WATER VAPOR FLUXES OVER EQUATORIAL CENTRAL AFRICA

INTRODUCTION

A good understanding of the causes of climate variability depend, to the large extend, on the precise knowledge of the functioning of the water cycle in each component of the climate system

CONTEXT

- ☐ relatively few studies in the Equatorial Central African (ECA) region
- ☐ previous study of inter-seasonal change of water cycle in the Congo basin based on only three years of data
- ☐ no study on inter-annual variability

OBJECTIVES

- ☐ new evaluation of seasonal cycle (long period)
- ☐ study of inter-annual variability of water vapor flux

DATA

Monthly mean NCEP/NCAR reanalysis data from 1968 to 2000

STUDY AREA

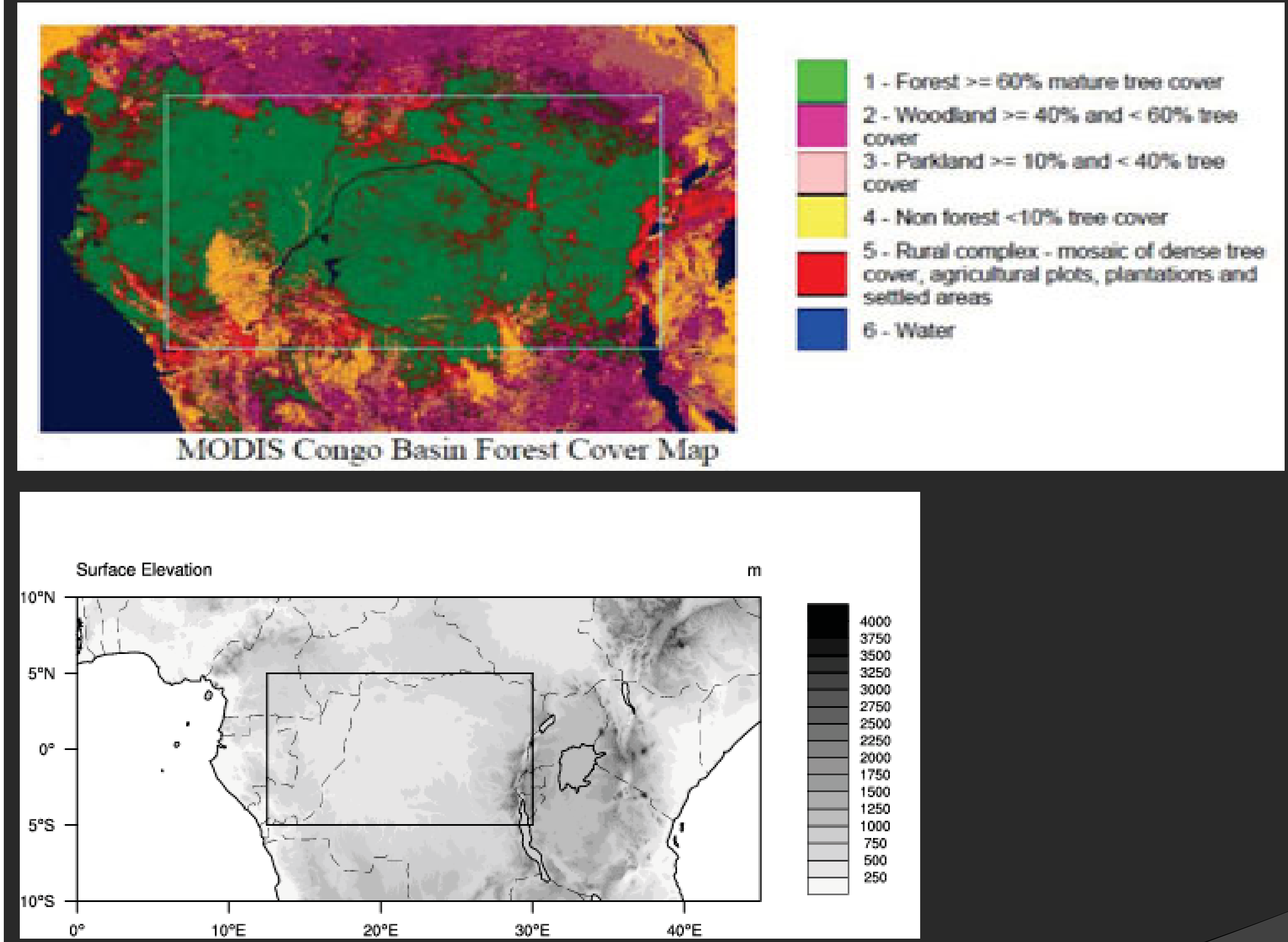


Fig. 1: Land surface characteristics (a) vegetation (b) Surface elevation (m) of tropical Africa and the region of study (ECA), defined as the region from 50S to 50N, 12.50E to 300E.

