

Water vapour

Atmospheric Composition Constellation Meeting (ACC-6)
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1. Background

- Water vapour is one of the designated GCOS ECVs
- It merits attention in the frame of CEOS-ACC and other international fora.
- It was not selected for the ESA CCI due to assessment that substantial further R&D would likely be necessary before an ECV data set of useful accuracy could be generated.
- However, it could be appropriate to assess current status and identify possible future steps.
- *Objective*: self-consistent profiles spanning the troposphere and stratosphere

2. Satellite data types

- Satellite sensors can potentially contribute individual components:
 - a) microwave imagers (eg SSM-I) – *total column (ie pbl)*
 - b) vis/near-ir spectrometers (eg GOME) – *total column (ie pbl)*
 - c) ir & microwave sounders (eg IASI, AMSU-B) – *troposphere*
 - d) ro (eg COSMIC) – *tropospheric profile*
 - e) ir & microwave limb-sounders (eg MIPAS, MLS) – *stratosphere / upper troposphere*
 - f) vis and ir solar occultation (eg SAGE-II, HALO) – *stratosphere / upper troposphere*
- How best to combine?
 - Assimilation
 - Validation

microwave imagers – total column (ie pbl)

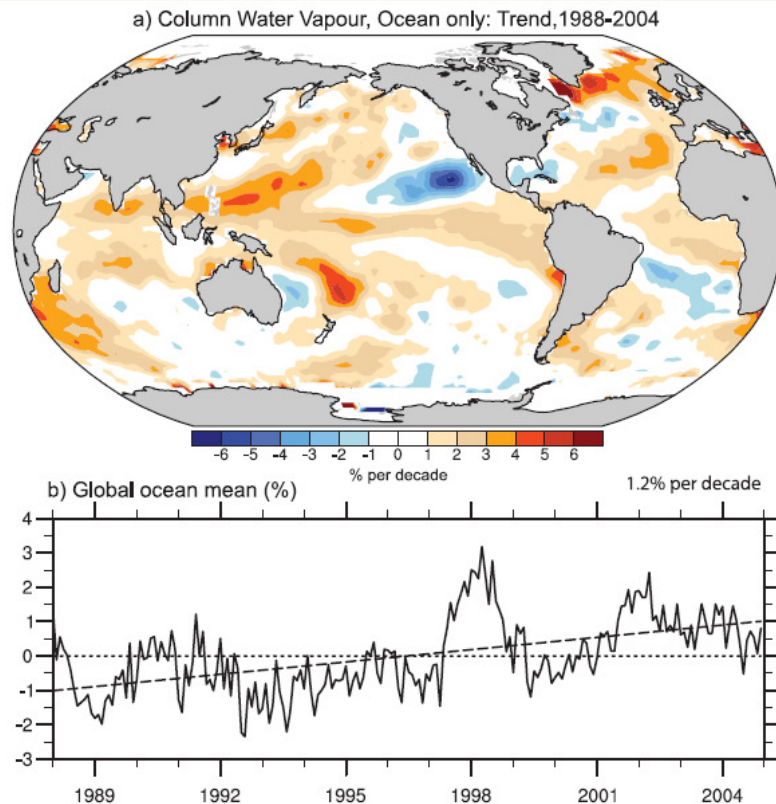
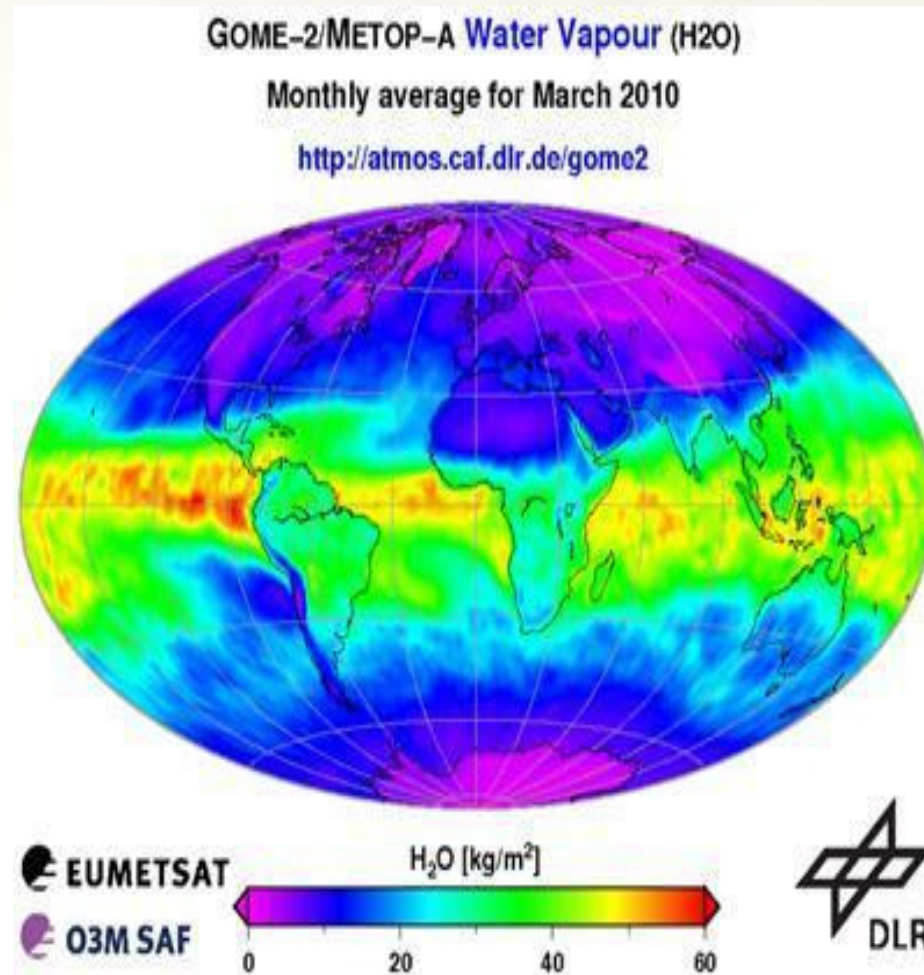


