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HEAT AND MOISTURE BUDGETS OF THE WALKER CIRCULATION AND ASSOCIATED RAINFALL ANOMALIES OVER SOUTH AMERICA MONSOON REGION

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1. INTRODUCTION

Large-scale aspects of the heat and moisture budgets of the Walker Circulation (WC) are analyzed for the Austral Summer during the period from 1970 to 2000. Since several earlier studies discuss theoretical and modeling aspects of the heat and moisture budgets of the WC, the main objective of the present article is to take an observational analysis of such heat and moisture budgets. For this purpose, data from NCEP/NCAR and GPCP are used. Analysis of the moisture budget in the near equatorial region of the Southern Hemisphere showed that the three continents (South America, Africa and Maritime Continents) are characterized by high precipitation and that low precipitation occurs in the intermediate oceans. Regions of high (low) precipitation are strongly associated with the vertically integrated moisture flux convergence (divergence). Analysis of the heat budget for the WC showed that diabatic heating (cooling) is balanced by adiabatic cooling (heating) over regions with convective (non-convective) regime. The loss of radiation to space over non-convective areas is balanced by adiabatic heating due to sinking motion. There is heating over the continents, probably associated with the ascending motion in the WC, and cooling over the intermediate oceans, which is related to the loss of radiation in the descending branch of the WC. As most studies have focused on the moisture and heat balance of the WC in a theoretical and numerical modeling view, studies concerning this focus using processed observational data can elucidate, in an observed frame, how moisture and heat budgets of the WC works.

2. DATA AND METHODOLOGY

In the study of the moisture budget it will be used the equation described by Yanay et al. (1973). This equation states that local variation of the precipitable water W in the atmosphere can be written as:

$$\frac{\partial W}{\partial t} = -\vec{\nabla} \cdot \vec{F} + E - P \qquad (1)$$

Where,

$$W = \frac{1}{g}\int_{pt}^{p0} q\,dp \qquad (2)$$

And $\vec{F} = F_\lambda \vec{i} + F_\phi \vec{j}$, is the vertically integrated moisture flux in an atmospheric column. The zonal and meridional components are given as:

$$F_\lambda = \frac{1}{g}\int_{p_t}^{p_0} qu\,dp \qquad (3)$$

$$F_\phi = \frac{1}{g}\int_{p_t}^{p_0} qv\,dp \qquad (4)$$

For the study of the WC heat budget, the thermodynamic energy equation in pressure coordinates is used (Newell et al. 1974)

$$\frac{\partial \overline{T}}{\partial t} + \frac{1}{a}\left[\frac{\overline{u}}{\cos\phi}\frac{\partial \overline{T}}{\partial \lambda} + \overline{v}\frac{\partial \overline{T}}{\partial \phi}\right] + \overline{\omega}\left(\frac{\partial \overline{T}}{\partial p} - \frac{R\overline{T}}{c_p p}\right) = \dot{\overline{Q}} \qquad (5)$$

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Where c_p is the specific heat of dry air at levels of constant pressure, R is the gas constant for the dry air, and p is the pressure. The heating term, $\dot{Q}$, includes contributions by the transfer of heat, by turbulent and molecular conduction, ($\dot{Q}_s$), by latent heat release ($\dot{Q}_l$), and by radiative processes ($\dot{Q}_r$). Since diabatic heating data are not available for the period considered in the present study three-dimensional diabatic heating rate fields are computed from Equation (5) as a residual, using monthly mean data. The quantities ($\overline{\ \ }$) indicate time averages.

3. RESULTS AND DISCUSSIONS

Main results of this extended abstract, including figures, will be compared with Veiga's paper (Veiga et al., 2005). Heat and moisture balances of the WC are analyzed for the Austral Summer season (DJF). First the characteristics of WC are discussed for the entire period of 31 years (1970-2000). Analysis of the heat budget for the entire period showed that the main balance occurs between the diabatic heating (cooling) and the adiabatic cooling (heating) during the vertical process of air displacement. The zonal variability of diabatic term showed that there is heating over the continents and cooling over the intermediate oceans. Heating is probably associated with ascending motion of the WC and cooling seems to be related to the loss of radiation in the descending branch of the WC. Evaporation seems to be less important indicating that it doesn't take part of the process maintaining the large-scale atmospheric heating, which is done mainly by the latent heat release during robust cloud formation (not showed). The positive (negative) anomalies of rainfall over the three continents are in general associated with the convergence (divergence) of moisture flux, see Fig. 1 for more details. In the climatology there is eastward moisture flux from the equator up to about 12º S. In the anomaly the moisture flux is high and westward to the west of about 140º E. The convergence of moisture flux in the climatology has changed to the divergence of moisture flux in the anomaly. These changes are associated with the changes in the rising and sinking branches of the WC. Thus, the changes in the WC are associated with the changes in the wind circulation, which are in turn associated with the changes in the divergence (not showed). The low level changes are associated with the moisture flux changes and these seem to be mainly responsible for the maintenance of rainfall anomalies during El Niño periods.

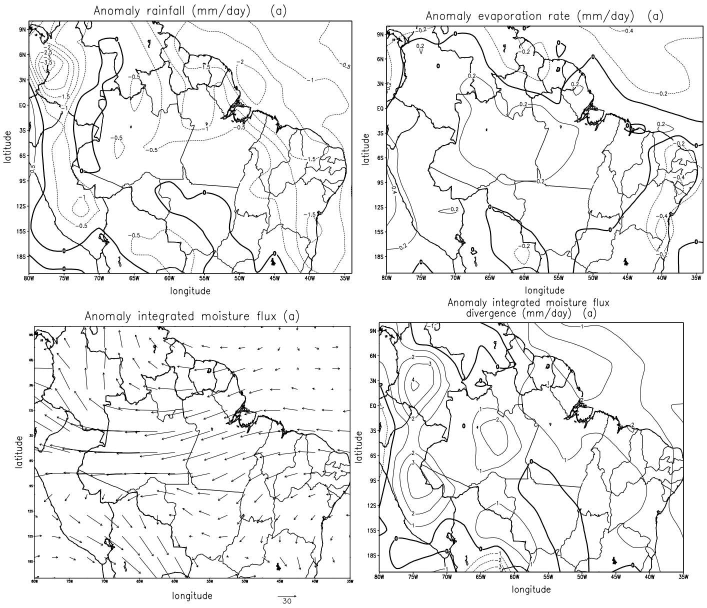

Figure 1-Fields of anomaly rainfall (a), anomaly evaporation rate (b), anomaly integrated moisture flux (c), and anomaly integrated moisture flux divergence (d) for DJF. Units are in *mm day^{-1}*.

4. REFERENCES

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