Analysis of small scales from satellite SST observations

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Objective :

Identify descriptors for the characterization of small scales (captured by satellite observations):

- Spectral approach
- Contour analysis (curvature, winding angle)
- Small scale spatial variability / mesoscale

to help the reconstruction of fine-scale textured structures in missing data interpolation of SST observations and reconstruction of high resolution ocean surface current.

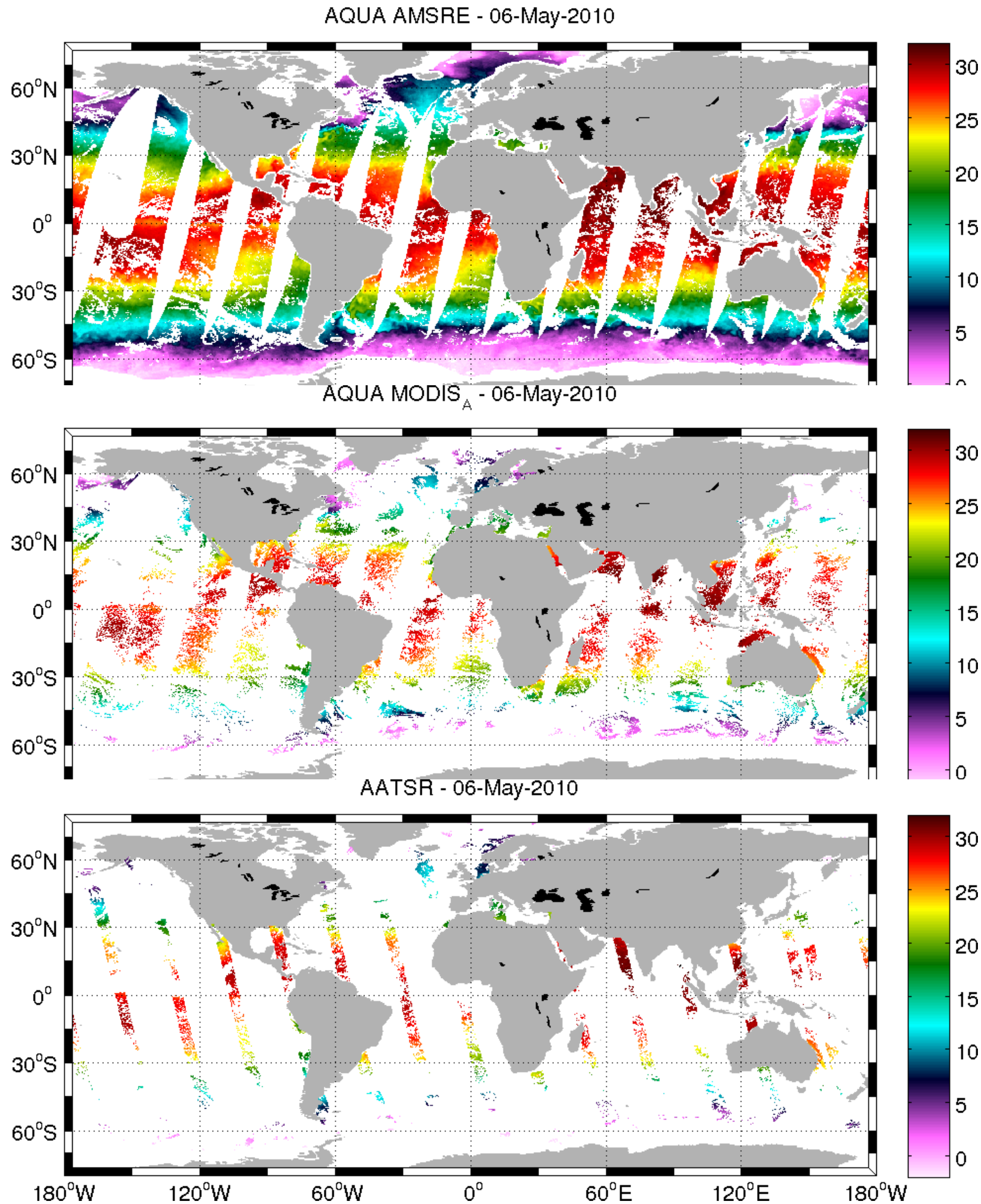
In this presentation :

- Some slides on SST observations
- Proposition for SST super-resolution

Satellite SST observations

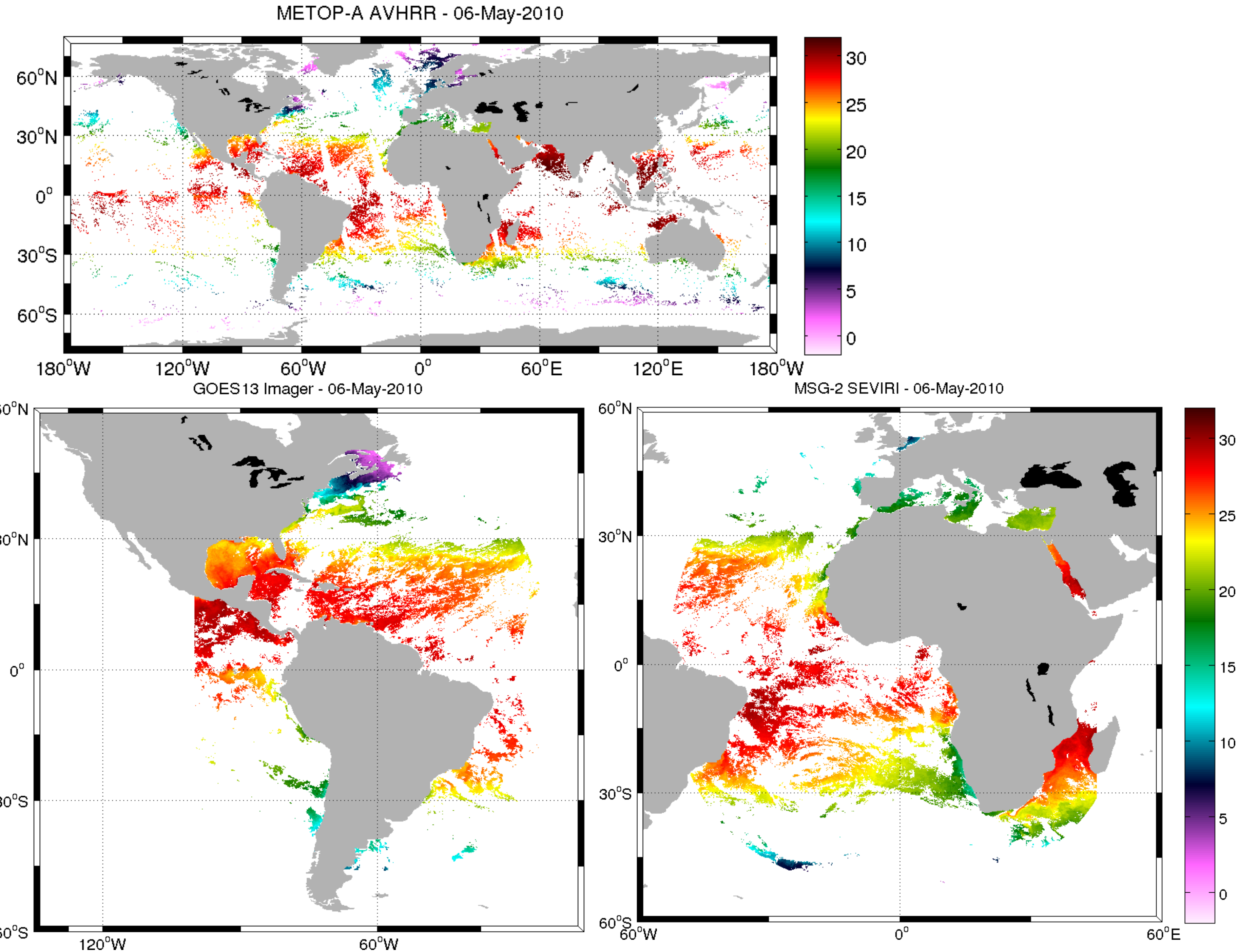
Big data:

AVHRR18_G-NAVO-L2P-v1.0	2006-Jan-25	Present	AVHRR-3	10
AVHRR19_G-NAVO-L2P-v1.0	2009-Oct-5	Present	AVHRR-3	10
AVHRR_NAVOCEANO_L2_2KM_MCSST_LAC	2002-Aug-5	Present	AVHRR-3	2
AVHRR_NAVOCEANO_L2_2km_MCSST_FRAC	2009-Jun-10	Present	AVHRR-3	2
AVHRR_NAVOCEANO_L2_9KM_MCSST_GAC	2001-Aug-29	Present	AVHRR-3, AVHRR-2	9
EUR-L2P-ATS_NR_2P	2005-Jan-31	2009-Sep-30	AATSR	1
EUR-L2P-AVHRR16_G	2005-Jan-31	2006-Aug-14	AVHRR-3	10
EUR-L2P-AVHRR16_L	2005-Feb-1	2005-Oct-26	AVHRR-3	2
EUR-L2P-AVHRR17_G	2005-Jan-31	2007-Feb-27	AVHRR-3	10
EUR-L2P-AVHRR17_L	2005-Jan-31	2007-Feb-26	AVHRR-3	2
EUR-L2P-AVHRR_METOP_A	2009-Sep-30	Present	AVHRR-3	1
EUR-L2P-SEVIRI_SST	2005-Jan-31	Present	SEVIRI	5
JPL-L2P-MODIS_A	2006-Jun-30	Present	MODIS	1
JPL-L2P-MODIS_T	2006-Oct-1	Present	MODIS	1
NAVO-L2P-AVHRR17_G	2006-Jun-21	2009-Jul-6	AVHRR-3	10
NAVO-L2P-AVHRR17_L	2006-Jun-21	2008-Sep-16	AVHRR-3	2
NAVO-L2P-AVHRR18_G	2006-Jan-25	Present	AVHRR-3	10
NAVO-L2P-AVHRR18_L	2006-Jan-25	2009-Sep-9	AVHRR-3	2
NAVO-L2P-AVHRR19_G	2009-Oct-5	Present	AVHRR-3	10
NAVO-L2P-AVHRR19_L	2009-Aug-26	Present	AVHRR-3	2
NAVO-L2P-AVHRRMTA_G	2007-Sep-26	Present	AVHRR-3	10
NEODAAS-L2P-AVHRR17_L	2008-Sep-2	2010-May-18	AVHRR-3	2
NEODAAS-L2P-AVHRR18_L	2008-Jul-26	2009-Aug-18	AVHRR-3	2
NEODAAS-L2P-AVHRR19_L	2009-Sep-6	Present	AVHRR-3	2
OSDPD-L2P-GOES11	2006-Dec-22	2011-Jul-10	GOES-11 Imager	5
OSDPD-L2P-GOES12	2006-Dec-22	2010-Jun-18	GOES-12 Imager	5
OSDPD-L2P-GOES13	2010-Jun-21	Present	GOES-13 Imager	5
OSDPD-L2P-GOES15	2012-Mar-8	Present	GOES-15 Imager	5
OSDPD-L2P-MSG02	2009-Nov-22	Present	SEVIRI	5
OSDPD-L2P-MTSAT1R	2009-Nov-22	2010-Dec-22	MTSAT 1R Imager	5
OSDPD-L2P-MTSAT2	2010-Sep-1	Present	MTSAT 2 Imager	5
REMSS-L2P-AMSRE	2002-Jun-1	2011-Oct-4	AMSR-E	25
REMSS-L2P-TMI	1998-Jan-1	Present	TMI	25
UPA-L2P-ATS_NR_2P	2008-May-27	2012-Apr-8	AATSR	1
VIIRS_NPP-NAVO-L2P-v1.0	2013-May-20	Present	VIIRS	.8



AQUA AMSRE - 06-May-2010
AQUA MODIS_A - 06-May-2010
AATSR - 06-May-2010
60°N
30°N
0°
30°S
60°S
180°W
120°W
60°W
0°
60°E
120°E
180°W
30
25
20
15
10
5
0

