La Plata River Plume, challenging waters for atmospheric correction and TSM algorithms

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Objective

• Characterise the dynamics of the La Plata river plume by the analysis of a multi-year archive of satellite maps of turbidity/TSM

Presentation

- Description of the area of study
- MODIS imagery (difficulties and first approach)
- MERIS imagery
- Needs and data availability

La Plata River Basin

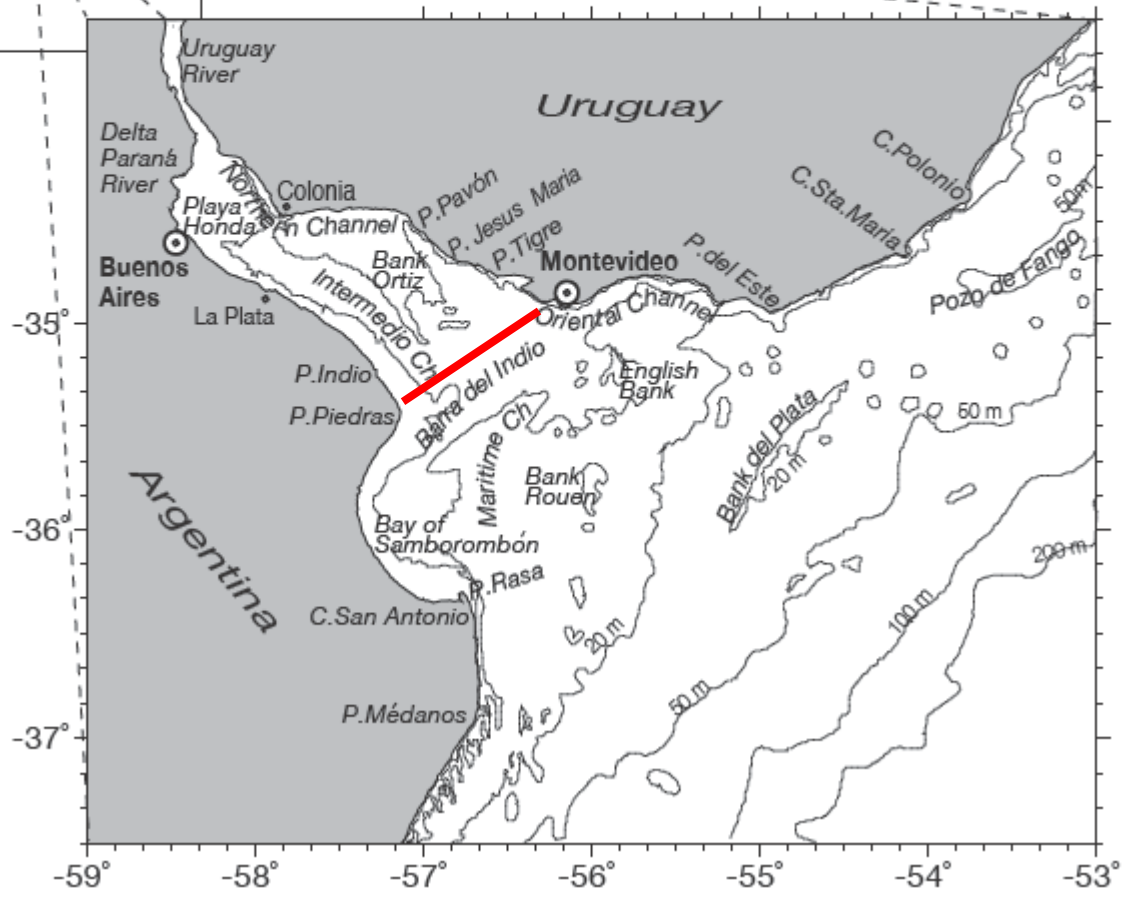
- The La Plata River (35°S) drains the second largest basin of South America
- Area: 3.1 10^6 km^2 (Argentina, Bolivia, Brazil, Paraguay, and Uruguay)
- Average freshwater discharge 23,000 $m^3 s^{-1}$
- Main tributary rivers:
  - Paraná (72.8 10^6 tons yr^{-1})
  - Uruguay (7.0 10^6 tons yr^{-1})

La Plata River estuary

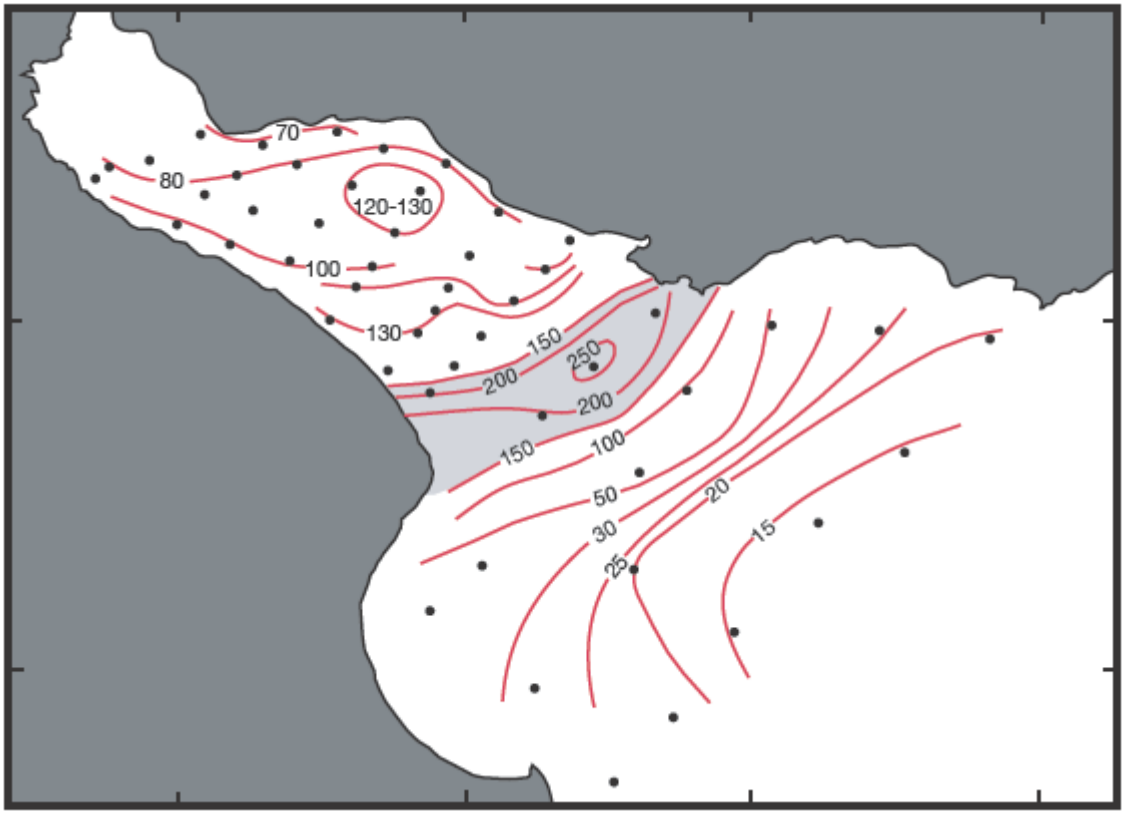
-The estuary (funnel shape) is ~300 km long (40– 220 km width)

- Can be divided into two regions: Upper/Lower, transition zone (maximum turbidity)

- Its position varies (tides, river flow and winds) and its mean location coincides with the Barra del Indio shoal



The turbidity maximum is clearly defined where the river water (100 mg l^{-1} to 300 mg l^{-1}) interacts with the clear shelf water.



