Introduction to Reprocessing

Mitch Goldberg, Program Scientist

August 2015 JPSS Science Meeting

Reprocessing is gaining traction

- Advocating reprocessing as part of the Cal/Val program
  - New algorithms need to be test on the full record before promotion to operations
    - thinned datasets are often used to speed up the validation
    - or collocations with truth
  - Today's computer power and low cost storage allows full records to be easily reprocessed.
  - Supported pathfinder projects with CIMSS and results so far are very encouraging.
  - Ocean color team has been very successful in reprocessed the entire data record.
- Part of Archive Refresh
  - The NOAA Archive Group has agreed to hosting reprocessed data - initially "clones" of the operational output.
- NESDIS AA supports the need for reprocessed datasets as a service component of NCEI

Path forward

- Continue pathfinder projects - learn a lot
- Develop a CONOP with NCEI
- Mission reprocessing of EDRs is different from multi-decadal reference data records.
- Right now I am focusing on reprocessed EDRs because we have a requirement to archive the EDRs and the user expects consistent quality of the mission EDR.

STAR Testbed/Reprocessing for Oceans Mission-long, Science-quality Time Series

Paul M. DiGiacomo and Veronica Lance
NOAA/NESDIS
Center for Satellite Applications & Research (STAR)

STAR/JPSS Annual Science Meeting
24-28 August, 2015
NOAA Center for Weather and Climate Prediction
College Park, Maryland, USA

Operational = Near Real-Time

Operational (only) = Near Real-Time

Salmon survival in 2011 – what happened?

Brian Burke
Fish Ecology Division
NWFSC, NOAA Fisheries

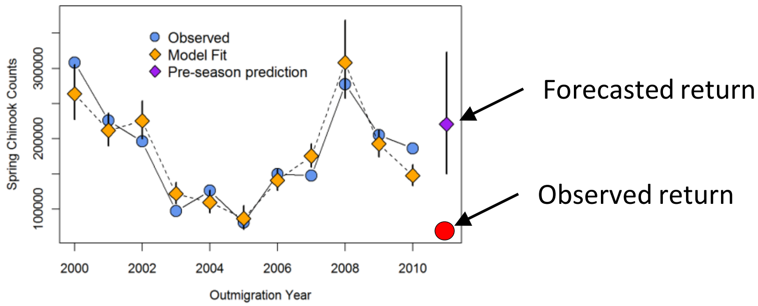


Figure 1. Observed and fitted adult spring Chinook salmon returns, with the forecasted and observed returns for fish entering the ocean in 2011.

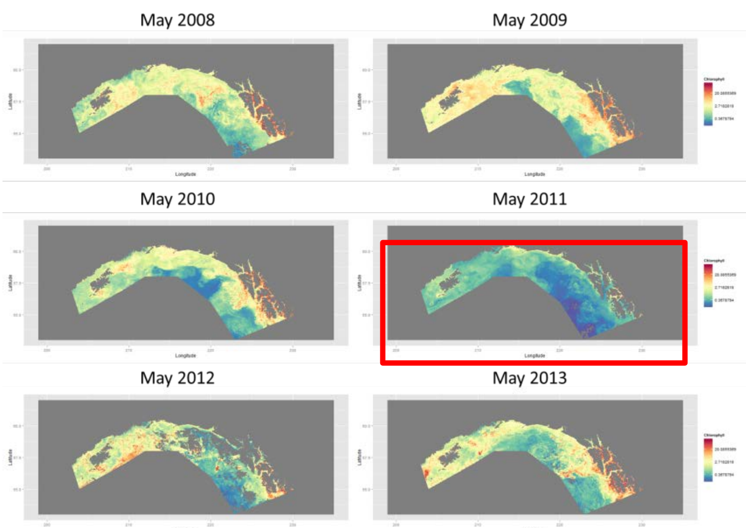


Figure 2. Chlorophyll concentration in May (2008-2013) in coastal Gulf of Alaska.

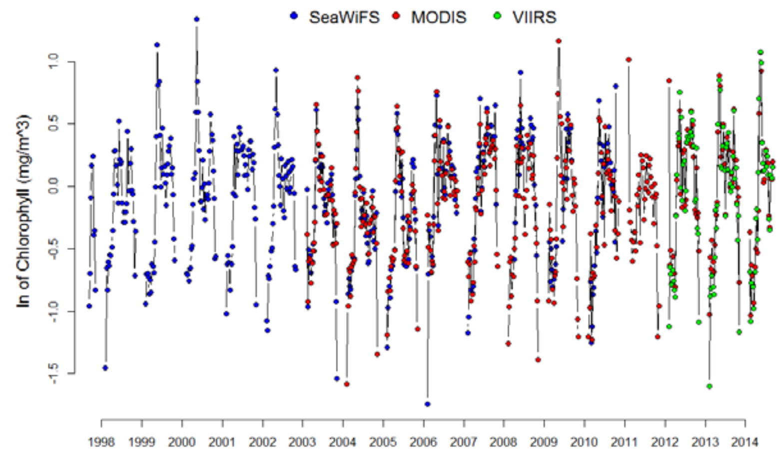


Figure 3. Time series of 8-day composite chlorophyll concentrations.

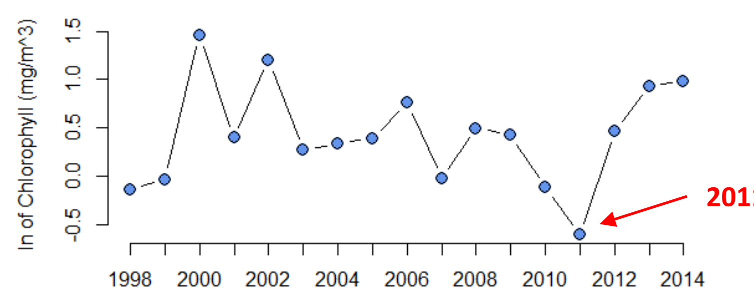
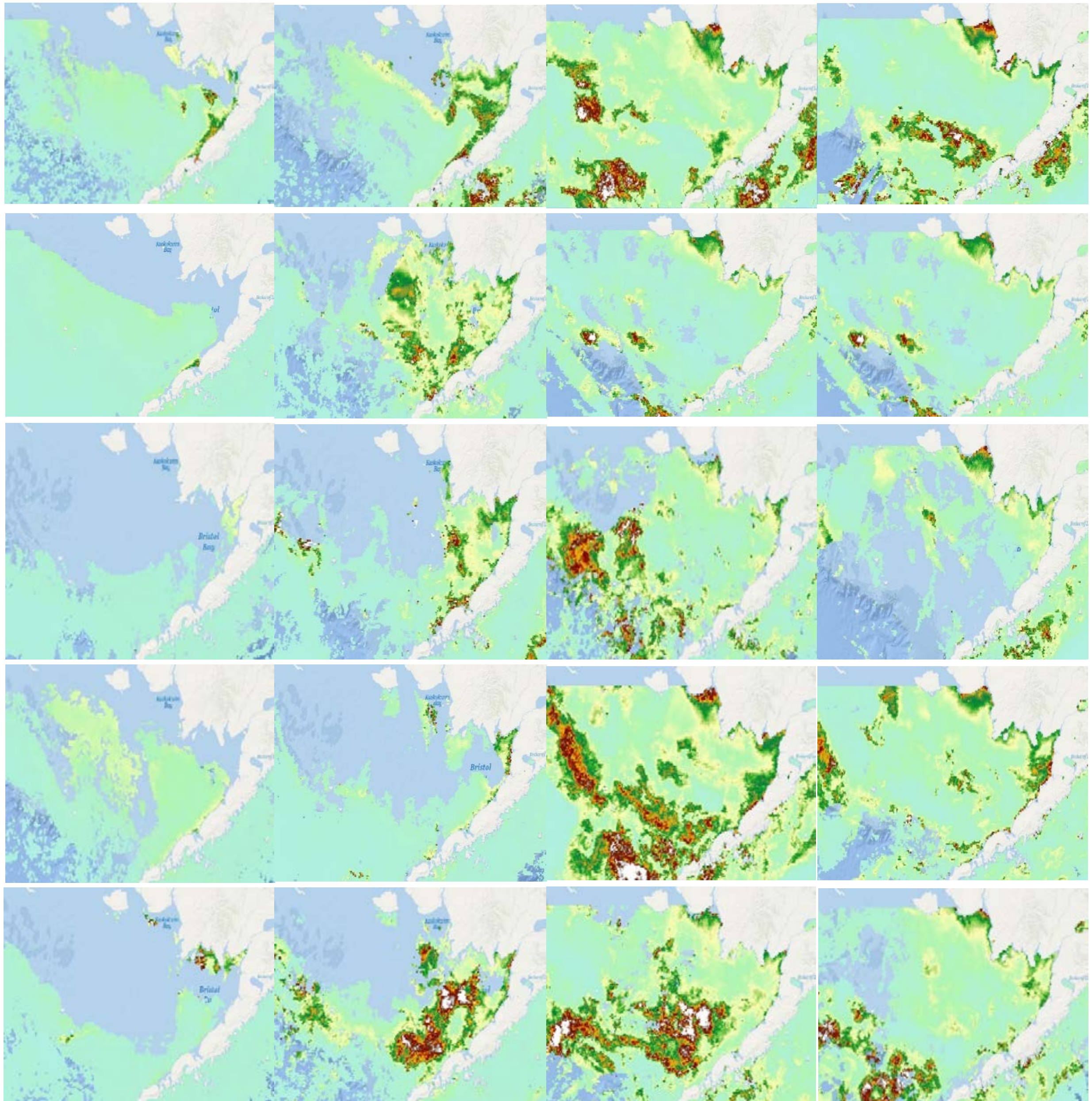


Figure 4. Time series of average April-May chlorophyll concentrations in coastal Gulf of Alaska. The lowest value (2011) suggests that low productivity could have negatively influenced salmon survival that year.

Jeanette Gann, NMFS/AFSC

April May Jun Jul

2006 2007 2008 2009 2010



2007 was an anomalous year for primary production, low nutrients, and low recruitment for pollock. Satellite data is crucial to fill in data gaps as our datasets and surveys are restricted to primarily late summer/early fall.

STAR Reprocessing for Oceans

- **ALL NOAA Line Offices** have expressed a need for consistent, fit-for-purpose quality, long-term time series of ocean satellite observations in support of executing their part of the NOAA Mission.

- **Reprocessing is essential** for the production of science quality time-series data from atmospheric, terrestrial and oceanic (e.g., ocean color, SST) satellite observations

- These reprocessing efforts support satellite research and applications, as acknowledged & expected by the ocean et al. communities, both providers and users.

STAR Reprocessing in Support of Satellite Ocean Research & Applications

STAR/SOCD is currently working to produce science quality time series data from satellite-based ocean observations in support of research & applications, including:

▪SST/ACSPO (*A. Ignatov et al.*)	VIIRS SNPP; AVHRR
▪Ocean Color/MSL12 (*M. Wang et al.*)	VIIRS SNPP
▪Blended 5km SST (*E. Maturi et al.*)	Multiple (Polar & GEO)
▪Sea Surface Height (*L. Miller, E. Leuliette)*	Multiple
▪SAR Winds (*F. Monaldo et al.*)	Sentinel-1;Radarsat-2 et al.

STAR Reprocessing for Oceans

STAR contributions in support of reprocessing efforts:

People
Scientific &
Satellite Expertise

Data Access
NOAA &
External Partners

Computing Resources
Processing
Storage

Product Generation
(NCEI, CIMSS)

Data Distribution
CoastWatch
(NCEI, PO.DAAC)

Archiving
NCEI

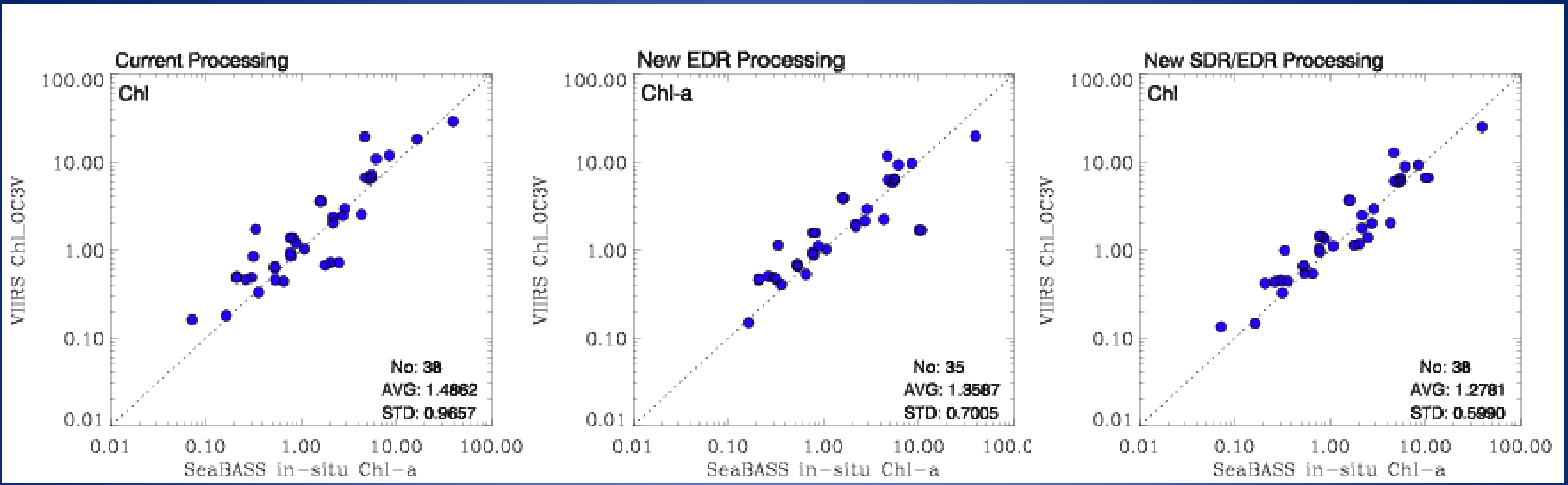
VIIRS Ocean Color EDR Reprocessing

Users require science quality time series Ocean Color data (i.e. NMFS, NOS, OAR, NWS, and outside NOAA agencies, academics, etc.)

The VIIRS Ocean Color EDR team is currently reprocessing mission-long, "Science Quality" VIIRS ocean color data.

Attribute	Near-Real Time	Science Quality Delayed Mode
Latency:	Best effort, as soon as possible (~12-24h)	Best effort, ~1-2 week delay
SDR:	IDPS Operational SDR	OC-improved IDPS SDR
Ancillary Data:	Global Forecast System (GFS) Model	Science quality (assimilated; GDAS) from NCEP
Spatial Coverage:	May be gaps due to various issues	Complete global coverage
Processed by:	CoastWatch, transferring to OSPO	NOAA/STAR
Distributed by:	CoastWatch	CoastWatch, NCEI
Archive Plans:	TBD	Yes, NCEI
Reprocessing:	No	Yes, ~2-3 years or as needed

Matchup Comparison of SeaBASS Chl-a



	Ratio of OC3V/Chl			OC3V vs Chl			log(OC3V) vs log(Chl)			No
	AVG	MED	STD	Slope	Intcpt	R^2	Slope	Intcpt	R^2	
Current Data Processing	1.4862	1.2273	0.966	0.812	1.225	0.78	0.866	0.112	0.81	38
New EDR Processing (2015-03-19)	1.3587	1.2210	0.701	0.487	1.391	0.66	0.743	0.102	0.77	35
New SDR/EDR Processing (2015-02-26)	1.2781	1.1933	0.599	0.652	1.099	0.83	0.857	0.085	0.89	38

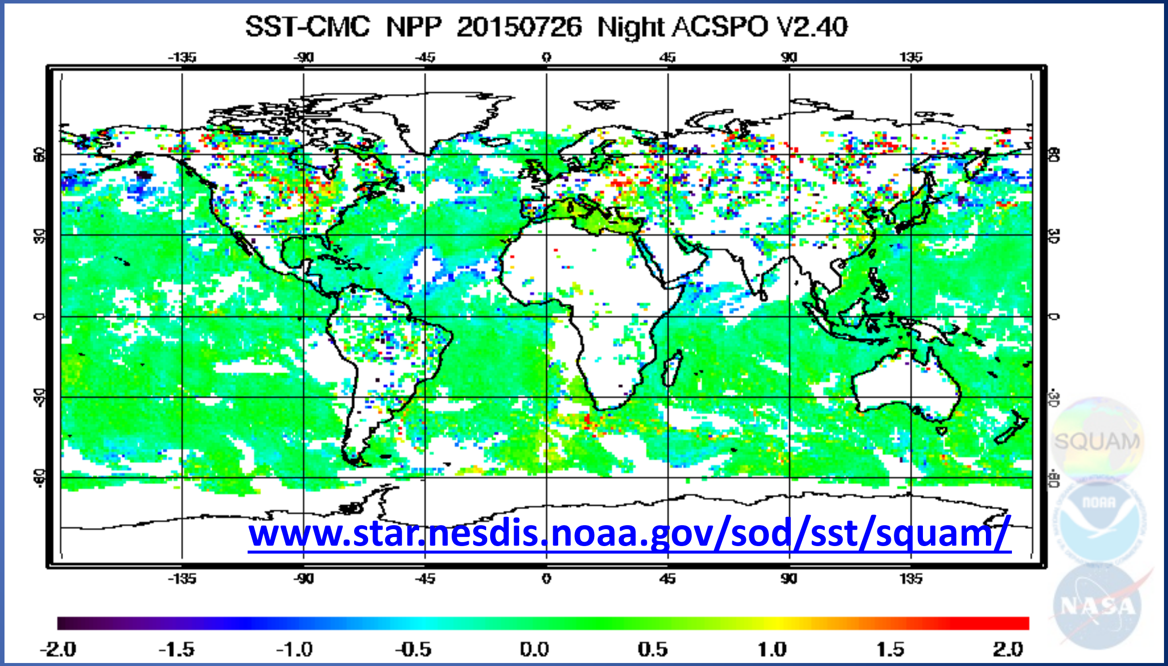
Improved with new MSL12 and new SDR/MSL12.

Accuracy for Chl-a is within ~30% for Chl-a of 0.1 to ~30 mg m^{-3}.

ACSPO VIIRS SST EDR Reprocessing

NOAA Advanced Clear-Sky Processor for Oceans (ACSPO) VIIRS SST product became operational in Mar 2014 and was declared fully validated with JPSS in Sep 2014

ACSPO SST has improved coverage over heritage and partners' SST products, especially over internal waters, in coastal and dynamic areas (Gulf Stream, Kuroshio, Agulhas), and in the Tropics and high latitudes



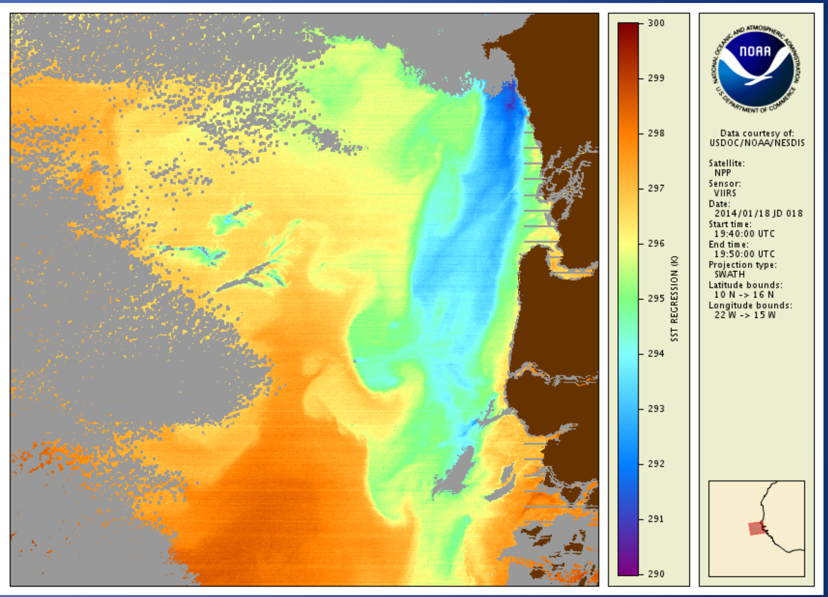
ACSPO VIIRS SST is monitored online in NRT in the NOAA SST Quality Monitor (SQUAM). Shown is deviation from Canadian Met Centre (CMC) global daily Analysis. ACSPO VIIRS SST has near-complete daily global coverage, during both day and night (except areas with persistent cloud). The VIIRS L2 and CMC L4 products are close. Reprocessing is underway to back-fill back to the beginning of the JPSS SST (Jan 2012), and generate uniform time series.

