LATMOS

Discussion on the relevant scales of water vapour for climate analyses

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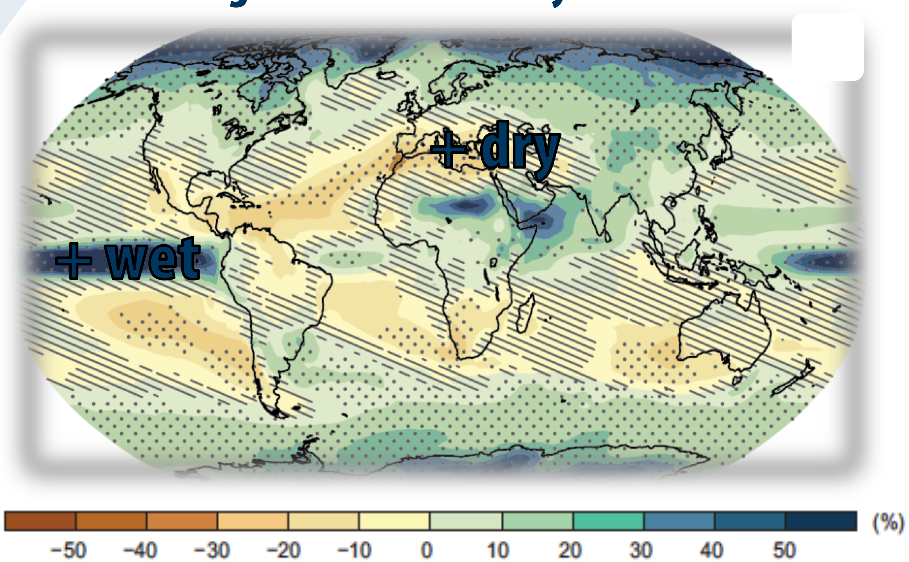
The global **surface warming** is associated to an **intensification of the water cycle**

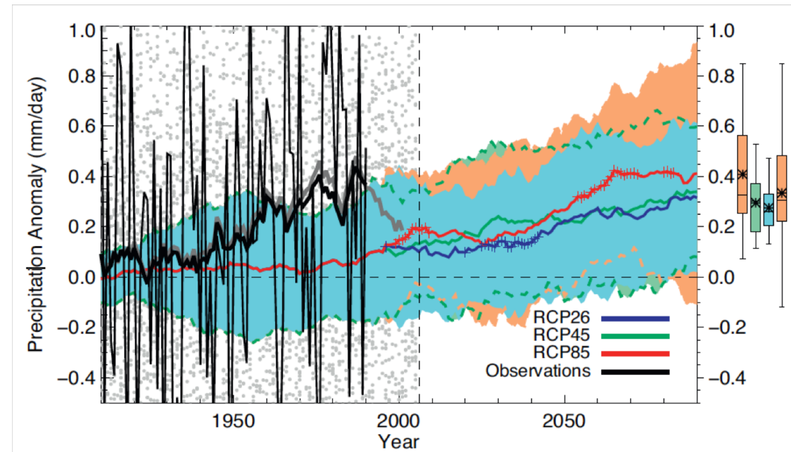
“wet gets wetter and dry drier”



Modelled changed in precipitations (end of 21st c)

[IPCC, 2014]

