



High-resolution (sub km) signature of upper ocean dynamics on SAR/SST/ocean color/sun glitter observations synergy

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Bertrand Chapron²

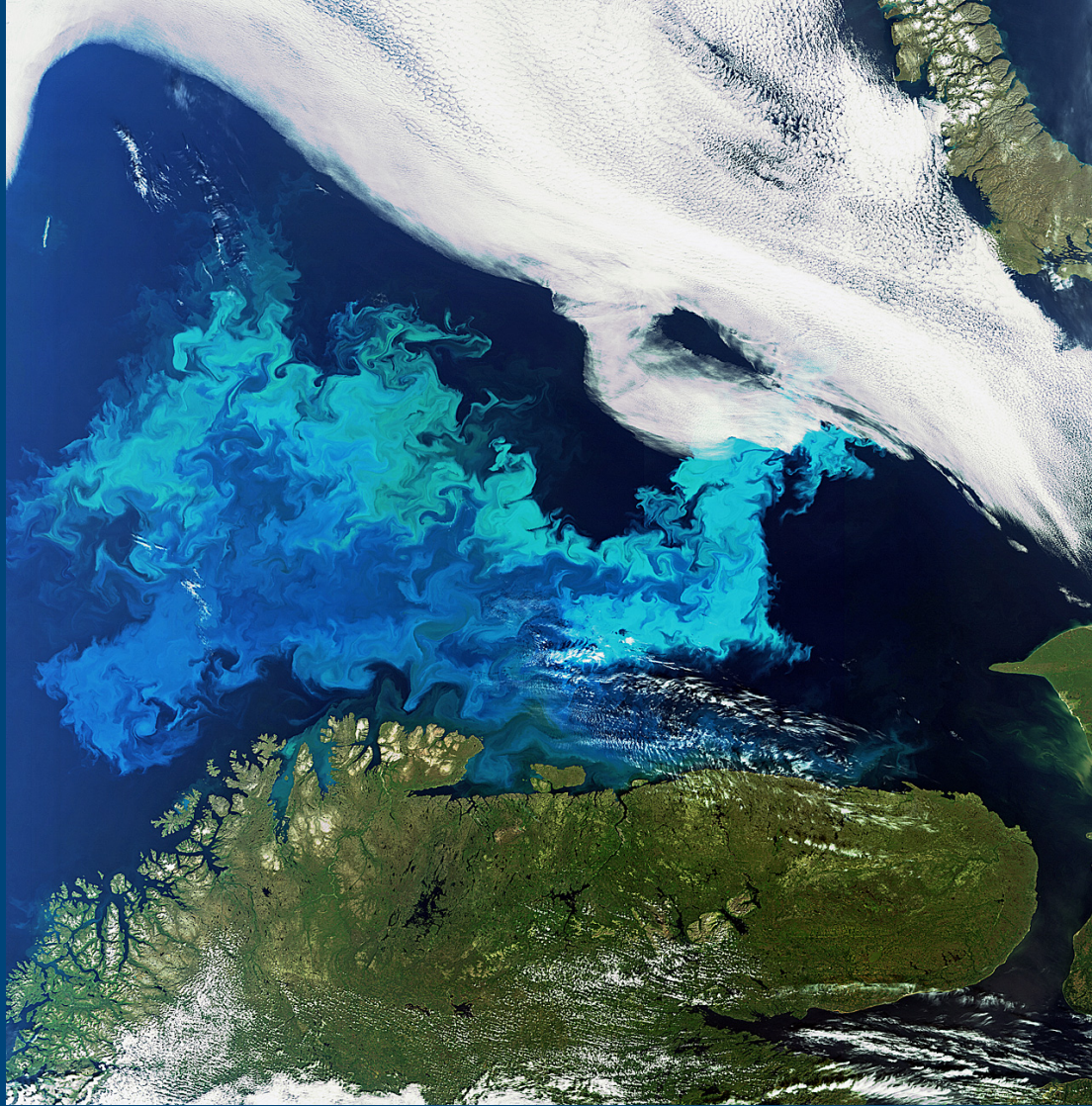
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2: Laboratoire d'Océanographie Spatiale – Ifremer- Plouzané, France

Satellite observation of upper ocean dynamics



- Roughness - a surface parameter of convergence / divergence zone (vertical velocities)
 - Understand roughness (wind, current, ...)
 - Quantify 3D motion of upper oceanic layers

Barents sea – Cape Nordkinn

SIOWS - SOLab Arctic Sea Ice Oil Wave System



Datasets



Hotspots



Permalink



Tour



About

Eng

Rus



1x

Daily

3-Day

Weekly

100.0% data from MNO21KM42011229.1005_sst11 from SST MODIS denoised (NASA, OceanDataLab)

36.14°, 69.15°

2004

2005

2006

2007

2008

2009

2010

2011

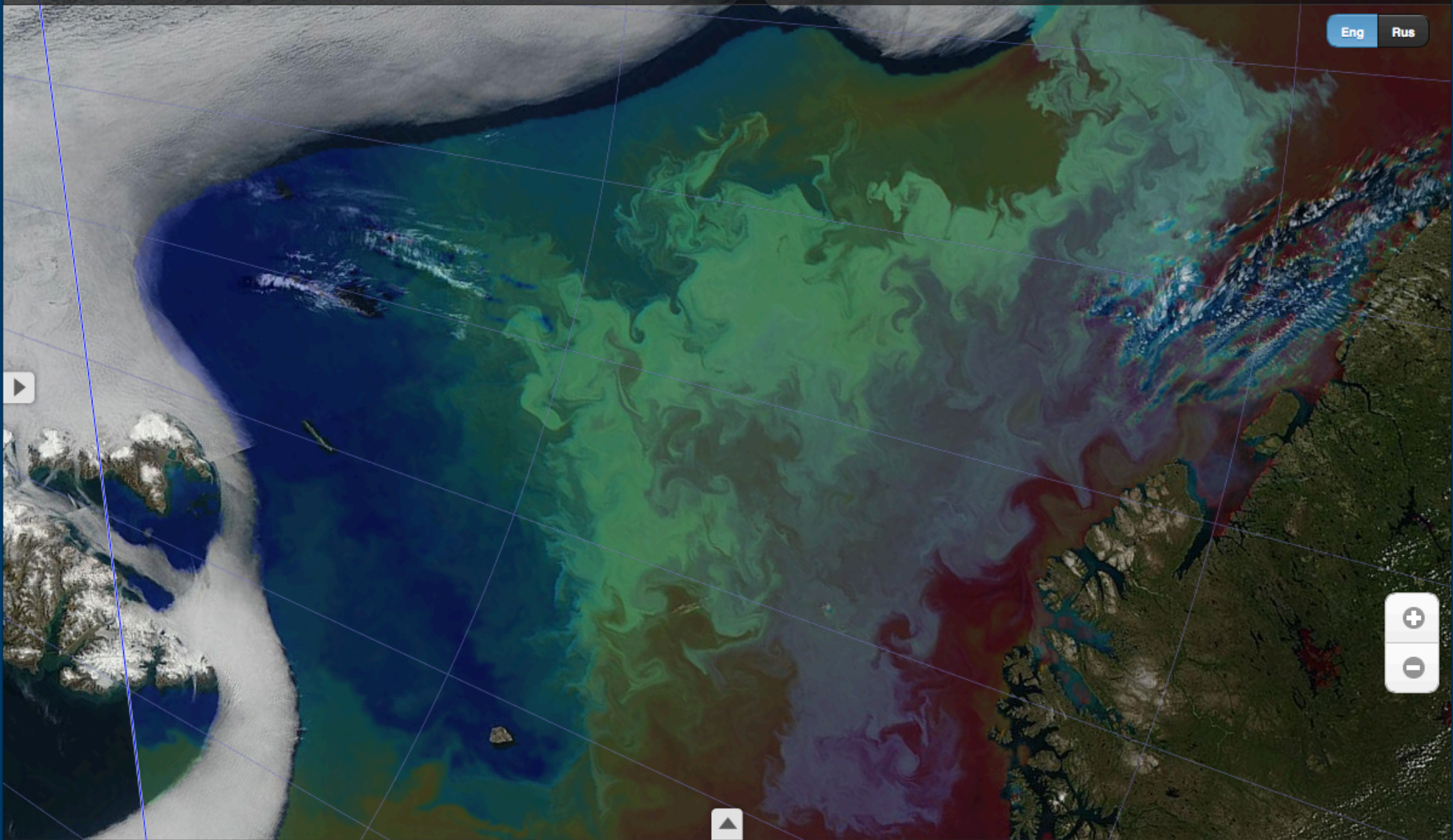
2012

2013

January February March April May June July August September October November December
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

SIOWS - SOLab Arctic Sea Ice Oil Wave System

Eng
Rus



▶
1x
Daily
3-Day
Weekly
100.0% data
42011229.1005_sst11 from SST MODIS denoised (NASA, OceanDataLab)
31.64°, 68.38°

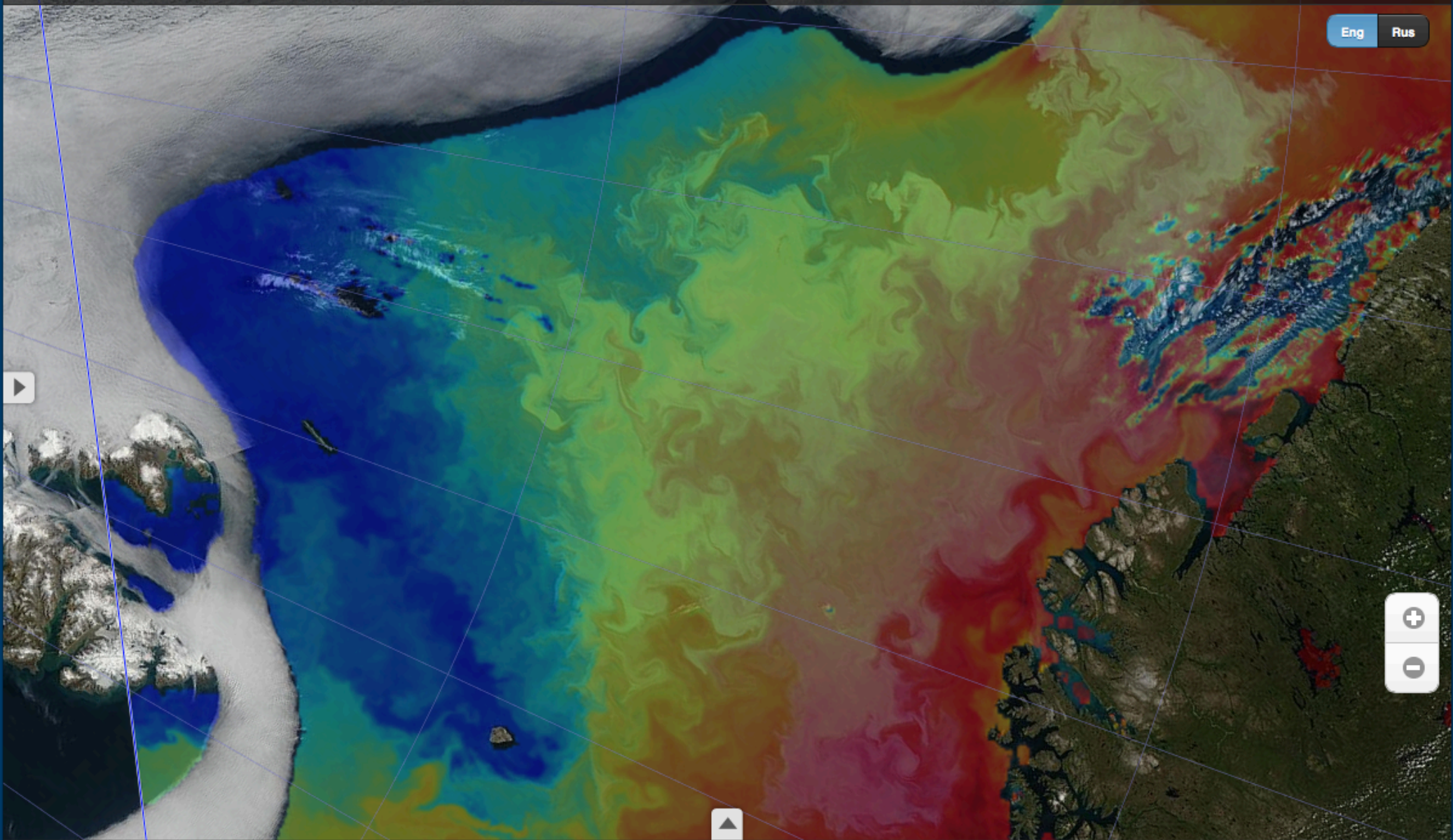
2004	2005	2006	2007	2008	2009	2010	2011	2012	2013																					
January	February	March	April	May	June	July	August	September	October	November	December																			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31



SIOWS - SOLab Arctic Sea Ice Oil Wave System

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- Hotspots
- Permalink
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- About

Eng **Rus**



1x
Daily
3-Day
Weekly
100.0% data
MND021KM:42011229.1005_sst11 from SST MODIS denoised (NASA, OceanDataLab)
30.00°, 68.26°

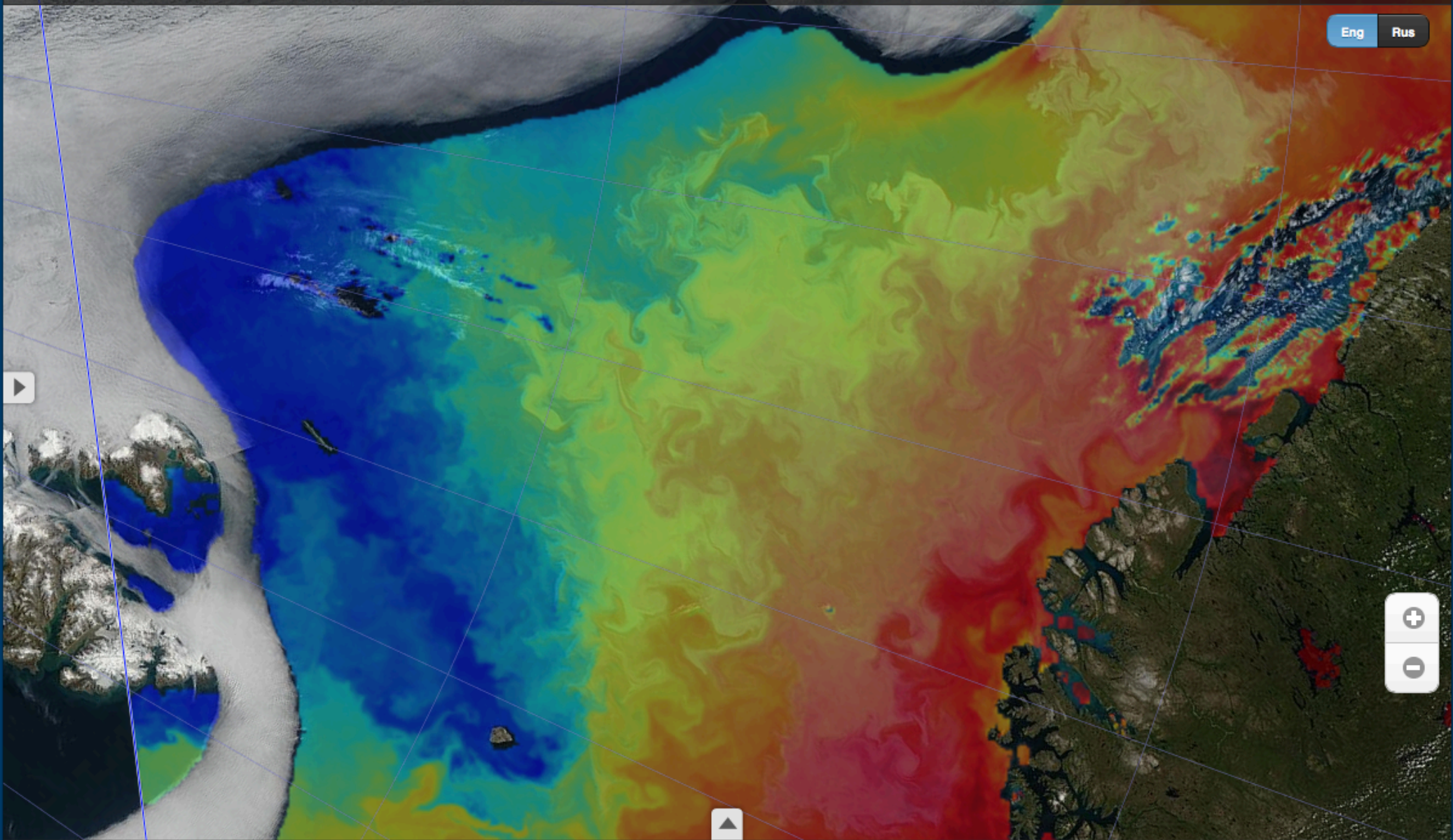
2004	2005	2006	2007	2008	2009	2010	2011	2012	2013																					
January	February	March	April	May	June	July	August	September	October	November	December																			
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SIOWS - SOLab Arctic Sea Ice Oil Wave System

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- Hotspots
- Permalink
- ?
- Tour
- i
- About

Eng Rus

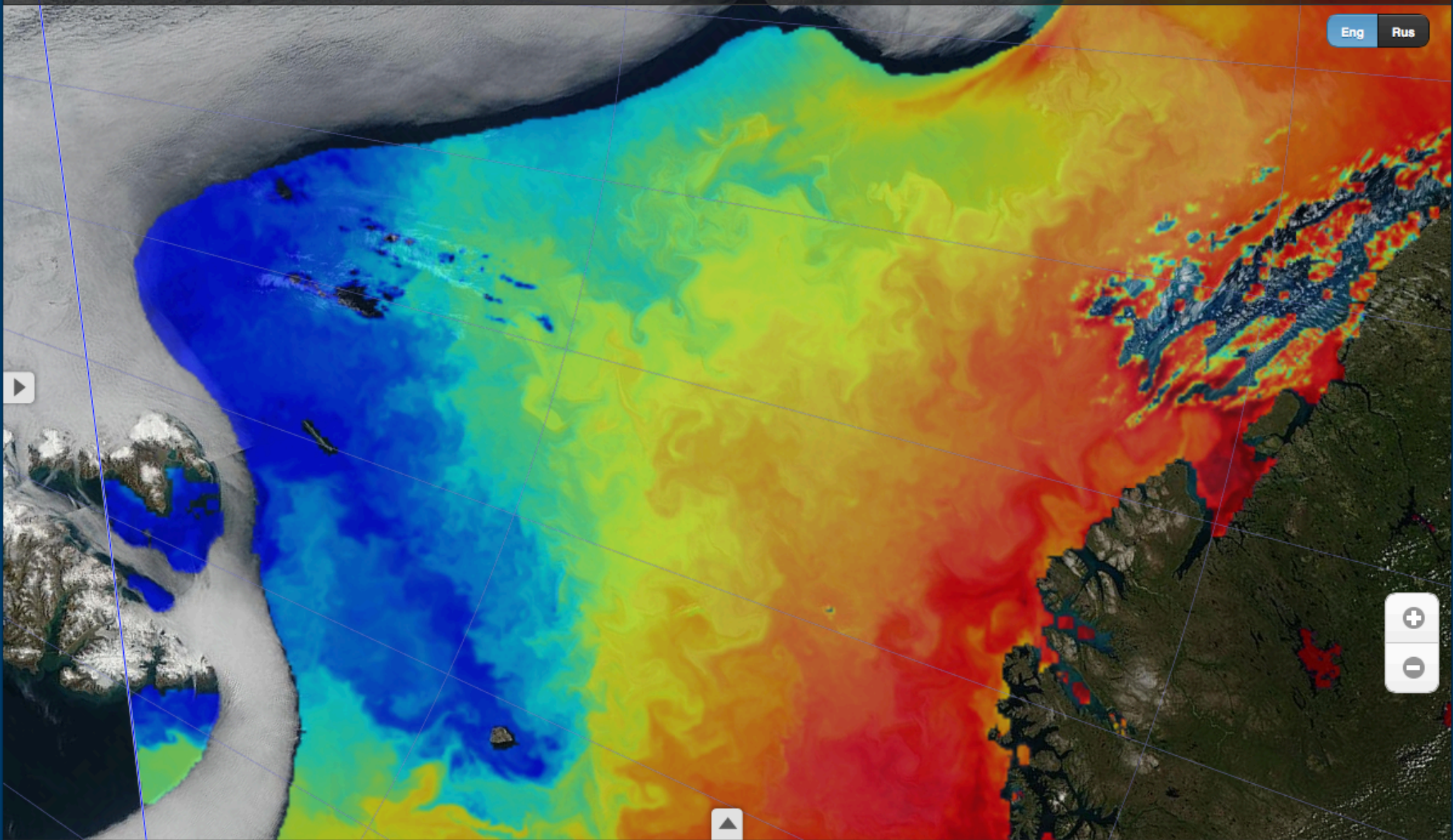


1x
Daily
3-Day
Weekly
100.0%
42011229.1005_sst11 from SST MODIS denoised (NASA, OceanDataLab)
25.82°, 68.94°

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

SIOWS - SOLab Arctic Sea Ice Oil Wave System

[Eng](#)
[Rus](#)



▶
1x
Daily
3-Day
Weekly
100.0%
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31.66°, 68.54°

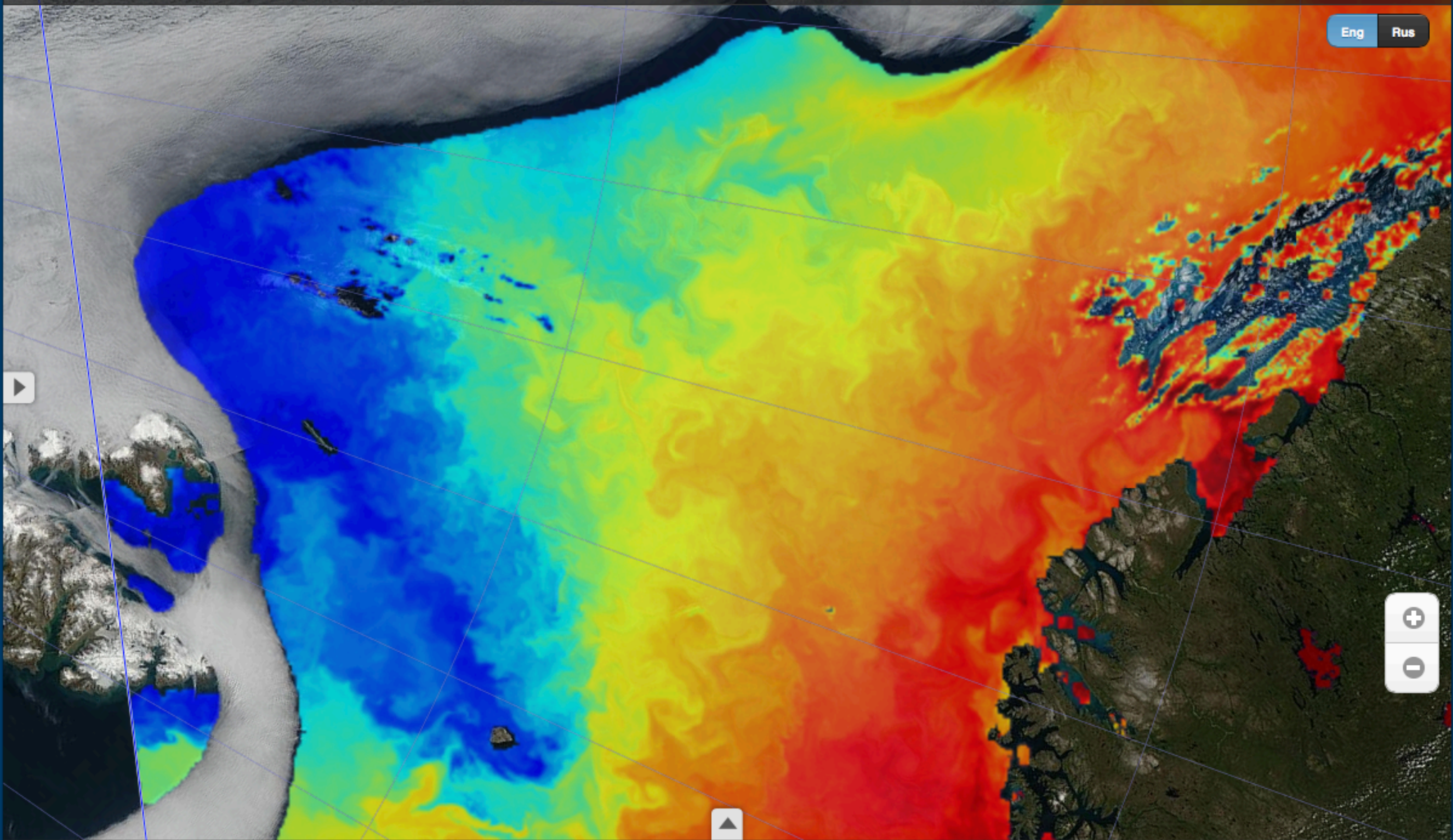
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January	February	March	April	May	June	July	August	September	October	November	December																			
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SIOWS - SOLab Arctic Sea Ice Oil Wave System

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- Hotspots
- Permalink
- ?
- Tour
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- About