RESULTS

ANNUAL CYCLE

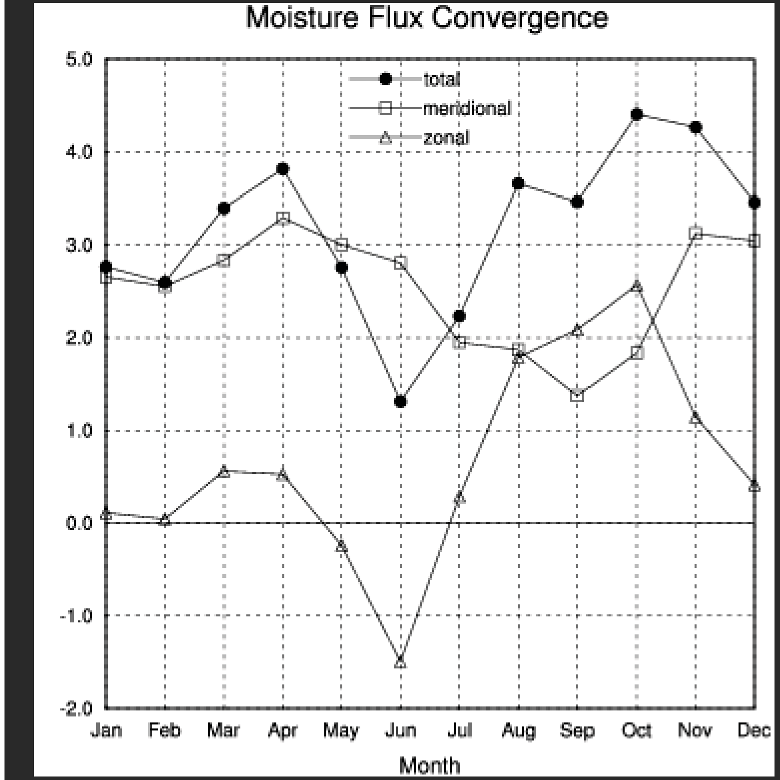


Fig. 2: The annual cycle of vertically integrated net water vapor flux (units: $10^{-5}Kg.m^{-2}.s^{-1}$), scaled by the area of the region: meridional component (square), zonal component (triangle) and total flux (bullets). Positive values Indicate flux convergence and negative values flux divergence

❑ bimodal distribution with maxima in March-April-May (MAM) and October-November (ON)

❑ Meridional flux is strong and convergent all year, with peaks in April and November-December (ND)

❑ In August to October zonal flux is high and convergent, being stronger than the meridional component

❑ MAM maximum in total convergence, brought about by strong meridional convergence

❑ Maximum from August to December is contributed by strong zonal convergence in ASO and strong meridional convergence in ND

Moisture stratification and general circulation feature lead to moisture convergence not being uniform in the atmospheric column. It is thus important to investigate vapor fluxes in separate layers of the atmosphere

