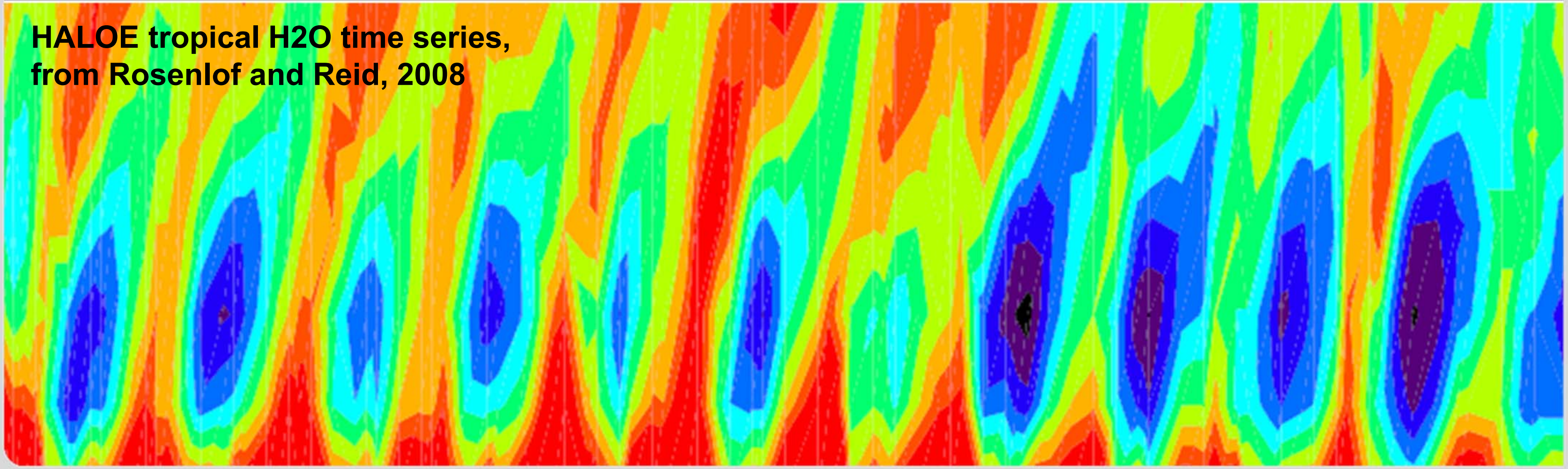
Global upper tropospheric/lower stratospheric water vapor from satellites

G.P. Stiller, S. Lossow, M. Kiefer, W. Read, K.H. Rosenlof, M. García-Comas, M.E. Hervig, G. Nedoluha, E.E. Remsberg, J.M. Russell III, T. Schieferdecker, L. W. Thomason, J. Urban, K.A. Walker, M. Weber, J.M. Zawodny

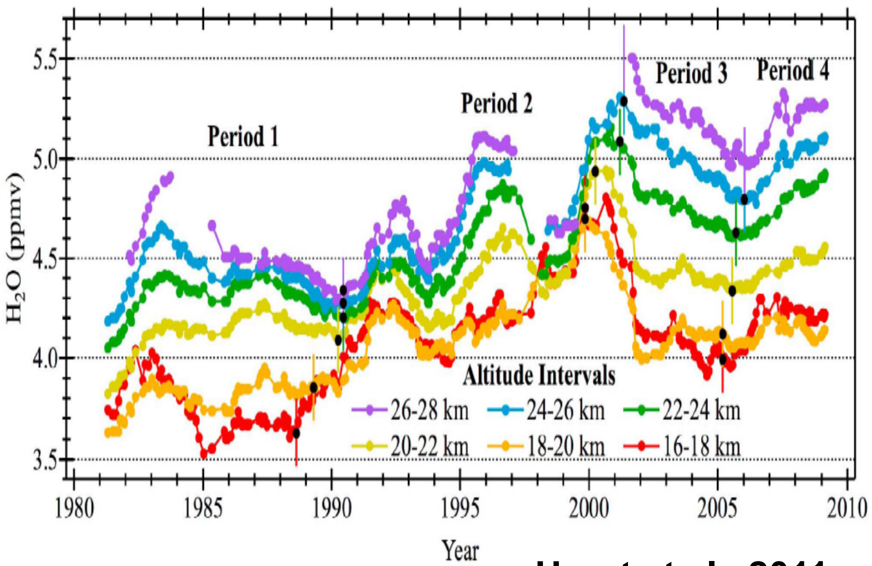
Institute for Meteorologie and Climate Research – Atmospheric Trace Gases and Remote Sensing



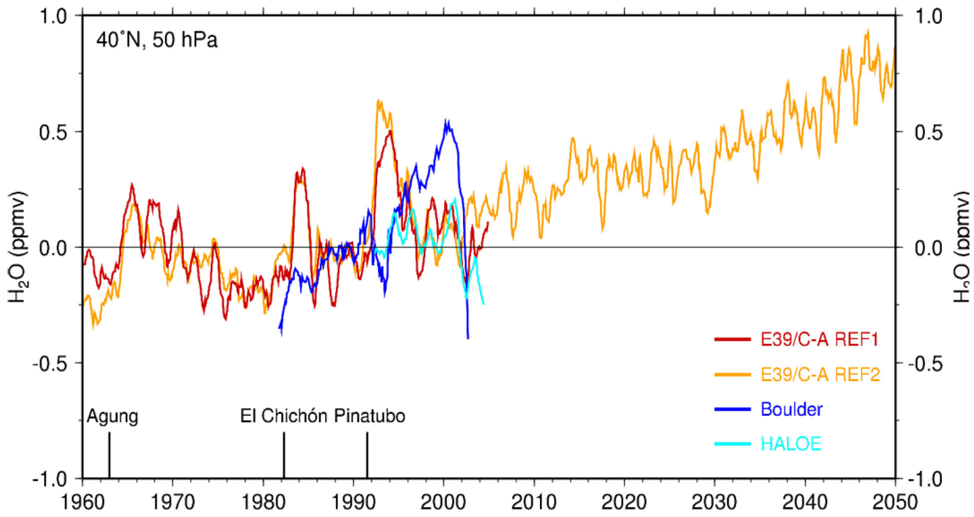
HALOE tropical H2O time series, from Rosenlof and Reid, 2008

Motivation

- Water vapor is the most powerful greenhouse gas in the atmosphere
- The temporal variation of lower stratospheric water vapor is not yet fully understood
- Water vapor transport into the stratosphere seems to be largely, but not fully ruled by the tropical tropopause temperatures

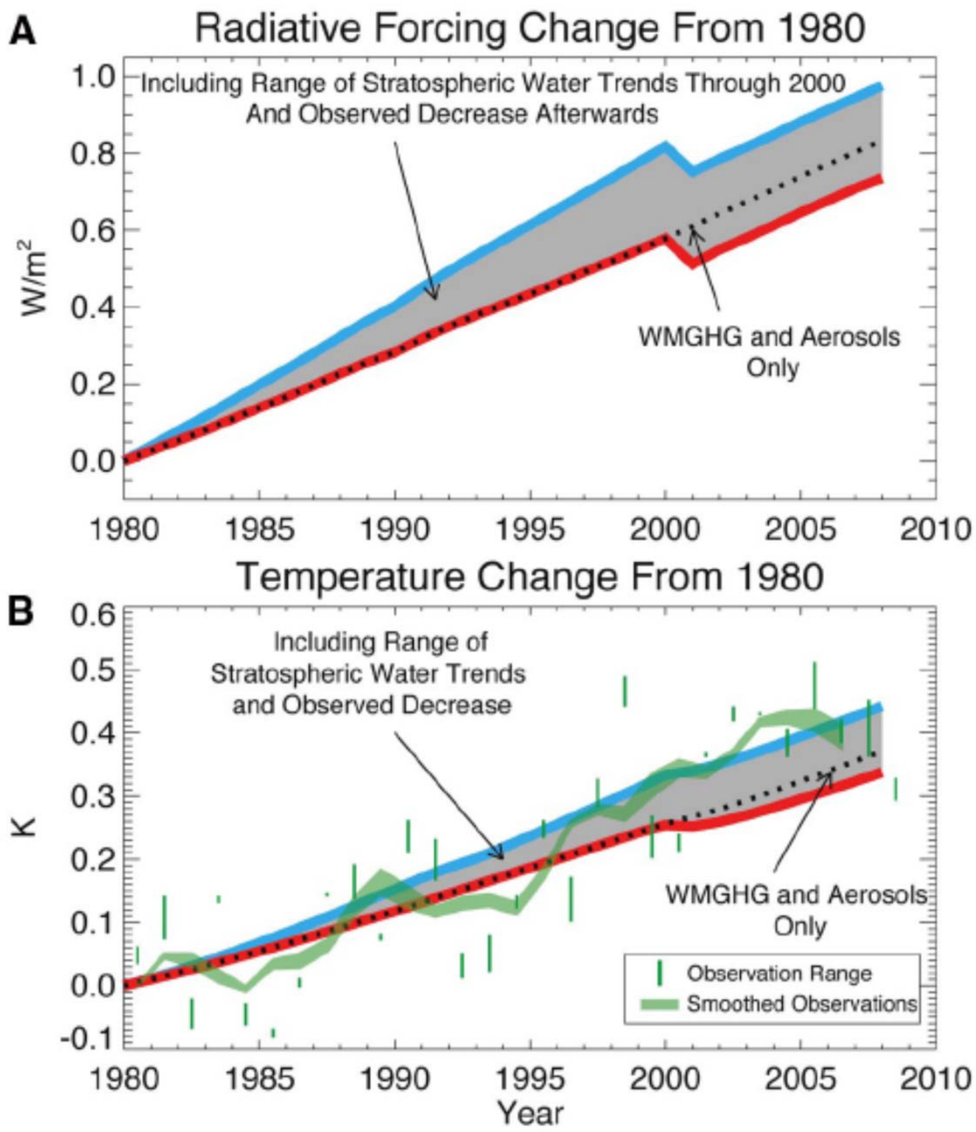


Hurst et al., 2011



Dameris et al.

Motivation: Why is UTLS water vapor important?