Figure 3.20. Linear trends in precipitable water (total column water vapour) in % per decade (top) and monthly time series of anomalies relative to the 1988 to 2004 period in % over the global ocean plus linear trend (bottom), from RSS SSM/I (updated from Trenberth et al., 2005a).

Trends in tropospheric water vapour (IPCC, 2007)

Lower tropospheric water vapour over ocean changes in accordance with SST

vis/near-ir spectrometers – total column (ie pbl)



ir & microwave sounders – troposphere

a) Upper Troposphere Moisture: T2-T12 Trend 1982-2004

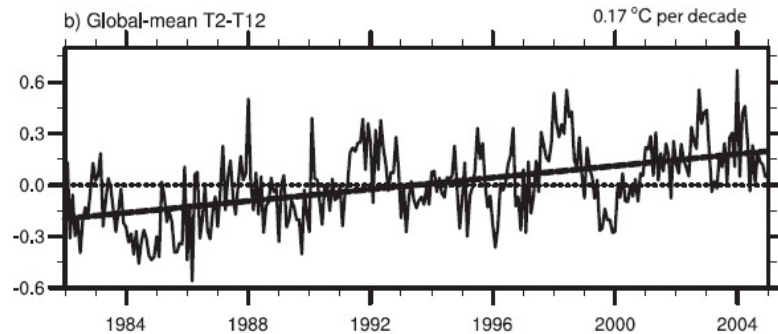
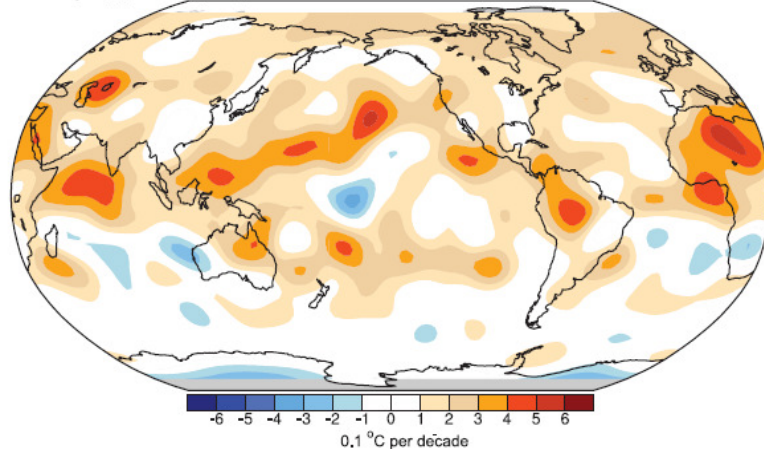


