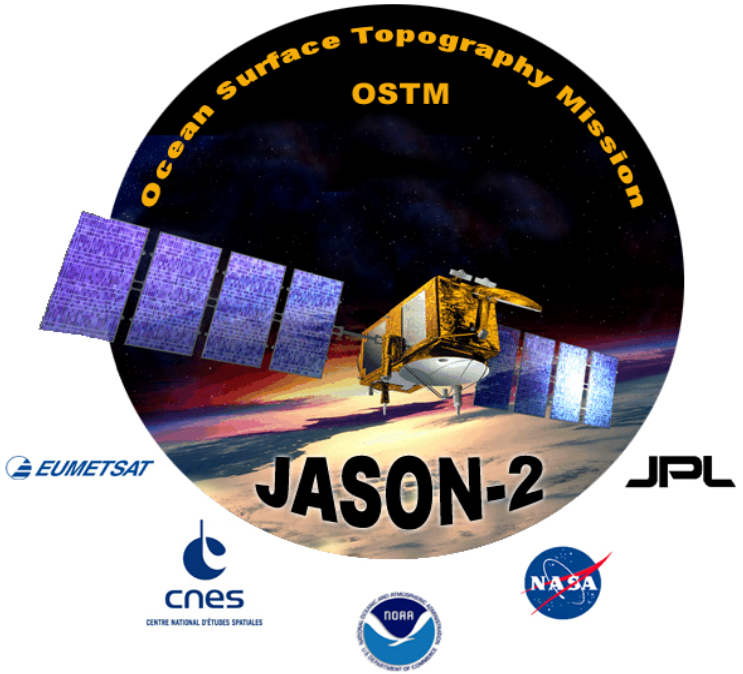
Near Real-Time Applications of Jason-2/OSTM Altimetry



Hans Bonekamp - EUMETSAT Project Scientist
John Lillibridge - NOAA Project Scientist

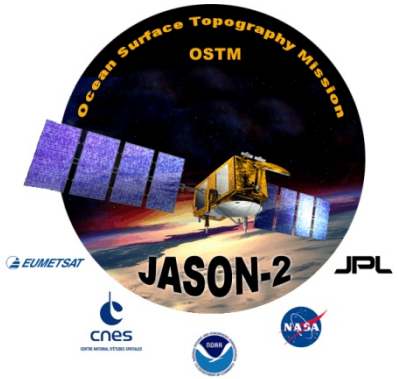
NOAA Goal Teams & Themes

Weather

Satellites

Research

Oceans



Fisheries

Coasts

Climate

Charting

European Commission's Kopernikus (GMES)

Kopernikus Services

The Kopernikus initiative comprises a group of vertical services aimed at monitoring Earth sub-systems (land, ocean, and atmosphere) and horizontal services addressing emergency and security issues. In addition, information provided by these services contributes to efforts in the climate change domain. See the general presentation of the available services or access by clicking the links below.

For an overview of Kopernikus services click here

For direct access to the services click on the links below

Land Environmental Services

Marine Environmental Services

Atmospheric Environmental Services

Support to emergency and humanitarian aid

Support to security-related Services

Kopernikus and climate change

Altimetric Applications

- **Wind & Wave**
  - **Validation/Assimilation in Global Wave Models**
    - NOAA WaveWatch-III
    - ECMWF WAM
  - **High Seas Hazards Monitoring**
- **Sea Surface Height & Ocean Currents**
  - **Hurricane Intensity Forecasting**
  - **Assimilation in Operational Ocean Models**
    - Real-Time Ocean Forecast System (Gulf Stream)
    - Navy Layered/Coastal Ocean Models (NLOM/NCOM)
    - Mercator (N. Atlantic/Mediterranean)
- **Multi-Mission Altimetry**
  - **DUACS**
  - **NRL Real-Time Ocean Environment**
- **Fisheries, Marine Transport, …**

Ocean (Near) Real Time?

Adopted from ESA's Sentinel-3 definitions:

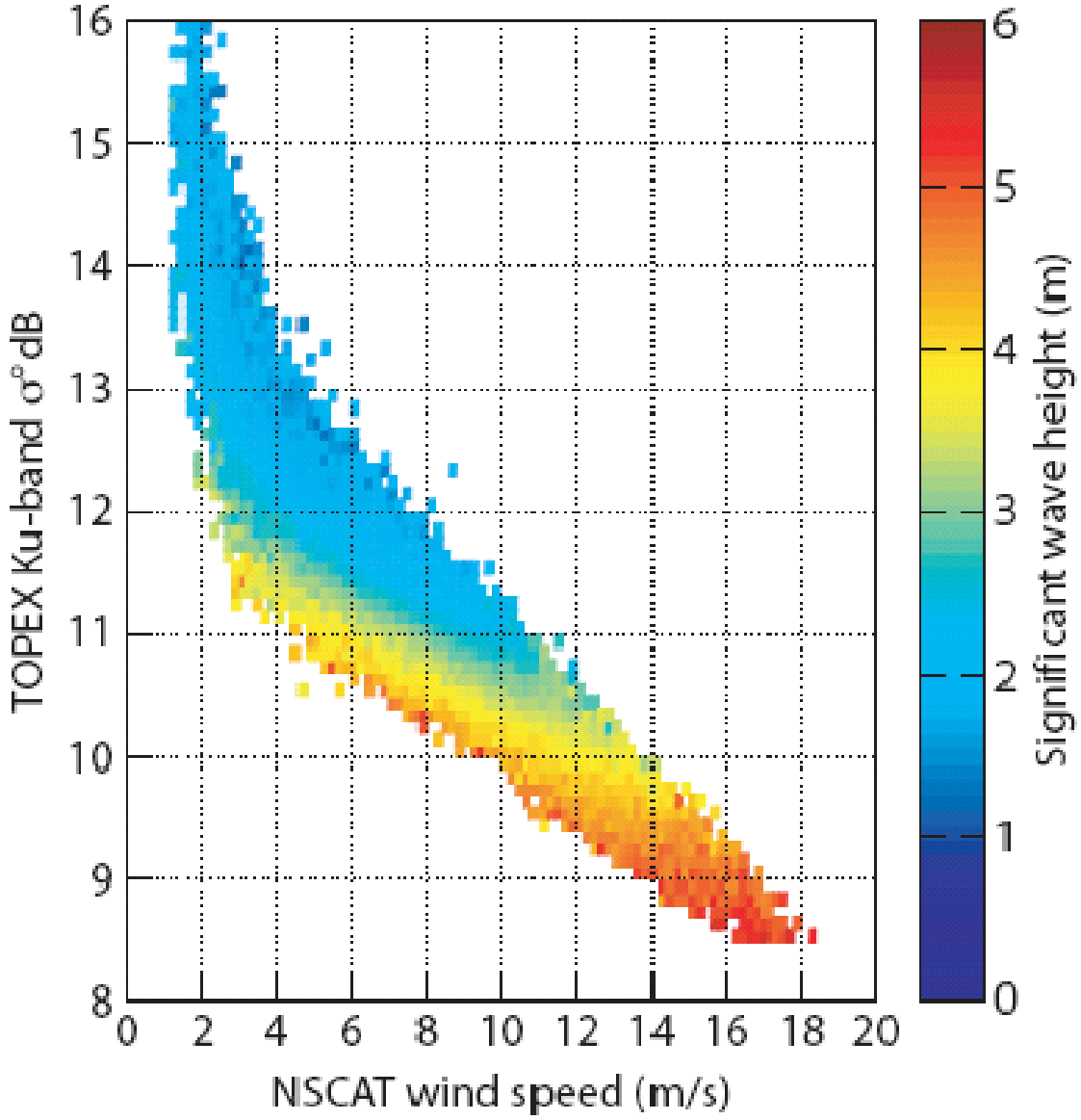
- NRT (Near-Real Time, 3 hours) OGDR
- STC (Short Time Critical 1–2 days) IGDR

"Ocean Near Real Time"

- NTC (Non-Time Critical,1 month) GDR

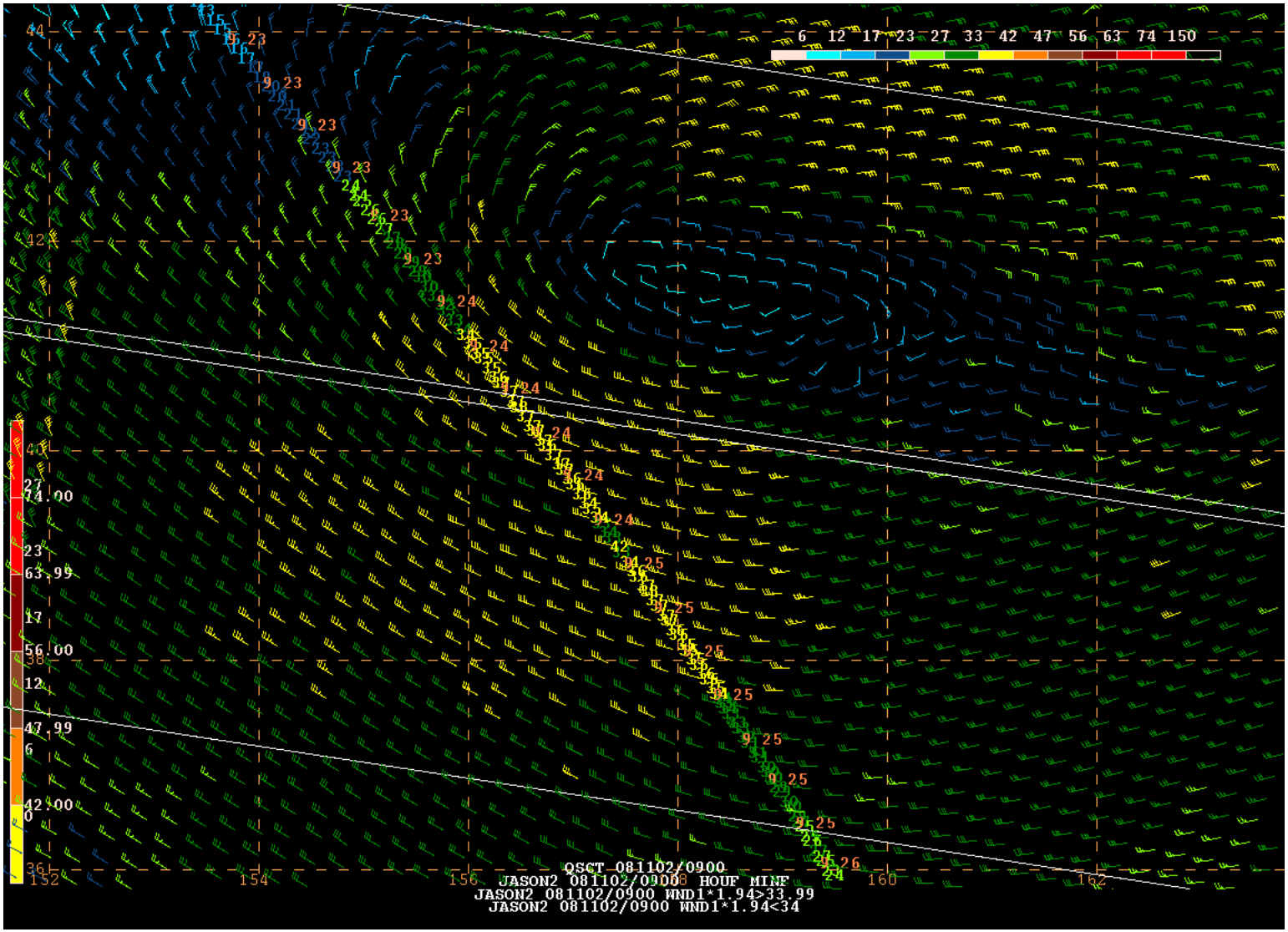
Wind & Wave

Backscatter, Winds and Wave Heights



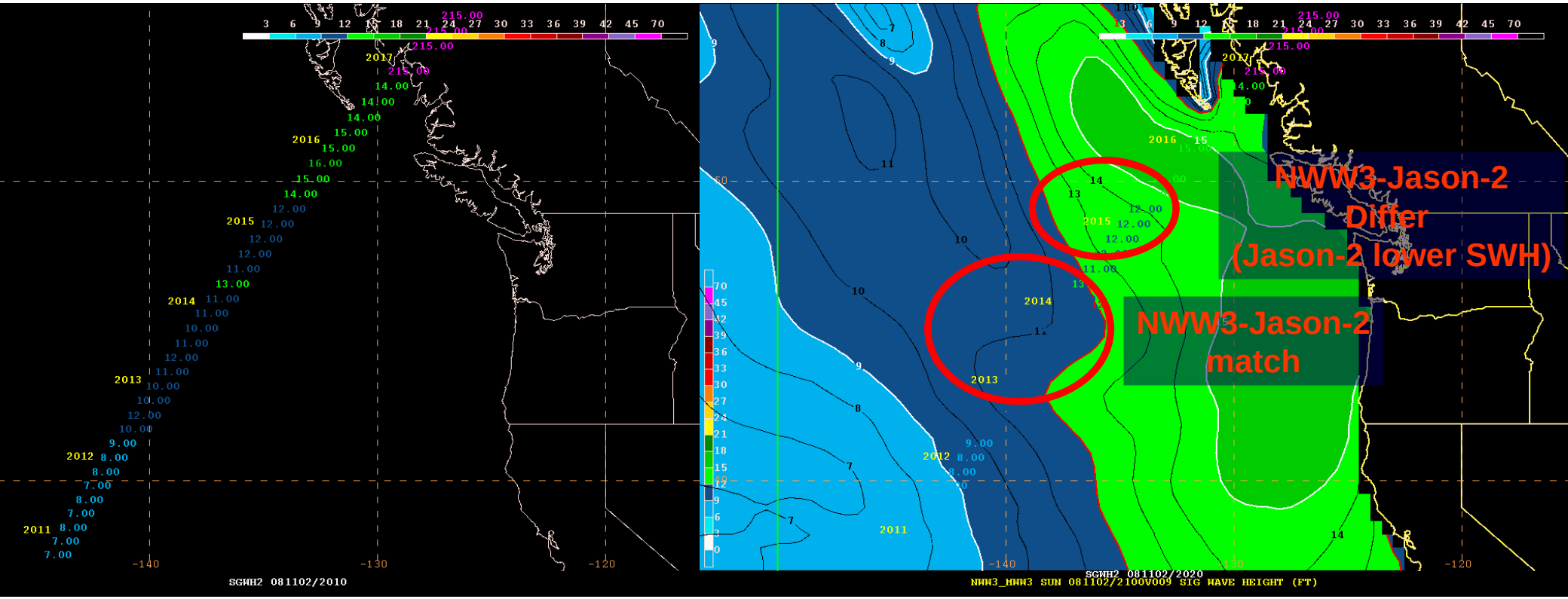
Gourrion et al. 2002

Jason-2 vs. QuickScat Winds



Jason-2 Wind Speed (knots) with QuikSCAT scatterometer winds.
Wind speeds color coded in knots according to scale at upper left.
Agree well with QuikSCAT winds - Courtesy J.Sienkiewicz (NOAA)

