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Trajectory mapping of middle atmospheric water vapor by a mini network of NDACC instruments

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Problem & Motivation

- **Satellites observe global coverage of middle atmospheric trace gases like H_2O or O_3**
- **Potential future lacking of space-based remote sensing platforms for atmospheric trace gas observations may lead to information gaps**
- **How to create synoptic maps from asynoptically gathered atmospheric measurements?**
- **Idea of TM: Synthesis of such synoptic maps by advecting measurements forward and backward in time using a trajectory model, driven by analyzed model wind fields (e.g. ECMWF)**

→ **In what quality can synoptic hemispheric H_2O maps be created without satellite data?**

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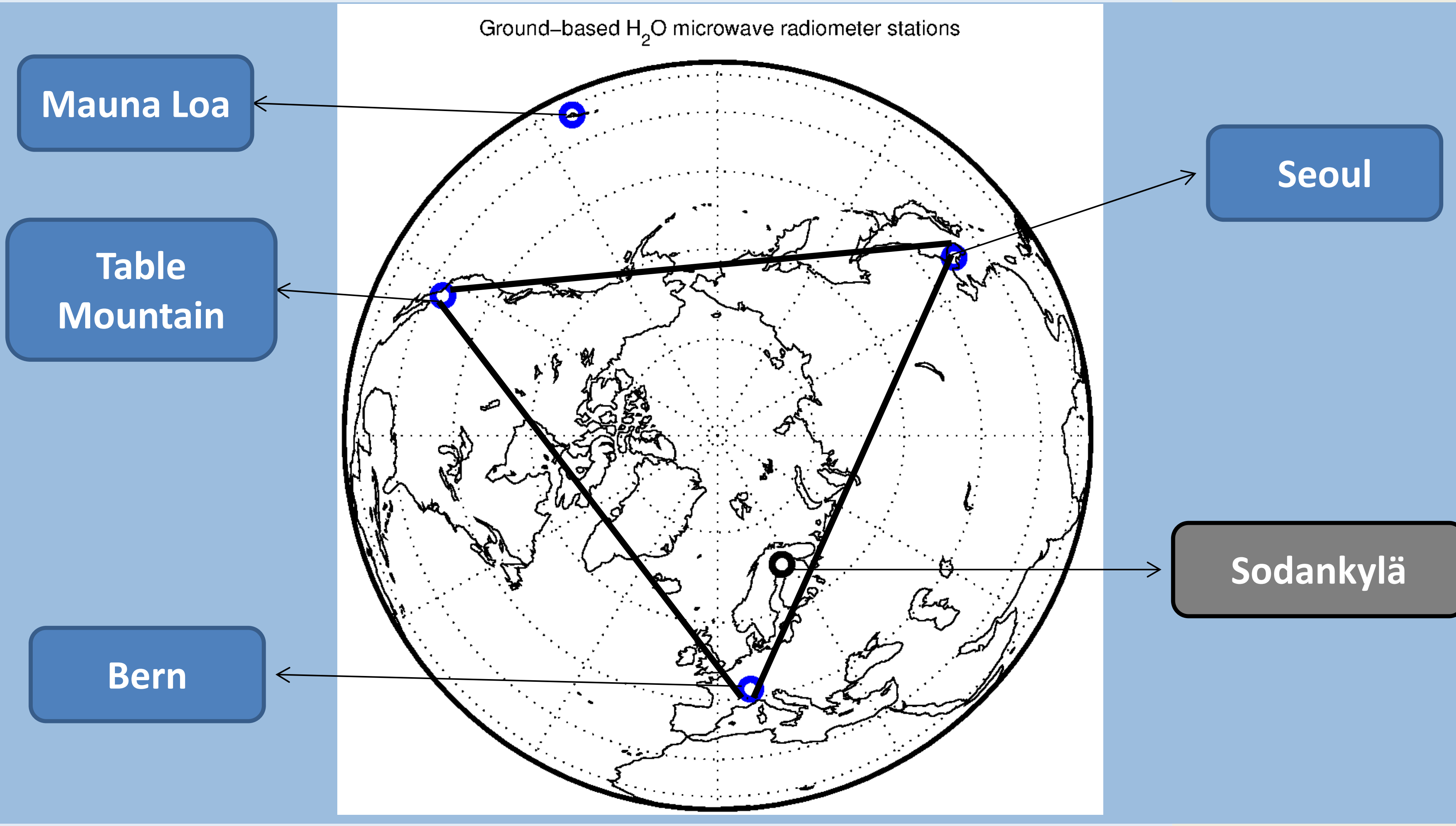
The ground-based H_2O microwave radiometer network