But difficulties to study the **regional scale**

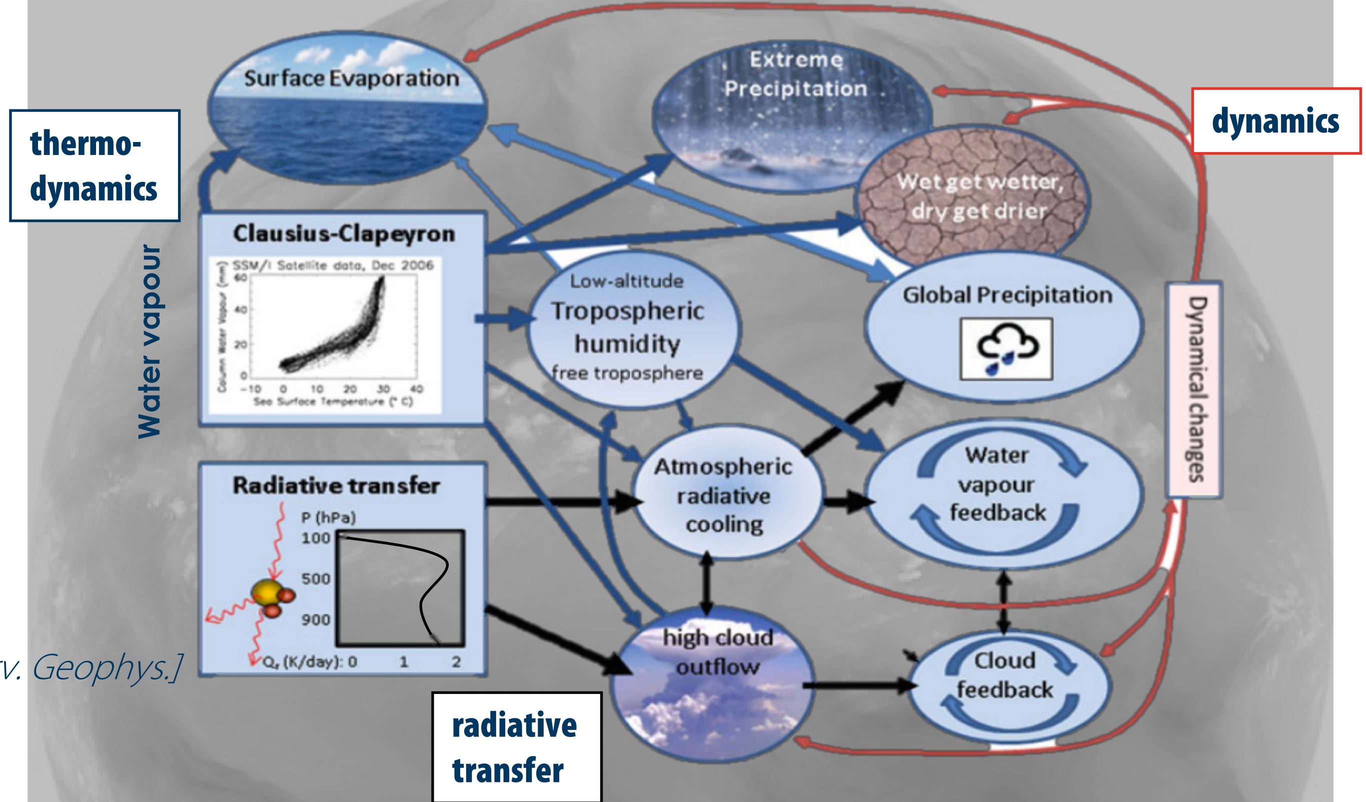


Anomaly of precip in France during WINTER

[Terray & Boé, 2013]

⇒ Most of the uncertainties are linked to **discrepancies between the modelled processes** and those that **occur in the climate system** linked to not fully understood processes

Atmospheric water vapor plays a central role in the Climate System



[Allan, 2012; Surv. Geophys.]

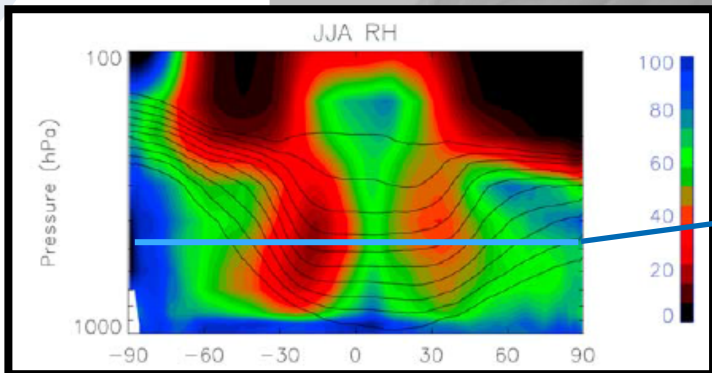
However there is *[Sherwood et al 2010; Rev. Geophys]*

- no universally accepted picture of the factors controlling wv amount
- no solid understanding of the mechanisms by which it influences atmospheric processes
- no precise knowledge of its concentration in many parts of the atmosphere

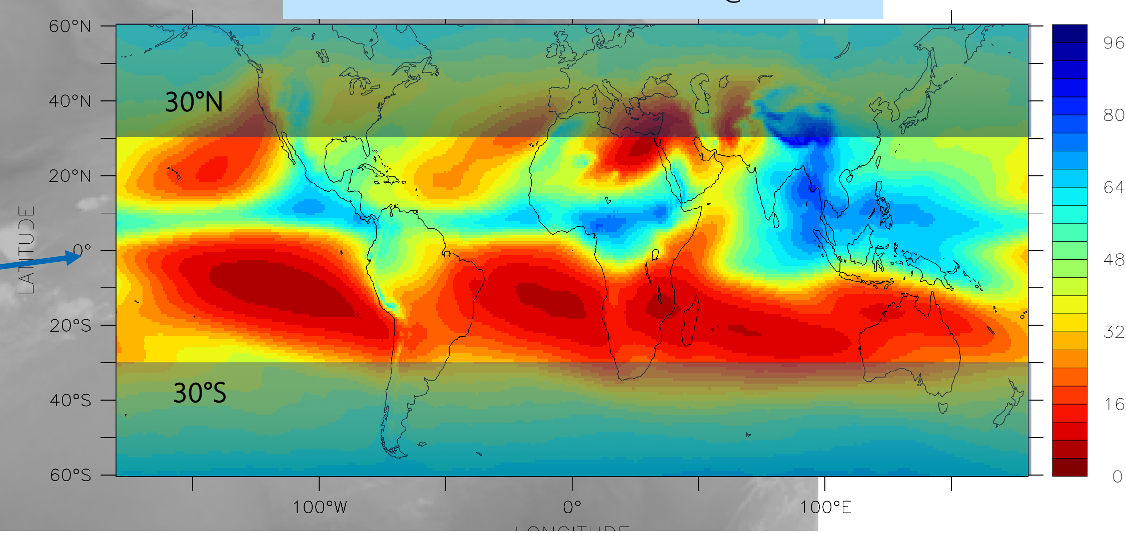
Accurate, height-resolved & global-scale measurements are key !
and are however difficult to obtain...
⇒ Need to **merge** different datasets for climate & process studies

