Hemmera
An Ausenco Company

Benjamins Mill Wind Project – Radar and Acoustic Monitoring

Prepared for:

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December 16, 2021

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1.0 INTRODUCTION

Natural Forces Developments LP (Natural Forces) retained Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Canada Inc. (Ausenco), to conduct spring and fall radar and acoustic monitoring of nocturnal migrating birds at the Benjamins Mill Wind Project (the Project). The Project is located approximately 13 kilometers (km) southwest (SW) of the Town of Windsor, Nova Scotia (NS).

The proposed Project will consist of up to 28 turbines ranging from a size of 4.2 to 6.2 megawatts (MW) for a total nameplate Project capacity between 50 and 150 MW. The final turbine model has not been selected for the Project. The range in turbine specifications being considered include a hub height between 100 and 131 meters (m), rotor diameter between 138 and 170 m, for a total turbine height (i.e., tip of blade) between 170 and 200 m above ground level (agl). The potential rotor swept area (RSA) of the turbines will range from 20 to 200 m agl.

The *Guide to Preparing an EA Registration Document for Wind Power Projects in Nova Scotia* (Nova Scotia Government 2021) specifies that avian radar studies are required for projects that include turbines greater than 150 m in height. Given that the Project turbine will have a maximum total height greater than 150 m, Natural Forces consulted with the Canadian Wildlife Service (CWS) and Nova Scotia Environment (NSE) regarding the development and implementation of an avian radar and acoustics study.

Hemmera, in partnership with Dr. Phil Taylor of Tabanid Consulting and Acadia University completed spring and fall avian radar and acoustic monitoring at the Project. This report provides a summary of the findings of those findings.

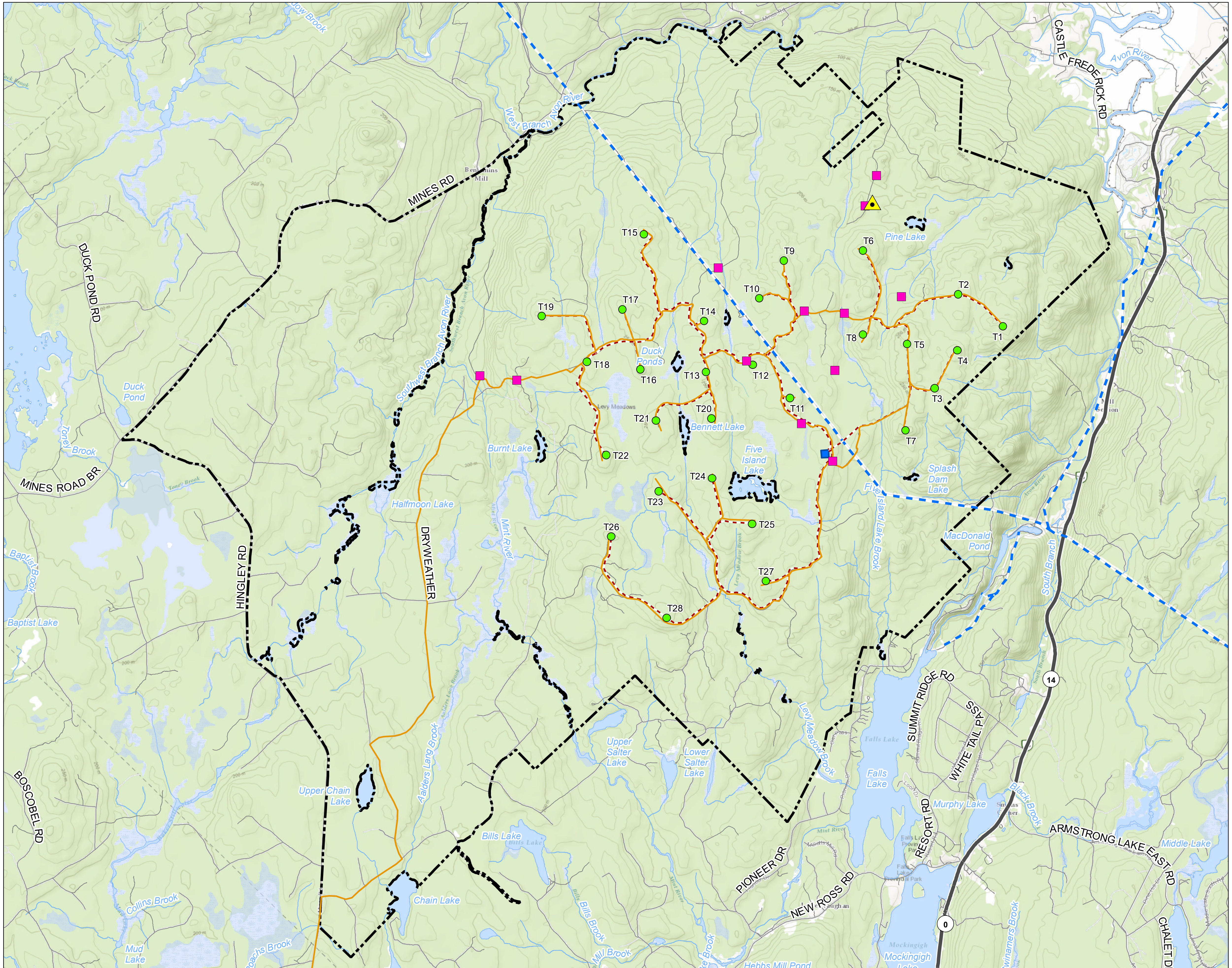
1.1 Project Location

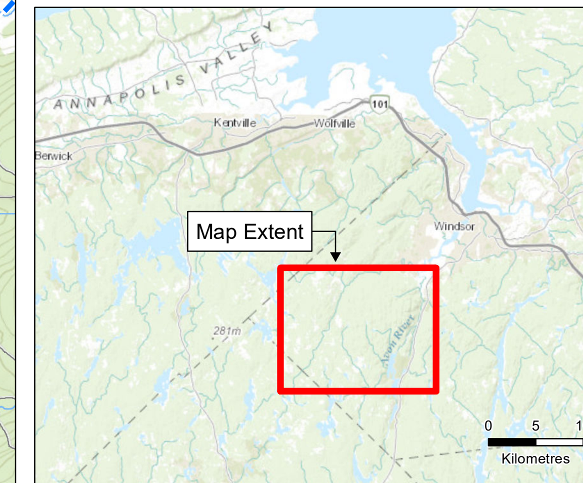
The location of the radar and acoustic equipment was chosen based on access to the Project area, site security and clear sight lines. The radar was placed on provincial crown land adjacent to an established and infrequently used logging road (See **Figure 1.1**), approximately 635 m form the nearest turbine. At that distance, the radar data provides sufficient representation of the movement of nocturnal migrants over the Project area.

The acoustic sensors were placed near the radar location and throughout the Project area (See **Figure 1.1**). This distribution of sensors allows for sampling of nocturnal migrants throughout the Project area.

Benjamins Mill Wind Project

Radar and Acoustic Survey Locations





Legend

- Audio Sensor Location
- Radar Location
- Turbine Location
- Access Road
- Collector Line
- Existing Transmission Line
- Project Location
- Substation

Basemap Layers

- Highway
- Road or Trail
- Watercourse
- Waterbody

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Contains information licensed under the Open Government Licence: Nova Scotia
- Basemap: ESRI World Topographic Map
- Inset Basemap: ESRI World Topographic Map

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natural forces

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2.0 METHODS

The following section provides a summary of the methodology used to collect and analyse the radar and acoustic data.

2.1 Radar Monitoring

Due to the limited available radar equipment at the time of initiating the spring migration season, different radar models were used at the Project during spring and fall. While the radar model and antenna orientation were different across seasons, both systems have been used in the past to assess migratory bird movements at proposed wind energy projects in NS and New Brunswick (NB) (e.g., see the Amherst Community Wind Farm Project [Lightfoot and Taylor 2014] for spring configuration and Burchill Wind Project [Taylor et al. 2020] for fall configuration), and have been proven to provide an adequate representation of bird passage rates and heights. Further, the radar and acoustic monitoring system used on this Project was initially developed through federal (i.e., CWS) grant funding and has been improved upon through multiple iterations over the past 15 years. The approach used has been implemented on no fewer than four wind energy projects in NB and three energy projects in NS, along with two successful Master of Science degrees and presented in peer reviewed scientific publications.

Each radar system is described in detail below.

2.1.1 Spring Migratory Season

A Furuno Electric Co. (Furuno) 1954C-BB (Camas, Washington, USA) X-band (3-cm wavelength) marine radar with a parabolic dish antenna was deployed at the site from May 10 until June 3, 2021 to capture the latter part of the spring migration season. The radar antenna made a complete 360° revolution (a scan) every 2.4 seconds. The antenna was set to a fixed angle of 25° off the horizontal to allow for line of sight over the nearby vegetation.

All output from the radar was processed using a digitizing card (Sigma Sd, Rutter Technologies Inc., NL) and recorded using radR, an open source, R-based platform (Equipment www.radr-project.org, Taylor et al. 2010). All data (date, time, and location in space) on targets ("blips") detected by the radar were stored in blip movie files for later processing (see Taylor et al. 2010 for details).

During the spring migration season, monitoring occurred from May 10 to June 3, 2021. During that 24 day period, due to technical issues with the equipment the radar functioned approximately 75% of the time. However, acoustic sensors were operational throughout the period.

Radar Data Processing

All recorded blip movies were filtered to remove signal clutter (e.g., backscatter from surrounding vegetation) using program radR (see http://radr-project.org). Targets visually assessed to behave like birds (e.g., where multiple detections of a target moving in a particular direction) were identified to determine a 'size' threshold for target inclusion. Parameters were established within the 'blip finding' plugin of radR and then extracted targets from recorded blip movies and saved to csv files, with corresponding information on height and location.

Weather data (wind speed and direction, pressure, temperature, and humidity) were acquired from the National Centers for Environmental Prediction (NCEP) (https://www.weather.gov/ncep/) downloaded via the RNCP package in program R (R Statistical Core Team V 3.02).

The spring radar unit appeared to be underpowered for unknown technical reasons. Therefore, analysis was focused on approximately 50% of nights when the radar was operational and on the airspace between 100 and 400 m agl, which encompasses the airspace of the turbines plus an additional 200 m agl. These data were then summarized by grouping into altitude (100 m bins) and time (30 min bins) and plotted. As such, for the spring analysis, all audio data collected is presented herein.

2.1.2 Fall Migratory Season

A Furuno (Camas, Washington, USA) 8252 marine radar operating in the microwave X-band (9410 ± 30 megahurtz (MHz), 25 kilowatt (kW)) with a 6-foot XN13A open-array antenna was deployed at the site for the fall season. The radar was mounted on a custom support framework in a vertical orientation to monitor the altitude of targets and was run in short pulse mode (2100 pulses per second) at 24 revolutions per minute (rpm). The approximate maximum range of detection was 4.6 km with a beam width of approximately 22° in the horizontal plane and approximately 1.35° in the vertical plane.

Prior to deployment, the radar was 'calibrated' while in a horizontal orientation using targets at a known distance. The radar image was digitized at 4.5 m range resolution with an azimuth resolution of 1.35° using a DSPNOR ScanStreamer (Bergen, Norway). Data were saved onto external hard drives and later analyzed using Cognitive Marine Tracker (CMT) radar analysis software, from the Cognitive Radar Corporation (Waterloo, Ontario).

During the fall migration season monitoring was completed from July 16 to October 31, 2021. Technical issues resulted in radar and acoustic sensors functioning for approximately 93% (i.e., 99 of the total 107 nights) of the fall season.

Radar Data Processing

Targets were extracted over background noise if they were at least 6 pixels in size, and the sensitivity to detect targets over the threshold in the CMT software (Pfa setting) was set at 0.02. These settings allowed for weak targets at long range to be identified over background noise, but also were sensitive enough to pick up insects at short range and birds at the edge of the radar beam. To filter out insects and birds on the periphery of the beam at close range, the peak power of the radar return for each target ("peak_val setting") was used and corrected for range, since returned power decreases with range to the fourth power. This analysis resulted in a variable termed as "scaled intensity". All targets below a scale intensity of 12 were filtered out to avoid contamination from insect targets. Based on our experience working extensively with similar radar data, targets with a minimum scaled intensity of 12 are detected by the radar at ranges up to 650 to 750 m.

Therefore, fall data presented within this report are from targets in a "column" of air starting at a distance along the ground between 300 and 320 m from the radar. This approach allows for smaller birds to be detected at high altitudes, while sampling low altitudes horizontally from the radar.

Radar data was visually inspected to determine periods of rain, which were excluded from analysis. Targets below 70 m agl were also eliminated because they are contaminated by ground clutter.

The effect of weather (tailwind assistance, barometric pressure, change in barometric pressure and humidity) on log of the number of targets detected, and variance in heading was modelled using generalized linear models. Model support was assessed using Akaike's Information Criterion (package MuMIn; Barton 2012) and relative variable importance (on a scale of 0 to 1) and full model-averaged coefficients were calculated using functions in AICcmodavg (Mazerolle 2012). This type of approach is useful when dealing with potentially large number of multi-way interactions in a model (Crawley 2007). Model-averaged coefficients show the relative strength of the relationship between the weather variable and the response, and the variable importance provides information on the amount of evidence that a particular variable has some effect on the response.

2.2 Acoustic Monitoring

Two types of acoustic monitoring devices were used to detect nocturnal flight calls (NFCs) of migratory birds (primarily passerines) at the Project area.

A 21c microphone system (Old Bird) (Old Bird Inc., Ithaca, New York, USA) was mounted in a bucket with the top oriented to the sky and connected to a secondary booster amplifier and power supply was located in proximity to the radar. Audio was recorded with a raspberry Pi3B (spring) or an iSound Recorder 7 (Abyss Media) (fall) and saved onto external hard drives. The microphone was programmed to start recording up to an hour prior to sunset, and to stop after sunrise.

In addition, a network of 12 acoustic sensors (Audiomoths™) were deployed across the Project area to record NFCs (see **Figure 1.1**). The sensors were programmed to begin recording approximately one hour before the end of evening civil twilight and finish recording one hour after the beginning of morning civil twilight and placed in open areas with a clear view of the sky. The sensors were checked every 14 days to replace batteries and download data from SD cards into an external hard drive. In the spring these sensors ran continuously between dusk and dawn; in the fall they were programmed to sample alternate 10 min periods.

The detection range of each recording unit is estimated to be up to 200 m or more for the Old Bird system (the type of unit located adjacent to the radar) and approximately 100 m for the Audiomoth (the units situated elsewhere in the Project area).

Acoustic Data Processing

All acoustic data were either sampled or resampled to 22 kilohertz (KHz) (the frequency range where most NFCs occur), then clipped to encompass only the period of time between the end of evening civil twilight and the beginning of morning civil twilight. It is during this period that birds make NFCs while actively migrating.

All acoustic files were processed using custom-built night flight call detectors developed using the OpenSoundScape program (www.opensoundscape.org). A library of about 50,000 identified groups of calls (modified from Sanders and Mennill, Appendix 1) were used to train a convolutional neural network model which was used to classify the recordings. The classifier assigns a 'score' to each species (or group), which is related to the probability that the detection is actually that species. These results were then visually examined to identify a threshold where we were approximately 85% certain that the identity was correct. For ease of presentation and interpretation of the data, the classifications were then amalgamated into two larger groups (sparrows and warblers).

