Southwestern Atlantic Currents from In-Situ and Satellite Altimetry Measurements

Martin Saraceno (currently in a field cruise)
Presented by Loreley Lago

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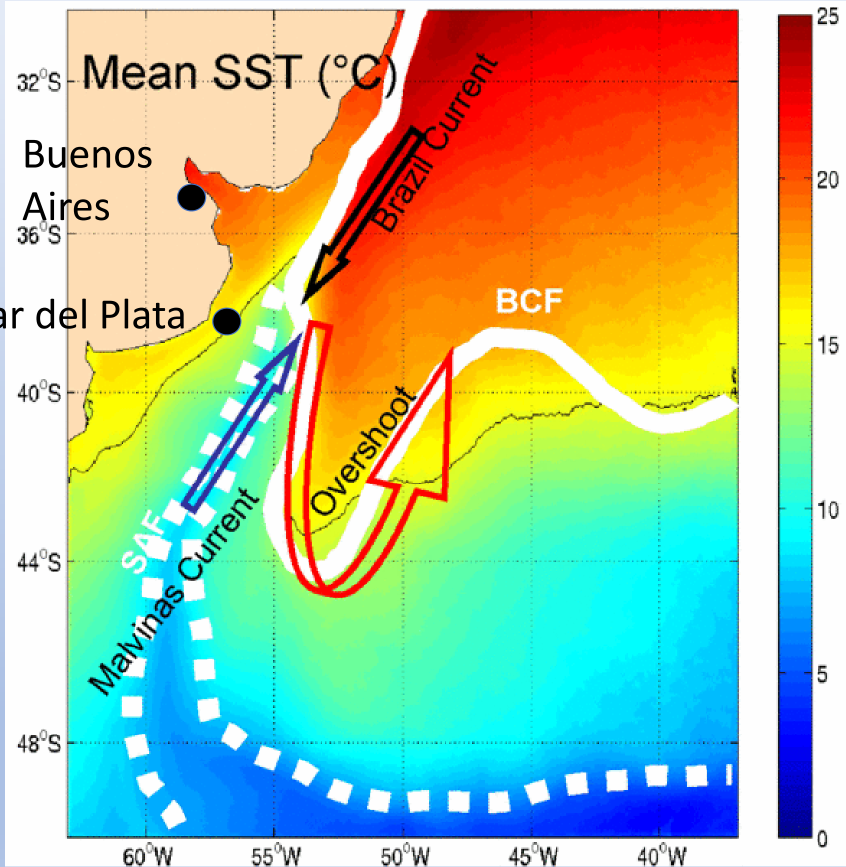
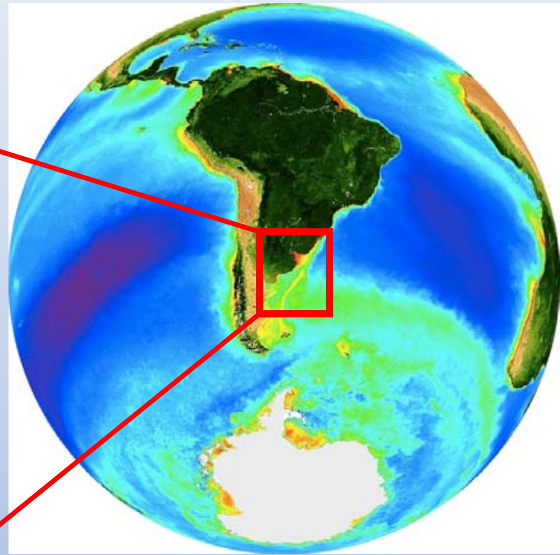
Southwestern Atlantic currents from in-situ and satellite altimetry

A work done by a large team, including:

G Paniagua R Ferrari L Lago C Artana A Piola R Guerrero C Provost

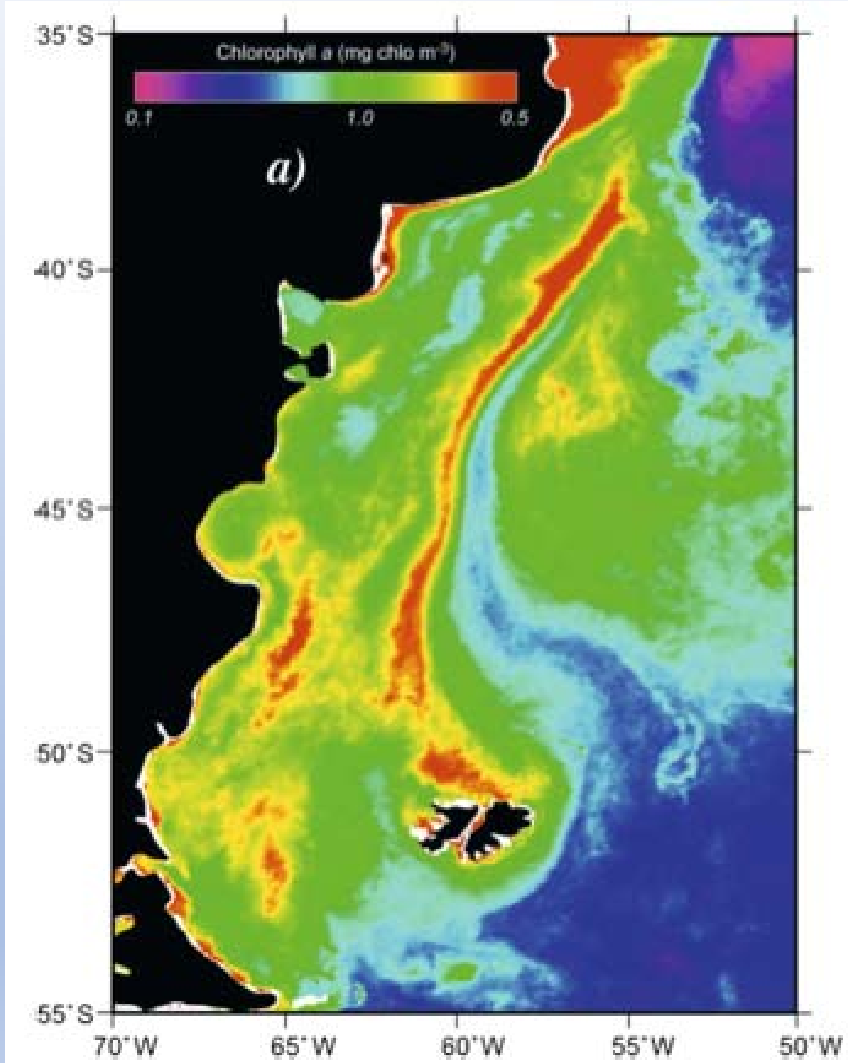
Why currents in the Southwestern Atlantic (SWA) are important?





1. Malvinas Current (MC) brings cold and nutrient rich waters to the North

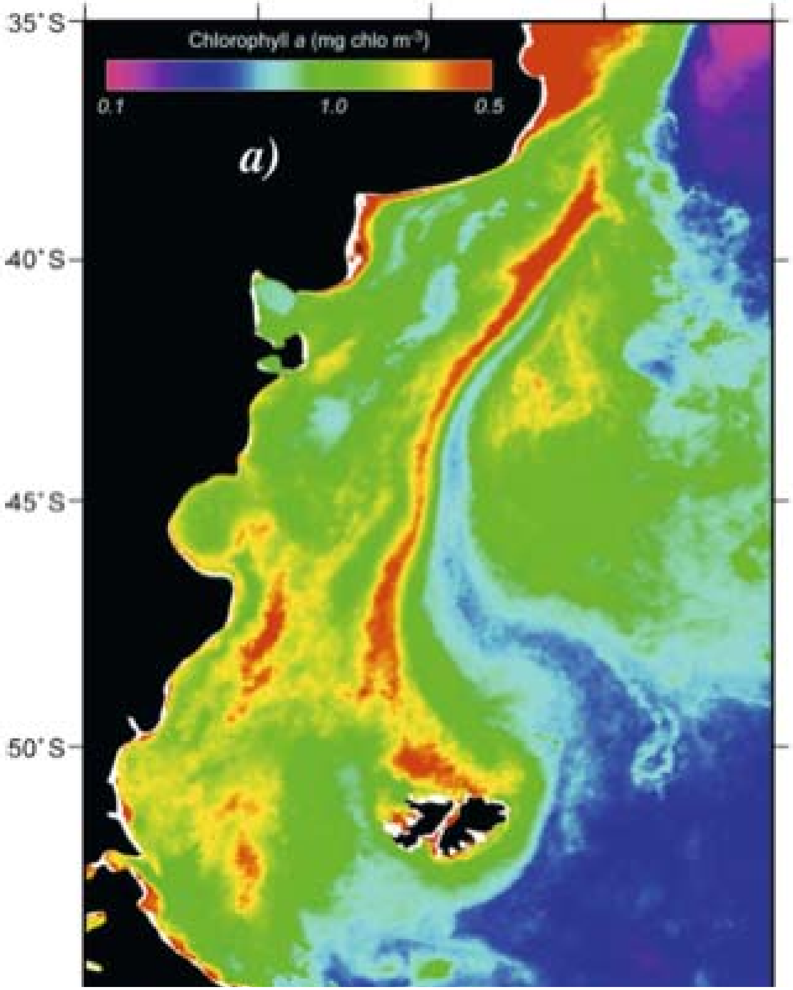
Why currents in the Southwestern Atlantic (SWA) are important?



2. The interaction of the MC with the bottom is responsible to maintain the sustained upwelling observed along the shelf-break

SeaWiFS Chlorophyll-a, mg/m3 - Summer

Why currents in the Southwestern Atlantic (SWA) are important?



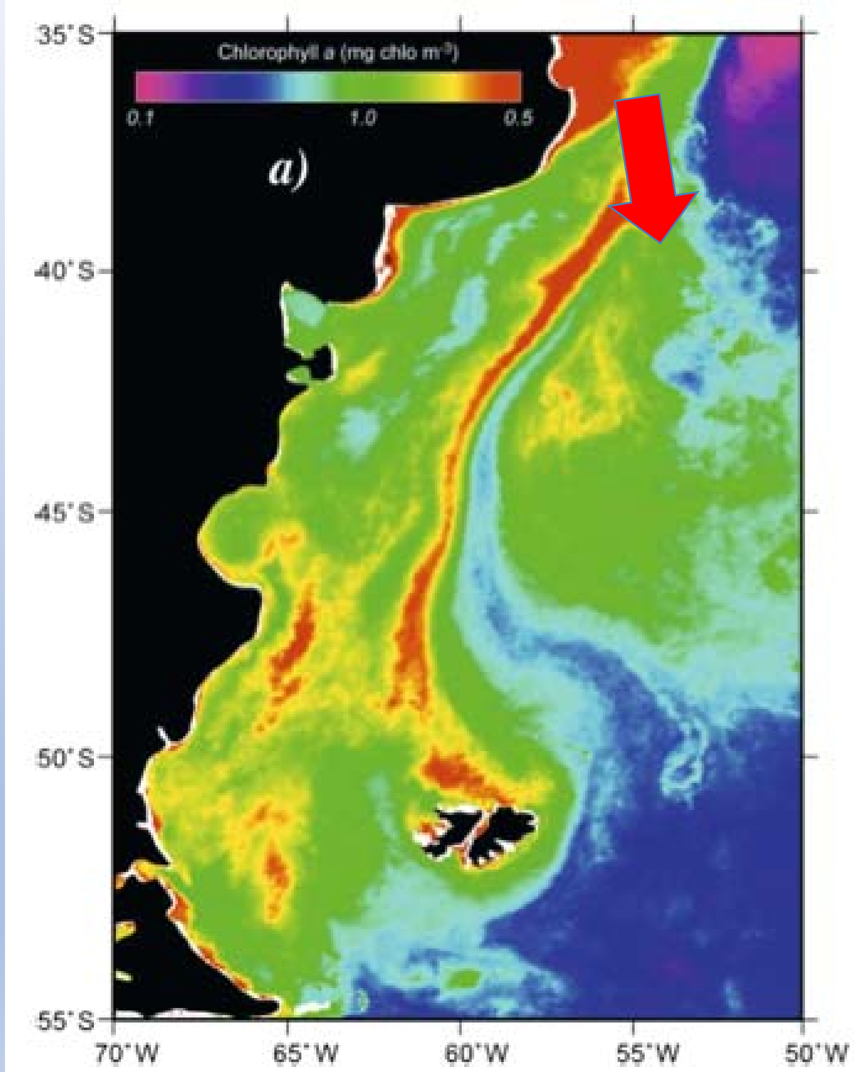
Average of Chlorophyll-a, mg/m3

Squid fishing vessels

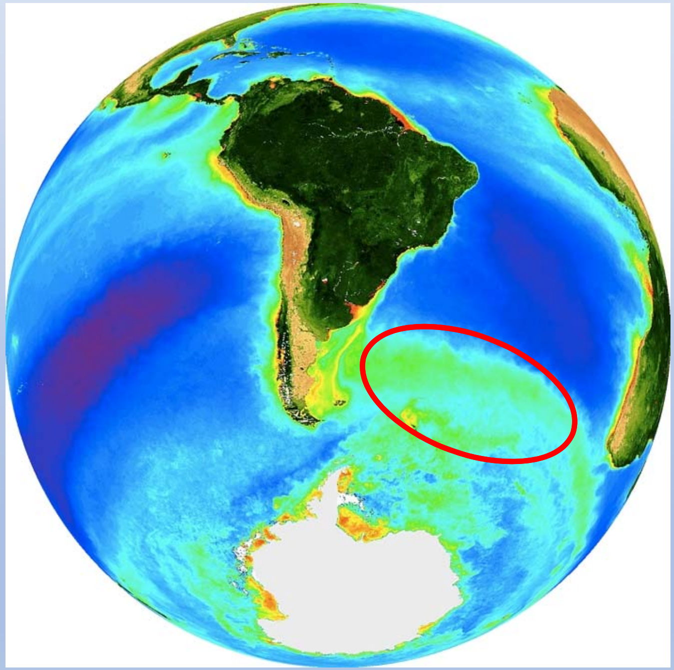
The upwelling observed along the shelf-break is the main source of nutrients that maintains important fisheries

Matano and Palma, 2008

Why currents in the Southwestern Atlantic (SWA) are important?



3. the MC is the main source of nutrients in the Southwestern Atlantic



Why currents in the Southwestern Atlantic (SWA) are important?

4. MC is part of the Meridional Overturning circulation in the Atlantic:
It contributes to regulate the climate of the Earth thanks to the exchange of heat and salt that occurs at the Brazil-Malvinas confluence region

Warm (red lines) and cold (blue and green) paths of the Meridional Overturning Circulation; Lumpkin 2007

Why currents in the Southwestern Atlantic (SWA) are important?

