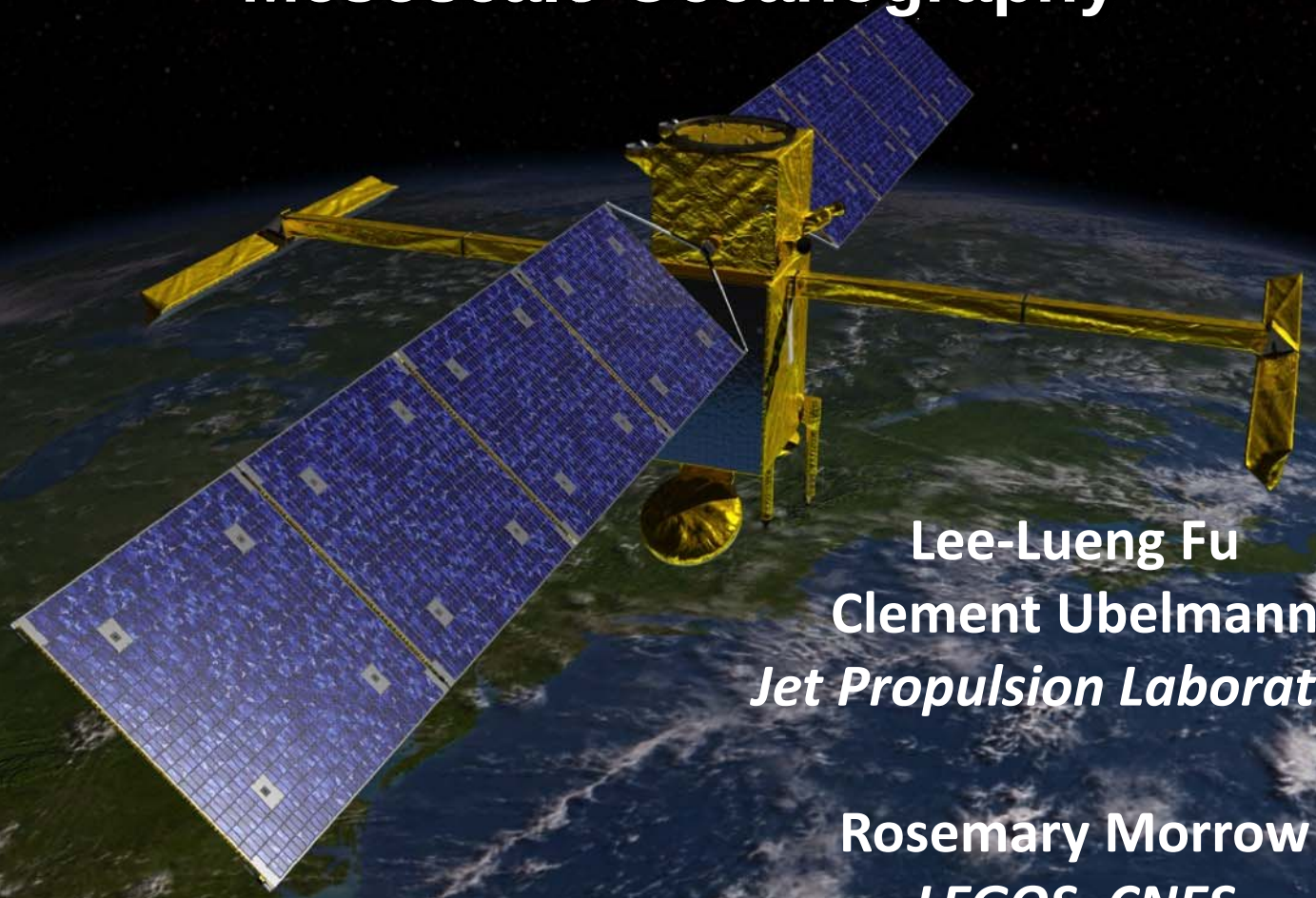
SWOT Mission Design for Advancing Mesoscale Oceanography



Lee-Lueng Fu
Clement Ubelmann
Jet Propulsion Laboratory

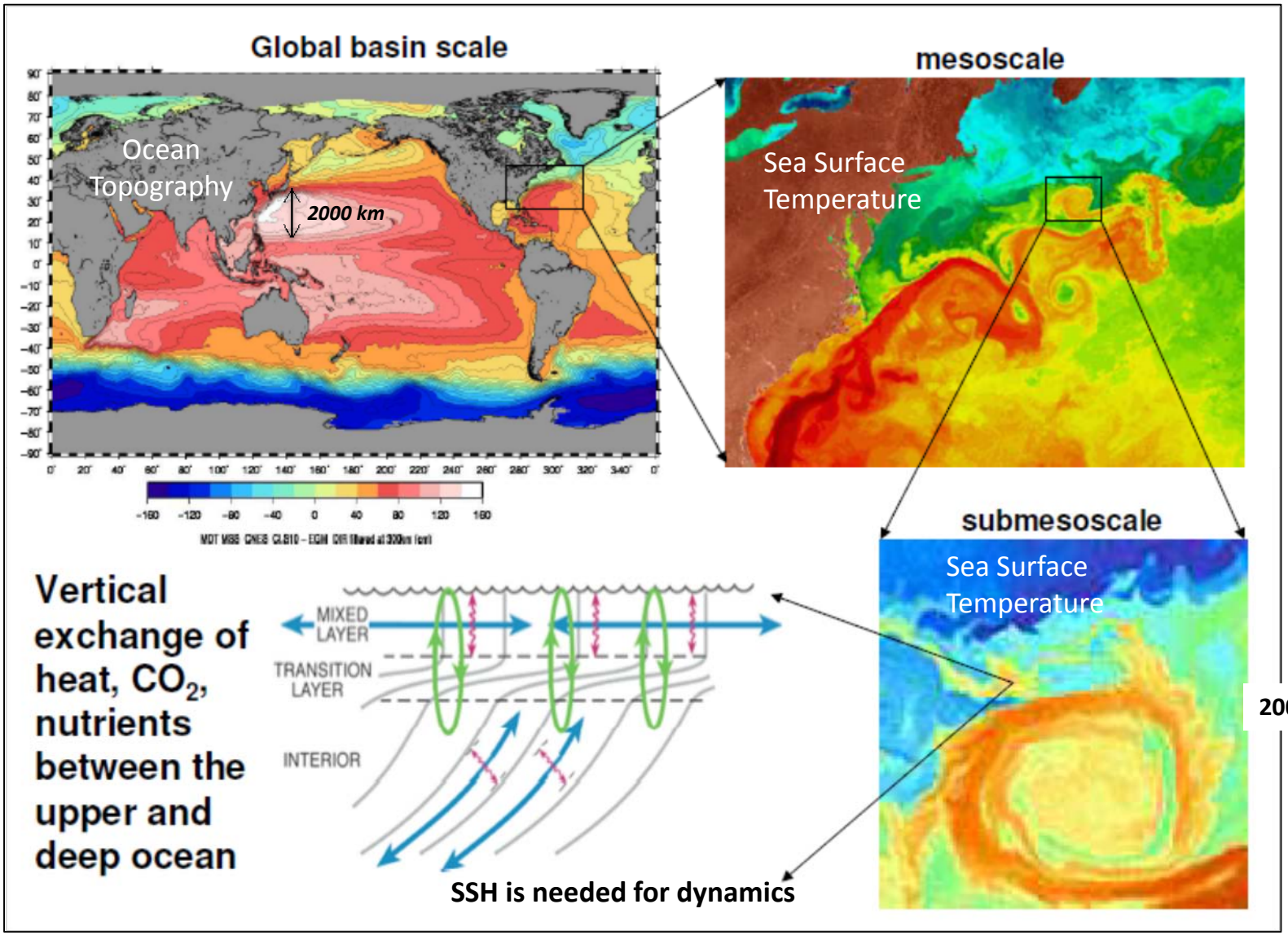
Rosemary Morrow
LEGOS, CNES

Ocean Surface Topography Science Team Meeting, October 8-11, 2013
Boulder, Colorado