Solomon et al., Science, 2010

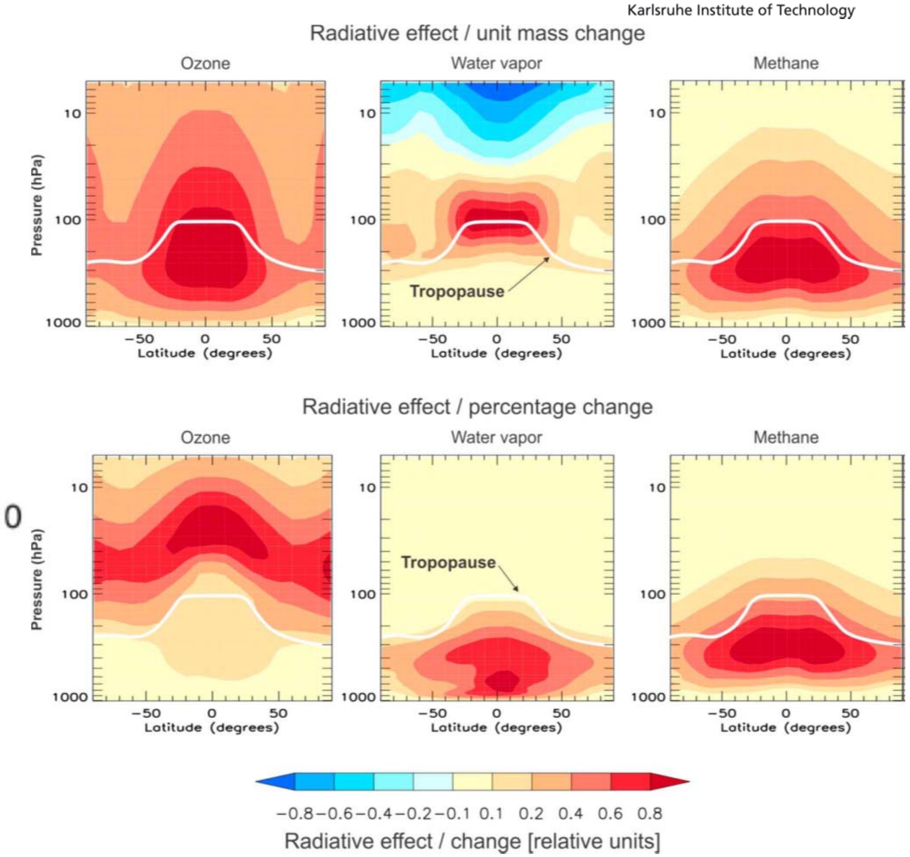
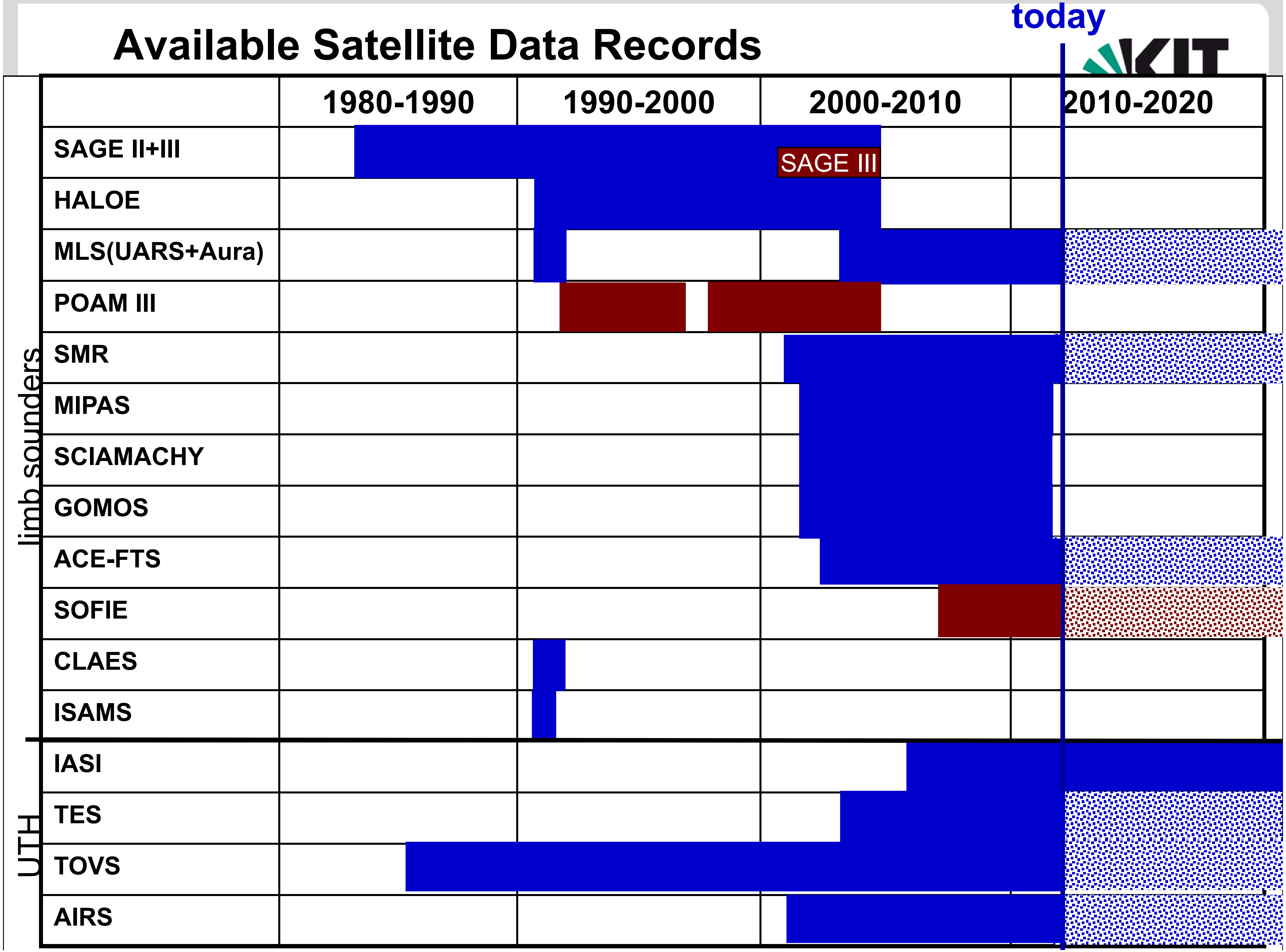


Figure by P. de Forster, from Riese et al., JGR, 2012

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

- Update of WAVAS-I report published in 2000 (SPARC report No. 2)
- Analysis of the quality of water vapor satellite records:
  - Compare satellite records **to ground-truth** (CFH, LIDAR, MW) measurements on basis of co-incident observations
  - Compare satellite records **among each other** on basis of co-incident observations; for special regions and latitude bands/seasons
  - Compare satellite records **on basis of climatologies**; collect available material and complete
  - Compare representation of **temporal variation** on basis of climatologies and within co-incident comparison to ground-truth instruments (seasonal, QBO, longer-term)
  - Compare **upper tropospheric specific humidity** from satellites (TES, IASI, AIRS, TOVS)
  - Compare available satellite data records on water vapor **isotopologues** (HDO, δD) and compare to ground-truth observations
- General approach: review of literature completed by dedicated studies where necessary

