climate change initiative

→ WATER VAPOUR

ESA CCI Water Vapour (WV_cci)

Phase 1 Overview

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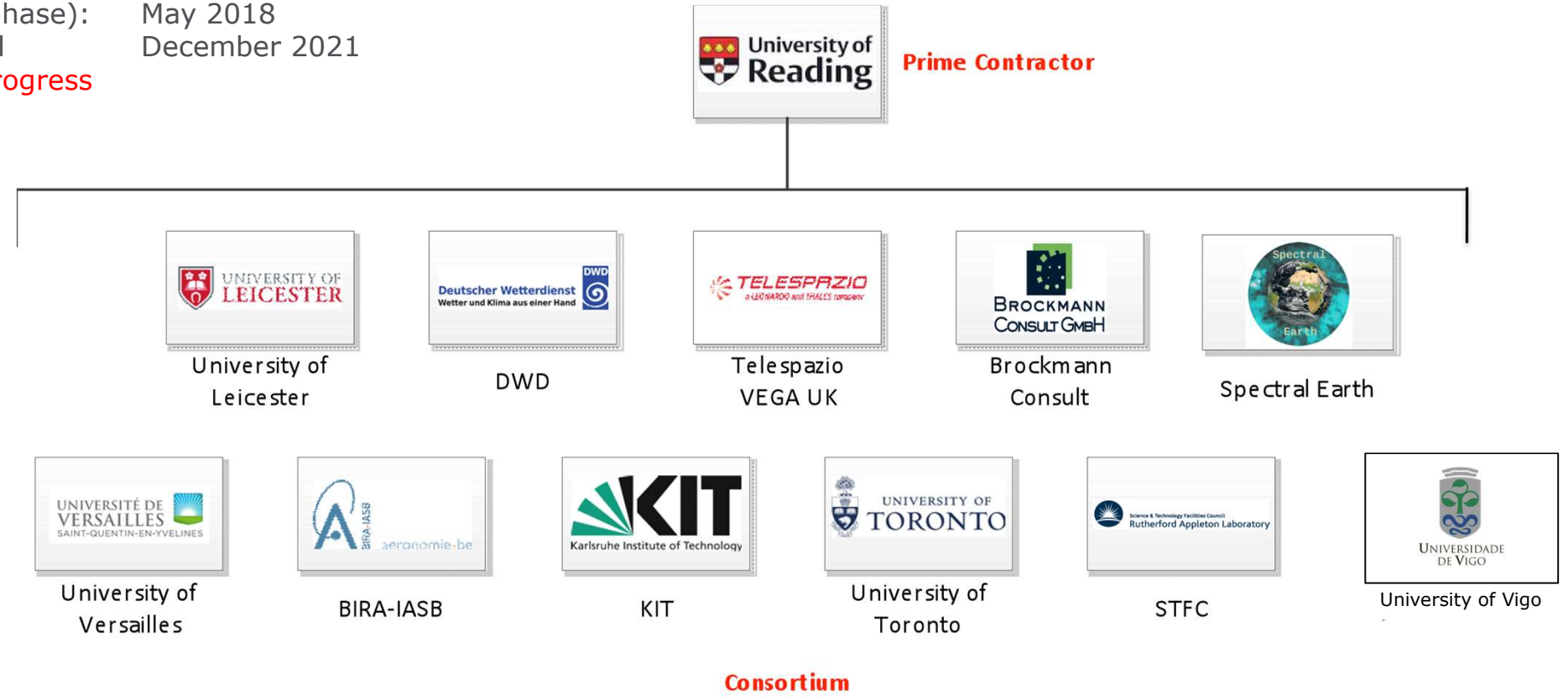
Marc Schröder *(Deutscher Wetterdienst)*
on behalf of the entire WV_cci science consortium

water vapour cci

WV_cci project partners / team

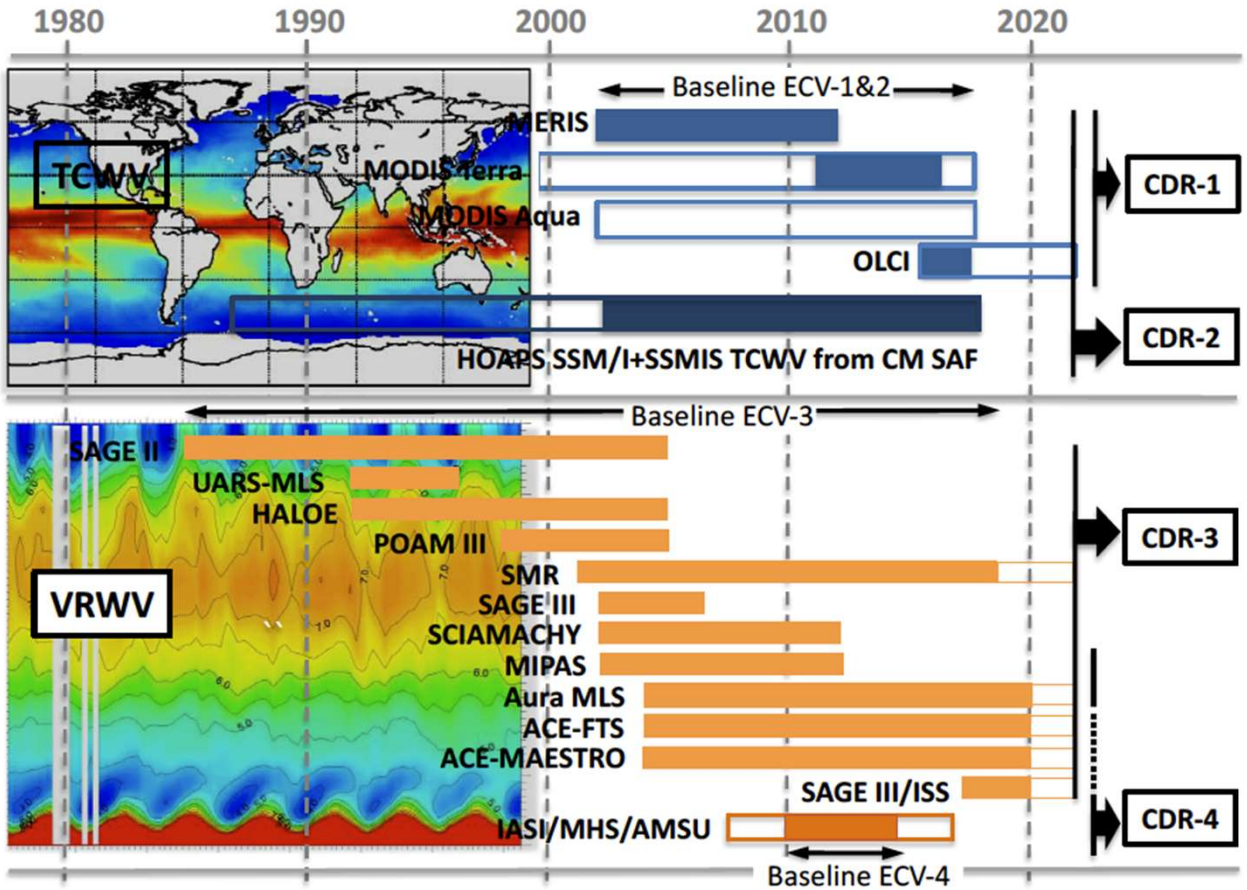
KO (first phase): May 2018
CCN2 until December 2021
Work in progress