ACSPO VIIRS SST Reanalysis (“RAN1”)

Users require science quality time series SST data (i.e. NMFS, NOS, OAR, NESDIS (STAR and NCEI), NWS NCEP, GHRSST, UK Met office, Canada Met Office, BoM of Australia, Japanese Met Agency, and other agencies, academics, etc.)

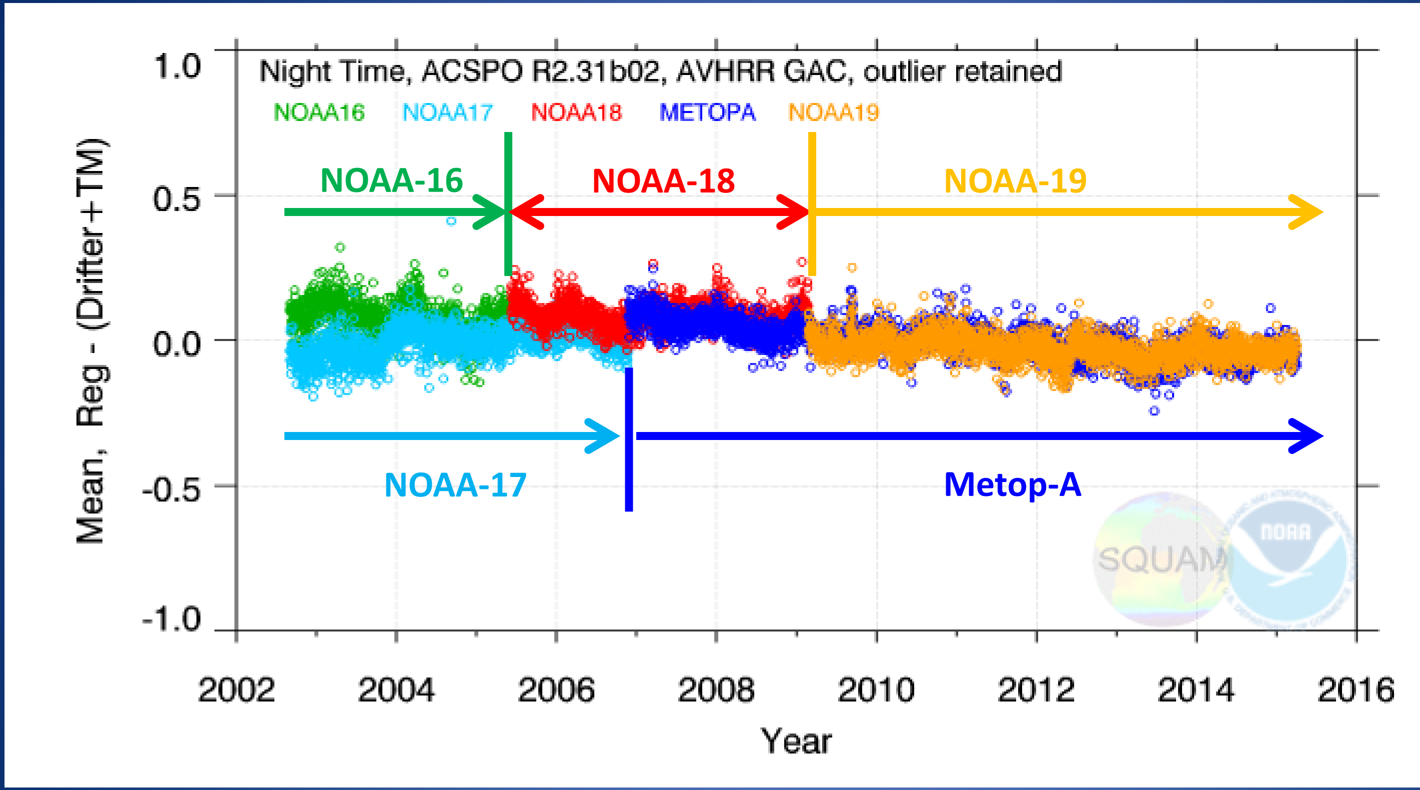
The ACSPO SST Team is currently doing mission-long, science quality VIIRS SST Reanalysis v1 (“RAN1”):

- In partnership with Univ. of Wisconsin – Madison, Space Science and Engineering Center (SSEC)
- RAN infrastructure has been set up and tested at UW/SSEC, including the following codes
    - Granulator (86sec → 10min)
    - destriping of individual VIIRS SST bands
    - ACSPO L2 (SST product in swath projection)
    - ACSPO L3U (0.02° gridded code)
- Validation and monitoring is an integral part of RAN
    - Match-ups with QCed in situ SSTs (from NOAA in situ SST Quality Monitor, iQuam www.star.nesdis.noaa.gov/sod/sst/iquam/
    - Display VIIRS RAN SSTs in NOAA SQUAM www.star.nesdis.noaa.gov/sod/sst/squam/
    - Display VIIRS RAN Brightness Temperatures in NOAA MICROS system www.star.nesdis.noaa.gov/sod/sst/micros/
- ACSPO VIIRS RAN1 L2 and L3U data from Jan 2012-pr will be archived w/PO.DAAC/Ed Armstrong and NCEI/Ken Casey
- NOAA CoastWatch will also serve reprocessed data to users
- Monitoring/Validation will be reported in SQUAM/MICROS



Example S-NPP VIIRS SST image produced by the NOAA ACSPO system

ACSPO VIIRS SST Reanalysis ("RAN1")



Afternoon

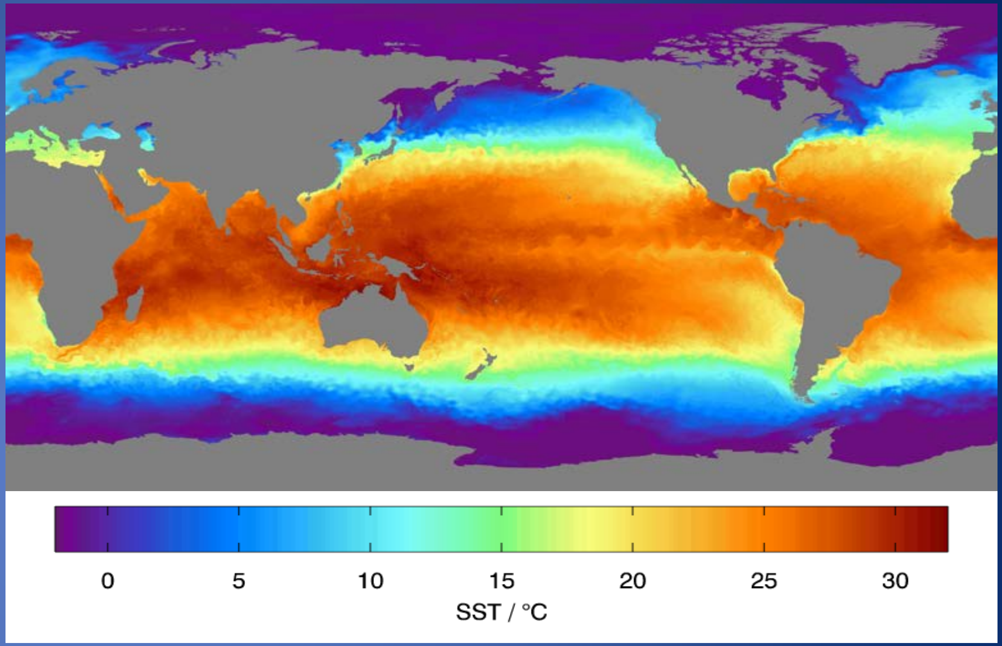
Mid-morning

- Unstable sensors/periods excluded = 5 AVHRRs reprocessed
- 2 platforms at a time: One mid-AM (N17, Metop-A) and one PM (N16/18/19)
- L2/L3U will be archived with PO.DAAC/Ed Armstrong & NCEI/Ken Casey
- Will be tested in NOAA geo-polar blended and other L4 analyses (2015/16)
- RAN2 (~2017) will reprocess 1994-pr; RAN3: 1981-pr

5 km Global Blended SST Analysis Reprocessing

These 5-km blended SST analyses are produced daily from 24 hours of polar and geostationary sea surface temperature satellite retrievals:

- •S-NPP
- •Metop-B,
- •GOES-E/W
- •Meteosat-10
- •MTSAT-2 (will be replaced by Himawari-8 in late 2015.)



PHASE I 2004 to present September 2015

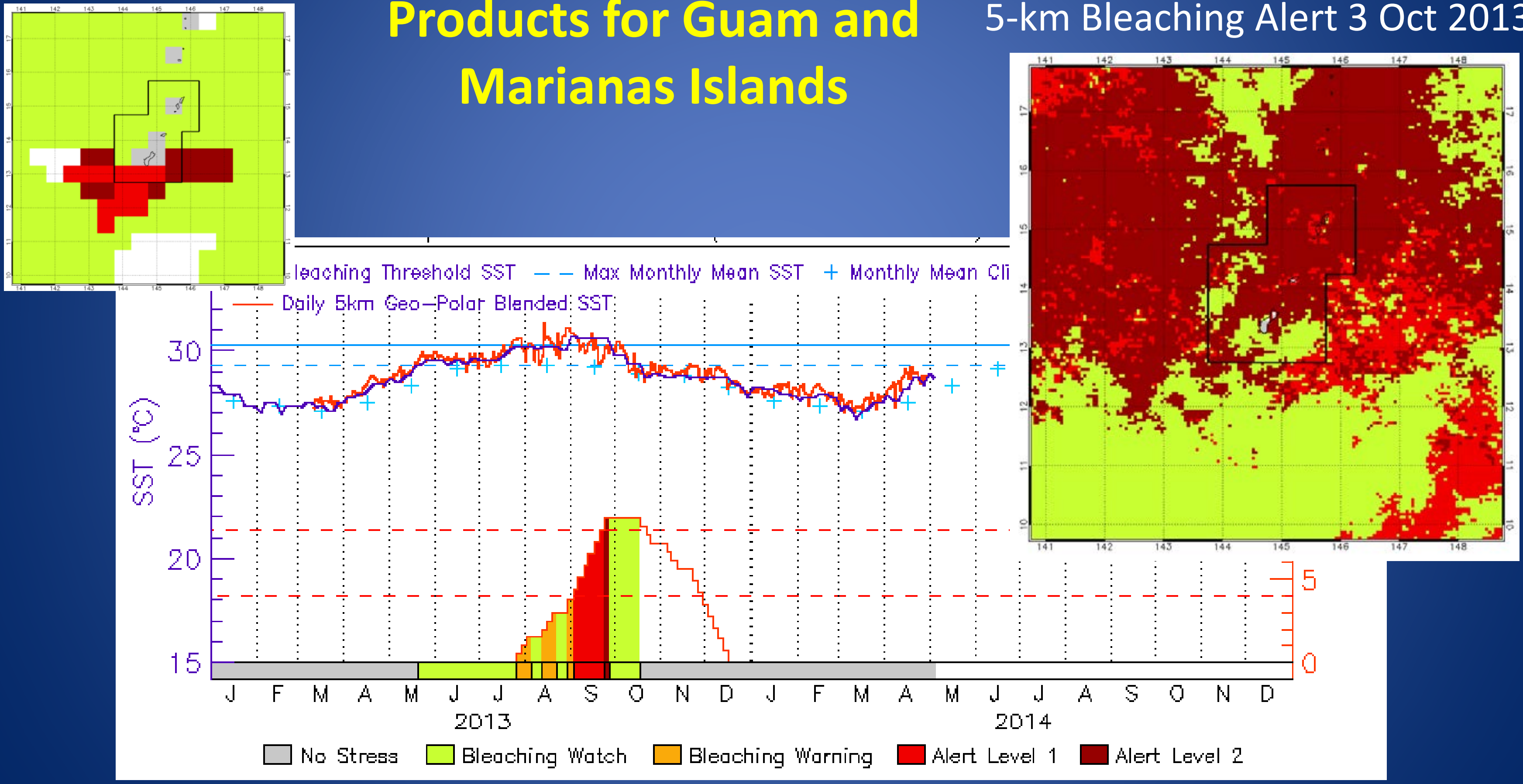
PHASE II 1994 to 2004 September 2016

Coral Reef Watch will use the latest 5 km global blended SST to generate a new climatology for their bleaching alert and monitoring products for the coral reefs around the globe.

Prototype Regional Alert Products for Guam and Marianas Islands

50-km, 3 Oct 2013

5-km Bleaching Alert 3 Oct 2013



Coral Reef Watch
5 km Global Blended SST

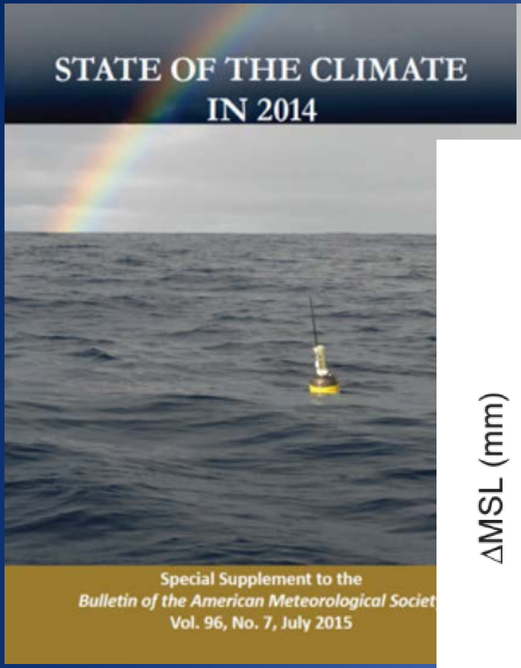
Phase I:

Polar satellites 2005 – today
Geo satellites & Geo-Polar Blending
Purpose: bias-adjust vs Pathfinder
Near completion

Phase II :

Polar satellites 1985 – today
Geo satellites & Geo-Polar Blending 1994 – today
Purpose: provide consistent climatology and record
Anticipated complete in 2016

Closing the Global Sea Level Budget



NOAA/STAR analysis shows 2/3 of recent sea level increase is due to mass (ice melt), 1/3 due to steric (ocean heating).

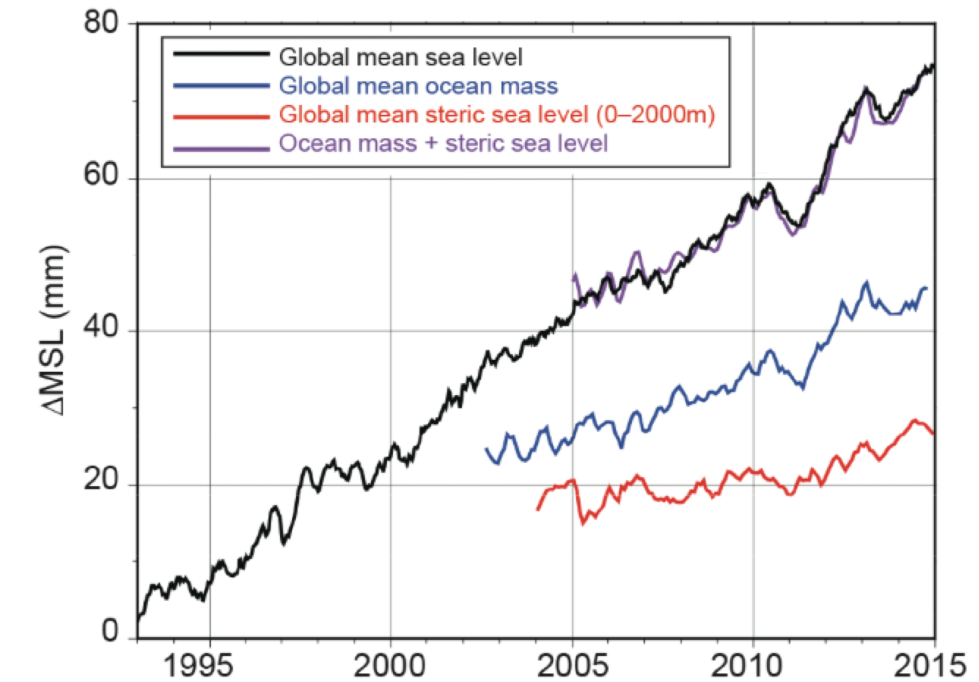


FIG. 3.27. Comparisons of global mean sea level from NOAA/NESDIS/STAR, global mean ocean mass from GRACE, and steric (density) sea level from Argo, with seasonal variations removed and 60-day smoothing applied.

Laury Miller and Eric Leuliette

Re-processing of Sentinel-1/Radarsat-2 Synthetic Aperture Radar Data: Winds

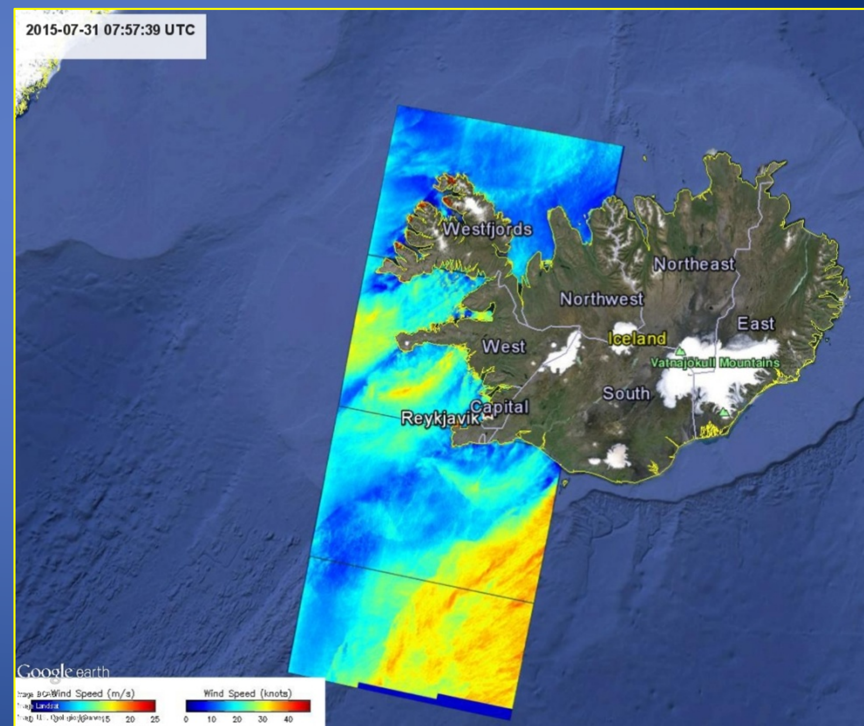
Sentinel-1 / Radarsat-2 SAR Imagery → Compute Wind Speed

NCEP Model GFS Data → Compute Wind Speed

IMS Ice Mask → Compute Wind Speed

Compute Wind Speed → NetCDF Files of Wind Speed

High resolution (50 m) SAR imagery is used to create a 500-m wind speed field stored in a netCDF file.