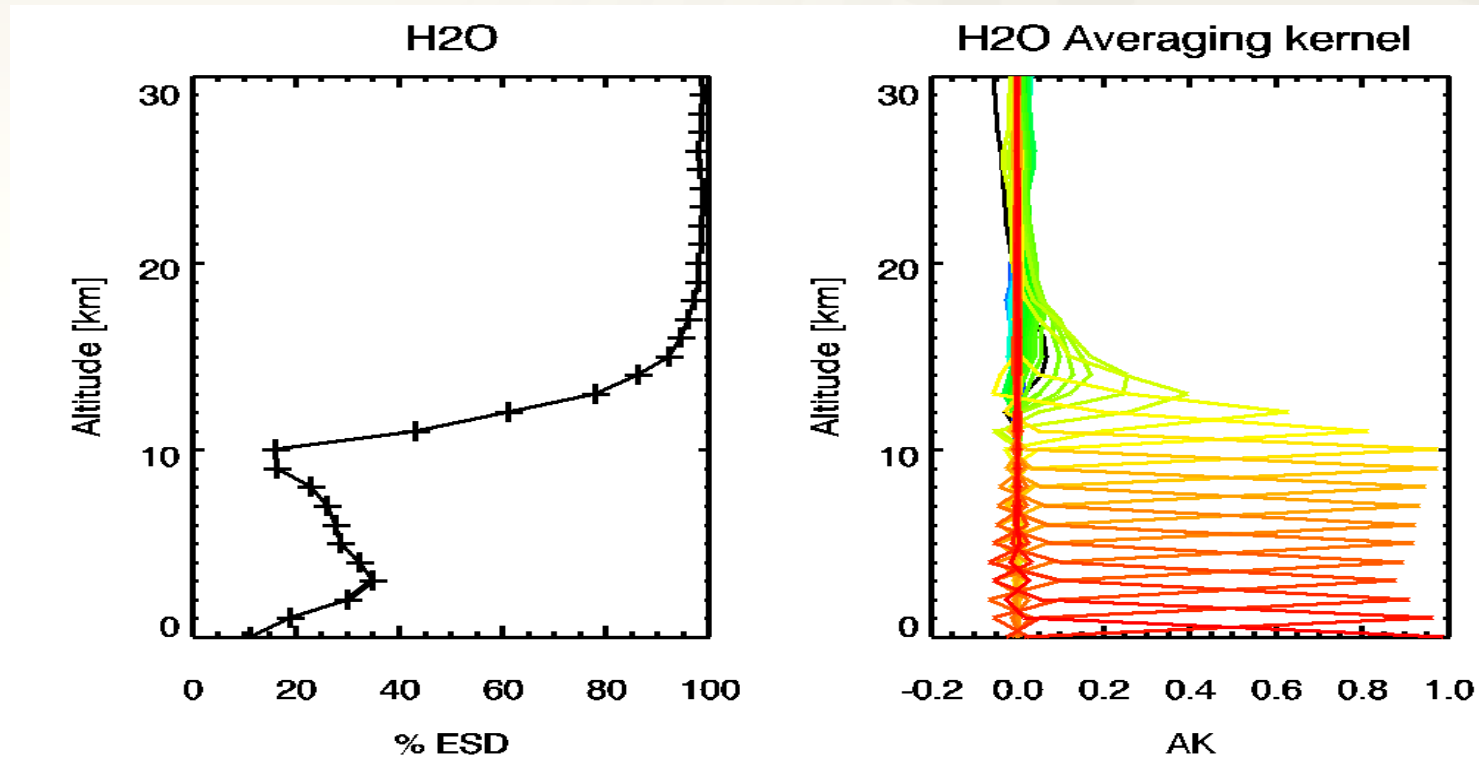
Figure 3.21. The radiative signature of upper-tropospheric moistening is given by upward linear trends in T2–T12 for 1982 to 2004 (0.1 °C per decade; top) and monthly time series of the global-mean (80°N to 80°S) anomalies relative to 1982 to 2004 (°C) and linear trend (dashed; bottom). Data are from the RSS T2 and HIRS T12 (Soden et al., 2005). The map is smoothed to spectral truncation T31 resolution.

Trends in tropospheric water vapour (IPCC, 2007)

Inferred changes in upper trop q consistent with observed T change and fixed relative humidity

HadIR project at the Hadley Centre – (NERC-METO)
Produce "climate quality" microwave (AMSU-B/MHS/SSMT-2) and IR (HIRS) radiances to compare with climate models using RTTOV.

IASI Estimated Standard Deviations & Averaging Kernels



- ESD & AK calculated for full spectral content; real NESR
- For H₂O, precision useful for $\Delta z = 1\text{km}$ 0 - 10km
- For H₂O, sensitivity even in near-surface layer (where $T(z) \rightarrow T(o)$)



The project aims at generating validated multi-annual global water vapour datasets with error estimates

Total column water vapour (TCWV):

- **SSM/I** only will be provided back to 1996 and potentially back to 1987
- Combined SSM/I (over ocean) and **MERIS** (over land) for 2003 – 2008 with daily and monthly products,
- MERIS data are only daylight
- **(A)ATSR-2** land and ocean for 1996 – 2008 in daily and monthly resolution
- **GOME/SCIA/GOME-2** over ocean and land for 1996 – 2008 with weekly and monthly resolution; product will be daylight only product

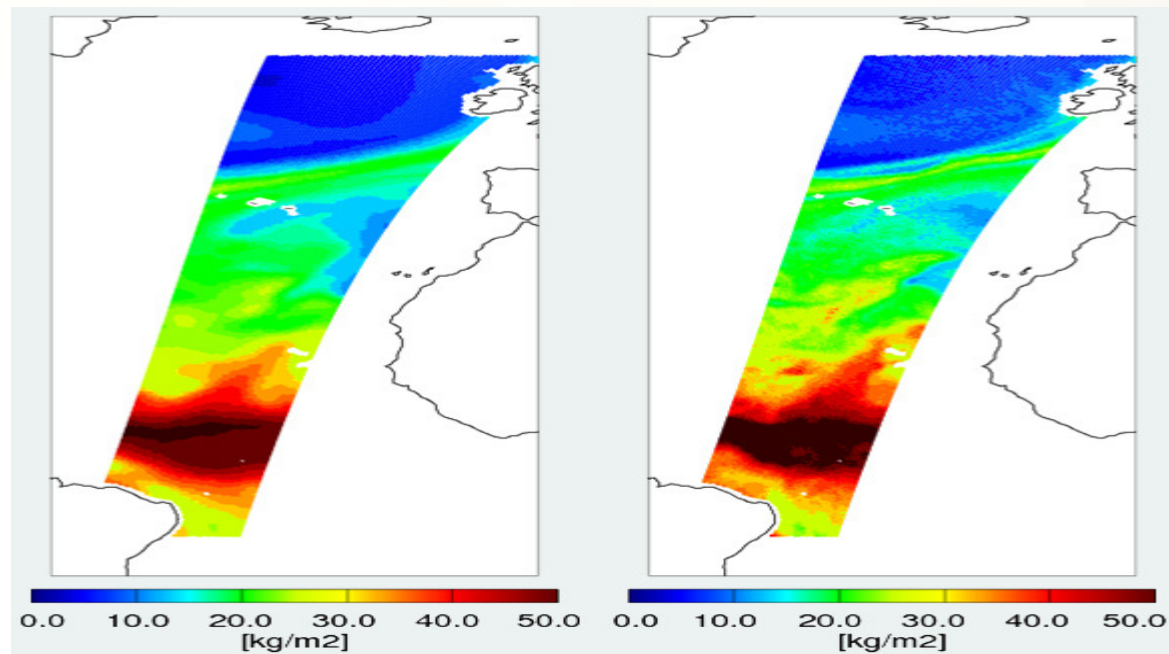
Vertically resolved water vapour (WV profile):

