

# **What Measures Can Be Taken To Improve The Understanding Of Observed Changes?**

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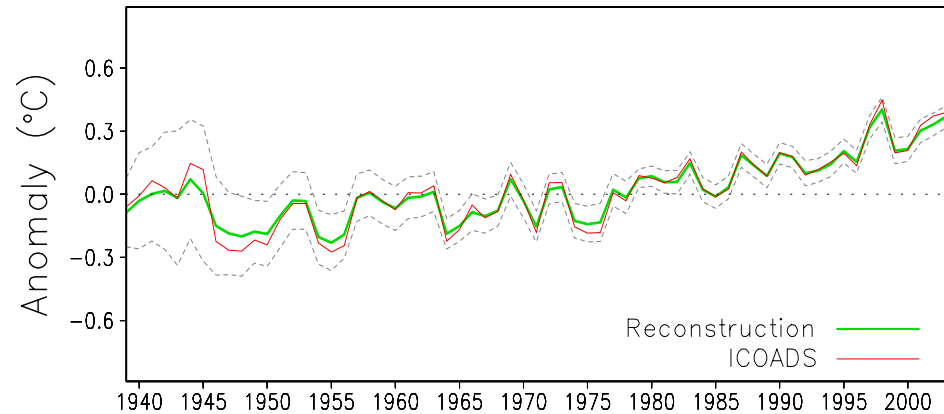
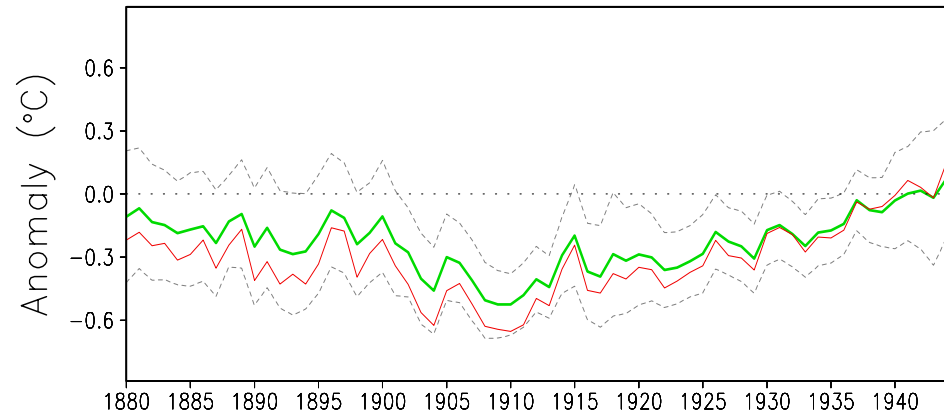
# **1. Using the Data That Already Exist**

# Surface Data

- ↗ **Need homogeneous multivariate data (T, q, MSLP, precipitation) more readily available**
- ↗ **Need metadata on instruments, observational techniques, data reduction, sites**
- ↗ **Surface temperature data trends need to be extended to surface moist static energy trends**
- ↗ **The surface observing sites need to be documented photographically**
- ↗ **The role of land-use change and vegetation dynamics on the surface and tropospheric temperature trends need to be quantified**
- ↗ **Snow cover, sea ice coverage, and frozen surface soils should be used to obtain more accurate diagnoses of surface temperature distributions**

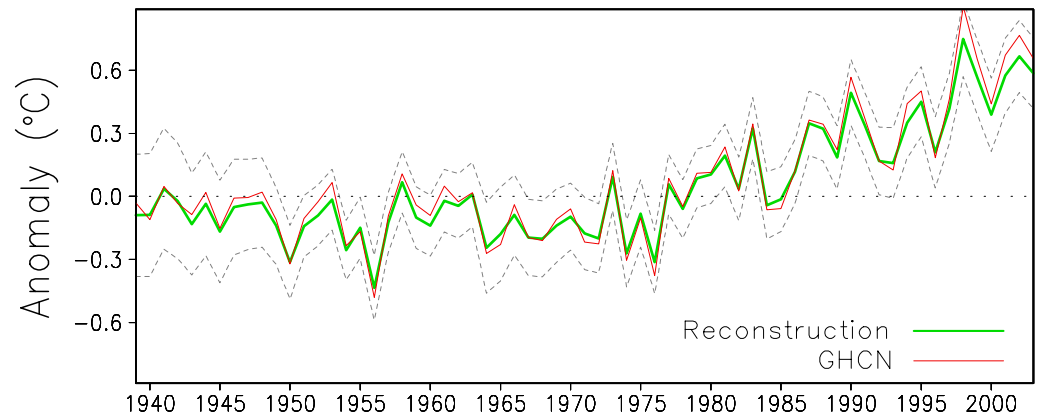
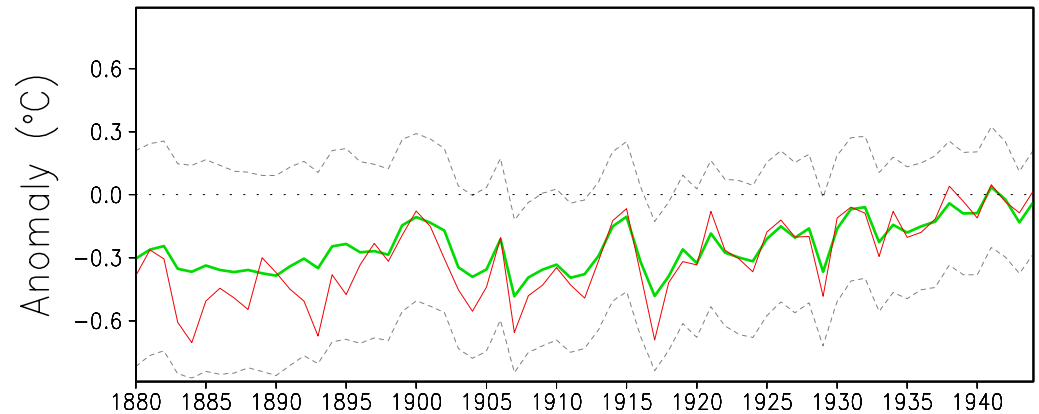
**SST reconstructed anomaly averaged annually and between 60°S and 60°N (green), with its 95% confidence intervals (dashed). Also shown is the simple average of the average ICOADS data (red**

