Introduction

- Atmospheric water vapour ($H_2O$) is critical to the climate and hydrological systems.
- Largest contributor to the atmospheric greenhouse effect.
- Positive feedback effect with climate warming.
- Changing spatial, temporal distributions, precipitation patterns with climate change.
- Consistent monitoring of $H_2O$ crucial to understanding the positive feedback effect with climate warming.
- Atmospheric measurements (especially co-located with observations of other greenhouse gases) can contribute to studies of impacts.
- GOSAT and other satellites can measure $H_2O$ (and its isotopologue, HDO).
- These require validation to ensure no spatial/temporal biases.
- Ground-based measurements can provide such validation.

Calibration of TCCON

- In order to use TCCON or MUSICA for satellite validation, they must also be calibrated.
- MUSICA uses validation against co-located plane flights (Dyroff et al. 2015) for HDO and $H_2O$.
- TCCON uses a limited selection of co-located aircraft or sounding measurements for $H_2O$ only; there is no HDO calibration.
- Only uses measurements simultaneous to calibration for other gases ($CO_2$, $CH_4$, etc.) (23 profiles, 4 sites).
- $1.0183±0.0010$ (right; Wunch et al., 2015).
- Many sites have more frequent co-located sounding launches; these can be used for a more extensive validation.
- No similar comparative measurements for HDO.
- Comparison to MUSICA best option.

GOSAT validation

- TCCON primary validation for GOSAT.
- Variety of coincidence criteria explored.
- Increasing temporal coincidence barely provides any greater number of matches, but doesn’t compromise fit.
- Increased spatial range increases number of coincidences but compromises fit statistics.

Ground-based FTIR $H_2O$ measurements

- Total Carbon Column Observing Network (TCCON) and Network for Detection of Atmospheric Composition Change (NDACC) – ground-based solar Fourier Transform InfraRed (FTIR) measurements.
- TCCON: NIR; column scaling; a priori dependent; 15 $H_2O$ (top right), 6 HDO (middle right) windows; temporally dense, moderate spectral resolution; >20 sites.
- NDACC: Multi-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water (MUSICA); MIR; profile retrieval; high spectral resolution; 5 $H_2O$, 2 $H_2D$, 2 $H_2D^+$ (bottom right); 11 sites (7 common to TCCON).

Updated Calibration

- 1000s of coincidences.
- Multiple sites ($>8$; Izana not shown in plot).
- Some sites – multiple soundings/day.
- Wider range of conditions.
- Diverges from linear at low $H_2O$ (Arctic) $1.0113±0.0018$.
- To be updated for GGG2016, including extra microwindows (e.g. Rokotyan et al, 2014).
- HDO to be validated via comparison to MUSICA.
- Limited in tropics – investigating empirical correction.

Altimeter effect

- High variability of $H_2O$ profile results in $xH_2O$ variations despite normalisation to surface pressure.
- Most clearly seen at sites near to variable topography (e.g. Wollongong, Dryden, Izana, Garmisch).
- Possible site specific coincidence criteria, or additional $d(alt)$ criterion.
- Alternatively: correct (e.g. Ohyama et al, 2016).

Acknowledgements

- Australian Research Council funding (DE140100178).
- GOSAT support via RA project.
- TCCON Pls (all sites), and sonic data providers (including Omaira Garcia, Rigel Kri, Marion Maturilli, Richard Quemel, Hisako Shinoz.)

References

