

A Climatological Perspective on the Seasonal and Regional Water Vapor Variability in the UT/LS from Air- and Balloon-Borne In-situ Measurements

TPCHANGE

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1 Water Vapor in the UT/LS – A Major Uncertainty in Current Observations and Future Climate Predictions

- In the UTLS region the atmospheric radiative forcing is highly sensitive to changes in water vapor concentrations
 - Here, the inconsistency between different observation (in-situ, satellite) and models is largest, with **differences of often 50 % and more**
 - In-situ data help reduce these uncertainties due to their high precision and ability to resolve large water vapor gradients

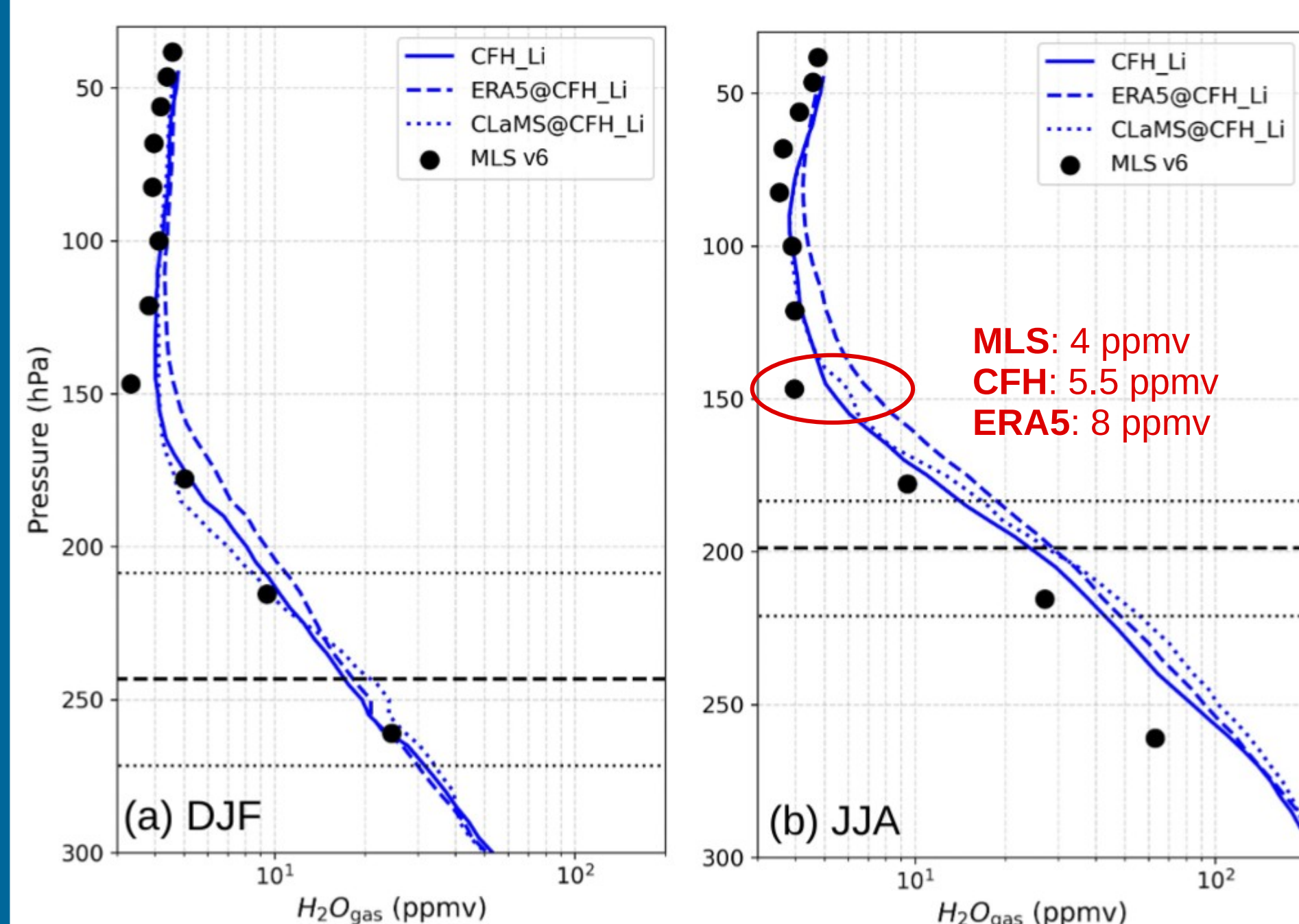
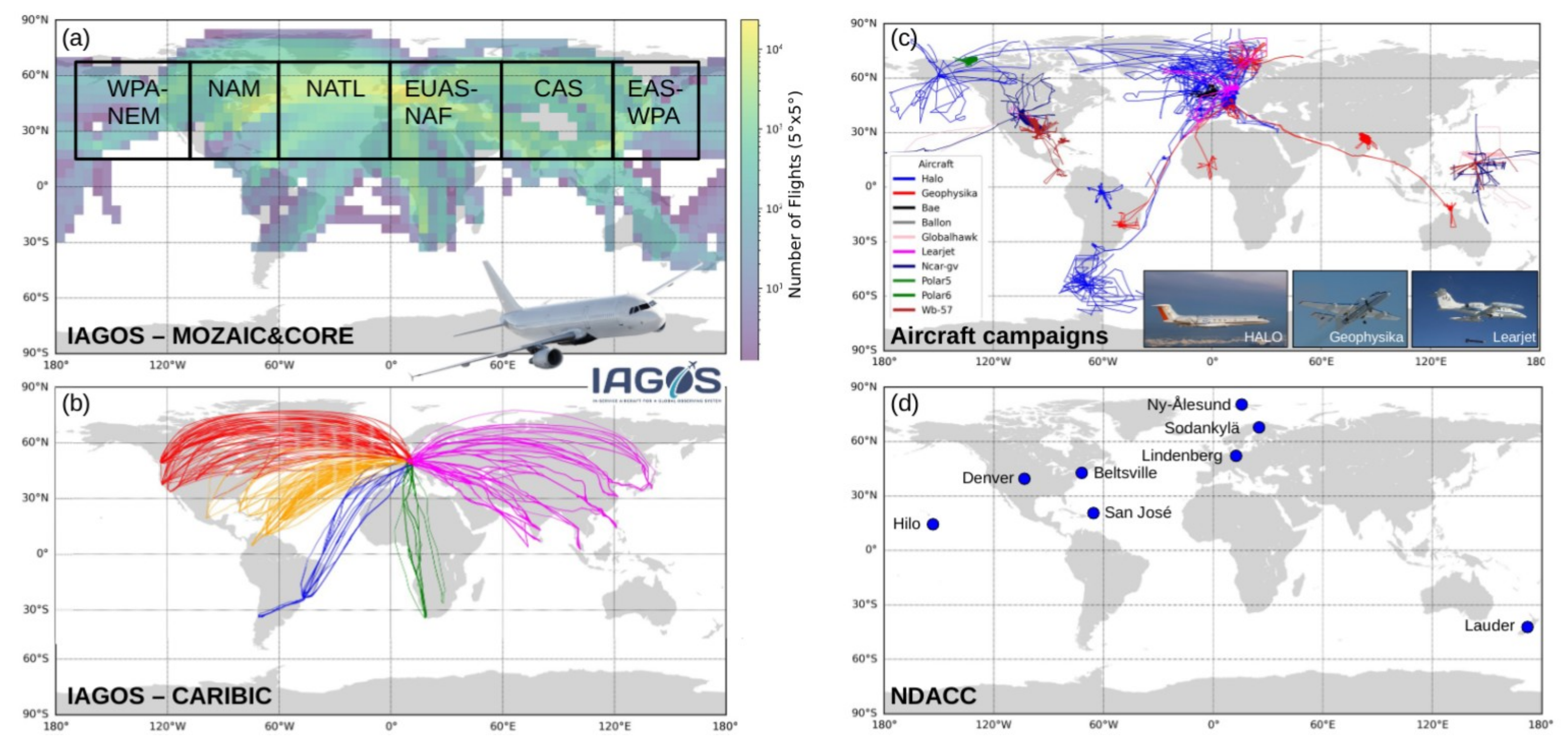


