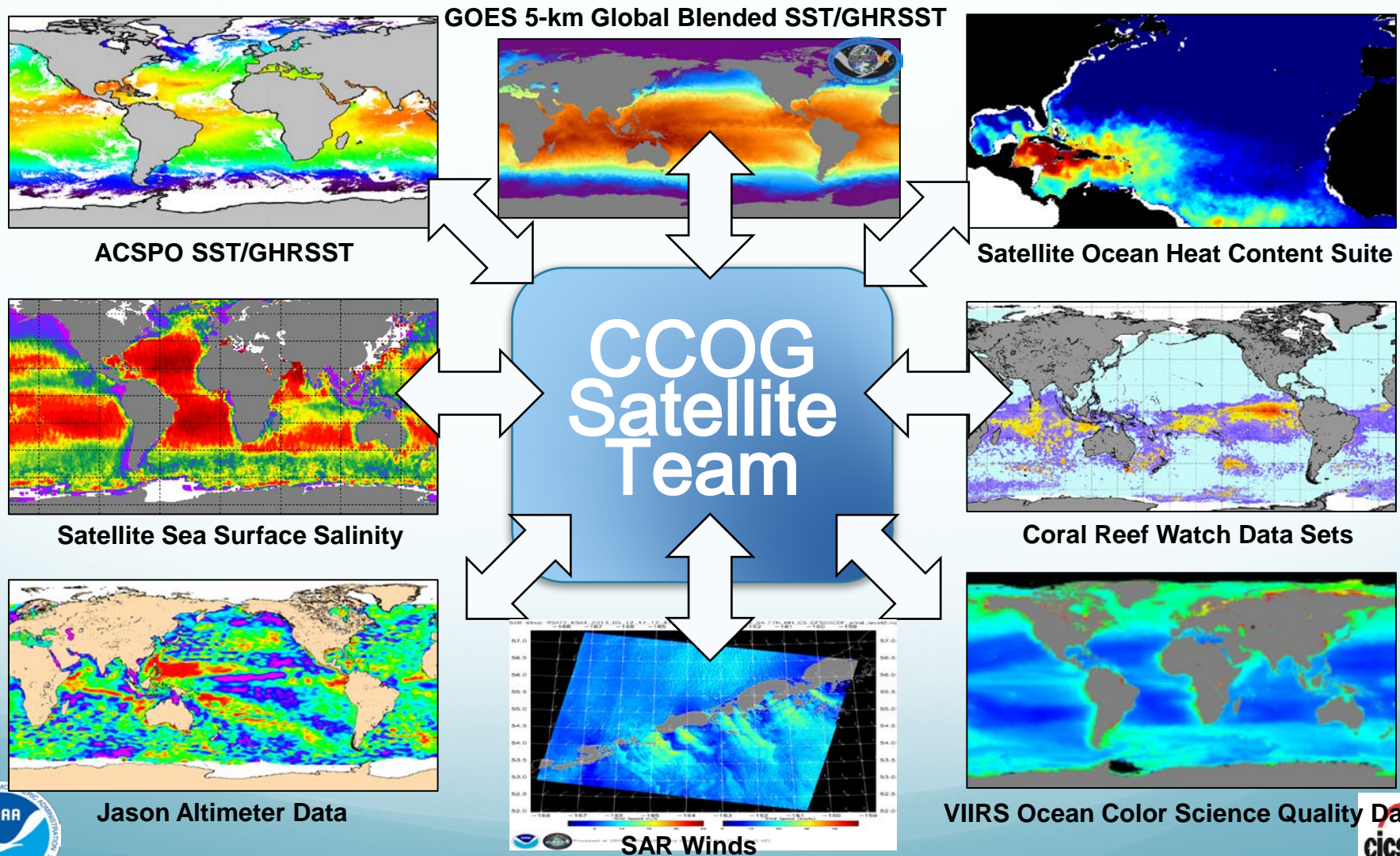# Scientific Stewardship of Ocean Satellite Data

Sheekela Baker-Yeboah[1,2], Korak Saha[1,2], Yongsheng Zhang[1,2], Dexin Zhang[2,3]

[1]University of Maryland CICS, [2]NOAA/NESDIS/National Centers for Environmental Information (NCEI), [3]Science and Technology Corporation

NCEI interacts with STAR to archive data products, provided quality control, generates data products, and make data discoverable to users

