climate change initiative

→ WATER VAPOUR

A combined total column water vapour data record from microwave imagers and near-infrared observations: validation and applications results from the ESA WV_cci project

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water vapour cci

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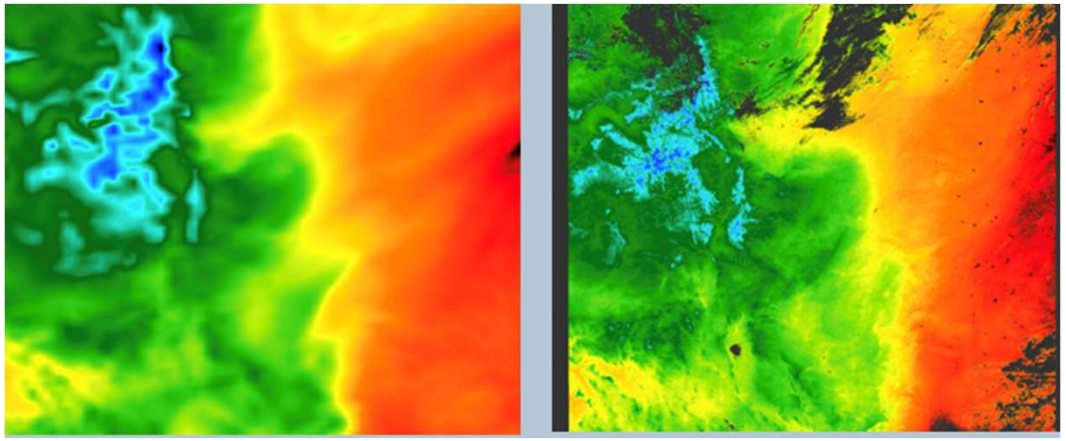
Overview

- Introduction and product overview
- Example results from validation and comparisons
- Example results from applications:
  Evaluation of CMIP6 models
  Variability and trends
- Conclusions



Courtesy Rene Preusker & Jürgen Fischer,
see also Carbajal Henken et al. (2015, GRL)

Introduction and product overview

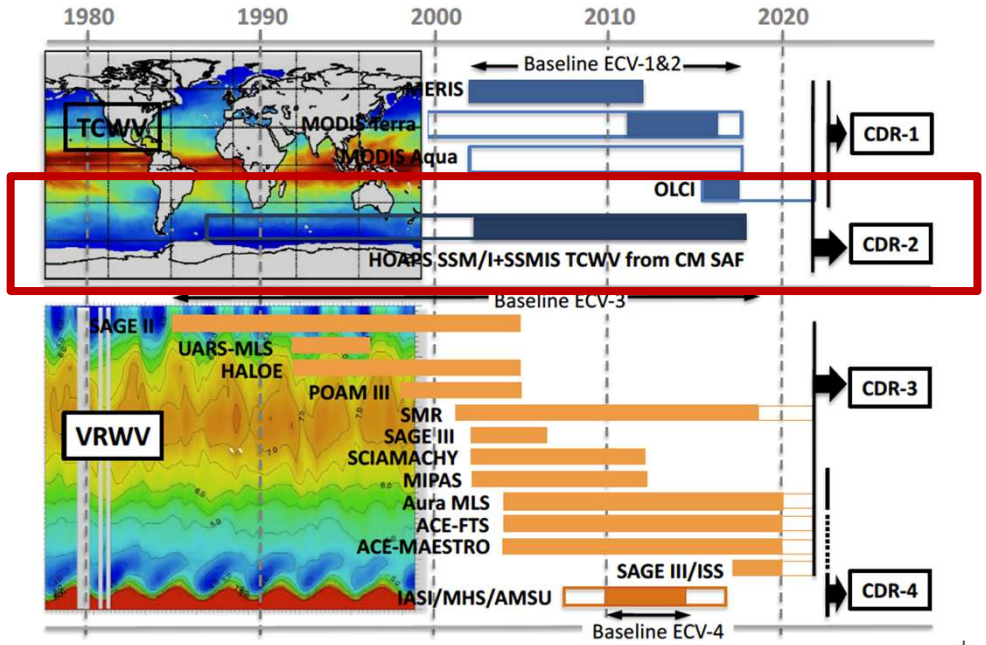
Water Vapour cci - introduction

Atmospheric water vapour (H_2O) is a key component of the Earth's hydrological cycle, critical in shaping the global environment and supporting life on Earth as we know it. It is also key in constraining the Earth's energy balance.

