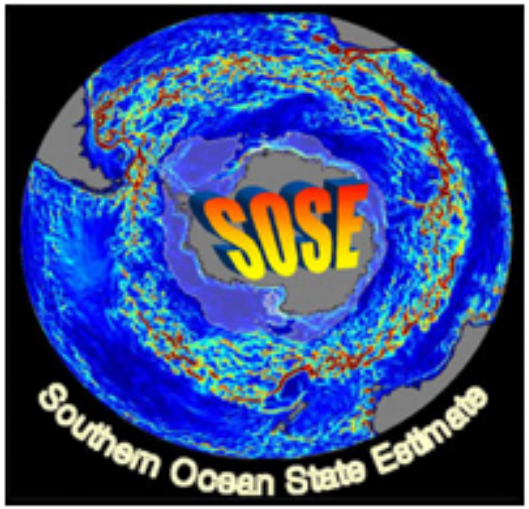
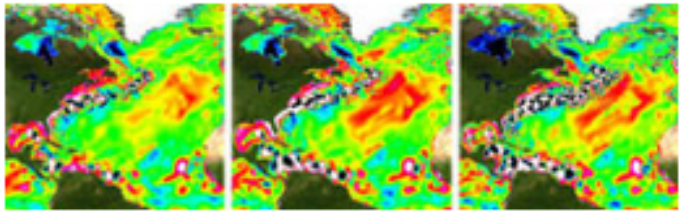
Science applications of the hi-res solutions





- Global cubed-sphere (CS510)
- Southern Ocean State Estimate
- Isotropic 80S-80N latitude-longitude

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Science applications of the hi-res solutions

Tong Lee
Evaluation of Indonesian-throughflow (ITF) transport estimated by ocean data assimilation (ODA) products using INSTANT observations

Josh Willis
Using Argo to estimate basin-integrated transport

Jessica Hausman
Sea state bias study

Brian Dushaw
Perth to Bermuda sound speed propagation

Ernesto Rodríguez
SWOT cross-over simulation

Evaluation of Indonesian-throughflow (ITF) transport estimated by ocean data assimilation (ODA) products using INSTANT observations

Tong Lee

Jet propulsion Laboratory, California Institute of Technology

Material extracted from Lee et al. (2009), submitted to ITF Special Issue in Dyn. Atmos. & Ocean

Mooring locations of the INSTANT Program (2004-2006)

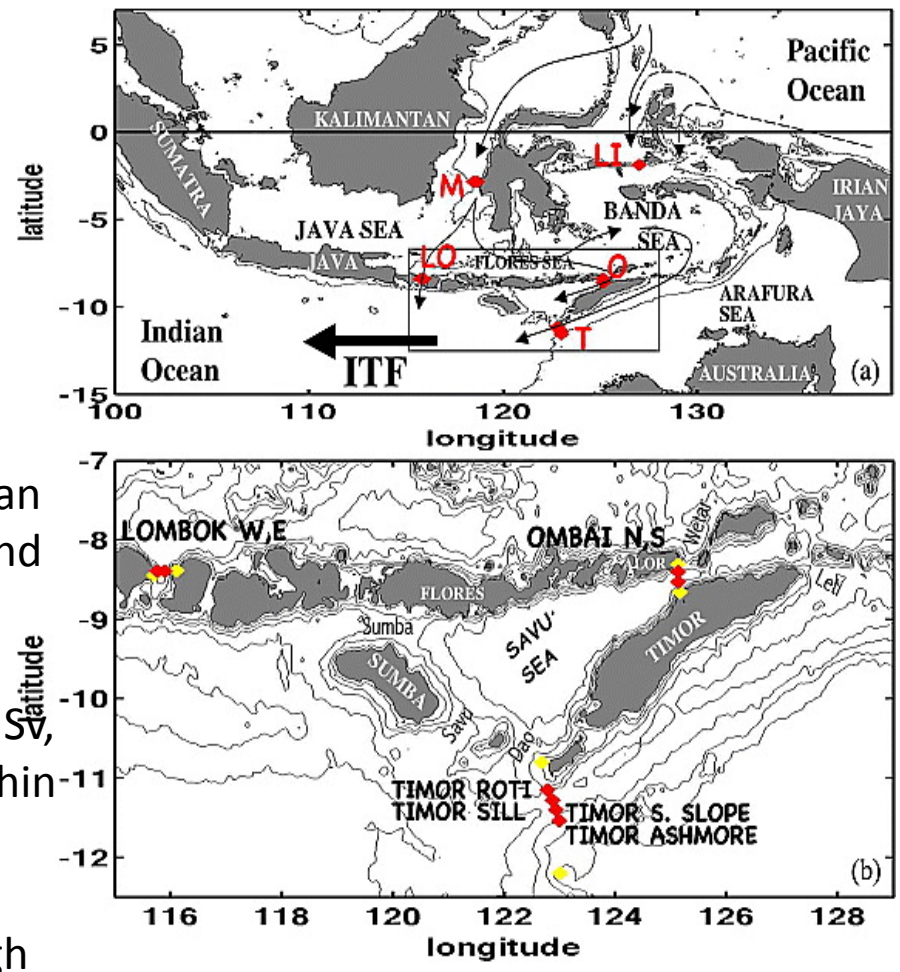
- ITF important to global ocean circulation & climate variability (e.g., Hirst & Godfrey 1993, Lee et al. 2002, Song et al. 2007).

- INSTANT observations (2004-2006) provide "near" direct measurements of ITF transport to evaluate ODA products.

ITF transport defined as the total Pacific-to-Indian Ocean volume transport through the Lombok and Ombai Straits and Timor Passage (see Fig.)

