(sub)Mesoscale Detection Capability with along-track altimeter data

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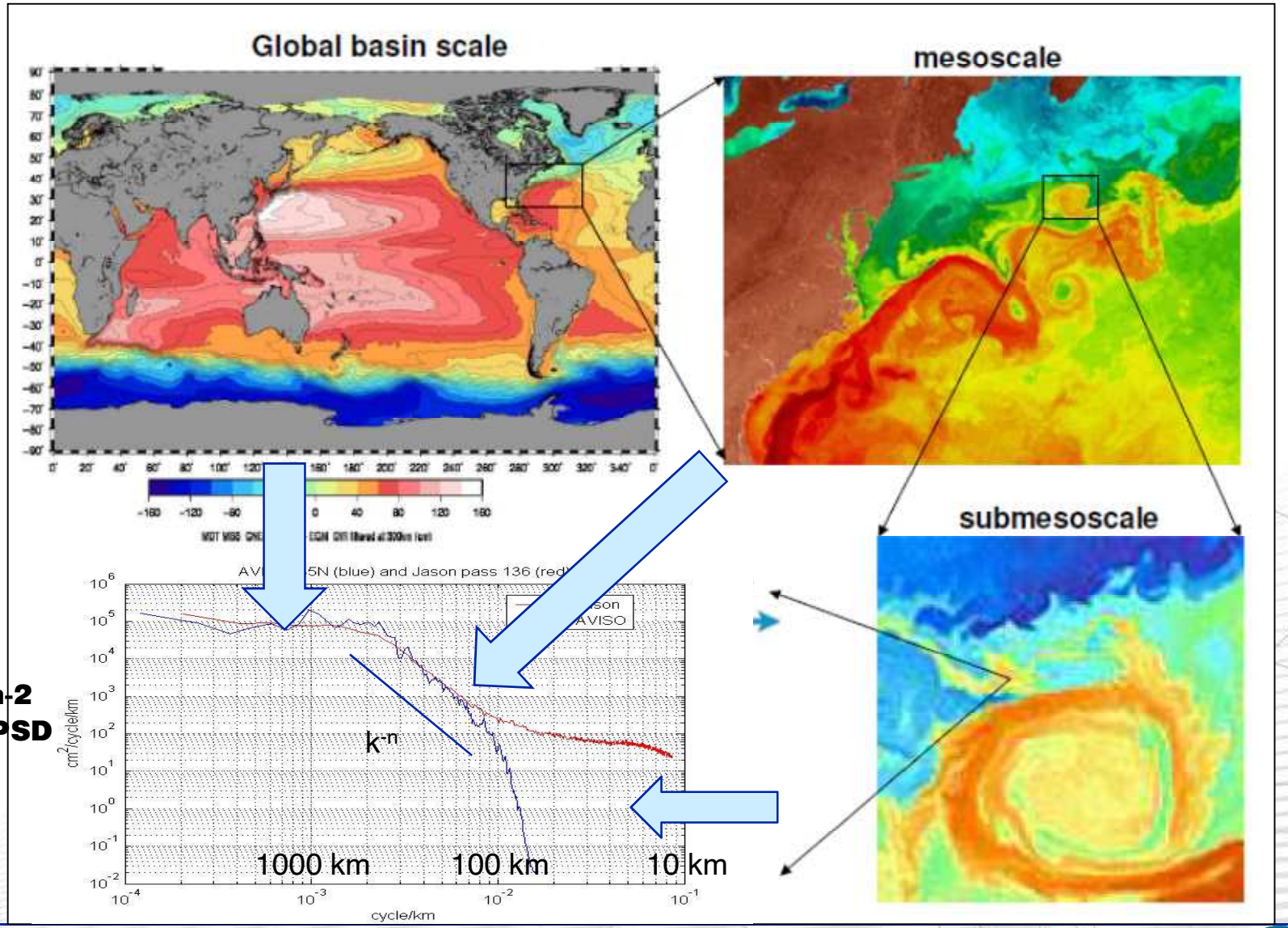
Motivation : Energy cascade & SSH Spectra



What are the current capabilities of alongtrack altimeter missions for detecting mesoscale structures?

=> Global survey of wavenumber spectra for JASON-2, CRYOSAT-2 LRM & PRLM, SARAL/ALTIKA

Geographical distribution in 10°x10° areas from March to October 2013

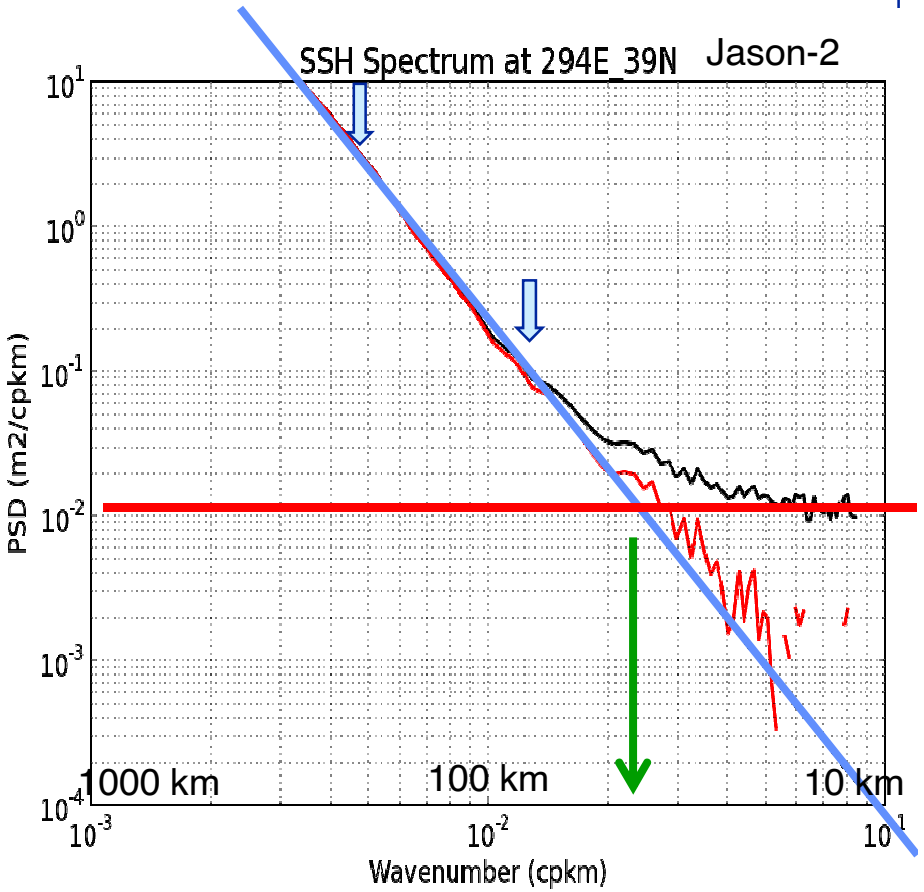
Seasonal variations in errors for Jason-2

Mesoscale Capability Determination

- 1hz **altimeter error** at scales ~10km limiting access to oceanic HR processes

- Energy cascade in turbulence theory = **Spectral slope** in SSH wavenumber spectra (90-270 km wavelength)

(following Xu and Fu 2012: noise removal before slope estimation)

