



Climate Change: The Move to Action (AOSS 605 (480) // NRE 501.076)

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Class News

- New experimental web site
 - <http://climateknowledge.org/class/aoss605/tiki-index.php>
- I know this course has a lot of fluidity
 - The schedule in ctools is being populated



Speakers subject to scheduling

- Maria Carmen Lemos (3/8)
- Andy Hoffman (3/20)
- Barry Rabe (4/3)
- Nina Mendelson
- Justin Felt (2/20)
- Meredith Fowlie
- Marie O'Neill (3/15)
- Phil Rasch (3/22)
- Sabrina McCormick (3/13)
- Henry Pollack (#/#)
- Rosina Bierbaum (3/29)
- Energy (Symposium)
- Adaptation




Ideas and Things

-
- **NEWS:** Anyone hear or read any news they want to discuss.



Observations and Observing System

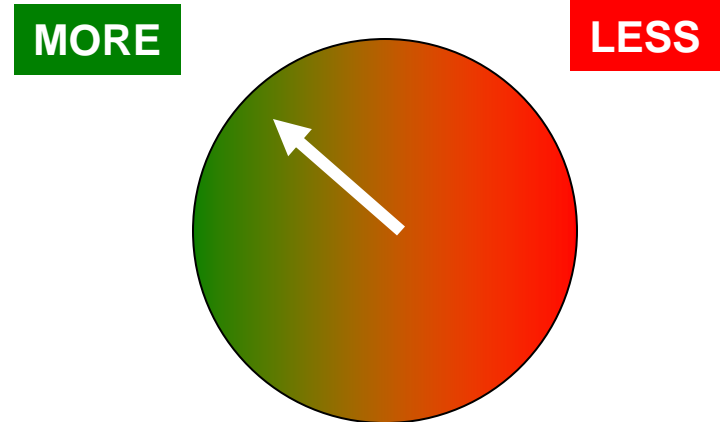
What parameters/events do we care about?

- Temperature
 - Water
 - Precipitation
 - Evaporation
 - Humidity
 - Droughts
 - Floods
 - Extreme Weather
 - Air Composition
 - Air quality
 - Aerosols
 - Carbon dioxide
 - Winds
 - Clouds / Sunlight
- 



A Moment With Uncertainty

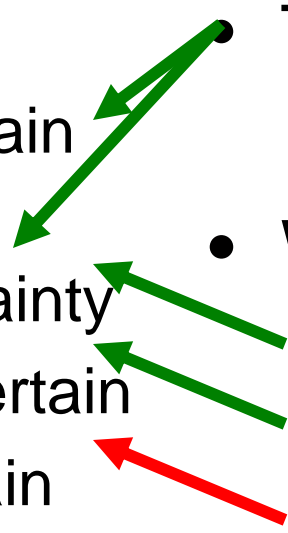
- Temperature
 - Prediction: More certain
 - Measurement: More certain
- Water
 - Prediction
 - Vapor: More certain
 - Ice: More certain
 - Liquid: Less certain
 - Measurement
 - Vapor:
 - Near surface → More certain
 - Above surface → Less certain
 - Ice: More certain
 - Liquid: Less certain





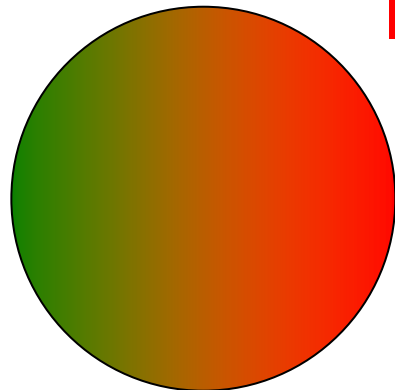
A Moment With Uncertainty

- Geographical
 - Global: More Certain
 - Continental: Intermediate Certainty
 - Regional: Less Certain
 - Local: Least Certain
- Temperature
 - Vapor
 - Ice
 - Liquid
- Water



MORE

LESS





Observations

- Observations
 - Motivate hypothesis and theory
 - Provide information on variability and trends
 - Used in attribution
 - Natural
 - Anthropogenic
 - Used to evaluate quality of predictive models
 - Best estimate of the “truth”
 - “Truth” changes with new observations and re-examination of old approximations



There are controversies with observations

- The quality of old observations
- The use of proxy observations
- The use of derived observations

- Modern observing system
 - Inconsistency between the satellite and surface observations
 - Three papers in the September 2, 2005 issue of Science magazine. Available electronically
 - <http://www.lib.umich.edu/ejournals/>
 - Mears and Wentz
 - Santer et al.
 - Sherwood et al.



Modern Temperature Observations

- Definition of “Modern” data system
 - Newer than 1870, lots of thermometers
 - World War II
 - International Geophysical Year, 1958
 - Operational satellites, 1979
 - Internationalization of satellites / new types of observations / “climate” satellites, 1990s →
 - Development of non-satellite “climate” observing systems



Outline of Lecture

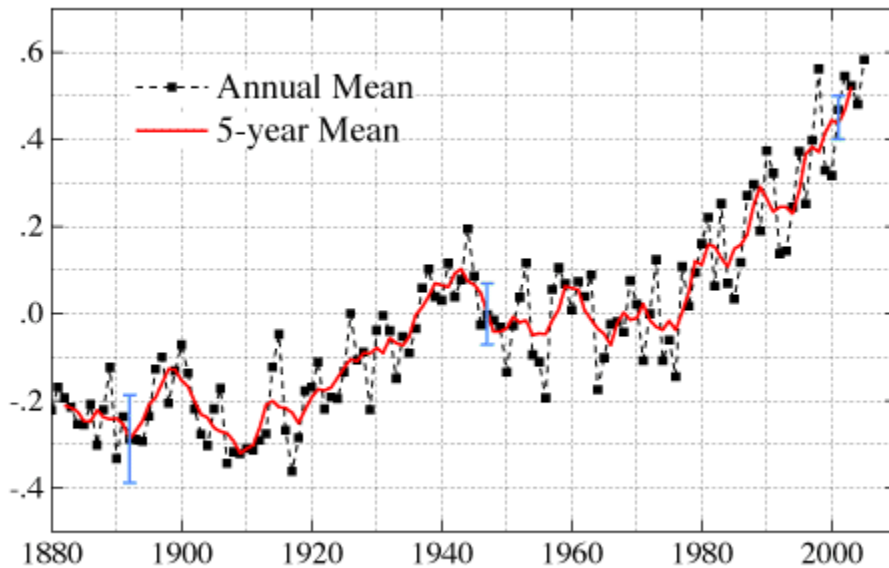
- Temperature, what does it look like?
- Temperature, how is it measured?
 - Surface
 - Atmosphere
 - From space
- “Conventional, Operational, and Research” Observations



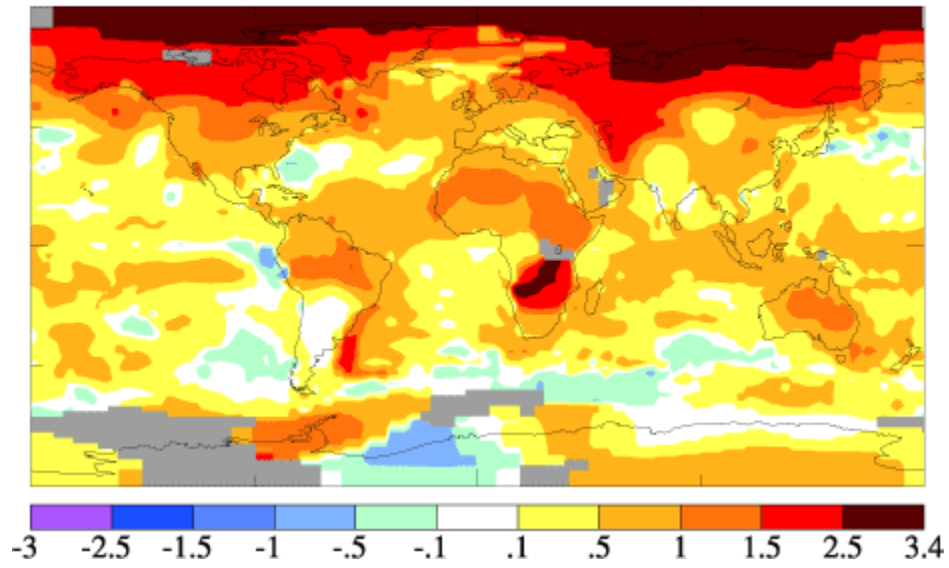
Temperature Anomaly in 2005

<http://data.giss.nasa.gov/gistemp/2005/>

(a) Global-Mean Surface Temperature Anomaly ($^{\circ}\text{C}$)



(b) 2005 Surface Temperature Anomaly ($^{\circ}\text{C}$)



Anomaly means difference from some average. Hence, anomaly is dependent on choice of averaging rules.

