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What do we learn about the impact of extreme hydrological events on tropical wetlands from the synergistic use of altimetry from Sentinel-3/SARAL-Altika and L-Band radiometry from SMOS/SMAP ?

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What do we learn about the impact of extreme hydrological events on tropical wetlands from the synergistic use of altimetry and L-Band radiometry ?

*Ahmad Al Bitar, Marie Parrens, Frederic Frappart,
Rodrigo Cauduro Dias de Paiva, Fabrice Papa, and Yann Kerr*
CESBIO, CNRS, CNES, LEGOS, IRD, ISPA, IPH

How are the **wetlands**
over tropical basins impacted by
the extreme hydrological events ?

Why monitor wetlands
and
How can we achieve this ?

How are the wetlands over tropical basins impacted by the extreme hydrological events ?

Why monitor wetlands
and
How can we achieve this ?

What does it tell us
about Droughts and
ENSO dynamics ?

Why, monitor Tropical wetlands ?

Water budget

The Amazon River contributes to **18%** of the global river discharge to the ocean and almost **5%** of all the continental masses.

So It is important to map the water surfaces in Tropical regions to understand the underlying processes (Alsdorf et al., 2007 ; Bakker, 2012 ; Finlayson et al., 1999 Vorosmarty et al., 2015; Costanza et al., 2014)

Case of the Amazon

CO₂ budget

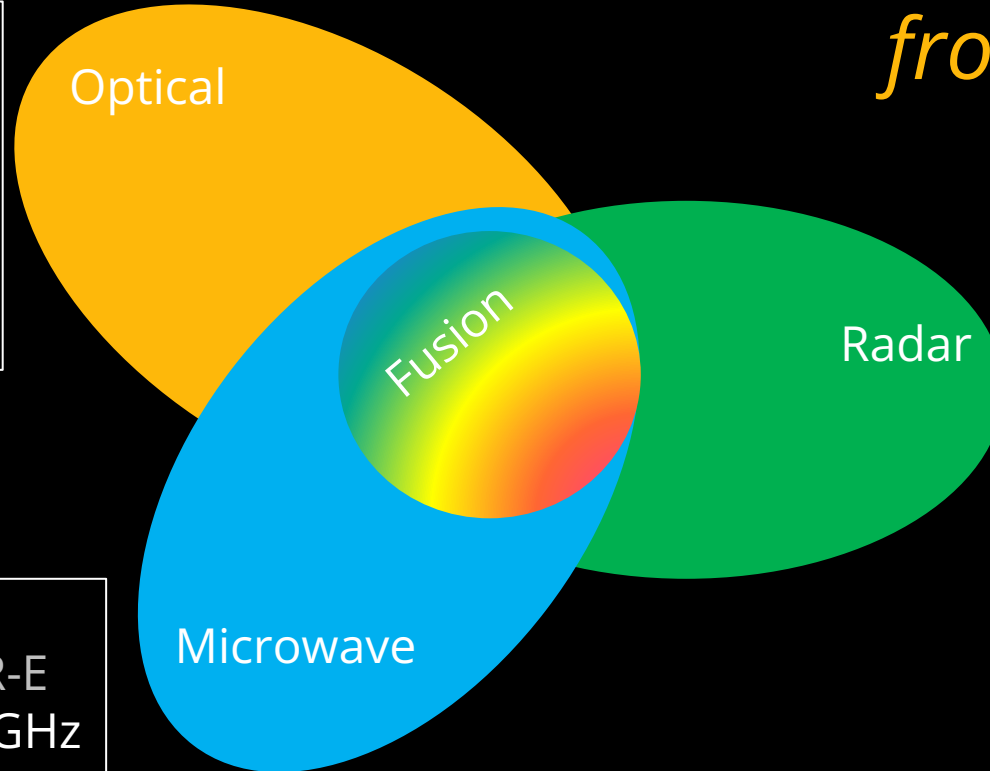
“Outgassing of CO₂ from rivers and **wetlands** constitut a carbon loss of 1.2 Mg C ha⁻¹ yr⁻¹. Overall carbon budget of rainforests, summed across terrestrial and **aquatic** environments closer to being in balance ” (Richey et al. *Nature* 2002)

“ ...a sediment load of **3 million tons** near its mouth” (Molinier et al., IAHS 1996)

How can we monitor wetlands surfaces ?

