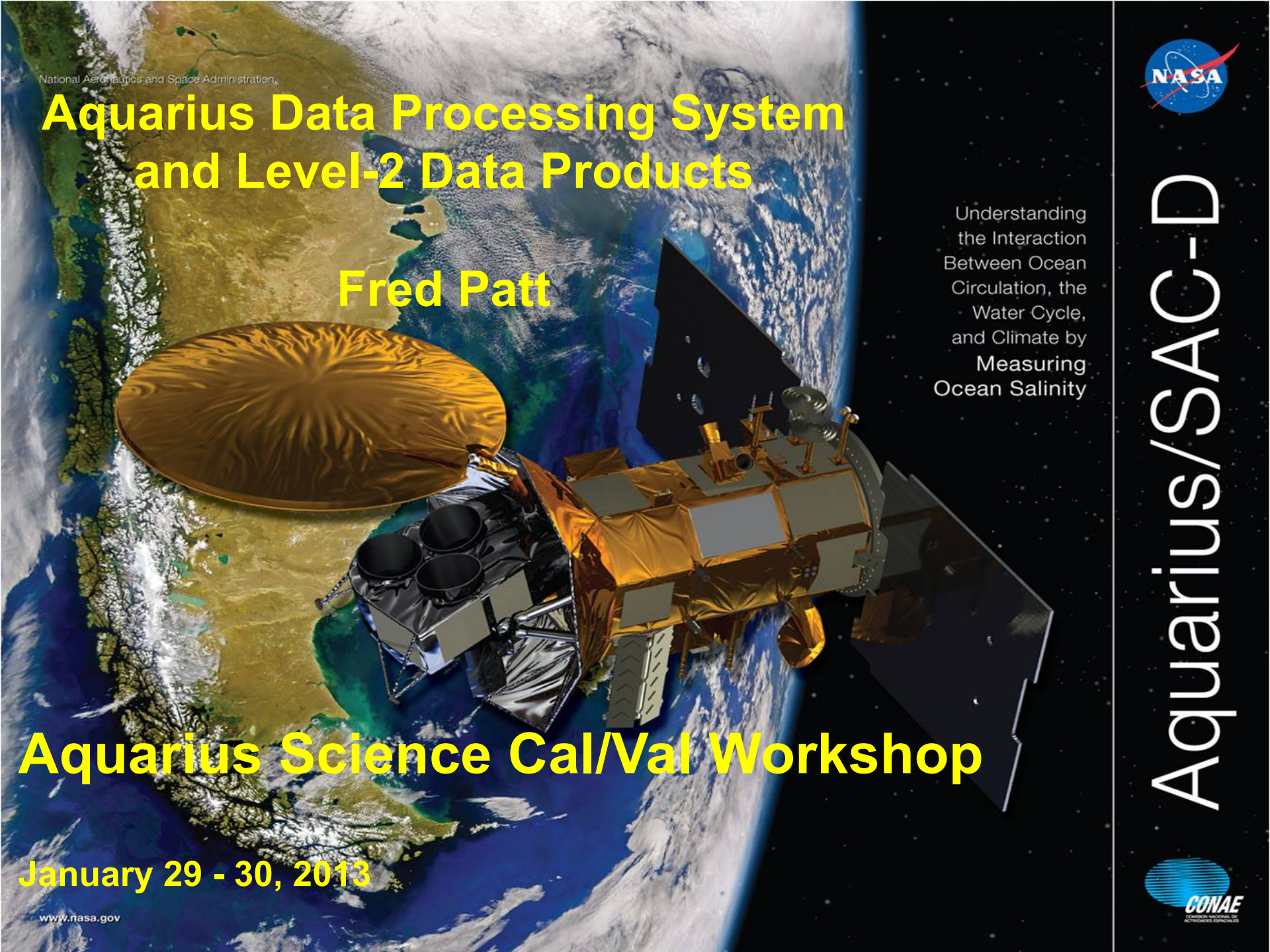
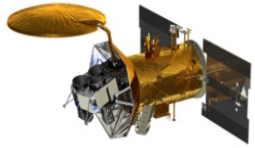
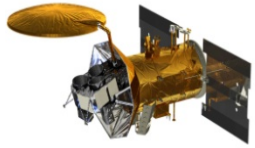

National Aeronautics and Space Administration
Aquarius Data Processing System and Level-2 Data Products
Fred Patt
Understanding the Interaction Between Ocean Circulation, the Water Cycle, and Climate by Measuring Ocean Salinity
Aquarius/SAC-D
Aquarius Science Cal/Val Workshop
January 29 - 30, 2013
www.nasa.gov
NASA
CONAE

Agenda



- Overview
- Software Changes Since Last Workshop
- Level-2 Data Product Changes

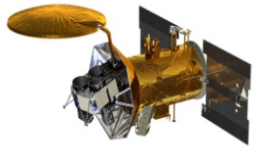
Aquarius Data Processing System OVERVIEW



The Aquarius Ground System at NASA/GSFC consists of the Aquarius Data Processing System (ADPS) and the Aquarius Command and Control System (ACCS)

- The ADPS supports the:
  - Acquisition and ingest of Aquarius/SAC-D data from CONAE.
  - Acquisition of dynamic ancillary required to support the science processing.
  - Processing of Aquarius data to standard and evaluation product levels using algorithms provided by the Science Team.
  - Quality control of data products using methods specified by the Science Team.
  - Match-up of Aquarius data with *in situ* salinity measurements and provide to AVDS.
  - Archive and distribution of all data products during the active life of the mission to the science team.
  - Delivery of ALL Aquarius data products to the PO.DAAC regardless of validation status.

