UK Centre for Ecology & Hydrology

Ballynahone Bog SAC January 2019 to December 2019

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Title Ballynahone Bog SAC Wind Data Analysis January 2019 to December 2019

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1 Introduction / background

Local prevailing wind patterns play a key role in atmospheric nitrogen (N) input to designated sites, in terms of local ammonia (NH_3) concentrations and N deposition originating from local, regional and transboundary sources. The aim of this study was to investigate local wind patterns and their temporal variability with locally measured weather data, and to analyse these data in conjunction with NH_3 measurements on and around Ballynahone Bog SAC. This report answers the following questions:

- What data are available from local met stations?
- What are the local wind patterns?
- How do local wind patterns influence NH_3 concentrations?

2 Wind data analysis

2.1 What wind data are available from local met stations?

A met station was installed by Ulster Wildlife on the southeast of Ballynahone Bog in 2016. The data are being shared with NIEA for the purposes of this project. The data recorded by this station are incomplete for the landscape monitoring period beginning February 2019, with periods of no data collection lasting several months (e.g. no data between February and mid-July 2019) and intermittent gaps in recording. A new weather station was installed on the bog on 2019, however this new station experienced technical problems and failed to record information which resulted in no data collection for spring and early summer months. The original weather station (while experiencing some periods of low data capture due to aged system) is still in use, but at the beginning of 2020, it was noted that some parameters were no longer recording on a 24-hour basis. This is possibly due to the aging power supply system (solar panel and battery) or insufficient power output from the small solar panel to maintain sufficient charge on the battery. This may explain low data capture in late December when power generation from the solar panel would have been at its lowest. NIEA is in the process of purchasing a new weather station with remote download capabilities (tendering in process June 2020).

Figures 1 and 2 show the data recorded at the met station which is programmed to log data at 30 minute intervals. Recorded wind direction is presented as a percentage of potential data capture at full functionality, which would amount to an entry every half hour.

This study also considered nearby met stations as potential additional or alternative sources of wind data to consolidate the measurements received from the met station located on the bog. Two nearby met stations were identified (Figure 3), from the Met Office MIDAS dataset[1].

- Lough Fea (~10km to the SW of the site) and
- Portglenone (~15km to the NW of the site).

Both Lough Fea and Portglenone have consistently higher daily capture of wind data than Ballynahone. For the same months as shown in Figure 2, Portglenone had < 100% data coverage for only 3 days, and Lough Fea had < 100% data coverage for only 8 days.

[1] Met Office (2006): MIDAS: UK Hourly Weather Observation Data. NCAS British Atmospheric Data Centre, *accessed 02/2020*. https://catalogue.ceda.ac.uk/uuid/916ac4bbc46f7685ae9a5e10451bae7c