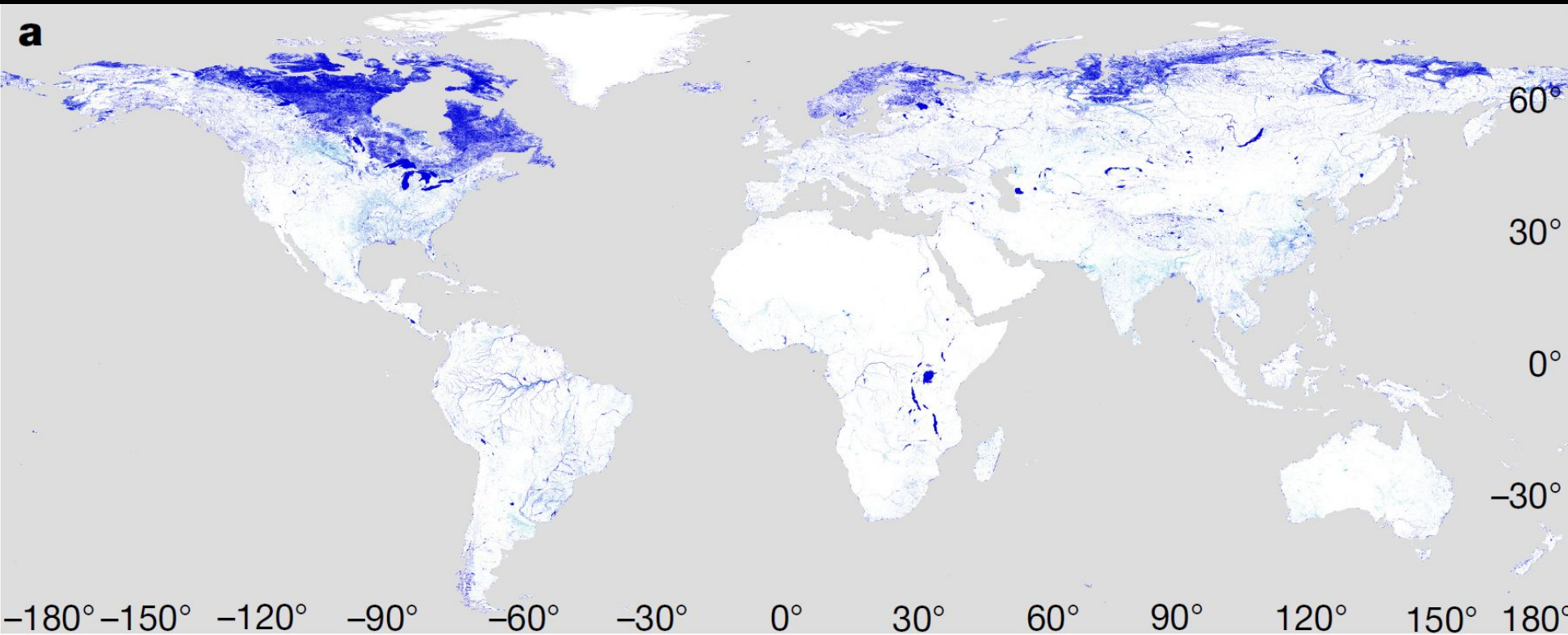
from space 

- Visible
 - Sentinel-2*
 - MODIS*
 - LANDSAT*
- NIR
 - LANDSAT*

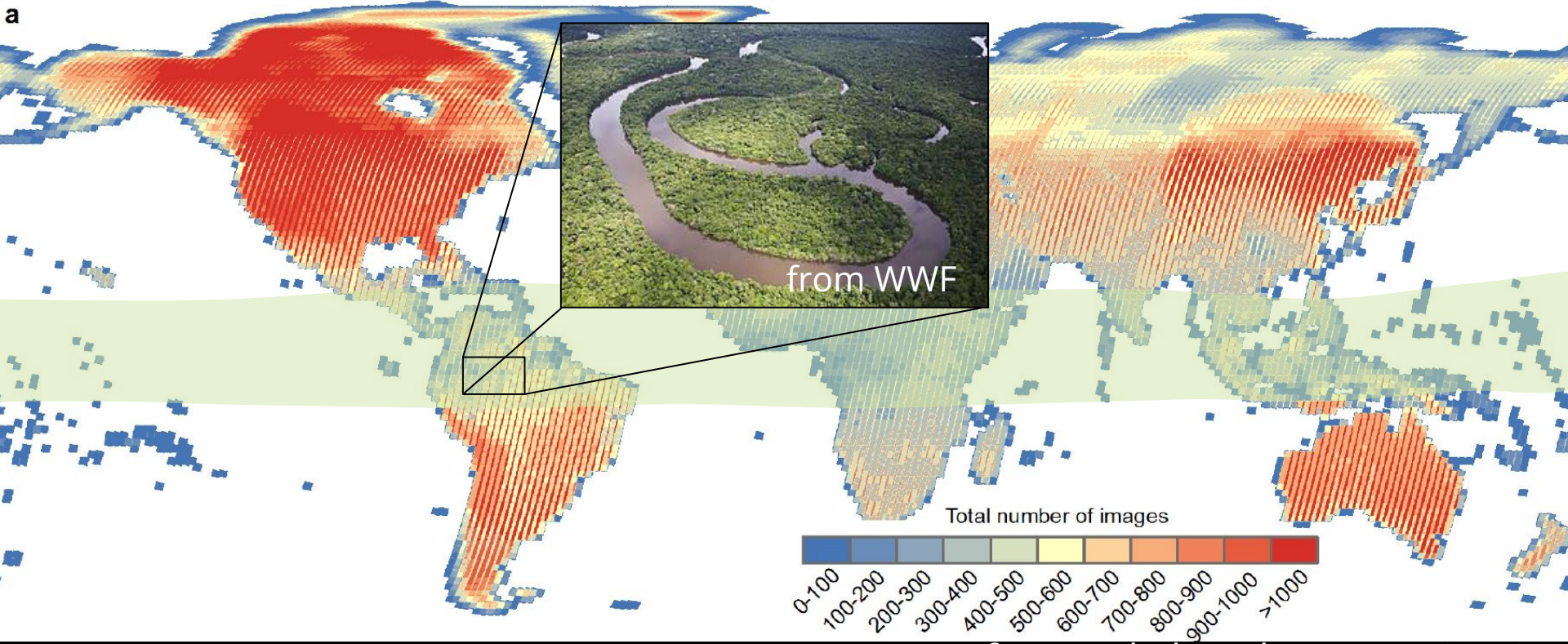


- C-band
 - AMSR-E*
- K - ka GHz
- SSMI

- C-band
 - Sentinel 1*
 - RadarSAT*
- L-band
 - PALSAR*
- X-band
 - TERRASAR*



from Pekel et al. Nature, 2016



from Pekel et al. Nature, 2016

Advantage of Microwave RS

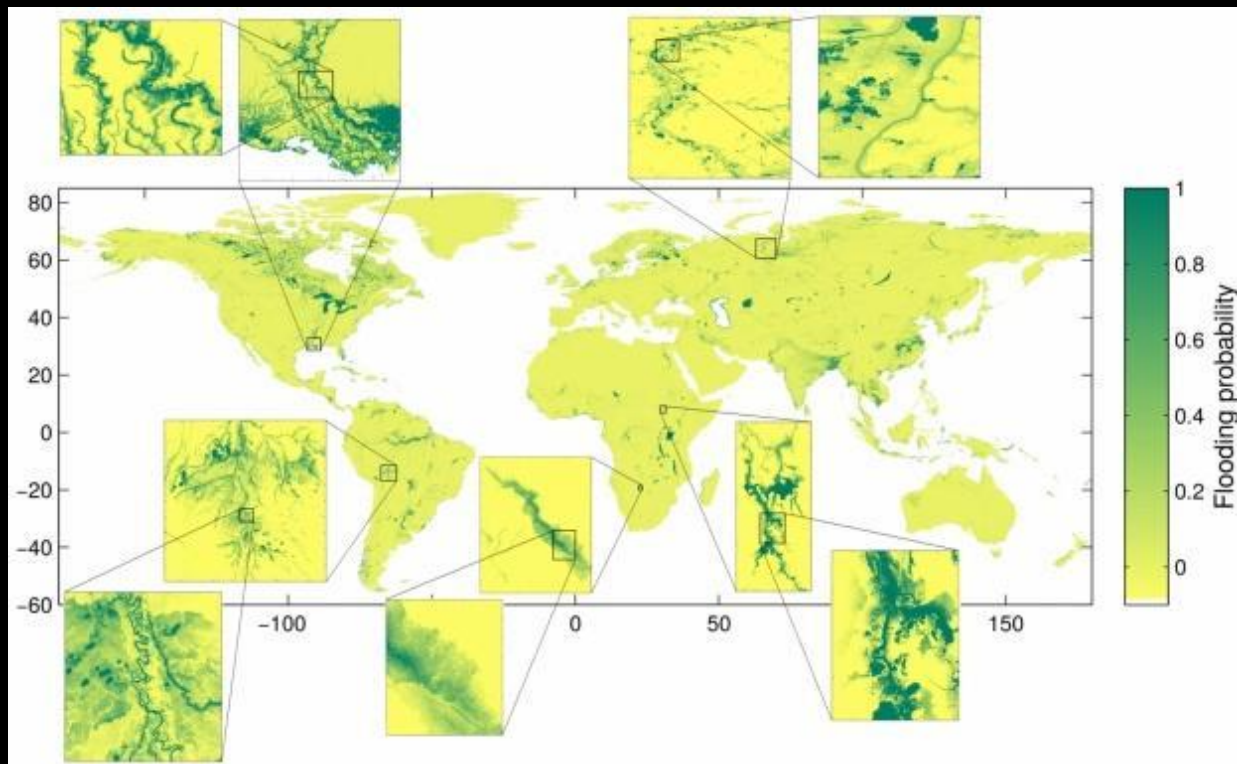
- Microwave has all weather capabilities.
- Sensors have a high revisit frequency (1-3 days).
- The Can provide signal underneath the vegetation (depending on frequency).
- Proof of concept and products exist since more than a decade.

But :

- Microwave sensors have a low spatial resolution : $\sim 0.25^\circ$.

So :

- Synergistic approached need to be privielaged (Prigent et al., 2008).



Aires et al. 2017

Advantage of Microwave RS

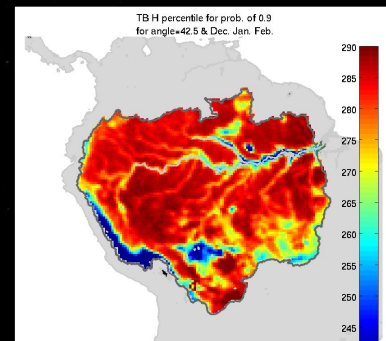
L-band

- The impact of vegetation is lower in L-band.
- The impact of heavy rainfall is also lower than C-band.
- Multi angular and full polarisation acquisitions are available

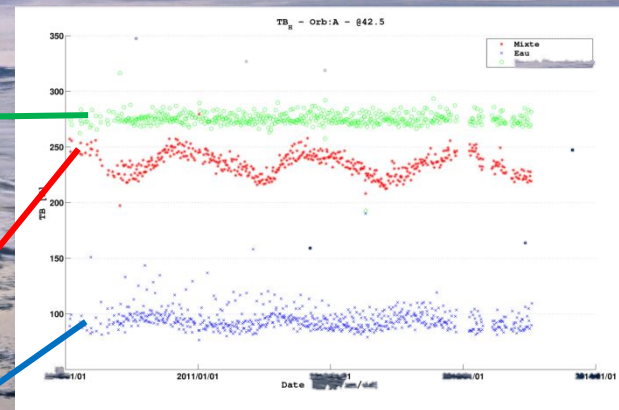
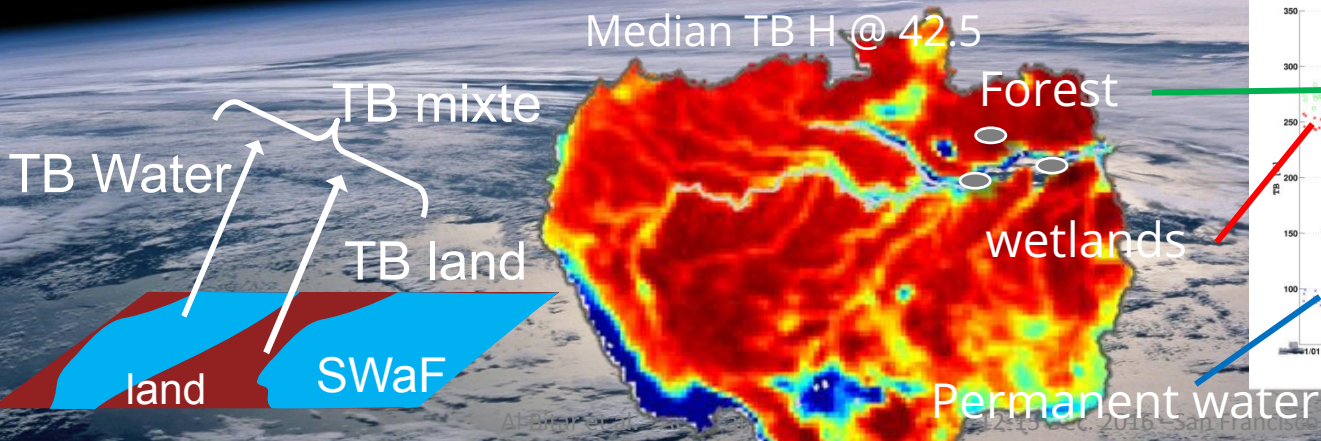
But :

- At which vegetation density it is still an open question
(Rahmoun et al. 2015, Parrens et al. 2015).