SSTA Average, 60°S–60°N

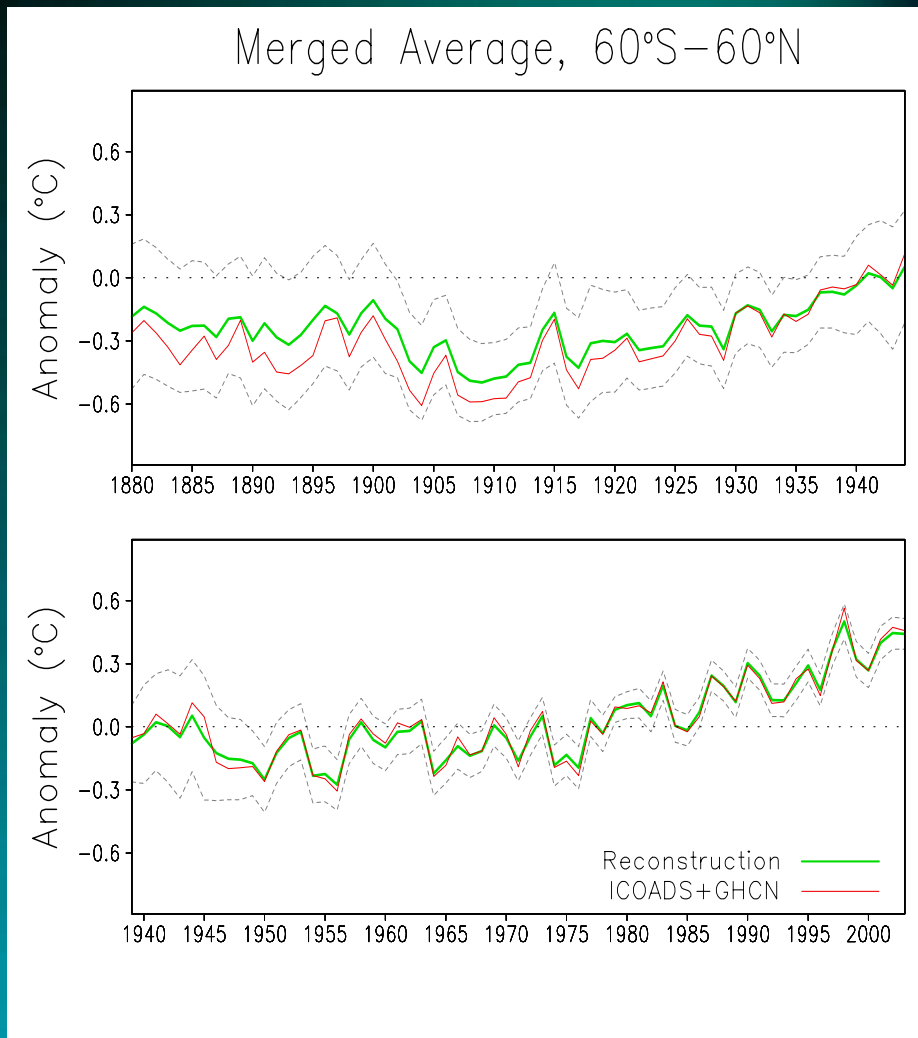


**Land-surface  
temperature  
reconstructed anomaly  
averaged annually and  
between 60°S and 60°N  
(green), with its 95%  
confidence intervals  
(dashed). Also shown is  
the simple average of the  
average GHCN data (red).**

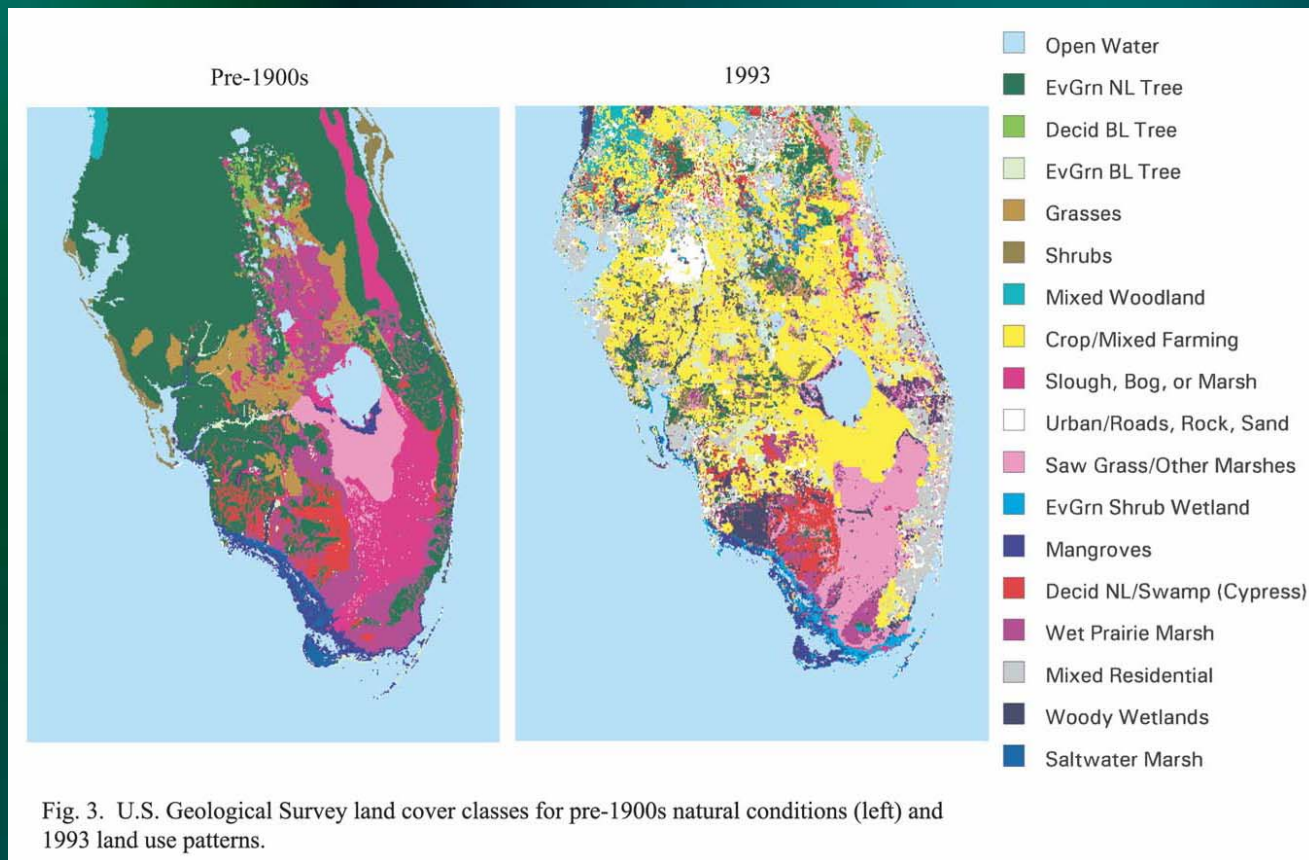
LSTA Average, 60°S–60°N



**Combined SST and land surface temperature reconstructed anomaly averaged annually and between 60°S and 60°N (green), with its 95% confidence intervals (dashed). Also shown is the simple average of the average ICOADS and GHCN data (red).**



USGS land-cover data for (left) pre-1900 natural land cover and (right) 1993 land use). From Marshall et al. (2004).





