Climate Data Records and Scientific Data Stewardship

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NOAA's National Climatic Data Center

(Thanks Jeff Privette and Bruce Barkstrom)

Outline

- Scientific Data Stewardship (SDS)
  - Characteristics of CDRs
  - A Model for CDR Maturity
  - Prioritizing Measurements and CDRs
  - Long-term Information Preservation
- GEWEX/ISCCP Water Vapor and Cloud CDRs
  - Water Vapor Trends
  - Role of Transients in the General Circulation
  - Objective Hurricane Trends
  - Enabling Science - Customer Service
- Toward a National Climate Service
  - ISCCP as an Operational Pilot

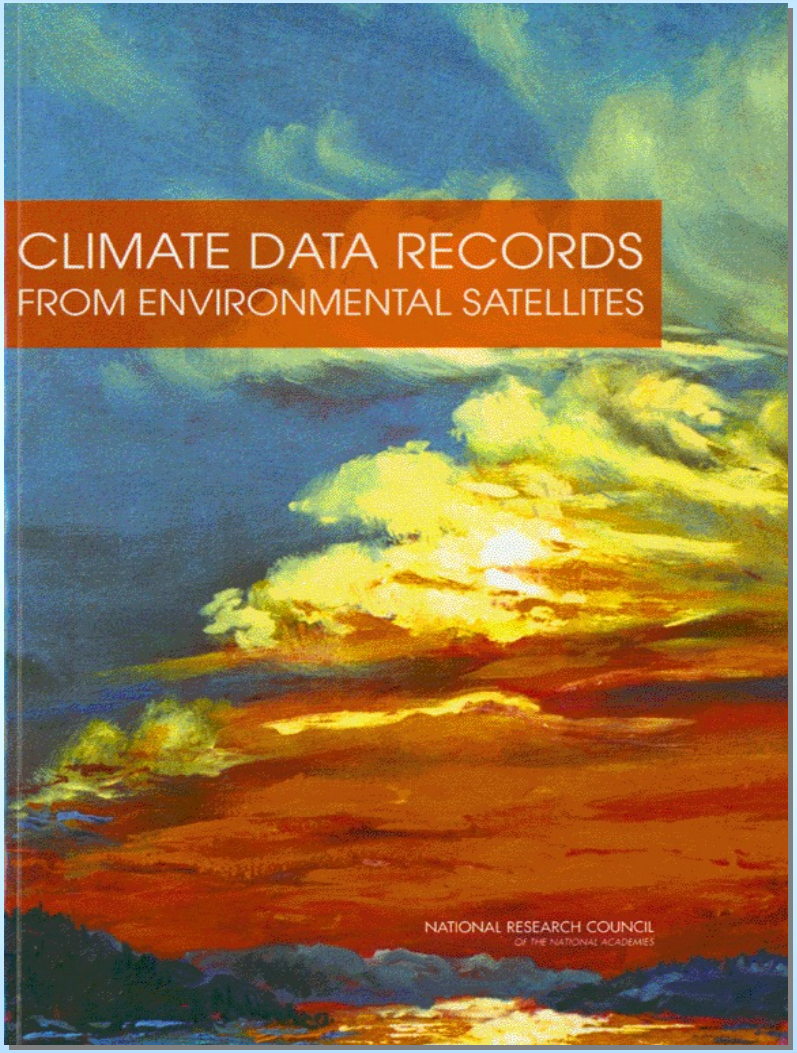
Scientific Data Stewardship (SDS)

Scientific Data Stewardship is a Systematic Approach to Observation, Production, and Preservation of Essential Climate Information

- Characteristics of CDRs
- A Model for CDR Maturity
- Prioritizing Measurements and CDRs
- Long-term Information Preservation

SDS and CDRs

- NOAA's Scientific Data Stewardship (SDS) rooted in NRC dialogue and reports
- A Climate Data Record (CDR) is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change



Key Elements of a Successful CDR Program

CDR Organizational Elements

- High-level leadership council
- Advisory council to represent climate research community and other stakeholders
- Fundamental Climate Data Record (FCDR) Teams
- Thematic Climate Data Record (TCDR) Teams

CDR Generation Elements

- High accuracy and stability of FCDRs
- Pre-launch characterization of sensors and lifetime monitoring
- Thorough calibration of sensors
- Well-defined criteria for TCDR selection
- Stakeholder involvement and feedback for TCDRs
- Well-defined criteria for TCDR validation
- Use of *in-situ* data for validation

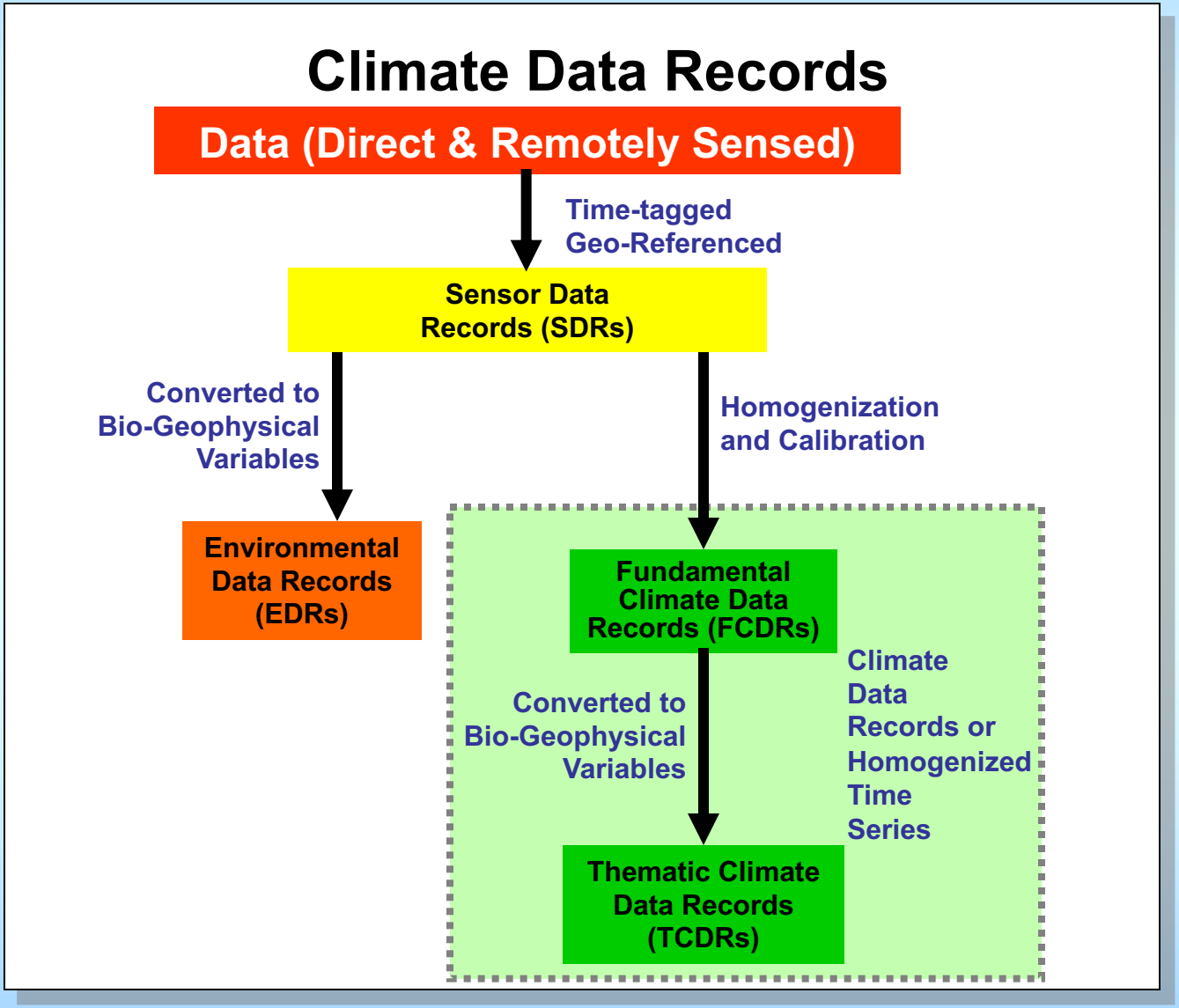
Sustaining CDR Elements

- Available resources for reprocessing CDRs as new information becomes available
- Provisions for feedback from scientific community
- Long-term commitment of resources for generation and archiving of CDRs and associated data

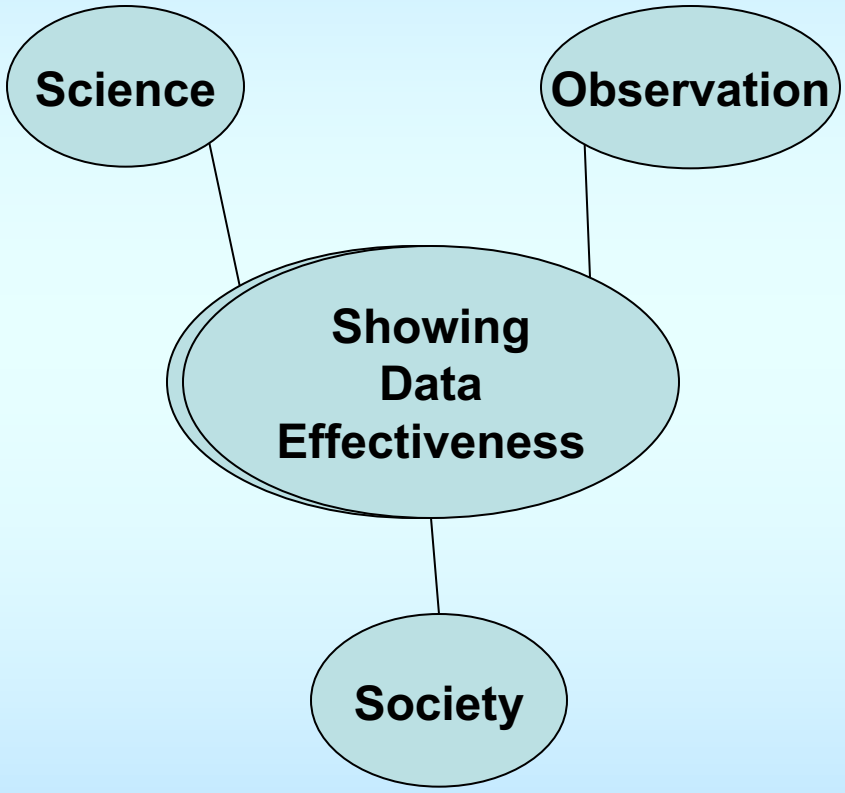
Fundamental Climate Data Record (FCDR): Time series of calibrated signals for a family of sensors together with the ancillary data used to calibrate them.