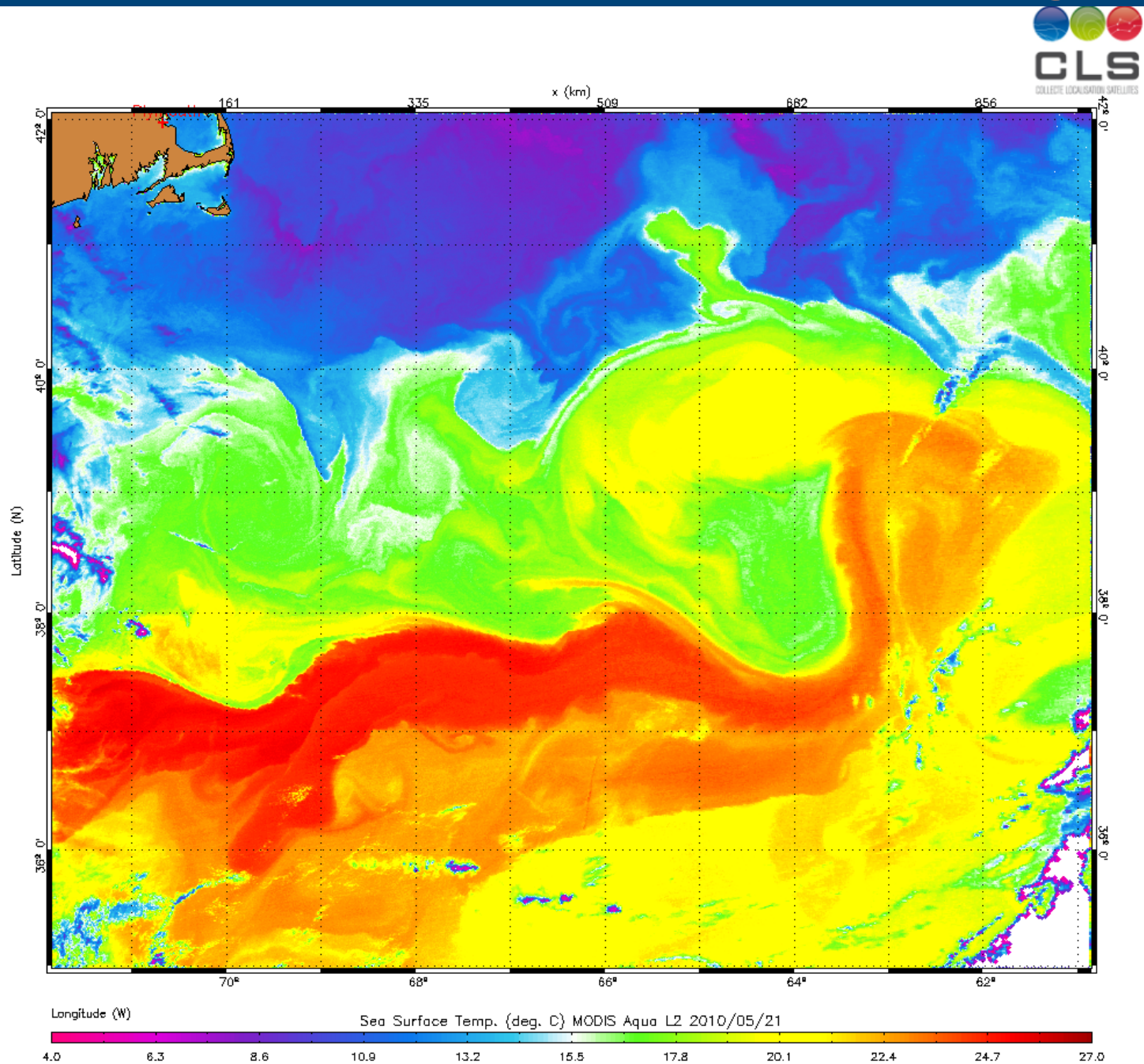
Eng Rus

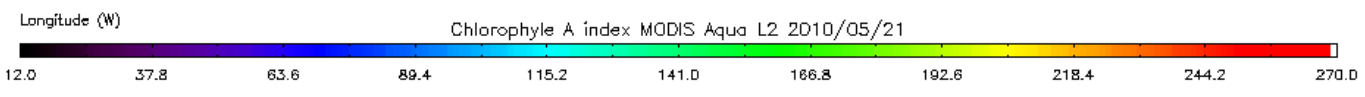
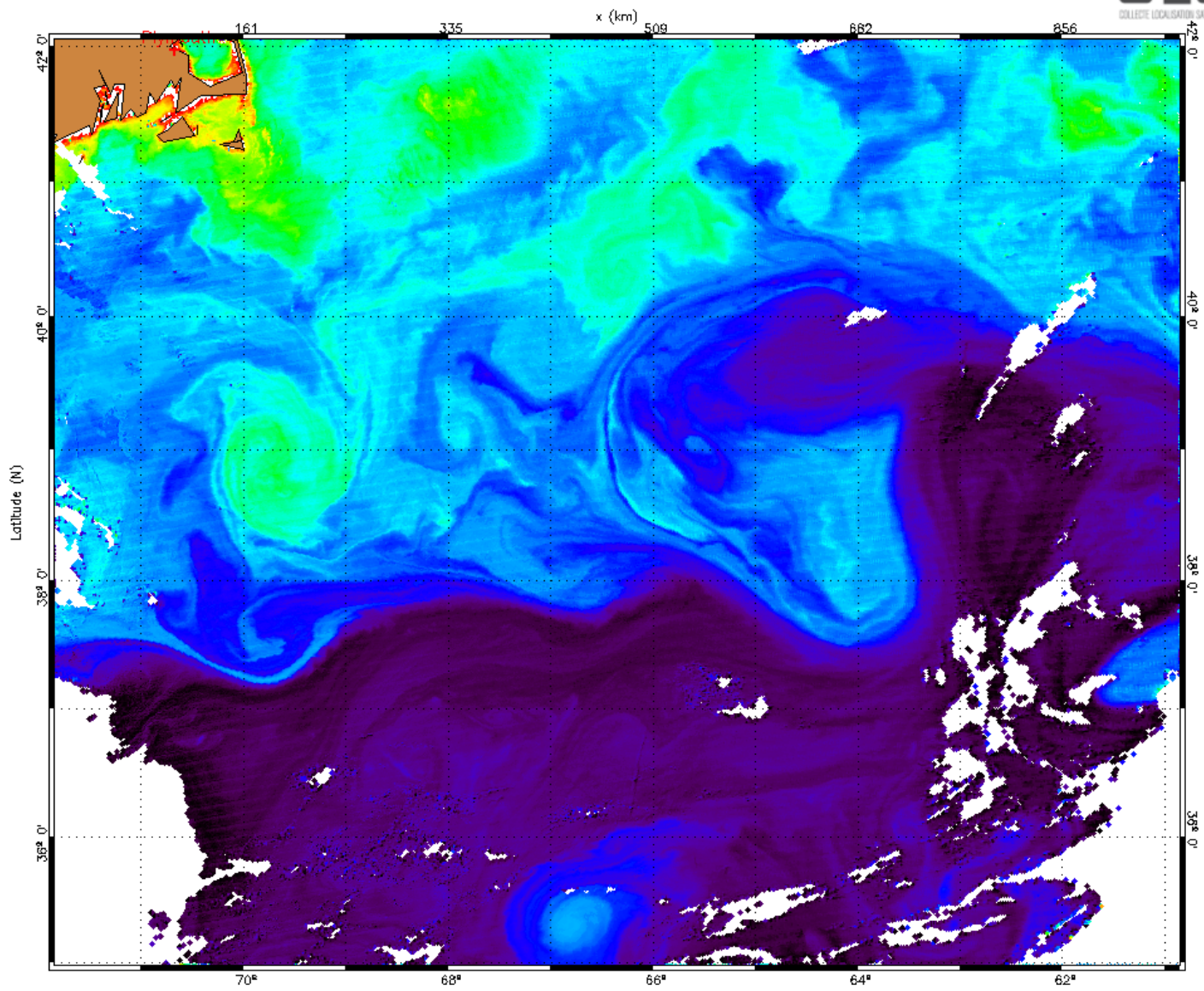


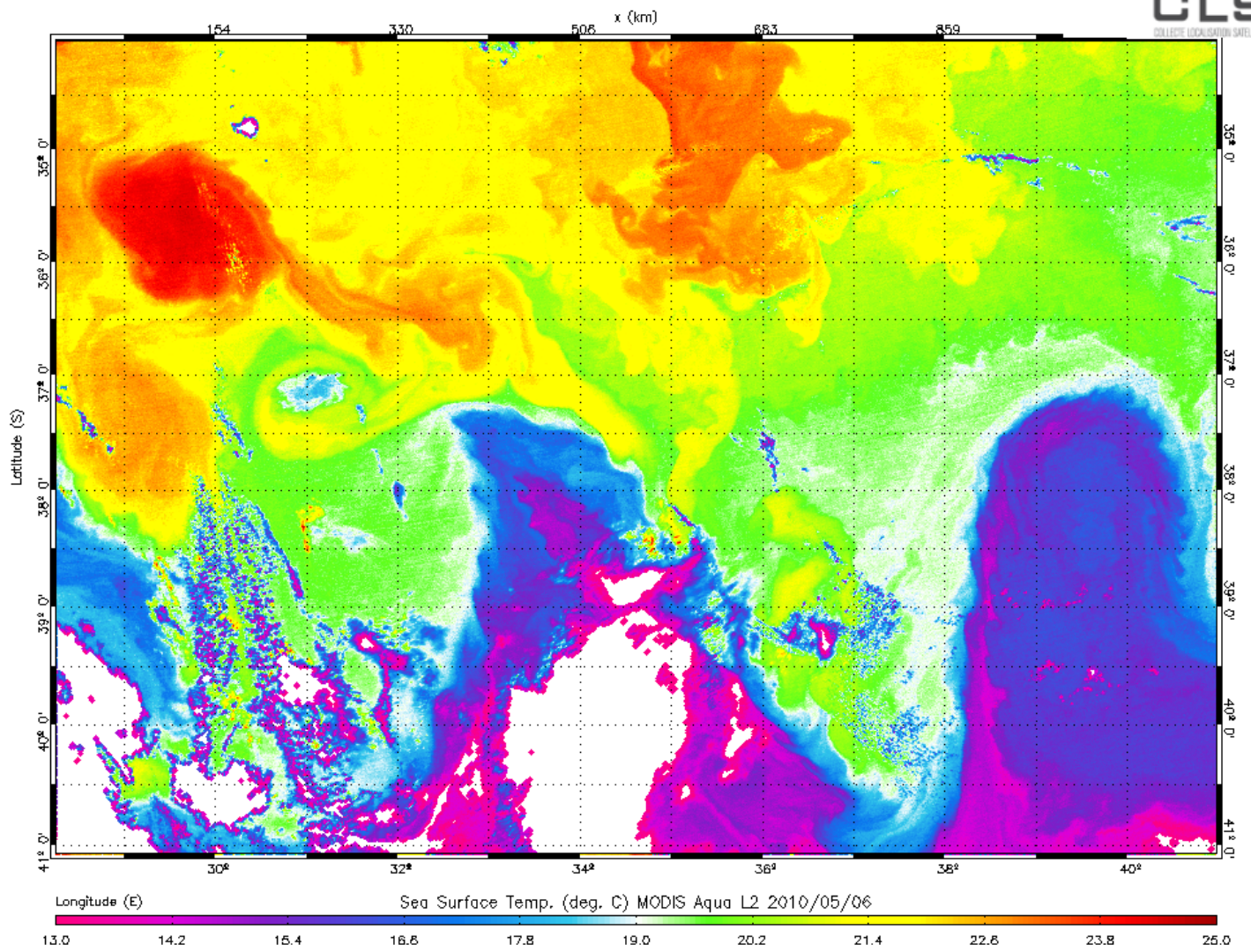
1x
Daily
3-Day
Weekly
100.0% data
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24.68°, 69.08°

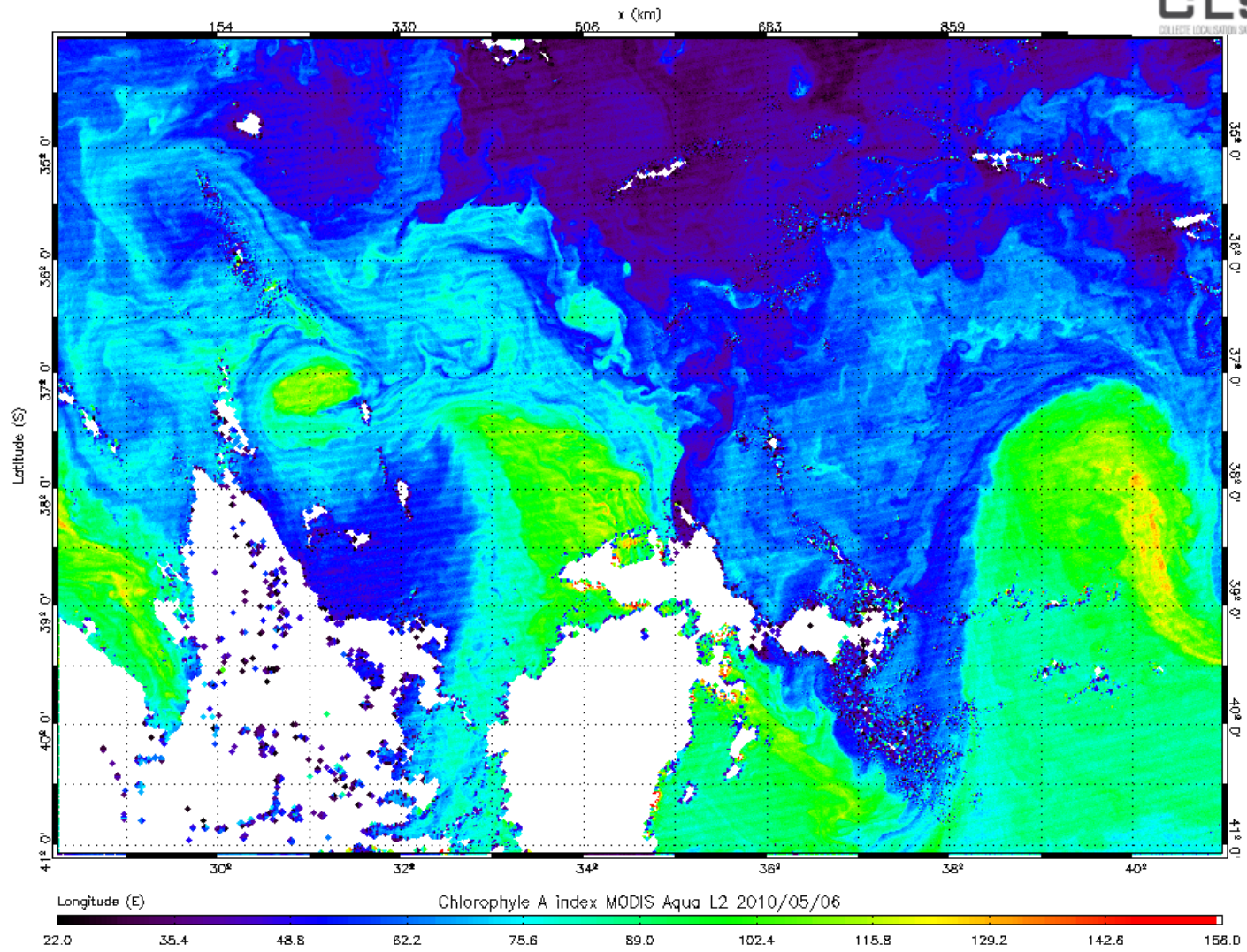
2004	2005	2006	2007	2008	2009	2010	2011	2012	2013																					
January	February	March	April	May	June	July	August	September	October	November	December																			
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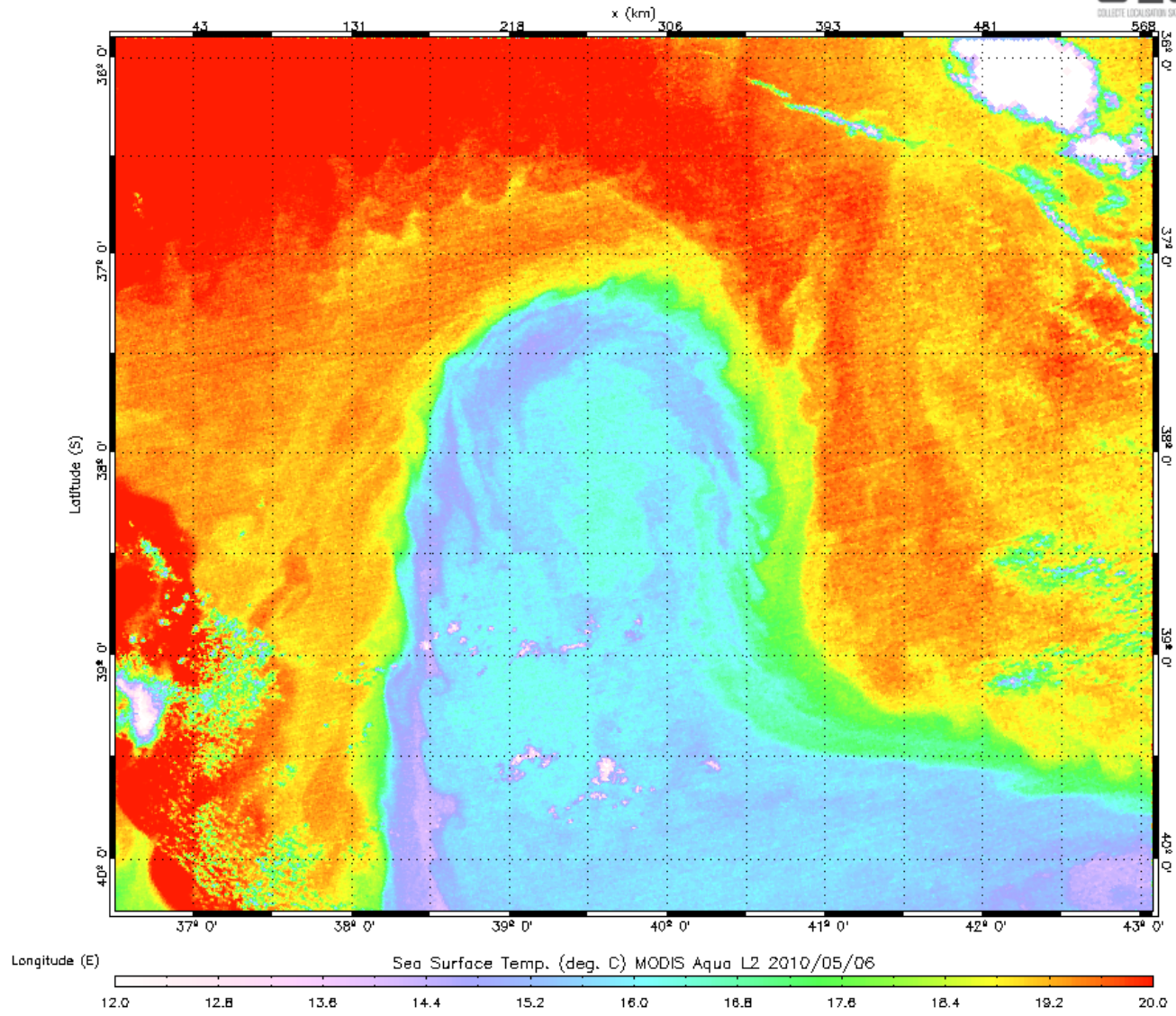
Numerous contemporaneous MODIS Brightness temperature and Ocean Colour surface signatures