WV_cci remit

Total Column Products from microwave and near infrared imagers, in close cooperation with EUMETSAT CM SAF.

Vertically Resolved (Profile) Products for the stratosphere (2D) from 12 limb sounder instruments, and upper troposphere/lower stratosphere (3D) from a combined Aura-MLS/MIPAS/IMS product.



SCIENCE HIGHLIGHTs

- **4 datasets finalised and partially published:**
  - CDR-1: CCI TCWV-land* **2002-2017**
  - CDR-2: CCI/CM SAF TCWV-global (COMBI)* **2002-2017**
  - CDR-3: CCI WV-strato **1985-2019**
  - CDR-4: CCI WV-UTLS (prototype version) **2010-2014**
- **5 published papers, 1 paper submitted, 2 papers in preparation**
- **22 oral presentations at international conferences and workshops**
- **8 poster presentations at international conferences and workshops**

*Note that CDR-1 and CDR-2 are available on request from the project. CDR-2 will be released by CM SAF.

General project achievements

- 10 Progress Meetings & 3 Annual Review Meetings
- Participation 3 Colocation (2019/2020/2021) & 3 CMUG meetings (2018/2019/2021)
- WV_cci webpage design & continuous updates
- Input to CSWG, DEWG, CMUG & other CCI activities
- **Review of IPCC AR6 chapters**
- **Support to add TCWV CDR into ESMValTool**
- **Contribution to the public consultation on GCOS requirements**
- **Video interview on atmospheric composition for COP.**

Specific project achievements

- **Established and updated water vapour user requirements**

  → WV_cci User Survey (2018) & User Workshop (2021)
- New algorithm development for both retrievals and merging
- Design of production system and production of four WV CDRs.
- Extended validation of input and merged CDRs with multiple reference datasets (CCMs, GCMs & NWP models, and observations)
- First attempt to uncertainty characterisation
- Finalised four user case studies.
- Produced comprehensive documentation / WV_cci deliverables:
  - PSD, DARD, PVP, PVASR, SSD, SVR, SRD, CRDP, PUG, PVIR part 1
  - updates in progress: CAR, PVIR, ATBD, ADP, E3UB, publications
  - Meeting minutes, MPRs, and QPRs

Validation

PVIR Part I (TCWV): currently under review

PVIR Part II (vertically resolved data): currently prepared (not yet submitted)

Results below are just a snapshot and not complete, neither in terms of references/comparisons nor in terms of metric.

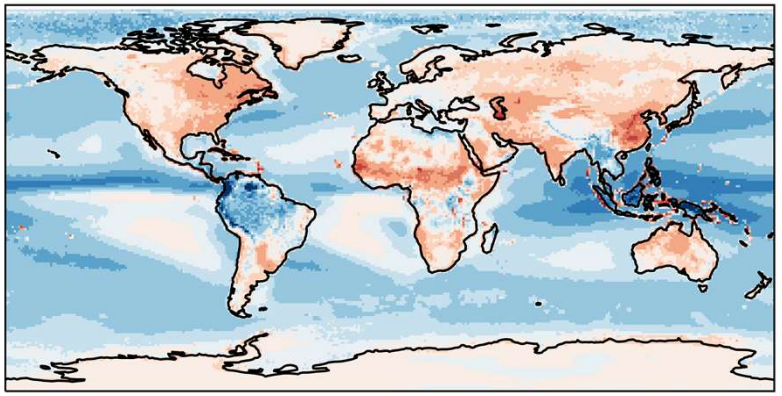
TCWV - validation

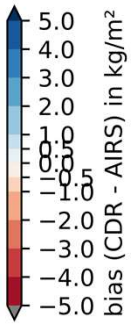
Also available for four more data records (PVIR currently under review)

