Atmospheric Rivers over Scandinavia

Spatial and temporal characteristics

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Introduction

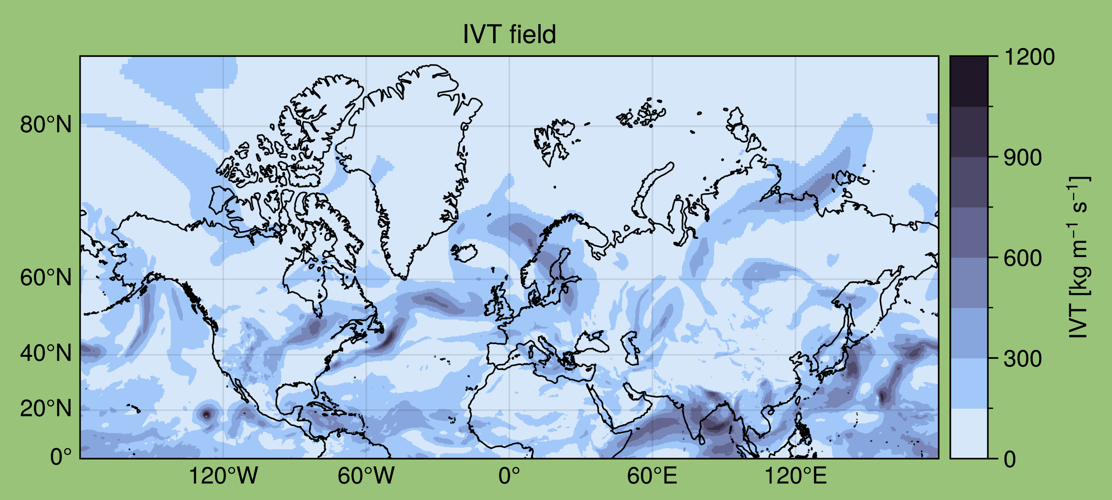
Atmospheric rivers (ARs) are long (>2000km) and narrow (<1000km) bands of unusually high atmospheric moisture transport. ARs play a critical role in the weather and climate in many parts of the mid- to high-latitudes. However, their role in the Scandinavian climate system is relatively uninvestigated.

Here, we want to answer two questions:

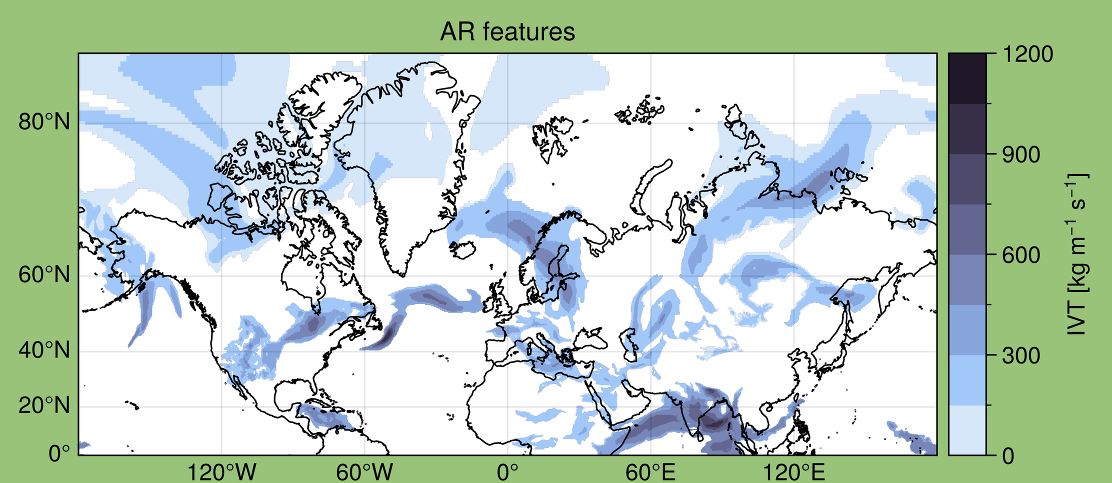
1. How do ARs that pass over Scandinavia vary by season?
2. How do teleconnections such as the North Atlantic Oscillation (NAO) influence the AR frequency and paths?

