20:15 UTC 10 FEB 2003 - CIMSS



U.S. Geological Survey land-cover classes for pre-1900's natural conditions (left) and 1993 land-use patterns (right). From Marshall, C.H., Pielke Sr. R.A., Steyaert, L.T., 2003. Crop freezes and land-use change in Florida. Nature, 426, 29-30.

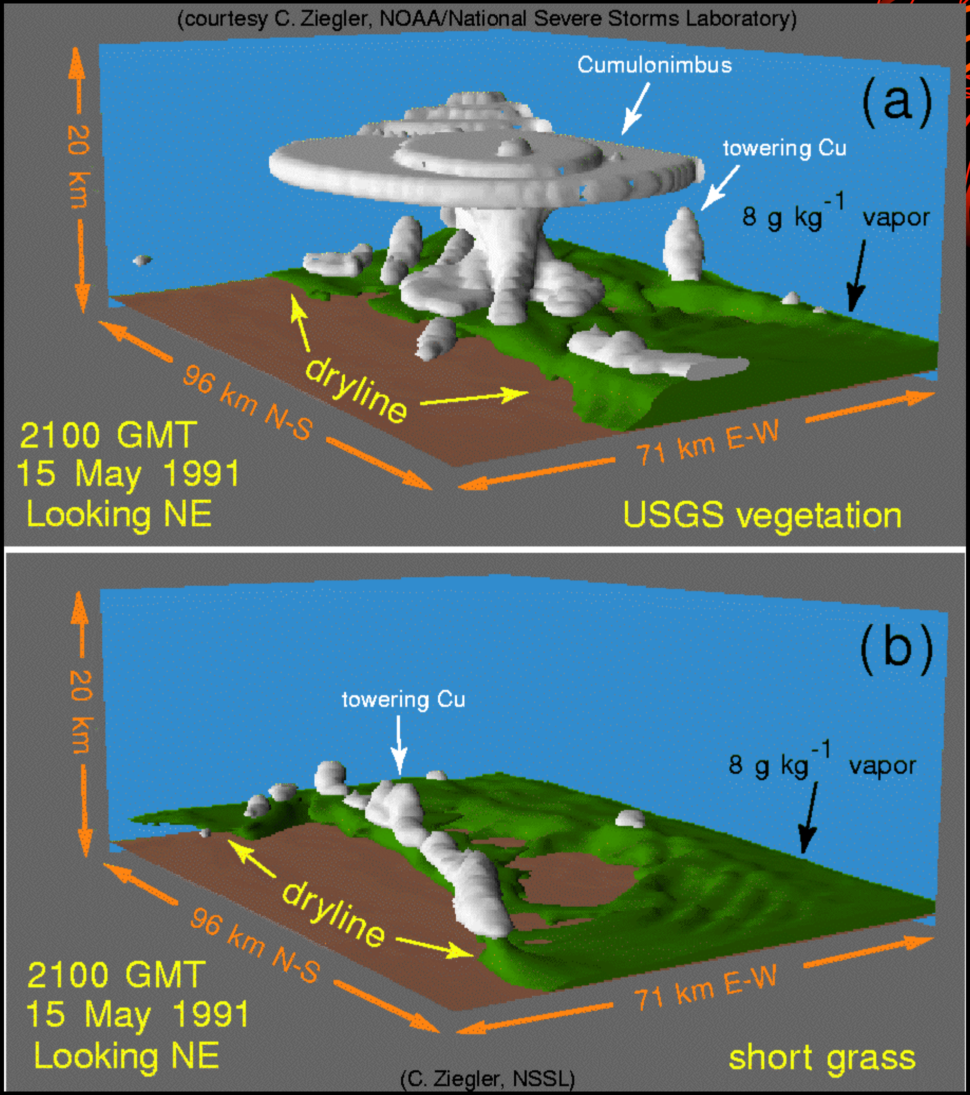
http://blue.atmos.colostate.edu/publications/pdf/R-277.pdf

Diverse Range of Aerosol Forcings as discussed in Dr. Beate Liepert's talk

TABLE 2-2 Overview of the Different Aerosol Indirect Effects Associated with Clouds

Effect	Cloud Type	Description	Sign of TOA Radiative Forcing
First indirect aerosol effect (cloud albedo or Twomey effect)	All clouds	For the same cloud water or ice content, more but smaller cloud particles reflect more solar radiation	Negative
Second indirect aerosol effect (cloud lifetime or Albrecht effect)	All clouds	Smaller cloud particles decrease the precipitation efficiency, thereby prolonging cloud lifetime	Negative
Semidirect effect	All clouds	Absorption of solar radiation by soot leads to evaporation of cloud particles	Positive
Glaciation indirect effect	Mixed-phase clouds	An increase in ice nuclei increases the precipitation efficiency	Positive
Thermodynamic effect	Mixed-phase clouds	Smaller cloud droplets inhibit freezing, causing supercooled droplets to extend to colder temperatures	Unknown
Surface energy budget effect	All clouds	The aerosol-induced increase in cloud optical thickness decreases the amount of solar radiation reaching the surface, changing the surface energy budget	Negative

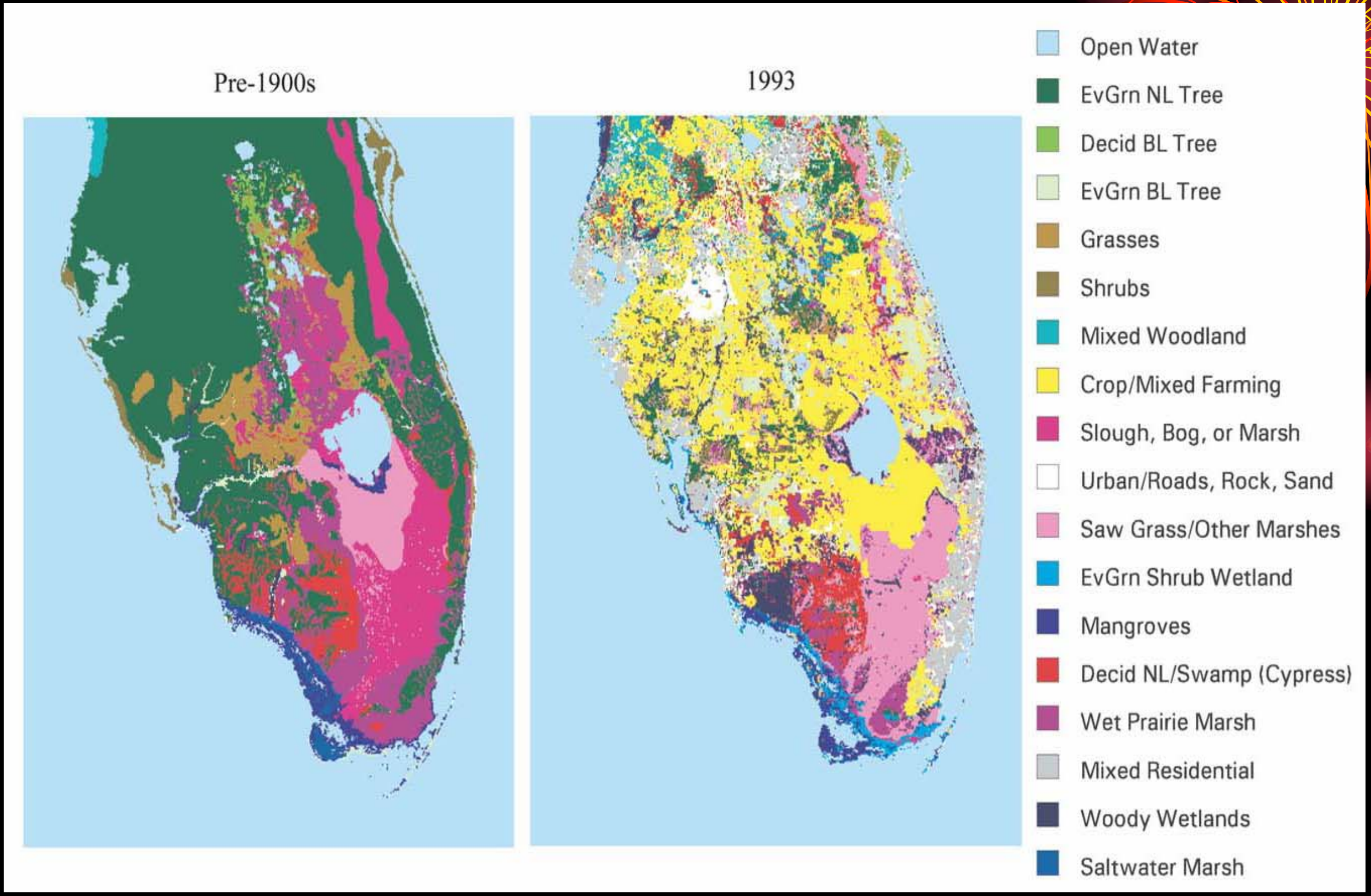
Effect of Land-Use Change on Deep Cumulonimbus Convection



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://blue.atmos.colostate.edu/publications/pdf/R-231.pdf

What are some other examples?

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://blue.atmos.colostate.edu/publications/pdf/R-272.pdf

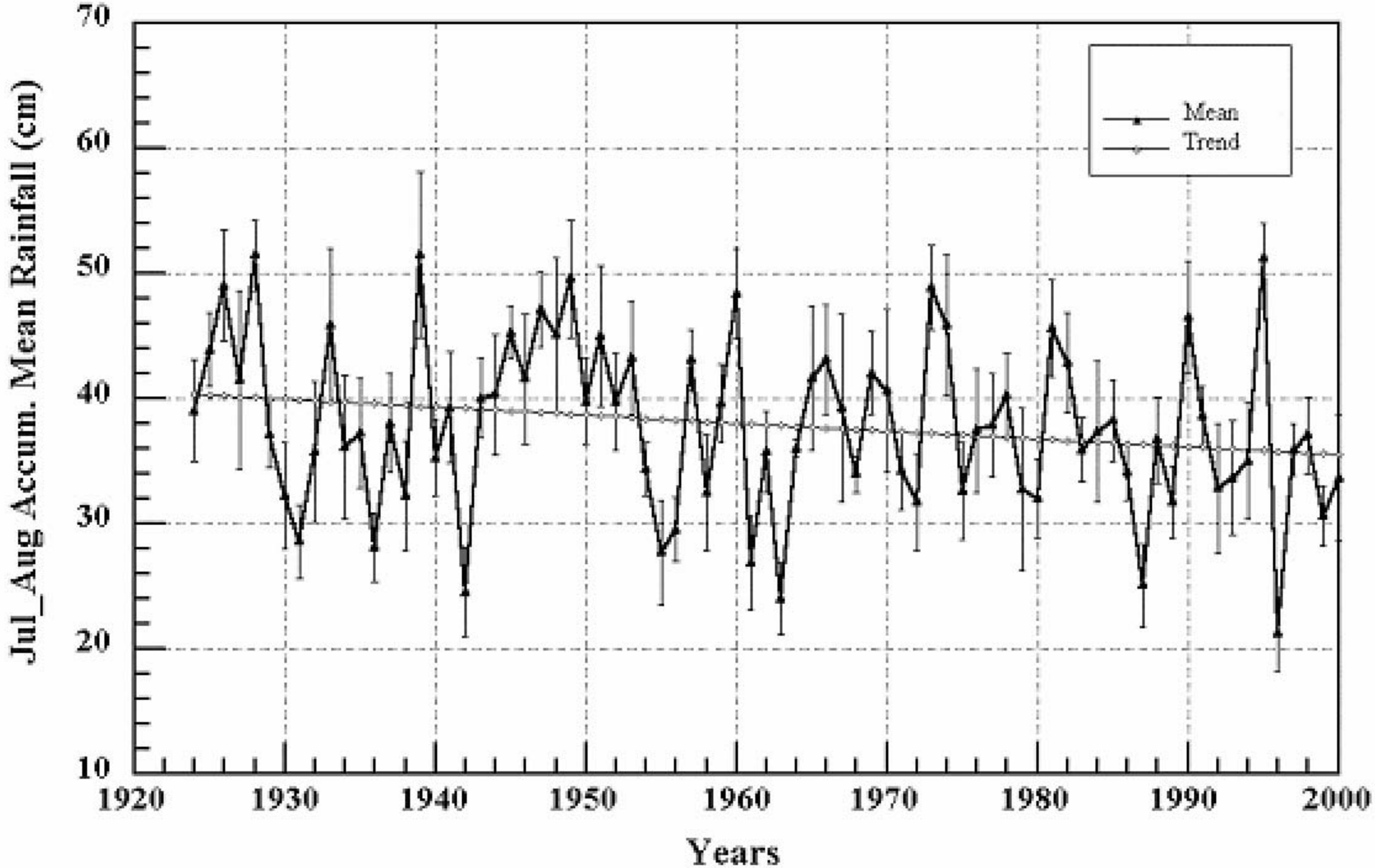


FIG. 25. Regional average time series of accumulated convective rainfall (cm) from 1924 to 2000, with corresponding trend based on linear regression of all July-August amounts. The vertical bars overlain on the raw time series indicate the value of the standard error of the July-August regional mean.