NWS Forecaster Workstation Display: Jason 2 Significant Wave Heights



Jason-2 SWH

Color coded in feet, every 10th value

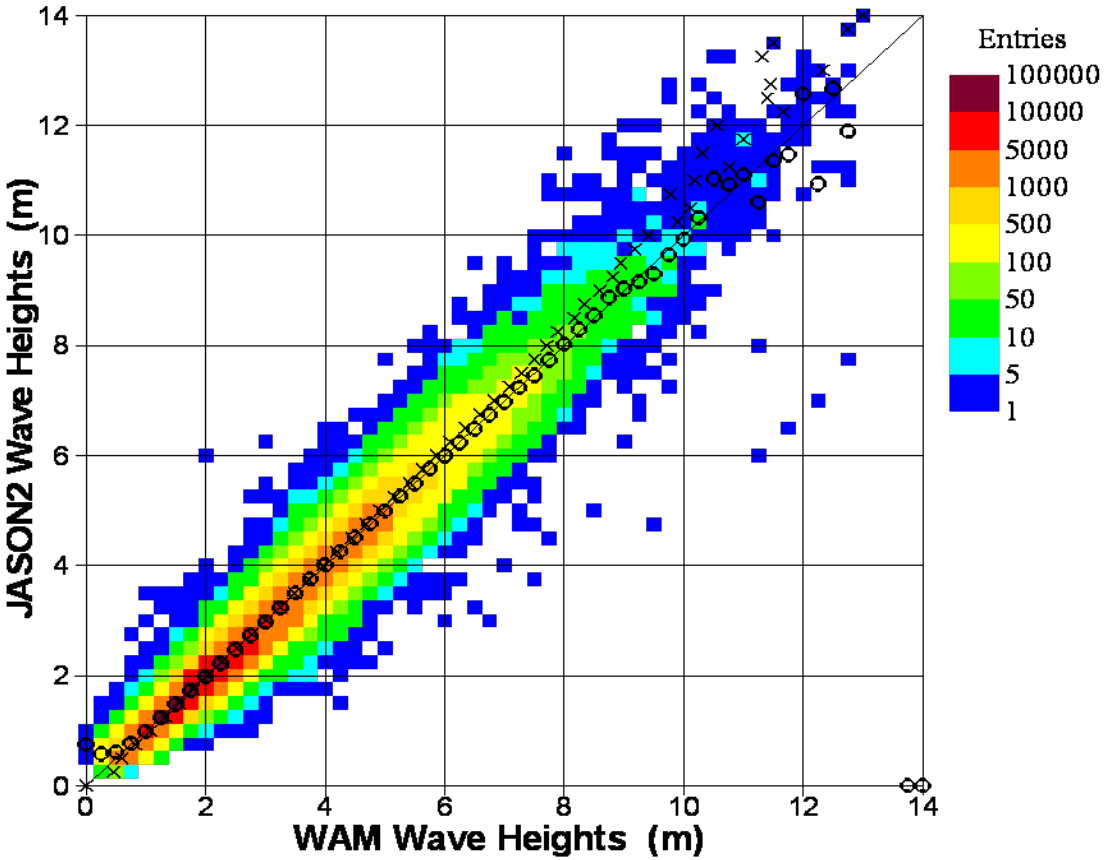
Forecasters can zoom and view every value

Jason-2 SWH w/ NOAA WAVEWATCH III Model (NWW3)

SWH Color coded in feet to highlight regions where Jason–2 observations differ from NWW3 forecasts/analyses-

Courtesy J.Sienkiewicz (NOAA)

Global comparison between Jason-2 Ku-Band and ECMWF wave model (WAM) first-guess SWH values **(From 01 August to 31 October 2008)**



STATISTICS

ENTRIES	314585
MEAN WAM	2.6966
MEAN JASON2	2.6848
BIAS (JASON2 - WAM)	-0.0118
STANDARD DEVIATION	0.2741
SCATTER INDEX	0.1016
CORRELATION	0.9820
SYMMETRIC SLOPE	1.0017
REGR. COEFFICIENT	1.0050
REGR. CONSTANT	-0.0253

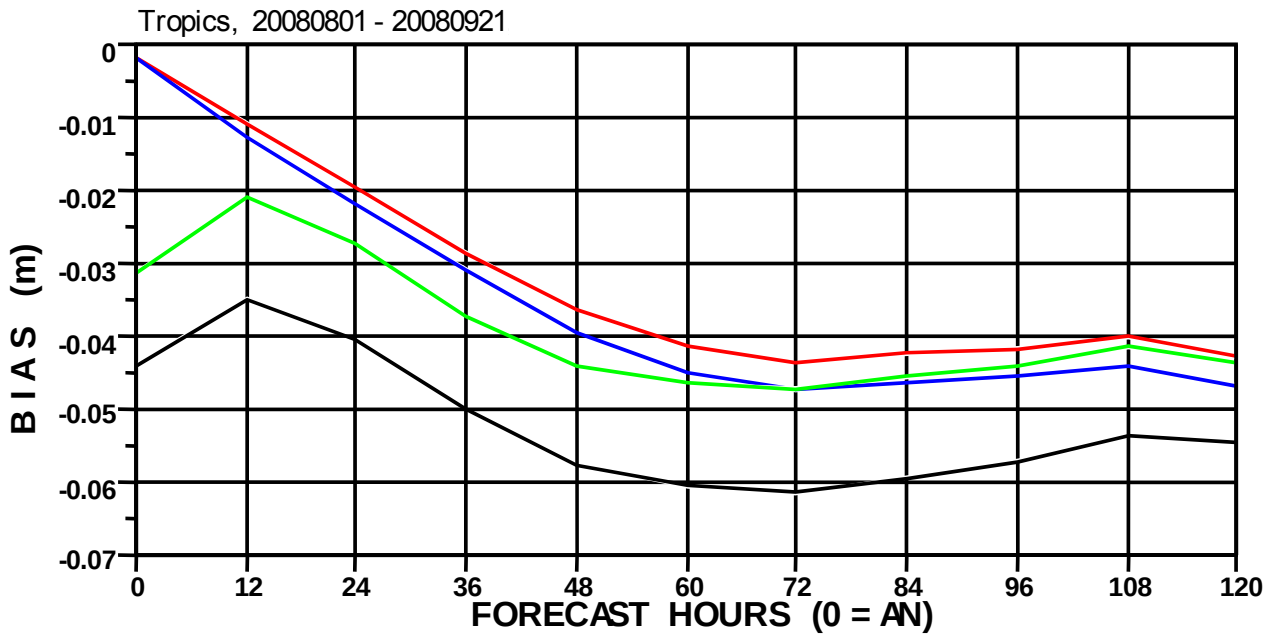
~unbiased

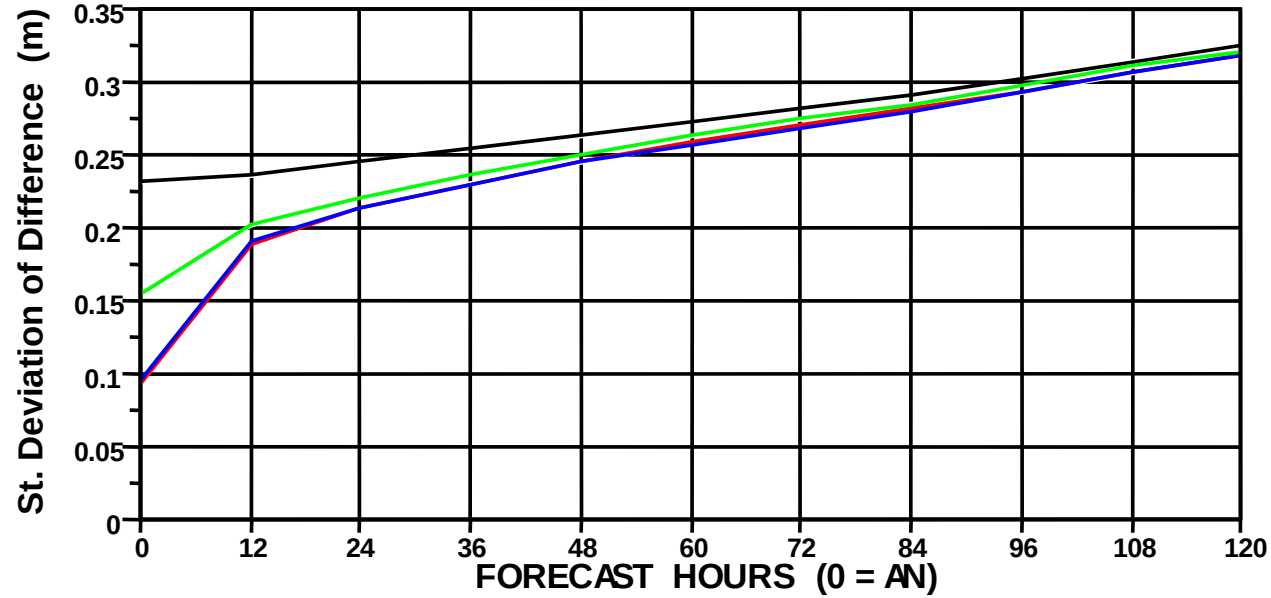
small

Courtesy S. Abdalla (ECMWF)

Impact of Jason-2 SWH assimilation on the model forecast errors in the Tropics

(From 01 Aug to 21 Sep 2008)

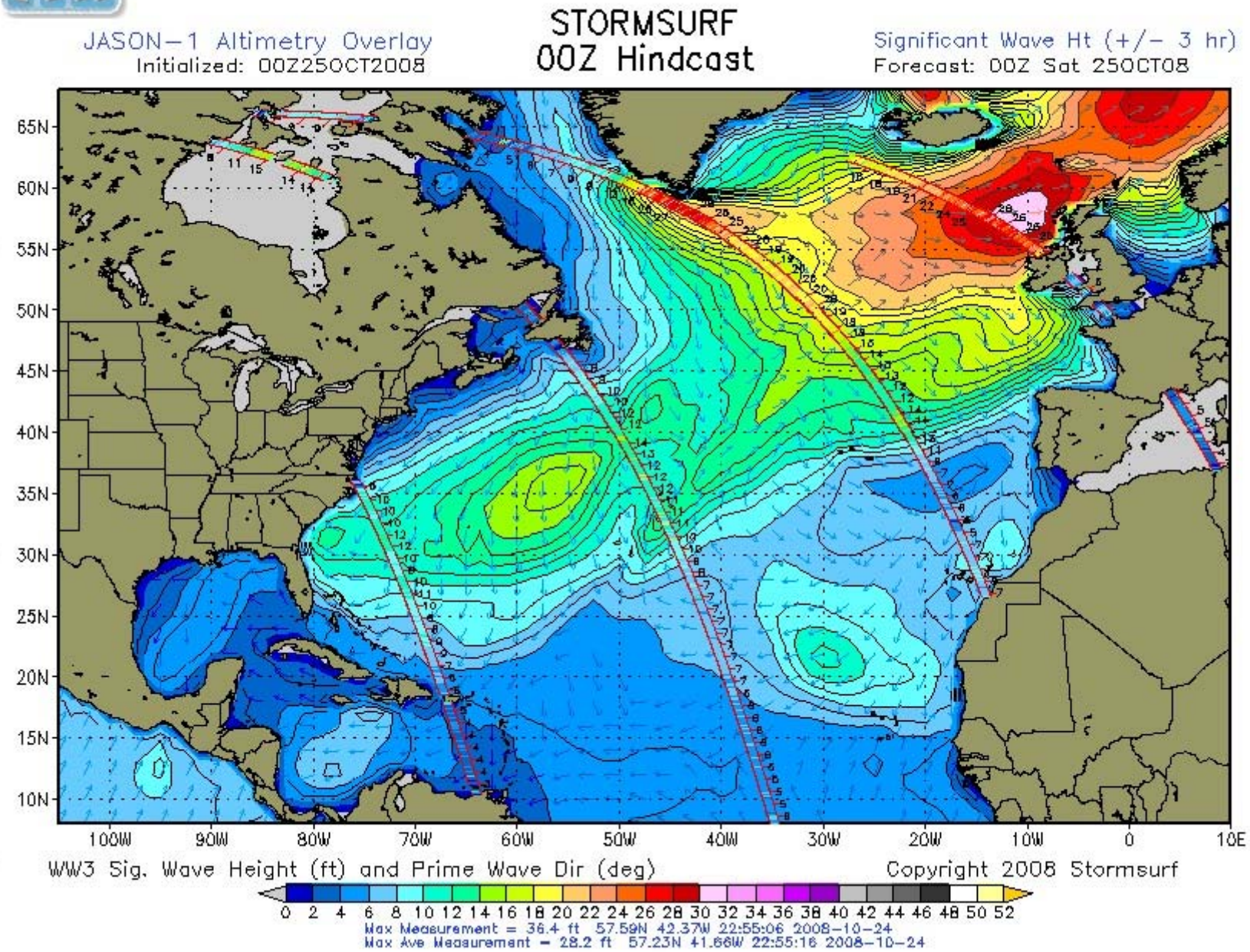




No data assim.
Jason-2 alone
Jason-1 & Envisat
Jason-2 & Envisat

Courtesy S. Abdalla (ECMWF)

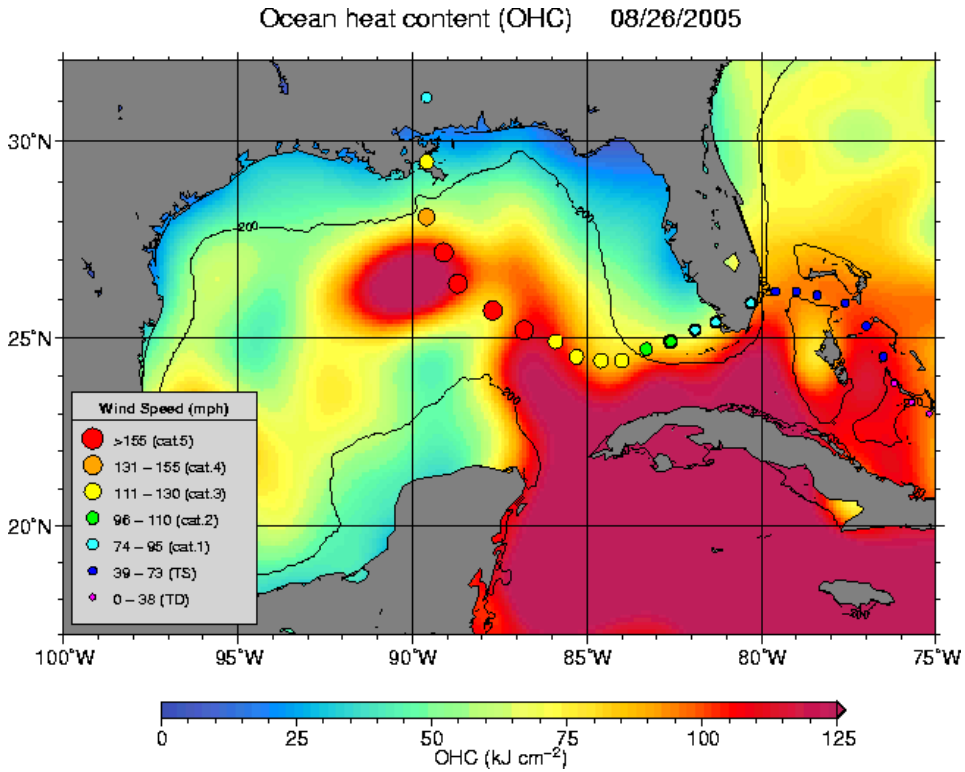
Big Wave Surf Forecasting

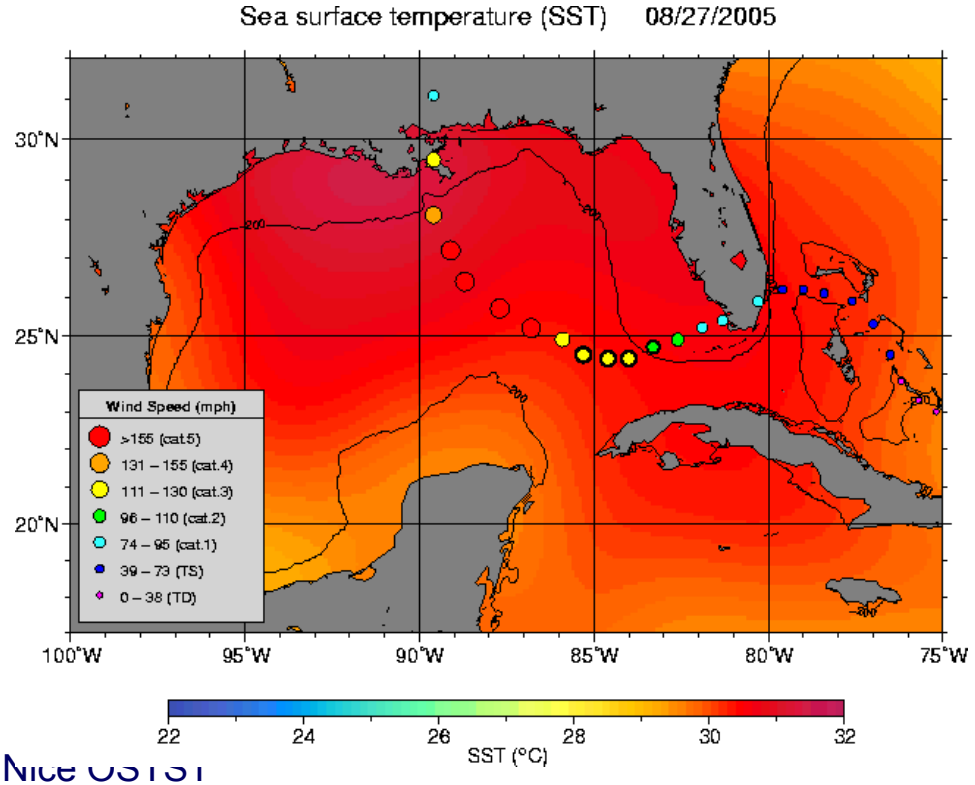


Hurricane Intensity Forecasting & Ocean Surface Currents

Hurricane Intensity Forecasting - Katrina

Ocean Heat Content – estimates the amount of heat available over a depth of warm water. The greater the depth the more available heat that can be potentially converted to energy.

