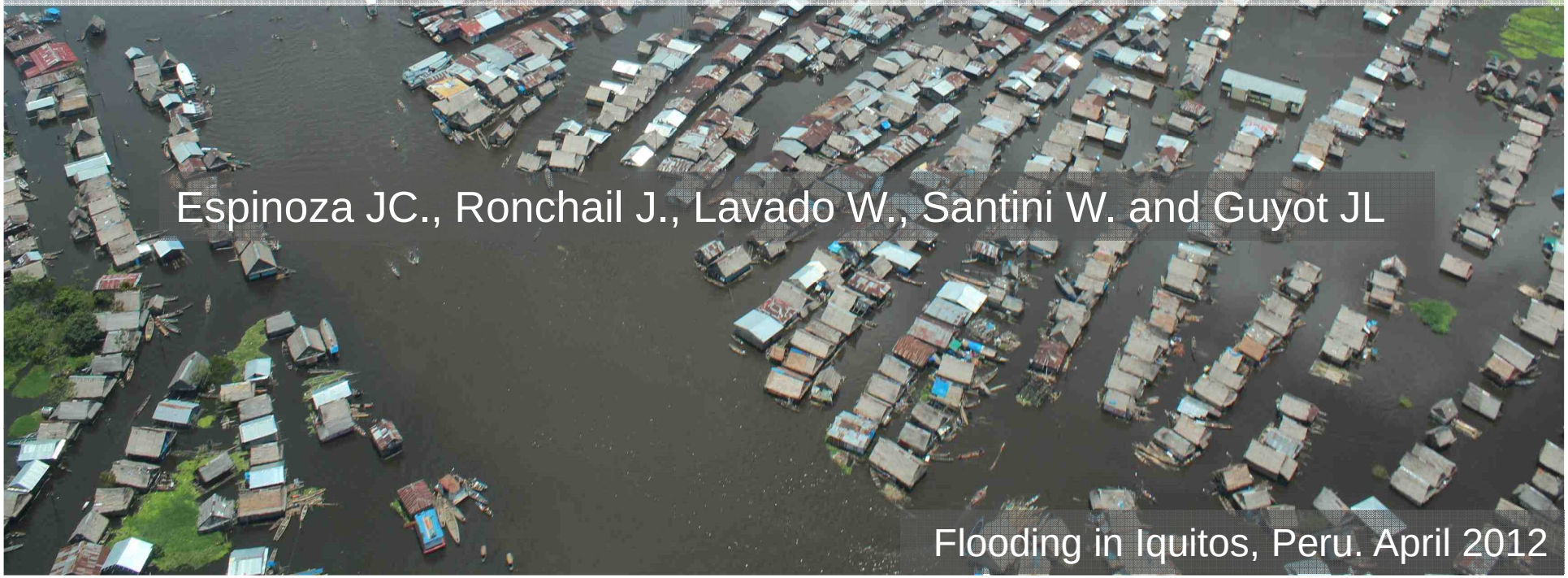
The recent extreme hydrological events in the upper Amazon Basin