GOES 5-km Global Blended SST/GHRSST

ACSPO SST/GHRSST

Satellite Ocean Heat Content Suite

CCOG Satellite Team

Satellite Sea Surface Salinity

Coral Reef Watch Data Sets

Jason Altimeter Data

SAR Winds

VIIRS Ocean Color Science Quality Data

CCOG Stewards the following satellite products

STAR

- National Polar-orbiting Partnership Visible Infrared Imager Radiometer Suite (NPP-VIIRS) Ocean Color Reprocessed Data
- Synthetic Aperture Radar (SAR) winds
- Coral Reef Watch (CRW)
- Group for High Resolution SST (GHRSST), including VIIRS ASPO SST, GOES products, …
- NOAA Jason Ground System
- Sea Level Rise (Jason Data)
- Satellite ocean heat content (SOHC)

NCEI

- Pathfinder Sea Surface Temperature
- Coral Reef Temperature Anomaly Database (CoRTAD)
- OISST (blended with in situ)
- Satellite Sea Surface Salinity (SSS) [STAR and Non_STAR products]

CCOG and STAR Interactions

NCEI: Krisa Arzaus, Rost Parson, Sheekela Baker-Yeboah, Yongsheng Zhang, Korak Saha, Viva Banzon, Zhankun Wang,Tim Boyer

STAR: Paul DiGiacomo, Veronica Lance, Menghua Wang, Eileen Maturi, Eric Bayer, John Lillibridge, Eric Leuliette, Laury Miller, Frank Monaldo, Christopher Jackson, Gang Liu, Alexander Ignatov

NOAA/NESDIS/STAR

- STAR (the Center for Satellite Applications and Research) is the science arm of the NOAA Satellite and Information Service.

www.star.nesdis.noaa.gov/star/index.php

NOAA/NESDIS/NCEI/CCOG

- Scientific Archival Stewardship of the nation's Ocean Satellite Data is provide by NCEI

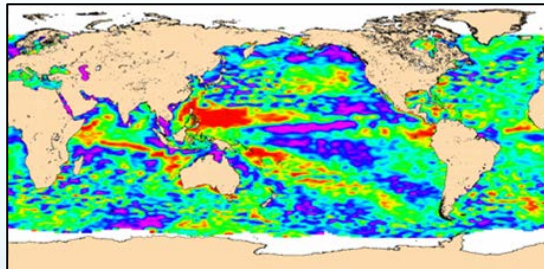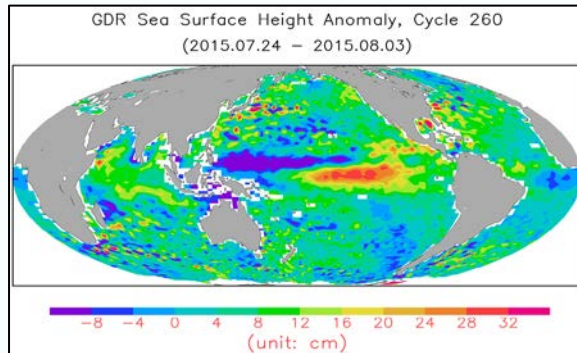 - CCOG Surface Ocean Section leads both ocean satellite and surface in situ stewardship efforts

www.ncei.noaa.gov

Data Example 1: Jason Altimeter data pipeline

NOAA/NESDIS/STAR

GDR Sea Surface Height Anomaly, Cycle 260
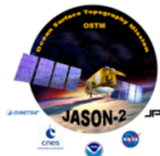(2015.07.24 – 2015.08.03)

NOAA/NESDIS/NCEI

NCEI/CCOG Satellite Team is important to NESDIS operations

- NCEI provides a mirror service for Jason data, replicating all GDRs directly from NOAA's (operational, limited-access) distribution service

- NCEI provides open and quick access to the Jason 2 data, <u>important to the Cal/Val analysis being done by STAR for Jason2 and Jason 3</u>

- NCEI provides reconciliation services to cross-check the US Jason records with those of the French space agency Centre National d'Études Spatiales (CNES)

- NCEI participates in NJGS Weekly Team Meetings

- NCEI archives STAR SLR product

NOAA NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

formerly the National Oceanographic Data Center (NODC)... more on NCEI

Satellite Oceanography Group

NODC Jason Archive

Latest Updates

- Data News
- xGDR Operations Messages

Introduction

This site contains an overview of the NOAA services being provided by the Satellite Oceanography Group of National Centers for Environmental Information (NCEI) for the Jason-2 (note: Jason-2 is also known as the Ocean Surface Topography Mission or OSTM) and Jason-3 satellites altimetry missions.

