climate change initiative

→ WATER VAPOUR

UTLS profiles from WV_cci (CDR-4):
Introduction to data records and validation

Hao Ye, Michaela Hegglin
University of Reading, UK

water vapour cci

With contributions from Brian Kerridge, Richard Siddans, Kaley Walker, Christopher Sioris, Martina Krämer, Christian Rolf, Alexandra Lang, Gabriele Stiller, Luis Millan, Gloria Manney, Dale Hurst, and Holger Vömel

ESA UNCLASSIFIED - For Official Use

Motivation

- Water vapour is the most important natural greenhouse gas in the atmosphere and provides a positive feedback to the climate forcing from CO_2, especially the water vapour in the UTLS
- The quality of the long-term UTLS WV records is limited due to the complex dynamical and chemical structure between the troposphere and the stratosphere
- Current reanalysis datasets do not assimilate WV in the UTLS region

Essential to climate research:
A globally harmonised climate WV data record with both tropospheric and stratospheric measurements

ESA WV_cci VRWV-UTLS Dataset

a) Bias-corrected in a non-coincident “climatological” approach

b) Monthly three-dimensional data from 2010-2014

c) Includes UTLS from 100 to 300 hPa

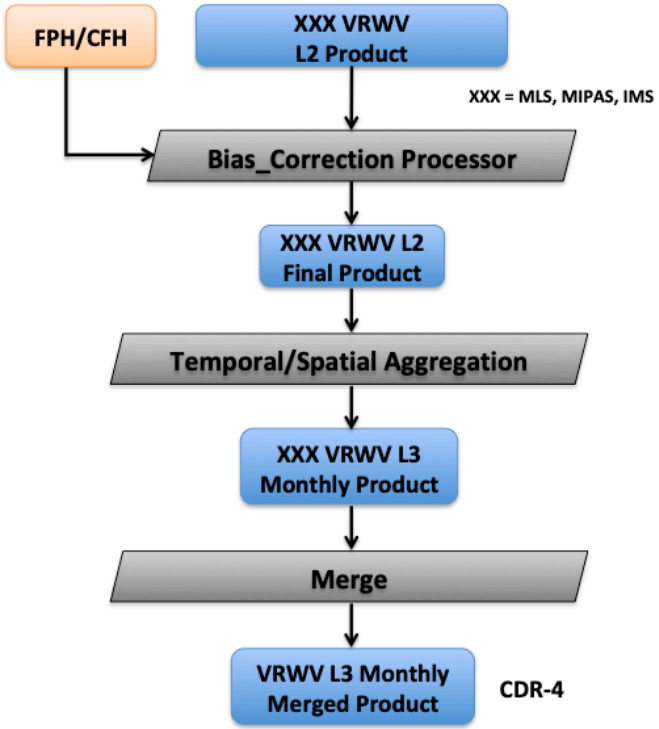
d) Extends from 1000 hPa to 10 hPa on 23 standard pressure levels

e) Global coverage with resolution of 5°× 5° in latitude and longitude

Currently, the data is expected to be publicly released later this year.

Dataset construction

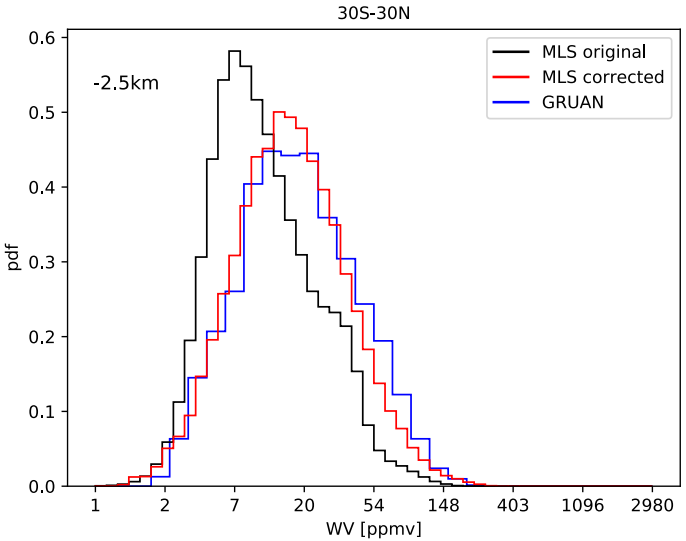
- **Input data (L2 satellite profiles)**
  - Limb-viewing: MLS (2010-2014) & MIPAS (2010-2012/04)
  - Nadir-viewing: RAL IMS (IASI+MHS+AMS, 2010-2014)
- **Reference data**
  - Balloon-borne: FPH & CFH, 2000-2017, 28 sites, 1300+ profiles
- **Bias-correction procedure**
  - In a "climatological" approach
  - Bias is applied to each L2 satellite profile
- **Temporal/Spatial aggregation**
  - All L2 profiles are interpolated to standard pressure levels
  - Average with regular lat/lon grids for each instrument
- **Merging into VRWV_UTLS data**
  - Merge L3 monthly satellite data into a harmonised data record



