ANALYSIS OF LARGE-SCALE ATMOSPHERIC WATER BUDGET ESTIMATIONS OVER WEST AFRICA DURING THE MONSOON SEASON

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CONTEXT

a number of scientific questions regarding the water cycle

- ✓ origin of sources of water (oceanic, continental...)
- ✓ significance of water recycling (P_{local}/P_{remote}), links with advection
- ✓ difference of signature between wet and dry years
- ✓ scales of variability (from diurnal to interannual)
- ✓ identification of coupling mechanisms, as well as the scale at which they operate....

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estimates at very large scale from re-analysis (NWP products) and existing observational products, most of them year or season average over the whole globe, *Trenberth & Guillemot (1998)...*, *Roads et al. (2002)*

earlier studies specifically over West Africa
Cadet & Nnoli (1987), *Gong & Eltahir (1996)....*

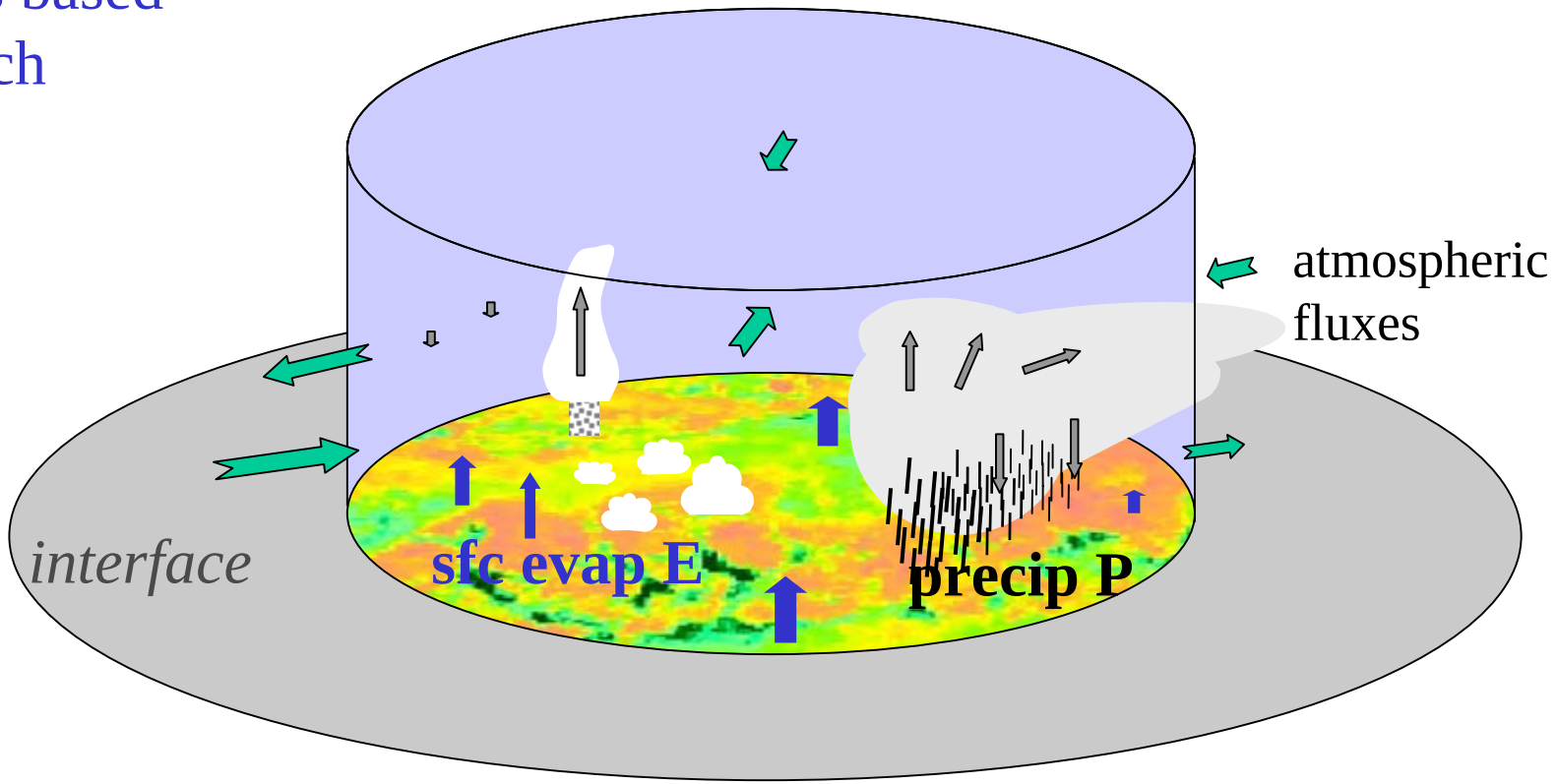
also, GCM process studies over West Africa, e.g. *Druyan & Koster (1989)*

...existing studies point to strong land-atmosphere interactions in West Africa

atmospheric water cycle at large-scale

process based approach

water budget

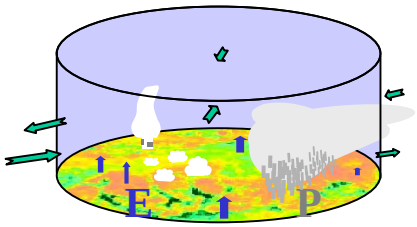


broad objective: assess what currently exists

methodology based on a combined use of :

- ❑ (re-)analyses (ECMWF, NCEP) , observations & observational products
- ❑ CRM simulations ***(CRM: cloud resolving model)***

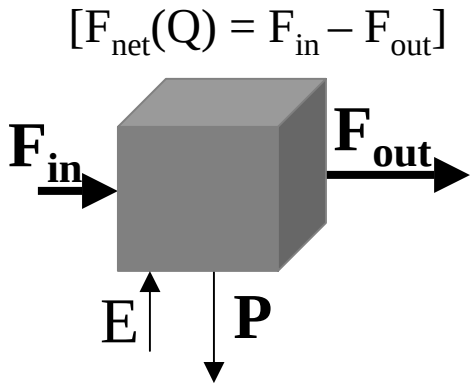
➡ *ideally down to scale: Δx = 500 km , Δt = intraseasonal (~5 days)*



➡ *0D* atmospheric water budget

$$\partial Q/\partial t = E - P + F_{net}(Q)$$

[Q: total water] simulated analysis



such (Δx,Δt) water budget results from very high sub(Δx,Δt) variabilities of all of its components, as well as from complex vertical structures (wind, water and vertical transport via convection)

accuracy issues

under-sampling & representativity (6-h sampling)

current weaknesses of models used for NWP *spin-down for rainfall, diurnal cycle of convection, impact on the surface..., links with model parametrizations*

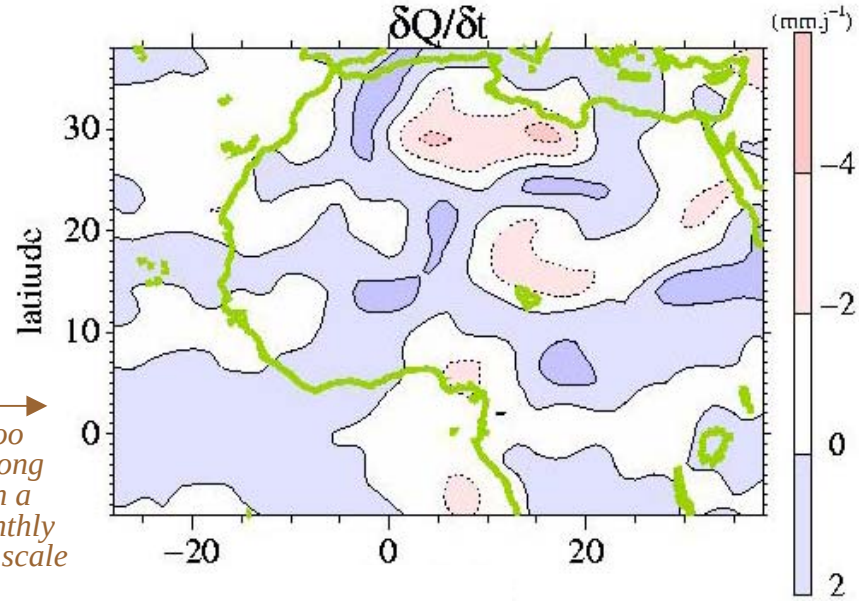
no constraint on conservation of water in (re-)analysis (atmosphere & soil)

accuracy of water flux also relies on water fields, not only on (re-)analysis velocity fields