Background

The Jason-2 satellite launched 20 June 2008 and is the latest in a series of ocean altimeter missions designed to observe ocean circulation, sea level rise, and wave heights. Earlier altimeter missions include Geosat and Geosat Follow-On satellites, which flew in 1985-1989 and 1998-2008, respectively, and the TOPEX/Poseidon (1992-2005) and Jason-1 (2001-present) missions, which were launched into the same orbit now occupied by Jason-2. Jason-3 is a follow-on mission to OSTM/Jason-2, which was launched on January 17, 2016. Jaosn-3 will secure the continuity of high quality ocean altimetry measurements in support of climate monitoring, operational oceanography and seasonal forecasting.

Jason-3 Level-2 X-GDR Data Access

- **HTTP:** http://data.nodc.noaa.gov/jason3/
- **FTP:** ftp://ftp.nodc.noaa.gov/pub/data.nodc/jason3/
- **OPeNDAP:** http://data.nodc.noaa.gov/opendap/jason3/
- **THREDDS:** http://data.nodc.noaa.gov/thredds/catalog/jason3/catalog.html
- **Jason-3 Products Handbook**

Jason-2 Level-2 X-GDR Data Access

- **HTTP:** http://data.nodc.noaa.gov/jason2/
- **FTP:** ftp://ftp.nodc.noaa.gov/pub/data.nodc/jason2/
- **OPeNDAP:** http://data.nodc.noaa.gov/opendap/jason2/
- **THREDDS:** http://data.nodc.noaa.gov/thredds/catalog/jason2/catalog.html
- **Jason-2 Products Handbook**

Quality Monitoring of the Science Data

For deriving long-term quality measurements on Jason satellite data, we have developed a climate-oriented quality monitoring system. This system uses the Rich Inventory concept developed at NGDC, providing a searchable database for tracking and discovering data quality, metadata, and data set attributes. A near real time data quality check comprising of 8 statistics calculated on 23 parameters is performed as each Level-2 data file is ingested into NCEI's archives.

- **Quality Monitoring:** Jason-2/3 GDR and IGDR quality monitoring

Frequently Asked Questions (FAQ)

- What is the difference between the OGDR, IGDR and GDR?

  A. The Operational Geophysical Data Record (OGDR) is produced within 1-2 hours of the satellite overflight. It has the lowest quality data and the most missing data. However, it is useful for time-critical applications. The Interim GDR is produced within 1-2 days of overflight. The orbital quality is far better. The science-quality "final" GDR is produced with a 60-day time lag. Note: A new, experimental OGDR is being produced at JPL within 7-9 hours of overflight. The quality of orbital information is equivalent to that of the IGDR. It is listed below.

Jason-2/3 Archive Quality Monitoring

Subscribe to RSS feed   [What is RSS?]

- **2015-Aug-10:Jason-2 IGDR product has been temporarily stopped**
  Jason-2 Cycle 261 IGDRs for passes 74 to 99 had large orbit errors and were withdrawn by CNES. Also, production of the IGDRs has temporarily stopped until the problem has been resolved.

Jason-2 xGDR Operations Messages

Subscribe to RSS feed   [What is RSS?]

- **Files exist on the DDS but not in CLASS**
  The following files exist on the DDS but not in ...

Archive Details

1. Requirements
2. Strategy
3. Submission Agreement
4. Services

Related altimeter datasets and products

These links will take you out of NCEI and we have no control over the content or whether these sites are kept up-to-date. Note that many of these sites require you to create a username and password in order to access the data.

- RADS (Radar Altimeter Database System) *
- High-quality experimental OGDRs from JPL. Note for RADS users: *RADS incorporates these.*
  - Jason-1
  - Jason-2
  - Envisat
- CTOH: high-frequency along-track data and coastal products
- PISTACH: experimental coastal products for Jason-2
- CNES Data Center a sister site with the official Jason-2 xGDRs, auxiliary and ancillary data as well as similar records for TOPEX/Poseidon, Jason-1, Envisat, and Cryosat. Hosted by AVISO.
- AVISO (gridded products and improved delayed-mode products)
- LSA CryoSat IGDR: The NOAA/NESDIS Laboratory for Satellite Altimetry has been producing Level-2 IGDR from CryoSat mission and provides anonymous ftp access to the data

NCEI works with the CLASS (Comprehensive Large Array-Data Stewardship System) within NOAA.

NCEI regulates the interactions with CLASS and the Data Provider and provides services to get data into the archive and to users.

- NCEI (user open access) and CLASS (user restricted access) generally ready to continue providing consistent access to the Jason 2/3 oceanographic satellite data via the CLASS Jason homepage:

- http://www.nsof.class.noaa.gov/saa/products/search?sub_id=0&datatype_family=JASON-XGDR&submit.x=13&submit.y=2.

