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Testing isotopologues as diabatic heating proxy for atmospheric data analyses

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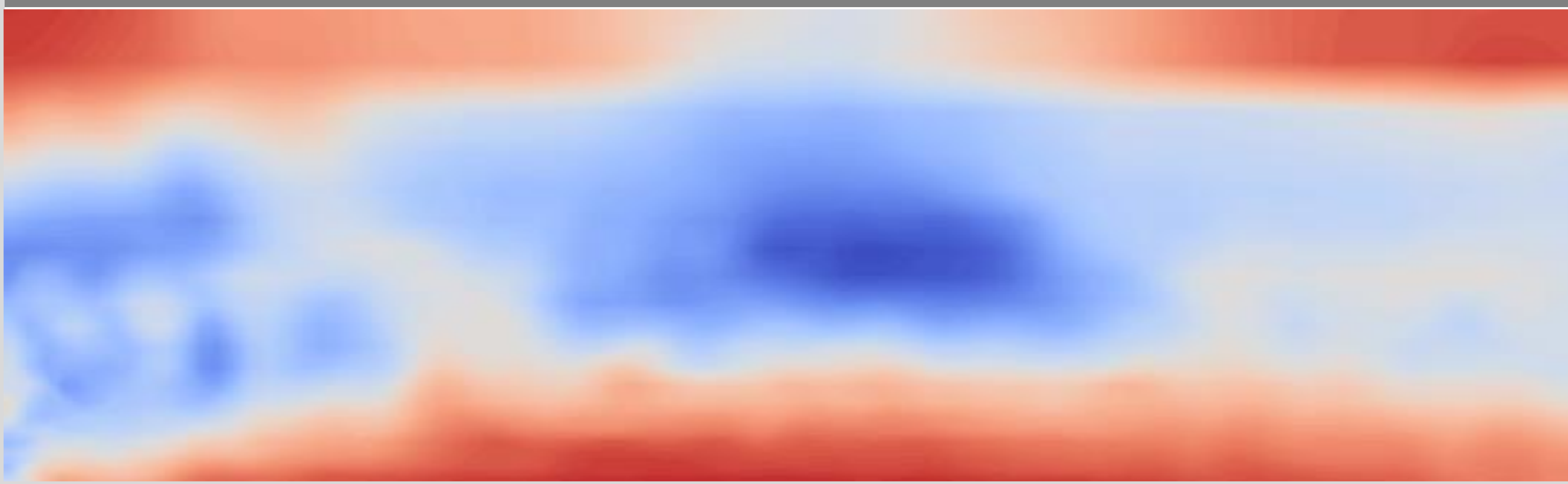
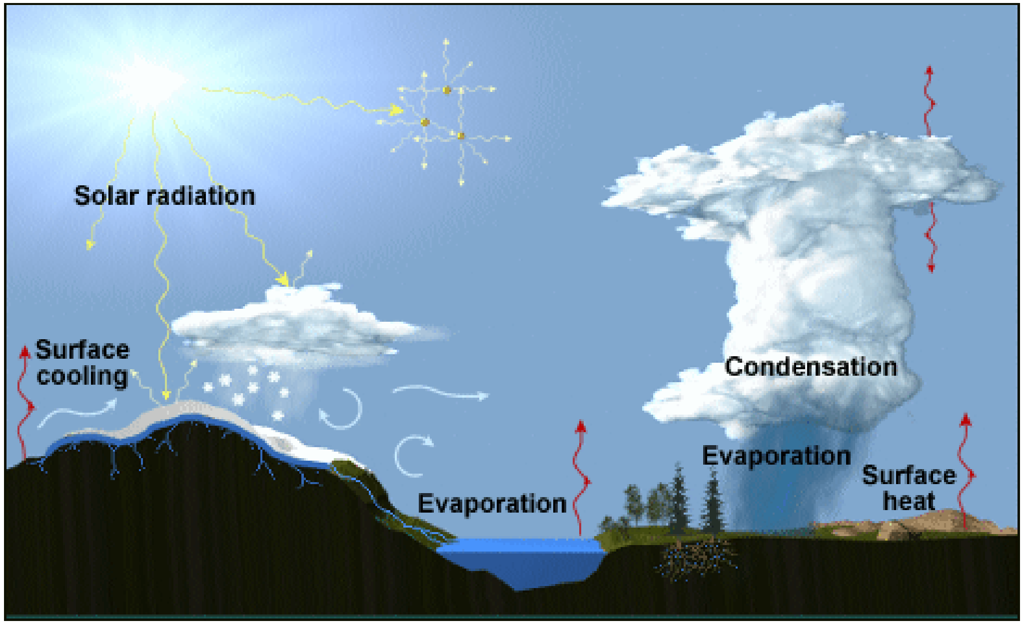
ATMOSPHERIC TRACE GASES AND REMOTE SENSING (ASF)
INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH (IMK)



Introduction



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Diabatic Heating

$$Q_{tot} = Q_{rad} + Q_{con} + Q_{sen}$$

Q_{rad} – radiative heating
Q_{con} – condensational heating
Q_{sen} – sensible heating

http://tornado.sfsu.edu/geosciences/classes/m201/buoyancy/SkewTMastery/mesoprim/skewt/stability_heat1.htm

Diabatic processes drive atmospheric motion. The release of the latent heat of condensation has important local effects, potentially leading to deep convection. In addition, evaporation and melting effects have a significant impact on lapse rates locally in instances of heavy precipitation.

