



# NOAA Satellite Climate Data Records (CDRs) and Applications for Societal Benefit (2015 CICS-MD Science Meeting)

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# Outline

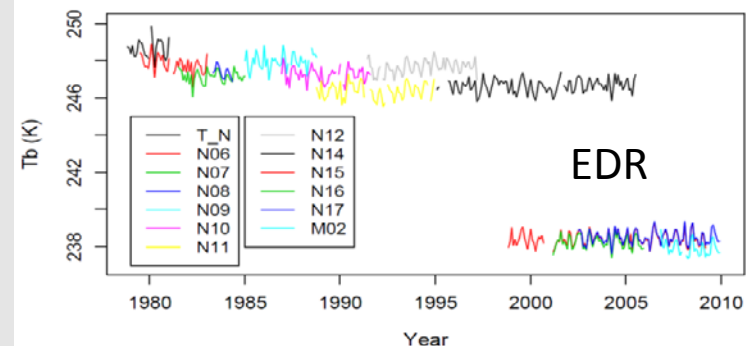
- What is a Climate Data Record (CDR)
- Mission objective of NOAA's CDR Program (CDRP) at NCEI
- Why are NOAA CDRs unique?
- NOAA CDR development, production, sustainment, archive, and distribution
- NOAA operational CDR products
- CDR application examples
- Future challenge and opportunity
- Summary

# What is A CDR?

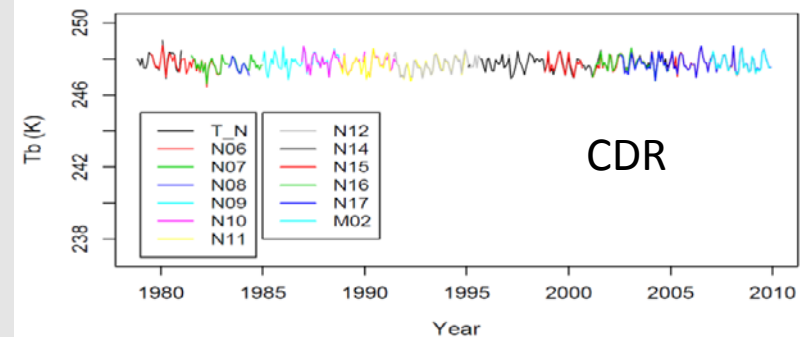
- “A **Climate Data Record (CDR)** is a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change” (US National Academy of Sciences, 2004)
- Application Specified definitions:
  - **Fundamental CDR (FCDR):**  
Calibrated/homogenized observations for a family of sensors together with the ancillary data used to calibrate them.
  - **Thematic CDR (TCDR):** Geophysical variables derived from FCDRs; may be generated by blending satellite observations, in-situ data, and model output.
  - **Climate Information Record (CIR):** A time series derived from TCDRs and related data that provides specific information about an environmental phenomena of importance to science and society.

Inter-calibration and homogenization in CDRs reduce artifacts imparted by observing systems in EDR, facilitating meaningful comparisons in space and time.

HIRS BT Timeseries, before inter-calibration

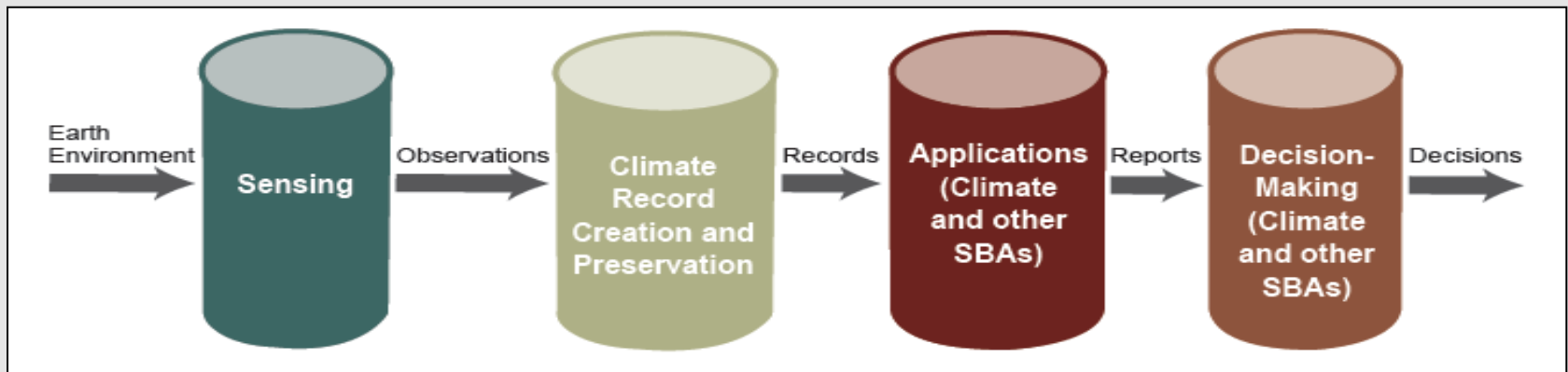


HIRS BT Timeseries, after inter-calibration



# NOAA CDRP's Mission Objective

- ❑ To develop and implement a robust, transparent, sustainable, and scientifically defensible approach for developing, producing, preserving, and provisioning CDRs generated from NOAA operational satellite observations and in-situ measurements.
- ❑ To provide end-to-end CDR data service to various user sectors (academy, industry, commercial, government, and the public).





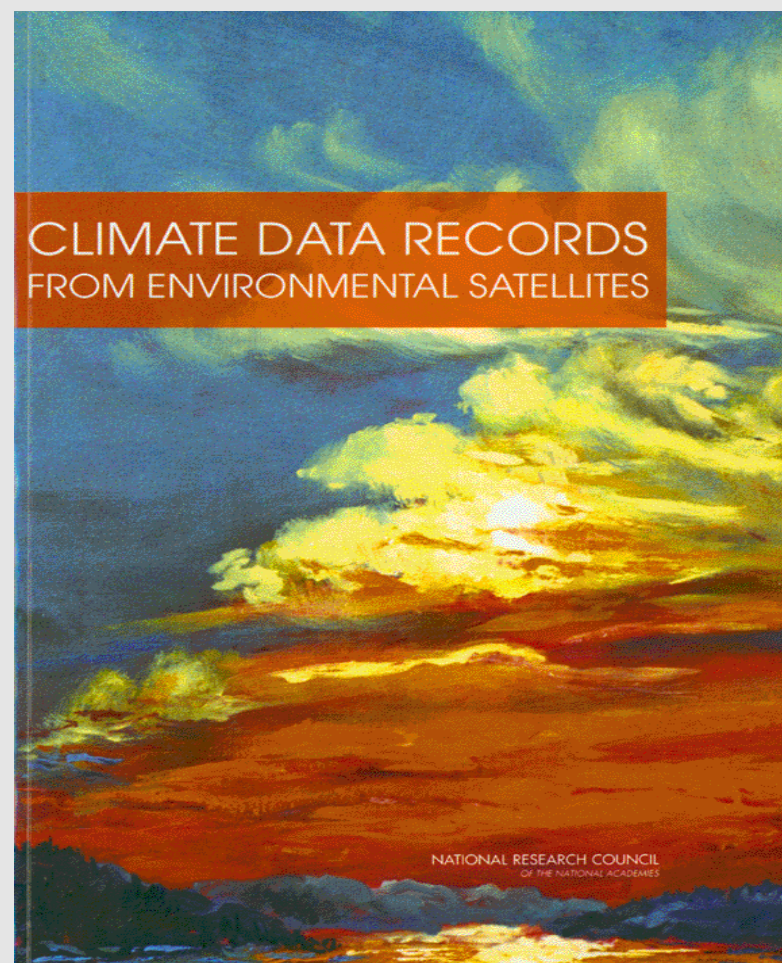
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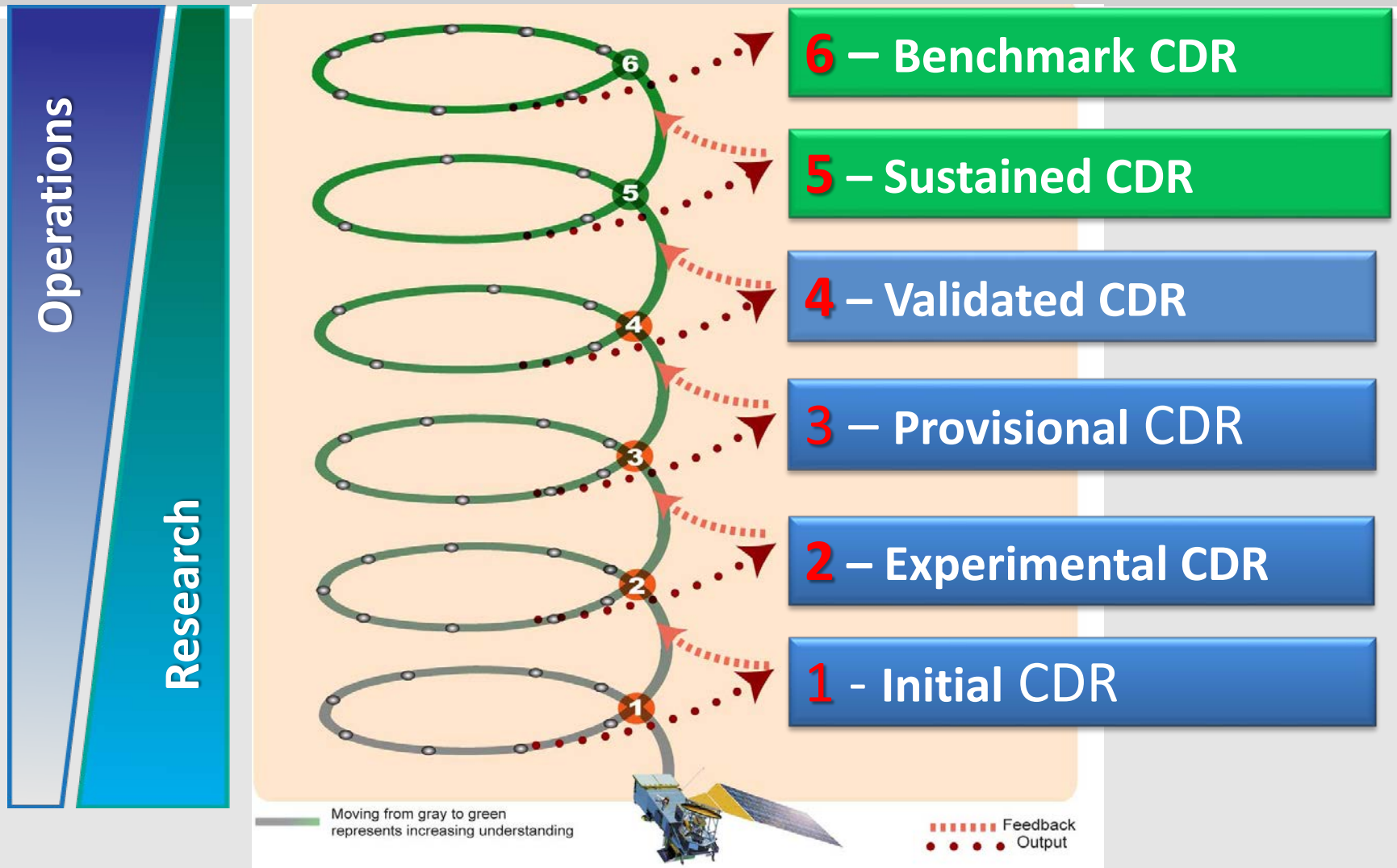