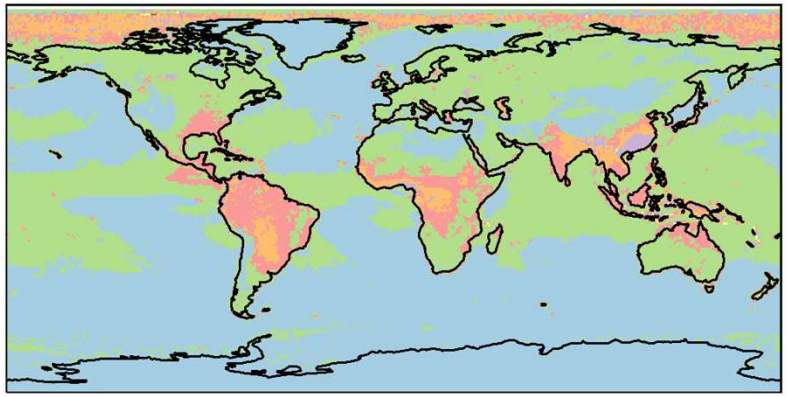
Bias

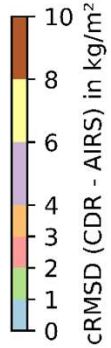
cRMSD

ERA5

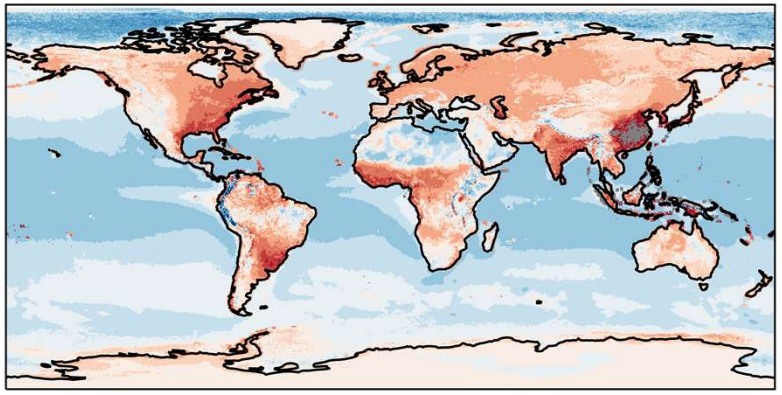


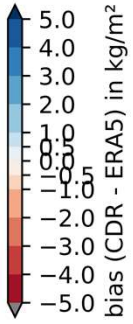


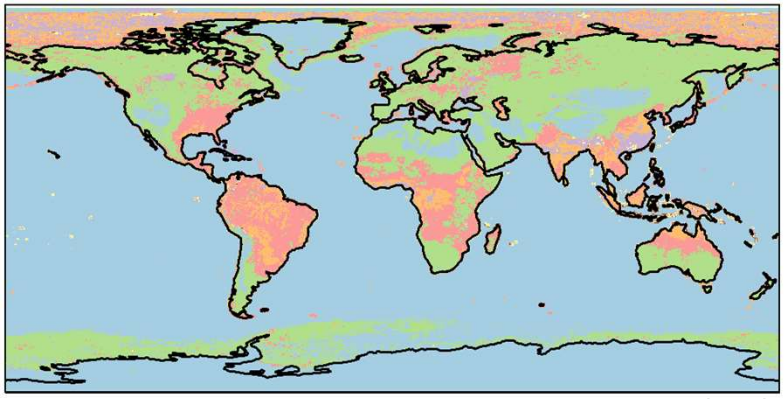


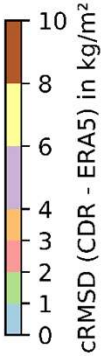


AIRS





