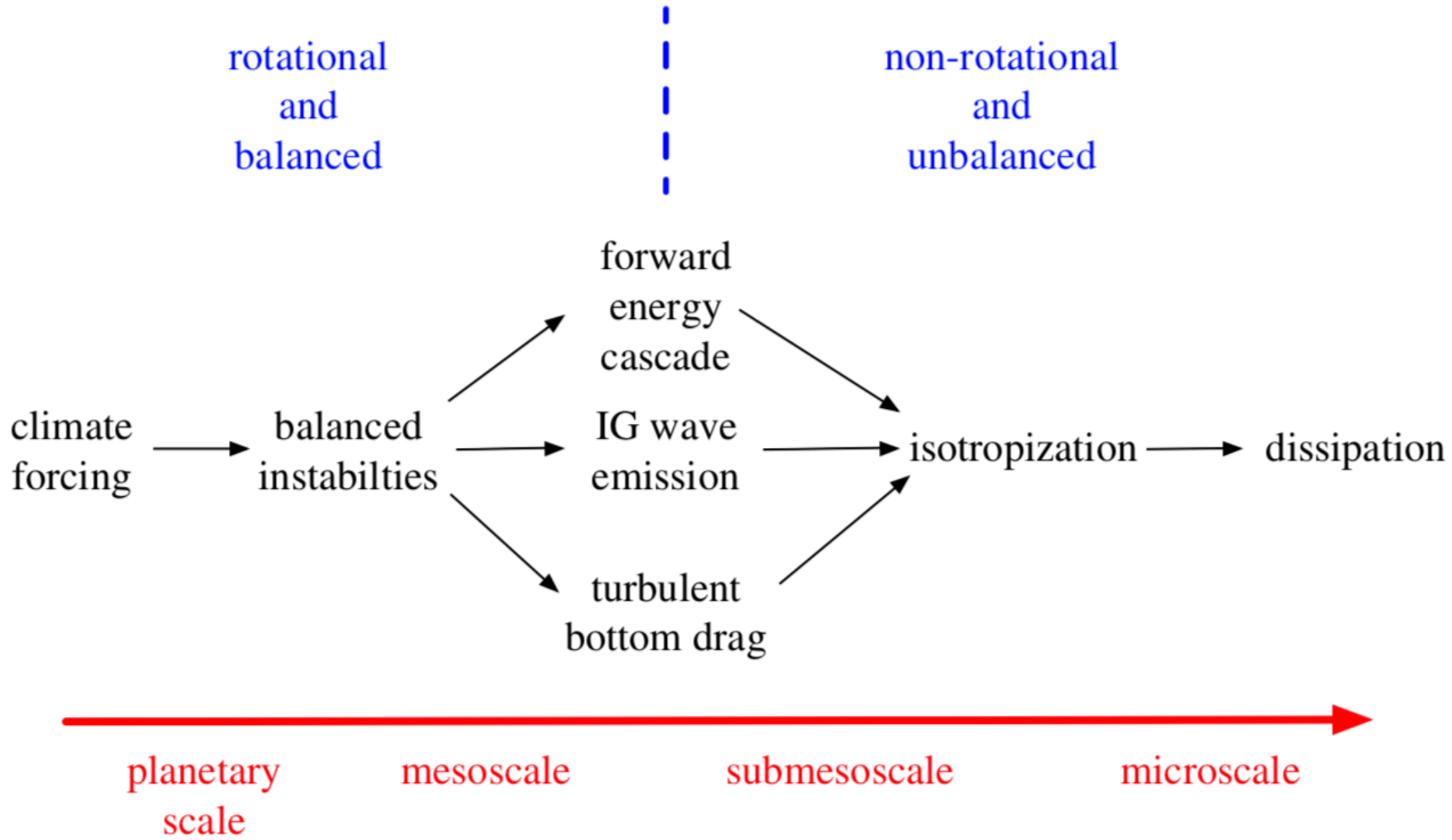
Impact of Balanced and Unbalanced motions on the Seasonality of Energy Cascade in the North Atlantic.

Adekunle Ajayi, Julien Le Sommer, Jean-Marc Molines, Guillaume Serazin, Brian Arbic and Patrice Klein.

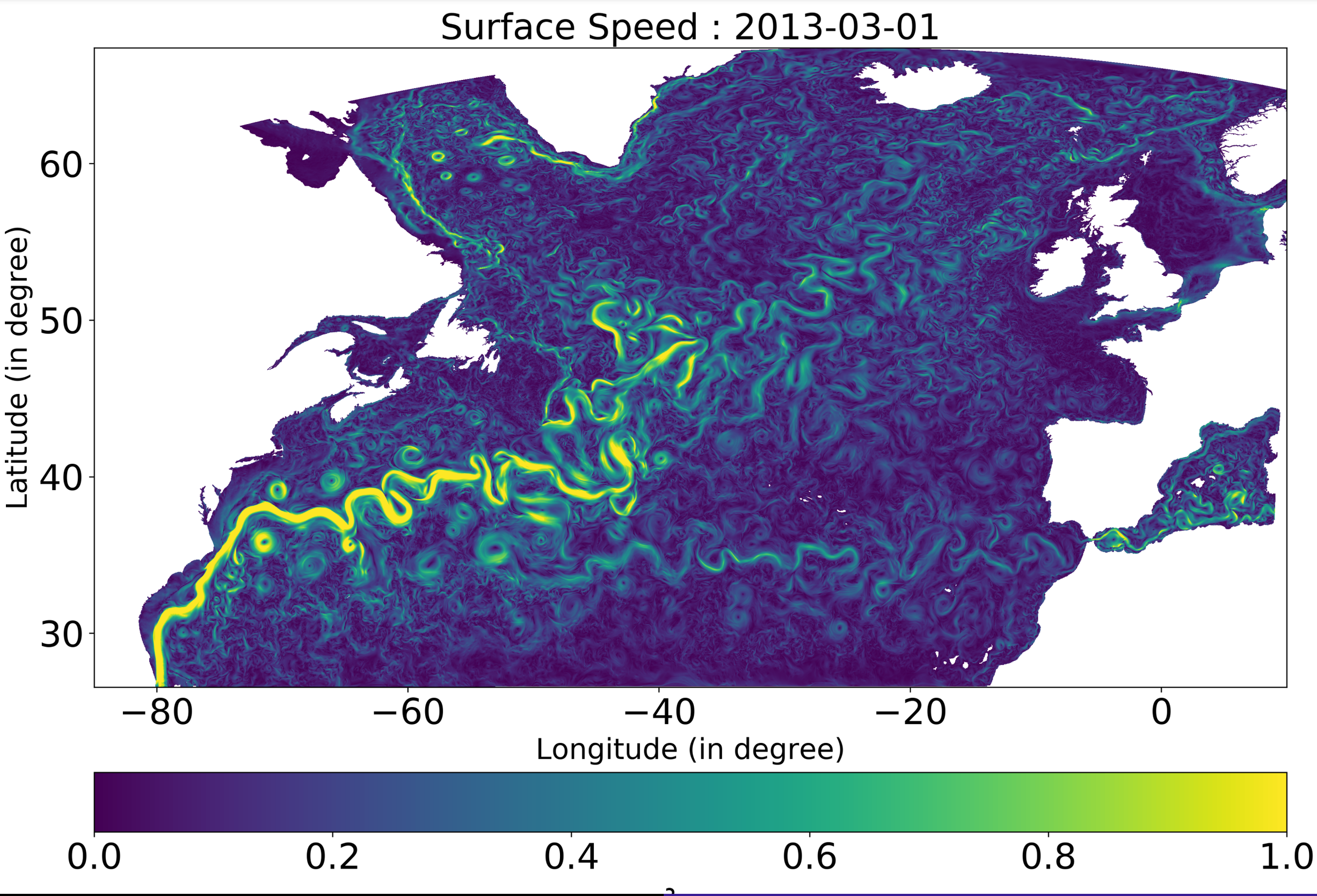
Date : 14 - 03 - 2019

Flow of energy



McWilliams (2016)

Model : NEMO based NATL60



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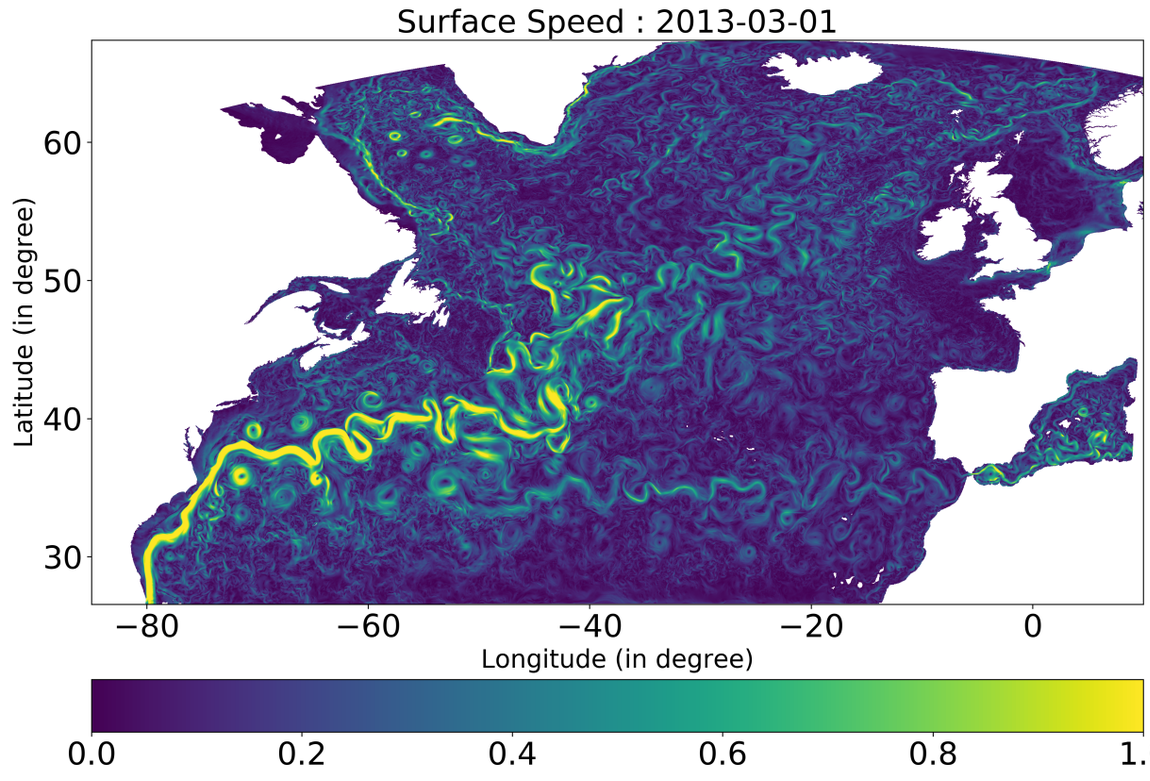
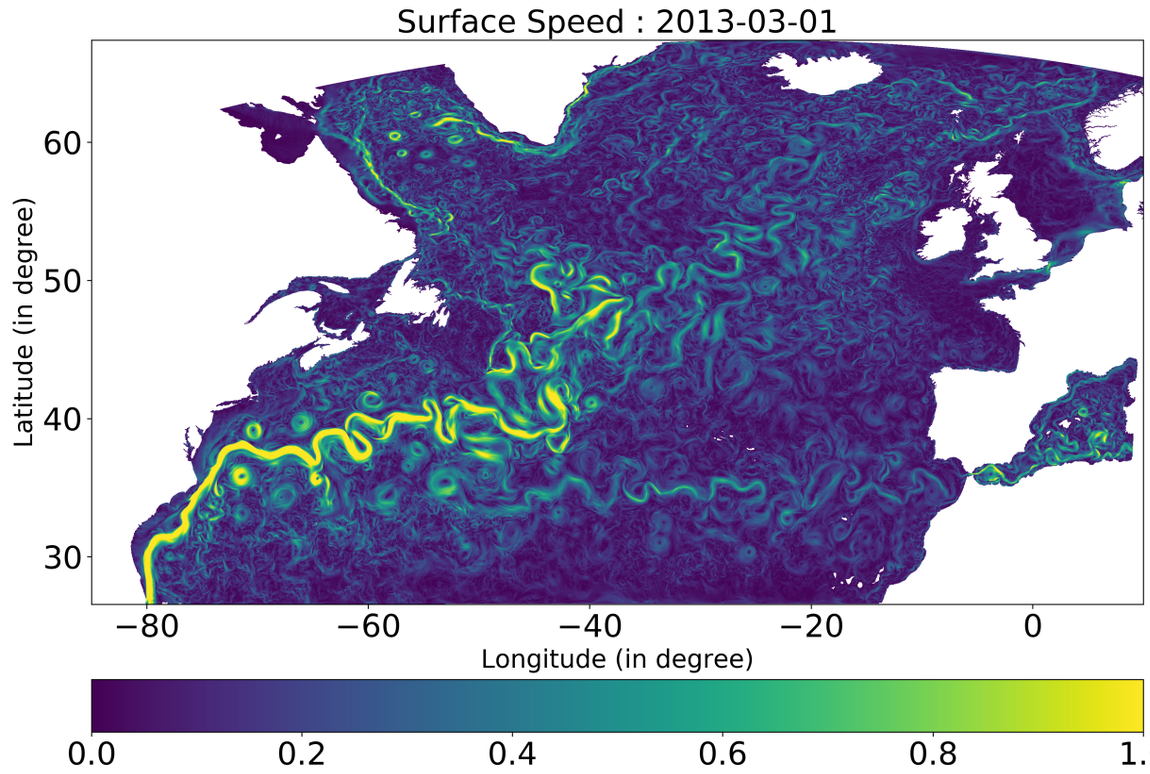


