Validation for Greenhouse Gases Measured by the Atmospheric Chemistry Experiment (ACE) Satellite

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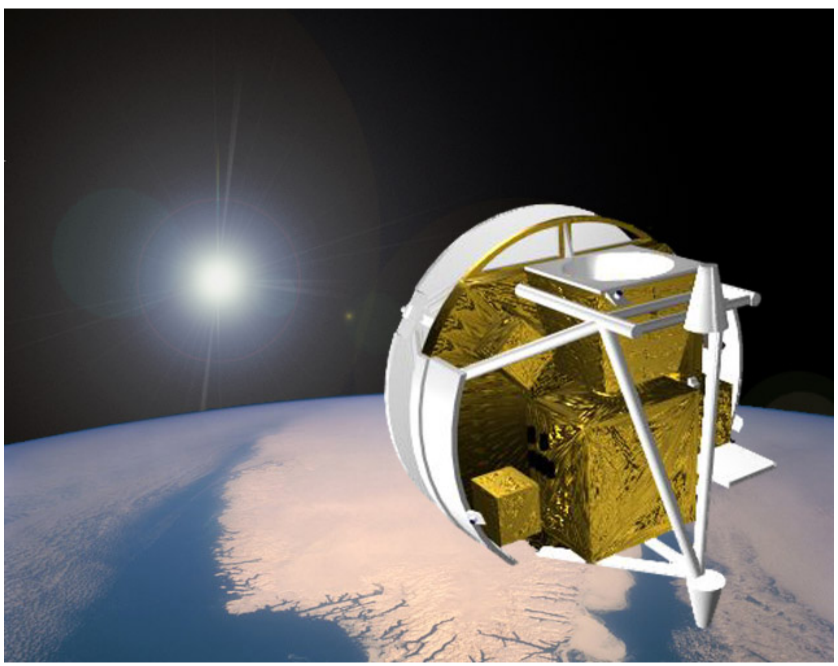
ACE on SCISAT-1

Atmospheric Chemistry Experiment (ACE) Satellite Mission:

Mission to measure atmospheric composition: profiles of trace gas species, cloud and aerosol extinction and temperature/pressure



Launch date: 12 August 2003

Orbit: 74° inclination at 650 km

Measurement mode: solar occultation

ACE-FTS:

- FTIR spectrometer, 2-13 microns at 0.02 cm^{-1} resolution
- 2-channel visible/NIR imager, 0.525 and 1.02 microns

MAESTRO:

- dual UV / visible / NIR grating spectrophotometer, 285 to 1030 nm at ~1-2 nm resolution