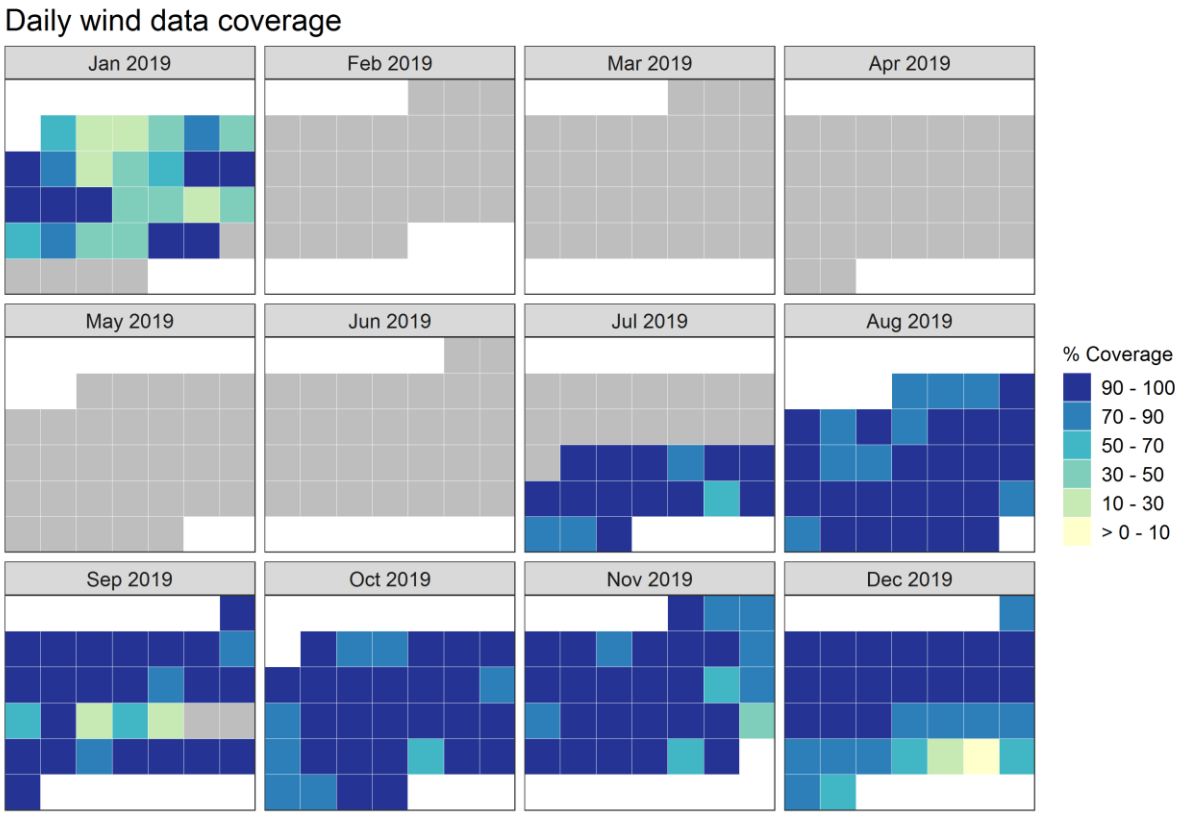

Figure 1: Daily % of data coverage from Ballynahone met station in 2019, calculated as the percentage of available 30 minute data of the total 24 hour period in each day.

