Altimetry errors in sea surface height at wavelengths less than 100 km

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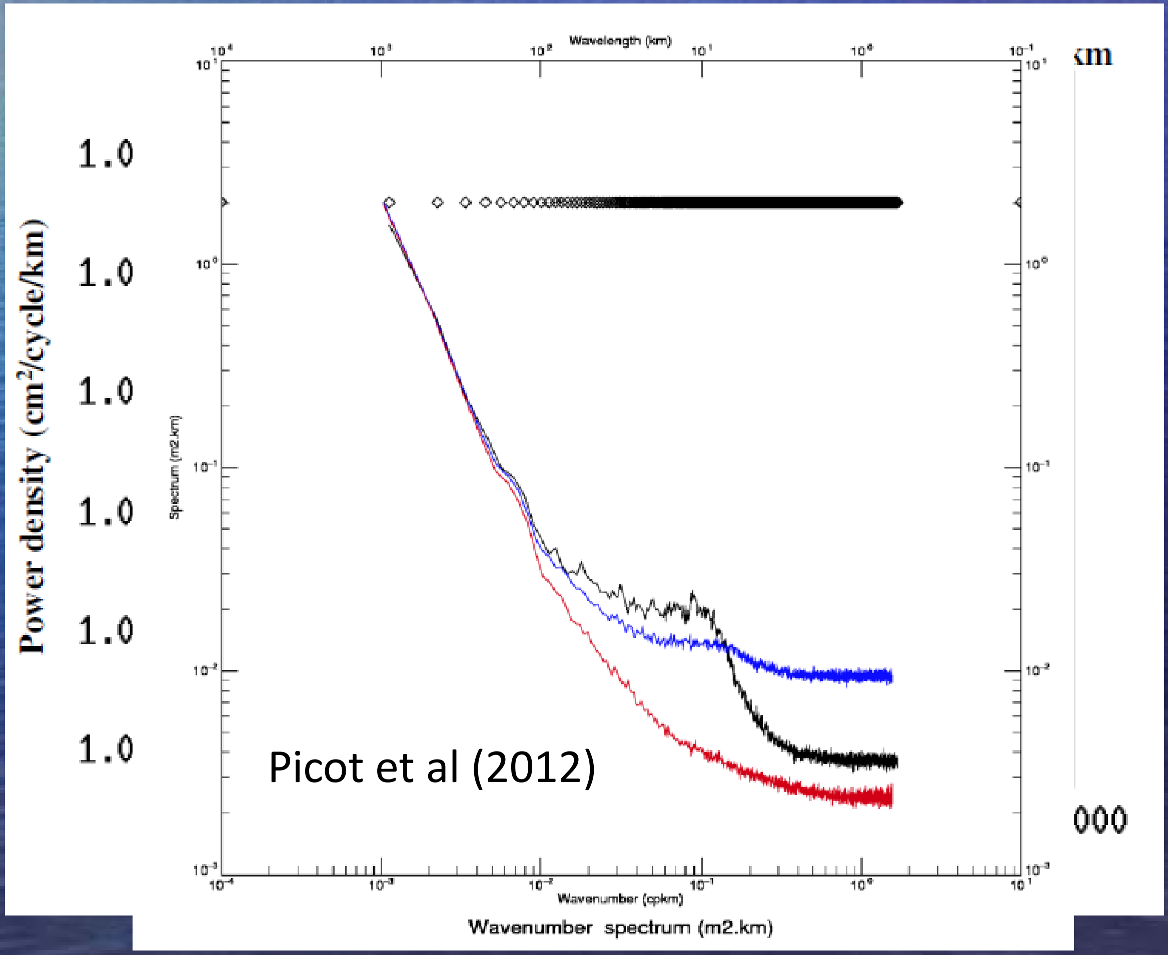
Outline

- Altimeter error spectrum
- Estimation of the instrument noise
- The effects of noise on the spectrum at long wavelengths
- Comparison to coastal high-frequency radar measurements
- Comparison to ADCP measurements
- SWOT and its advantages and challenges