# NOAA CDR Program (CDRP) is Well-Grounded in Science and External Expert Guidance

- National Research Council (NRC) of US National Academy of Sciences (NAS) (2004, 2008)
- Global Change Research Program (CCSP, 2006)
- WMO/Global Climate Observing System (GCOS, 2003)
- US EOP/Office of Science and Technology (OSTP), NOAA/NESDIS guidance



# Well Defined Maturity Model (6-Level)





# Three Phase R2O Transition Process

## 1. ID

- **Initial Development (ID):** Through grant and contract, PIs develop algorithm, source code, dataset, metadata, and documentation
- PI brings the product to at least Maturity Level-4

## 2. IOC

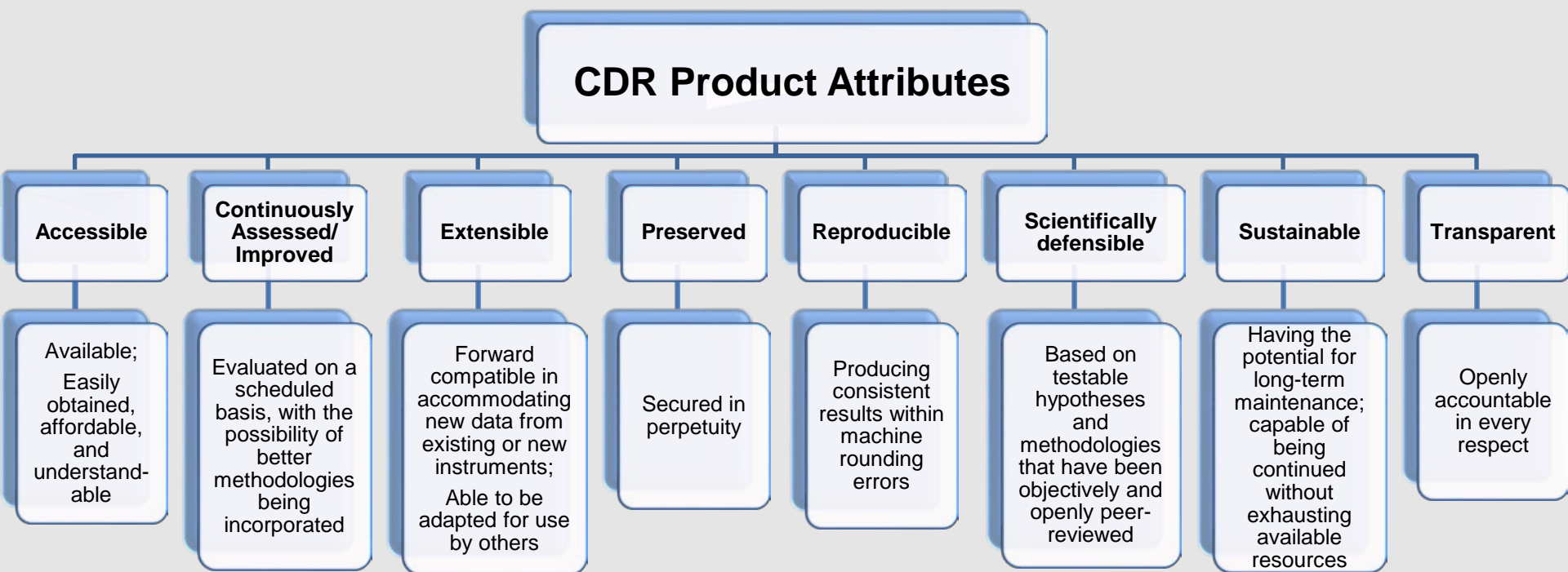
- **Initial Operational Capability (IOC):** The dataset, metadata, source code and documentation are quality checked, archived and made openly and transparently available for public access at data center.
- PI provides operational support and maintenance/updates

## 3. FOC

- **Full Operational Capability (FOC):** CDR is systematically and routinely generated by the data center using codes and systems that conform to the NOAA CDR Program's IT security, coding and documentation standards
- CDR operational support and maintenance/updates can be accomplished independent of the PI [Maturity Level-6]



# Comprehensive Product Attributes



# Cover Three Major NOAA Satellite Epochs (Sustained in Operational Environment)

1970

1980

1990

2000

2012

2020

2030

POES/GOES/DMSP

NPP

JPSS/JASON-3/GOES-R

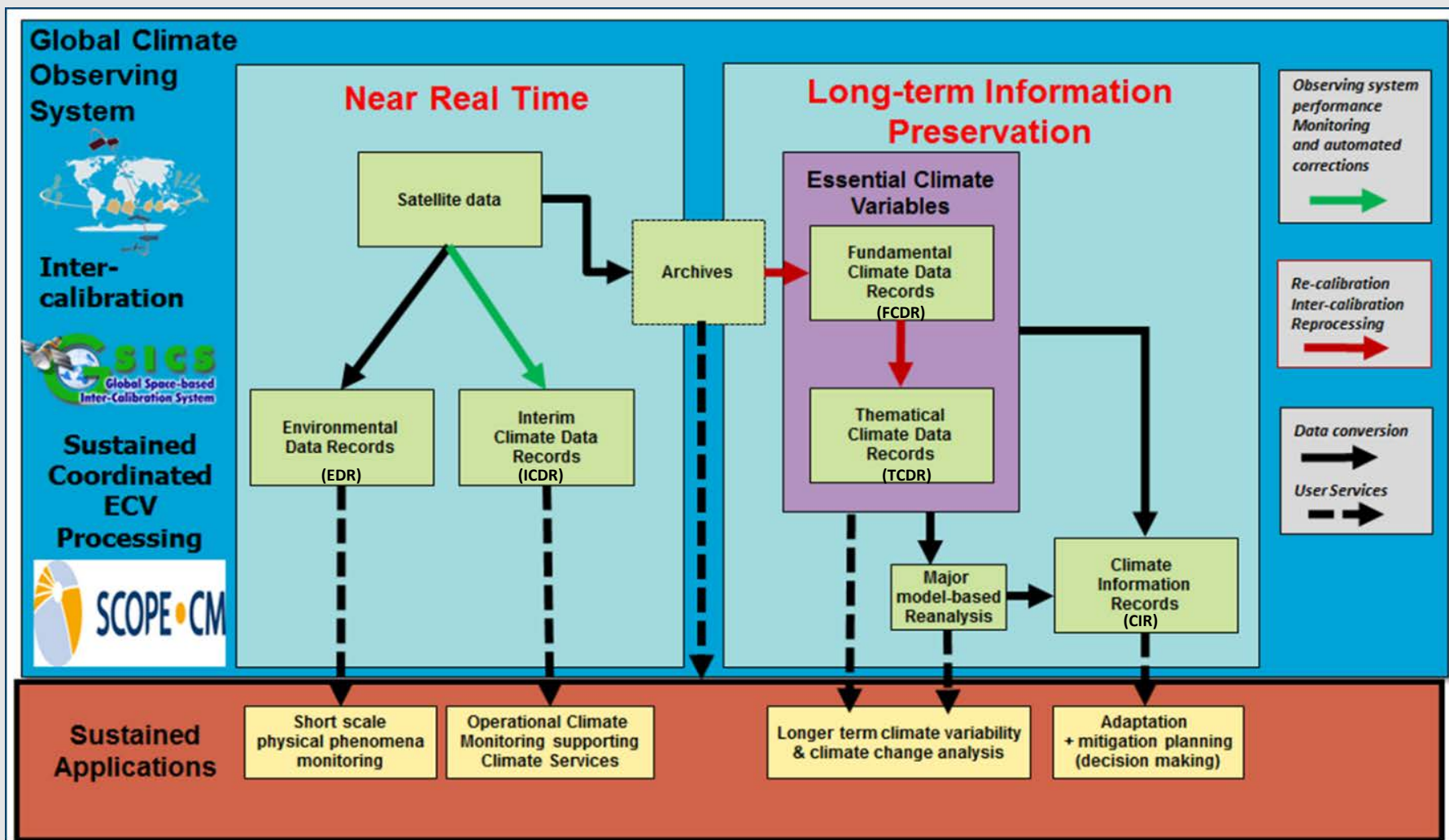
Reveal latent climate trend information  
in four decades of heritage operational data

