Windy Ridge 2023 Radar and Acoustic Monitoring Baseline

Prepared for:

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Disclaimer

This work was performed in accordance with the Contract for Services between Ausenco Sustainability ULC a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and Windy Ridge Wind Limited (Client), dated 2 March 2023 (Contract). This report has been prepared by Ausenco, based on fieldwork conducted by Ausenco, for sole benefit and use by Windy Ridge Wind Limited In performing this work, Ausenco 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.

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List of Acronyms and Abbreviations

Acronym / Abbreviation	Definition
AI	Artificial Intelligence
agl	above ground level
Ausenco	Ausenco Sustainability ULC
COSIWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
EA	Class I Environmental Assessment
ECCC	Environment and Climate Change Canada
FLAC	Free Lossless Audio Codec
GB	Gigabyte
IAA	Impact Assessment Agency of Canada
MBCA	*Migratory Bird Convention Act*
MBR	Migratory Bird Regulations
NCEP	National Centers for Environmental Prediction
NFC	nocturnal flight call(s)
NS Environment	Nova Scotia Department of Environment and Climate Change
NSDLF	Nova Scotia Department of Lands and Forestry
rpm	revolutions per minute
RSZ	rotor-swept zone
SARA	*Species at Risk Act*
SD	Secure Digital
SSD	Solid-State Drive

List of Symbols and Units of Measure

Symbol / Unit of Measure	Definition
kHz	kilohertz
km	kilometre
kW	kilowatt
m	metre
MW	megawatt
MHz	megahertz

1.0 Introduction

Windy Ridge Wind Limited retained Ausenco Sustainability ULC (Ausenco), to conduct spring and fall radar and acoustic monitoring of nocturnal migrating birds at the proposed Windy Ridge Wind Project (the Project) in 2023. Ausenco conducted this work with the technical support of Dr. Phil Taylor of Tabanid Consulting Ltd.

This report provides a summary of the data collected during spring and fall 2023 seasons and an assessment of risk to nocturnally migrating birds at the Project as per Environment Canada recommendations (Government of Canada 2022). The primary objective of this study was to measure and describe the general patterns of nocturnally migrating birds at the Project site prior to construction. General flight patterns were evaluated by visually inspecting the total flight volumes throughout the migratory periods and comparing the flight volumes within and above the rotor-swept zone (RSZ; which is the area between lowest and highest rotor tip height). Flight volumes were also visually inspected against select weather variables, and relevant weather variables were statistically tested against flight volumes to understand if collision risk increases under certain weather conditions.

1.1 Project Details

The Project is located in the Cobequid Mountains of Colchester County in northern Nova Scotia (NS), approximately 30 kilometres (km) northwest of the Town of Truro (**Figure 1.1**). Windy Ridge Wind Limited proposes to install and operate 49 turbines, each with an individual energy capacity of 7 megawatts (MW). The total Project rated capacity will be up to a maximum of 343 MW. The turbine model selected for the Project is the Nordex N163/7.X, which has a maximum height of 199.5 metres (m) above ground level (agl), which includes a tower height of 118 m and a blade length 81.5 m.

Windy Ridge Wind Project
Nova Scotia, Canada

Turbine Locations

Legend

- Acoustic Sensor
- Alternative Turbine Location
- Turbine Location
- Radar Location
- Radar Beam

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(s) - Prince Edward Island
- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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107060-01	Production Date: Mar 20, 2024	Figure 1

Ausenco

Windy Ridge
Wind Limited

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1.2 Regulatory Context

Nova Scotia

The Nova Scotia *Environment Act* [SNS 1994-95, c 1] requires all wind energy projects that produce at least 2 MW of energy to submit a Class I Environmental Assessment (EA) to the NS Department of Environment and Climate Change (NSECC). An EA registration document must be prepared and assessed by the EA Branch of NS Environment. Avian radar study is required for projects that include turbines greater than 150 m in height (Nova Scotia Government 2021). Other relevant provincial legislation includes the Nova Scotia *Endangered Species Act* (S.N.S 1998, c.11), which protects species that may not be federally protected. The following guidance document has been used to implement the regulatory requirements into this report: *Guide to Preparing an EA Registration Document for Wind Power Projects in Nova Scotia* (NSEAB 2021).

Federal

Key federal legislation relevant to environmental aspects of wind energy development includes the *Migratory Bird Convention Act* [SC 1994, c 22] (MBCA), the Migratory Bird Regulations [SOR/2022-105] (MBR), and the *Species at Risk Act* [SC 2009, c 29] (SARA), particularly Schedule 1 of the Act (Committee on the Status of Endangered Wildlife in Canada 2021). Additional statutes under the jurisdiction of NAV Canada, Transport Canada, and Natural Resources Canada may also be relevant to wind energy development. A federal EA pursuant to the *Impact Assessment Act* [SC 2019, c. 28, s. 1] (IAA; Government of Canada 2019) is not required for land-based wind project development in Canada. Sections 42 through 45 of the Physical Activity Regulations under the IAA [SOR 2019-285] identify thresholds for renewable energy facilities. Recently, the Supreme Court of Canada found that the Physical Activity Regulations are in part unconstitutional. At the time of writing, no new projects are being assessed under IAA until new regulations are in place.

Key federal regulatory requirements relevant to environmental studies for wind energy development include *Wind Turbines and Birds: A Guidance Document for Environmental Assessment* (Government of Canada 2007a), *Recommended Protocols for Monitoring Impacts of Wind Turbines on Birds* (Government of Canada 2007b), and *CWS Atlantic Region – Wind Energy & Birds Environmental Assessment Guidance Update* (Government of Canada 2022). The latter document was prepared by ECCC-CWS Atlantic Region to provide updated standards and best approaches related to impact assessment for wind energy development in Atlantic Canada. ECCC-CWS Atlantic Region recommends using radar and acoustic monitoring during the spring and fall migration periods, in addition to standard avian surveys, for a minimum of 2 years of consecutive monitoring. These monitoring periods are designed to facilitate assessment of impacts to multiple avian species groups which use coastal regions. Although not ideal monitoring could start during construction year (Government of Canada 2022).

2.0 Methods

This study uses radar and acoustic monitoring to evaluate the numbers and species of bird that migrate through the Project area during spring and fall migration. The methods used to collect and analyse radar and acoustic data to assess risk to nocturnal avian migrants at the Project are described in the following sections.

2.1 Radar Monitoring

The purpose of radar monitoring was to characterize the volume (i.e. passage rate) and flight height of nocturnal migrants in the Project area. Radar is an acronym for radio detection and ranging which describes how objects (targets) that pass through a beam of pulsed electromagnetic energy are recorded when the energy beam reflects off the object and returns to the recording instrument. Biologists use this technology to record the presence and height of migrating birds at night, which cannot be observed with the unaided eye. Radar data are used in conjunction with acoustic data to assess the potential risk to birds interacting with an operational wind facility.

2.1.1 Radar Data Collection

Automated radar monitoring was conducted during the spring and fall migration seasons. The radar was programmed to begin operation approximately 30 minutes before sunset, which is when nocturnal migrants generally start flight (Alerstam 1990), and operation ended approximately 30 minutes after sunrise during each night to align with the acoustic recordings (see **Section 2.2.1**). Recordings were made in 10-minute increments, three times each hour, throughout the night. The location of the radar was selected based on availability of participating landowners to host the radar, access throughout the Project area, site security, and clear sight lines with minimal clutter to get a representative sample of the nocturnal migrants that pass through the project area. The radar was oriented perpendicular to the anticipated flight direction to maximize the likelihood of target detection (**Figure 1.1**).

Ausenco employed a Furuno 1962 BB marine radar operating in the microwave X-band 9410 ± 30 megahertz (MHz), 25 kilowatt (kW) with a 1.8 metre XN13A open-array antenna. This system has a beam width of approximately 22 degrees in the horizontal plane and approximately 1.35 degrees in the vertical plane. The radar was mounted on a custom support framework in a vertical orientation, which allows for a more accurate measurement of flight elevation compared to a horizontal orientation. The radar ran in a short pulse mode (2100 pulses per second) at 24 revolutions per minute (rpm). The top of the radar was oriented at 19 degrees from true north, which meant that the radar beam was projecting 289 and 109 degrees from true north. The radar signal was digitized at 4.5 m range resolution with an azimuth resolution of 1.35 degrees using a DSPNOR ScanStreamer (Bergen, Norway). Before deployment, the radar was calibrated in a horizontal orientation using targets set at a known distance.

It is important to note that the total number of targets detected includes all organisms using the airspace above the radar, which may include birds, bats, and insects. Our radar data filtering approach is not able to remove all non-bird targets, which is why this report refers to targets rather than birds when presenting radar results. Methods to identify and remove non-avian targets are described in **Section 2.1.2**.

The radar registers movement of targets from 70 m up to approximately 1000 m agl. This radar system has been an effective tool to evaluate migration activity in the Atlantic Region over the past three years. The system has been proven to provide an adequate representation of target flight volume and flight heights (Ausenco Sustainability ULC 2022; Hemmera Envirochem Inc. 2021).

Raw radar data (i.e. unprocessed radar scans) were stored locally on an SSD (Sodid-State Drive) drive during the sampling period. At the end of each field season, raw radar data were copied to external hard drives and archived. Raw radar data were processed locally throughout the sampling period. Processed data were uploaded to a remote server each hour as described below.

2.1.2 Radar Data Processing

Radar processing is a two-step process: 1) autonomous hourly processing during recording in the field and 2) secondary data cleaning after the radar data has been uploaded.

During the first step of radar data processing, radar scans are processed using standalone software that captures radar sweeps. Radar sweeps are numerical data from a single rotation of the antenna. Every hour, radar sweeps are automatically amalgamated and converted into blipmovies, which are a data format similar to a video, using the open-source software package radR (Taylor et al. 2010). The processed data include an associated SQLite database of target detections. The parameters for these locally processed data are liberal, in the sense that they include radar clutter and smaller non-bird and non-bat targets. Radar clutter is defined as surfaces or particles such as grass, trees, water, clouds, or atmospheric particles, etc. which obscure target detection.

During the second step of radar data processing, blipmovies are processed again with radR using more conservative parameters to eliminate radar clutter and non-bird targets. These parameters vary by site, so professional judgment is required to effectively filter out unwanted data while retaining a sufficiently large sampling area. The data are also filtered to include only detections within an ‘area’ that is a specific distance from the radar, thus effectively capturing the activity in a vertical column a set distance from the radar. This step helps reduce bias caused by the radar beam sampling a larger area of space at greater ranges. Finally, periods of heavy rain are filtered from the processed dataset using automated methods because targets cannot be detected in the presence of rain. Rain is readily identified by sharp changes in the presence of targets, such that very large numbers of targets occur at all altitudes, and usually appear quite suddenly. Analysts examine processed radar files to validate the presence of rain. In addition, targets below 70 m agl are filtered out because they are often masked by ground clutter and are located below the RSZ of turbines determined based on the turbine models currently proposed for the site. The remaining targets form the dataset used for further analysis and data visualization.

Representative nights with large numbers of radar and acoustic detections were selected to illustrate the different migration activity patterns observed throughout the study. The full Spring 2023 radar and acoustic dataset is provided in a visual format in **Appendix A**. The full Fall 2023 radar and acoustic dataset is provided in a visual format in **Appendix B**.

2.2 Acoustic Monitoring

Automated acoustic monitoring sensors were used to assess the composition of bird species migrating through the Project area. The acoustic sensors detect and record nocturnal flight calls (NFC) of migratory birds with a microphone as the birds fly through the microphone’s detection cone. These data are used in conjunction with the radar data to assess risk to species and species groups.

2.2.1 Acoustic Data Collection

AudioMoth™ full-spectrum acoustic recorders were deployed to detect migrating bird calls at 11 sampling locations that were easy to access and provided a good representation of the Project area (**Figure 1.1**) which had a clear view of the sky. Acoustic data collection occurred each night during the spring and fall migration seasons. Acoustic recordings were programmed to start at 30-minutes before sunset, which is when nocturnal migrants generally start flight (Alerstam 1990) and to end 30-minutes after sunrise, which prevents interference with daytime calls of non-migratory birds (Smith et al. 2014).

Recordings were made with a 10 minute on / off cycle throughout the night. Acoustic data were recorded at a sample rate of 32 kHz to allow NFC to be filtered at a frequency range of 0-16 kHz, which is the typical range of passerine NFC (Evans and O'Brien 2002). The recording units were checked approximately every 30 days to replace batteries and download data onto an external hard drive. The recording units have a maximum detection range of approximately 200 m, which is within the range of the RSZ for turbines under consideration for the Project (i.e. 40 to 200 m agl). Acoustic data are stored locally on 64 GB (Gigabyte) micro-SD (Secure Storage) cards. Data cards are retrieved monthly; a new data card is swapped in the field, and the used card is returned to the lab. All SD cards are uniquely identified with a 4-digit number which is recorded upon deployment and associated with a given recording unit and location.

