Spatial and Temporal Variability of Coherent Structures in the North Atlantic in preparation for SWOT

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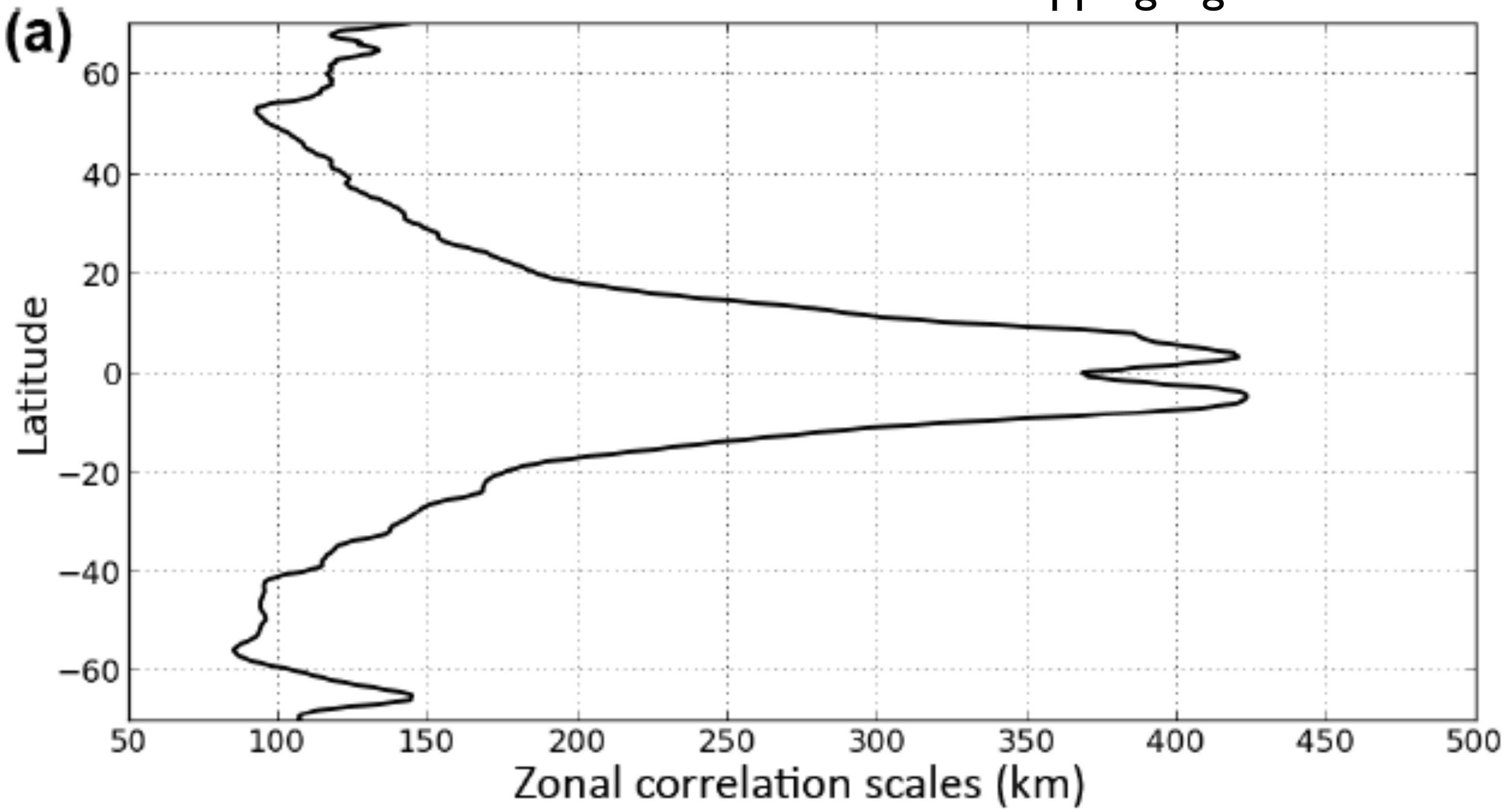
Date : 27 - 06 - 2018

Motivation

Motivation :

- A priori hypotheses about sea surface height correlation scales is used in inversion and mapping algorithms for altimeter data.
- These hypotheses will need to be revisited in SWOT data processing chains (smaller scales, seasonal variability)

Zonal correlation scale used in AVISO mapping algorithm



© Pujol et al 2016

In this perspective,
we aim to describe the spatial and temporal variability of the scale of eddy structures the North Atlantic and assess the robustness of model predictions

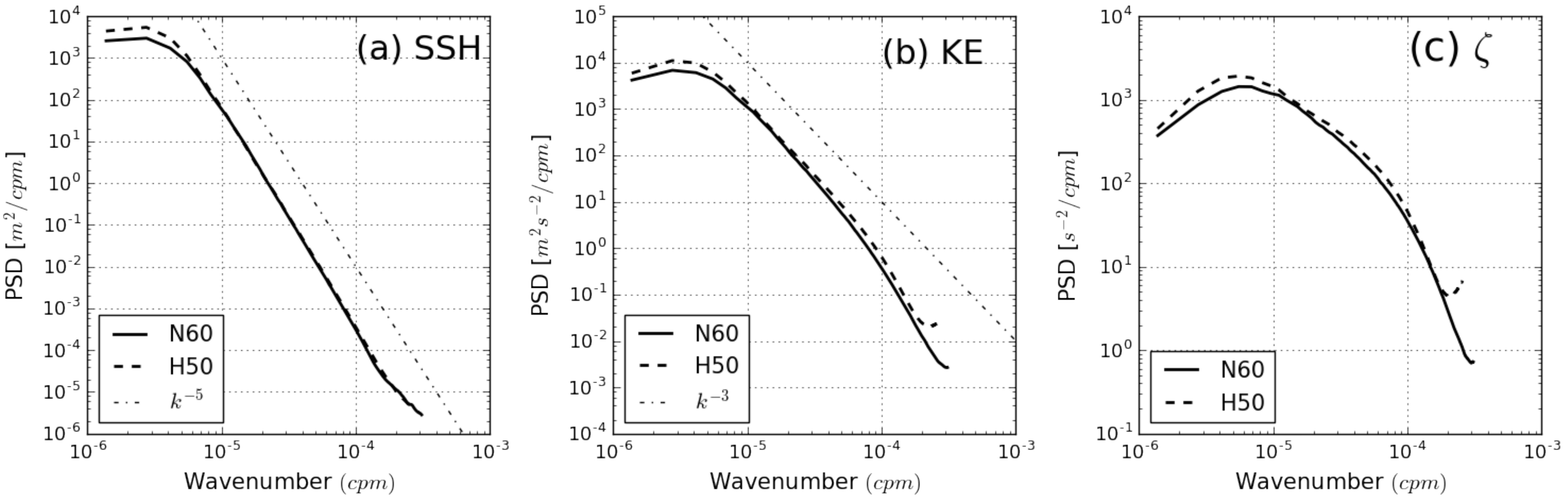
NATL60 and HYCOM50

	NATL60	HYCOM50
Domain	26.5N - 65N	28S - 80N
Numerical Code	Nemo v.3.6	Hycom
Horizontal grid	1/60° : 0.9km - 1.6km	1/50° : 1.1km - 2.2km
Vertical coordinate	Z partial cells	Isopycnal
Vertical grid	300 Levels : 1m - 50m	32 Levels
Boundary conditions	GLORYS2v3	GDEM
Atmospheric forcing	DFS5.2	ERA-40
Horizontal Viscosity	3rd order Upstream-Biased	Laplacian & Biharmonic

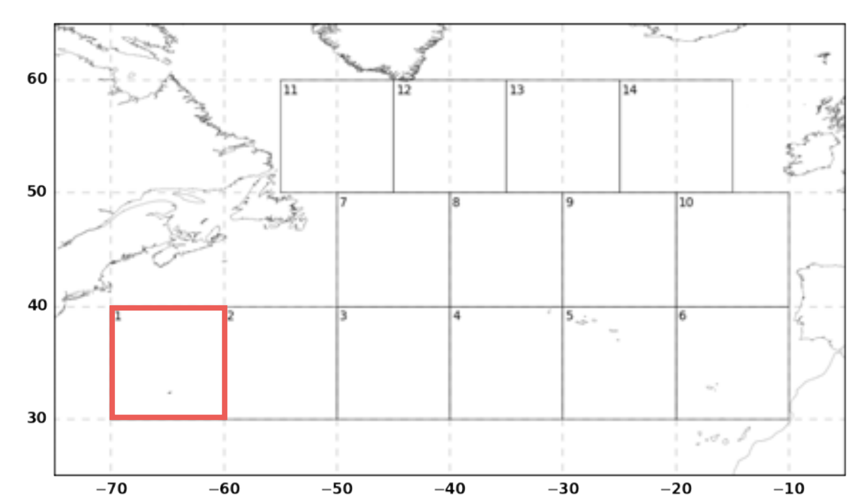
- NATL60 model configuration is designed in order to explicitly simulate the scales of motions that will be observed by SWOT.
- Both NATL60 and HYCOM50 are submesoscale permitting ocean models that can serve in capacity as virtual observation dataset for SWOT.
- Effective resolution of NATL60 & HYCOM50 ≃ 10km (dx~1-2km)

