

# **An Overview of NOAA's Satellite, Data, and Information Stewardship Program**

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**National Oceanic and Atmospheric Administration**

**National Environmental Satellite Data and Information  
Service**

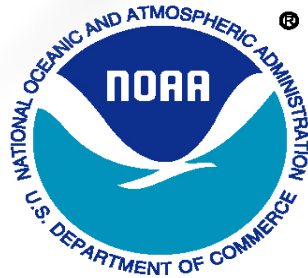


# NOAA's SATELLITE DATA AND INFORMATION STEWARDSHIP

DATA RESCUE

INFORMATION  
TECHNOLOGY CLASS

SCIENTIFIC DATA  
STEWARDSHIP



# Scientific Data Stewardship

- ✓ **The goal is to ensure that satellite observations and products are processed and used in a manner that is scientifically defensible, not only for real-time assessments and predictions of climate, but for retrospective analyses, re-analyses, and reprocessing efforts.**
- ✓ **Primary functions are:**
  - Careful monitoring of observing system performance for long-term applications
  - Generation of climate data records
    - CDRs provide information to:
      - monitor change (climate variability and trends) of the Earth's climate.
      - predict change – especially SI forecasts
      - input to model re-analyses (note: reanalysis is also a CDR)
      - validate climate prediction models and model reanalyses
      - understand processes ( water vapor-cloud-radiation feedback)
- ✓ **In preparation of this new program, NESDIS is developing a plan for generating CDRs from NOAA operational satellites, which will be reviewed by the National Academies.**



# What is a CDR?

- ✓ **A climate data record is a collection of data that can be used to construct a high quality time series with quantified error characteristics.**
- ✓ **The time series should be free of instrument artifacts and changes in algorithms.**





# Motivation for Developing A Plan for Operational Climate Data Record Production

- ✓ **Increasing demand for credible climate information to monitor and predict climate change and variability.**
- ✓ **NOAA's operational satellites are a major source of sustained long term observations of the Earth's climate**
- ✓ **NOAA is not fully exploiting these satellites to meet the needs of climate change investigators**
- ✓ **Observations from EOS, METOP, NPP and NPOESS**
- ✓ **FY05 Initiative to begin Scientific Data Stewardship**



# NOAA Operational Satellite Products

## ✓ Atmosphere

- Temperature soundings
- Moisture soundings
- Winds
- Clouds
- Aerosols
- Earth Radiation Budget
- Precipitation
- Ozone

## ✓ Ocean

- Surface temperature
- Ice cover
- Surface winds
- Color
- Sea level

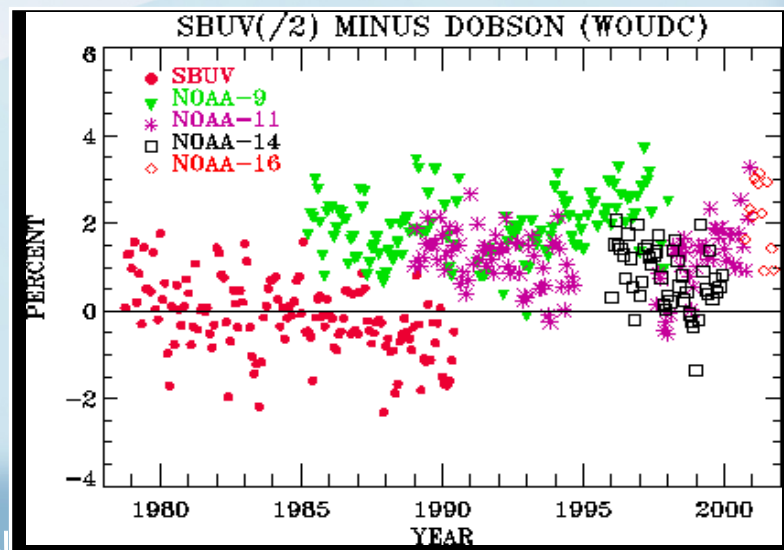
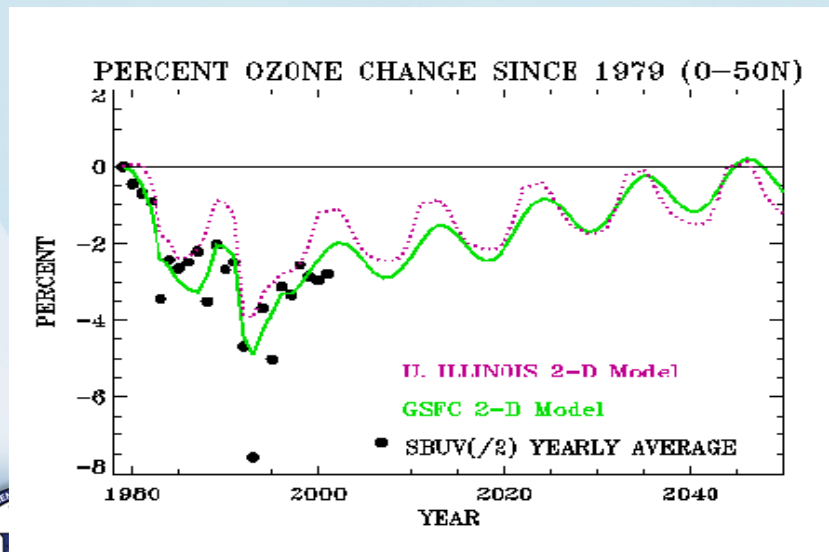
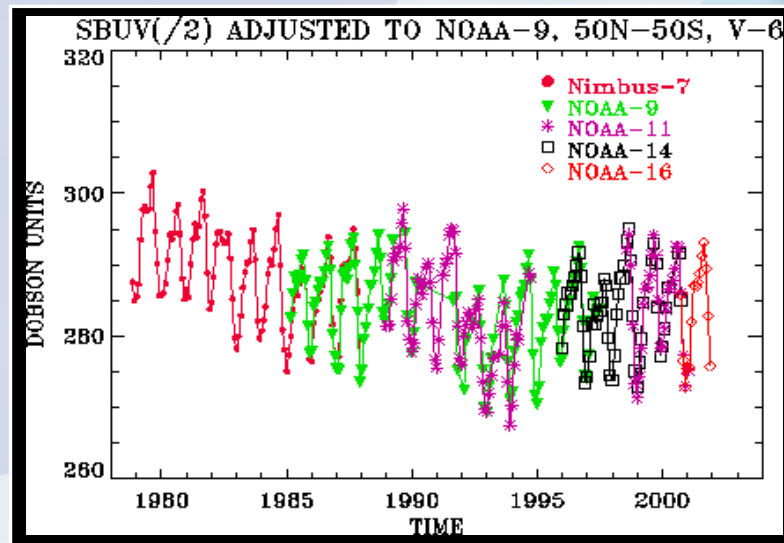
## ✓ Land

- Vegetation condition
- Snow cover
- Other land characteristics (e.g., albedo, skin temperature, insolation)
- Fire locations/Smoke Plumes