Introduction

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- Diabatic heating is the major driving force of atmospheric circulation on weather and climate time scales
- However, diabatic heating rates from current global reanalyses show significant inconsistencies
- This jeopardises the accuracy of:
  - Climate predictions
  - Numerical Weather predictions
- Major reason: diabatic heating rates cannot be directly observed

Atmospheric Trace Gases and Remote Sensing
Institute of Meteorology and Climate Research

Motivation

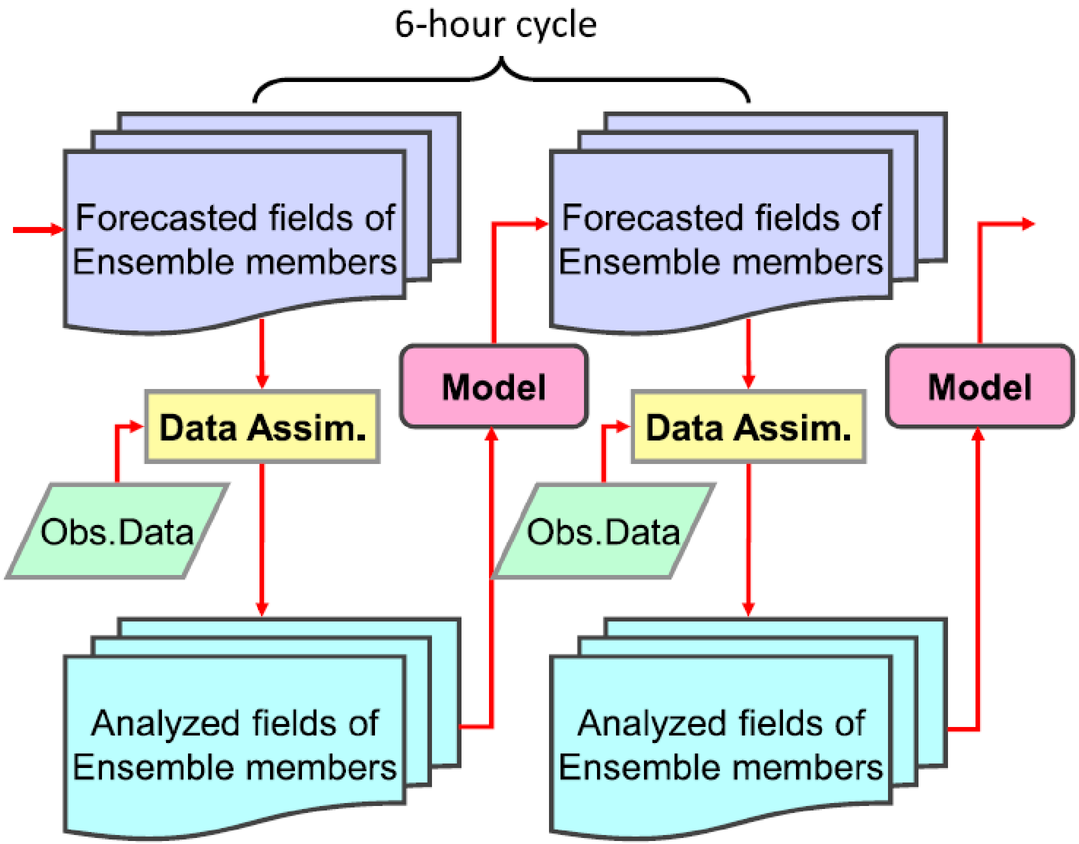
Can the assimilation of water isotoplogues help to improve diabatic heating rates?

- DFG Project TEDDY – Testing isotopologues as diabatic heating proxy for atmospheric data analyses
- Assimilation of IASI data into an isotope enabled model (IsoGSM) to test if diabatic heating rates and thus atmospheric circulation can be improved

Method

- Isotopologues observations from IASI (Infrared Atmospheric Sounding interferometer) onboard MetOp-A and MetOp-B (Schneider et al. 2015, 2016)
- OSSE- Observation System Simulation Experiment (Yoshimura et al. 2014)
- Impact assessment of the idealized assimilation experiment done by using the spread (SD) and RMSD of the ensemble

Method



Model: IsoGSM (Yoshimura et al., 2008)
Data Assim.: LETKF (Miyoshi, 2011)
Obs.Data: Synthesized IASI data

Yoshimura et al. (2014)

Method

- Data Assimilation: Local Ensemble Transform Kalman Filter (LETKF)
- Model: Isotope-incorporated GCM IsoGSM
  - PREPBUFR: common assimilation
  - PREPBUFR+IASI: additionally IASI is assimilated (at 4.2 km)
- Ensemble simulations (size 96) with resolution T62L28 (1.875° x 2°)
- Initial conditions: 6-hourly 01.07.2017
- Evaluation with the Nature ("Truth") for the period Jul-Aug 2016

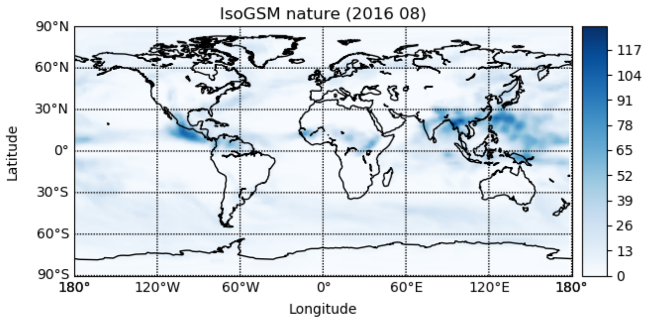
Results for the Idealized Assimilation Experiment (OSSE)

