Exploring synergy between satellite ocean color and salinity observations near the Amazon outflow

Doug Vandemark[1], Séverine Fournier[2], Nicolas Reul[2], Joseph Salisbury[1] and Bertrand Chapron[2]

[1]University of New Hampshire, Durham, NH, USA
[2]Laboratoire Océanographie Spatiale, IFREMER

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Large rivers, an important part of the freshwater cycle (E-P-R and MLD)

- Surface freshwater (R) can impact air-sea interactions by modifying :
  - open ocean SSS (& density)
  - buoyancy flux, vertical stratification, and barrier layers

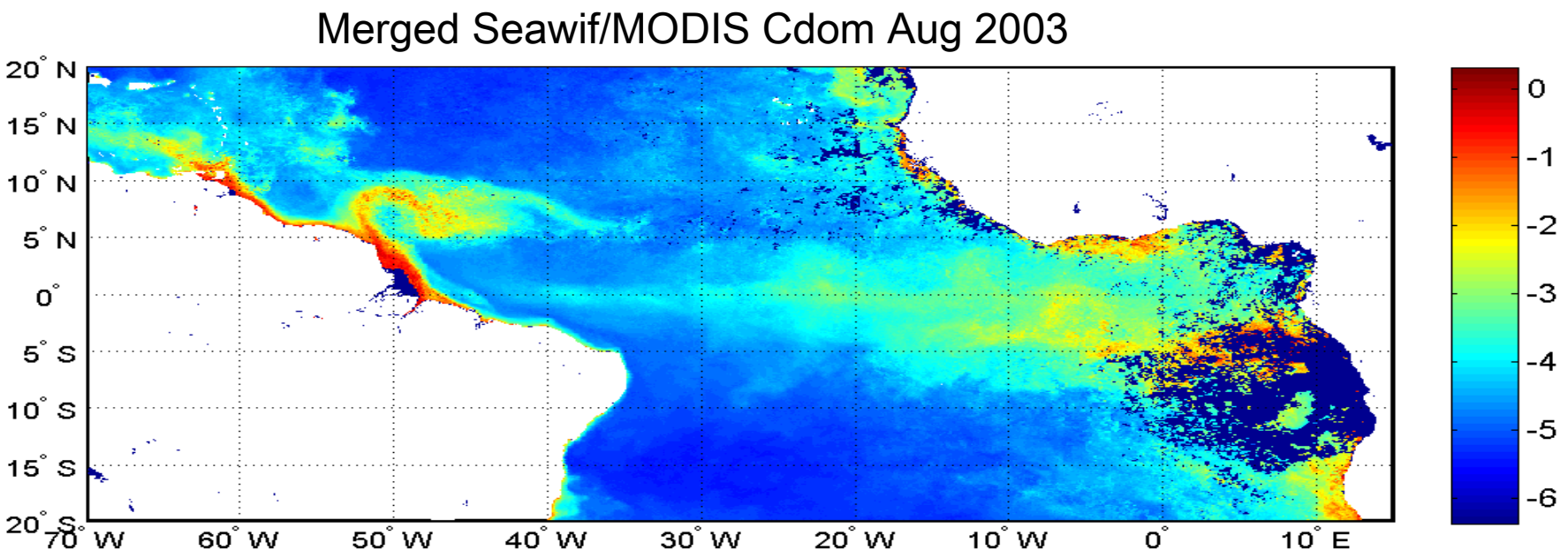
→ Large Rivers : important factor in upper ocean processes

- Sources of organic & inorganic materials which have a key role in many biological, physical, and chemical processes

→ Rivers represent key hydrological controls of biogeochemistry including productivity and air-sea CO2 flux

- Case in point, the Amazon River plume : the world's largest river freshwater discharge source and a good satellite test-bed

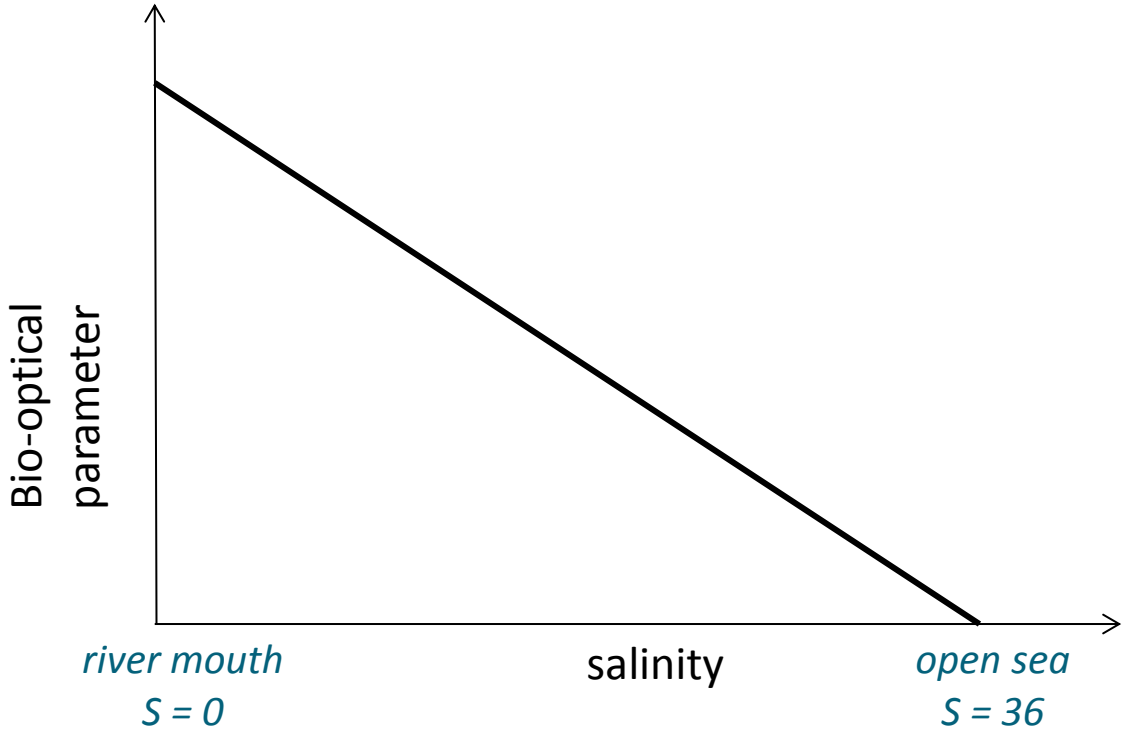
Ocean color long known to see the rivers



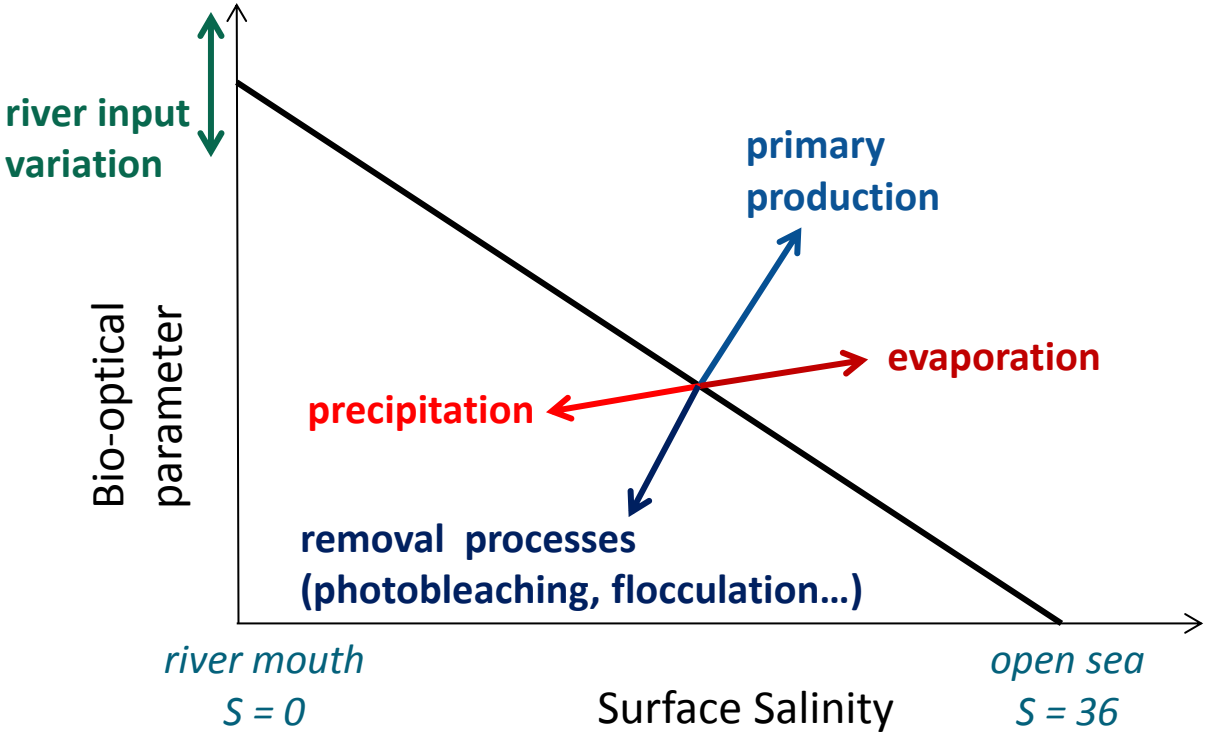
Conservative Mixing of Plume Waters

- SSS vs. optical properties ⟹ conservative mixing
- A well known inverse correlation in SSS/light absorption and SSS/light attenuation

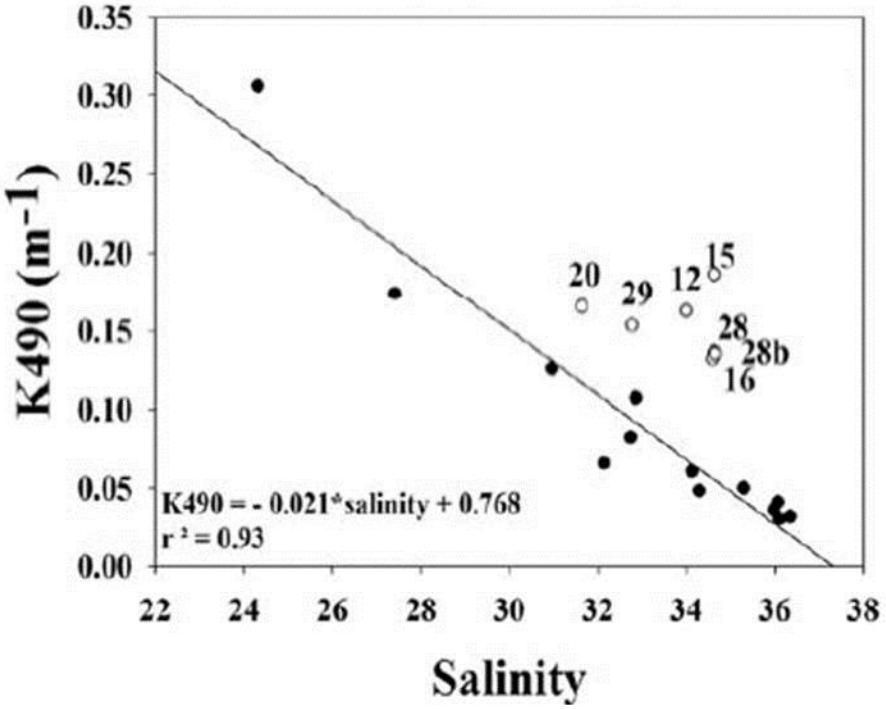
(Hu et al. 2004, Del Vecchio & Subramaniam 2004, Molleri et al. 2010, Salisbury et al., 2010)