Aquarius Data Processing Overview



Standard Data Processing

Raw Level-0 Downlink File

Level-0 Preprocessor

Level-0

SAC-D HKT Data

Level-0 to 1A

Level-1A temp

Level-1A Merge

Level-1A orbit

Dynamic Ancillary Data

Level-1A to 2

Level-2 Quicklook

Compute Offset Corrections

Static Ancillary Data

Level-2

Level-2 to 3 Smoothing

Level-2 to 3 Binning

Level-3 Mapping

Level-3 Bin

Level-3 Binning

Level-3 Map

Web-Based Telemetry Monitoring Tools

Level-0 Report

Level-1a Report

Automated Telemetry Analysis Tool

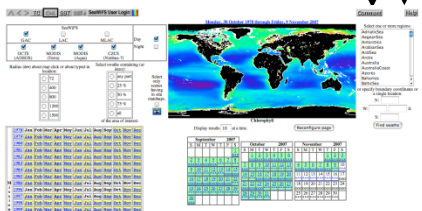
Telemetry Report & Files

Automated Telemetry Alert

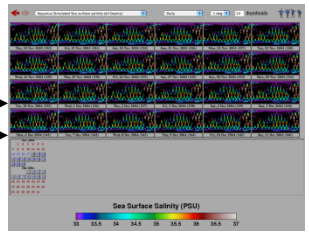
Predicted Downlink Times

SAC-D HKT Data

CONAE-provided Interactive Telemetry Analysis Tool



Web-Based Browse, Download and Order Tools

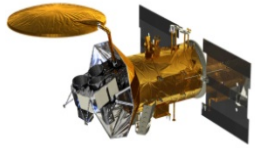


INPUT FILE

OUTPUT FILE

PROGRAM

Periodic Reprocessing



Development and test environments allow for multiple algorithm versions to be run concurrently on the entire mission data set to test the impacts of calibration and algorithm improvements.

The results of these evaluation runs are made immediately available to the science team members via web and ftp mechanisms and via the PO.DAAC

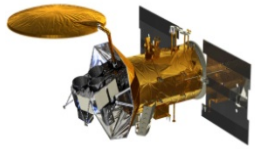
Once the calibration/algorithm changes have been validated and approved by the Science Operations Control Board, a mission-long reprocessing will be initiated and the new products will be made available to the PO.DAAC and science community.

File naming convention and metadata attributes allow traceability of all products to software version and reprocessing status.

With the new processing servers installed, throughput is around 20,000x.

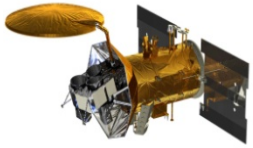
Full mission reprocessing in less than one day!

Agenda



- Overview
- Software Changes Since Last Workshop
- Level-2 Product Changes

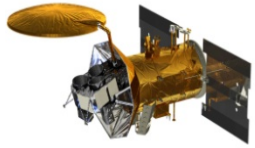
Aquarius Data Processing System
Changes since March (1 of 3)



Major Science Software Versions

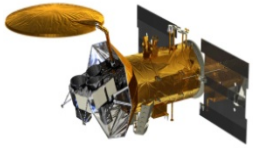
- V1.3 (April): Major update to the radiometer science software:
  - Improved scatterometer-based roughness correction.
  - Updated radiometer flag structure.
- V1.3.1 (May):
  - Pointing angle adjustments.
  - Exclude SA1 from averages.
- V1.3.2 (July): New radiometer flag thresholds
- V1.3.3 (August):
  - Exponential radiometer calibration corrections.
  - Solar flare ancillary data for flags.
- V1.3.4 (September):
  - Radiometer science software updates from RSS.
  - Updated RFI thresholds.

Aquarius Data Processing System
Changes since March (2 of 3)



- V1.3.5 (September):
  - Scatterometer science software updates
  - New Level-2 parameters
- V1.3.6 (November): Scatterometer model updates
- V1.3.7 (December): radiometer offset corrections using new approach to separate instrument and model effects.
- V1.3.8 (January):
  - Latest exponential calibration correction to support radiometer offset correction calculations.
  - Corrected HYCOM interpolation.
- V1.3.9 (January): Final radiometer offset corrections.
- **V2.0 (January)**

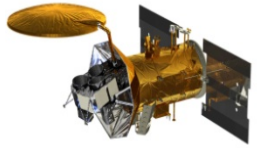
Aquarius Data Processing System
Changes since March (3 of 3)



Other Software Changes:

- Improved handing of off-Earth navigation.
- Set navigation flags for non-science AOCS mode.
- Add non-nominal pointing and anomaly description metadata.
- Leap second correction on July 1, 2012.

Aquarius Data Processing System
Major Events and Software Changes



We have continued to post all software updates and other significant mission events on the Ocean Color web site under the "Major Events and Software Change Log" link at:

http://aquarius.nasa.gov/data.html

Thursday 1/10/2013:

The first meeting of the ASTR/AOCS Tiger Team was held with Dave Mangus as the team leader.

A CSC was performed at the request of the Aquarius Science team, with an 8-minute dwell starting at 09:18. This CSC was timed to coincide with an ocean-to-land crossing.

A star tracker standby event, not associated with Moon interference, resulted in an AOCS transition to SHO at 09:42, immediately after the CSC. The AOCS was commanded back to SCI at 10:25 by the reinforcement command.

Peggy Li delivered updated HYCOM interpolation tables that resolved the 1-degree latitude shift in both the salinity and the land mask.

Monday 1/14/2013:

The HYCOM data for the entire mission were re-acquired and reprocessed.

Wednesday 1/16/2013:

The V1.3.8 processing of the entire mission data set was completed. This version included the latest TND exponential correction, to use in computing the radiometer offset corrections for V1.3.9.

Friday 1/18/2013:

The V1.3.9 processing of the entire mission data set was completed. This version added the radiometer offset corrections to V1.3.8.

Thursday 1/24/2013:

Fred delivered V2.0 of the Level-2 product format specification.

Friday 1/25/2013:

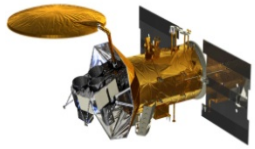
The V2.0 quicklook processing of the entire mission data set was completed.

