

Extreme drought in the upper Solimões River (Western Amazon Basin): Understanding the exceptional 2010 drought

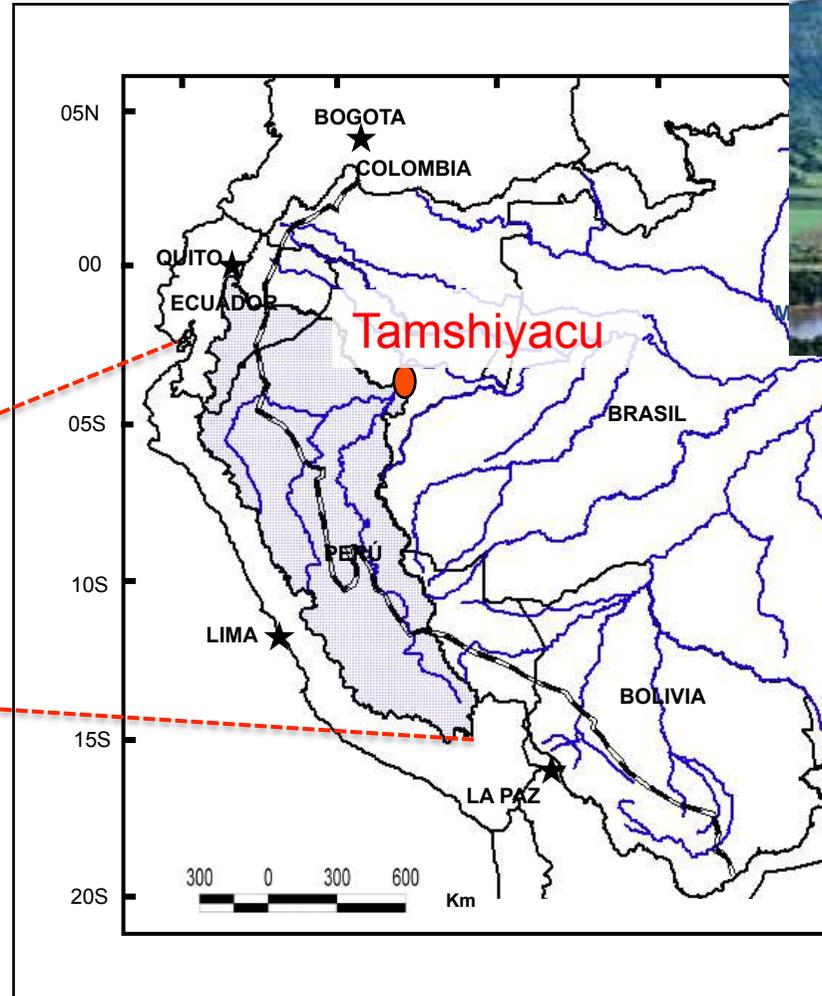
JC Espinoza;
J Ronchail; JL Guyot; C Junquas; W Lavado; G Drapeau; R Pombosa; P Vauchel