For the spring acoustic data, summaries are presented of all nights for which data was collected by the Old Bird microphone (at the radar site) and from a set of approximately 12 Audiomoths across the site. For the fall acoustic data, summaries from the same set of acoustic detectors used in the spring are presented for a set of 12 nights that showed different patterns of bird behaviour at the site, across the season.

2.3 Data Analysis

All analyses were conducted using program R (R Statistical Core team; V 3.02).

2.3.1 Visualization patterns

All radar and acoustic detections were plotted to visually explore the patterns of bird movement at the site in conjunction with wind direction and strength at the surface and aloft. Analysis within this report is restricted to a summary of those observations.

All nights with data from the spring and 12 nights from the fall, that had large numbers of targets showing different patterns of bird behaviour at the site were visualized. These nights spanned the second half of the migration period for the spring and the full range of migration periods for songbirds in the fall.

The full set of visualizations for fall data are presented in **Appendix A**.

2.3.2 Audio

Recordings from all units, for the sample of nights described above were classified. We then extracted all calls with scores above a threshold value that ensured (separately for each species group) that most detections were valid.

2.3.3 Radar

The objective was to describe the number of targets observed below 225 m in altitude relative to above 225 m, and how simple weather variables were related to the total number of targets observed.

Two response variables were derived from the raw radar data. The first was the number of targets detected in each hourly period (excluding rain) across all nights. The second was the ratio of the number of targets detected under 225 m altitude and the number of targets above that altitude. That ratio is positively related to the proportion of targets flying beneath 225 m but does not represent the actual proportion, since the probability of detecting targets decreases with increasing altitude due to changes in the shape and size of the radar beam, and the size of the targets. As such, the ratio described overestimates the proportion of targets observed at lower altitudes to some unknown extent. Regardless, it serves as a useful indicator to determine under which conditions and times more targets are flying at relatively lower altitudes.

Surface and upper altitude weather data was obtained using the NCEP database accessed via the RNCEP package (Kemp et al. 2012; func on NCEP.interp) in program R. All weather data were interpolated for the location of the radar at the surface, and for wind data, at three additional pressure levels (altitudes approximating 140 m, 792 m and 1,492 m). For this report, wind data from the surface and 792 m altitude was used.

The relationship between targets aloft and weather is complex and nonlinear. Statistical models of such relationships can be quite complex and difficult to interpret. Therefore, primarily simple models were fit to show the dominant relationships between the two response variables described above and the weather variables. Furthermore, since relationships between wind speed, wind direction and the number of birds aloft can also be complex, a 'tailwind assistance' variable was elected for use to provide simplicity, which is a measure of how much the wind would assist a given bird flying in a specific direction. It is known that nocturnal migratory fly with positive tailwind assistance (Peckford and Taylor 2008). Tailwind assistance was calculated using an assumed direction of 225 degrees (see Peckford and Taylor 2008). Thus, if the wind was flowing from the direction of 225 degrees, then the birds' tailwind assistance would be negative (a headwind); if the wind was flowing towards 225, the birds' tailwind assistance would be positive. The strength of the assistance is a function of both the direction of the wind, and its speed.

In addition to the weather variables described above, terms were fit for time of night (sunset and sunrise, which encompassed the periods 45 minutes after the end of evening civil twilight and 45 minutes before the beginning of morning civil twilight) and the rest of the night (middle), as well as the month of the year. These variables help assess how total numbers differed at migratory initiation (sunset), cessation (sunrise) and during the night, as well as how numbers differed with time of year (a potential measure of species composition).

All models were fit using program R (v. 3.5.2; R Core Team 2018). For data manipulation and visualization the tidyverse package (Wickham et al. 2019) was used and for statistical modelling we used the function 'glmer' in package 'lme4' (Bates et al. 2015). In all cases, we fit mixed effects models, with the day of the year as a random effect. Treating day as a random effect allows the model to account for additional variation in counts that is not fully captured by the weather or timing variables. Models of the total counts were fitted with a 'poisson' family (i.e., the relationship between the response and the predictor variables was on a log scale) and measure of the proportions were filled using a 'binomial' family, which transforms the response using a log-odds ratio. Model fits were assessed by examining residual plots.

3.0 RESULTS

3.1 Nocturnal migration patterns

In spring 2021, of the data collected, active migration was observed on May 16, 17 and 18. Similarly, in fall 2021, the majority of migration occurred on relatively few nights. The peaks in number of radar targets detected varied with altitude (**Figure 3.2)**. Low altitude targets (within the range of the RSA) were less common.

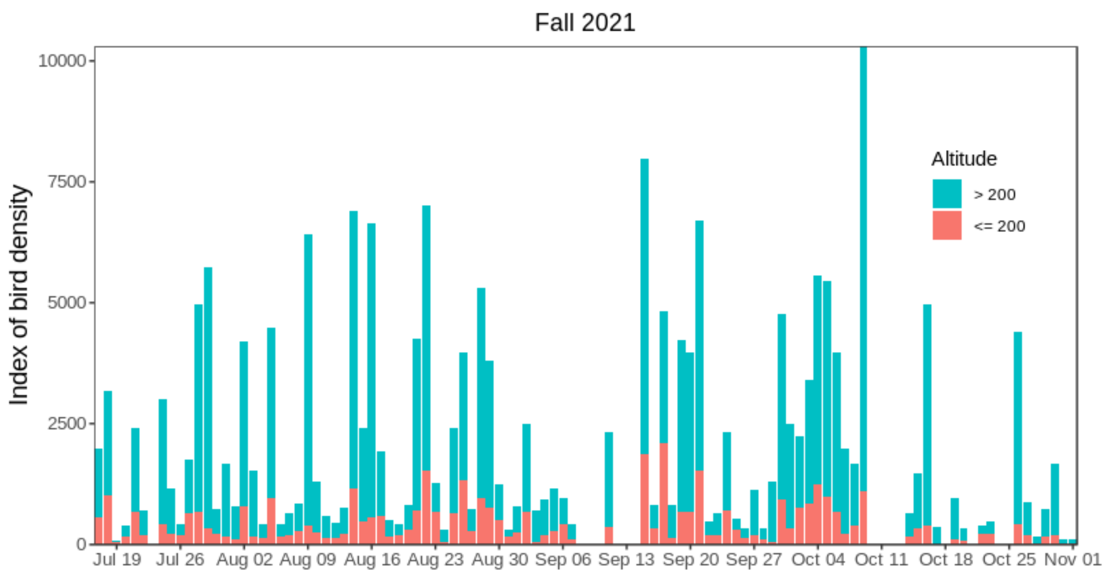

Figure 3.1 Radar Detections by Altitude Across the Fall 2021 Season

Figure 3.2, **Figure 3.3**, and **Figure 3.4** are plots showing the altitudinal, seasonal, and within night distribution of radar targets for select nights in the spring and fall, 2021. These nights were selected for closer analysis as they represented nights where high migratory activity was observed. The full set of nights for fall 2021 can be found in the **Appendix A**.

Each plot within the Figures below is a separate night, with the beginning and end of civil twilight indicated by the vertical green and yellow lines, respectively. Date and time are on the x-axis and altitude is on the y-axis. Hexagonal points are radar detections divided into time and altitude bins and are scaled from light grey (few detections) through dark purple to yellow (many detections). Wind direction and strength at the surface (red arrow) and aloft (790 m; green arrow) for each hour are displayed at the top of each plot. The blue box represents a period of rain when we were unable to distinguish between raindrops and bird detections. Red lines represent the approximate altitudinal range of the RSA.

Acoustic detections (a single NFC) are red points along the base of each plot. Note that detections are more frequent when the radar shows targets at lower altitudes.

There are many species that migrate without calling (e.g., vireos and flycatchers), so the number of radar targets does not always correlate with the number of acoustic detections.

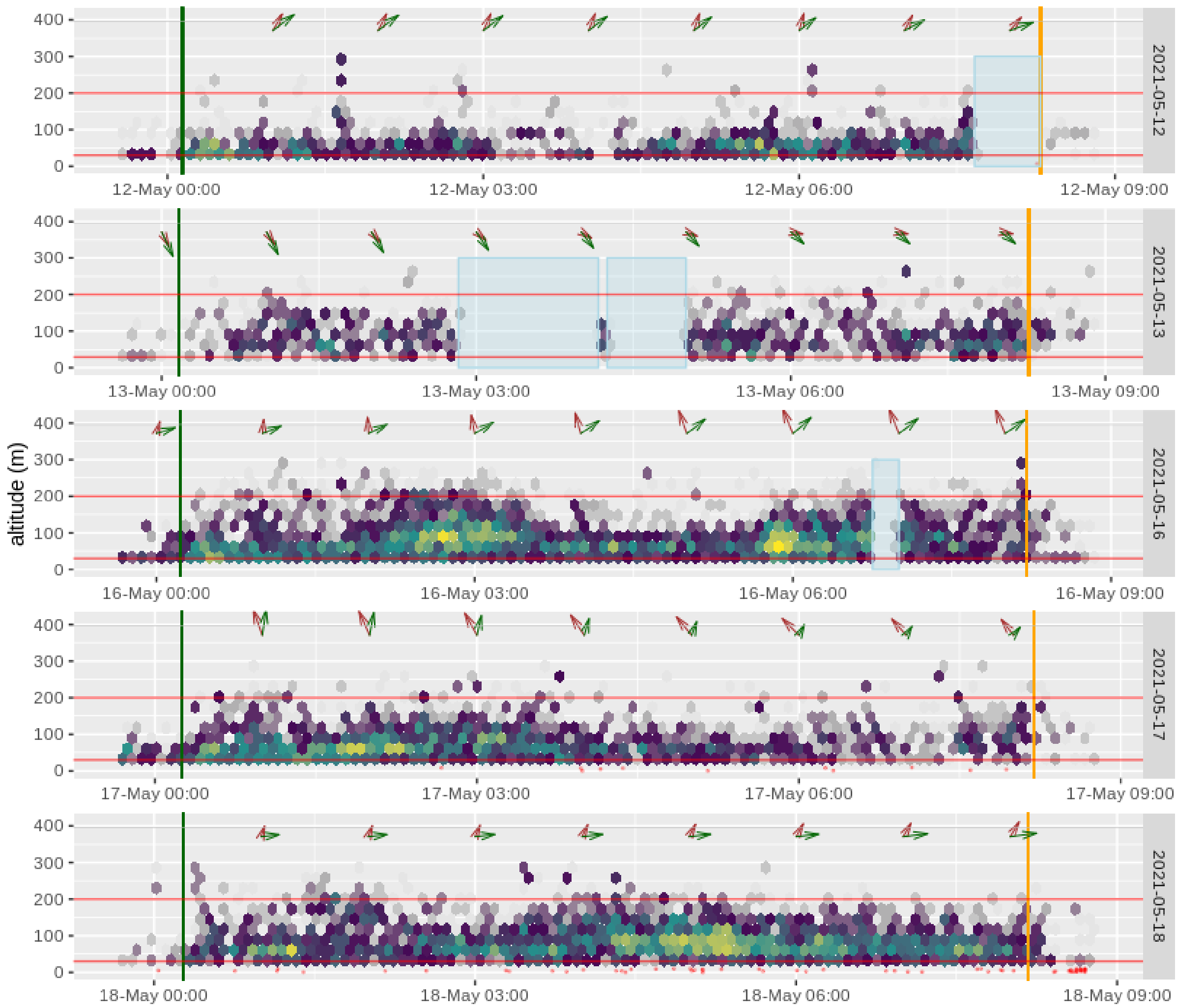

Figure 3.2 Radar and Acoustic Detections and Wind Conditions on Five Select nights in Spring 2021.

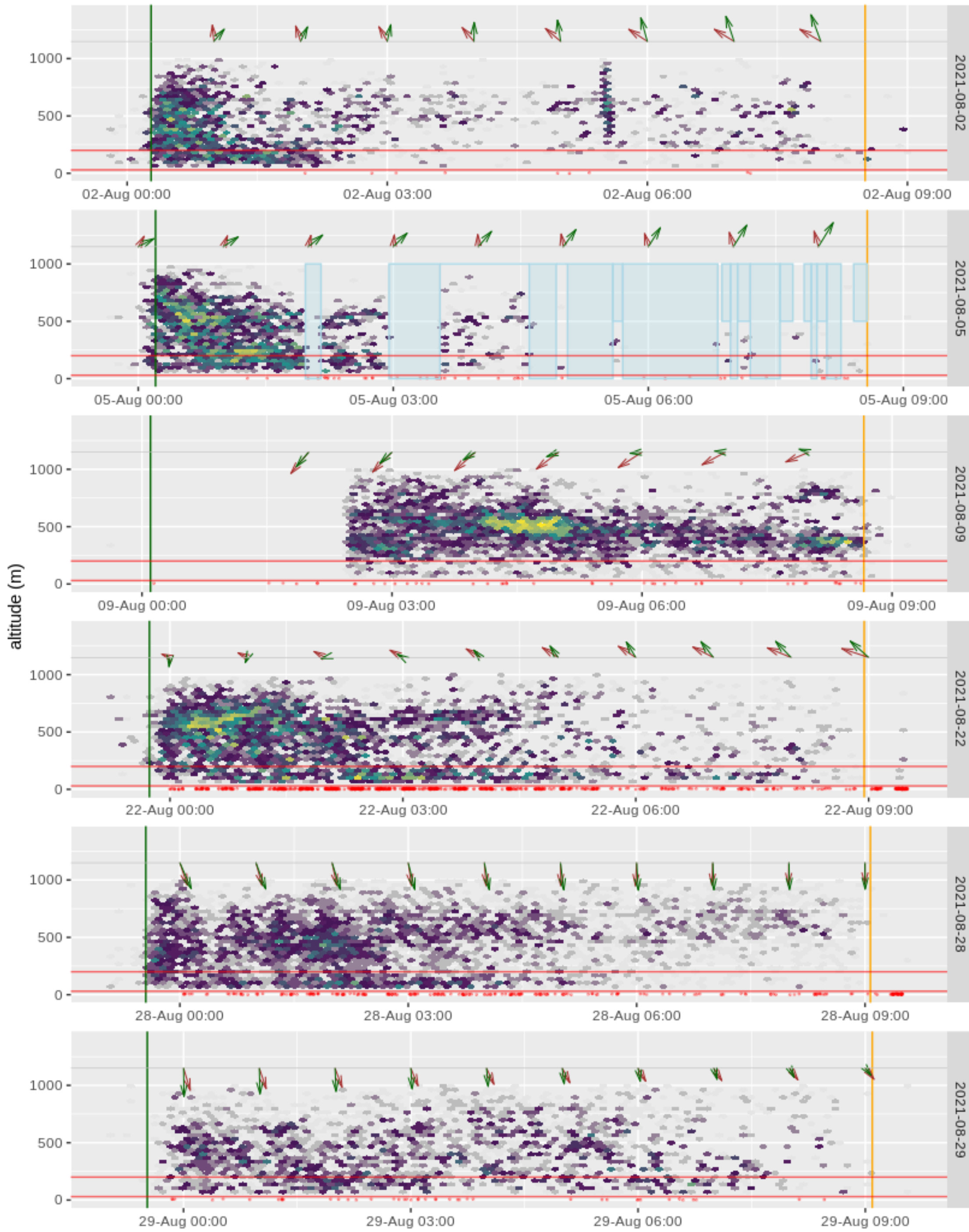

Figure 3.3 Radar and Acoustic Detections and Wind Conditions on Six Select Nights in Early Fall 2021.