Outline

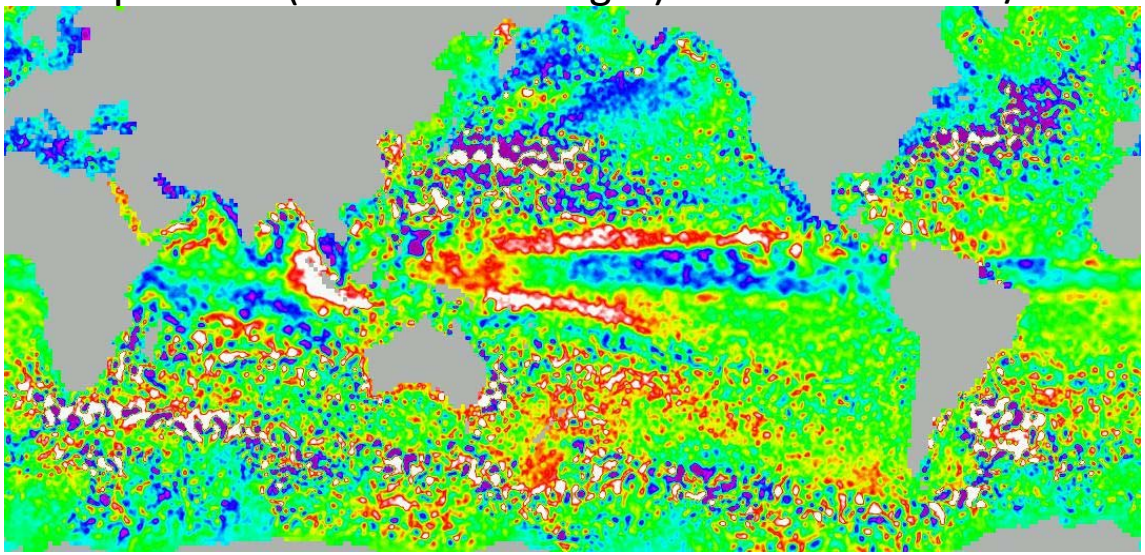
- ***Mesoscale perspectives***
- ***Observational challenges***
- ***A wide swath mission***
- ***Global spectrum and resolution***
- ***Wet tropo correction***
- ***Cal/val with nadir altimeter***
- ***High-frequency signals***
- ***Orbit sampling***

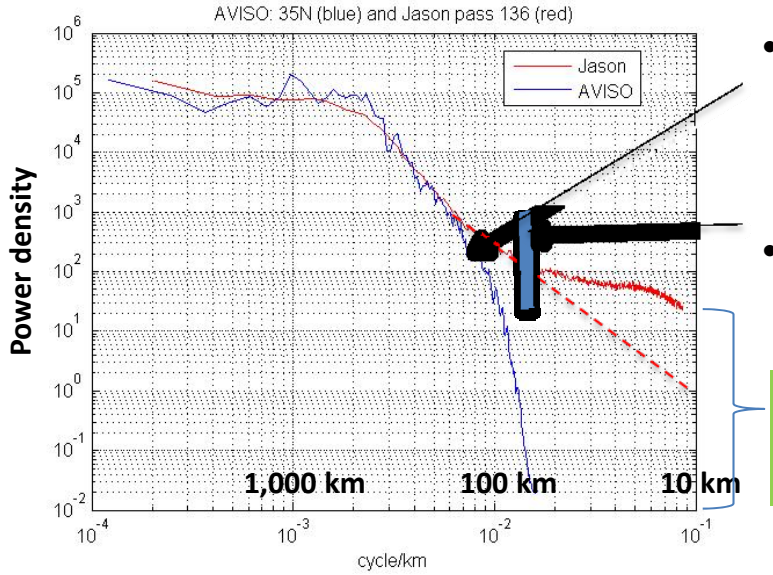
Targeting the dynamics of the smallest scales of ocean currents



The limit of resolution of Jason-1/2

A snapshot of (sea surface height)SSH from Jason-1/2

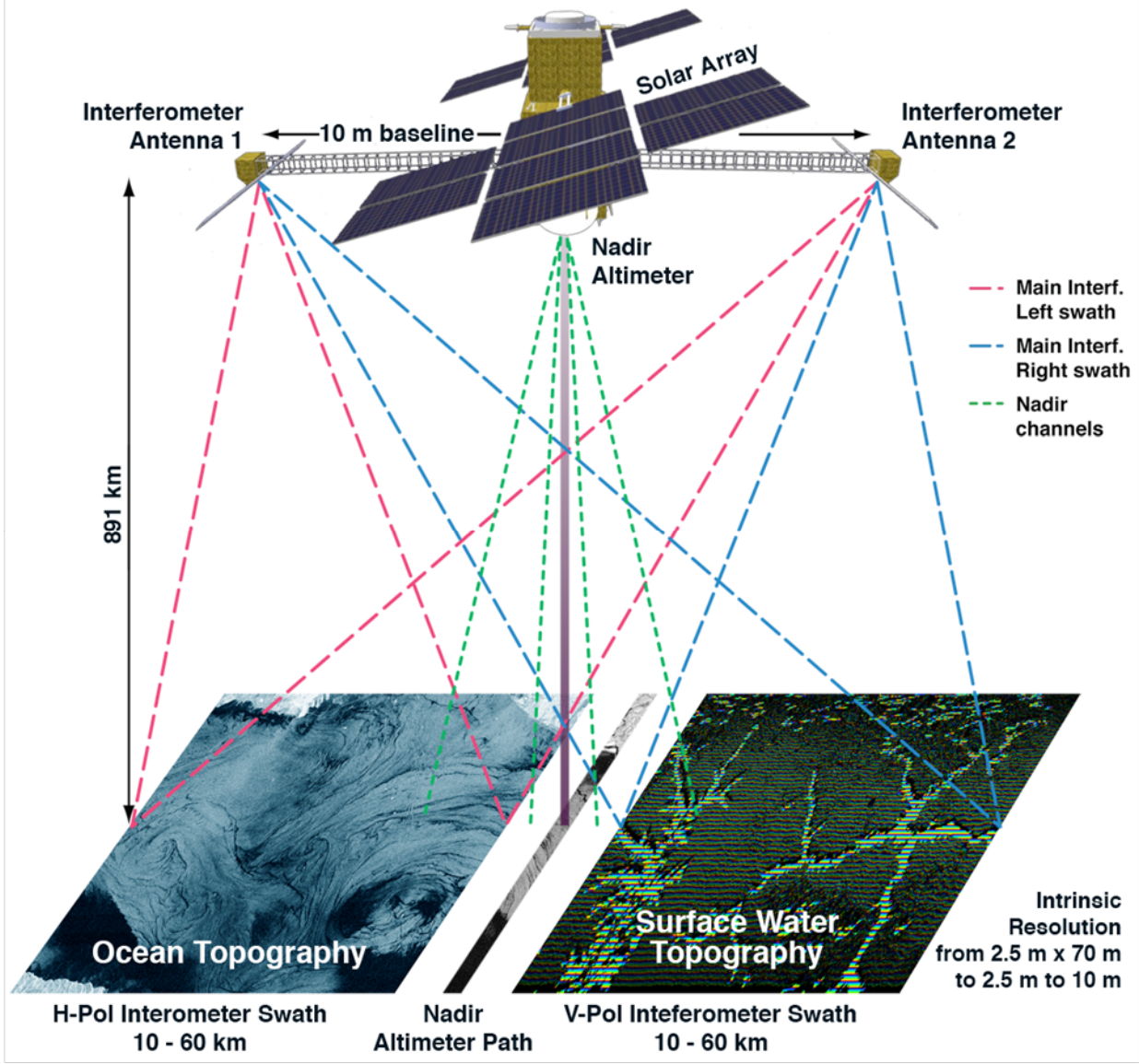




- **Drop in energy of 2-D gridded SSH spectrum (blue) vs alongtrack spectrum (red) at 200 km marks the mapping resolution with 2 altimeters.**
- **The ultimate resolution is limited to 70-100 km due to the instrument noise.**

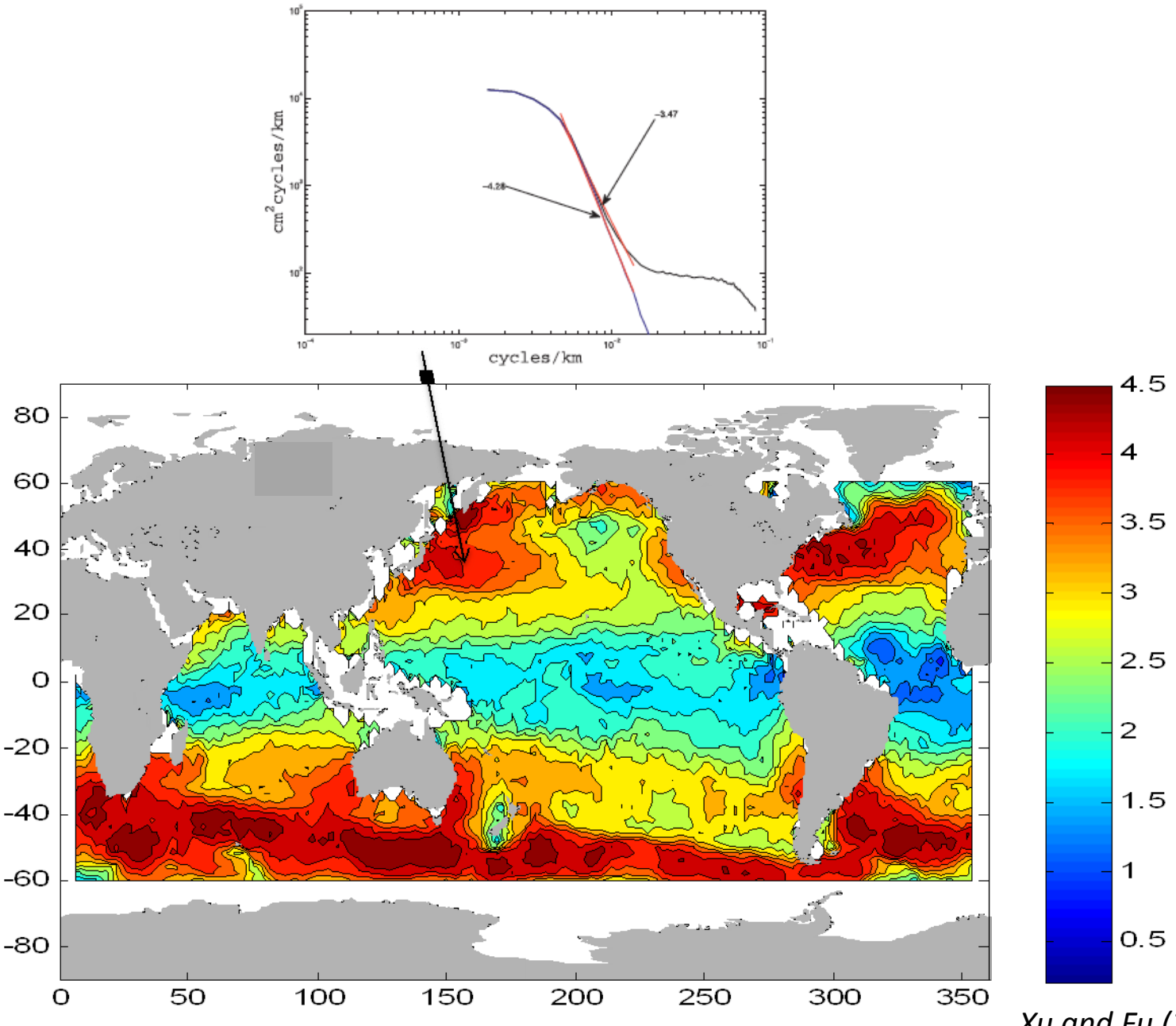
SWOT will extend the measurement down to 15 km