Extend CDRs  
using future  
sensors

Ensure climate quality data from new operational  
system and extend CDRs period of record

# NOAA CDRs Sustain Climate Information

(Critical for improving science understanding of climate changes and the world's resilience to climate changes and variability)



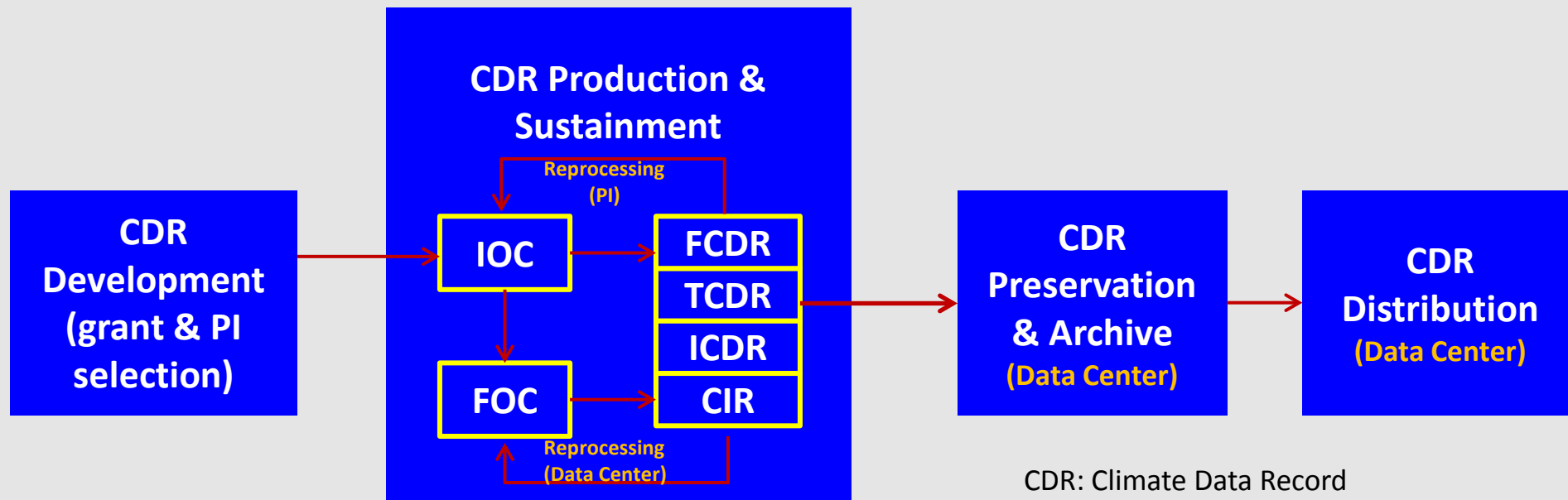


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# Development, Production, Sustainment, Archive, and Distribution of CDRs



CDR: Climate Data Record

PI: Principal Investigator

IOC: Initial Operational Capability

FOC: Full Operational Capability

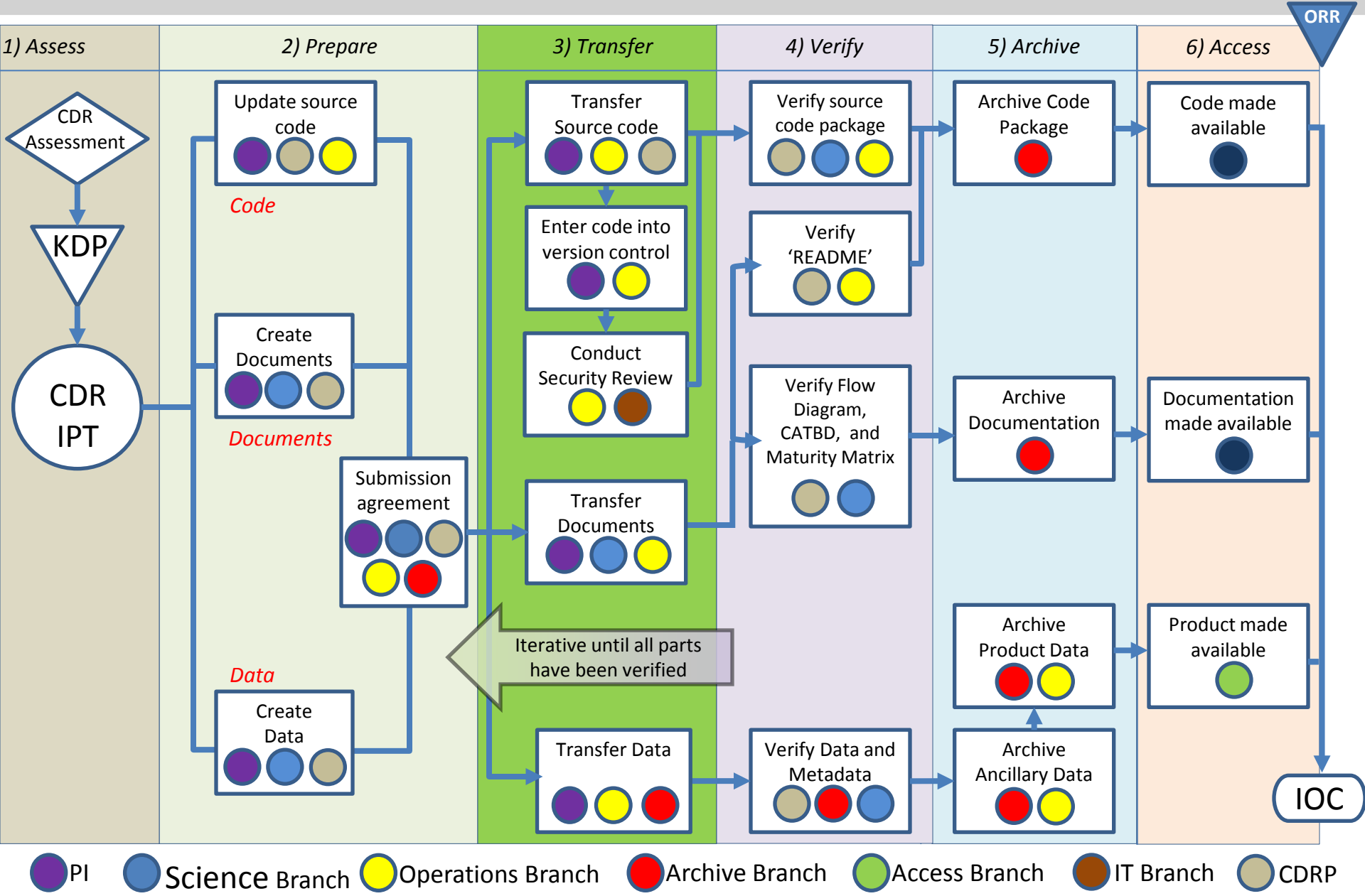
FCDR: Fundamental CDR

TCDR: Thematic CDR

ICDR: Interim CDR

CIR: Climate Information Record

# R2O Transition Procedures





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# Inventory of NOAA CDR Products

