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Investigating long-term changes of water vapour in the upper troposphere and lowermost stratosphere derived from in-situ observations in frame of the European infrastructure IAGOS

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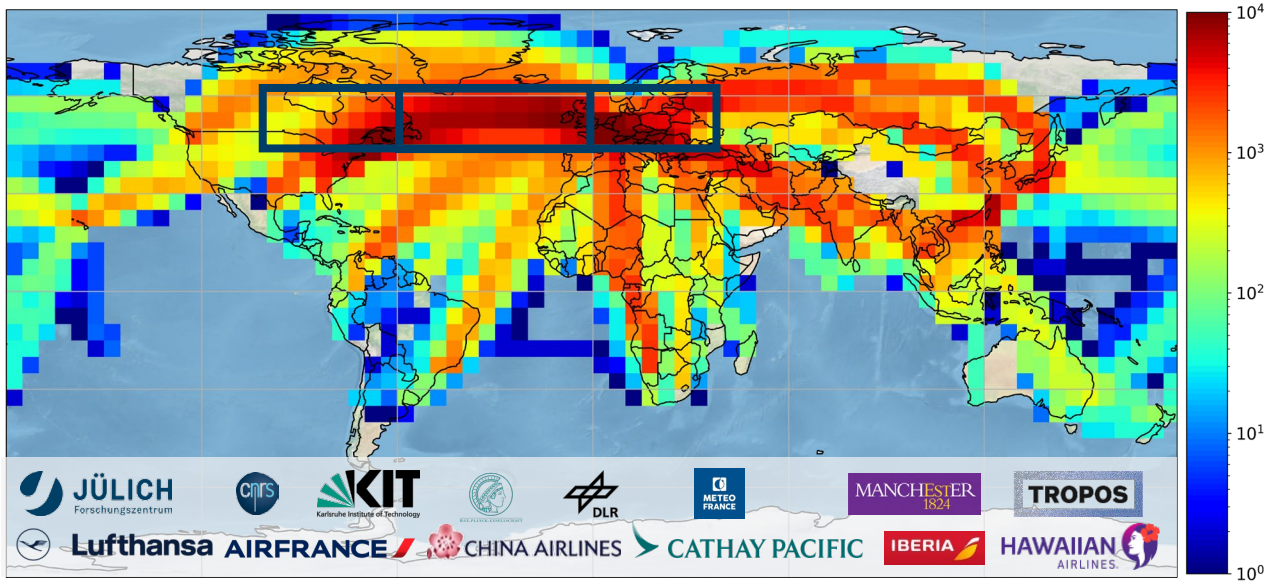
IAGOS IN-SERVICE AIRCRAFT FOR A GLOBAL OBSERVING SYSTEM

JÜLICH Forschungszentrum

Atmospheric Composition Dataset from Instrumented Passenger Aircraft



- European Research Infrastructure since 2014 (MOZAIC: 1994-2014 / CARIBIC 2004-2014)
- Regular in-situ monitoring of essential climate variables H_2O, RH_{ice}, O_3, CO, NO_x, CO_2, CH_4, aerosols, clouds
- 8 long-haul aircraft + 1 Flying Laboratory
- Open data policy; visit www.iagos.org

H_2O /RH_{ice} data record spans 25 years.

Data analysis focusing on:
North Atlantic
+ Eastern North America and Europe.

The IAGOS Workflow

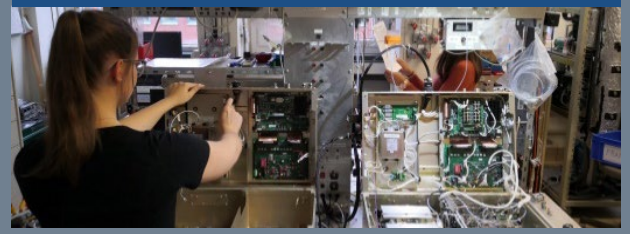
https://www.iagos.org/
=> link to new data portal!

OBSERVATIONAL DATA

DERIVED AND ELABORATED PRODUCTS

New features before summer:
Data provision service, KPIs, etc.