Total Column Water Vapour (TCWV) from microwave (ocean) and near infrared imagers (land, sea-ice, coasts), in close cooperation with EUMETSAT CM SAF.
The spatial complementarity is utilized to combine both into a global TCWV water vapour product by reserving the individual characteristics and advantages.

NIR: high resolution (~300 m), mostly single satellite, channels around 900 nm

MW: fairly low resolution (~40 km or better), various satellites, also in a low Earth orbit, channels around 22 GHz



Product overview

Technical specifications

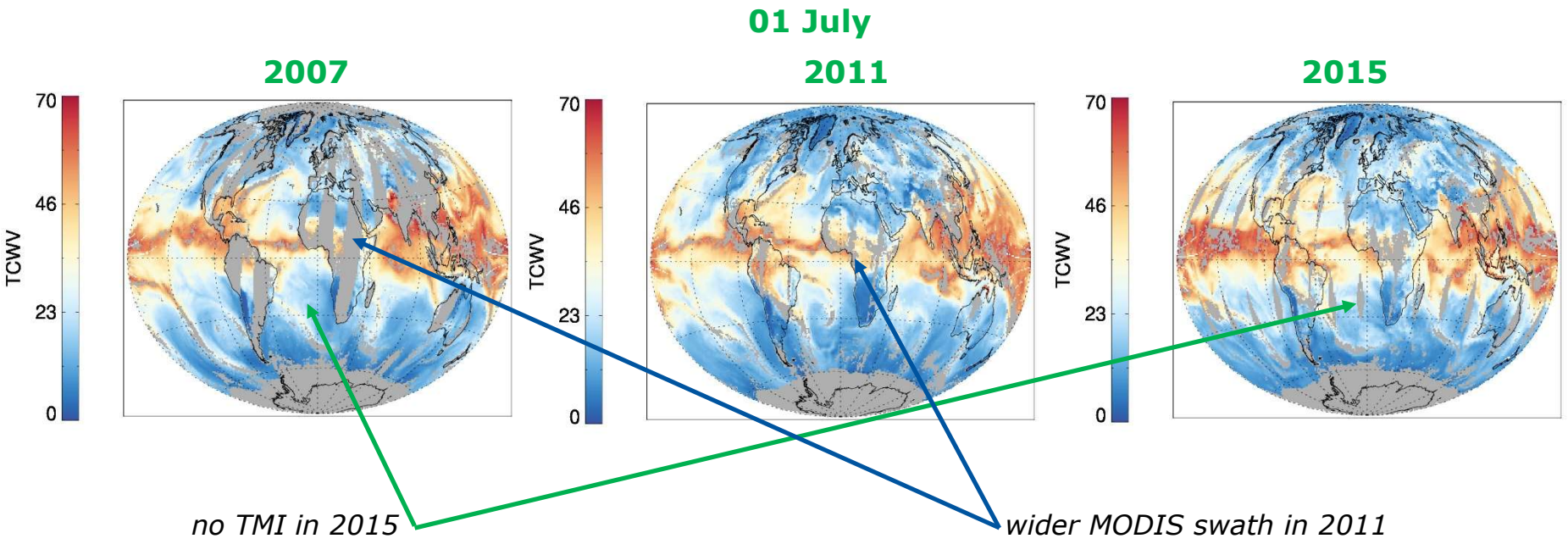
Dimension	Specification
Temporal resolution	Daily averages and monthly averages
Temporal coverage	July 2002 – December 2017
Spatial coverage	Global
Spatial resolution	0.5 or 0.05 degrees