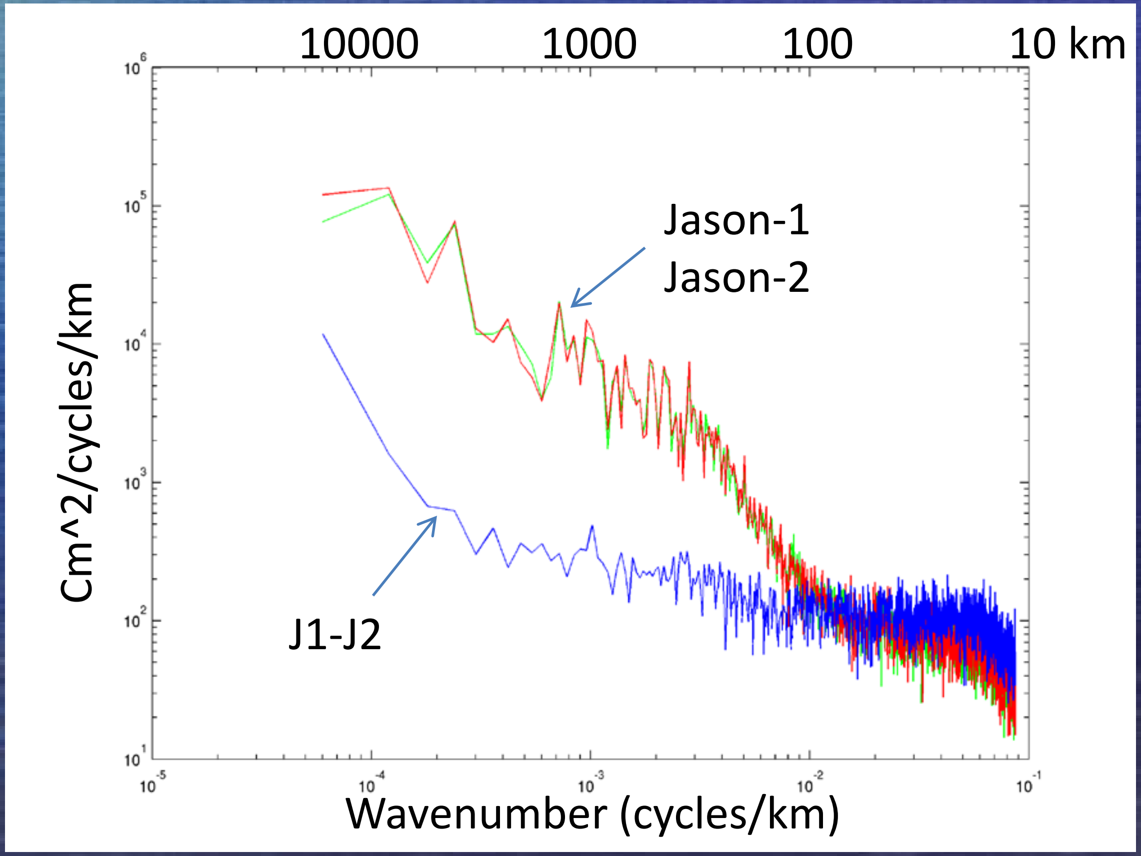
Altimeter instrument noise

- A typical altimetric SSH wavenumber spectrum exhibits quasi-white noise characteristics.
- The rapid drop at high wavenumber end reflects the effects of gridding as well as radar footprint-related errors.
- A slight slope at wavelengths less than 100 km is mixed with the noise.



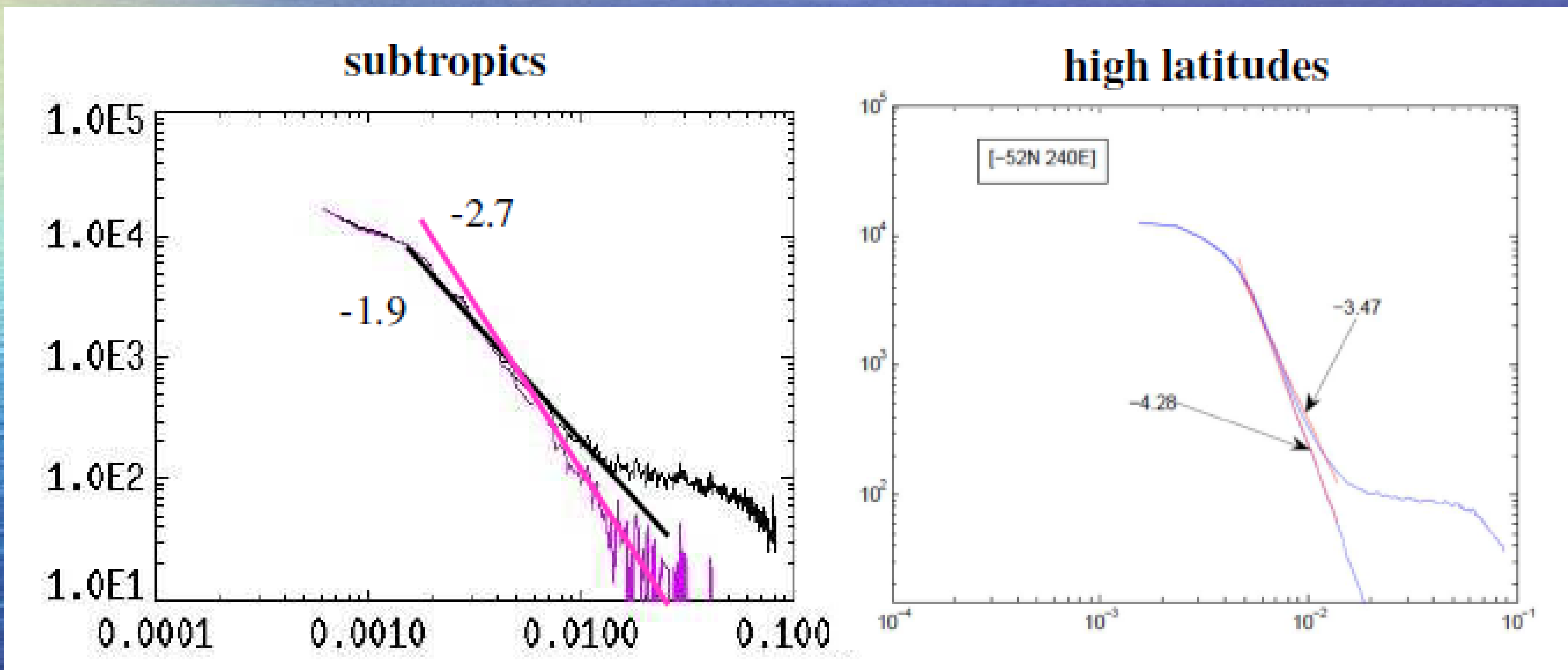
Scales of altimeter measurement errors

- The spectrum of the difference between Jason1 and Jason2 during the cross-calibration phase reveals the scales of measurement errors.
- The difference spectrum shows a more clear noise floor.
- The rise of the spectrum at longer wavelengths reflects systematic errors of various sources (SSB, orbit, wet-tropo, etc.)
- If these errors are uncorrelated , the difference spectrum/2 can be viewed as the lower bound of altimeter measurement error (common errors canceled).