Research Institutions



calibration data

metadata

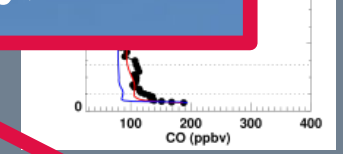
deployment

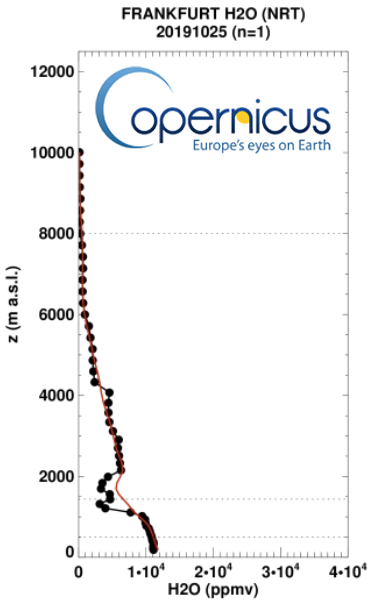
maintenance

IAGOS dat

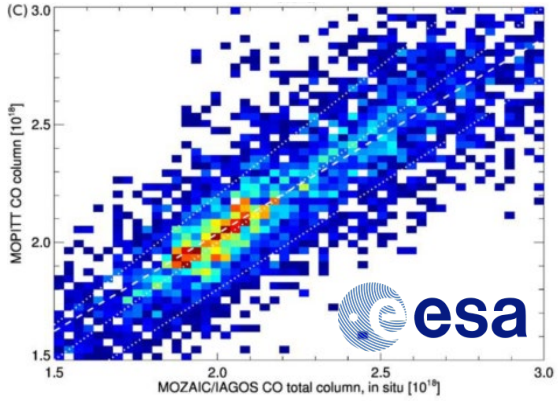
IAGOS Da
hosted
in Toulou

Lufth

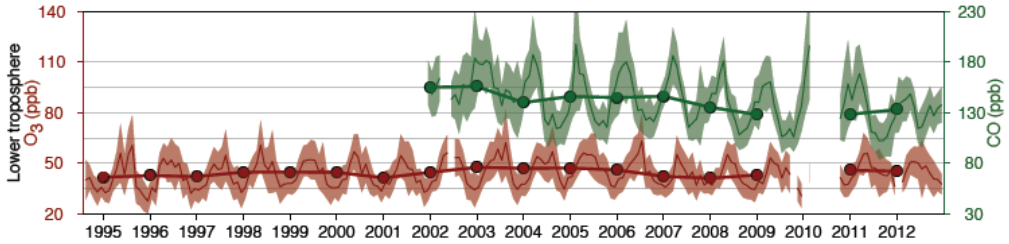




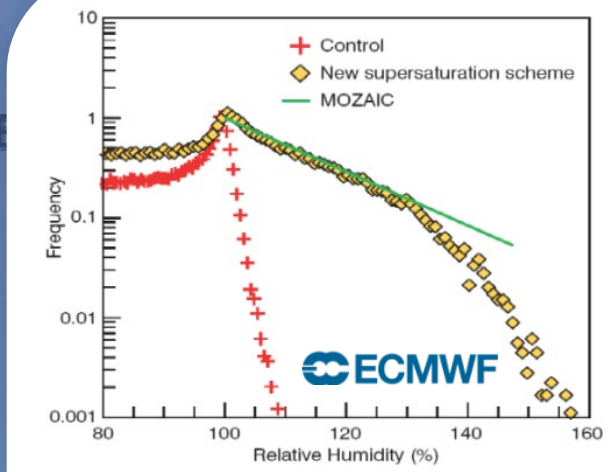
atmosphere monitoring



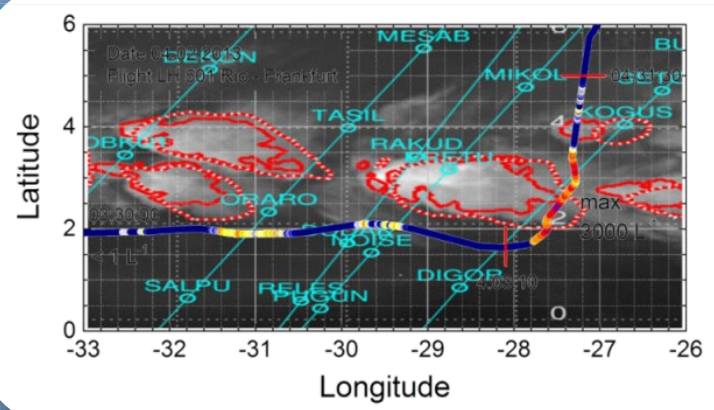
validation of satellite products



atmospheric long-term observation studies
trends in atmospheric composition change