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://blue.atmos.colostate.edu/publications/pdf/R-272.pdf

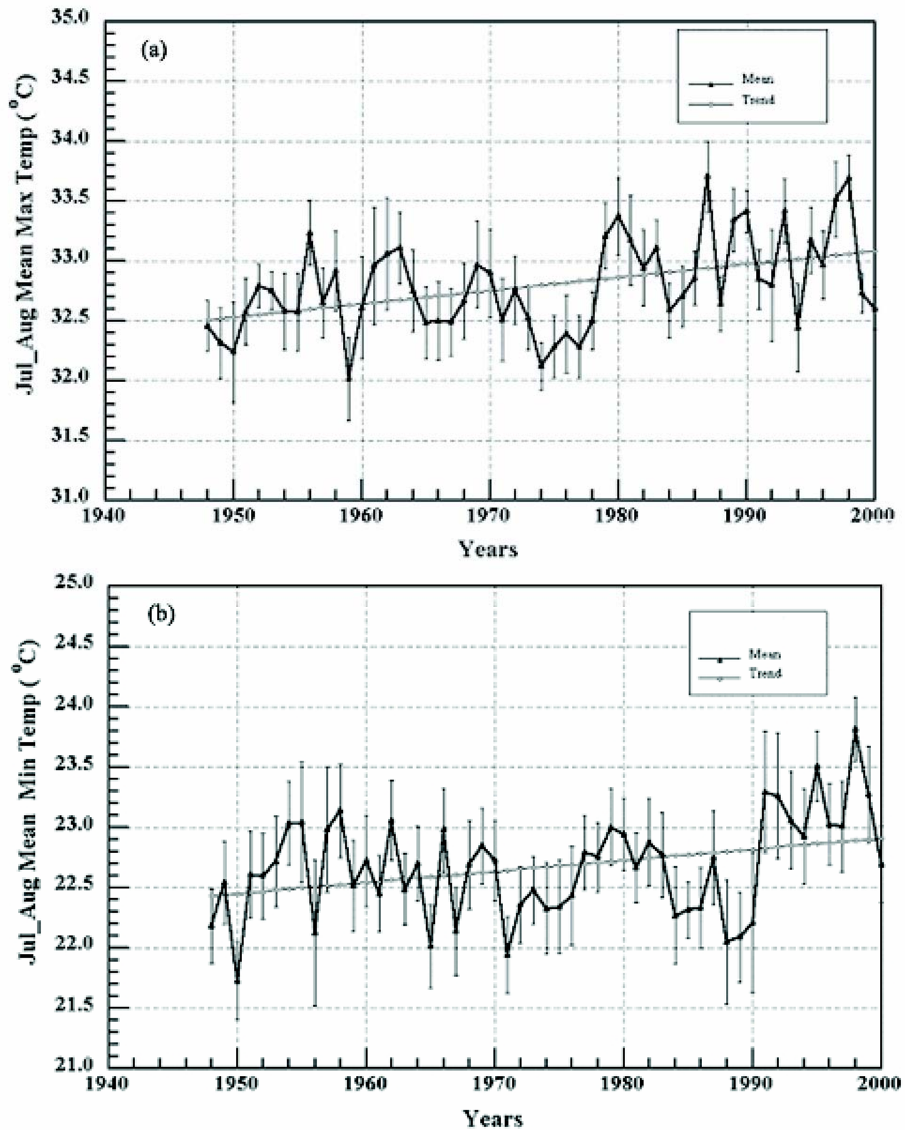
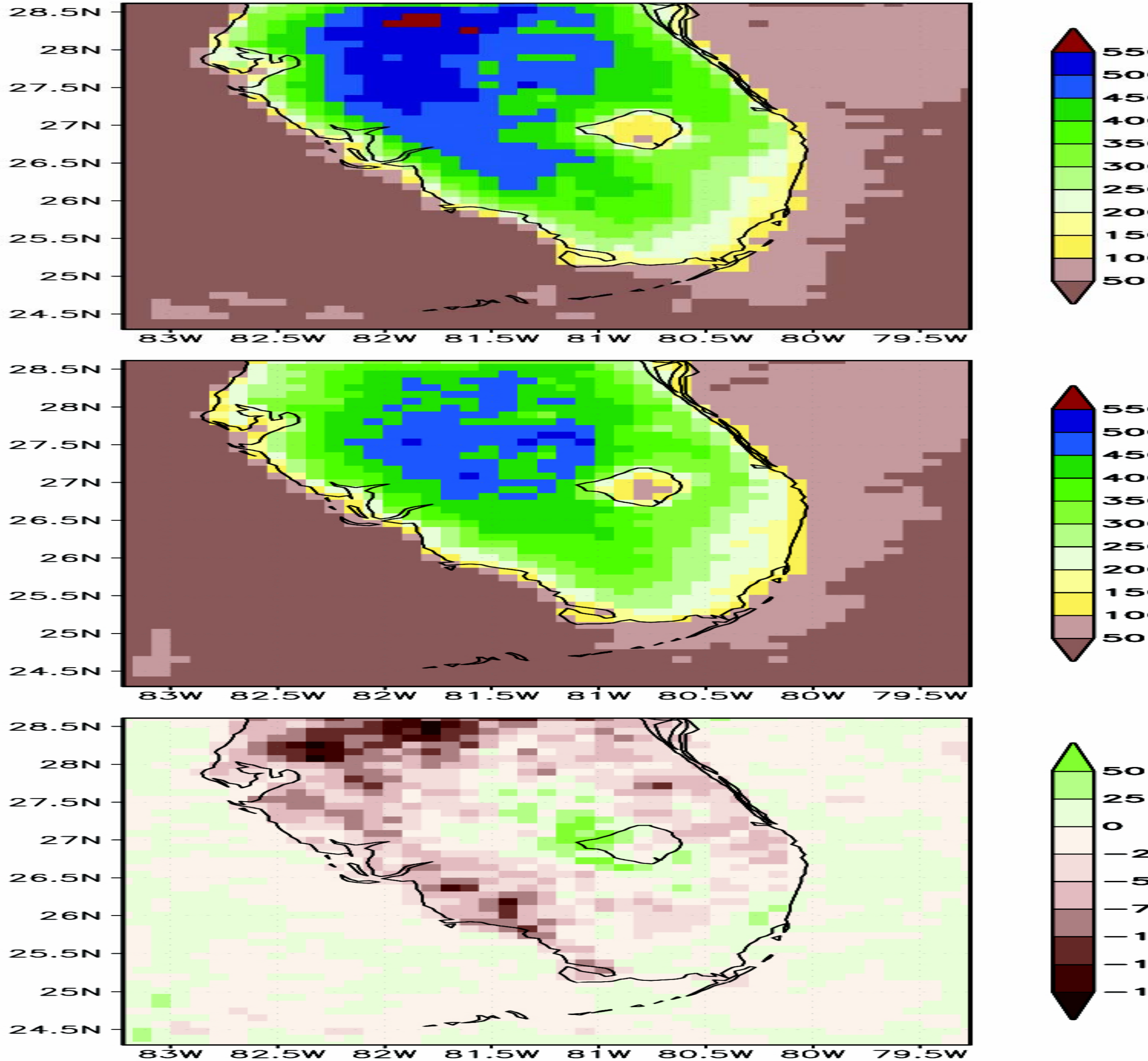


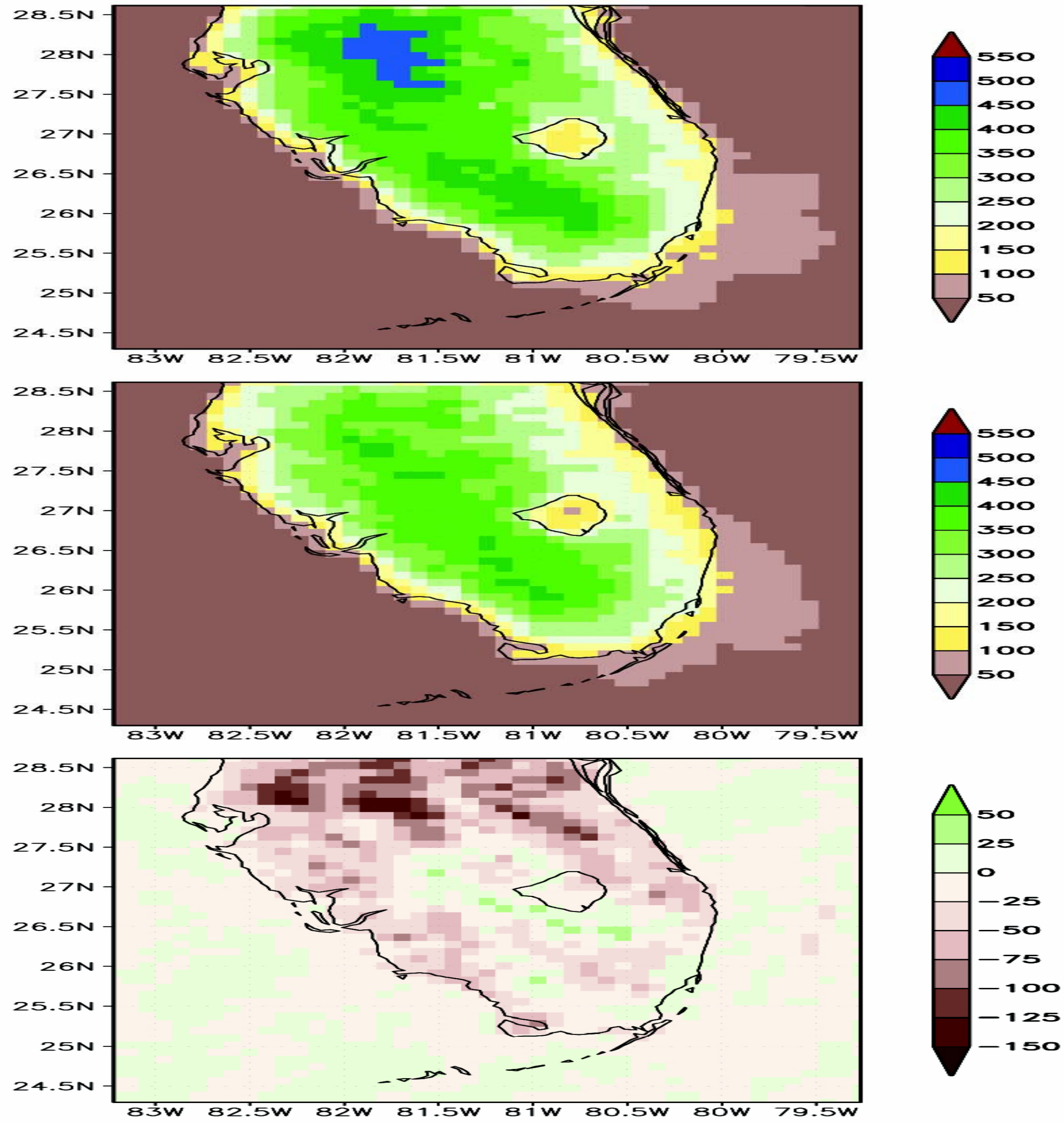
FIG. 26. Same as in Figure 25, except for daily (a) maximum and (b) minimum shelter-level temperature (°C)

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://blue.atmos.colostate.edu/publications/pdf/R-272.pdf