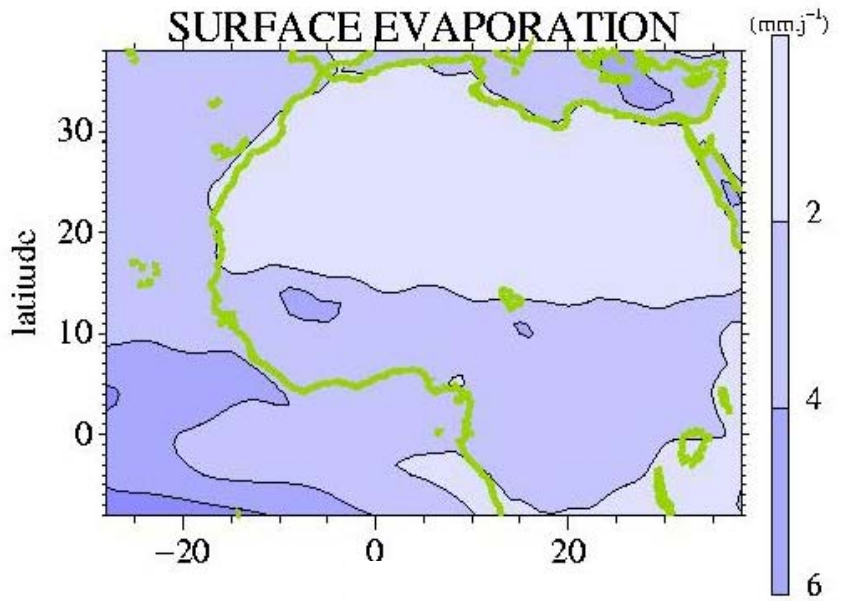
ECMWF IFS, August 2000 atmospheric water budget

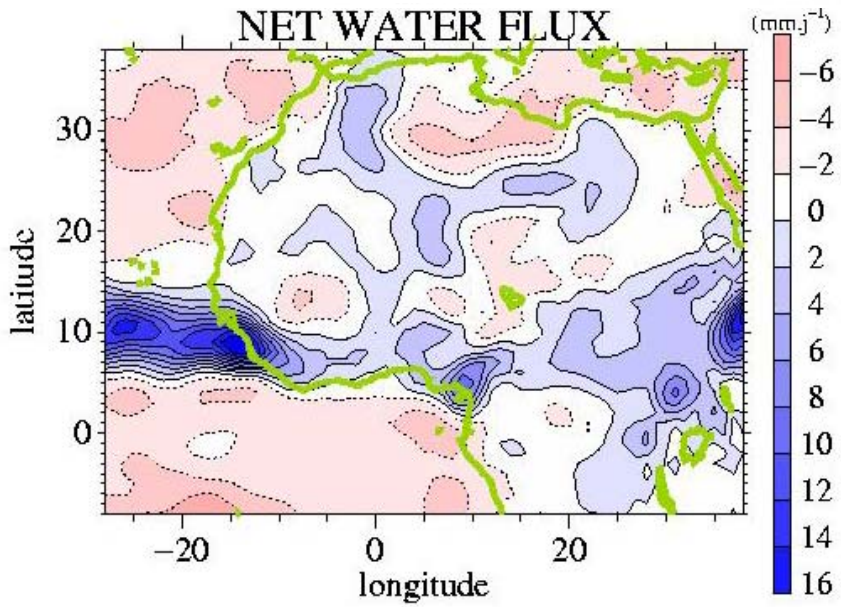
$\partial Q/\partial t = E - P + F_{net}(Q)$ (all terms: simulated)

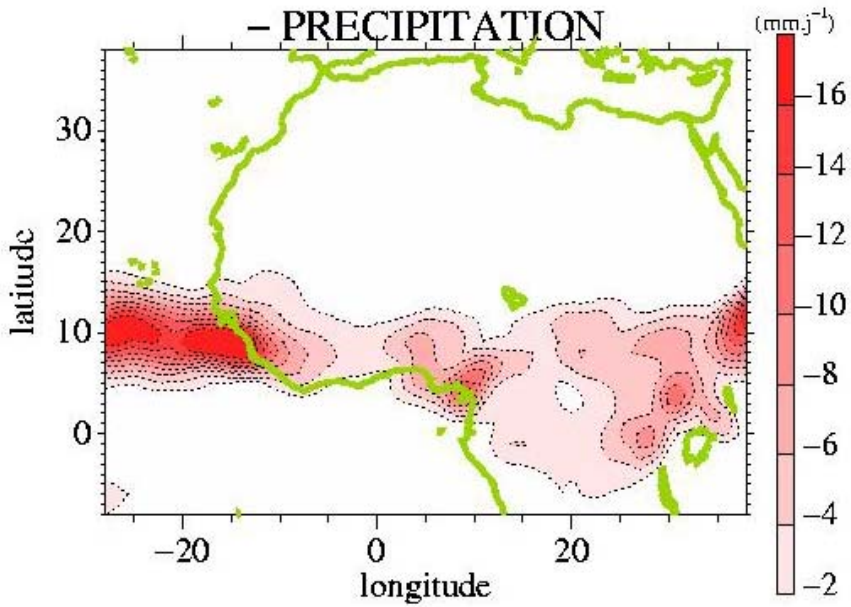
[T+12,T+36]
model levels



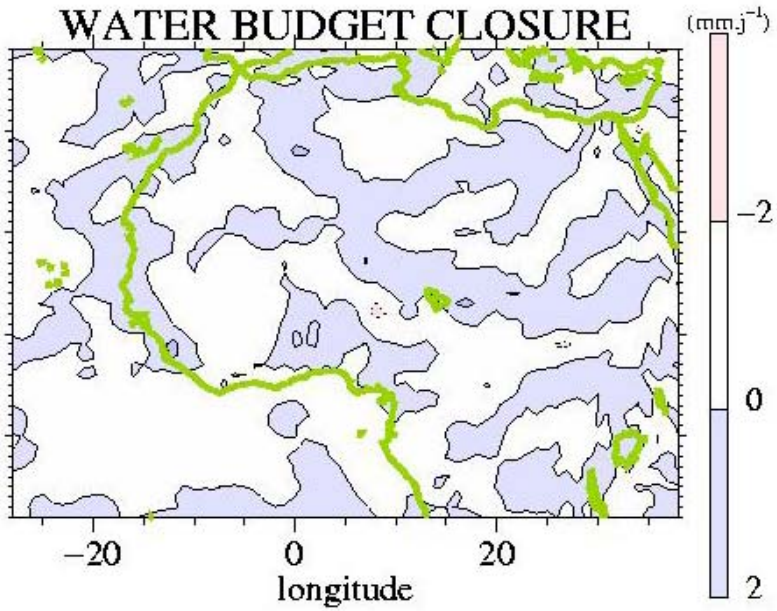
too strong on a monthly time scale







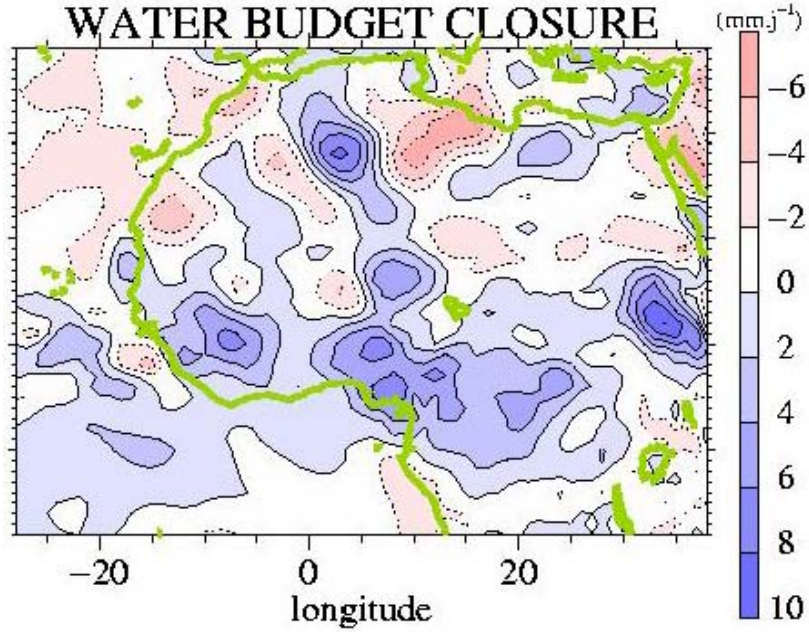
ECMWF IFS, August 2000 atmospheric water budget



$\partial Q/\partial t = E - P + F_{net}(Q)$

(all terms: simulated)