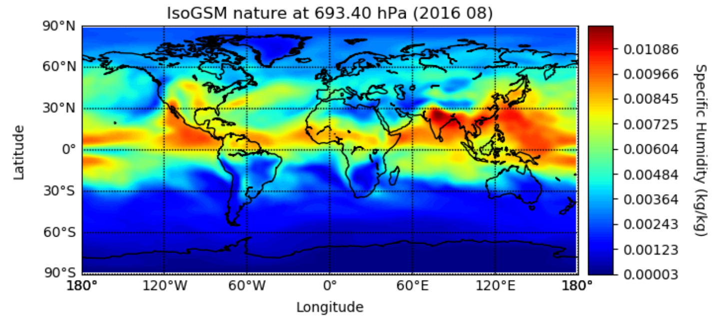
IsoGSM Results

Precipitation

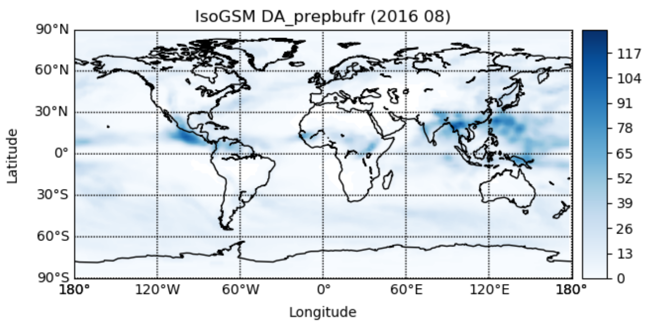
Specific Humidity

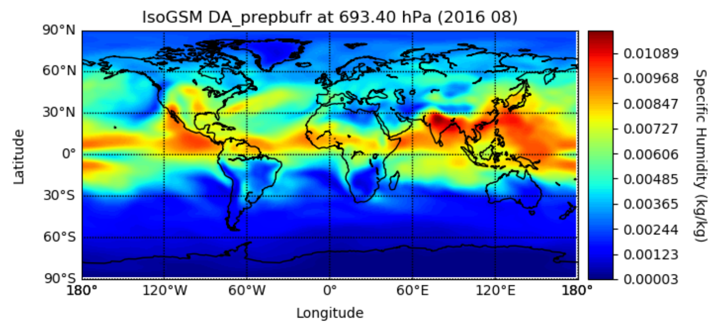
Ensemble Mean



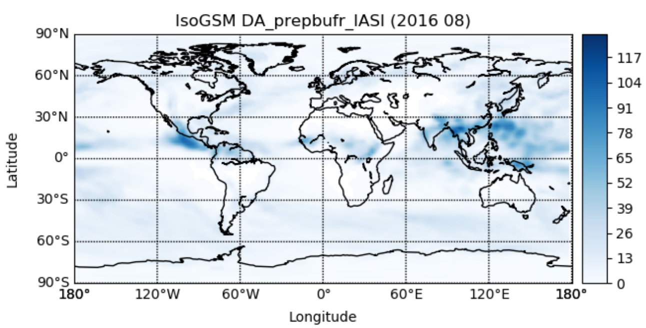


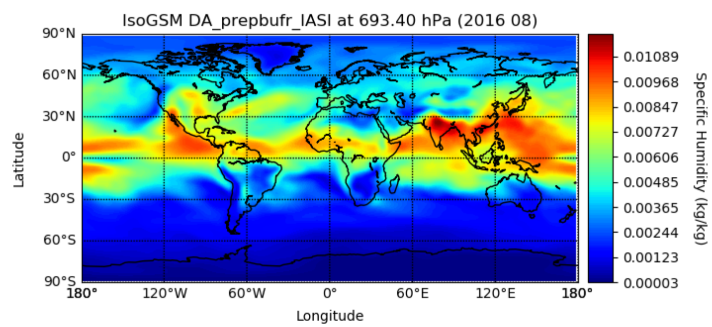
Nature





PREPBUR





PREPBUFR + IASI

Vertical Cross Sections (δD)

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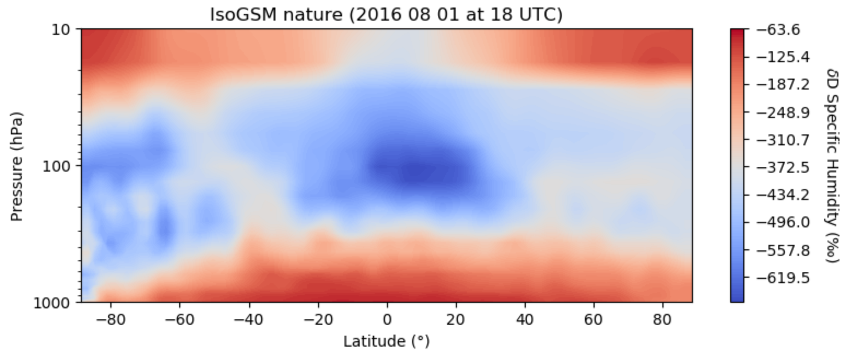
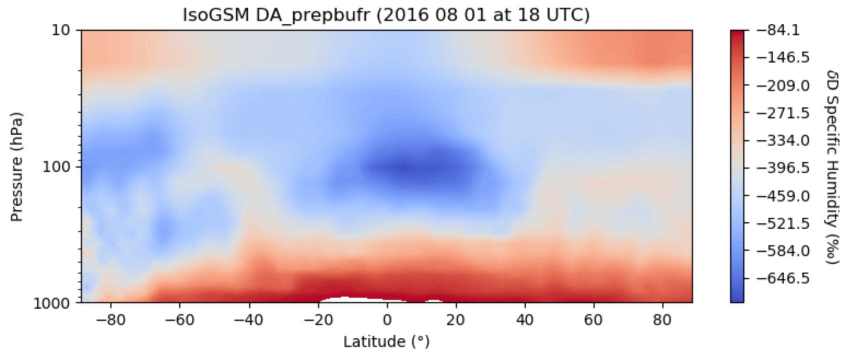
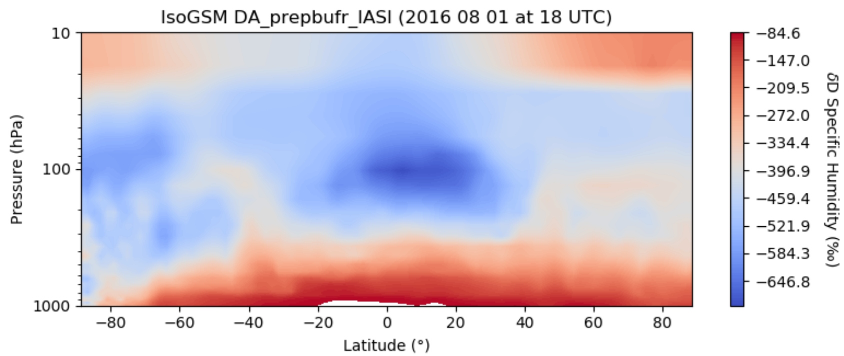
Nature



