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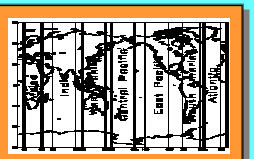
Regional Variability of the ITCZ and of the Hadley Cell

G. A. Dalu, M. Gaetani, R. A. Pielke Sr., M. Baldi, G. Maracchi

E-mail: G.Dalu@ibimet.cnr.it, m.gaetani@ibimet.cnr.it

We examine the seasonal behavior of the ITCZ and of the Hadley cell, zonally averaged, and averaged over seven longitudinal sectors: Africa, India, West Pacific, Central Pacific, East Pacific, South America, and Atlantic.



ZONAL HADLEY CELL

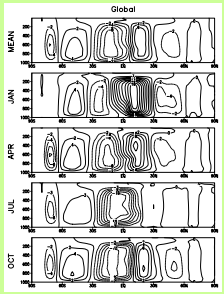
The **meridional circulation** in each hemisphere is composed of three cells: the **Hadley**, the **Ferrel** and the **polar cell**. The Hadley cell in the winter hemisphere always prevails over the cell in the summer hemisphere. In the average, the flow is stronger in the austral hemisphere.

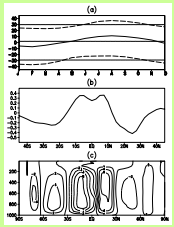
(a) The **ITCZ** migrates following the Sun in a sinusoidal seasonal pattern with a 3° bias to the north, because the continents favor the monsoonal regime to the north of the equator.

(b) A permanent feature of the tropics is the inhibition of deep convection across the equator due to the **Svendrup vorticity balance**.

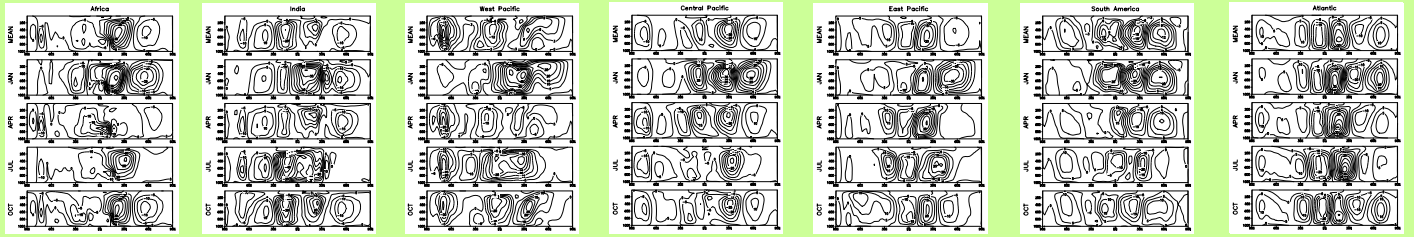
(c) The yearly mean zonal tropical meridional circulation mainly results from the average of the cells during solstices.

ZONAL-MEAN MASS STREAM FUNCTION [1E10 kg/s]





REGIONAL HADLEY CELL



METHOD

Dataset: NCEP/NCAR Reanalysis

MASS STREAM FUNCTION

$$\Psi = \frac{2\pi R \cos\theta}{g} \int_{p}^{p_{top}} [v]\, dp$$

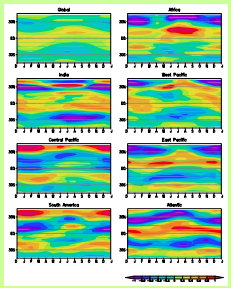
VERTICAL VELOCITY

$$[w] = \frac{1}{2\pi R^2 \rho \cos\theta} \frac{\partial \Psi}{\partial z}$$

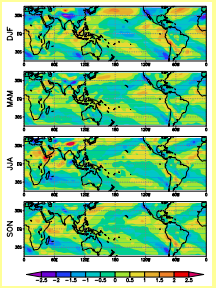
ITCZ LATITUDE

$$\theta_{ITCZ} = \frac{\int_{-25}^{25} \theta\, [\omega_+]\, d\theta}{\int_{-25}^{25} [\omega_+]\, d\theta}$$

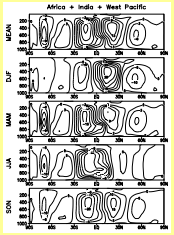
VERTICAL VELOCITY MERIDIONAL PROFILE [cm/s] (500 hPa)



VERTICAL VELOCITY [cm/s] (500 hPa)



SUMMARY AND CONCLUSIONS



OCEANS

- **Atlantic**: the ITCZ mainly resides north of the equator.
- **Pacific**: the **SPCZ** is a permanent south easterly tilted convergence line. The ITCZ resides mainly in the austral hemisphere in the central Pacific because of the SSTA distribution in this region.
- The position of the ITCZ is mainly determined by the SSTA distribution.

CONTINENTS

- The **East Africa-Asia-Australia monsoon** is a major climatic planetary system, where the convective activity has multiple cells, spatially and temporally separated.
- The continents introduce a strong variability which gives a general strengthening of the Hadley cell, and this effect is stronger in summer because of the monsoons.
- **Africa** and **South America** are the only two continents crossed by the equator where the convective monsoonal activity shows up mainly in correspondence to a latitudinal broading and strengthening of the ITCZ.
- In South America the monsoon displaces the ITCZ southward.
- South Africa and South America have a one weak center during the austral summer
- North Africa has three main centers of monsoonal activity during the boreal summer. The presence of the Saharan desert enforces the summer boreal Hadley cell.