ECCO2 2004-2006 mean ITF transport about 13 Sv, consistent with INSTANT estimate (15 Sv) to within uncertainty (25%)

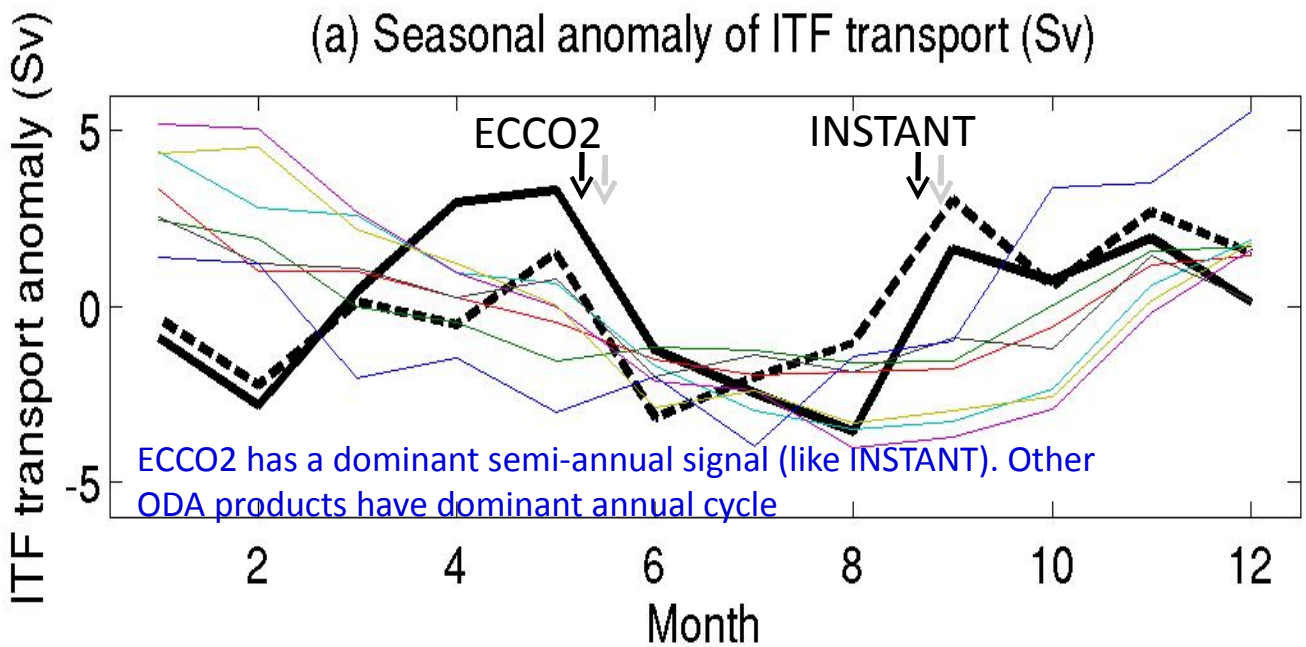
ECCO2 has realistic time-mean transport through Lombok Strait, too much flow through Ombai, too little flow through Timor.