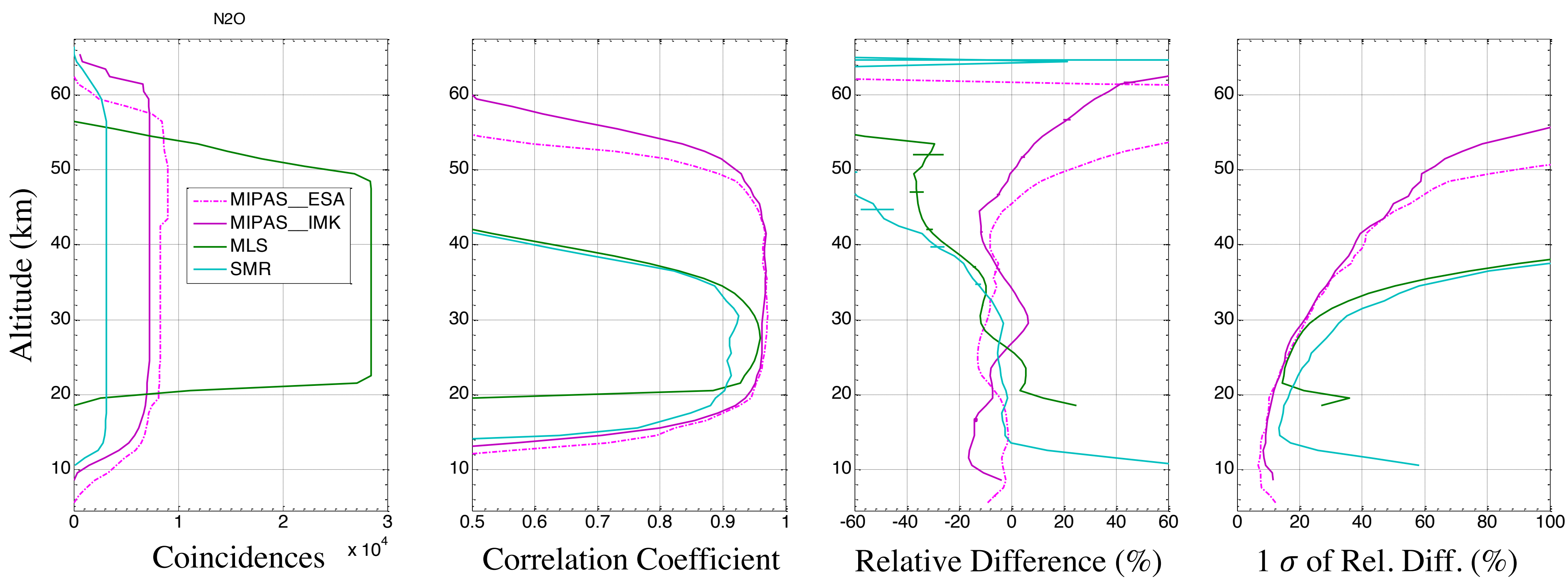
Pointing: suntracker in ACE-FTS

ACE Data Products

- ACE-FTS profiles (current version 3.5; previous v2.2+updates):
  - Tracers: H_2O, O_3, N_2O, NO, NO_2, HNO_3, N_2O_5, H_2O_2, HO_2NO_2, N_2
  - Halogen-containing gases: HCl, HF, $ClONO_2$, CFC-11, CFC-12, CFC-113, COF_2, $COCl_2$, COFCl, CF_4, SF_6, CH_3Cl, CCl_4, HCFC-22, HCFC-141b, HCFC-142b
  - Carbon-containing gases: CO, CH_4, CH_3OH, H_2CO, HCOOH, C_2H_2, C_2H_6, OCS, HCN and pressure / temperature from CO_2 lines
  - Isotopologues: Minor species of H_2O, CO_2, O_3, N_2O, CO, CH_4, OCS
  - Research species: CH_3CN, acetone, SO_2, peroxyacetyl nitrate (PAN)…
- MAESTRO profiles (current version 3.13; validated version 1.2):
  - O_3, NO_2, optical depth, aerosol and water vapor (research version)
- IMAGERS profiles (current version 3.5; validated version 2.2):
  - Atmospheric extinction & aerosol extinction at 0.5 and 1.02 microns

Limb satellite comparisons – N_2O

- Mean differences of pairs of coincident profiles within 6 hours; 500 km – calculated as (ACE-FTS v3.5/3.6 – instrument)
- Reasonable agreement below 40 km; comparison degrades as N_2O concentration decreases into upper stratosphere