Thematic Climate Data Record (TCDR): Geophysical variables derived from FCDRs, often generated by blending satellite observations, in-situ data, and model output.

Defining Scientific Data Stewardship - Characteristics of Climate Data Records



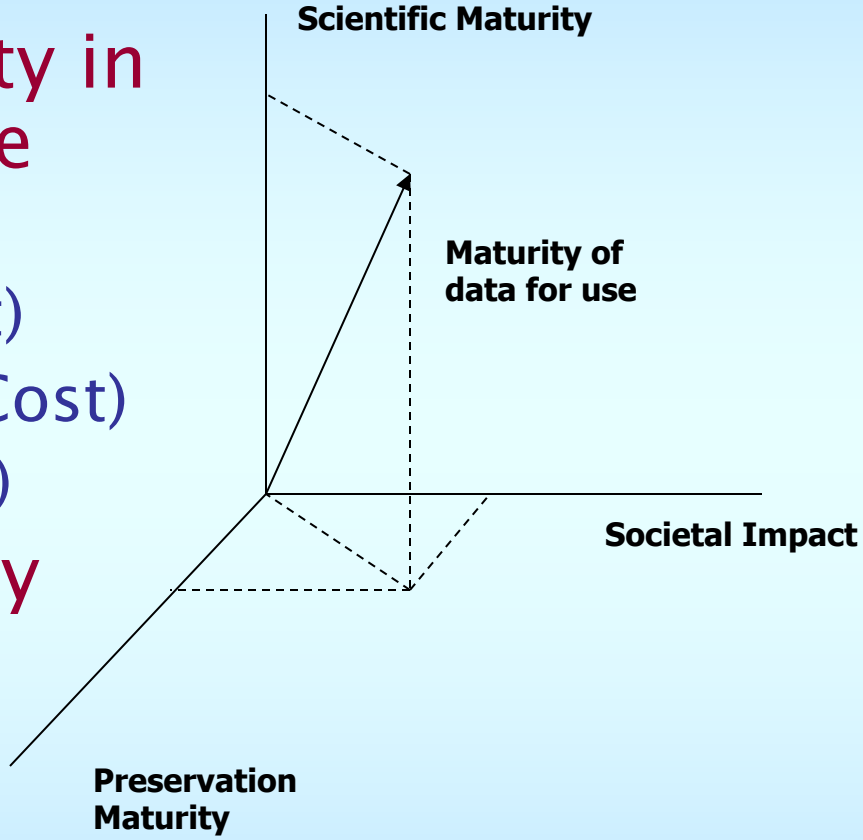
Climate Data Record Cost-Benefit Need for a Maturity Model



- Interagency & International views of observational maturity and science data stewardship needs reflect wide diversity
  - Vocabulary
  - Experience
  - Background
- Need understandable approach

A Simple CDR Maturity Model

- Represent data maturity in terms of three separate dimensions:
  - Scientific Maturity (Cost)
  - Preservation Maturity (Cost)
  - Societal Impact (Benefit)
- Total maturity is simply length of vector

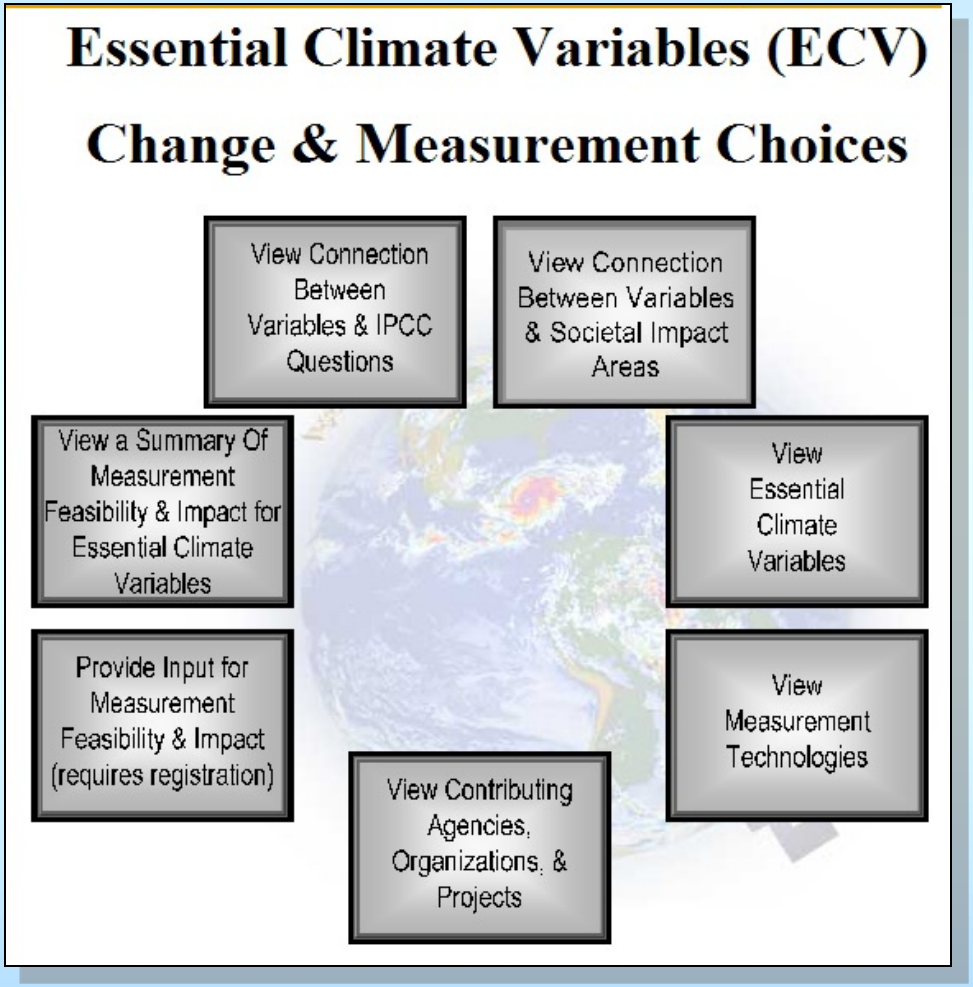


Maturity Model Key Attributes

- Scientific Maturity
  - Physical Understanding of Measurement Process
  - Measurement of Key Instrument Characteristics
  - Public Accessibility of Data Processing
  - Rigorous Validation
- Preservation Maturity
  - Systematic Approach to Guaranteeing Preservation of Data Understanding
  - Systematic Reduction of Threats to Preservation
  - Assurance of Preservation Cost Effectiveness
- Societal Benefits
  - GEOSS Benefit areas (bottom up)
  - Key Science Issues (top down)

Prioritizing Observations CDRs Societal Benefits and Key Science Issues

- Societal benefits of the Global Earth Observations System of Systems (GEOSS) emphasize the tradition of applied climatology but using 21st century systems
- Key Science Intergovernmental Panel on Climate Change (IPCC) Issues address the policy-relevant scientific research topics of highest priority for Climate and Global Change studies

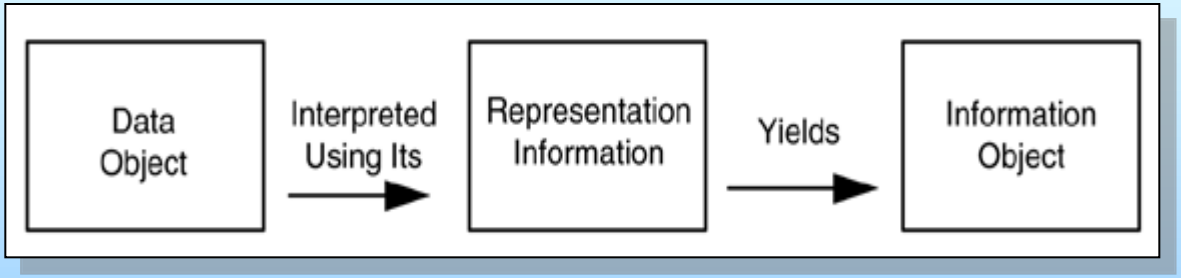


NCDC Prioritization Web Site

Scientific Data Stewardship – Information Preservation in an Archive

- A CDR producer must negotiation with an archive to ensure their information content is preserved by an archive
- In turn, to ensure information preservation an archive* must:
  - Negotiate and accept information from information producers
  - Obtain sufficient control to ensure long-term preservation
  - Determine which communities (designated) need to be able to understand the preserved information
  - Ensure the information to be preserved is **independently understandable** to the Designated Communities
  - Follow documented policies and procedures that ensure the information is preserved against all reasonable contingencies
  - Make the preserved information available to the Designated Communities in forms understandable to those communities

*Open Archive Information System – Reference Model (ISO Standard)