1973

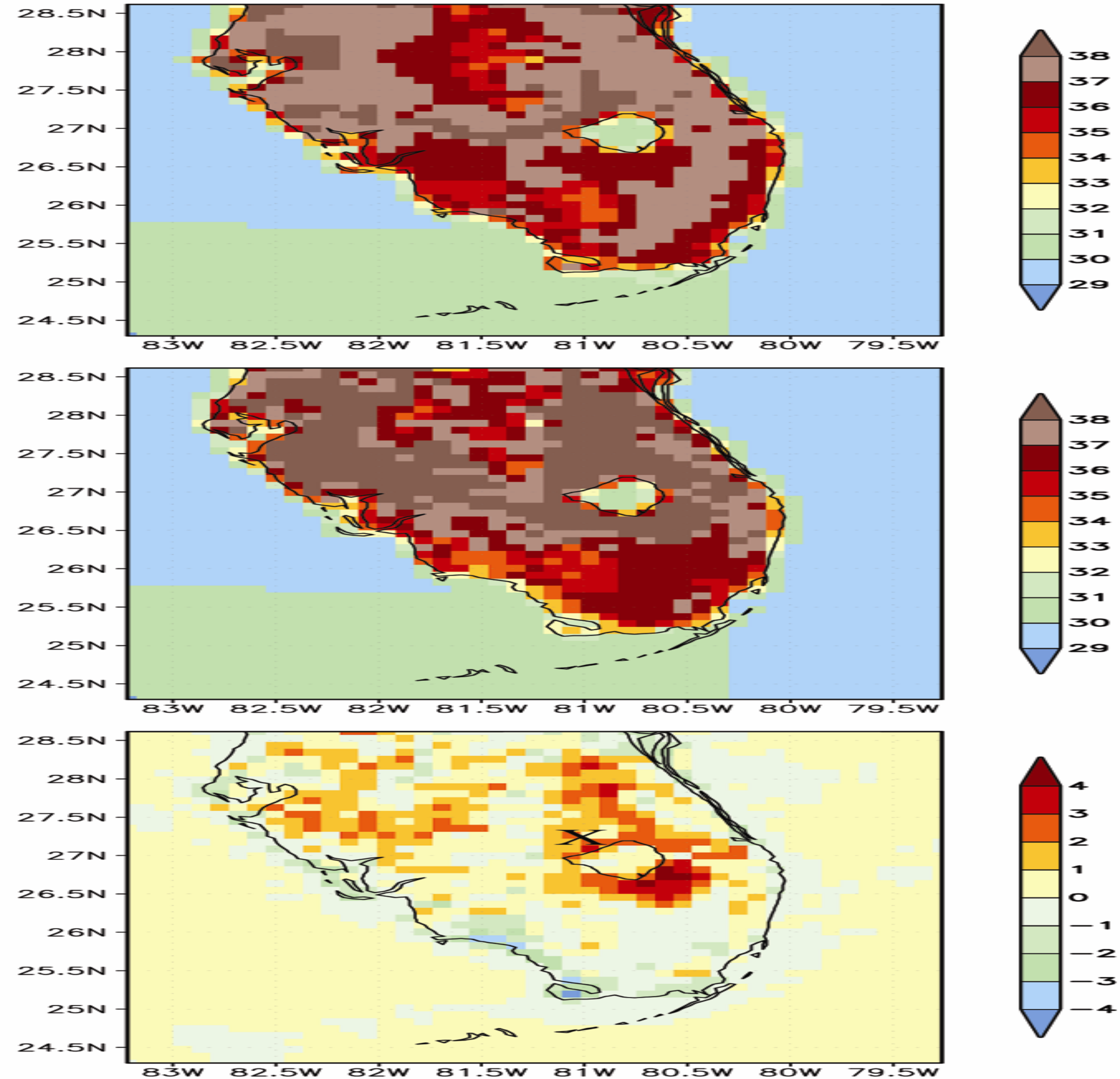

28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
83W
82.5W
82W
81.5W
81W
80.5W
80W
79.5W
50
25
0

1989


28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
83W
82.5W
82W
81.5W
81W
80.5W
80W
79.5W
550
500
450
400
350
300
250
200
150
100
50
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
83W
82.5W
82W
81.5W
81W
80.5W
80W
79.5W
550
500
450
400
350
300
250
200
150
100
50
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
83W
82.5W
82W
81.5W
81W
80.5W
80W
79.5W
50
25
0
−25
−50
−75
−100
−125
−150

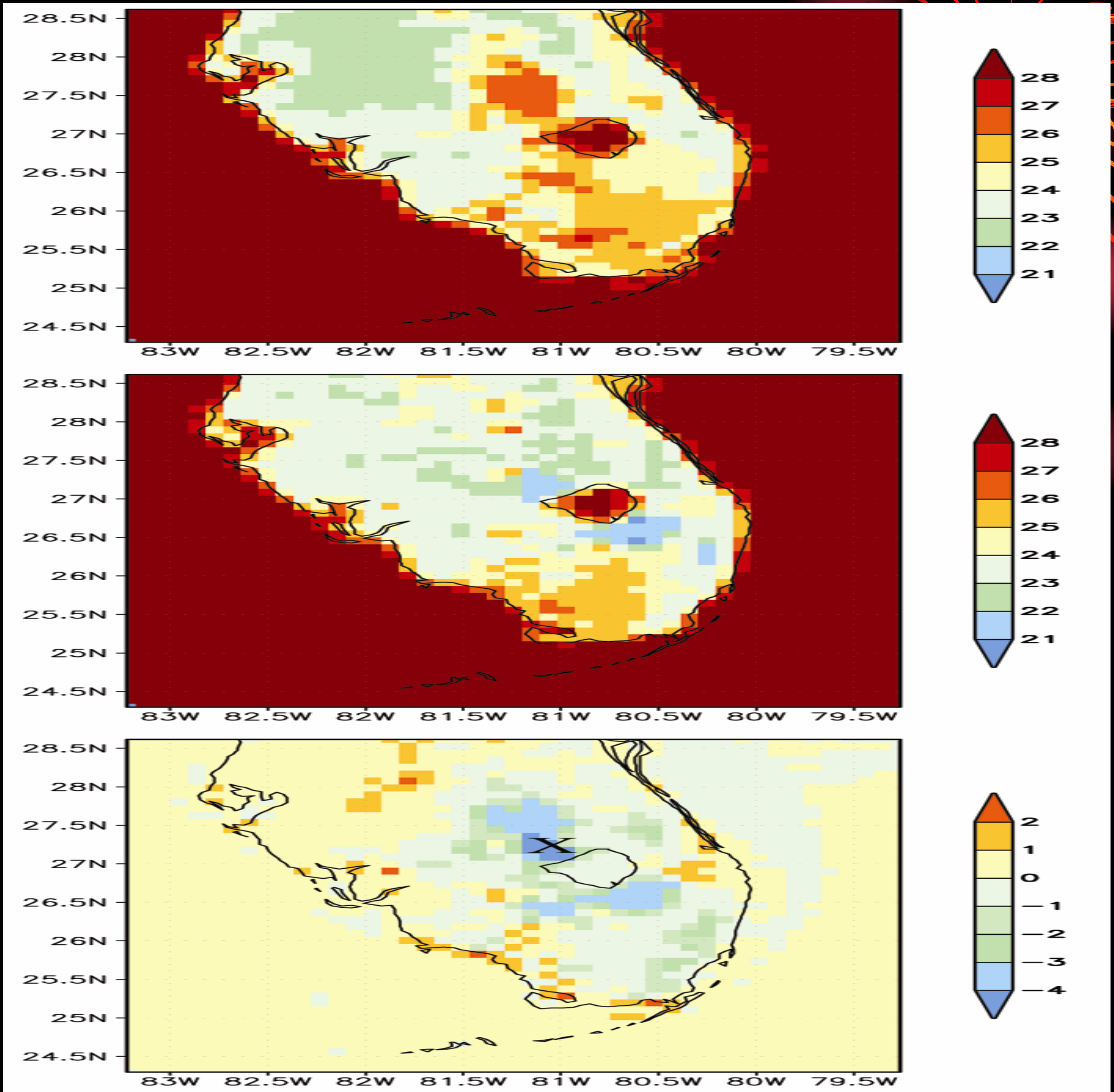
1989

T Max


28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
83W
82.5W
82W
81.5W
81W
80.5W
80W
79.5W
38
37
36
35
34
33
32
31
30
29
4
3
2
1
0
−1
−2
−3
−4

1989

T min


28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
83W
82.5W
82W
81.5W
81W
80.5W
80W
79.5W
28
27
26
25
24
23
22
21
2
1
0
−1
−2
−3
−4
X

Regional Land-Use Change Effects on Climate in Florida in the Winter

Marshall, C.H. Jr., R.A. Pielke Sr., and L.T. Steyaert, 2003: Crop freezes and land-use change. *Nature*, 426, 29-30.

http://blue.atmos.colostate.edu/publications/pdf/R-277.pdf

Marshall, C.H., R.A. Pielke Sr., and L.T. Steyaert, 2004: Has the conversion of natural wetlands to agricultural land increased the incidence and severity of damaging freezes in south Florida? Mon. Wea. Rev.

http://blue.atmos.colostate.edu/publications/pdf/R-281.pdf

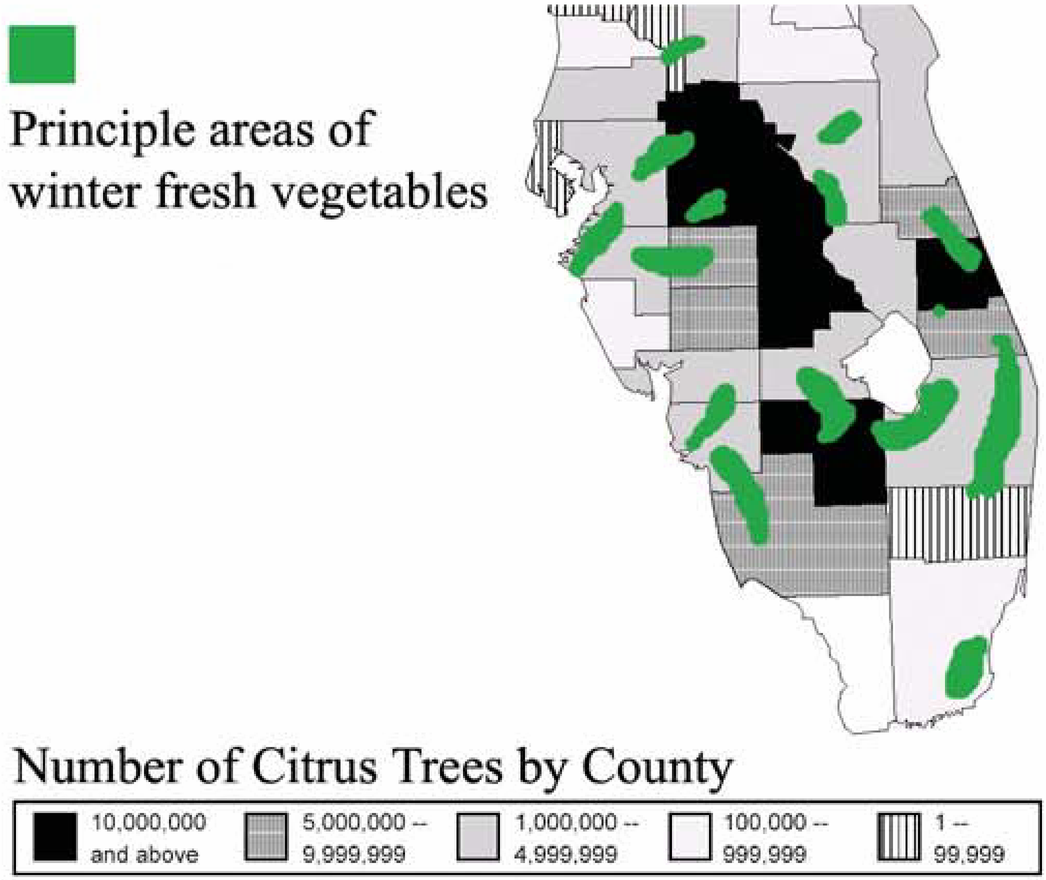


Fig. 1. Number of citrus trees per county and principle areas of winter fresh vegetable production. Figure adapted from Florida Agriculture Facts Directory 2002.