NATL60 and HYCOM50

Comparison of power spectra result in a region close to the gulf stream

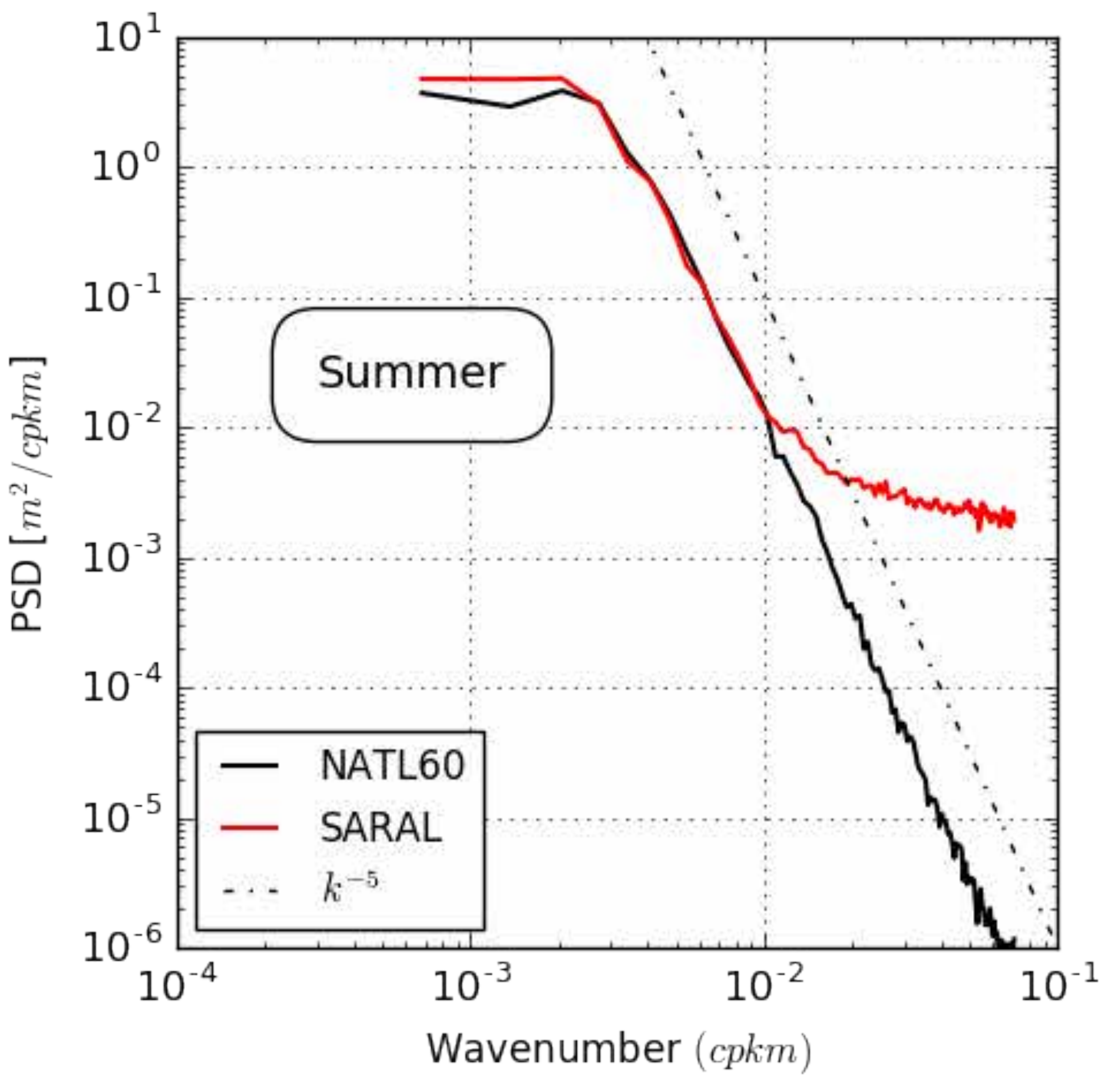


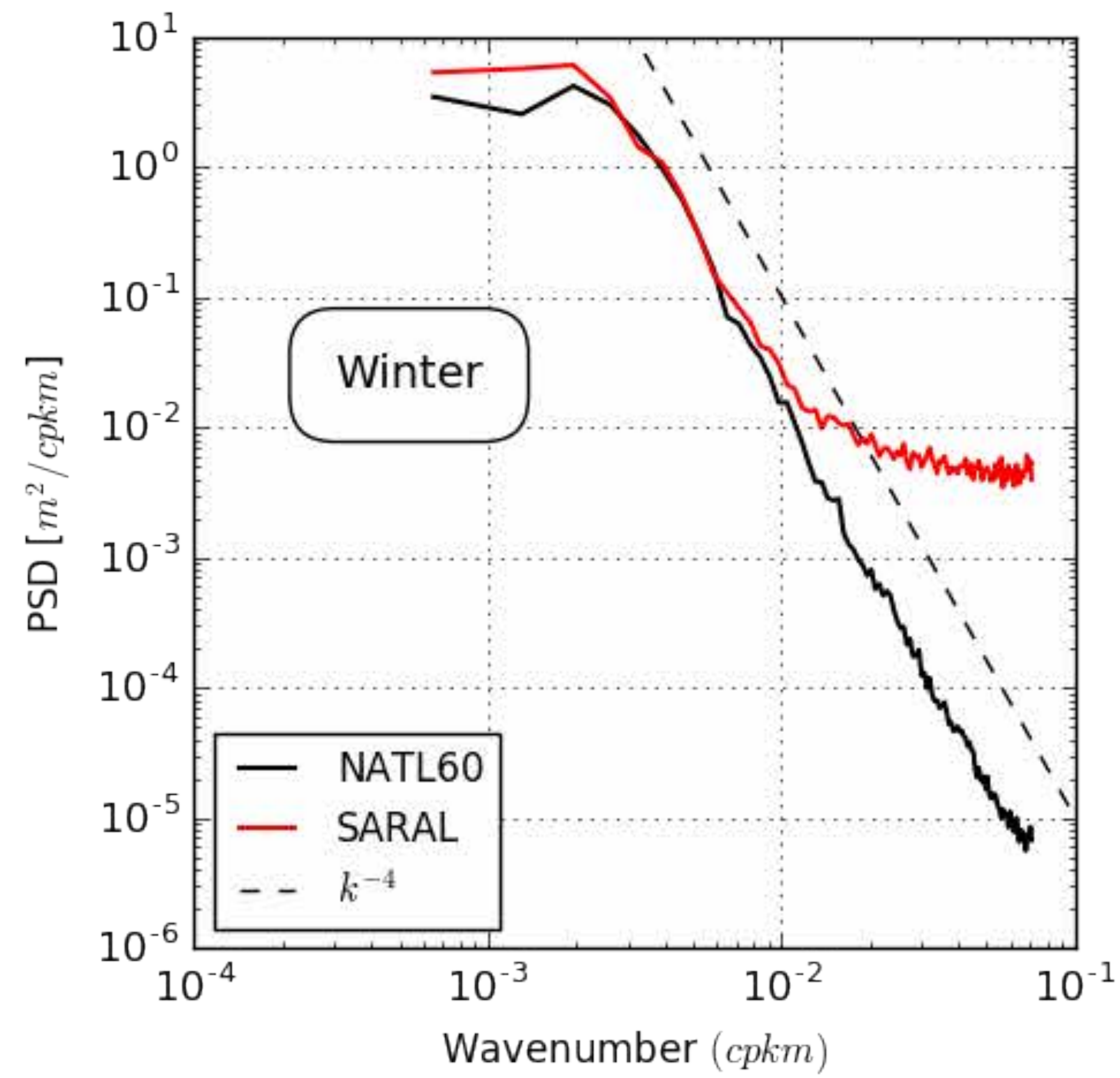
SSH spectral slopes of both model compare favourably and agree with the prediction of Quasi-geostrophic dynamics.