# Ozone: A True NESDIS CDR

- ✓ Ozone is adjusted to NOAA-9
- ✓ Validated against Dobson Stations
- ✓ Reprocessed when new algorithms are developed
- ✓ Compared with models





# *Academy Study*

Provide NOAA with advice in developing the Plan

- ✓ **The NRC involvement will consist of two phases:**
  - Phase 1 -- (August 2003) Information gathering workshop, including review of NOAA white paper on generation of CDRs and an interim report to NOAA
  - Phase 2 – Review of NOAA draft plan (March 2004)





# NOAA White Paper on Climate Data Records

- ✓ **Provide background information, issues, and initial NOAA thoughts on CDR creation:**
  - Motivation to establish end-to-end system for creating climate data records (CDRs) from operational satellites
  - Review of current programs to create CDRs (NOAA and external)
  - Summary of lessons learned in the use of satellite observations for climate monitoring
  - Conceptual framework for moving ahead
  - Additional issues for Committee to consider
- ✓ **Serves as a draft background section of the NOAA Plan for Creating CDRs from Operational Satellites**



## *Lessons Learned*

### Impediments to Generation of Climate Quality Data Sets at NOAA

- ✓ **Limitations of satellite instruments mainly designed for weather observations**
- ✓ **Constraints of a real-time operational processing system developed for weather satellite data**
- ✓ **No standard methodologies for creating CDRs**
- ✓ **Lack of infrastructure at NESDIS for climate data generation systems for near-real time and retrospective processing/reprocessing**



## *Where are We Going?*

### Creating Quality Climate Data Records Requires:

- Lowest level of data (level 1) be preserved with complete documentation and metadata, includes data that records the satellite and instrument performance
- Observing performance monitoring to minimize spatial and temporal biases
  - Tools to detect and account for changes in the observing system
- Science team guidance and participation
- Near Real-Time CDR Generation
  - Tight connection between algorithm developer and CDR generator (may be same group)
  - Strong calibration/validation program
  - Research with the data set as part of the program
  - Collaboration with user communities (e.g., diagnosticians, modelers) to obtain feedback





# *Where are We Going?*

## Creating Quality Climate Data Records Requires (cont):

- Re-processing
  - An improved algorithm is developed
  - New information on an instrument
  - An error is discovered in the processing system
- Research and Application
  - Development of climate quality algorithms
  - Analysis of time series to detect emerging trends
  - Joint studies with climate modeling community
  - Production of periodic assessments for decision makers, other climate researchers and the public
- Data Requirements
  - End-to-end data management
  - Near real-time access to data (including raw radiances)
  - Development of community consensus algorithms and data standards
  - Complete archiving: data, meta data, source code, ancillary data, etc.
  - Free and open sharing and exchange of climate data
    - » Nationally and internationally



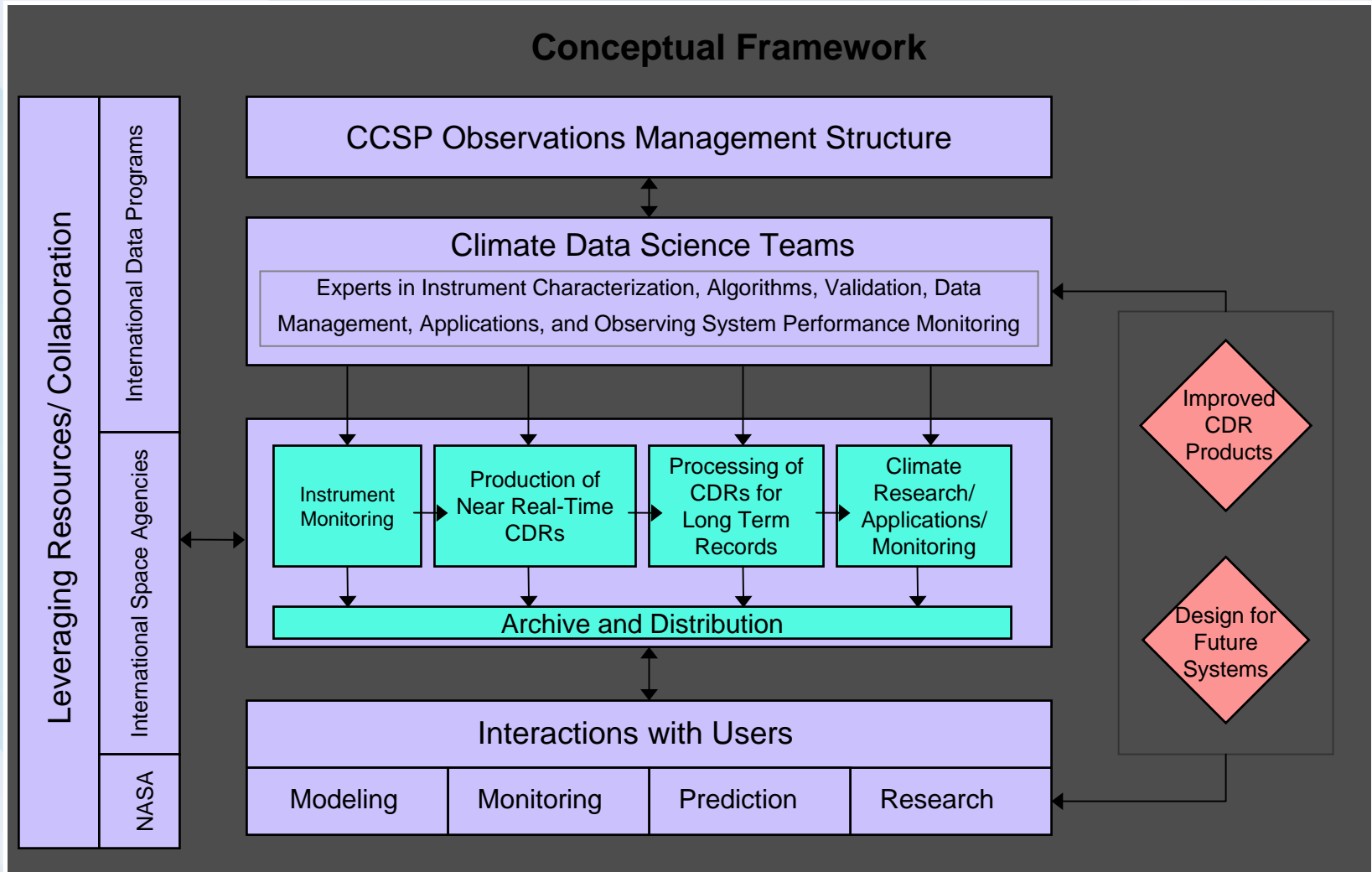
# *Where Are We Going?*

## Functional Areas

- ✓ **An end-to-end process for creating CDRs could consist of 5 functional areas**
  - Real-time instrument monitoring
    - Detect problems early
  - Production of near real-time CDRs
    - Monitor current state of climate system and short -term variations
  - Reprocessing of CDRs for long-term records
    - Consistent, seamless, high quality time series with minimized bias
  - Climate research, applications, and monitoring
    - Joint activities with external community
    - Includes observing system performance monitoring
  - Archive and distribution
    - Includes output of above activities, metadata, and timely distribution