	NATL60
Domain	26.5N - 65N
Numerical Code	Nemo v.3.6
Horizontal grid	1/60° : 0.9km - 1.6km
Vertical coordinate	Z partial cells
Vertical grid	300 Levels : 1m - 50m
Boundary conditions	GLORYS2v3
Atmospheric forcing	DFS5.2
Horizontal Viscosity	3rd order Upstream-Biased

Model : NEMO based NATL60



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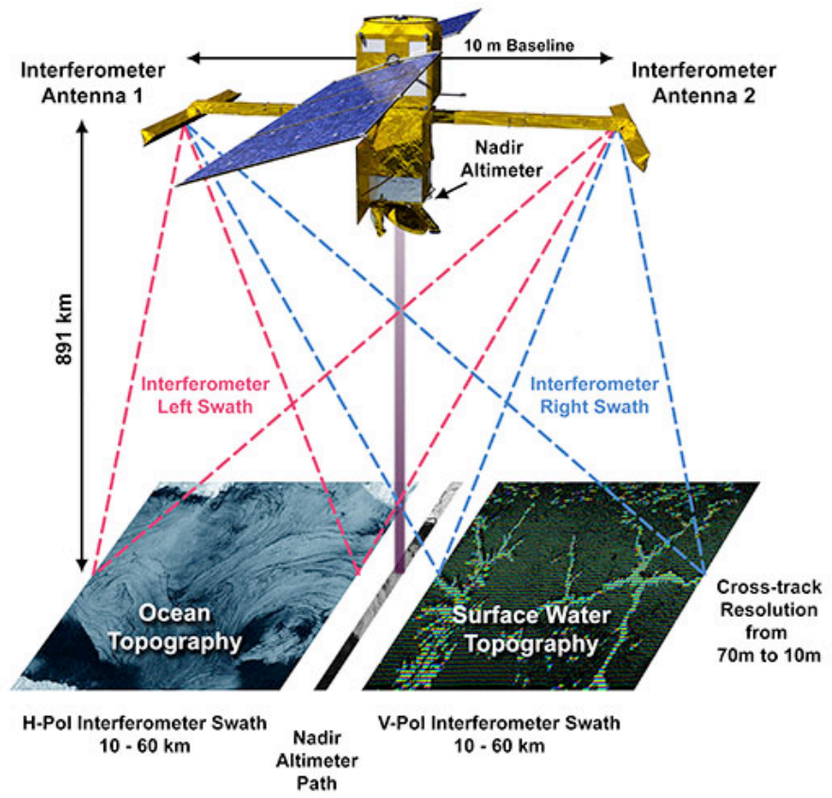
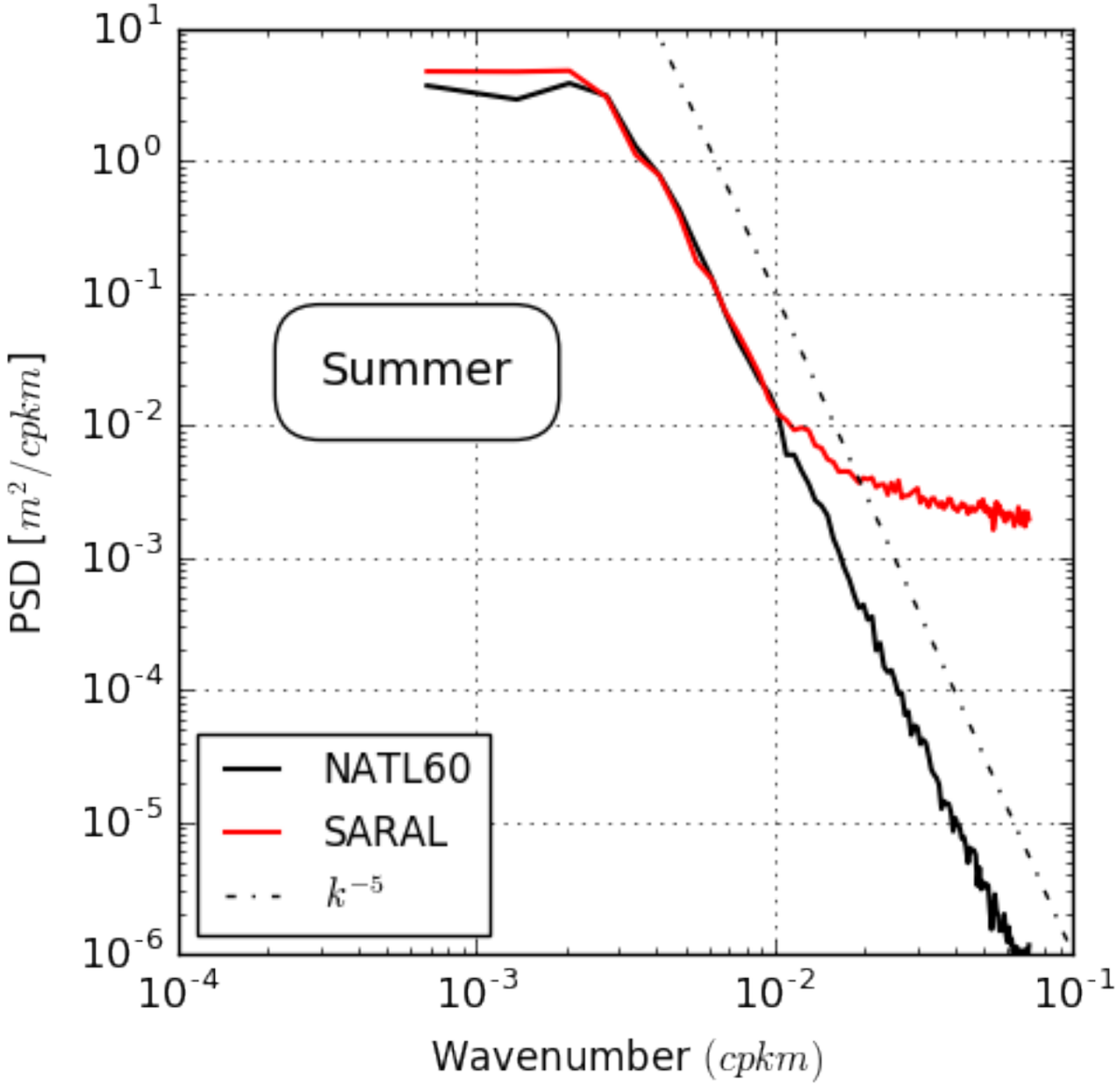
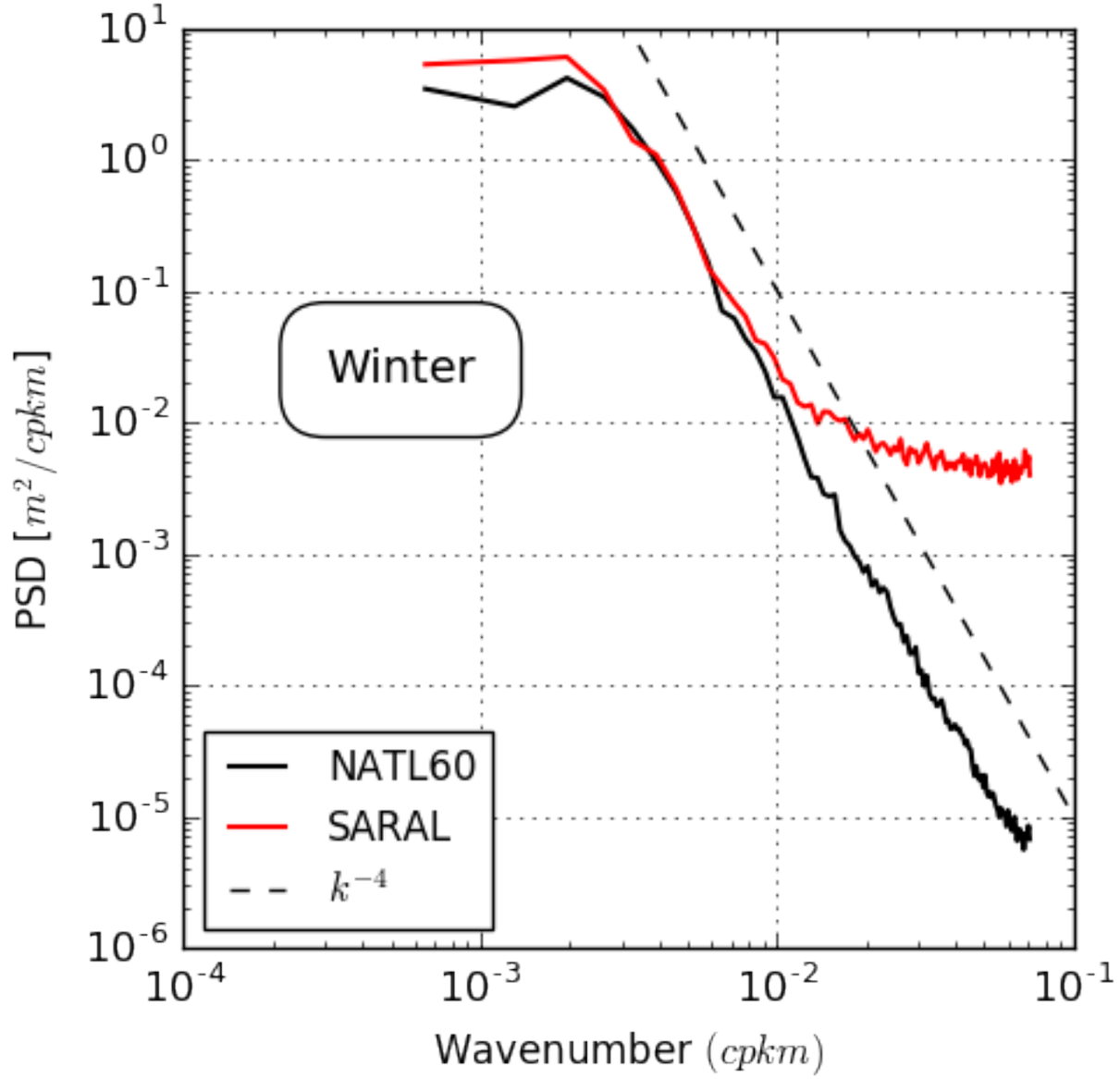
- NATL60 is a submesoscale permitting ocean model that can serve in capacity as virtual observation dataset for **SWOT**.
- NATL60 Effective resolution ≃ 10km