closure ~ ok

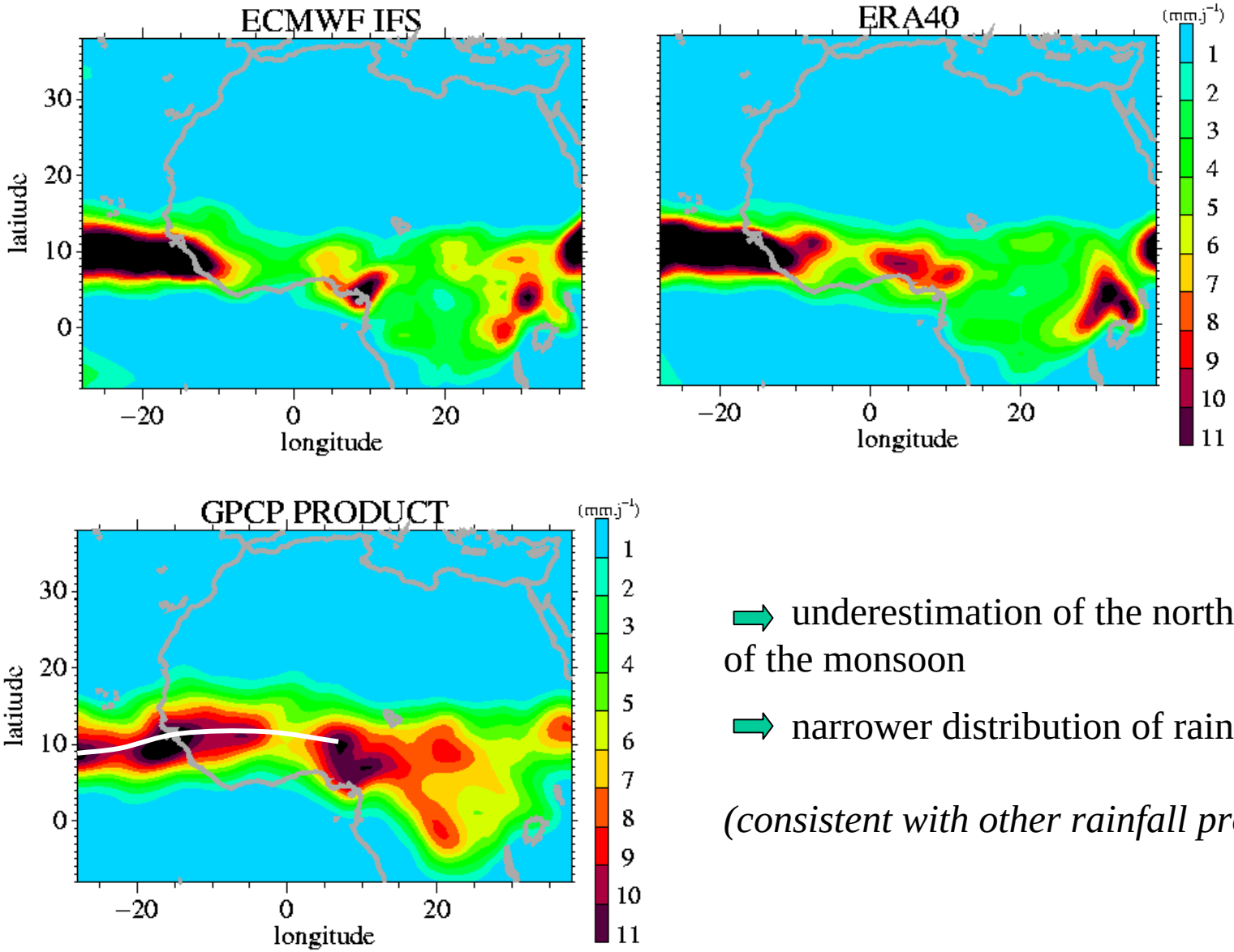


$\partial Q/\partial t = E - P + F_{net}(Q)$

(terms: simulated analysis)

closure problem, reflects:
spinup/down issues
large biases, associated with the physics
signature of the orography...

August 2000 average precipitation : comparison with obervational products

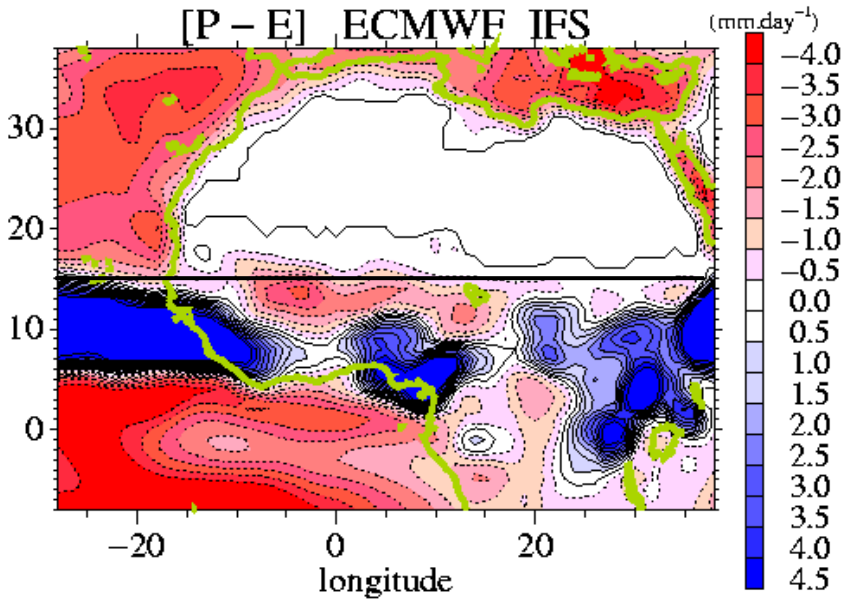


⇨ underestimation of the northern extension of the monsoon

⇨ narrower distribution of rainfall

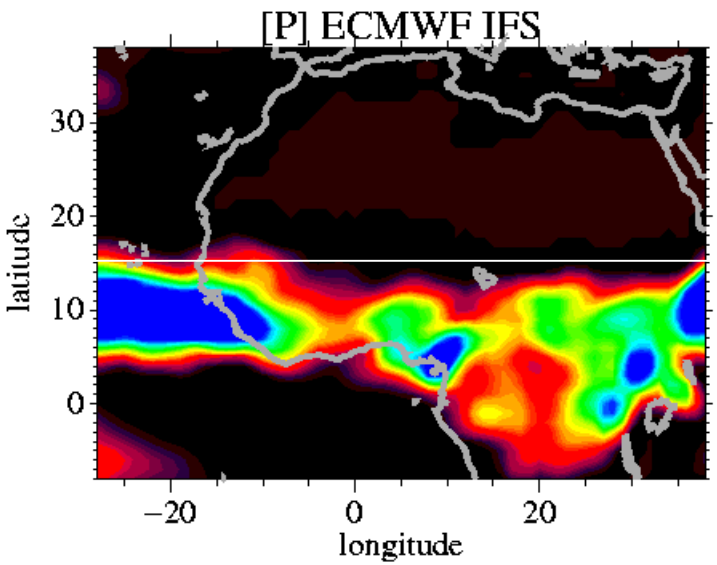
(consistent with other rainfall products)