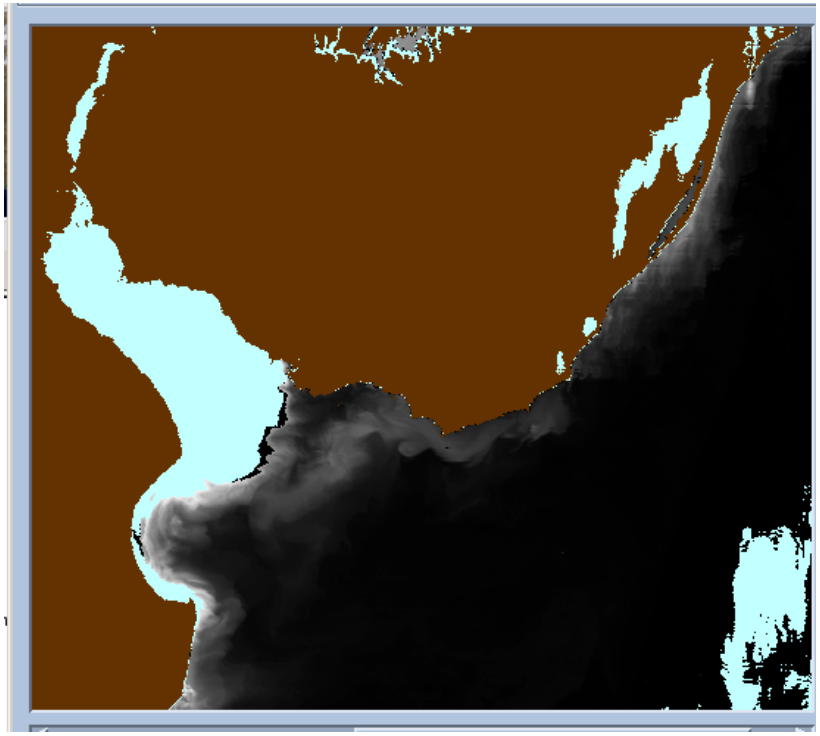
Mean surface suspended sediment concentration (surveys 1981-1987). Taken from Framiñan (1985).

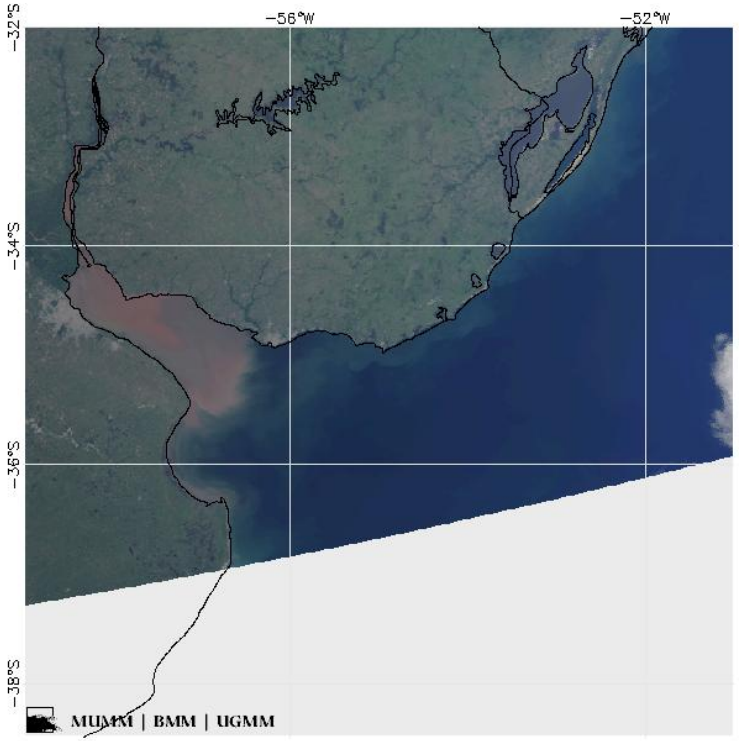
Satellite images from La Plata river

MODIS-Aqua image processing masks the upper and frontal part of the La Plata river plume: HILT and CLOUD.

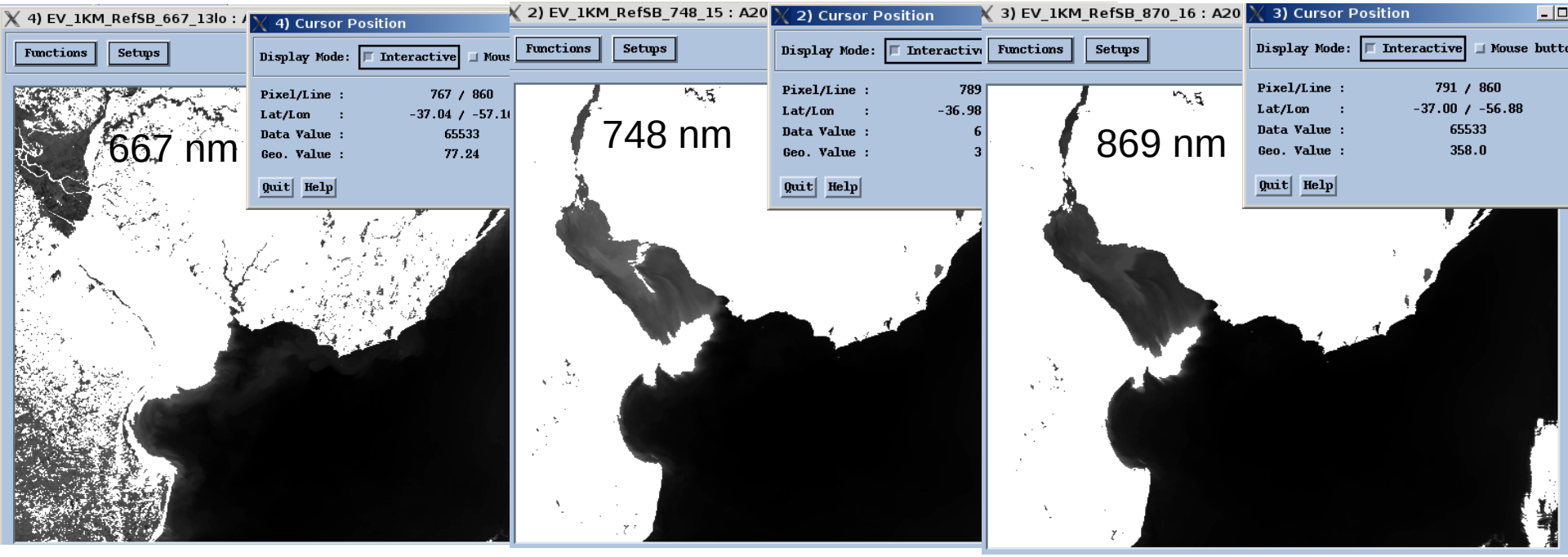
HILT MASK (High Total radiance)