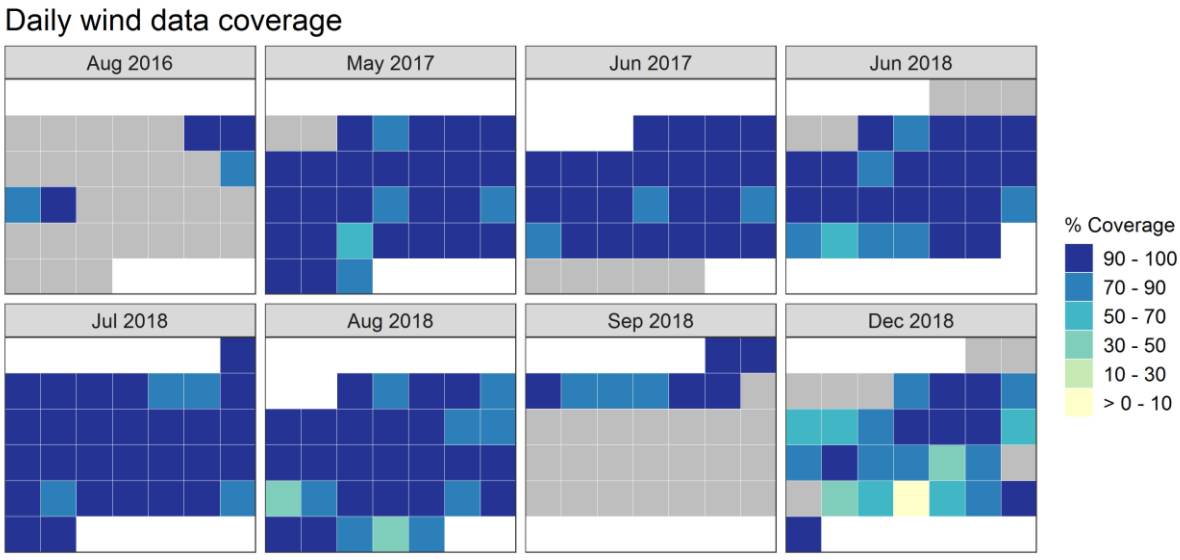

Figure 2: Daily % of data coverage for available months preceding this study, calculated as the percentage of available 30 minute data of the total 24 hour period in each day.

There is higher elevation land & much more undulating and complex terrain around Lough Fea and Portglenone, compared to the relatively flat terrain surrounding Ballynahone Bog (Figure 3). This makes the 2 stations less suitable/less representative as a proxy for Ballynahone Bog, however they are more reliable than Ballynahone in terms of better data capture. Portglenone is in an area of flatter land near the bog, but

may be sheltered from Easterly winds due to its position at the foot of a low slope to the East.

