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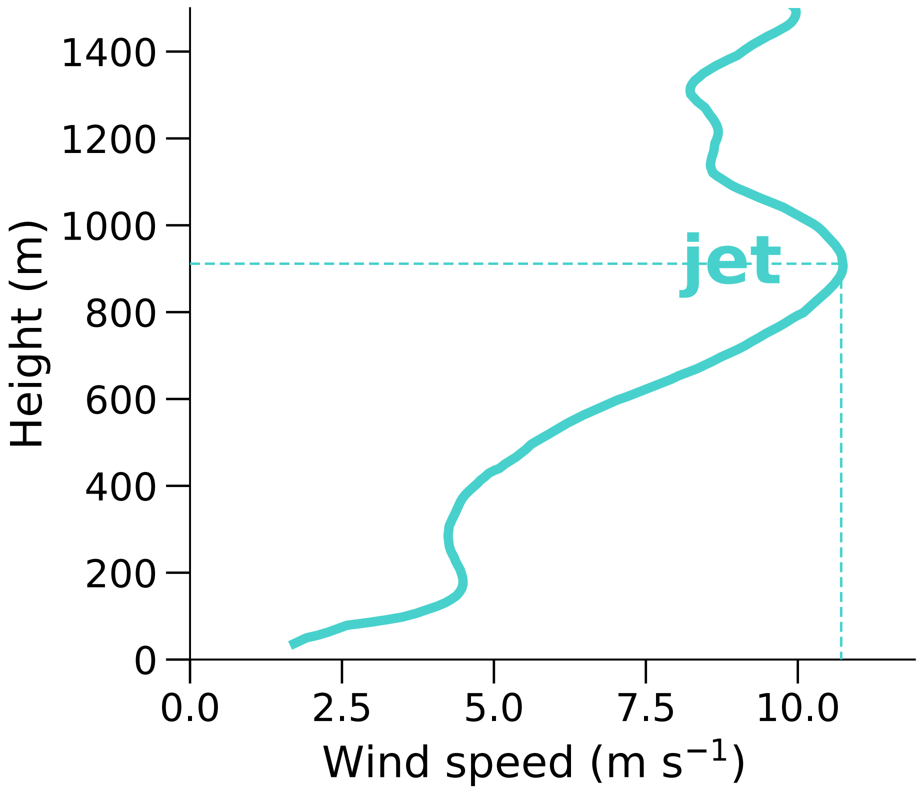
Statistics of low-level jets features in Scandinavia using the NORA3 and CERRA datasets

Clio Michel, Birgitte Rugaard Furevik, Hilde Haakenstad, and Øyvind Breivik



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Abstract

Low-level jets (LLJ) are well-defined local maxima in the vertical wind speed profile. LLJs are here detected for 16 years (2000-2015) of the 3-hourly NORA3 hindcast (*Haakenstad et al.*, 2021) and CERRA reanalysis (*Schimanke et al.*, 2021) using a method close to *Tuononen et al.* (2015). This report presents maps of the most frequent speed, height, direction, month and hour of occurrence of the LLJs detected over a large domain covering Scandinavia and the Nordic Seas. Our results show that both datasets exhibit very similar LLJs statistics. This report provides complementary results to our original publication (*Michel et al.*, 2025).

Keywords

low-level jets, boundary layer

Magnar Reistad	Øyvind Breivik
Disciplinary signature	Responsible signature

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Norwegian Meteorological Institute
Org.no 971274042
post@met.no
www.met.no / www.yr.no

Oslo
P.O. Box 43, Blindern
0313 Oslo, Norway
T. +47 22 96 30 00

Bergen
Allégaten 70
5007 Bergen, Norway
T. +47 55 23 66 00

Tromsø
P.O. Box 6314, Langnes
9293 Tromsø, Norway
T. +47 77 62 13 00

Contents

1 Introduction

We have detected low-level jets (LLJ) over 16 years (2000-2015) in the 3-hourly NORA3 hindcast (*Haakenstad et al.*, 2021) and the CERRA reanalysis (*Schimanke et al.*, 2021) using a method close to *Tuononen et al.* (2015). Please see *Michel et al.* (2025) for more details on the data and methodology used in this analysis. We here present the most frequent LLJ speed, height, direction values (binned), month and hour of occurrence over a large domain covering Scandinavia and the Nordic Seas. The most frequent feature value is the value associated with the most frequent bin in the feature distribution, as illustrated in Fig. 1. The following figures were inspired from the work by *Olsen et al.* (2024).

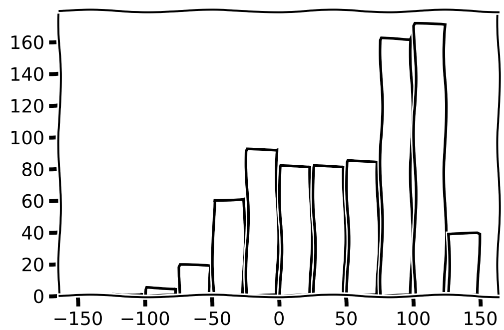

Figure 1: The most frequent bin in this distribution is the bin between 100 and 125 and will have the value 112.5, which is the centre of the bin 100-125.

2 NORA3

2.1 Whole period

Considering all years, we find that the LLJ speed is larger over sea than land, except over Iceland, Svalbard, and Novaya Zemlya (Fig. 2a). The LLJ height is low off some coasts, such as e.g. along the Norwegian coast, and over Iceland, Svalbard, Novaya Zemlya, parts of Norway, and parts of the North and Baltic seas (Fig. 2b). LLJs are the highest southwest of Svalbard as discussed in *Michel et al.* (2025). The main LLJ direction seems driven by land (Fig. 2c). There is a clear wake created by the United Kingdom over the North Sea and another clear wake around the eastern side of Iceland. Notably, there is a strong direction contrast between the western parts of Norway, where LLJs come from southeasterly directions, and the regions of Northern Sweden and Southeastern Norway, where the jets come from northwesterly directions. The main months of occurrence are from May to August over the Norwegian, Greenland, and Barents seas (Fig. 2d). Over the North and Baltic seas, LLJs most often occur in April and May. Over most of Sweden, Finland, and Russia, the main month of occurrence is January followed by December and February. There is a gradient across 80°N between the Arctic Ocean and the Barents Sea with a most frequent occurrence in fall to the north and shifting towards spring to the south. LLJs can occur at any time of the day over the ocean, as there is no clear pattern (Fig. 2e) except for the North Sea. Over continental land, the British Isles, and the North Sea, LLJs most often occur at night between 21 and 03UTC.