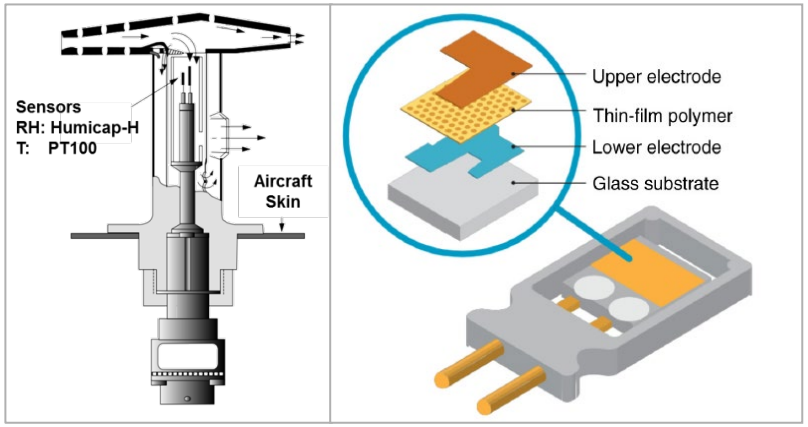


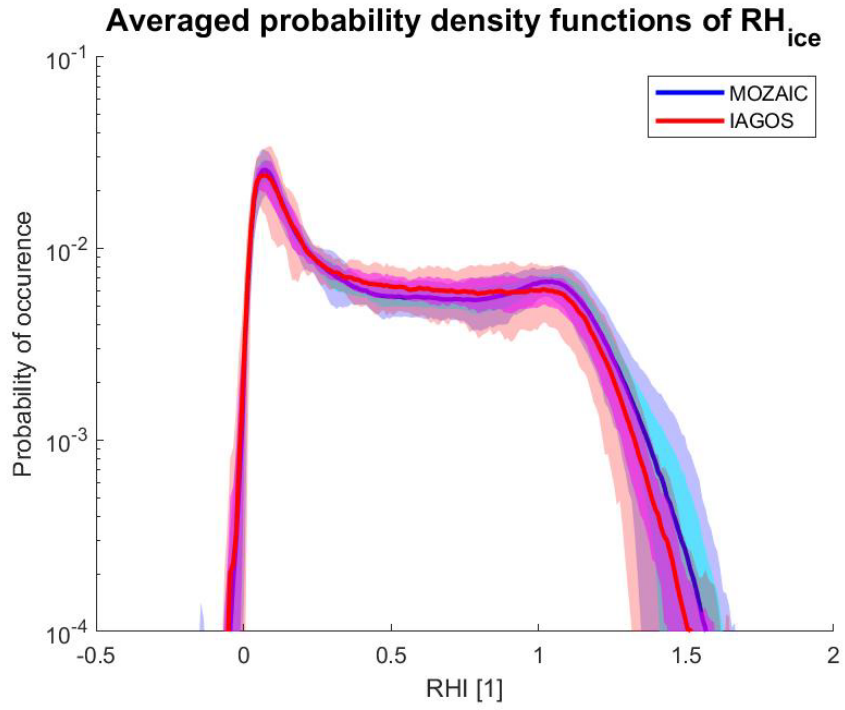
numerical weather prediction



safe
aircraft
routing

MOZAIC/IAGOS CAPACITIVE HYGROMETER (MCH/ICH)





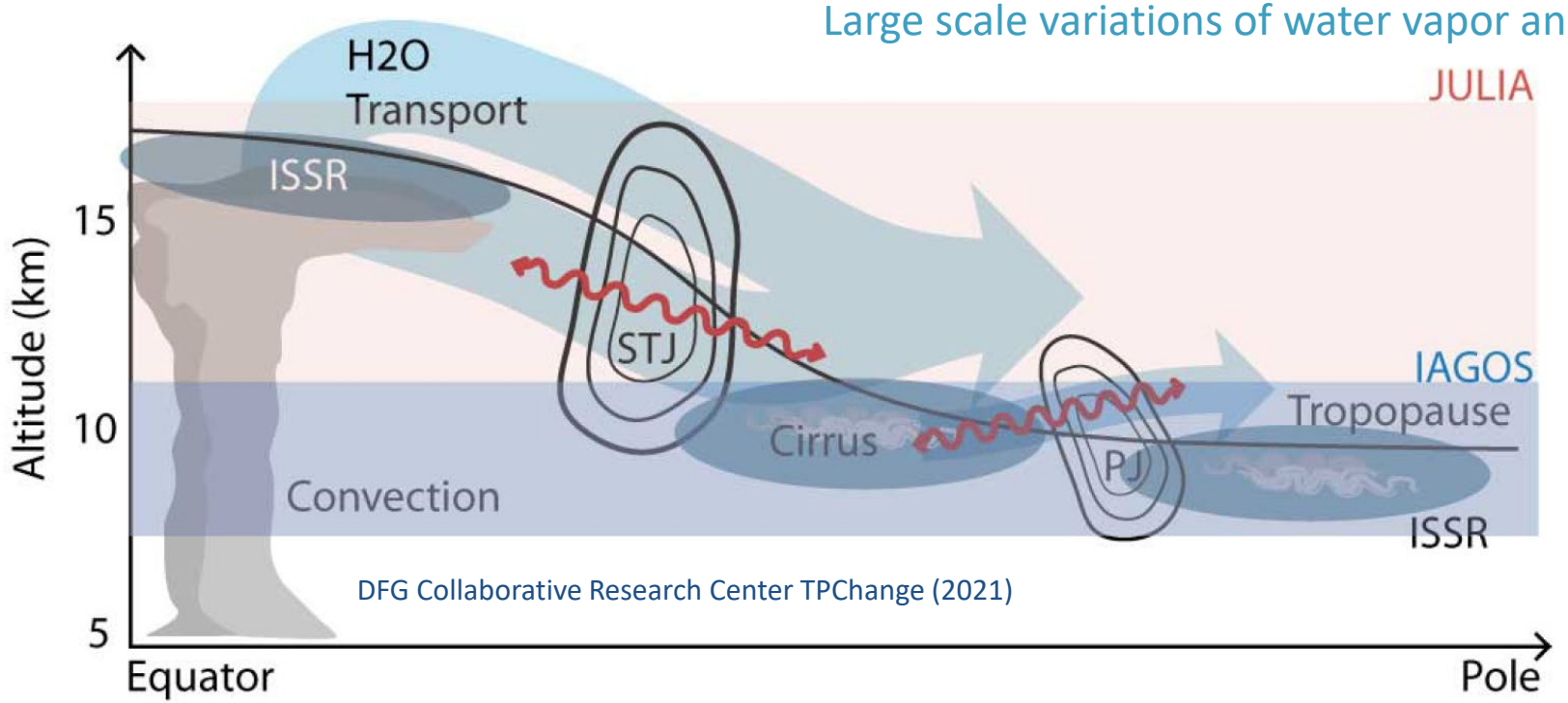
- Hydroactive Polymer Film which adsorbes H_2O
- Capacitance depends on relative humidity (RH);
- Calibrations traceable to frost point mirror
- Low maintenance requirements
- In-flight blind intercomparison:
  5% RH_{liquid} uncertainty, LOD approx. 10 ppmv

- In Flight Calibration (IFC) accounts for offset drift
- The 2σ - variability of observed Ice Supersaturation (ISS) at 10^{-4} occurrence probability: max. 155% RH_{ice}.
- Values fit into the range of homogeneous freezing thresholds
- **L2 IAGOS-RH data released!**