AR Detection

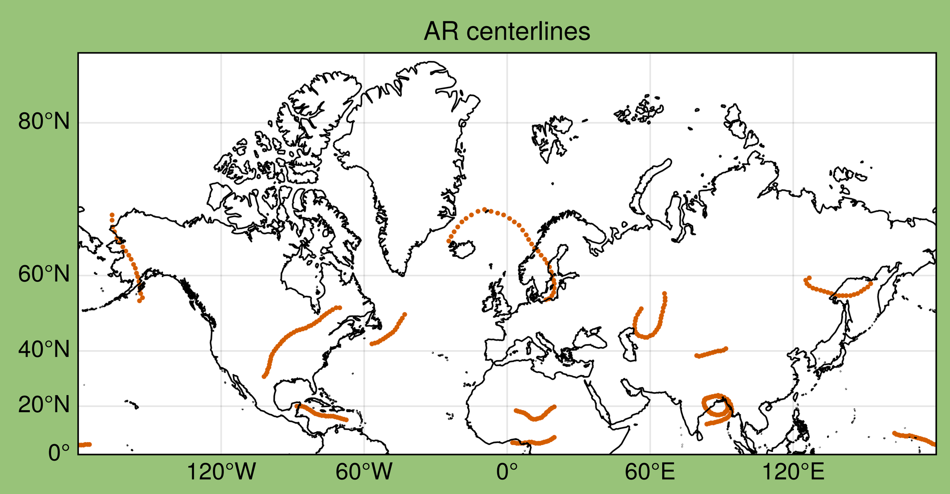
ARs are identified using the integrated water vapour transport (IVT), which is the product of the specific humidity (q) and the zonal (u) and meridional (v) wind integrated over the troposphere. Grid points with values below the 1979-2020 85th percentile are masked out.



From the masked IVT field we identify continuous "blobs" of unusually high IVT as the initial AR features. The features are filtered based on their length and width.



For the remaining features we calculate the centerlines based on following the maximum IVT intensity and its direction, using an approach from Pan and Lu (2019).



Data

ERA5 reanalysis:

- 1979-2020
- 6 hourly
- 15 pressure levels
- 0° to 90°N

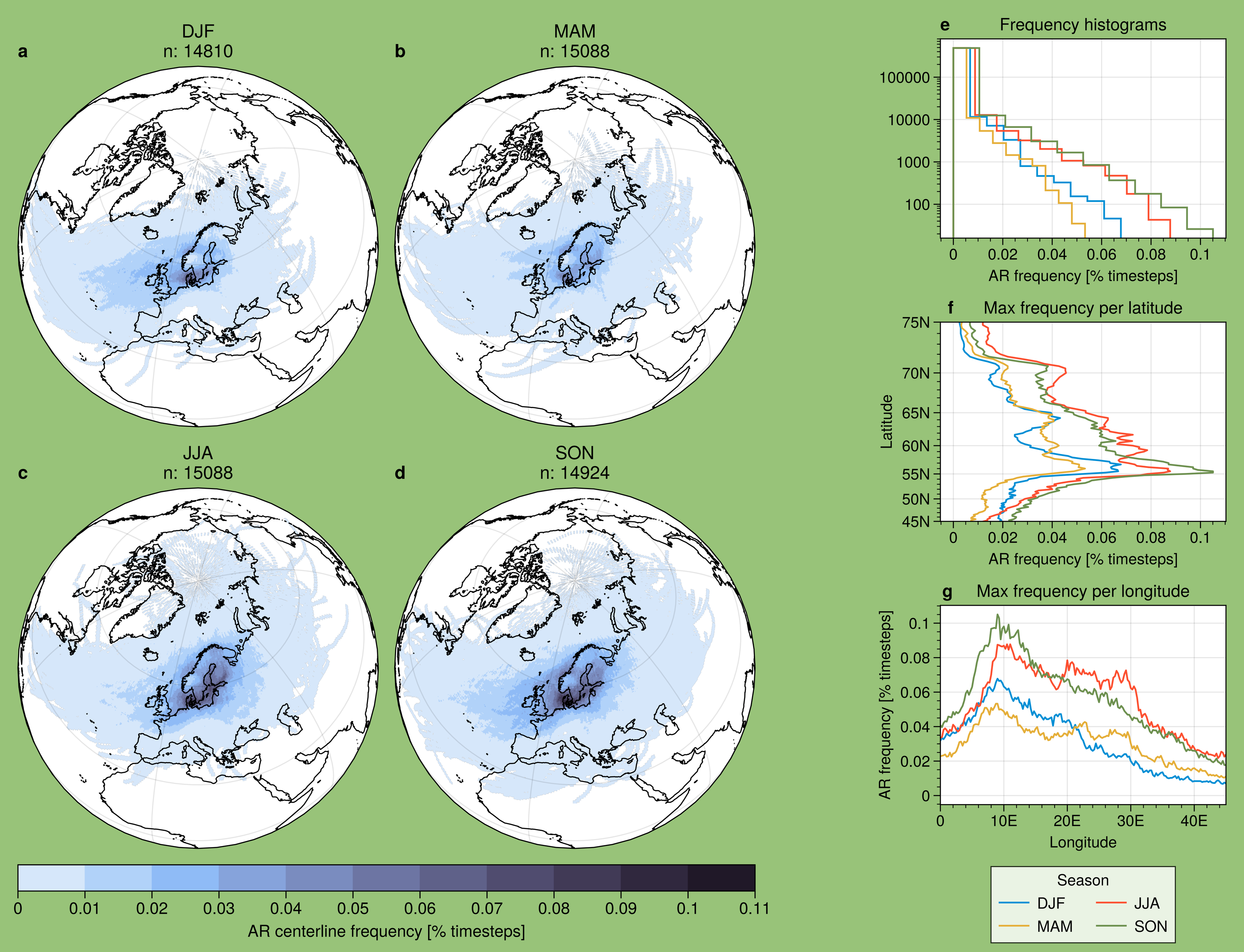
Variables:

- Specific humidity
- u component of wind
- v component of wind

AR frequencies

To compute AR frequencies we identified, in each time step, the AR centerlines that intersect Scandinavia, here defined as the combined outlines of Denmark, Finland, Norway, and Sweden.

