

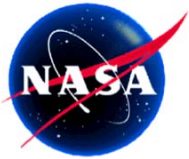
# Dense, High-Accuracy Sea Surface Height Data in Near-Real-Time from the Jason-1, Jason-2, and ENVISAT Missions

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October 20, 2011

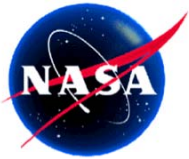


# Objective



- Value-added products with high-accuracy measurements of SSHA in Near-Real-Time (NRT).
  - Typical 3-7 hour latency
- Improve density of NRT SSHA measurements using three missions: Jason-2, Jason-1, and **ENVISAT (new)**.

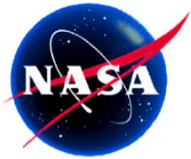
Sea Surface Height Component	Jason-2 OGDR	Jason-1 OSDR	ENVISAT FDGDR
Altimeter Range Measurements	Yes	Yes	Yes
Wet Troposphere Range Correction (Radiometer)	Yes	Liquid, Vapor	Yes
Dry Troposphere and Inv. Bar. Corrections	Yes	No	Yes
Ionosphere Range Correction	Yes	TEC	Yes
Sea State Bias (SSB) Range Correction	Yes	SWH/Wind	Yes
Geophysical Corrections (Tides, MSS)	Yes	No	Yes
Radial Orbit Accuracy from DIODE real-time	<b>3-5 cm</b>	<b>10-25 cm</b>	<b>10-25 cm</b>



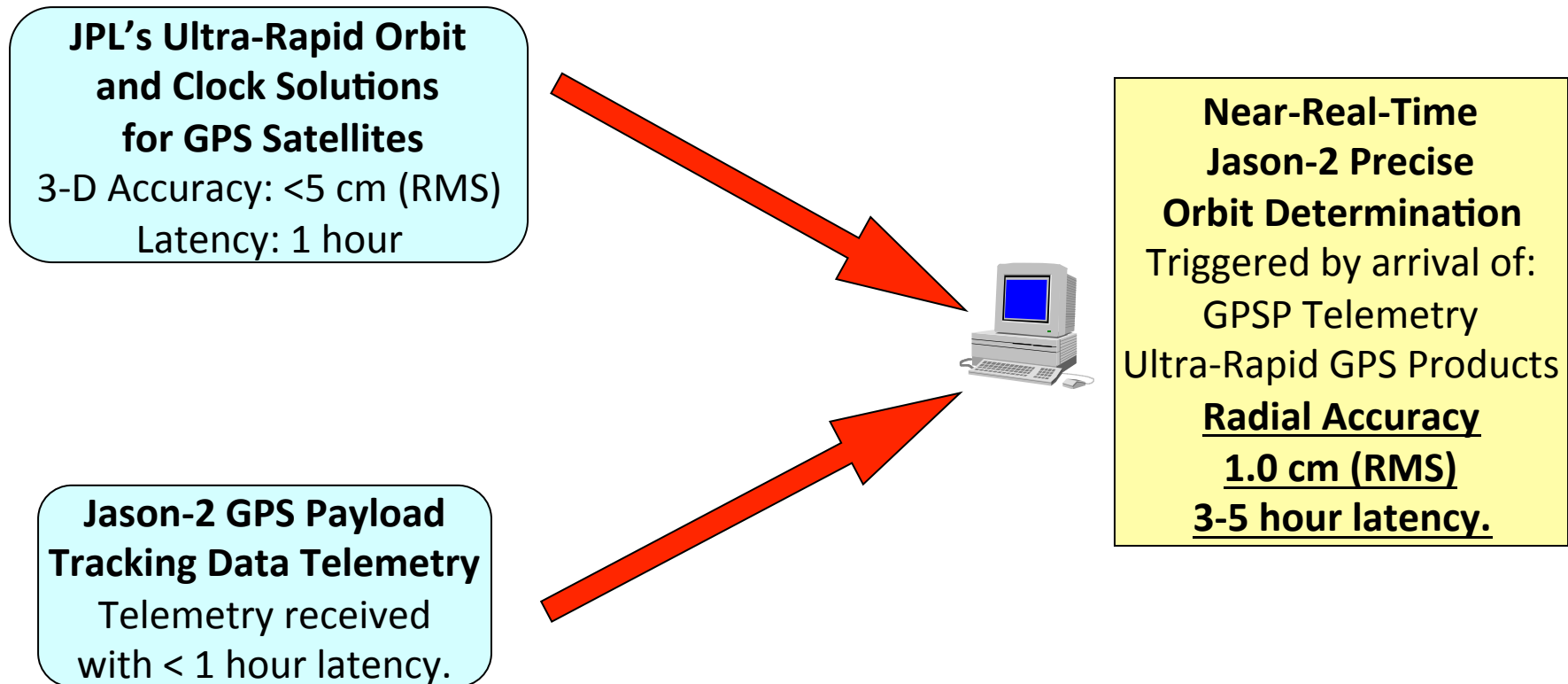
# Approach

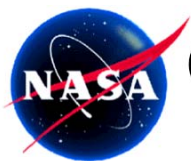


- Models for SSB and other geophysical corrections for Jason-1.
- Forecast pressure fields from National Centers for Environmental Prediction (NCEP)
  - Dry troposphere, and inverse barometer correction for Jason-1 and ENVISAT.
- Orbit altitude accuracy is limiting error source for SSHA from project products.
- Improve orbit altitude accuracy:
  - Jason-2: GPS-based NRT precise orbit determination.
  - Jason-1 and ENVISAT: Inter-satellite SSH crossover-based orbit altitude determination with respect to Jason2 reference.



# Jason-2 NRT GPS-Based Precise Orbit Determination



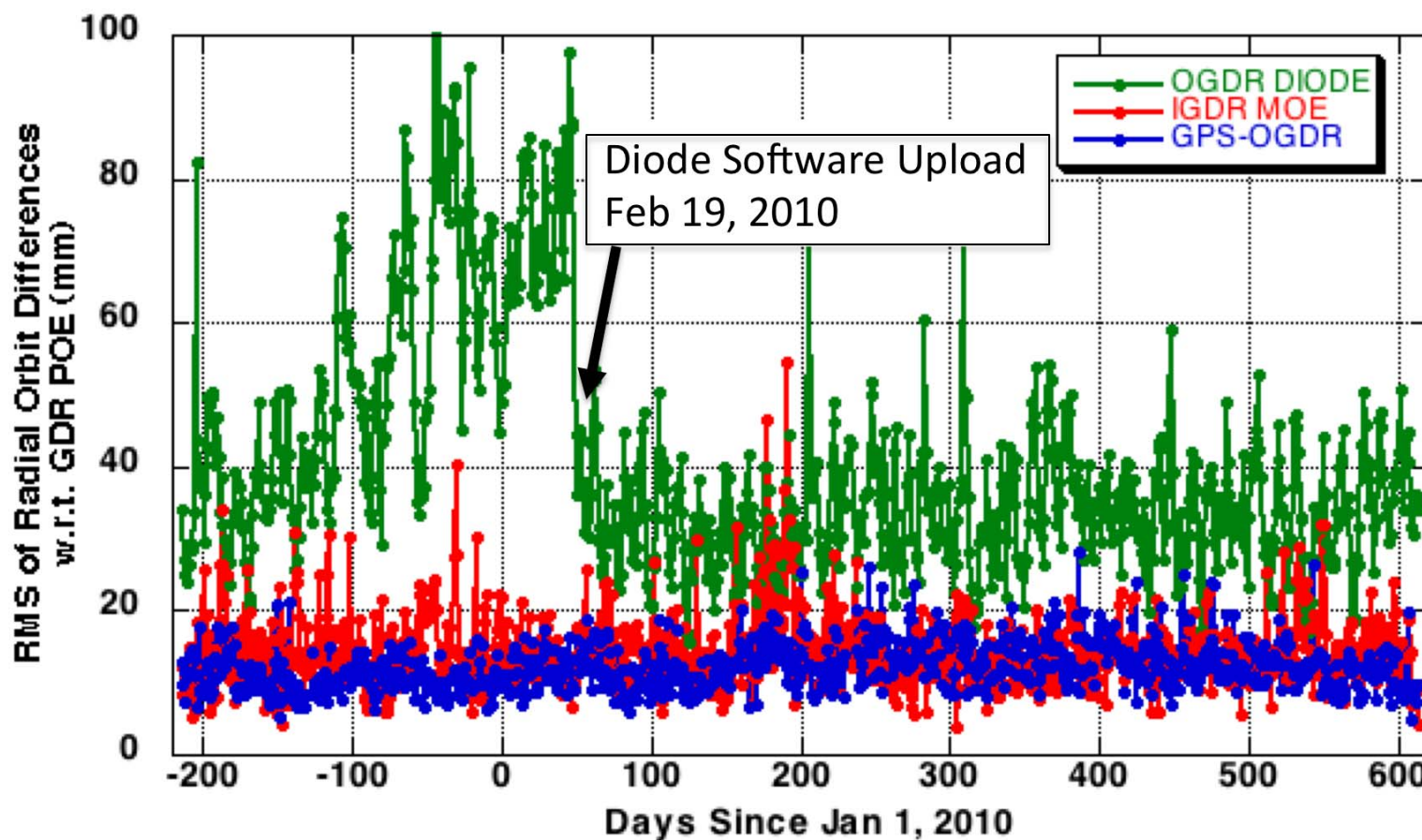


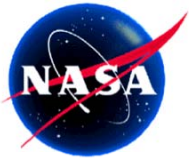
# Orbit Altitude Differences with GDR-T Precise Orbit Ephemeris (DORIS+SLR+GPS): Jason-2