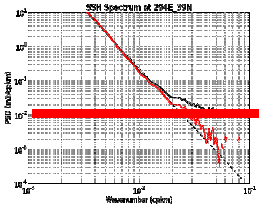


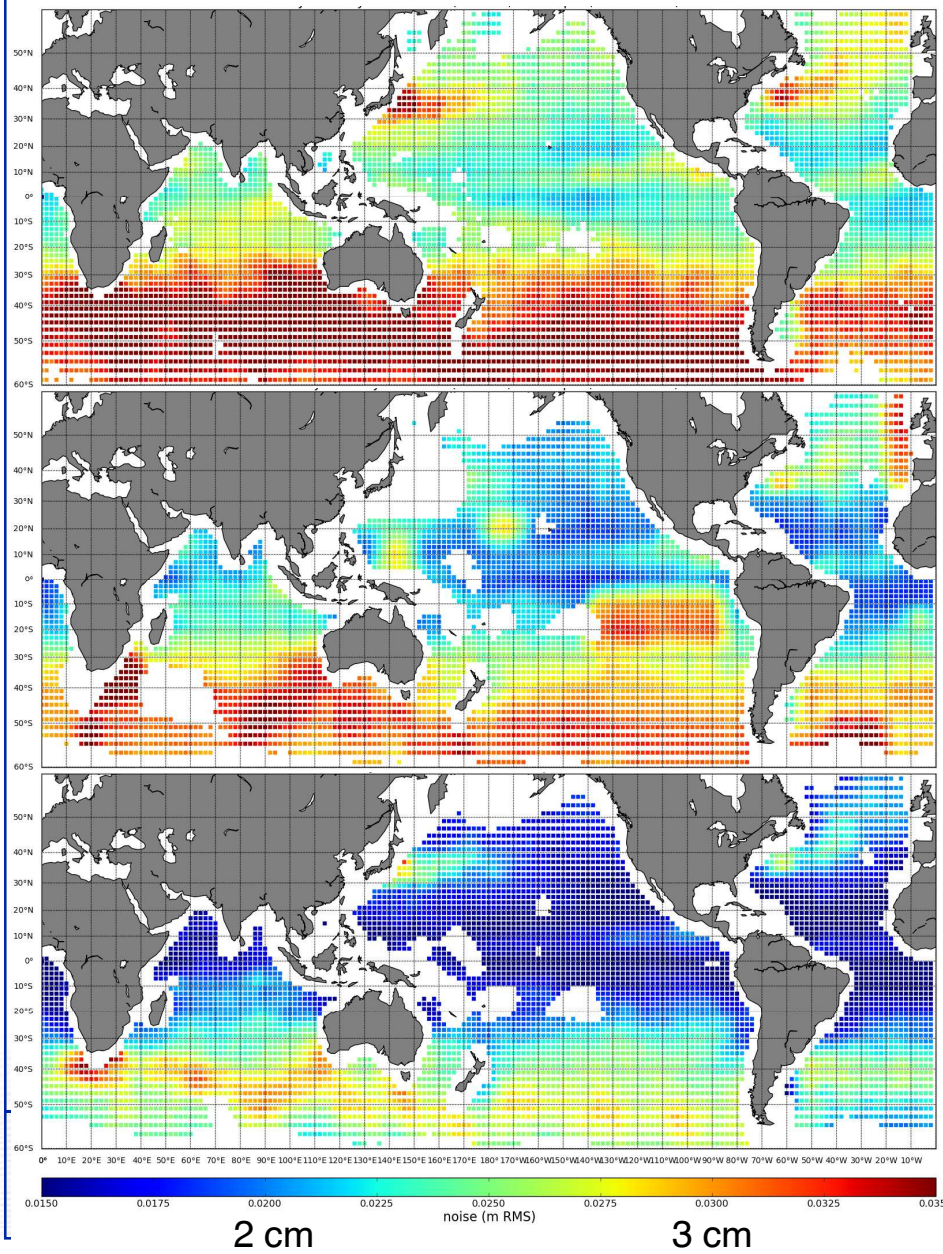
Smallest wavelength scale accessible

signal/noise ratio = 1

Mesocale capability

1hz Error Level in LRM missions





Jason-2

Cryosat-2 LRM & PLRM

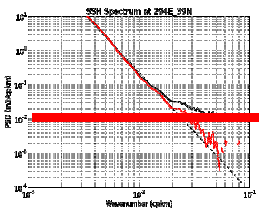
SARAL/Altika

Boxes with too few samples are not plotted.

Mar-Oct : S Hem. Winter

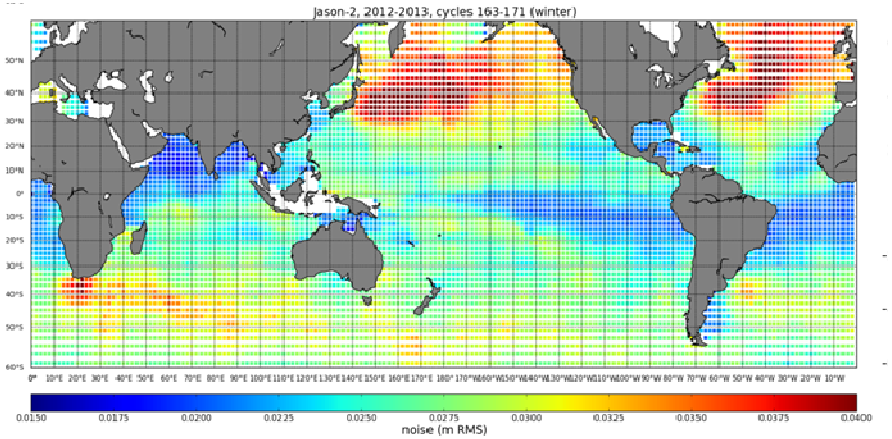
- Error level in Jason-2 is important in the southern hemisphere in austral winter due to a higher SWH level.
- Cryosat-2 PLRM areas have a greater error than LRM mode.
- Altika has a lower noise level.