SWAF - Water fraction using SMOS data

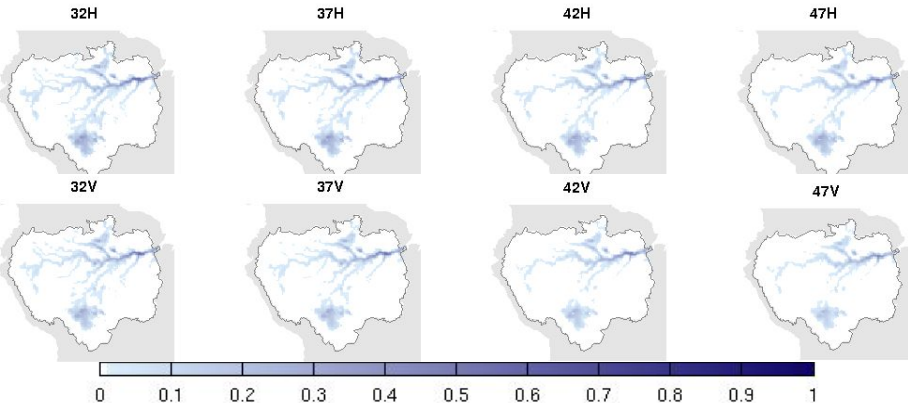


Al Bitar et al., in review

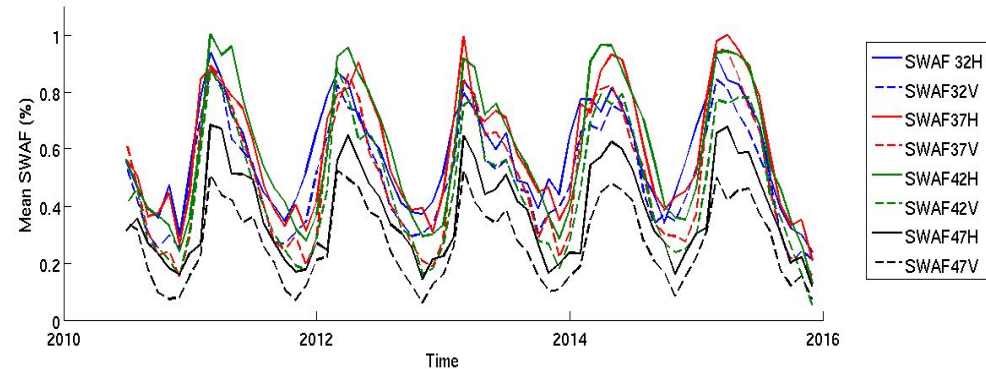


Impact of polarisation and incidence angle

Mean SWAF for 2010 - 2016



Timeseries over entire basin

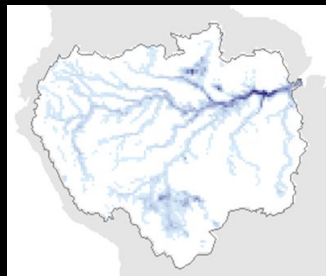


Parrens et al. 2017

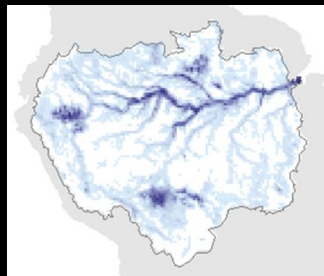
Validation of the SMOS Water fraction

Against static maps

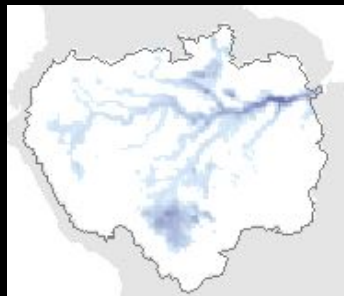
IGBP



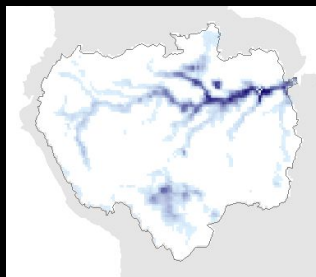
GlobCover



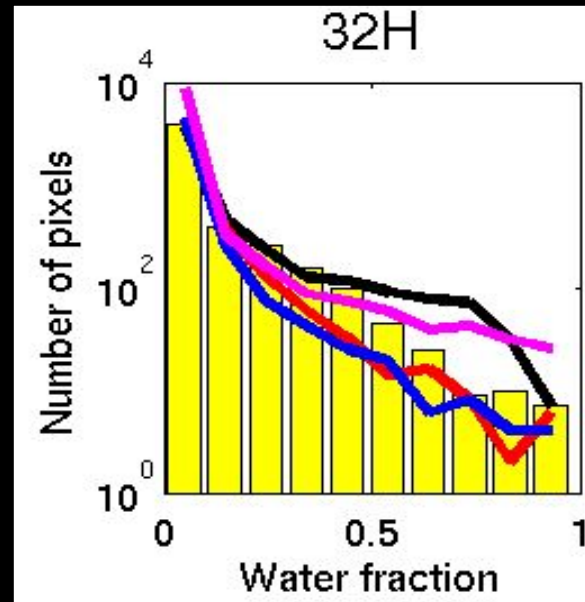
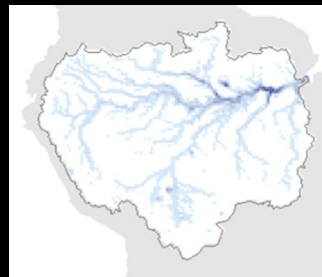
SWAF



GIEMS



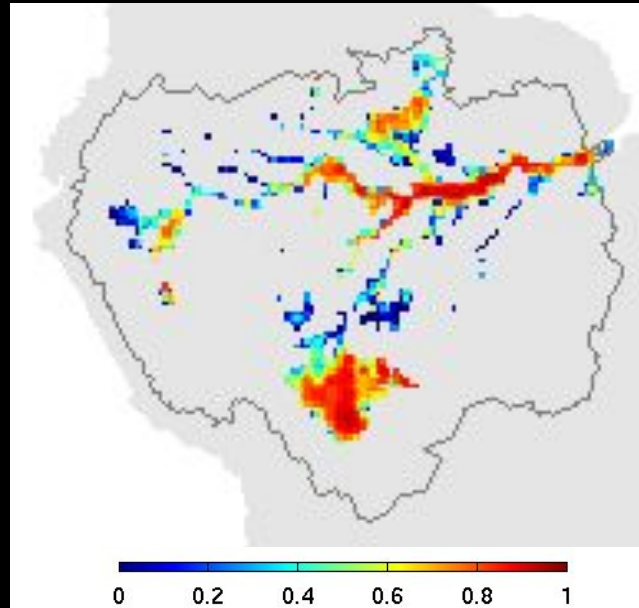
ESA CCI



Validation of the SMOS Water fraction

Against dynamic maps

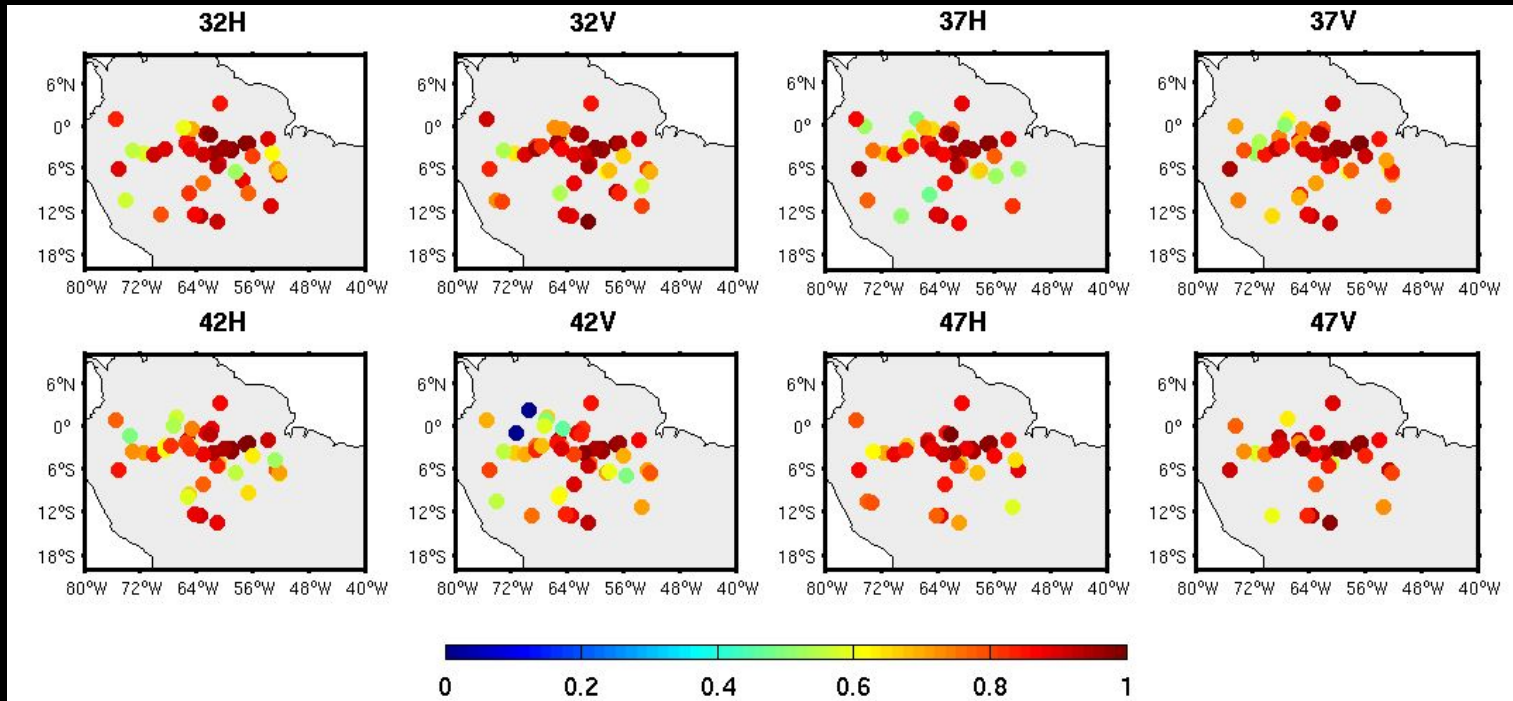
Temporal correlation between SWAMPS and SWAF products