Median of Daily RMS of Orbit Differences (After DIODE Software Update)

OGDR DIODE	IGDR MOE	GPS-OGDR
32.8 mm	13.7 mm	12.4 mm



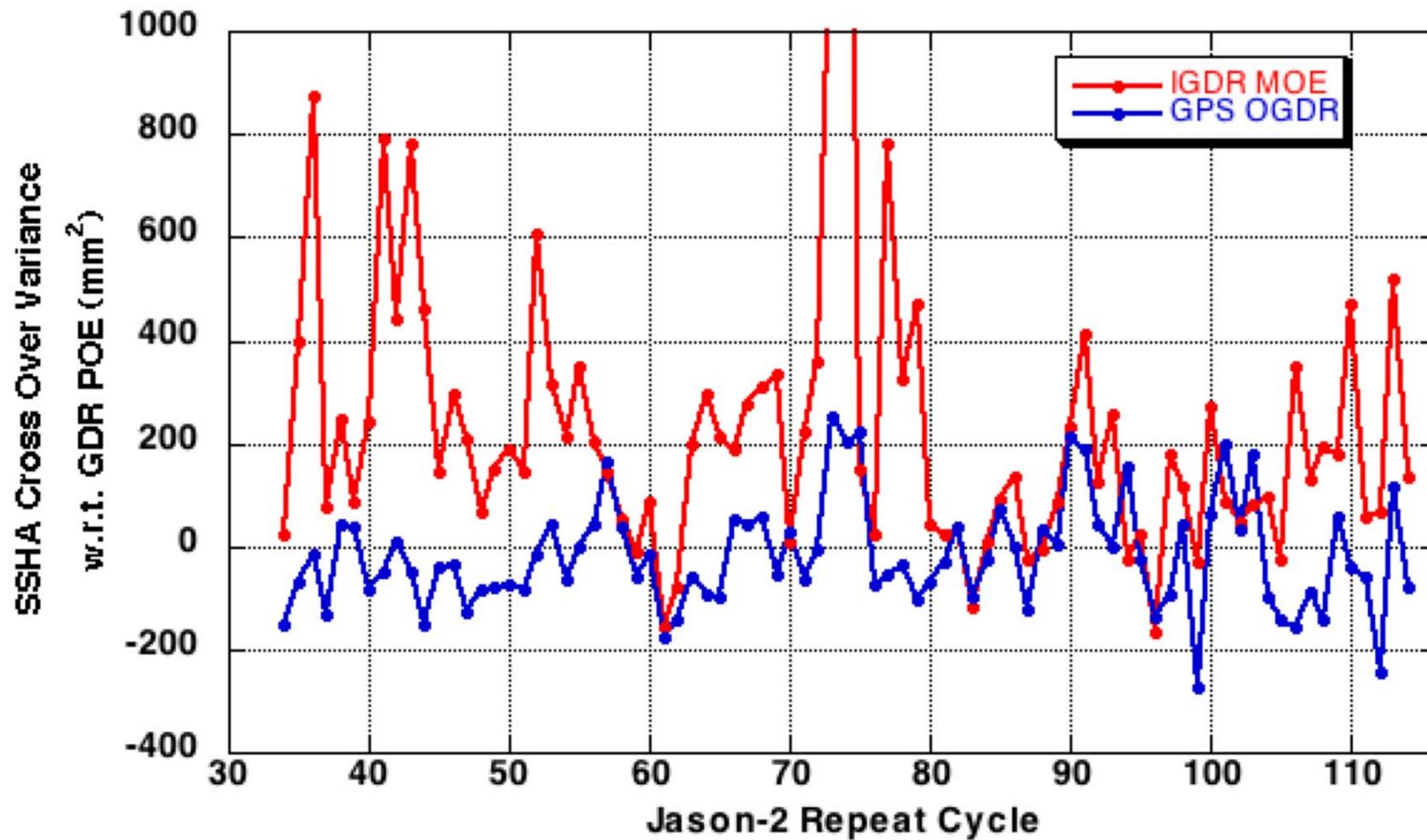


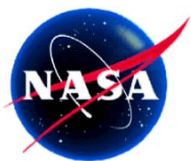
# Jason-2 SSHA Crossover Variance Comparison



Average SSHA Crossover Variance w.r.t. GDR-T POE

IGDR MOE	GPS-OGDR
+230 mm <sup>2</sup>	-20 mm <sup>2</sup>





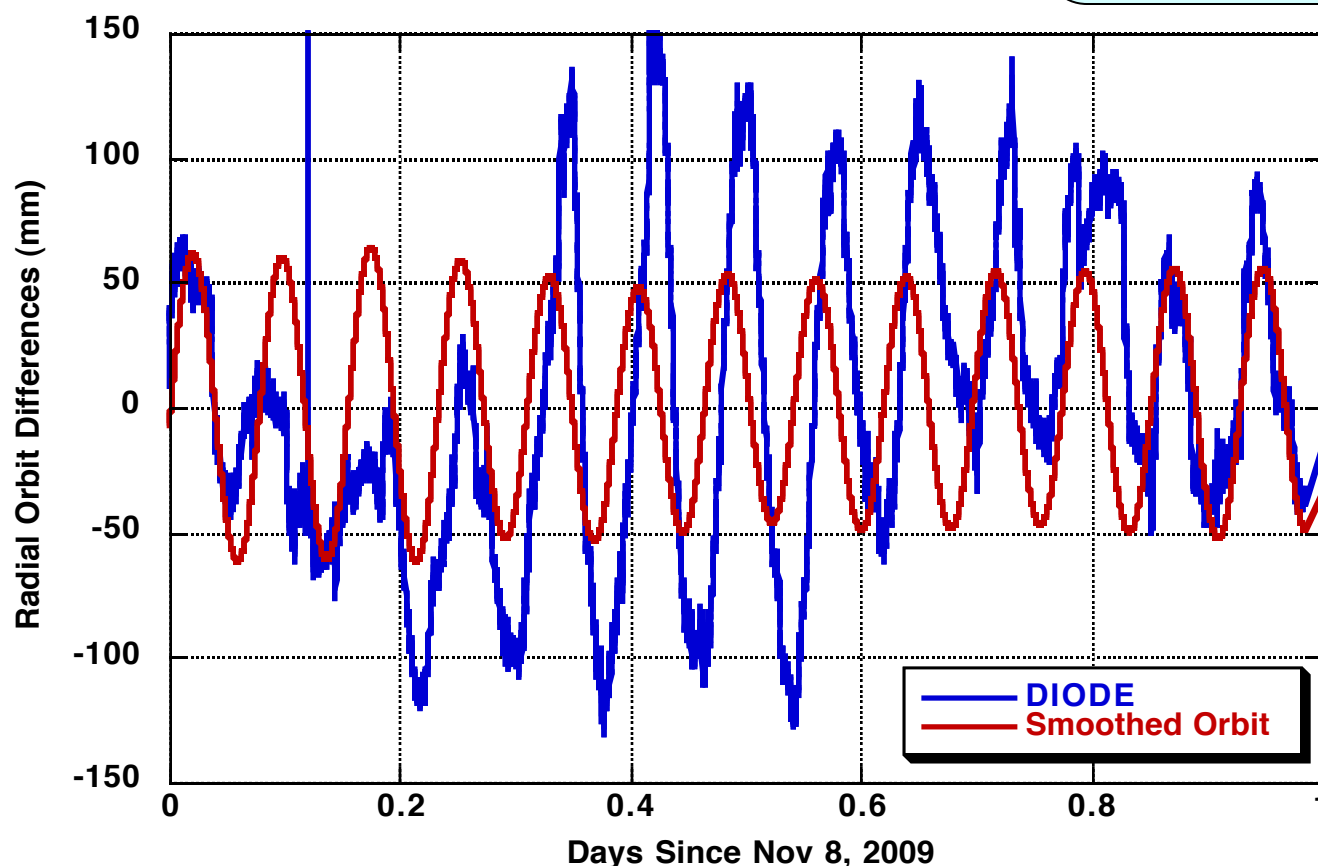
# Dynamic, Filtered, Backward-Smoothed Jason-1 or ENVISAT Orbit Solution



DIODE Telemetry  
Previous 3 days

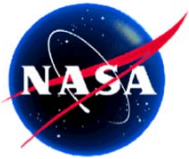


Smooth Dynamic Orbit Solution  
Use precise models  
(gravity, solar pressure, drag, attitude model)  
Treat DIODE solutions as tracking data