Available Satellite Data Records

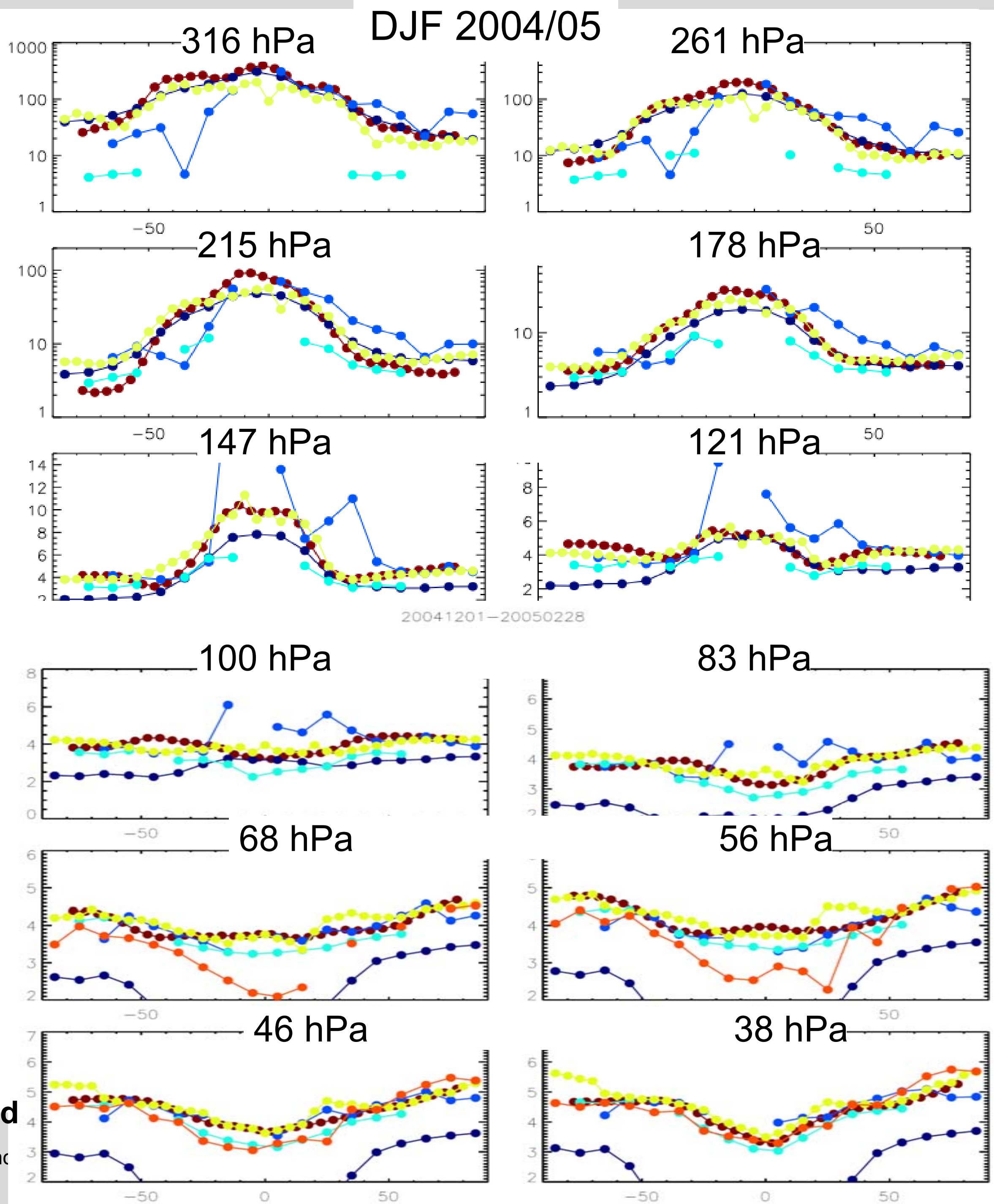


Examples

Latitude cross sections of H20

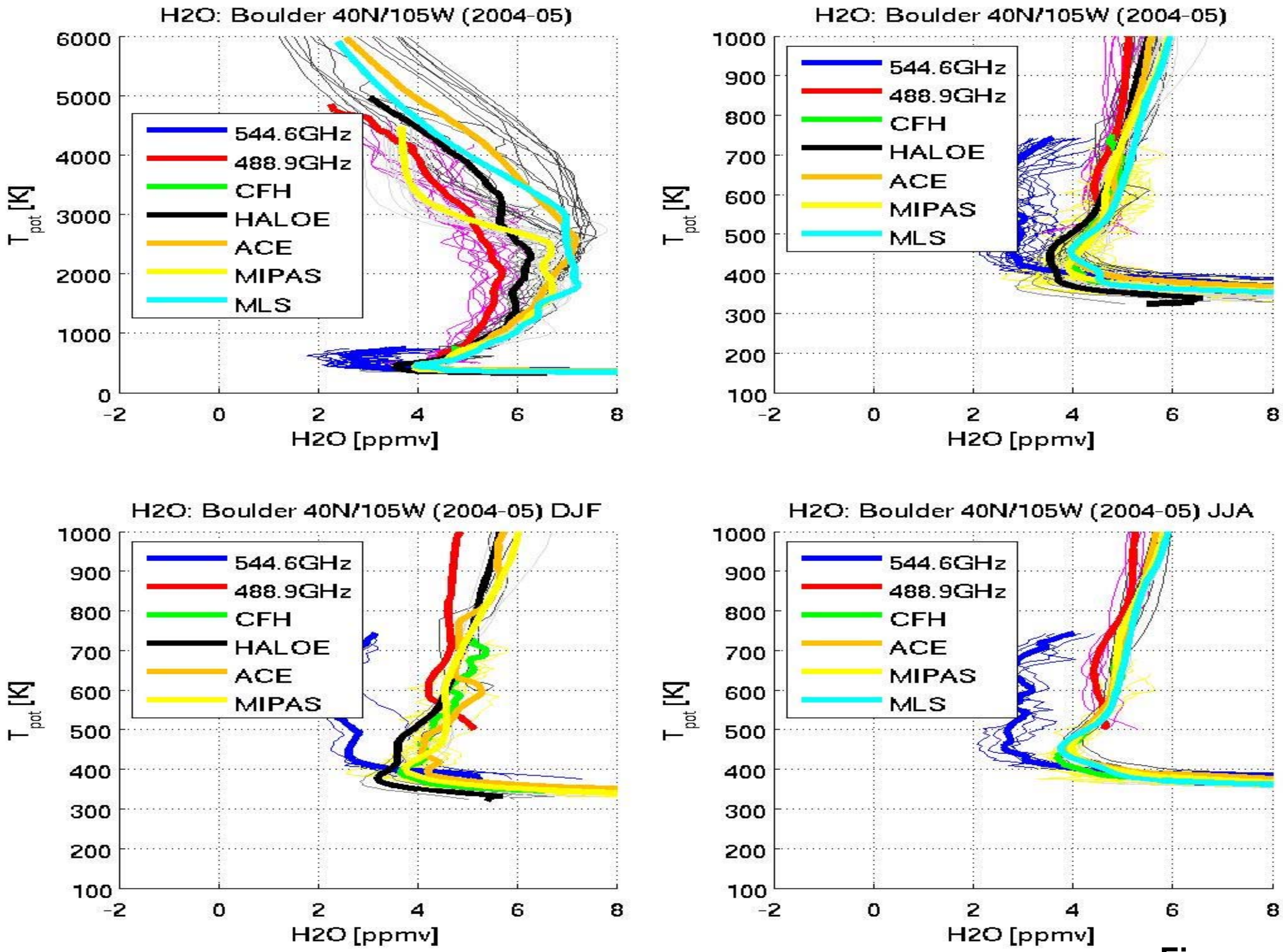
MLS v3
HALOE
MIPAS
ACE-FTS
AIRS
SMR

- HALOE is dry for most altitudes
- SMR has a pronounced dry bias in the tropics below 38 hPa
- Sparse statistics for ACE-FTS
- AIRS not to be used above 100 hPa
- MIPAS dryer than MLS below 200hPa and wetter around tropopause

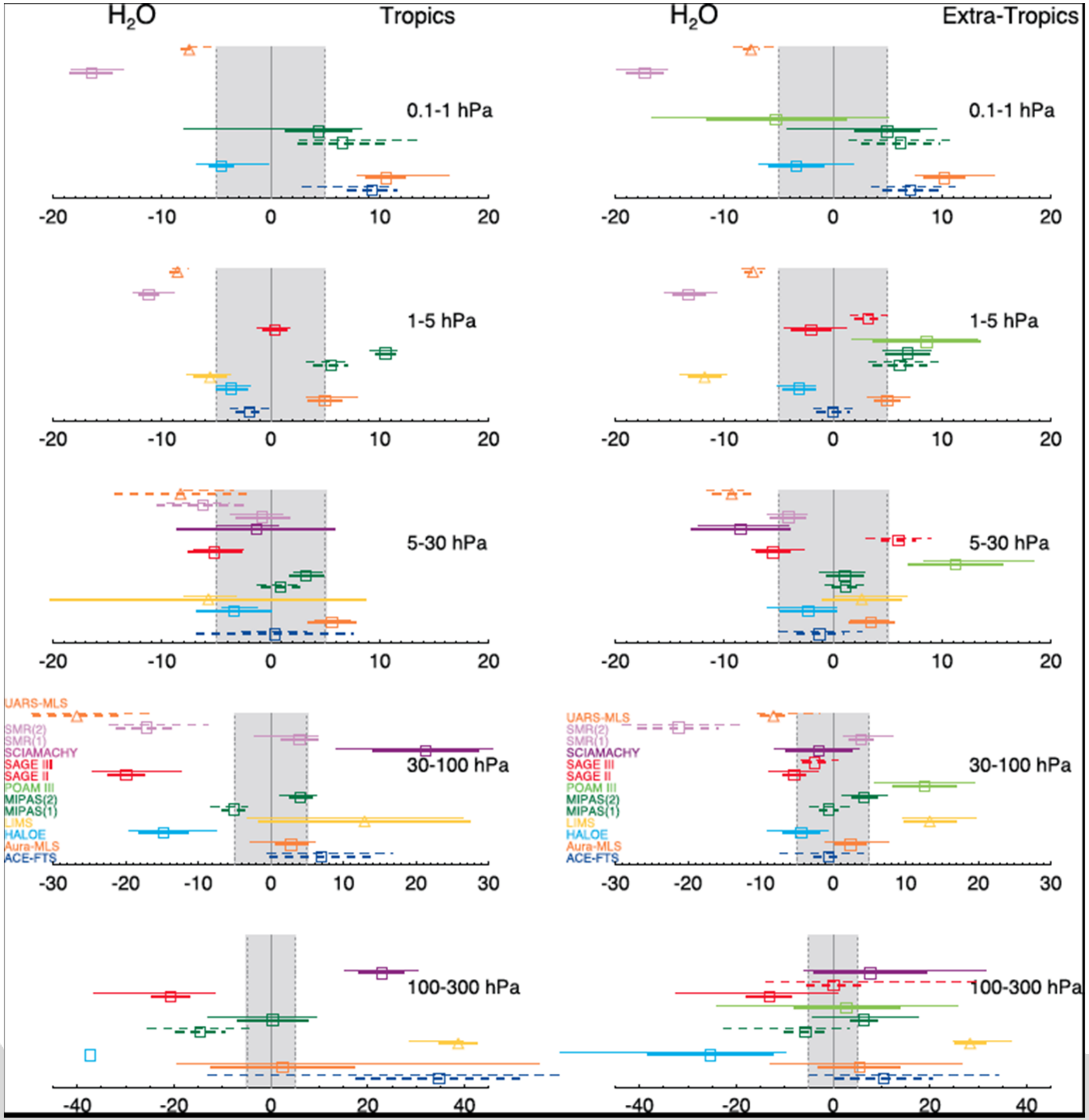


Figures by Bill Read

Consistency of satellite records: extra-tropics



Figures by Jo Urban



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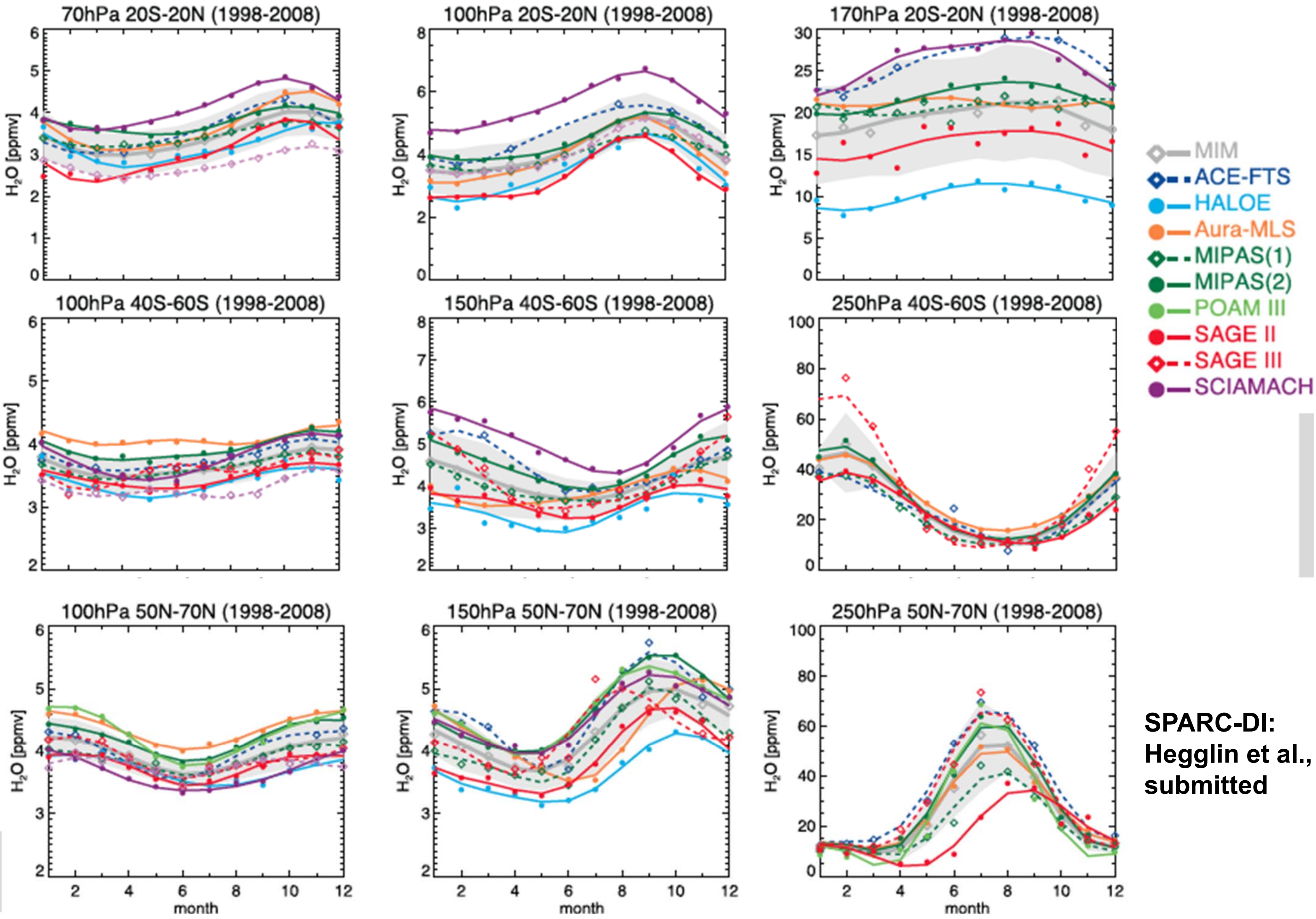
Bias among the satellite data sets