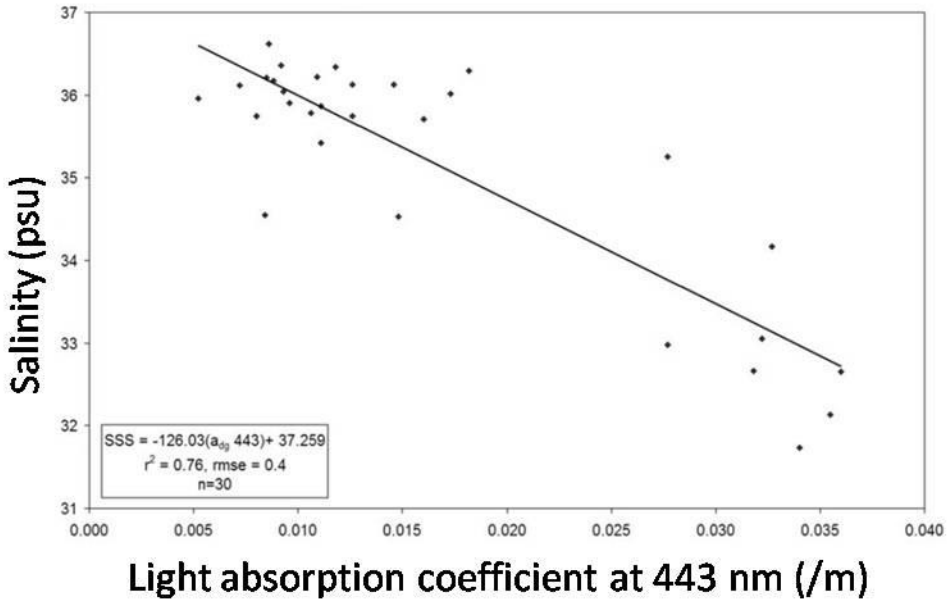
- Possible deviations from this conservative mixing :
  - Physical processes
  - Bio-optical & bio-chemical processes



- Up to now, the monitoring of the Amazon River plume and of the conservative mixing were limited due to a lack of joint SSS/optical properties observations



Del Vecchio and Subramaniam, 2004

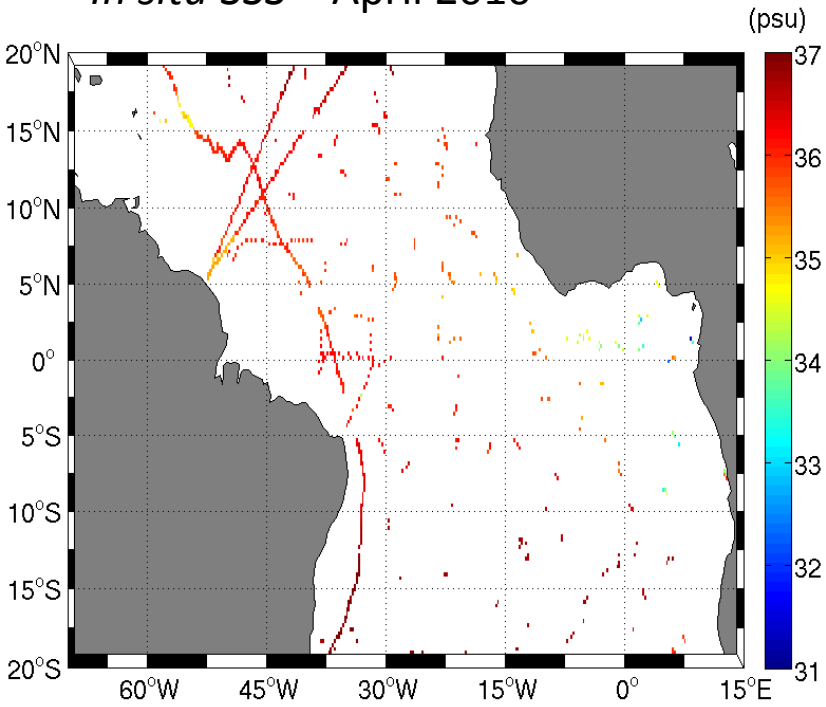


Molleri et al, 2010

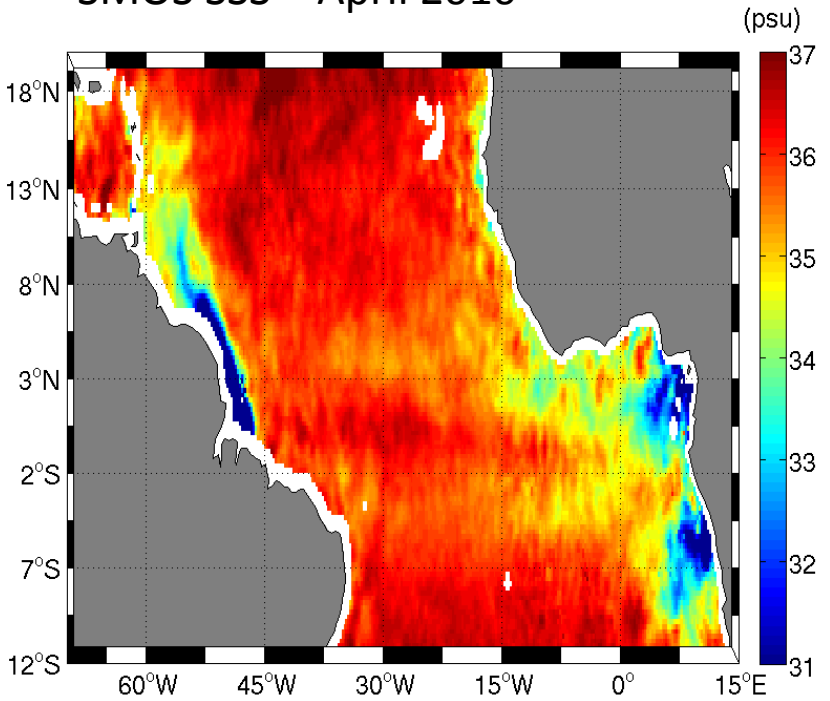
- Since 2010, L-band spaceborne measurements of SSS are available for the first time from SMOS & Aquarius