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

# **SST Analyses and Associated Products**

- **SST Analyses**
  - Optimum Interpolation (OI.v2)
  - Extended Reconstruction SST (ERSST.v2)
- **Combined SST and Land Surface Temperature Analysis**
- **In Situ Data Requirements for satellite bias correction**
  - Buoy Network

# **The Optimum Interpolation (OI) SST Analysis**

**Reynolds et al. (2002)**

- **Data: *in situ* and satellite-based observations blended for global coverage**
- **Record: Begins November 1981, when satellite data become available, weekly and monthly through the present**
- **Analysis method: bias corrections are applied to the satellite data; optimum interpolation (OI) to produce the blended analysis**

# AVHRR Nighttime Biases

- **Volcanoes**

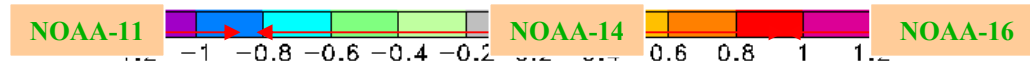
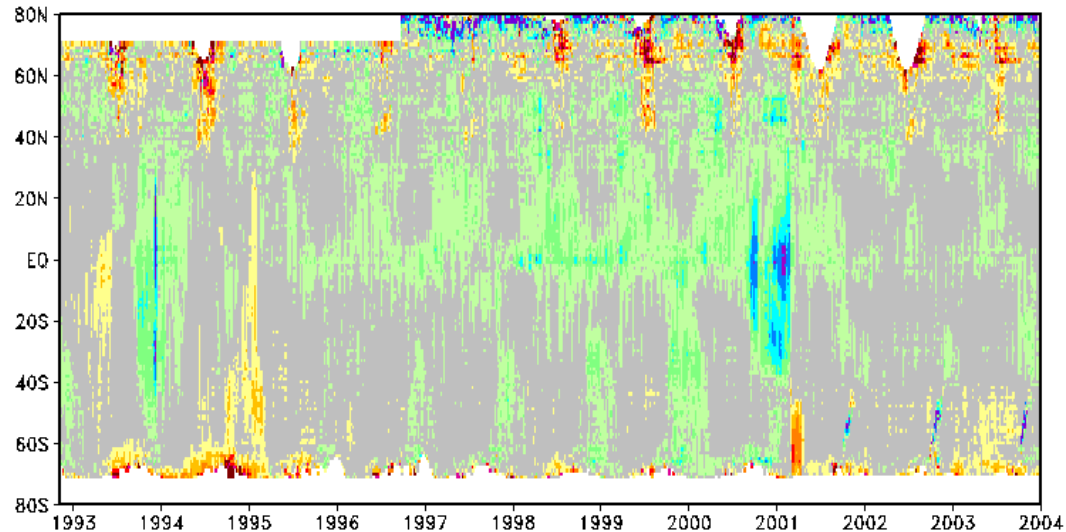
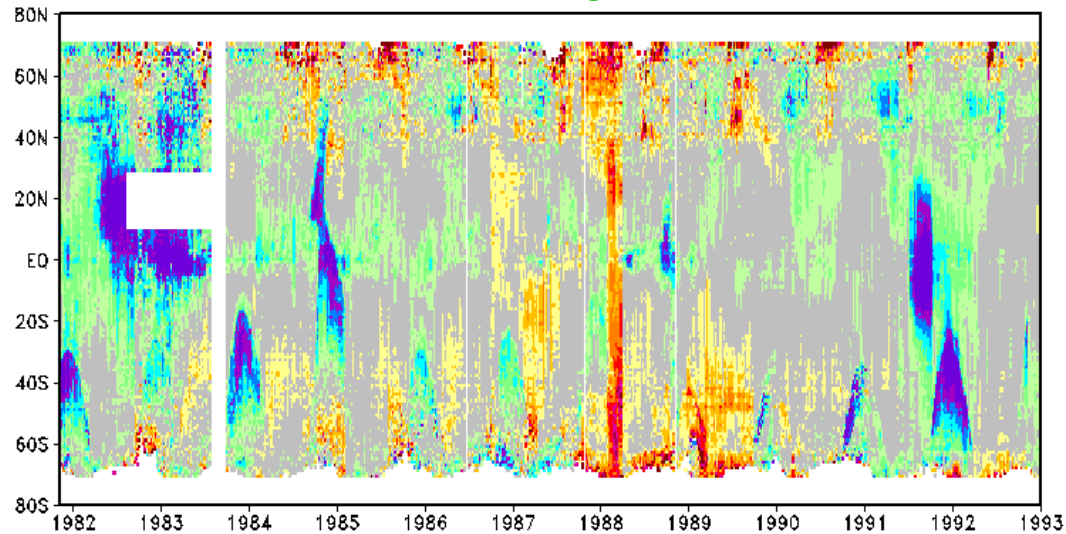
- El Chichón: Mar '82 - Sep '83
- Mt. Pinatubo: Jun '91 - Mar '92

- **NOAA Satellite Periods**

- NOAA-7: Nov '81 - Feb '85
- NOAA-9: Feb '85 - Nov '88
- NOAA-11: Nov '88 - Dec '94
- NOAA-12: Dec '94 - Apr '95
- NOAA-14: Apr '95 - Feb '01
- NOAA-16: Feb '01- .....