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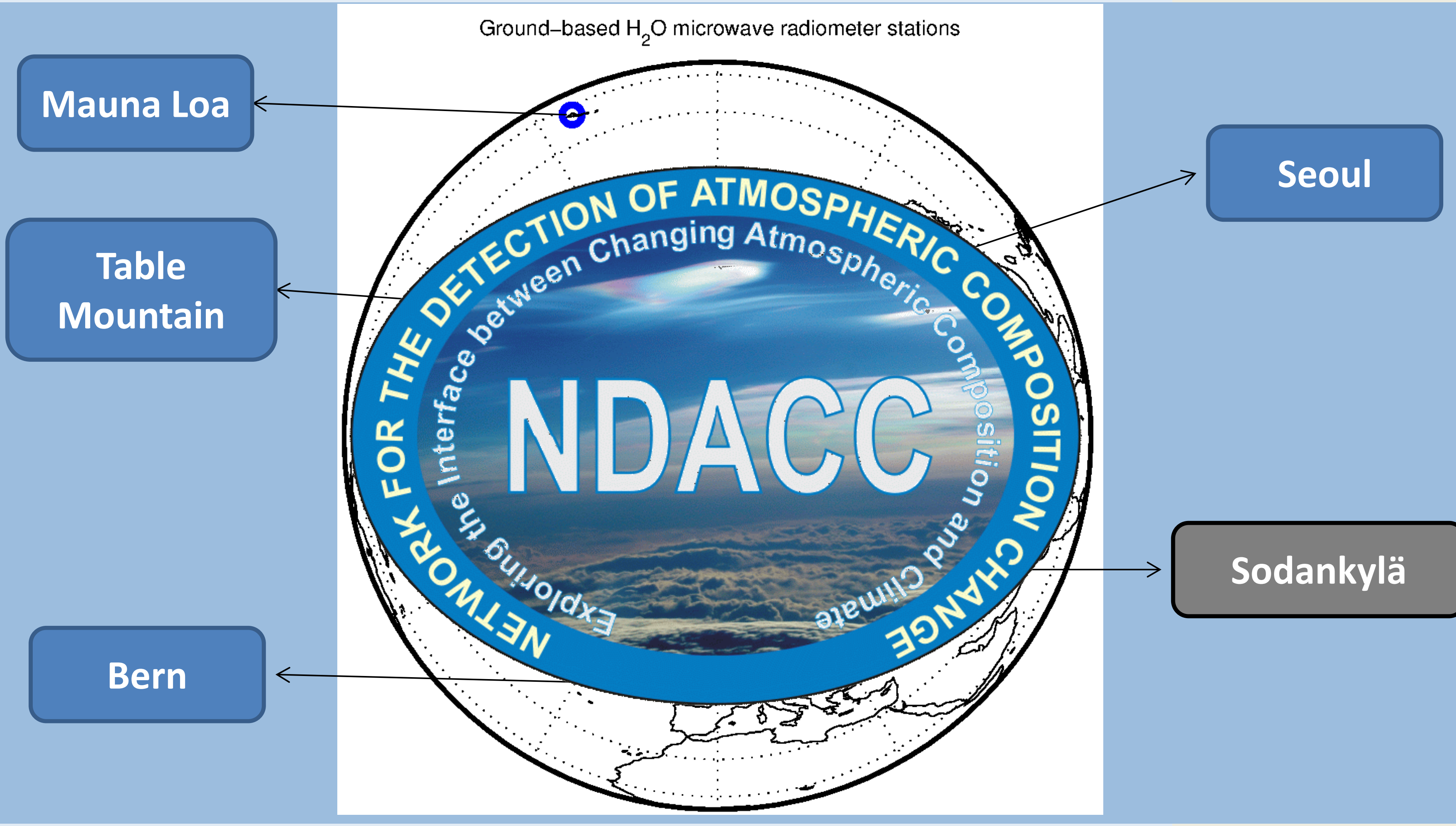
The ground-based H_2O microwave radiometer network



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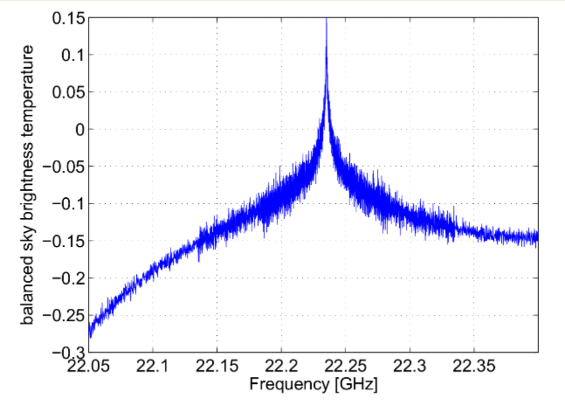
The ground-based H_2O microwave radiometer network

WVMS5

WVMS4

MIAWARA

- **Operating during day and night in almost all weather conditions (except precipitation)**
- **Measure the pressure broadened rotational transition line of H_2O at 22.235 GHz**