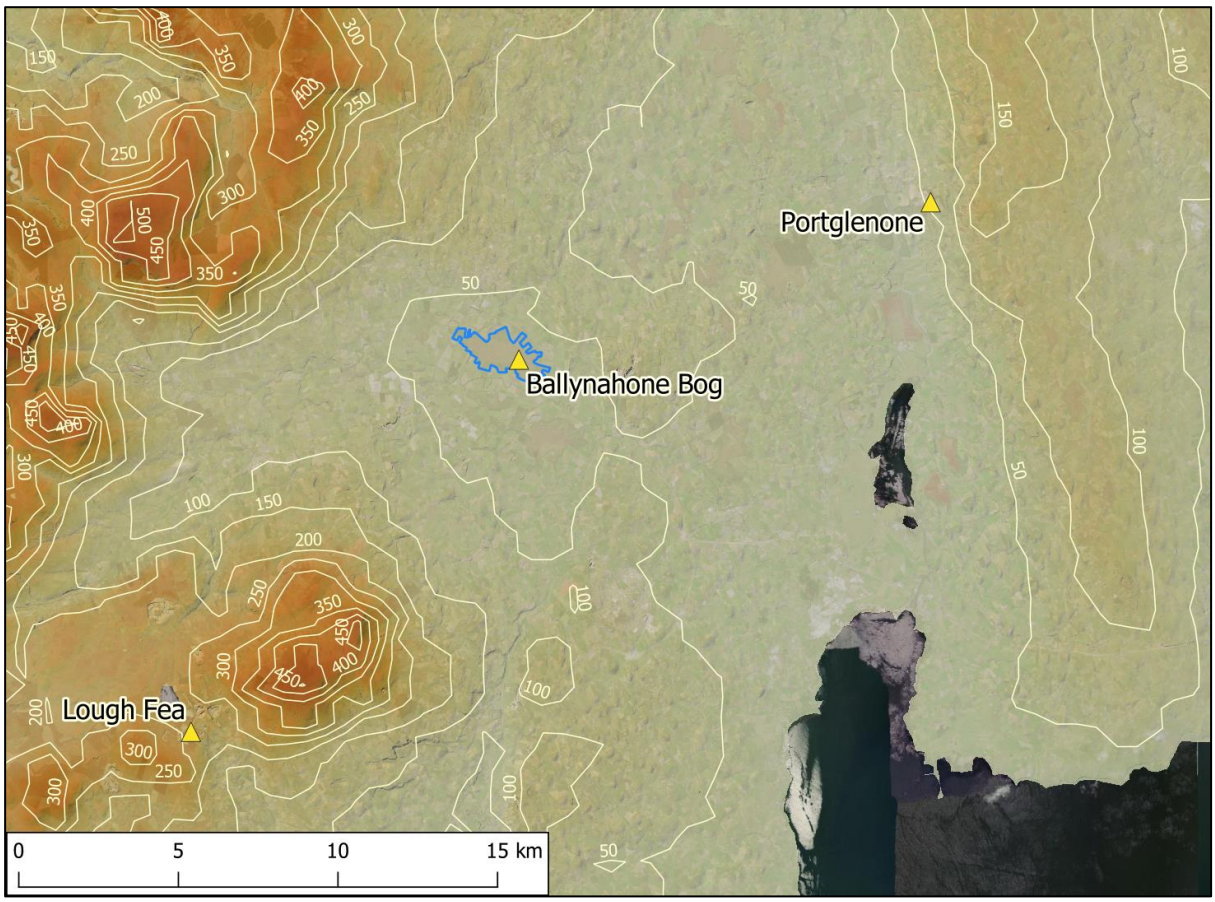

Figure 3: Map showing location of Portglenone and Lough Fea met stations in relation to Ballynahone Bog and terrain of the area. Uses OSNI Open Data 10M DTM as elevation data (Land and Property Services 2015). Contains public sector information licensed under the Open Government Licence v3.0.)

2.2 What are the local wind patterns?

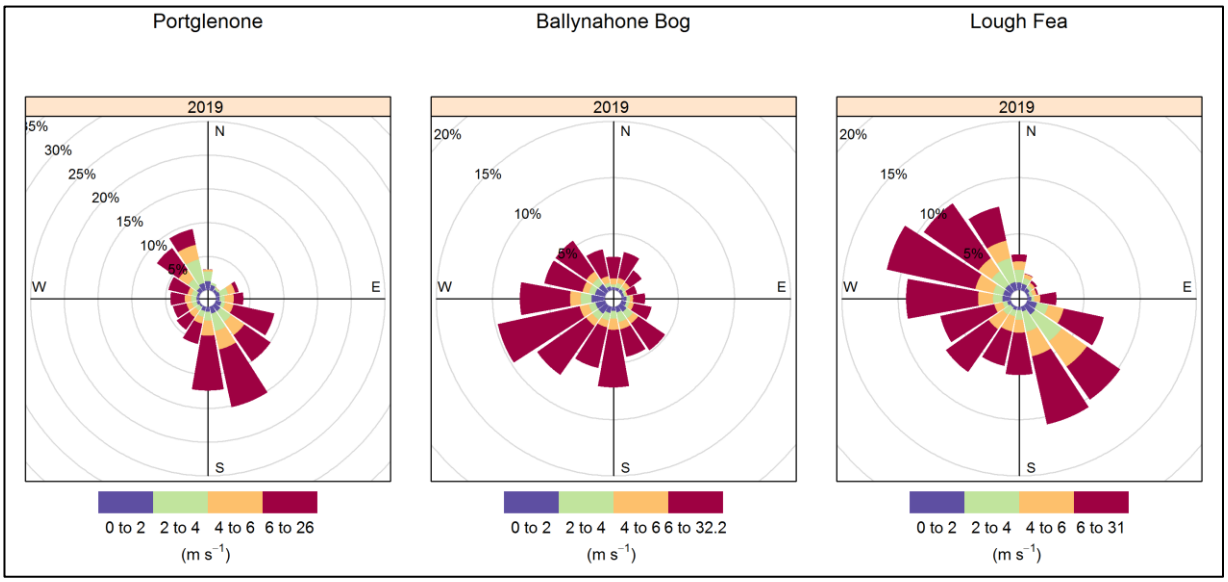

Figure 4: Wind roses for met stations at Portglenone, Ballynahone Bog and Lough Fea, showing wind speed and direction. Data have been subset to compare only the matching period(s) where data are available from

For the periods when data are available from all three met stations during 2019, Ballynahone Bog shows a prevalence of SW winds (Figure 4). Both Lough Fea and Portglenone show a prevalence of NW/SE winds (Figure 4), which is a consistent pattern across 2014 – 2019 data (data not shown).

