Sea level response to pressure and wind forcing in a shallow estuary: Validation of two barotropic models with tide gauge and altimetry data

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INTRODUCTION

Study Area: Rio de la Plata

The Río de la Plata is the estuary formed by the confluence of the Uruguay River and the Paraná River on the border between Argentina and Uruguay.

-Very populated region (Buenos Aires, Montevideo, + than 30million people)

-Ecologically important: home of a large biodiversity

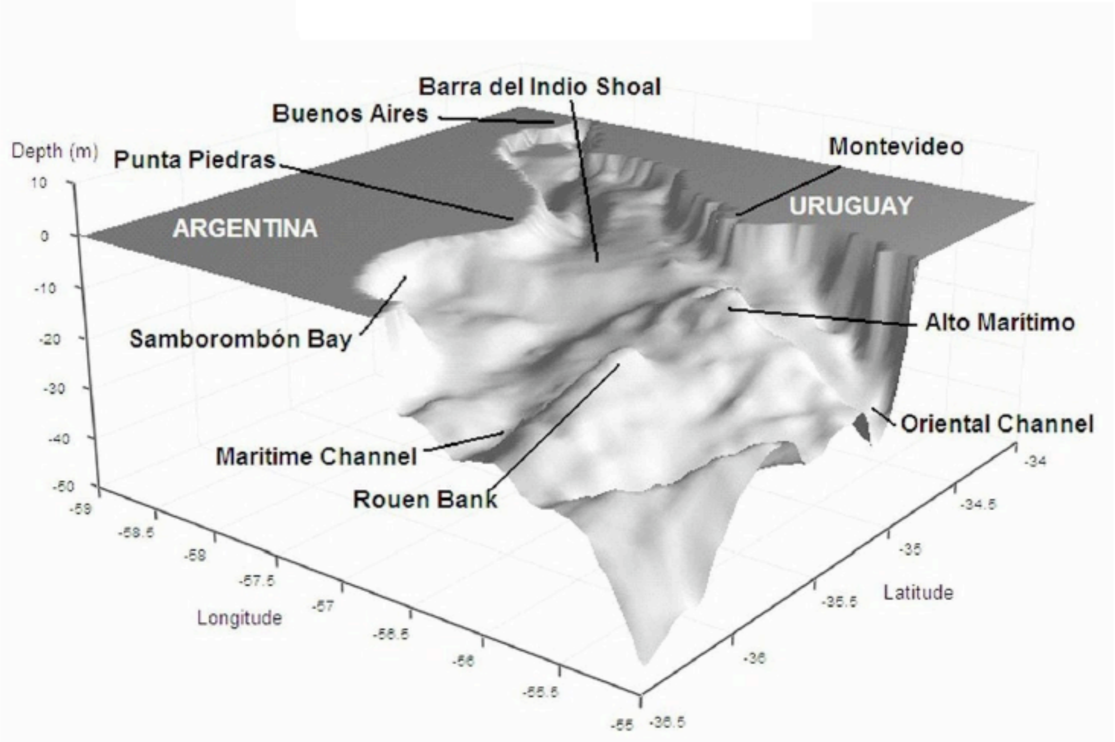
- One of the widest estuaries of the world: 220km (290km long)

-The Río de la Plata behaves as an estuary in which freshwater and seawater mix

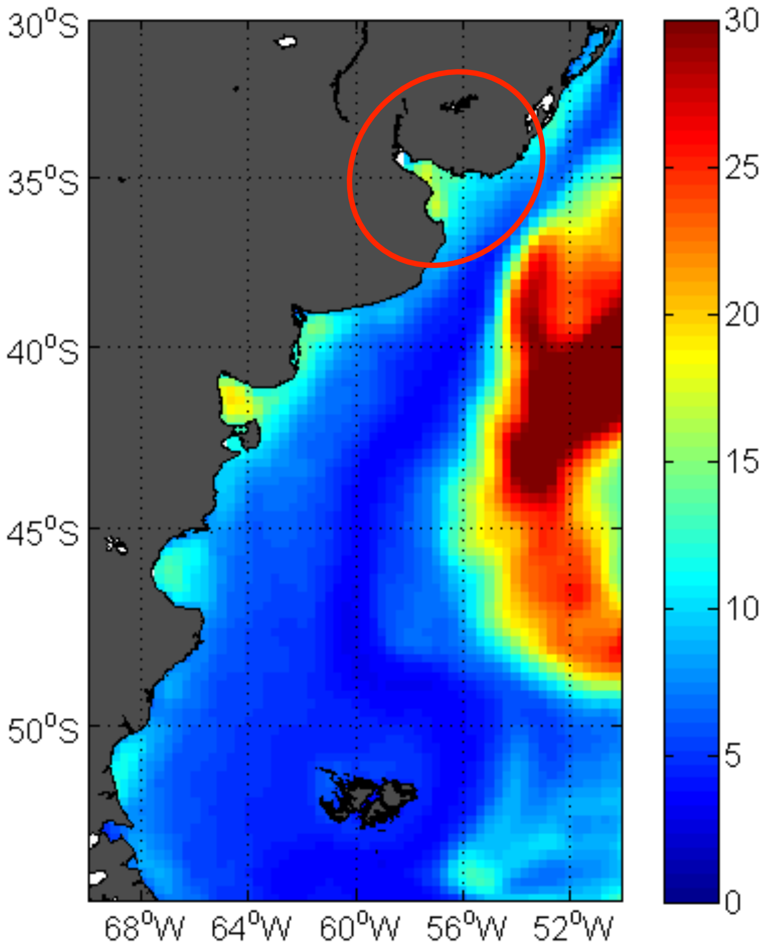
-Very shallow: upper part between 1 to 5m depth.

Study Area: La Plata basin

The waters of the Rio de la Plata are divided into an inner freshwater riverine area and an outer brackish estuarine area by the turbidity front which corresponds to a submerged shoal "Barra del Indio".



The region is characterized by the large variability discharge of the Rio de la Plata (mean 22.000 m^3/s, but ranges 8.000 80.000 m^3/s), important storm surge events and upwelling events.

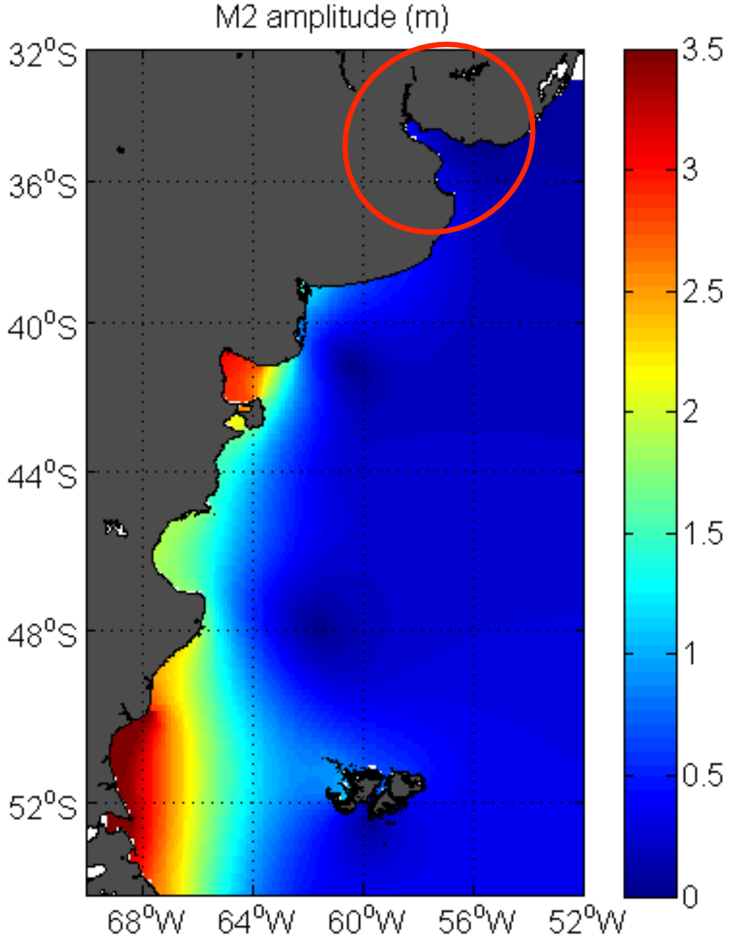


RMS (cm) of gridded SSH

Can we use satellite SSH in the region to study spatio-temporal variability?

Are altimetry corrections good enough?

RMS Brazil-Malvinas Confluence: up to 40cm.
RMS RdP: ~18cm. quite large. Real? Due to a physical process or is just bias because of not-so good corrections applied to the altimetry data?



Tide

In the Rio de la Plata and adjacent continental shelf region, tidal models, such as Fes2004 and GOT4.7, show good agreement with independent observations (Saraceno et al., CSR 2010).