- There is sufficient information in the netCDF to re-compute wind speed using different model functions as they improve.
- Re-processing valuable for producing wind speed climatologies applicable to offshore wind power turbines.
- If we require wind speed resolutions smaller than 500-m, we need to re-process from the original SAR imagery.

Frank Monaldo

STAR Reprocessing for Oceans

- **Conclusion:**

- **ALL NOAA Line Offices** have expressed a need for consistent, fit-for-purpose quality, long-term time series of ocean satellite observations in support of executing their part of the NOAA Mission.

- **Reprocessing is essential** for the production of science quality time-series data from atmospheric, terrestrial and oceanic (e.g., ocean color, SST) satellite observations

- These reprocessing efforts support satellite research and applications, as acknowledged & expected by the ocean et al. communities, both providers and users.

NUCAPS and ACSPO Reprocessing at CIMSS/SSEC/UW

Liam Gumley, Steve Dutcher, Bruce Flynn, Jim Davies
JPSS STAR Science Team Meeting, 8/25/2015

Overview

Question: What would it take to reprocess the entire SNPP mission record to generate a consistent set of NUCAPS and ACSPO products?

- NUCAPS and ACSPO are the NOAA enterprise algorithms for Suomi NPP atmospheric profiles and sea surface temperature.
- STAR would like to have consistent calibration and retrieval algorithms, LUTs, and products for the entire mission. Therefore, start with RDRs.

CIMSS Key Ingredients

- Complete archive of VIIRS, CrIS, and ATMS RDRs at CIMSS since start of SNPP mission.

- CSPP SDR processing software (to convert RDR to SDR) based on Mx 8.4, with LUTs for entire mission.

- Excellent collaboration with STAR NUCAPS and ACSPO enterprise algorithm development teams for preparing CSPP release packages.

- Cluster compute, storage, and expertise at CIMSS.

CIMSS Cluster Overview

- 82 compute nodes (servers) with 8 to 16 cores per node. Total core count = 1184. 64-bit Linux CentOS.
- Approximately 4 GB to 8 GB of memory per core.
- Each compute node has between 0.3 - 1.0 TB of workspace.
- Total of 2 Petabytes of cluster storage.
- Network delivers data from storage to compute nodes speeds of up to 30 gigabits/second (aggregated).

Job Management

- We use a PostgreSQL database to keep track of more than 50 million files from multiple satellites (Suomi-NPP, Aqua, Terra, Metop-A/B, Caliop,…)

- We use Condor as our workload management system which provides dynamic scheduling based on job requirements (e.g., memory, disk space).

- We use custom workflow manager (Flo) that scans the database for files to process and then uses Condor to submit the jobs.

Data Volumes

Input RDR volumes:

VIIRS RDR = 74 TB; CrIS & ATMS RDR = 18 TB

Intermediate SDR volumes:

VIIRS SDR (GMTCO + 6 M-bands required by ACSPO) = 70 TB

CrIS & ATMS SDR = 54 TB

Level 2 product volumes:

NUCAPS L2 = 11 TB

ACSPO L2, L2/L3 SQUAM, MICROS, L3U = 145 TB

NUCAPS Overview

Inputs (per 8 minutes)

1 x CrIS RDR, 8m aggregated

3 x ATMS RDR, 8m aggregated

2 x GFS AVN

Outputs (32 second granules)

15 x NUCAPS EDR

15 x NUCAPS CCR

15 x statistic file for analysis

Science Software

CSPP SDR v2.0.1

CSPP NUCAPS v1.0.2

Time Period Processed

May 1, 2012 through Jul 31, 2015

Some data missed due to:

- inability to produce ATMS before May 1, 2012
- missing/failed CrIS/ATMS processing
- missing GFS AVN ancillary data

Job Granularity

Single 8 minute aggregated CrIS granule per job

Extra downloads of ATMS data due to processing of single granule, however …

Smaller job granularity parallelizes better on cluster increasing overall job throughput

1184 Days * 180 granules/day = ~66K jobs

NUCAPS Processing

ATMS SDR Processing

~3 hours/year

CrIS SDR Processing

~9 hours/year

NUCAPS Processing

1184 days * 180 granules/day = 66K jobs

45 outputs per job = 3M outputs

32 minutes/job * 1184 cores = 30 hours/year

Total Processing

42 hours/year for ATMS/CrIS SDR + NUCAPS (Speedup: 208X)

~97% product yield

1 week to reprocess entire mission

NUCAPS Lessons

Yield can be improved

- Need to investigate CrIS/ATMS SDR processing failure cases to improve yield (this includes ATMS SDR pre May 1, 2012).
- It appears NUCAPS does not handle CrIS granules with less than 4 scan lines (known issue).

Helpful improvements for cluster environment

- Specify all required inputs on command line.
- Assume software tree is read-only.
- Assume the network is not available, i.e. can’t download ancillary data (the workflow manager will provide it).

ACSPO Overview

Inputs

VIIRS RDR (86-second)

Ancillary: CMC, OSTIA, Daily Reynolds, iQUAM

Outputs

png/json files for web

product files

Science Software

CSPP VIIRS SDR v2.0.1 with VCST LUTS

ACSPO v2.40

Time Period Processed

May 1, 2012 through Jul 31, 2015.

Some data missed due to inability to produce VIIRS before March 1, 2012.

Job Highlights

1210 Days =1.4 million jobs.

Saving intermediate products from various stages produced 500 TB of data.

Network sustained 30 gigabits/second when delivering large dataset to compute nodes.

ACSPO Processing

VIIRS Processing (granularity = 86 seconds)

~52 hours/year

Aggregate/Destripe (granularity = 10 minutes)

~6 hours/year

ACSPO Processing (granularity = 1 day)

ACSPO: ~35 hours/year

ACSPO MICROS: ~30 hours/year

ACSPO L2 SQUAM: ~33 hours/year

ACSPO L3 SQUAM: ~10 hours/year

Total Processing

165 hours to reprocess 1 year of through all ACSPO steps (Speedup: 53X)

3.5 weeks to reprocess the entire record

ACSPO Lessons

Yield can be improved

Need to investigate VIIRS SDR processing failures for March 2012 and get a working set of LUTS allowing us to got back to Jan 2012.

Helpful improvements for cluster environment

Our biggest challenge was IDL integration. We needed to find a way to run IDL jobs in IDLRT cluster mode. ACSPO team and CIMSS worked together to solve this problem.

Numerous jobs had long run times (~10 hours), which makes the feedback loop for debugging purposes difficult. Jobs that have smaller runtimes are highly preferred not only for debugging purposes but also it will parallelize better over the cluster.

Reprocessing Summary

Numerous software packages need to be adapted to cluster environments,for example:
- removing hard coded paths
- dynamic ancillary selected prior to job submission
- keeping the granularity small (~1 hour) helps in both debugging and optimal use of the cluster hardware.

Understanding the software such that jobs can be scheduled based on resources needed (cpu, memory, disk) is critical to reprocessing as fast as possible.

There is much attention to detail needed to achieve 99% data coverage over the life of the mission.

Conclusion

Thanks to NOAA/NESDIS/STAR NUCAPS and ACSPO for their close collaboration.

CIMSS team (Steve Dutcher, Bruce Flynn, Jim Davies) put in many hours on this demonstration project.

We will work with STAR to resolve outstanding issues in the NUCAPS and ACSPO reprocessed datasets.

We look forward to future collaboration with STAR on reprocessing tasks.

NOAA CDR Program Overview

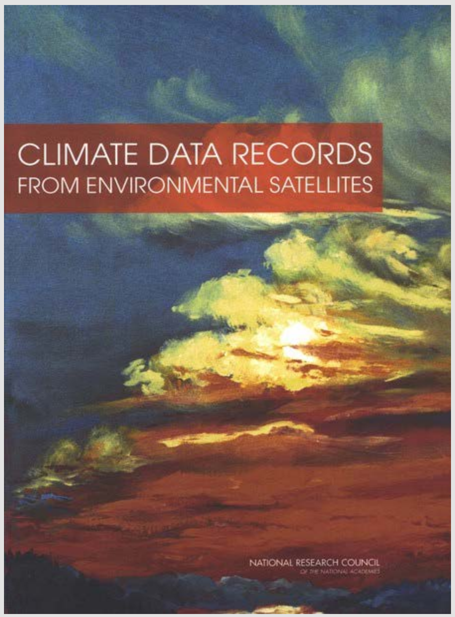
Sustained Production & User Engagement

W. Jesse Glance, Jr.
Program Manager

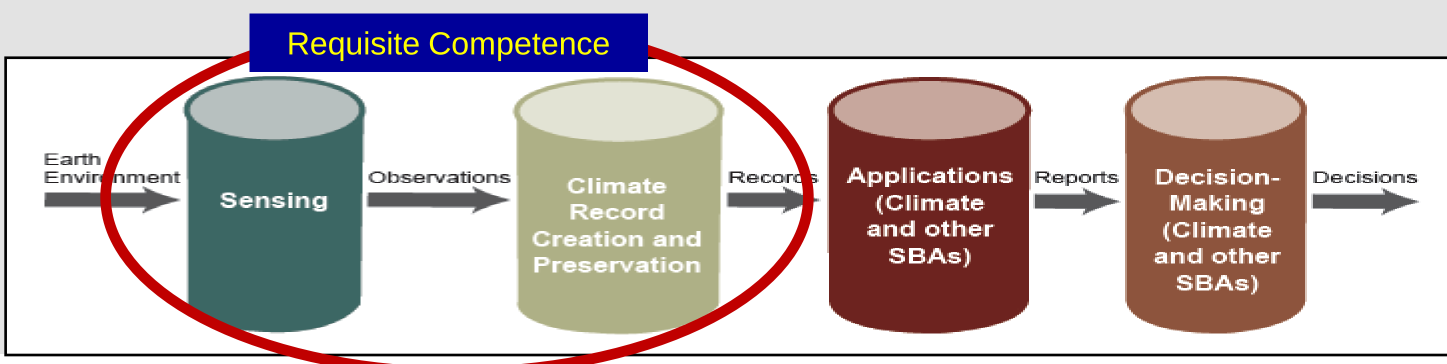
Center for Weather and Climate
NOAA's National Centers for Environmental Information

August 28, 2015

From Conception …



- **National Research Council** (NRC) of National Academy of Sciences (NAS) (2004)
- Office of Science and Technology (**OSTP**), NOAA/NESDIS guidance
- **Scientific Data Stewardship** (**SDS**) Program (2007 & 2008)
- The American Recovery and Reinvestment Act of 2009 (**ARRA**)
- FY **2009** First NOAA CDR Grant Opportunity (**FFO**)
- FY **2010 "CDR"** Established as a NOAA/NESDIS **Budget Line**
- FY **2011** Second NOAA CDR Grant Opportunity (**FFO**)



… to Recognized Success!

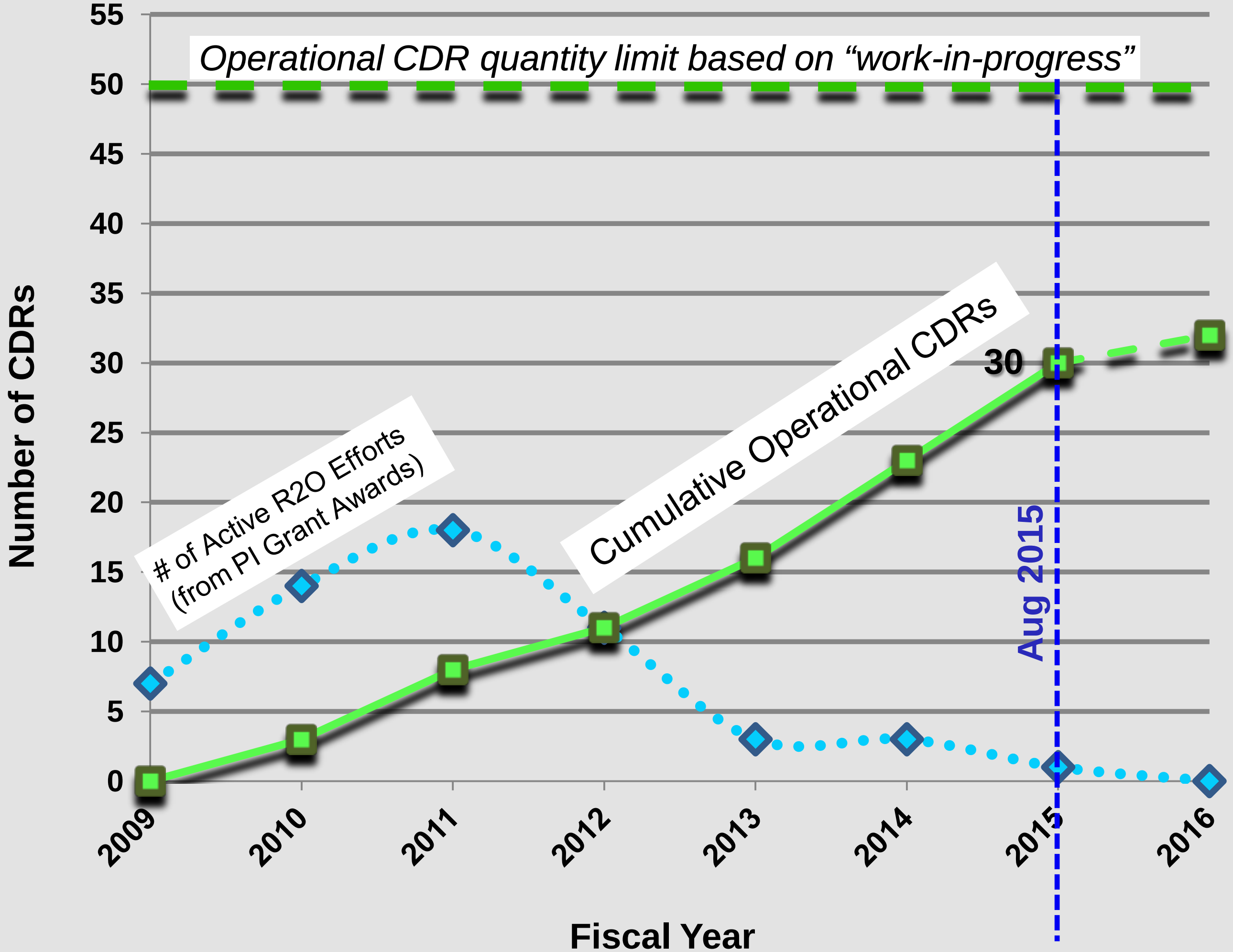
U.S. Department of Commerce

2014 Gold Medal Award

CITATION:

For creation and operational implementation of a new, extensible community standard for the production and preservation of climate data records.

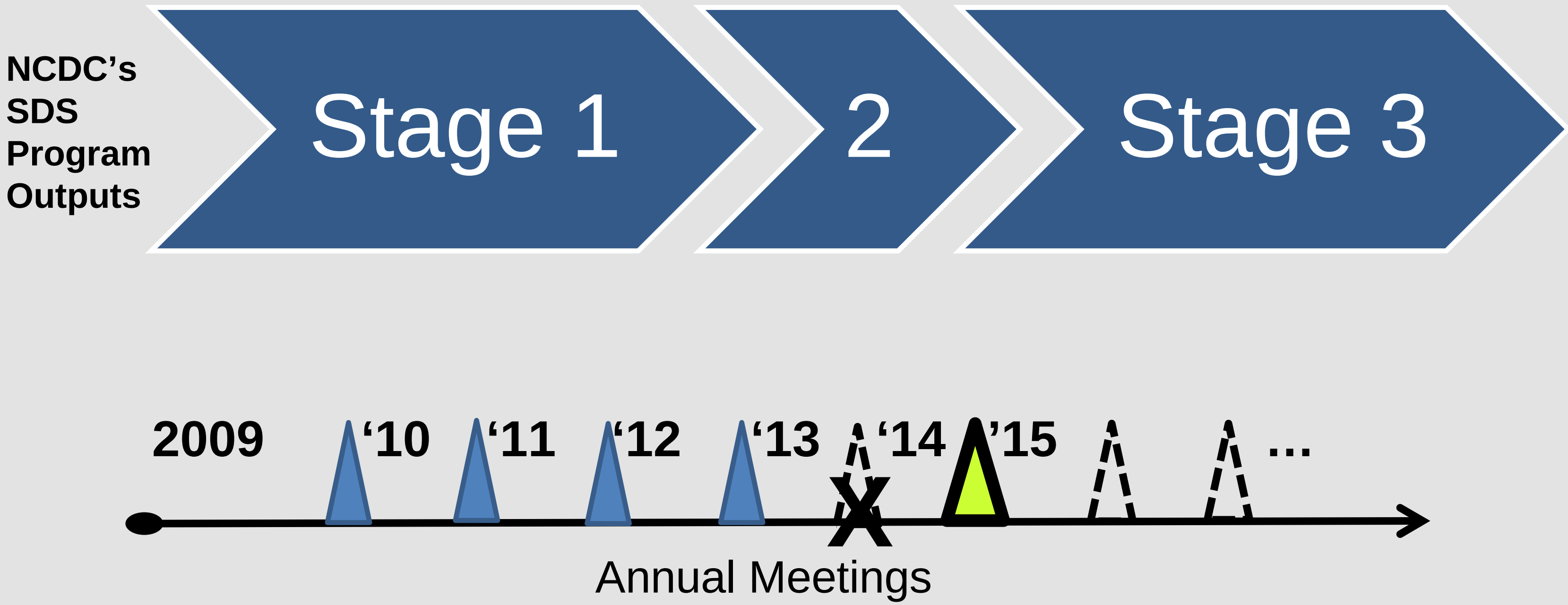
CDR R2O Transition Status



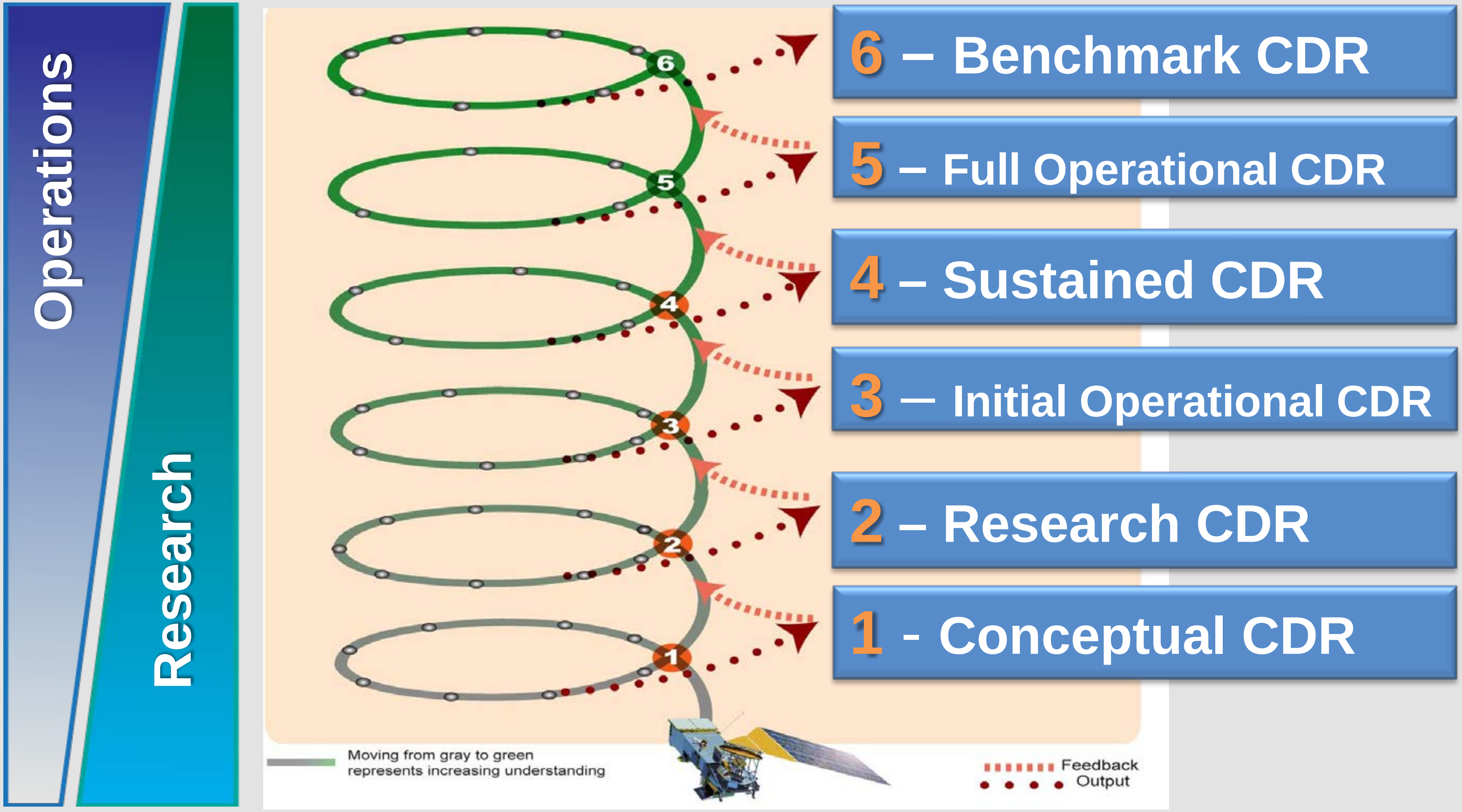
- PI R2O “work-in progress”, from Grant Competition
- 20+ more individual CDRs in the work “Pipeline”
- Sustainment cost also limits operational CDR carrying capacity