- Combined **IASI/SEVIRI** data set over the SEVIRI full disk for three vertical layers (surf. - 850 hPa, 850 hPa - 500 hPa, 500 hPa - 200 hPa)
Period: October 2007 - December 2008.

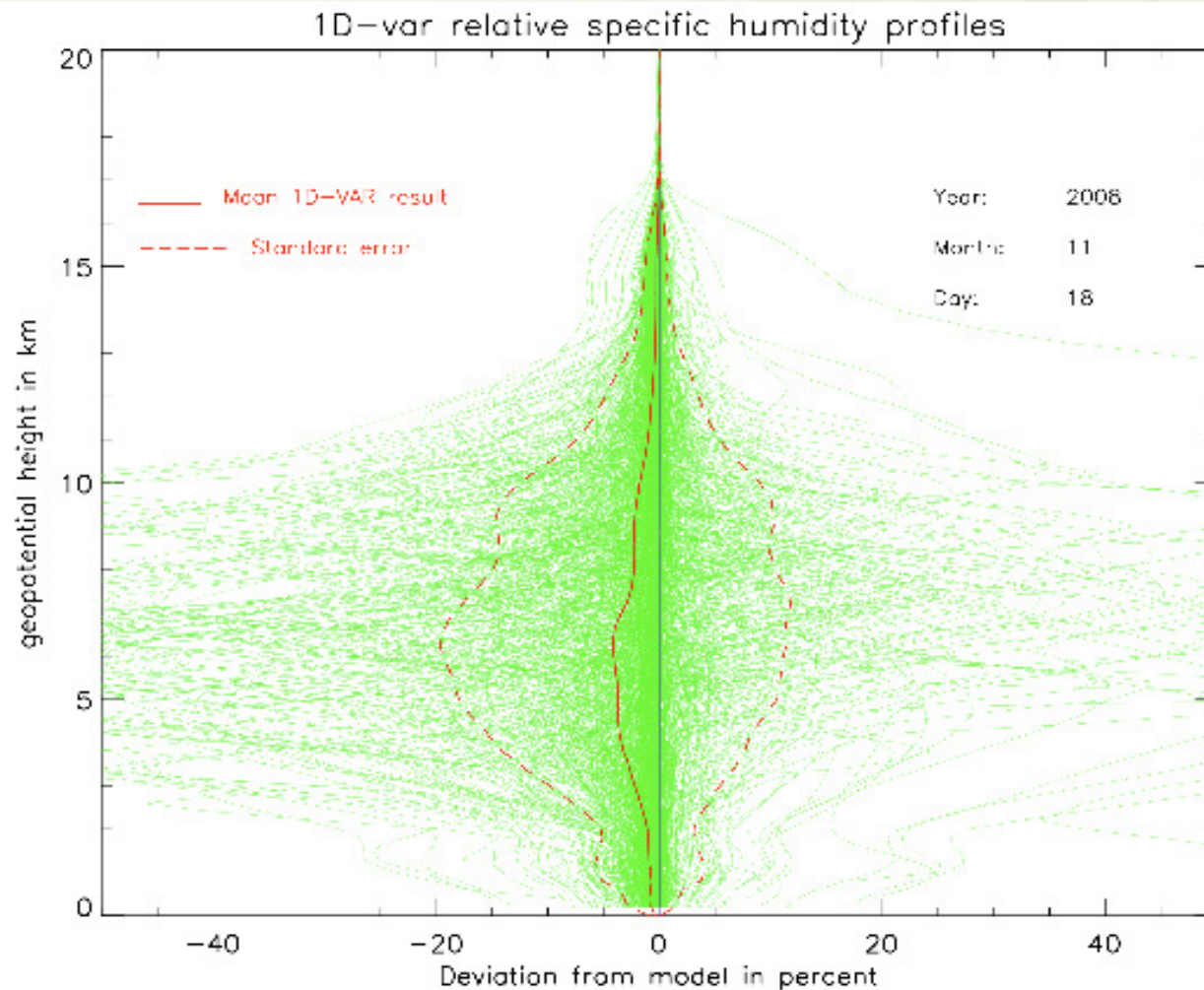