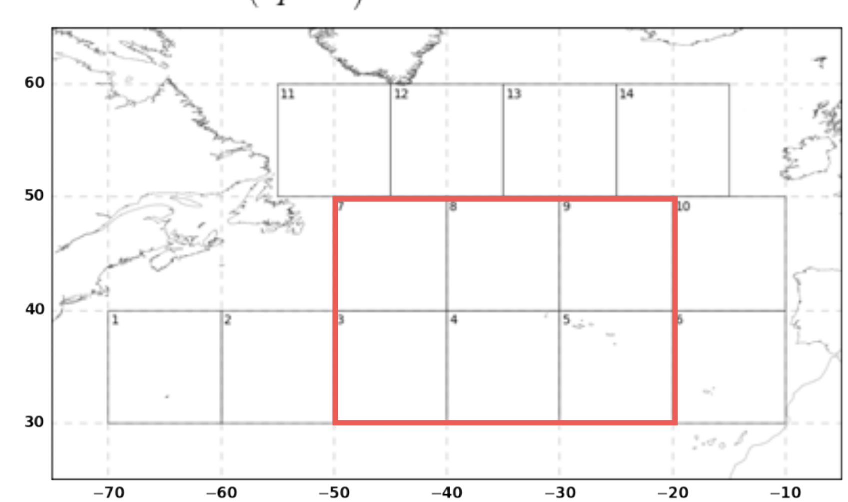
NATL60 and SARAL

SSH Wavenumber spectra. [Lat : 30 to 50, lon : -50 to -20]



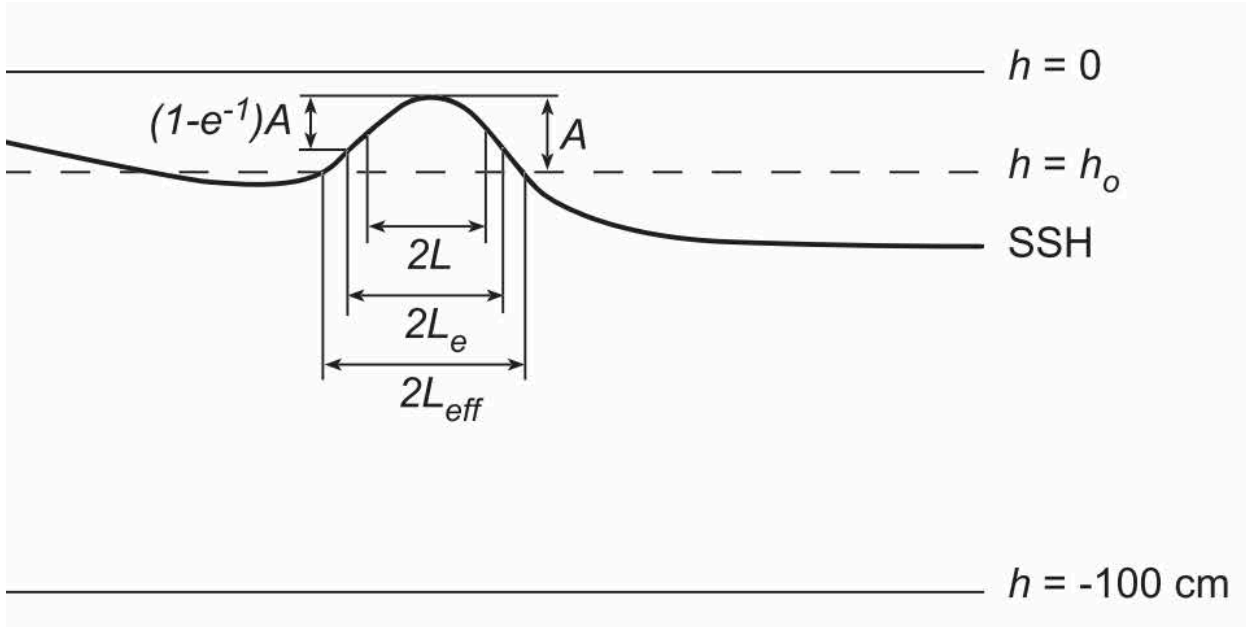


Fair agreement between NATL60 and SARAL at the mesoscale range. (similar agreement is also found with Sentinel-3A SAR mode data)



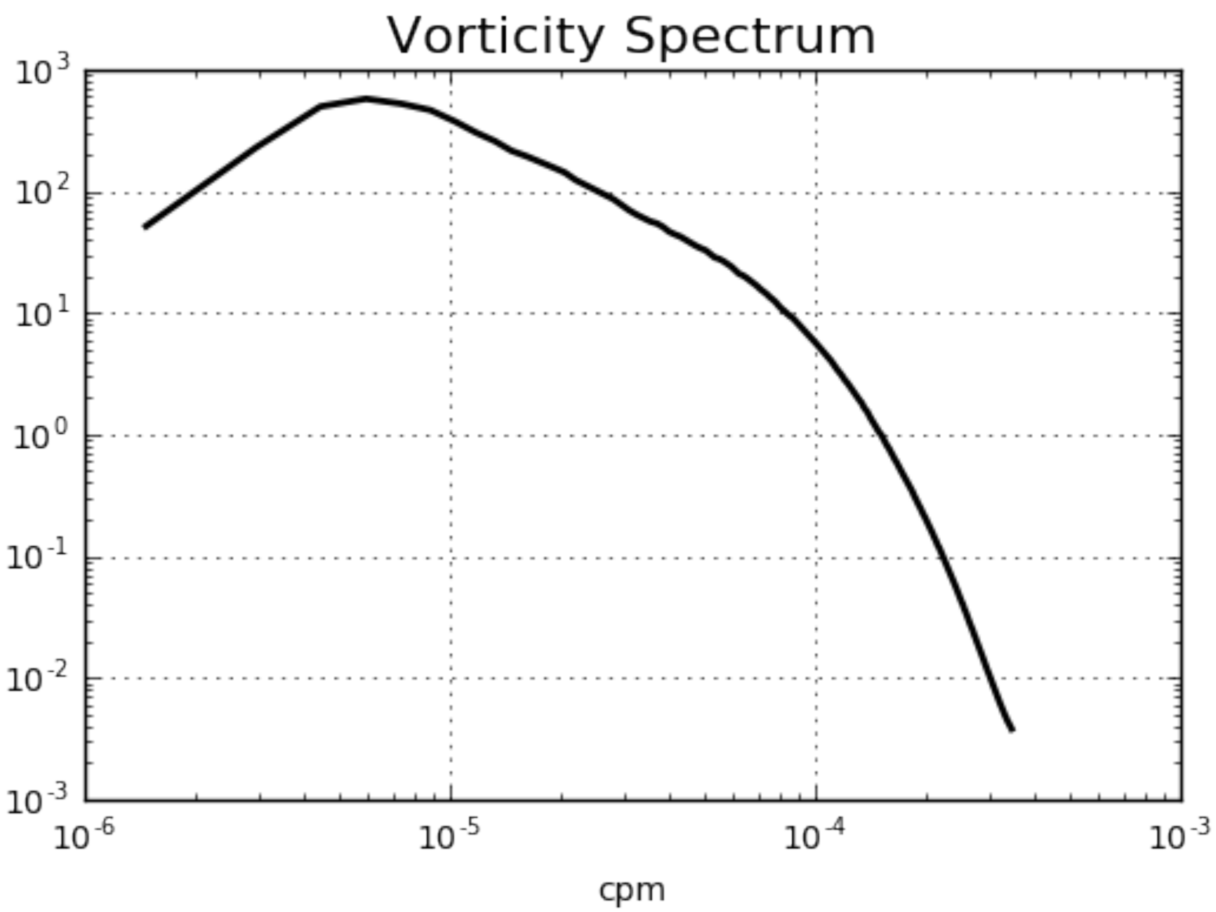
Scale Estimation Metric

Eddy scale from SSH (Lη) Contour using eddy detection algorithm.