## Quality Control Rich Inventory Statistics

- Extract metadata from granule headers and calculator descriptive statistics for the parameters in the files.

- Data anomalies are monitored and reported to interested parties (archivist, producer and users).
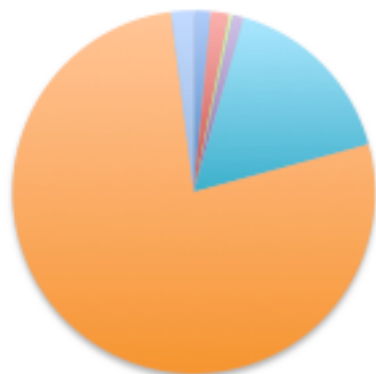
- Made available as part of data discovery system.

J3 IGDR Sea Surface Height Anomaly
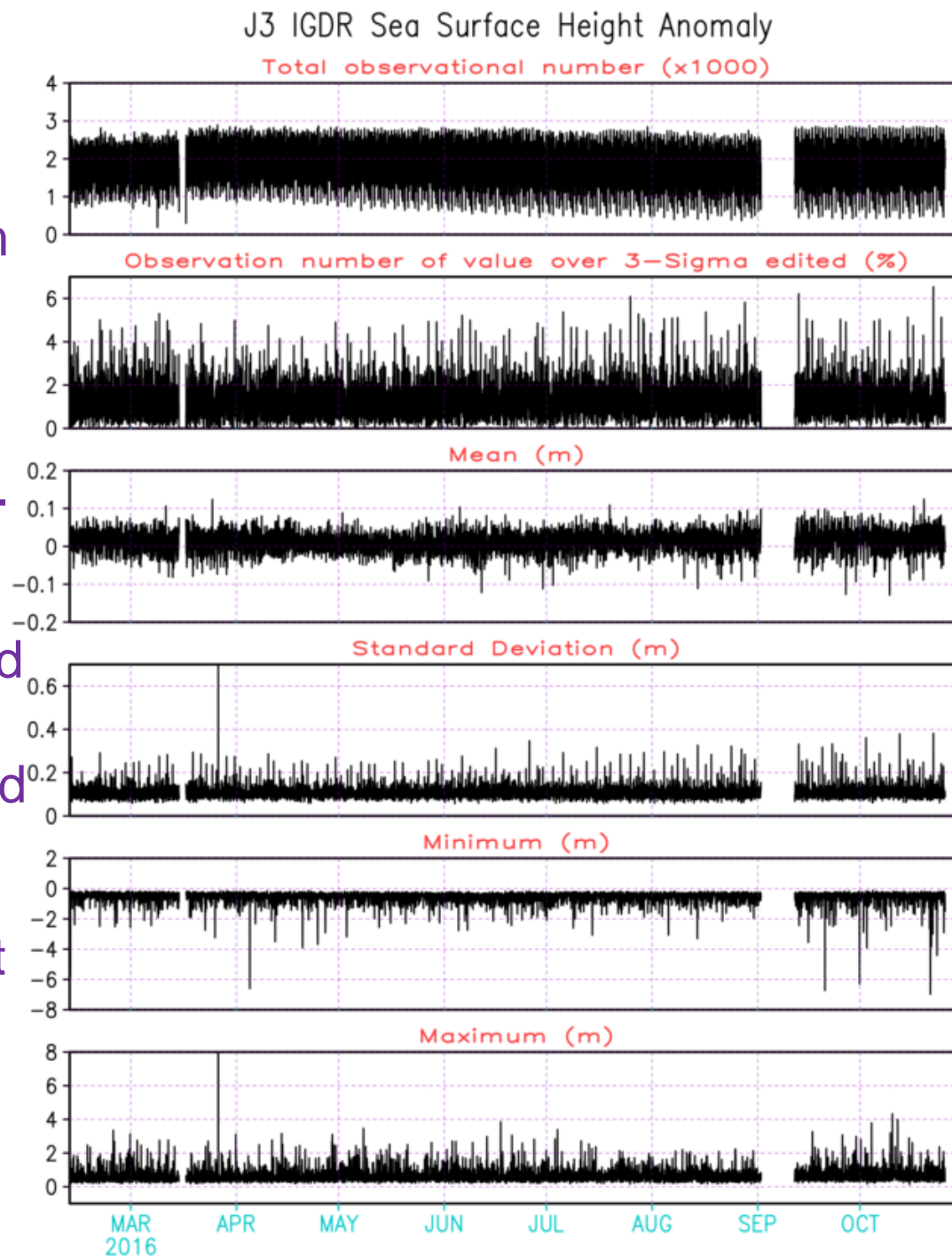
NOAA Jason User Communities (Broad)