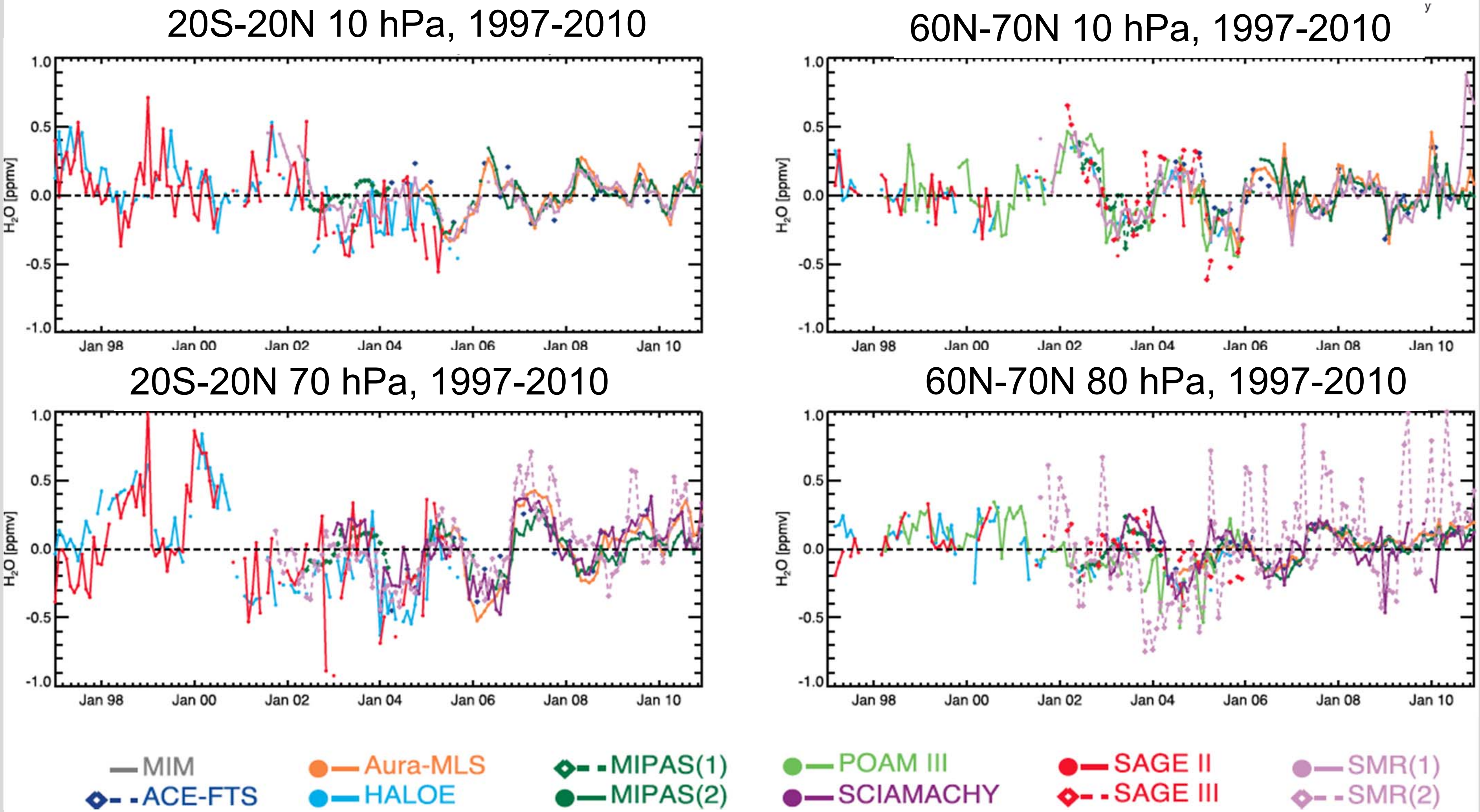
SPARC-DI: Hegglin et al., submitted

Amplitudes and phases of the seasonal cycles



SPARC-DI: Hegglin et al., submitted

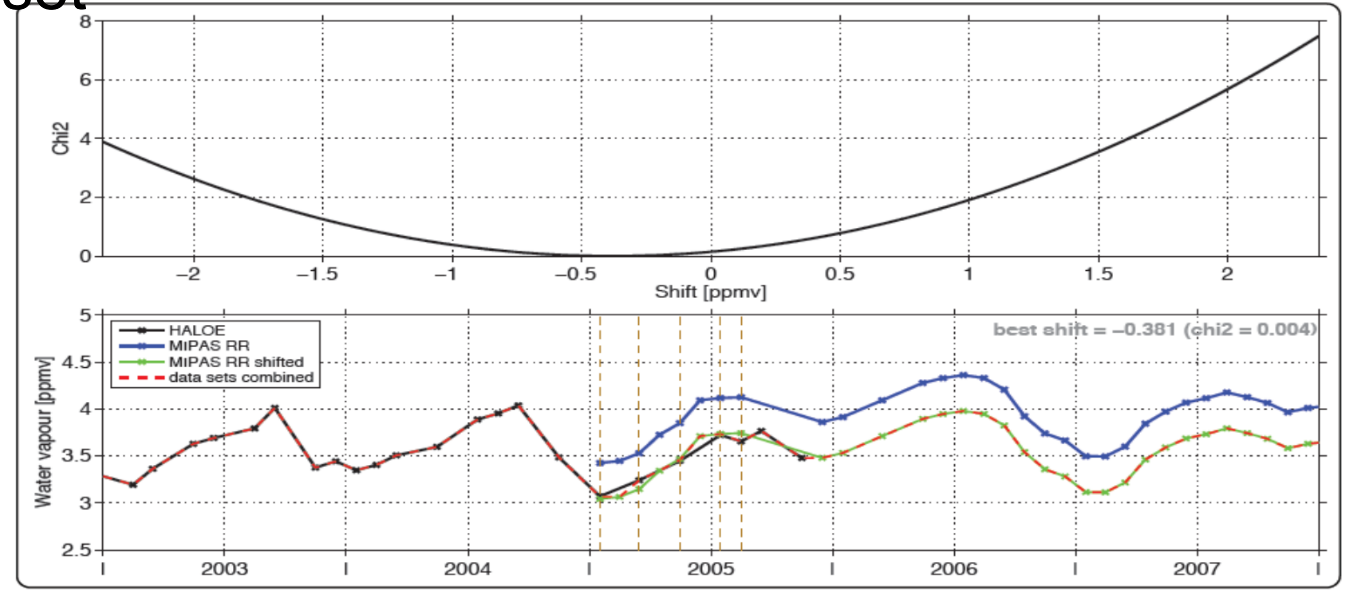
Anomalies (de-biased and de-seasonalized)