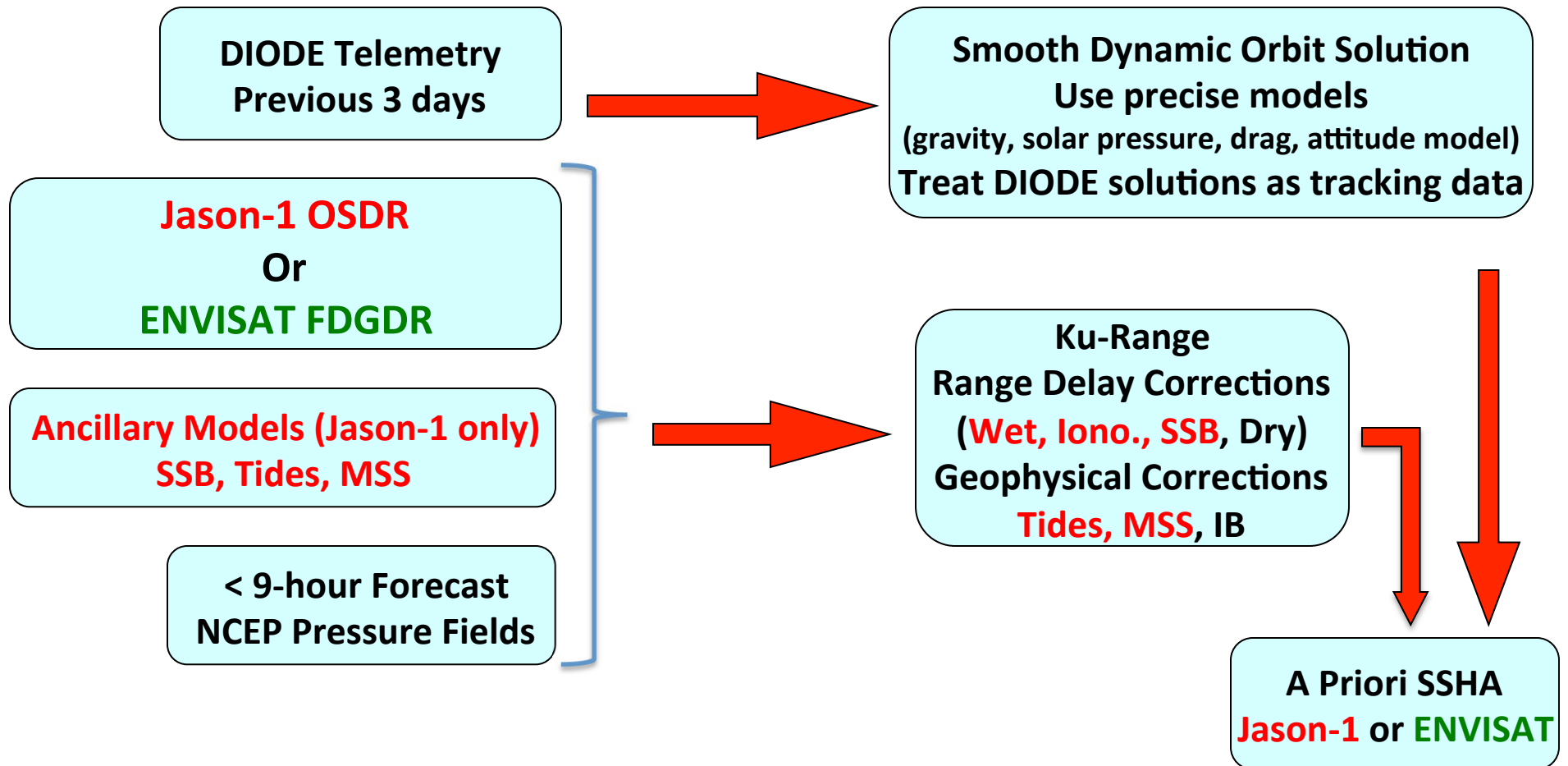


- Serves as low-pass filter to create smooth orbit solution.
- Enables use of rigorous force models.
- Remaining errors are mainly initial condition errors that manifest at 1 cpr.