- **Vertical H_2O profile retrieval by the Optimal Estimation Method**

SWARA

MIAWARA-C

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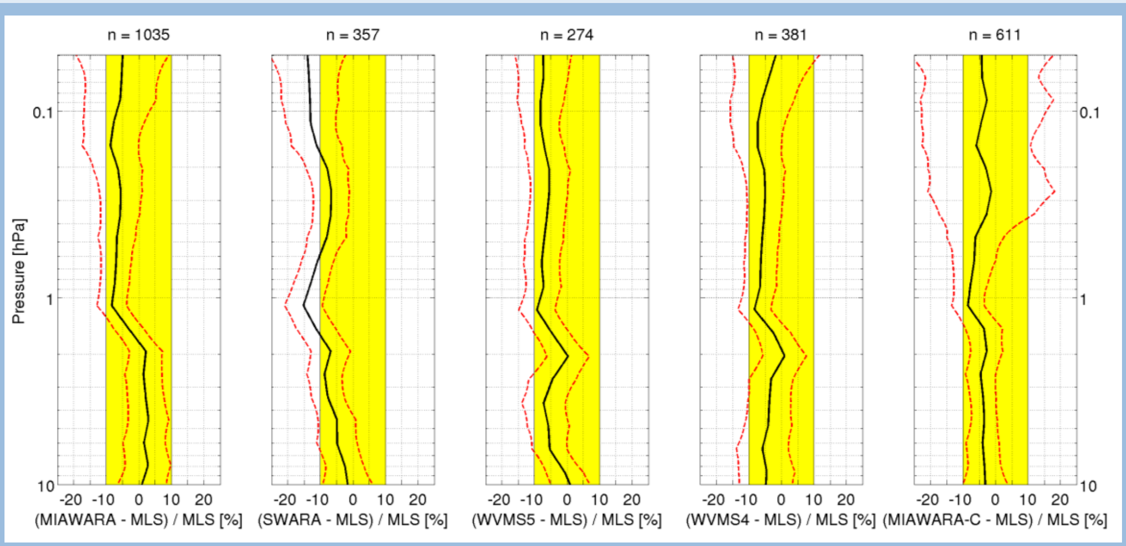
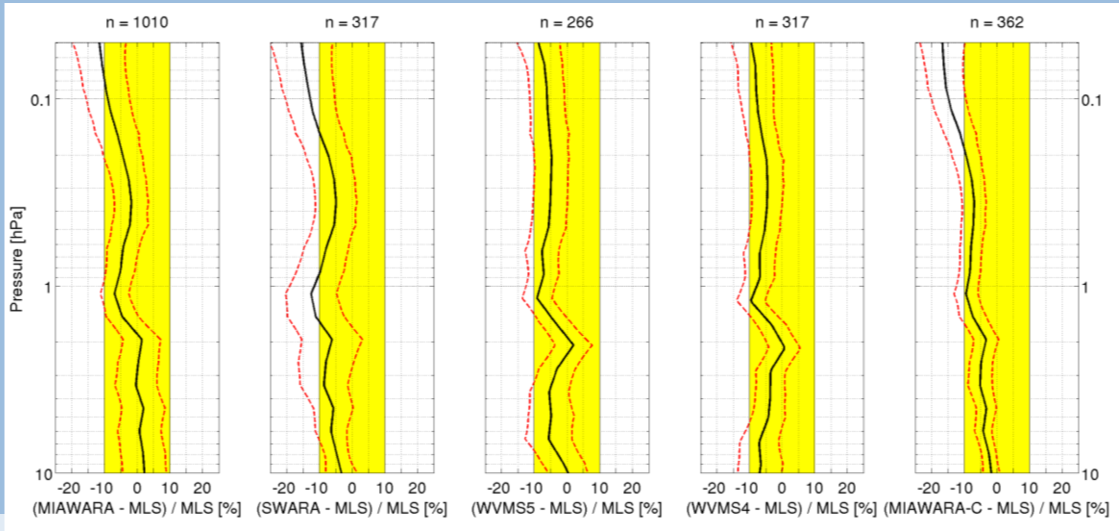
Data harmonization (BIAS correction)

Aura MLS as travelling standard





NH winter season (Oct, Nov, Dec, Jan, Feb, Mar) mean D_{rel} of H_2O difference profiles

2010-08 – 2013-08

NH summer season (Apr, May, Jun, Jul, Aug, Sep) mean D_{rel} of H_2O difference profiles

Trajectory mapping (TM) method

LAGRANTO - The trajectory model

- **LAGRANTO – Software tool to analyze Lagrangian aspects of atmospheric phenomena**
- **Requirement: Time series of 3-D wind fields (NetCDF)**

- **ECMWF operational analyses data from daily model runs (cycle 37R3 T1279) – 6 hourly time spacing**
- **Horizontal resolution: 1.125° x 1.125°**
- **91 vertical model levels from the surface up to 0.02 hPa**

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Trajectory mapping (TM) method

- **Trajectory calculations for tracking air parcels start from all 5 GBMW locations (LAT, LON) and on 1000 pressure levels between 10 and 0.05 hPa**

- **Up to 240 h forward and backward trajectories to assign the H_2O VMR profile data along the trajectory paths (trajectory calculation start every 6 hours) + correction of the VMR values**

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Trajectory mapping (TM) method

Assumptions

Constant H_2O VMR in air parcels while moving along kinematic trajectories

No turbulent mixing

No phase changes

No photolysis or chemical reactions

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Trajectory mapping (TM) method

Synthesis of hemispheric H_2O maps

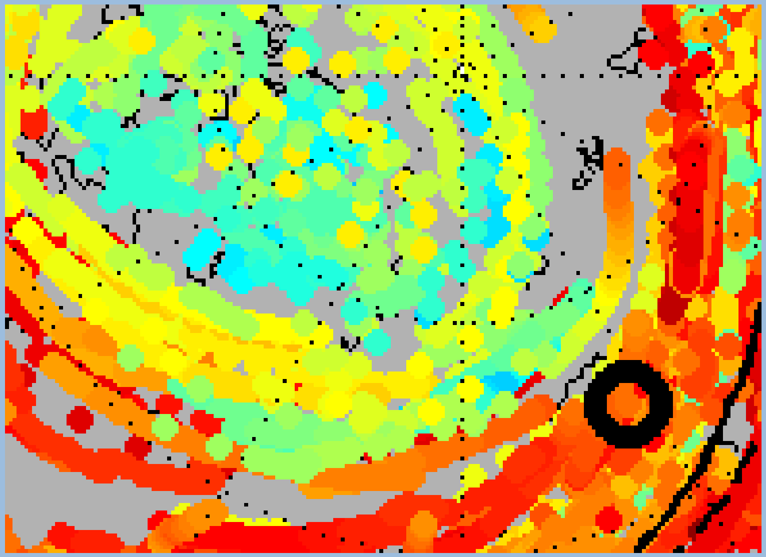
- **Pressure layer definition to filter TM data**

Pressure layer	Altitude	Region
0.13 – 0.07 hPa	≈ 64 km	Mesosphere
1.3 – 0.7 hPa	≈ 48 km	Stratopause
3.5 – 2.5 hPa	≈ 40 km	Stratosphere
12 – 8 hPa	≈ 32 km	Stratosphere