Validation of the SMOS Water fraction

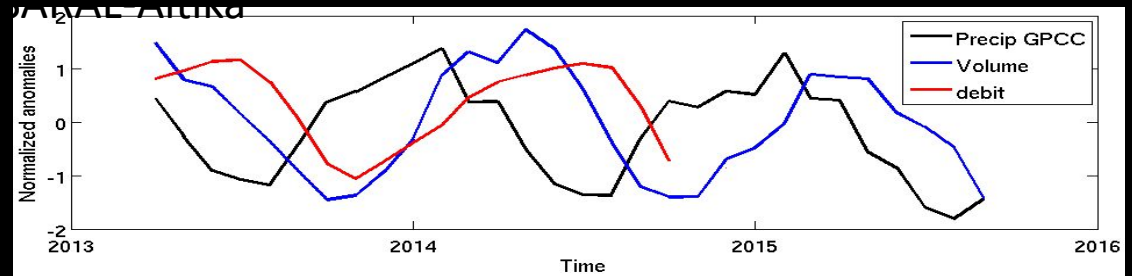
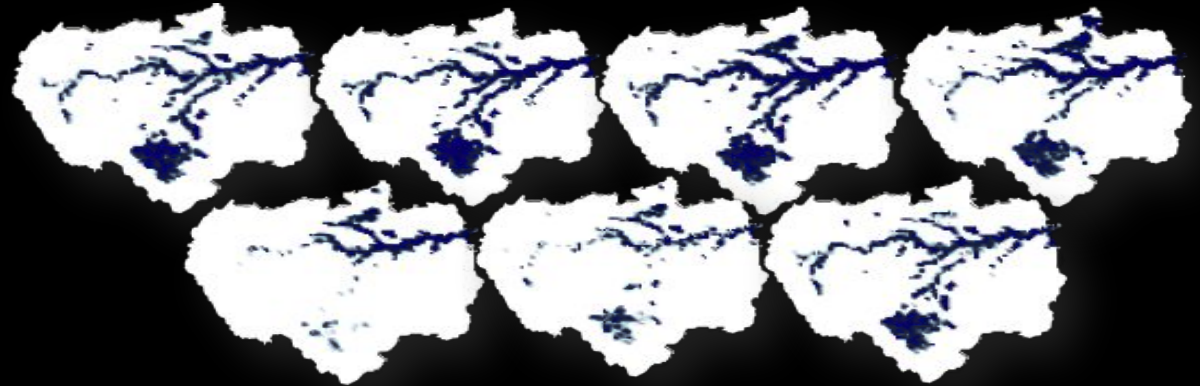
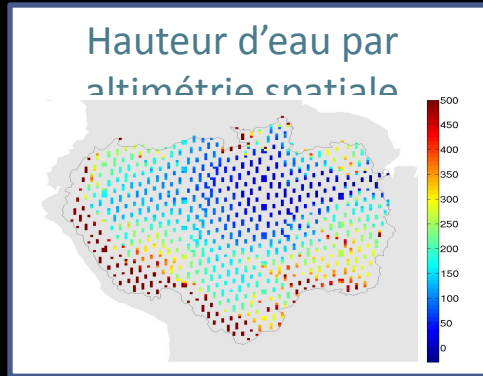
Against heights from altimetry

Correlation between Jason-2 water heights and SWAF

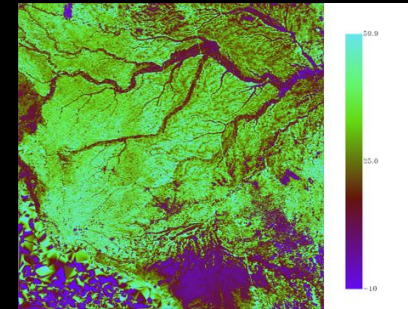
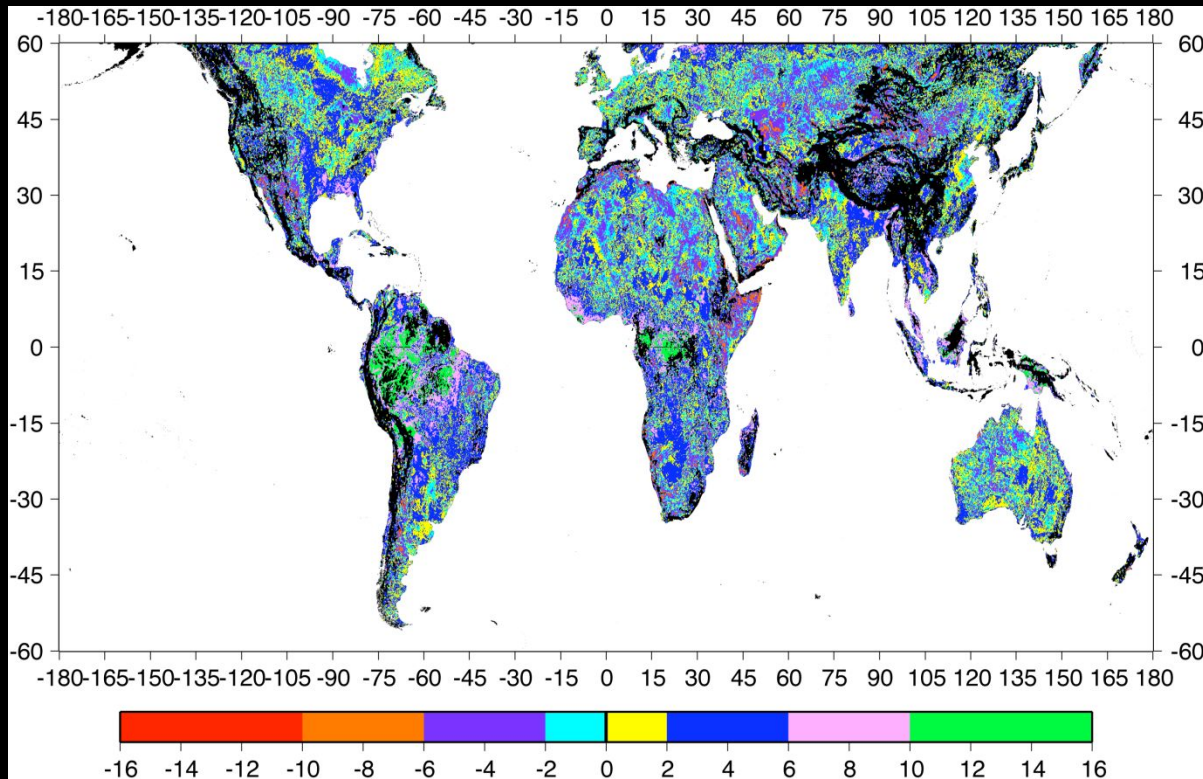


Nodes with high topography are excluded

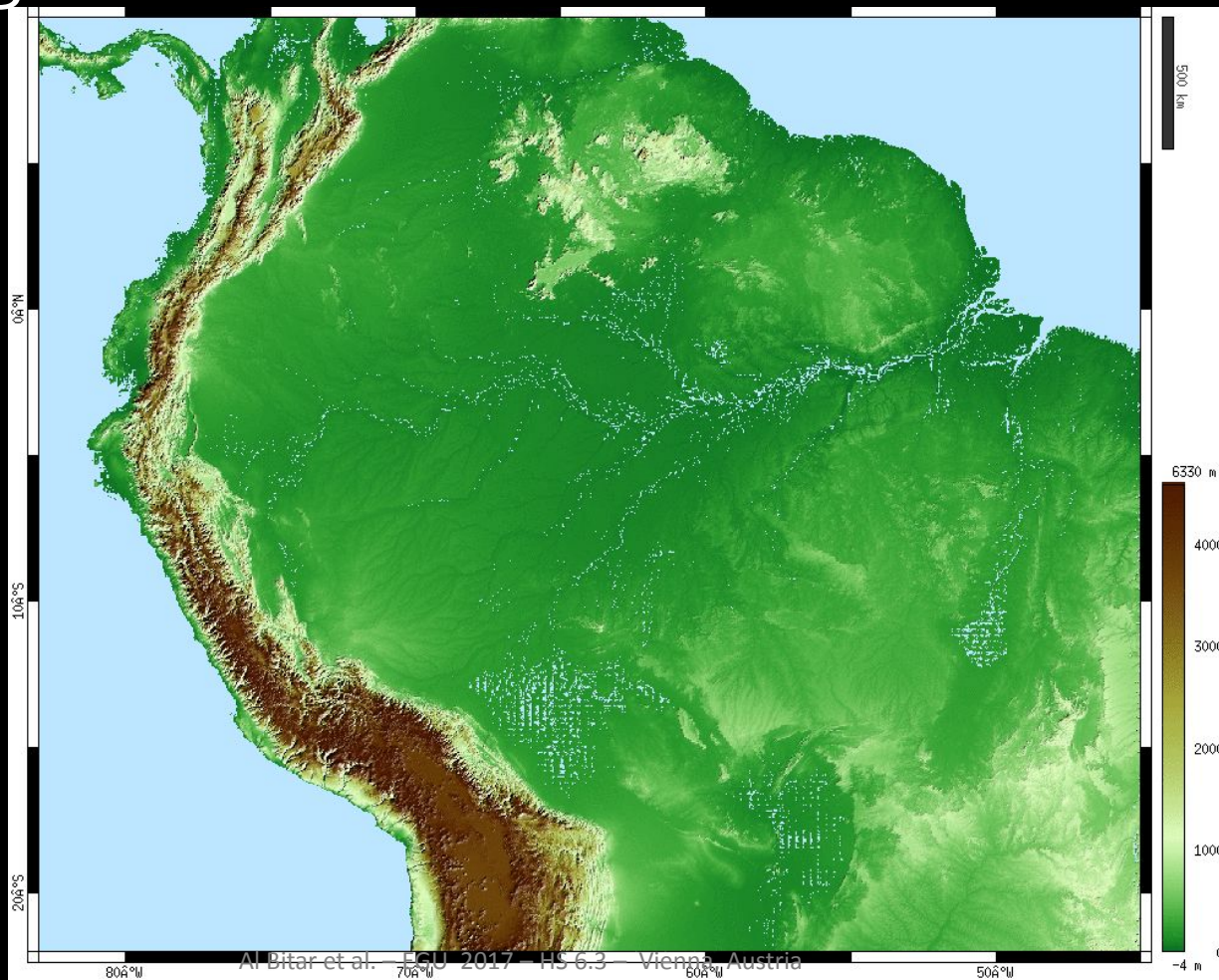
Water storage from Altimeters and L-band SARAL-Altika / SMOS



GDEM dataset ACE2



Toward high resolution water volumes from L-Band



How are the wetlands over tropical basins impacted by the extreme hydrological events ?