30 CDRs in Ops. now

<http://www.ncdc.noaa.gov/cdr>

Current IOC Operational CDRs			
FCDR	Atmosphere	Ocean	Land
<ul style="list-style-type: none"> <li>AVHRR Reflectance – PATMOS-x</li> </ul>	<ul style="list-style-type: none"> <li>MW Mean Layer Temperature (STAR, RSS, UAH, UCAR)</li> </ul>	<ul style="list-style-type: none"> <li>SST (OISST &amp; Pathfinder &amp; WHOI)</li> </ul>	<ul style="list-style-type: none"> <li>Surface Reflectance (AVHRR)</li> </ul>
<ul style="list-style-type: none"> <li>HIRS Brightness Temperature (BT)</li> </ul>	<ul style="list-style-type: none"> <li>Precipitation (PERSIANN)</li> </ul>	<ul style="list-style-type: none"> <li>Sea Ice Concentration</li> </ul>	<ul style="list-style-type: none"> <li>Snow Cover Extent (NH)</li> </ul>
<ul style="list-style-type: none"> <li>SSMI(S) BT (CSU, RSS)</li> </ul>	<ul style="list-style-type: none"> <li>Cloud Properties (PATMOS-x AVHRR)</li> </ul>	<ul style="list-style-type: none"> <li>Ocean Surface Heat Fluxes</li> </ul>	<ul style="list-style-type: none"> <li>NDVI (AVHRR)</li> </ul>
<ul style="list-style-type: none"> <li>VIIRS C-RDR (*)</li> </ul>	<ul style="list-style-type: none"> <li>OLR (Monthly - HIRS &amp; Daily - GridSat)</li> </ul>	<ul style="list-style-type: none"> <li>Ocean Near-surface Atmospheric Properties (T, V, specific humidity)</li> </ul>	<ul style="list-style-type: none"> <li>LAI/FAPAR (AVHRR)</li> </ul>
<ul style="list-style-type: none"> <li>MSU/AMSU BT</li> </ul>	<ul style="list-style-type: none"> <li>Aerosol Optical Thickness (AVHRR)</li> </ul>		
<ul style="list-style-type: none"> <li>GOES BT (GridSat)</li> </ul>	<ul style="list-style-type: none"> <li>Ozone (ESRL)</li> </ul>		
<ul style="list-style-type: none"> <li>Solar Irradiance (total &amp; spectral)</li> </ul>			

\*<http://www.ncdc.noaa.gov/data-access/satellite-data/satellite-data-access-datasets/c-rdr-viirs>

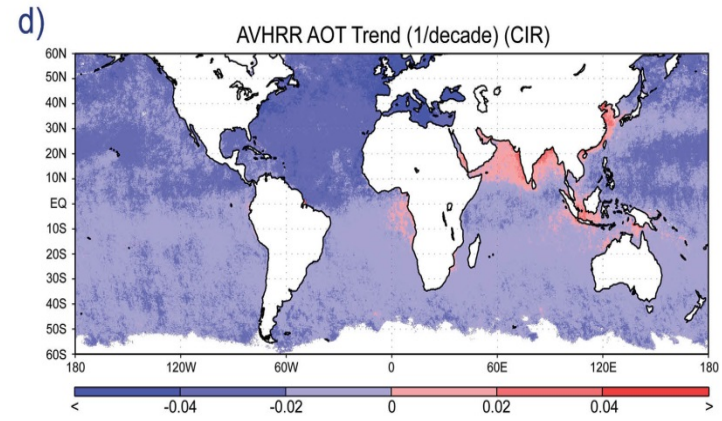
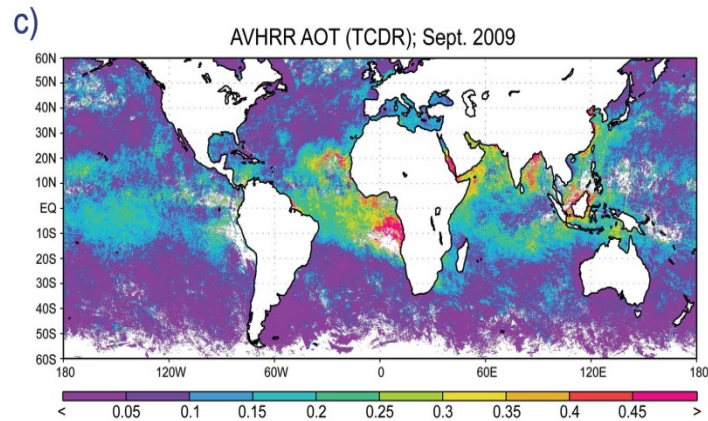
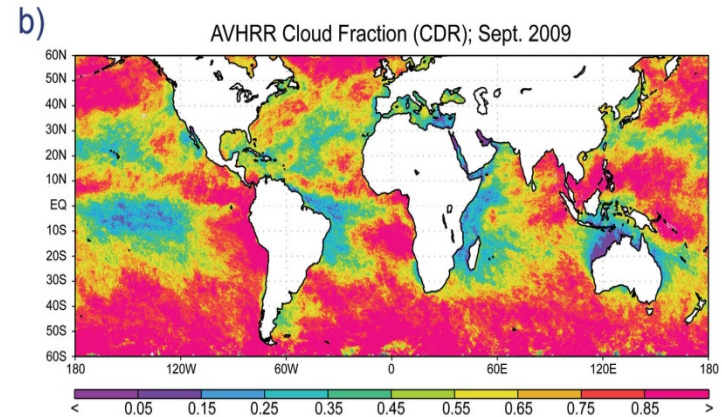
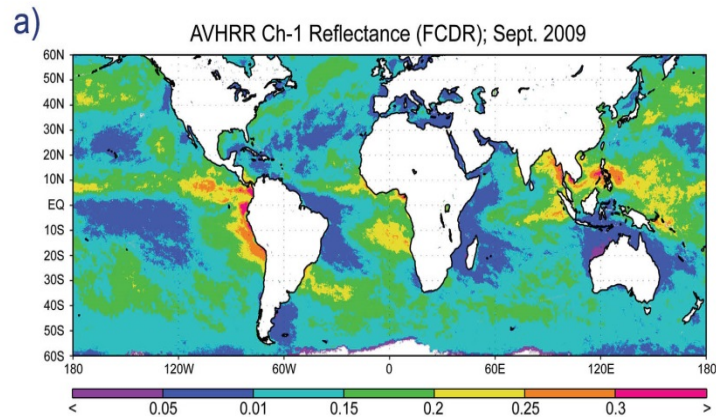


# CDRs Under Development

Research-to-Operation CDRs (work-in-progress)			
FCDR	Atmosphere	Ocean	Land
	<ul style="list-style-type: none"><li>Precipitation (MSPPS/MIRS, GPCP, CMORPH, NEXRAD)</li></ul>	<ul style="list-style-type: none"><li>Sea Level Height</li></ul>	<ul style="list-style-type: none"><li>Geo-Surface Reflectance</li></ul>
	<ul style="list-style-type: none"><li>Cloud Properties (ISCCP &amp; CERES)</li></ul>	<ul style="list-style-type: none"><li>Ocean Color?</li></ul>	<ul style="list-style-type: none"><li>Snow and Ice Concentration</li></ul>
	<ul style="list-style-type: none"><li>Ozone (CPC)</li></ul>		
	<ul style="list-style-type: none"><li>Earth Radiation Budget (ISCCP-ERB)</li></ul>		