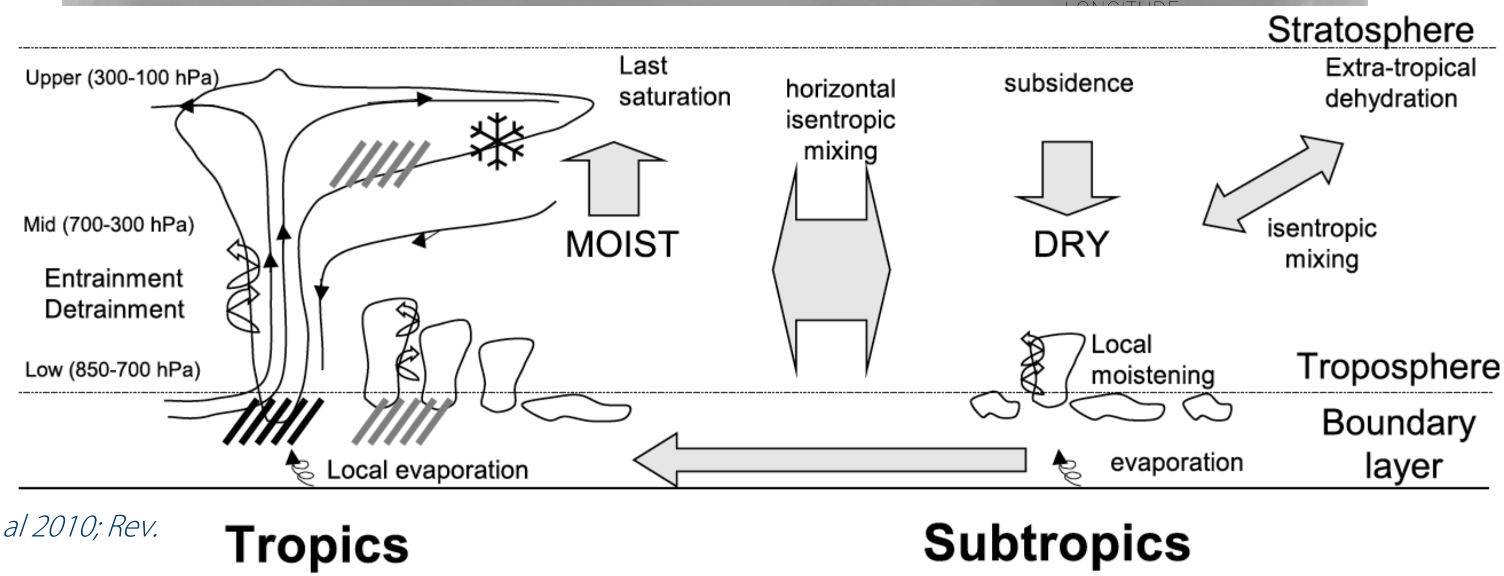
⇒ The **tropical wv** distribution and its variability are driven by a **variety of processes** that **interacts at all scales**

AMSU-AIRS obs : zonal average (JJA 2008)