Curator: OceanColor Webmaster
Authorized by: gene carl feldman

Privacy Policy and Important Notices
Updated: 29 January 2013

EXAMPLE

Agenda



- Overview
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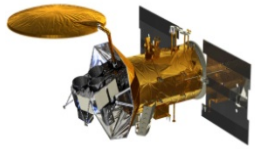
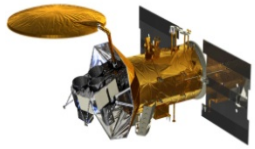
- Level-2 Product Changes

Level-2 Product and Format Changes



- Multiple changes to science parameters:
  - Addition of radiometer fields for intermediate processing steps and corrections (e.g., Tb with/without land and roughness corrections).
  - Updates to scatterometer fields from user manual.
- Calibration correction added as attributes.
- Revised radiometer flag structure to improve use of array elements.
- Addition of navigation quality information:
  - Attributes for non-nominal pointing and anomalies
  - AOCS mode as a data field.
- Level-2 format specification updates for most software versions.
- V2.0 format spec has descriptions of science and ancillary data fields.



anc_wind_speed: The wind speed from NCEP GFS GDAS at 10 m. Data is available from: ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/. In the L2 algorithm this NCEP GDAS wind speed is multiplied by a factor of 1.03 in order to make it consistent with observations from buoys and microwave satellites (SSM/I, WindSat).

anc_wind_dir: The wind direction over the ocean is obtained from the NCEP GFS GDAS 10 meter level. The direction conforms to the meteorological convention (i.e. the wind direction is the direction from which the wind is blowing). In the current algorithm for the roughness correction, the direction dependence is determined using this value (expressed as azimuthal angle relative to the look direction, **celphi**). Both radiometer and scatterometer observations are corrected for wind direction. (ATBD, Addendum I). Data is available from: ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/.

anc_ cwat: The total columnar liquid water above the viewed location. In the processing, it is used to calculate the integral along the slant path of the radiometer boresight. Approximately, this is the value obtained by dividing by cosine (**celtht**, see Table 3). The actual calculation is done slightly differently (see ATDB). The data are obtained from the NCEP GFS GDAS at: ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/.

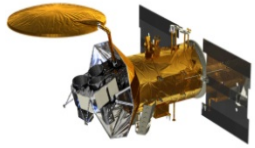
a**nc_ swe:** The snow water equivalent from NCEP GFS GDAS. Data is obtained from: ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/.

anc_surface_temp: The surface temperature over the ocean is the NOAA OISST (Reynolds) product. Over land, the NCEP GFS GDAS product for the surface layer (0-10 cm) is used because emission from this layer is most closely correlated with soil moisture. Data is available from: ftp.emc.ncep.noaa/gov/cmb/sst/oisst_v2/YEARLY_FILES

anc_surface_pressure: Atmospheric pressure is obtained from the NCEP GFS GDAS. The value at the surface at radiometer boresight is listed in this field (the vertical profile is used in the algorithm; ATBD, Section 2.3.2). Data is obtained from: ftp.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/.

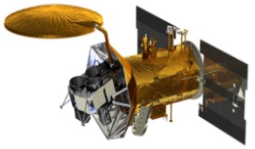
anc_SSS: The reference sea surface salinity used for computing **rad_exp_TbX** . It is obtained from the hybrid coordinate ocean model (HYCOM: http://hycom.org) operated in support of US Navy operations and provided by the Florida State University Center for Ocean-Atmosphere Prediction Studies (FSU/COAPS).

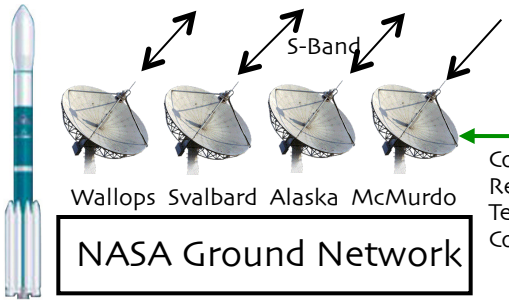
anc_trans: A measure of attenuation through the atmosphere. It is the parameter, $\tau(0,S)$, defined in equation 28-29 in the section 2.3.1 of the Level-2 ATBD. When $\tau(0,S) = 0$ the path is completely opaque.



Backup Slides

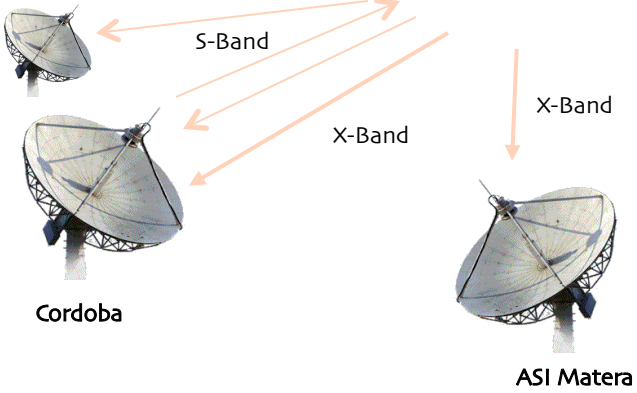
Aquarius Data Processing System INTERFACES





Commands
Real-Time
Telemetry &
Coordination

CONAE
- Data Archive (CUSS, CODS)
- Mission Operations Command Center
- RF Services



Aquarius Data, SAC-D Telemetry and Orbit Products

Schedule Confirmation And Reports

Aquarius Command Schedules And Reports

Ancillary Data Sources

Algorithms & Science Code

Science Team and Algorithm Providers

Evaluation Products

ADPS Aquarius Data Processing System

ACCS Aquarius Command & Control System

Calibration & Instrument Configuration Change Requests

Principal Investigator and Science Planning Team

Anomaly Reports

Recovery Procedure and Timelines

Instrument Engineering Team

Aquarius Instrument Test bed Flight Software Updates

AVDS Aquarius Validation Data System

Insitu Data Bias Adjustments

Aquarius Match-up Data

Level 0, 1, 2, 3 Aquarius Data Documentation & Software

PO.DAAC

Aquarius L1, 2, 3 Data Ancillary Data Feedback

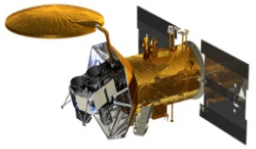
SeaDAS

Software

Data Users and Science Team

1- SAC-D Ground System to Aquarius Ground System ICD
2- SAC-D / NASA PSLA, Network Requirements Document & Scheduling Interface
3- SD - Observatory Ground IF Specification Document
4- Aquarius Science Team to Aquarius Ground System ICD
5- AQ - Aquarius Ground System – Aquarius Instrument Team Anomaly ICD and Aquarius Test bed User Manual
6- Aquarius Data Product User Guide (PO.DAAC) & Format Specification (ADPS)
7- Ocean Data Processing System Data and Software Management Plan, ATBD's and Software User's Guides
8- A V D S to A D P S ICD
9- Aquarius Ground System to PO.DAAC ICD