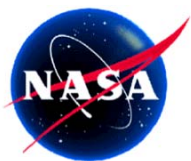




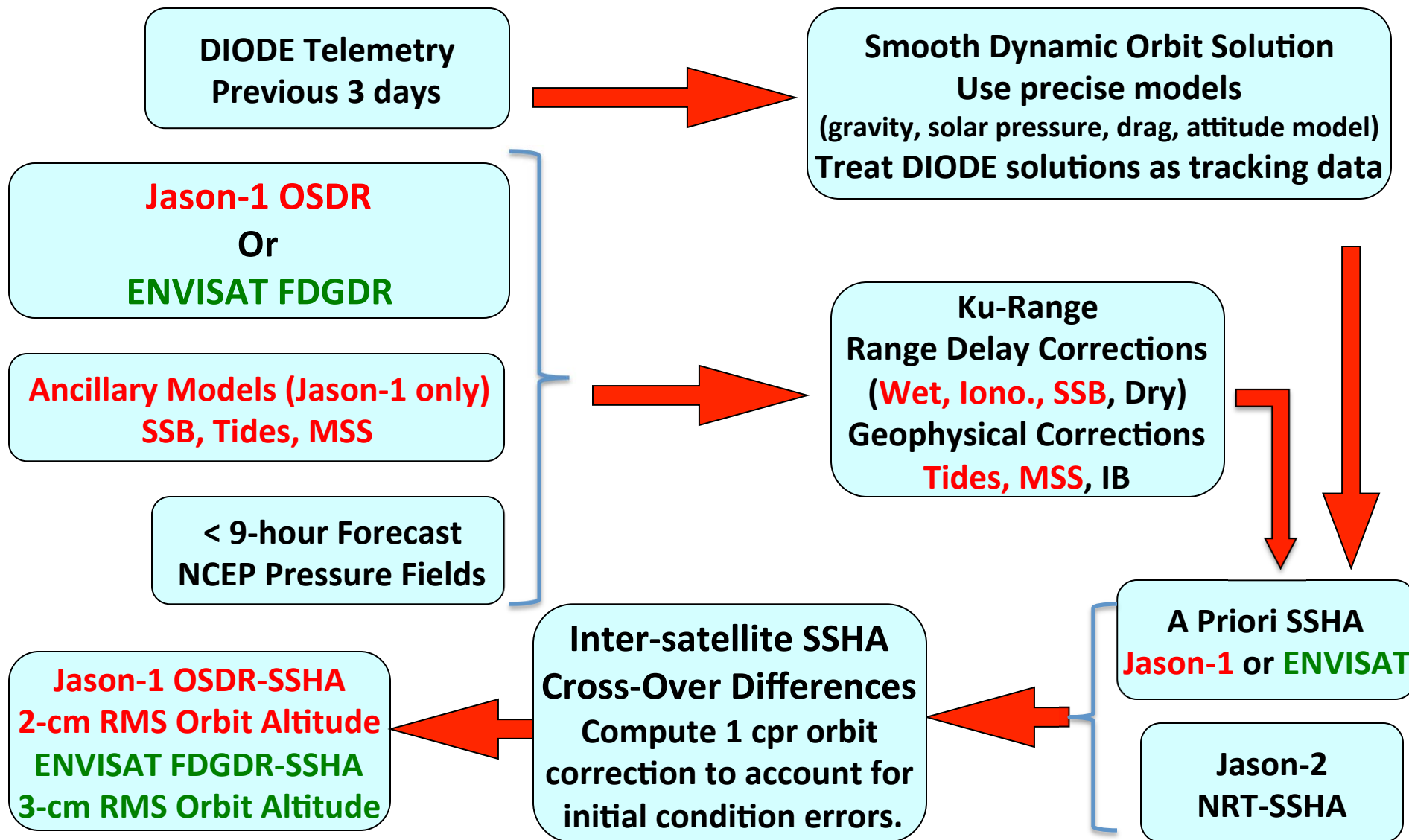
# A Priori Jason-1 or ENVISAT SSHA

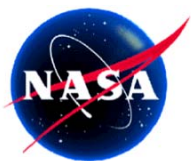






# Jason-1 OSDR-SSHA or ENVISAT FDGDR-SSHA



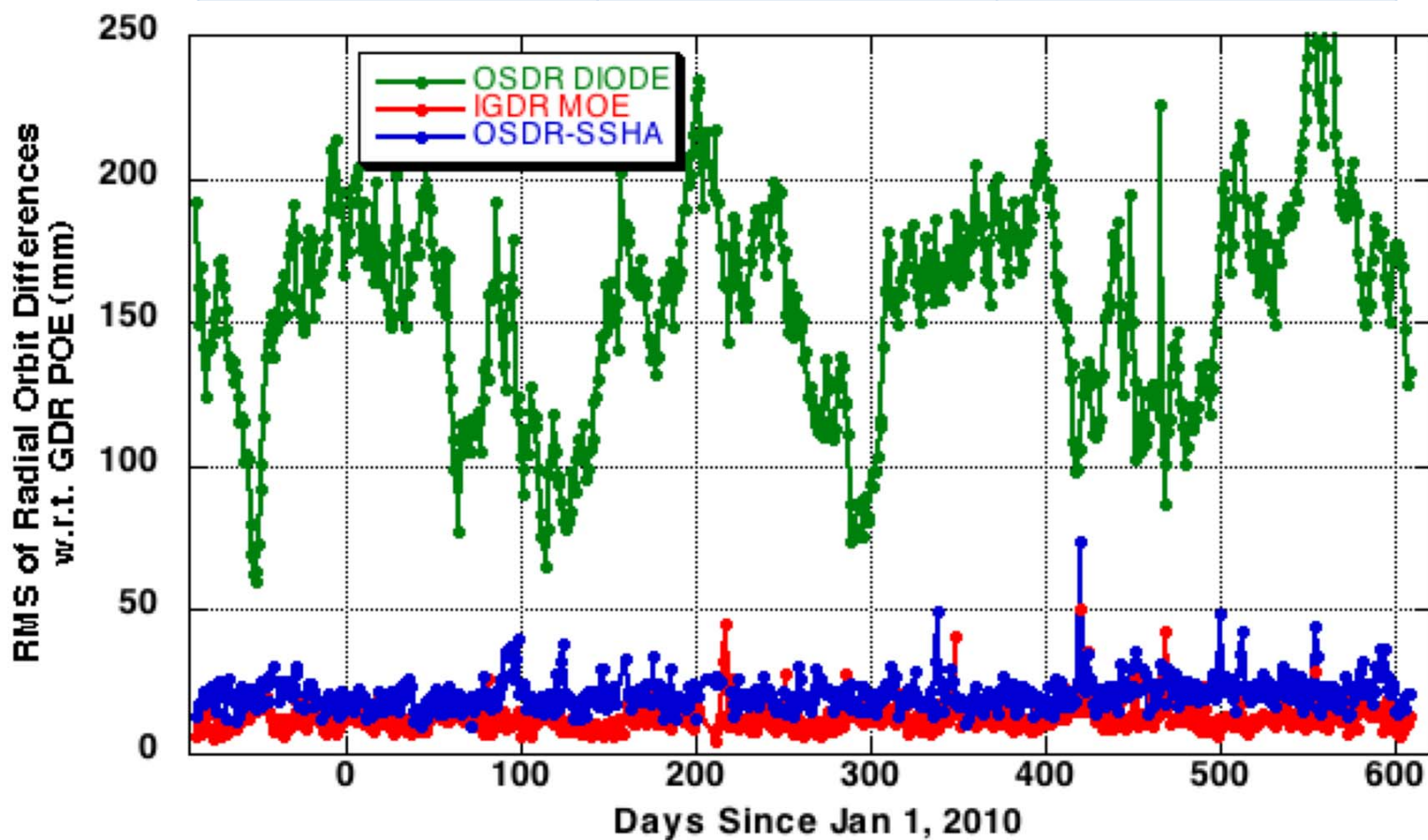


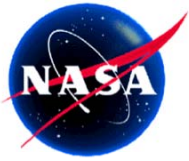
# Orbit Altitude Differences with GDR Precise Orbit Ephemeris (DORIS+SLR): Jason-1



Median of Daily RMS of Orbit Differences

OSDR DIODE	IGDR MOE	OSDR-SSHA
161.8 mm	12.1 mm	20.0 mm



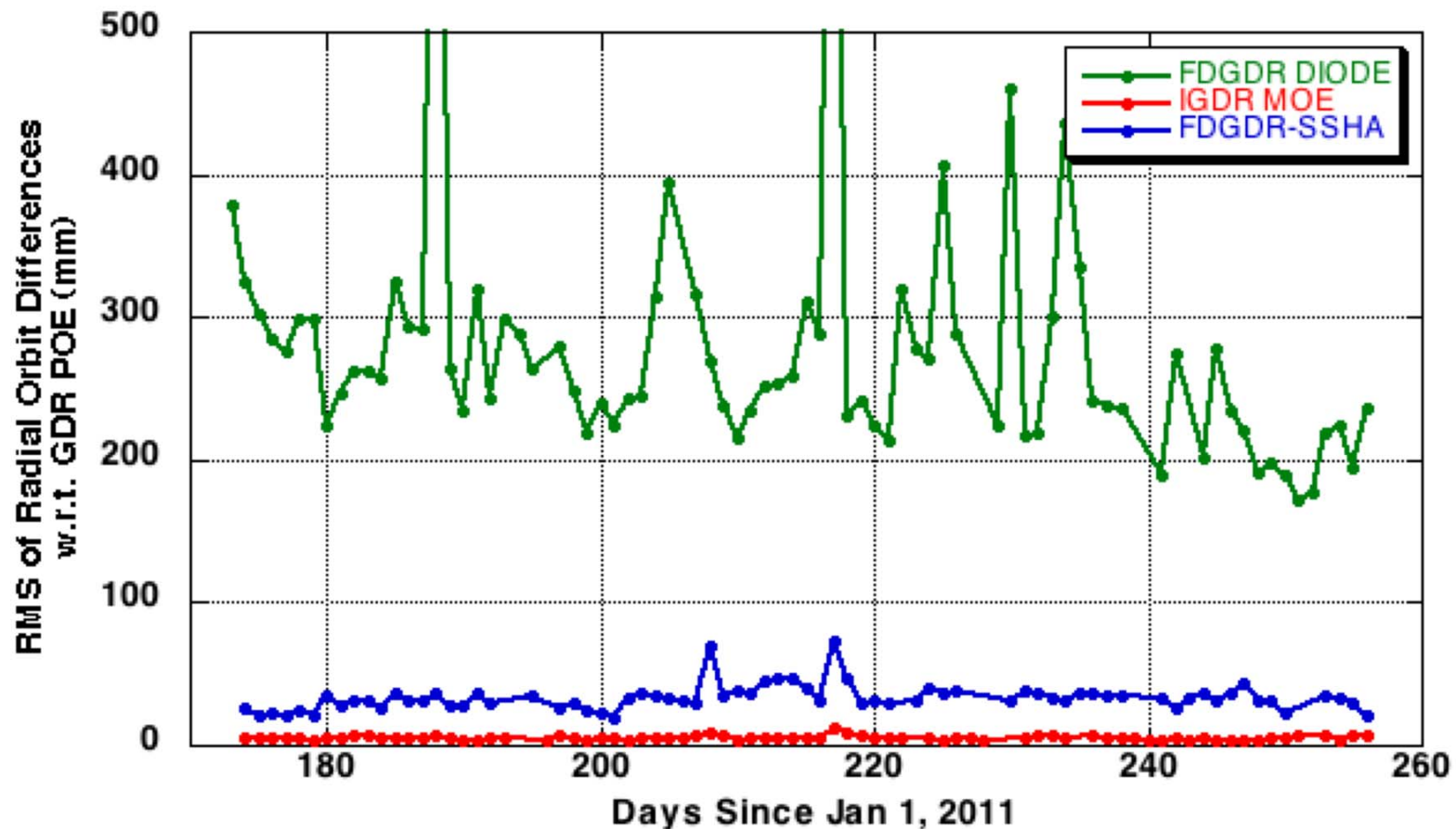


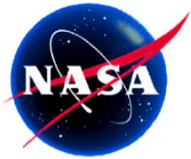
# Orbit Altitude Differences with GDR Precise Orbit Ephemeris (DORIS+SLR): ENVISAT



Median of Daily RMS of Orbit Differences

FGDR DIODE	IGDR MOE	FDGDR-SSHA
257.0 mm	5.3 mm	32.8 mm





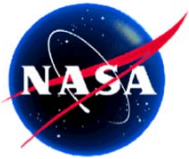
# Standard Deviation of Differences with GDR