CDR Program is Maturing

- Program Evolution



NOAA CDR Operational Spiral Development

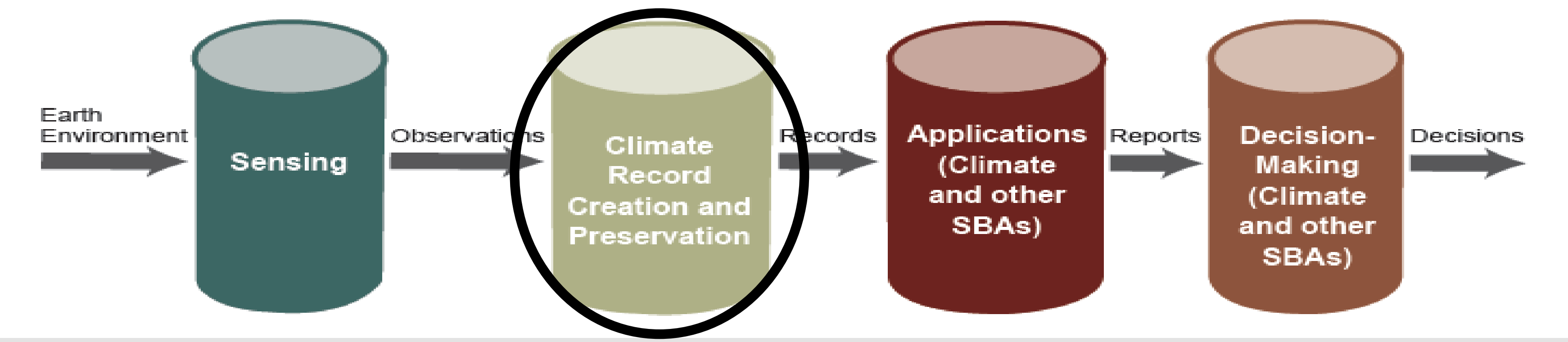


NOAA CDR Program (CDRP) – Stage 1

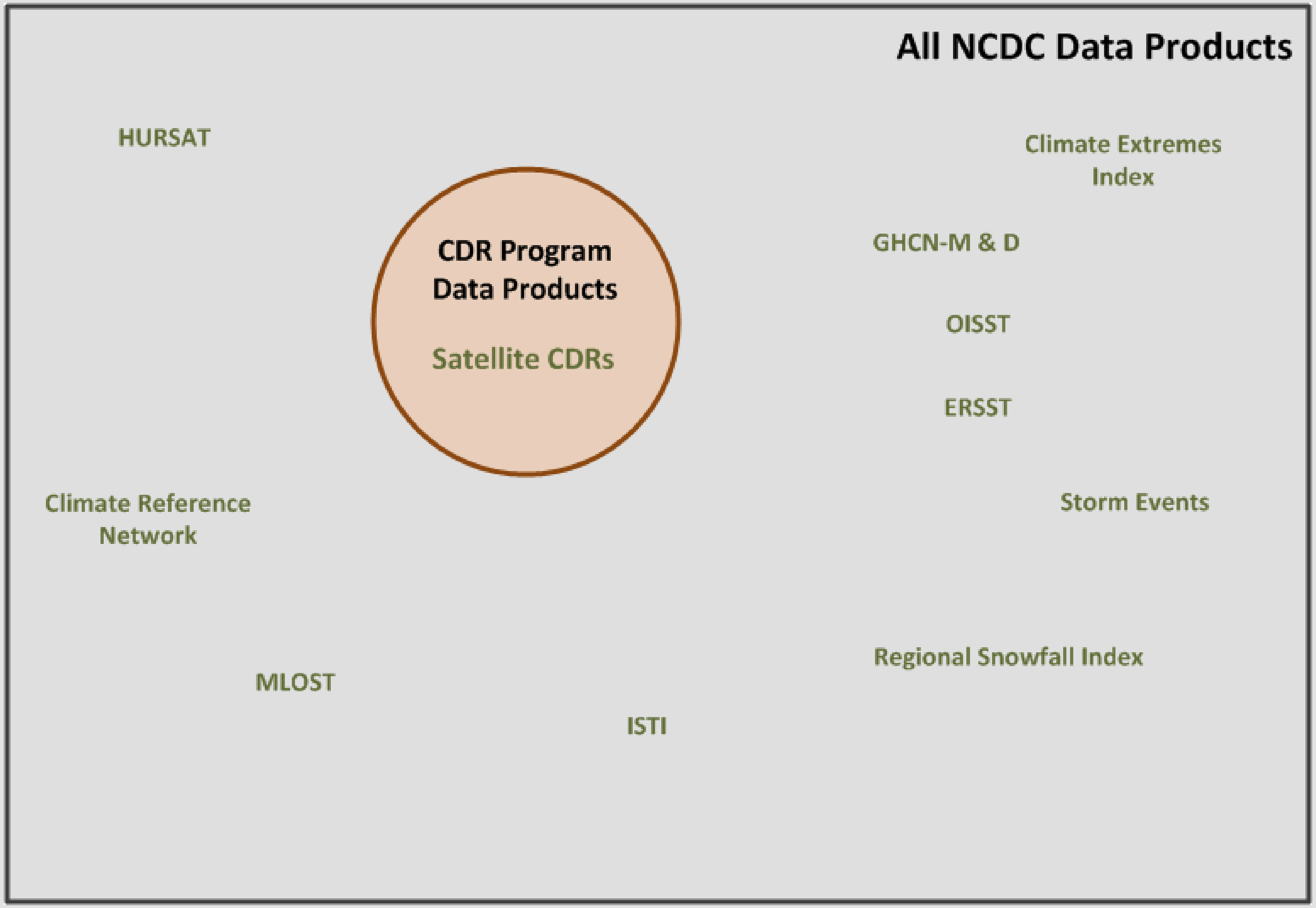
Annual Meetings #1-3

CDRP began in **2009** as an outgrowth of the National Climatic Data Center (NCDC) Science Data Stewardship (SDS) Program.

- Focus: **Essential Climate Variables** (ECVs); **"critical" CDRs** identified by international experts were top priority.
- **R2O** awards based on **best science** and **most mature** algorithms.
- **Grant competition** captured leading knowledge from the research community. (U.S. agencies, universities, private companies)
- CDRP **coordinated** with NASA, USGS, and international partners.



Stage 1
Product Scope: 2009 - 2011

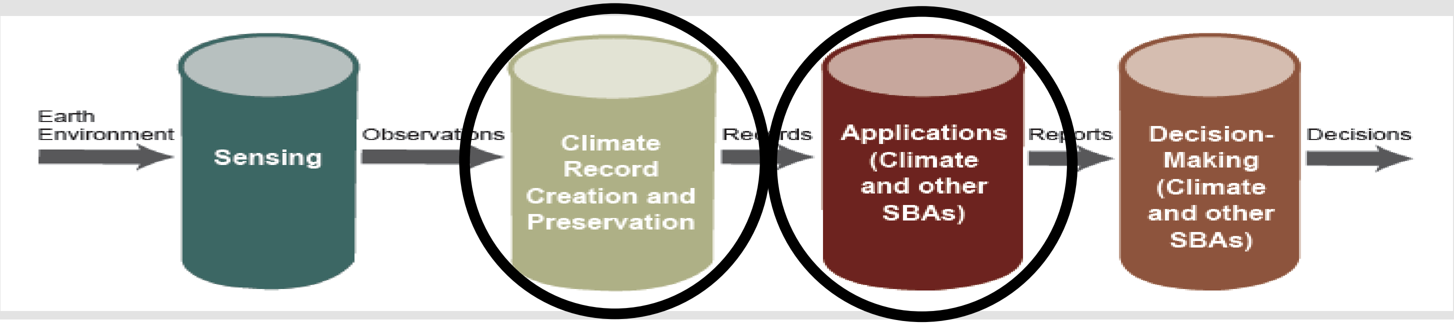


NOAA CDR Program – Stage 2

Annual Meeting #4

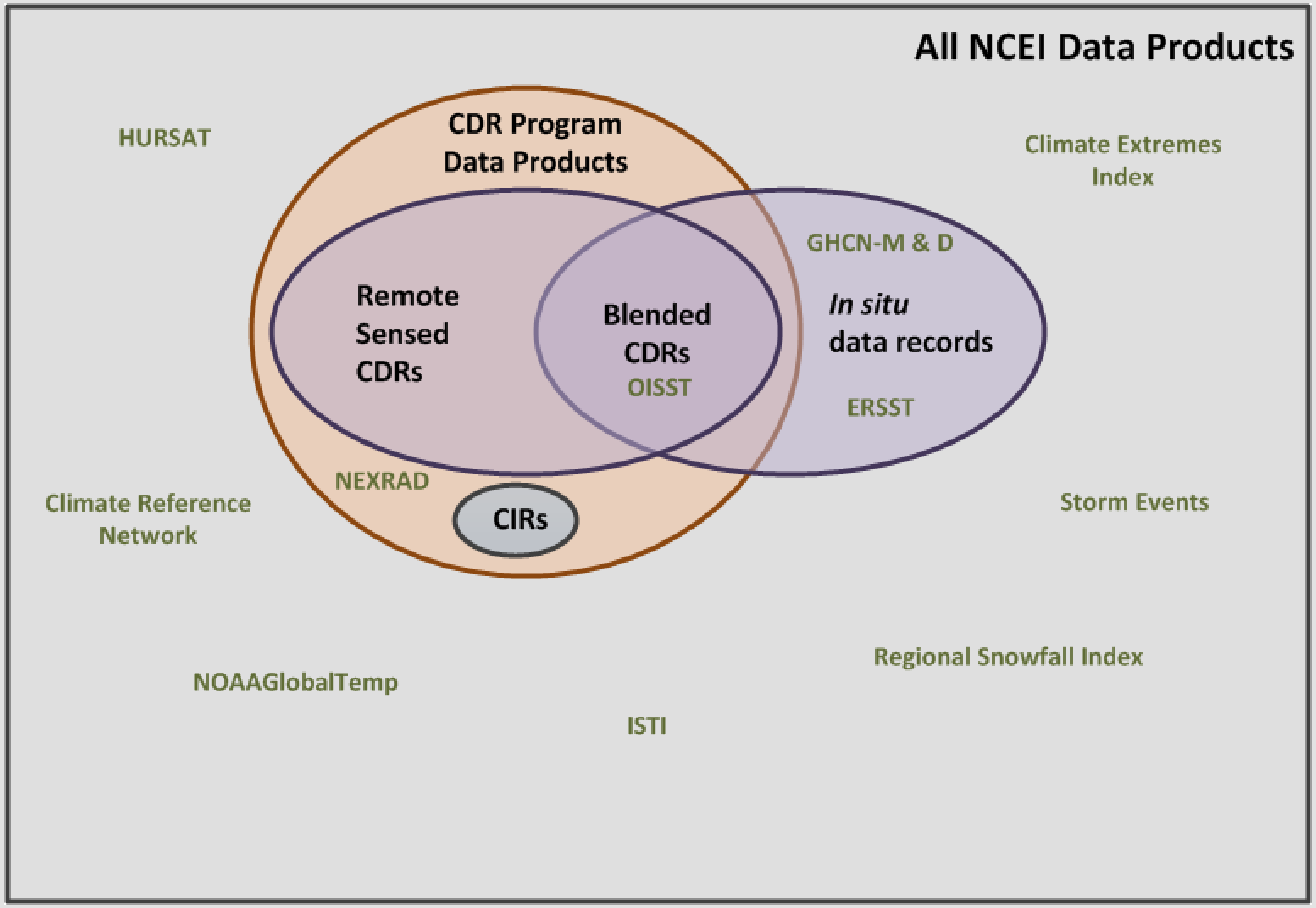
CDRP in **2013** Expanded its Target Users to Include non-climate research Applications & Users.

- Priority moved to "**best use**" regardless of Societal Benefit Area (SBA).
- Began **interactions with industry and public** to identify needs and prioritize CDRs capable of meeting them.
- Formalized **R2O processes**, cost-estimating, policies, and procedures for transition activities and information preservation.
- Began **CDR O&M** using **NOAA Contracts** & **IAAs** with other agencies, universities, and private industry with provisions for deliverables, configuration mgmt., and quality assurance, and user/usage statistics.



Stage 2

Product Scope: 2012 –2015

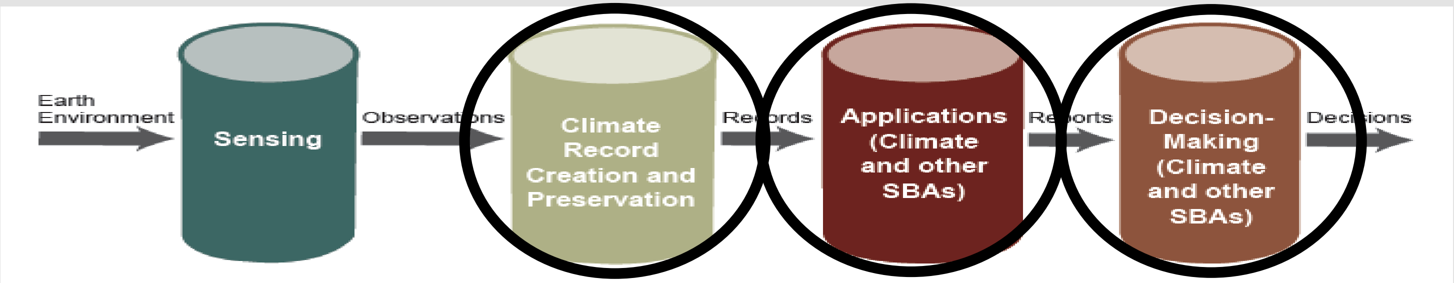


NOAA CDR Program – Beginning Stage 3

2015 Annual Meeting (*Now)

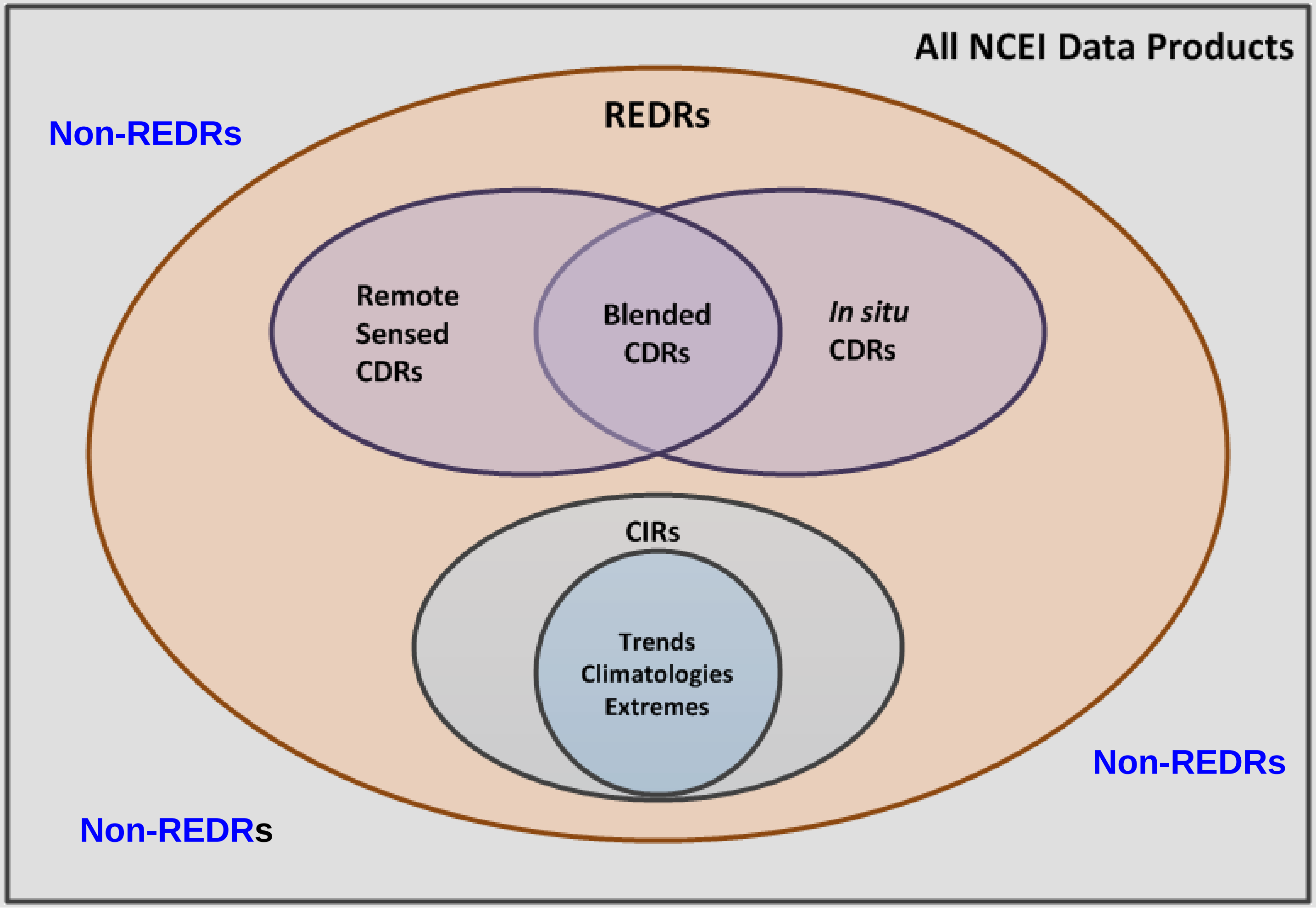
CDRP in **2015** is focused on: Sustaining NOAA's Operational CDRs and Users Requiring trusted environmental information products. (e.g. informed decision making, management, and climate applications including science)

- Incorporating ***in-situ* and blended products** into the CDR portfolio to preserve those products for the future in addition to the satellite data products.
- **Developing Climate Information Products** that target User needs and requirements.
- Supporting decision-makers with lower-latency "Preliminary" or **ICDRs** that employ the most mature algorithms, but are not yet CDRs.
- Accelerating **high-demand, less scientifically maturity products**, e.g. NEXRAD weather radar reprocessing for hi-res precipitation CDRs/CIRs requested by Users.



