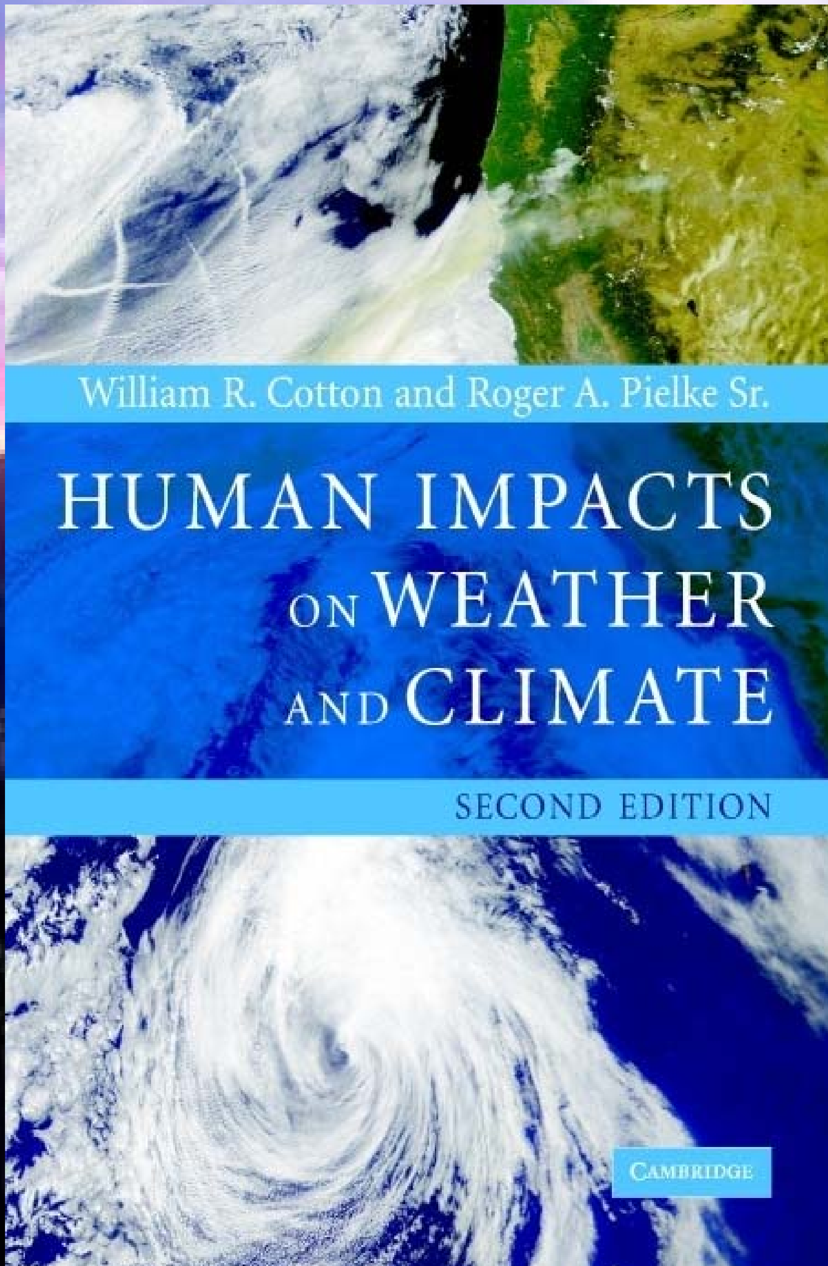
Global Warming and Climate Change - Have You Been Presented The Full Story?

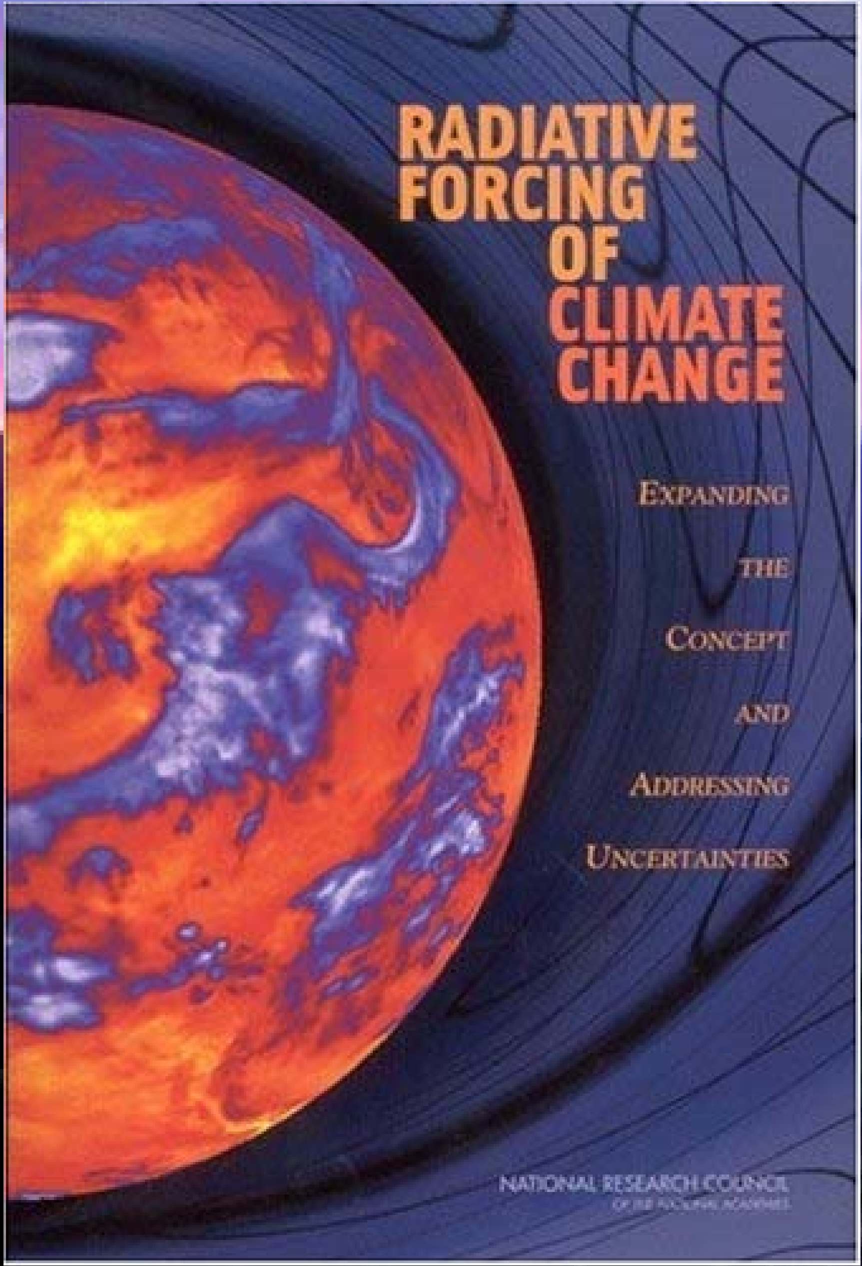
Roger A. Pielke Sr., University of Colorado at Boulder

2007 Collegiate Peaks Forum Series Lecture

Buena Vista, Colorado, August 31, 2007



Cotton, W.R. and R.A. Pielke, 2007: Human impacts on weather and climate, Cambridge University Press, 330 pp.



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

IPCC Perspective

2007 IPCC SPM View

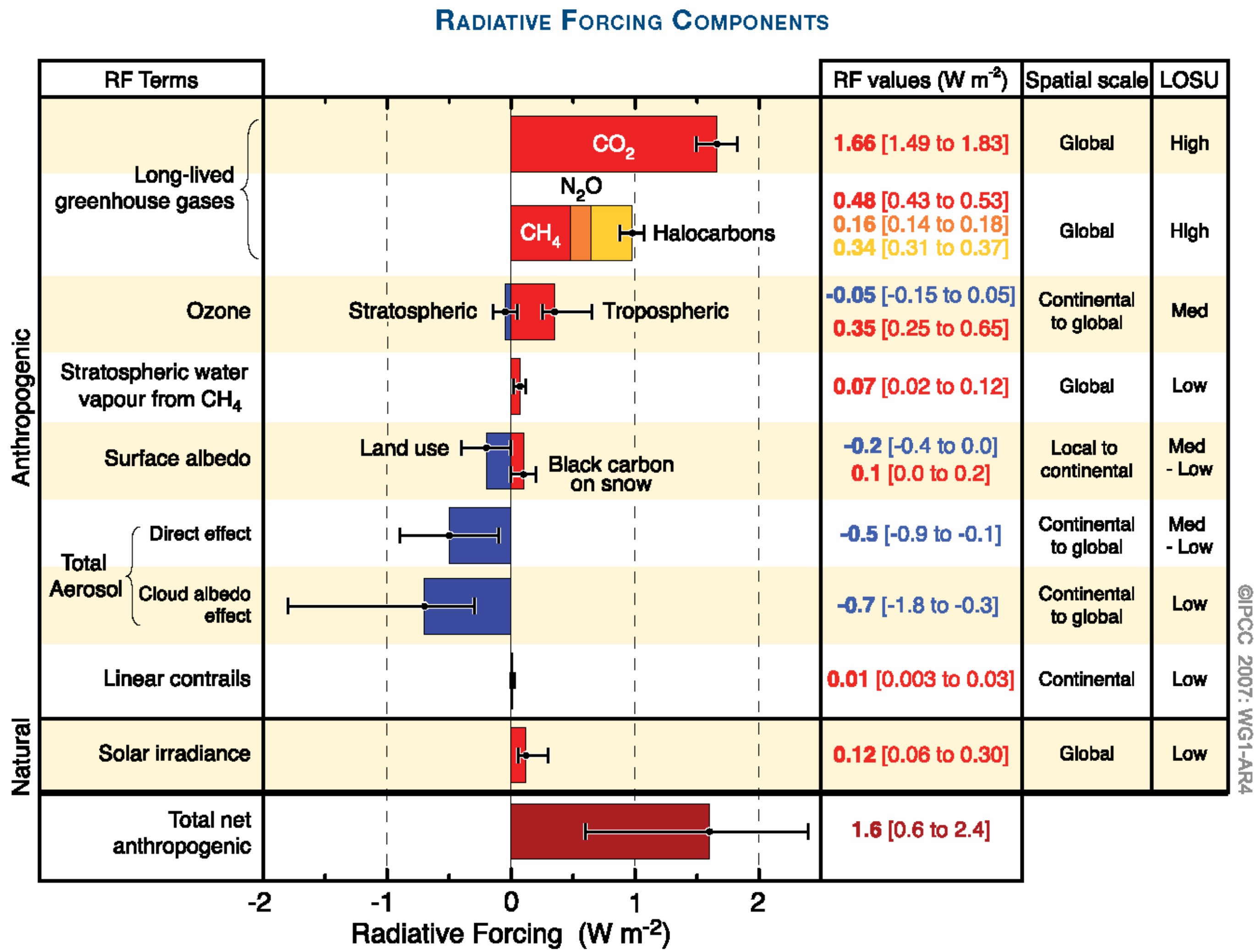
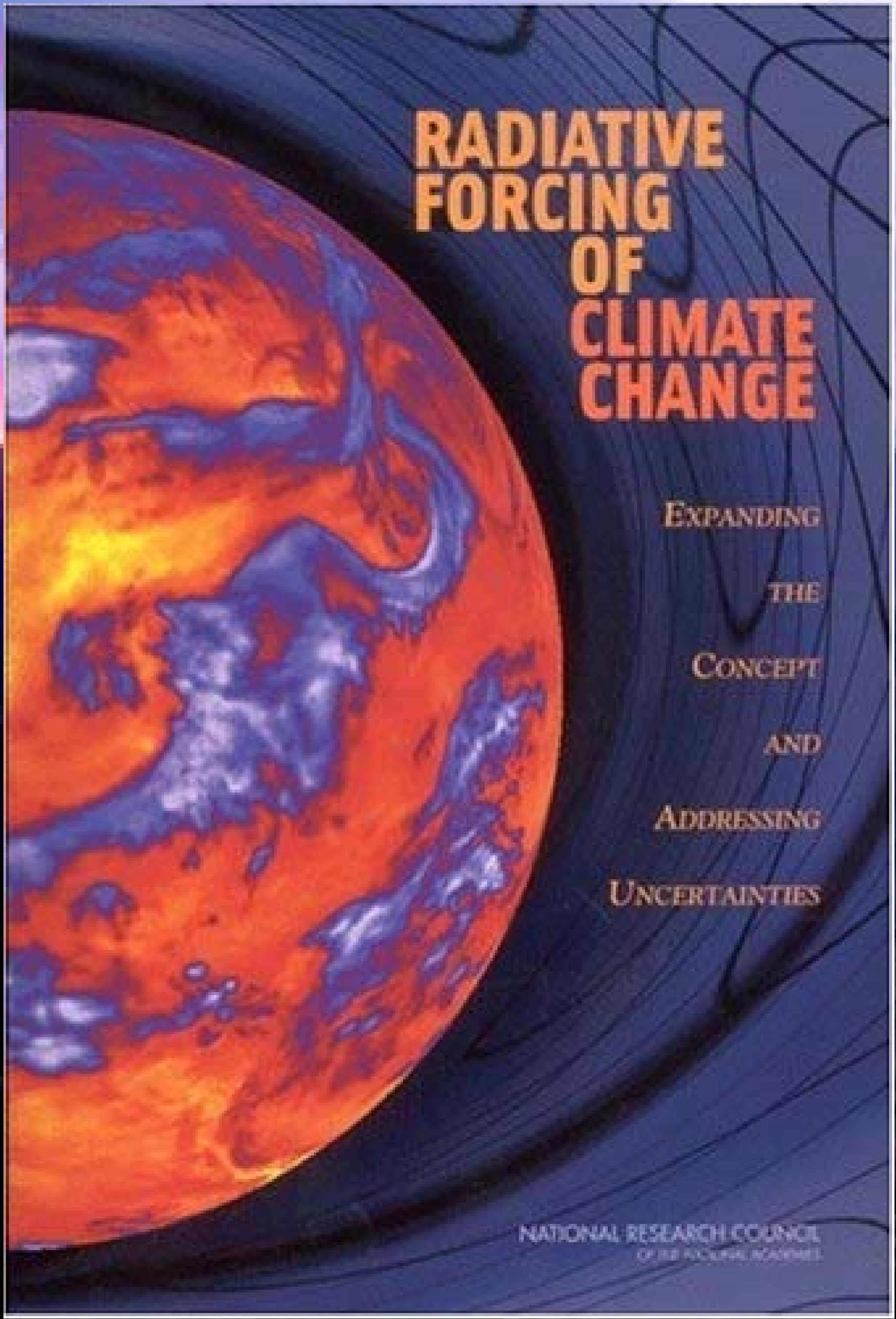


Figure SPM.2. *Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level 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}*



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

NRC 2005 Perspective
Breath of Fresh Air

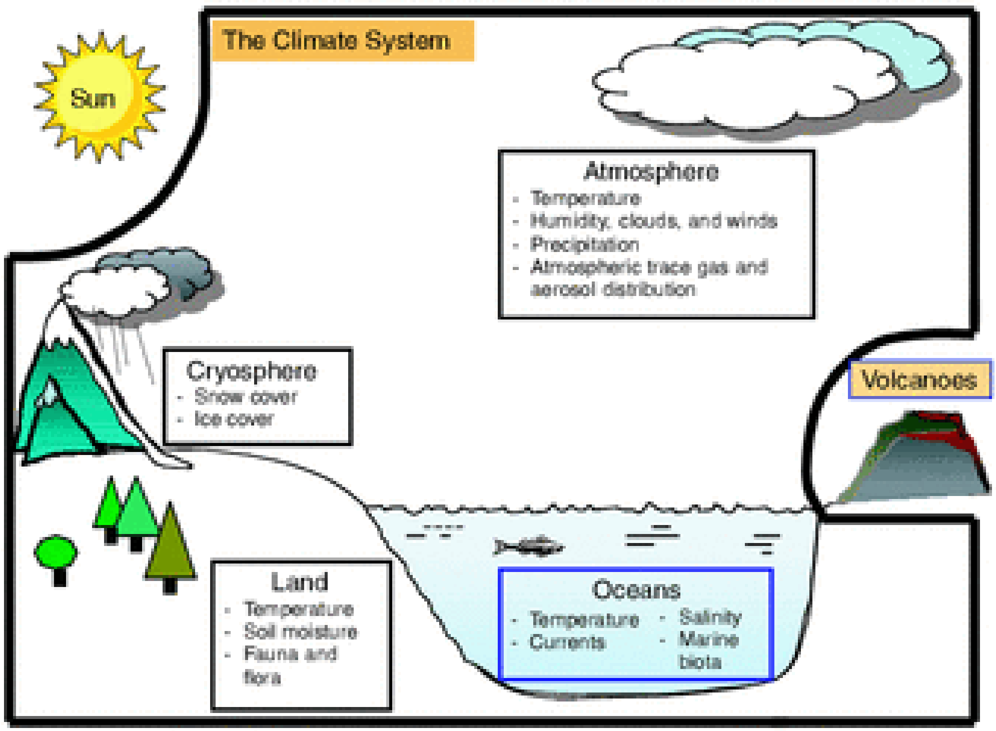


FIGURE 1-1 The climate system, consisting of the atmosphere, oceans, land, and cryosphere. Important state variables for each sphere of the climate system are listed in the boxes. For the purposes of this report, the Sun, volcanic emissions, and human-caused emissions of greenhouse gases and changes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

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

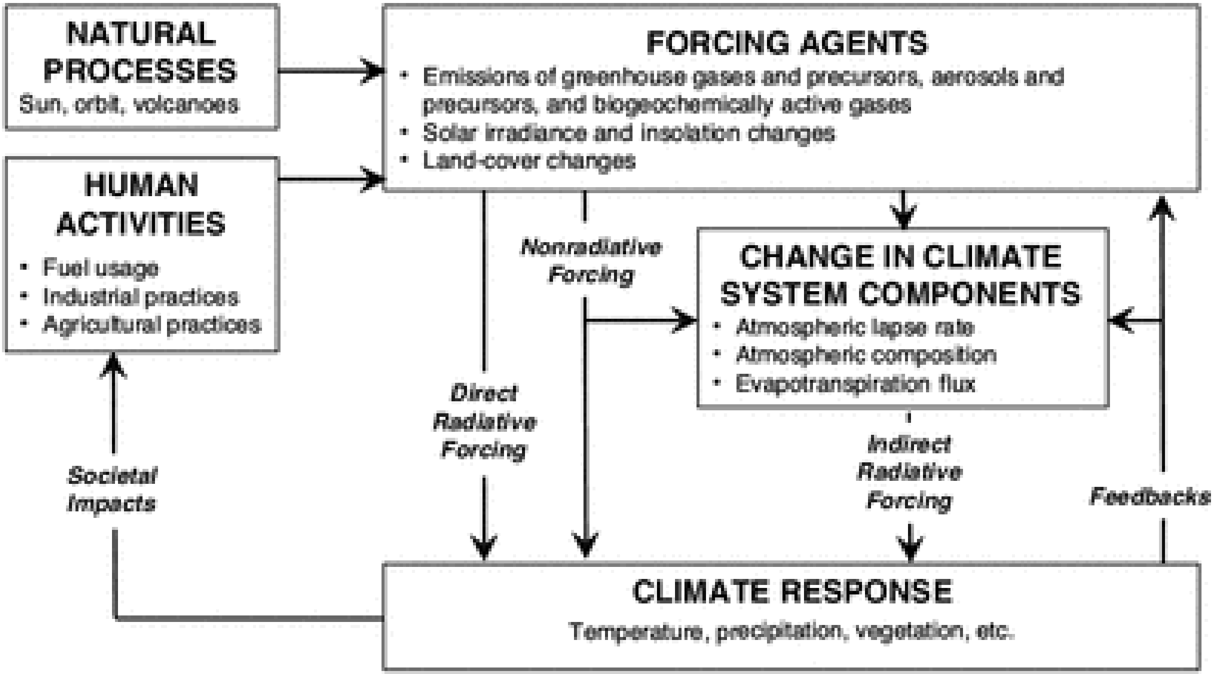


FIGURE 1-2 Conceptual framework of climate forcing, response, and feedbacks under present-day climate conditions. Examples of human activities, forcing agents, climate system components, and variables that can be involved in climate response are provided in the lists in each box.

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

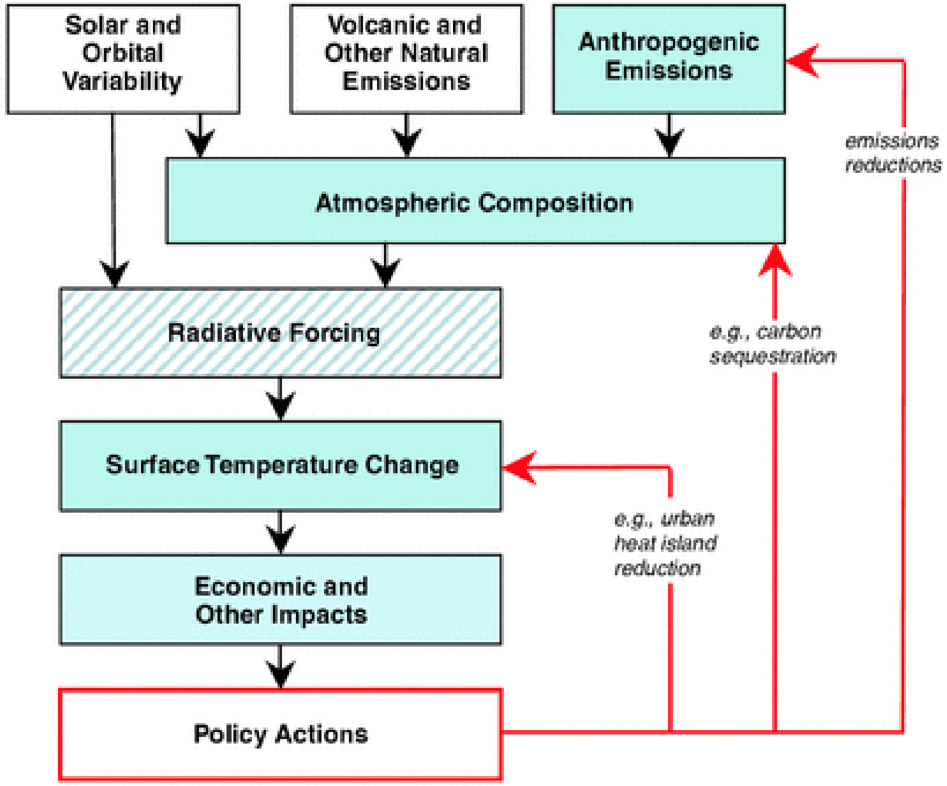


FIGURE 1-4 Conceptual framework for how radiative forcing fits into the climate policy framework. Blue-shaded boxes indicate quantities that have been considered as policy targets in international negotiations and other policy analyses. Radiative forcing (striped box) has not been treated as a policy target in the same explicit way that limiting emissions (e.g., Kyoto Protocol), limiting concentrations (e.g., greenhouse gas stabilization scenarios), and limiting temperature changes and impacts (e.g., environmental scenarios) have. That is, an explicit cap on anthropogenic radiative forcing levels has not been proposed analogous, for example, to the Kyoto Protocol cap on emissions. Note that land-use change has not received much attention as a forcing agent and is not included here, though this report recommends that it should be.

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

Not Included Climate Forcings, e.g.,

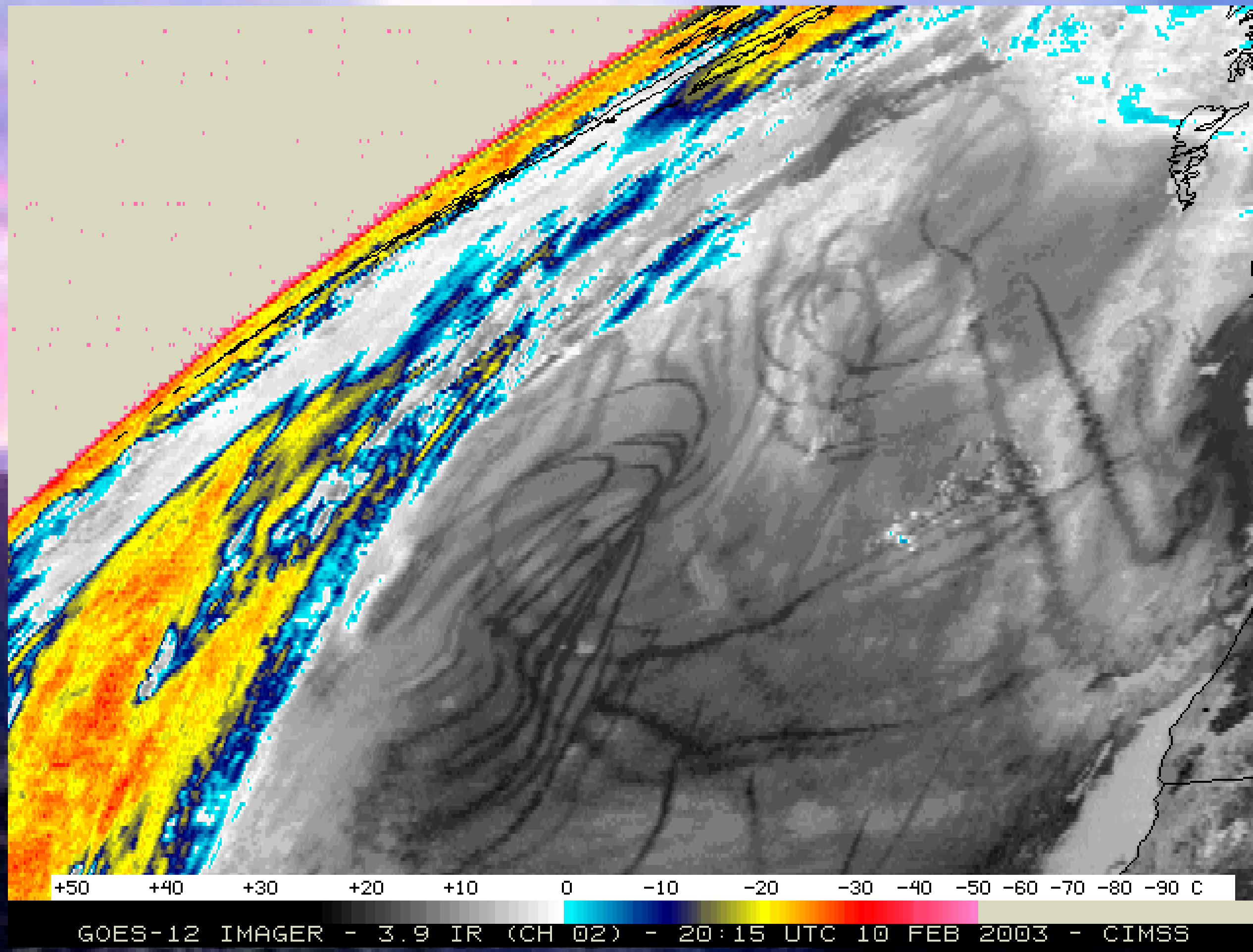
- Land-use change as it affects transpiration, physical evaporation and sensible heat fluxes
- biogeochemical forcing due to increased CO_2
- biochemical forcing due to nitrogen deposition
- biogeochemical forcing due to changes in the direct/diffuse solar irradiance through aerosols
- effect of anthropogenic aerosols on precipitation efficiency

These effects alter not only the global radiative fluxes but the regional structure of spatial heating and cooling.