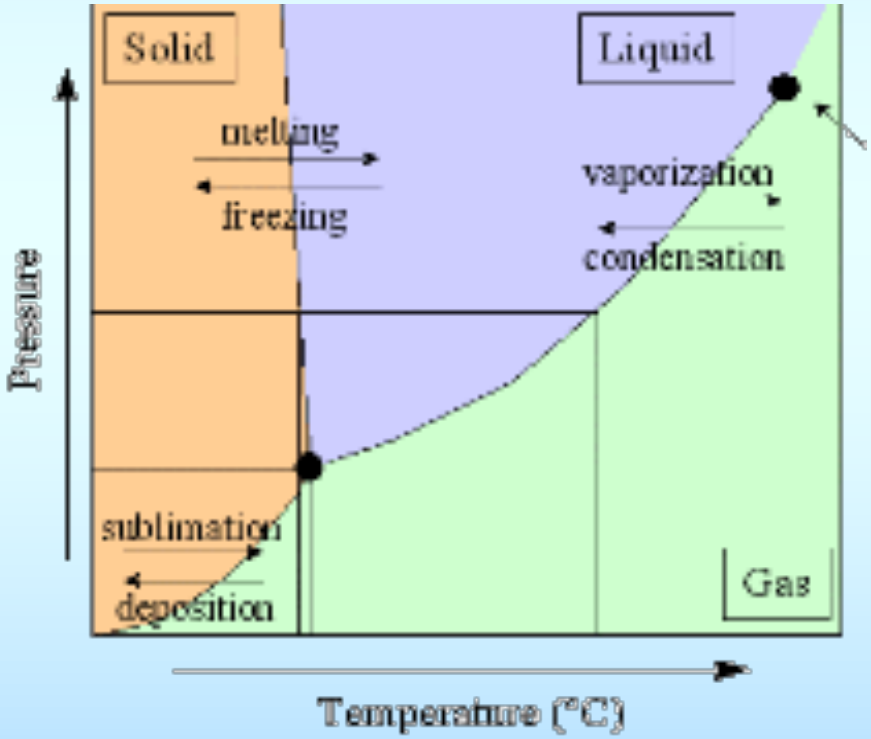


GEWEX/ISCCP Water Vapor and Cloud CDRs

- Water Vapor Trends
- Role of Transients in the General Circulation
- Objective Hurricane Trends
- Enabling Science - Customer Service

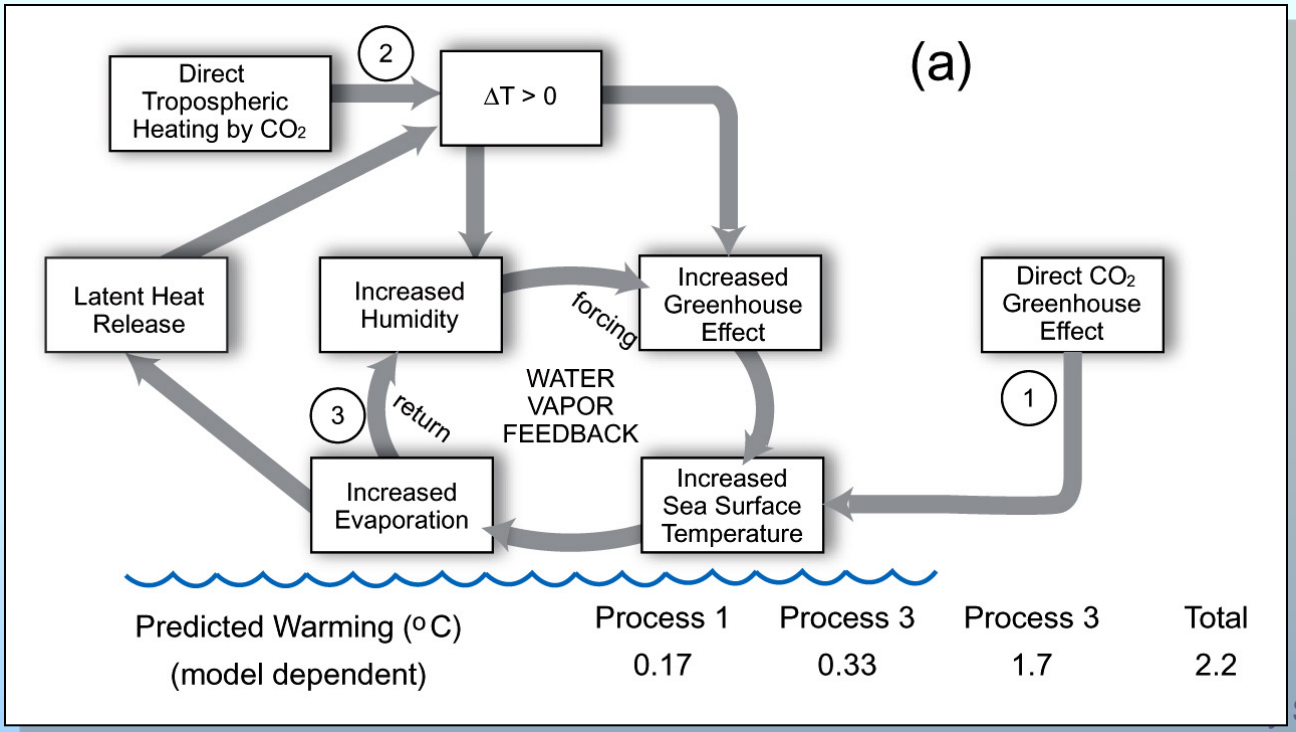
Water Vapor Feedback in the Tropical Upper Troposphere

- Models keep humidity constant as temperatures increase leading to a large positive feedback
- Tropical and mid-latitude humidity distribution is complex
- What is observed on seasonal, interannual and decadal time scales using satellite data?

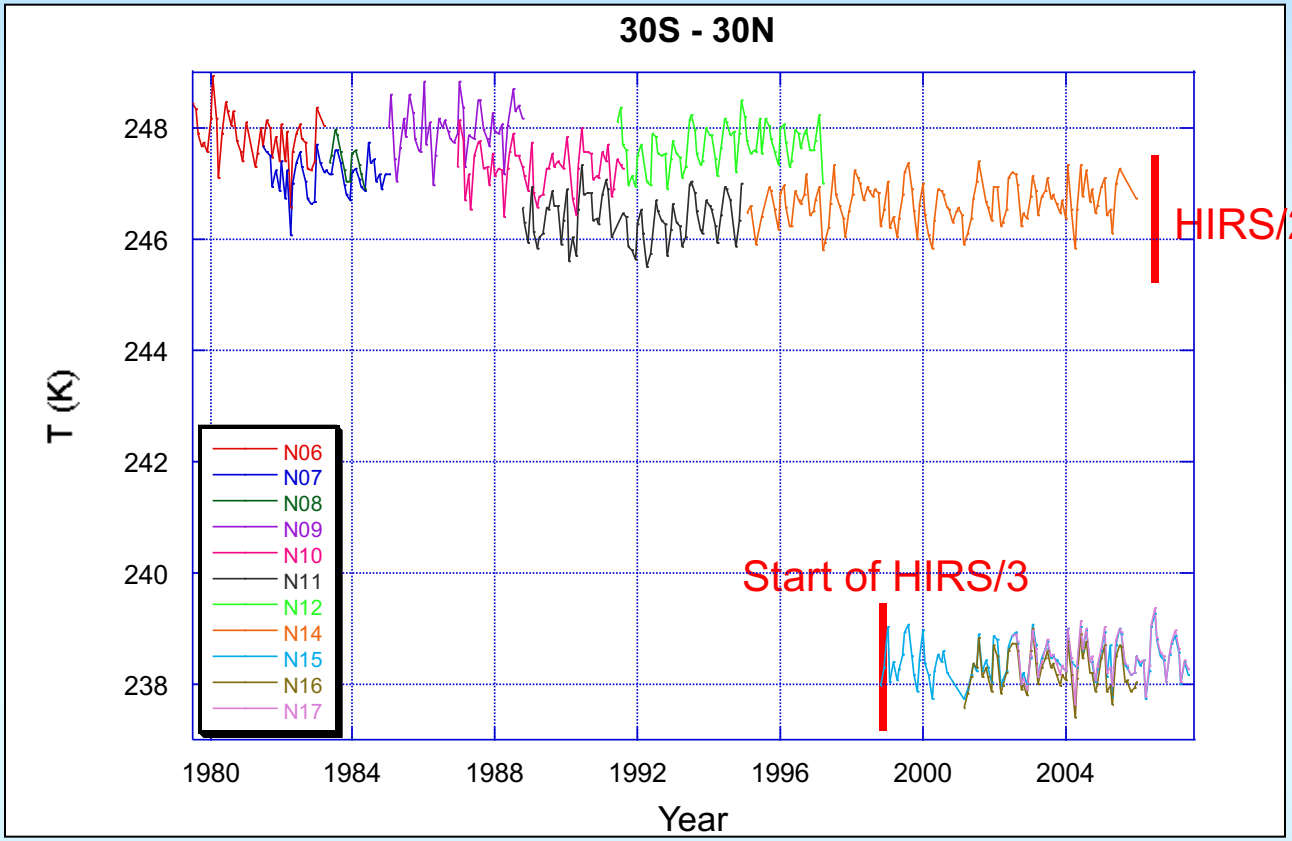


Simple Water Vapor Feedback

- Assume (most models work this way) that the relative humidity remains constant as man-made greenhouse gasses initially warm the atmosphere and ocean
- More moisture is evaporated from the surface and the total amount of water in the atmosphere increases
- The increased water vapor traps more outgoing radiation thereby further increasing global temperatures – upper troposphere is key
- This is a major positive feedback – increasing the man-made warming by 2-3 times