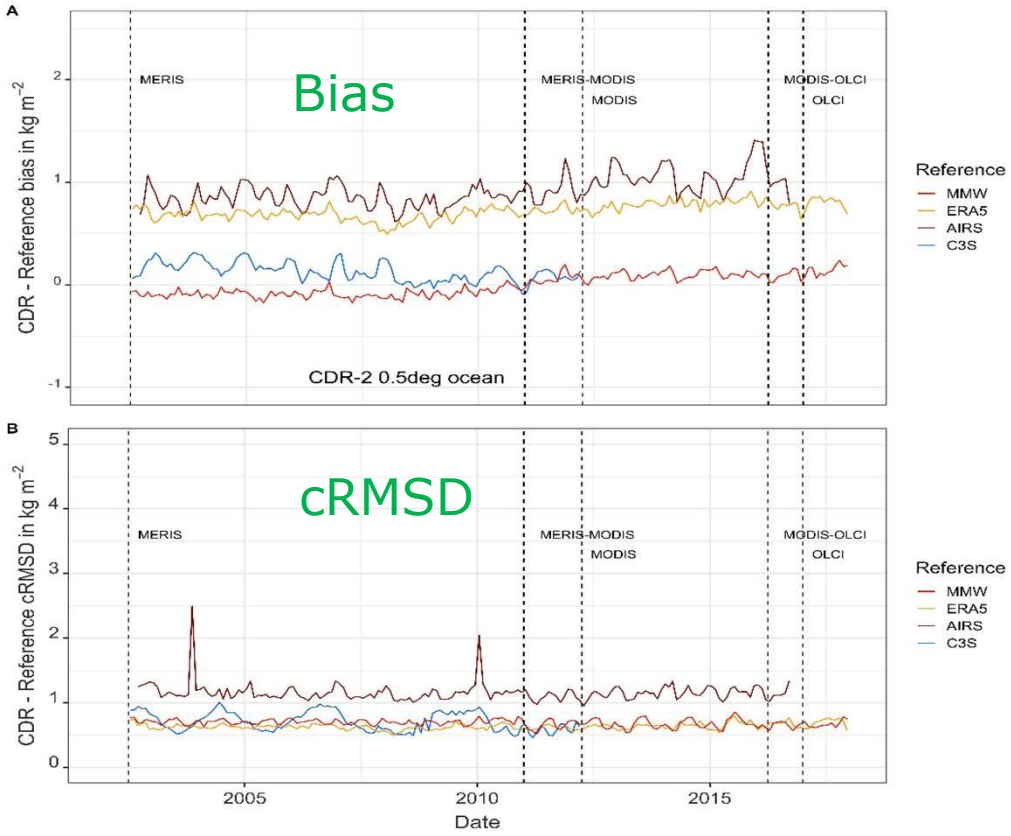




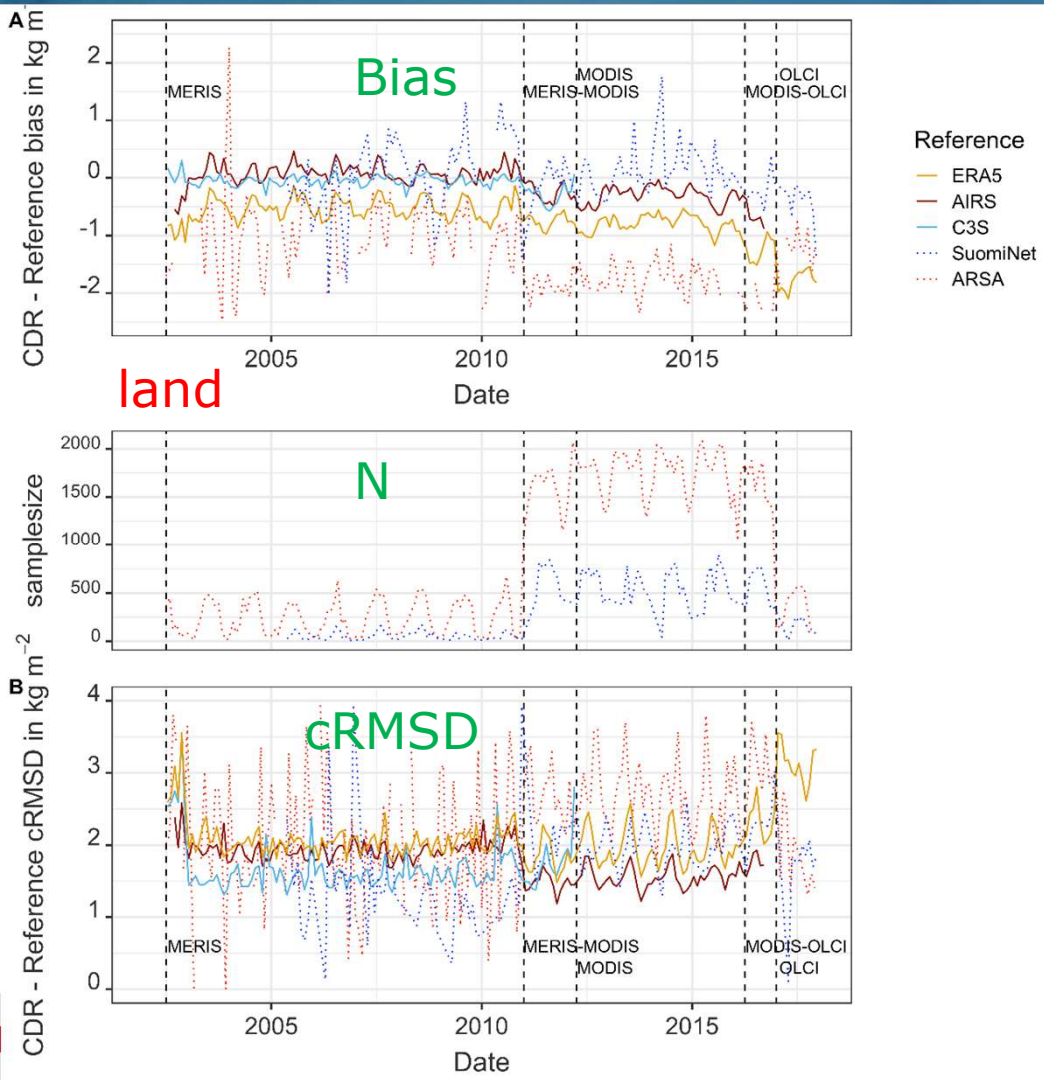
TCWV - validation

Time series of bias and cRMSD over ocean (REMSS, ERA5, AIRS, C3S) and land (ERA5, AIRS, C3S, ARSA, SuomiNet).

ocean



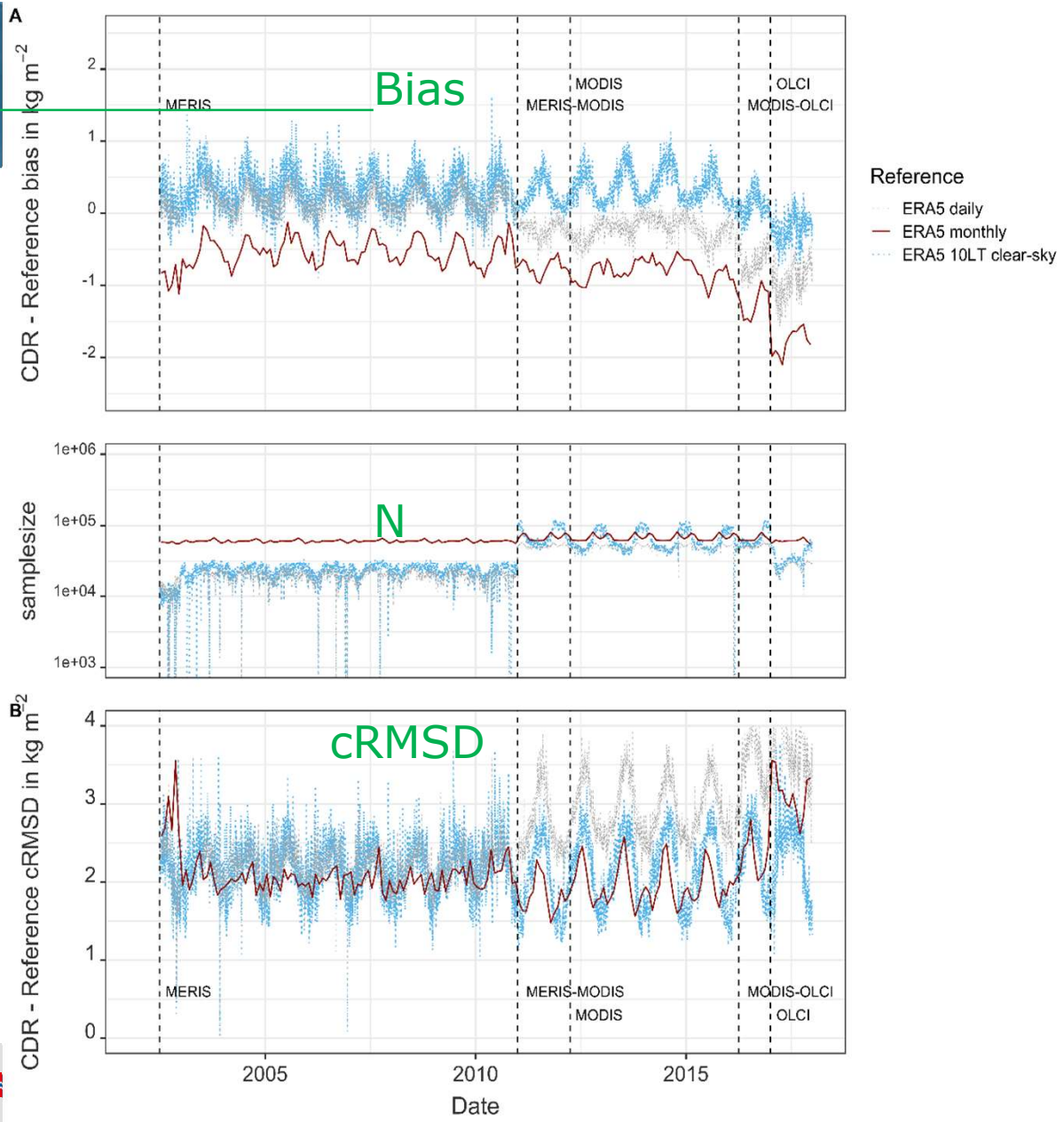
land



Time series (global land surfaces)