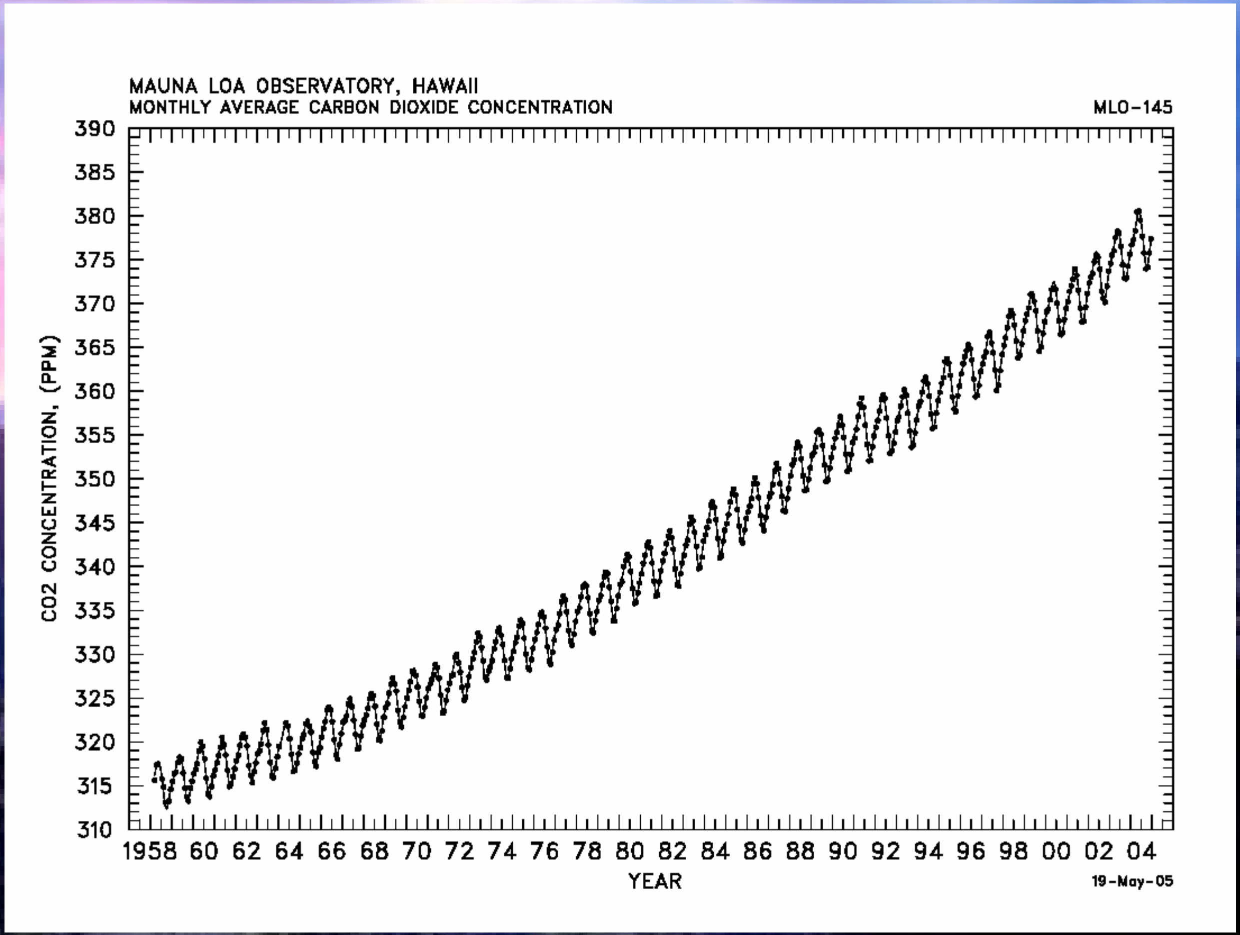
Example of a pyrocumulus cloud (copyright 2001, Axel Thielmann).

Example of industrial emissions from a smokestack

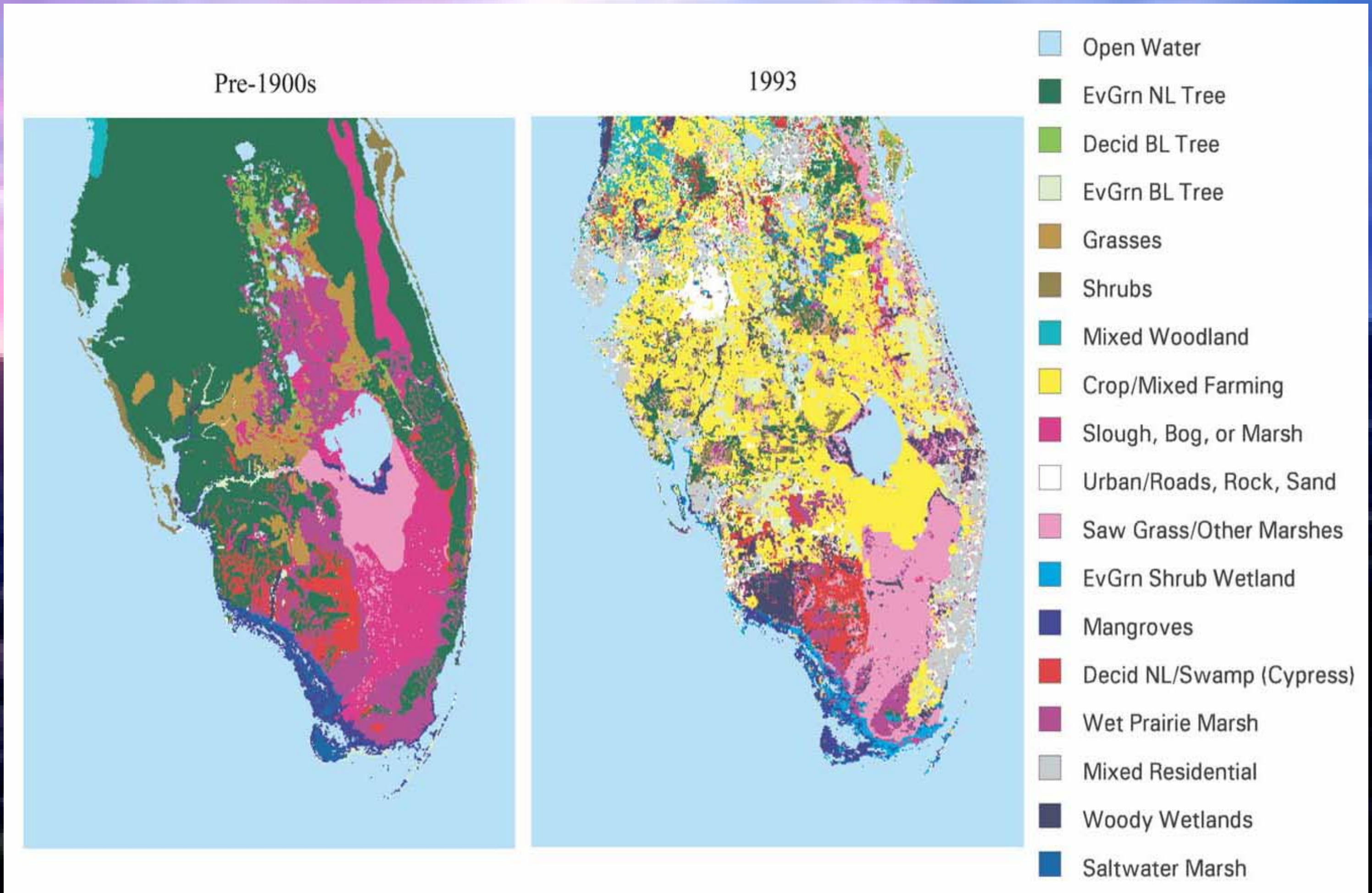
From http://earthobservatory.nasa.gov/Laboratory/Aerosol/Images/anthro_smokestack.jpg



GOES-12 imagery over the northern East Pacific Ocean on 10 February 2003. Particles in the exhaust plumes of ships tend to act as cloud condensation nuclei (CCN), creating streaks consisting of smaller cloud droplets within the pre-existing cloud deck. The resulting changes in the emissivity of the marine layer stratocumulus are easily detected using the 3.9 micrometer (shortwave)IR channel data. The ship tracks exhibit a colder 3.9 micrometer Infrared (IR) brightness temperature at night (above, darker blue enhancement), while during daylight hours these features exhibit a warmer brightness temperature (below, darker gray enhancement) due to this channel's sensitivity to the component of reflected sunlight (Image courtesy of the Cooperative Institute for Research in the Atmosphere website original imagery from the NOAA/NESDIS Forecast Products Development Team.)



Atmospheric carbon dioxide record from Mauna Loa. C.D. Keeling and T.P. Whorf, Carbon Dioxide Research Group, Scripps Institution of Oceanography, University of California, La Jolla, California 92093-0444. Period of Record, 1958-2004
http://cdiac.esd.ornl.gov/trends/co2/graphics/mlo145e_thrudc04.pdf



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://climatesci.colorado.edu/publications/pdf/R-277.pdf

What is the Accepted View on the Ability of Climate Models to Make Skillful Multi-Decadal Regional Predictions?

1. From page 145 of the 2006 Response to the Public Comment of the CCSP Report Synthesis and Assessment Product 1.1 ‘Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences’

“Owing to natural internal variability, models cannot be expected to reproduce regional patterns of trend over a period as short as 20 years from changes of radiative forcings alone.”

2. From MacCracken, Michael, Joel Smith and Anthony C. Janetos, 2004. Reliable regional climate model not yet on horizon. Nature Vol. 429, No 6993, p. 699, June 17, 2004.

“The US National Assessment of the Potential Consequences of Climate Variability and Change (USNA) - in which we were involved-did not attempt to provide regional or even national predictions of climate change.”

Later in the letter in Nature, they conclude with,

“We strongly agree that much more reliable regional climate simulations and analyses are needed. However, at present,...such simulations are more aspiration than reality.”

3. From the February 2004 issue of Scientific American Magazine, Jim Hansen has an interesting quote on page 24 in ‘Defusing the Global Warming Time Bomb’

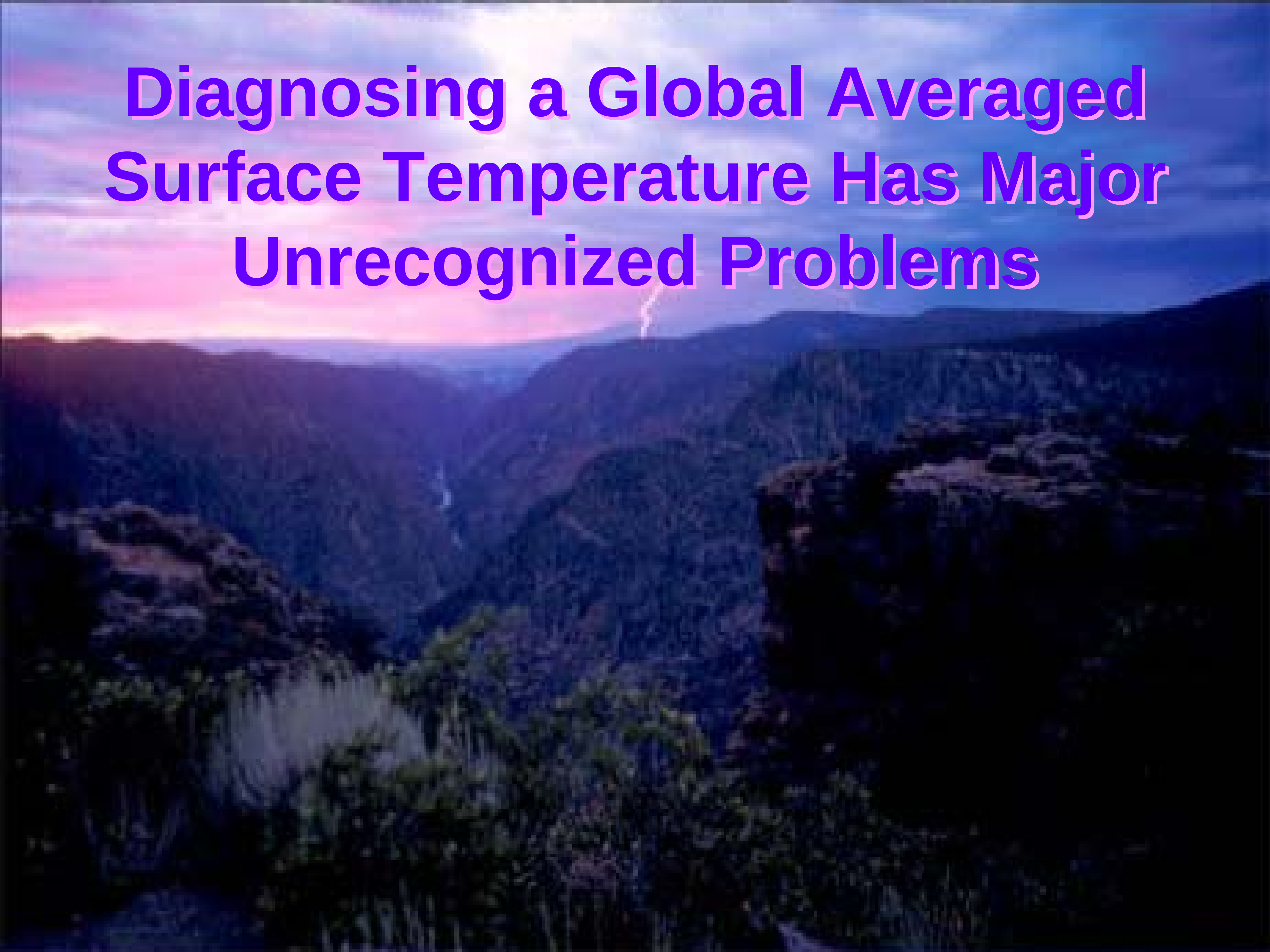
“It will not be possible to optimize strategies for dealing with global warming until all important climate forcings, including carbonaceous aerosols, have been well quantified.”

“In fact there are no predictions by IPCC at all. And there never have been. The IPCC instead proffers "what if" projections of future climate that correspond to certain emissions scenarios.”

"...the science is not done because we do not have reliable or regional predictions of climate."

By Olive Heffernan on behalf of Kevin Trenberth http://blogs.nature.com/climatefeedback/2007/07/global_warming_and_foreca

Diagnosing a Global Averaged Surface Temperature Has Major Unrecognized Problems



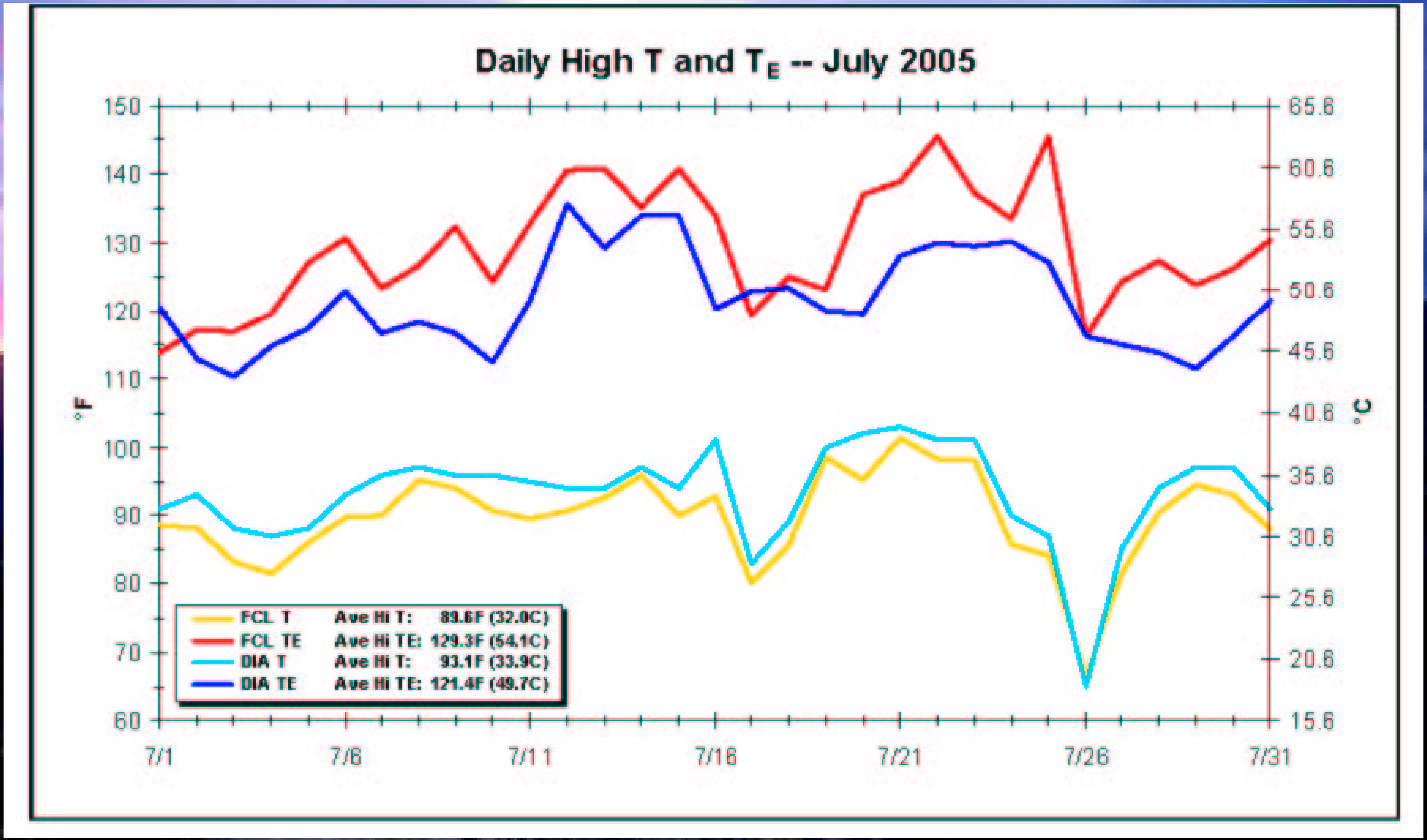
Missing Land - Atmosphere Surface Data Issues

- Moist Enthalpy
- Microclimate Exposure
- Vertical Lapse Rate Trends
- Uncertainty in the Homogenization Adjustments

Moist enthalpy provides a proper measure of surface air heat content, which is not provided by air temperature alone.

$$T_E = H/C_p$$

$$H = C_p\, T + L\, q$$



Hourly data from automated weather stations at Fort Collins and DIA are used to pick and calculate the highest air temperature and effective temperature for each day in July 2005. The average high air temperature is higher at DIA, while the average high effective temperature is higher at Fort Collins. From Pielke, R.A. Sr., K. Wolter, O. Bliss, N. Doesken, and B. McNoldy, 2005: July 2005 heat wave: How unusual was it. National Weather Digest, submitted.

http://climatesci.colorado.edu/publications/pdf/R-313.pdf

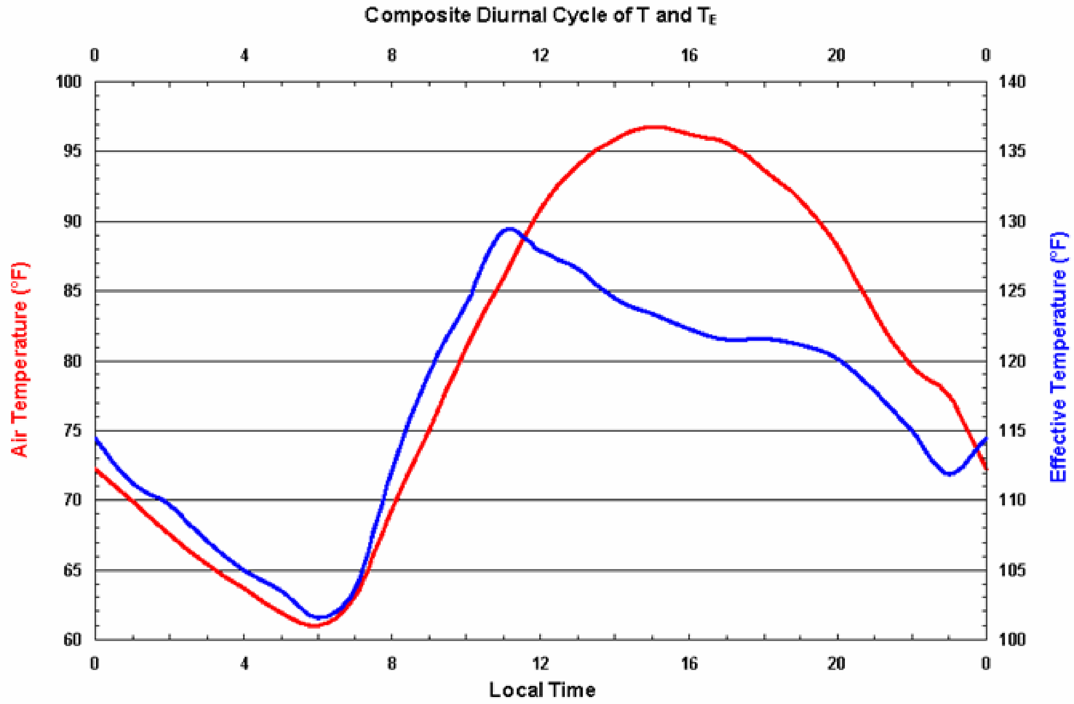
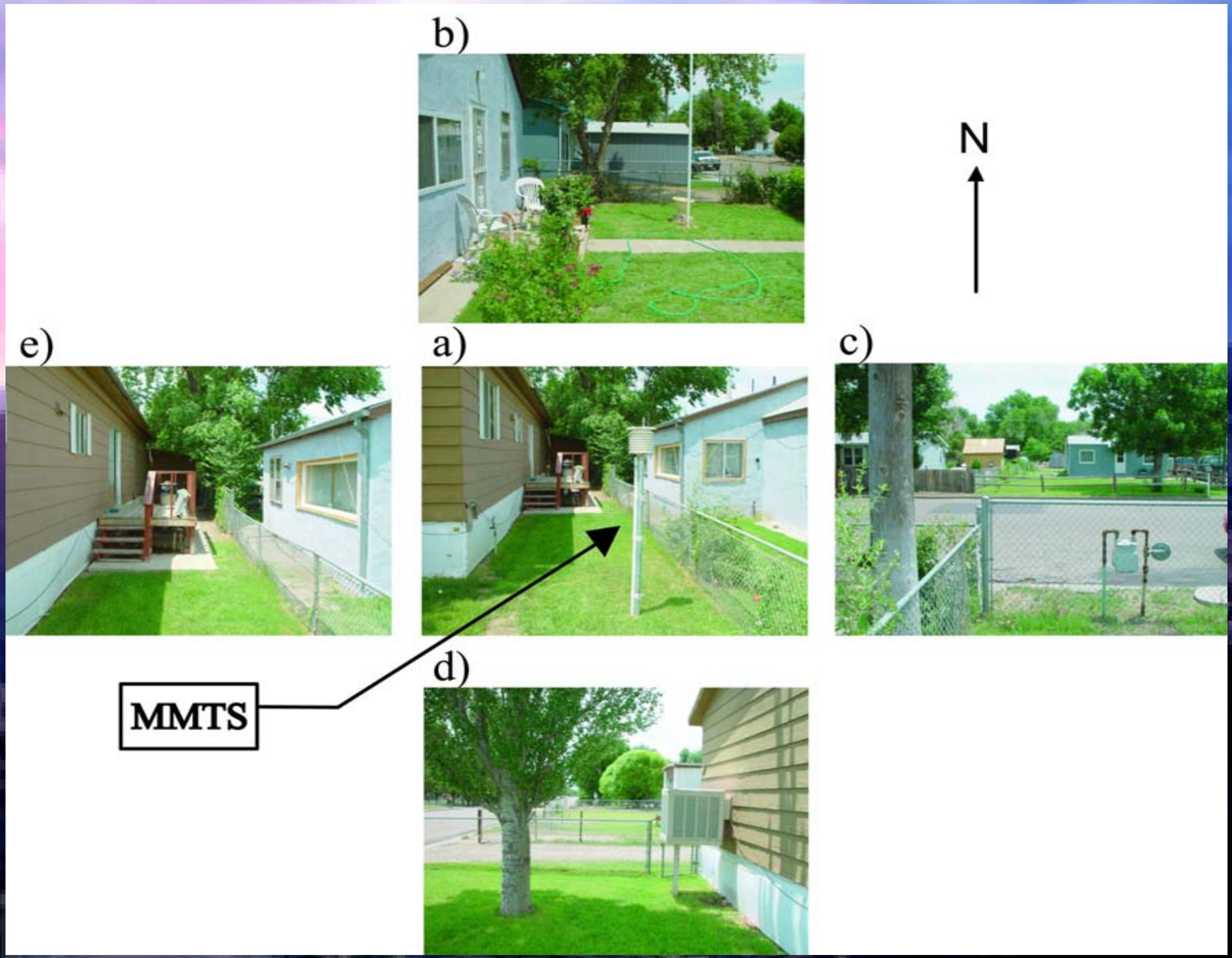