Science Data Processing

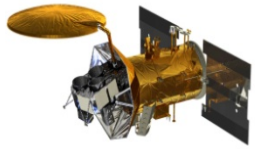


The Aquarius science data processing consists of the following steps:

- Level-0 Preprocessor – process each HRD downlink file to produce a single time-ordered set of Aquarius science blocks and removes duplicates– developed by Joel Gales - ADPS.
- Level-0-to-1A – separate Level-0 files into orbits, unpack science data, incorporate overlapping ephemeris and SAC-D HKT and convert Aquarius HKT – developed by Joel Gales - ADPS.
- Telemetry Analysis – HKT data from Level-1A files analyzed for web display on the Aquarius web site – developed by Norman Kuring and Liang Hong (ADPS/ACCS) and Aq. Inst. Team.
- Interactive Telemetry Analysis - HKT files analyze using CONAE-provided telemetry viewer.
- Level-1A Merge – consolidate Level-1A files from overlapping downlinks into a single, best-quality full orbit product – Joel Gales - ADPS.
- Level-1A-to-2 – perform calibration, atmospheric correction and salinity retrieval for Aquarius science data – radiometer and scatterometer code delivered by RSS and JPL, respectively; integration and input/output code developed by Joel Gales and Liang Hong - ADPS.
- Level-2-to-3 Binning – Level-2 salinity retrievals for one day geographically projected and collected into equal-area bins – existing OBPG software modified by Joel Gales- ADPS.
- Level-2-to-3 Smoothing – Level-2 salinity retrievals for one day optimally interpolated into equal-area bins – algorithm by Jonathan Lilly/ESR implemented by Joel Gales - ADPS.
- Level-3 Binning and Mapping – Level-3 binned files aggregated to longer time periods (weekly, monthly, etc.) and projected onto map grid – existing OBPG software.

All processing steps are run automatically when all input data sets are available.

Ground System Staffing



NASA Management – Gene Carl Feldman: Oversight of the overall effort, communication/coordination with other NASA organizations and centers and CONAE; oversight of **science** support, algorithm integration, QC, validation and in situ data support.

Budget/Resources – Barbara Conboy: Financial oversight and reporting of Aquarius Project budget with interfaces to JPL, ESSP Program Office and NASA Headquarters.

Contractor Management – Fred Patt: Oversight of **contract** support staff, including hiring, tasking, review of deliverables and schedules; ADPS interface definition and product format specification.

Mission Planning and Instrument Operations, Instrument and Algorithm Analysis – Liang Hong and Alicia Scott: Instrument operations and commanding support; interface with Aquarius instrument engineers and CONAE mission operations. Working with the Instrument and Science Teams, develop methodologies, tools, procedures and reports for instrument operations and monitoring; ACCS documentation.

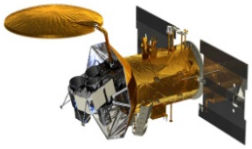
Data Systems Engineering – John Wilding and Tommy Owend: Technical lead for the data system integration effort; overall system design, implementation and testing.

Software Engineering – Joel Gales: Technical lead for the level conversion / product generation software, including development of the Level 0-to-1 software and integration/packaging of the science (Level 2 and 3) processing software to be provided by the algorithm developers.

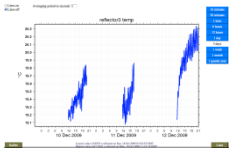
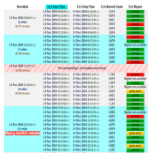
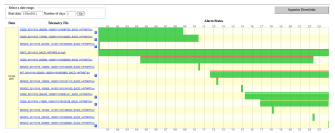
Systems Administration – Paul Smith: Specify and acquire new processing and data storage hardware, integrate into existing data processing facility, verify/upgrade network capability for external data transfers.
for data analysis and quality control, building upon the existing SeaWiFS Bio-optical Archive and Storage System (SeaBASS).

Archive and Distribution – Norman Kuring and Sean Bailey: Incorporate Aquarius product browse, search, order and distribution into existing web-based Ocean Color capability and work with JPL PO.DAAC regarding "institutional" archive support requirements.

Data Quality Control



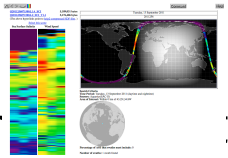
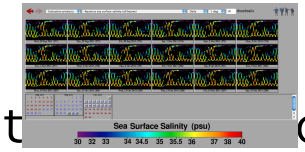
- Automated telemetry monitoring, alarm notification and web tools updated on every downlink

- Interactive telemetry monitoring tools

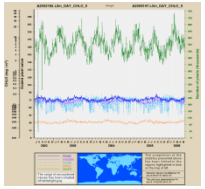
- Automated science data quality checks* to be performed on each file as defined by science team (*to be provided within 6 months post commissioning)

- Visual inspection via web tools for Level-2 and Level-3 data products

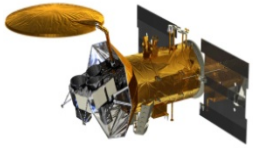



- Level-3 Lor [illegible] at [illegible] oring tool

- AVDS data analysis by Science Team



Data Archive and Distribution



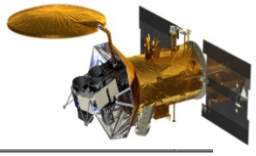
- Aquarius data product archiving is performed using the existing OBPG archive catalog database and RAID-based data storage system (> 3 PetaByte of current storage for SeaWiFS, MODIS (Terra and Aqua), MERIS, OCTS, CZCS, etc.)

- Aquarius data distribution to the Science Team will be performed during the active life of the mission using the existing OBPG browse, order and distribution system (examples to follow) which also serves as one of the data quality monitoring tools.

