Karlsruhe Institute of Technology

The SPARC Water Vapor Assessment II - Quality assessment of water vapor data records from satellites

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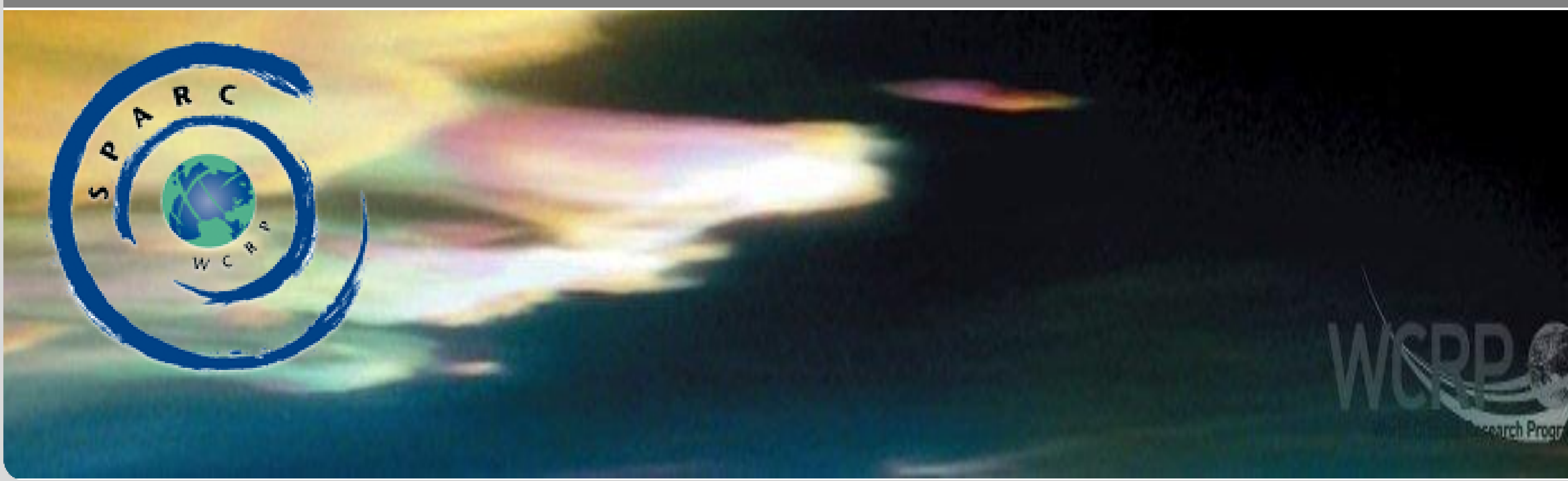
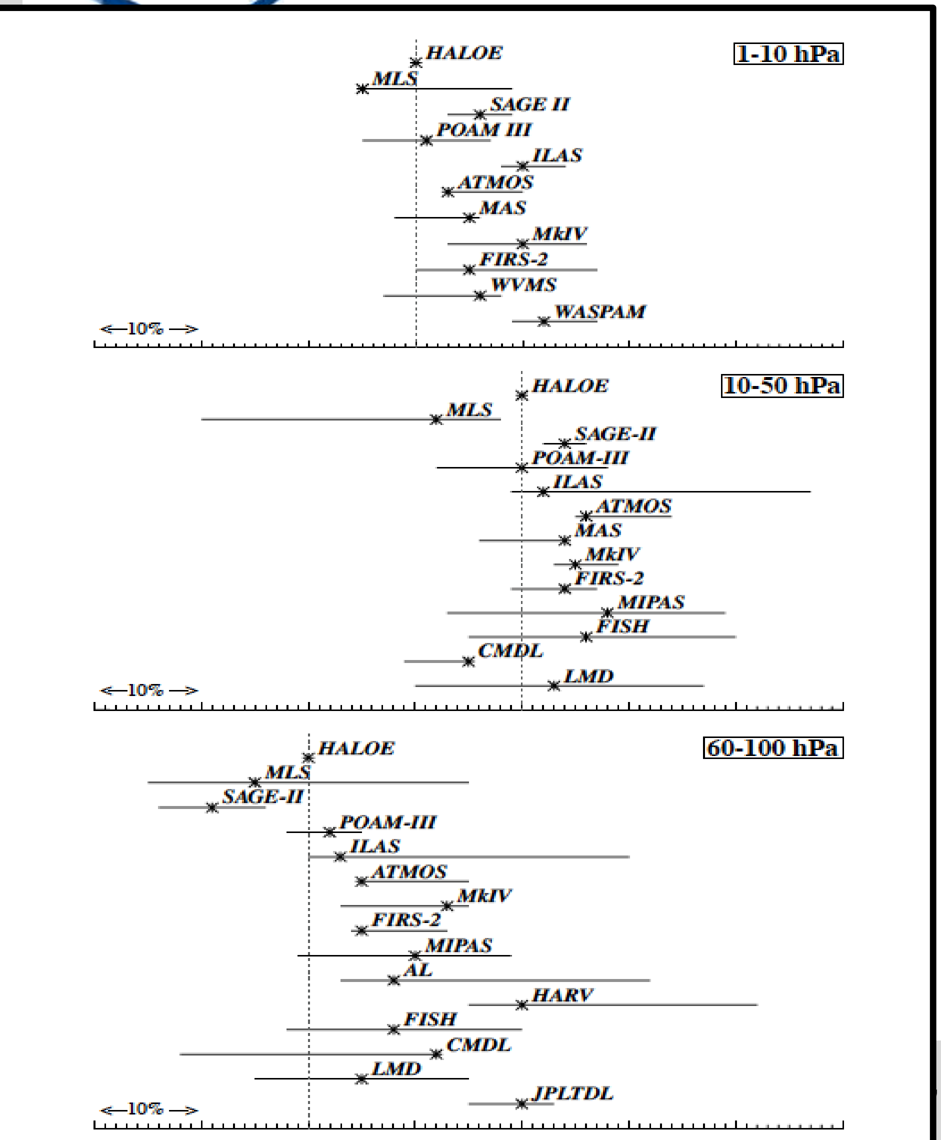
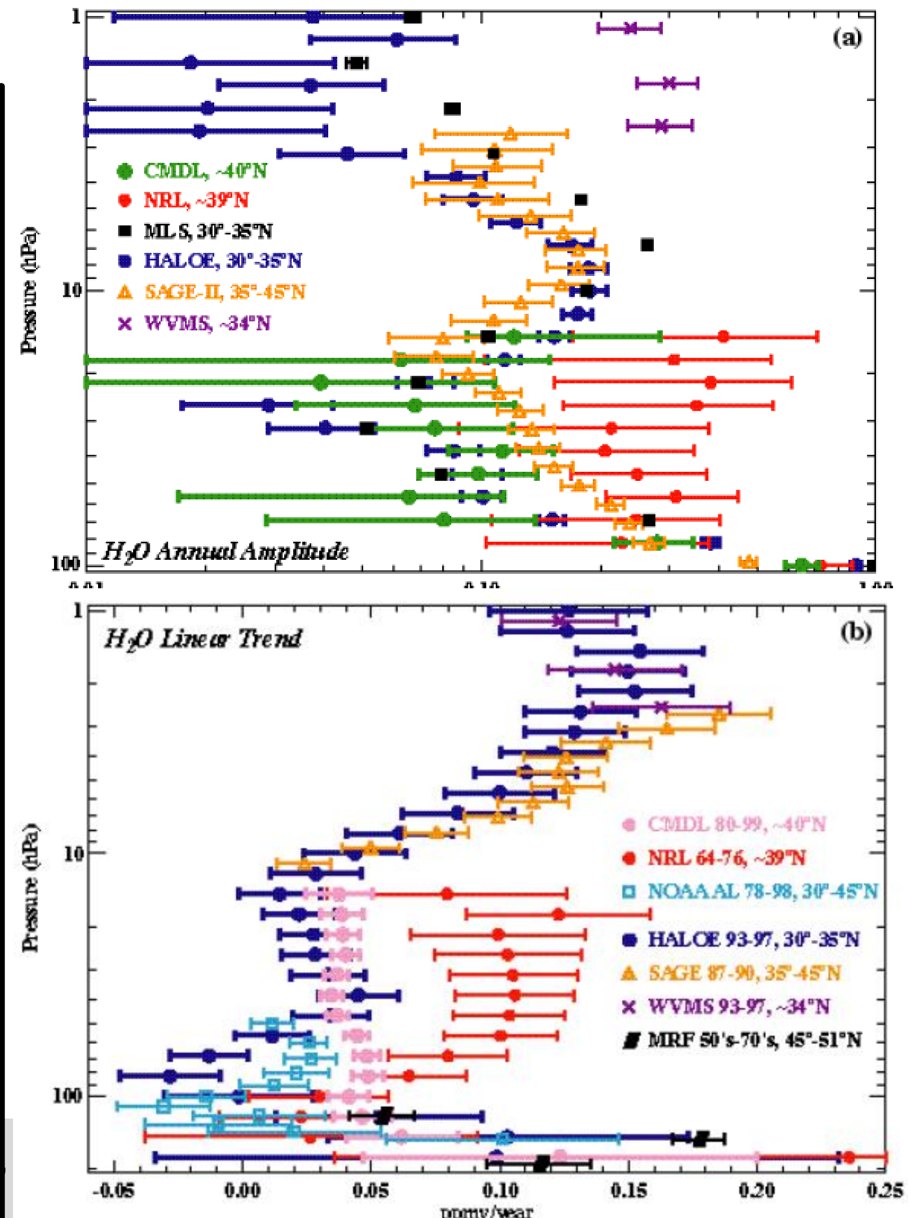
Institute for Meteorology and Climate Research (IMK-ASF)