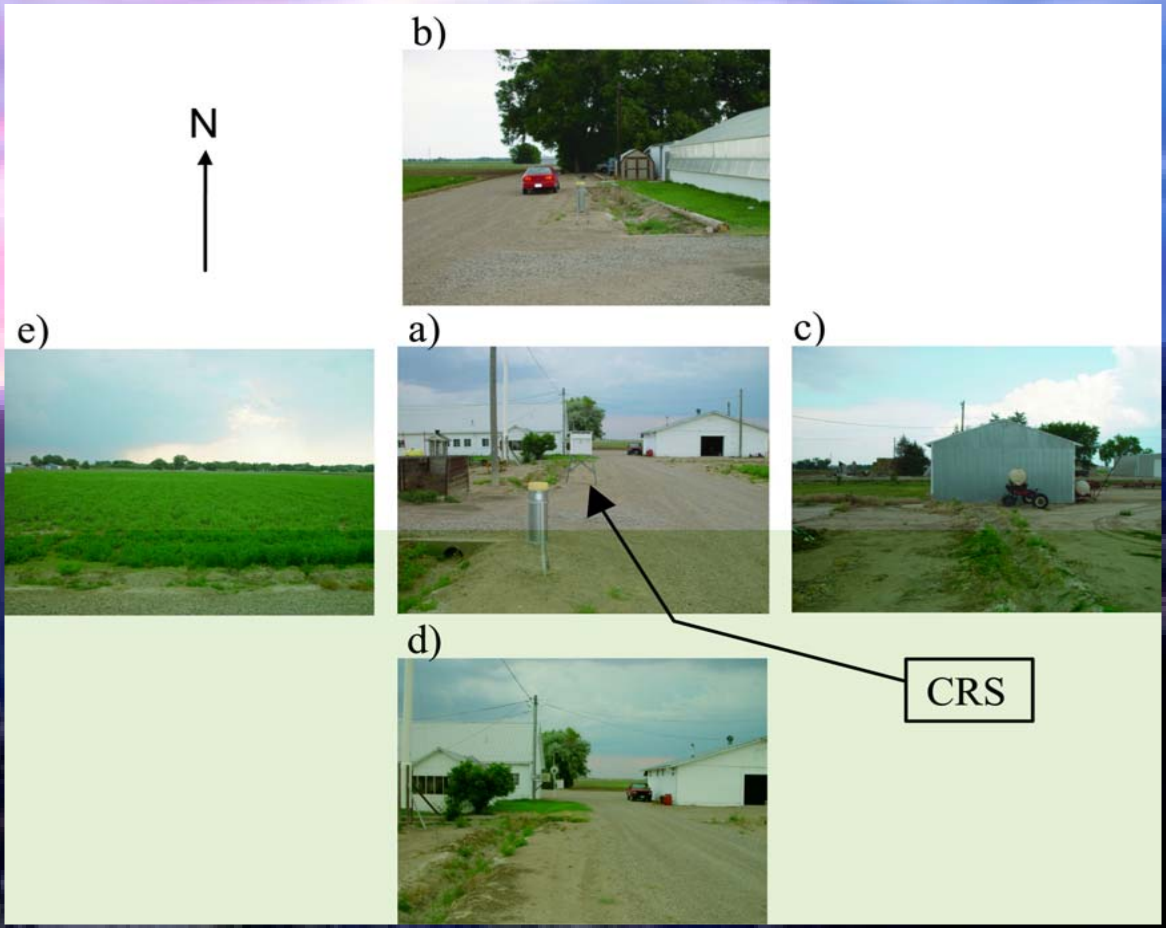
Figure 10. A daily composite of air temperature (red line) and effective temperature (blue line). The composite is created by averaging hourly data during the five days with highest air temperature in each of the three years considered in this section – fifteen days total. This shows the pattern of heating and cooling on the station's extreme hottest days. Note how the effective temperature peaks approximately four hours before the air temperature peaks. Typically, the hottest days are characterized by exceptionally low relative humidity in the late afternoon, which explains the premature drop in effective temperature.

http://climatesci.colorado.edu/publications/pdf/R-313.pdf

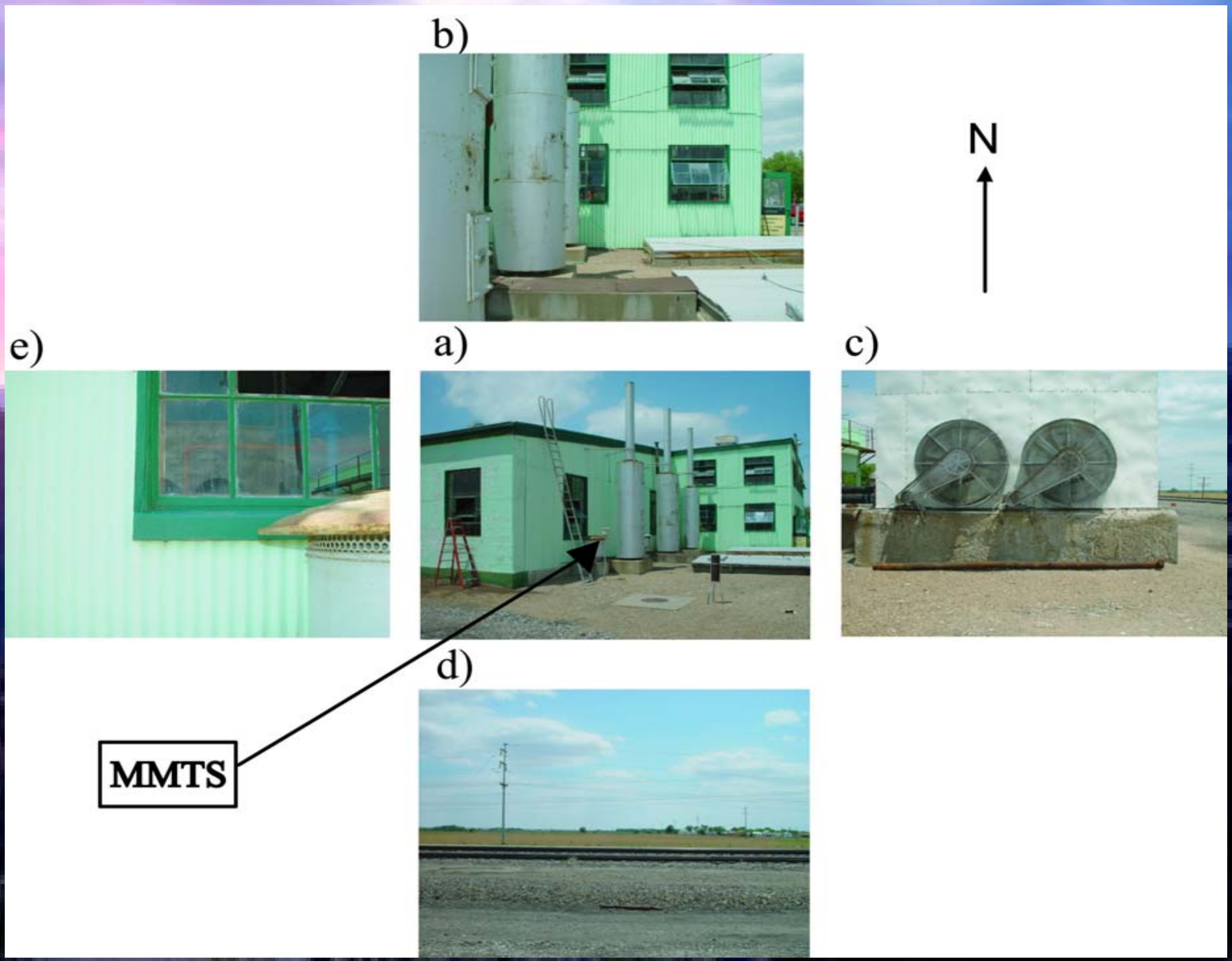
Microclimate Exposure



Photographs of the temperature sensor exposure characteristics of the NWS COOP station at Lamar, CO. Panel a) shows the temperature sensor, while panels b)-e) illustrate the exposures viewed from the sensor looking N, E, S, and W, respectively. From 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., 4, 497–504.
http://climatesci.colorado.edu/publications/pdf/R-274.pdf



Photographs of the temperature sensor exposure characteristics for the NWS COOP station near Rocky Ford, Colorado. Panel a) shows the temperature sensor, while panels b)-e) illustrate the exposures viewed from the temperature sensor looking N, E, S, and W, respectively. (CRS-Cotton Region Shelter). From 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., 4, 497–504. http://climatesci.colorado.edu/publications/pdf/R-274.pdf



Photographs of the temperature sensor exposure characteristics of the NWS COOP station at Las Animas, CO. Panel a) shows the temperature sensor, while panels b)-e) illustrate the exposures viewed from the sensor looking N, E, S, and W, respectively. From 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., 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)

This is the climatological station of record for Odessa, Washington. It is at the residence of a COOP weather observer administered by NOAA. The photo was taken by surfacestations.org volunteer surveyor Bob Meyer. From: http://www.norcalblogs.com/watts/

USHCN station exposure at Greensburg, Kentucky. From: Pielke Sr. et al., 2007: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Research, accepted. http://climatesci.colorado.edu/publications/pdf/R-321.pdf

USHCN station exposure at Greensburg, Kentucky. From: Pielke Sr. et al., 2007: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Research, accepted. http://climatesci.colorado.edu/publications/pdf/R-321.pdf

USHCN station exposure at Greensburg, Kentucky. From: Pielke Sr. et al., 2007: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Research, accepted. http://climatesci.colorado.edu/publications/pdf/R-321.pdf

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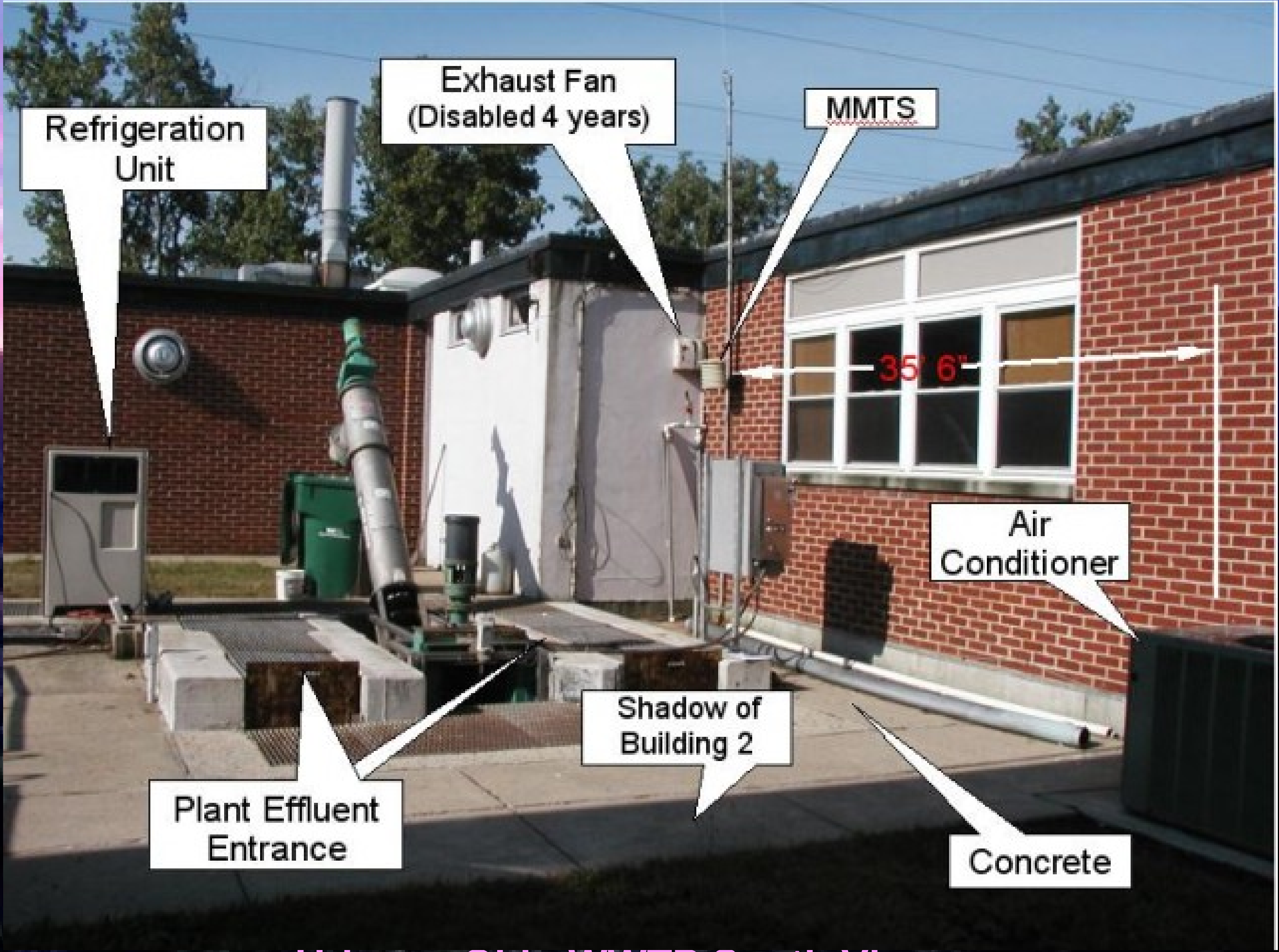
Tucson, AZ station. From: http://www.norcalblogs.com/watts/

From: http://www.norcalblogs.com/watts/



Urbana, Ohio WWTP South View
From: http://www.norcalblogs.com/watts/

Roseburg, Oregon, looking northwest

From: http://www.norcalblogs.com/watts/

Importance of Regional Climate Change Relative to Global Average Climate Change

The 2005 National Research Council report concluded that:

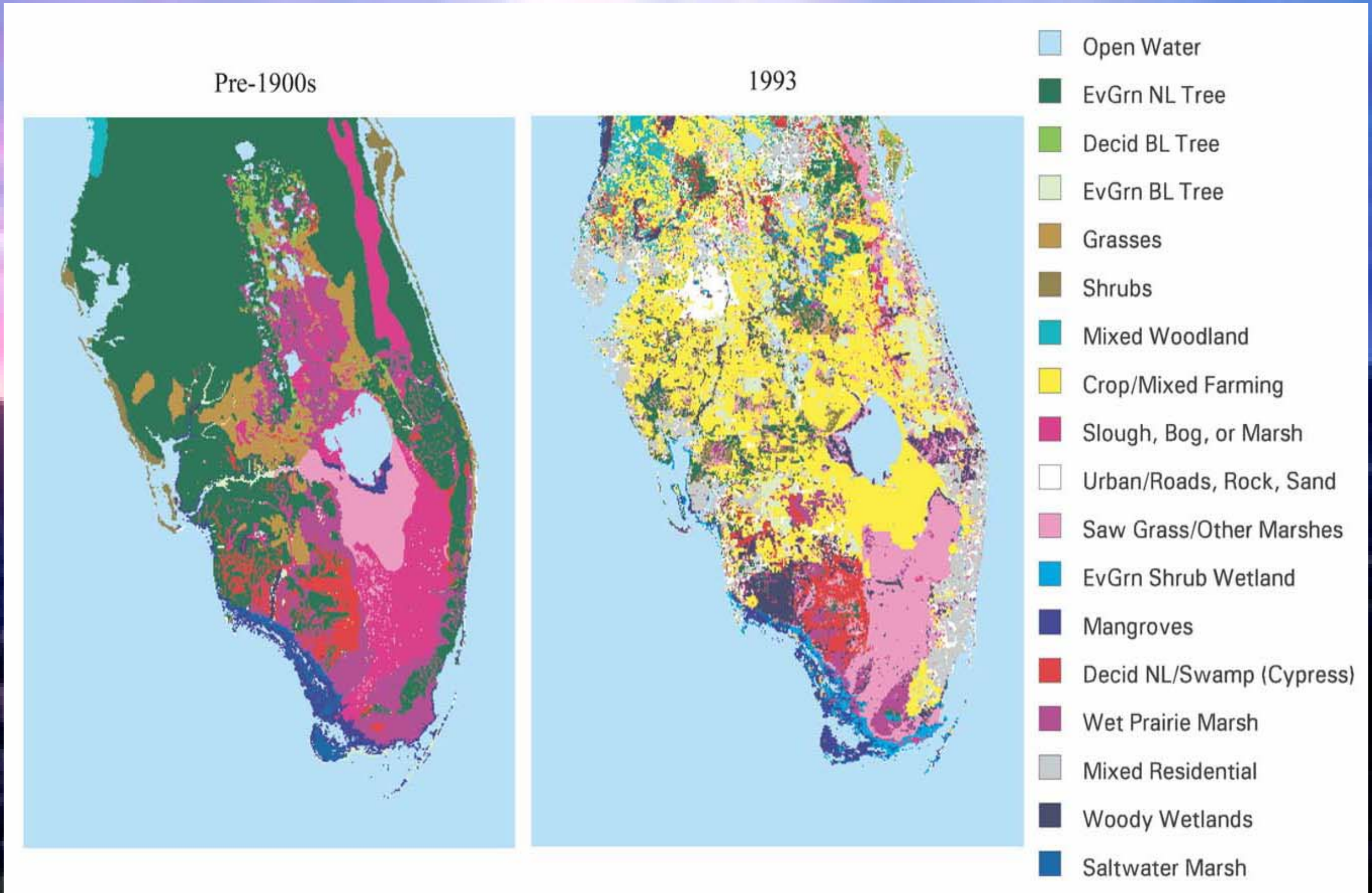
> "regional variations in radiative forcing may have important regional and global climate implications that are not resolved by the concept of global mean radiative forcing."

And furthermore:

> "Regional diabatic heating can cause atmospheric teleconnections that influence regional climate thousands of kilometers away from the point of forcing."

> This regional diabatic heating produces temperature increases or decreases in the layer-averaged regional troposphere. This necessarily alters the regional pressure fields and thus the wind pattern. This pressure and wind pattern then affects the pressure and wind patterns at large distances from the region of the forcing which we refer to as teleconnections.

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

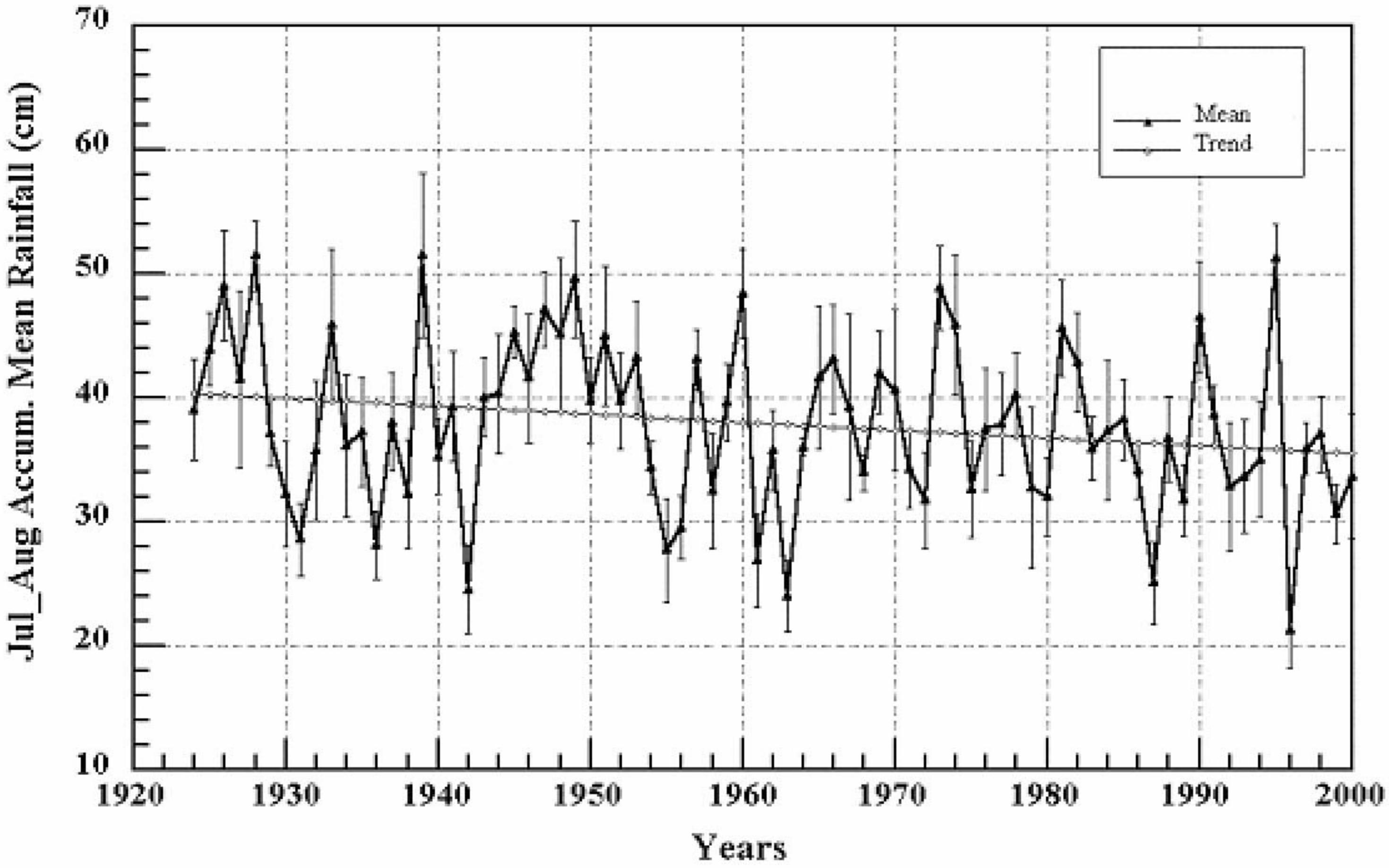
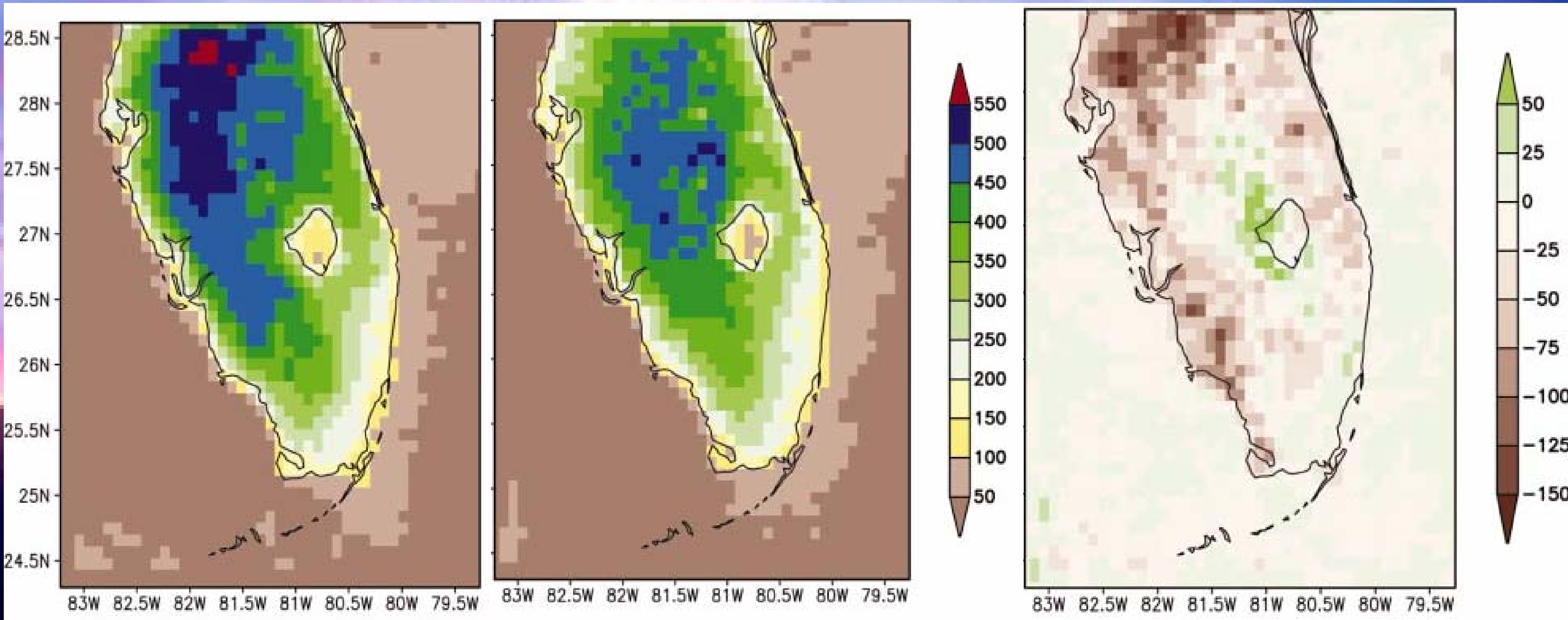
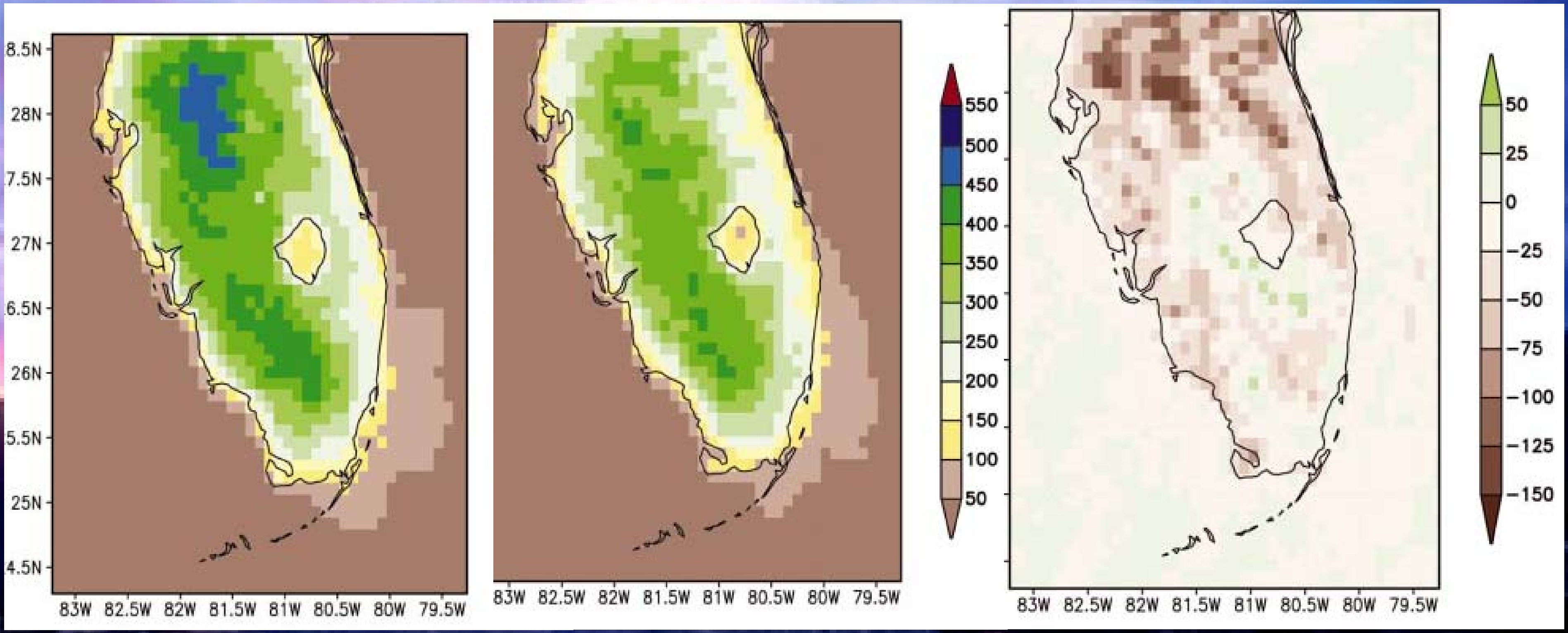