Information layers:

- TCWV
- Standard deviation, mean retrieval uncertainty and its squared counterpart
- Quality flag based on cost function from retrievals
- Surface type flag, flags for cloud and heavy precipitation
- Number of observations, days and hours

SSM/I microwave observations hardly exceeds a spatial resolution of ~0.5 deg. Thus, the product over ocean is oversampled to 0.05 deg while the product over land is averaged

Example figures



Note the differences in sampling over time caused by changes in the observing system.

Validation

Data records for comparison and methods

Data records:

- Merged Microwave by REMSS (MW), ERA5, AIRS (including AMSU) version 6 (AIRS), the predecessor version to the WV_cci TCWV CDR-2 by C3S (C3S), GOME Evolution Climate (GOME) and IMS for the spatial assessment of biases and cRMSD.
- ERA5, AIRS, C3S, SuomiNet and GRUAN for global land surfaces.
- MMW, AIRS, ERA5, C3S for global ice-free ocean,
- AIRS, ERA5, C3S, GOME and IMS for global surfaces.

Methods:

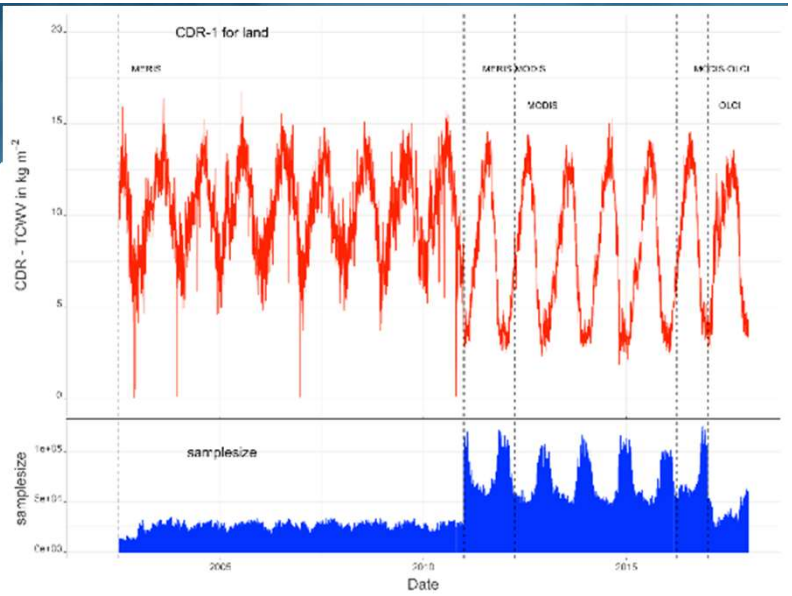
- Bias, RMSD, homogeneity, stability, correlation, trend estimation
- Spatial maps, time series, histograms
- Uncertainty validation/verification, compliance with requirements, physical consistency with surface temperature

Full results in PVIR (https://climate.esa.int/en/projects/water-vapour/), overview paper underway.

Specific comments

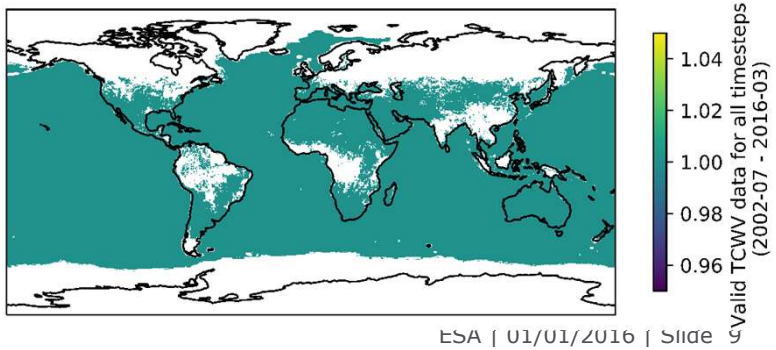
Clear-sky bias: clear-sky is (mostly) systematically drier than all-sky observations.