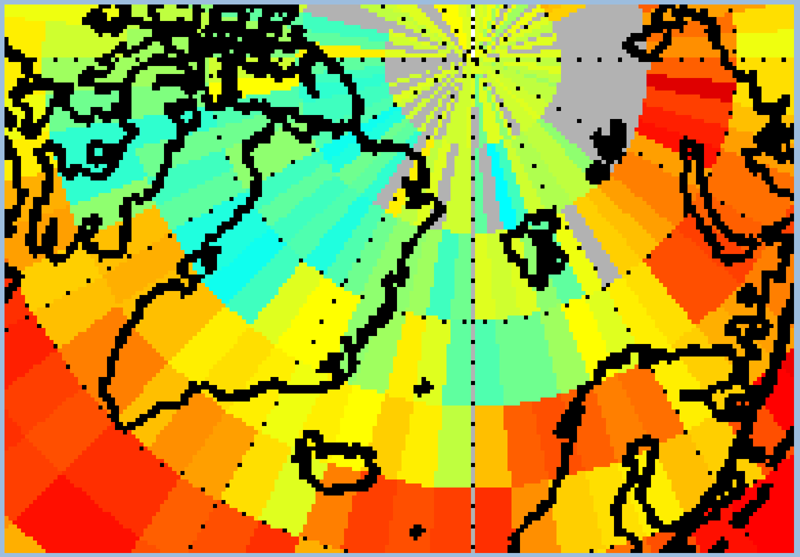
Trajectory mapping (TM) method

Synthesis of hemispheric H_2O maps

Raw TM H_2O map



3D domain averaged



- **Binning and averaging TM data in 3D domains**
- **Stratospheric domains: 2.5° x 2.5°**
- **Mesospheric domains (including stratopause level): 5.0° x 5.0°**

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TM case A – NH winter (stable polar vortex)

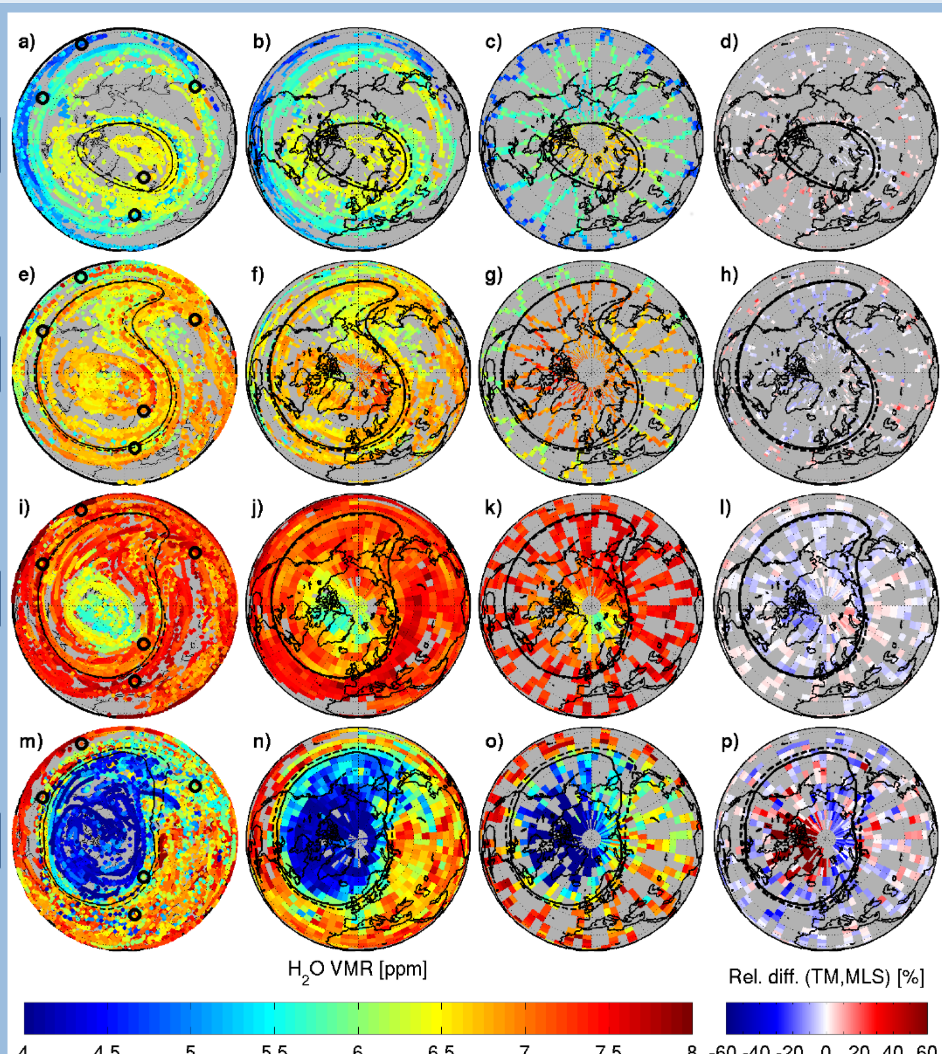
2012-02-28 12 UTC

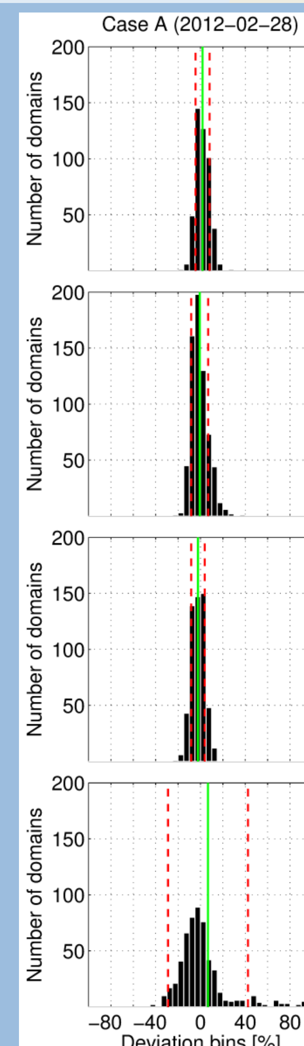
12 – 8 hPa

3.5 – 2.5 hPa

1.3 – 0.7 hPa

0.13 – 0.07 hPa





Percentage of rel. diff. domains within ±10 (20) % deviation

89.0 (99.8)

