Continuous monitoring of surface water vapor isotopic composition at Neumayer-III station, East Antarctica

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Introduction

Understanding the processes influencing the stable water isotopic composition and variability of the atmospheric vapor under different climate conditions is essential for a more accurate interpretation of Antarctic ice core isotopic data as a temperature proxy. This can be achieved by a combination of direct observation and climate modeling simulations of the water vapor isotopic composition of Antarctic precipitation.

Method

- A Cavity Ring-Down Spectroscopy analyzer has been installed in January 2017 at the Neumayer-III station (on the Ekström ice shelf within the Weddell Sea) in Antarctica for high frequency continuous in situ observations of the water vapor isotopic composition.
- Observations have been compared with the simulated isotopic composition of vapor from ECHAM5-wiso, an atmospheric general circulation model (AGCM) equipped with water isotope diagnostics.
- Meteorological data of the Neumayer station is taken from PANGAEA data center.
- Moisture sources have been estimated over our observation period based on air masses dispersion simulations with FLEXPART model.

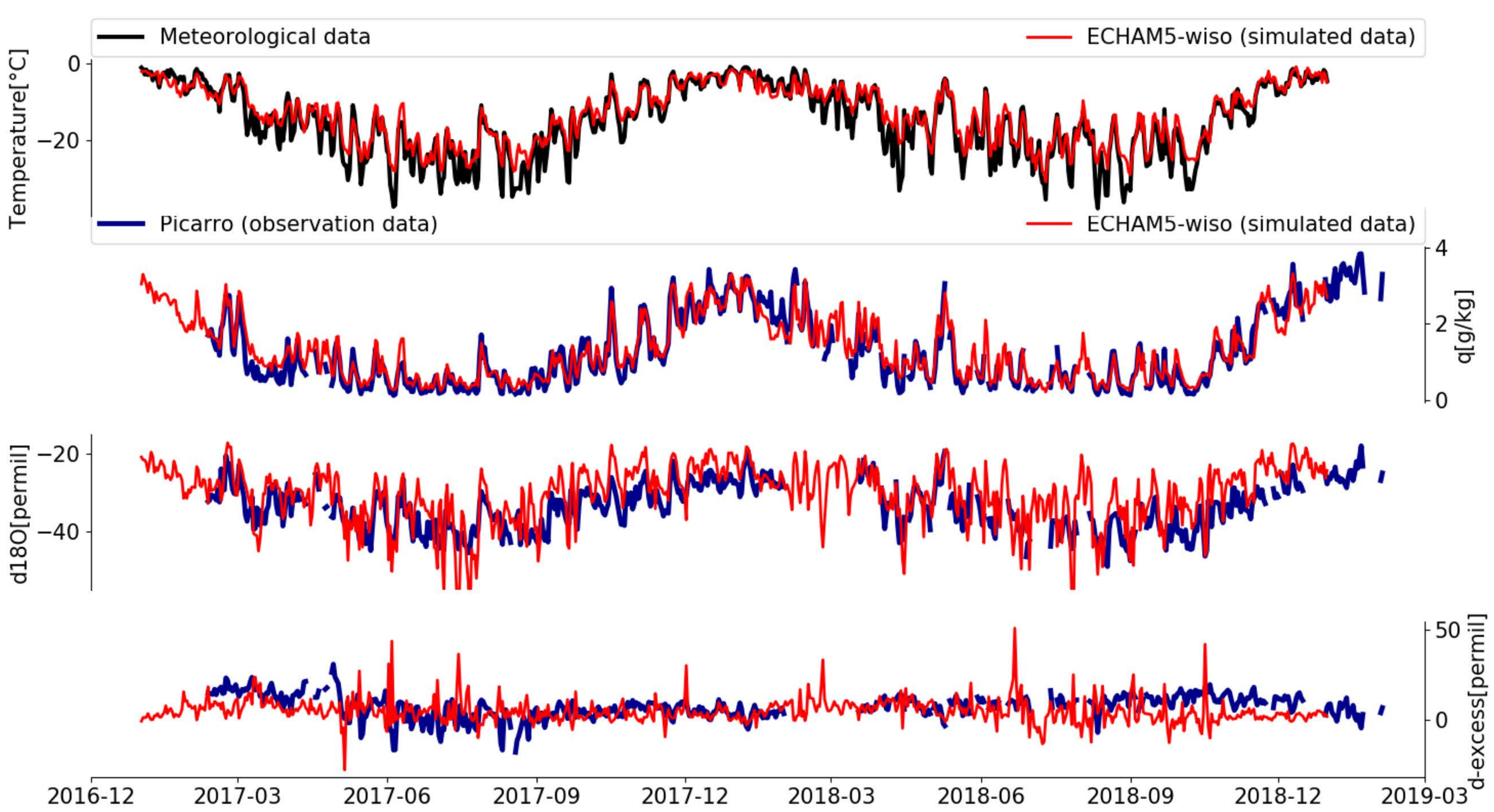


Fig. 1. Comparison of observations (**blue**) and simulated data (**red**) at the Neumayer station in Antarctica (Feb2017 – Feb2019). Downwards: temperature (Metrological & modeled), humidity, $\delta^{18}O$, and d-excess.

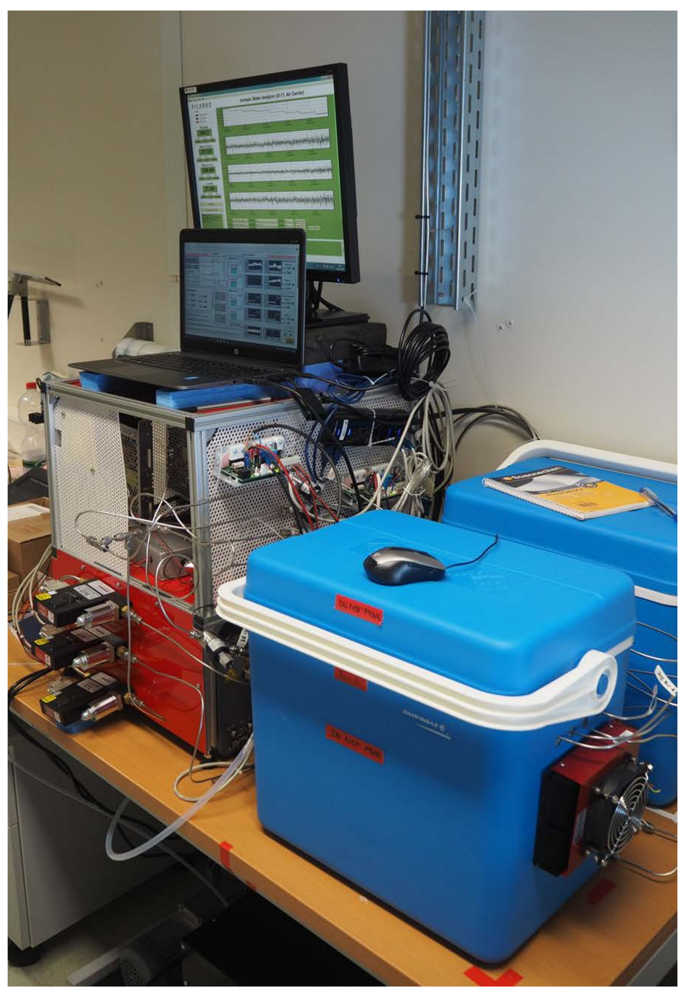
Conclusions

We observe, model, and trace **water vapor isotopes** in Antarctica (at the Neumayer-III station).

- **High correlation** between **$\delta^{18}O$ & temperature**
- **High agreement** between **model & observations**
  - Compared to observations, ECHAM5-wiso model can reproduce the synoptical and seasonal isotope and temperature variations, reliably.
- **Seasonally different origins** of the **water vapor**
  - The moisture sources of water vapor coming to the Neumayer station are seasonally different.
- **Wind as an important driver**
  - The value of $\delta^{18}O$ and the relation between temperature and $\delta^{18}O$ changes with the change of wind pattern.

