

# Progress toward Integrated Earth System Analysis

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- Some progress
- Is a part of CCSP
- But has been limited?
- Is essential

**2007 AMS mtg: Martin Luther King Day**

# I have a dream!

Apologies to Martin Luther King



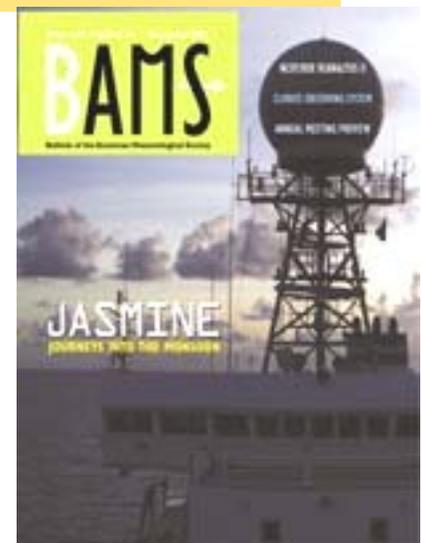
## THE NEED FOR A SYSTEMS APPROACH TO CLIMATE OBSERVATIONS

BY KEVIN E. TRENBERTH, THOMAS R. KARL, AND THOMAS W. SPENCE

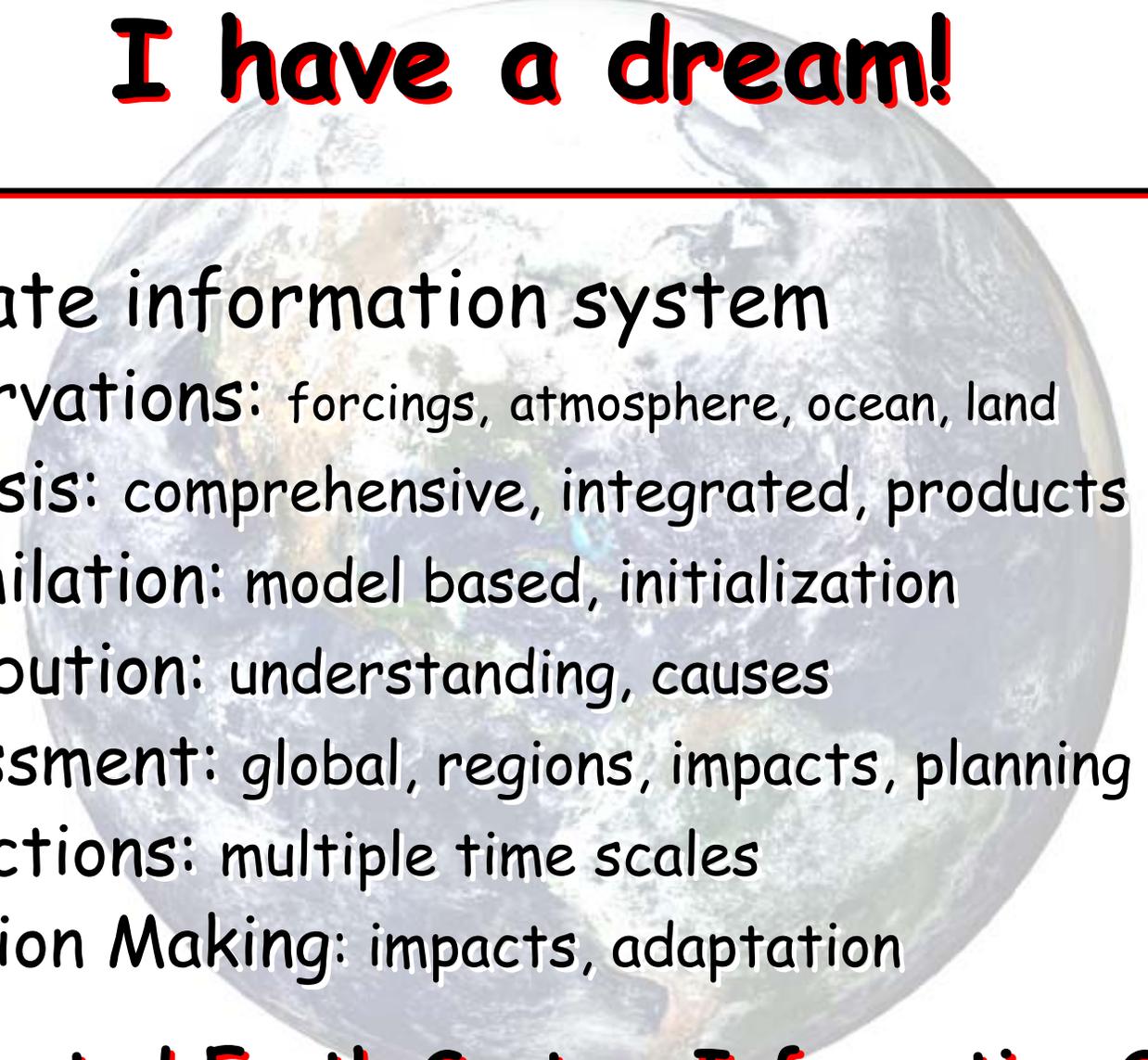
Because climate is changing, we need to determine how and why. How do we best track and provide useful information of sufficient quality on climate?