Espinoza et al., 2011. *Geophys. Res. Lett.*, 38, L1340

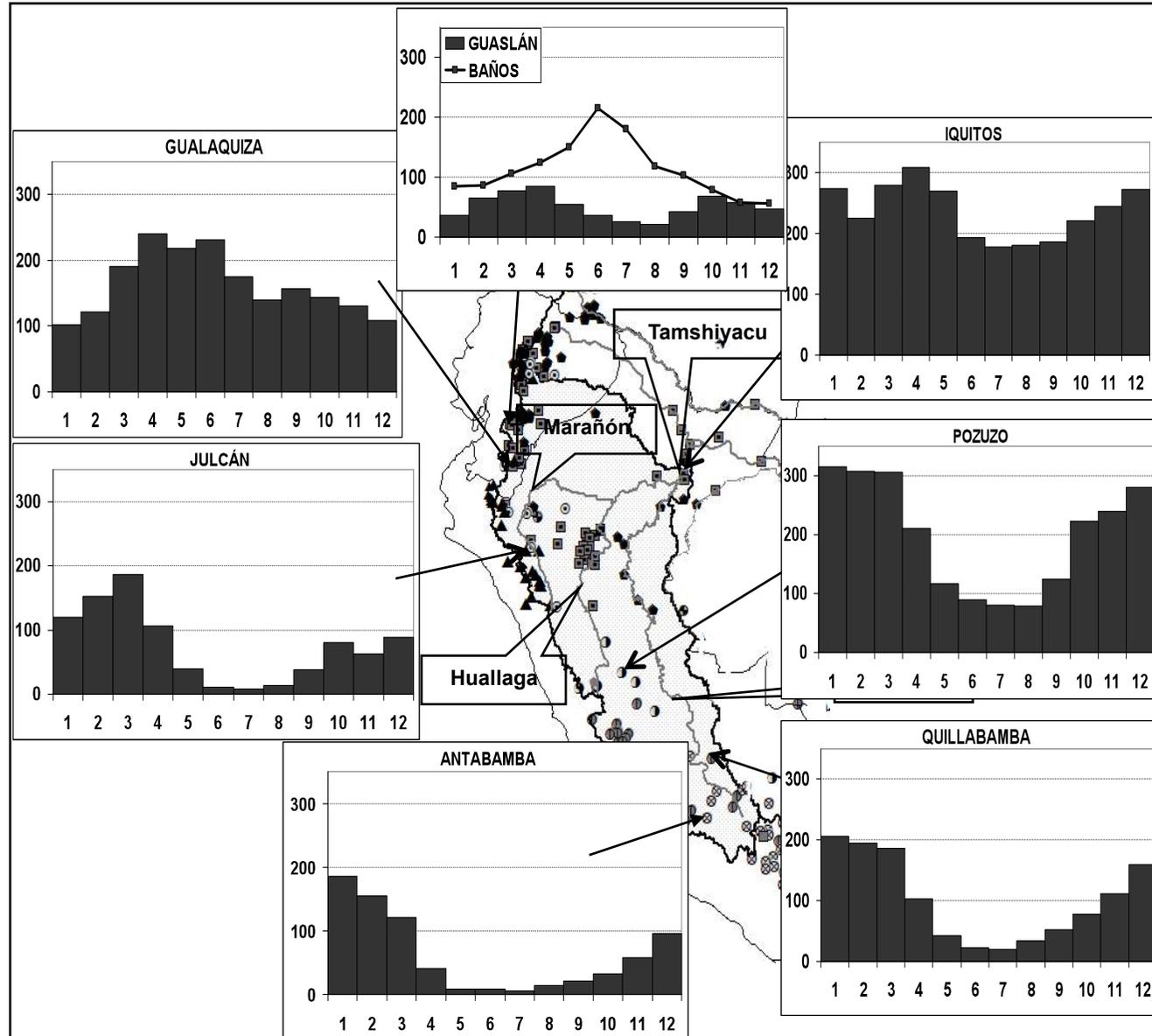
J. Carranza

The Amazon Basin and the upper Solimões Basin

The upper Solimões at Tamshiyacu: between 0 and 15°S
750 000 km² (12% of the AB surface),
Around 30 000 m³/s (15% of the Amazon discharge at the estuary),
50% above 500 m ([Espinoza et al. 2006, 2009](#))



Upper Solimões basin: rainfall data



Espinoza et al., 2009 IJC

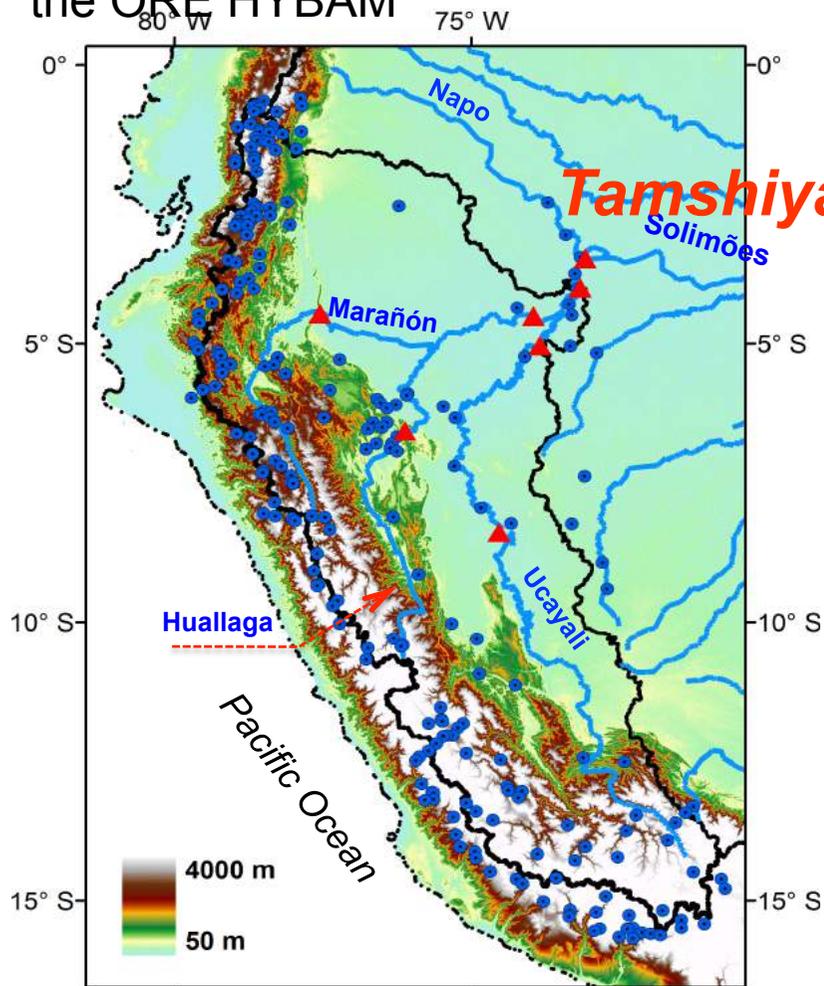
**237 rainfall stations
from Peruvian and
Ecuadorian
meteorological
services.**

1963-2009



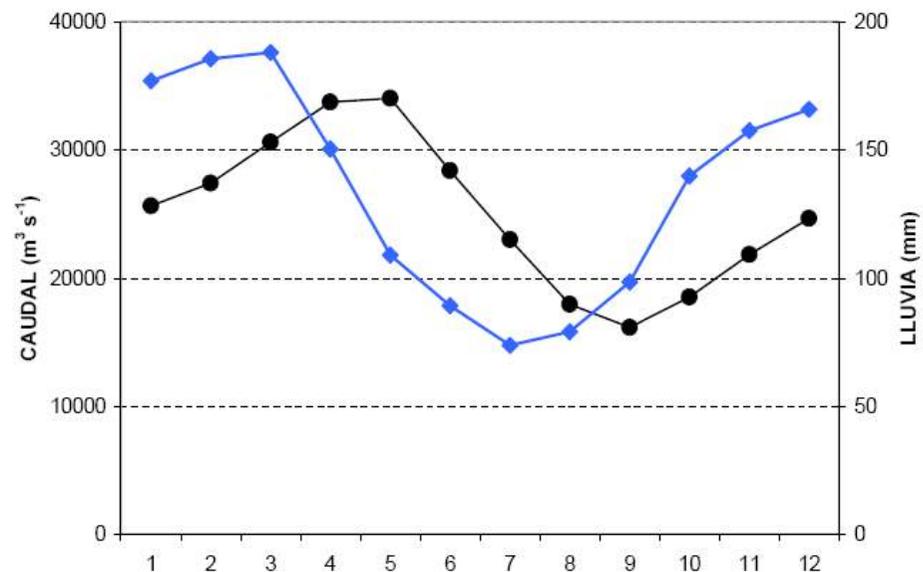
Upper Solimões: hydrological data

Tamshiyacu: 1970-2010 period
Water level from the Peruvian hydrological services - River gauging and rating curve from the ORE HYBAM



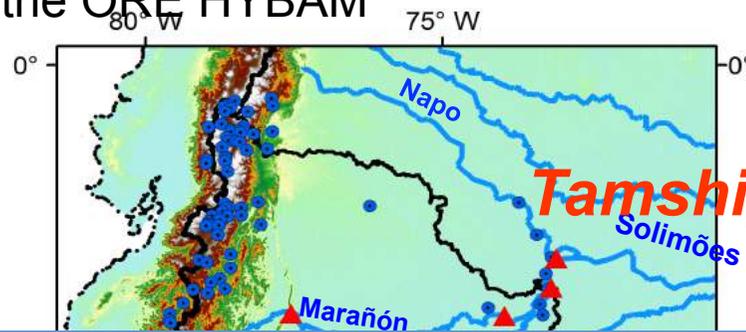
Blue line: mean monthly rainfall in the basin (1970-2009)

Black line : monthly discharge (1970-2009)



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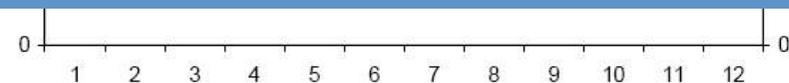
Black line : monthly discharge

RECENTLY VARIOUS SEVERE DROUGHTS OCCURED DURING THE LOW STAGE SEASON.