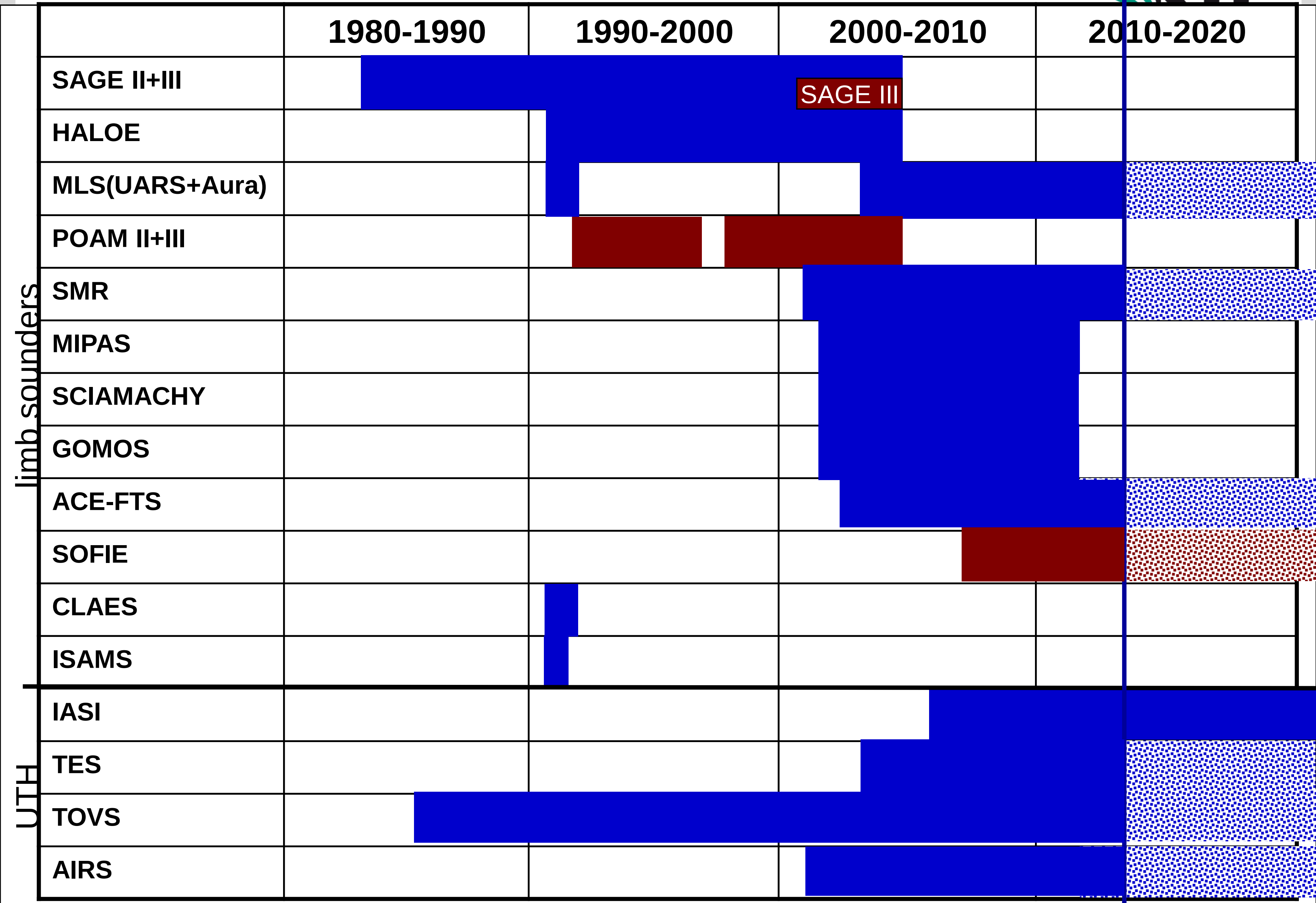
“Assessment of Upper Tropospheric and Lower Stratospheric (UTLS) Water Vapour” – SPARC Report No. 2 (2000)





ASF

Available Satellite Data Records



SPARC WAVAS-II satellite data quality assessment: Aims and scope

- Quantitative quality assessment of the new satellite data sets and improved data version of previous satellite data sets
- Be as inclusive as possible
- 4 main questions:
  - How do satellite data compare to frost point hygrometer and ground-based microwave data?
  - How do coincident satellite data compare to each other for certain regions and time periods?
  - How is temporal variability represented in the satellite data sets?
  - How is upper tropospheric humidity represented in limb and nadir sounding satellite data?
- Vertical range ~250 hPa to 0.1 hPa
- Assess quality of water vapor isotopologue data sets as well (mainly HDO/δD)
- Not considered here: relative humidity/supersaturation/cloud formation
- Focus strictly on satellite data records; no intercomparison of ground-based, aircraft, balloon-borne instruments

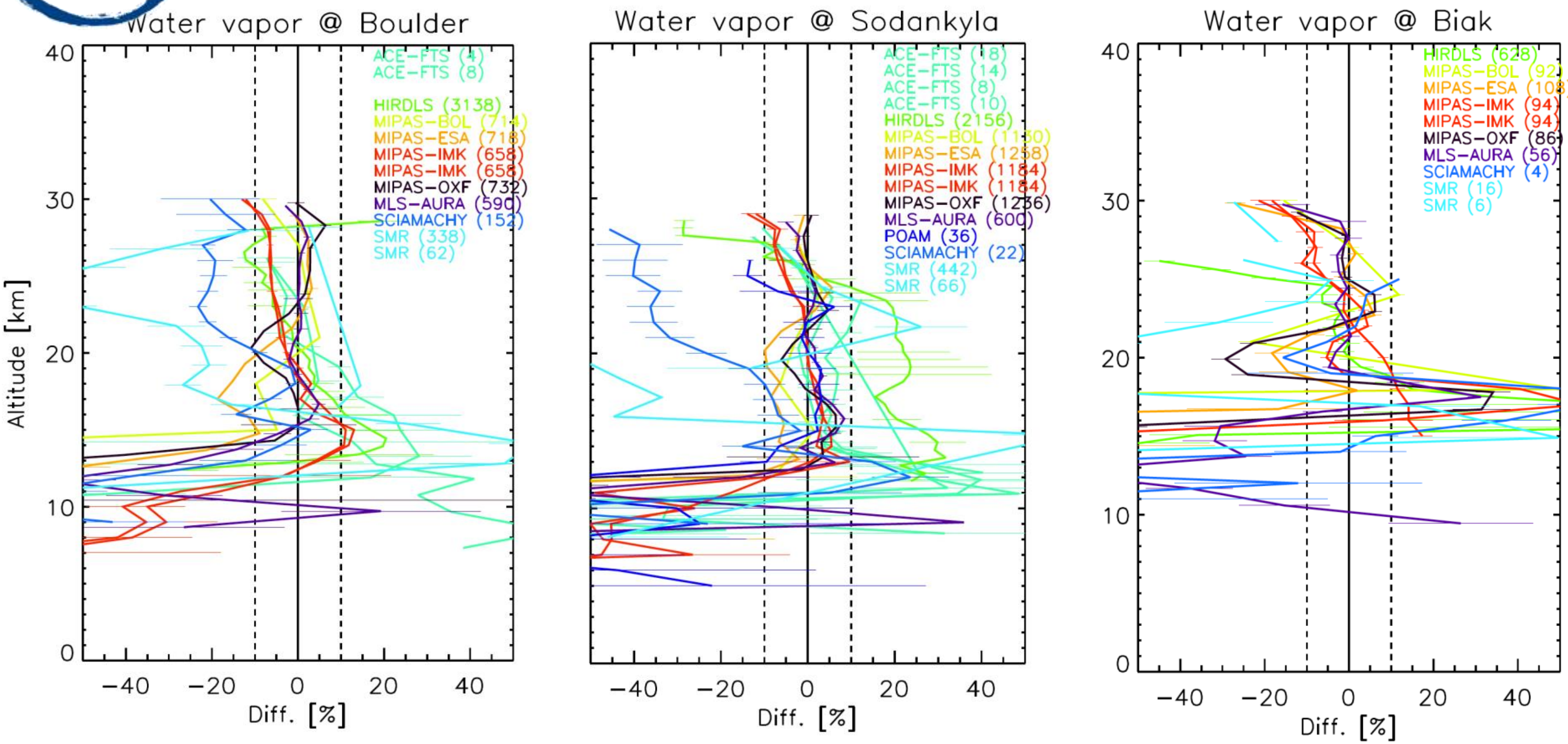
Comparisons to frost-point hygrometer data

Site	Period	Instrument	PI's
Bandung	2003-2004	CFH	Masatomo Fujiwara
Beltsville	2006-2011	CFH	Holger Vömel, Dave Whiteman
Biak	2006-2012	CFH	Fumio Hasebe
Boulder	1980 - present	CFH / NOAA FPH	Dale Hurst, Sam Oltmans, Holger Vömel
Fort Sumner	1996 - 2004	NOAA FPH	Sam Oltmans
Hanoi	2007-2011	CFH	Shinja Ogino
Hawaii	2002 - present	CFH / NOAA FPH	Dale Hurst, Holger Vömel
Heredia	2005 - present	CFH	Holger Vömel, Selkirk
Huntsville	2002	NOAA FPH	Holger Vömel
Kiruna	1991 - 2003	NOAA FPH	Therry Deshler, Holger Vömel
Kototabang	2007 - 2008	CFH	Masatomo Fujiwara
Kunming	2009 - 2012	CFH / NOAA FPH	Jianchun Bian
La Reunion	2005 - 2011	CFH	Holger Vömel
Lauder	2003 - present	NOAA FPH	Dale Hurst
Lhasa	2010, 2013	CFH	Jianchun Bian
Lindenberg	2006 - present	CFH	Holger Vömel
Midland	2004	CFH	Holger Vömel
Ny Alesund	2002 - 2004, 2013 - present	CFH / NOAA FPH	Marion Maturili
Research Vessel Mirai	2011	CFH	Junko Suzuki
San Cristobal	1998 - 2007	CFH / NOAA FPH	Holger Vömel
Sodankyla	1995 - present	CFH / NOAA FPH	Rigel Kivi, Holger Vömel
Southern Great Plains	2003	CFH	Holger Vömel
Table Mountain	2006 - 2009, 2013	CFH / NOAA FPH	Thierry Leblanc, Holger Vömel, Dale Hurst
Tarawa	2005 - 2010	CFH	Masato Shiotani
Tengchong	2010	CFH	Xiangdong Zheng
Watukosek	2001 - 2003	NOAA FPH	Masatomo Fujiwara
Yangjiang	2010	CFH	Holger Vömel