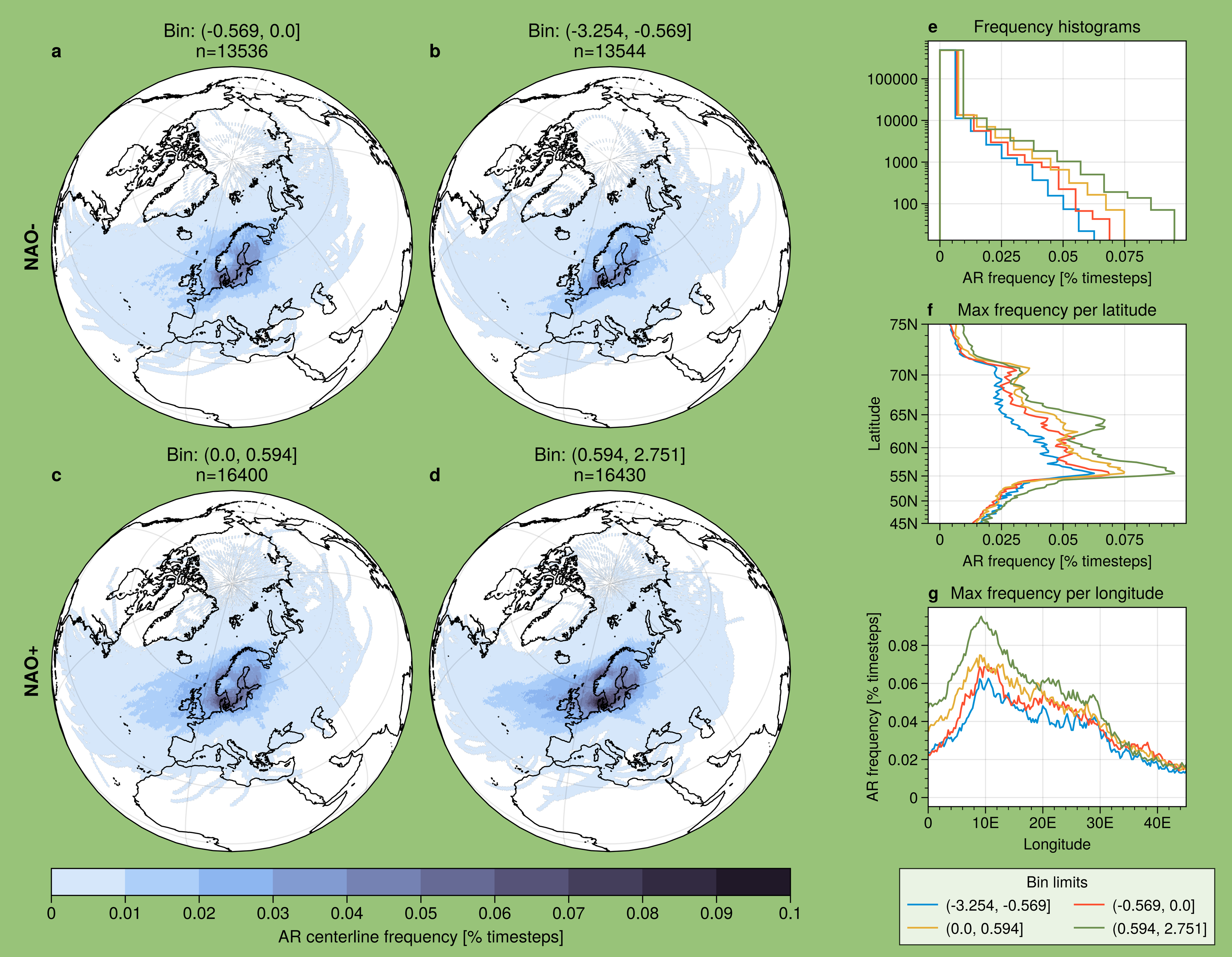
We then aggregated the time steps, resulting in a grid of AR frequencies. We smoothed the field using a sliding window mean.



AR frequencies grouped by season

Maps (panels a-d) to the left show AR frequencies grouped by season. These show that the AR activity over Scandinavia peaks during June, July, August (JJA, panel c), and September, October, November (SON, panel d). The maximum AR frequency is ~0.1% of the time steps, equivalent of ~150 time steps. The seasonal frequency difference is further highlighted in the frequency histogram (e). Along with the increased frequencies, there is also a change to the spatial extent in the origins of Scandinavian ARs between the season.

The plots of maximum frequency along the latitude (f) and longitude (g) highlight the spatial variations and how these change with the season. The maximum frequencies, during all seasons, are found around 55°N and 10°E. Along the latitude, there is a second peak around 65°N during both DJF and MAM which is not present in JJA or SON.



AR frequencies grouped by NAO

Figures to the right show AR frequencies grouped by NAO-index. The four NAO bins are centred around 0 and further divided into bins with similar samples sizes to depict the weak and strong modes of the negative and positive phase. Frequencies during negative NAO are shown in panel a and b, whereas panel c and d show the AR frequencies during positive NAO.

The grouping shows that ARs are more frequent during the strong positive phase of the NAO (c-e). The longitudinal extent of the area showing higher frequencies during the strongly positive phase of the NAO is also indicating longer ARs compared to the other phases. For the strongly negative phase (b) there appears to be a southward shift of the AR paths.

The maximum frequencies are found around 55°N and 10°E for all groups, with the group of stronger positive NAO exhibiting the highest frequencies. Notably, a secondary peak with high frequencies appear between 60°N and 65°N in the group with ARs during the strong phases of positive NAO.

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References

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Pan, M., & Lu, M. (2019). A Novel Atmospheric River Identification Algorithm. Water Resources Research, 55(7), 6069–6087