Statistical analysis of small scale processes from satellite SST observations

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Small scale :

- ~ Roughly 1-80 km

- Submesoscale features as fronts, filaments, spirals are numerous in high resolution satellite images.

- Processes at this scale, associated to large vertical velocities, play an important role in the vertical transport from the surface to the interior and in exchanging gases between the atmosphere and the ocean.

- Objective: Analysis of dynamical properties and guided identifications from instantaneous 2D observations: Identify descriptors for the characterization of the submesoscale

$$spectrum(x) = |fft(x)|^2$$: distribution of variance over a range of scales
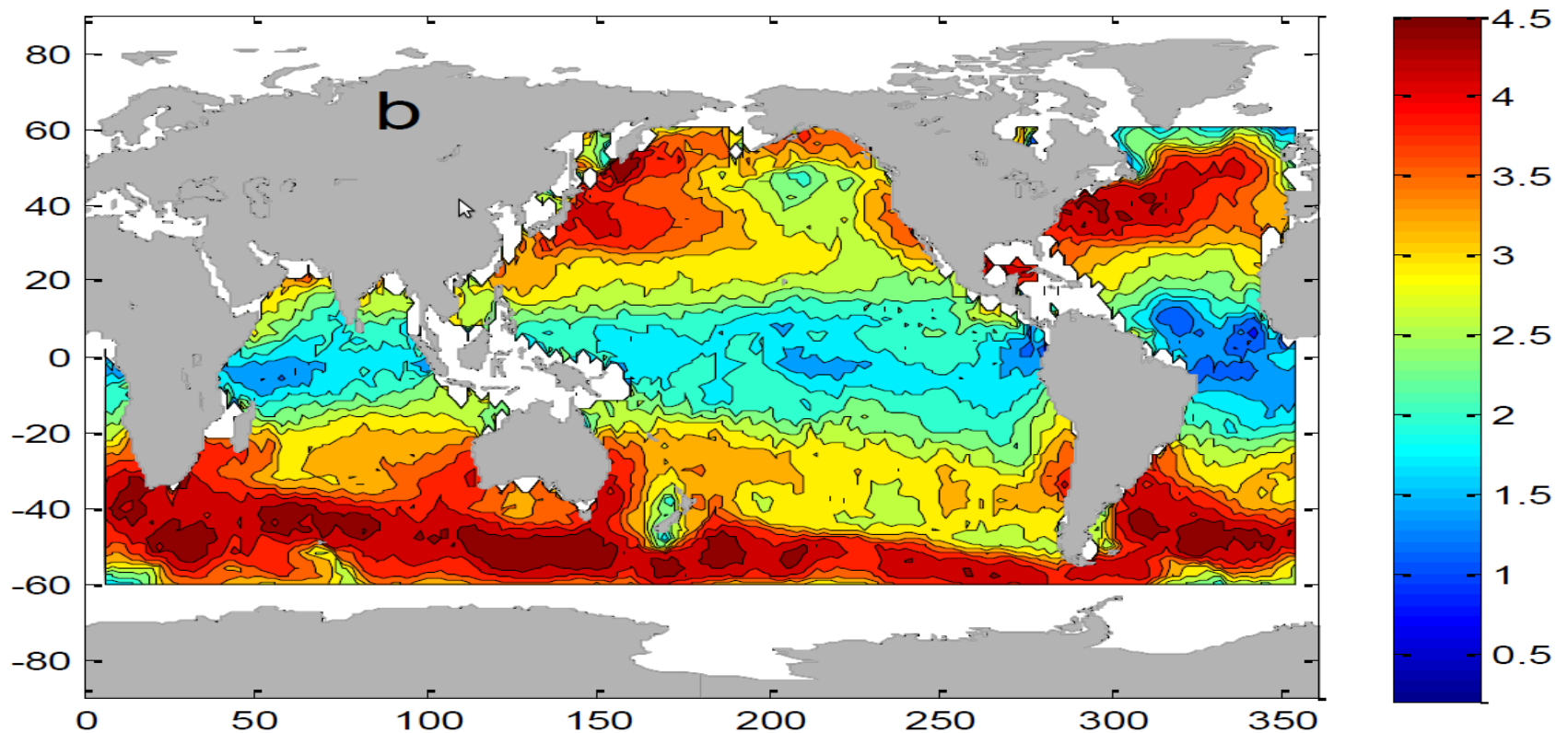
In terms of dynamics :

Wavenumber spectrum, the distribution of kinetic energy
over a range of spatial scales, used as information on the
underlying processes of oceanic turbulence.
Various theories predict the shape (power law) of the
wavenumber spectrum.

Characterizing the submesoscale   -   Spectral approach
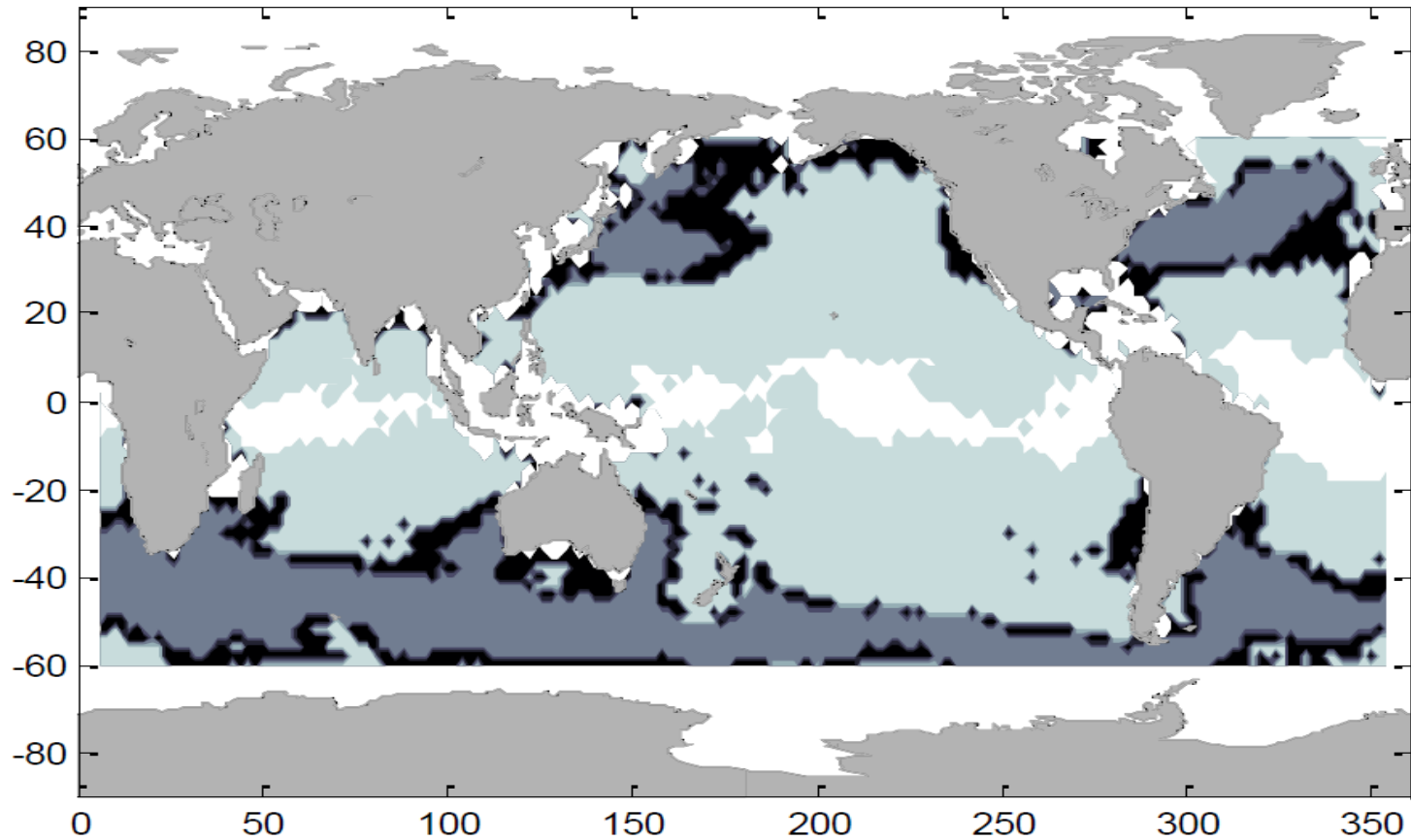
SSH wavenumber spectral slopes in the **70-250 km** band

Global distribution of SSH spectral slope (Xu and Fu 2011, Xu and Fu 2012)

2003-2009 mean of the wavenumber spectral slope in the 70-250 km wavelength band from Jason 1 Along-Track data (within 10°x10° box) at 2°x2° grid resolution

Characterizing the submesoscale - Spectral approach

SSH wavenumber spectral slopes in the **70-250 km** band

Black : ~ -11/3 (SQG), transition zones from the edge to the core of the major ocean current systems
Dark Gray : steeper than -11/3 , ocean dominated by fronts
Light gray : flatter than -11/3 ,steeper than -2, extratropical areas

from Xu and Fu, 2012
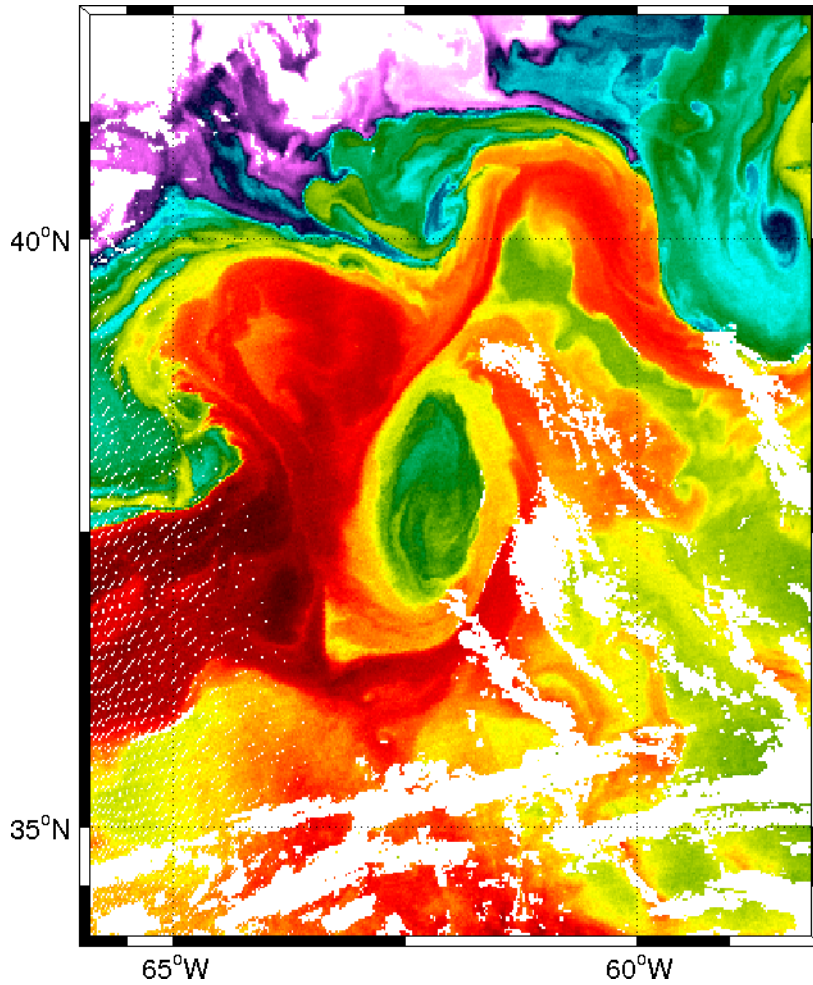
Characterizing the submesoscale - Spectral approach

