A Lagrangian Analysis of the Moisture Transport Associated with Drought Conditions in the Amazon River Basin

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OBJECTIVES

In this analysis, some of the last severe drought episodes in the Amazon River Basin (ARB) were investigated in terms of the anomalous transport of moisture from and towards the basin. We propose a Lagrangian diagnostic scheme that uses the model FLEXPART integrated with the ERA-Interim data for the period 1980-2014. The drought episodes over the ARB are identified and characterized through the Standardised Precipitation-Evapotranspiration Index (SPEI). In order to study the role of the ARB as a receptor of moisture during the drought episodes, the anomalies of its moisture sources are computed through backward analysis. The effect of the dryness over the ARB on its climatological moisture sinks is estimated through the forward runs.

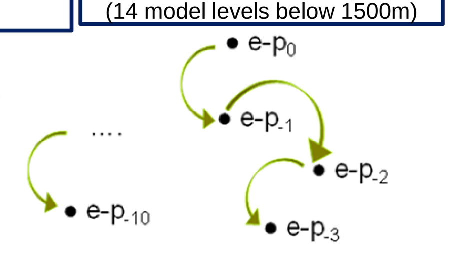
I. LAGRANGIAN SCHEME

(e.g., Stohl and James , 2014)

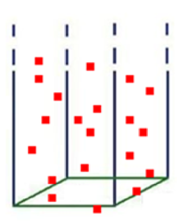
FLEXPART v9.0 model + Reanalysis ERA-Interim	The atmosphere is divided homogeneously into approximately 2 million particles with the same mass *m*	ERA-Interim available every 3 hours with a 1ºx1º resolution on 60 vertical levels (14 model levels below 1500m)

For each particle, the increases (*e*) and decreases (*p*) in moisture along the trajectory can be calculated through changes in (q) with the time:

$$e - p = m\frac{dq}{dt}$$



When adding (e-p) for all the particles residing in the atmospheric column over an area, we can obtain (E-P), the surface freshwater.



$$E - P \approx \frac{\sum_{k=1}^{K}(e-p)}{A}$$

E → evaporation
P → precipitation
K → nº particles

The particles were recorded every 6 hours and the tracks were calculated limiting the transport time to 10 days