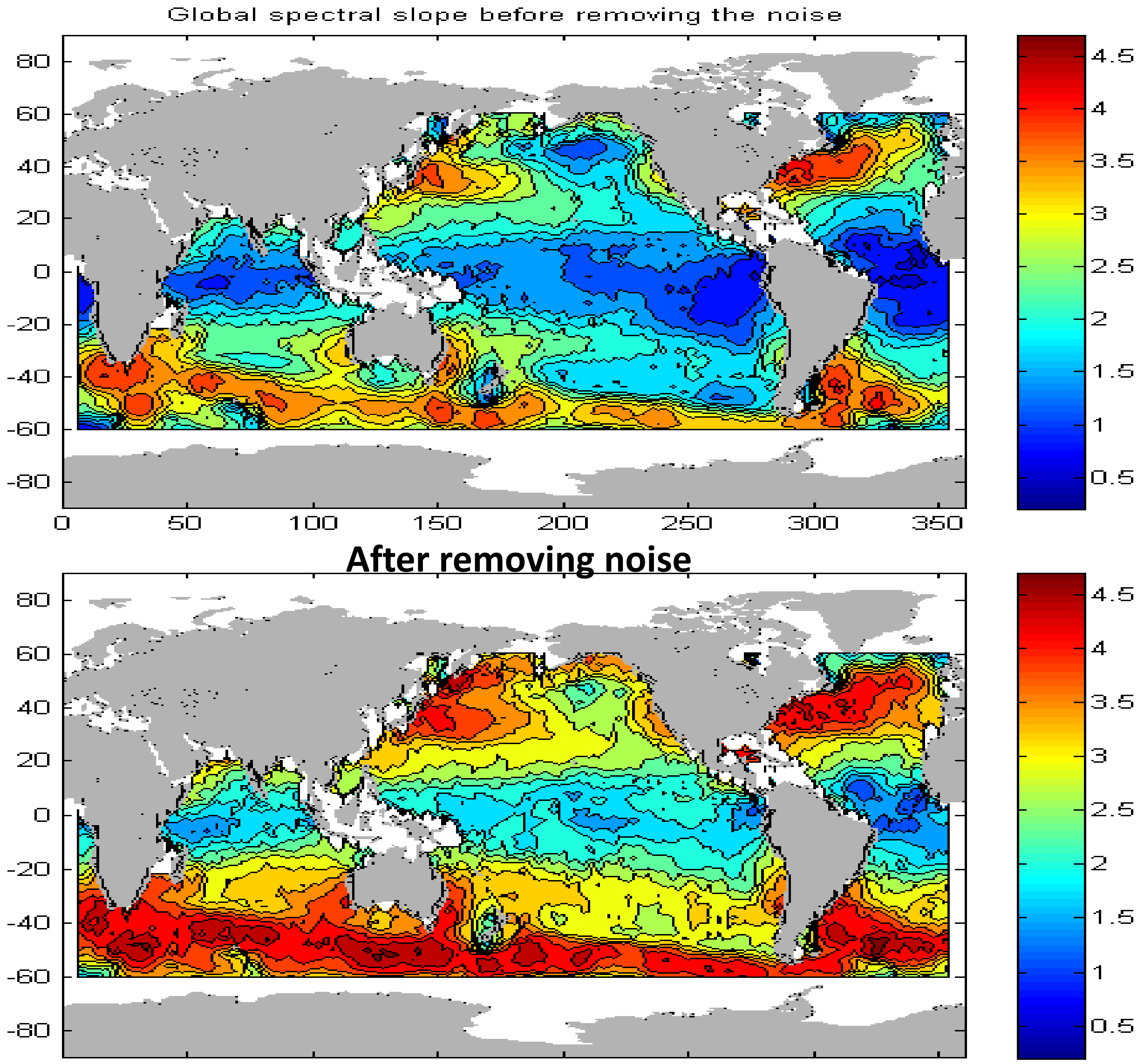
The effects of noise on the spectrum at long wavelengths

Removing noise level estimated from 25-35 km wavelengths has significant effects on spectral slope estimates



Xu and Fu (2012)

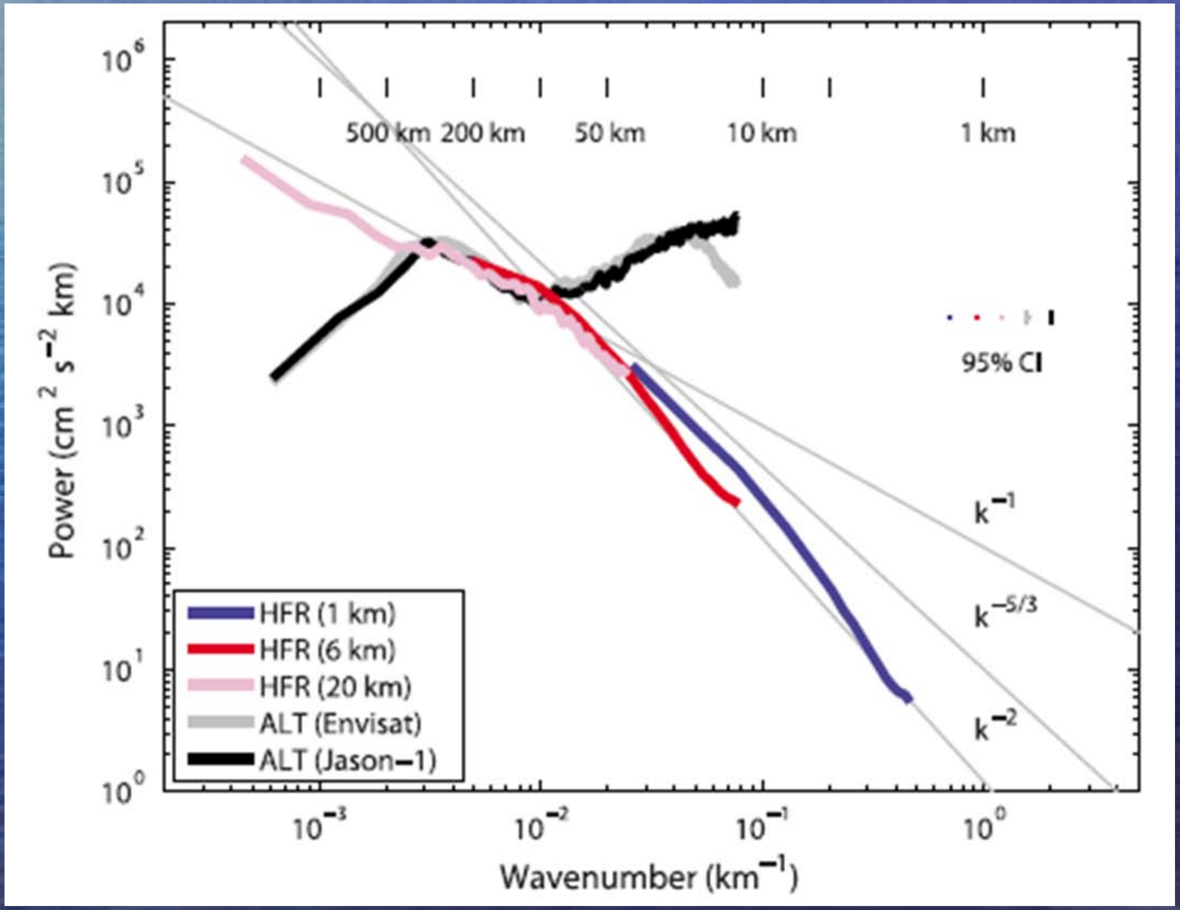
Comparison of spectral slope estimates before and after removing measurement noise



