TCCON H_2O retrievals for satellite validation

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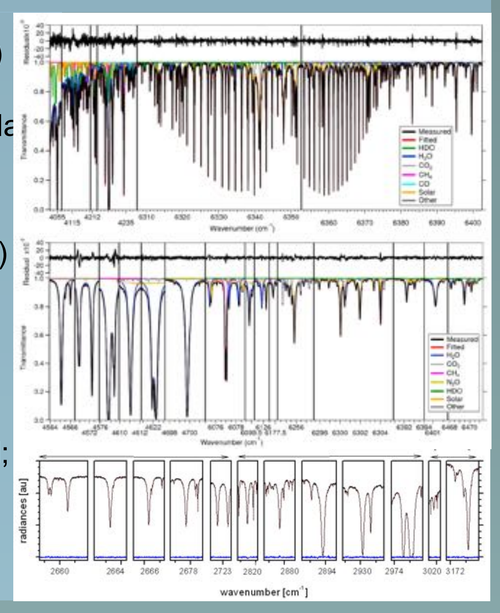
Introduction

- 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
- Satellite 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

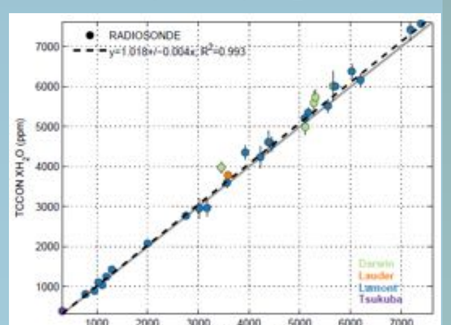
Ground-based FTIR H_2O measurements

- Total Carbon Column Observing Network (TCCON) and Network for Detection of Atmospheric Composition Change (NDACC) – ground-based sola 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, 5 HDO, 2 $H_2{}^{18}O$ (bottom right); 11 sites (7 common to TCCON)

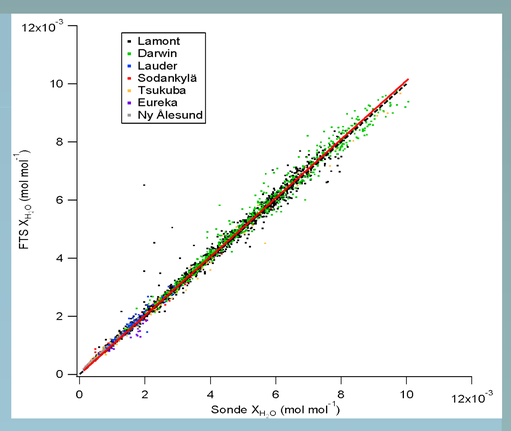


Calibration of TCCON

- 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 sonde 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 ± 0.0100 (right; Wunch et al, 2015)
  - Many sites have more frequent co-located sonde launches; these can be used for a more extensive calibration of H_2O
    - No similar comparative measurements for HDO
    - Comparison to MUSICA best option