SST wavenumber spectral slopes in the **80-250 km** band
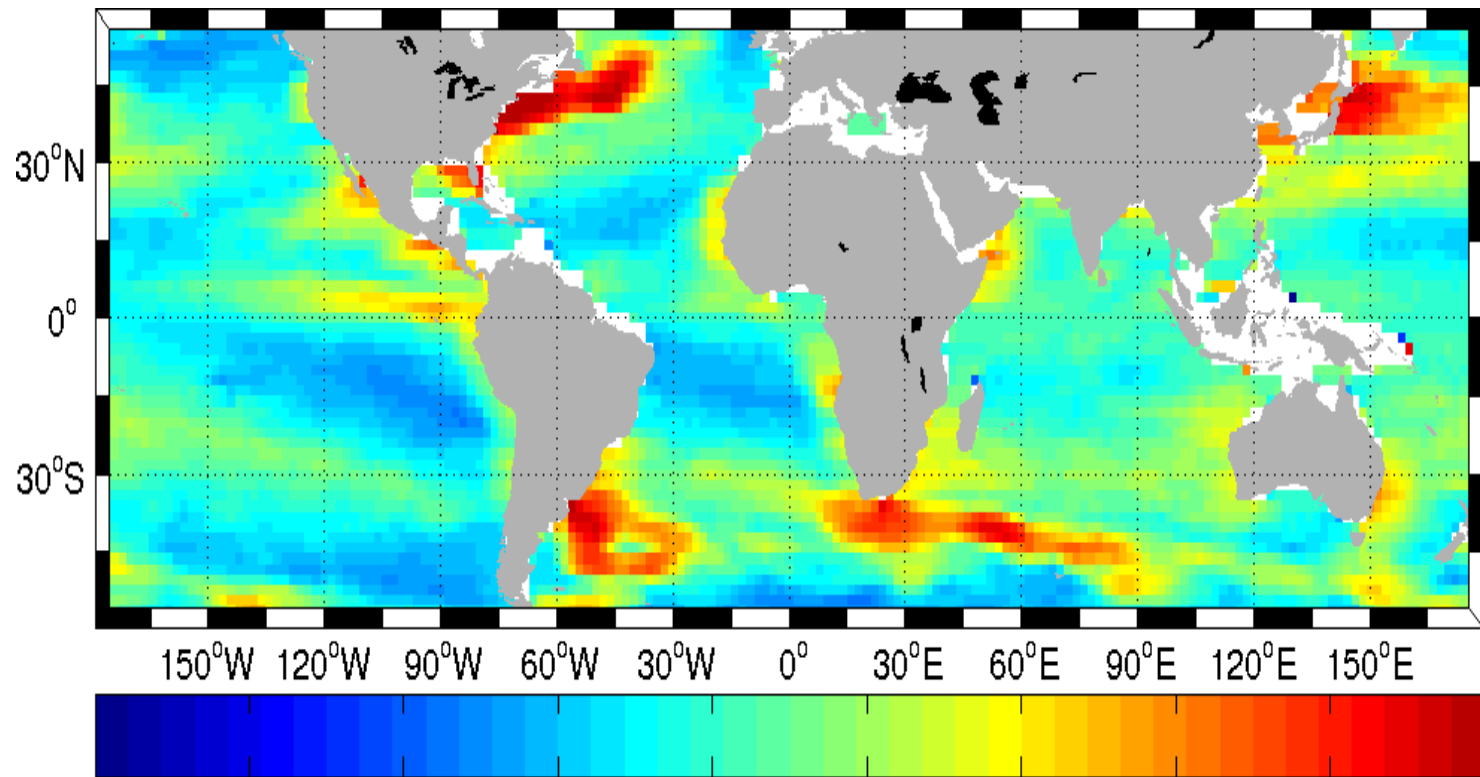
2003-2009 mean of the wavenumber spectral slope in the 80-250 km wavelength band calculated from AMSRE L3 data (within 8°x8° box) at 2°x2° grid resolution
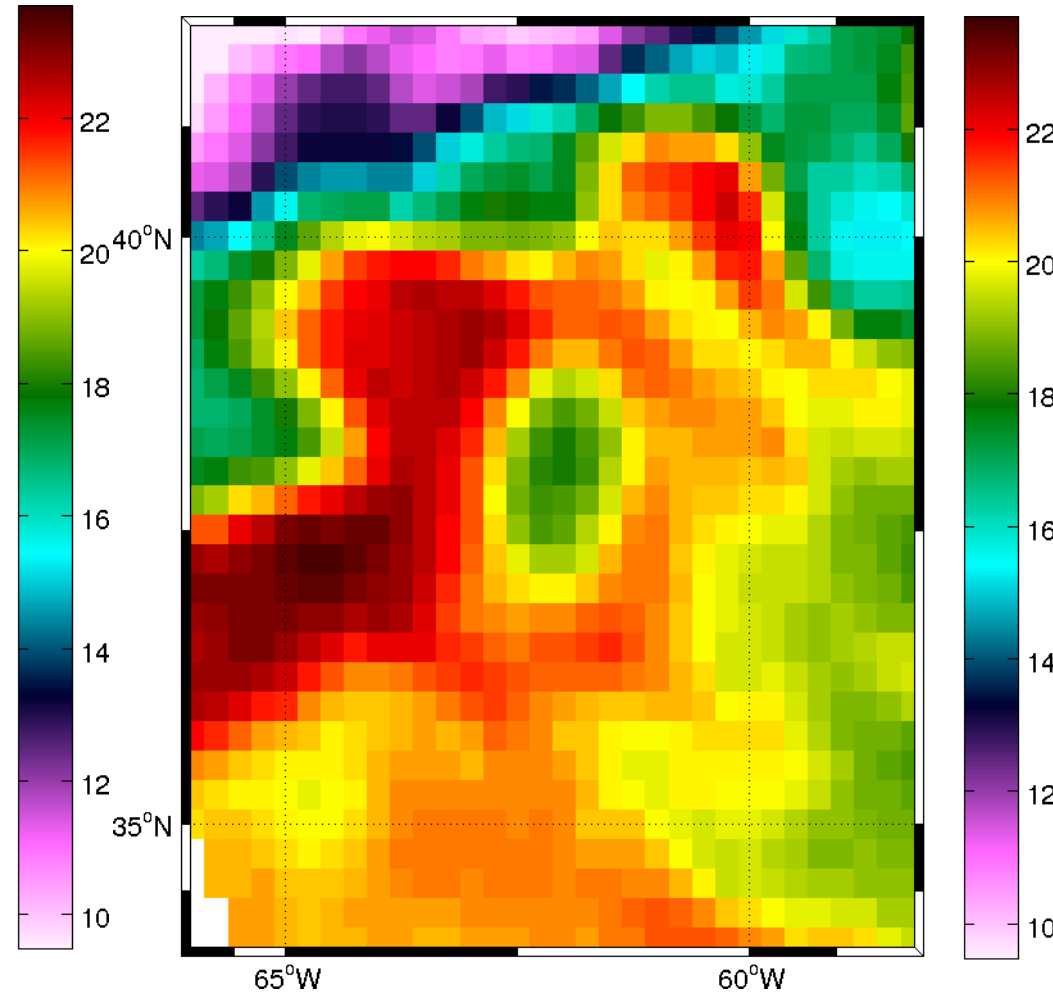
Characterizing the submesoscale   -   Spectral approach
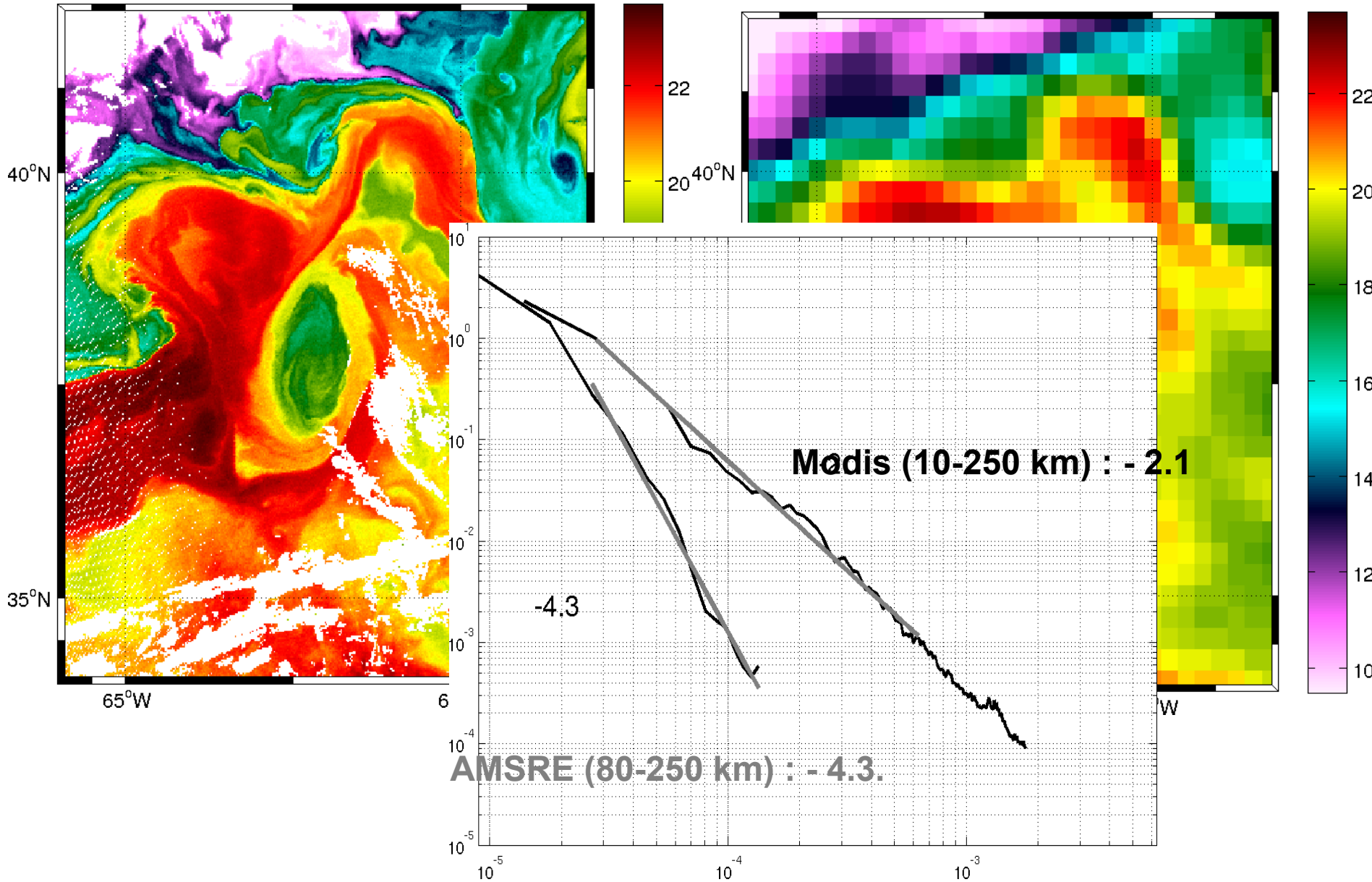
SST – Modis(L2P)

SST – AMSRE(L3)
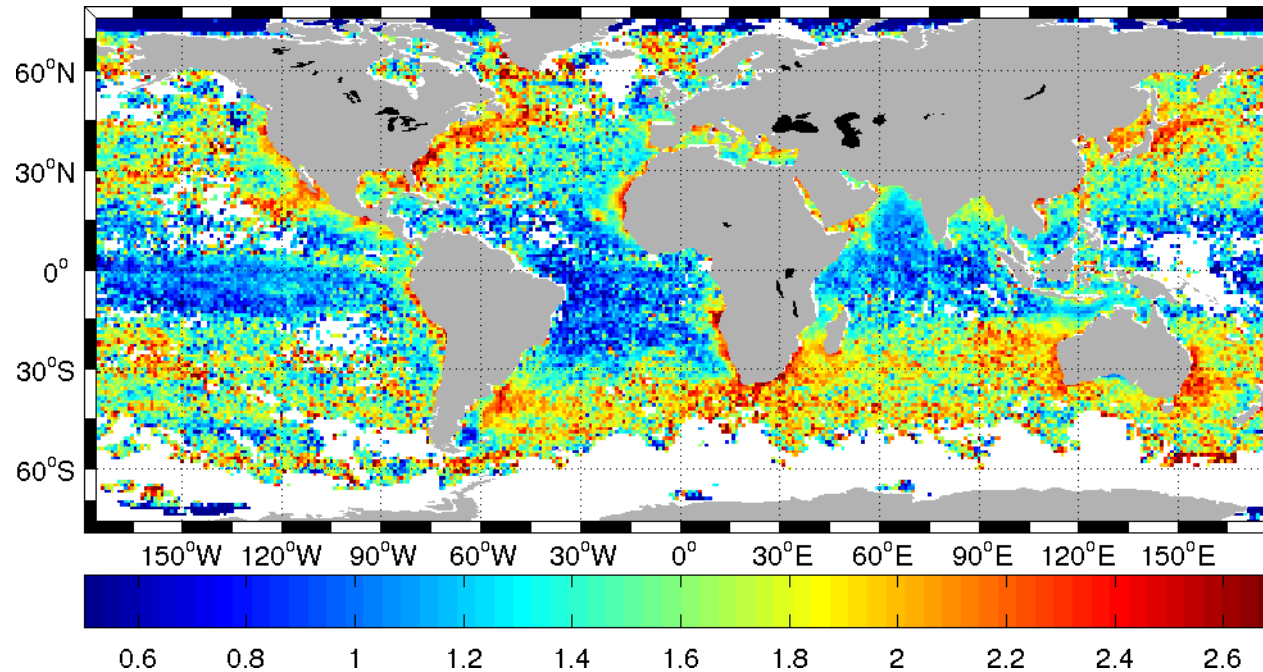
Characterizing the submesoscale - Spectral approach

SST – Modis(L2P)

SST – AMSRE(L3)

Modis (10-250 km) : - 2.1

-4.3

AMSRE (80-250 km) : - 4.3.