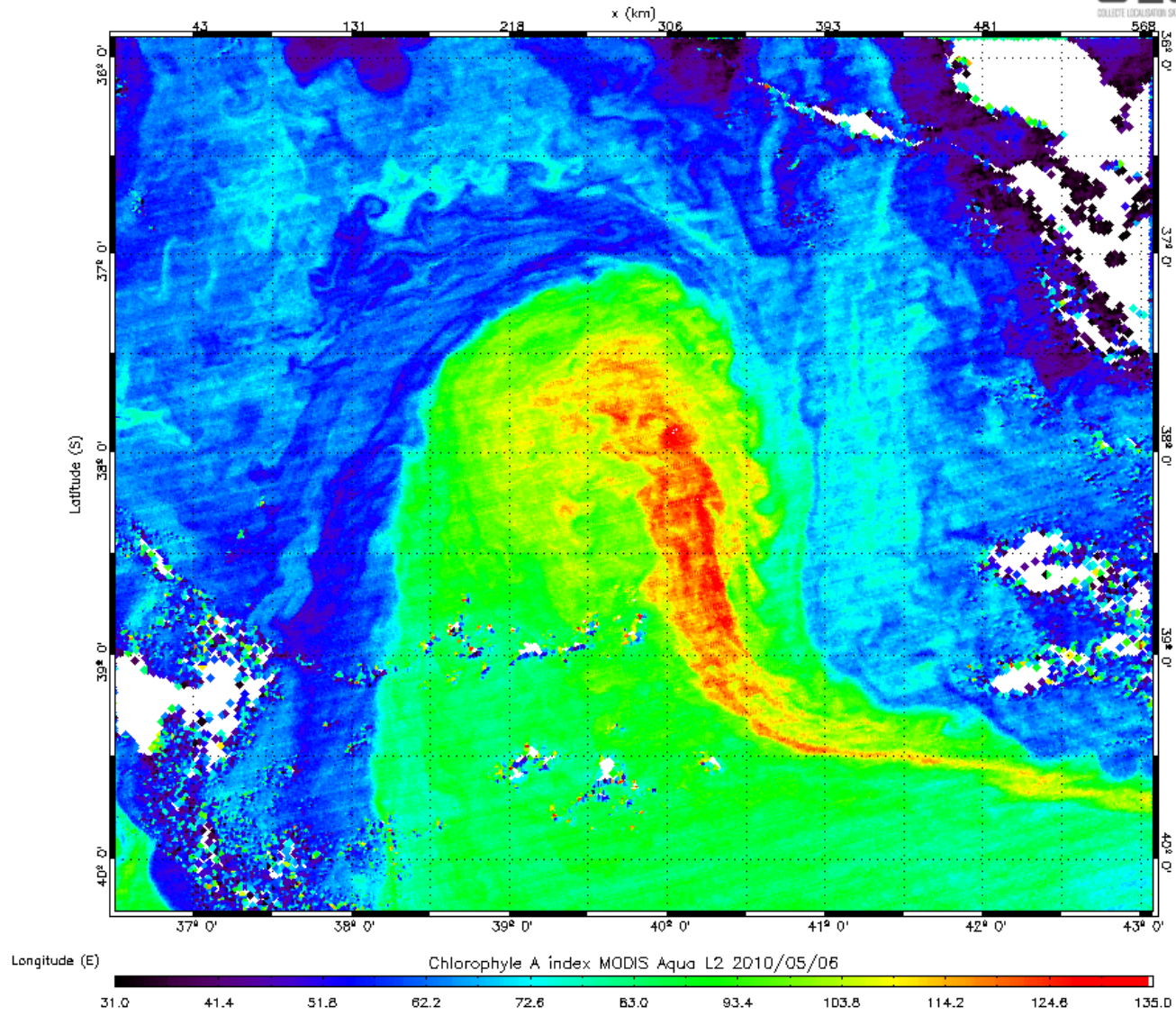


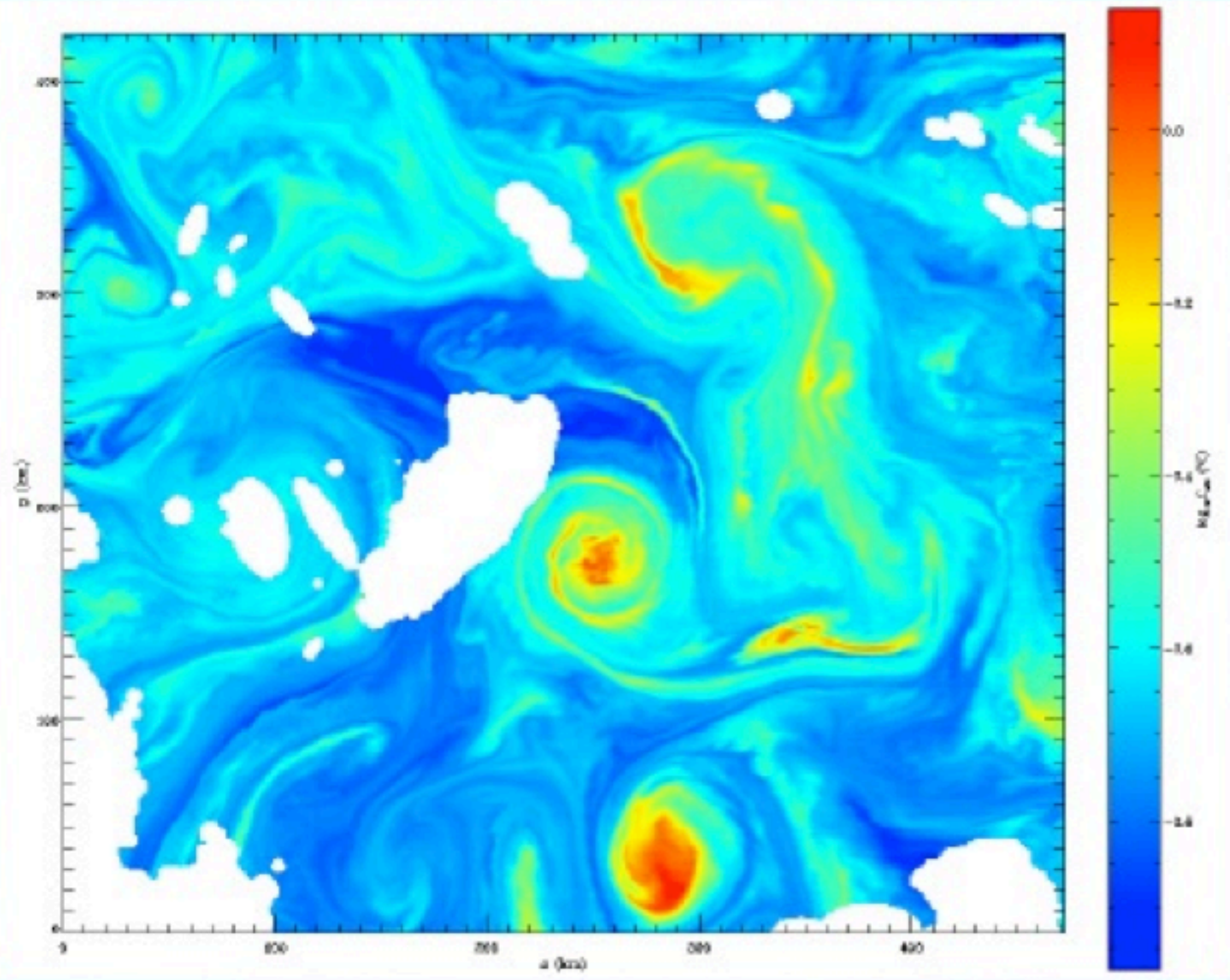


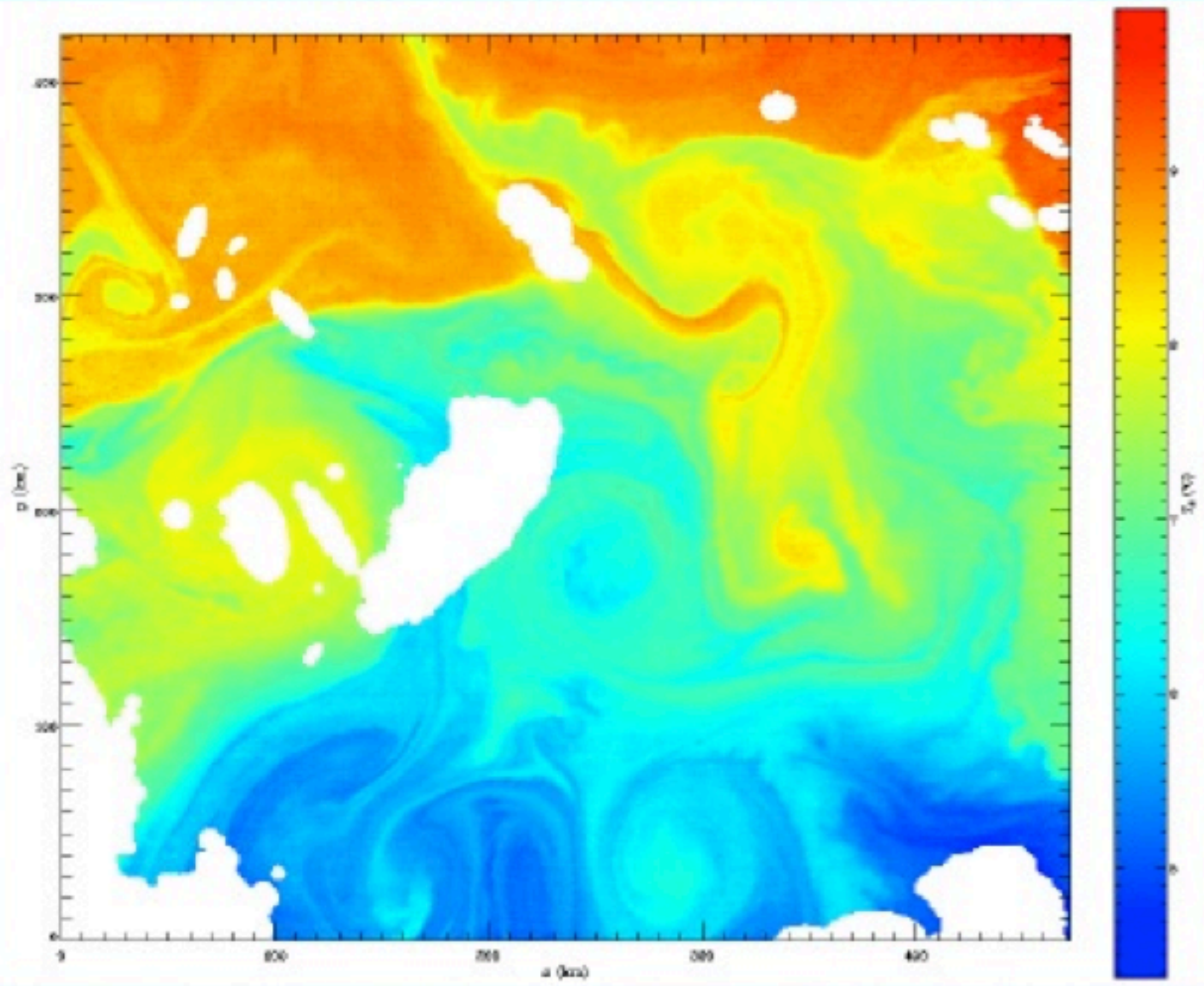


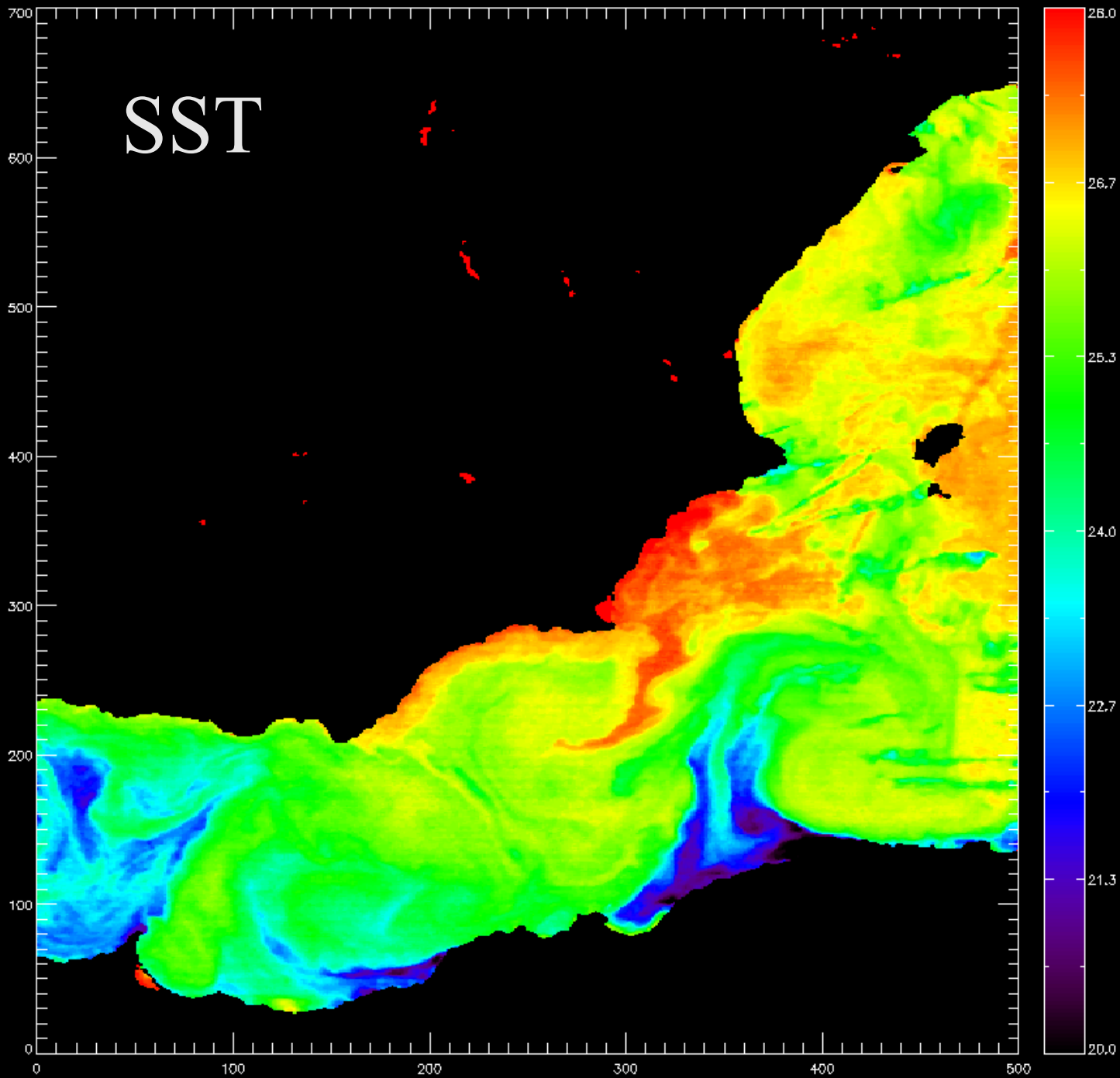


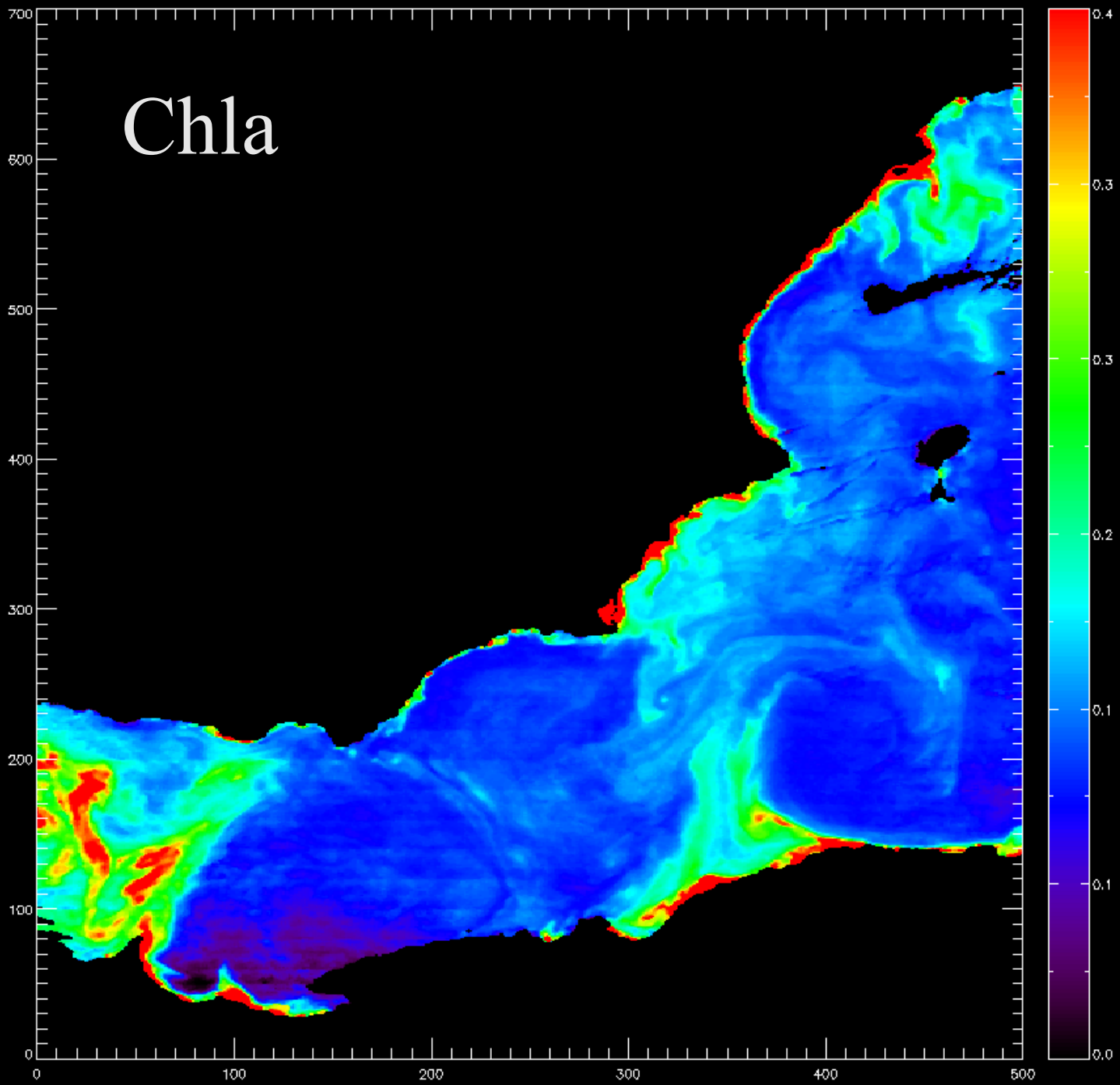




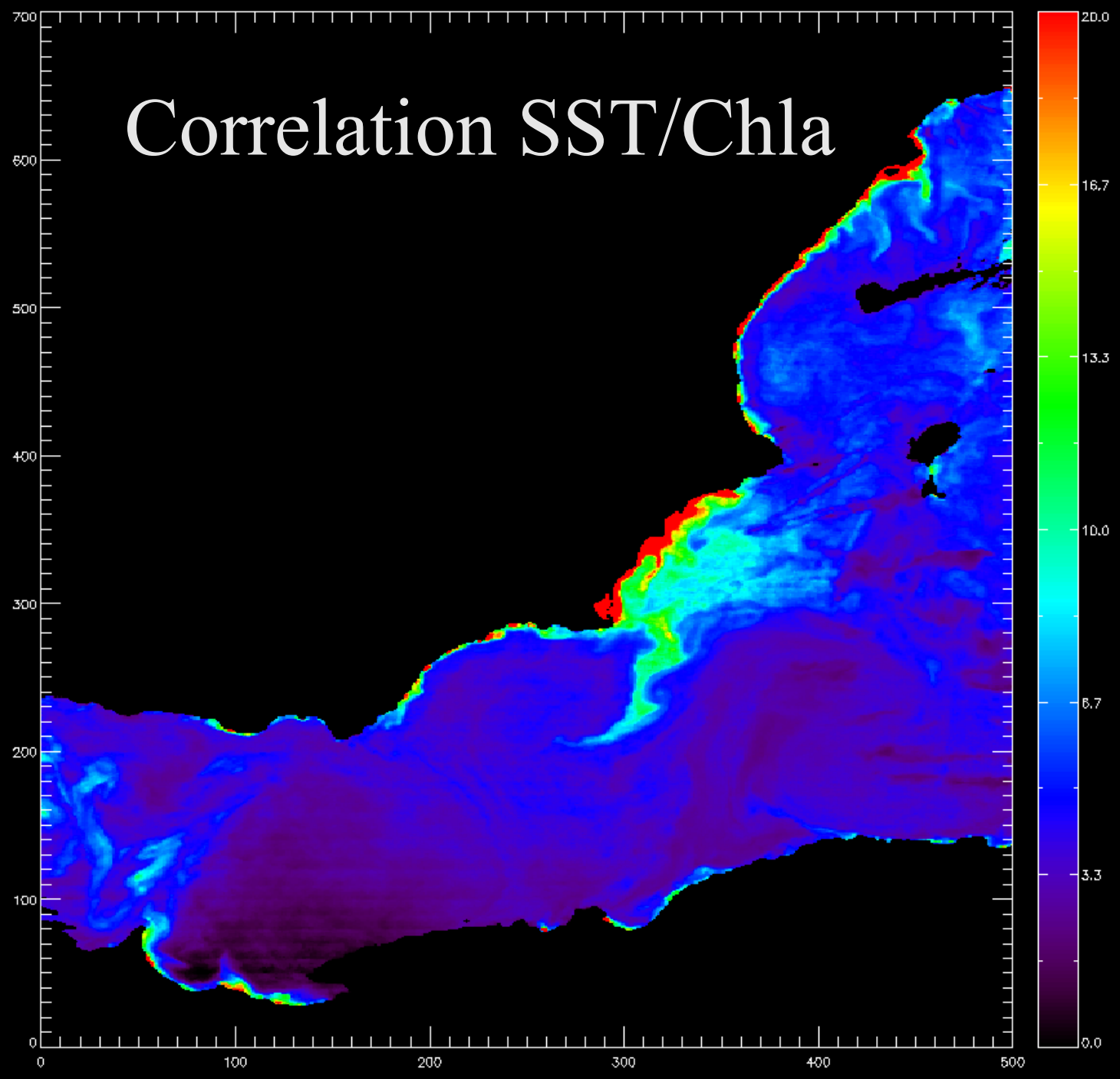


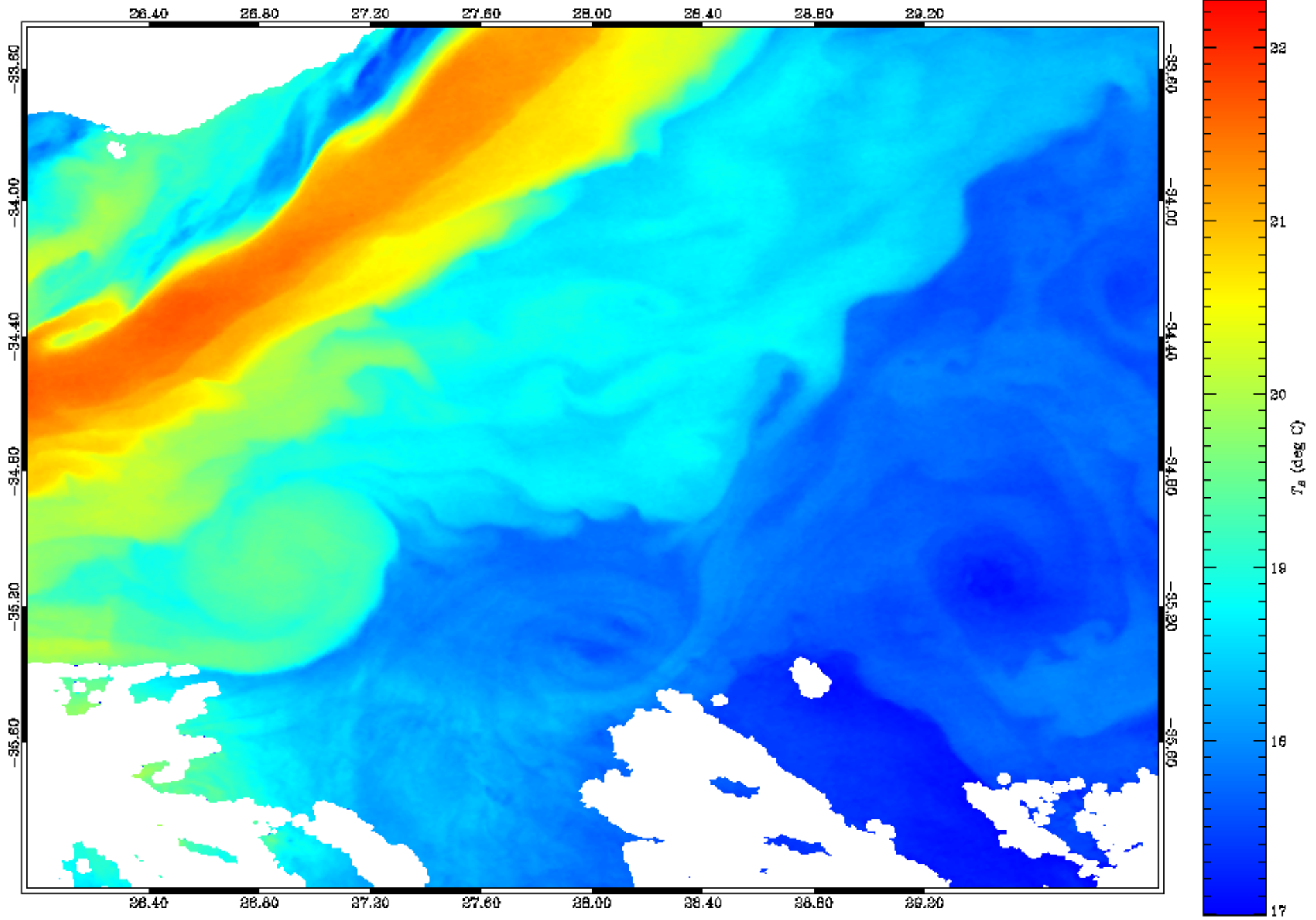


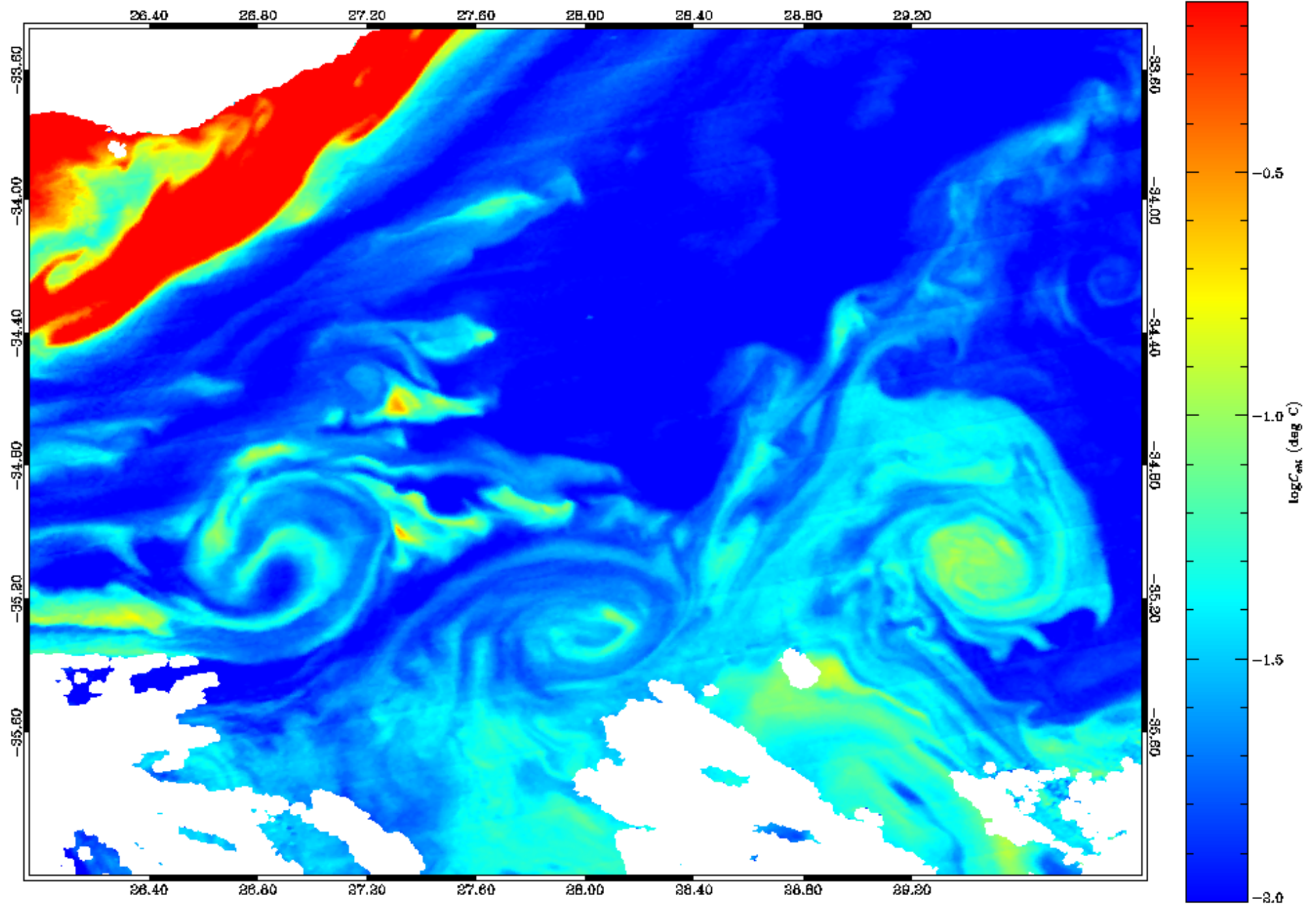




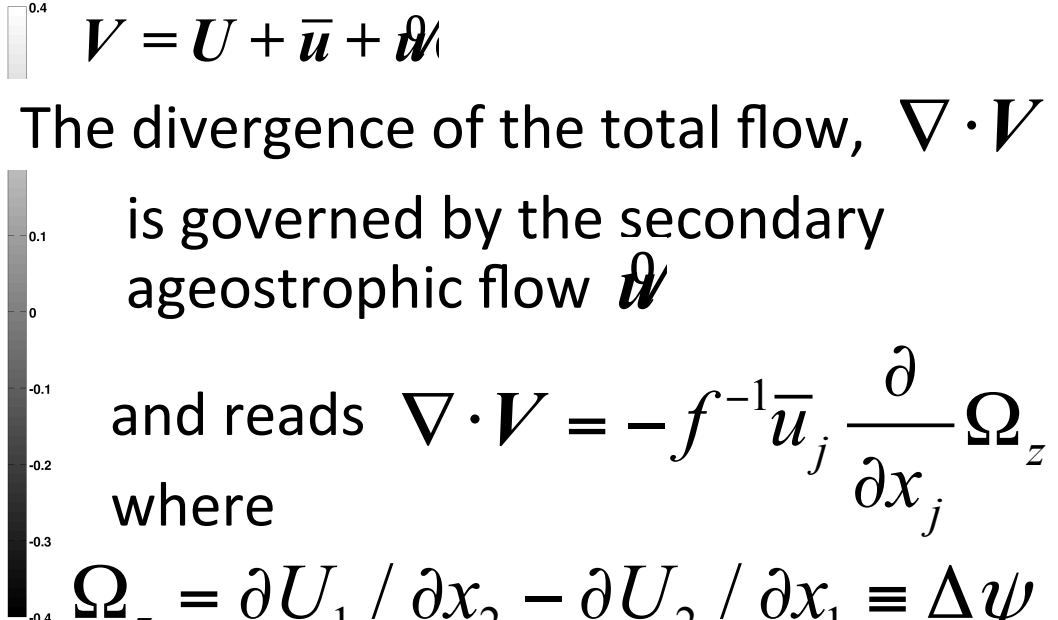
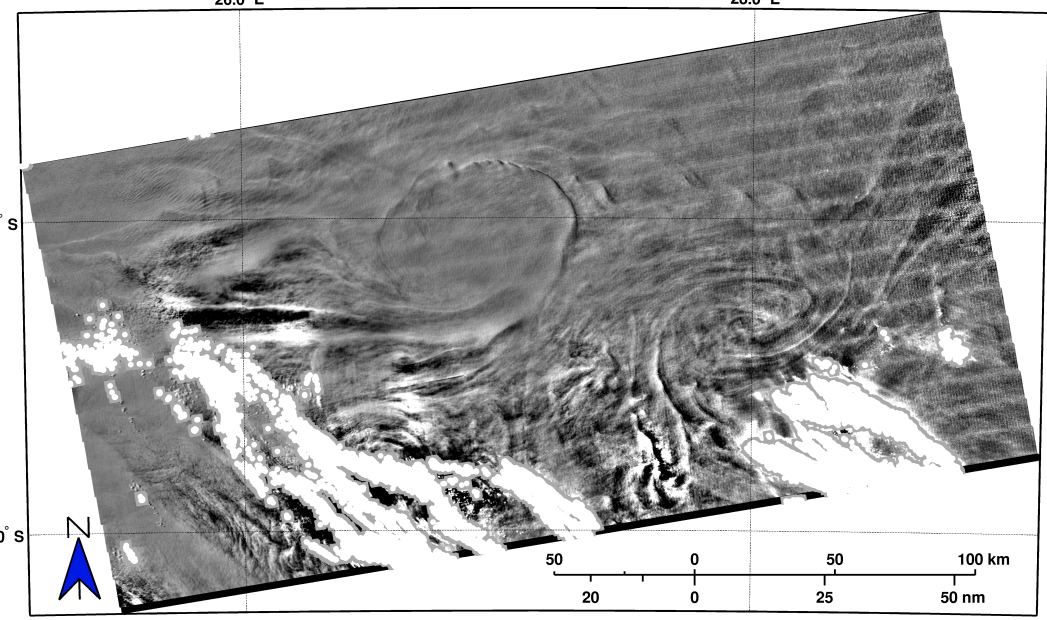
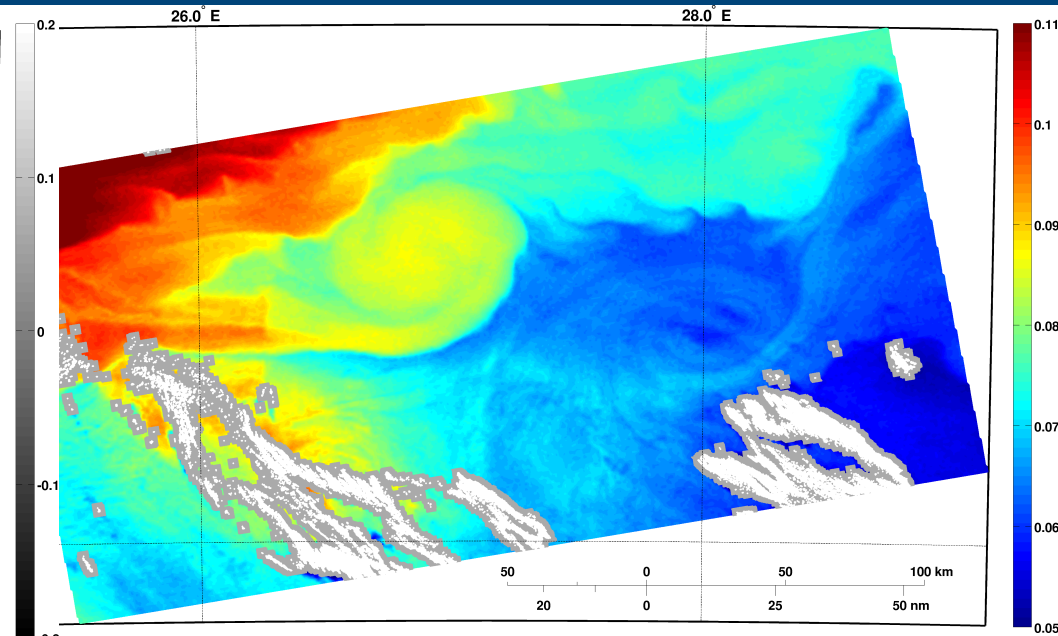
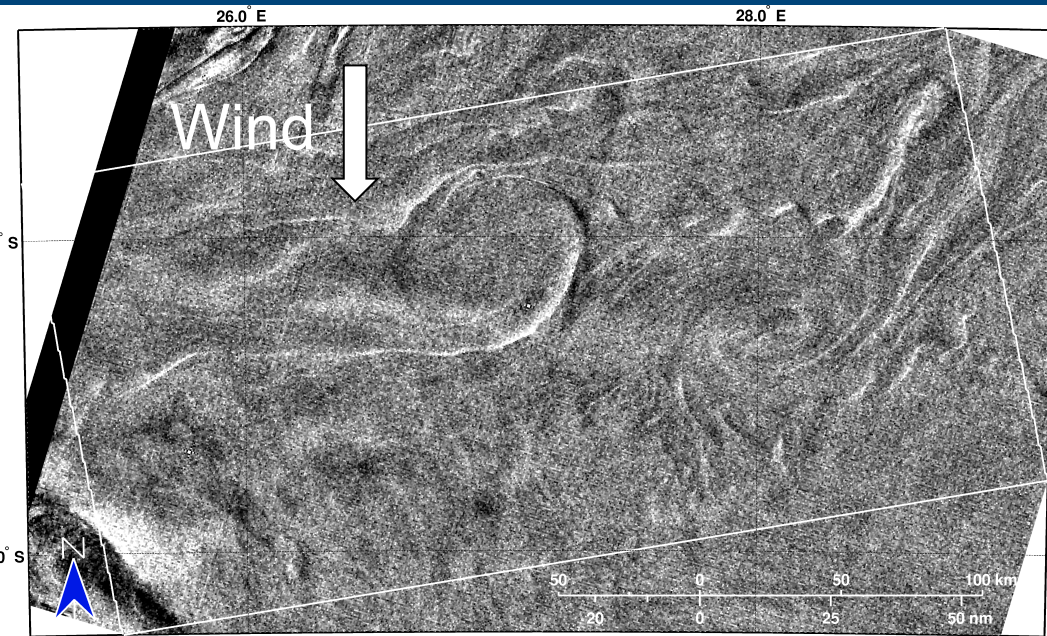
Correlation SST/Chla