Espinoza JC., Ronchail J., Lavado W., Santini W. and Guyot JL

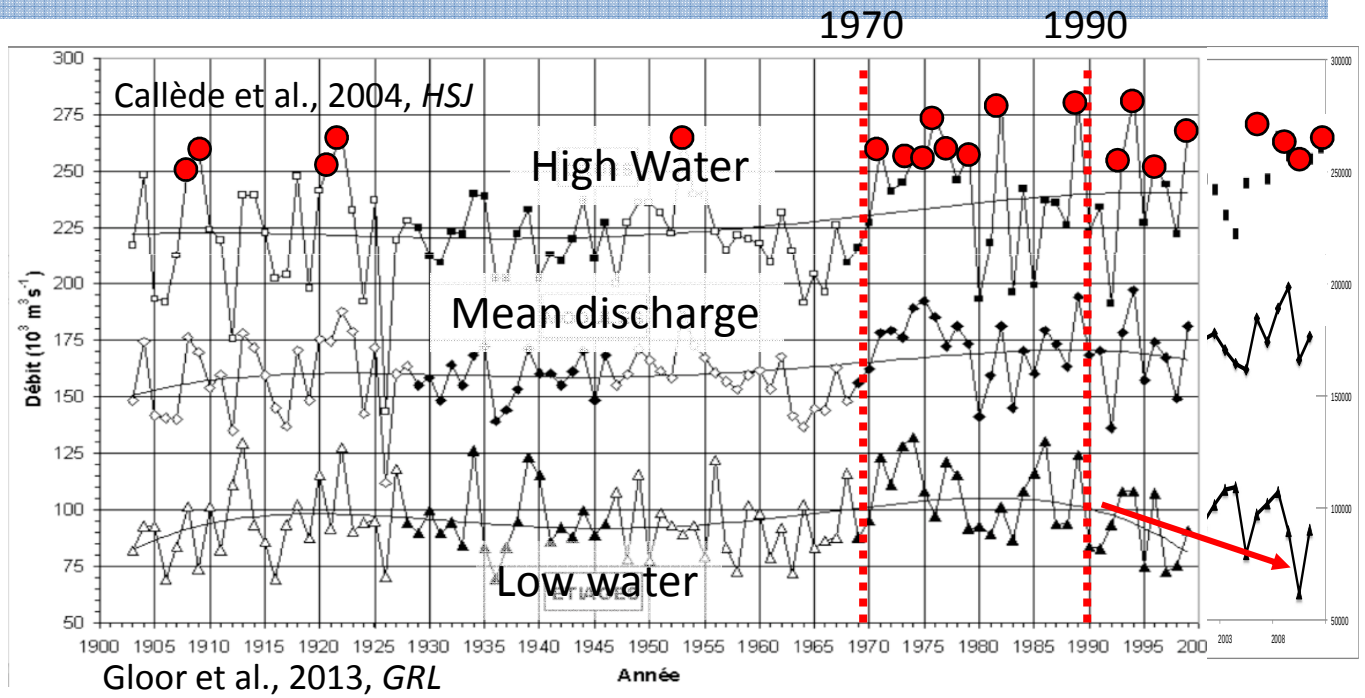


Flooding in Iquitos, Peru. April 2012

Hydrological evolution in Amazon River at Óbidos (Brazil): 1903 - 2012

- High discharges during the 1970s.
- High frequency of strong flooding after 1970: 16 events higher than 250 000 m^3/s after 1970 (only 5 between 1903 and 1970).
- Significant discharge diminution since 1990.





Gloor et al., 2013, *GRL*

Extreme hydrological events are more frequent : Extreme drought in 2005 and 2010; hystorical flooding in 2009 and 2012.

04 extreme events in the last 10 years

Amazonas-Solimões River (Peruvian and Ecuadorian Amazon)

The Amazonas at Tamshiyacu: 750 000 km^2 (12% of the Amazon basin surface),

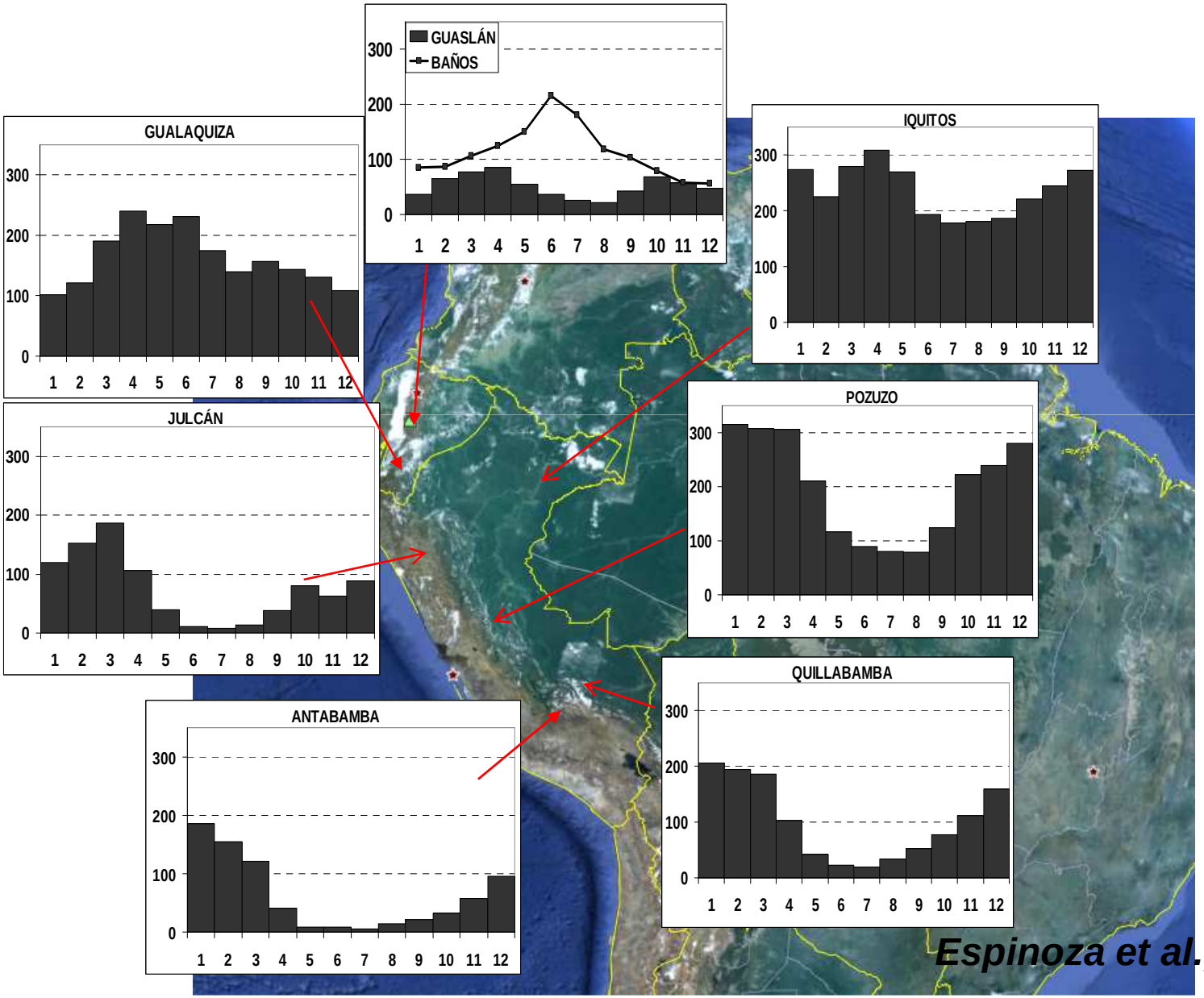
50% in the Andes







Several rainfall regimes over the Amazonas Basin



Espinoza et al., Hyd. Sc. J. 2006

Monitoring the hydrological variability

ORE-HYBAM Observatory

Discharge measurements (ADCP)