SWOT Payload Configuration



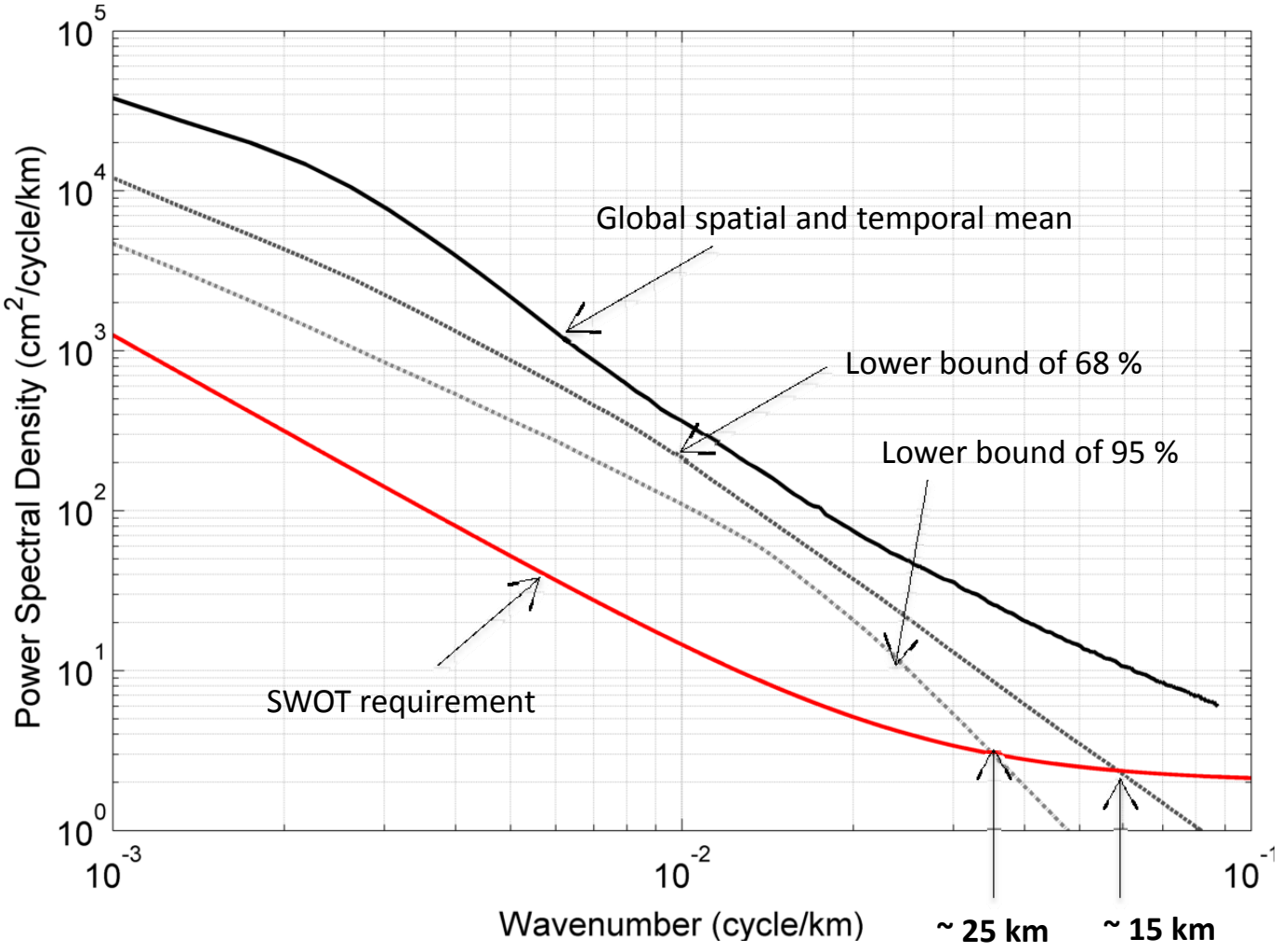
- ***SAR resolution on the order of 10 m***
- ***Average to 1 km to reduce noise***
- ***What is the resolution of SWOT?***
- ***Analyze the global SSH wavenumber spectra.***

SSH spectral slope in the global ocean

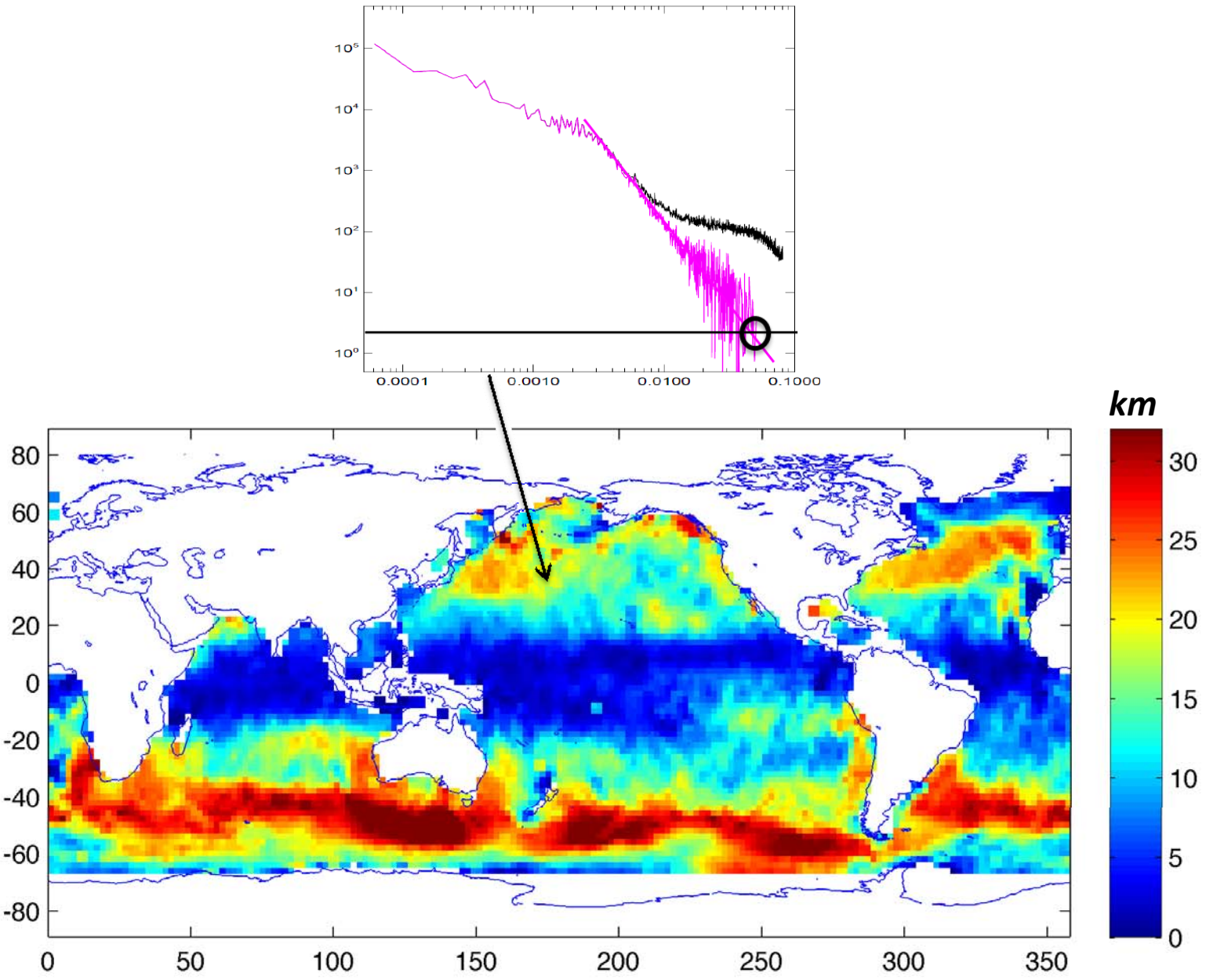


Xu and Fu (2012)