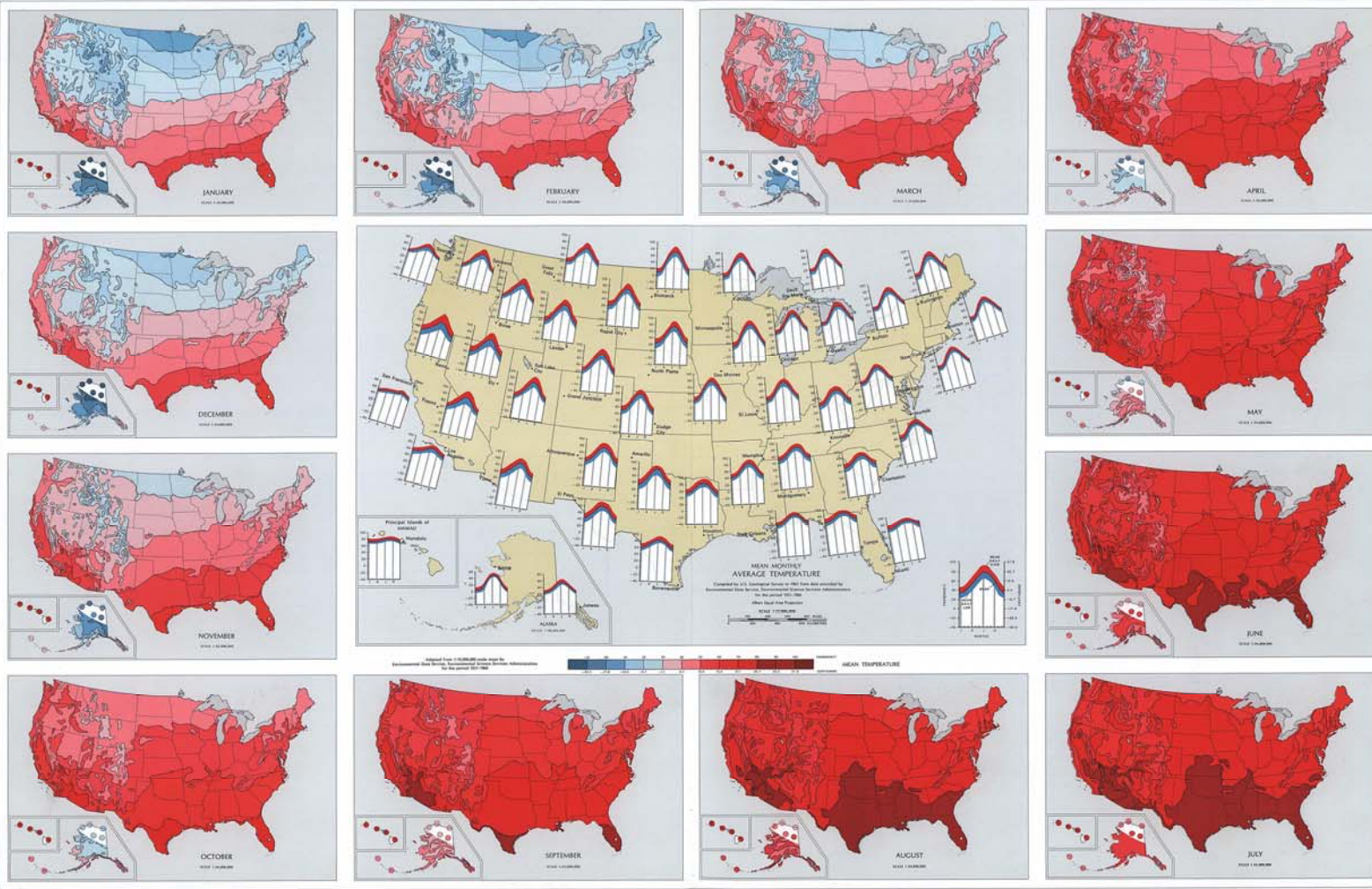
How are the measurements taken? (Thermometers.)