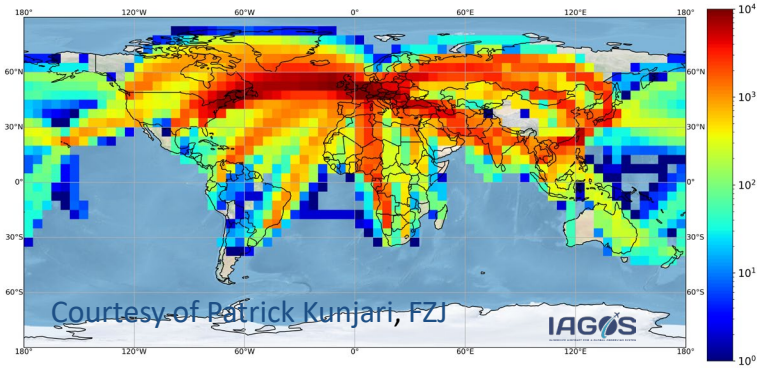
P. Neis et al., Atmos. Meas. Tech. 2015; P. Neis et al., TellusB, 2015; Smit et al., JAOT, 2008; Smit et al., ACP 2014 ; Petzold et al., ACP, 2020

IAGOS Contributions to Tropopause Research

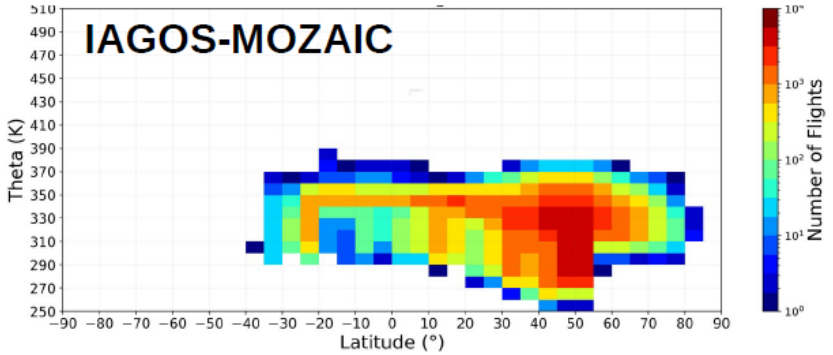
Large scale variations of water vapor and ice supersaturated regions



DFG Collaborative Research Center TPChange (2021)