# Where Are We Going?





# Vision

*A climate science community empowered with the high quality satellite-based climate data records needed to define global climate variations and change*



# Backup slides



National Climatic Data Center



# Scientific Data Stewardship

## Generic Guiding Principles

1. Careful monitoring of observing system performance for long-term applications
2. Generation of authoritative long-term records through validation of the calibration process, reprocessing, product generation and the blending of *in situ* and satellite measurements
3. Provide state of the environment information for decision makers and place the current state in its historical context
4. Archive and access to fundamental measurements, products and metadata (supported by CLASS)
5. Data archaeology and improved use (supported by CDMP)





# *Introduction*

## NOAA Mission and Strategic Goals

### ✓ **Mission**

- Understand and predict changes in the earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs

### ✓ **Strategic Goals**

- Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
- Understand climate variability and change to enhance society's ability to plan and respond
- Serve society's needs for weather and water information
- Support the nation's commerce with information for safe, efficient, and environmentally sound transportation



## Introduction

# NOAA Strategic Goal to Understand Climate Variability and Change

Measurable Outcomes	Strategies	
<ul style="list-style-type: none"><li>• Increased use and effectiveness of climate observations to improve long-range climate, weather, and water predictions.</li><li>• Increased use and effectiveness of climate information for decision makers and managers.</li><li>• Increased use of the knowledge of how climate variability and change affect commerce.</li></ul>	<ul style="list-style-type: none"><li>• <b>Monitor and Observe:</b> Invest in high-quality, long-term climate observations and encourage other national and international investments to provide a comprehensive observing system in support of climate assessments and forecasts.</li><li>• <b>Understand and Describe:</b> Increase understanding of the dynamics and impacts of coupled atmosphere/ocean/land systems by working with national and international partners to conduct research on climate variability and change.</li></ul>	<ul style="list-style-type: none"><li>• <b>Assess and Predict:</b> Provide decision makers with reliable, objective information, by improving the skill and accuracy of intraseasonal and interannual climate forecasts and regional, national, and international assessments and projections.</li><li>• <b>Engage, Advise, &amp; Inform:</b> Help customers effectively use climate information to enhance public health and safety; support environmental, economic, and community planning; maximize potential benefits; and minimize the impacts of climate variability.</li></ul>



# White Paper Contents

- ✓ **Section 1 *Introduction***
  - Provides background on mandates, initiatives and NRC recommendations
  
- ✓ **Section 2 *Where Are We Now?***
  - Examples of climate records derived from operational satellites
  - NESDIS Satellite data and data management resources (POES, NPP, NPOESS, CLASS)
  
- ✓ **Section 3 *Lessons Learned***
  - Issues and recommendations resulting through use of operational satellite data to produce climate records
  
- ✓ **Section 4 *Where Are We Going?***
  - Some thoughts on components of end-to-end system for creating CDRs





# *Introduction*

## Background

- ✓ **At request of White House, National Research Council (NRC) recommends several research priorities for climate research (2001)**
- ✓ **President Bush announces Climate Change Science Program (CCSP) to integrate Federal climate research (2002)**
- ✓ **CCSP finalizes its Strategic Plan (2003)**
- ✓ **NOAA initiates development of a Plan to Create CDRs from Operational Satellites (2003)**



# Why Now?

- ✓ **Increasing importance of climate information**
  - NRC's Climate Change Science report: “ensure the existence of a long-term monitoring system that provides a more definitive observational foundation to evaluate decadal- to century-scale changes...”
  - Economic value of improved seasonal-interannual climate forecasts
- ✓ **Observations and Monitoring are a key component of recently released Strategic Plan for U.S. Climate Change Science Program**
- ✓ **Earth Observations Summit has initiated 10-year program to develop an international, comprehensive, coordinated and sustained Earth observation system**



## *Where are We Now?*

# Climate Products Produced from Operational Satellites in Different Ways

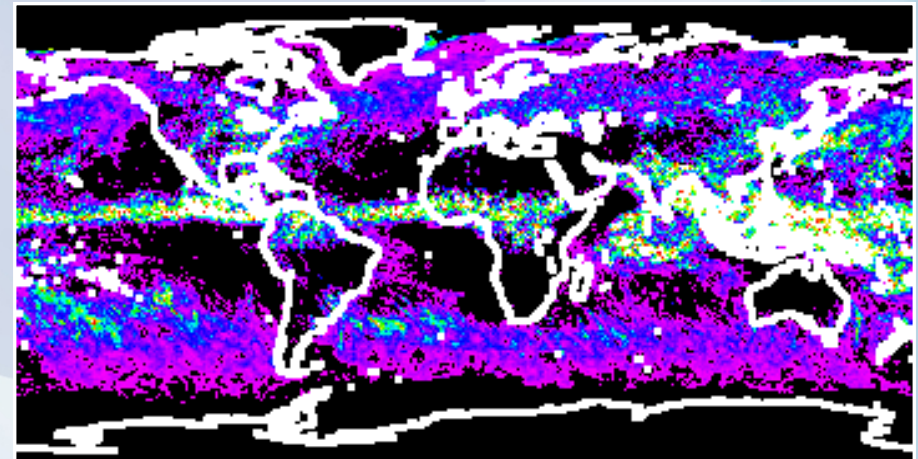
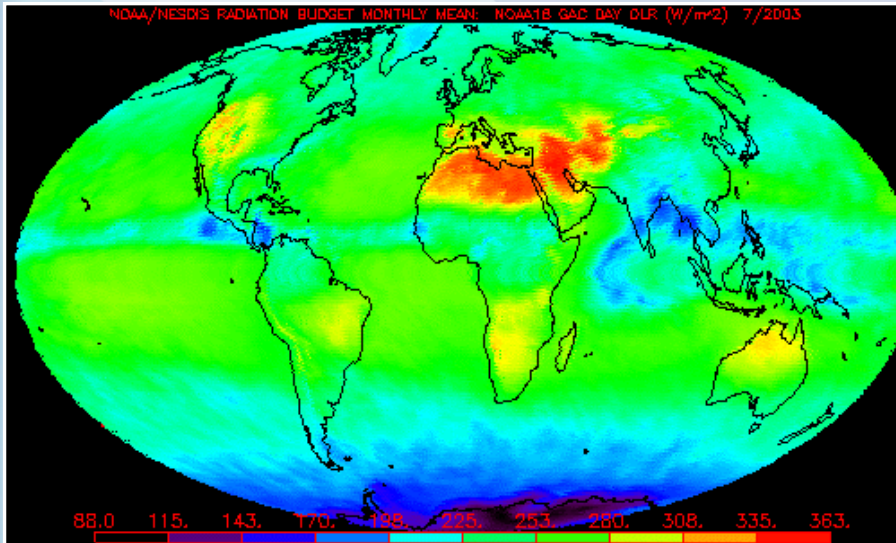
- ✓ **Operational products gridded to climate scale by NOAA or external investigators (Several DMSP SSM/I products; ERB, SST, vegetation and aerosols from AVHRR)**
- ✓ **NOAA/NASA collaborations (Ozone from SBUV and ATOVS/HIRS)**
- ✓ **Produced by external investigators (Atmospheric temperatures from MSU, snow cover from AVHRR)**
- ✓ **One-time projects such as NOAA/NASA Pathfinder**
- ✓ **International climate projects (ISCCP: clouds and GPCP: precipitation)**