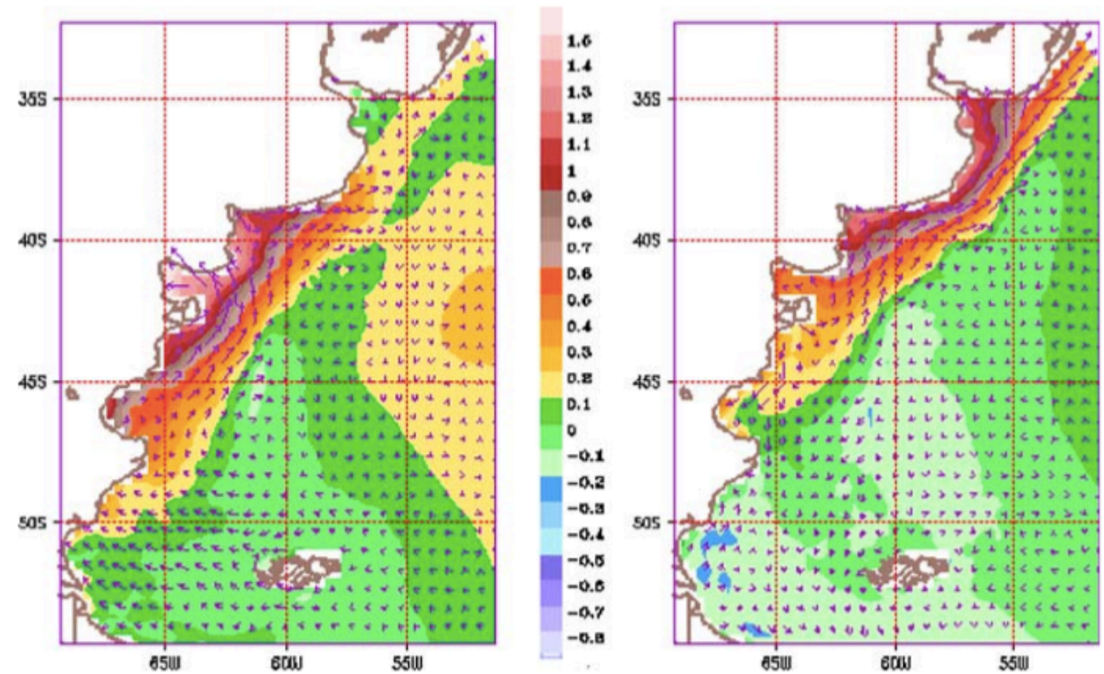
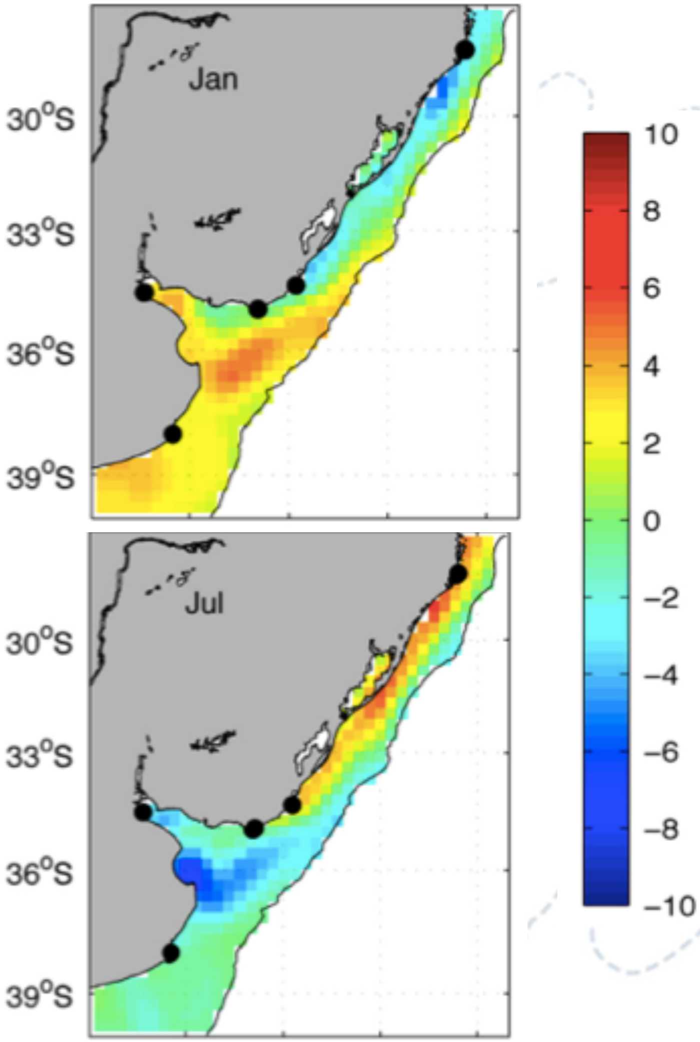


Fig. 7 Two snapshots of a typical winter storm surge due to a deepening large-scale low in SWS Atlantic from July 26 to 28, 2007; the storm surge level is in colors (m) and the total (tide and surge) currents are plotted. The cyclone moves off-shore between 46° S and 42° S (not shown), while the surge extends along the coast, propagating northward

Etala et al. 2009

<u>DAC</u>

Atmospheric correction is crucial in this region: shallow bathymetry, complex coastline, coastal trapped waves propagation from the south contribute to amplify the SSH response to this correction term.



SLA climatology (cm)

At seasonal scales, the sea level anomaly variability is well represented by altimetry (Saraceno, et al., 2014 CSR; Ruiz-Etcheverry et al., 2014 accepted CSR)

But what about shorter scales?

This work:

- Focus on evaluate atmospheric correction:
  - Regional models (Hamsom, SMARA)
  - Global model (Mog2D)
- Spatial analysis of the SSH due to atmospheric forcing

DATA

DAC models:

Global

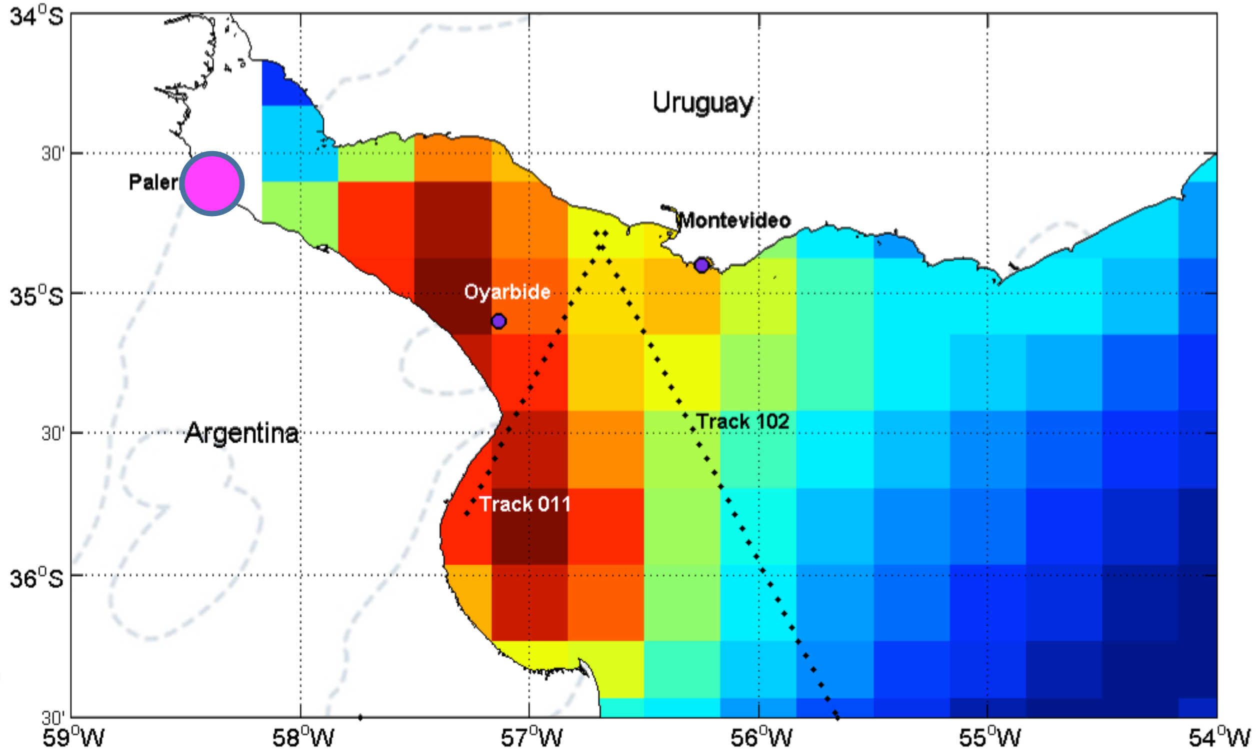
- DAC (AVISO): Mog2D (Carrère and Lyard 2003) + IB (>20days) period 1/1/1993-31/12/2012, 6-hourly, 1/4x1/4, forced by ECMWF.

Regional

- Hamsom (validated by Simionato et al. 2006): period 1/1/1993-31/12/2004, 6-hourly, 3kmx3km, forced by NCEP.
- SMARA (validated by Etala et al. 2009): period 1/1/2007-29/2/2012, 3-hourly, 1/20x1/20 forced by NCEP.