- ALL Aquarius data products **regardless of validation status** will be delivered to the JPL PO.DAAC for official and permanent archive, value-added services and long-term distribution as described in the PO.DAAC presentation.

Aquarius Level-1-2 Data Browser

http://oceancolor.gsfc.nasa.gov/cgi/aquarius



Comment Help

Thursday, 25 August 2011 through Monday, 17 October 2011

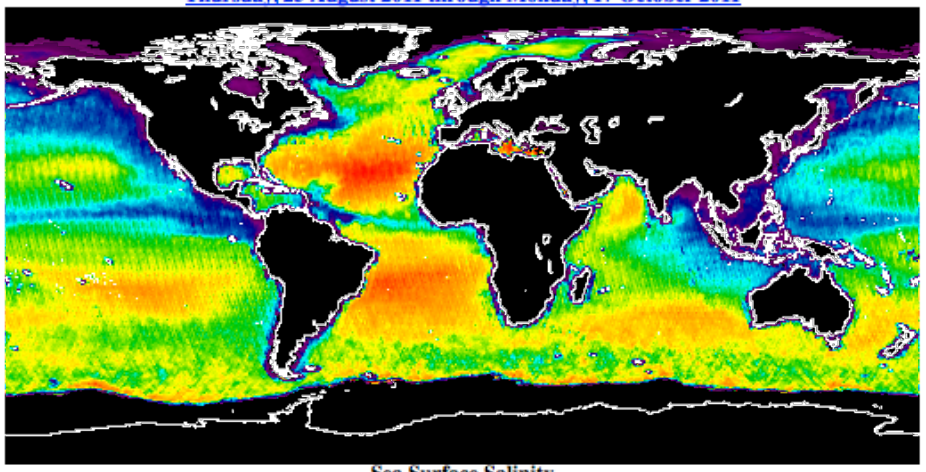
Radius (*km*) about map click or about typed-in location:

- (•) 72
- ( ) 400
- ( ) 800
- ( ) 1200
- ( ) 1500

Select swaths containing *(at least)*:

- (•) any part
- ( ) 25 %
- ( ) 50 %
- ( ) 75 %
- ( ) all

of the area of interest.



Sea Surface Salinity

Select one or more regions:

AdriaticSea
AegeanSea
Antarctica
ArabianSea
AralSea
Arctic
Australia
AustraliaCoast
Azores
Bahamas
BalticSea

or specify boundary coordinates or a single location:

N:
W: :E
S:
Find swaths

Display results 10 at a time. Reconfigure page

Mission	2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

August 2011

S	M	T	W	T	F	S
	1 xxx	2 xxx	3 xxx	4 xxx	5 ^^^	6 ^^^
7 ^^^	8 ^^^	9 ^^^	10 ^^^	11 ^^^	12 ^^^	13 ooo
14 ooo	15 ooo	16 ooo	17 ooo	18 ooo	19 ooo	20 ooo
21 ***	22 ***	23 ***	24 ***	25 ***	26 ***	27 ***
28 ***	29 xxx	30 xxx	31 xxx			

September 2011

S	M	T	W	T	F	S
				1 xxx	2 xxx	3 xxx
4 xxx	5 xxx	6 ^^^	7 ^^^	8 ^^^	9 ^^^	10 ^^^
11 ^^^	12 ^^^	13 ^^^	14 ooo	15 ooo	16 ooo	17 ooo
18 ooo	19 ooo	20 ooo	21 ooo	22 ***	23 ***	24 ***
25 ***	26 ***	27 ***	28 ***	29 ***	30 xxx	

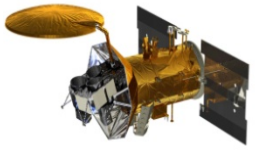
October 2011

S	M	T	W	T	F	S
						1 xxx
2 xxx	3 xxx	4 xxx	5 xxx	6 xxx	7 xxx	8 ^^^
9 ^^^	10 ^^^	11 ^^^	12 ^^^	13 ^^^	14 ^^^	15 ^^^
16 ooo	17 ooo	18 ooo	19 ooo	20 ooo	21 ooo	22 ooo
23 ooo	24 ***	25 ***	26 ***	27 ***	28 ***	29 ***
30 ***	31 ***					

AQUARIUS
Sea Surface Salinity from Space

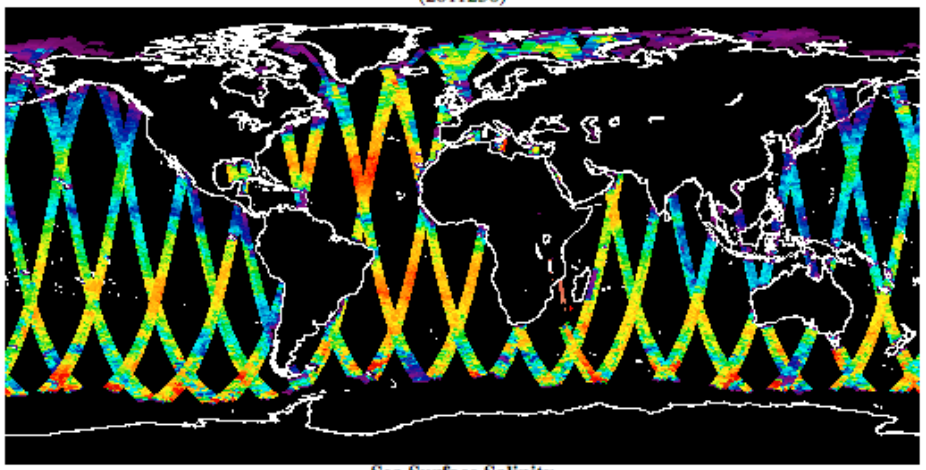
Aquarius Level-1-2 Data Browser

http://oceancolor.gsfc.nasa.gov/cgi/aquarius



Comment Help

Tuesday, 13 September 2011
(2011256)



Sea Surface Salinity

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- (•) 72
- ( ) 400
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N:
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S:
Find swaths