Satellite SST observations



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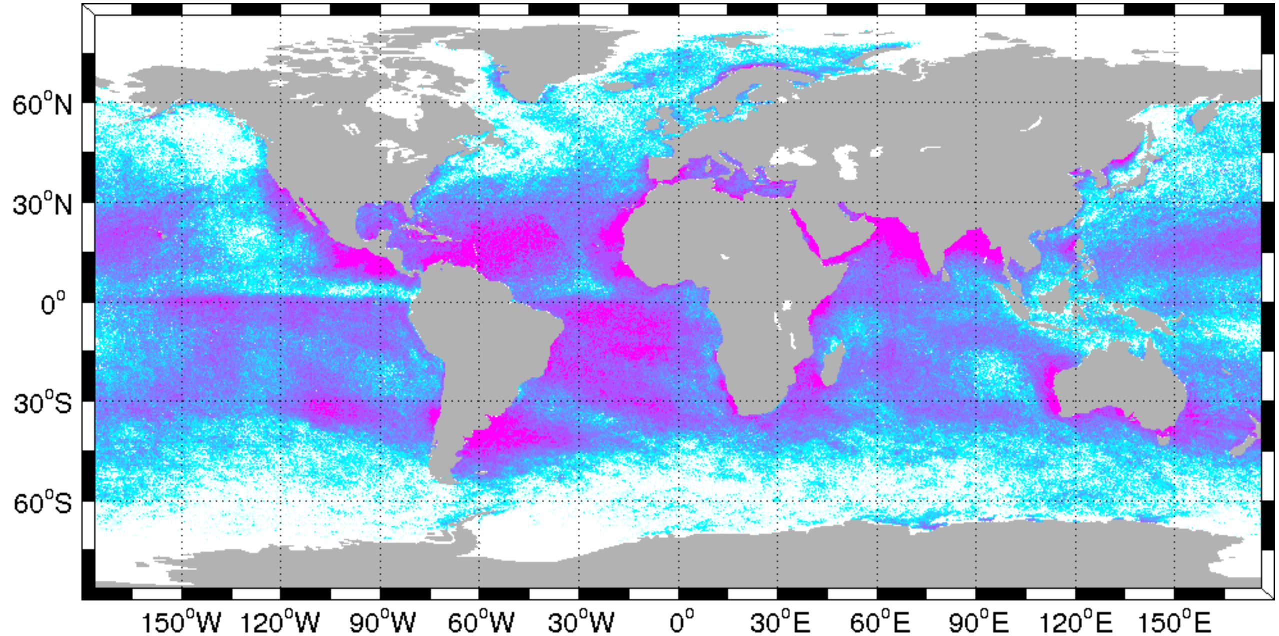
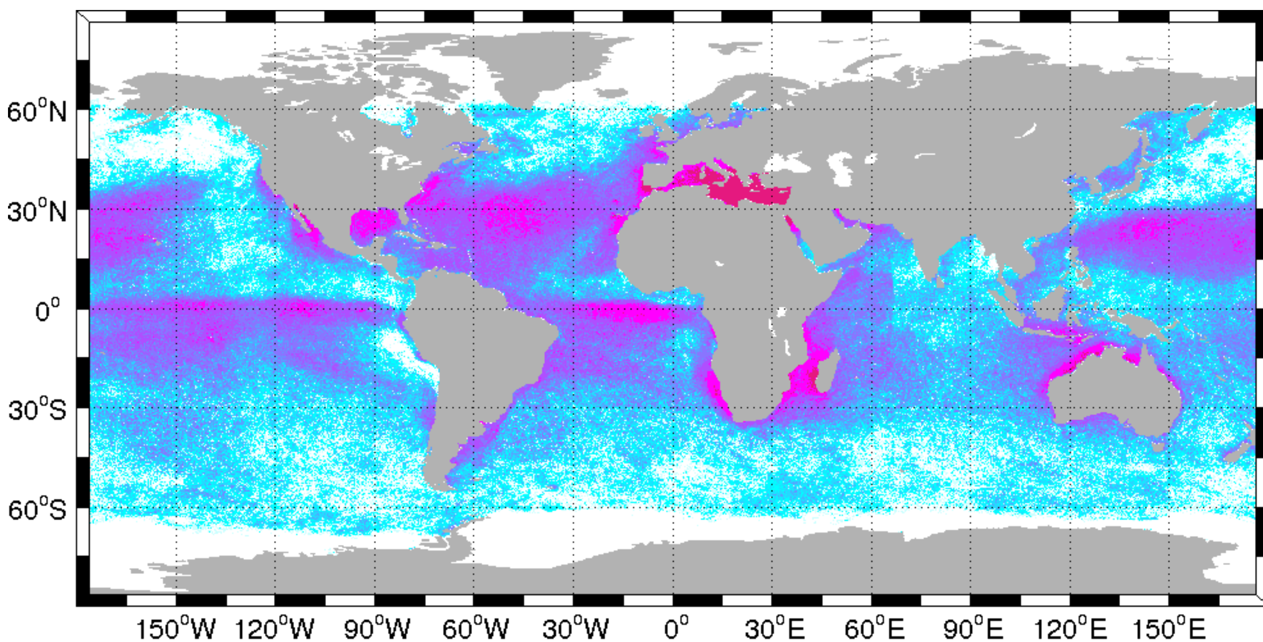
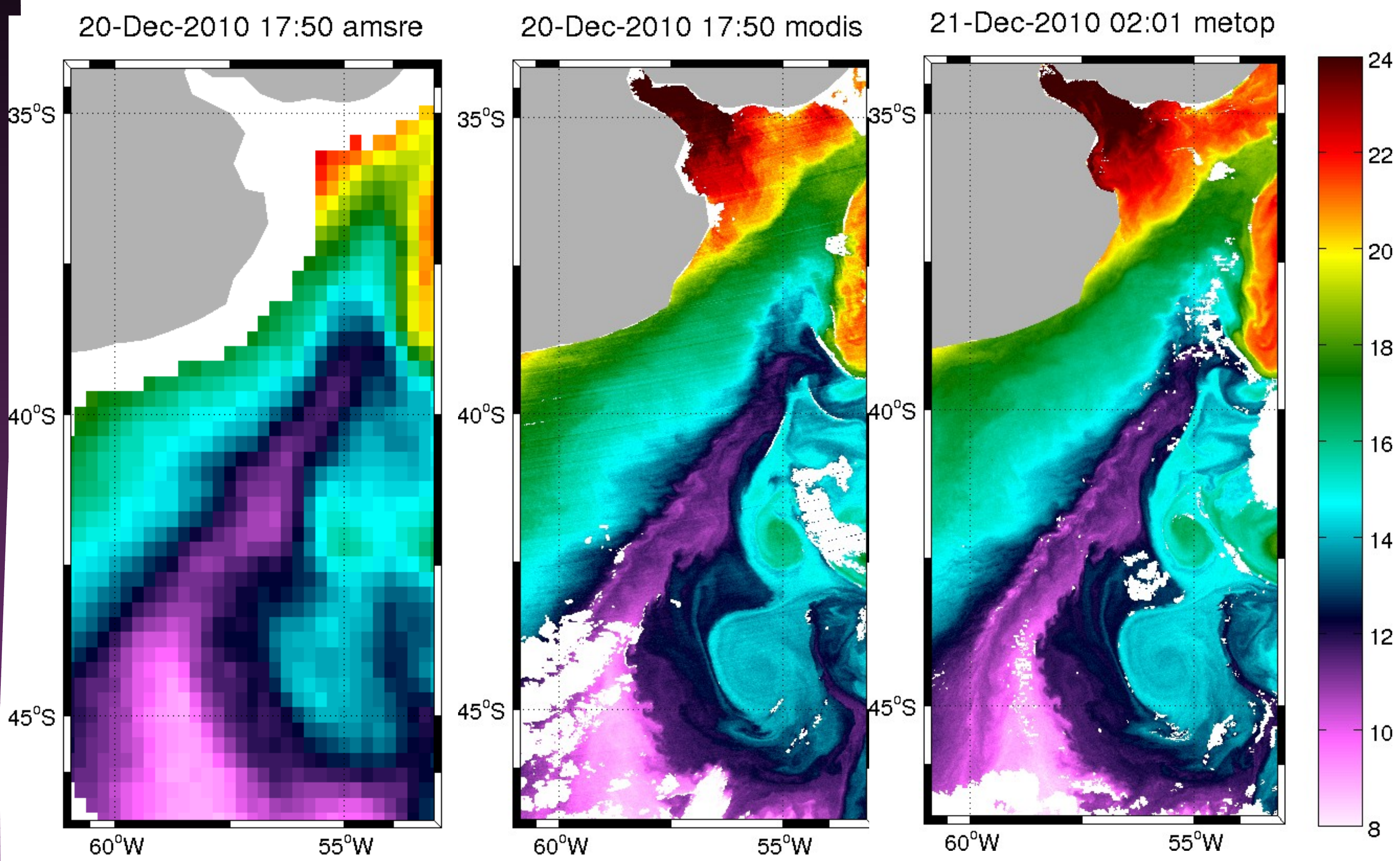
Satellite SST observations





Satellite SST observations



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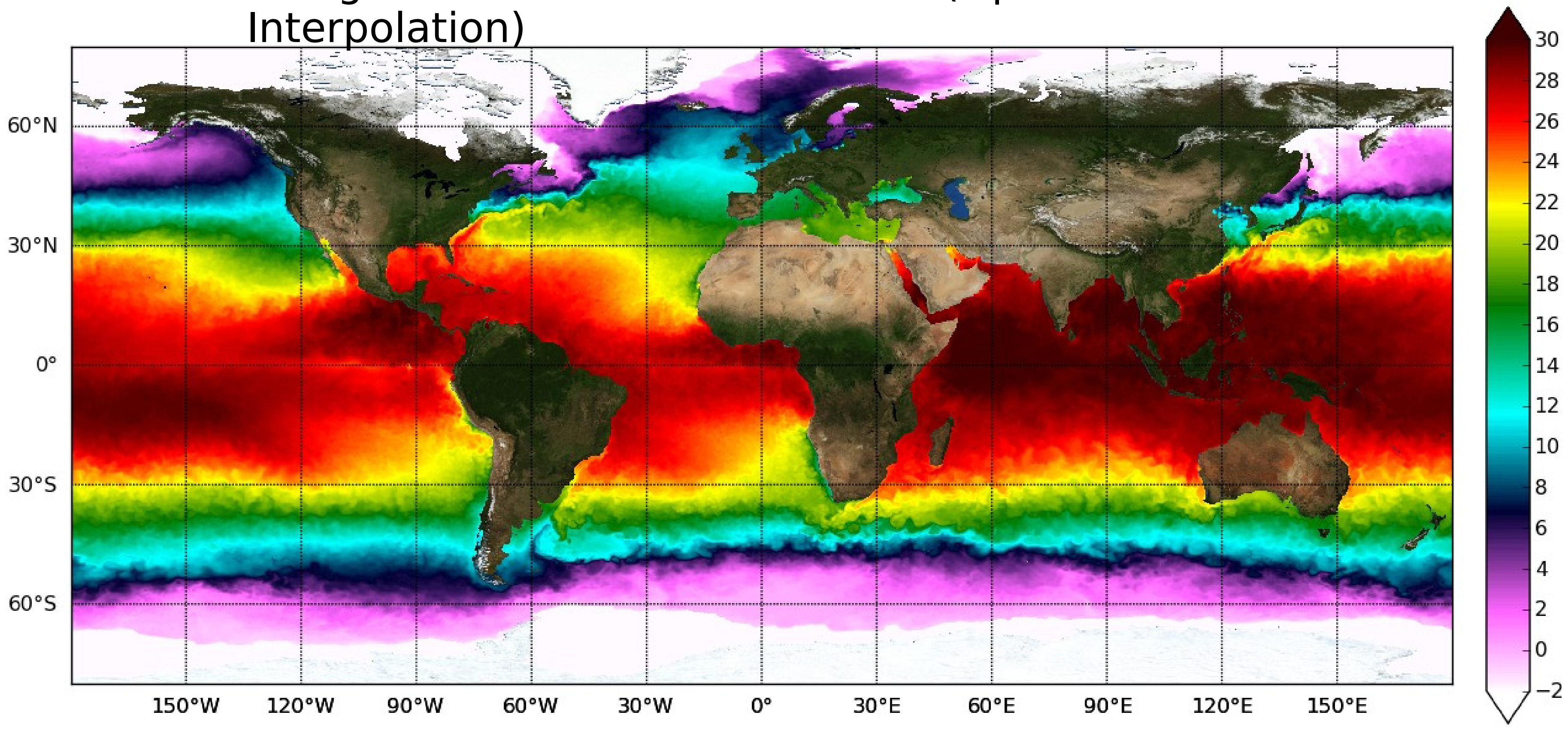
Satellite SST observations

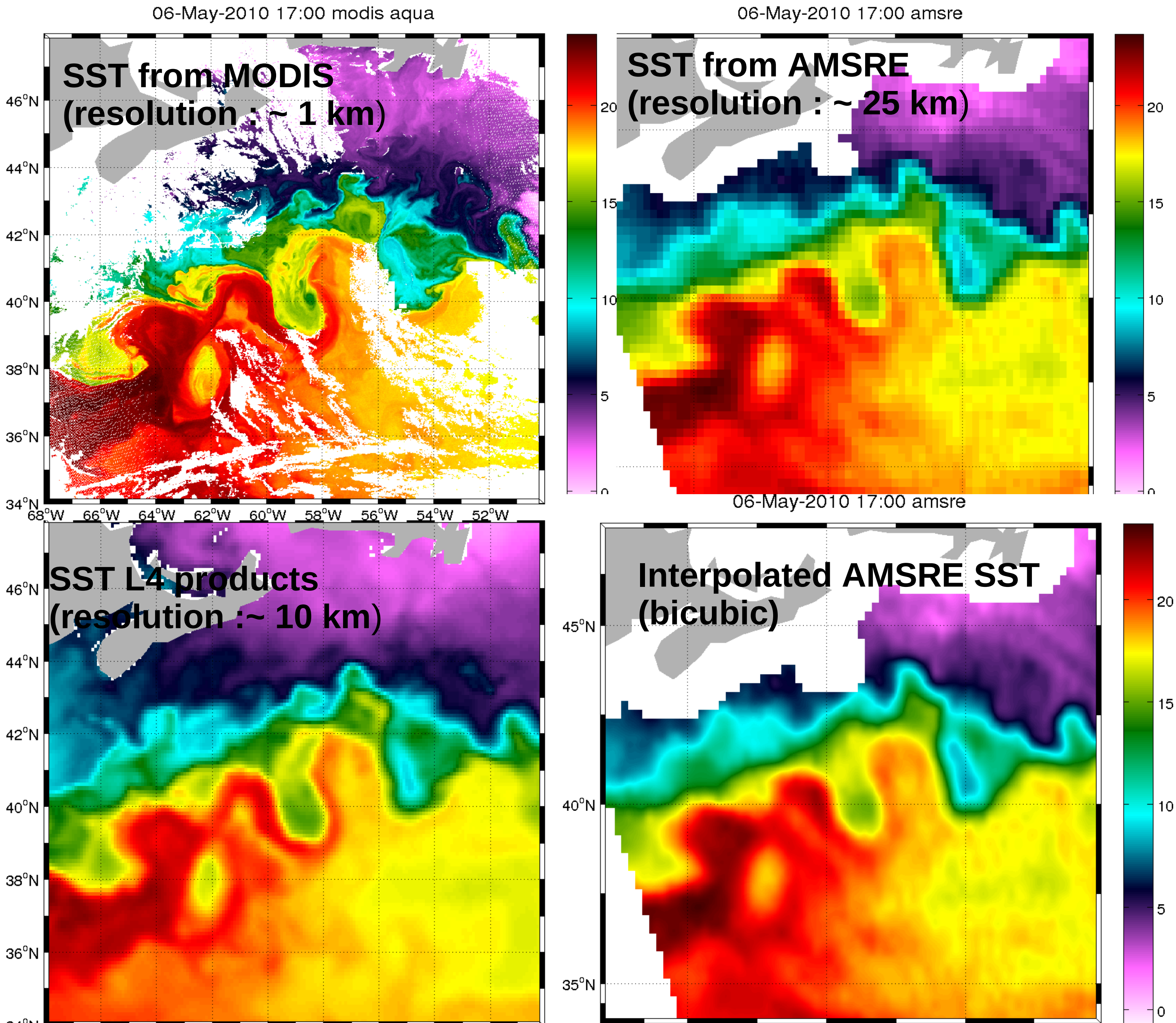
Production of « high resolution » SST data sets :

- ~ 10 global SST analysis (2 km to 25 km) produced on a daily basis currently available.