➡ unprecedented SSS spatial & temporal resolution

In situ SSS – April 2010



SMOS SSS – April 2010



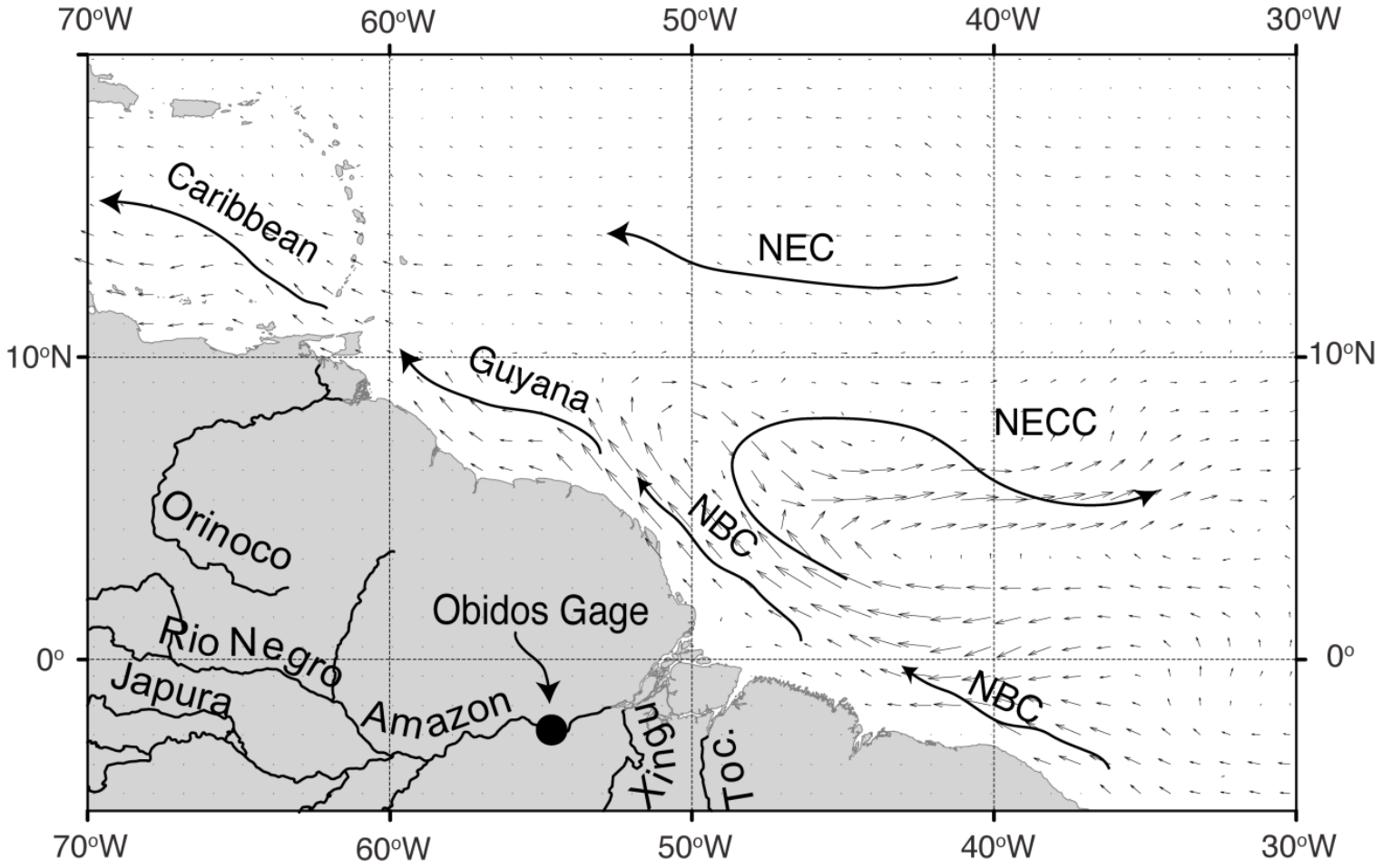
Objectives

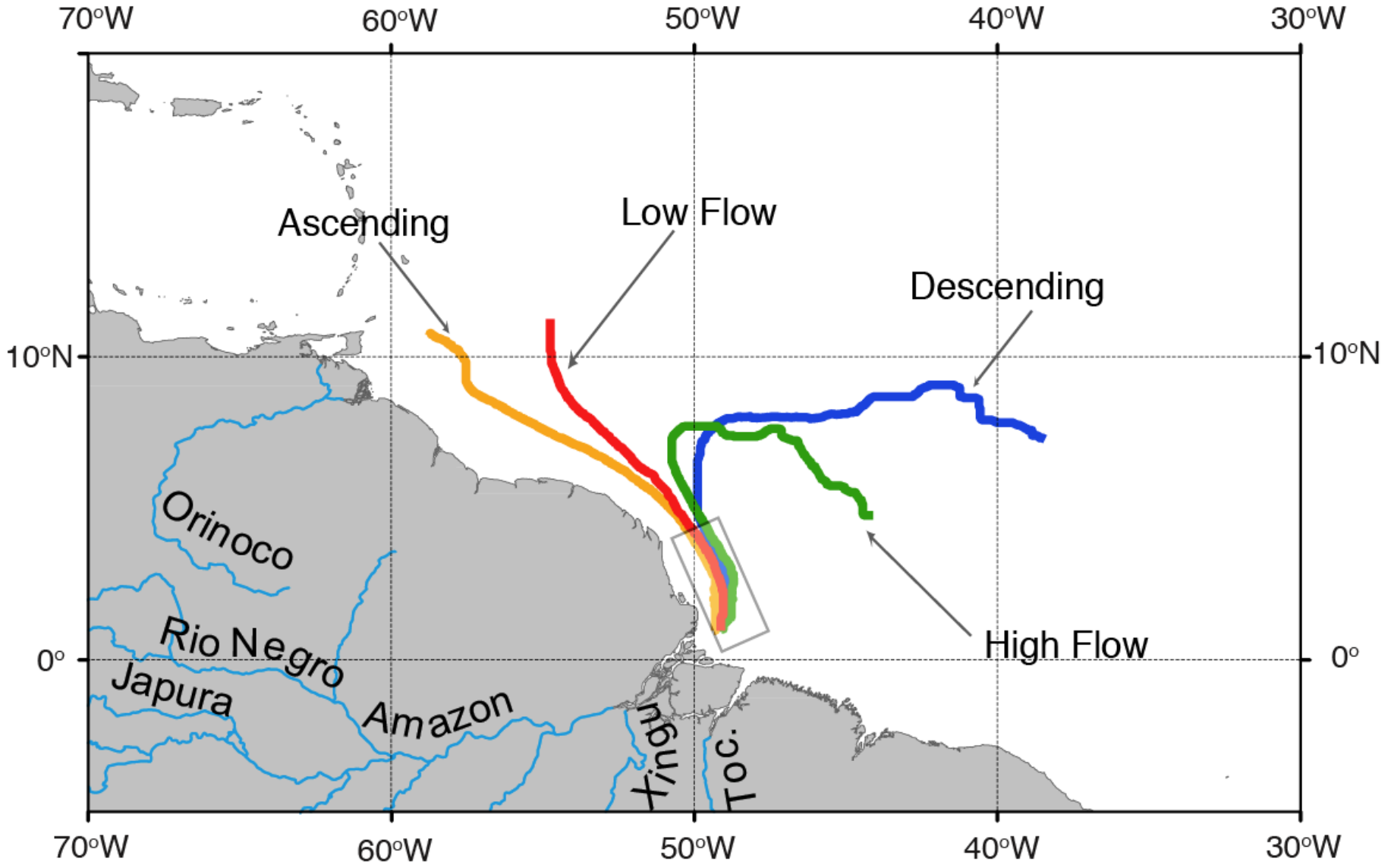
- Investigate **new monitoring methods** for tracking oceanic freshwater generated by Amazon discharge
- Detect potential **seasonal variation in conservative mixing** as derived from the satellite SSS and Ocean Color properties
- Investigate **non-conservative behaviour** - can ocean color actually provide well-behaved passive tracers?
- Estimate **SSS at high spatial resolution** (*O*(4 km)) using ocean color data blended with L-band measurements

Study Datasets

- **SMOS SSS**: 10-day daily running mean, 0.25 degree resolution (CATDS CEC products)
- **O COLOR - MERIS/MODIS/SeaWIFS CDM** absorption: 10-day daily running mean, 4-km resolution (GlobColour ACRI-ST)
- ***In situ* SSS** (ARGO, IRD, various research campaigns)
- **ORE HYBAM** Amazon & Orinoco discharges at Obidos & Bolivar river discharge gauges
- **O Color -** 8-day Carbon based Production Model (CbPM) **Net Primary Productivity (** from OSU, Behrenfeld)

Amazon Plume & Regional Currents



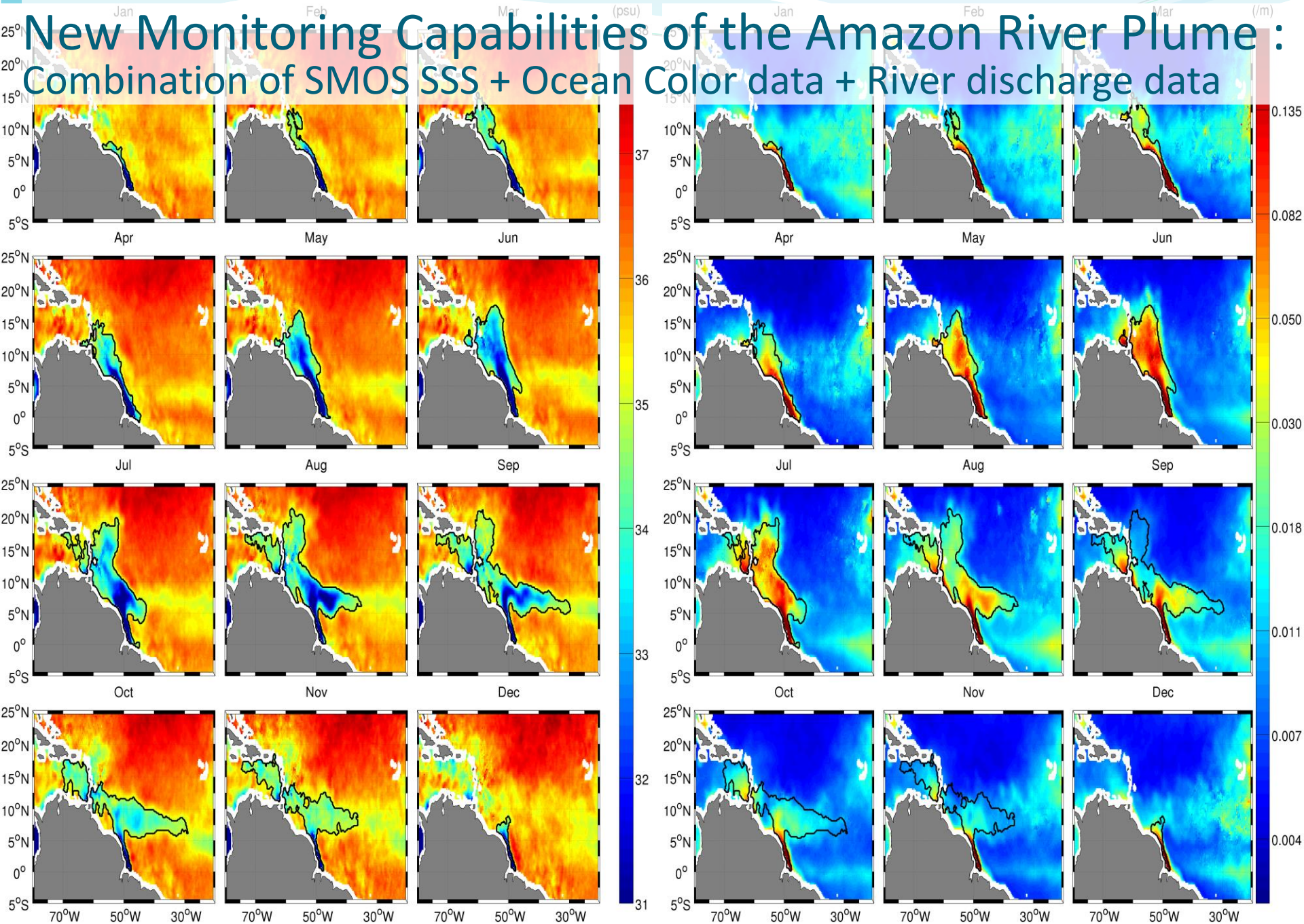

70°W
60°W
50°W
40°W
30°W
10°N
0°
Ascending
Low Flow
Descending
High Flow
Orinoco
Rio Negro
Japura
Amazon
Xingu
Toc.

Satellite SSS - 2010

GlobColour Acdm - 2010

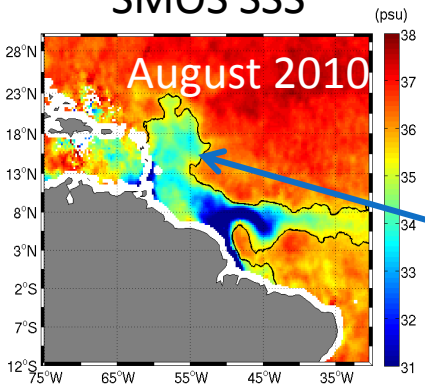
New Monitoring Capabilities of the Amazon River Plume :

Combination of SMOS SSS + Ocean Color data + River discharge data



SMOS plume monitoring vs. measured discharge

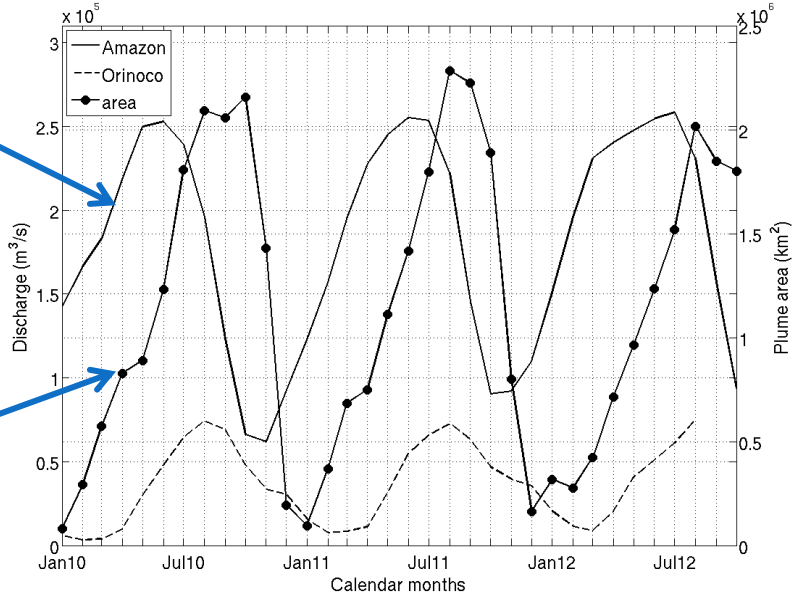
SMOS SSS

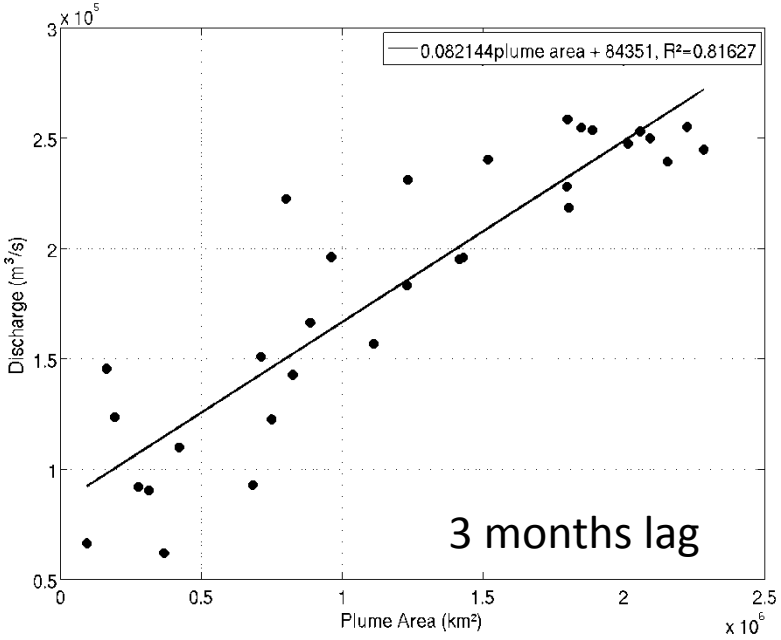


35 psu contour

Amazon discharge

Plume area (35 psu contour)