# A Suite of Products

$(FCDR \rightarrow CDR \rightarrow TCDR \rightarrow CIR)$



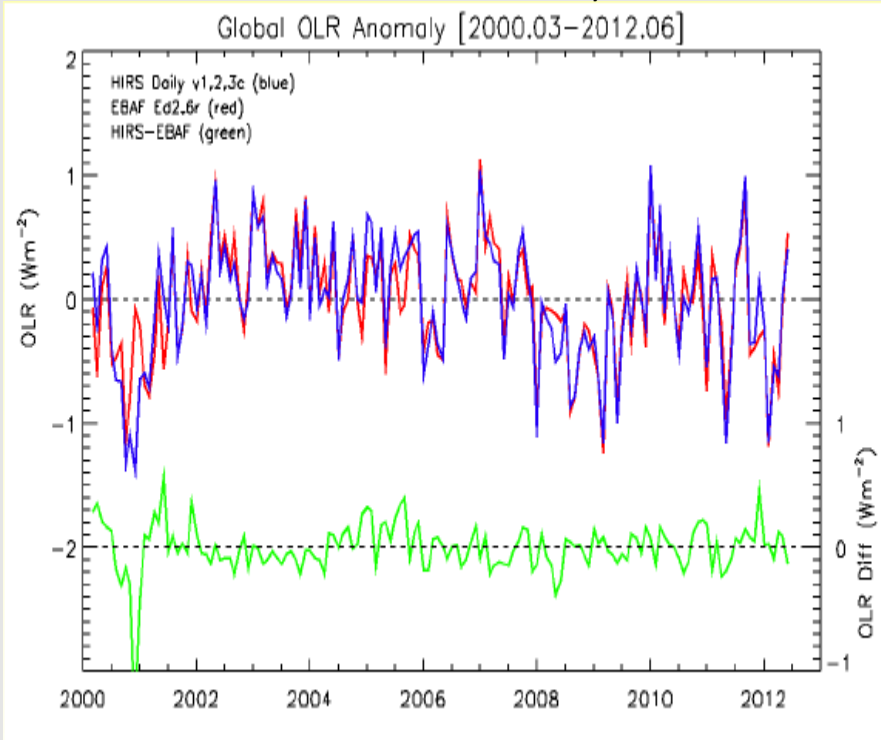


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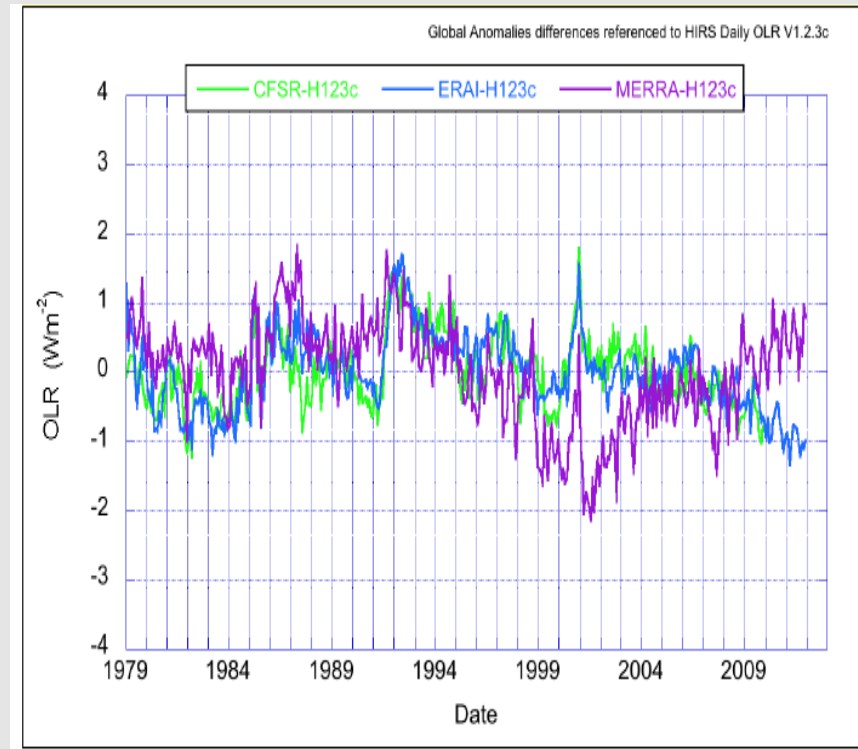
# Example of OLR CDR Application (Assessment of Climate Analysis)

## Difference of Global OLR Anomalies (Long-term Historical HIRS CDR vs Short-term Current CERES CDR)



*Slope of OLR anomalies diff =  $0.03 \pm 0.09 \text{ Wm}^{-2}/\text{decade}$  with 2-sigma*

## Difference of Global OLR Anomalies (Reanalysis minus HIRS CDR )

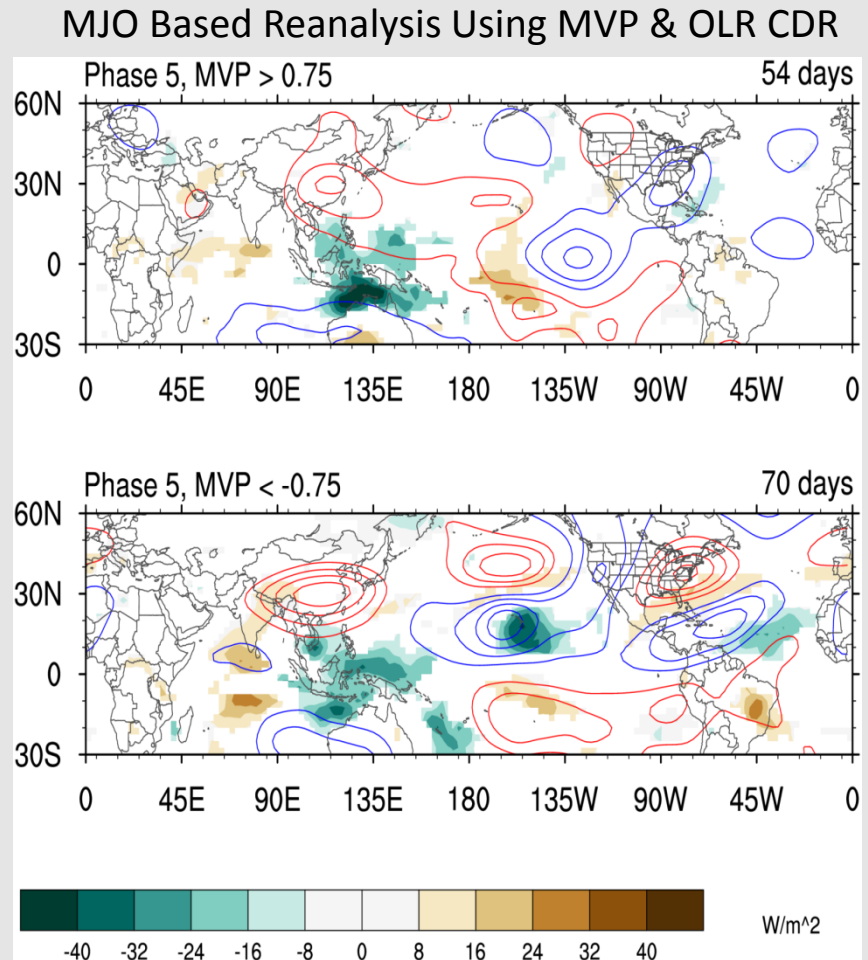
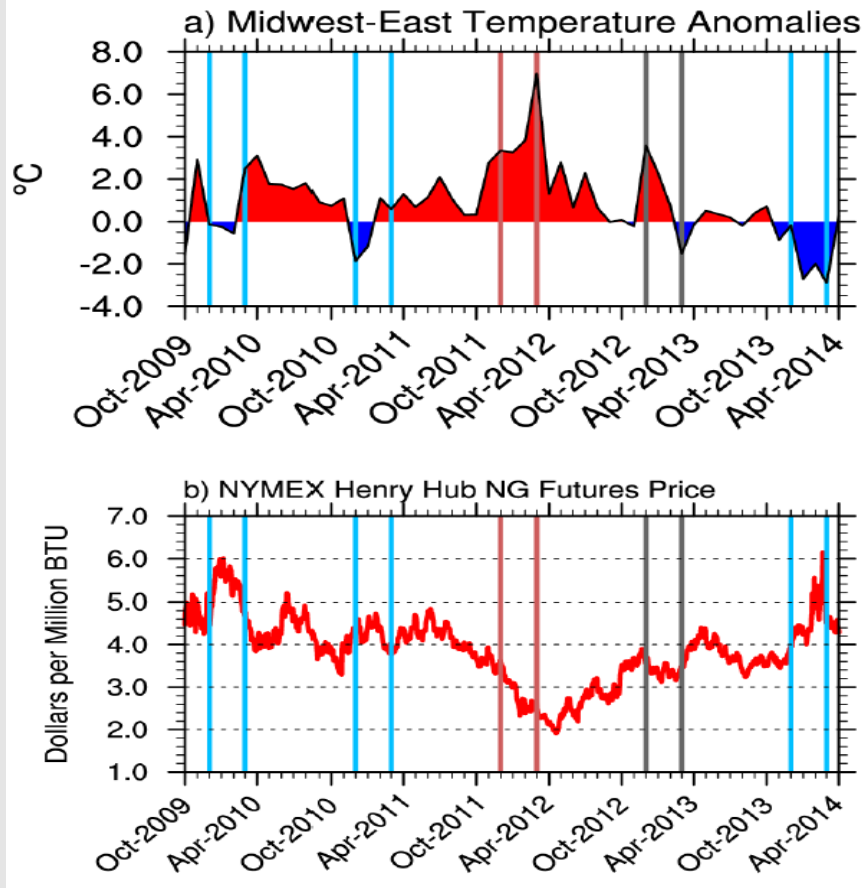


(Courtesy of Dr. Hai-Tian Lee)