OK Bias Range:  $-0.2^{\circ}\text{C} - 0.2^{\circ}\text{C}$

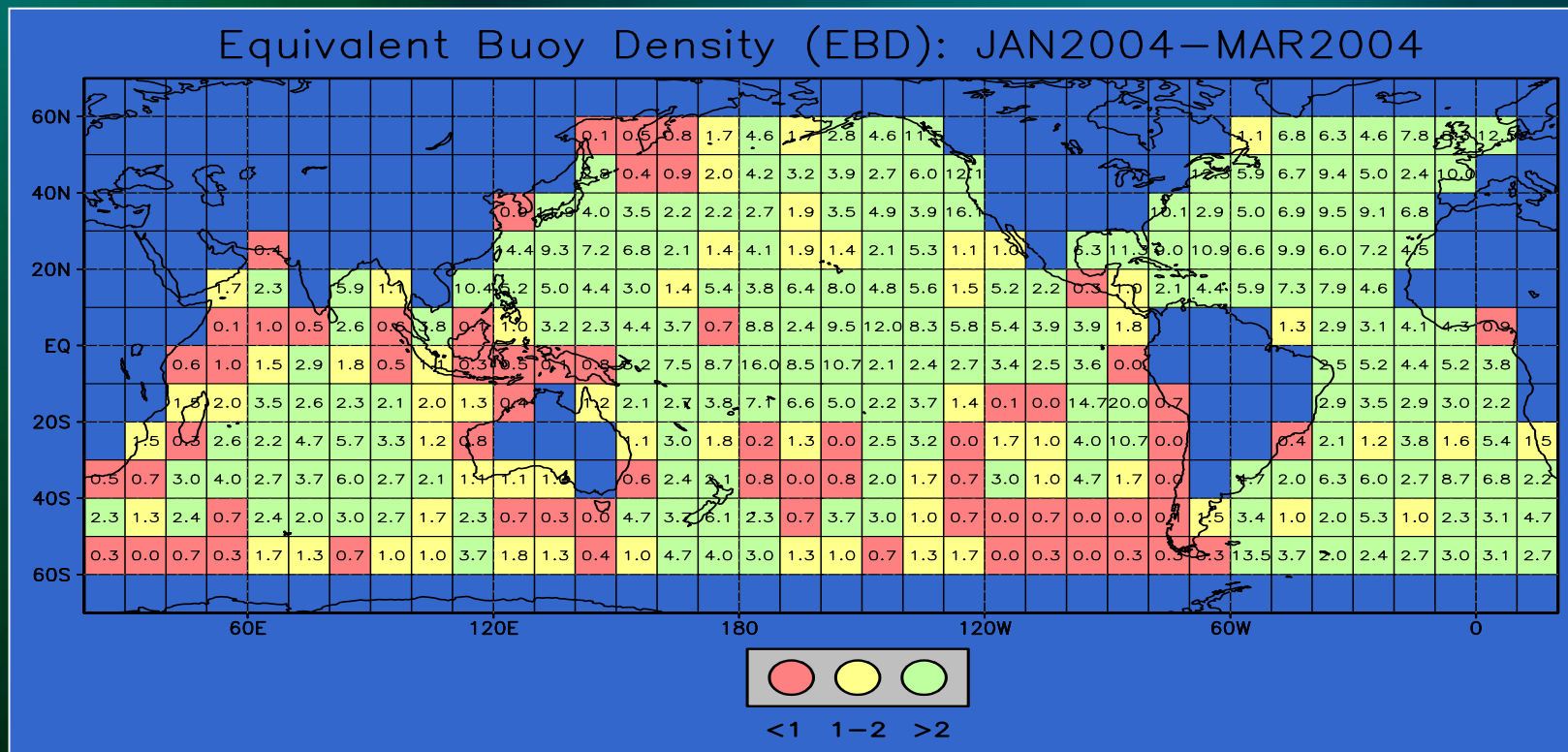
## Zonal Difference: Night Satellite-OI.v2



# Buoy Equivalent Density

"Buoy Equivalent" defined by:  $\text{Number of Ships}/7 + \text{Number of Buoys}$

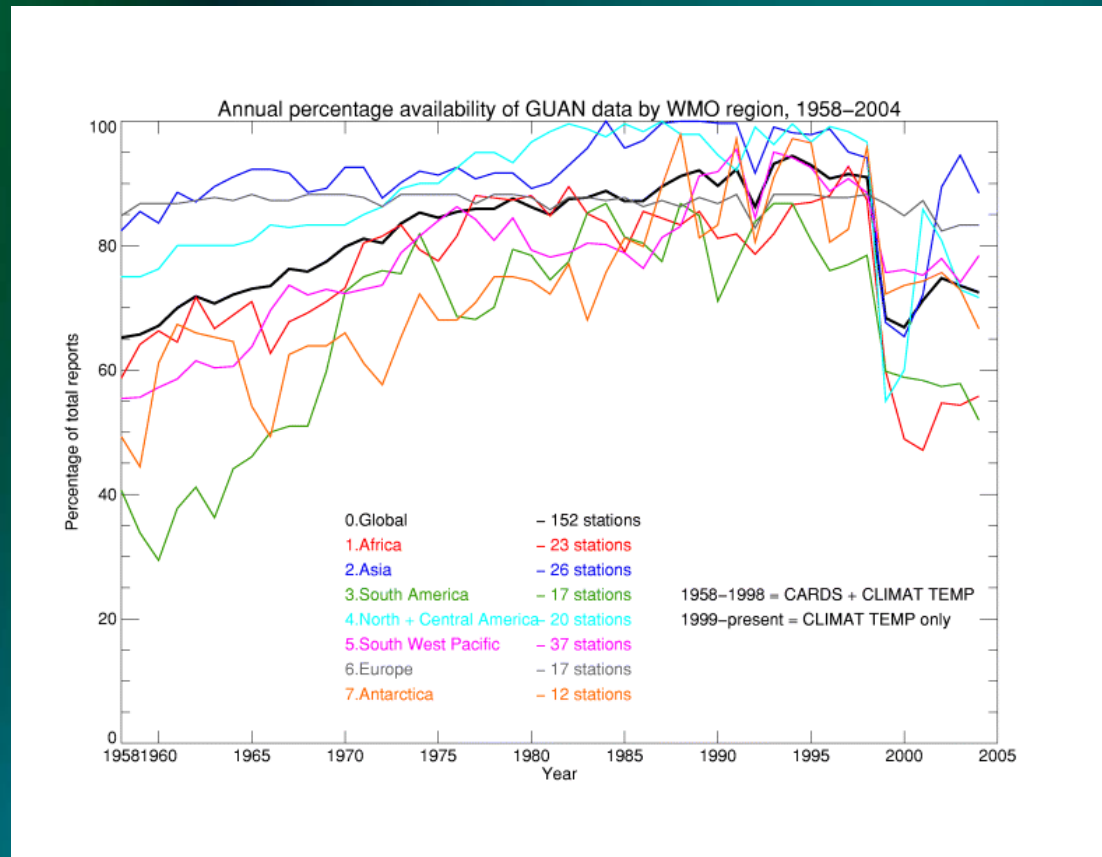
Because ships are nosier than buoys, 7 ships equals 1 buoy