FIG. 25. Regional average time series of accumulated convective rainfall (cm) from 1924 to 2000, with corresponding trend based on linear regression of all July-August amounts. The vertical bars overlain on the raw time series indicate the value of the standard error of the July-August regional mean.

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://climatesci.colorado.edu/publications/pdf/R-272.pdf



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.

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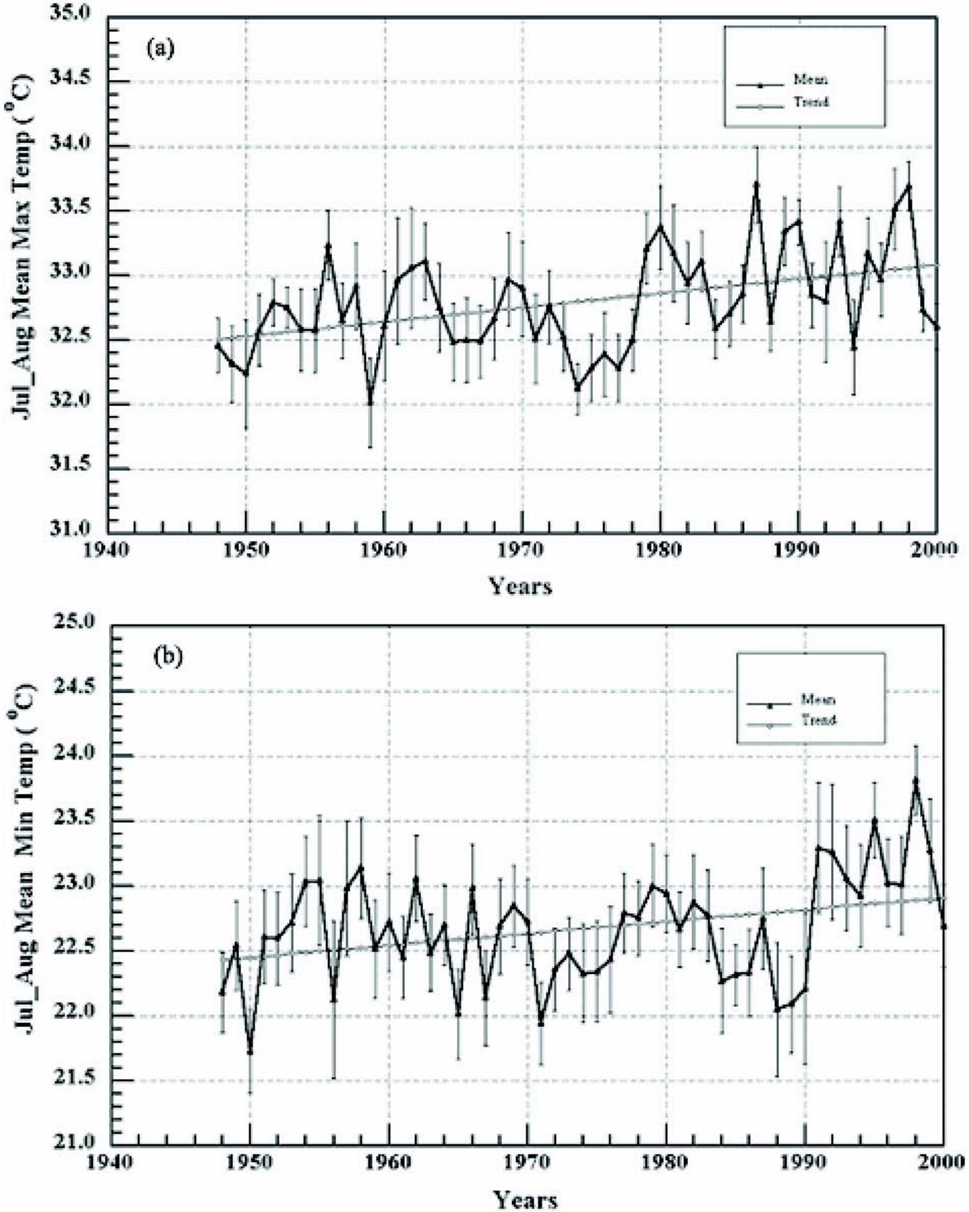
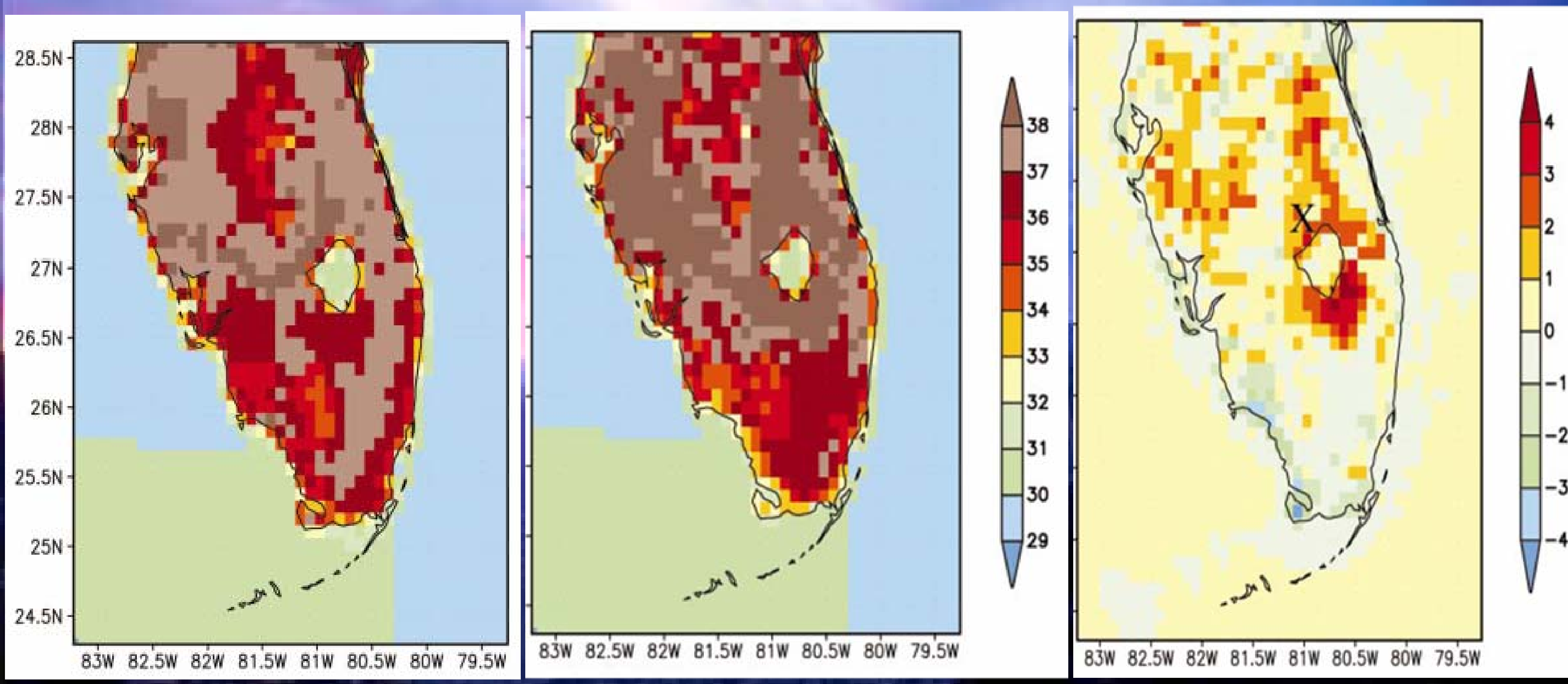


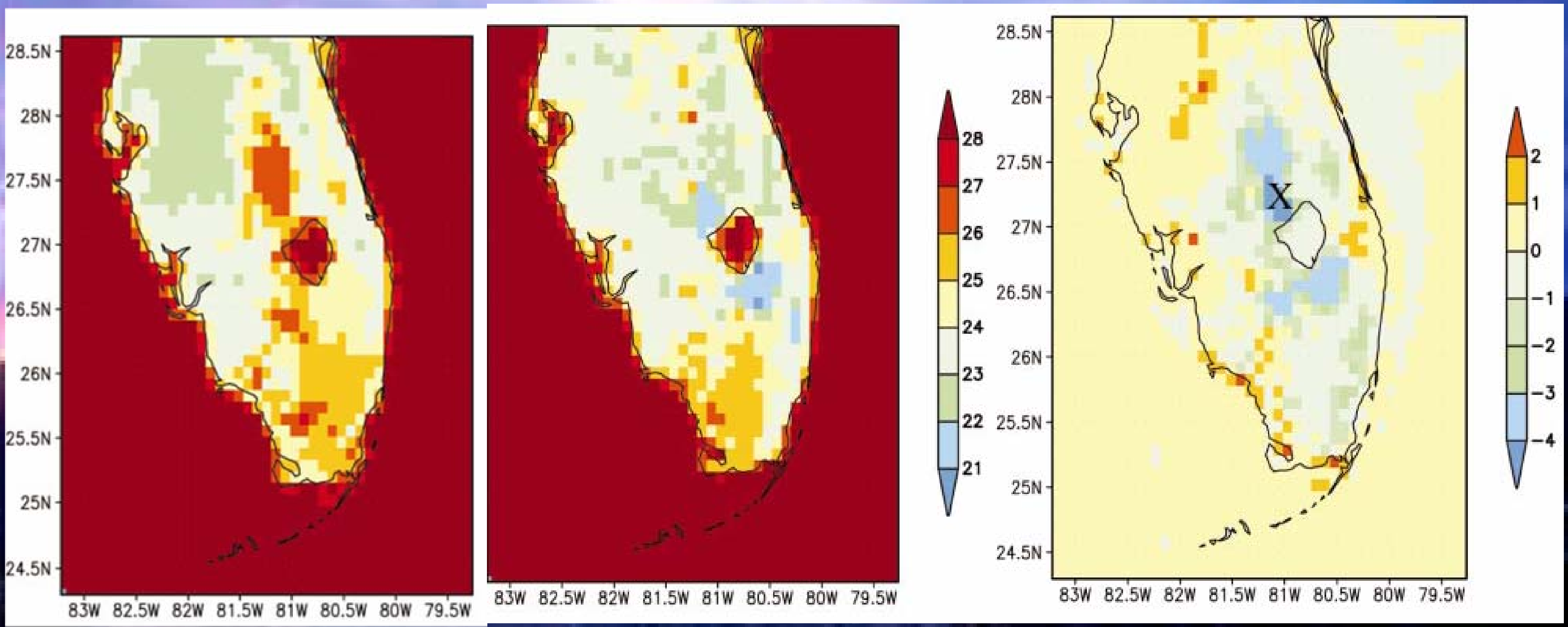
FIG. 26. Same as in Figure 25, except for daily (a) maximum and (b) minimum shelter-level temperature (°C)

Max and Min Temp Trends



Two-month average of the daily maximum shelter-level temperature (°C) from the model simulations of Jul-Aug 1989 with (top) natural land cover, (middle) current land cover. 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 daily minimum temperature. 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

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

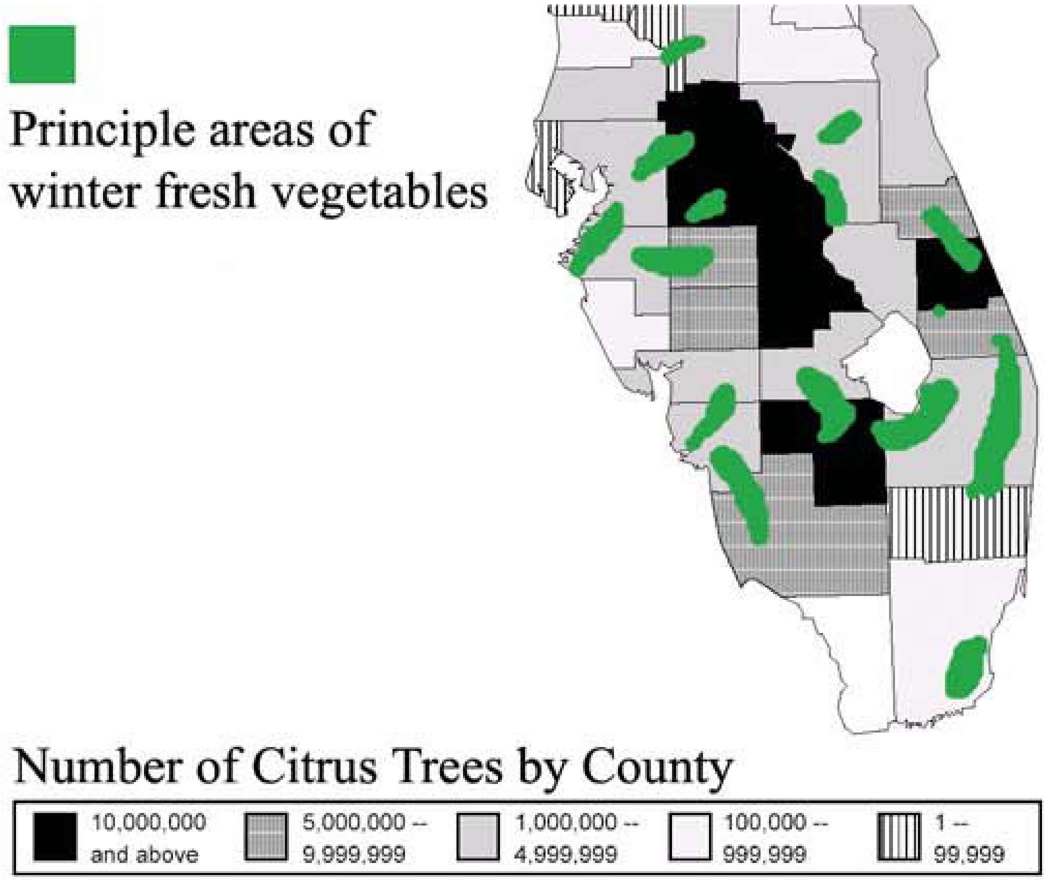


Fig. 1. Number of citrus trees per county and principle areas of winter fresh vegetable production. Figure adapted from Florida Agriculture Facts Directory 2002.

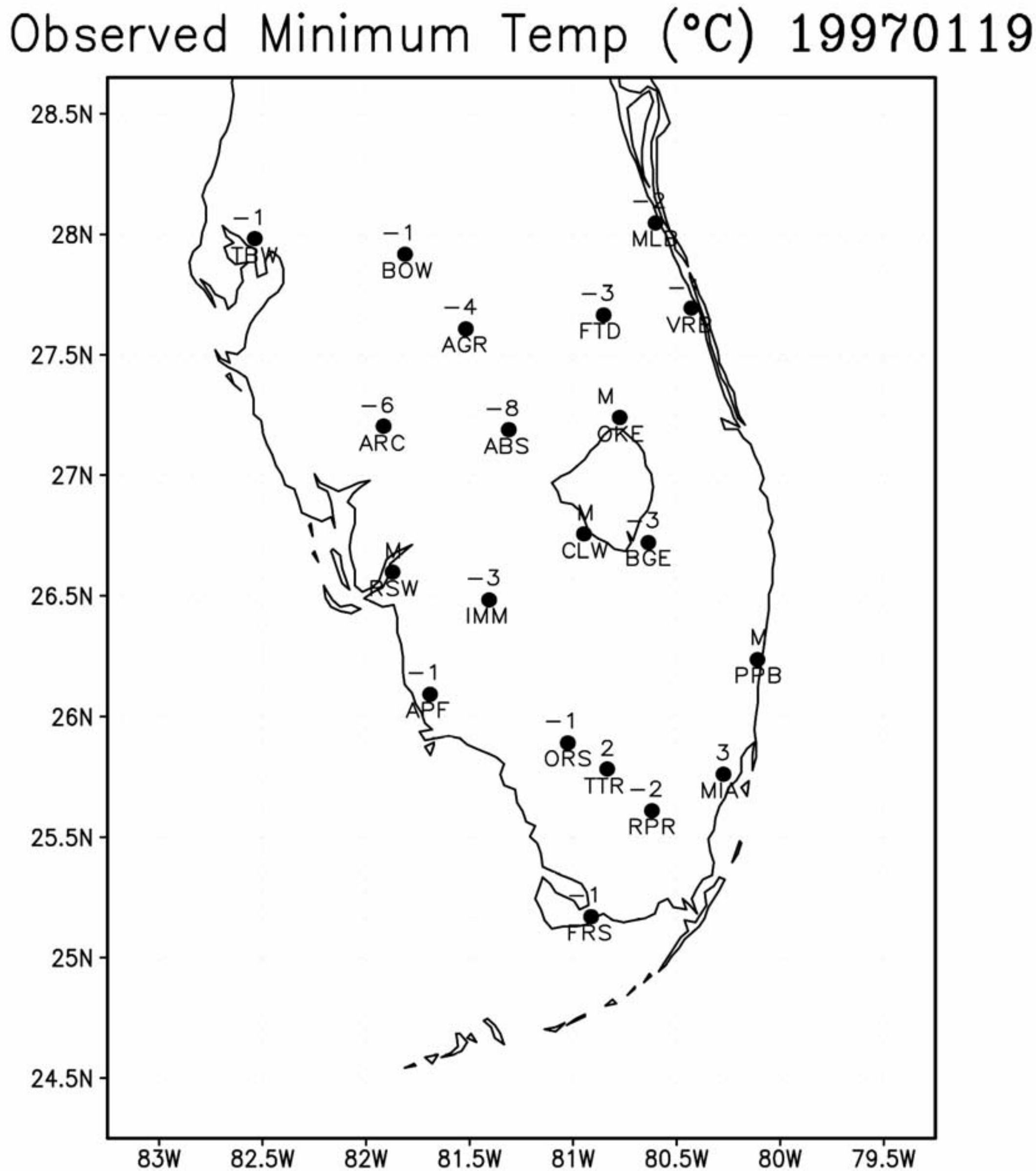
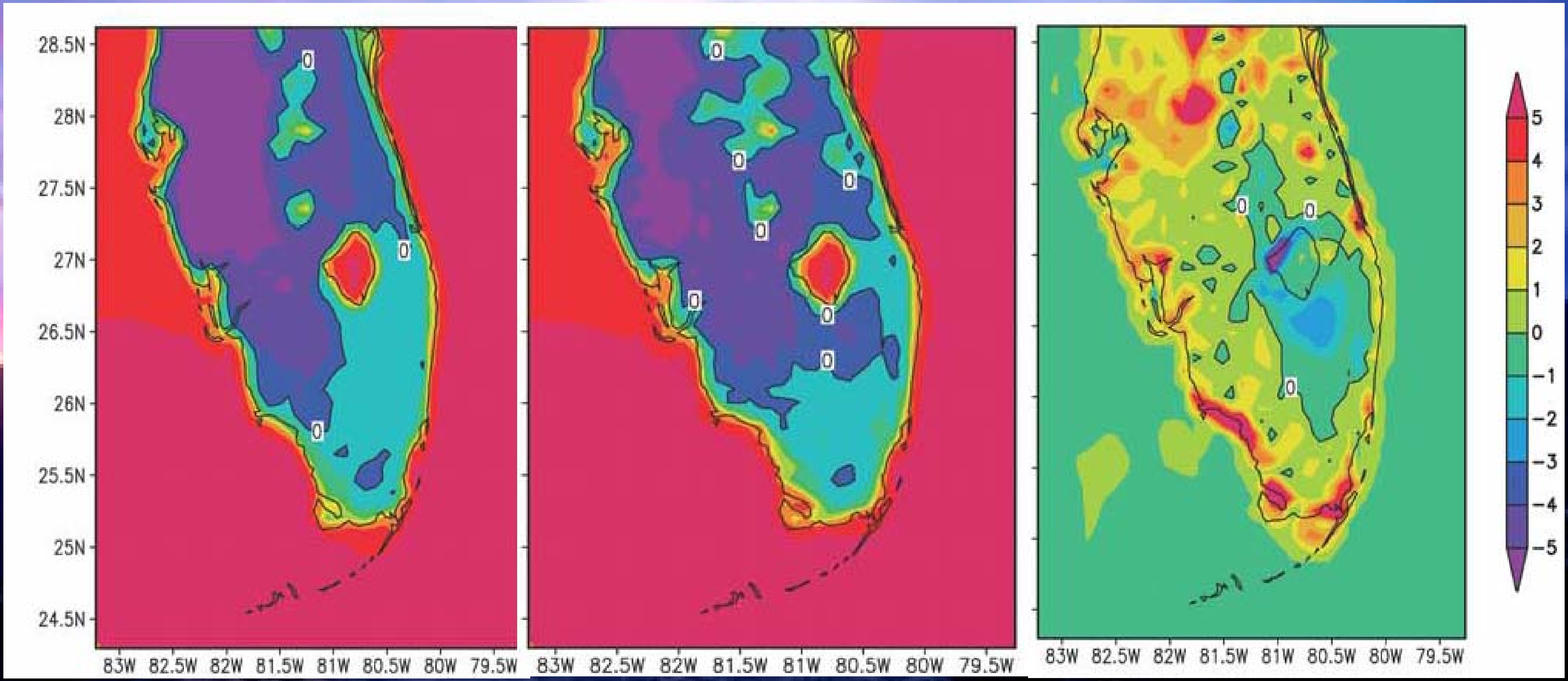
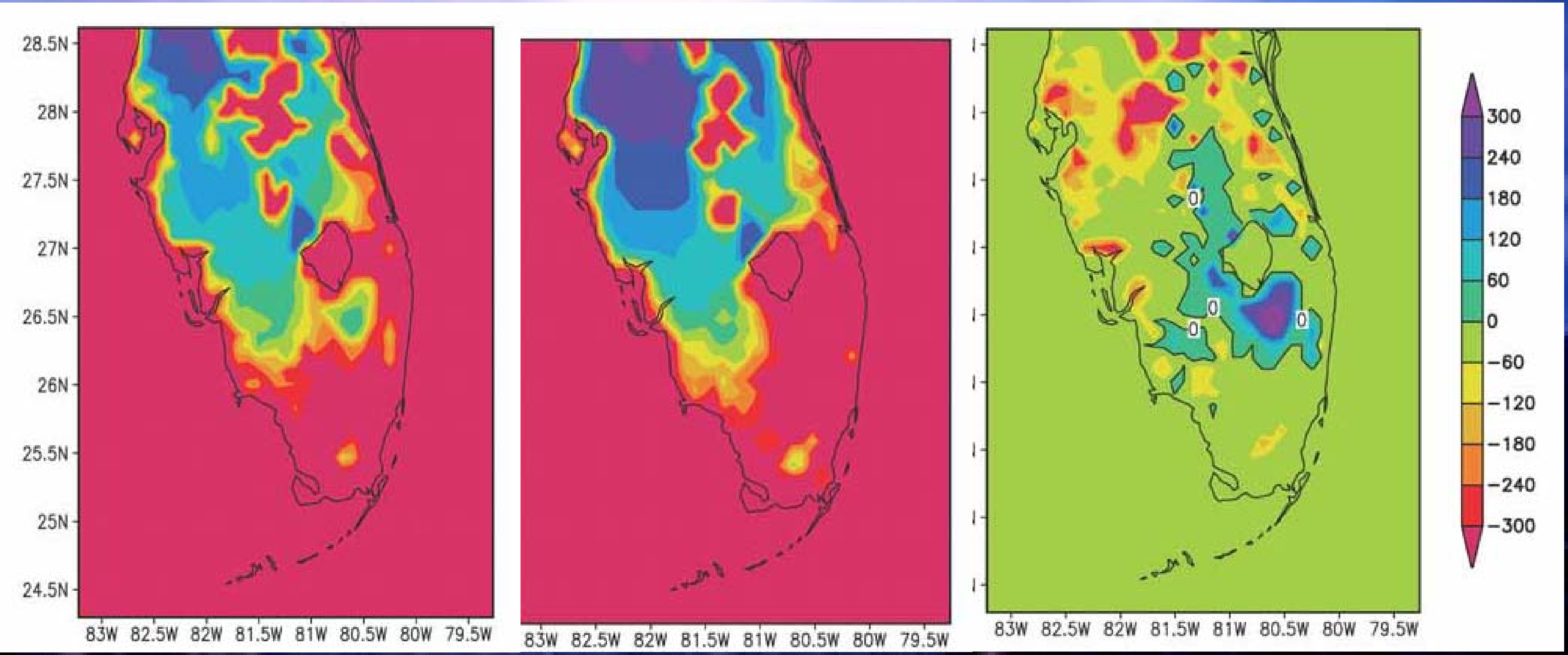


Fig. 2. Observations of minimum temperature from the National Weather Service Cooperative Observer Network on the morning of January 19, 1997.