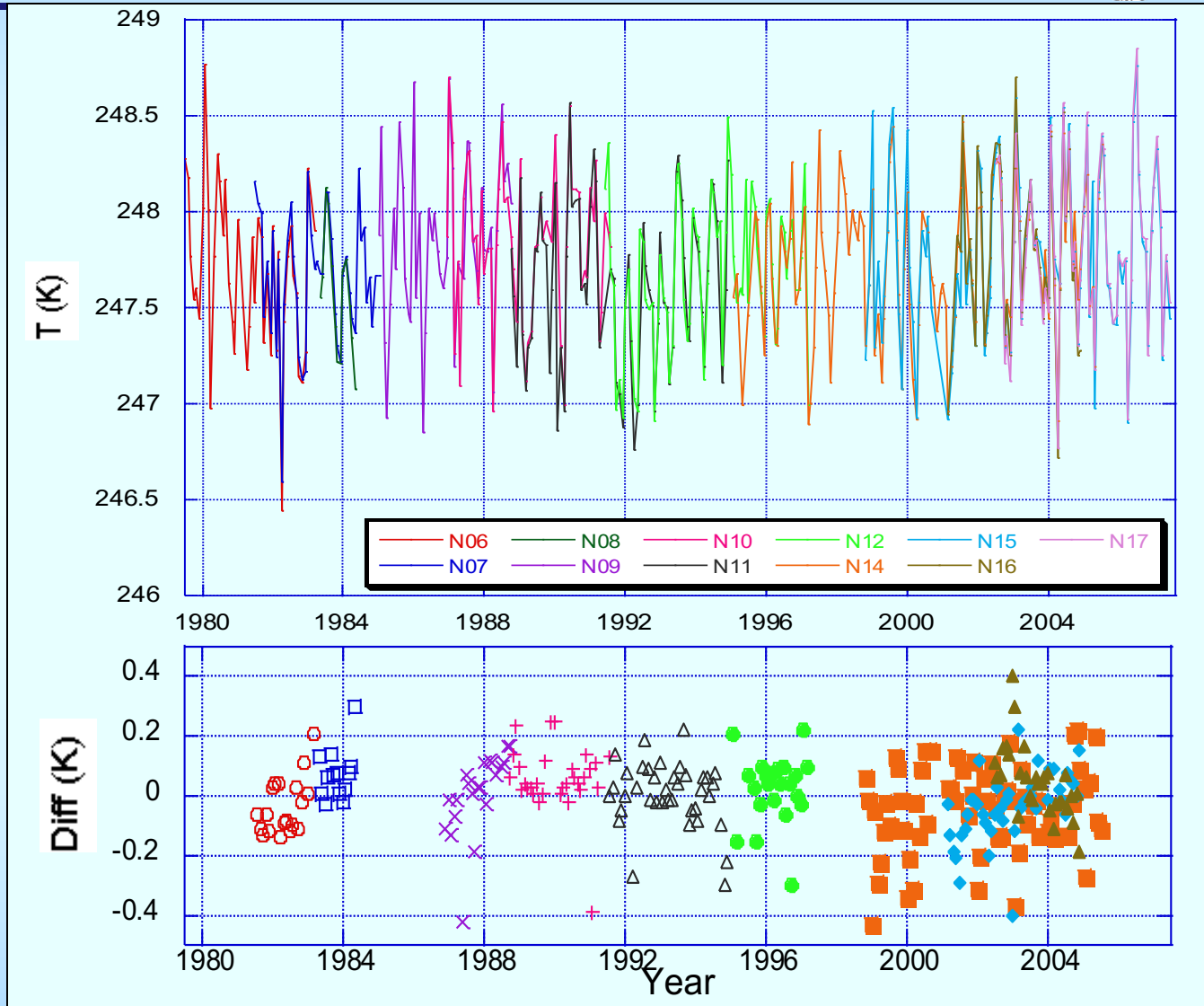
Upper Tropospheric Water Vapor Data Sets from NOAA Operational Satellites



- Due to the independence of individual HIRS instrument's calibration, biases exist from satellite to satellite.
- These intersatellite biases have become a common source of uncertainty faced by long-term studies.

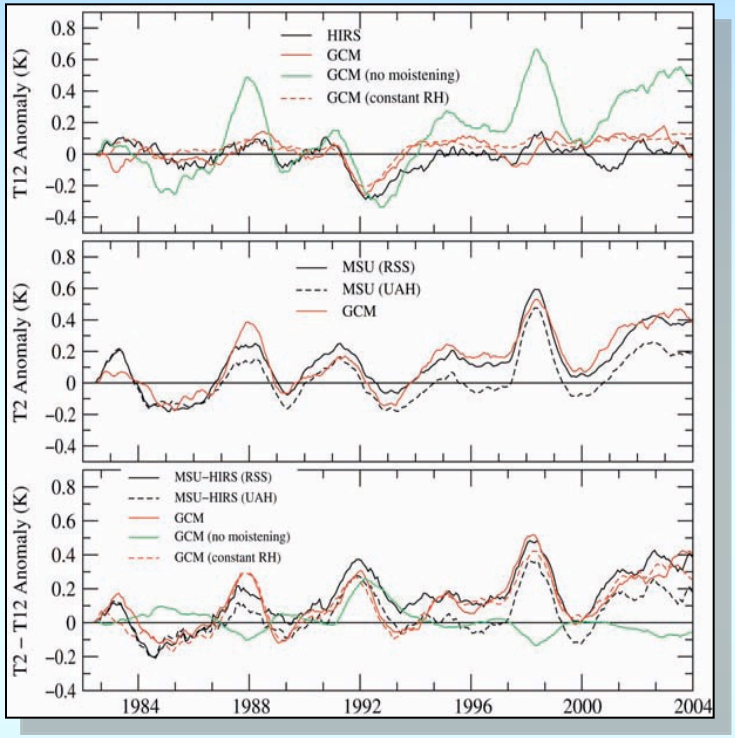
Intersatellite Calibrated Create a Fundamental Climate Data Record (FCDR) for Users

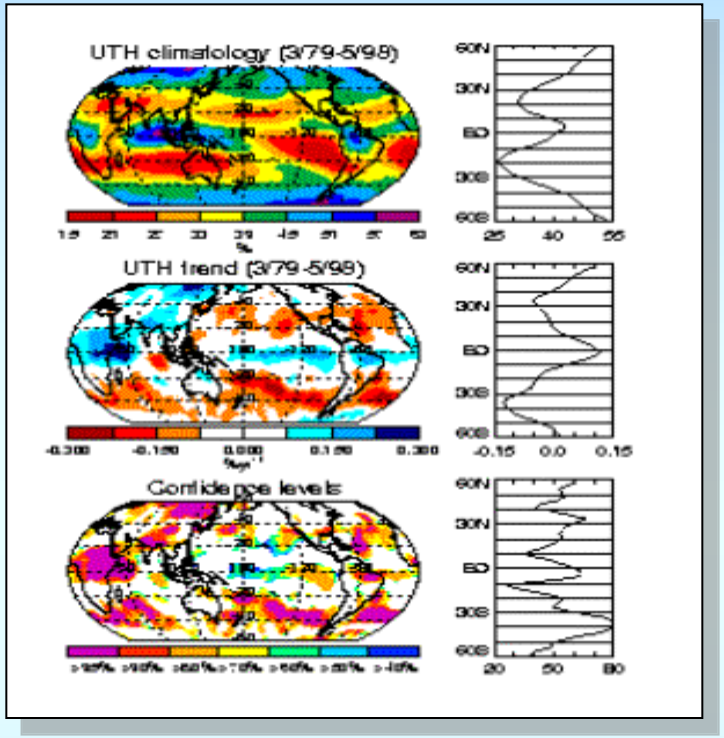
- Biases minimized.
- Temperature dependent biases accounted for.
- Similar overall variances between HIRS/2 and HIRS/3.
- Time series can be extended as variance preserved.



Pairs	N06-N07	N07-N08	N09-N10	N10-N11	N11-N12	N12-N14	N14-N15	N15-N16	N16-N17
Ave Diff	-0.065	0.073	0.008	0.059	0.006	0.048	-0.042	-0.035	0.048

HIRS12 FCDR Has Been Used for Trend Studies and GCM Evaluation

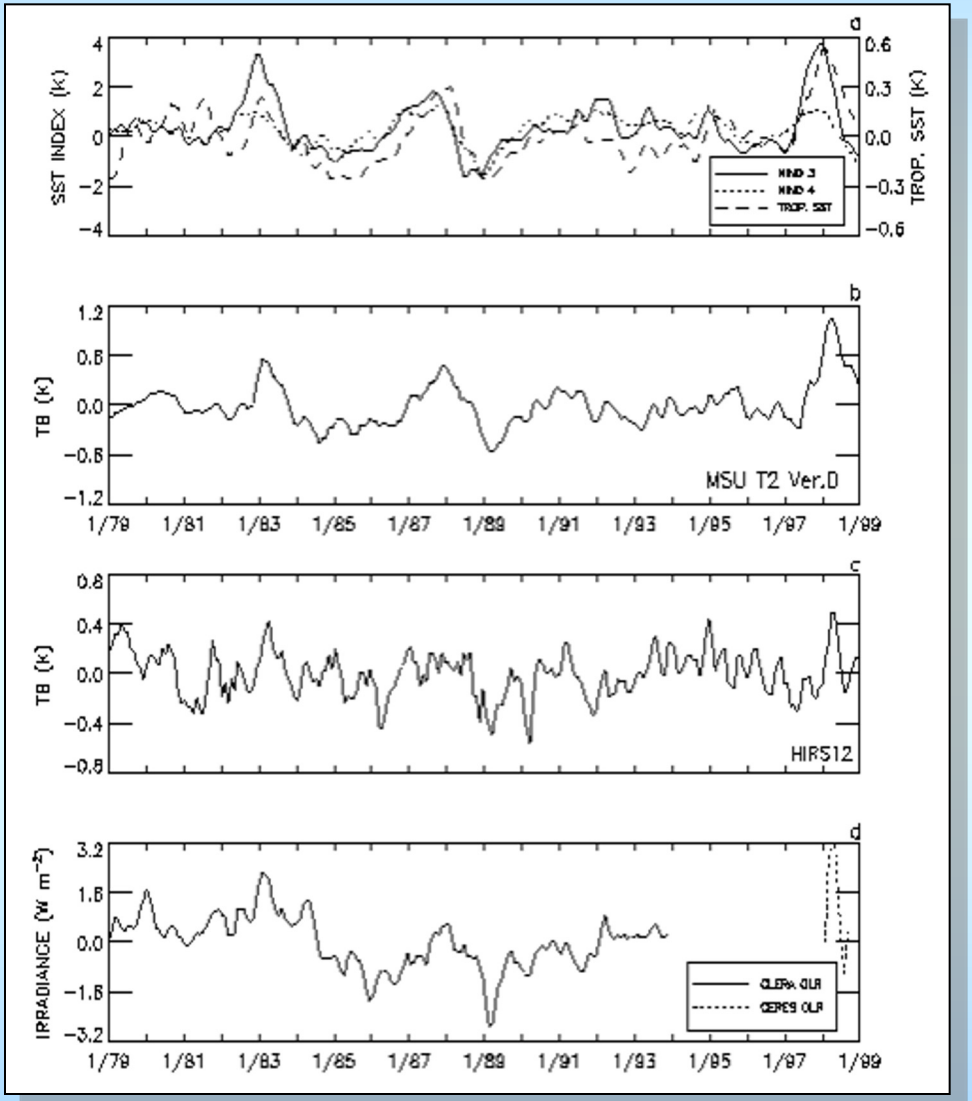




- Soden et al (2005-left)) show the GFDL GCM simulations of upper tropospheric moisture agree well with HIRS12 FCDR
- Trend analysis (Bates et al., 2001-right)) show little global trend but some significant regional trends