Early result from GlobVapour

TCWV calculated from
ERA-Interim data

TCWV from SSM/I 1D-Var
scheme for DMSP-13



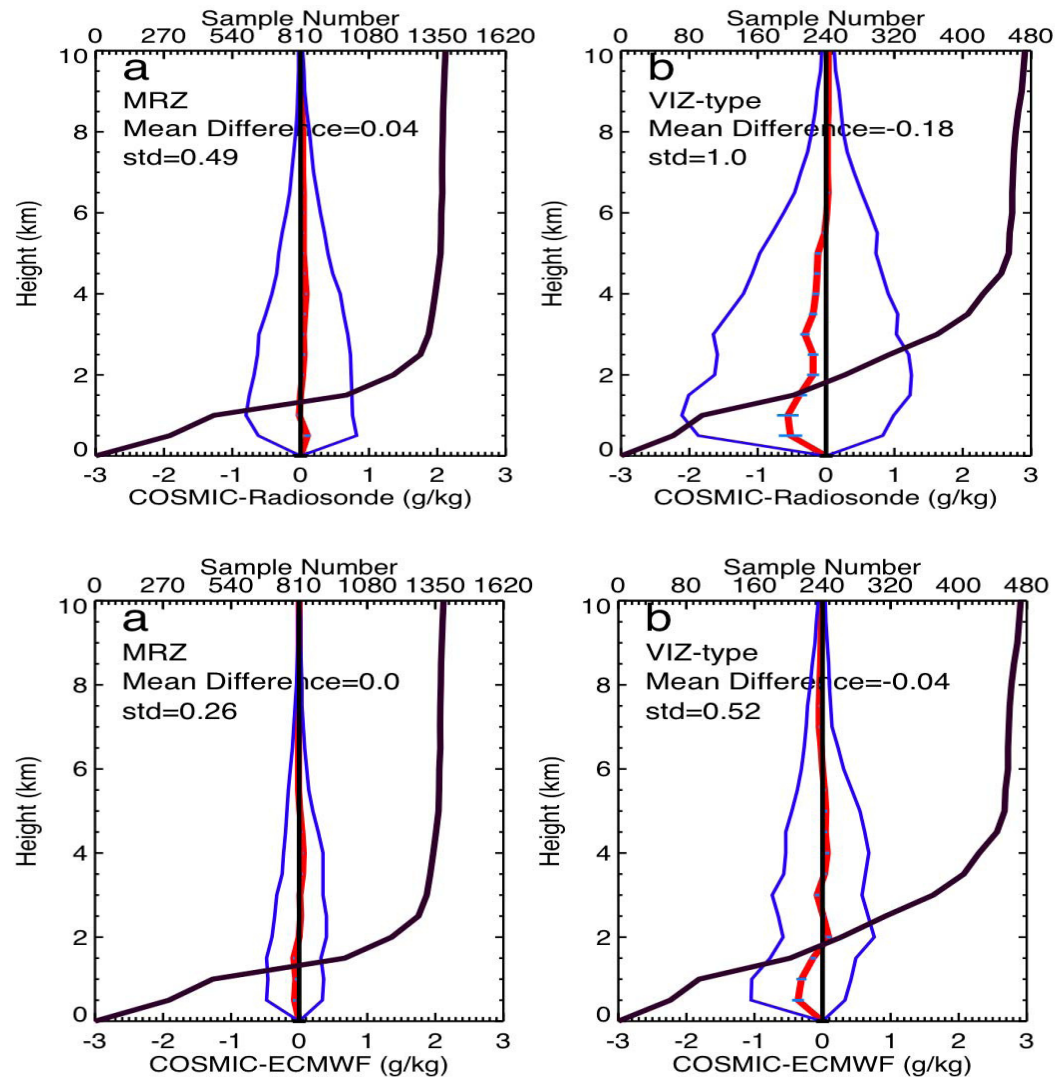
Radio Occultation – tropospheric profile