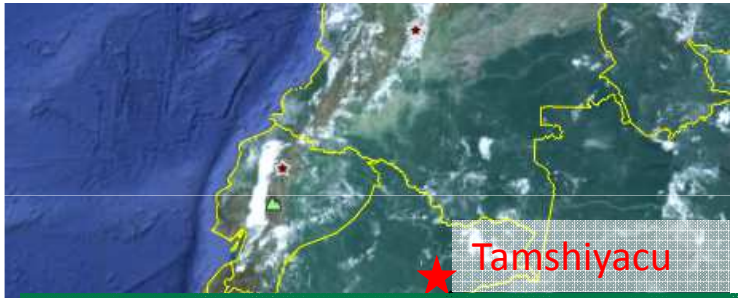




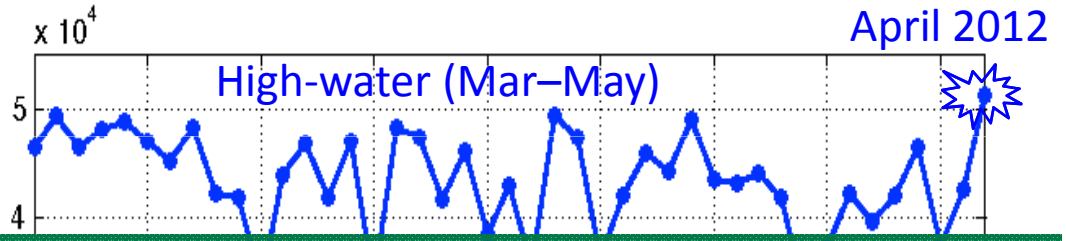
Long term hydrological variability

~32 000 m^3/s (15% of the Amazon discharge at the estuary)

Recently, severe hydrological extremes occurred:
2005 and 2010 droughts and 2012 flood



Historical discharge time-series since 1970



Why do these events occur?

Why are they more frequent?

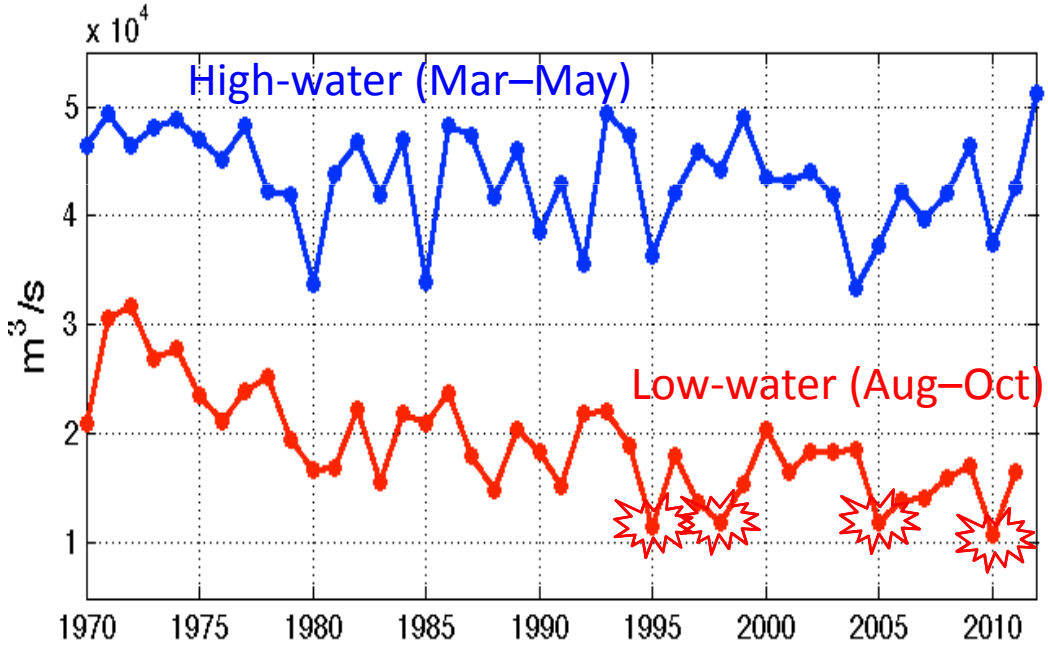
Information about the Brazilian Amazon:
(Marengo et al. 2008, Zeng et al. 2008, Tomasella et al 2010, Lewis et al., 2011; Marengo et al., 2011)

Droughts in the Amazonas River

GRL | Geophysical Research Letters Espinoza et al., 2011 AGU American Geophysical Union

Extreme drought years: monthly low flow runoff below the tenth percentile (~500 mm or ~12000 m^3/s): **1995; 1998; 2005 y 2010.**





