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”

But difficulties to study the **regional scale**

Anomaly of precip in France during WINTER

[IPCC, 2014]

⇒ 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.

However, there is 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]

Tropics

Subtropics
# Variability of the very dry subtropics: central for the radiative cooling

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

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.

? 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 anvil**s 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 extratropical jets inhibit the development of convection

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

? 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 \( \omega \) @ 500hPa (ERA-Interim)


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)


Strong signature of the circulation in the mid-tropo: less contrasts by $\omega_{500}$ 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: overall drying of the troposphere while icy thin clouds (=cirrus) strongly increase to the detriment of icy opaque clouds (=anvils) => ↓ OLR

=> cloud-wv-radiation feedback

*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

- 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

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