- Main steps :
  - Data collection (~ 80 Go / day)
  - Data selection and intercalibration
  - SST gridded fields reconstruction (Optimal Interpolation)

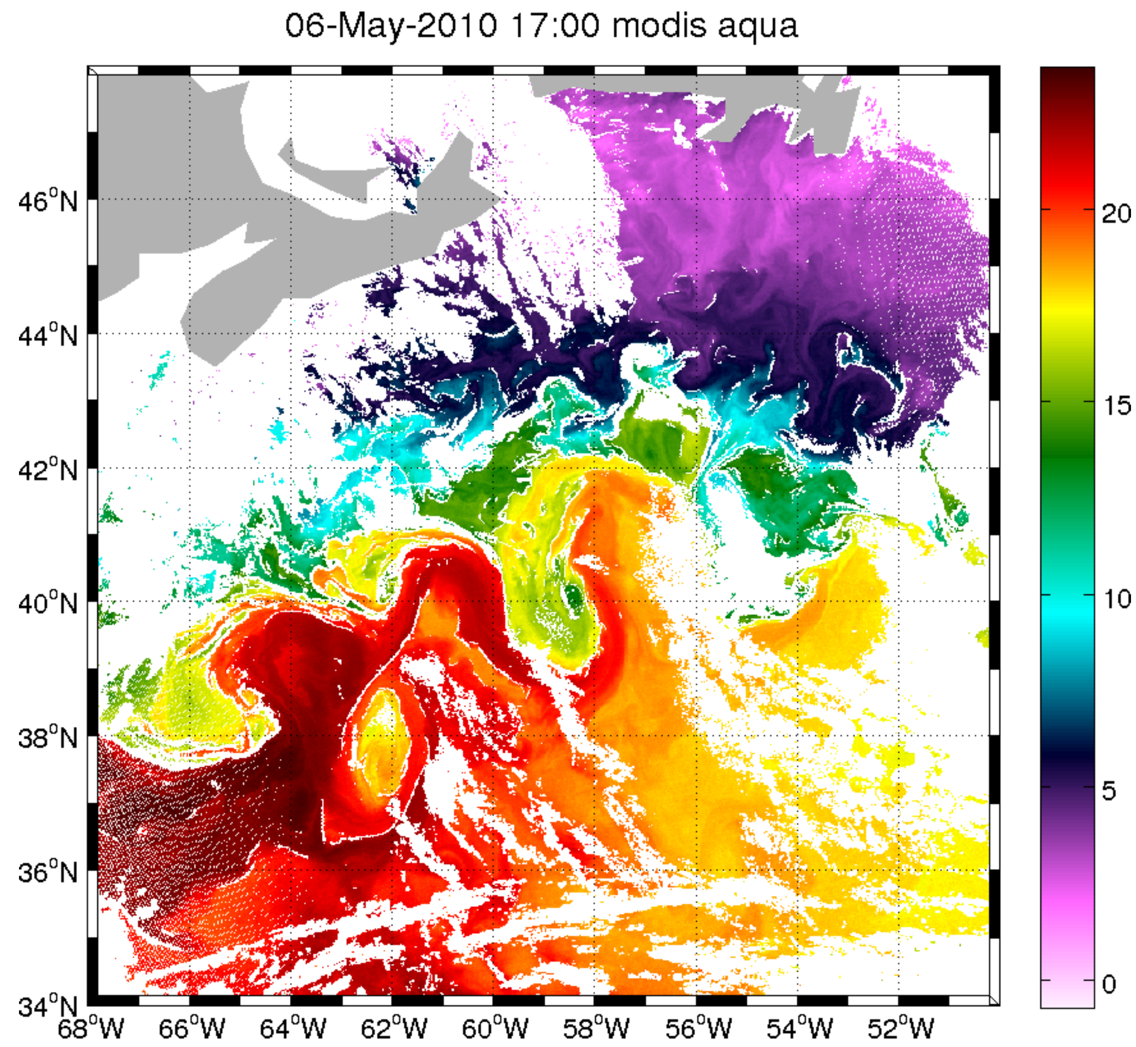


Satellite SST observations

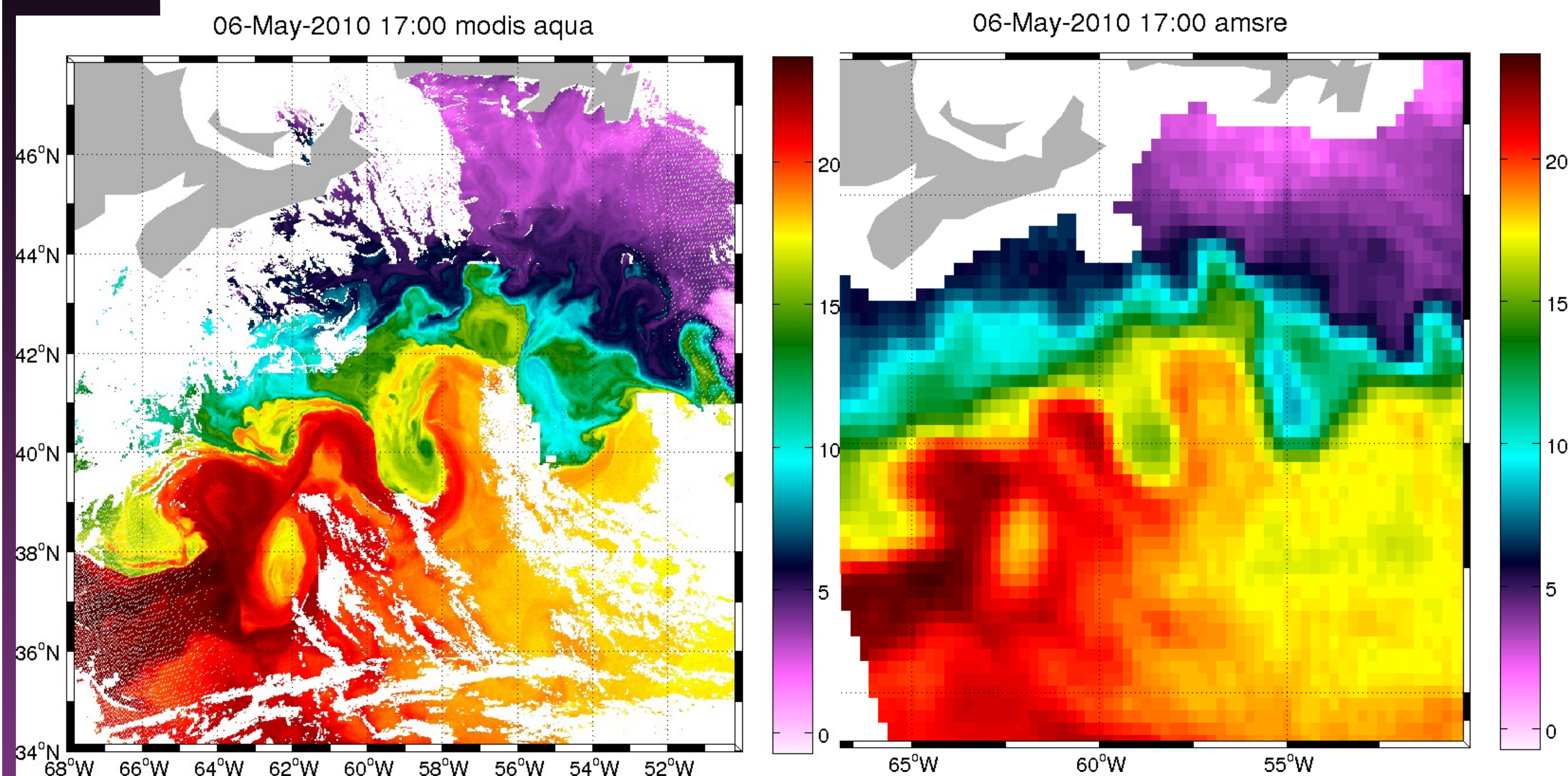


Small scales / mesoscale

Exploring co-localized IR/MW data from AQUA



Small scales / mesoscale



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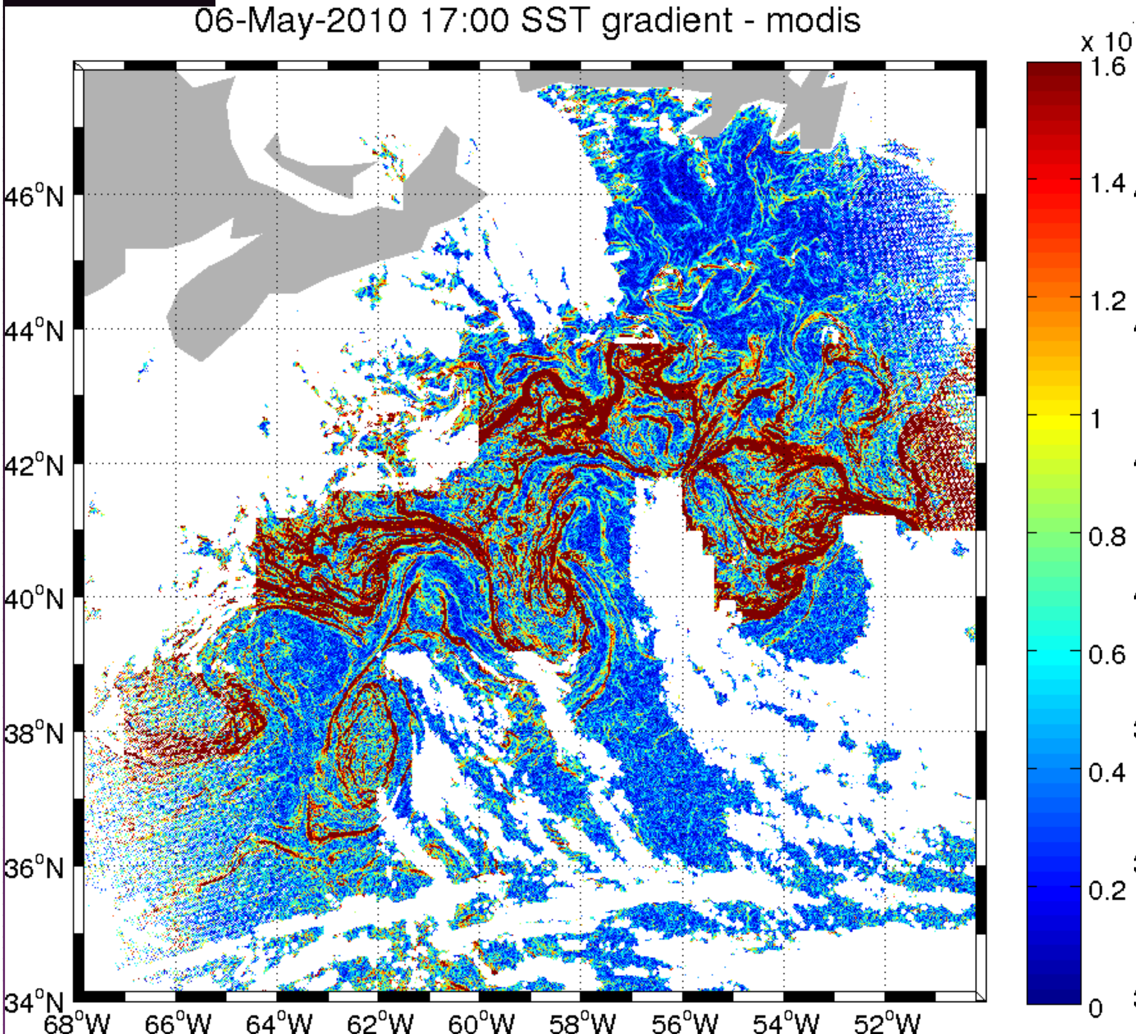