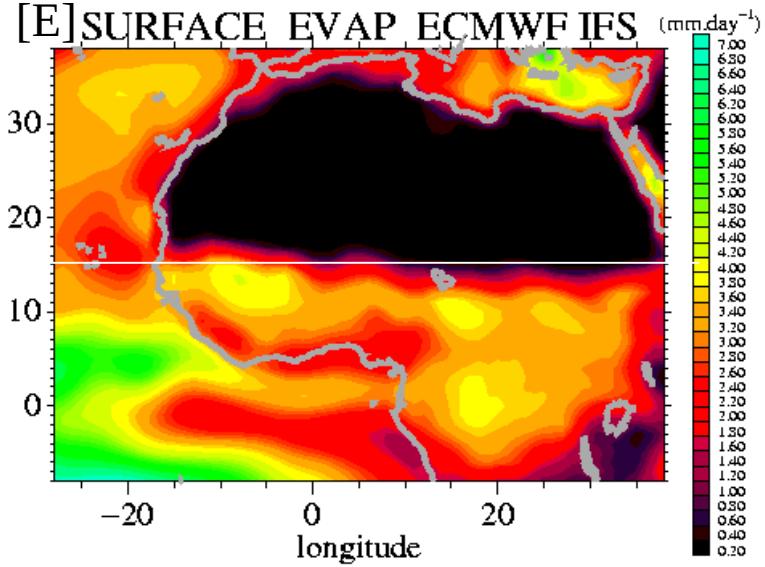
August 2000 average



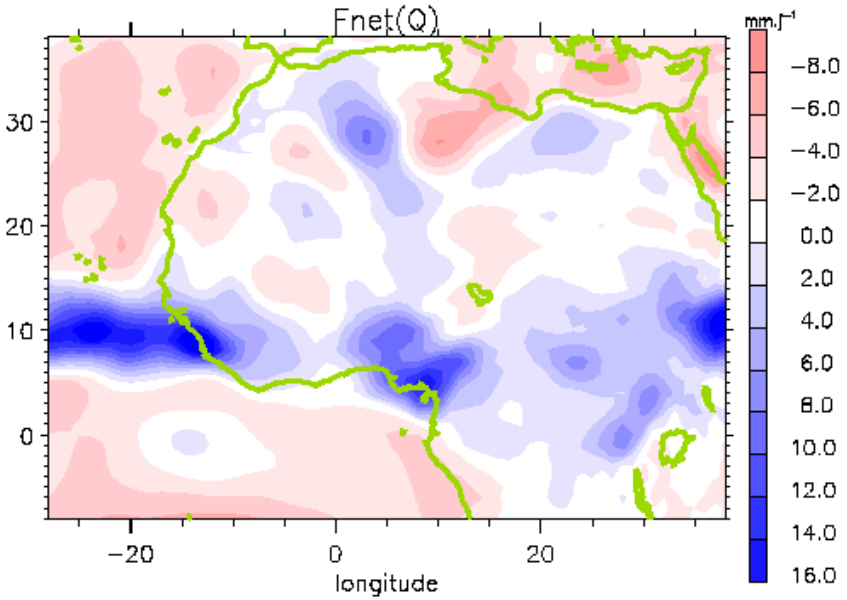
➡ P-E <0 with P~0

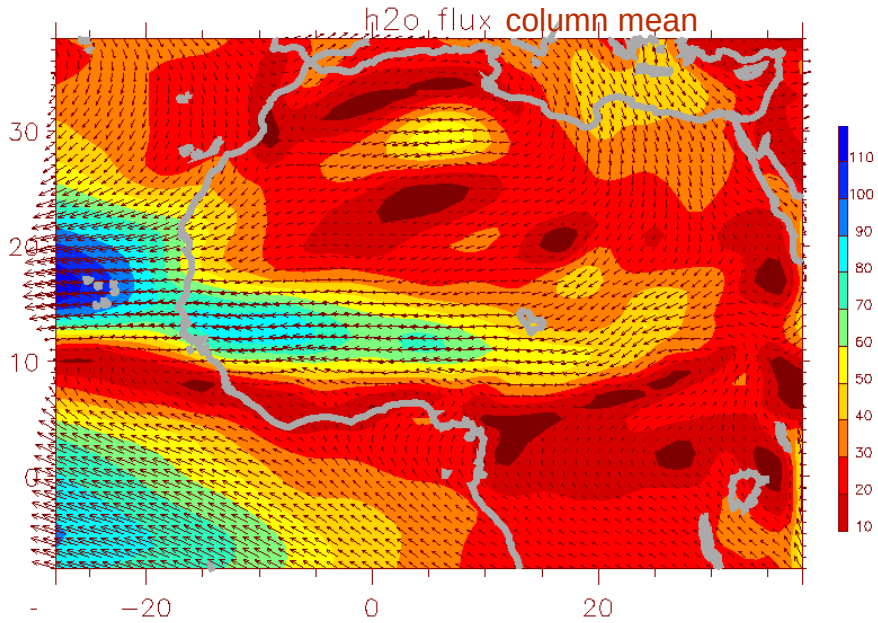
not explained by previous rainfall





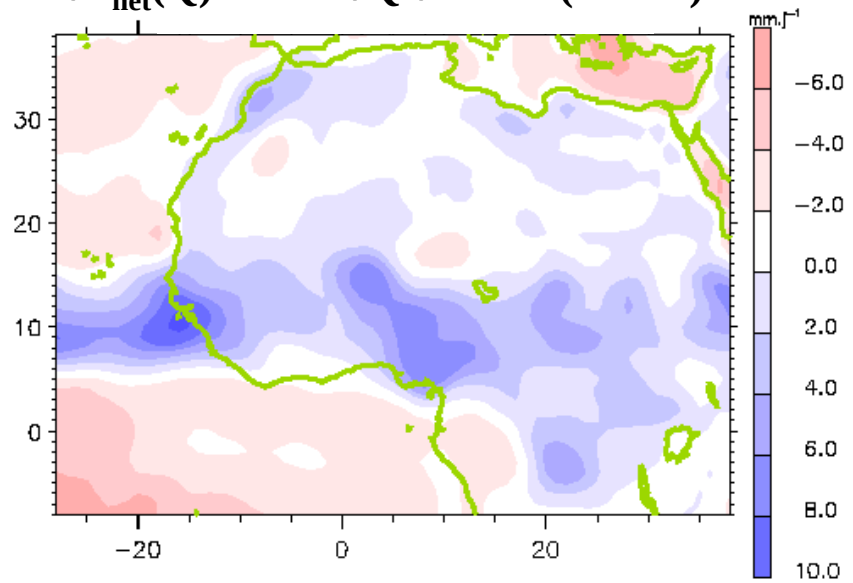
net water flux



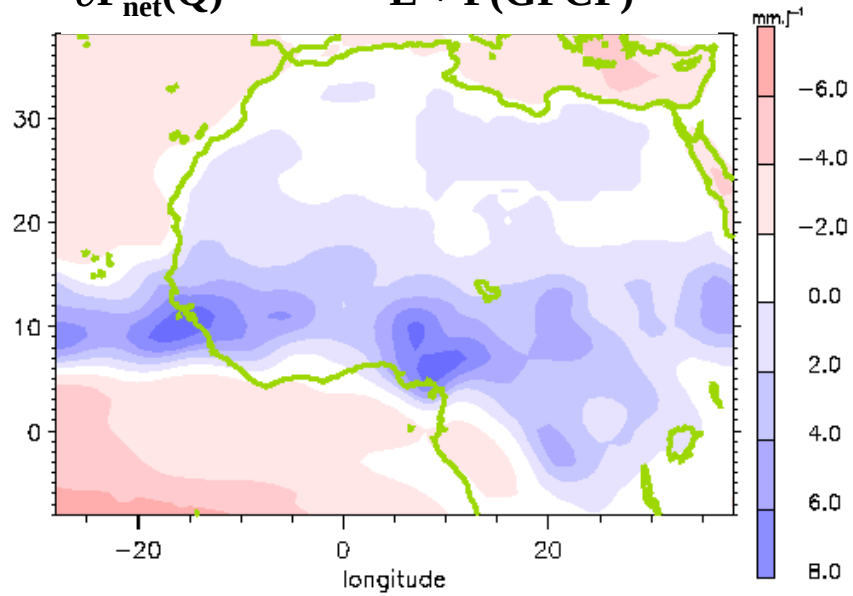


pseudo net water fluxes

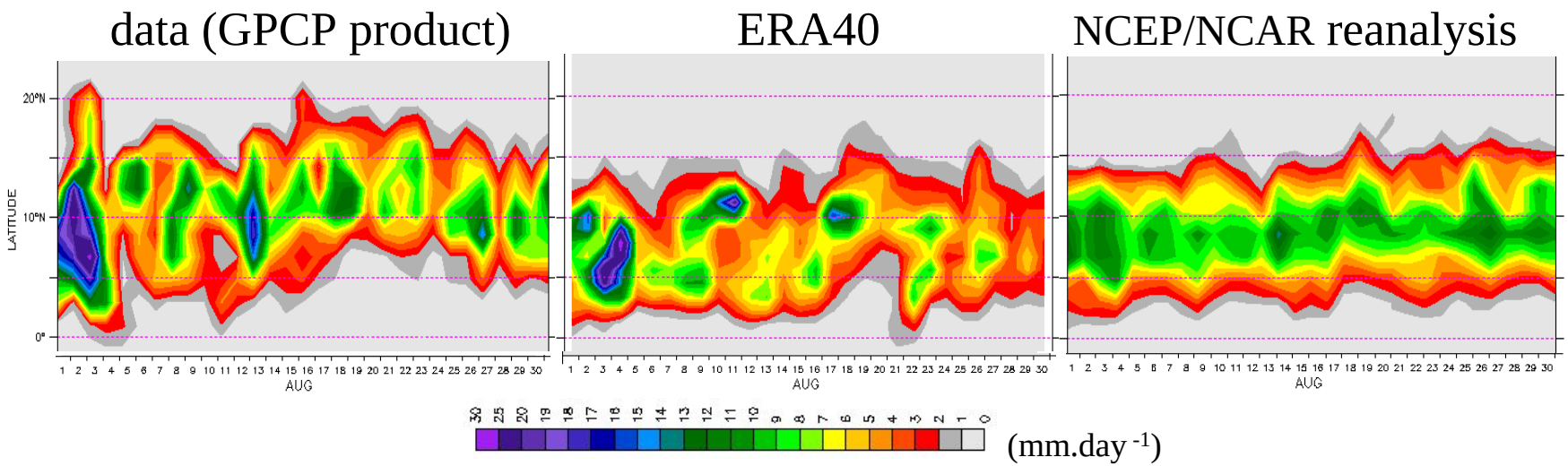
$\partial F_{net}(Q)^{pseudo} = \partial Q/\partial t - E + P(GPCP)$



$\partial F_{net}(Q)^{pseudo} = -E + P(GPCP)$



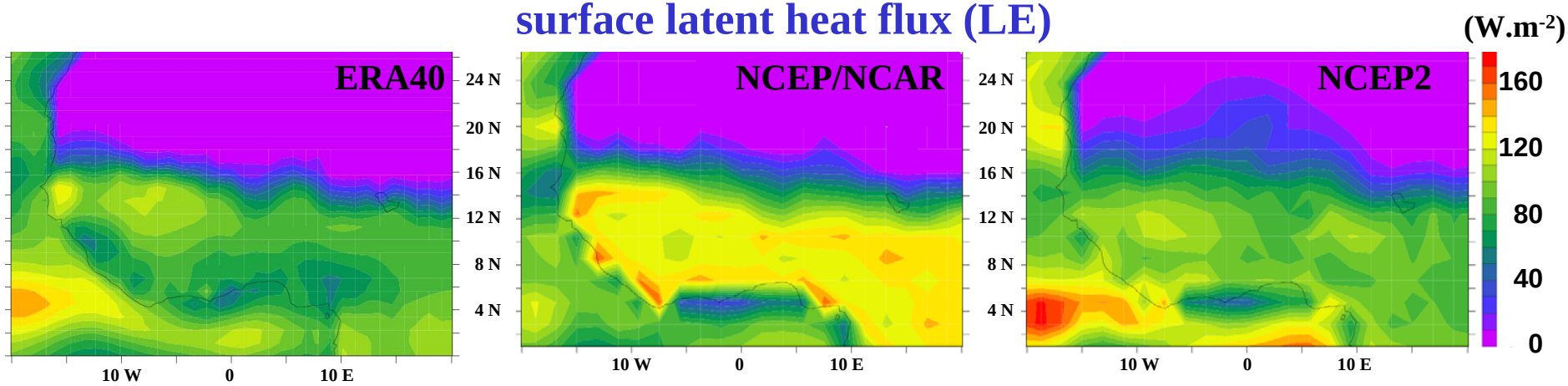
August 2000 [10W,10E] daily rainfall time series



- underestimation of the northern extension of the monsoon in both reanalyses
- contrasted amplitudes of day to day variability, ERA40 closer to GPCP data product