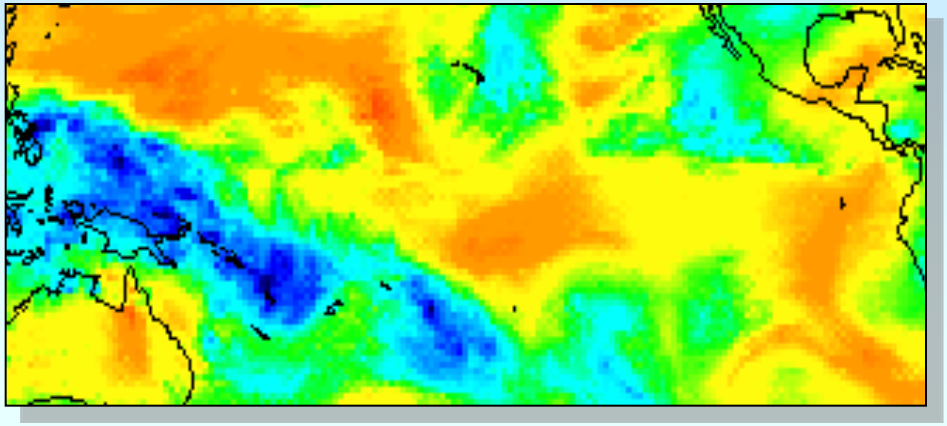
Understanding Interannual and Intraseasonal UTH Tropical Variability

- ENSO frequency dominates 30N-30S SST and temperature time series
- Higher frequencies dominate 30N-30S upper-troposphere water vapor and clear-sky OLR time series
- Extremes are synchronous in both time series – Why? – Interannual-Seasonal-Intraseasonal Interactions

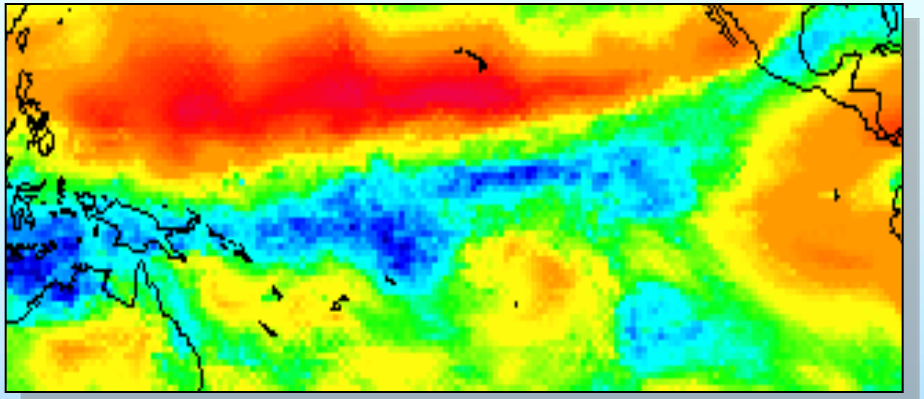


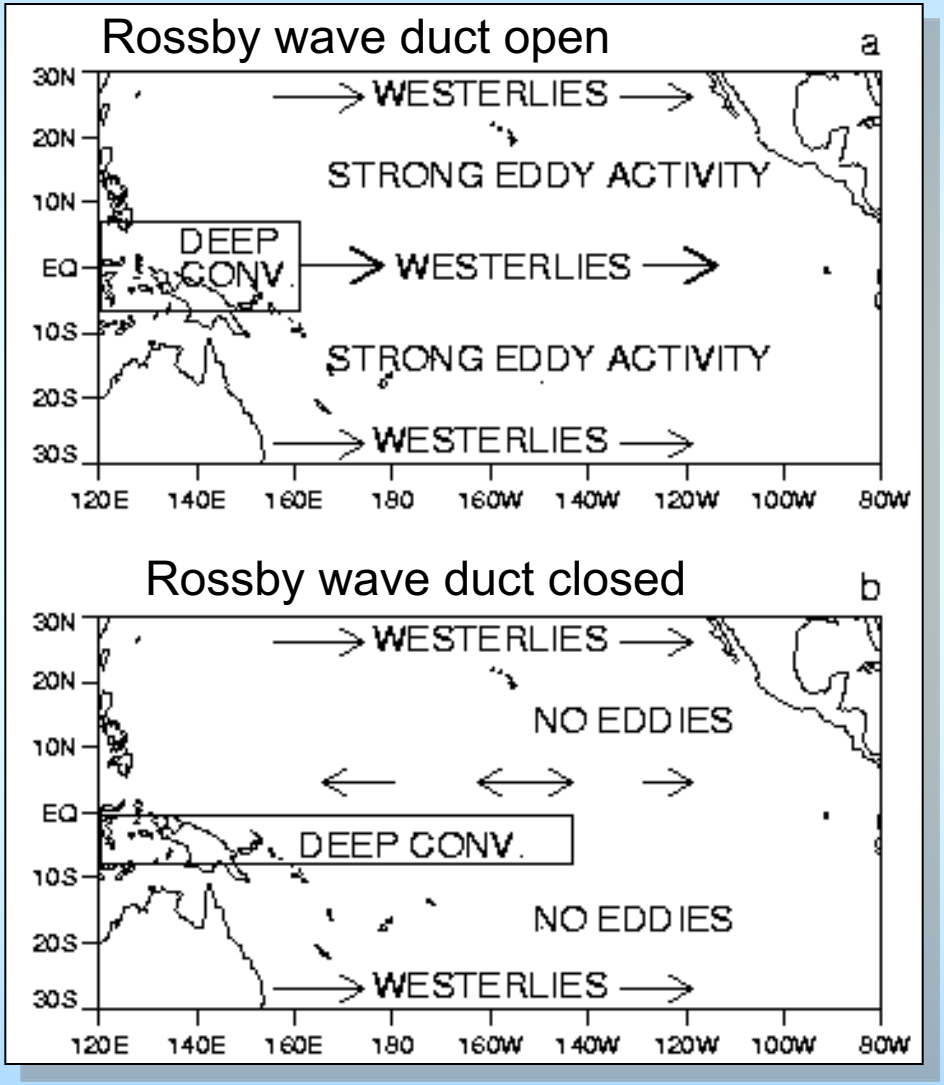
A Question of Balance – Dynamic-Thermodynamic Scale Interactions Constrain Feedbacks