United States Temperature

NATIONAL ATLAS

MONTHLY AVERAGE TEMPERATURE

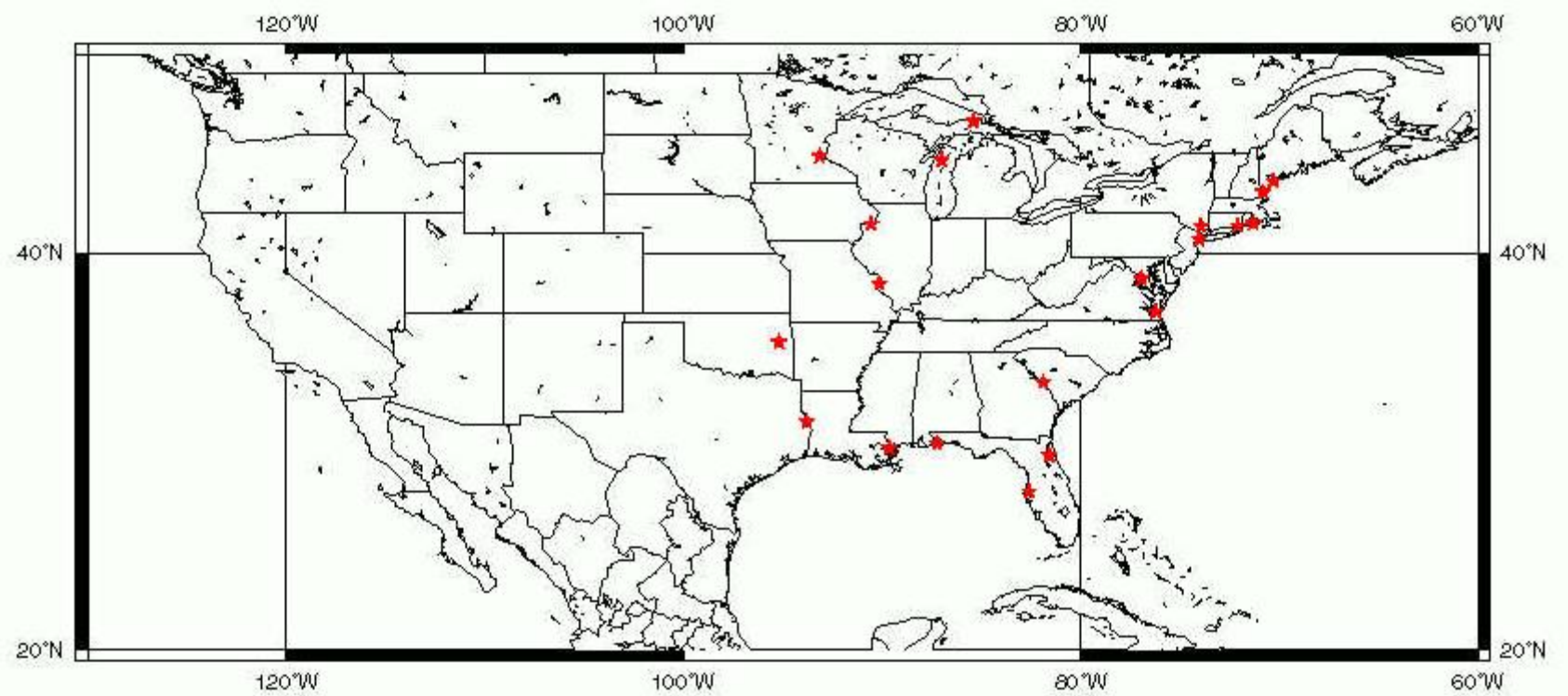


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103



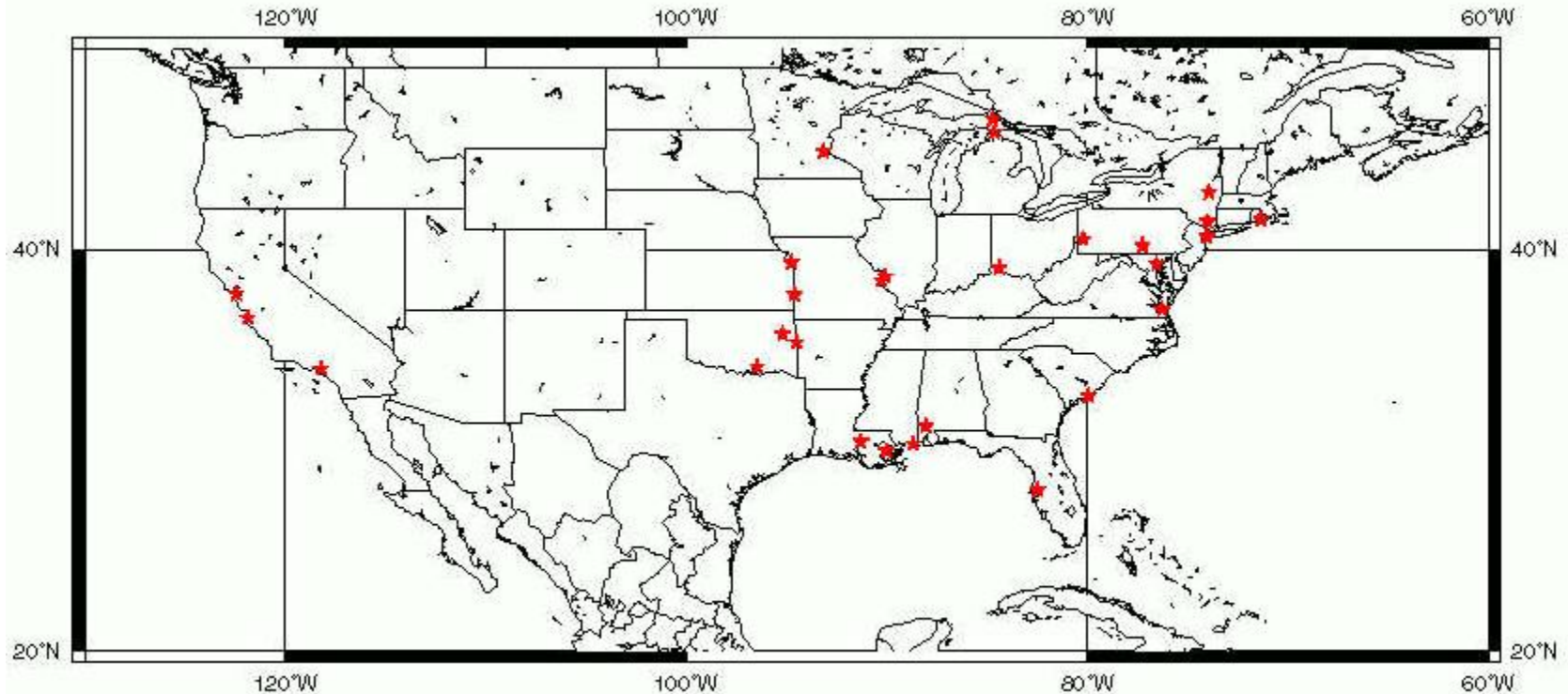
U.S. Surface Observations 1828



<http://www.ncdc.noaa.gov/oa/ncdc.html>



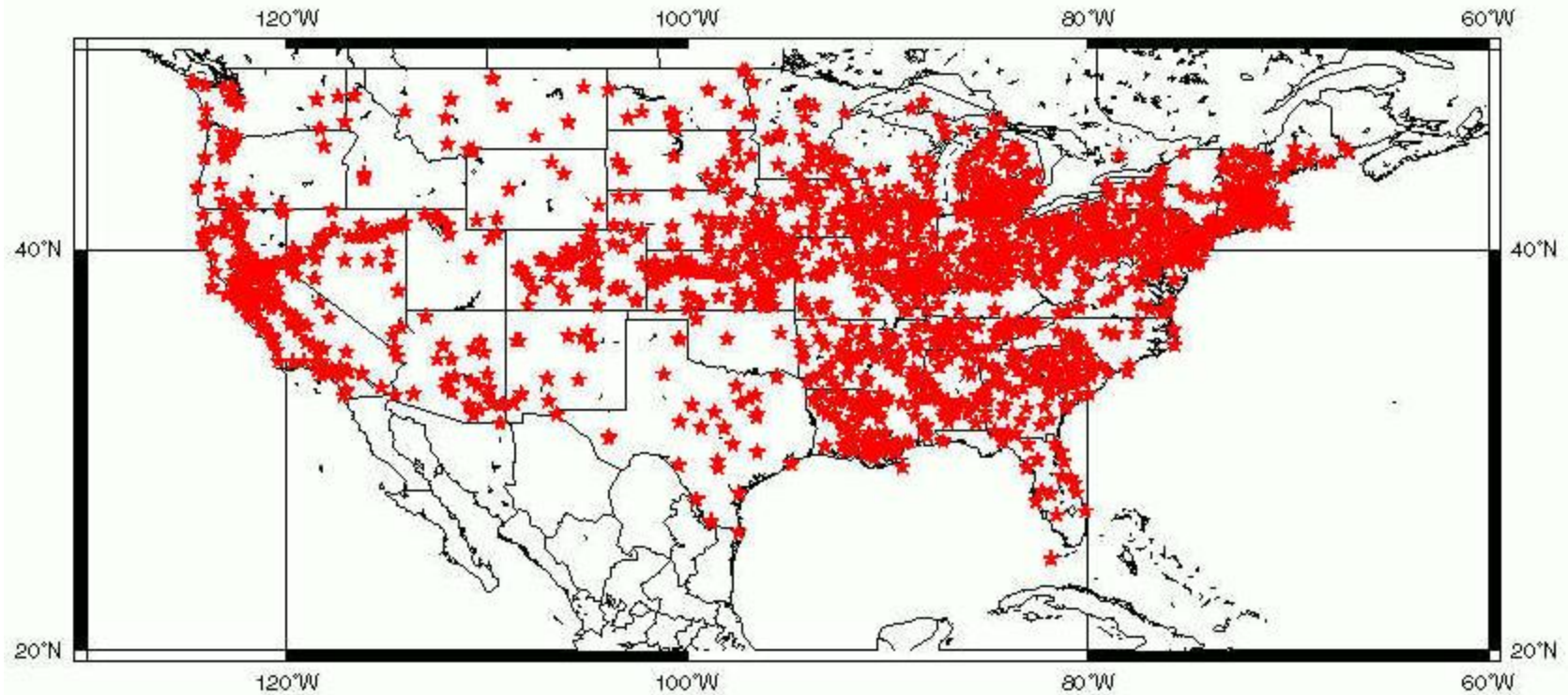
U.S. Surface Observations 1848



<http://www.ncdc.noaa.gov/oa/ncdc.html>