1hz Error Level in LRM missions



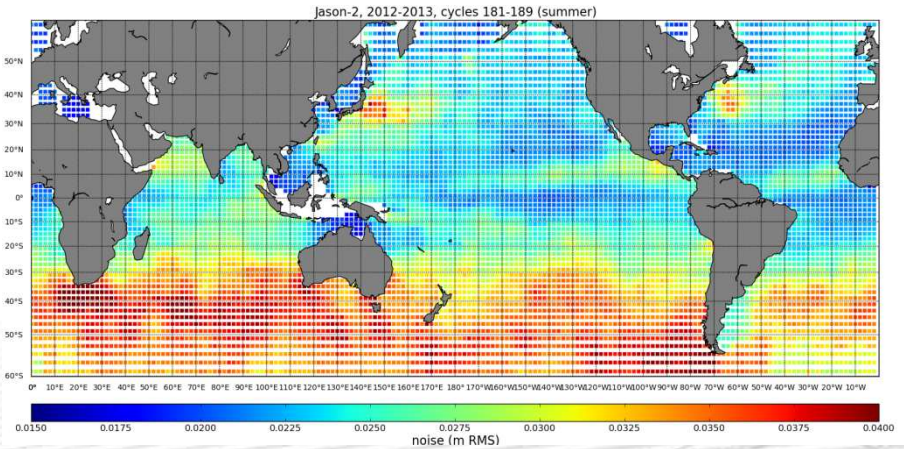
Jason-2 1hz error level for each Season

DJF



Winter in the northern hemisphere

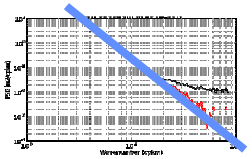
JJA

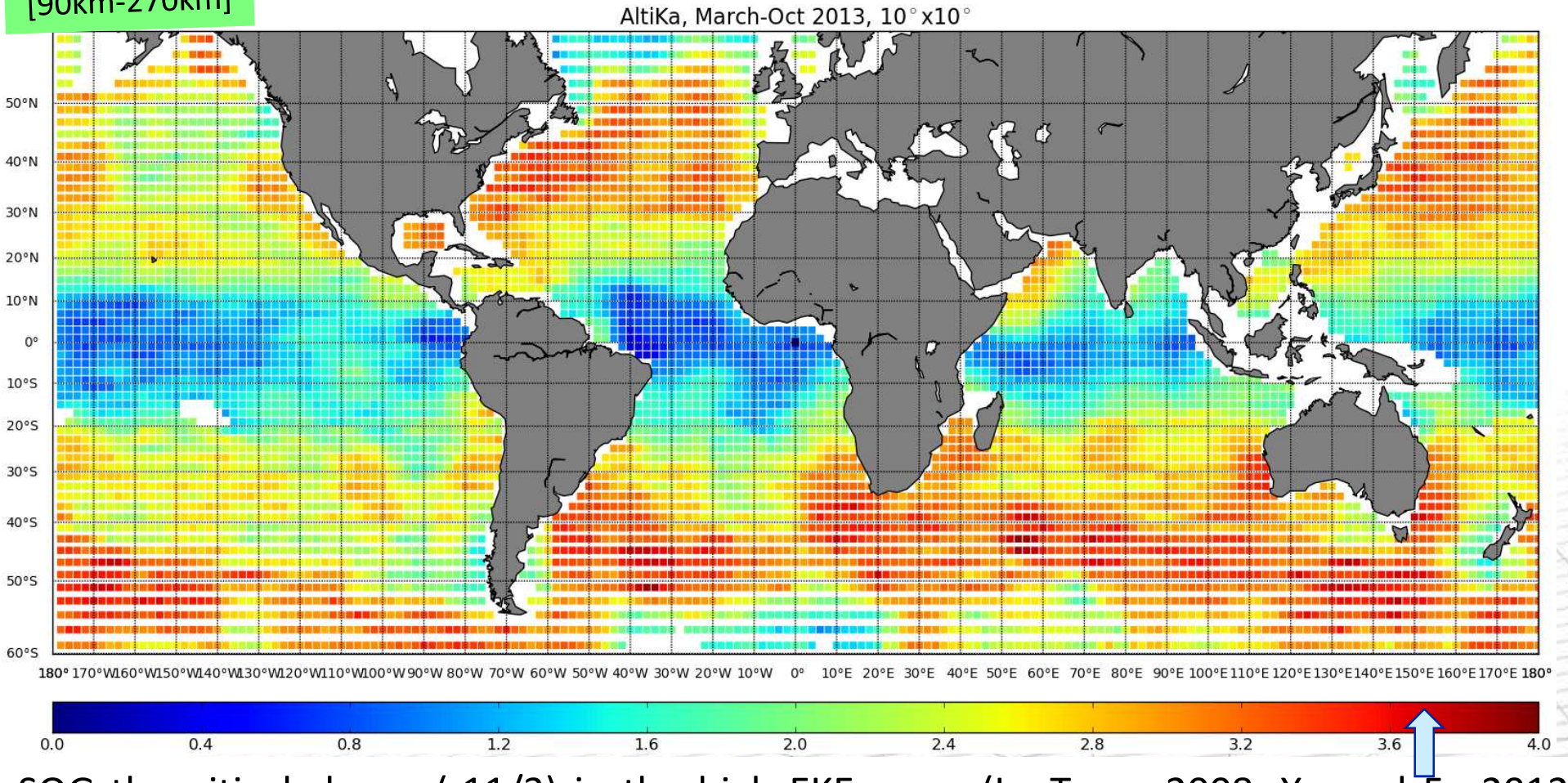


Winter in the southern hemisphere

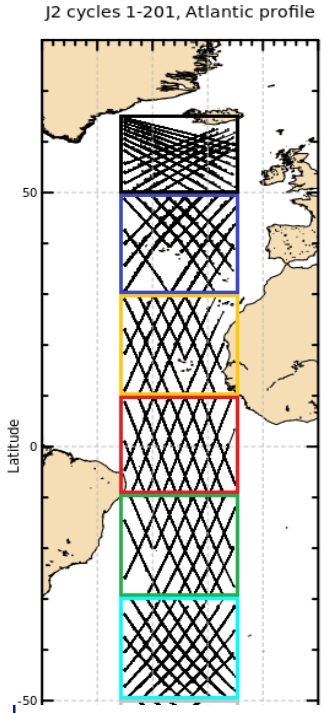
Altimeter Spectral Slopes

Spectral slopes [90km-270km]