RESULTS

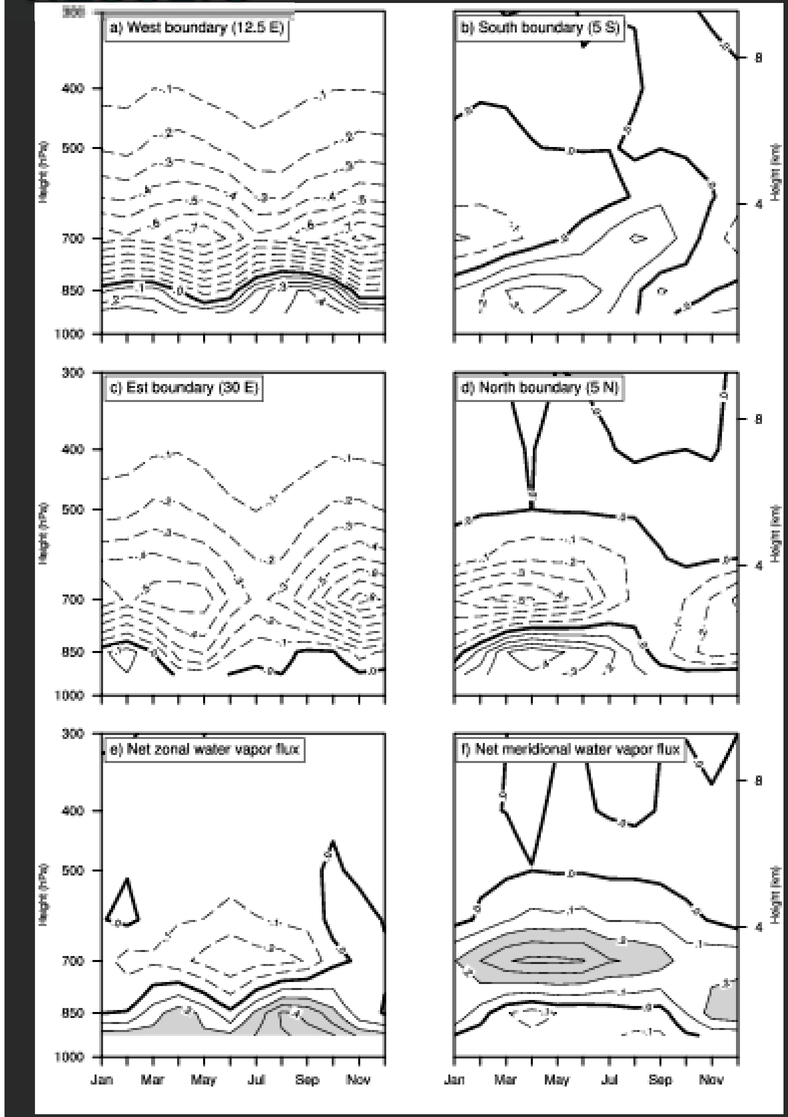


Fig. 3: The time-height sections of water vapor fluxes (units: 10^{-5}Kg.m^{-2}.s^{-1}) in ECA scaled by the surface area of the region: (a) West , (b) East,(c) net zonal (East minus West), (d) South , (e) North,(f) net meridional (North minus South); Shaded indicates moisture convergence greater than 0.2x10^{-5}Kg.m^{-2}.s^{-1} in ECA .

ANNUAL CYCLE

❑ In both meridional and zonal directions, upper and lower layers net fluxes have opposite signs.

In meridional direction

❑ strong upper level convergence all year results from strong influx across the northern border,

❑ low level divergence from January to August

is a consequence of strong outflow in the North and weaker inflow in the South.

In the zonal direction

❑ in the upper level, in seasons AMJ and OND outflow across the West boundary and the inflow across the East boundary are all strong, but the latter is weaker in AMJ giving a small net zonal divergence

❑ two maxima around 700hPa on Fig. 3a and 3c mark the crossing by the AEJ-N of the region's boundary outward and inward respectively.

❑ In the lower level, zonal convergence occurs all year

❑ The weak zonal moisture flux divergence in the upper level (Fig. 3e) from November to March is associated with the localization of AEJ-N inside ECA.