- SeaWiFS: band 6 or 7 are higher than "knee" value in the gain curve (~760counts)
- MODIS: If any of the sensor saturates (~4096 counts)





MODIS L1B (DN*)



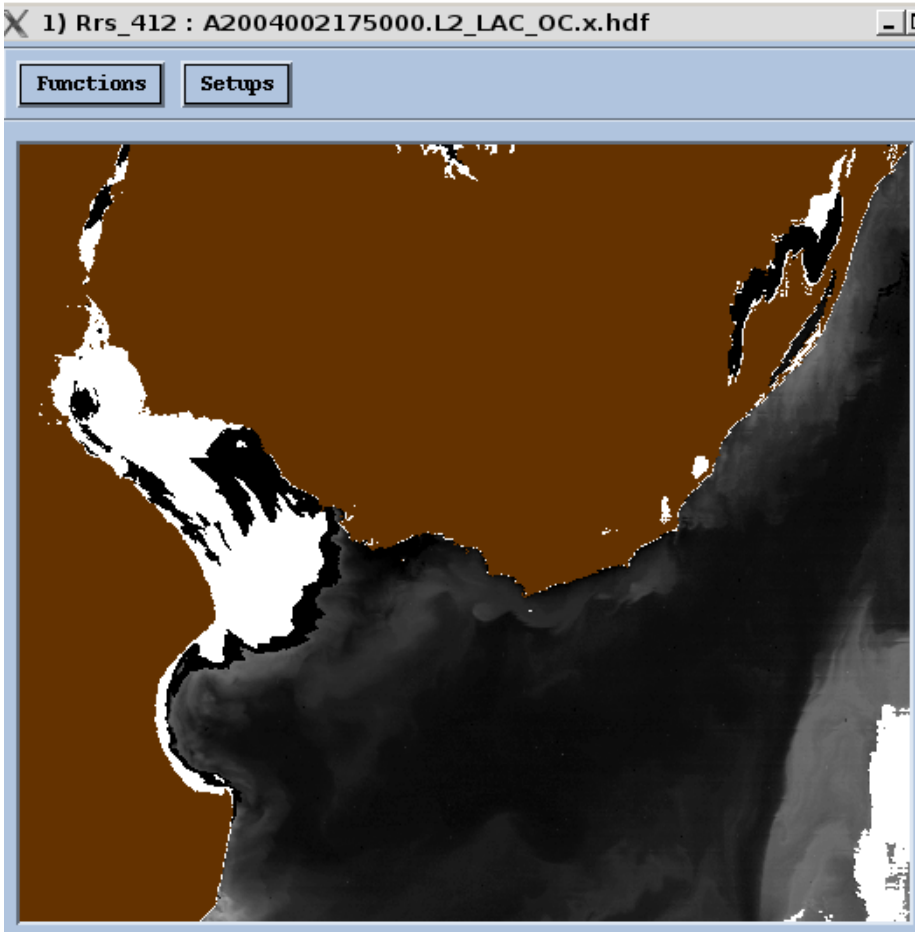
- Problem due to sensor saturation

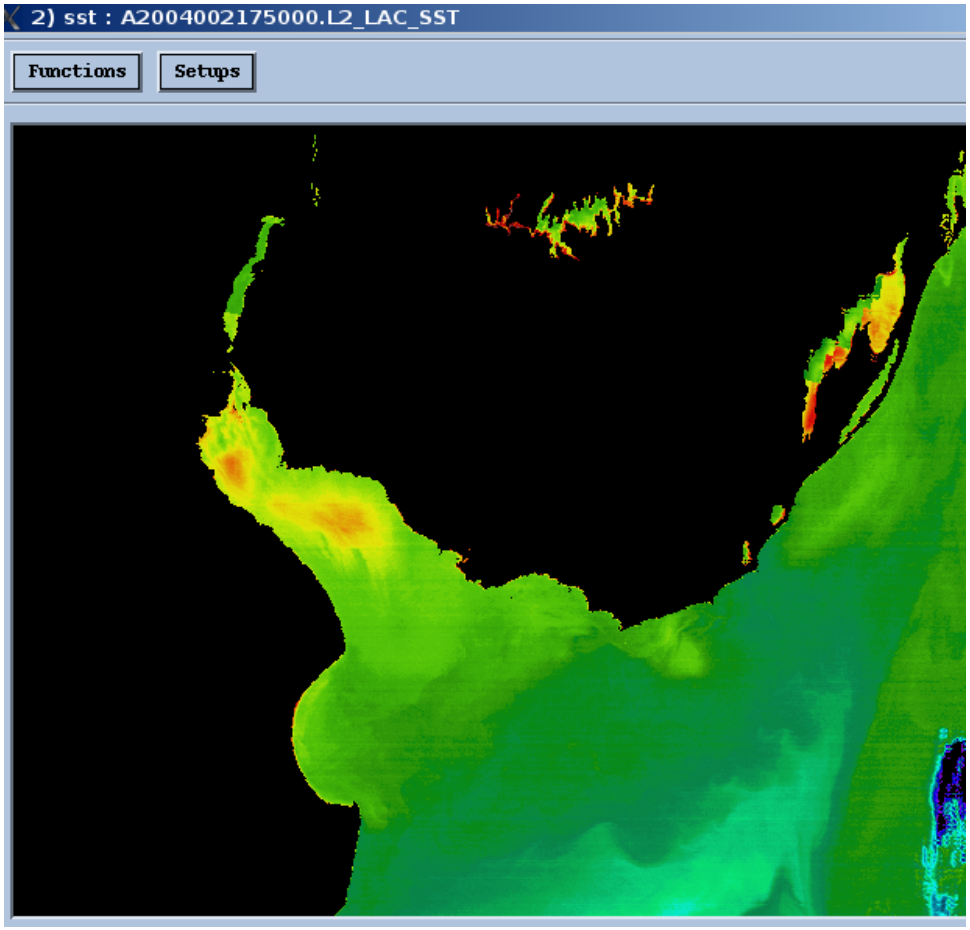
CLOUD MASK

- When $\rho_s(865) > 0.027$ (Rayleigh corrected reflectance)