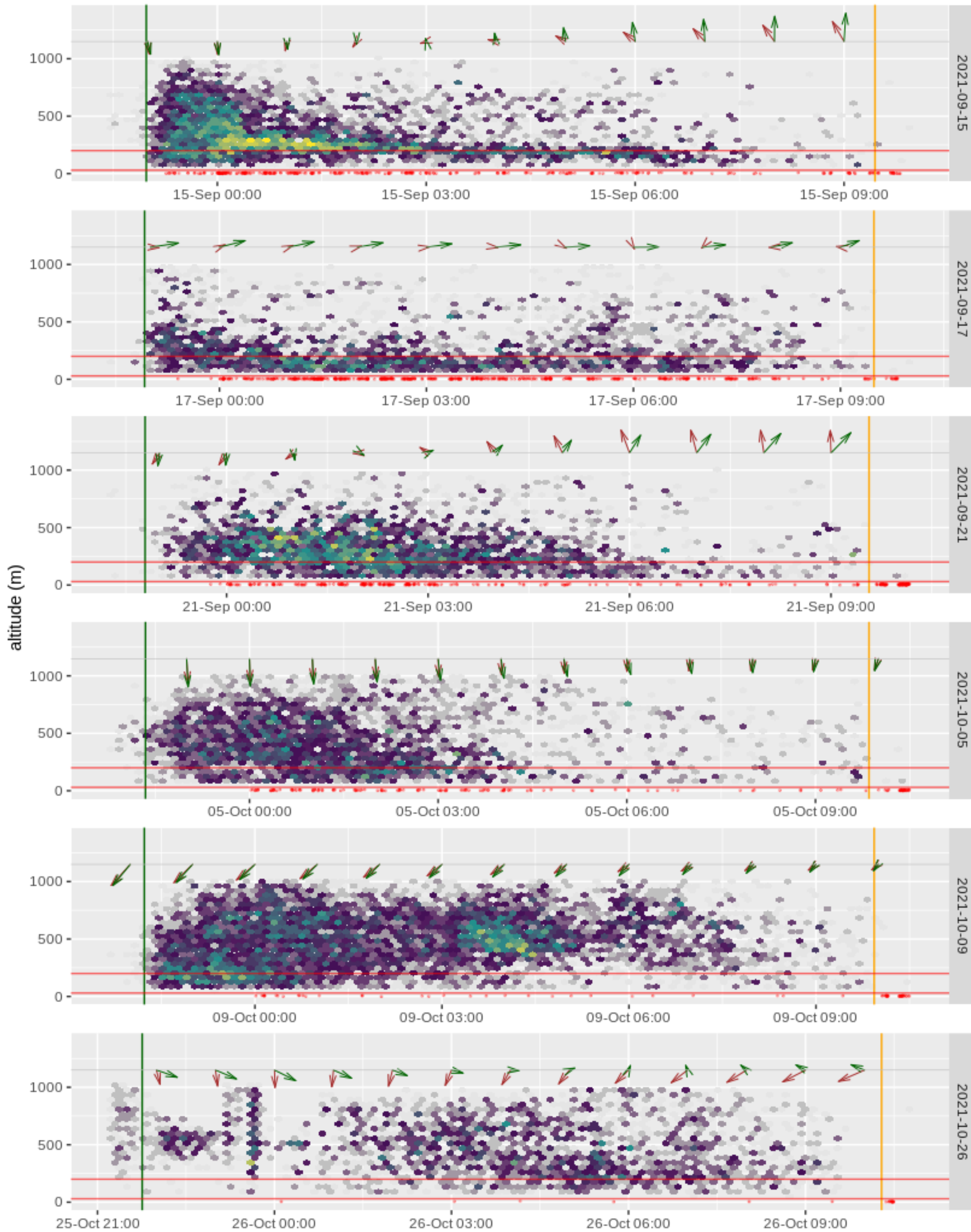

Figure 3.4 Radar and Acoustic Detections and Wind Conditions on Six Select Nights in Late Fall 2021.

3.2 Night Flight call detections

Flight calls were summarized for all nights in spring 2021 and select nights in fall 2021 and grouped into ‘Warblers’ and ‘Sparrows’. **Figure 3.5** shows the pattern NFC detections of each species group during the spring, and **Figure 3.6** shows the detections during select days during the fall.

Within **Figure 3.5** and **Figure 3.6** each dot represents a NFC detection; the different colours represent different acoustic sensors sites all within 1,000 m of the proposed turbines (See **Figure 1.1**). During the fall the Audiomoth recorders were programed to record in alternate 10-minute periods, which accounts for the banded pattern observed within nights in **Figure 3.6**.

During the spring, where we show all data collected, the majority of migration occurred across a small proportion of nights (**Figure 3.5**).

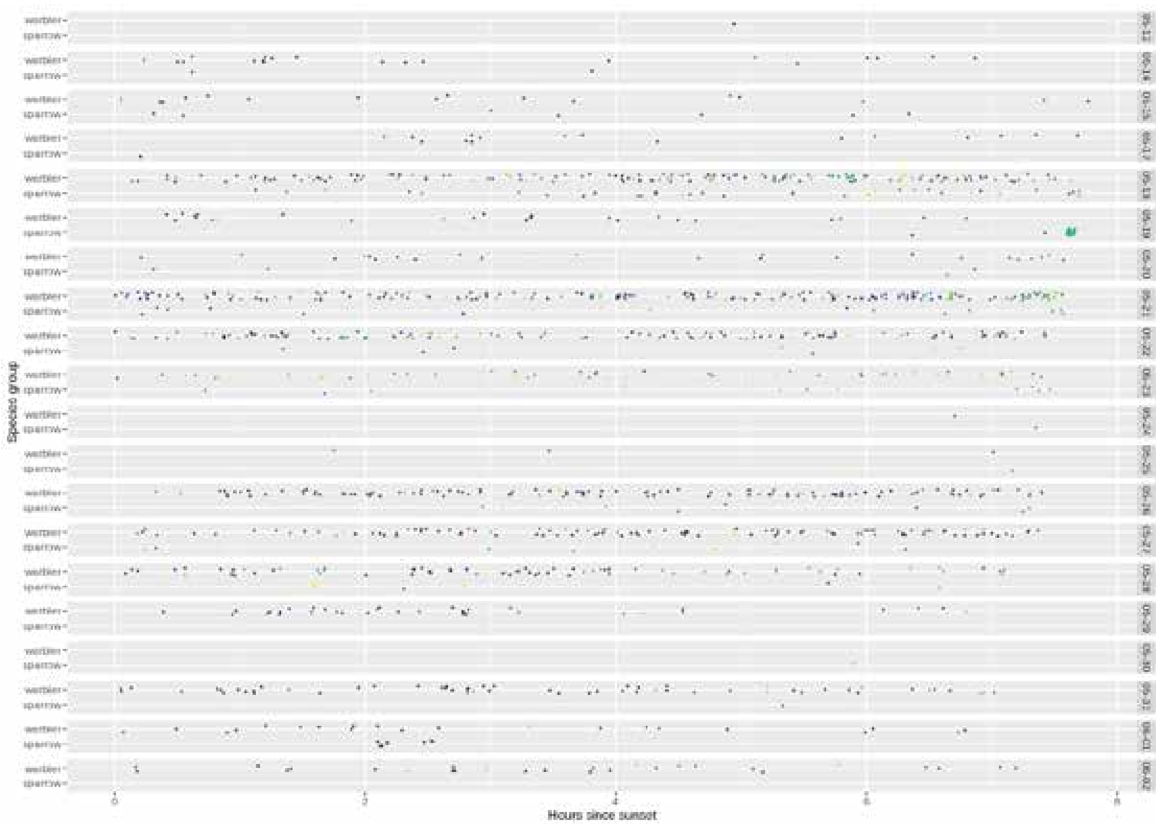

Figure 3.5 Nocturnal Flight Calls Detected through the Spring by Species Group

During the fall we see the expected pattern of more warblers detected during the early part of the season and more sparrow detections during the later part of the season.

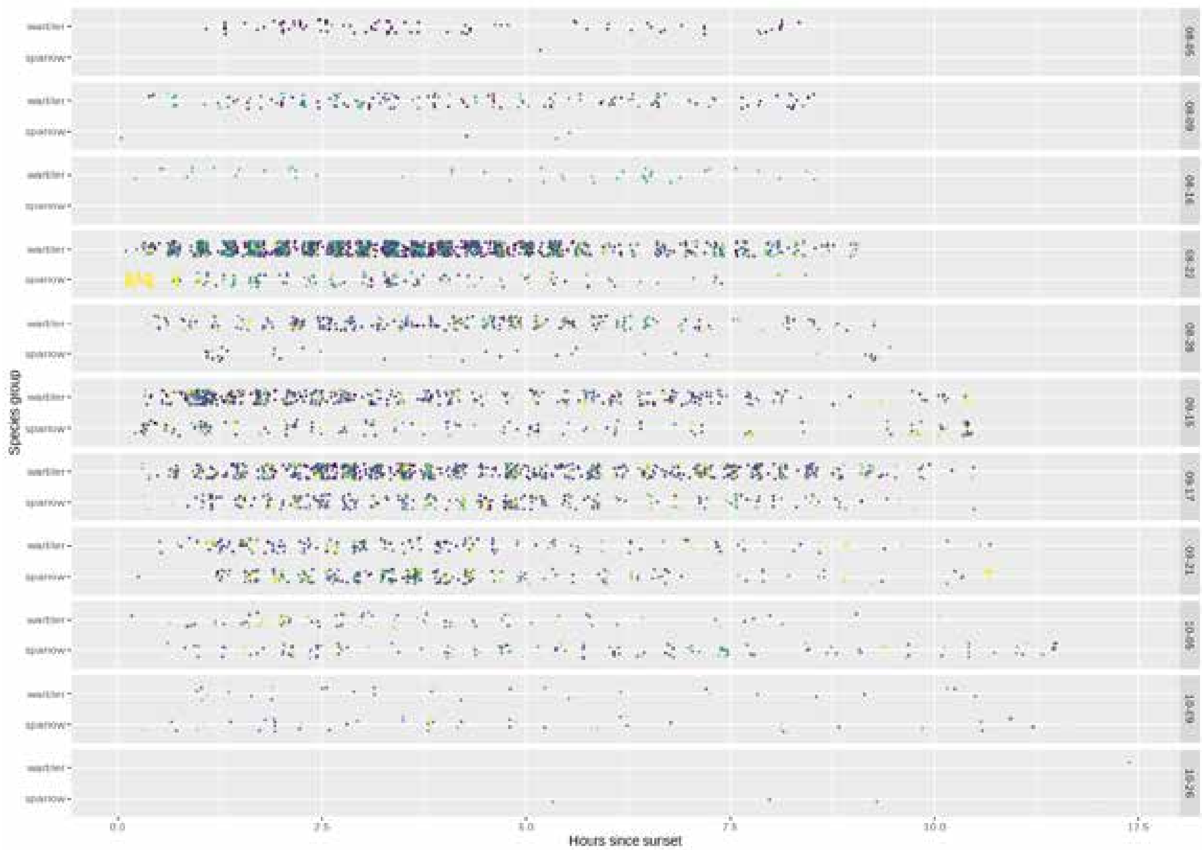

Figure 3.6 Nocturnal Flight Calls Detected during Select Fall Nights by Species Group

3.3 Altitudinal distribution of radar targets

Across all nights, the number of targets generally decreased with altitude (**Figure 3.7**). Most targets were at lower altitudes, but the distribution leveled out at around 300 m. The number of targets detected declines above approximately 600 m agl; this decline is partly due to an actual decrease in the number of birds, but also reflects the declining probability of detecting birds at more distant ranges. It is difficult to separate the effects of these two variables. Also, the data show a peak in detections at the lowest possible bin (i.e., 70 m to 95 m agl), however, at that height there is a greater likelihood of data being contaminated with insects and ground clutter.

The red line shown in **Figure 3.7** represents the maximum potential height of the turbines.

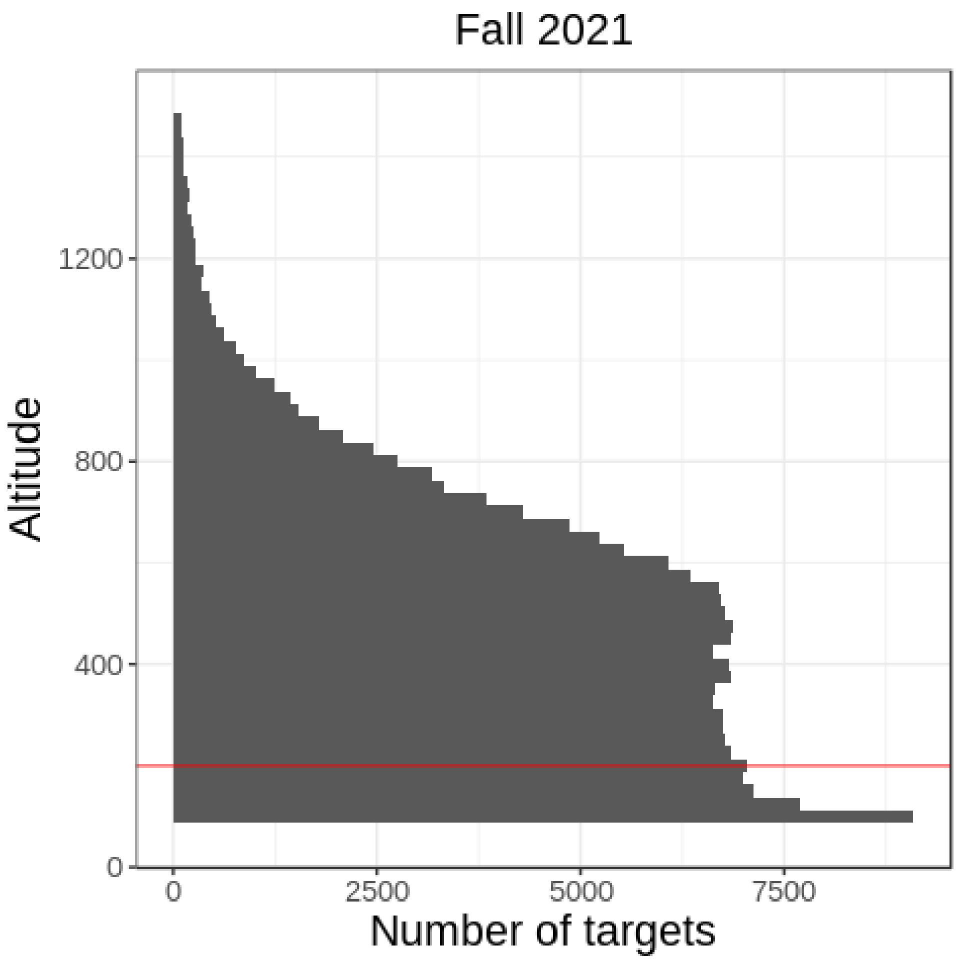

Figure 3.7 Number of Radar Targets Detected by Altitude for Fall 2021

Figure 3.8 shows the density of radar detections by altitude for twelve selected nights in fall 2021 that contained the most migration. Each night is presented with a different density scale, to emphasize the pattern instead of the actual number of detections. Note that the decline in detections above about 600 m is due to both a declining probability of detection, and fewer birds. The red line indicates the maximum height of the turbines.