Results

- $\delta^{18}O$ and δD have a maximum in February and a minimum in July.
- $\delta^{18}O$ and δD are very well correlated with each other (R=0.99) and they show a high correlation with temperature (R=0.86) and humidity (R=0.82).
- The slope of the relation between $\delta^{18}O$ and temperature is 0.55 ‰°C^{-1} ($\delta^{18}O$ [‰] =0.55 T [°C] – 25.06).
- The ECHAM5-wiso model correctly captures the seasonal and synoptic variability of $\delta^{18}O$ and δD with a high correlation with observations (R=0.75).
- Most of the moisture was transported to the station by cyclonic circulation patterns, with significant seasonal variations (dominant source from the north-west in spring, from the east in fall and from the west in winter).
- 86% of warm events at the Neumayer station coincide with winds from east that bring more humidity from the ocean, form clouds and make $\delta^{18}O$ richer. Cold events are associated with winds from south and southwest which bring the cold and dry air from East Antarctic Plateau to the station and make the sky clear. $\delta^{18}O$ from the south is more depleted following the temperature.



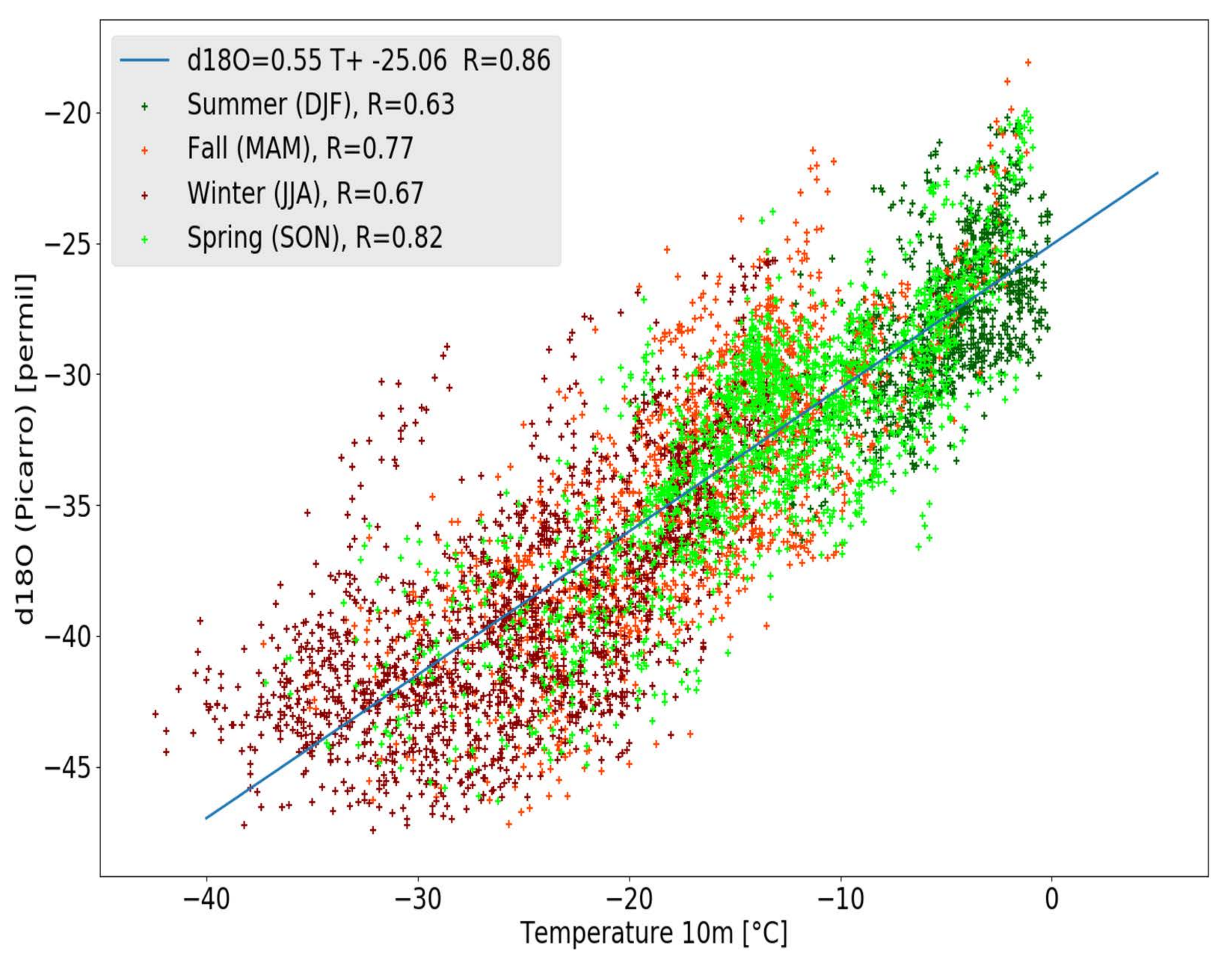
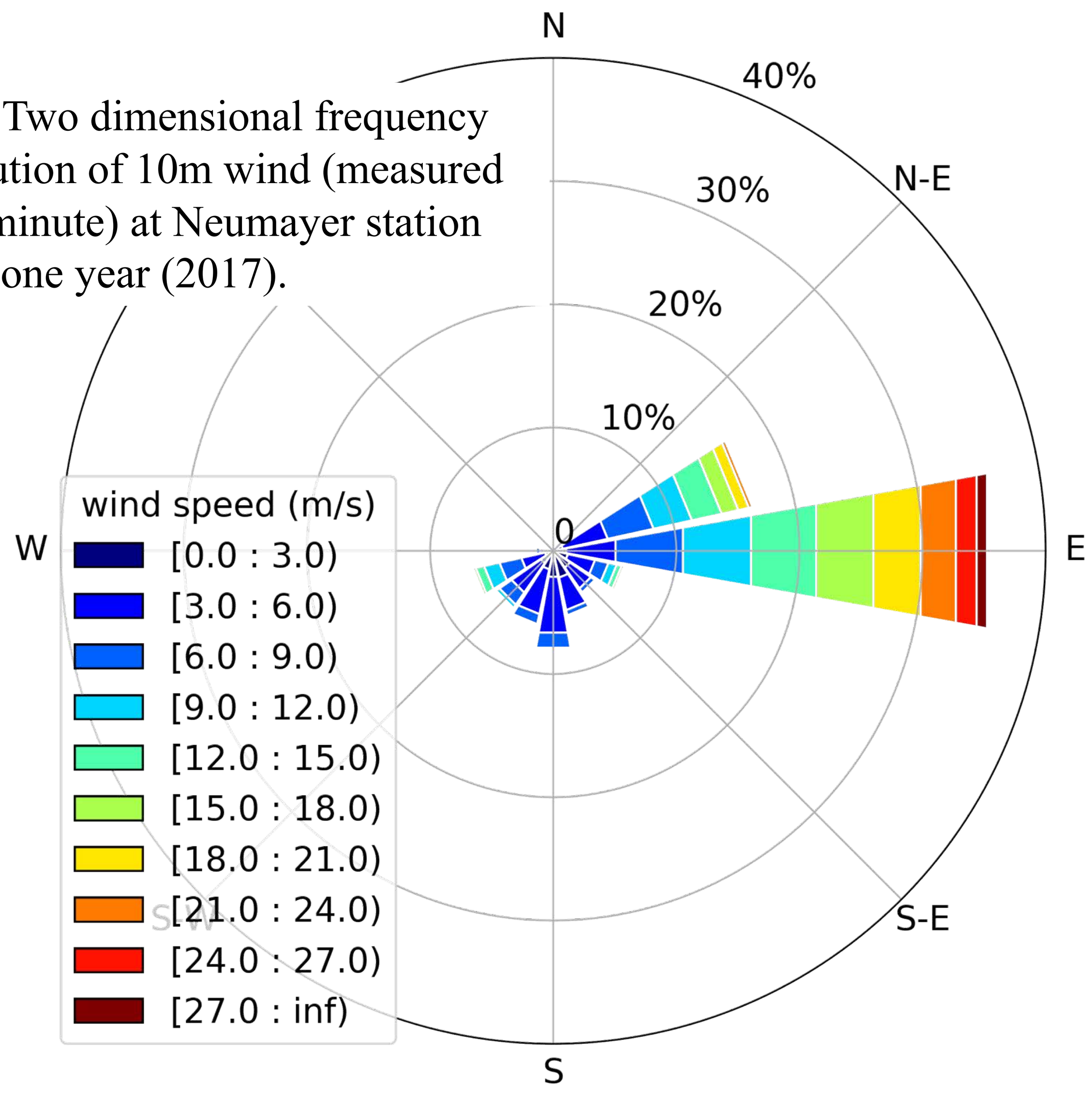