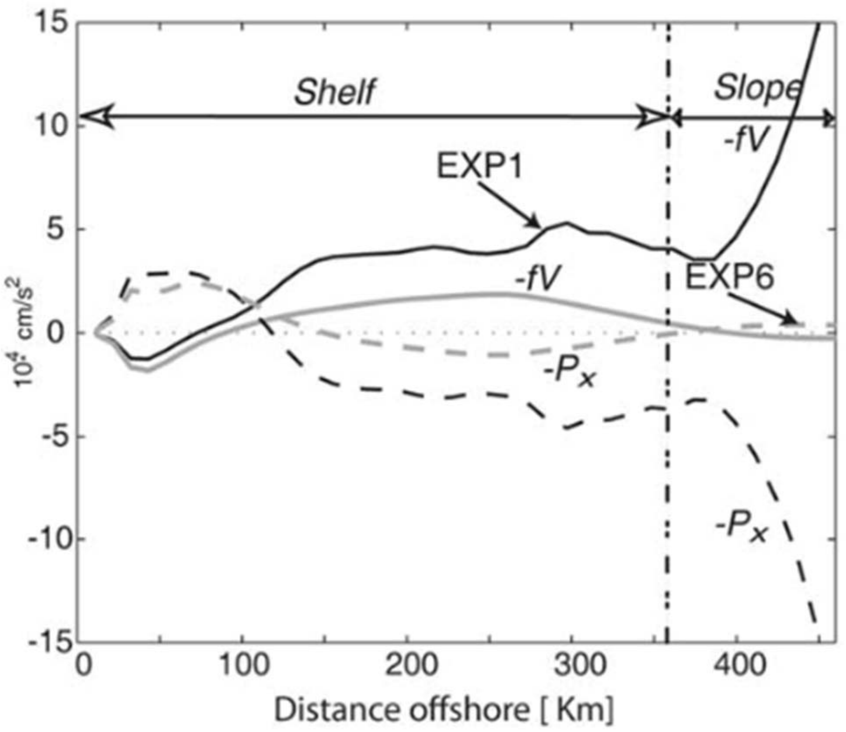


Figure 17. Comparison of the annual mean depth-averaged cross-shelf momentum balance at the NACS section (C3) of experiment EXP6 (no boundary current inflow, gray lines) and experiment EXP1 (including the MC, black lines).

5. The intensity of the MC is proportional to:

- transport of currents over the shelf &
- Intensity of the upwelling in the shelf-break

Matano and Palma, 2008

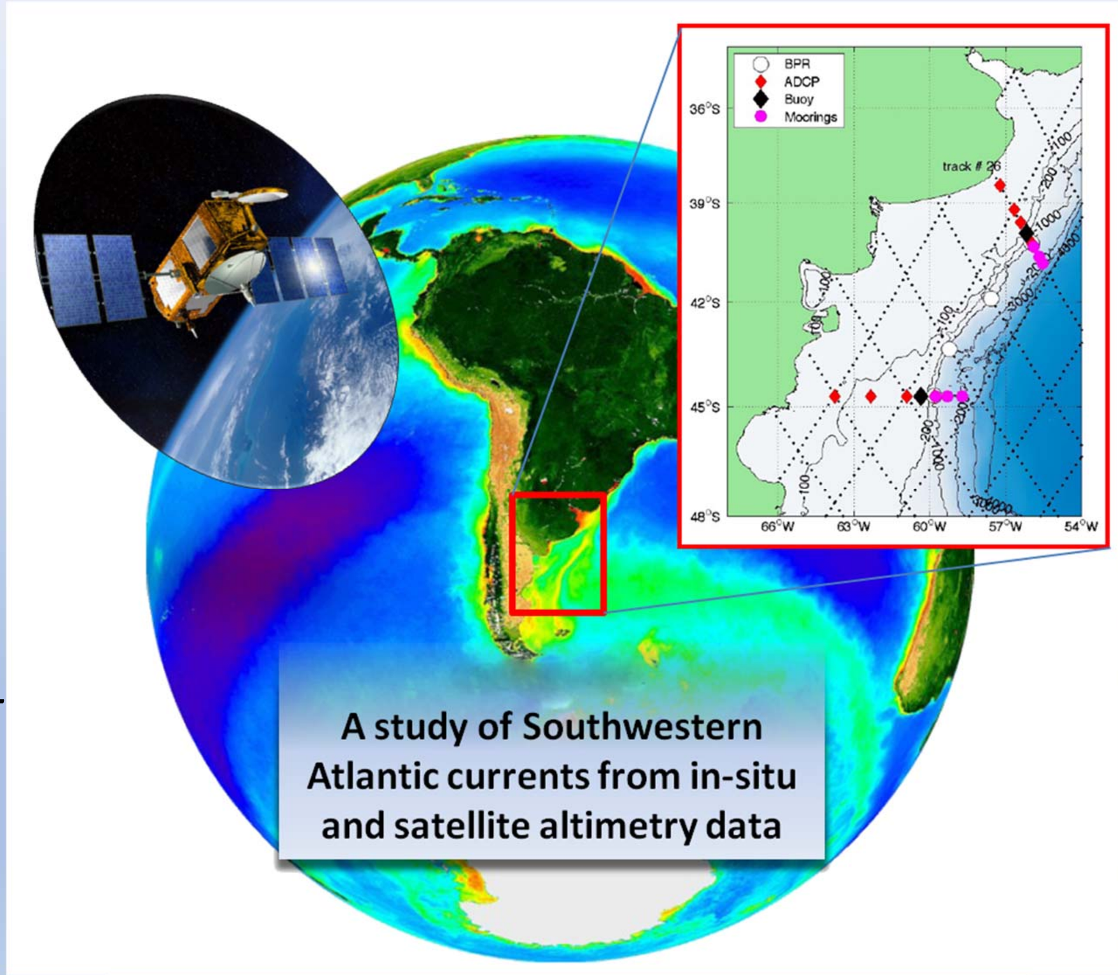
Monitoring the MC is therefore a key issue

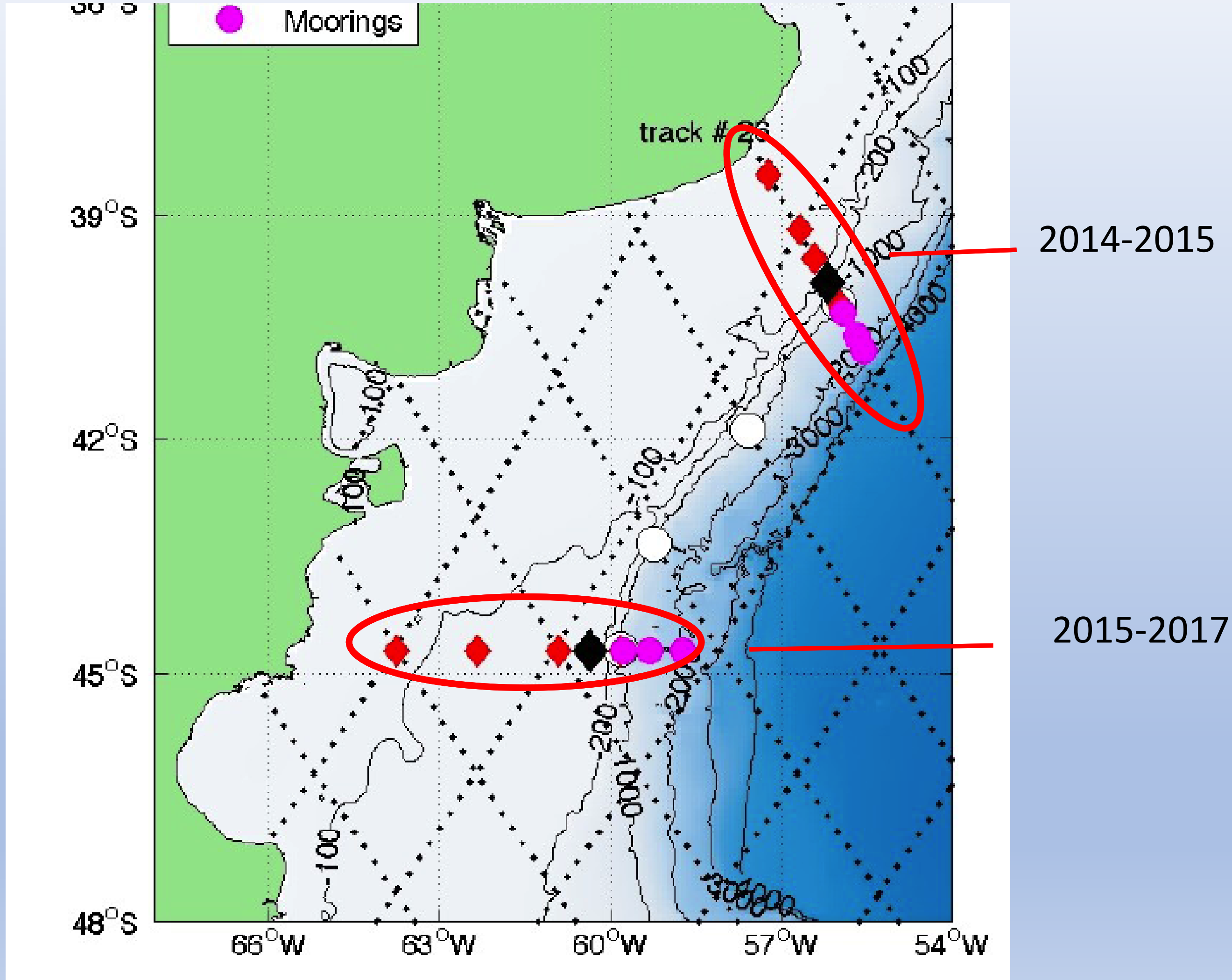
C A S S I S

Southwestern Atlantic currents from satellite and in situ data

A project of Unité Mixte International Institut Franco-Argentin Etudes Climat et Impact (UMI-IFAECI/CNRS-UBA-CONICET)



CASSIS project: Mooring array



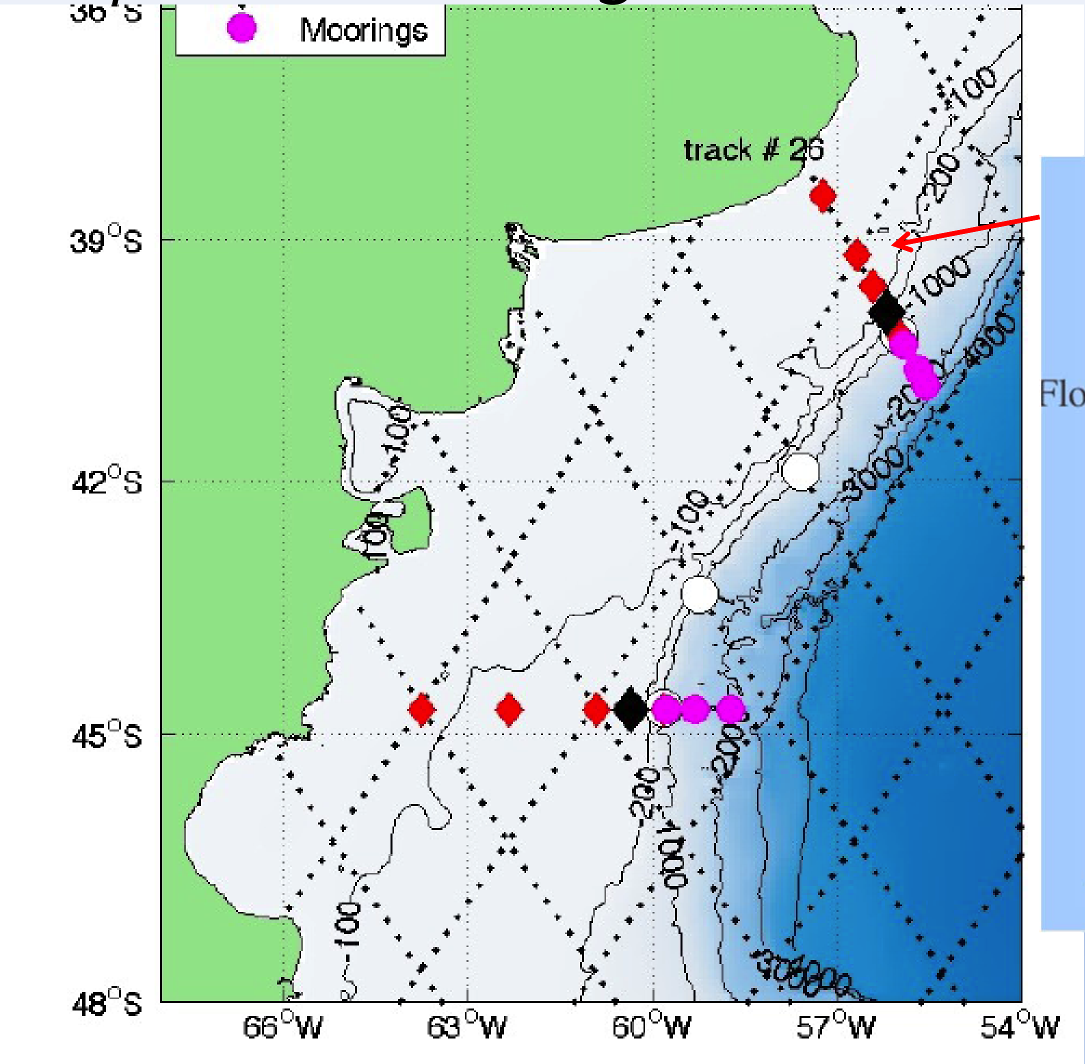
8 moorings:

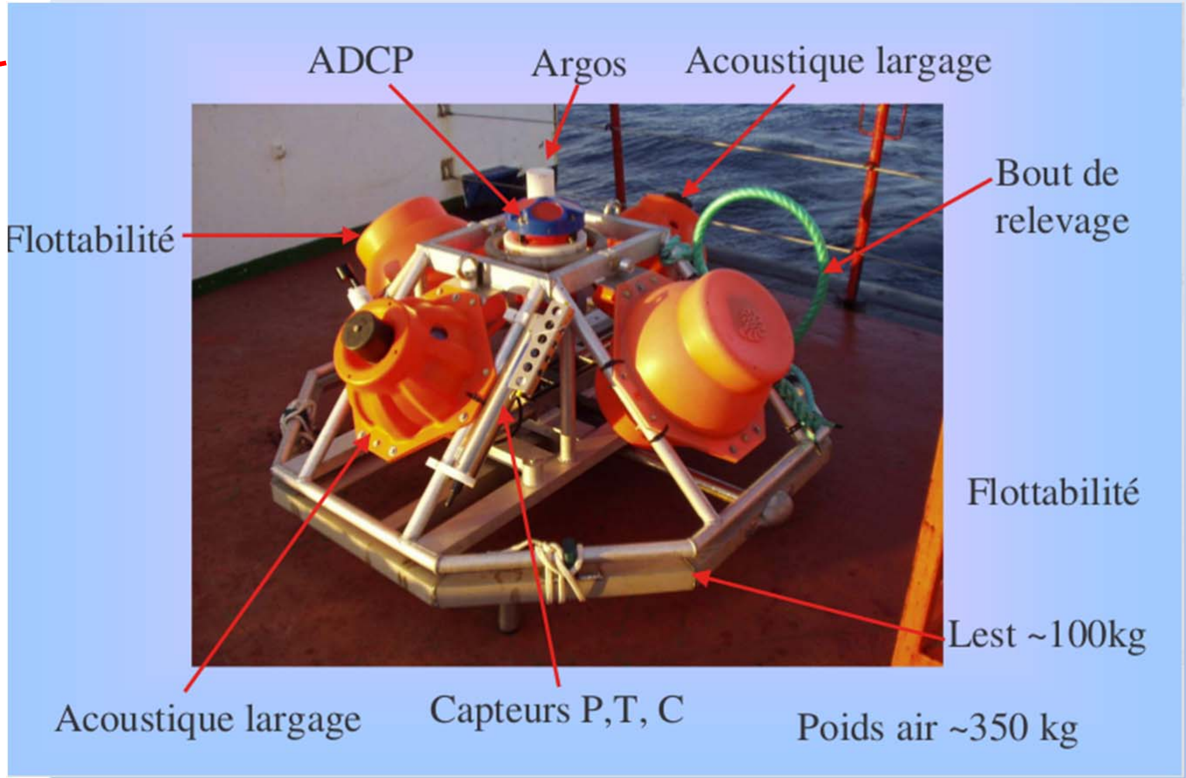
- 4 upward-looking ADCP
- 1 oceanographic buoy
- 3 tall moorings

- Along-track #26: 1 year (Dec 2014- Nov 2015)

- Section at 44.7 S: 1.5 year
- (Dec 2015- May 2017)

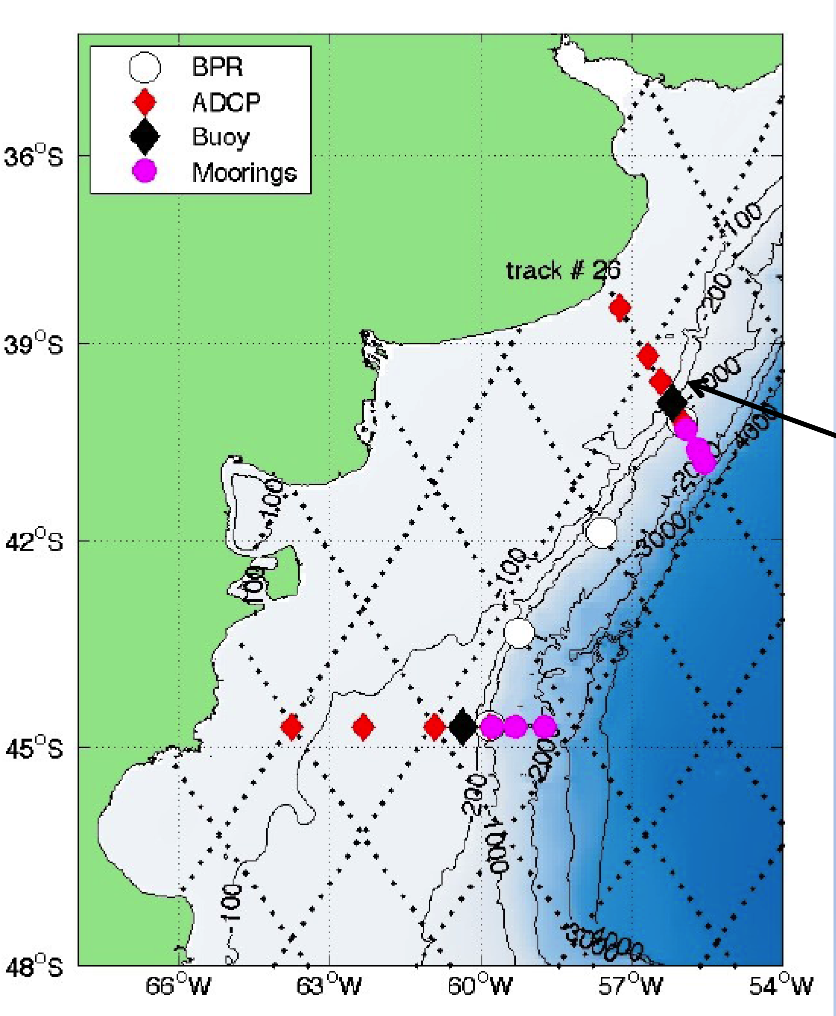
Upward looking ADCP





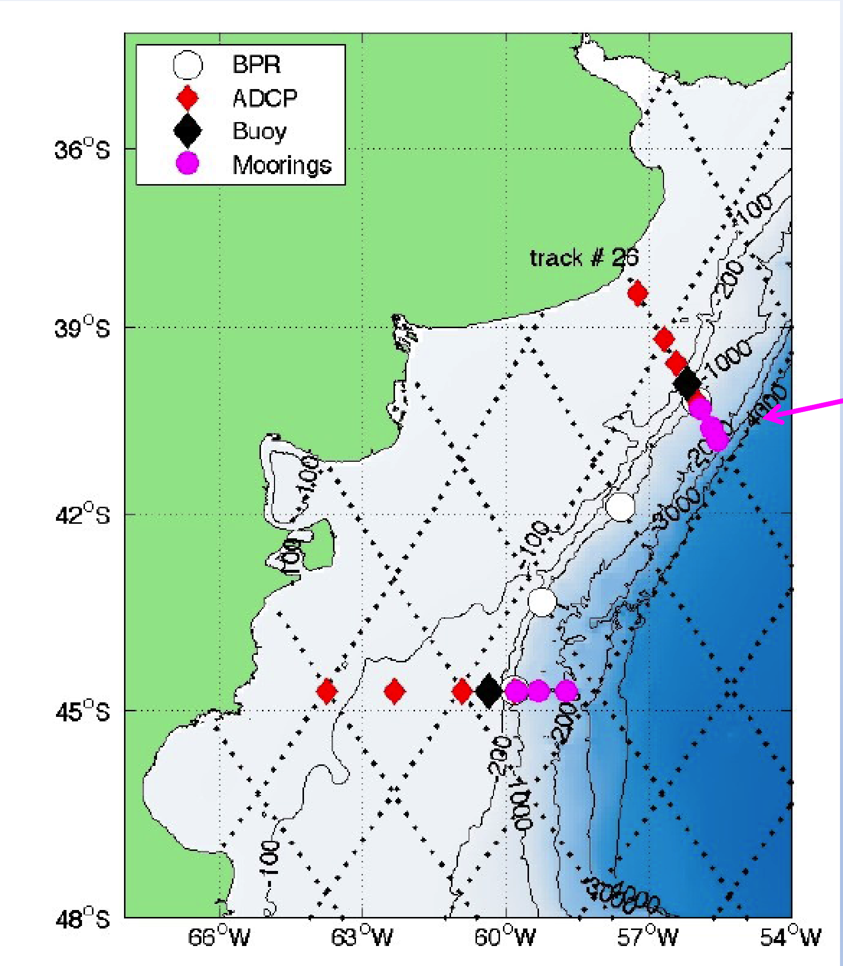
Laboratoire d'Océanographie Physique et Spatiale
LOPS

Full oceanogaphic buoy



- 1 Downward-looking ADCP
- 5 CTD SBE37
- Meteorological station at surface (wind speed and direction, relative humidity, sea level pressure and air temperature sensors)
- Satellite Inmarsat C transmission for real-time data telemetry
- Powered with in-hull batteries rechargeable via solar panels.

Tall moorings



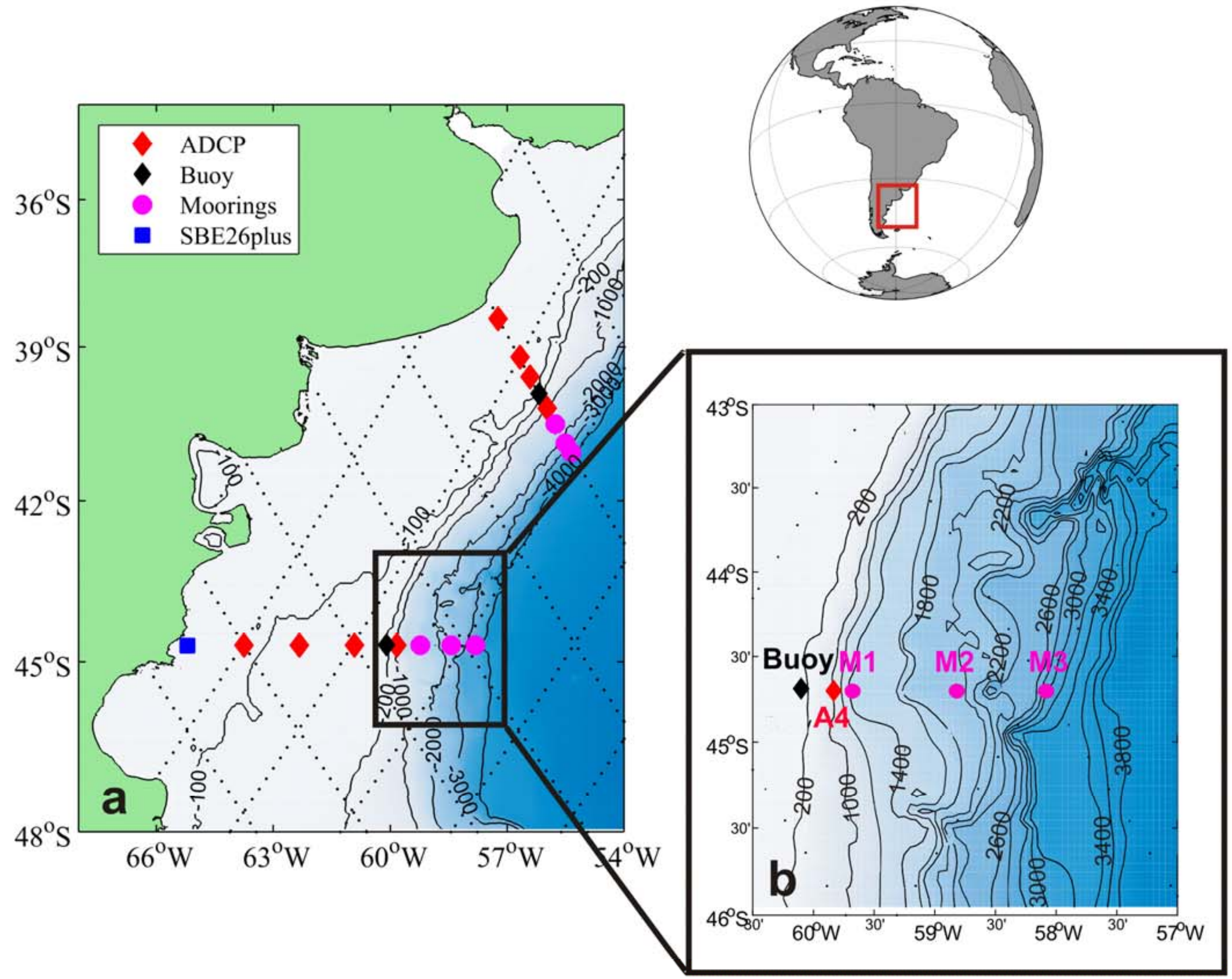
Results

1. Paniagua, G. F., Saraceno, M., Piola, A. R., Guerrero, R., Provost, C., Ferrari, R., Lago, L. S. and Artana, C. I. (2018), **Malvinas Current at 40°-41°S: First Assessment of Temperature and Salinity Temporal Variability**. J. Geophys. Res. Oceans. https<11doi.org/32.1029/4239JC235888
2. Artana, C., Lellouche, J., Park, Y., Garric, G. , Koenig, Z. , Sennéchael, N. , Ferrari, R., Piola, A. R., Saraceno, M. and Provost, C. (2018), **Fronts of the Malvinas Current System: Surface and Subsurface Expressions Revealed by Satellite Altimetry, Argo Floats, and Mercator Operational Model Outputs**. J. Geophys. Res. Oceans. https://doi.org/10.1029/2018JC013887
3. Artana, C., Ferrari, R., Koenig, Z., Sennéchael N., Saraceno, M., Piola, A. R. and Provost, C. (2018), **Malvinas Current volume transport at 41°S: a 24-year long time series consistent with mooring data from 3 decades and satellite altimetry**, Journal of Geophysical Research: Oceans, 123. https://doi.org/10.1002/2017JC013600
4. Ferrari, R., Artana, C., Saraceno, M., Piola, A. R., & Provost, C. (2017), **Satellite altimetry and current-meter velocities in the Malvinas Current at 41°S: Comparisons and modes of variations**. Journal of Geophysical Research: Oceans, 122. https://doi.org/10.1002/2017JC013340
5. Lago L.S., Saraceno M., Martos P., Guerrero R.A., Piola A.R., Paniagua G.F., Ferrari R., Artana C.I. and Provost C. (2019), **On the wind contribution to the variability of ocean currents over wide continental shelves: a case study on the northern Argentine continental shelf**, https://doi.org/10.1029/2019JC015105
6. Lago et al, **Transport variability in the northern continental shelf of Argentina**, under preparation
7. Paniagua et al, **Current Measurements at 44.7°S**, under preparation
8. Saraceno et al, **Malvinas Current Transport at 44.7°S,** under preparation