RESULTS

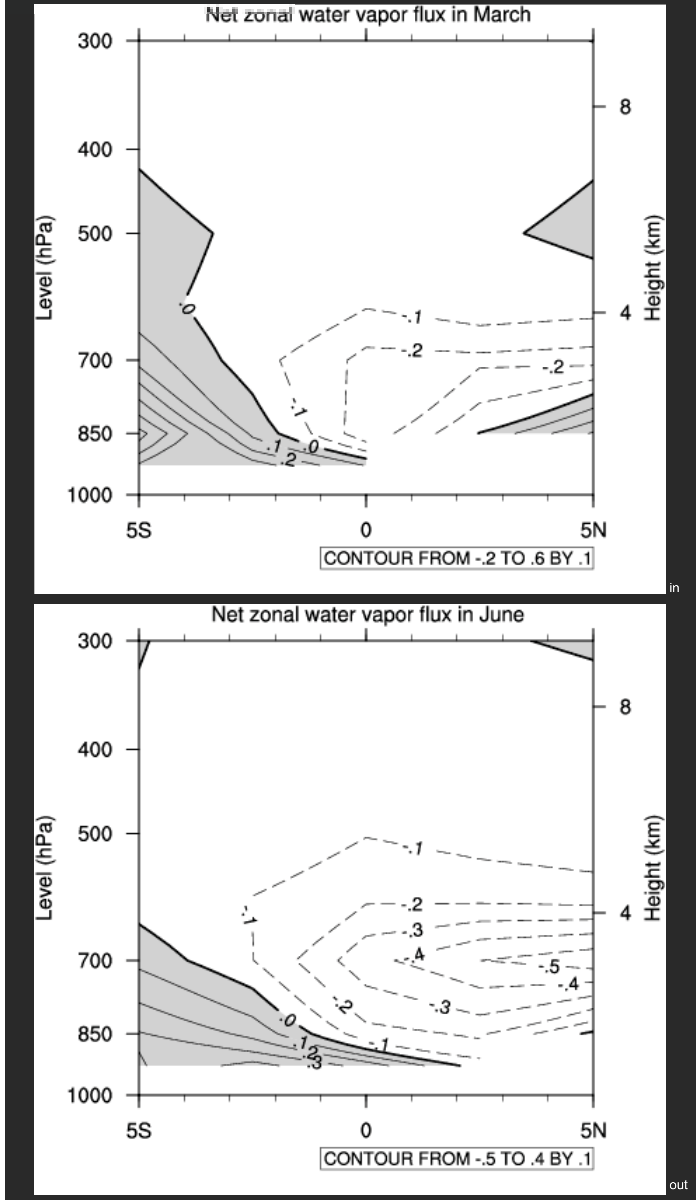


Fig. 4: The latitude-height sections of net zonal (west-east) vapor flux in March (a) and June (b)(units: 10^{-5} Kg.m^{-2}.s^{-1}); scale by the area of the region A. Shading correspond to convergence in ECA.

ANNUAL CYCLE

❑ At the western boundary (12.5^{0}E) vertical structures of moisture flux are similar in March and June.

❑At the eastern boundary (30^{0}E), the influx is more intense in March due to the strength of AEJ-N and its location around 5^{0}N

❑ As a consequence there is less upper level divergence in March than June
(Fig. 4a and 4b).

❑ This suggests an important role for AEJ-N on water budget in ECA.

RESULTS

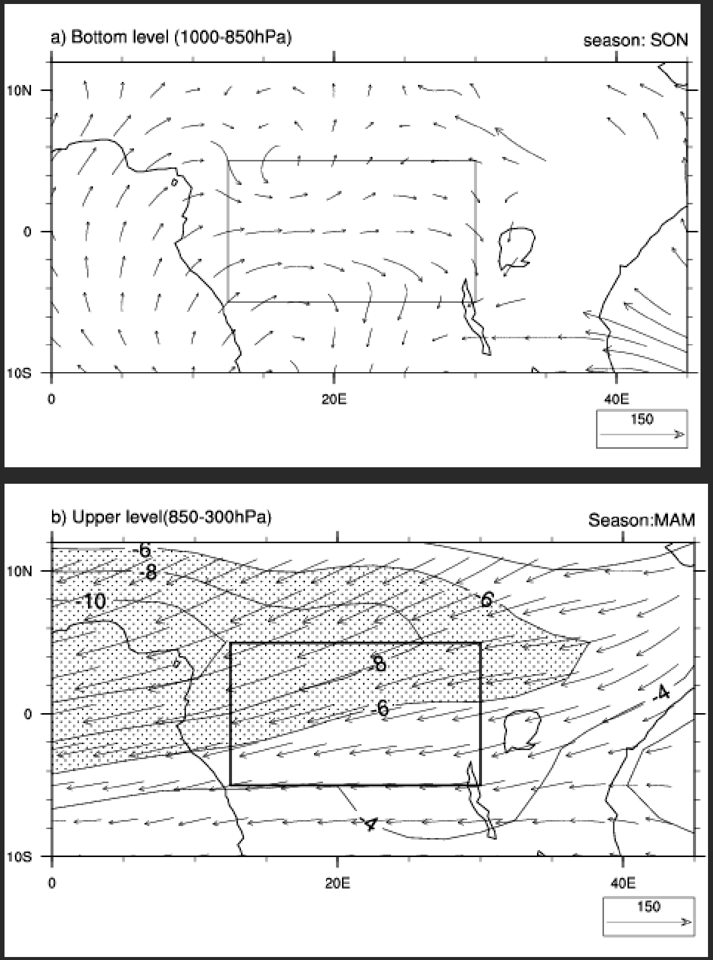


Fig. 5: The vertically integrated water vapor flux (Kg.m-1.s-1) (a) in bottom layer in season SON, and (b) upper layer in season MAM with zonal wind (m.s-1) averaged between 600hPa and 700hPa, contour interval 2 m.s-1. Shaded area (wind speeds greater than 6 m.s-1) indicates the mean position of the jet.