Stage 3
Product Scope: 2016 +

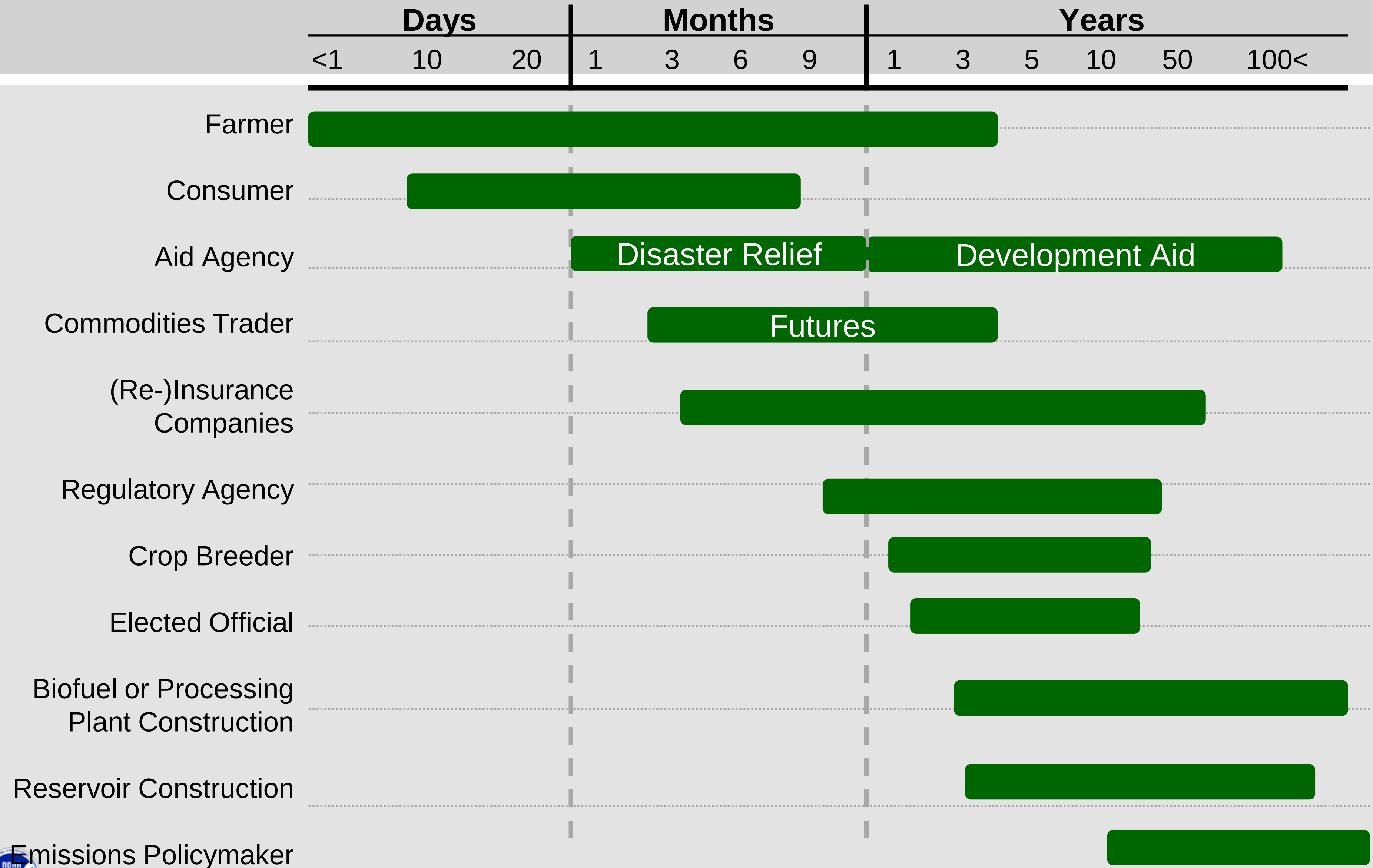
Reference Environmental Data Records (REDRs)



User Needs Met are Society's Benefit

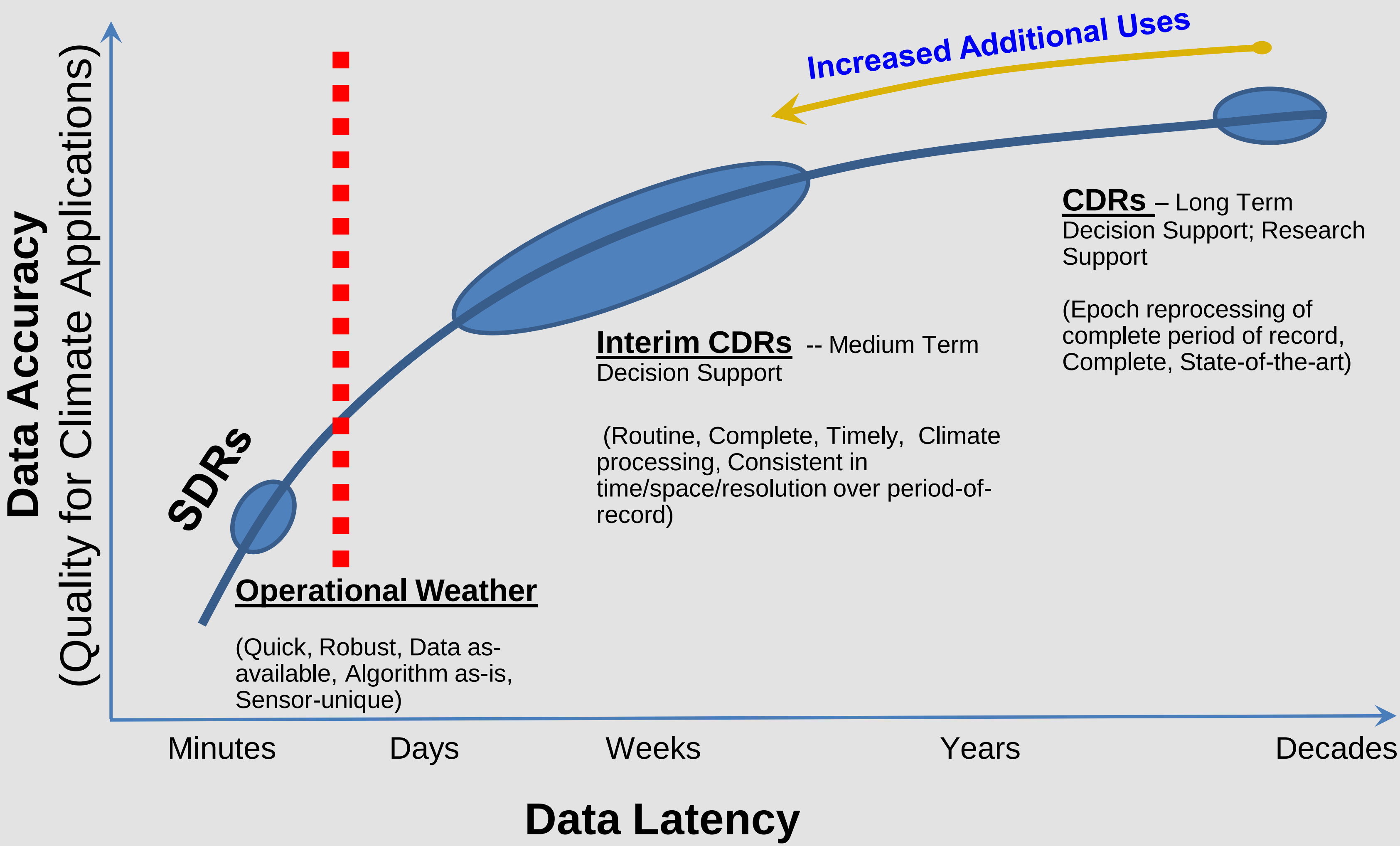
One must first Understand the End-User's Needs!

Agricultural Stakeholder Temporal Outlook

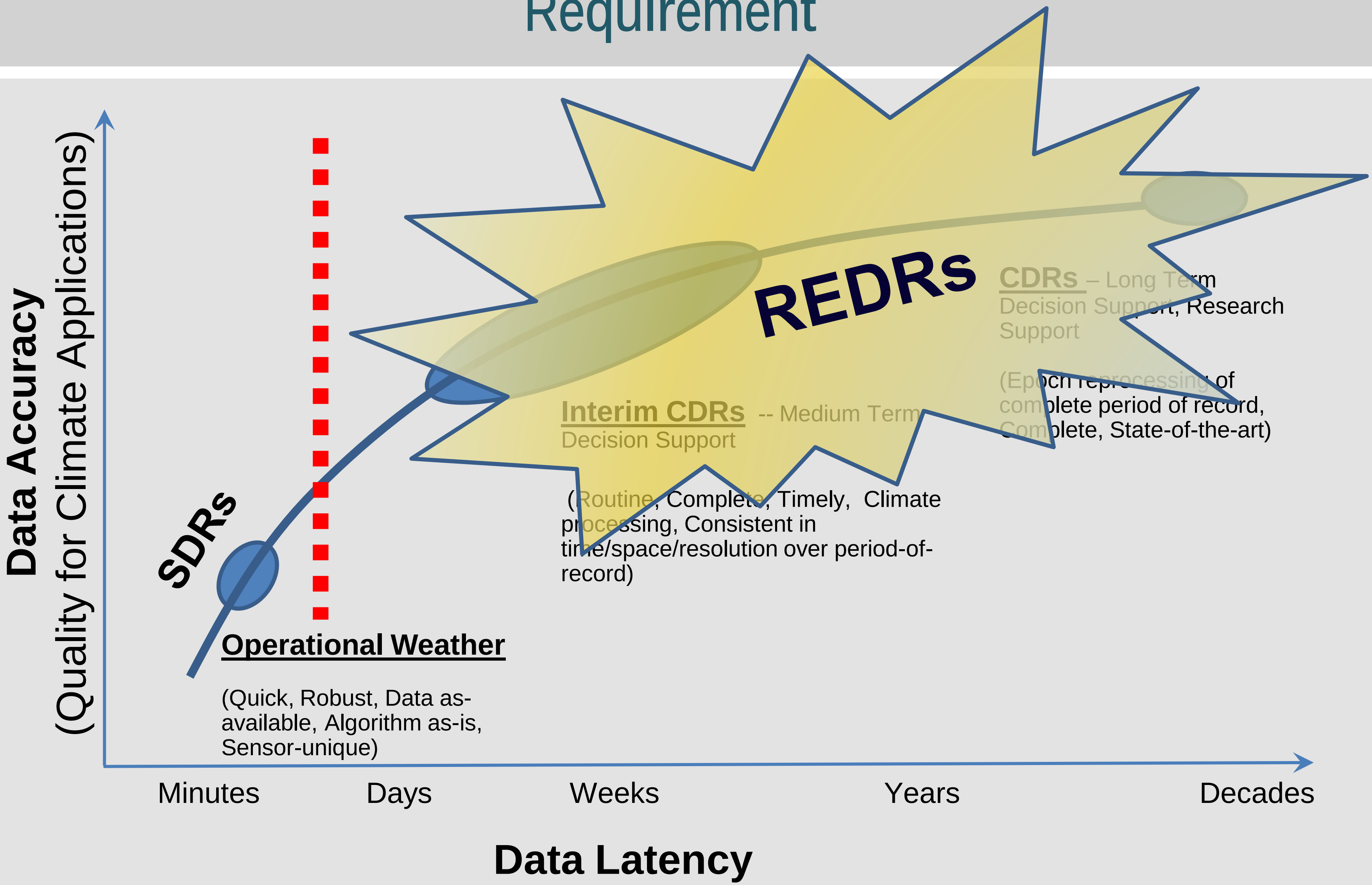


Accuracy vs. Latency

CDRs Have Higher Latency, but are Better for Long-Range Decisions than Low Latency Operational Weather Data Products

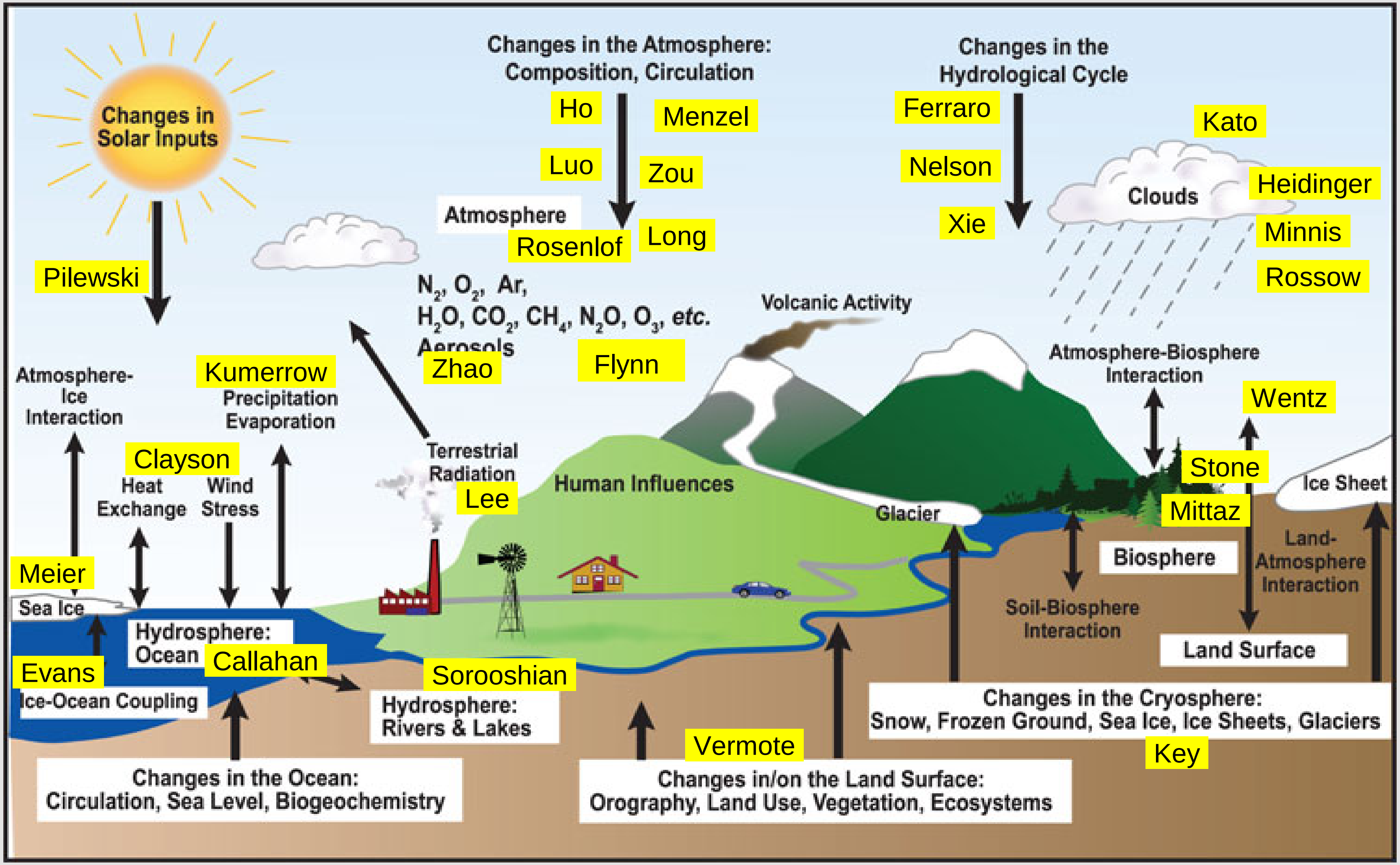


REDRs: Able to Meet Any Higher-Latency Application / Requirement



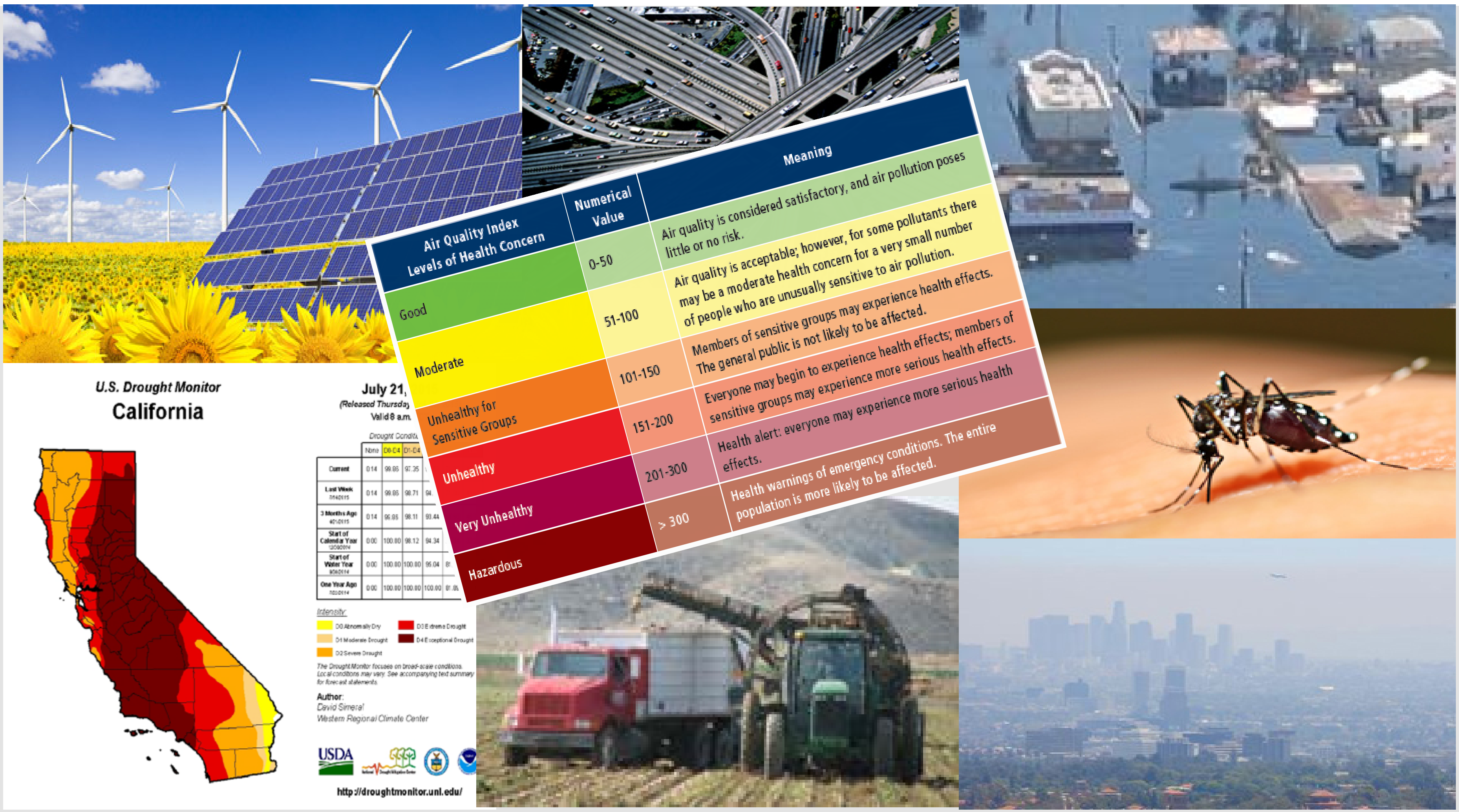
NOAA CDR Environmental Variable Coverage

(with Principle Investigator's Names Highlighted near their Area of Contribution)



NOAA Operational CDRs Support User Needs

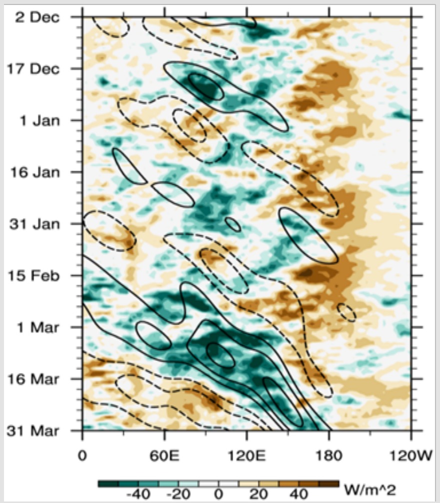
(Details to be Presented in the Poster Session!)