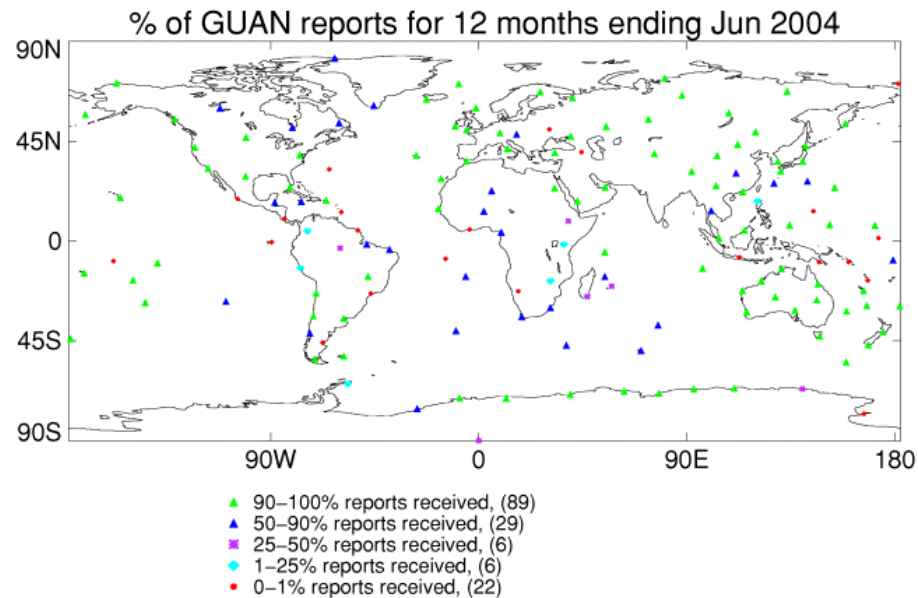
# Tropospheric Data

- ↪ Need homogenous multivariate data (T, Q, winds) more readily available
- ↪ Need metadata on instruments, observational techniques, data reduction
- ↪ Use measurements of the same parameter by radically different means (e.g., MSU, radiosonde for T) as a means of validation
- ↪ Use known physical relationships between different variables to improve quality and gain understanding

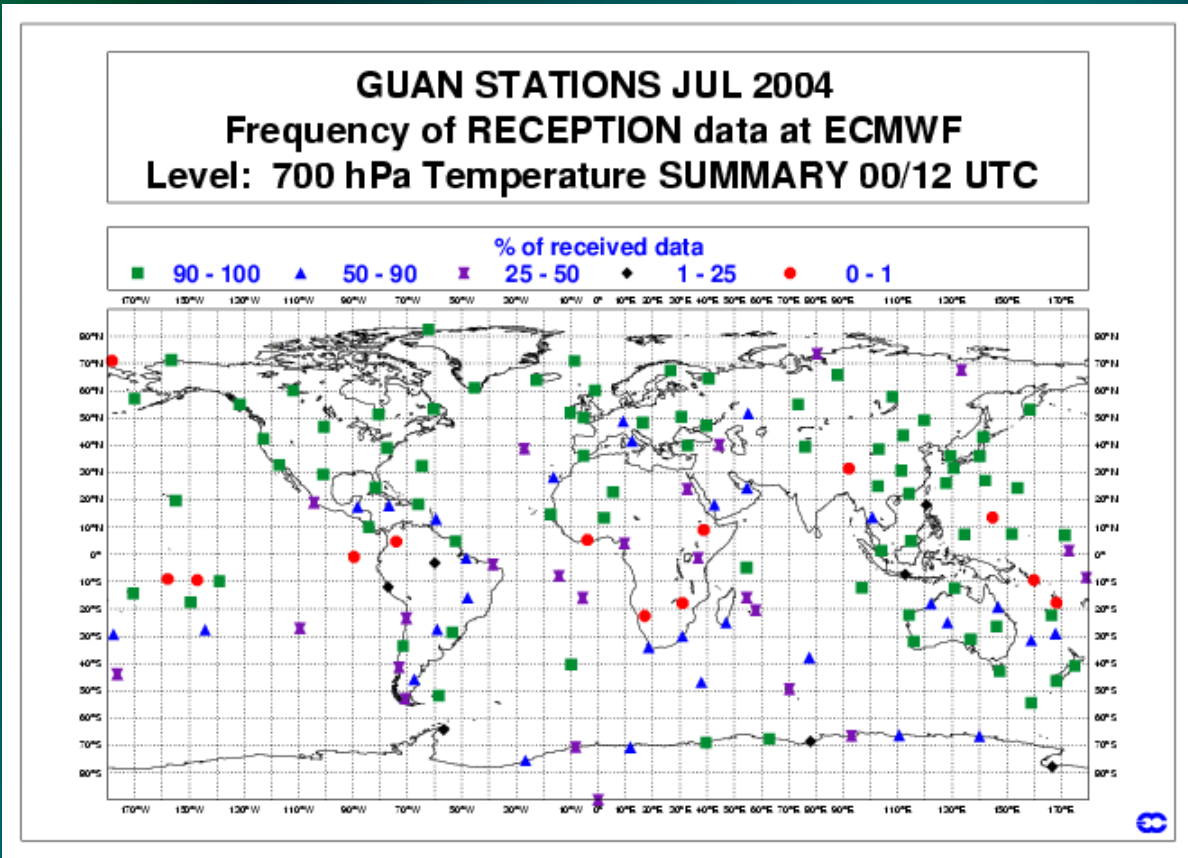
# Increased Availability Of Recent Radiosonde Data



# Tropics, Oceans, And Southern Hemisphere Are Particularly Sparse



# For Good Reanalyses, Daily As Well As Monthly Data Should Be Complete



# We Also Need Reliable, Complete Metadata

[NCDC / Climate Data / Cards Station History / Search / Help](#)