Chelton et al 2011

Enstrophy weighted scale (Lζ) from vorticity wavenumber spectra

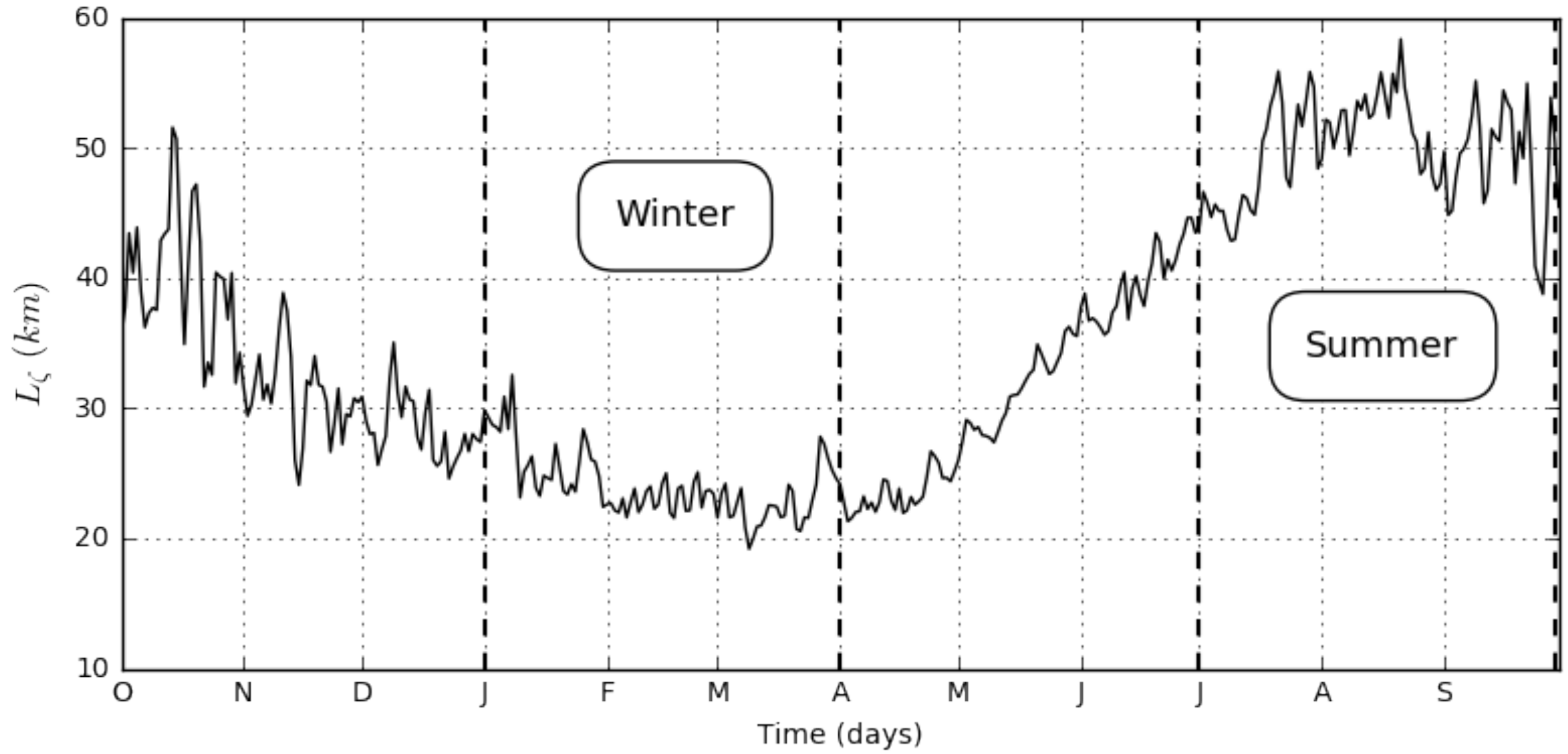


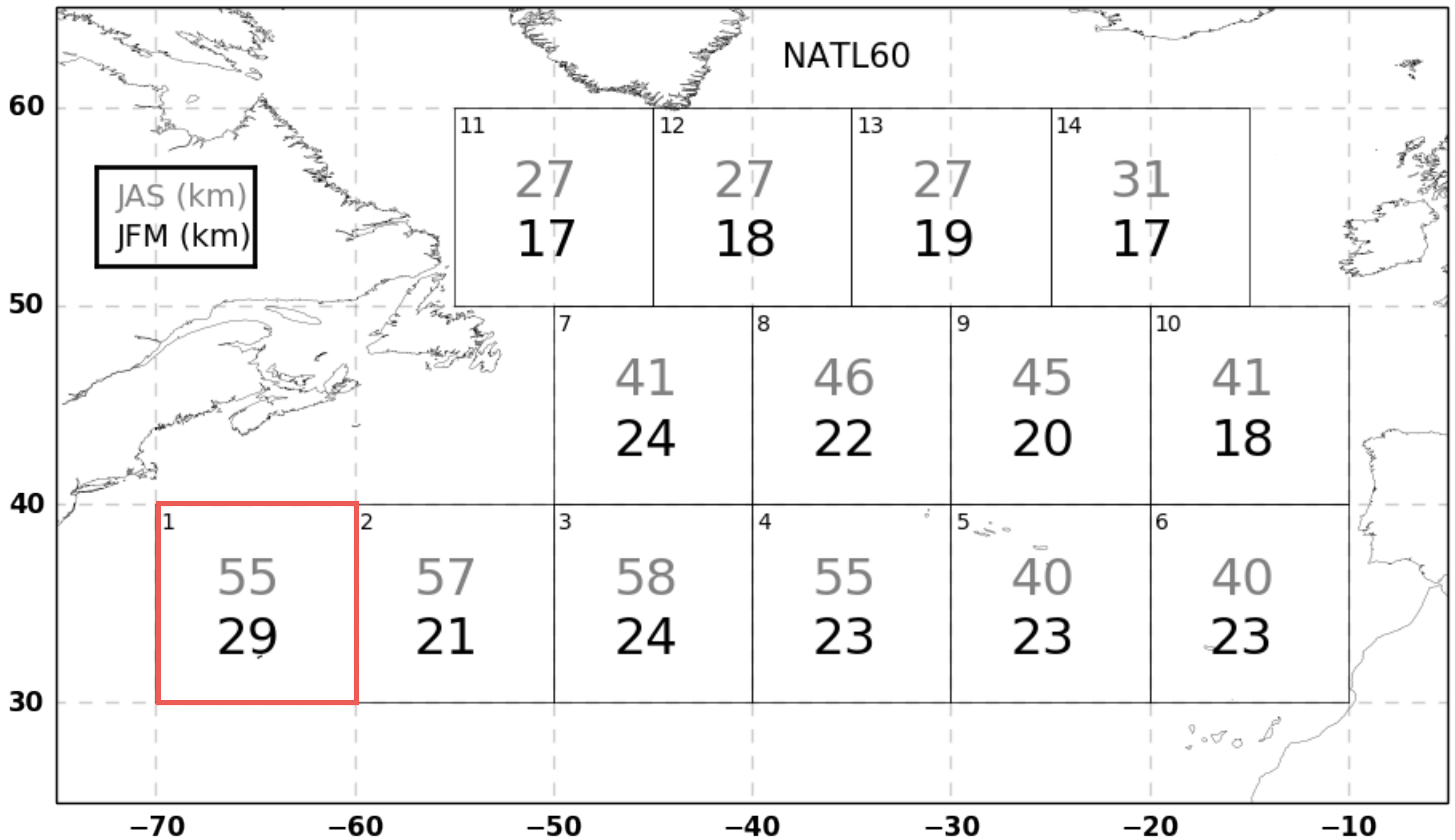
$$L_\zeta = \frac{\int\int Z(k,l)dkdl}{\int\int \sqrt{k^2+l^2}Z(k,l)dkdl}$$

Robert B. Scott 2001

Temporal Variability

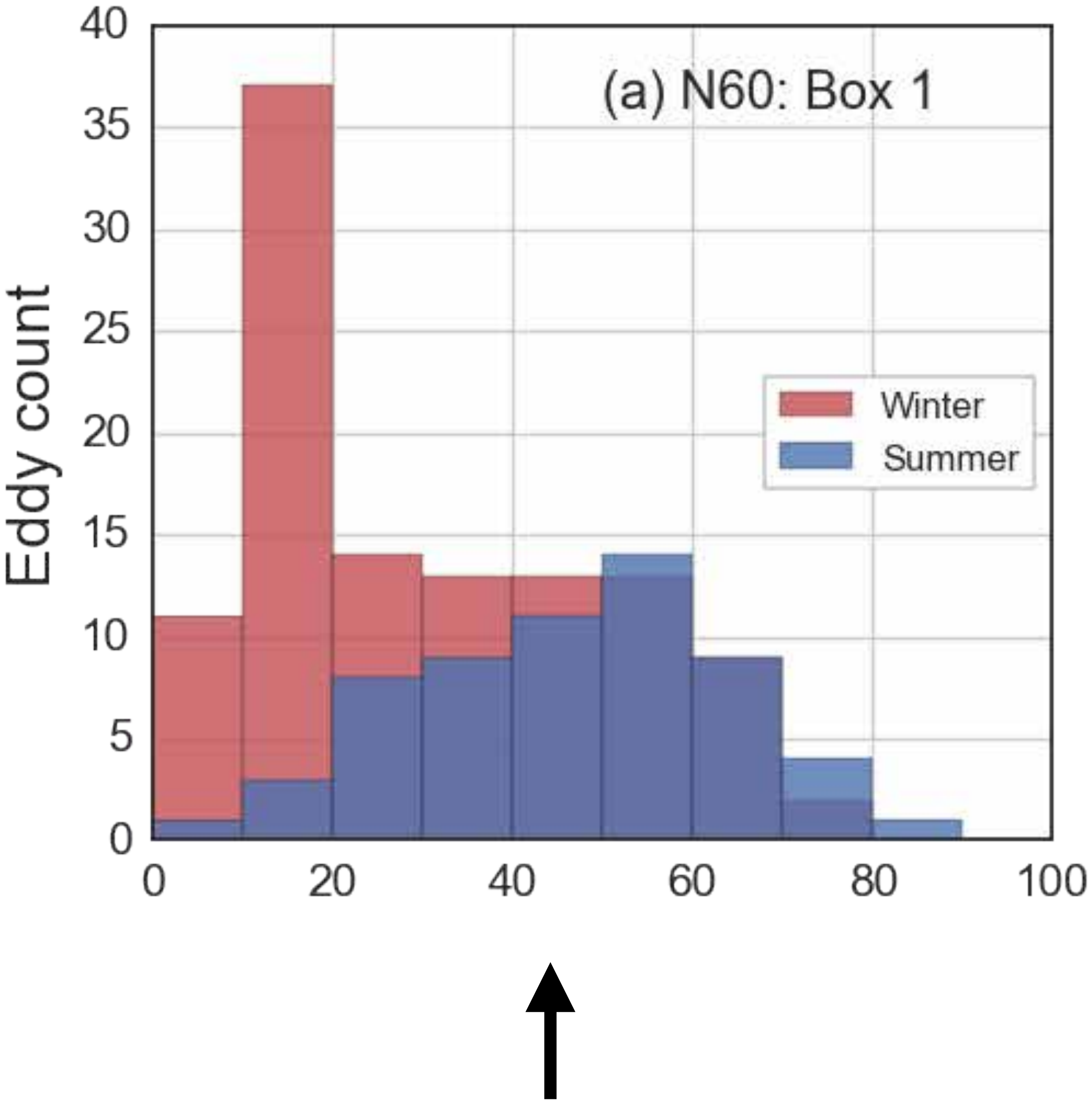
Seasonality of enstrophy weighted scale in Box 1