When monthly profiles of wind directions are compared between the 3 met stations, Lough Fea shows the best agreement in wind direction with Ballynahone Bog (Figure 5). This suggests that Lough Fea could provide useful information to aid interpretation of Ballynahone Bog concentration data (2014 - 2018) in the absence of met data from the bog over that period.

Although the Portglenone met station is situated in similar terrain to Ballynahone (Figure 3), the wind direction data are less consistent with Ballynahone Bog, with a frequent strong prevalence of Southerly winds (Figure 6). Meteorology at the Portglenone site is likely influenced by topography, due to its location in close proximity to a ridge of elevated ground on the east side of the met station (Figure 3) which will tend to deflect and channel winds into a different direction. Portglenone therefore cannot be recommended as a proxy met station site for Ballynahone Bog.

Figure 5: Monthly wind roses for met stations at Ballynahone Bog and Lough Fea. Lough Fea data haves been subset to show only wind direction from dates where data are available from Ballynahone Bog for comparison. Number in red font indicates percentage of monthly data included in each month from both met stations.

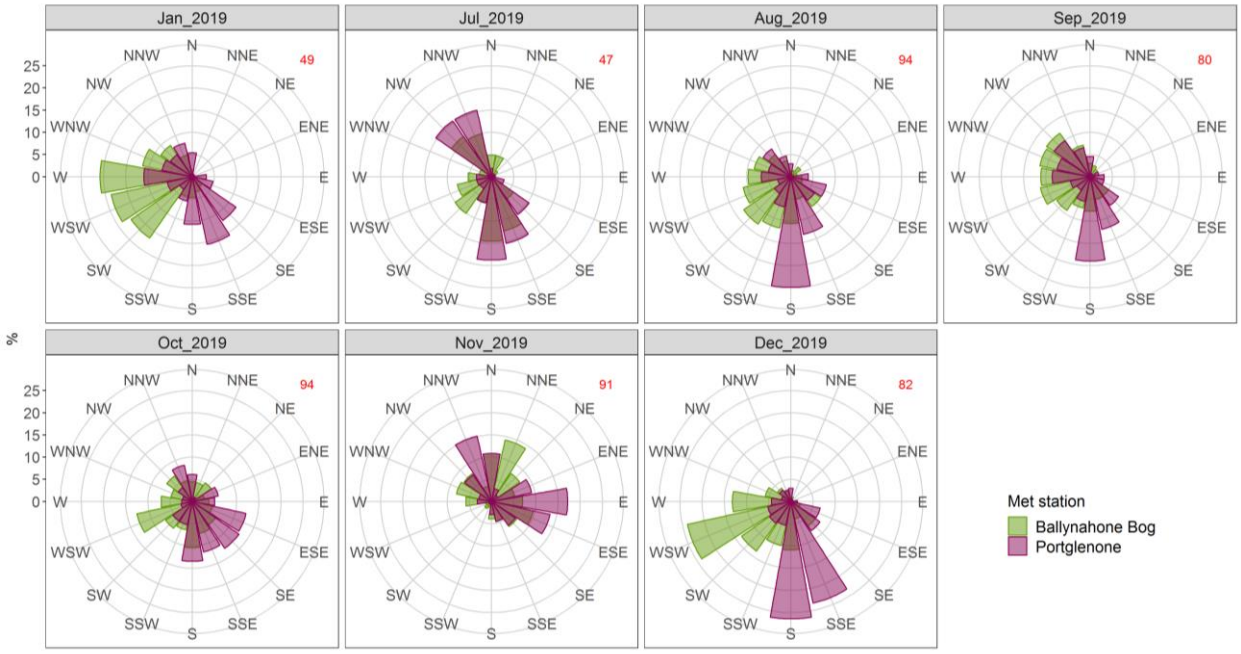

Figure 6: Monthly wind roses for met stations at Ballynahone Bog and Portglenone. Portglenone data have been subset to show only wind direction on dates where data are available from Ballynahone Bog for comparison. Number in red font indicates percentage of monthly data included in each month from both met stations.