Droughts in the Amazonas River

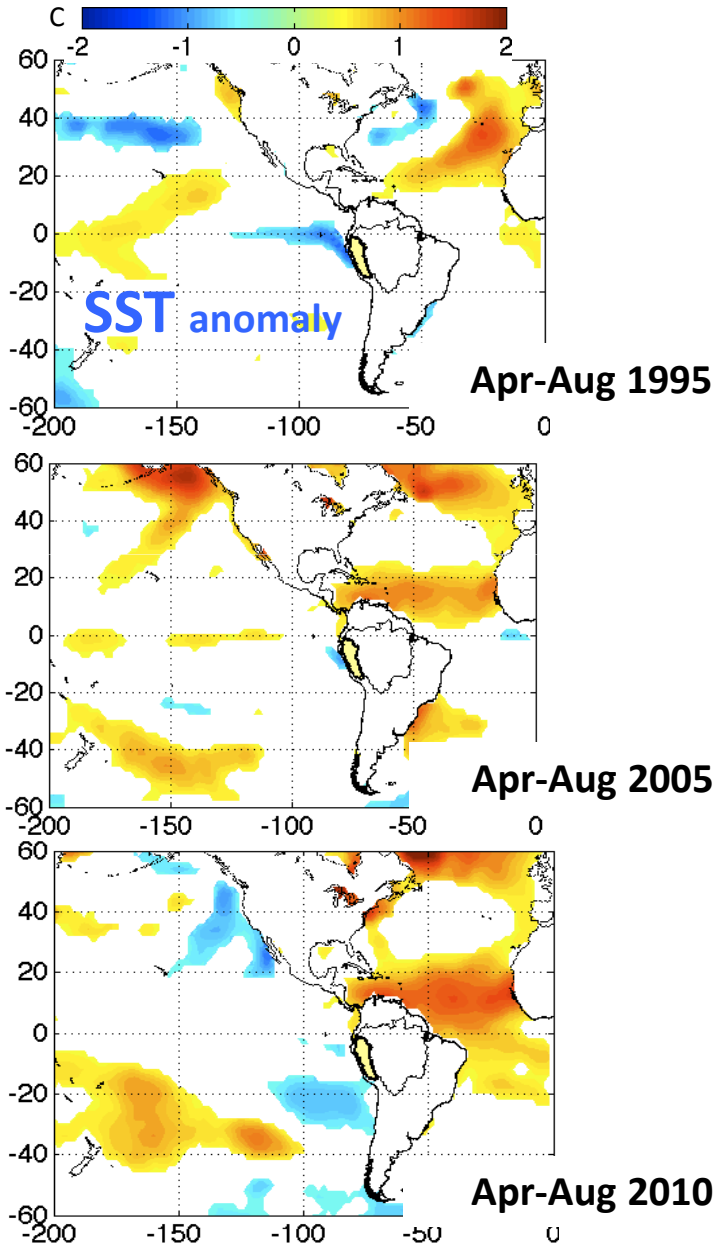
Data :

Global monthly SST data [Smith et al, 2008]

2.5° x 2.5° latitude and longitude horizontal and vertical wind, geopotential high and humidity data from NCEP–NCAR reanalysis [Kalnay et al., 1996]

Focus on April-August period preceding the low-stage season

Droughts in the Amazonas River



Data :

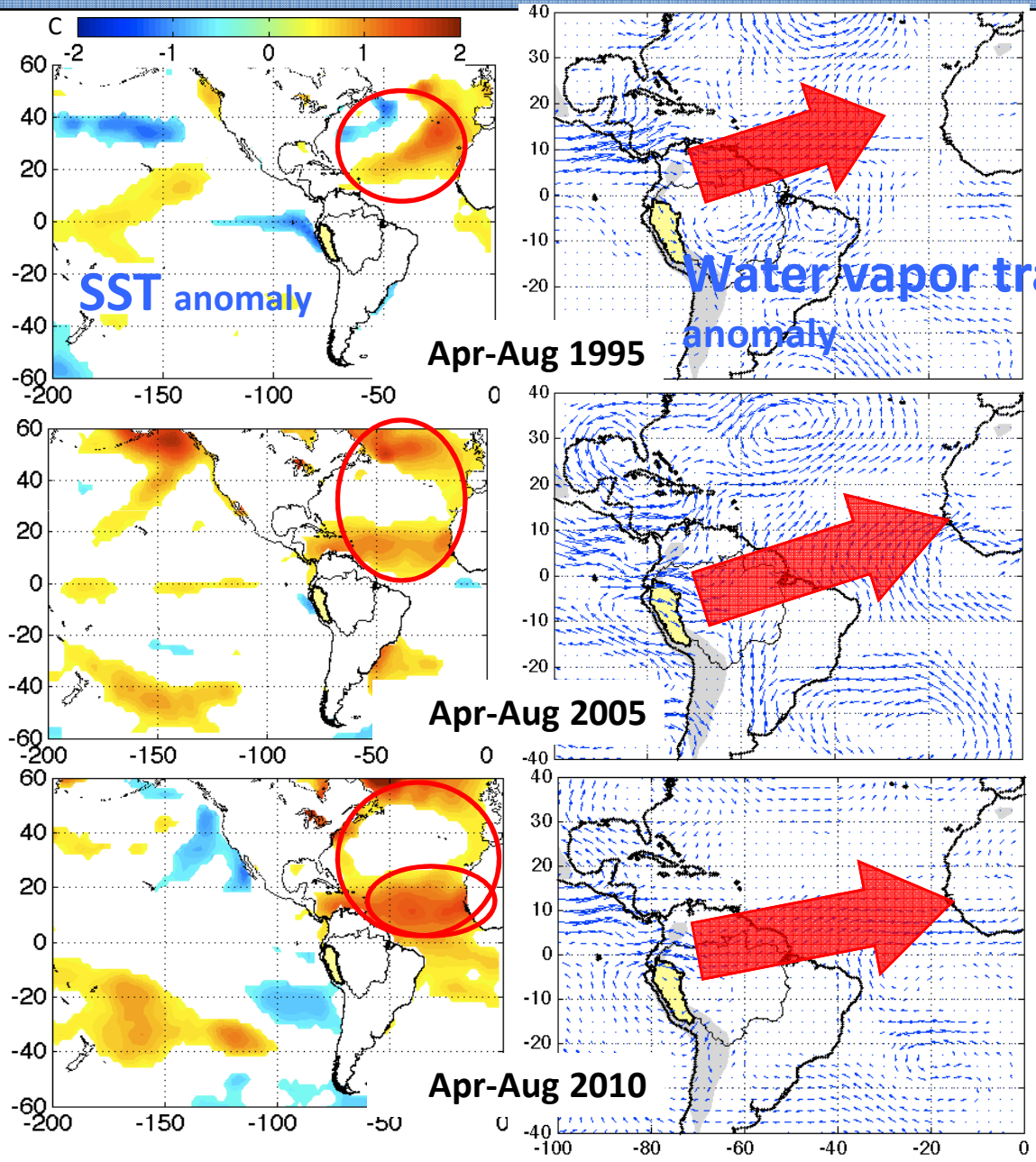
Global monthly SST data [Smith et al, 2008]