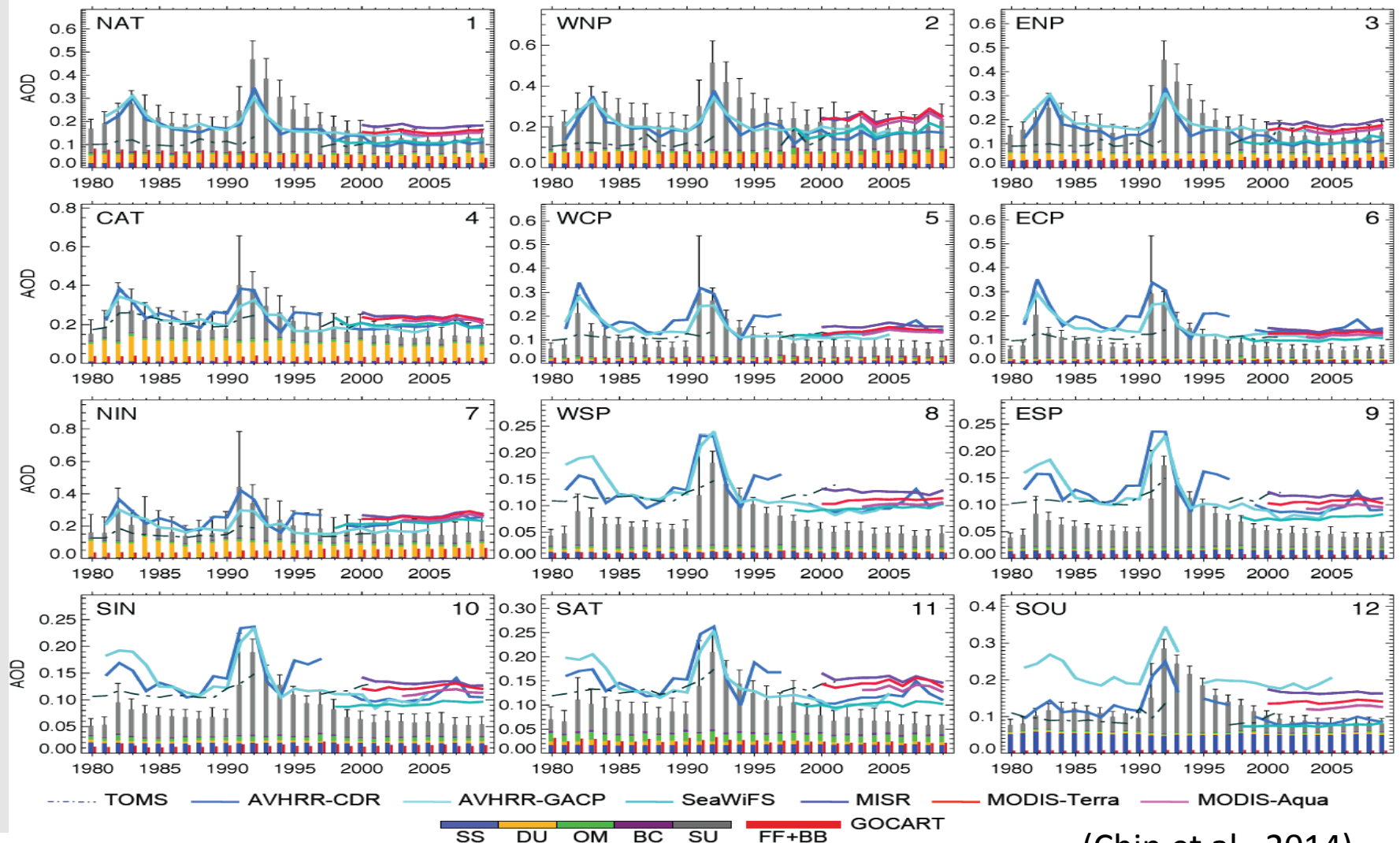
# Example of OLR CDR Application

## (MVP Index CIR Application-Provides Commercial Benefit)



(Courtesy of Dr. Carl Shreck)

# Example of AVHRR AOT CDR Application (AeroCom: Model Evaluation)



(Chin et al., 2014)

# Example of NDVI/LAI CDRs Application (Forest Change Detection)

## Percent Tree Cover Change in Amazon Basin



1990 (AVHRR CDRs)



2000 (MODIS Data)



2010 (MODIS Data)

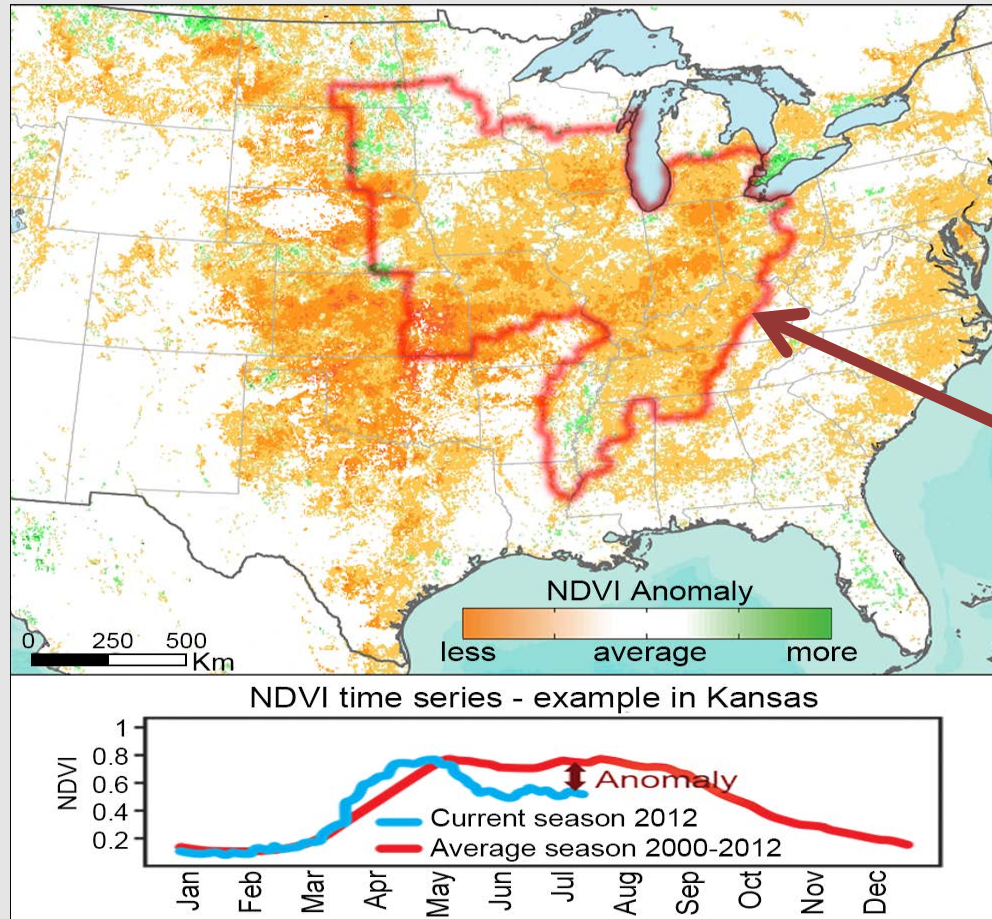


(Courtesy of Dr. Eric Vermote)



# Example of NDVI CDR Application (Supporting Farming and Agribusiness)

**2012 drought  
monitored by  
the Vegetation  
Index CDR in  
the context of  
climate  
anomaly**



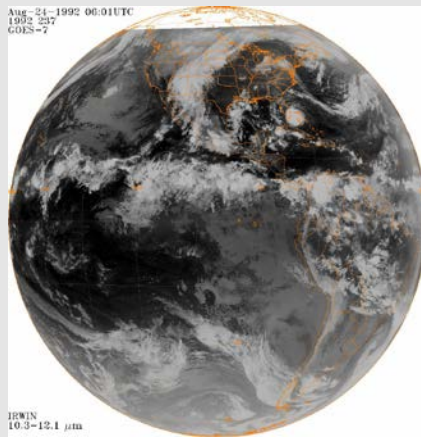
Primary U.S.  
corn and  
soybean region  
(Ohio, Indiana,  
Iowa)

(Courtesy of Dr. Eric Vermote)