NATL60 vs SARAL

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

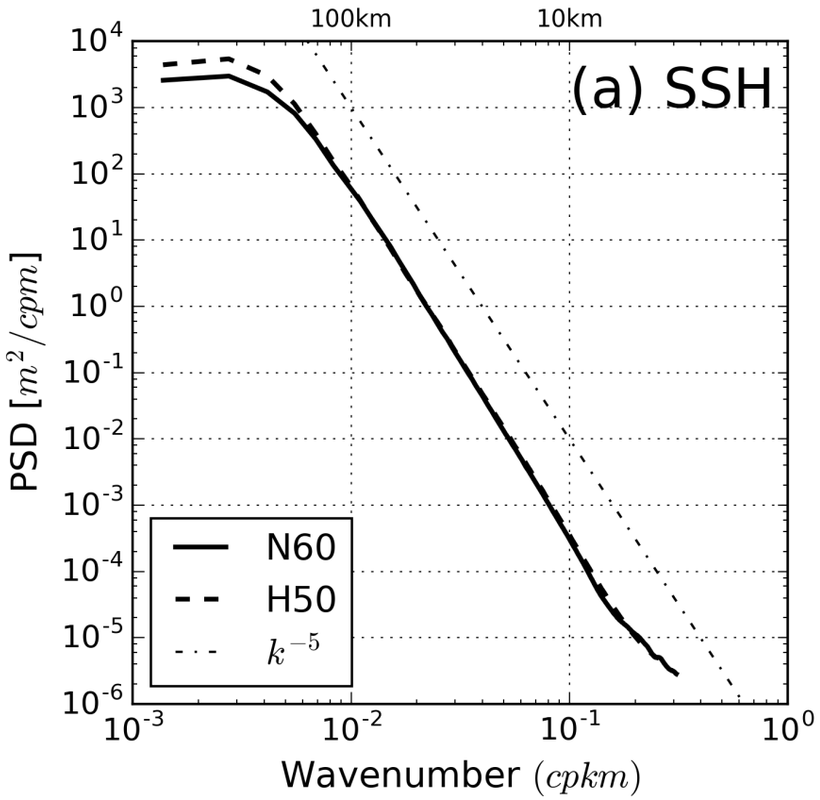


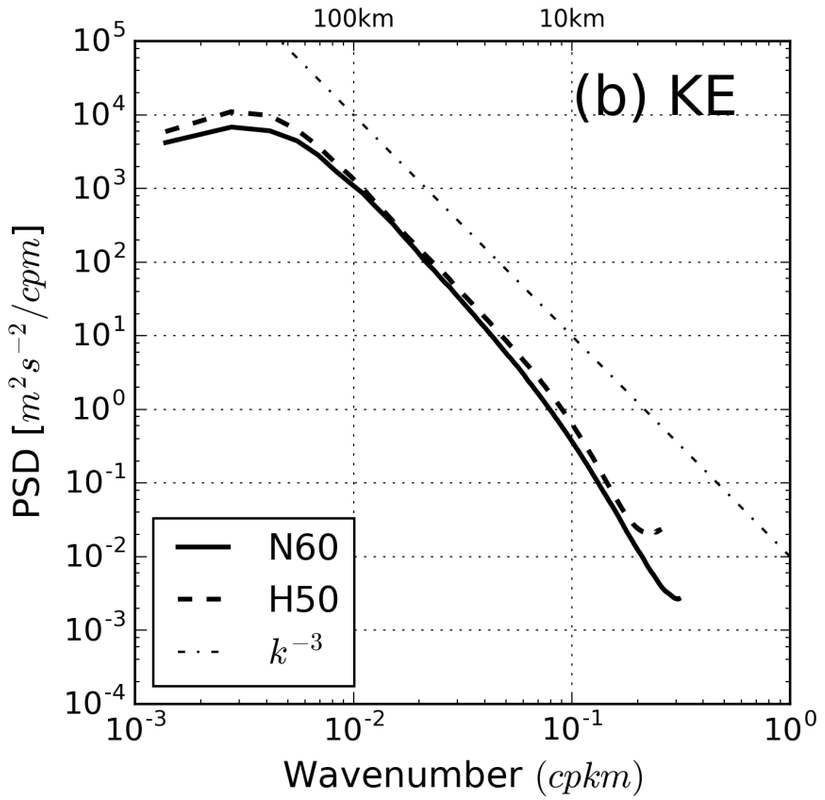


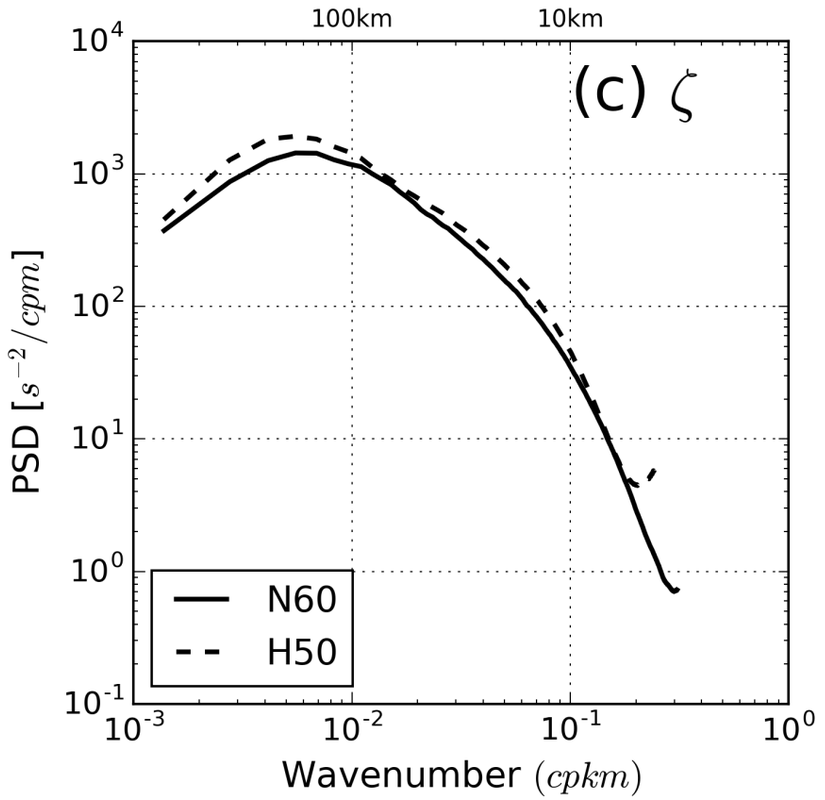
Fair agreement between NATL60 and SARAL at the mesoscale range.

NATL60 vs HYCOM50

Spectra result in a region close to the gulf stream







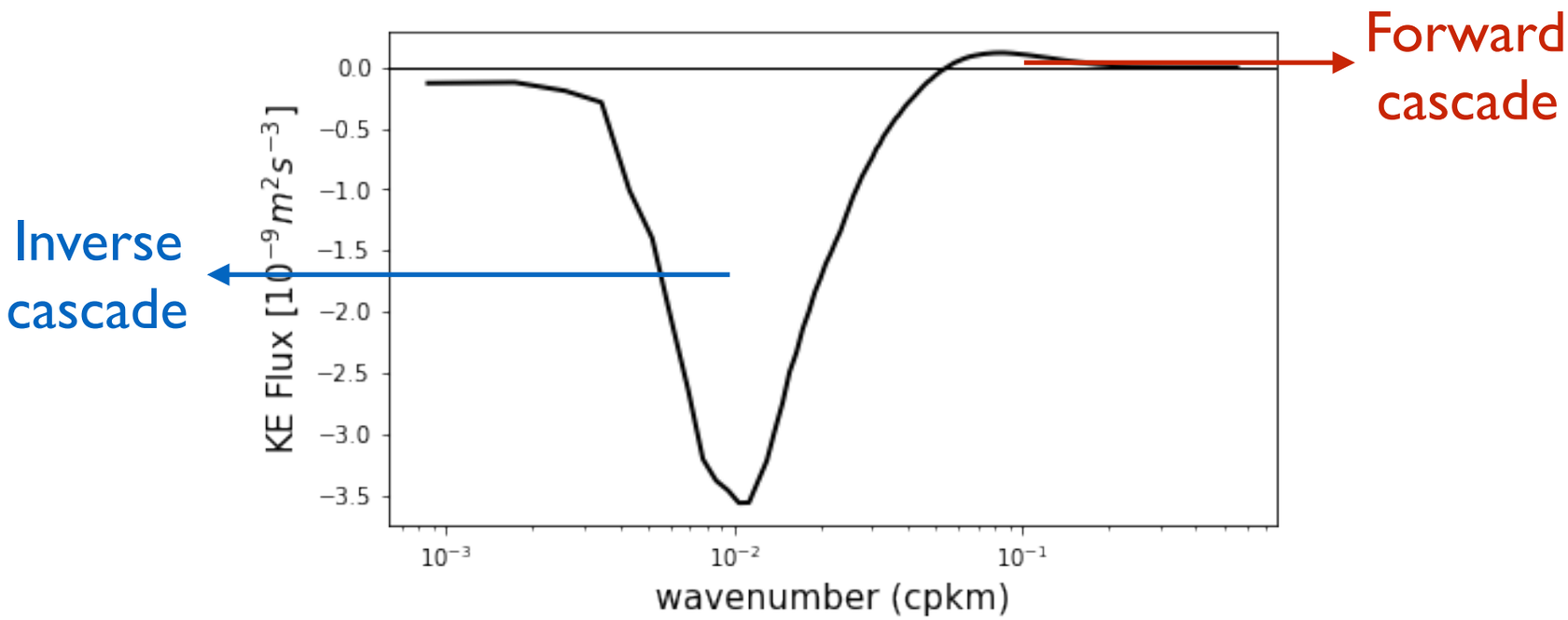
Spectra slopes agrees with the prediction of Quasi-geostrophic dynamics.

(See Julien's talk)

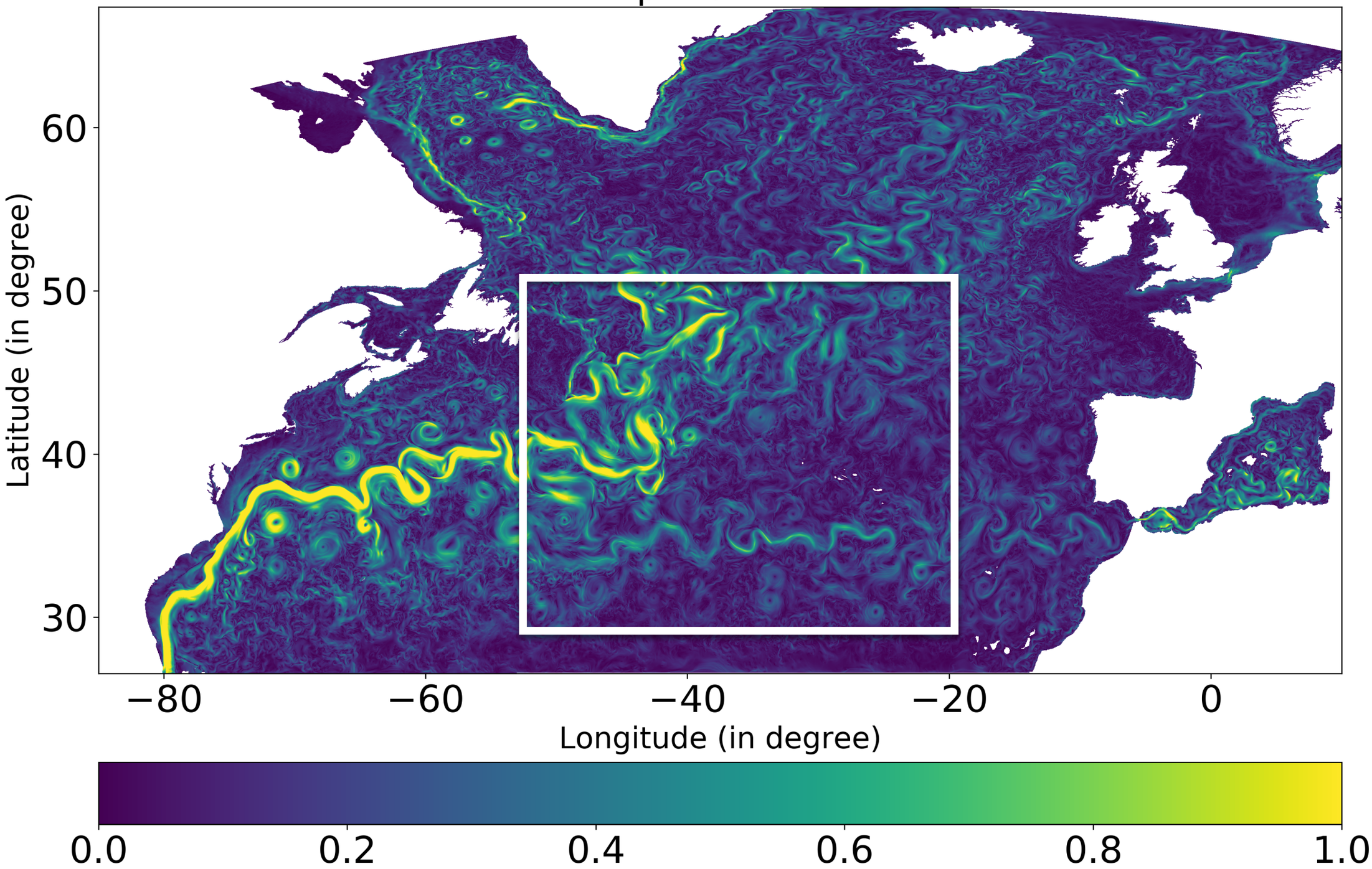
KE spectra flux from advective term

$$\Pi_A(k) = \int_k^{k_s} -\mathrm{Re}\left[\widehat{\mathbf{u}}^* \cdot \left(\widehat{\mathbf{u} \cdot \nabla_H \mathbf{u}}\right)\right](k)\, dk,$$

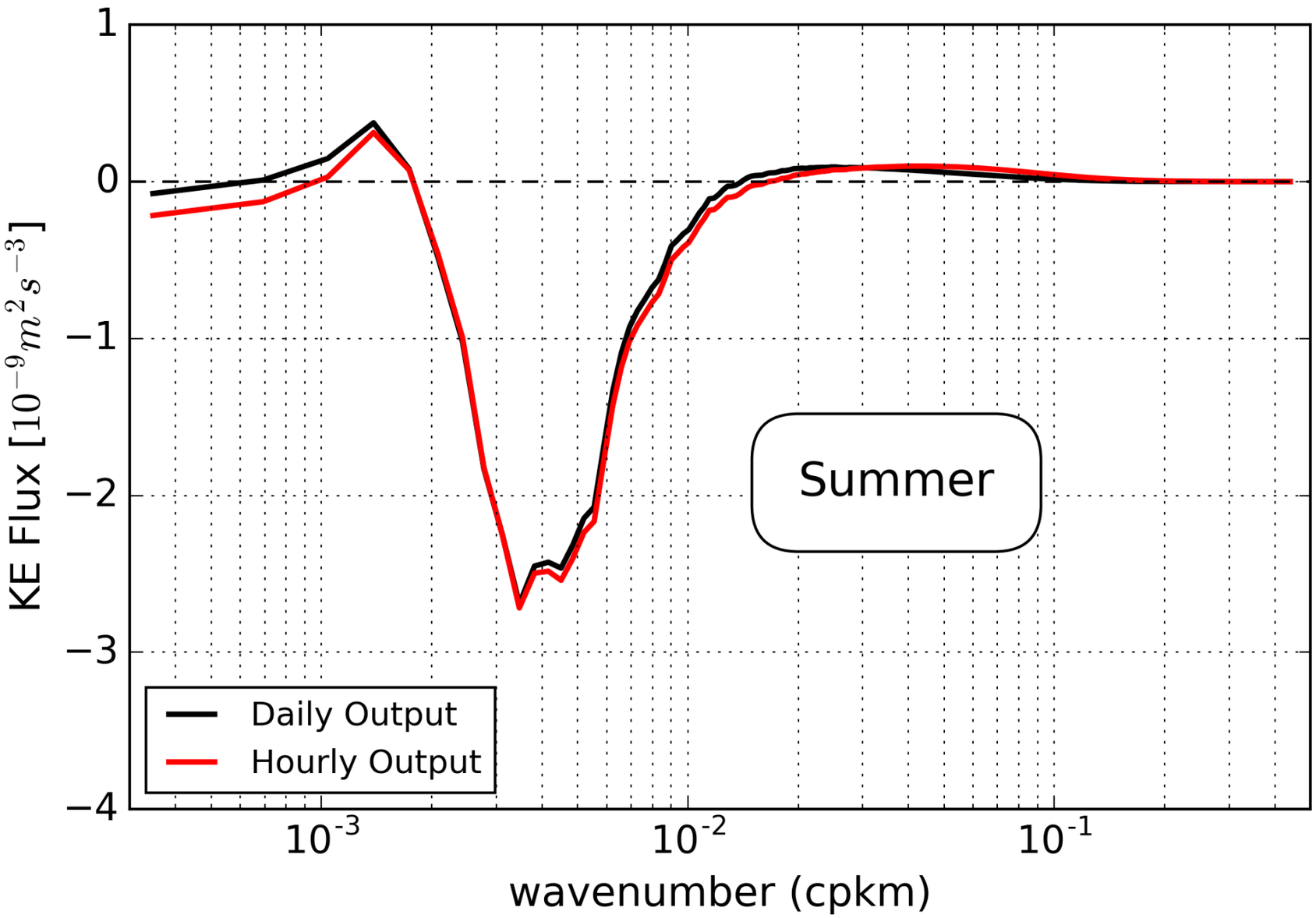
Π is integral of the local horizontal advective term from k to the largest wavenumber k_s. k_s is the wavenumber corresponding to the gridsize.