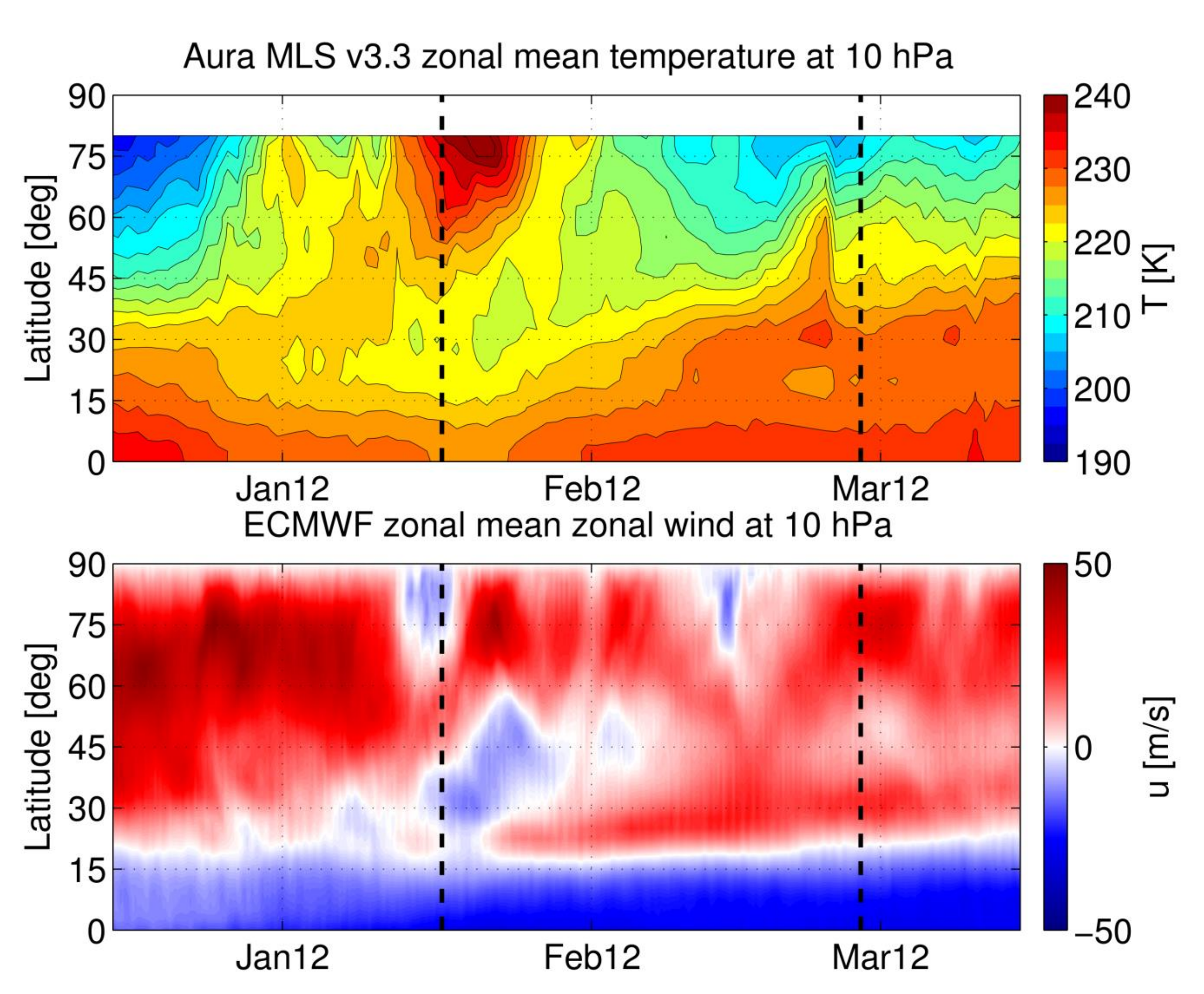
83.1 (98.5)

88.6 (99.8)

50.0 (76.5)

TM case B – NH winter (SSW)

Zonal mean time series of T and u



Case B **Case A**

- **T increase of 25 K in about 1 weak north of 60°**
- **Reversal of the prevailing wind from westerlies to easterlies**