Units: mm

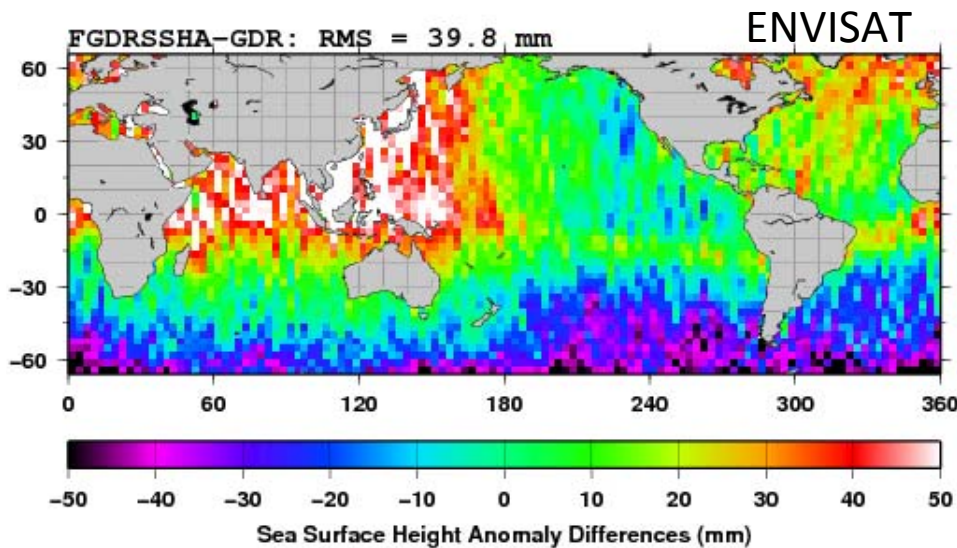
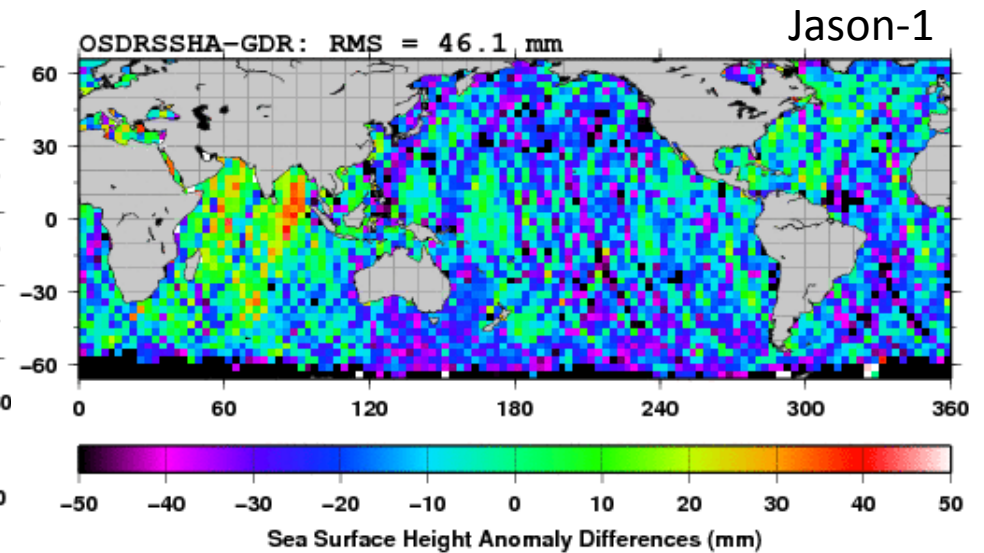
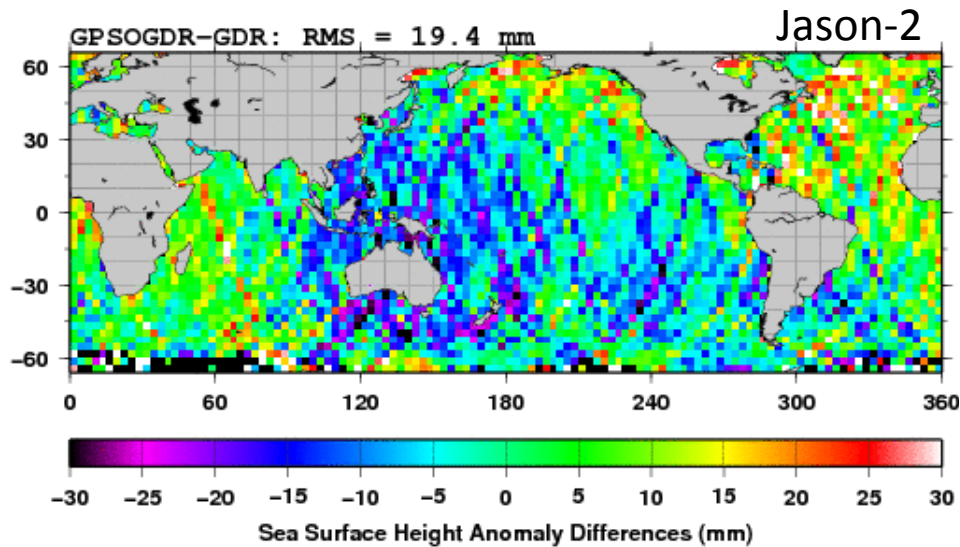


Parameter	Jason-2 GPS-OGDR-SSHA	Jason-1 OSDR-SSHA	ENVISAT FDGDR-SSHA
Orbit Altitude	14	21	35
Ku-Band Range (2-m SWH)	2 (1)	37 (26)	1(1)
Sea State Bias (2-m SWH)	0 (0)	8 (7)	0
Ionosphere Delay	1	11	7
Wet Troposphere Delay	0	0	0
Dry Troposphere Delay	2	2	2
Mean Sea Surface	0	0	1
Inverse Barometer	7	9	11
Solid Earth Tide	0	0	0
Ocean Tide	0	3	3
Pole Tide	0	0	0
SSHA – RSS (2-m SWH)	16 (16)	46 (37)	38
<b>SSHA Accuracy</b>	<b>&lt; 3.5 cm (RMS)</b>	<b>&lt; 4.0 cm (RMS)</b>	<b>&lt; 5.0 cm (RMS)</b>

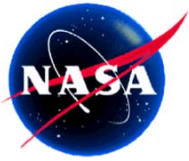




# Geographical Differences with GDRs



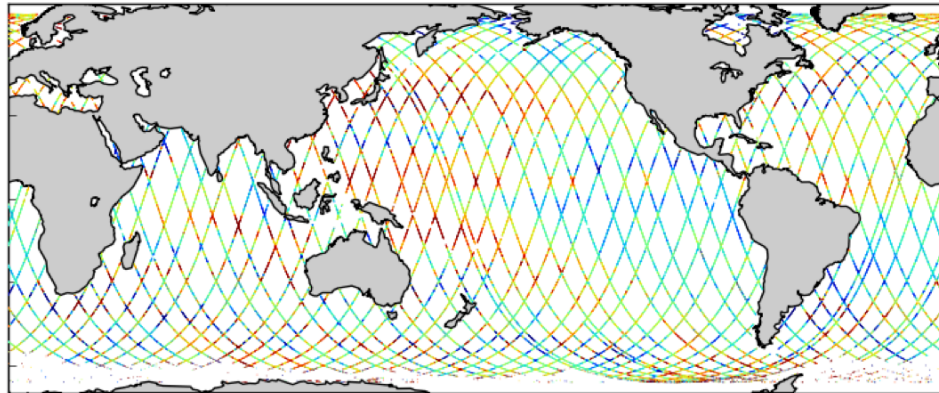
- Jason-2: SSHA differences with GDR smaller than IGDR.
- Jason-1: 65% of SSHA differences due to range.
- ENVISAT: Differences dominated by orbit errors.



# 3-day Snapshot of SSHA from Each of Three Missions

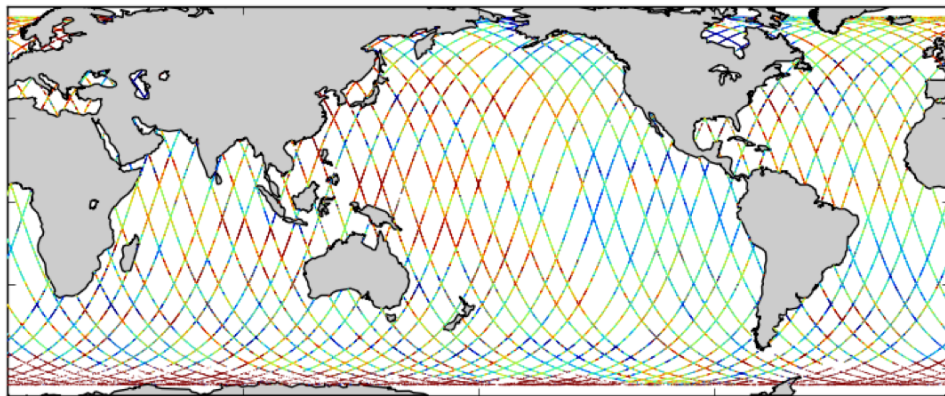


### Jason-2/OSTM GPS-OGDR-SSHA

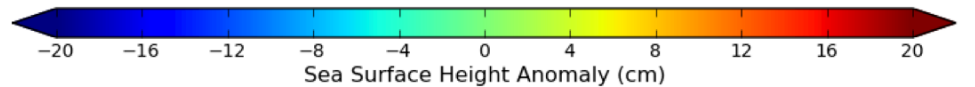
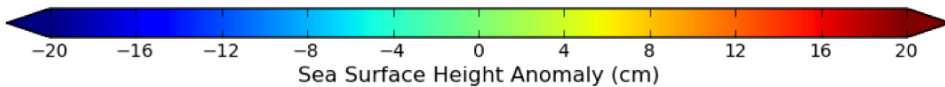
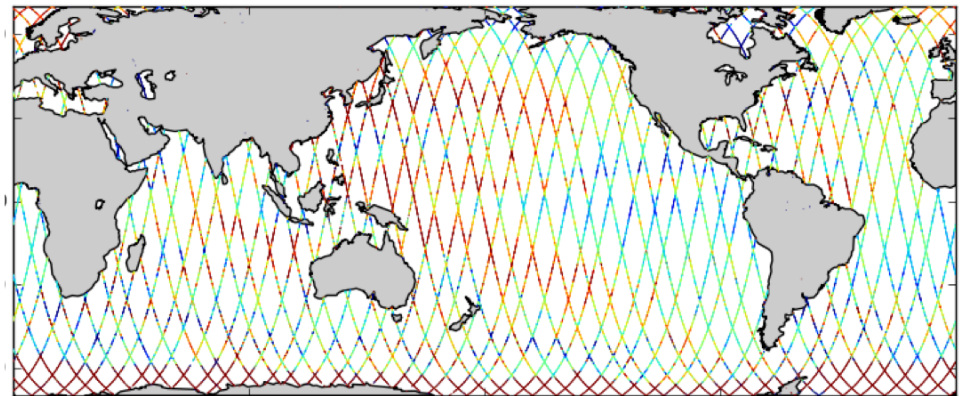