ERA-Interim 1981-2010 RH@500hPa

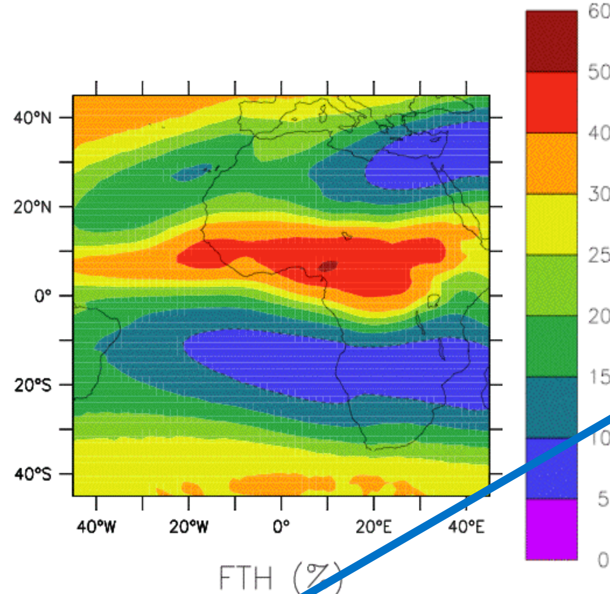


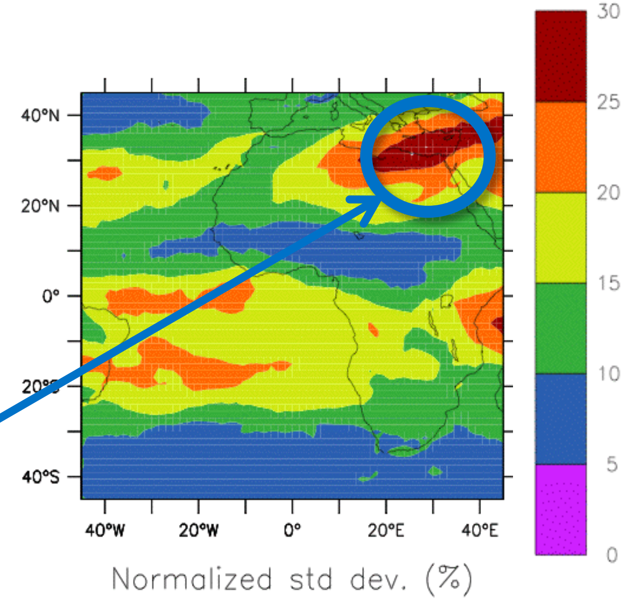


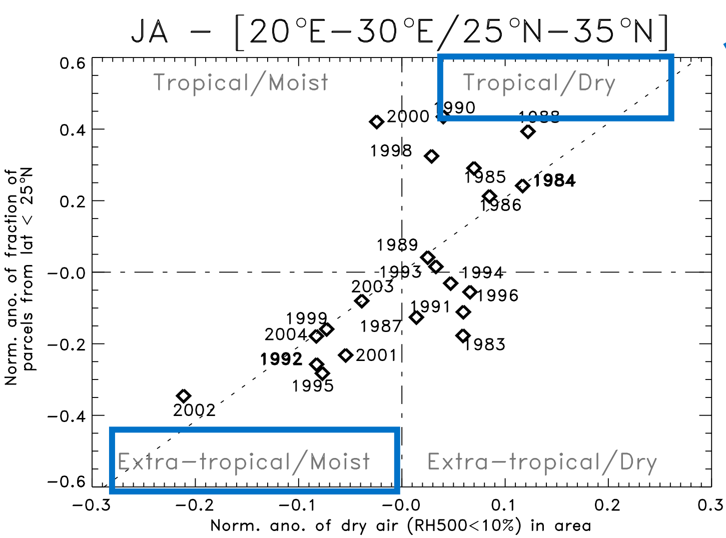
[Sherwood et al 2010; Rev. Geophys]

Variability of the very dry subtropics : central for the **radiative cooling**

FTH/METEOSAT FCDR
JA 1983-2005







⇒ On 1st order the dryness of the subtropics can be explained by **lateral mixing** (moistening from convection & dehydration from extratropics)
and the coldest-point encountered during the advection defines the level of dryness

Pierrehumbert & Roca (1998); Galewsky et al. 2005; Sherwood (2006); Brogniez et al. (2009)

? Do they vary with surface warming ? (water vapor feedback : RH=cst *[Held & Soden, 2000]*)
? How do they affect the development of boundary layer clouds ?

Variability of the moister ITCZ: it stores heat and drives the circulation and the meridional transport

Place of numerous **interactions** with the **cloudy environment** at different scales (in-cloud processes, cloud-to-cloud interactions and mesoscale structures, …)

(i) Space-borne observations have shown that **deep convection**, forced by SST, transports vertically moisture in the **UT**

[Soden & Fu (1995); Sassi et al. (2002); Roca et al. (2002)]

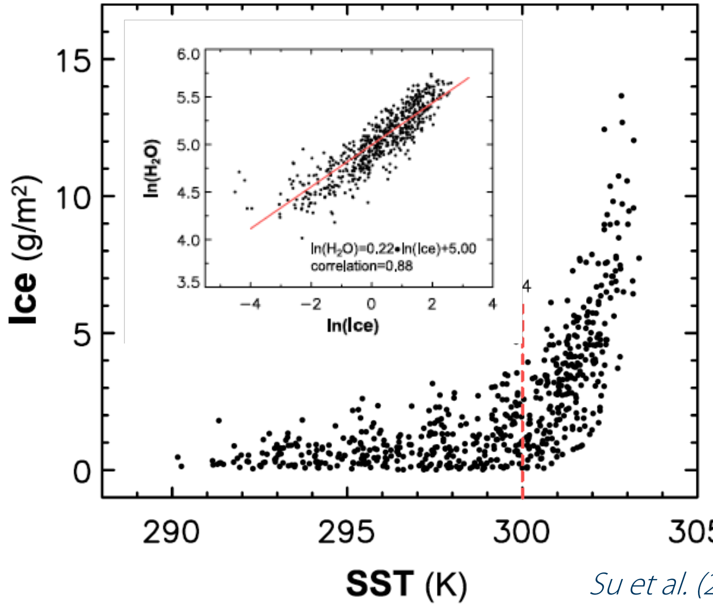
(ii) **cirrus anvils** associated to deep convection **ventilate moisture** in the surrounding environment