Why monitor wetlands
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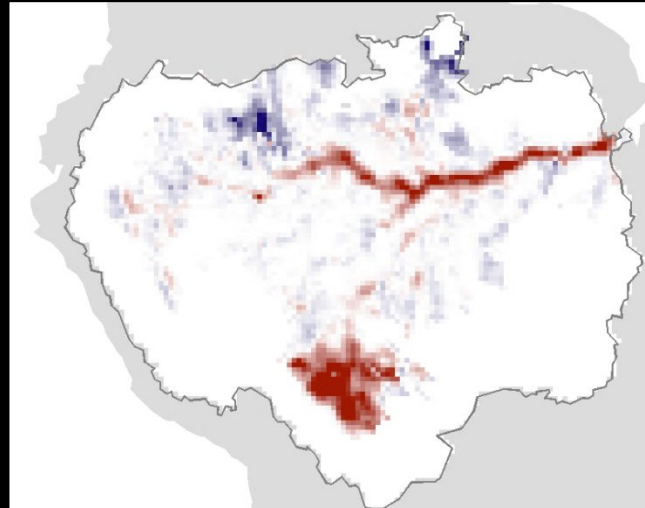
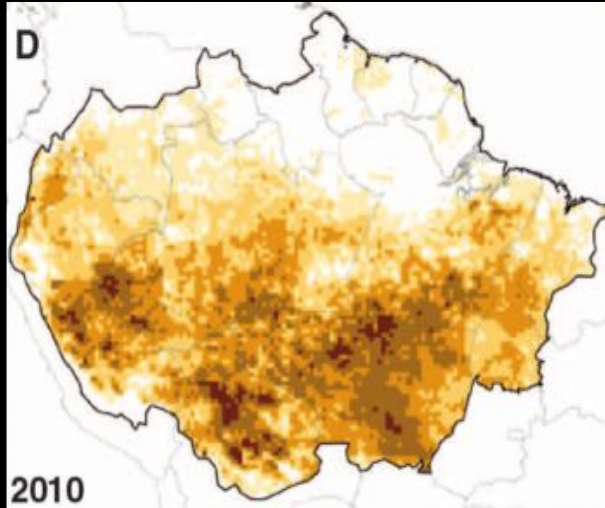
What does it tell us
about Droughts and
ENSO dynamics ?

Droughts of 2010

Clim. Water. Index

Anomaly of water fraction
Jul. – Sept. 2010

Drought depicted for the South amazon but also for the inundation plains, which can not be detected using the Clim. Water Index which is based on optical data.



water deficit

anomaly of SMOS water fraction

(Lewis et al., Science 2011)

abnormally dry

abnormally wet



Reuters ©

Droughts of 2010 vs 2015

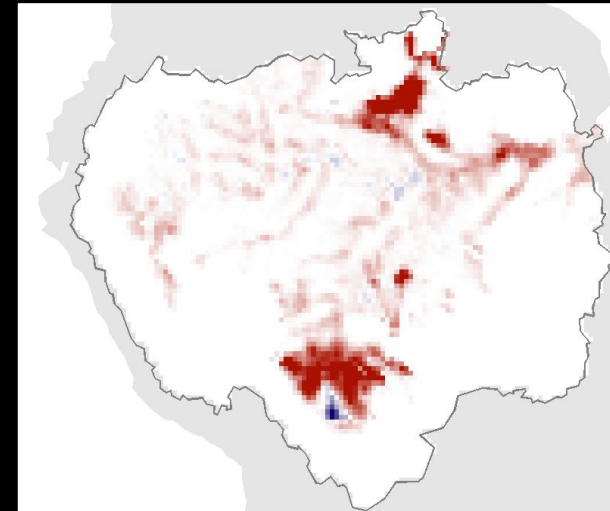
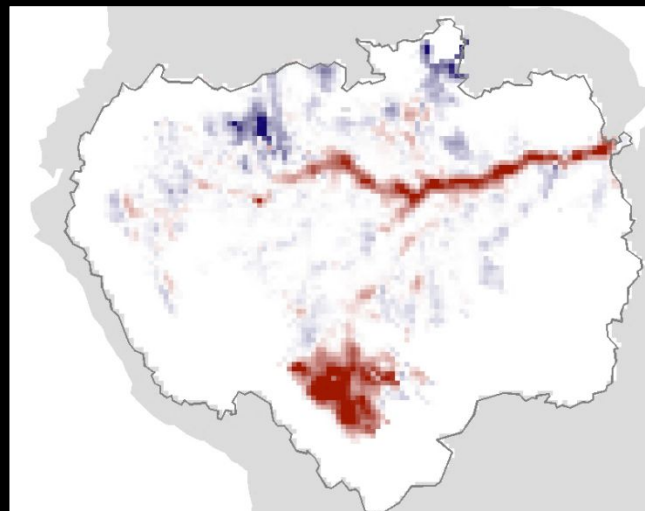
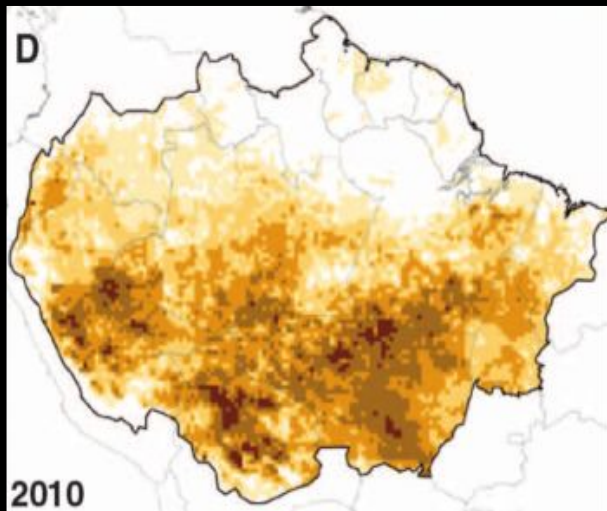
Clim. Water. Index

Anomaly of water fraction

Anomaly of water fraction

Jul. – Sept. 2010

Oct. – Dec. 2015



water deficit

anomaly of SMOS water fraction

anomaly of SMOS water fraction



(Lewis et al., Science 2011)

abnormally dry

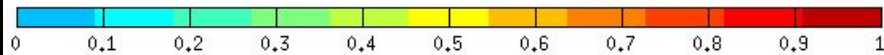
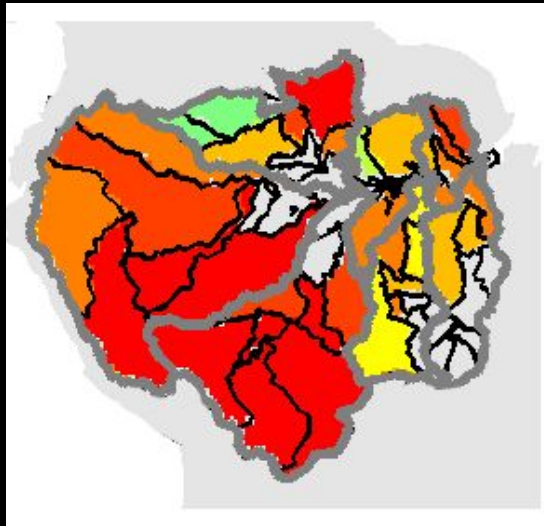
abnormally wet

abnormally dry

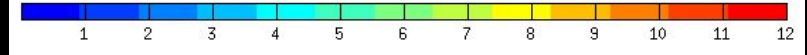
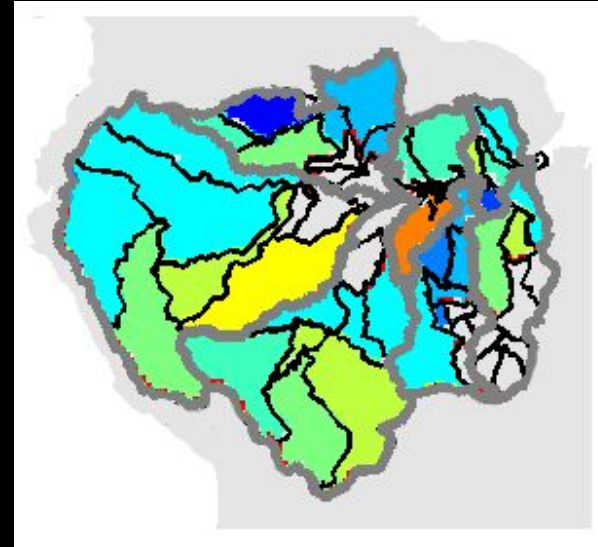
abnormally wet

Link between Precipitation and SWAF

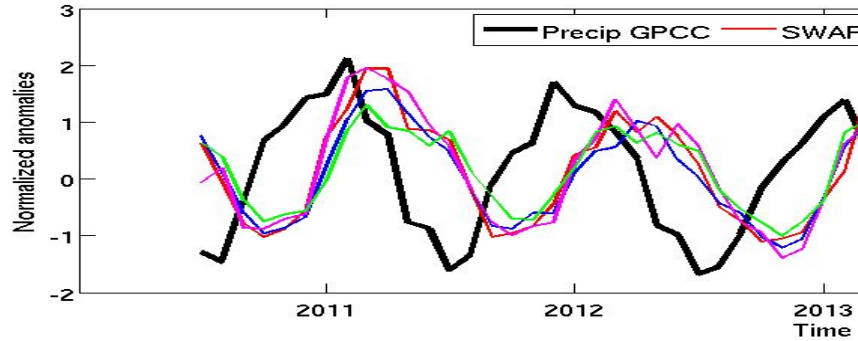
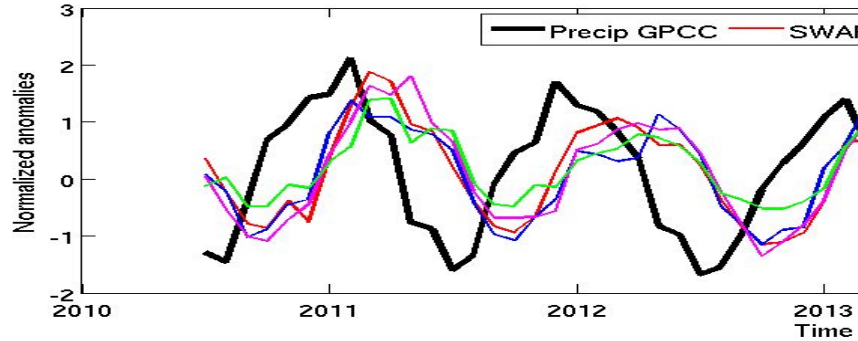
Correlation value (r)



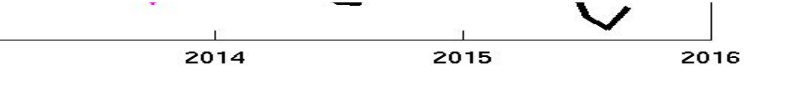
Time lag (weeks)