Characterizing the submesoscale - Spectral approach

SST wavenumber spectra in the 10-80 km band

2007-2010 wavenumber spectral slopes mean at 1°x1°
resolution in the 8x-70 km wavelength band calculated from
MODIS SST data (~1 km resolution). 2D-Spectra computed
over ~ 1.28°x1.28° area with high coverage (>95%)

Characterizing the submesoscale - Spectral approach

⬤   SST observations can reveal a wide range of sizes and a variety of shapes, with a large occurrence of frontal sytems. Consequently, this textural richness often leads to continuous spectral estimates that span a very wide range of scales. Variances of these scales are found to follow similar power-law distributions (in agreement with recent numerical simulations, Sazaki, 2012)

   Global distribution : spectral slope ~ 1.6 - 3

⬤   Spectral slope estimation hampered by resolution and noise level

⬤   Spectral forms may only be very weak constraints concerning the structure of the underlying flows, as coherent structures essentialy sign in the phase information (Armi & Flament 1985)

Characterizing the submesoscale   -   small scale / mesoscale

- Temporal and spatial variability
of small scales / mesoscale (MW SST or altimetry)

06-May-2010 17:00 modis aqua
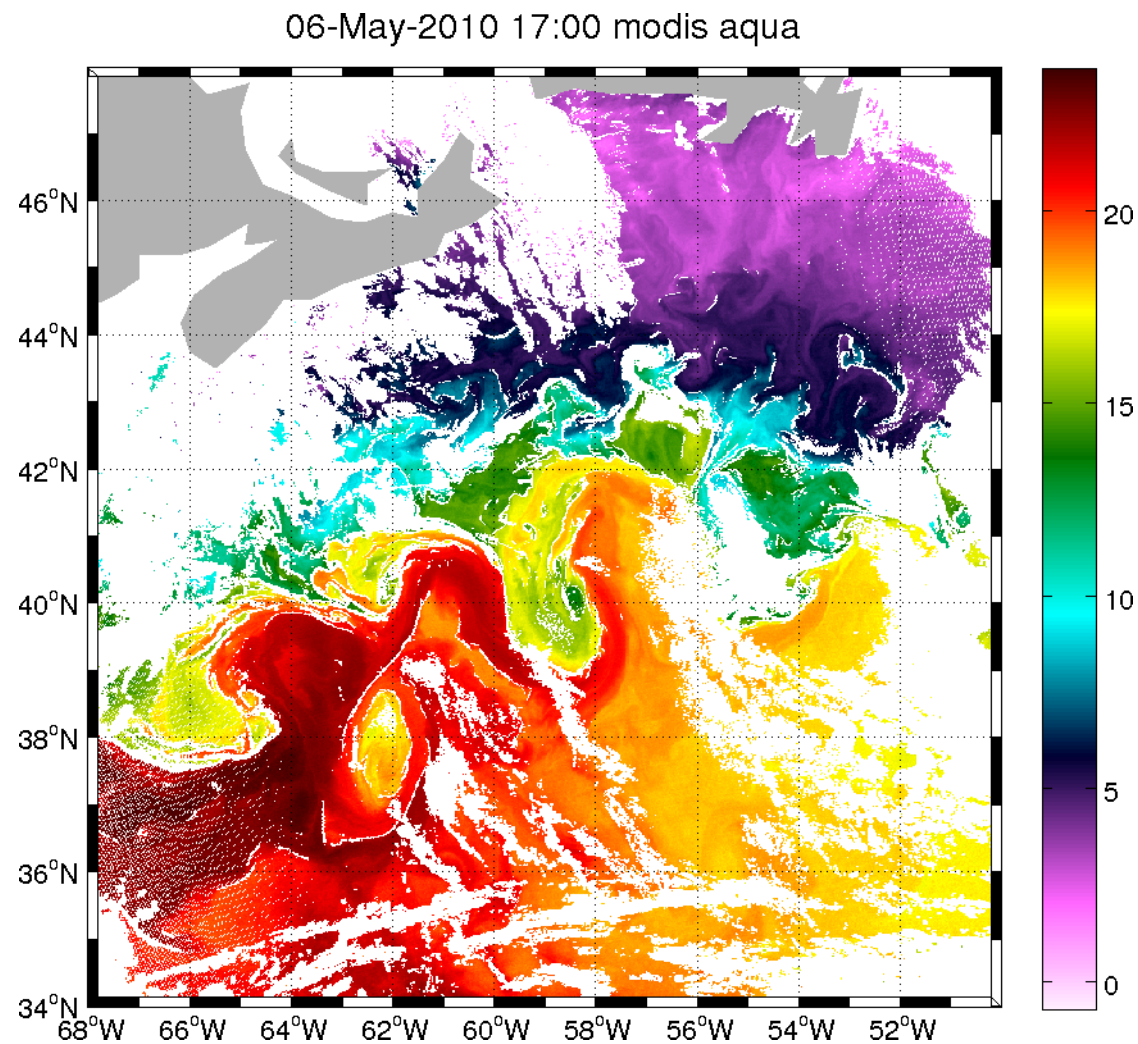
Characterizing the submesoscale - small scale / mesoscale
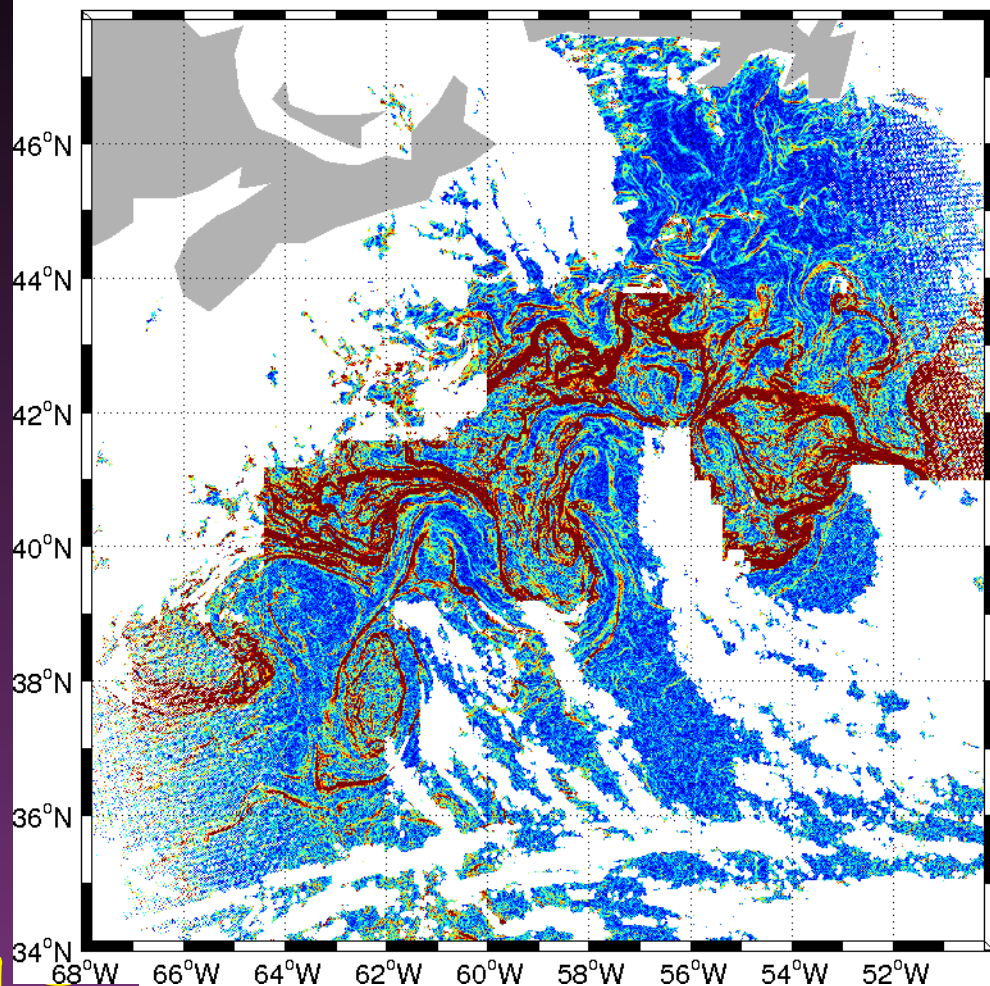
06-May-2010 17:00 modis aqua
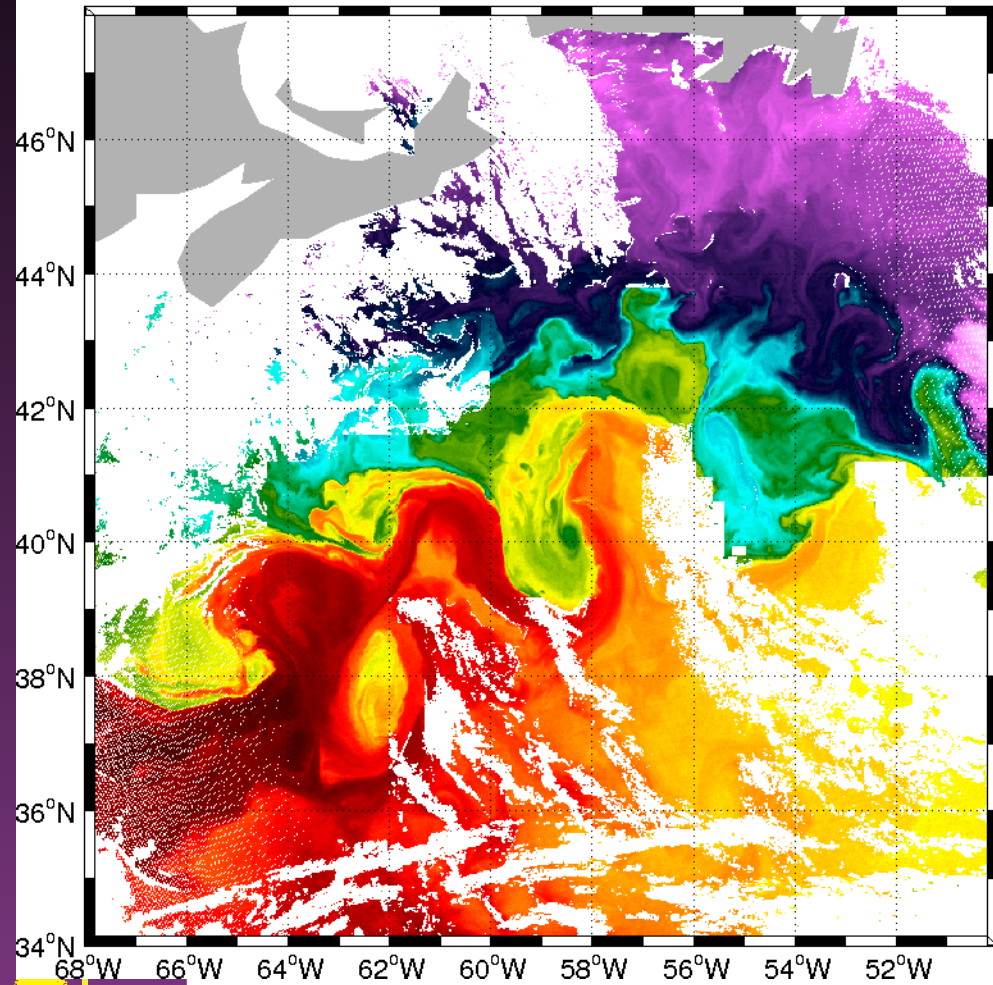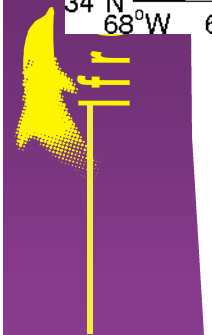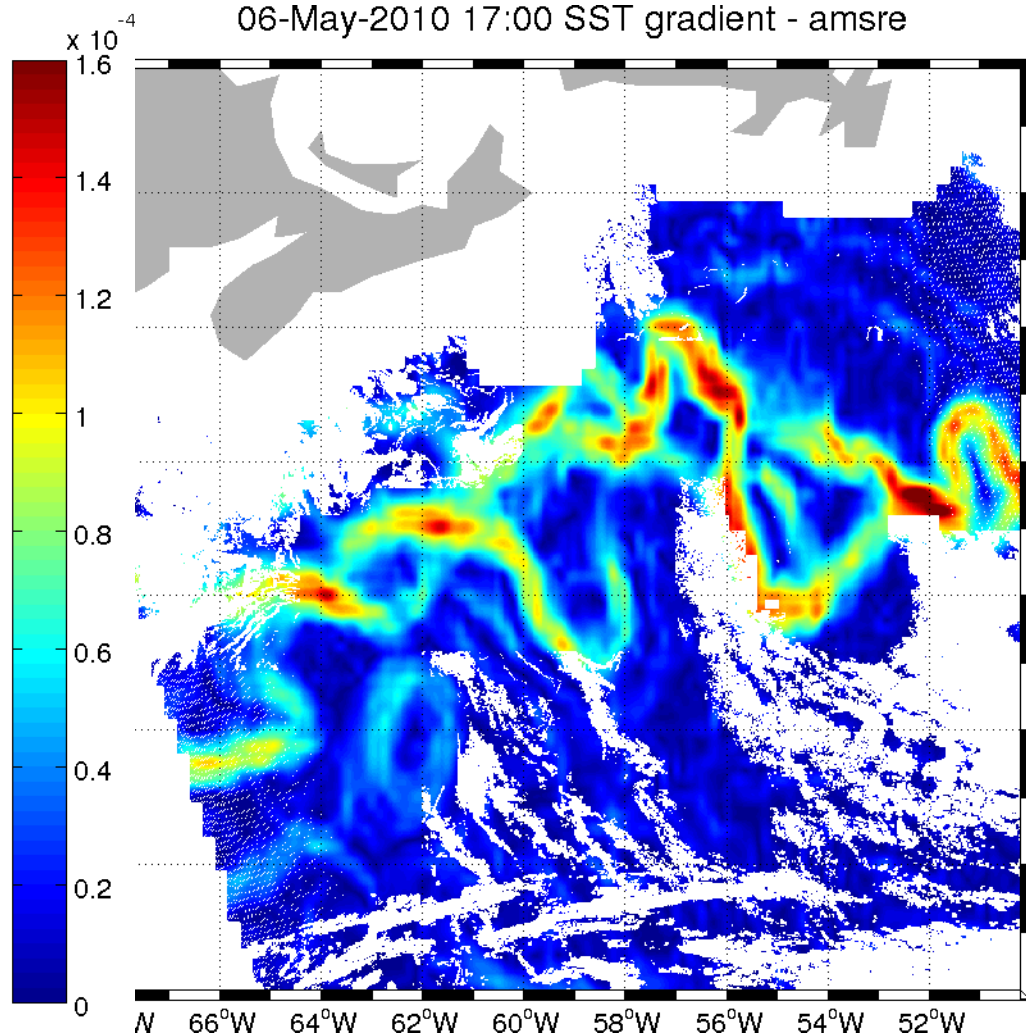
06-May-2010 17:00 amsre
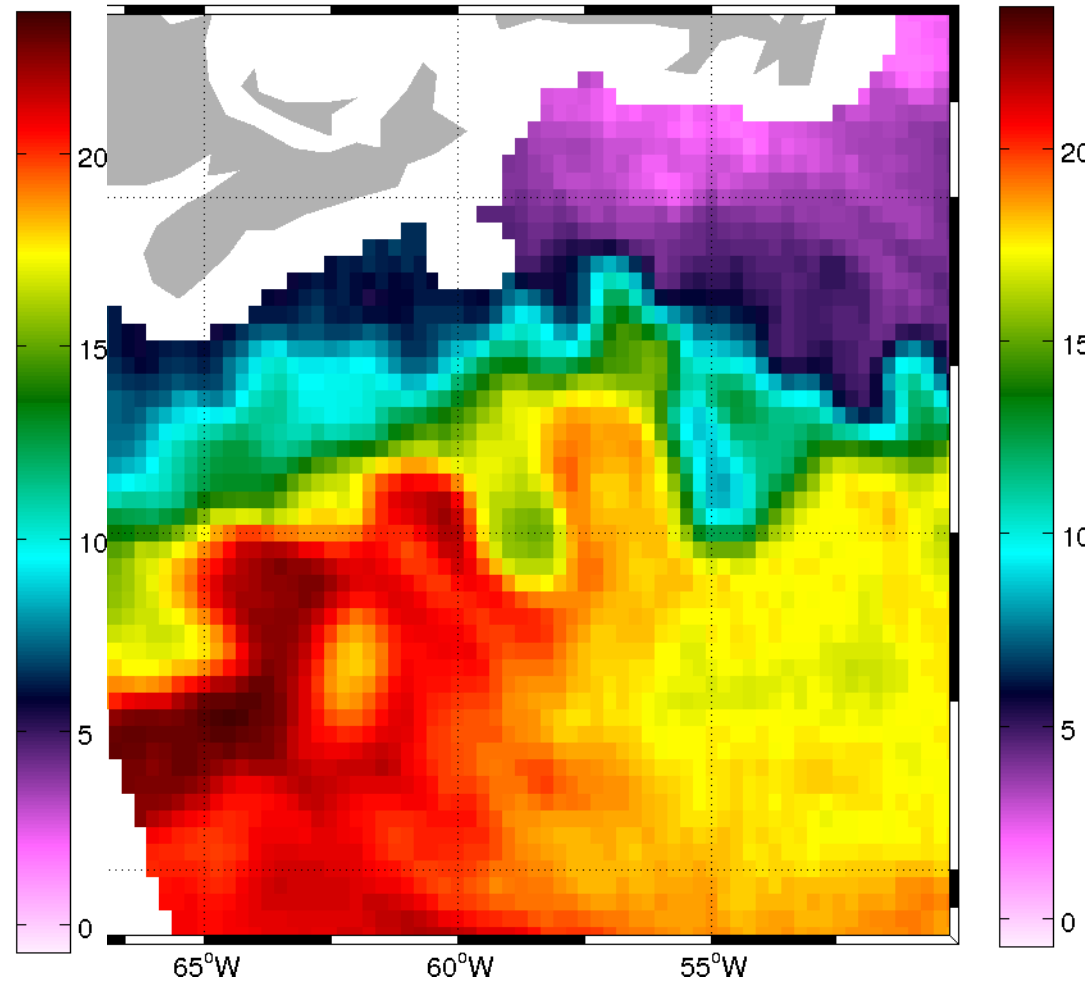
Characterizing the submesoscale - small scale / mesoscale
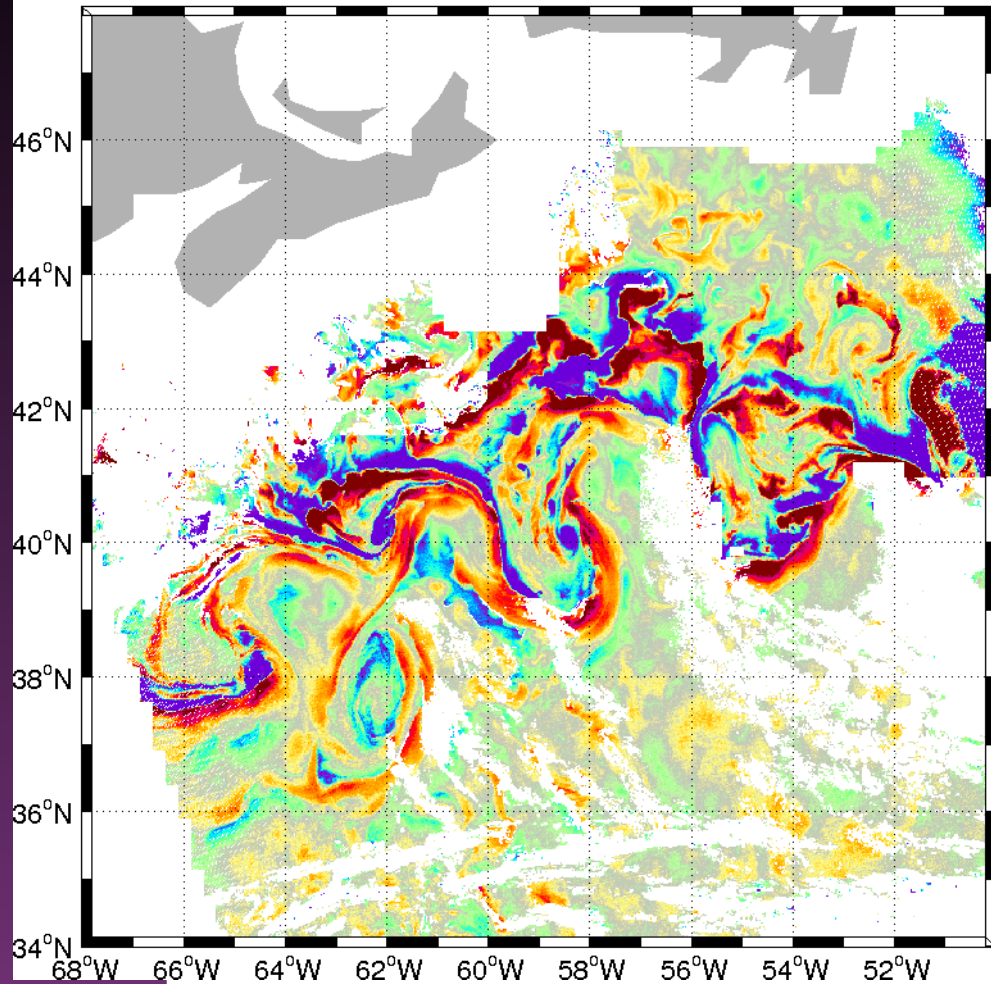