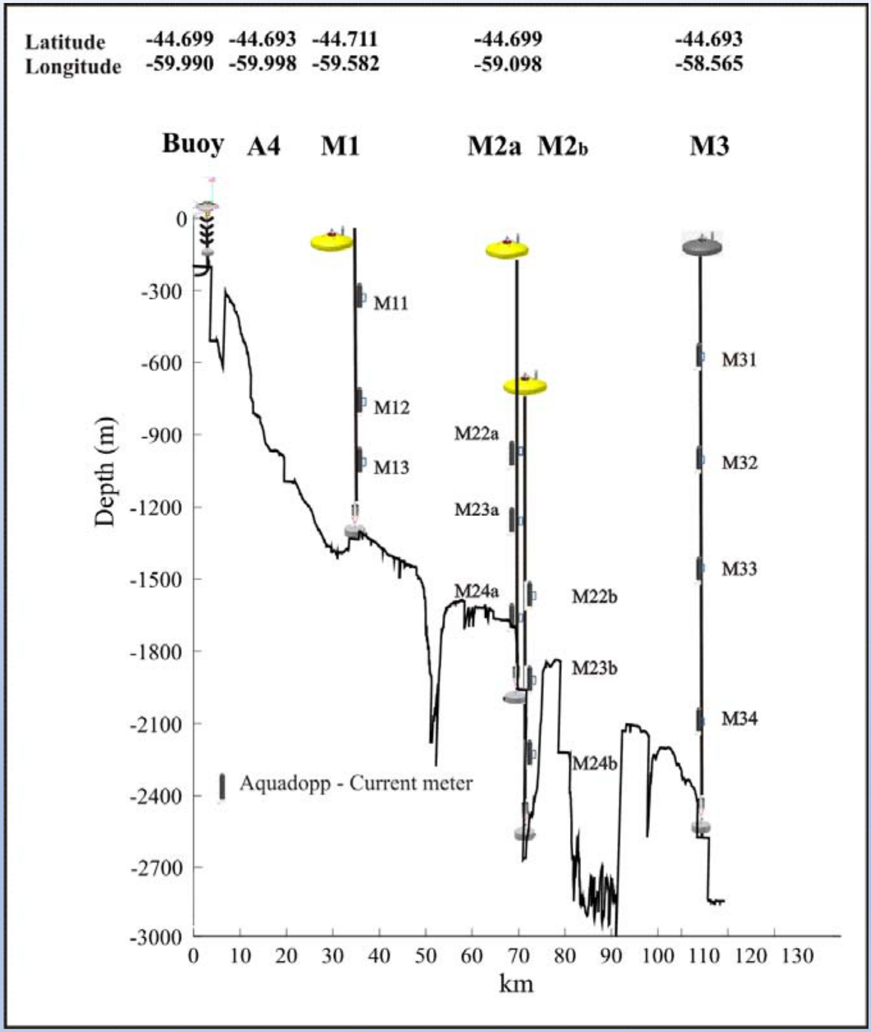
In this meeting

- Continental shelf
    - Lago et al, Volume Transport from In-situ and Altimetry Data Over a Wide Continental Shelf, talk this morning in the Coastal Altimetry Session

- Shelf-break @ 44.7S
    - This talk


ADCP
Buoy
Moorings
SBE26plus
36°S
39°S
42°S
45°S
48°S
66°W
63°W
60°W
57°W
54°W
a
b
Buoy
M1
M2
M3
A4
43°S
44°S
45°S
46°S
60°W
59°W
58°W
57°W

Shelf-break results



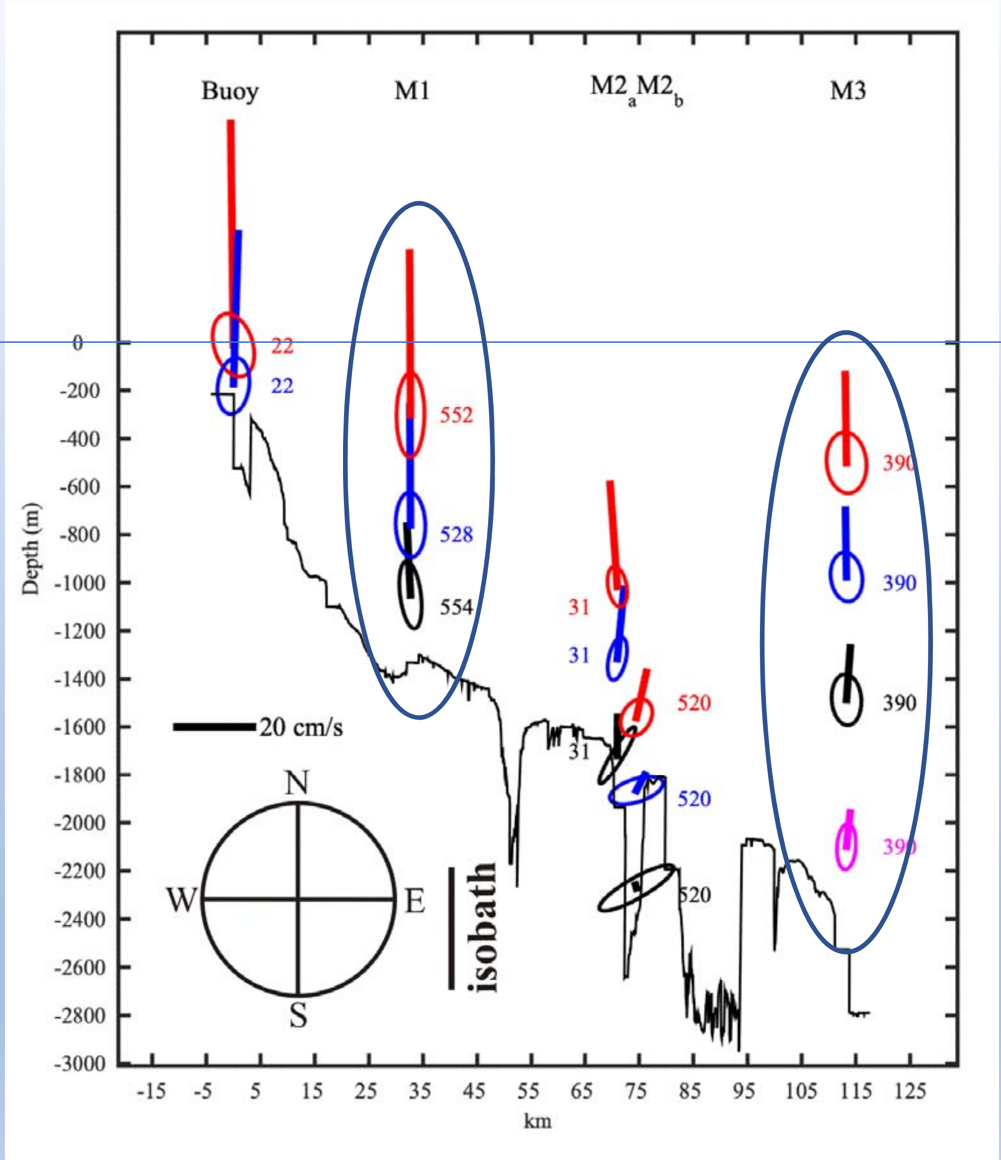
CASSIS shelf-break array (2015-2017)

- M2: fished and re-deployed 500m deeper
- A4: lost
- Buoy: 22 days

But:

✔ M1 & M2: up to 554 days

✔ M3: 390 days



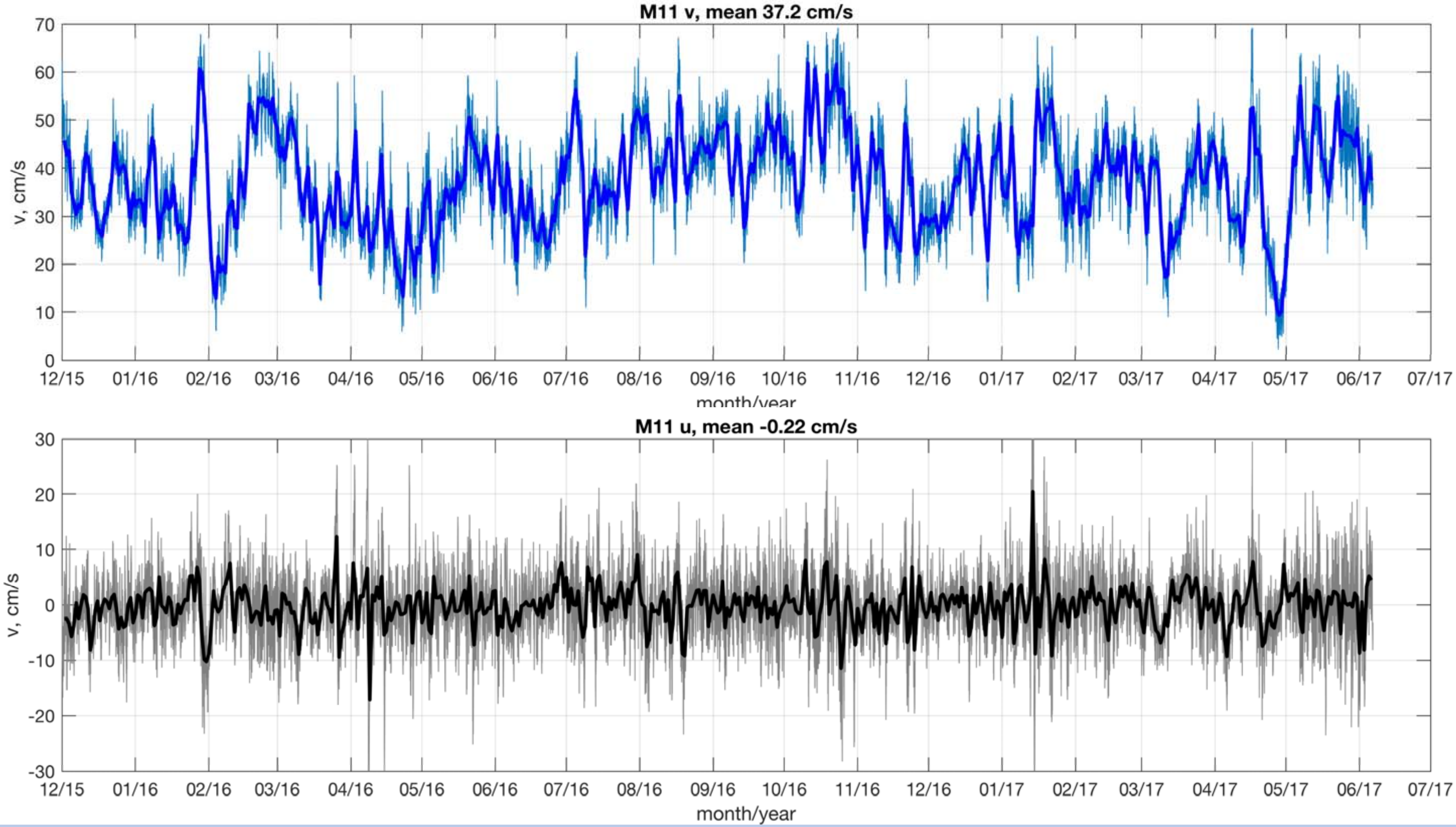
Average currents:

- Northward
- M2b fall into a canyon: not considered for transport estimation
- Barotropic equivalent structure: up to 62cm/s @ 300m and 40cm/s @ 1100m
- Variance ellipses are more round-shaped towards the east