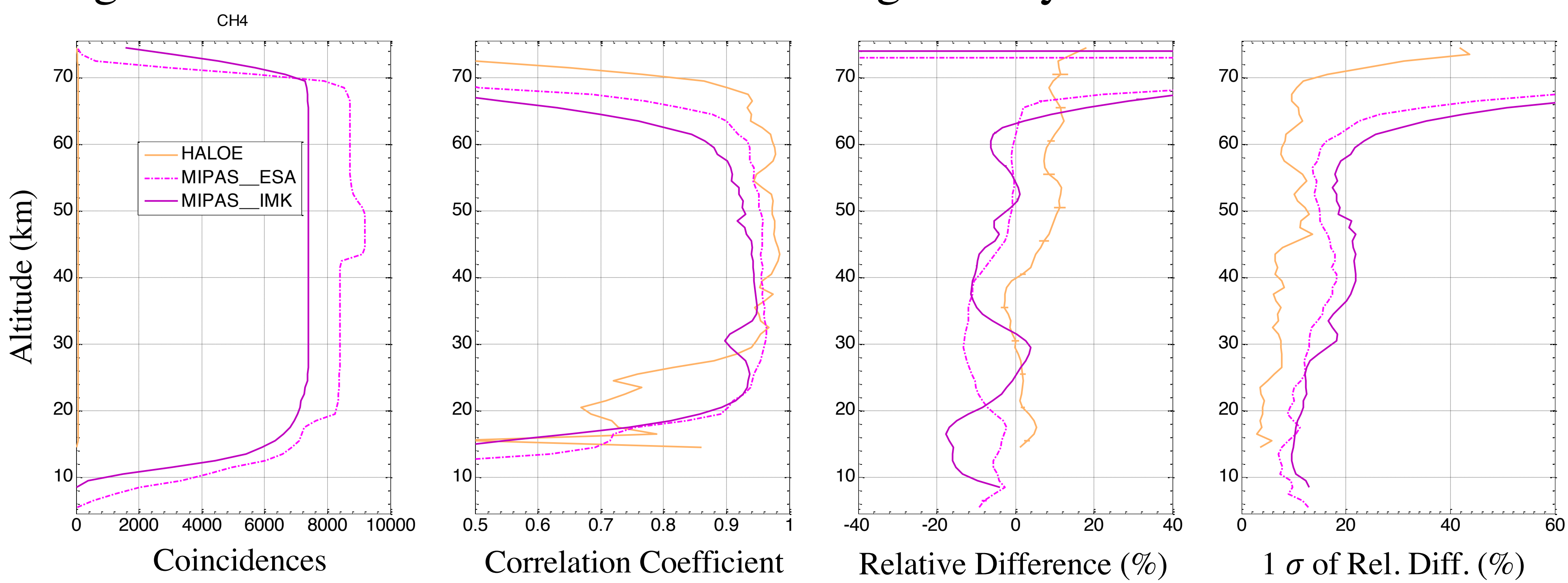


MLS v4.2; SMR v2.1; MIPAS IMK-IAA v5R 220; MIPAS ESA v7

Patrick Sheese

Limb satellite comparisons – CH_4

- Comparisons with HALOE (2004-2005) and two MIPAS processor versions (ESA and IMK-IAA – 2005-2012)
- Mean differences of coincident profiles within 6 hours; 500 km
- At lower altitudes, better agreement with HALOE, switching to better agreement with MIPAS above 40 km – generally ±10-15% above 20 km



HALOE v19; MIPAS IMK-IAA v5R 220; MIPAS ESA v7

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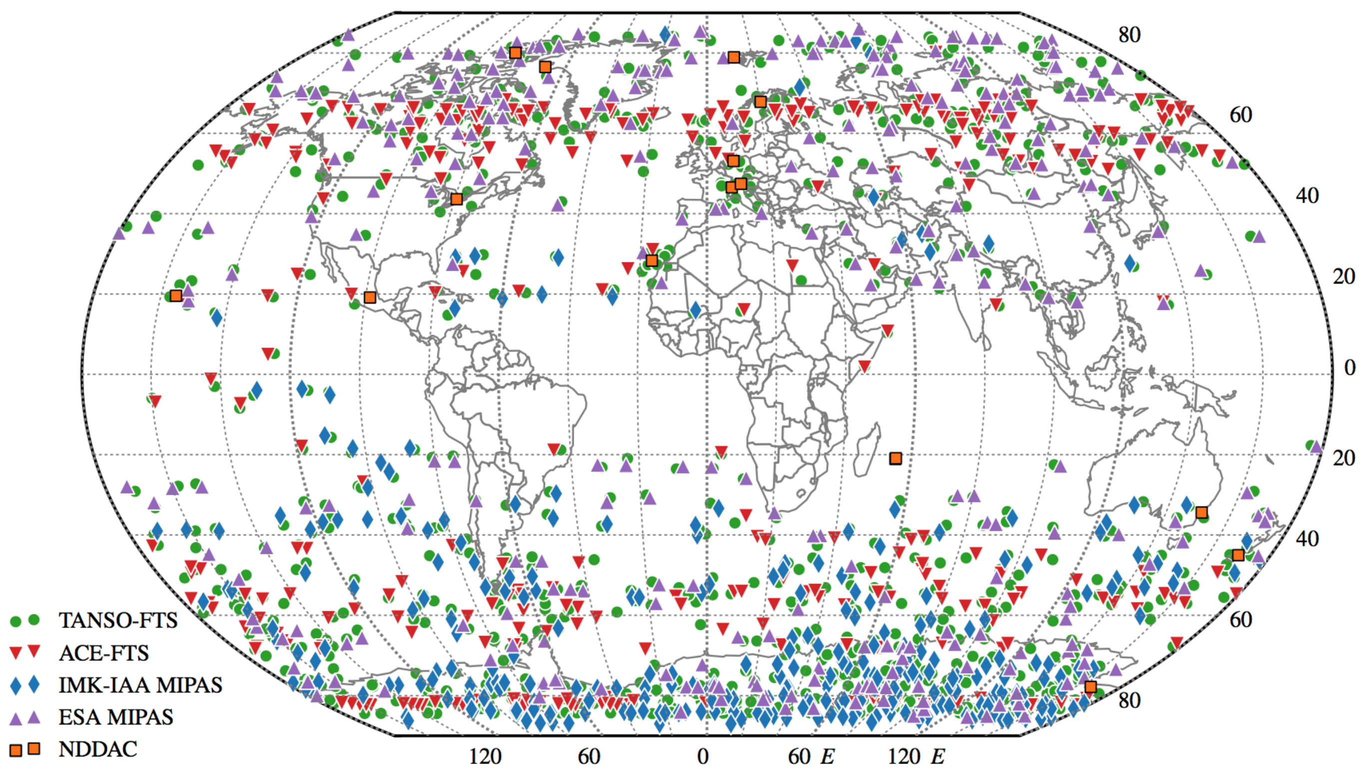
Cross-Validation of GOSAT TIR CH_4