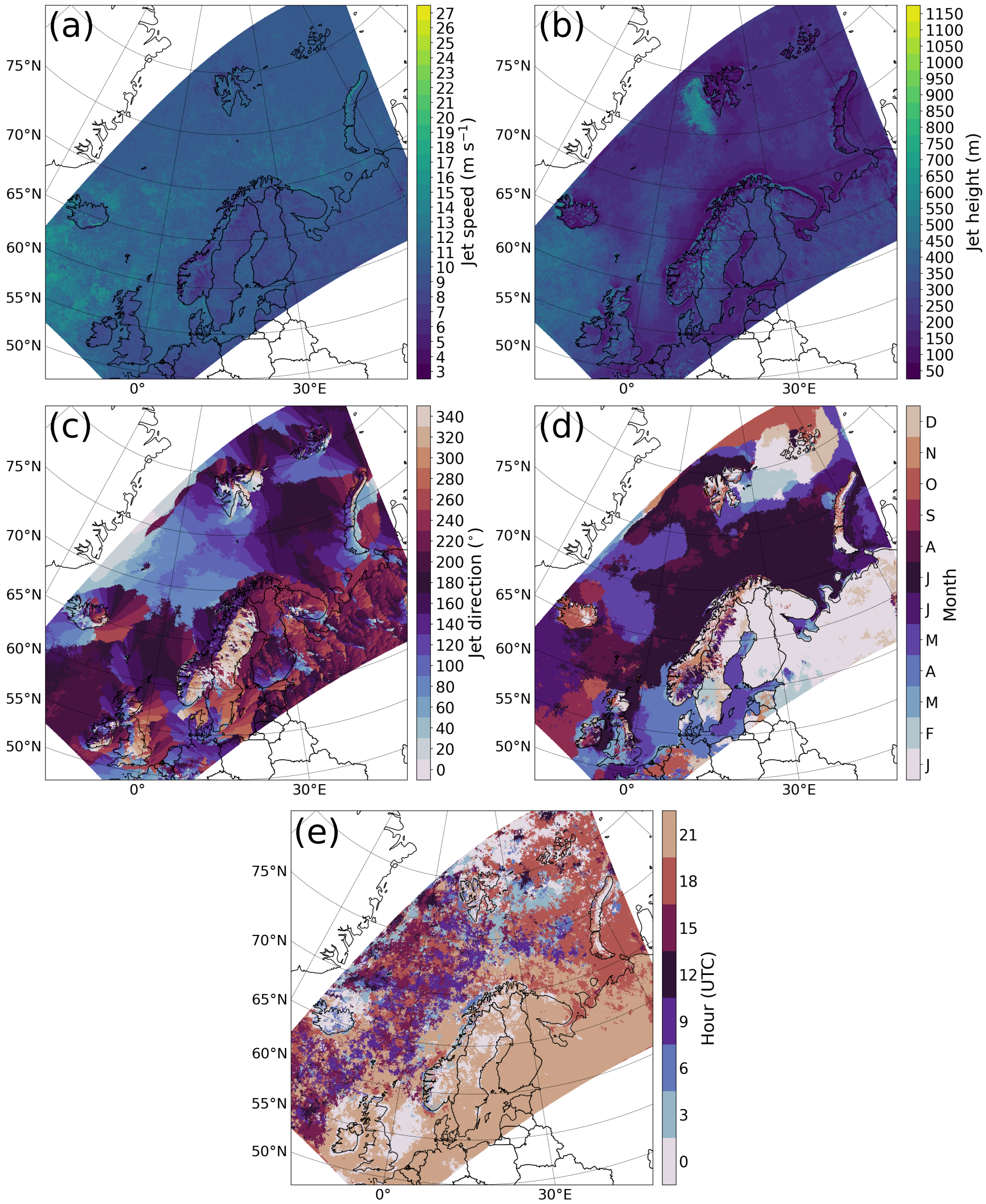

Figure 2: (a) Most frequent low-level jets speed, (b) height, (c) direction, (d) month, and (e) hour of occurrence. Valid for the NORA3 dataset.

2.2 Seasonality

LLJs are faster in winter and fall than in summer and spring over both land and sea (Fig. 3). They are also usually higher in winter than in summer especially over sea (Fig. 4). The shoulder seasons spring and fall exhibit different regions with high and low LLJs. The LLJs directions are also dependent on the season in some areas (Fig. 5). For example, the North Sea is dominated by westerly LLJs in winter, but other directions can be more frequent in summer, especially over the Eastern North Sea. The Norwegian Sea is dominated by south-westerly to westerly LLJs in winter, but by north-eastern to eastern LLJs in summer. The most frequent hour of occurrence is still undetermined over most of the domain represented, especially over the ocean (Fig. 6). However, over the southeastern part of the domain, from the North Sea to Russia, the most frequent hours of occurrence are 18 and 21UTC in fall and winter and 21 and 00UTC in spring and summer. Note that in winter there is little or no impact from solar radiation on the LLJs formation and maintenance.

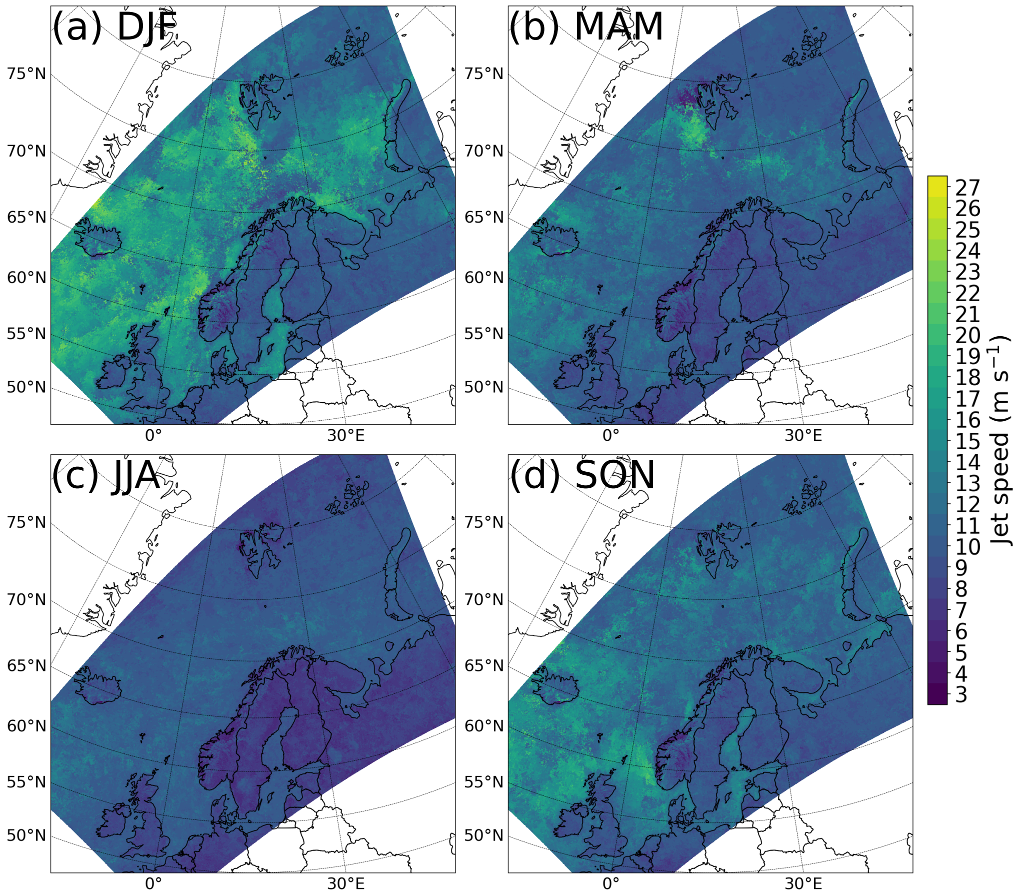

Figure 3: Most frequent low-level jets speed in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