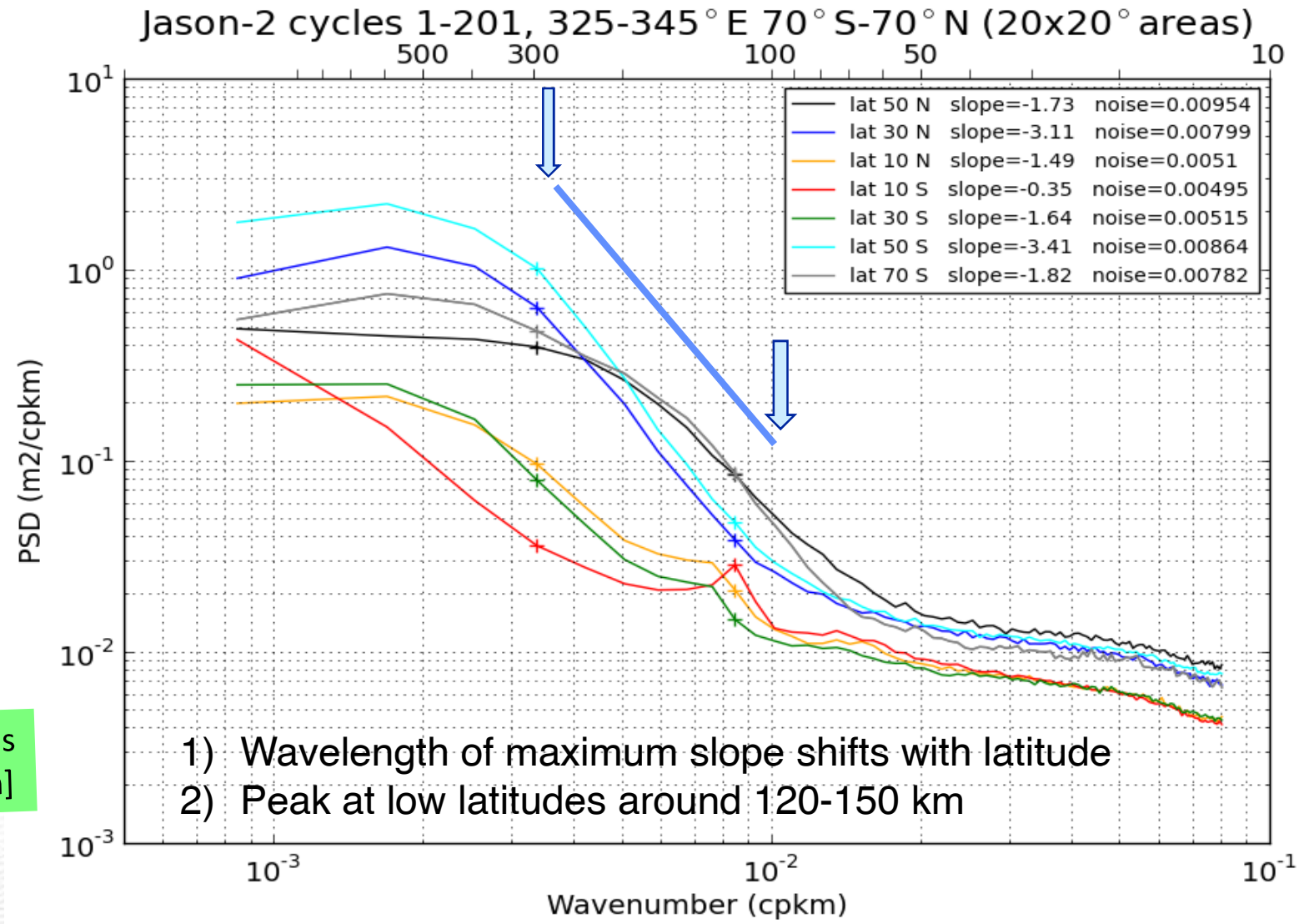




SQG theoritical slopes (-11/3) in the high EKE areas (Le Traon 2008, Xu and Fu 2012).
Low-slopes areas may be influenced by internal waves & tides

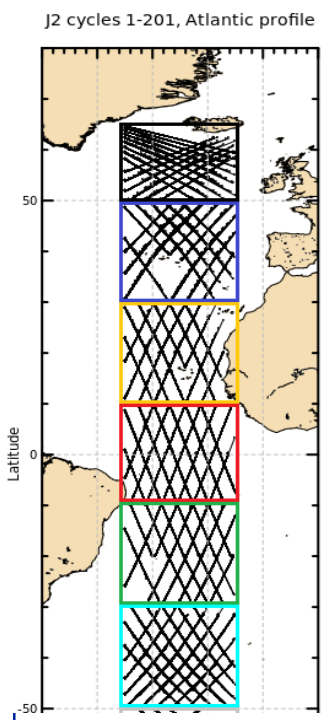


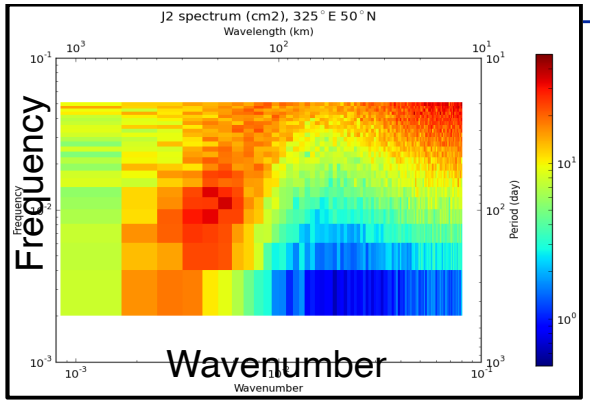
1D spectral analysis in Atlantic (20°x20° areas)

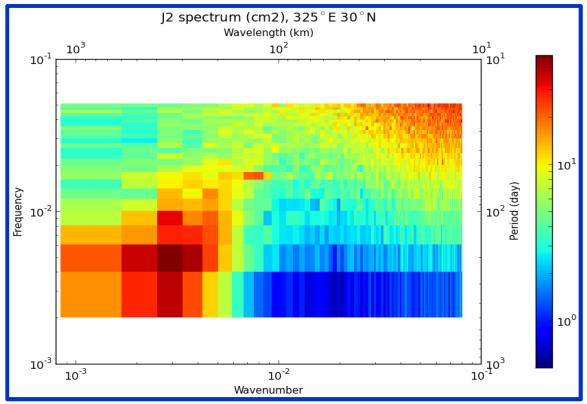


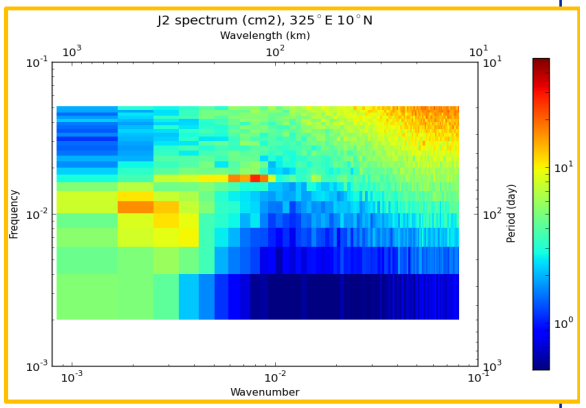
Spectral slopes [90km-270km]

1) Wavelength of maximum slope shifts with latitude
2) Peak at low latitudes around 120-150 km





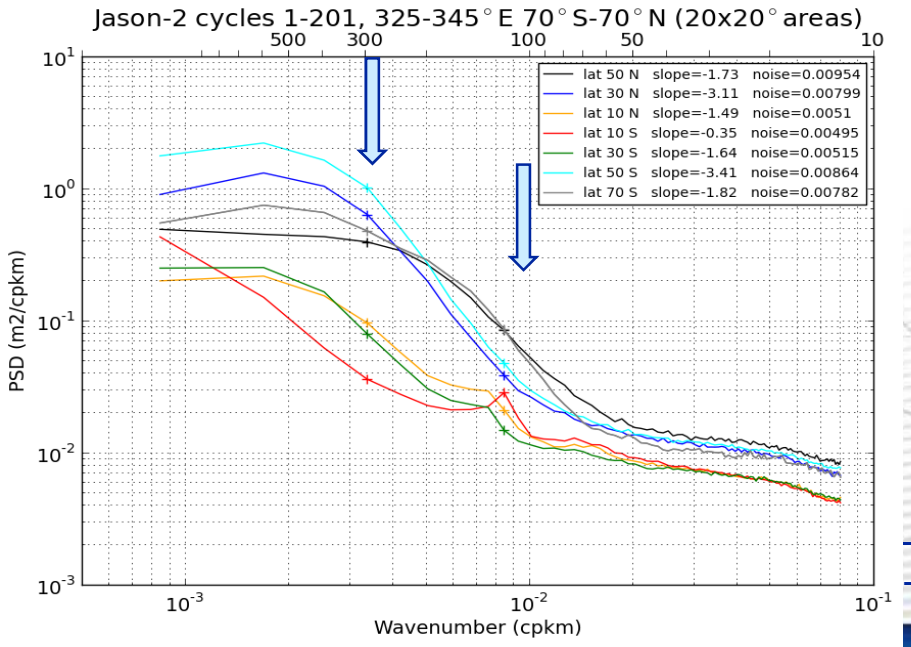


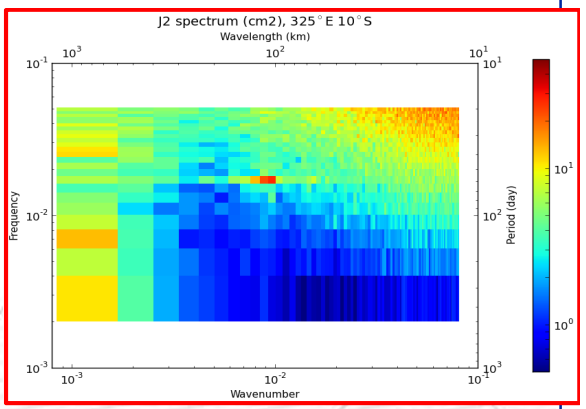


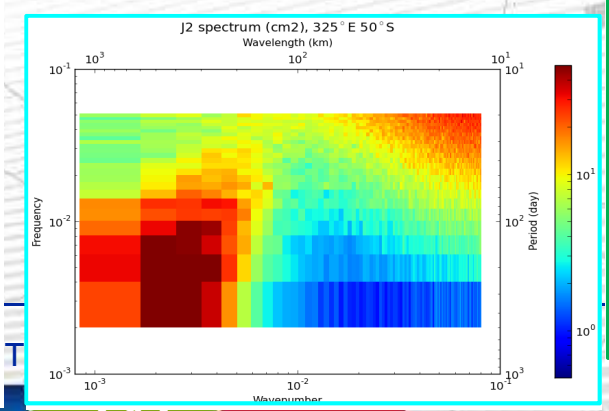
1D & 2D spectral analysis in Atlantic (20°x20° areas)