UTWV for ENSO Cold Event Jan 1987



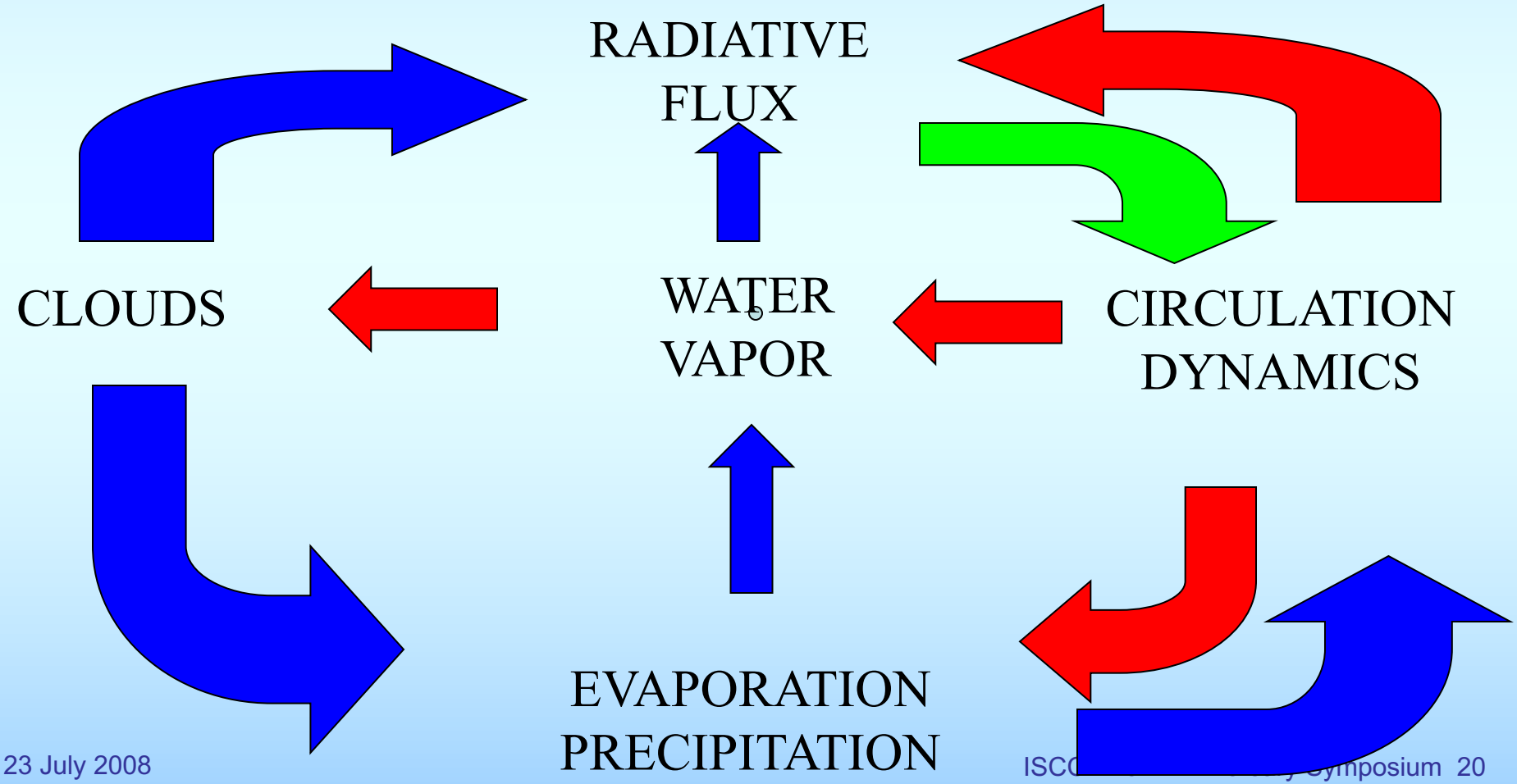
UTWV for ENSO Warm Event Jan 1983





Simple Water and Energy Cycle

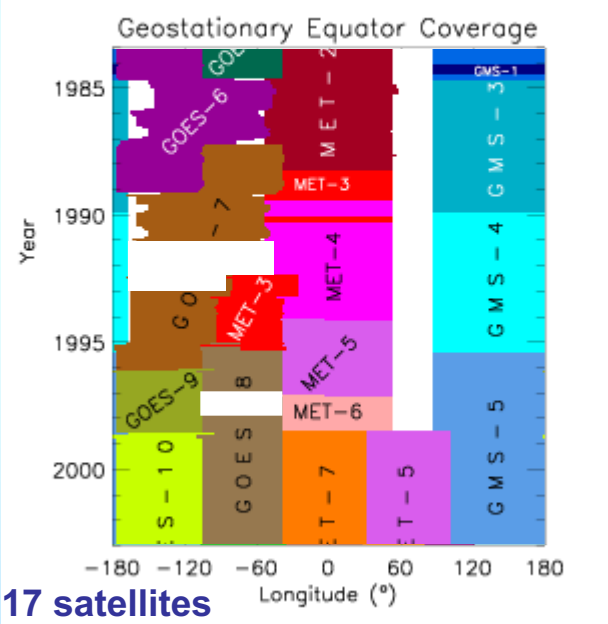
Analysis of ISCCP and other GEWEX data sets has given new insights into the interactions between dynamics and thermodynamics and organized convective scale to general circulation scale



ISCCP B1 FCDR Rescue Efforts

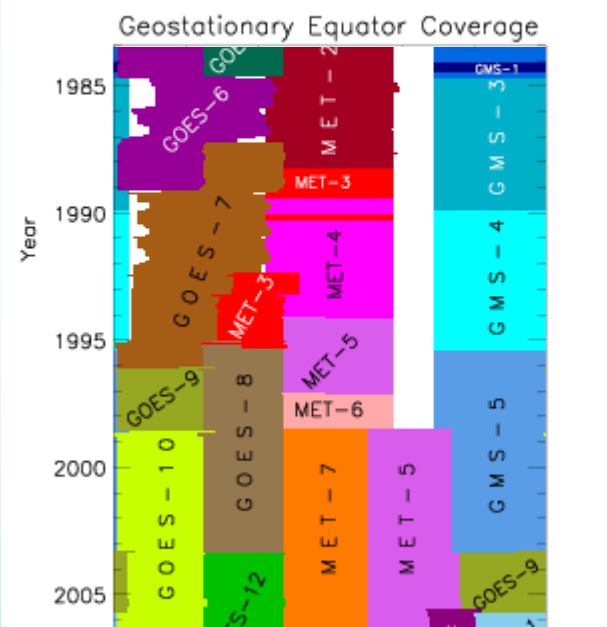
ISCCP B1 data (10km, 3 hr) was stored without stewardship for 15 years at NCDC. We began stewarding it in 2003, putting together 9 formats, 7 navigation, and multiple calibrations into a single accessible FCDR

B1 Status - 2003



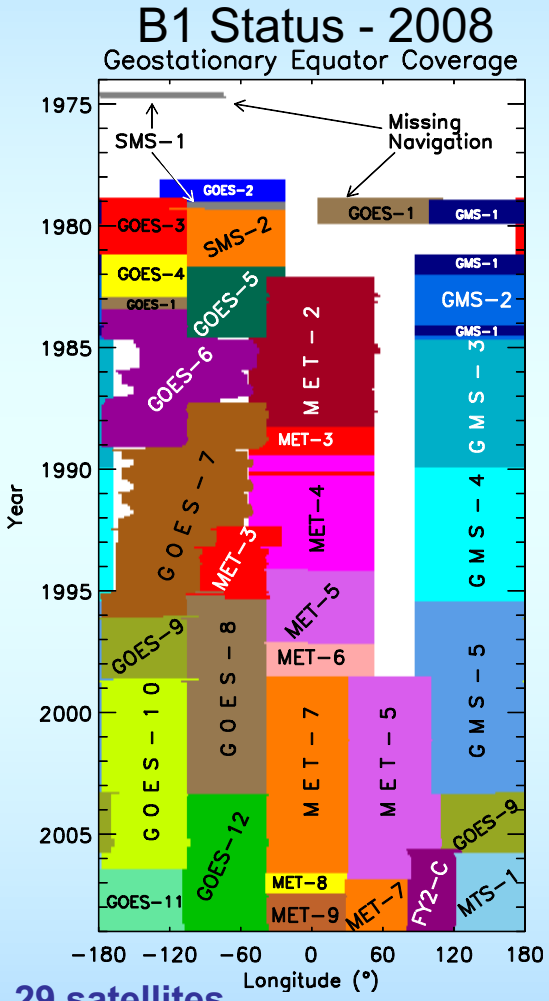
17 satellites

B1 Status - 2006



22 satellites

B1 Status - 2008

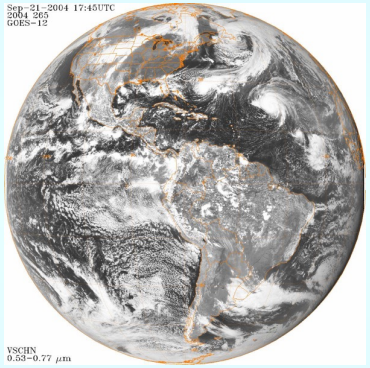


29 satellites

Climate Information Records

29 Operational Geostationary Satellites
+ 16 Operational Polar Satellite

Raw Satellite Data

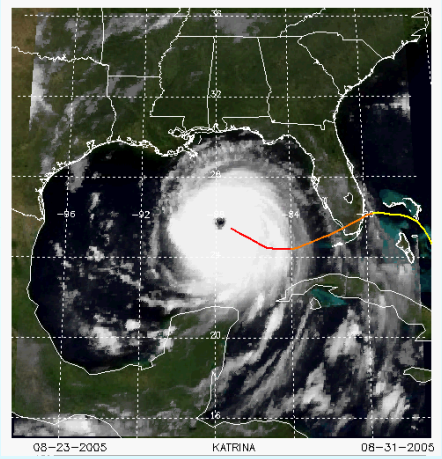


Geostationary Imagers
- Infrared window
- Visible
- Infrared water vapor

Format? Navigation?
Remapping?
Data volume?

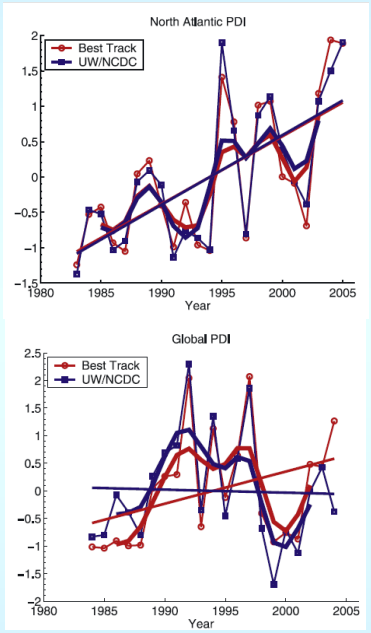
30 Year FCDRs

HURSAT



HURSAT-B1
- Brightness Temperatures
- Geo-located
- Calibrated
- netCDF
- 8km, 3-hourly

Global and Basin Objective Hurricane Intensity Trends



- New intensity estimates (e.g., Kossin et al. 2007)

ISCCP Global Archive Customer Service at NCDC

- 9/25/2006

Hello,

I want to order the ISCCP 'D1' dataset, but only for 1 variable (percent cloud cover) and for one 'point' on the globe (65.84165 N, -163.69318 E), and only for July, August and September in 1999.

Can you tell me how I can go about getting this, and what format the data are in, and whether other data formats are available, or what tools there are to access the time series data. **I know virtually nothing about satellite data, so any information you can give me would be most helpful.**

Thank you in advance for your help.

Regards,

Willow -------

(PhD student,

- 10/11/2006

Dear Sir or Madam,

I am currently conducting some research on ISCCP DX data, that is, the GOE-10 IR Threshold Result and IR-Retrieved Cloud Top Temperature in 2000.

However, each data set of GOE-10 at ftp://eclipse.ncdc.noaa.gov/ have many variables, so I have to extract IR Threshold Result and IR-Retrieved Cloud Top Temperature from the raw data. And moreover, what I really need is a group of time series formed by these two variables, **but I don't know to get it in the most effective way.** Here is a detailed description of my question...