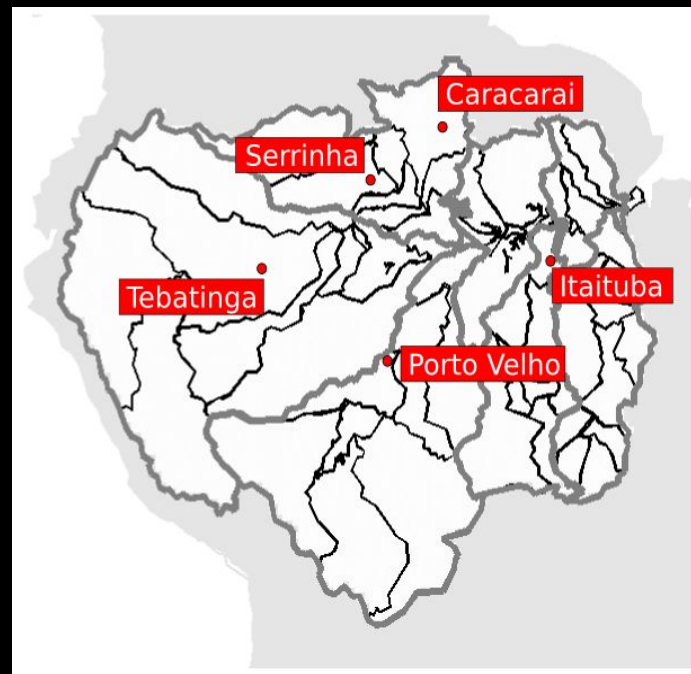
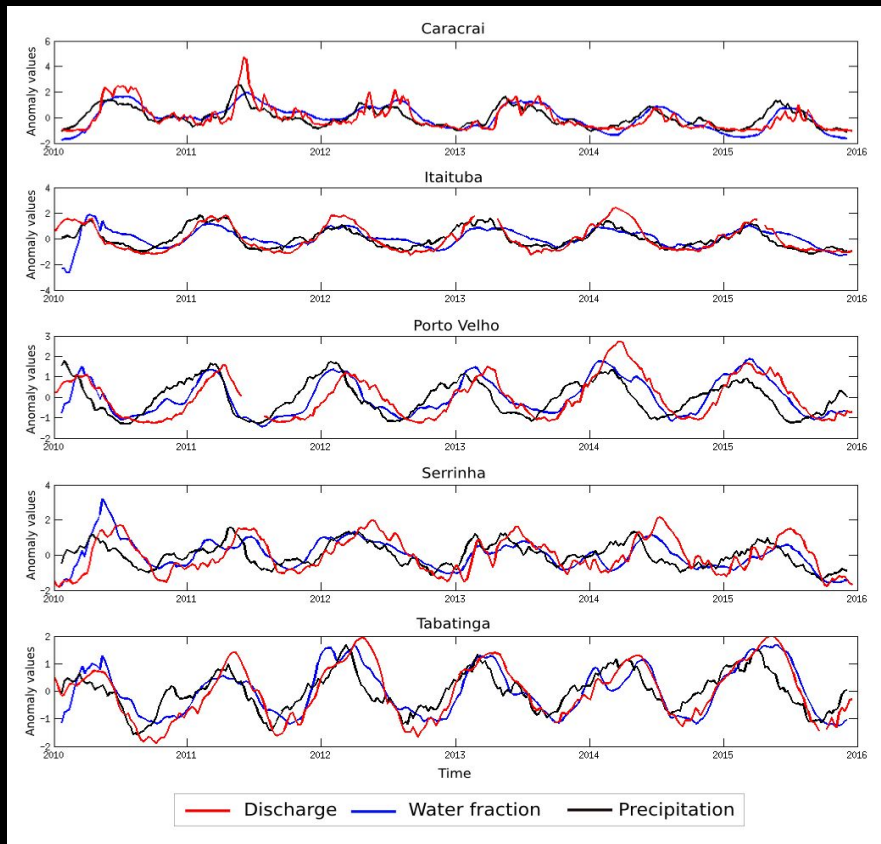
Comparison of the SMOS water fraction With precipitation data (GPCC – monthly products)



SWAF Configuration	R	Time lag (months)
32H	0.69	3
37H	0.63	3
42H	0.73	3
47H	0.50	3
32V	0.70	3
37V	0.65	3
42V	0.74	3
47V	0.51	4

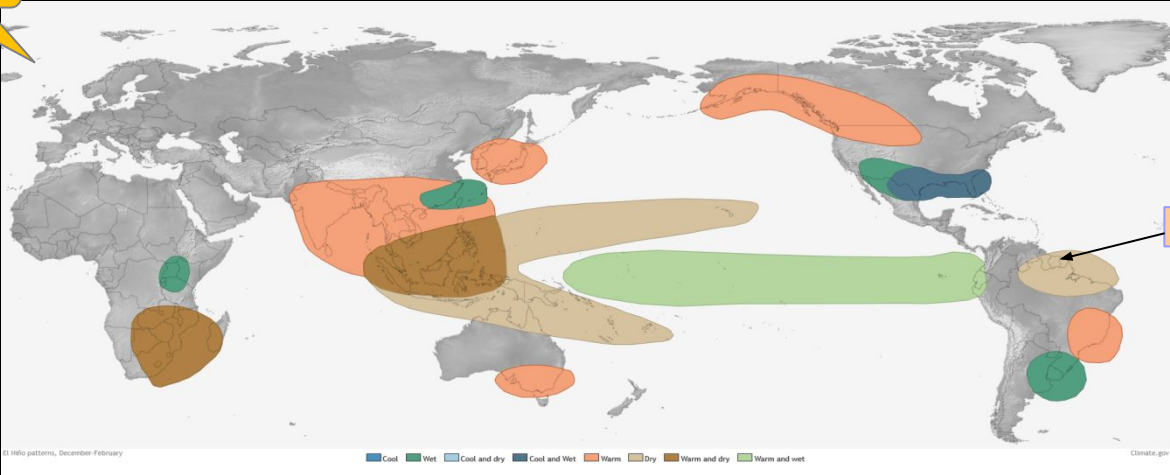


Link between Discharge and SWAF

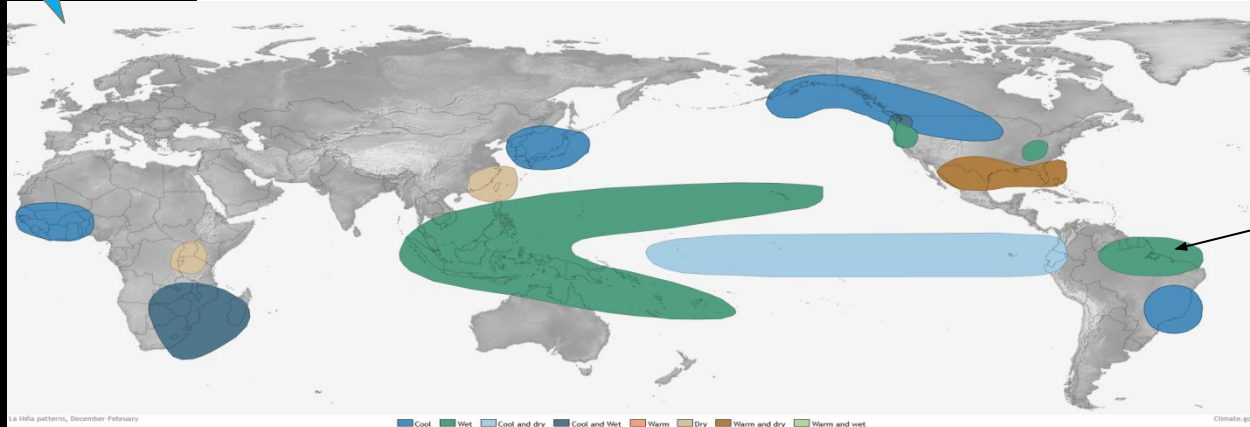


What are the changes during ENSO years ?

El Nino



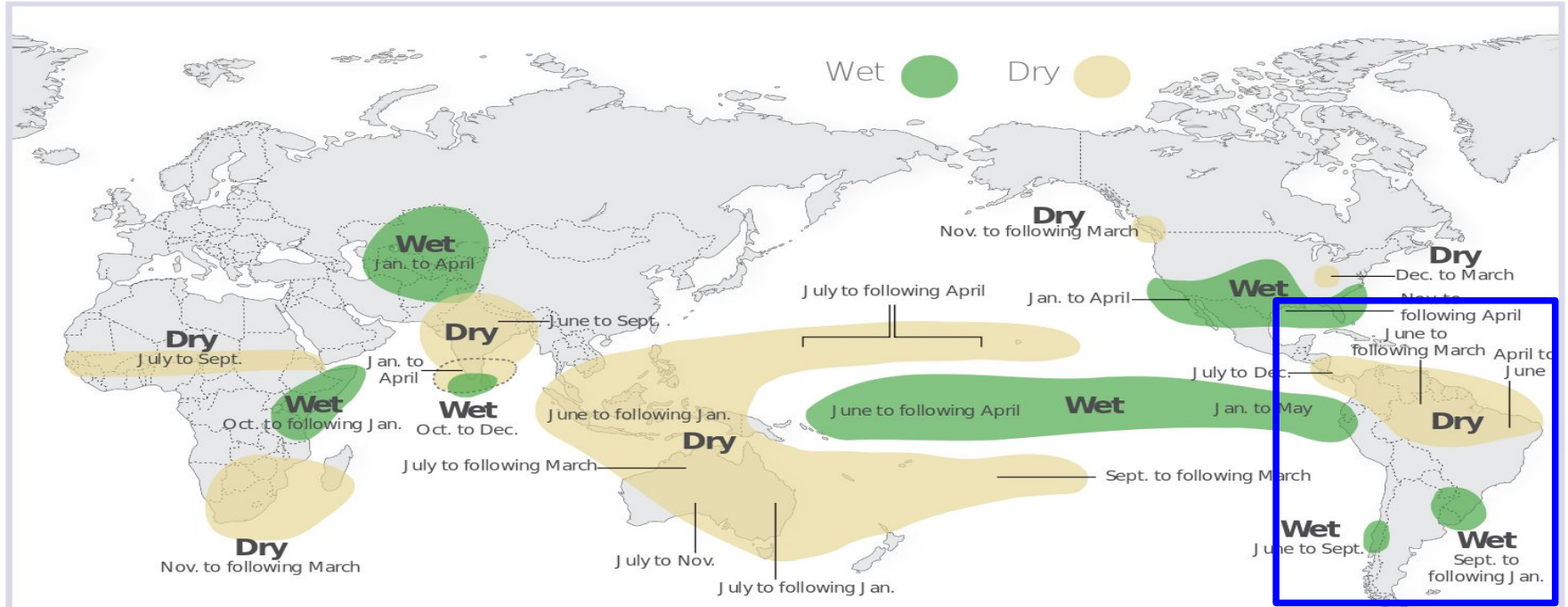
La Nina



What are the changes during ENSO years ?