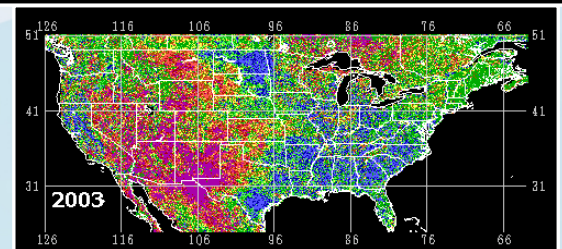
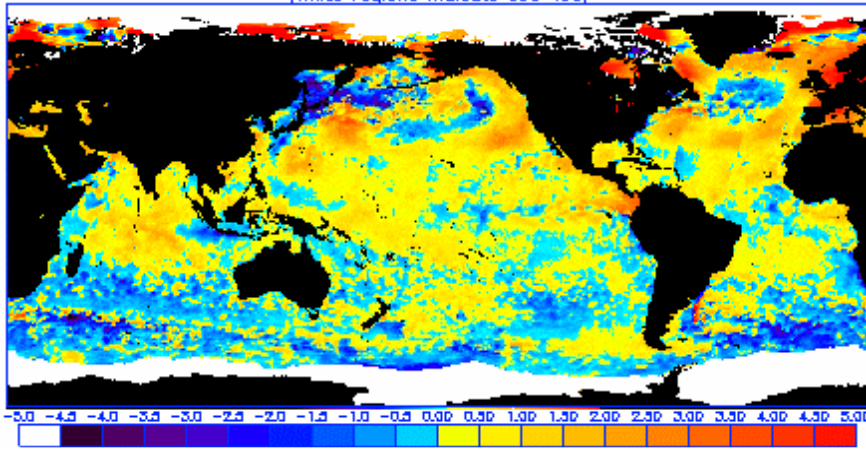
# Where are We Now?

## CDRs Produced by NESDIS by Gridding Operational Products to Climate Scale



Rainfall 7-03

NOAA Current SST Anomalies (C), 8/12/2003  
(white regions indicate sea-ice)

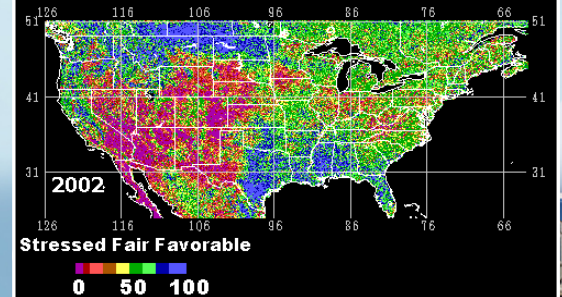


Vegetation

Health

8-10-03 and

8-10-02



National

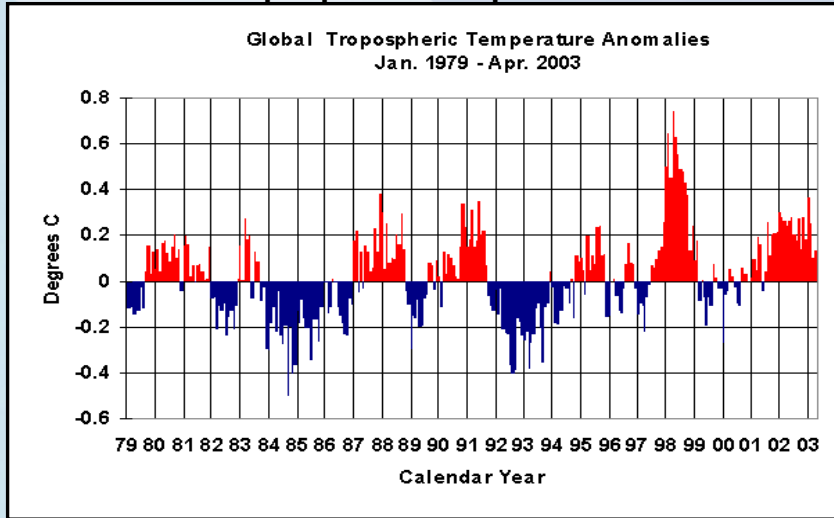
Stressed Fair Favorable

0 50 100

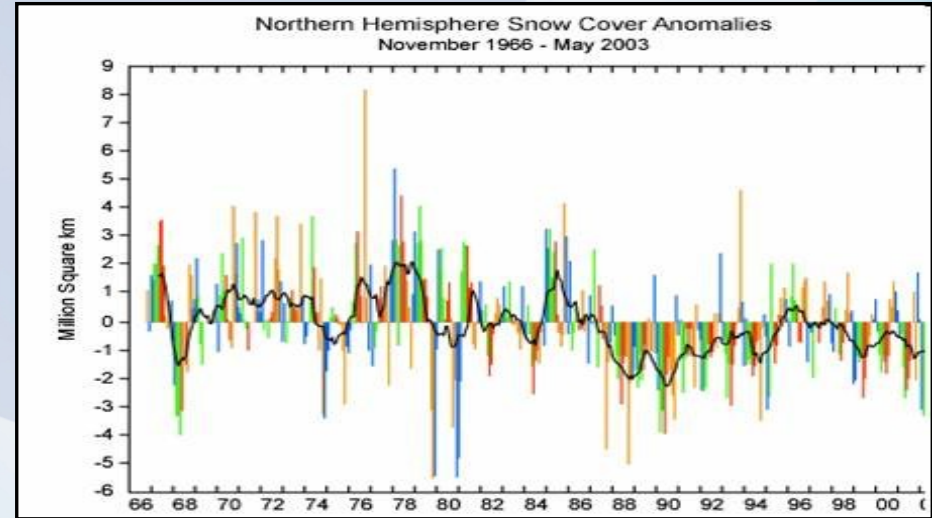
# Where are We Now?