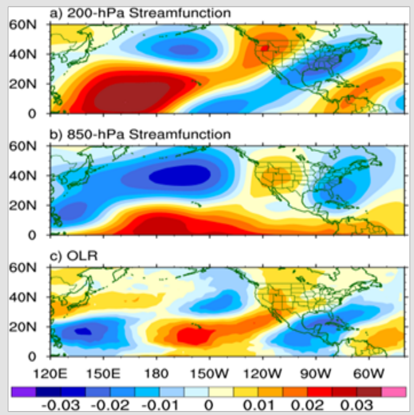
Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

NOAA CDRs are Being Used to Improve Monthly to Seasonal Forecasts

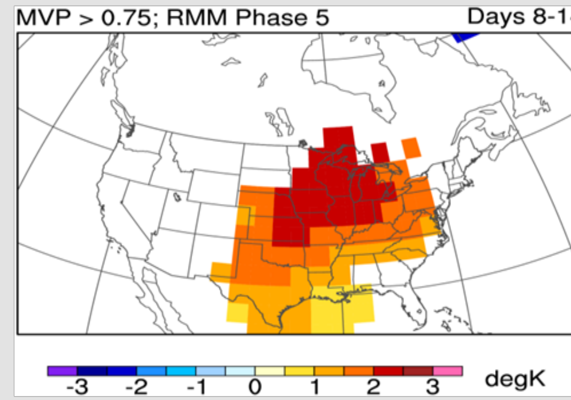
Satellite CDRs



Reanalysis



Improved 2-week Forecast



- **NOAA's Outgoing Longwave Radiation (OLR) CDR is used to measure the Madden-Julian Oscillation (MJO) evolution**
- **Reanalysis leads to estimates of the future MultiVariate Pacific-North American (MVP) index**
- **MJO plus MVP provides a useful forecasting tool for future extratropical responses over US**

Courtesy of ***Dr. Carl Schreck****,*
CICS-NC

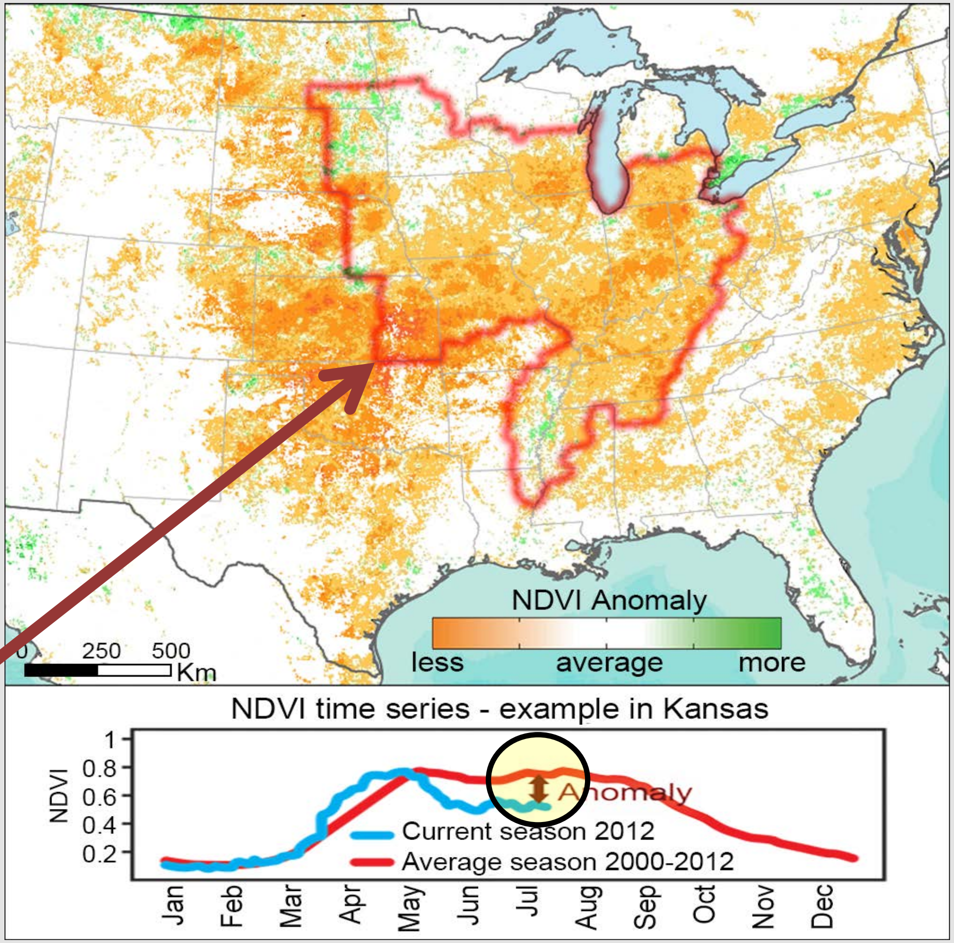
NOAA CDRs Supporting Farming / Agribusiness

Enables understanding of anomalies and discovery of analogs.

- Subset of 5-km resolution, “wall-to-wall” global NDVI CDR.
- Historical record from **1981- to Present.**
- Env. Variables Also Available:
  - Surface Reflectance
  - Leaf Area Index (LAI)
  - FPAR (photosynthetically active radiation)

Primary U.S. Corn and Soybean Production Region

2012 U.S. Drought as depicted using Vegetation Index CDR for July 17th



NOAA CDRs Supporting Resource Management

Example: Forest Change Detection Using NOAA CDRs

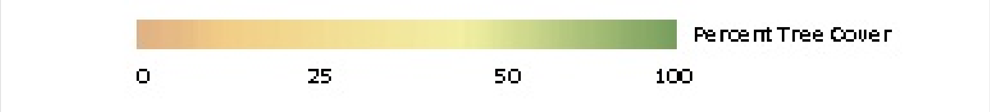
Percent Tree Cover Change in the Amazon Basin

1990 (AVHRR NOAA CDRs)

2000 (MODIS Data)

2010 (MODIS Data)

AVHRR-based NOAA CDR Variables:



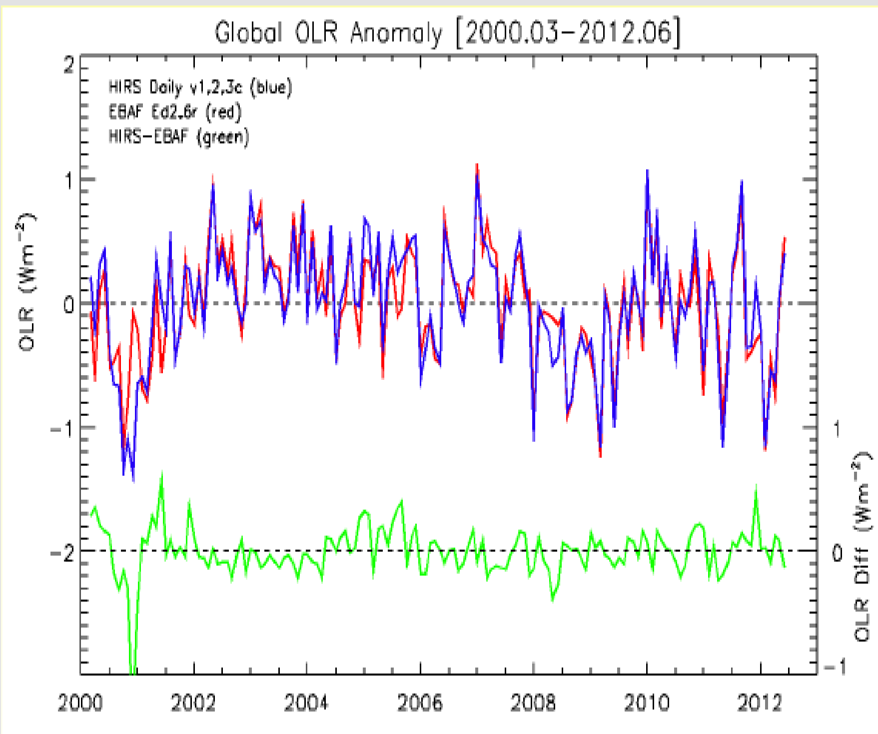
- Normalized Difference Vegetation Index (NDVI)
- Leaf Area Index (LAI)

http://www.ncdc.noaa.gov/cdr/operationalcdrs.html

(Courtesy of **Dr. Eric Vermote**)

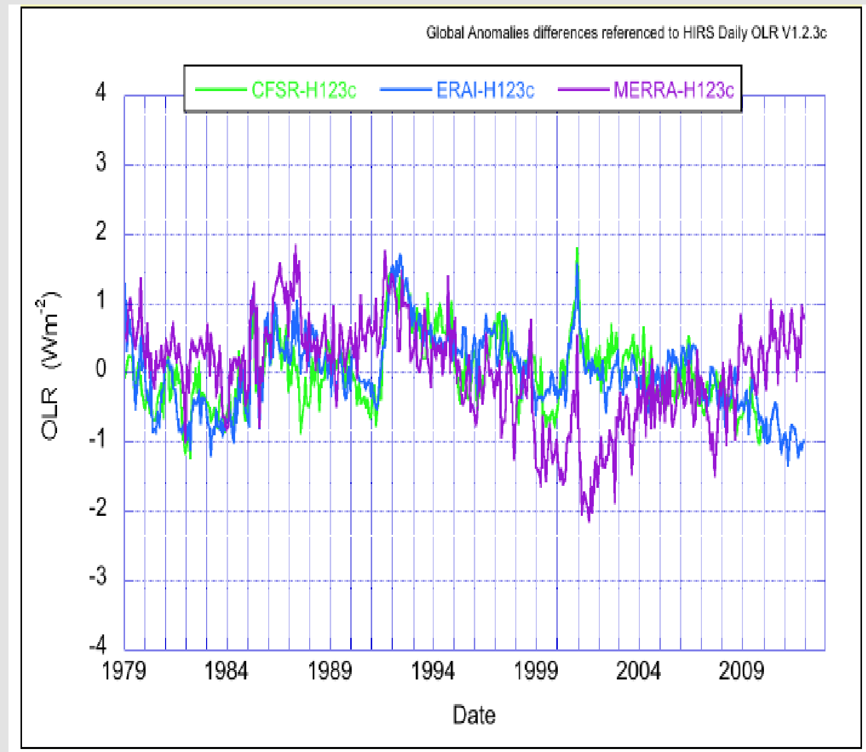
NOAA CDRs Support Climate Analysis
and Climate Model Improvement

Difference of Global OLR Anomalies
(Long-term HIRS CDR vs. Short-term CERES CDR)



Slope of OLR anomalies diff = 0.03 ± 0.09 Wm^{-2}/decade with 2-sigma

Difference of Global OLR Anomalies
(Reanalysis minus HIRS CDR)



Near-Term Major Activities

- **O&M (Sustainment)** for CDRs that Evidence Continued User Demand
- **End-User Application Projects** that Verify CDRs alone, or in combination with other Products, Can Meet Specified User Needs (may precede R2O)
- Complete the **R2O Transitions** Backlog
- Transition **Period of Record Extensions** to CDRs Using New Sensor Data (from SNPP/JPSS, NASA-GPM, METOP, etc.)
- With NOAA/NESDIS/OSGS and other Partner assistance, determine best path for attaining a **CDR re-processing capability**

CDR Program's Vision - 2016 & Beyond

Meet End-User Needs for Environmental Information by:

- **Making vital contributions to an emerging market for a new class of environmental information products.**
- **REDRs** leveraging CDRP and Partner best practices, experiences and lessons learned.
- Acknowledging some Users require lower-latency products and are **willing to sacrifice accuracy to obtain decreased latency** (i.e. ICDRs and products derived from or blended with them).
- Addressing User needs across **multiple Societal Benefit Areas** (SBAs), including global climate change research.

Questions?

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

Backup Slides

CDRs Supporting Resource Management

Example CDR Application: USDA *Forest Change Detection*

Background

- USDA and NASA are collaborating to develop a capability to assess forest health using a satellite-derived Vegetation Index.

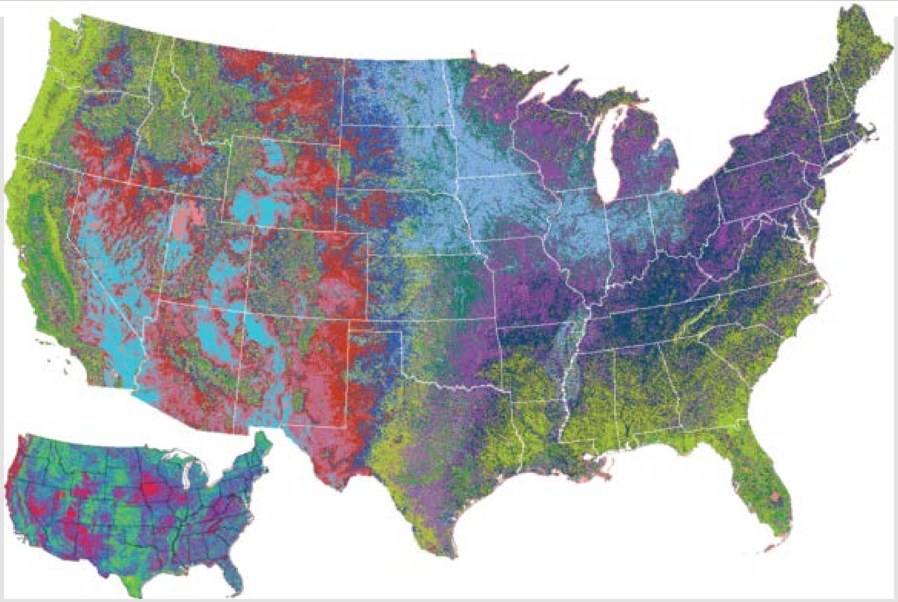
NOAA CDR Contribution

- Verify the feasibility of using NOAA's operational NDVI CDR. If successful, NASA's research can be "operationalized" by USDA, since the NOAA CDR is an operationally sustained product.

Expanding ranges of forest scavengers, linked to climate trends.

Gypsy Moth Larvae

Pine Beetles



Expected Output and Impact

- NOAA CDR Program sustains a 30-year times series Vegetation Index suitable for identifying forest health trends, enabling improved U.S. forest resource management.

Partners

- USDA Southern Research Station, NASA, and NOAA.

Enterprise Plan for Algorithm Development and Integration to Operations

August 28, 2015

Walter Wolf

Slides from the following people were used:

Tom Schott
NOAA/NESDIS, Office of Satellite Ground Services (OSGS)
Jaime Daniels and Lihang Zhou
NOAA/NESDIS, Center for Satellite Applications and Research (STAR)
Shanna Sampson, Tom King, and Bigyani Das
IMSG, Inc.

Look towards the future

- Little or no monies are available to maintain older operational satellite science algorithms as GOES-R and JPSS systems are developed and become operational
- OSPO is looking to retire products and product systems as new products become operational
- OSGS is moving towards one Ground Enterprise ARchitecture System (GEARS) where the algorithms become services

Current Algorithm Problem

- Multiple versions or type of algorithms for similar products are run in operations

- Multiple versions of algorithms are running in different systems on different hardware within OSPO

Solution

- Develop Enterprise Algorithms

- Implement Enterprise Algorithms within common system within OSPO
  - Eventually the GEARS system

Enterprise Algorithm Definition

- An enterprise algorithm is algorithm that uses the same scientific methodology and software base to create the same classification of product from differing input data (satellite, in-situ or ancillary)

Motivation – Users

- Brings continuity of NOAA products between current and future NOAA operational satellites

- Supports the NWS Office of Science and Technology's implementation strategy of multi-sensor algorithms and products

Motivation – NESDIS

- Enterprise Algorithms have the following advantages:
  - Continuity of NOAA products between current and future NOAA operational satellites
  - Cost effective processing for NOAA products
  - Maintenance of fewer algorithms and systems within operations
  - One transition of the algorithm service to the GEARS system

Algorithms

Types of Algorithms

- Individual – One algorithm suite per program per instrument (stovepipes)
- Linked – Algorithms that are developed for one instrument and may be dependent upon other products from that instrument (JPSS and GOES-R)
- Individual Enterprise Algorithm Suite – Algorithms that run on multiple instruments within one system
- Complex Enterprise Algorithm Suite – Algorithms that run on multiple instruments that have been designed to be transitioned to GEARS

Individual Algoritms

- Independent software base
- Minimal software reuse – algorithm team must develop data readers and writers for the instrument used
- Project only hardware – may or may not be shared with other instrument algorithms
- Medium development cost
- High maintenance cost

Linked Algorithms

- New system for new algorithm suite
- Products are linked together – product precedence
- Coordinated product development
- Project does not care about other satellites and/or instruments – requirements outside the project have no weight
- High cost
- System complexity determines maintenance cost

Individual Enterprise Algorithm Suites

Individual Enterprise Algorithm Suites

- Individual Enterprise Algorithm Suite is a program that has been developed by a science team to create their suite of products for multiple satellites
  - AVHRR Clear-Sky Processor for Oceans (ACSPO) – SST for polar satellites, currently being updated to process AHI data
  - Microwave Integrated Retrieval System (MiRS) – Microwave product suite for most microwave instruments
  - NESDIS Unique CrIS and ATMS Product System (NUCAPS) – Sounding product suite created using AIRS, IASI and CrIS hyperspectral sounding data

Software

- Algorithm methodology and software is reused for multiple instruments
- Reduced algorithm development time
- Algorithms and software may not have been designed to be transitioned into a service base system

Issues: Run in Multiple Systems

- The Enterprise Algorithm Suites are currently run in multiple processing systems within OSPO
- Different versions of the suites are run in each of the processing systems
- Regression tests may not be conducted – deliveries for each instrument individually

Steps Towards GEARS

- Consolidate Enterprise Algorithm Suites onto one or two processing system within OSPO
- Remove versionitis by conducting regression tests for the products
- Minimize software deliveries by updating algorithm for multiple satellites at once
- Evaluate algorithm implementation and work with STAR development team to create GEARS like algorithm service interfaces

Complex Enterprise Algorithm Suite

Complex Enterprise Algorithm Suite

- STAR Enterprise Processing Framework
- Overall program that keeps common data in memory
  - Individual algorithm teams create their own subroutines to plug into the program
  - Algorithm teams are dependent upon products from other algorithm teams
- Redundancy removed that is common amongst algorithms

More Enterprise Algorithms

- Work is being conducted to modify NOAA Heritage Cloud, Cryosphere, Volcanic Ash, and Aerosol algorithms to work on VIIRS data

- For most products, the heritage algorithm is the GOES-R algorithm.

