Ocean Surface Topography Science Team
status report to GOVST VII – Tony Lee

prepared by John Wilkin and Rosemary Morrow
on behalf of the entire OSTST community

There are now an unprecedented 6 altimeters in the operational constellation

JASON-2
2008

CRYOSAT-2
2010

HY-2A-G

2A	2011
2B	2018
2C	2018
2D	2019
2E	2021
2F	2020
2G	2022

SARAL
2013

JASON-3
2016

SENTINEL-3A-D

3A	2016
3B	2017
3C	Before 2020
3D	20??

CFOSAT
2018

JASON-CS/ SENTINEL-6

A	2020
B	2025

SWOT
2021

CURRENT and **FUTURE** altimeter missions

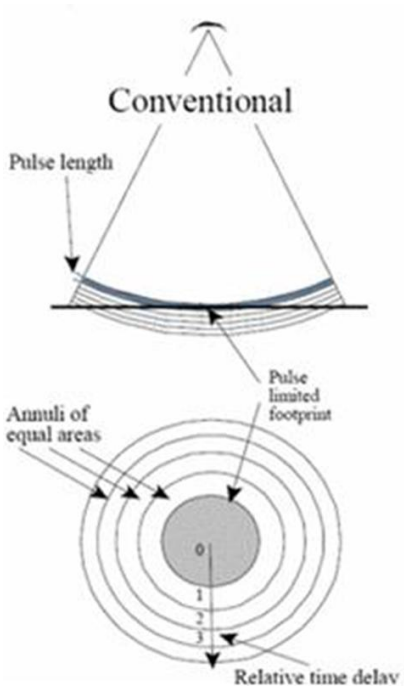
Operational milestones reported at OSTST meeting

La Rochelle – France – Nov. 1-4, 2016

- Launch of Jason-3 in January 2016 (15 Feb. first OGDR)
- Successful execution of the *Tandem Mission*
  - Inter-calibration of J-2/J-3 orbiting 80 s apart; error ~ 1 mm between instruments
- Shift of Jason-2 to *Interleaved Orbit* (since 14 Oct. 2016)
  - Midway between tracks of reference orbit; notionally "best" for mesoscale oceanography; same as Jason-1 in 2009-2011
- Shift of SARAL/AltiKa to drifting orbit (since 4 Jul. 2016)
  - Engineering concerns in keeping ground-track; orbit change to drifting ground-track to acquire geodetic data; but with continued oceanographic operations
- Successful launch of Sentinel-3A (16 Feb. 2016)
  - Under EUMETSAT control since July 2016; preparations for S-3B launch in 2017

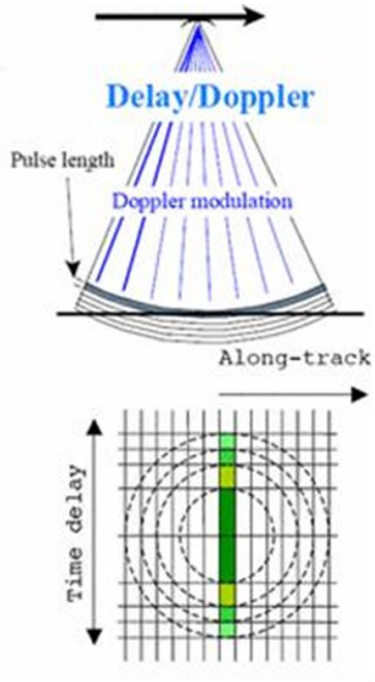
Understanding along-track signal and noise in Low Resolution Mode (LRM) vs. Delayed Doppler ("SAR mode")