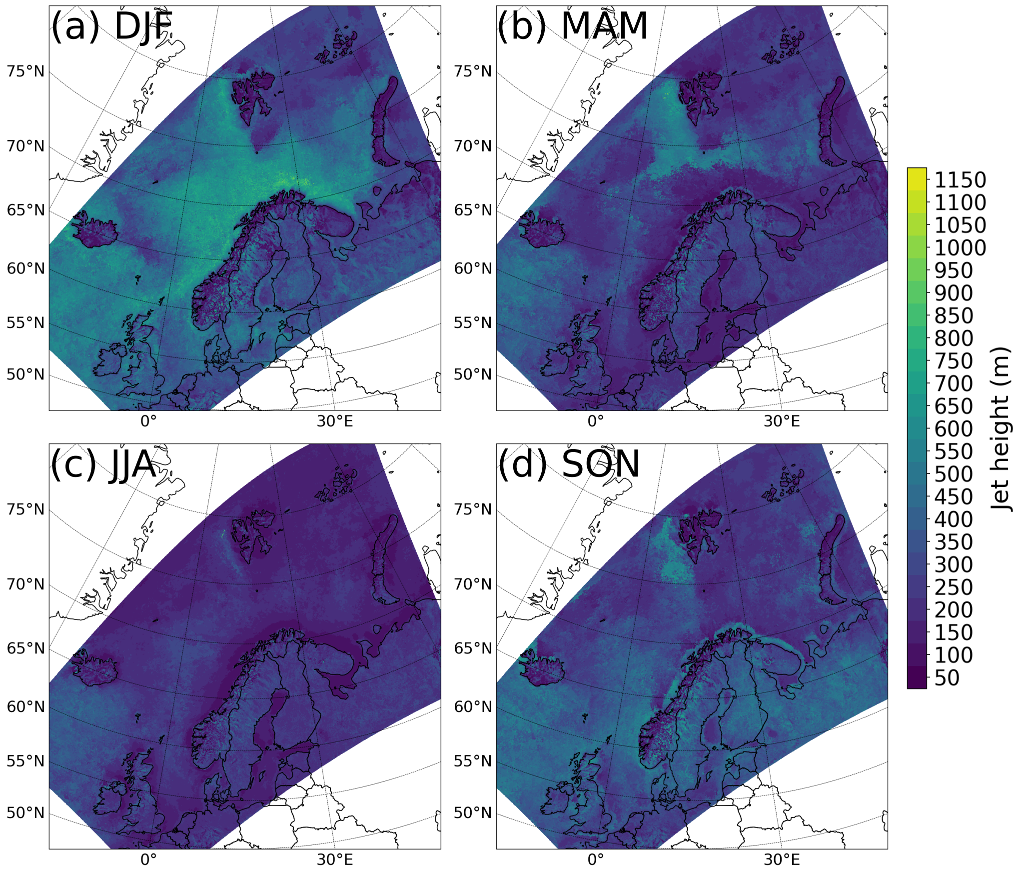

Figure 4: Most frequent low-level jets height in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

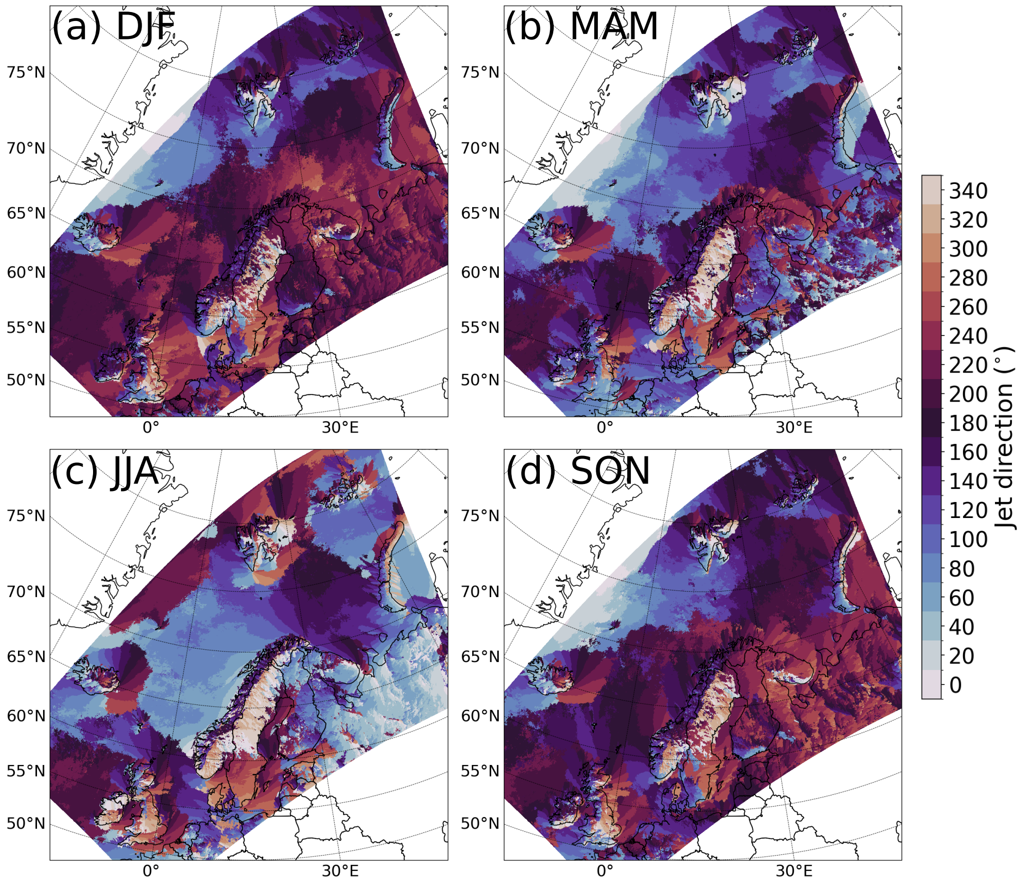

Figure 5: Most frequent low-level jets direction in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