- This will bring scientific consistency between the GOES-R products and VIIRS products

VIIRS and GOES-R Cloud Products

- Cloud Mask
- Cloud Top Phase
- Cloud Type
- Cloud Top Height
- Cloud Cover Layers
- Cloud Top Temperature
- Cloud Top Pressure
- Cloud Optical Depth
- Cloud Particle Size Distribution
- Cloud Liquid Water
- Cloud Ice Water Path

(All GOES-R heritage)

VIIRS and GOES-R Aerosol Products

- Aerosol Detection
- Aerosol Optical Depth
- Aerosol Particle Size

- Volcanic Ash Mass Loading
- Volcanic Ash Height

(All GOES-R heritage)

VIIRS and GOES-R Cryosphere Products

- Binary Snow Cover
- Fractional Snow Cover
- Ice Concentration and Cover
- Ice Surface Temperature
- Ice Thickness/Age

(Ice products have GOES-R heritage, Snow products have operational heritage)

Cloud and Wind Enterprise Algorithms

- Cloud algorithms from AVHRR and GOES are being migrated to a common software base (the SAPF) in operations

- Derived Motion Winds algorithms from AVHRR and MODIS are being migrated to a common software base (the SAPF) in operations

- All cloud and wind products in operations will be consolidated when these projects are complete

Transition to Enterprise Algorithms

STAR ASSISTT

- The Algorithm Scientific Software Integration and System Transition Team (ASSISTT) designs and develops algorithm processing suites/systems that are transitioned to OSPO

- Once these satellite suites/systems are transitioned to operations, STAR works in coordination with OSPO to maintain the science within these systems.

- ASSISTT specializes in this end to end process (design, development, transition to operations, and maintenance) for algorithm processing systems and their products.

Satellite Algorithm Integration for Common Ground System

Tasks

Transition Algorithms and Processing Systems to Operations

- Lead Process Lifecycle Reviews
- Provide scientists with software development guidance
- Integrate algorithms into processing systems
- Perform unit, regression and system tests
- Package and deliver algorithms/systems to OSPO
- Requirements development and tracing
- Configuration Management
- Risk Management
- Implementation of one program to create all satellite products
- Implementation of a hardware cluster for algorithm testing and reprocessing

Projects

Supported by ASSISTT

- GOES-R
- JPSS
- NDE (Six projects)
- Himawari-8
- GCOM (AMSR-2 Instrument)
- GOES Clouds, Winds, Fog, Land Surface Temperature, and Radiation Budget
- AVHRR Clouds and Volcanic Ash
- Product Tailoring
- Product Monitoring
- Direct Broadcast
- OSGS Algorithm Prototype

Enterprise

Implementation of the STAR Enterprise Algorithms *

- Winds – GOES-R ABI, Himawari-8, S-NPP VIIRS, GOES, AVHRR, SEVIRI, MODIS
- Cloud Products – GOES-R ABI, Himawari-8, S-NPP VIIRS, GOES, AVHRR, SEVIRI, MODIS, MTSAT
- Volcanic Ash – GOES-R ABI, Himawari-8, S-NPP VIIRS, AVHRR
- Cryosphere Ice Products – GOES-R ABI, Himawari-8, S-NPP VIIRS
- Aerosol Detection – GOES-R ABI, Himawari-8, S-NPP VIIRS
- Aerosol Optical Depth – GOES-R ABI, Himawari-8, S-NPP VIIRS

Steps towards GEARS

Transition Steps for Algorithms to GEARS

- Create Enterprise Algorithms
- Implement Enterprise Algorithms into a common system(s)
- Migrate common system Enterprise Algorithms to GEARS system

Motivation – OSGS

- Enterprise Algorithms have the following advantages for a GEARS implementation:
  - Development cost reduction
  - One transition of the algorithm to the GEARS system
  - Enables easier transition to algorithms a service

Summary

- Enterprise algorithms are a logical step in the transition to the GEARS system
  - Consolidation of science
  - Consolidation of systems
  - Minimization of operational software to maintain

- Goal is for these enterprise algorithms to become GEARS services

Backup Slides

ASSISTT – Enterprise Algorithms

- Winds – GOES-R ABI, Himawari-8, S-NPP VIIRS, GOES, AVHRR, SEVIRI, MODIS
- Cloud Products – GOES-R ABI, Himawari-8, S-NPP VIIRS, GOES, AVHRR, SEVIRI, MODIS, MTSAT
- Volcanic Ash – GOES-R ABI, Himawari-8, S-NPP VIIRS, AVHRR
- Cryosphere Ice Products – GOES-R ABI, Himawari-8, S-NPP VIIRS
- Aerosol Detection – GOES-R ABI, Himawari-8, S-NPP VIIRS
- Aerosol Optical Depth – GOES-R ABI, Himawari-8, S-NPP VIIRS

Meeting Objectives

- ✓ **Review Science Teams Readiness for JPSS-1**
  - ✓ SDR/EDR Algorithm Development/Improvements for J1
  - ✓ R2O, Support for Operational flow Transitions
  - ✓ Schedules and Milestones
  - ✓ Cal Val plans
  - ✓ Major Accomplishments/Highlights Moving Towards J1
- ✓ **Review Science Teams Support for Suomi NPP**
  - ✓ Suomi NPP Long Term Monitoring and Adaptation to JPSS-1
  - ✓ Integrated Calibration Validation System (ICVS) for SDRs/EDRs
- ✓ **Interaction/Communication Among Stake Holders**
- ✓ **Feedback from User Community**

Please submit the RFA form or email me: Lihang.Zhou@noaa.gov

SDR Overview
(Ken Carey)

- The STAR JPSS SDR team has been reorganized to enhance the management and technical cohesiveness, effectiveness and delivery. STAR has close working relationships with NASA and vendor scientists for each of the instruments. The JPSS SDR major accomplishments in 2015 included:

- Completed comprehensive SDR Cal/Val Plans for JPSS-1. The cal/val tasks are presented with clear role and responsibility, task objective, expected outcomes, and lessons learned from SNPP
- Developed an offline CrIS full spectral resolution (FSR) SDR processing system and made the FSR products available to user community
- Developed ATMS radiance-based radiometric calibration, replacing Rayleigh-Jeans approximation in two-point calibration system
- Developed J1 VIIRS DNB waiver mitigation and delivered pre-operational software to IDPS program on-time, and implemented the operational straylight correction in DNB band
- SNPP OMPS earth view SDR products have reached the validated maturity level after updating LUTs of wavelength scale, solar irradiance and earth view radiance coefficients
- Integrated Cal/Val System (ICVS) – Lite version was successfully transitioned to GRAVITE for NASA Flight and OSPO operational uses

ATMS SDR Path Forward
Ninghai Sun

- JPSS-1 ATMS Readiness
  - Prepare for JPSS-1 ATMS TVAC regression testing
  - Derive JPSS-1 ATMS PCT using full radiance process algorithm using TVAC regression testing datasets
  - Test reflector emissivity correction algorithm
  - Evaluate striping noise for JPSS-1 ATMS
  - Validate JPSS-1 ATMS mounting matrix
- Prepare for ATMS SDR FRP operational implementation
- Develop ATMS reflector emissivity correction operational code for IDPS implementation
- Develop ATMS geolocation accuracy trending package for ICVS
- Keep supporting S-NPP ATMS scan reversal activities

VIIRS SDR Breakout Session 6a Summary (Changyong Cao)

- A successful and productive session;
- Presentations focused on J1 VIIRS readiness, waiver mitigation, instrument performance, and validation capability development;
- Presenters included STAR scientists, instrument vendor, NASA, and the Aerospace Corp. which facilitated excellent technical interchange.
- The team made significant progress toward J1 readiness:
  - STAR successfully delivered J1 VIIRS DNB geocode change as part of the waiver mitigation on schedule;
  - J1 VIIRS SDR LUT ver1.0 has been delivered;
  - Completed prelaunch data analysis and instrument characterization;
  - RSB autocal will be turned on in a week;
  - Validation capabilities have been expanded, including new tools for waiver validations;
  - Cal/Val plan has been developed, with additional field campaign preparation planned.

VIIRS SDR Breakout Session 6a Actions (Changyong Cao)

- A number of actions have been generated to address issues and challenges:
  1. Prepare and provide simulated images of I3 with noisy detector (d4), and DNB images with op21,op21/26 for the EDR teams;
  2. Investigate possible M5 biases relative to MODIS using spectrally flat targets;
  3. Determine the J1 VIIRS DNB extent of the extended earth view based on useful earth view scan angles;
  4. Prepare and provide the official parameters for the J1 VIIRS polarization for EDR teams to use in their algorithms;
  5. Re-assess the need for quarterly WUCD; deep dive analysis on BB calibration to mitigate impacts on SST spikes;
  6. Prepare reprocessing by researching the best approaches leveraging similar activities for the RSB; perform feasibility study of a SDR L1.5 product working closely with the SST team;
  7. Further verify the effect of NOVAS library updates (initially estimated to be up to 400m near the poles).

CrIS Breakout Session
Yong Han/Dave Johnson

- 8 Presentations cover various areas critical for both S-NPP and J1 mission with a focus on J1 readiness
- **Preliminary J1 SDR algorithm and calibration LUTs have been delivered and algorithm updates are progressing towards an on schedule delivery.** The cal/val team continues to make good progress in optimizing the performance of the SDR algorithm.
- **CrIS radiometric performance for SNPP and J1 is approaching levels sufficient for climate trending.**
- J1 and SNPP CrIS spectral calibration accuracy is on the order of 2 ppm.
- The J1 CrIS bit trim and impulse noise masks are ready for launch, and based on SNPP data techniques show promise for correcting the remaining few radiation spikes that slip through the current impulse mask.
- Good progress is being made on **further improvements to geolocation accuracy at the ends of the CrIS cross track scan.**
- A 2-hour CrIS SDR team face-to-face meeting was held on Thursday afternoon to discuss ongoing and future work

Sounding

Mark Liu/Tony Reale

- 16 presentations
- ***NWS forecasters support use of NUCAPS sounding products as a valuable tool via AWIPS-2***
- Presentations focused on scientific performance, utility and visions for NOAA sounding EDR on a global scale.
- NOAA/CPC uses OLR for precipitation diagnostic and verification
- Trace gas products are evolving with applications for air quality monitoring
- NASA OCO-2 very successful and good for CrIS CO2 validation
- Hyperspectral sounder on GEO (MTG) in 2019/2020 to provide new high resolution sounding and associated validation challenges
- CALWATER and other field campaigns provided hydrometeor and ozone testbeds
- International working group including NOAA/STAR coordinating on radiative transfer model comparisons and retrieval algorithms.

Ozone
Larry Flynn

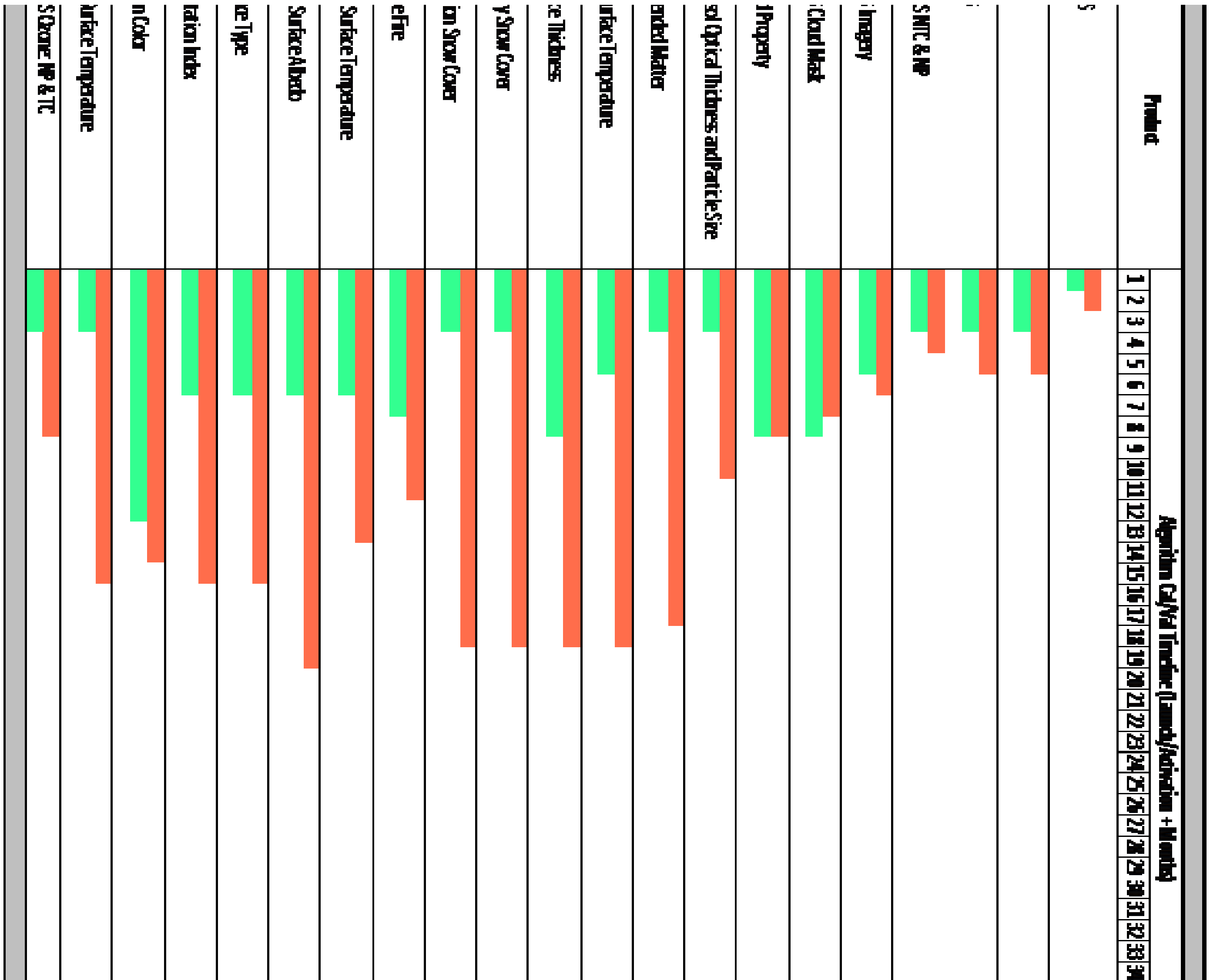
- The product session for ozone provided coverage of a busy and productive year for operations, applications and research.

- There was good progress as we delivered both the V8Pro and V8TOz as enterprise heritage algorithms and have high performing research versions of algorithms to generate SO2 and NO2 products.

- OMPS ozone products (total column, nadir profile and limb profile) are stable and precise and fulfill their role as the satellite component of NOAA's ozone monitoring system.

- Projects are underway that show the added value of ozone and other OMPS products for air quality, hazard identification and aerosols applications.

JPSS-1 vs. SNPP Cal Val Timeline Beta



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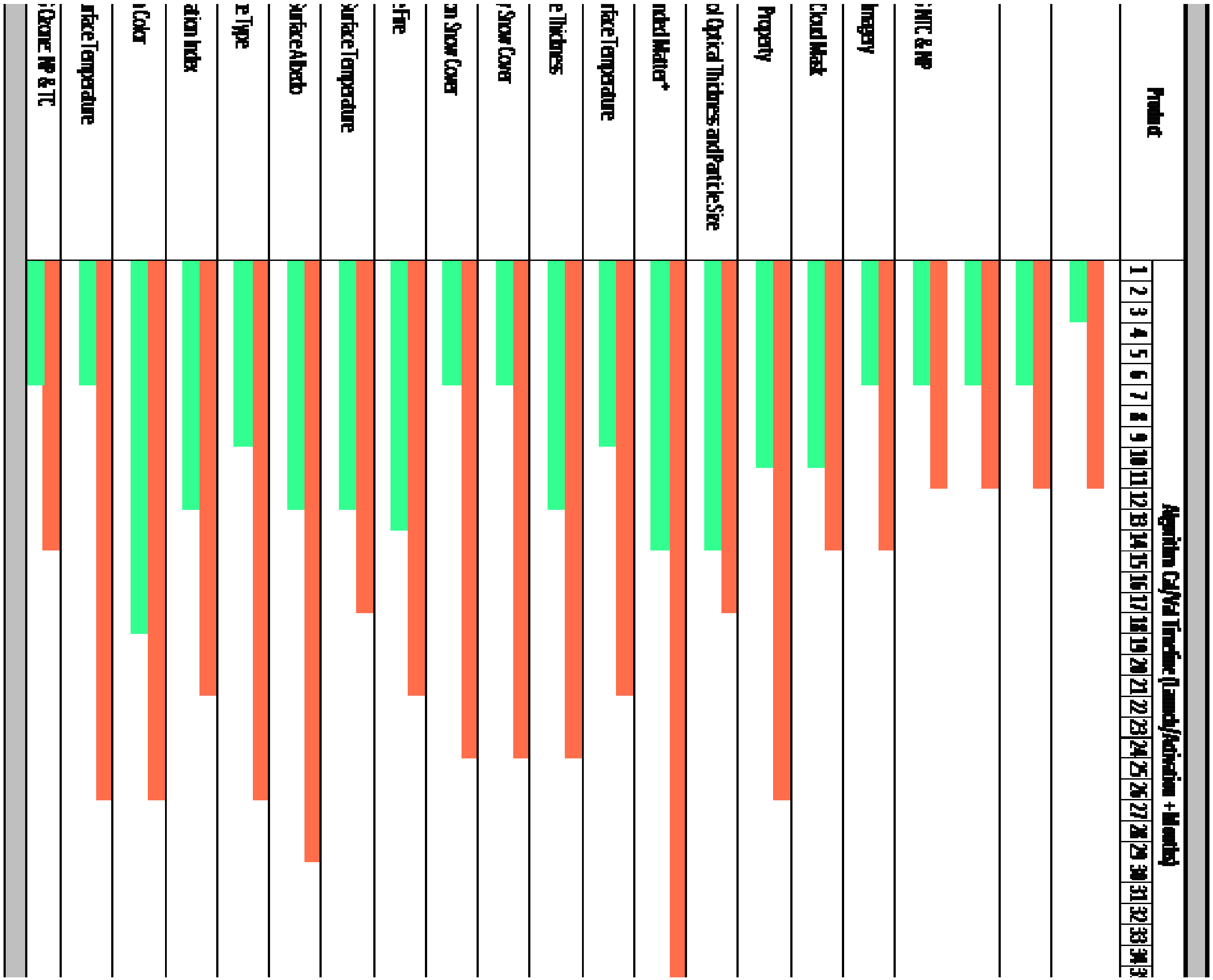
JPSS-1 vs. SNPP Cal Val Timeline Provisional