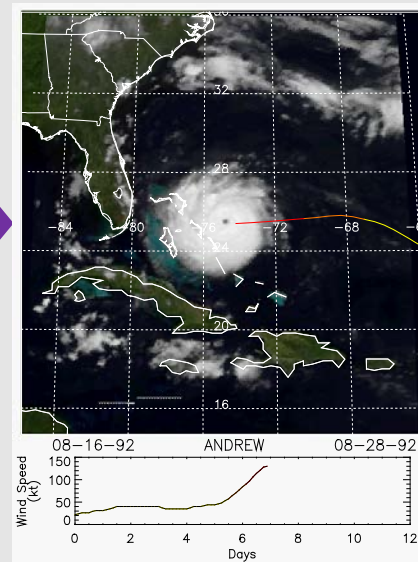


# Example of FCDR/CDR/CIR Application (Disaster Management Support)

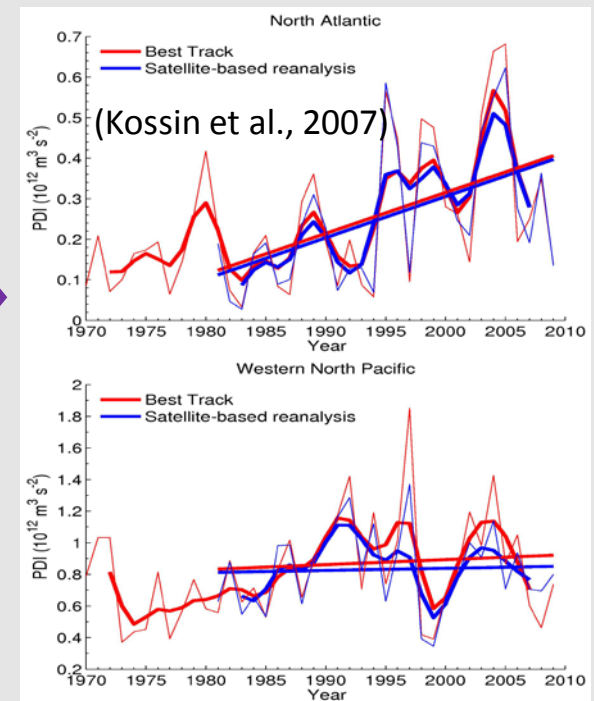
## GridSat FCDR



## Blended TCDR



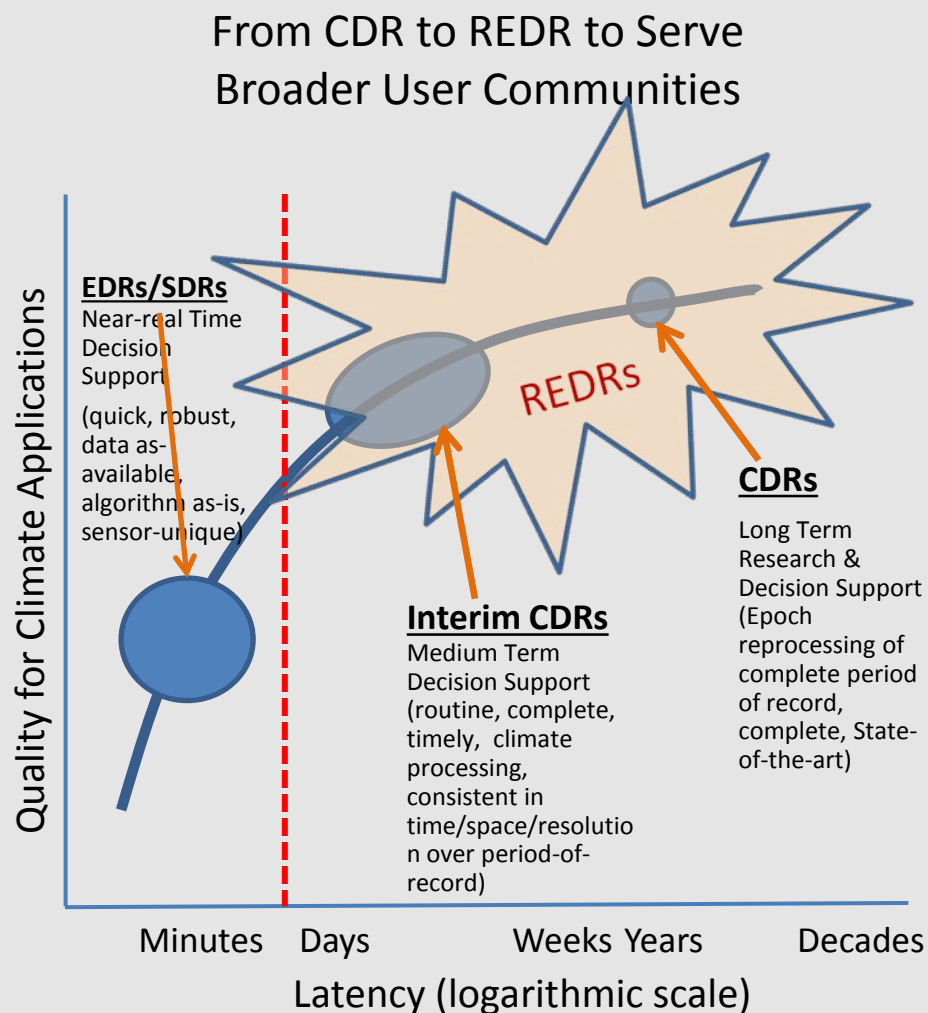
## CIR



(decision support  
information)

# Future Challenge and Opportunity

- Extend the operational CDRs seamlessly to new NOAA satellite observations.
  - Suomi-NPP/JPSS, JASON-3 and GOES-R series
- Expand CDR to REDR
  - Reference Environmental Data Record (REDR) is a time series of scientifically-based measurements of the Earth's environment with sufficient length, consistency, and continuity to provide stakeholders and decision-makers with timely, relevant, and reliable information.
  - REDR includes remote sensing, in-situ, and blended observations.
- Distribute CDRs/REDRS to broader user communities in a more convenient & efficient way.





# Summary

- The NOAA CDR Program **well-grounded in science** is reaching out to address **users' needs**, and continues to improve **open & transparent** stewardship practices for satellite data, non-satellite data and blended products.
  - Includes CIRs, and interim CDR products.
- The NOAA CDR Program at NCEI is **now sustaining 30 satellite data CDRs in operations**, and is preparing CDR data, algorithms, workflows, and documentation for broader user applications.
  - CDRs include **not just the data, but the algorithms, workflows, and documentation as well.**
- CDR will be expanded to REDR to serve broader user communities (academy, industry, commercial, government, public).

<http://www.ncdc.noaa.gov/cdr>



# Thank you!

## Questions?





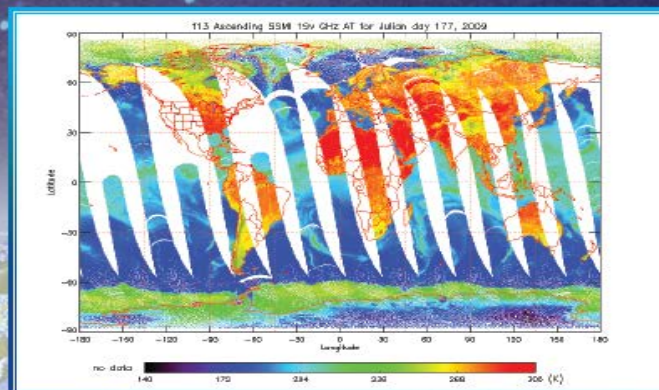
# Backup Slides



# NOAA's Climate Data Record (CDR) Program

SSM/IS BRIGHTNESS TEMPERATURE  
COLORADO STATE UNIVERSITY

## SSM/IS - CSU



### SSM/IS CLIMATE DATA RECORD SPECIFICATIONS

- Global Coverage
- Resolution varies by Channel (14 x 16 km, 45 x 70 km)
- 101 Minutes Per Orbit
- 1987–Present
- Updated Daily

### INPUTS TO THE SSM/IS CLIMATE DATA RECORD

- Navy-NESDIS Special Sensor Microwave Imager/Sounder [SSM/IS]
- Antenna Temperature

### SOME USES OF THE SSM/IS CLIMATE DATA RECORD

- Input into Precipitation Products
- Determining Sea Surface Winds
- Calculating Sea Ice Extent and Snow Cover
- Long-term Global Climate Applications
- Estimating Cloud Liquid Water