## Examples of CDRs Produced by External Groups

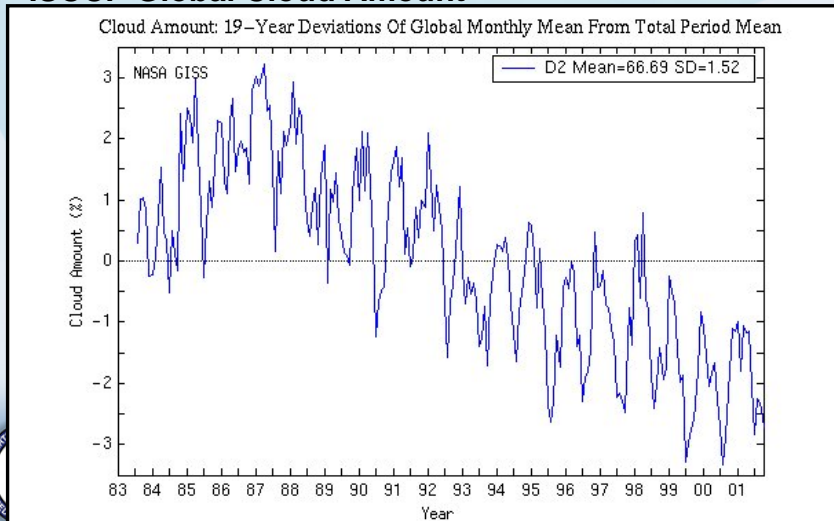
### U. Alabama Tropospheric Temp



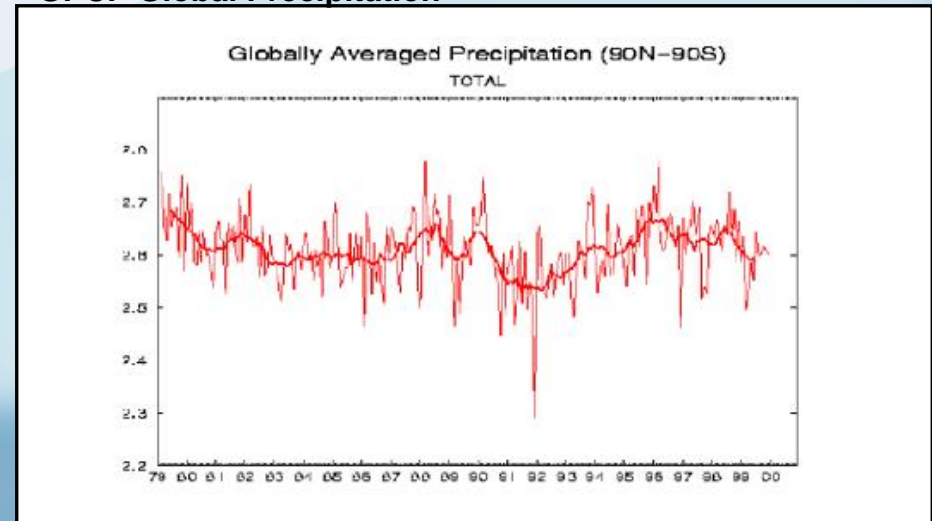
### Snow Cover Anomalies



### ISCCP Global Cloud Amount



### GPCP Global Precipitation





## *Where are We Now?*

# The NOAA/NASA Pathfinder Project: A One-Time Reprocessing Project

- Initiated in the early 1990s to generate climate quality data sets from the archived observations of the U.S. operational environmental satellites
- AVHRR (since 1981), TOVS (since 1979), SSM/I (since 1987), GOES (since 1978)
- Guided by scientific working groups
- Transcribed the data from hundreds of thousands of magnetic tapes to more accessible media for processing;
- Developed improved instrument calibration histories
- Selected community consensus algorithms for generating geophysical products
- Processed, validated, and provided access to the data sets
- Produced CDRs: temperature and moisture profiles, cloudiness, precipitation, earth radiation budget, and aerosols





# Where are We Now?

## Examples of Climate Data Records Based on Operational Satellite Observations

Climate Product	Satellite Instrument	Produced by	Since
Earth Radiation Budget (ERB) Outgoing long-wave radiation (OLR) Absorbed solar radiation (ASR)	POES/AVHRR	NESDIS	1978
Ozone	POES/SBUV/2 & POES/ATOVS/HIRS	NESDIS/NASA	1985
Blended Sea Surface Temperature (SST)	POES/AVHRR	NESDIS/NWS	1981
DMSP SSM/I Climate Products (rainfall, rain frequency, snow cover, sea ice cover, clouds, water vapor, and oceanic wind speed)	DMSP SSM/I	NESDIS	1987
Vegetation (NDVI and drought index)	POES/AVHRR	NESDIS	1982
Atmospheric Temperature	POES/MSU	Univ. of Alabama	1979
Snow Cover	POES/AVHRR, GOES, Meteosat, GMS Visible imagery, DMSP/SSM/I	Rutgers Univ. Climate Laboratory	1966
Clouds	POES/AVHRR, GOES, Meteosat, and GMS Visible/IR imagery	WCRP/International Satellite Cloud Climatology Project	1983
Precipitation	POES/AVHRR, GOES; Meteosat and GMS Visible IR imagery, DMSP SSM/I	WCRP/Global Precipitation Climatology Project	1986

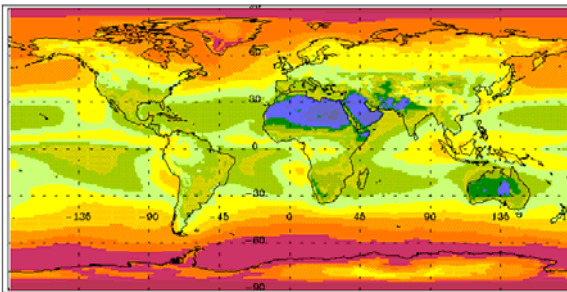


## *Where are We Now?*

# The NOAA/NASA Pathfinder Project: A One-Time Reprocessing Project (cont)

Mean Global Maps Based on 20 Years of AVHRR Observations

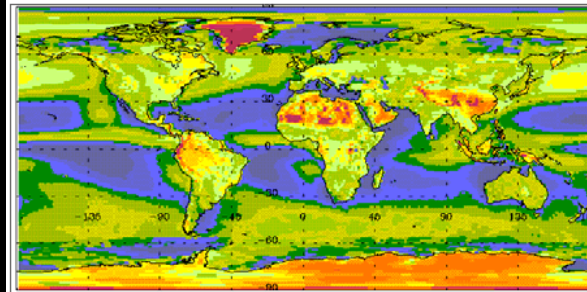
Cloud Amount



Mean Cloud Amount (%)

2. 16. 30. 44. 58. 72. 86. 100.

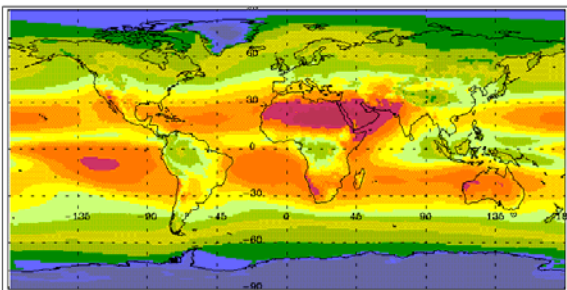
Reflected Solar Radiation



Mean Reflected Solar Radiation ( $\text{W m}^{-2}$ )

50. 70. 90. 110. 130. 150. 170. 190.