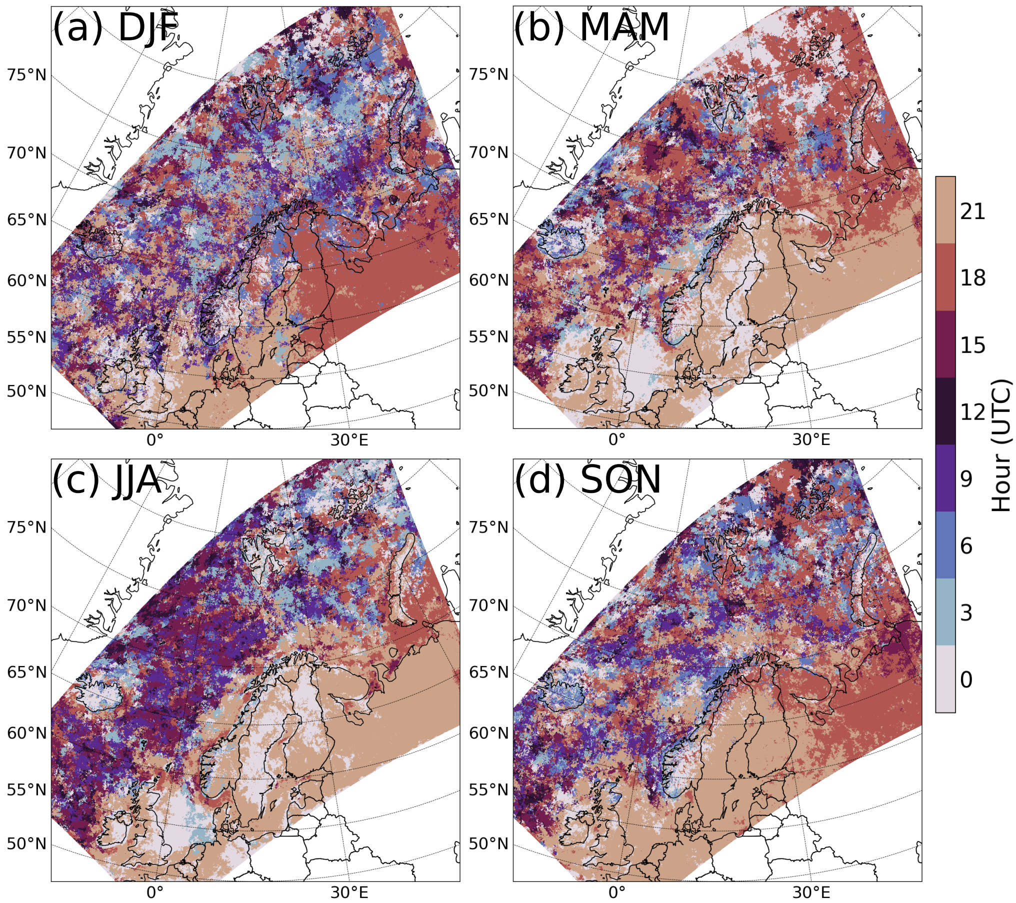

Figure 6: Most frequent low-level jets hour of occurrence in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

3 CERRA

The 3-hourly CERRA dataset over the same 16-year period exhibits very similar LLJ features as NORA3 (Figs. 7, 8, 9, 10, and 11).

3.1 Whole period

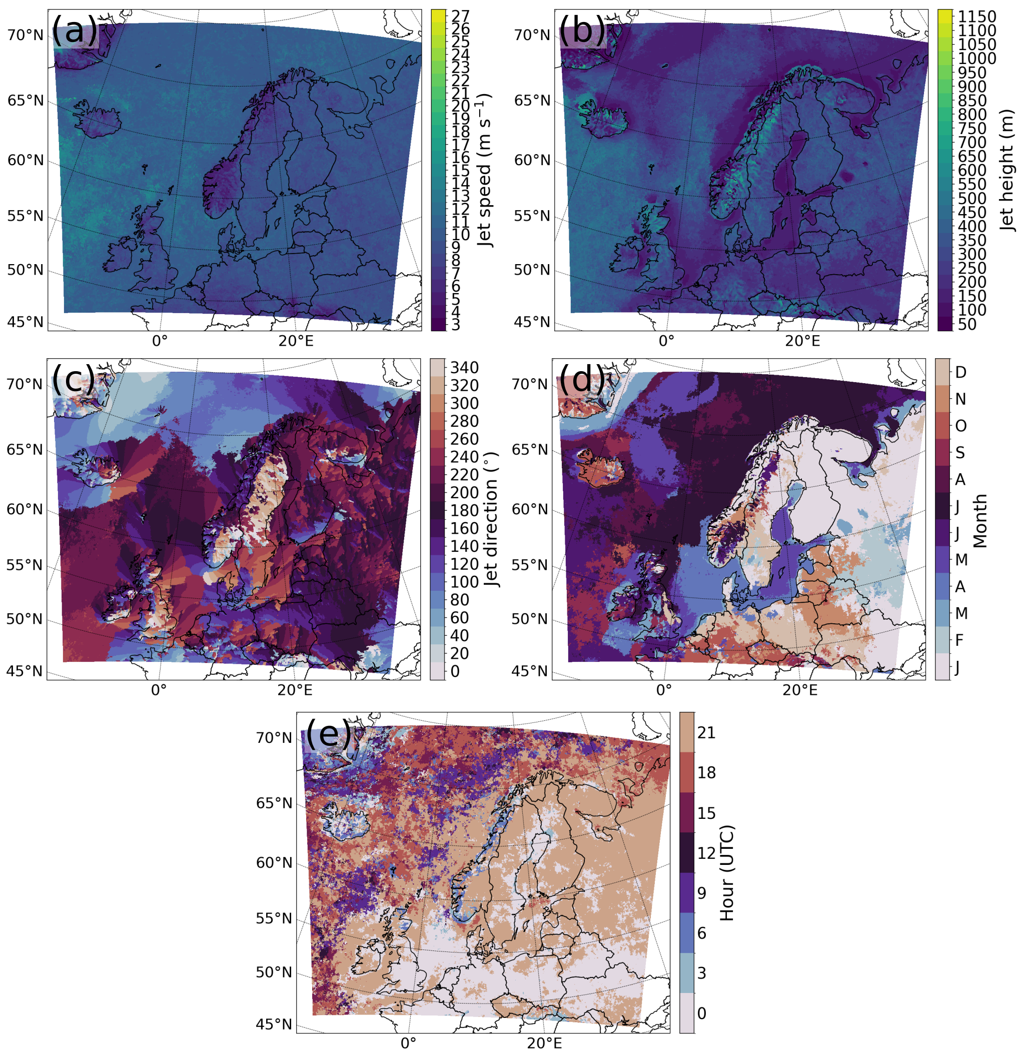

Figure 7: (a) Most frequent low-level jets speed, (b) height, (c) direction, (d) month, and (e) hour of occurrence. Valid for the CERRA dataset.