J-2,3, AltiKa

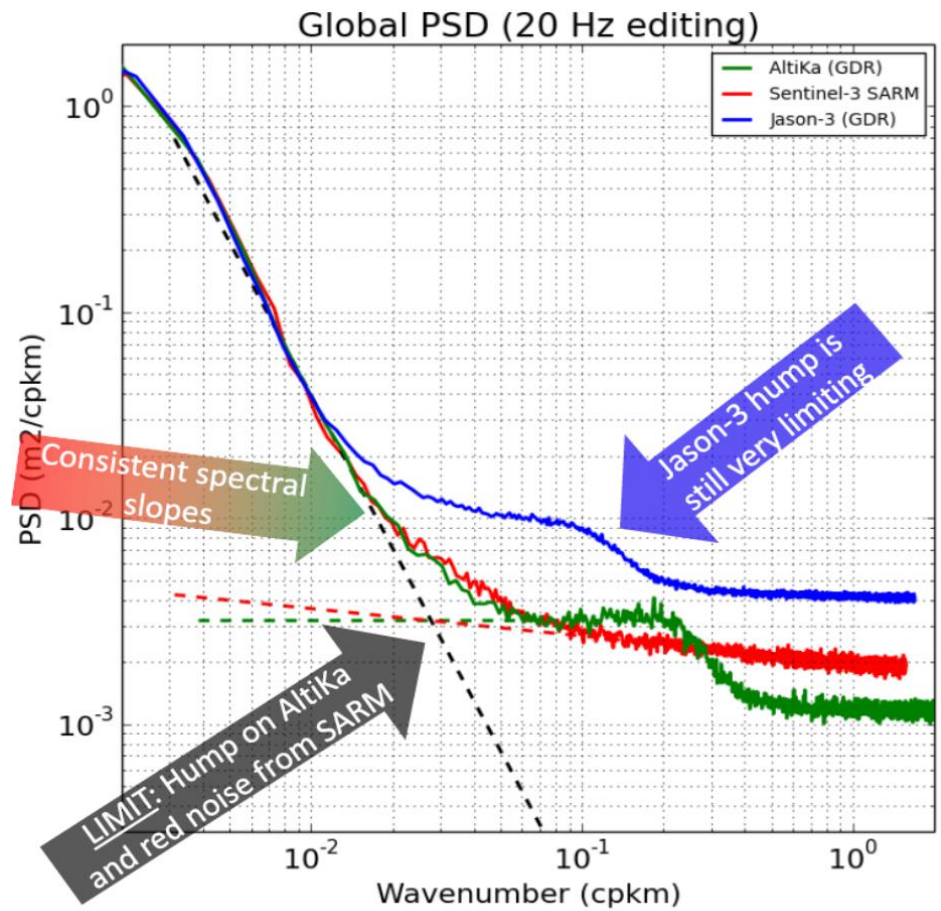


5-7 km radius

S-3, Cryosat-2



300 m along-track
5-7 km cross-track



Inhomogeneity (wind-wave/swell/rain) of radar reflectors in the large footprint of nadir pulse introduces noise as a "spectral bump" at 100 km to 10 km scale that exceeds instrument noise floor at 5 km

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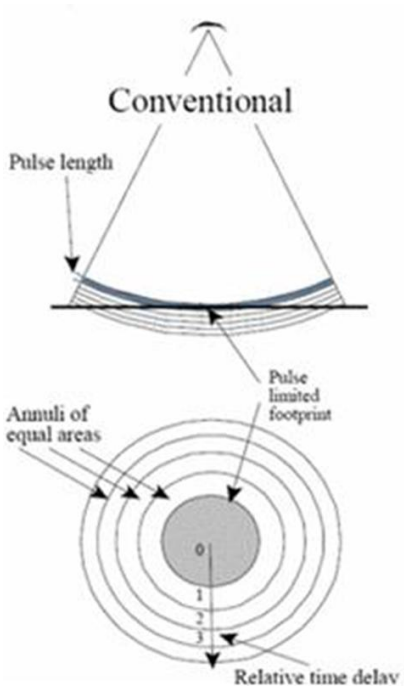
J-2,3, AltiKa