## CARDS Station History Information

### CARDS Station Information

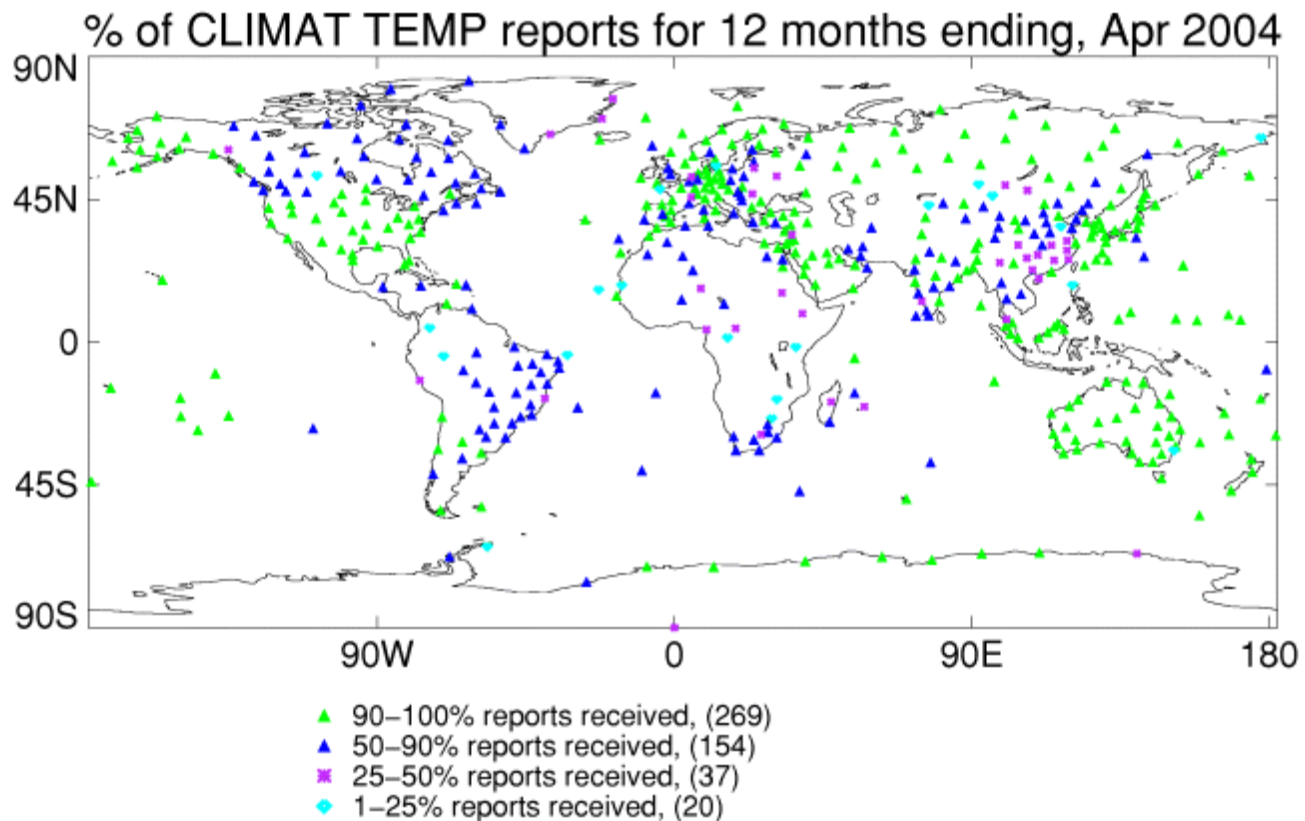
CARDS Number : **606800** Station Name : **TAMANRASSET**  
 Call Sign : **XXXX** Elevation : **1378** Latitude : **22.783** Longitude : **5.517**  
 Fips Country Code/Country : **AG/Algeria** State : **XX**  
 Begin Date : **1957** End Date : **2000** GUAN : **Yes** Previous Cards ID :

### CARDS Metadata

Date of Change	Type of Change	Previous Equipment or Practice	New Equipment or Practice	Generic Data Source*	Date Flag
1999110811	Radiosonde	VAISALA-RS80	937	Data Headers	Equipment or practice already in use
1998010199	Ground equipment	Dacos	15	WMO	Equipment or practice already in use
1993000099	Radiation correction	VRS80-1986	906	Gaffen	Unknown
1993000099	Radiosonde	VAISALA-RS80	938	Gaffen	Equipment or practice already in use
1982000099	Radiation correction	NO_CORRECTION	101	Gaffen	Unknown
1982000099	Radiosonde	VAISALA-RS18	936	Gaffen	Equipment or practice already in use
1976000099	Radiosonde	MESURAL-FMO-1943B	702	Gaffen	Unknown

\* Text Version may contain more detailed information on the data source as well as additional comments.

Reception of monthly CLIMAT TEMP reports from radiosonde stations worldwide, May 2003 through April 2004 (Courtesy Mark McCarthy, Hadley Centre, Met Office, UK). CLIMAT TEMP messages contain monthly average temperature, dewpoint, wind, and numbers of days' data for standard pressure levels in the troposphere and stratosphere and for the surface at the station. A map for the most recent available 12-month period is on <http://www.guanweb.com/>



# Other Analyses

- ↪ Use reanalyses to improve data and understanding; and use the improved data and understanding to improve reanalyses.
- ↪ Interpret regional patterns of trends in terms of regional forcings (e.g., aerosols) as well as global forcings (e.g., GHGs).
- ↪ The entire spectrum of global and regional climate forcings and feedbacks need to be applied to explain observed surface and tropospheric temperature trends.

## **2. Improving and Using the Models**

# Parameterizations

- ↪ **Observed negative feedbacks on tropospheric temperature trends need to be explored in the context of the climate change models**

# Use and Value of Reanalyses

- **Quantitative comparisons between the different available reanalyses and radiosondes need to be performed, and their degree of independence clearly articulated**
- **Given the inhomogeneity in time of the reanalyses, a focus on regions of particularly large regional trends can provide robust evaluations of tropospheric trends, and can be compared with the surface temperature data in the same regions**
- **An emphasis on lower tropospheric temperature data and the use of integrated metrics, such as the distance between pressure surfaces, the vertical shear of the horizontal wind, and precipitable water should priority diagnoses from the reanalyses**

# Model Testing

- ↪ The GCM global *and regional* projections of climate change need to be quantitatively compared to observed surface and tropospheric temperature and moist static energy changes for the period from 1979-present, which is when the most accurate data are available
- ↪ Regional observed ocean heat content changes need to be related observed surface and tropospheric temperature trends in the same region, as well as compared with the GCM climate change projections of these trends

**From: Chase, T.N., R.A. Pielke Sr., B. Herman, and X. Zeng, 2004:  
Likelihood of rapidly increasing surface temperatures unaccompanied  
by strong warming in the free troposphere. Climate Res., 25, 185-190.  
<http://blue.atmos.colostate.edu/publications/pdf/R-271.pdf>**