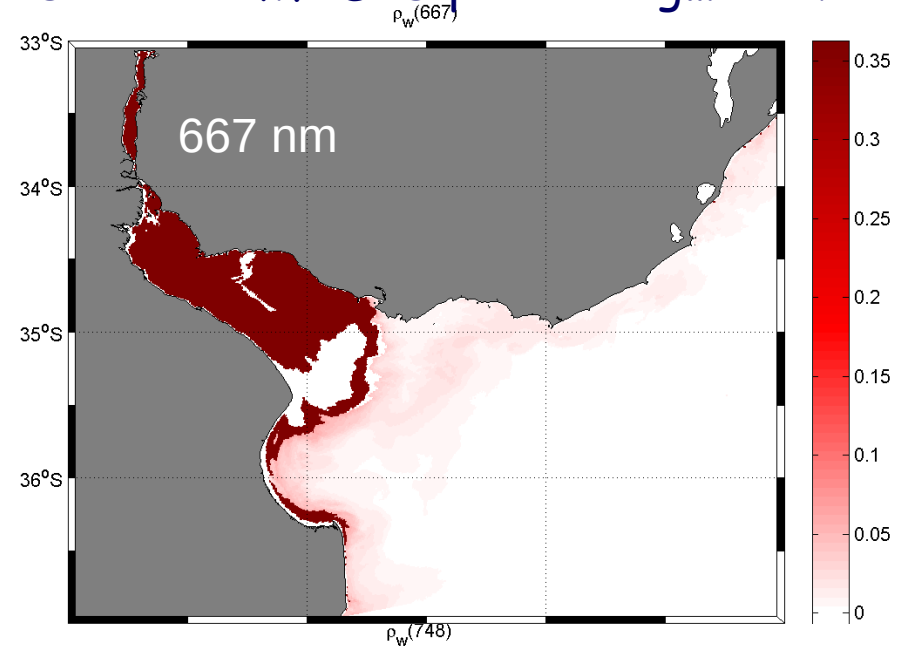
  - Modify the threshold value
  - Use SST and Visible bands

MODIS - SST



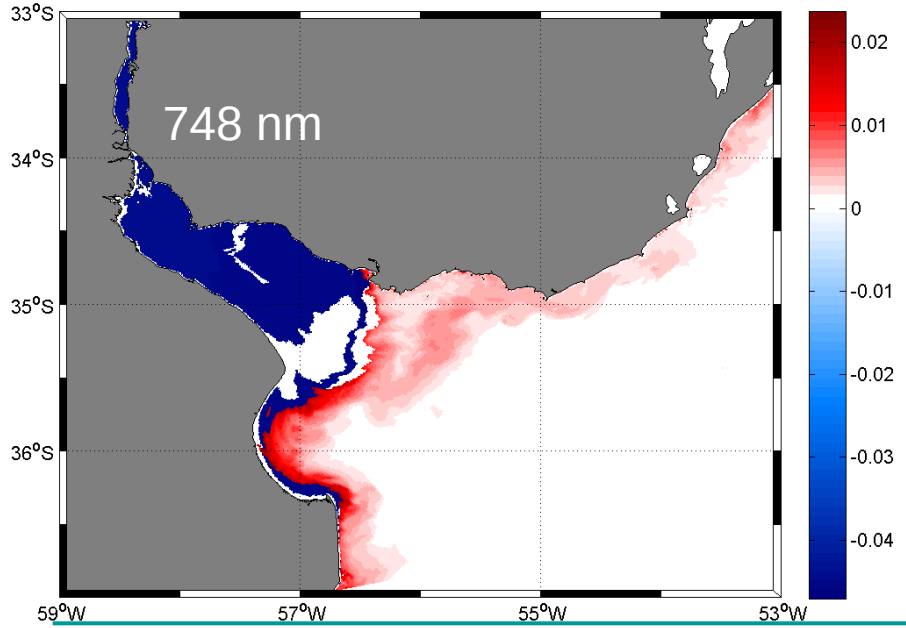


Standard MODIS processing… with only LAND mask set

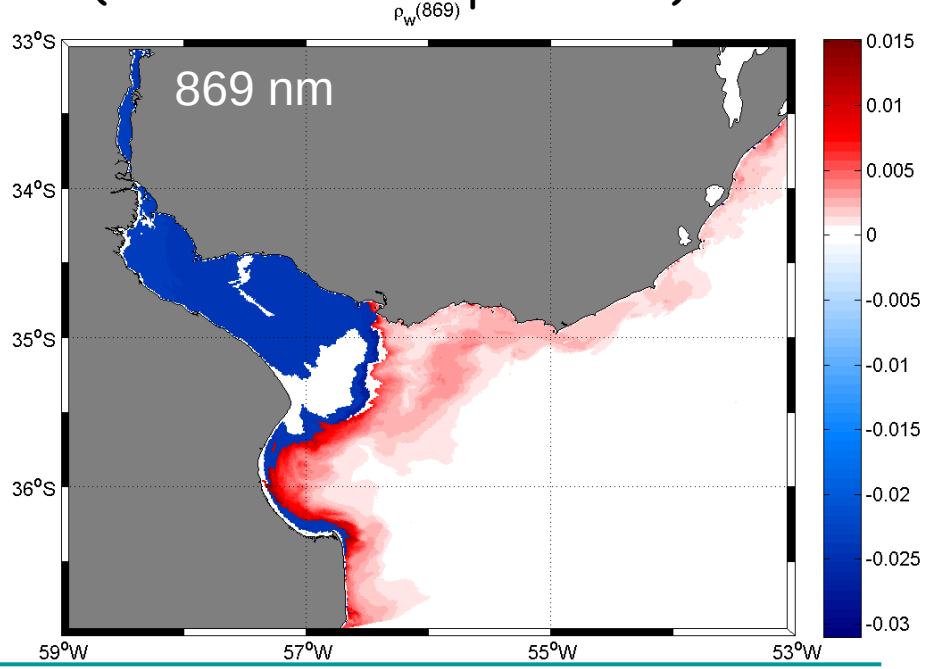


At 667 nm river is masked due to sensor saturation

$$\rho_w(\lambda) = R_{rs}(\lambda) \times \pi$$



At 748 and 869 nm river has negative values (atm. correction problems)



Total Suspended Matter (TSM)

- Single band algorithm (Nechad *et al.* 2010)

The model first relates TSM concentration (S) to the ratio of total backscattering to total absorption ($\omega'_b=b_b/a$). Assumptions and approximations are made and

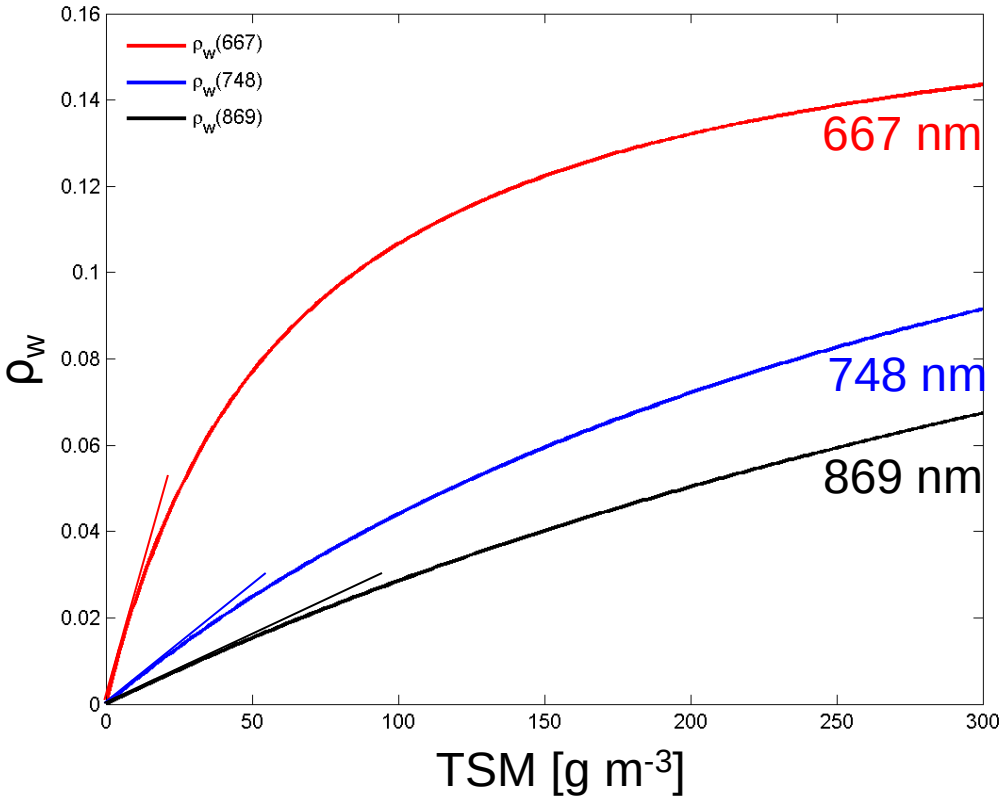
$$S = A\frac{\omega'_b}{1-\omega'_b/C}[gm^{-3}] \qquad A = \frac{a_{np}}{b^*_{bp}}[gm^{-3}] \qquad C = \frac{b^*_{bp}}{a^*_p}$$