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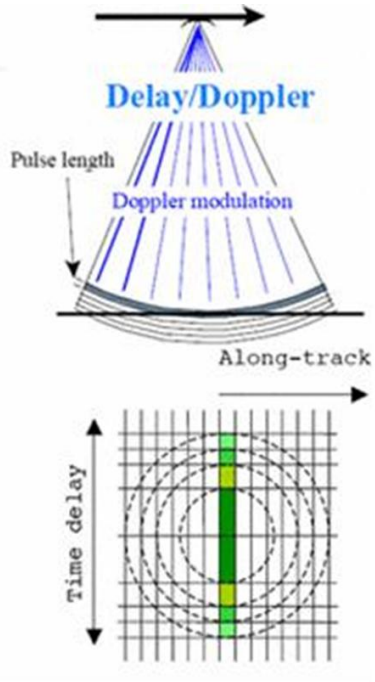

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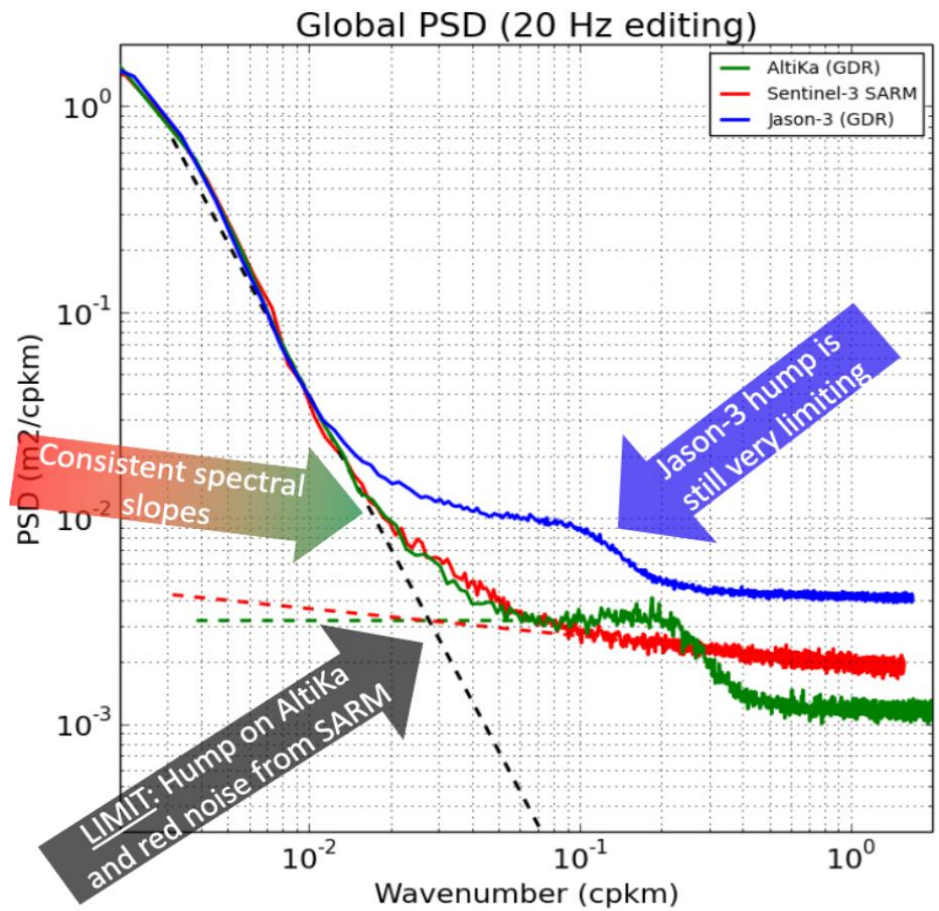
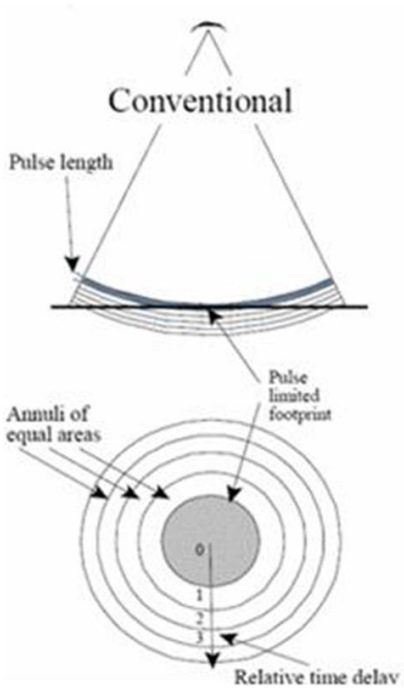