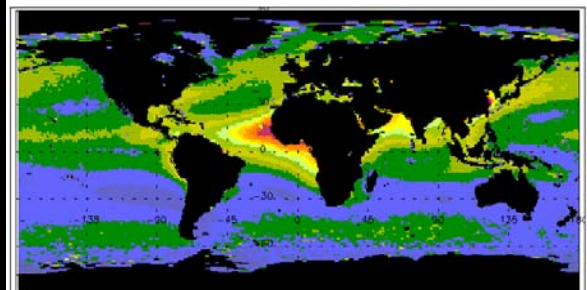
OLR



Mean Outgoing Longwave Radiation ( $\text{W m}^{-2}$ )

150.0 170.0 190.0 210.0 230.0 250.0 270.0 290.0

Aerosol Amount



Mean Aerosol Optical Thickness

0.00 0.07 0.14 0.21 0.28 0.35 0.42 0.49



## *Lessons Learned*

# Important Questions Spawned via Production of Climate Records Using Operational Data

- What are the priority climate products that an operational center should produce and how?
- What methods and good practices should be used to facilitate access to a variety of products, metadata, and raw data?
- What in situ baseline observations are required to use for long-term calibration and validation of space-based observations?
- What critical performance measures should be monitored in real-time to avoid single-point failures in long-term records of critical climate variables?
- How do we reconcile different observations and analysis techniques to achieve the best and/or consensus climate data records?