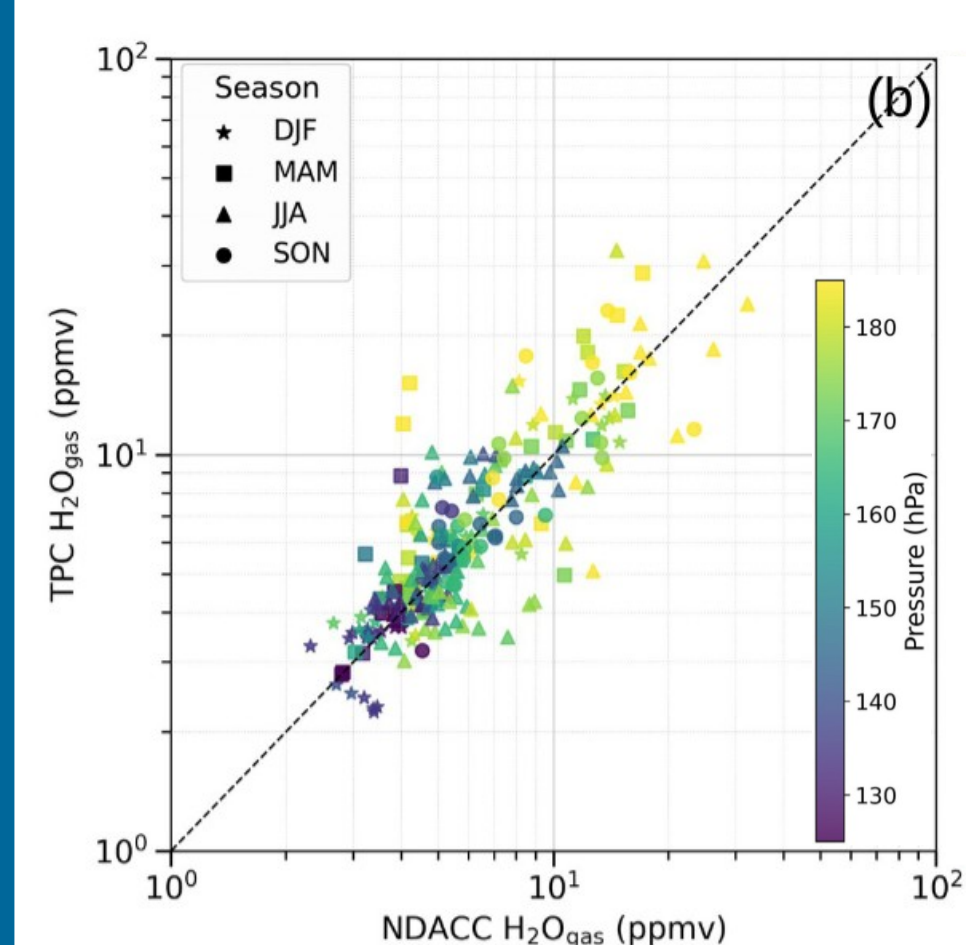
Figure: Intercomparison of satellite (MLS), in-situ (CFH) and model (CLaMS, ERA5) data. Blue solid line: balloon borne CFH obs. over Lindenberg (Germany). In addition, collocated MLS, ERA5 and CLaMS profiles are shown. Horizontal solid & dotted lines: Mean and 10-90% percentile tropopause level, respectively.

2 A novel Set of In-situ Observations for a better Assessment of UT/LS Water Vapor

- 1) IAGOS-MOZAIC&CORE:** Adjusted climatologies derived from 70,000 passenger aircraft flights (Konjari et al., 2025)
- 2) IAGOS-CARIBIC:** 500 passenger aircraft flights with sophisticated measurements
- 3) Jülich in-situ database (JULIA):** Observations from 32 campaigns
- 4) NDACC frost point hygrometer:** Records from 8 locations