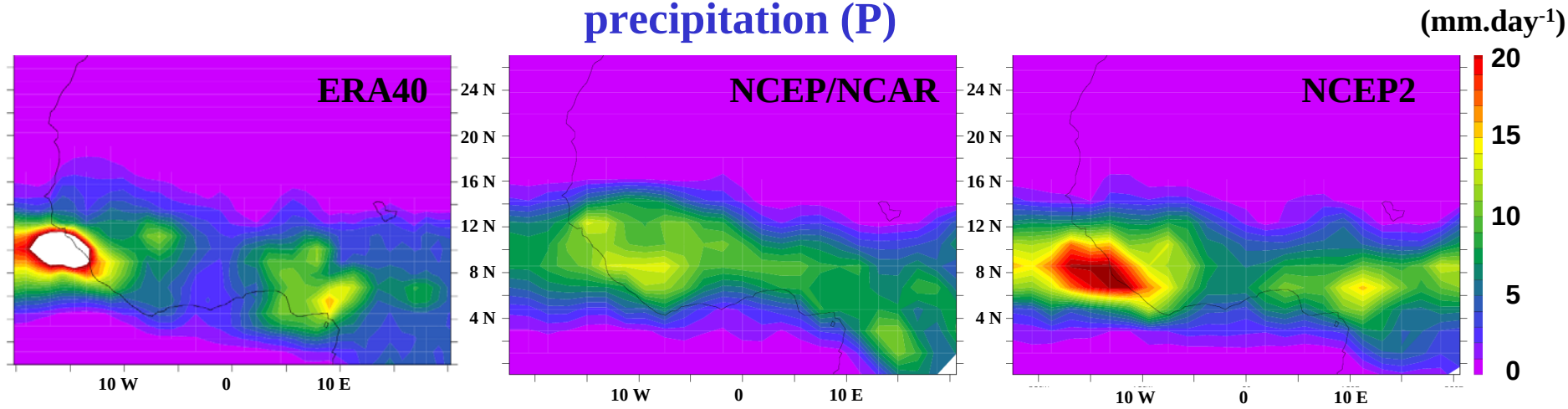
August 2000, more re-analyses comparison

surface latent heat flux (LE)



contrasted [∂ (LE)/ ∂ (latitude)] ; ERA40 & NCEP2 relatively close patterns ; NCEP2: LE>0 far North ; what links with precipitation seen by the surface?

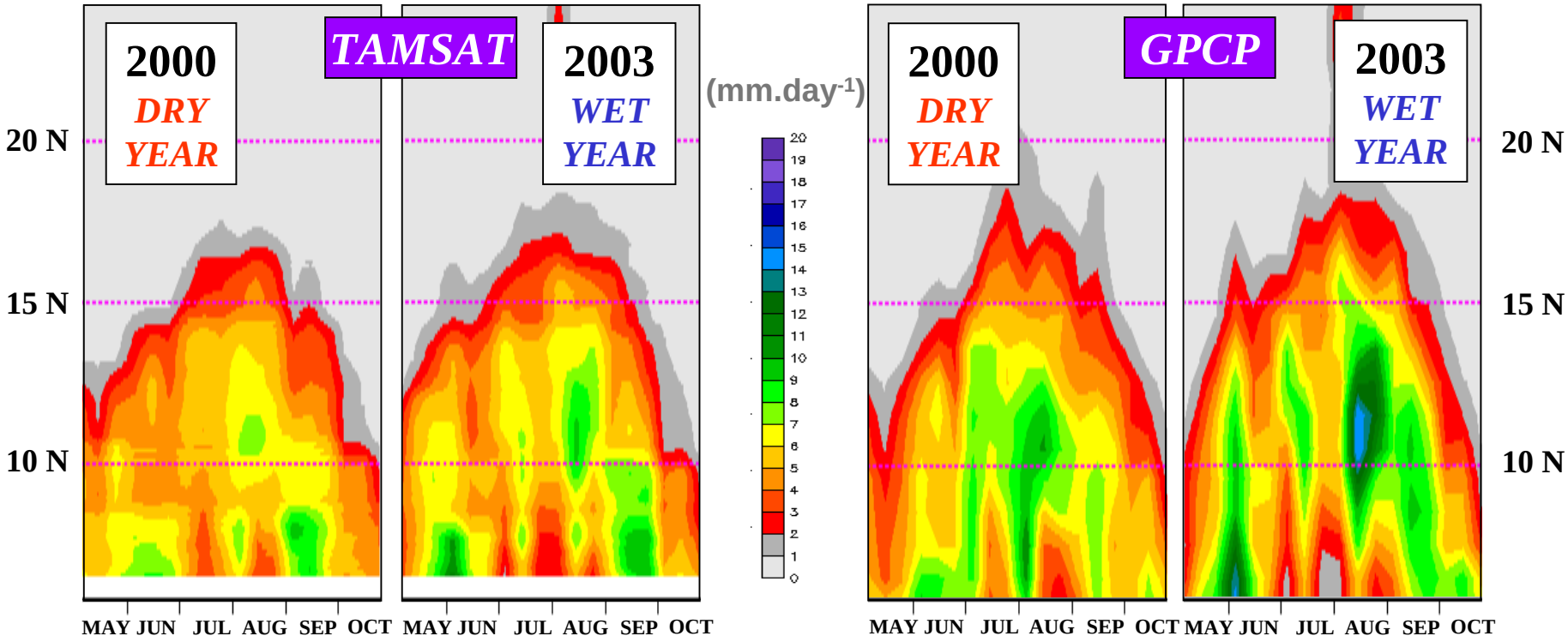
precipitation (P)



contrasted precipitation fieds ; different (LE,P) correlations among re-analyses ; again ERA40 & NCEP2 relatively close patterns

too large fluctuations among precipitation products

precipitation [10W-10E] decadal values.



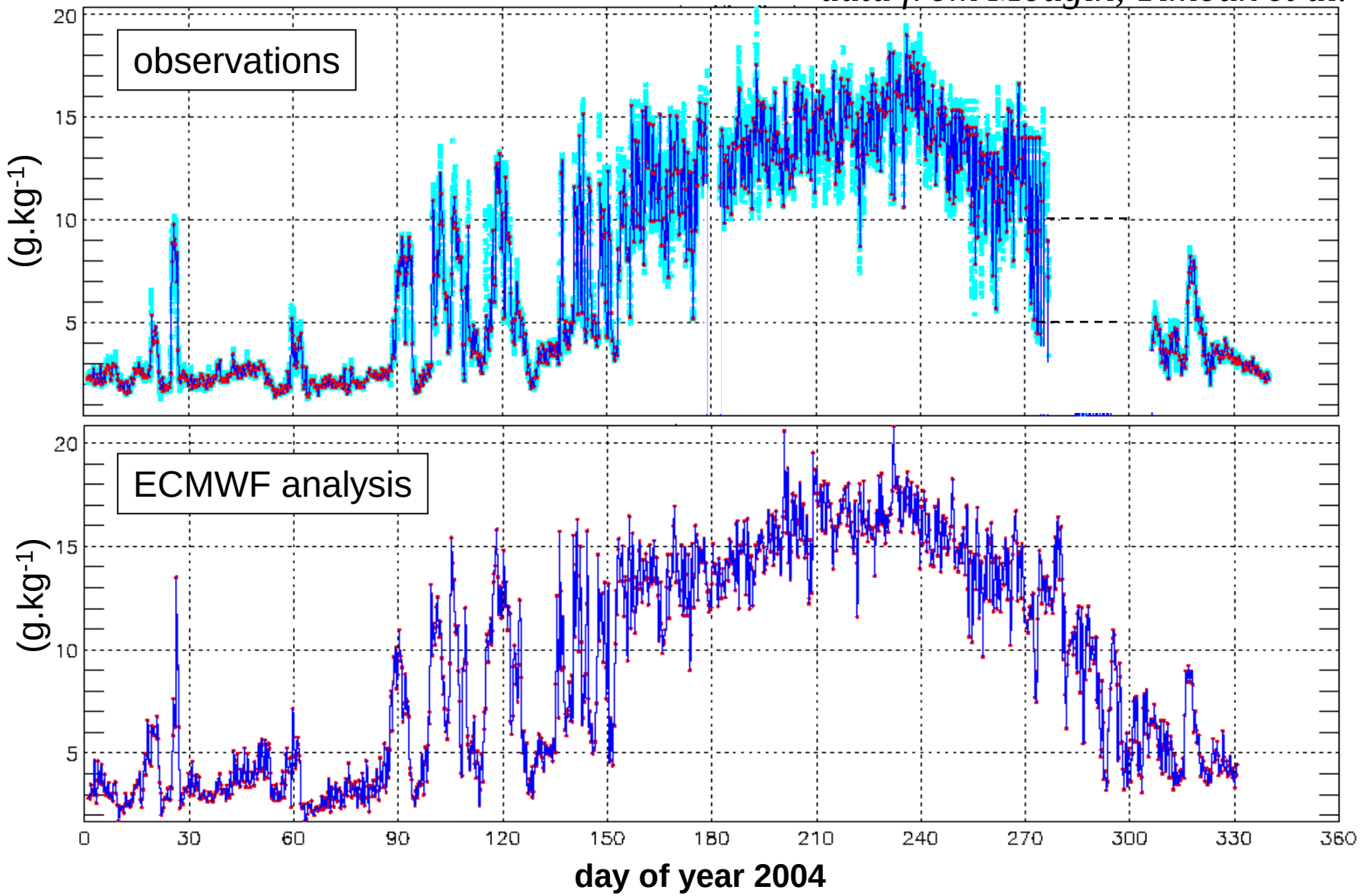
comparison with long time series of local measurements
an example from the malian Gourma site