3.2 Seasonality

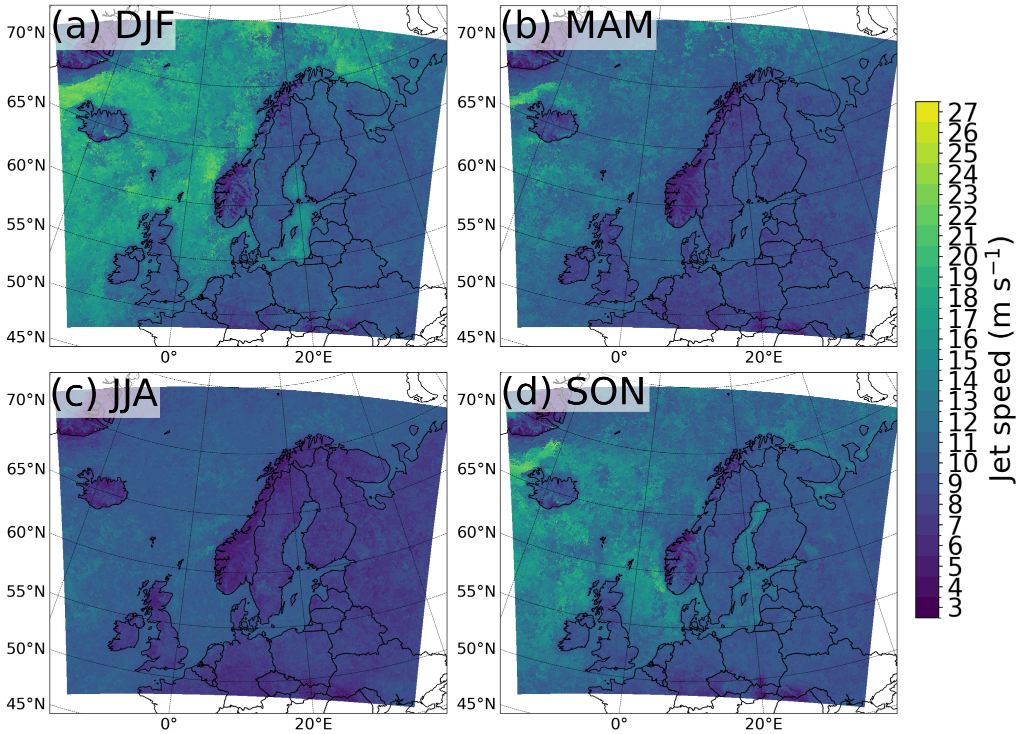

Figure 8: Most frequent low-level jets speed in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the CERRA dataset.

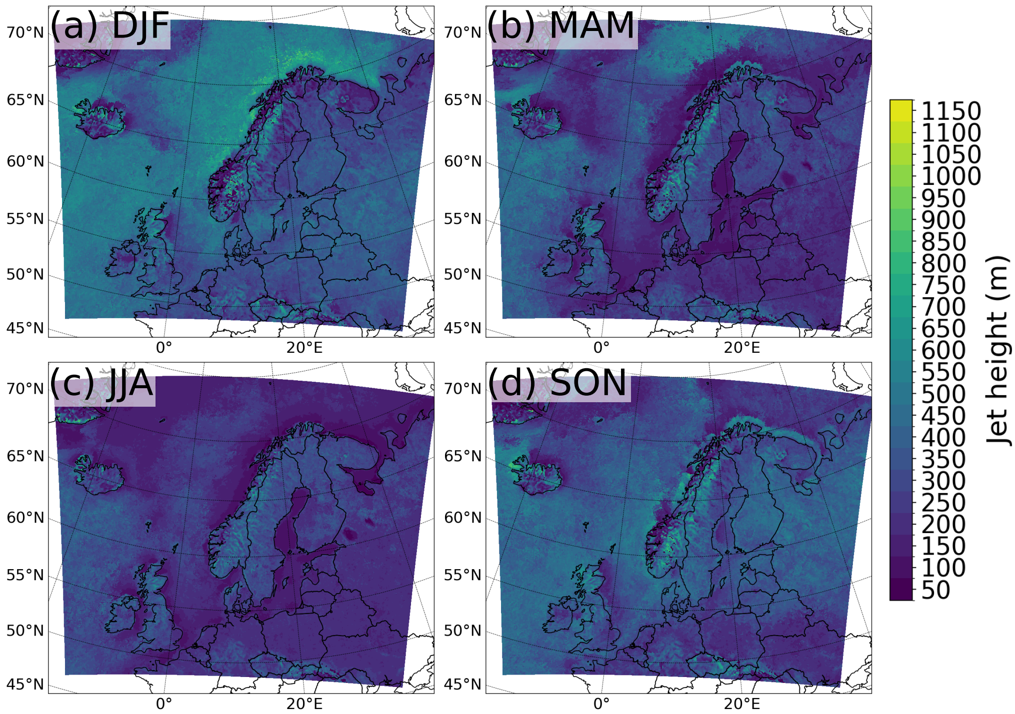

Figure 9: Most frequent low-level jets height in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the CERRA dataset.

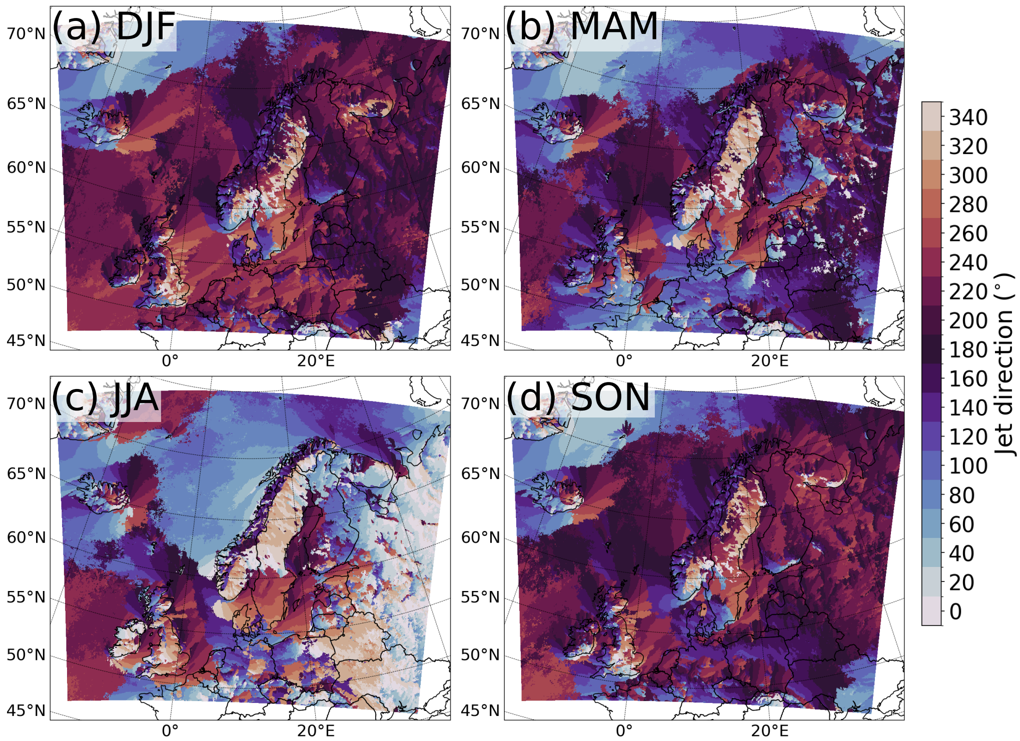

Figure 10: Most frequent low-level jets direction in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the CERRA dataset.