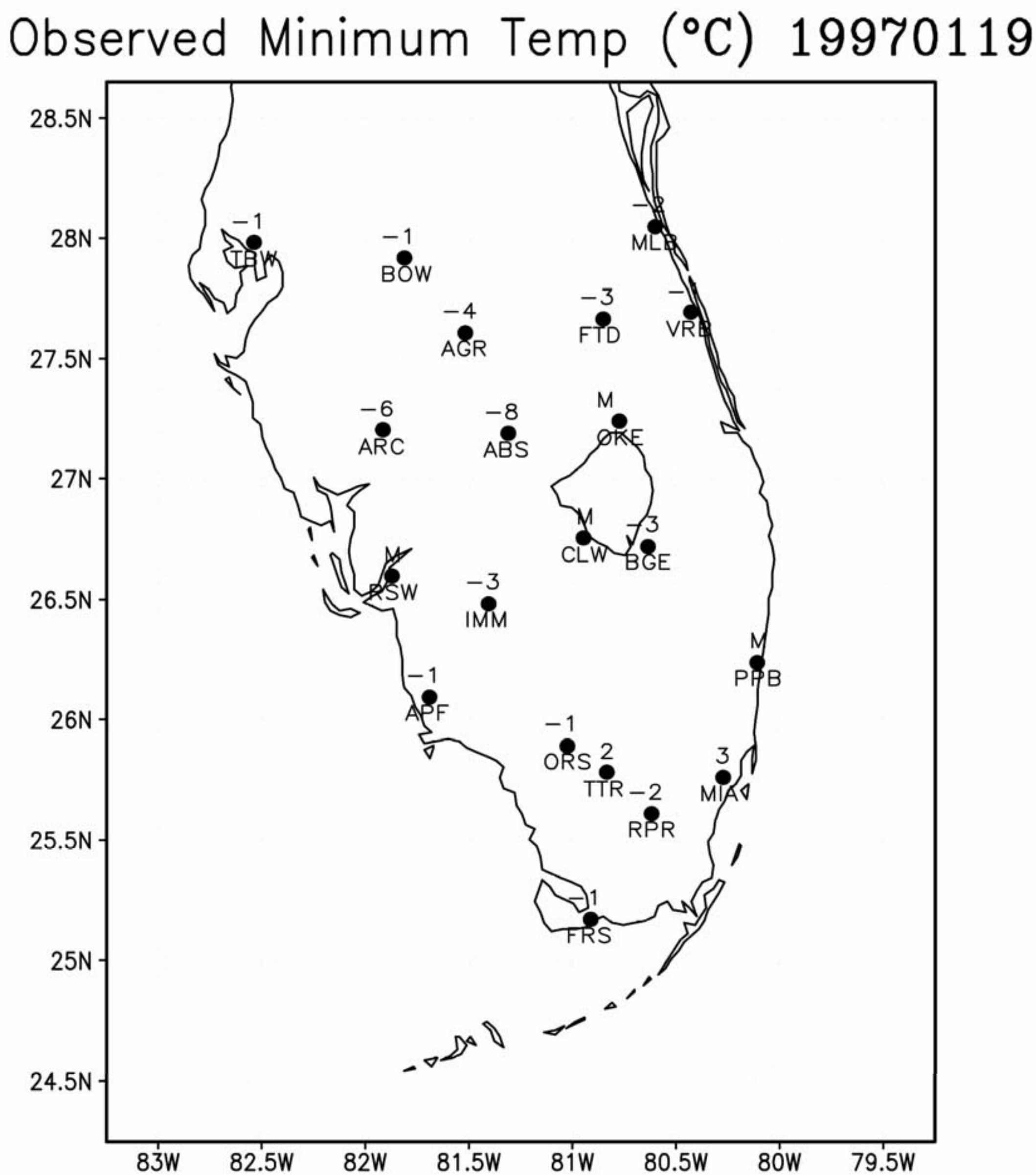


Fig. 2. Observations of minimum temperature from the National Weather Service Cooperative Observer Network on the morning of January 19, 1997.

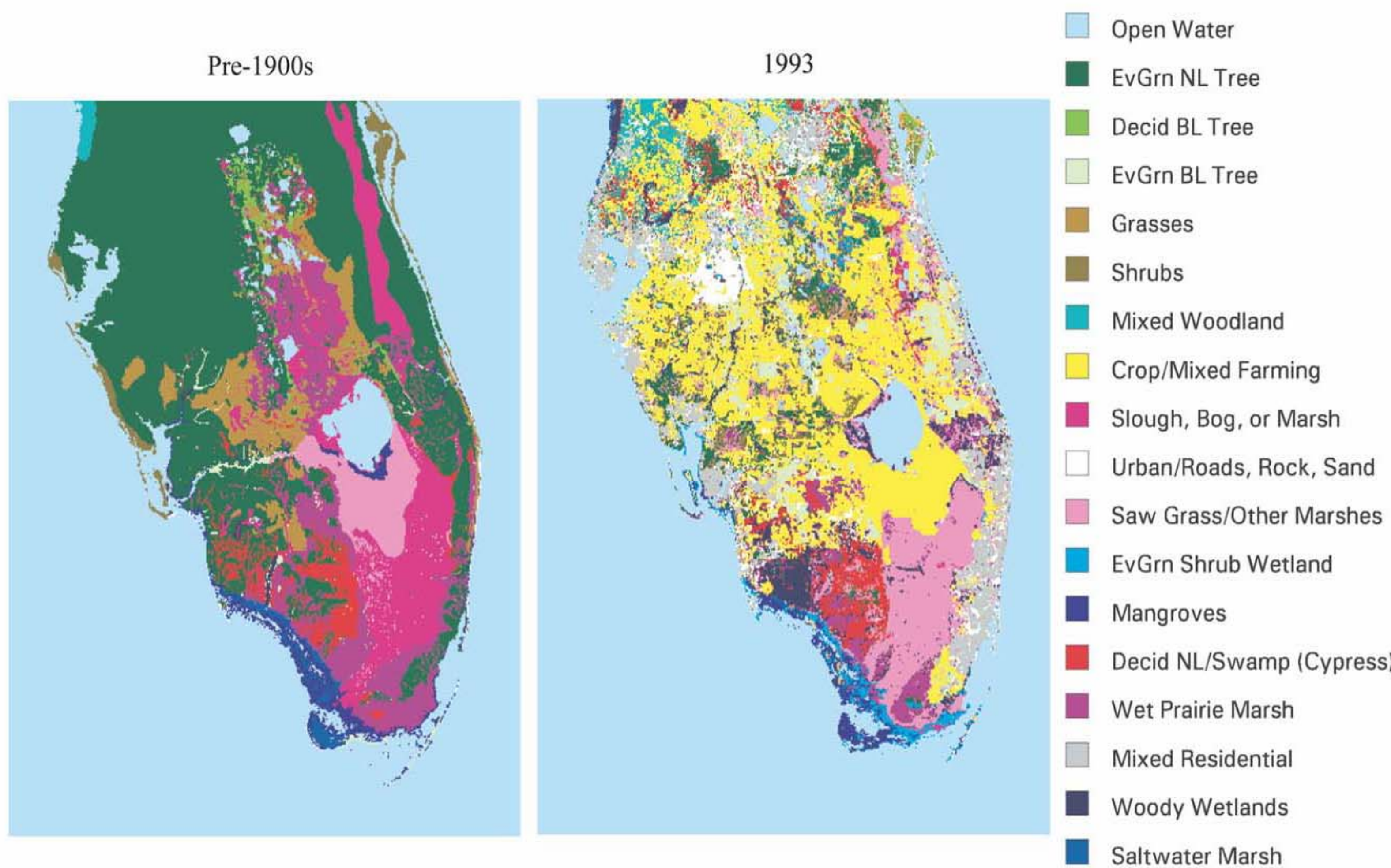


Fig. 3. U.S. Geological Survey land cover classes for pre-1900s natural conditions (left) and 1993 land use patterns.

1997

Min T

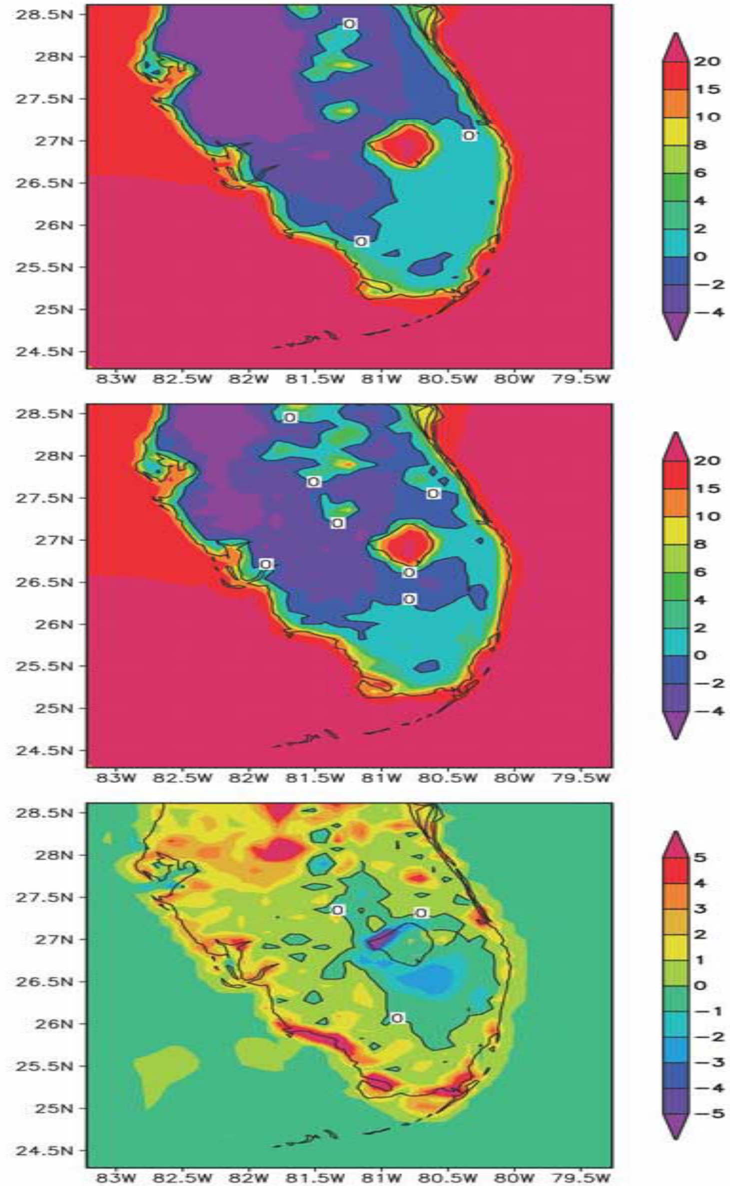


Fig. 4. Model simulated 2 meter minimum temperatures on the morning of January 19, 1997 for the pre-1900s scenario (top panel), the1993 sceanrio (middle panel), and the difference of the two (1993 minus pre-1900s scenario; bottom panel).

1997

duration

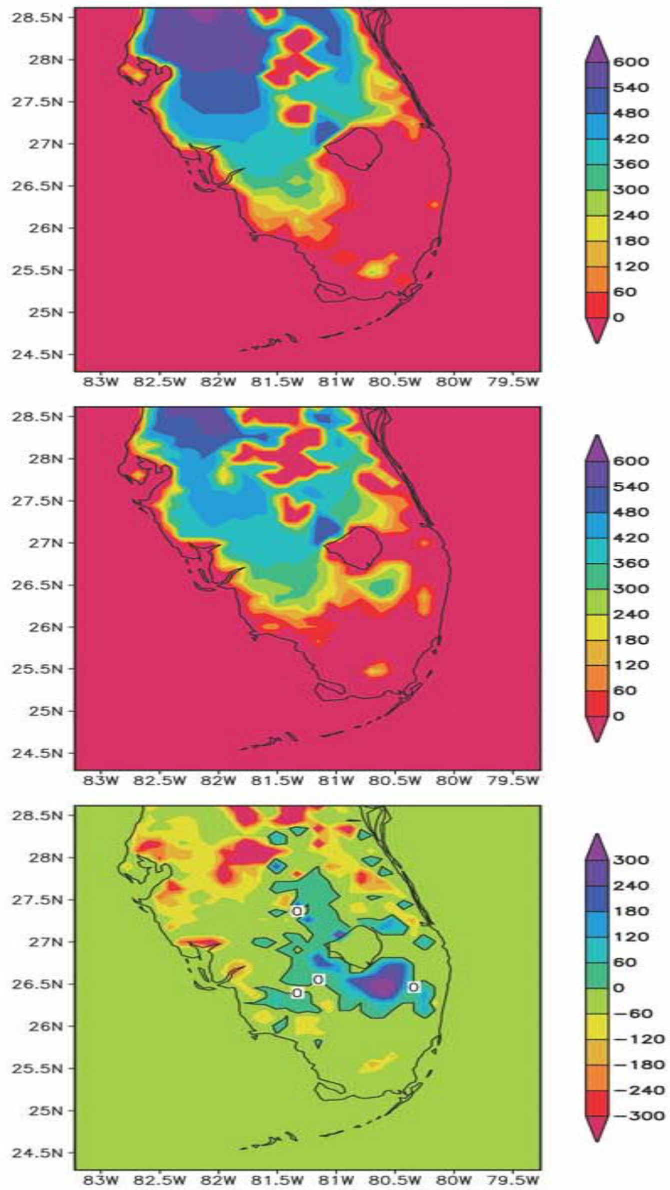


Fig. 5. Time spent below freezing (minutes) for the night prior to the morning of January 19. 1997, for the pre-1900s land cover scenario (top), the 1993 land cover scenario (middle) and the difference of the two (bottom).