*Bulletin of the American Meteorological Society:*

November 2002, **83**, 1593-1602



# I have a dream!



## A climate information system

- Observations: forcings, atmosphere, ocean, land
- Analysis: comprehensive, integrated, products
- Assimilation: model based, initialization
- Attribution: understanding, causes
- Assessment: global, regions, impacts, planning
- Predictions: multiple time scales
- Decision Making: impacts, adaptation

**An Integrated Earth System Information System**

# Global Warming

**The climate is changing.**

We can and should take **mitigating actions** that will slow and eventually stop climate change.

Meanwhile we must **adapt** to climate change.

**But adapt to what?**

We do not have predictions.

We do not have adequate reliable observations.

**We do not have the needed information system!**



# Global Warming

We probably can not stop climate change: we can slow it down!

Highly desirable to allow greater time for planning and adaptation.

Disruption arises more from rapid change.

Rapid change is bad because we are adapted to our current climate.

However, mitigation effects mainly payoff beyond 2050.

So we must adapt to climate change:

we will adapt, whether unplanned (disruptive untold damage and loss of life), autonomously, or planned.



In Science Editorial Dec 15, 2006, Alverson and Baker :

"Understanding human impact on the global environment requires **accurate and integrated observations** of all of its interconnected systems. Increasingly complex **models**, running on ever more powerful computers, are being used to **elucidate dynamic links** among the atmosphere, ocean, earth, cryosphere, and biosphere. But the real requirement for integrated Earth system science is a **systematic, sustained record of observations**, starting from as early as we can get quantitative information and extending reliably into the future. In particular, the **ocean** is critically undersampled both in space and time, and national and intergovernmental observational commitments are essential for progress."



# Global Warming

Global climate change from human influences is already with us. The long lifetime of Carbon Dioxide and other GHGs means that there is already a commitment to further global temperature increase of at least  $0.6^{\circ}\text{C}$ .

That would assume zero future emissions, and so this is the lowball value.