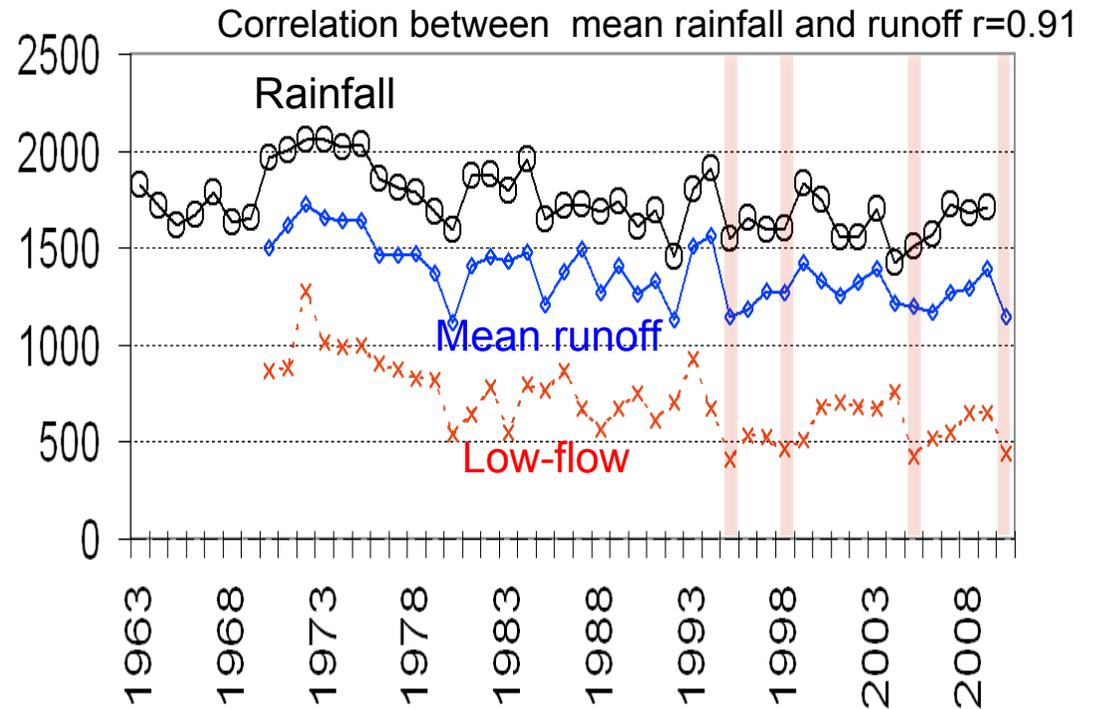
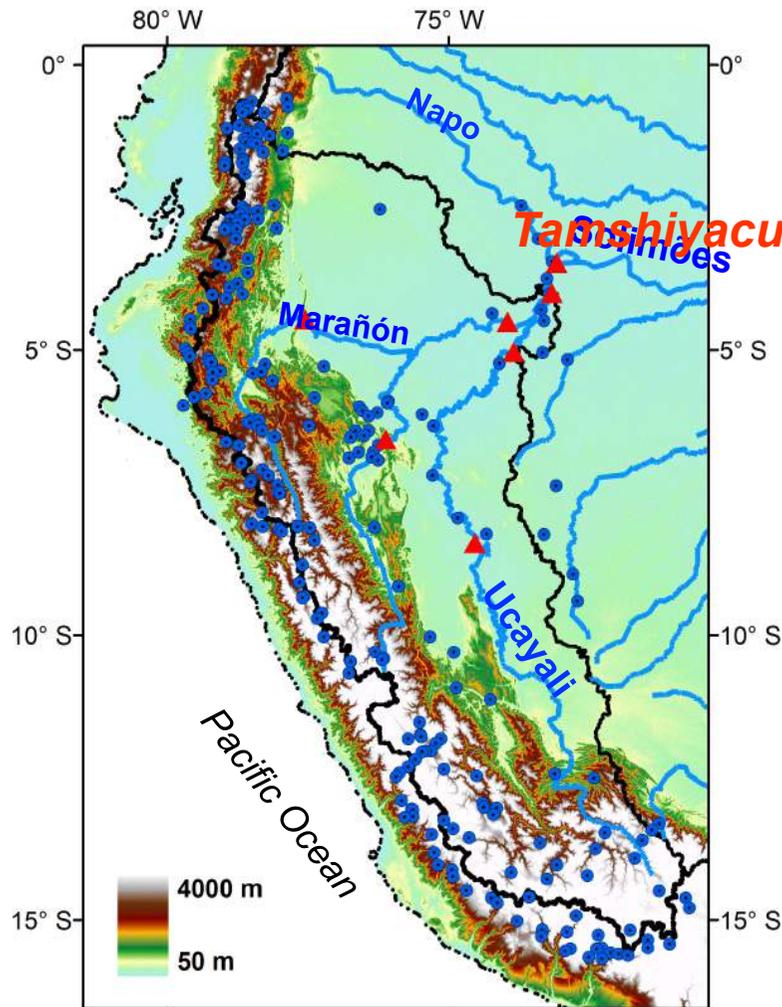
THE LAST ONE: 2010

WHY ?