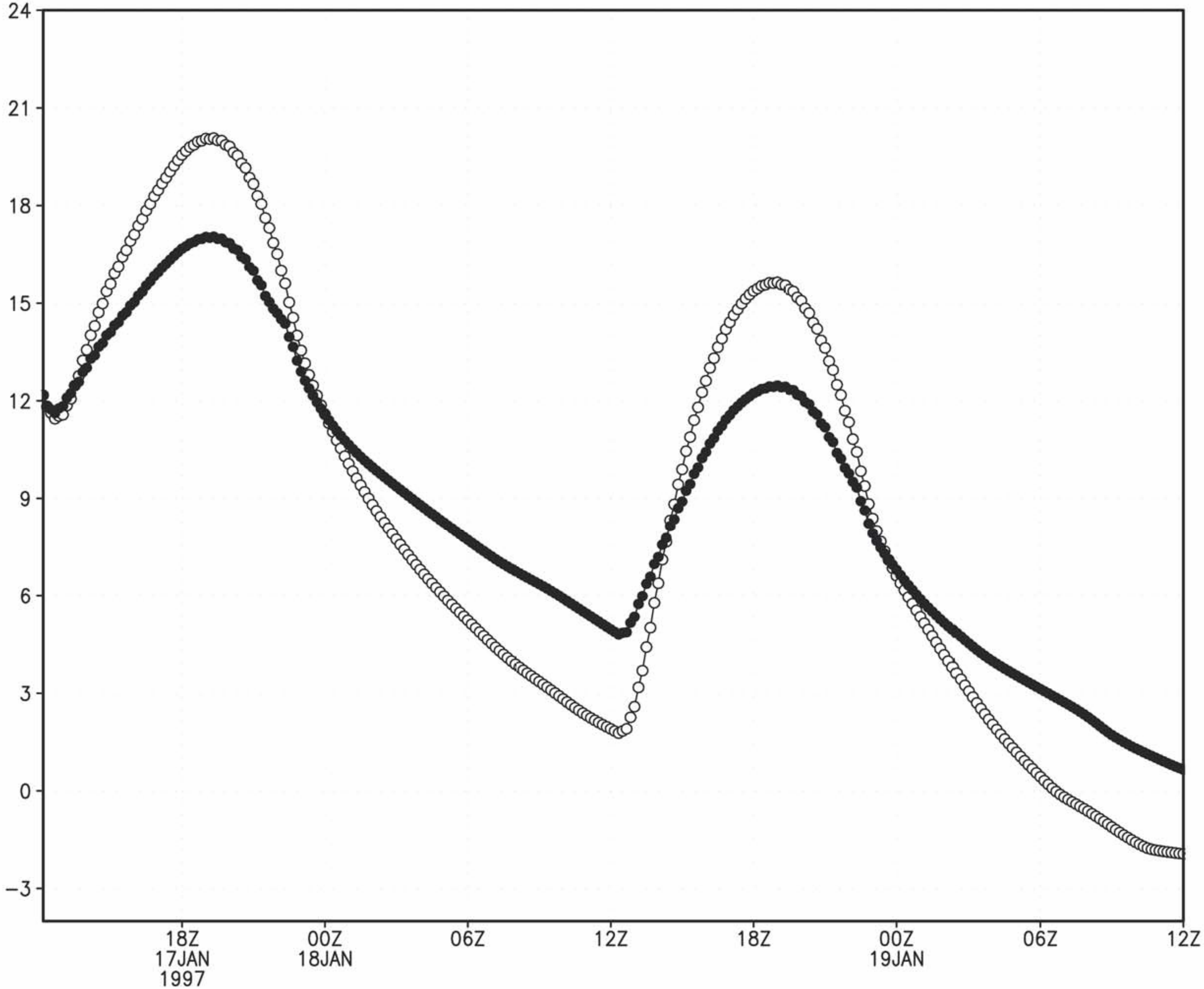


Fig. 7. Time series of 2 meter temperature for a model grid point located just south of Lake Okeechobee for the pre-1900s land cover scenario (filled circles) and the 1993 land cover scenario (open circles).

Does Land Use Change Alter the Global Water and Energy Cycle?

$$Q_N + Q_H + Q_{LE} + Q_G = 0$$

$$Q_N = Q_S(1 - A) + Q_{LW}^{\downarrow} - Q_{LW}^{\uparrow}$$

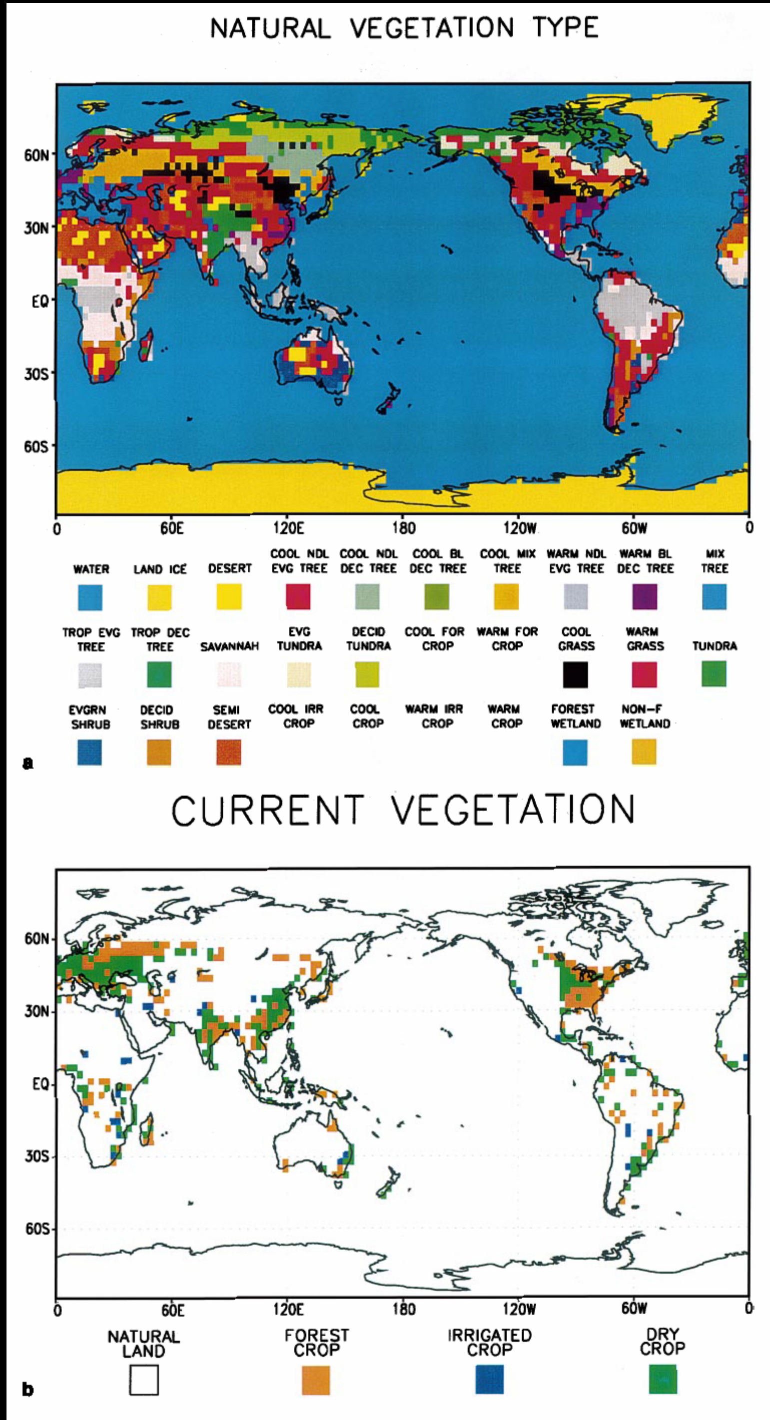
From Pielke Sr., R.A., G. Marland, R.A. Betts, T.N. Chase, J.L. Eastman, J.O. Niles, D. Niyogi, and S. Running, 2002: The influence of land-use change and landscape dynamics on the climate system- relevance to climate change policy beyond the radiative effect of greenhouse gases. *Phil. Trans. A. Special Theme Issue*, 360, 1705-1719. http://blue.atmos.colostate.edu/publications/pdf/R-258.pdf

Spatial Redistribution of Heat is also Associated with a Spatial Redistribution of Water

$$R_N = Q_G + H + L(E+T)$$
$$P = E + T + RO + I$$

New Metric: Changes in δP; δT; δRO; δI

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://blue.atmos.colostate.edu/publications/pdf/R-231.pdf



Vegetation classifications for (a) natural vegetation and (b) current vegetation in regions where current and natural vegetation differ (i.e., anthropogenically disturbed regions in the current case).

From: Chase, T.N., R.A. Pielke, T.G.F. Kittel, R.R. Nemani, and S.W. Running, 2000: Simulated impacts of historical land cover changes on global climate in northern winter. Climate Dynamics, 16, 93-105. http://blue.atmos.colostate.edu/publications/pdf/R-214.pdf

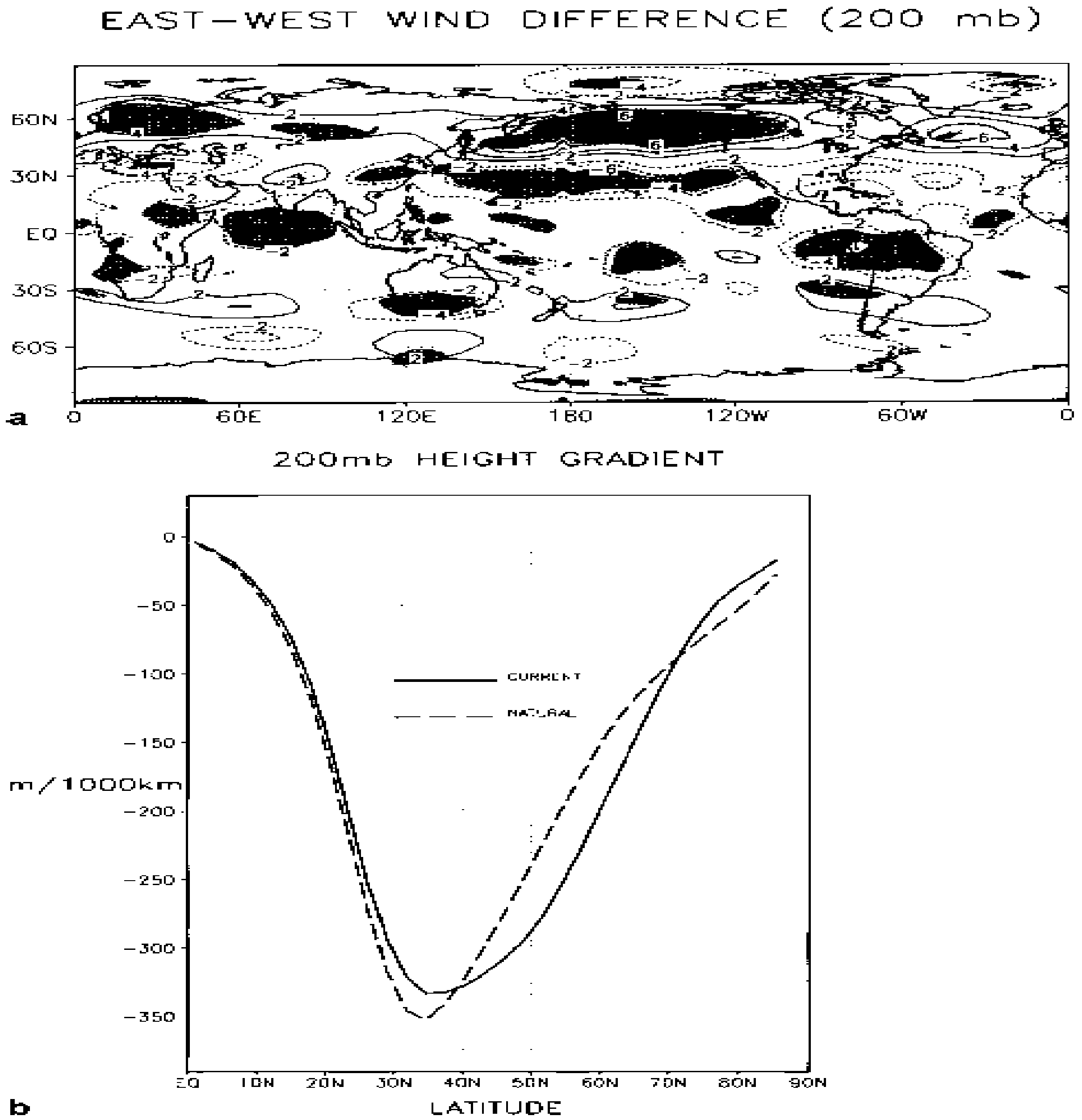
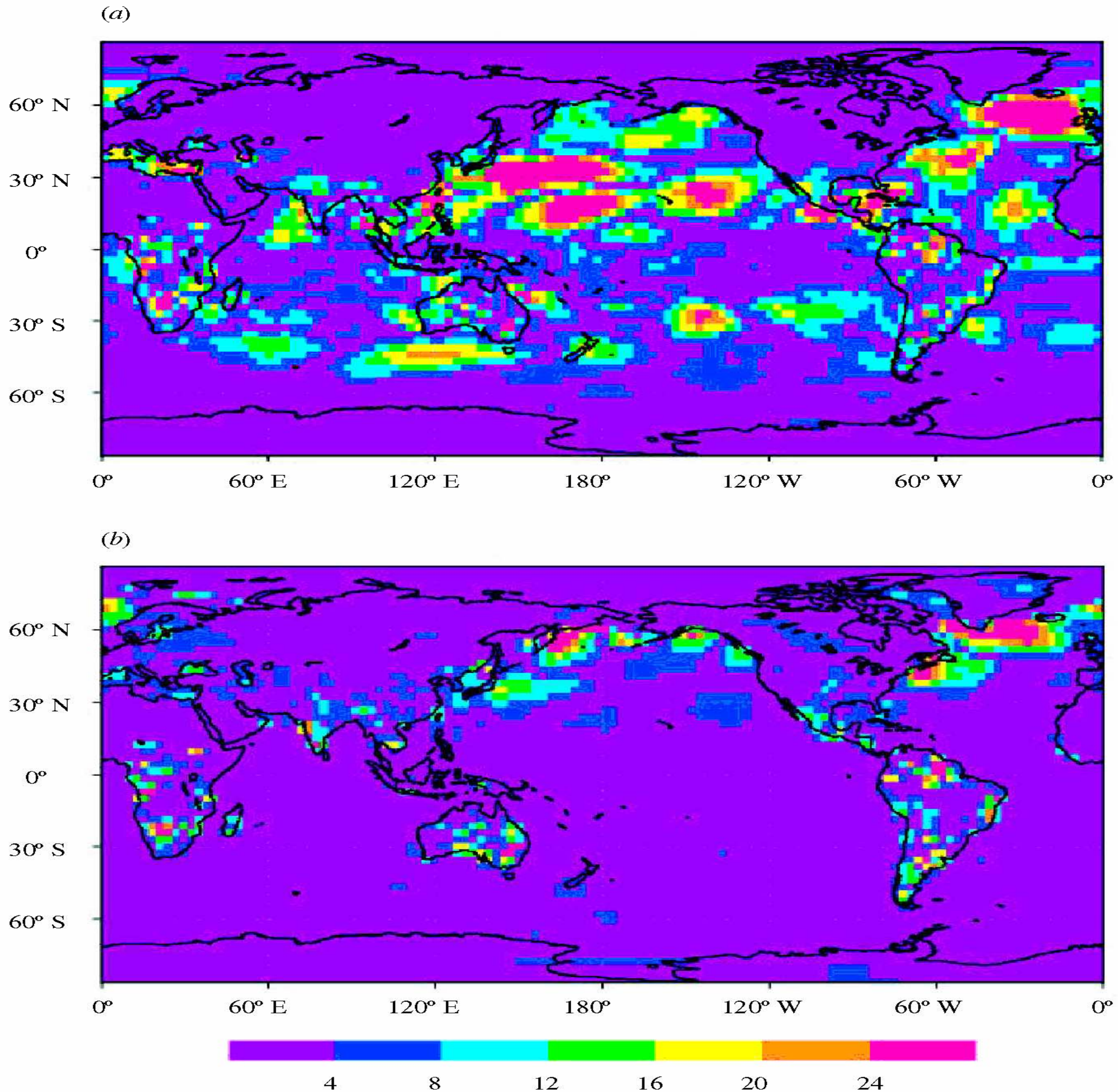