All MetOp profiles from November 18, 2008



Comparison of COSMIC with Sondes & ECMWF



Comparison statistics

Mean: red

Standard-error-in-mean: light blue

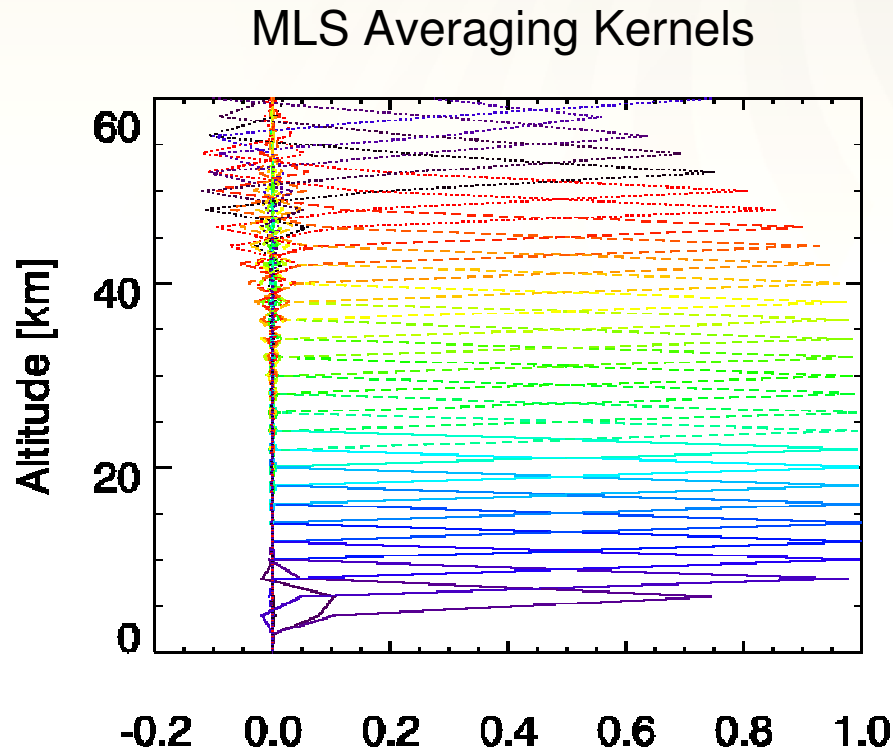
Mean \pm standard deviation: blue

Number of comparisons: black

Shu-peng Ho et al

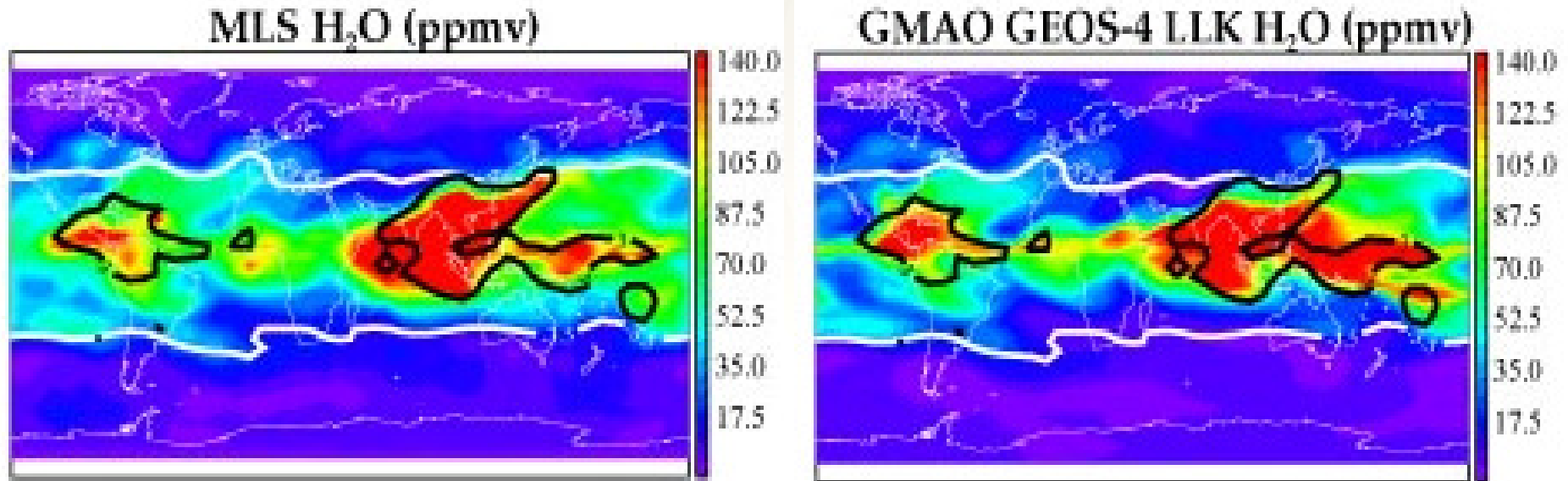
Remote Sens. **2010**, 2, 1320-1330;
doi:10.3390/rs2051320

ir & microwave limb-sounders (eg MIPAS, MLS, SMR) – stratosphere / upper troposphere



- HPBW: ~4km (190 GHz)
→ Vertical resolution <HPBW
achievable for H₂O
- tangent-height spacing 2km
 - p-broadening