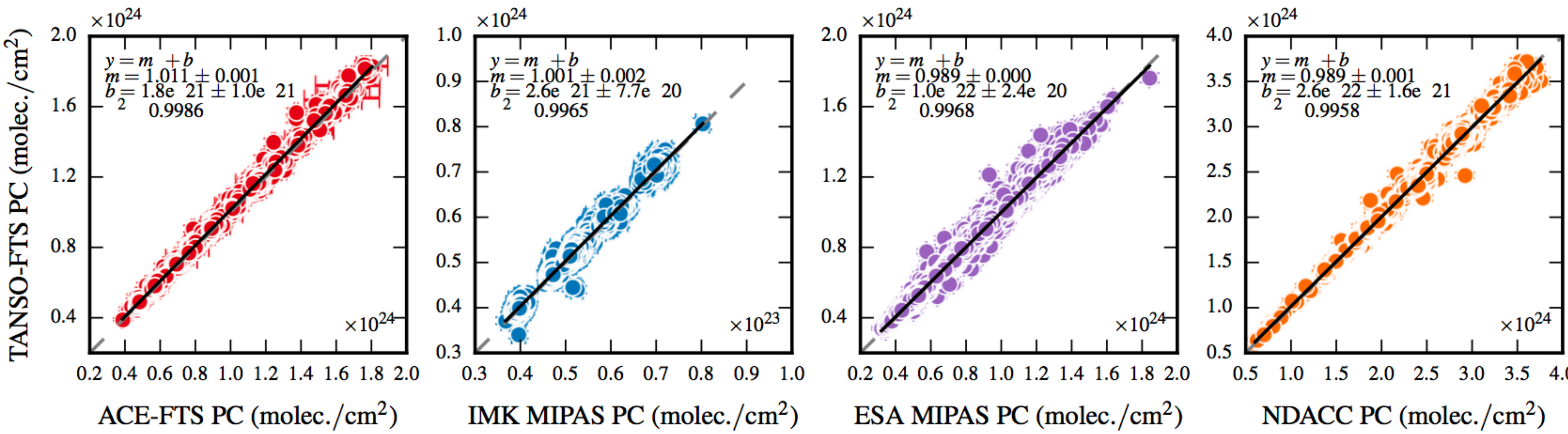
- Comparing TANSO-FTS (v1), ACE-FTS (v3.5), MIPAS (ESA ML2PP v6 and IMK-IAA V5R_CH4_224/225) and NDACC FTIR measurements globally
- First 200 coincidences of 2012 shown on map below



K. Olsen et al., Atmos. Meas. Tech., 10, 3697-3718 (2017).

CH_4 Comparisons versus GOSAT

- Because of measurement sensitivity and altitude range, need to work with partial columns for comparisons – tightly correlated for pairs of data sets
- Differences change by ~0.1 % per ten degrees latitude, these are smaller over equator and greater towards poles