The smaller footprint of the AltiKa Ka-band radar, and better overall noise performance improves the signal/noise ratio, but still the spectral bump occurs

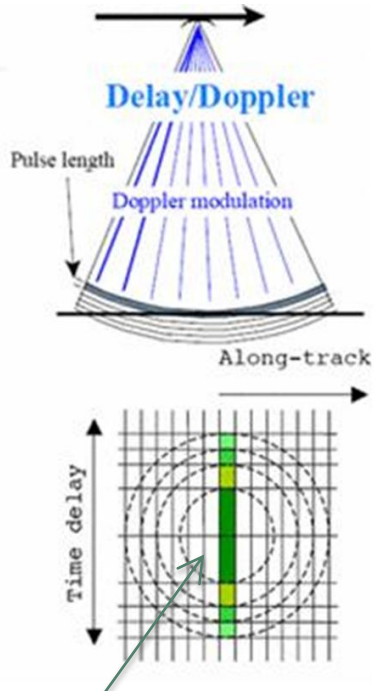
Understanding along-track signal and noise in Low Resolution Mode (LRM) vs. Delayed Doppler ("SAR mode")

J-2,3, AltiKa



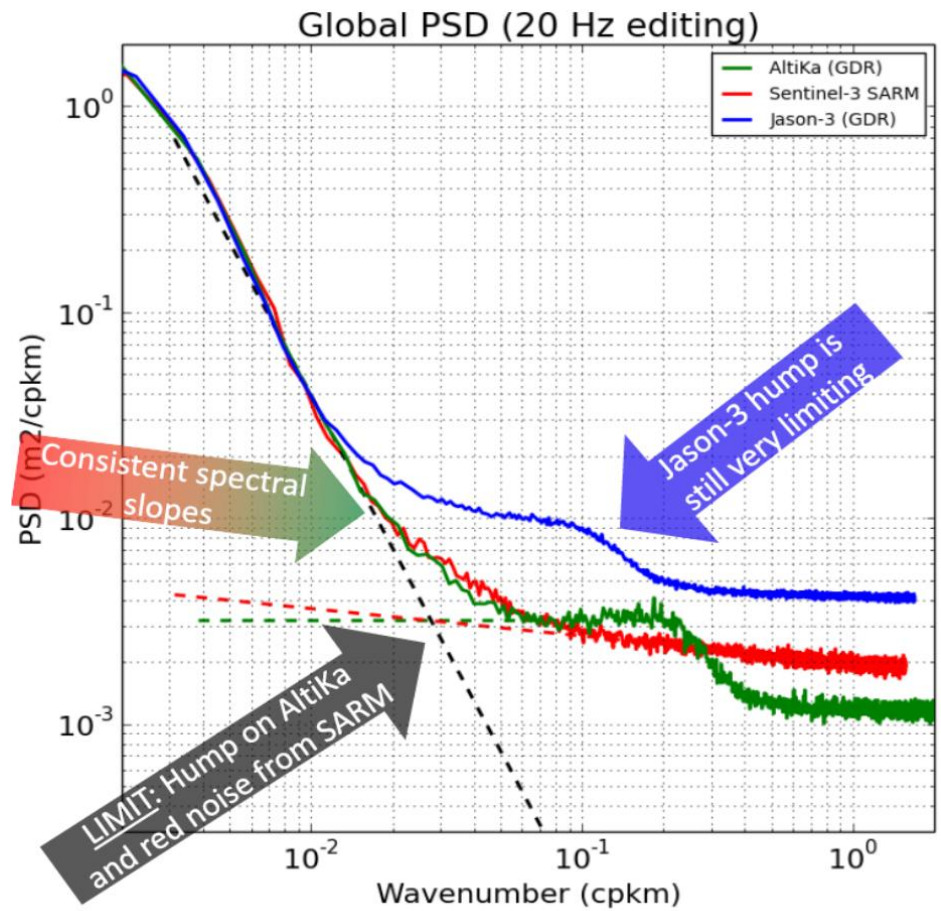
5-7 km radius

S-3, Cryosat-2



300 m along-track
5-7 km cross-track

Anisotropy of footprint compared to circular LRM footprint. Swell direction affects SAR mode due