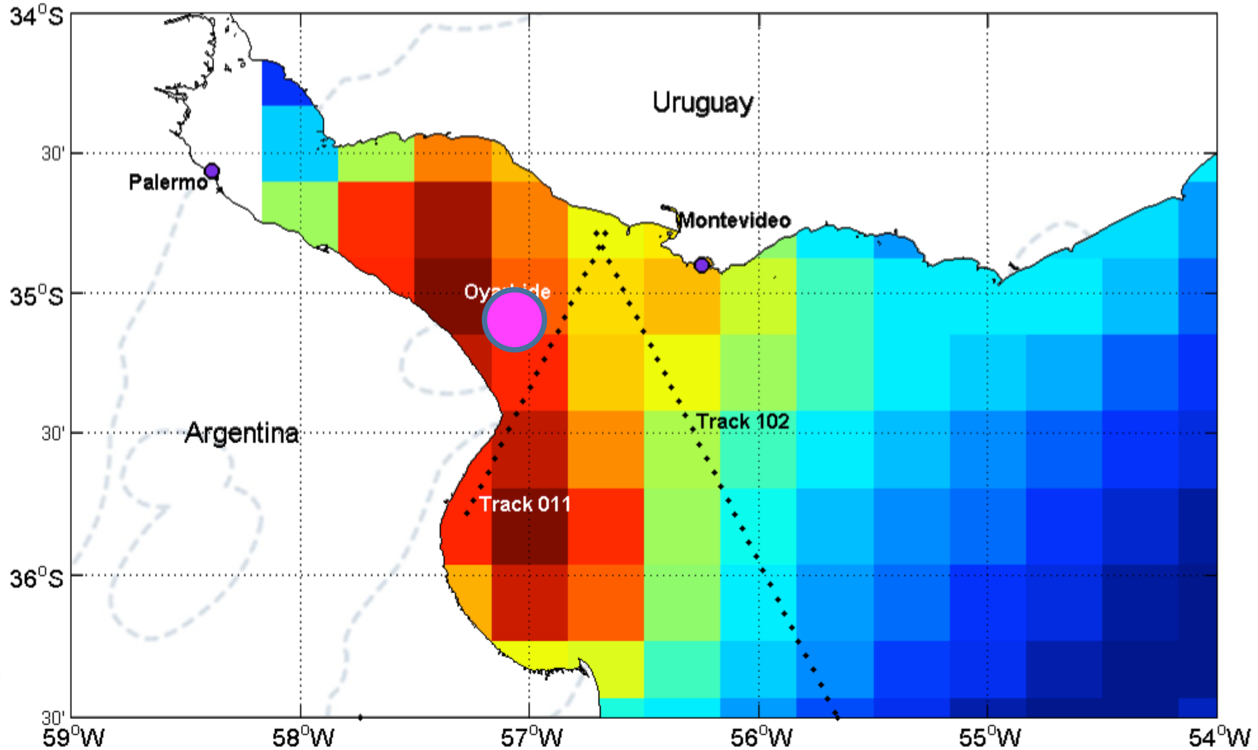
In situ data:

- **TG Palermo (SHN): hourly time serie, period 1/1/1965-31/12/2012**



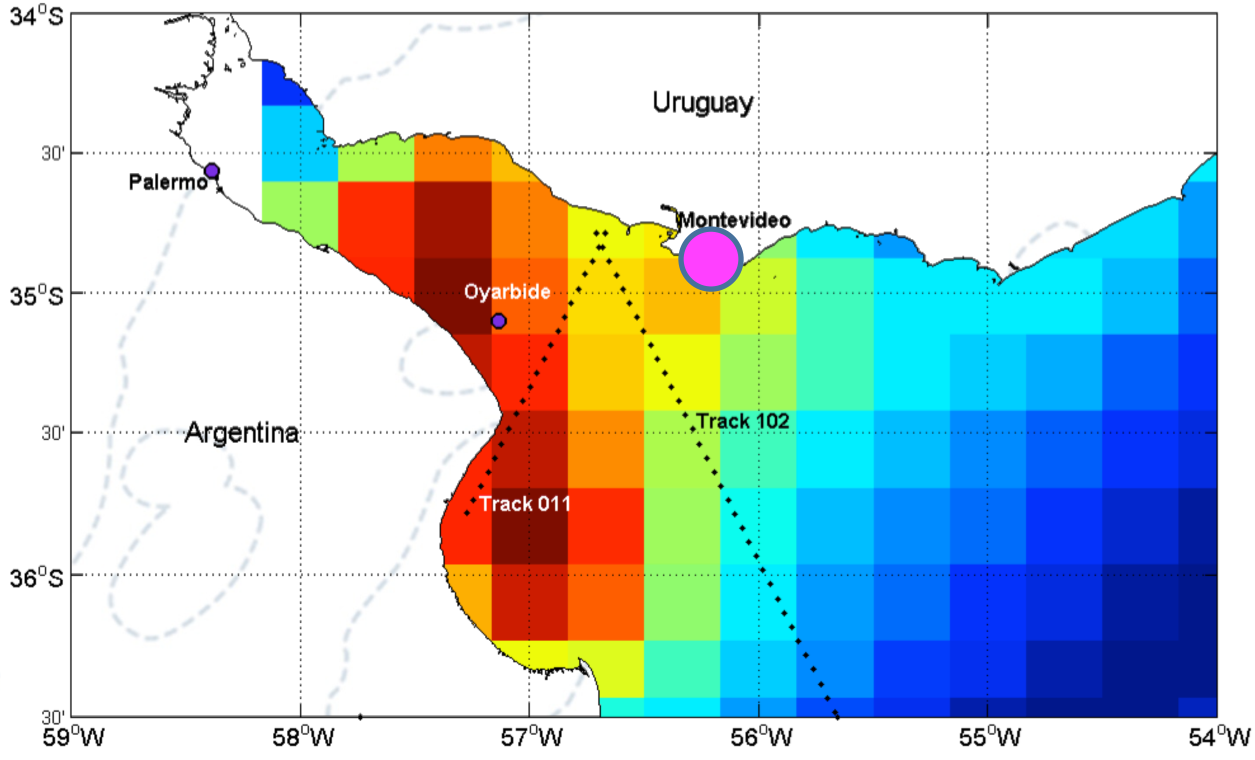
In situ data:

- TG Buenos Aires (SHN): hourly time serie, period 1/1/1965-31/12/2012
- **TG Oyarbide (SHN): hourly time series, period 1994-2008**



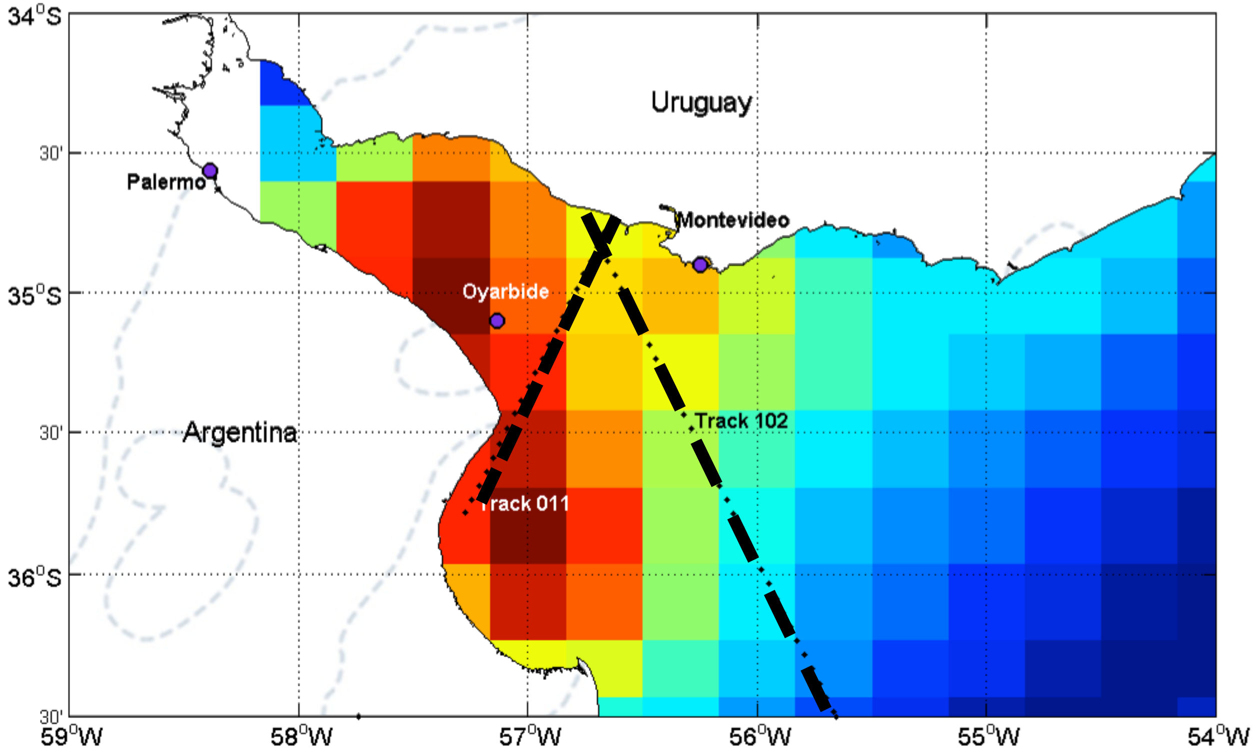
In situ data:

- TG Buenos Aires (SHN): hourly time serie, period 1/1/1965-31/12/2012
- TG Oyarbide (SHN): hourly time series, period 1994-2008
- **TG Montevideo (PSMSL): monthly time series, period 1993-2004**



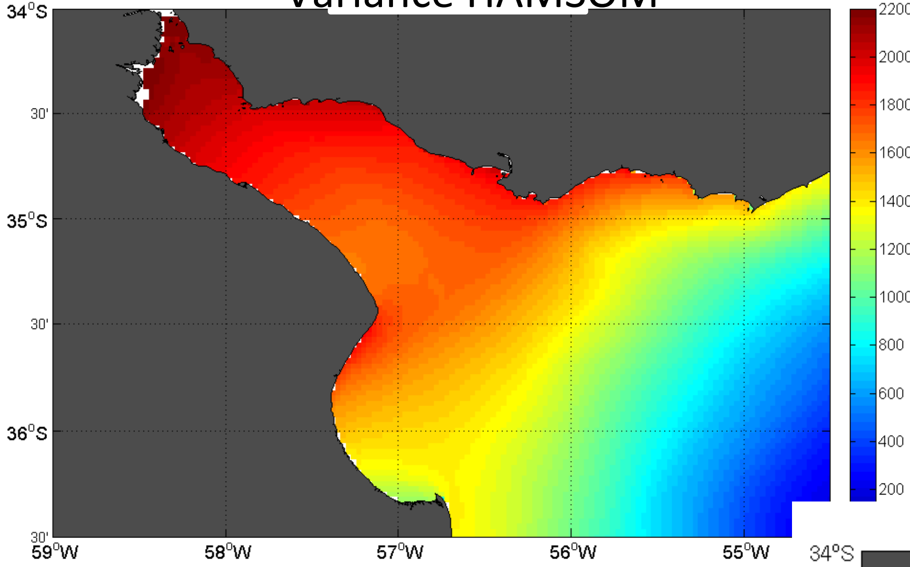
Satellite data:

- **Jason 1 along track from RADS.**
- **Jason 1+2+TP along track from CTOH.**



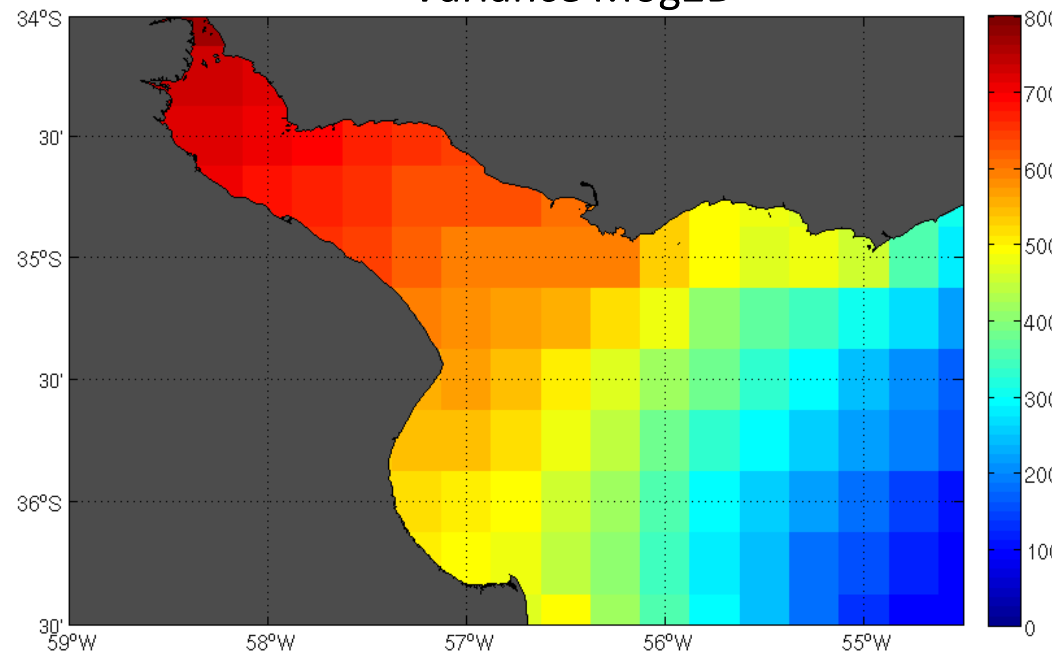
RESULTS

Variance HAMSOM

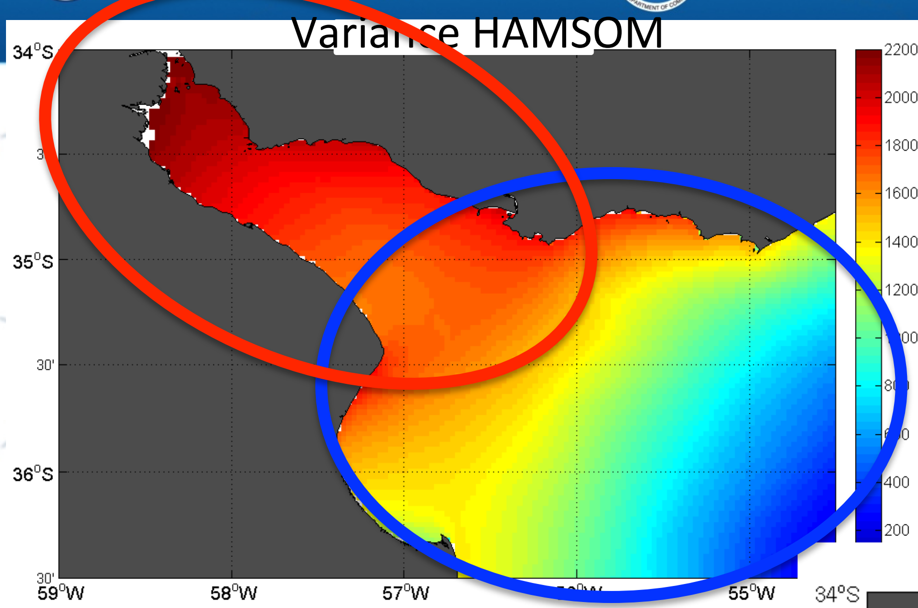


Variance of the sea level (cm^2) due to pressure and wind forcing simulated by Hamsom