Informations about the Brazilian Amazon (Ronchail et al 2002, Espinoza et al. 2009a and b, Marengo et al. 2008, Zeng et al. 2008, Tomasella et al 2010, Yoon and Zeng 2010)



Long term variability and droughts



- Extreme drought years: monthly low flow runoff below the tenth percentile (~ 500 mm or ~ 12000 m³/s): 1995; 1998; 2005 and 2010.
- Diminution in rainfall and mean and low-flow discharge since the seventies

Toward an explanation of extreme low-flow discharge

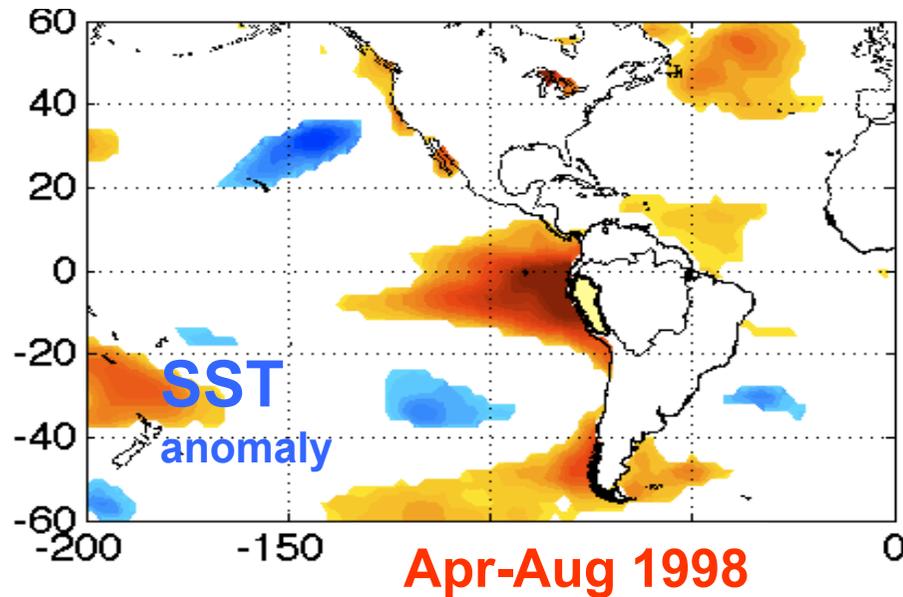
Data :

Global monthly SST data [Reynolds and Smith, 1994]

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

Case 1: the 1998 drought related to the 1997-98 El Niño event



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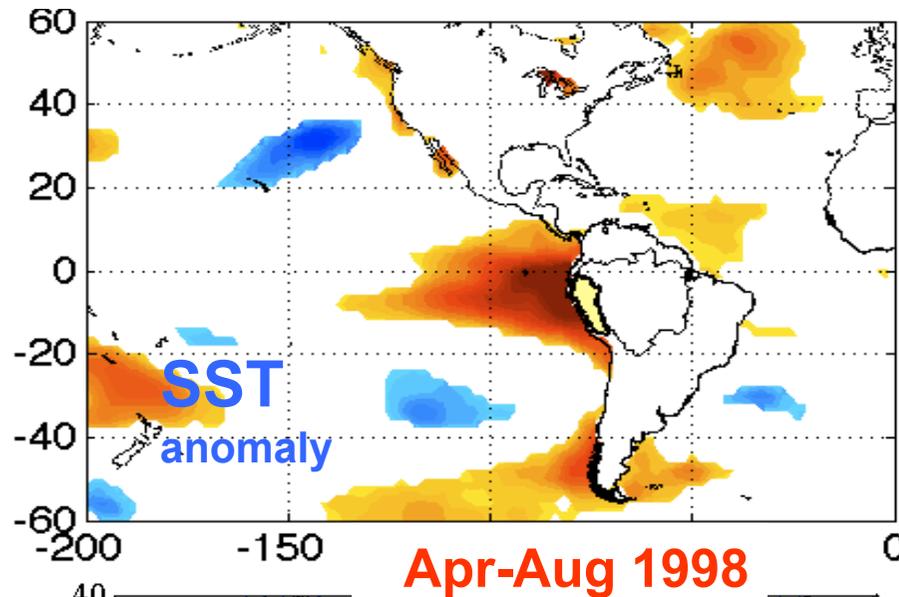
Positive SST anomalies in the eastern tropical Pacific (ending of the 1997-98 El Niño)