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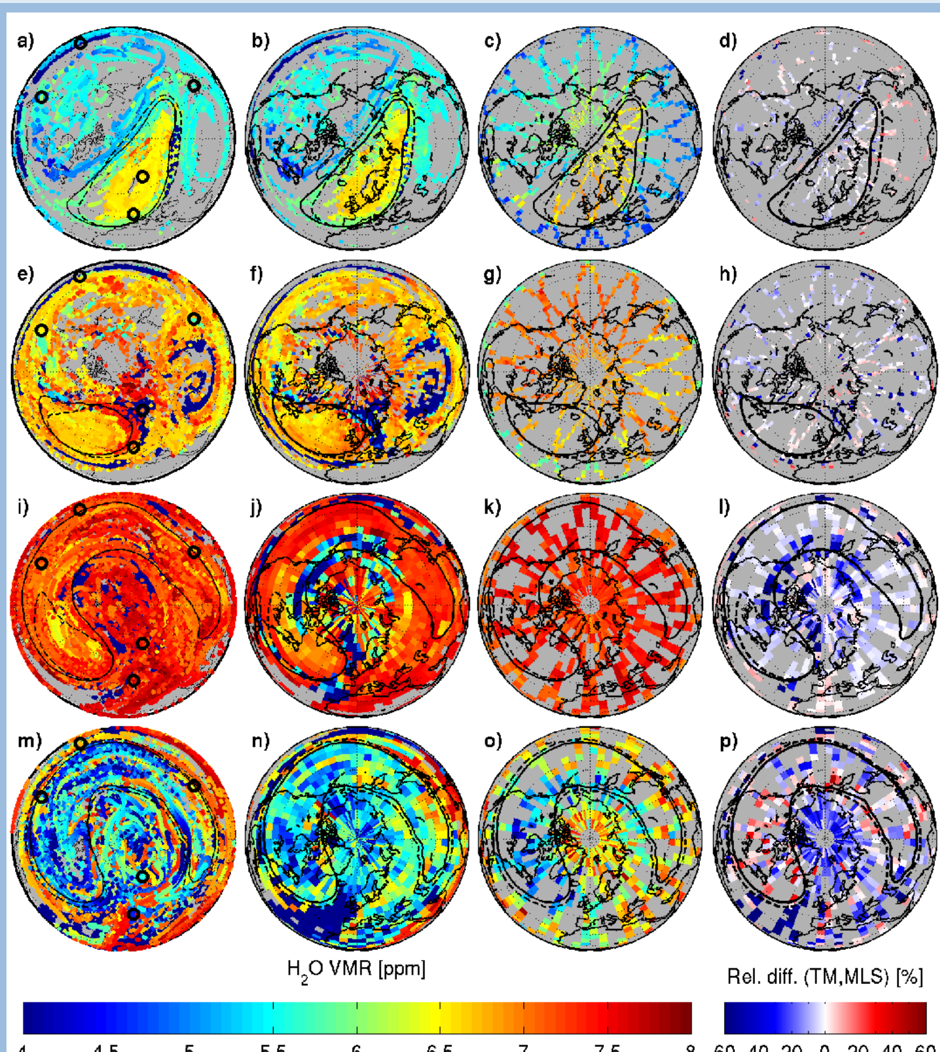
TM case B – NH winter (SSW)
2012-01-17 12 UTC

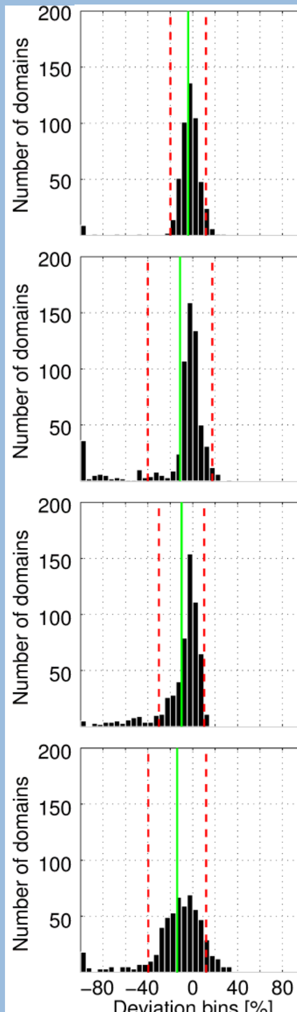
12 – 8 hPa

3.5 – 2.5 hPa

1.3 – 0.7 hPa

0.13 – 0.07 hPa





Percentage of rel. diff. domains within ±10 (20) % deviation

77.8(96.8)

71.5(83.7)

69.1(82.4)

38.7(66.2)

Conclusions

- **TM method showed a high accuracy up to 1 hPa compared to MLS**
- **Deviations to MLS become larger in the mesosphere - Inaccurate model wind fields (too low temporal resolution?)**
- **Polar vortex structures are well represented by correct displayed horizontal gradients of H_2O VMR, even on 10 hPa level during the January 2012 SSW**

→ **TM works but …**

- **a second high latitude (>60°N) measurement site would be desirable during the winter season to fill up data gaps**