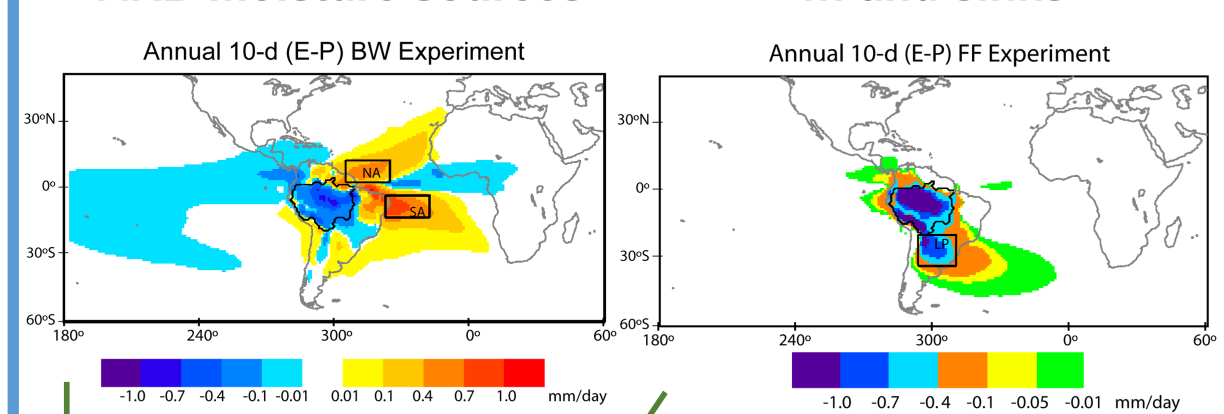
II. LAGRANGIAN EXPERIMENTS

- **We track (E-P) from Amazon Basin *backward* and *forward* in time along the trajectories.**
- ***Backward tracking (BW):* identifies where the particles gain humidity along their trajectories towards the ARB (moisture uptake - sources: *E-P* > 0).**
- ***Forward method (FF):* identifies those particles that leave the basin and follows them to find where they lose moisture (moisture lose - sinks: *E-P* < 0).**
- **Area of sources (sinks) defined based on the percentile method (~95%: 0.4mm/d) applied in the 1980-2014 annual mean of *E-P* > 0 (*E-P* < 0) values from the BW (FF) experiment.**
- **For every episode we analyse monthly anomalies of the moisture sources (sinks) through *E-P > 0 (E-P < 0)* values integrated along 10-d trajectories .**
- **Monthly anomalies of CRU precipitation P and potential evapotranspiration PET (Harris, I. et al., 2014).**

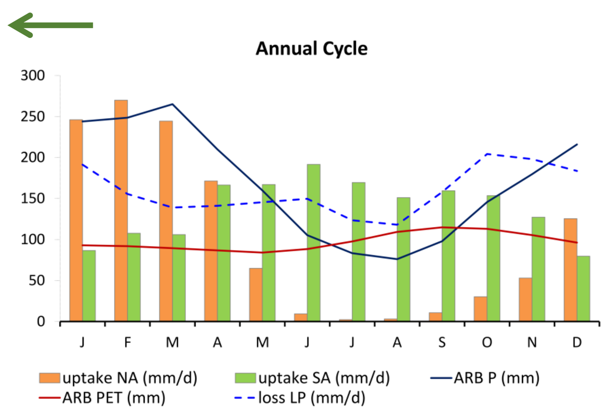
III. CLIMATOLOGICAL PATTERNS

(adapted from Drumond et al., 2014)

ARB moisture sources … **and sinks**



- ARB Precip: max JFM; Min JAS (when PET > P)
- Major *remote sources*:
  - *-Northern Atlantic(NA)* : max JFM; min JJAS
  - *-Southern Atlantic (SA)*: max AMJJ, Min DJFM
- *La Plata (LP) remote sink*: Max ONDJ, min JA