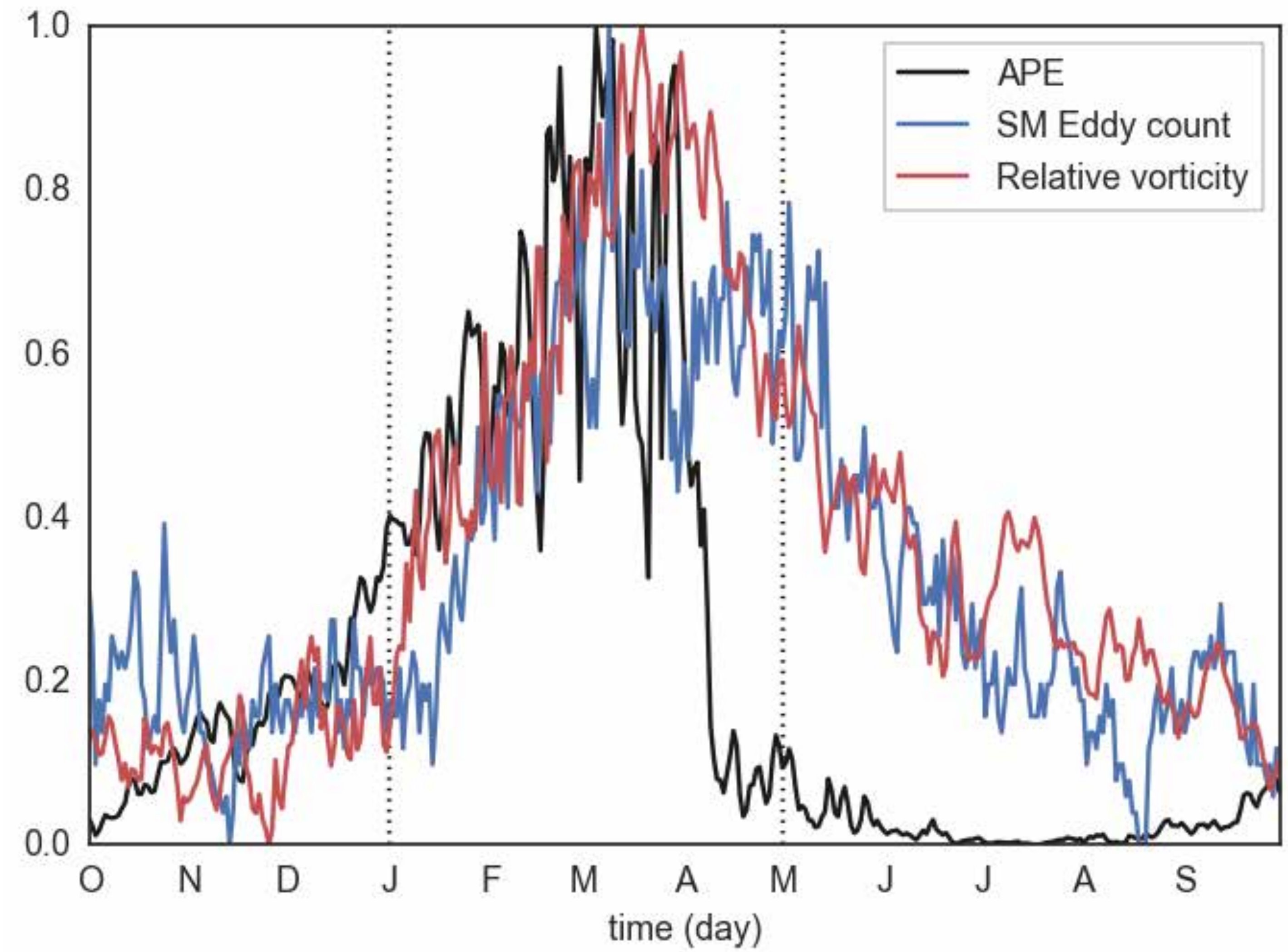
Winter / summer averaged values of enstrophy weighted scale in all the boxes.

Temporal Variability



Seasonality is due to the emergence of small scale vortices in wintertime

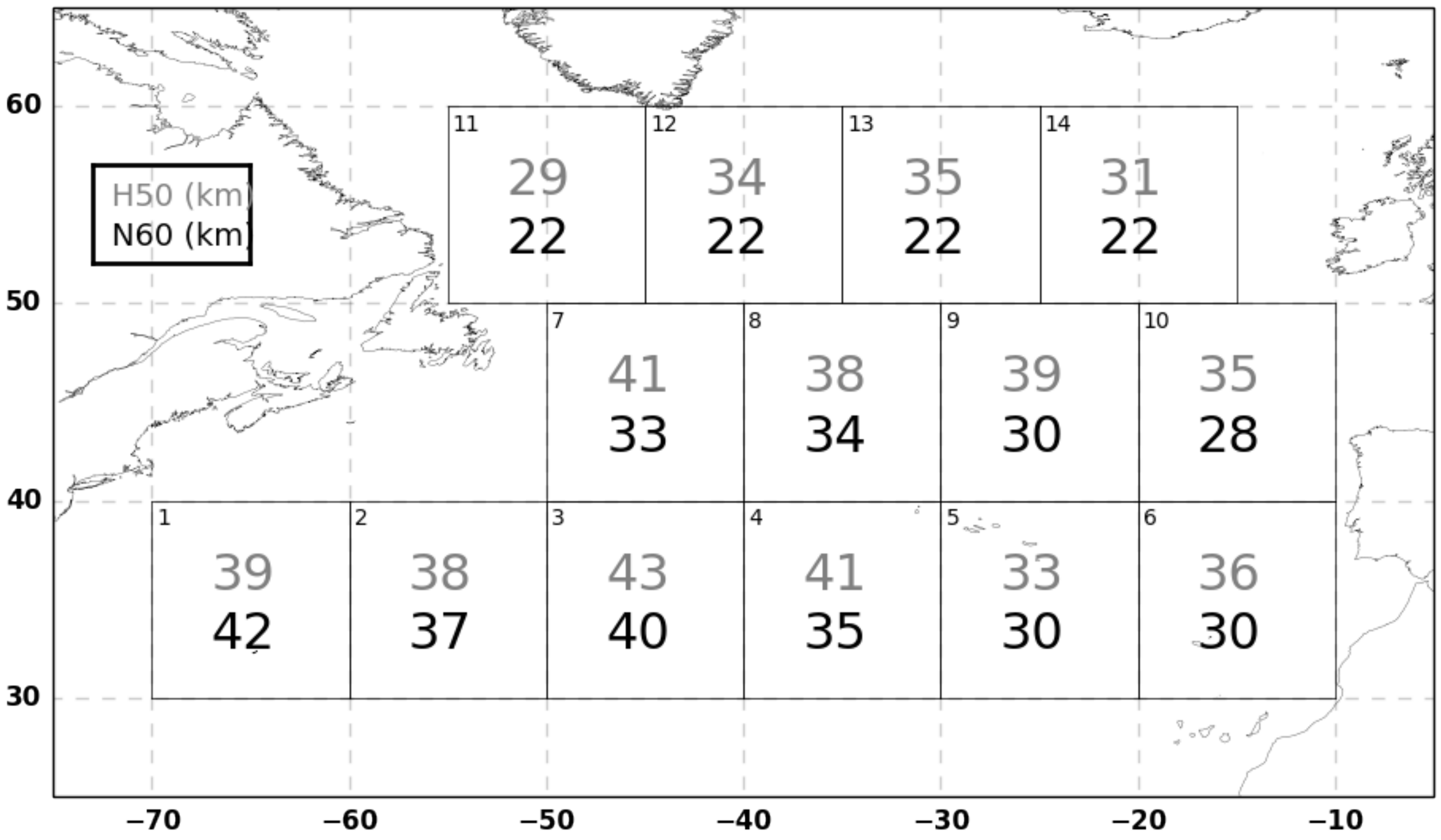
Increased population of small scale eddies in winter is driven by MLI.