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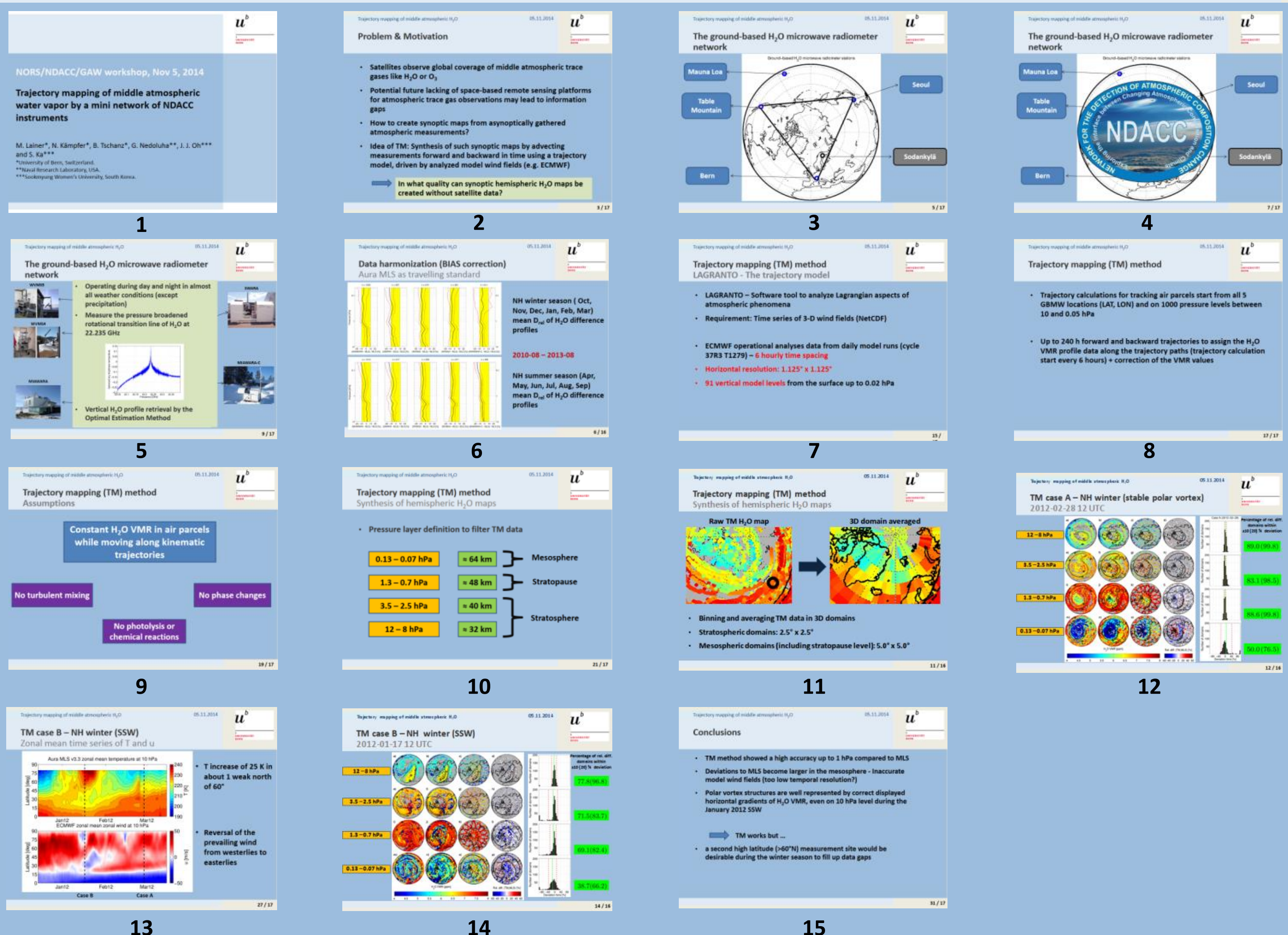
THE END

Thank you for your attention! Questions?



THE END

ADDITIONAL SLIDES

ADDITIONAL SLIDES

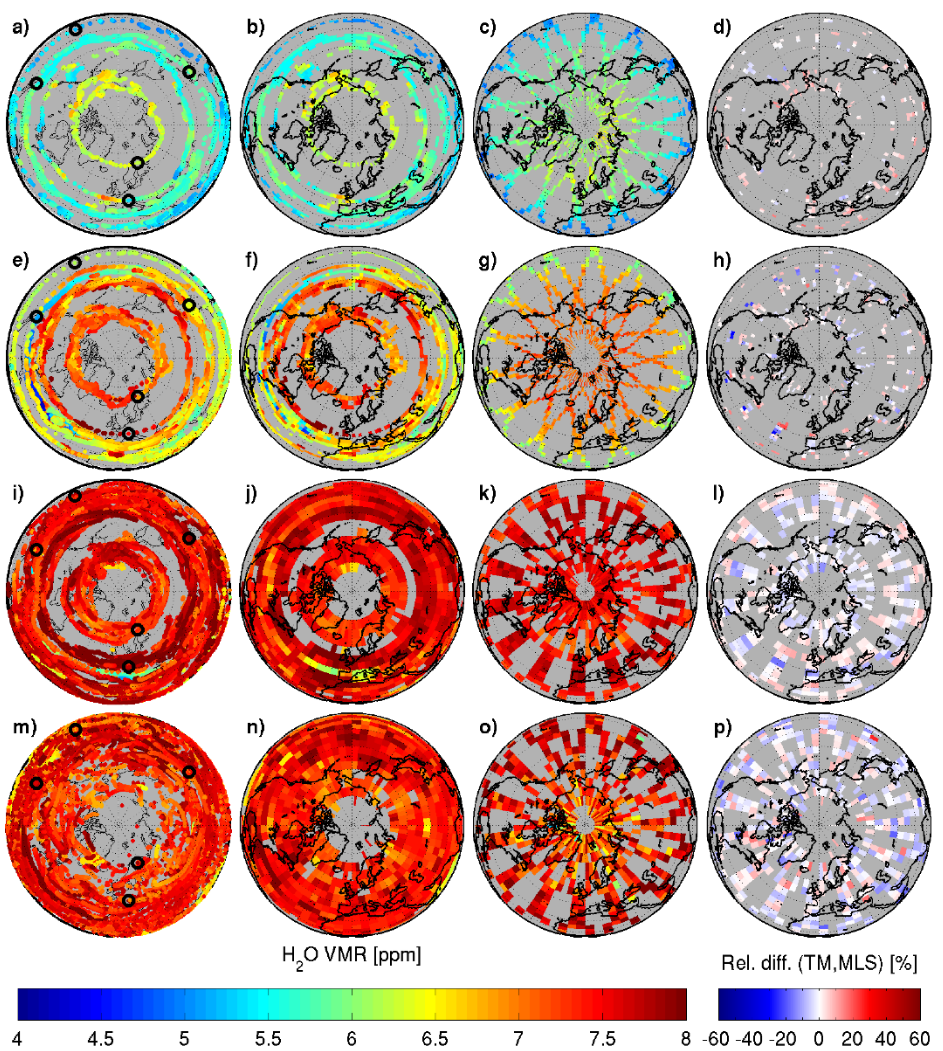
TM case C – NH June solstice 2012-06-12 12UTC

