Analysis of water vapour clear-sky bias from satellite observations

climate change initiative

→ WATER VAPOUR

esa

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References

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INTRODUCTION

Atmospheric water vapour is an important (natural) greenhouse gas. Total column water vapour can be retrieved from satellite observations on a global scale since the late 1970's. Measurements are obtained over land and ocean in different parts of the electromagnetic spectrum: among others, the ultraviolet/visible (UV/vis) and infrared (IR), and with high spatial resolution over land in the near infrared (NIR) frequencies. All related retrievals are predominantly applied under **clear-sky conditions**.

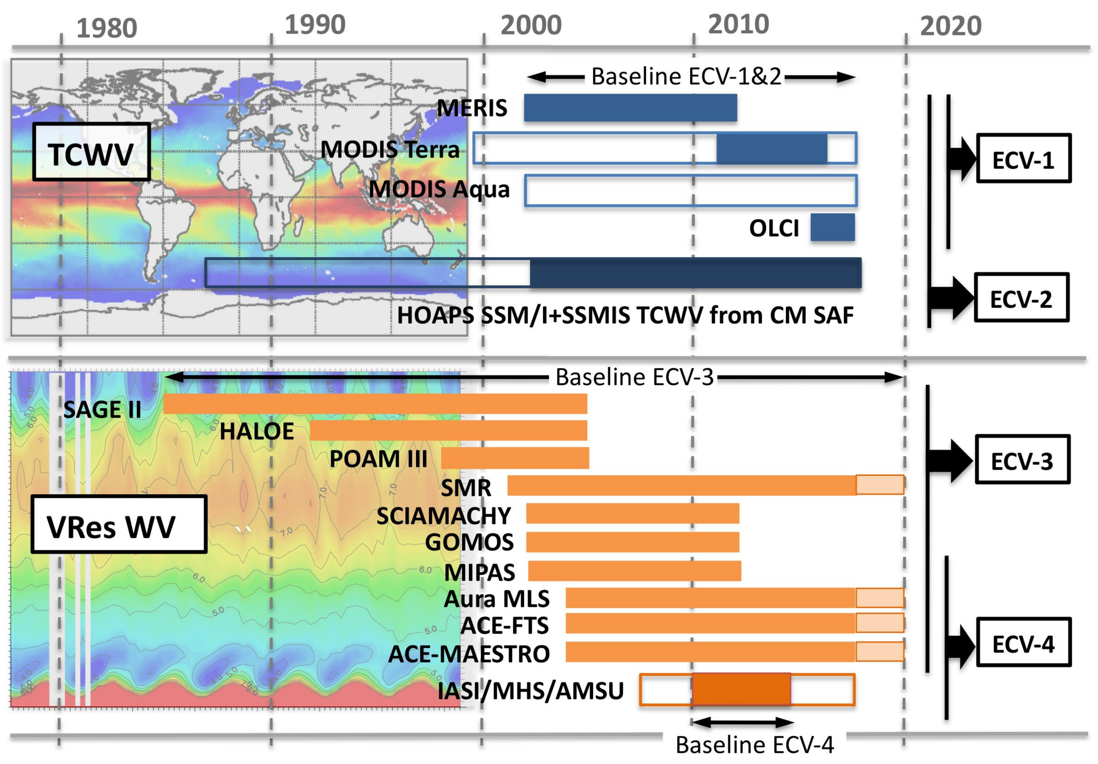
Though instantaneous water vapour products show high quality and low uncertainty, this is not necessarily true for the gridded and temporally averaged products: Conditions in clouds are typically more humid than the surrounding clear-sky areas, and are not taken into account by the satellite's clear-sky observations. This effect is called clear-sky bias and is in the order of 10%. In order to provide a reliable uncertainty estimate for gridded and temporally averaged clear-sky products the contribution of this source of uncertainty to the total uncertainty needs to be characterized.

We present results from the analysis of the **clear-sky bias** as a function of **local time, monthly time scale** and **spatial components.** This analysis relies on water vapour and cloud information from the latest reanalysis of the European Centre for Medium-Ranged Weather Forecasts, ERA5. The data is used as it provides the relevant parameters gap-free and at required spatial and temporal resolutions. In addition, the clear-sky bias will be assessed using collocated Global Navigation Satellite System (GNSS) and Medium Resolution Imaging Spectrometer (MERIS) data during the specific satellite overpass. This data is used to validate clear-sky bias analysis and to assess the uncertainties made by satellites observations clear-sky sampling.

OVERVIEW of WV CCI

The **Water Vapour Climate Change Initiative** (**WV_cci**) is a newly funded ESA project with the overall goal to establish climate data records (CDR's) of water vapour for use in climate research.

Figure 1: Planned climate data records (CDRs) of essential climate variables (ECV's) for total column and vertically resolved H_2O with respective input observations.