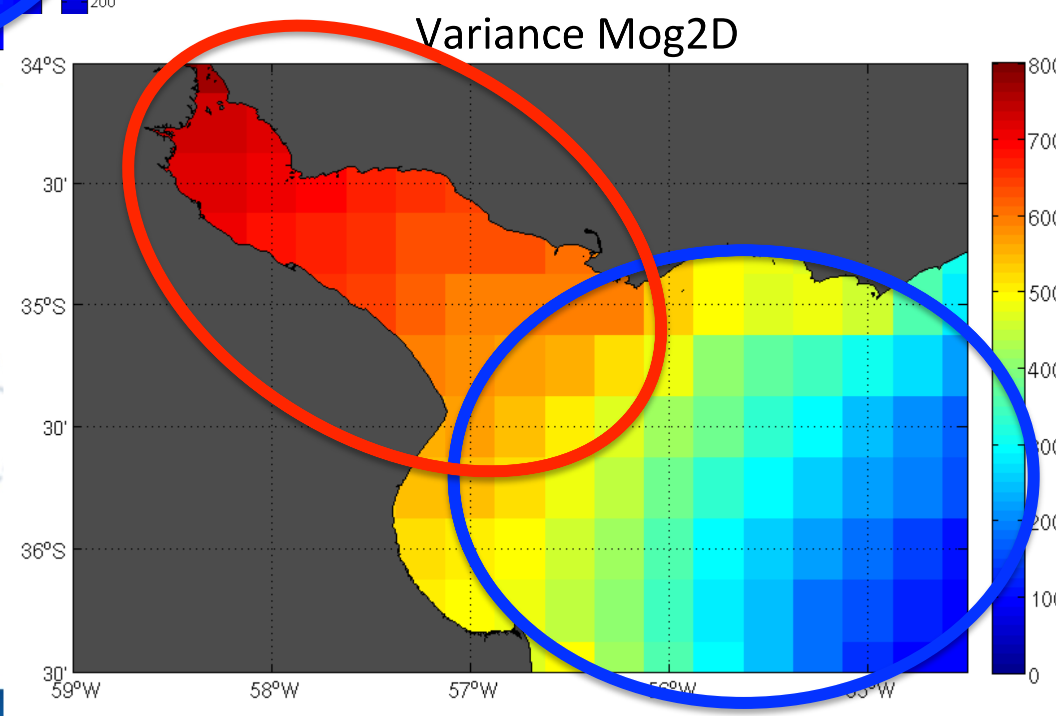
Variance Mog2D



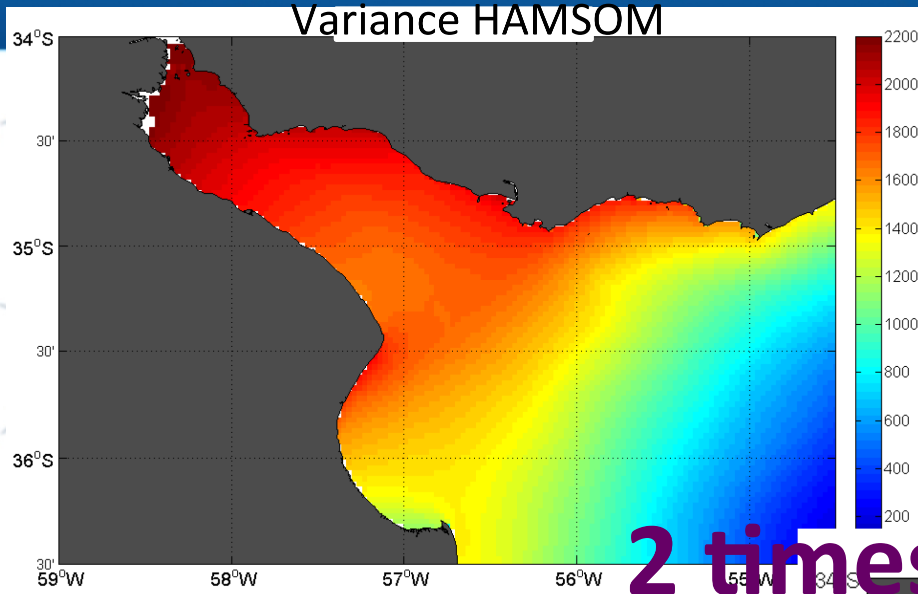
Variance of the sea level (cm^2) due to pressure and wind forcing simulated by Mog2D



Variance of the sea level (cm²) due to pressure and wind forcing simulated by Hamsom

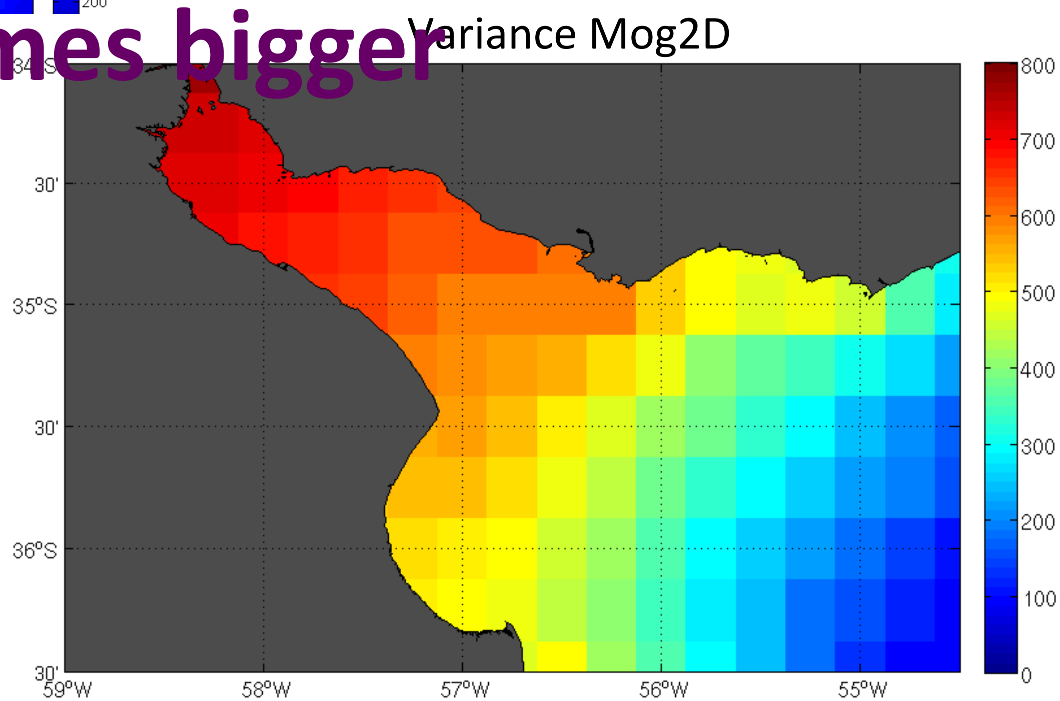


Variance of the sea level (cm²) due to pressure and wind forcing simulated by Mog2D

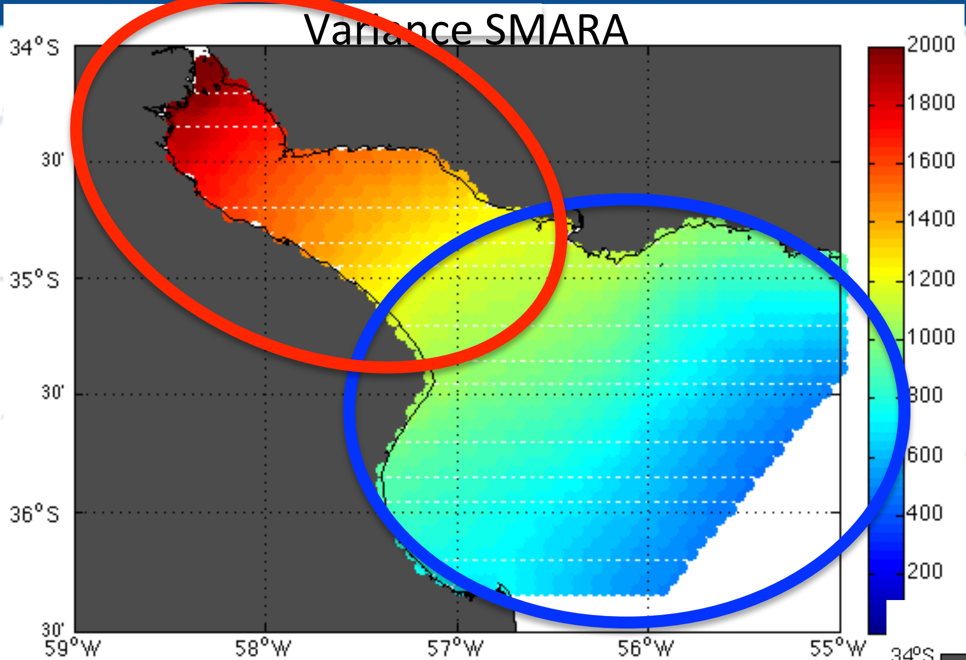


Variance of the sea level (cm^2) due to pressure and wind forcing simulated by Hamsom

2 times bigger

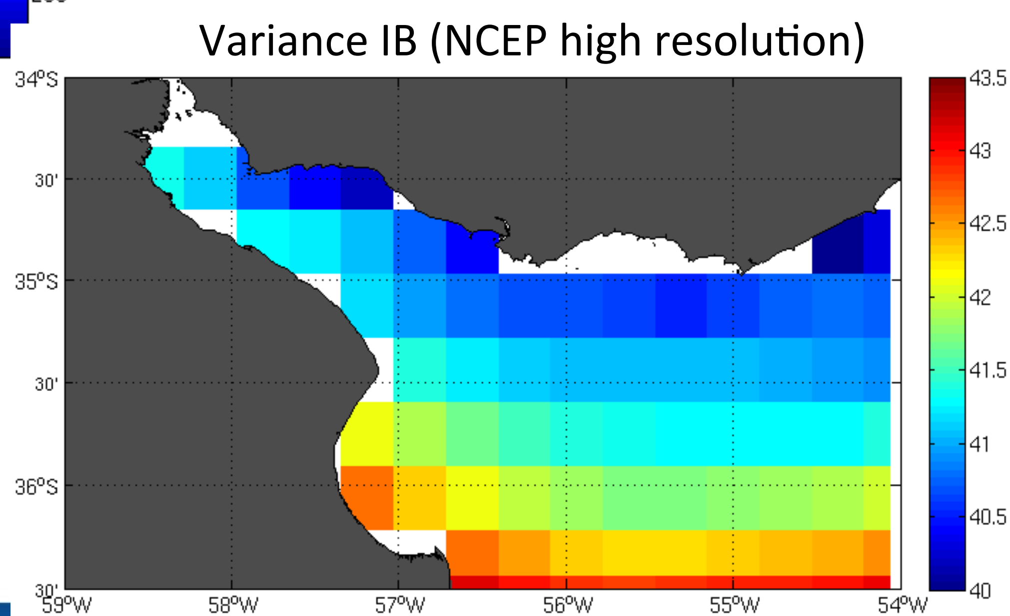


Variance of the sea level (cm^2) due to pressure and wind forcing simulated by Mog2D