Best regards,

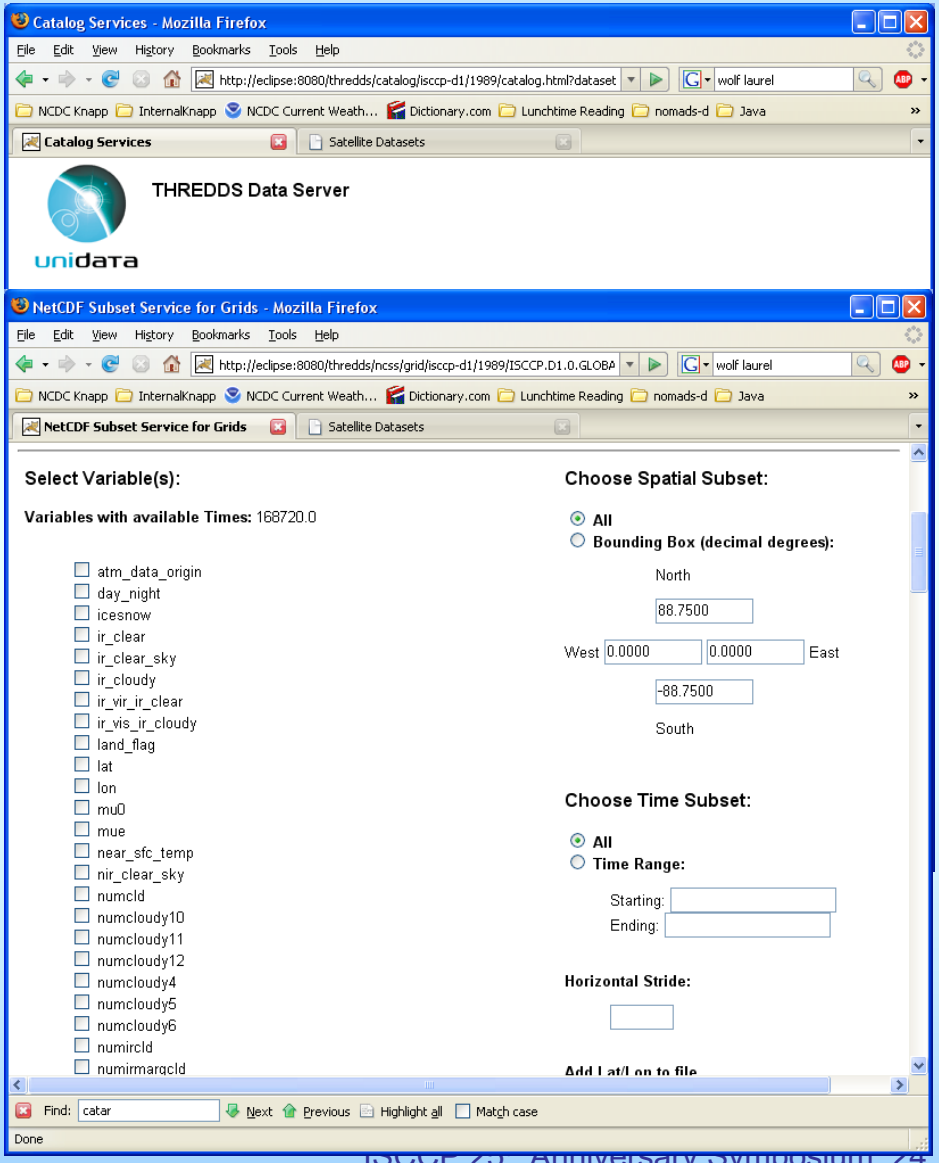
Kun ---

Duke University

Most data sets are poorly suited for time series studies!

Transparent Access to ISCCP

- ISCCP D1 data
  - 3-hourly data gridded to 2.5 deg
  - 1983-2007
  - more than 100 variables
- THREDDS Data Server (TDS) provides interface allowing users to download data as:
  - netCDF
  - OpenDAP binary
  - ASCII

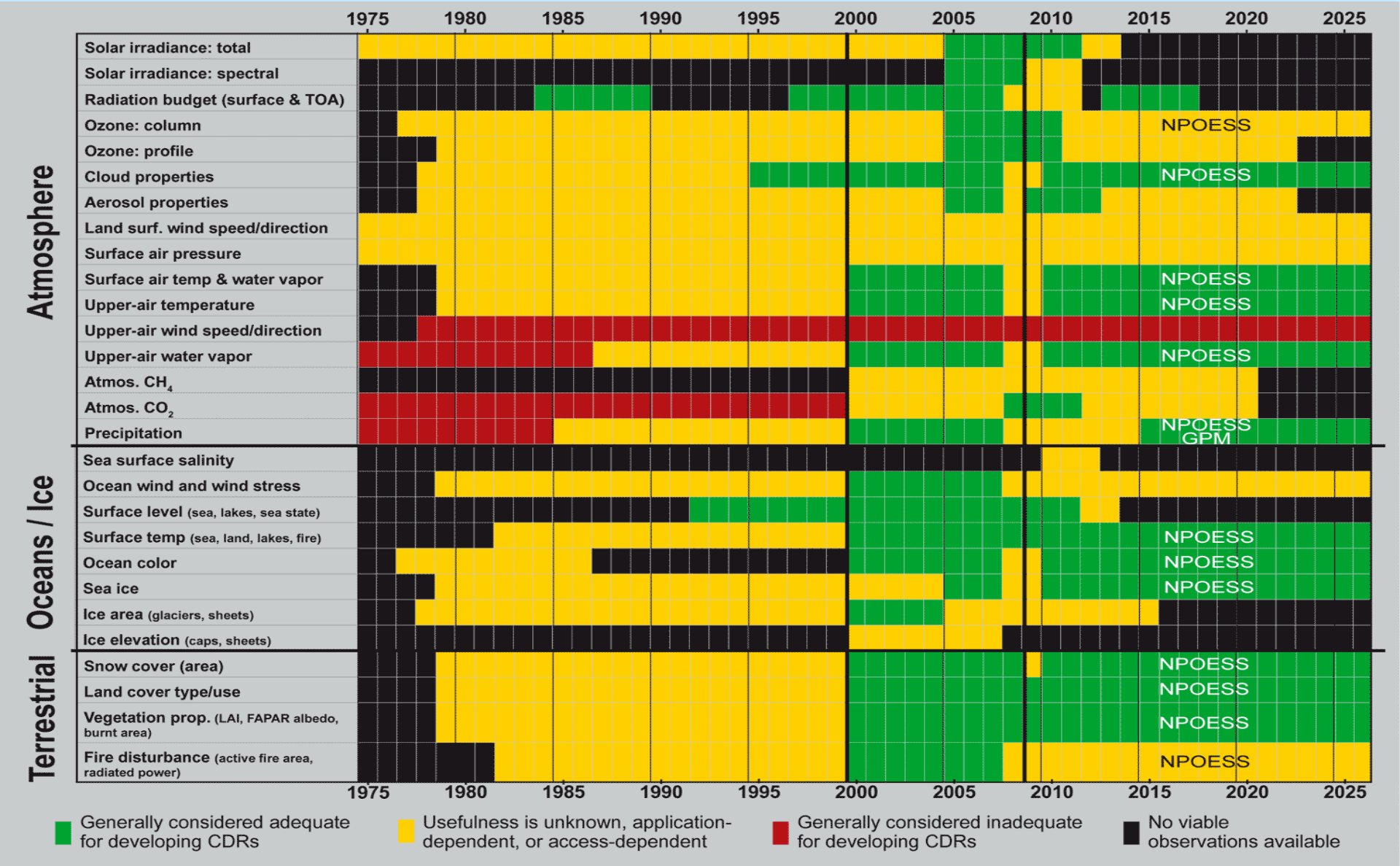


Toward a National Climate Service

- NOAA has been providing Operational Climate Services through the National Climatic Data Center (NCDC) and the Climate Prediction Center (CPC) for many years (mainly focused on in situ data)

- NCDC has recently participated in a Joint NASA-NOAA Working Group to restore climate sensors to NPOESS (following the Nunn-McCurdy restructure) and to begin operational production of satellite CDRs (beginning in FY09)

Global Essential Climate Variables (ECVS-Groups of CDRs) with Heritage Records



NPOESS Nunn-McCurdy Certification

Reductions of Climate-Relevant Sensors

NPOESS Instruments	NPP	EARLY-AM		MID-AM			PM	
		New C2 (2016)	New C4 (2020)	Old (C3) (2013)	MetOp	Old (C6) (2016)	New C1 (2013)	New C3 (2018)
		Old (C2) (2011)	Old (C5) (2015)				Old (C1) (2009)	Old (C4) (2014)
Reduced Capability Sensors								
CMIS*		✓	✓					✓
Reduced Coverage Sensors								
CrIS/ATMS	✓				IASI/AMSU ✓		✓	✓
VIIRS	✓	✓	✓		AVHRR ✓		✓	✓
De-manifested Sensors								
TSIS								
CERES/ERBS							CERES ✓	
ALT								
OMPS**	✓						✓	✓
APS								

Remains Intact
Reduced Capability
Deleted
No Change/Not Relevant
Related Missions
✓ Implies Sensor Present