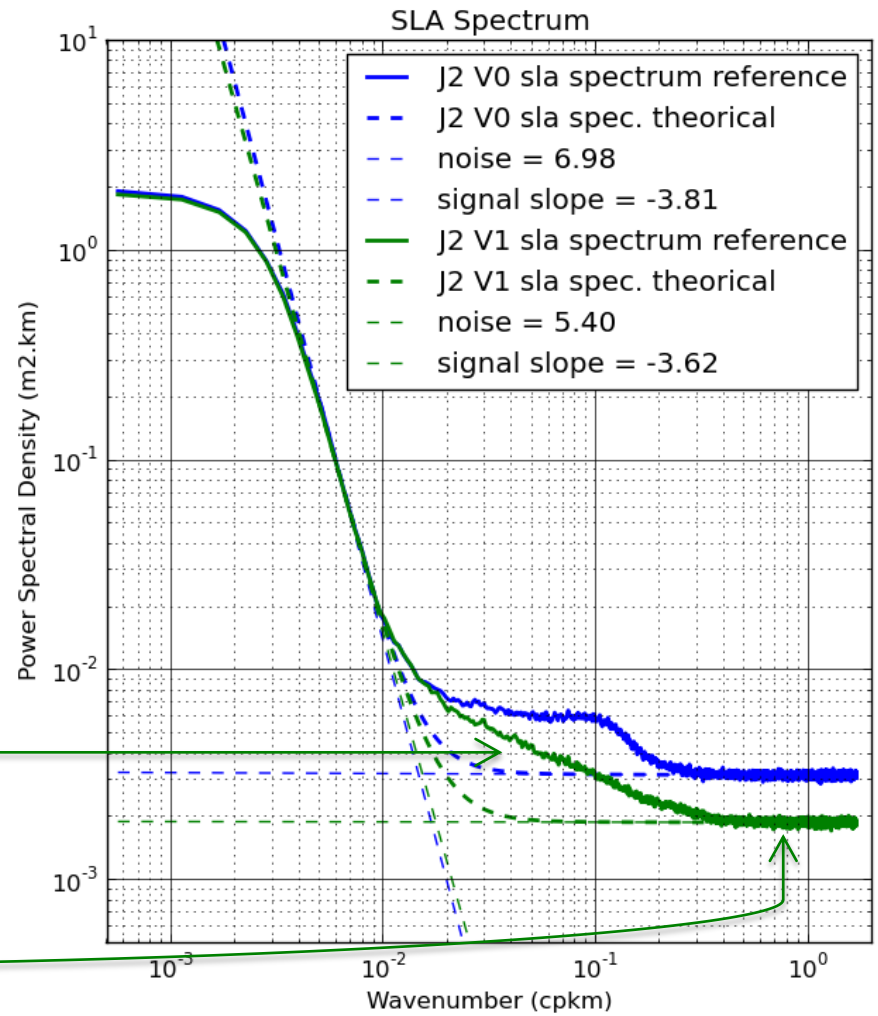
The much smaller footprint of the Delayed Doppler altimeter (300 m along-track; 5-km across track) eliminates the spectral bump

Improved editing of LRM signals (J-2/3, AltiKa)

Issue: Seek improved LRM data to better observe small ocean scales (< 100 km):

Editing and new re-tracking are the main sources of expected improvement (M. Raynal et al).