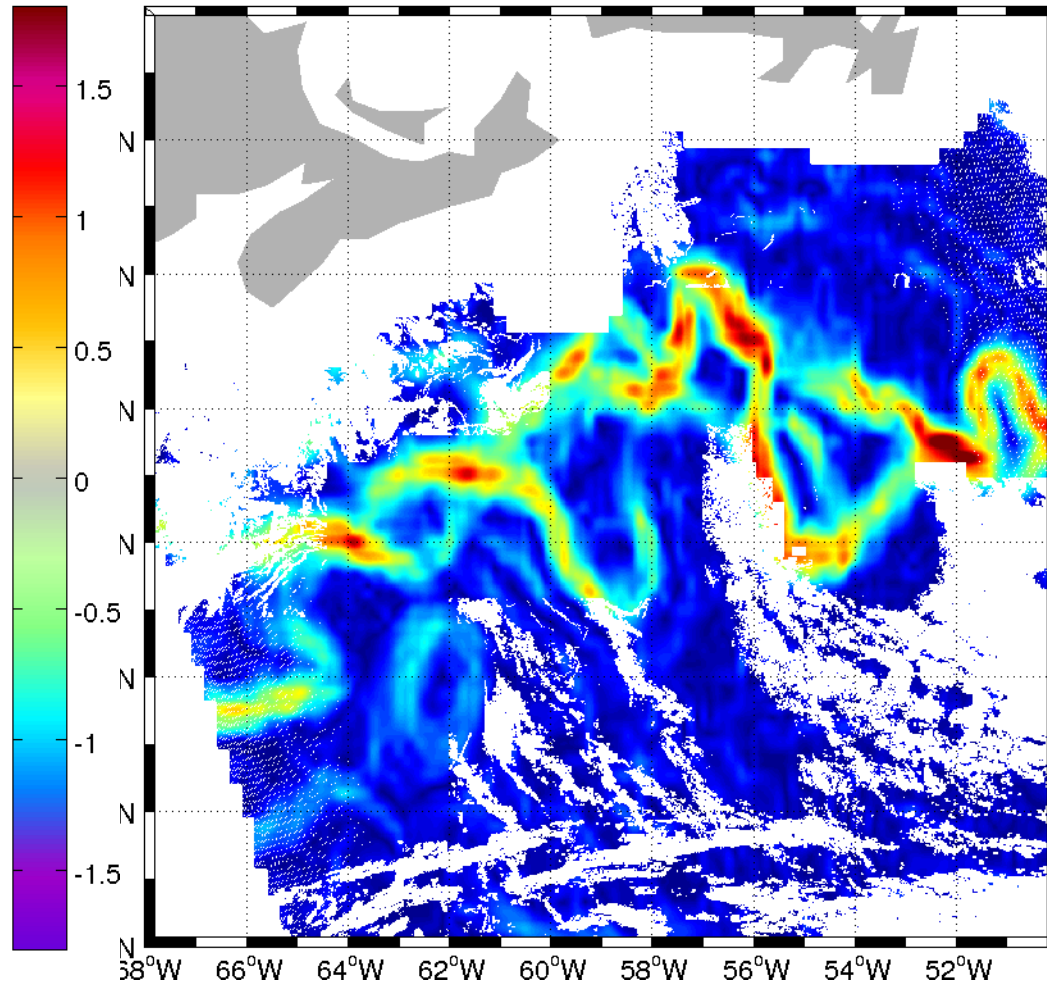06-May-2010 17:00 SST gradient - modis

06-May-2010 17:00 SST gradient - amsre

Characterizing the submesoscale   -   Multiscale analysis

06-May-2010 17:00 SST anomaly: modis aqua - amsre

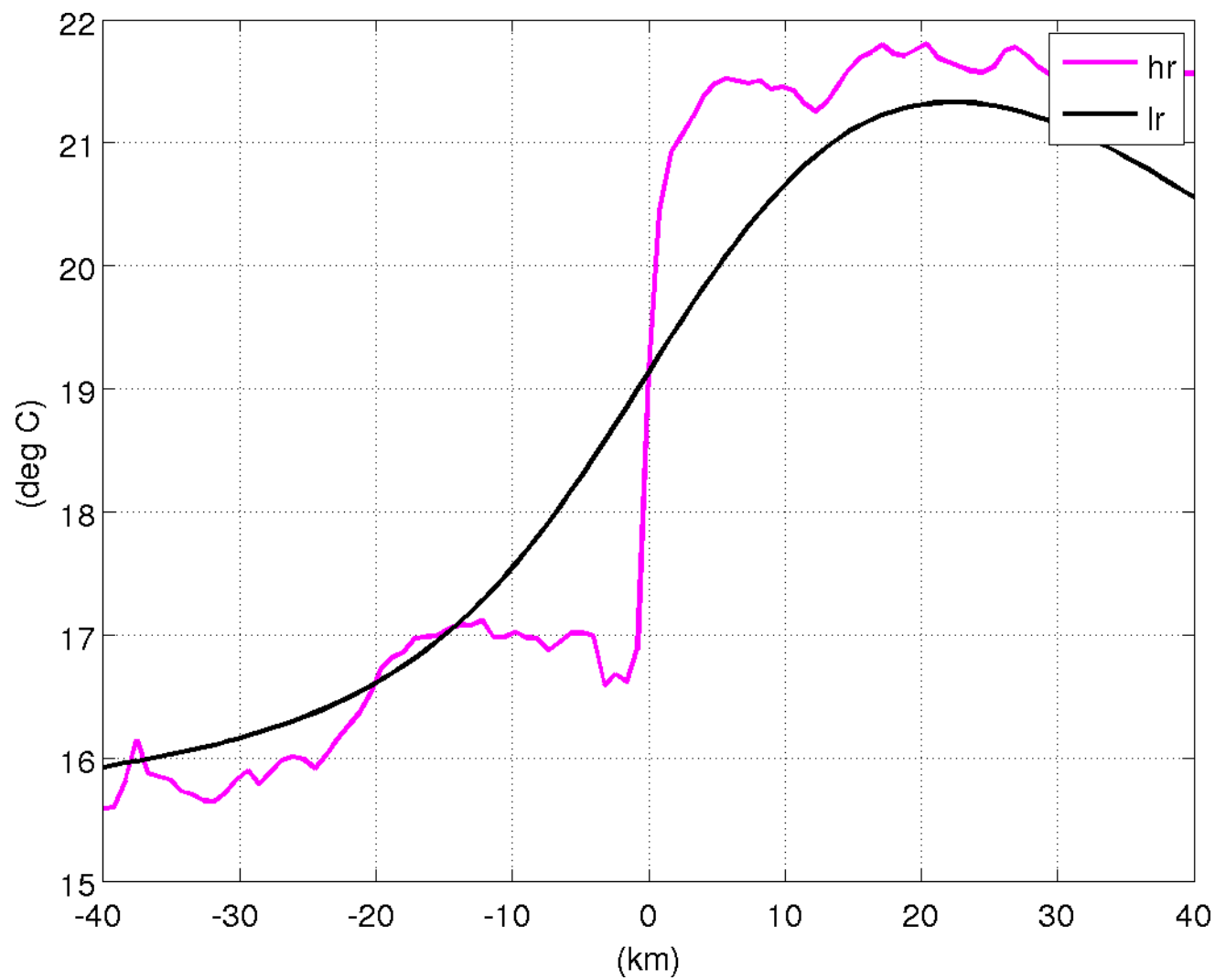06-May-2010 17:00 SST gradient - amsre

(large scale bias removed)