- **Protocols** **for data continue to show**
  - **ftp downloads are preferred by users, as is anonymous access.**

All Downloads - by Host

Legend: OPeNDAP, WWW, FTP
X-axis: Q2 Hosts, Q3 hosts, Q4 hosts
Y-axis: 0 to 4,000
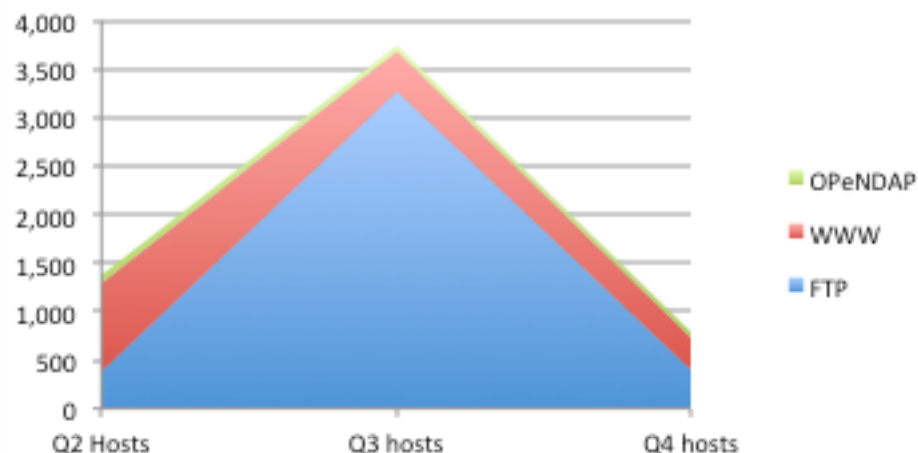
Open Access System Q4 Volume 7019 GB
- .noaa.gov
- other .gov
- .mil
- .edu
- .com
- foreign (67 countries + .int)
- unknown

Restricted Access System Q4 Volume 855 GB
- Domain .noaa.gov
- Domain other .gov
- Domain .mil
- Domain .edu
- Domain .com
- Domain foreign (CA, AU, IT)
- Domain unknown

J3 Monthly FTP Summary

```
month: #reqs: #pages:

--------: -----: ------:

Jul 2016: 10386:  10386:  ████████████
Aug 2016:  2091:   2091:  ██
Sep 2016: 19474:  19474:  ████████████████████
Oct 2016:  6407:   6407:  █████
```

J3 Monthly WWW Summary

```
month: #reqs: #pages:

--------: -----: ------:

Jun 2016:    13:     13:  ▪
Jul 2016: 19372:   1415:  ██████████████████
Aug 2016: 21048:   1403:  ██████████████████
Sep 2016: 14442:   1146:  ████████████
Oct 2016:  5091:   1647:  █████████████████████
```


Legend:
- noaa.gov
- rmit.edu.au
- 206.112
- nasa.gov
- 206.196
- apnic.net
- comcast.net
- 39
- optonline.net
- 109
- Other

~65%
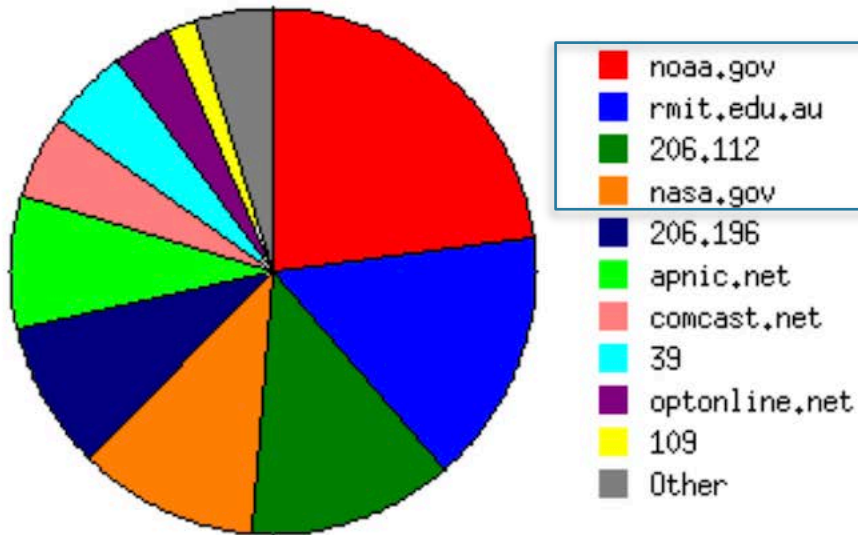
The wedges are plotted by the number of requests.