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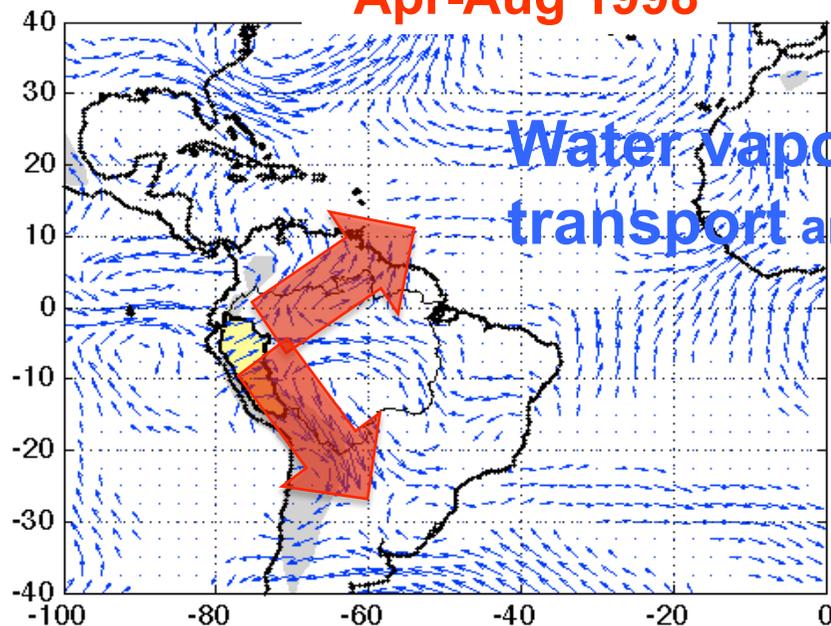
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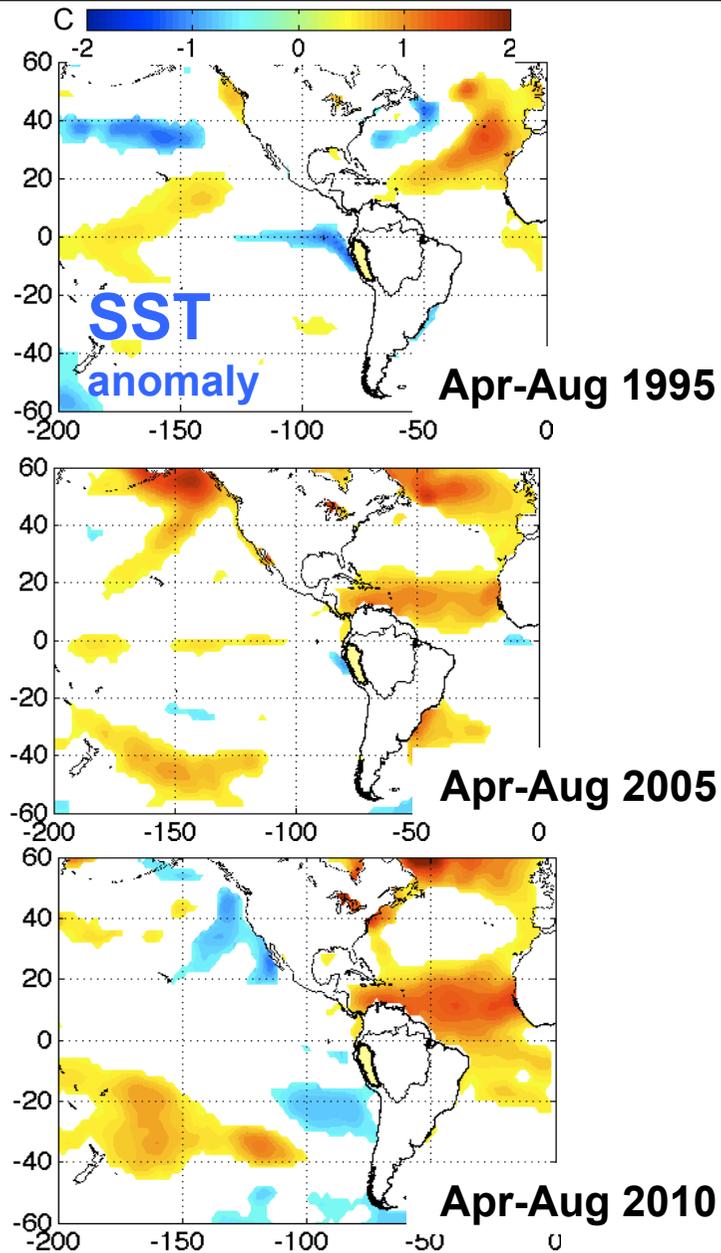


Positive SST anomalies in the eastern tropical Pacific (ending of the 1997-98 El Niño)



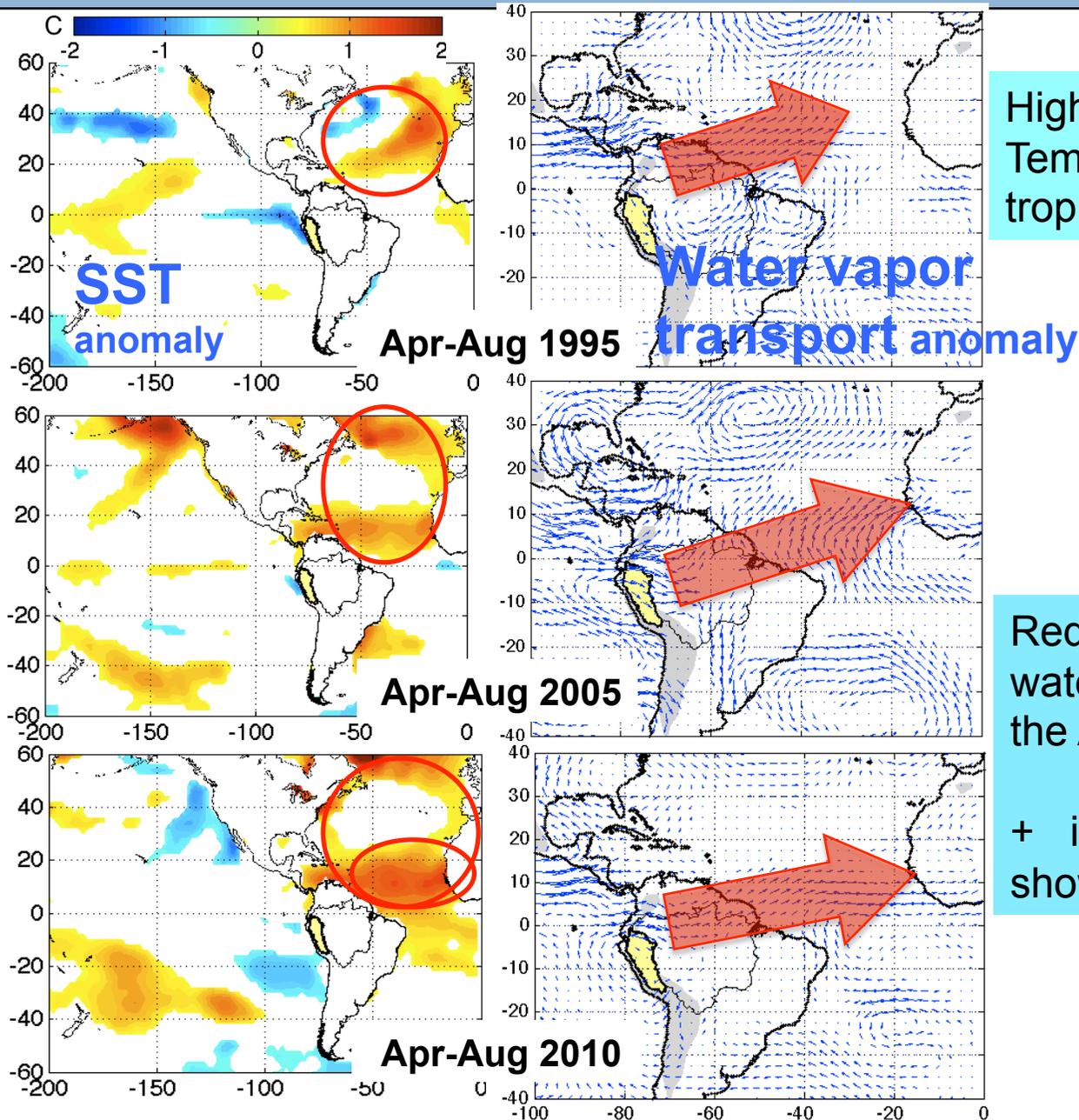
Strong divergence in water vapour transport in the upper Solimões basin (and subsidence in the troposphere)