SM : Eddies < 50km

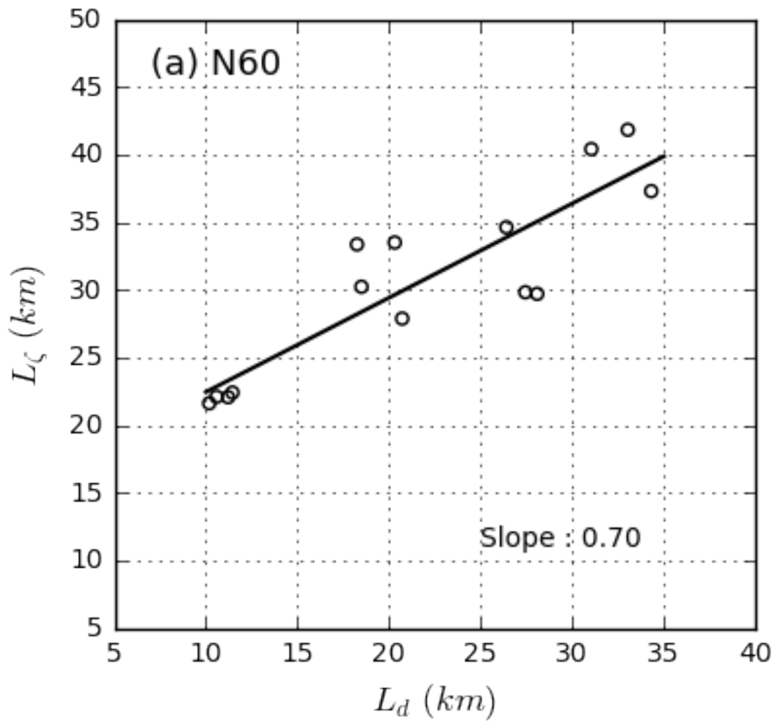
$$APE = \langle w'b' \rangle_{xyz} \propto \left(\langle h \rangle_{xy} \right)^2 \cdot \langle \nabla_h \bar{b} \rangle_{xyz}$$

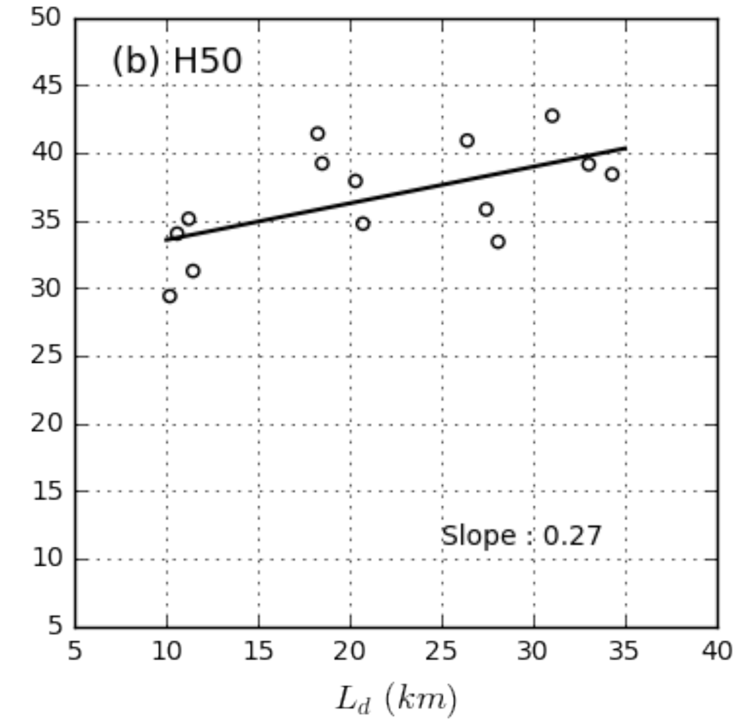
Spatial Variability



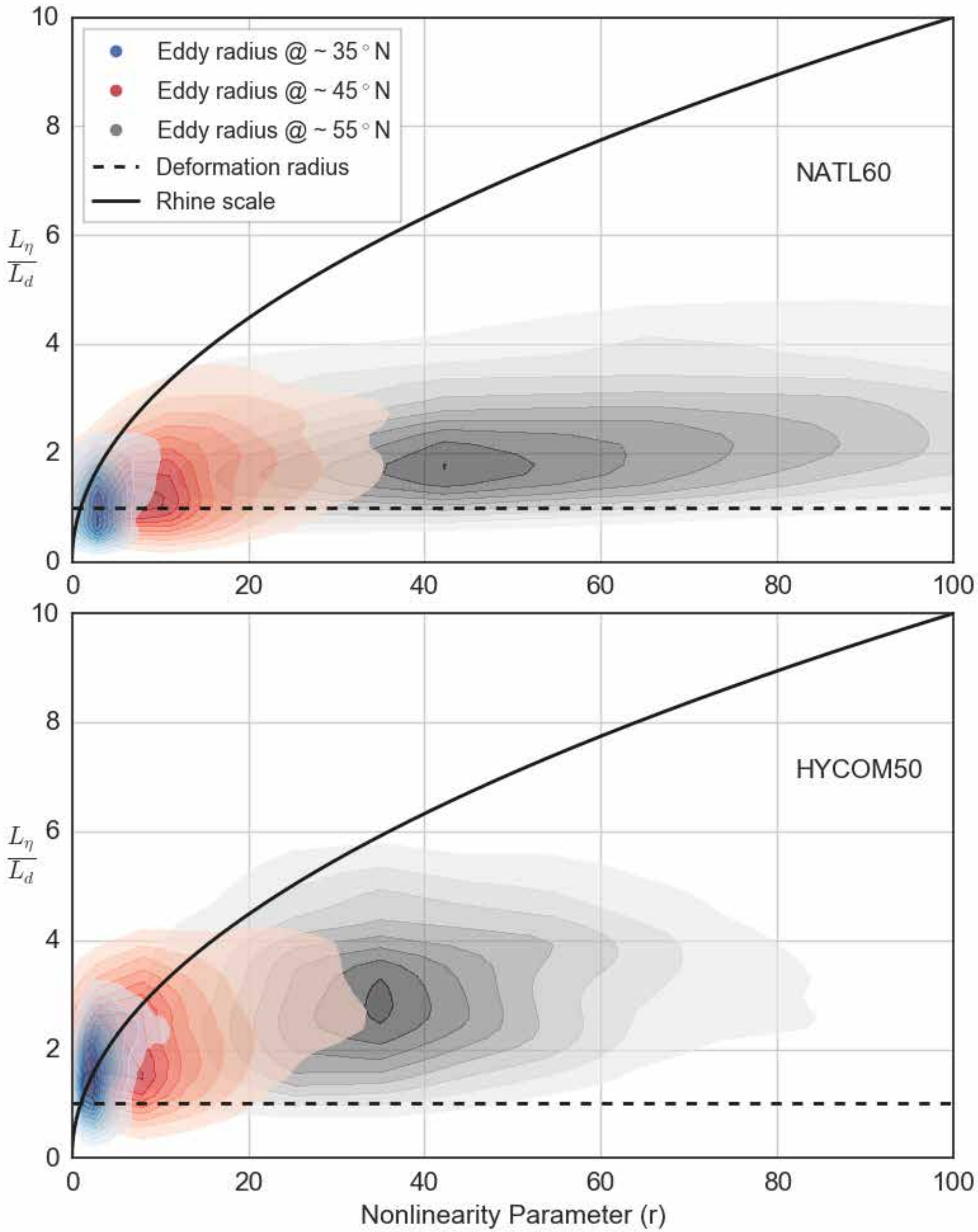
The typical size of eddy structures vary in space

Scales roughly follows the Rossby radius





Scale and Nonlinearity : (following Klocker 2016)



Normalised eddy scale : $$\frac{\text{Eddy scale}}{\text{Rossby Radius}} = \frac{L}{R_d}$$

Nonlinearity parameter : $$\frac{\text{Eddy velocity}}{\text{Rossby wave speed}} = \frac{U_{eddy}}{\beta R_d^2}$$

- Most of the eddy scales lie between the Rossby radius of deformation and the Rhine scale.
- Most of the eddies in the North Atlantic are nonlinear and the nonlinearity increases with latitude.
- Eddies in the 55 lat band are more linear in NATL60 compare to HYCOM50.
- Eddies in HYCOM50 tend to follow more closely the Rhine scale (stronger inverse cascade ?).

Summary

- NATL60 prediction in terms of SSH power spectrum compare favourably well with HYCOM50
- Both model show strong seasonality in the distribution of eddy scale in the North Atlantic.
- The seasonality of the distribution of eddy scale is due to the emergence of a population of small scale eddies (< 50km) in winter.
- This emergence of small scale eddies is driven by mixed layer instability (MLI).
- This suggest that spatial correlation scales for SWOT inversion and mapping algorithms should vary seasonally.
- A similar analysis could be undertaken to investigate the temporal correlation scales.