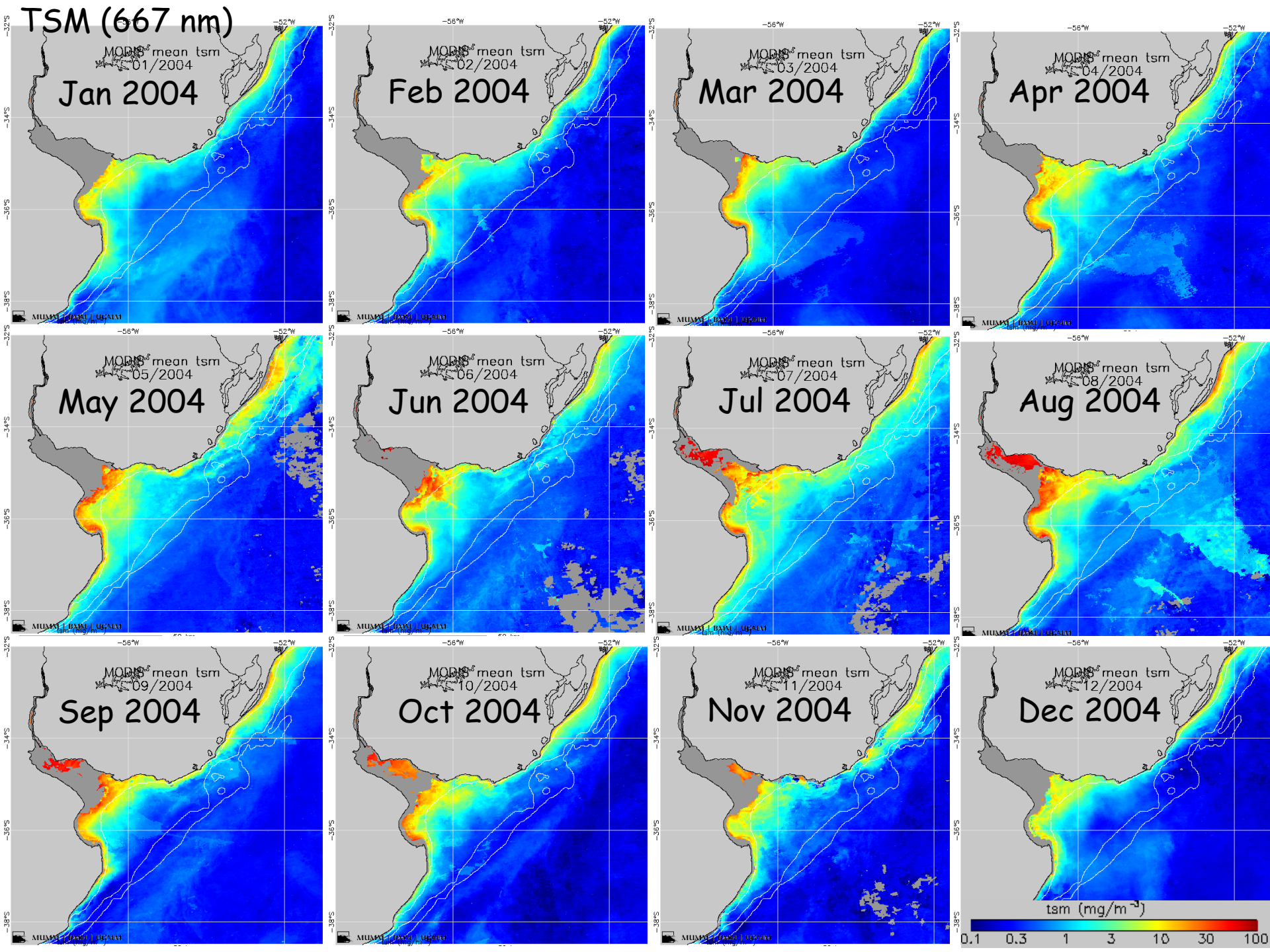
then using a simplified reflectance model (Gordon *et al.* 1988), S is related to ρ_w

$$S = A^\rho \frac{\rho_w}{1-\rho_w/C^\rho}$$

C^ρ and A^ρ were calibrated and validated using "standard" IOP and seaborne reflectance measurements, respectively.