When SD cards are returned to the lab, analysts copy the data stored on each card into folders on a portable drive with the same name as the SD card. These files are then bulk processed to create a set of new files that are compressed using Free Lossless Audio Codec (FLAC) format. The compressed files are also renamed using a master metadata spreadsheet, such that each file retains its original timestamp, but also includes a site name, unit number and the site's latitude and longitude. This information is used in subsequent audio manipulation.

2.2.2 Acoustic Data Processing

Bird species and species groups were identified from the acoustic recordings using an AI (Artificial Intelligence) model trained on ~12,000 0.5 sec clips of classified NFCs validated by Tabanid Consulting. The model was built using OpenSoundScape V0.90 (Lapp et al. 2023; www.opensoundscape.org). Score thresholds were determined separately for each species by calculating precision-recall curves using the yardstick package in program R (R Core Team 2021).

From these curves we determined a score threshold for each species, where the 'recall' (the proportion of calls that are truly positive that were identified as such) exceeded 0.7. For each of these thresholds, the 'precision' (the proportion of the calls classified as True that were actually true) was then calculated. For most species, precision exceeded 0.9 (that is, the model classified these calls very well). Herein, we only report on species where model precision exceeded 0.5.

The model was subsequently run across all recordings obtained from all units at the site. Model precision and recall can change when a model is presented with novel data (recordings from new locations, or using new equipment) so, we further validated the results by sampling calls for each species that exceeded the value of 2 units below the threshold calculated above. Samples were obtained using a stratified random approach, with up to 5 calls selected for each week of the year, recording unit, and score group (calculated by rounding the score to the nearest 2 units). These samples were then manually confirmed as Valid (or not) and provided a means of estimating the precision and recall for the novel data.

We then selected a new threshold for each species, as above, but with a minimum recall of 0.85, and filtered all detections of all calls from all recording units at the site that exceeded that threshold. For the most part, precision was near 1 for this set; species where precision was less than 0.5 were dropped. A full list of potential species for each species category is presented in **Table 2.1**.

Table 2.1 Nocturnal Flight Call Species Categories

Species Categories	Potential Species
Cup-Sparrows	• Chipping sparrow (*Spizella passerina*) • Field sparrow (*Spizella pusilla*) • American tree sparrow (*Spizelloides arborea*)
Fox / Song Sparrow Complex	• Fox sparrow (*Passerella iliaca*) • Song sparrow (*Melospiza melodia*)
Zeeps	• Bay-breasted warbler (*Setophaga castanea*) • Blackburnian warbler (*Setophaga fusca*) • Blackpoll warbler (*Setophaga striata*) • Cape may warbler (*Setophaga tigrina*) • Magnolia warbler (*Setophaga magnolia*) • Northern waterthrush (*Parkesia noveboracensis*) • Yellow warbler (*Setophaga petechia*)
Single-banded downsweep	• Pine warbler (*Setophaga pinus*) • Northern parula (*Setophaga americana*) • Yellow-throated warbler (*Setophaga dominica*) (very rare) • Prairie warbler (*Setophaga discolor*) (very rare)
Double-up	• Black-throated green warbler (*Setophaga virens*) • Tennessee warbler (*Leiothlypis peregrina*) • Nashville warbler (*Leiothlypis ruficapilla*) • Orange-crowned warbler (*Leiothlypis celata*)
Thrushes – group 1	• Hermit thrush (*Catharus guttatus*) • American robin (*Turdus migratorius*) • Grey-cheeked thrush (*Catharus minimus*) (very rare) • Bicknell's thrush (*Catharus bicknelli*) (very rare) • Eastern bluebird (*Sialia sialis*), (very rare) • Wood thrush (*Hylocichla mustelina*), (very rare)
Thrushes – group 2	• Swainson's thrush (*Catharus ustulatus*) • Veery (*Catharus fuscescens*) • Rose-breasted grosbeak (*Pheucticus ludovicianus*)(very rare) • Scarlet tanager (*Piranga olivacea*) (very rare)

Species Categories	Potential Species
Full Species	Sparrows: ▫ White-throated sparrow (*Zonotrichia albicollis*) ▫ Savannah sparrow (*Passerculus sandwichensis*) Warblers: ▫ American redstart (*Setophaga ruticilla*) ▫ Black-and-white warbler (*Mniotilta varia*) ▫ Canada warbler (*Cardellina canadensis*) ▫ Chestnut-sided warbler (*Setophaga pensylvanica*) ▫ Common yellowthroat (*Geothlypis trichas*) ▫ Mourning warbler (*Geothlypis philadelphia*) ▫ Ovenbird (*Seiurus aurocapilla*) ▫ Palm warbler (*Setophaga palmarum*) ▫ Wilson's warbler (*Cardellina pusilla*) ▫ Yellow-rumped warbler (*Setophaga coronata*) Other: ▫ Common nighthawk (*Chordeiles minor*) ▫ American woodcock (*Scolopax minor*) Poorly detected/classified: ▫ Red-breasted nuthatch (*Sitta canadensis*) ▫ Pine siskin (*Spinus pinus*) ▫ Golden-crowned kinglet (*Regulus satrapa*)

For auditory and visual examples of these calls for each species group, see Rhinehart (2022).

2.3 Weather Data

Weather may influence migration patterns and thus alter the degree of risk to birds flying through the Project area. Weather variables were collected to assess the effects of weather on flight volumes and the proportion of flights within RSZ. Avian migrants generally prefer to fly with positive tailwind assistance (Bagg 1950; Muller 1976; Akesson & Hedenström 2000; Peckford and Taylor 2008) and as such collision risk may be higher when strong southern winds occur during the spring migration. Rain also plays an important part in predicting migration activity. In general, flight activity is reduced during periods of rainfall (Parslow 1969; Erni et al. 2002), which is likely due to the increased energetic cost of flying in rain (Erni et al. 2002). Birds generally wait for rain to pass before continuing migration, which often leads to increased flight activity on the first day after heavy rainfall (Erni et al. 2002). In cases where birds continue flight in rain, flight heights tend to be lower in altitude which increases the risk of collision, drowning, or heat loss (Kennedy 1970; Richardson 1978). Another factor which influences migration activity is temperature. Spring migration is generally triggered by higher and rising temperatures (Muller 1976), although temperature was found to be less consistent in predictor of migration activity than wind and rain (Richardson 1990). Atmospheric pressure, humidity and cloud cover have also been argued to influence migration intensity (Muller 1976; Richardson 1978; Akesson *et al.* 2001).

The following weather variables were selected to quantify weather effects on the radar and acoustic data:

- Wind speed
- Wind direction
- Precipitation.

Weather data were acquired from the National Centers for Environmental Prediction (NCEP) and National Center for Atmospheric Research (NCAR) Reanalysis data product (NCEP-NCAR Reanalysis 1; https://psl.noaa.gov/data/gridded/data.ncep.reanalysis.html) and downloaded via the RNCEP package (Kemp et al. 2011).

2.4 Data Analysis

The two response variables in our radar data analysis are:

1. Flight volume, which is the total number of targets.
2. The proportion of targets within the RSZ, which is the ratio of number of targets within the RSZ. compared to the number of targets above the RSZ.

Flight volume is used to describe temporal trends in targets detected at the Project location, and flight elevation is used to evaluate the likelihood of flights occurring within the RSZ. Targets were divided in two groups:

1. Low risk targets were located above RSZ (i.e. above 200 m).
2. High-risk targets were located within the RSZ (i.e. between 70 and 200 m).

Targets below 70 metres were excluded from analysis because ground clutter made it impossible to reliably identify targets, as described in **Section 2.1.2**. Airspeed was calculated with the vector addition procedure called "triangle of velocities" (C.J. Pennycuick 1968), using flight direction, flight speed, wind direction and wind speed as input variables. Since the exact flight trajectory of the birds are unknown, a heading of 45 degrees was assumed for the spring migration and a heading of 225 degrees was assumed for the fall migration. Tailwind assistance is then calculated as the difference between the ground speed (speed relative to the ground) and airspeed (speed relative to the air). When a flying bird's power output remains constant, but the wind behind the bird increases, the airspeed remains unchanged, whereas the ground speed increases. This results in a positive tailwind assistance. When wind blows against a flying bird (e.g. wind from the south during fall migration), birds experience a headwind, indicated by a negative tailwind assistance.

To determine the effect of weather on flight volume and proportion of targets within RSZ, tailwind assistance plotted against the flight volume and proportion of targets within RSZ. Time of night was added as additional explanatory variable and was grouped as:

- Sunset (sunset until 2 hours after sunset)
- Sunrise (2 hour before sunrise until sunrise)
- Middle (representing the remaining hours in the night).

3.0 Results

Spring migration was observed for a total of 62 nights between April 14 and June 15, 2023, and fall migration was observed for 111 nights between July 15 through Nov 10, 2023. The late start in the spring was due to impassable snow on the roads. The radar functioned properly during all spring nights and approximately 94% of all nights during the fall. During spring migration one Audiomoth recorded successfully during all nights between April 15 and May 10, and ten Audiomoths recorded successfully during all nights between May 10 and June 14. Only one acoustic recorder was installed at the radar site in April because other sites were inaccessible due to the snow on the roads. During fall migration eleven Audiomoths successfully recorded all nights between July 14 and November 20. The following sections describe the observed flight volumes, flight patterns, and species composition.

3.1 Data Visualization

During the spring monitoring period, the highest target volumes were observed in late April and the highest proportion of flights within the RSZ was observed in early May (**Figure 3.1**).

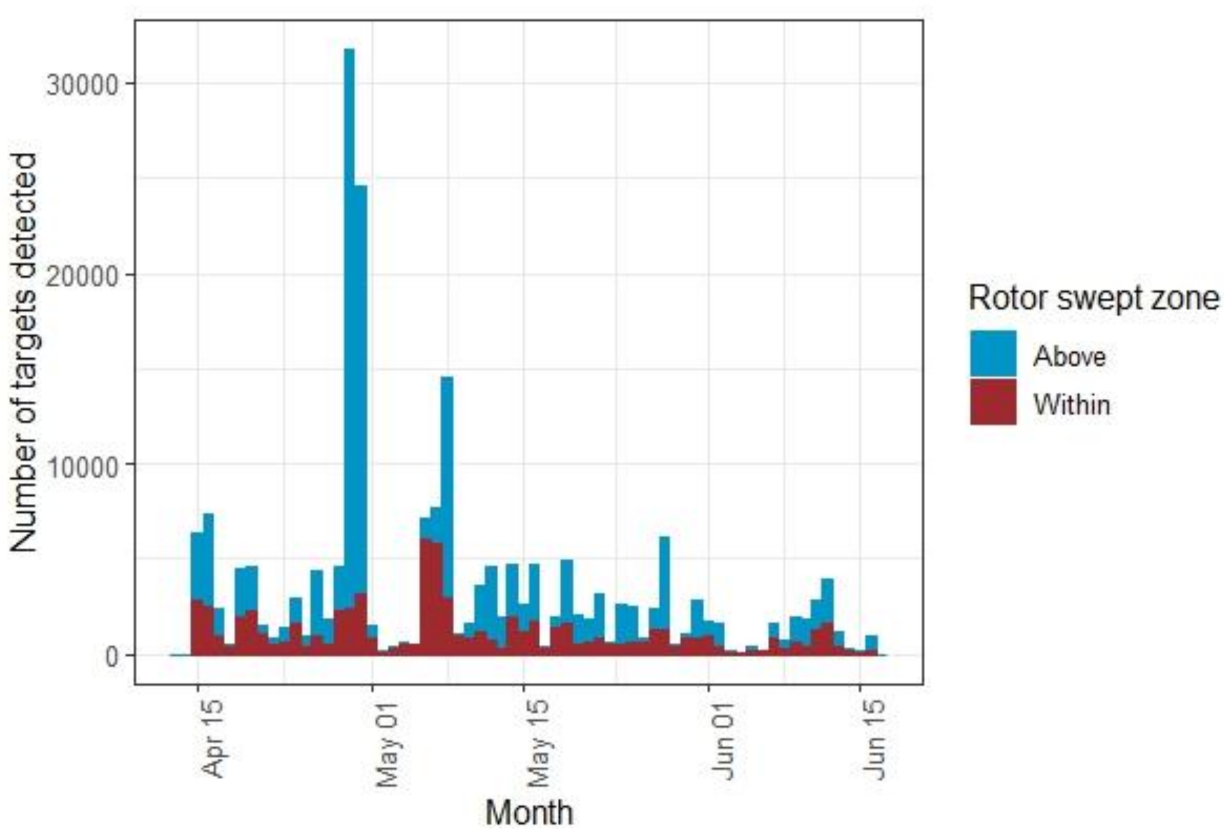


Figure 3.1 Radar detections per survey night during spring 2023

During the fall monitoring period, the highest target volumes were observed in late September and early October and the highest proportion of flights within the RSZ was observed in early October (**Figure 3.2**).