Processing chain

Bias-correction Procedure

- **A "climatological" distribution** of balloon-borne hygrometer profiles in tropopause coordinates is used as a reference for bias-correction.
    1) 3-monthly FPH/CFH profiles over the full period (2000-2017)
    2) Divide globe into 5 latitude bands (every 30° except for tropics)
    3) 1 km altitude bins in tropopause coordinates
- **Quantile-mapping technique** is used to apply biases to L2 satellite profiles, not a constant offset
- Bias-correction is performed only in UTLS: 300-100 hPa
    1) MLS and MIPAS WV for 100–10 hPa
    2) RAL IMS WV for 1000–300 hPa

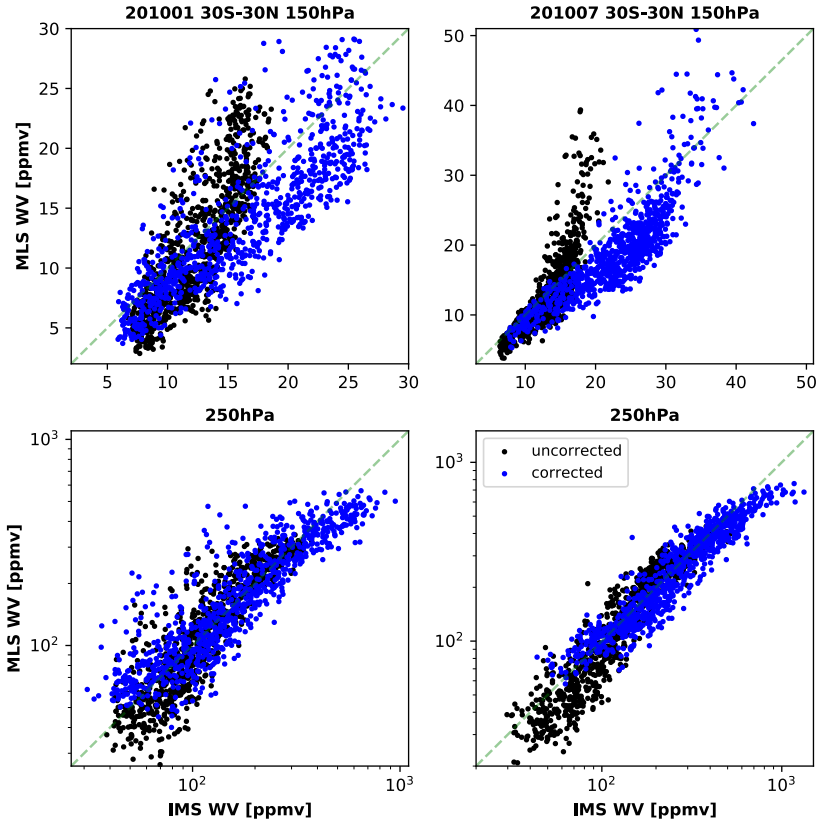


Example: 2-3 km below tropopause
MLS 2010/06
GRUAN May/June/July

Example of bias-correction

150 hPa

250 hPa

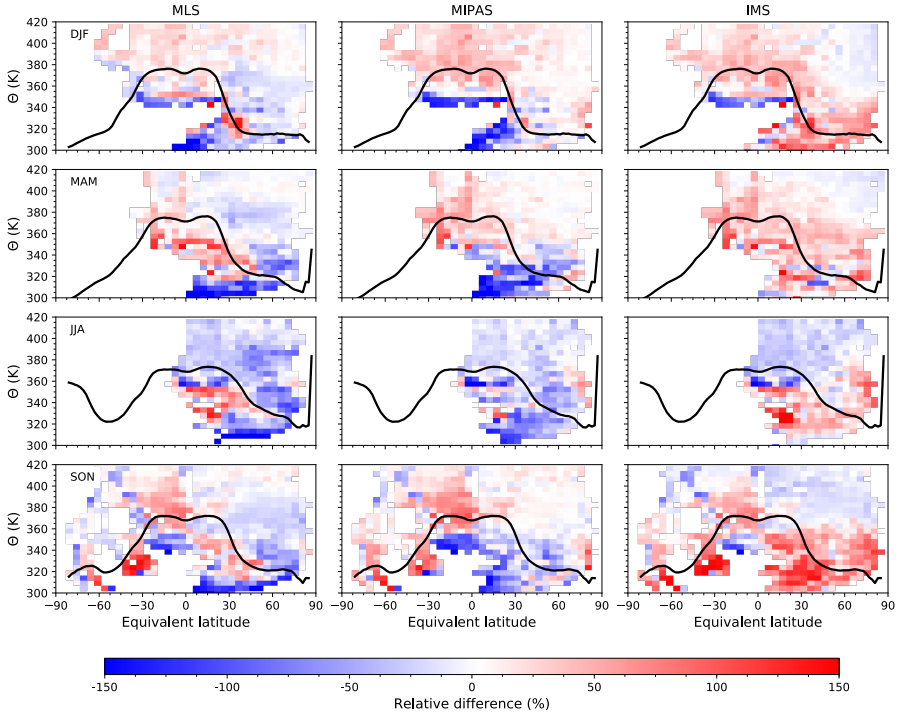


IMS & MLS bias-correction example

- Black dots: gridded before bias-correction
- Blue dots: gridded after bias-correction

Independent comparison with JULIA

Comparison with JULIA data (Non-corrected)



Airborne field campaigns (JULIA data)

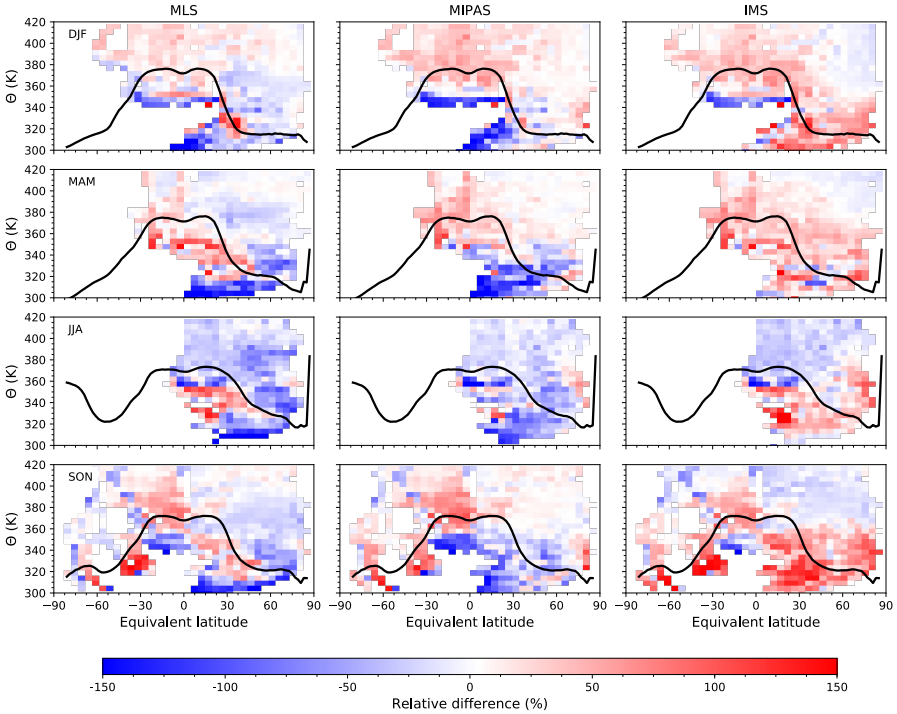
- 436 flights from 55 field campaigns
- Mostly over Europe
- **See talk tomorrow by Christian Rolf!**