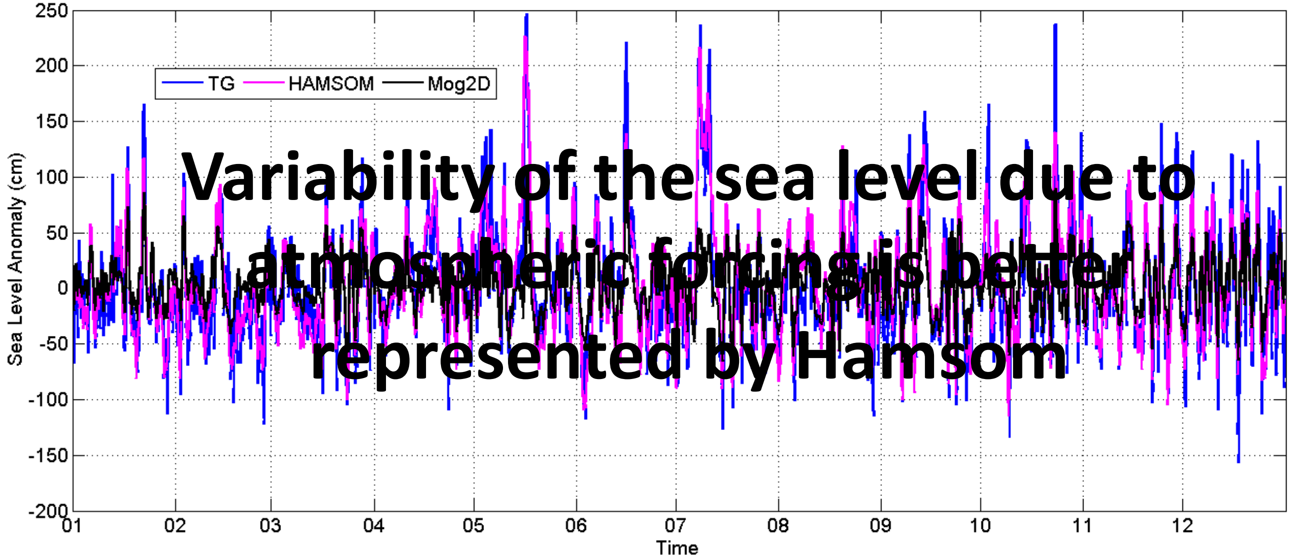


Variance of the sea level (cm^2) due to pressure and wind forcing simulated by SMARA

Variance of the sea level (cm^2) due to pressure (inverted barometer)



In-situ sea level height: TG Palermo



Variability of the sea level due to atmospheric forcing is better represented by Hamsom

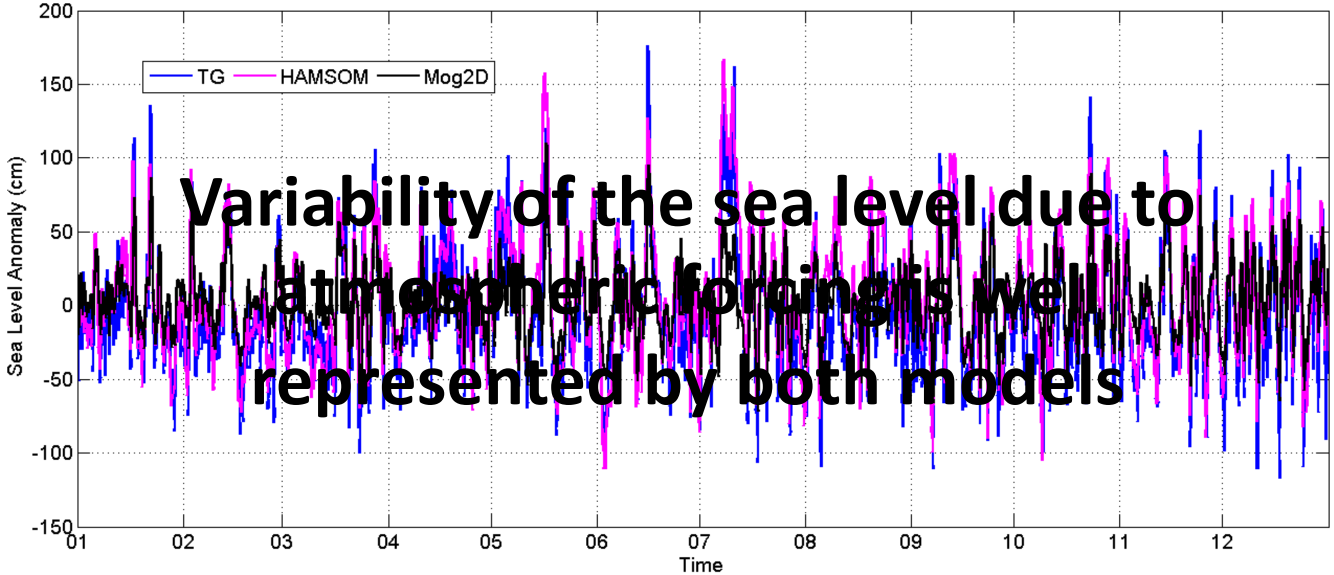
ΔT=1hs

cm²	-----	Tide	Hamsom	Mog2D	SLA tide+hamsom (↓ 67%)	SLA tide+mog2D (↓ 57%)
Variance	2939.0	650.2	2090.6	710.0	756.5	973.9

ΔT=1 month

cm²	-----	Hamsom	Mog2D	SLAHamsom (↓ 82%)	SLAmog2D (↓ 14%)
Variance	152.16	118.40	8.72	78.27	131.58

In-situ sea level height: TG Oyarbide



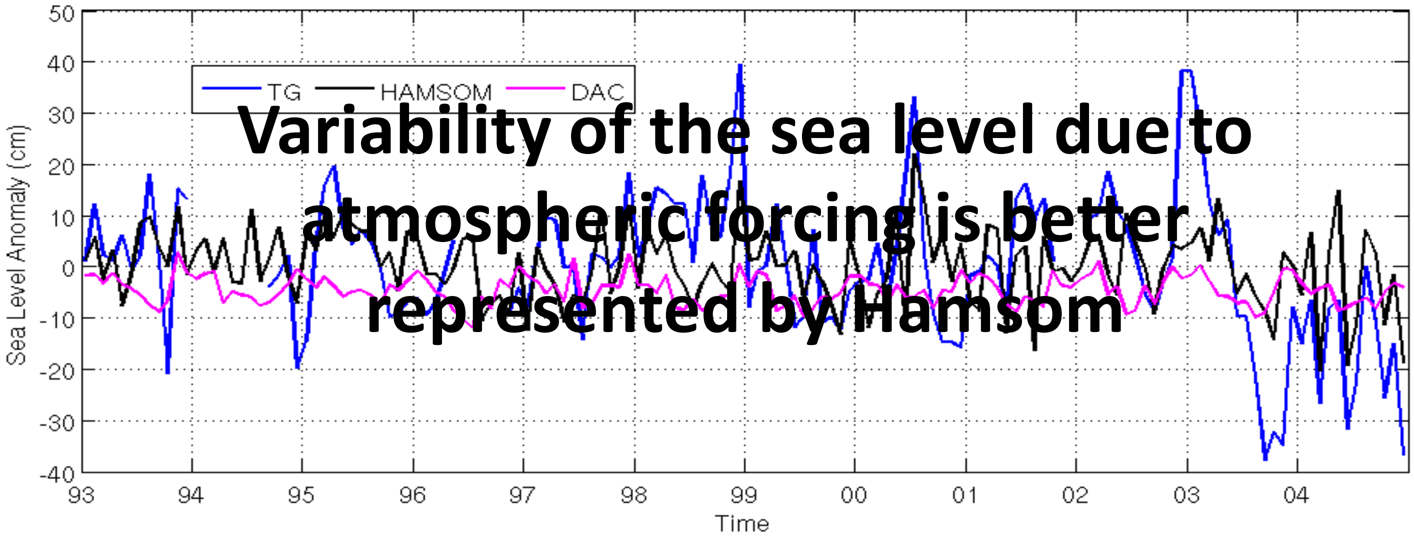
ΔT=1hs

cm²	-----	Tide	Hamsom	Mog2D	SLA tide+hamsom (↓ 62%)	SLA tide+mog2D (↓ 67%)
Variance	2348.6	757.9	1657.6	706.3	611.3	519.8

ΔT=1 month

cm²	------	Hamsom	Mog2D	SLAHamsom (↓ 14%)	SLAMog2D (↓ 6%)
Variance	133.8	58.6	8.2	114.6	126.0

In-situ Sea Level Height: TG Montevideo



Variability of the sea level due to atmospheric forcing is better represented by Hamsom