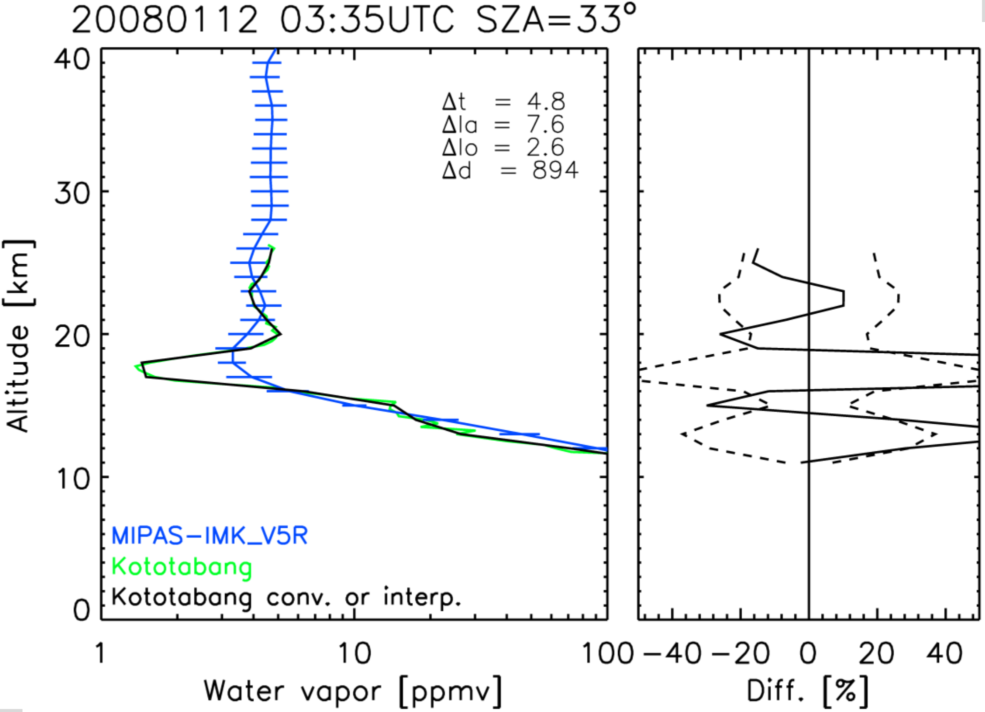
Coincidence criteria: Time difference < 12h and distance < 1000 km (circle)

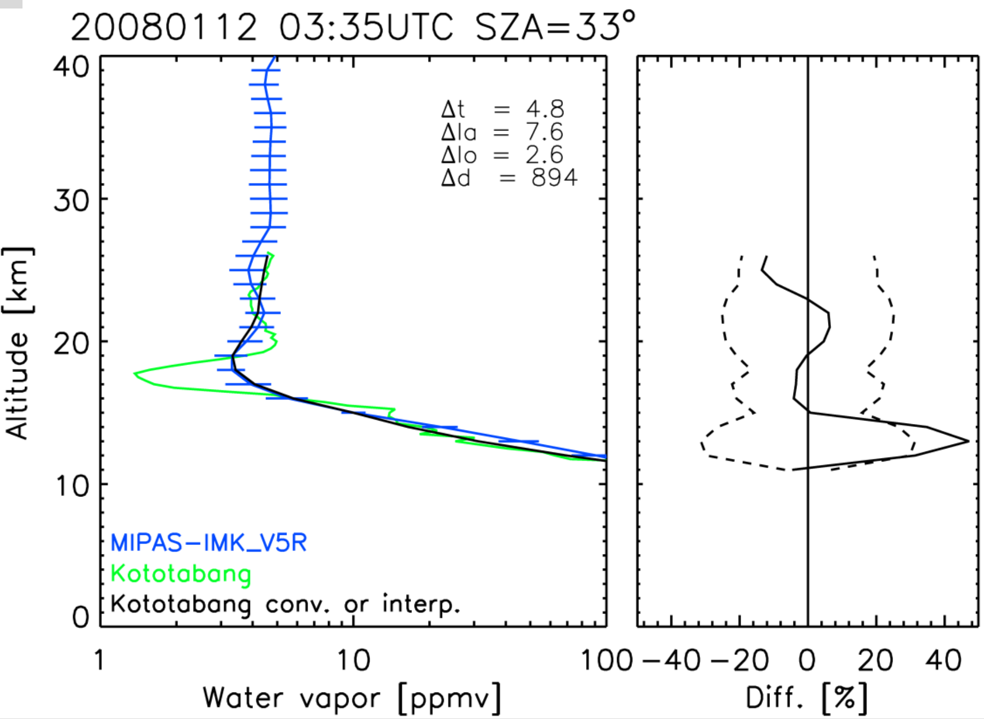
Note: each satellite or CFH/FPH profile can be chosen multiple for a colocation

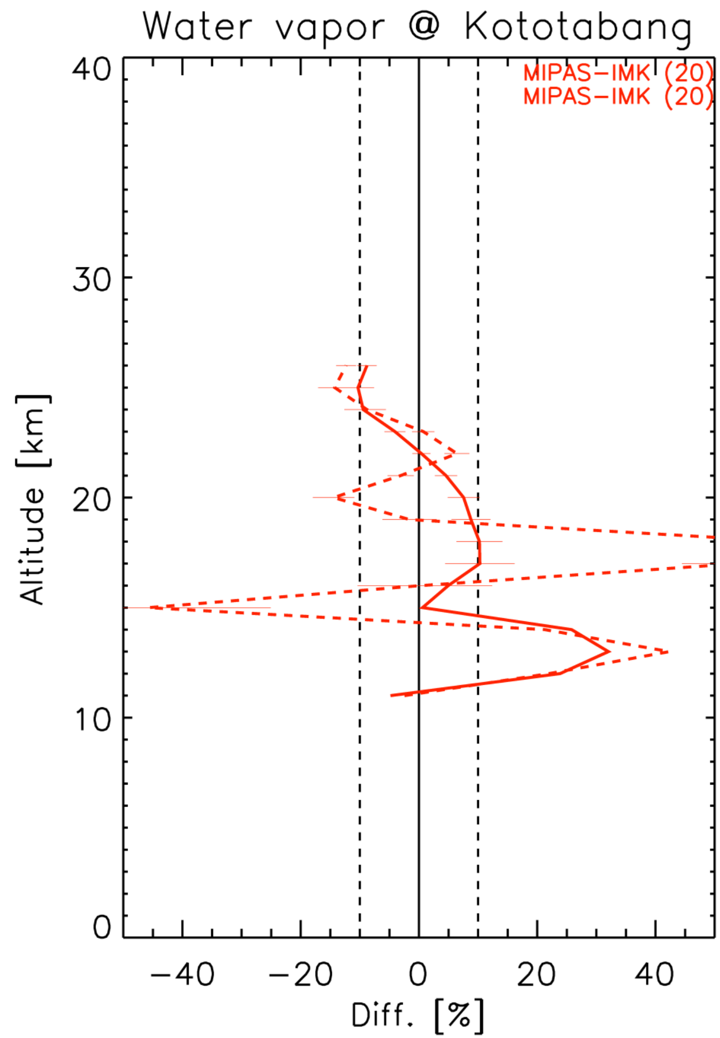
Examples: Boulder, Sodankylä, Biak



Still to do:
Reduce coincidence time/radius (at least for some of the instruments)
Complete for all satellite instruments
Compare to ground-based MW instruments for upper stratosphere
Redo analysis with averaging kernels applied
Analyze for potential drifts







Note: Application of the averaging kernel provides a measure how well the instrument performs compared to the best it could do (given by its principle measurement setup).

Intercomparison of co-incident satellite profiles

- Comparison on basis of co-incident observations avoids sampling artifacts due to e.g. density of coverage etc.
- A major intercomparison problem coming from different tropopause/hygropause heights can be widely avoided/diminished by restriction to co-incident observations
- Standard coincidenc criteria: < 1000 km, < 24 h; however, strongly reduced for dense samplers (e.g. < 250 km, < 6 h for MIPAS vs. MLS)
- Only the best coincidence is used (weighted by normalized sum of temporal and spatial distance)
- Some data sets require individual filtering (remove unphysical outliers)
- Examples for: global, certain latitude bands, Asian summer monsoon region, West Pacific etc.

Global, all year, reference: Aura/MLS

Water vapour comparisons for Aura/MLS

Creation Time:
02-12-2013
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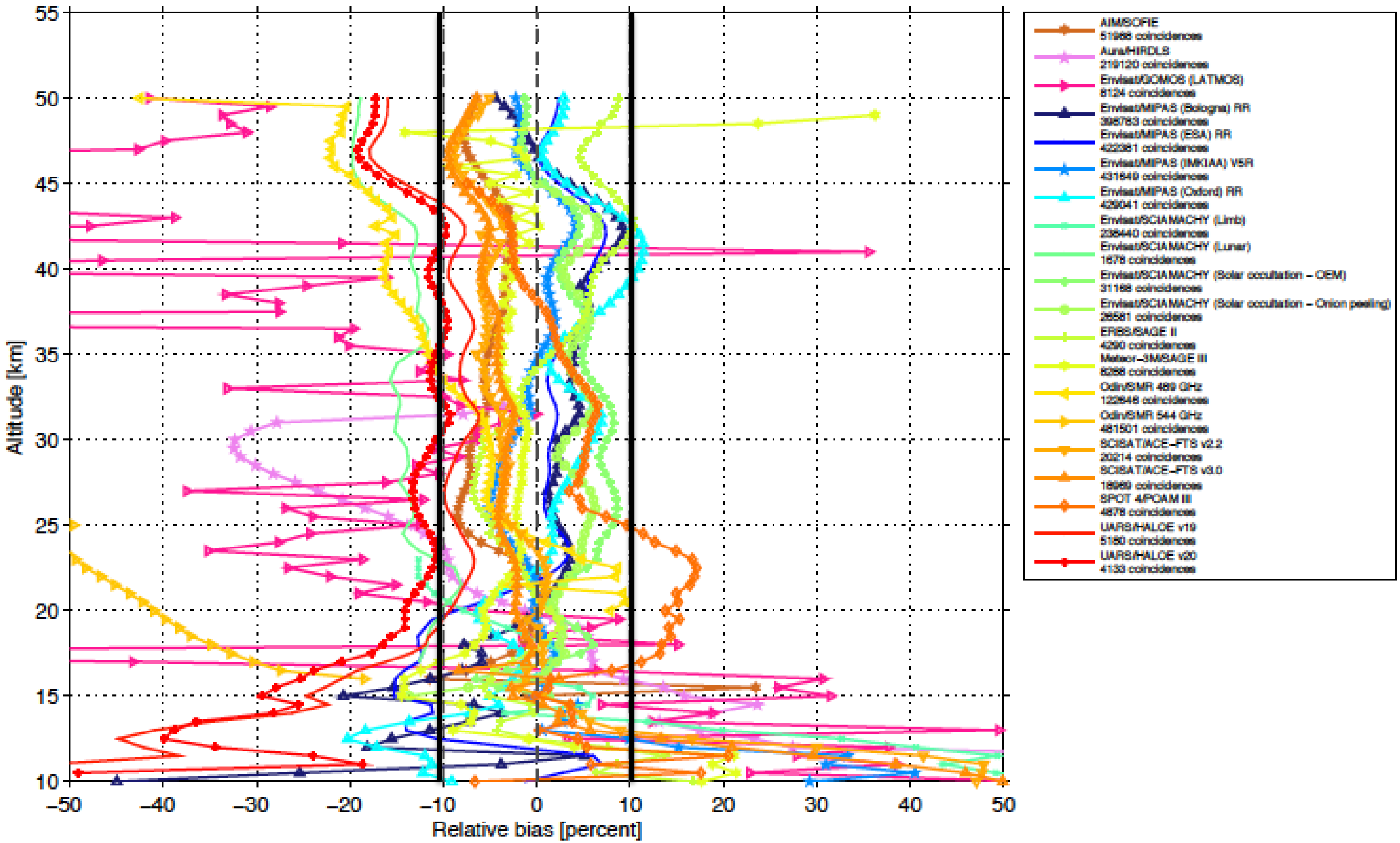
Considered: Day of year: 1 – 366 Latitude: 90 S – 90 N Longitude: 180 W – 180 E