[Luo & Rossow (2004); Soden (2004); Su et al. (2006); Zelinka & Hartman (2009)…]

(iii) **Dry air intrusions** in the low & middle troposphere (800-400hPa) from extra-tropical jets inhibit the development of convection

[Zuidema et al. (2006); Roca et al. (2005)]

Cloud ice & UTWV (MLS/Aura) with SST (Reynolds)
Monthly means over 08/2004-07/2005



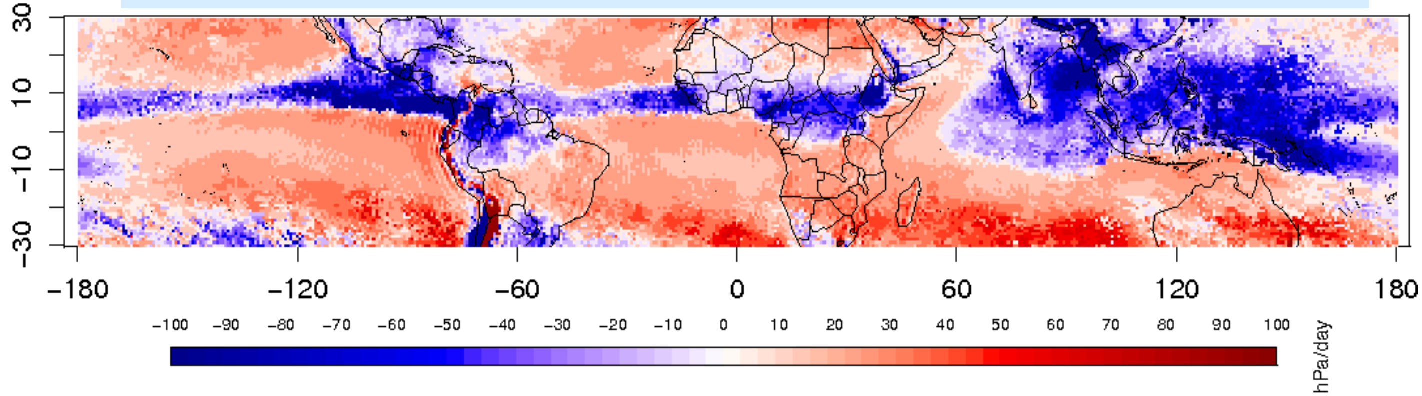
Su et al. (2006)

? How does the development of Mesoscale Convective Systems affect their surroundings and what is the distance of interactions ?
? Can we test theoretical & conceptual models on tropical climate behavior ? (Iris, FAT, …)

Interannual variability : the concept of « trend » encounters numerous hurdles due to the datasets themselves & due to the strong horizontal variability induced by the processes

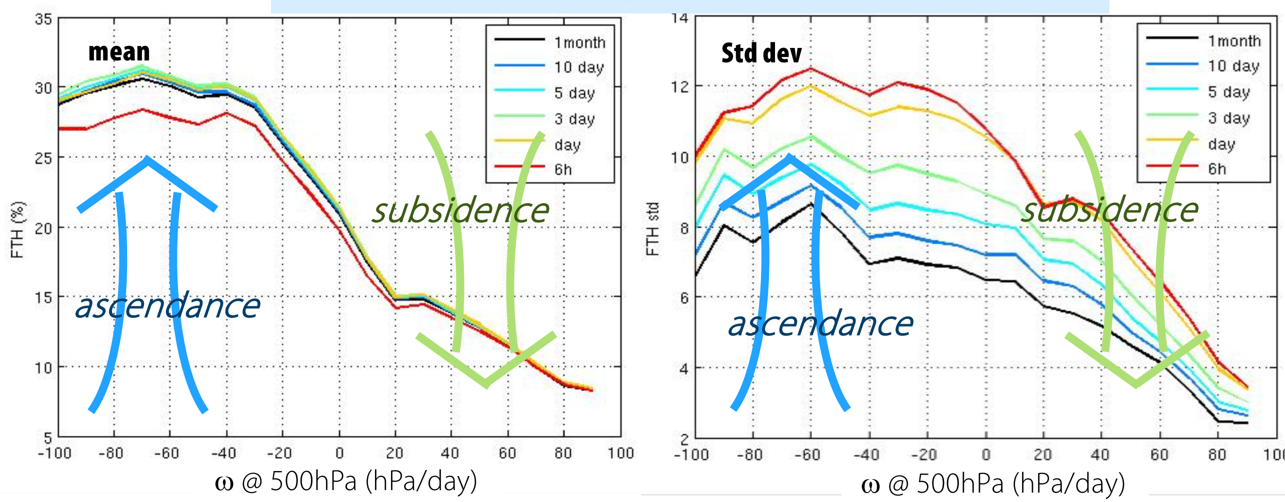
⇒ « process-oriented » trends, such as according to categories of vertical motion