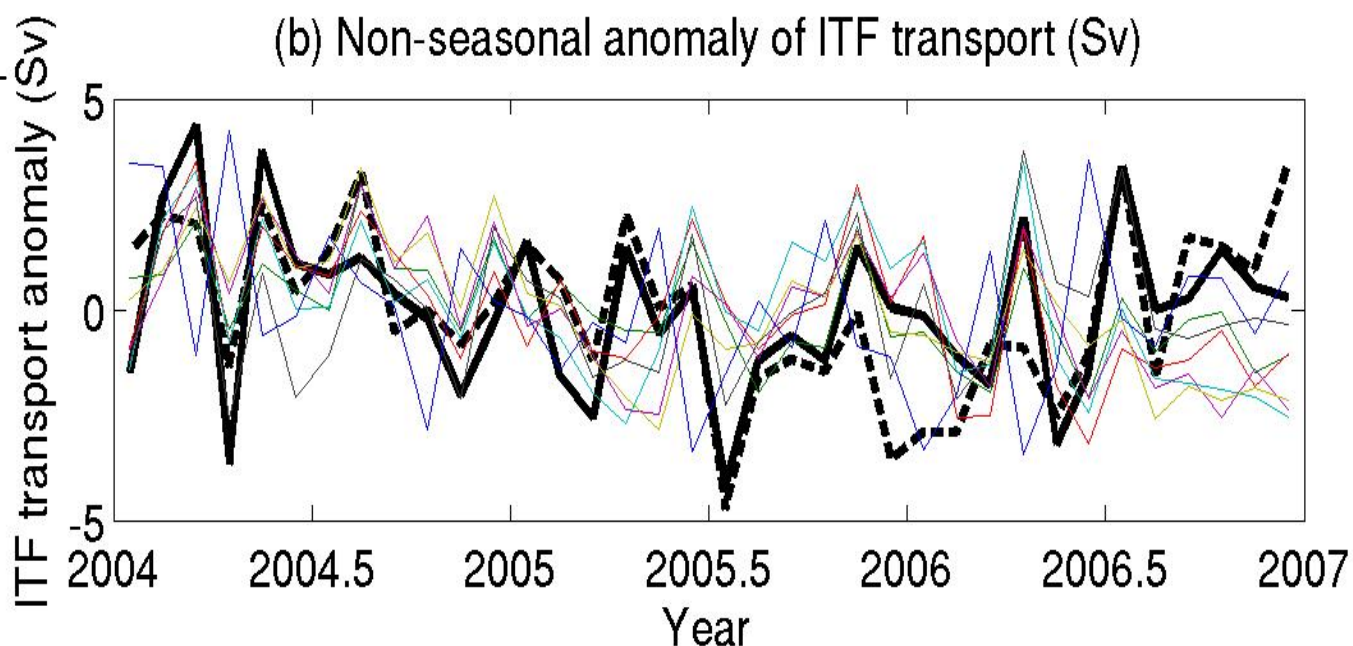


Comparison of seasonal & non-seasonal anomalies of ITF transport

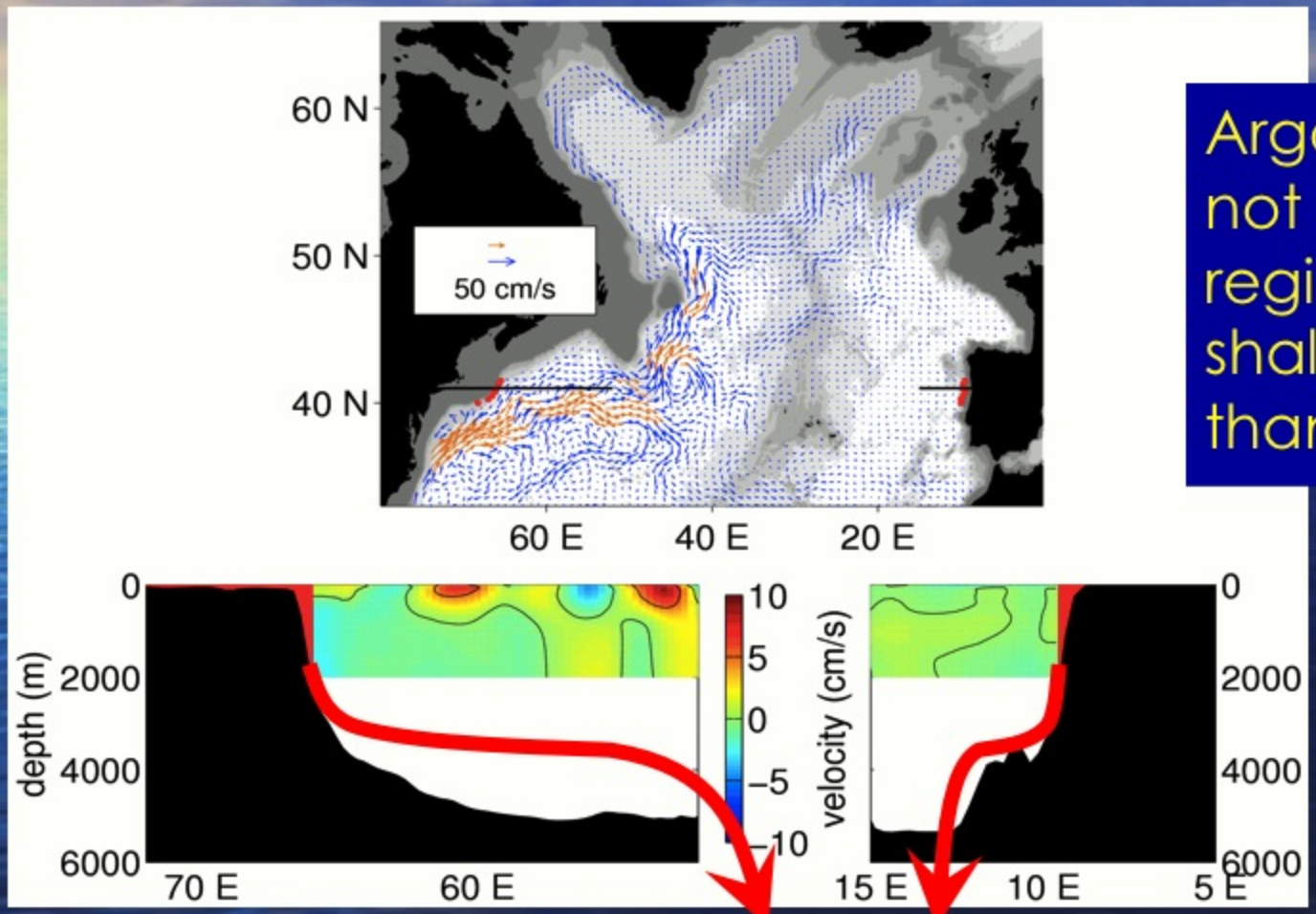
Color curves represent other ODA products:
CERFACS (France),
ECCO-GODAE-v3,
ECCO-JPL,
ECMWF,
INVG (Italy),
Mercator (France),
MOVE-G (Japan),
SODA
(all of which have lower resolutions, 0.4° to 2°)

The better agreement between ECCO2 & INSTANT is attributed to its higher resolution on a C-grid that allows a better representation of flows through narrow channels (esp. deep signals from the IO, e.g., semi-annual waves)