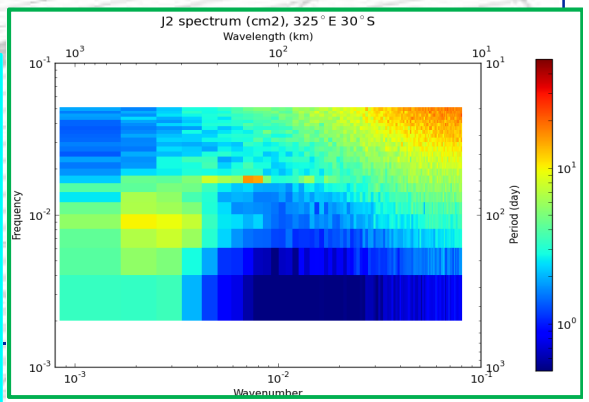
➔ Latitude dependence of PSD-peak at the 62 d period

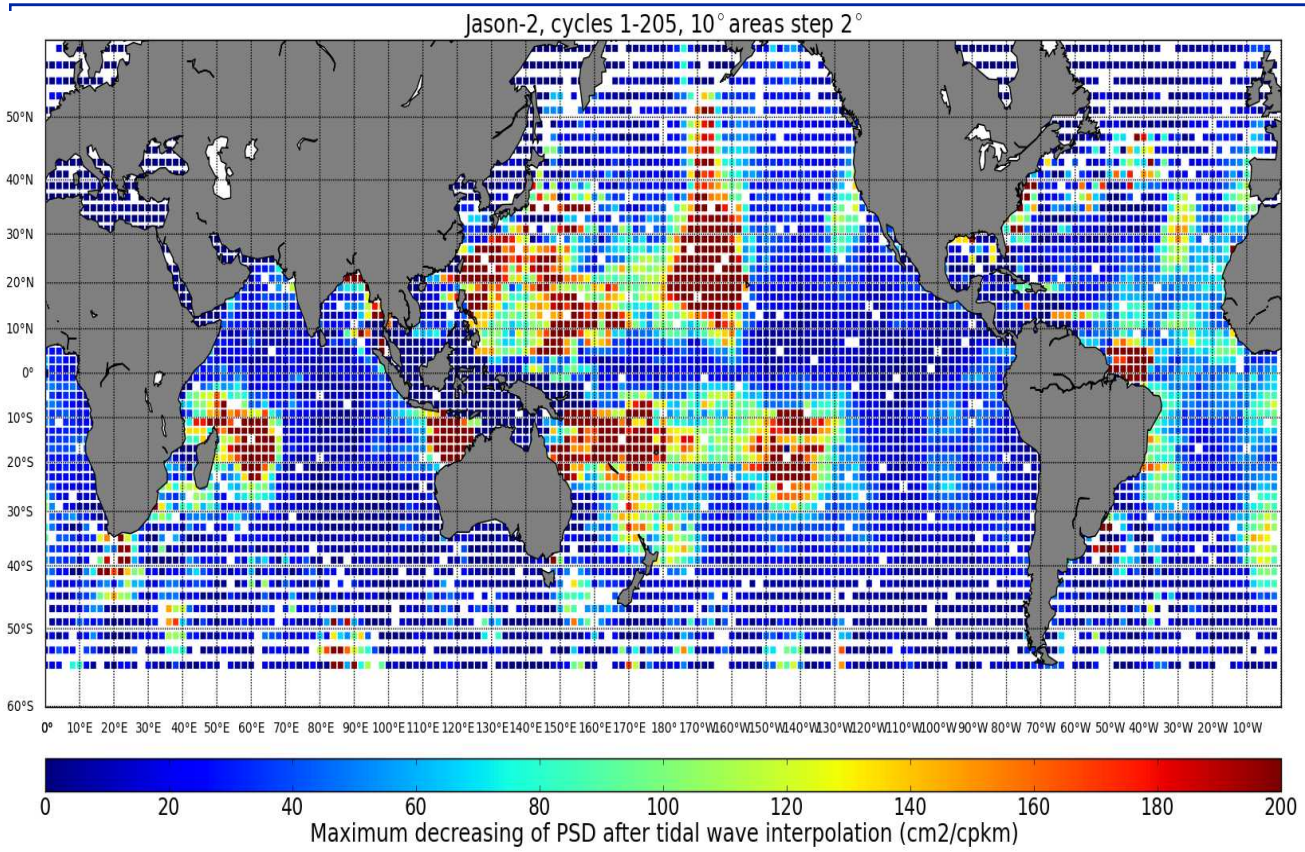
➔Internal tides





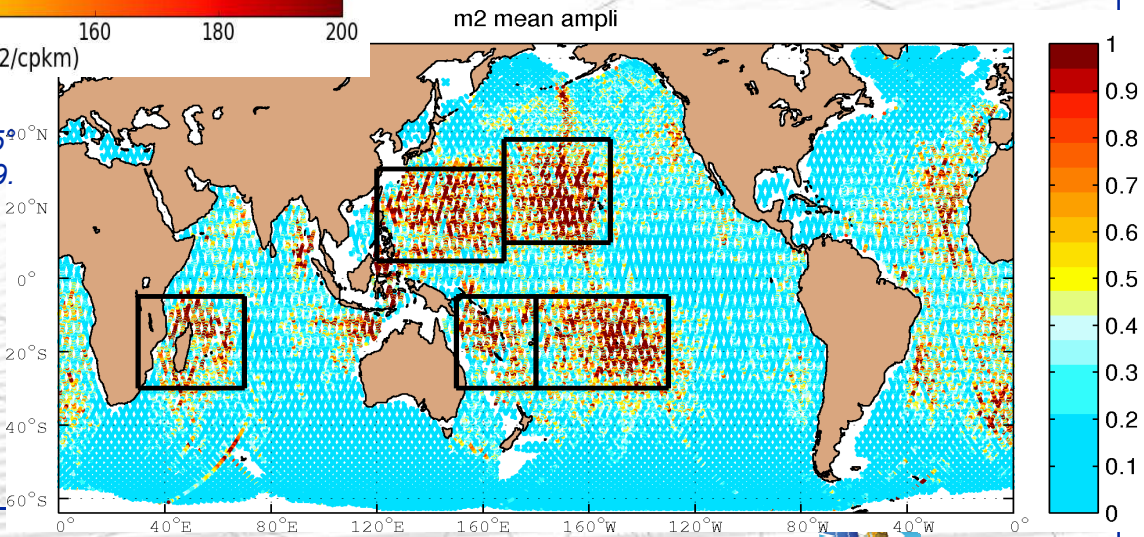






Decrease in SSH PSD after removing internal tidal energy in 2D spectra.