Improvement of Jason-2 LRM data at small ocean scales is achieved by applying adapted editing algorithm and Zaron's empirical method to reduce the correlated noise between altimeter range and SWH (M. Raynal et al.)

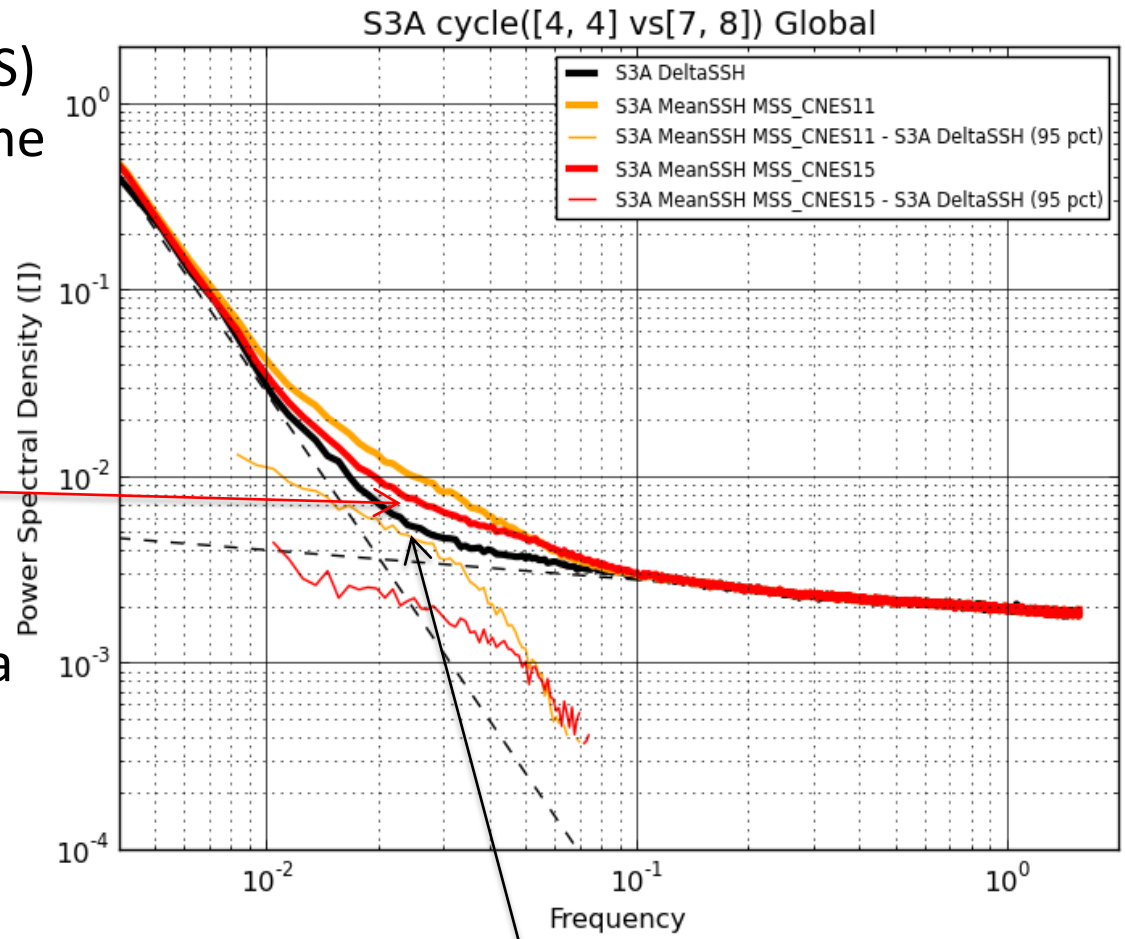


Will help GOV systems in principle, but not available for operational GDRs (OGDRs)

New Mean Sea Surface products (all missions)

Issue: Mean Sea Surface (MSS) is less accurately known off the reference mission tracks (Jason 10-day and ERS/ AltiKa 35-day repeat orbits).