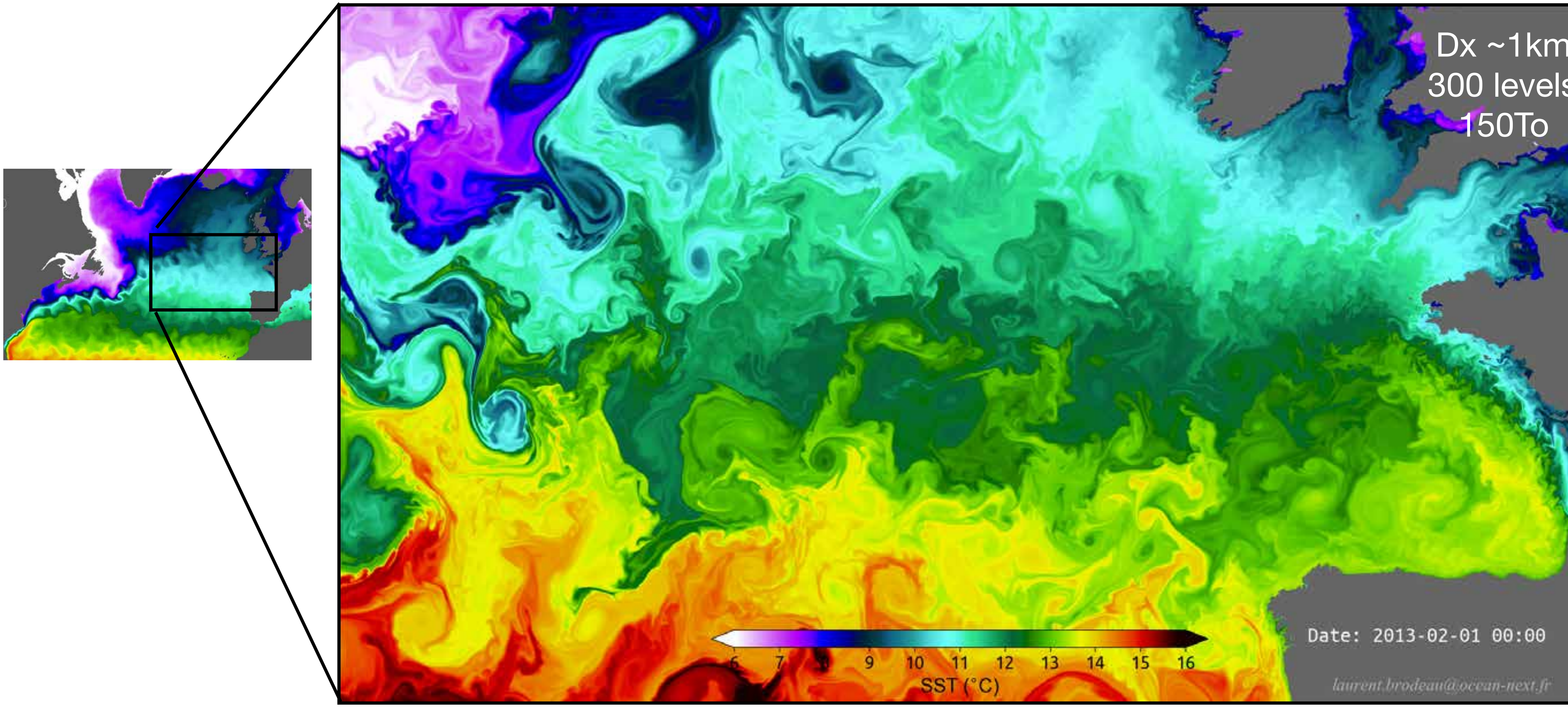
Update on the NEMO North Atlantic model simulations plan for 2018-2019 in Grenoble

Julien Le Sommer, Laurent Brodeau
and the MEOM Group@IGE.

Date : 27 - 06 - 2018

NATL60 : 1/60° North Atlantic NEMO-based model

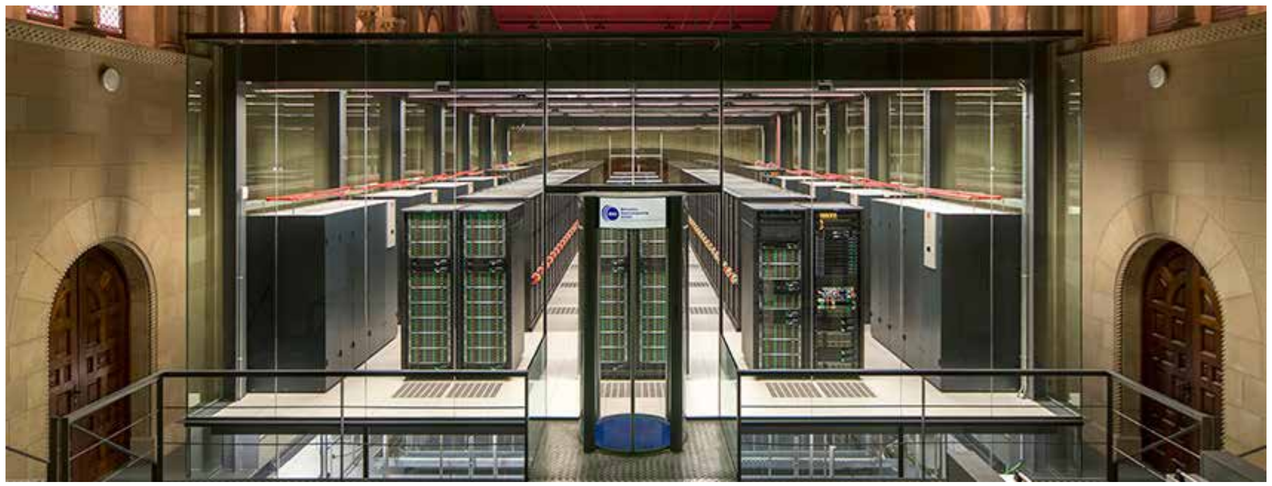
NATL60 : a model dataset for preparing inversion methods for SWOT data



- numerical code : NEMO v3.6
- grid : 1/60° (**dx ~1km**)
- **300 levels** (dz : 1 to 20m)
- realistic geometry, boundary conditions and forcing
- 12 month runs available (+ 6 months spin-up)
- used by about 10 groups / 1 paper, 2 sub, 4 in prep

limitations : no tidal forcing, short runs, small domain

eNATL60 : A new NEMO model configuration

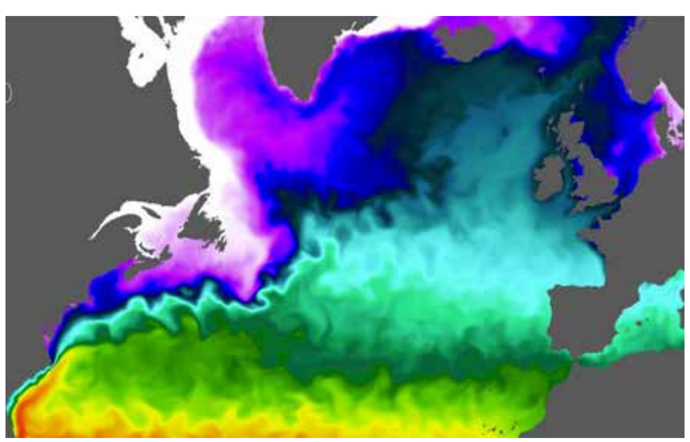


MareNostrum @ BSC, Spain

40M cpuh allocated through PRACE

Scientific objectives
- energy exchange across scales
- interaction between balanced/IGWs
- dataset for preparing SWOT mission