Synergies with surface roughness



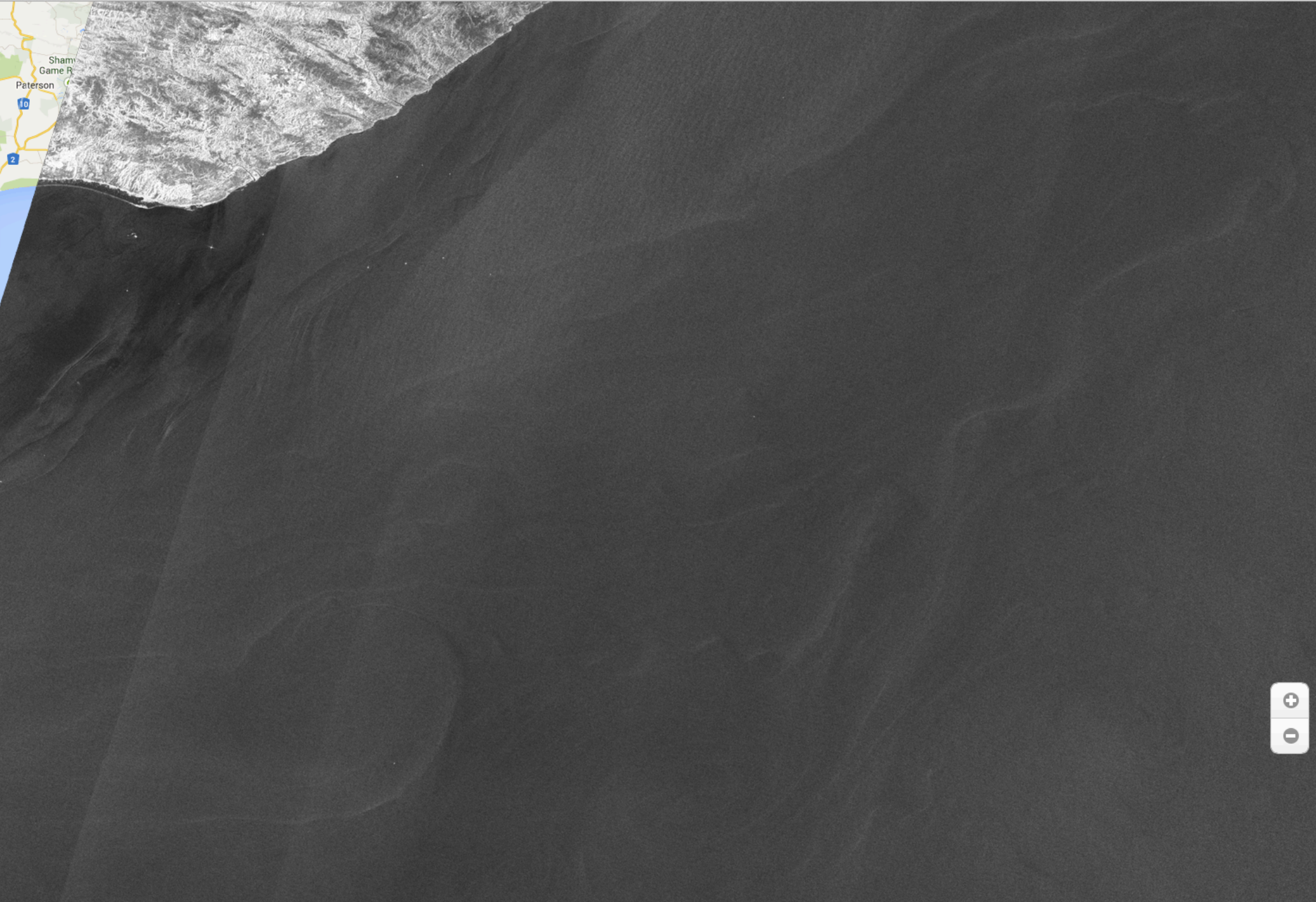
$$\mathbf{V} = \mathbf{U} + \bar{\mathbf{u}} + \mathbf{v}$$

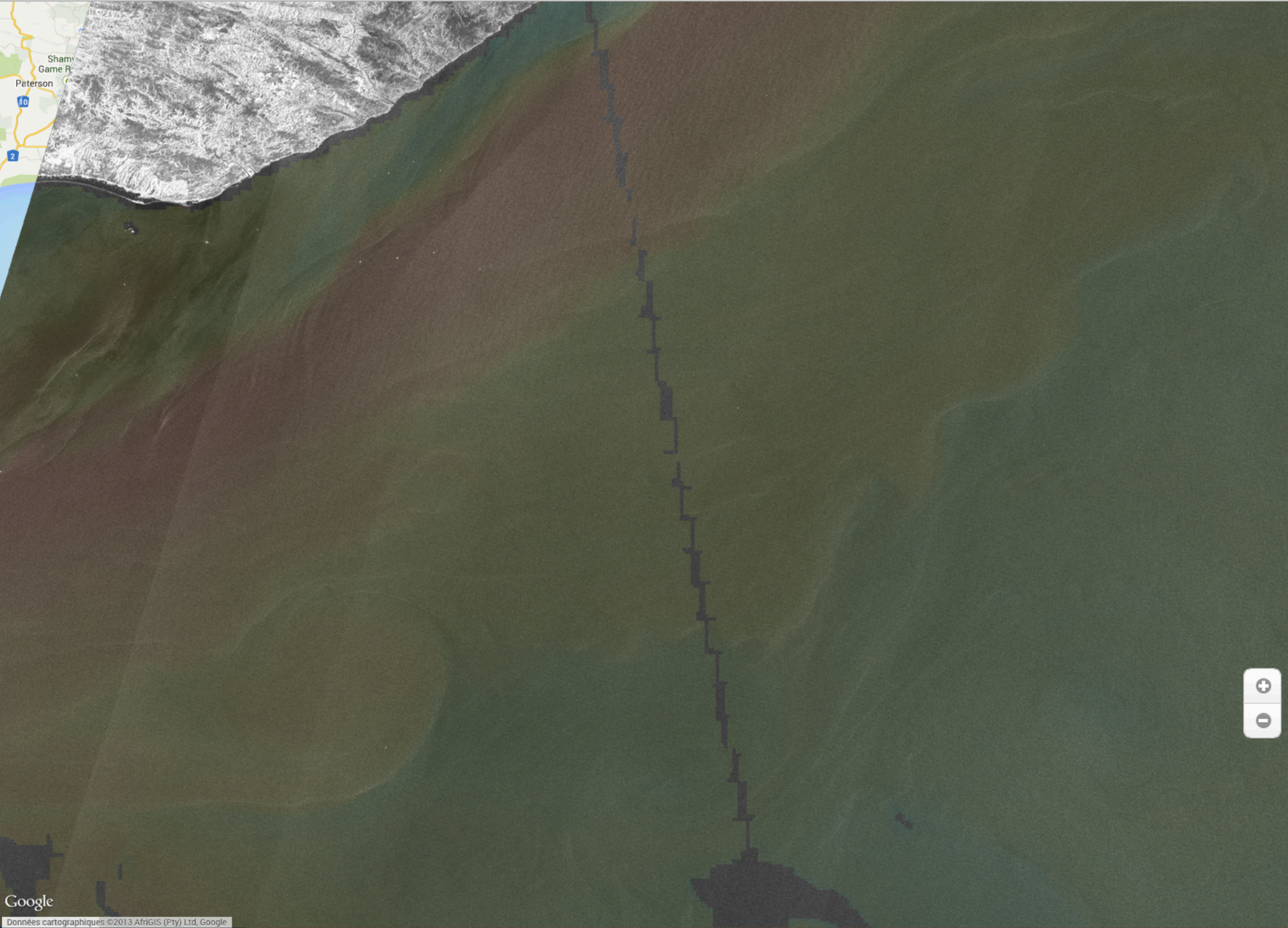
The divergence of the total flow, $\nabla \cdot \mathbf{V}$ is governed by the secondary ageostrophic flow \mathbf{v}

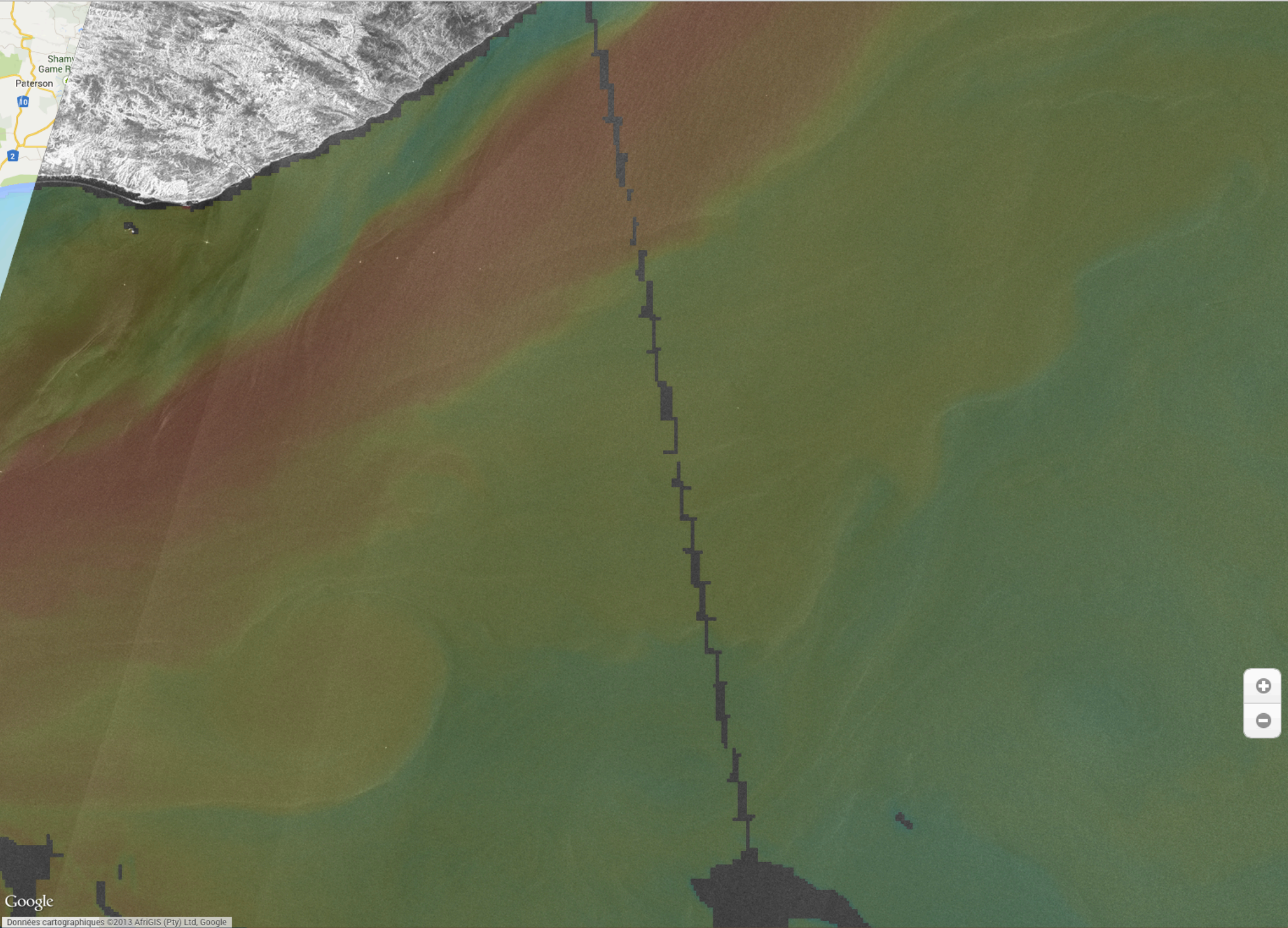
and reads $\nabla \cdot \mathbf{V} = -f^{-1} \bar{u}_j \frac{\partial}{\partial x_j} \Omega_z$
 where

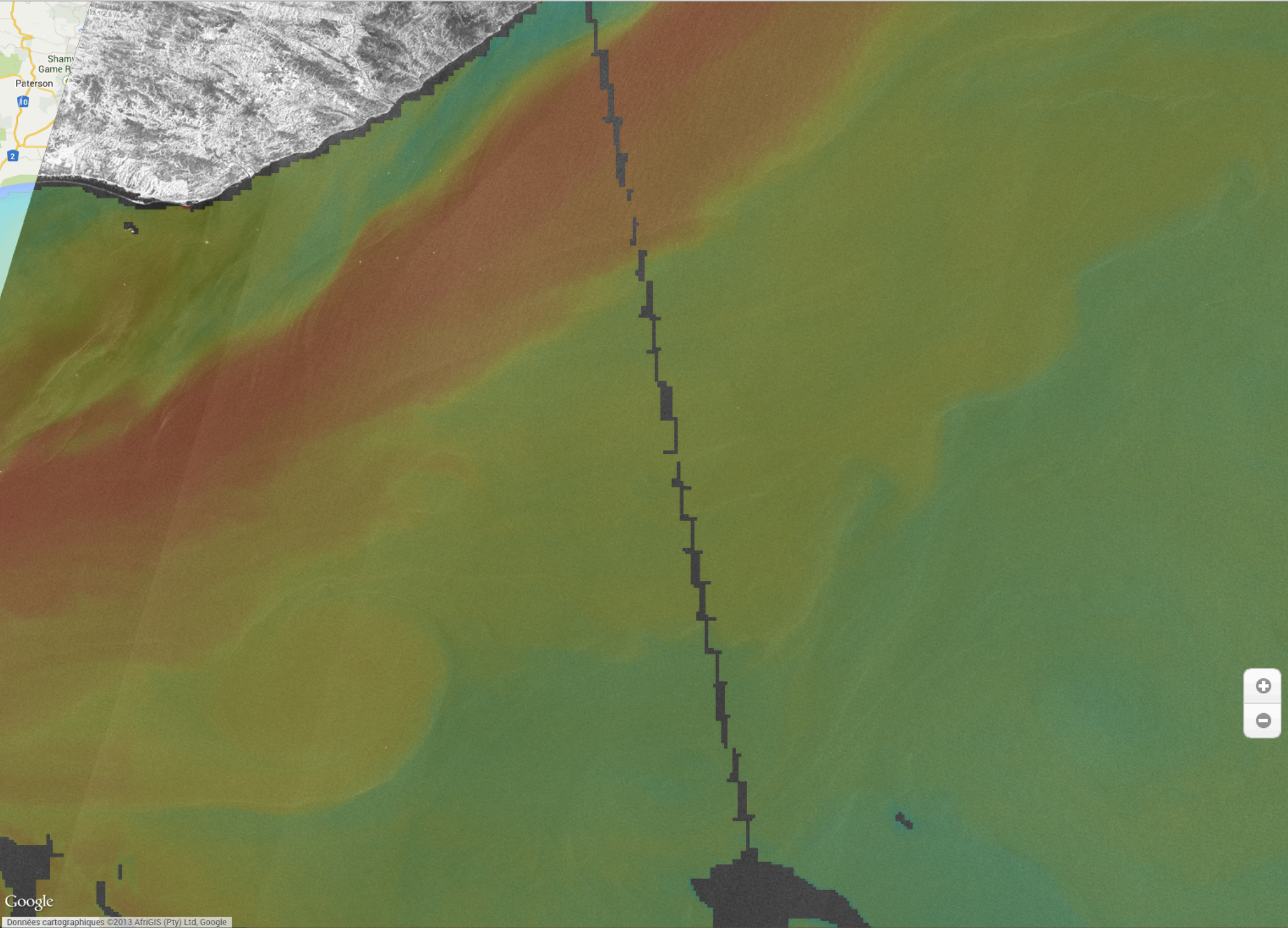
$$\Omega_z = \partial U_1 / \partial x_2 - \partial U_2 / \partial x_1 \equiv \Delta \psi$$

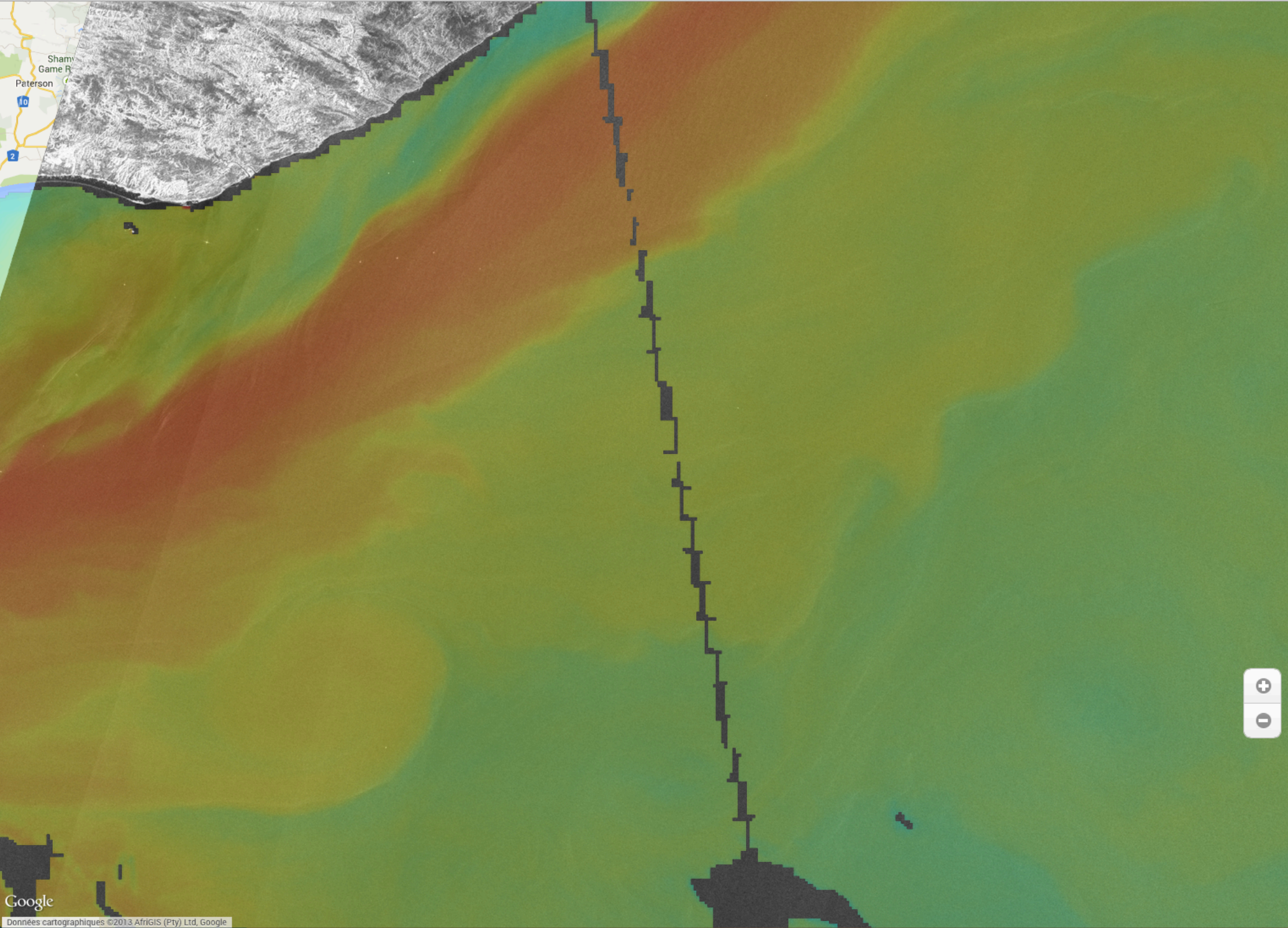
is the vorticity of the QG currents

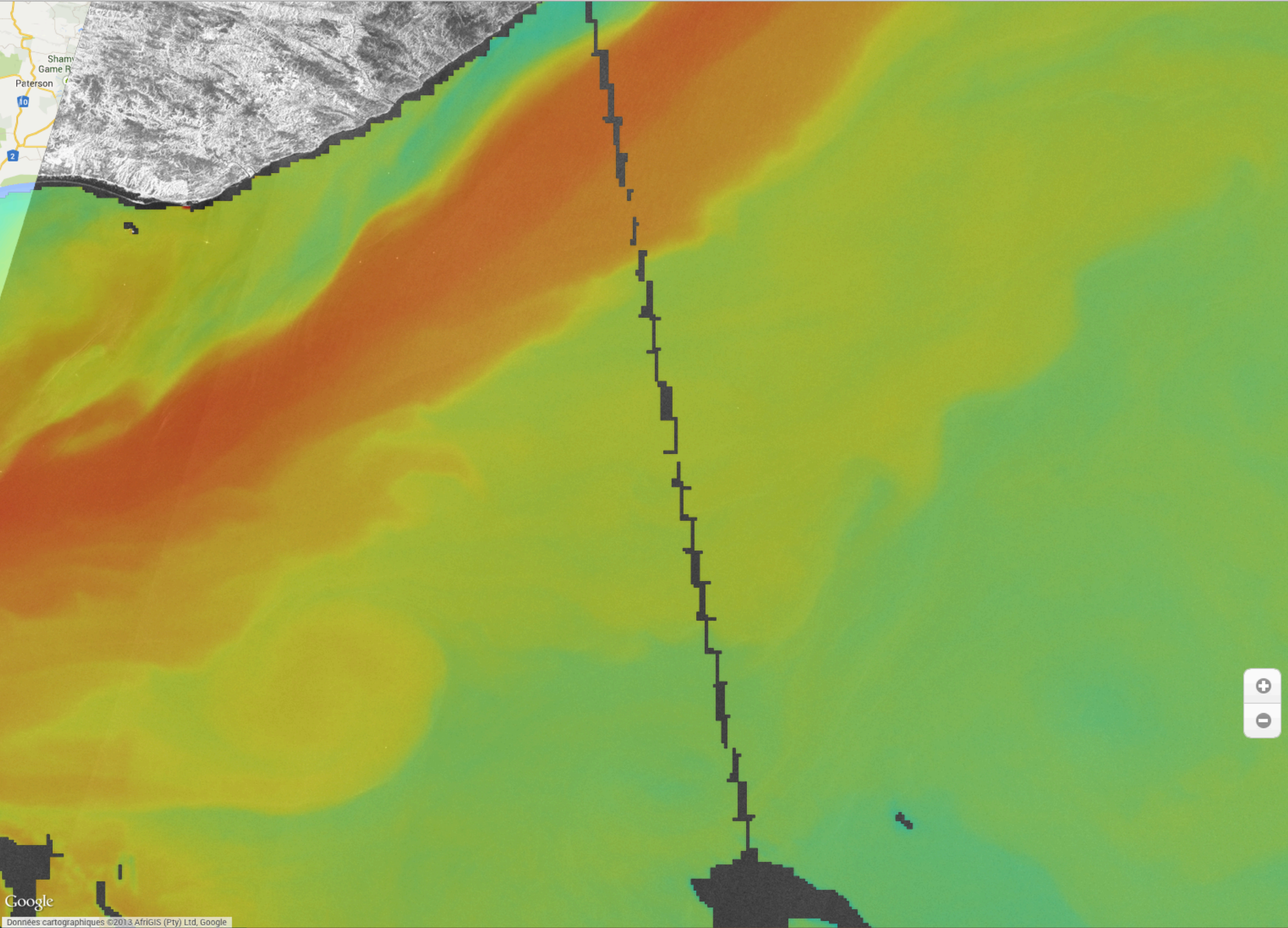


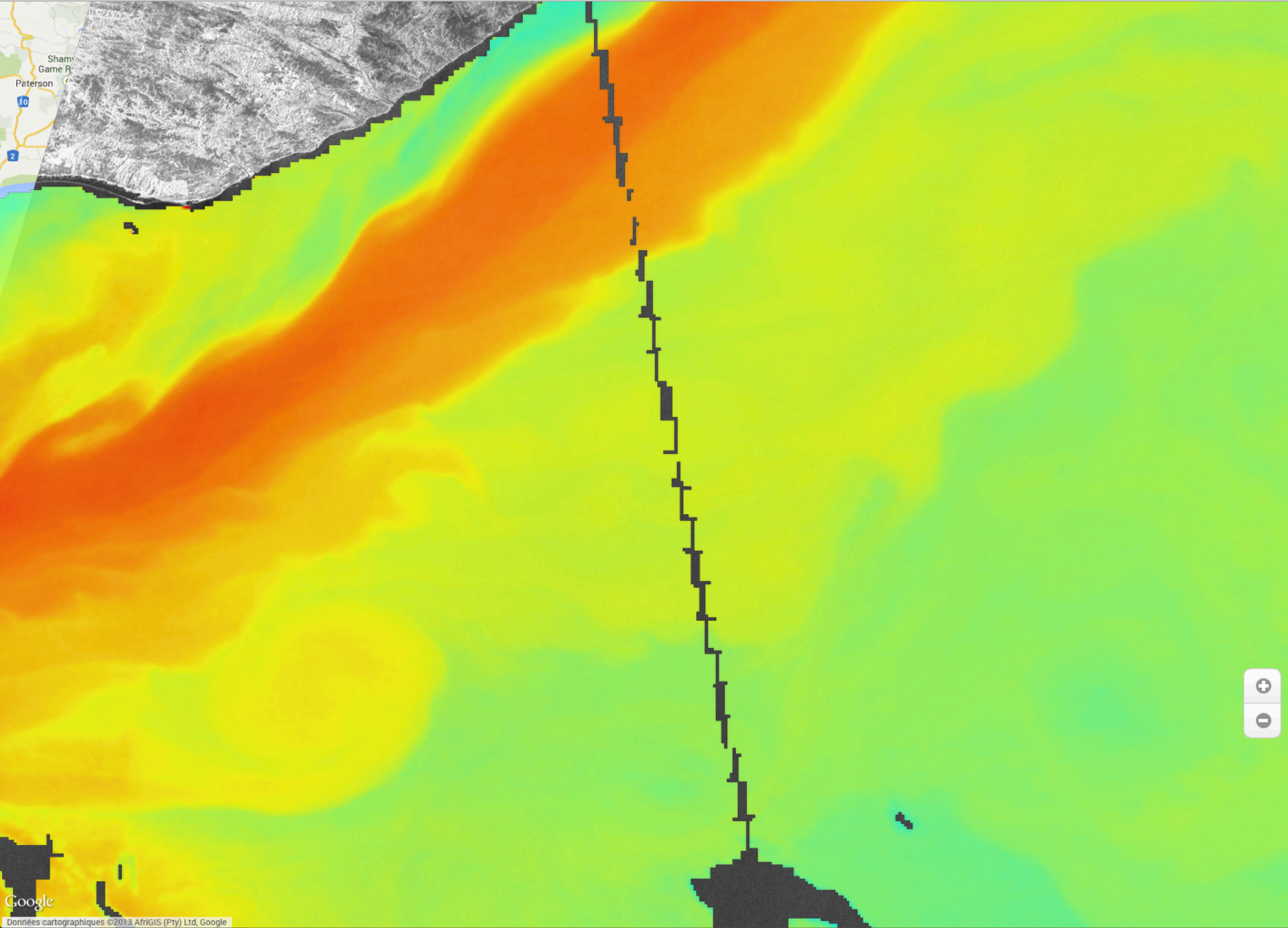








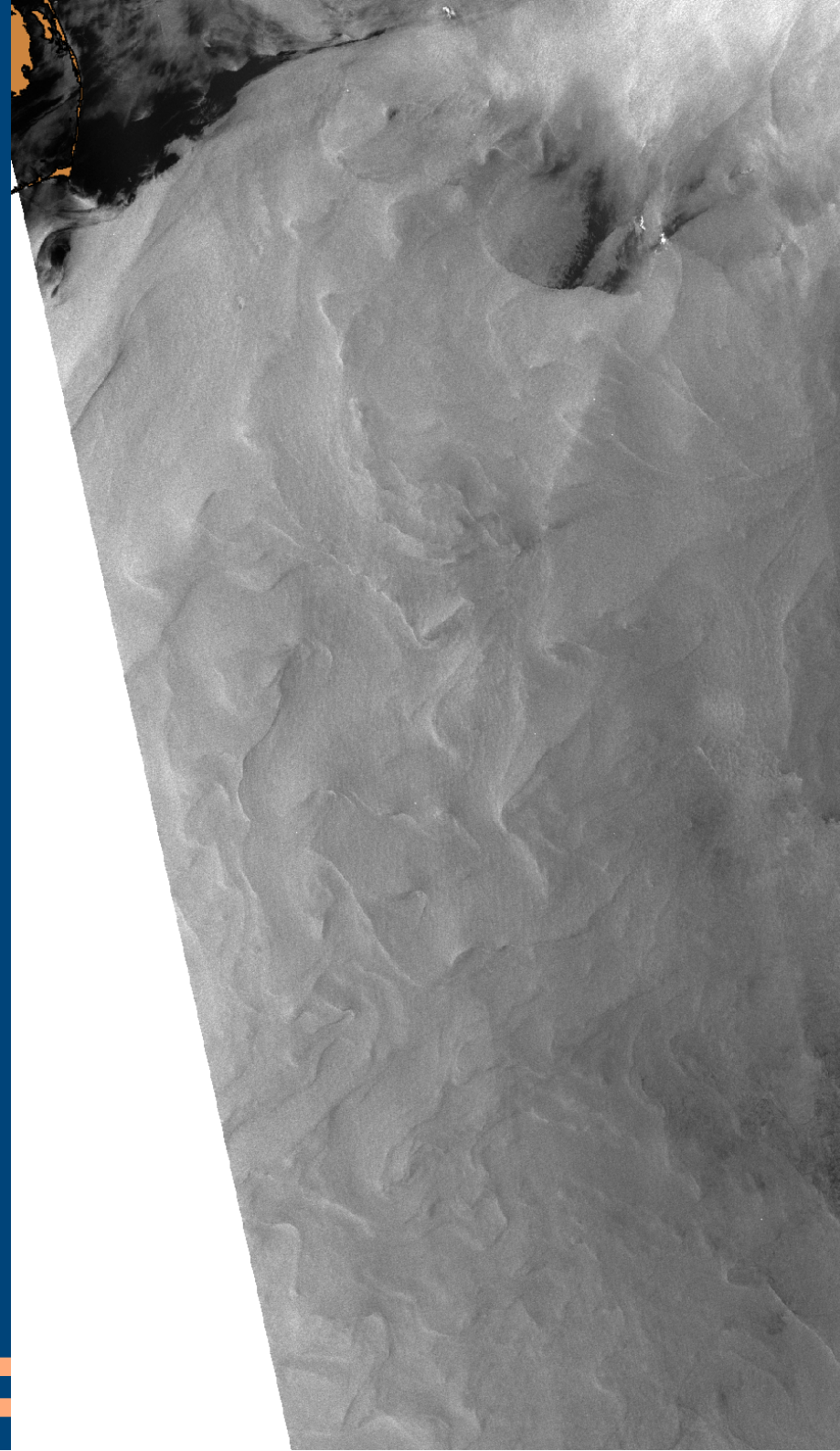




Roughness ...