ANNUAL CYCLE

Main Results

❑ The first maximum of total moisture convergence in season MAM is contributed by upper level (850-300hPa) meridional convergence in the same season, caused by moisture advected by the AEJ-N, whose core is then near the northern boundary (Fig. 5b) of ECA.

❑ Moreover during the period of residence of AEJ-N out of ECA, upper layer moisture divergence increases.

❑ The second maximum in SON is due to zonal moisture convergence in the bottom layer (1000-850hPa) . This low level zonal moisture originates from the Atlantic ocean (Fig. 5a)

❑ In both meridional and zonal directions, upper and lower layers net fluxes have opposite signs. This suggests the presence of Hadley and Walker type circulations in the region

Do these relationships with circulation patterns also control inter-annual variability?

RESULTS

INTERANNUAL VARIABILITY

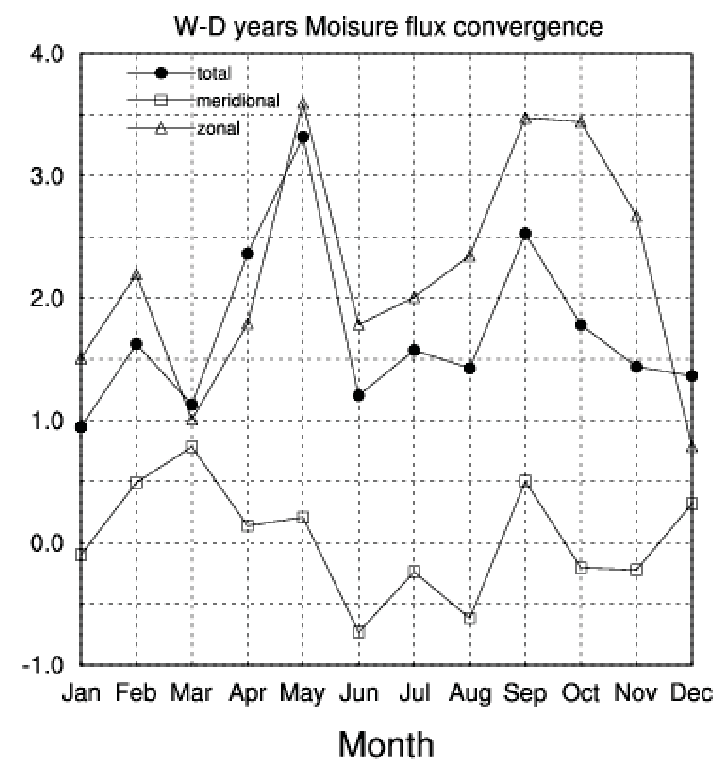


Fig. 6: The vertically integrated water vapor flux (Kg.m-1.s-1) (a) in bottom layer in season SON, and (b) upper layer in season MAM with zonal wind (m.s-1) averaged between 600hPa and 700hPa, contour interval 2 m.s-1. Shaded area (wind speeds greater than 6 m.s-1) indicates the mean position of the jet.

- Total column moisture convergence is stronger (weaker) in wet (dry) years.

- It is dominated by the bottom layer component which is convergent all year

- less upper level divergence for months when AEJ-N is located inside ECA.

These results indicate that the enhanced moisture convergence in wet years is contributed mainly by the low level.