...

more systematic assessment for precipitable water
presented by of Olivier Bock

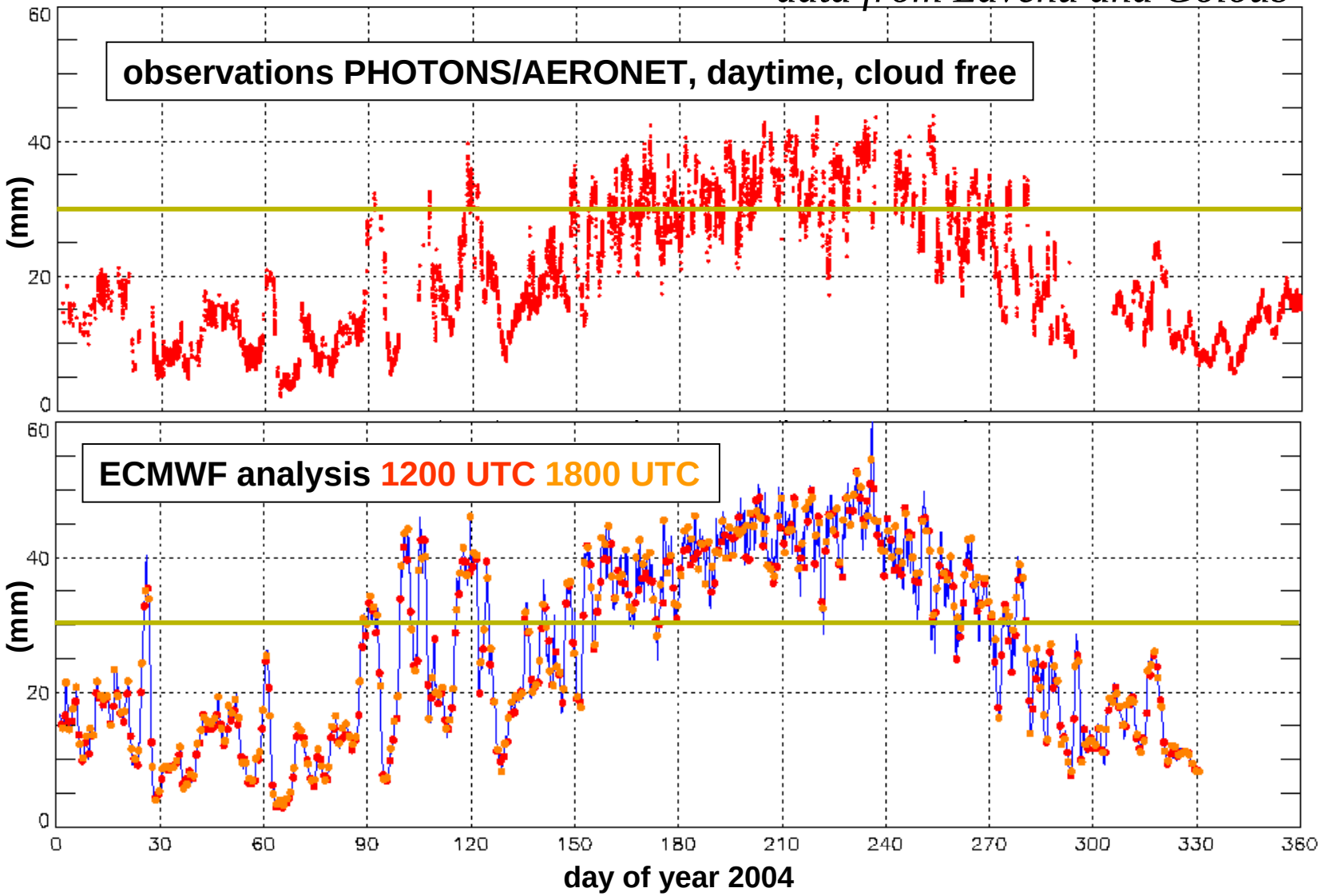
q_v at 2m AGL, 1.5°W, 15.3°N (Gourma site)

data from Mougin, Timouk et al.

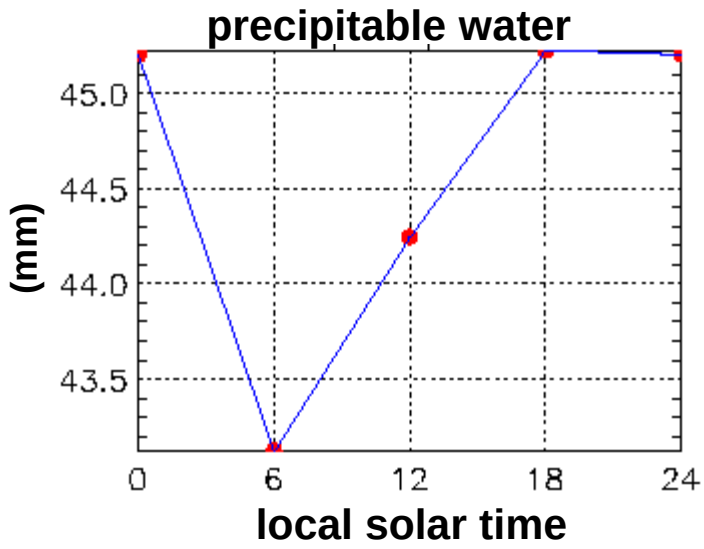


precipitable water, 1.5°W, 15.3°N (Gourma site)

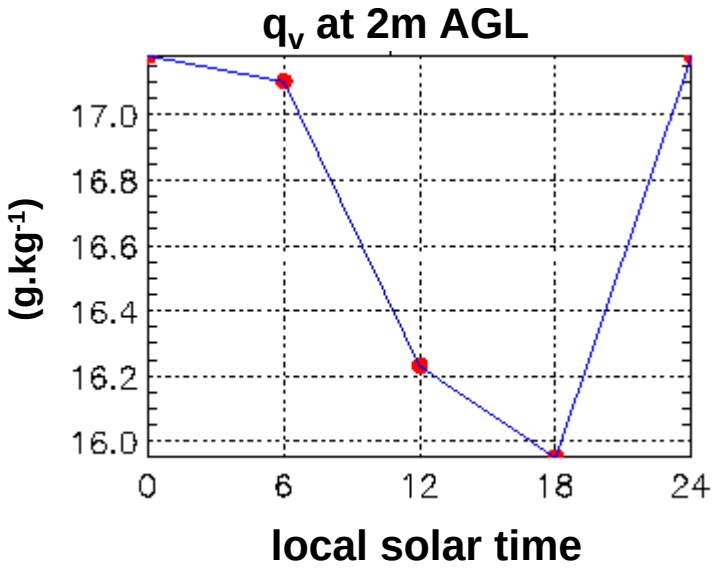
data from Lavenu and Goloub



ECMWF analysis, diurnal composite for August 2004 (1.5°W, 15.3°N)



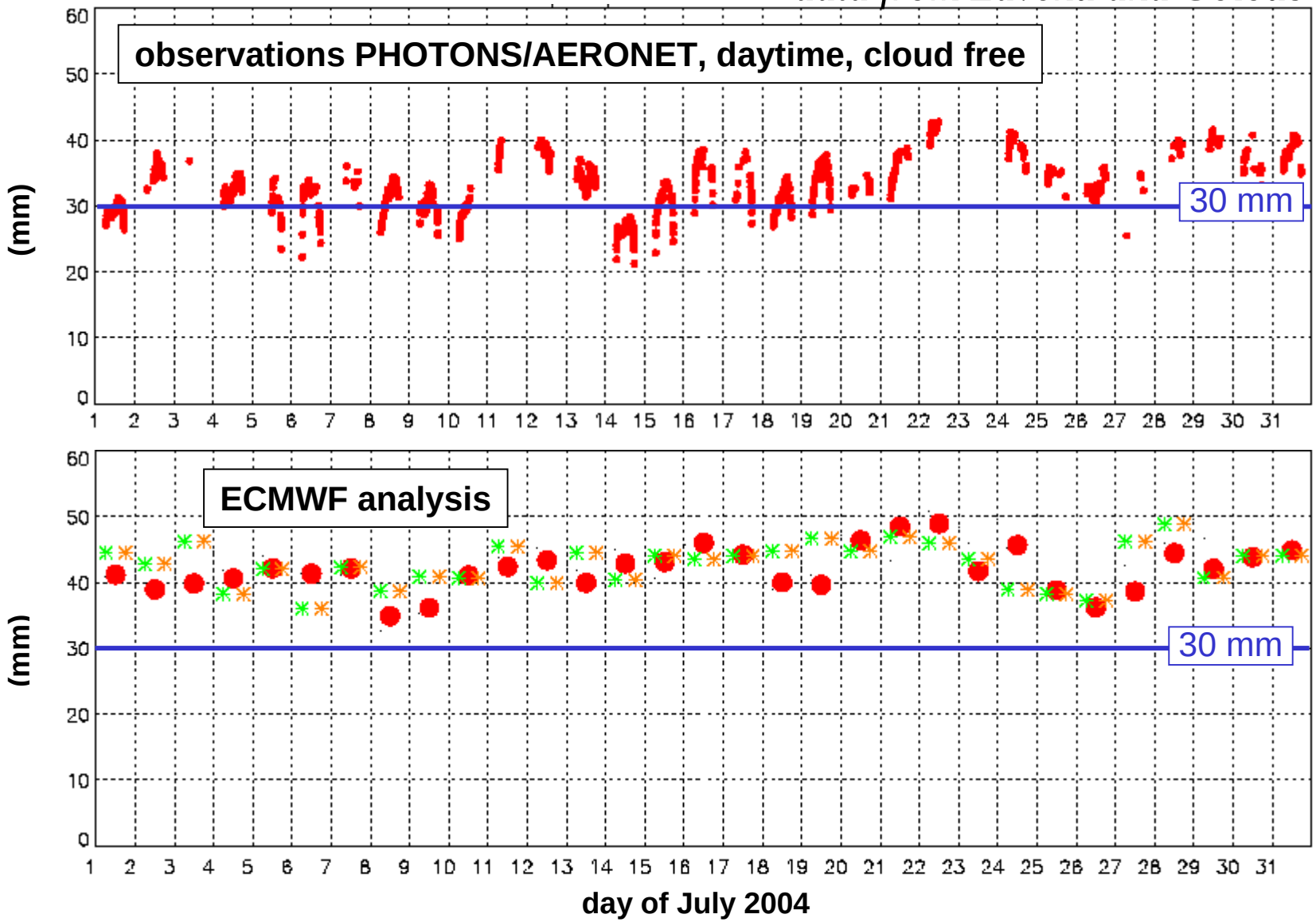
PW diurnal cycle involving disctint diurnal cycles from each of the water-related processes