2.3 How do local wind patterns influence NH_3 concentrations?

Wind data on the bog are not available for February –June 2019, a period which covers key months for ammonia emissions from landspreading of slurries and manures in the wider area. High NH_3 concentrations (>10 µg NH_3) were recorded across several measurement sites in March on the bog, but it is difficult to interpret the main sources of emissions contributing to the elevated concentrations without suitable wind data.

Data from the met station on Ballynahone Bog from October to December 2019 are reasonably complete (total monthly coverage of 82–94%), and these months show contrasting wind patterns and measured NH_3 concentrations (Figure 7). Monitoring sites for these months show similarly contrasting concentration values. These values were recorded during the closed period with no landspreading, where lower concentrations are expected across the wider landscape. NH_3 emissions during this period would instead be expected to be related to nearby animal housing and manure storage sources. Indeed, Site 8 in the southeast corner of the bog, which is furthest from possible emissions sources, remains relatively clean during these months, as do many of the wider landscape sites (Figure 8). In October and December 2019, concentrations of 4 - 7 µg NH_3 m^{-3} were recorded at sites (site 6) in the SW direction of the bog, with the prevailing SW wind direction passing over local emissions sources before reaching the bog. High local monthly average concentrations are likely to be dominated by livestock farming in close proximity to the bog, with several animal houses within 500 m of the site boundary. November saw lower concentrations (maximum of 2 - 3 µg NH_3 m^{-3}) across all NH_3 measurement sites, with the prevailing wind direction from the N/NE, away from emissions sources. These contrasting months give a good illustration of the importance of wind patterns on local NH_3 concentrations in general, and an indication of the role of wind direction in influencing ammonia concentrations across Ballynahone Bog, in particular.

N.B. Monthly met data is calculated for calendar months (e.g. 31 days in January), whereas monthly exposure periods for the measured NH_3 concentrations are generally calendar month +/- 5 days. This difference of a few days is not expected to change the wind rose profile for comparison with NH_3 data. However, for scientific accuracy, in the next assessment, met data will be extracted over the periods matching to the exact exposure duration of each monthly sample.