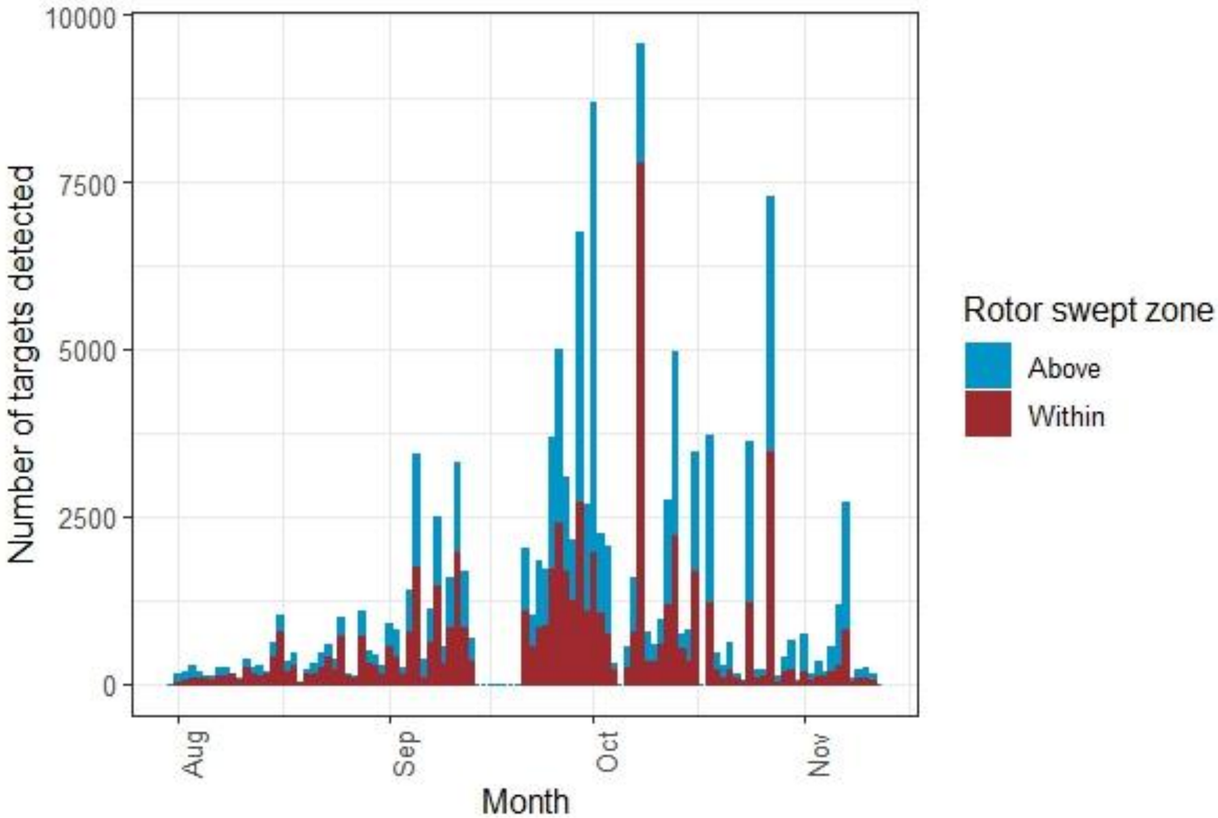
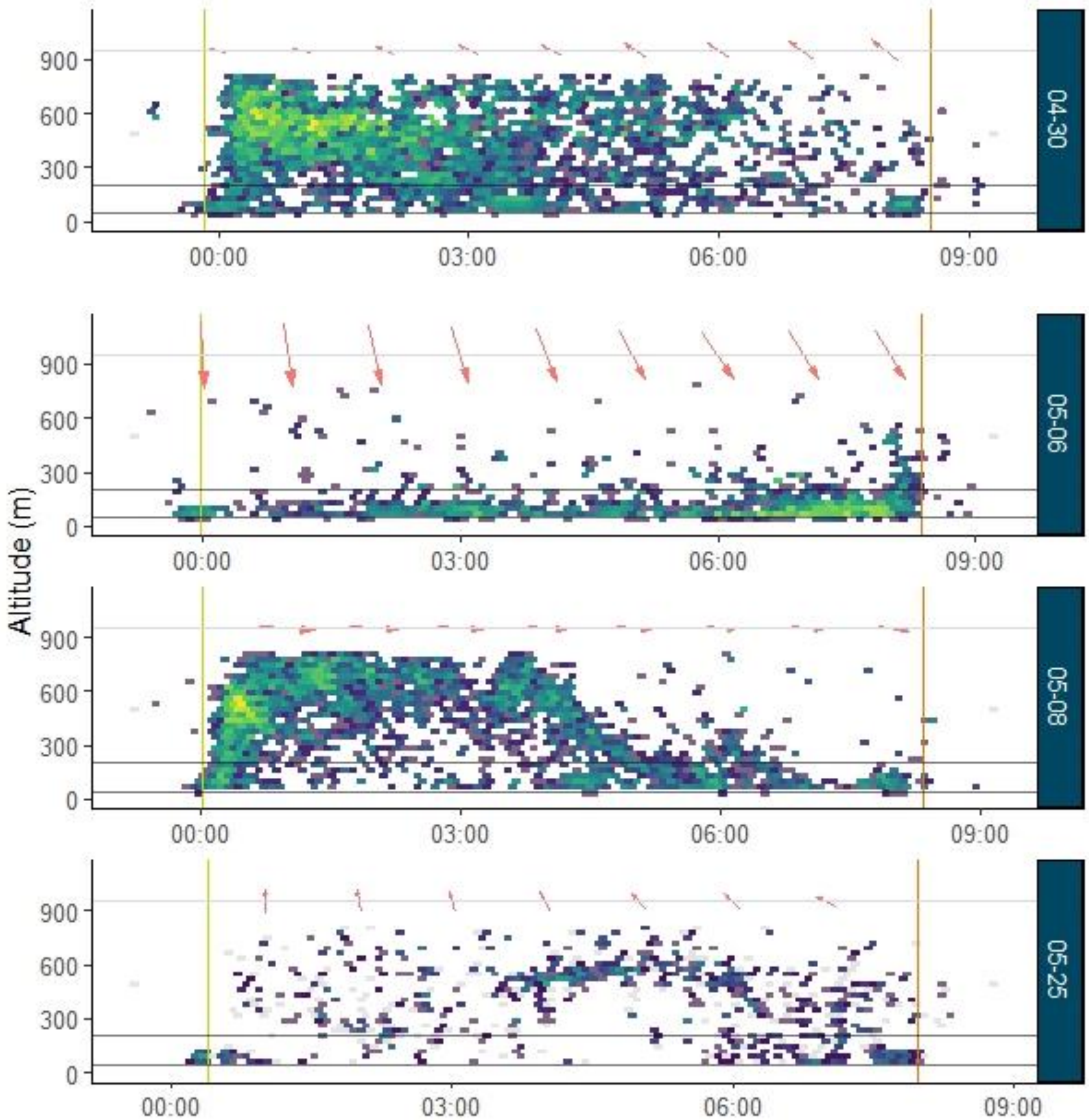


Figure 3.2 Radar detections per survey night during fall 2023

To illustrate how flight volumes change throughout the night, radar data has been visualized for a subset of high-volume nights in the spring and fall migration period. The selected spring nights include April 30, May 6, 8, 25, 28, and June 1 (**Figure 3.3**). During these selected nights, flight volumes varied widely between nights, with greater flight volumes at the start of the night on April 30, May 8, 28, and June 1, but greater volumes at the end of the night on May 6 and May 25. The flight volumes on May 6 are greatest within the RSZ, which is likely caused by strong head winds (indicated by the red arrows at the top of the graph) forcing the birds to fly lower. Target flight altitude extends to 800 m agl in the Project area throughout each night and throughout the season, suggesting that nocturnally migrating birds use a large airspace above the ground. A summary of flight volumes within the RSZ is presented below.



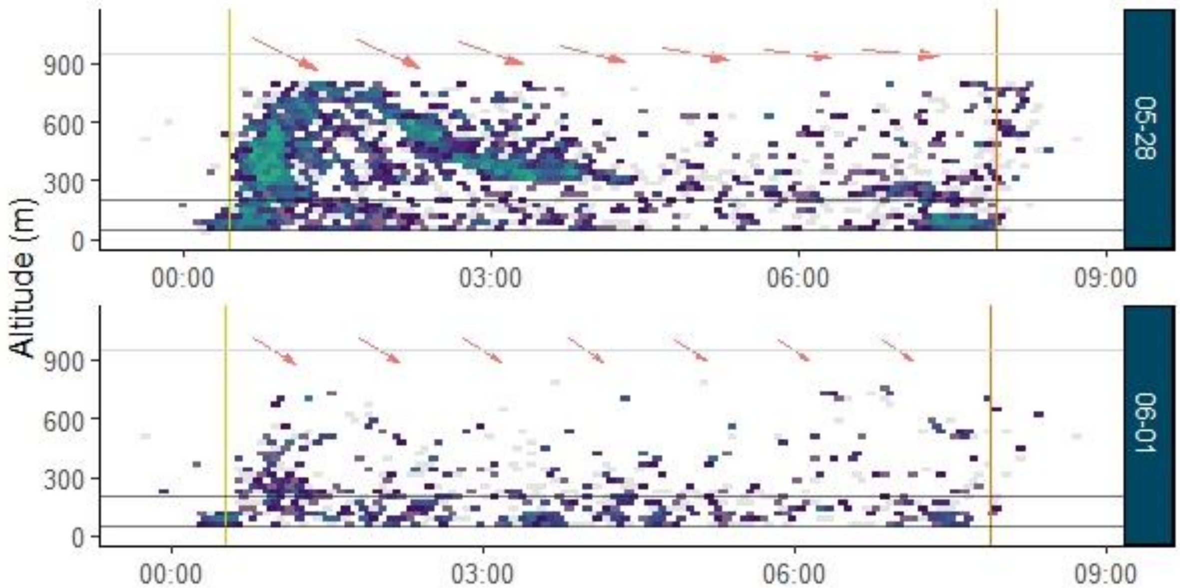
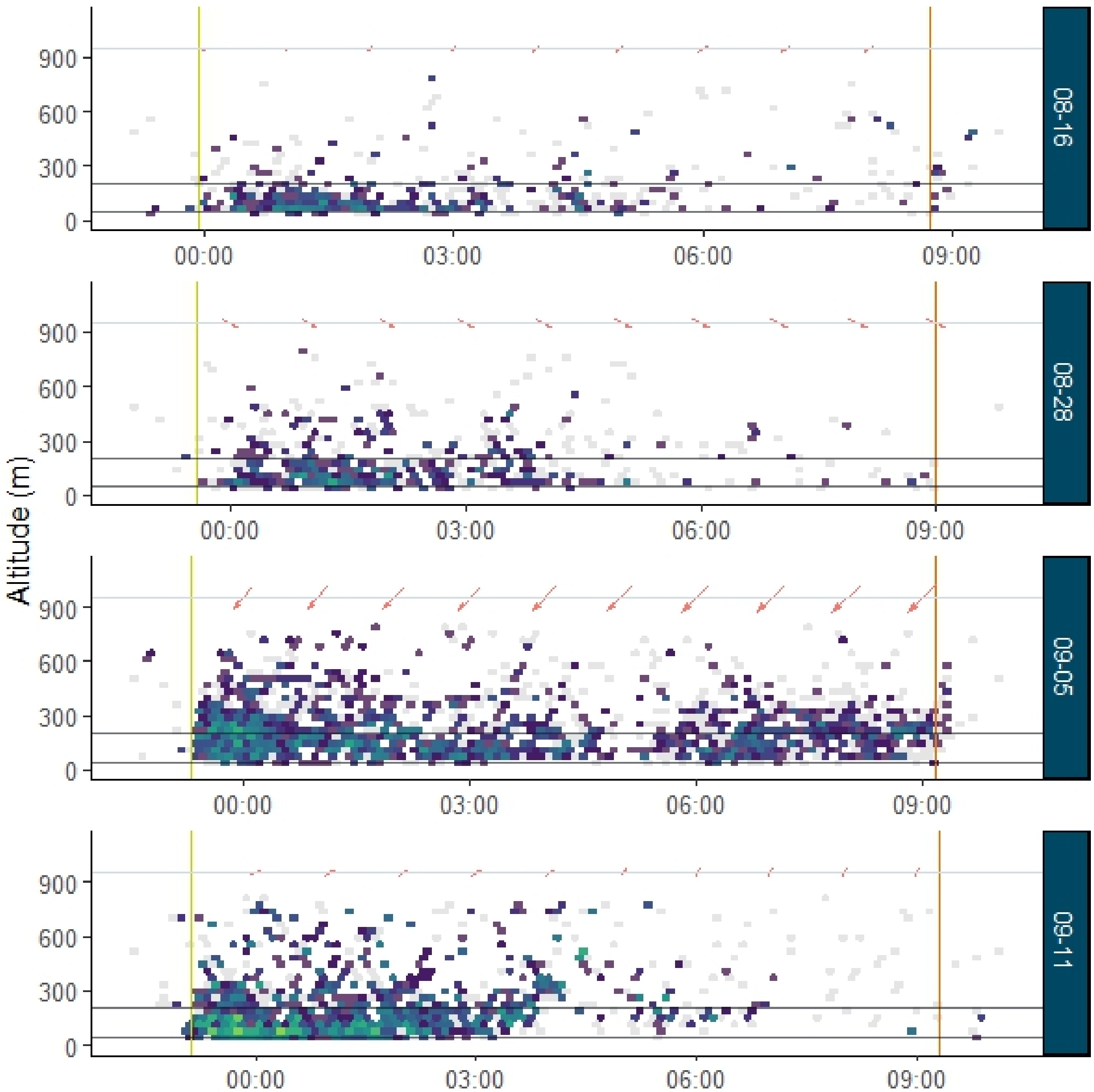