→ 62-day signal is changed by the mean of previous (55d) and next (71d) values on internal tide wavelengths

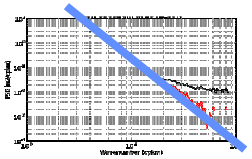


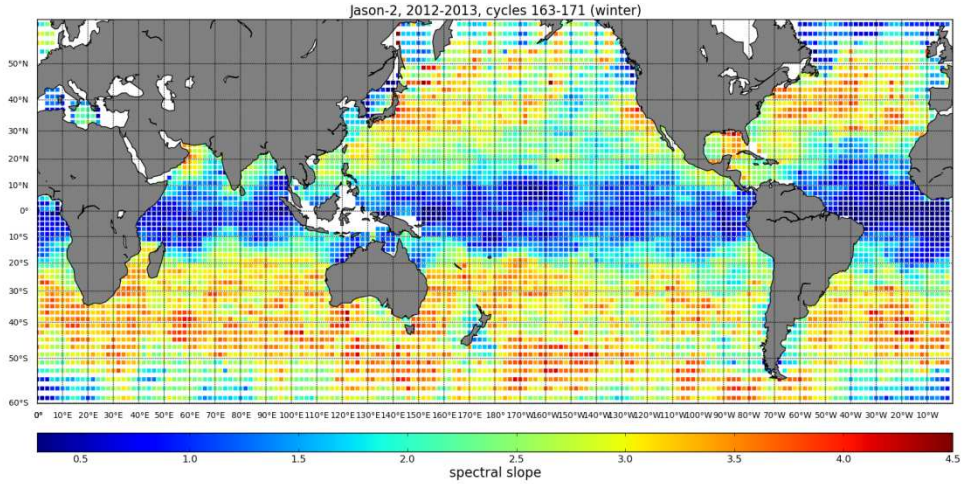
Mean of the M2 internal tide amplitude (cm) from global HYCOM (1/12.5° HYbrid Coordinate Ocean Model). Simulation data from 2005-2009. [**Shriver, Richman, Arbic, 2014**]

Posters in tide session :

#23 : Carrere et al… Estimates of internal tides from altimetry
#25 Orstynowicz et al. Internal tide signatures in SSH spectra

Altimeter Spectral Slopes





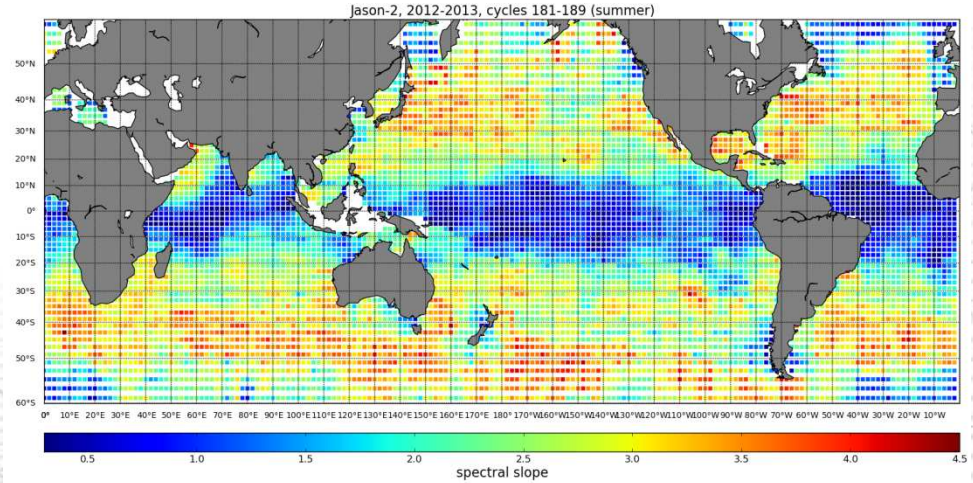
DJF

TIME VARIABILITY

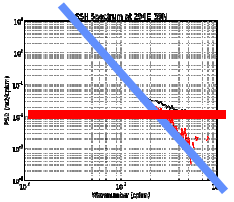
Minor increase in spectral slopes in summer

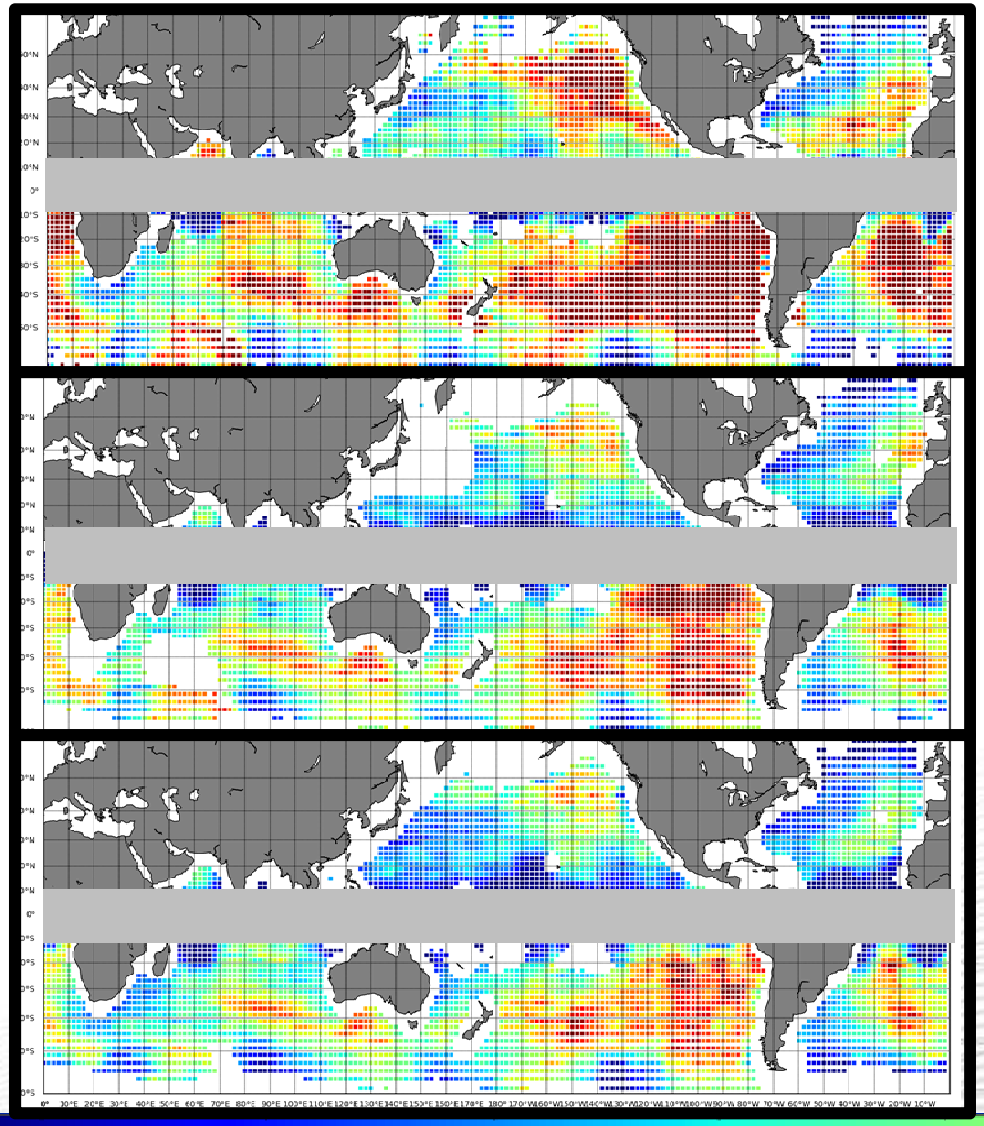
=> More small-scale mixed layer instabilities in winter : kicks up the tail & reduces the slope

JJA



Current mesoscale capability





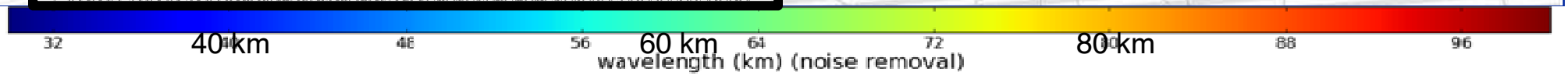
Jason-2

Cryosat-2 LRM & PLRM

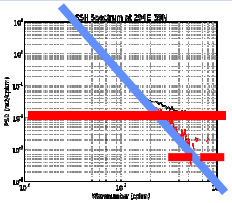
SARAL/Altika

Same spatial distribution for each mission

Smaller error for AltiKa allows smaller wavelength values & a better mesoscale capability.