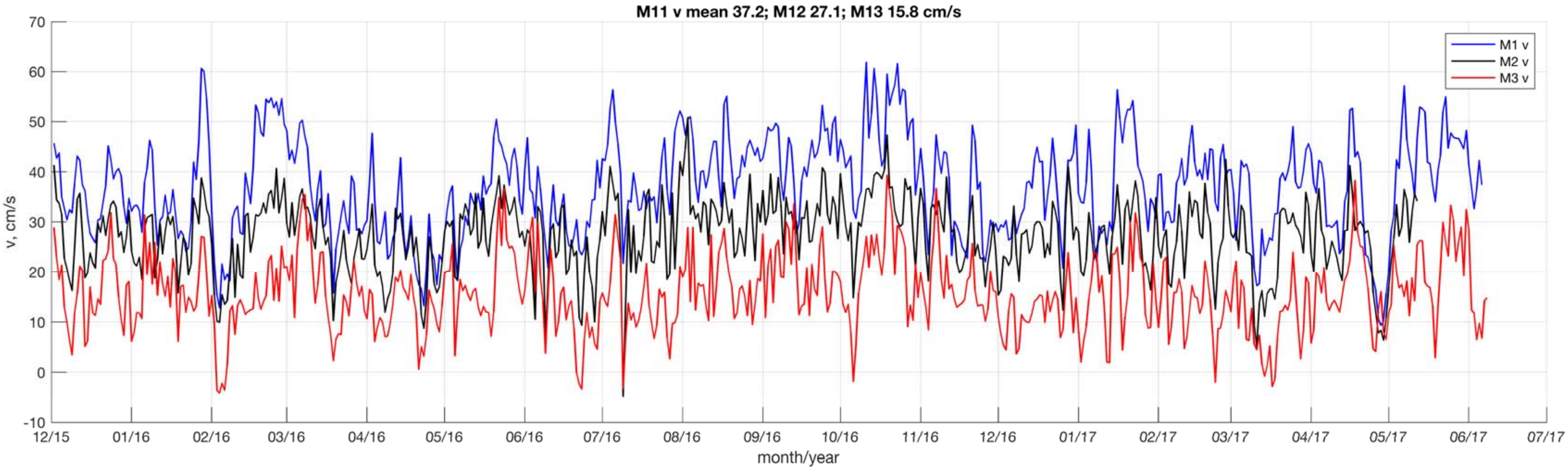
v >> u

M11 v

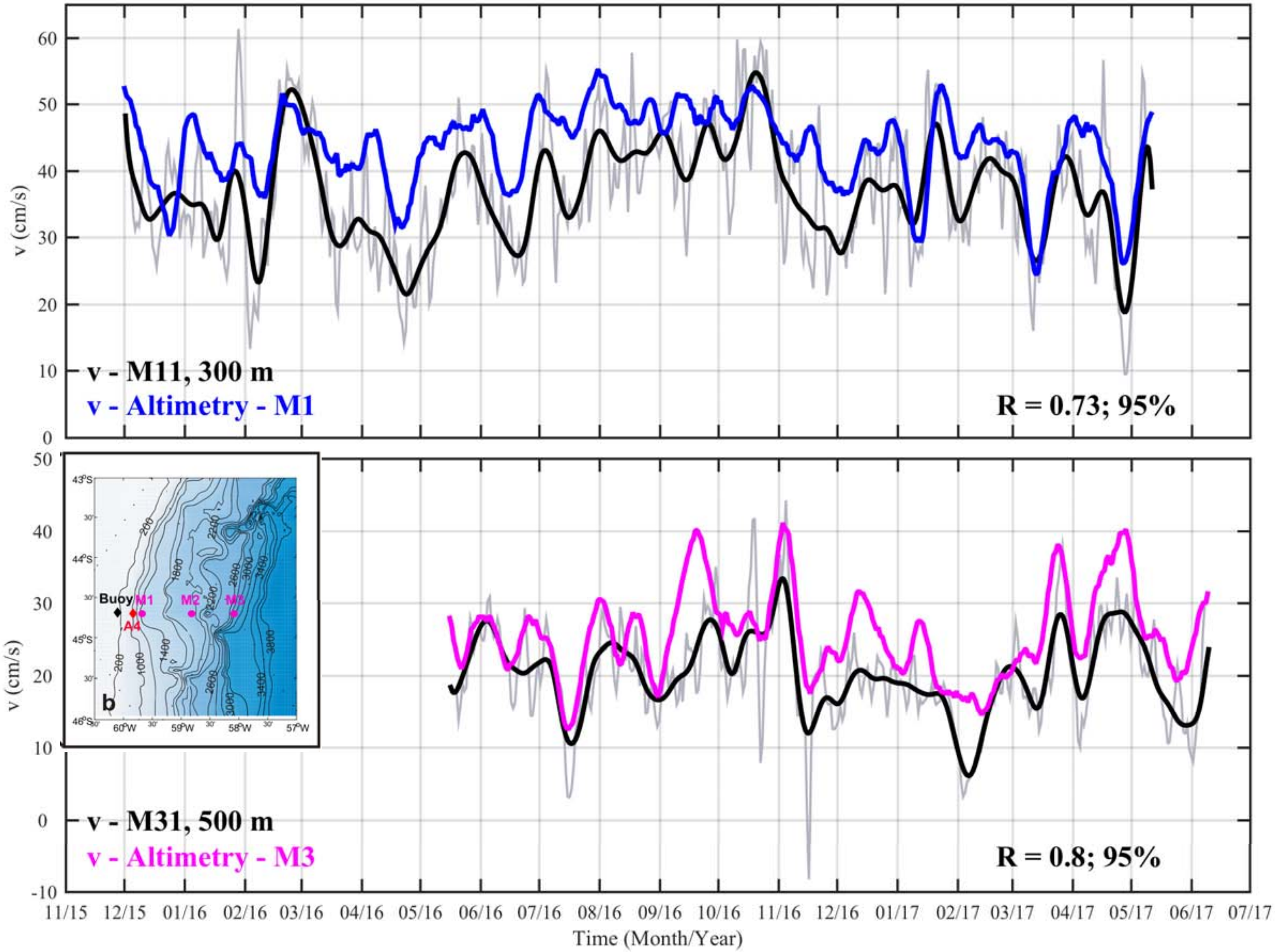
M11 u


M11 v, mean 37.2 cm/s
v, cm/s
month/year
M11 u, mean -0.22 cm/s
v, cm/s
12/15 01/16 02/16 03/16 04/16 05/16 06/16 07/16 08/16 09/16 10/16 11/16 12/16 01/17 02/17 03/17 04/17 05/17 06/17 07/17
month/year

M1 - v

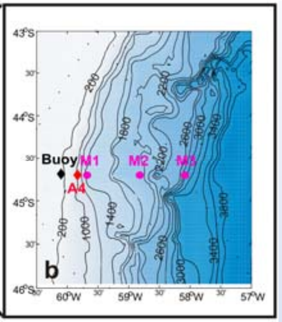


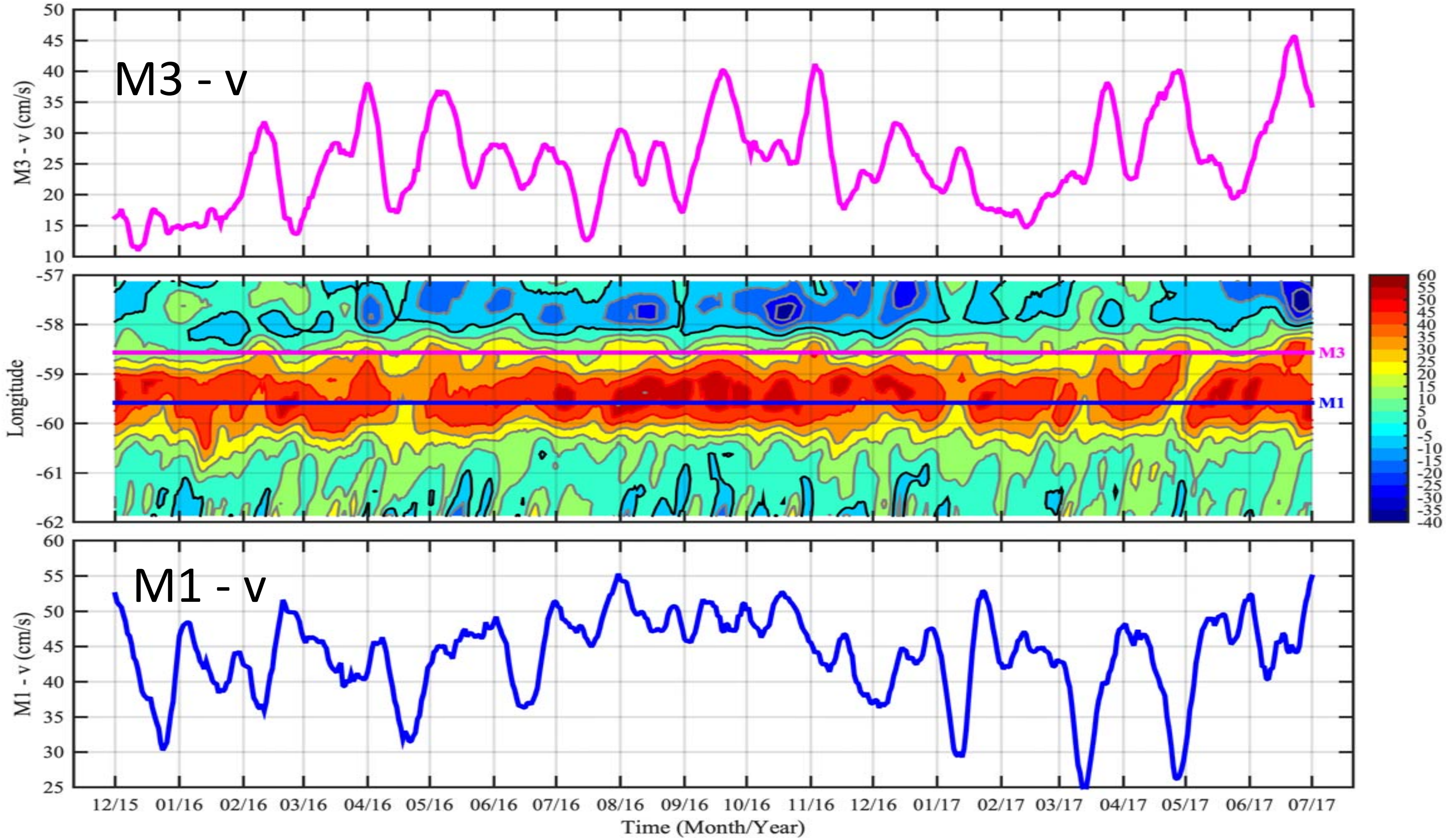
Barotropic-equivalent structure



Comparison with altimetry

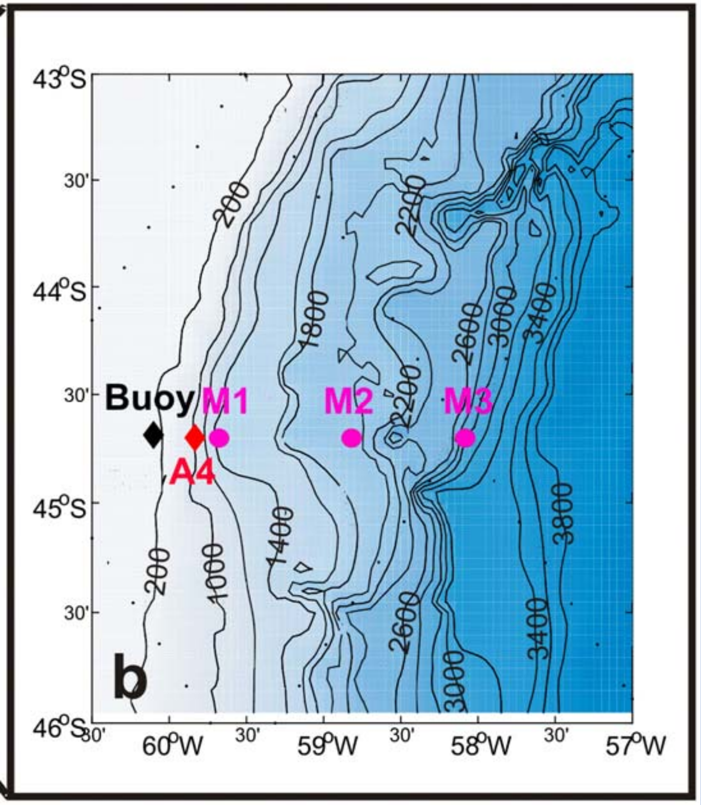
- Gridded data works better than along-track
- Best correlation when in-situ data are lowpass filtered at 20days-1
- M11 and M31 not correlated





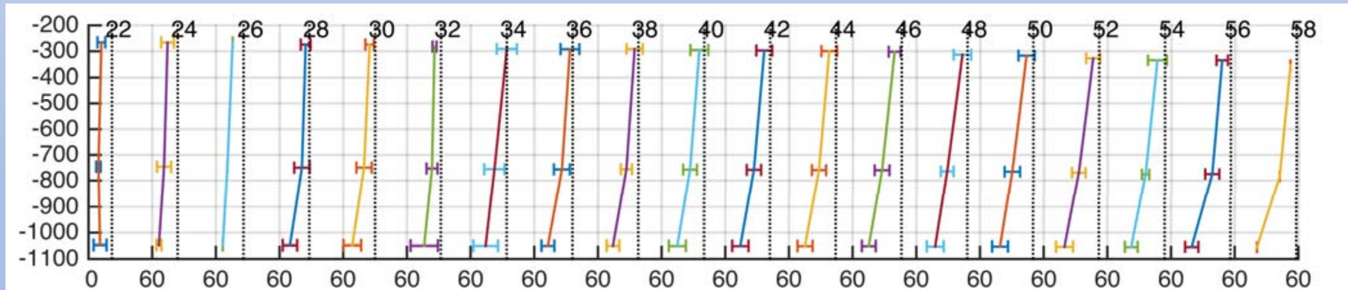
- Oscillating jet-like structure more centered on M1

- Blocking events

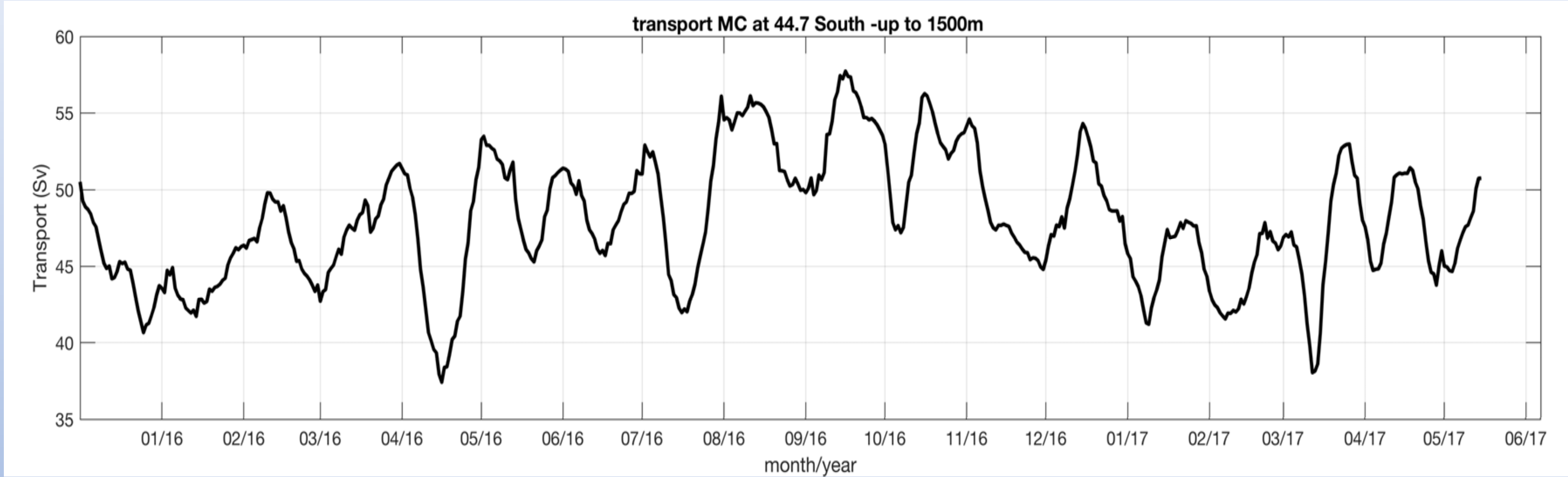


Transport estimation

- look-up table constructed with in situ data
- Satellite altimetry used along the whole section
- Computed in the top 1500m