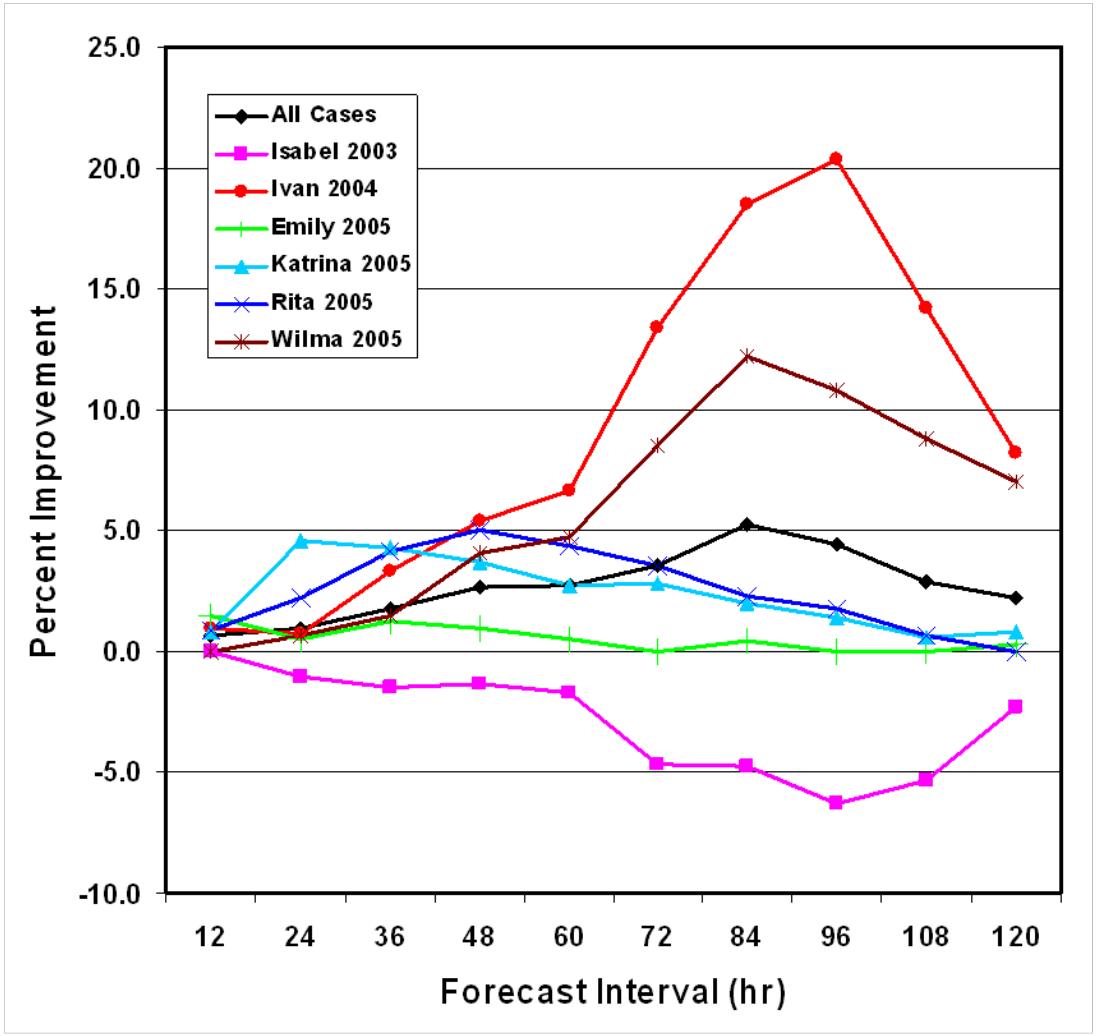




Sea Surface Temperatures only provide a view of the very top layer of the ocean.

Courtesy G. Goni (NOAA)

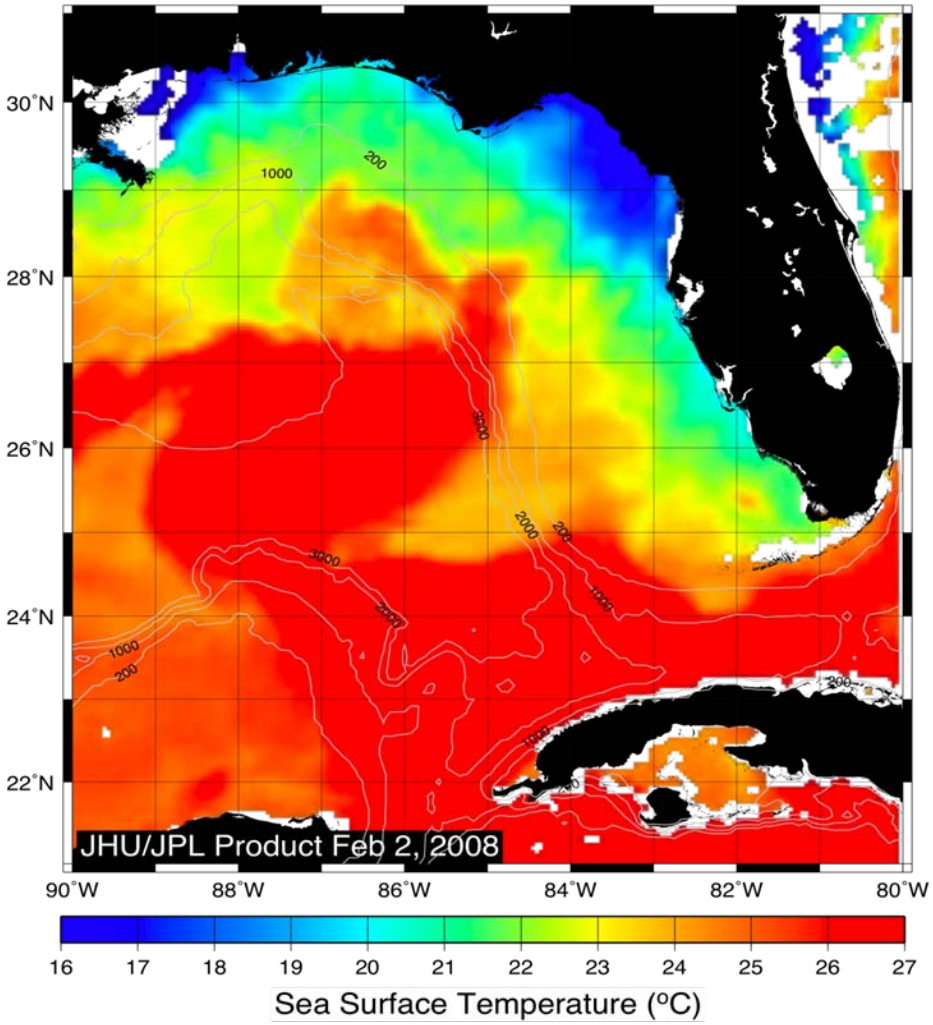
Improvements in Statistical Hurricane Intensity Prediction Scheme (SHIPS) Model

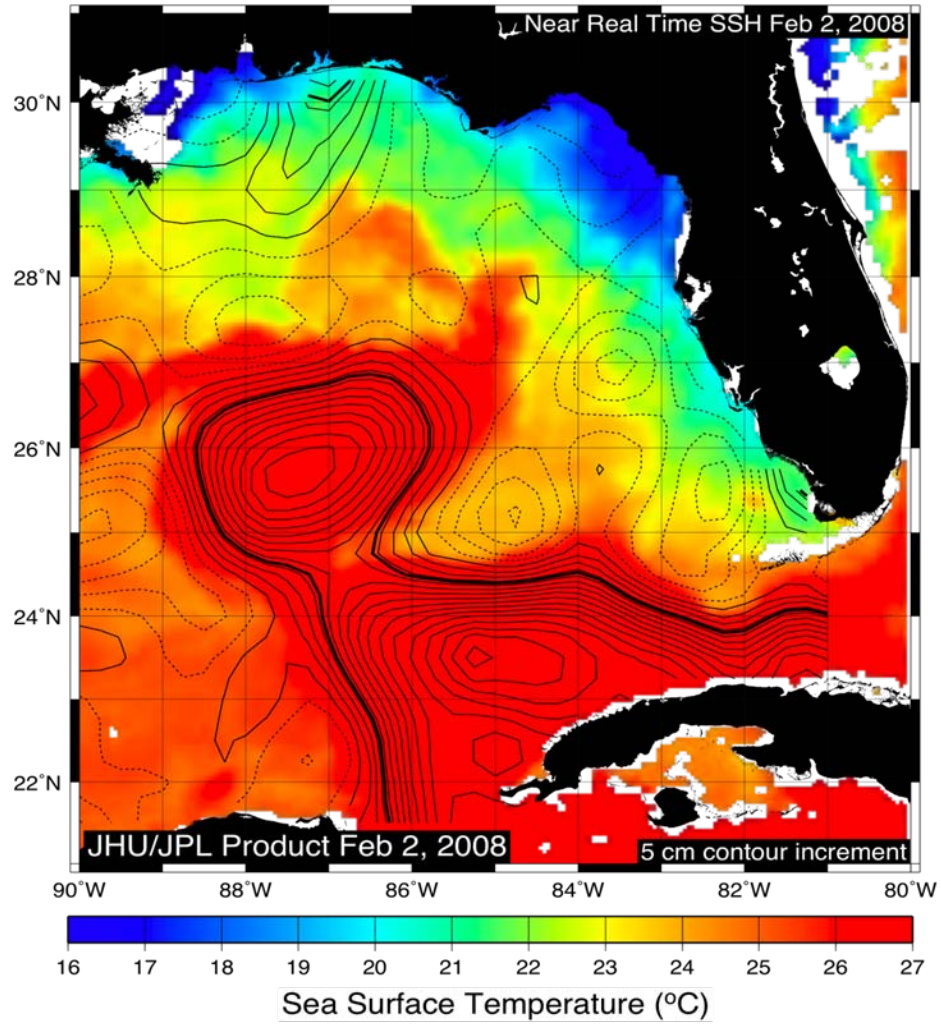


- For largest tropical storms (Cat 4-5)
- Improvement measured as decrease in difference of forecast wind speed with vs. without altimetry (% of WS)
- All cases except Isabel improved
- Ivan shows 20% improvement in 96-hour intensity forecast

Mainelli et al., 2008
Courtesy G. Goni (NOAA)

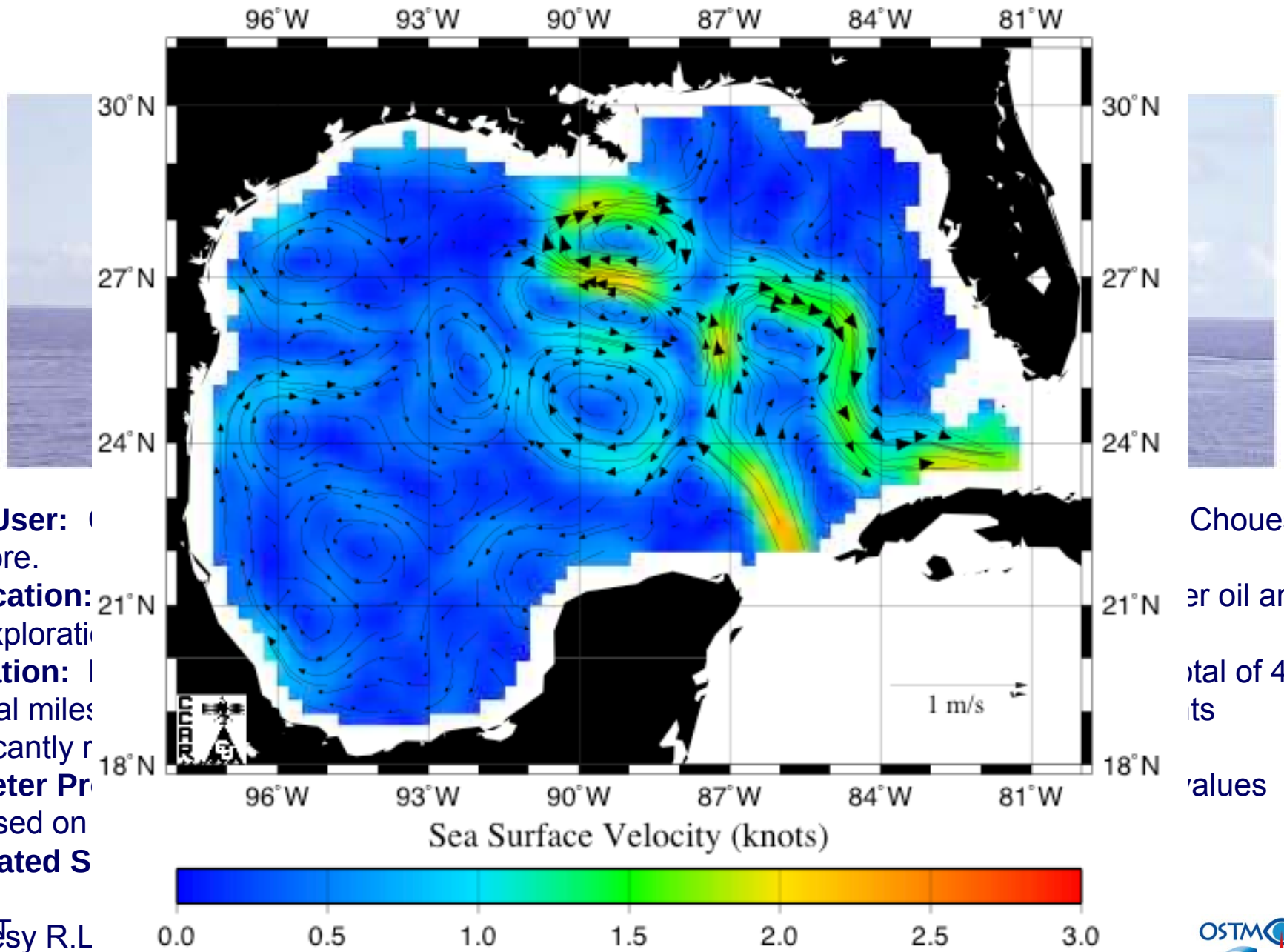
Near Real-time Analyses at CCAR





Courtesy R.Leben (U. Colorado)

Offshore Operational Support: Gulf of Mexico



Data User: (Chouest Offshore.