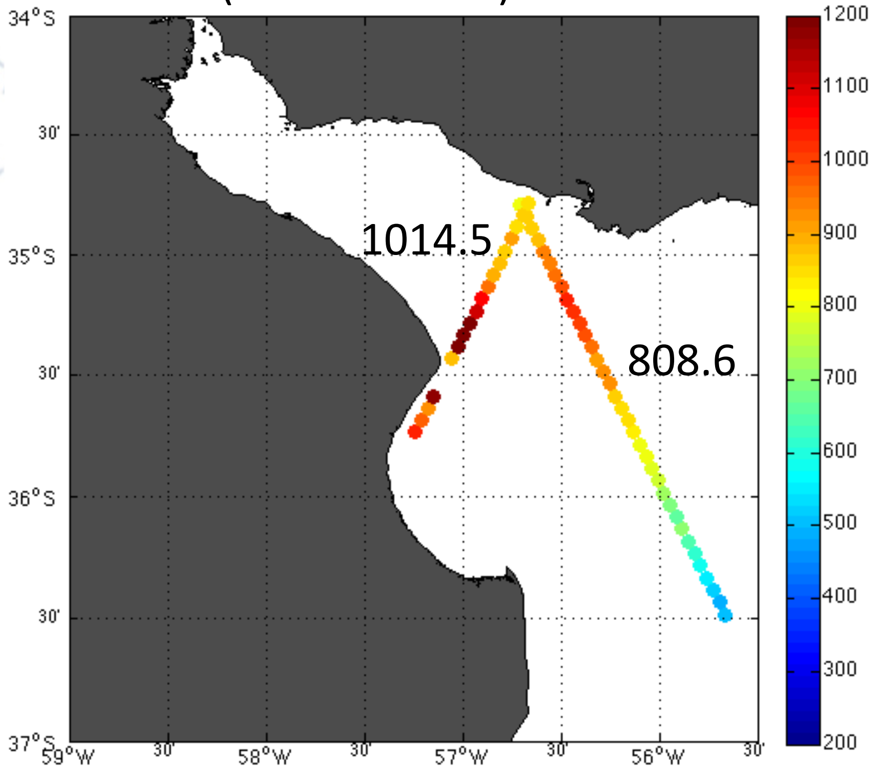
↓ 25% ↓ 2%

ΔT=1 month

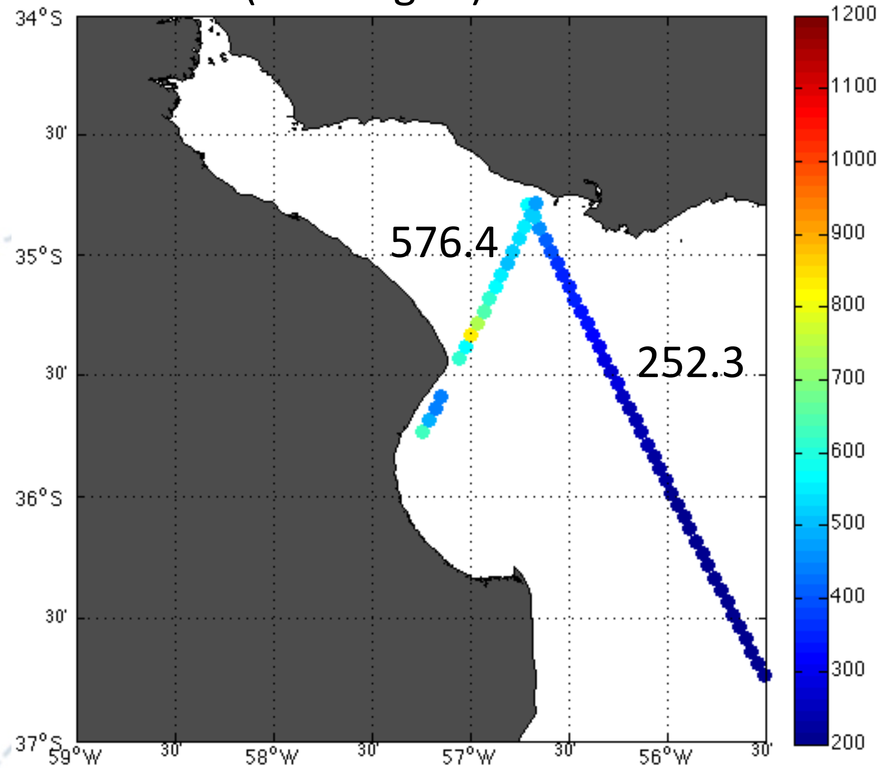
cm^2	-----	Hamsom	Mog2D	SLAHamsom	SLA Mog2D
Variance	198.7	55.0	7.9	148.3	194.6

Satellite sea level height: Jason 1 (RADS)