Transport time series while measuring in-situ



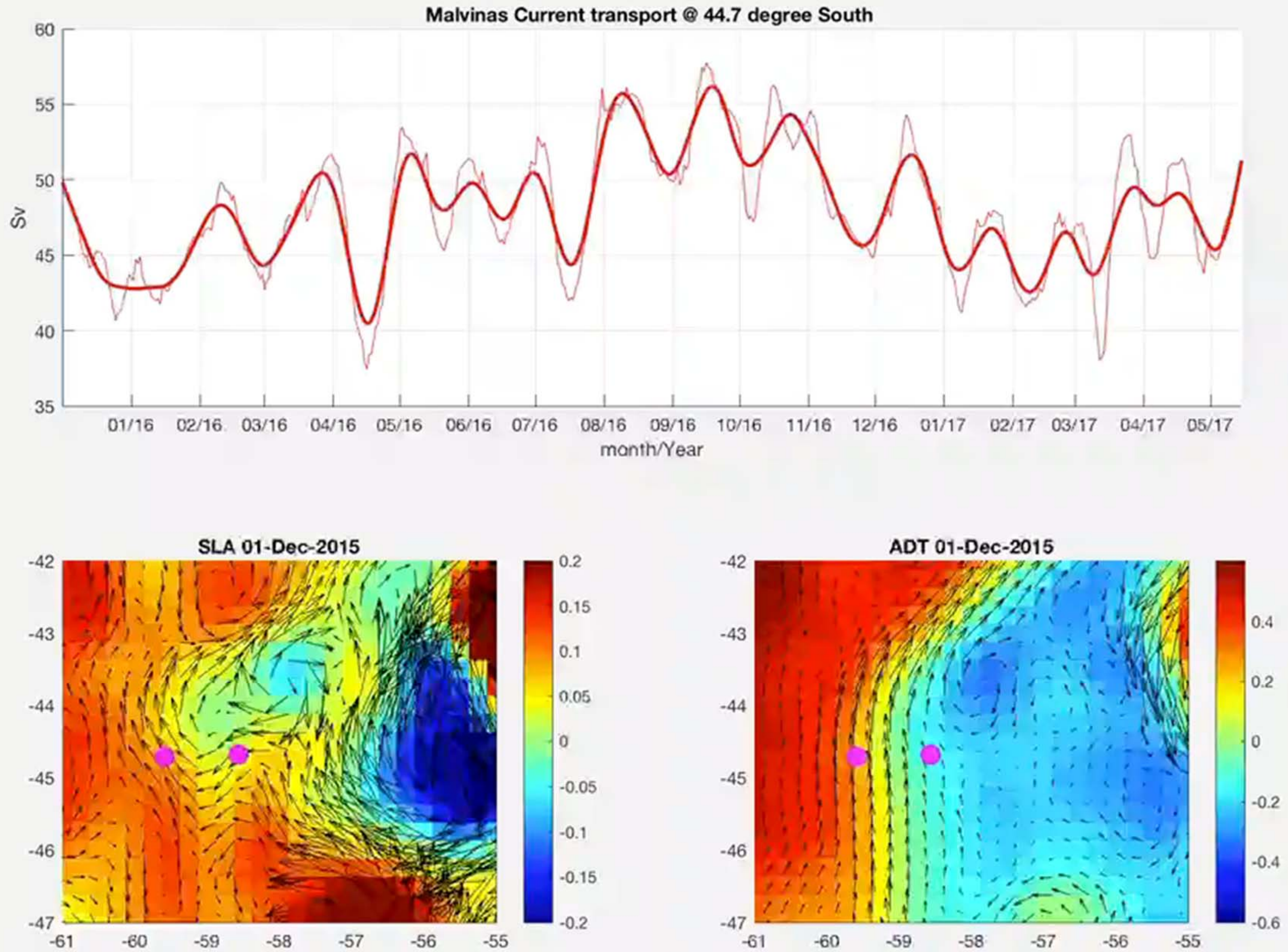
Mean: 48 Sv
Standard deviation: 4.1 Sv

Annual cycle?
Sub-seasonal oscillations

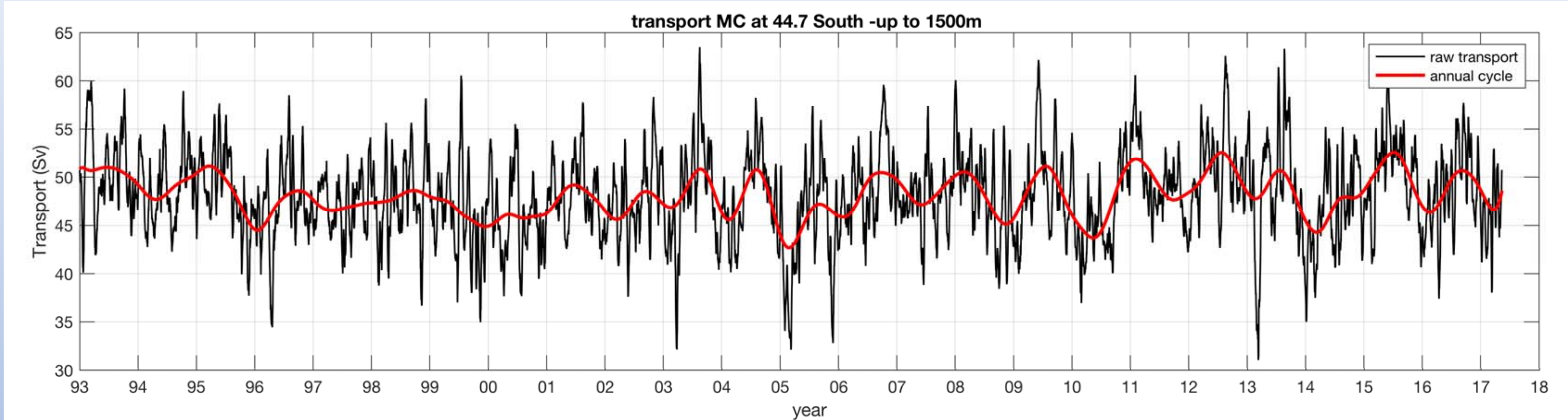
Sub-seasonal oscillations

- large interaction between MC and eddies

- origin of the eddies?



26-years transport time series at 44.7 South



Mean: 48 Sv
Standard deviation: 4.6 Sv

26-years transport time series at 44.7 South

Periodicities (days):

38

75

94

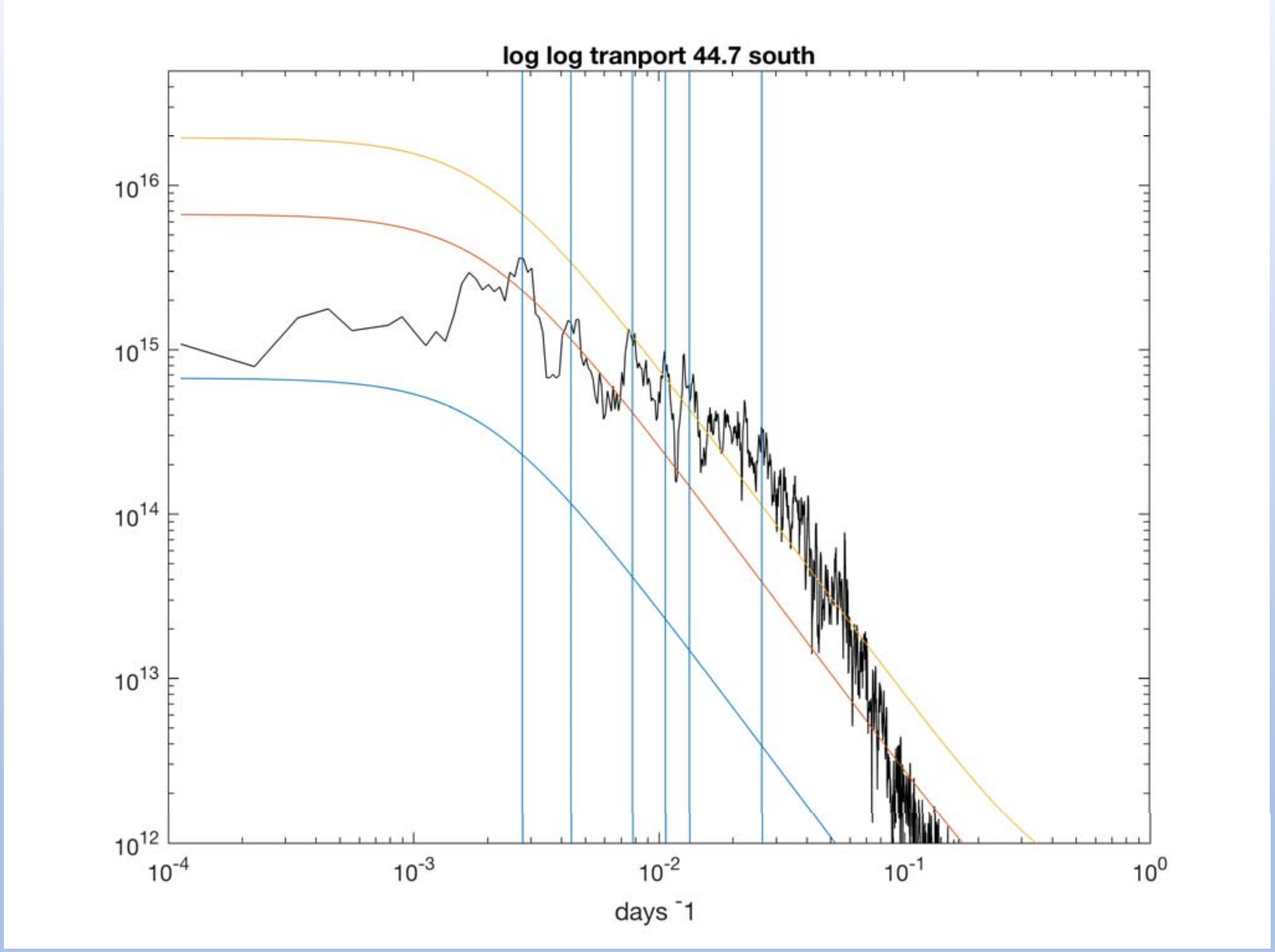
128

228

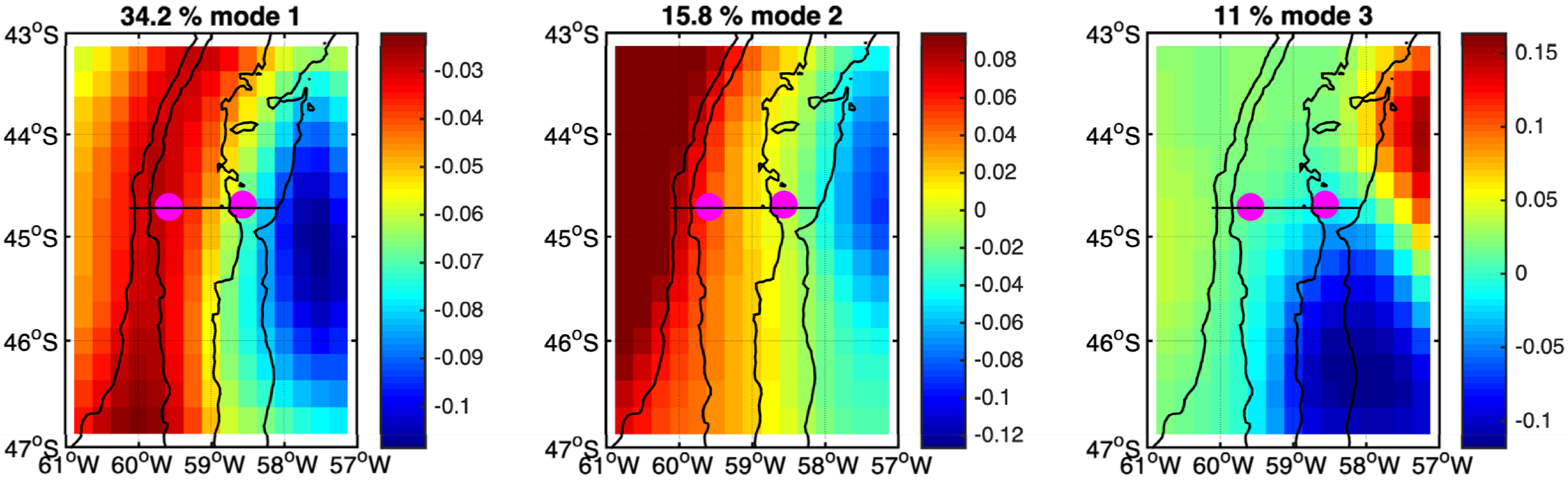
365

Annual cycle not significant. Probably because it is not always present.

Significant periodicities at 38, 75 and 128 days



EOF SLA 1993-2018

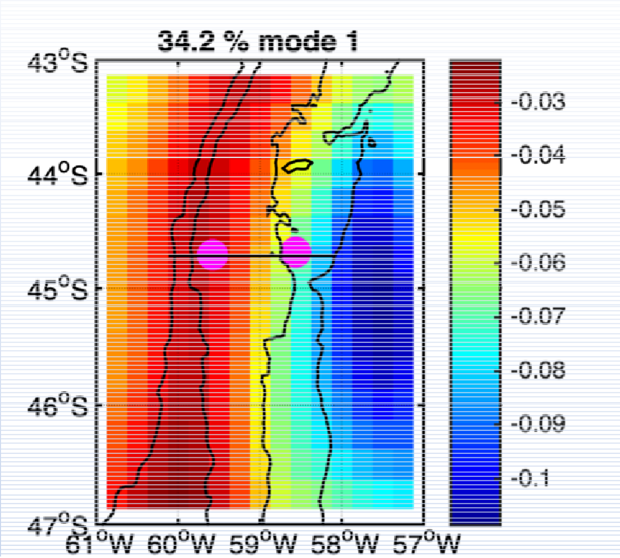


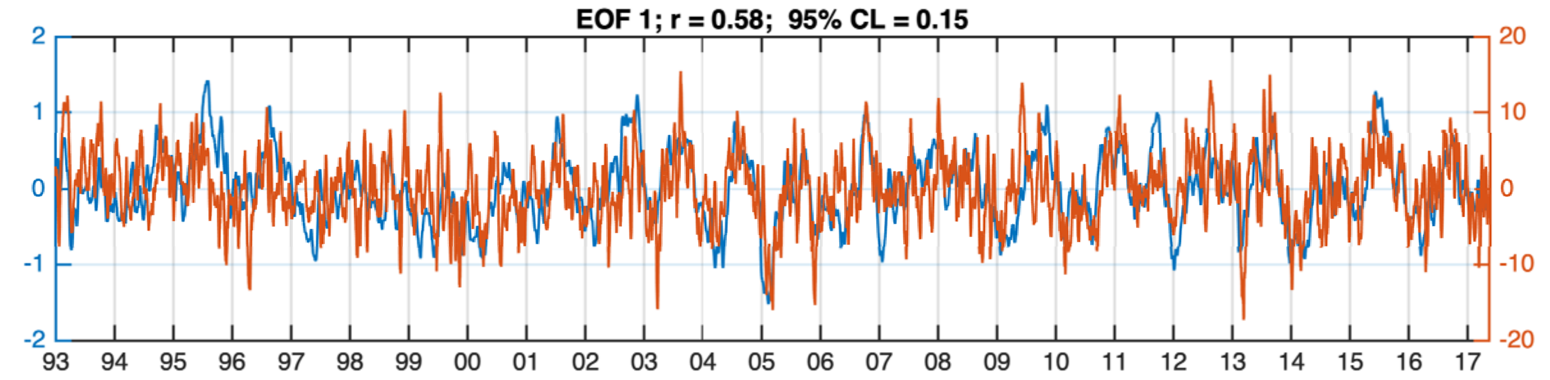
1st mode:
- all negative values
- Large values indicate influence of eddies on the East of the MC

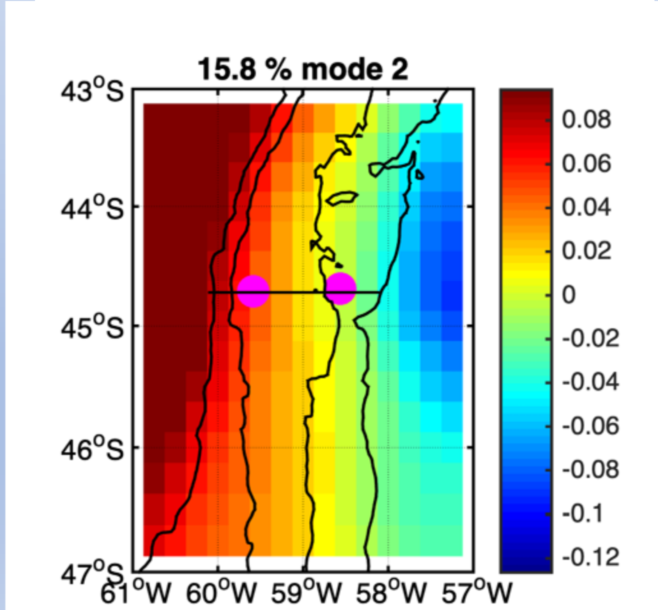
2nd mode:
- positive and negative values
- Large values indicate influence of the continental shelf and of eddies on the East of the MC