Courtesy of Patrick Kunjari, FZJ

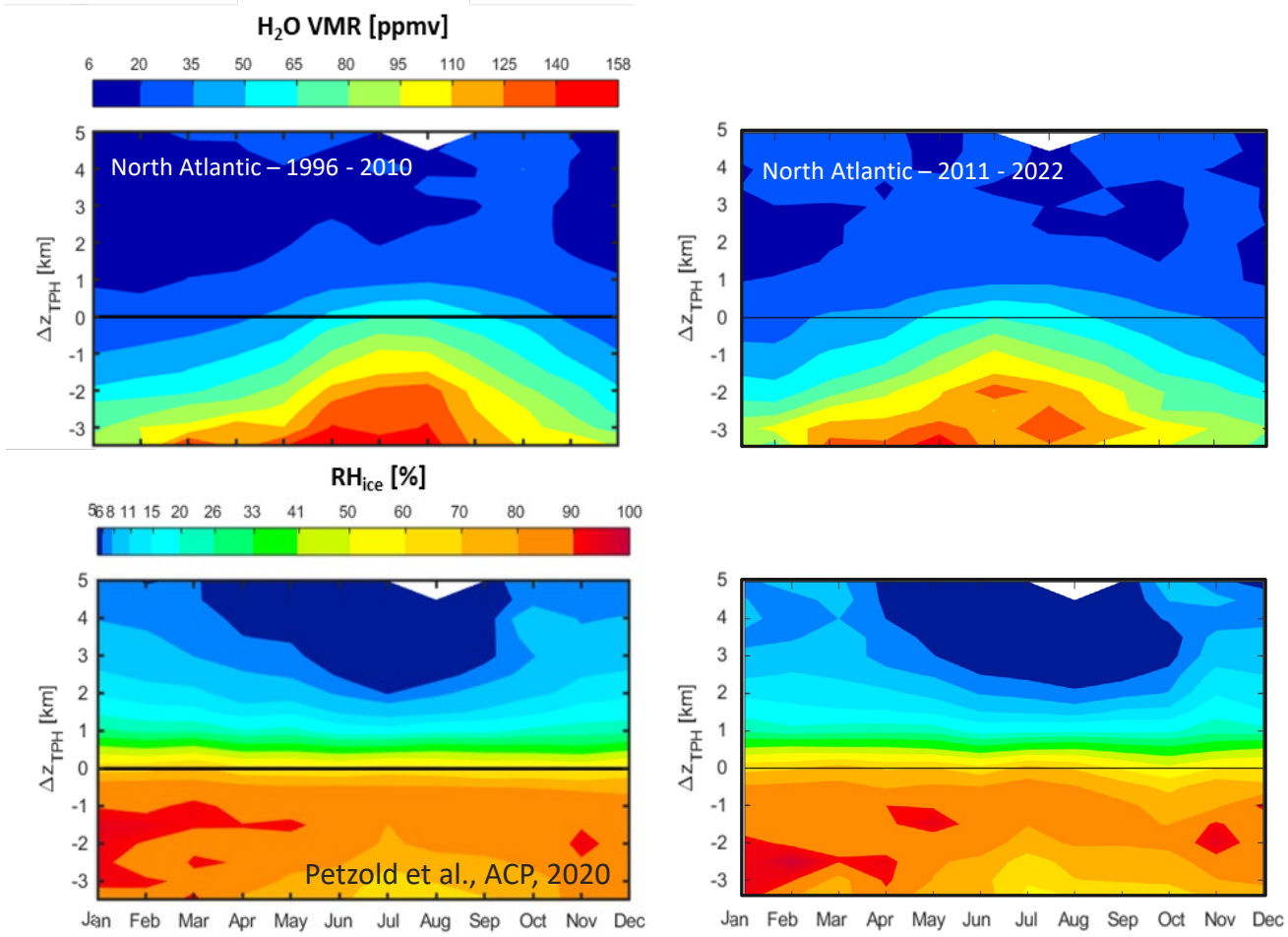


MOZAIC/IAGOS-CORE:

dense coverage at NH cruise

Winter season - number of flights on a 5°lat. x 5K theta resolution

Seasonal Variation of RH_{ice} Across the North Atlantic Tropopause



⇒ H_2O VMR:

Clearly visible moistening of the LMS in summer.

⇒ RH_{ice}:

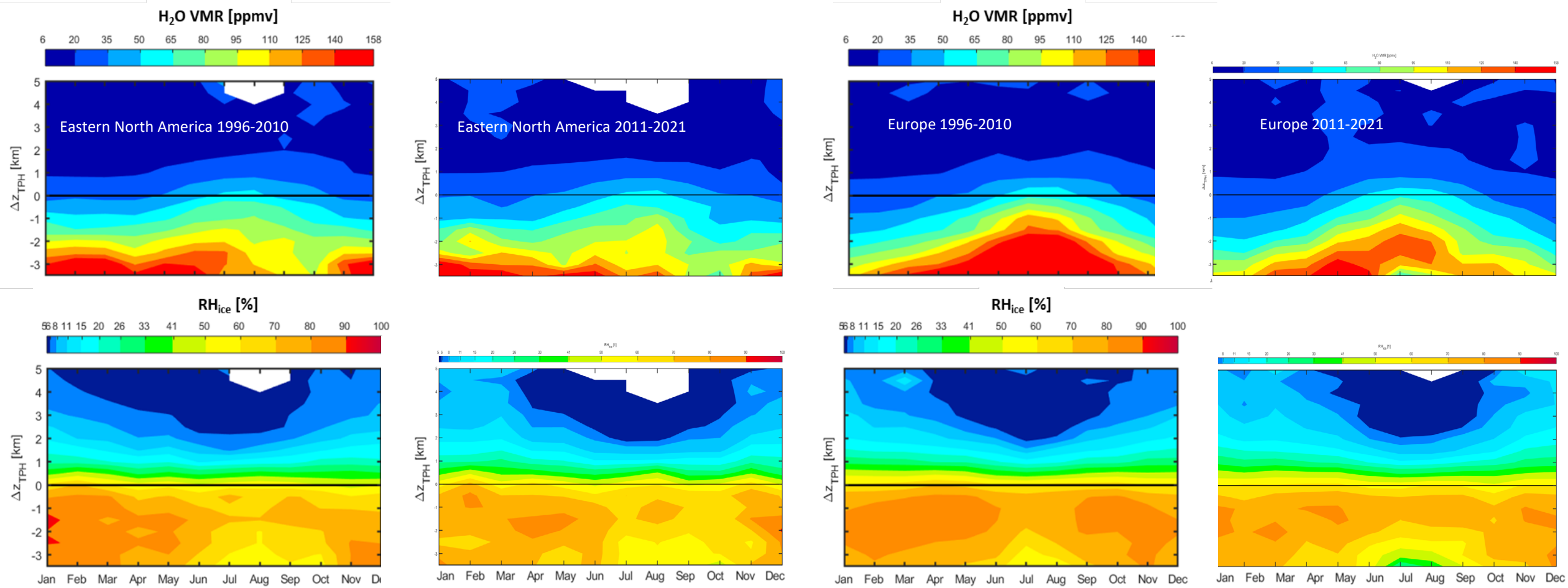
Uppermost troposphere close to ice saturation.

Averaged annual cycles of RH_{ice} for Lat: 40 °N to 60 °N, Lon: -65 °E to -5 °E

Distribution relative to the WMO thermal tropopause height z_{TPH}.

Seasonal Variation of RH_{ice} Across:

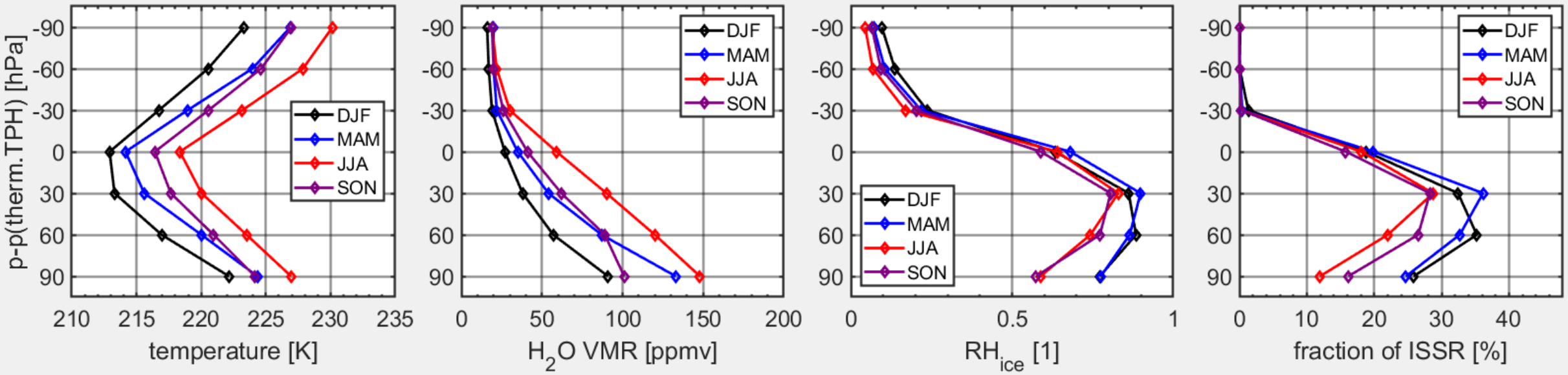
Eastern North American Tropopause AND European Tropopause