El Niño and Rainfall

El Niño conditions in the tropical Pacific are known to shift rainfall patterns in many different parts of the world. Although they vary somewhat from one El Niño to the next, the strongest shifts remain fairly consistent in the regions and seasons shown on the map below.

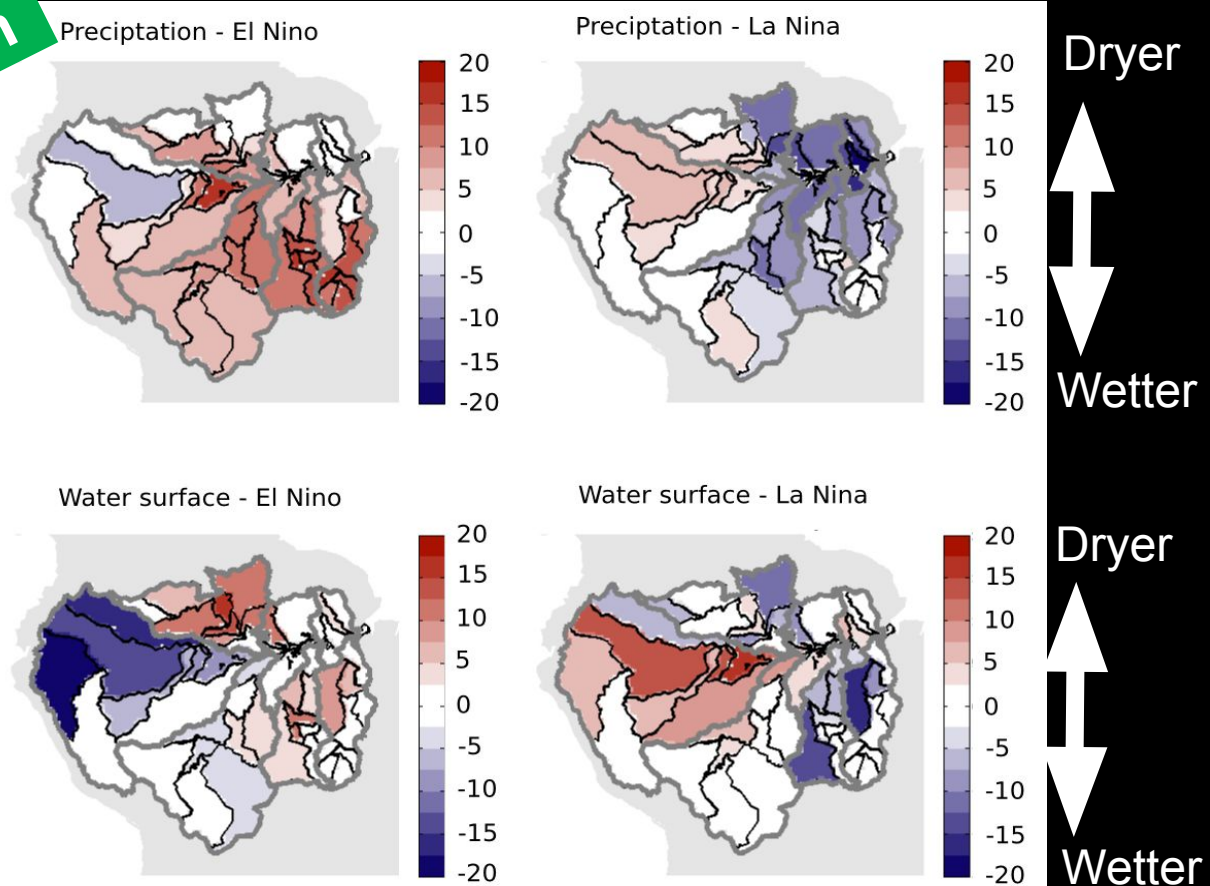


For more information on El Niño and La Niña, go to: <http://iri.columbia.edu/ENSO>

Sources: Ropelewski, C. F. and M. S. Halpert, 1989: Precipitation patterns associated with the high index phase of the Southern Oscillation. *J. Climate.*, 2, 268-284.
Mason and Goddard, 2001: Probabilistic precipitation anomalies associated with ENSO. *Bull. Am. Meteorol. Soc.* 82, 619-638

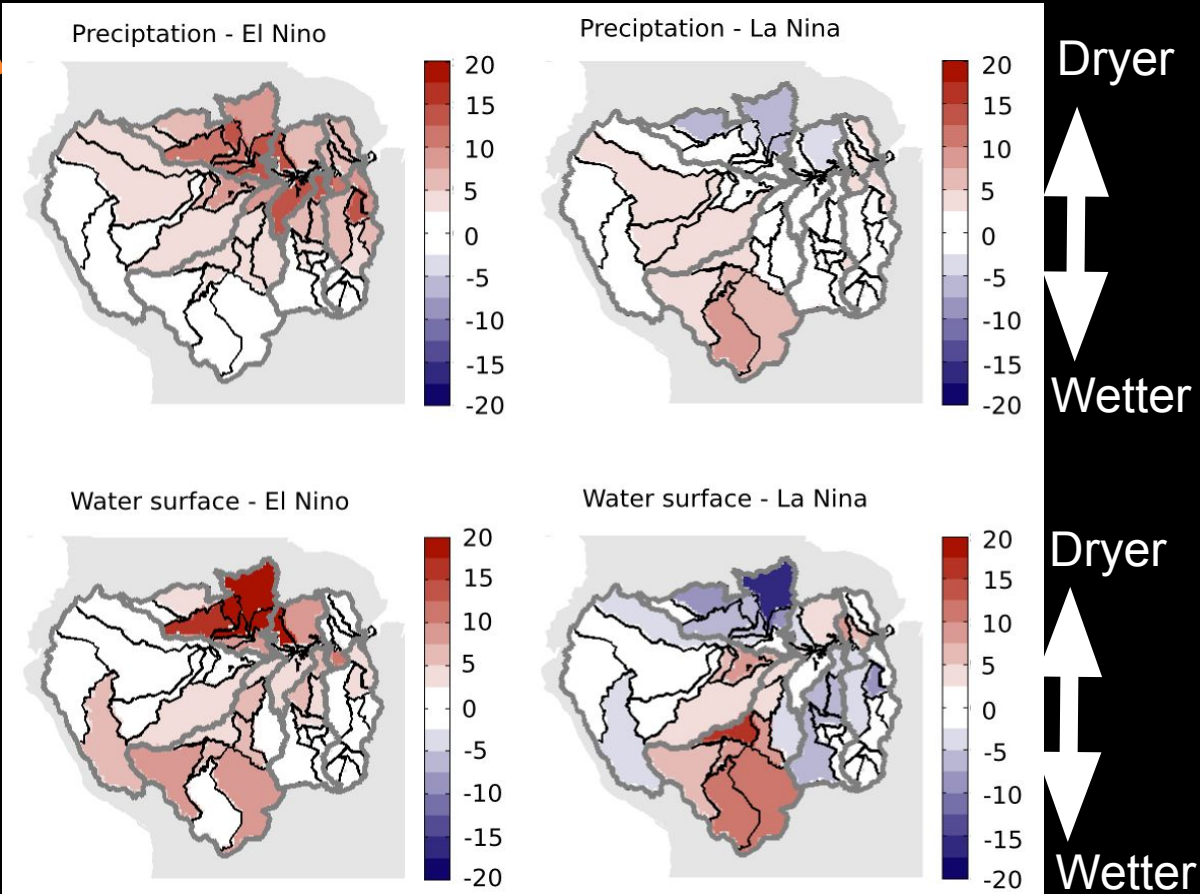
Difference of anomaly of integrated water surfaces

rainy season

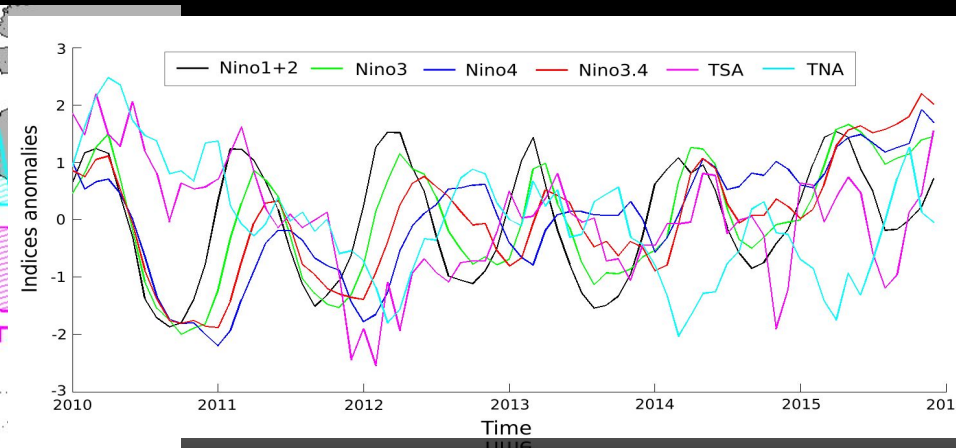
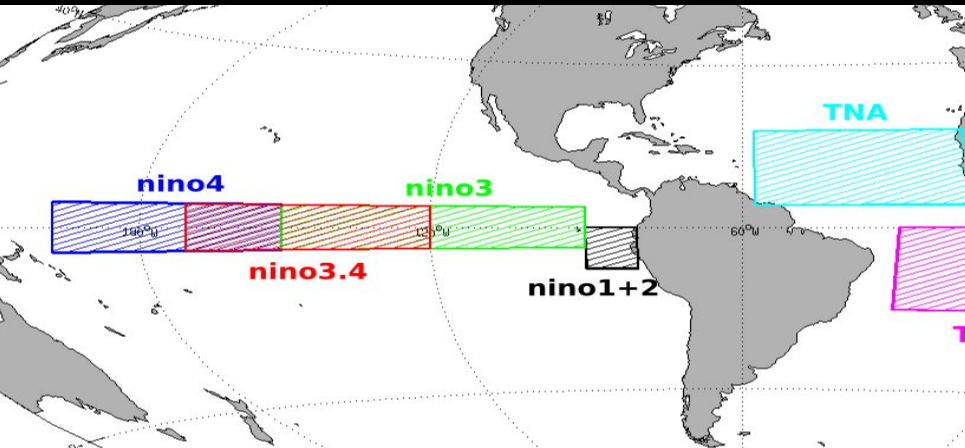