PV-based EqL-θ coordinate

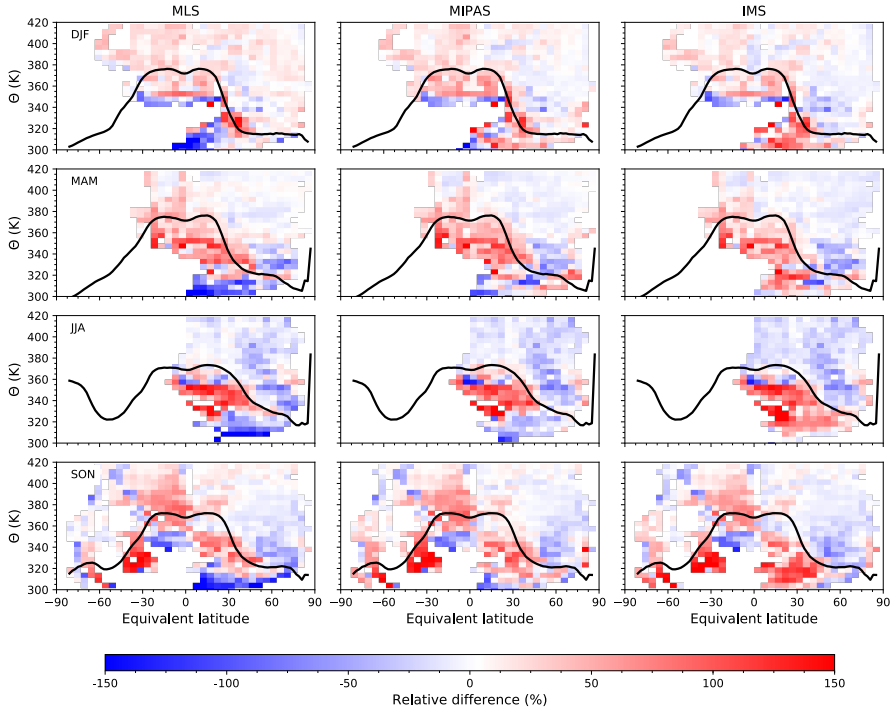
- Widely used in the UTLS region for chemical transport studies
- Allows greater latitude/height coverage
  - Aircraft data are generally obtained along a couple constant altitude/flight levels!