Application: er oil and gas explorati

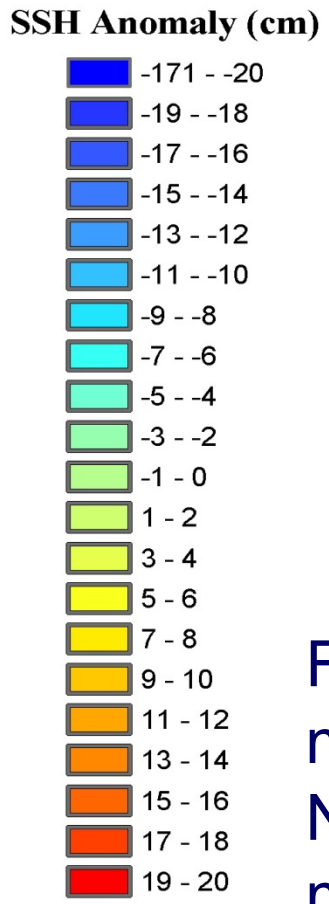
Operation: tal of 425 nautical miles its significantly r

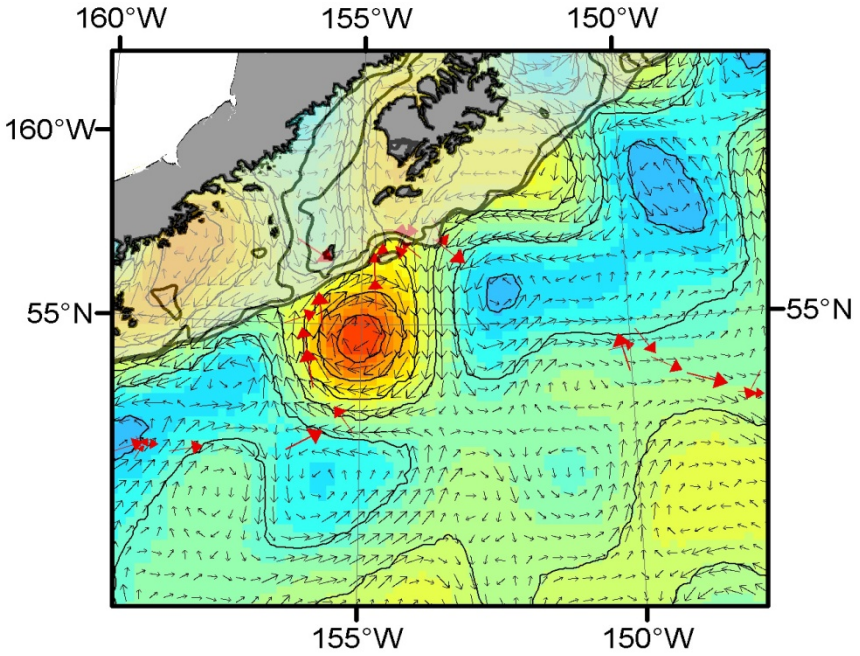
Altimeter Pr values accessed on

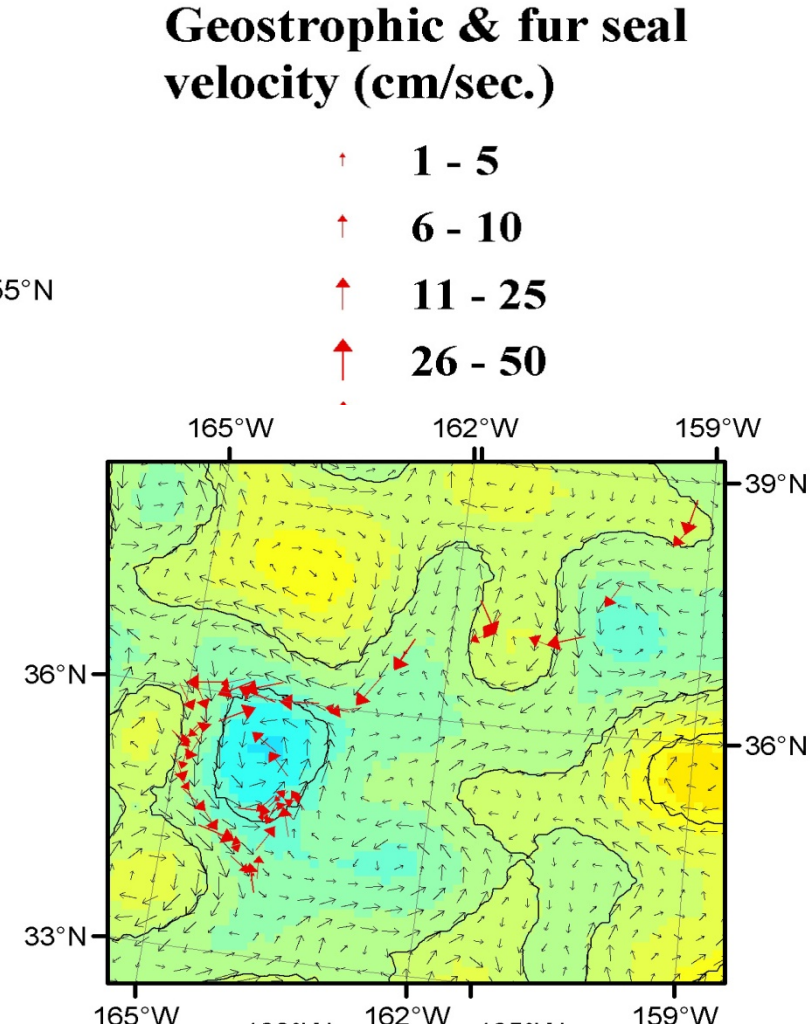
Estimated S

Courtesy R.L

Satellite tracked northern fur seals



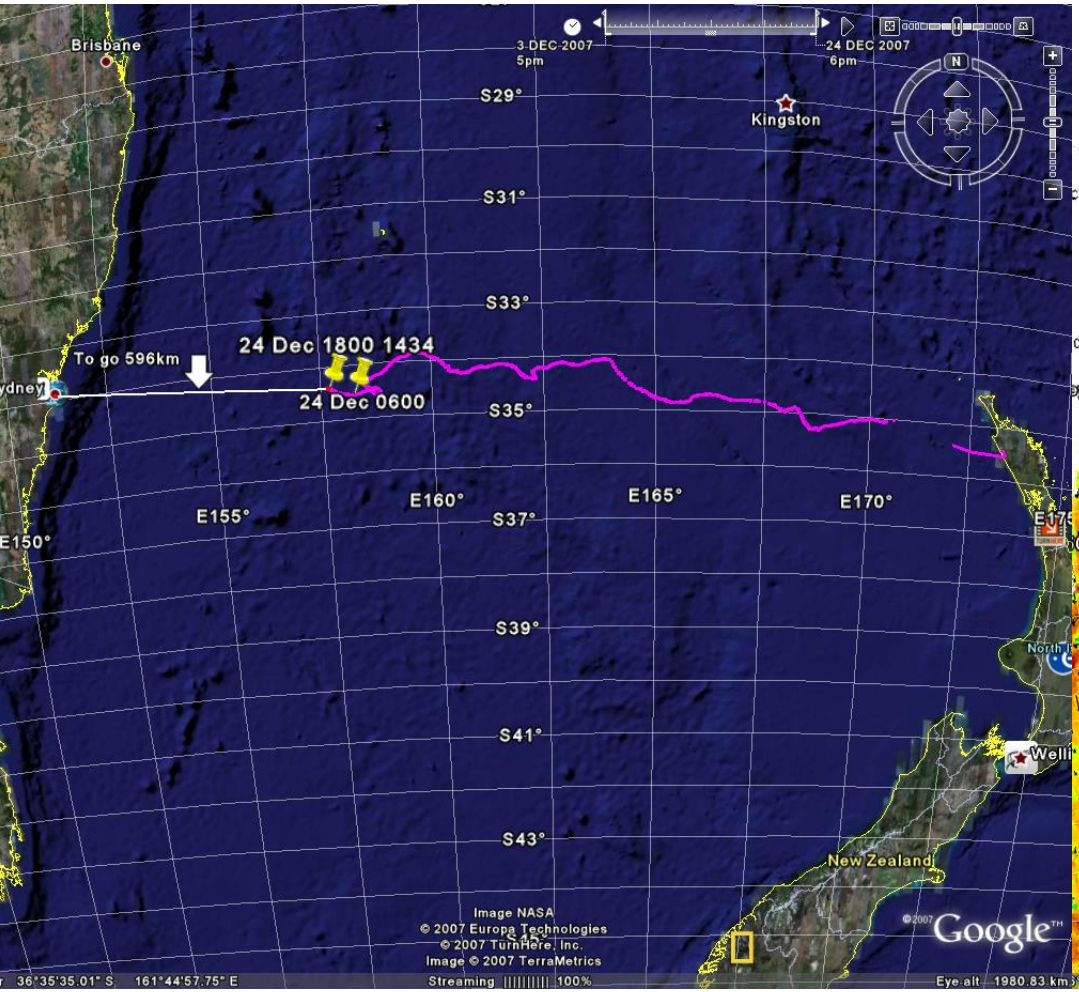


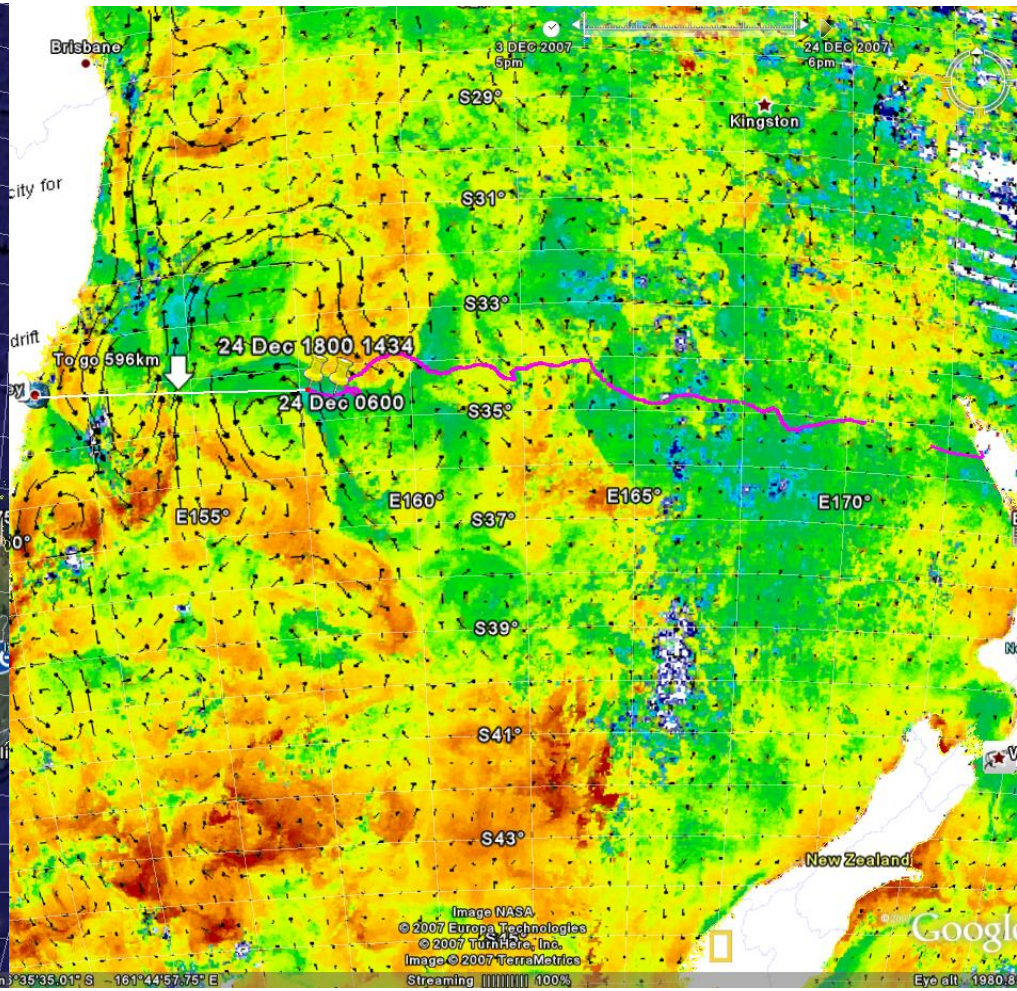


Fur seals linger near mesoscale eddy features in North Pacific during wintertime migration.

Courtesy R.Leben (U. Colorado)