Model simulated 2 meter minimum temperatures on the Morning of January 19, 1997 for the pre-1900's scenario (right) the 1993 scenario (middle), and the difference of the two (left)

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



Time spent below freezing (minutes for the night prior
To the morning of January 19, 1997 for the pre-1900's land-cover scenario (left), the 1993 land-cover scenario (middle), and the difference of the two (right).
http://climatesci.colorado.edu/publications/pdf/R-272.pdf

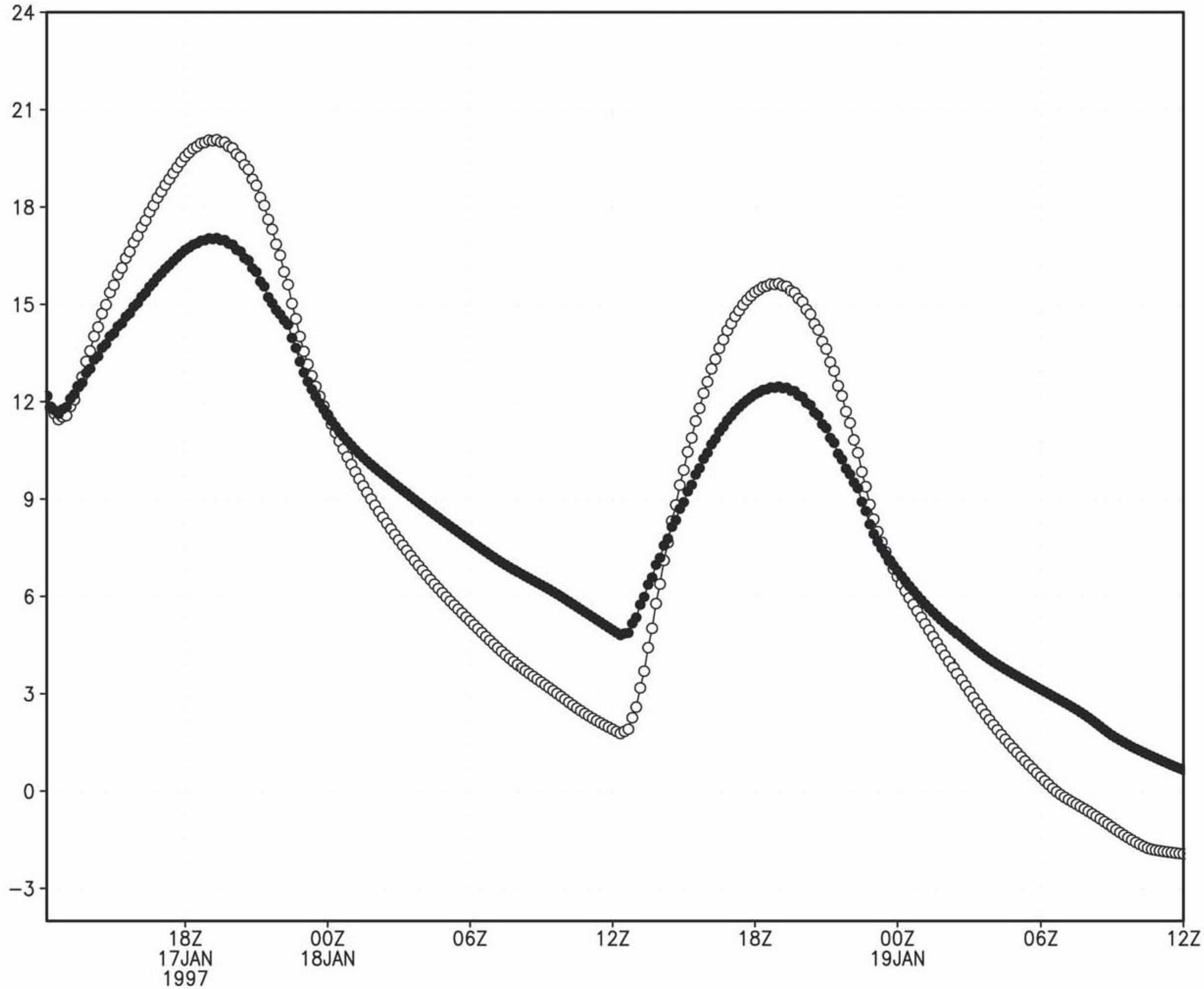


Fig. 7. Time series of 2 meter temperature for a model grid point located just south of Lake Okeechobee for the pre-1900s land cover scenario (filled circles) and the 1993 land cover scenario (open circles).

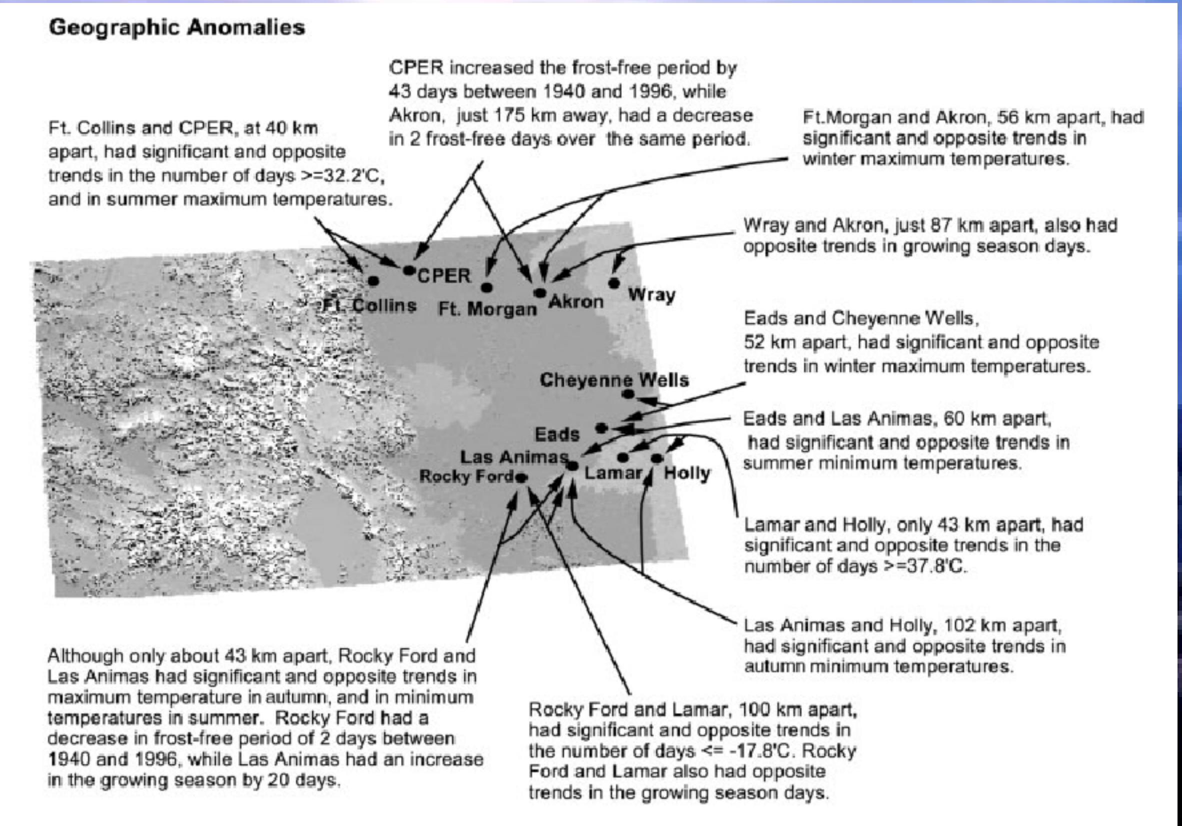


Figure 2. Geographic anomalies in temperature trends in eastern Colorado

From: Pielke Sr., R.A., T. Stohlgren, L. Schell, W. Parton, N. Doesken, K. Redmond, J. Moeny, T. McKee, and T.G.F. Kittel, 2002: Problems in evaluating regional and local trends in temperature: An example from eastern Colorado, USA. Int. J. Climatol., 22, 421-434. http://climatesci.colorado.edu/publications/pdf/R-234.pdf

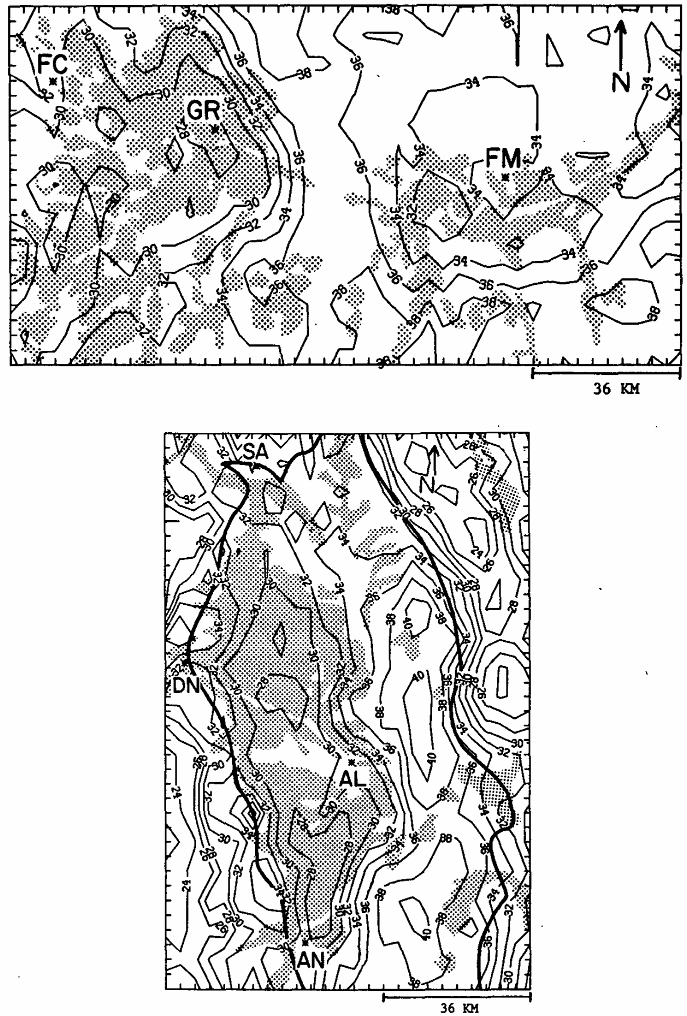


FIG. 11. Composite of GOES derived surface temperature at 1300 LST for the period 1 August 1986 to 15 August 1986 (a) for northeast Colorado (FC—Fort Collins; FM—Fort Morgan; GR—Greeley), (b) for the San Luis Valley in Colorado (AL—Alamosa; AN—Antonito; DN—Del Norte; SA—Saguache). The lower valley is outlined by a dark line separating it from significant elevated terrain. Irrigated areas are shaded.

From: Segal, M., R. Avissar, M.C. McCumber, and R.A. Pielke, 1988: Evaluation of vegetation effects on the generation and modification of mesoscale circulations. J. Atmos. Sci., 45, 2268-2292. http://climatesci.colorado.edu/publications/pdf/R-84.pdf

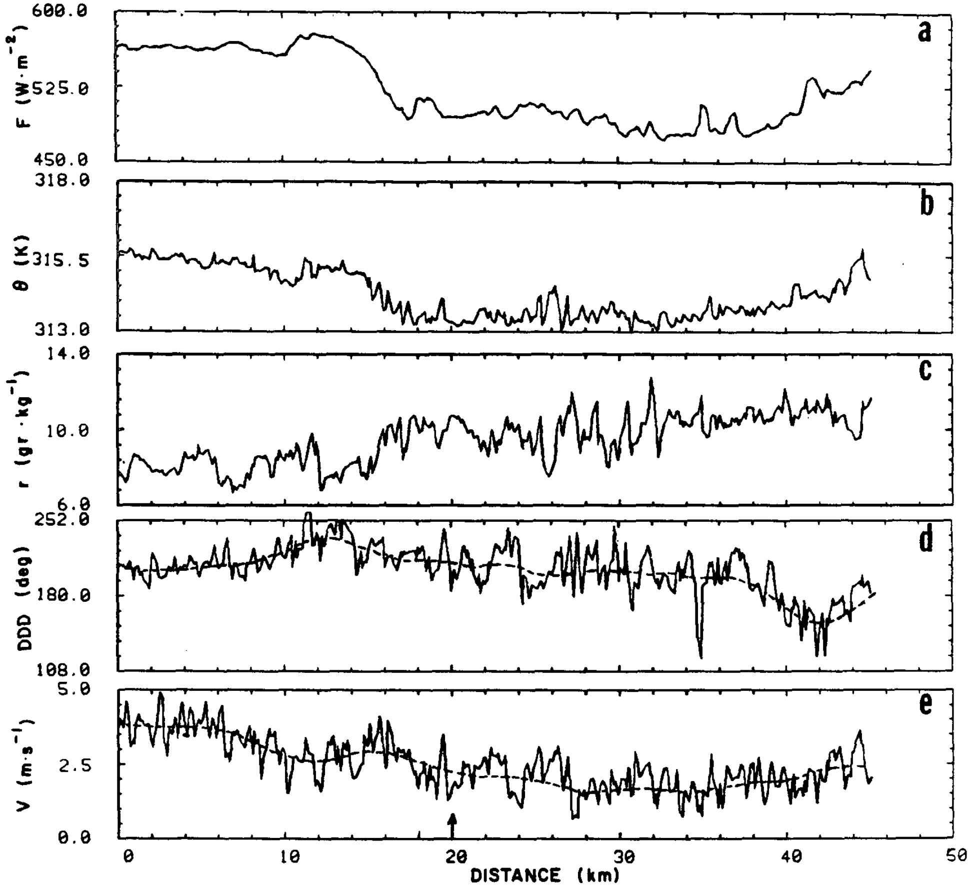


FIG. 4. Measured meteorological variables for flight 16 along transect No. 1 from Briggsdale (dry land) to Windsor (irrigated area) (Briggsdale and Windsor are indicated respectively by BR and W in Fig. 1) at the altitude of ≈180 m above ground level: (a) surface IR radiative flux, (b) potential temperature, (c) moisture mixing ratio, (d) wind direction, (e) wind speed [in (d) and (e) the dashed lines indicate a subjective estimate of the running mean]. The location of the observed crop-dry land boundary is indicated by an arrow.

From: Segal, M., W. Schreiber, G. Kallos, R.A. Pielke, J.R. Garratt, J. Weaver, A. Rodi, and J. Wilson, 1989: The impact of crop areas in northeast Colorado on midsummer mesoscale thermal circulations. Mon. Wea. Rev., 117, 809-825. http://climatesci.colorado.edu/publications/pdf/R-88.pdf

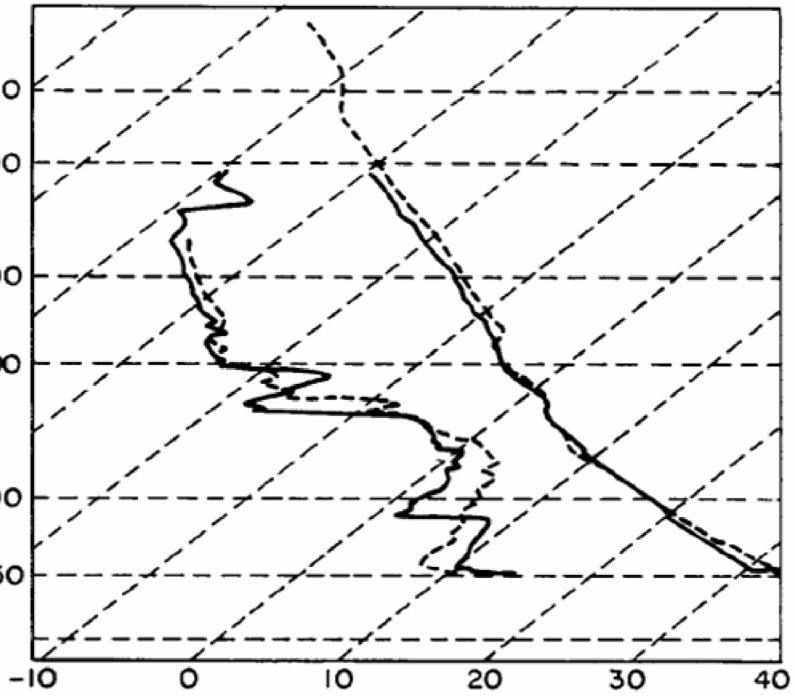


Figure 6. Radiosonde measurements of (right) temperature and (left) dew point temperature for a dry land area (dashed curve) and an irrigated area (solid curve) in northeast Colorado at 1213 local standard time (LST) on July 28, 1987. Reprinted from *Pielke and Zeng* [1989] with permission from National Weather Association.

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

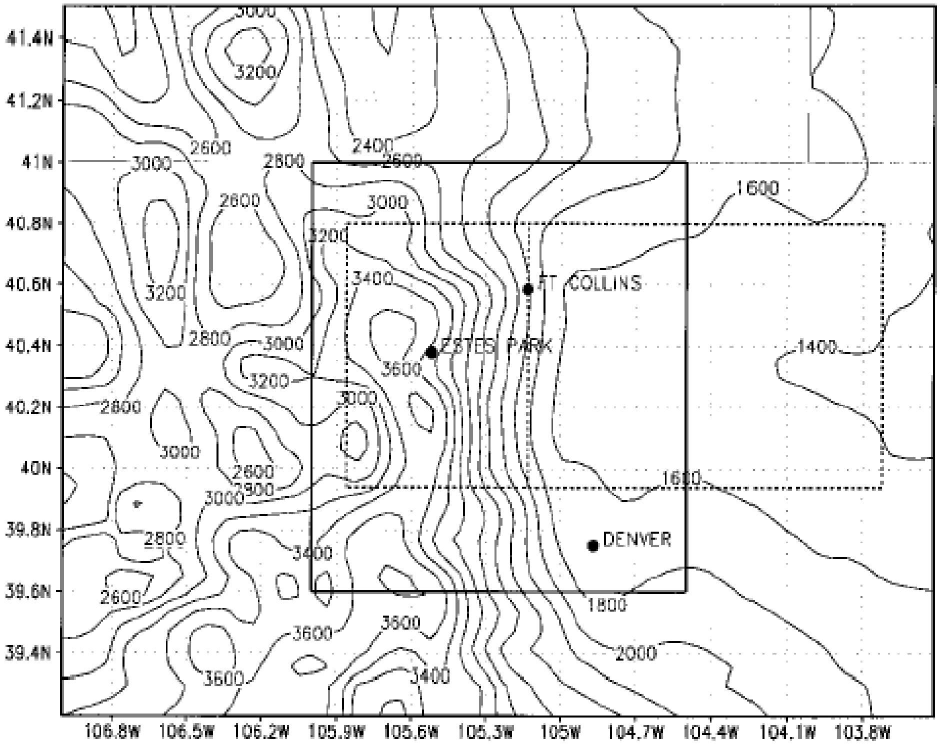


Figure 2. Topography on the fine (6.5 km) grid. Contours are by 200 m. The solid boxed region is a subdomain used in Figures 6c, 6d, 6e, and 6f. The dotted boxed region represents the subdomain used for meridional averages (discussed in text. The dotted line through Fort Collins represents the approximate division between mountains and plains regions.

From: Chase, T.N., R.A. Pielke, Sr., T.G.F. Kittel, J.S. Baron, and T.J. Stohlgren, 1999: Potential impacts on Colorado Rocky Mountain weather due to land use changes on the adjacent Great Plains. J. Geophys. Res., 104, 16673-16690. http://climatesci.colorado.edu/publications/pdf/R-178.pdf

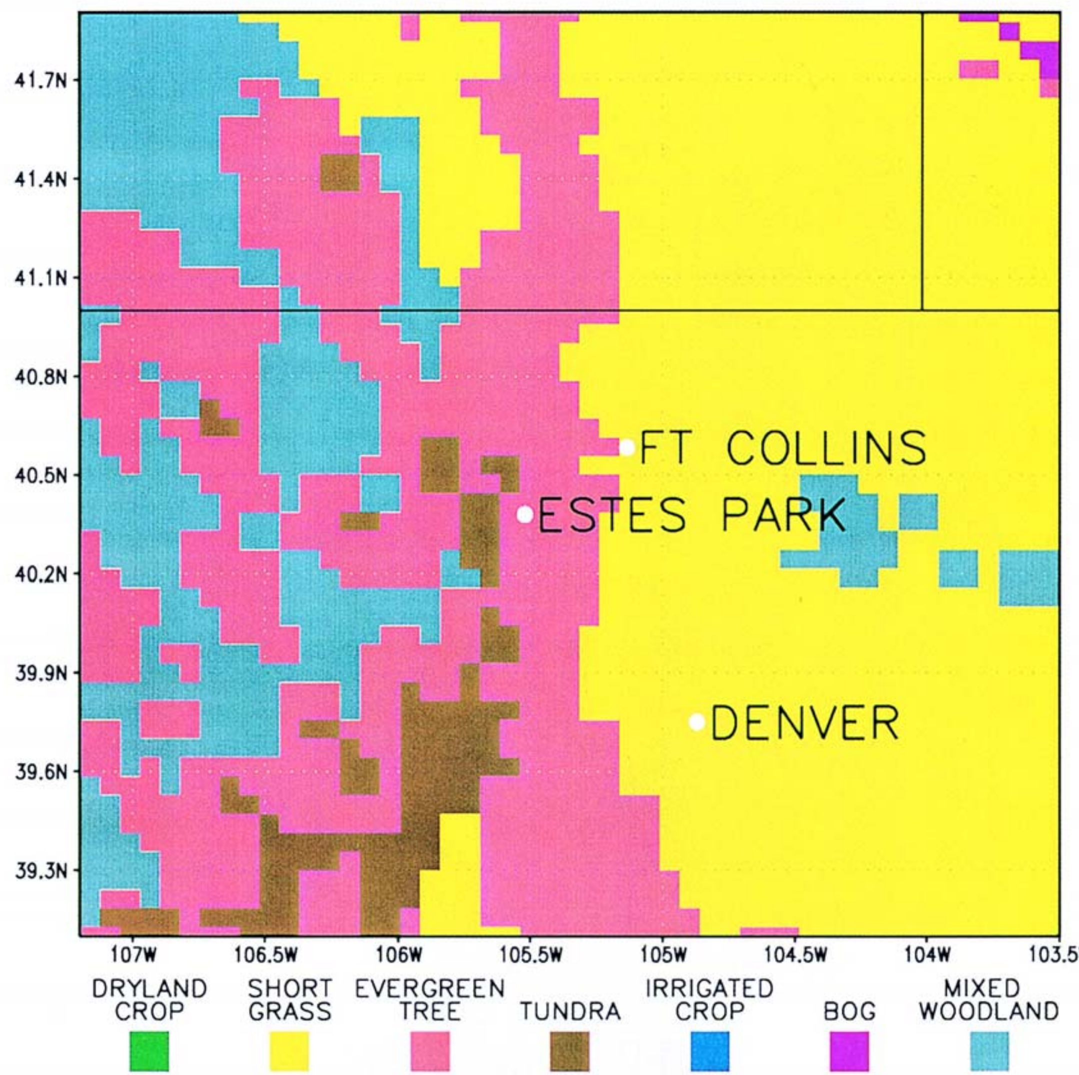


Plate 1a. Land cover types on the finest grid for the Natural case.