Independent comparison with JULIA

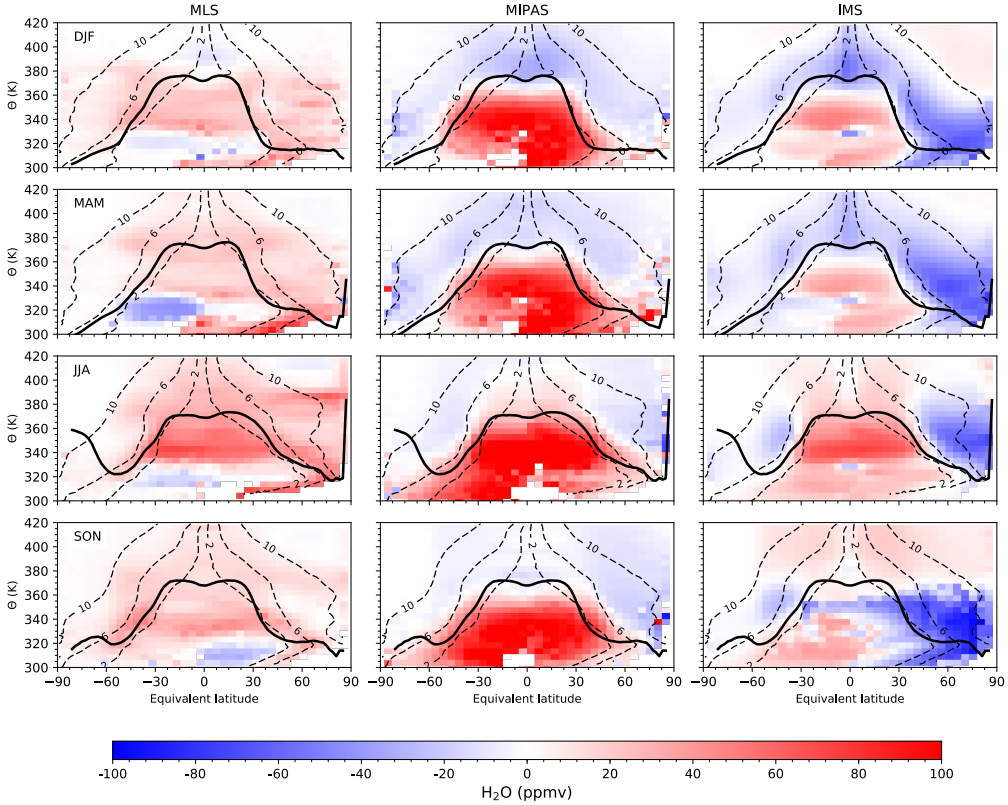
Comparison with JULIA data (Non-corrected)