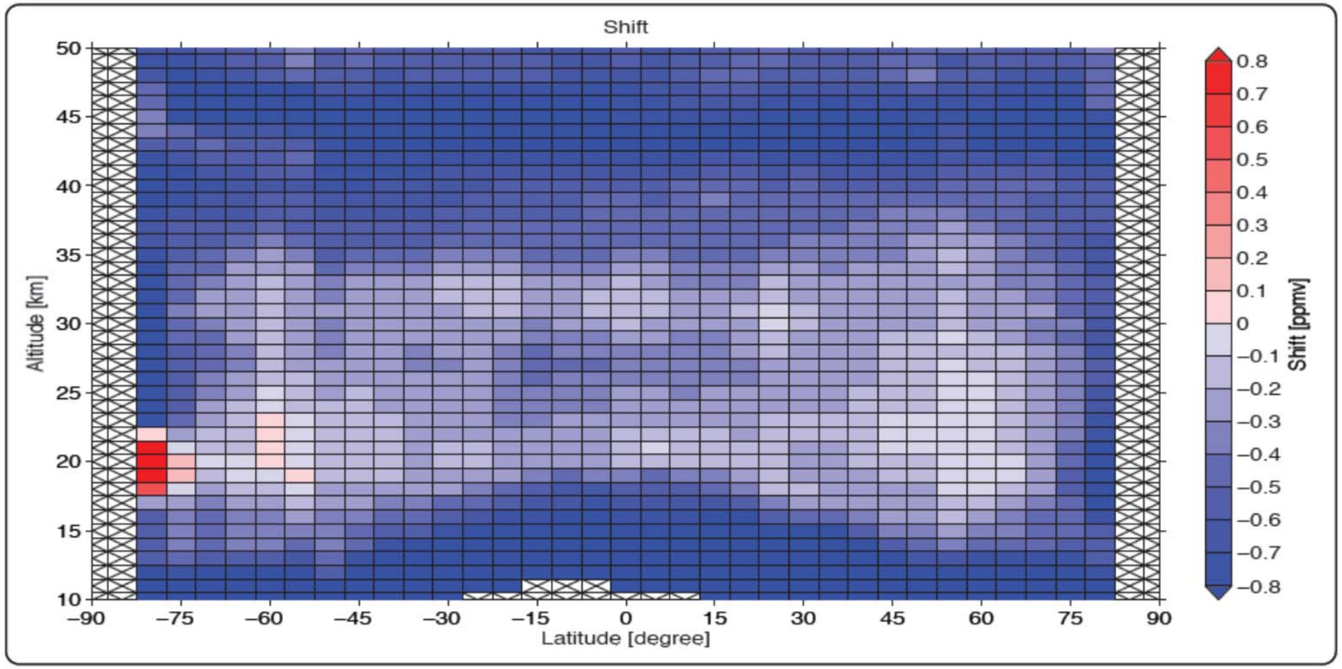
SPARC-DI: Hegglin et al., submitted

Combination of HALOE and MIPAS to one harmonized data set

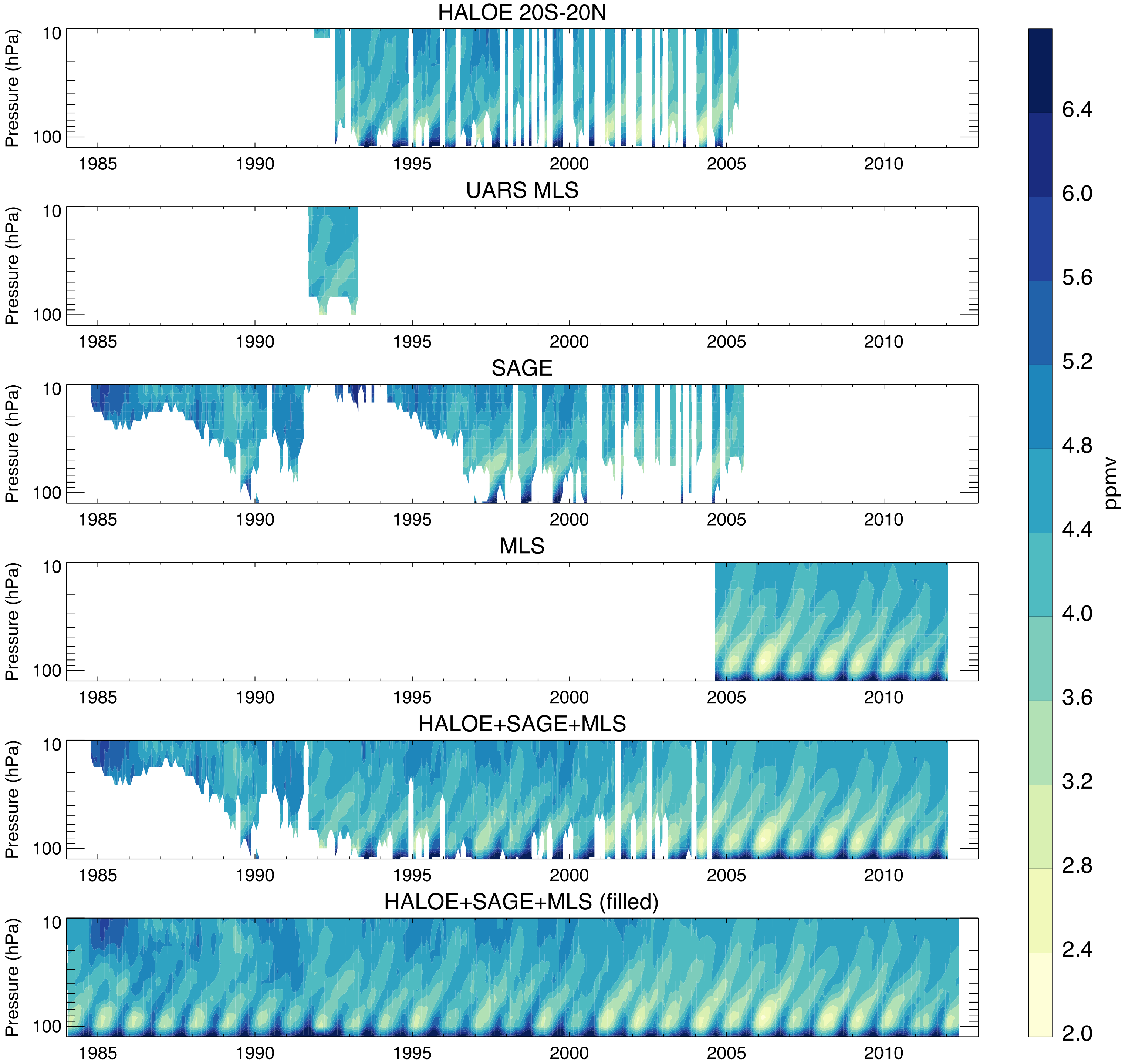
For one altitude/latitude bin:



Resulting shift for all bins:



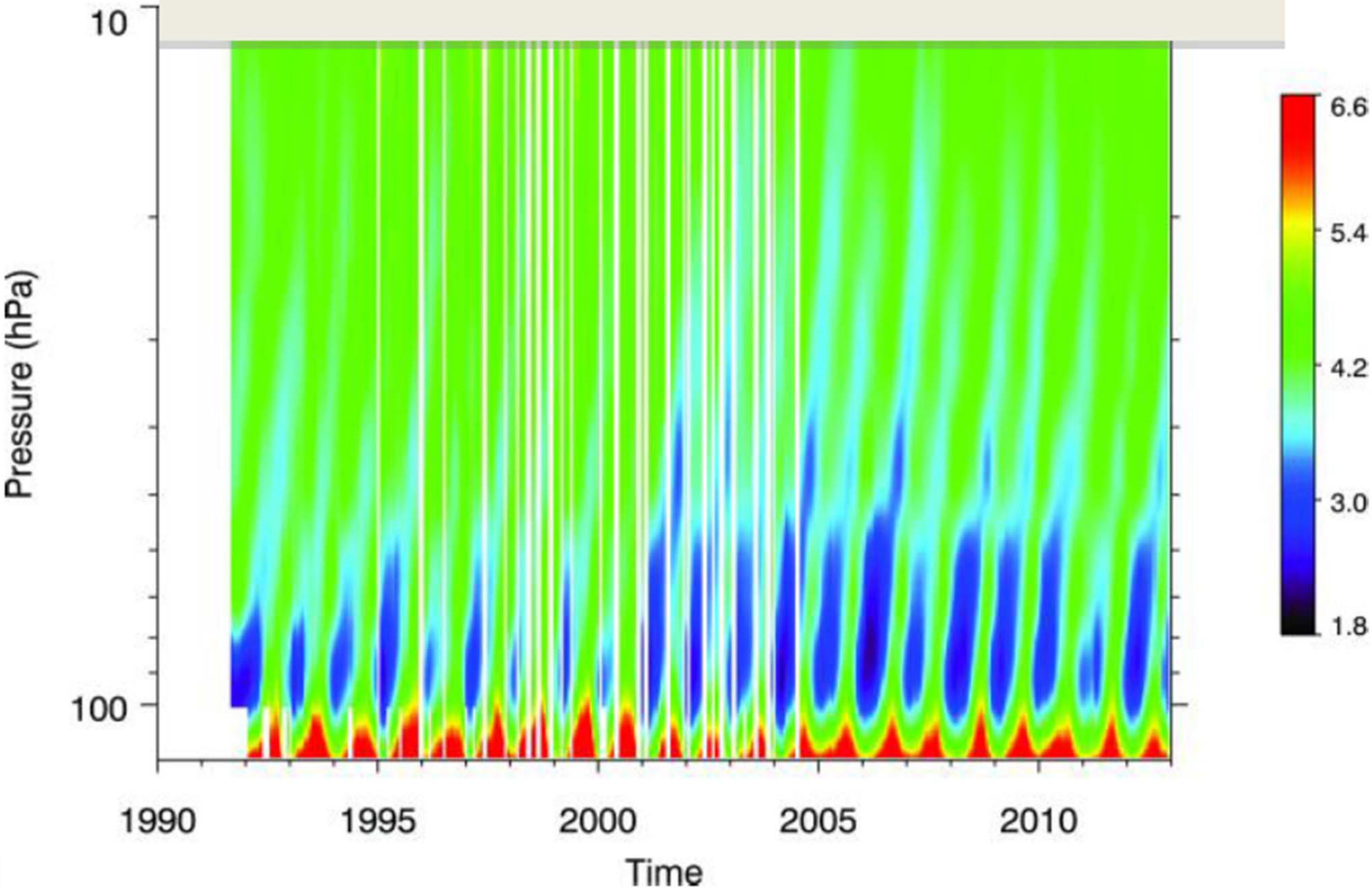
Not resolved yet: differences in the amplitudes of seasonal/QBO/… variations



SWOOSH data set (S. Davis and K. Rosenlof, NOAA)

LS H2O from satellites,
G. Stiller, IMK-ASF, KIT

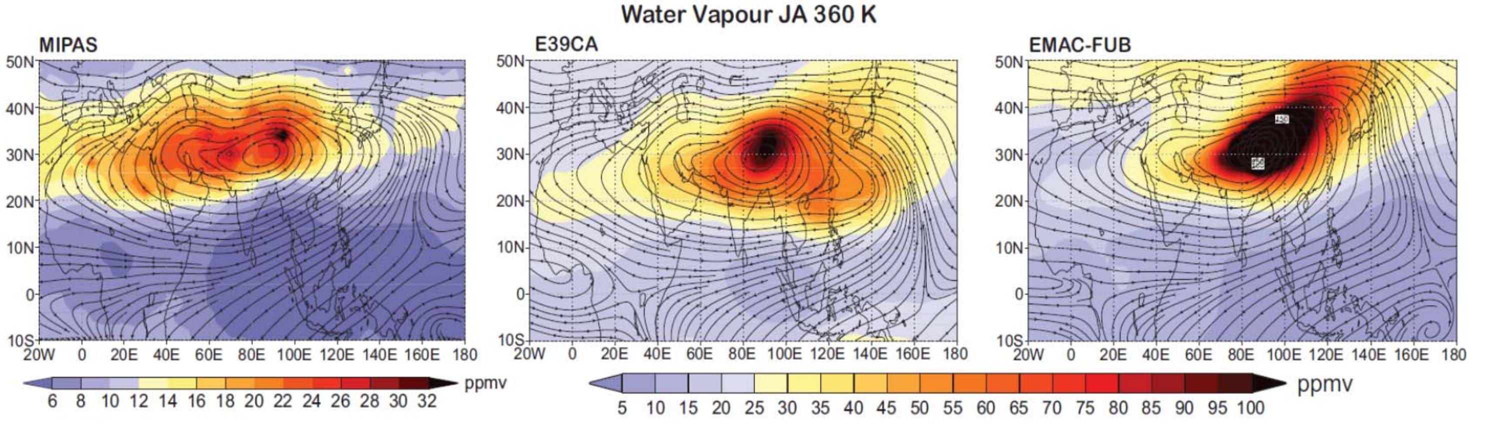
Merged GOZCARDS H_2O tropical "tape recorder"



From MEASURES-GOZCARDS README documentation, L.Froidevaux, et al., 2013

lites,
G. Stiller, IMK-ASF, KIT

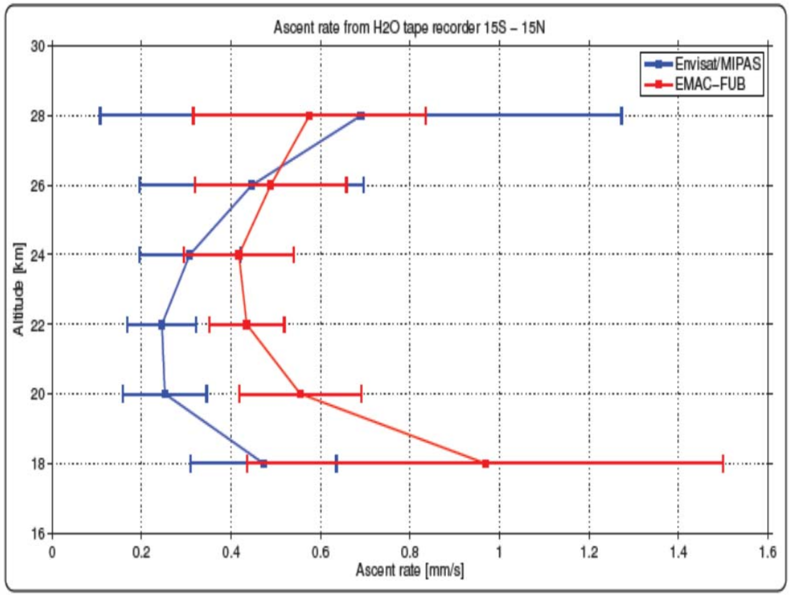
Confrontation of CCMs to observational data



Kunze et al., 2010

1. Understanding of processes, here: WV transport through monsoon systems

2. Understanding of temporal variation and trends: no single trend in observational data; CCMs: check piecewise linear trends, ascent rates of the tape recorder, volcanic signals, etc.. How realistic are model predictions then?