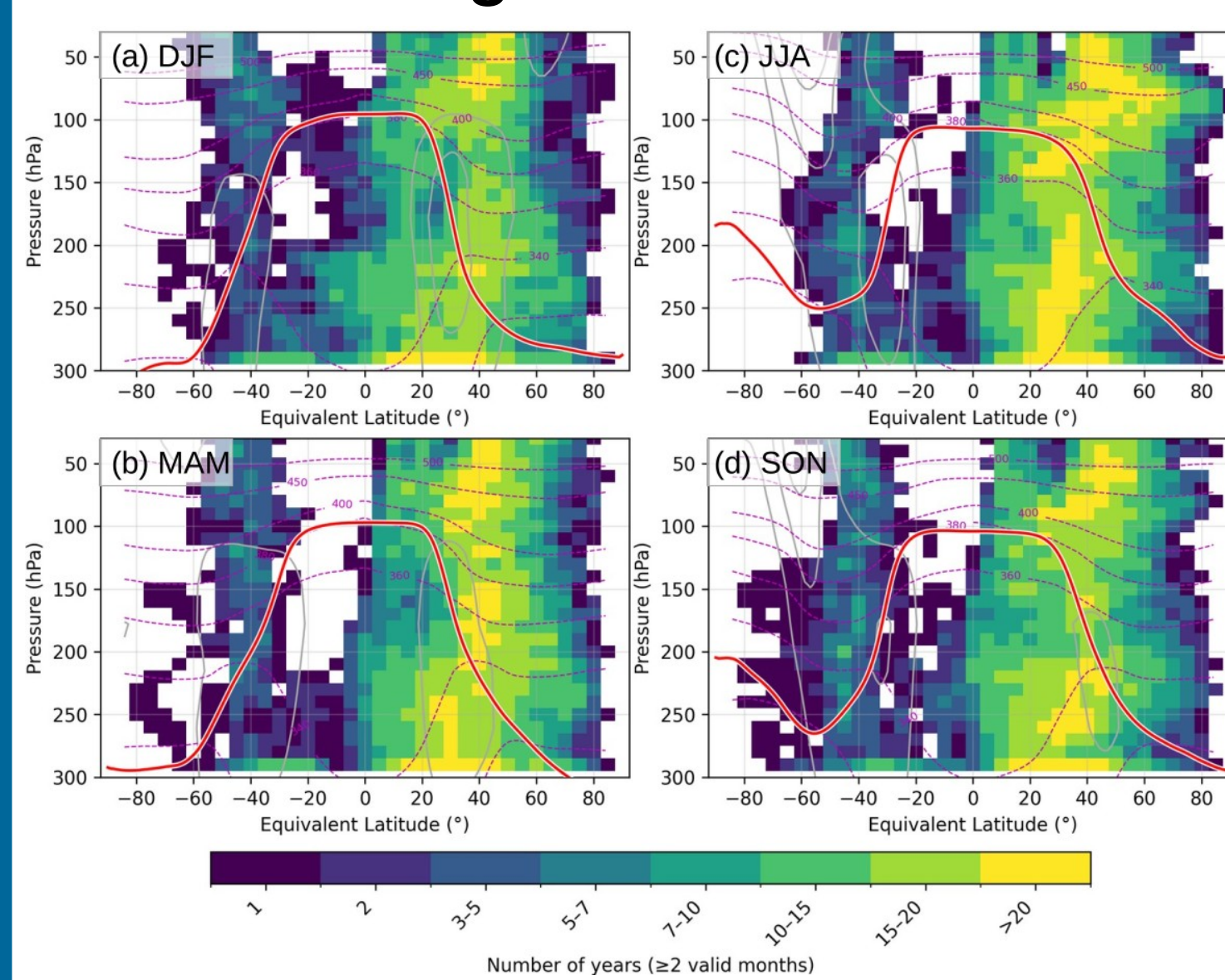


3 Water Vapor Climatologies derived from Merging Available In-Situ Datasets

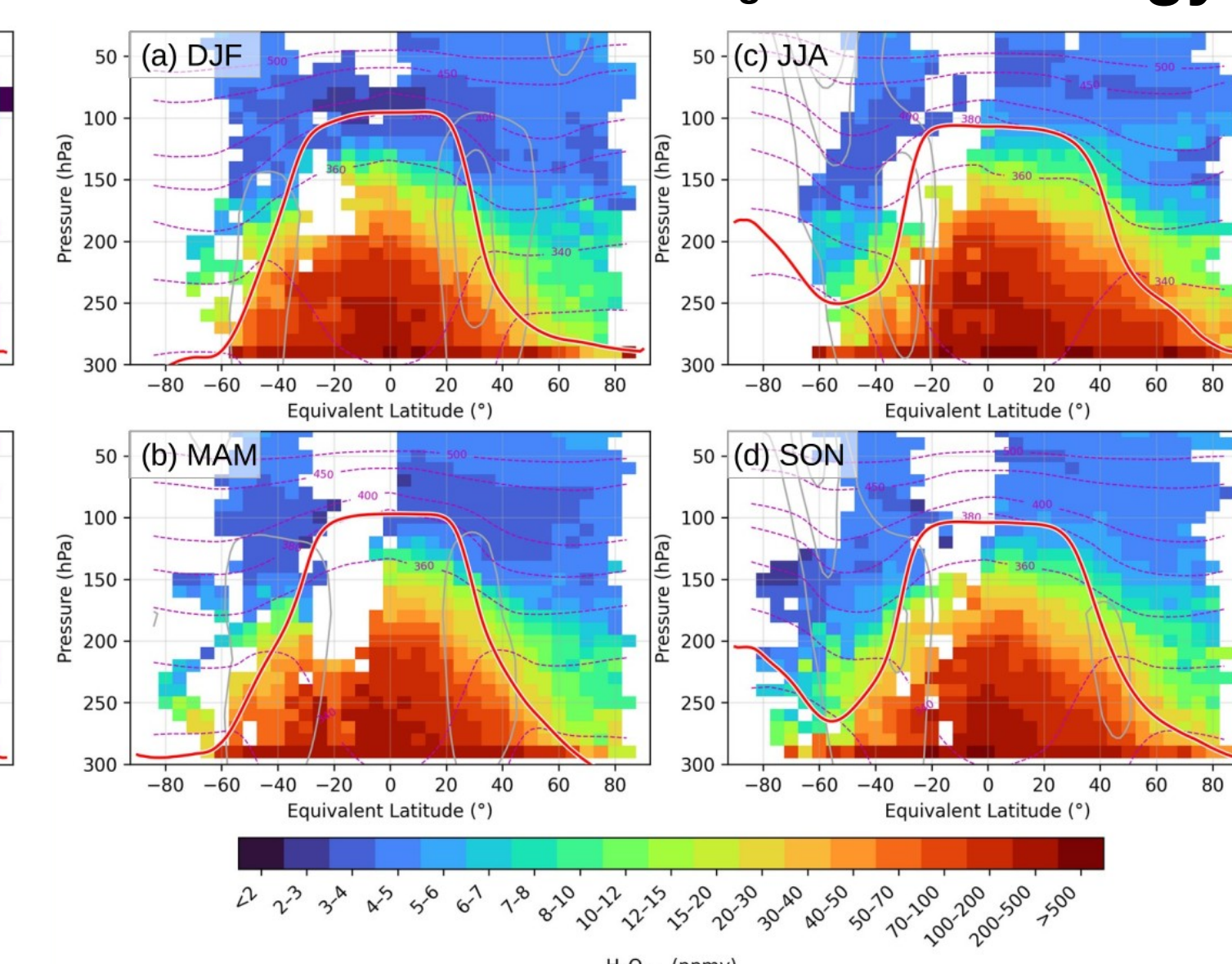


- CARIBIC & JULIA were shown to be consistent (Konjari et al., 2025) and were merged into the **TPChange (TPC) dataset**
- Next: Assess consistency of TPC and NDACC
 - Sampling by EqLat, Theta, longitude, seasons: Good agreement with no systematic deviation
 - Merging into the **TPC&NDACC dataset**