Case 2: Common ocean-atmospheric features during the 1995, 2005 and 2010 droughts



High positive Sea Surface Temperature anomalies in the tropical north Atlantic

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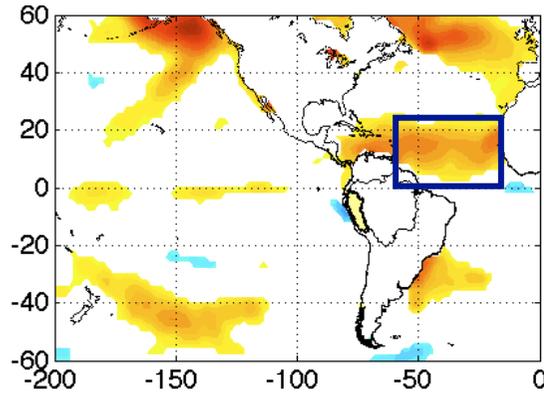


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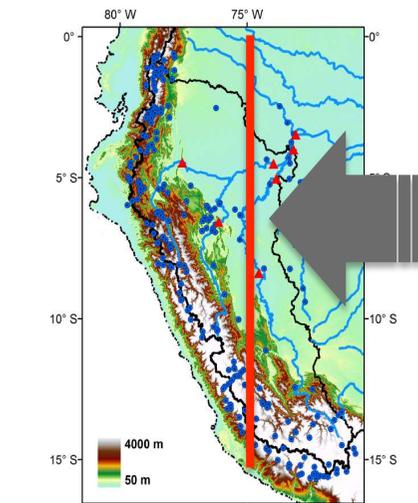
Reduced trade winds and water vapour transport toward the Amazon basin

+ increased subsidence (not shown)

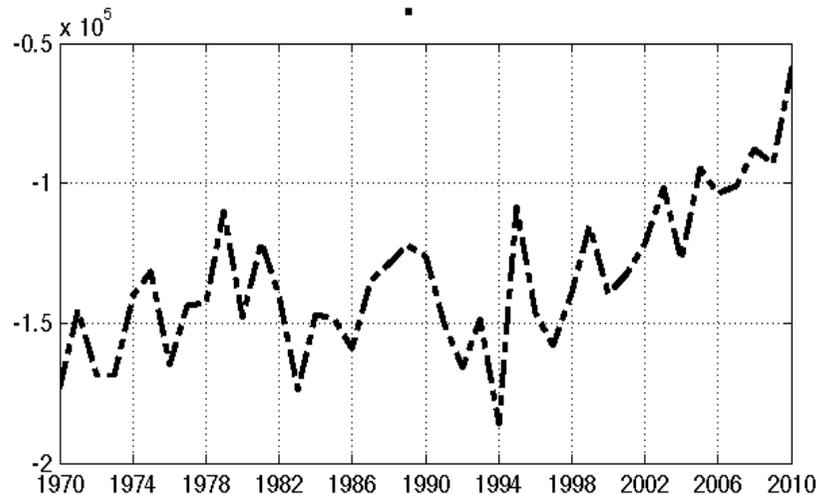
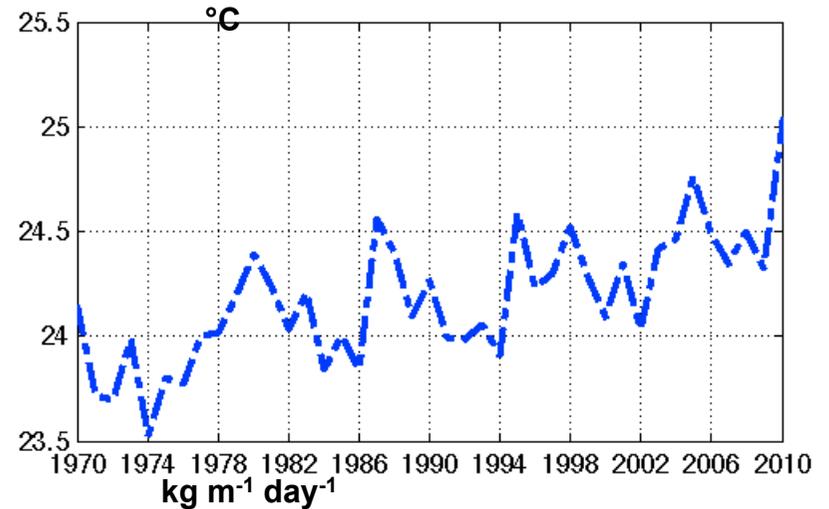
Why extreme droughts are more frequent after the 90's ?



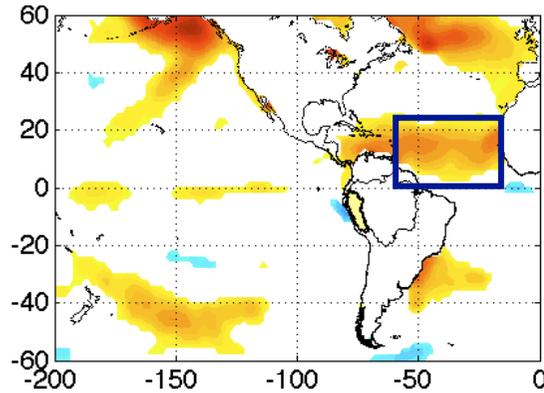
Mean SST in the 20-60W and 30°N-0° region (April to August, 1970-2010)