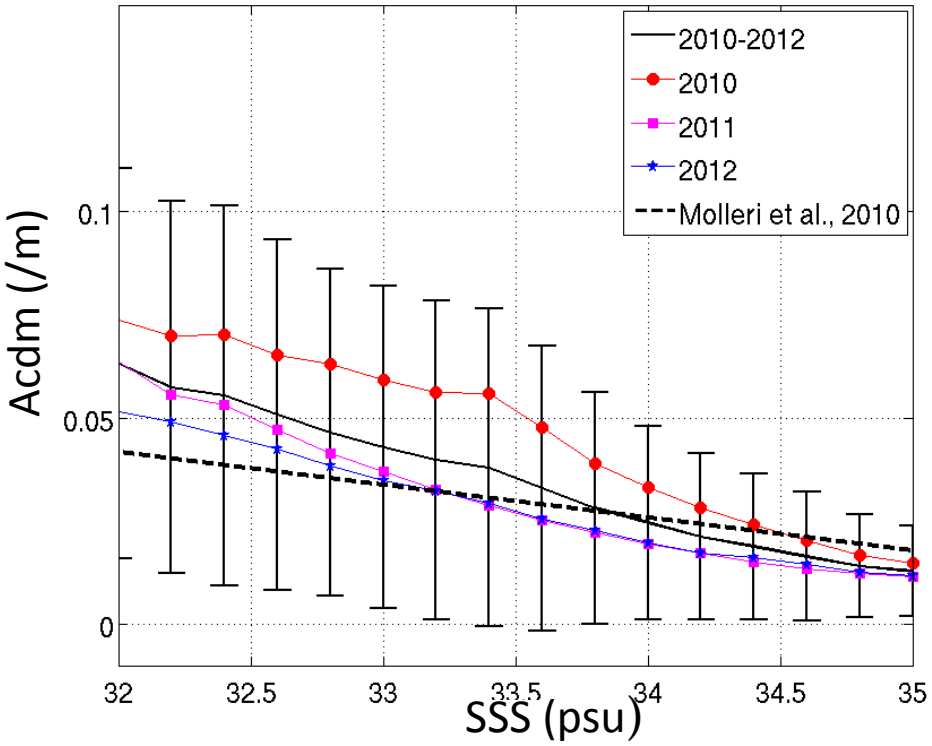
Lagged Amazon plume coverage

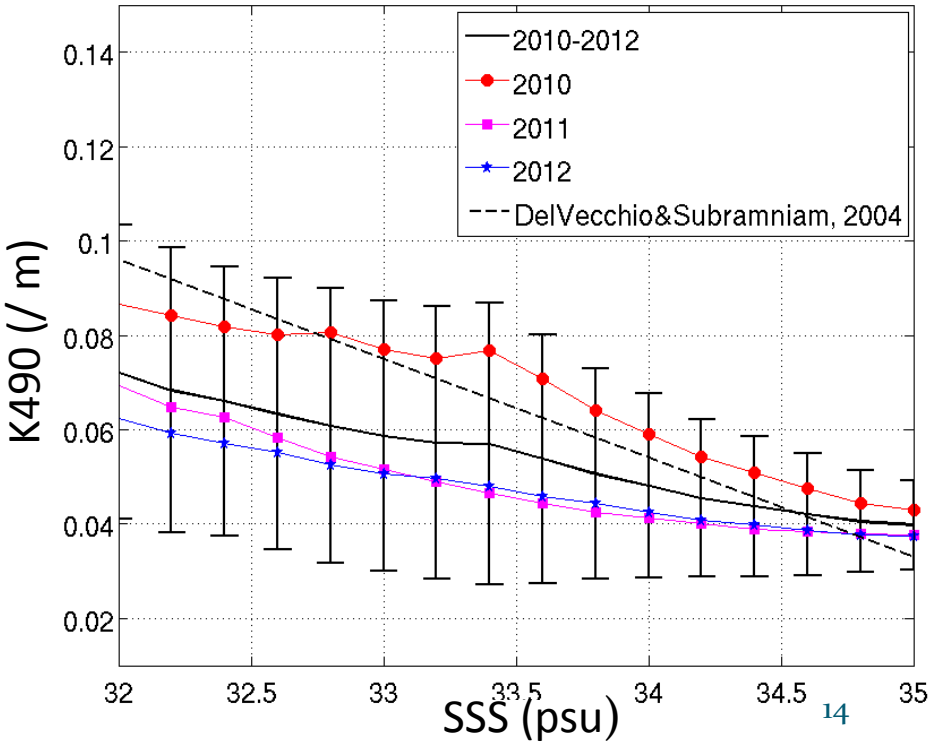
=

Amazon discharge proxy

Evaluating O. color as a passive tracer: SSS, O. Color and the conservative mixing relation

Annual relationships in CDOM and Light attenuation

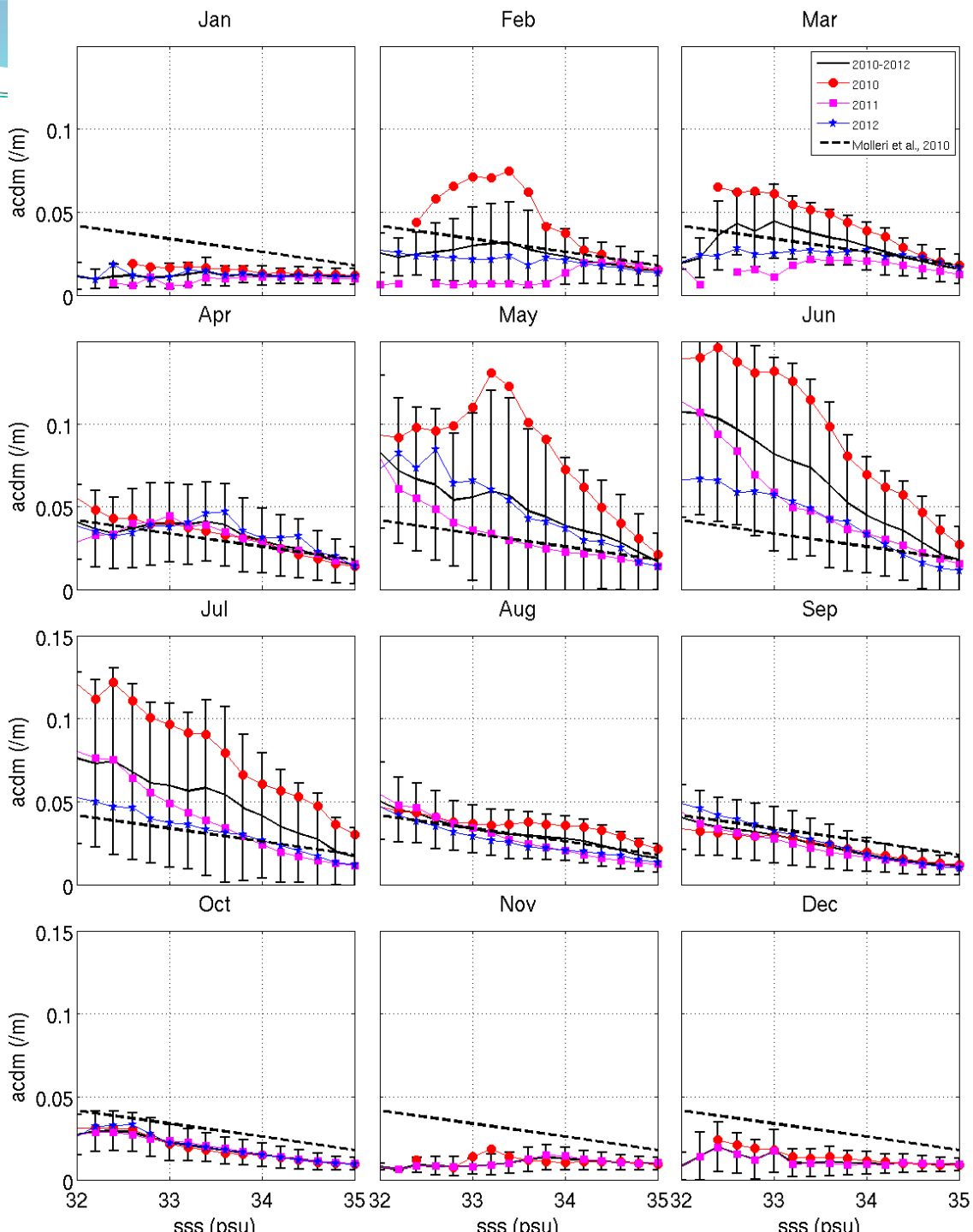




Observed seasonal and interannual variability in SSS vs. a_{CDM}

Sources of these variabilities can be explored in terms of:

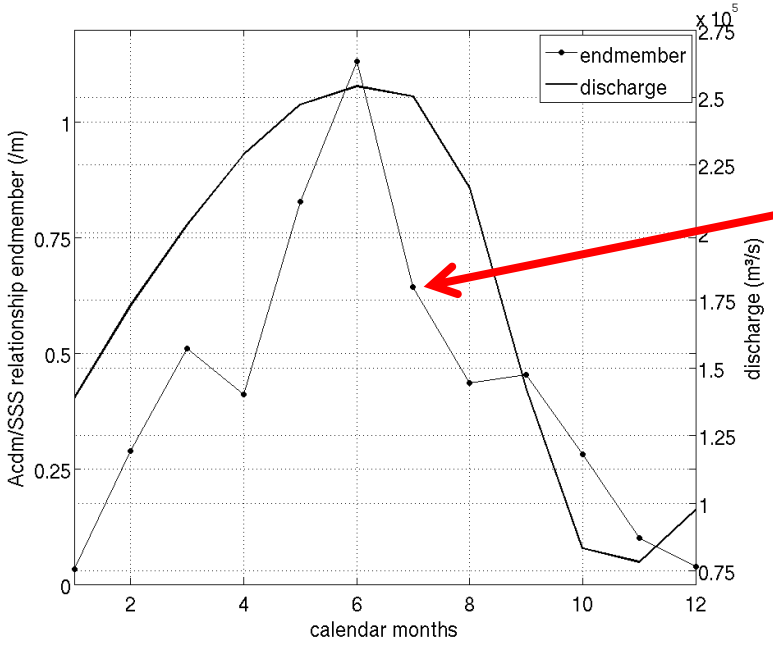
- River cycle (endmember variations, Amazon tributaries)
- Biogeochemical processes (photobleaching, primary production)
- Physical processes (advection, wind, rain)

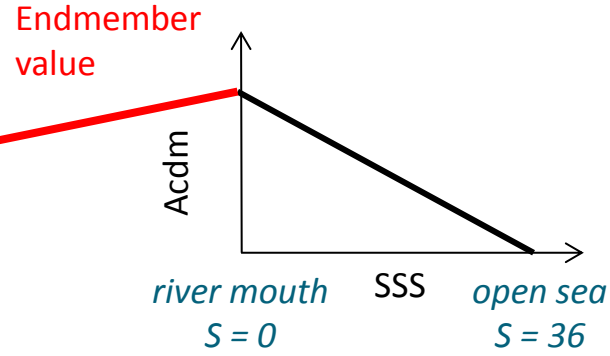


Observed seasonal and interannual variabilities in the SSS vs. a_{CDM} relationship

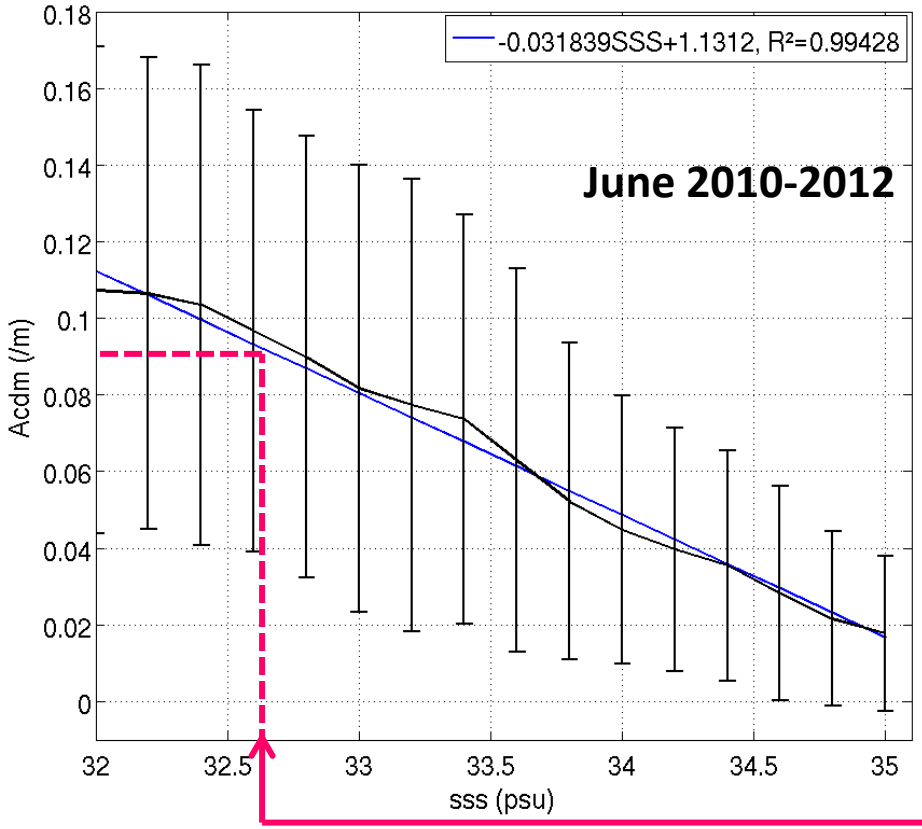
- Amazon discharge in phase with the freshwater (0 psu) endmember of the SSS/a_{cdm} relationship

→ sourcewater organics = main source of the seasonal cycle in the dilution model

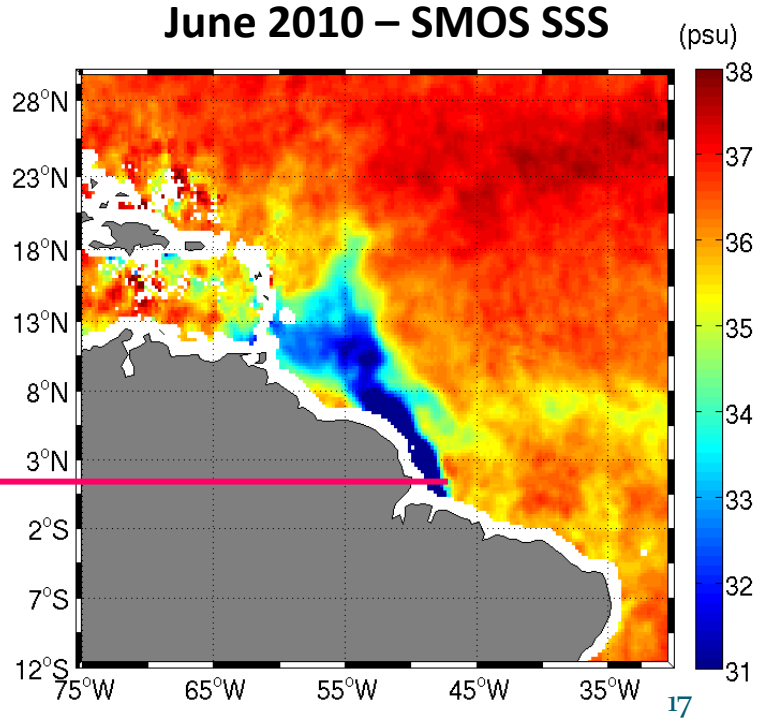




Deviations from the conservative mixing



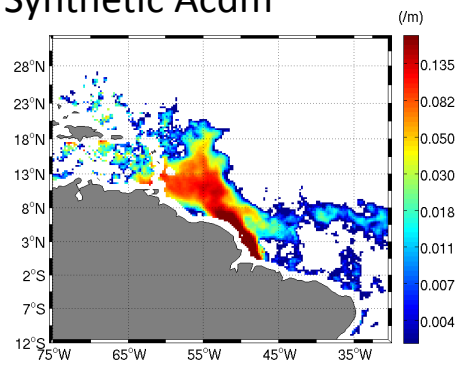
Estimation of Acdm from SMOS SSS and the monthly 2010-2012 SSS/Acdm relationship