Global mean SSH spectrum and the SWOT requirement



SWOT SSH resolution in the global ocean



Fu and Ublemann (2013)

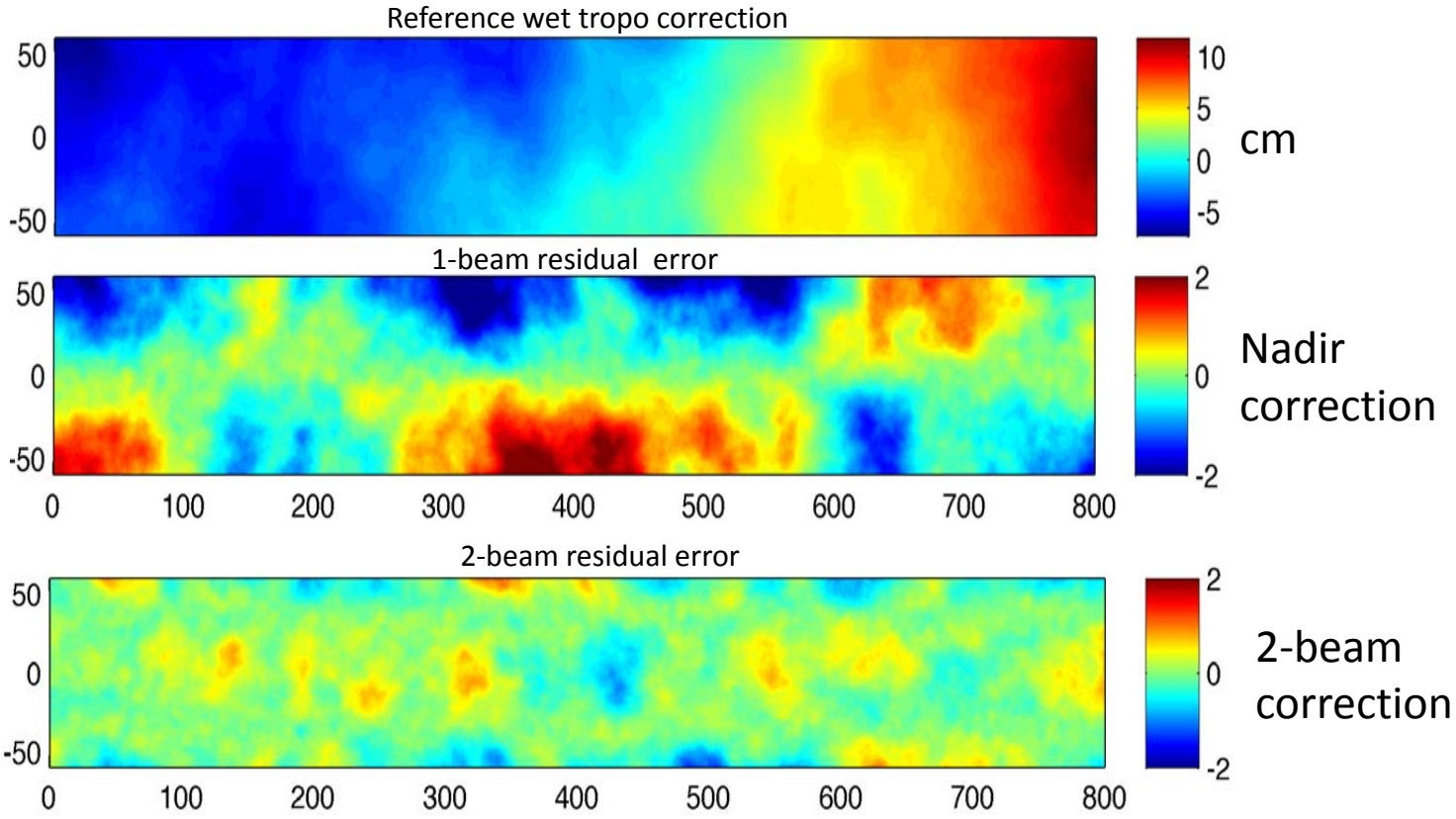
Wet tropospheric correction

- Conventional nadir-looking one-beam radiometer is not sufficient for correcting the cross-track variability of the range errors caused by the tropospheric water vapor.
- The two-dimensional swath measurement of SWOT needs a two-beam radiometer for wet-tropospheric corrections.