E39CA-REF-B1 (DLR)
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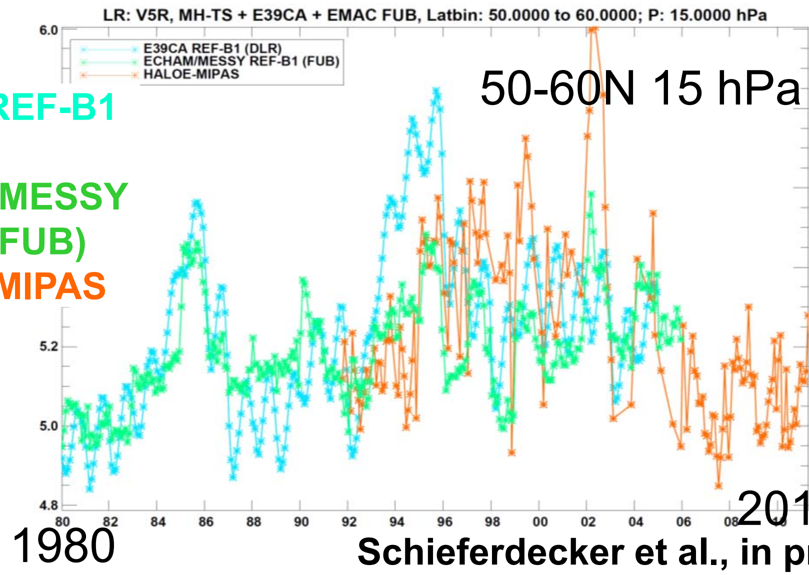
HALOE/MIPAS

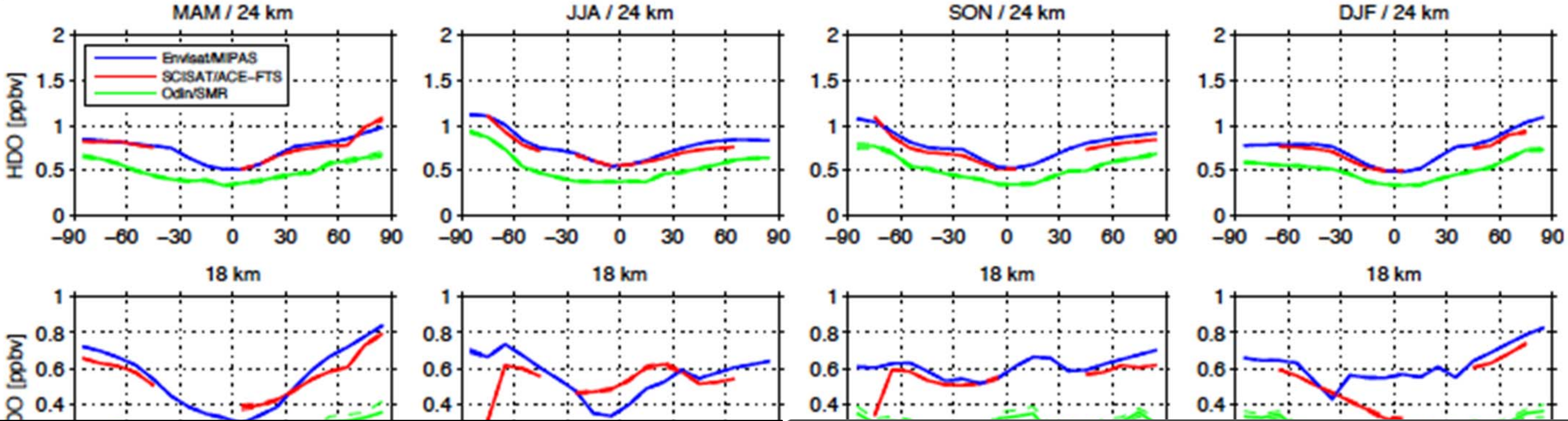


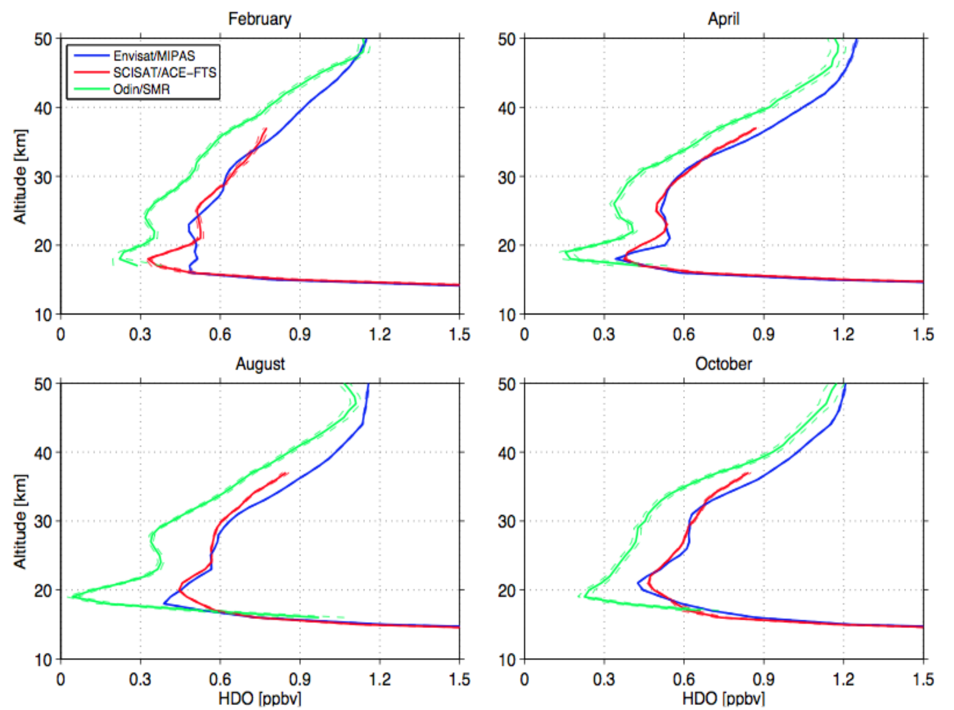
Schieferdecker et al., in prep.

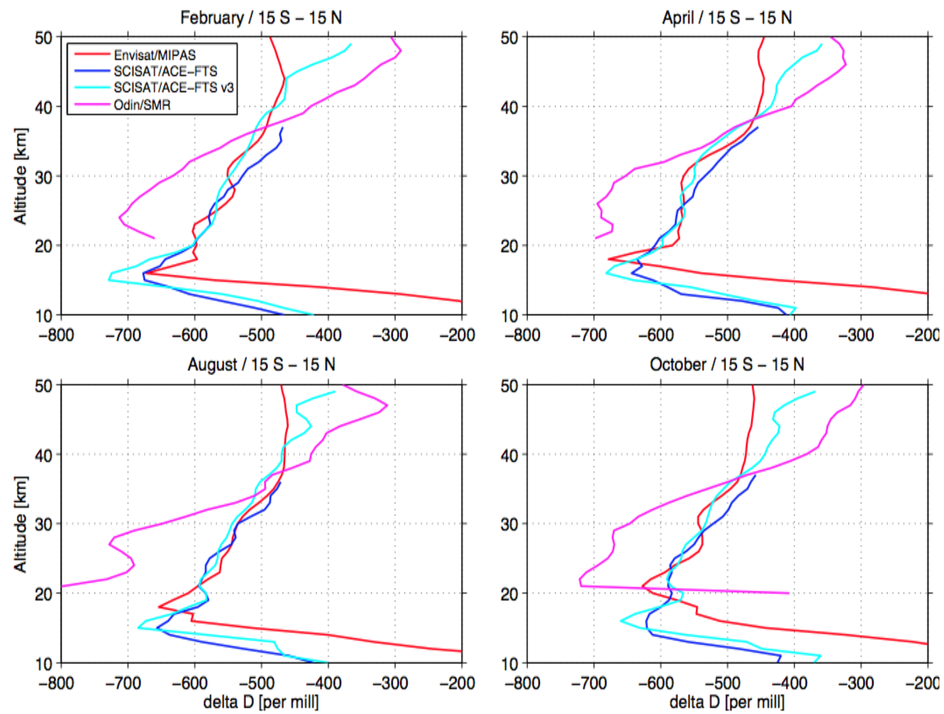
Water vapor isotopologues: Comparison of HDO from SMR, ACE-FTS and MIPAS