Tropics, MAM, reference: Aura/MLS

Water vapour comparisons for Aura/MLS

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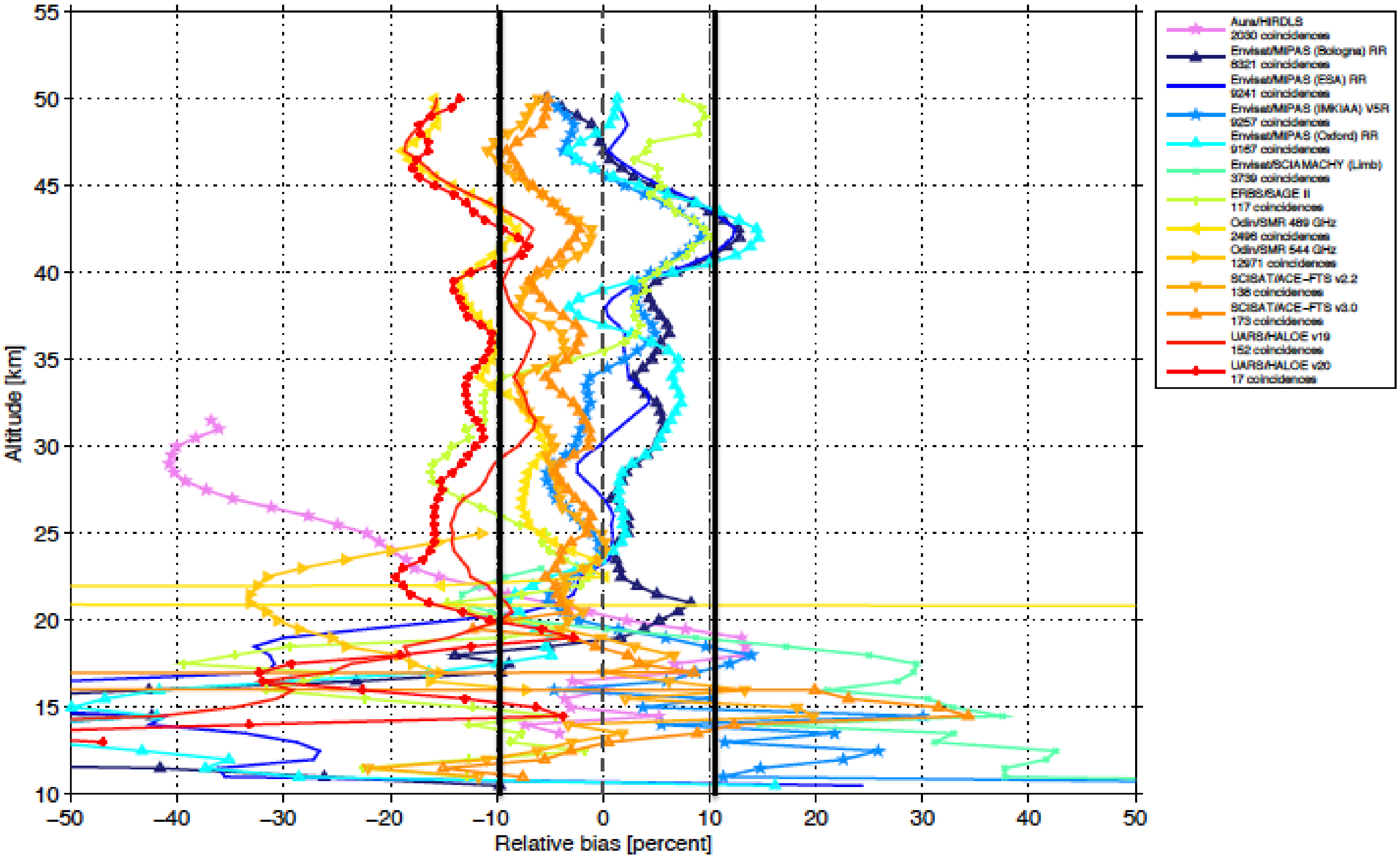
Considered: Day of year: MAM Latitude: 15 S – 15 N Longitude: 180 W – 180 E



Tropics, MAM, reference: MIPAS/Envisat

Water vapour comparisons for Envisat/MIPAS

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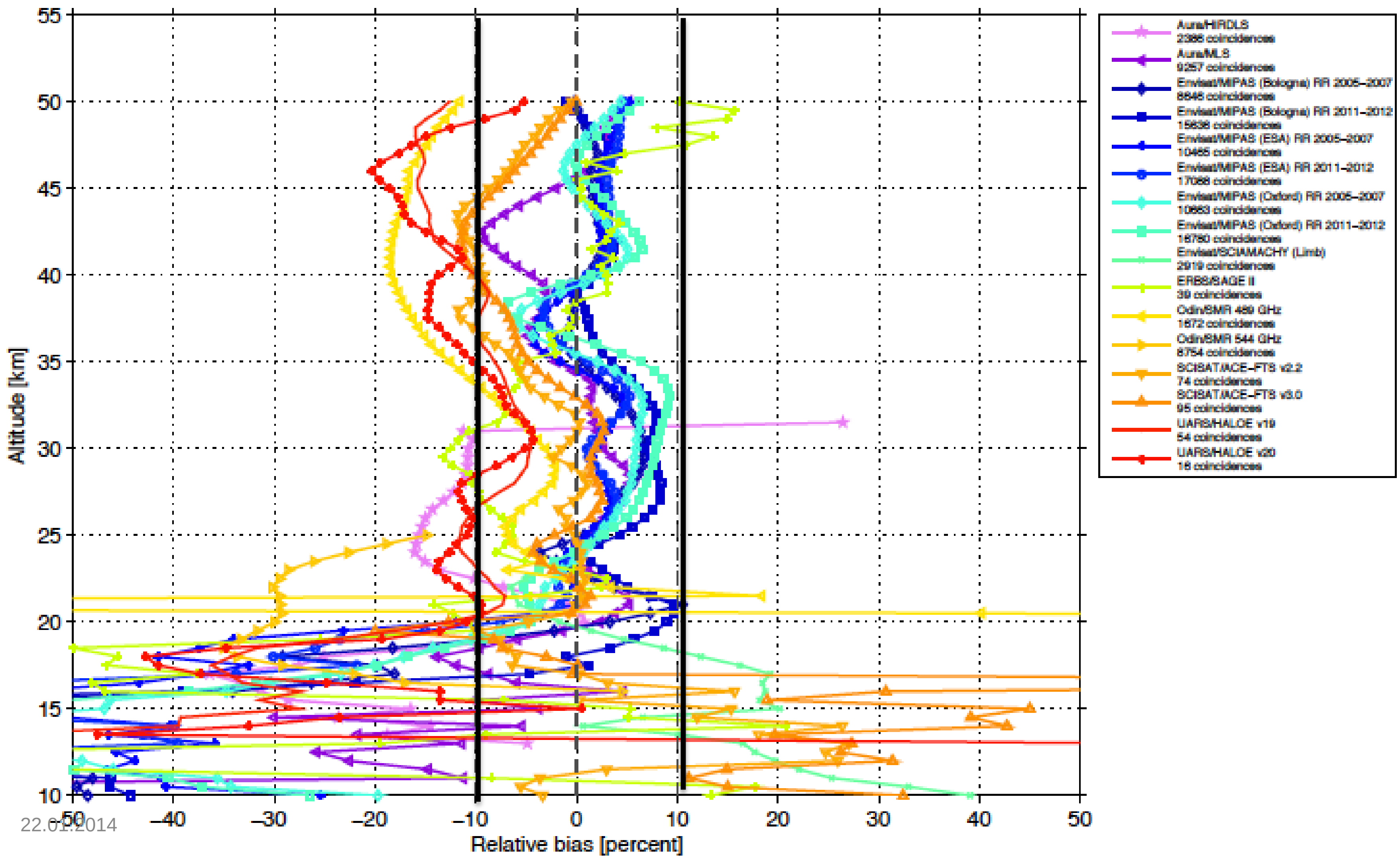
Considered: Day of year: MAM Latitude: 15 S – 15 N Longitude: 180 W – 180 E