Sea Kayaking “The Gap”: NZ to Australia

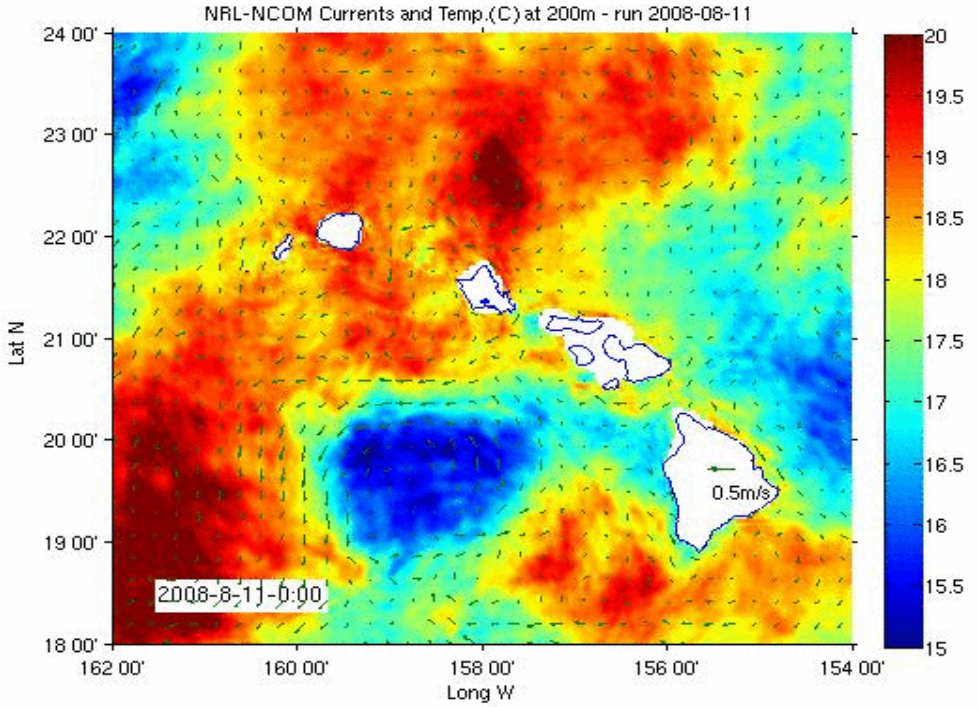


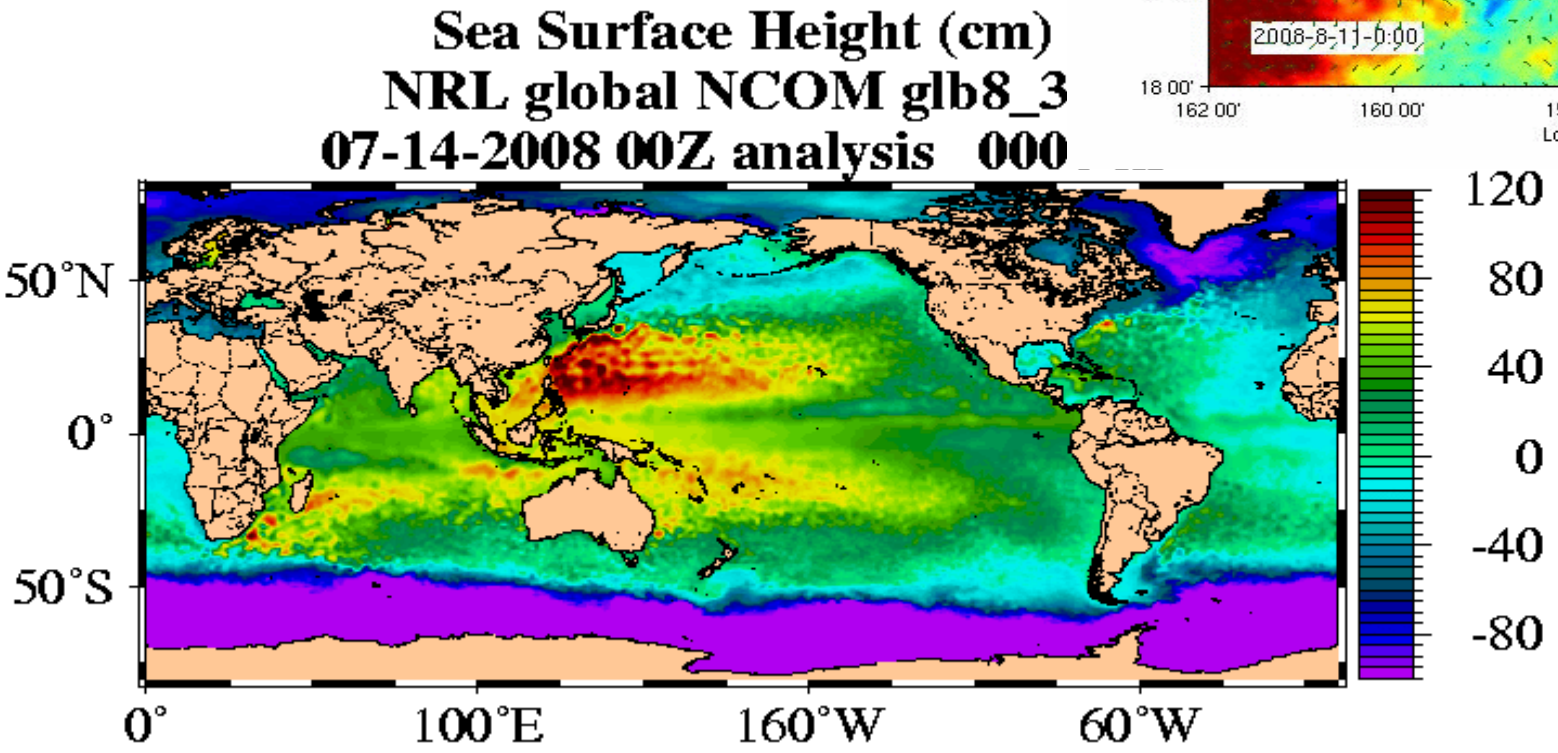


Ocean Modeling & Data Assimilation

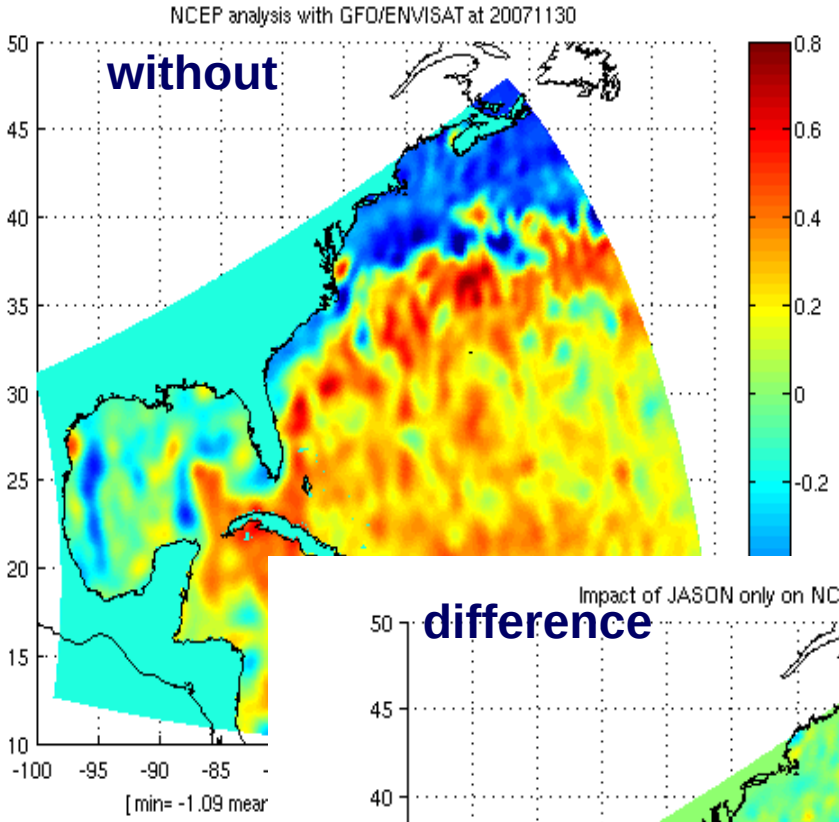
Jason-2 Data & U.S. Navy Ocean Models

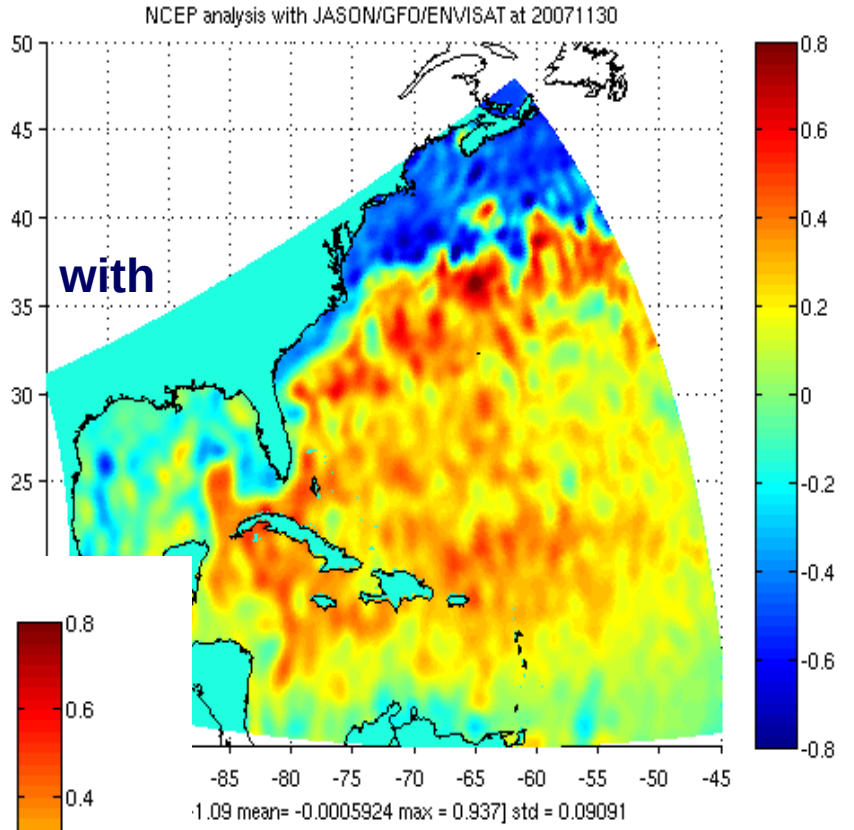
Define tests that must be met to declare Jason-2 operational at NAVOCEANO for the purposes of Navy ocean forecasting.

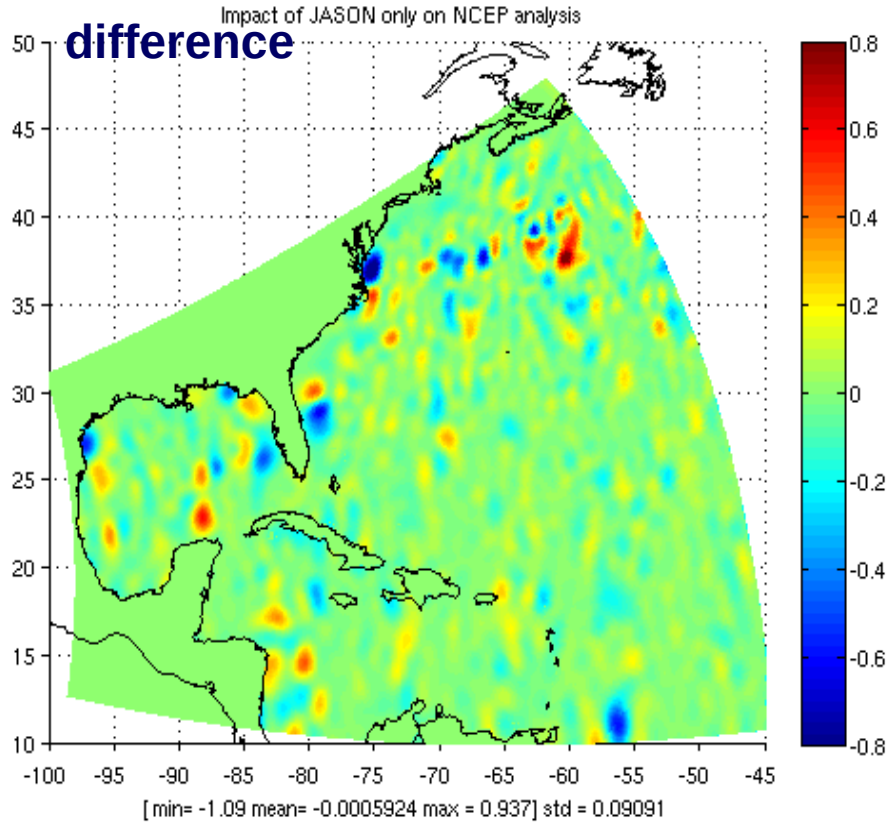




Courtesy
G. Jacobs (NRL)







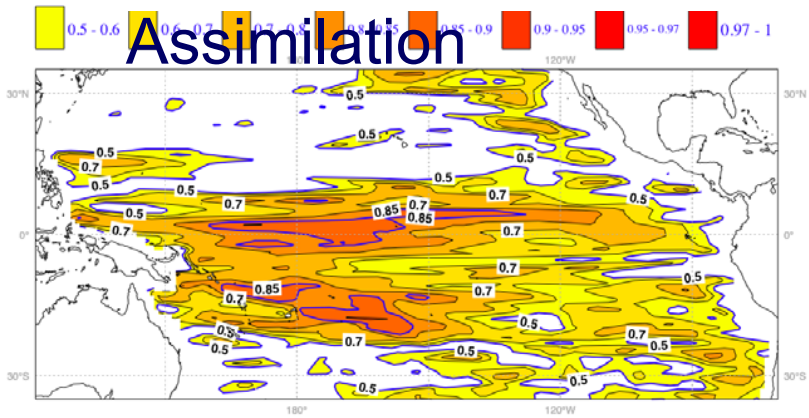
NOAA Real-Time Ocean Forecast System (RTOFS):

Effects of adding Jason-1 data to analysis with GFO and ENVISAT data.

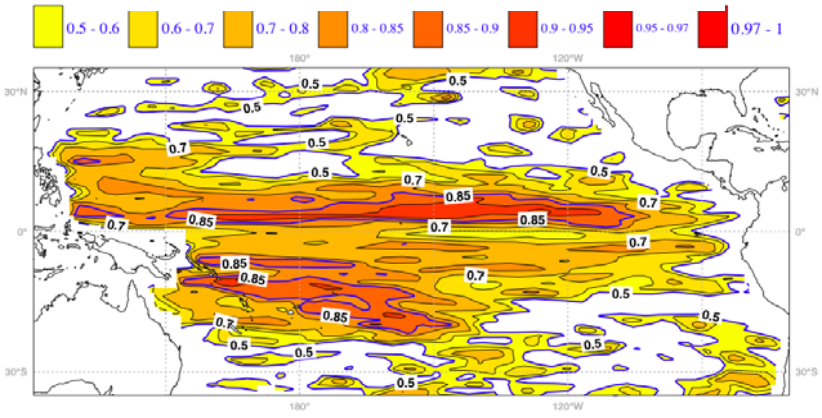
Courtesy A. Mehra (NOAA)

ECMWF Seasonal Forecasting Ocean Model: Effect on currents

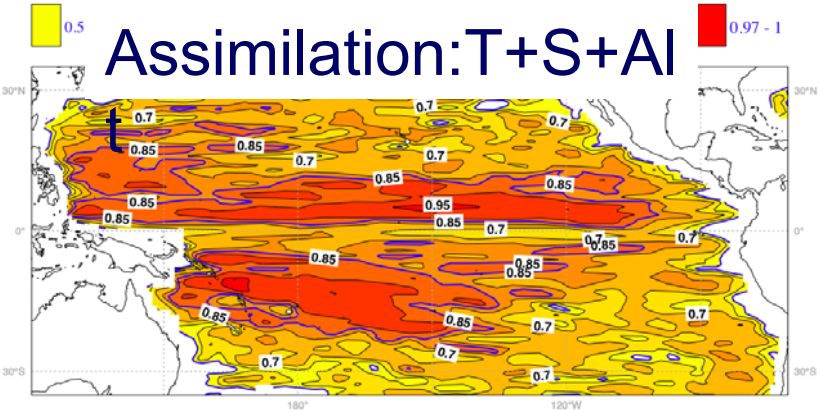
No Data Assimilation



Assimilation:T+S



Assimilation:T+S+AI



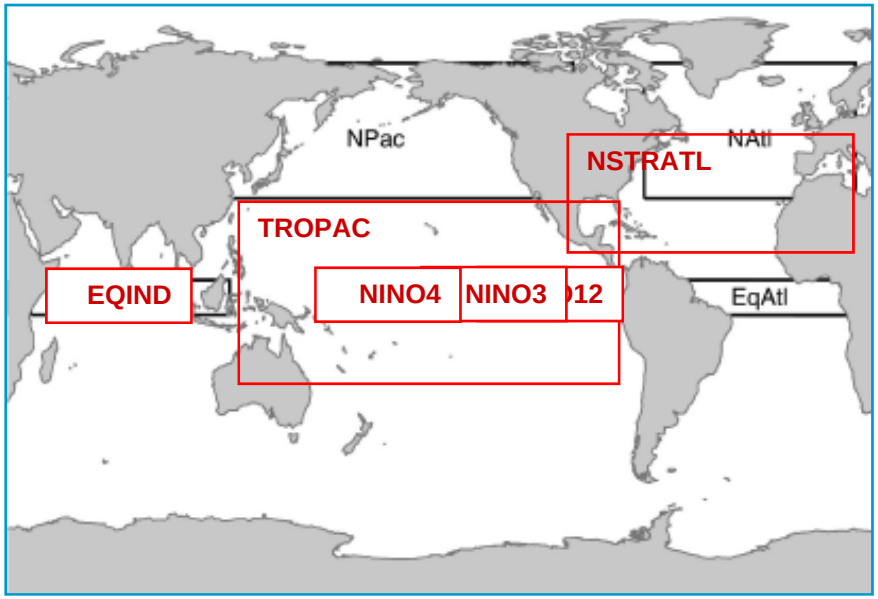
Correlation with OSCAR currents (taken as truth)