Specific goals within WV_cci include:

- **Quantifying uncertainties** useful to the end users, with special focus on the clear-sky bias.
- **Analysing variability and trends** on different spatial and temporal scales, including consistency with theory.
- **Seeking cooperation** with ongoing activities within SPARC, GEWEX/G-VAP, GCOS, and others.
- **Validation of CCI+ water vapour** in terms of bias, RMSD, homogeneity and stability :
  - ❖ for total column water vapour (**TCWV**) over land and ocean (CDR-1/2)
  - ❖ for vertically resolved H_2O in the upper troposphere and stratosphere (CDR-3/4)

METHODOLOGY / EARLY RESULTS

Calculation of the **clear-sky bias (CSB)**:

- characterisation of **climatologies** for each grid point and associated standard deviation on the basis of ERA5 [4]
- application of **cloud mask**: total column cloud cover, **tcc** < 0.95, and total column cloud liquid water [2], **tclw** < 0.005 kg/m²
- The CSB is estimated here as the difference of the sampled data to the climatology, applied to each grid point: $csb_{i,j}(t) = x_{i,j}(t) - \overline{C_{i,j}}^{(2002-2012)}$
- We dissect the CSB into its local time scale, monthly and spatial components: *CSB = Function(LT, month, longitude, latitude)*
- like so: $\overline{csb_{i,j}}^{T} = \overline{\left(x_{i,j}(t) - \overline{C_{i,j}}^{(2002-2012)}\right)}^{T}$

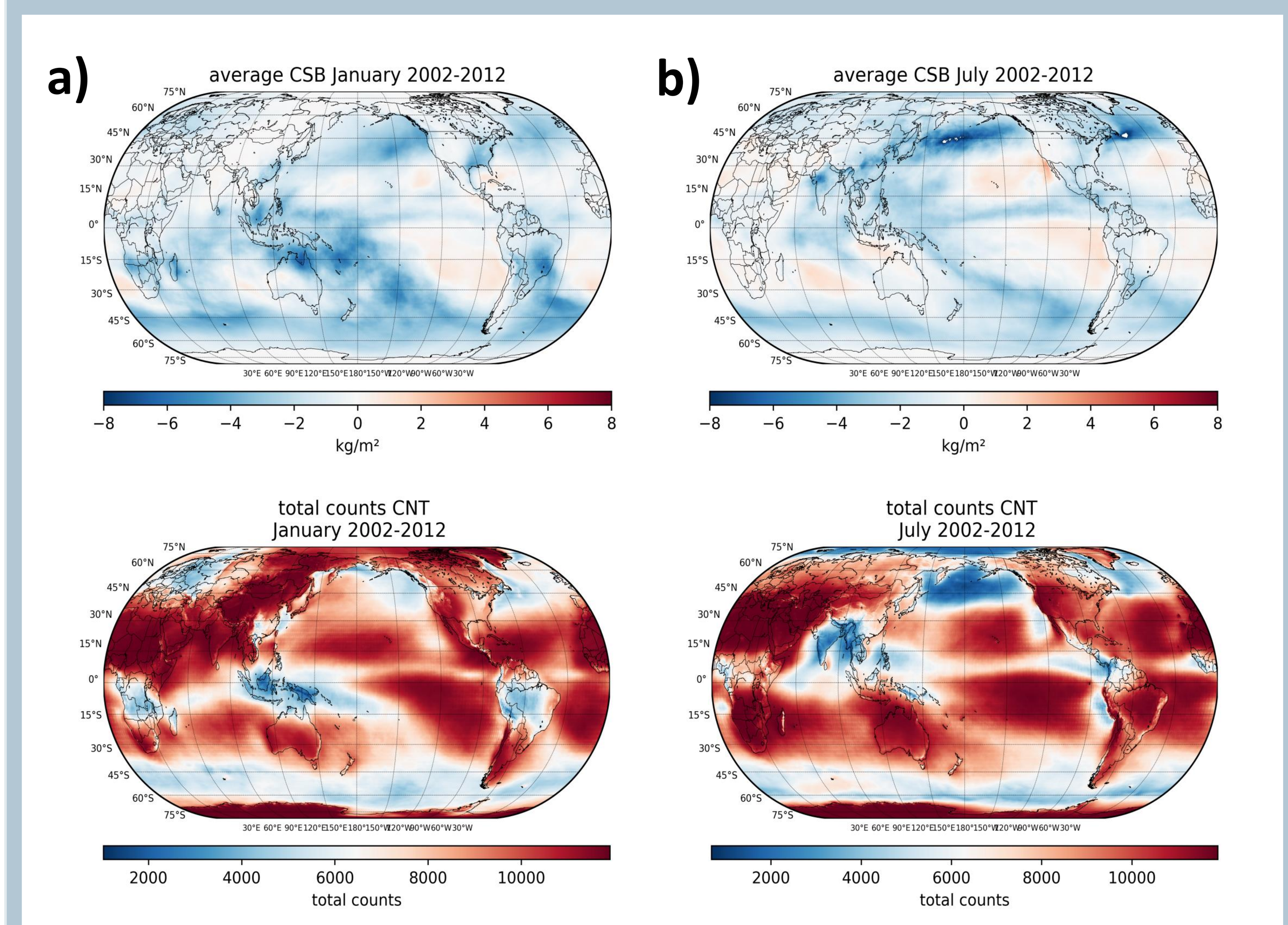


Figure 1: CSB and total number of counts (CNT) per month, calculated over 11 years for the months a) January and b) July, time period 2002 – 2012, on ERA5 data grid (0.25° resolution).