- Sep 23-26, 2011
- < 9 hour latency
- 1-Hz SSHA data directly from products
- No Smoothing

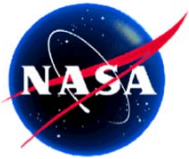
### Jason-1 OSDR SSHA



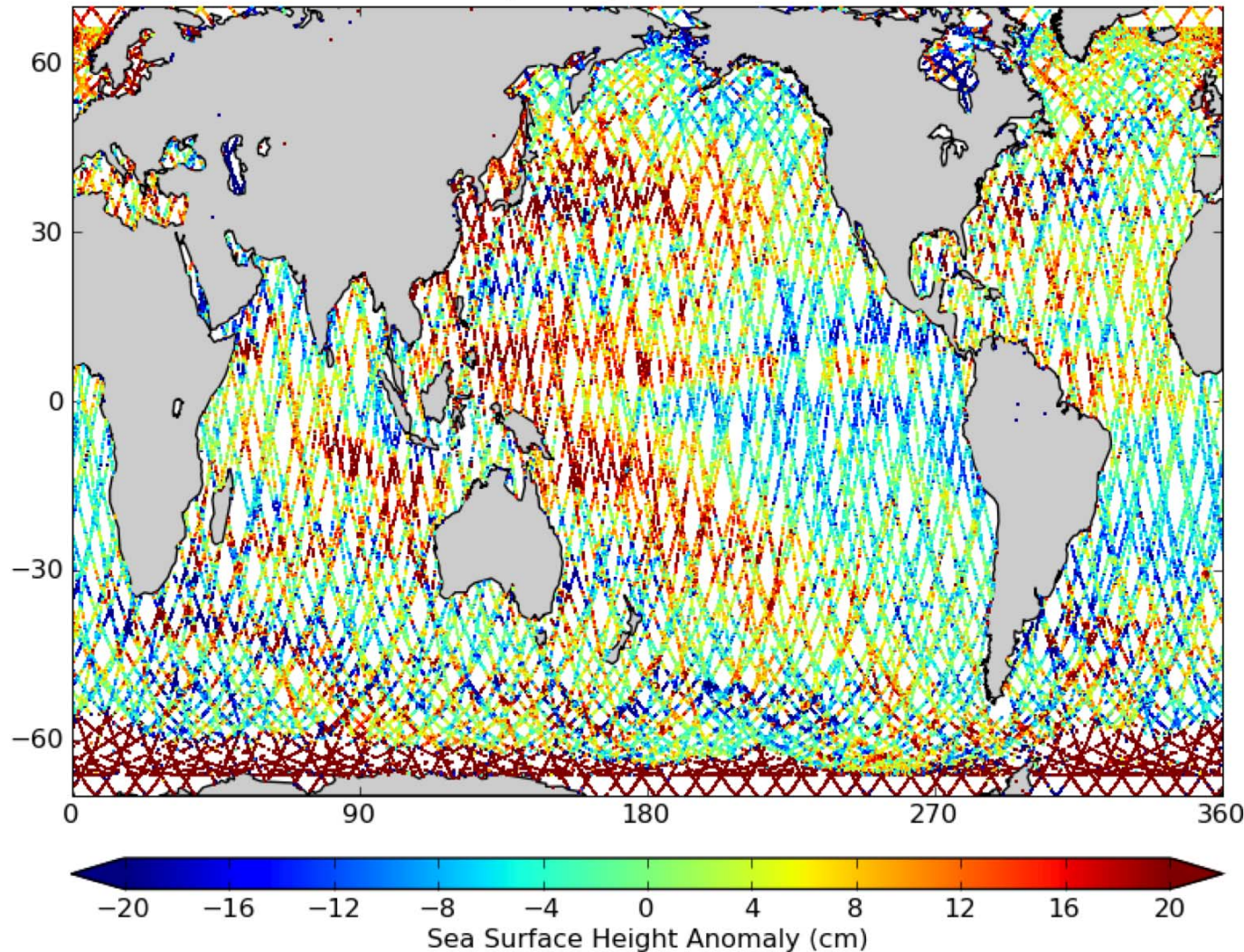
### ENVISAT FDGDR-SSHA





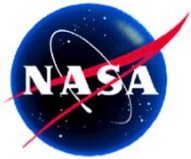


# High Density 3-Day Snapshot of SSHA using Combination of Three Missions



- Sep 23-26, 2011
- < 9-hour latency
- 1-Hz SSHA data directly from products
- No Smoothing



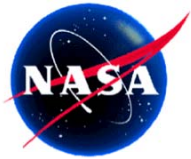


# Conclusions

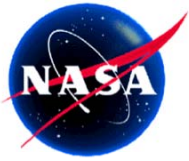


NRT SSHA Product	Orbit Altitude Accuracy (cm)	1-Hz SSHA Accuracy (cm)	Latency (hours)	Release Date
Jason-2 GPS-OGDR-SSHA	1	< 3.5	3-5	June 5, 2009
Jason-1 OSDR-SSHA	2	< 4.0	7-9	Dec. 17, 2009
ENVISAT FDGDR-SSHA	< 3	< 5.0	7-9	<b>Aug. 5, 2011</b>

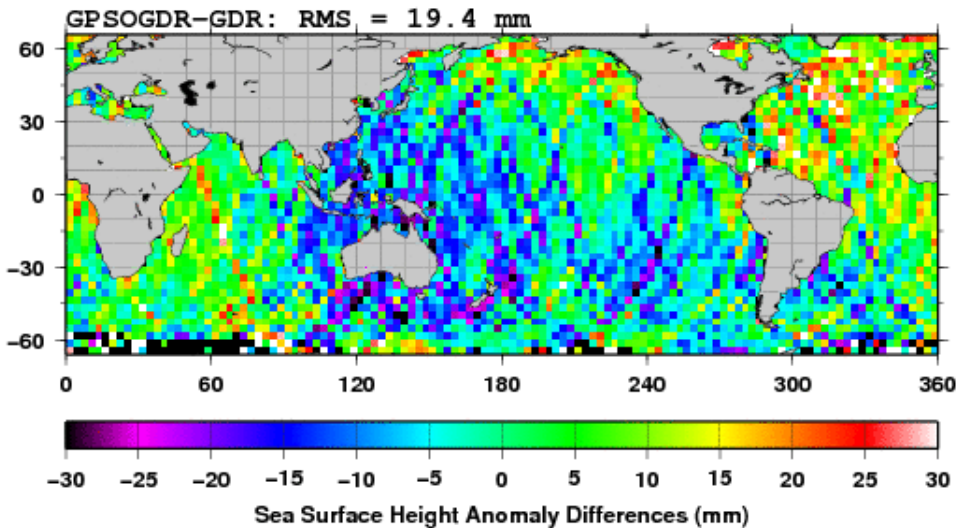
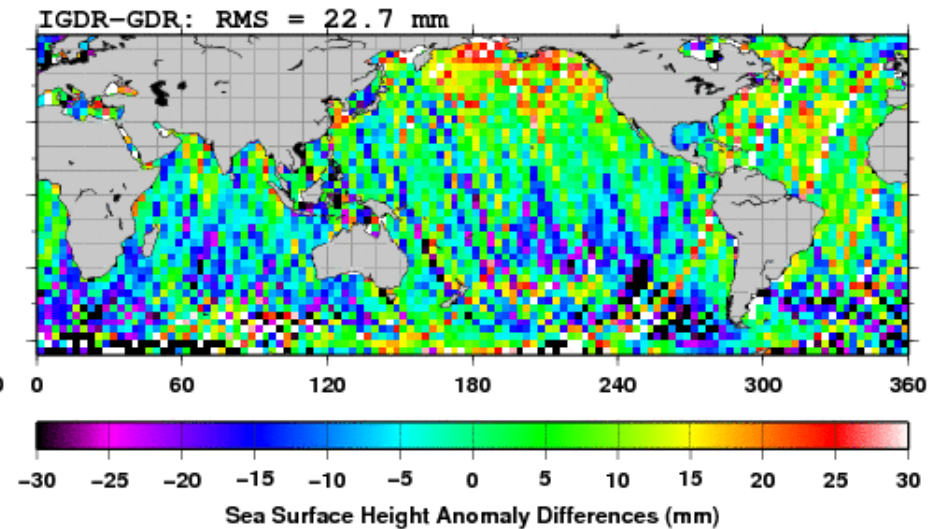
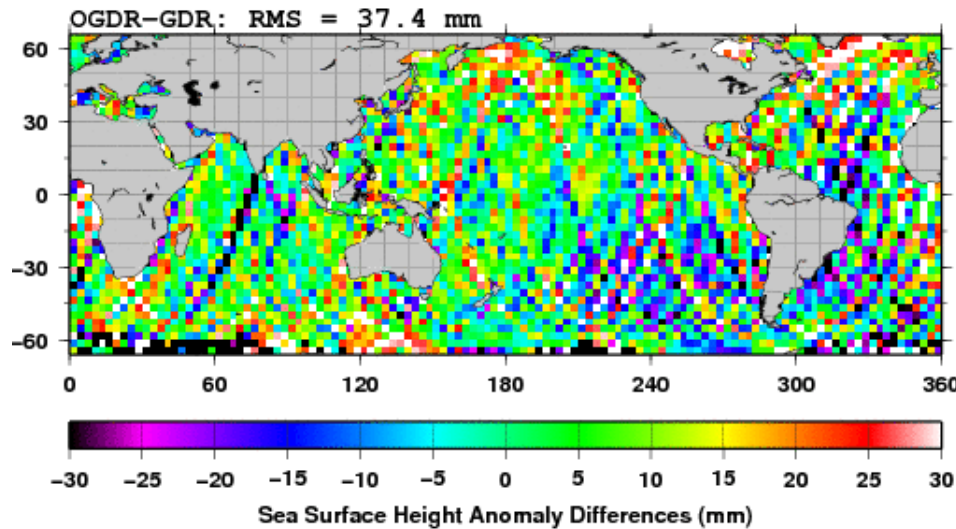
- Jason-2 NRT GPS-based precise orbit determination accuracy similar to GDR-T POE.
- Jason-1 and ENVISAT NRT orbit altitude accuracy slightly worse than MOE.
  - Additional tuning possible to improve Jason-1 and ENVISAT NRT orbit altitude accuracy.
- Significant advances in DIODE capability from ENVISAT, to Jason-1, to Jason-2.
- NRT SSHA products should not be considered as definitive climate records:
- Available at Physical Oceanography Distributed Active Archive Center:  
<ftp://podaac.jpl.nasa.gov/SeaSurfaceTopography/>
- **ENVISAT NRT FDGDR-SSHA product testament to productive partnership between ESA, CNES, and JPL.**