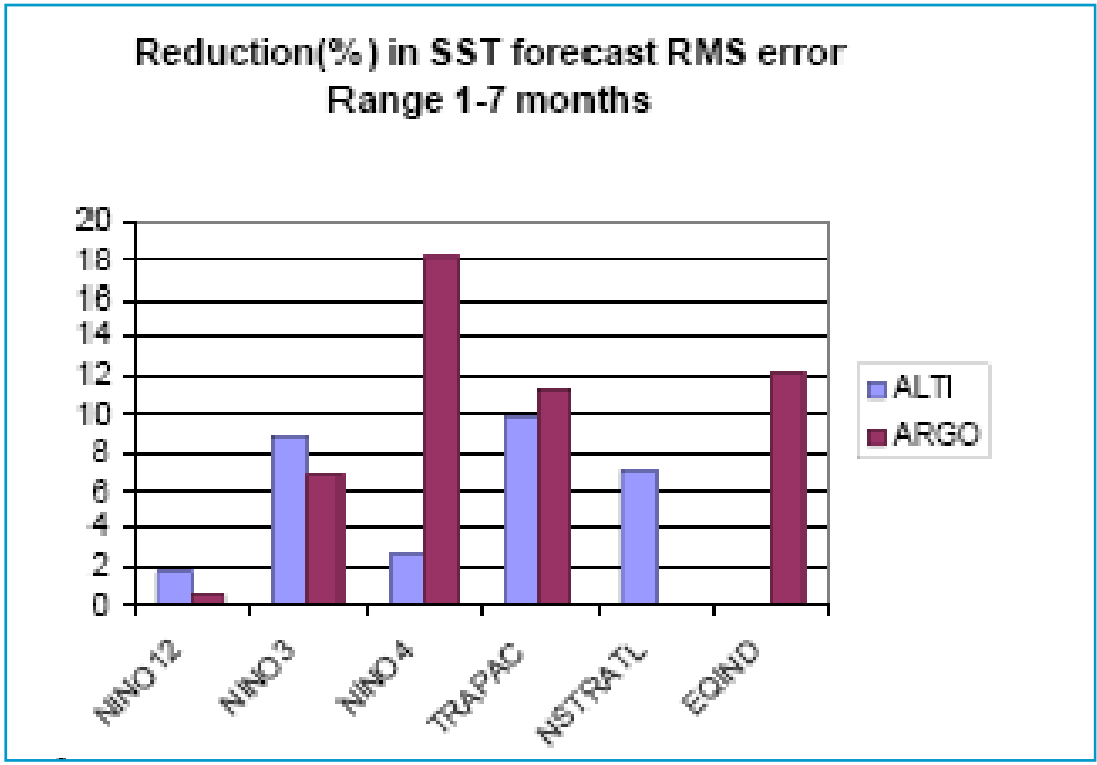
Monthly means, period: 1993-2005

Seasonal cycle removed

Courtesy M. Balmaseda (ECMWF)

Seasonal Forecasting at ECMWF

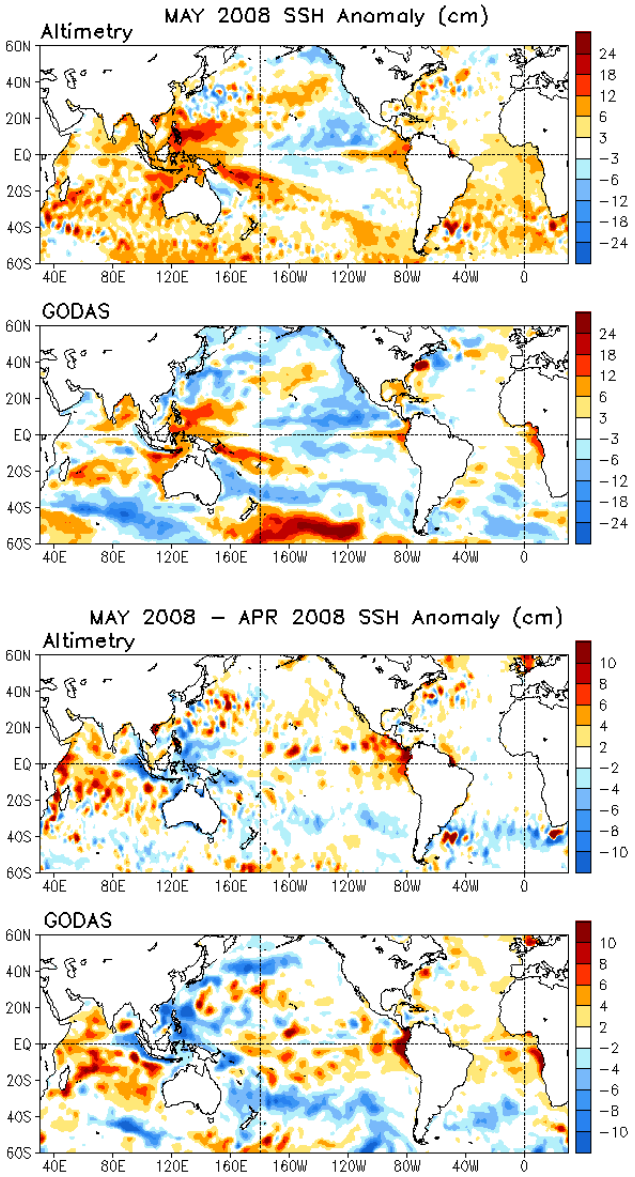


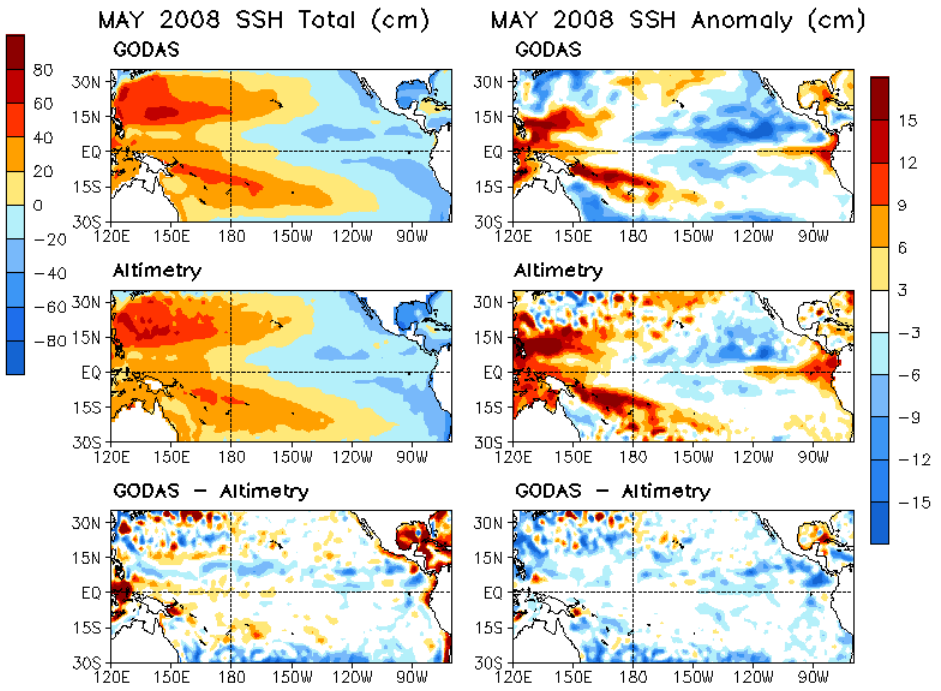


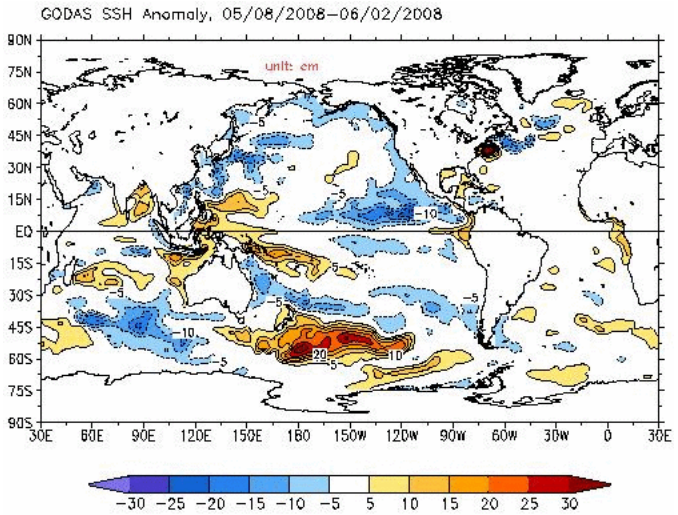
- **Observing systems are complementary:**
- **• Altimeter has largest impact in Eastern Pacific and Atlantic**
- **•Argo has largest impact in Western Pacific/Indian Ocean**

Courtesy M. Balmaseda (ECMWF)

Global Ocean Data Assimilation System & El Niño





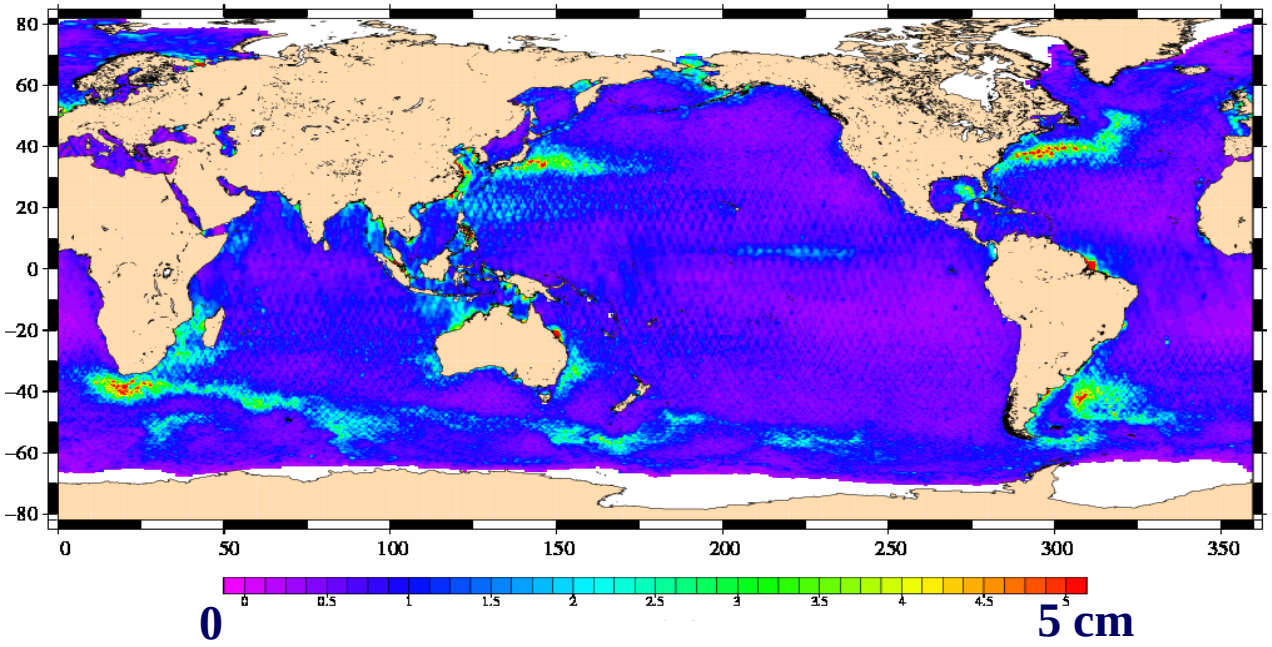


Nice OSTST
Nov 10-12, 2008

Courtesy Y. Xue (NOAA)

DUACS System: RT+NRT vs. NRT

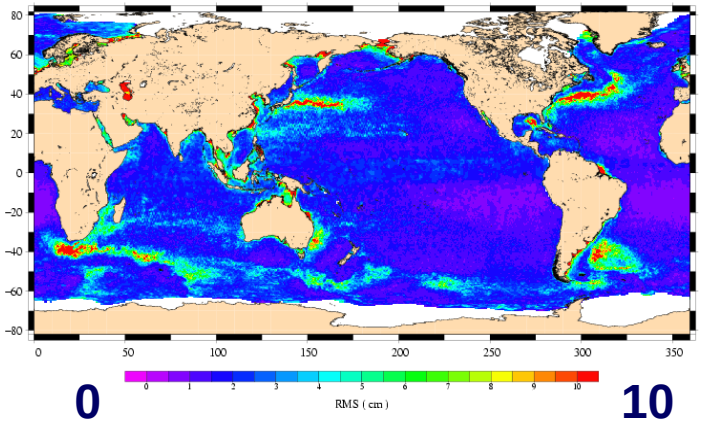
RMS of the differences between NRT classic SLA and combined NRT+RT SLA



■ **OGDR/FDGDR data have a major impact on areas with important spatial & temporal variability**

→ **Improved restitution of measoscale structures (Pascual & al, 2008)**

RMS of the differences between NRT and DT SLA (Pascual & al, 2008)



■ **RMS of the differences between classical NRT and experimental NRT+RT products represents up to 40% of the of signal observed between DT and NRT products**

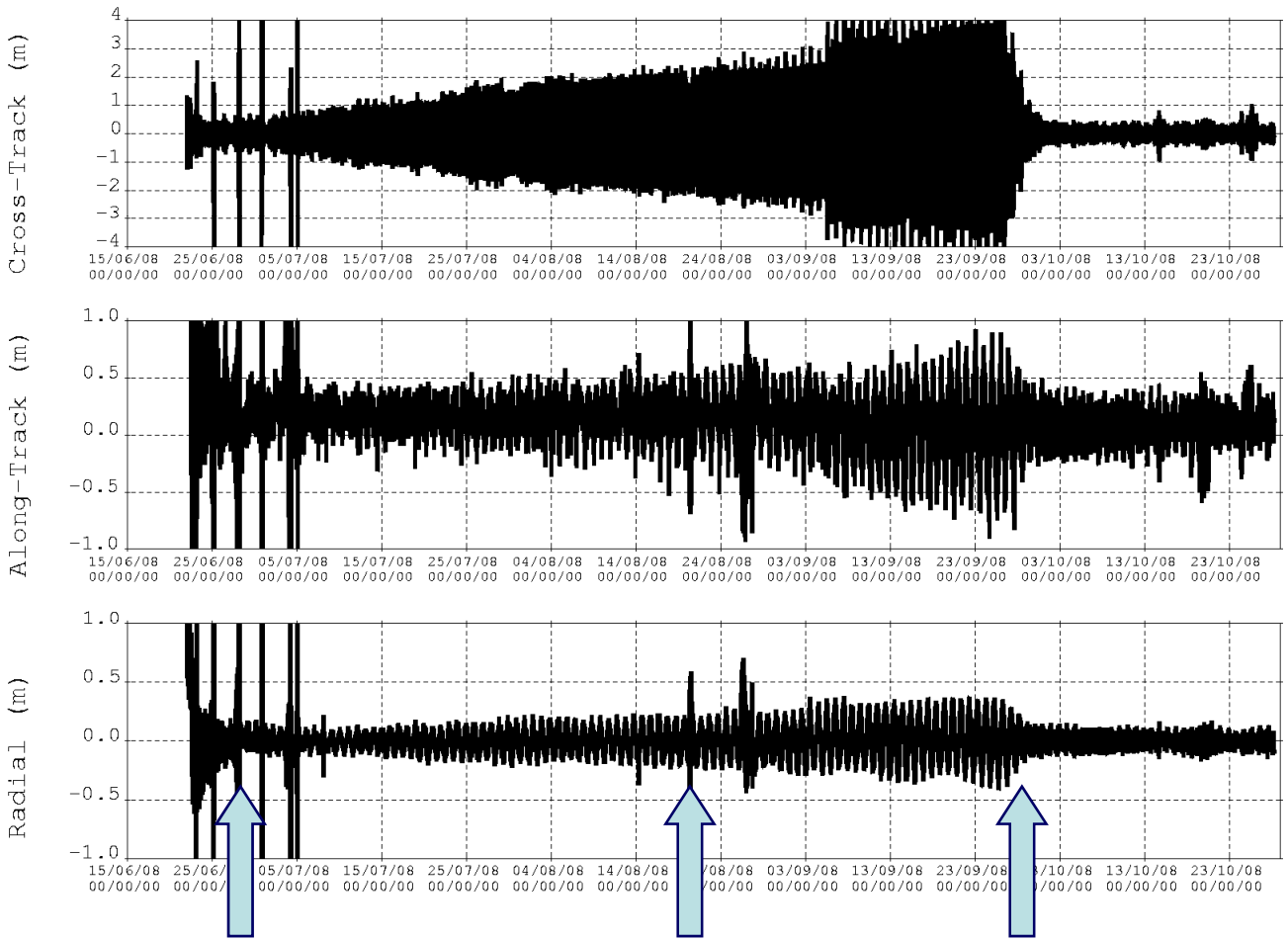
→ **OGDR/FDGDR data allow to restore a significant part of the variability lost by the non-centered time window in NRT**