A potential bias caused by the non-sampling under presence of strong precipitation is considered to be small.



For climate change analysis we recommend:

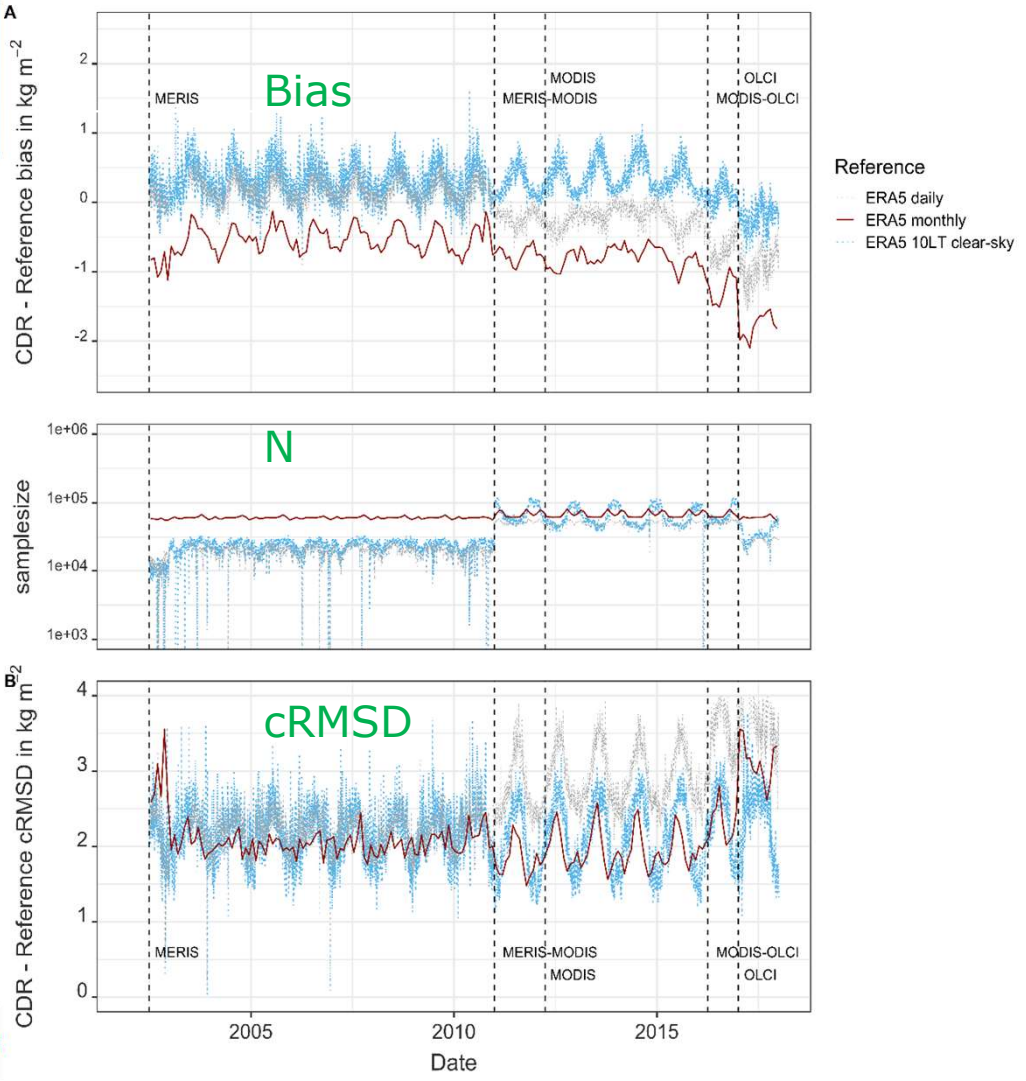
- to apply a conservative climatological cloud mask.