Asian Monsoon, JA, reference: Aura/MLS

Water vapour comparisons for Aura/MLS

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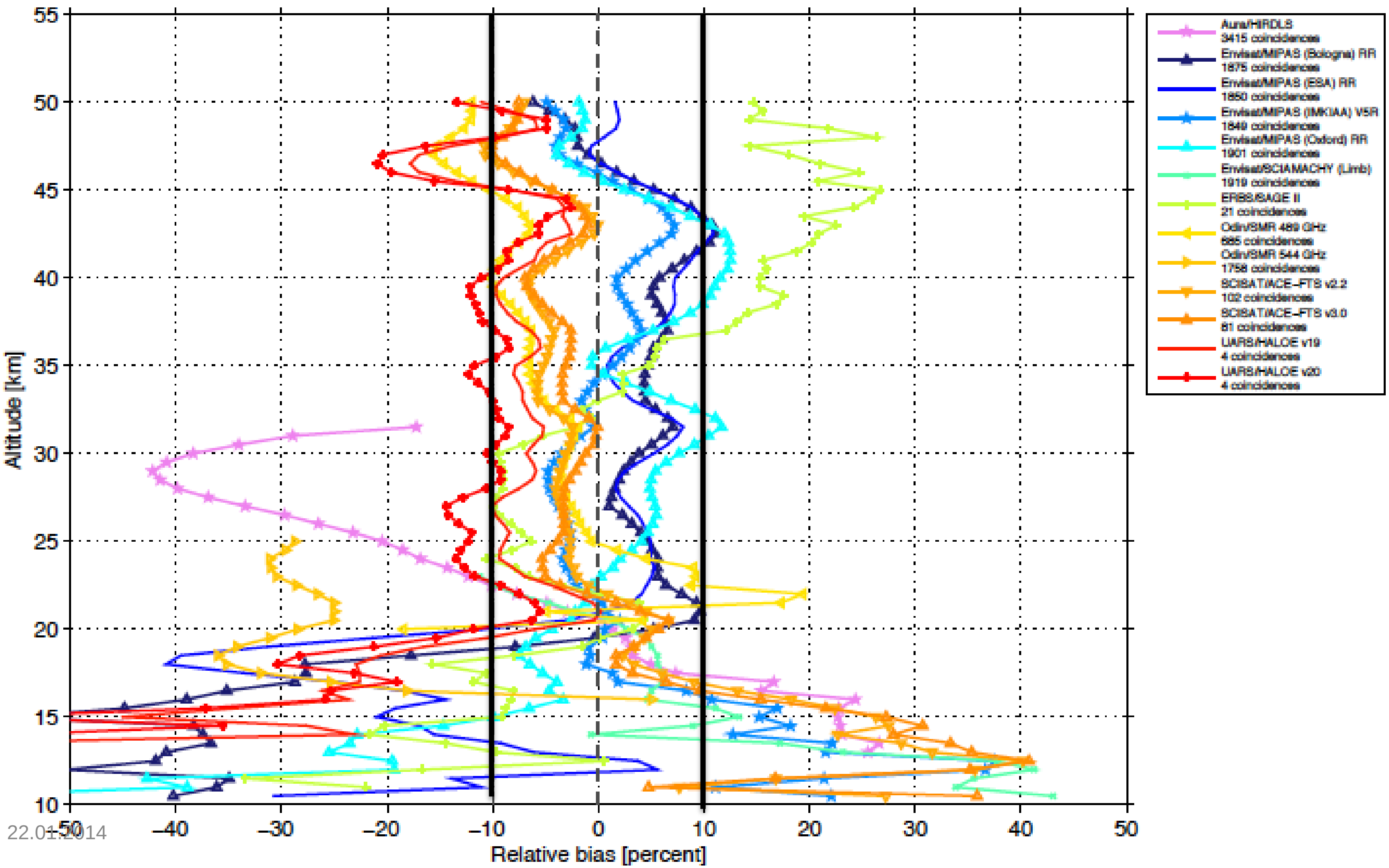
Considered: Day of year: 182 – 243 Latitude: 20 N – 45 N Longitude: 20 E – 120 E



West Pacific, DJF, reference: Aura/MLS

Water vapour comparisons for Aura/MLS

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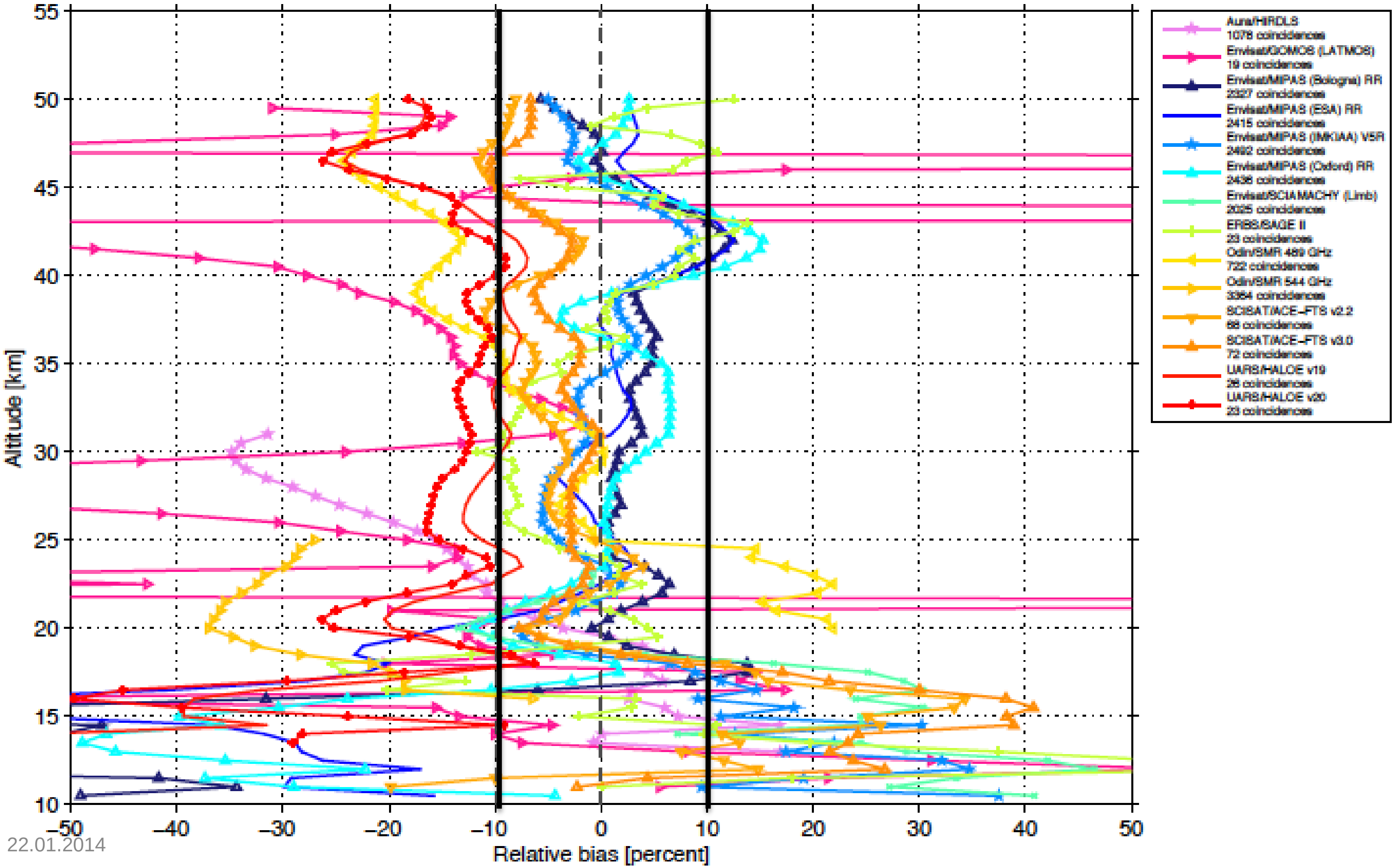
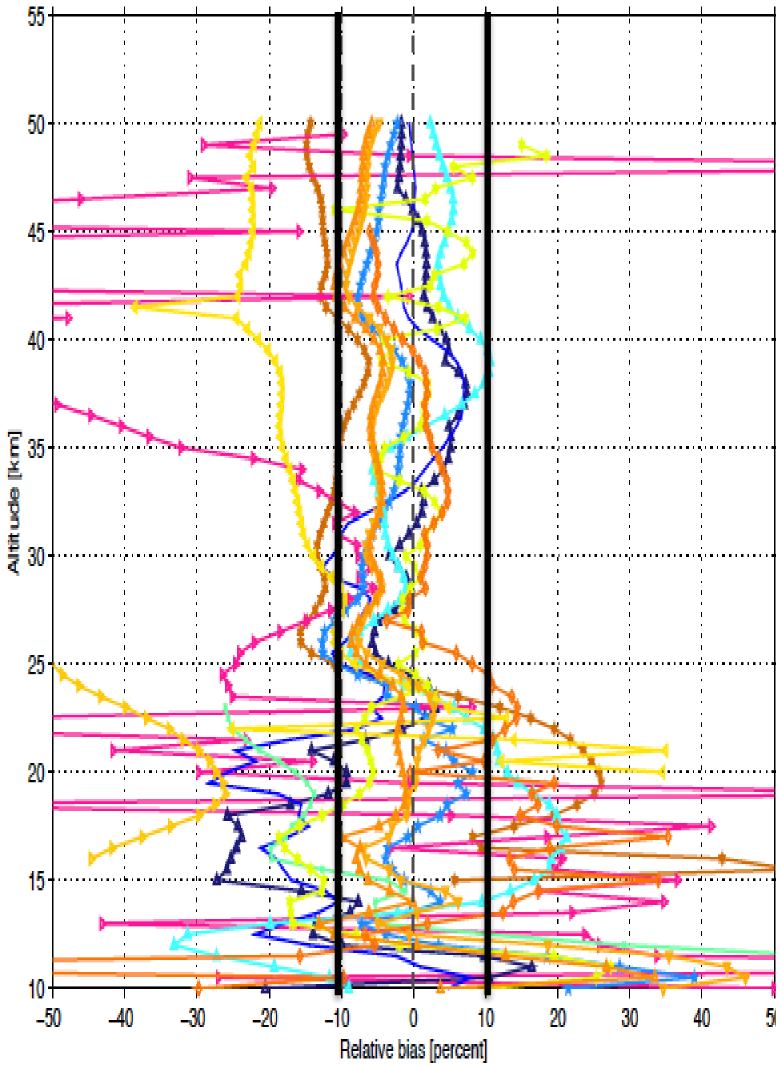
Considered: Day of year: DJF Latitude: 20 S – 20 N Longitude: 180 W – 120 W