When focusing on the nights when most migration occurred, many nights show that the bulk of migration occurred above the highest potential turbine RSA (e.g., see August 9, August 28 and October 10 plots in **Figure 3.8**).

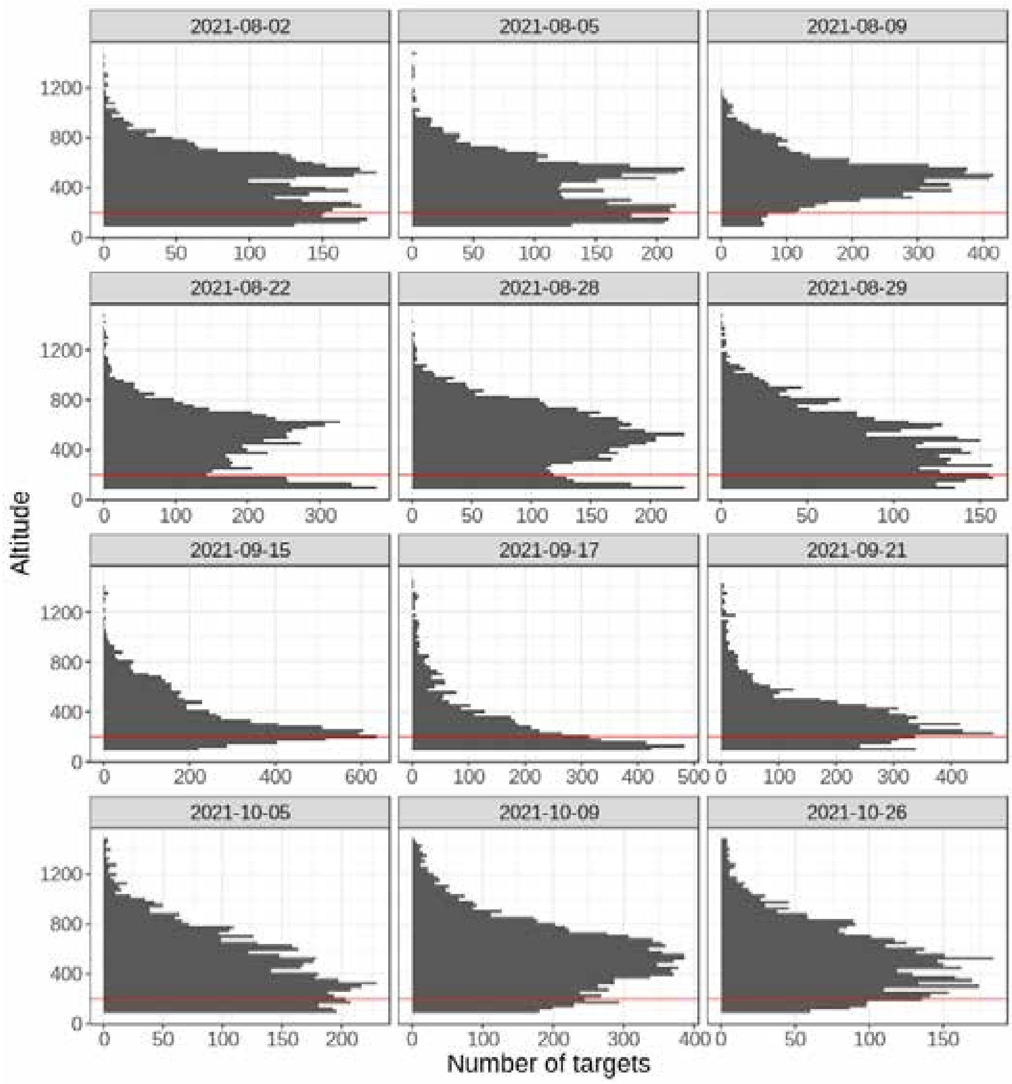

Figure 3.8 Number of Radar Targets by Altitude for Twelve Select Nights During Fall 2021

3.4 Statistical Analysis of Fall Radar Data

Total numbers of birds

Statistical models provided evidence that the total number of birds per hour was related to tailwind assistance, time of night (sunset, sunrise and the rest of the night) and weather (temperature, surface pressure and relative humidity). The most important differences are summarized in **Figure 3.9** and can be attributed to different behaviours through the night – the radar detects numerous targets immediately after the initiation of migration (take-off after sunset) and during the middle of the night (continued migration), and fewer in the morning. August and September have the highest average number of targets, followed by October. That the period immediately before dawn sees many fewer targets likely reflects that birds are either not landing within the Project area following migration or they are consistently ending their migration flights early in the night (also see **Figure 3.3**, **Figure 3.4** and **Appendix A**).

The number of targets detected is low in strong headwinds (negative tailwind assistance) and highest with light through moderate tailwinds. In October, few birds were detected on nights with very strong tailwinds (**Figure 3.9**). This follows a general pattern that birds prefer to migrate with tailwinds or very light headwinds (e.g., Peckford 2006).

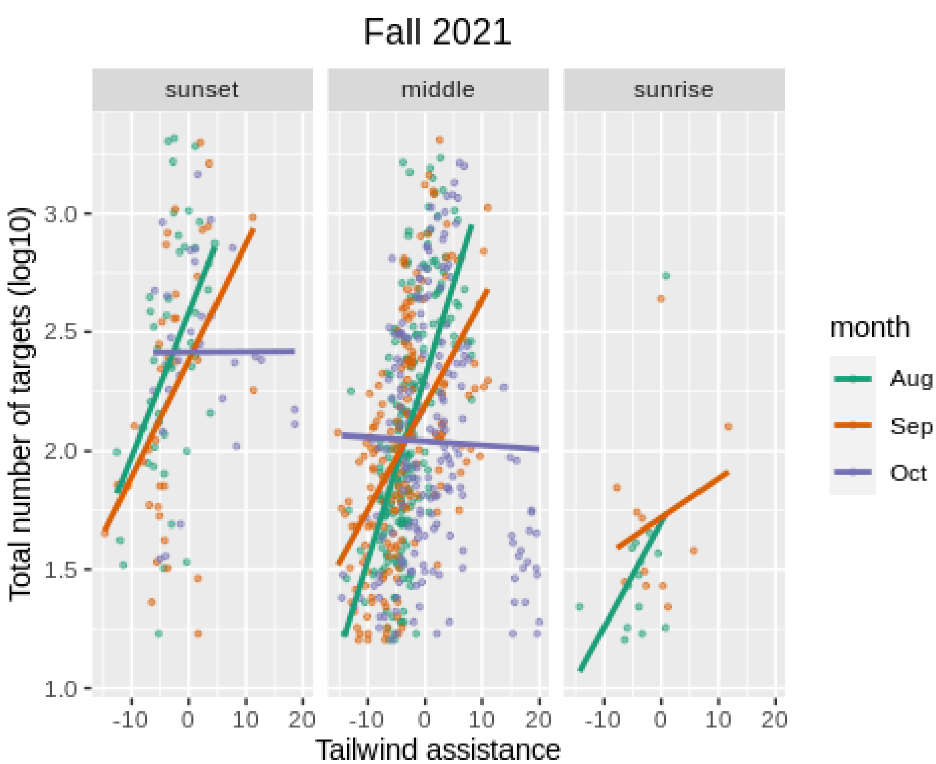

Figure 3.9 The Relationship Between Tailwind Assistance on Total Number of Targets Across Time of Night and Months

Within **Figure 3.9** each point represents the number of targets in hourly bins, classified by time periods (panels) and month (colours). The lines are linear regressions for each group, showing a positive relationship for the bulk of the night. During time periods with the largest numbers of targets there is a narrow range of tailwind assistance.

Relative number of birds at lower altitudes

The index of the proportion of targets flying at low altitudes was related to the overall number of migrants, as well as all timing and weather variables. The value of tailwind assistance at low altitudes (approximately 100 m) provided a better fit than tailwind assistance at higher altitudes (approximately 750 m) in this model (**Figure 3.10**). In the figure, each dot represents the number of birds detected below 225 m divided by the total number of birds observed, in each hourly bin, classified by time of night. The lines are smoothed relationships between the index, and the total number of targets on a log scale.

On nights when large numbers of targets were detected there tended to be fewer of those targets at lower altitudes (**Figure 3.10**).

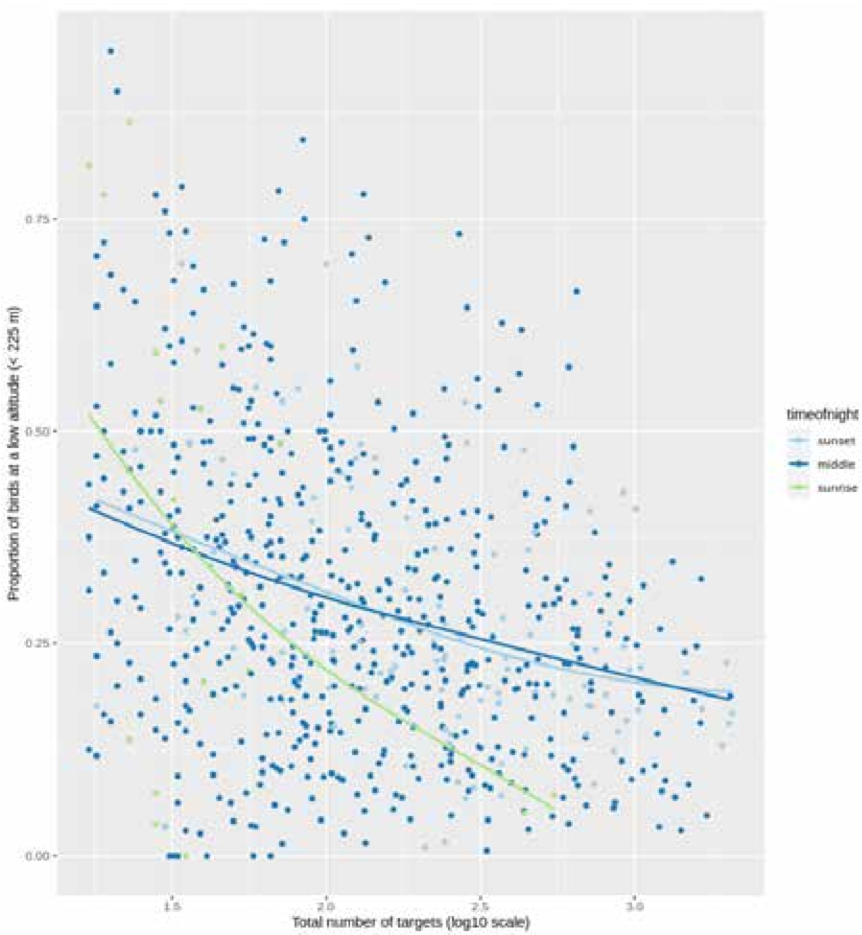

Figure 3.10 Proportion of targets at Low Altitude in Comparison to Total Number of Targets at Three Time Periods.

4.0 SUMMARY

Radar and acoustic monitoring were completed at the Project area throughout the latter half of the spring 2021 migration season and the entirety of the fall 2021 migration season. Data were collected using a marine radar located within approximately 635 m of the nearest proposed turbine and acoustic data were obtained through a network of sensors located across the Project area.

While some level of migration was observed on most nights, a large proportion of the migratory activity observed in each season was limited to a few nights. Also, most activity was observed when favourable tailwinds were present. These findings are typical to other radar and acoustic studies completed in Nova Scotia (e.g., Peckford and Taylor, 2008).

Targets were detected at heights throughout the area sampled (i.e., between 70 m and approximately 1,200 m agl), with the majority being below 600 m. However, given that the probability of detecting small birds decreases as distance from the radar increases, there decrease in number of detections of birds higher than 600 m is likely a combination of fewer birds aloft and a decreased detectability. Regardless, when examining nights when large numbers of targets were detected (i.e., when most of the migration occurred) the bulk of the migratory movements were detected at around 500 m and there tended to be fewer of targets at lower altitudes (i.e., within the RSA). These findings suggest that while the proposed turbines for the Project are taller than previous generations of turbines constructed in Nova Scotia, the bulk of migration will be above the RSA and the additional proportion of migration volume within the RSA compared to older turbine models is minimal.

When examining differences in detections within nights, most activity was observed during the middle of the night, and secondarily during the early portion of the night. Fewer detections were observed near dawn, suggesting that migrants may not be using the Project area as a stopover location. It is possible that migrants were landing earlier in the night. However, given the consistency in distribution of activity within nights, this is less likely the reason for the activity pattern observed.

Assessment of Risk

The assessment of collision risk by migratory birds with turbines using radar and acoustic data are difficult and have not been proven to be that effective. In general, mortality associated with windfarms is thought to be low, relative to the effects of other human infrastructure (Zimmerling et al. 2013).

While risk may be correlated with volume of migration, without multiple, standardized radar/acoustic studies conducted across a broader region (i.e., across Nova Scotia), it is difficult to make definitive statements about whether the volume of migrants at any particular site is more or less than what might be expected elsewhere. Therefore, while the observations made at the Project were in general alignment with radar and acoustic monitoring completed in other areas of Nova Scotia (e.g., focused on a few nights during the season and when tailwinds were light to moderate) a direct or relative comparison of density isn't possible.

Risk of migratory bird collisions is also hypothesized to be increased when birds are landing within a project area or if large numbers of birds are "forced" to fly lower due to weather variables such as fog. As indicated above, it appears from the data that large numbers of birds are not using the Project area as a stopover site. Also, given that during the peak nights of migration most detections were observed higher than 225 m and because the Project is not located in proximity to the coastline where fog would be presumed to be more prevalent, increased collision risk due to landing or lower altitude flight due to weather is likely limited for this Project.

Recommended Next Steps

Due to the timing of radar and acoustic monitoring completed during the spring 2021 migration season, we recommend that an addition spring season of monitoring occur in 2022 from April 1 through May 30. While spring migration in Nova Scotia is known to have fewer migrants than other areas of the Maritimes (i.e., New Brunswick), and of lesser intensity than the fall season, we feel a complete assessment of the spring season would be appropriate to fully understand migratory timing of the area. With the exception of the additional spring data, we do not believe that additional radar and acoustic monitoring would add significant additional information related to migratory patterns at the Project area.