Using Argo to estimate basin-integrated, transport



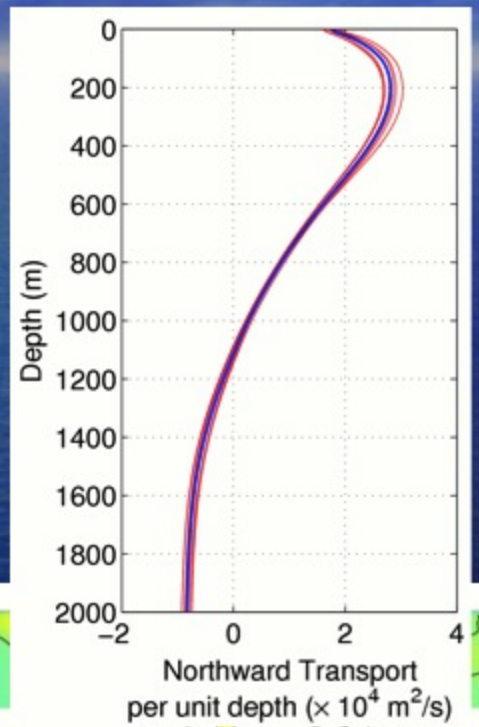
Argo does not sample regions shallower than 2000 m

$$\text{Error} \sim \sqrt{e_1^2 + e_2^2}$$

Josh Willis

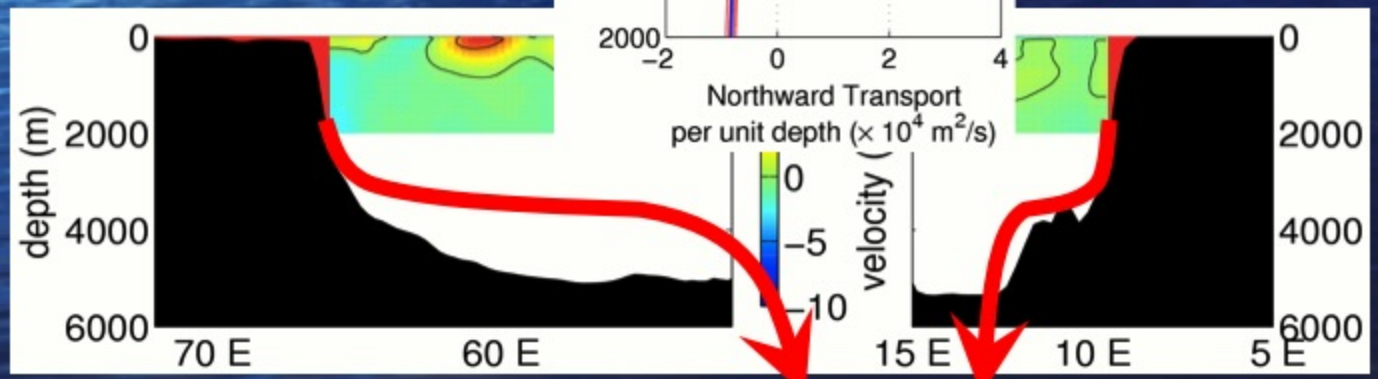
Does dynamic height at 2000 m isobaths give accurate transport?