Time series (global land surfaces)

The seeming change in bias in 2011 vanishes when clear-sky data is considered (however, not in 2016)!

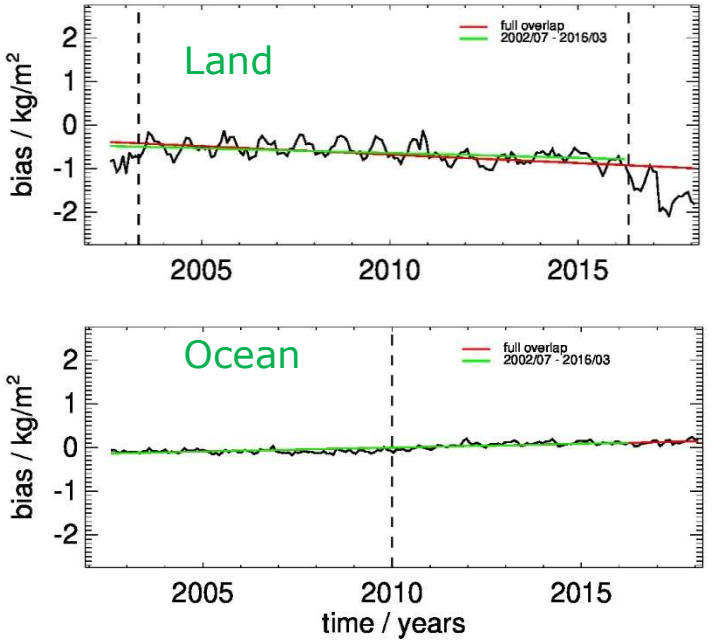
This is likely not caused by changes in number of valid observations and sampling of the spatial structure of the bias but caused by changes in sampling the clear-sky bias through differences in cloud masks.



Homogeneity and stability

- Stability (red, green, kg/m2/decade): change in bias over time (linear regression)
- Homogeneity (dashed): break points in time series of the bias (as in Wang, 2008, also applied in GEWEX Water Vapor Assessment, e.g., Schröder et al., 2019)
- Bias (solid): versus M. Microwave (ocean) and ERA5 (land), subset of results

surface type	dataset	Stability (full overlap period)	Stability (recommended period)
Land	AIRS	-0.39±0.09	-0.35±0.09
Land	ERA5	-0.39±0.09	-0.22±0.09
Ice-free Ocean	Merged Microwave	0.18±0.04	0.02±0.05
Global	AIRS	0.08±0.06	0.09±0.08
Global	ERA5	0.09±0.05	0.13±0.05
Land	ERA5 clear-sky	-0.11±0.02	0.02±0.02