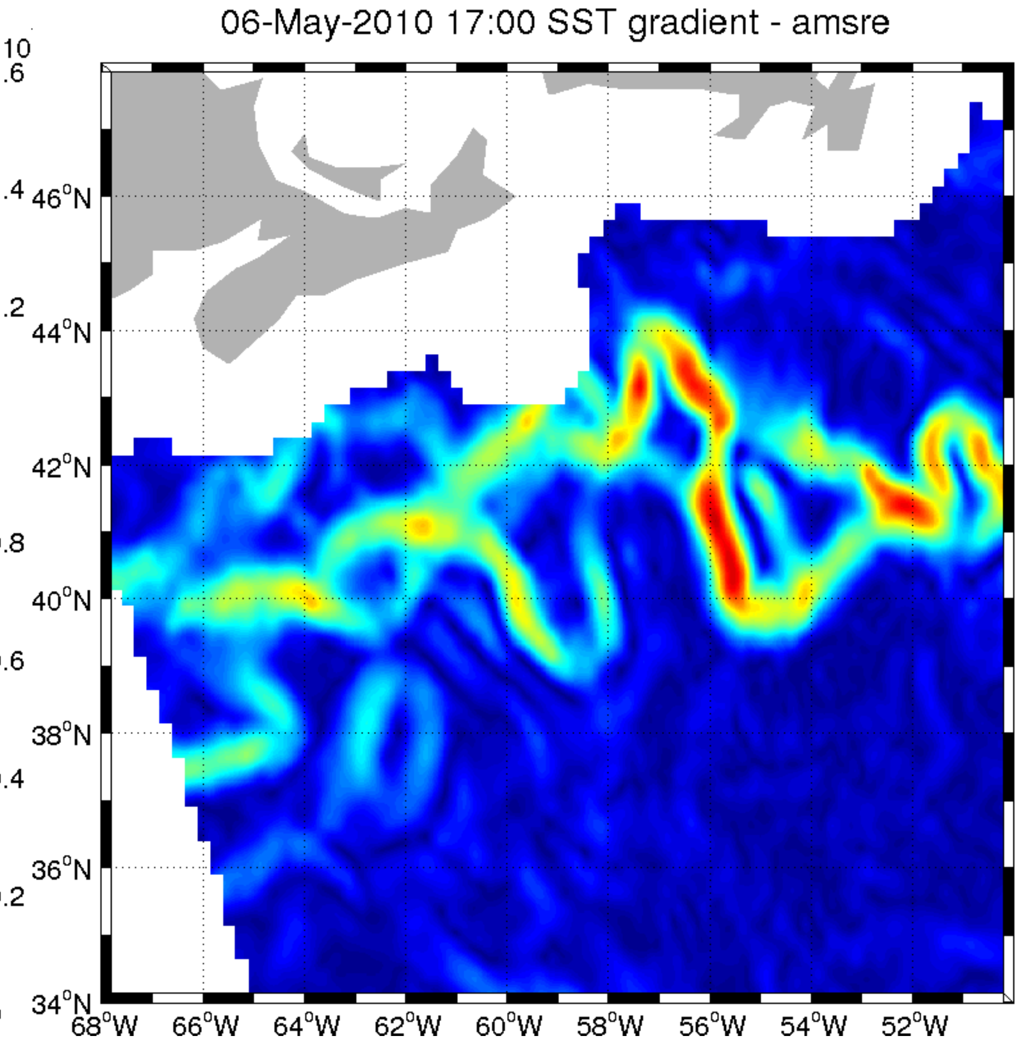

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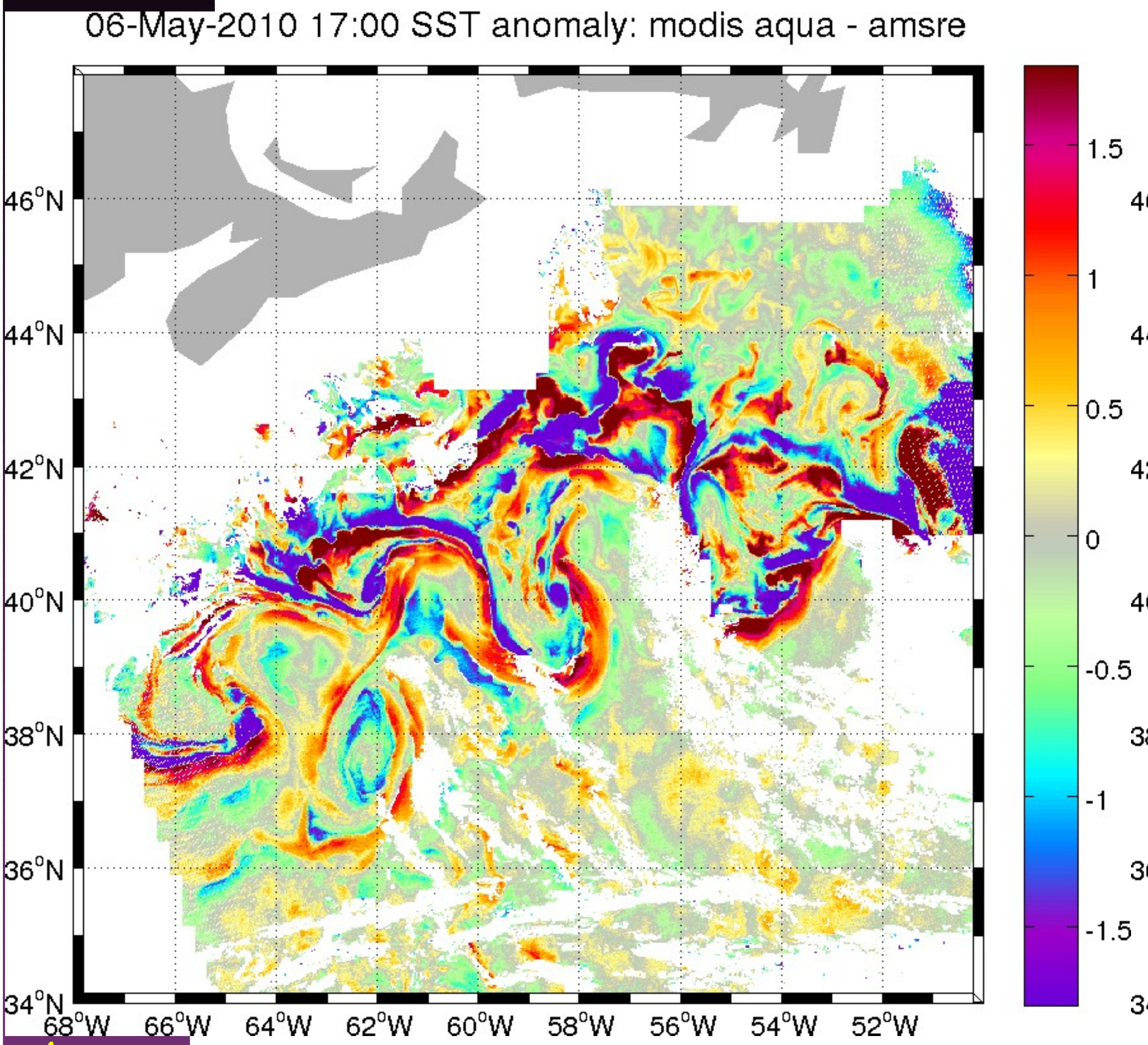
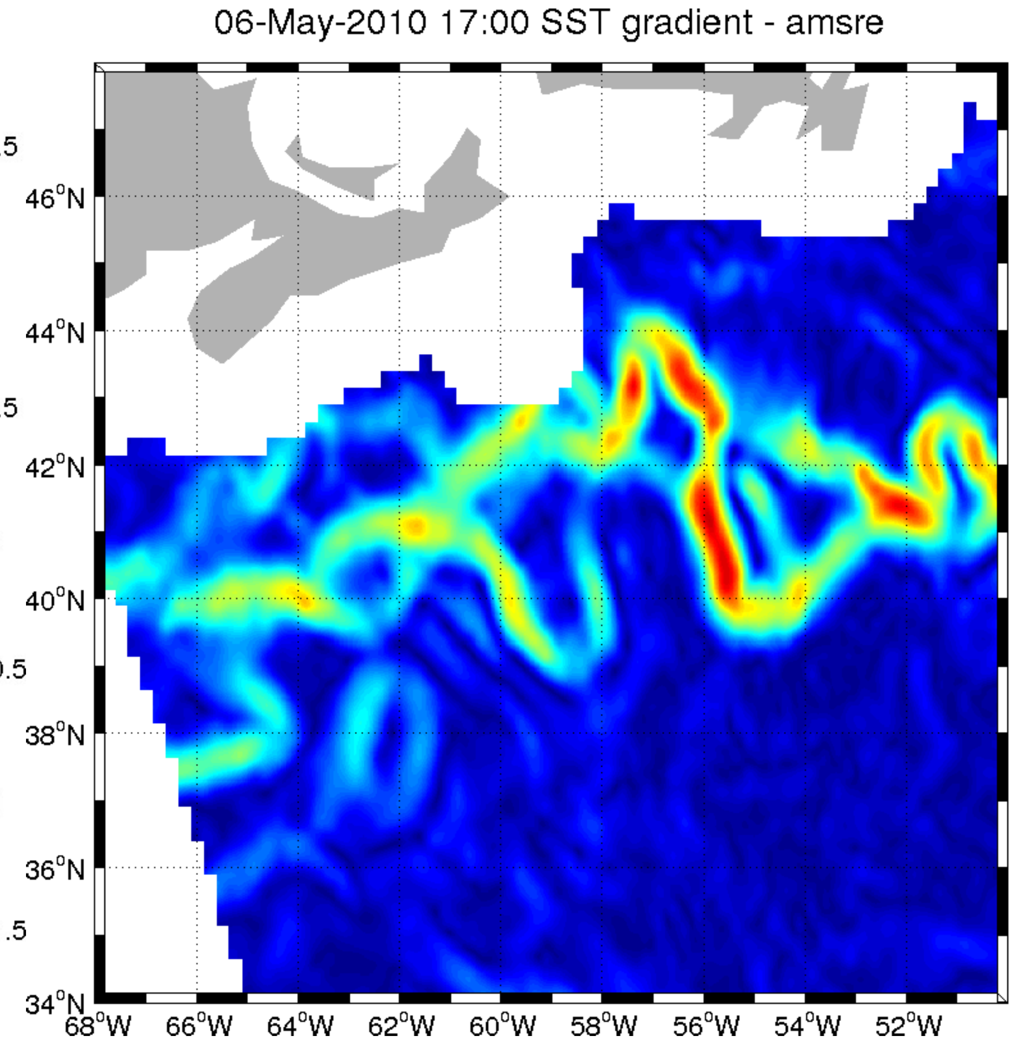
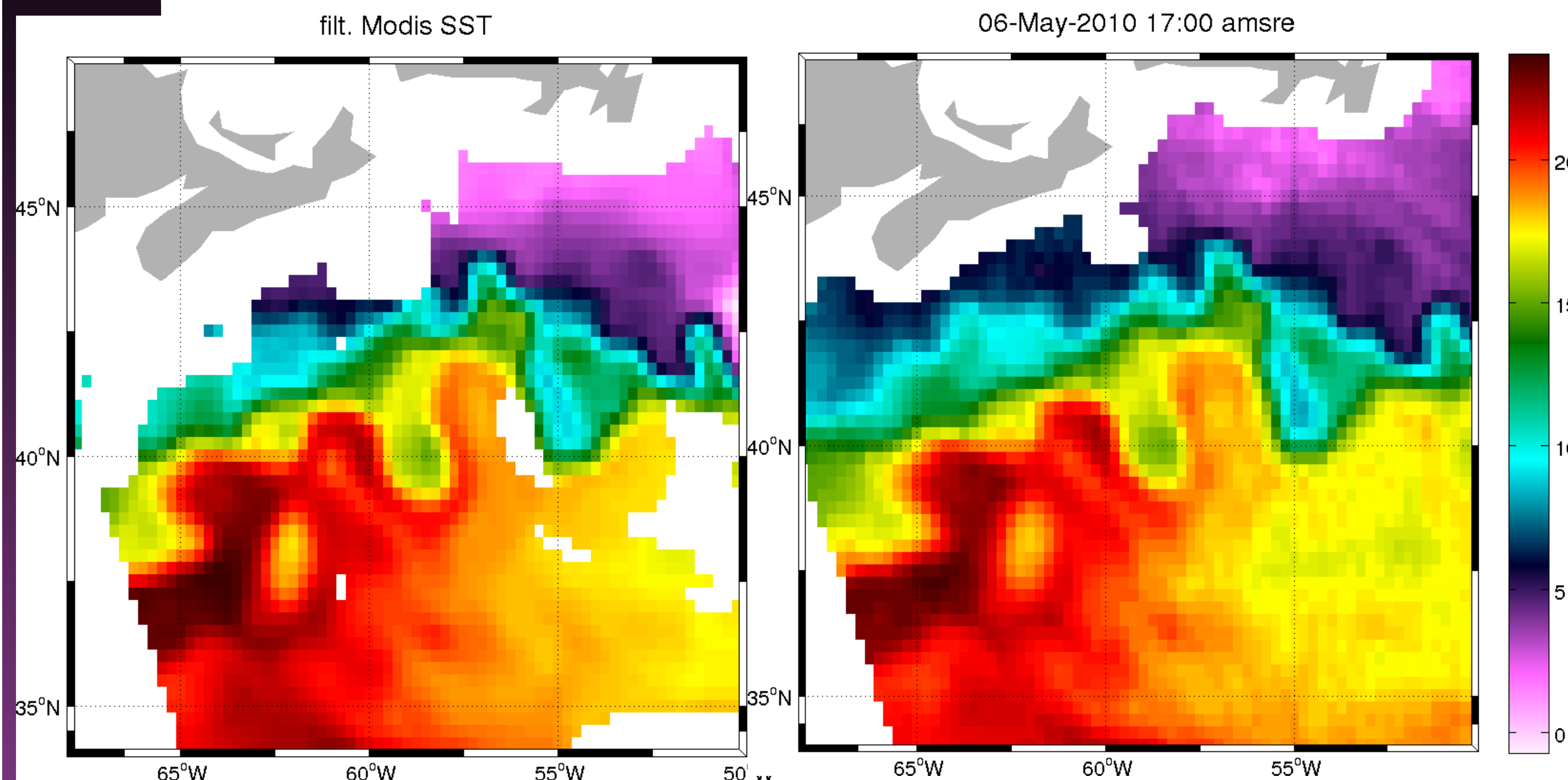