Dynamic height difference across the basin



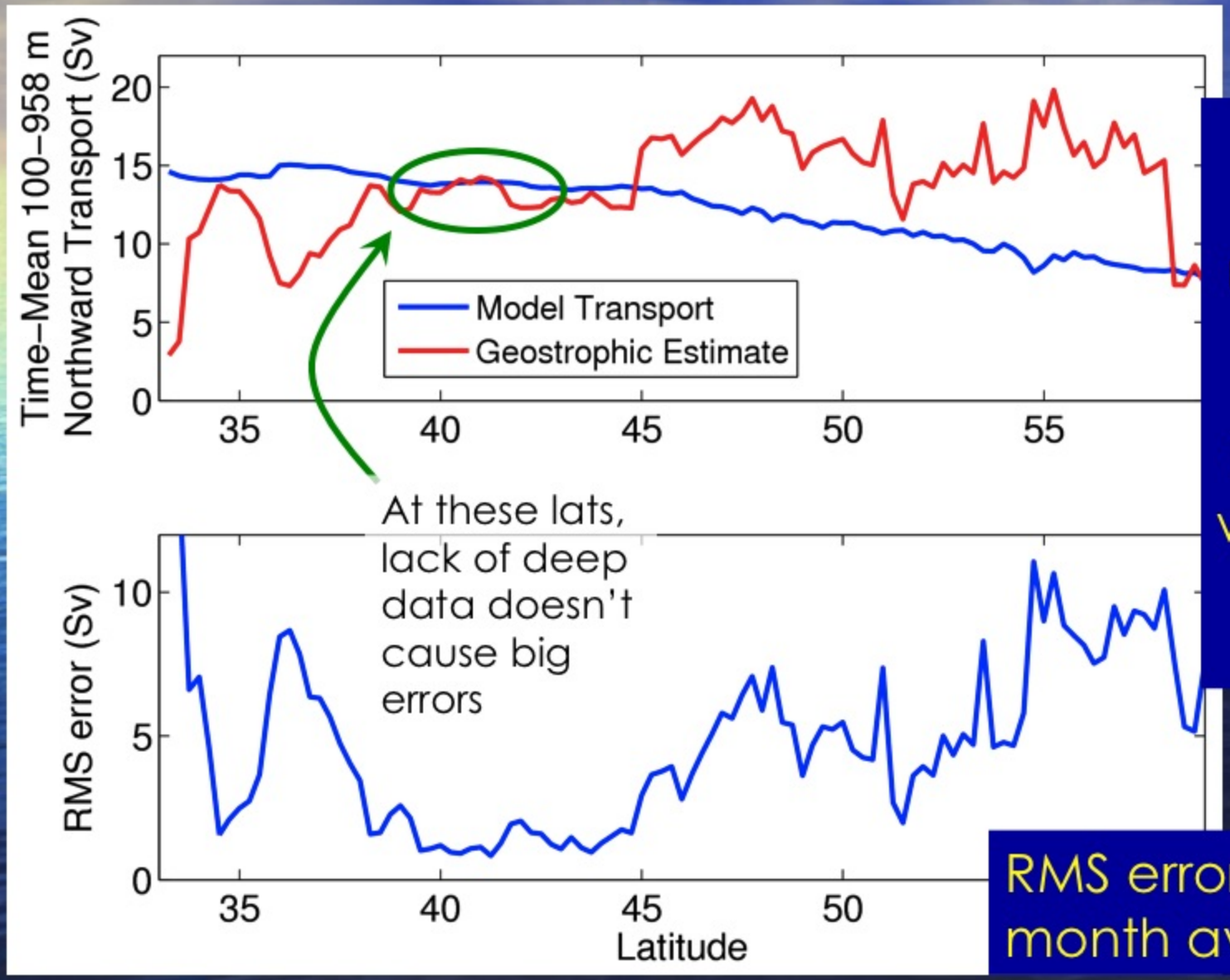
Northward flow of surface water

NADW Return flow



$$\text{Error} \sim \sqrt{e_1^2 + e_2^2}$$

Estimating transport error



100 to 1000m northward transport from ¼° ECCO run with 2000m isobath mask

RMS error in 3-month ave: 0.8 Sv

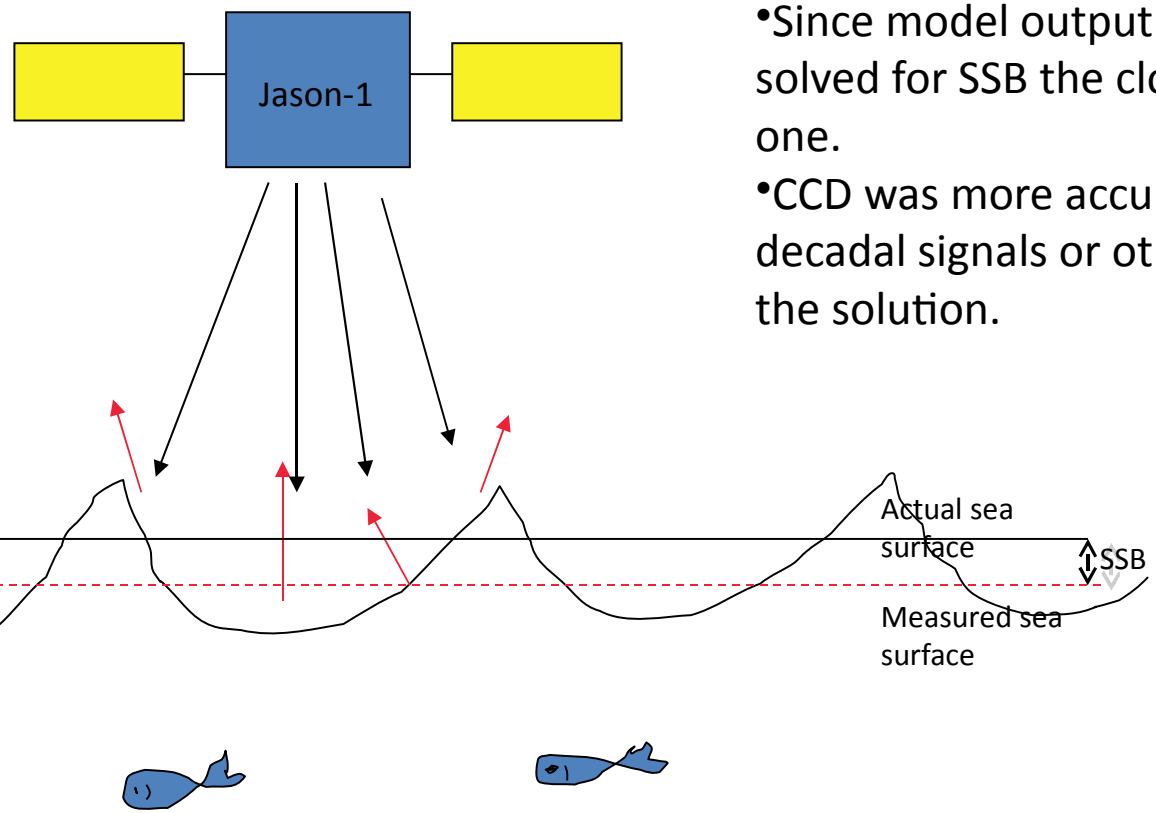
Using ECCO2 in a Sea State Bias Study

J. Hausman and V. Zlotnicki

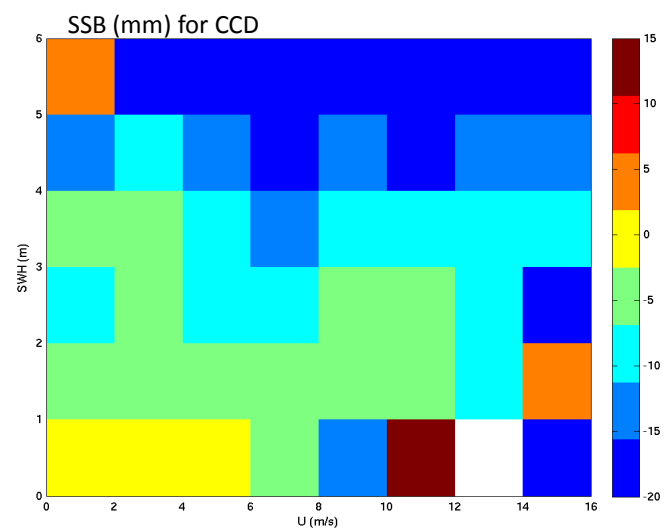
Since wave troughs are better reflectors than wave crests, radar altimeters measure the sea surface lower than what it really is. To correct this you add a **sea state bias (SSB)**.

