Large Tropical River Plume Monitoring with SMOS to better estimate Land-Sea Freshwater Fluxes

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Rivers, important variables in oceanography

- Surface freshwater is important to Air-Sea interactions by modifying:
  - open ocean SSS (density)
  - buoyancy of the surface layer & vertical stratification

  Rivers: important factors of the Air/Sea interactions

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

  Rivers represent key hydrologic components of freshwater Land/Sea exchanges

- Particularly the Amazon River plume: the world’s largest river in terms of discharge levels
Conservative Mixing in Rivers’ plume

- SSS/optical properties → conservative mixing
- A well known inverse correlation SSS/light absorption and SSS/light attenuation

(Hu et al. 2004, Del Vecchio & Subramaniam 2004, Mollerri et al. 2010, Salisbury et al., 2010)
• Deviations from the 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, spaceborne measurements of SSS are available for the first time from SMOS & Aquarius missions.

unprecedented spatial & temporal resolution

In situ SSS – April 2010

SMOS SSS – April 2010
Objectives

- Illustrate the **new monitoring capabilities** for the oceanic freshwater pool generated by the Amazon discharge

- Study the quasi-linear **seasonnally varying conservative mixing** derived from the satellite SSS and Ocean Color properties

- Investigate non conservative behaviours of the conservative mixing

- Estimate the **SSS at high spatial resolution** (4 km) from Ocean Color data
Data

- **SMOS SSS**: 10-day daily running mean, 0.25 degree resolution (CATDS CEC products)
- **MERIS/MODIS/SeaWIFS CDM** absorption: 10-day daily running mean, 4-km resolution (GlobColour ACRI-ST)
- **In situ SSS** (Coriolis, IRD, various research campaigns)
- **ORE HYBAM** Amazon & Orinoco discharges at Obidos & Bolivar gauges
- 8-day Carbon based Production Model (CbPM) **Net Primary Productivity** from Ocean Productivity
Amazon Plume - Local Ocean Currents
New Monitoring Capabilities of the Amazon River Plume: Combination of SMOS SSS + Ocean Color data + River discharge data
SMOS plume monitoring capabilities

Amazon plume extension

Amazon discharge proxy

SMOS SSS
August 2010

35 psu contour

Plume area
(35 psu contour)

3 months lag

Discharge ($m^3/s$)

Plume Area ($km^2$)

$0.082144 \times \text{plume area} + 54351, R^2=0.81627$

Discharge ($m^3/s$)

Calendar months

Amazon
Orinoco
area

$10^5$

$10^6$
The Conservative Mixing seen by SMOS and Ocean Color Color Sensors

Annual relationships
Observed seasonal and interannual variabilities in the SSS/ACDM relationship

Sources of these variabilities have to 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/ACDM relationship

- Amazon discharge in phase with the endmember of the SSS/Acdm relationship

  discharge = main source of the conservative mixing seasonal cycle
Deviations from the conservative mixing

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

June 2010-2012

\[ y = -0.031839 \times \text{SSS} + 1.1312, R^2 = 0.99428 \]
Deviations from the conservative mixing
June 2010

Synthetic Acdm

GlobColour Acdm

Observed Acdm

Anomaly

Primary productivity Acdm

Acdm pred - Acdm (m)

Npp (mg/m²/d)

Net Primary Productivity

Deviations from the conservative mixing

June 2010

Synthetic Acdm

GlobColour Acdm

Observed Acdm

Anomaly

Primary productivity Acdm

Acdm pred - Acdm (m)

Npp (mg/m²/d)

Net Primary Productivity
High resolution SSS from Ocean Color

- Ocean Color sensors: 4 km – SMOS: 25 km
distinguish structures not well-resolved by microwave SSS sensors
- Data available from 2002
- Coastal observations

4-km Acdm

25-km SMOS SSS
High resolution SSS from Ocean Color

June 2010 4-km Globcolour Acdm

Colibri TSG transect - June 2010
High resolution SSS Validation

SSS (psu)

in situ
SMOS
from Ocean Color

SSS (psu)

in situ SSS (psu)

SMOS, rms = 1.0624
from Ocean Color, rms = 0.80857
Conclusions

• Consistency between SMOS SSS (microwave instrument) & Ocean Color (optical instrument)

• New approach of the SSS/Acdm relationship thanks to remote sensing: largely improved spatio-temporal monitoring

• For the first time, the seasonal and interannual variabilities of the conservative mixing are highlighted

• Study of the deviations from the conservative mixing

• High Resolution SSS estimates can be retrieved
Thank you for your attention

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