Averaged annual cycles of RH_{ice} for Lat: 40 °N to 60 °N,
Lon: -105 to -65 °E (Eastern North America); Lon: -5 °E to 60 °E (Europe)

Distribution relative to the WMO thermal tropopause height z_{TPH}.

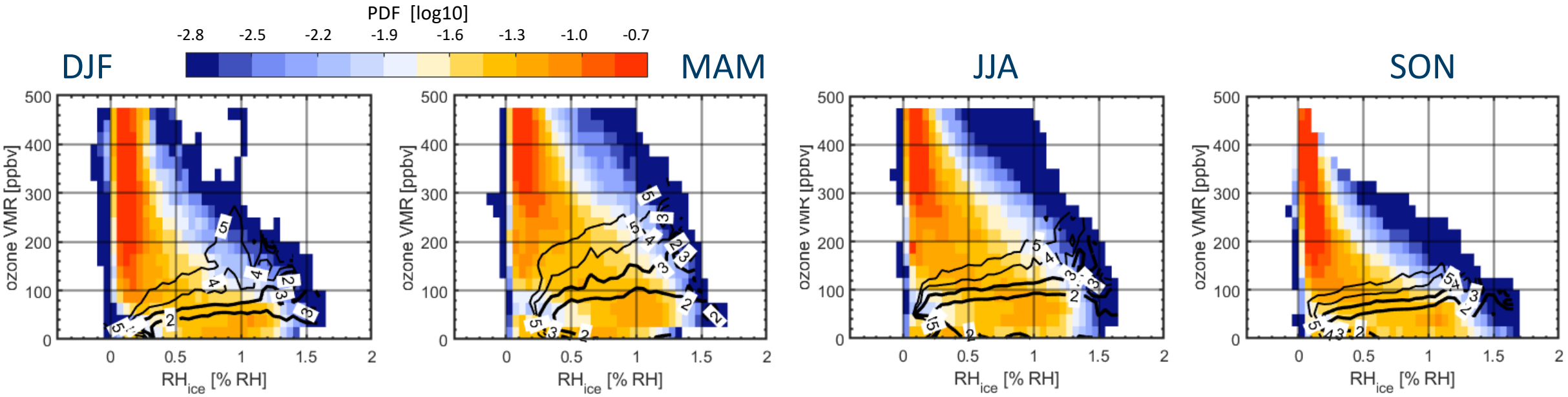
Vertical distribution of mean temperature, H2O mixing ratio, RH_{ice} and fraction of ice-supersaturated regions (ISSR) around the North Atlantic tropopause



Vertical distribution for seven pressure layers around the thermal tropopause; layer thickness is 30 hPa

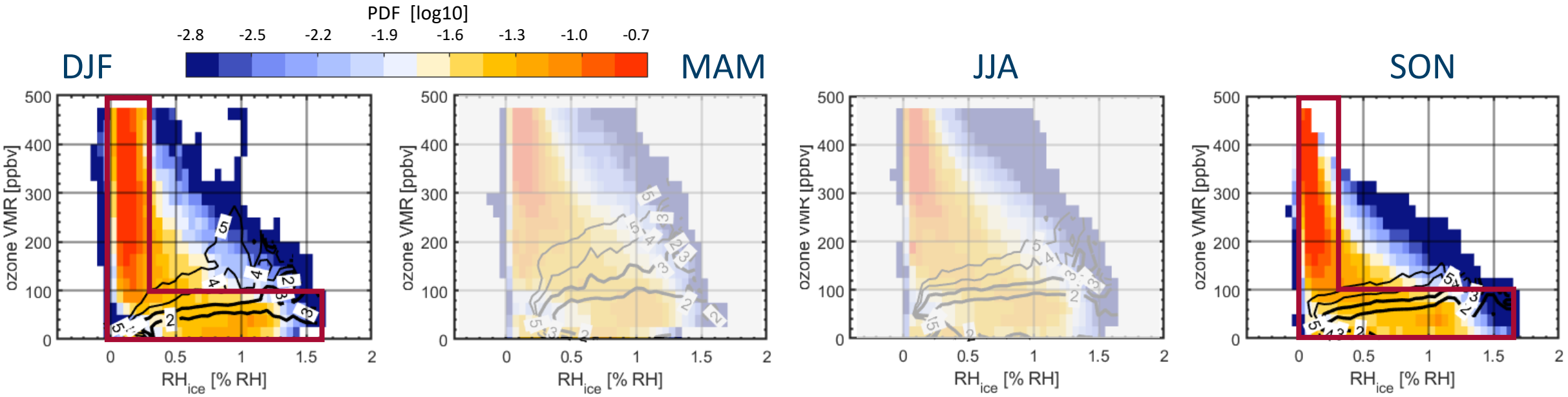
- Temp: seasonal cycle with highest values in summer
- H_2O VMR: highest values in summer + decrease with height.
- RH_{ice}: highest values in winter/spring in layer 30 hPa below tropopause
- ISSR: highest values in winter/spring in layer 30 hPa below tropopause