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

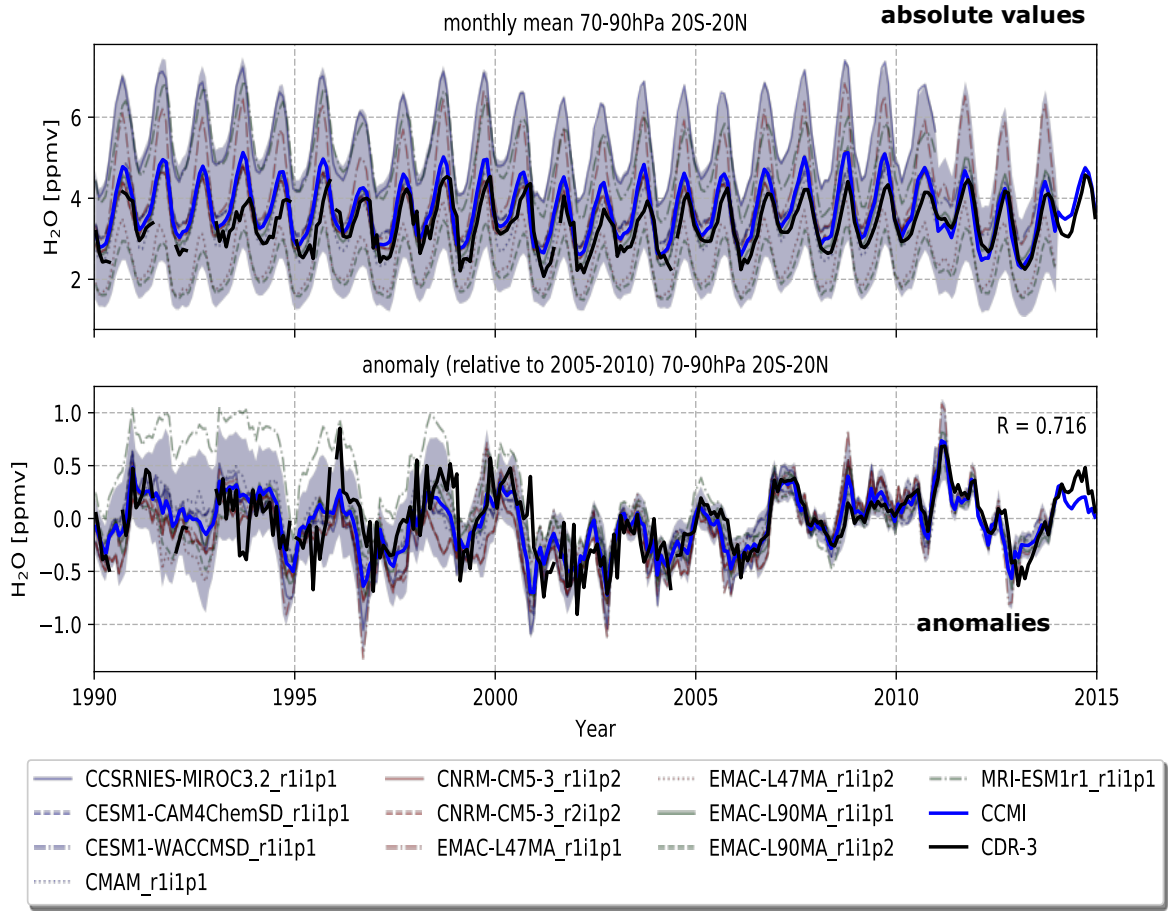
We think that this is not caused by changes in number of valid observations and sampling of the spatial structure of the bias but caused by changes in sampling the clear-sky bias through differences in cloud masks.



Water Vapour cci – stratospheric profiles

Stratospheric VRWV – CDR-3

Comparison of CDR-3 with chemistry-climate model simulations nudged to observed meteorology shows very good agreement, especially when **ESA ENVISAT** satellite instruments (2004-2012) are available.