From: Chase, T.N., R.A. Pielke, Sr., T.G.F. Kittel, J.S. Baron, and T.J. Stohlgren, 1999: Potential impacts on Colorado Rocky Mountain weather due to land use changes on the adjacent Great Plains. J. Geophys. Res., 104, 16673-16690. http://climatesci.colorado.edu/publications/pdf/R-178.pdf

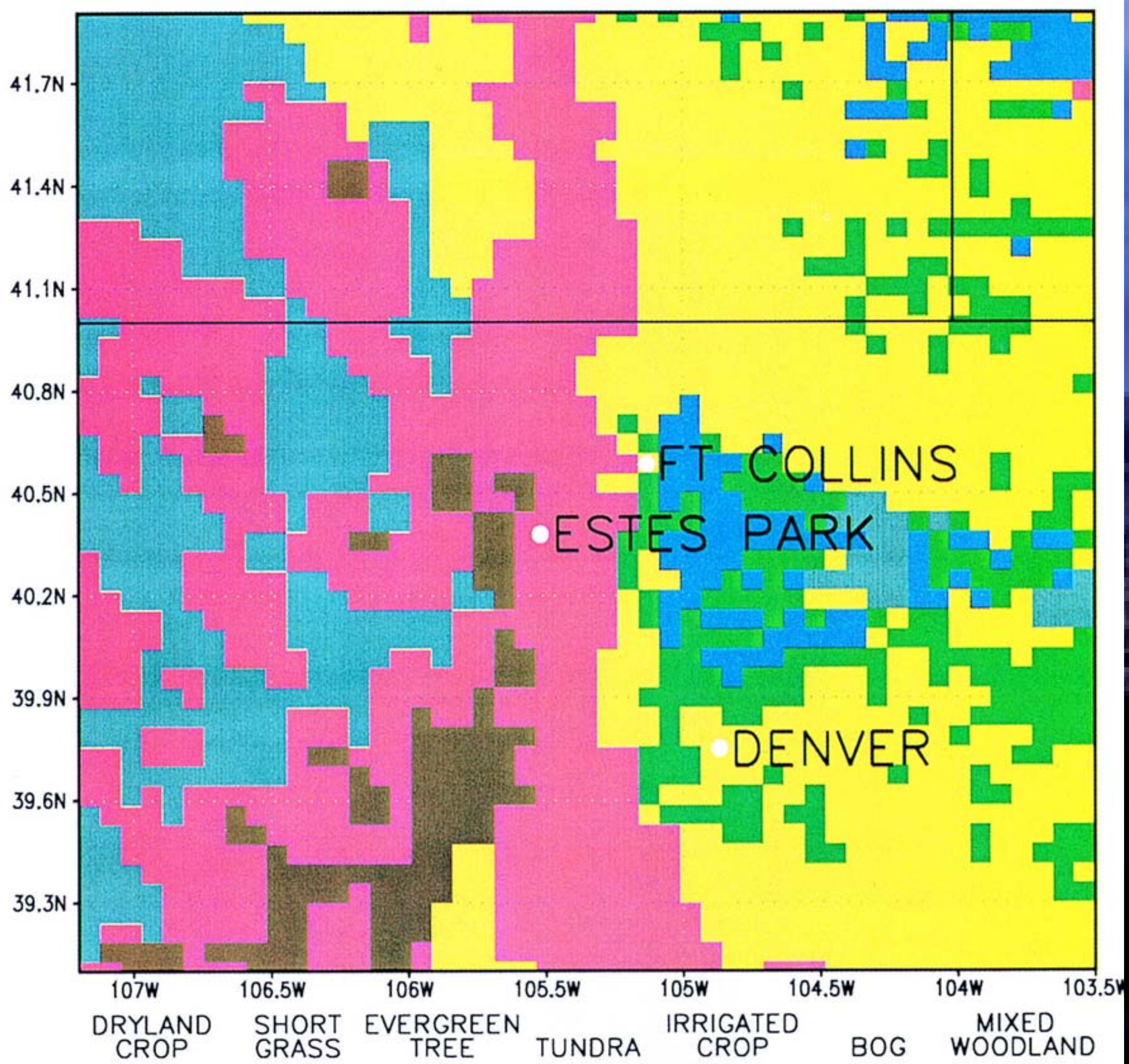


Plate 1b. Same as Plate 1a, except for the Current case.

From: Chase, T.N., R.A. Pielke, Sr., T.G.F. Kittel, J.S. Baron, and T.J. Stohlgren, 1999: Potential impacts on Colorado Rocky Mountain weather due to land use changes on the adjacent Great Plains. J. Geophys. Res., 104, 16673-16690. http://climatesci.colorado.edu/publications/pdf/R-178.pdf

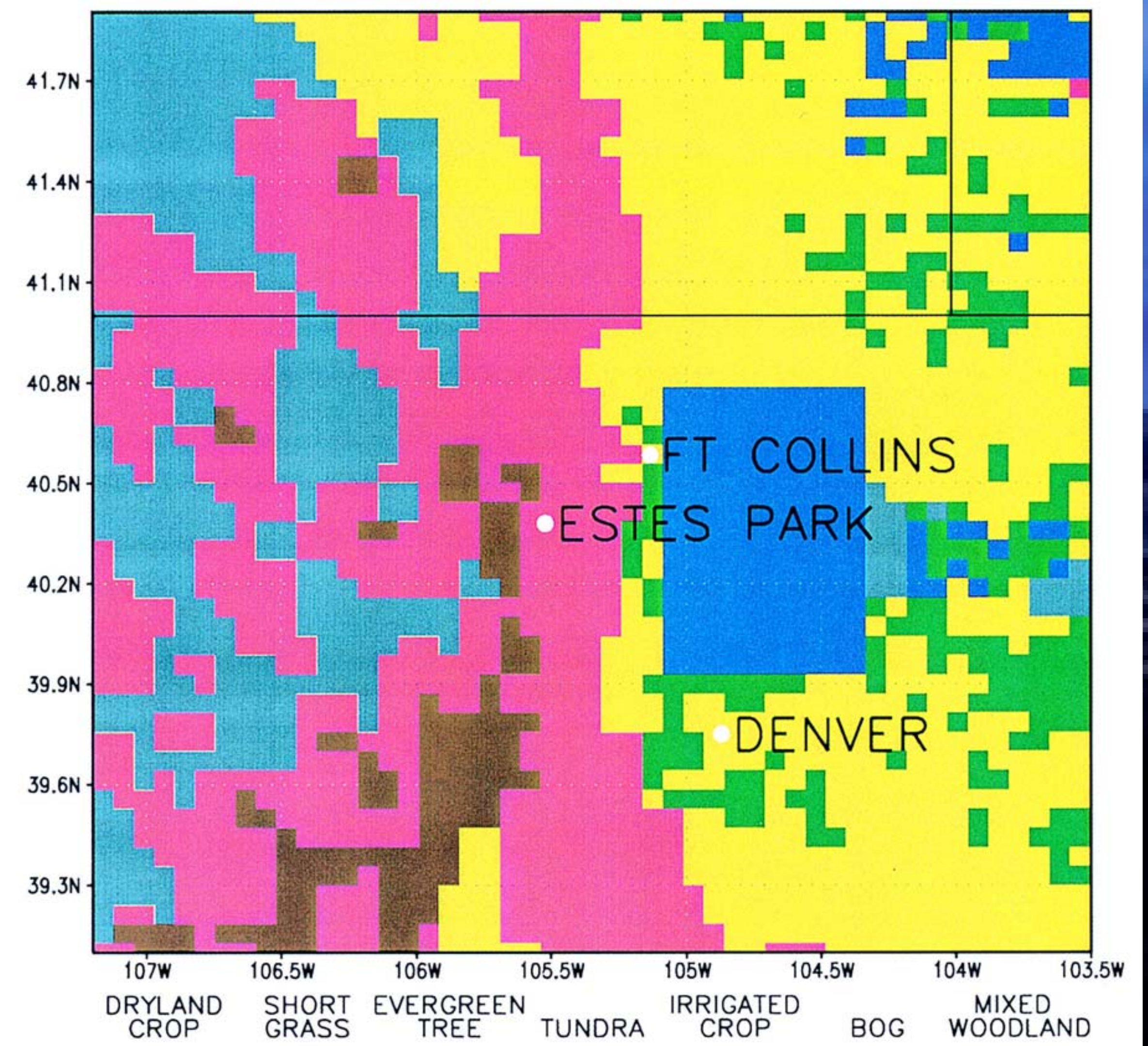


Plate 1c. Same as Plate 1a, except for the Superirrigated case.

From: Chase, T.N., R.A. Pielke, Sr., T.G.F. Kittel, J.S. Baron, and T.J. Stohlgren, 1999: Potential impacts on Colorado Rocky Mountain weather due to land use changes on the adjacent Great Plains. J. Geophys. Res., 104, 16673-16690. http://climatesci.colorado.edu/publications/pdf/R-178.pdf

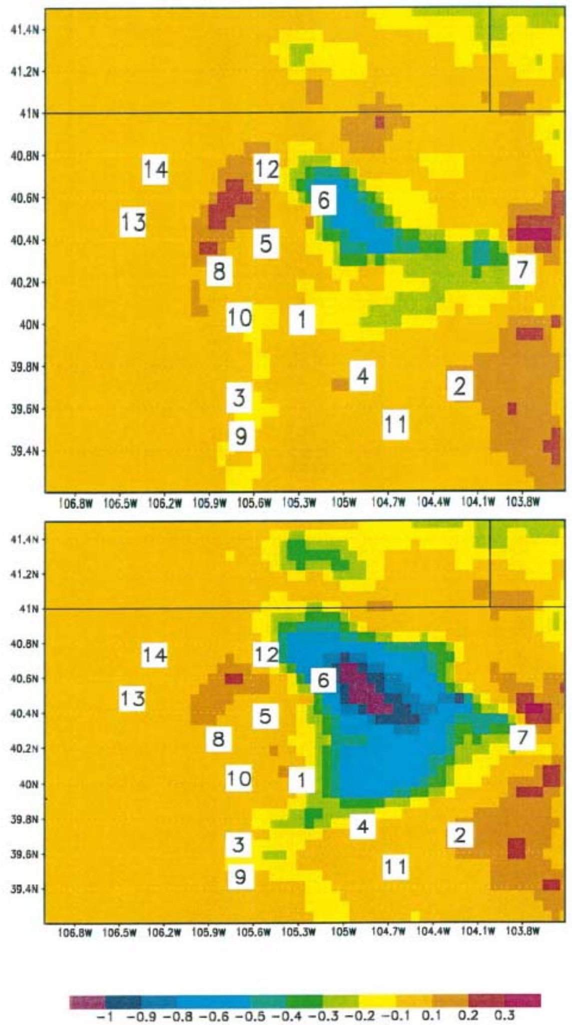
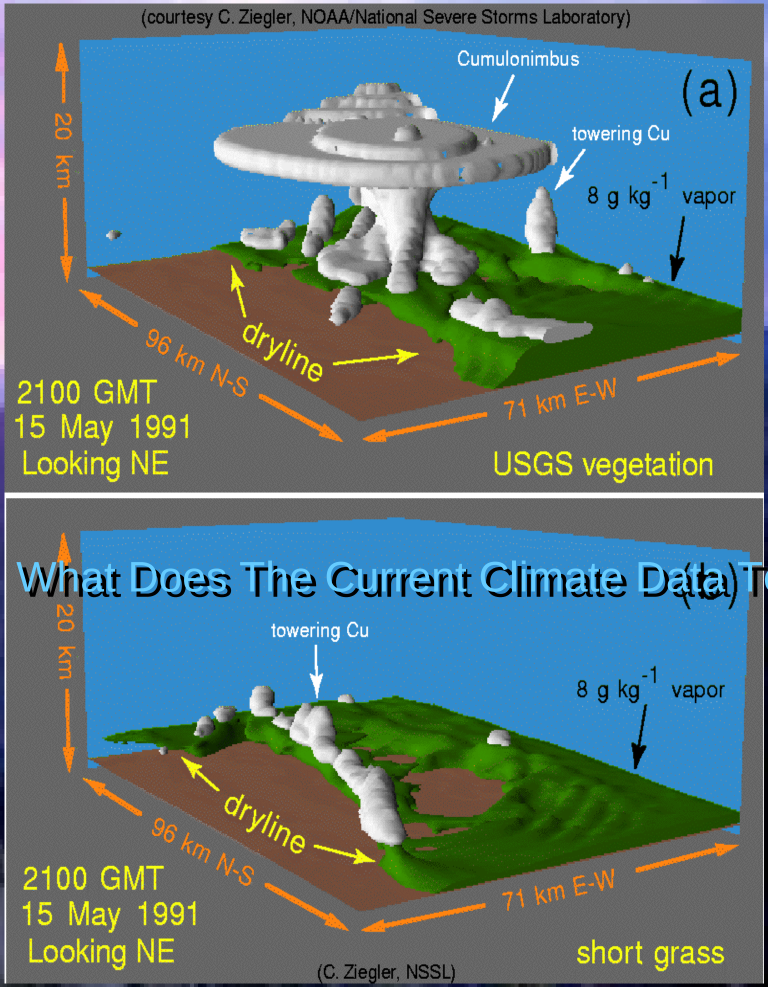


Fig. 3 Output from RAMS simulations: (a) differences in afternoon (12–6 LST) average temperature between the current and natural patterns of vegetation (Fig. 2b minus 2a); and (b) differences in afternoon temperature between increased irrigated vegetation cover and natural vegetation (Fig. 2c minus 2a). Sites were numbered as in Fig. 1.

From Stohlgren, T.J., T.N. Chase, R.A. Pielke, T.G.F. Kittel, and J. Baron, 1998: Evidence that local land use practices influence regional climate and vegetation patterns in adjacent natural areas. Global Change Biology, 4, 495-504. http://climatesci.colorado.edu/publications/pdf/R-198.pdf

What Does The Current Climate Data Tell Us



From: Pielke, R.A., T.J. Lee, J.H. Copeland, J.L. Eastman, C.L. Ziegler, and C.A. Finley, 1997: Use of USGS-provided data to improve weather and climate simulations. Ecological Applications, 7, 3-21.
http://climatesci.colorado.edu/publications/pdf/R-175.pdf

What Does The Current Climate Data Tell Us

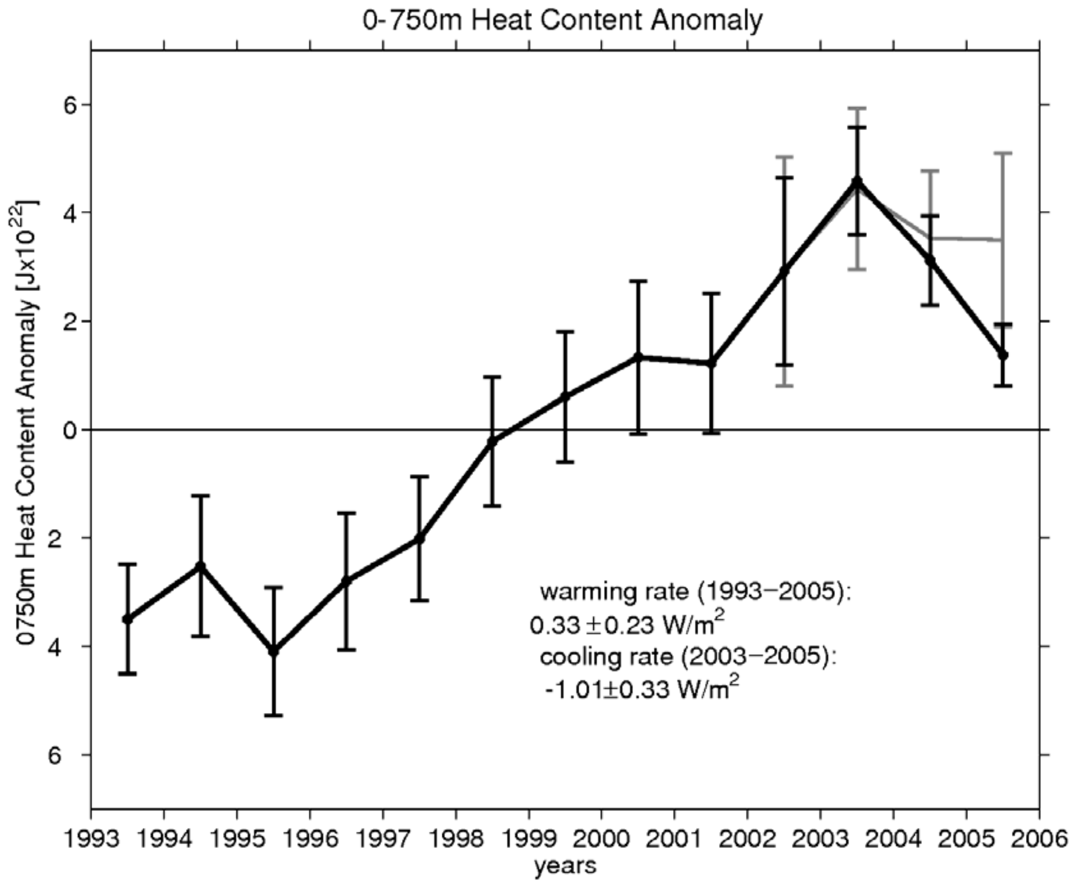


Figure 1. Globally averaged annual OHCA [10^{22} J] in the upper 750 m estimated using in situ data alone from 1993 through 2005 (black line) and using in situ data excluding profiling floats (gray line). Error bars (from Figure 3) reflect the standard error estimates discussed in Section 3. Linear trends 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 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 warming

Other data also show little if any global warming since 2002

SSTs tropospheric temperatures [RSS and UAH MSU data]

2007 IPCC SPM View

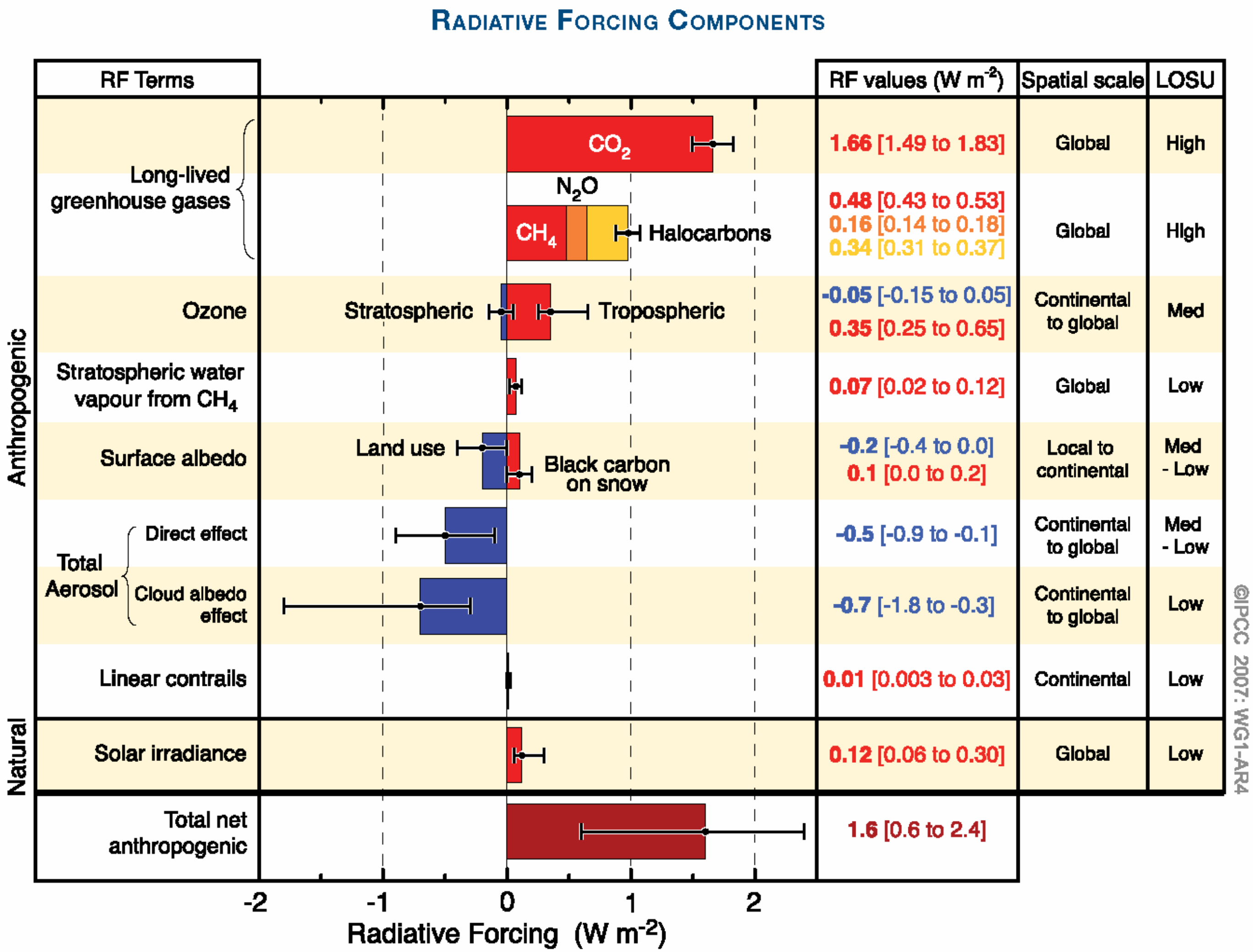


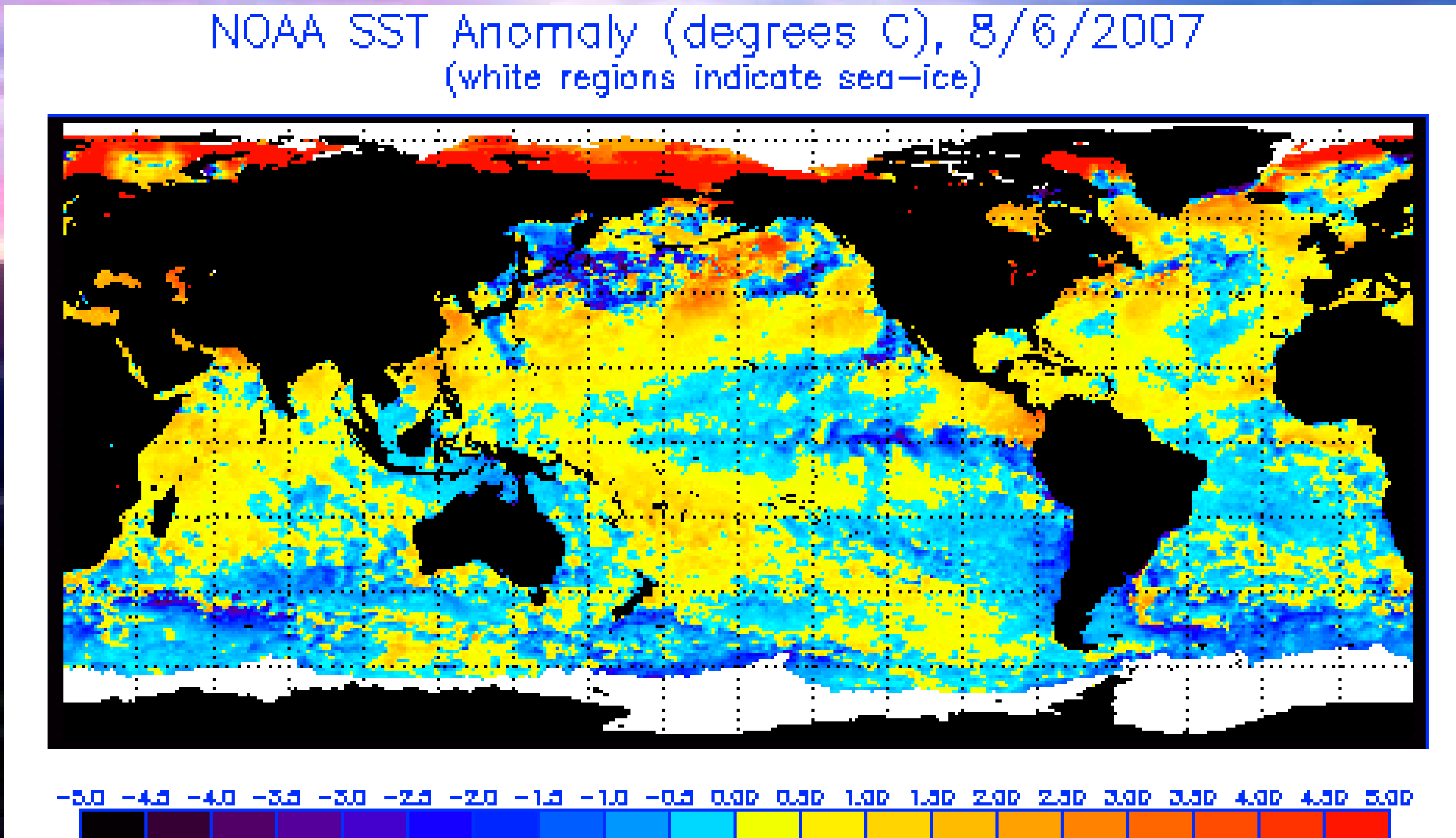
Figure SPM.2. *Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level 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