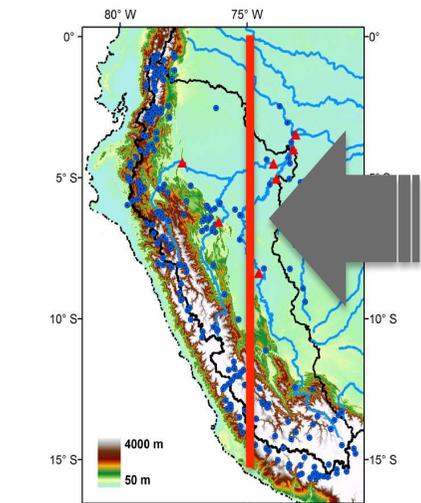
Mean water vapor flux on 0 to 15°S at 75°W (April to August, 1970-2010)



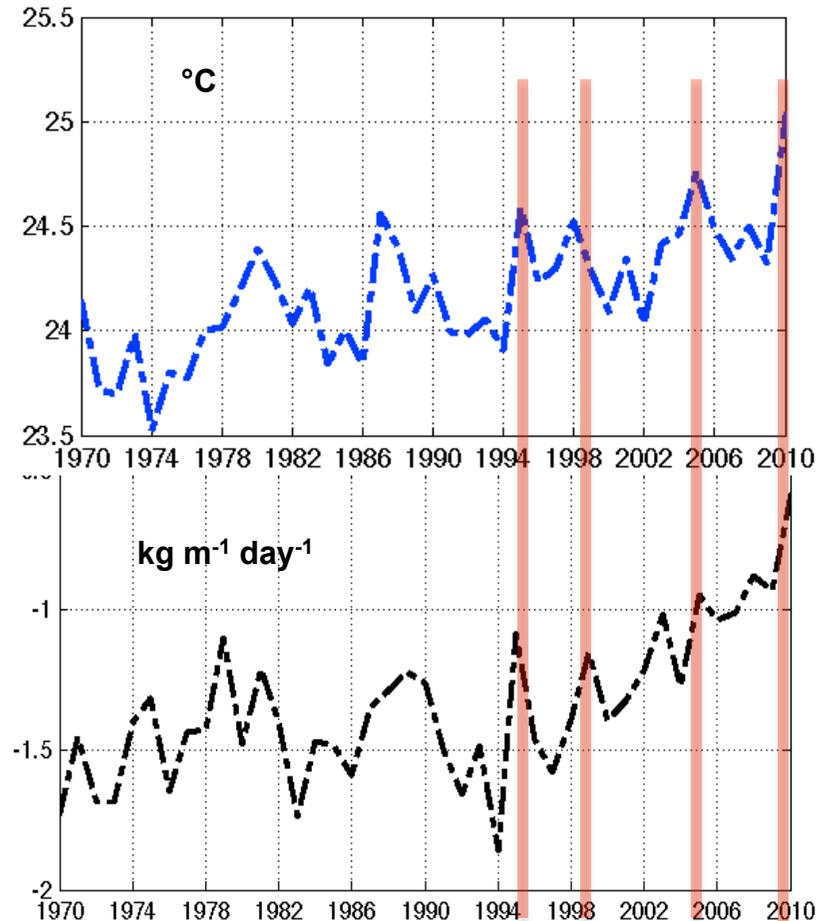
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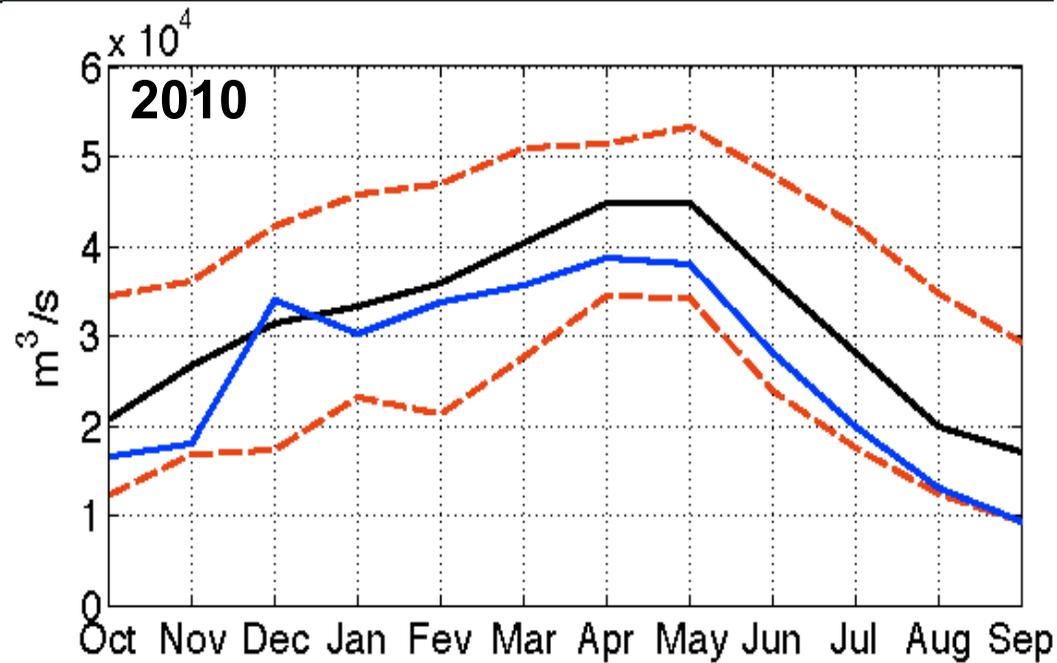


Mean water vapor flux on 0 to 15°S at 75°W (April to August, 1970-2010)



- Positive trend in North Atlantic SST and in water vapour transport
- Concomitant peaks in both variables, $r = 0.68$ ($p < 0.001$)