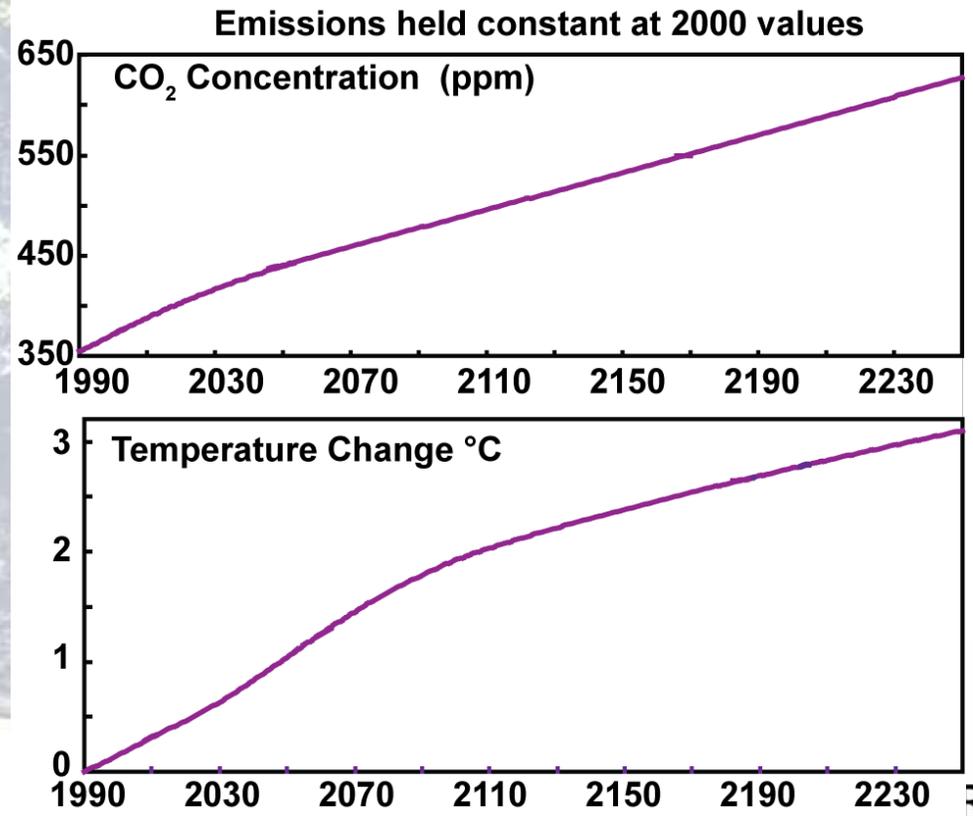
More likely emissions will continue at something like at least today's values (it could be much worse):



# Global Warming

The Kyoto Protocol basically calls for a freeze on emissions to 1990 levels for **developed** countries. Similarly, the Montreal Protocol for ozone depletion initially called for a freeze on CFC emissions and only later was this changed to a phase out.

**A freeze on emissions means that concentrations of carbon dioxide continue to increase. Climate continues to change, temperatures rise and sea level continues to rise.**



# Global Warming

Increasingly, the climate of the past is not a good guide to the future. But that is what is widely used for planning and design: water use, buildings, energy, agriculture...

All climate change has a cause, even if natural. E.g., It is possible for the atmosphere to warm at the expense of cooling the oceans. E.g. El Niño. But we can track, in principle, what is happening to the oceans and they too are warming. What about clouds? A major feedback.

The **imperative** is to build an observing and information system to better plan for the future.

# We have some Global Earth Observations

# We don't have:

## Discipline Specific View

## Whole System View

Atmospheric Observations



Data Systems



Ocean Observations



Space Observations



Technology Development

**Innovations**      **Efficiencies**      **Mass**  
**Breakthrough**      **Cost**      **Productions**

**Breakthrough**  
**Innovations**  
**Efficiencies** **Cost**  
**Mass Productions**

20<sup>th</sup> Century

21<sup>st</sup> Century

**OBSERVING SYSTEM TIMELINE**



Courtesy: Tom Karl



The challenge is to better determine:

- 1) how the **climate** system is changing ☺
- 2) how the **forcings** are changing ☺
- 3) how these **relate** to each other (incl. feedback) ☹
- 4) **attribution** of anomalies to causes ☹
- 5) what they mean for **future** climate ☹
- 6) **Value** of climate information ☹
- 7) **selection** of appropriate time scales ☹
- 8) how to **communicate** information for informed planning ☹
- 9) how to **manage** the data and reanalyze it routinely ☹
- 10) how to **disseminate** products around the world ☹
- 11) how to **interact** with users and stakeholders and add regional value ☹

# Information System

# Major technological advances occurring now!

They do not make a climate observing system:

## Some issues:

Huge volumes of data: we use but a fraction

- distilling into information
- not climate quality
- Developing observations for climate
  - satellites change and drift in orbit
- Establishing climate data records
  
- Stewardship and archival of data
- Access to data
- Reanalysis of observations
- Improving models: developing new parameterizations
- Managing ensemble projections for many years into the future

# Satellite Observations

- **NPOESS cutbacks** demonstrate the lack of adequate priority being given to climate and the need for **continuity** of long-term homogeneous observations. 😞
- **GCOS** has provided a new report to supplement the **GCOS Implementation Plan** on satellite observations at request of **CEOS**. 😊
- **CEOS** in turn has provided a response on how the space agencies may address this. 😊
- **Reprocessing** of past observations is also needed and must be coordinated across agencies and variables.