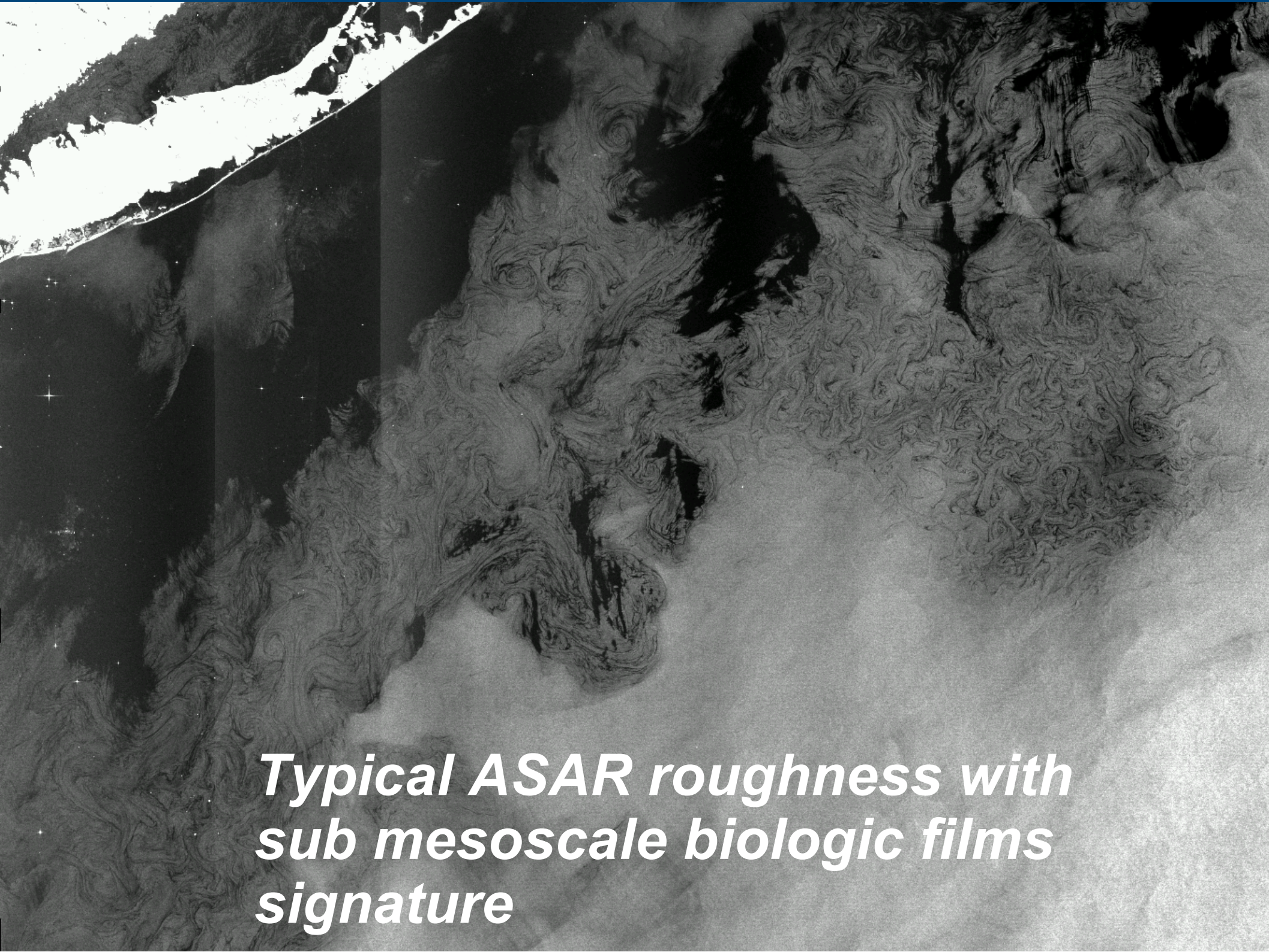
... a major revealing parameters of meso and submesocale variability

- Surface current gradients
 - Surface wind gradients
-
- Zone of interest : strong currents
 - Agulhas
 - Gulf stream
 - ...



***Typical ASAR roughness with
sub mesoscale fronts signature***



The image is a grayscale ASAR (Amplitude Scintillometry) scan of a surface. The top-left corner shows a bright, irregular boundary, likely representing a shoreline or a change in terrain. The rest of the image is filled with a complex, swirling pattern of dark and light gray tones, indicating surface roughness and texture. The patterns are irregular and somewhat chaotic, consistent with the description of a 'signature' from sub-mesoscale biologic films. The overall appearance is that of a highly textured, possibly biological or geological, surface.

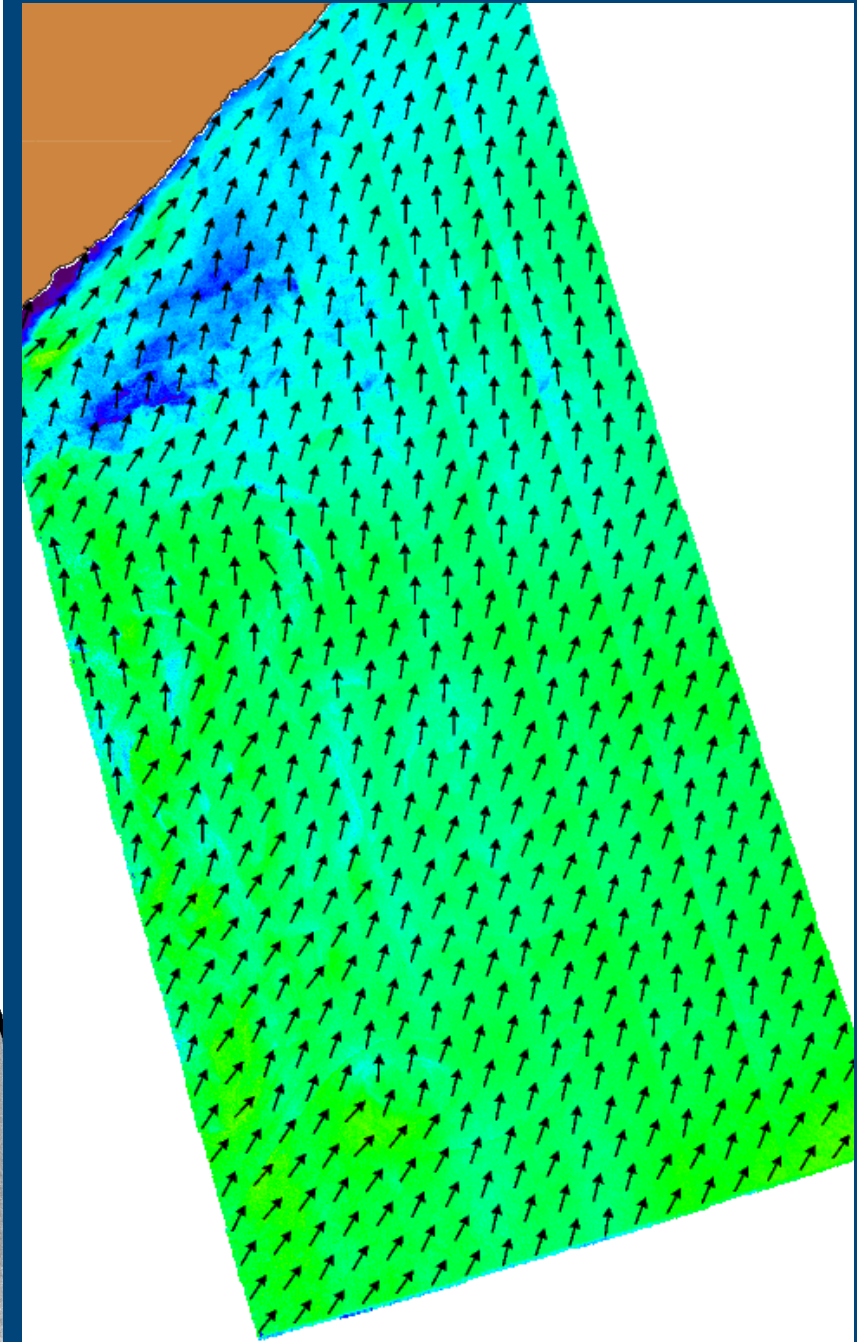
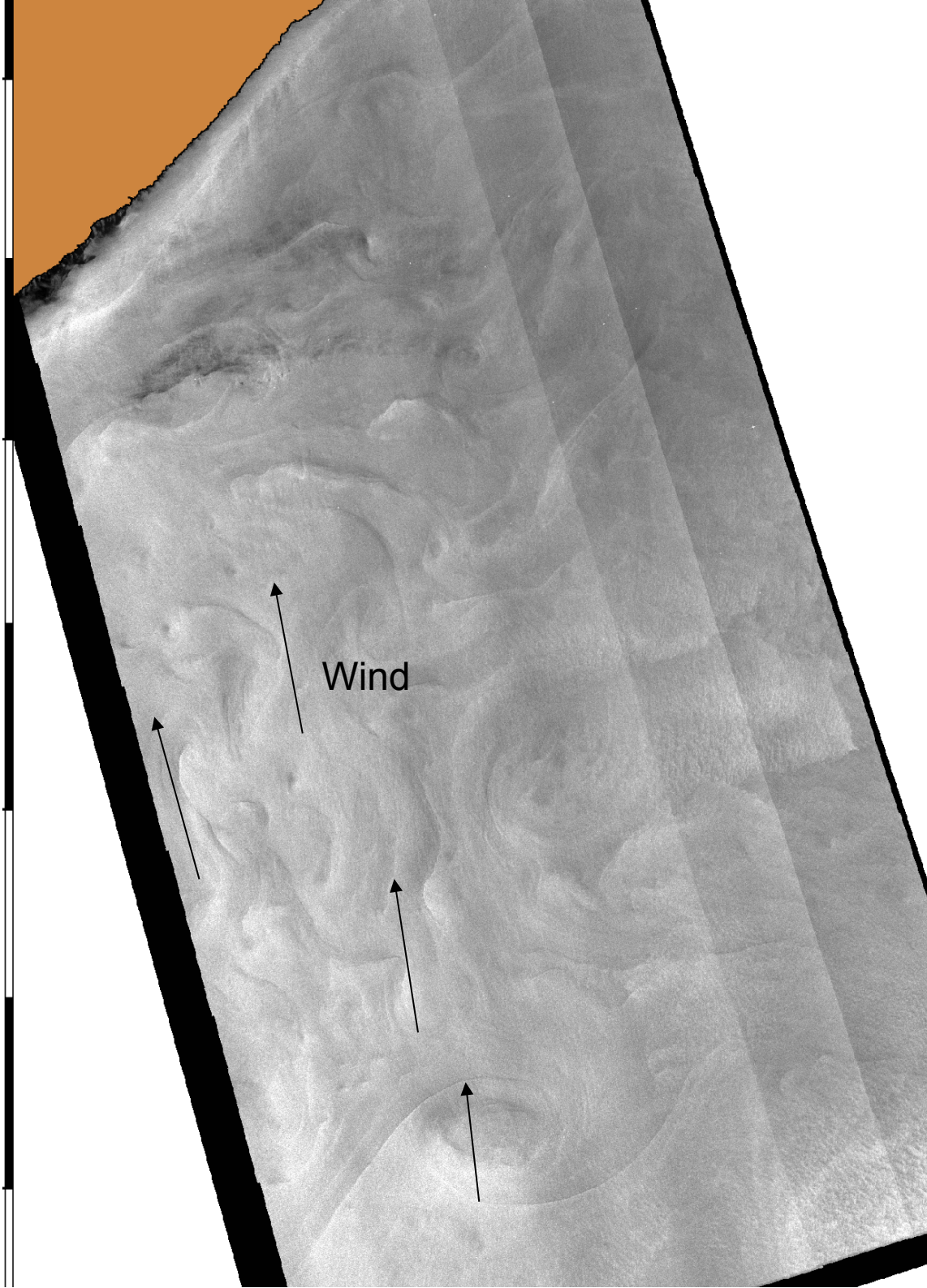
***Typical ASAR roughness with
sub mesoscale biologic films
signature***

sub mesoscale fronts signature

Southern hemisphere

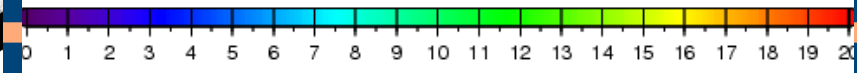


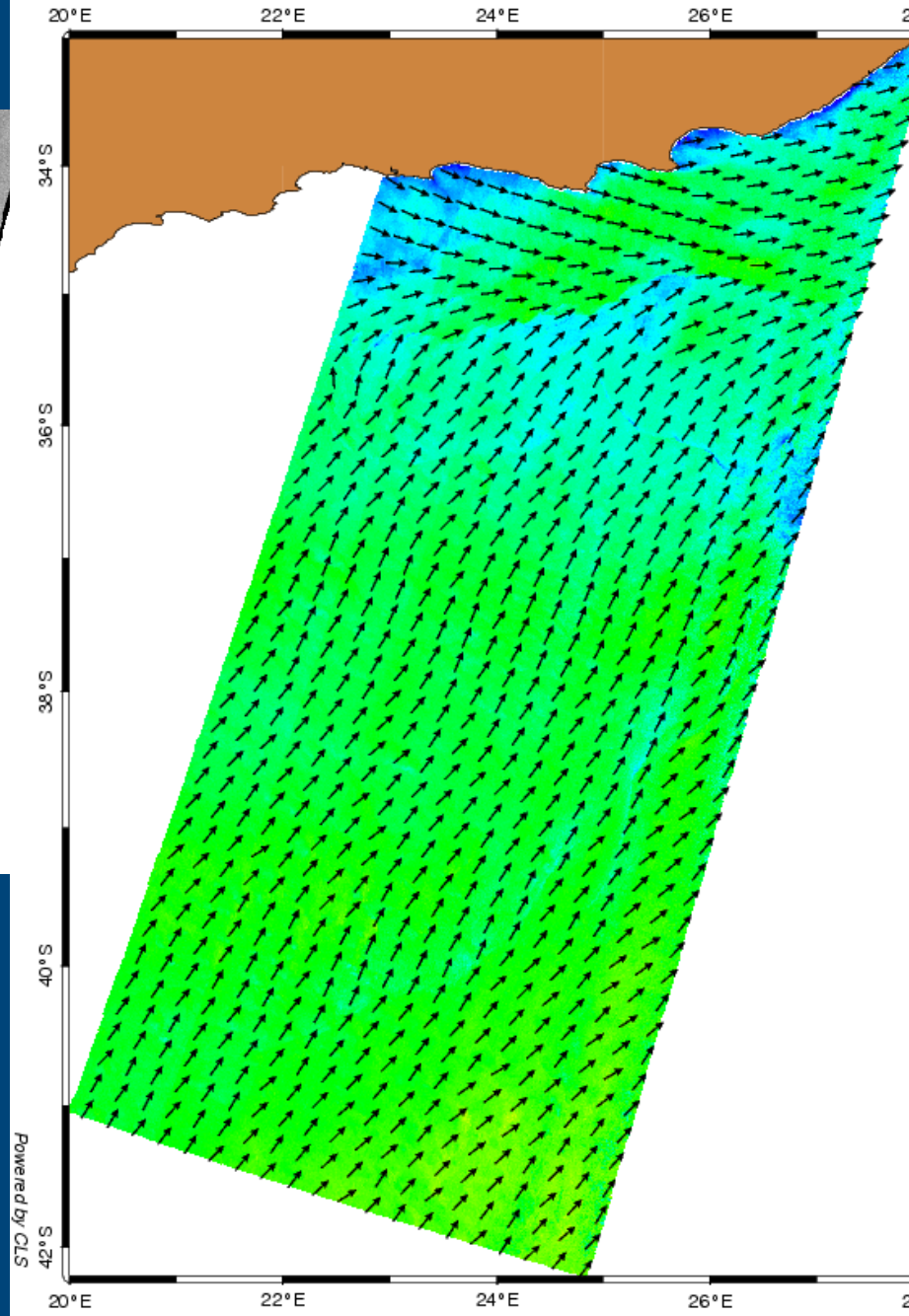
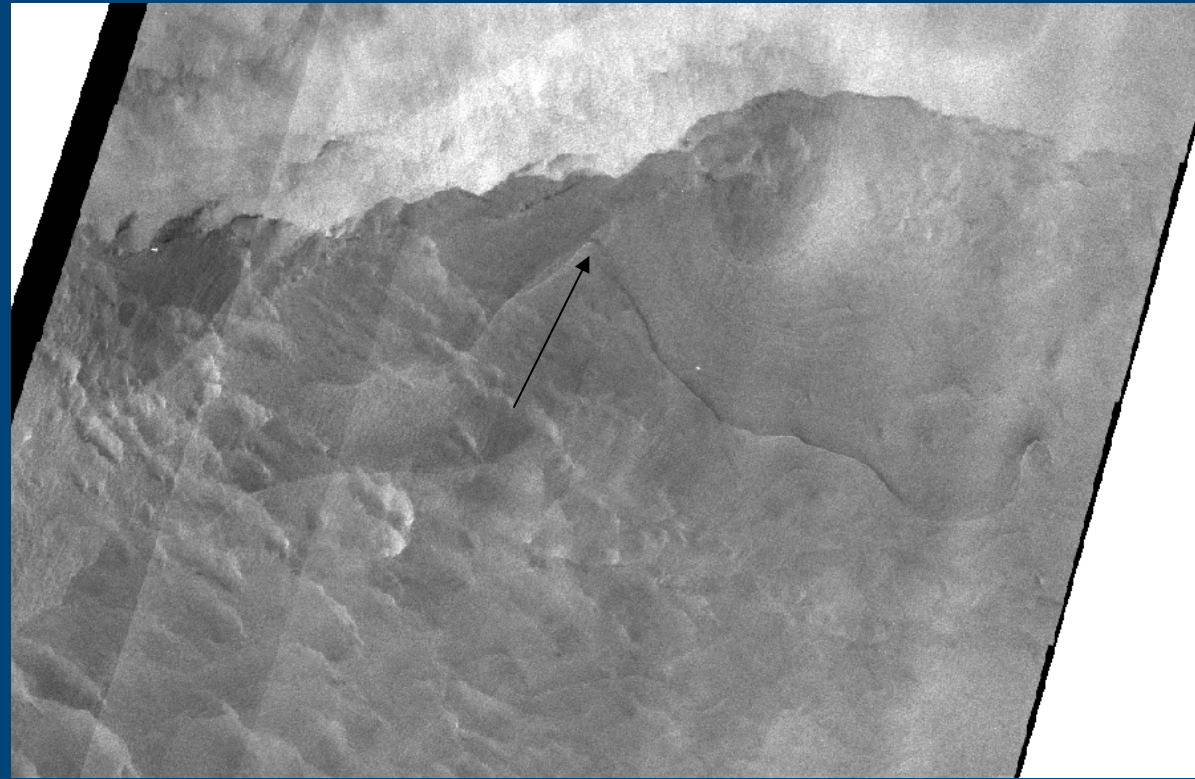
12 Sept 2010 20:41



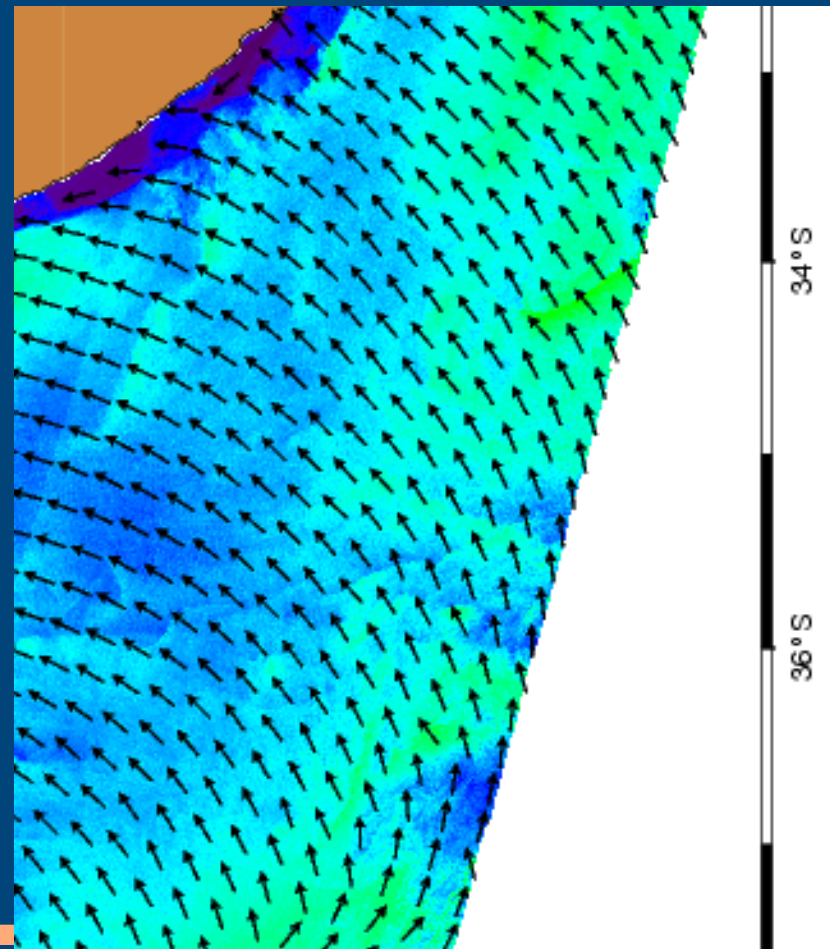
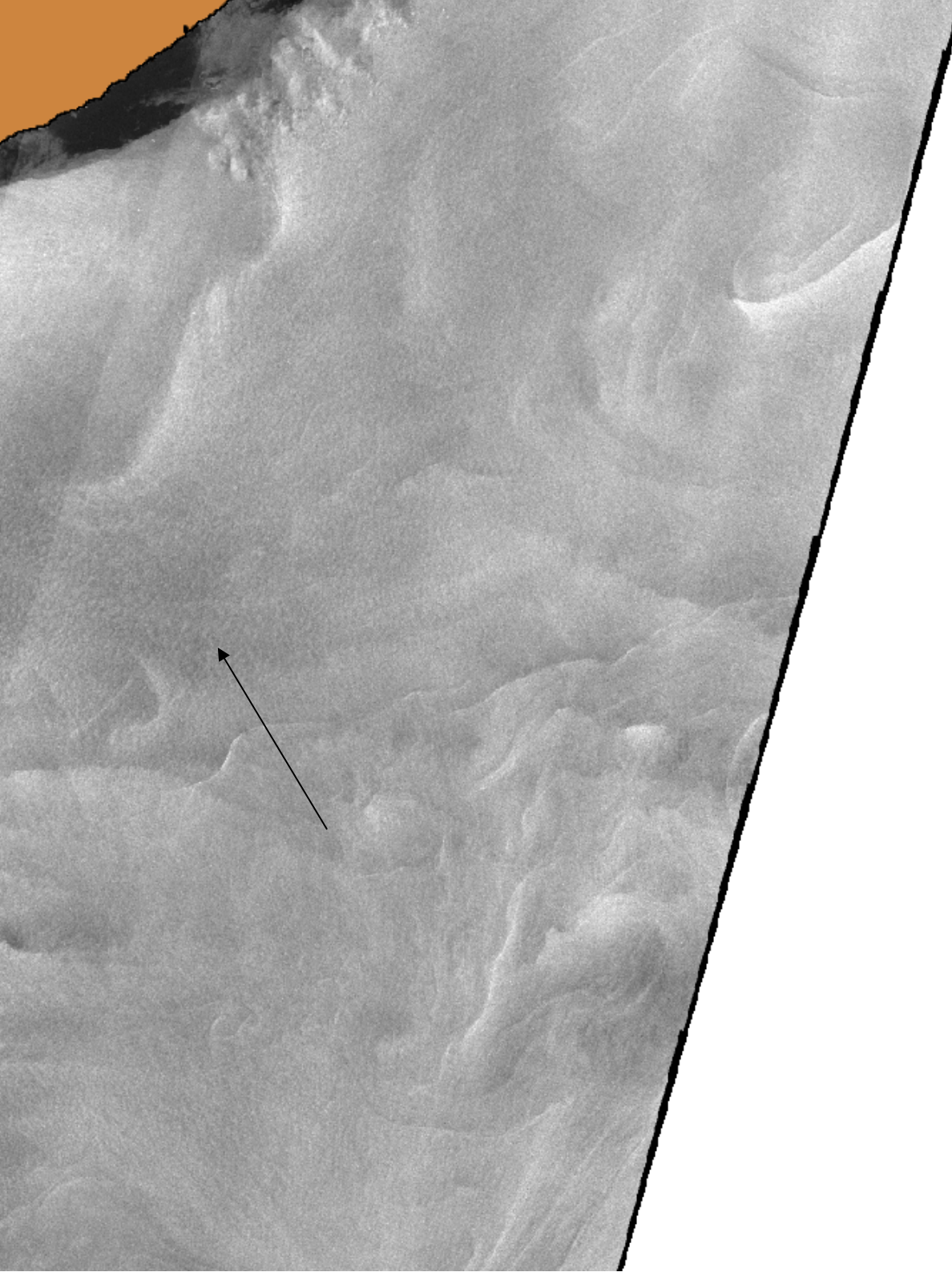
8°E 29°E 30°E 31°E 32°E 33°E 34°E

Wind Speed [m.s⁻¹]