At a given wavenumber k, Π corresponds to the KE that fluxes from smaller wavenumbers to larger wavenumbers. A POSITIVE (negative) value corresponds to a FORWARD (inverse) KE cascade.

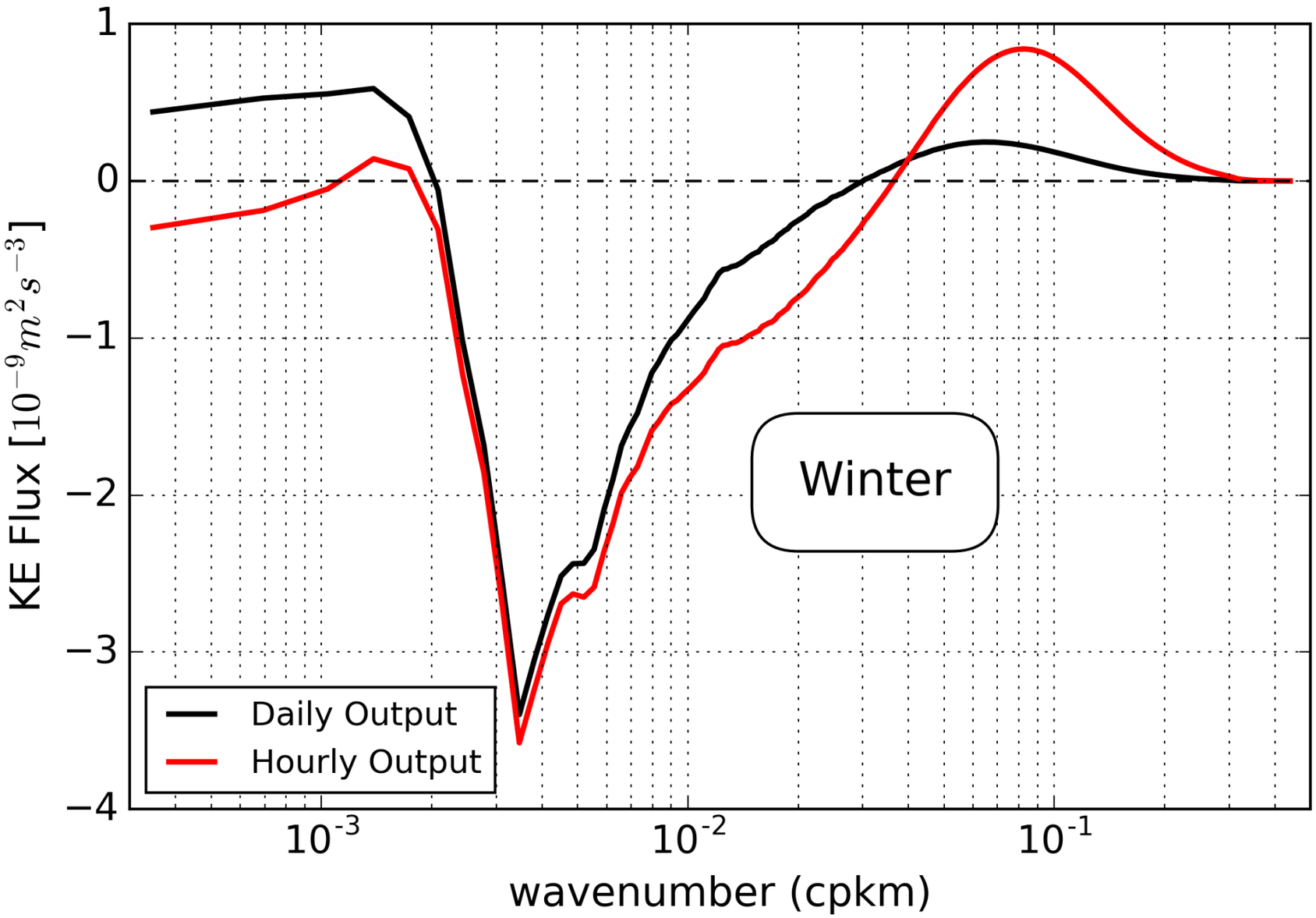

Surface Speed : 2013-03-01
60
50
40
30
Latitude (in degree)
−80
−60
−40
−20
0
Longitude (in degree)
0.0
0.2
0.4
0.6
0.8
1.0

KE spectra flux : JAS



- Inverse cascade of energy dominate in summer time.
- Inverse cascade from 100km upward.

KE spectra flux : JFM



- Inverse cascade from 30km upward (submesoscale feeding large scale flows).
- Direct cascade at high wavenumber with stronger cascade in hourly outputs. Why ?
- A factor of 4 difference between Hourly / Daily forward cascade.
- This difference in hourly/daily KE spectra flux is observed only in winter time.

Frequency-Wavenumber Spectra

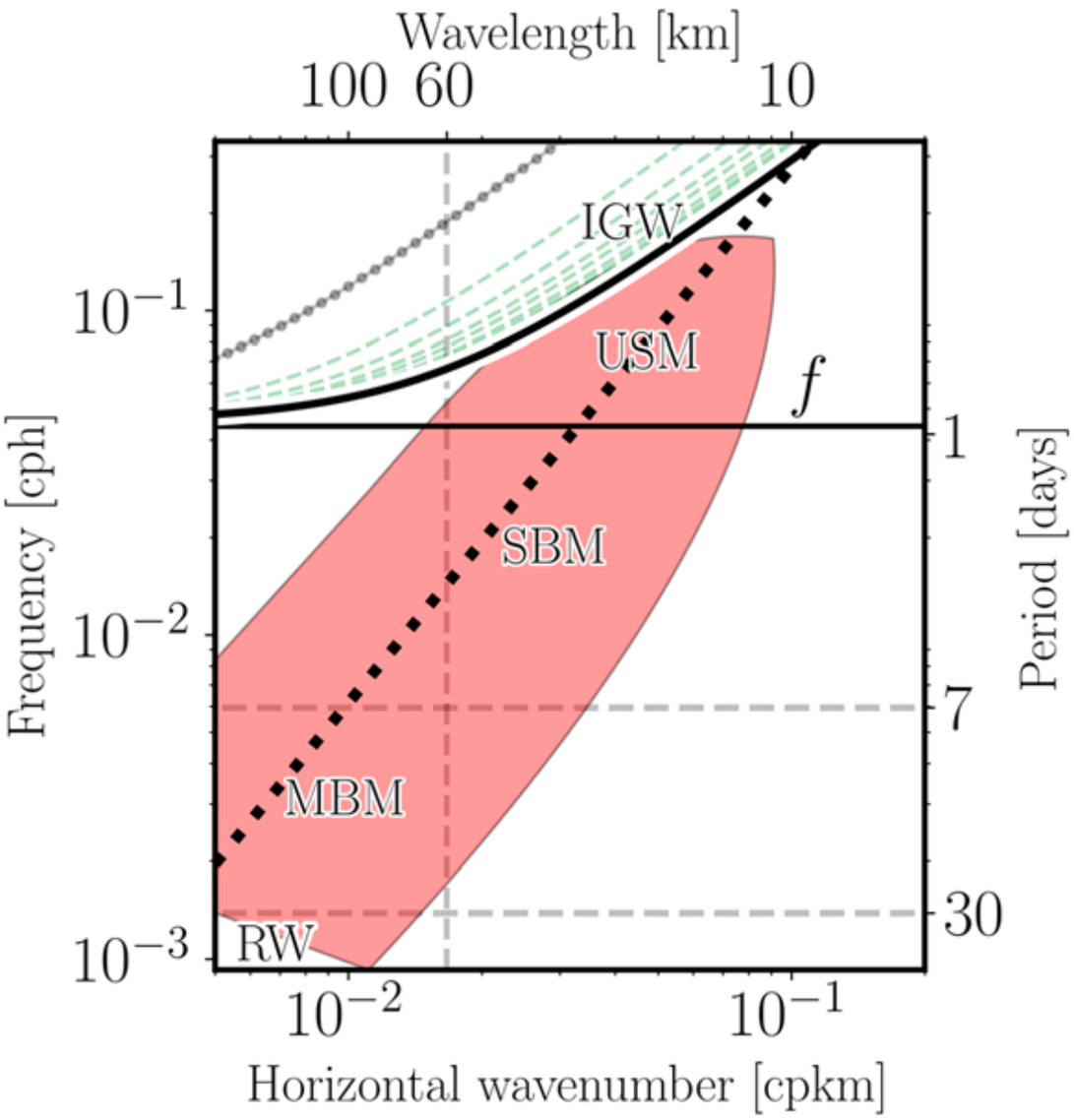
Journal of Geophysical Research: Oceans

RESEARCH ARTICLE
10.1029/2018JC014438

Key Points:
- The respective signature of balanced motions and internal gravity waves on different surface oceanic fields has been revealed

Partitioning Ocean Motions Into Balanced Motions and Internal Gravity Waves: A Modeling Study in Anticipation of Future Space Missions

Hector S. Torres[1], Patrice Klein[1,2], Dimitris Menemenlis[1], Bo Qiu[3], Zhan Su[1], Jinbo Wang[1], Shuiming Chen[3], and Lee-Lueng Fu[1]



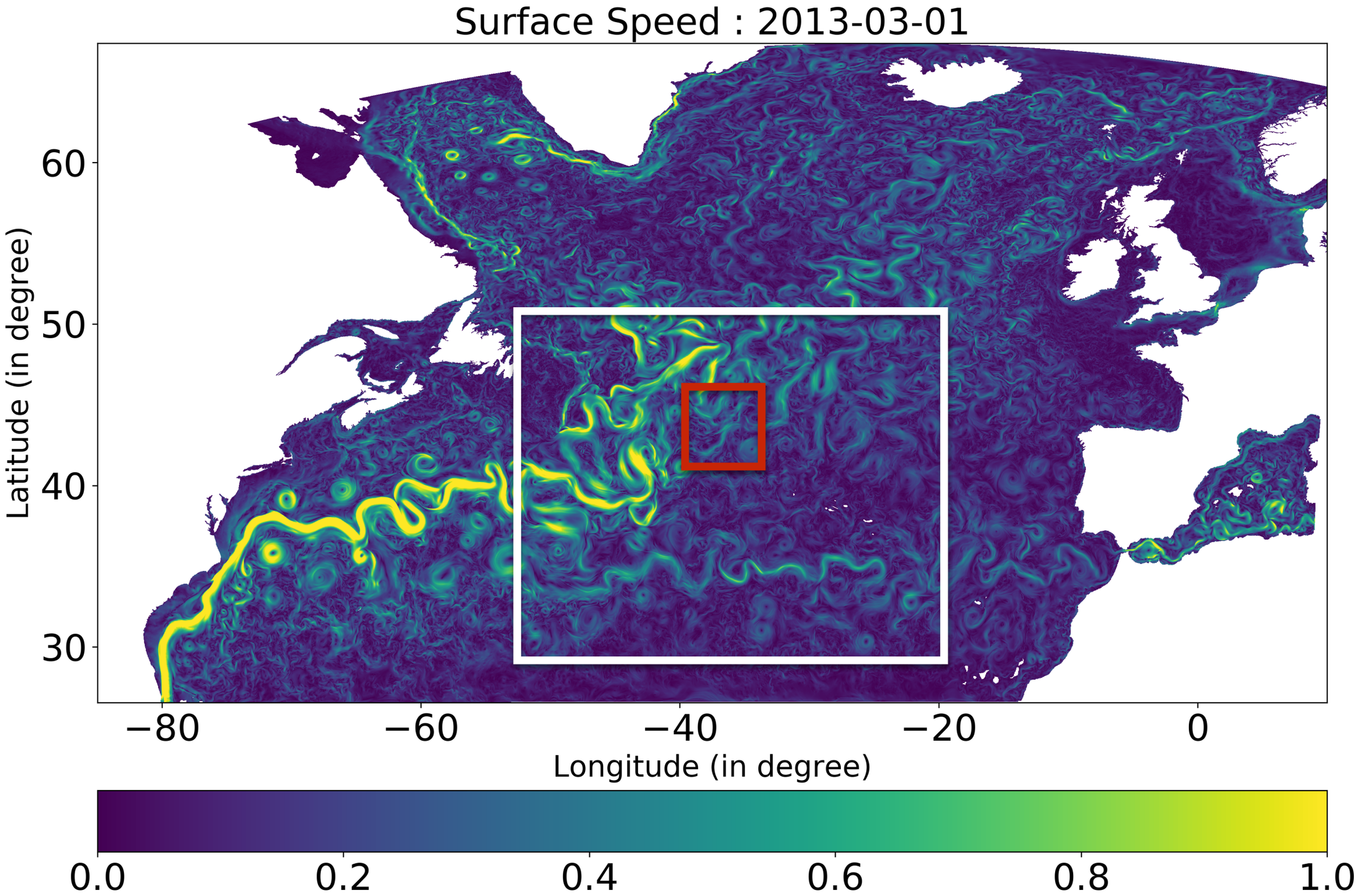
RW : Rossby Waves.