*CMIS to be redefined as a less capable, less expensive sensor

**OMPS Limb Subsystem is cancelled and only the Nadir capability is maintained

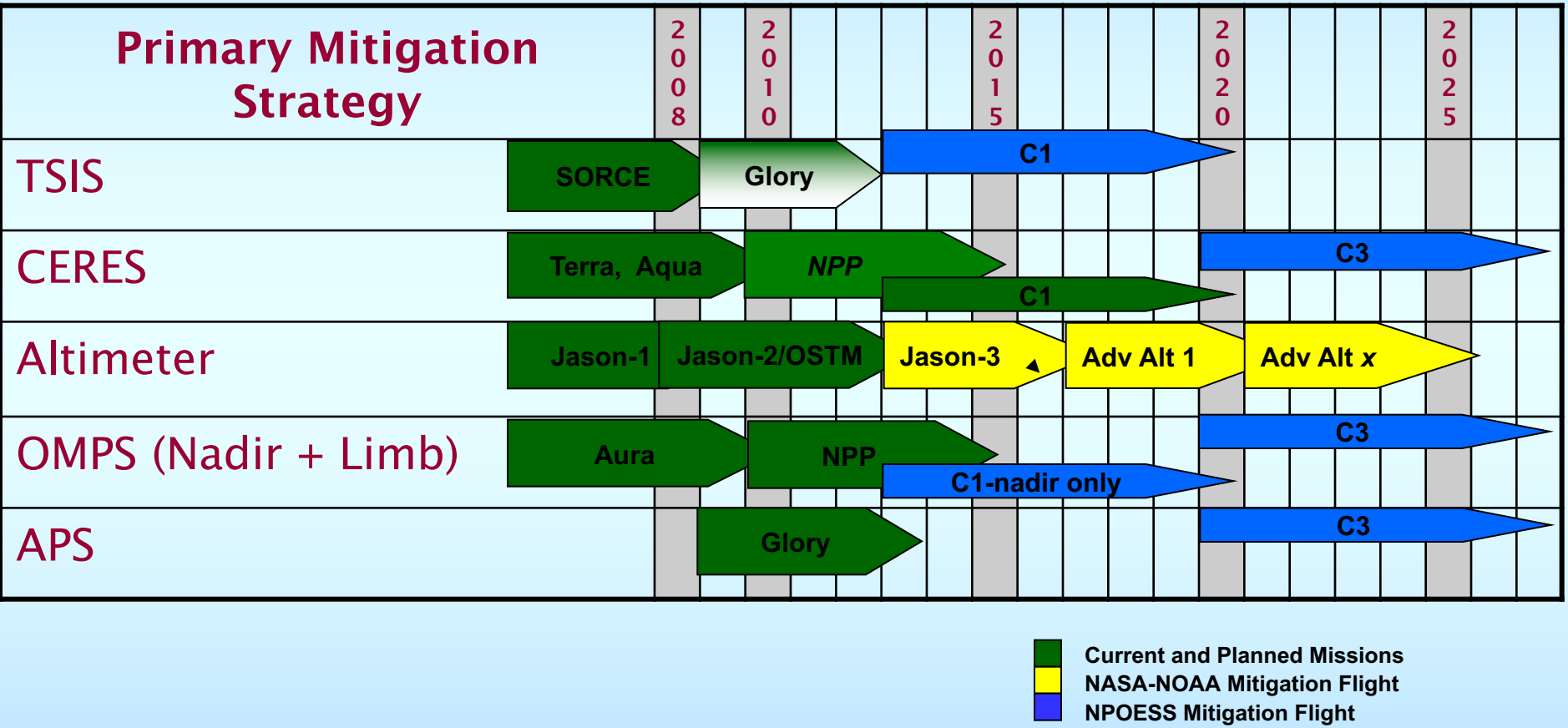
Summary of Activities

- **The White House Science Office requested NOAA and NASA to provide:**
  - An analysis of possible mitigation options of the climate impacts of the NPOESS Nunn-McCurdy Certification through 2026
  - An assessment of the potential costs of these options
- **Primary goal: Ensure continuity of long-term climate records**
- **NOAA and NASA analyzed the following options:**
  - Remanifesting the climate sensors on NPOESS spacecraft
  - Placing sensors on currently planned non-NPOESS spacecraft
  - Developing new gap-filling climate satellite missions
  - Partnering opportunities
- **Key results:**
  - NOAA's FY 2009 Passback included $74M to mitigate the loss of climate sensors on NPOESS and to provide long term Climate Data records
    - Specifically targeted for most cost effective options for launching Clouds and Earth's Radiant Energy System (CERES) and Total Solar Irradiance Sensor (TSIS), as well as support for initial work on Climate Data Records

Recovery of NPOESS De-Manifested Climate Sensors - Status

- **TSIS**
  - EXCOM approved option for the TSIS instrument to fly on the NPOESS C1 mission
    - NPOESS C1 option offers lowest cost solution, with an acceptable level of technical and schedule risk
    - Options to fly TSIS on spacecraft other than NPOESS were examined by NASA – these options are more expensive and present greater schedule risk in terms of assuring measurement continuity
  - We have identified required funding to implement TSIS on NPOESS C-1 including accommodation costs
- **CERES**
  - The CERES instrument originally scheduled for a 2013 flight on NPOESS C1 has been accelerated to fly in 2010 on NASA's NPOESS Preparatory Project (NPP) mission
  - EXCOM approved additional CERES to fly on C1
- **ALT**
  - NOAA plans to provide operational continuity for satellite altimetry data with a Jason-3 mission (Jason-2 launch scheduled June 20)
  - Jason-3 is a NOAA-EUMETSAT partnership mission, planned for launch in 2013
- **OMPS**
  - OMPS limb added back to NPP (but not to NPOESS)
- **APS**
  - NOAA is monitoring NASA's development of APS scheduled to launch in March 2009 on the GLORY mission and will evaluate it before making a decision

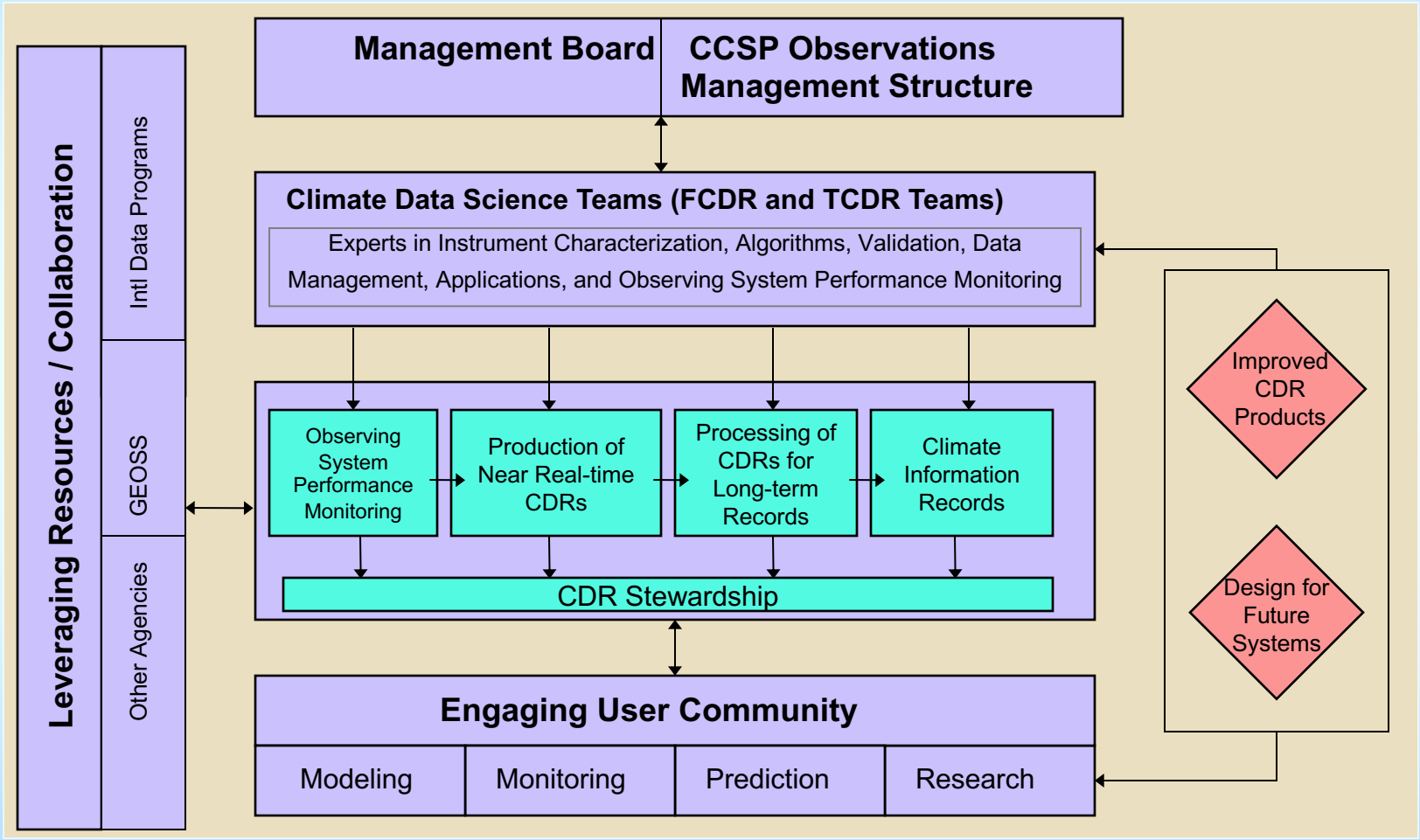
Flight Schedule – Climate Sensors



NOAA Climate Data Record (CDR) Science Support

- Includes development, production, reprocessing, stewardship, and distribution
- Assumes data from all NPOESS certified sensors and mitigation sensors / sources
- Covers about 30 Climate Change Science Program essential climate variables
- Includes a range of options bounded by a 'proof of concept' costing only for Fundamental CDRs (FCDRs) to a full production costing for all Thematic CDRs (TCDRs) and Climate Information Records (CIRs)

SDS Generational Elements - Creating Quality CDR Data Flow Diagram



Conclusions

- ISCCP is the example for Scientific Data Stewardship and Climate Data Records
- The foundations of research-operations transition of satellite CDRs has begun within NOAA and NASA
- A NOAA program to restore climate sensors to NPOESS has been successful in garnering resources within NOAA to add sensors back
- Within NOAA, an operational program for Scientific Data stewardship to generate operational Climate Data Records has begun with ISCCP global processing as one of the prototypes