Characterizing the submesoscale   -   small scale / mesoscale
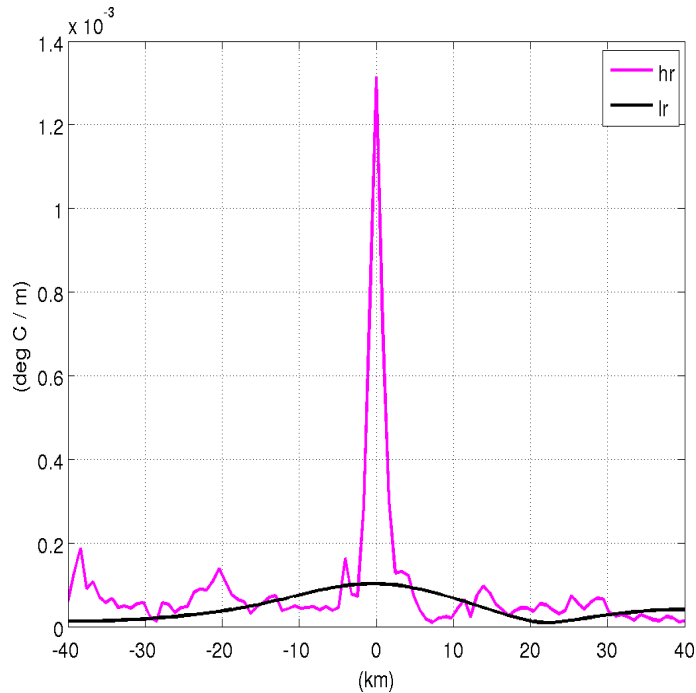

Modis SST – Amsre SST versus Amsre SST gradient
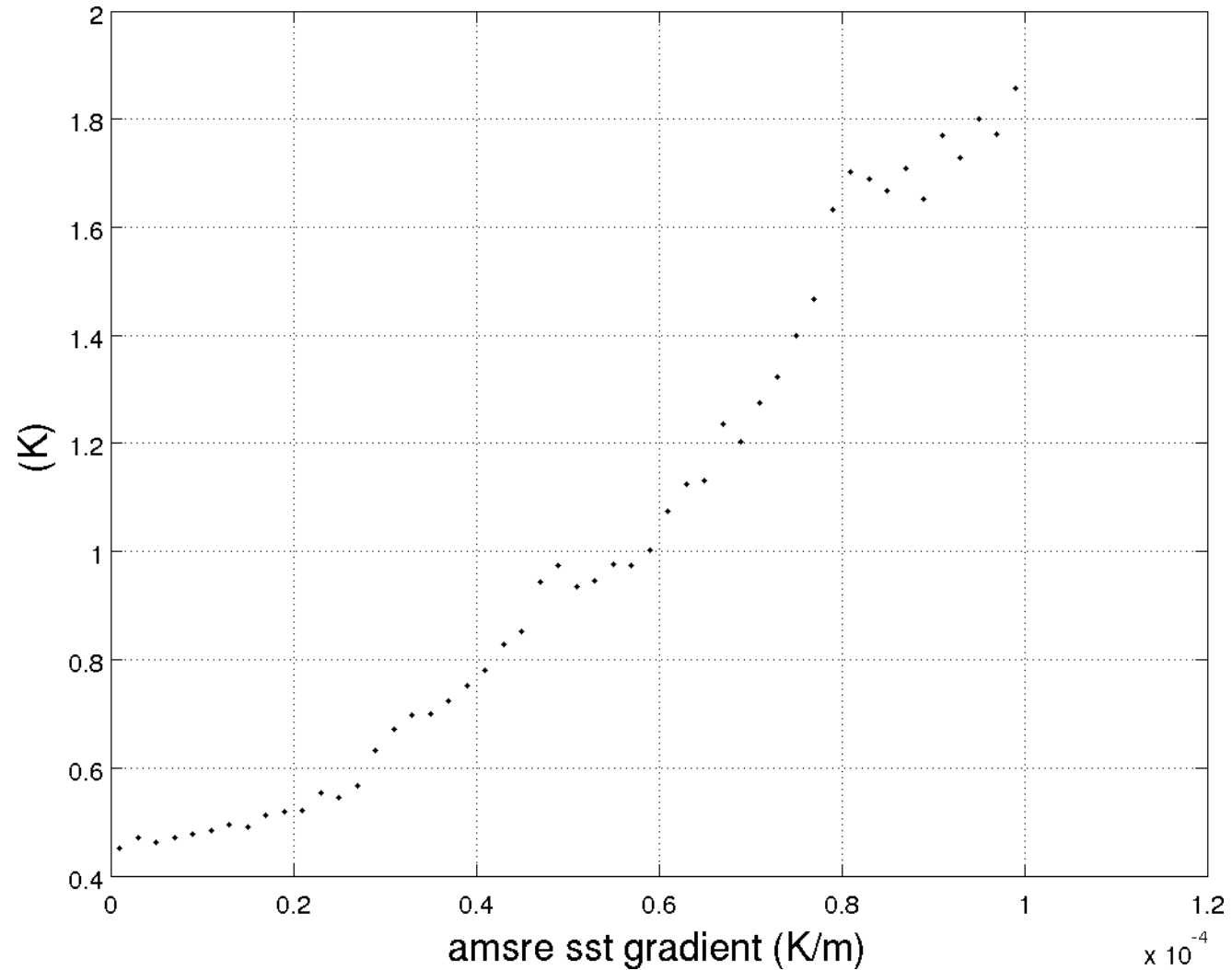
Characterizing the submesoscale   -   small scale / mesoscale