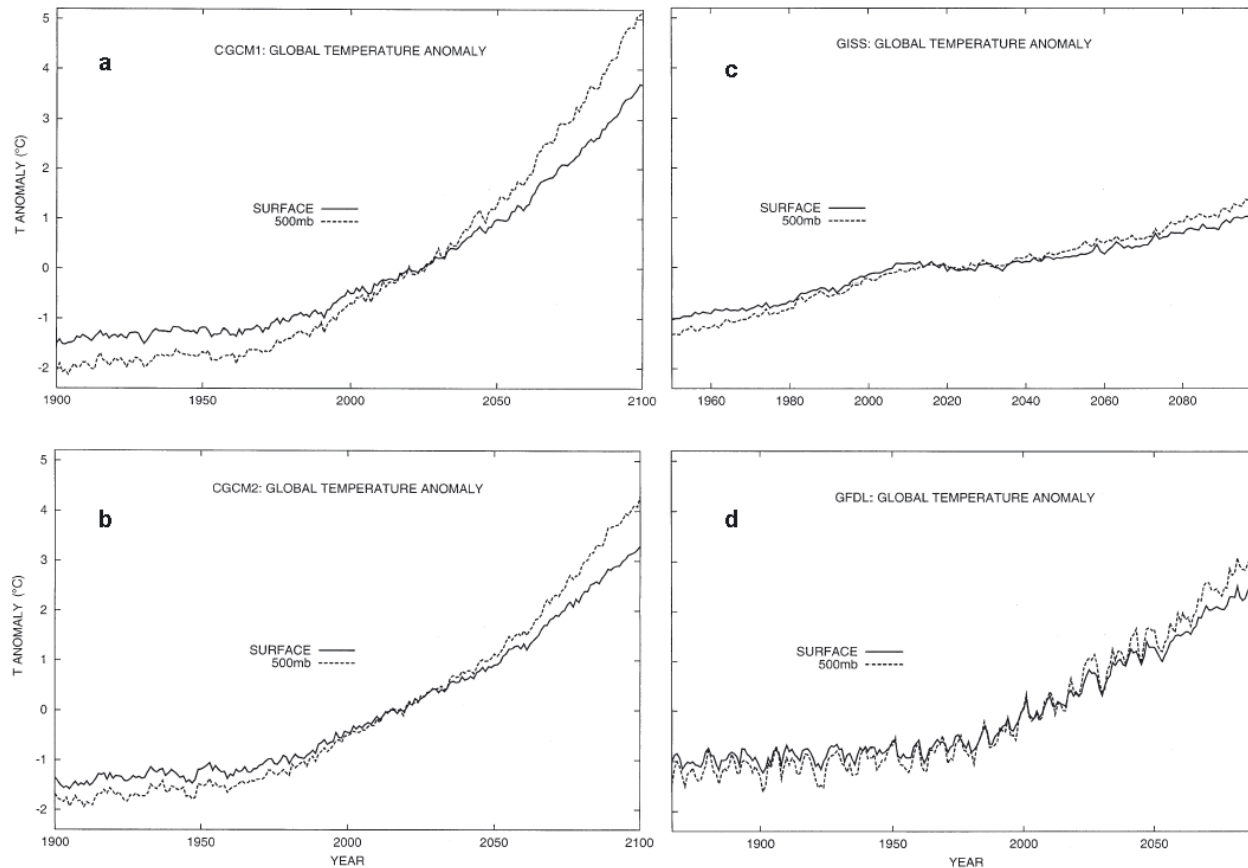
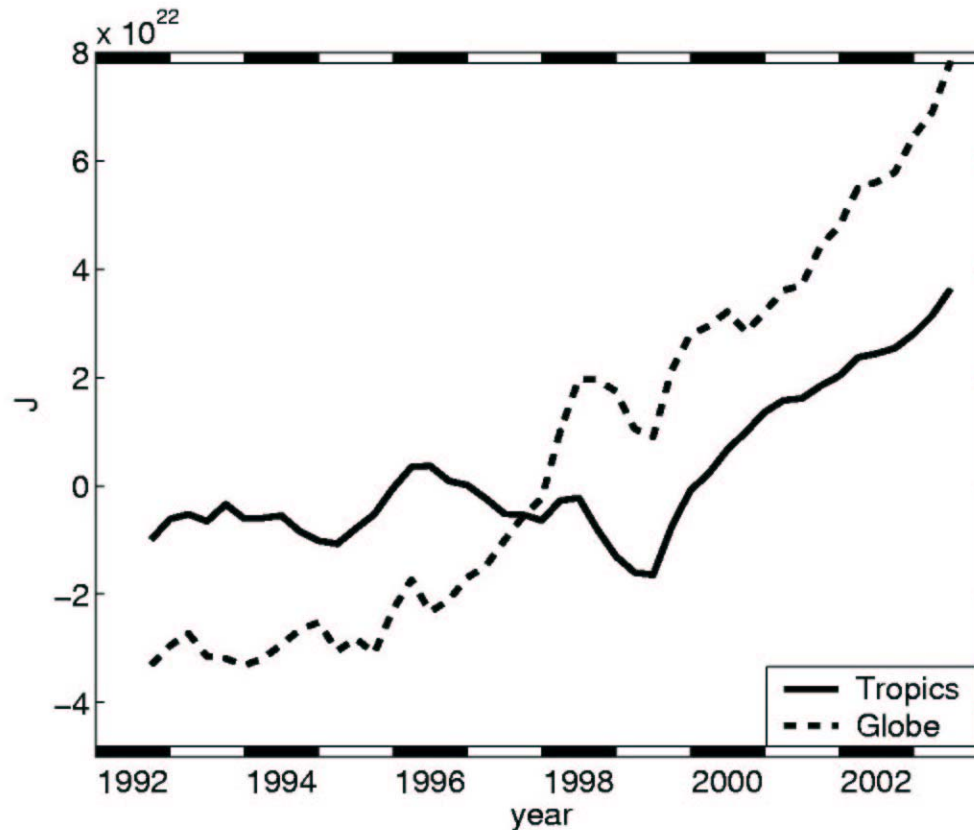
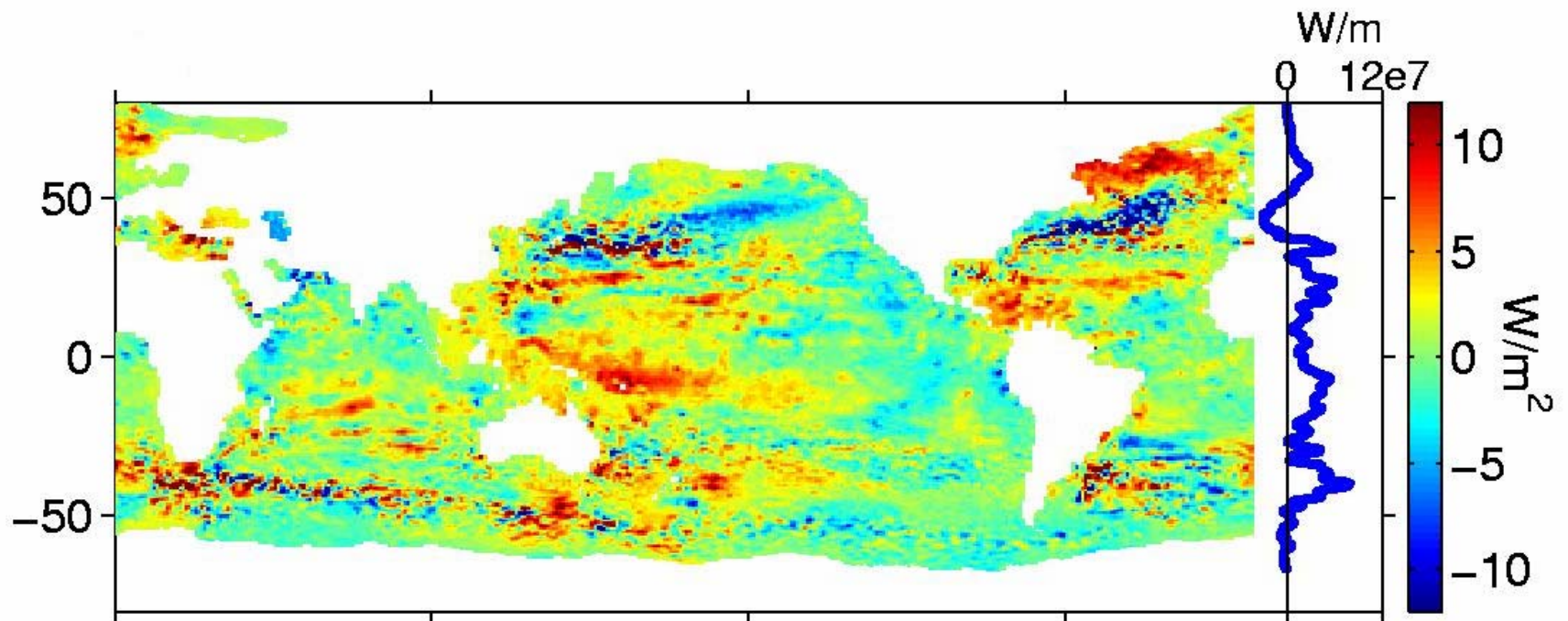