JJAS 2012-2017 - main regime of vertical velocity ω @ 500hPa (ERA-Interim)

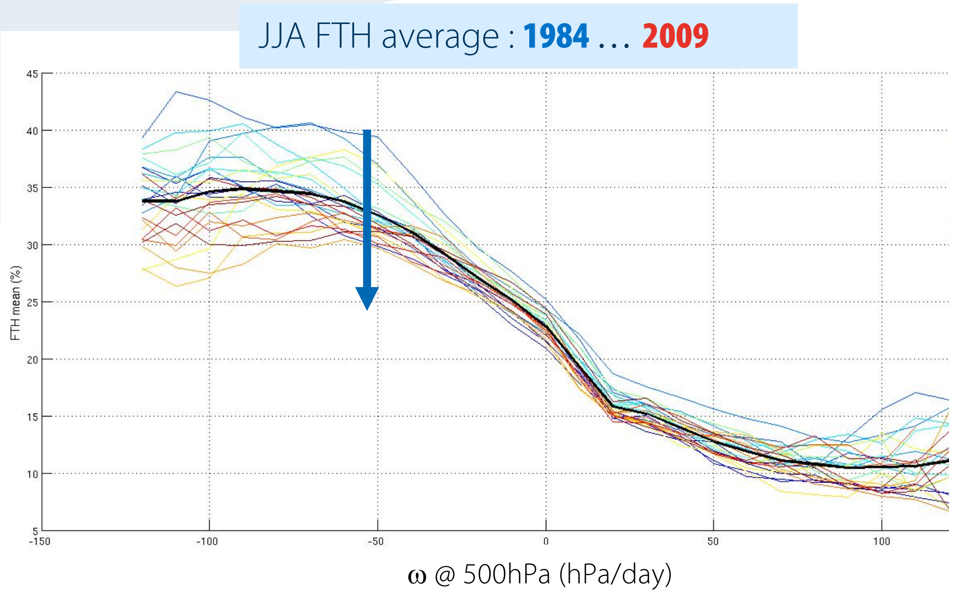


1) Evolution of Free Tropospheric Humidity (METEOSAT CDR 1983-2009):

Year 2003 as an example – [45°N : 45°S / 45°W : 45°E]



⇒ **Daily averages** keep the information on the distribution !



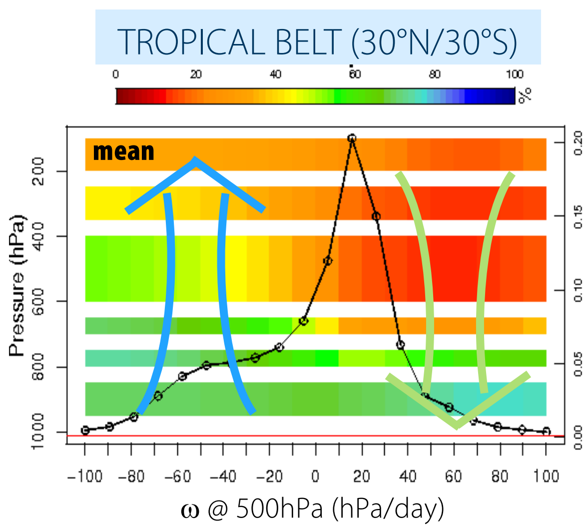
A pattern seems to emerge since 1984:

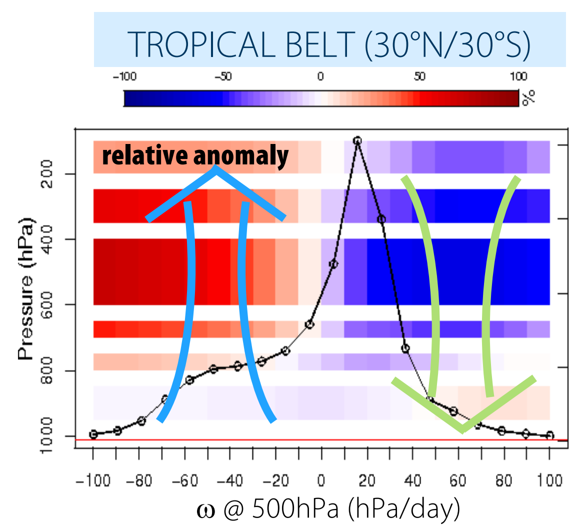
⇒ drying of ascending regions linked to convective activity ?