29 August 2010 07:26



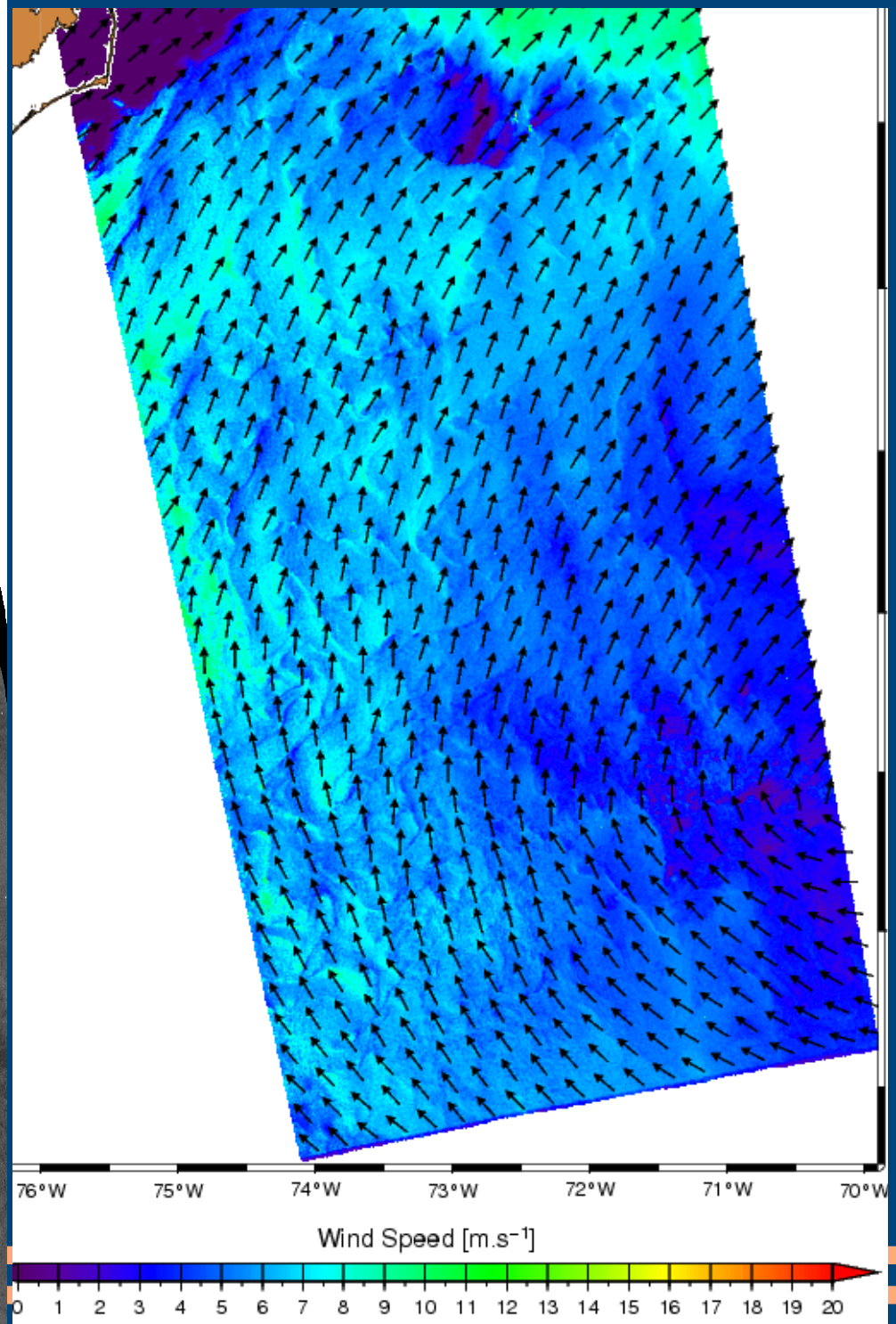
sub mesoscale fronts signature

Northern hemisphere





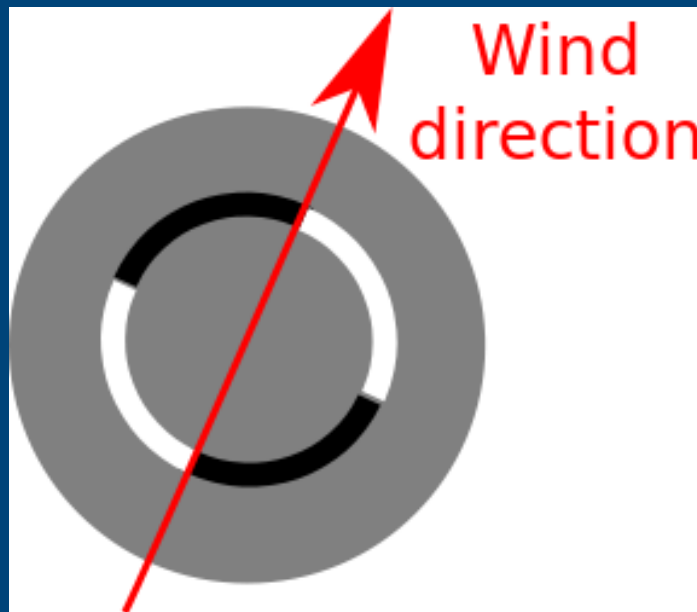
47



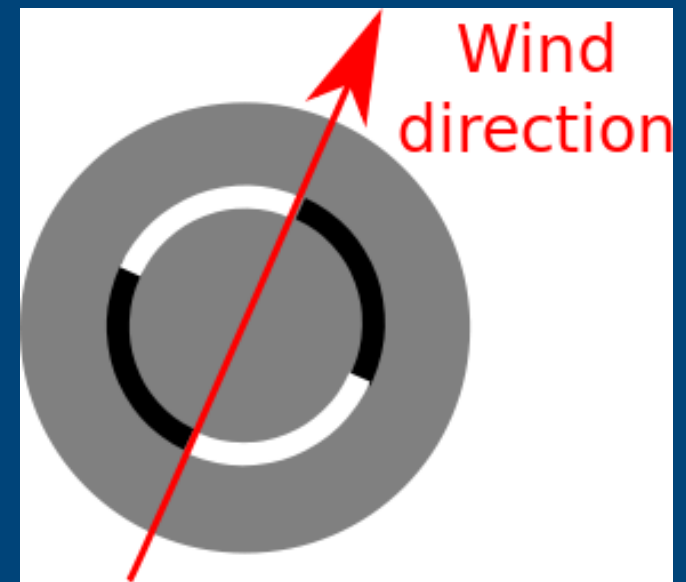
First qualitative Observation of surface roughness modulation at Meso & submesoscale frontal zone

Observation of enhancement or reduction of roughness contrast depending on relative angle between wind and front direction.

(with apparent independence of SST gradient and current shear)



Northern hemisphere

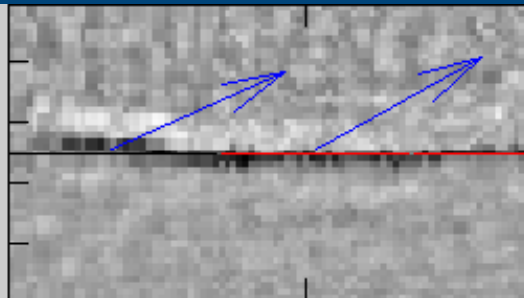


Southern hemisphere

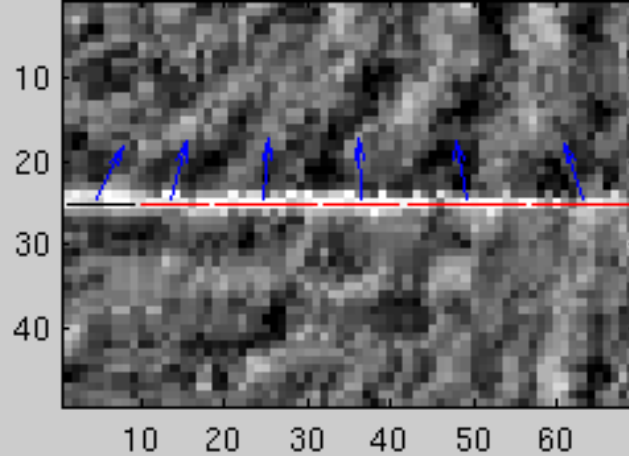
Statistical overview

- Statistical estimation of global wind effect on enhanced/reduced surface roughness zone
 - Methodology
 - Manual / automatic front selection
 - Contrast adjustment for front positioning
 - Front classification (direction / wind, curvature)
 - Mean wind estimation over a front (ECMWF model, ..)
 - Statistical representation
-
-

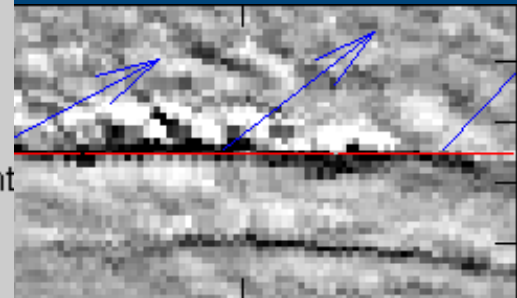
Front se



50

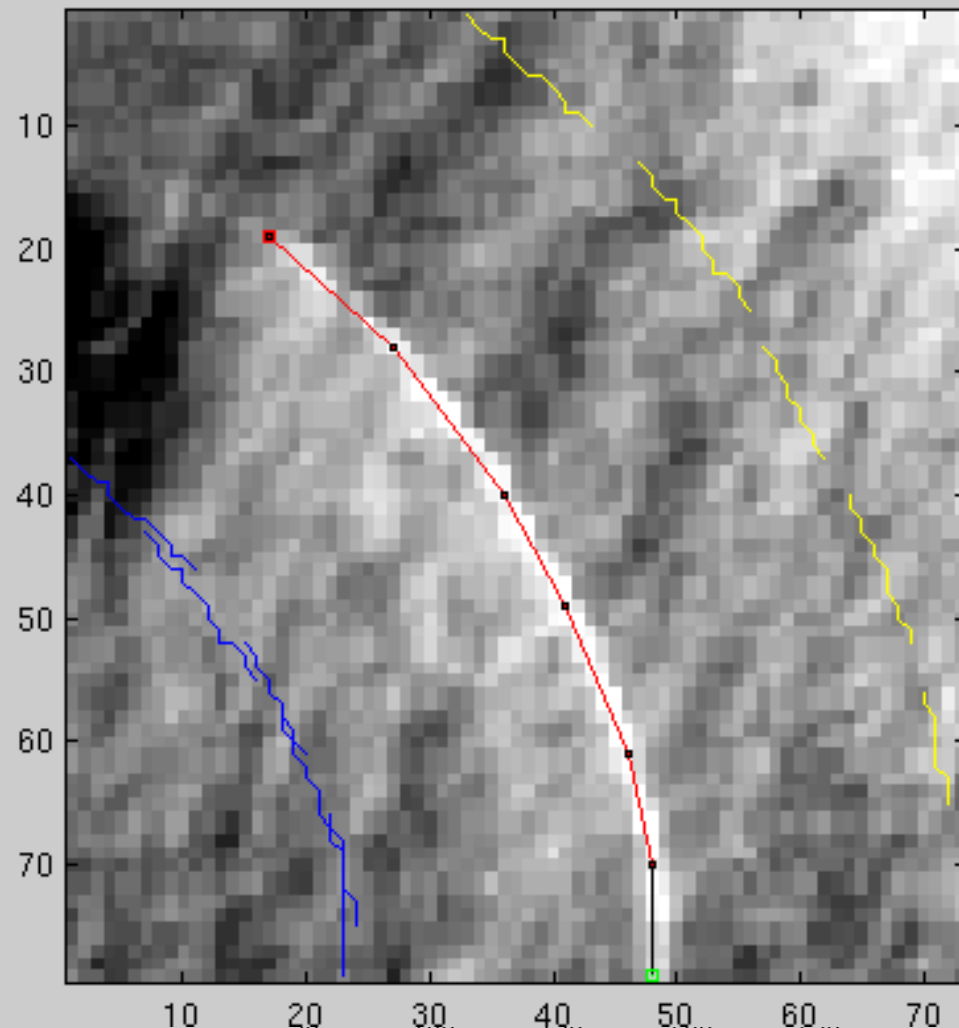


is tool

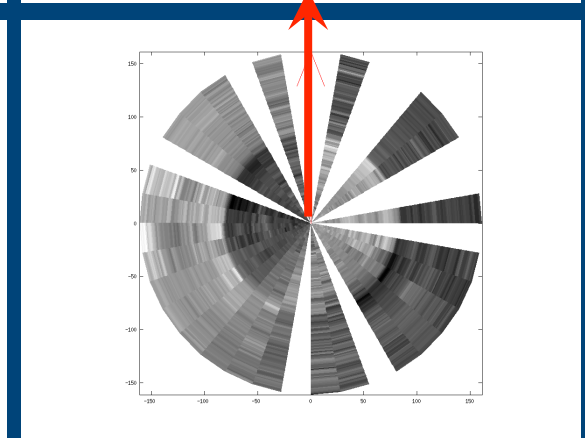
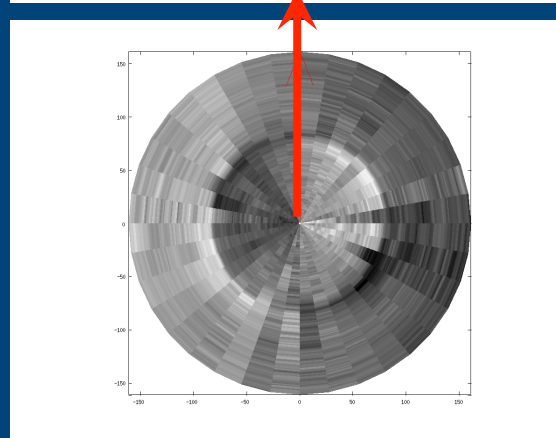
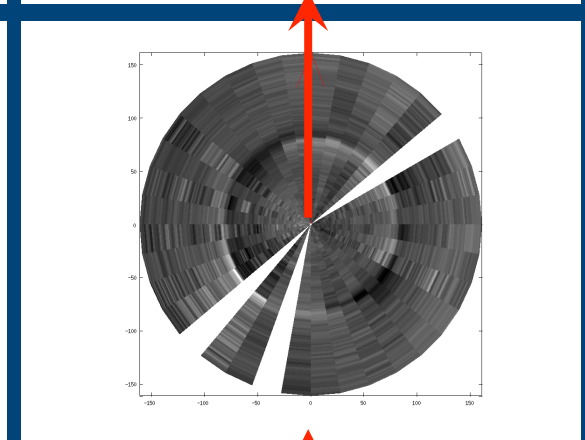
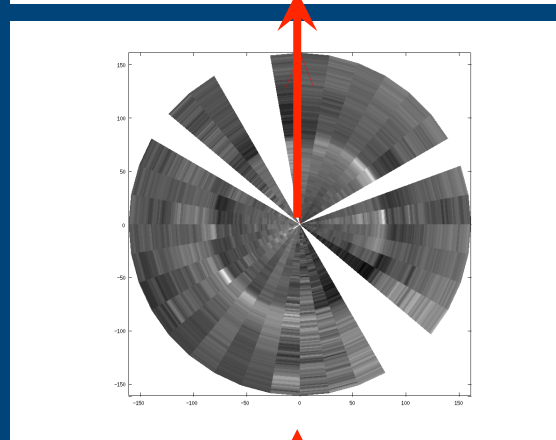
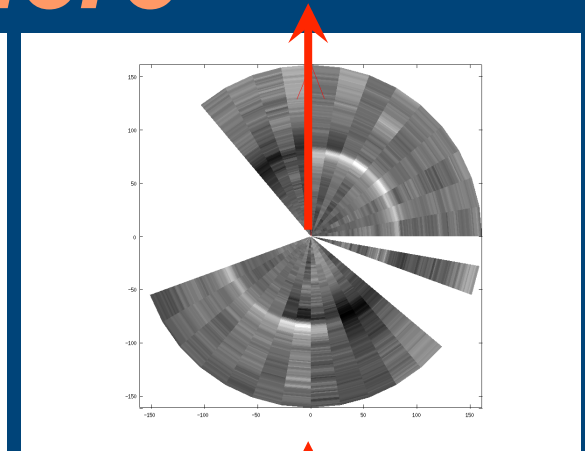
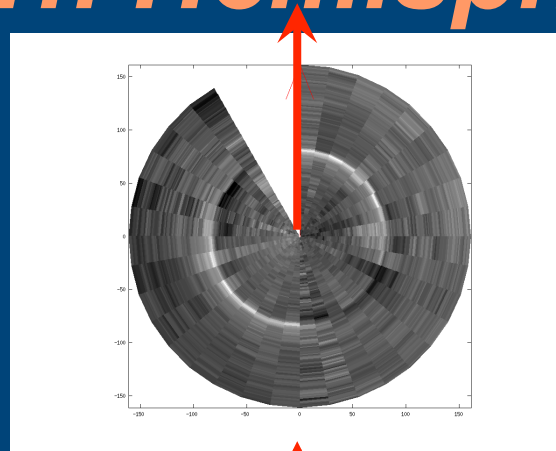
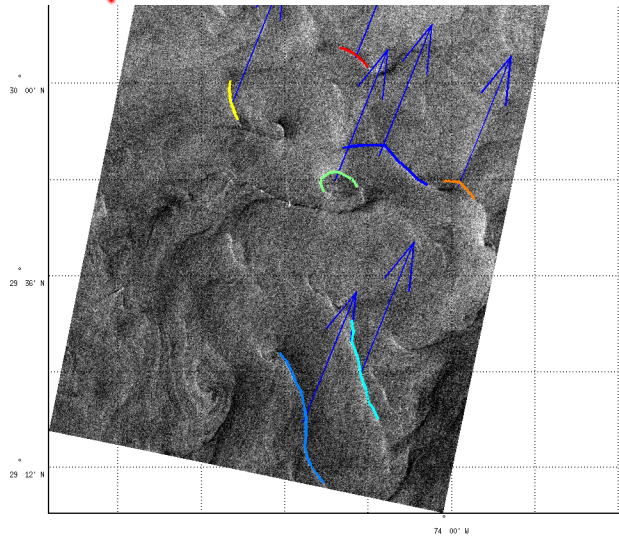
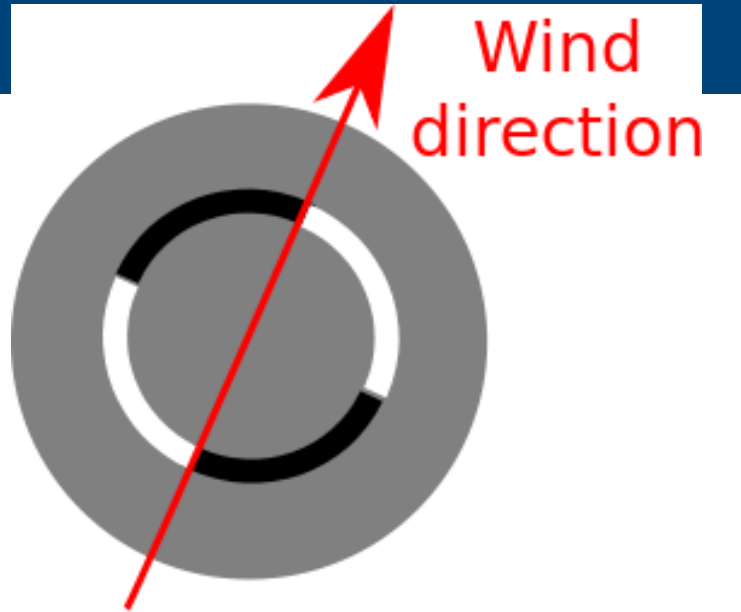


300

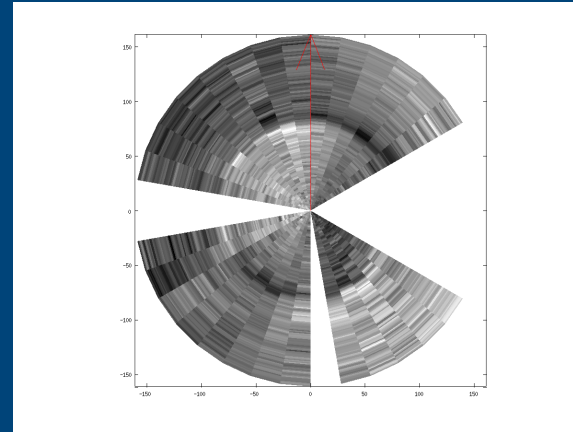
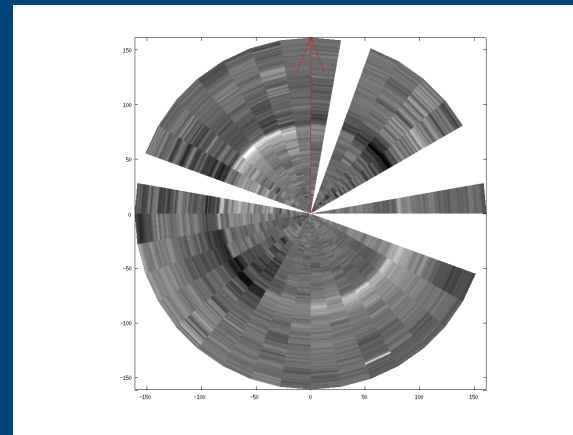
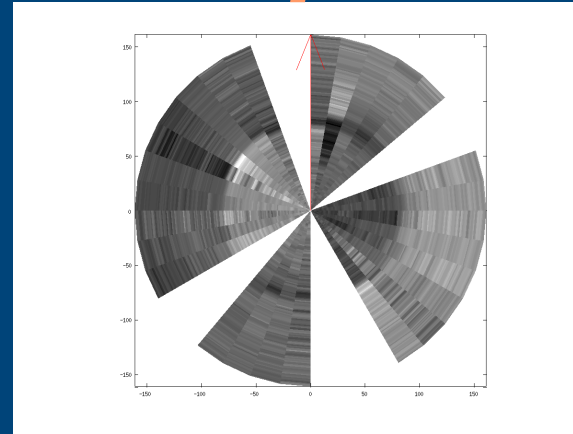
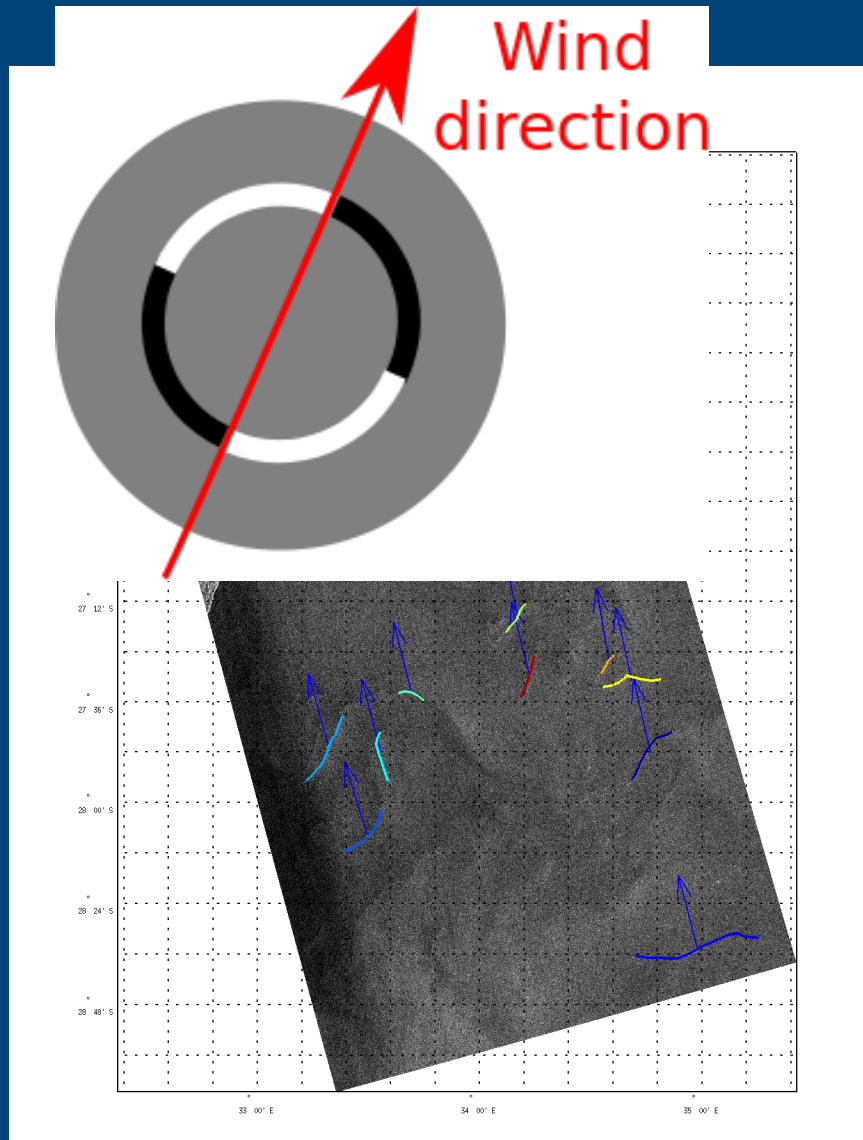
Left clic : move point / Middle clic : add point / Right clic : remove point



ASAR Northern Hemisphere



ASAR Southern Hemisphere



Roughness modulation in MERIS images

$$B = \frac{\rho E_s}{4 \cos \theta_v \cos^4 \beta} P(Z_x, Z_y)$$

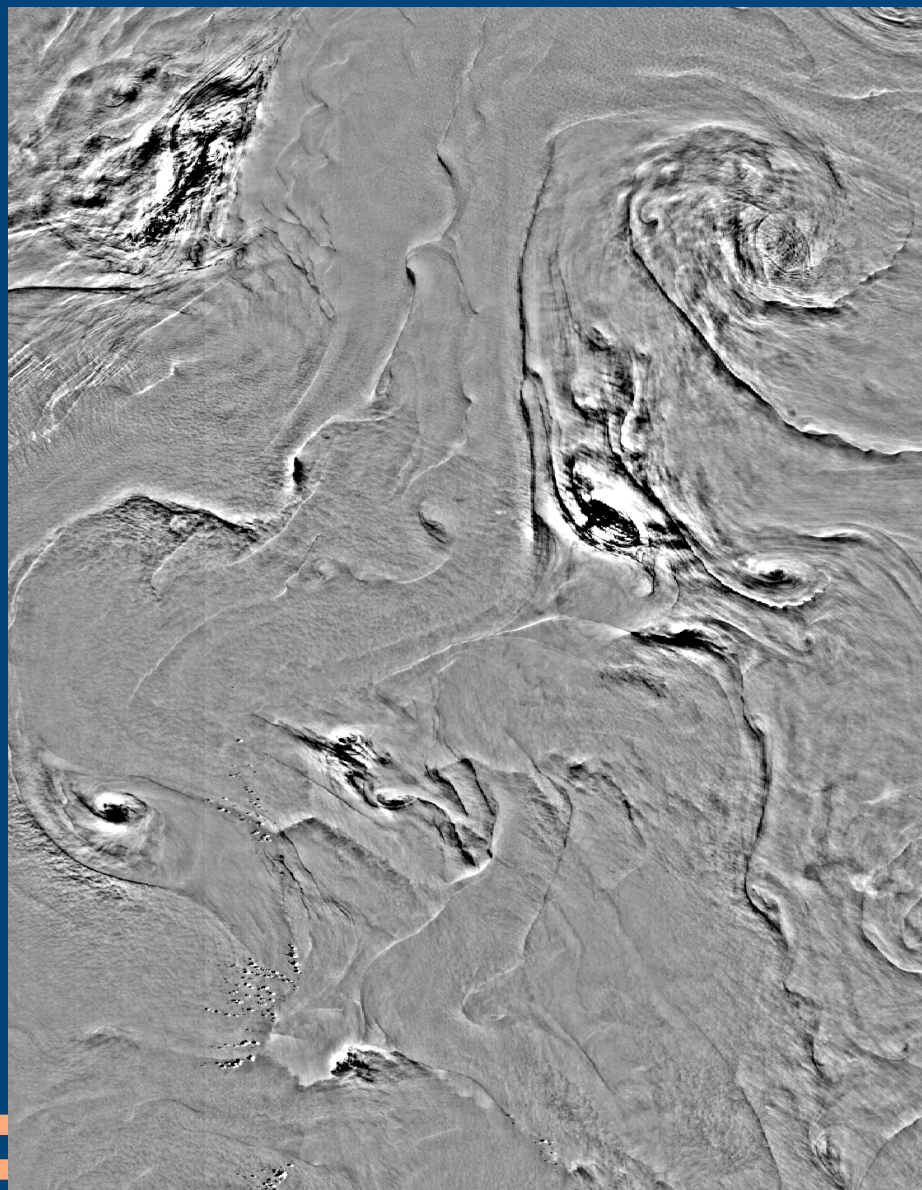
- Red channel on sea surfaces depends on surface roughness.