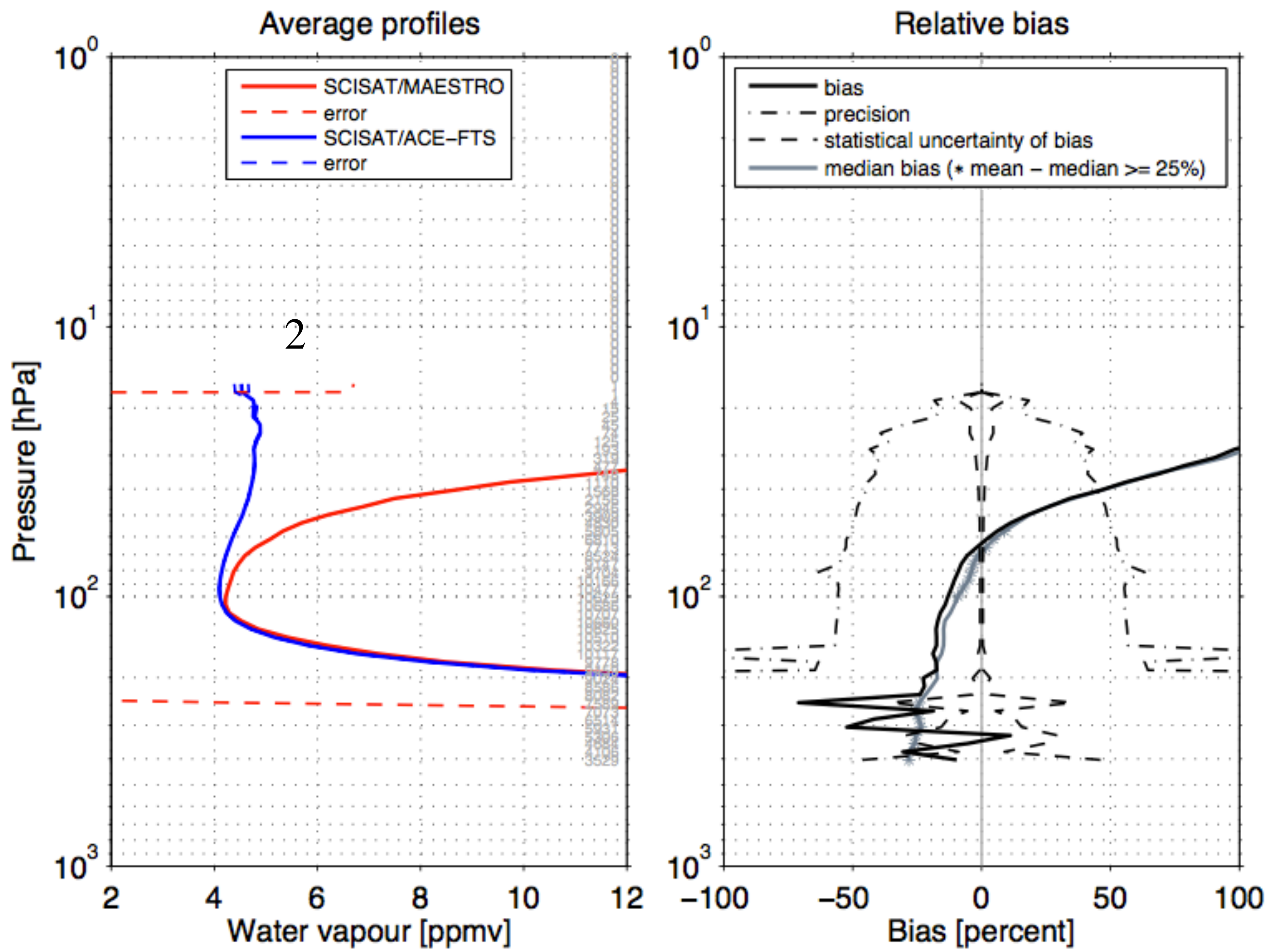


- TANSO-FTS vertical profiles agree with ACE-FTS and both MIPAS retrievals' within 4 % below 15 km (smoothed) – differences can be on the order of 25 % without smoothing