Range errors

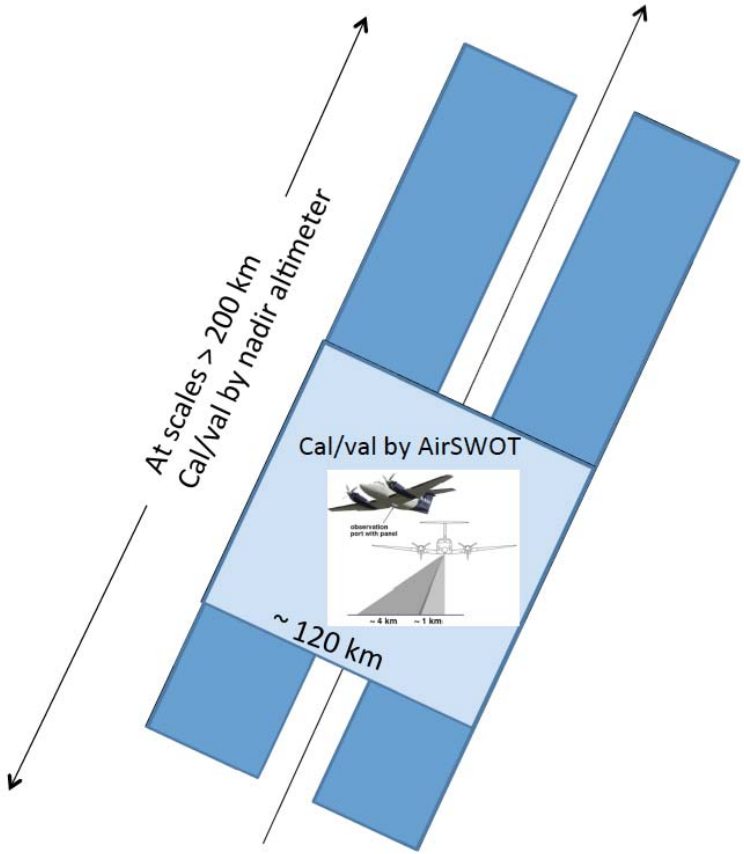
cross-track errors

residual errors

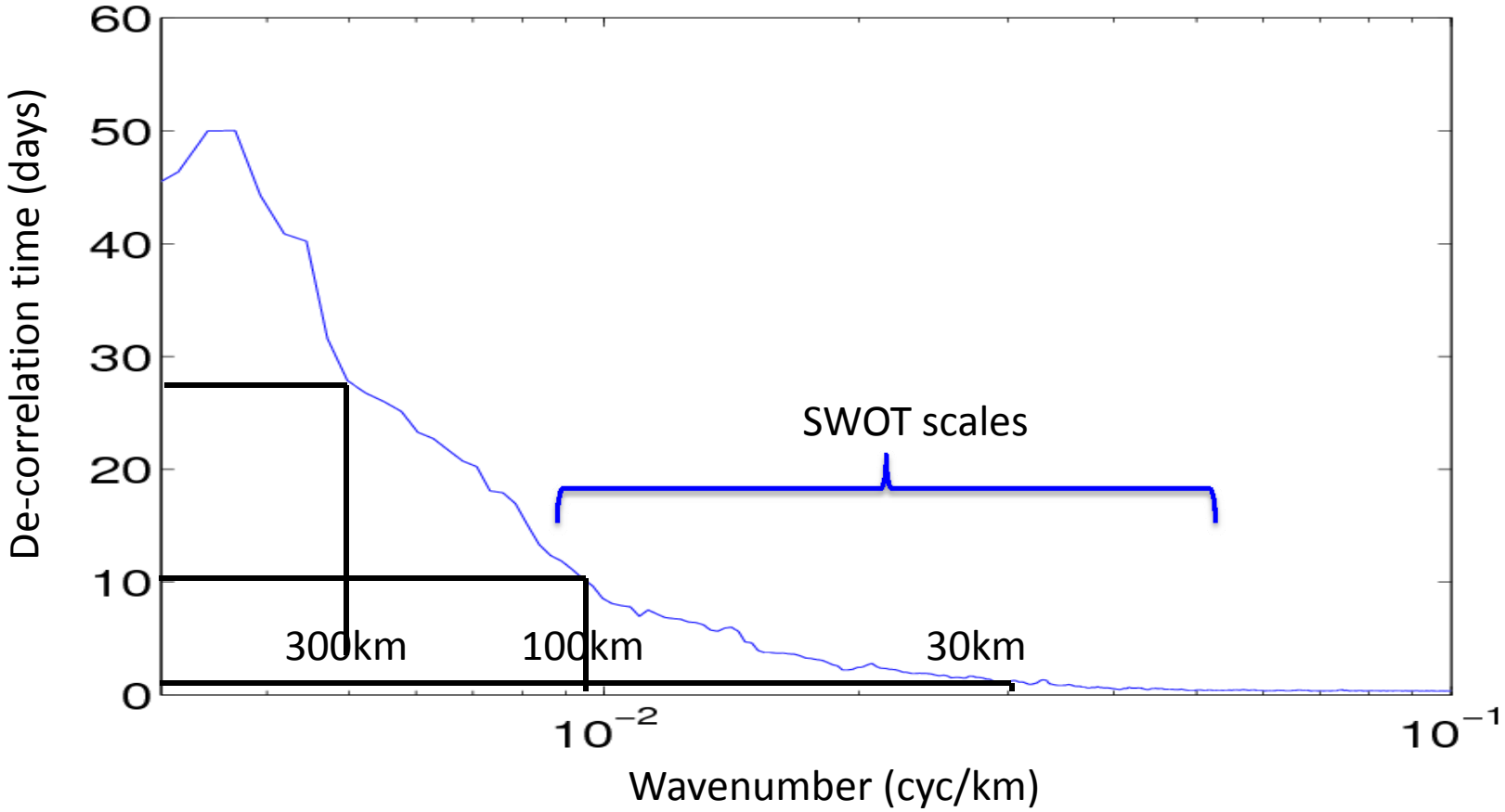


Need of a Nadir altimeter

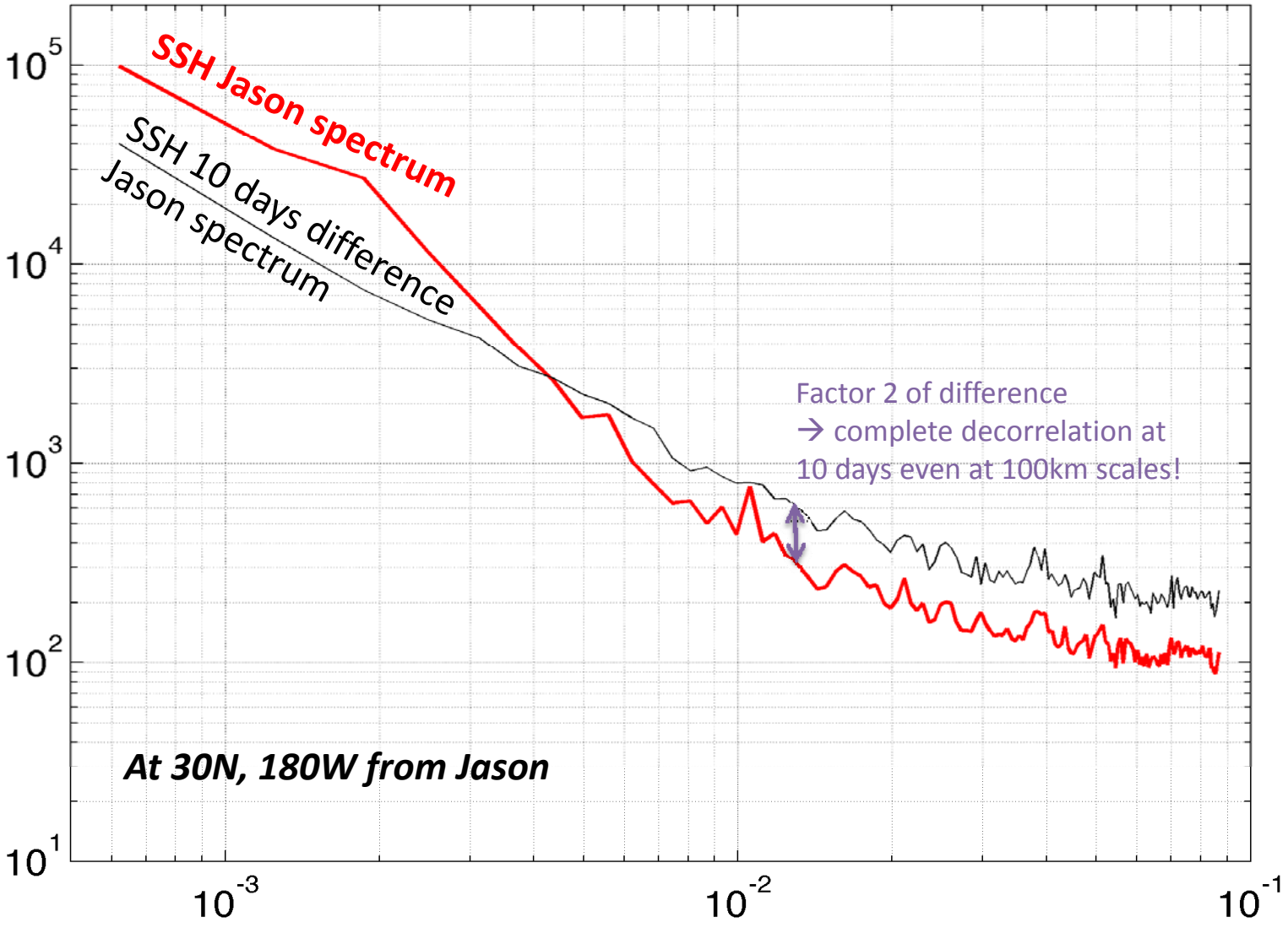
- The long-wavelength accuracy of the SSH measurement is expected higher for the altimeter than KaRIn.
- By combining the two measurements simultaneously, a consistent measurement from short (KaRIn) to long wavelengths (altimeter) can be obtained.
- Calibration and validation of SWOT in setting the standard for the next generation altimetry missions to continue the climate data record of sea level and improve its resolution and coverage.