MBM : Mesoscale Balanced Motions.

SBM : Submesoscale Balanced Motions.

USM : Unbalanced Submesoscale Motions.

IGW : Internal Gravity Waves.


Surface Speed : 2013-03-01
60
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Latitude (in degree)
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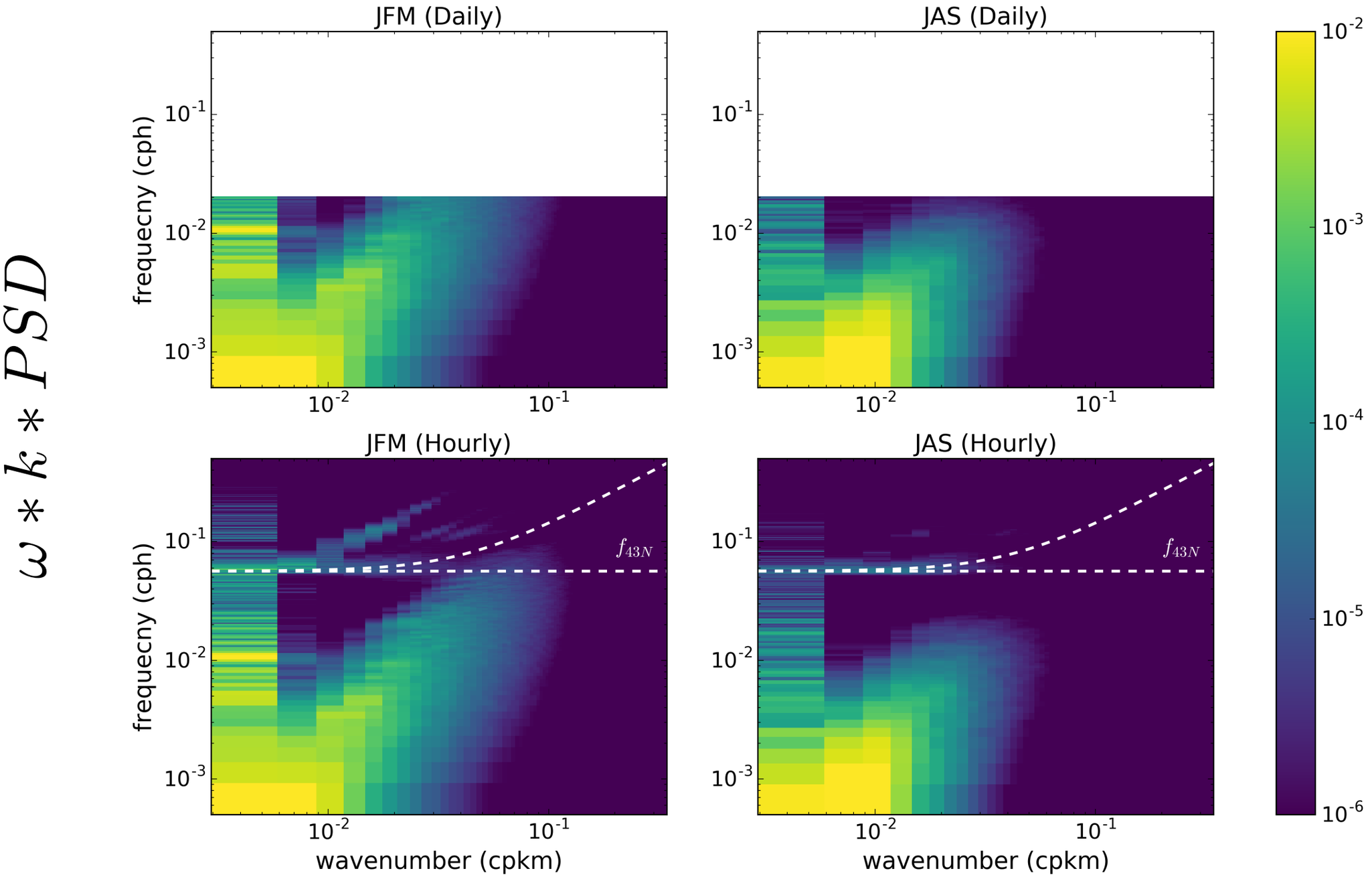
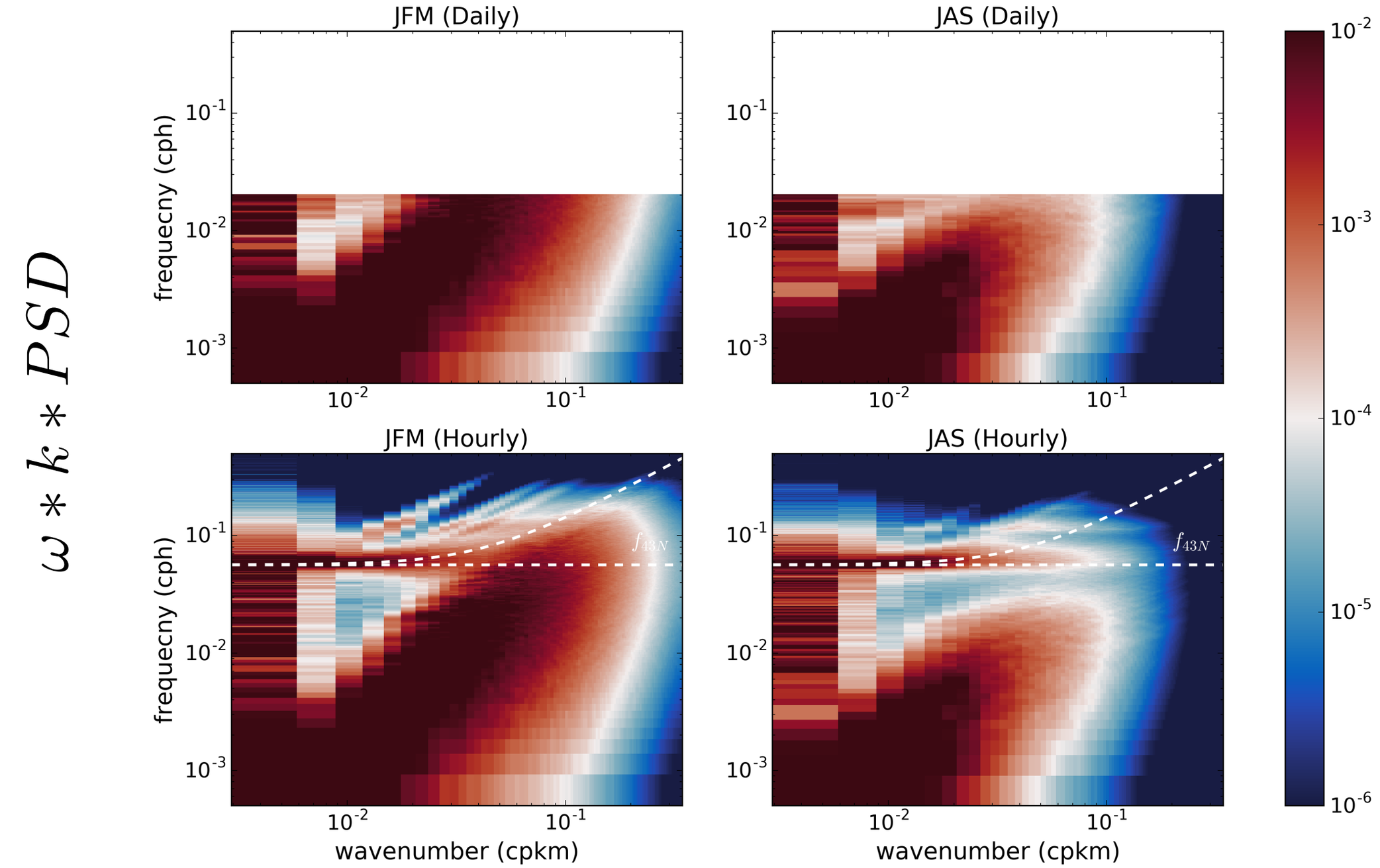
SSH : w-k spectra



- We resolve high frequency motions (IGWs and USM) in winter for hourly output.

KE : w-k spectra

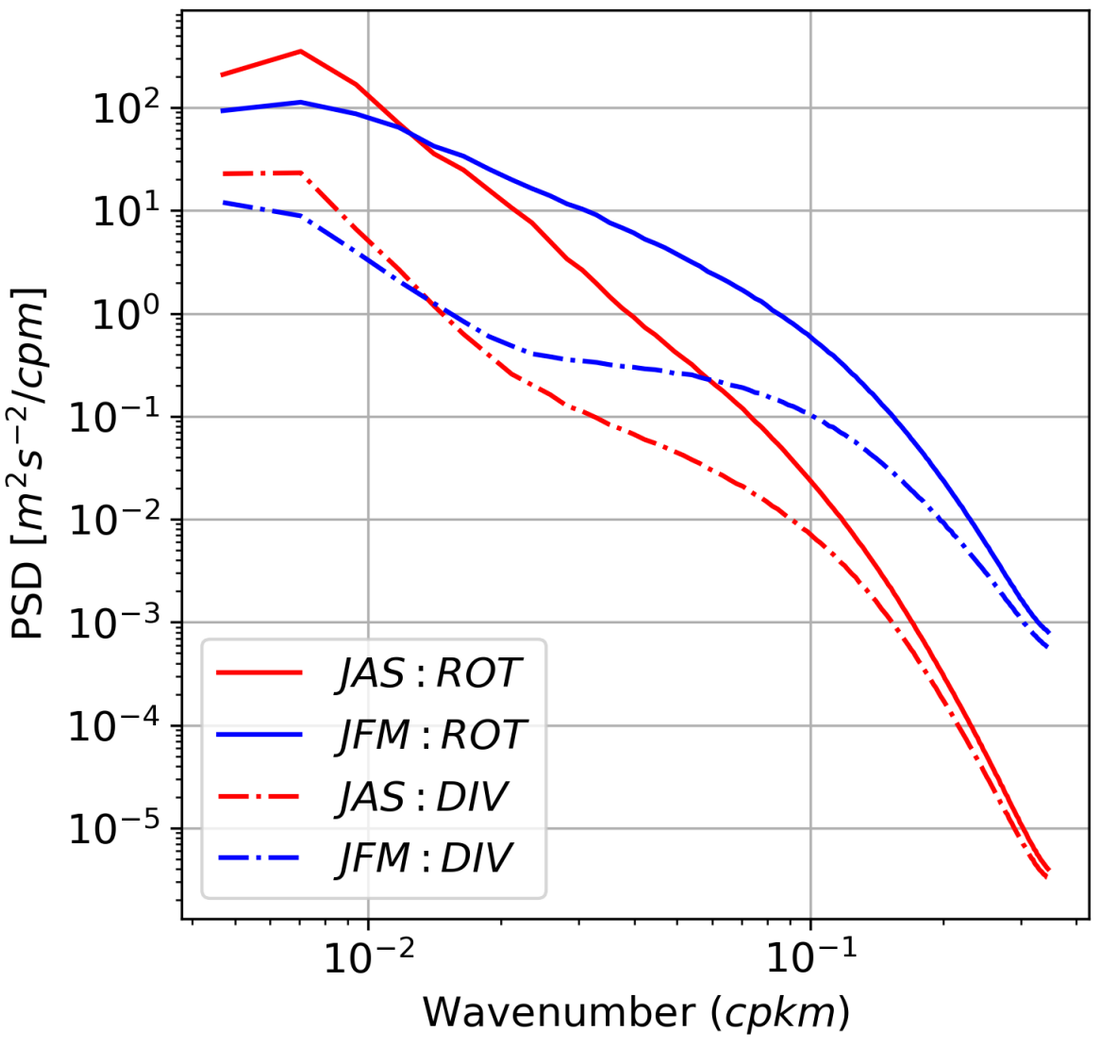


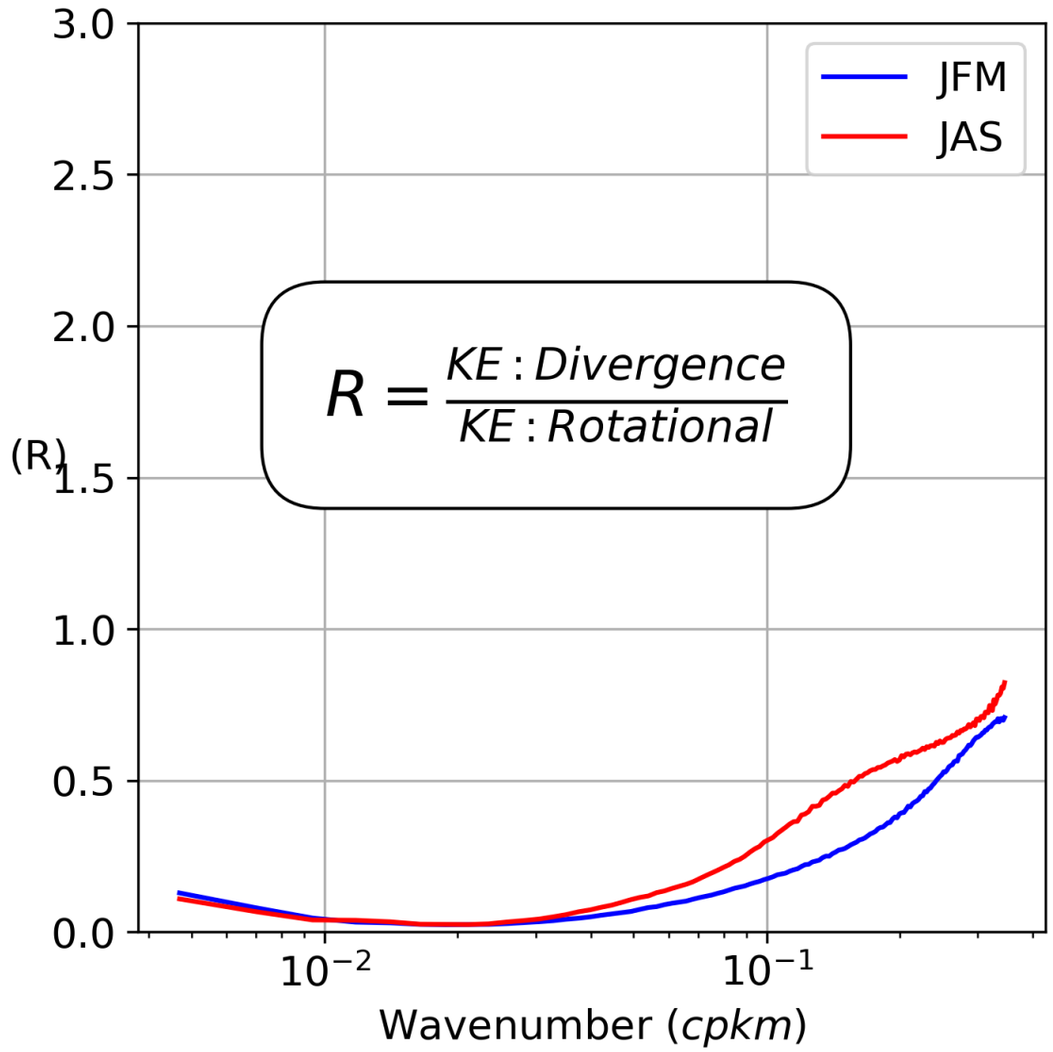
- We resolve high frequency motions (IGWs and USM) in winter for hourly output.
- Stronger signature of high frequency motions in KE spectra compare to SSH spectra.
- Weaker signature of IGW in summer time.
- Balanced and unbalanced motions are more energetic in winter