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High positive Sea Surface Temperature anomalies in the tropical North Atlantic

Common ocean-atmospheric features during the 1995, 2005 and 2010 droughts

Common ocean-atmospheric features during the 1995, 2005 and 2010 droughts



High positive Sea Surface Temperature anomalies in the tropical north Atlantic

Reduced trade winds and water vapour transport toward the Amazon basin

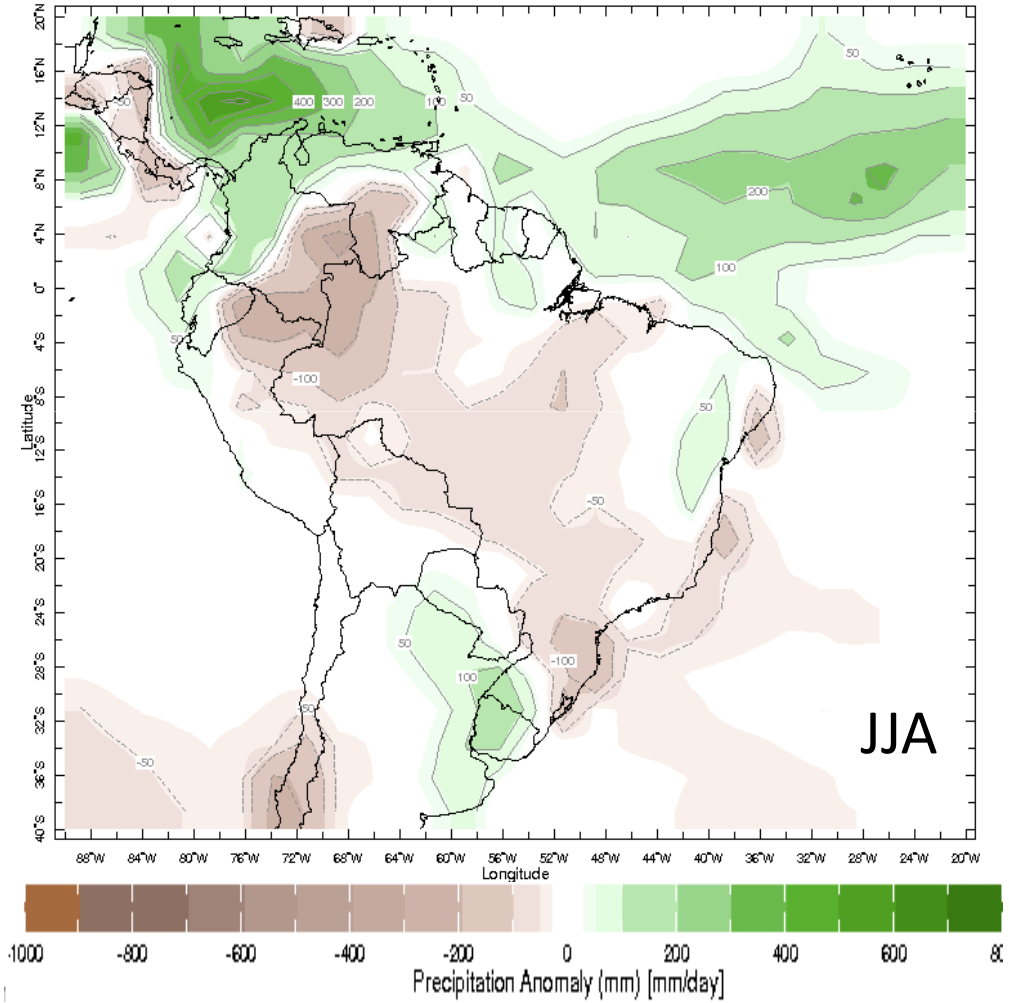
\+ increased subsidence (not shown)