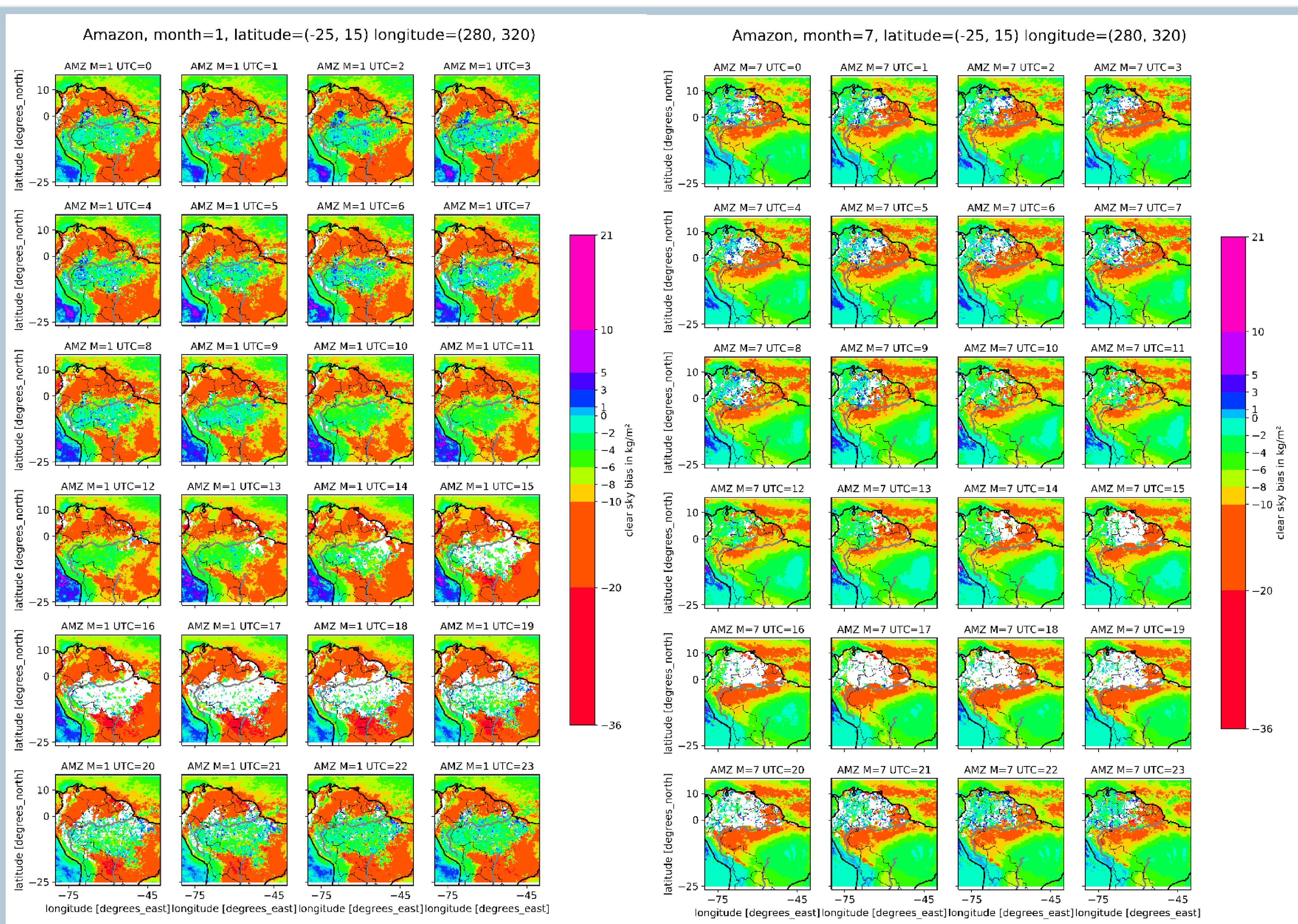


Figure 2: Diurnal cycle of CSB averaged over the time period 2002 – 2012, example for the South American Amazon region.

Summary

- ❖ Pronounced daily course in specific regions in TCWV and clouds
- ❖ Pronounced diurnal cycle of clouds and persistent cloud cover at specific local times in the tropics
- ❖ Location of ITCZ impacts relation of seasonal to diurnal variability
- ❖ Higher latitudes, e.g., Northern Pacific: seasonality outweighs daily variability

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