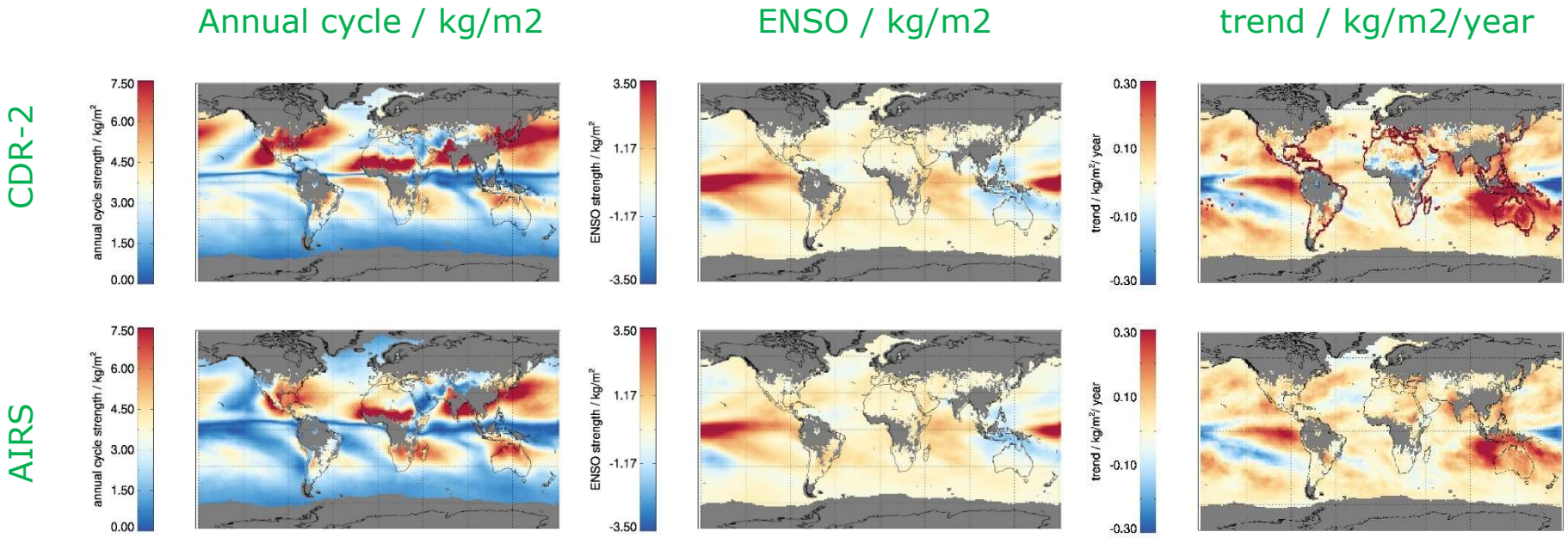
Application examples

Applications using TCWV

- Analysis of atmospheric rivers using TCWV and ERA5 data (U. Vigo, Eiras-Barca et al., 2022, submitted to QJRMS)
- Evaluation of the tropical water vapor of CMIP6 GCMs with TCWV data from WV_cci data (UVSQ, He et al., 2022, ACPD, see next slides)
- Joint analysis of cloud data and TCWV in CMIP6 evaluation context (DLR, CMUG, Lauer et al., 2022, submitted to JClim)
- Evaluation of CMIP6 using TCWV (U. Bremen, CMUG, see next talk)
- Analysis of variability, trends and compliance with theoretical expectation (DWD, see next slides)
- …

Trends and variability

Method as in Schröder et al. (2016, 2019), JAOT, Rem Sens



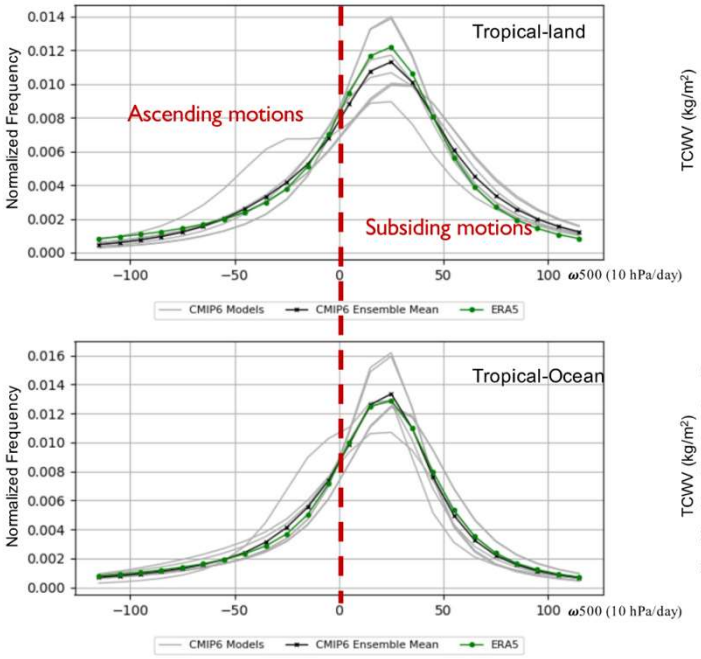
Evaluation of CMIP6 models

-- TCWV with respect to ω500 in the Tropical Area (30S ~ 30N)