U.S. Surface Observations 1888

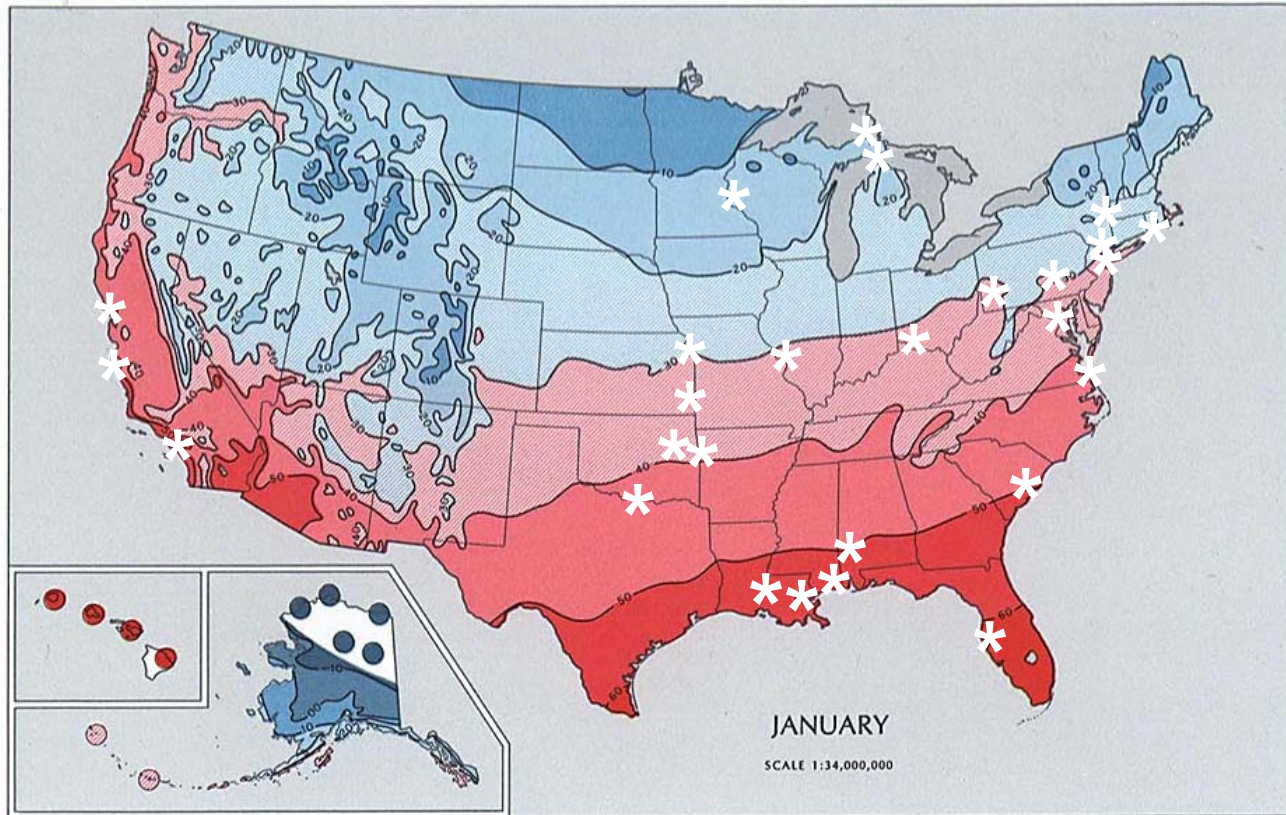


<http://www.ncdc.noaa.gov/oa/ncdc.html>



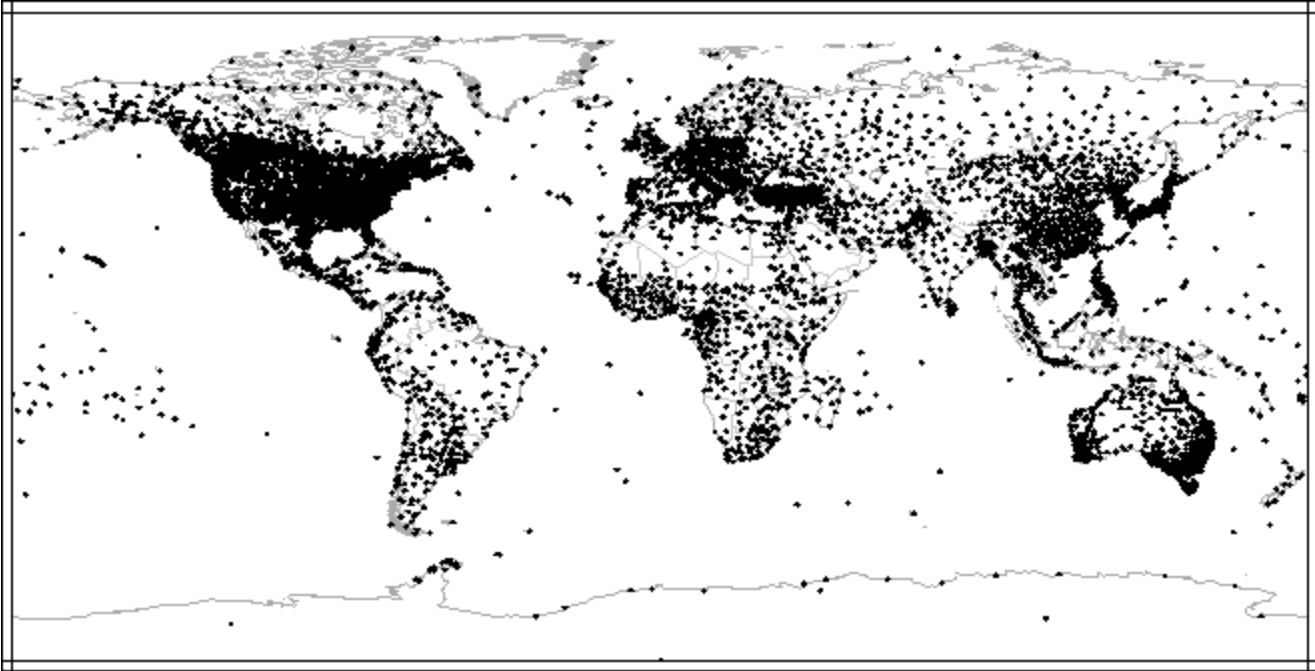
United States Temperature

(January mean with 1848 observations superimposed)





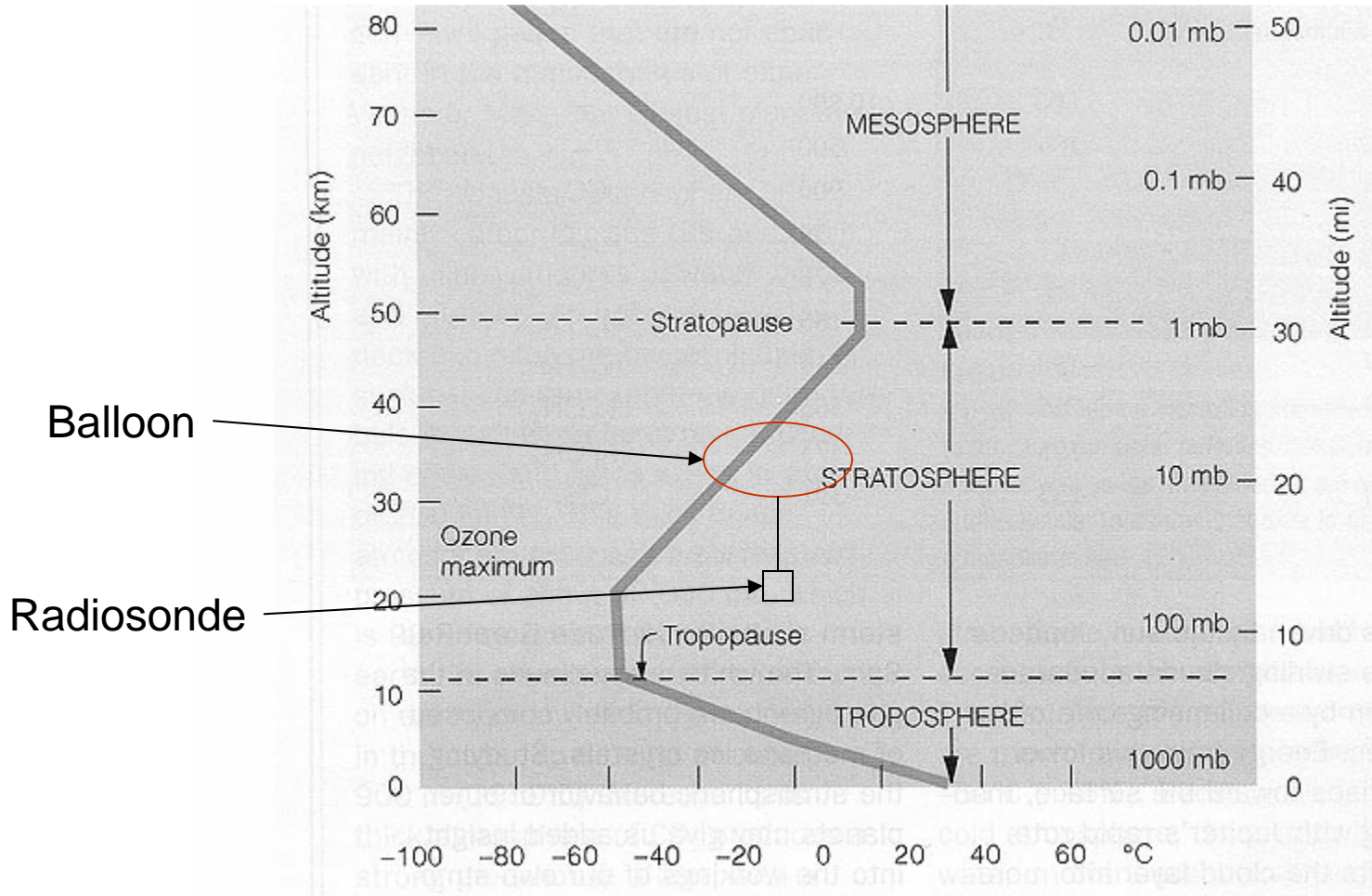
Global Surface Temperature Observations



<http://www.ncdc.noaa.gov/oa/ncdc.html>



Average vertical temperature profile (looking up!)