Difference of anomaly of integrated water surfaces

dry season



ENSO - SST indices



TNA: Tropical Northern Atlantic Index
 TSA: Tropical South Atlantic Index

ONI : Oceanic Nino Index

Normal years : 2012, 2013, 2014
 El nino year : 2015
 La nina year : 2011

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2010	1.3	1.2	0.9	0.5	0.0	-0.4	-0.9	-1.2	-1.4	-1.5	-1.4	-1.4
2011	-1.3	-1.0	-0.7	-0.5	-0.4	-0.3	-0.3	-0.6	-0.8	-0.9	-1.0	-0.9
2012	-0.7	-0.5	-0.4	-0.4	-0.3	-0.1	0.1	0.3	0.3	0.3	0.1	-0.2
2013	-0.4	-0.4	-0.3	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2	-0.3	-0.3	-0.3
2014	-0.5	-0.5	-0.4	-0.2	-0.1	0.0	-0.1	0.0	0.1	0.4	0.5	0.6
2015	0.6	0.5	0.6	0.7	0.8	1.0	1.2	1.4	1.7	2.0	2.2	2.3
2016	2.2	2.0	1.6	1.1	0.6	0.1	-0.3	-0.6	-0.7			

Lagged correlation with SST indices

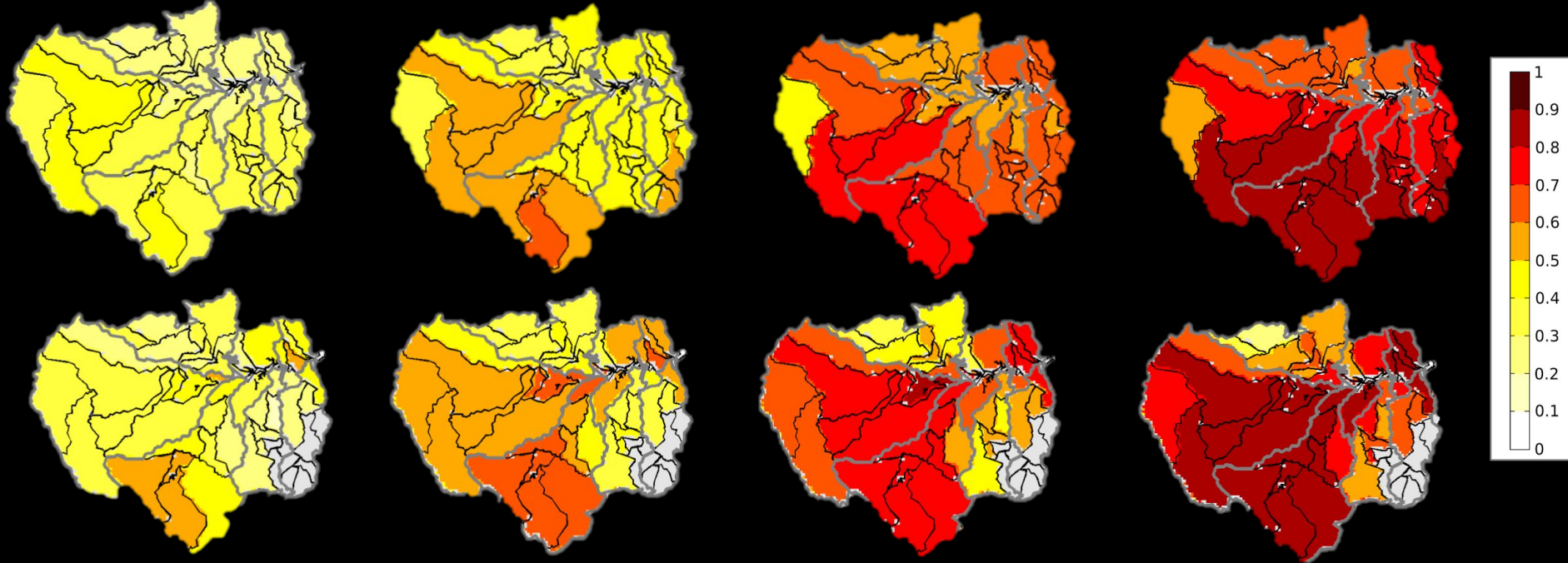
TRMM precipitation

Nino-4

Nino-3

Nino-2

Nino-1



Summary

On the technics in monitoring tropical wetlands surfaces

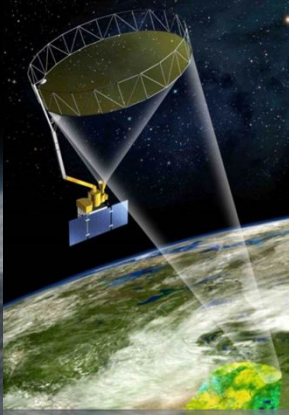
- SMOS L-band microwave can deliver accurate water surface maps at coarse scale and 7 days frequency over Tropical basins.
- Distributed as a L4 product from SMOS - <http://www.catds.fr>

On the impact of extremes events and ENSO dynamics

- Water surface dynamics show a distinct signal compared to rainfall
- The predictibility of ENSO from Water surface anomalies is higher than that of Rainfall using nino1+2

Futur work

Synergistic use of **L-band** and new generation of altimeters, Jason CS, Sentinel-3, **SWOT**.

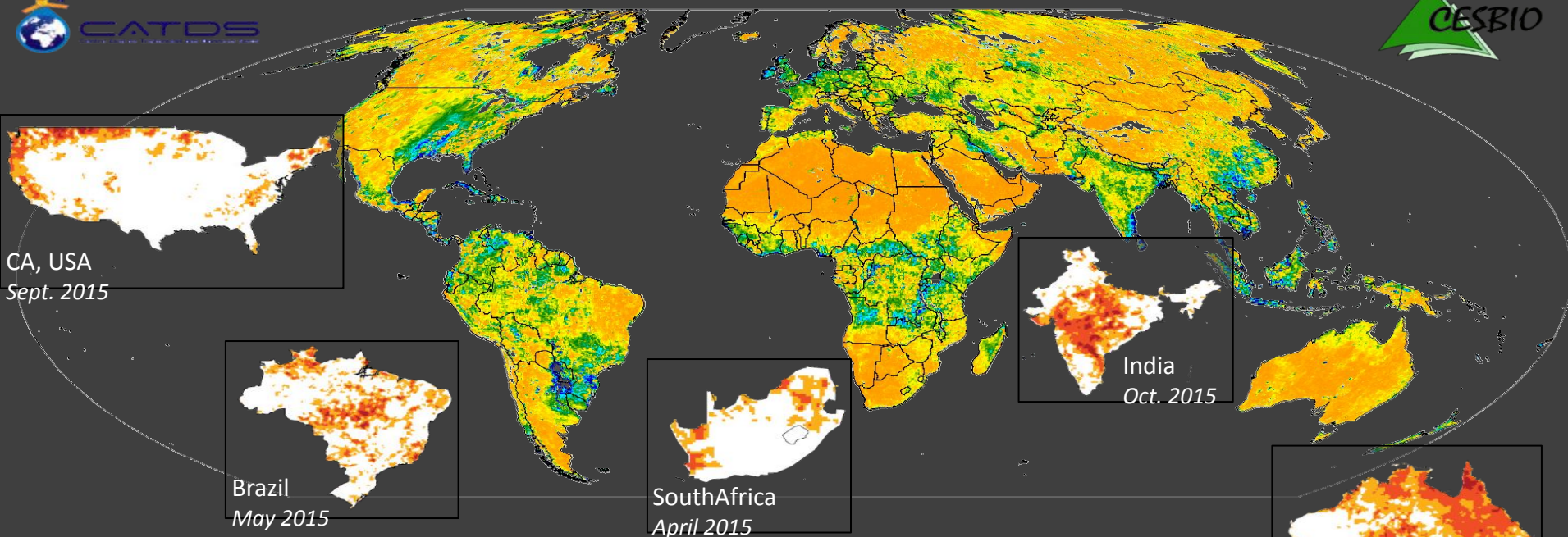


Thank you

Acknowledgements

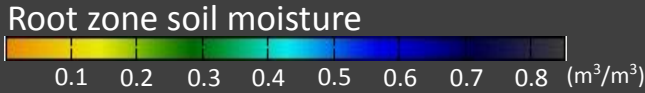
Support from the [CNES TOSCA SOLE](#) and [TOSCA SMOS](#) grants. Dr. Marie Parrens was financed by the [CNES post -doctoral program](#). The altimetric Jason-2 data was aquired using the [Theia Hydroweb](#) database. The SARAL-Altika data was aquired using the [CLS AVISO+](#). The SMOS data was delivered by the [CATDS](#) (Ifremer/CNES) center.

SMOS monitoring 5 major droughts in 2015



Thank you !

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec



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