Extension of NATL60 domain



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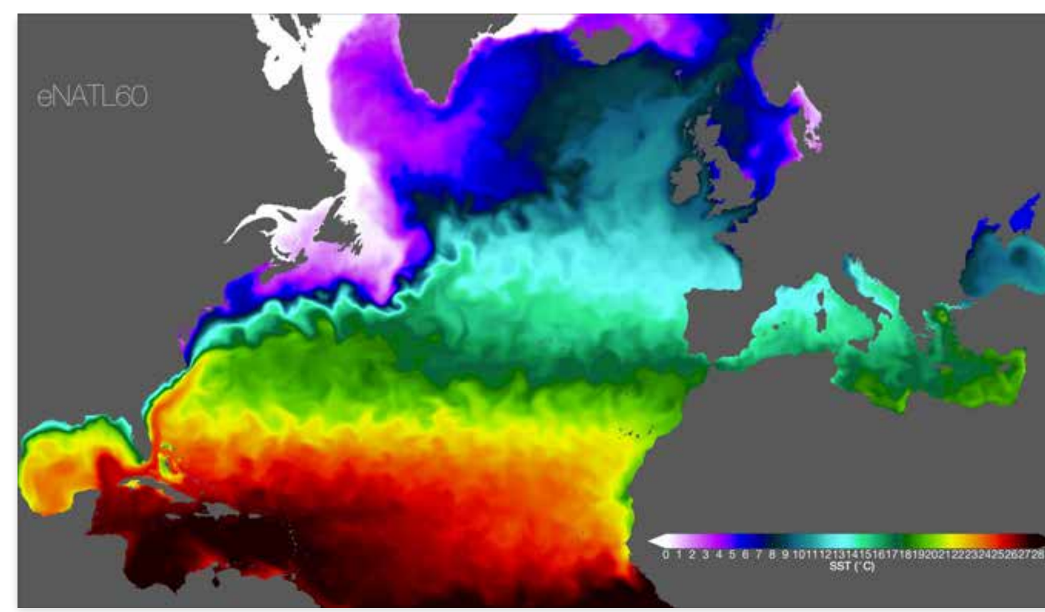
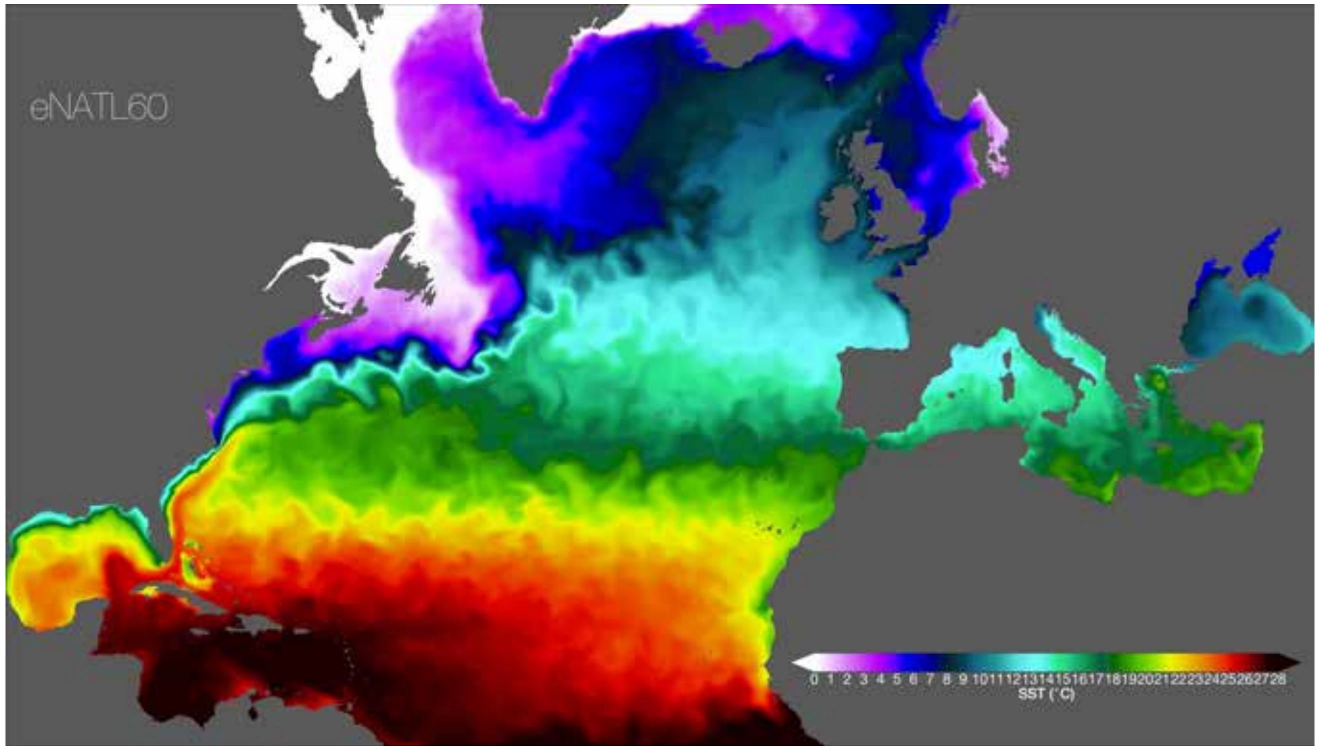


extended domain covers : subtropical gyre, Med. sea, Gulf of Mexico



eNATL60 :
- ✓ - extended domain
- ✓ - with tidal forcing and IGWs
- ✓ - multi-year long simulations

collaborative effort with :
B. Arbic, F. Lyard,
Mercator-Ocean, Ocean Next

Simulation plan :
- *control* : 18 month spin-up + 5 years runs, no tides
- *sensitivity* : 4 x (6month spin-up + 1 year), with tides

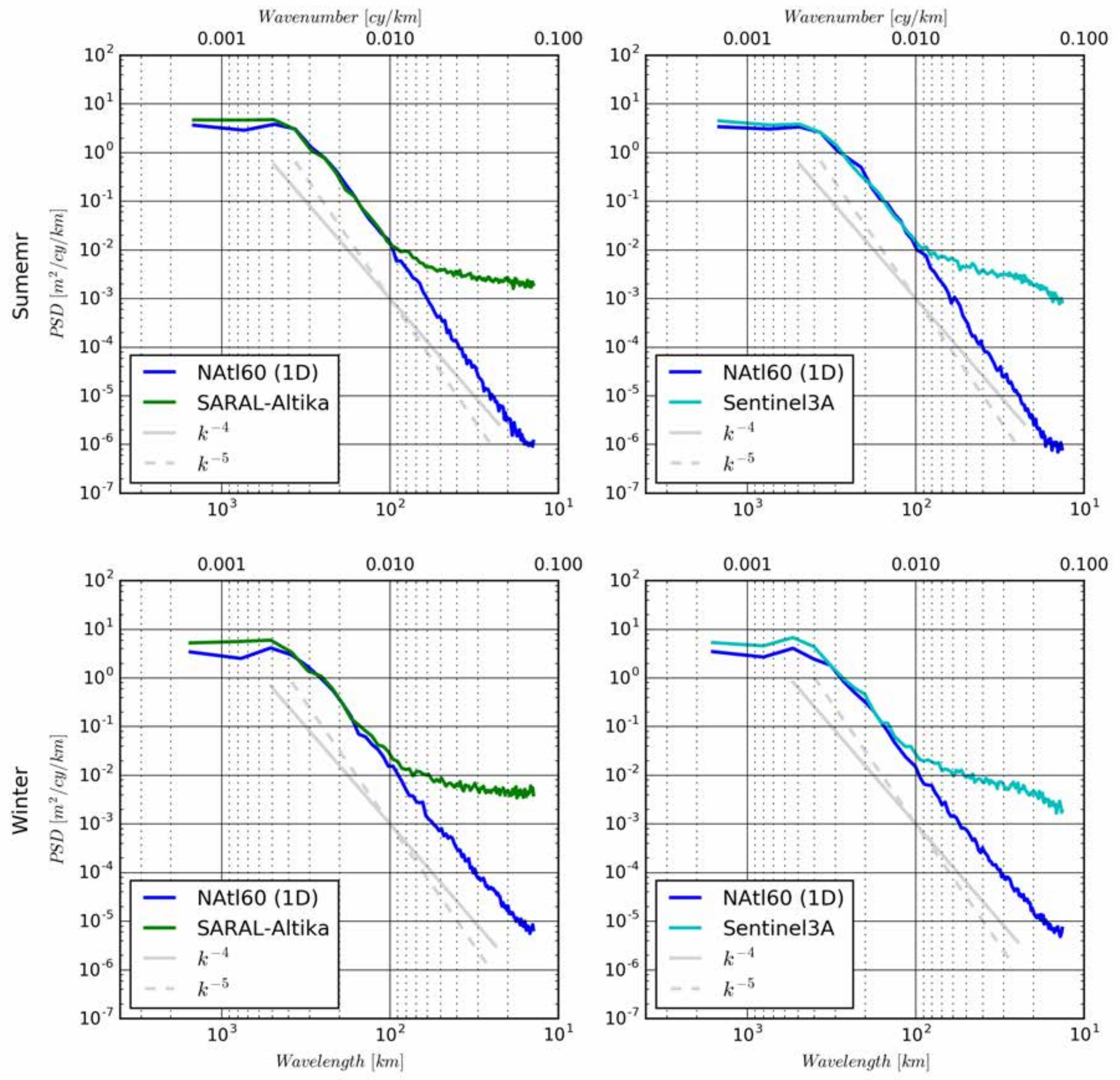
Other improvements
- boundary conditions
- bathymetry + coastlines

Current status
- the model is now running, currently undergoing scalability tests (number of cpu)
- production "control" run: July/Sept. 2018; production "tides" run : October/Dec. 2018

Open to discussion
- output strategy and specific diagnostics.

Please get in touch with us !

Supplementary material


Sumemr
Winter
Wavenumber [cy/km]
0.001
0.010
0.100
PSD [m²/cy/km]
Wavelength [km]
NAtl60 (1D)
SARAL-Altika
Sentinel3A
k^{-4}
k^{-5}