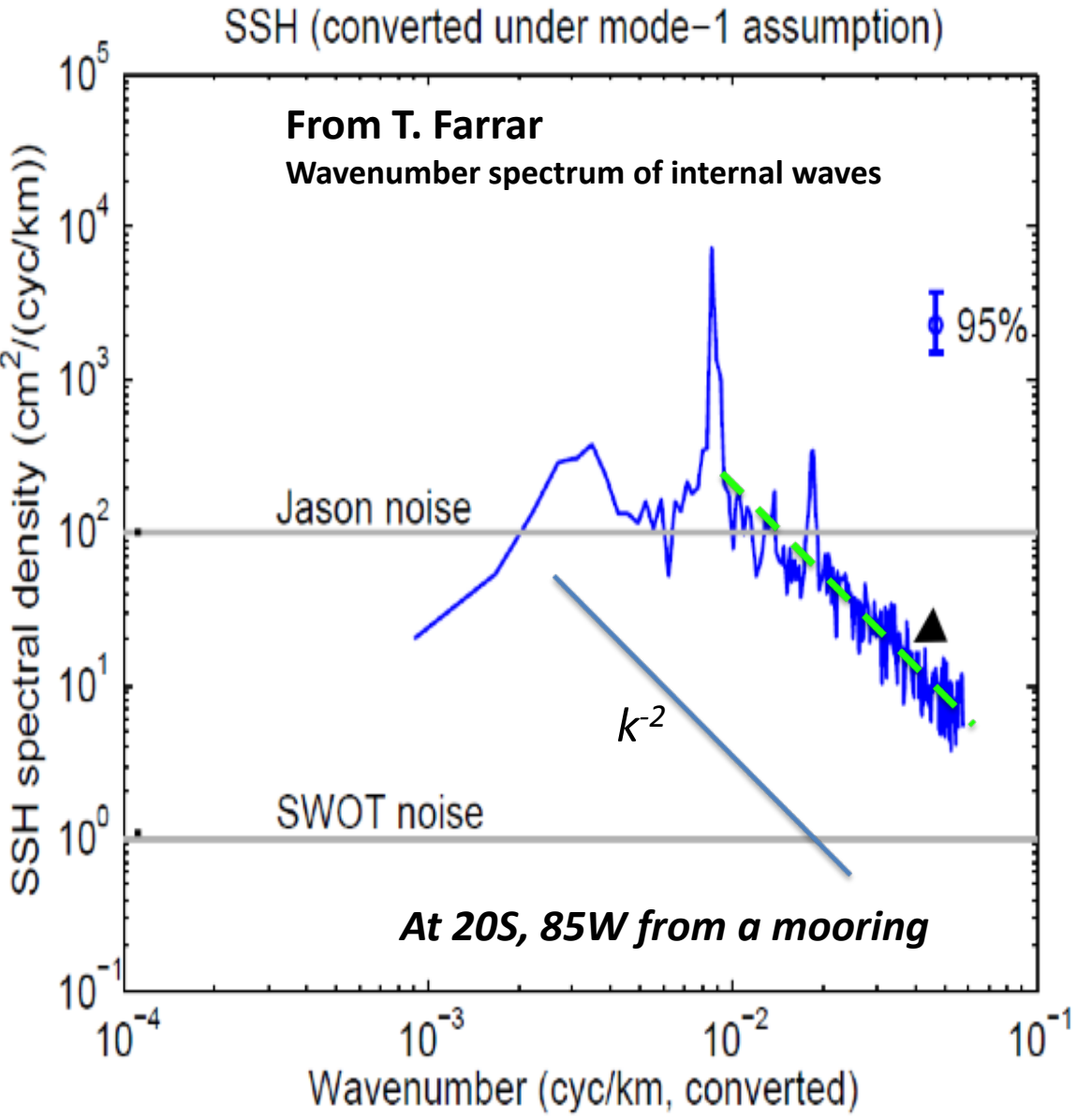


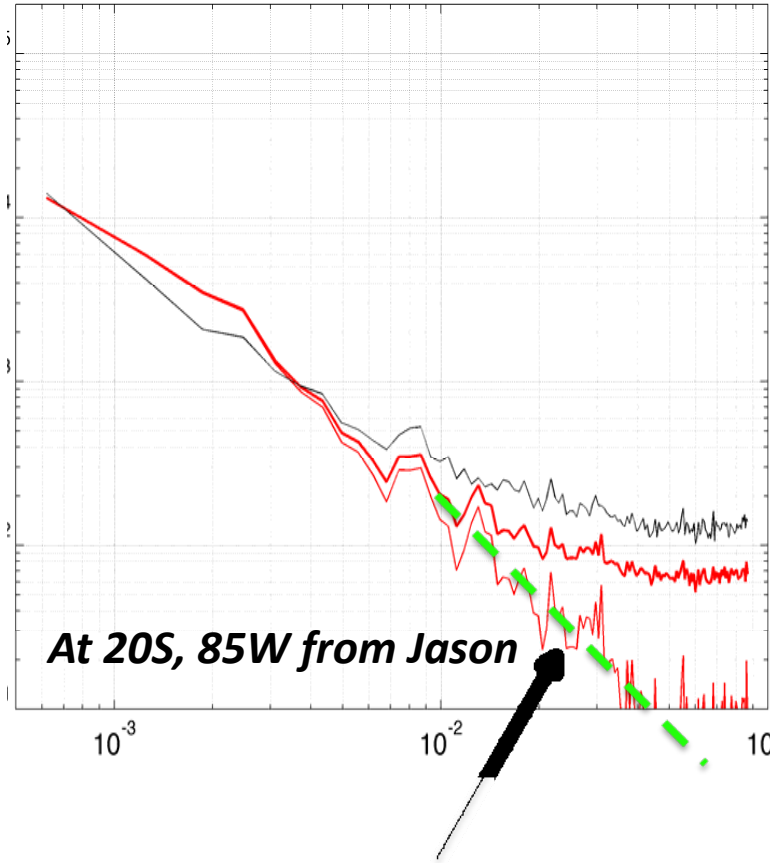
Time scales of ocean variability decrease with spatial scales



Small-scale SSH signals de-correlate over 10 days







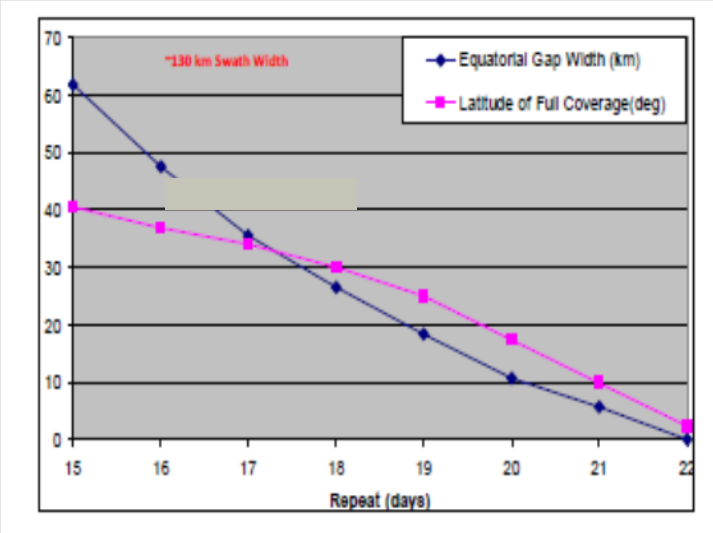
After removing the white noise floor, the Jason SSH spectrum seems consistent with internal waves at wavelengths less than 100 km.

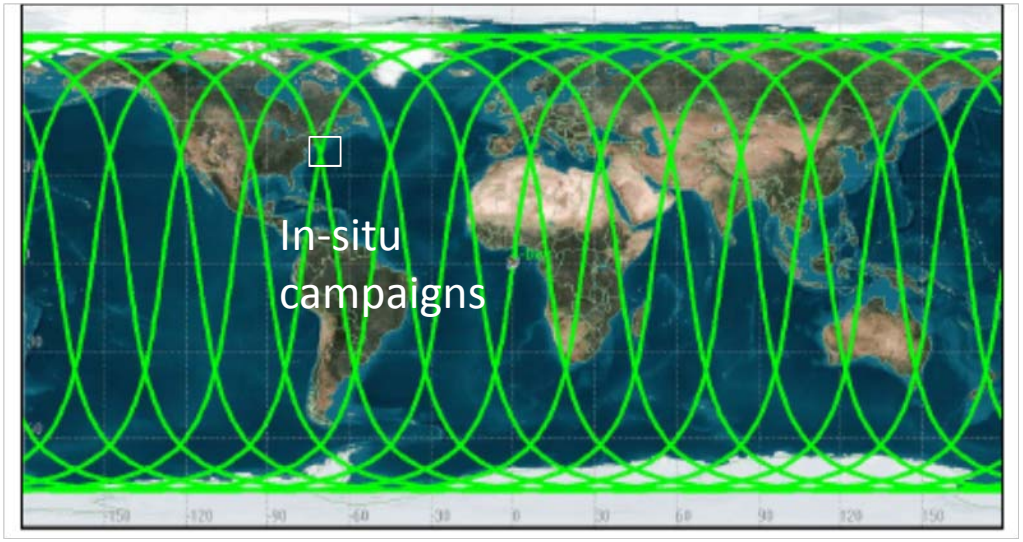
Orbit Requirements

• Global coverage and more frequent sampling dictates a compromise in orbit **repeat period of 21 days with 10-day subcycle.**

• **Inclination of 77 degrees** to achieve non sun-synchronous orbit to minimize tidal aliasing and to ensure coverage of major water bodies on land.

• **1 day repeat period during the initial cal/val phase** for fast sampling to achieve the cal/val objectives and study rapidly changing phenomena.





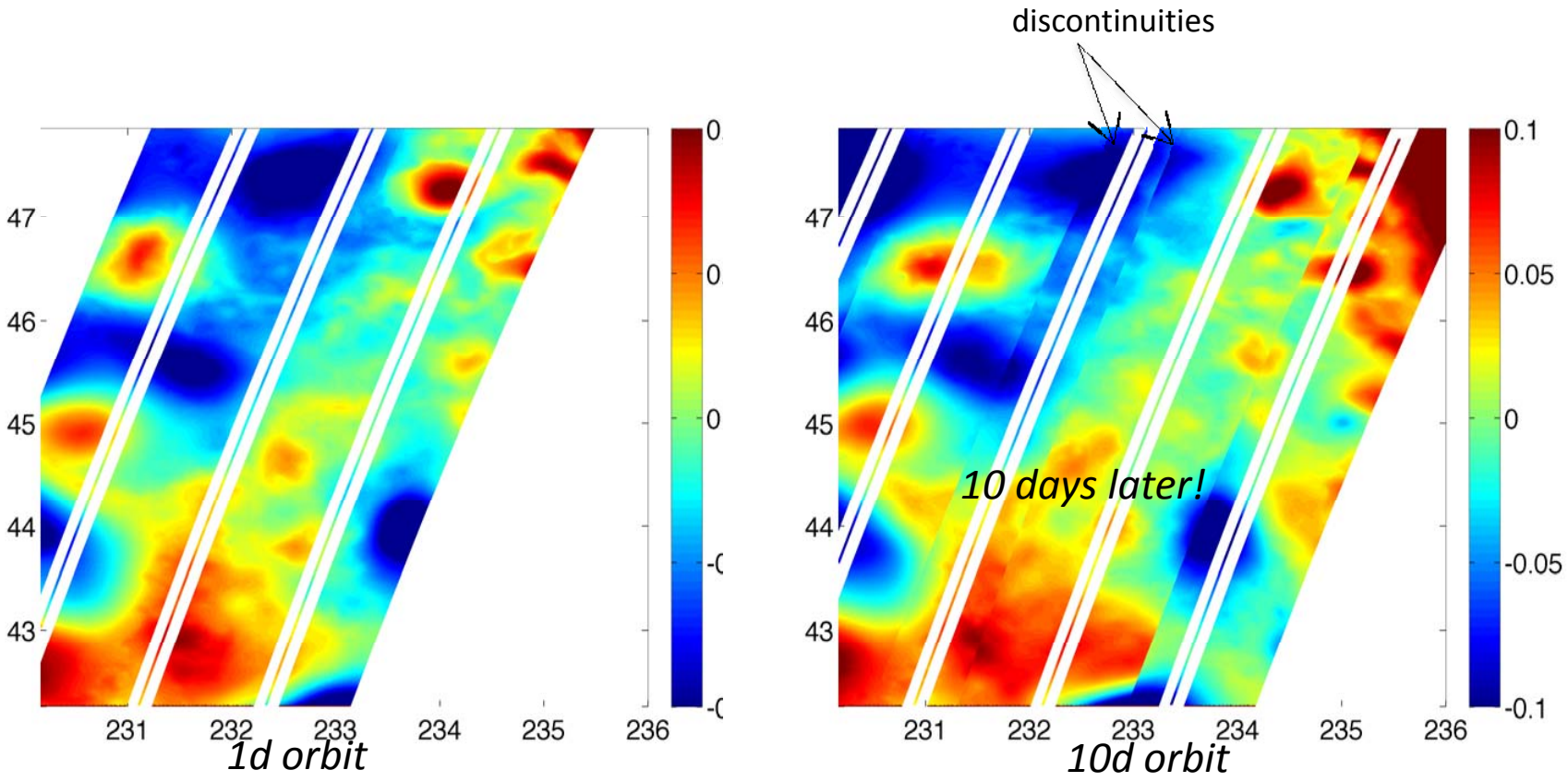
- Longitude crossings to be determined.
- A SPURS-like experiment with AirSWOT.
- A cal/val working group will be formed soon to address the various issues (cal/val sites, in-situ observations, strategy for separation of signals and errors, etc.)