PREPBUFR



PREPBUFR+IASI



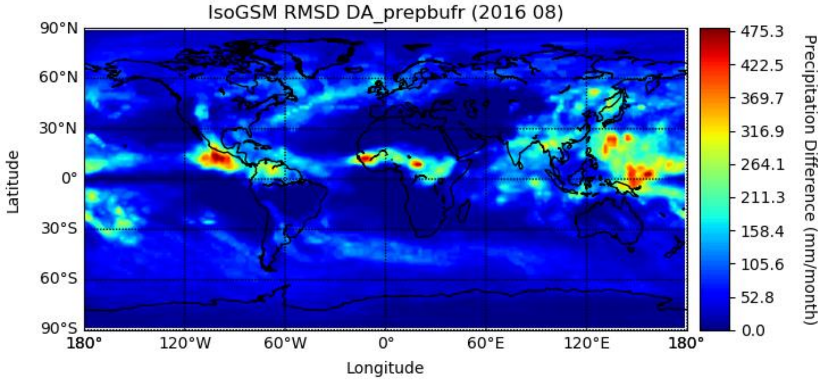
Ensemble Mean

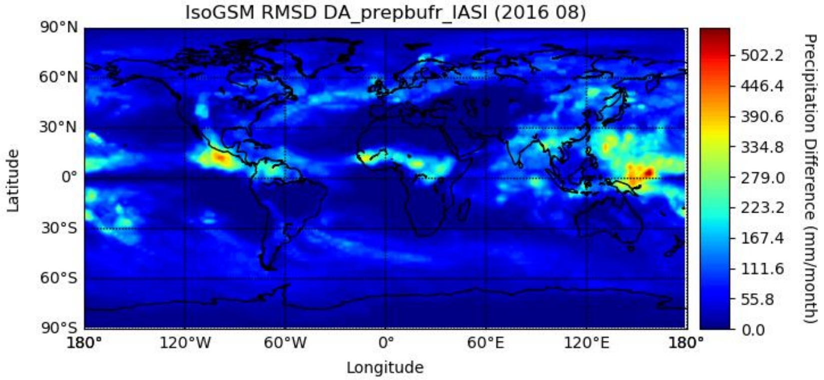
Qualitative comparison shows only small differences

Quantitative assessment using Spread and RMSD helps to assess the impact

RMSD Precipitation (2016-08)

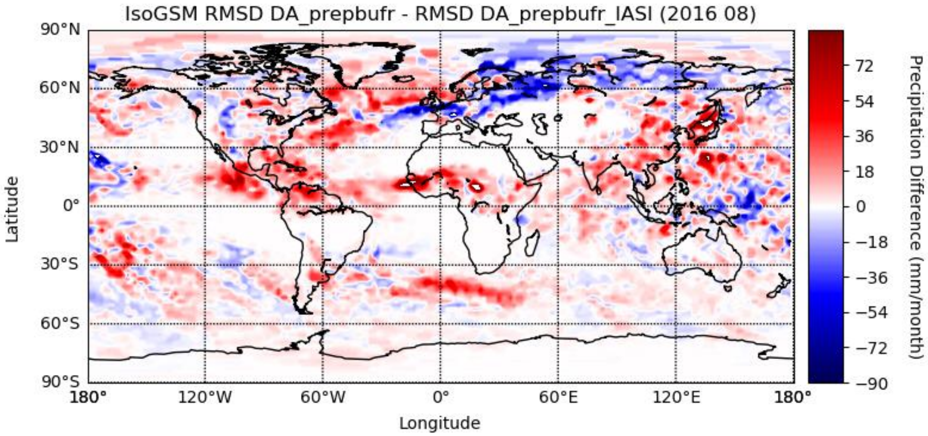
PREPBUFR





PREPBUFR+IASI

(PREPBUFR) – (PREPBUFR+IASI)



Red - Improvement
Blue - Degradation

Difference RMSD (2016-08)