KE : Helmotz Decomposition

Rotational $\quad \zeta = v_x - u_y, \quad ROT = |\hat{\zeta}|^2 / k^2$

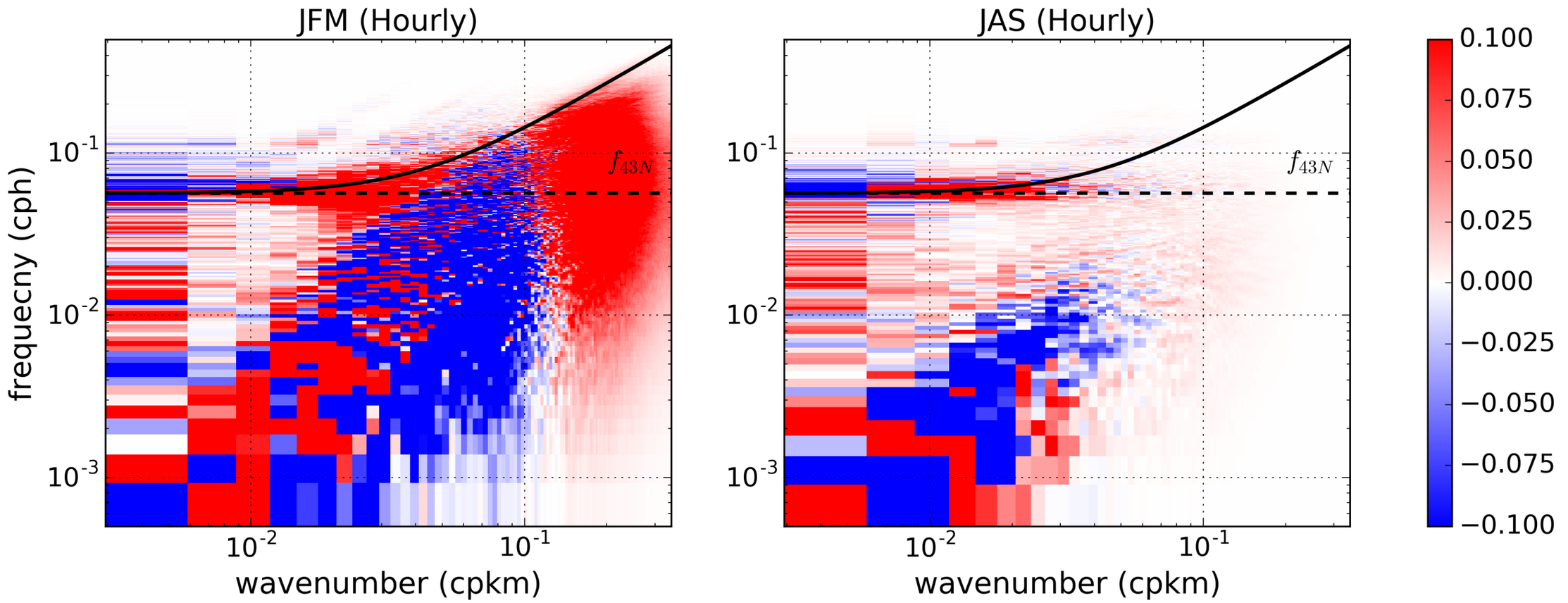
Divergent $\quad \delta = u_x + v_y, \quad DIV = |\hat{\delta}|^2 / k^2$



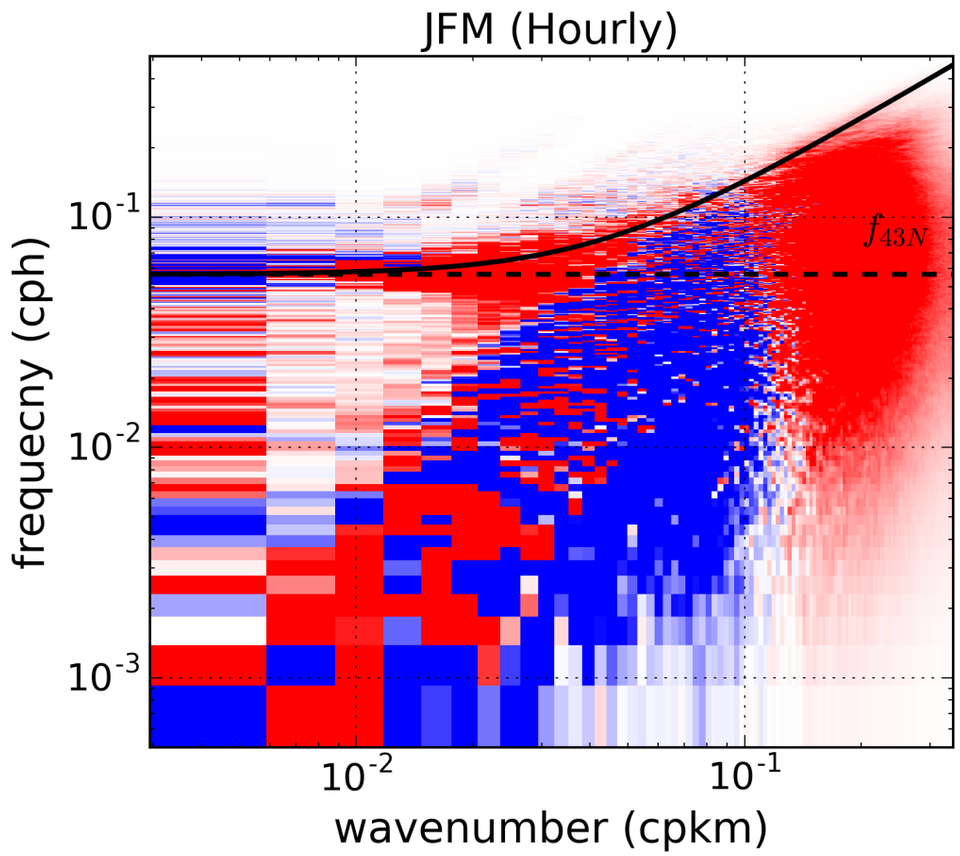


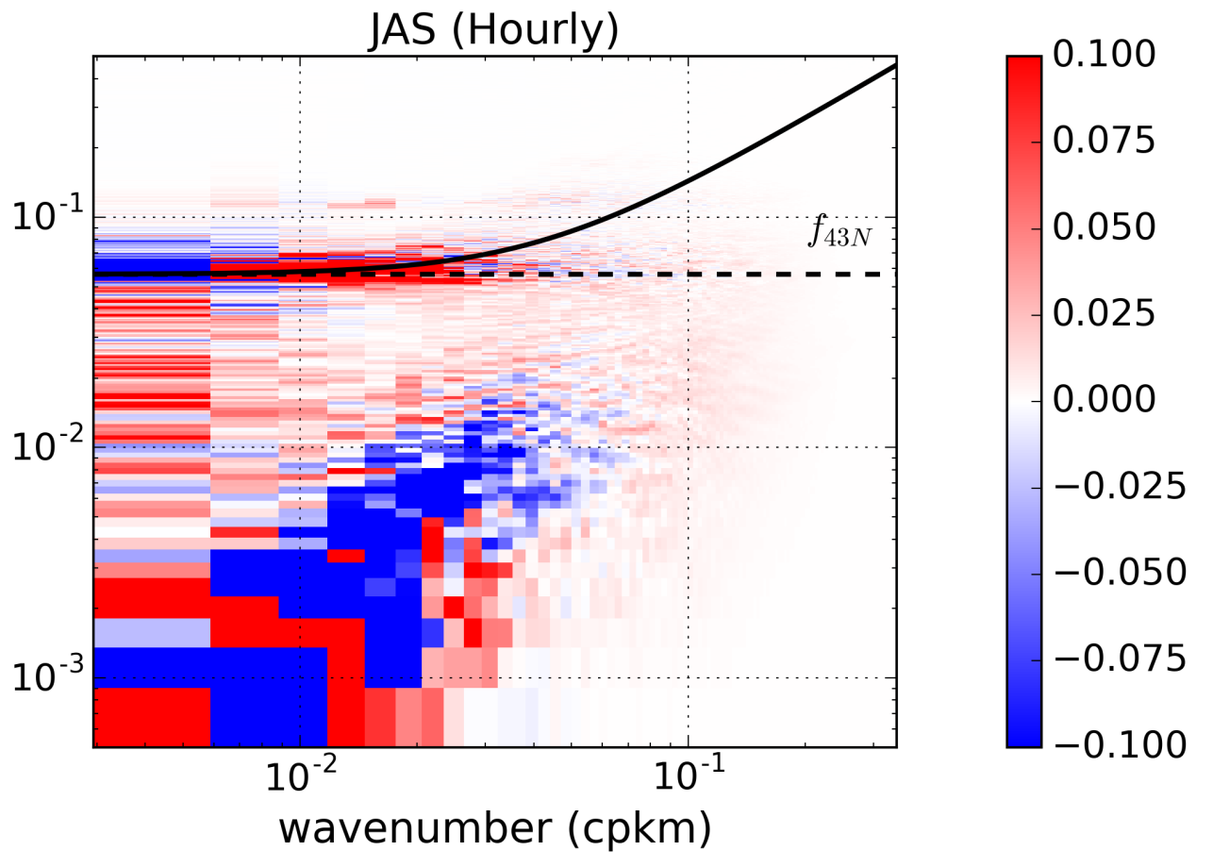
- Rotational flow is more energetic than divergent flow across all scales in both seasons
- Flow dynamics is dominated by balanced motions.