5.0 CLOSURE

This work was performed in accordance with the Purchase Order between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and Natural Forces Developments LP (Client), dated March 2, 2021 (Contract). This report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for the sole benefit and use by the Client. In performing this work, Hemmera has relied in good faith on information provided by others and has assumed that the information provided by those individuals is both complete and accurate. This work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and Project terms of reference; further, the findings are time sensitive and are considered valid only at the time the report was produced. The conclusions and recommendations contained in this report are based upon the applicable guidelines, regulations, and legislation existing at the time the report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

We sincerely appreciate the opportunity to have assisted you with this Project and if there are any questions, please do not hesitate to contact the undersigned.

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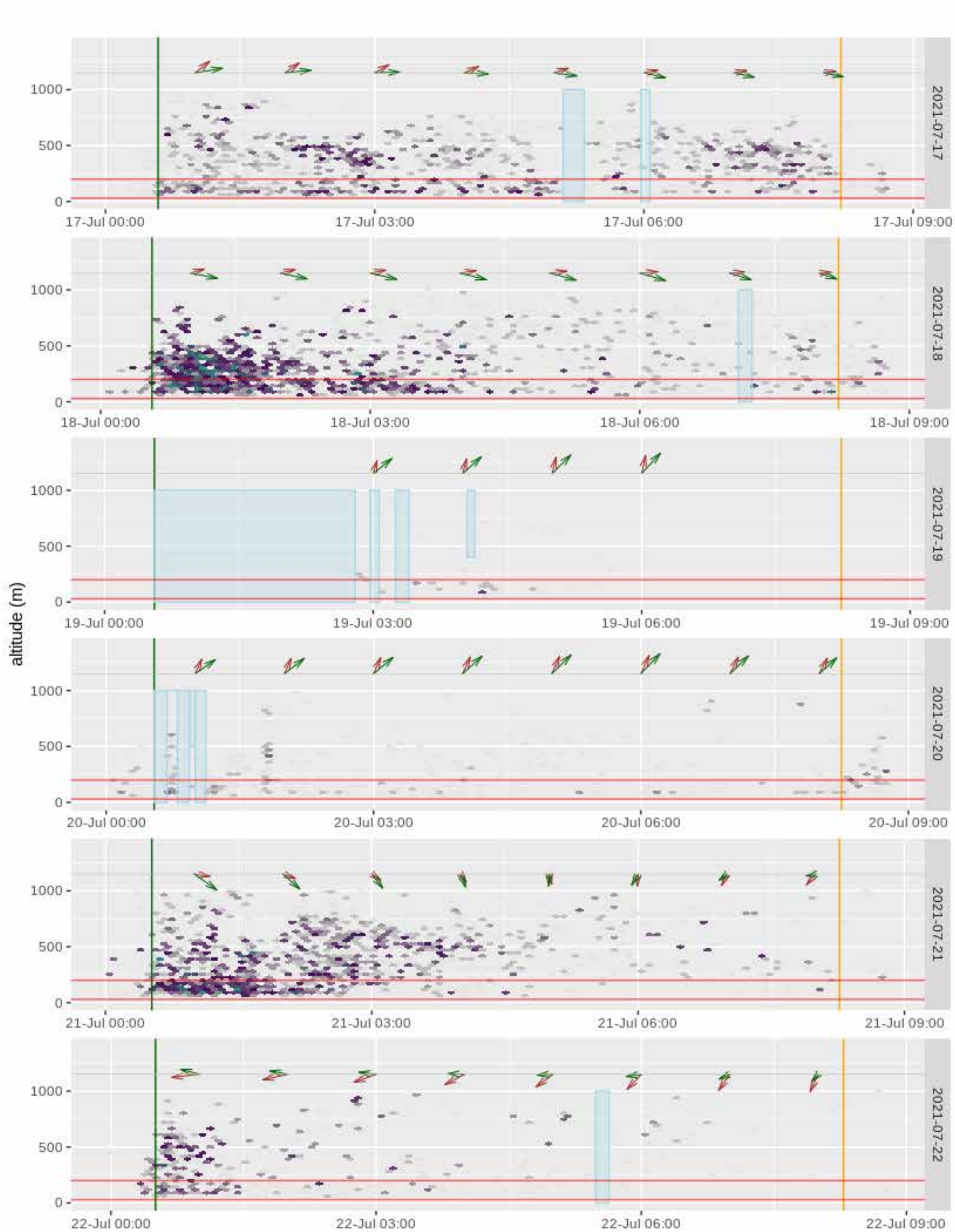
APPENDIX A
Complete Fall Radar and Acoustic Data