There are two methods to solve for SSB, consecutive cycle differences (CCD) and differences from a mean

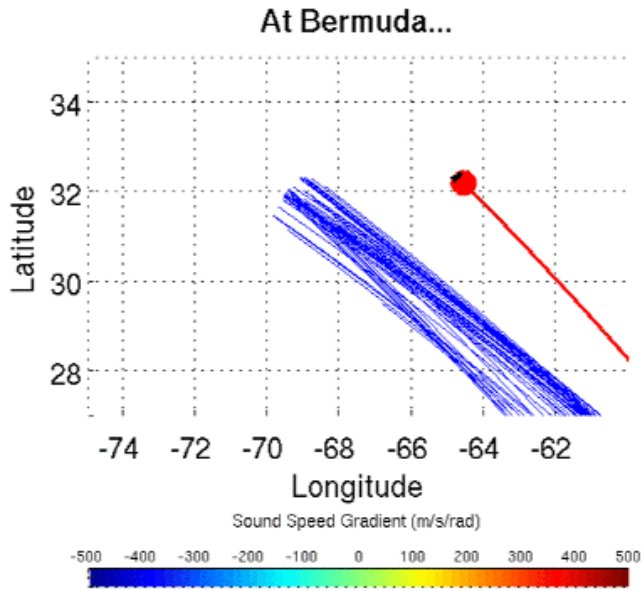
- To see which method is more accurate we calculate SSB using wind and wave data from Jason-1 and sea surface height from ECCO2.



- Since model output has no SSB, the method that solved for SSB the closest to zero was the more accurate one.
- CCD was more accurate. Using a mean allows for decadal signals or other low frequencies to "leak" into the solution.



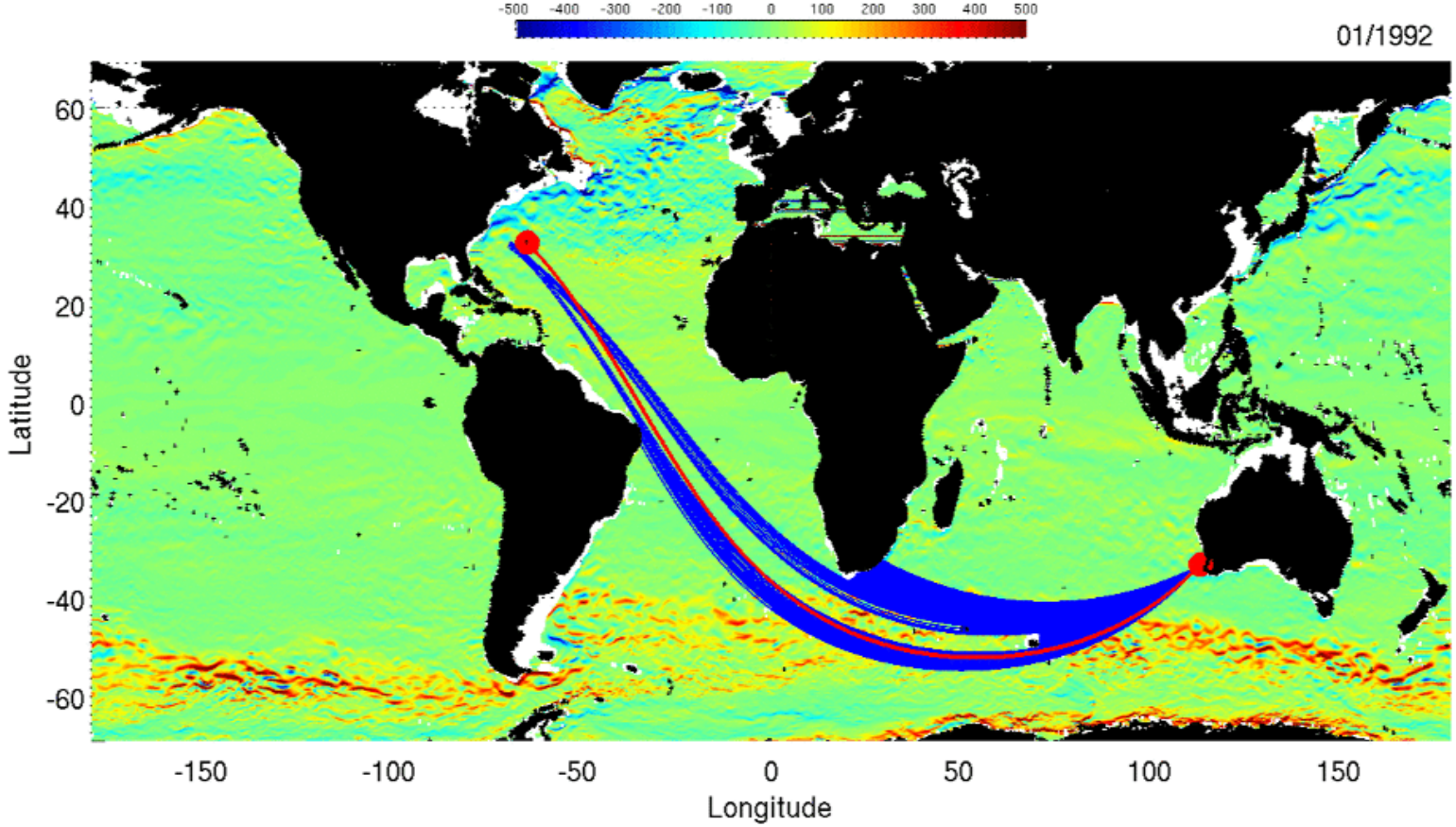
Brian Dushaw: Perth to Bermuda sound speed propagation