Lossow et al., ACP, 2011

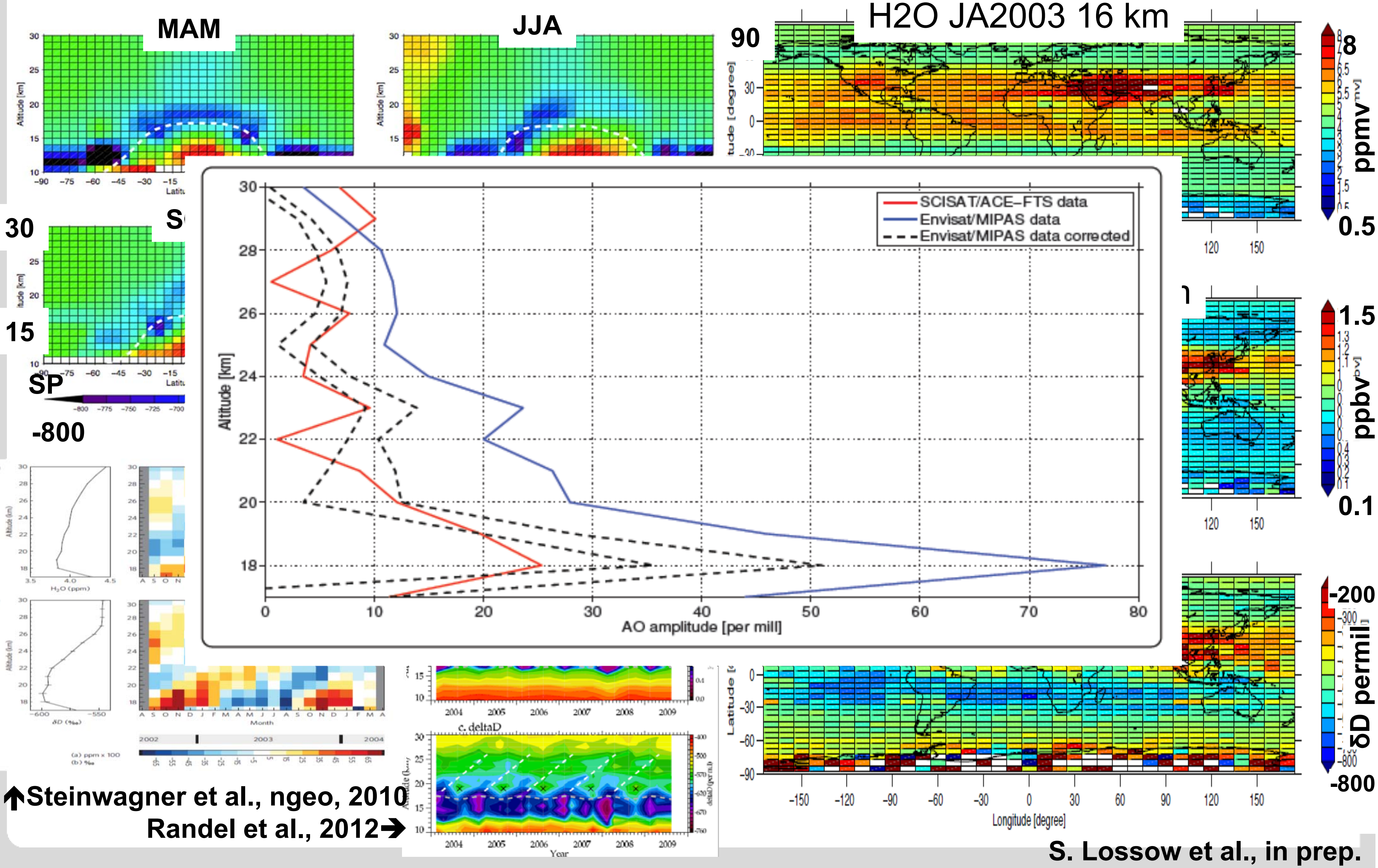
Karlsruhe Institute of Technology







Water vapor isotopologues: Tape recorder and monsoon systems



↑Steinwagner et al., ngeo, 2010

Randel et al., 2012→

S. Lossow et al., in prep.

Future perspectives

- Satellite missions covering water vapor observation still in orbit:
- MLS
- ACE-FTS
- SOFIE
- SAGE III-ISS
- SMR
- AIRS
- TES
- IASI
- Most of them are aged missions with limited remaining lifetime
- In Europe: no plans for limb sounders before 2020

Summary

- The last decade was a ‘golden age’ for global water vapor observation from satellites
- The SPARC WAVAS-II activity plans a thorough satellite data quality assessment
- Satellite data records have large biases (lat/alt dependent) and reproduce seasonality differently (amplitude and phase of the tape recorder)
- Water vapor isotopologues (HDO/δD) shed light on condensation/freezing processes during TST of water vapor
- Three available data sets – ACE-FTS and MIPAS largely consistent in HDO, but disagree in δD.
- A gap of vertically resolved UTS water vapor observations is to be expected for the next decade

Acknowledgment

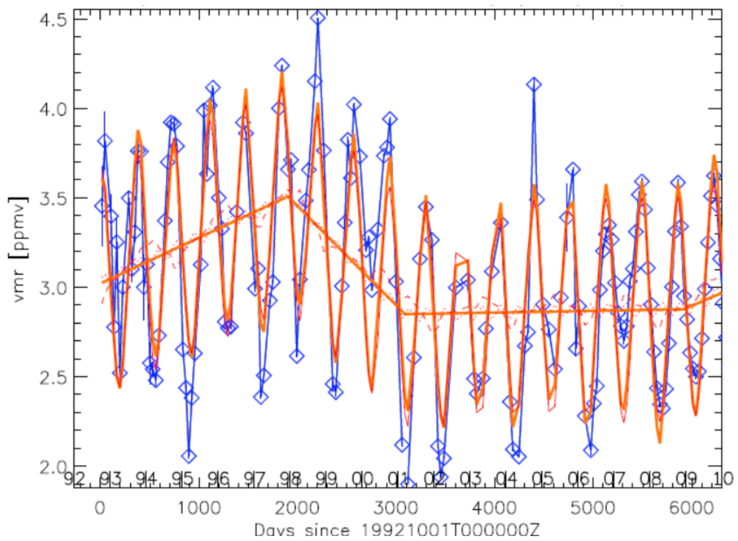
- Stefan Lossow, Michael Kiefer – KIT (MIPAS)
- William Read – JPL (MLS)
- Karen H. Rosenlof – NOAA (WAVAS activity leader)
- Jean-Loup Bertaux – LATMOS (GOMOS)
- Maya García-Comas – IAA, CSIC (MIPAS)
- Mark E. Hervig – GATS Inc. (SOFIE)
- Gerald Nedoluha – NRL (POAM)
- Ellis E. Remsberg – NASA Langley (HALOE)
- James M. Russell III – Hampton University (LIMS, HALOE, AIM)
- Larry W. Thomason – NASA Langley (SAGE)
- Jo Urban – Chalmers University (SMR)
- Kaley A. Walker – University of Toronto (ACE-FTS)
- Mark Weber – University of Bremen (SCIAMACHY)
- Joseph M. Zawodny – NASA Langley (SAGE)

Thank you for your attention!