Display results 10 at a time. Reconfigure page

Mission 2011 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

August 2011

S	M	T	W	T	F	S
	1 xxx	2 xxx	3 xxx	4 xxx	5 ^^^	6 ^^^
7 ^^^	8 ^^^	9 ^^^	10 ^^^	11 ^^^	12 ^^^	13 ooo
14 ooo	15 ooo	16 ooo	17 ooo	18 ooo	19 ooo	20 ooo
21 ***	22 ***	23 ***	24 ***	25 ***	26 ***	27 ***
28 ***	29 xxx	30 xxx	31 xxx			

September 2011

S	M	T	W	T	F	S
				1 xxx	2 xxx	3 xxx
4 xxx	5 xxx	6 ^^^	7 ^^^	8 ^^^	9 ^^^	10 ^^^
11 ^^^	12 ^^^	13 ^^^	14 ooo	15 ooo	16 ooo	17 ooo
18 ooo	19 ooo	20 ooo	21 ooo	22 ***	23 ***	24 ***
25 ***	26 ***	27 ***	28 ***	29 ***	30 xxx	

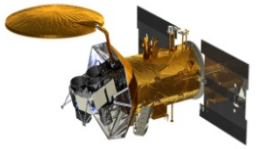
October 2011

S	M	T	W	T	F	S
						1 xxx
2 xxx	3 xxx	4 xxx	5 xxx	6 xxx	7 xxx	8 ^^^
9 ^^^	10 ^^^	11 ^^^	12 ^^^	13 ^^^	14 ^^^	15 ^^^
16 ooo	17 ooo	18 ooo	19 ooo	20 ooo	21 ooo	22 ooo
23 ooo	24 ***	25 ***	26 ***	27 ***	28 ***	29 ***
30 ***	31 ***					

AQUARIUS
Sea Surface Salinity from Space

Aquarius Level-1-2 Data Browser

http://oceancolor.gsfc.nasa.gov/cgi/aquarius

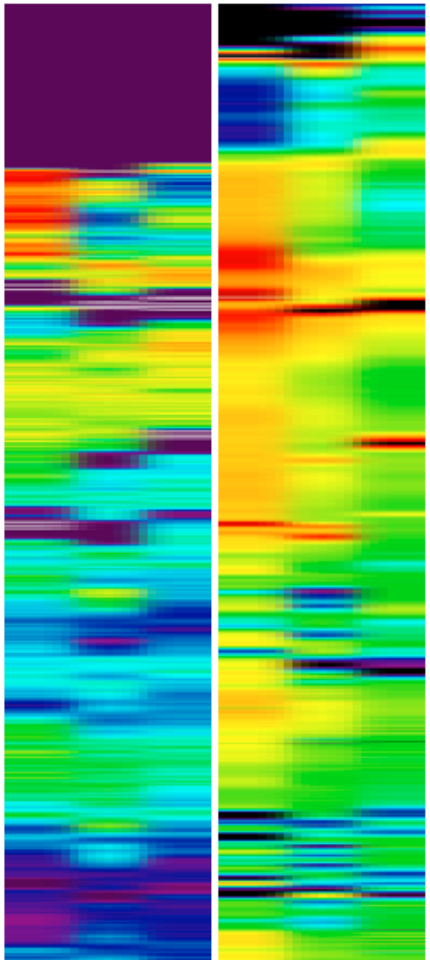


Comment Help

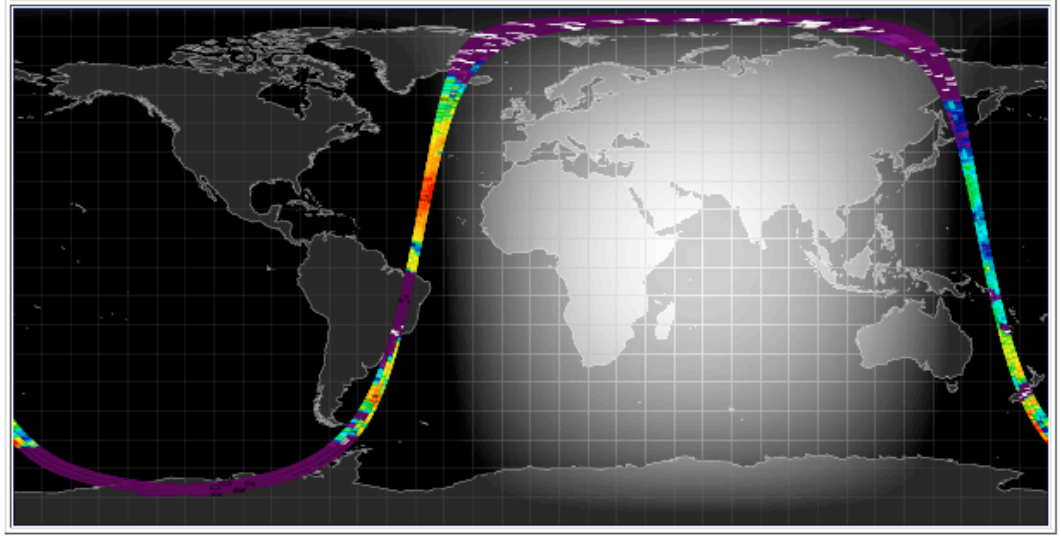
Q2011256071500.L1A_SCI 5,189,031 bytes
Q2011256071500.L2_SCI_V1.1 5,176,406 bytes
(The above hyperlinks point to bzip2-compressed HDF files.)