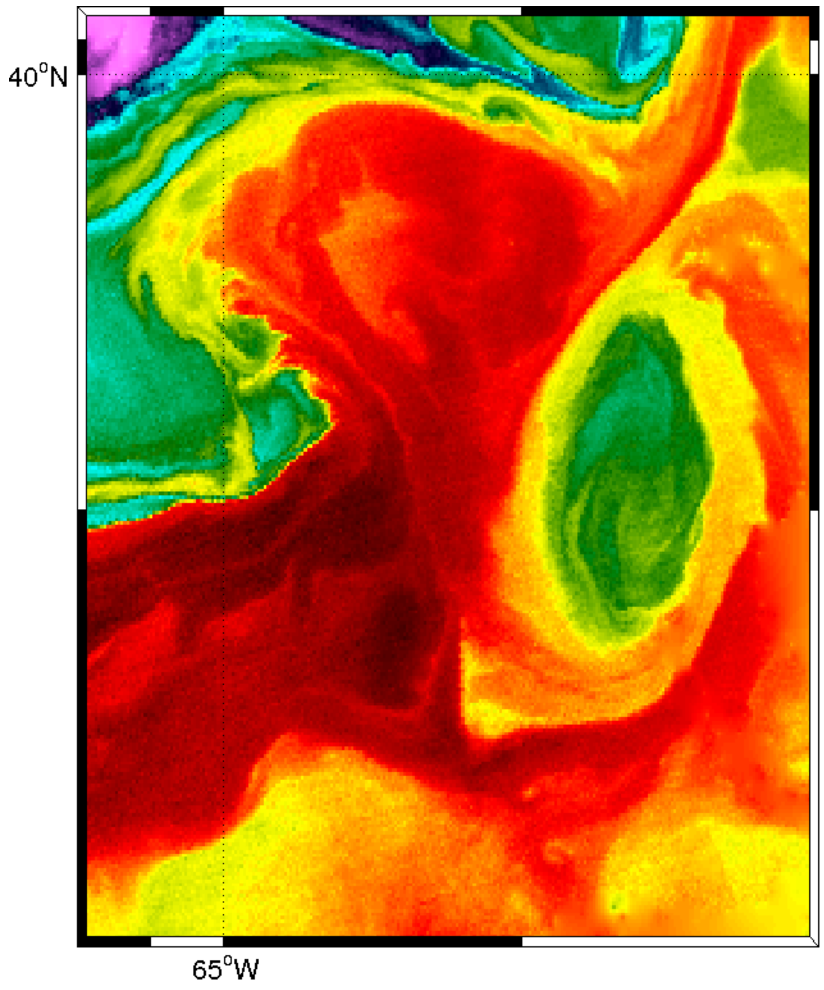
(large scale bias removed)

Small scales / mesoscale

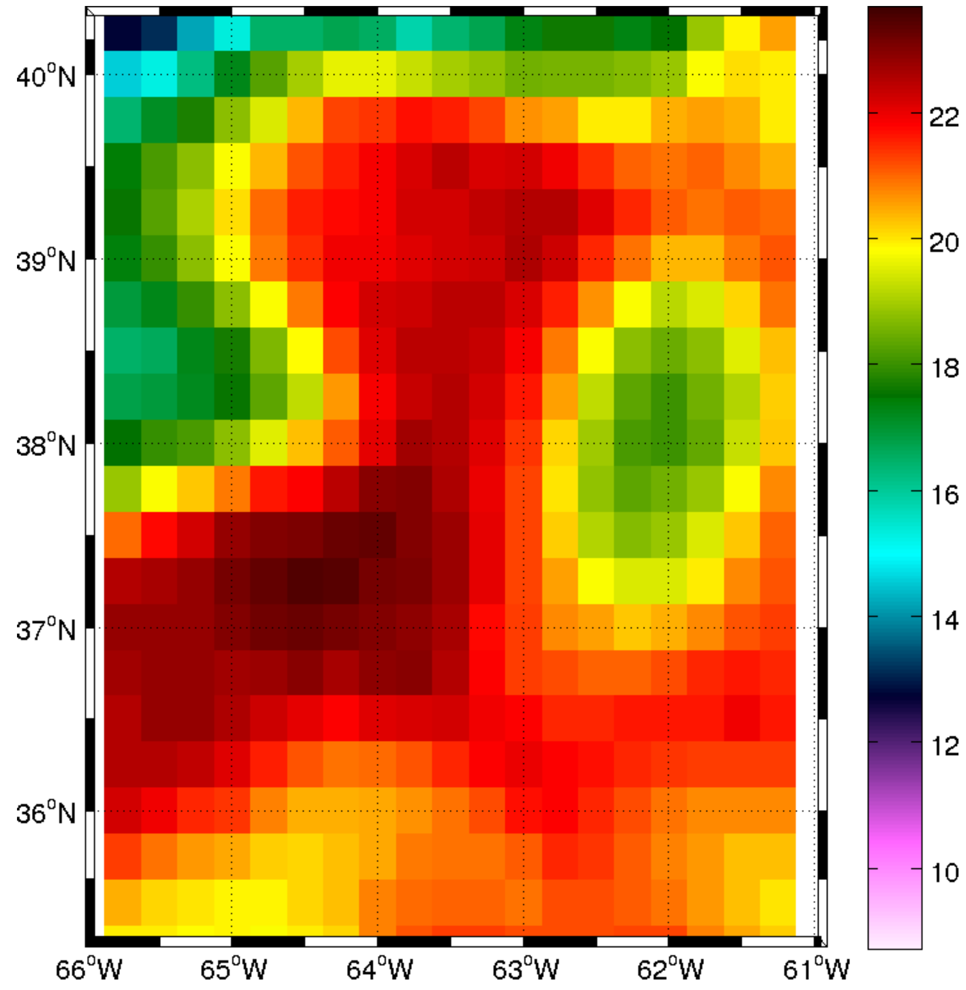


Small scales / mesoscale

SST – Modis(L2P)



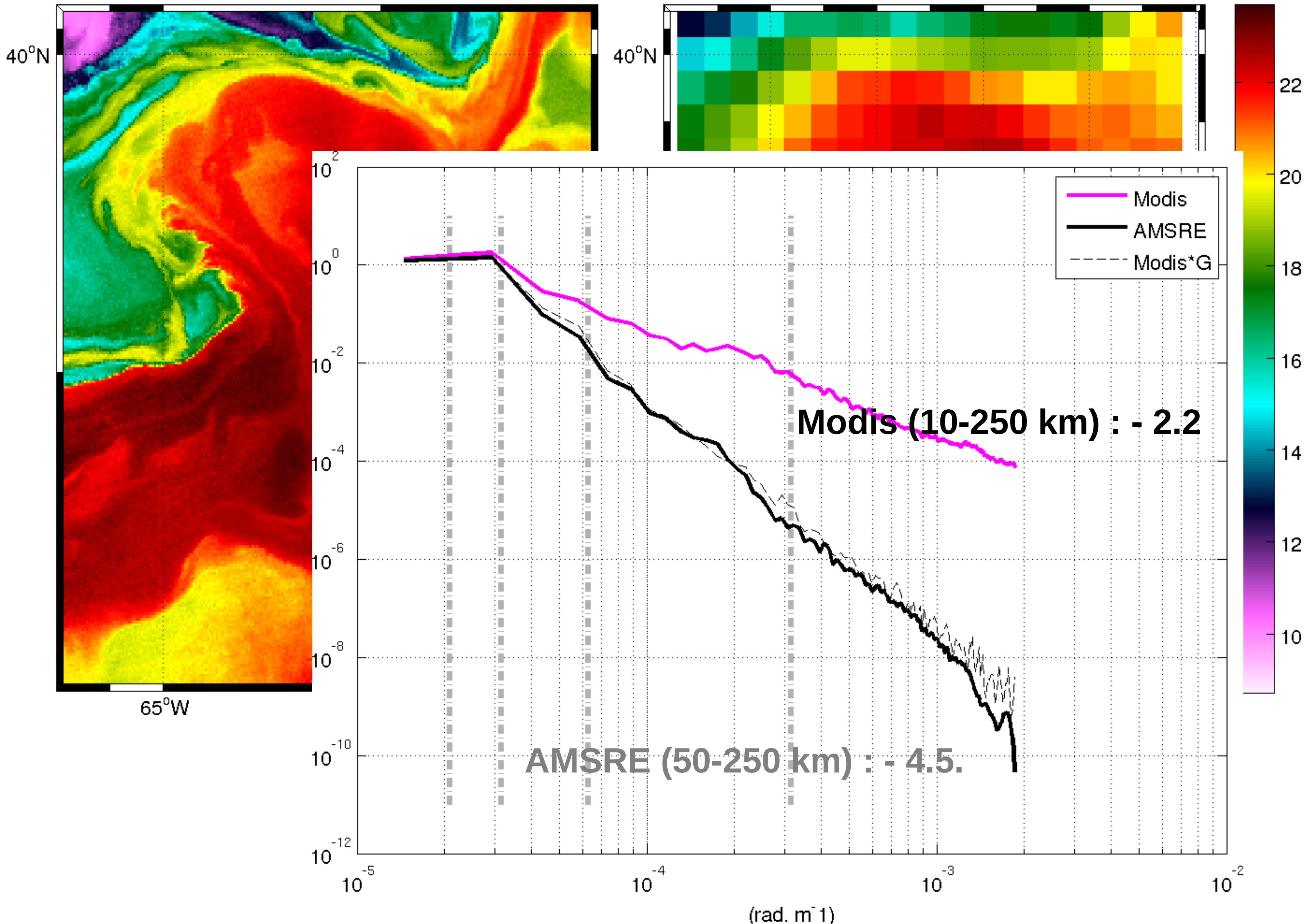
SST – AMSRE(L3)



Small scales / mesoscale

SST – Modis(L2P)

SST – AMSRE(L3)



Small scales / mesoscale

- MW observation system could be considered as an average filter (here ~60 km) ~ 1/k filter for scales smaller than 250 km

- => Inverse filter ?

Proposition 1 :   x k

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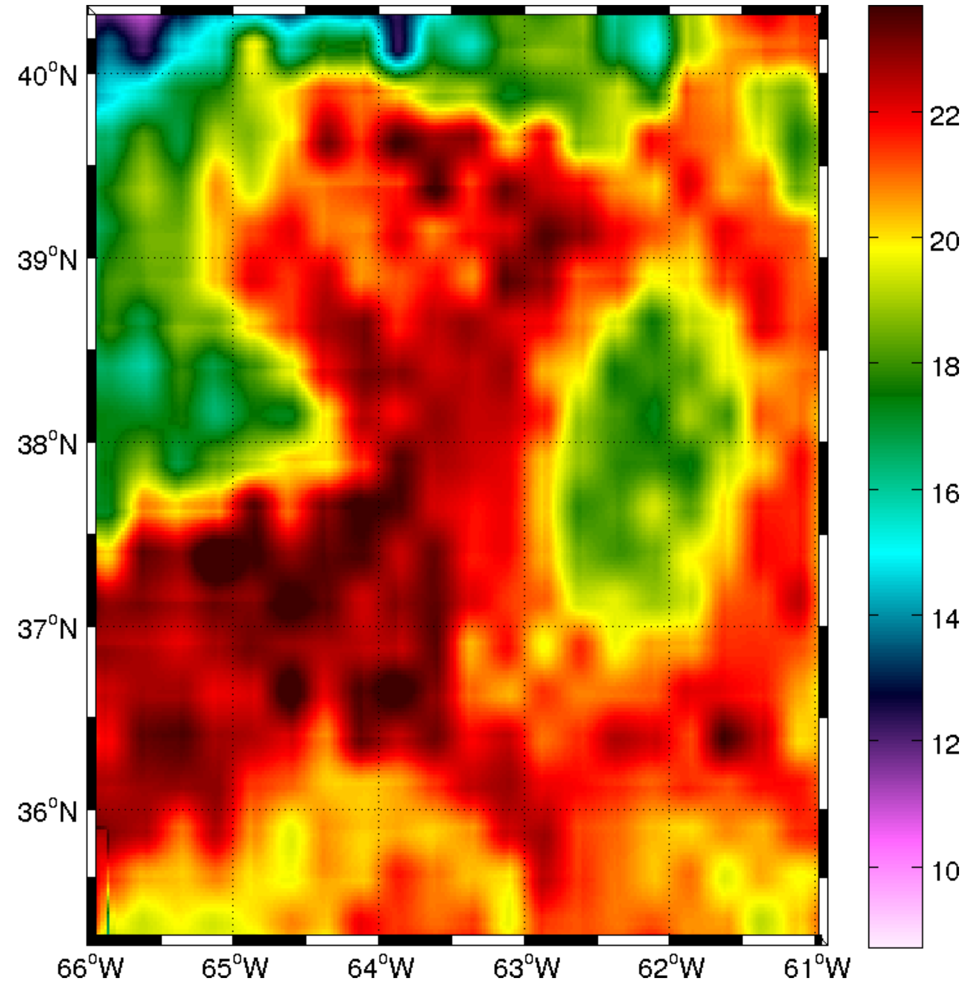

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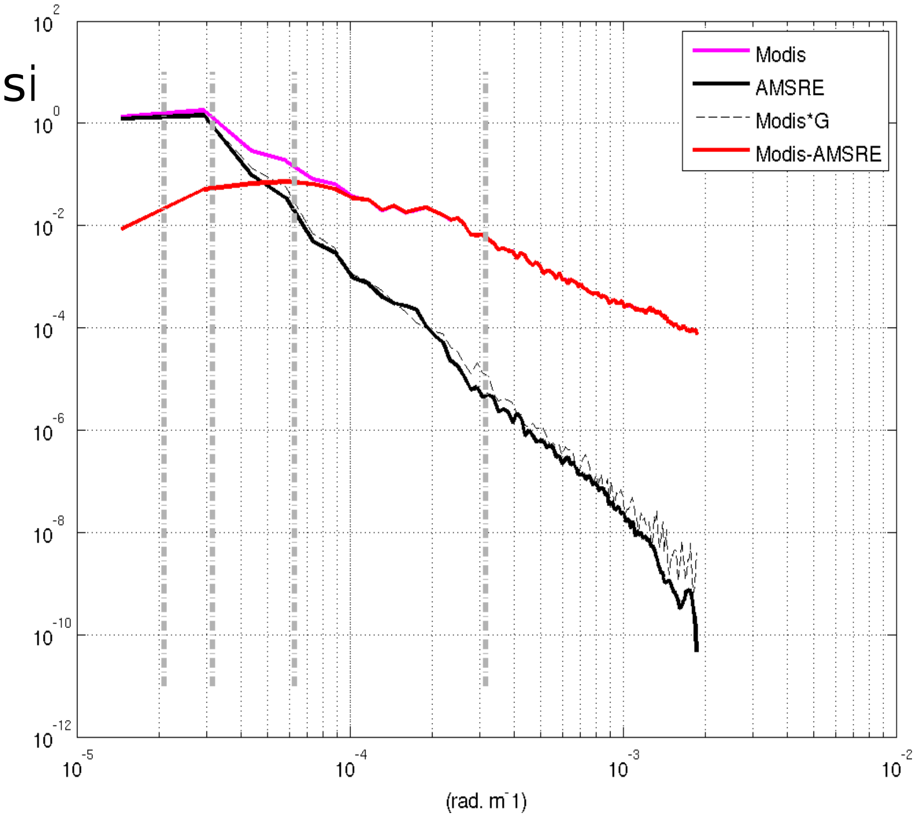