Very high vertical resolution. Most accurate measurement in the atmosphere.

(This is representative of the tropics)

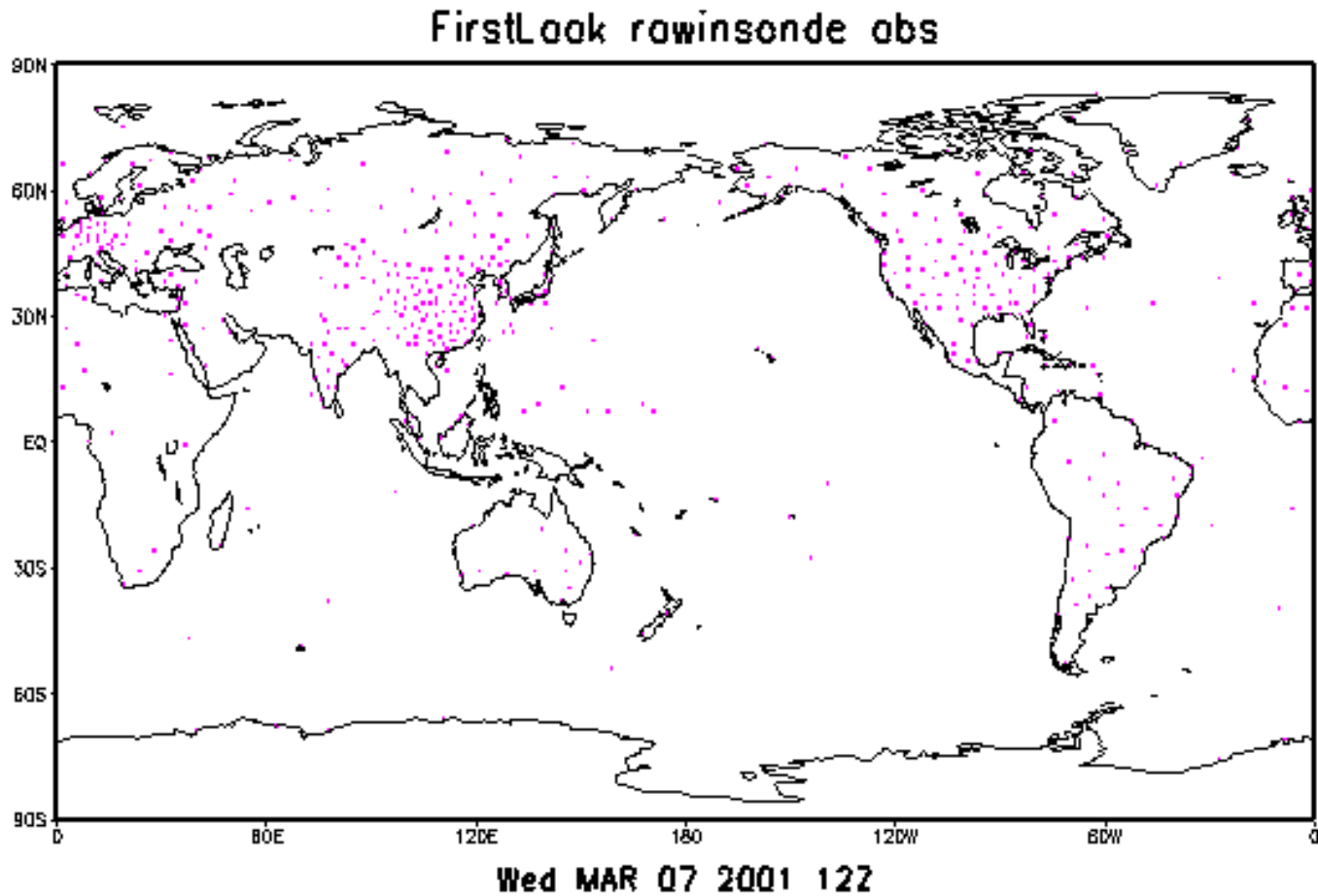


A radiosonde





Radiosonde network (2001)





Think about data systems for a moment

- Coverage varies with time
- Coverage is high in some areas, low in others
 - Where people live
- Data, for the most part, not taken for climate
 - Weather
 - Agriculture
 - Transportation
 - Research
 - ...



Some more thinking about data

- Quality control of calibration
 - How does instrument hold up over time?
 - New types of instrument
 - New manufacturers of instrument
 - Different countries have different instruments
 - ...
- The measurement site changes
 - The tree grows up and its in the shade
 - A parking lot is built
 - They move the airport
 - ...



Some more thinking about data

- The measure site isn't "representative"
 - Next to the harbor
 - Top / Bottom of the hill
 - In the middle of the city
 - Next to the exhaust vent
- Measurement standards vary
 - 12 inches off the ground
 - 5 feet off the ground
 - Shielded from sun and wind
 - Time of day it is recorded
- The data is recorded incorrectly
-

This is what the Sherwood paper in science is about



“Climate” Radiosondes

Station Network For Improved Radiosonde Temperature Dataset

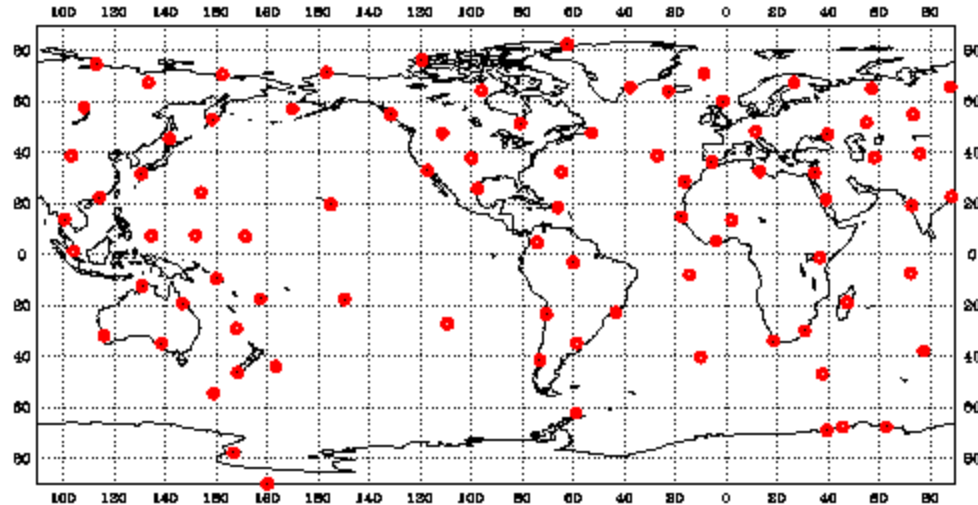


Figure 1 - Locations of 87 stations for improved radiosonde temperature dataset.

Selected because of length and quality of the record. Revisit this data and look for errors and correct them. Commitment to standards in the future. ...

See: <http://www.ncdc.noaa.gov/oa/cab/igra/index.php>
<http://www.ncdc.noaa.gov/oa/cab/ratpac/index.php>



What about satellites?