Xu and Fu (2012)

Observations by coastal high-frequency radar (HFR)

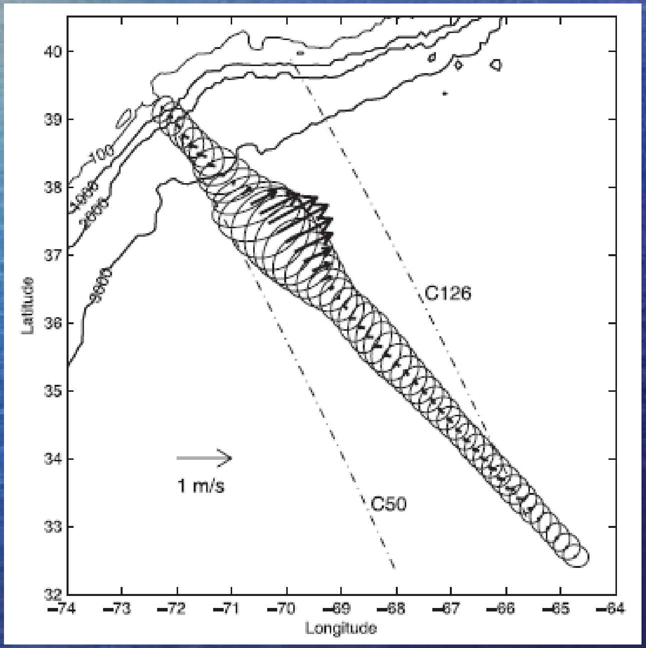
- At short wavelengths the HFR observations show a steeper spectrum than from altimetry
- In terms of SSH, HFR shows a slope of -4 vs -2 ~ -3 from altimetry in the same region (California Coast)

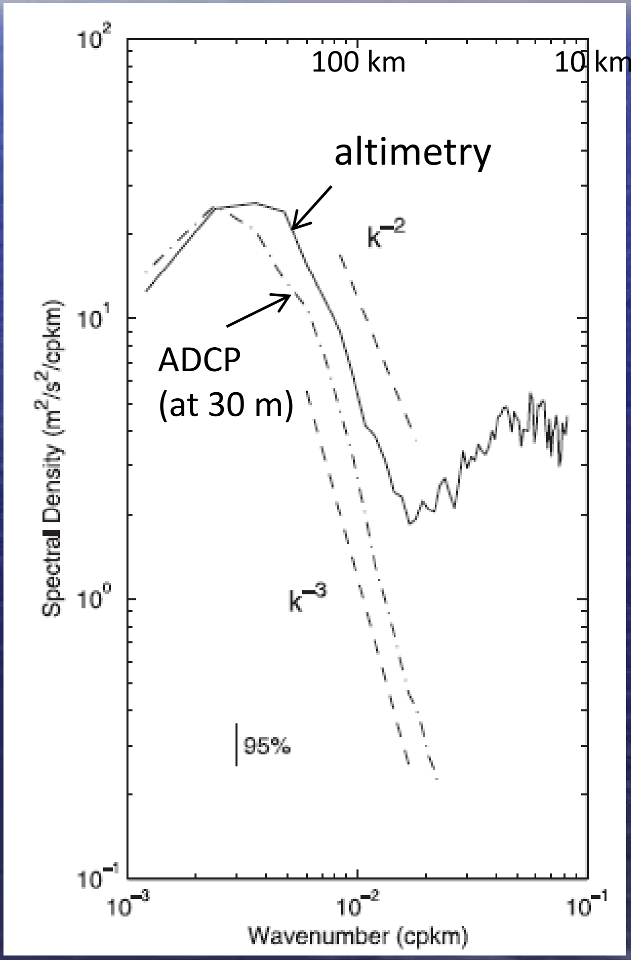


Kim et al 2010

ADCP observations

- ADCP observations in the Gulf Stream reveal a steeper kinetic energy spectrum with lower variance than from altimetry
- Are the altimeter observations valid at these scales?