Fig. 2. $\delta^{18}O$ against temperature (Hourly average) in different seasons marked by colors during one year (Feb 2017-Feb 2018).

Fig. 3. Two dimensional frequency distribution of 10m wind (measured every minute) at Neumayer station during one year (2017).



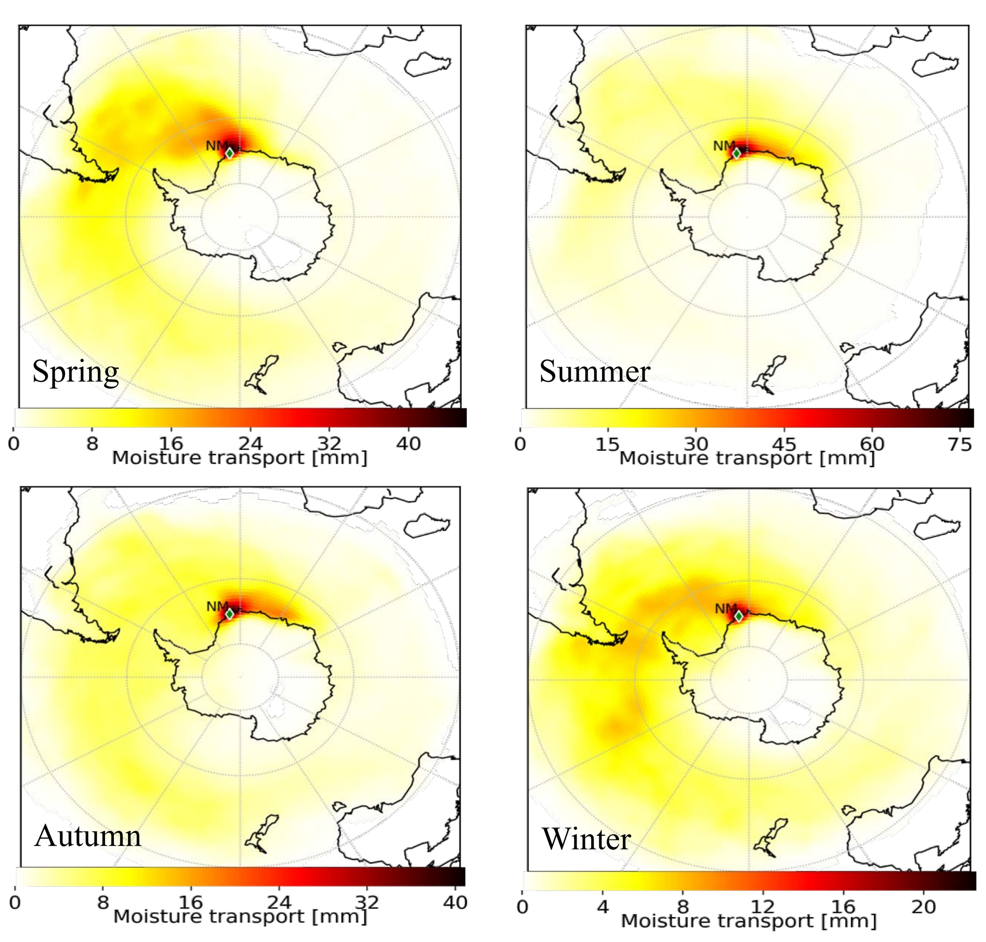


Fig. 4. Simulated seasonal moisture transport towards Neumayer-III modelled by FLEXPART

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