Interest zone → Glint area

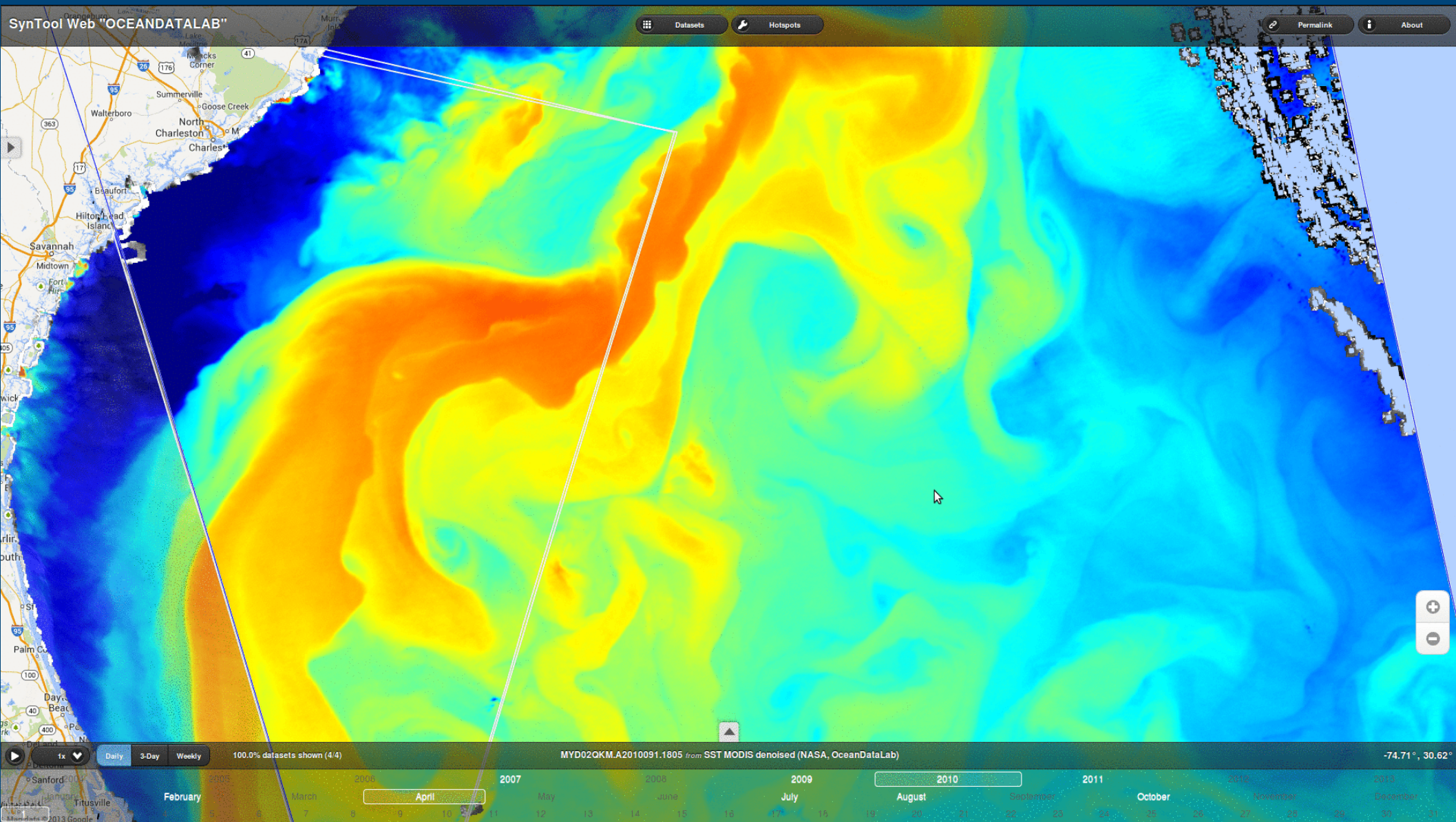
- Large scale background (sun glitter width)
- Small scale details (contrast)



Optical image -MERIS- Sun glint area in Near Red channel

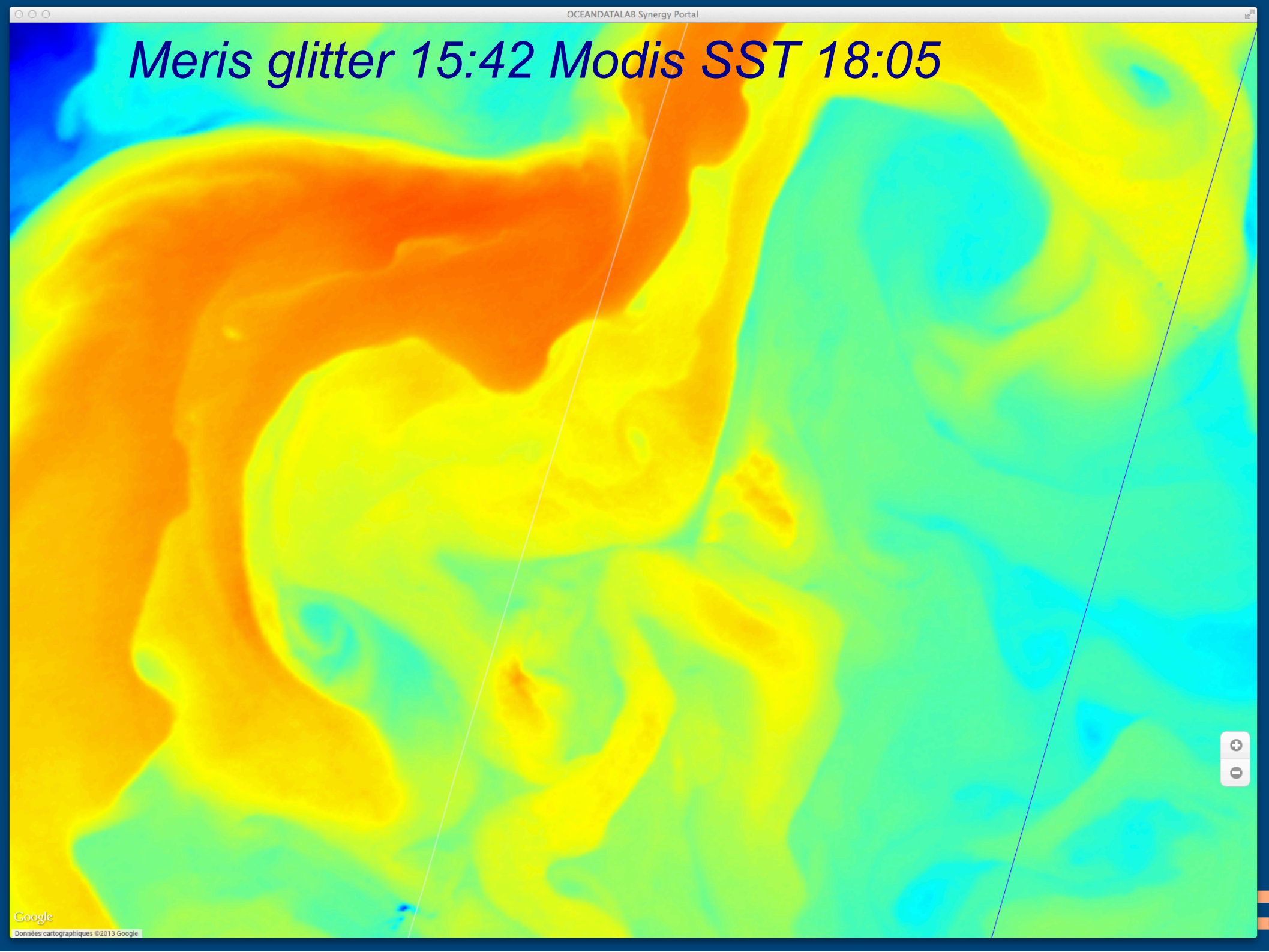


MODIS IR SST and Optical Sun Glint

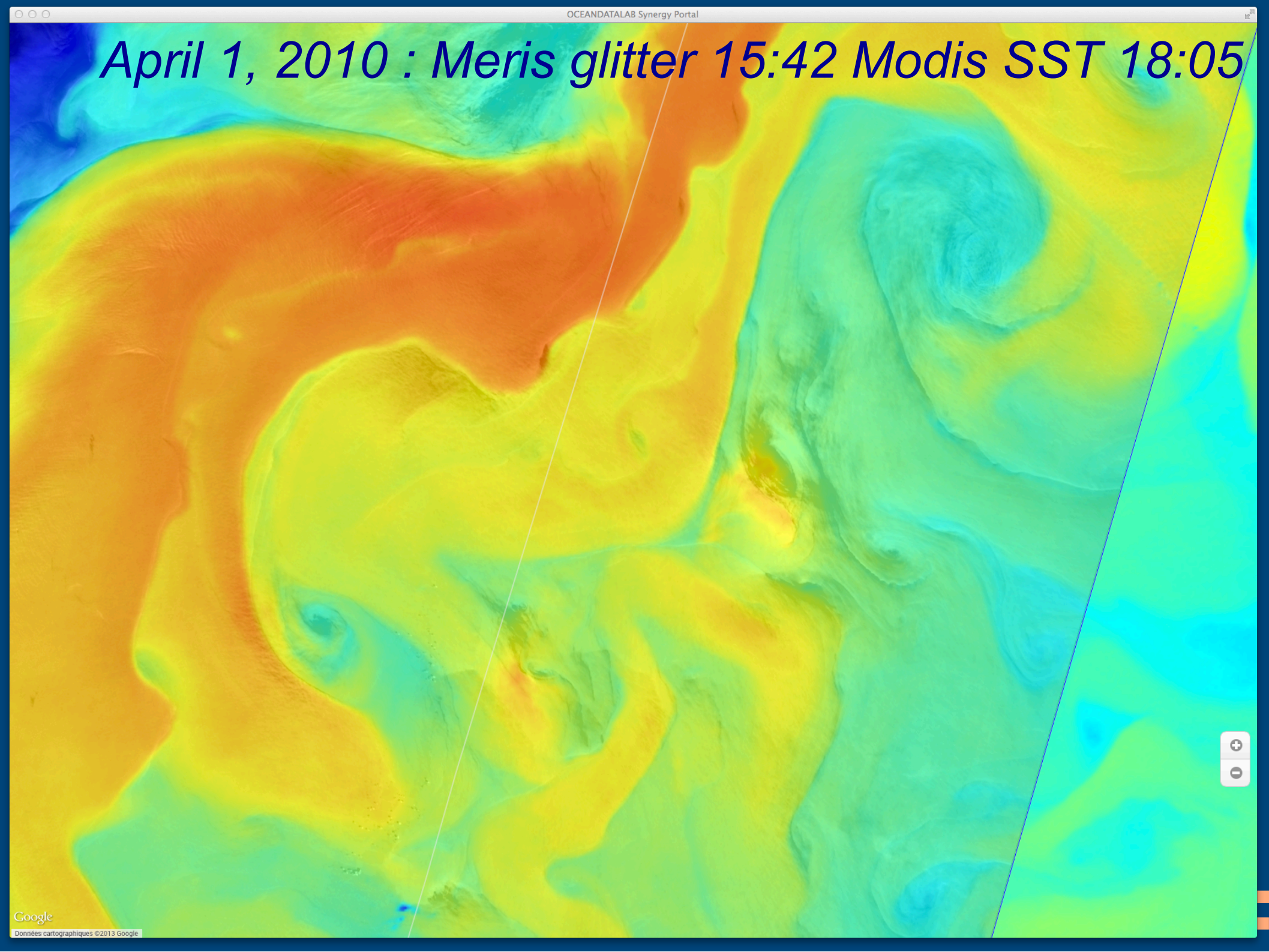


<http://oceandatalab.syntool.org>

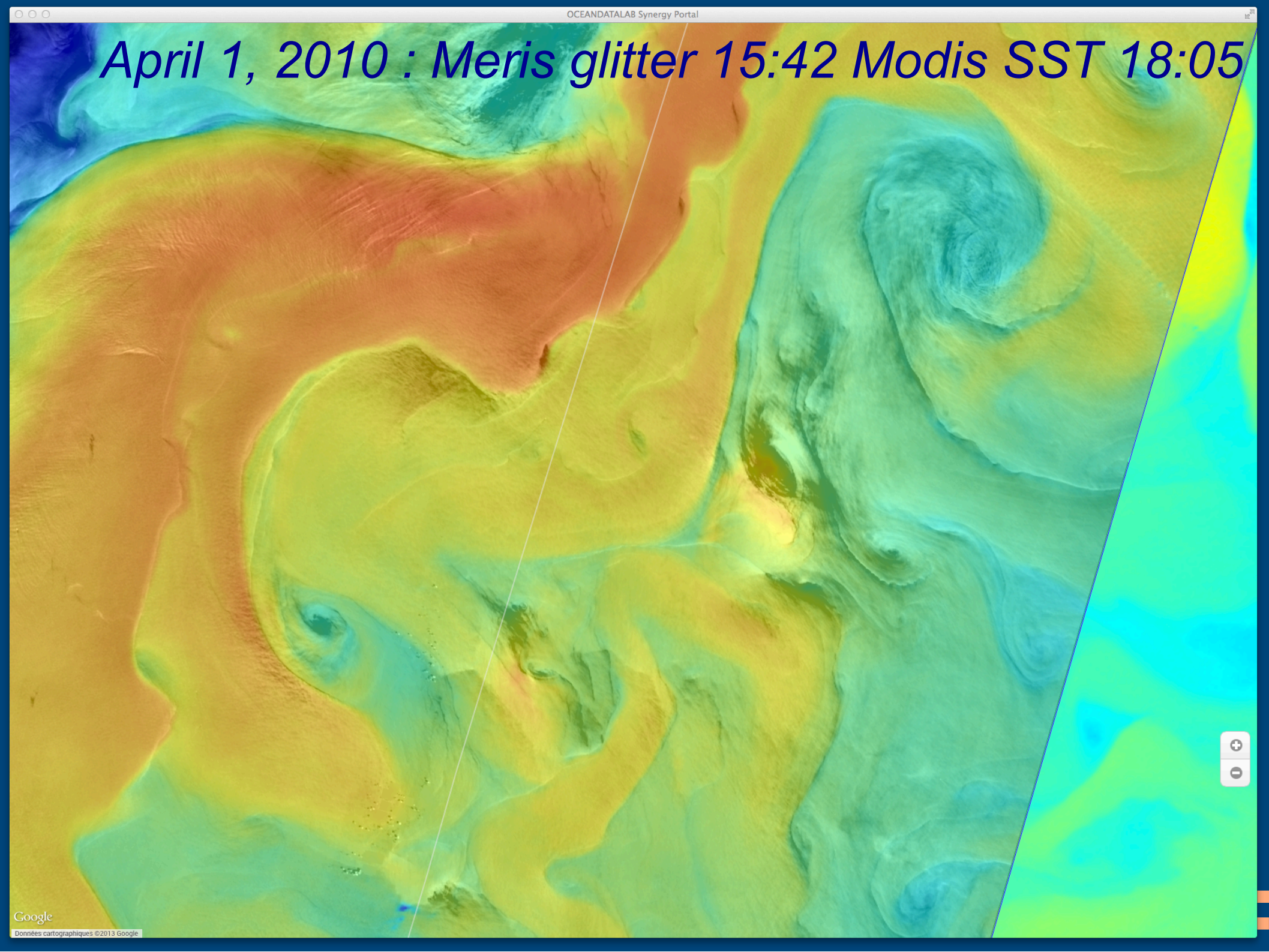
Meris glitter 15:42 Modis SST 18:05



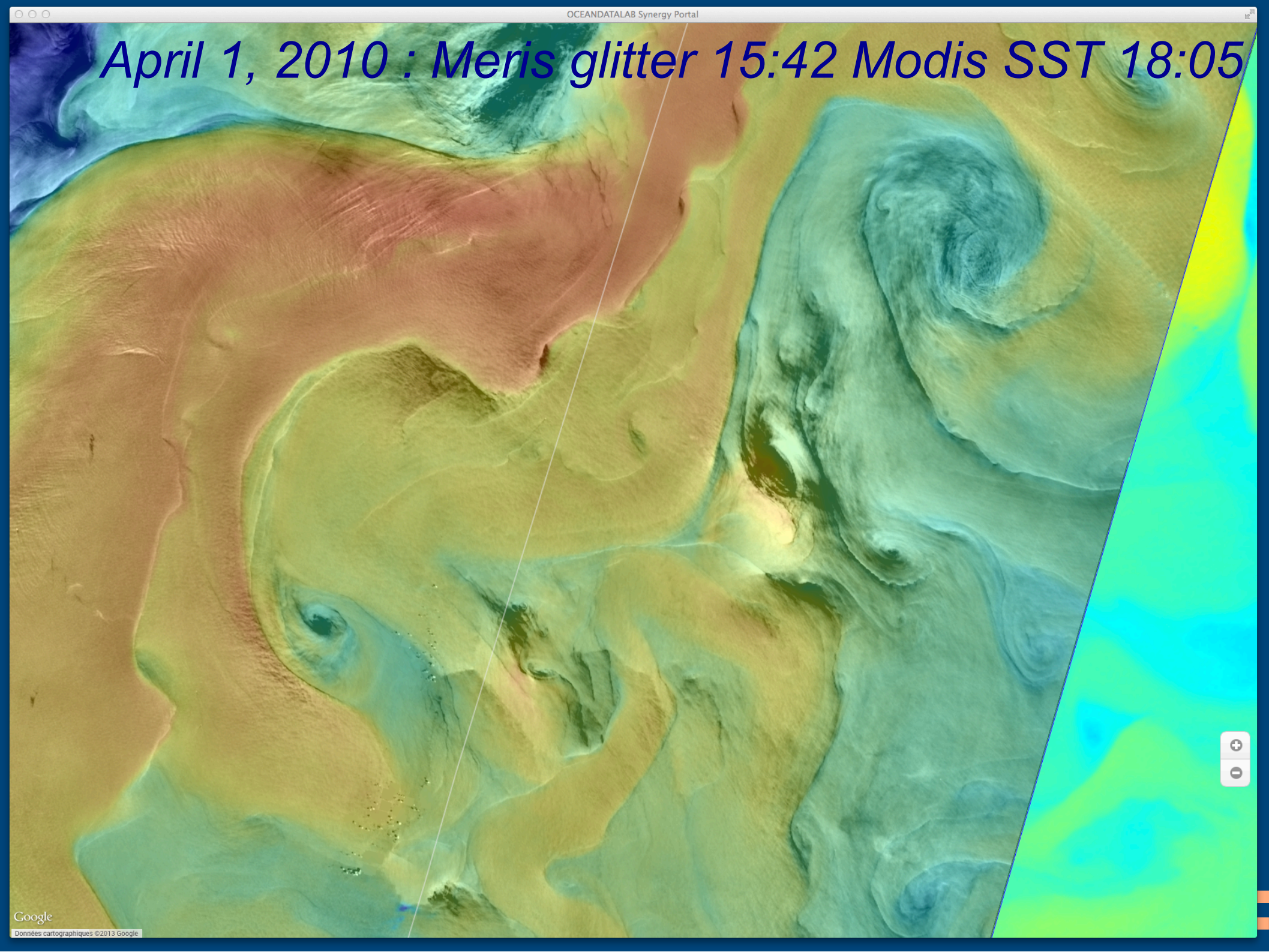
April 1, 2010 : Meris glitter 15:42 Modis SST 18:05



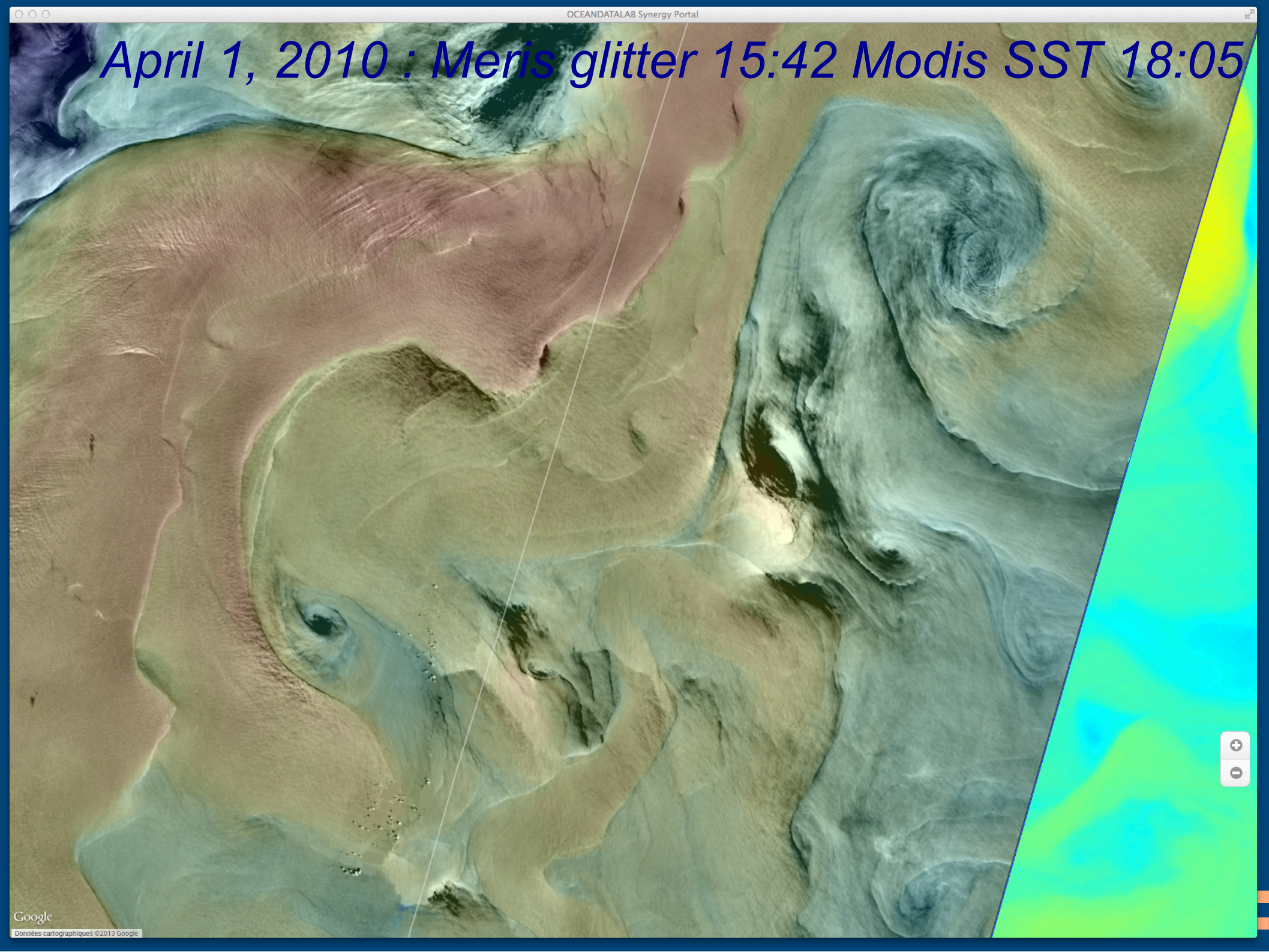
April 1, 2010 : Meris glitter 15:42 Modis SST 18:05



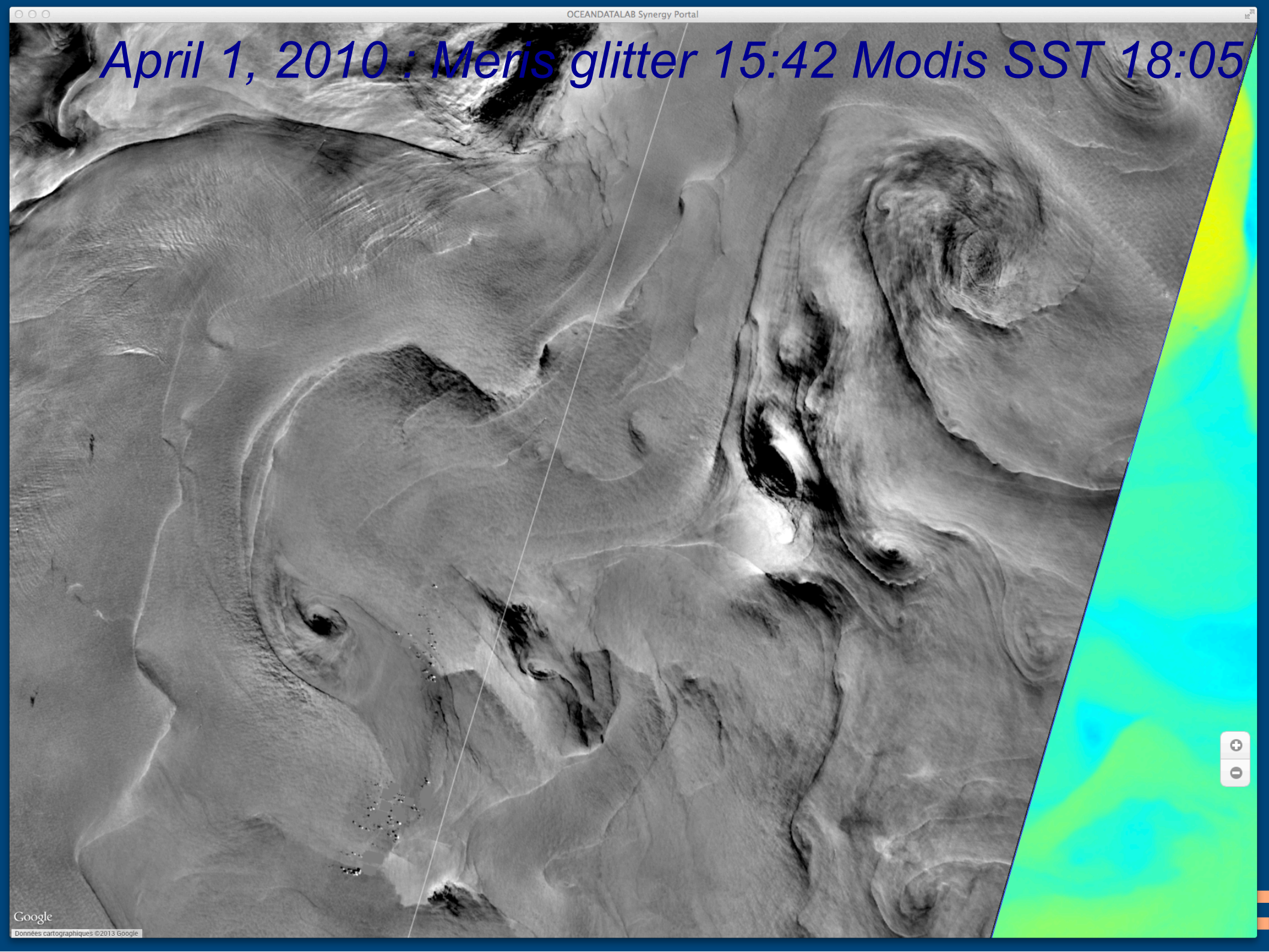
April 1, 2010 : Meris glitter 15:42 Modis SST 18:05