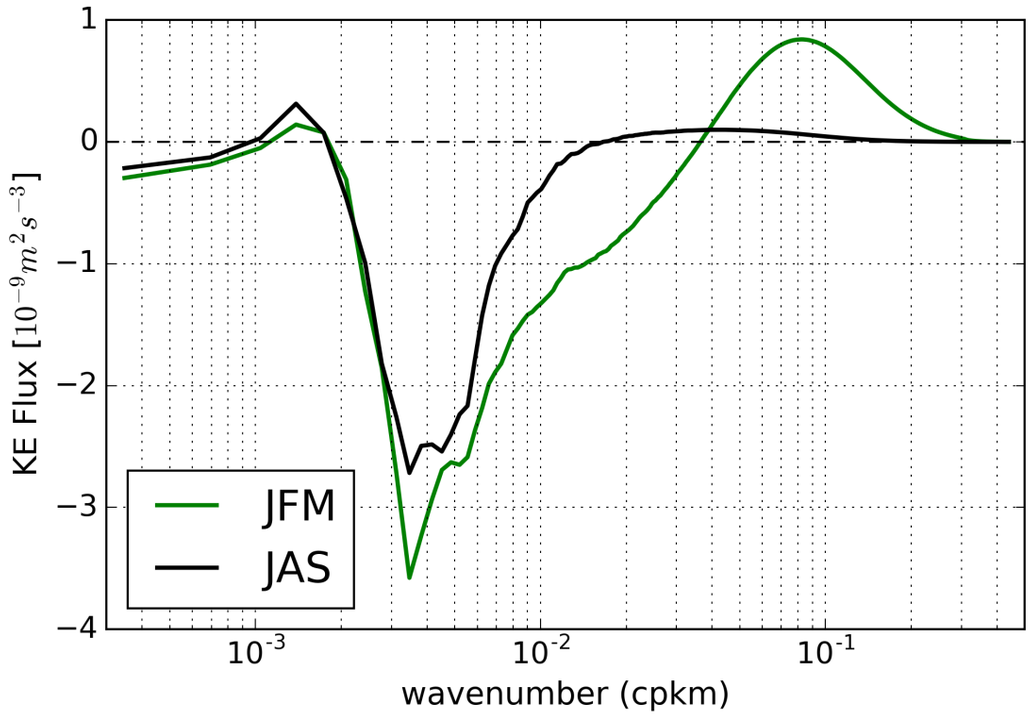
KE transfer : w-k spectra



KE transfer : w-k spectra







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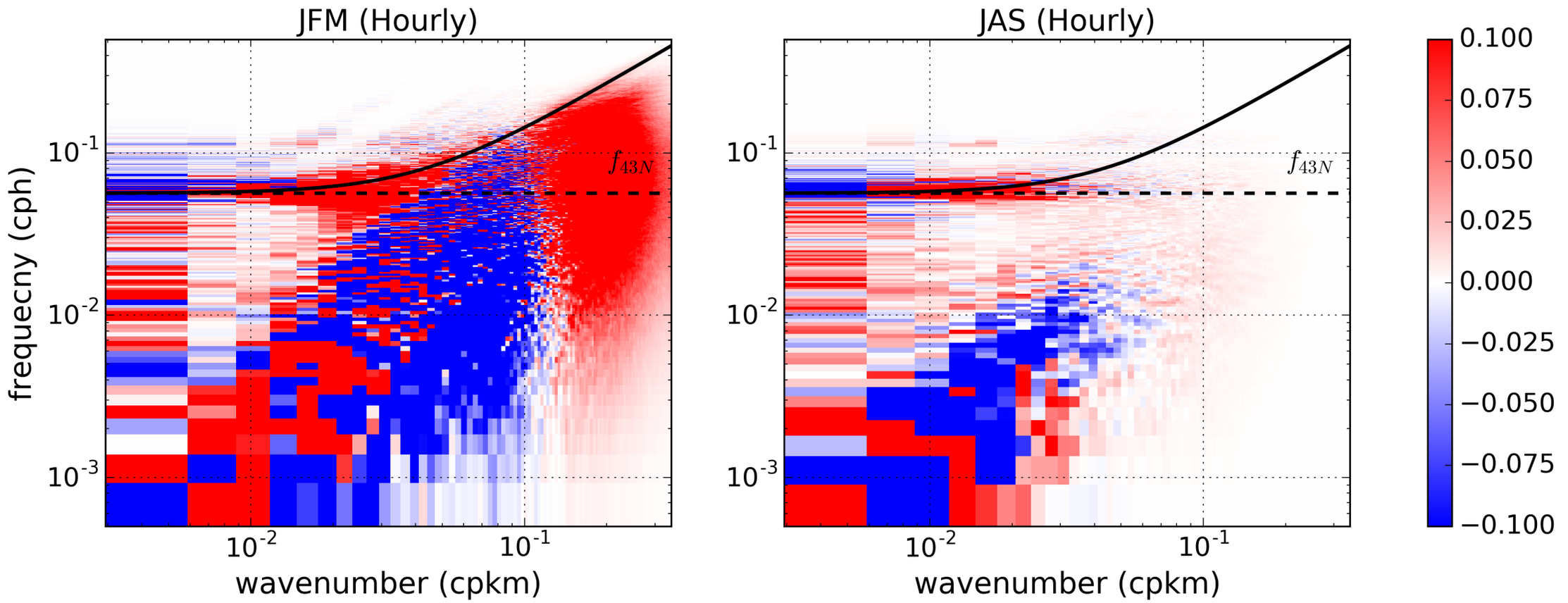
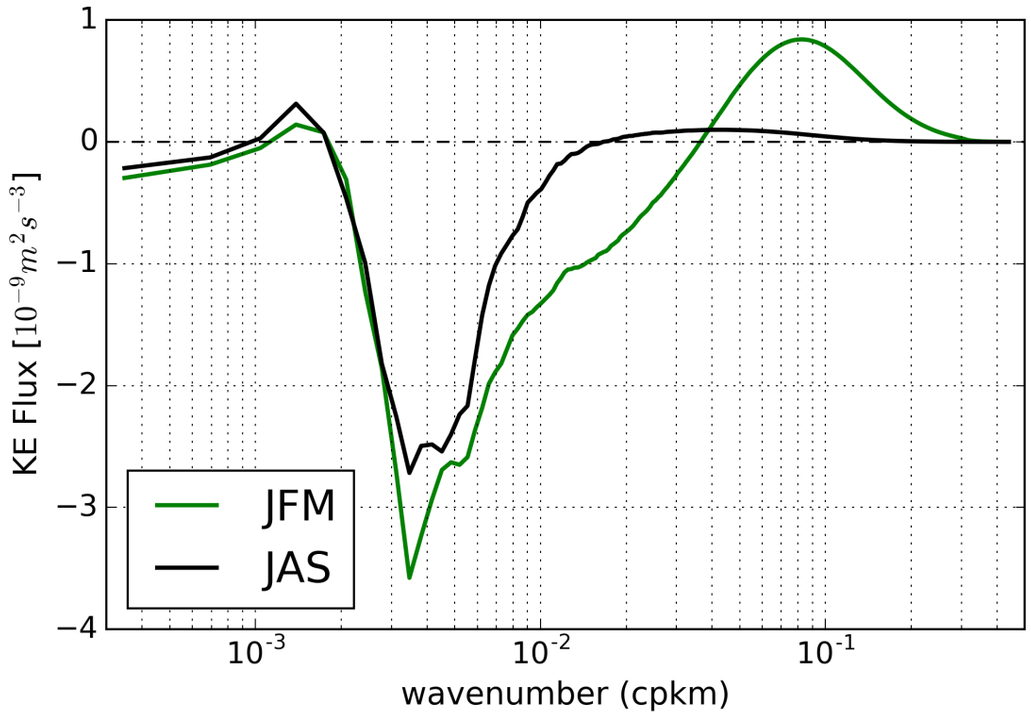


- Balanced motions are associated with upscale transfer of energy.
- In winter, there is a well-defined separation scale across all frequency band at which kinetic energy is transferred to centimetre scale.



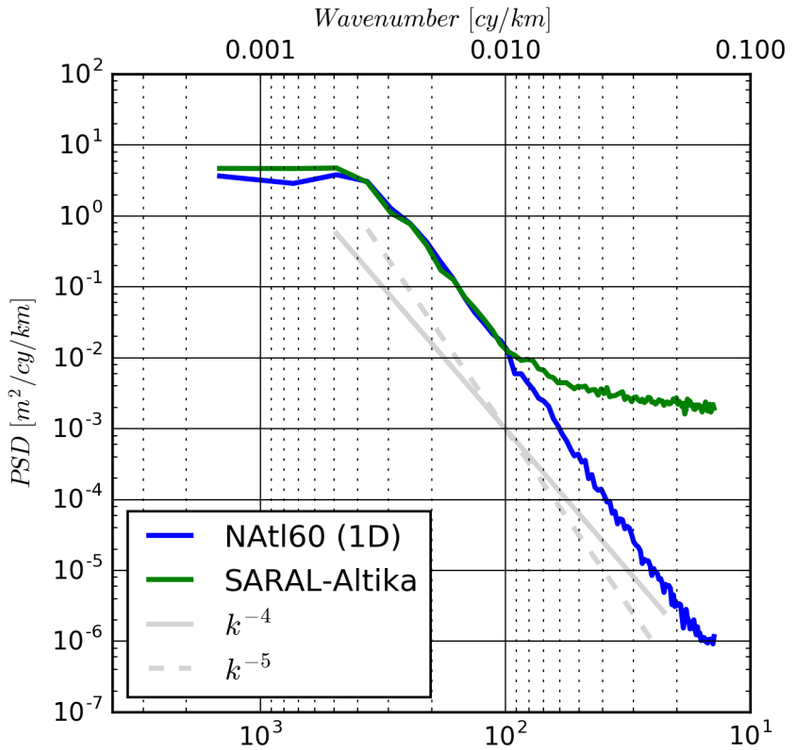
In summary

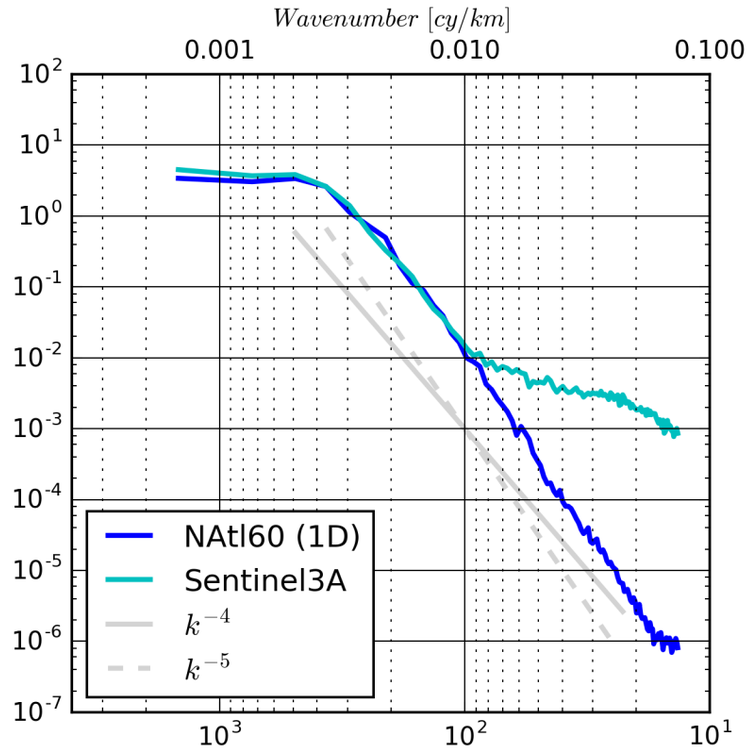
- SBMs are more energetic in winter compare to summer and they mostly represent a source of energy for large scale flow through inverse cascade.
- High frequency motions have stronger signature in KE spectra than in SSH spectra and are involved both in inverse cascade and a direct cascade of energy towards dissipation.
- In this model simulation (without tides), high frequency motions have almost no impact on energy transfer in summer time.

Future Work :

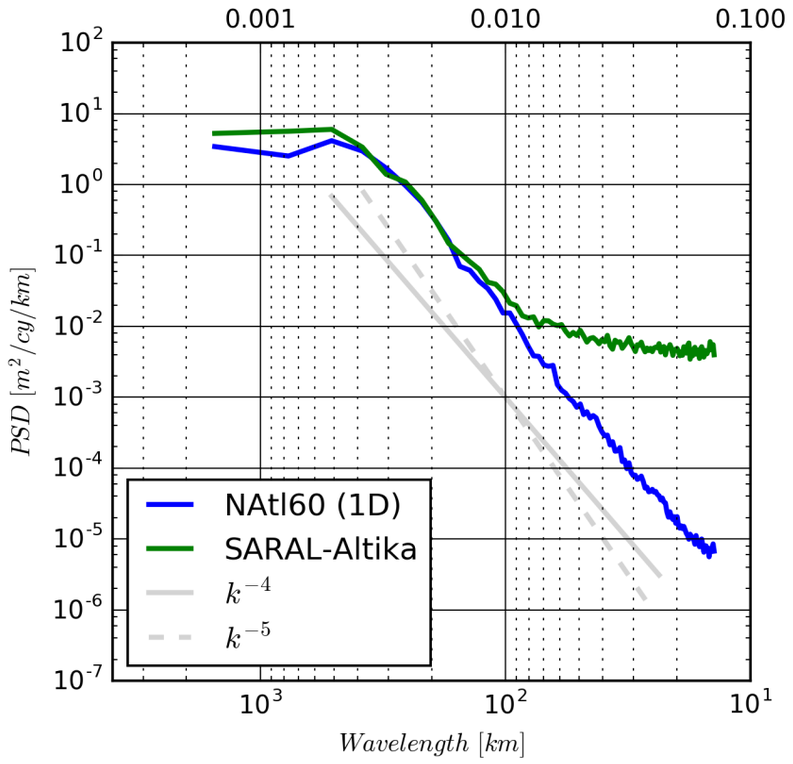
- Estimate w-k spectra for w'b'
- Reproduce this analysis with eNATL60 (NATL60 + Tides)