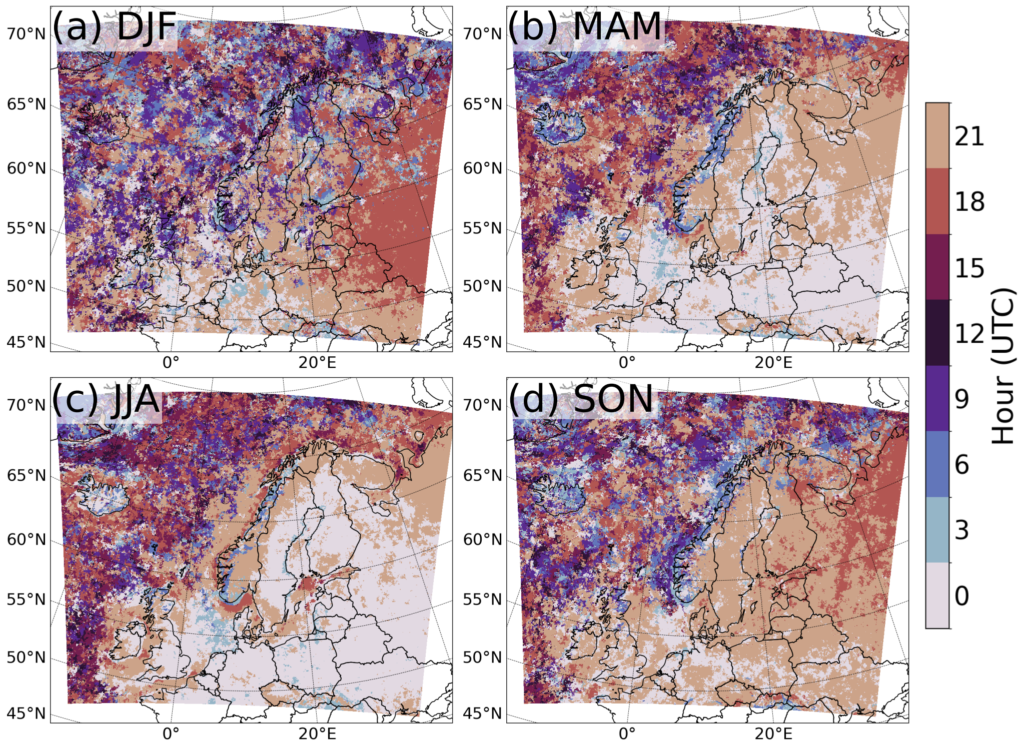

Figure 11: Most frequent low-level jets hour of occurrence in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the CERRA dataset.

4 Close-up on the North Sea with the NORA3 data

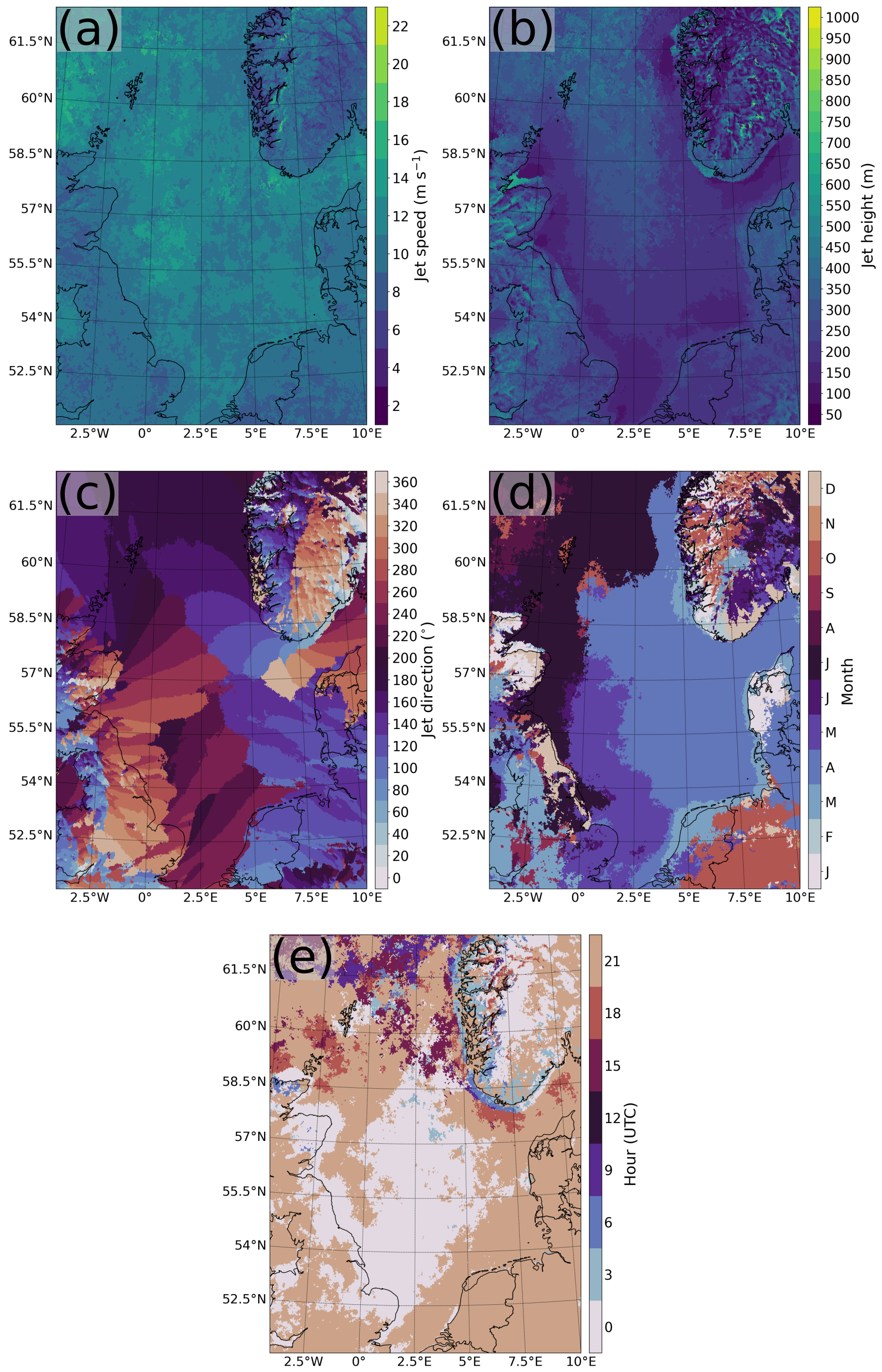

Figure 12: (a) Most frequent low-level jets speed, (b) height, (c) direction, (d) month, and (e) hour of occurrence. Valid for the NORA3 dataset.