NH/SH polar winter, reference: Aura/MLS

Water vapour comparisons for Aura/MLS **SH/JJA**

Considered: Day of year: JJA Latitude: 90 S – 60 S Longitude: 180 W – 180 E



Water vapour comparisons for Aura/MLS **NH/DJF**

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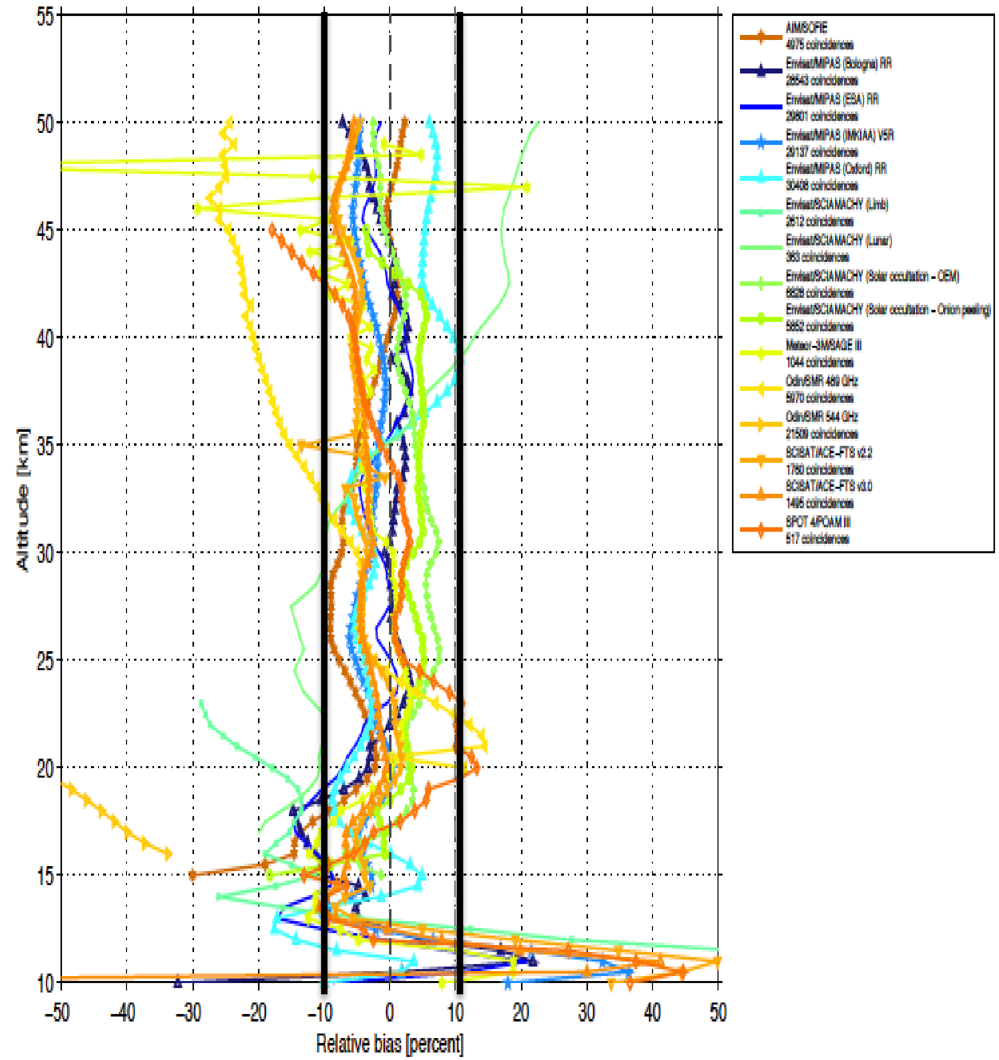
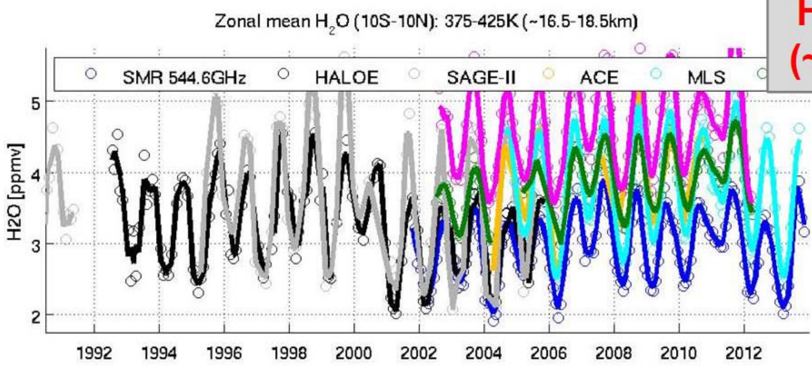
Considered: Day of year: DJF Latitude: 60 N – 90 N Longitude: 180 W – 180 E

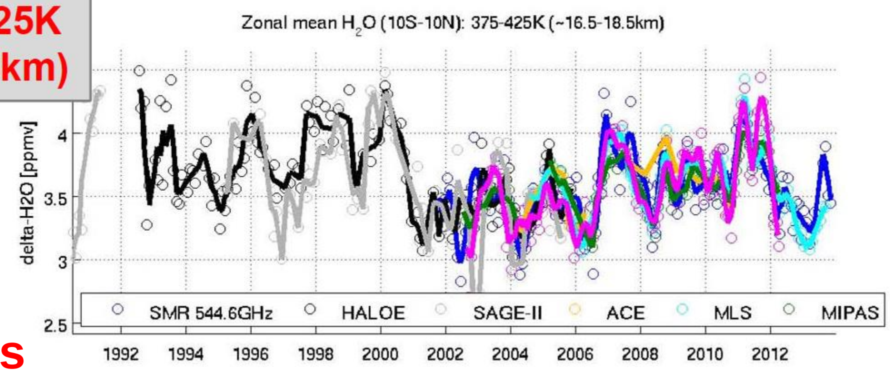


Representation of temporal variation

Tropics

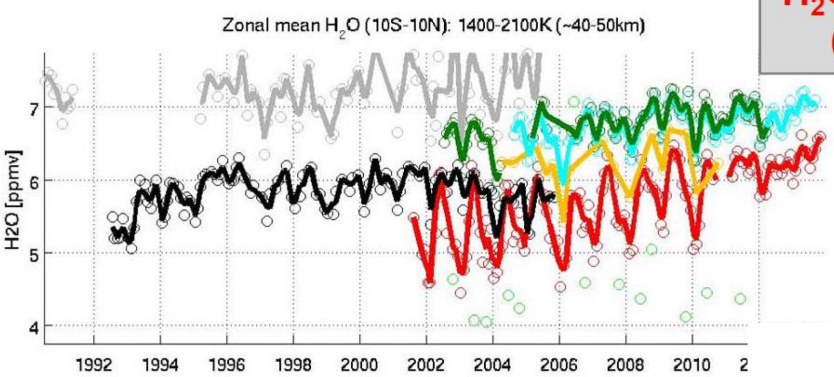
H_2O 375-425K (~16.5-18.5km)

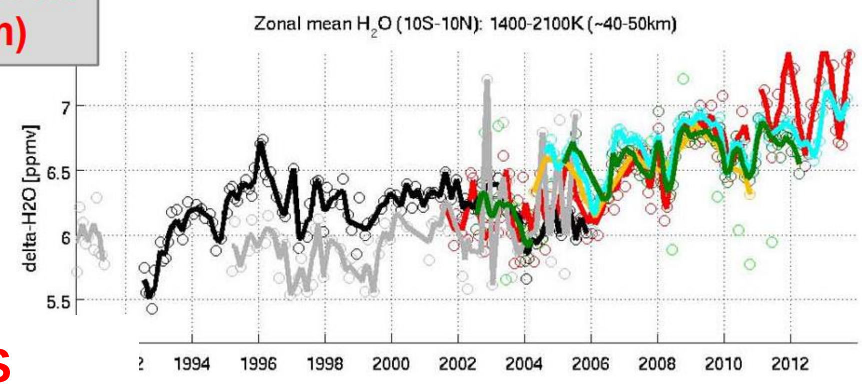




Tropics

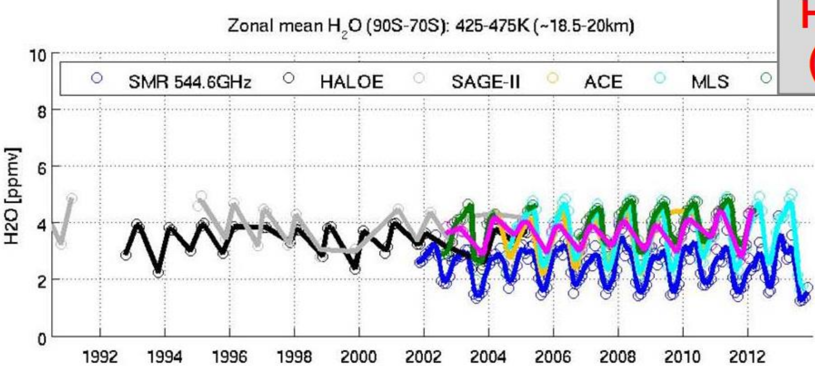
H_2O 1400-2100K (~40-50km)

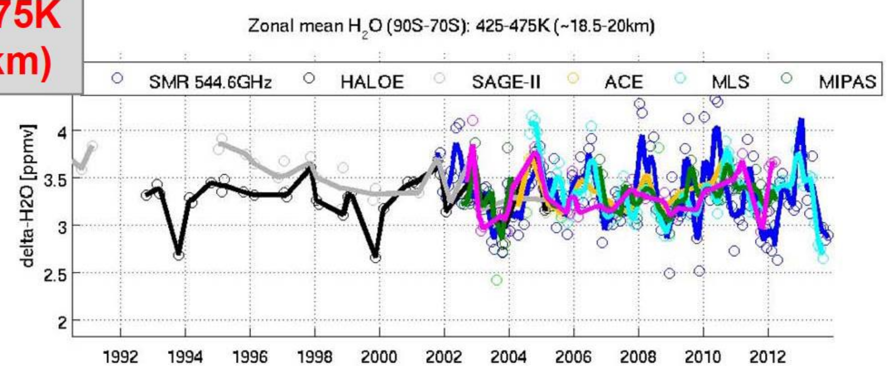




70-90 S

H_2O 425-475K (~18.5-20km)





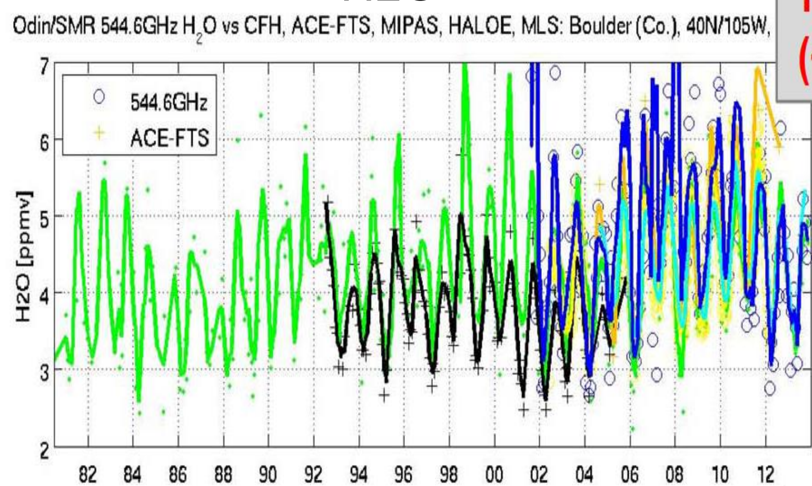
Representation of temporal variation – comparison vs. Boulder FPH time series