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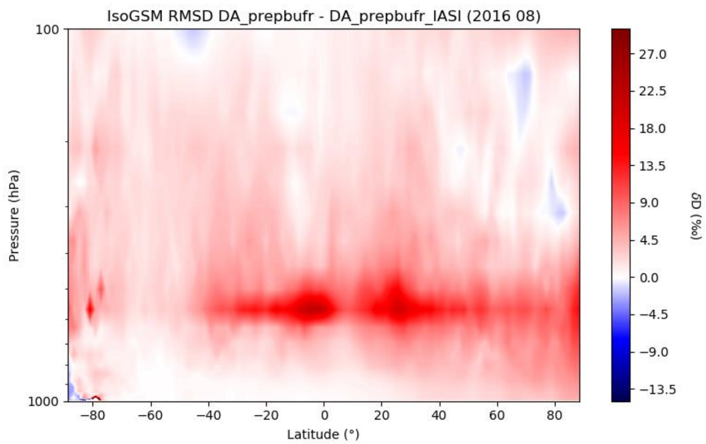
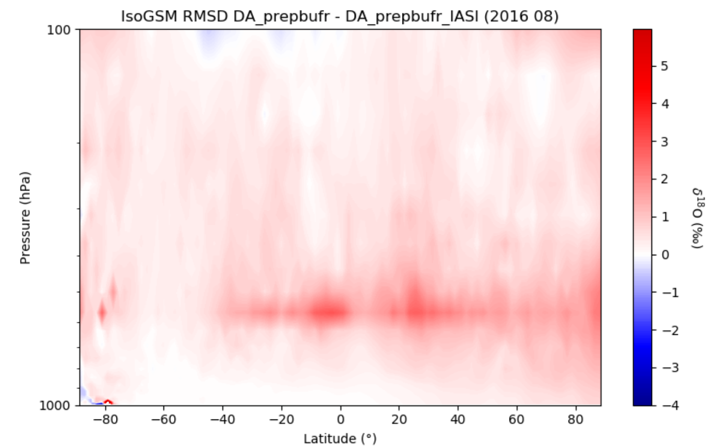
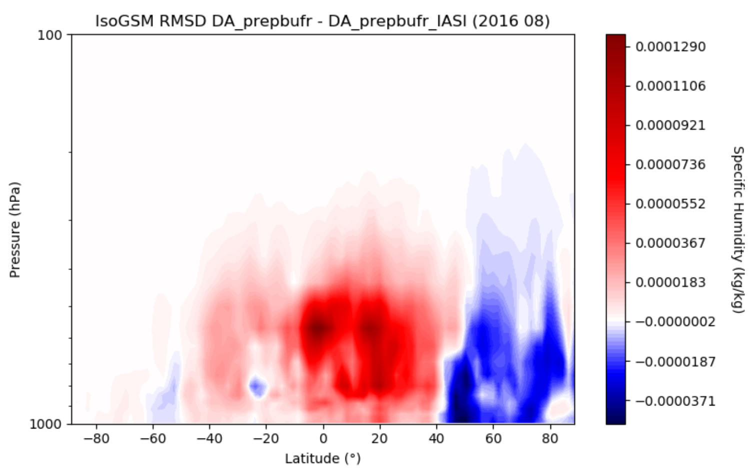
δD