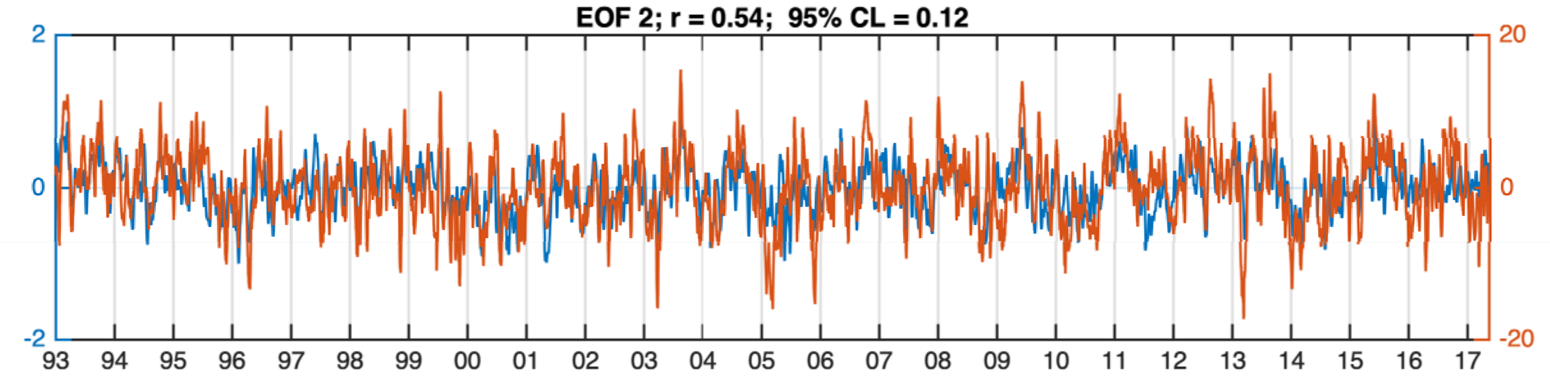
3rd mode:
- Positive and negative values
- Dipole that possible affects more cross-shelf currents

EOF vs transport





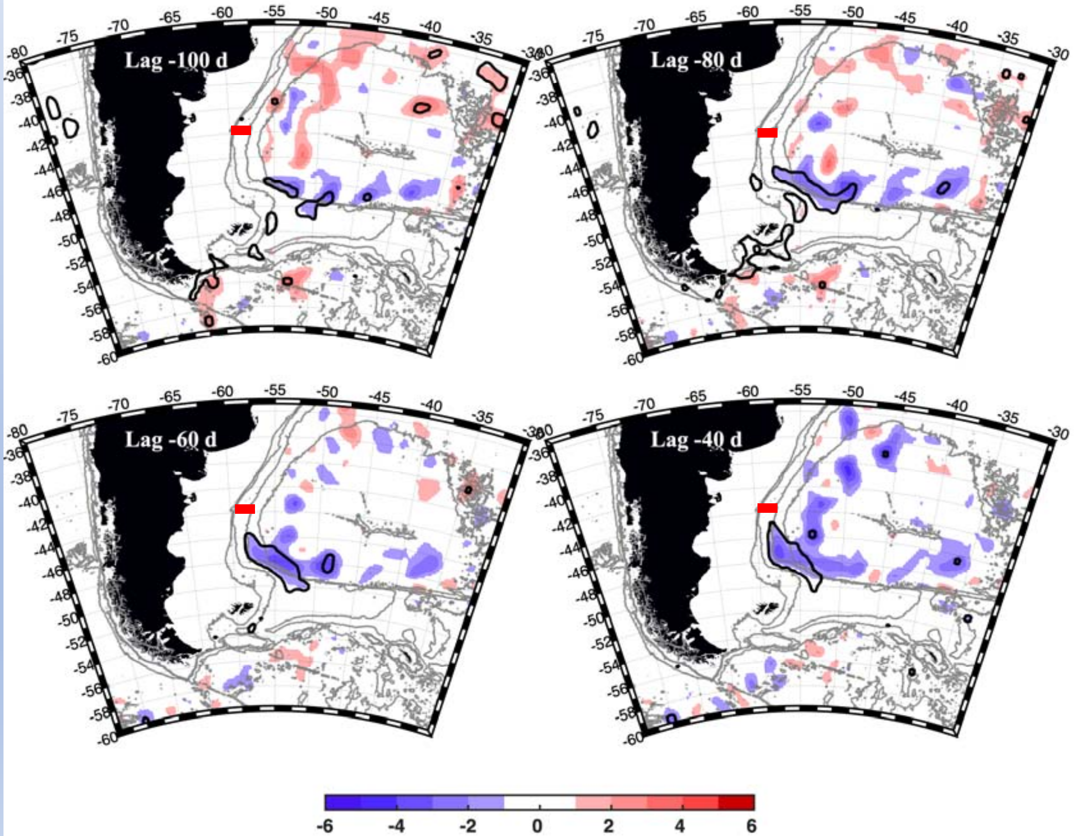


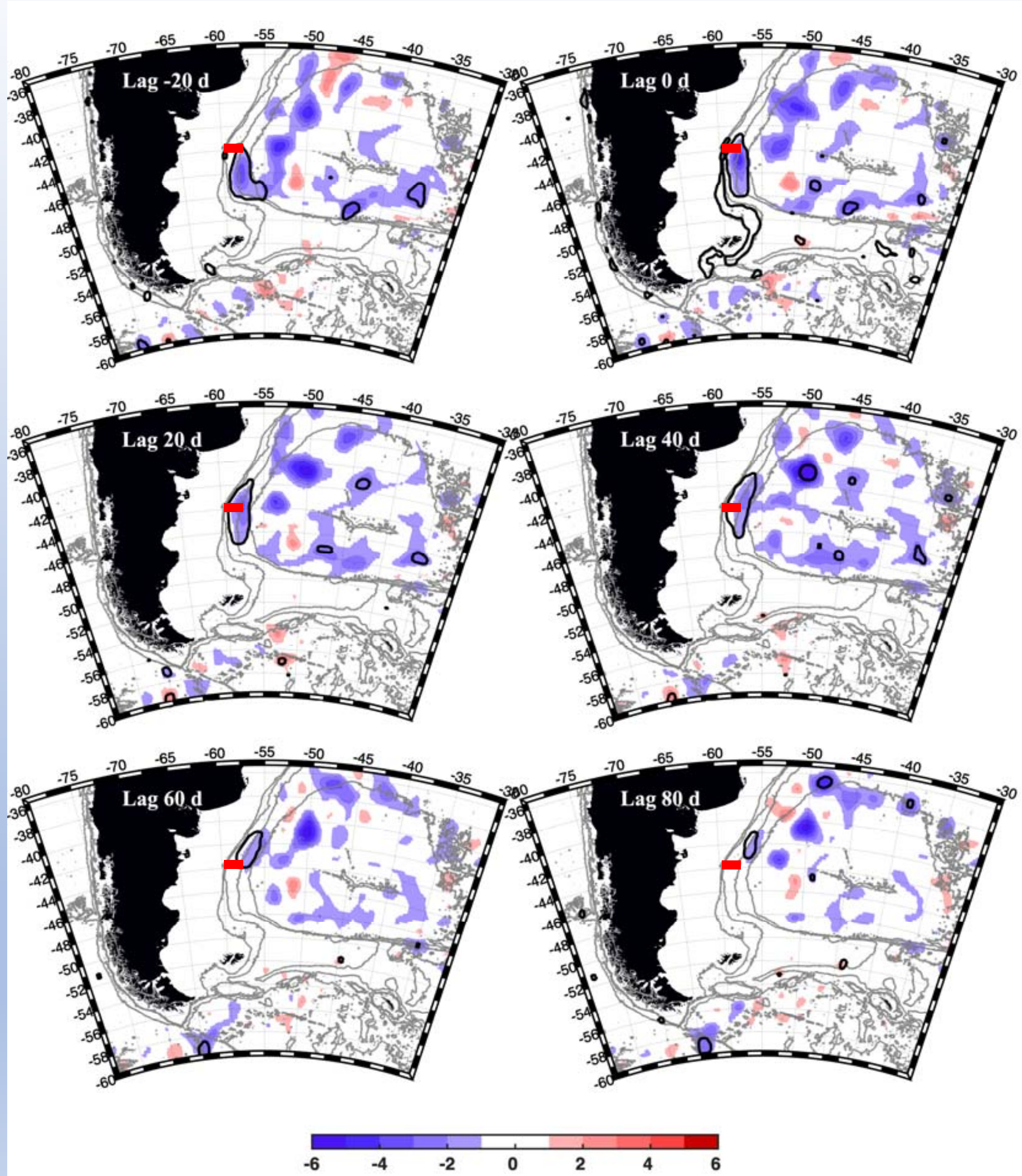


EOF 1: more correlated with transport at sub-seasonal time scales (eddies)
EOF 2: more correlated with transport at higher frequencies (coastal trapped waves)
3rd mode not correlated with transport

Regression at different lags between SLA and transport

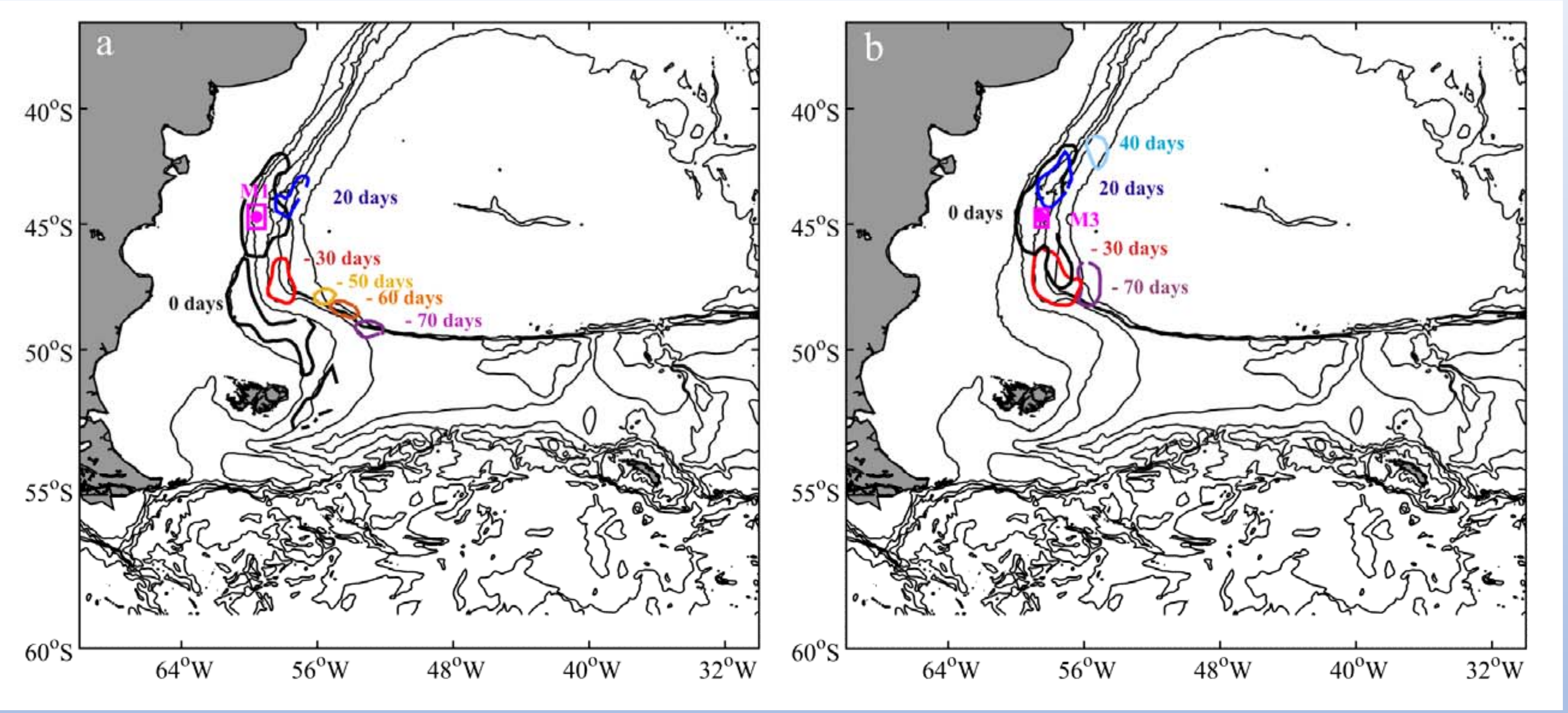
- SLA that affect the transport of the MC at 44.7S propagate from the south along the shelf-break



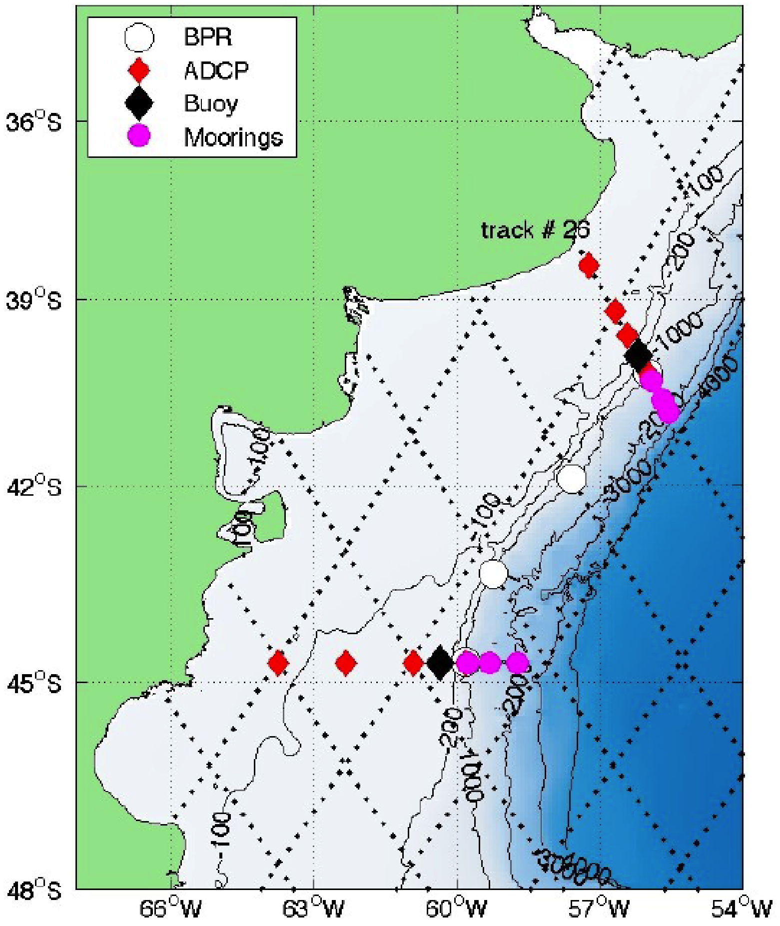


Regression at different lags between v at M1 and M3 and SLA

- Propagation of SLA that affect v at M1 and M3 along the shelf-break (~3000m isobath)
- Faster coastal trapped waves not detected with satellite altimetry correlate at lag 0 with M1 (~1000m isobath)