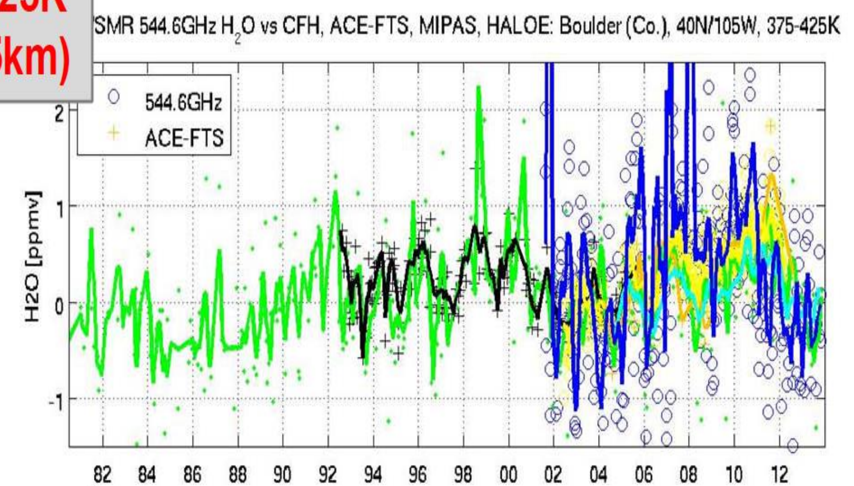
Boulder FPH SMR1 SMR2 MIPAS ACE-FTS HALOE MLS

H2O

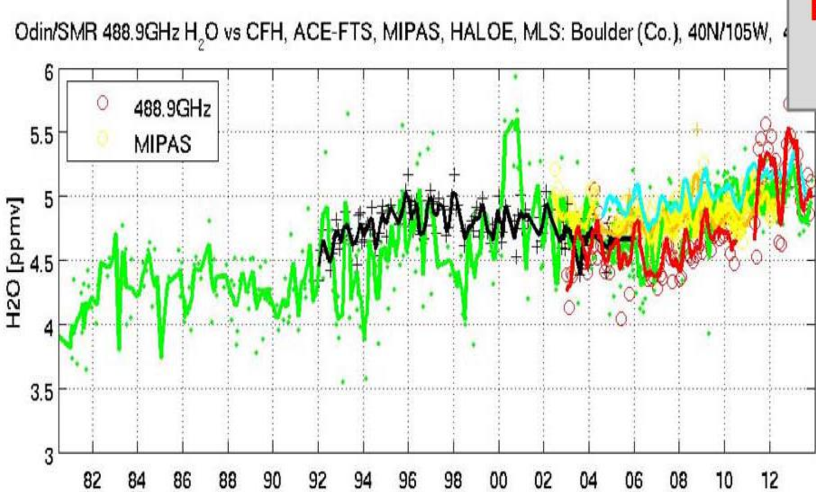
H2O anomaly

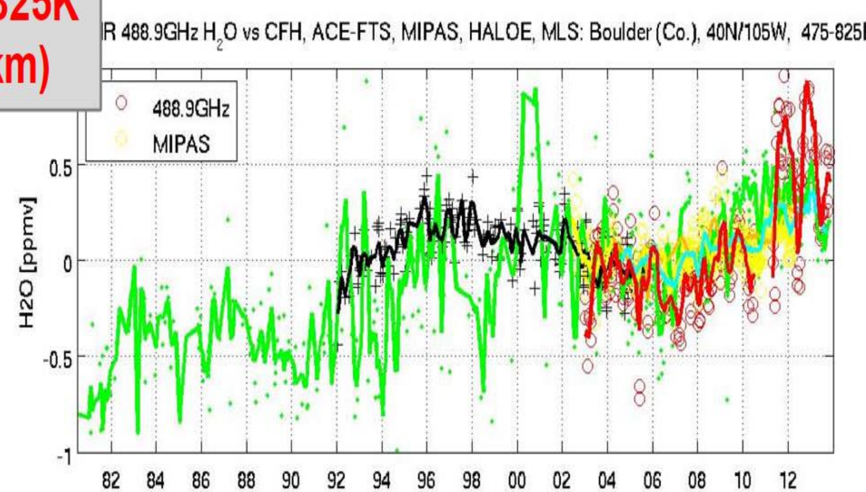
H2O 375-425K (~16.5-18.5km)





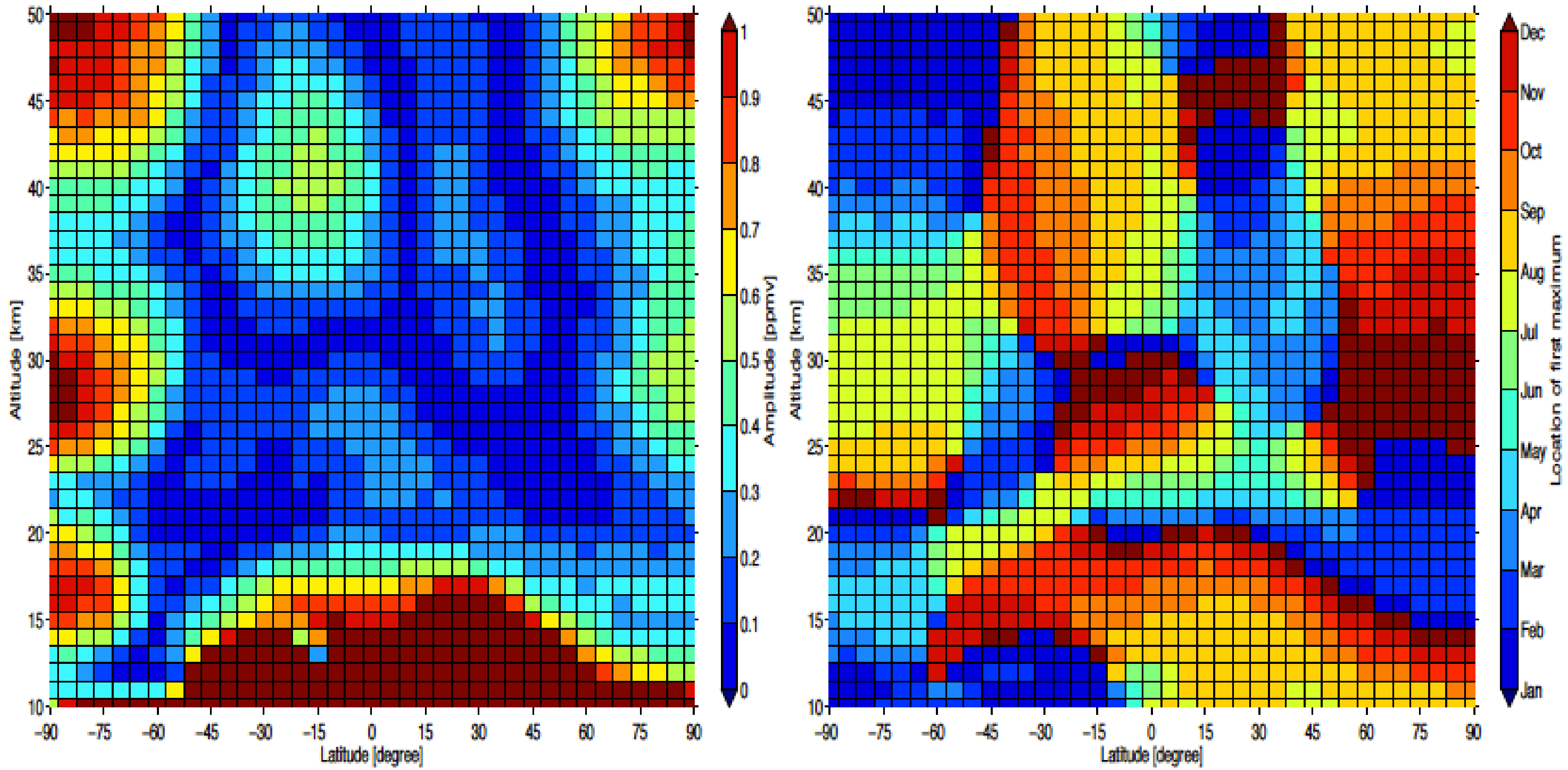
H2O 475-825K (~20-30km)