Fig. 1. Globally averaged surface and 500 mb temperature anomalies (relative to the 1979–2000 mean) for 1 realization of: (a) the Canadian Center for Climate Modelling and Analysis coupled model I (CGCM1) ensemble, (b) CGCM2, (c) the Goddard Institute for Space Studies (GISS) model, and (d) the Geophysical Fluid Dynamics Laboratory (GFDL) model

Interannual variability in heat content integrated over the region from 20°N to 20°S (solid line) and over the entire globe (dashed line). From Willis et al. (2004).



Map of 10-year change in heat content in  $\text{W m}^{-2}$  for the difference estimate (combined altimeter and in-situ data). From Willis et al. (2004).



# **3. Planning Observations For the Future**

↪ **Follow the GCOS Climate Monitoring Principles**

↪ **Long-term, stable surface climate observing sites should be a high priority. These sites should be co-located as much as possible with hydrologic and ecological observing sites, in order to facilitate an improved understanding of the observed trends**

# Surface

- ↪ **Develop surface reference network**
- ↪ **Implement cooperative modernization**

# Tropospheric In-Situ

- ↪ **Measure heights directly using GPS; this will provide check on integrated virtual temperatures**

- ↪ **Improve parameterization of deep convection**
- ↪ **Optimal reanalyses should have homogeneous input data as well as frozen model formulation, if they are to be used to assess trends as skillfully as possible.**
- ↪ **Compare different reanalyses and use them to test climate-prediction models**

# Satellite

- ↪ **Replacement satellite launches should be planned to take place at least a year prior to the expected time of failure of a satellite**
- ↪ **One-year overlap (this is a GCOS Climate Monitoring Principle!)**

# Combined Observational Procedure

- ↪ A priority should be given to the assessment of global and regional surface and tropospheric variability and trends using multiple observational systems and multiple analysis teams
- ↪ Use measurements of the same parameter by multiple observing systems as a means of validation
- ↪ Multiple analysis teams need to work together to obtain consistent conclusions on global and regional trends

# **GCOS Climate Monitoring Principles**

- 1. Impact of new systems/changes to existing systems should be assessed prior to implementation.**
- 2. A suitable period of overlap for new and old observing systems.**
- 3. Metadata should be documented and treated with the same care as the data themselves.**
- 4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.**
- 5. Needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional, and global observing priorities.**

# **GCOS Climate Monitoring Principles (Continued)**

- 6. Operation of historically-uninterrupted stations and observing systems should be maintained.**
- 7. High priority for additional observations should be focussed on data-poor regions, poorly-observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.**
- 8. Long-term requirements should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.**
- 9. Conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.**
- 10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.**

# **4. Summary**

**Our major recommendation for the future is for better homogenization of the surface and tropospheric data sets that are collected. Reanalyses should play a major role in assessing trends, but these model-based tools need to focus on long-term trends, which includes the use of frozen codes for the entire period of study. A stable suite of observational data must also be supported indefinitely into the future with a focus on monitoring and for insertion into the reanalyses. These data include surface, radiosonde and satellite observational platforms. Satellite replacements need to be made early enough to permit sufficient time for overlap. Multiple observational systems need to be analyzed together, and multiple analyses teams need to constructively work together to obtain consistent conclusions on global and regional trends.**

**There remains a need to reconcile the existing data with respect to recent trends. Despite the inhomogeneities in the data sets, we need to narrow the uncertainty and decide as a community which trends to reject as inconsistent with the set of available observations. This assessment needs to be made with regional scale data as well as with the global average. Both surface and tropospheric trends need to be evaluated. The GCM simulations of trends for the period 1979-present (which has the most complete global coverage) need to be quantitatively compared with global and regional surface and tropospheric observations and reanalyses as a necessary test of model predictive skill.**