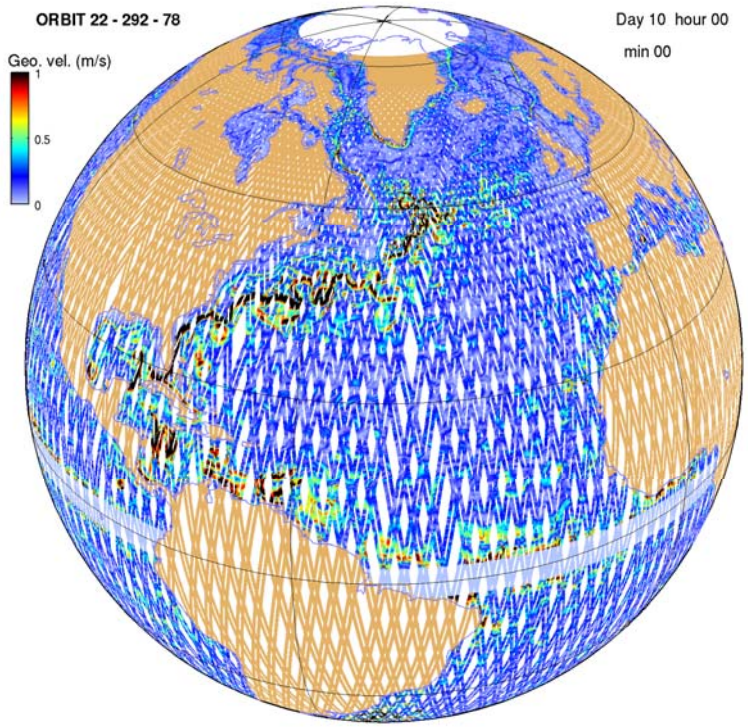
Conclusions

- ***SWOT will provide the first opportunity to explore ocean dynamics with wavelengths less than 100 km.***
- ***The mission is designed to achieve wavelength resolution of 15-25 km.***
- ***A two-beam radiometer is required to minimize errors from cross-track variability of water vapor effects.***
- ***A conventional nadir altimeter is required to calibrate and validate SWOT for maintaining consistency with existing data record.***
- ***The missions orbit is selected to optimize the global sampling of eddies. (21 day repeat with 10-day subcycle)***
- ***Ageostrophic motions like internal waves might create challenges.***
- ***A 1-day repeat sampling phase for 90 days will provide an opportunity to address high-frequency signals and its possible separation from low-frequency signals.***

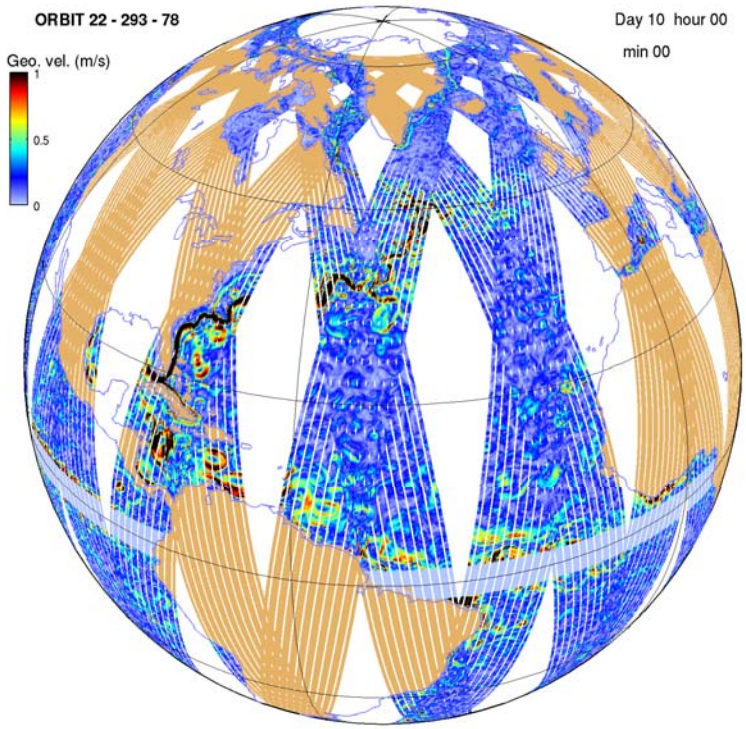
Back-up

Mapping pattern of the 1-d versus 10-d orbits





10d orbit after 10 days



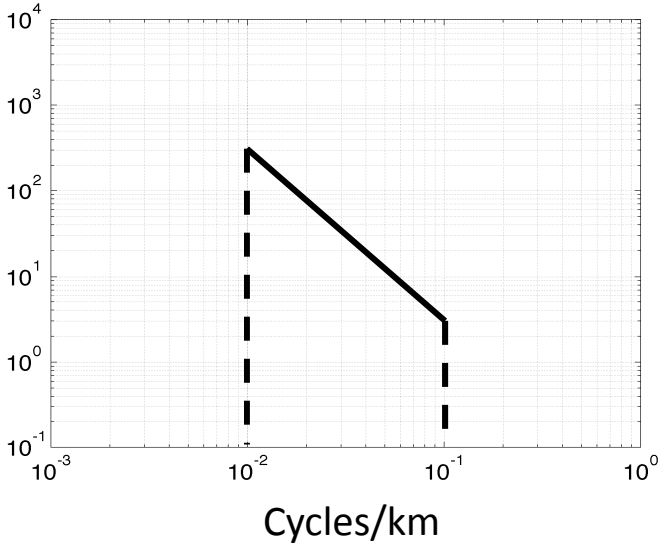
1d contingency orbit after 10 days

- Quasi-global mapping every 10 days with the 10d orbit + global mapping every cycle (21 day)
- Only 1 Global mapping every cycle (21 days) with the 1d orbit

→ **Large and intermediate mesoscale with decorrelation over 10 days:** would highly benefit from the 10-day sucycle (inter- gappy-swath mapping) of the 10d orbit. Clearly **redundant observations with the contingency orbit:** strongly affects the performances of traditional mapping of large and intermediate mesoscales

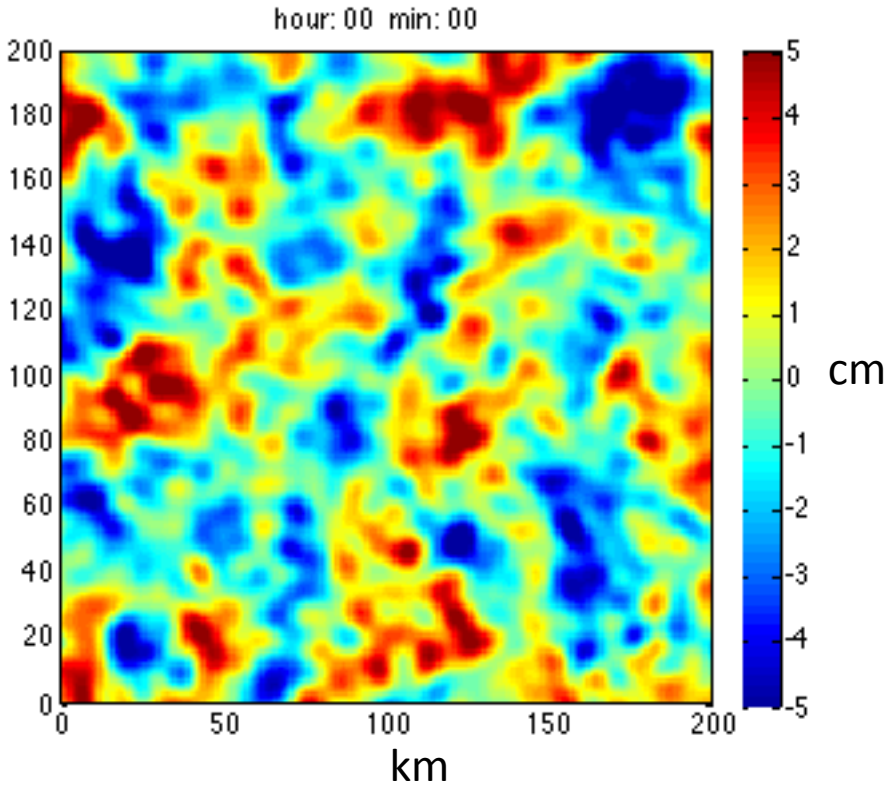
→ **But what about short mesoscales and submesoscales (intra-swath) who have a decorrelation time below 10 days?**