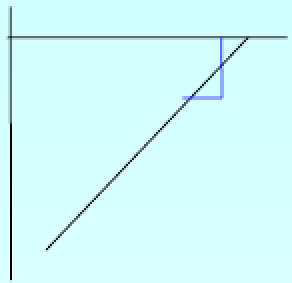




Wang et al, 2010

Mixing argument : **Departure of ML dynamics from SQG is explained by the vertical mixing : mixing has to be included in the momentum eqs.**

Ponte et al., 2012 (submitted to JPO)



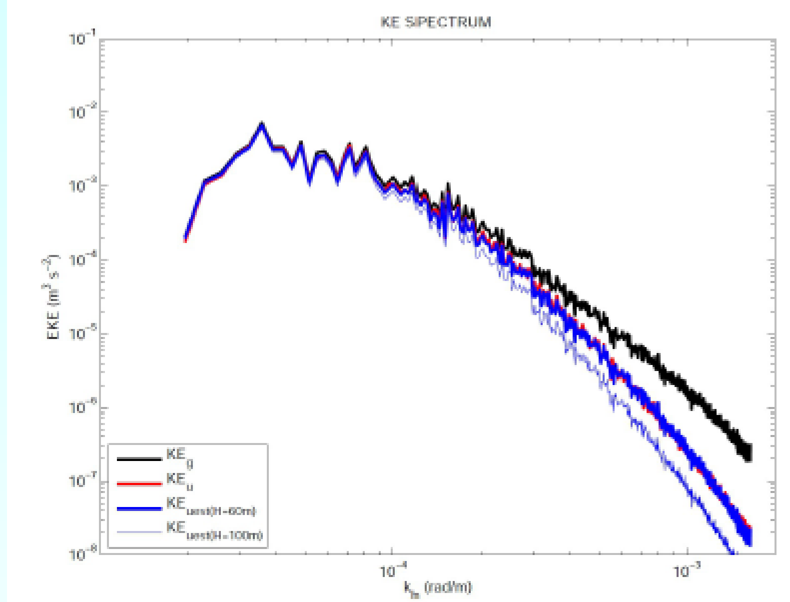
Klein et al (2012)

$$\widehat{u_e}(k_x, k_y) = \widehat{u_g}(k_x, k_y, 0)\frac{f}{kNH}[1 - exp(\frac{-kNH}{f})]$$

Black curve: spectrum from SSH(Ug,Vg)

Red curve: spectrum from observed surface currents

Thick blue curve: spectrum from estimated surface currents assuming that Ug and Vg are well mixed over a ML of depth H **(60m)**