# Continuity, continuity, continuity

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- As there is no absolute calibration for most variables, for climate we must avoid gaps for space-based measurements.
- The NPOESS cutbacks highlight the real risk of **gaps**.
- Benchmarks, such as GPS Radio Occultation (cf COSMIC), and reference radiosondes provide some insurance. Neither are guaranteed.





## COSMIC

Launch on April 14, 2006

Vandenberg AFB, CA

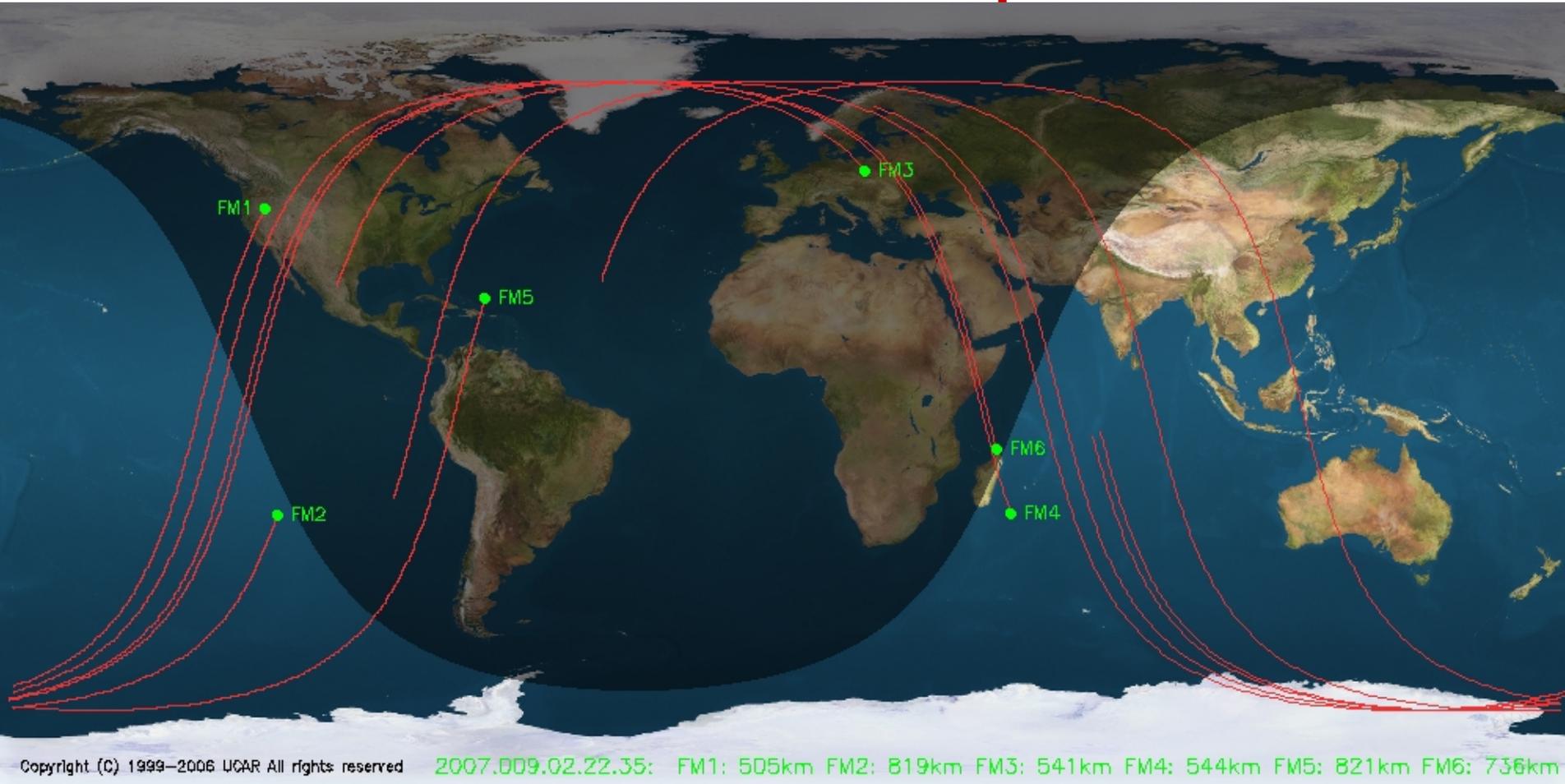
- All six satellites stacked and launched on a Minotaur rocket
- Initial orbit altitude ~500 km; inclination ~72°
- Being maneuvered into six different orbital planes for optimal global coverage (at ~800 km altitude)
- All satellites are in good health and providing data