OVERVIEW

The following plots provide the radar and acoustic detections and wind conditions on all nights monitoring at the Project in fall 2021. Each plot is a separate night, with the beginning and end of civil twilight indicated by the vertical green and yellow lines, respectively. Date and time are on the x-axis and altitude is on the y-axis. Hexagonal points are radar detections divided into time and altitude bins and are scaled from light grey (few detections) through dark purple to yellow (many detections). Acoustic detections (a single NFC) are red points along the base of each plot (These have not been processed, and so on some nights may be contaminated by insects, raindrops or other noise). Wind direction and strength at the surface (red arrow) and aloft (790 m; green arrow) for each hour are displayed at the top of each plot. The blue box represents a period of rain when we were unable to distinguish between raindrops and bird detections. Red lines represent the approximate altitudinal range of the rotor sweep area.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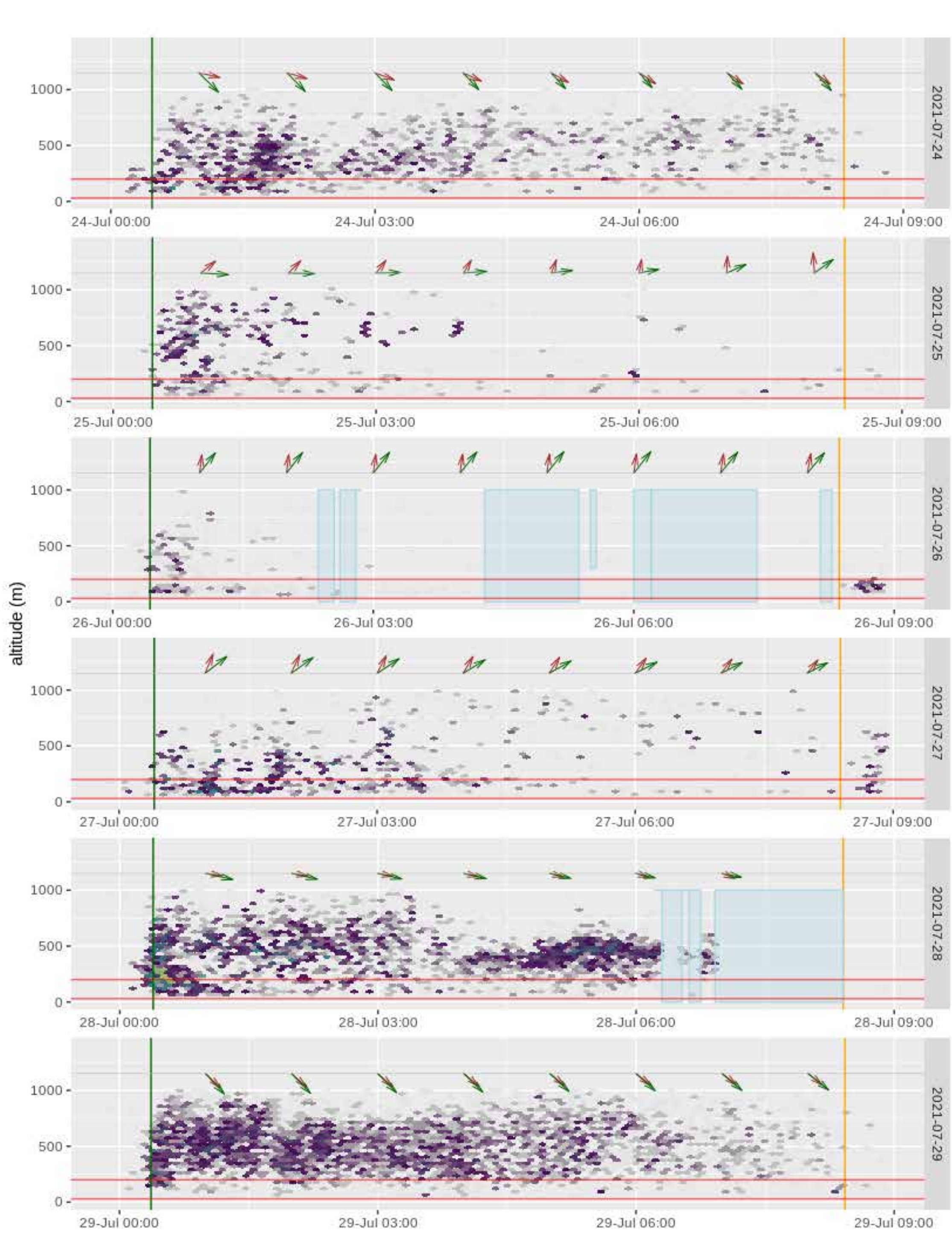
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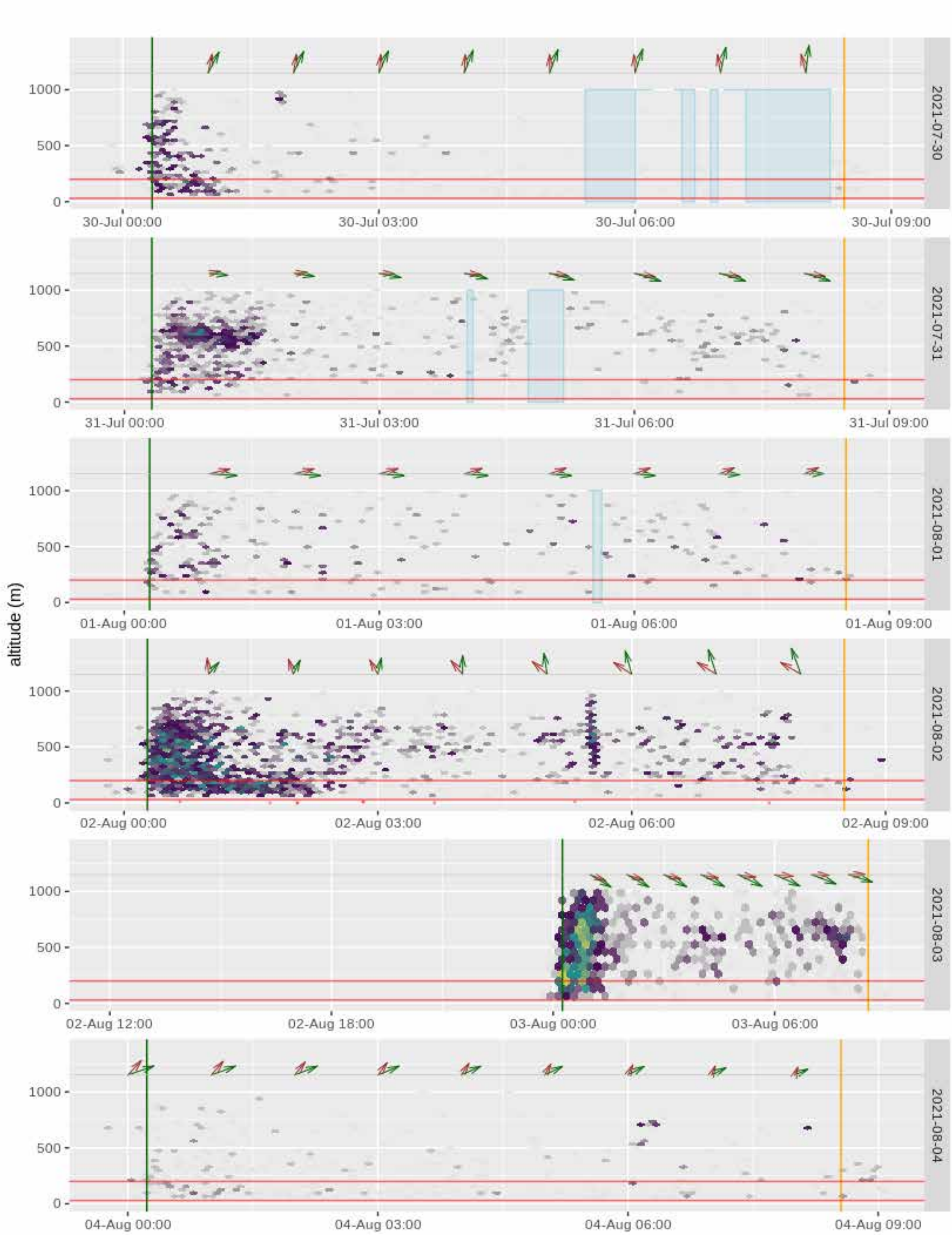
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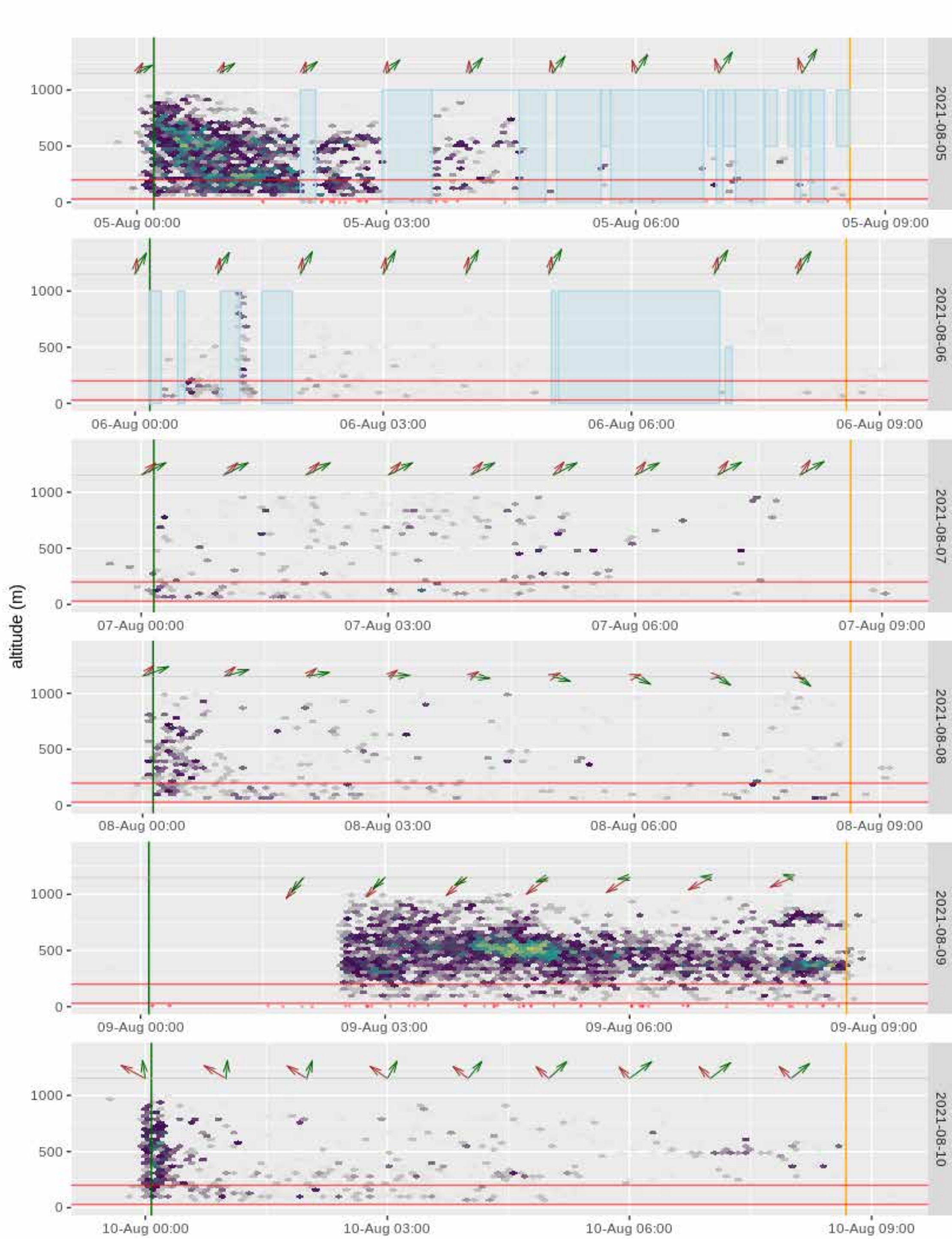
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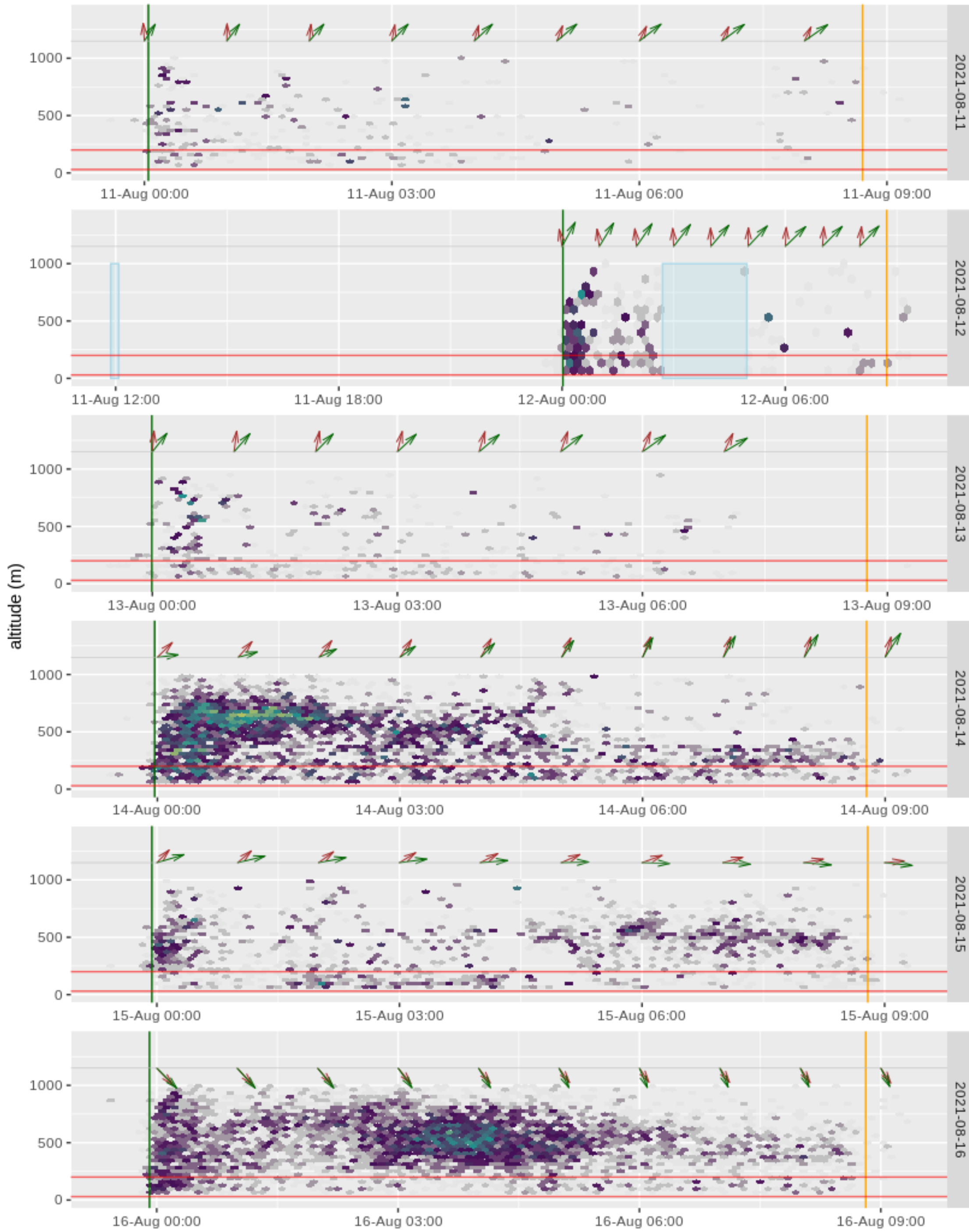
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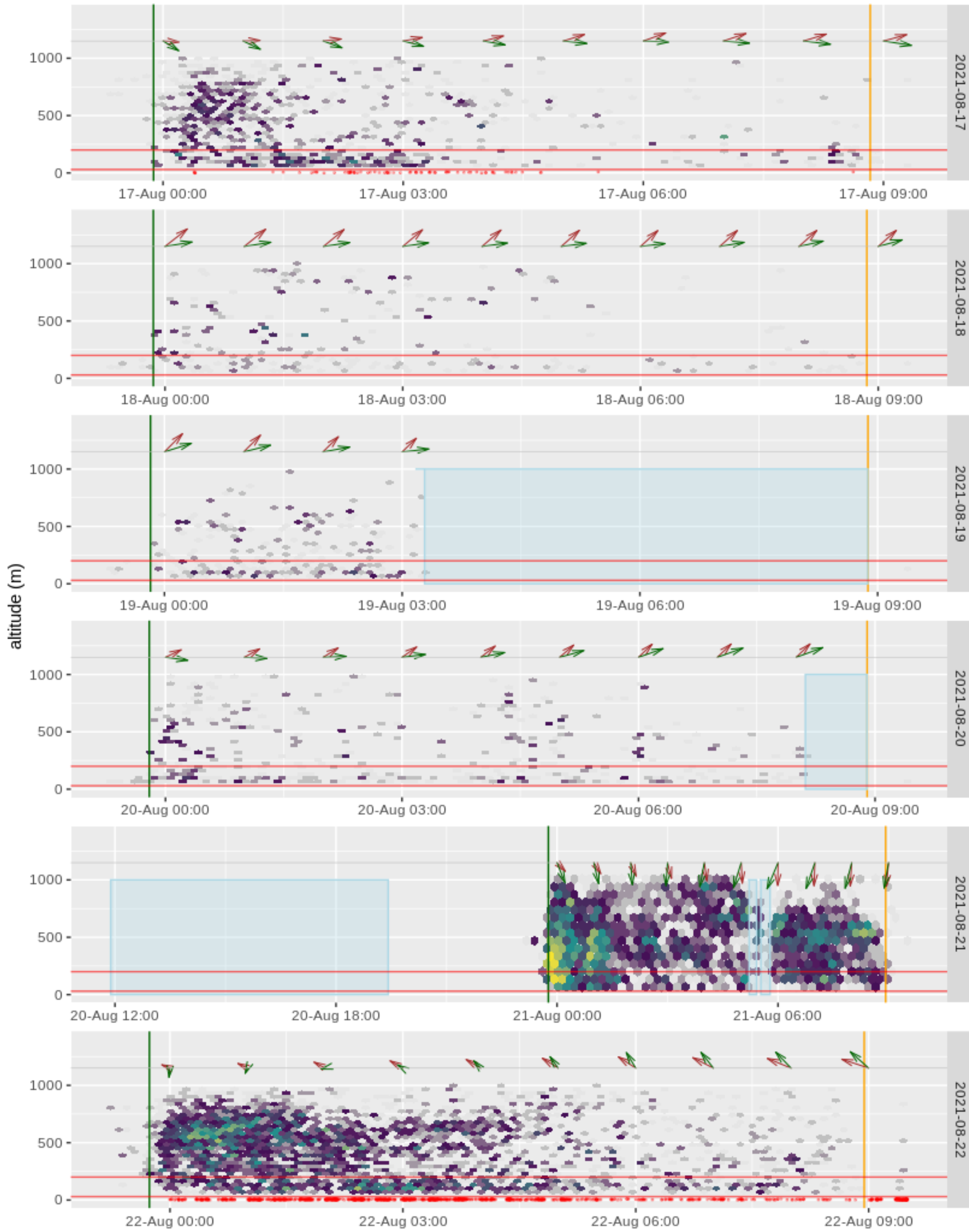
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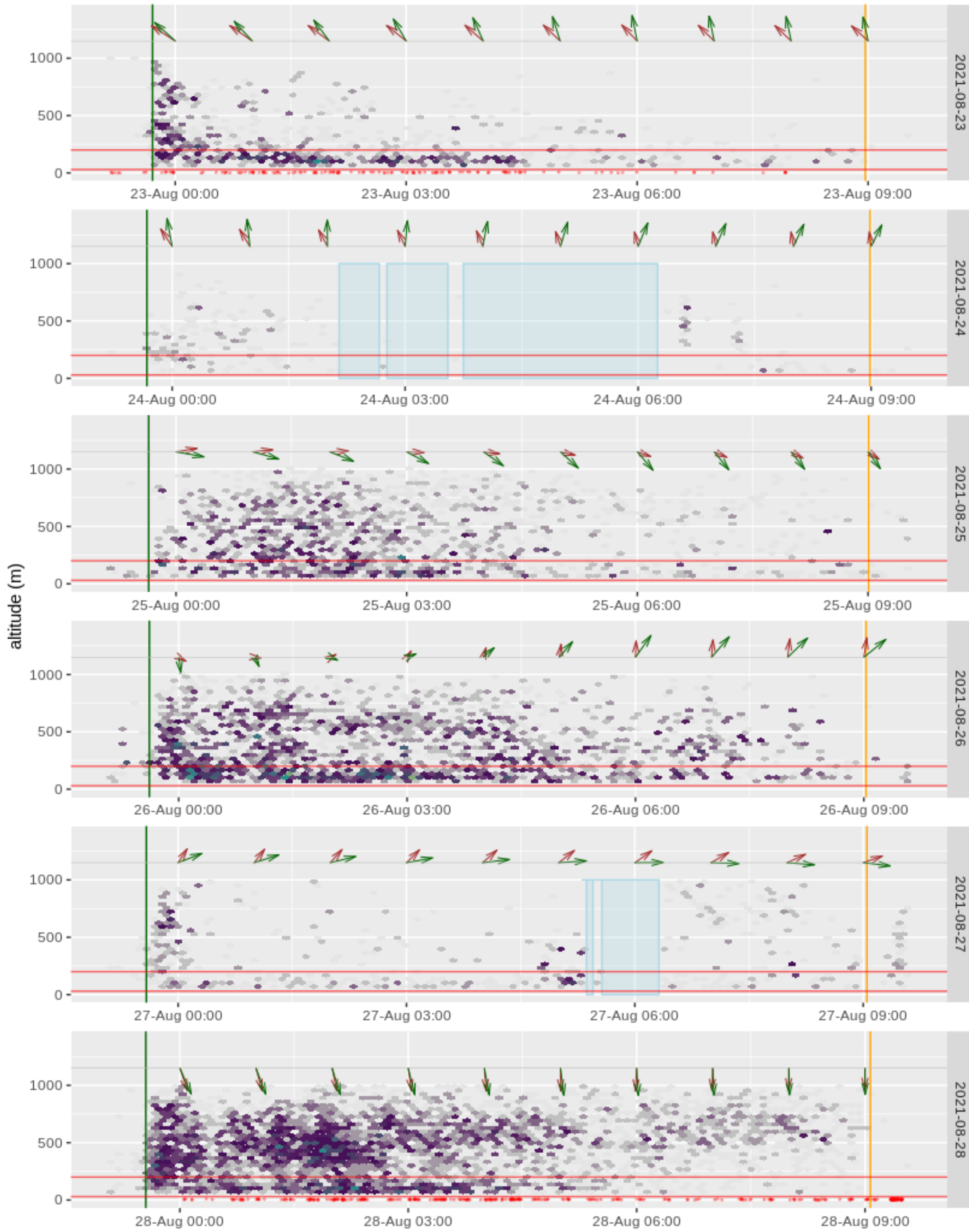
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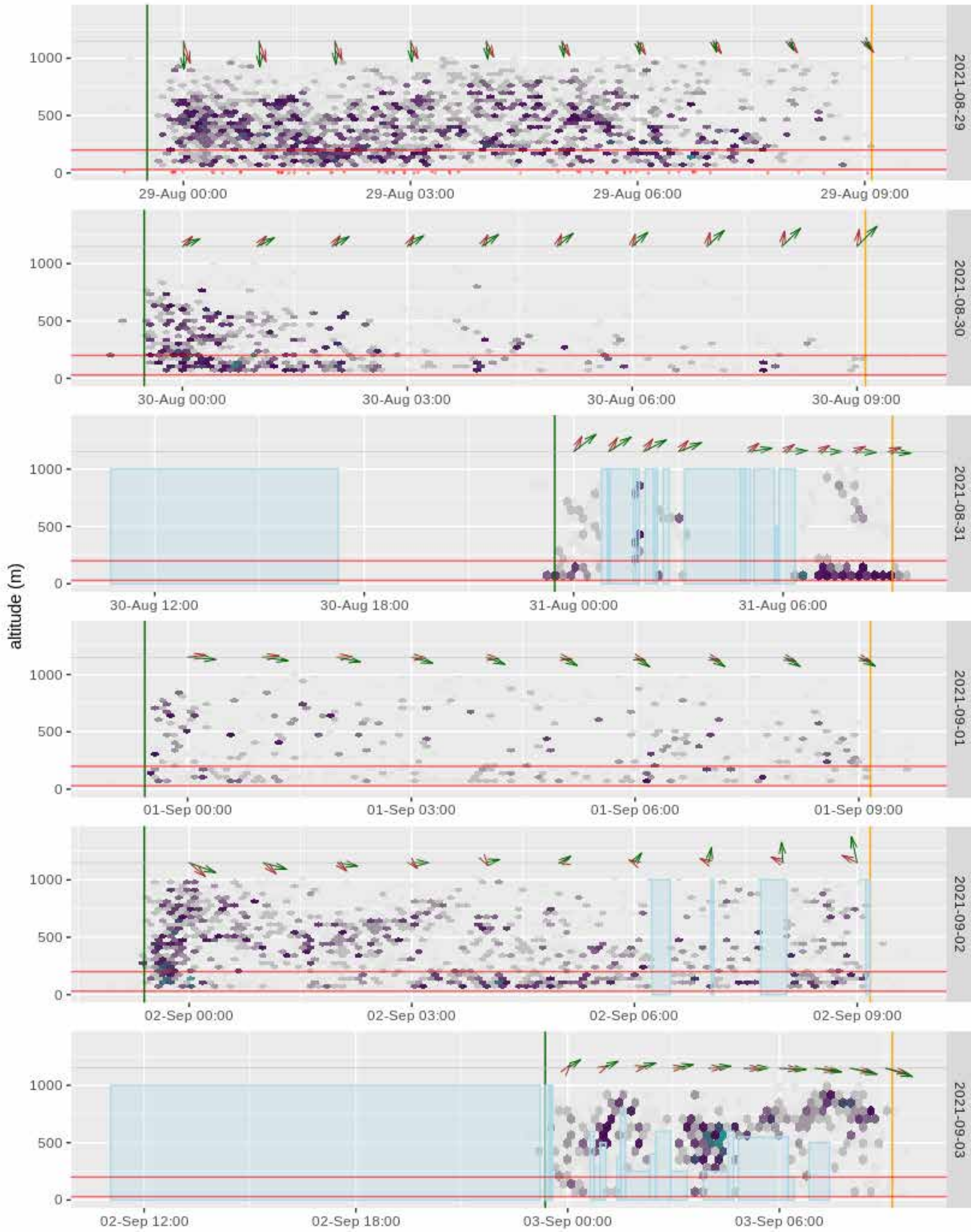