Select this scene

Sea Surface Salinity | Wind Speed



Tuesday, 13 September 2011
2011256



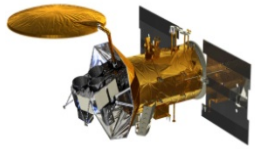
Search Criteria
Time Period: Tuesday, 13 September 2011 (daytime and nighttime)
Sensors: Aquarius(SAC-D)
Area of Interest: Within 0 km of 43.2N,34.8W

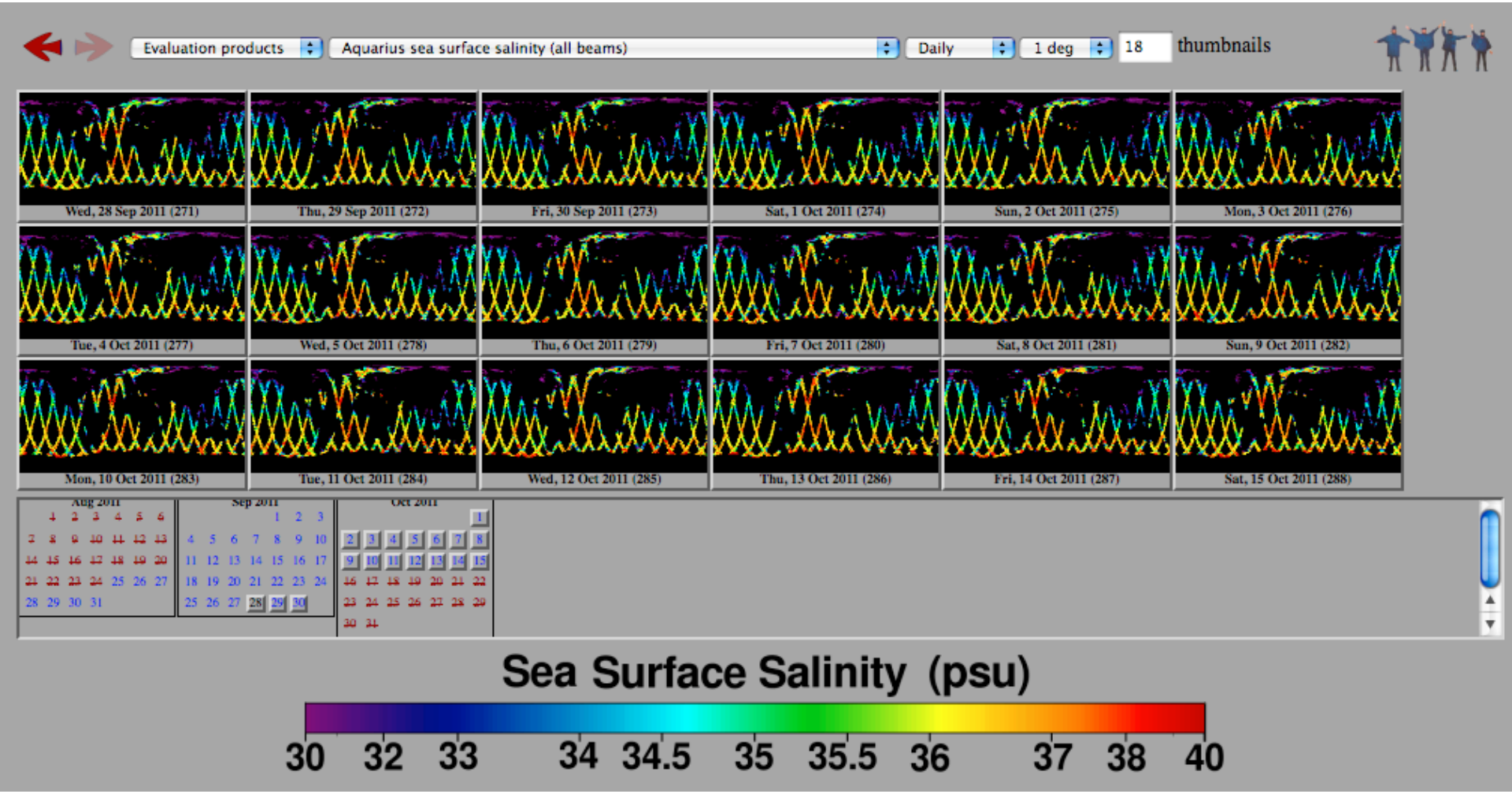
Percentage of AOI that swaths must include: 0