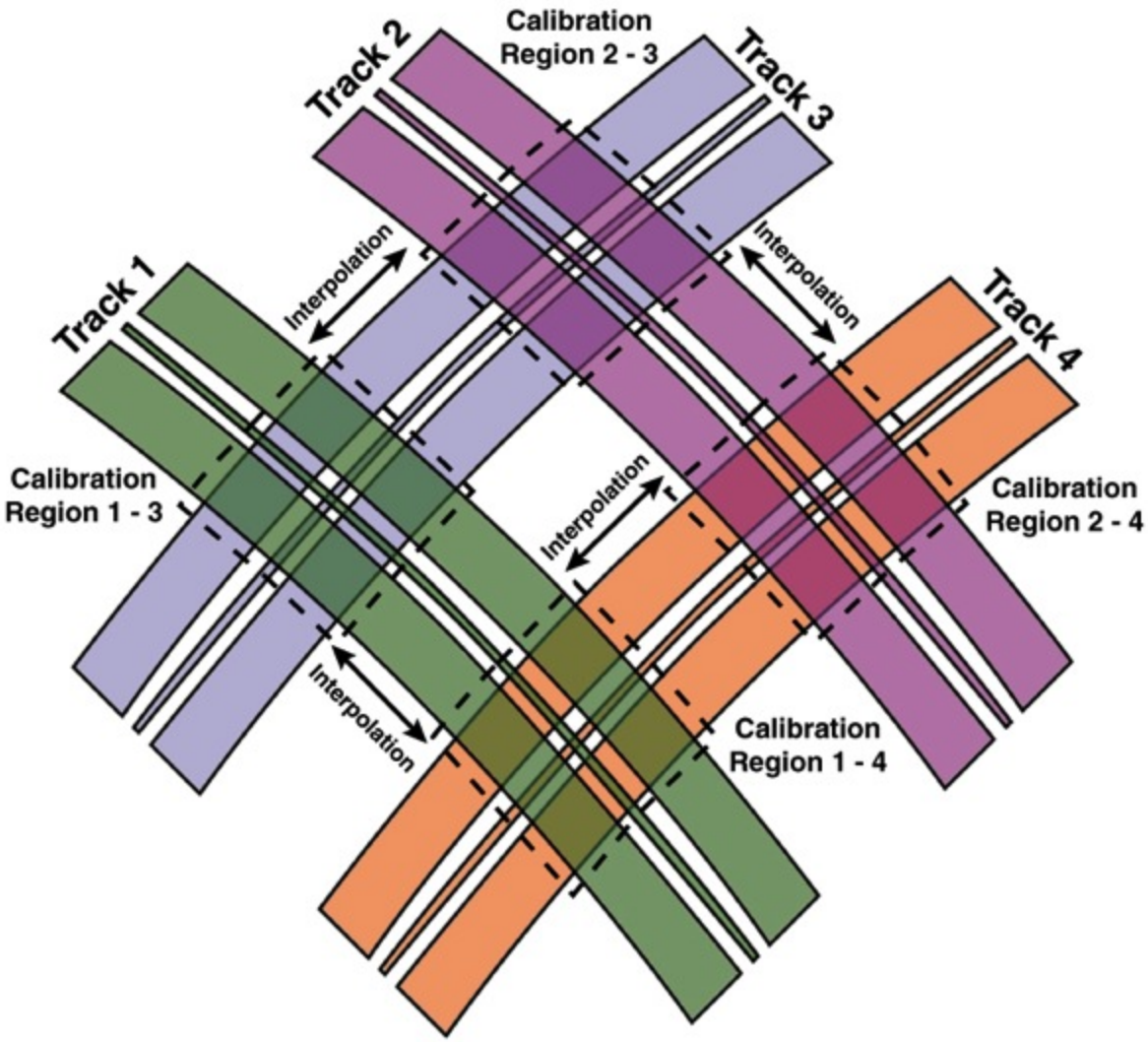
Color shows meridional gradient of mode-1 phase speed.

Does not include bathymetric and higher-mode propagations.

Mode-1 sound speed gradients alone do not allow ray paths to reach Bermuda.



SWOT Ocean Cross-Over Calibration Concept



- Roll errors must be removed by calibration
- Assume the ocean does not change significantly between crossover visits
- For each cross-over, estimate the baseline roll and roll rate for each of the passes using only interferometer-interferometer cross-over differences, which define an over-constrained linear system.
- Interpolate along-track baseline parameters between calibration regions by optimal interpolation, assuming roll error correlation function is known