After bias-correction



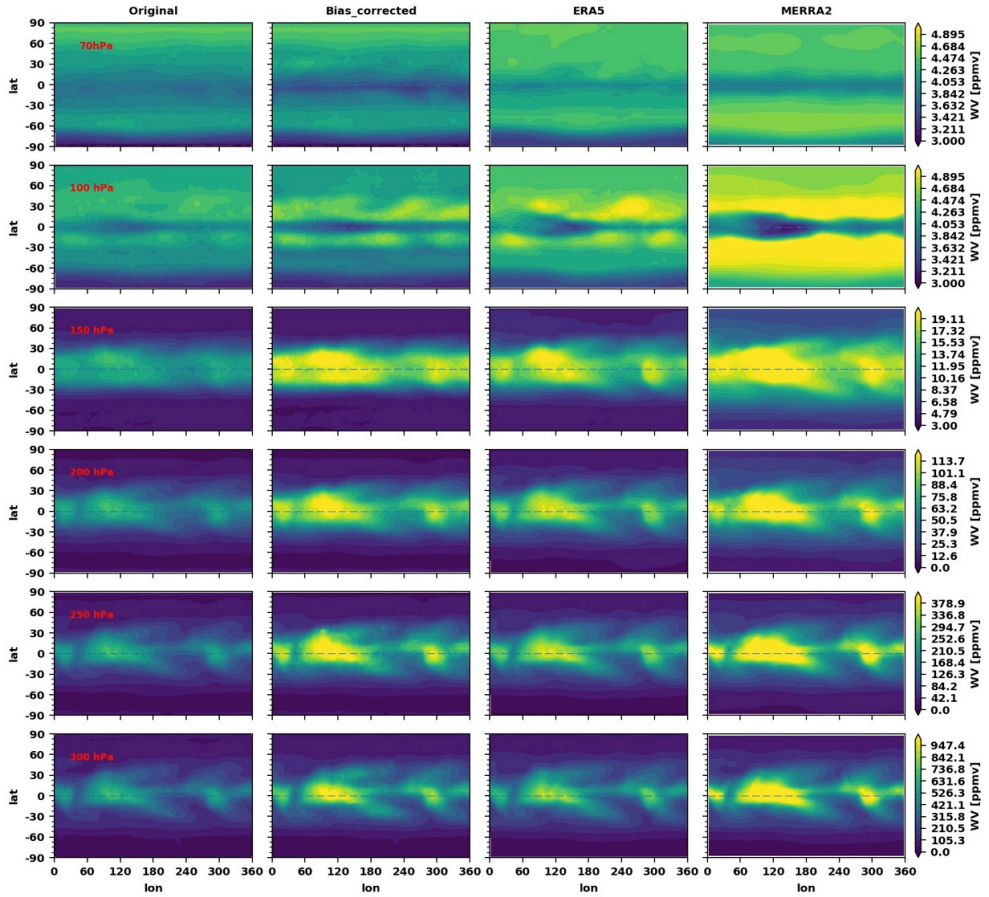
Independent comparison with JULIA



Relative change from bias-correction

- Relative to original non-corrected fields
- Bias-correction tends to increase water vapour in UT and decrease water vapour in LS
- Large changes to MIPAS in the UT and IMS in the LS

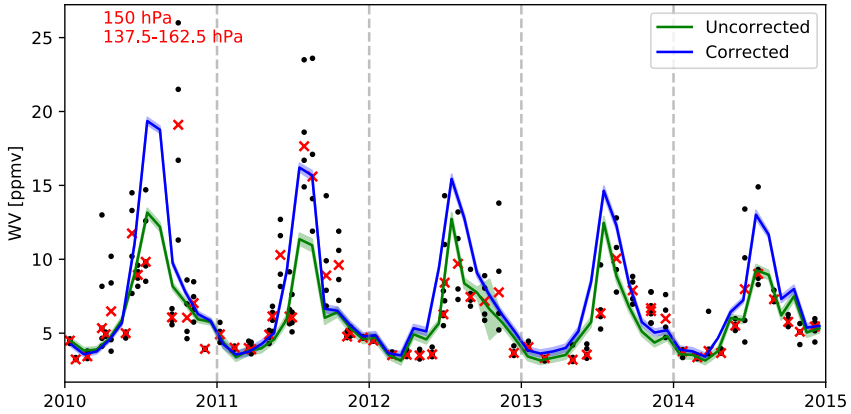
Merged Dataset

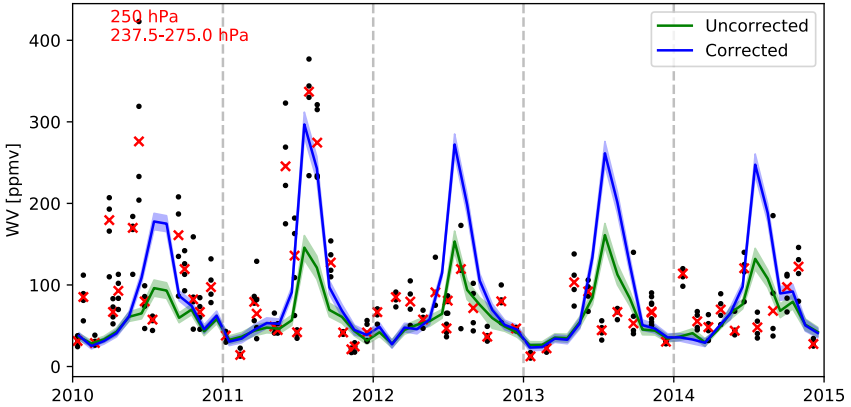


Comparison with reanalysis datasets

- Bias correction keeps the horizontal distribution pattern
- Bias correction method largely increases water vapour in the upper troposphere

Comparison with local profiles





Boulder 2010-2014

- Bias-correction improves WV in summer significantly
- Note that these comparisons are done for local profiles, while the bias-correction are based on the climatological distribution in a certain latitude band

Summary

- A new approach is introduced which uses “climatological” distribution of balloon-borne measurements in tropopause coordinates for bias-correction on satellite observations
  - Allows highly sparse in-situ water vapour profiles to be used to characterize biases
  - Applies varying biases through Quantile-mapping technique
  - Provides an approach to merge limb- and nadir-view satellite observations apart from the complex averaging kernels between different satellite instruments
- The new 3-D global vertically-resolved VRWV_UTLS data record
  - Exhibits a significant increase of water vapour in the upper troposphere
  - Captures the high water vapour content during summer season over both tropics and mid-latitude regions

Thanks!