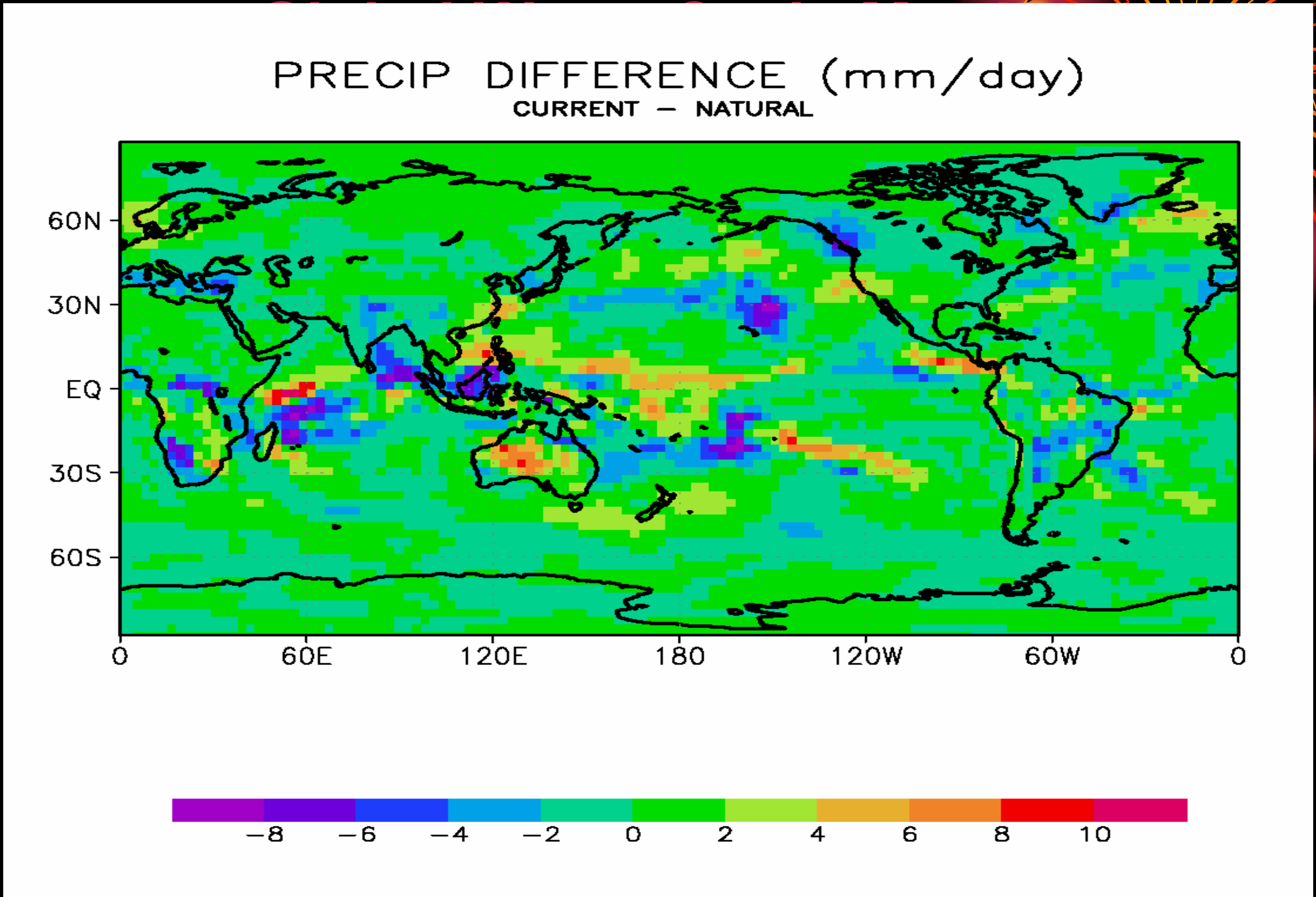
Fig. 9 a Difference in 200 hPa east-west wind (current-natural), contours are 2 m s [1]. *Shaded regions* as in Fig. 3. **b** Comparison of north-south derivative of zonally averaged 200 hPa heights (d(Z200)/dy) in Northern Hemisphere


(a)
60° N
30° N
0°
30° S
60° S
0°
60° E
120° E
180°
120° W
60° W
0°
(b)
60° N
30° N
0°
30° S
60° S
0°
60° E
120° E
180°
120° W
60° W
0°
4
8
12
16
20
24

Redistribution of Heat Due to the Human Disturbance of the Earth's Climate System

Globally-Average Absolute Value of Sensible Heat Plus Latent Heat		
Only Where Land Use Occurred	July January	1.08 Watts m^{-2} 0.7 Watts m^{-2}
Teleconnections Included	July January	8.90 Watts m^{-2} 9.47 Watts m^{-2}

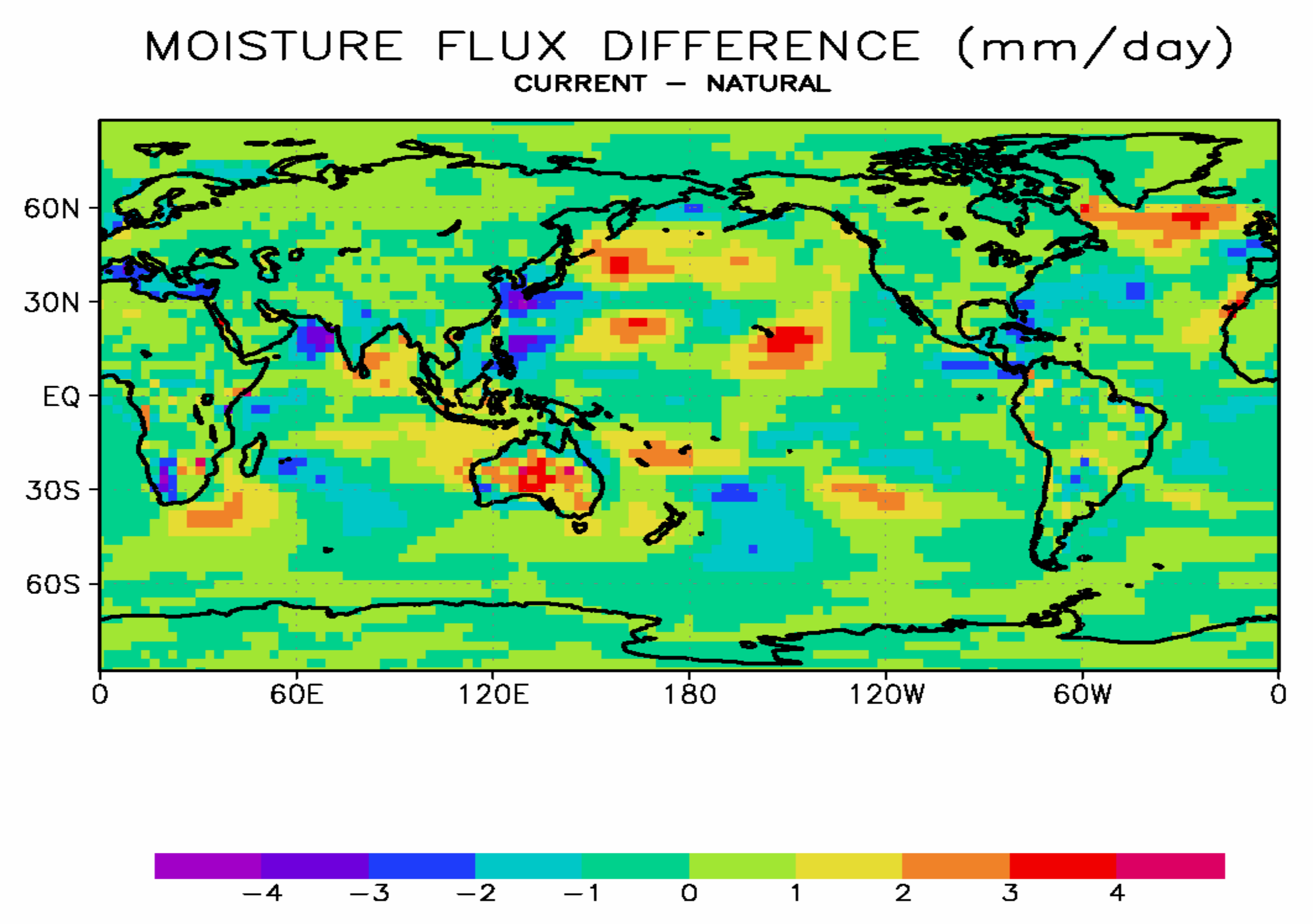
Global redistribution of heat is on the same order as an El Niño.



Absolute Value of Globally-Averaged Change is 1.2 mm/day.

Prepared by T.N. Chase, CU, Boulder, CO.

Global Water Cycle Metric



Absolute Value of Globally-Averaged Change is 0.6 mm/day

Prepared by T.N. Chase, CU, Boulder, CO.