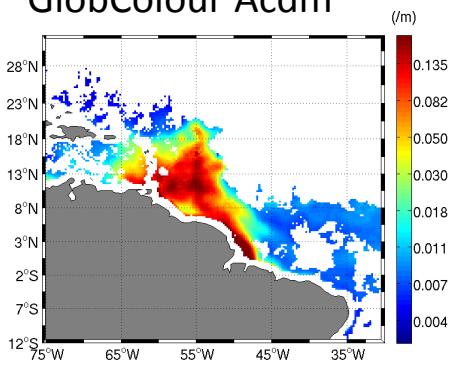
Deviations from the conservative mixing

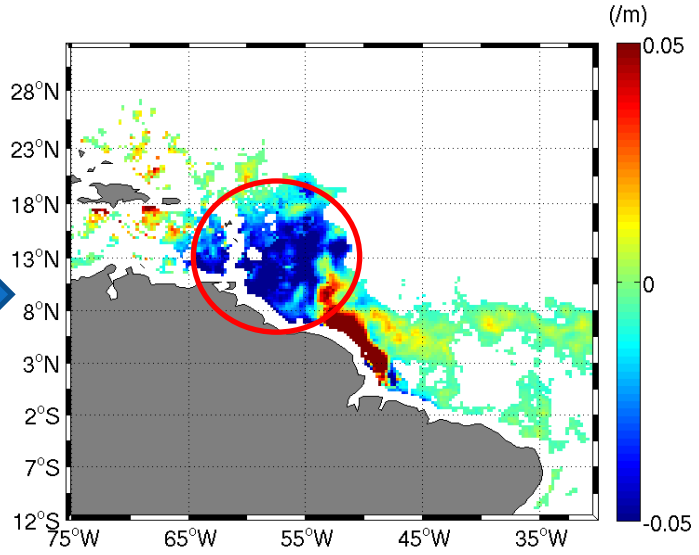
June 2010

Synthetic Acdm



GlobColour Acdm





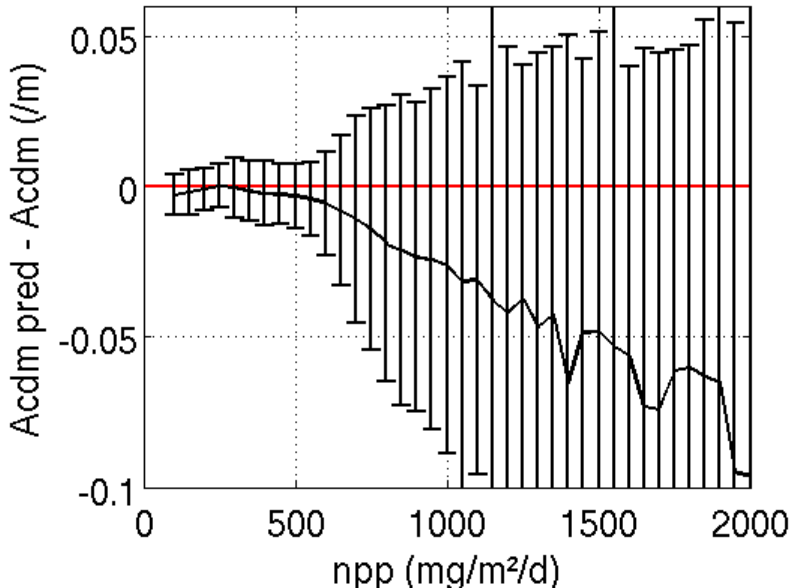
Observe

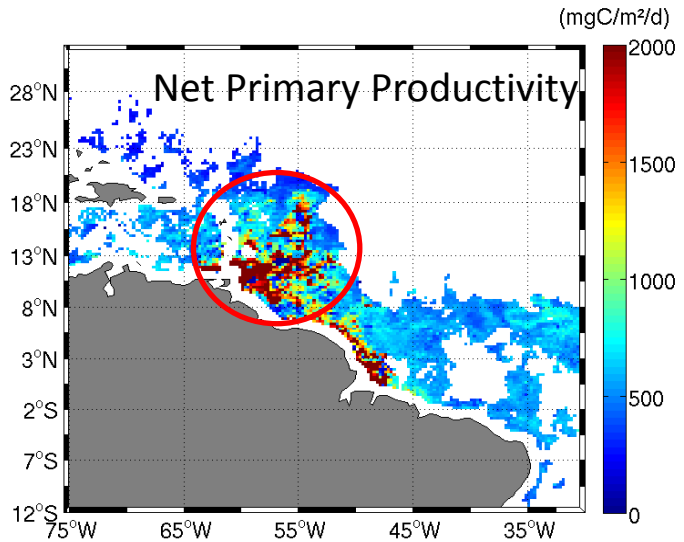
Anoma

Synthetic

Anom

Observe



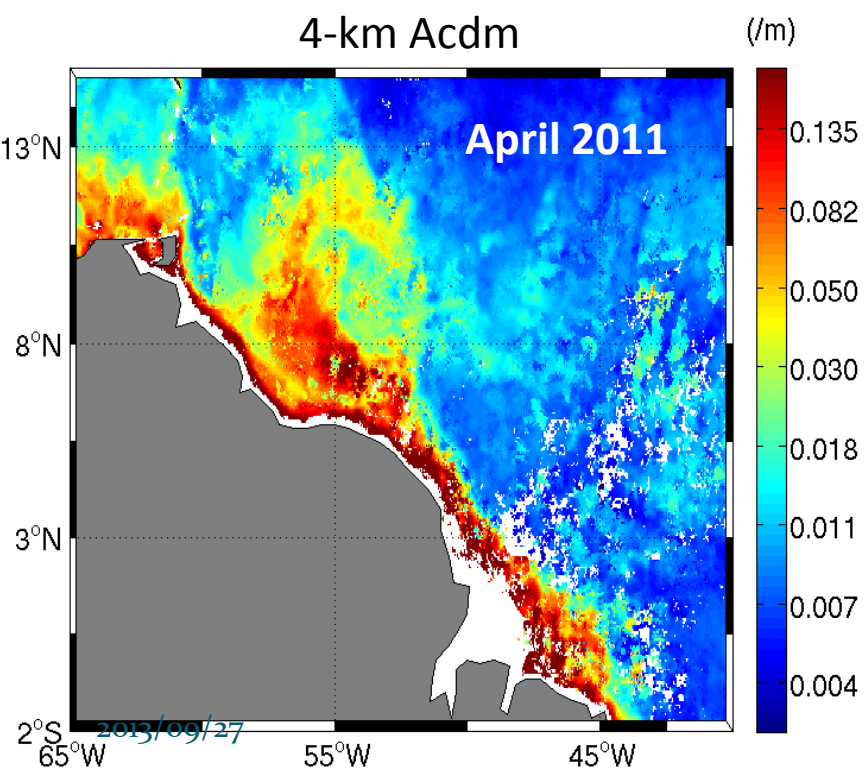


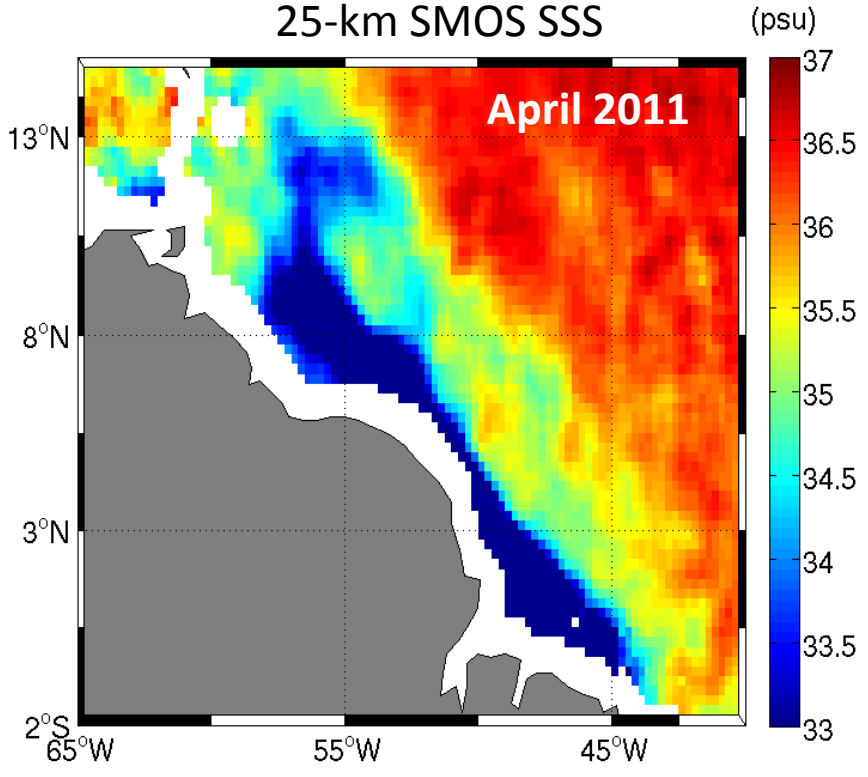
High resolution SSS from Ocean Color?

- Ocean Color sensors : 4 km – SMOS : 25-50 km, Aquarius 100 km

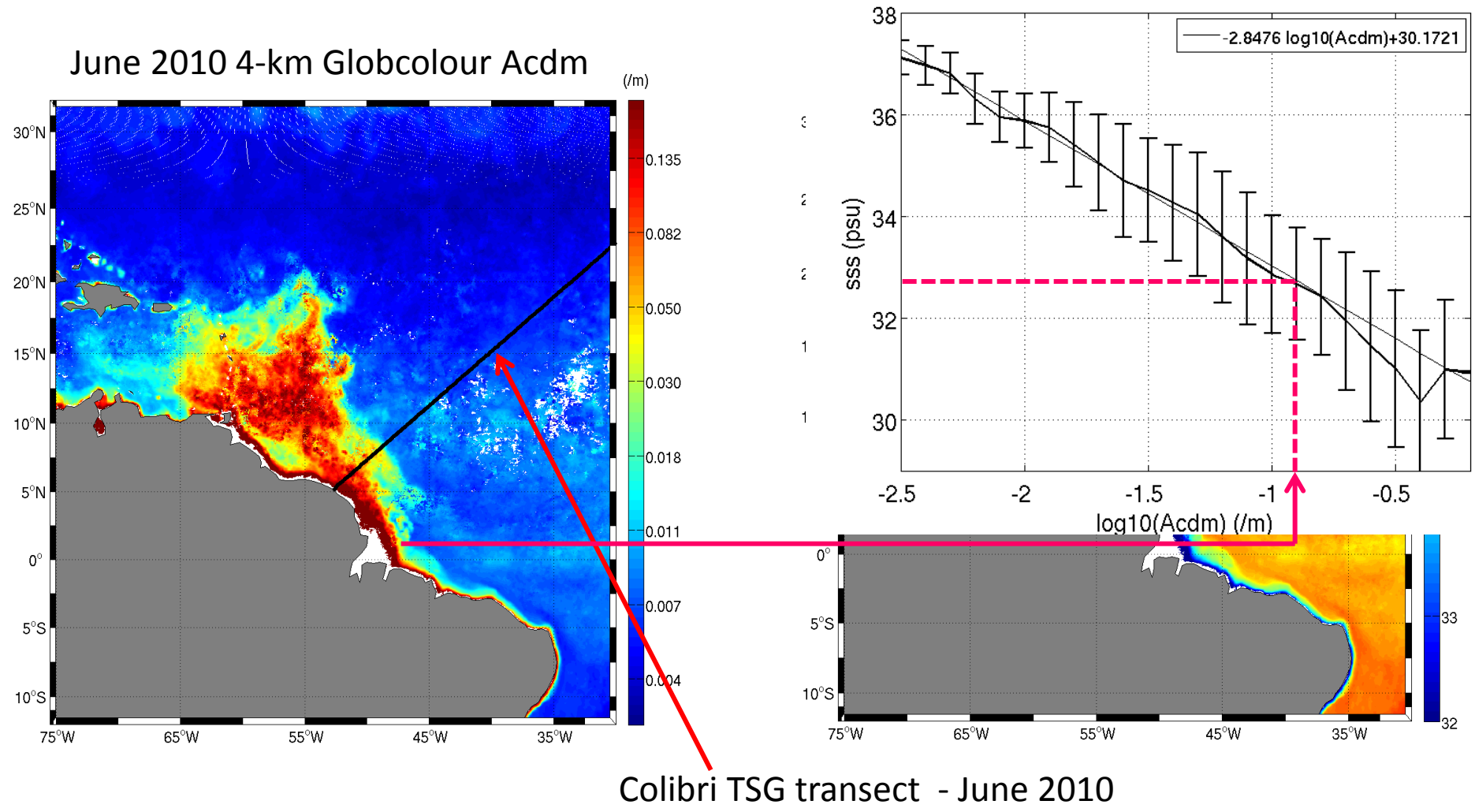
  ➡ distinguish structures not well-resolved by microwave SSS sensors

- Data available from 1998 (SeaWiFs , then MERIS & MODIS)
- A coastal margin observational complement