K. Olsen et al., Atmos. Meas. Tech., 10, 3697-3718 (2017).

MAESTRO "Research" H_2O

- Method described in Sioris et al., Adv. Space Res. (2010)
- Chahine inversion using observed differential optical depth spectra from 926.0–969.7 nm
- UTLS product from ~5 km (cloud tops) to ~22 km
- Tends to be too wet in tropics; too dry in south pole summer

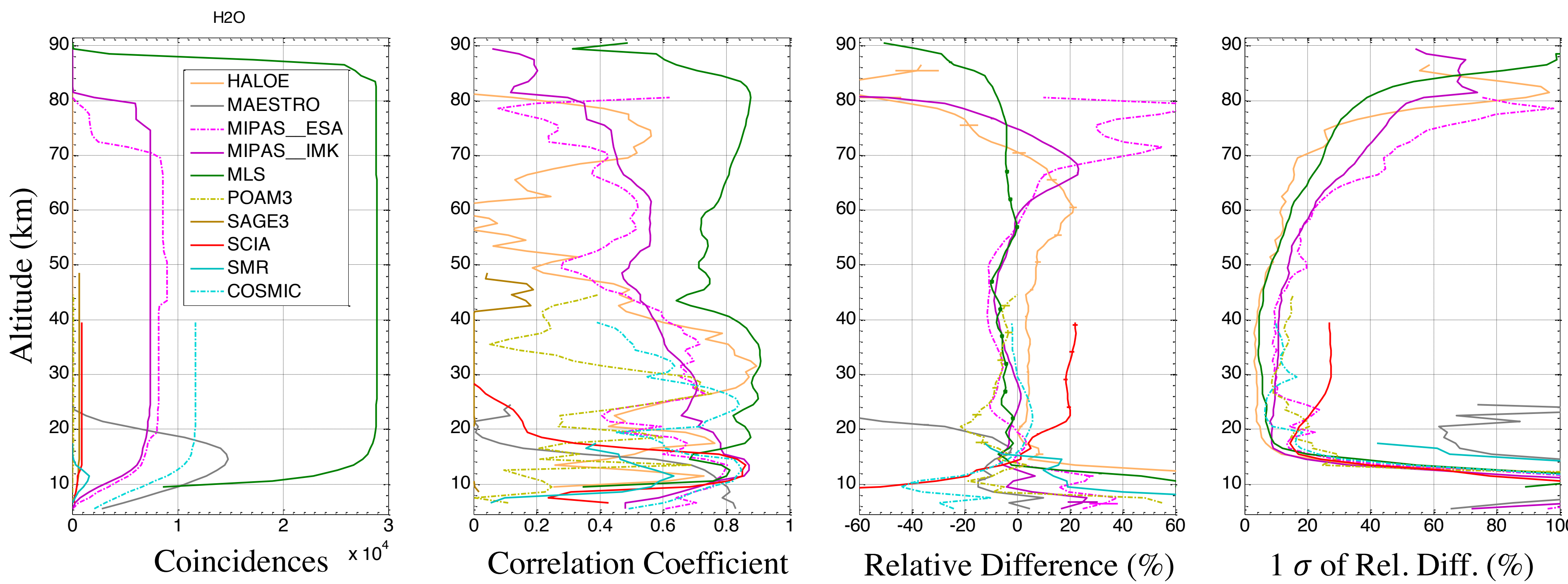


2004-2010 global; 12541 pairs; ACE-FTS; MAESTRO

Chris Sioris and Stefan Lossow

Limb satellite comparisons – H_2O

- Detailed comparisons being done as part of SPARC WAVAS-II project – better consistency seen above 20 km
- Note, MAESTRO retrieval works best in troposphere