- **What is the importance of more heterogeneous climate forcings relative to more homogeneous climate forcing such as the radiative forcing of CO_2 ?**

An Example For Aerosol Climate Forcing

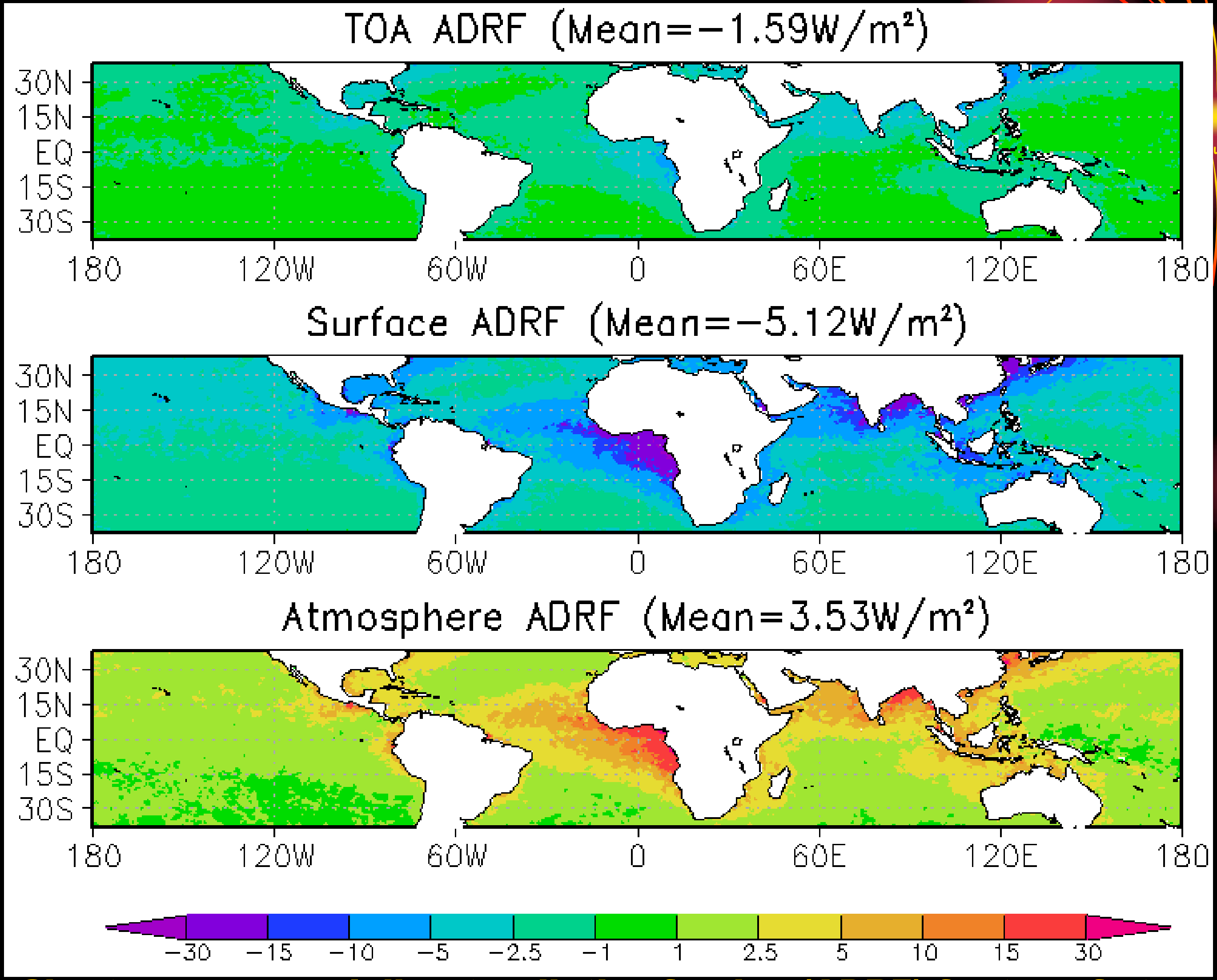


Figure 1. Shortwave aerosol direct radiative forcing (ADRF) for top-of atmosphere (TOA), surface, and atmosphere. From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. Geophys. Res. Letts., 33, L11813, doi:10.1029/2006GL025974.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

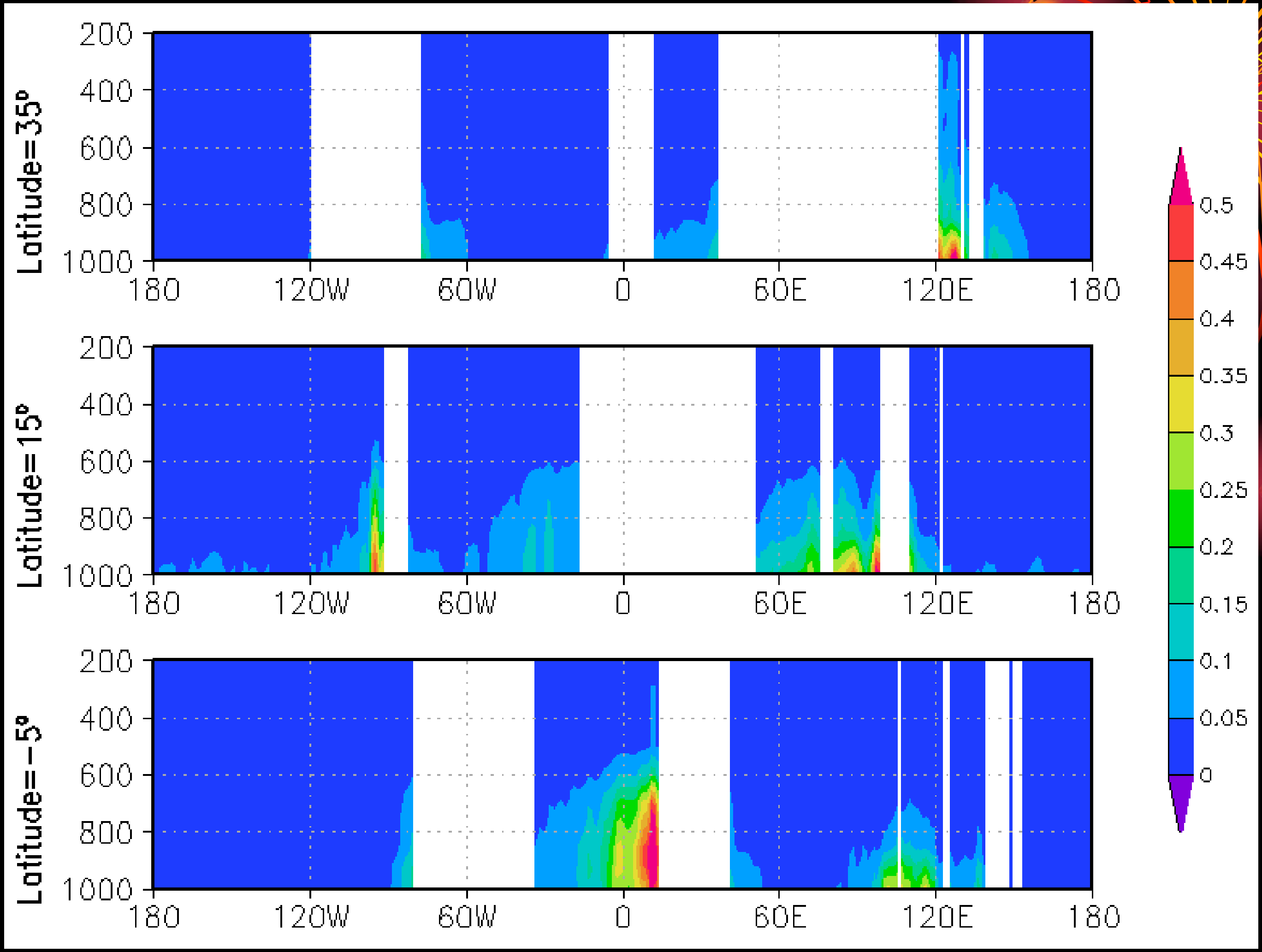


Figure 2. Vertical profile of atmospheric heating rate (K day^{-1}) due to shortwave ADRF. Vertical coordinate is pressure level (mb). From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. Geophys. Res. Letts., 33, L11813, doi:10.1029/2006GL025974.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

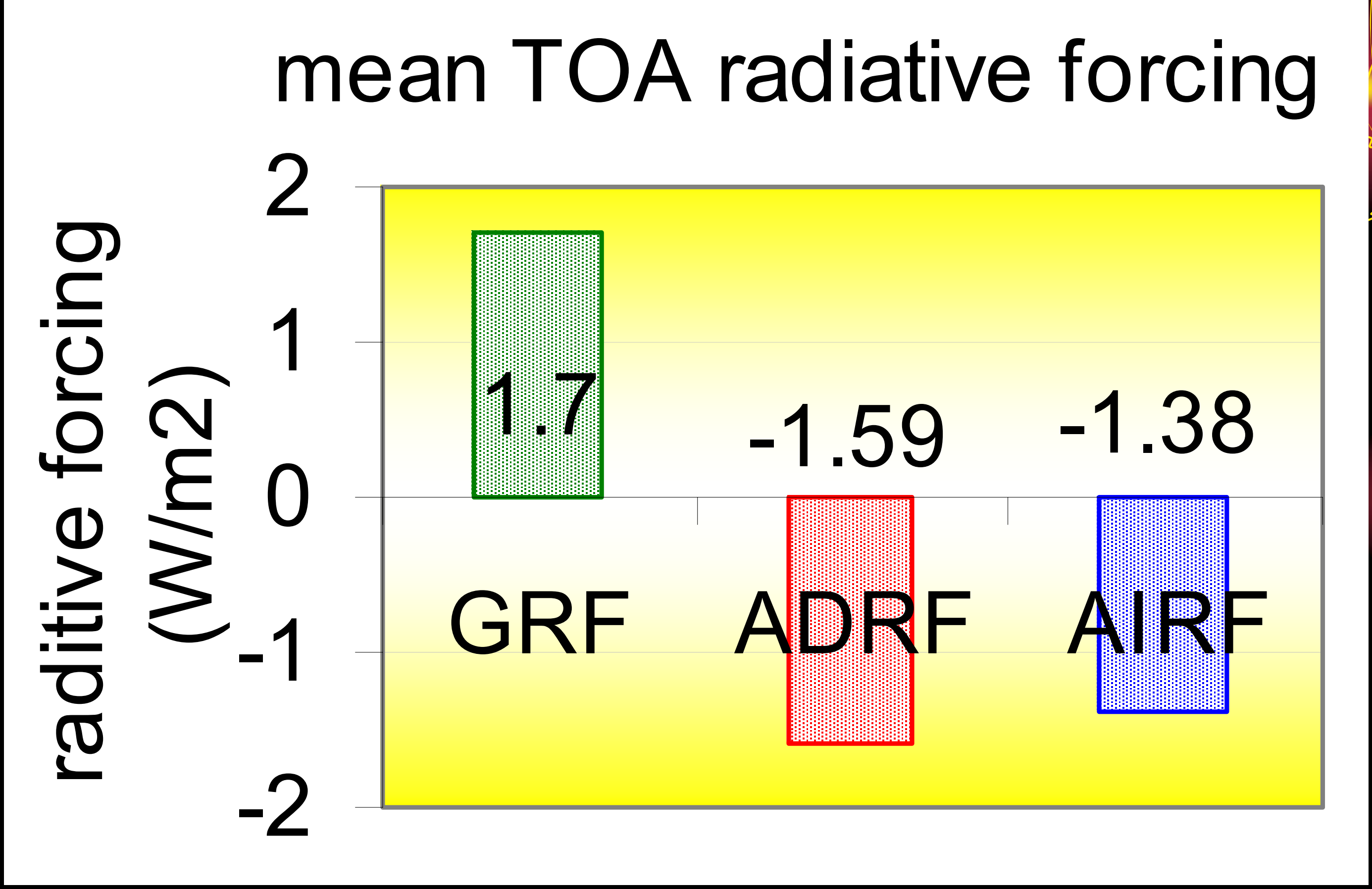
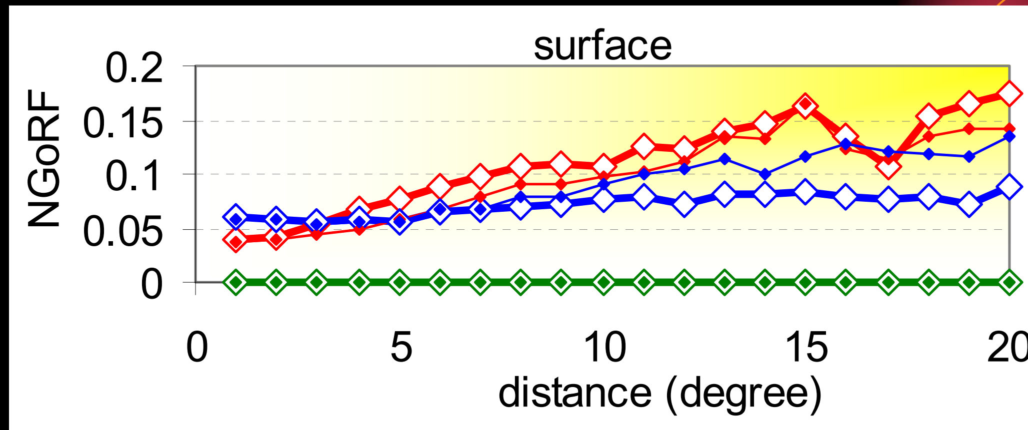


Figure 4. Comparison of Mean TOA radiative forcing between infrared GRF, shortwave ADRF, and shortwave AIRF. From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. Geophys. Res. Letts., 33, L11813, doi:10.1029/2006GL025974.
http://blue.atmos.colostate.edu/publications/pdf/R-312.pdf