possibly strong component from BL dynamics

precipitable water, July 2004 (1.5°W, 15.3°N)

data from Lavenu and Goloub



day to day variability of q_v at 2m better than the one of precipitable water

summary

documentation of the uncertainties in water budget estimate from (re-)analyses and observational products (precipitation), still quite large

errors ~1mm/day or more, persisting on monthly mean, other systematic errors

need to precise the sources of error in water fluxes estimated from re-analyses

wind versus water

need to complement with the energy budget, at least at the surface

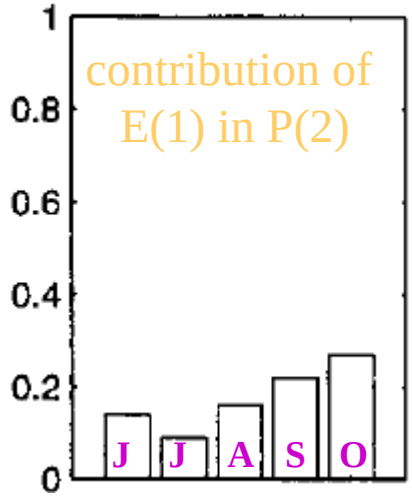
for (re)analyses: relying on improvement of NWP models

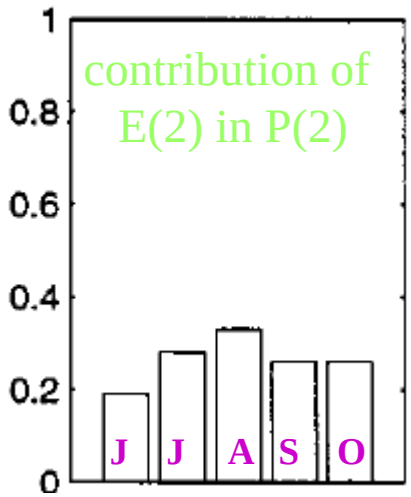
assimilation but also parametrizations

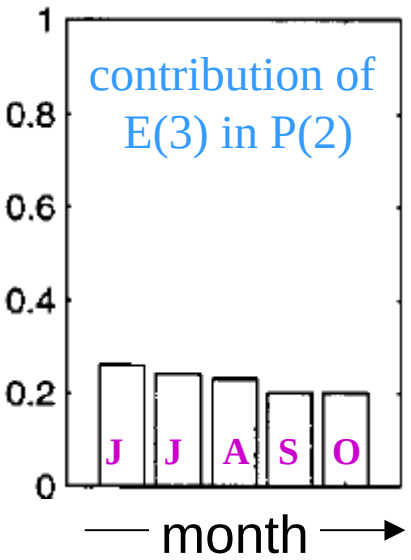
for rainfall: requirement of improved products

for surface evaporation: interest in AMMA land-surface multi-scale database *(Boone et al.)*

more broadly, the AMMA dataset (sounding network, GPS, precipitation estimates) is expected to help narrowing the actual range of uncertainty affecting the estimates of the atmospheric water budget

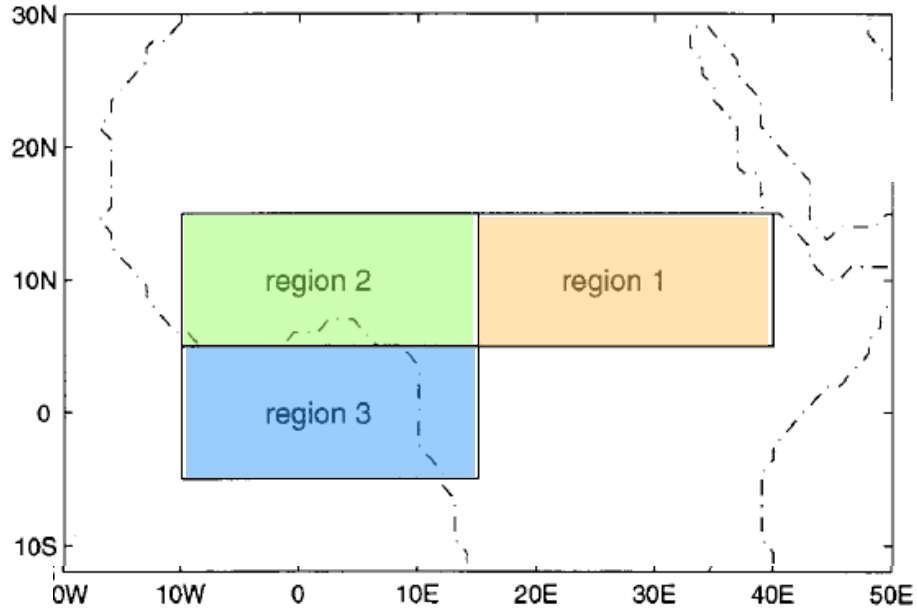






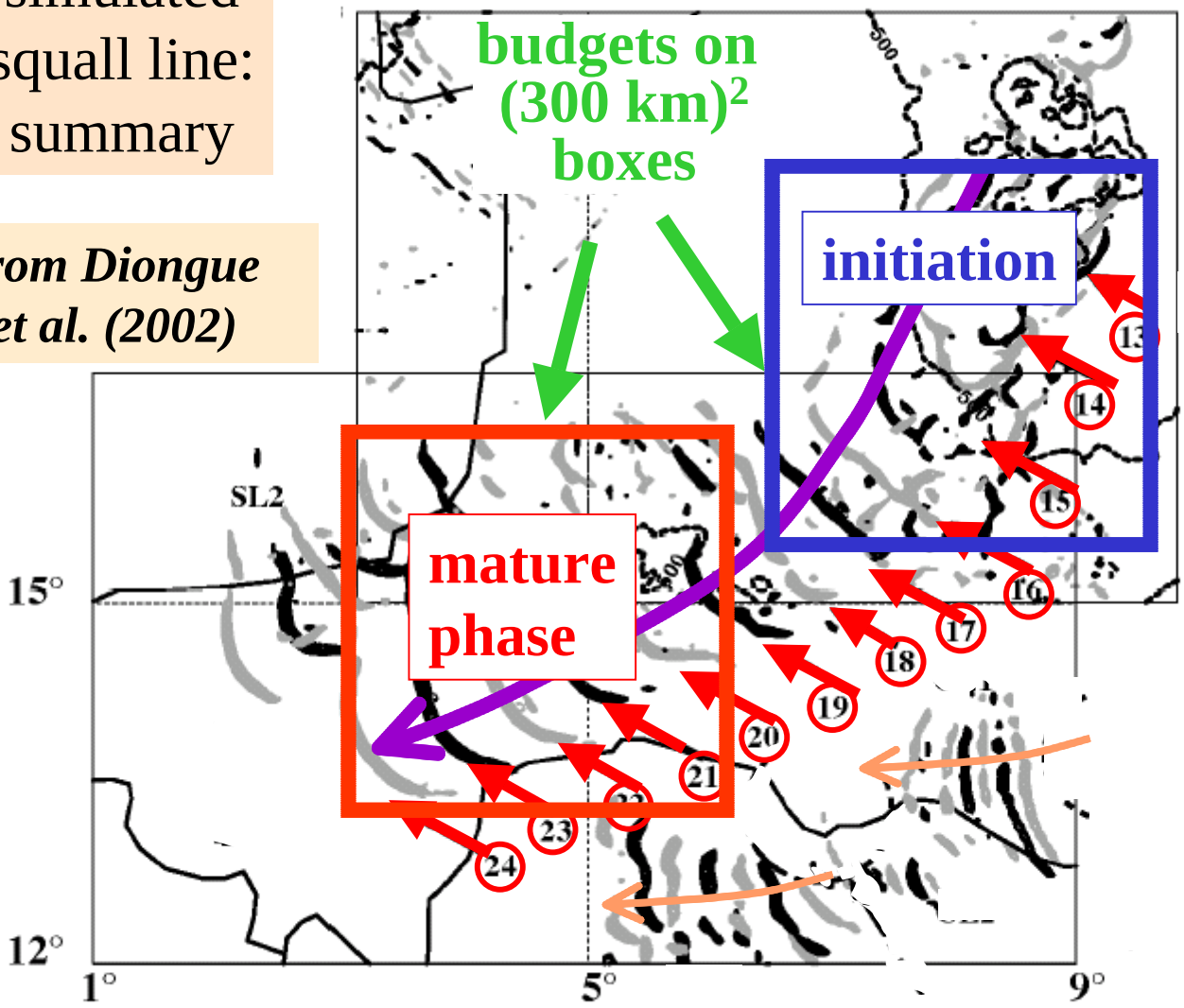
Gong & Eltahir (1996)