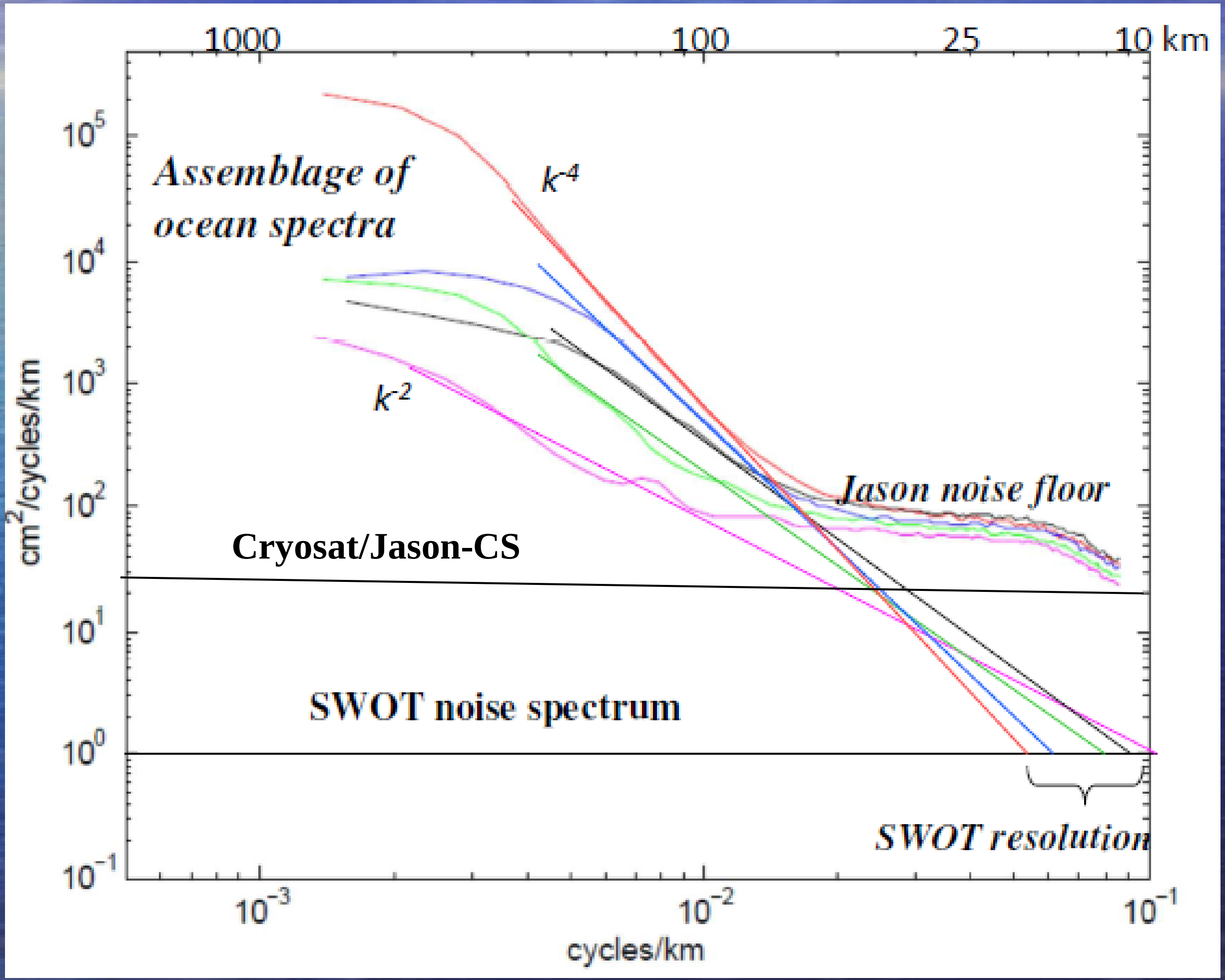


=> This analytical solution only requires the knowledge of

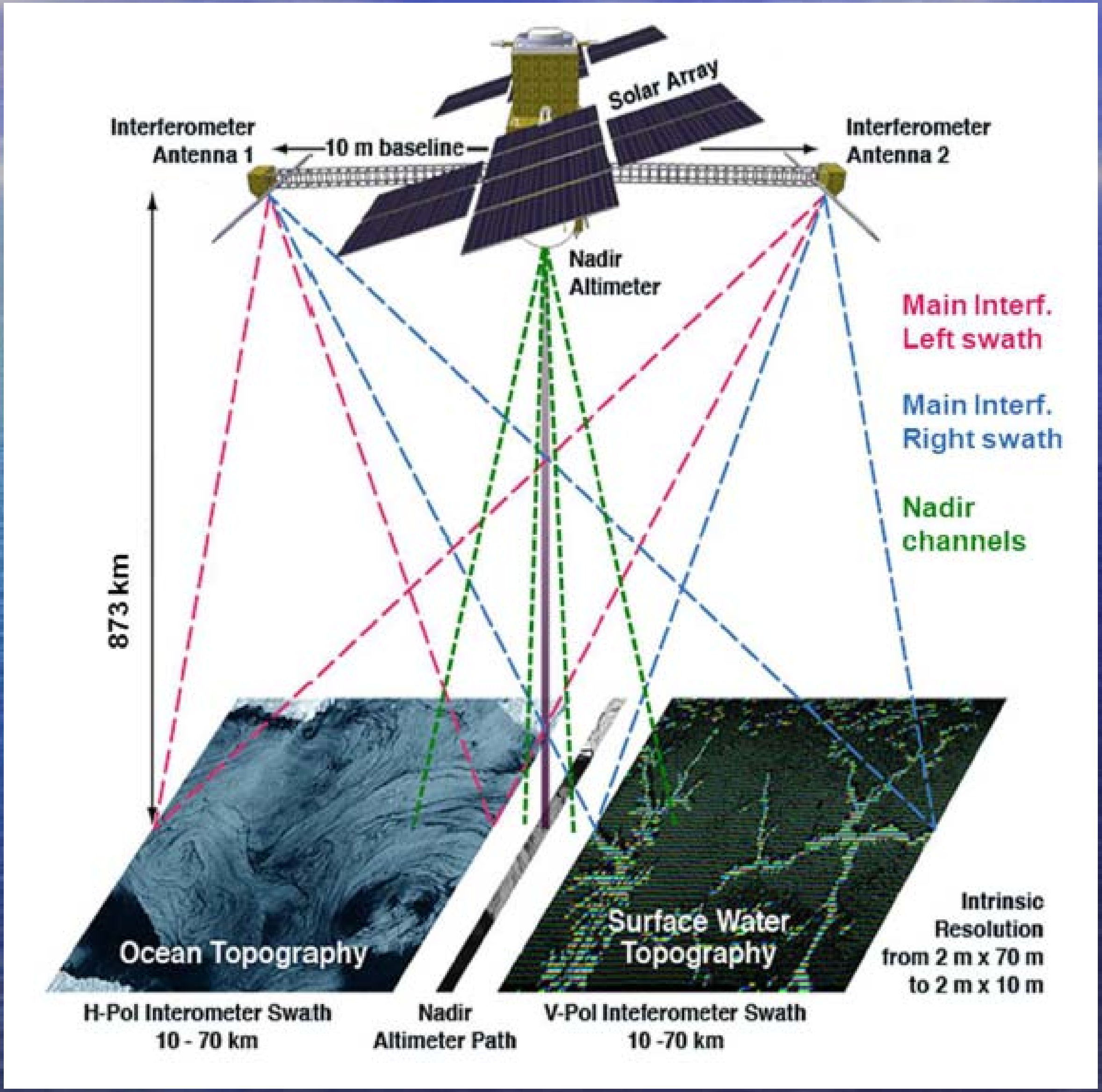
high resolution SSH and climatological ML depth values