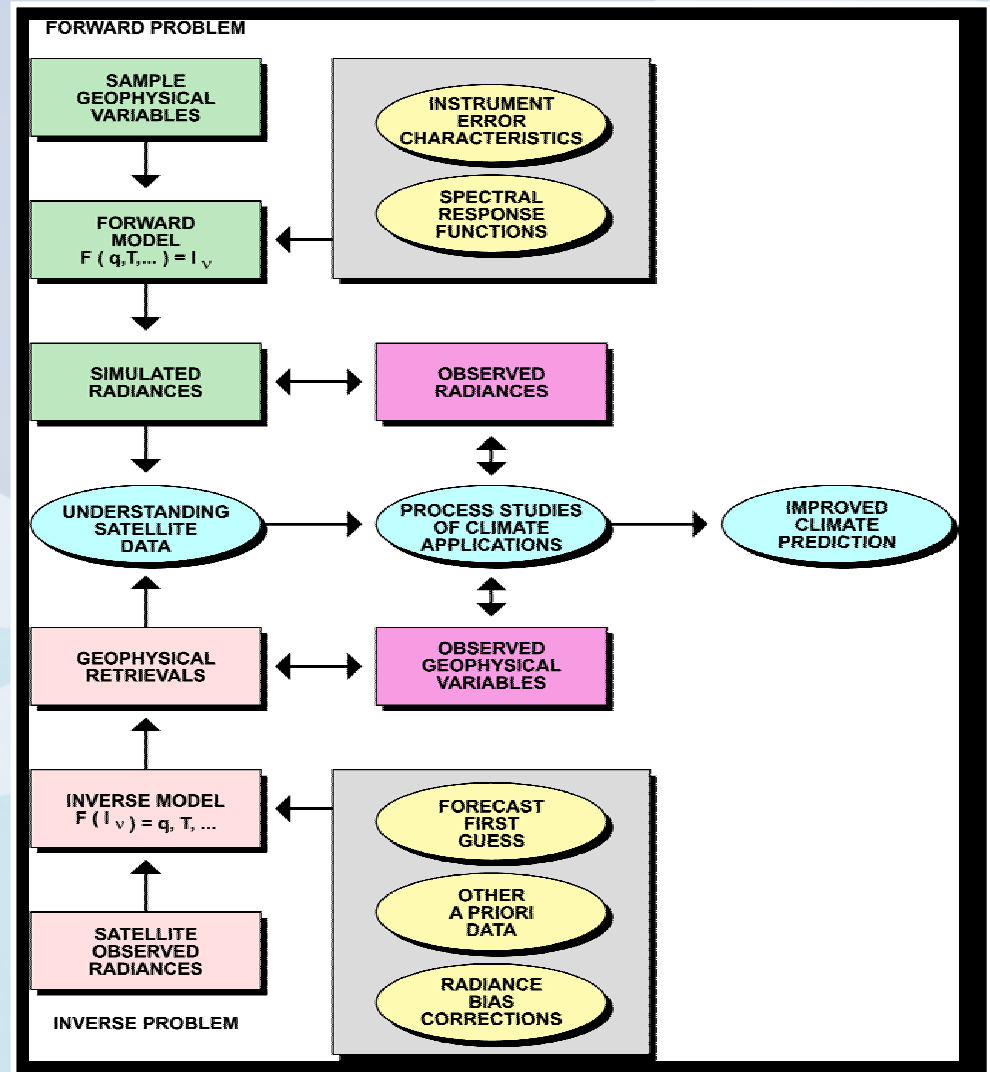




# Lessons Learned

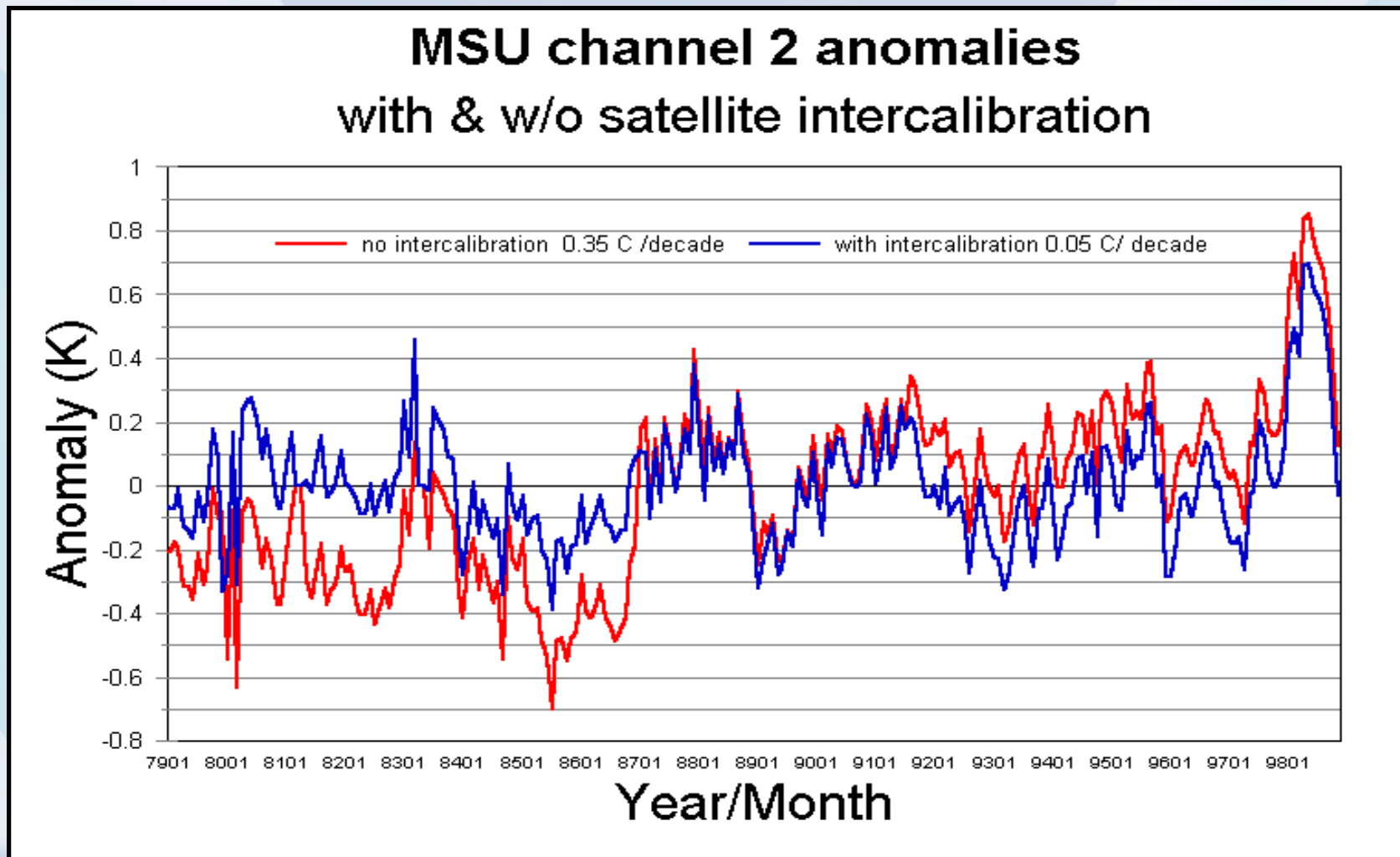
## Minimize Bias

- ✓ Application of the forward and inverse radiative transfer equation to climate studies emphasizes the need to minimize systematic bias in the raw data and retrieval method



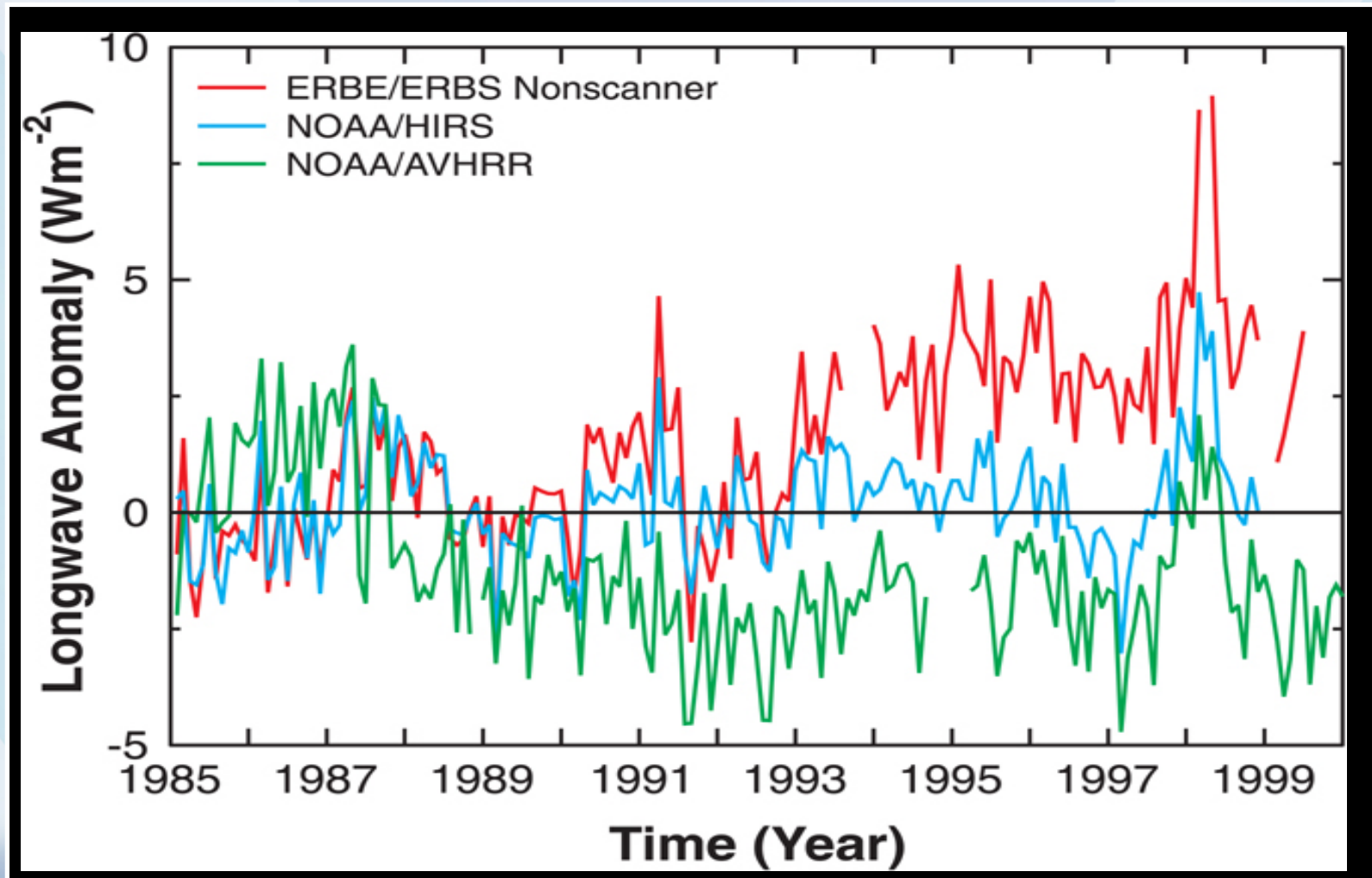
# Lessons Learned

## Importance of Satellite Intercalibration



# *Lessons Learned*

## Importance of Multiple Independent Observations and Analyses



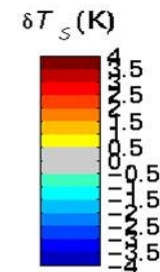
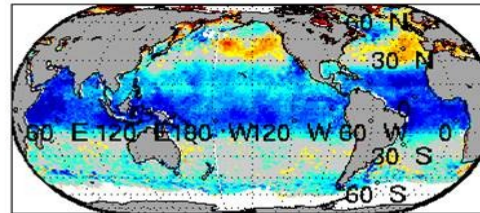