Number of swaths: 1 swath found

Aquarius Level-3 Data Browser

http://oceancolor.gsfc.nasa.gov/cgi/l3

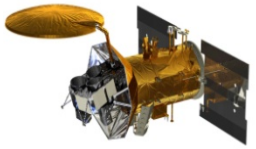


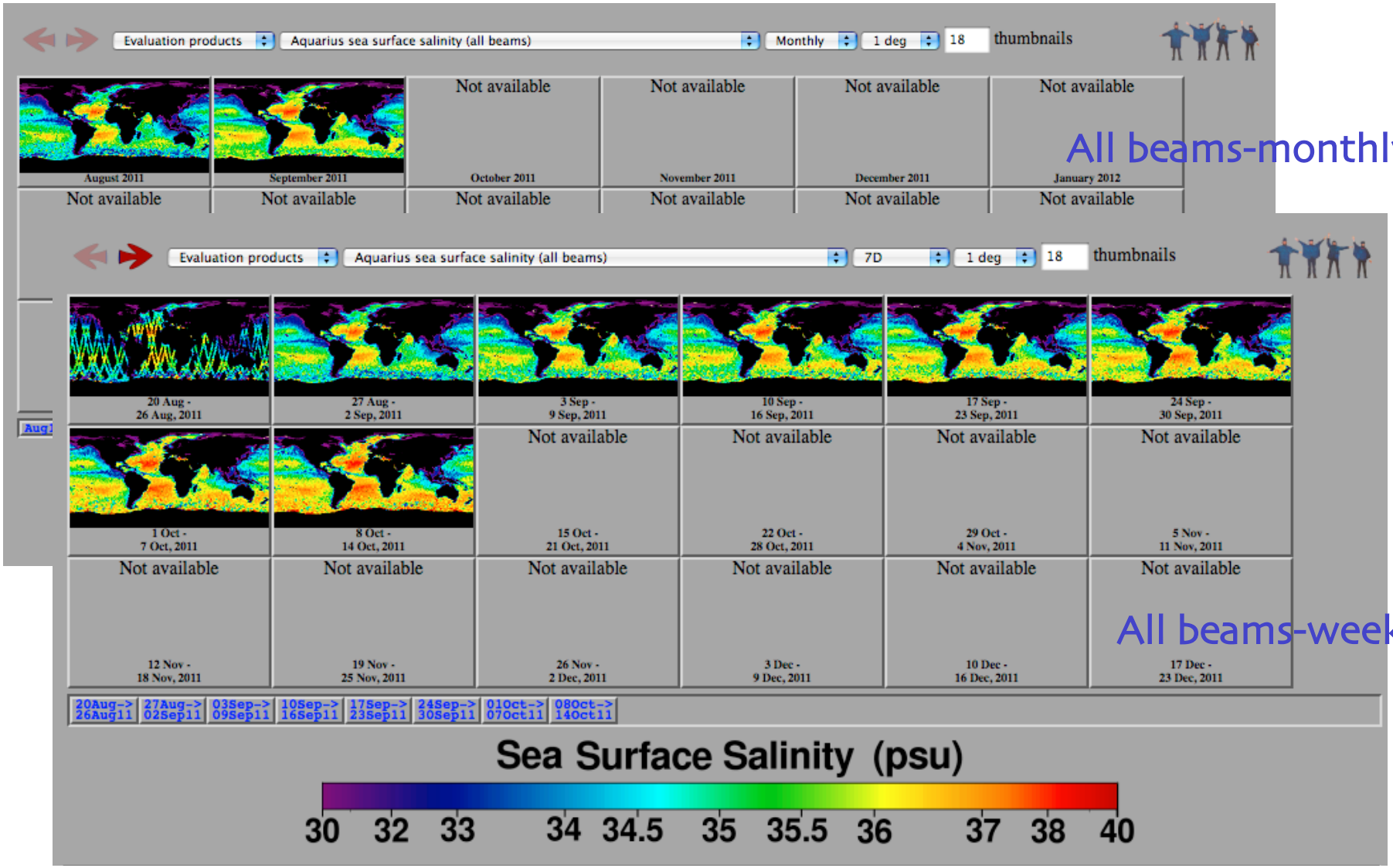


All Beams - daily

Aquarius Level-3 Data Browser

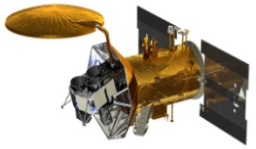
http://oceancolor.gsfc.nasa.gov/cgi/l3

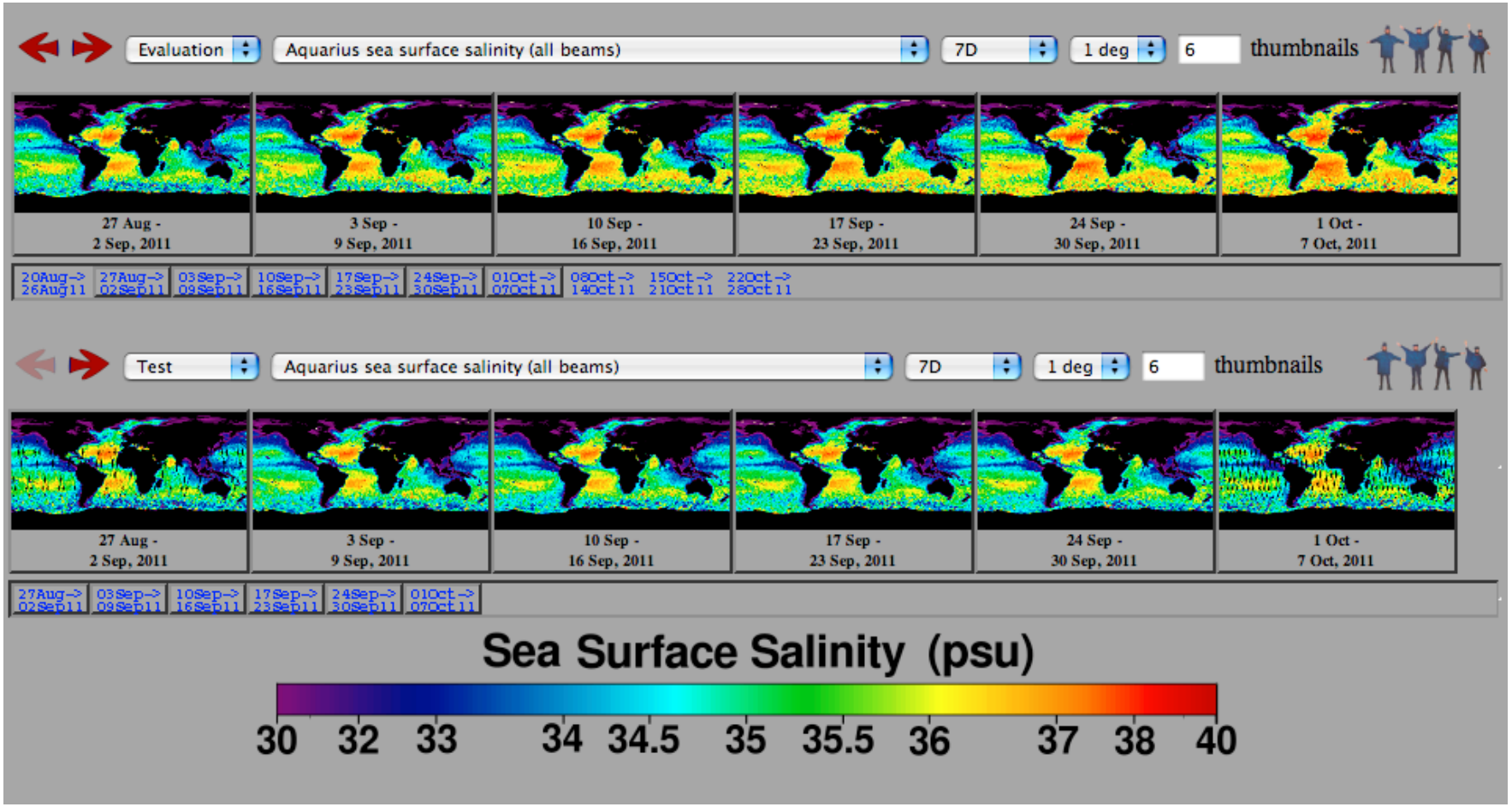




Aquarius Level-3 Data Browser

http://oceancolor.gsfc.nasa.gov/cgi/l3





Can also be used as a data quality assessment tool

Drift correction and RFI flag update in "test" product as compared to operational products