High resolution measurement from SWOT

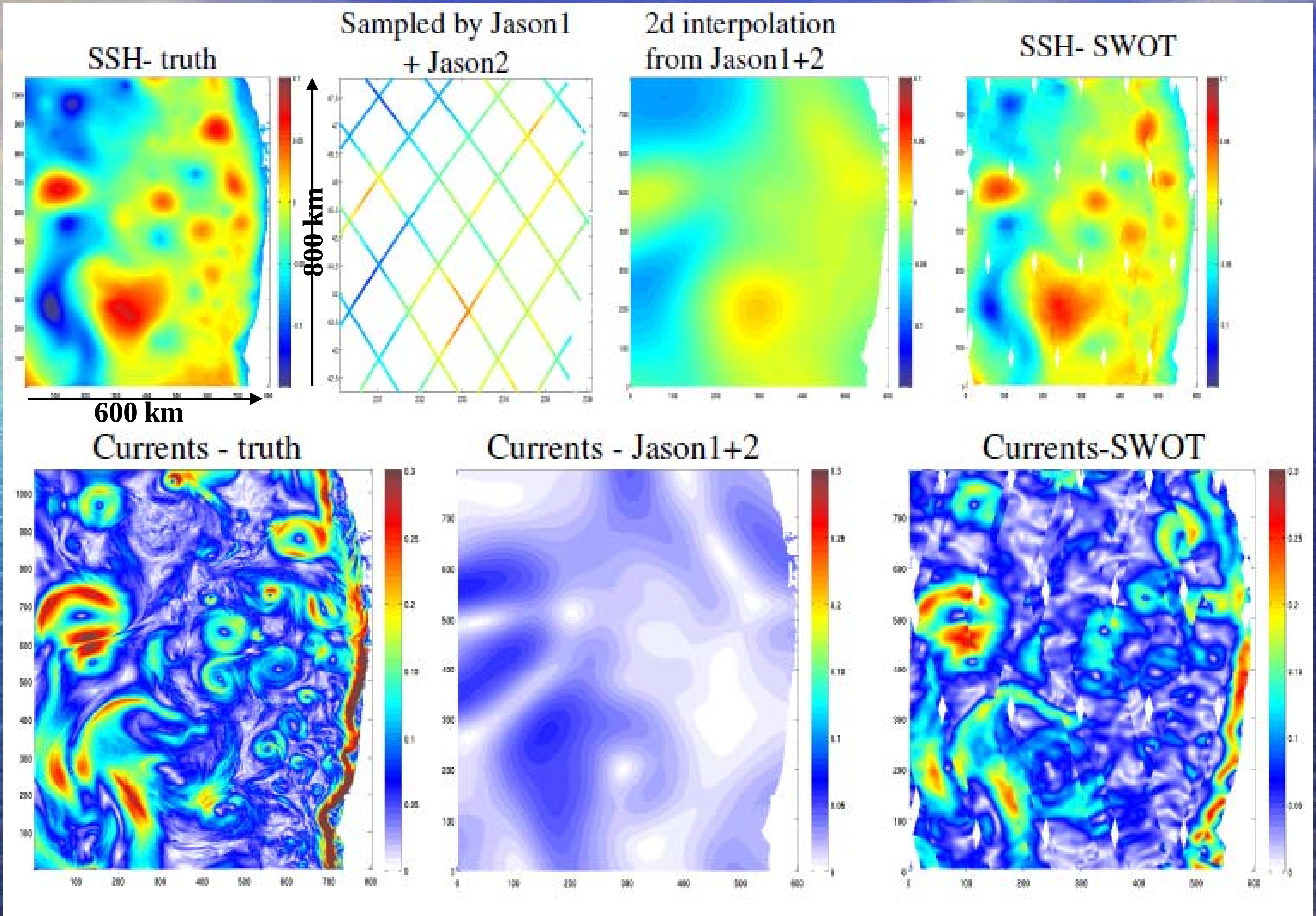
- In order to observe SSH variability at small scales, the noise level needs reduction by 2 orders of magnitude