NOAA Jason User Communities (Broad)

USA Public Users

- **USA Higher Education (colorado.edu UMD, MIT, …)**

- **High Schools (Classroom Applications)**

- **Commercial (Googlebot.com Amazonaws.com, zinetcom.com)**

- **Networks (optonline.net)**

NOAA, NASA, Navy, NSF

- **NOAA Center for Satellite Applications and Research (STAR)**

- **NOAA Center for Weather and Climate Prediction (NCWCP)**

- **US Military Home land Security**

National/International

Australia	**Sweden**
China	**Ireland**
France	**Belarus**
Colombia	**New Zealand**
Commercial	**Taiwan**
Denmark	**Spain**
Guatemala	**Czech Republic**
Portugal	**Ukraine, .**
Peru	**…**
Russia	
Germany	**Other unresolved**
Thailand	**domains**
India	***RADS**
Singapore	***Other**
Latvia	
United Kingdom	
Mozambique	
Chili	
Vietnam	
Indonesia	
Iran	
Japan	
China	

Research Products/Topics

- **Sea Level Rise Response to climate change**
- **Global warming studies**
- **Sea Surface Height Anomalies**
- **Ocean Currents**
- **Ocean Wave Height and wave dynamics**
- **Ocean Bottom Topography**
- **Mesoscale Eddies**
- **Tropical cyclogenesis forecast**
- **Regional physical oceanography**
- **US and Non-US climate models and data assimilation**
- **Arctic Sea Ice, …**

Data Example 2: Satellite Sea Surface Salinity and in situ salinity data base (NCEI provides data products)

Level-2 (STAR)

Aquarius
- Data ended 1253 7 Jun 2015
- ADPS V4.0 released 17 Jul 2015

SMOS
- v622 near-real-time processing implemented 5 May 2015
  - Revised data format
  - Sea-ice thickness data now available
- SMOS v3.0 reprocessing (v622 algorithm)
- Calibration Data Bias: 15 Oct – 2 Dec 2014
  - Correction will be included in v3.0 reprocessing

Annual mean of NCEI-binned level-3 monthly sea surface salinity based on NASA Aquarius standard level-2 retrievals (September 2011 to May 2015)

Aquarius NCEI—binned ADPS V4.0

http://data.nodc.noaa.gov/SMOS/nodc_binned_V3.0/
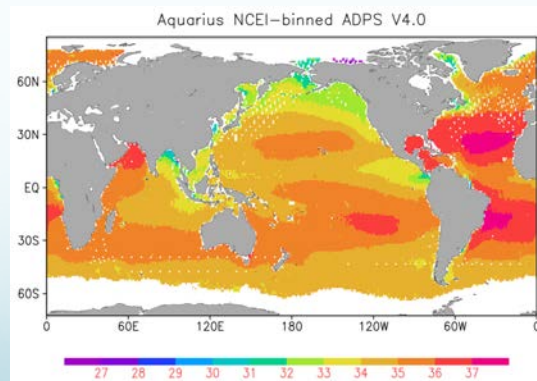
Level-3 (NCEI)

Aquarius
- 1°×1° binned products (7-day, monthly) produced
  - ADPS v3.0 update (without SST adjustment)
  - CAP v3.0 update (without rain adjustment)

SMOS
- 1°×1° binned product (3-day, monthly) produced

Sea Surface Salinity Databases
- Develop a thermosalinograph (TSG) database.
- Incorporate TSG, GTS, and World Ocean Database data into iQuam and 4SQM
- Effort to develop an overall matchup database for satellite data, eg. ocean color, SSS, and SST to improve IQuam

Data Example 3: NCEI interacts with STAR on VIIRS Ocean Color Reprocessed Data

VIIRS Ocean Color Reprocessed Data: Stewardship, archive, distribution and quality monitoring of satellite derived science-quality satellite data records and environmental data records (e.g. Level 2 and Level 3 water-leaving radiances, chlorophyll-a, diffuse attenuation coefficient). Stakeholders include NESDIS STAR, NMFS, societal applications, etc.