Courtesy A. Pascual (UiB/CLS)

OGDR Improvements

DIODE orbits compared with DORIS MOE

DIODE DGXX bord // MOE JASON2 21/06 - 27/10 2008



(Cross-Track is less observable)

Slow secular degradation understood and fixed

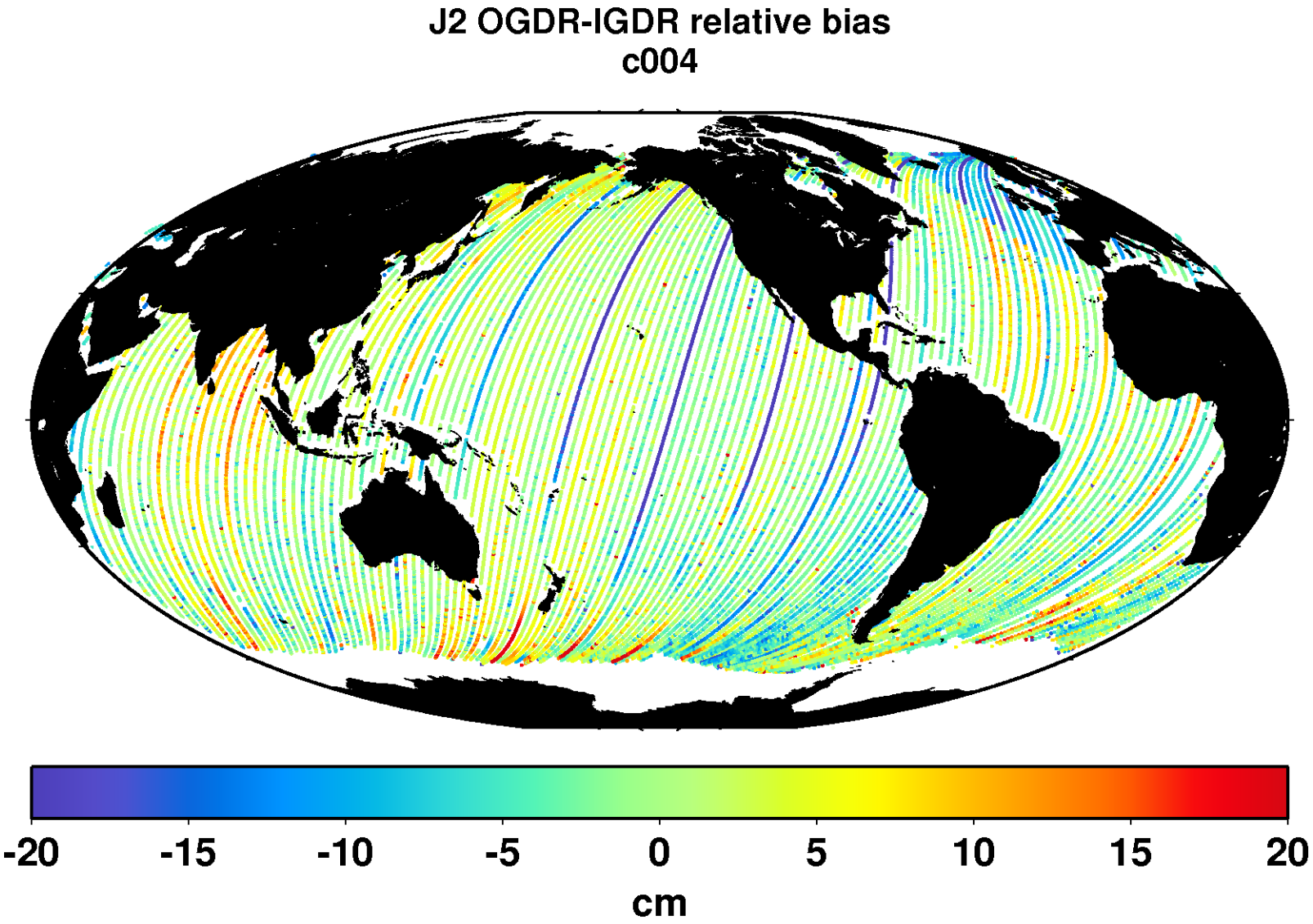
Effects of large orbit acquisition maneuvers

Yaw transitions: an "error" in DIODE software

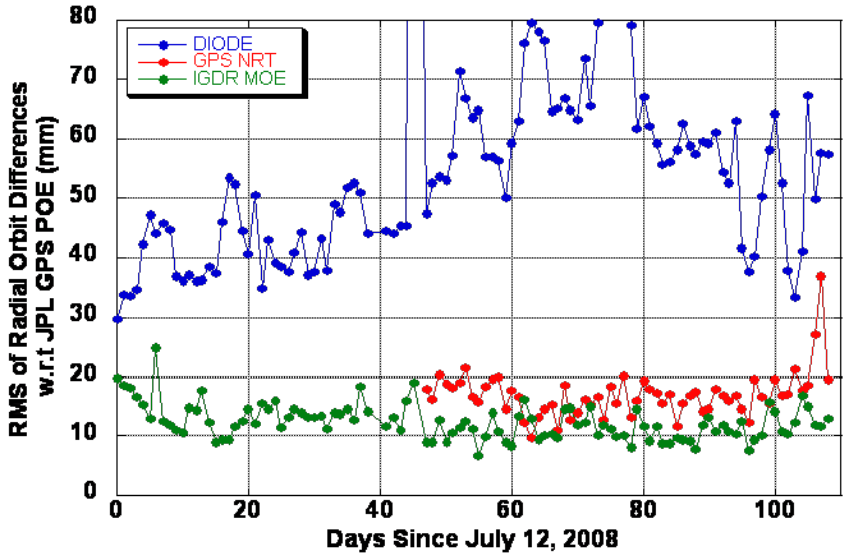
Pole covariance changed (and attitude model used)

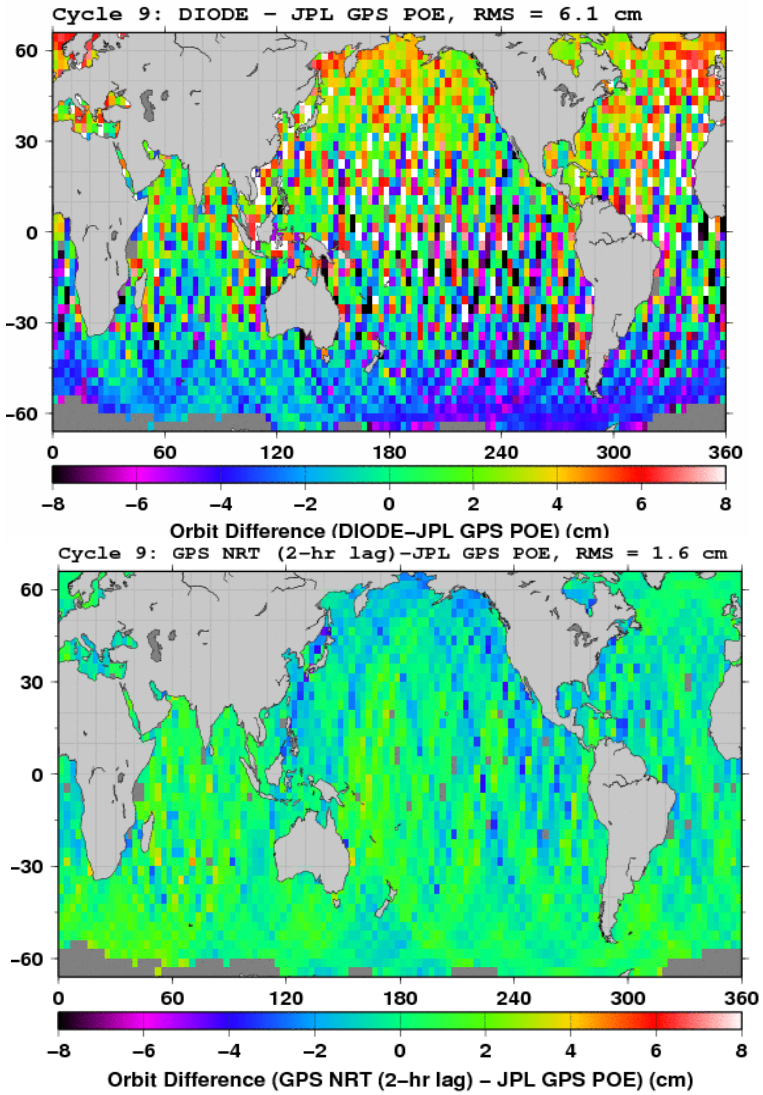
Courtesy C. Jayles (CNES)

Jason-2 OGDR vs. IGDR



Near Real Time GPS-Based Orbit Determination for OGDRs





- JPL will generate a GPS-based OGDR-SSHA research product beginning in February 2009
  - Distributed through PO-DAAC
- Will add two fields to project OGDR:
  - SSHA derived from GPS-based NRT orbit
  - GPS-based NRT orbit altitude
- RMS radial orbit differences of GPS NRT & POE orbits < 2.0 cm

Courtesy S. Desai (JPL)