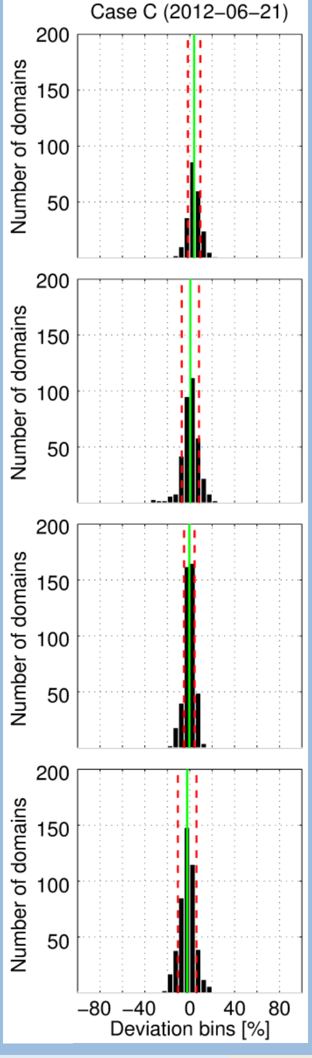
12 – 8 hPa

3.5 – 2.5 hPa

1.3 – 0.7 hPa

0.13 – 0.07 hPa





Percentage of rel. diff. domains within ±10 (20) % deviation

85.7 (99.6)

85.3 (97.5)

94.5 (100)

83.4 (99.1)

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ADDITIONAL SLIDES

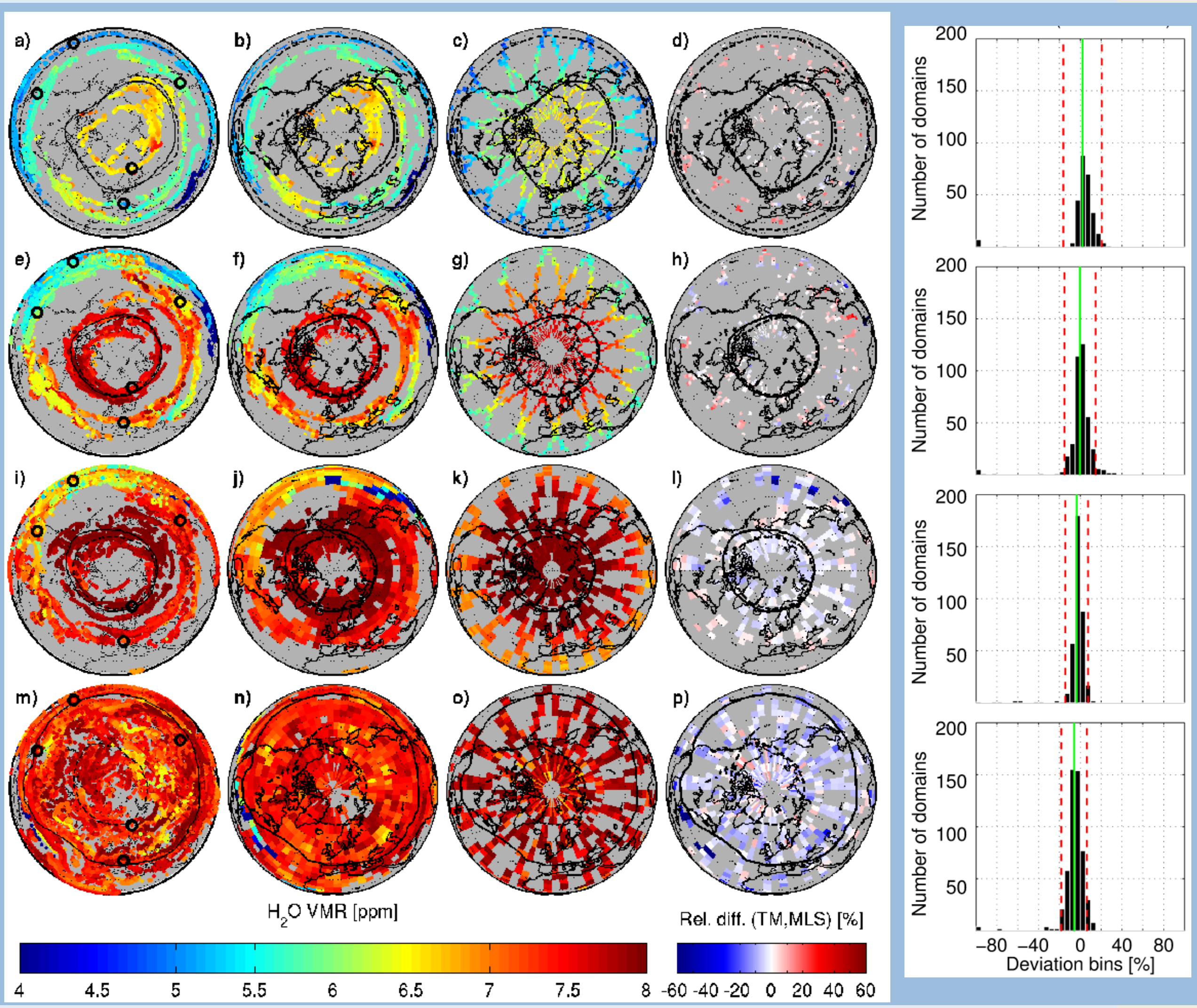
TM case D – NH fall equinox 2012-09-22 12UTC

12 – 8 hPa

3.5 – 2.5 hPa

1.3 – 0.7 hPa

0.13 – 0.07 hPa



Percentage of rel. diff. domains within ±10 (20) % deviation

77.8 (95.1)

82.3 (95.5)

93.7 (97.0)

80.0 (96.7)