COSMIC launch picture provided by Orbital Sciences Corporation



NCAR

# Status of COSMIC spacecraft



Jan 9, 2007

Status and updates of COSMIC spacecraft can be found at:

<http://www.cosmic.ucar.edu/>

# Attribution

One area of major growth should be developing the ability to not only **track** climate anomalies but also to **attribute** them on multiple time scales to:

- external forcings (solar, volcanoes, atmospheric composition)
- internal forcing (ocean content, soil moisture, sea ice, the atmosphere)
- feedbacks
- natural variability

Why has the winter been so warm on the east coast?  
Why is it so snowy in Colorado?  
Why is it so cold in San Antonio?

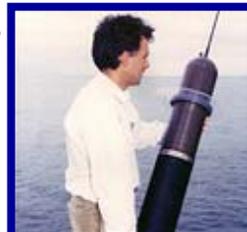
This requires an operational numerical experimentation program running ensembles of models.

And a better observing system.

NBC NEWS



Robert Bazell



# Reprocessing and Reanalysis

Given the continuing improvement in our understanding of climate observations and the need for long time series, reprocessing is a hallmark of every climate observing system.

NOAA Climate and Global Change WG report, April 1-3 2003.

Ongoing Analysis  
of the Climate System:  
A Workshop Report

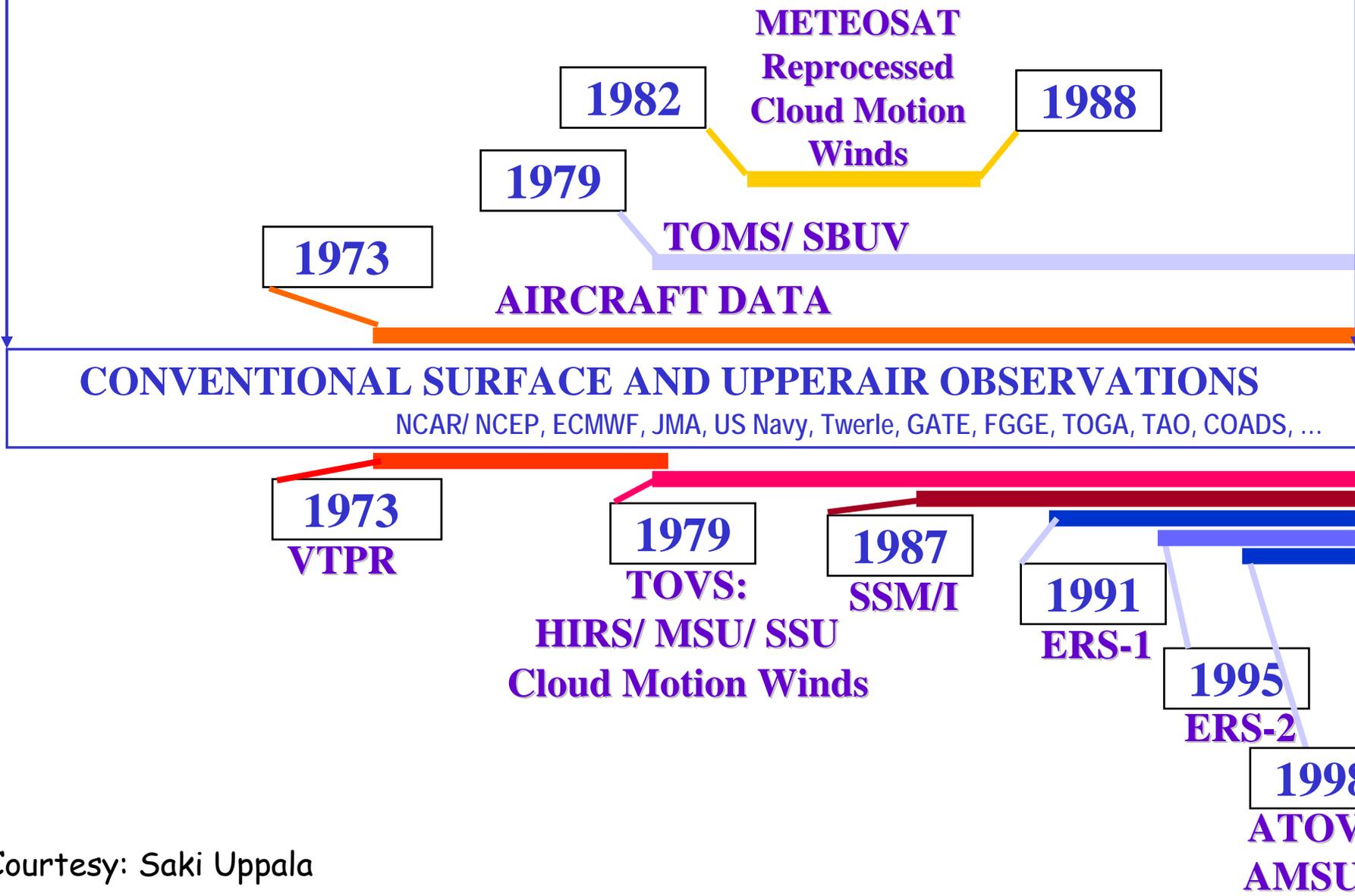


August 18-20, 2003  
Boulder, CO  
Sponsored by NOAA, NASA & NSF

# Observing Systems in ERA-40

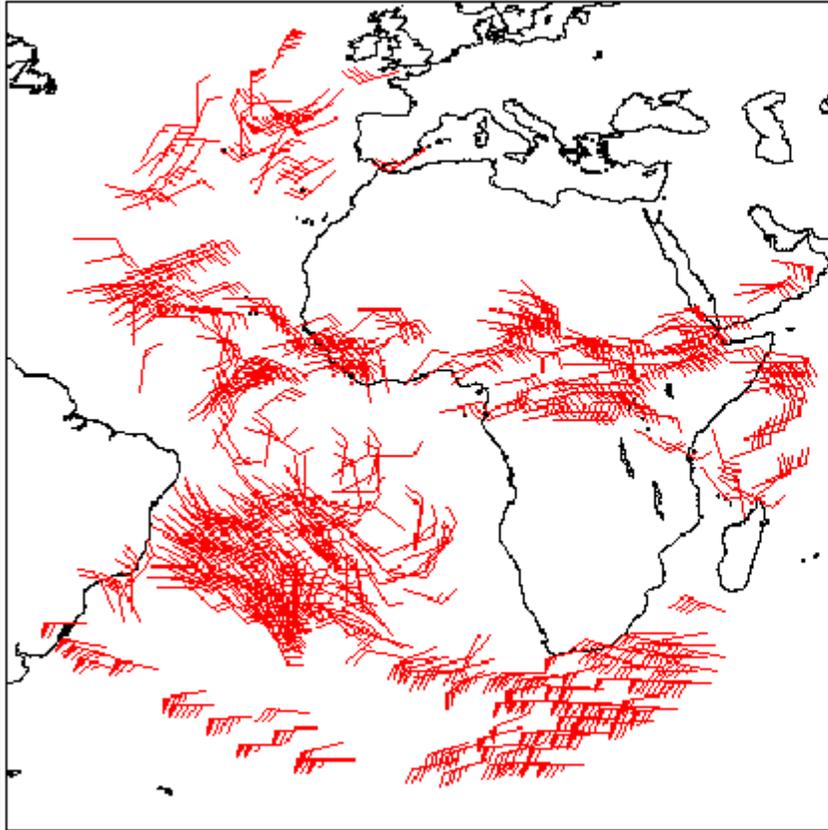
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2002