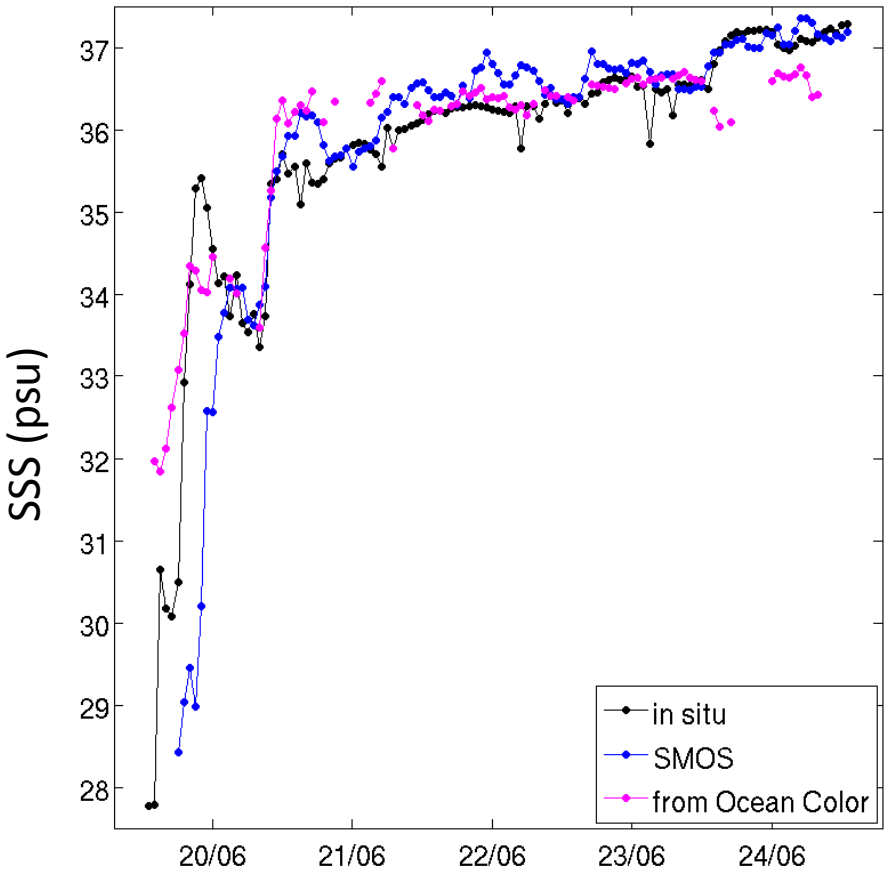


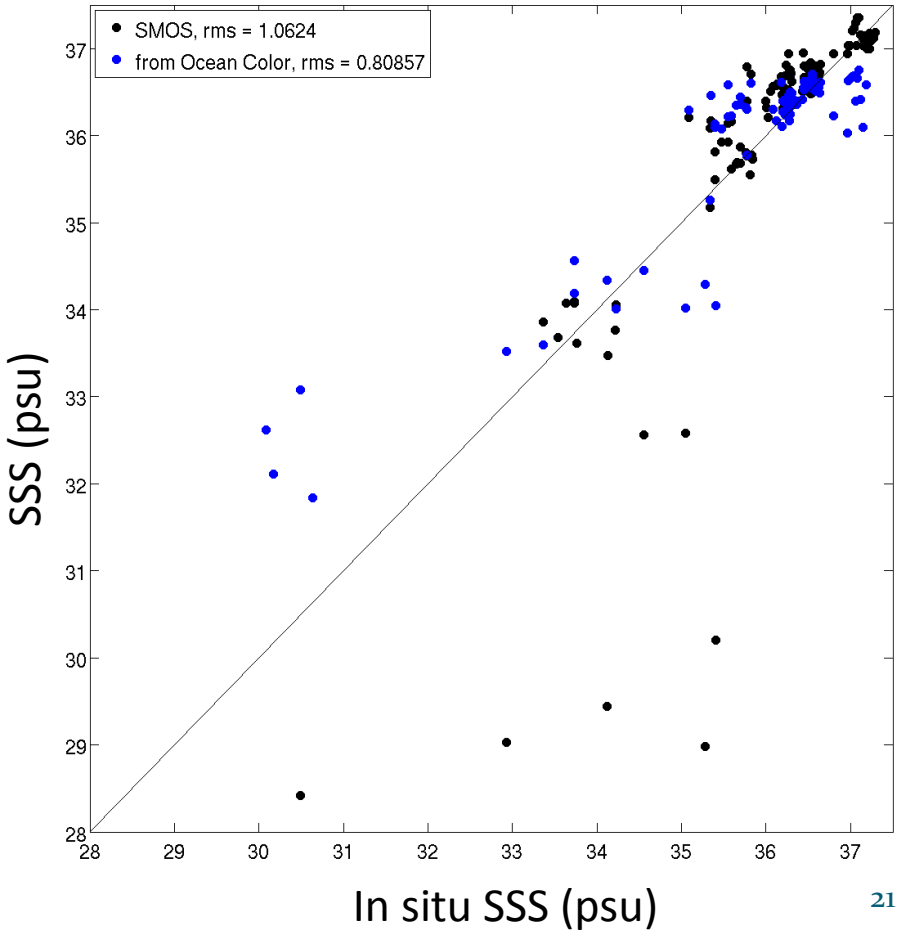


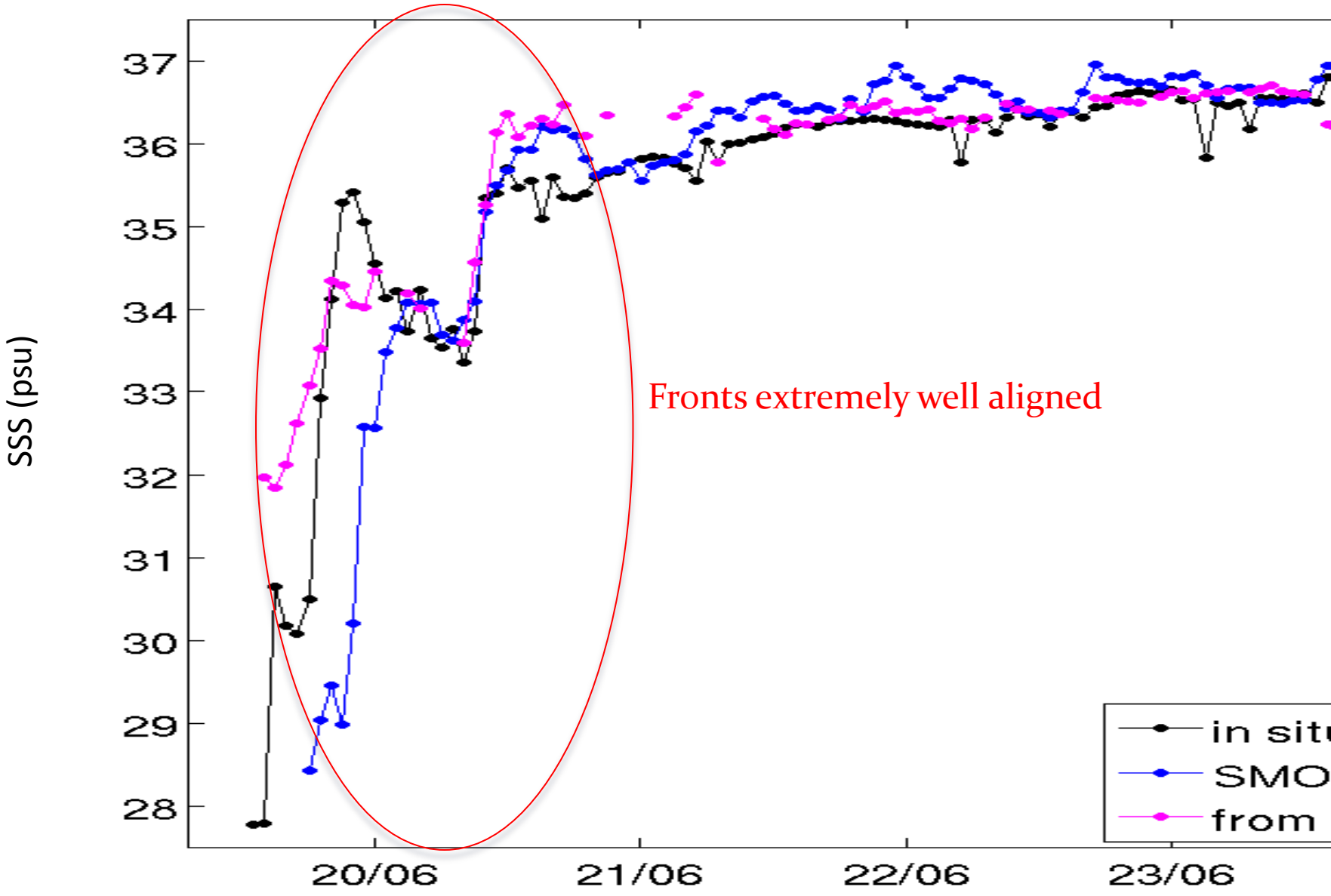
High resolution SSS from Ocean Color

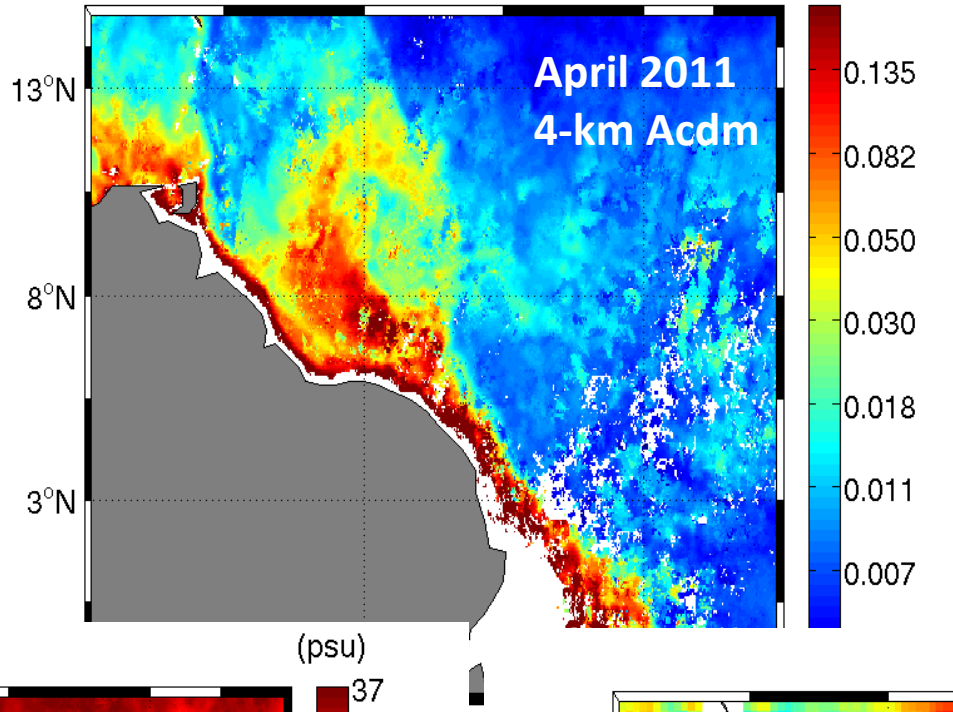


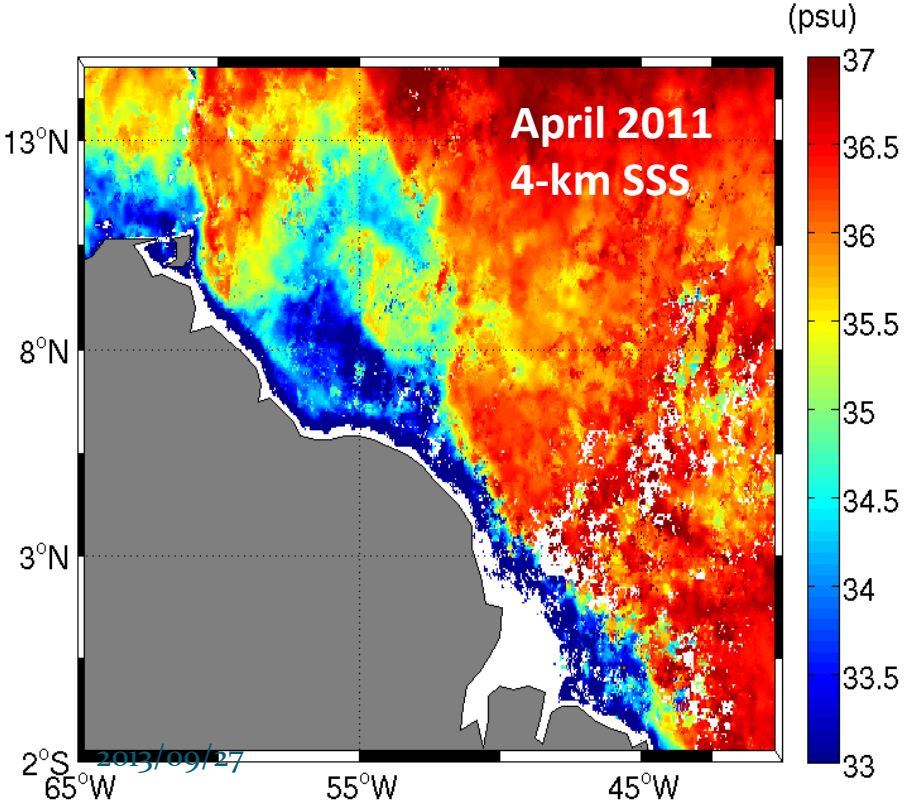
High resolution SSS vs. shiptrack TSG data