New CNES MSS (2015) decreases errors in 30-100 km wavelengths for missions off reference tracks, i.e. Altika (in drift phase), Sentinel-3 (new repeat orbit), Cryosat, HY-2A, Jason-1 geodetic mission (M. Raynal et al., M.I. Pujol et al.)



Sentinel-3A SLA spectrum is reduced further after removing the MSS error comparing 2 consecutive cycles N and N-1 (M.I. Pujol et al.)

<u>GODAE projects should switch to new MSS derived SLA immediately</u>

Internal waves in SSH data from new DDA (SAR) altimetry

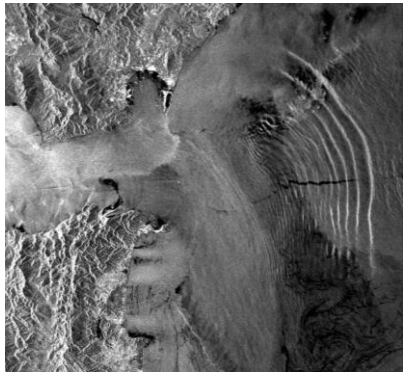
Issue: Internal waves are not corrected for in the along-track data (never were), nor in blended AVISO maps.

Previously, OI scales filtered out these errors, but new L4 products from AVISO have smaller space/time scales and may suffer internal wave effects.

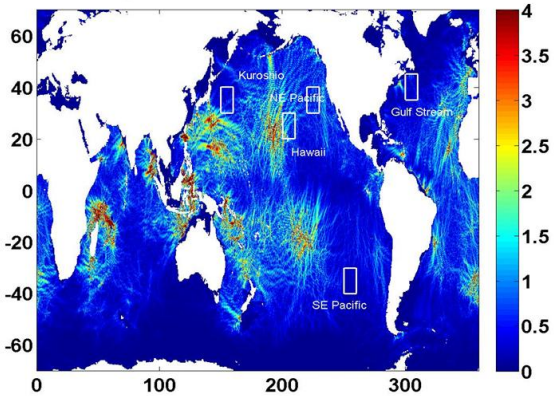
Internal tide corrections (R. Ray) are being evaluated and are anticipated to become new range corrections in future OGDR and GDR.

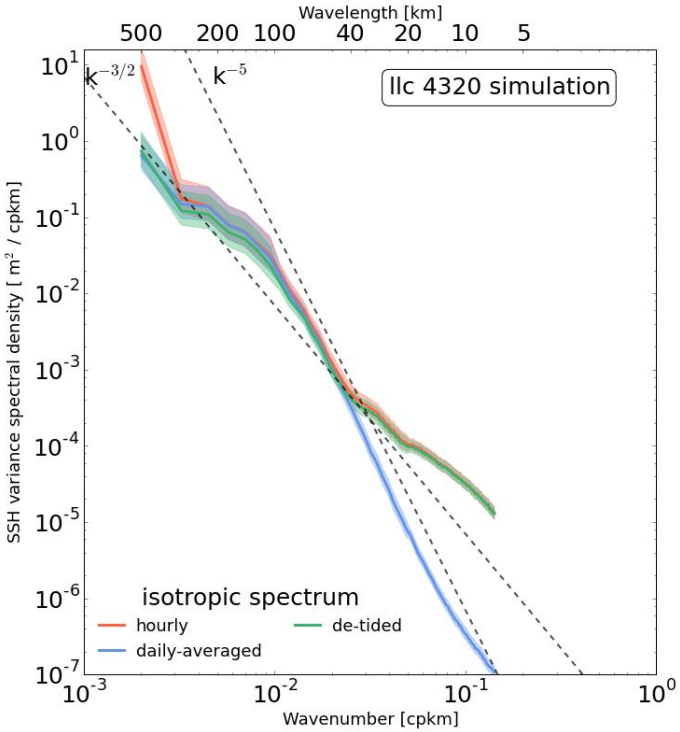
Incoherent tides still an issue?