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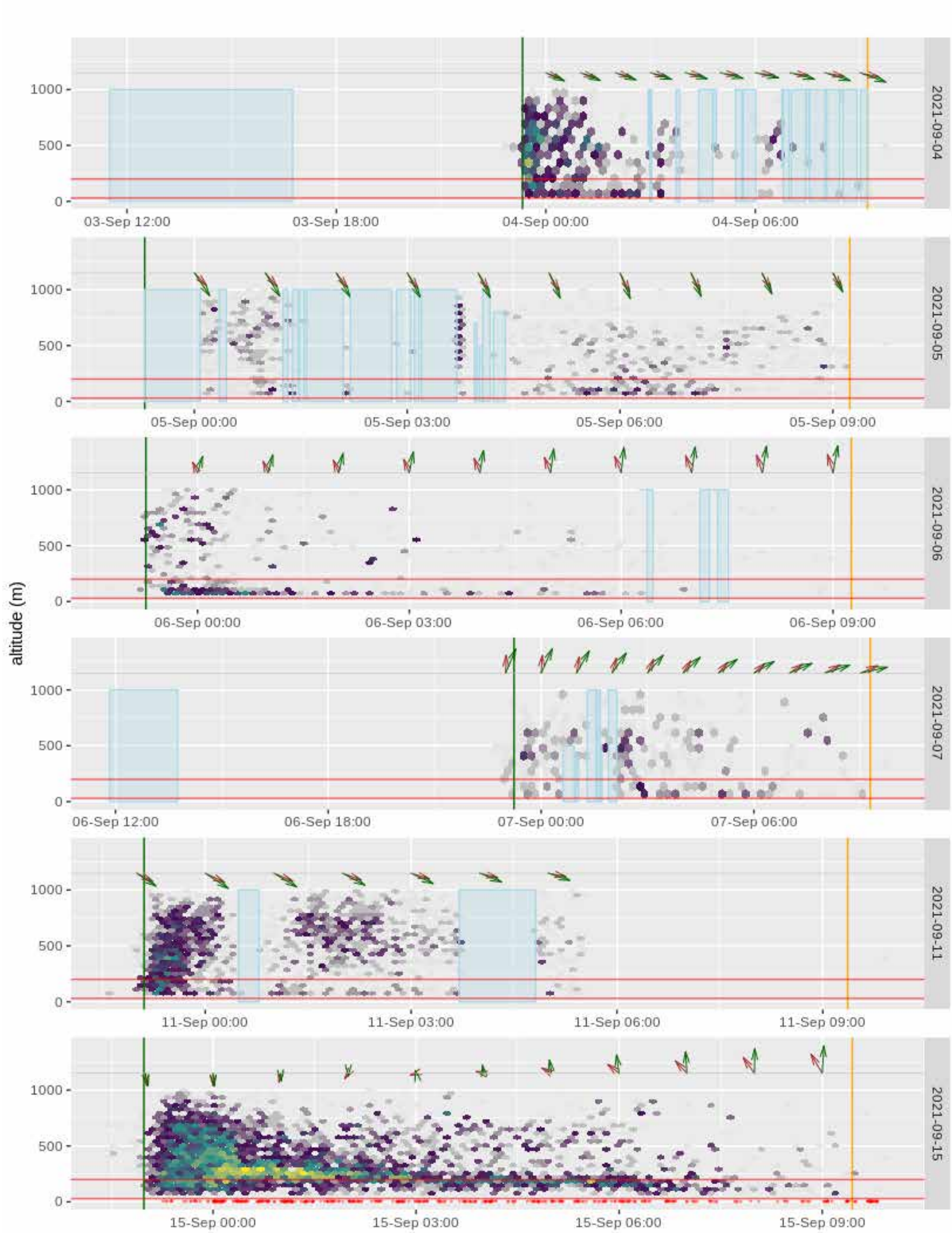
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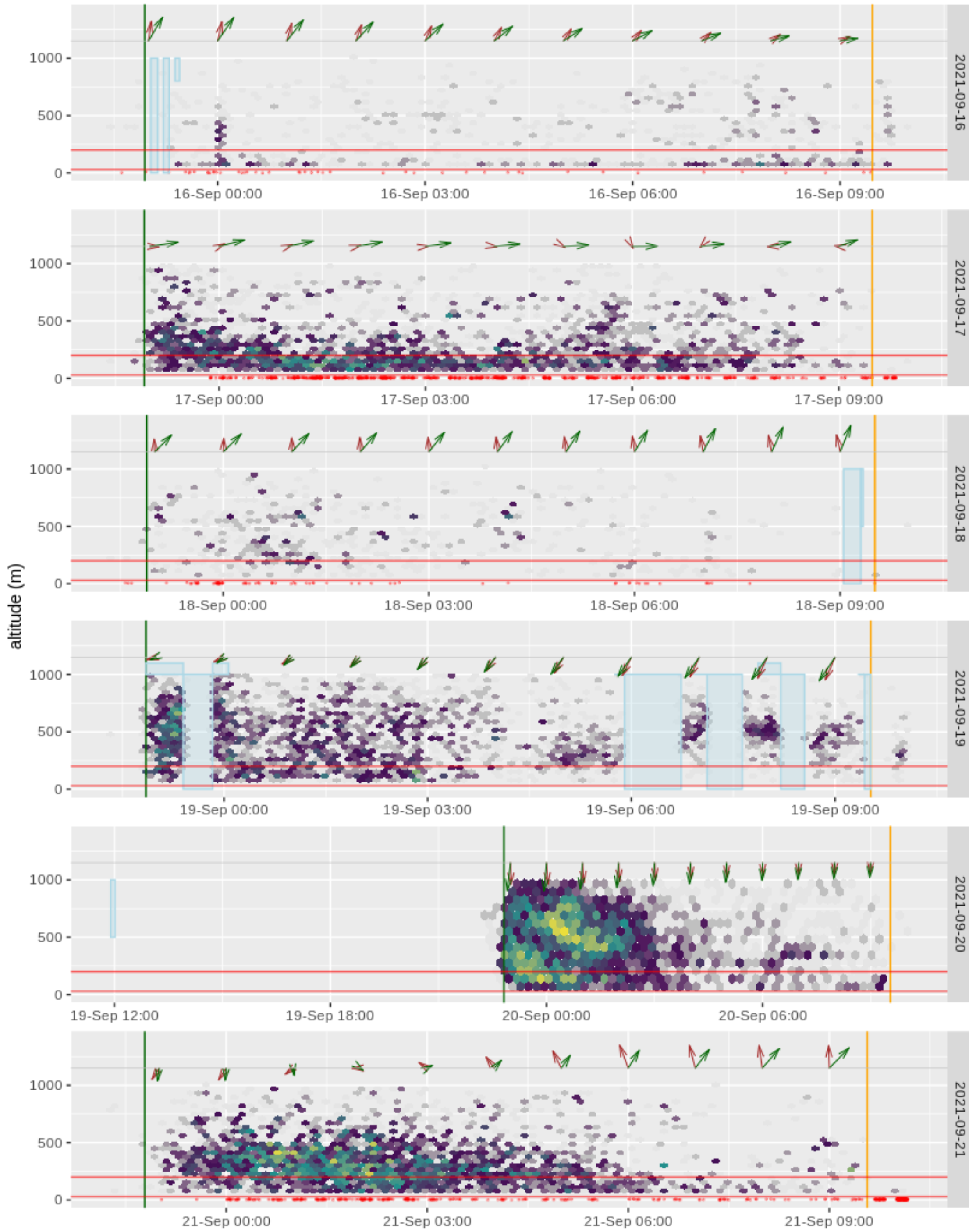
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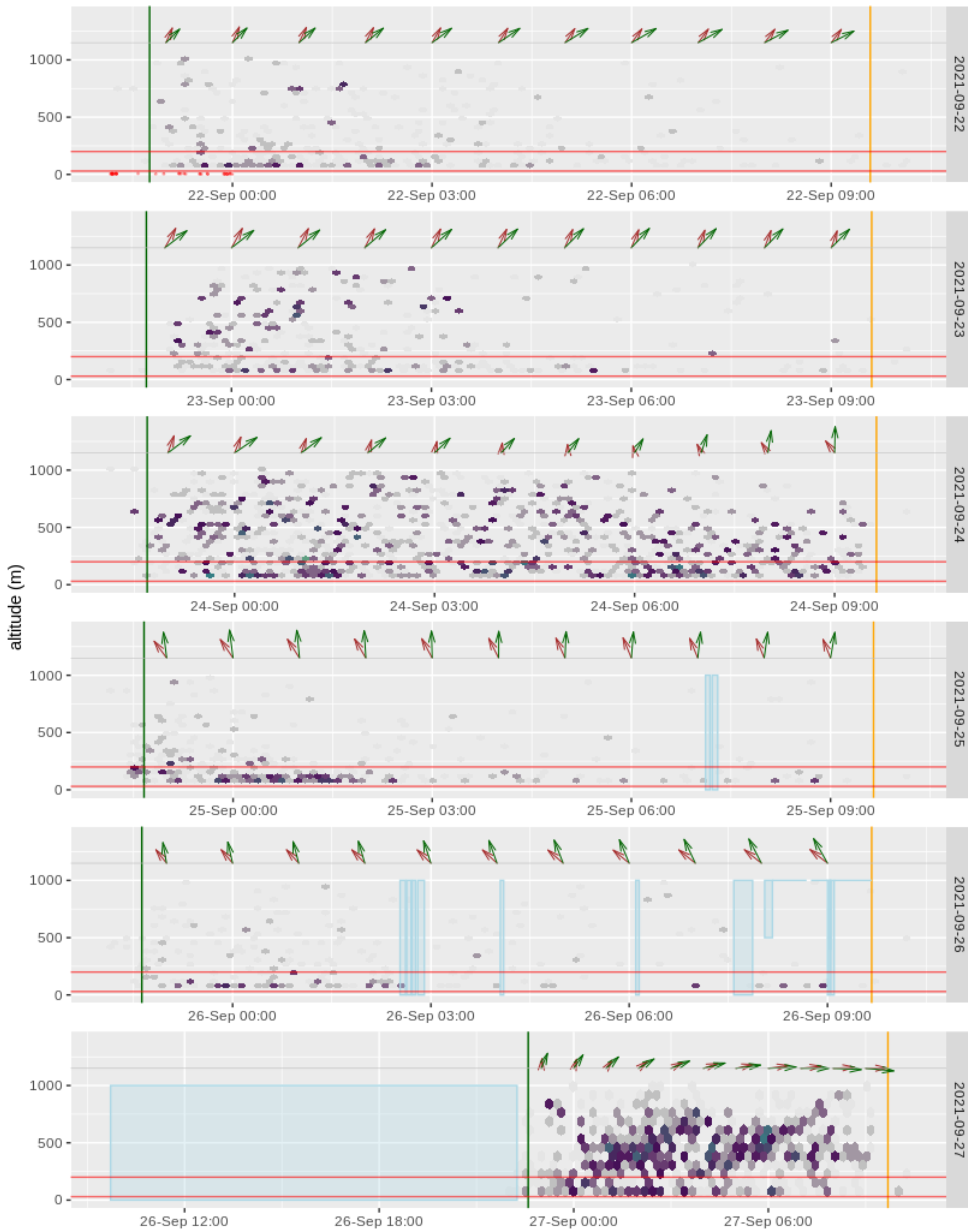
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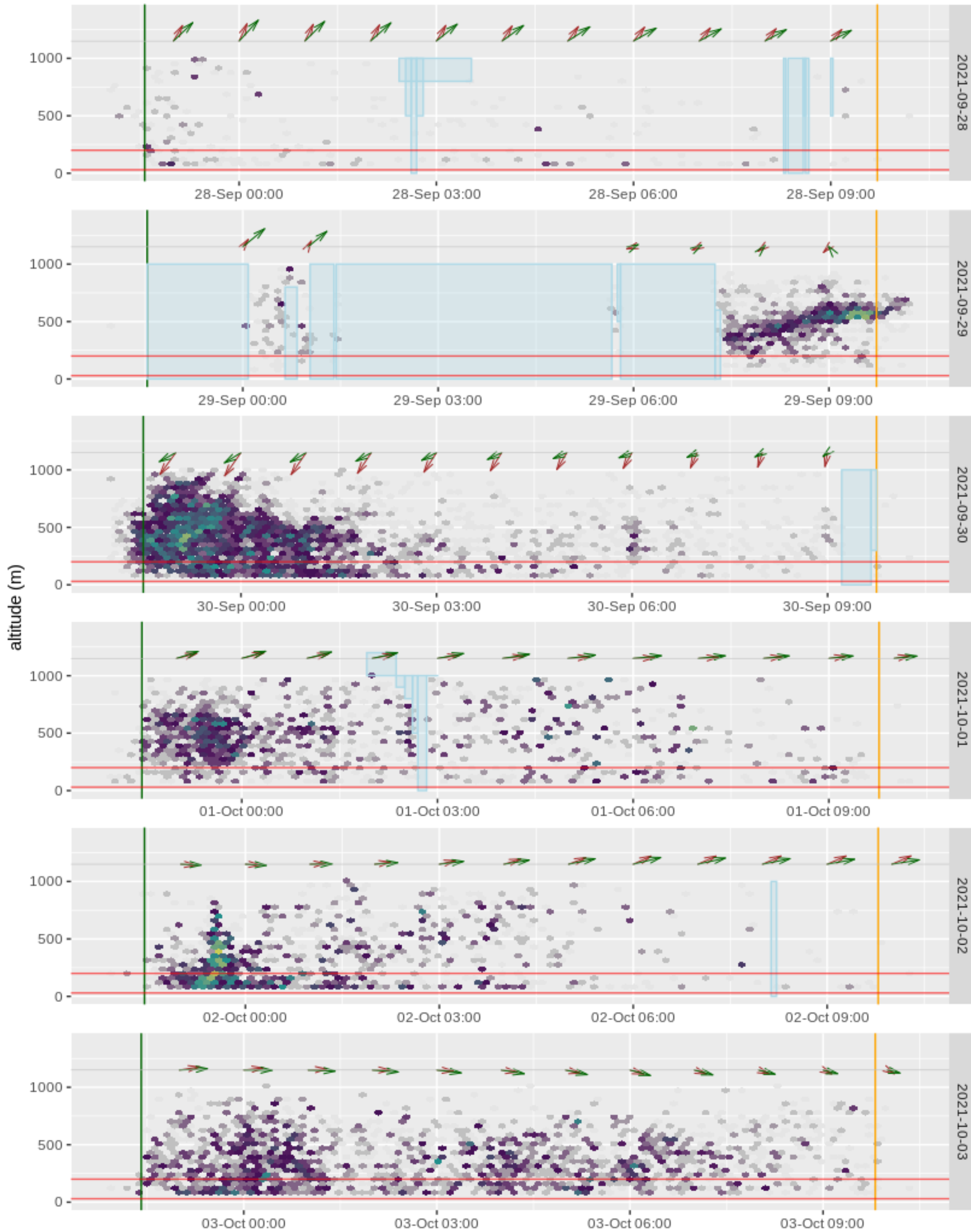
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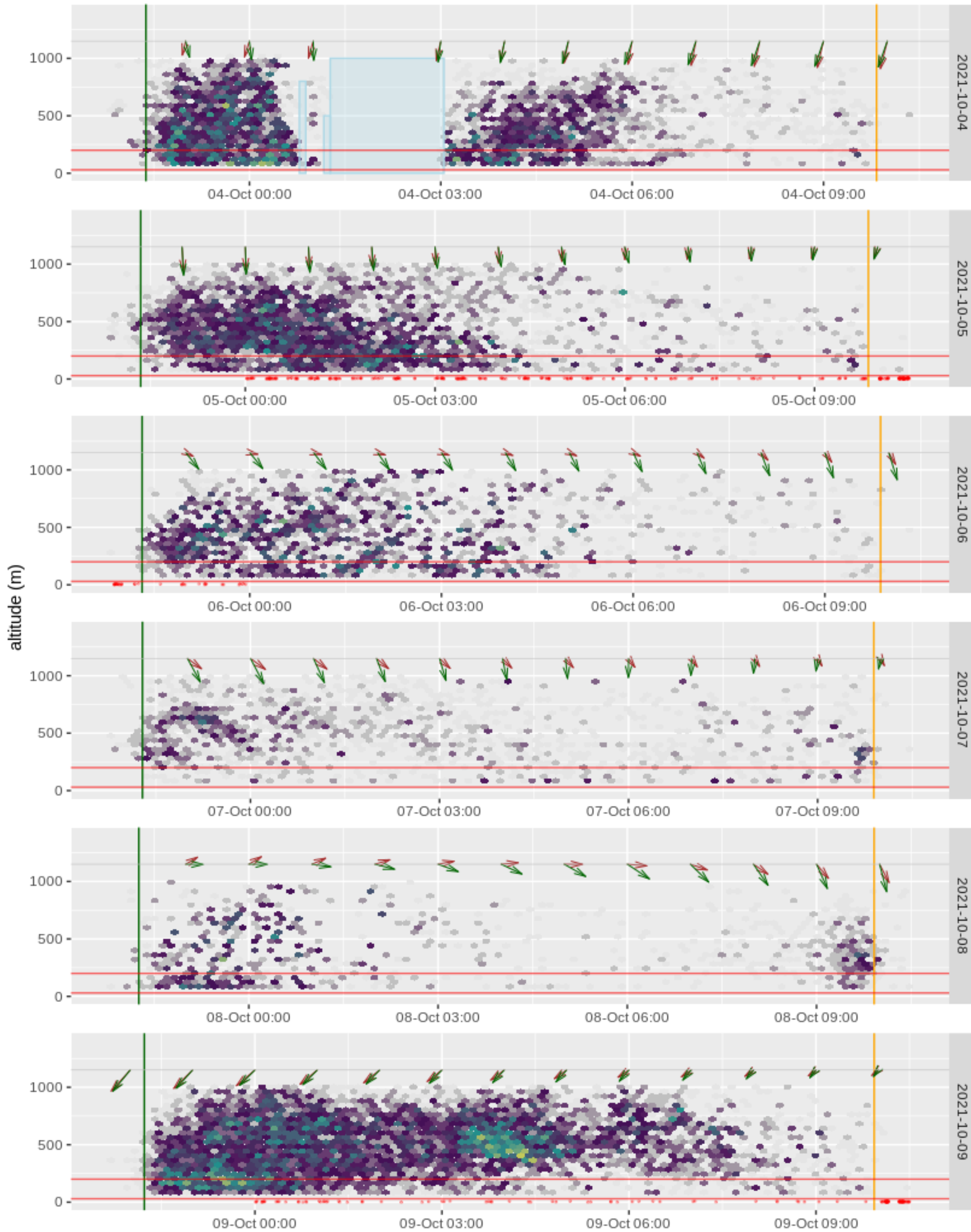
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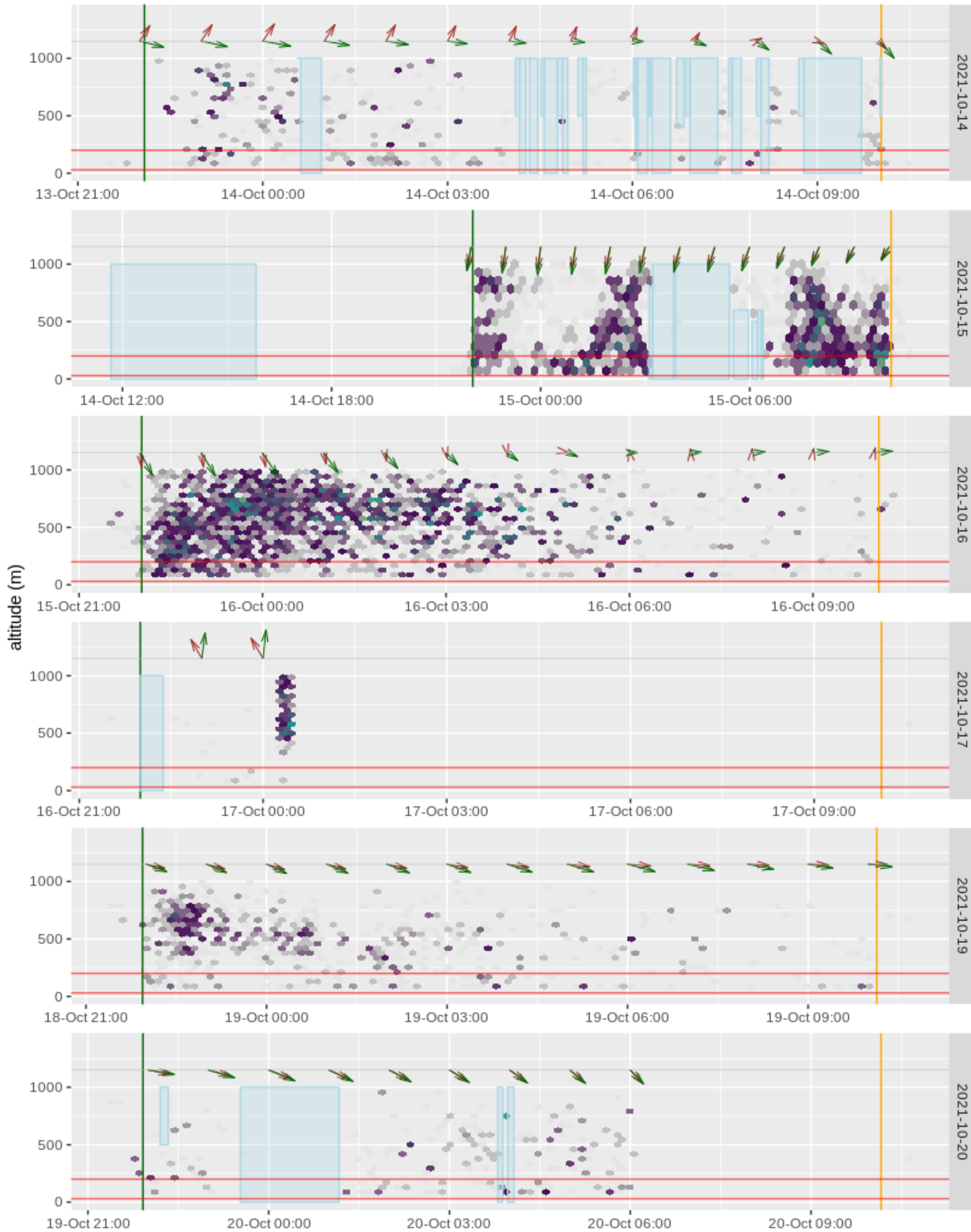
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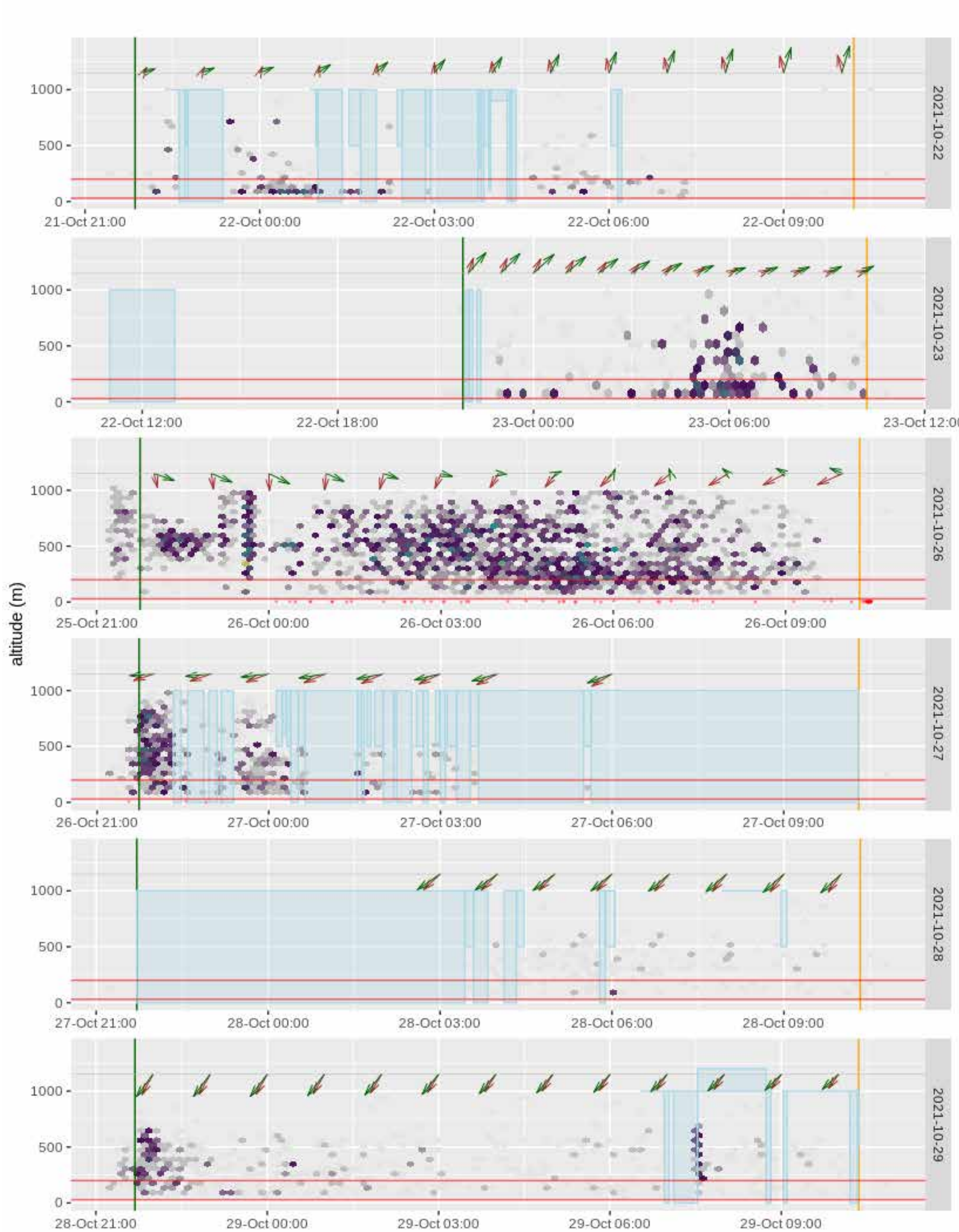
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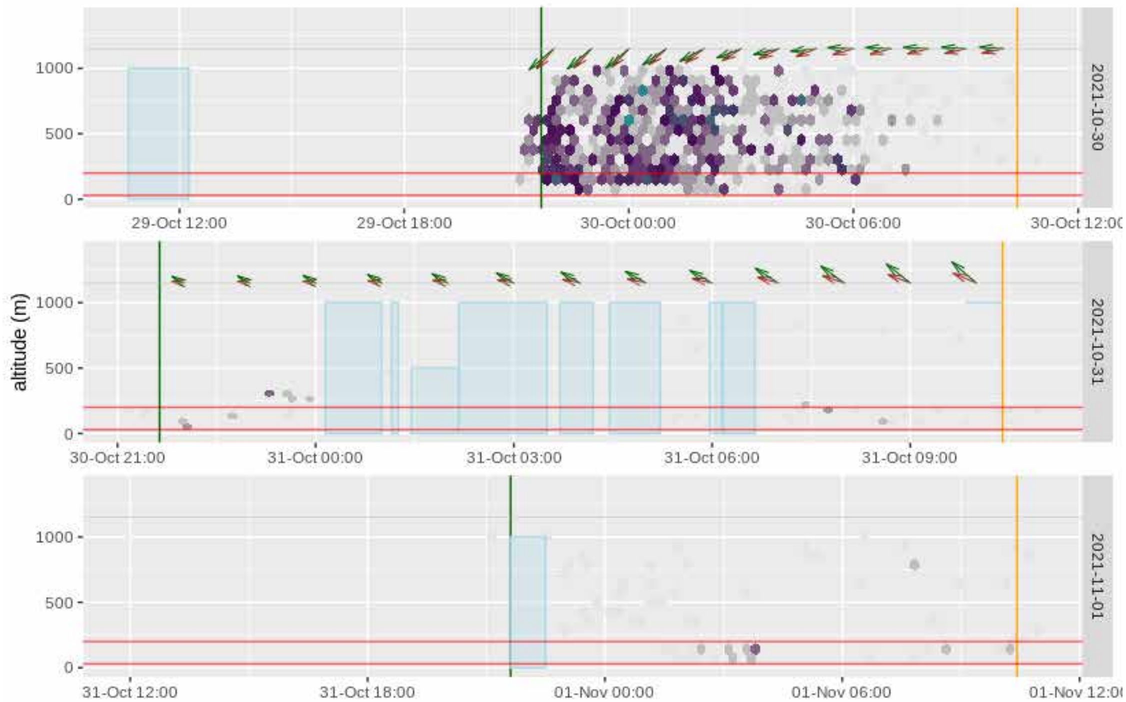
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