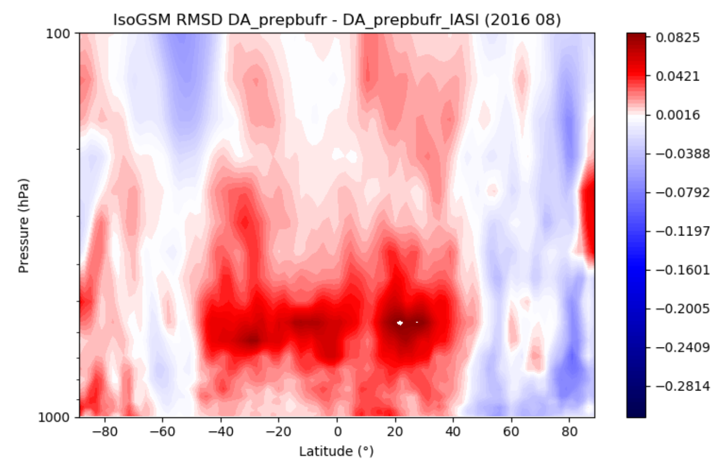




δ18O

Q



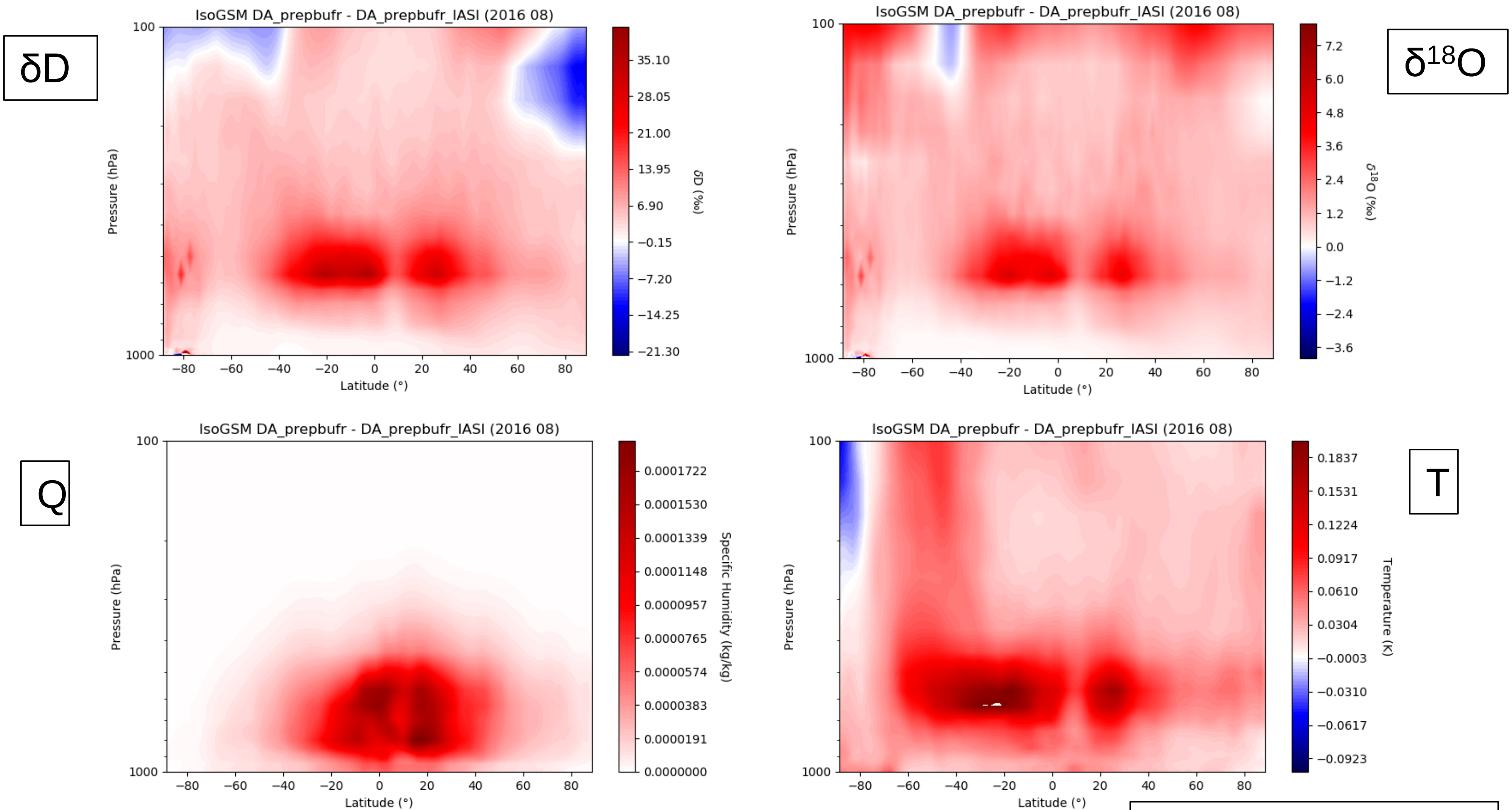


T

RMSD (PREPBUFR) – RMSD (PREPBUFR+IASI)

Red – Improvement
Blue – Degradation

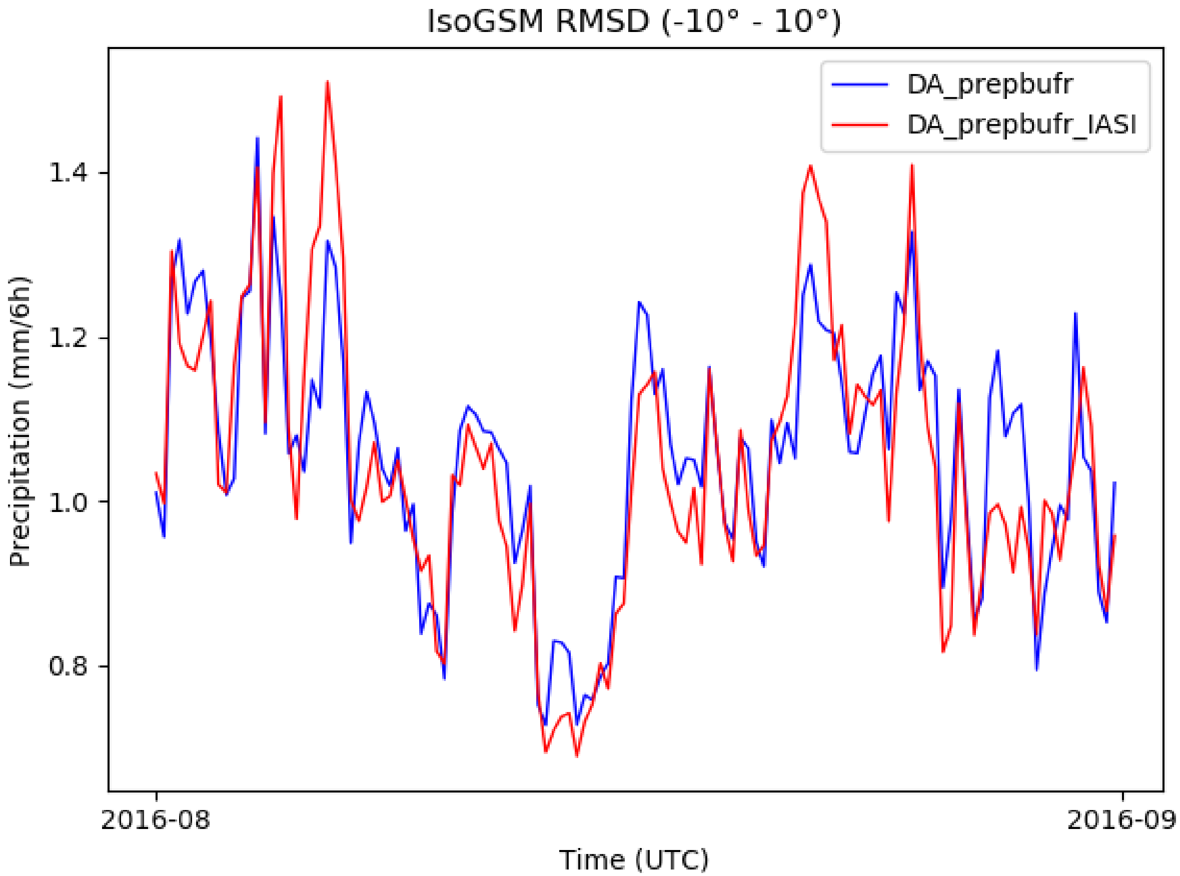
Difference Ensemble Spread (SD)



SD (PREPBUFR) – SD (PREPBUFR+IASI)