⇒ nothing clear in subsiding regions

Need to extract natural variability (El Nino, Pinatubo, etc)

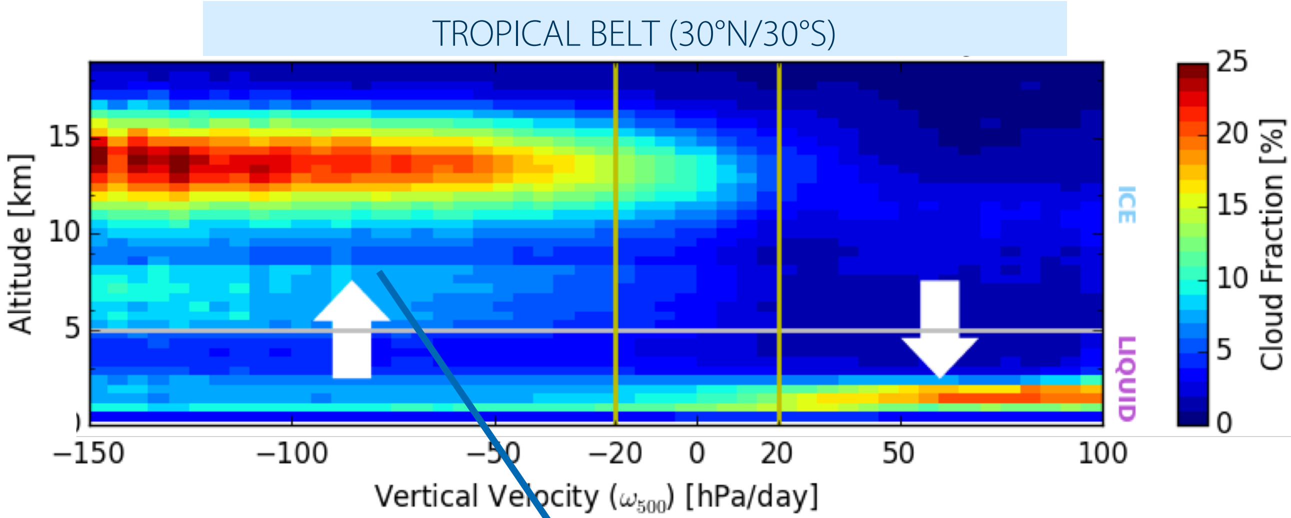
2) Evolution of vertical profiles RH(p) (SAPHIR/Megha-Tropiques 2011-2018):





Strong signature of the circulation in the mid-tropo: less contrasts by ω_{500} in the LT & UT

3) Link with SST and clouds : CALIPSO/CloudSat/SAPHIR (2012-2017):

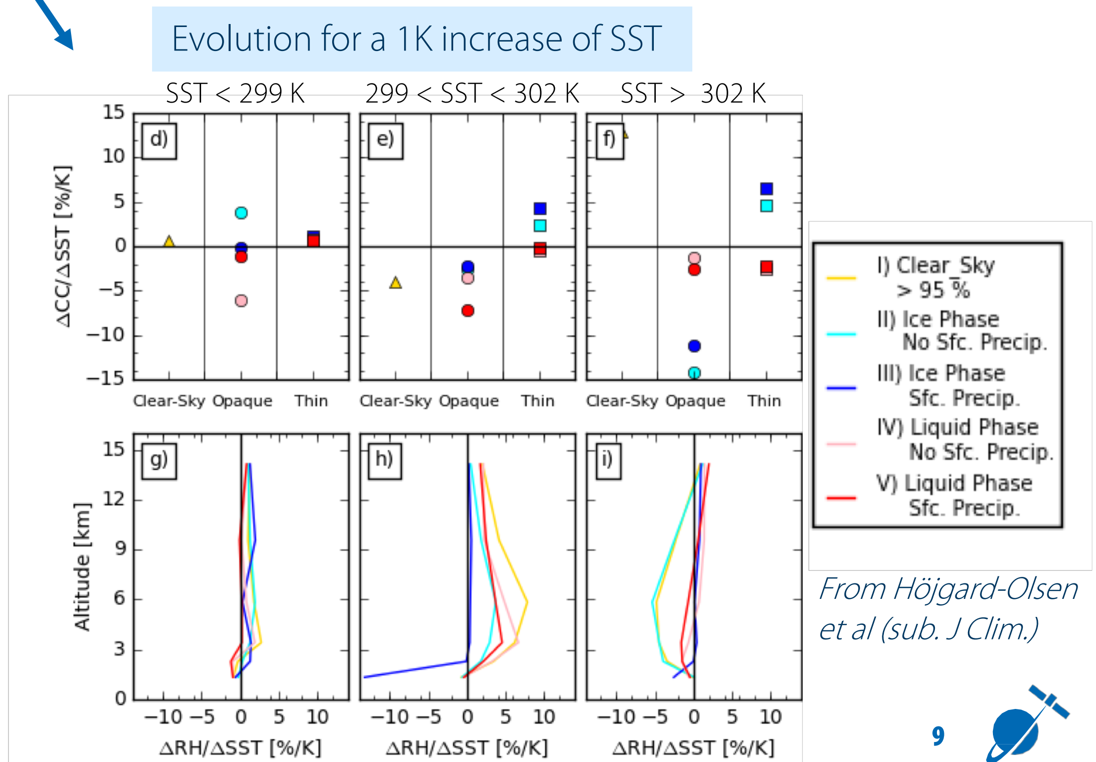


- SST < 302 K : moistening of the troposphere with a slight decrease of opaque clouds in parallel to an increase of thin cloud