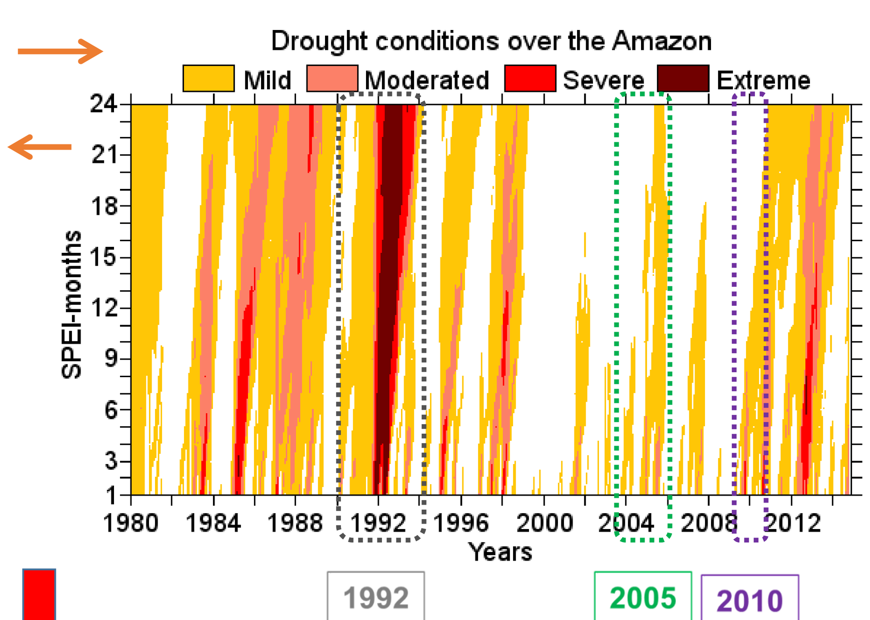


IV. ANALYSIS OF DROUGHT EPISODES OVER THE AMAZON USING SPEI

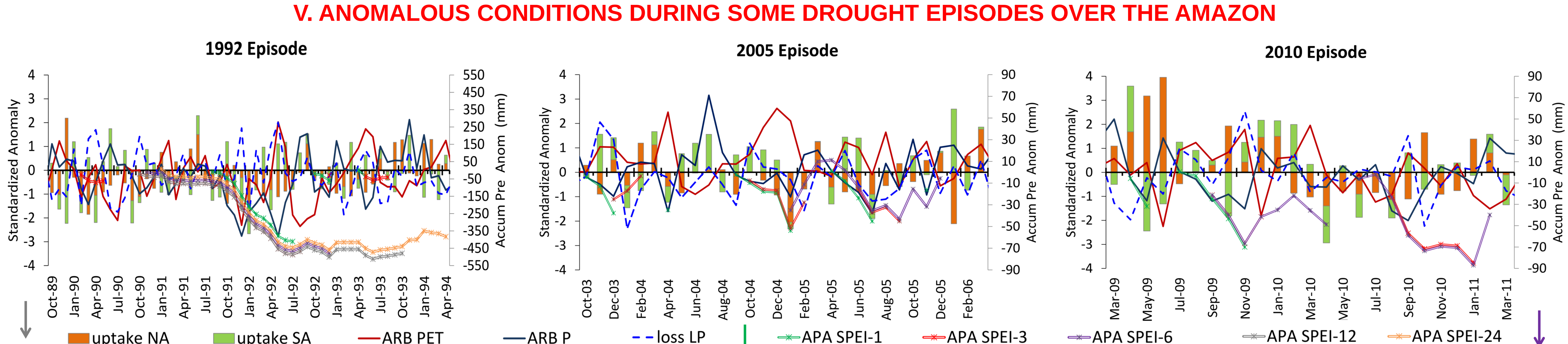
- **SPEI (Vicente-Serrano et al., 2010): reference period 1980-2014**
- **CRU precipitation P and potential evapotranspiration PET (0.5º horizontal resolution) averaged over the ARB are used in the calculation of SPEI**
- **analysis focuses on time scales 1, 3, 6, 12, 24**
- ***Drought episode*: The drought begins when the SPI first falls below zero and ends with the positive value of SPI following a value of -1.0 or less (McKee et al. ,1993)**
- ***SPEI categories*: [-0.99, 0.0[mild; [-1 .49,-1.0] moderate; [-1.99 ,-1.5] severe; <-2.0 extreme**

Drought conditions over the ARB during 1980-2014 (via SPEI)

- Three episodes selected: 1992, 2005, 2010
- Although reported by literature as extreme droughts (e.g. Marengo et al., 2013), 2005 and 2010 not associated with extreme SPEI values at SPEI-1;3;6. Not detected at SPEI-12;24
- 1992 reached extreme SPEI at all time scales. One of the most intense episodes at 6, 12, 24 time-scales. However, it is not discussed in literature
- Possible causes: type of drought, spatial and time scales, reference period, impacts, etc



V. ANOMALOUS CONDITIONS DURING SOME DROUGHT EPISODES OVER THE AMAZON



- **~ 1990-1994**
- extreme in longer time-scale probably due to accumulated effects of the 1988 drought? (fig sec IV)
- negative ARB precip anomalies prevailed aug91 -aug92, with reduced NA (mainly) and SA uptakes
- 90-jul92: negative peaks ARB P anomalies with enhanced contribution towards LP.

- **~ 2003-2005**
- Aug04: negative uptake SA, ARB PET positive anomaly (intense aug04-feb05)
- negative ARB precip anomalies prevailed sep04-sep05
- negative uptake NA prevailed sep04-oct05
- From oct05 mixed signal uptakes anomalies.

- **~ 2009-2011**
- MJ090: lower uptake over SA: SON09: P reduced and PET increased over ARB; J-N09: Higher loss over LP prevailed; Summer 09/10: SA and NA uptakes increased
- 2010: reduced SA and NA uptake. ASO10: P decreased. Oct10: mixed signal uptakes anomalies.

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