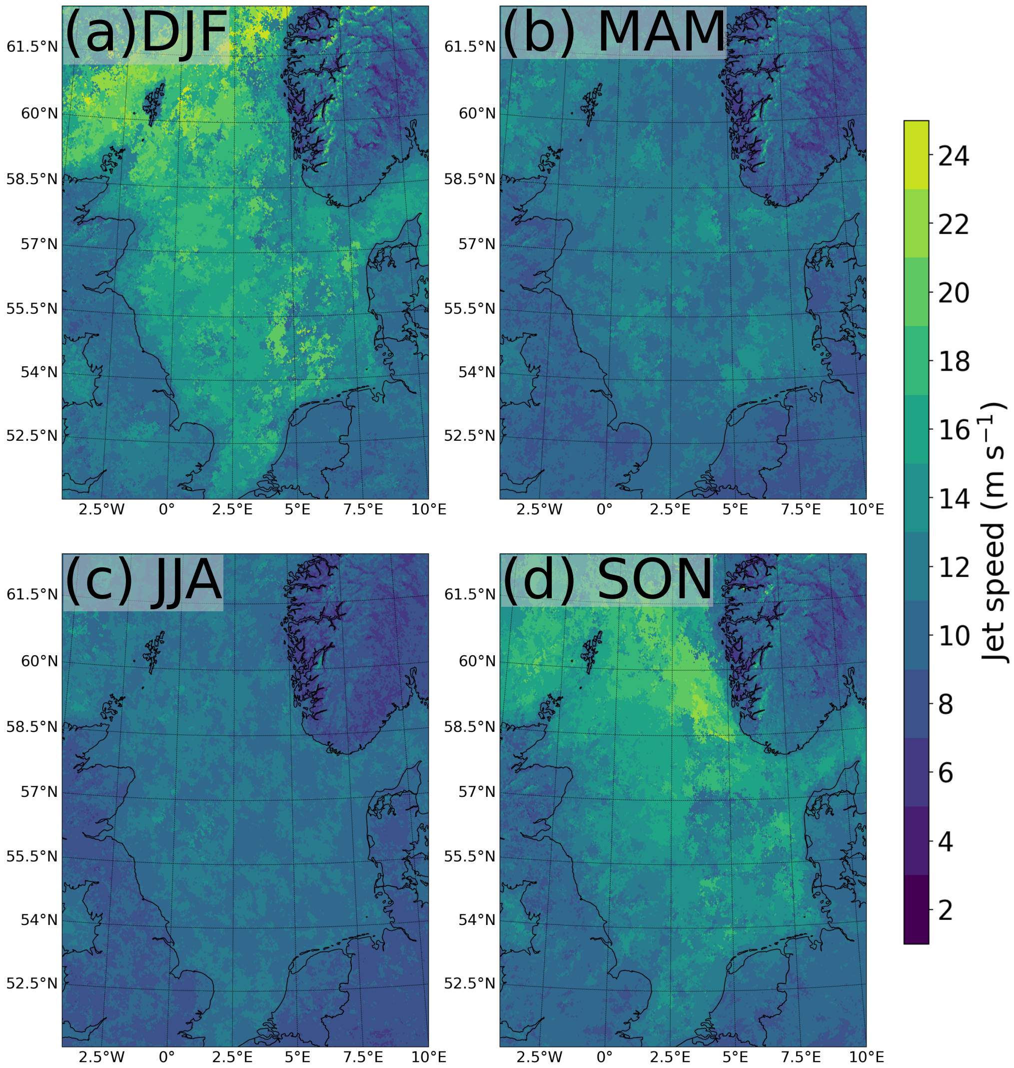

Figure 13: Most frequent low-level jets speed in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

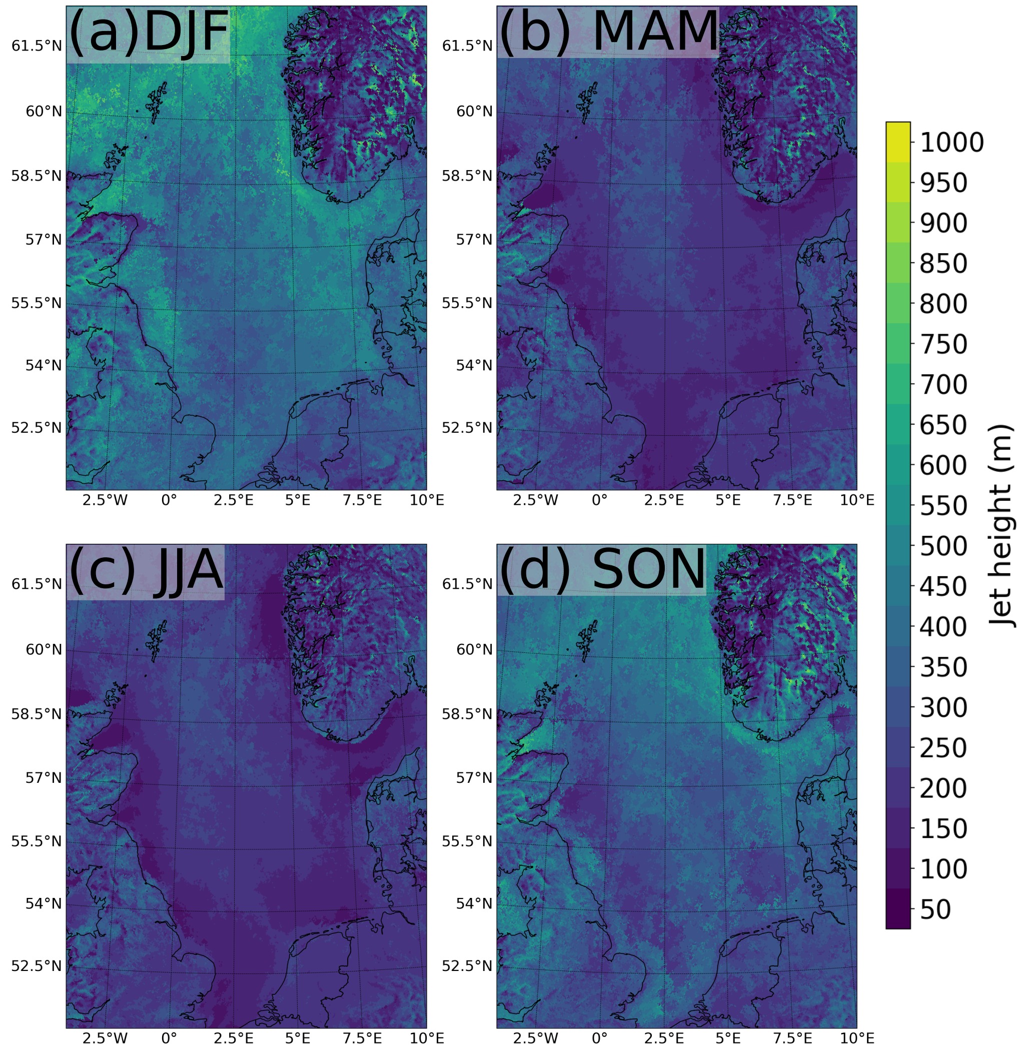

Figure 14: Most frequent low-level jets height in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