CDR-3 in black

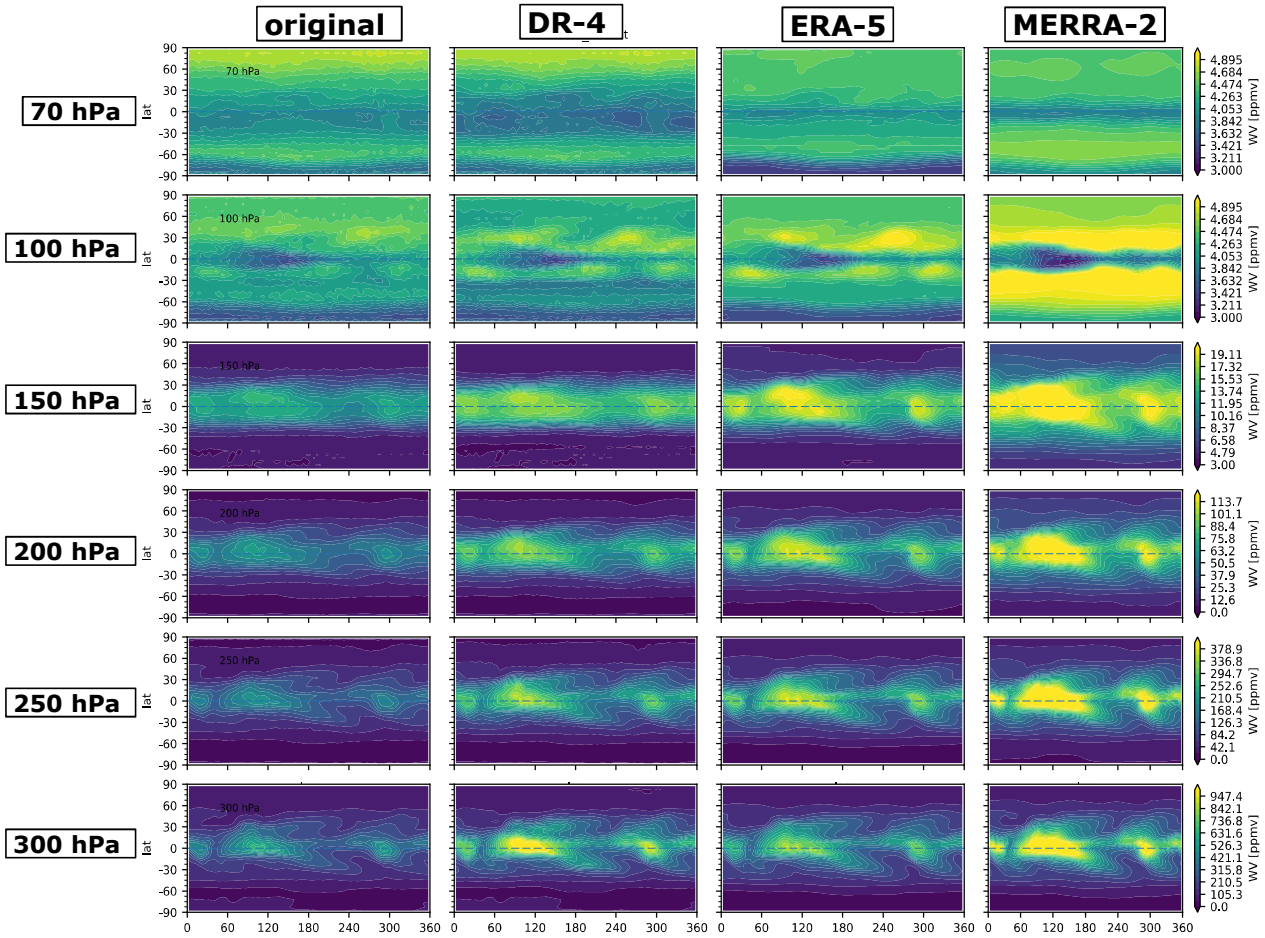
Hegglin et al, *in preparation*

Water Vapour cci – profiles in UTLS

UTLS VRWV – CDR-4

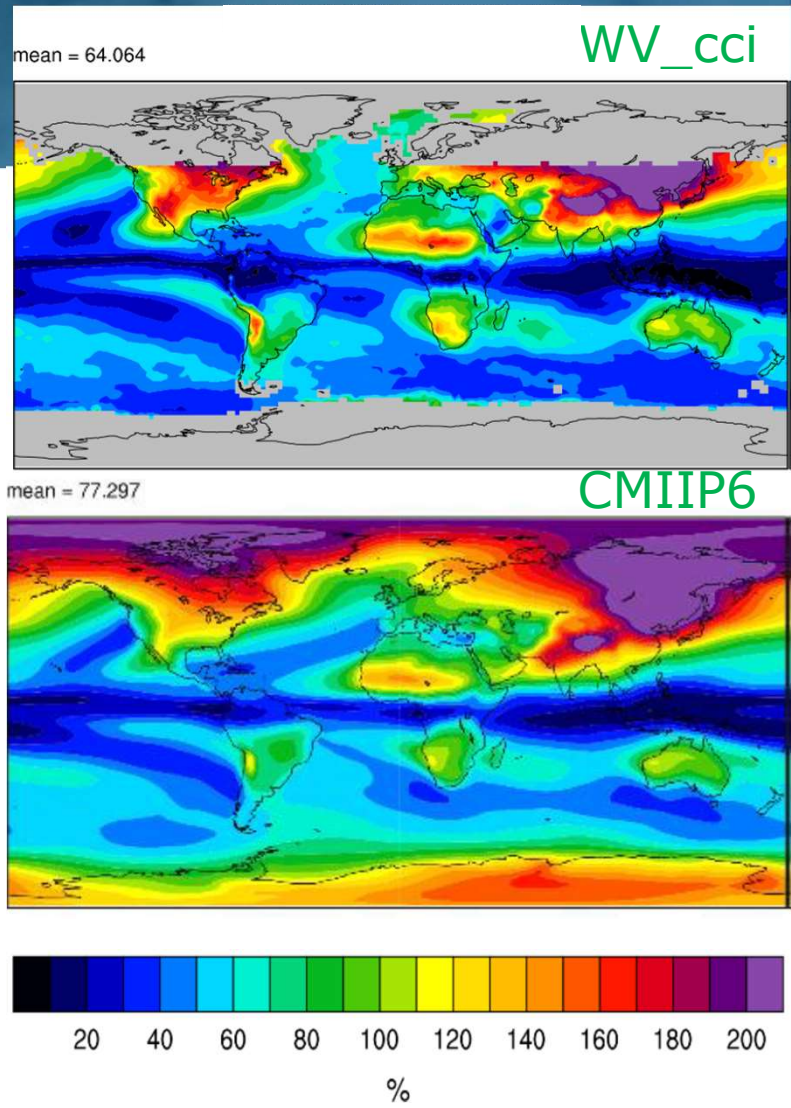
Comparison of CDR-4 (prototype version) with reanalyses from ECMWF and NASA exhibit the large uncertainties in our knowledge of water vapour in the upper troposphere/lower stratosphere region.