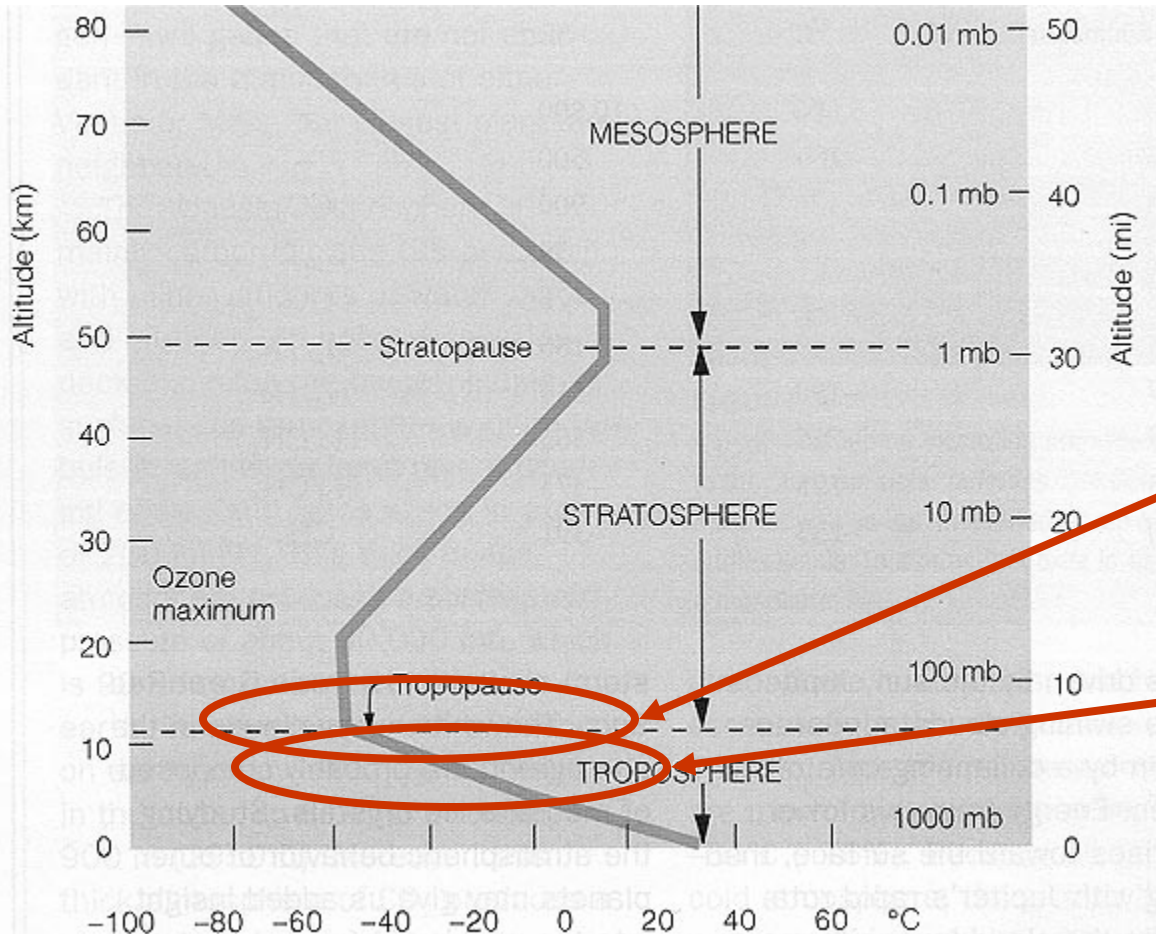


Satellites

- Satellites can measure the absorption or emission of radiative energy.
- This energy can be related to temperature.
- This is not easy.
 - Satellite is going fast.
 - Launching shakes things up.
 - Space is a harsh environment.
 - Once you have a radiance measurement, how do you make it temperature?
- Absolute calibration from one satellite to the next



Average vertical temperature profile (looking up!)



Layers overlap each other

Radiance measured in smeared out layer of atmosphere

(This is representative of the tropics)



Need an algorithm to transform radiance to temperature

Radiance = FUNCTION (Temperature, (perhaps Ozone, Carbon Dioxide ...))

Temperature = INVERSE (FUNCTION (Radiance))

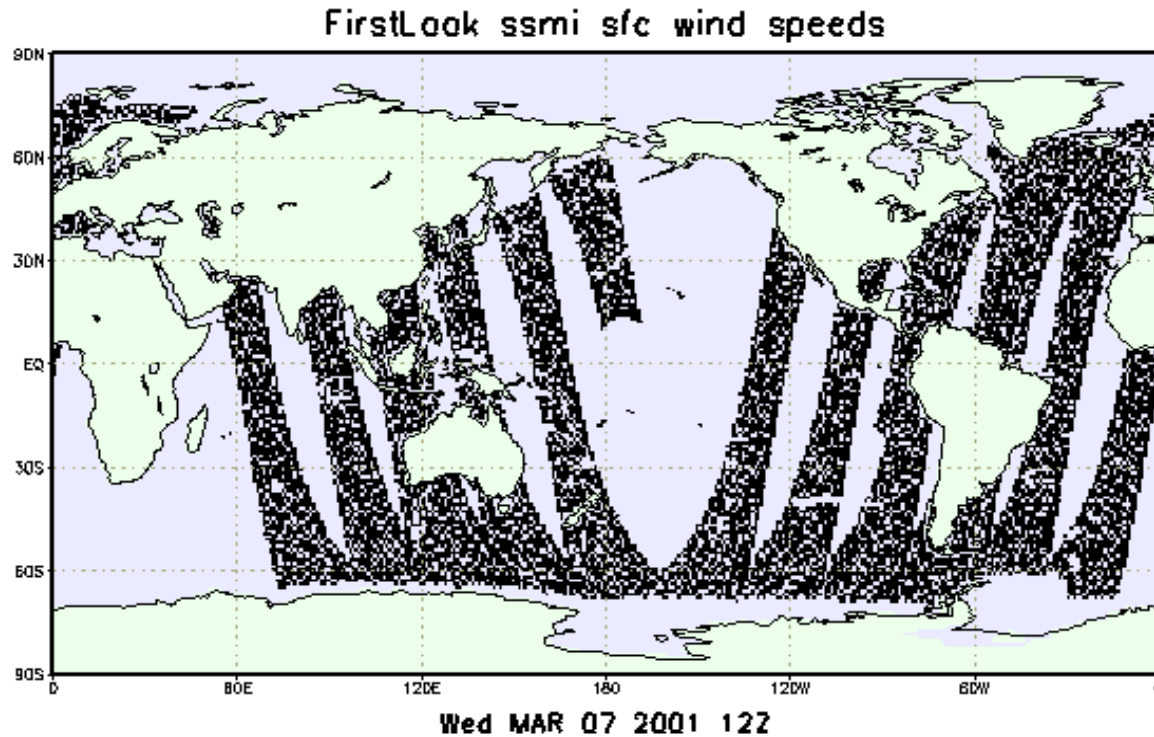
And:

- Inverse is not unique: more than one answer possible
- Need a “first guess” of what temperature looks like
- Need to account for behavior and changes of the instrument
- ...

This is what Mears and Wentz paper in Science is about



Why satellite data?

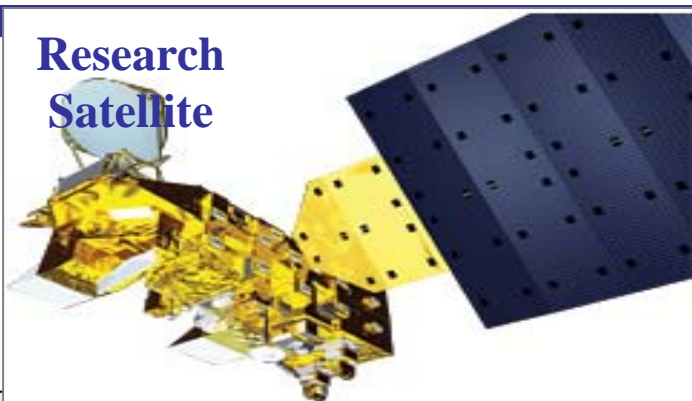


Coverage, coverage, coverage. Only calibrate one instrument.