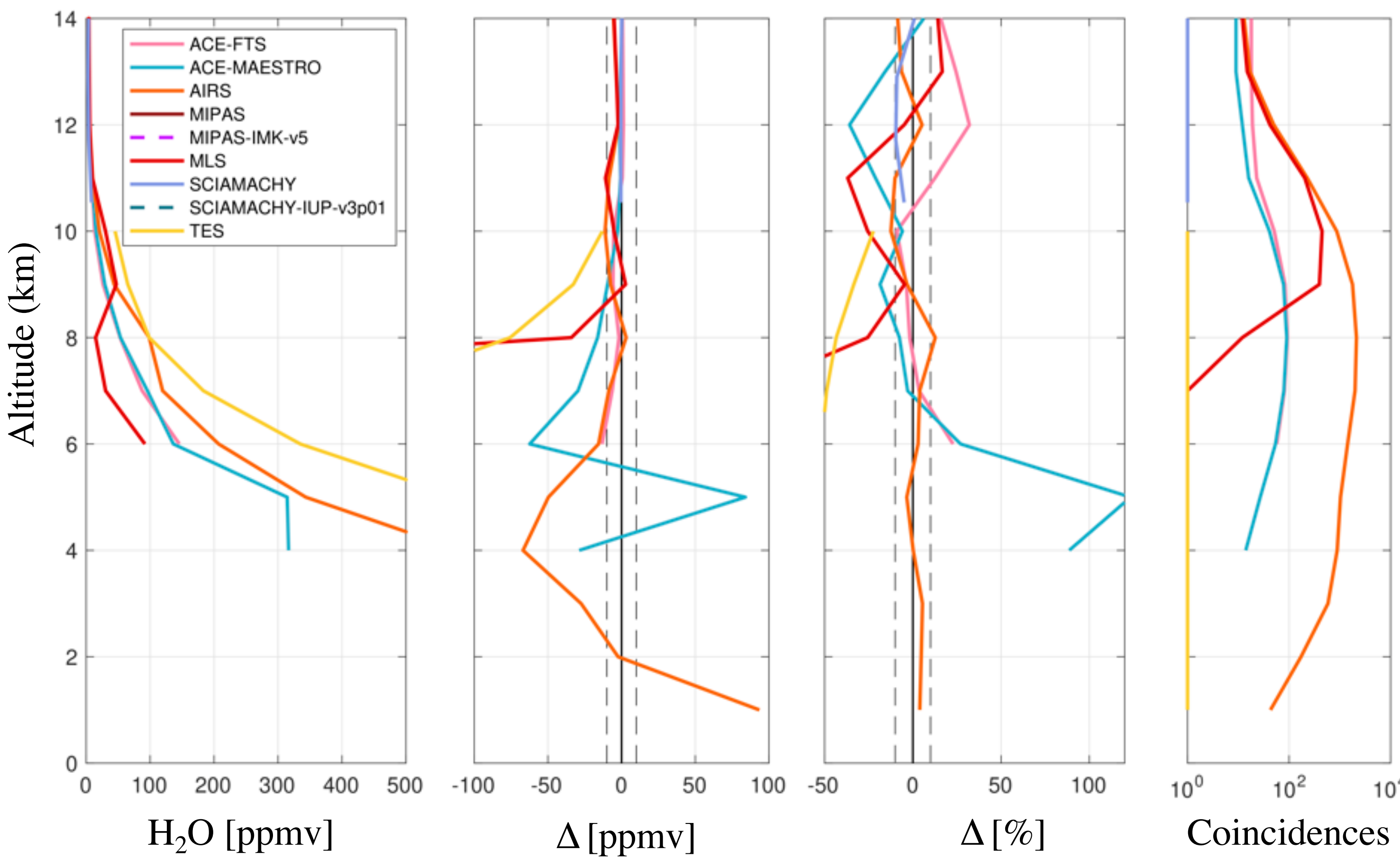


MAESTRO v30; MLS v4.2; SMR v2.1; COSMIC v3520; SCIAMACHY 3.0; HALOE v19; MIPAS IMK-IAA v5R 220; MIPAS ESA v7; SAGE III v3; POAM III v4

Patrick Sheese

H_2O profiles versus Radiosondes

- Using coincident radiosondes from Eureka Weather Station (~80 N, 86W)
- Tropospheric performance shown for ACE-MAESTRO
- 2009-2017 period for comparisons



Calculated as (Satellite – Radiosonde); Relative to Radiosonde

D. Weaver et al., in preparation.

Summary

- ACE Instruments and satellite are continuing to function nominally and produce excellent results
- Profile measurements for greenhouse gases including N_2O, CH_4 and H_2O are available
  - Reprints available from http://www.ace.uwaterloo.ca

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