Figure 3.3 Targets detected by radar on April 30, May 6, and May 8, May 25, May 28, and June 1.

Each panel in the figures is a separate survey night. Time is indicated using Global Mean Time (GMT) on the x-axis with the beginning and end of civil twilight indicated by the vertical green and orange lines, respectively. Target altitude is on the y-axis, including the proposed RSZ (i.e. 70-200 m) indicated with black horizontal lines. Data points are radar detections scaled from light grey (few detections) through dark purple, to yellow (many detections). Wind direction (cardinal direction of red arrow) and wind strength (relative arrow size) at approximately 700 m agl is indicated for each hour at the top of each plot.

The selected fall nights include August 16, 28, September 5, 11, 26, and October 1, 8, 27 (**Figure 3.4**). Interestingly the greatest proportion of targets are detected within RSZ at most nights. The greatest flight volumes are observed on October 8 where most of the targets flew within RSZ, and the flight volumes dropped suddenly with the onset of heavy rain (indicated by the blue box). A similar drop of flight volumes with the onset of heavy rain can be seen on October 27. The high concentration of targets within RSZ on October 8 is likely caused by the strong headwinds that night, as indicated with the red arrows at the top.



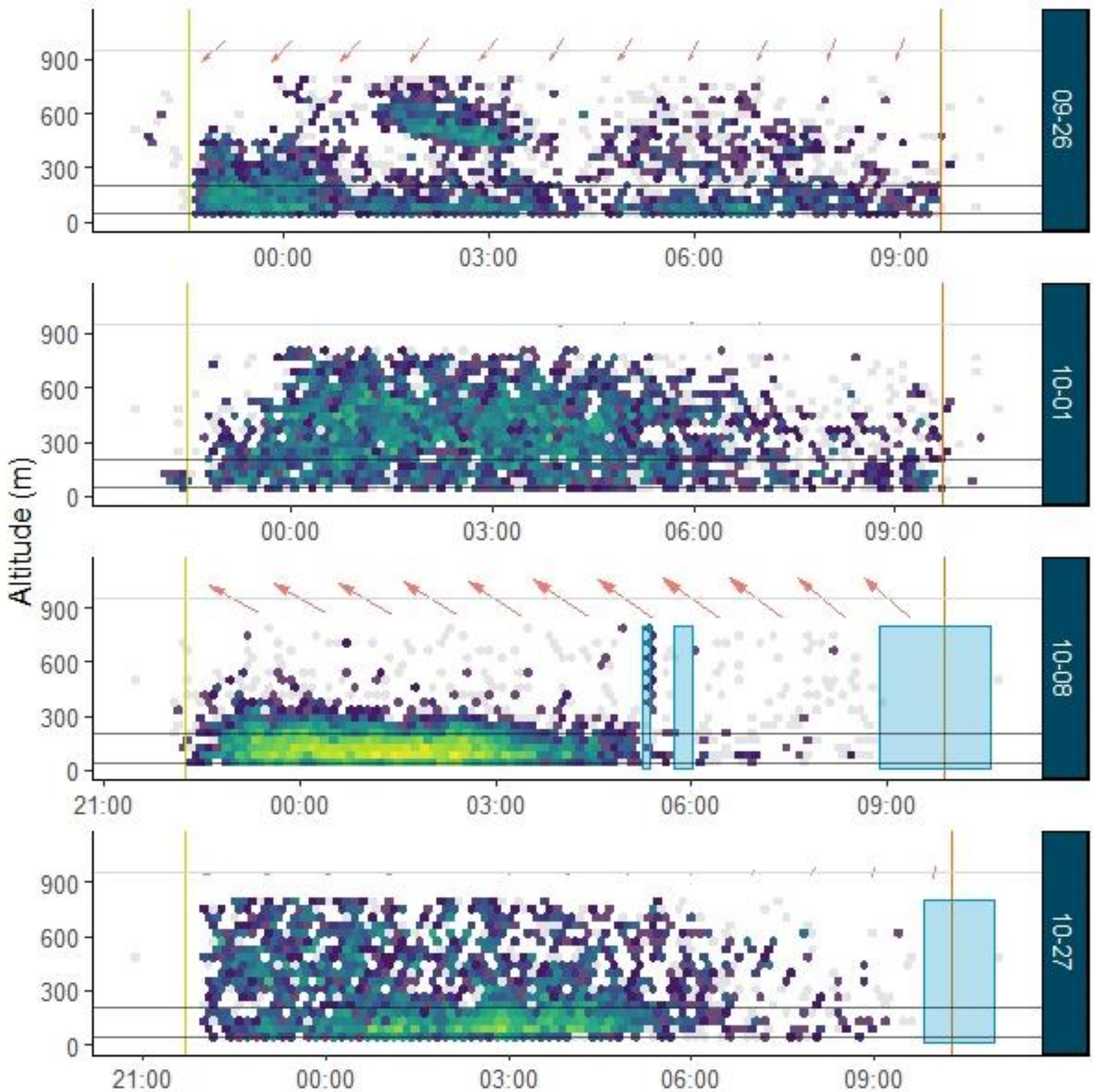


Figure 3.4 Targets detected by radar on August 16, 28, September 5, 11, 26, October 1, 8 and 27.

Each panel in the figures is a separate survey night. Time is indicated using Global Mean Time (GMT) on the x-axis with the beginning and end of civil twilight indicated by the vertical green and orange lines, respectively. Target altitude is on the y-axis, including the proposed RSZ (i.e. 70-200 m) indicated with black horizontal lines. Data points are radar detections scaled from light grey (few detections) through dark purple, to yellow (many detections). Wind direction (cardinal direction of red arrow) and wind strength (relative arrow size) at approximately 700 m agl is indicated for each hour at the top of each plot. Periods of rainfall are indicated with blue boxes.

Target flight height in the spring was observed in a bimodal pattern during spring monitoring, with the highest volume of targets detected between 70 and 150 m agl, and a second region of increased flight volumes around 500 m agl (**Figure 3.5**). Cumulatively, most targets in the spring were detected above the RSZ. During the fall migration season the greatest number of targets were detected within RSZ, and the number of targets gradually decreases with increasing altitude (**Figure 3.6**).

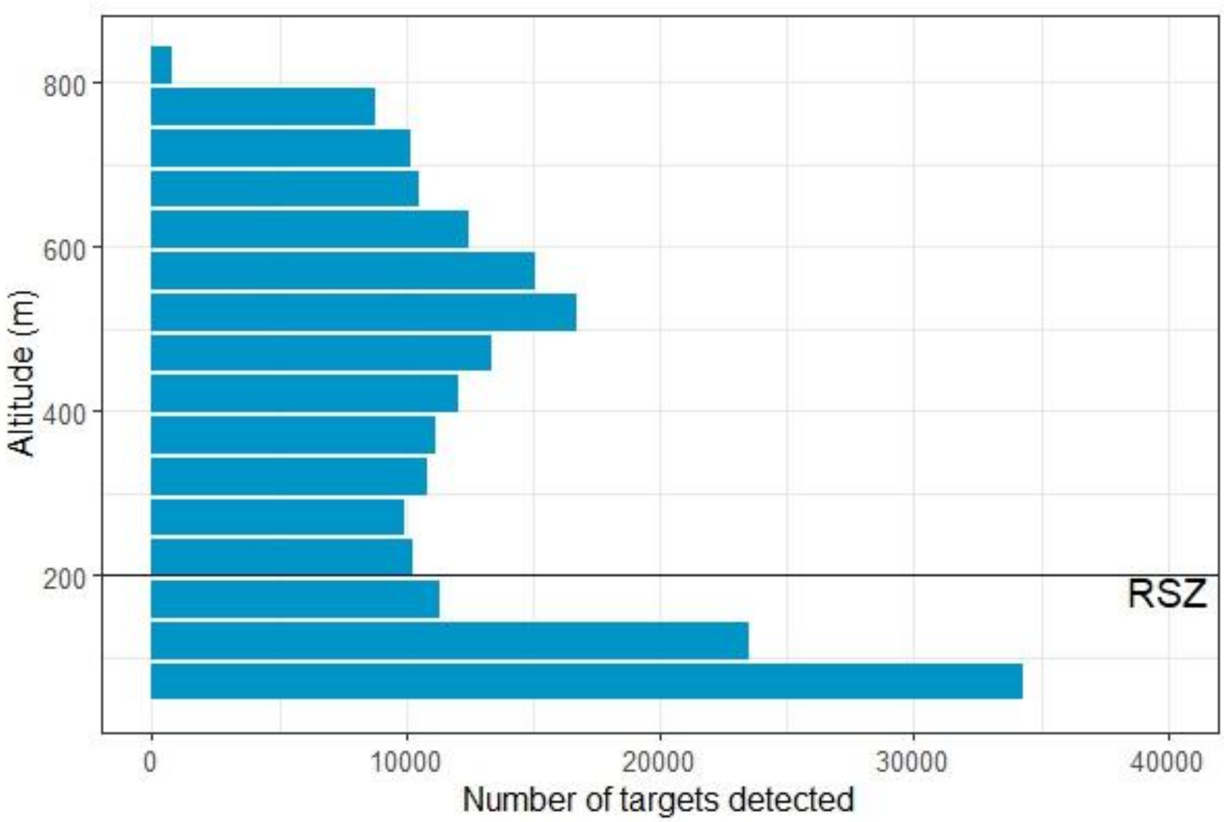


Figure 3.5 Elevational profile of targets detected in spring 2023

The x-axis shows the number of targets detected and the y-axis shows elevation bins measuring 50 m vertically, between 70 m agl and 850 m agl. The maximum rotor sweep height of approximately 200 m is indicated with a red horizontal line.