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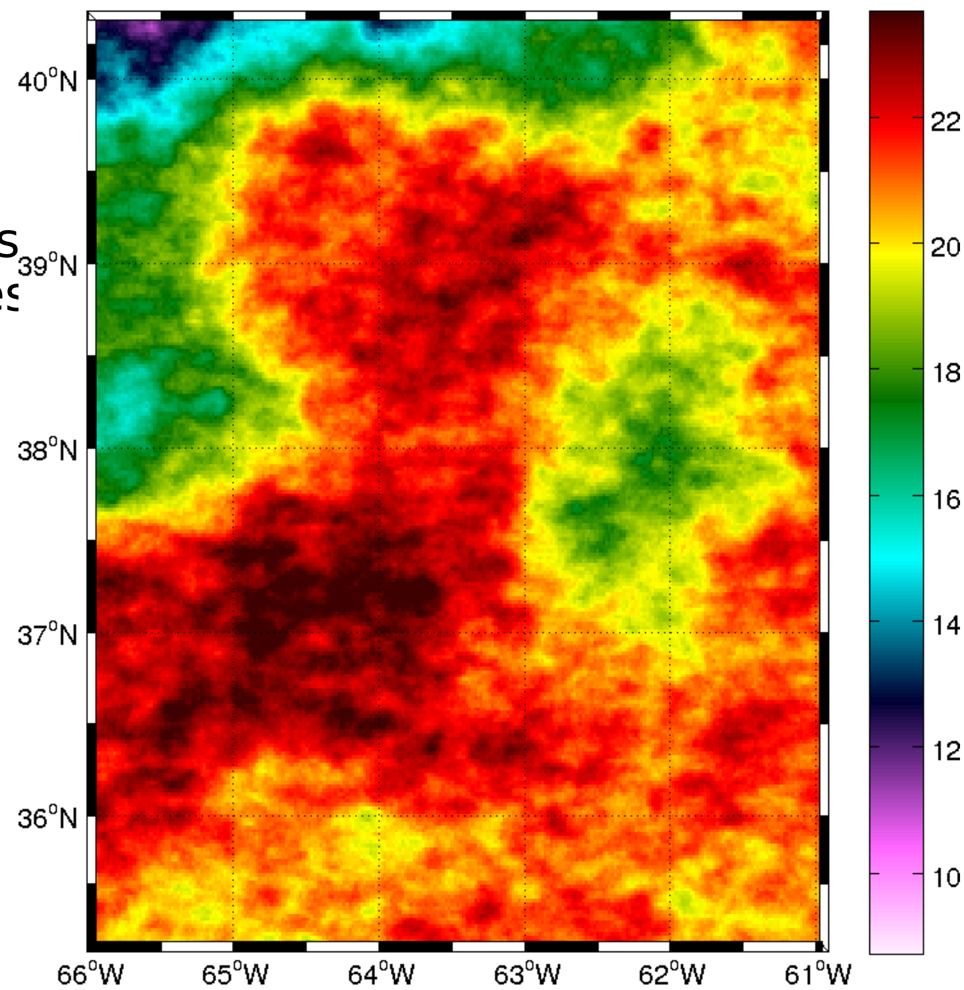

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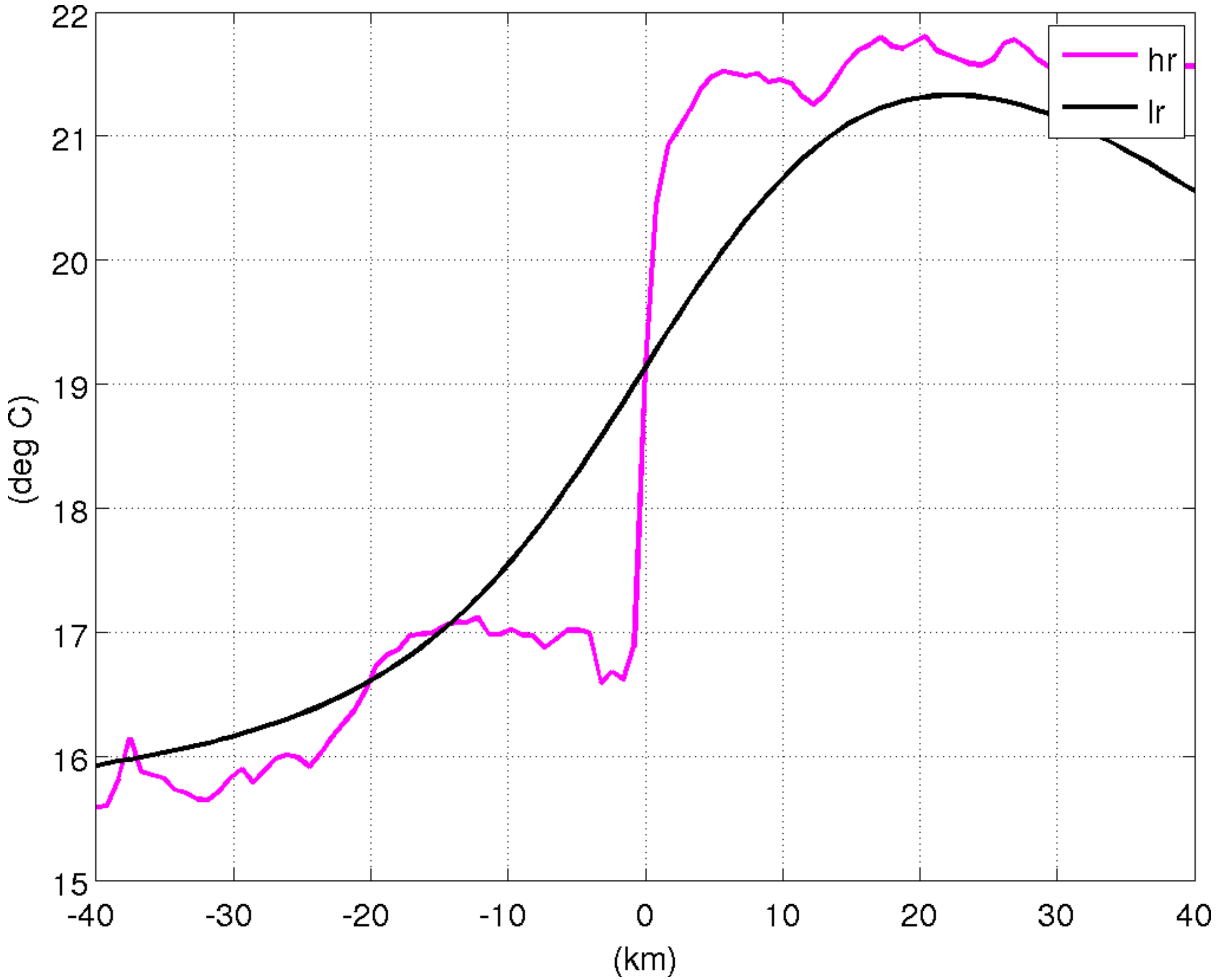

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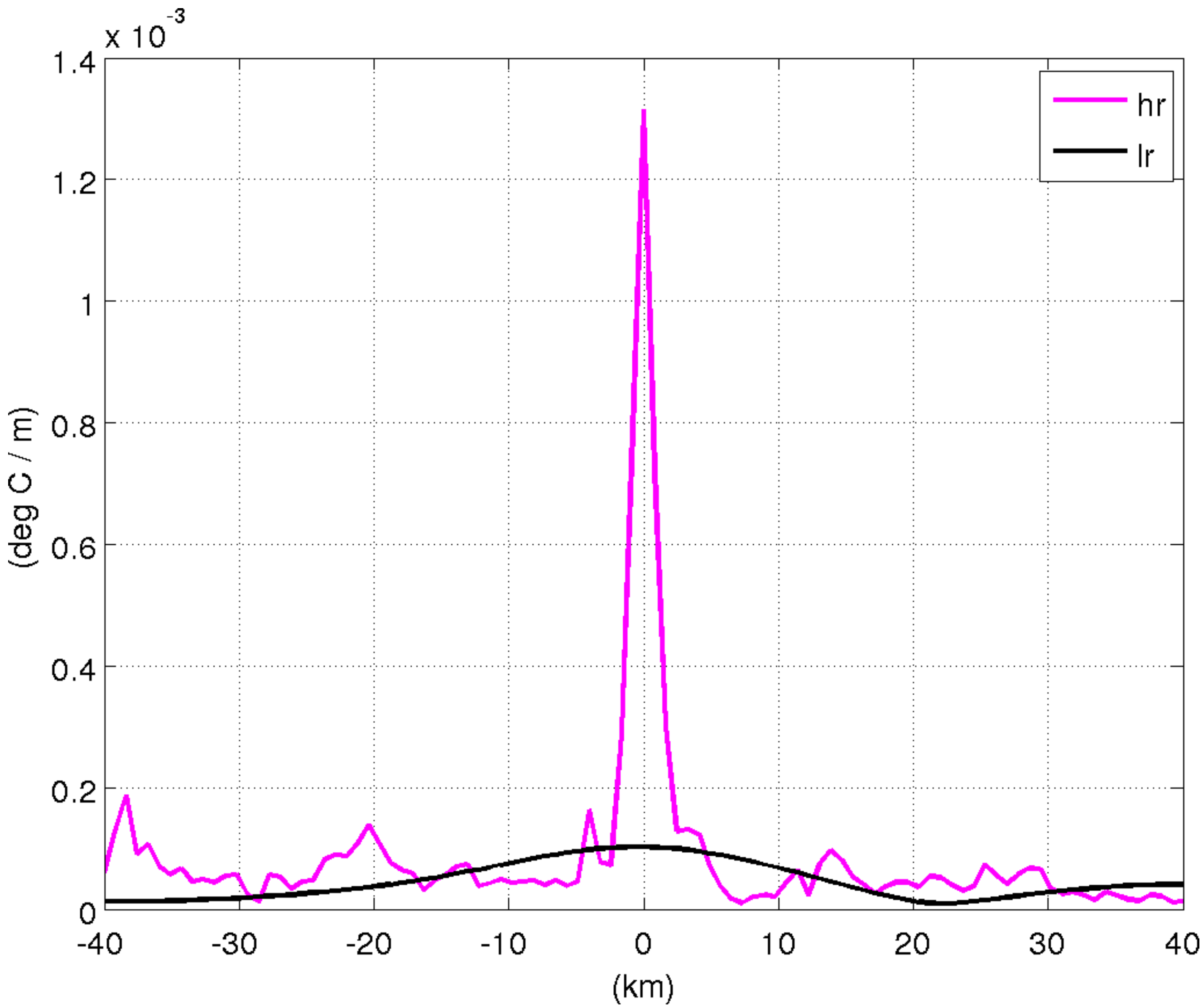
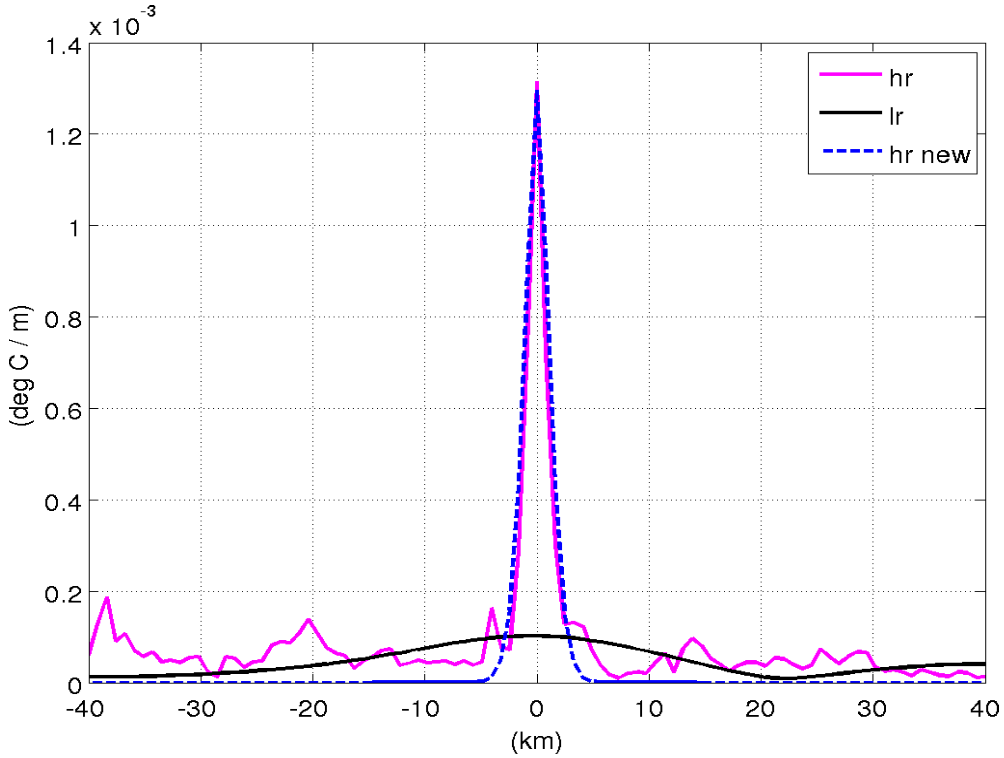