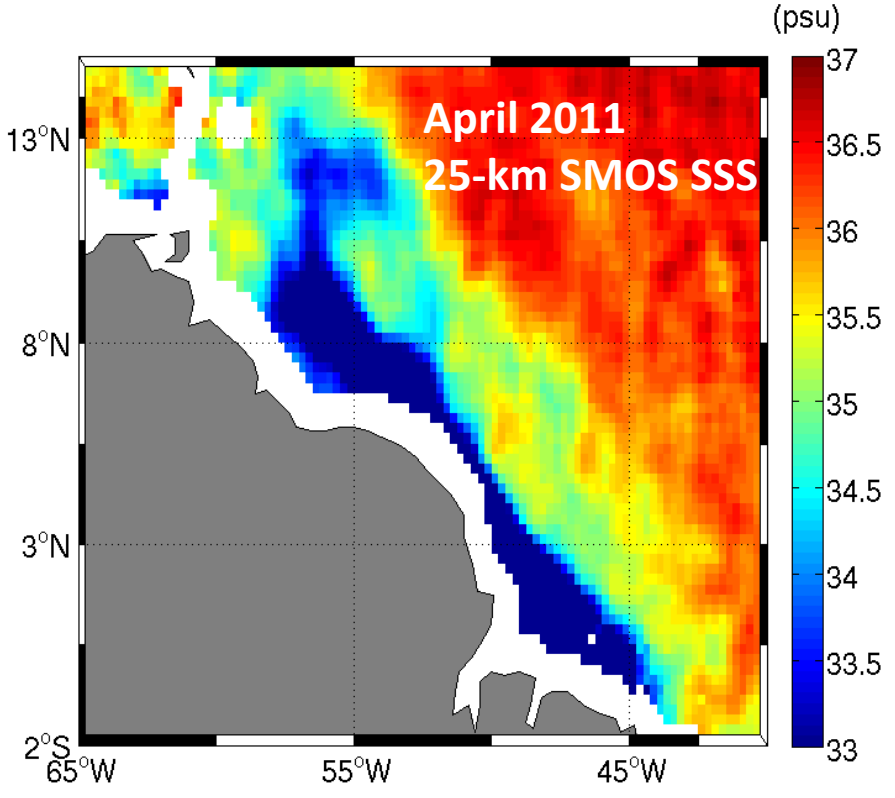


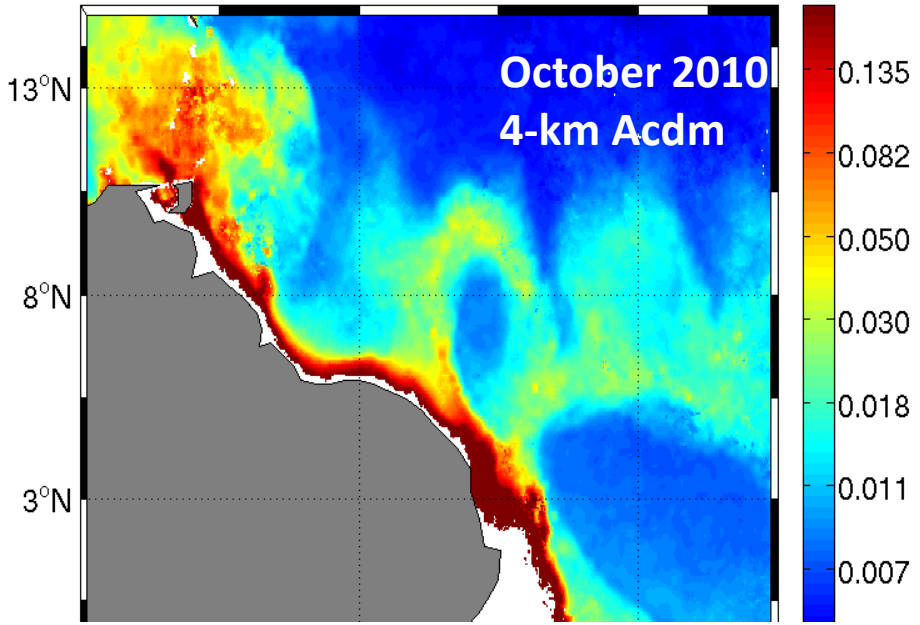


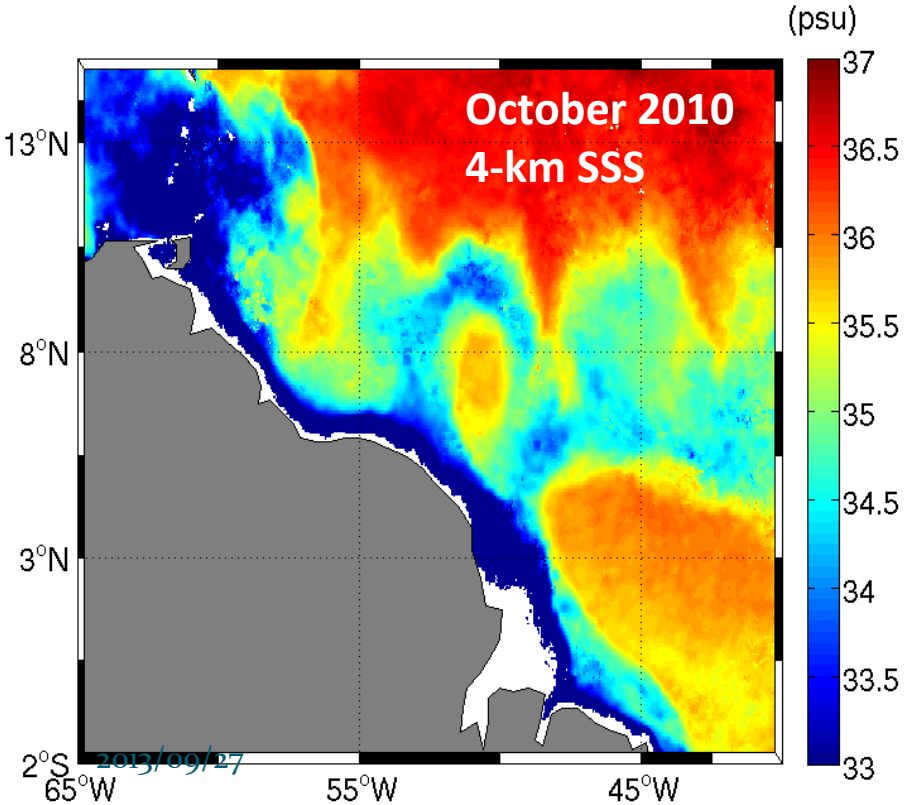

SSS (psu)
37
36
35
34
33
32
31
30
29
28
20/06
21/06
22/06
23/06
Fronts extremely well aligned
in situ
SMO
from

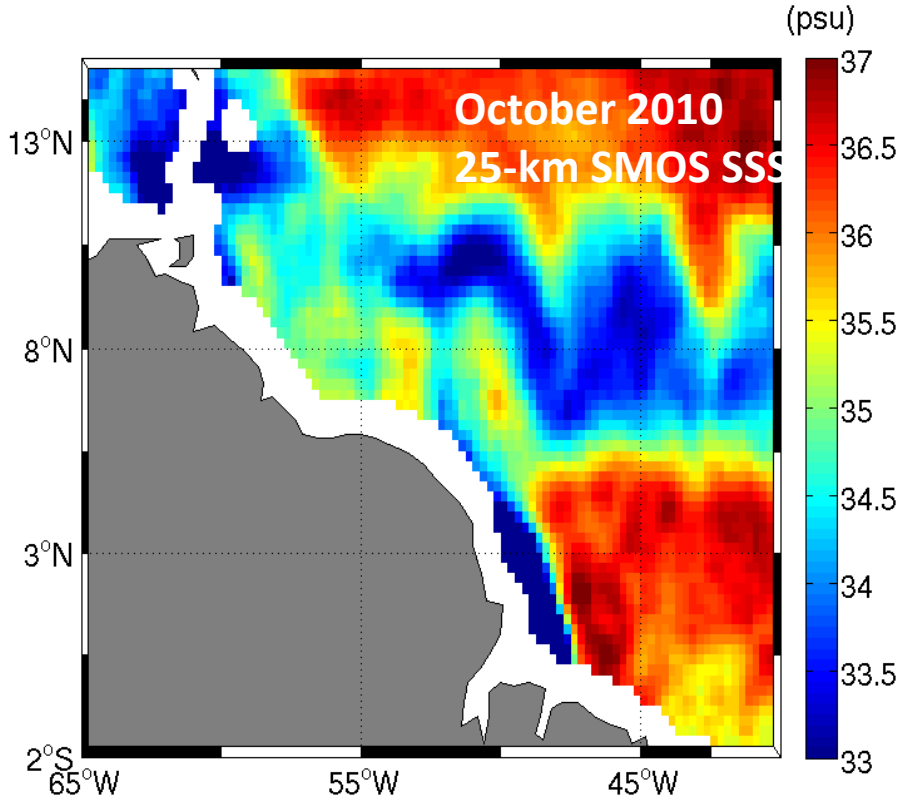

April 2011
4-km Acdm
13°N
8°N
3°N
0.135
0.082
0.050
0.030
0.018
0.011
0.007


April 2011
4-km SSS
(psu)
13°N
8°N
3°N
2°S
65°W
55°W
45°W
37
36.5
36
35.5
35
34.5
34
33.5
33
2013/09/27


April 2011
25-km SMOS SSS
(psu)
13°N
8°N
3°N
2°S
65°W
55°W
45°W
37
36.5
36
35.5
35
34.5
34
33.5
33


October 2010
4-km Acdm
13°N
8°N
3°N
0.135
0.082
0.050
0.030
0.018
0.011
0.007


October 2010
4-km SSS
(psu)
13°N
8°N
3°N
2°S
65°W
55°W
45°W
37
36.5
36
35.5
35
34.5
34
33.5
33


October 2010
25-km SMOS SSS
(psu)
13°N
8°N
3°N
2°S
65°W
55°W
45°W
37
36.5
36
35.5
35
34.5
34
33.5
33

Conclusions

- Consistency between L-band SSS (L-band microwave instrument) & Ocean Color (optical instrument)
- New approach to solidify SSS/Acdm relationship thanks to remote sensing -> potentially improved spatio-temporal monitoring
- For the first time, the seasonal and interannual variabilities in conservative mixing can be examined and quantified
- Deviations from conservative mixing can be bounded
- Such high resolution SSS estimates may prove useful

Thank you