Work in progress!
Quarter 2 in archive
-moving forward with **OneStop** approach (CLASS as storage only)

Example: NCEI regulates the interactions with CLASS and STAR on VIIRS Ocean Color Reprocessed. (Satellite Team and DSD/Software Engineering efforts)

NCEI Satellite Team works with STAR PI,PS, Project leads
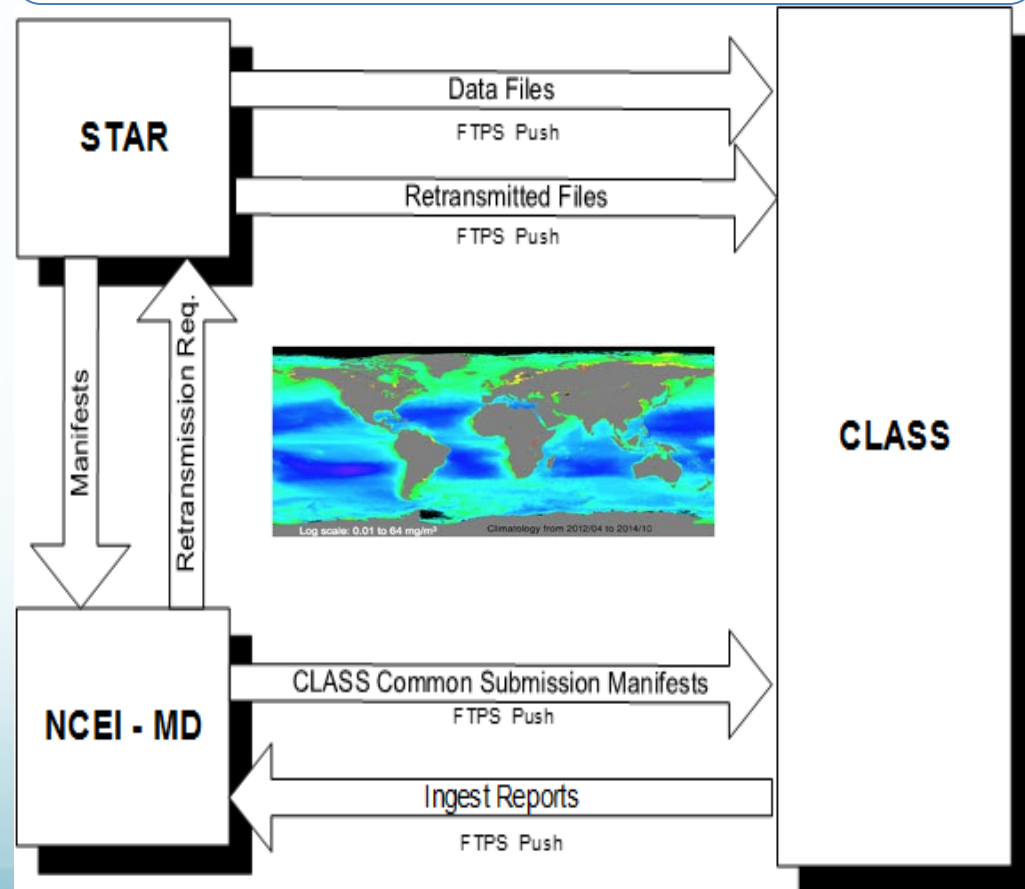
NCEI helping Data Providers meet requirements for archive and user access

Existing Services that will be expanded/migrated

Data Discovery services (all files)
- Federal Geospatial Digital Content (FGDC)-compliant metadata published via a Web Accessible Folder (WAF) supporting the NOAA Global Earth Observation - Integrated Data Environment (GEO-IDE)
- Catalog Service for the Web (CSW)

Data Access services - Level 2 data (science data)
- OpenDAP server
- ftp
- http
- Web Coverage Service (WCS)
- THREDDS Data Server (TDS)

Data Archive services (all files)
- Provision of versioning, offline backup and redundancy
- Comprehensive Large Array-data Stewardship System (CLASS)
- Data quality monitoring/notification for Level-2 products (e.g., Rich Inventory) (upgrade from *experimental* to *archive-operational*)

Data Example 4: Pathfinder Sea Surface Temperature Climate Data Record

Pathfinder v5.3 L3C sea_surface_temperature for 1981357 (night)

NCEI develops and maintains the high resolution, long-term, CDR of global satellite SST going back to 1981.
*The Pathfinder SST algorithm is applied consistently over the full time period.
*Compares well to CMC0.2 global foundation SST and OISST products.