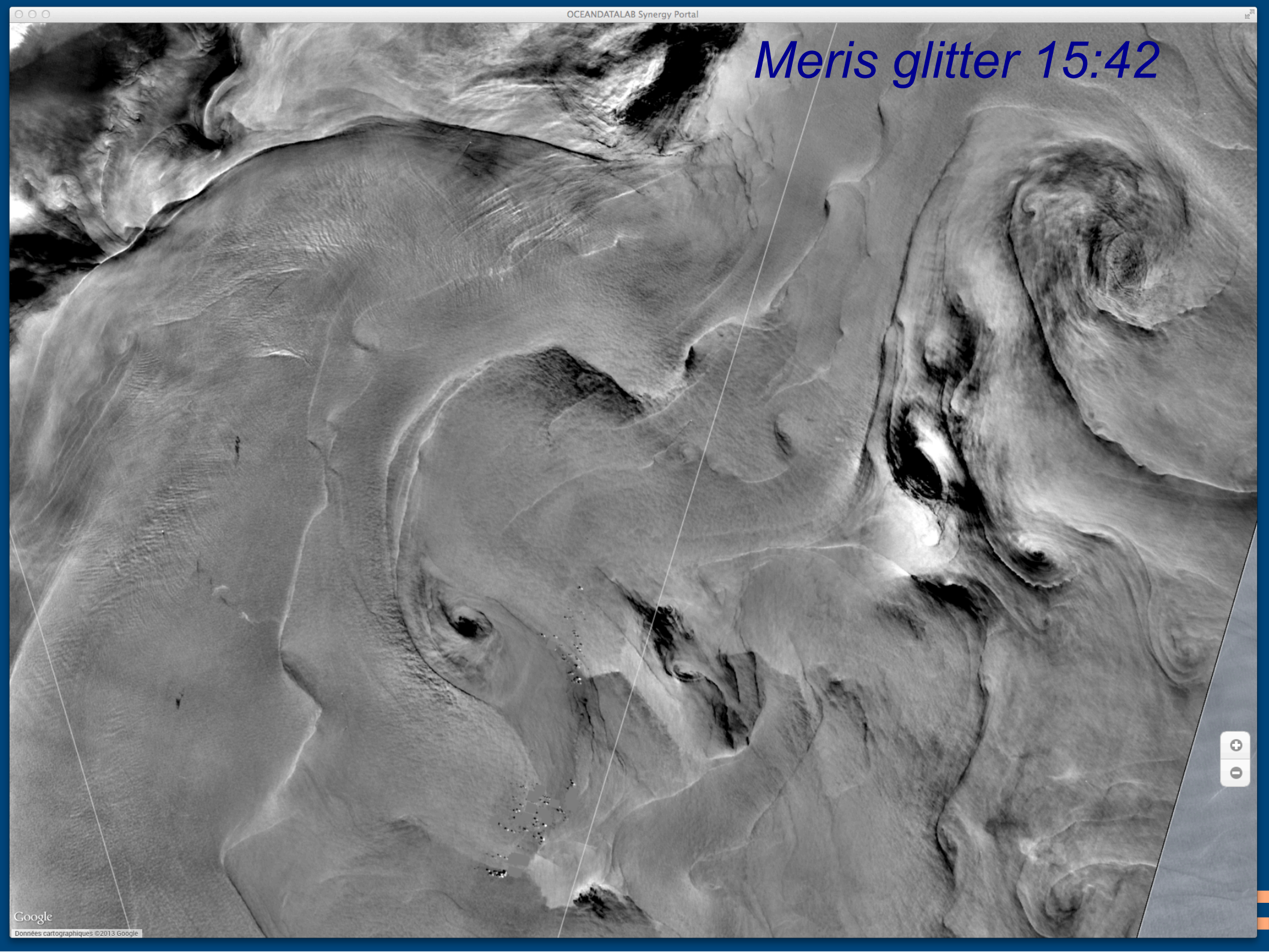
April 1, 2010 : Meris glitter 15:42 Modis SST 18:05



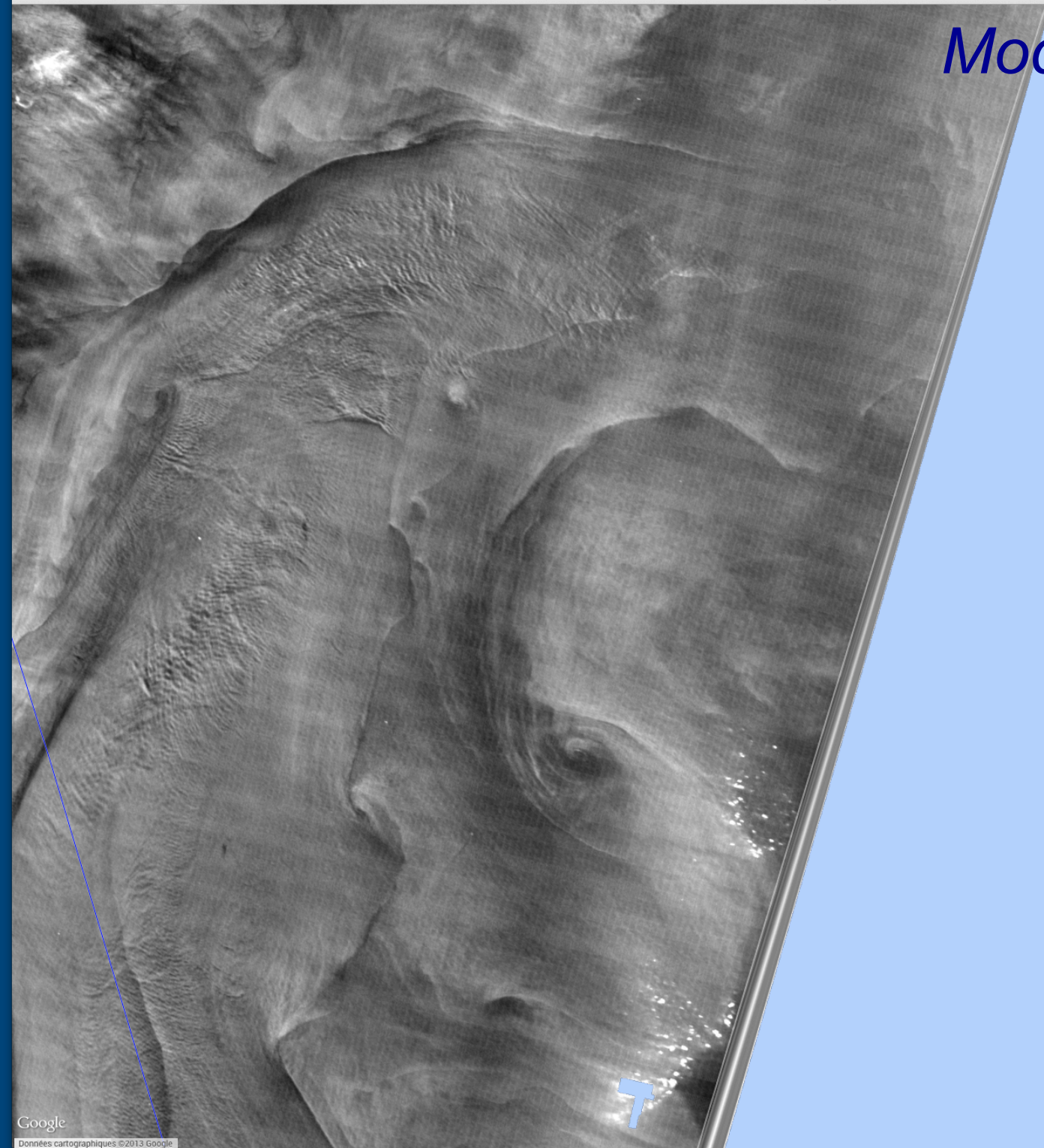
April 1, 2010 : Meris glitter 15:42 Modis SST 18:05



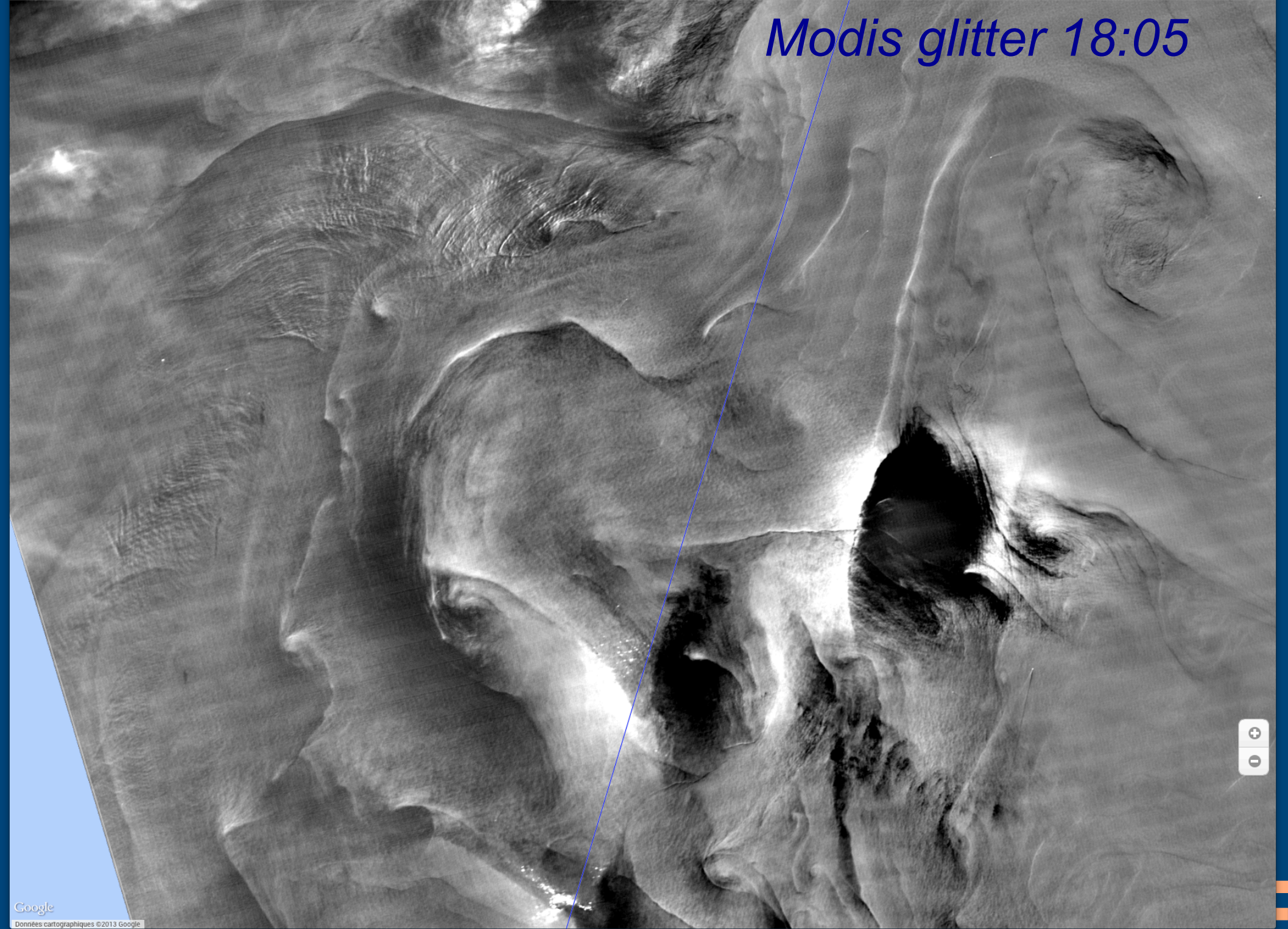
Meris glitter 15:42

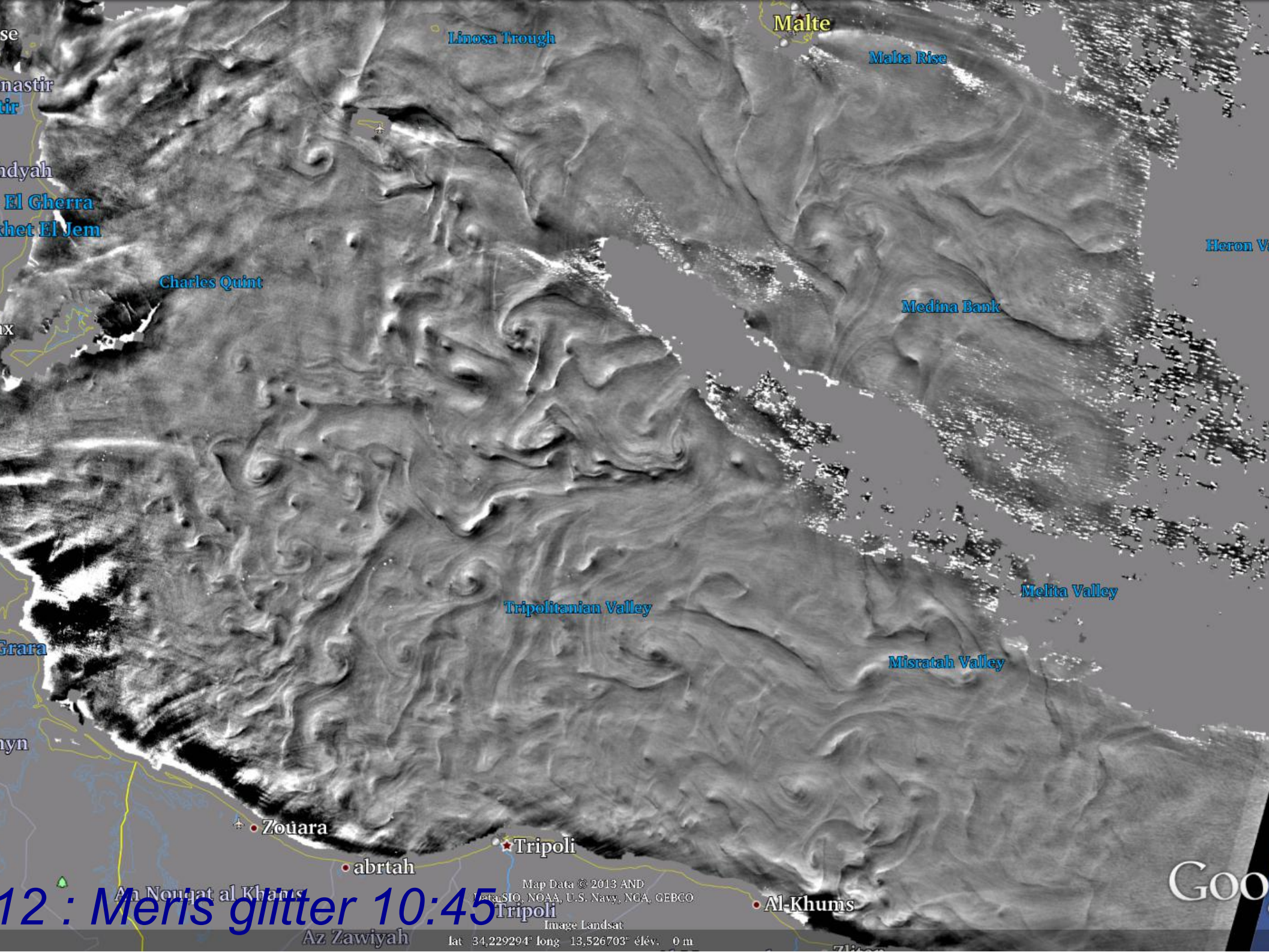


Modis glitter 16:30



Modis glitter 18:05





Linosa Trough

Malte

Malta Rise

Heron V

nastir
tir

ndyah

El Gherra
chet El Jem

Charles Quint

Medina Bank

Tripolitanian Valley

Melita Valley

Misratah Valley

Grara

nyn

Zouara

abrtah

Tripoli

Al-Khums

An Nougat al Khamis

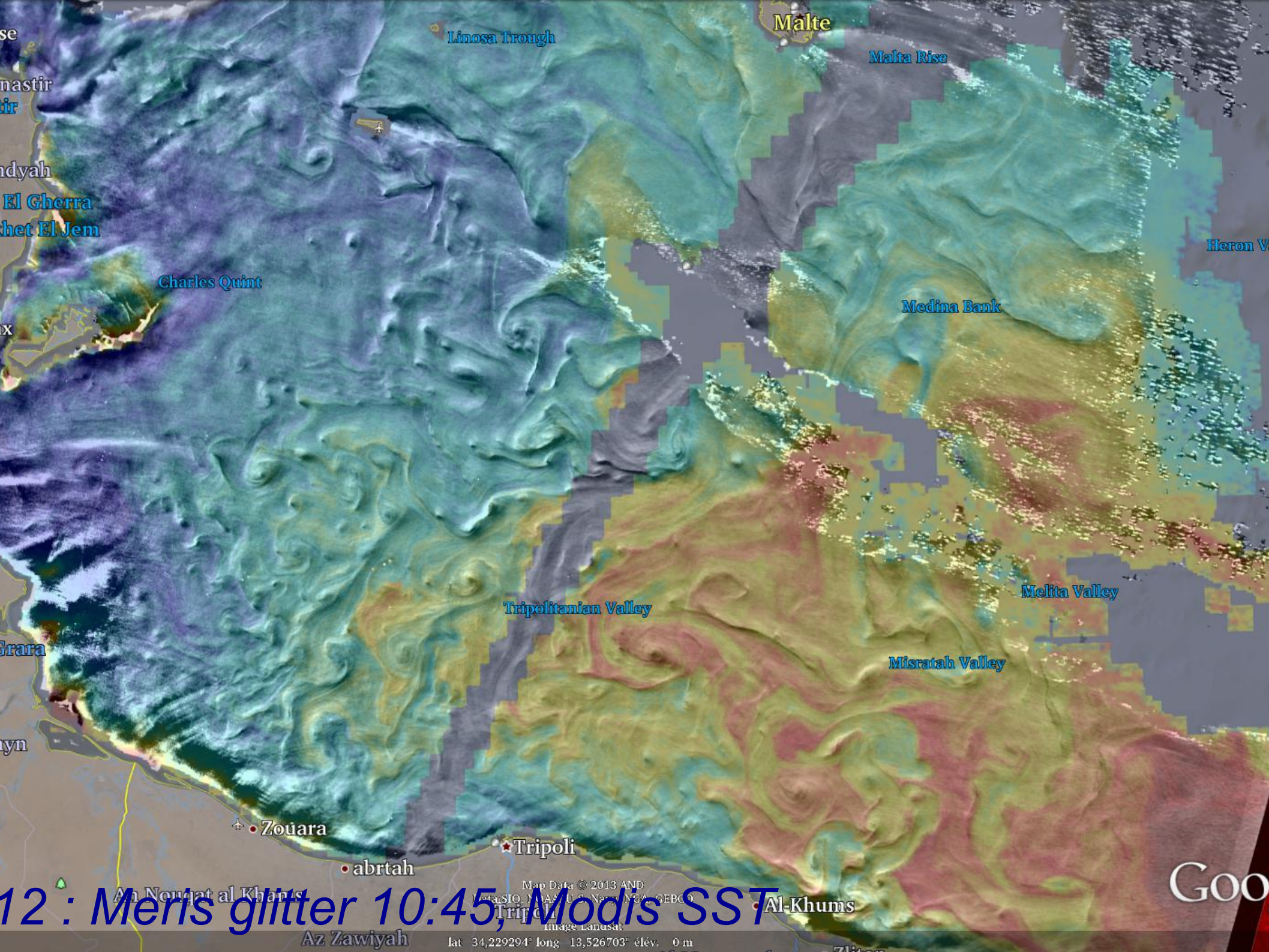
Az Zawiyah

lat 34,229294° long 13,526703° elev. 0 m

GOO

12 : Meris glitter 10:45

Map Data © 2013 AND
IERS, SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat



Linosa Trough

Malte

Malta Rise

Heron V

nastir
tir

ndyah

El Gherra
het El Jem

Charles Quint

Medina Bank

X

Tripolitanian Valley

Melita Valley

Grara

Misratah Valley

ayn

Zouara

Tripoli

abrtah

Al-Khums

GOO

12 : Meris glitter 10:45, Modis SST

An Nougat al Khams

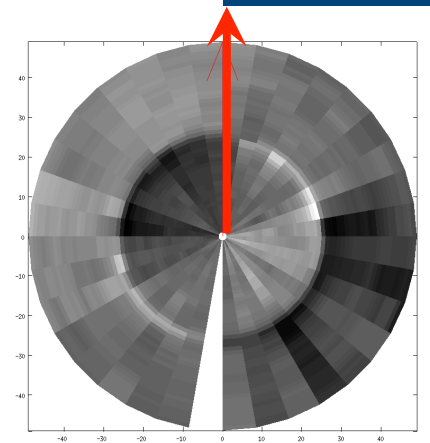
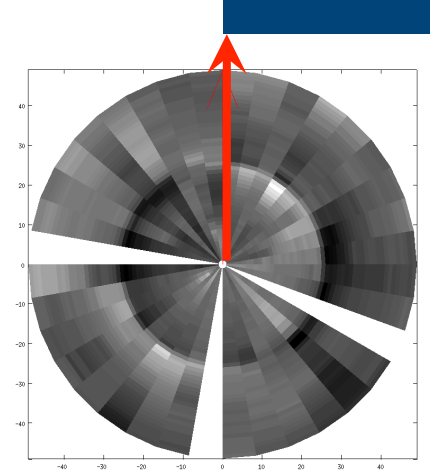
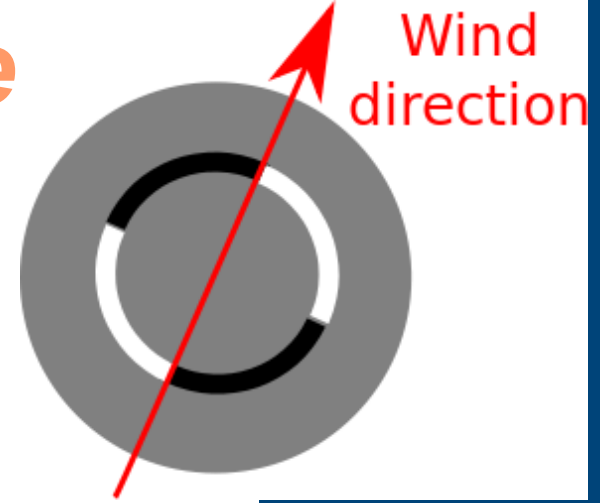
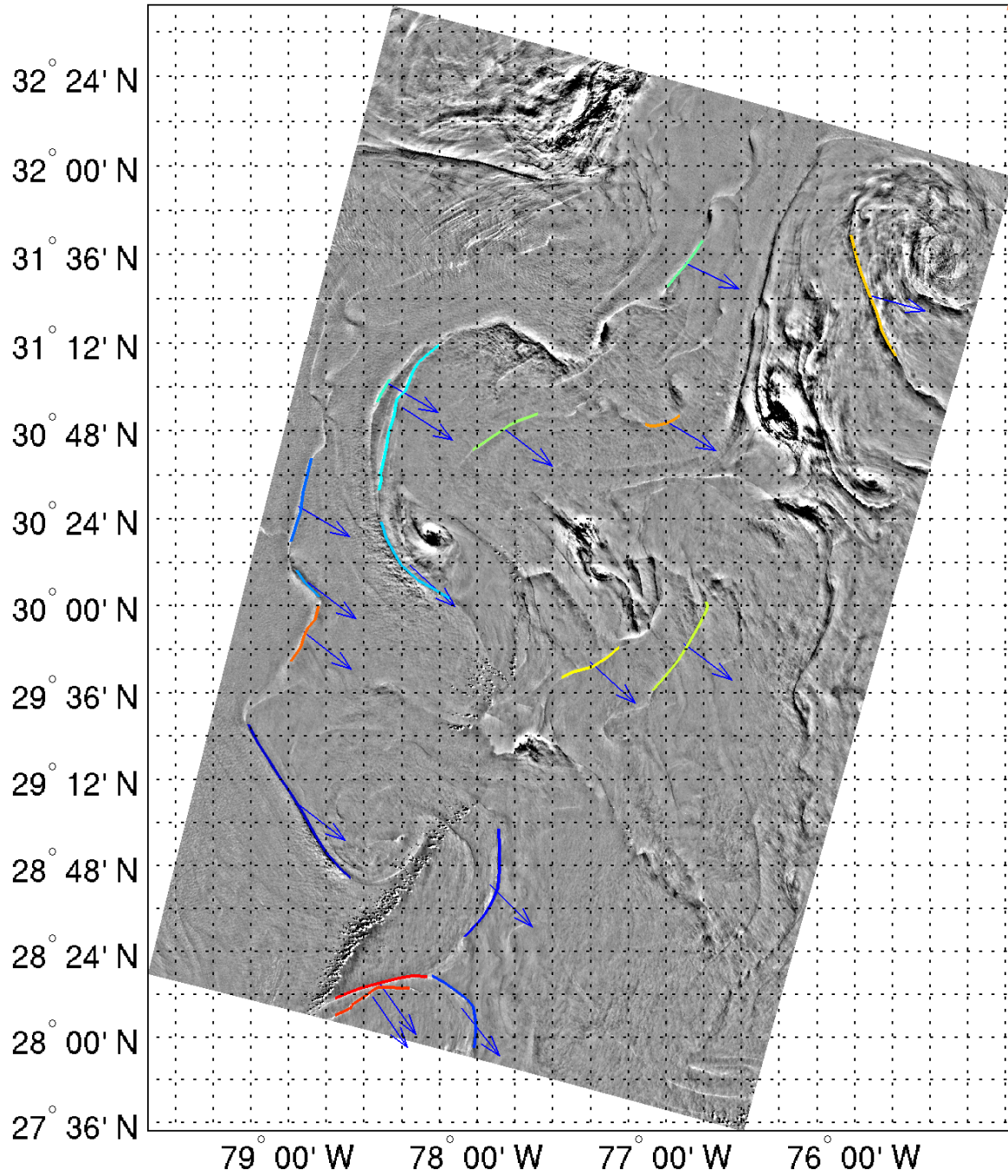
Map Data © 2013 AND
TERASIO, JAPAN U.S. Navy, NOAA, GEBCO
Tripoli
Image Landsat

Az Zawiyah

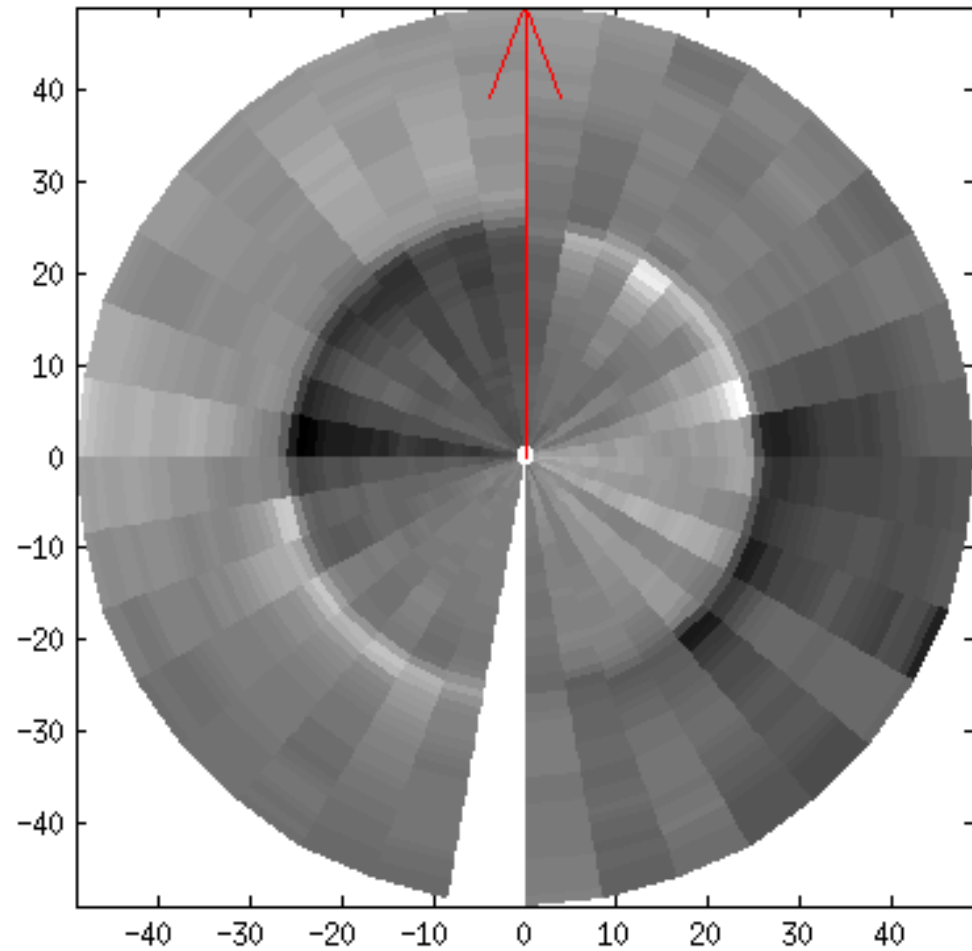
lat 34,229294° long 13,526703° élév. 0 m

Zlitan

MERIS Northern hemisphere



Mean MERIS Northern hemisphere



Conclusion & Perspectives

- Front roughness variation is clearly wind direction dependent (mostly on direction relative to observation azimuth angle)
 - Observed in ASAR surface roughness mostly at low incidence (20 to 30 deg) and wind direction near the azimuth direction.
 - Observed in MERIS derived roughness mostly in wind direction near the range direction. Direction of specular slopes is dependant on local Sun zenith and azimuth.
 - Quantitative analysis in terms of sst gradient strength and associated ageostrophic circulation interaction with Eckman current needs to be checked.
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Thank you

Satellite views available at :
<http://arctic.syntool.org>
<http://oceandatalab.syntool.org>