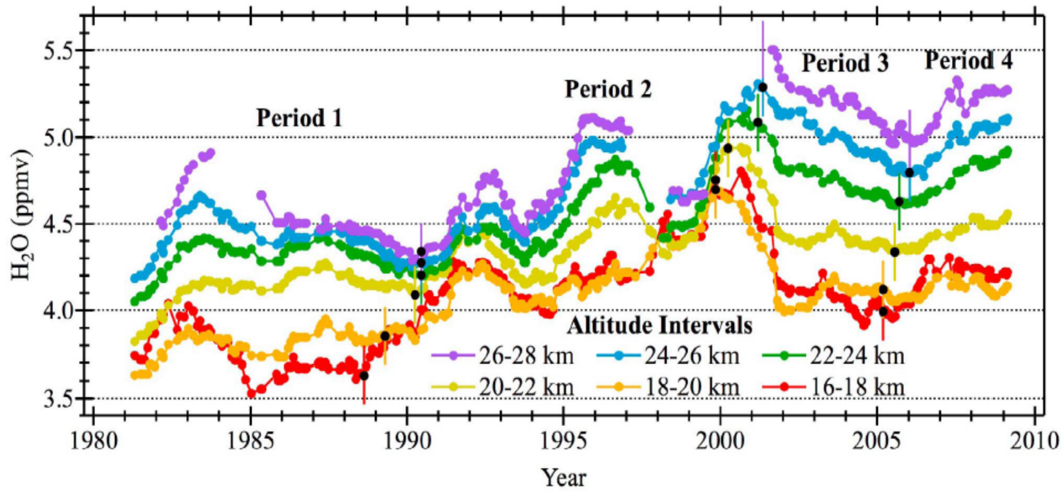
Additional slides

Temporal variation in satellite records and Boulder time series

HALOE+MIPAS, 0-10deg N, 18 km

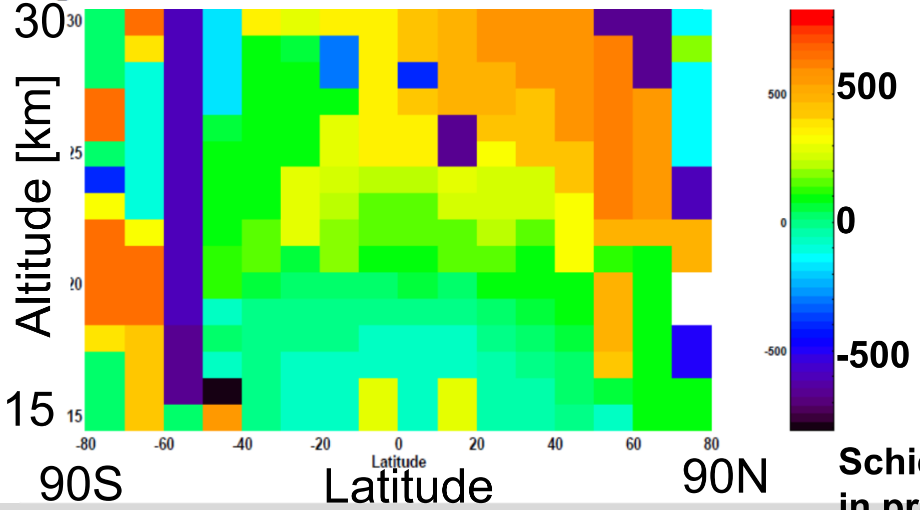


Hurst et al., 2011



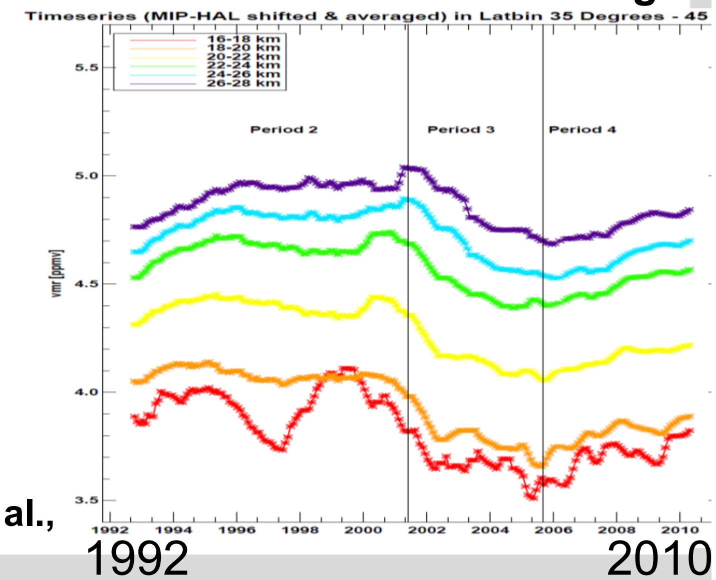
Date of H2O drop from H+M

Days after 01/01/2001

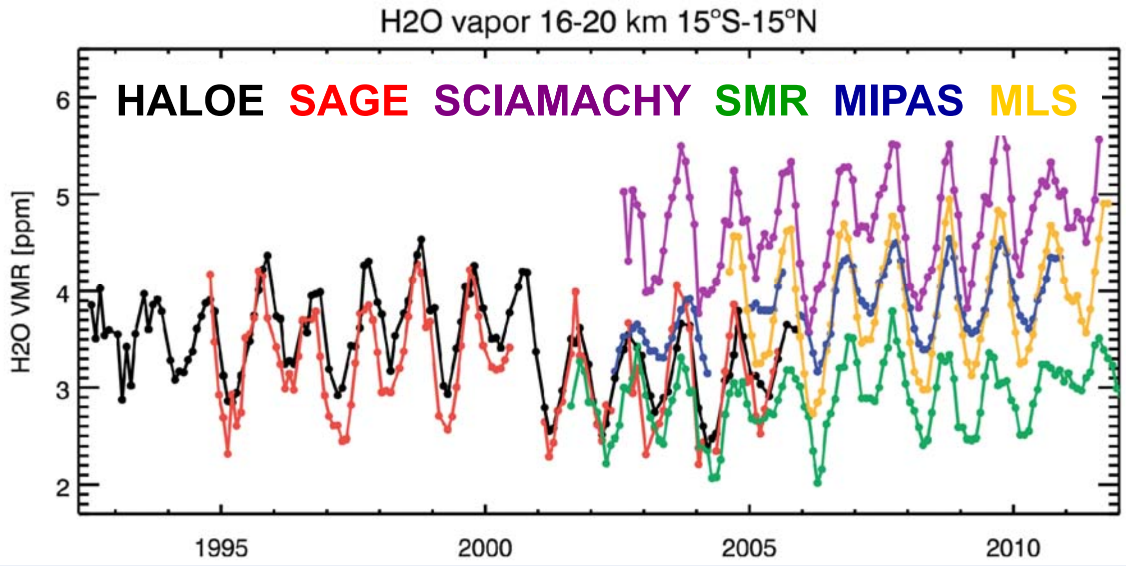


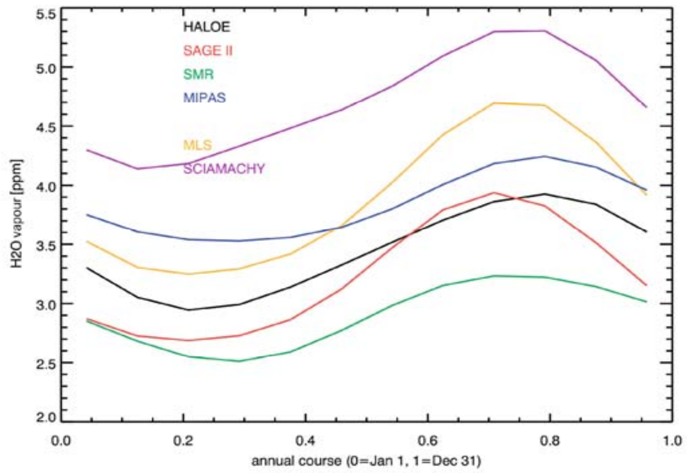
Schieferdecker et al., in prep.

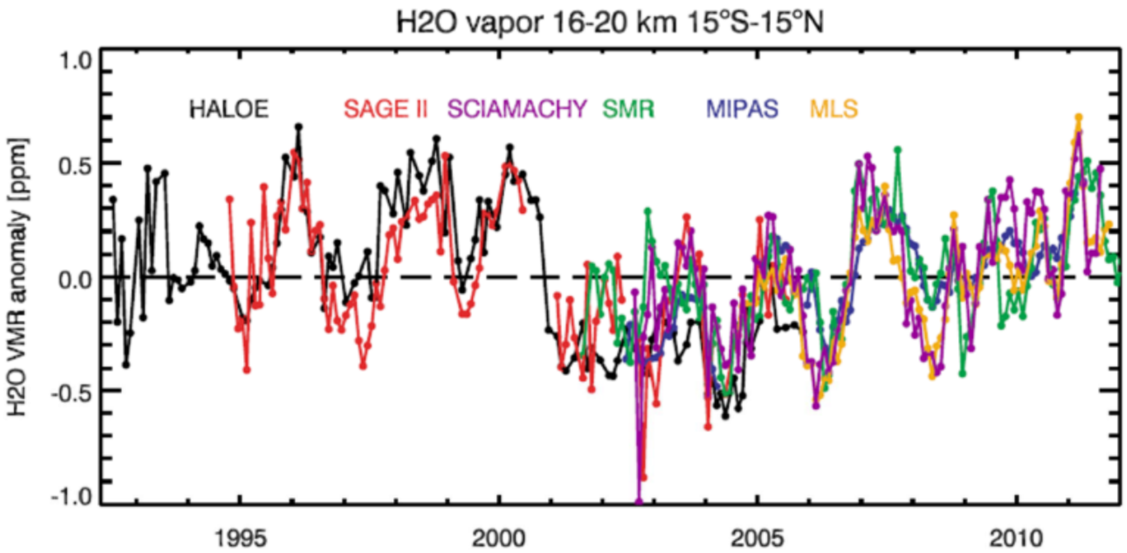
HALOE+MIPAS 35-45 deg N



Consistency of satellite records: tropics



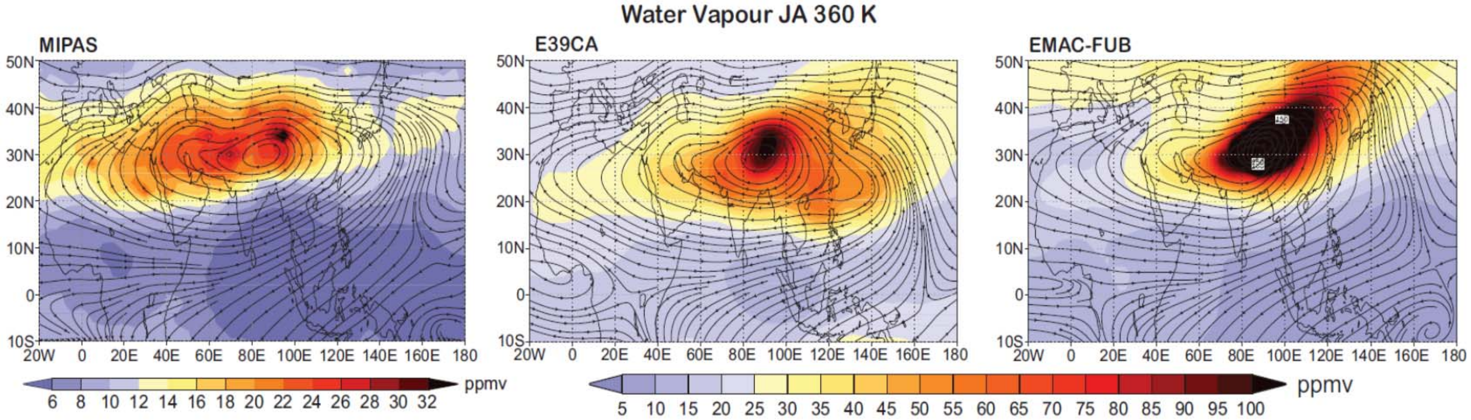




- Large biases
- Strong variability in the amplitude of the tape recorder
- Data records agree much better after de-seasonalization

Figures by Mark Weber

Confrontation of CCMs to observational data



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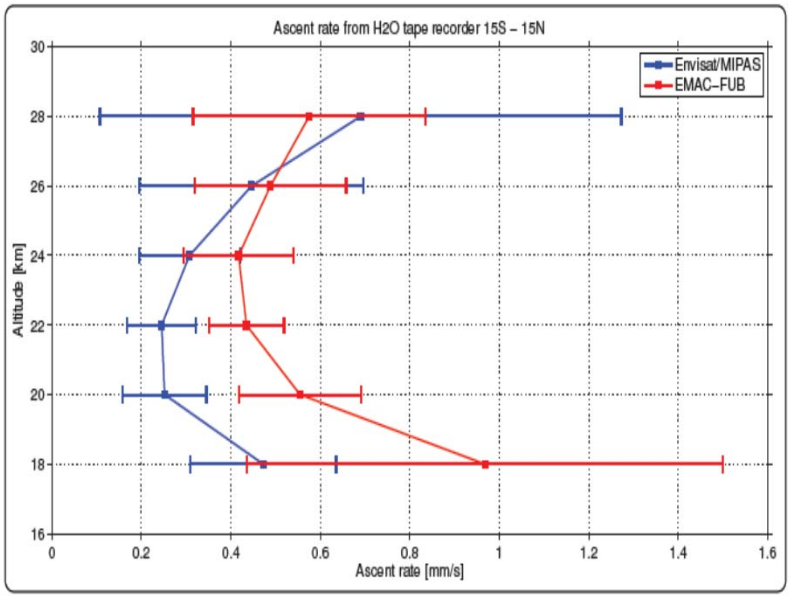

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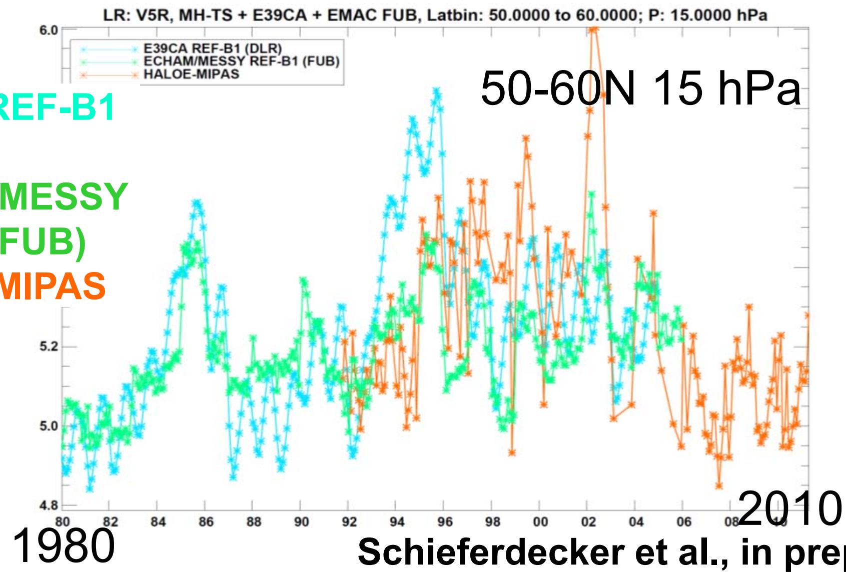

Schieferdecker et al., in prep.