Updated Calibration

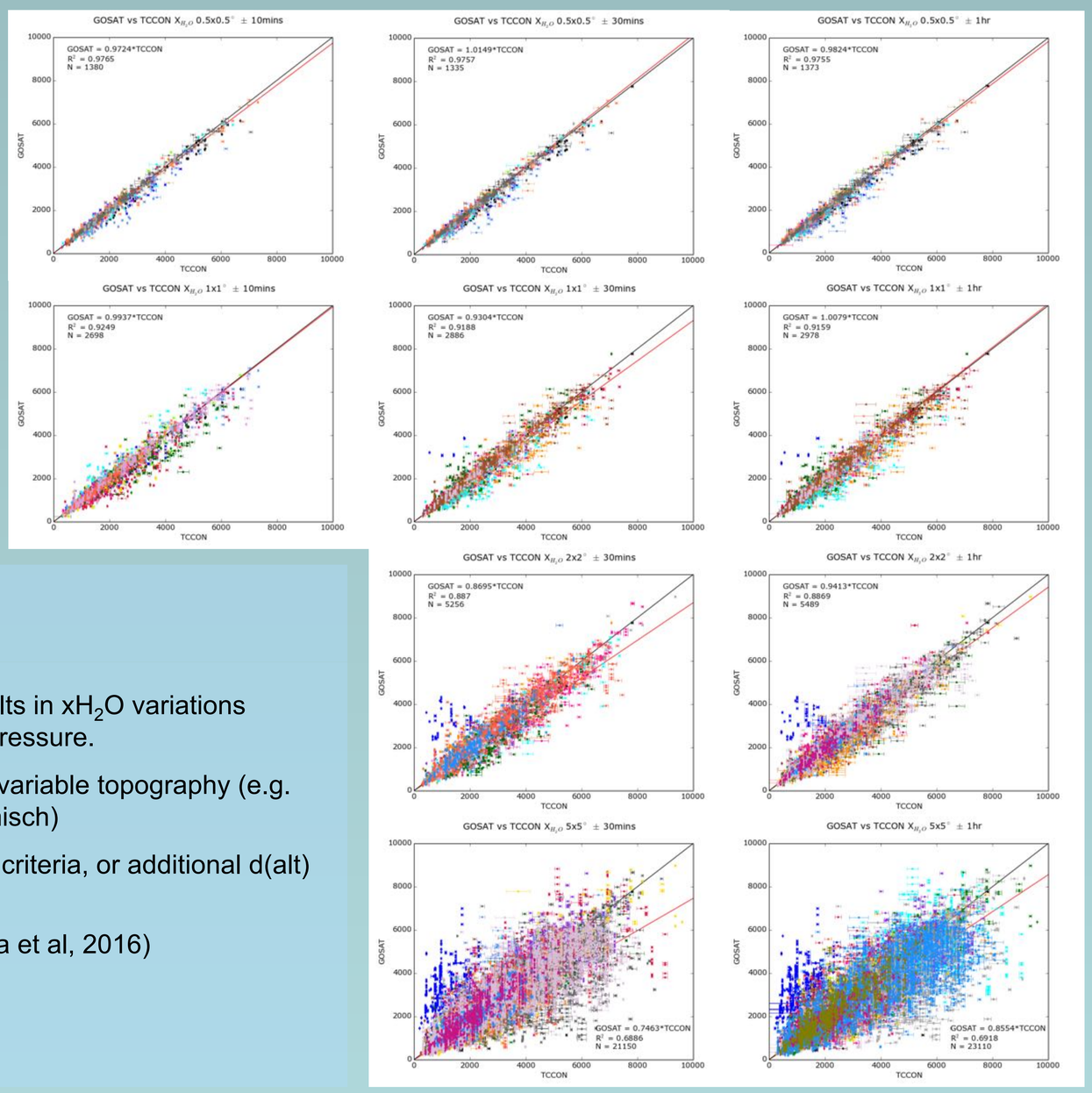


- 1000s of coincidences
- Multiple sites (>= 8; Izana not shown in plot)
  - Some sites – multiple soundings/day
- Wider range of conditions
  - Diverges from linear at low xH_2O (Arctic)
- 1.0113 ± 0.0018
- To be updated for GGG2016, including extra microwindows (e.g. Rokotyan et al, 2014)
- HDO to be validated via comparison to MUSICA
  - Limited in tropics – investigating empirical correction

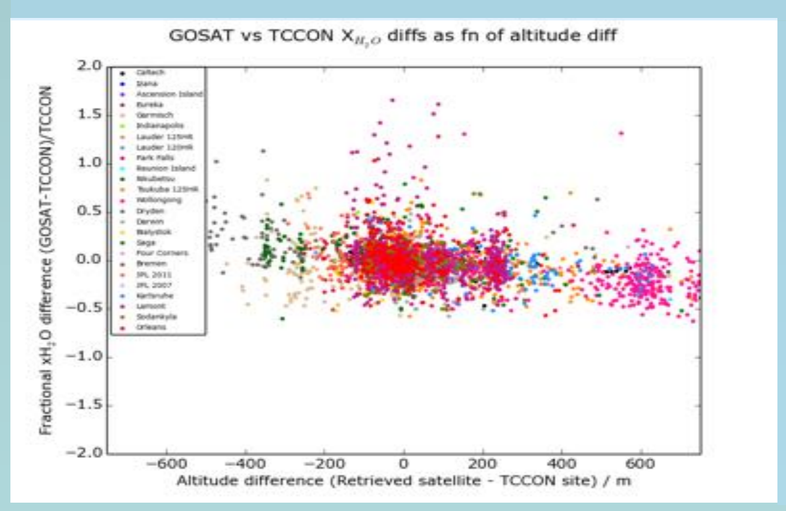
GOSAT validation

- 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

Temporal	Spatial	Slope	N	r^2
1 hour	$5x5^0$	0.8554	23110	0.6918
	$2x2^0$	0.9413	5489	0.8869
	$1x1^0$	1.0079	2978	0.9159
	$0.5x0.5^0$	0.9824	1373*	0.9755
30 minutes	$5x5^0$	0.7463	21150	0.6886
	$2x2^0$	0.8695	5256	0.8870
	$1x1^0$	0.9304	2886	0.9188
	$0.5x0.5^0$	1.0149	1335*	0.9757
10 minutes	$1x1^0$	0.9937	2698	0.9249
	$0.5x0.5^0$	0.9724	1380	0.9765



Altitude 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)

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