Simulation of a random2D field following the internal-wave spectrum observed at 20S, 85N (from T. Farrar)

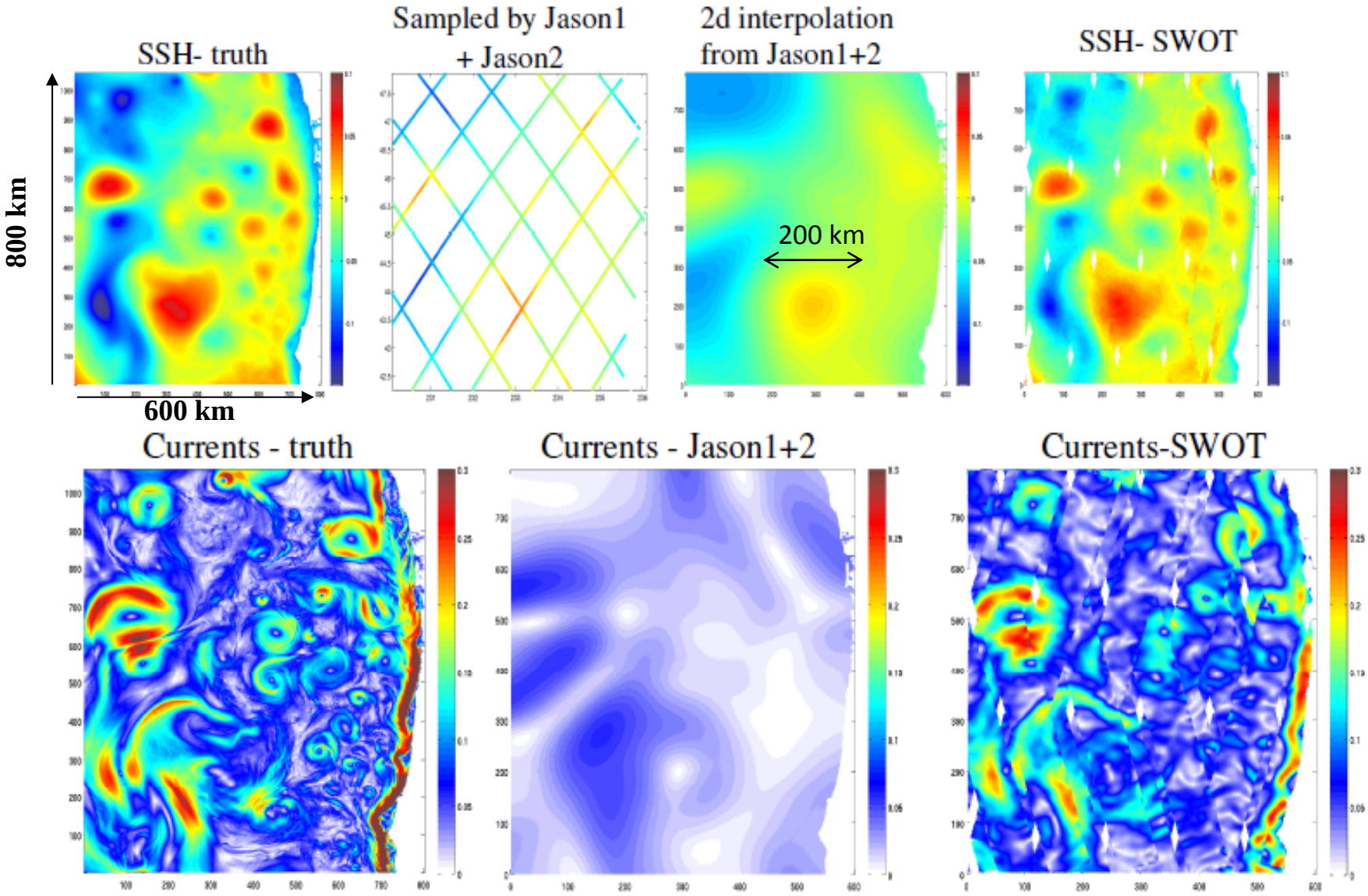


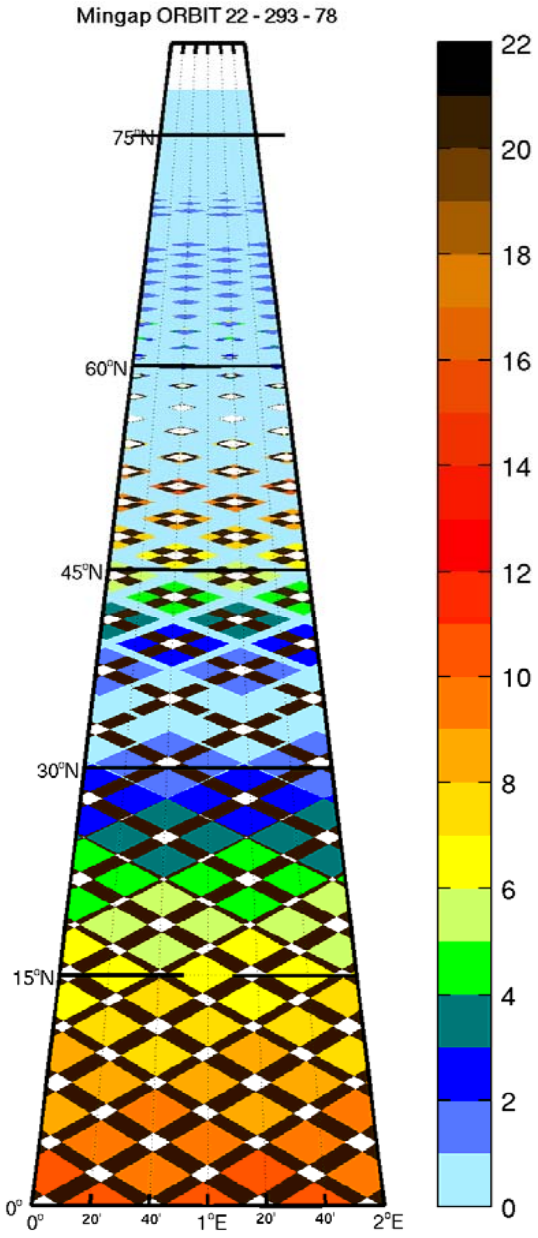
Following the dispersion relation:

$$\omega^2 = c^2 k_h^2 + f^2$$

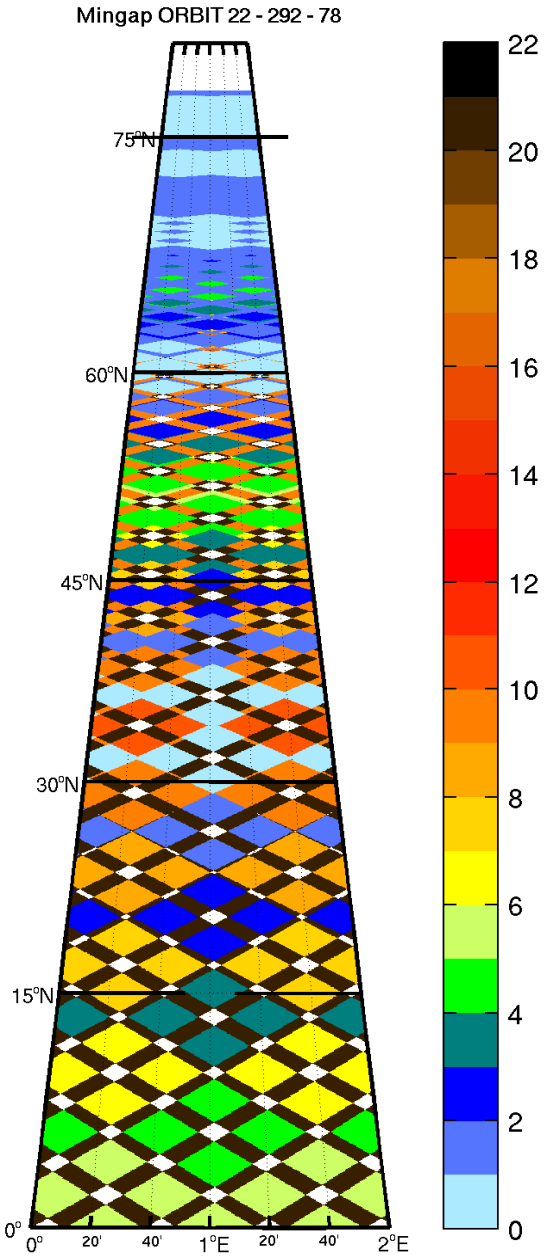


Simulated SWOT Ocean Observations





1-day subcycle



10-day subcycle