MLS maps – 215hPa 12-18th Jun'05

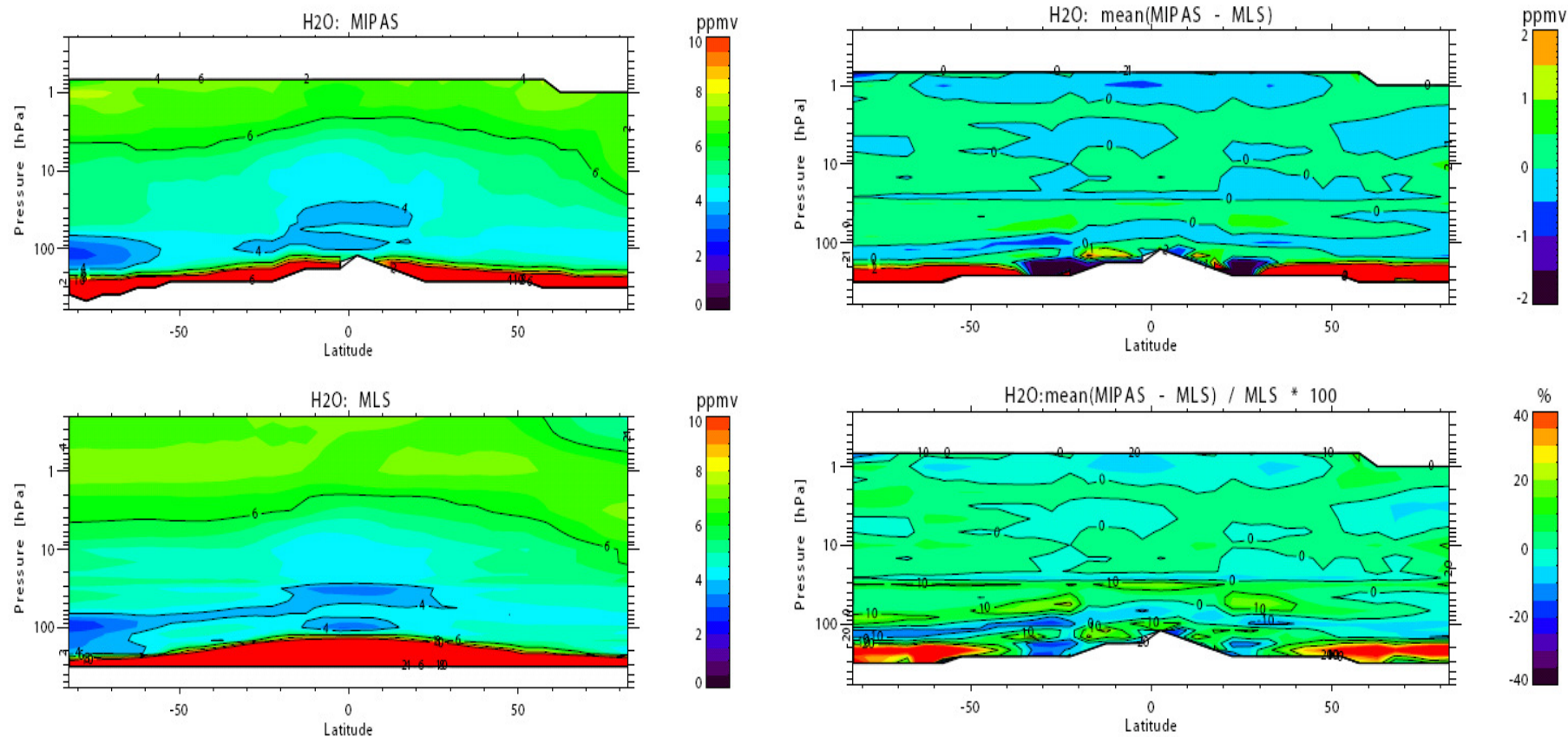


Improved understanding of **spectroscopy** means higher accuracy should be possible in joint reprocessing of UARS & Aura MLS data

N.Livesey (JPL, USA)

MLS – UARS (1991) & Aura (2003)

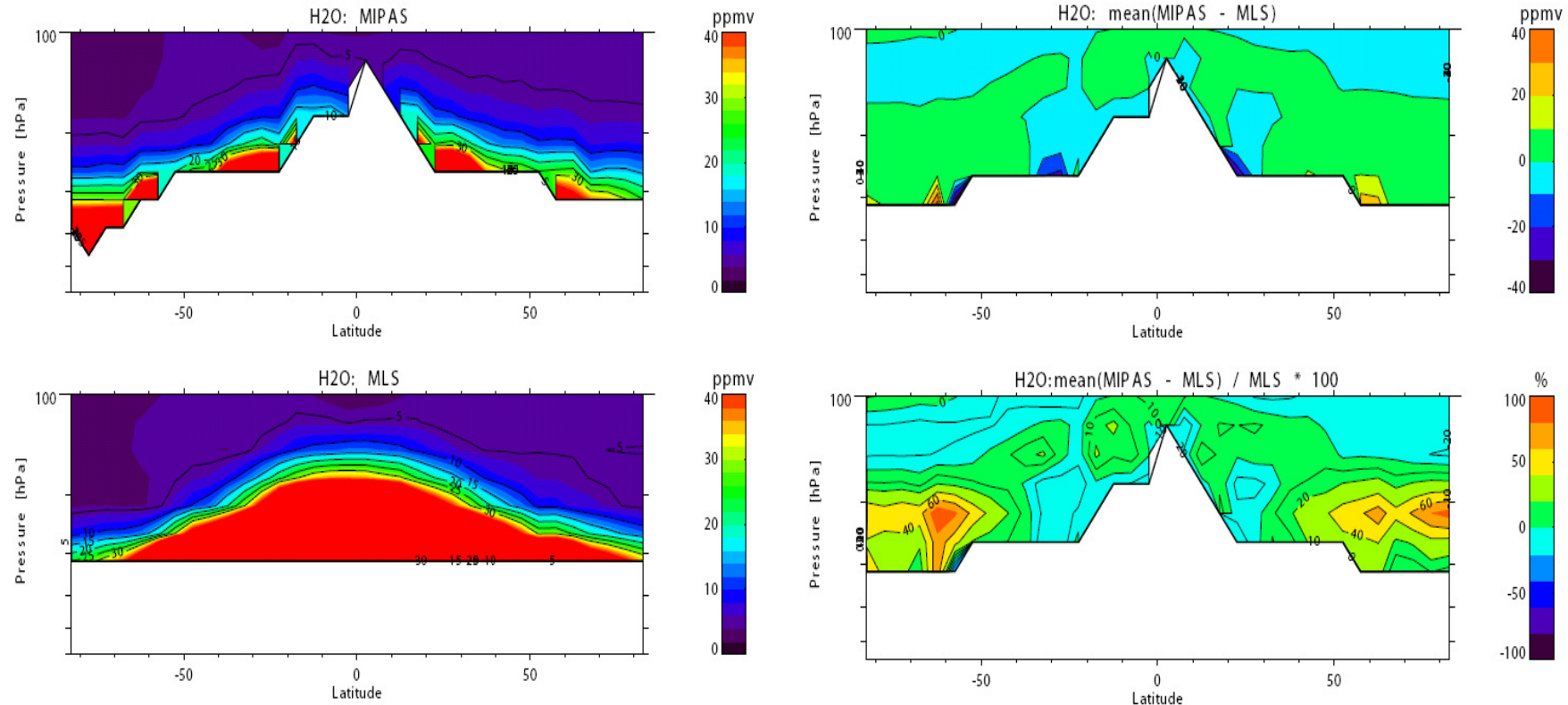
MIPAS (UTLS-1) and MLS (v2.2) H₂O ZM cross-sections 6th Nov – 7th Dec'05