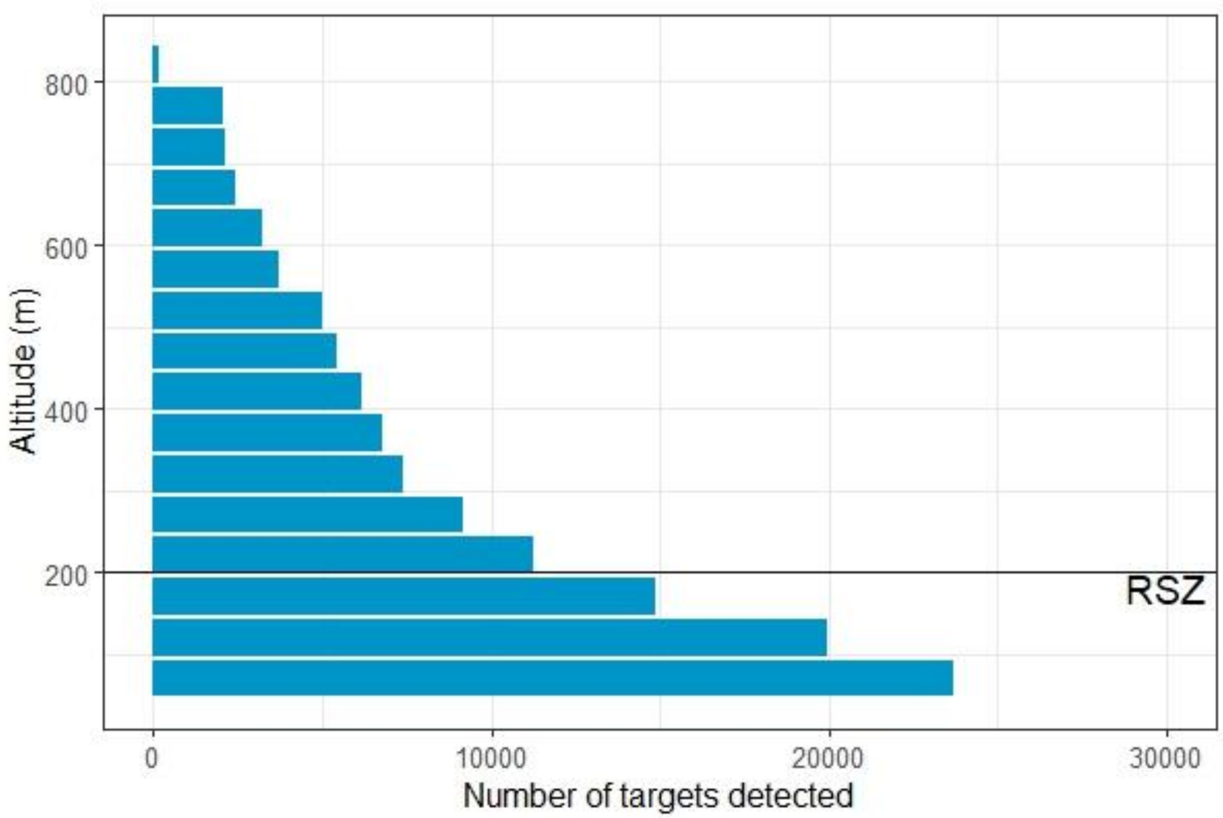


Figure 3.6 Elevational profile of targets detected in fall 2023

The x-axis shows the number of targets detected and the y-axis shows elevation bins measuring 50 m vertically, between 70 m agl and 850 m agl. The maximum rotor sweep height of approximately 200 m is indicated with a horizontal line.

The elevational profile of targets was observed to change from night to night, due to changing migratory conditions. During spring migration, the flight volume is greater above the RSZ than below during most nights, except for May 6 where flight volumes within the RSZ are much greater than above the RSZ (**Figure 3.7**). This is most likely caused by a strong headwind during the night (**Figure 3.3**).

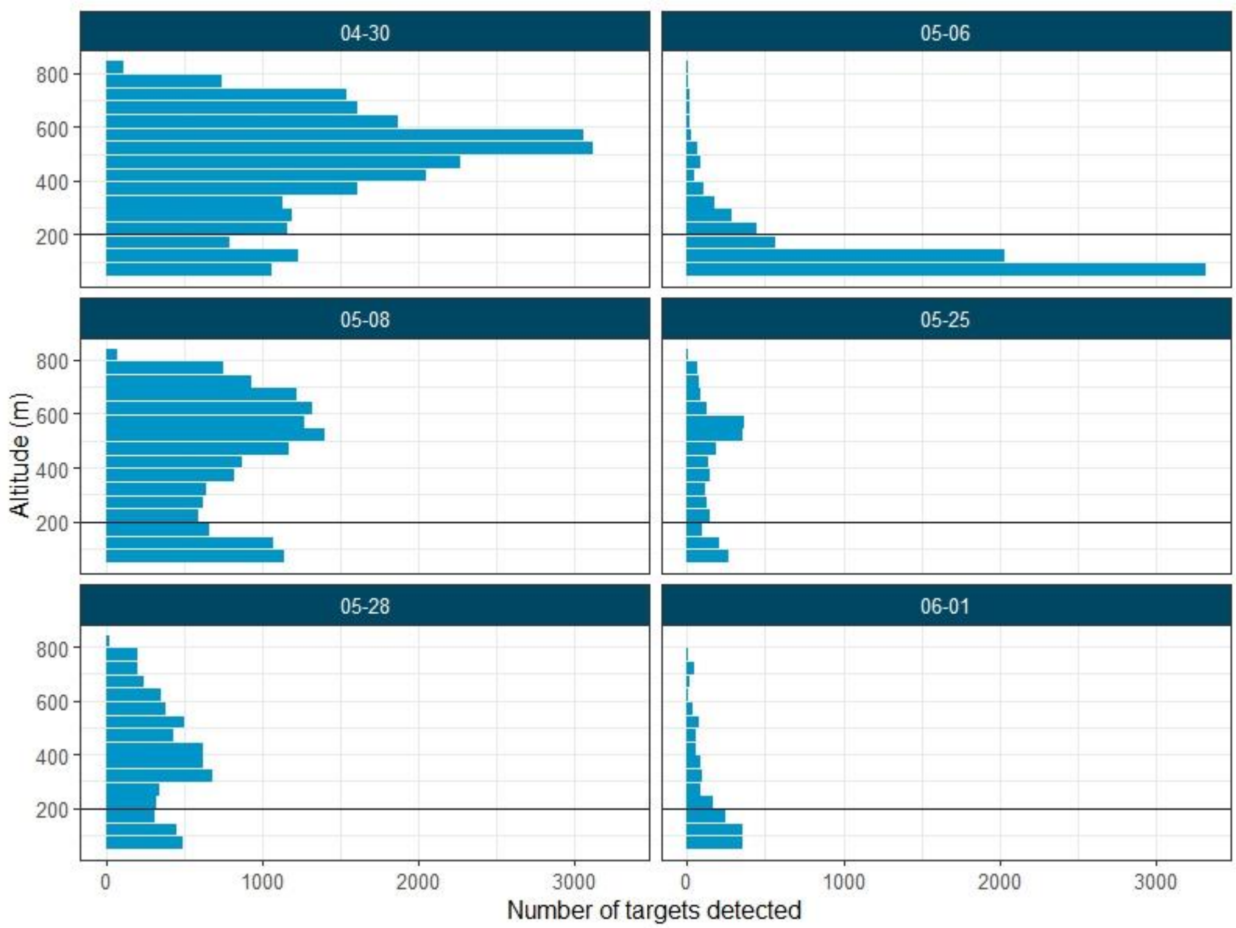


Figure 3.7 Altitude profiles of targets detected on April 30, May 6, May 8, May 25, May 28, and June 1 during spring 2023

In contrast to the spring migration (**Figure 3.7**) the flight volumes were greatest within the RSZ at most nights during the fall migration, except for October 1 (**Figure 3.8**).

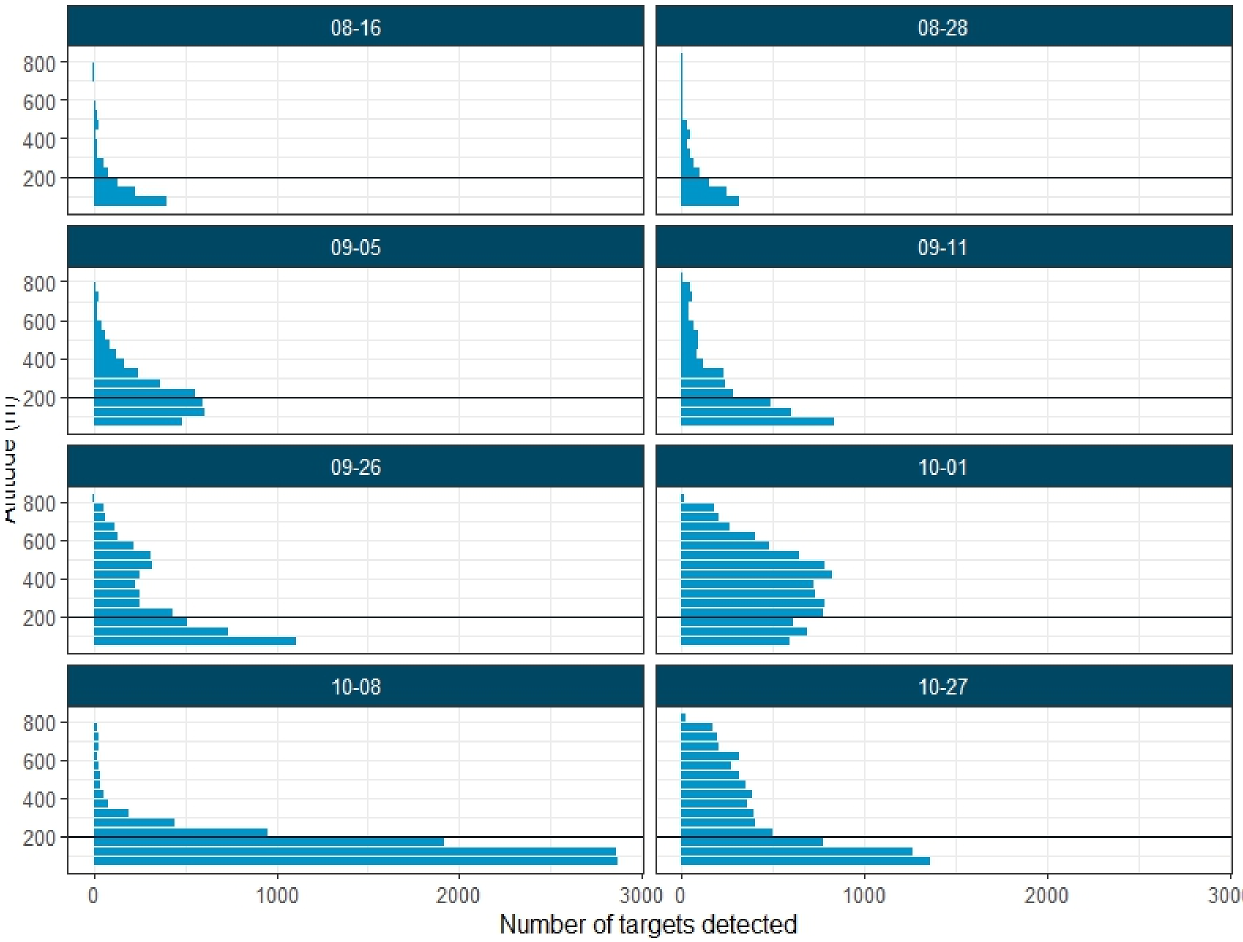


Figure 3.8 Elevational profiles of targets detected on August 16, 28, September 5, 11, 26, October 1, 8 and 27 during fall 2023

During spring migration, target detections increase steeply with tailwind assistance during the Sunset period (**Section 2.4**) and in the Middle period but remain constant during the Sunrise period (**Figure 3.9**). A similar effect from tailwind assistance can be observed in the fall migration data, with only a decrease observed during sunrise in October (**Figure 3.10**).