Seasonal Variation of RH_{ice} Across the North Atlantic Tropopause



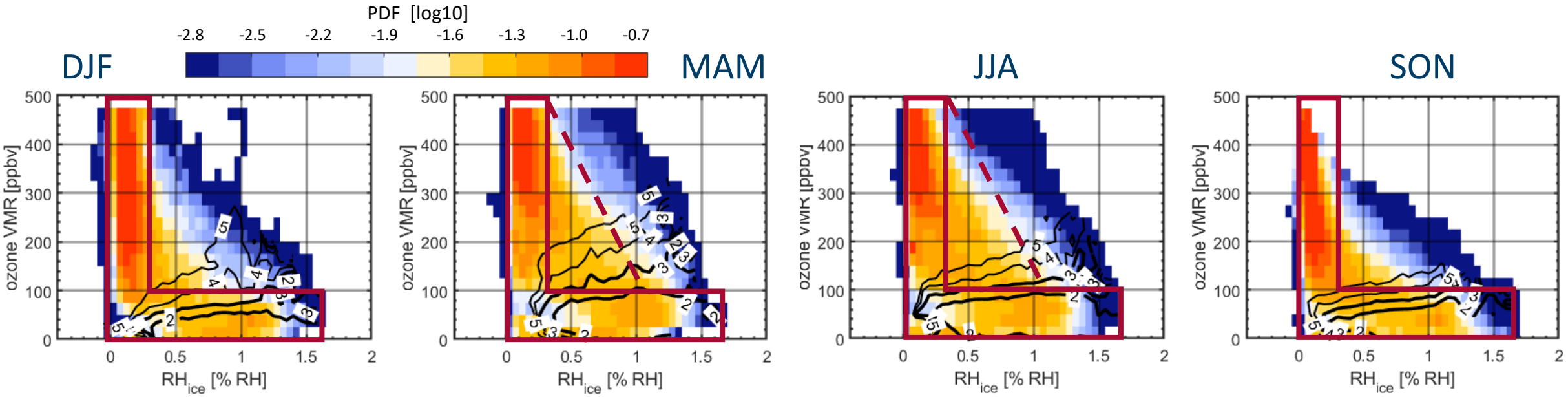
- Uppermost troposphere close to ice saturation.

Seasonal Variation of RH_{ice} Across the North Atlantic Tropopause from 2011 to 2021



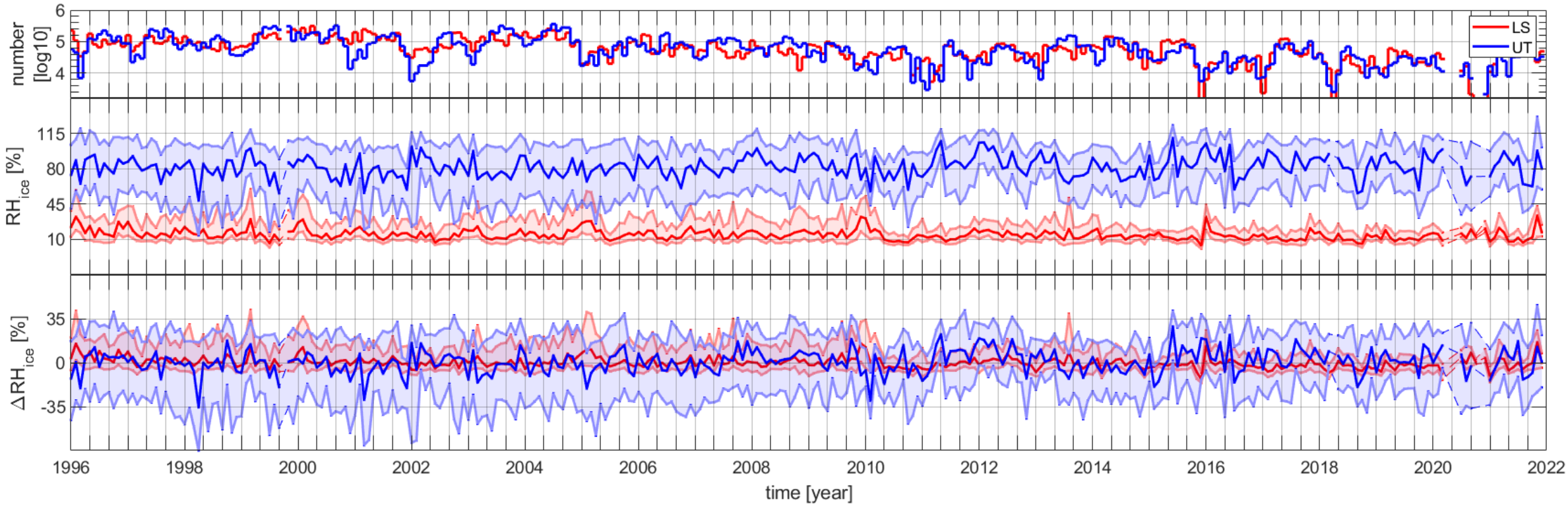
- Uppermost troposphere close to ice saturation.
- No cross-TP mixing of RH_{ice} in Fall and Winter.