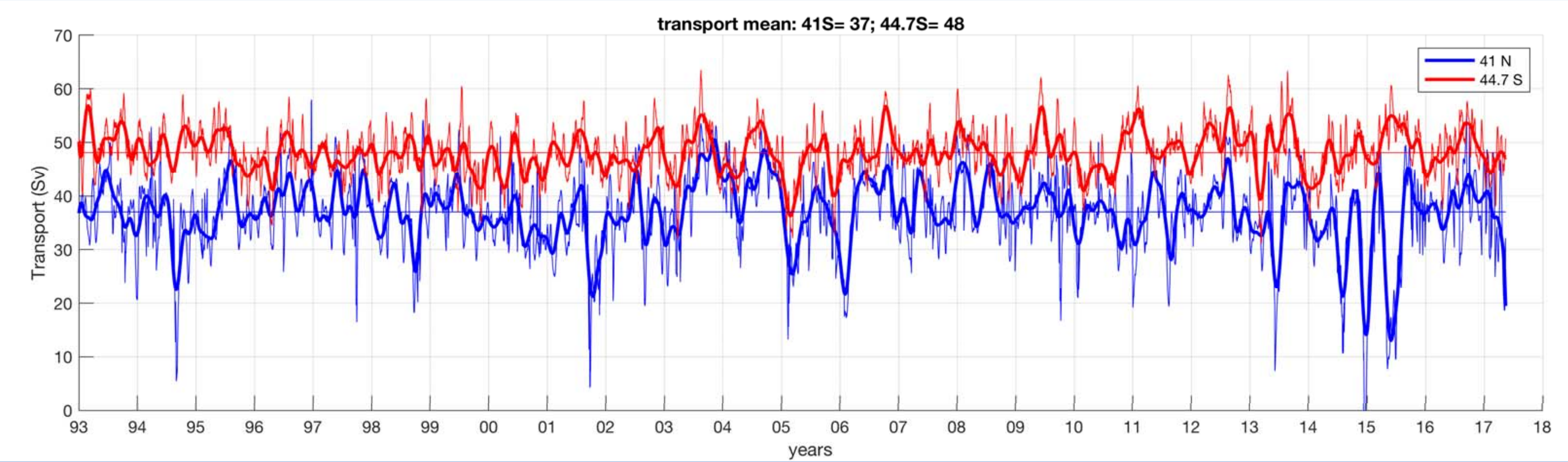
MC comparison at the norther and southern array



MC @ southern and northern arrays correlates very well with satellite altimetry

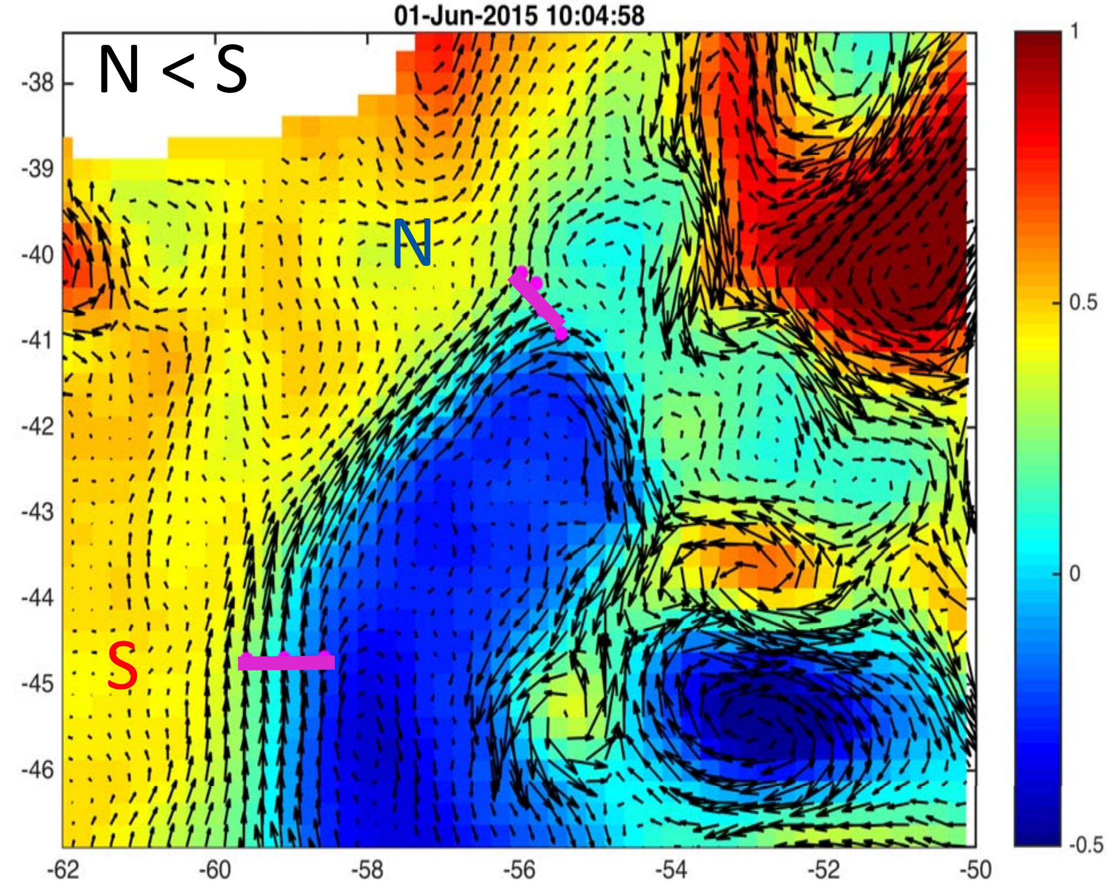
Then, we can compare MC velocities at the N and the S sections with confidence, despite we didn't measure at the same time

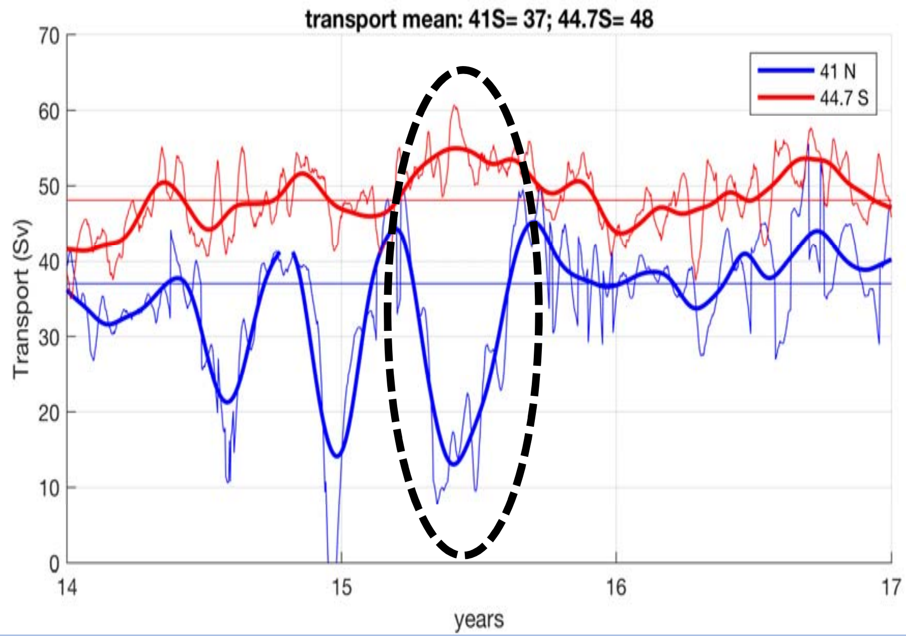
MC comparison at the norther and southern array



- Both transport in the top 1500m
- MC at 41S > MC at 44.7S
- Difference in mean can be due to different width of the MC:
    - Length section at 41S: 104km
    - Length section at 44.7S: 154km
- Largest differences are due to excursions of the MC at 41S forced by Brazil Current

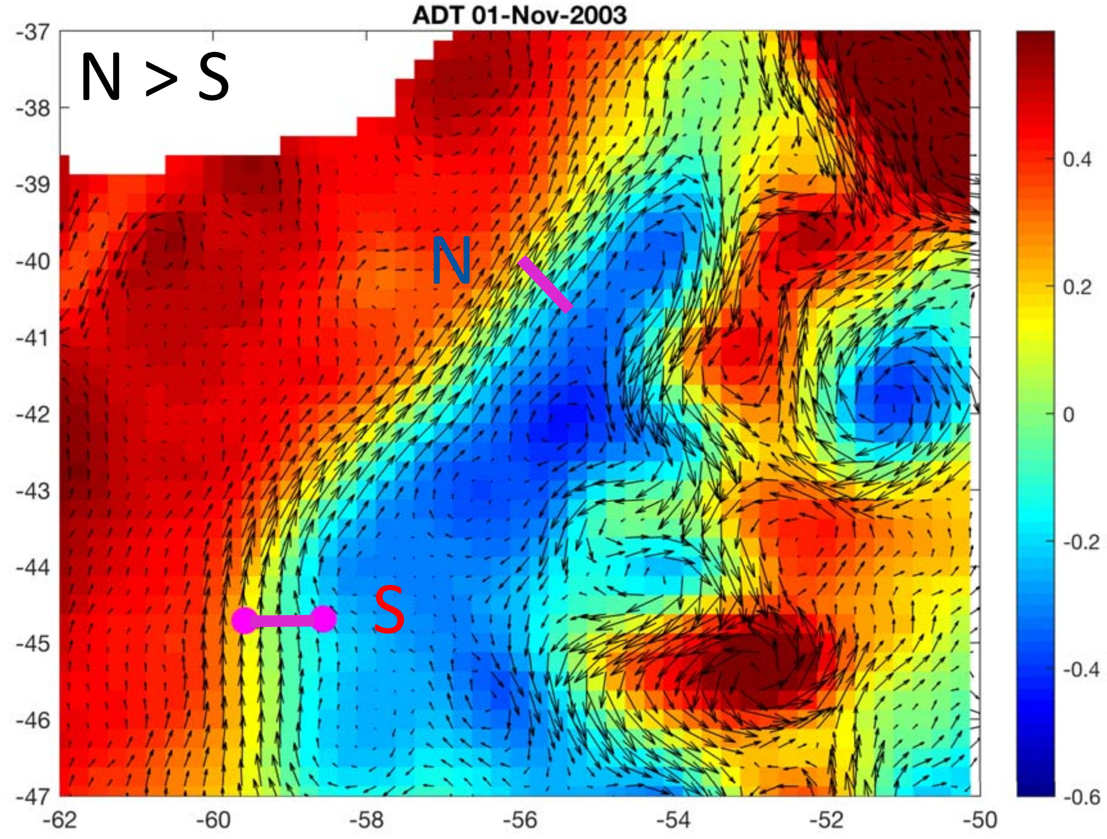
Altimetry along shelf-break mean velocities @ North & South CASSIS deployments

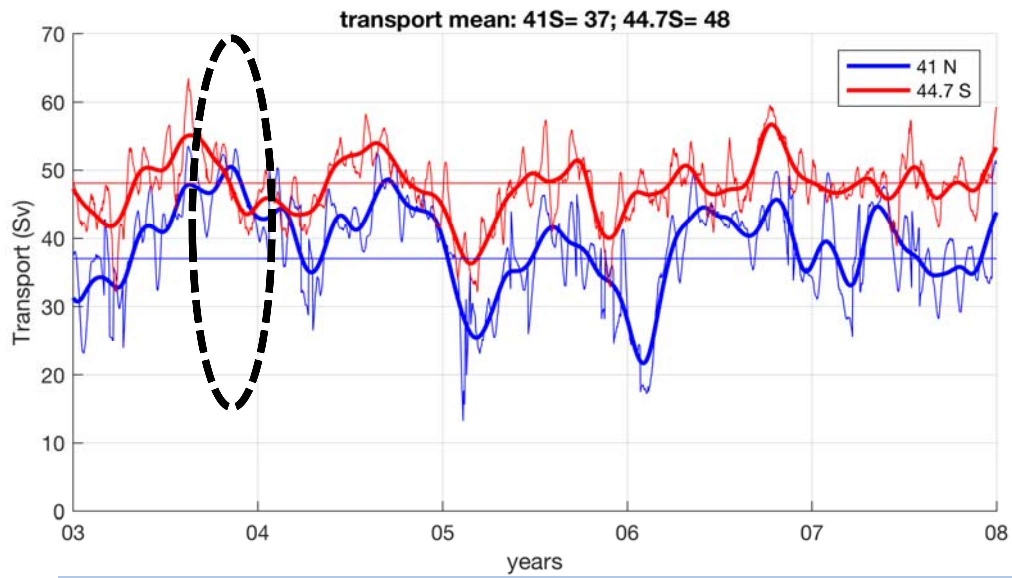




N<S: MC deflect SW

Altimetry along shelf-break @ North & South CASSIS deployments





N>S: recirculation cell in the N and/or blocking in the S

Summary of results (1/2)

- ✓ Malvinas Current transport measured at 44.7 south (1st time)
- ✓ Satellite altimetry allows to extend the time series and investigate the origin of the variability
- ✓ Large oscillations due to:
  - ✓ Coastal trapped waves propagating along the shallowest portion of the shelf-break
  - ✓ SLA propagating from the Argentine Basin
- ✓ No trend

Summary of results (2/2)

- ✓ Large interannual variability
- ✓ Comparison between transport measured at 41S and 44.7 show large differences:
  - ✓ Mean transport at 44.7S > than transport at 41S
  - ✓ Largest differences are due to retroflection of the MC
  - ✓ Complex interaction between MC and oceanic mesoscale

Thank you for your attention

Acknowledgments

- To the crew of Puerto Deseado and SBE-15 Tango
- To all the people that helped and supported
- To funding agencies (CNES, CONICET, Mincyt, FYPF, SHN)