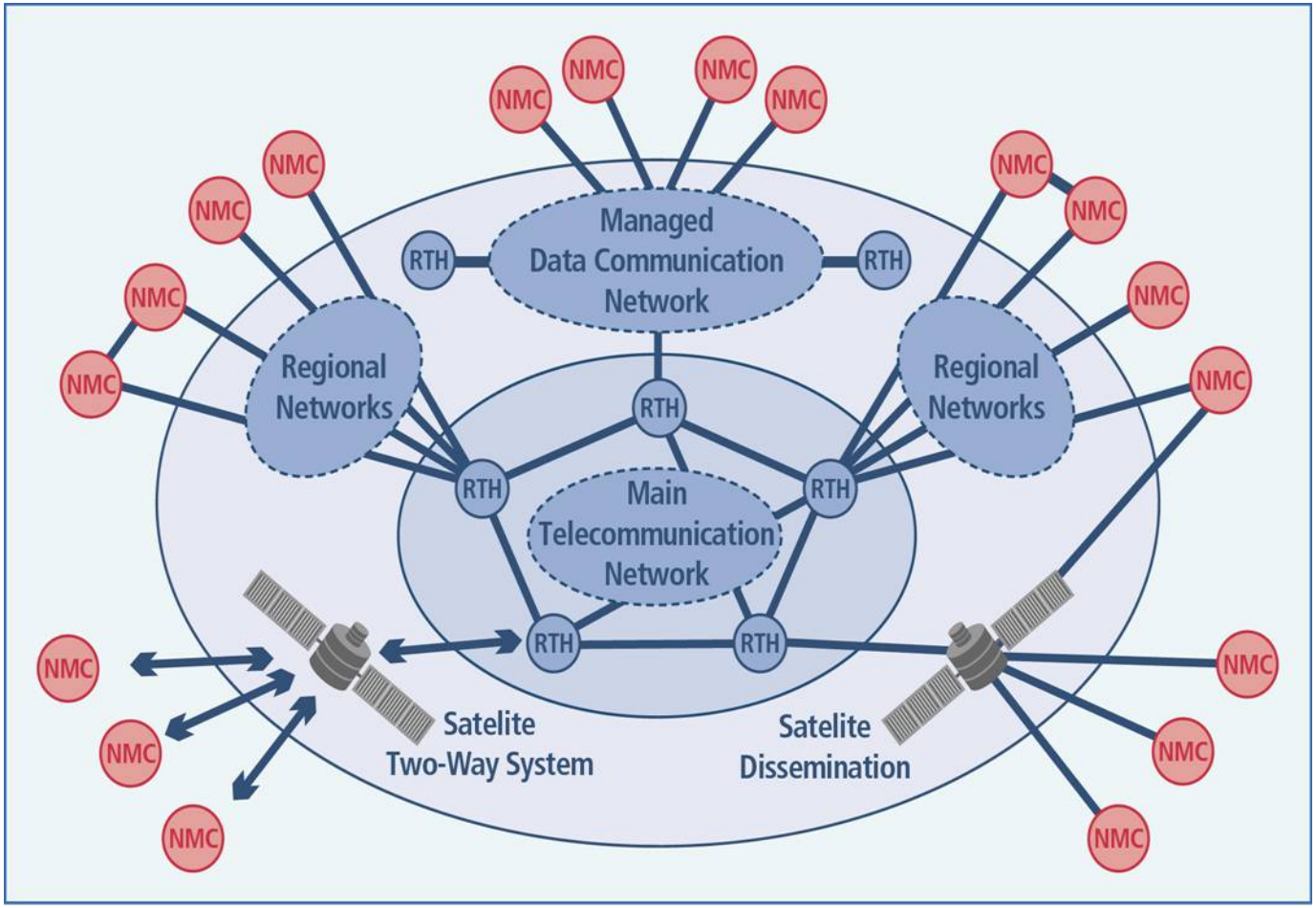
Dissemination

OGDR Data Access

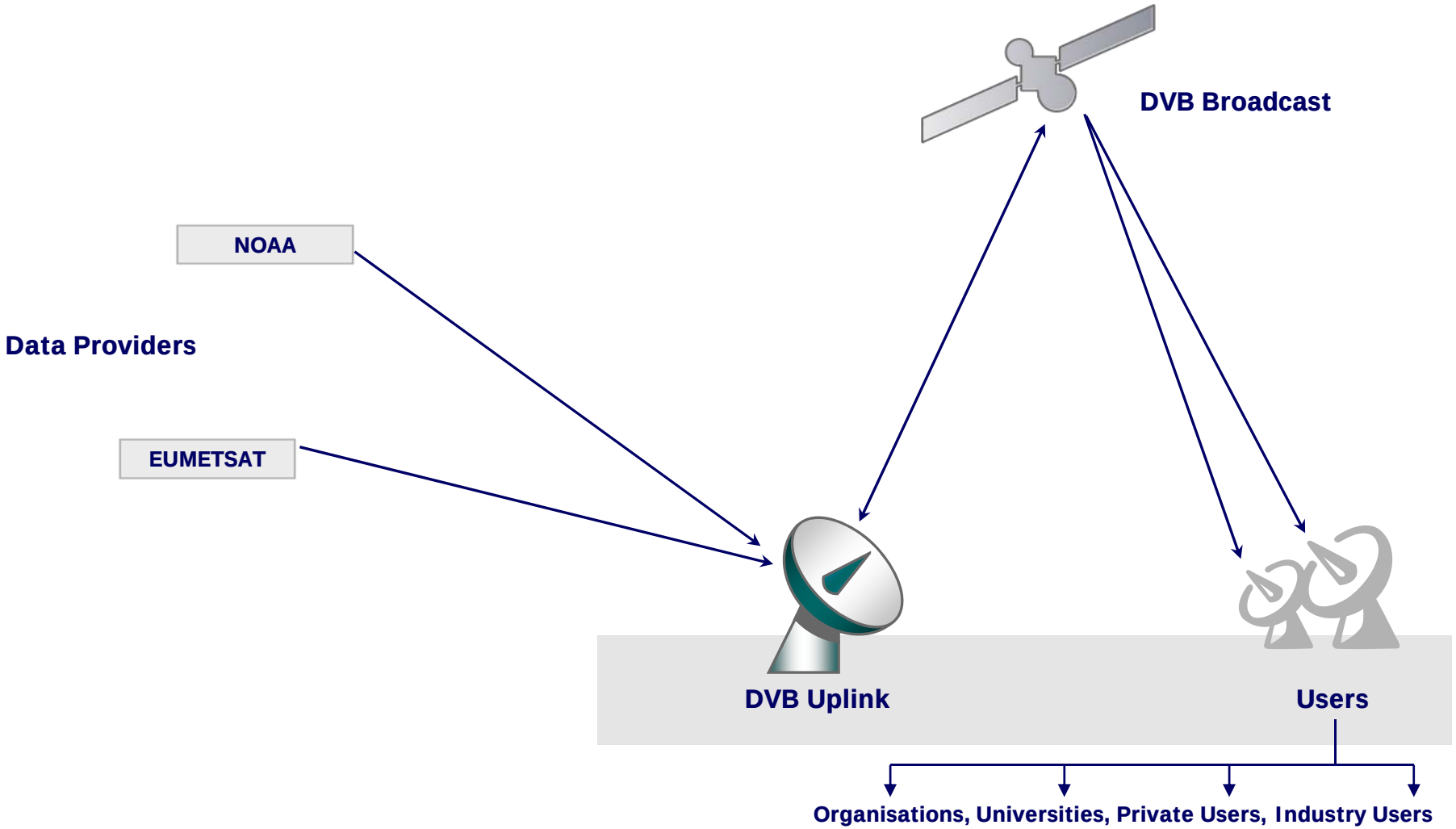
- **OGDR-BUFR:**
  - **Global Telecommunication Network (Met. Offices)**
    - OGDR-BUFR injected by NOAA & EUM for their respective products
  - **EUMETCast/GeoNetCast satellite broadcast**
  - **ftp from NOAA/DDS**

- **OGDR, OGDR-SSHA & OGDR-BUFR:**
  - **ftp from EUMETSAT/UMARF**
  - **archive available from NOAA/CLASS or CNES/AVISO**

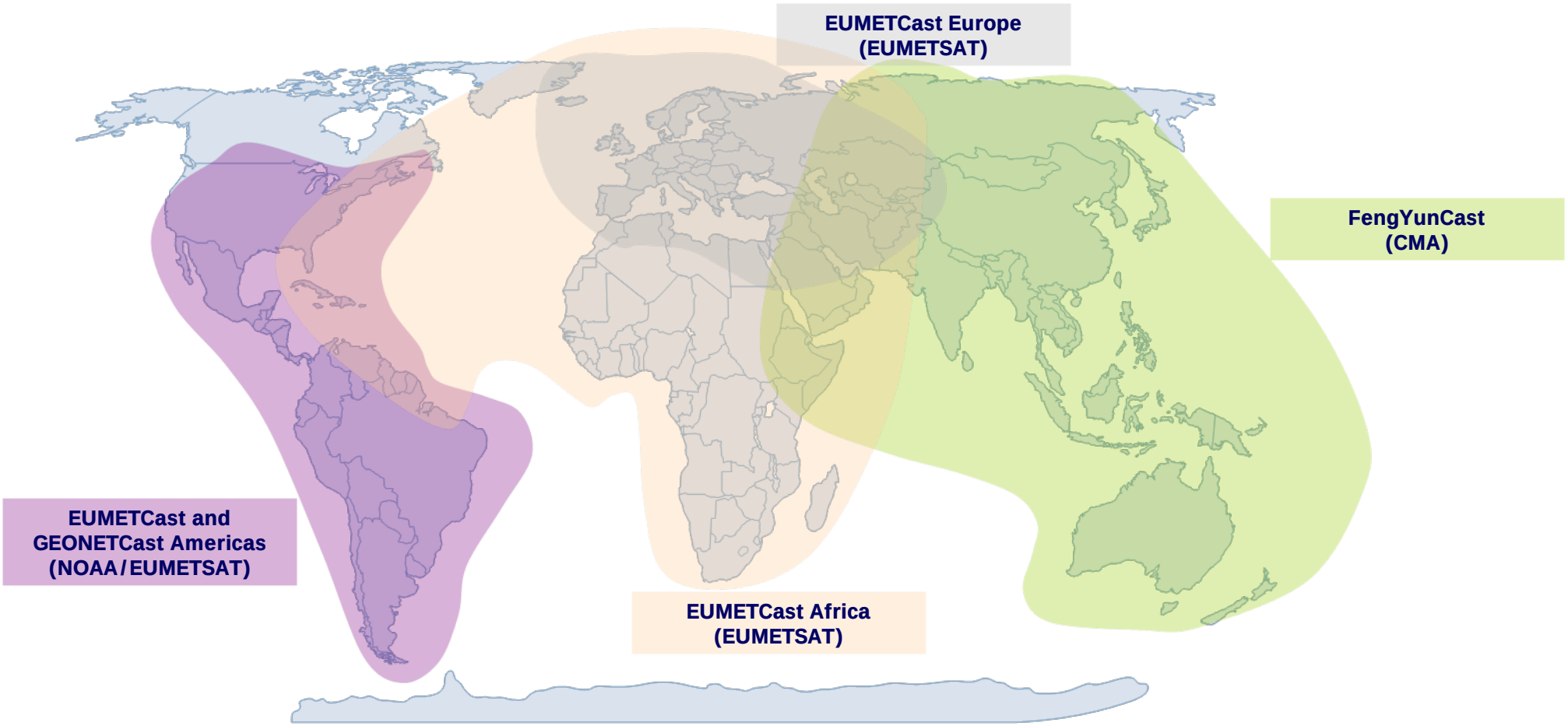
Global Telecommunication Network

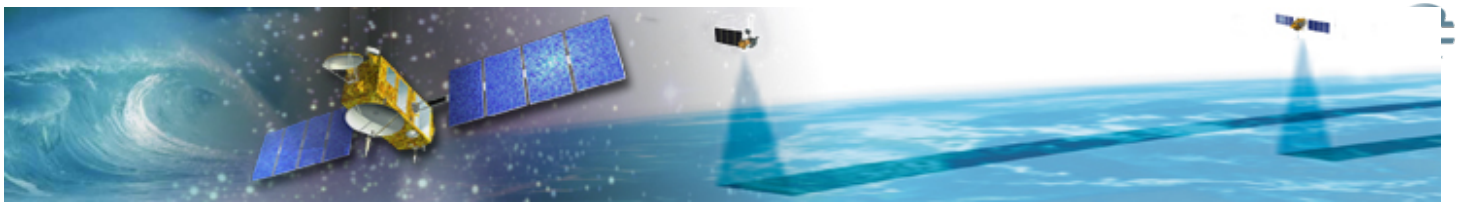


GEONETCAST: Broadcasting the satellite data



GEONETCast Coverage





Near Real-Time Altimeter Validation System

Sea Surface Height Anomaly Statistics, Units (m)

Parameter: ssha Section: Statistics_Table Reports Directory

File Name	Start Time	End Time	Median	Mean	Std. Dev.	No. Obs.	Total Obs.	Defaulted Lat/Lon	Flagged (total)	Defaulted (total)	3-Sigma Edited	1 cpr Amp.
JA2_OPN_2PTS003_039_20080802_094339_20080802_114054	2008-08-02 09:43:40	2008-08-02 11:40:53	0.153	0.160	0.096	3871	6897	0	2998	0	28	0.064
JA2_OPN_2PTS003_041_20080802_114054_20080802_133703	2008-08-02 11:40:55	2008-08-02 13:37:02	0.184	0.185	0.085	4102	6839	0	2651	0	86	0.019
JA2_OPN_2PTS003_044_20080802_133703_20080802_153433	2008-08-02 13:37:04	2008-08-02 15:34:32	0.212	0.212	0.094	3949	6918	0	2899	0	70	0.063
JA2_OPN_2PTS003_046_20080802_153433_20080802_184306	2008-08-02 15:34:34	2008-08-02 18:43:05	0.203	0.213	0.113	7434	11096	0	3521	0	141	0.105
JA2_OPN_2PTS003_049_20080802_184306_20080802_203339	2008-08-02 18:43:07	2008-08-02 20:33:38	0.229	0.235	0.129	3808	6500	0	2569	0	123	0.067
JA2_OPN_2PTS003_051_20080802_203339_20080802_224146	2008-08-02 20:33:40	2008-08-02 22:41:45	0.210	0.210	0.091	3788	7437	0	3524	0	125	0.051
JA2_OPN_2PTS003_053_20080802_224146_20080803_005023	2008-08-02 22:41:47	2008-08-03 00:50:22	0.161	0.156	0.085	4035	7567	0	3445	0	87	0.052
JA2_OPN_2PTS003_053_20080802_224146_20080803_024104	2008-08-02 22:41:47	2008-08-03 02:41:03	0.155	0.154	0.079	7471	14085	0	6453	0	161	0.024
JA2_OPN_2PTS003_057_20080803_024104_20080803_060924	2008-08-03 02:41:05	2008-08-03 06:09:23	0.183	0.186	0.100	8453	12266	0	3609	0	204	0.053
JA2_OPN_2PTS003_061_20080803_060924_20080803_080808	2008-08-03 06:09:25	2008-08-03 08:08:07	0.140	0.170	0.154	3753	6890	0	3119	0	18	0.128
JA2_OPN_2PTS003_063_20080803_080808_20080803_100654	2008-08-03 08:08:09	2008-08-03 10:06:53	0.180	0.178	0.092	4069	6987	0	2834	0	84	0.046
JA2_OPN_2PTS003_065_20080803_100654_20080803_120338	2008-08-03 10:06:55	2008-08-03 12:03:37	0.163	0.157	0.085	4066	6868	0	2758	0	44	0.032
JA2_OPN_2PTS003_068_20080803_120338_20080803_135950	2008-08-03 12:03:39	2008-08-03 13:59:49	0.179	0.179	0.088	3983	6840	0	2780	0	77	0.036
JA2_OPN_2PTS003_070_20080803_135950_20080803_153531	2008-08-03 13:59:51	2008-08-03 15:35:30	0.232	0.231	0.105	3340	5533	0	2106	0	87	0.077
JA2_OPN_2PTS003_071_20080803_153531_20080803_174440	2008-08-03 15:35:32	2008-08-03 17:44:39	0.204	0.211	0.094	4712	7595	0	2821	0	62	0.058
JA2_OPN_2PTS003_074_20080803_174440_20080803_194121	2008-08-03 17:44:41	2008-08-03 19:41:20	0.212	0.226	0.109	4335	6861	0	2388	0	138	0.098
JA2_OPN_2PTS003_076_20080803_194122_20080803_213844	2008-08-03 19:41:23	2008-08-03 21:38:43	0.198	0.206	0.119	2441	6903	0	4421	0	41	0.077
JA2_OPN_2PTS003_078_20080803_213844_20080803_231752	2008-08-03 21:38:45	2008-08-03 23:17:51	0.226	0.223	0.078	2720	5734	0	2940	0	74	0.016
JA2_OPN_2PTS003_079_20080803_231752_20080804_011336	2008-08-03 23:17:53	2008-08-04 01:13:35	0.163	0.154	0.098	3920	6815	0	2810	0	85	0.052
JA2_OPN_2PTS003_079_20080803_231752_20080804_013751	2008-08-03 23:17:53	2008-08-04 01:37:50	0.164	0.159	0.088	5018	8243	0	3086	0	139	0.047
JA2_OPN_2PTS003_082_20080804_013751_20080804_043604	2008-08-04 01:37:52	2008-08-04 04:36:03	0.170	0.171	0.090	7050	10395	0	3225	0	120	0.046
JA2_OPN_2PTS003_085_20080804_043604_20080804_063237	2008-08-04 04:36:05	2008-08-04 06:32:36	0.192	0.190	0.139	3678	6860	0	3138	0	44	0.155
JA2_OPN_2PTS003_087_20080804_063237_20080804_083143	2008-08-04 06:32:38	2008-08-04 08:31:42	0.126	0.122	0.100	3117	7006	0	3723	0	166	0.095
JA2_OPN_2PTS003_089_20080804_083143_20080804_102951	2008-08-04 08:31:44	2008-08-04 10:29:50	0.204	0.207	0.089	3993	6956	0	2871	0	92	0.028
JA2_OPN_2PTS003_091_20080804_102951_20080804_122618	2008-08-04 10:29:52	2008-08-04 12:26:17	0.178	0.177	0.073	4175	6857	0	2583	0	99	0.025
JA2_OPN_2PTS003_094_20080804_122618_20080804_142259	2008-08-04 12:26:20	2008-08-04 14:22:58	0.188	0.191	0.078	3943	6866	0	2771	0	152	0.027
JA2_OPN_2PTS003_096_20080804_142259_20080804_161207	2008-08-04 14:23:00	2008-08-04 16:12:06	0.232	0.236	0.092	3624	6418	0	2709	0	85	0.042
JA2_OPN_2PTS003_098_20080804_161208_20080804_180734	2008-08-04 16:12:09	2008-08-04 18:07:33	0.215	0.218	0.080	4623	6790	0	2053	0	114	0.029
JA2_OPN_2PTS003_100_20080804_180734_20080804_200340	2008-08-04 18:07:35	2008-08-04 20:03:39	0.231	0.233	0.088	3588	6828	0	3004	0	236	0.050
JA2_OPN_2PTS003_100_20080804_180734_20080804_214329	2008-08-04 18:07:35	2008-08-04 21:43:28	0.238	0.249	0.102	5689	12601	0	6622	0	290	0.067
JA2_OPN_2PTS003_103_20080804_214329_20080804_234050	2008-08-04 21:43:30	2008-08-04 23:40:49	0.212	0.216	0.076	3397	6807	0	3335	0	75	0.032
JA2_OPN_2PTS003_106_20080804_234050_20080805_013559	2008-08-04 23:40:51	2008-08-05 01:35:58	0.203	0.199	0.081	3231	6781	0	3464	0	86	0.059
JA2_OPN_2PTS003_106_20080804_234050_20080805_030118	2008-08-04 23:40:51	2008-08-05 03:01:17	0.185	0.186	0.077	7214	11804	0	4481	0	109	0.036
JA2_OPN_2PTS003_109_20080805_030118_20080805_045827	2008-08-05 03:01:19	2008-08-05 04:58:26	0.169	0.178	0.103	4574	6893	0	2221	0	98	0.044
JA2_OPN_2PTS003_111_20080805_045827_20080805_065606	2008-08-05 04:58:28	2008-08-05 06:56:05	0.183	0.184	0.111	3362	6828	0	3434	0	32	0.089
JA2_OPN_2PTS003_113_20080805_065606_20080805_085527	2008-08-05 06:56:07	2008-08-05 08:55:26	0.155	0.156	0.087	3729	6926	0	3105	0	92	0.038
JA2_OPN_2PTS003_115_20080805_085527_20080805_105308	2008-08-05 08:55:28	2008-08-05 10:53:07	0.189	0.190	0.077	4086	6929	0	2791	0	52	0.006
File Name	Start Time	End Time	Median	Mean	Std. Dev.	No. Obs.	Total Obs.	Defaulted Lat/Lon	Flagged (total)	Defaulted (total)	3-Sigma Edited	1 cpr Amp.

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