- SST > 302 K : overal drying of the troposphere while icy thin clouds (=cirrus) strongly increase to the detriment of icy opaque clouds (=anvils) => ↘ OLR

=> cloud-wv-radiation feedback

Ramanathan & Collins (1991); Pierrehumbert (1995); Dewey & Goldblatt (2018)



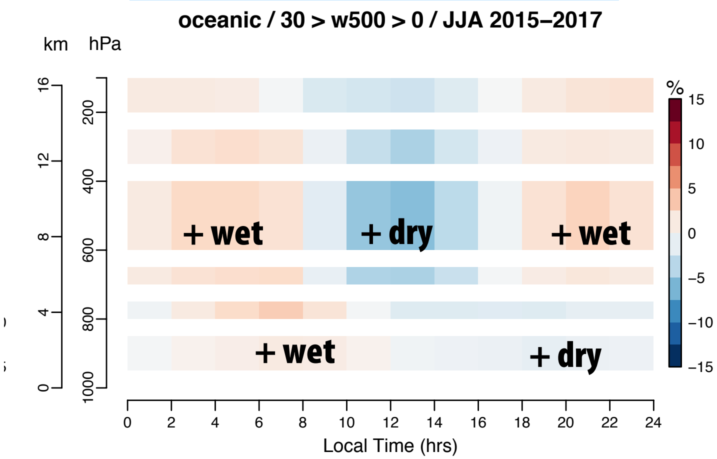
From Höjgard-Olsen et al (sub. J Clim.)

Diurnal cycle : fundamental element driven by solar forcing with still opened questions

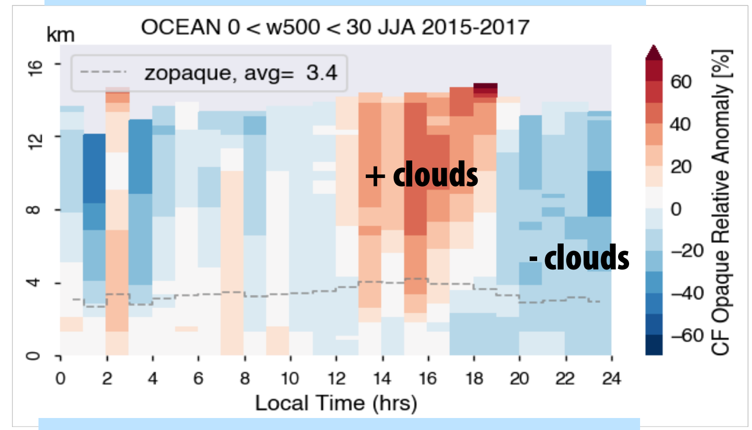
? how does it vary with large-scale atmospheric variability ?
? what are the interactions between the elements ?

⇒ aggregation of data according to LT + sorting into vertical motion : **global scale**

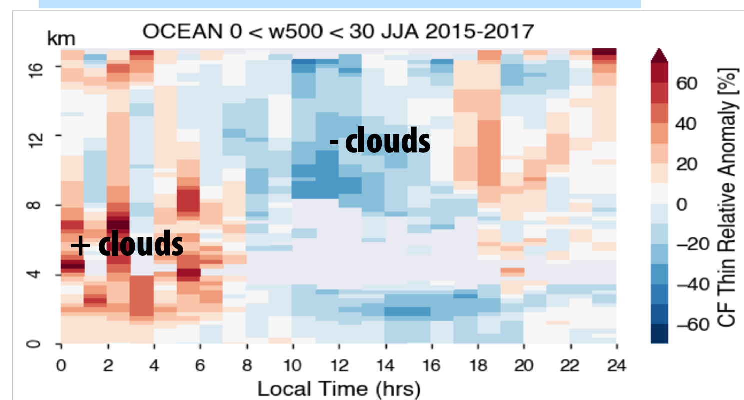
Anomaly of RH (SAPHIR/MEGHA-TROPIQUES)



Opaque cloud fraction (CATS/ISS)



Thin cloud fraction (CATS/ISS)



From Chepfer, Noel & Brogniez, 2019 (Nature Sc. Report)

- Weak moistening in the BL ~6-8am follows the development of low-level clouds that peak during night-time
- Drying of the FT associated to solar heating
- Dissipation of opaque high-altitude clouds after sunset that precludes the moistening of the FT

key points

⇒ Importance of both **MW and IR** observing systems

⇒ Importance of **climate records (IR+MW)** of **daily** sampling : monthly averages are unrepresentative of the large-scale variability and thus not useful for model evaluation

⇒ Importance of **vertical profiles (MW) and subdaily** observations to have a robust description of the diurnal cycle to understand the interactions between