Small scales / mesoscale

Proposition 3 *:*

1/ gradient profile model (density function of a generalized exponential distribution) for HR and LR-> 'transformation model'



Small scales / mesoscale

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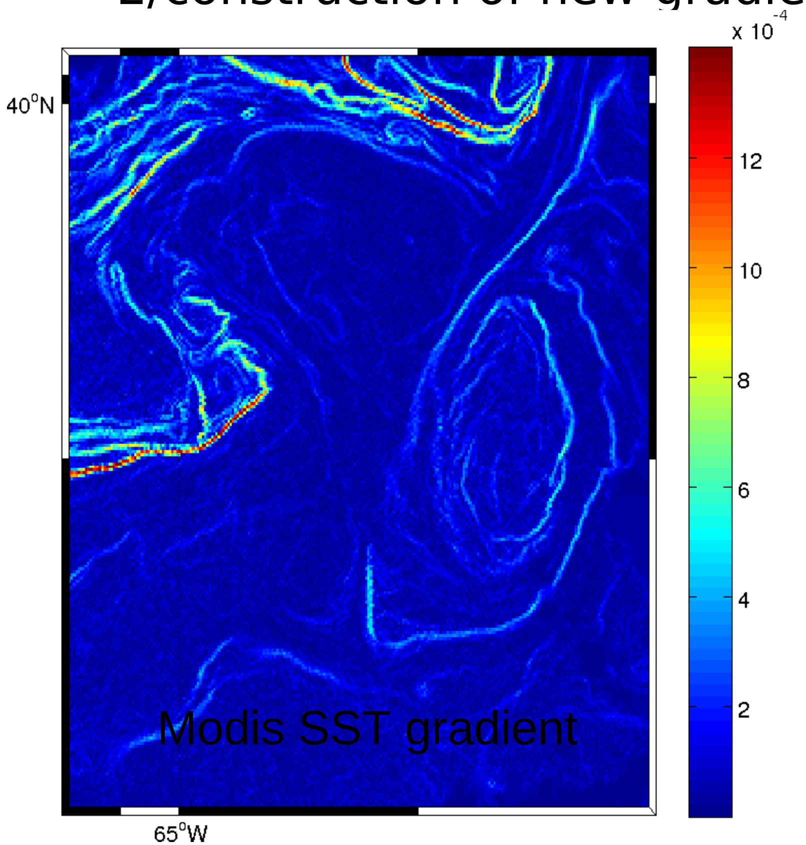
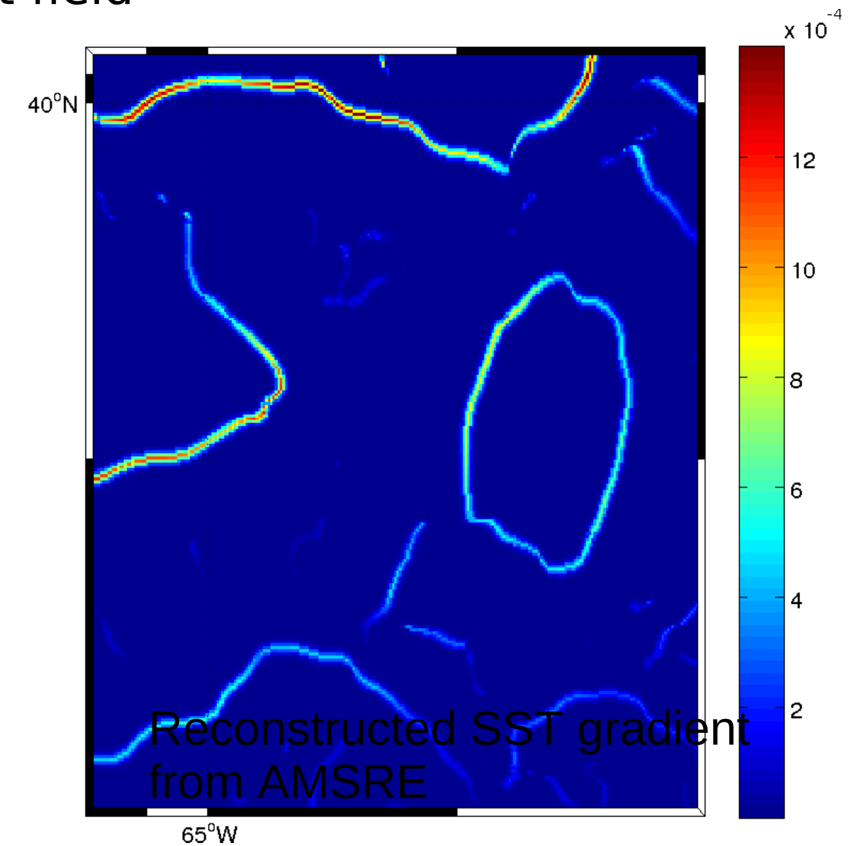
1/ gradient profile model (density function of a generalized exponential distribution) for HR and LR-> 'transformation model'

2/construction of new gradient field





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3/ LR SST field « + » reconstructed gradient field :

Minimization of :

$$E(I_h \,|\, I_l, \widetilde{\nabla I}_h) = E_i(I_h \,|\, I_l) + \beta E_g(\nabla I_h \,|\, \widetilde{\nabla I}_h)$$

with $E_i(I_h \,|\, I_l) = |(I_h * G) \downarrow - I_l|^2$

$$E_g(\nabla I_h \,|\, \widetilde{\nabla I}_h) = |\nabla I_h - \widetilde{\nabla I}_h|^2$$

=> new HR SST field

Small scales / mesoscale

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3/ L

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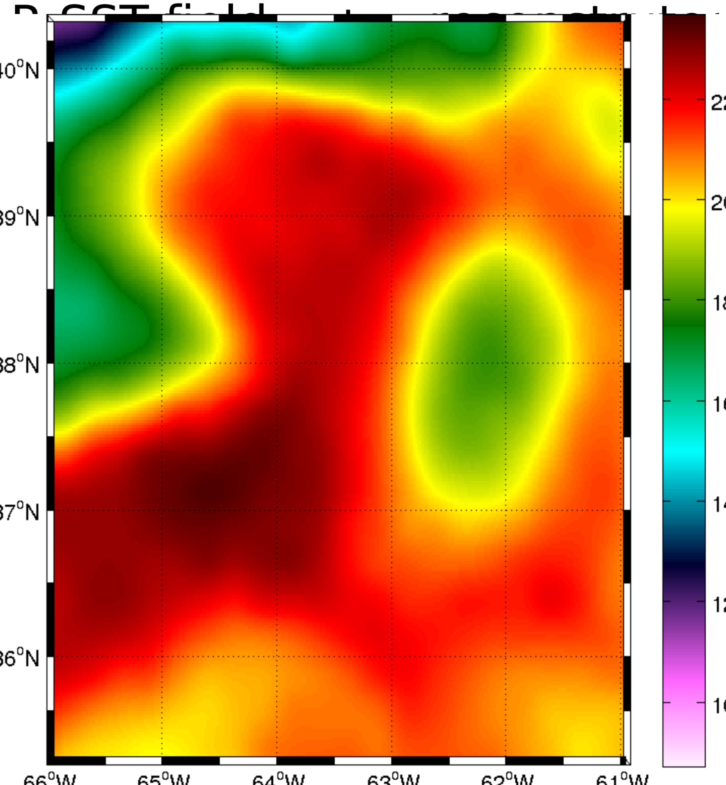

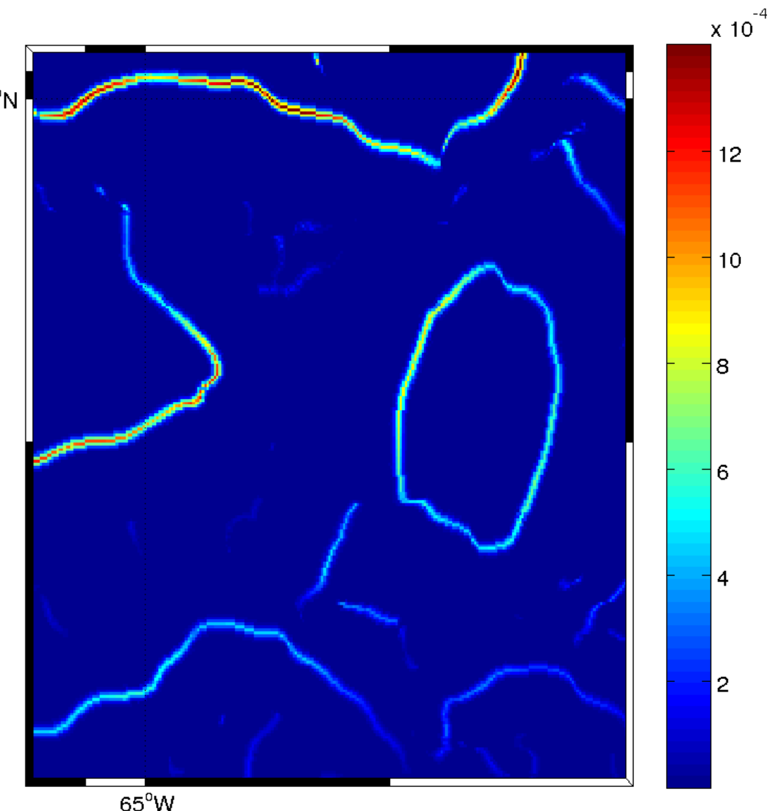

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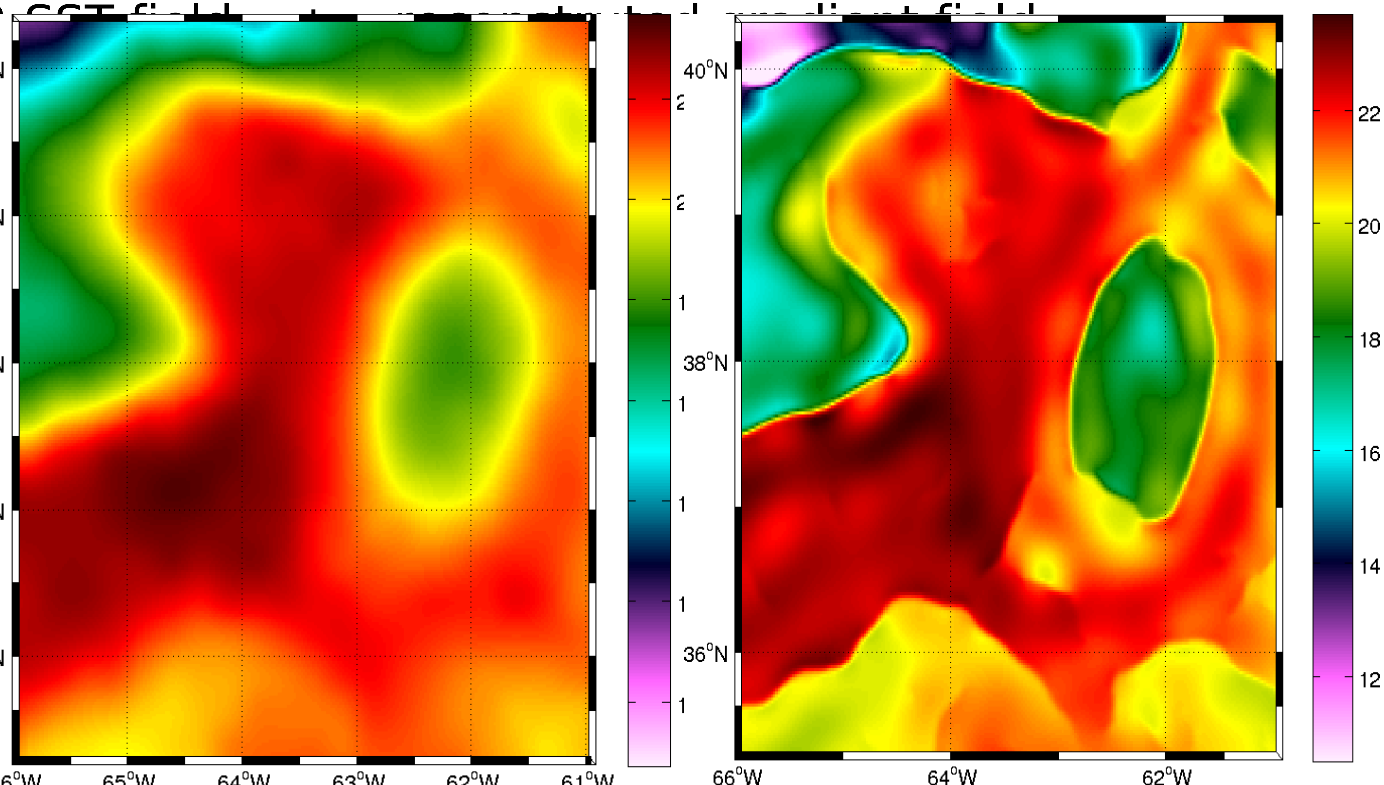