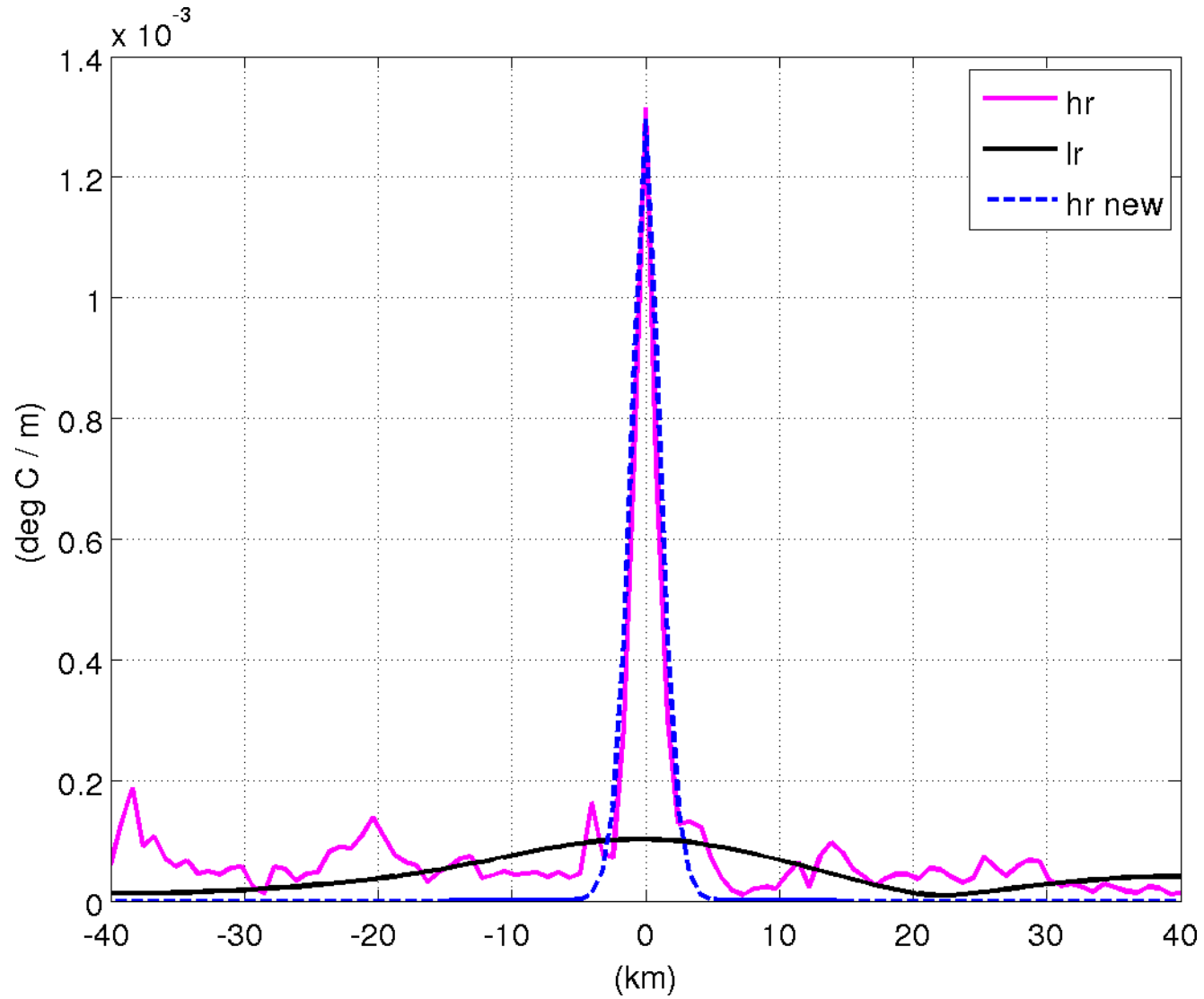Characterizing the submesoscale - small scale / mesoscale
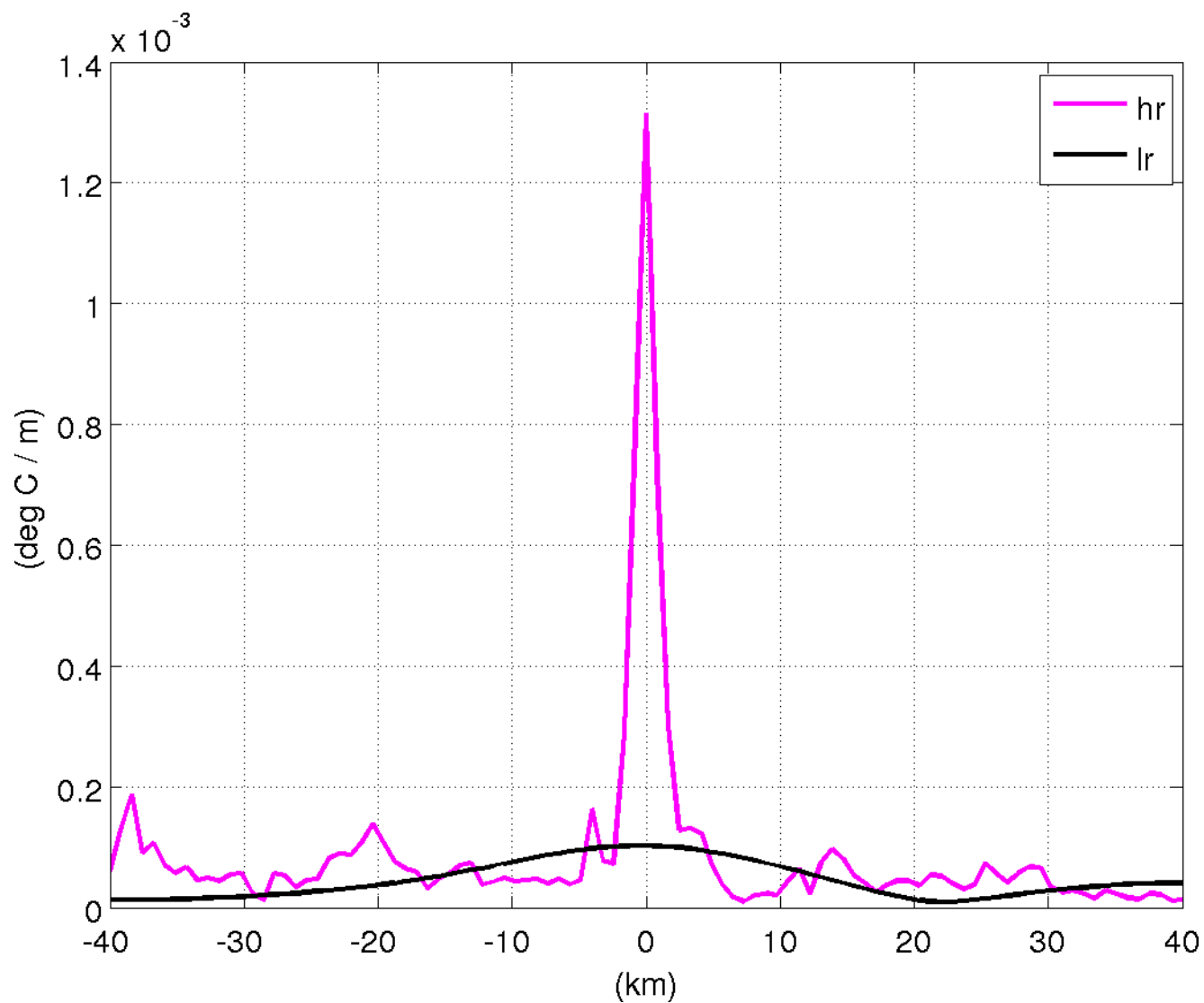
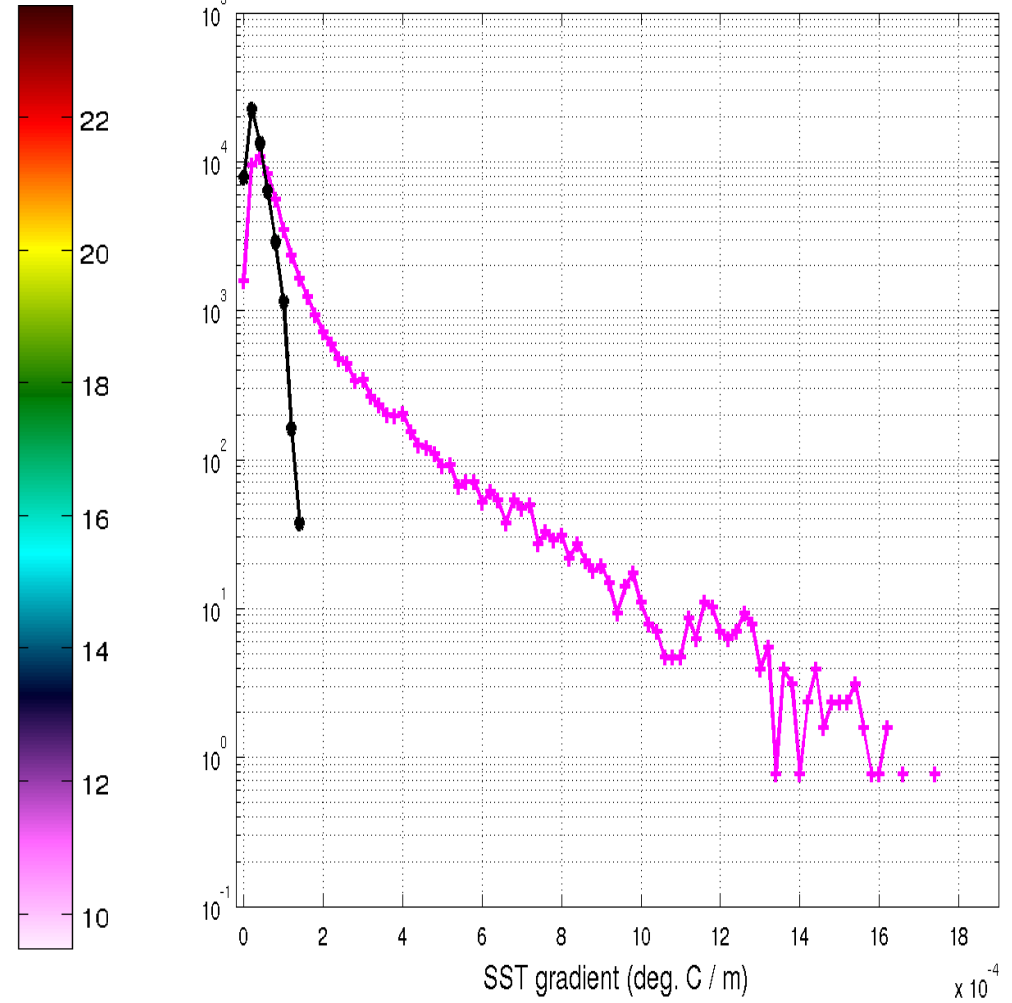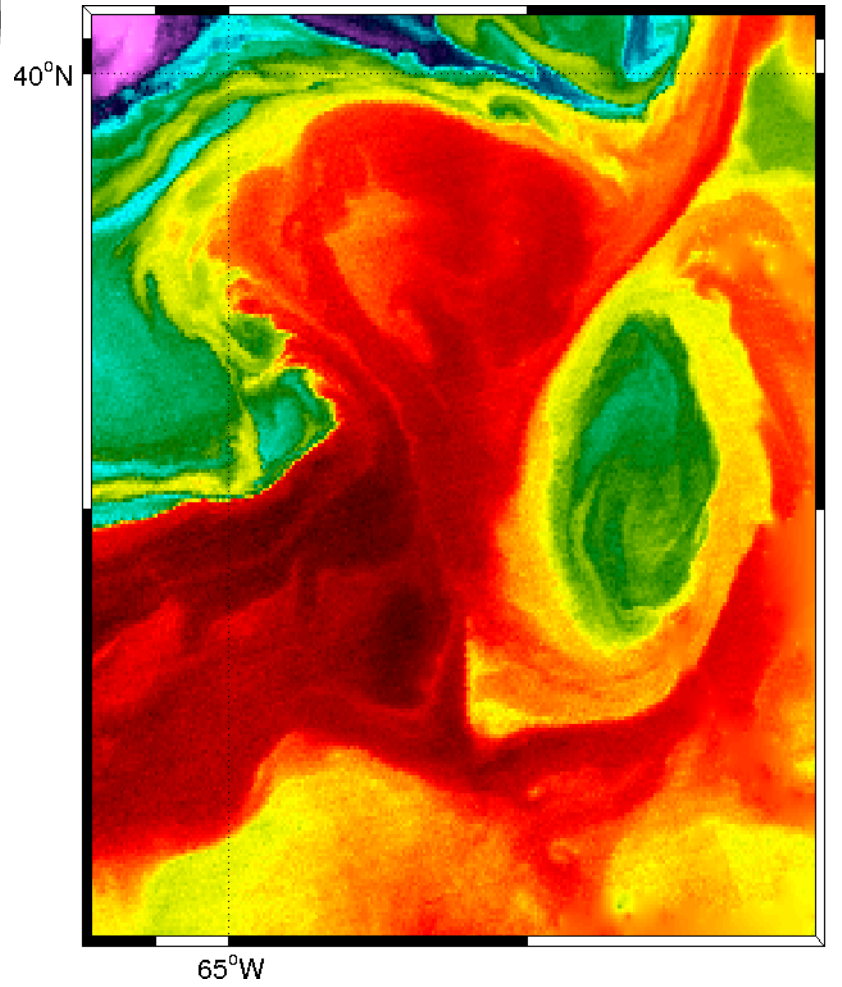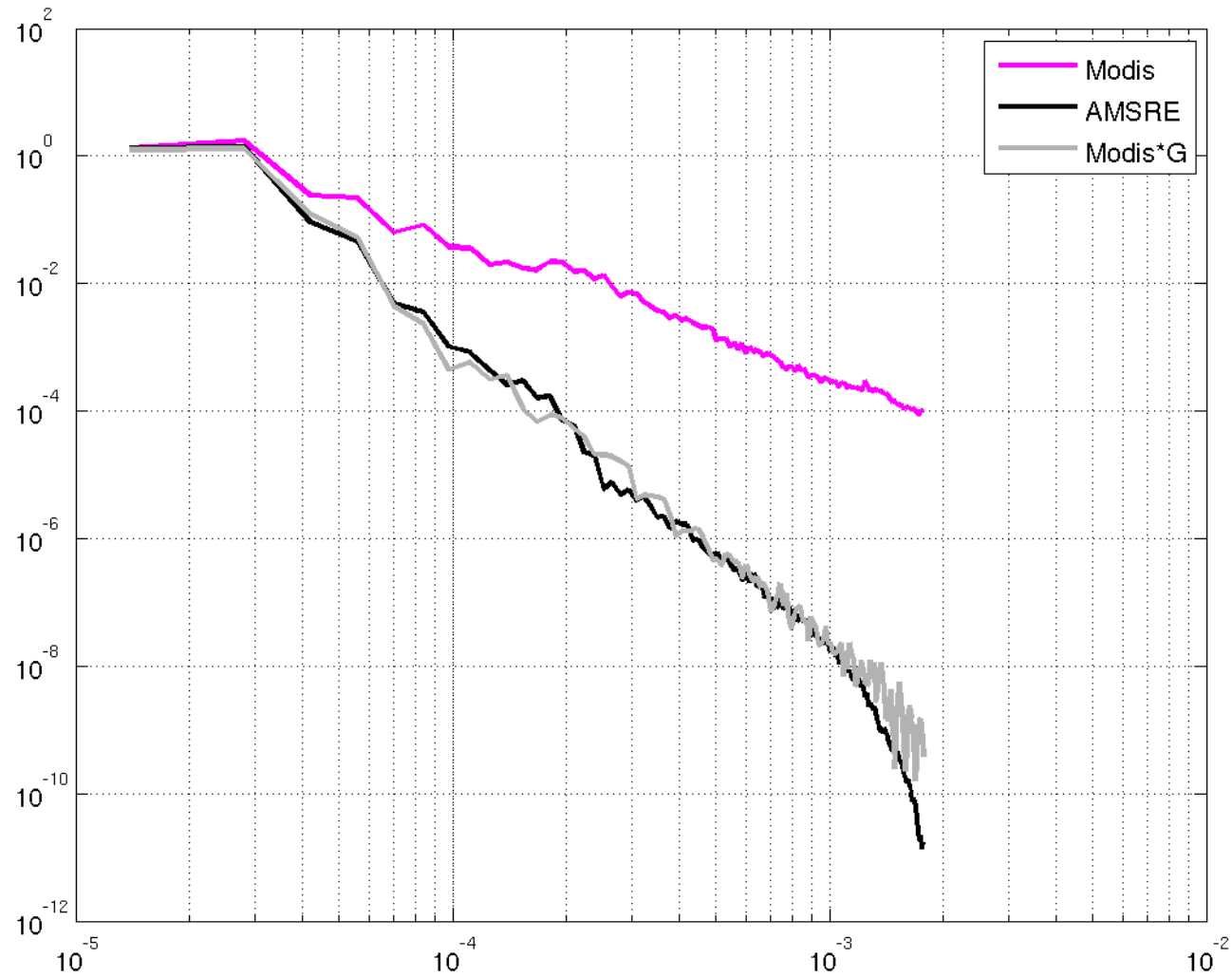# Characterizing the submesoscale - small scale / mesoscale

Proposition: estimate the variance explained by the enhancement of large gradient present in low resolution field