SWOT measurement configuration

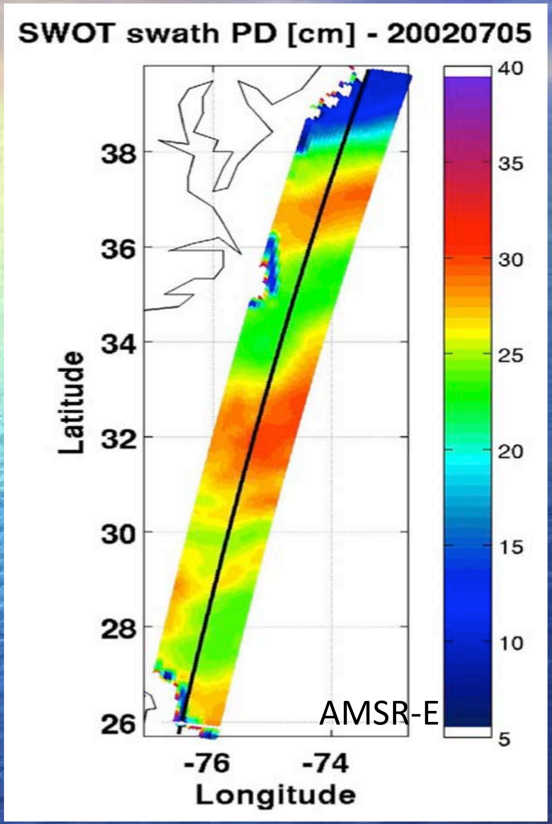


Simulated SWOT Ocean Observations

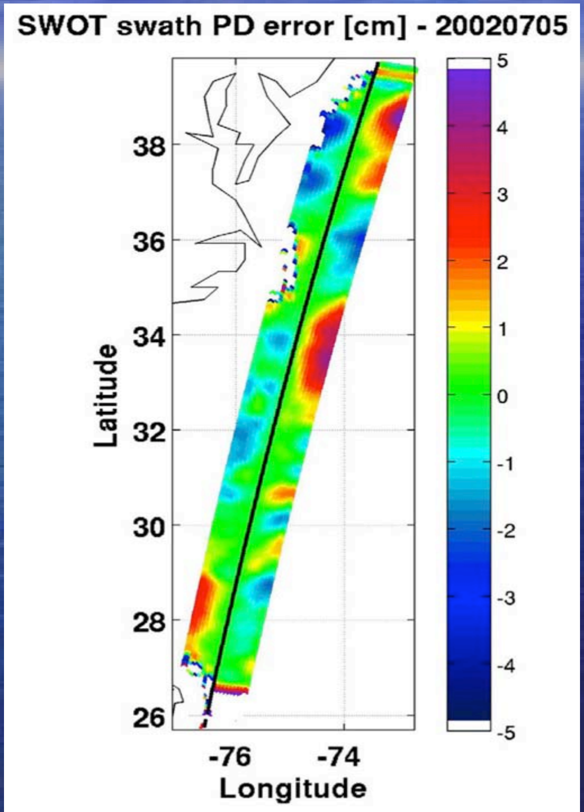


The challenge of wet-tropo correction

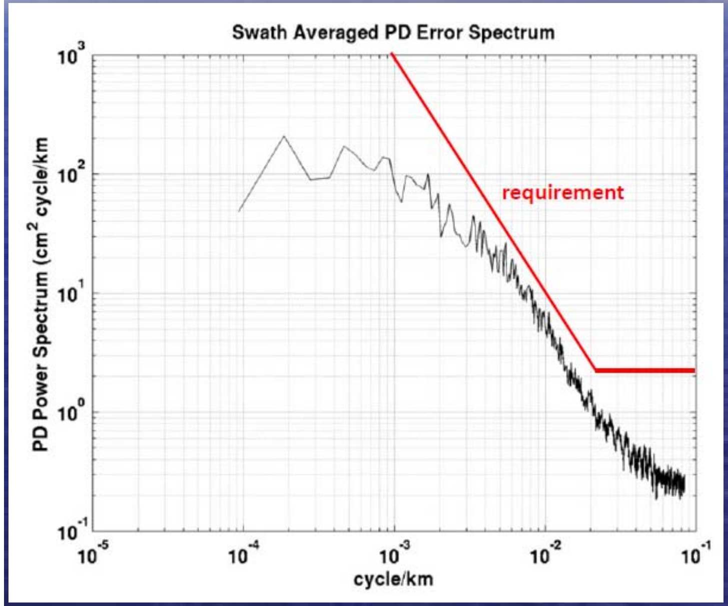
- **Conventional single-beam radiometer leaves residual errors pressing against measurement requirement**



Path deay error



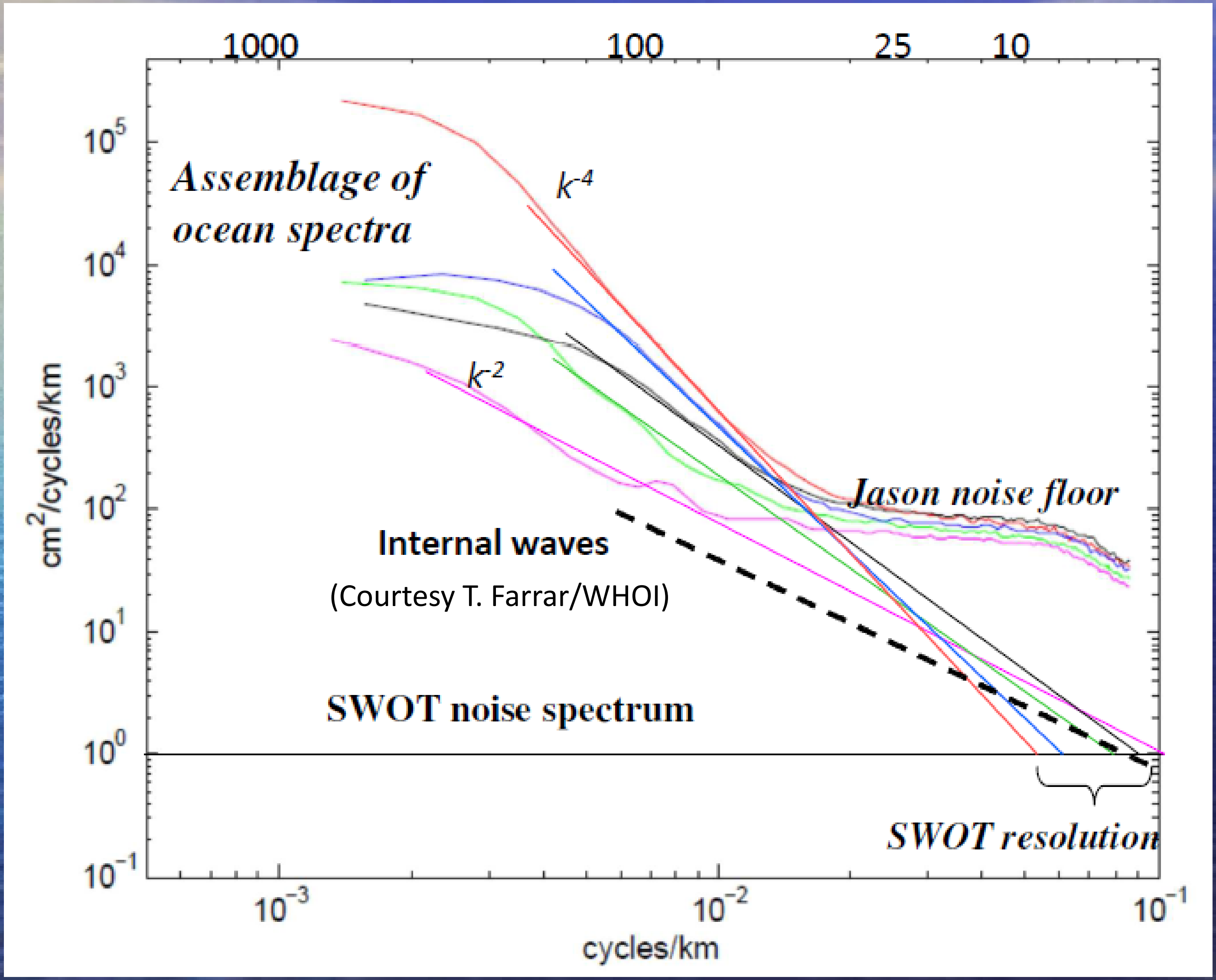
Residual error



Residual error spectrum

S. Brown (2012)

The challenge of oceanic internal waves



Conclusions

- Estimation of instrument noise from cross-calibration difference.
- Proper removal of noise spectrum improves the spectrum at long wavelengths.
- Discrepancies between altimeter observations and coastal HF radar and ADCP observations are subjects of investigation.
- SWOT is expected to reduce measurement noise by 2 orders of magnitude, revealing signal spectrum to 10-20 km.
- SWOT will significantly advance high-resolution 2-D observations
- Cross-track variability of water vapor is a concern, requiring a multi-beam radiometer
- Effects of internal waves pose a significant challenge for interpreting SSH observations at wavelengths less than 30-50 km.