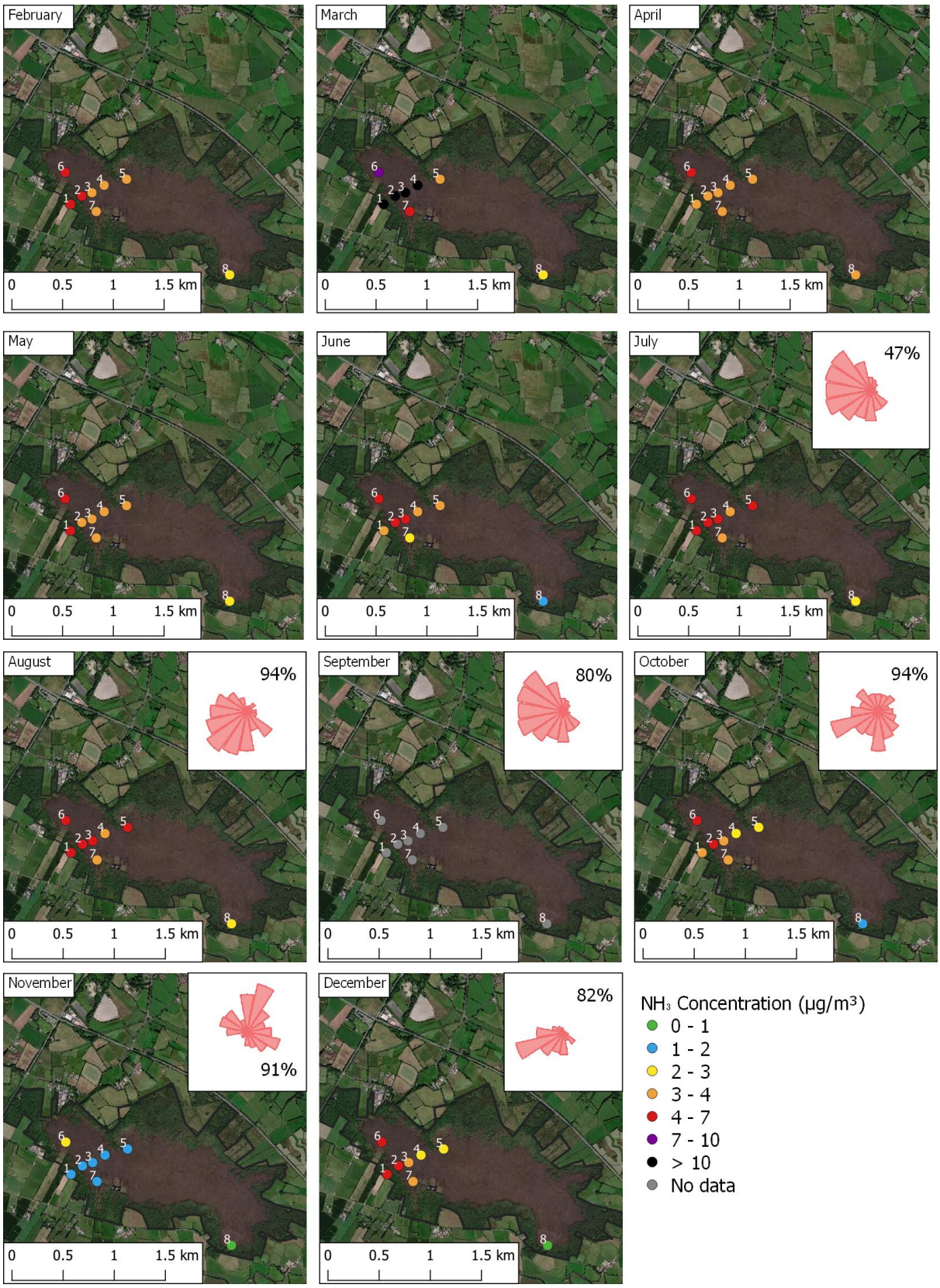

Figure 7: Monthly NH_3 concentration at measurement sites on Ballynahone Bog, with wind roses for months with available data from the Ballynahone bog met station. Wind roses shown are were derived from met data with data capture of between 47 - 94 %.