1/ gradient profile model for HR and LR-> 'transformation model'
2/construction of new gradient field
3/ LR SST field + new gradient field (variational approach)=> new HR SST field
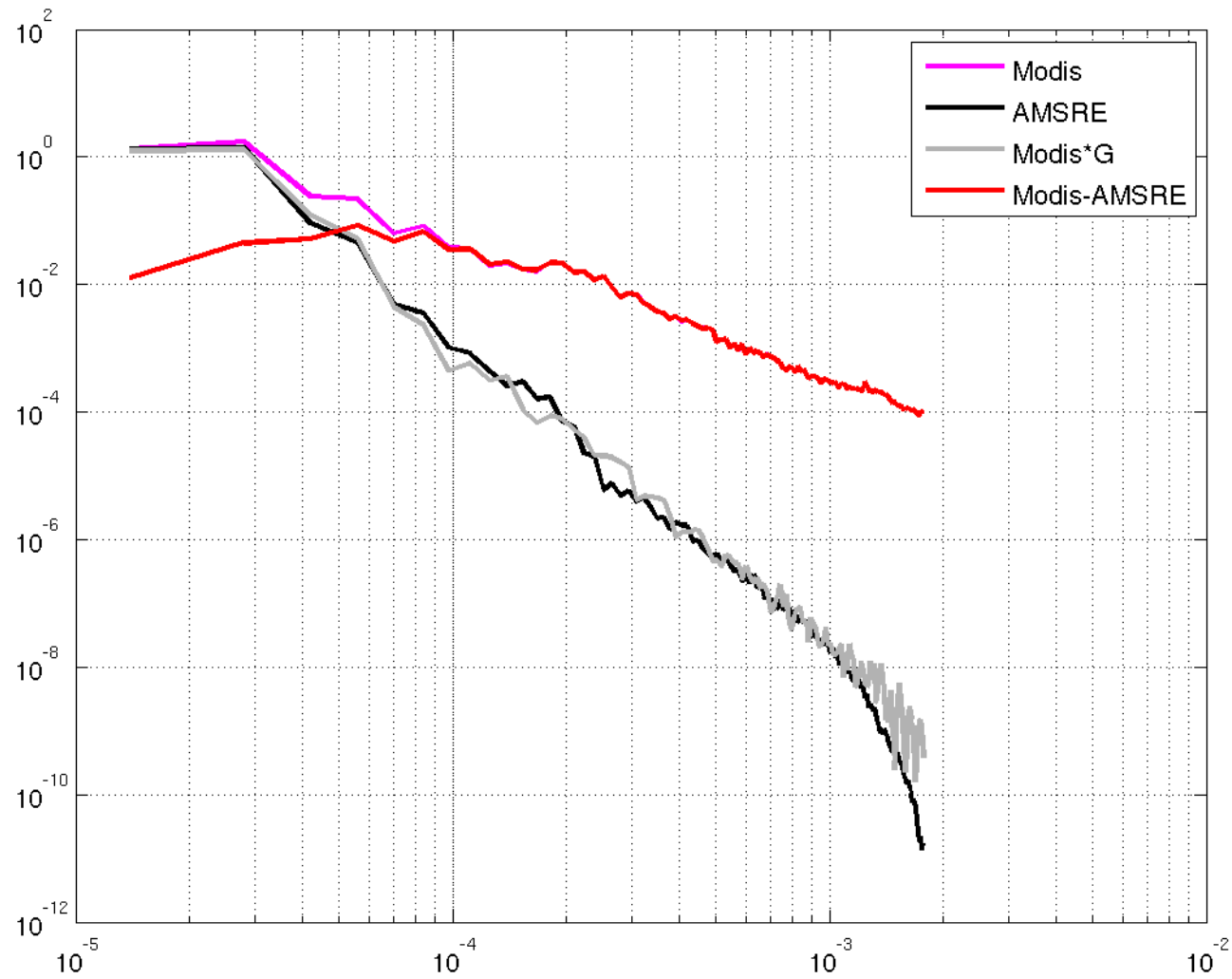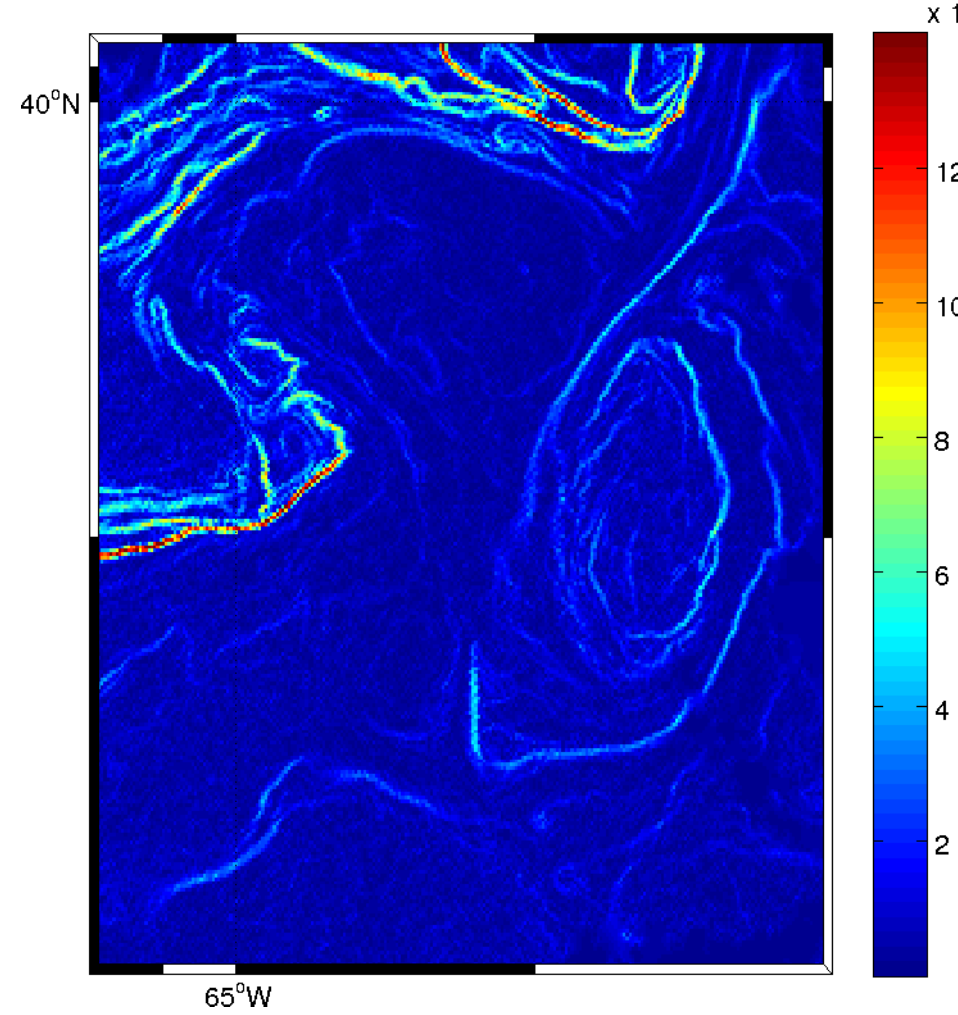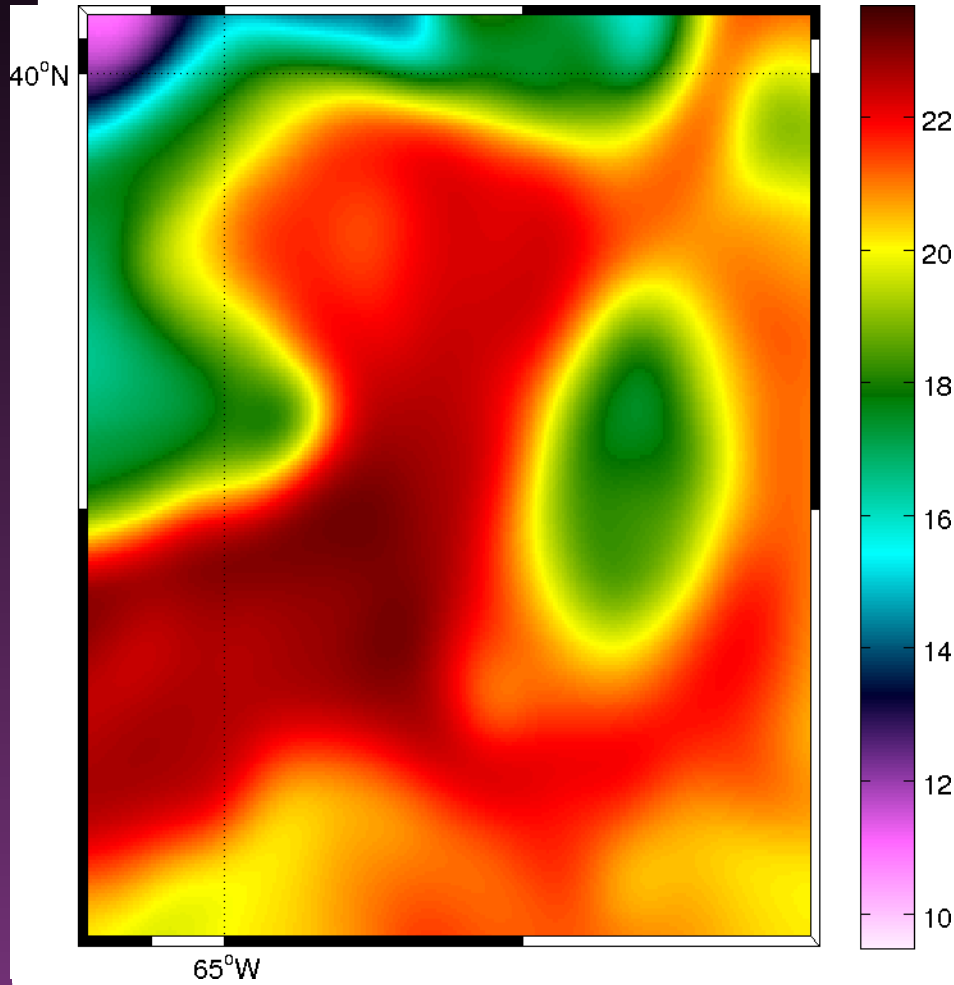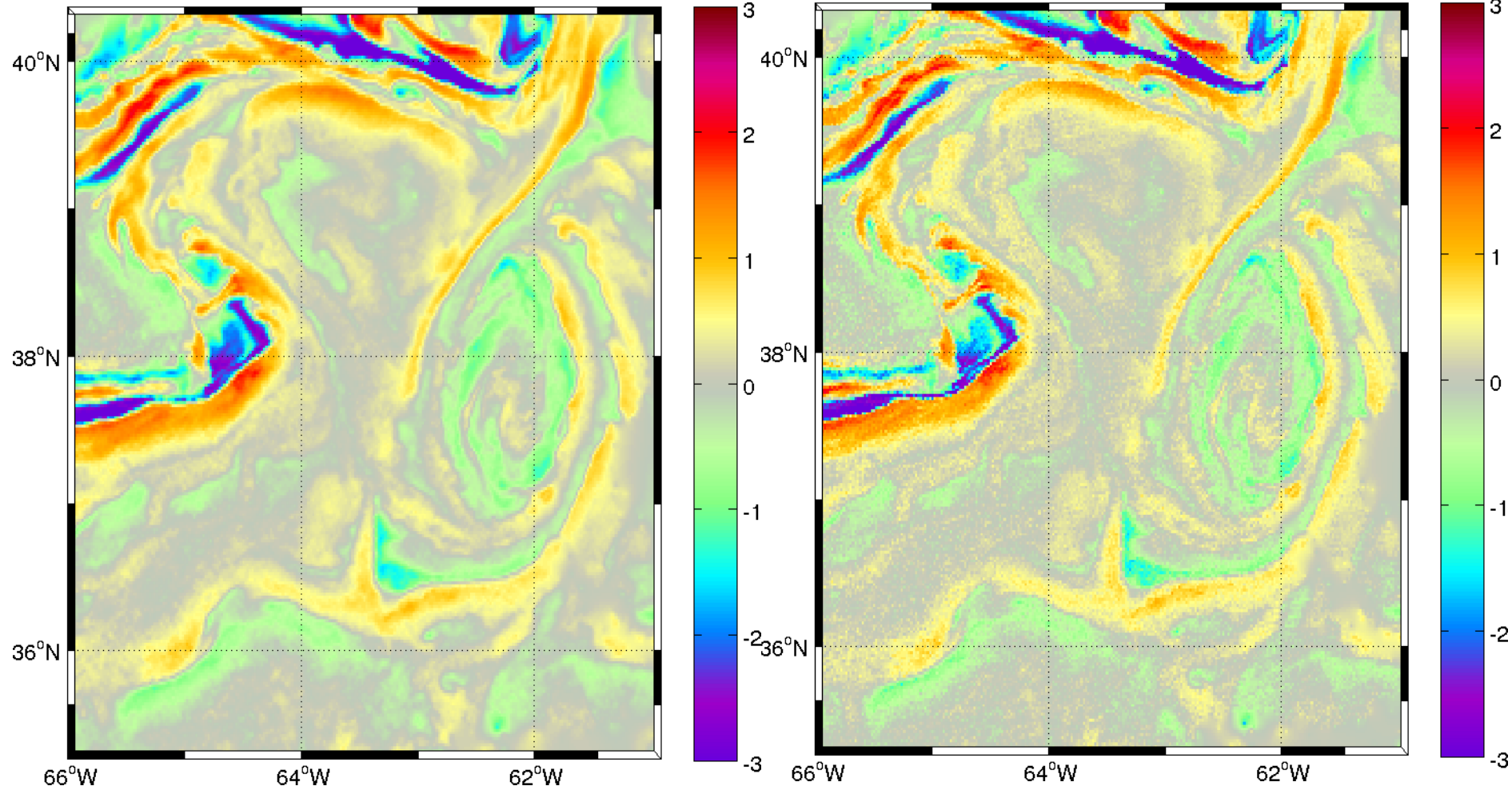
Characterizing the submesoscale - small scale / mesoscale