Coverage of TPC&NDACC



TPC&NDACC H2O gas Climatology

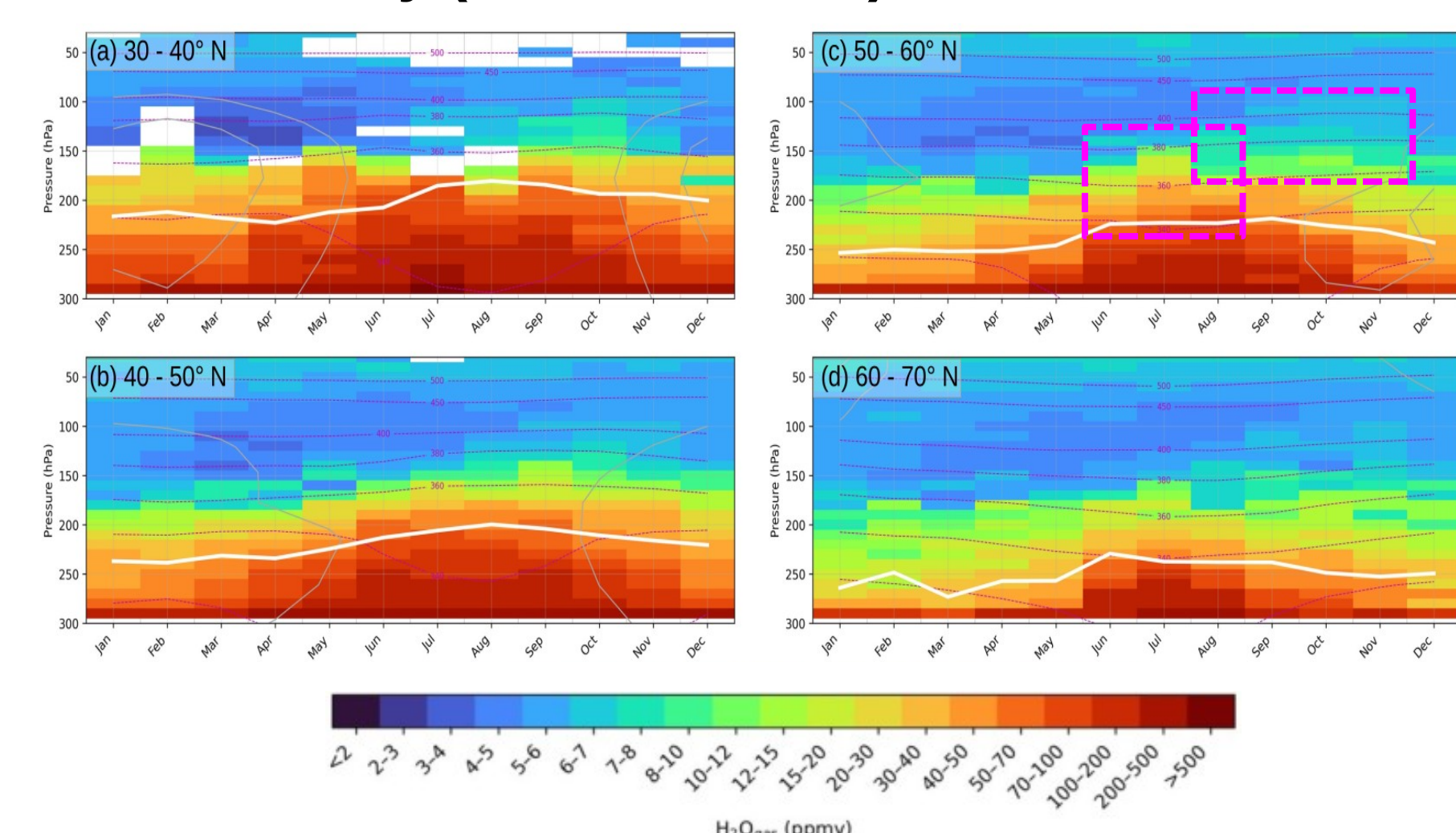


4 Seasonality of UT/LS Water Vapor in the Northern Hemisphere Extratropics

- Two moistening features:

- (1) Summer; UT/LS below 380 K:** Closely resembles the seasonal temp. cycle, possible influence of convection, especially from the American monsoon
- (2) Fall; LS above 360 K:** „Flooding“ of Asian monsoon air masses

Seasonality (60° W to 40° E) from TPC&NDACC



6 Conclusion and Outlook

- Water vapor data from a novel set of in-situ measurements were sampled into bins of similar dynamical origin and properties (as in OCTAV-UTLS)
 - Important features of the UT/LS water vapor are revealed, including the role of the N. Atlantic as a gateway of moister air masses into the LS during winter
 - The shown results are soon to be published
- The next step is to determine the radiative effect of the observed water vapor amounts to improve their representation in estimates of its effects in current and future climate

Reference

Konjari, P., Rolf, C., Hegglin, M. I., Rohs, S., Li, Y., Zahn, A., Bönisch, H., Nedelec, P., Krämer, M., & Petzold, A. (2025). **Technical note: Water vapour climatologies in the extra-tropical upper troposphere and lower stratosphere derived from a synthesis of passenger and research aircraft measurements.** *Atmospheric Chemistry and Physics*, 25, 4269–4289. <https://doi.org/10.5194/acp-25-4269-2025>