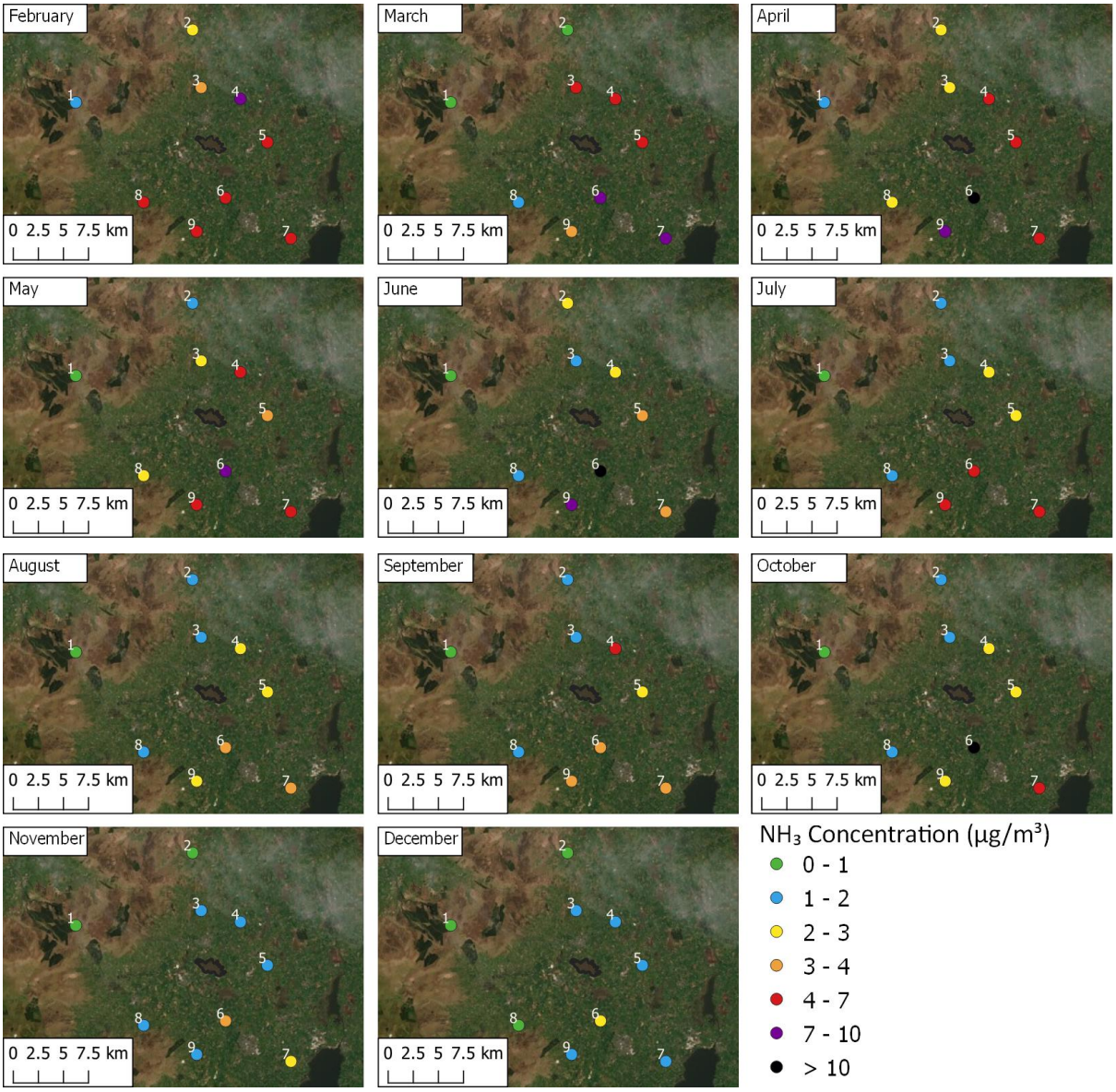

Figure 8: Monthly NH_3 concentration at measurement sites around Ballynahone Bog.

3 Conclusions

Wind direction data can provide a valuable insight into inferring the sources of high ammonia concentrations measured at a site, and with recent months of relatively complete wind data from Ballynahone Bog, we are able to make links between the ammonia concentrations and wind direction. Continued parallel monitoring of wind direction and NH_3 concentrations at the site will be useful to capture a whole cycle of relevant emission sources and events throughout a year, including more diffuse sources, such as landspreading, across the wider area during the spring months. With neither of the two other local met stations entirely suitable as a proxy for wind direction at Ballynahone Bog, having a reliable source of met data on site would be key to ensure accurate interpretation of concentration data. The project will benefit from the DAERA procured weather station to increase reliability, and enable remote downloading of data, to quickly identify and rectify any malfunction, rather than requiring regular visits for downloading and checking.

Further work could explore comparing the multi-year time series of measurements at Ballynahone Bog, which date back to September 2014, to wind patterns from Lough Fea, which would be the more suitable one of the two nearby met station for this purpose.

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