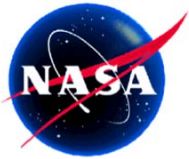
# Back-Up Slides



# Geographic SSHA Differences with GDR Jason-2/OSTM Cycle 79

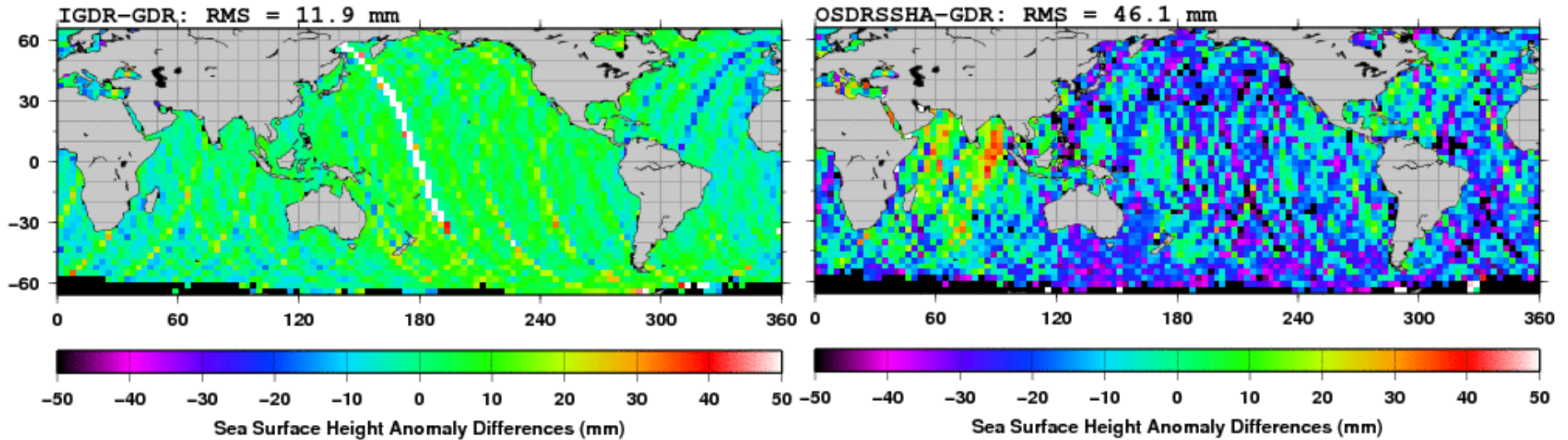


- Jason-2 SSHA differences with GDR are factor of 2 smaller when using NRT GPS orbit instead of DIODE orbit.
- Smaller SSHA differences with GDR when using GPS-OGDR instead of IGDR.

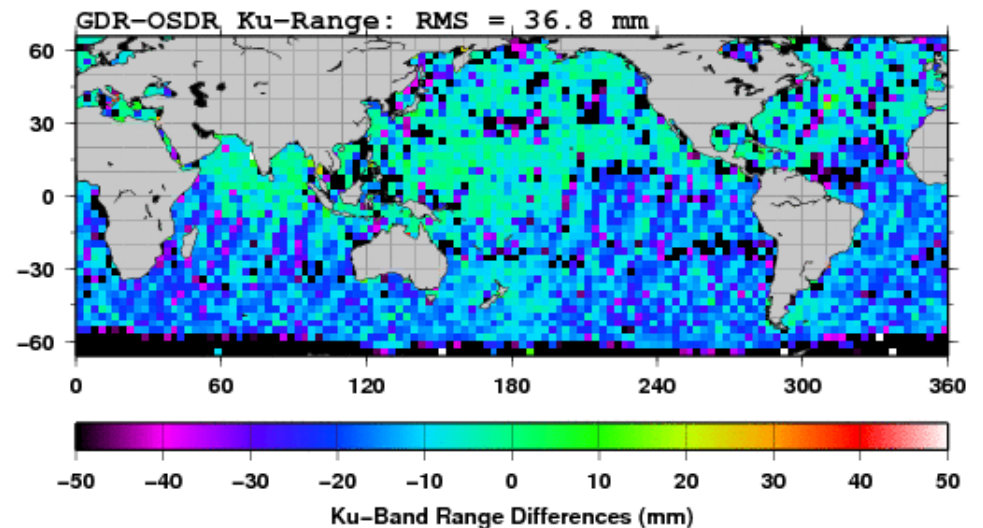


# Geographic SSHA Differences with GDR

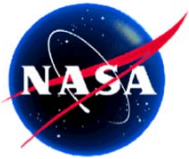
## Jason-1 Cycle 317



- ~65% of variance in SSHA differences between OSDR and GDR are due to differences in Ku-band range.
  - OSDR uses onboard retracking.
  - IGDR uses MLE4 ground retracking.
  - Ku-band range differences are consistent with uncorrelated errors, e.g.
    - OSDR and IGDR range error quoted as 18 and 16 mm.