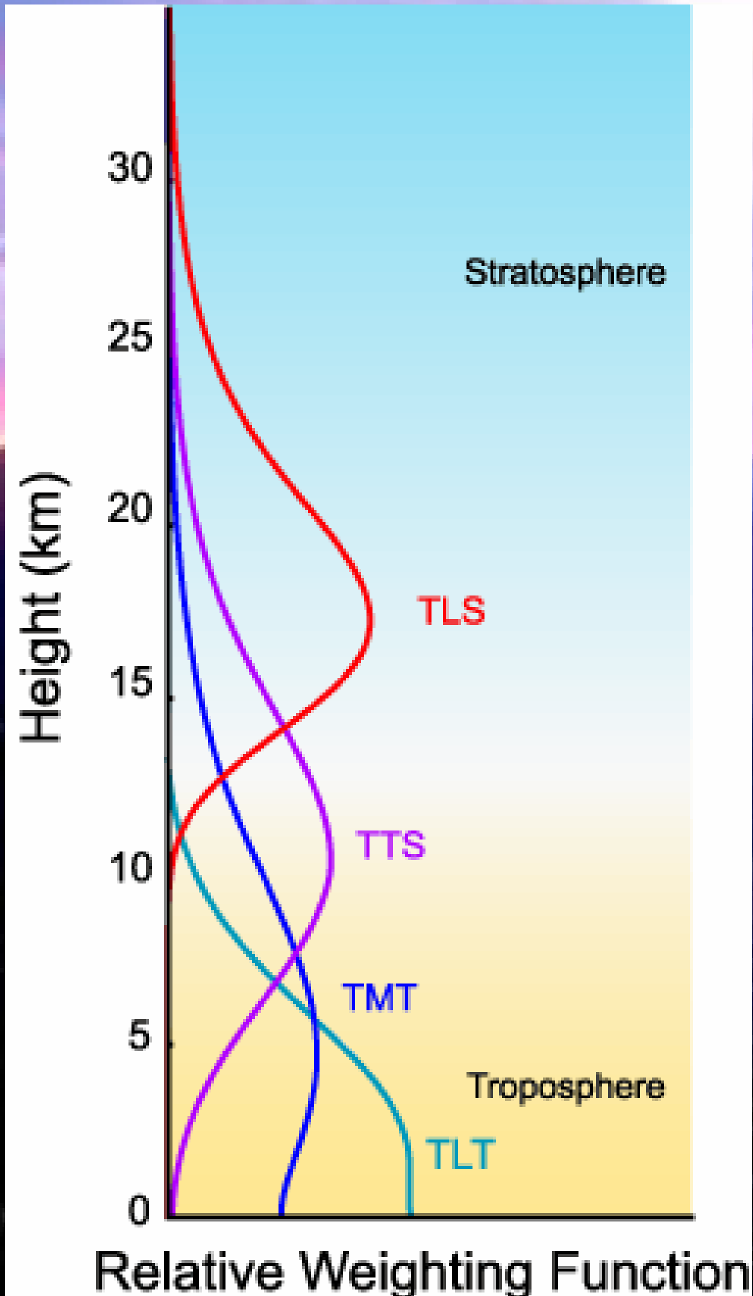
Best Estimate of Total Radiative Imbalance (1993-2005) = 0.33 (0.10 to 0.56) Watts per meter squared

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

Current SST Anomalies



http://www.osdpd.noaa.gov/PSB/EPS/SST/climo.html



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.

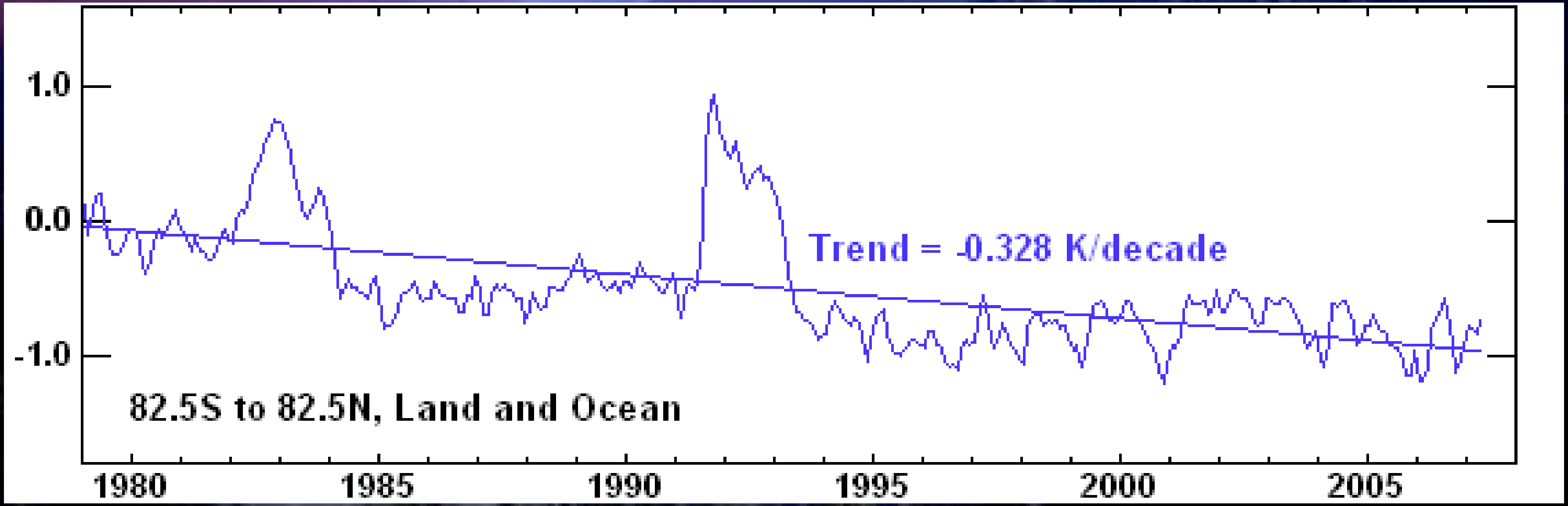
The weighting functions are available on the FTP site at

ftp.ssmi.com/msu/weighting_functions

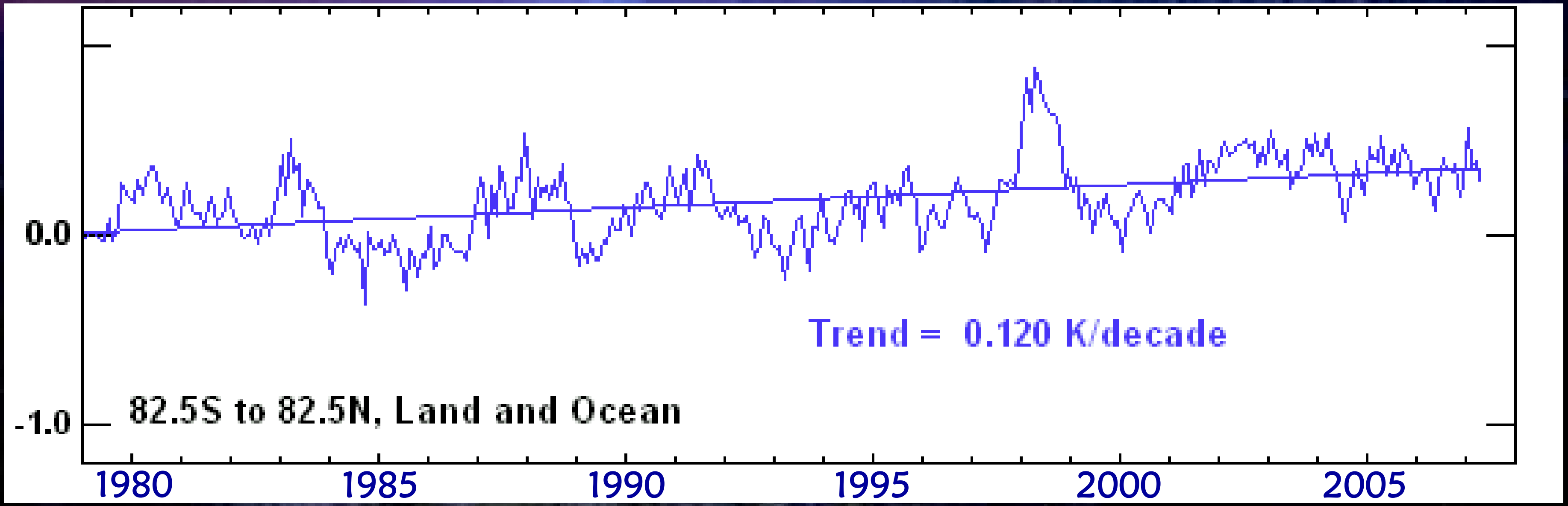
http://www.remss.com/msu/msu_data_description.html#msu_amsu

Global, monthly time series of brightness temperature anomaly for channel TLS. 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).

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

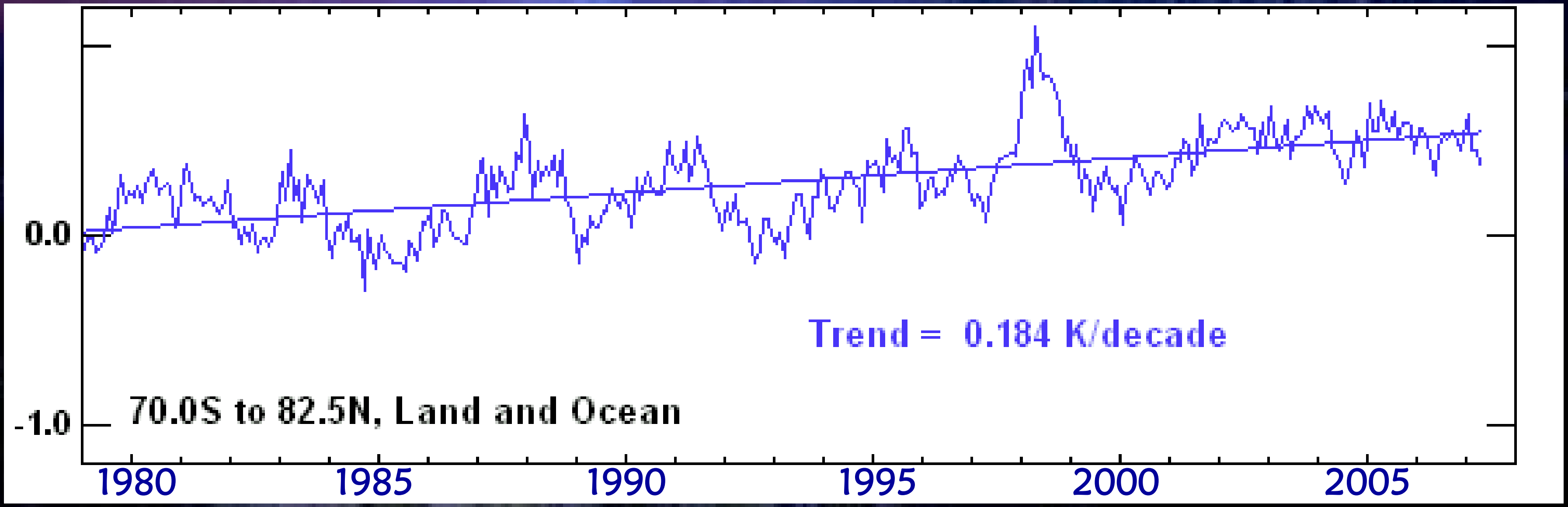


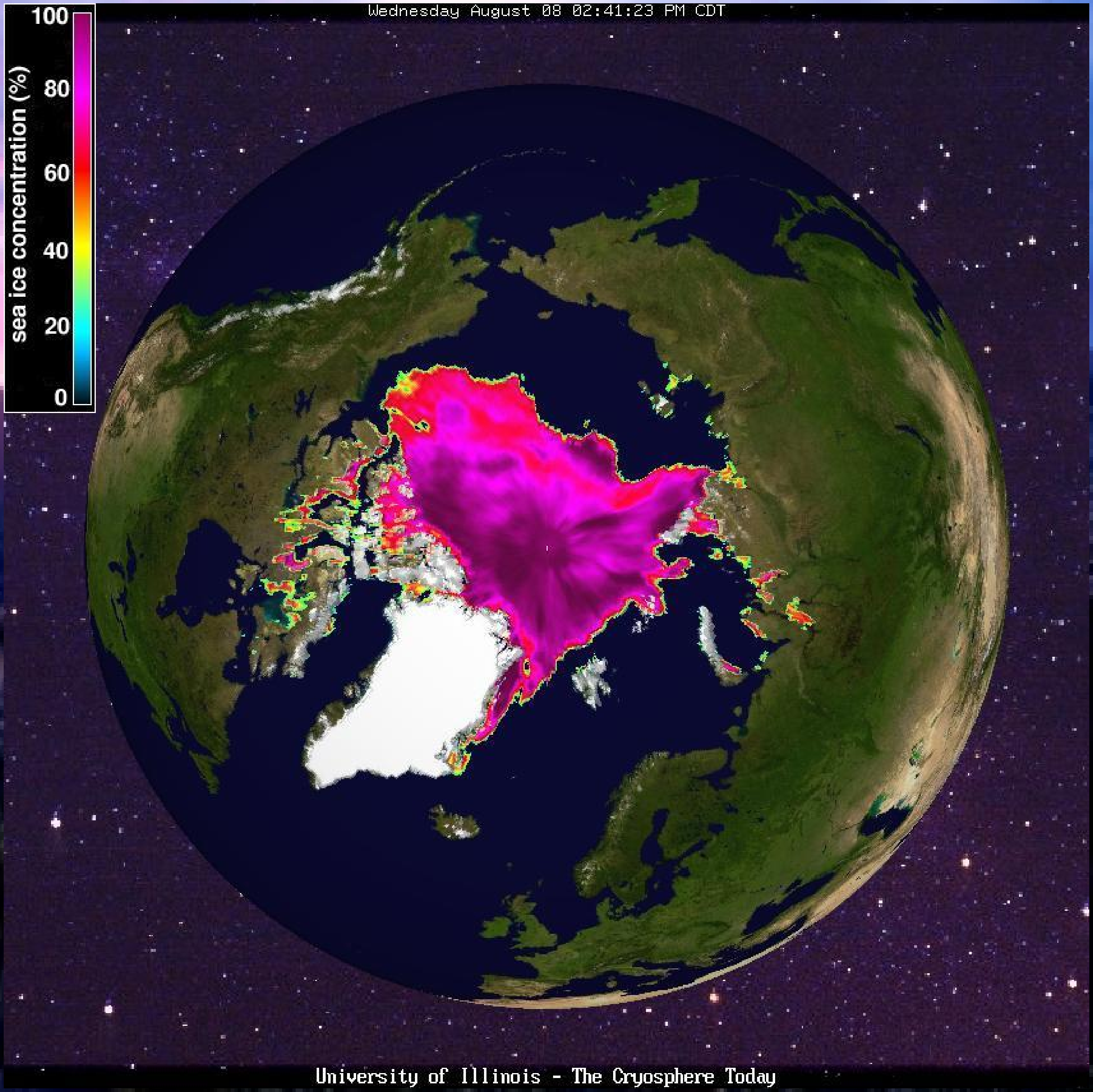
Global, monthly time series of brightness temperature anomaly for Channel TMT (Middle Troposphere), the anomaly time series is dominated by ENSO events and slow tropospheric warming. The three primary El Niños during the past 20 years are clearly evident as peaks in the time series occurring during 1982-83, 1987-88, and 1997-98, with the most recent one being the largest. http://www.remss.com/msu/msu_data_description.html#msu_decadal_trends



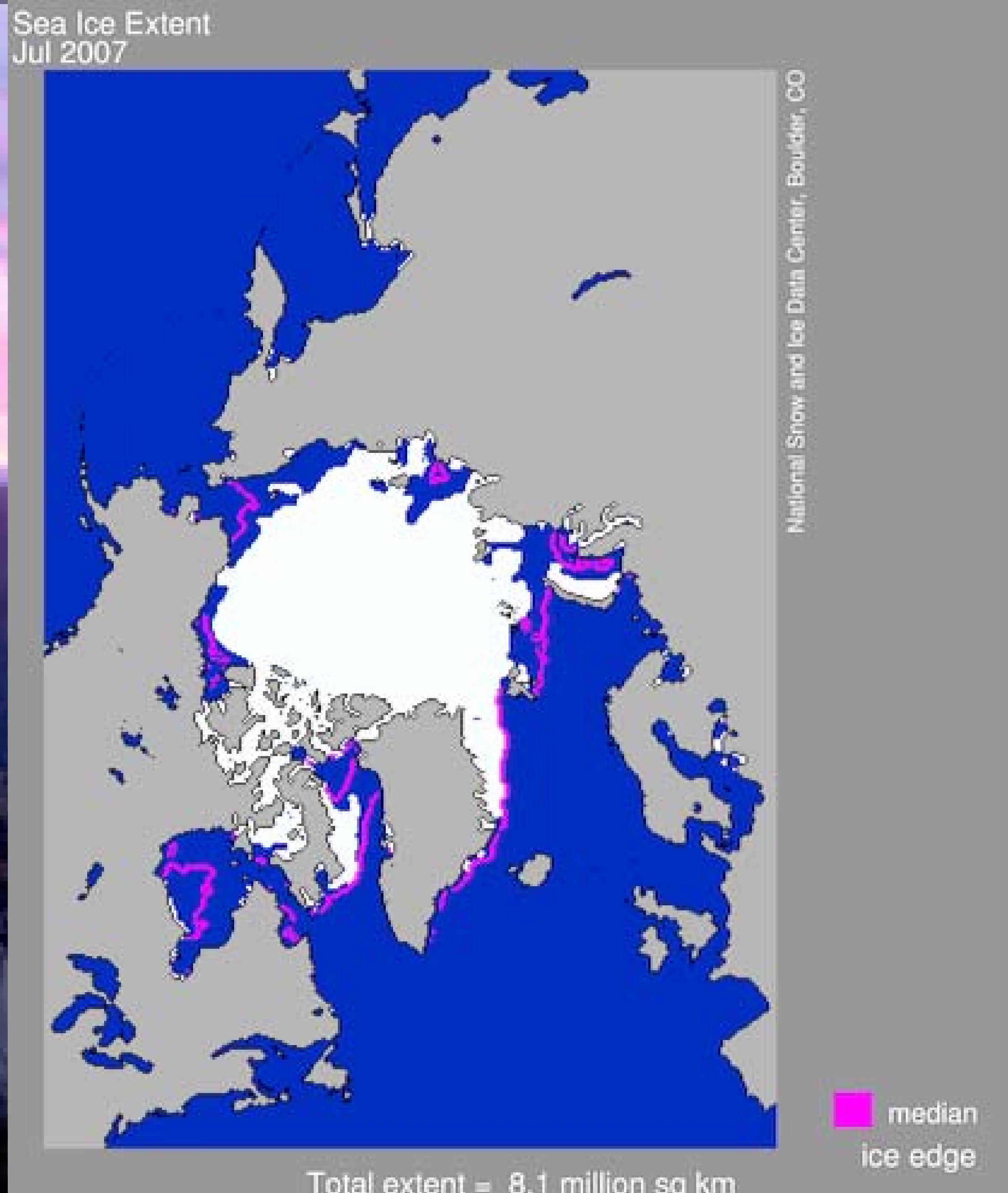
Global, monthly time series of brightness temperature anomaly for Channel TLT (Lower Troposphere), the anomaly time series is dominated by ENSO events and slow tropospheric warming. The three primary El Niños during the past 20 years are clearly evident as peaks in the time series occurring during 1982-83, 1987-88, and 1997-98, with the most recent one being the largest.