E: surface evaporation
P: precipitation



simulated squall line: summary

from Diongue et al. (2002)



w > 1m.s^{-1}
600m AGL

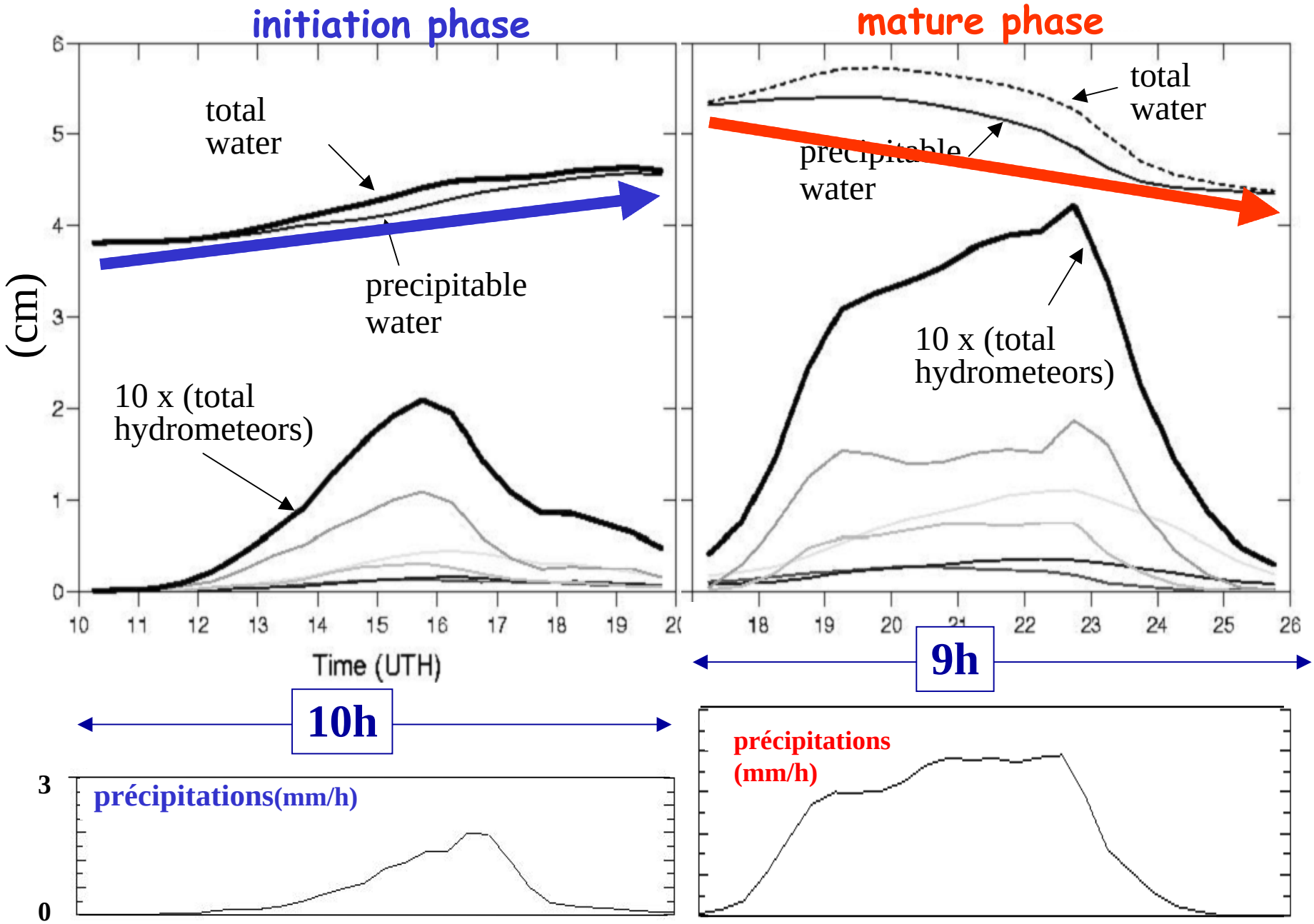
2.n hours

2.n+1 hours

« quasi-stationary » behaviour during several hours

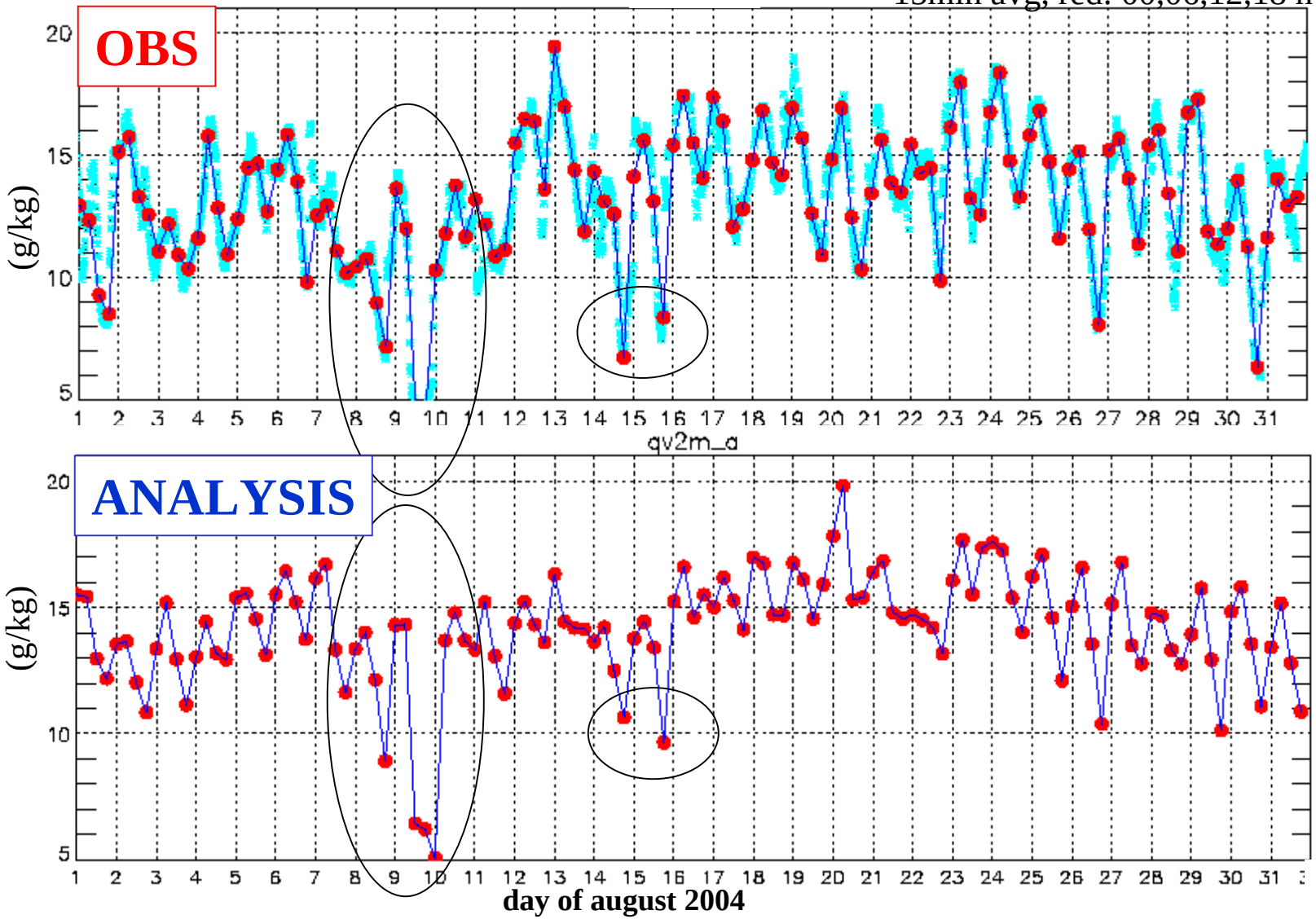
cover 1000 km in 15 hours, propagation speed of 17 m.s^{-1}

CRM simulation: average budgets on (300 km)^2 boxes



q_v at 2m august 2004 in Bamba (~17N, 1W)

data from CESBIO/ROSELT (Mougin, Timouk) 15min avg, red: 00,06,12,18 h



analysis moister than data but sharply dry periods generally well seen
(relatively large-scale feature as infered from data at 17N,1W & 15N,1W)