### SSM/IS CLIMATE DATA RECORD

<http://www.ncdc.noaa.gov/cdr/operationalcdhrs.html>

### CLIMATE DATA RECORD PROGRAM INFORMATION

<http://www.ncdc.noaa.gov/cdr/index.html>



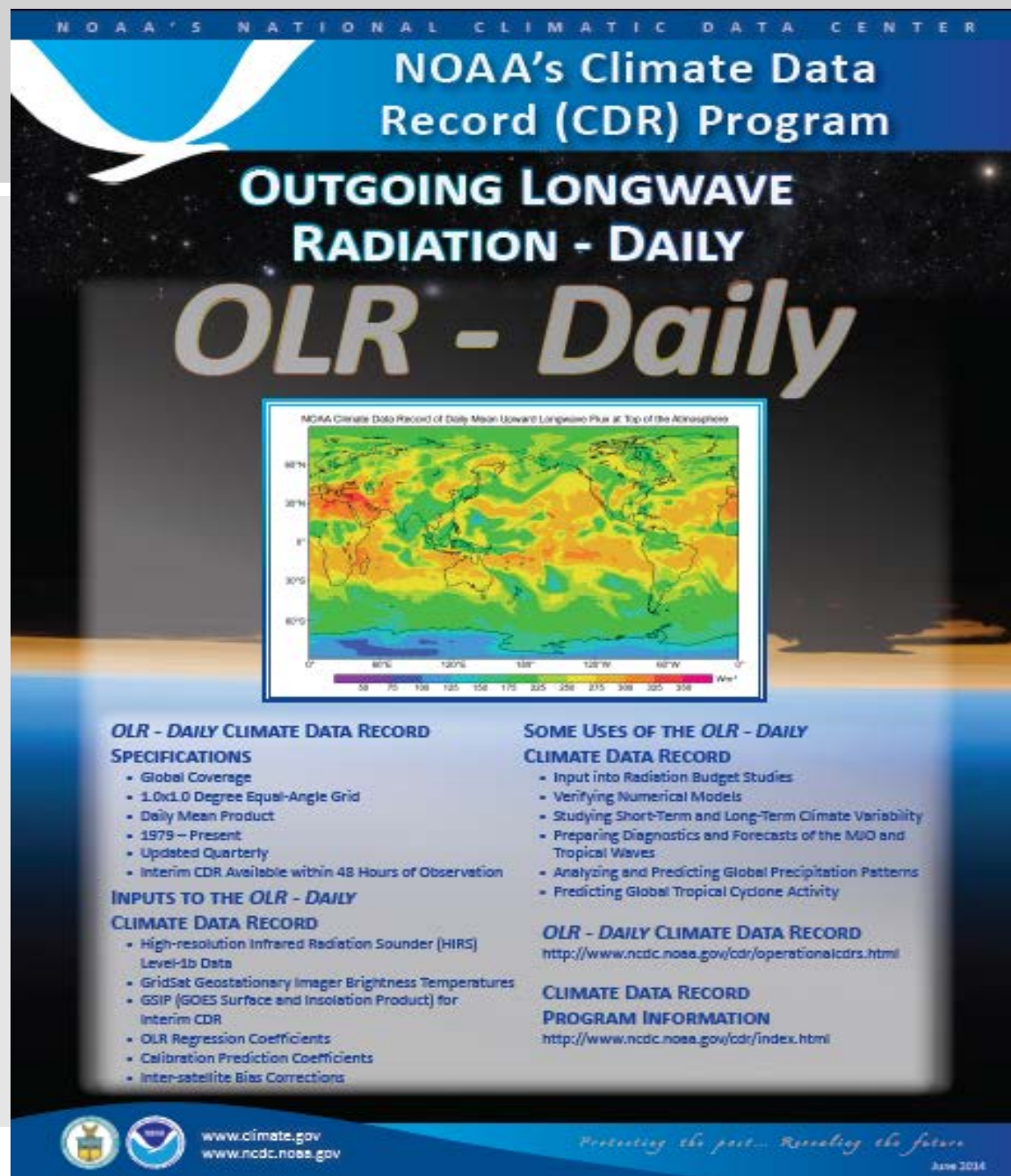
[www.climate.gov](http://www.climate.gov)  
[www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)

*Protecting the past... Revealing the future*

July 2013

Example  
of FCDR

# Example of Atmospheric CDR (CMIP5/Obs 4MIPS Candidate)

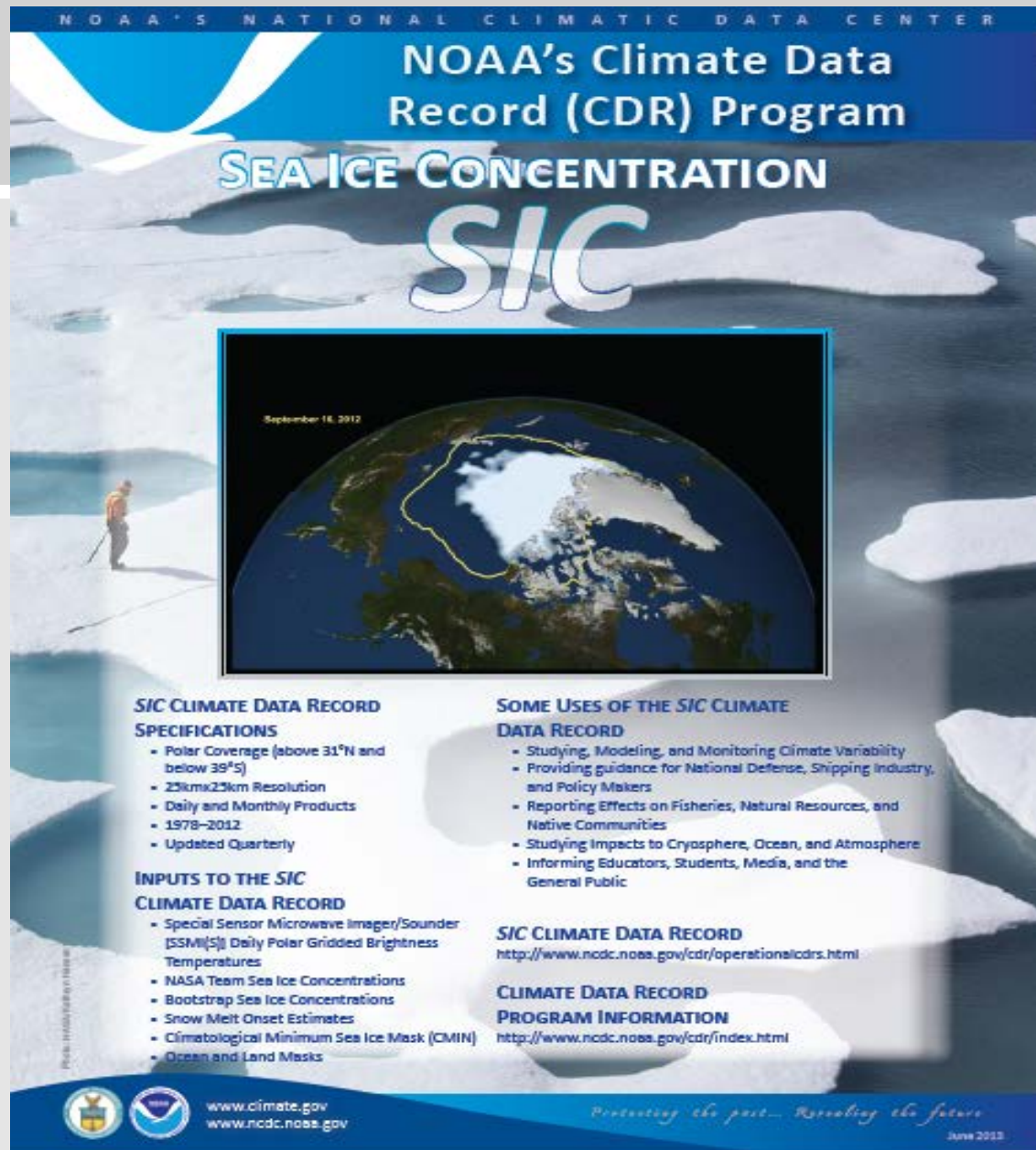




# Example of Ocean CDR (CMIP5/Ob s4MIPS Candidate)



# Example of Ocean CDR (CMIP5/Obs4MI PS Candidate)



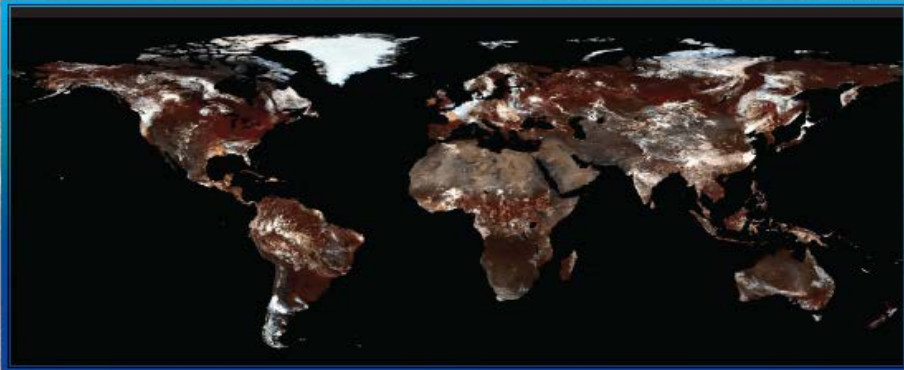


Example of  
Land CDR  
(USGS /EROS  
GEO TIFF  
product  
candidate)

NOAA'S NATIONAL CLIMATIC DATA CENTER

# NOAA's Climate Data Record (CDR) Program

## AVHRR SURFACE REFLECTANCE



**AVHRR SURFACE REFLECTANCE CLIMATE DATA RECORD SPECIFICATIONS**

- Global Coverage
- 0.05x0.05 Degree
- Daily Product
- 1981–Present
- Routinely Updated (10 day latency)

**INPUTS TO THE AVHRR SURFACE REFLECTANCE CLIMATE DATA RECORD**



- AVHRR Global Area Coverage Level 1b data
- TOMS ozone data
- NCEP water vapor data
- USGS digital elevation model
- MODIS land/water mask, BRDF database, and BRDF-corrected reflectance climatology

**SOME USES OF THE AVHRR SURFACE REFLECTANCE CLIMATE DATA RECORD**

- Input to derive climate data records of:
  - Normalized Difference Vegetation Index (NDVI),
  - Leaf Area Index (LAI),
  - Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)
- Studying long-term climate variability
- Verifying and validating global climate models

**AVHRR SURFACE REFLECTANCE CLIMATE DATA RECORD**  
<http://www.ncdc.noaa.gov/cdr/operationalcdrs.html>

**CLIMATE DATA RECORD PROGRAM INFORMATION**  
<http://www.ncdc.noaa.gov/cdr/index.html>

  [www.climate.gov](http://www.climate.gov) [www.ncdc.noaa.gov](http://www.ncdc.noaa.gov)

*Protecting the past... Revealing the future*  
May 2014