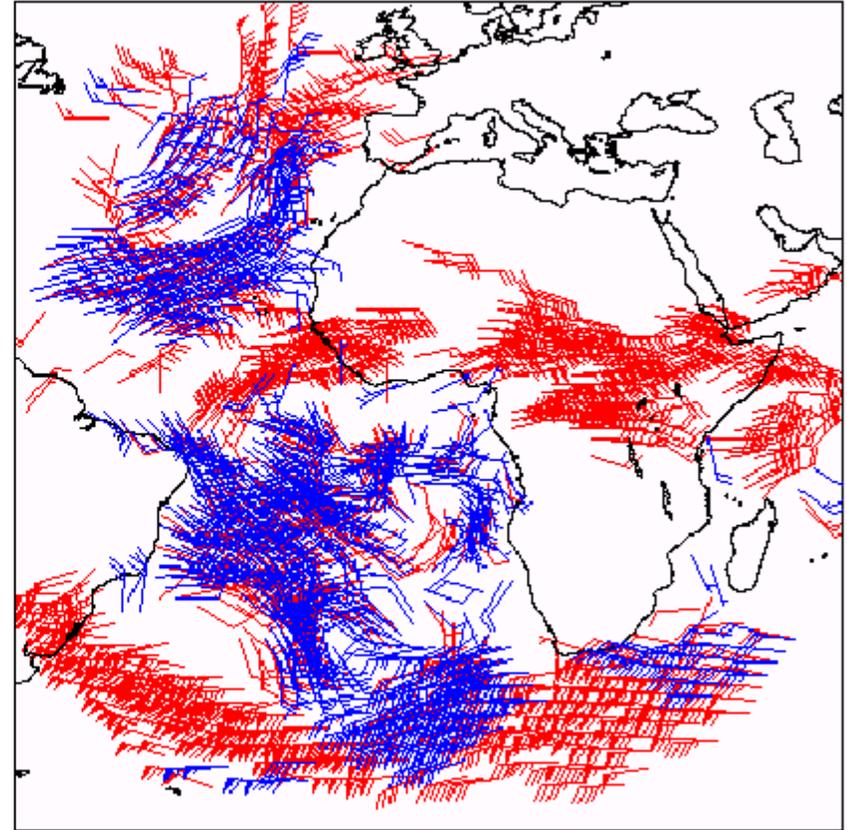


# METEOSAT Reprocessed Winds

a) Old operational IR data



b) Reprocessed ELW data, IR and VIS



What about GOES, and would reprocessed winds be compatible?

# Reanalysis:

WCRP Observations and Assimilation Panel and GCOS have set up a WG for "**development of improved observational data sets for reanalyses.**"

Terms of Reference include actions related to:

- (i) Review and enhance the holdings of data centres
- (ii) develop a plan for **construction, revision and management of comprehensive data sets**: merging, duplicates, metadata, data management and services, version control, formats, identification of an "Implementing Centre", updates in real time, a catalog.
- (iii) oversee the **progress** made by the Implementing Centres,
- (iv) **report** regularly to AOPC and WOAP on the progress

Members from major reanalysis and data centers: NCAR, ECMWF, NCEP, JMA, NASA, EUMETSAT, NCDC, BMRC, CRU, UKMO etc.



# GEOSS: A possible way to implement?



**Natural & Human Induced Disasters**



**Water Resources**



**Terrestrial, Coastal & Marine Ecosystems**



**Human Health & Well-Being**



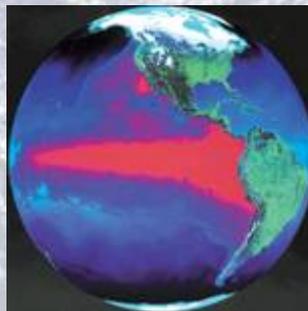
**Energy Resources**



**Sustainable Agriculture & Desertification**



**Weather Information, Forecasting & Warning**



**Climate Variability & Change**



**Biodiversity**

In Science Editorial Dec 15, 2006, Alverson and Baker :

"The IOC is now working with the Global Earth Observation System of Systems (GEOSS) to identify national focal points for ocean observation efforts and to integrate these efforts into a truly global system. Unfortunately, there is still no plan for sustaining individual measurement programs, for integrating them into a coherent observing system, or for supporting them with **stable funding**. With a few notable exceptions, substantial multilateral **government support** for coordination and integration remains elusive."

Some good progress in NOAA in Mike Johnson's program in integrating in situ ocean observations: much more needed



# Some other issues:

- Who benefits from such a system?  
-all do.
- Who pays?
- The main technological capabilities exist in developed countries
- Developed countries have been the main cause of climate change to date
- Altruism?



**We need to do it!**

**I have a dream today!**



**The Challenge:  
Sustainable Management of an Ever-Changing Planet**



NCAR