Internal waves radiating from Strait of Gibraltar (ESA)



M_2 internal tide amplitude (cm) HYCOM (Arbic et al. 2012)





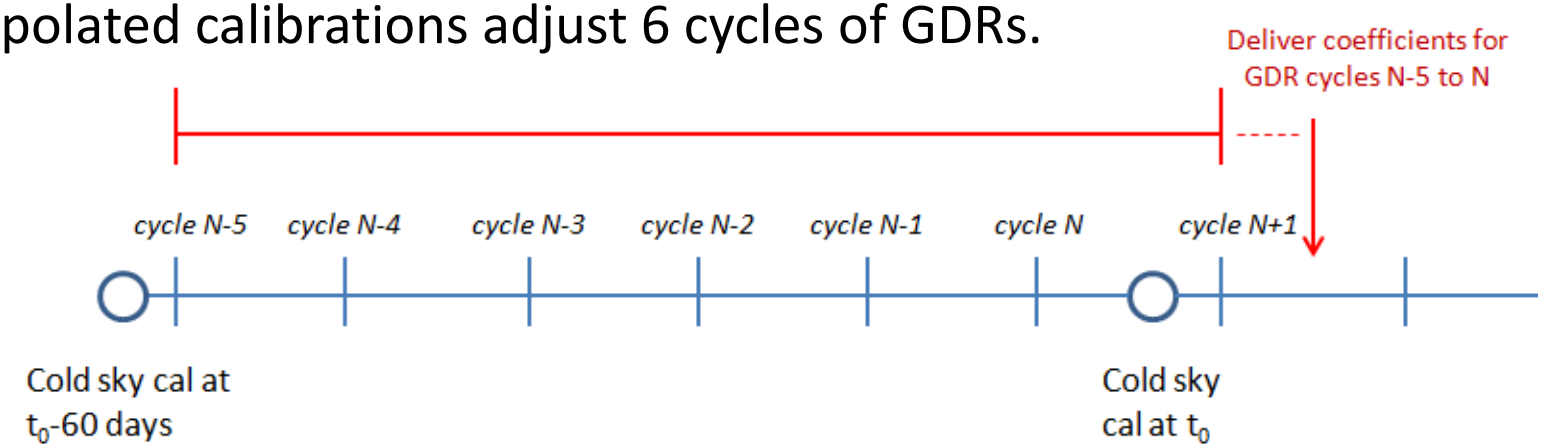
“Cold sky” AMR microwave radiometer calibration

Issue: Stability and accuracy of the wet troposphere range correction depends on AMR calibration.

For J-3 (and now J-2) calibration is supplemented by periodic spacecraft pitch maneuvers to point the radiometer to cold sky, offering a high-precision 1-point calibration.

Attitude maneuvers on the pitch axis, magnitude 80°, over land, with the satellite in sun eclipse, can be executed every 2 months; duration about 6 min (nominal case) (S. Brown).

Interpolated calibrations adjust 6 cycles of GDRs.



Not available for OGDRs due to the 60d needed for cold sky maneuver/calibration

Summary of OSTST recommendations on science and operations

La Rochelle – France – Nov. 1-4, 2016

- Jason-3 GDRs are approved – will be released Dec. 2016
- Jason-2 is on interleaved orbit – recommend a 2-year mission
- Move J-2 to long-repeat orbit (-27 km in altitude) in Oct. 2018
  - Objective: geodetic/MSS improvement
  - SSH obs. should continue to meet present requirements for accuracy/latency etc.
  - -27 km *graveyard* orbit protects the reference and interleaved orbits for future
- J-3 GDR latency requirement relaxed to 90 days (65 day median)
  - Enables “cold sky” radiometer calibration in all GDRs

The altimeter constellation is in excellent health

- Six operational satellites
- Sustained global sea level rise time series
- Continued improvement in resolution, accuracy and precision
- Robust plan for future missions to sustain and expand the constellation capabilities
- International interagency cooperation and collaboration
- Vigorous science applications: submesoscale, coastal ocean, global ocean, rivers and lakes
- Science team engaged in analysis of new measurement challenges from internal waves, infra-gravity waves, swell and sea state