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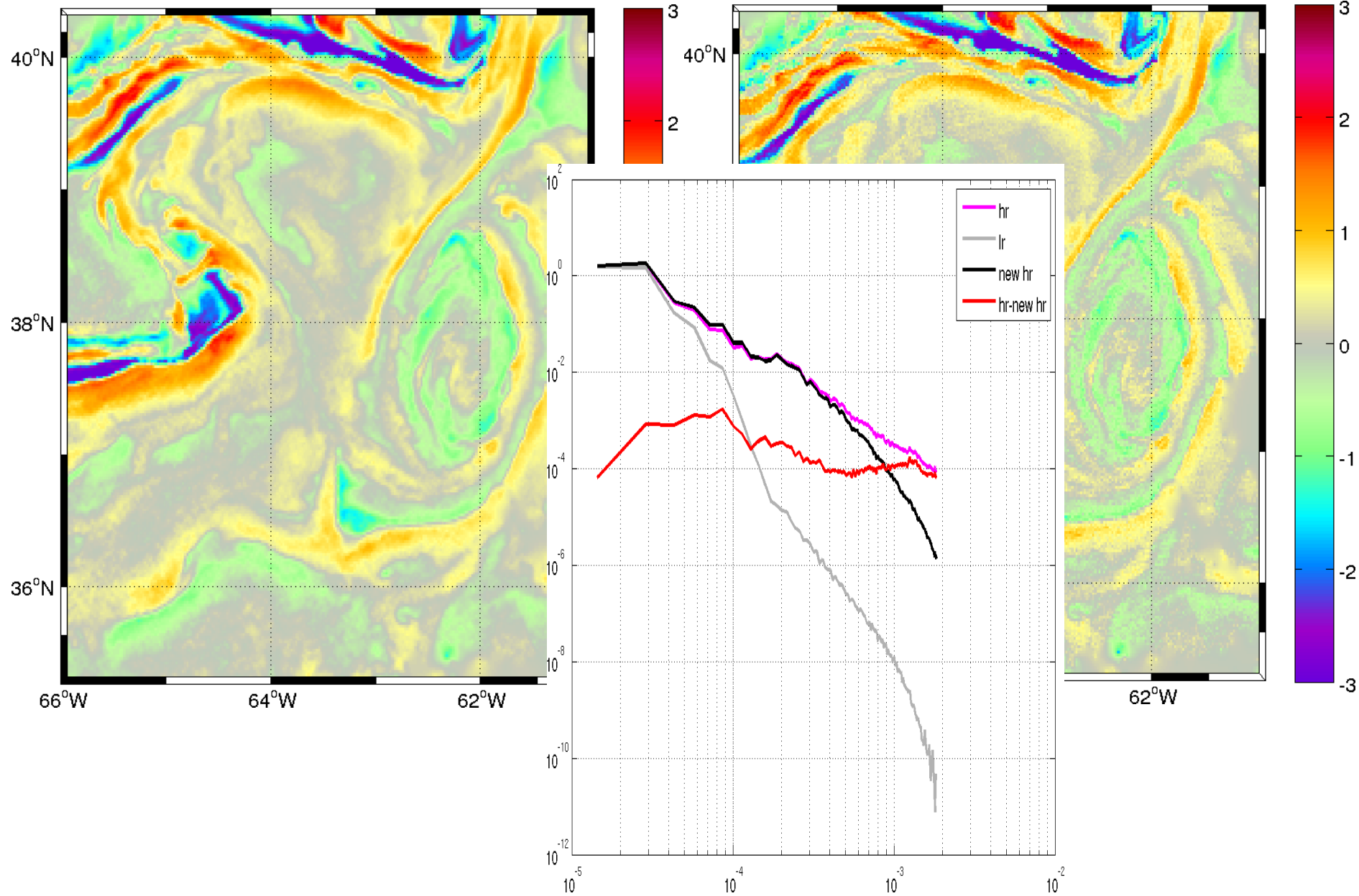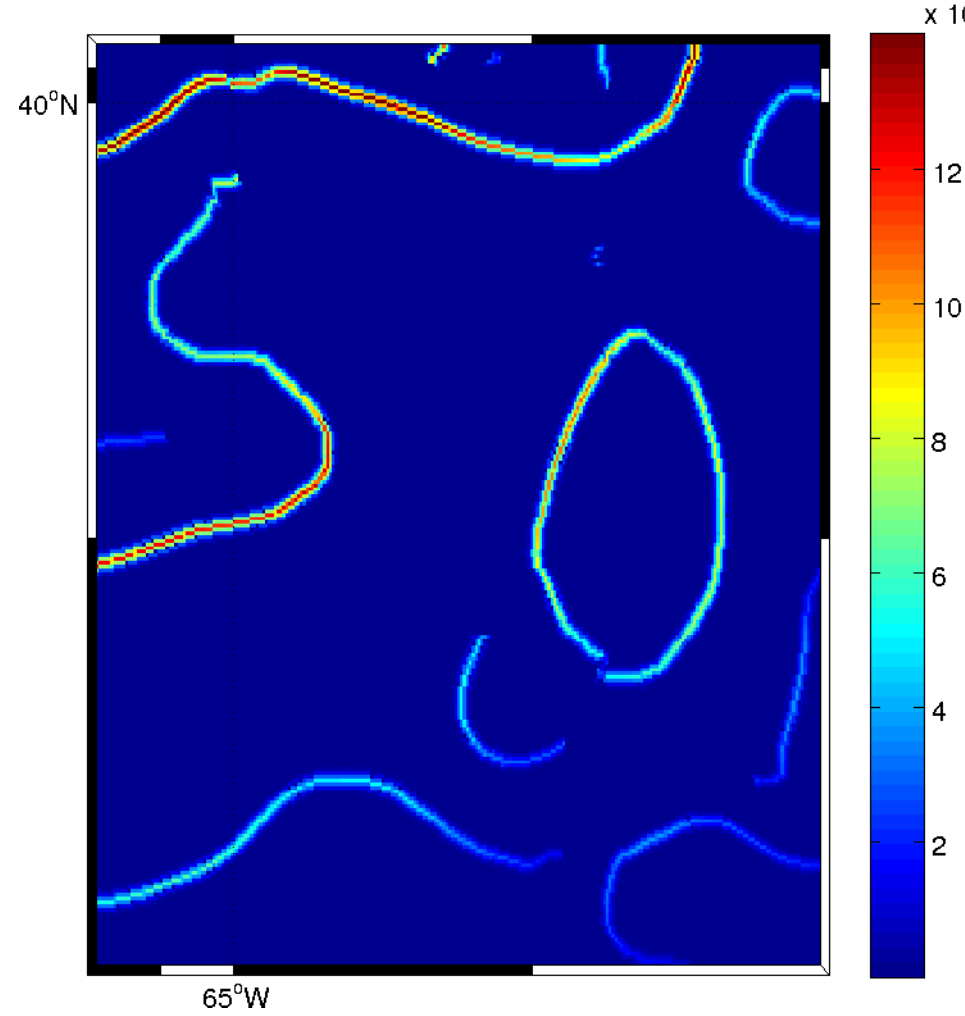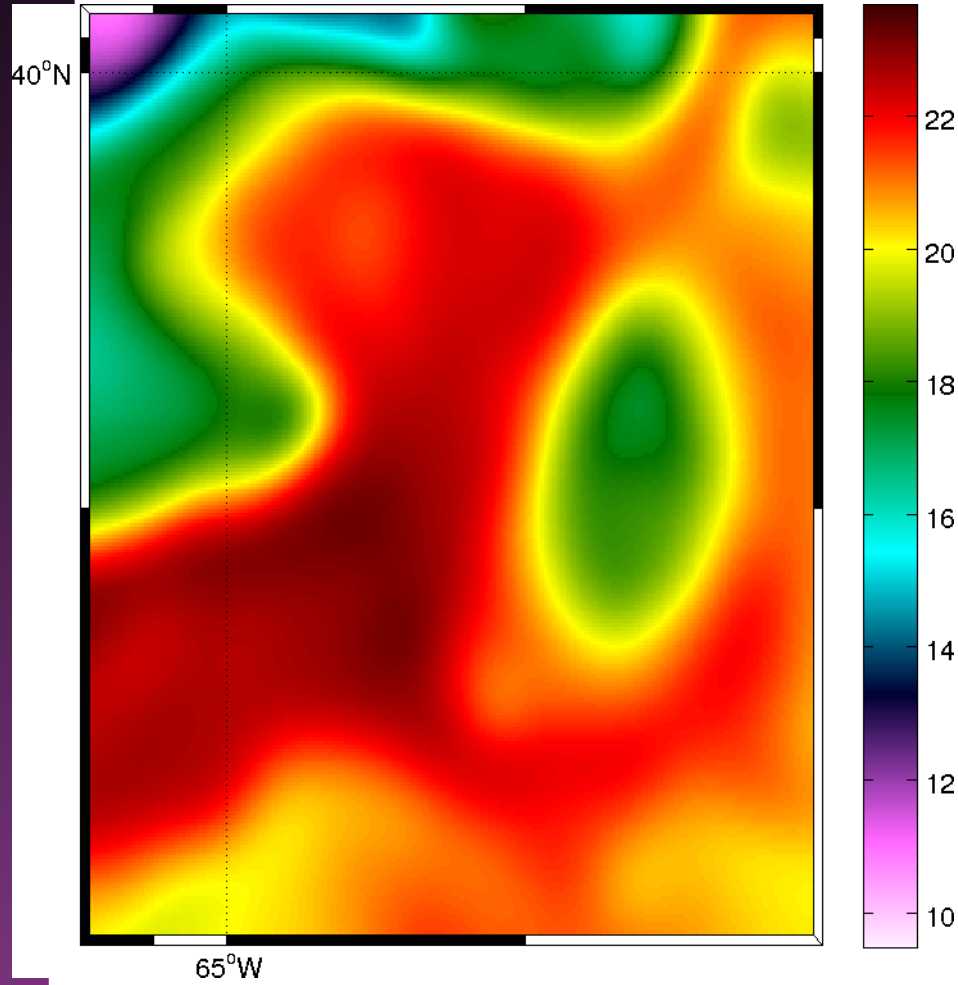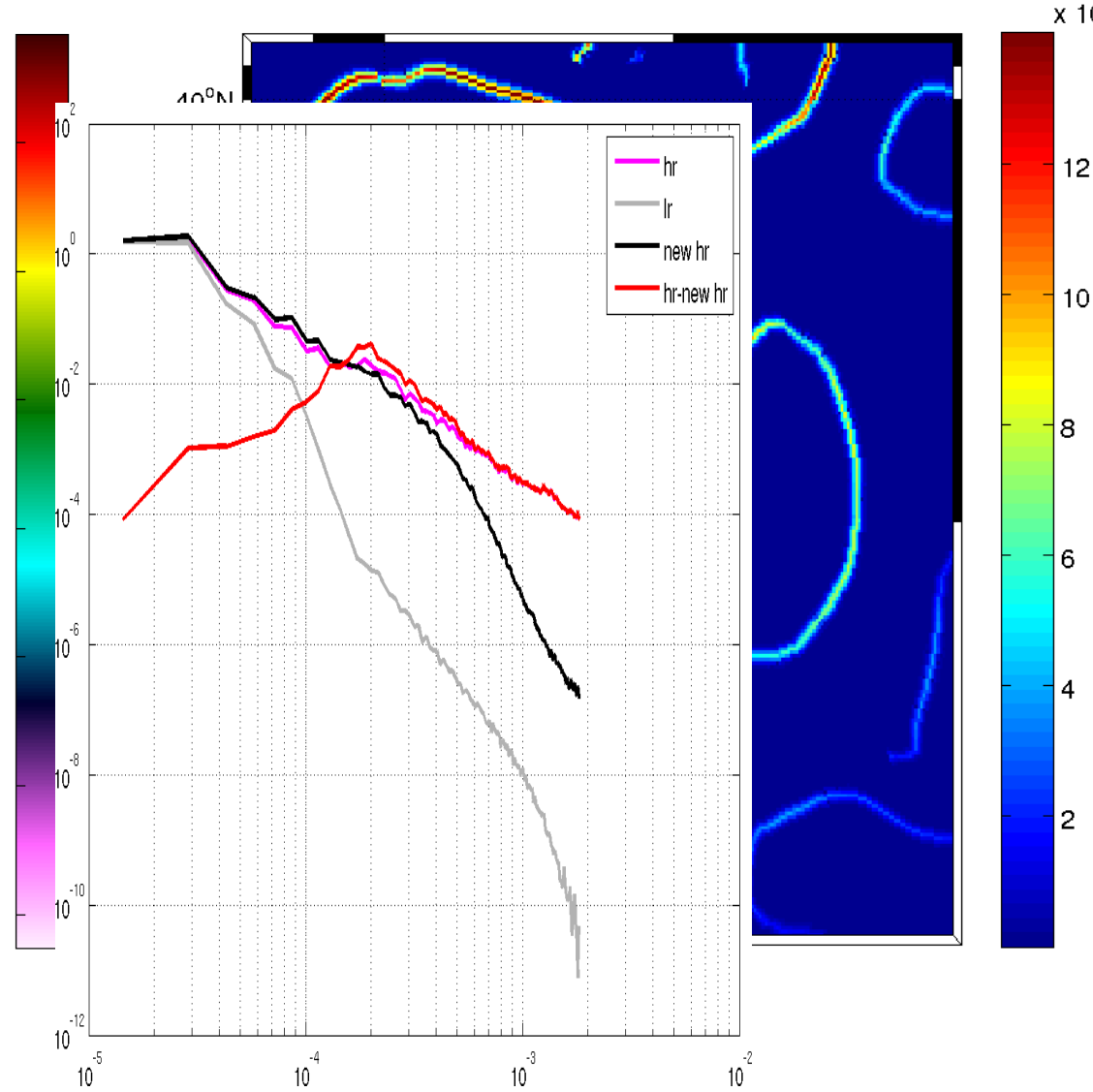# Characterizing the submesoscale - small scale / mesoscale

Characterizing the submesoscale   -   small scale / mesoscale

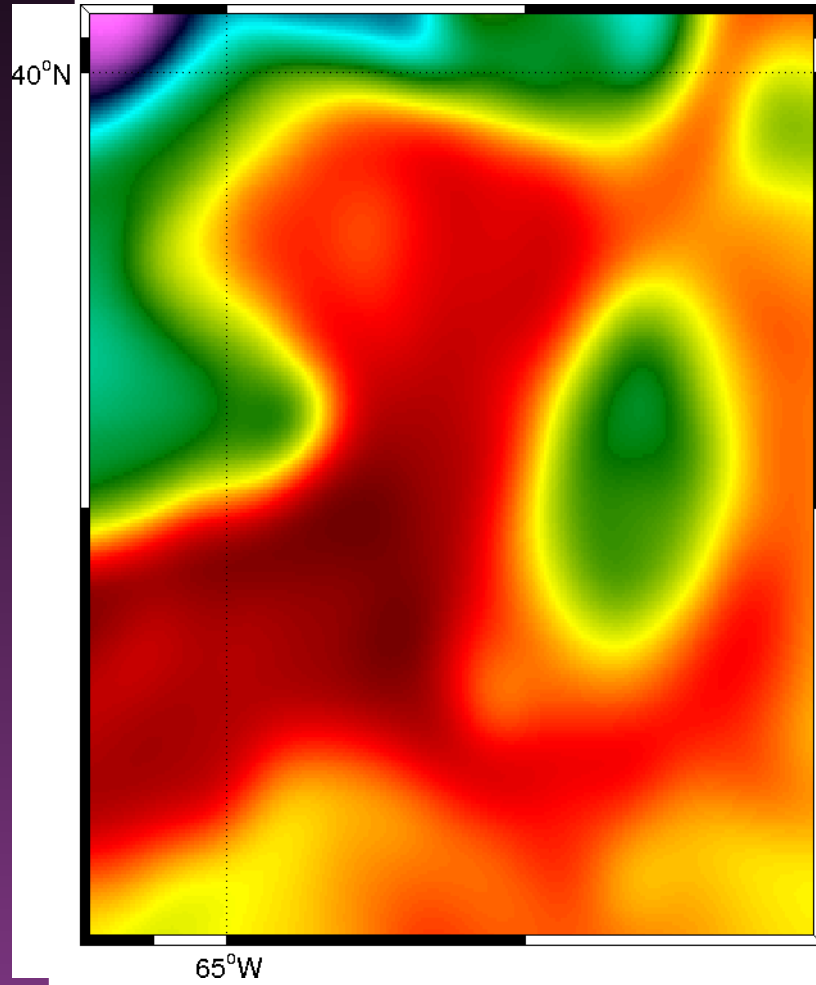Characterizing the submesoscale   -   small scale / mesoscale

Characterizing the submesoscale - small scale / mesoscale

Characterizing the submesoscale - small scale / mesoscale

Conclusion

🔵 Preliminary results : Eulerian descriptors for the charaterization of submesoscale processes have been investigated :
- Spectral approach
- Contour analysis : fractal analysis, curvature (not shown here)
- Small scale spatial variability / mesoscale

🔵 Objective : explore the use of such statistical descriptors for the reconstruction of fine-scale textured structures in missing data interpolation of SST observations and reconstruction of high resolution ocean current