Seasonal Variation of RH_{ice} Across the North Atlantic Tropopause (from 2011-2021)



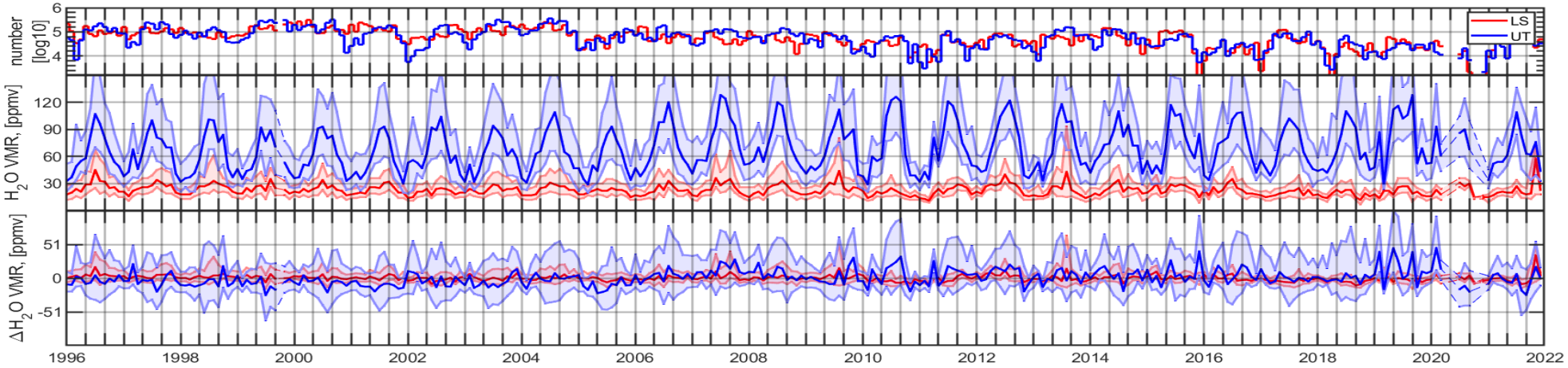
- Uppermost troposphere close to ice saturation.
- No cross-TP mixing of RH_{ice} in Fall and Winter.
- Cross-TP mixing of RH_{ice} in Spring and Summer.

Long-Term Evolution of RI_{ice} Across the North Atlantic Tropopause

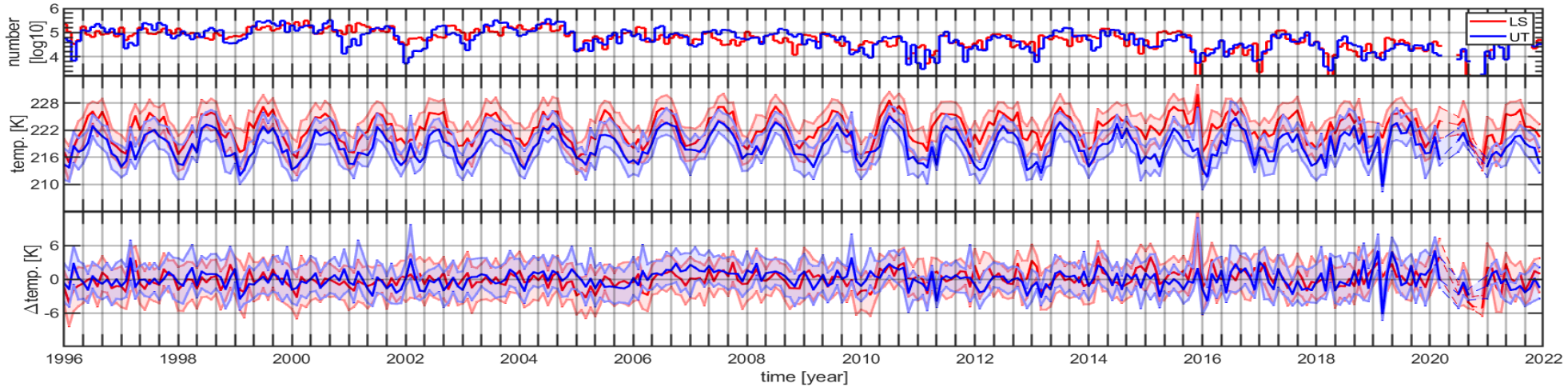


- Median RH_{ice} of UT ≥ 80%.
- No long-term change in RH_{ice} observed for UT and LMS over 25 years.
- In-depth trend analyses are subject of ongoing work.

Long-Term Evolution of H_2O and Temp Across the North Atlantic Tropopause



H_2O



Temp

- No long-term change in H_2O VMR and Temp. observed for UT and LMS over 25 years.
- In-depth trend analyses are subject of ongoing work.

SUMMARY

- MOZAIC and IAGOS RH_{ice} measurements from 1996 to 2021 over the North Atlantic show a clear separation in the vertical humidity distribution around the tropopause.
- UT air masses are most probable around ice saturation. RH_{ice} decreases rapidly in the LS with increasing distance to the tropopause.
- The observed seasonal cycle in the temperature and H2O VMR reaches its maximum values in summer, while RH_{ice} and fraction of ISSR reach their minimum.
- First trend analysis of H2O VMR, RHice, and Temp. show no significant trends for the period 1996 – 2021.