$$\rho_w = \frac{S}{(A^\rho + S/C^\rho)}$$

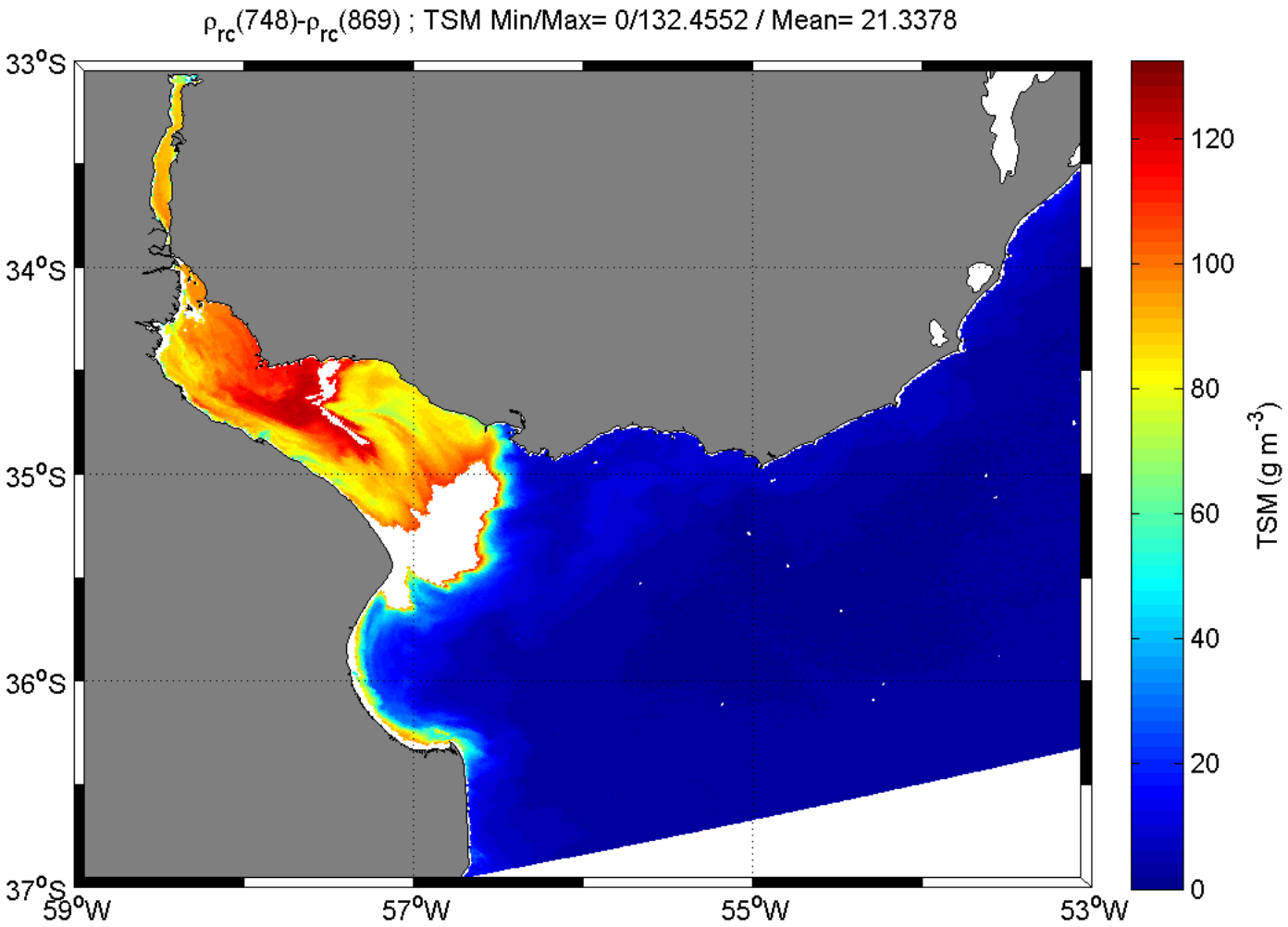



TSM (667 nm)
MODIS mean tsm 01/2004
Jan 2004
MODIS mean tsm 02/2004
Feb 2004
MODIS mean tsm 03/2004
Mar 2004
MODIS mean tsm 04/2004
Apr 2004
MODIS mean tsm 05/2004
May 2004
MODIS mean tsm 06/2004
Jun 2004
MODIS mean tsm 07/2004
Jul 2004
MODIS mean tsm 08/2004
Aug 2004
MODIS mean tsm 09/2004
Sep 2004
MODIS mean tsm 10/2004
Oct 2004
MODIS mean tsm 11/2004
Nov 2004
MODIS mean tsm 12/2004
Dec 2004
tsm (mg/m-3)
0.1 0.3 1 3 10 30 100

Another approach…

- Rayleigh corrected reflectance band difference (assuming white aerosols)
- Δρ expressed as a linear function of S (assuming low reflectance region, $C^{\rho} \rightarrow \infty$)

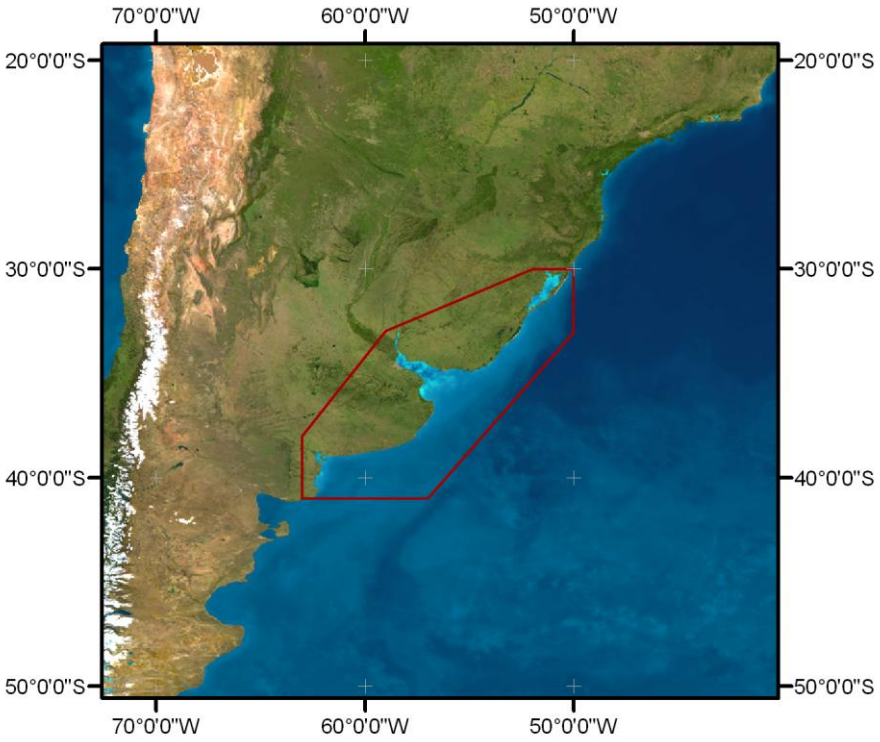
$$S = \Delta\rho_w (A_7^{\rho} \cdot A_8^{\rho}) \cdot (A_8^{\rho} - A_7^{\rho})^{-1}$$



Future steps…

- Apply the complete model (not assuming TSM in the linear range)
- Use SWIR bands and OLCi 1020 nm band

CoastColour Champion User Test Site #27: Rio La Plata



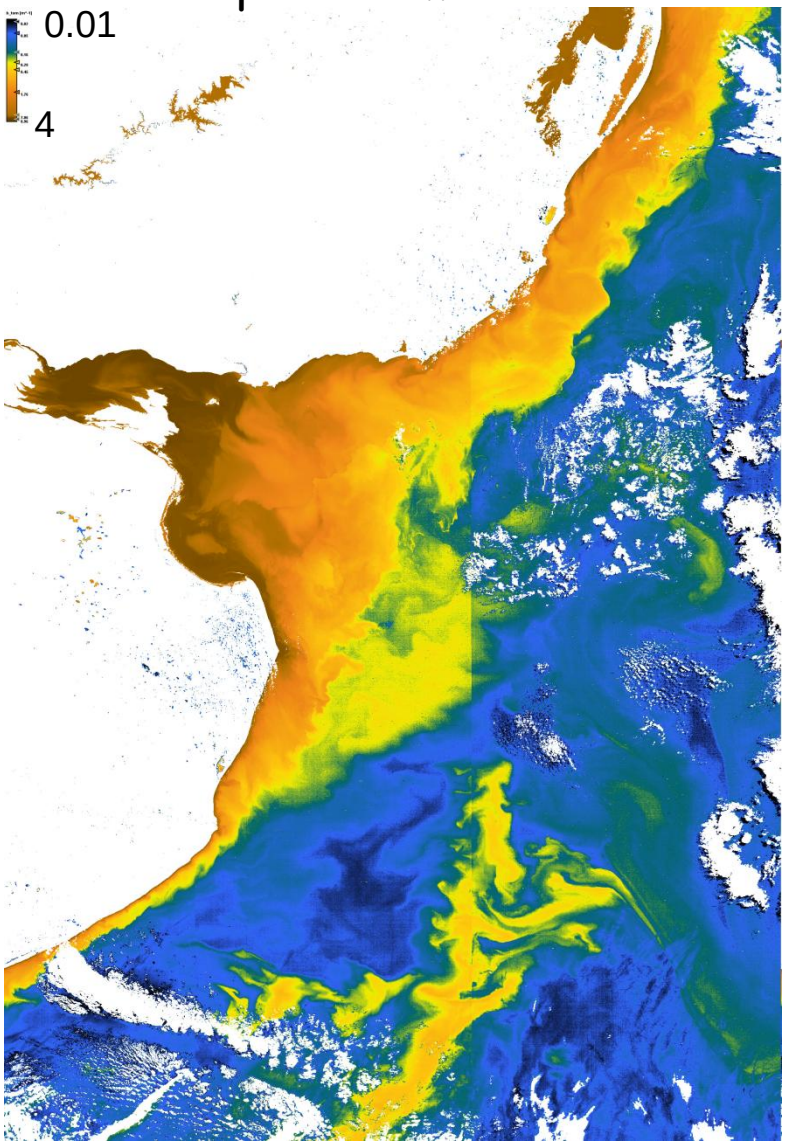
Standard products:

* Surface reflectances
* Inherent optical properties
* Water constituent concentrations
* Water transparency/turbidity information
* Chlorophyll Indices

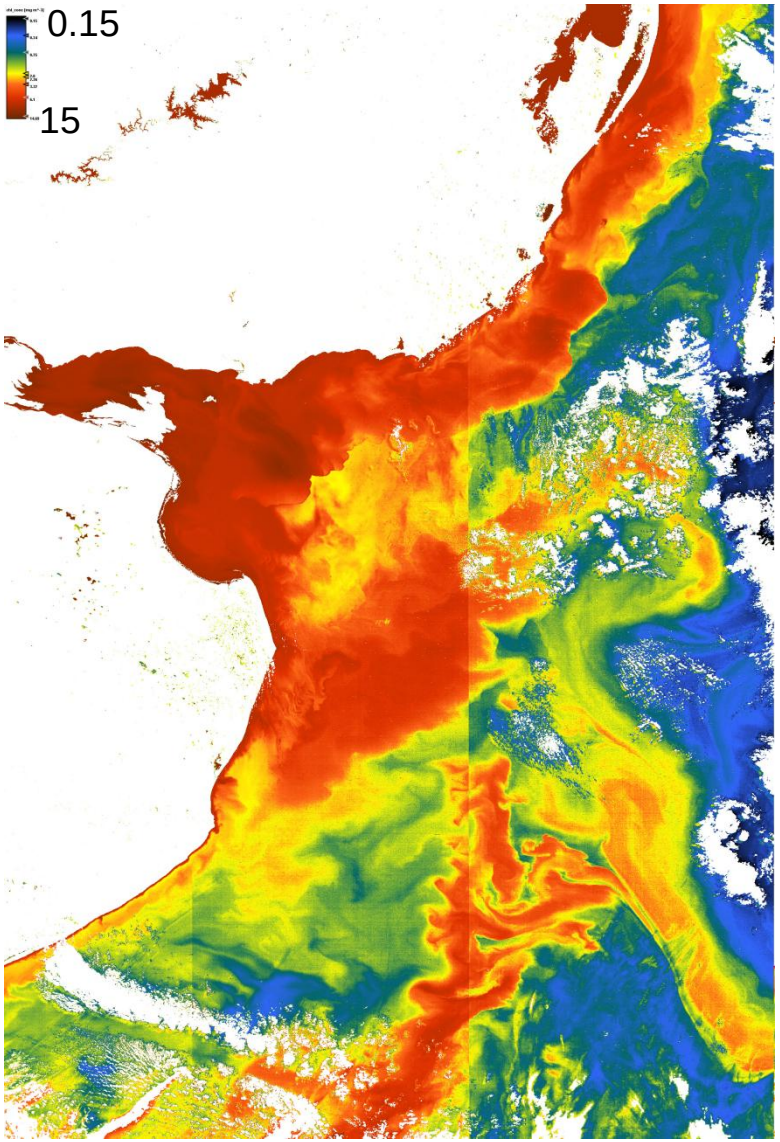
Sample products from MERIS (CC): 16 March 2008 (Orbit: 31598)

Quasi-True Colour

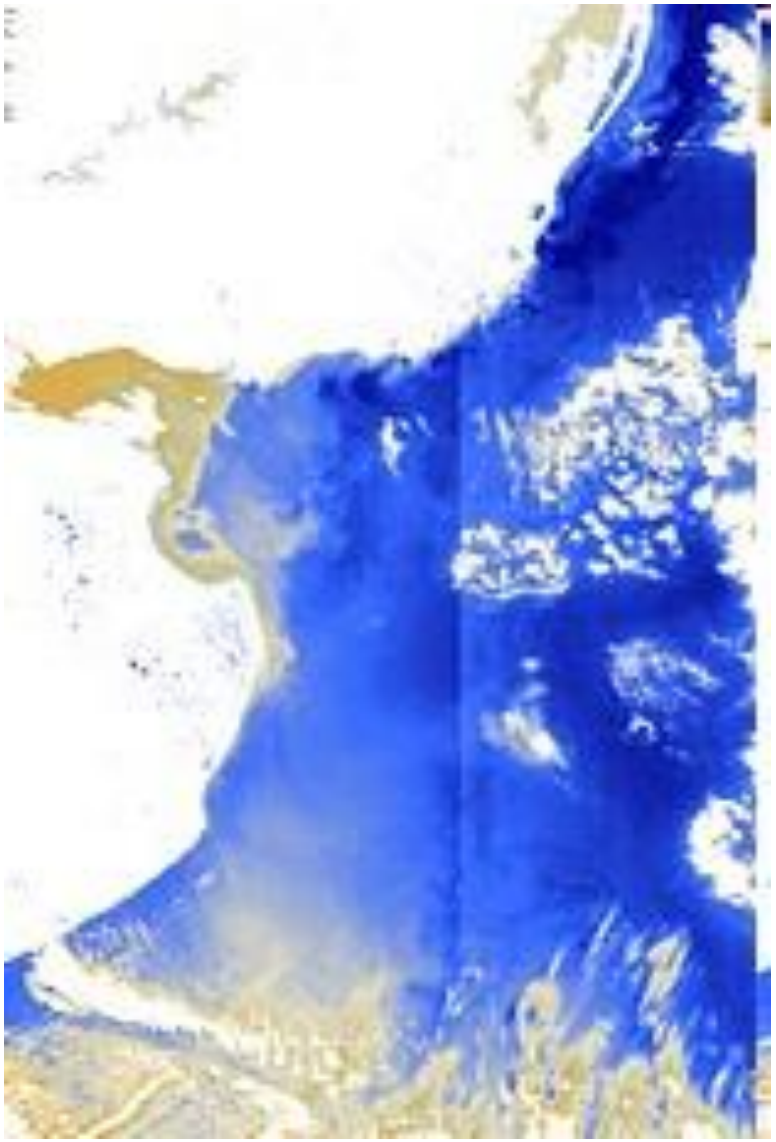
Backscatter coefficient of suspended matter