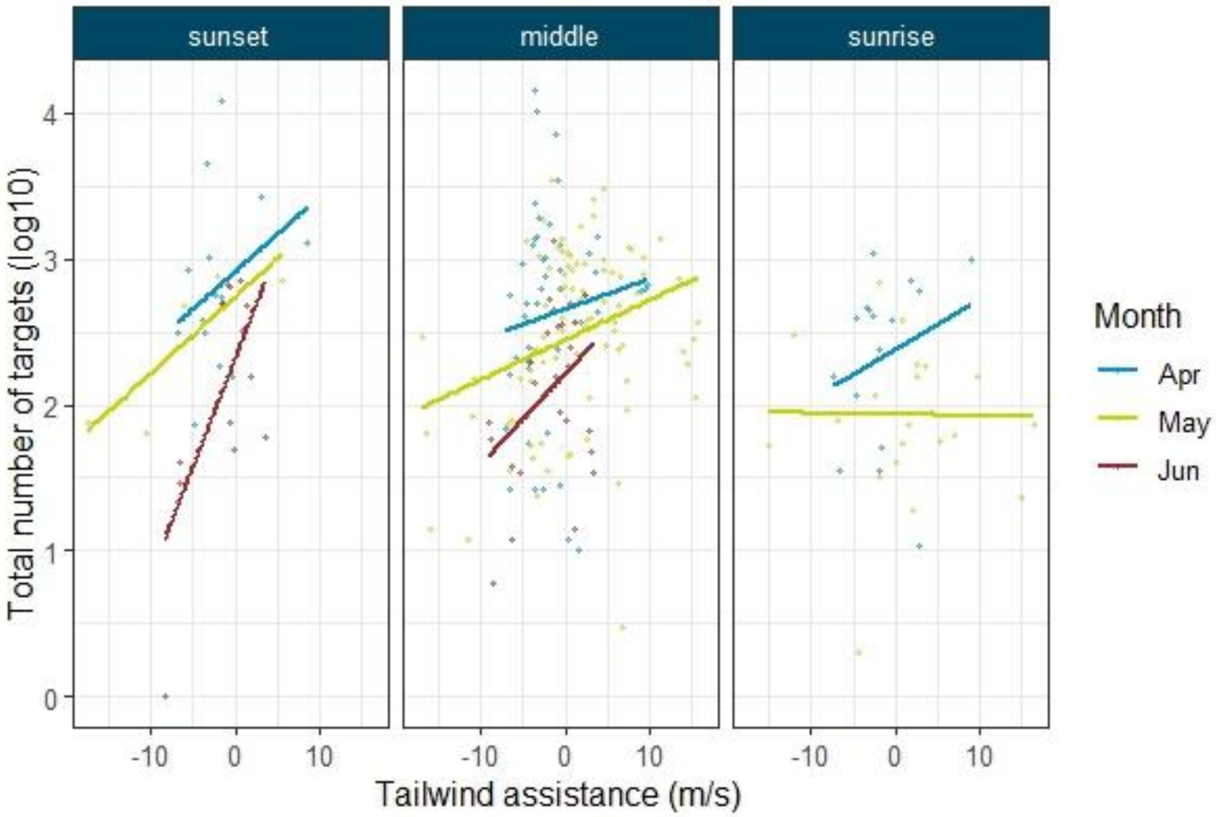


Figure 3.9 Relationship between tailwind assistance and the total number of targets across time of night and season during spring 2023.

Tailwind assistance is plotted on the x-axis, with negative numbers representing headwind and positive numbers representing tailwind. Coloured lines represent the trend between total number of detections (log10) and tailwind assistance. Horizontal lines indicate no effect from tailwind assistance on total number of targets and an inclining line means a positive effect from tailwind assistance on total number of targets.

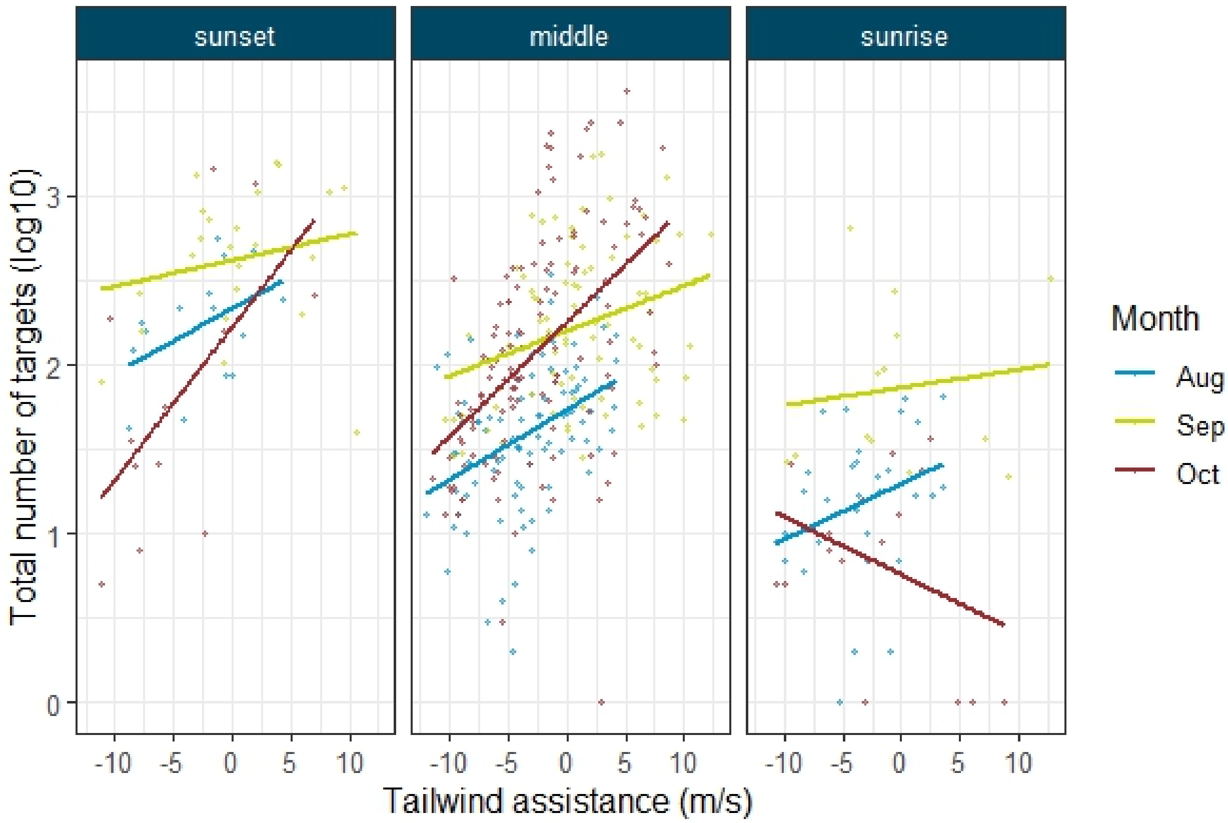


Figure 3.10 Relationship between tailwind assistance and the total number of targets across time of night and month during fall 2023

Tailwind assistance is plotted on the x-axis, with negative numbers representing headwind and positive numbers representing tailwind. Coloured lines represent the trend between total number of detections (log10) and tailwind assistance. Horizontal lines indicate no effect from tailwind assistance on total number of targets and an inclining line means a positive effect from tailwind assistance on total number of targets.

When tailwind assistance is plotted against the proportion of flights within the RSZ during spring migration the proportion of targets within the RSZ increases with headwinds (**Figure 3.11**). This is consistent with the patterns observed on May 6th where most of the targets were detected within the RSZ during strong headwinds (**Figure 3.3**). Although the proportion of targets within the RSZ increases with increasing headwinds, the total number of targets decreases (indicated by the narrow boxplots).

During spring migration, the highest numbers of targets were observed at a tailwind assistance between -4 and +4 metres per second (m/s), where the proportion of targets within RSZ during sunrise is similar to that at a tailwind assistance of -8 (**Figure 3.11**). During fall migration there is no obvious increase in proportion of targets within RSZ when headwind increases (**Figure 3.12**). This is consistent with with the nightly patterns observed in August and September (**Figure 3.4**). The proportion of targets within the RSZ does not vary substantially with wind.

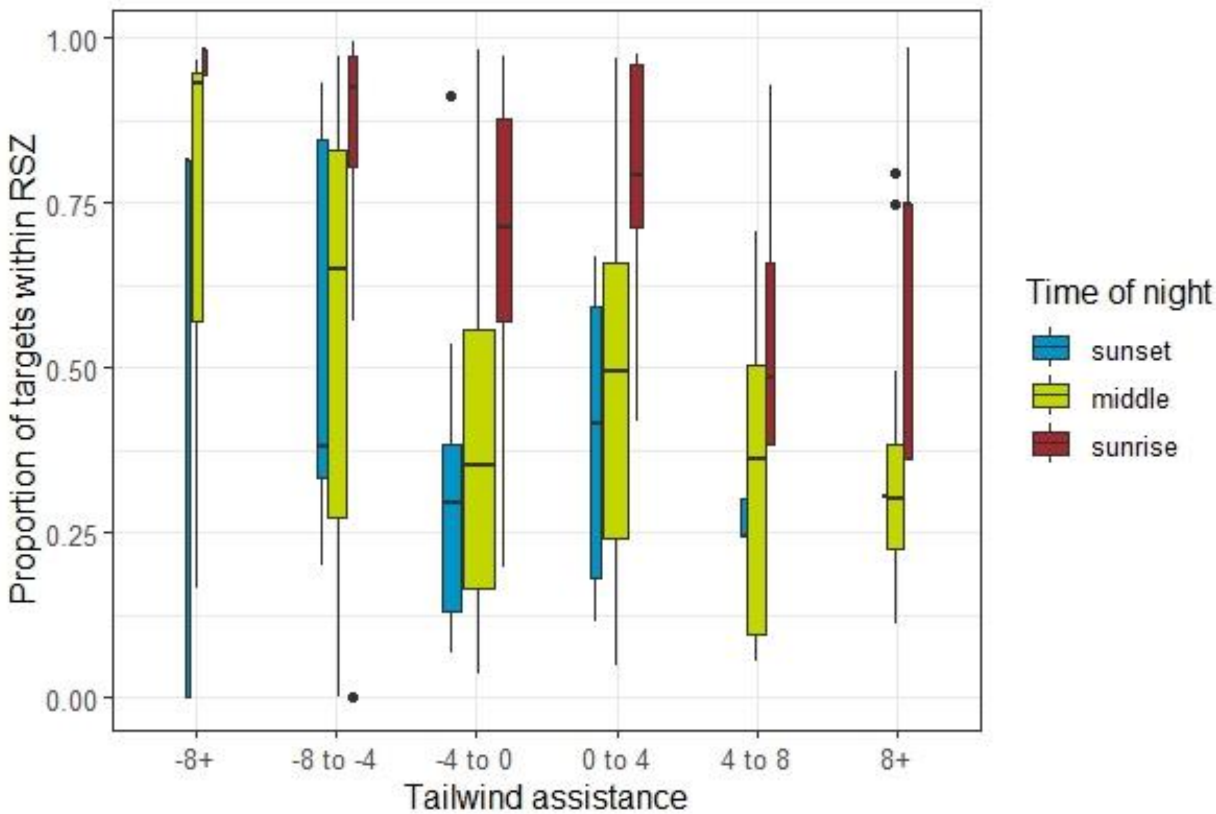


Figure 3.11 Relationship between tailwind assistance and the proportion of targets within RSZ across time of night during spring 2023

Tailwind assistance is plotted on the x-axis, with negative numbers representing headwind and positive numbers representing tailwind. The proportion of targets within RSZ are grouped by time of night indicated with light blue, dark blue, and green. In each boxplot 50 percent of the data is centred around the median in colour, and the median is shown with a black horizontal line. The upper and lower 25 percent of the data are shown with black vertical lines, and outliers are shown as black points. The total number of targets is illustrated by the relative width of the boxplot; a wider boxplot means a greater number of targets.

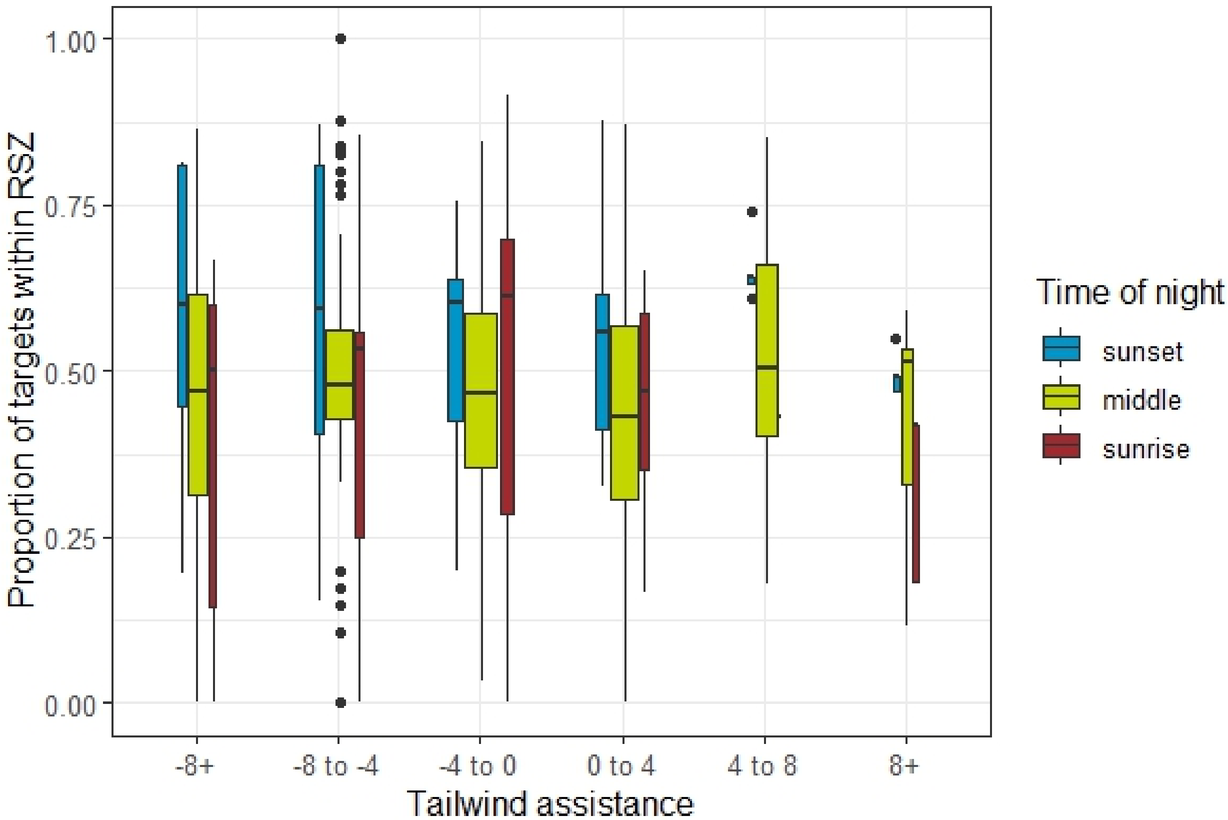


Figure 3.12 Relationship between tailwind assistance and the proportion of targets within RSZ across time of night during fall 2023

Tailwind assistance is plotted on the x-axis, with negative numbers representing headwind and positive numbers representing tailwind. The proportion of targets within the RSZ are grouped by time of night as indicated with blue, green, and red. In each boxplot 50 percent of the data is centred around the median in colour, and the median is shown with a black horizontal line. The upper and lower 25 percent of the data are shown with black vertical lines, and outliers are shown as black points. The total number of targets is illustrated by the relative width of the boxplot; a wider boxplot means a greater number of targets.