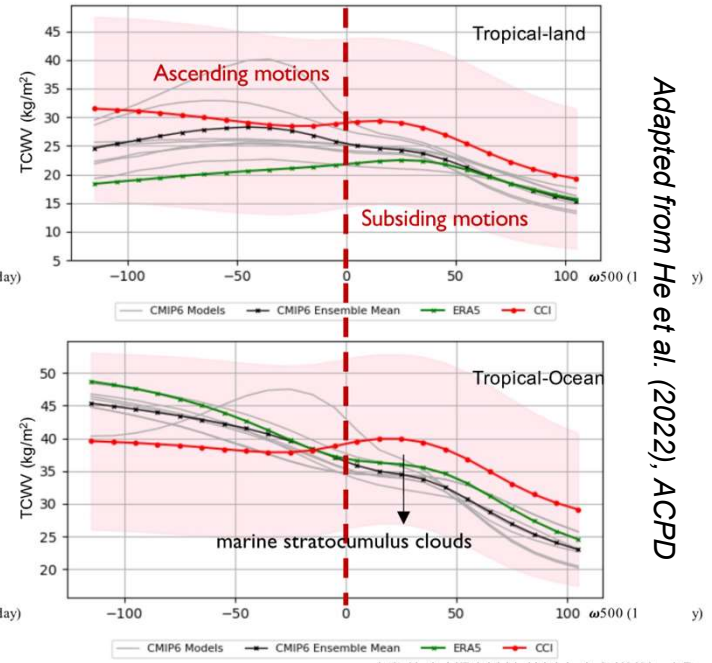
- **ω500 is employed as the proxy of the large-scale circulation;**
- Convective motion to moist troposphere;
- Subsiding motion to dry troposphere;

❖ Clear-sky observation over land and all-weather (except heavy precipitation) for all data records are employed for analysis.

Normalized frequency of ω500 (hPa/day)



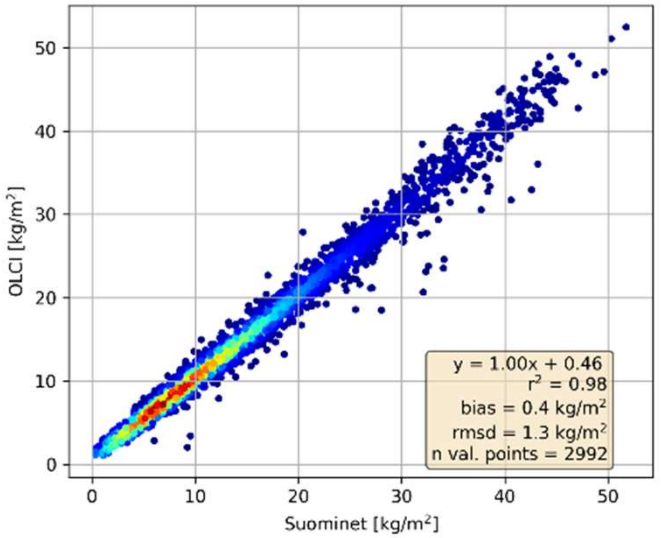
TCWV (kg/m^2) according to ω500



Adapted from He et al. (2022), ACPD

Conclusions

- CDR-1 and CDR-2 are mostly within product and user target requirements.
- Careful use over inland water bodies, coasts and sea-ice.
- For climate analysis use clear-sky data only until March 2016 and apply common cloud mask.
- Break between MODIS and OLCI is only partly affected by clear-sky bias.
- Small break in TCWV over ocean but not impacting stability significantly.



- The product will be released via **EUMETSAT CM SAF** (Satellite Application Facility on Climate Monitoring, https://wui.cmsaf.eu/)

Thank you very much for your attention!

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