RESULTS

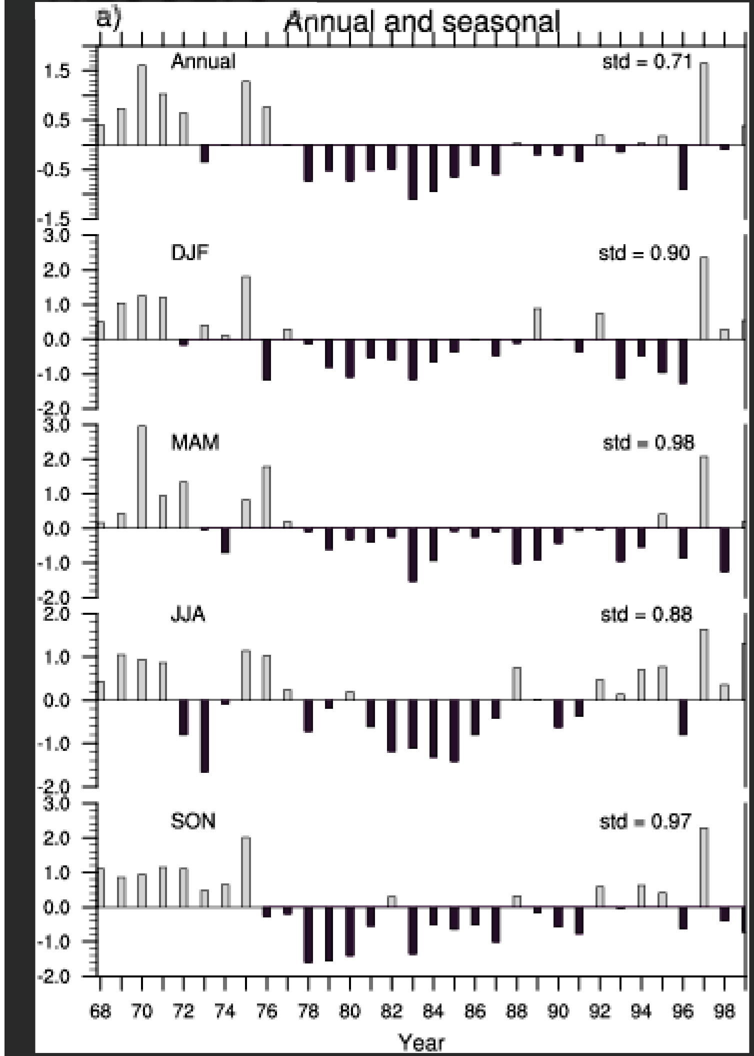
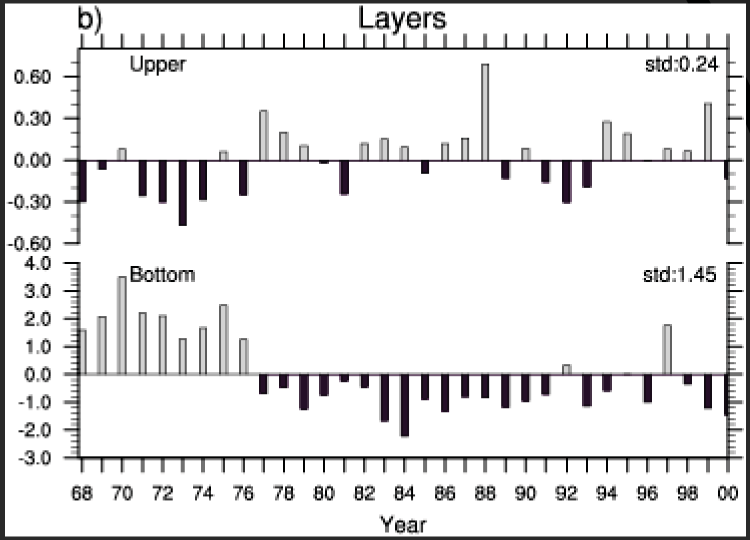


Fig. 7: Times series of the anomalies of (a) annual and seasonal, and (b) layers moisture moisture flux convergence over ECA. For each diagram it's indicate the corresponding season (in (a)) or layer (in (b)) together with its standard deviation (std). Positive values mean more net flux convergence; negative values mean less net flux convergence.

INTERANNUAL VARIABILITY



- Overall, the annual and seasonal signals are in phase
- Low frequency variability with a period longer than 10 years is visible in the rainy seasons up to the second half of the 1970s
- DJF and JJA have highest year to year variations of moisture flux convergence in ECA
- Notable feature here is the similarity between annual all layer (Fig. 7a) and bottom layer (Fig. 7b) inter-annual variability
- Atlantic ocean have a crucial role for low level moisture convergence in ECA

CONCLUSION

Several points must be underlined:

1) the signals explaining the inter-annual variability and linked to the atmospheric water vapor flux convergence are often different from those that control the mean annual cycle

2) based on seasonal variation, the north component of the African Easterly Jet plays an important role for moisture budget in the region by decreasing zonal moisture divergence when it’s located in the north part of ECA (January- March and October-December)

3) in the same period it increase upper level meridional moisture flux convergence;

4) an important part of moisture fluxes vertically integrated in layer 1000-850hPa advected into ECA, from August to November, originate from Atlantic ocean

5) on inter-annual variability, for both differences between wet and dry years and year to year variability, lower level moisture convergence from Atlantic ocean modulate the entire atmospheric column moisture variability.

Thank you for your listening