Ye et al, *in preparation*

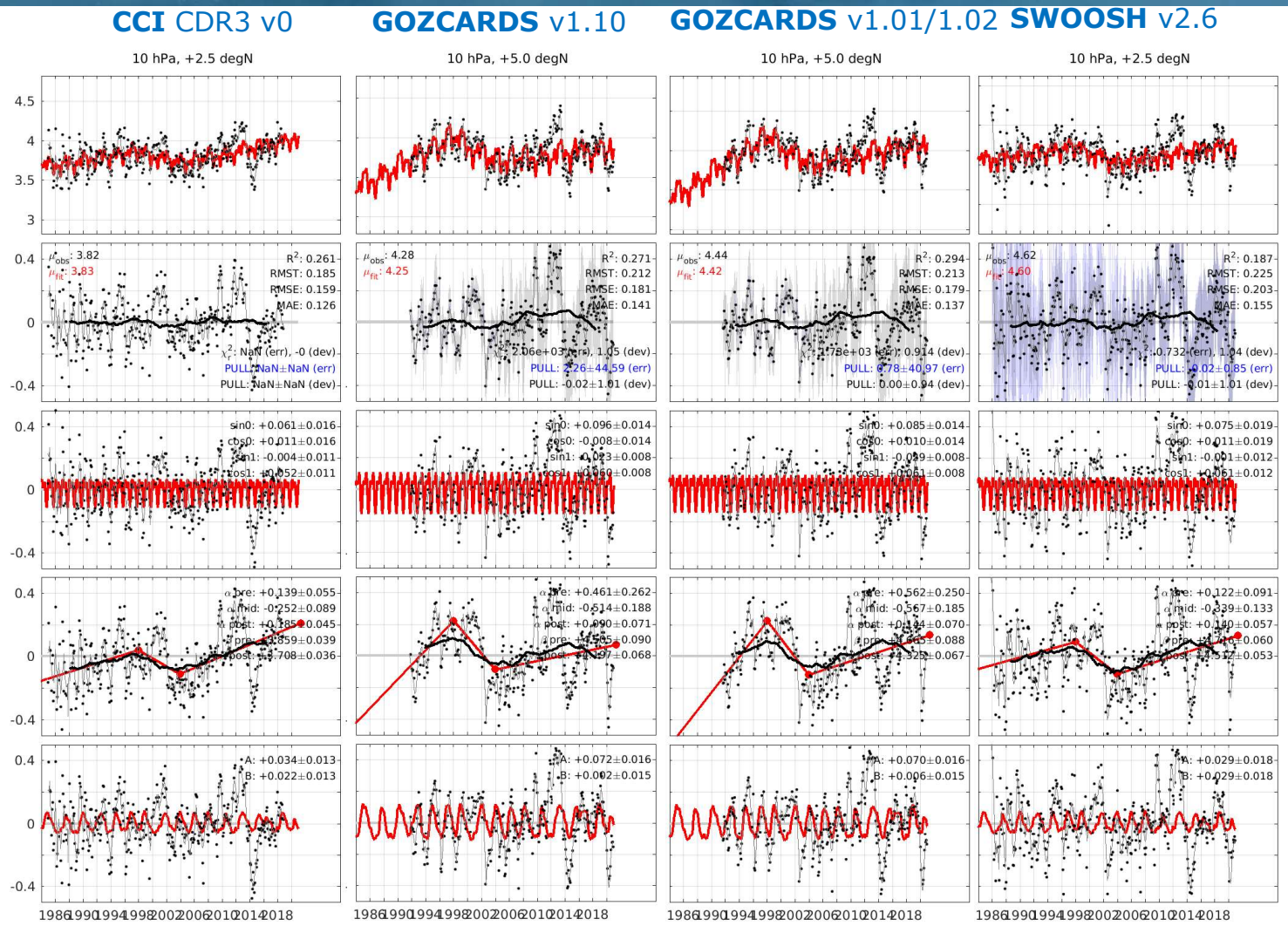


Use case studies - applications

- Analysis of atmospheric rivers using WV_cci and ERA5 data (U. Vigo)
- Analysis of variability and trends in vertically resolved WV_cci data (BIRA)*
- Evaluation of the tropical water vapor of CMIP6 GCMs with TCWV data from WV_cci data (UVSQ)*
- Analysis of variability, trends and compliance with theoretical expectation (DWD)
- Utilisation within CMUG by A. Lauer (DLR)
  - Implementation in ESMValTool v2.3
  - Example results on right – relative mean seasonal amplitude (preliminary!)
- Data not officially released yet. Nonetheless, scientists already expressed interest.



Use case – trends and variability in stratosphere
(BIRA – D. Hubert, J.-C. Lambert)



Good agreement for all CDRs, except:

- Significant difference in multi-annual mean
- Disagreement in 1998-2003 period (depends on Aura MLS version & data sets included)

CCI includes more sensors → more information compared to other CDRs

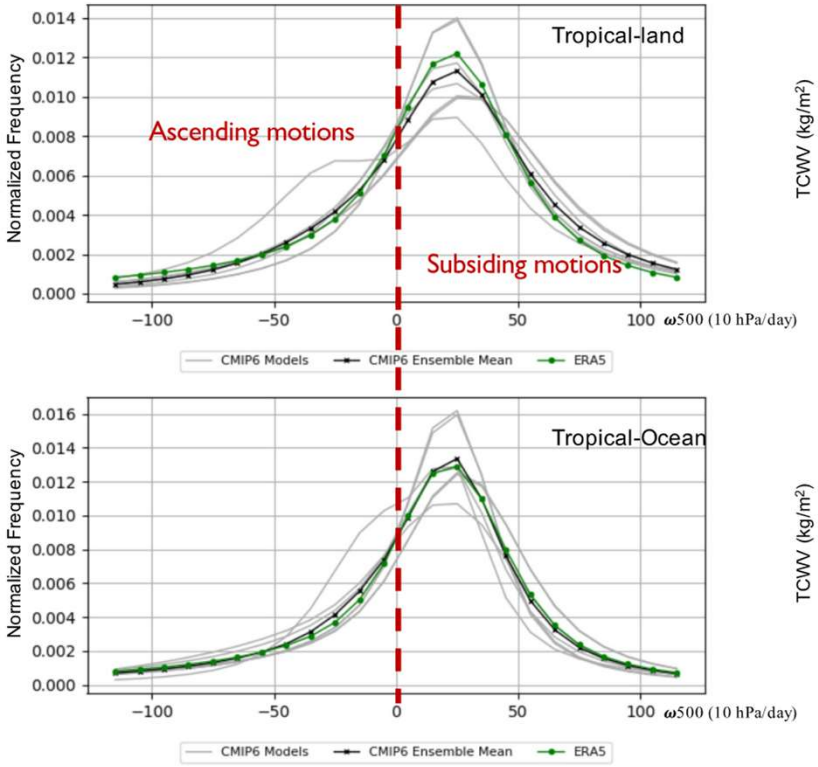
Use case – Evaluation of CMIP6 models (UVSQ – J. He, H. Brogniez)

