ANNUAL CYCLE OF THE MOISTURE CONTRIBUTION FROM THE TROPICAL ATLANTIC OCEAN TO THE AMAZON REGION: A LAGRANGIAN ANALYSIS

Anita R. M. Drumond*[12], Raquel Nieto[13], Luis Gimeno[1] and Tercio Ambrizzi[2]
1University of Vigo, Ourense, Spain
2 University of Sao Paulo, Sao Paulo, Brazil
3 University of Lisbon, CGUL, IDL, Lisbon, Portugal

1. INTRODUCTION

The role of the Amazon region in providing humidity to the SAMS is well known nowadays, as well as the importance of the tropical Atlantic Ocean as a moisture source for the Amazon and consequently for the SAMS (e.g. Vera et al., 2006). However, a detailed comprehension of the annual cycle of the oceanic moisture contribution to the Amazon is still needed in order to get a better understanding of the monsoon system development. To answer this question, this work presents a climatological analysis of the major sources of moisture over western and eastern Amazon, focusing on the relative importance of the tropical north and south Atlantic Oceans in providing humidity.

2. DATA AND METHODS

The method is based on the calculation of a large number of trajectories with the Lagrangian particle dispersion model FLEXPART (Stohl and James, 2004, 2005). FLEXPART uses data from the European Centre for Medium-Range Weather Forecasts (ECMWF, 2002) (P. W. White (Ed.), IFS documentation, European Centre for Medium-Range Weather Forecasts, Reading, UK, 2002, available at http://www.ecmwf.int) to calculate both the grid-scale advection as well as the turbulent and convective transport of so-called particles. The atmosphere is divided homogeneously into a large number of particles and then these particles are transported by the model using 3D winds, with their positions and specific humidity (q) being recorded every 6 hours. The increases (e) and decreases (p) in moisture along the trajectory can be calculated through changes in (q) with time (e-p = m dq/dt), (m) being the mass of the particle. When adding (e-p) for all the particles residing in the atmospheric column over an area, we can obtain (E-P), where the surface freshwater flux (E) is the evaporation and (P) the precipitation rate per unit area. The method can also track (E-P) from a region backward in time along the trajectories, choosing particles appropriate for finding sources of moisture and precipitation.

In this work we used the tracks of 1,398,801 particles over a 5-year period (2000–2004) computed using ECMWF operational analysis available every six hours (00, 06, 12 and 18 UTC) with a 1ºx1º resolution and all 60 vertical levels.

(E-P) can be traced backwards or forwards from the region of interest, limiting the transport times to 10 days, which is the average time that water vapour resides in the atmosphere (Namaguti, 1999). For the first trajectory time step, all the target particles resided over the defined regions and (E-P) is the region-integrated net freshwater flux. For subsequent trajectory time steps, (E-P) represents the net freshwater flux into the air mass travelling to (from) the region in a case of a back (forward) integration.

We traced (E-P) backwards from Western Amazon (10ºS-1ºN; 62ºW-75ºW) and from Eastern Amazon (10ºS-1ºN; 58ºW-47ºW) regions in order to find the moisture sources for each area. Monthly and seasonal analyses were performed. In order to summarize the results, we show here only the seasonal total $(E\text{-}P)^{10}$ integrated over days 1 to 10.

In the figures, results corresponding to regions characterised by E-P>0 are represented by reddish colours and E-P<0 by bluish ones. In the first case, evaporation dominates over precipitation, which indicates that air particles located within that vertical column (and bound to reach the analyzed areas in a backward case or that emanate from these regions in a forward integration) gain moisture. These regions are therefore identified as moisture source regions. In contrast, bluish colours (E-P<0) reveal regions where precipitation dominates over evaporation.

3. PRELIMINARY RESULTS

The results suggest the importance of the tropical Atlantic as a moisture source for Amazon.

For the western Amazon, it seems that the tropical north Atlantic is the most important moisture source in the austral summer (figure 1a). However, the contributions from both sides of the ocean for the eastern Amazon are relevant in the same season, specially the south Atlantic (figure 2a). While the contribution from the tropical north Atlantic to the Amazon vanishes in the austral winter (figures 1c e and 2c for Western and Eastern Amazon, respectively), the tropical south Atlantic acts as a source for the region along the year (figure 1 and 2).

Complementing the analysis, forward integrations for the following 10 days are being conducted to track the trajectories of the particles emanating from the oceanic regions. Forward integrations forced by boxes limiting the source regions identified in the Figure 1 and 2 will be done and presented elsewhere.