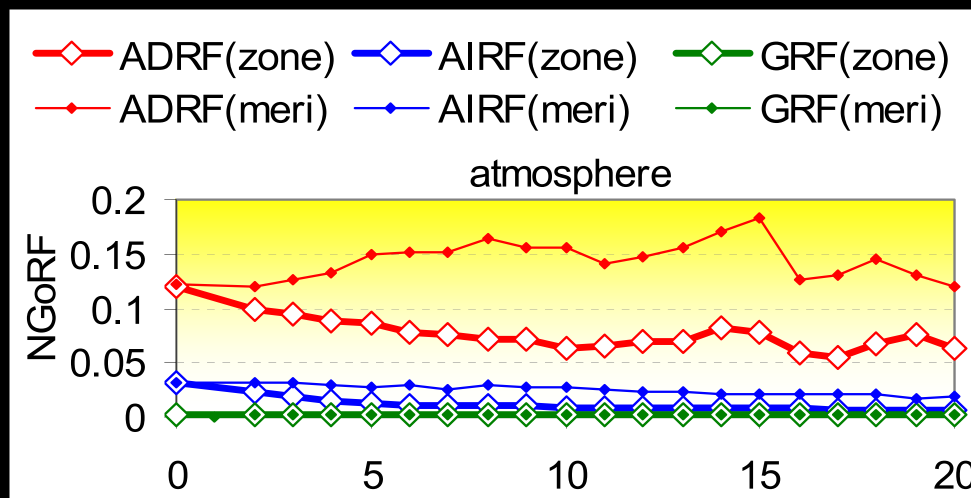
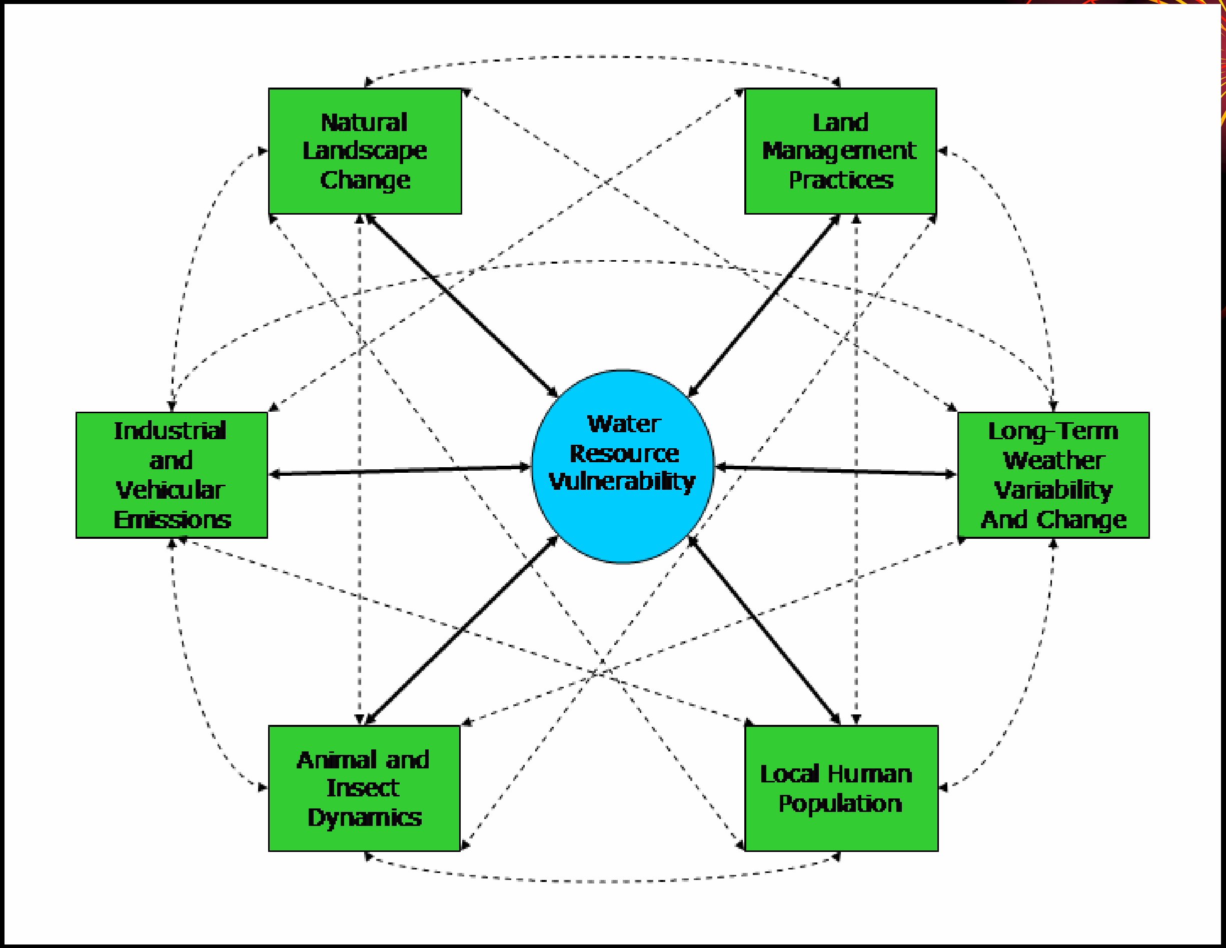


Figure 5. Comparison of the meridional and the zonal component of NGoRF between infrared GRF, shortwave ADRF, and shortwave AIRF for atmosphere and surface. From: Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. Geophys. Res. Letts.,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

Do We Need a New Perspective On The Role of Environmental Variability and Change on Society and the Environment?

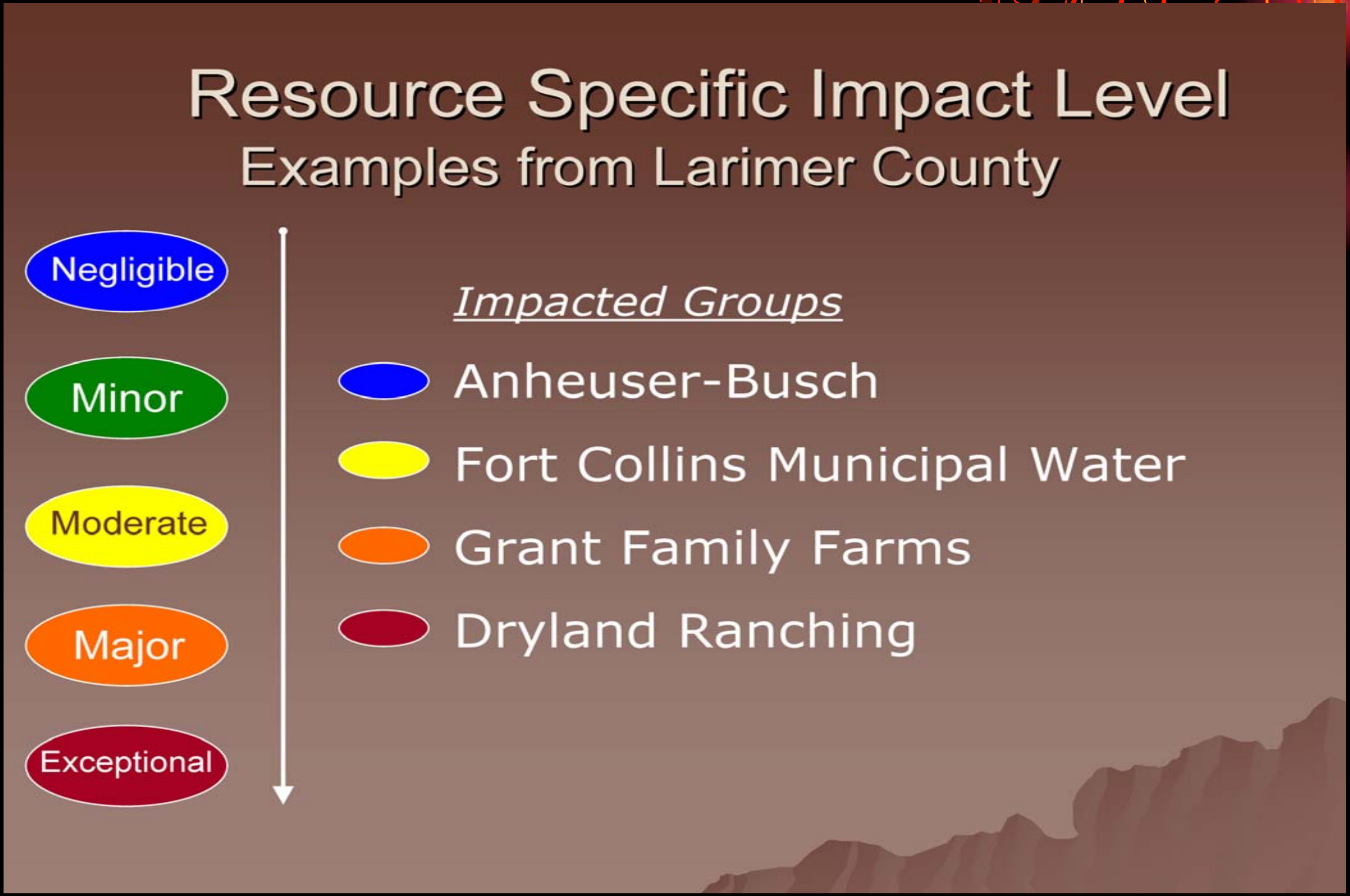
A Focus on Vulnerability



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://blue.atmos.colostate.edu/publications/pdf/NR-139.pdf

Resource Specific Impact Level with Respect to Water Resources - June 2004



➢ Question

If you were given 100 million dollars to spend on environmental benefits in Delaware, where would you use that money?

1. subsidies for alternative energy
2. purchasing wilderness areas (e.g., through the Nature Conservancy)
3. building/enlarging water impoundments
4. building pipelines to transport water over large distances
5. purchasing open spaces in growing urban areas
6. funding additional mass transit

→ Where Should This Money Come From?

1. carbon usage tax
2. mileage driven tax
3. lottery
4. tax on large private vehicles
5. state income tax increase
6. property tax increase

What is your opinion on climate change?

Where do you stand on climate change?		
There is no warming; its a fabrication based on inaccurate measurement. It is arrogant to presume that we can have any effect on Nature.	[**0**]	[0.00%]
The recent warming is entirely natural. CO2 has nothing to do with it. It could well be the Sun.	[**3**]	[6.67%]
There may be some changes in the atmosphere, but the changes are all within natural limits. The 'scares' are exaggerations with a political motive.	[**6**]	[13.33%]
It's so confusing I can't make my mind up; it is getting warmer but I don't know why. All of the arguments sound convincing & I can't decide who to trust.	[**3**]	[6.67%]
There is warming and CO2 may cause some of it, but the science is too uncertain to be sure. The IPCC probably underestimates some of the natural forcings and overestimates the role of CO2.	[**19**]	[42.22%]
The mainstream scientific view, as per the IPCC, has got it more or less right. I	[**4**]	[8.89%]

accept that the scientists probably know what they are doing and we are warming the planet		
The IPCC is compromised by political intervention; I agree with the scientists who say that it is underestimating the problem and something needs to be done about it soon.	[**2**]	[4.44%]
Too much of the science is conservative in its findings; I think it's probably worse than they are saying.	[**0**]	[0.00%]
If we don't do something about emissions in the next few years, we are in real trouble. Action is needed now to mitigate the threat of serious warming and other impacts.	[**4**]	[8.89%]
We are on the edge of a disaster, which we may not be able to prevent. We are messing up the earth's natural systems and will pay the price in some ways even if we act now.	[**4**]	[8.89%]

From http://fergusbrown.wordpress.com/2007/04/13/what-is-the-public-opinion-on-climate-change/

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 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 and cooling.

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.

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 CO_2 relative to the role of the diversity of other human climate forcing on global warming, and more generally, on climate variability and change.

Global and regional climate models have not demonstrated skill at predicting climate change and variability on multi-decadal time scales.

Attempts to significantly influence regional and local-scale climate based on controlling CO_2 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.

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.

Humans are significantly altering the global climate, but in a variety of diverse ways beyond the radiative effect of carbon dioxide. The IPCC assessments have been too conservative in recognizing the importance of these human climate forcings as they alter regional and global climate. These assessments have also not communicated the inability of the models to accurately forecast the spread of possibilities of future climate. The forecasts, therefore, do not provide any skill in quantifying the impact of different mitigation strategies on the actual climate response that would occur.

- **The Current IPCC Focus is to Promote Energy Policy Changes, Not to Provide an Effective Climate Policy**
- **Policymakers Need To Be Informed Of This Very Important Distinction**
- **We Need To Separate Climate Policy From Energy Policy.**

Roger A. Pielke Sr. Research Group Weblog

http://climatesci.colorado.edu

Roger A. Pielke Sr. Website

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

PowerPoint Presentation Prepared by
Dallas Jean Staley
Research Assistant and Webmaster
University of Colorado
Boulder, Colorado 80309