3.2 Nocturnal Migration Species Composition

Acoustic data were used to characterize the avian community using the Project area during migration. During spring 2023 a total of 13 distinct species and 4 species groups were identified with the nocturnal flight call recordings. Common nighthawk was the species most commonly detected, comprising 68.2 percent of the total detections. This species is known to be attracted to clear-cut areas in forests for hunting on insects and breeding on the bare ground. It is therefore likely that these detections represent a few resident individuals which are using the Project area regularly and possibly breeding in the area. Common nighthawk is federally listed as Special Concern on Schedule 1 of the SARA. The regulatory implications for presence of this species are discussed in **Section 3.3** below.

The second most commonly detected species in spring was split between the white-throated sparrow (*Zonotrichia albicollis*), which comprised 3.8 percent of the total detections, with the Swainson's thrush (*Catharus ustulatus*) which also comprised 3.8 percent of total detections. A summary of all nocturnally migrating species detected in spring 2023 is provided in **Table 3.1**. The species recorded and identified using acoustic data represent nocturnal migratory activity below approximately 200 m in agl.

Table 3.1 Nocturnal flight call detections by species and species group, spring 2023

Species or Species Group(a)	Total Number of Calls Detected	Proportion of Calls Detected
Common nighthawk	5182	68.2
Single-banded downsweep[a]	493	6.5
White-throated sparrow	290	3.8
Swainson's thrush	290	3.8
Common Yellowthroat	207	2.7
Black-and-white warbler	163	2.1
Zeep[b]	157	2.1
Ovenbird	140	1.8
Northern waterthrush	131	1.7
Veery	121	1.6
American Robin	76	1
American redstart	64	0.8
Chestnut-sided warbler	59	0.8
Northern parula	56	0.7
Savannah sparrow	51	0.7
Song- or Fox sparrow	32	0.4
Solidarity- or Spotted sandpiper	32	0.4
Mourning warbler	21	0.3
Black-throated blue warbler	20	0.3
Canada warbler	14	0.2
Total	**7599**	**100**

(a) "Single-banded downsweep" species group includes Pine Warbler, Northern Parula, Yellow-throated Warbler, and Prairie Warbler.

(b) "Zeep" species groups includes Bay-breasted Warbler, Blackburnian Warbler, Blackpoll Warbler, Cape May Warbler, Magnolia Warbler, Northern Waterthrush and Yellow Warbler.

During fall 2023 a total of 14 distinct species and 1 species group were identified from the nocturnal flight call recordings. Ovenbird (*Seiurus aurocapilla*) was the species most commonly detected, comprising 18 percent of the total detections. The second most commonly detected species was veery (*Catgarus fuscescens*), which comprised 13.7 percent of the total detections, followed by the black-and-white warbler (*Mniotilta varia*) which comprised 10.3 percent of total detections. A summary of all nocturnally migrating species detected in fall 2023 is provided in **Table 3.2**. The species recorded and identified using acoustic data represent nocturnal migratory activity below approximately 200 m in agl.

Table 3.2 Nocturnal flight call detections by species and species group, fall 2023

Species or Species Group[(a)]	Total Number of Calls Detected	Proportion of Calls Detected
Zeep[a]	4179	23.5
Ovenbird	3200	18.0
Veery	2428	13.7
Black-and-white Warbler	1838	10.3
Northern Parula	1083	6.1
Northern Waterthrush	1083	6.1
Swainson's Thrush	1005	5.7
Chestnut-sided Warbler	706	4.0
American Redstart	623	3.5
Dark-eyed Junco	532	3.0
Mourning Warbler	369	2.1
Savannah Sparrow	271	1.5
Unknown	253	1.4
Canada Warbler	114	0.6
Common Nighthawk	45	0.3
White-throated Sparrow	41	0.2
Total	**17770**	**100**

(a) “Zeep” species groups includes Bay-breasted Warbler, Blackburnian Warbler, Blackpoll Warbler, Cape May Warbler, Magnolia Warbler, Northern Waterthrush and Yellow Warbler.

The most-commonly detected species during spring migration was the common nighthawk. While this species was not detected until the end of May, the number of detections of common nighthawk was substantially higher than all other species combined. The highest number of detections recorded for the common nighthawk was close to 1500 during one night at the start of June (**Figure 3.13**). Detections of common nighthawk peaked at sunset, midnight, and sunrise, with the highest number of detections at sunrise in May (**Figure 3.14**). Although the common nighthawk was still detected in during fall migration, the numbers of detections were lower (**Figure 3.15**). The most-frequently detected species during the fall migration were warblers peaking at almost 1500 detections per night in late August and early September, followed by thrushes with almost 500 detections in early September (**Figure 3.15**). Detections of both species groups peaked around midnight (**Figure 3.16**).

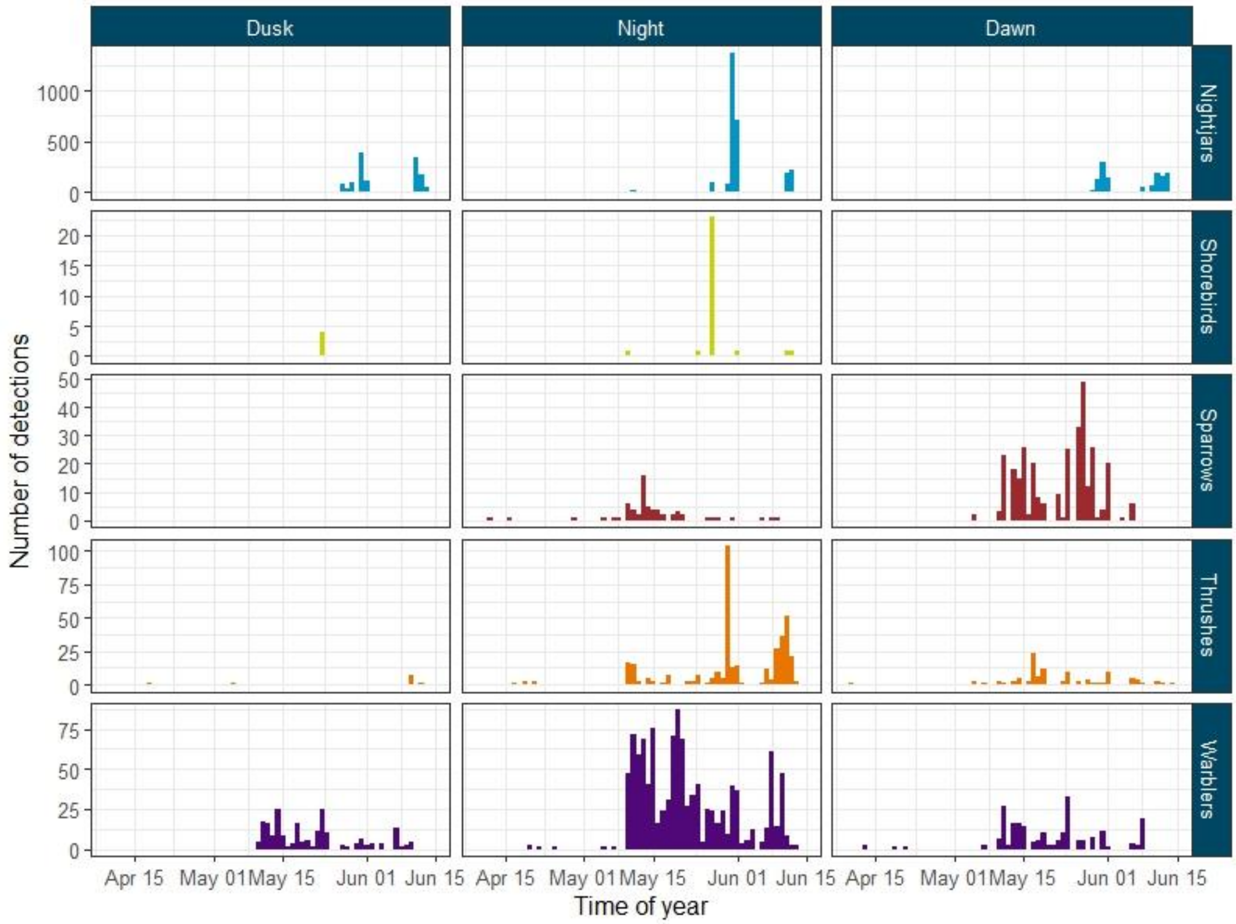


Figure 3.13 Acoustic detections by species groups during spring 2023. Detections are grouped by time of night in panels and displayed as detections per hour of the night. Note the y-axis scale differs by species group.

Figure 3.14 Acoustic detections by species groups during spring 2023. Detections are grouped monthly in panels and displayed as detections per hour of the night. Note the y-axis scale differs by species group.

Figure 3.15 Acoustic detections by species groups during fall 2023. Detections are grouped by time of night in panels and displayed as detections per hour of the night. Note the y-axis scale differs by species group.