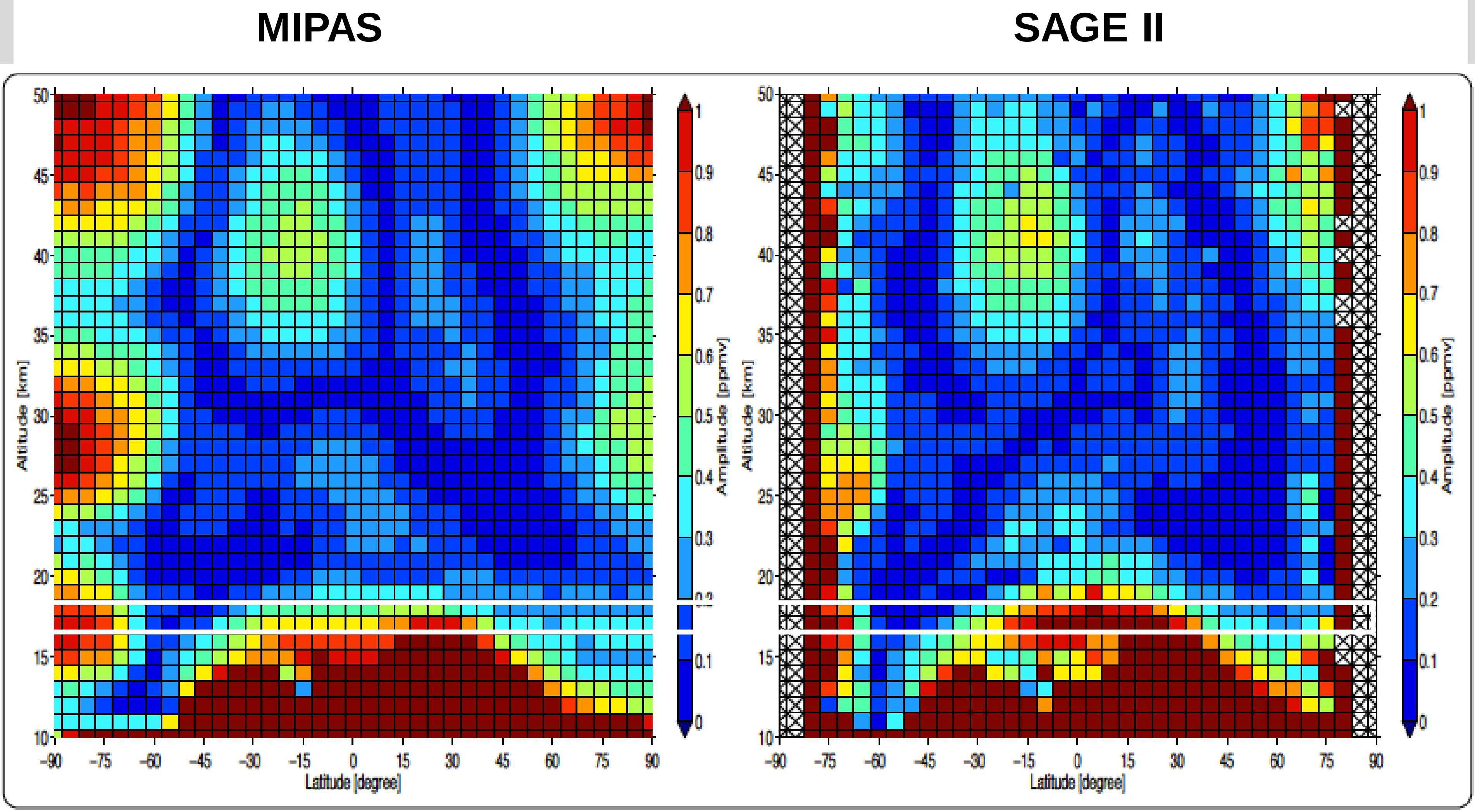
Seasonal variation: amplitude and phase

Amplitude 0 – 1 ppmv **Month of seasonal maximum Jan – Dec**



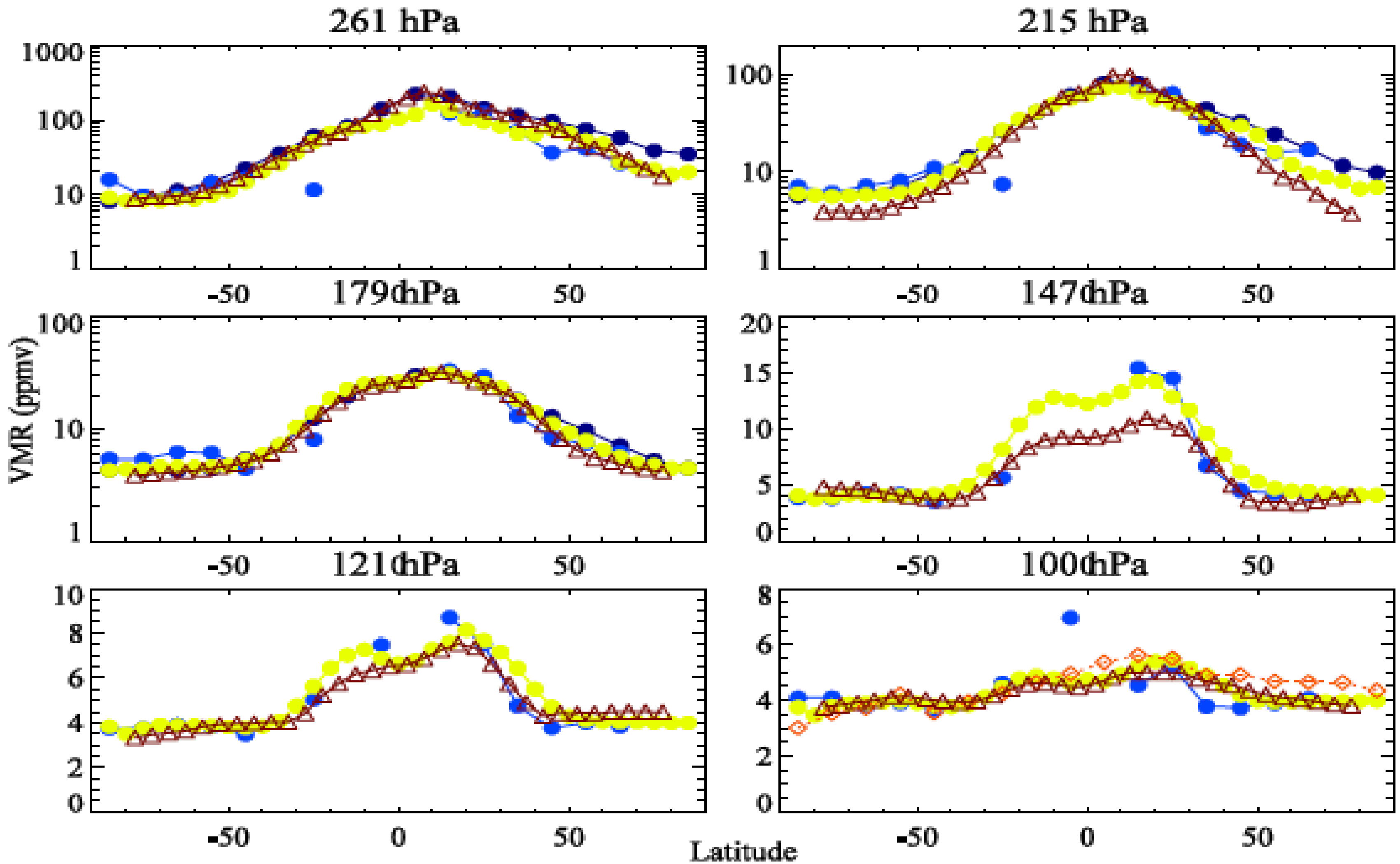
 SPARC-GA, Queenstown, New Zealand, 12-17 January 2014 G. Stiller, IMK-ASF

Comparison of amplitudes of seasonal variation among instruments



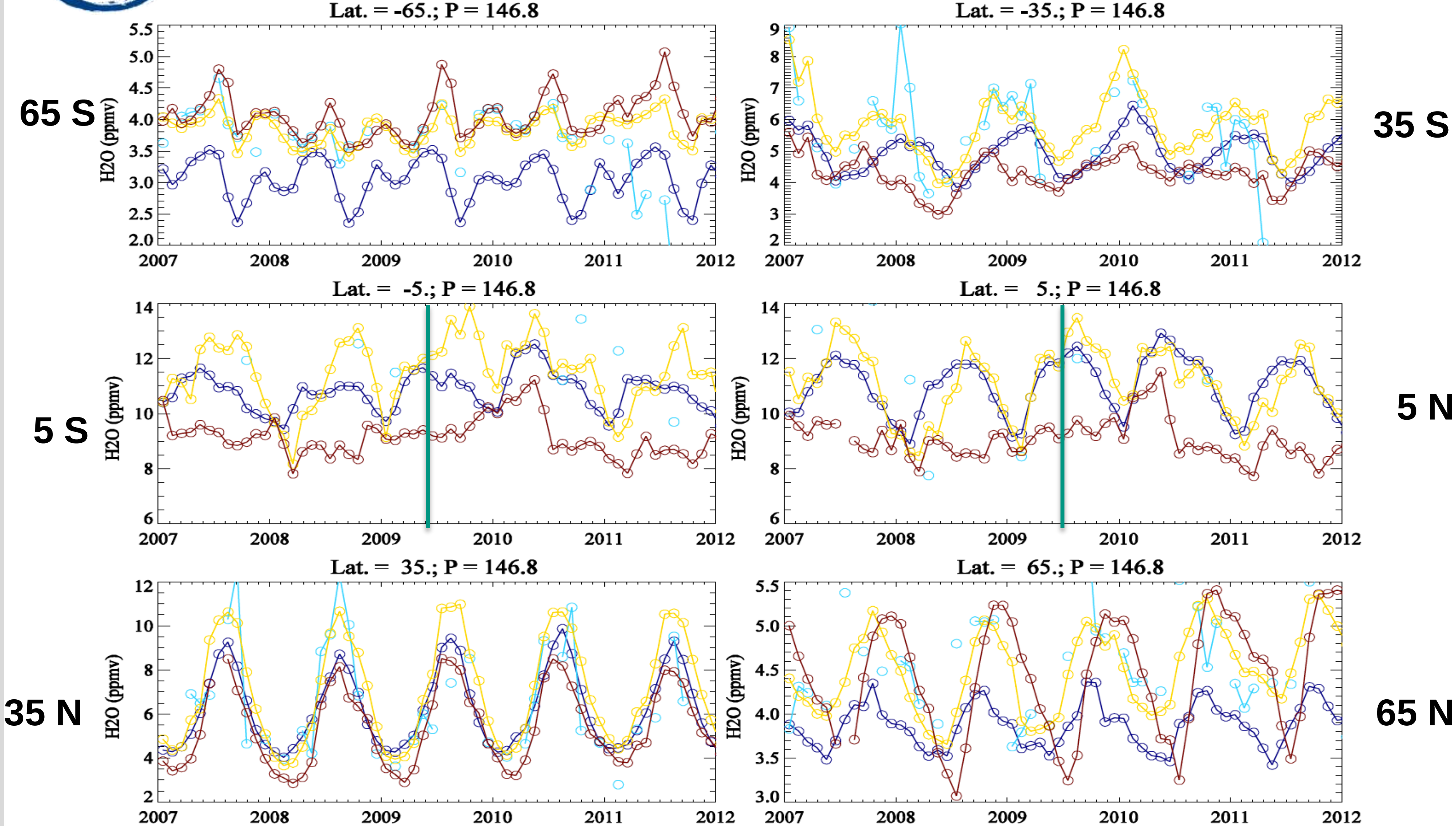
Comparison of upper tropospheric humidity

JJA 2009



AIRS v6 (L3), ACE FTS, MIPAS IMK, Odin SMR, MLS v3

UTH: Temporal evolution at 147 hPa



AIRS v6 (L3), ACE FTS, MIPAS IMK, Odin SMR, MLS v3

Summary and conclusions (so far)

- Above the hygropause many satellite instruments agree within ±10% with frost point hygrometer data.
- Sharp and deep hygropauses cannot be resolved by any satellite instrument.
- Below the hygropause deviations are much larger, with negative and positive biases of 40% and more.
- Inter-satellite comparisons agree often within 10%, at least above the hygropause.
- Large deviations below the hygropause; related to differing hygropause altitudes despite coincident observations?
- Temporal evolution: representations are different in absolute terms (bias, amplitude of seasonal cycle); agreement for de-biased, de-seasonalized time series ist much better.
- UTH: Latitudinal cross-sections are well reproduced by most instruments; time-series differ significantly
- Time-line: work to be finished and paper submitted by end of 2014

Global, all year, reference: MIPAS/Envisat

Water vapour comparisons for Envisat/MIPAS

Creation Time:
02–12–2013
19:09:38 LT

Considered: Day of year: 1 – 366 Latitude: 90 S – 90 N Longitude: 180 W – 180 E