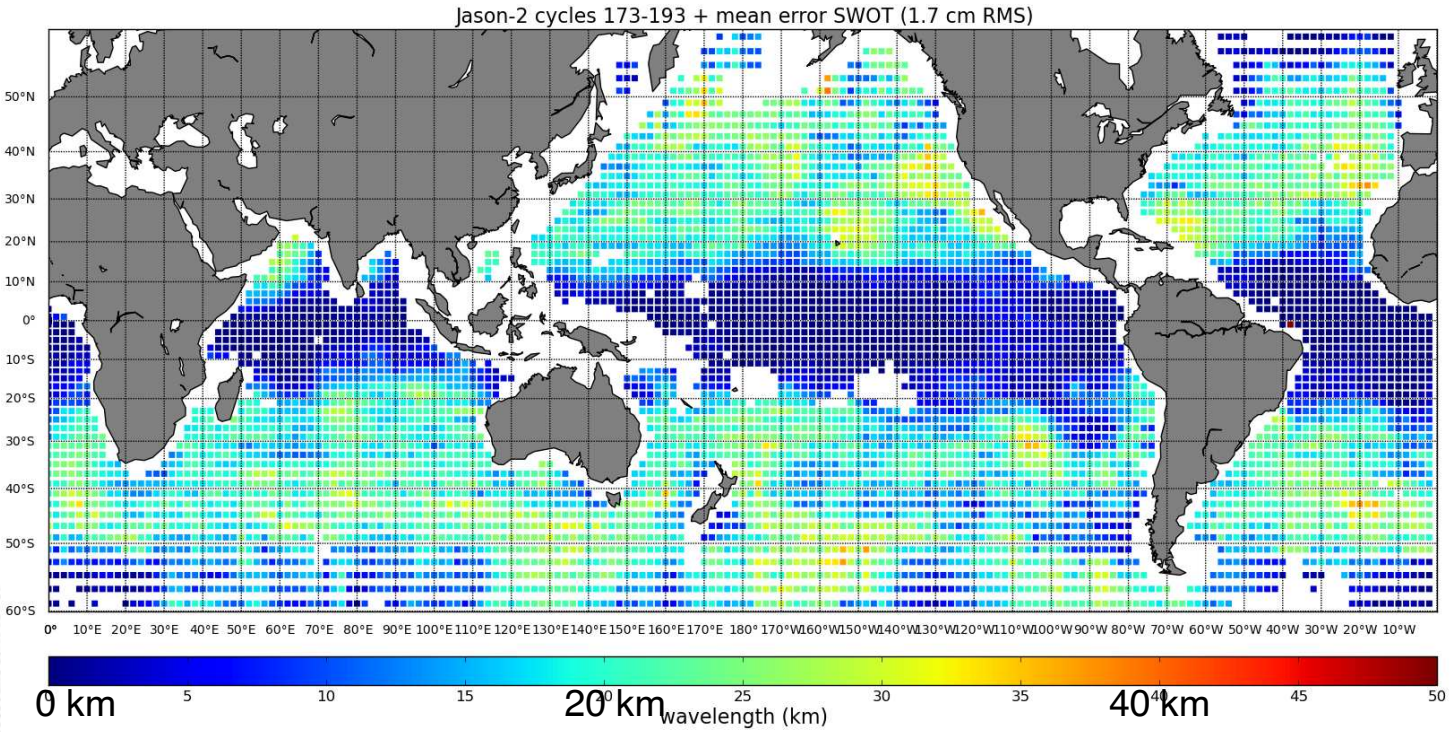


Future mesoscale capability



Simulated noise level in KaRIN : Mean error in swath = 1.7 cm RMS for 1 km²

➔ 5.78 cm²/cpkm in PSD spectrum



Conclusions

❖ **Background error from different missions varies geographically and seasonally** – impacts on signal-noise ratio and mesoscale observability

⇒ Need to better understand the regional contributions to the error budget

❖ **Spectral slopes agree with sQG theory in energetic mid-latitudes**

- Spectral slope values are affected by internal tides signal in areas where their contribution is strong.

▪ Wavelengths for slope calculation varies at different latitudes ... Need a regional modification to the set 90-270 km range

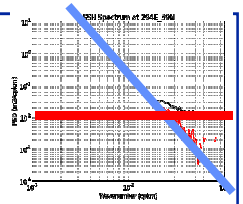
▪ Impacts of other dynamics – eg internal waves

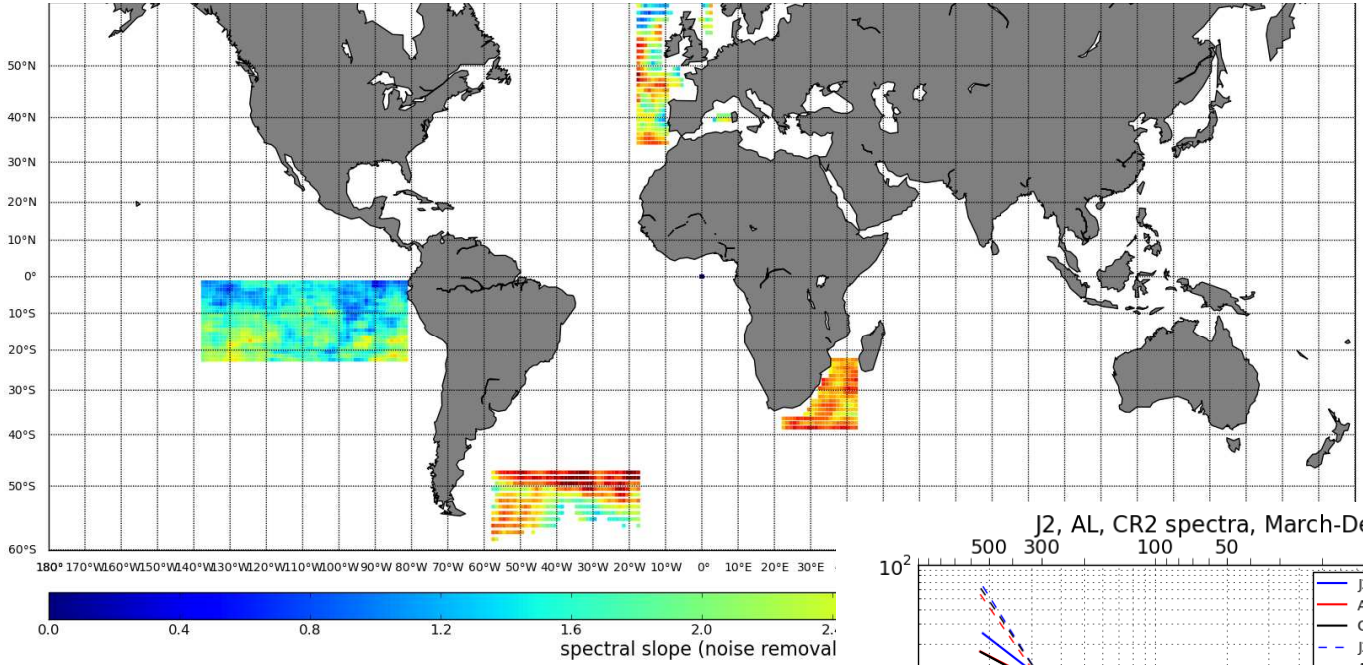
❖ **SARAL/AltiKa has lower noise and better mesoscale capabilities**