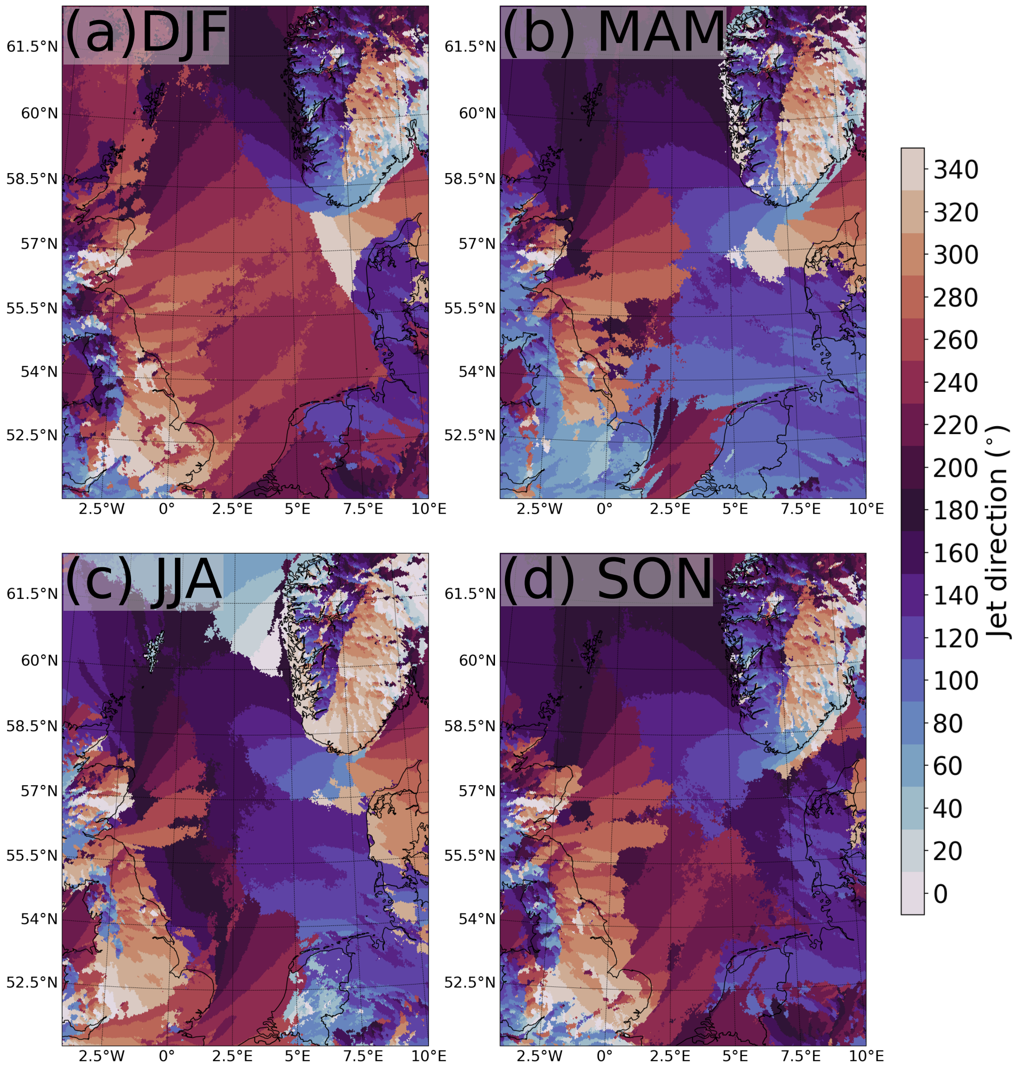

Figure 15: Most frequent low-level jets direction in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

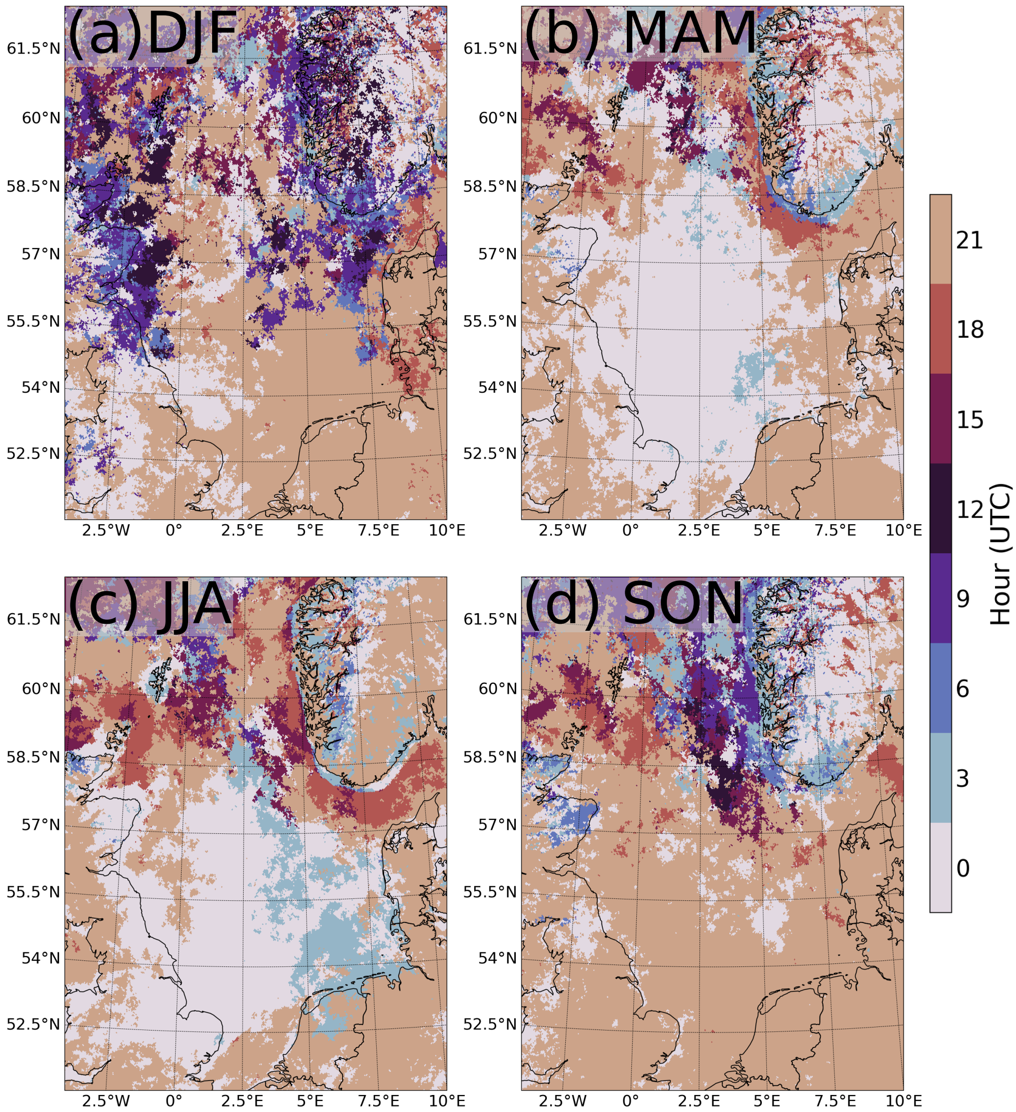

Figure 16: Most frequent low-level jets hour of occurrence in (a) winter (DJF), (b) spring (MAM), (c) summer (JJA), and (d) fall (SON). Valid for the NORA3 dataset.

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