Droughts in the Amazonas River

Rainfall anomalies during warm episodes in the North tropical Atlantic

Green: Positive rainfall anomaly

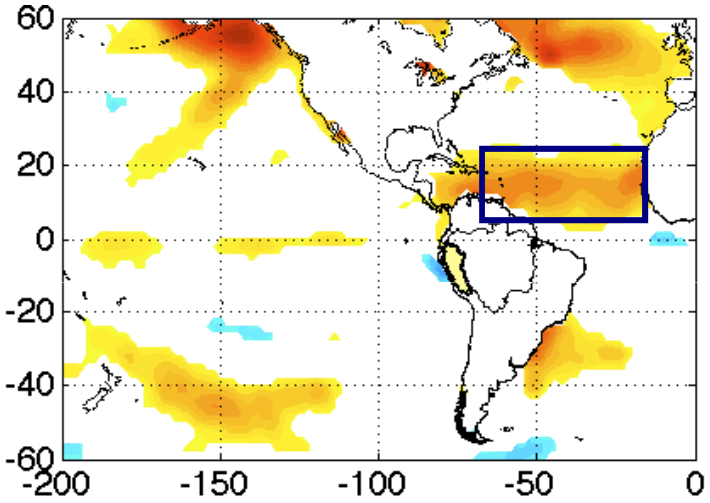
Brown: Negative rainfall anomaly

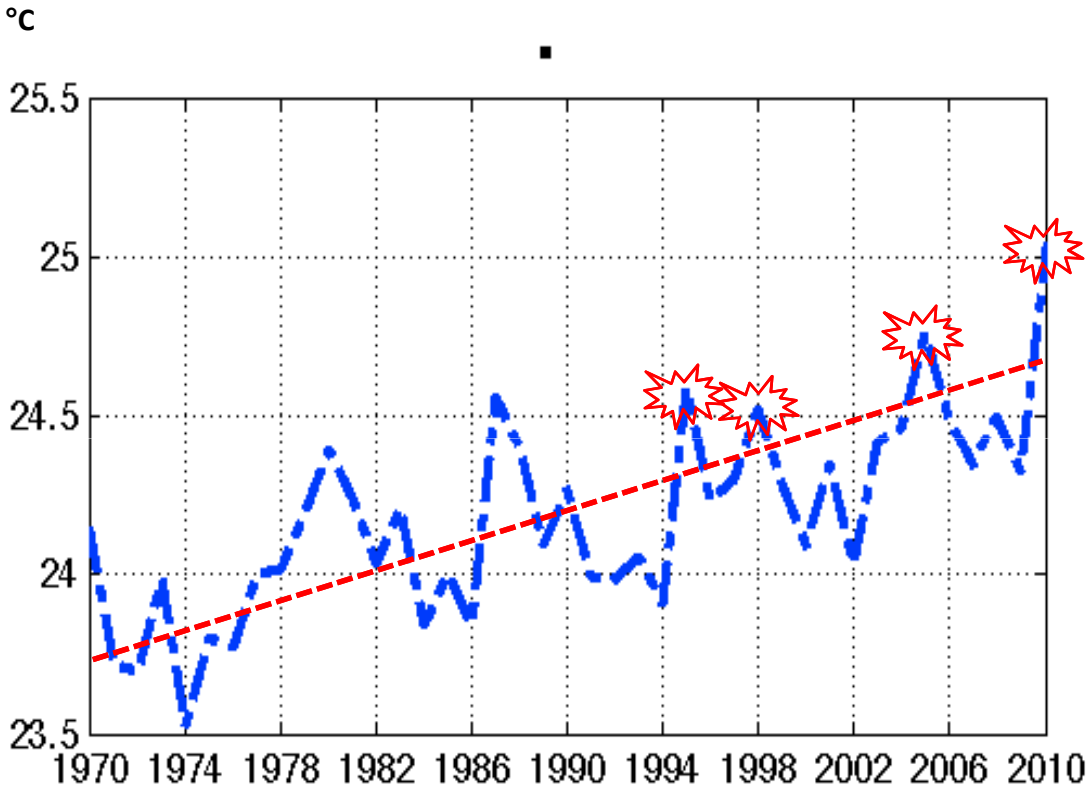


From http://iridl.ldeo.columbia.edu/

Droughts in the Amazonas River

Why are these events more frequent ?





SST evolution in the 20-60W and 30°N-0° region (Apr-Aug, 1970-2010)