* *Corresponding author address:* Anita R.M. Drumond, Facultade de Ciencias de Ourense, Universidade de Vigo, Campus de As Lagoas s/n 32004. Ourense, Spain, e-mail: anitadru@uvigo.es

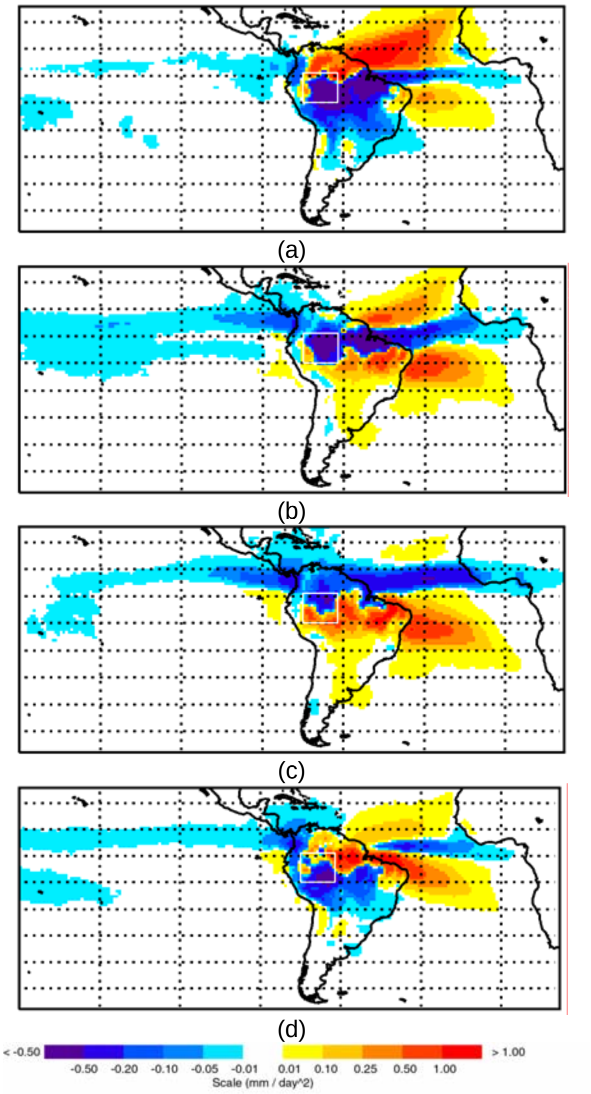
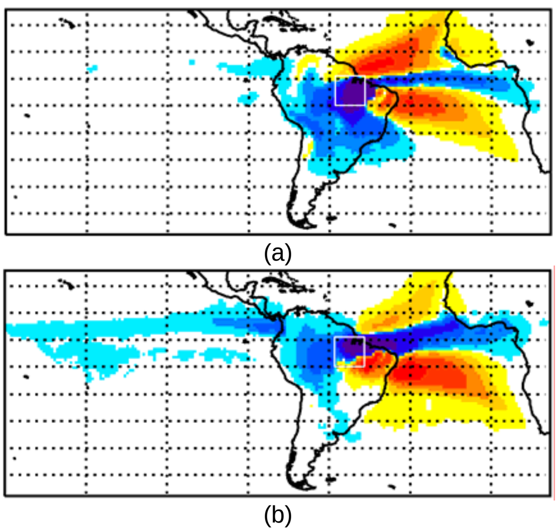


Figure 1a: Austral summer average (E-P)[10] of the Western Amazon from the backward tracking; b: the same as a, for austral autumn; c: the same as a, for austral winter; d: the same as a, for austral spring



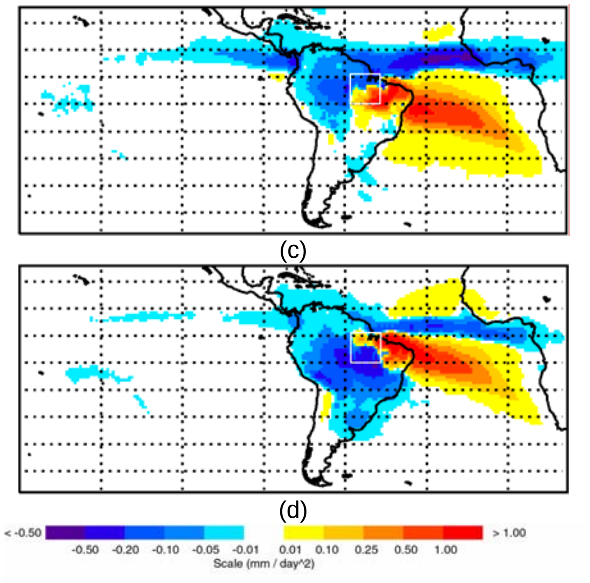


Figure 2a: Austral summer average (E-P)[10] of the Eastern Amazon from the backward tracking; b: the same as a, for austral autumn; c: the same as a, for austral winter; d: the same as a, for austral spring

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5. REFERENCES

Stohl, A., P. James, 2004: A Lagrangian analysis of the atmospheric branch of the global water cycle. Part 1: Method description, validation, and demonstration for the August 2002 flooding in central Europe. *J. Hydrometeor.* 5, 656– 678.

Stohl, A., P. James, 2005: A Lagrangian analysis of the atmospheric branch of the global water cycle: 2. Earth’s river catchments, ocean basins, and moisture transports between them. *J. Hydromete.* 6, 961–984.

Vera, C., W. Higgins, J. Amador, T. Ambrizzi, R. Garreaud, D. Gochis, D. Gutzler, D. Lettenmaier, J. Marengo, C. R. Mechoso, J. Nogues-Paegle, P Silva Dias, C. Zhang, 2006: A Unified View of the American Monsoon Systems, *J. Clim.*, 19, 4977–5000.

White, P.W., 2002: IFS documentation. ECMWF Rep., Reading, United Kingdom. – Available online at http://www.ecmwf.int