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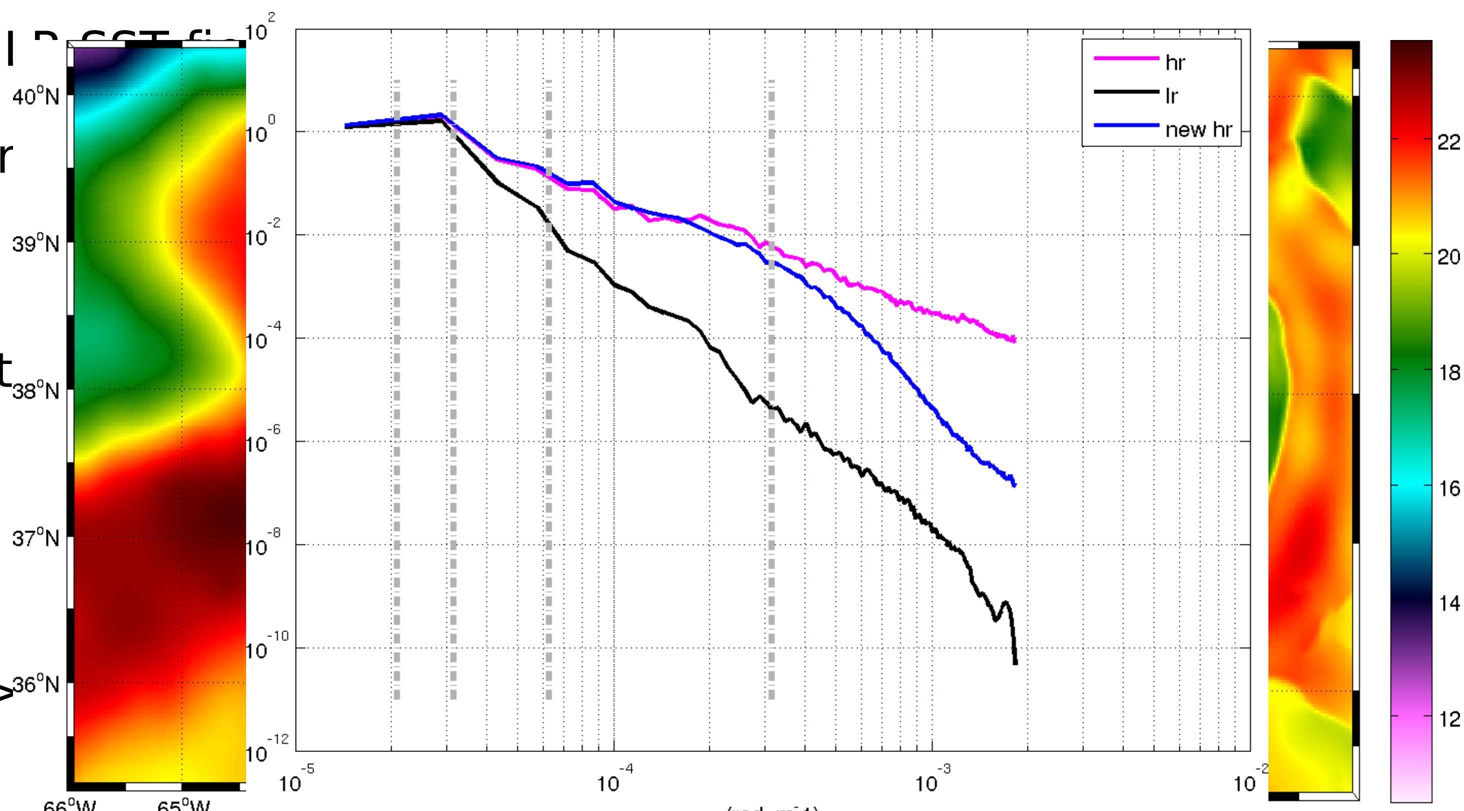

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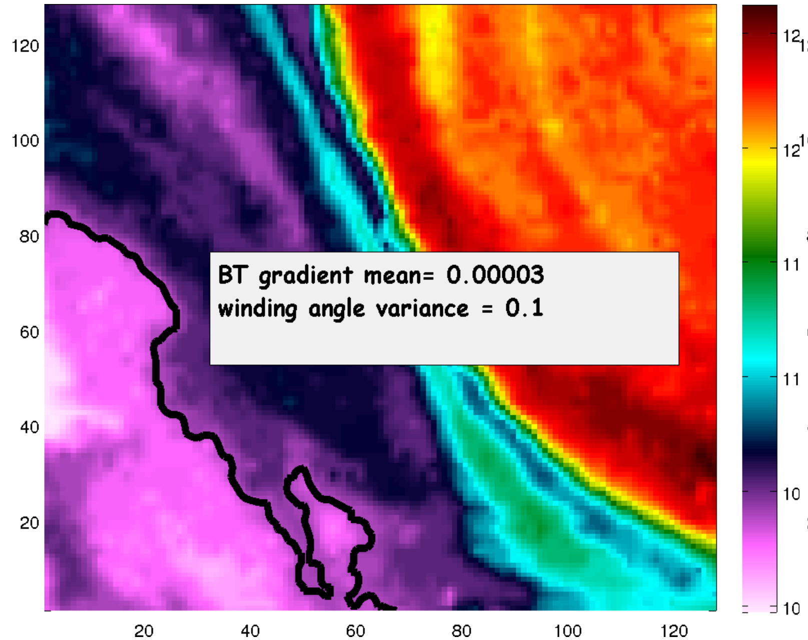
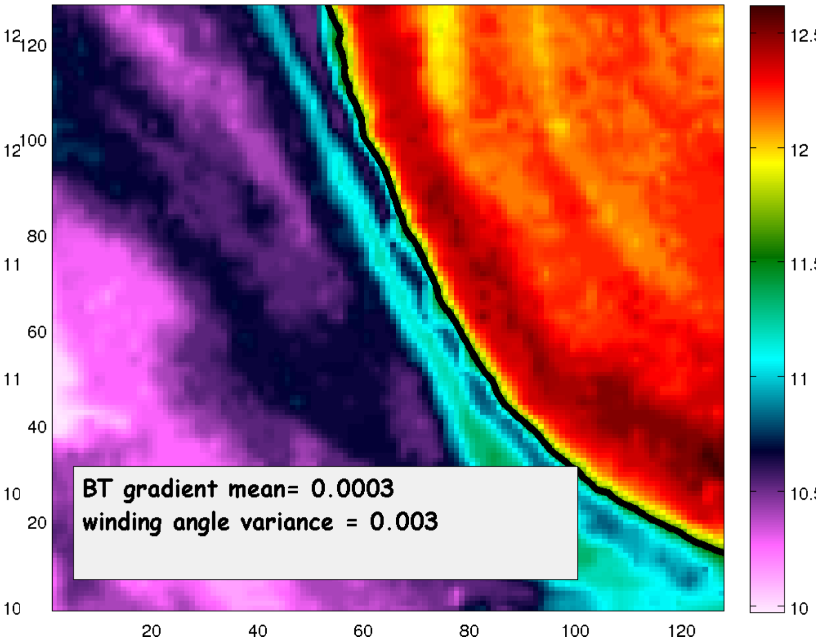
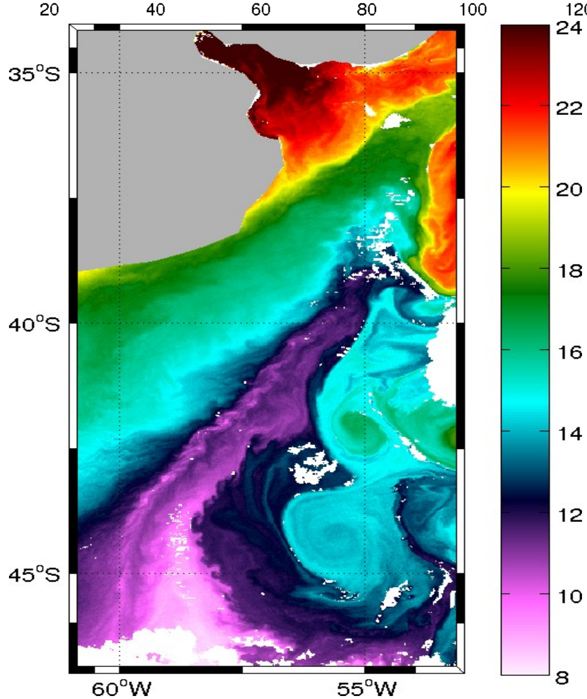
Proposition 4 *:* ***Proposition 3*** + contour characterization : statistical analysis of the tracer level-set geometry, in particular the conditional statistics of small-scale isoline meanderings along larger scale fronts

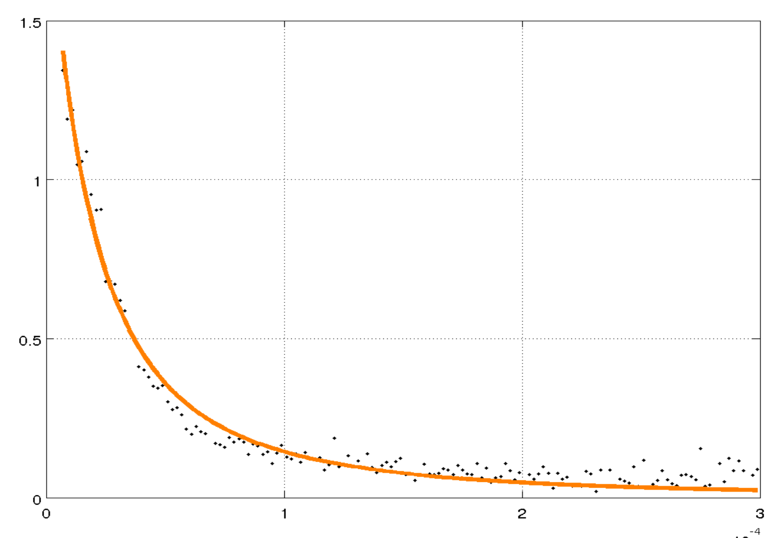
Small scales / mesoscale

Proposition 4 : ***Proposition 3*** + contour characterization









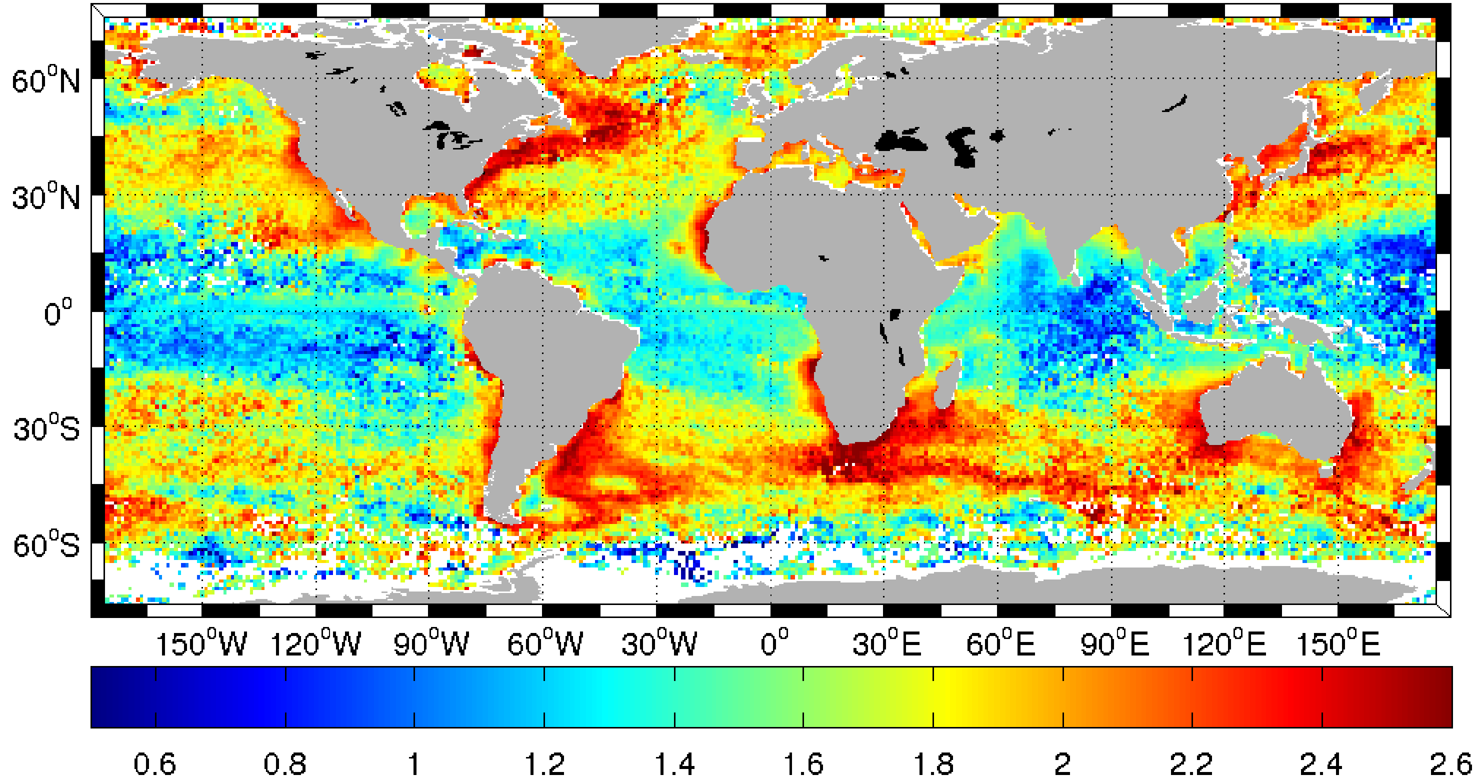
Conclusion

- Descriptors for the charaterization of small scales have been investigated :

Spectral approach :Spectral slopes in the mesoscale and submesoscale range estimated from different SST datasets have been compared and the sensitivity to resolution and noise level has beeb investigated thoroughly. The global distribution of spectral slopes estimated from AVHRR Metop observations was then obtained.

Spectral approach

SST wavenumber spectra in the 8-70 km band



2008-2013 wavenumber spectral slopes mean at 1°x1° resolution in the 8-70 km wavelength band calculated from METOP-A-AVHRR SST data (~1 km resolution).

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Coherent structures essentially sign in the phase information of the satellite snapshots, and we propose the analysis of the **spatial conditional variability of small scales relative to larger scales**.

- Estimate the variance explained by the enhancement of large gradients present in low resolution field
- Statistical analysis of the tracer level-set geometry