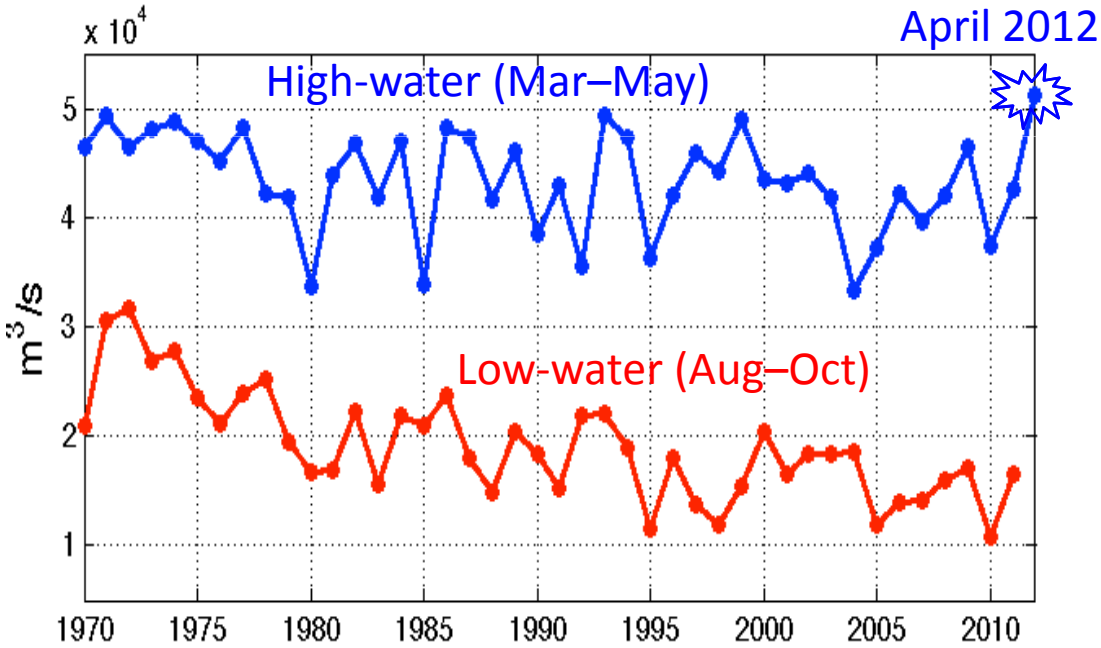
The frequency of drought might be related to this positive trend

Long term hydrological variability

Historical flooding in Peruvian Amazon:

55 400 m^3/s in April 2012





Historical discharge time-series since 1970

Floods in the Amazonas River

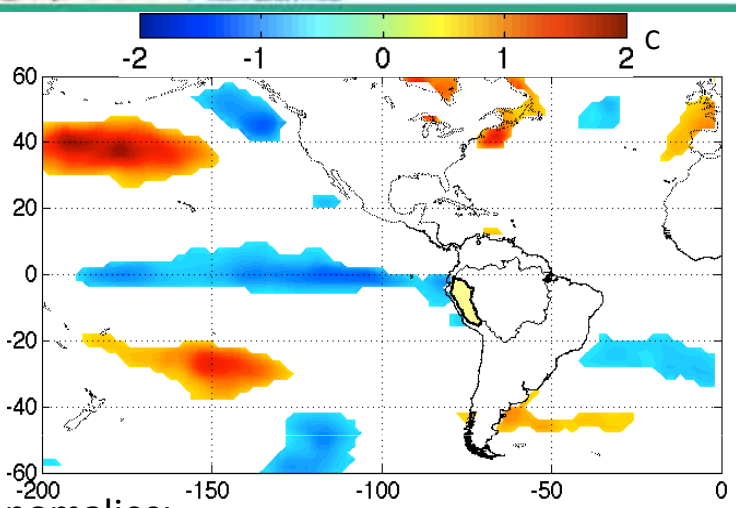


Flood in Iquitos: April 2012

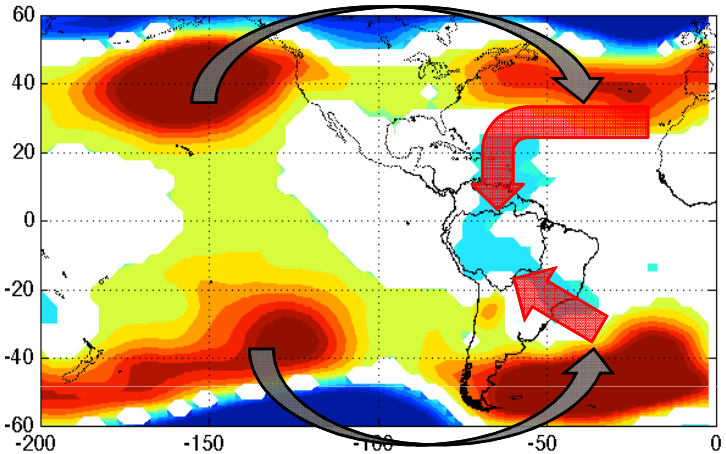
Floods in the Amazonas River

AMERICAN METEOROLOGICAL SOCIETY
JOURNAL OF HYDROMETEOROLOGY

Espinoza et al., 2013

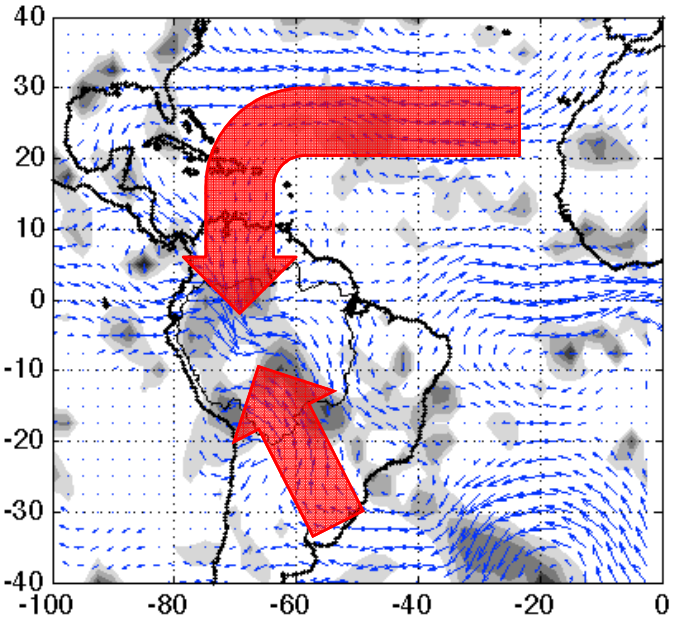


SST anomalies:
Dec-Mar 2012



Geopotential anomalies
at 850 hPa

Humidity transport flux anomalies
(vectors)
And its convergence (gray)