Chauhan et al:

<http://www.atmos-meas-tech.net/2/337/2009/amt-2-337-2009.pdf>

MIPAS (UTLS-1) and MLS (v2.2) H₂O ZM cross-sections 6th Nov – 7th Dec'05



- **Sampling differences w.r.t humidity / cloud structure and local time**
- **Vertical fields of view and limb-view spacing w.r.t. humidity profile**
- **Spectroscopy**

vis and ir solar occultation (eg SAGE-II, HALO, ACE) – stratosphere / upper troposphere

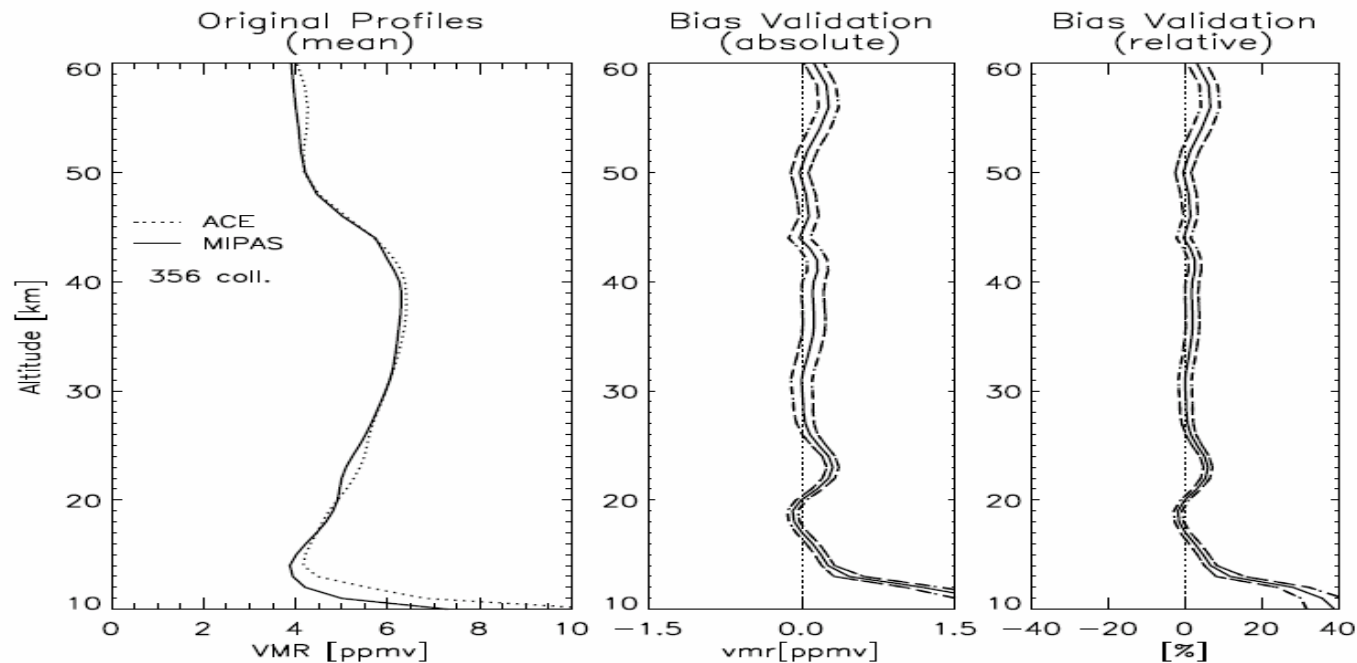


Fig. 6. Bias between MIPAS and ACE-FTS; for details, see Fig. 2.

Milz et al

<http://www.atmos-meas-tech.net/2/379/2009/amt-2-379-2009.pdf>

K. Rosenlof: upper troposphere & stratosphere climatology (1990 – present)

3. Summary

- As a GCOS designated ECV, water vapour merits attention
- To generate self-consistent height-resolved data spanning stratosphere and troposphere, several satellite components would be required.
- Individual components have reached different levels of maturity
 - For some, further R&D required and foreseen
- To combine these into a self-consistent ECV data-set would be a challenge.
- For tropospheric water vapour, there are issues additional to attributes & quality of existing data sets from individual sensors eg:
 - Relationship with other met observables eg GCOS ECVs cloud, T & SST
 - *Assimilation* into GCM to combine info of diverse types (FCDR & TCDR) eg ERA-CLIM?
- ESA GlobVapour underway; Eumetsat to lead (tropospheric) water vapour ECV
- CEOS-ACC an appropriate forum, in view of responsibilities of operational agencies (eg Eumetsat and NOAA) for met variables and other agencies (eg ESA, NASA & CSA) for stratospheric data
- Timely to:
 - stimulate progress on stratospheric water vapour profiles from limb-sounding
 - consult user community, eg ESA CCI climate modelling group, to consider requirements for future water vapour ECV