Discharge and rainfall during the extreme 2010 low-flows in Tamshiyacu



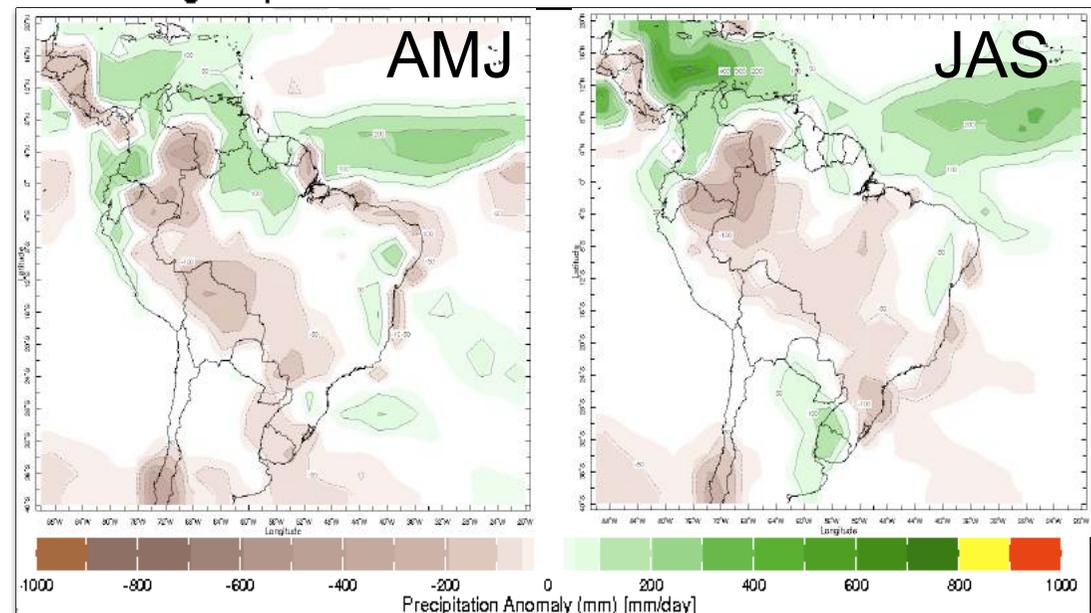
Discharge

Black= long term mean annual cycle

Blue= drought year monthly values

Red = extreme monthly values

The lowest **daily** discharge in forty years has been observed in September 2010: 8 300 m³/s



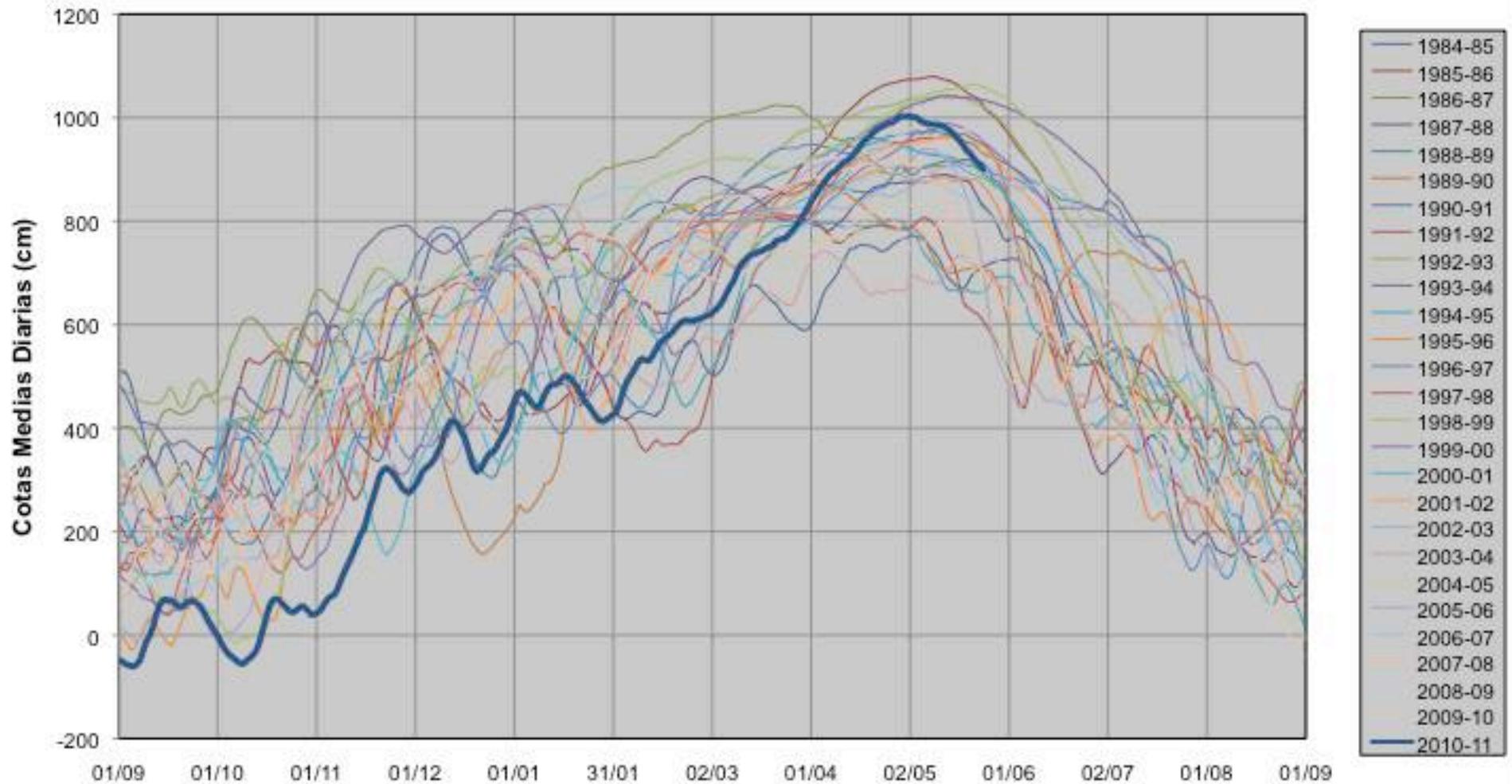
From <http://iridl.ldeo.columbia.edu/>

El Niño event + warm SST in tropical Atlantic

Estación: 10075000 = Tamshiyacu (Amazonas)

Captor: J-1 = Datos criticados

Cotas Medias Diarias



Espinoza et al., 2011b GRL; Marengo et al., 2011a GRL

Conclusions and questions

- In the Peruvian Amazon, droughts during the low-stage season are associated with warm SST in the northern Atlantic or with El Niño (consistent with previous works)
- Are there other origins ?
- Presently, the increase of the drought frequency may be associated with a positive trend in the North Atlantic SST
- Is this trend associated with the natural multidecadal variability of the Atlantic which entered in a positive phase in the early nineties ? Is it a result of the global climate change ?
- Impact on fluvial navigation. On health ? On fishery ? Fires?...



Thank you for your attention !

JL Guyot