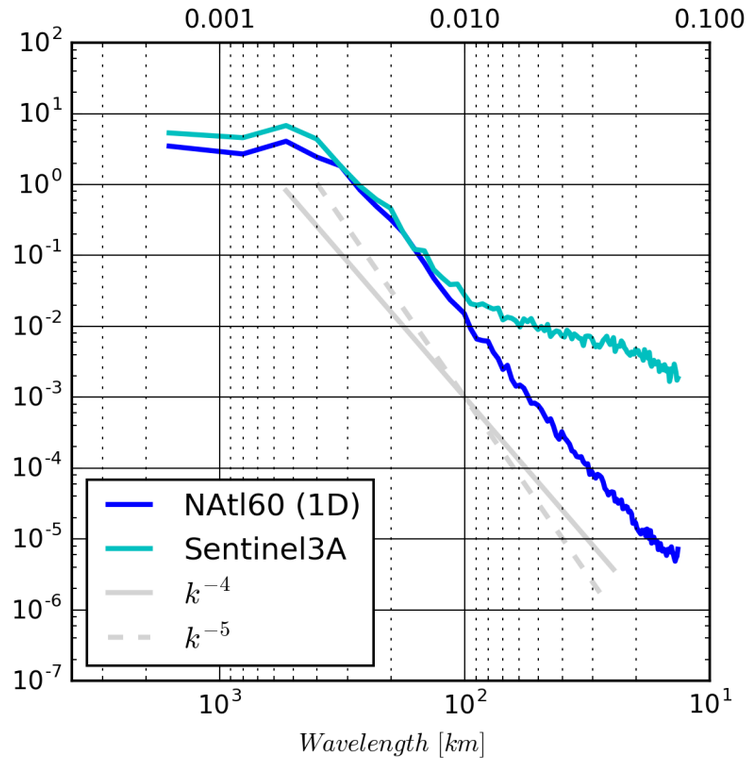
Sumemr

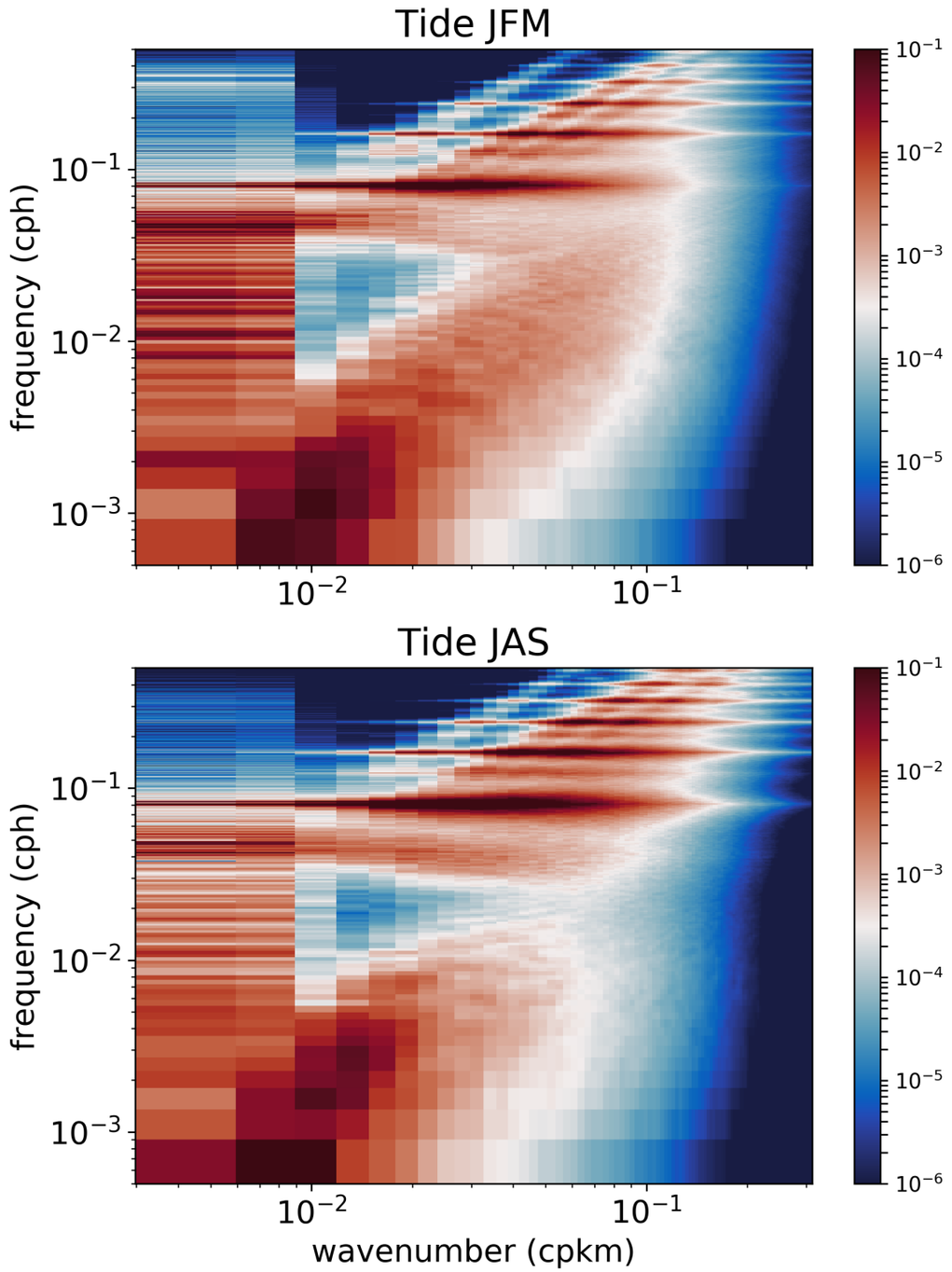




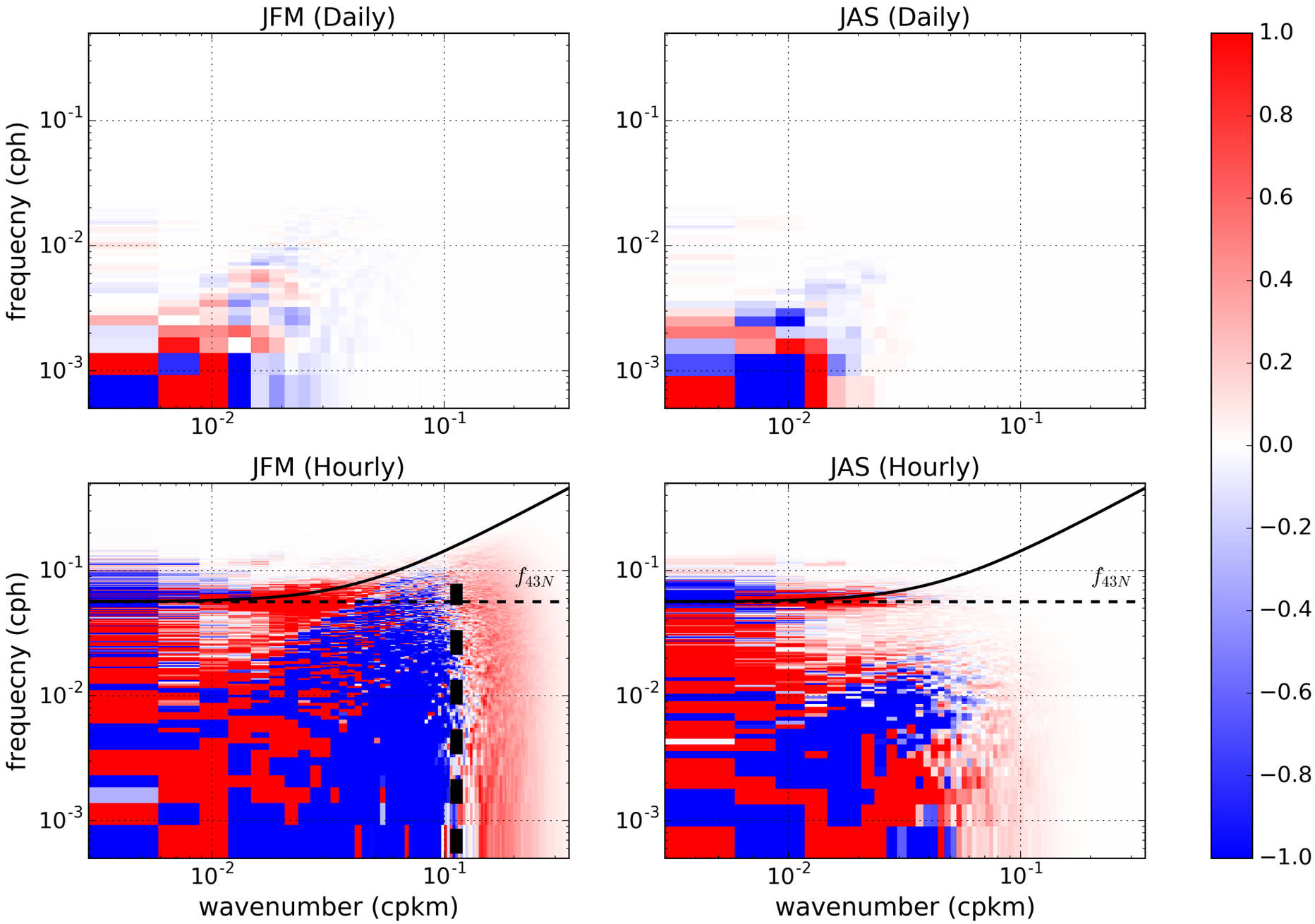
Winter



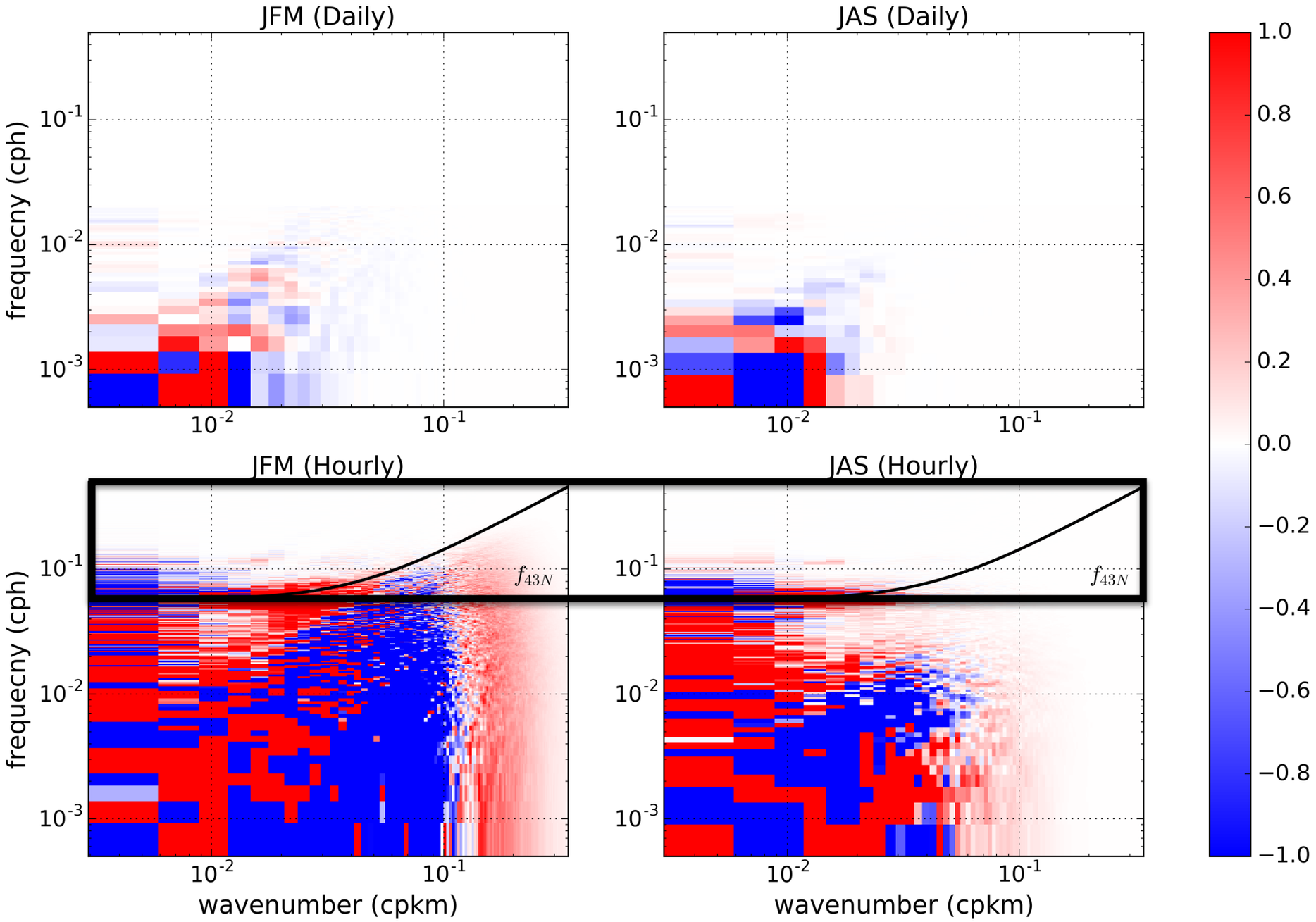



Tide JFM
No tide JFM
Tide JAS
No tide JAS
frequency (cph)
wavenumber (cpkm)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}

KE transfer : w-k spectra



KE transfer : w-k spectra



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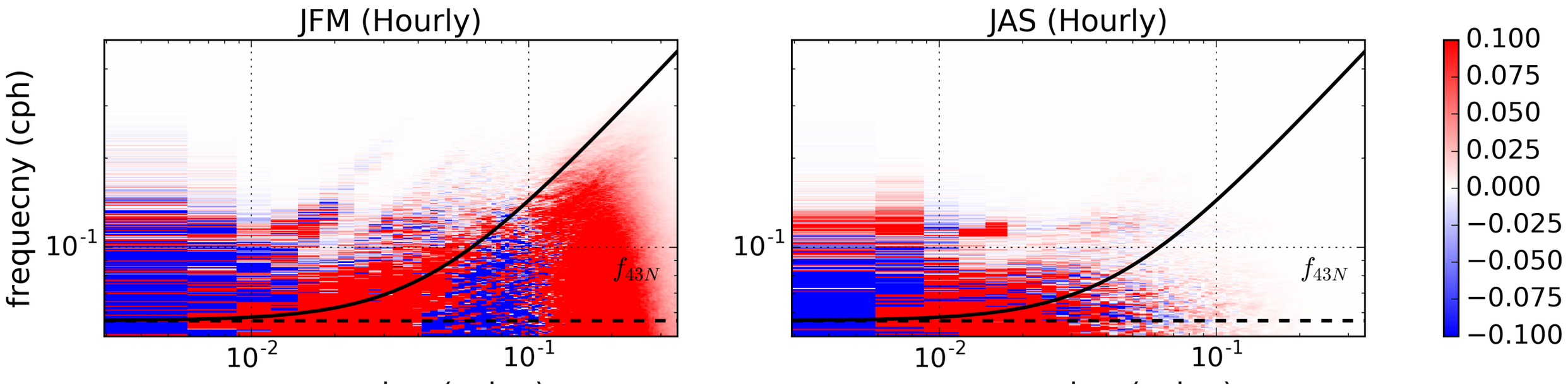

- Stronger signature of IGW in winter