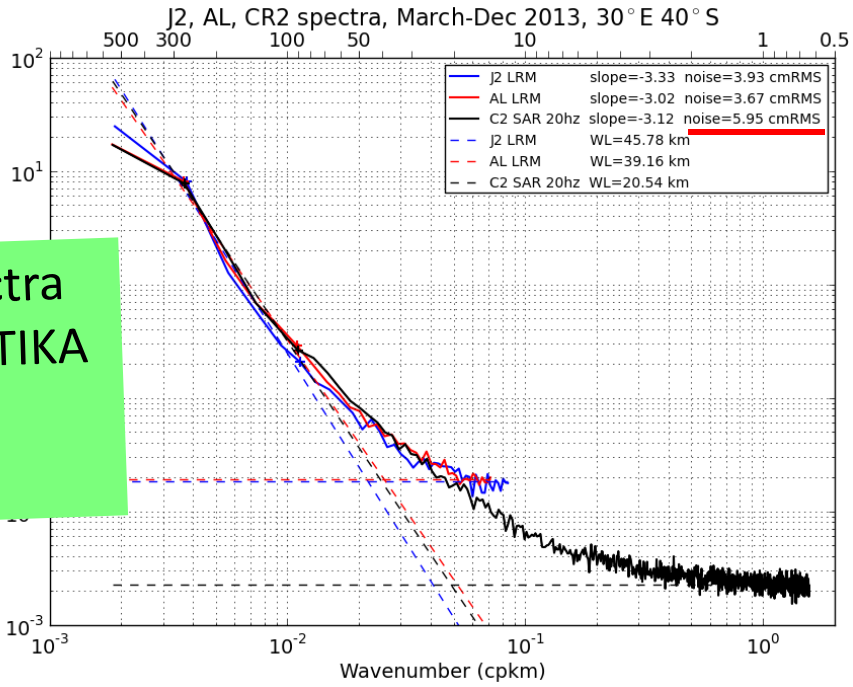
❖ Results with **future SWOT mission indicate improved mesoscale capability** and 2D fields

❖ SWOT error budget also varies spatially, and the SWH & sigma-0 dependency should be taken into account.

Appendix : Zoom on Cryosat-SARM regions





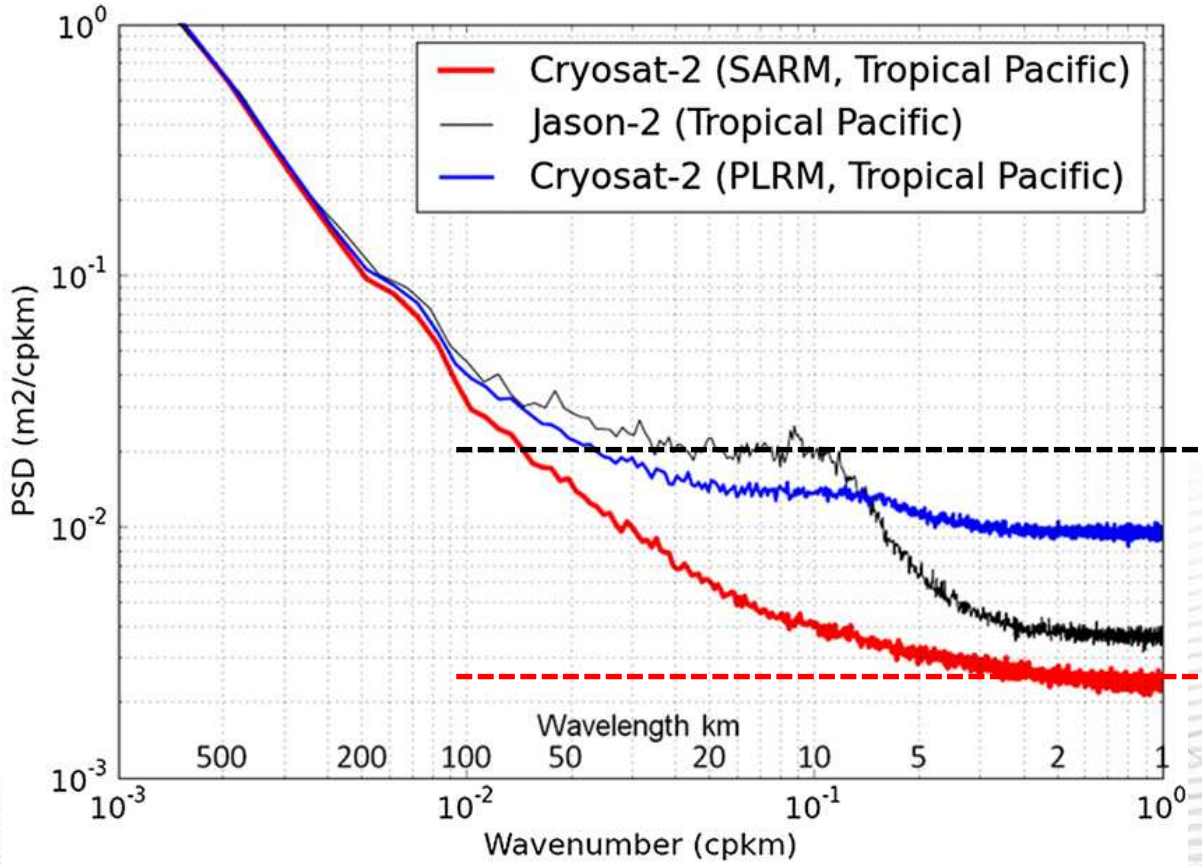


⇔ 1.33 cm RMS 1hz

On-going survey of wavenumber spectra JASON-2, CRYOSAT-2 SARM, SARAL/ALTIKA in 5°x5° areas from March to December 2013

20hz Cryosat-2 SARM compared to 1hz spectra

1hz altimeter error at scales <20km can be linked to the spectral “bump” seen on 20hz spectra. So, the 1hz spectral noise estimation at scales <20km can be compared to the 20hz SARM spectral noise estimated at scales <1km which does not exhibit a spectral bump.

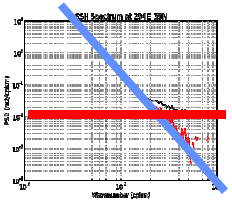


Mean SSH anomaly from Jason-2 (black), Cryosat pseudo-LRM (blue), and Cryosat SAR (red) (Dibarboure and al., 2014)

Jason-2 LRM altimeter error estimation

Cryosat-2 SARM altimeter error

Future mesoscale capability



Mean error in swath = 1.7 cm RMS for 1 km² + SWH dependency

From mean SWH from Jason-2 [March to October 2013] -> map of future SWOT error level during similar period -> length scales higher !