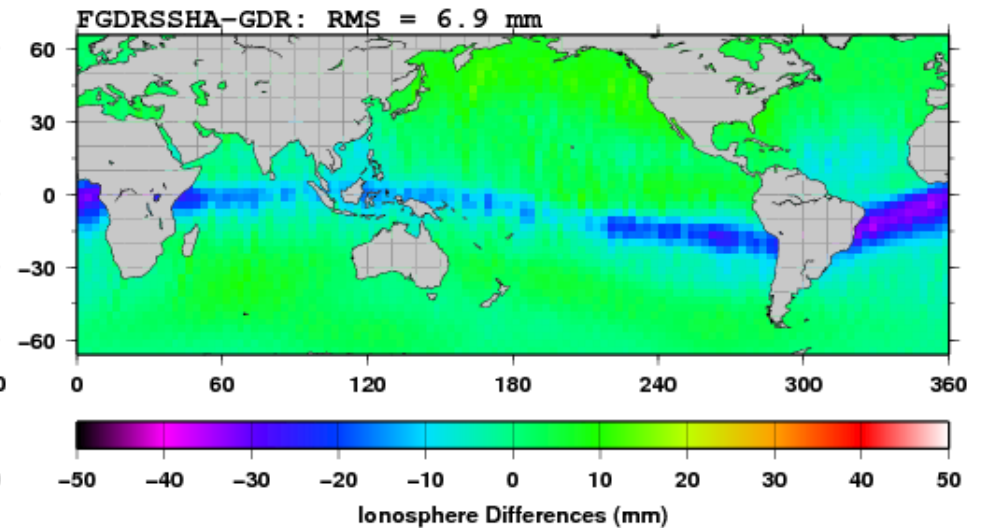
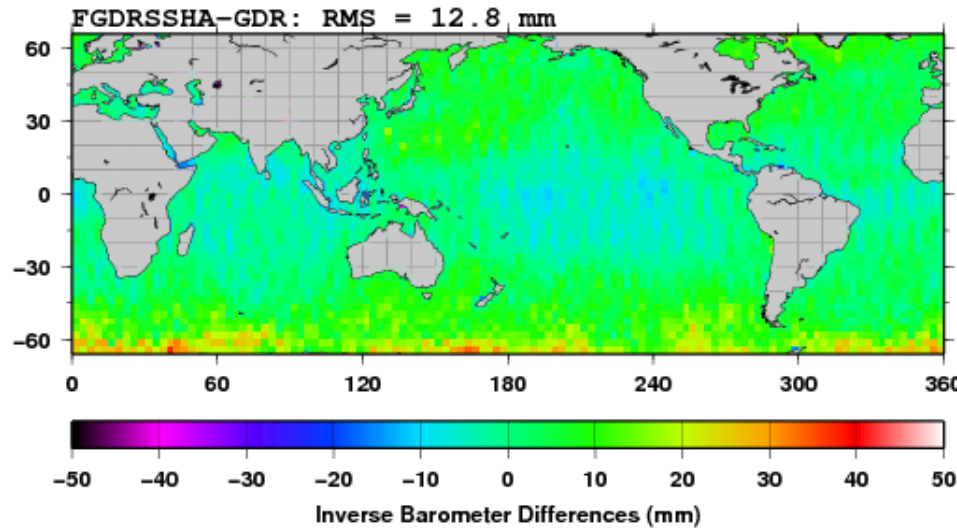
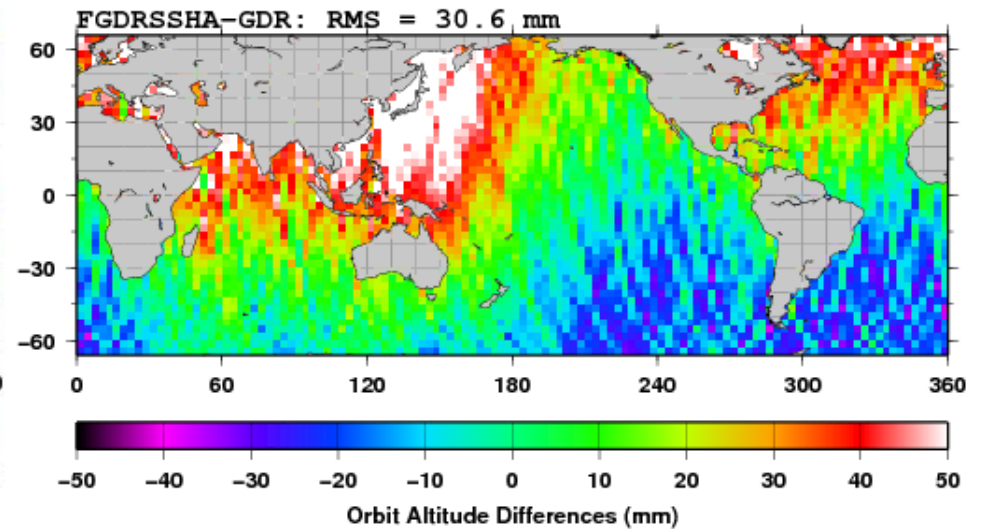
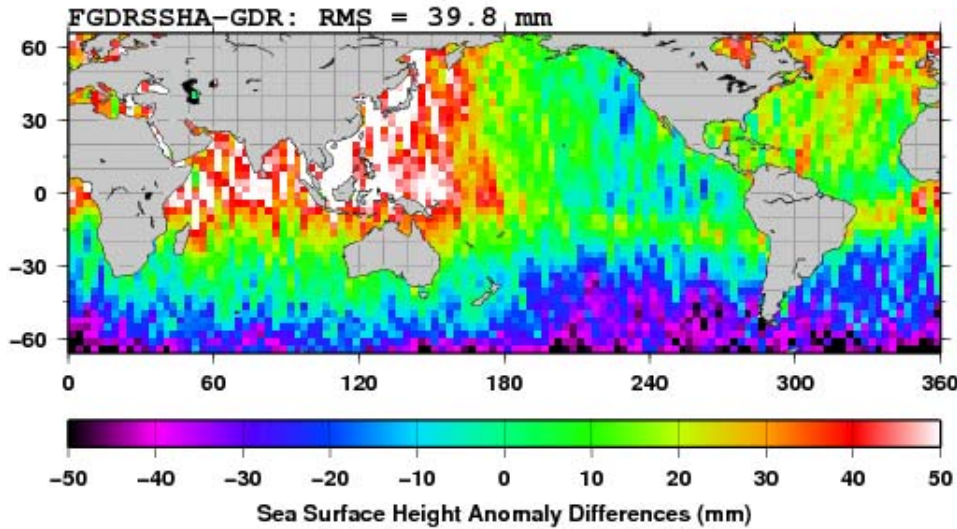


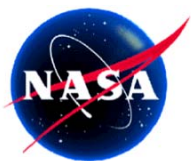




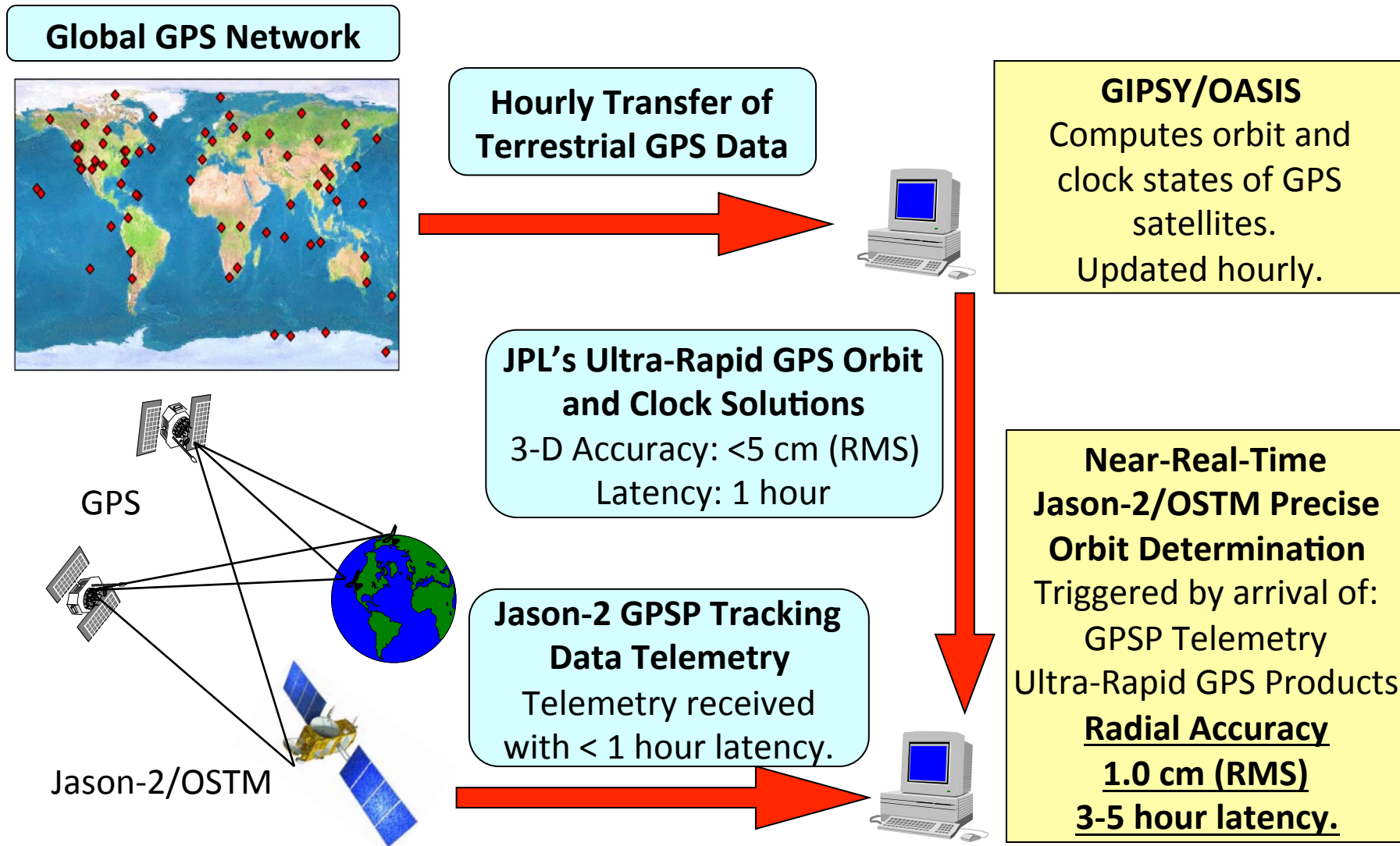
# Geographic SSHA Differences with GDR

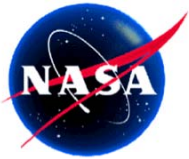
## ENVISAT Cycle 105





# Jason-2/OSTM NRT GPS-Based Precise Orbit Determination





# ENVISAT FDGDR-SSHA