# Lessons Learned

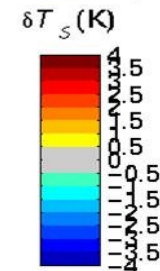
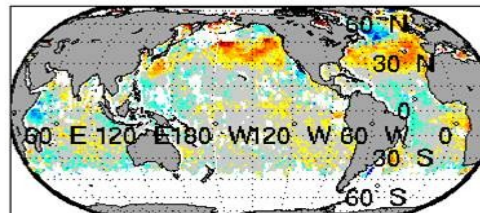
## Expect the Unexpected

Volcanic eruptions contaminate infrared-only SSTs. Lesson is that we must have robust observing methods for critical climate variables

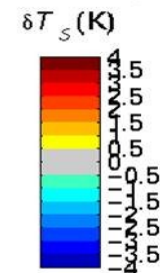
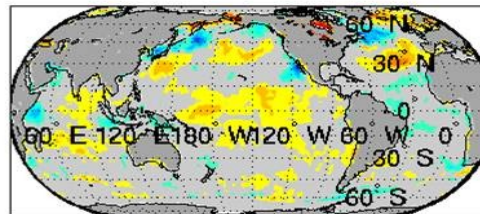
PATMOS Mean MCSST Anomaly – Aug1991



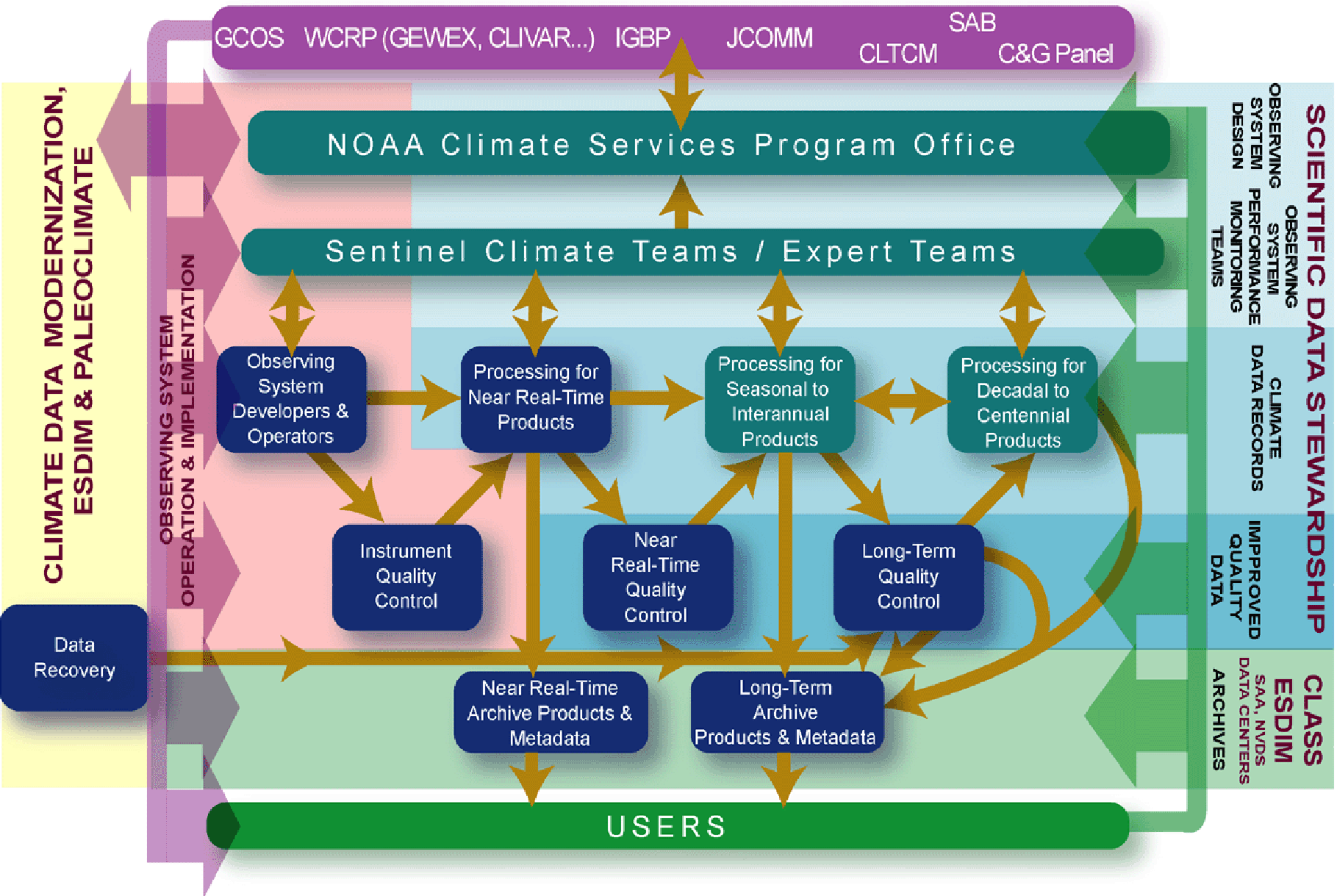
PATMOS Mean AMCSST Anomaly – Aug1991



NCEP Reynolds Mean OISST Anomaly – Aug1991



# NOAA CLIMATE OBSERVATIONS AND MONITORING




# NOAA's Satellite, Data, and Information Stewardship FY03

Data Sets and Observations		Data Rescue Stewardship		Information Technology Stewardship (CLASS)				Scientific Data Stewardship (SDS)				
		Planning	Rescue	Ingest	Store	Access	Migrate	Observing System Performance Monitoring (Near Real-Time)		Climate Data Records (Long-Term Processing)		Assessing State of the Environment (Ongoing)
								Bias Monitoring	Products, Assimilation, Metadata	Data Characterization	Sentinel Blended Products	Information for Decision Makers
Historical	In-Situ Research	Implemented	Implemented	Implemented	Phase 2	Phase 2	Phase 2	Phase 3	Phase 3	Phase 3	Phase 2	Phase 2
	Land	Implemented	Phase 3	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Phase 2	Implemented
	Ocean	Implemented	Phase 2	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Phase 2	Implemented
Current	DMSP	Implemented	Implemented	Implemented	Phase 2	Phase 2	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
	POES	Implemented	Implemented	Implemented	Phase 2	Phase 2	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
	ASOS	Implemented	Implemented	Implemented	Phase 2	Phase 2	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
	NEXRAD	Implemented	Implemented	Implemented	Phase 2	Phase 2	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
	GOES	Implemented	Implemented	Implemented	Phase 2	Phase 2	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
Future	MODEL OUTPUT	Implemented	Phase 2	Phase 2	Phase 3	Phase 3	Phase 3	Phase 2	Phase 2	Phase 2	Phase 2	Phase 2
	New In-Situ Land & Ocean	Implemented	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
	NPP	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
	NPOESS	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3
	EOS	Phase 2	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3	Phase 3

 = Implemented

 = Phase 2 Implementation

 = Phase 3 Implementation