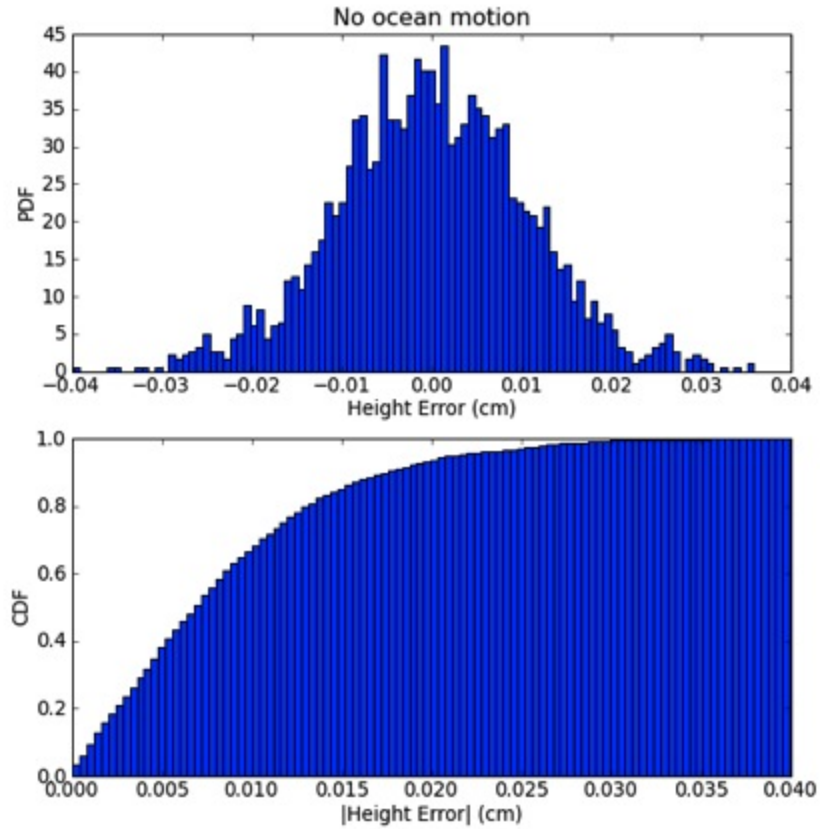
Using ECCO-2 for Cross-Over Simulation

- Issues relative to previous WSOA studies
  - The repeat time has increased from 10 days to 22 days. The revisit time between cross-overs has increased
  - Change in orbit inclination relative to Jason altimeter means that cross-over geometry has changed
  - To capture these changes, a realistic representation of the ocean mesoscale is required
    - ECCO-2 provides a unique capability for representing the ocean mesoscale realistically.
  - Used 30 days of ECCO-2 data to assess the validity of the cross-calibration process
  - The initial assessment was sufficient to assess the SWOT feasibility. However, getting global statistics requires a longer global data set.
  - A gobal simulation of SWOT data products will be conducted using one year of ECCO-2 data (Thank you ECCO-2 community!)

Results without ocean motion

- Results show that changes in cross-over geometry have not affected the calibration accuracy
- Results also show that interferometer only calibration is sufficient for roll restitution
- Interferometer-Altimeter cross-calibration required for range calibration to altimeter global frame

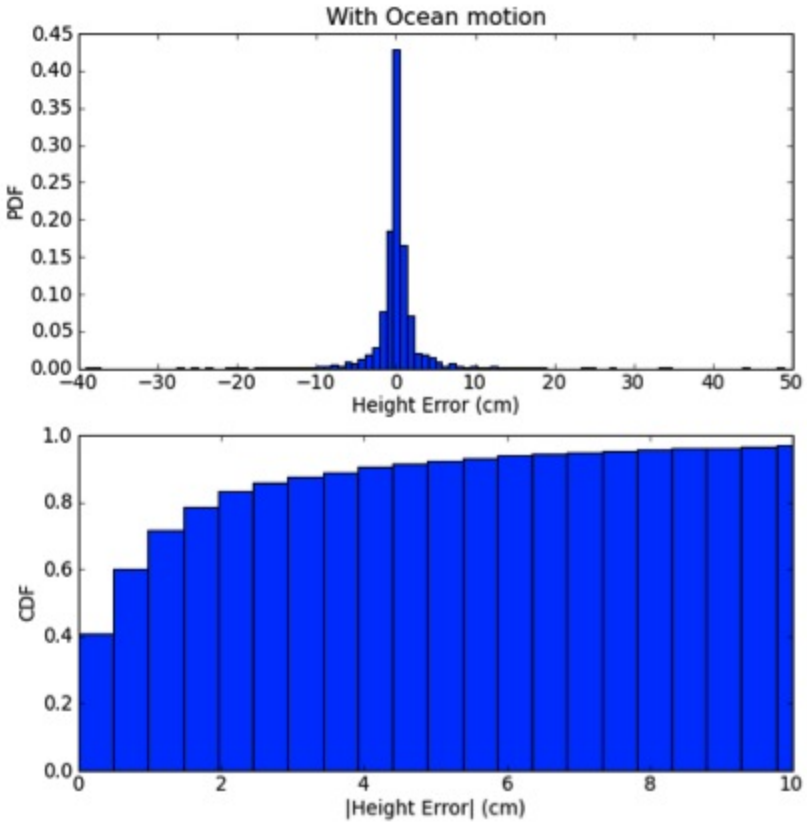
Error represents swath average error



Simulations with ocean motion

- Ocean motion between cross-over revisits is the dominant contributor to the roll calibration error budget
- In general, the calibration parameters are well behaved, but the distribution has large tails
- 68% error < 1.5 cm
- 80% error < 2.0 cm
- 90% error < 5.0 cm

Error represents swath average error



Assessment of cross-over calibration impacts

- The roll stability 1km-1000km (requirement) is not dependent on the cross-over calibration, but on platform stability
- Wavelengths longer than 1000km (goal) are dependent on the roll calibration
- Results of the simulation using ECCO-2 data show that the long-wavelength errors of SWOT can be calibrated with an accuracy consistent with nadir altimeter missions
- Results presented here are preliminary
  - Final results will use one year of ECCO-2 data
- Issues that need to be investigated:
  - Dropping cross-overs with long revisit times
  - Dropping cross-overs over regions of high mesoscale activity
  - Dropping estimates inconsistent with optimal interpolation
- Key issue in the mission design:
  - Correlation time for spacecraft roll