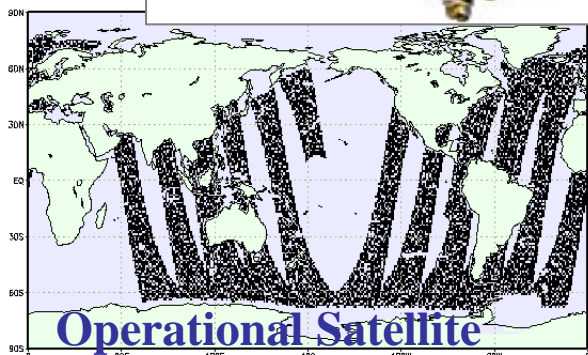
The Elements of the Data System

Research Satellite



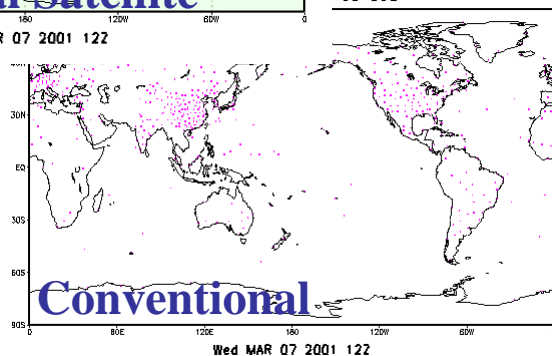
Applications: Prediction and Hindcast

- Objective evaluation of change
- Alternative scenarios for climate forcings
- How to use observations in prediction
- Predictions for multi-member ensembles



Applications: Process Definition

- Definition of physical mechanisms
- Use of observations to define feedback mechanisms
- Reanalysis data sets



Observation mission support

- Quality Control/Instrument Monitoring
- Validation (linking different scales)
- Definition of future observing system
- Retrieval of geophysical parameters

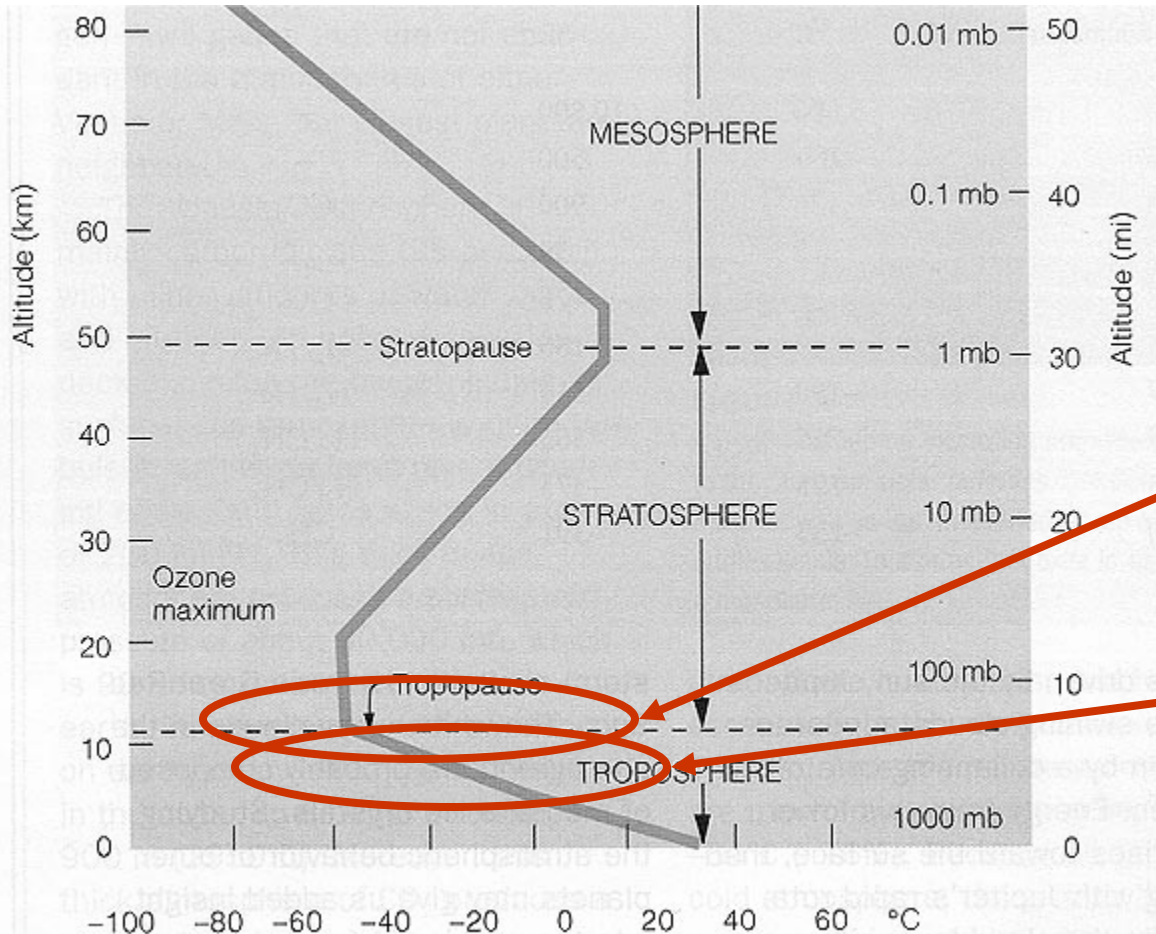


The satellite surface controversy

- The warming trend at the surface should extend into the lower troposphere.
- There should be cooling in the stratosphere.
- The satellite data did not show the warming in the lower troposphere.



Average vertical temperature profile (looking up!)



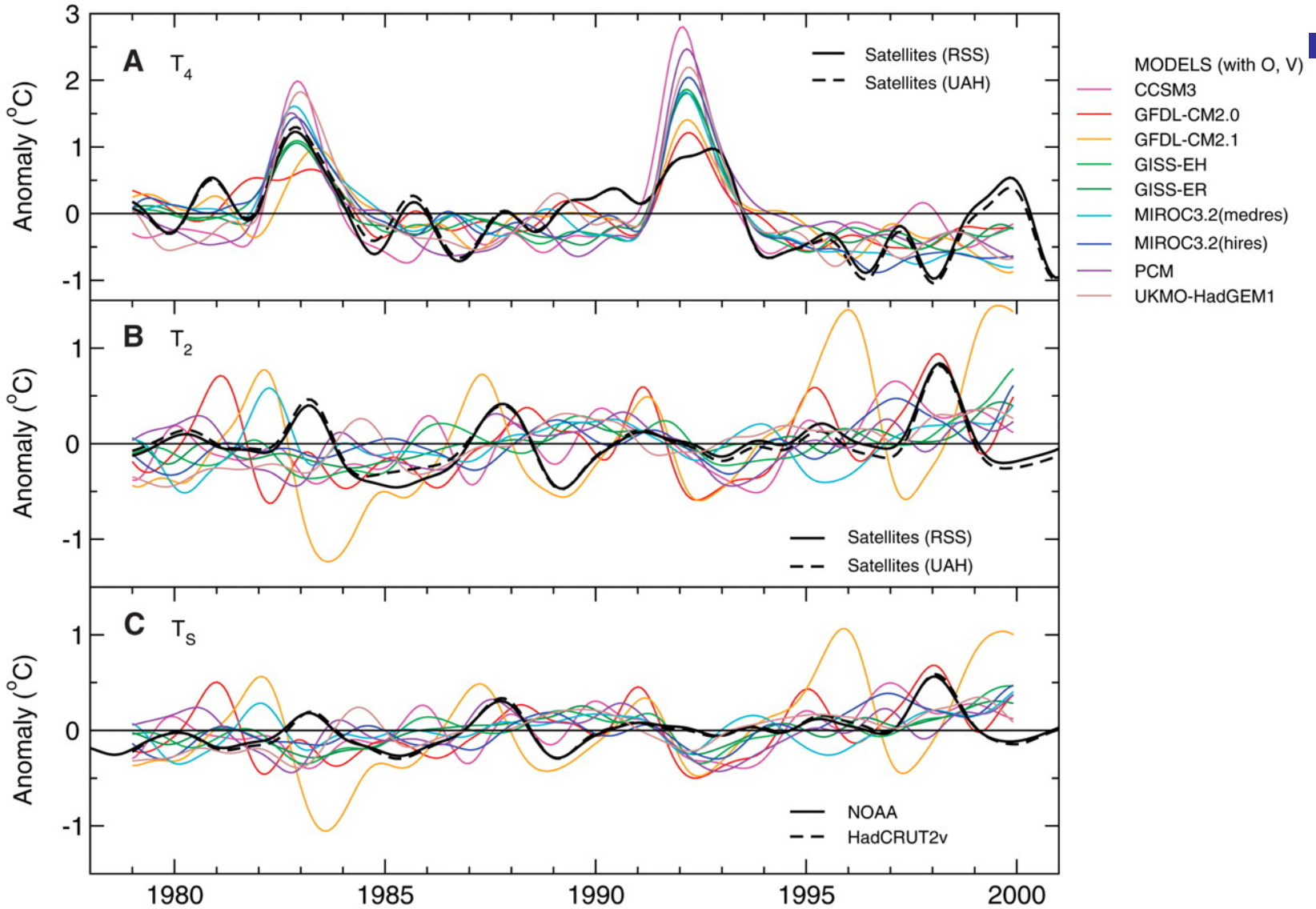
Layers overlap each other

Radiance measured in smeared out layer of atmosphere

(This is representative of the tropics)