Red – Decrease
Blue – Increase

Time Series (RMSD) - Tropics

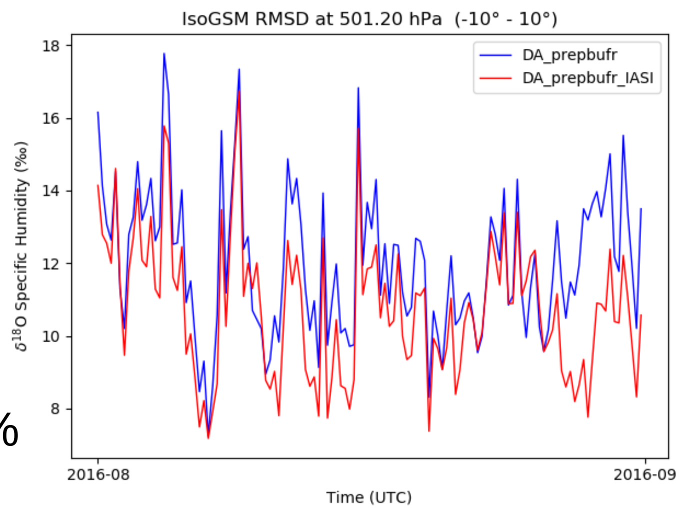


-1.35 %

Precipitation

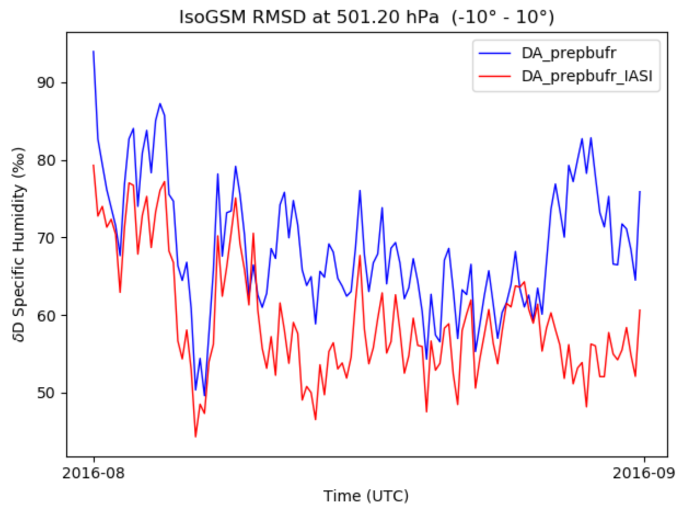
Time Series (RMSD) – Tropics at 501 hPa

δ18O



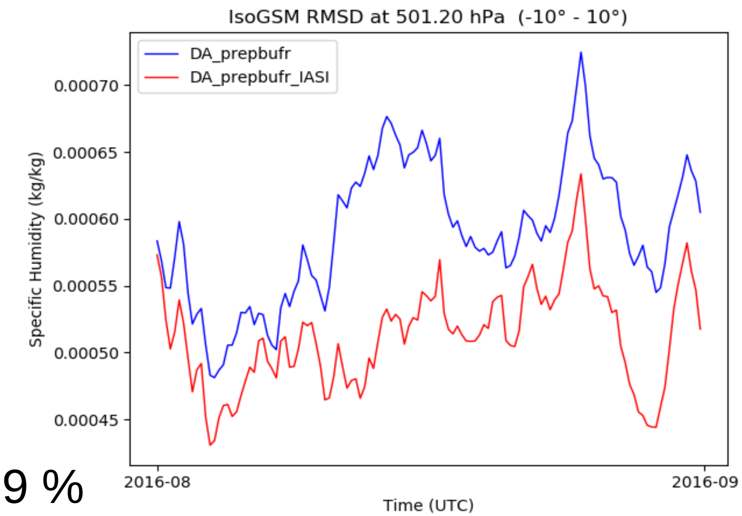
-11.2 %

δD



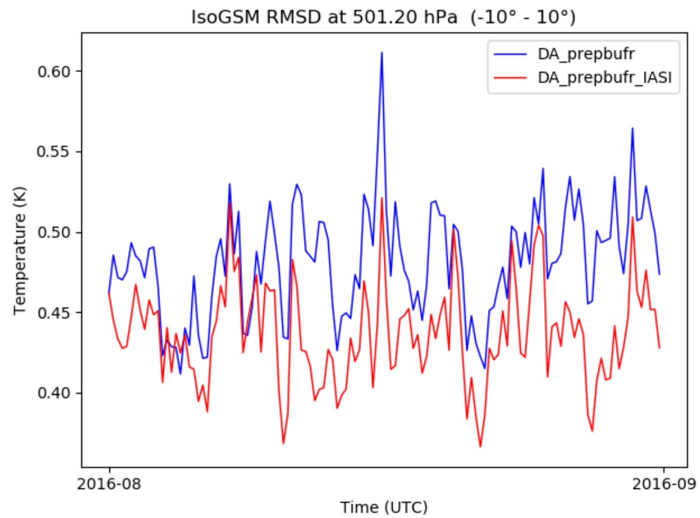
-14.9 %

Q



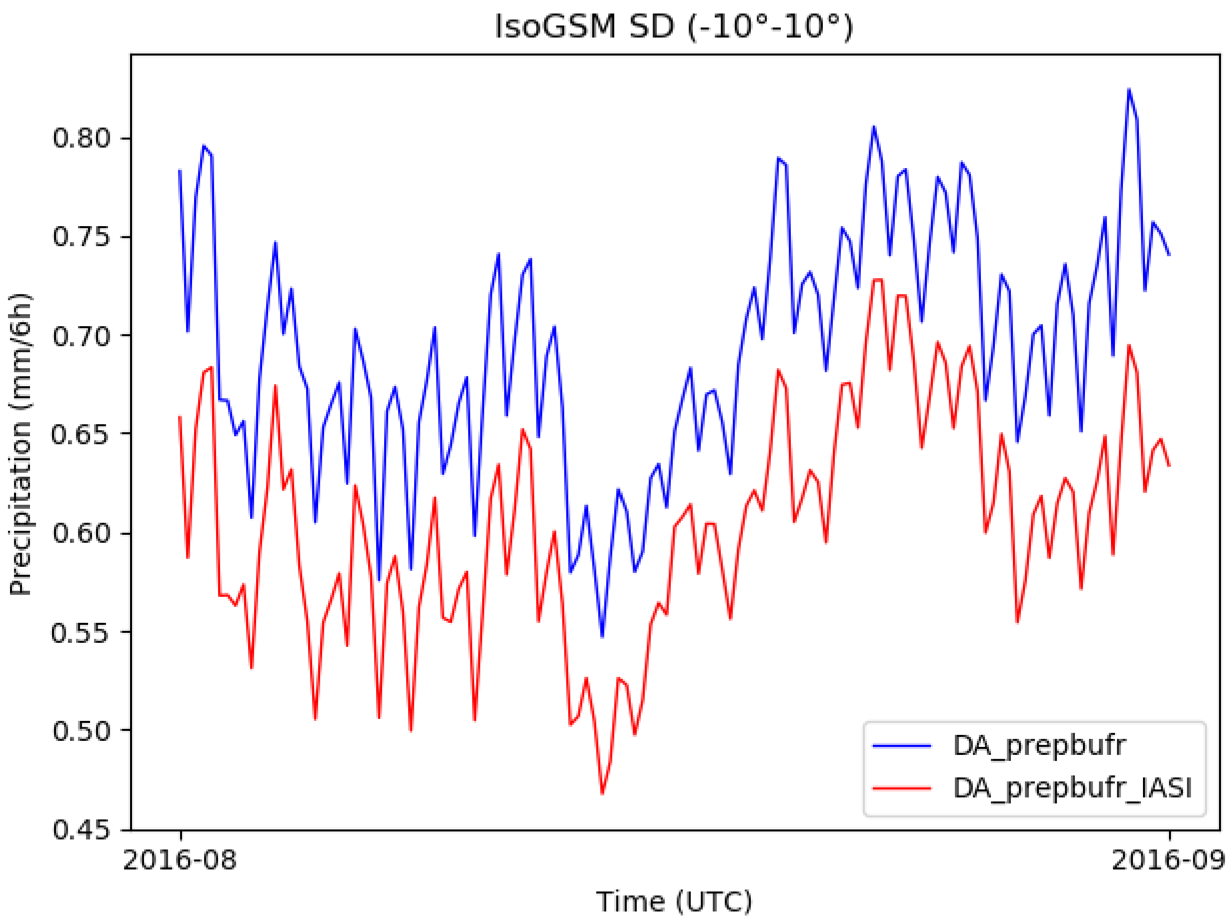
-13.9 %

T



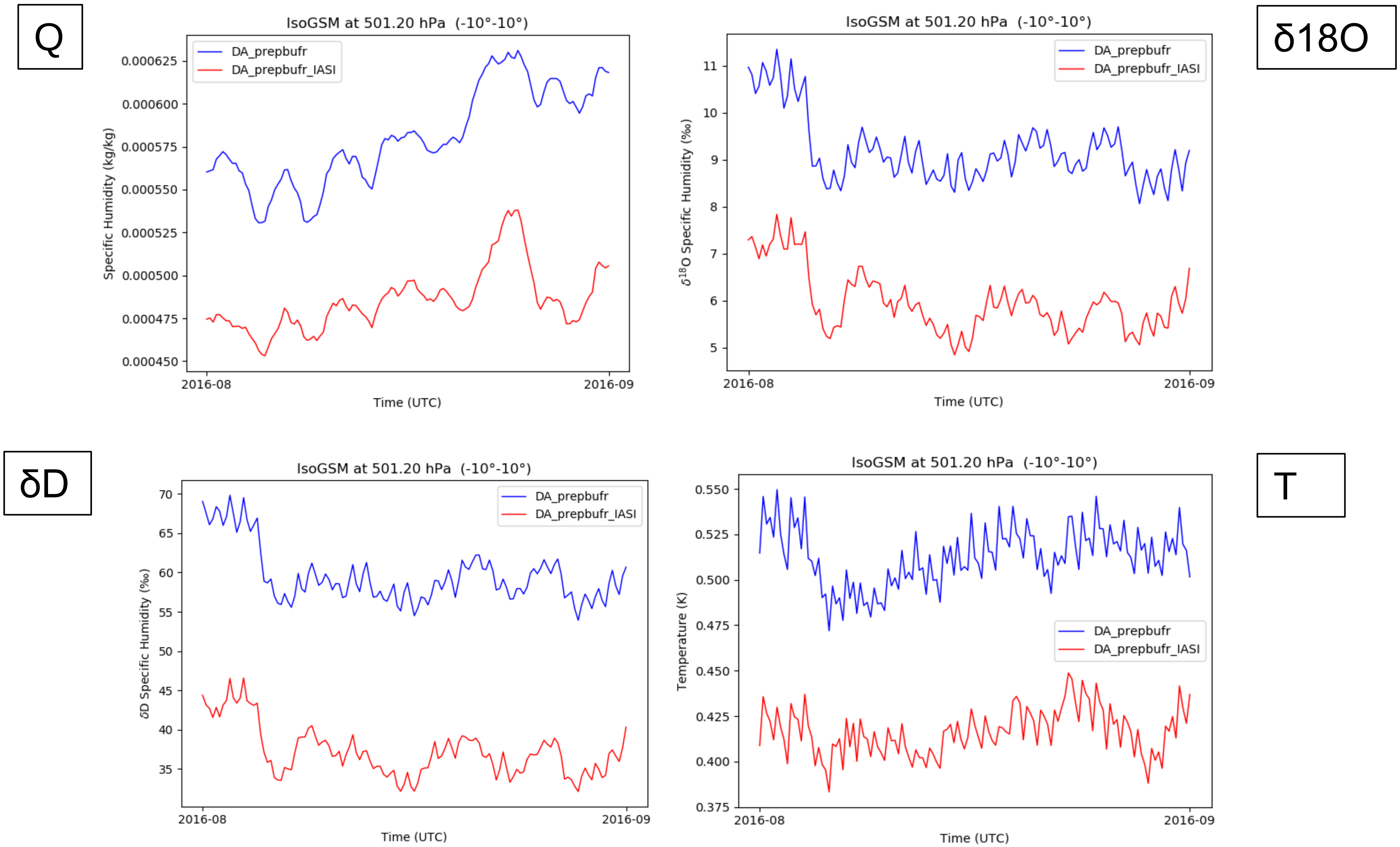
-9.8 %

Ensemble Spread (SD) - Tropics



Precipitation

Ensemble Spread (SD) - Tropics



Conclusions

- Idealized assimilation experiment with mocking IASI data into OSSE shows that the ensemble spread can be reduced and the RMSD decreased
- Highest decrease/improvement in the tropics and at ~4.2 km where IASI has the highest sensitivity
- This shows that the assimilation of IASI data has the potential to improve diabatic heating rates and thus also weather forecasts and climate predictions
- Analyses of real experiments will be done in the future ……