Mean SST difference

Mean SST difference
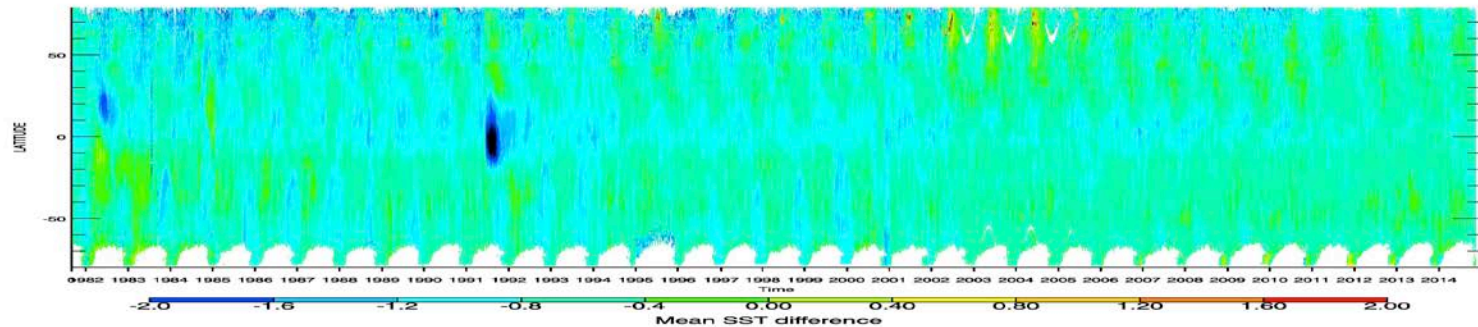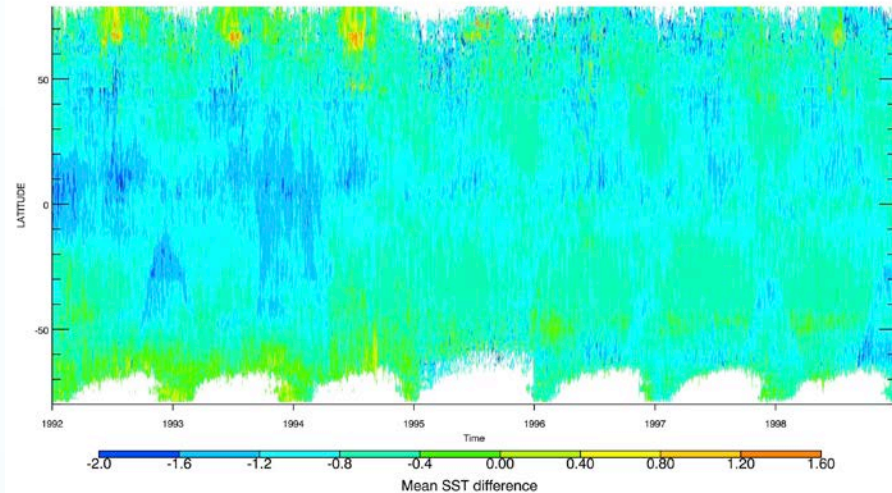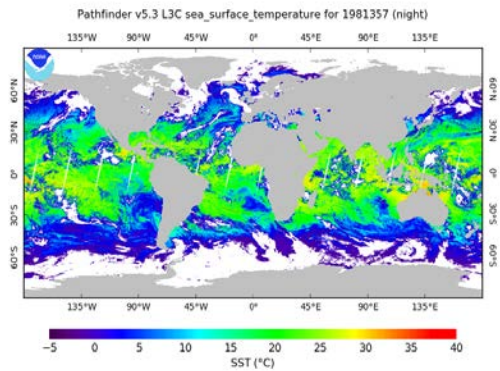
Looking Ahead: A PIES Database to come

*Sea Surface Height Variability from PIES (Pressure Inverted Echo Sounders) for groundtrack comparisons!

* PIES Time series comparisons reveal high correlation coefficients with Jason data
* Furt(e.g., Baker-Yeboah, Watts, & Byrne, 2010, along the Agulhas Eddy Corridor)

 * Geopotential height integrated from the surface to a deep (4500 dbar) reference level has added value in understanding barotropic mass load vs steric.
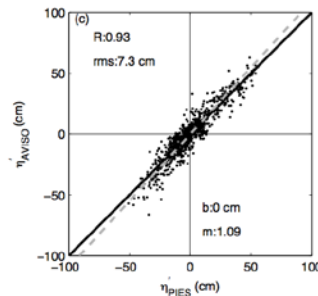
$$\eta'_{PIES} = \eta' - \eta_{IB} = \eta'_{bt} + \eta'_{bc}.$$

$$\eta' - \eta_{IB} + H = \int_{\overline{P_a}}^{\overline{P}} \frac{1}{\rho g} \, dp + \int_{\overline{P}}^{p_{bot}} \frac{1}{\rho g} \, dp,$$

$$= \frac{1}{g} \int_{\overline{P_a}}^{\overline{P}} \left[\alpha(35, 0, p) + \delta \right] dp + \frac{(p_{bot} - \overline{P})}{\rho_b g}$$

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ACSPO SST/GHRSST

GOES 5-km Global Blended SST/GHRSST

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