Var(SLAHAMSOM) 1993-2004



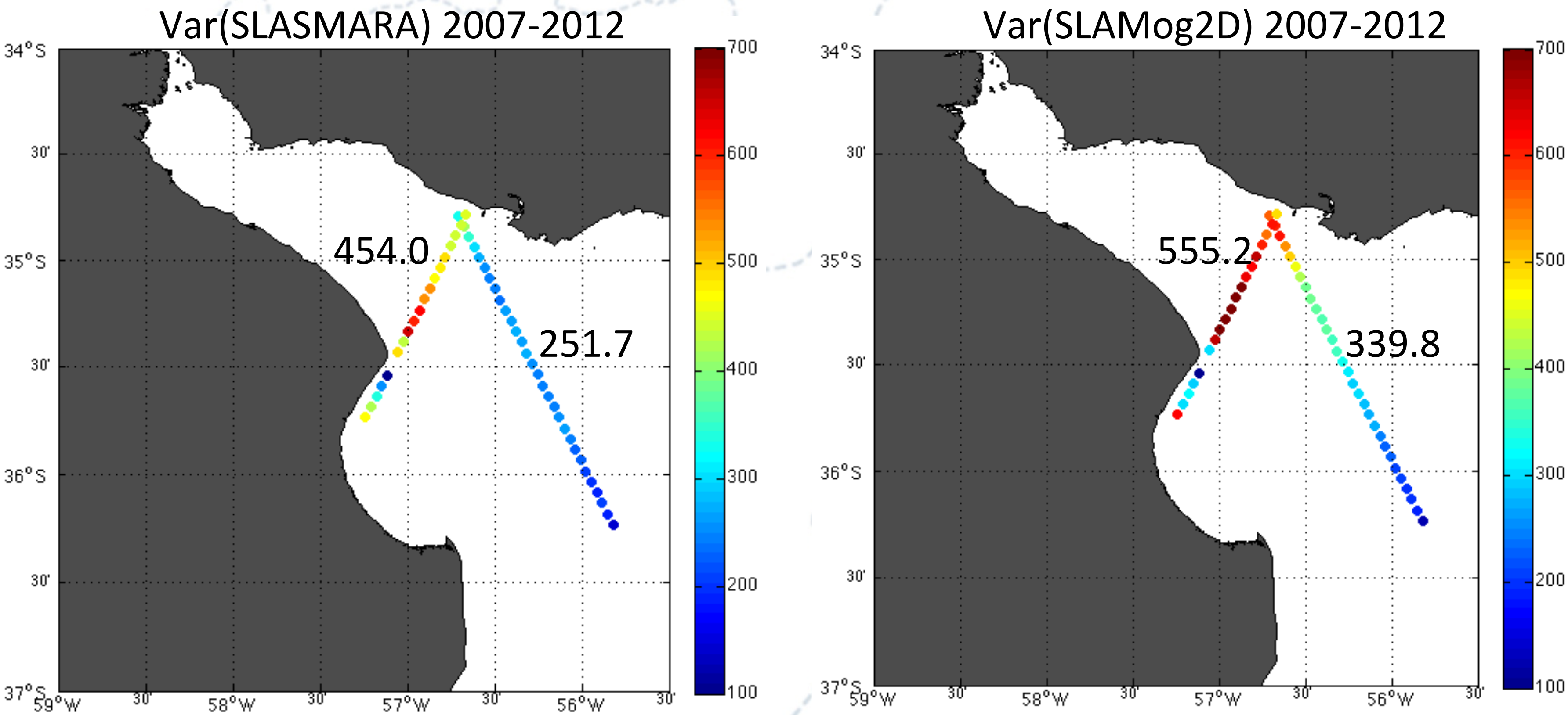
Var(SLAMog2D) 1993-2004



Variance of the SLA track 11 with wind and pressure: 1698.6 cm^2 ↓ 40%, 66%

Variance of the SLA track 102 with wind and pressure: 890 cm^2 ↓ 9%, 72%

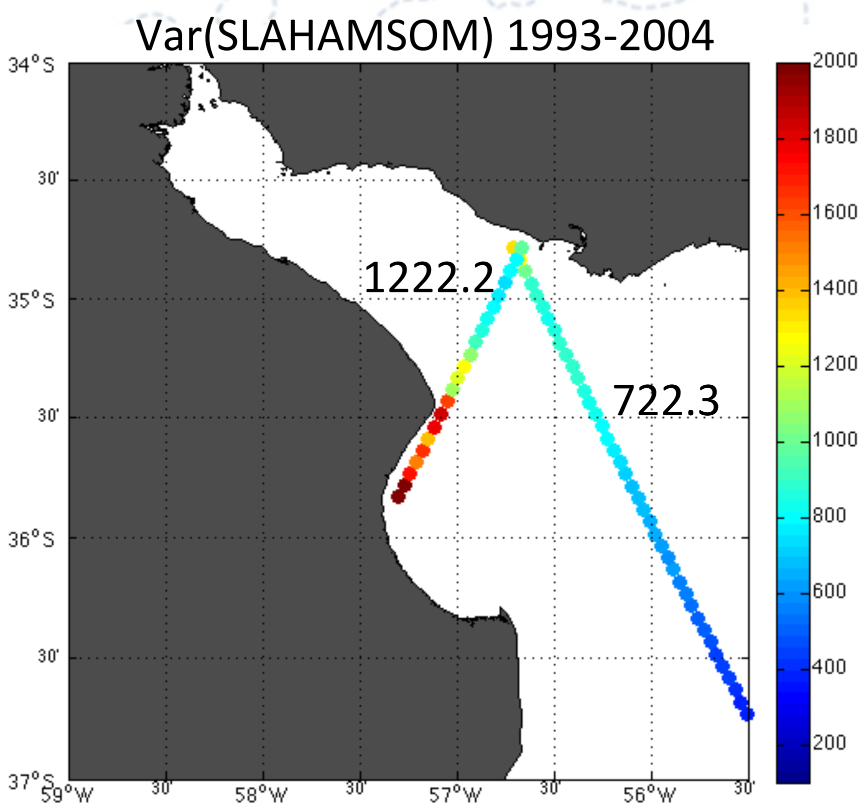
Satellite sea level height: Jason 1 (RADS)

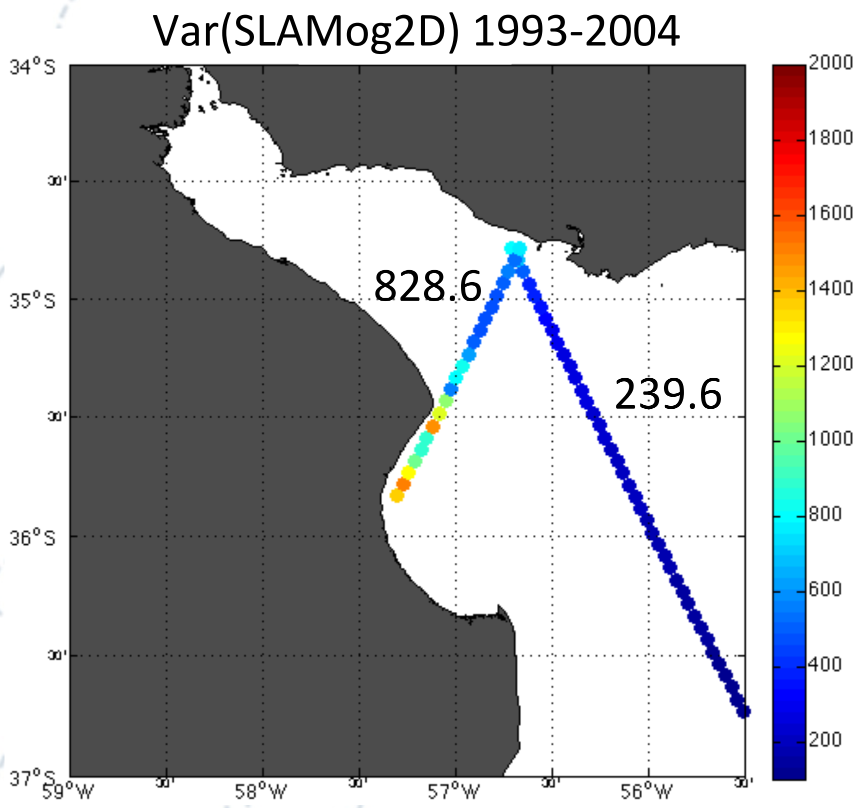


Variance of the SLA track 11 with wind and pressure: 1737.7 cm^2 ↓ 74%, 68%

Variance of the SLA track 102 with wind and pressure: 1010.6 cm^2 ↓ 75%, 66%

Satellite sea level height: CTOH (J1-J2-TP)

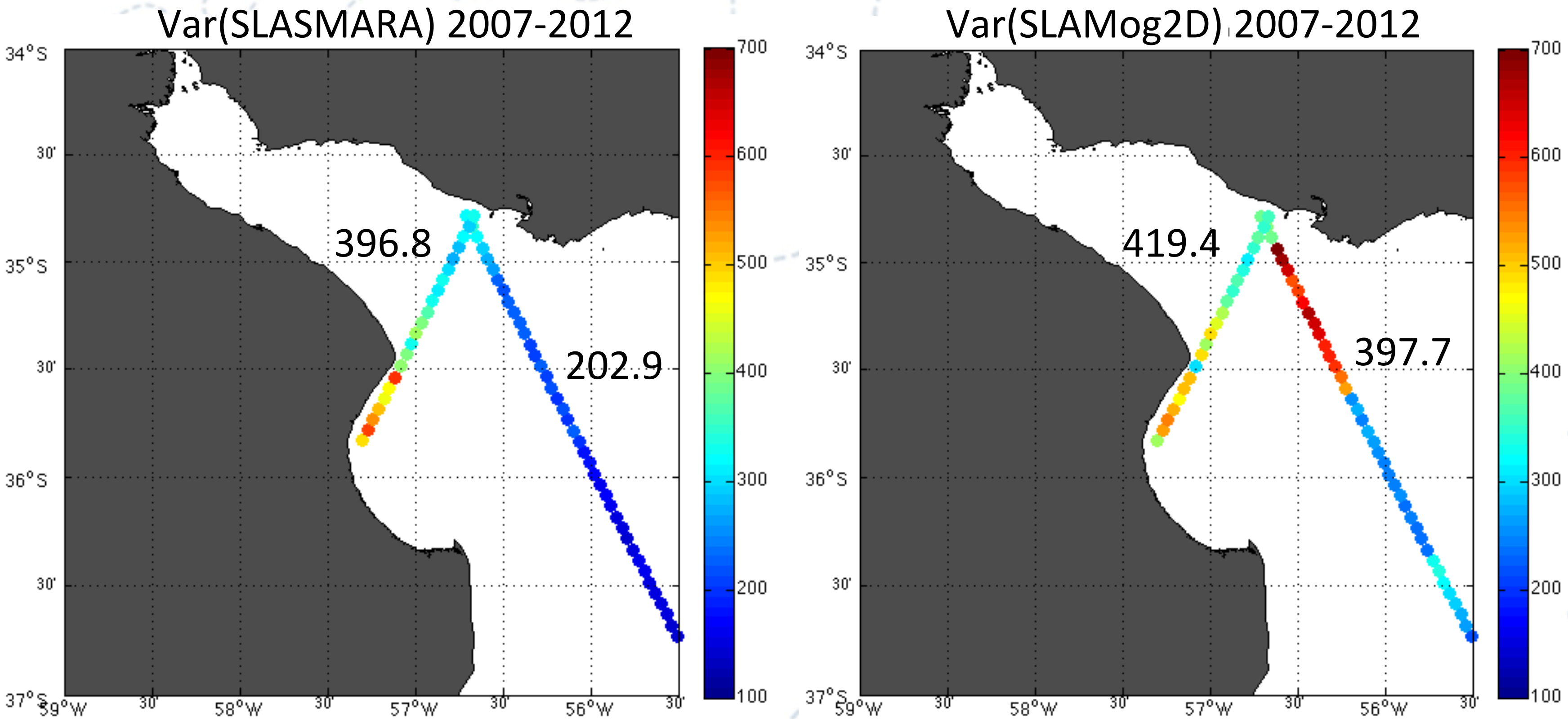




Variance of the SLA track 11 with wind and pressure: 1787.4 cm^2 ↓ 32%, 54%

Variance of the SLA track 102 with wind and pressure: 776.0 cm^2 ↓ 7%, 69%

Satellite sea level height: CTOH (J1-J2-TP)



Variance of the SLA track 11 with wind and pressure: 1251.5 cm^2 ↓ 68%, 66%

Variance of the SLA track 102 with wind and pressure: 911.2 cm^2 ↓ 78%, 56%

Table: summary of the SLA variance (cm^2)

	HAMSOM		Mog2D		SMARA		Mog2D	
N Track	011	102	011	102	011	102	011	102
RADS	1014.5	808.6	576.4	252.3	**454.0**	**251.7**	555.2	339.8
CTOH	1222.2	722.3	828.6	239.6	**396.8**	**202.9**	419.4	397.7

CONCLUSIONS

- The atmospheric models analysed show a similar spatial distribution of the variance of the sea level: High variability is observed in the upper Estuary and decreases towards the Lower part.
- DAC models show an order of magnitude larger variances than IB correction, confirming that wind effects dominate SLA variability in the region.
- Mog2D underestimates the variability of the sea level response to wind and pressure forcing. HAMSOM and SMARA represent it more accurately.
- At monthly scales, the variance of the in-situ sea level from Palermo, Oyarbide and Montevideo is reduced more significantly using HAMSOM.
- Results suggests that SMARA regional model is the most adequate correction to remove the atmospheric variability in the altimetry data.

Acknowledgments

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Thank you for your attention

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