Conclusions

Drought: Warm conditions in the tropical North Atlantic (April – August). Ej. 2010, 2005, 1995

Floods: Cool conditions in central Pacific (Dec – Mar). Ej. 2012, 2011, 1999



Drought: are more frequent due to the positive trend of SST in tropical North Atlantic

Recent events have strongly impacted the Amazonian society: fluvial transport, agriculture, ecology, etc

Impacts on the Amazonian rainforest

Rainfall anomalies and tree mortality during the 2005 and 2010 doughts

Rainfall anomalies

Drought intensity
(correlated to tree mortality)

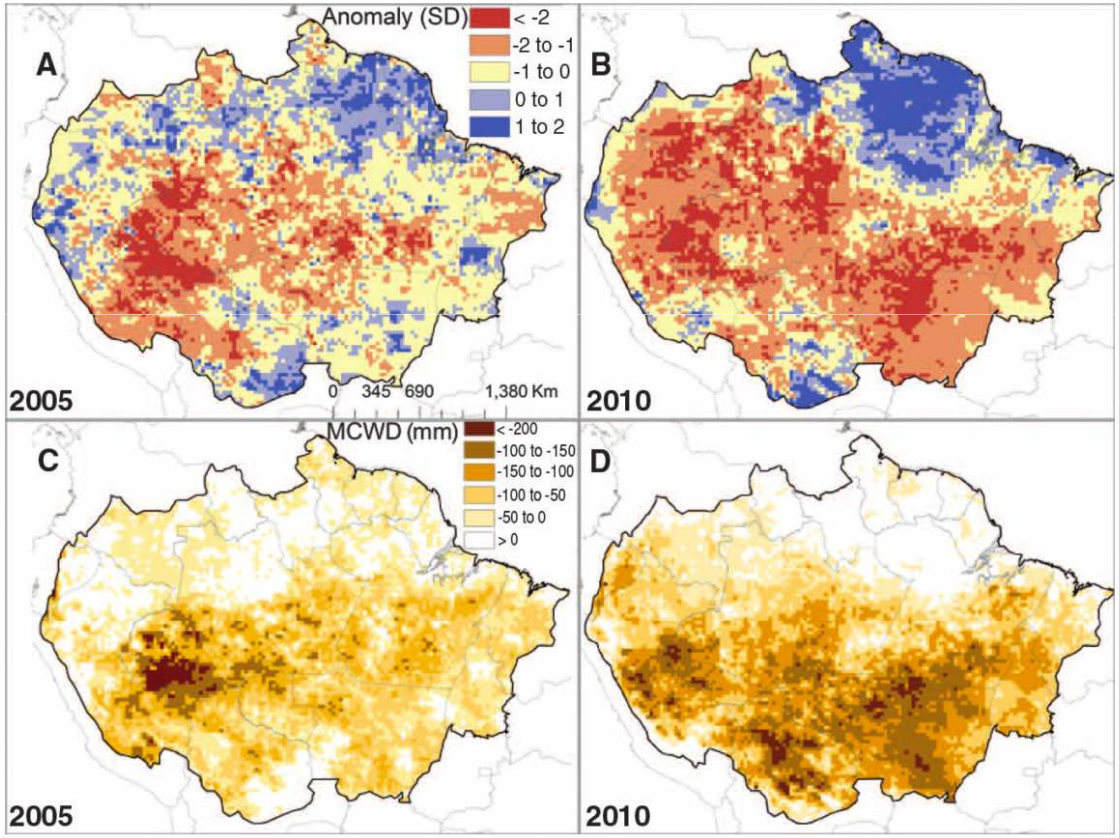


Fig. 1. (**A** and **B**) Satellite-derived standardized anomalies for dry-season rainfall for the two most extensive droughts of the 21st century in Amazonia. (**C** and **D**) The difference in the 12-month (October to September) MCWD from the decadal mean (excluding 2005 and 2010), a measure of drought intensity that correlates with tree mortality. (A) and (C) show the 2005 drought; (B) and (D) show the 2010 drought.

Lewis et al., 2011, Sience

Impacts on the Amazonian society

2010: Serious problems in fluvial transport and impacts on economy



Iquitos and other towns in Peru's rainforest region **have no road links to the rest of the country**, and depend on the Amazonas and its tributaries for transport.

Food and other supplies are now being brought in by smaller boats that can navigate the shallow channels, weaving between exposed mud banks.

For instances, the bottled gas-price (used for cooking) increased from **$13 to $40 in few days**

Conclusions

Improve the forecast of extreme hydrological events is an important challenge for scientific community of upper and lower Amazonian countries.

Better understand the dynamics between climate, hydrology and land-use in order to reduce the uncertainties of extreme hydrological events in the future.

Thank you



Institut de recherche pour le développement