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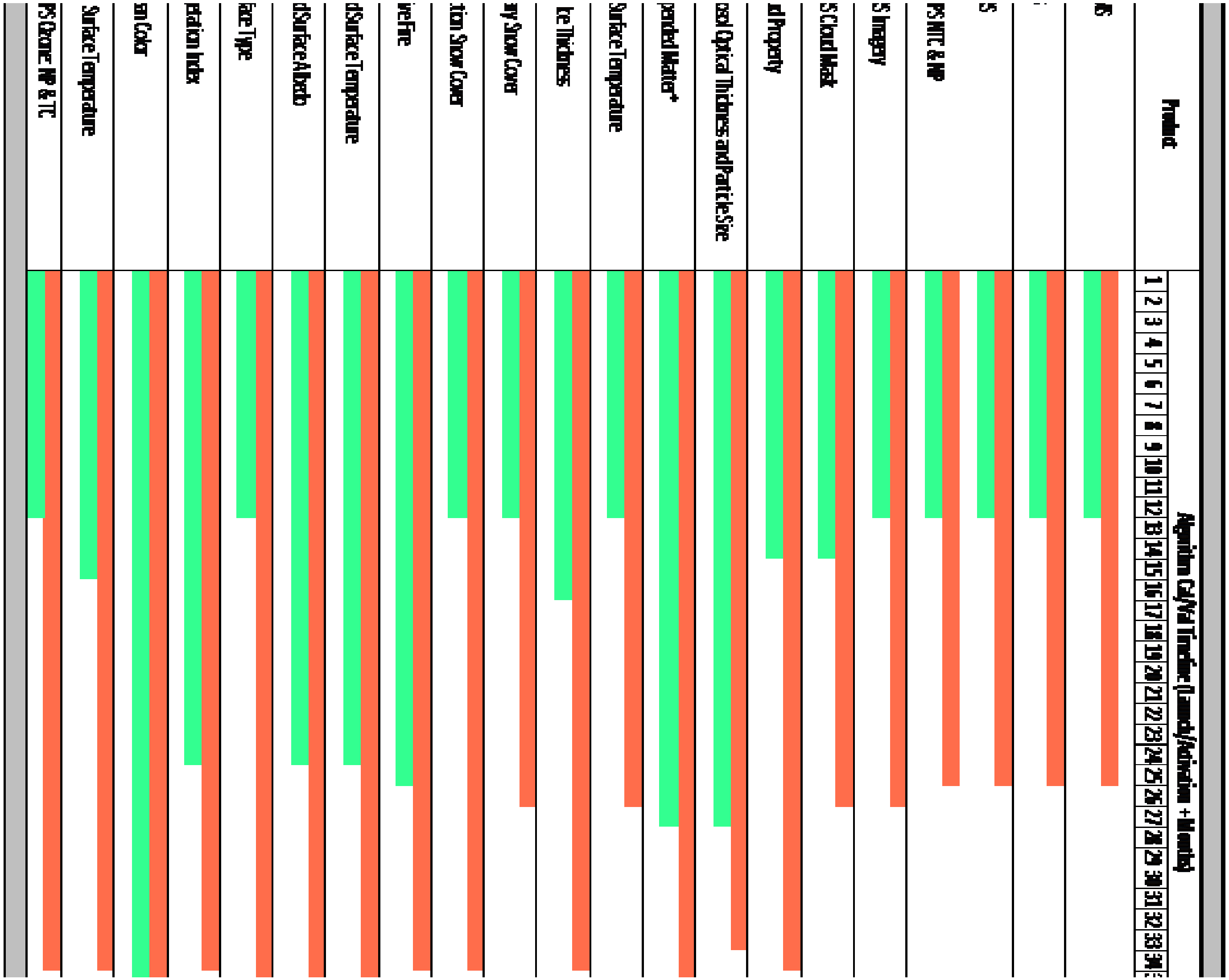
JPSS-1 vs. SNPP Cal Val Timeline Validated



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Near Term Actions

- **Finalize FY16 Plans**
  - Deliverables and Schedules
  - Finalize J1 Cal Val Plans
- **Enterprise Algorithm Detailed Roadmaps**
  - Each product team; timelines; reviews
  - Users interactions/facilitation
- **Coordinated Science Quality Data Processing**
  - Work with each team on setting up the capability
  - Work with key program stake holders on implementation, archive and distribution
- **J2 Waiver Analysis and Coordination**
- **Coming New JSTAR Teams:**
  - GCOM-W Cal Val/LTM (Paul Chang/Ralph Ferraro)
  - MIRS (Cal Val/LTM) (Jerry Zhan)
  - Vegetation Health/Fraction Cal Val/LTM (Marco Vargas/Felix Hogan)

NOAA NESDIS Mission & Challenge
From Steve's talk on Monday

Our mission is to deliver accurate, timely, and reliable satellite observations and integrated products and to provide long-term stewardship for global environmental information in support of our Earth Observation mission.

Our challenge is to provide these observations and products reliably while improving the information content and evolving to stay current with the expanding complexity of the Earth Observing contributors

We have made a lot of progress!
We still have a long way to go…

STAR JPSS 2015 Annual Sciences Team Meeting

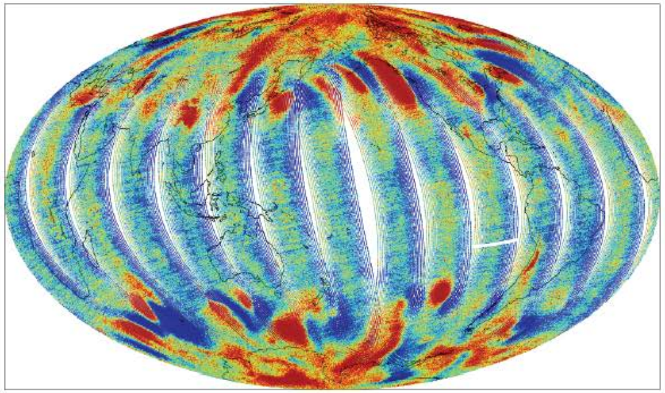
Session 6c ATMS SDR Summary

Prepared by: Ninghai Sun
Date: August 28, 2015

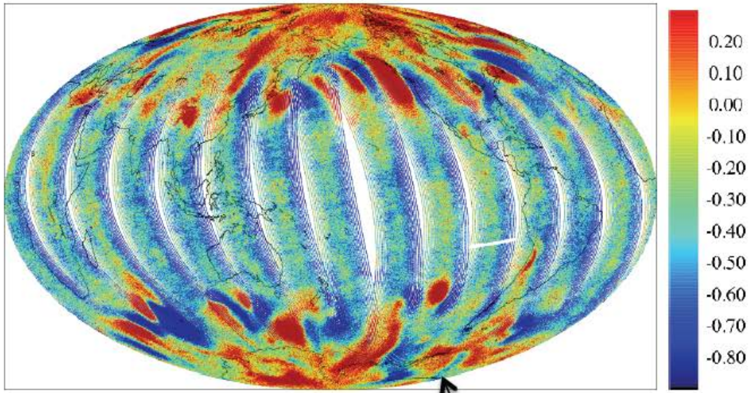
S-NPP ATMS Striping Mitigation

Global O-B Distributions of ATMS Channel 8

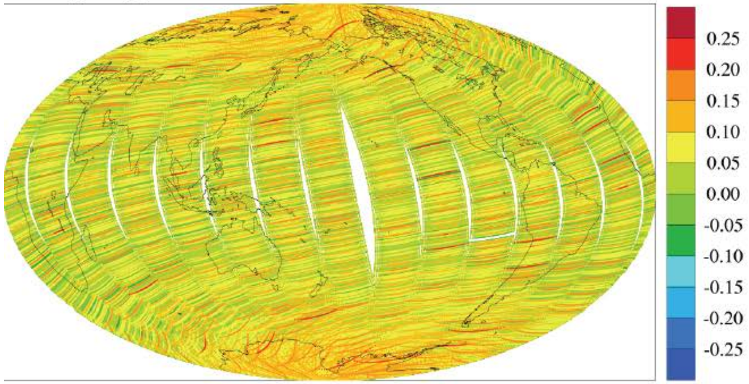
Before de-striping



After de-striping

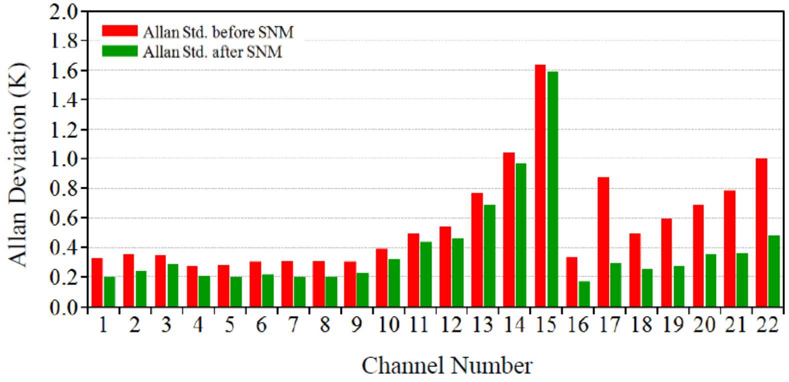


Striping noise filtered



Striping noise is not visibly seen anymore in the global O-B field after de-striping using the PCA/ SymFilter algorithm.

Channel noise is reduced after de-striping



Xiaolei Zou, *et. al.* (UMD/ESSIC)

JPSS-1 ATMS Readiness

Summary of ATMS Status

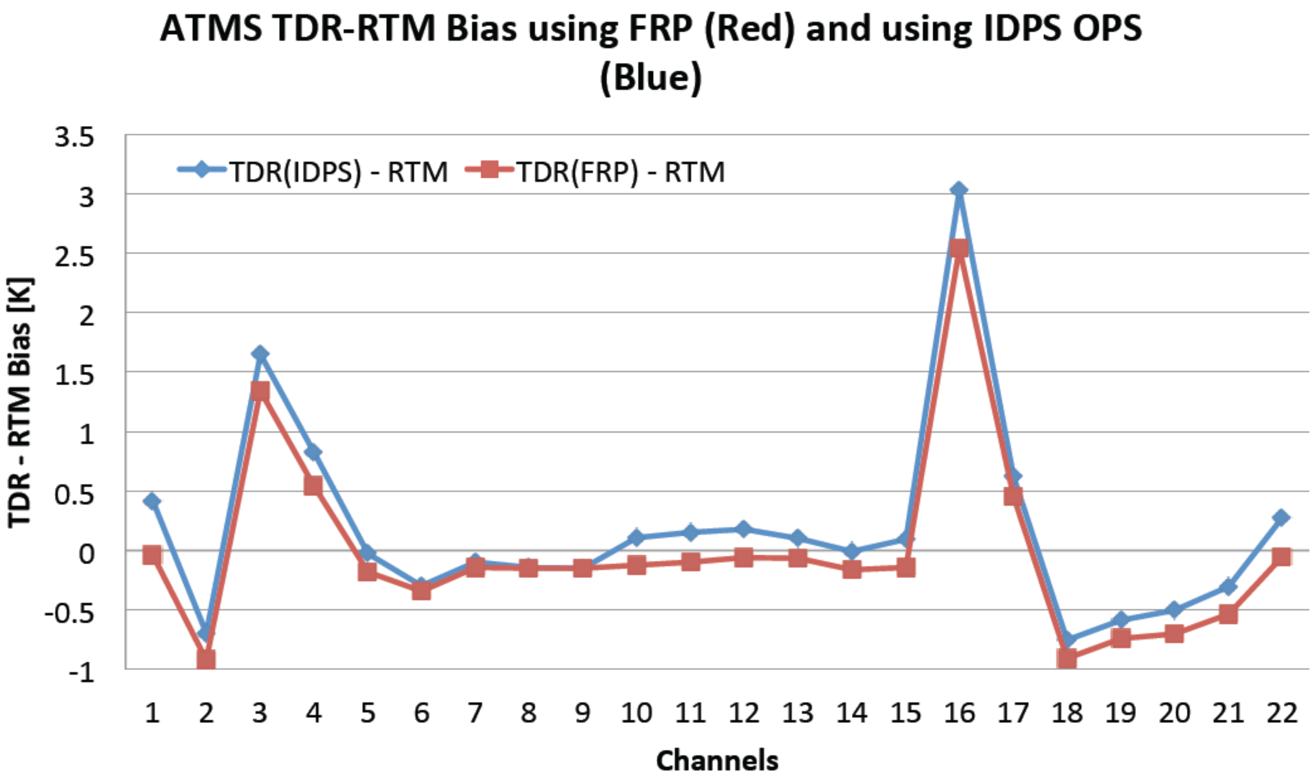
- <u>S-NPP flight unit status</u>
  - Post-launch validation activities have confirmed S-NPP ATMS is meeting or exceeding its performance specifications (see papers in S-NPP special issue of JGR)
  - On-orbit testing of scan drive mitigation (reversals) is in progress
- <u>J1 flight unit status</u>
  - just completed 1 year of re-work, and begun environmental re-testing
  - If environmentals are problem-free, J1 unit installs on s/c in Nov
  - J1 observatory-level tests partly done using EDU as stand-in
  - J1 observatory-level TVAC probably in early CY2016
  - If those tests stay on schedule, then launch date is looking good
- <u>J2 flight unit status</u>
  - procurements have begun

Ed Kim, *et. al.* (NASA/GFSC)

ATMS SDR Full Radiance Process (FRP)

Global Mean TDR-RTM Bias

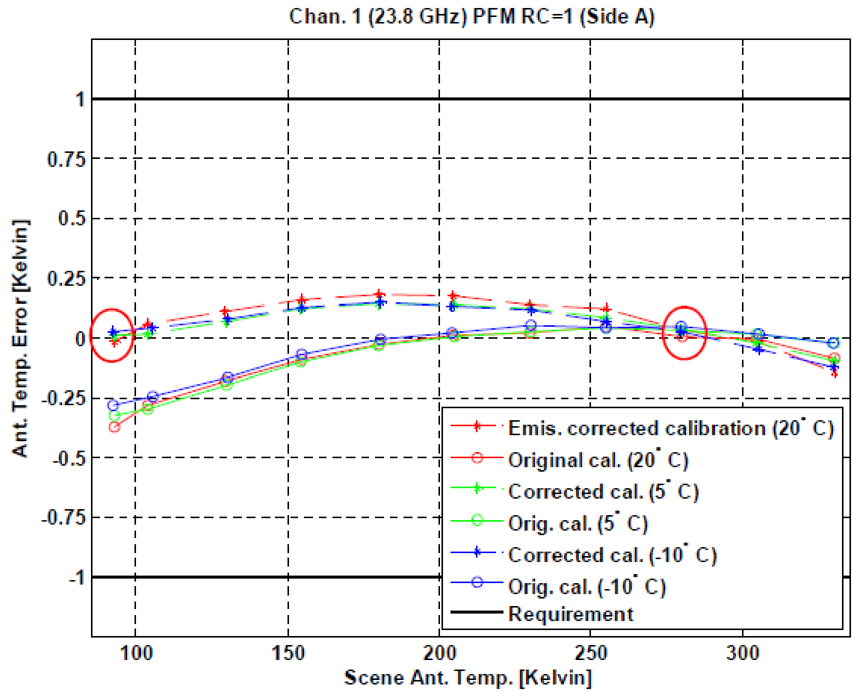
- Calibrated scene temperature from ADL-Full radiance are consistently lower than IDPS at all ATMS channels
- Major cause of the difference is due to the incorrect application of nonlinearity correction in IDPS

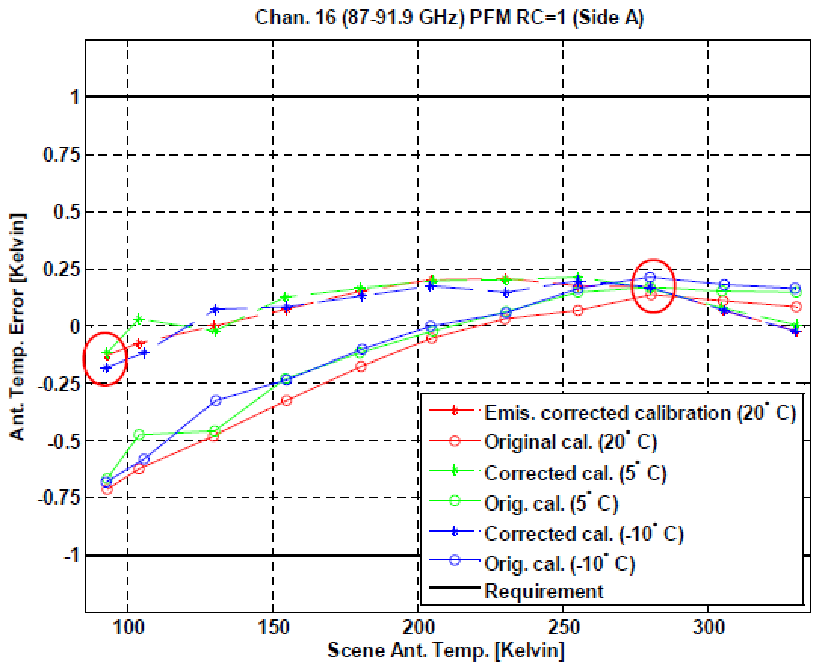


Hu (Tiger) Yang, *et. al.* (UMD/ESSIC)

S-NPP ATMS Reflector Emissivity Correction

Applying Correction to Calibration Testing

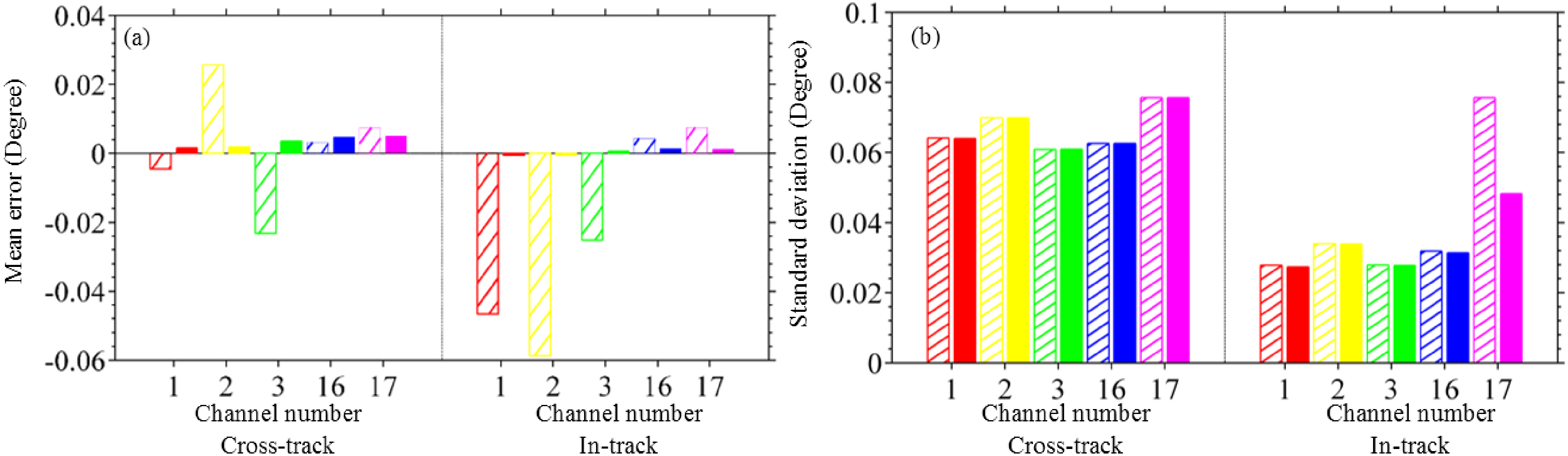




- The error of quasi-V channels moved close to zero at the two calibration points
- V-band quasi-H channels also moved closer to zero

Vince Leslie *et. al.* (MIT/LL)

S-NPP ATMS Geolocation Validation



	K	Ka	V	W	G
Roll	-0.0525	0.1645	-0.1967	-0.0103	0.0186
Pitch	0.3538	0.4388	0.1992	-0.0219	-0.0132
Yaw	-0.0938	-0.0594	-0.0524	0.0682	-0.0954

- S-NPP ATMS in-track and cross-track geolocation errors meet the requirement
- A rotation correction matrix is derived based on the analysis to improve the geolocation accuracy

Ninghai Sun, *et. al.* (STAR/ERT)

ATMS SDR Path Forward

- JPSS-1 ATMS Readiness
  - Prepare for JPSS-1 ATMS TVAC regression testing
  - Derive JPSS-1 ATMS PCT using full radiance process algorithm using TVAC regression testing datasets
  - Test reflector emissivity correction algorithm
  - Evaluate striping noise for JPSS-1 ATMS
  - Validate JPSS-1 ATMS mounting matrix

- Prepare for ATMS SDR FRP operational implementation

- Develop ATMS reflector emissivity correction operational code for IDPS implementation

- Develop ATMS geolocation accuracy trending package for ICVS

- Keep supporting S-NPP ATMS scan reversal activities