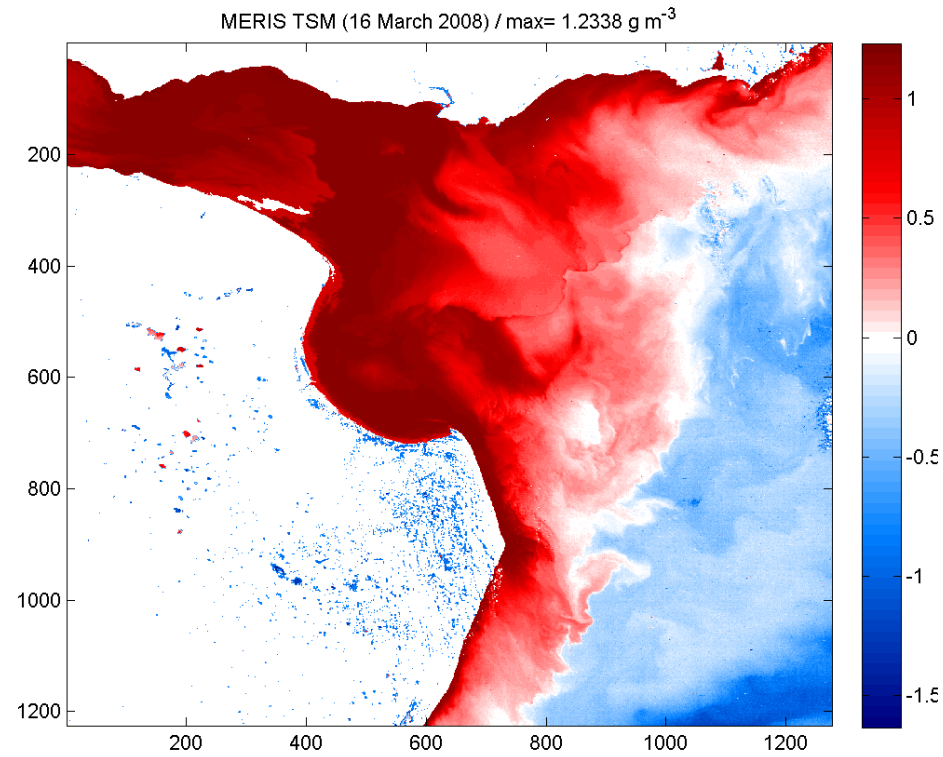
Chlorophyll concentration



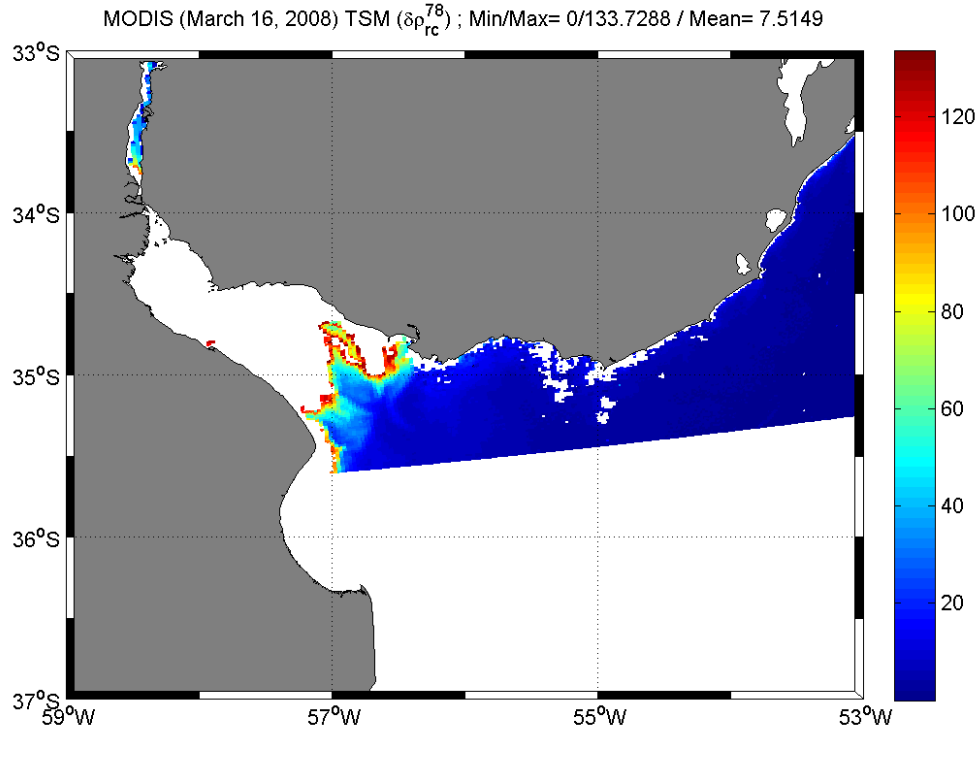
Aerosol Optical thickness at 555 nm



MERIS FR TSM product



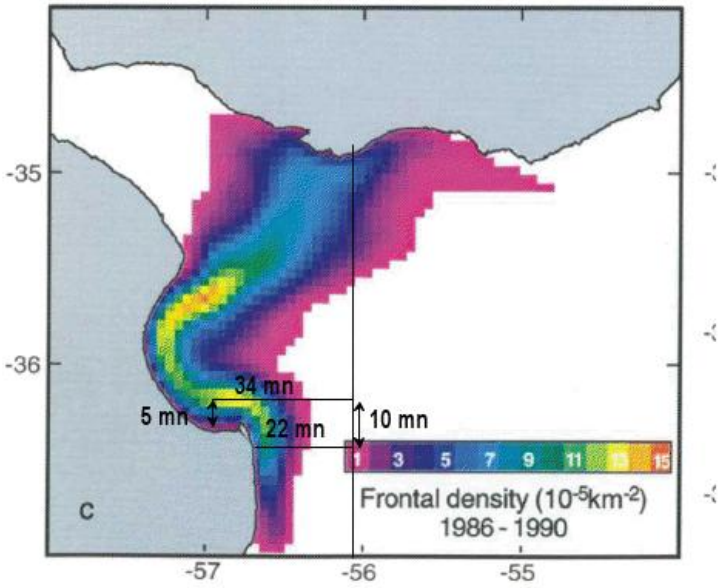
MODIS (1 km) TSM



- Improvement in TSM product in this region (out-of-the-scope)
- Can TSM be estimated in both high (inner part) and low (external) TSM concentrations?
- Does MERIS bands saturates over La Plata turbid waters?
- TOA reflectances
- Atmospheric corrected reflectance (errors)

In situ data

- Monthly one-day cruise (2 transects, 5 stations each) in the southern part of Samborombón bay (TSM).



- Data taken within FREPLATA Project (Argentina/Uruguay/France)

  Objective: to develop an hydrological and sedimentological model of La Plata river.

  - Permission has been requested

Thank you!