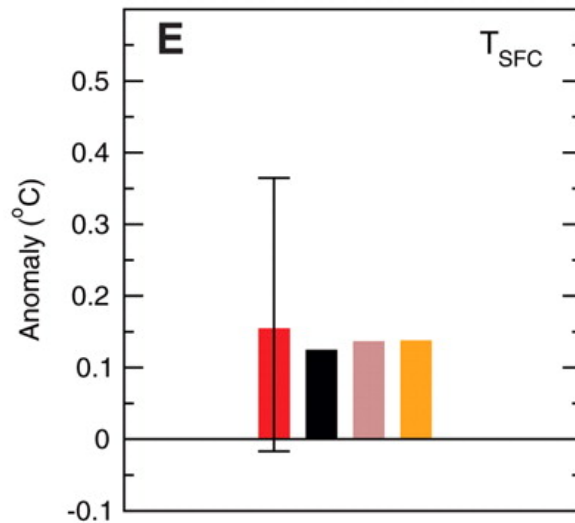
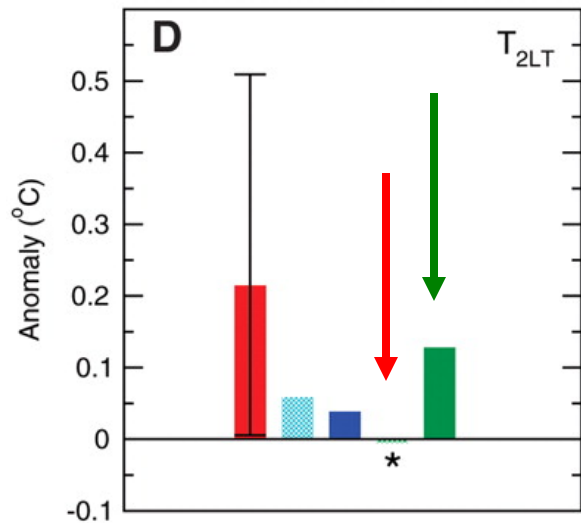
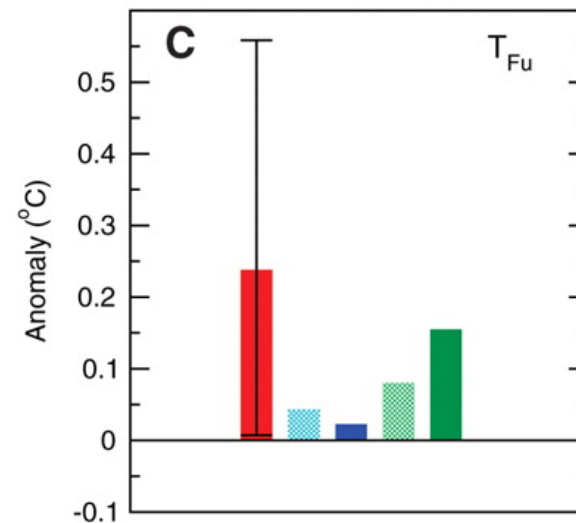
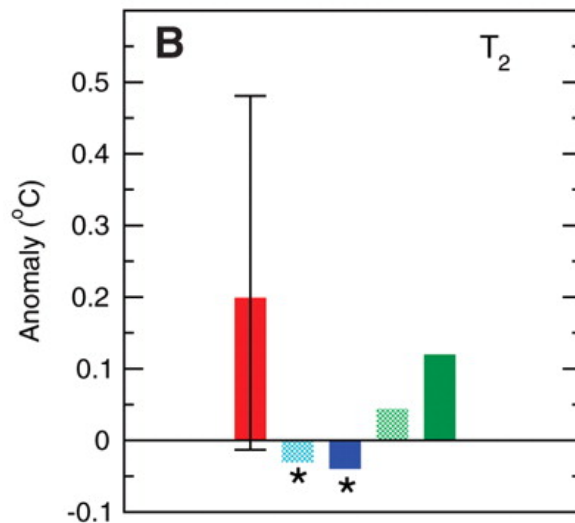
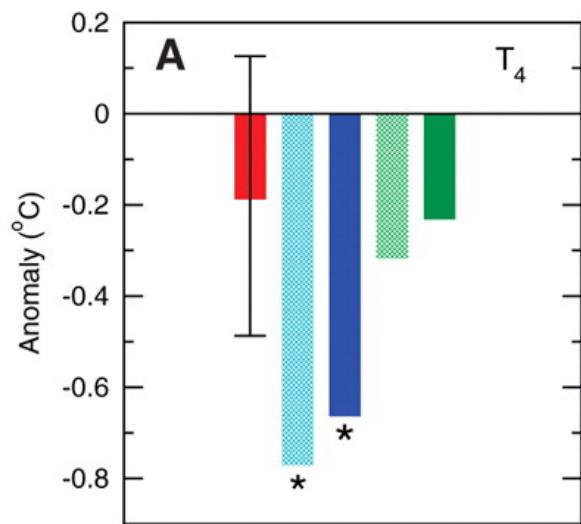


Santer, Figure 1





Santer, Figure 2



- Models
- Radiosondes (RATPAC)
- Radiosondes (HadAT2)
- Satellites (UAH)
- Satellites (RSS)
- Surface (NOAA)
- Surface (HadCRUT2v)
- Surface (HadCRUT2v; subsampled)



The satellite surface controversy

- The warming trend at the surface should extend into the lower troposphere.
- The satellite data did not show the warming in the lower troposphere.
- Identification of error in the retrieval algorithm used to turn satellite radiance measurements into temperatures.
 - Examination of observations by an independent group.



It's hard to keep track of it all.

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- Have any of you read Fred Hoyle's "The Black Cloud?"



Summary

- Observations, theory, and predictions of greenhouse effect and global warming.
- Warming is expected to occur rapidly because it is forced by large changes in greenhouse gases, which are essentially waste products of our enterprise.
- Warming is large enough that it is expected to impact ecosystems, agriculture, society.



Summary

- The increase in greenhouse gases is directly related to use of energy – the burning of fossil fuels which is basically cheap and easy.
- The use of energy is directly related to success of societies and standard of living.
- Societies will seek to acquire energy resources.



Summary

- Improving the standard of living of more and more of the increasing population will require more and more use of energy.
- More and more use of energy will increase the waste gases, which are greenhouse gases, and which will warm the atmosphere.
- The atmosphere will respond to this warming → ocean, land, ice ...



Summary

- We could keep going, in crescendo, adding how virtually all elements of society are touched by global warming.
- We can find some places where there are obvious threats. We can find some places where there are obvious benefits.
- We need to evaluate this huge, complex body of knowledge. Decide what to do. Leave it to fate? Decide that our waste is benign?



For certain

- There are no simple solutions. There is no magic bullet.
- How to approach the problem.
 - What are the facts of the problem?
 - What is the scale of problem?
 - Hence, the scale of the solutions.
 - What are the consequences?
 - What are the fundamentals of the problem?
 - Why can't we just prescribe a solutions?
 - Who are the owners of the problem?
 - What are the intangibles of belief and ethics and behavior?
 - ...
 - What are the paths towards a solution?



One fundamental

- The true cost of energy and the treatment of the waste of energy use are not incorporated into our economy.
- One strategy, which currently has wide favor in the developed world, is to make this cost real, to incorporate it into the market. If the cost of dealing with the waste is real; then, people will work to reduce the waste.
- Next lecture is on International Carbon Trading Market.