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

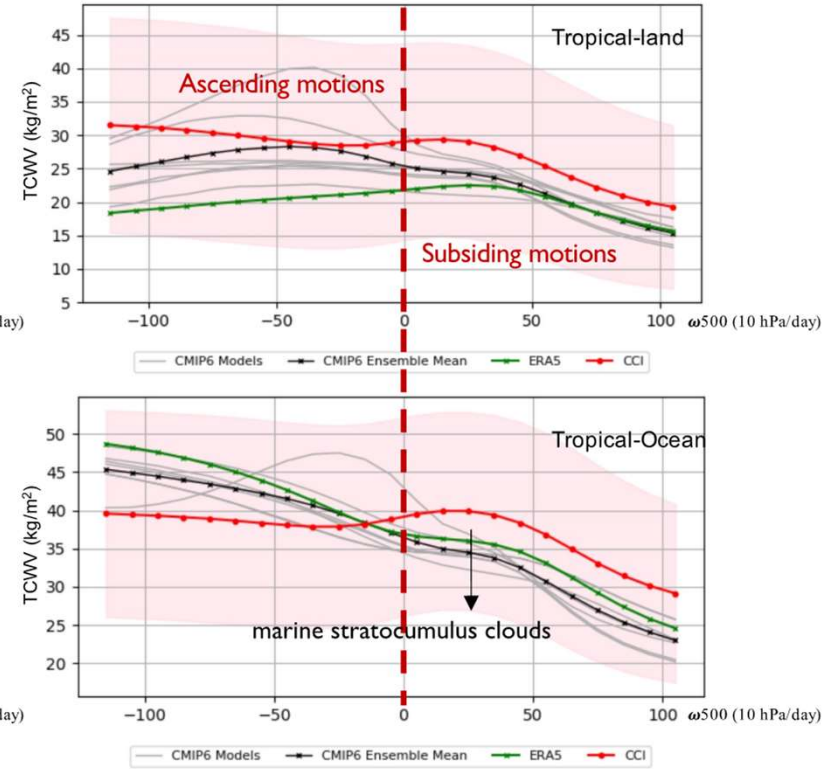
- **ω500 is employed as the proxy of the large-scale circulation;**
- Convective motion to moist troposphere;
- Subsiding motion to dry troposphere;

❖ 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/m²) according to ω500



WAY FORWARD

- Finalising deliverables for phase 1.
- And writing proposal for CCI+ phase 2.
- Key components of proposed work:
  - Further development of CDR merging algorithms.
  - Extension of input data forward and backward.
  - Addition of high-resolution TCWV product.
  - Further refinement of uncertainty budgets.
  - Inclusion of additional reference datasets for validation (GPS RO and aircraft).
  - Design of new exciting user case studies.
- ...

List of WV_cci publications

WV_cci project publications

- **Preusker et al.,** Retrieval of daytime total column water vapour from OLCI measurements over land surfaces; Remote Sensing, 13, 932, https://doi.org/10.3390/rs13050932, 2021.
- **Eiras-Barca et al.,** Analysis of the main sources associated with moisture transport events with the new ESA CCI CDR v2 Water Vapour Initiative Data, submitted.
- **He et al.,** CMIP6 analysis, to be submitted (coming soon)
- **Trent et al.,** Overview and evaluation of RAL IMS tropospheric water vapour and temperature profiles from IASI, GMD, to be submitted (coming November)

WV_cci related papers:

- **Hegglin, M. I., et al.,** Overview and update of the SPARC Data Initiative: comparison of stratospheric composition measurements from satellite limb sounders, Earth Syst. Sci. Data, 13, 1855–1903, https://doi.org/10.5194/essd-13-1855-2021, 2021.
- **Fadnavis et al.,** A rising trend of double tropopauses over South Asia in a warming environment: Implications for moistening of the lower stratosphere. *Int. J. Climatol*., 1–16, DOI: 10.1002/joc.6677, 2020.
- **Popp et al.,** Consistency of satellite climate data records for Earth system monitoring. *Bull. Amer. Meteor. Soc.,* doi: https://doi.org/10.1175/BAMS-D-19-0127.1, 2020.
- **Dorigo et al.,** Consistent monitoring of global water cycle variability across scales: Where do we stand?, BAMS, https://doi.org/10.1175/BAMSD-19-0316.1, 2021.

List of WV_cci presentations

- IPCC/CMIP6 TriMIPathlon, Reading (2018; Hegglin, oral)
- SPARC GA, Kyoto (2018; Hegglin, poster)
- FORUM, Florence (2018; Hegglin, oral)
- CMUG integration, Exeter (2018; Schröder/Hegglin, oral) and Barcelona (2019; Popp/Hegglin, oral)
- OCTAV-UTLS, Mainz (2018; Hegglin, oral)
- ESA-ATMOS, Salzburg (2018; Popp/Hegglin, oral)
- Colocation, Exeter (2019; Popp/Hegglin, oral) and webinar (2020; Hegglin/Schröder et al; poster)
- S3VT, Frascati (2019; Falk, poster)
- LPS, Milan (2019; Falk, poster)
- 10th Atmospheric Limb WS, Greifswald (2019; Walker, oral)
- 8th GVAP meeting, Madrid (2019; Schröder, oral)
- AI for the water cycle, webinar (2019; Hegglin, oral)
- AGU Fall Meeting, webinar (2019; Falk, two posters)
- ESA GEWEX EO for water cycle science, webinar (2020; Hegglin, Schröder, Falk, three oral presentations)
- Sentinel-3 validation team meeting, webinar (2020; Falk, oral)
- CCI Mid-Term Review meeting, webinar (2020; poster and contribution to atmosphere oral presentation)
- AGU Fall Meeting, webinar (2020; Ye, poster)
- 43rd COSPAR Scientific Assembly, webinar (2020; Walker, oral)
- WV_cci user workshop, webinar (Hegglin, Ye, Schröder, Falk, Eiras-Barca, He, 7 presentations)