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





http://arctic.atmos.uiuc.edu:80/cryosphere/IMAGES/arctic.jpg



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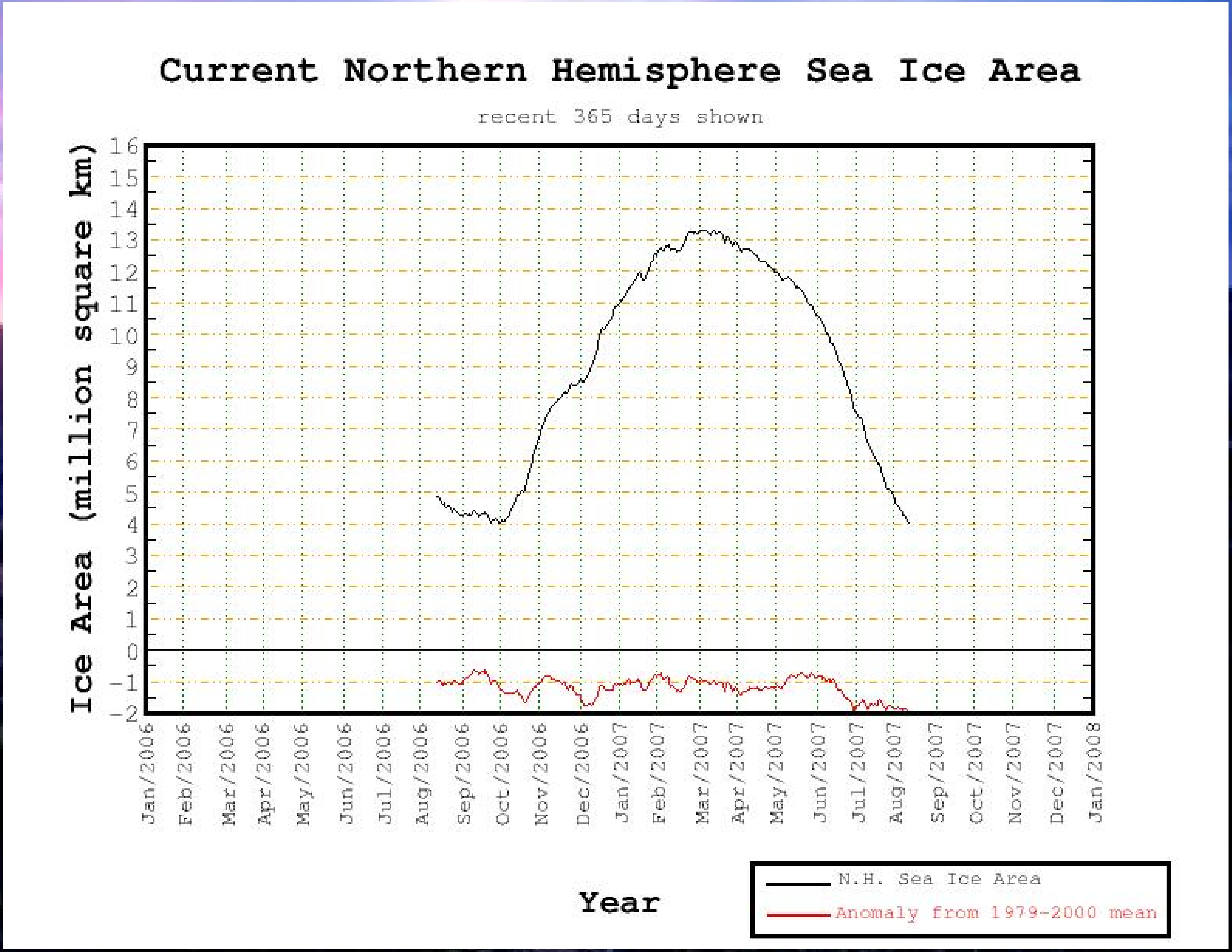
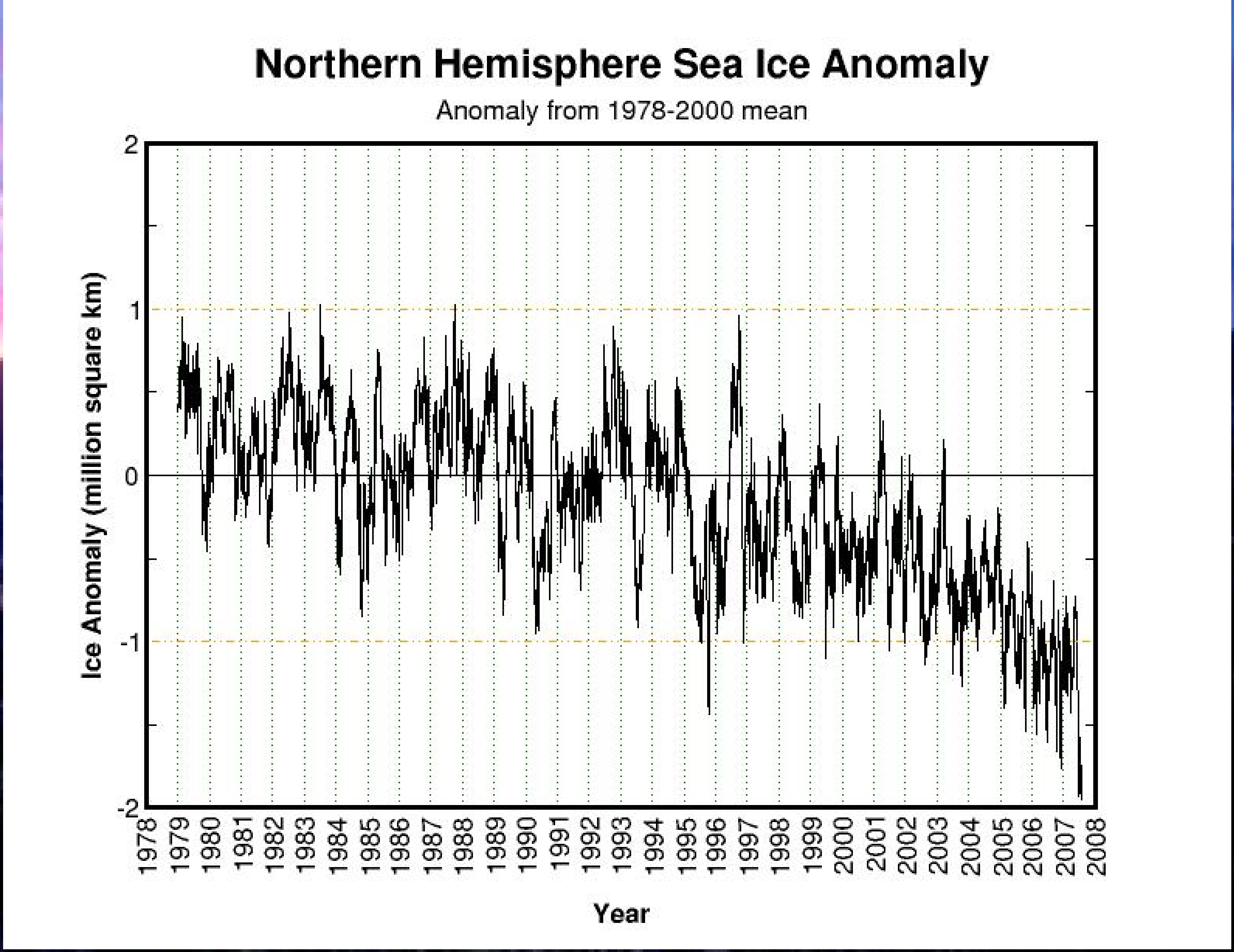
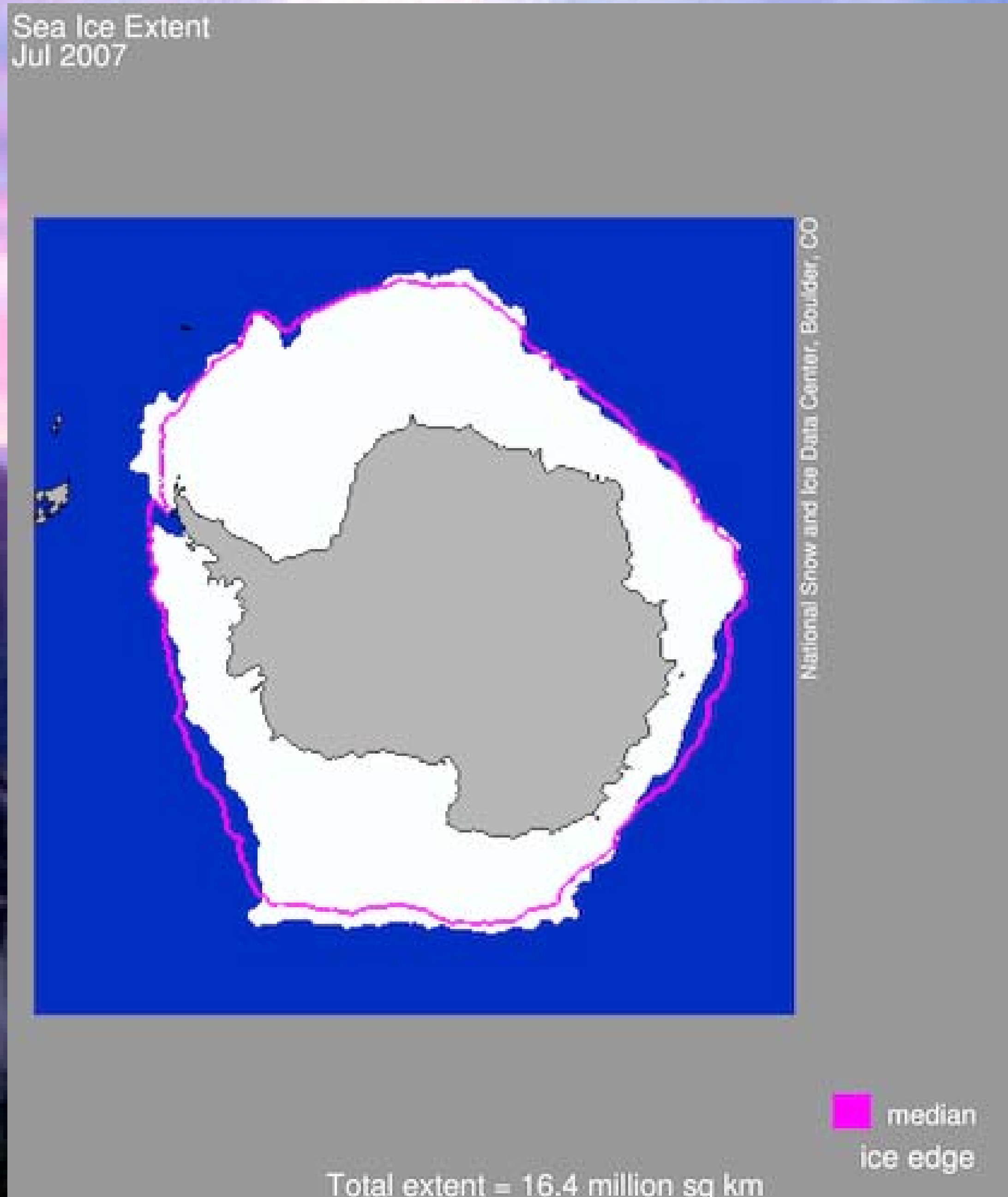


http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/current.365.jpg



http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/current.anom.jpg



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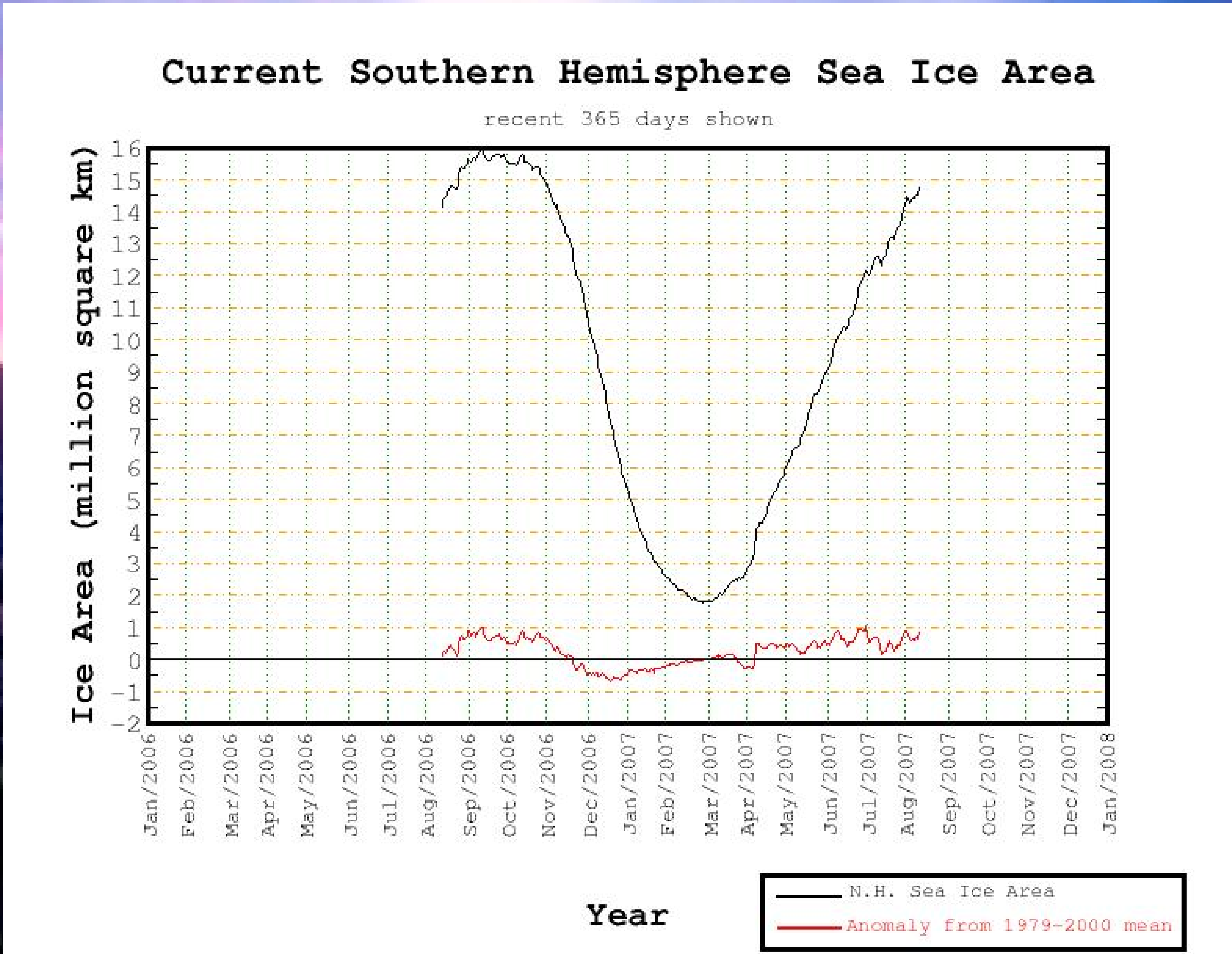


http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/current.365.south.jpg

The Future of Climate Science

Climate is an integration of physical, chemical and biological processes

Climate involves the oceans, atmosphere, land surface, and continental ice

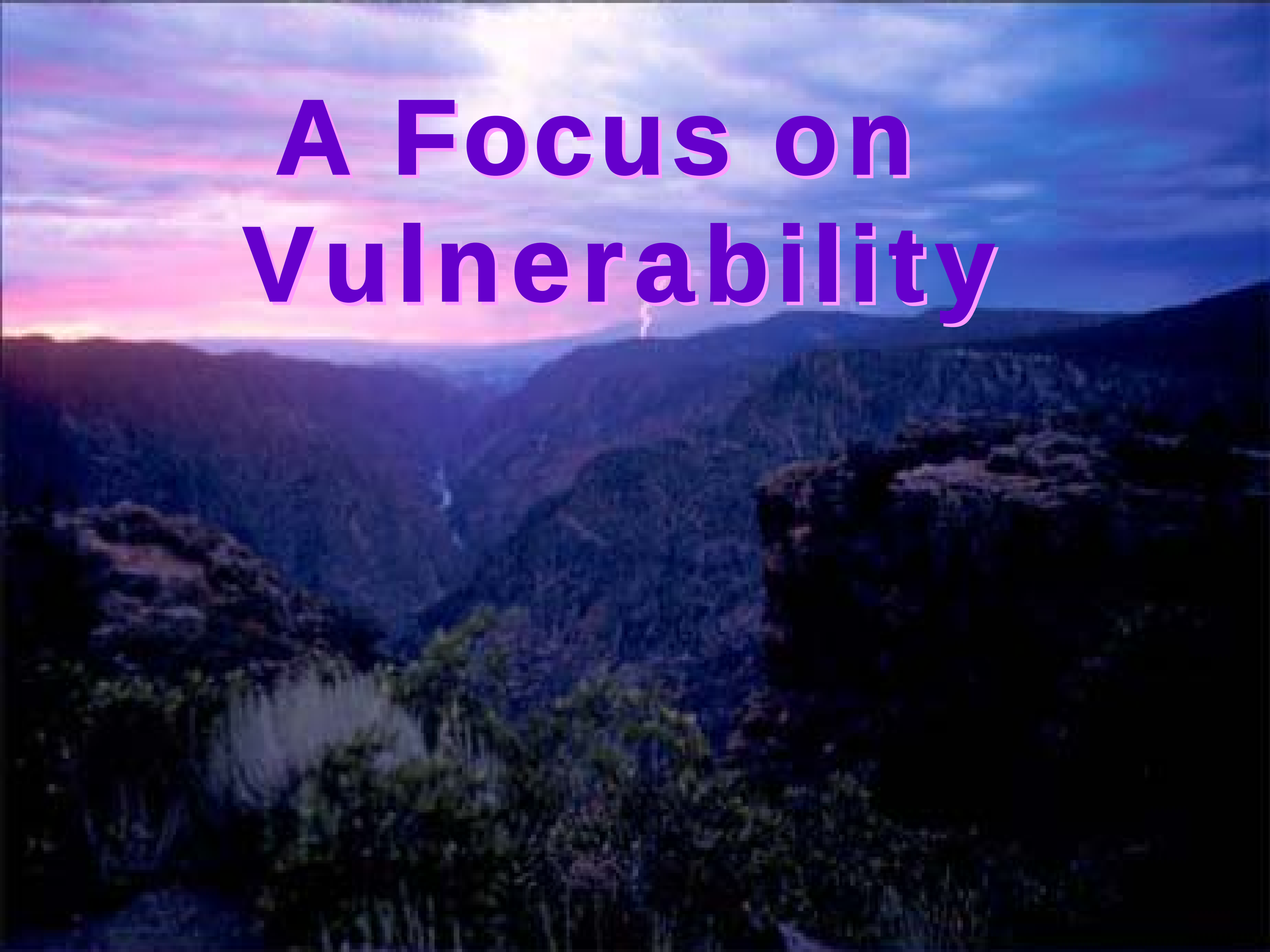
We need to move beyond the current narrow focus of climate change as equivalent to “global warming.”

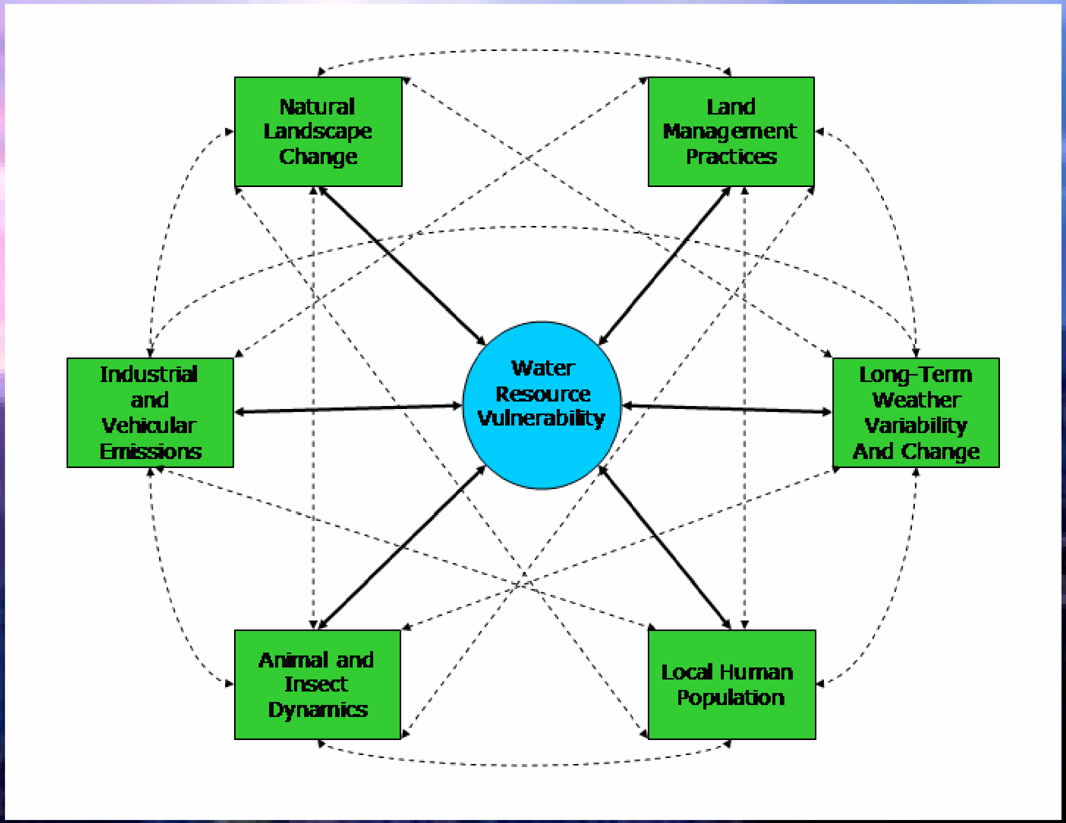
Skillful multidecadal climate forecasts have not been demonstrated

An inversion of the IPCC Assessment Procedure is needed

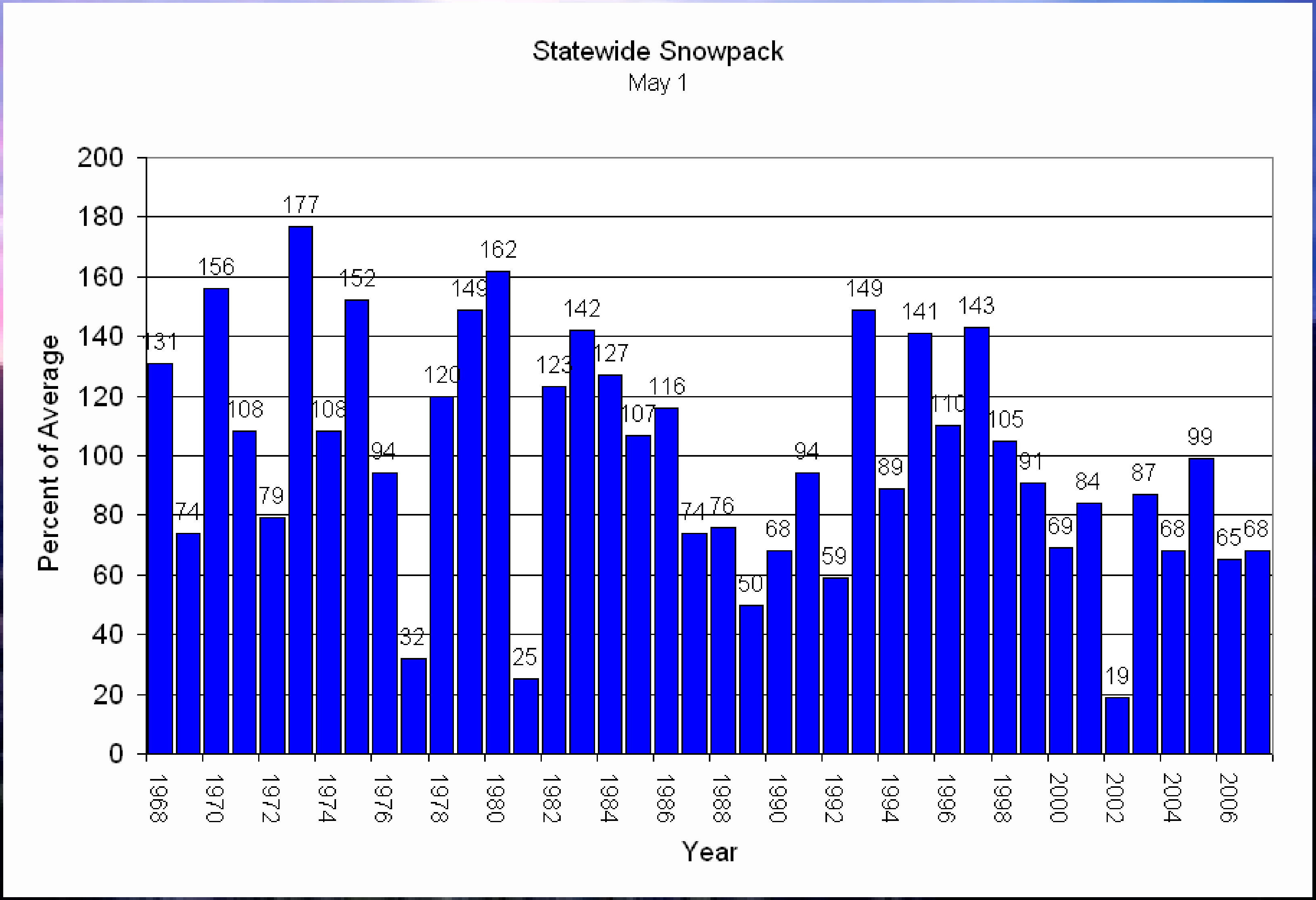
- **We need an approach that is more inclusive and scientifically defensible**

An Alternate Paradigm is Needed


A Focus on
Vulnerability

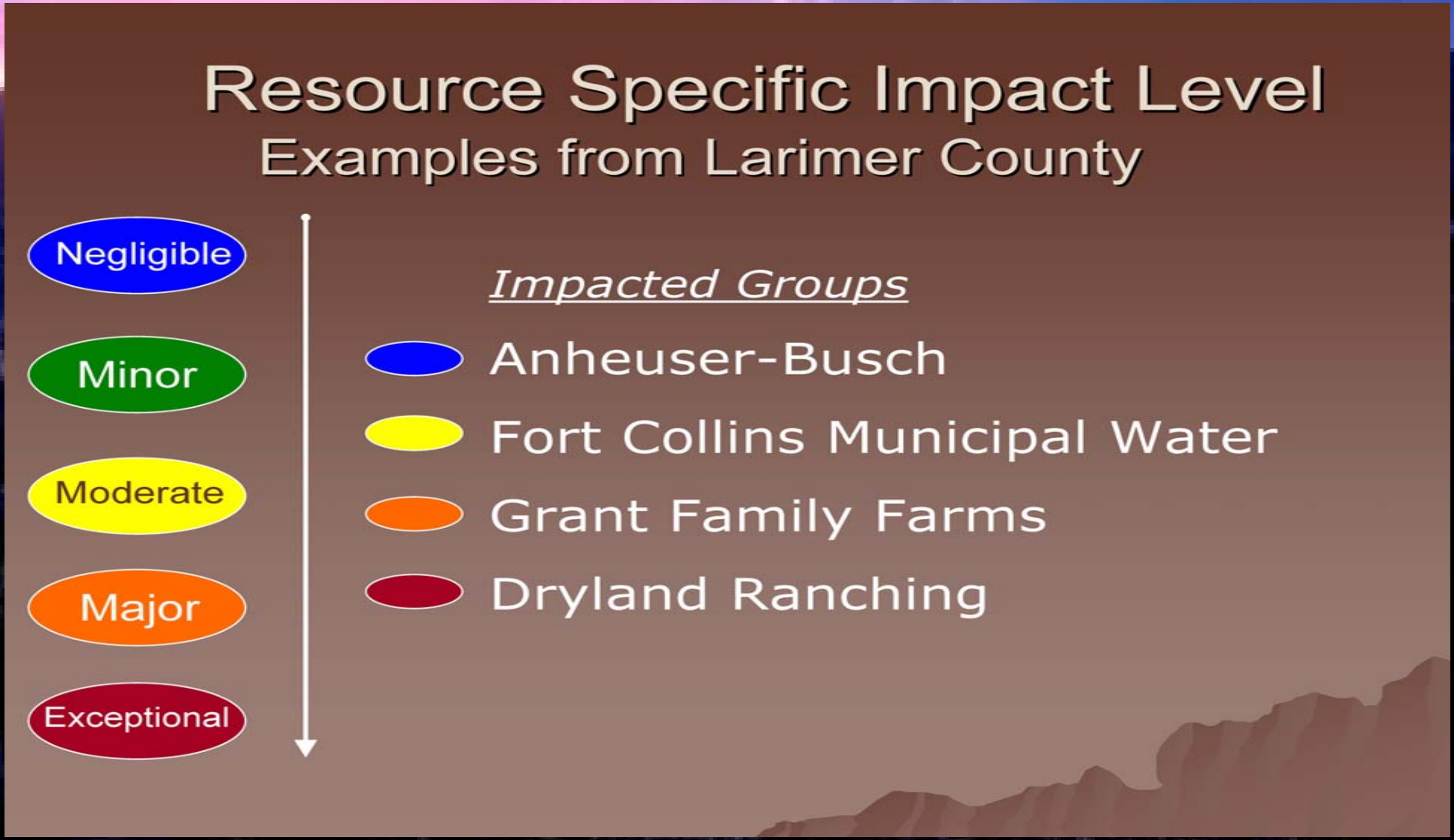


Schematic of the relation of water resource vulnerability to the spectrum of the environmental forcings and feedbacks (adapted from [3]). The arrows denote nonlinear interactions between and within natural and human forcings. From: Pielke, R.A. Sr., 2004: Discussion Forum: A broader perspective on climate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



May 1 snowpack percent of average for the state of Colorado for years 1968 through 2007.
ftp://ftp-fc.sc.egov.usda.gov/CO/Snow/snow/watershed/monthly/maystatetime.gif

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 Colorado, 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

Conclusions

1. 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.
2. 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.

3. 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.
4. The spatial pattern of ocean heat content change is the appropriate metric to assess climate system heat changes including global warming.

5. 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.
6. Global and regional climate models have not demonstrated skill at predicting climate change and variability on multi-decadal time scales.

7. Attempts to significantly influence regional and local-scale climate based on controlling CO_2 emissions alone is an inadequate policy for this purpose.
8. 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.

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
dallas@cires.colorado.edu