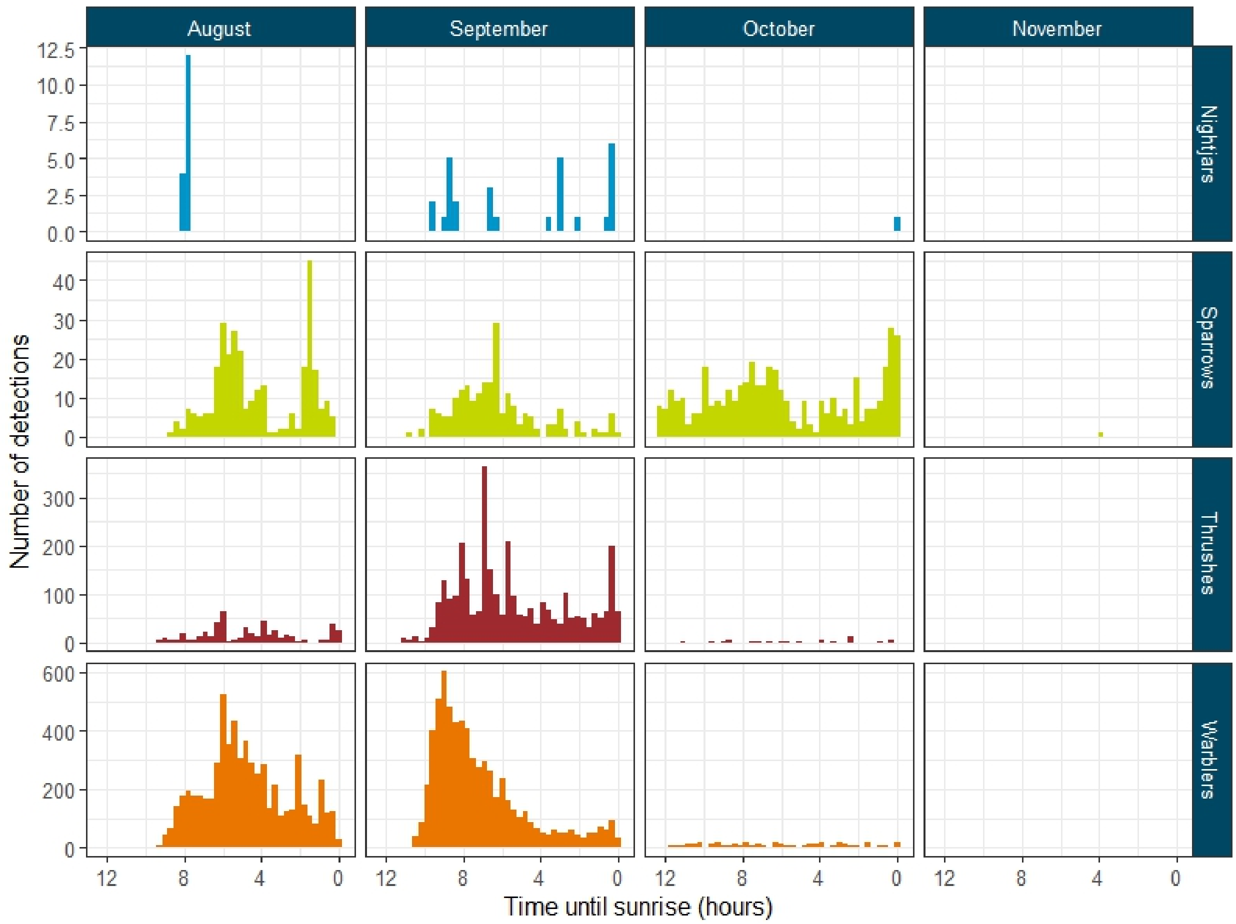


Figure 3.16 Acoustic detections by species groups during fall 2023. Detections are grouped monthly in panels and displayed as detections per hour of the night. Note the y-axis scale differs by species group.

3.3 Species at Risk

Two species at risk were detected during the acoustic surveys, the common nighthawk and Canada warbler (**Table 3.3**). The status and threats for each species are described below.

Table 3.3 Species at risk detected within the Project area.

Common Name	Scientific Name	Federal Status	Provincial Status
Common nighthawk	*Chordeiles minor*	Special Concern	Threatened
Canada warbler	*Cardellina canadensis*	Special Concern	Endangered

<u>Common nighthawk</u>

The Canadian population of common nighthawk is estimated at approximately 270,000 birds, which accounts for roughly 10 percent of the global population (Hache et al. 2014). This species has been declining rapidly since the late 1960s, with an estimated population decline of nearly 80% in 2005

(Environment Canada 2016). Although this trend has been somewhat stabilized in recent years, the persistence of this species remains a concern. The common nighthawk was assessed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2007. A federal Recovery Strategy for the species was drafted in 2016. The species was downlisted by COSEWIC in 2018 and is currently listed as Special Concern on Schedule 1 of the SARA (Environment Canada 2016; COSEWIC 2018). Provincially this species is listed as Threatened under the Nova Scotia *Endangered Species Act*.

In 2021, the Nova Scotia Department of Natural Resources and Renewables (NSDNRR) developed a recovery plan for the common nighthawk in Nova Scotia (NSDLF 2021b). The provincial plan adopted sections from the federal Recovery Strategy that are relevant to Nova Scotia. The short-term population objective for the common nighthawk is to stop the population decline by 2025, while ensuring that the population does not decline more than 10 percent between 2015 to 2025. The long-term objective is a positive population trend after 2025. The distribution objective is to maintain the current range throughout Canada (Environment Canada 2016).

The high detection rate of the common nighthawk in the project area during the breeding season suggests that the project area is likely suitable foraging and breeding habitat for the common nighthawk. Clearcut areas in forest are known to be suitable habitat for the common nighthawk for both breeding and foraging (Campbell et al. 2006). Because common nighthawks can forage several kilometres away from their nesting locations (Environment Canada 2016), it is possible that the project area is only used for foraging.

Canada warbler

The Canadian population of Canada warbler is estimated at approximately 3,000,000 birds, which accounts for roughly 75% of the total population (Partners in Flight Science Committee 2013). The Canada warbler population declined by approximately 71 percent between 1970 and 2012 (Environment Canada 2014d). The species was listed as Threatened under Schedule 1 of the SARA in 2010 (S.C. 2002, c. 29), and was listed as Endangered in the Nova Scotia endangered species legislation (S.N.S 1998, c.11).

In 2021, the NSDNRR developed a recovery plan for the Canada warbler in Nova Scotia. The provincial plan adopted sections from the federal Recovery Strategy (NSDLF 2021a) that are relevant to Nova Scotia. The short-term population objective for the Canada warbler is to stop the population decline by 2025, while ensuring that the population does not decline more than 10 percent between 2015 to 2025. The long-term objective is a positive population trend after 2025. The distribution objective is to maintain the current range throughout Canada (Environment Canada 2015).

The Canada warbler nocturnal call was detected 6 times in the spring season, and 115 times in the fall season. These numbers are relatively low and only comprise 2.7 and 2.8 percent of the total spring and fall detections respectively. Because this species is diurnal and only migrates at night these detections are only from migratory birds. It is possible that the Canada warbler also breeds in or nearby the project area, though it is unclear if the habitat inside or nearby the project area is suitable for this species. In Nova Scotia the Canada warbler is known to prefer moist sites with cinnamon fern (*Osmunda cinnamomea*), speckled alder (*Alnus incana*) or other deciduous shrubs, and the birds are often associated with sphagnum (NSDLF 2021).

4.0 Discussion

The radar and acoustic data collected for this study characterize nocturnal migrating bird activity in the Project area during spring and fall 2023 to inform project development and potentially help refine the project design to lessen the potential for the project to adversely affect migratory birds in the Project area.

The radar data show that 60 percent of all targets detected in the Project area occurred above the RSZ, and 40 percent of all targets were detected within the RSZ (**Figure 3.3, Figure 3.4**). Flights within the RSZ particularly occurred during nights with strong headwinds, such as May 6, May 7, and October 8 (**Appendix A**, **Appendix B**,). Therefore, some weather conditions may increase risk of collision with turbines.

The following assumptions are important for interpreting data presented in this report and assessing potential collision risk for the Project.

- Although the radar data is filtered to extract only bird targets, some bats or larger insects in proximity to the radar may have strong reflective power, similar to that of a small bird at distance, and may therefore be included as radar targets. This analysis maintains a conservative assumption that all targets were birds.
- The volume of detections low to the ground may have been caused by ground clutter, bats, or insects, rather than birds, which means the actual migration intensity and associated number of birds within the RSZ may be lower.
- Since a vertical radar was used, it is unknown whether flight volume differs spatially across the Project area. The present analysis assumes that flight volumes were homogeneous across the Project area.
- The proportion of flight volume within RSZ presented in this report is greater than the proportion of targets that may collide with turbines. This is due to the fact that the RSZ takes up only a small portion of the total airspace of the Project area.

The common nighthawks call was detected frequently in the project area, all detections came from two locations in the project area (**Appendix C**). A total of 4954 calls recorded at AudioMoth 603 and 195 calls recorded at AudioMoth 604 were selected by the acoustic model as the common nighthawk calls. By analyzing the audio files all detections before May 25th turned out to be false detections, which changes the positive detections to a total of 4940 for AudioMoth 603 and 187 for AudioMoth 604.

Common nighthawks are known to use clearcut areas for foraging and nesting, so the clearcut areas in the Project area are likely suitable habitat for the common nighthawk. The high detection rate of this species suggests that this species is using this area for foraging rather than simply passing through on migration. So, although the detection rate is very high, there may only be a few individuals foraging in the Project area. The common nighthawk was not only the most-commonly detected species during the spring, but also the only species at risk detected in the Project area (**Table 3.3**). Although the common nighthawk is a species of concern, studies show that wind turbines are generally no threat to this species (COSEWIC 2018). Compared to other species, common nighthawks have among the lowest reported collision rates with vehicles, buildings, and wind turbines (Bishop & Brogan 2013; Longcore et al. 2013; Loss et al. 2014; Fense et al. submitted). A comprehensive post-construction monitoring report based on 147 datasets from 70 wind energy projects across Canada shows that the common nighthawk only accounted for approximately 0.11 percent of all bird casualties (Bird Studies Canada 2016). Any losses from collisions may also be offset by the increasing availability of open terrain favoured by the common nighthawk for foraging and nesting (Campbell et al. 2006).

Although the Canada warbler is also a species at risk protected under the Nova Scotia *Endangered Species Act* (S.N.S 1998, c.11), the numbers of call detections for Canada warbler were much lower than for the common nighthawk (**Table 3.3**). The Canada warbler was also only detected as a migrant and is less likely to use the project area for foraging and nesting. The Canada warbler forages under the canopy of trees and shrubs, and nests in dense vegetation (Len et al 2020), as such the open clearcut areas of the Project area are likely unsuitable habitat for this species. The collision risk for Canada warbler is therefore judged to be low. Post construction monitoring will be required to accurately predict potential mortality for the Canada warbler in the project area.

The prediction of collision risk by nocturnally-migrating birds with turbines using pre-construction radar and acoustic data is complex and has not been well established in Atlantic Canada. The best indicator of risk is the volume of birds migrating within the RSZ, though only a small fraction of the birds migrating at this height may collide with the turbine rotors. Several models have been developed to predict the collision risk based on the flight volume, species, rotor height, RSZ, etc. (Band et al. 2007; Masden & Cook 2016; Kleyheeg-Hartman et al. 2018). Although these models are useful to predict potential mortality and may be used to prevent potentially high collision rates by allocating turbines to less risky locations, post-construction research has shown that model predictions often underestimate the actual mortality (Ferrer et al. 2012; Schippers et al. 2020), indicating the importance of post-construction monitoring. Although the risk of collision may be correlated with volume of migration, without multiple, standardized radar/acoustic studies conducted across a broader region (i.e. across Nova Scotia), and without post-construction mortality data to validate predictions, forecasts will have substantial error and uncertainty.

5.0 Data Limitations

The following are limitations related to the data that help understand and interpret the results presented in this report.

5.1 Radar Data

Radar data can provide a good understanding of nocturnal avian migration trends at proposed wind energy projects. Data limitations as associated with radar studies are:

- While it is assumed that most targets are migratory birds, some proportion of targets may be insects, bats, ground clutter and or precipitation.
- Detection probability of targets varies with several external factors such as: distance from radar, atmospheric conditions, ground clutter, altitudinal coverage, interference from large objects, and radar orientation. Given that target density varies these external factors, making direct comparison of passage rates across sites can be difficult.
- Detections at very low altitudes (i.e. below 70 metres) are difficult to capture with a radar due to ground clutter and background noise from vegetation.

5.2 Acoustic Data

Acoustic data provides information about the avian community migrating through the Project area, including species identification and passage volumes, although there are several factors that may impact calling rates and detectability, such as:

- Only one microphone recorded successfully in the first month. This means that there is insufficient audio data collected during the first month and flight calls do not represent the whole project area.
- Microphone sensitivity may cause detection rates to change due to rainfall, background noise, vegetation cover, and technology (microphones need to be calibrated frequently) underestimating number of birds (detections) within the study area.
- Because the acoustic microphones have a limited range of approximately 200 metres, birds flying at elevations higher than 200 metres will not be picked up by the microphones, and therefore may underestimate the total number of migratory birds (detections) within the study area.
- Weather conditions have the potential to influence calling rates. Data collected during cold or rainy conditions may underestimate the number of birds (detections) or species within the study area.
- The density of migrants has the potential to influence calling rates.
- Calling rates may vary with species composition as not all species call, and some species may call more frequently than others.

6.0 Recommendations

The pre-construction data shows that the highest volumes of birds fly within the RSZ during strong head winds. The risk of collision is therefore expected to increase with strong northern winds during spring migration.

The presence and local abundance of common nighthawk and Canada warbler in the Project area is notable. The species are federally and provincially protected under the MBCA, MBR, and the SARA, as well as the provincial Nova Scotia *Endangered Species Act*. No regulatory protection is conferred to species listed as Special Concern and a SARA permit is unlikely to be required for the Project. However, mortality from collision with the wind turbines should be minimized to meet the recovery strategy objectives for these species (NSDLF 2021a; NSDLF 2021b). To determine whether mitigation measures are needed for these species, Ausenco recommends 2-year post-construction monitoring to determine the mortality rate of these species at the Project area. Post-construction monitoring will also help determine what type of mitigation is best suited for these species.

7.0 Closure

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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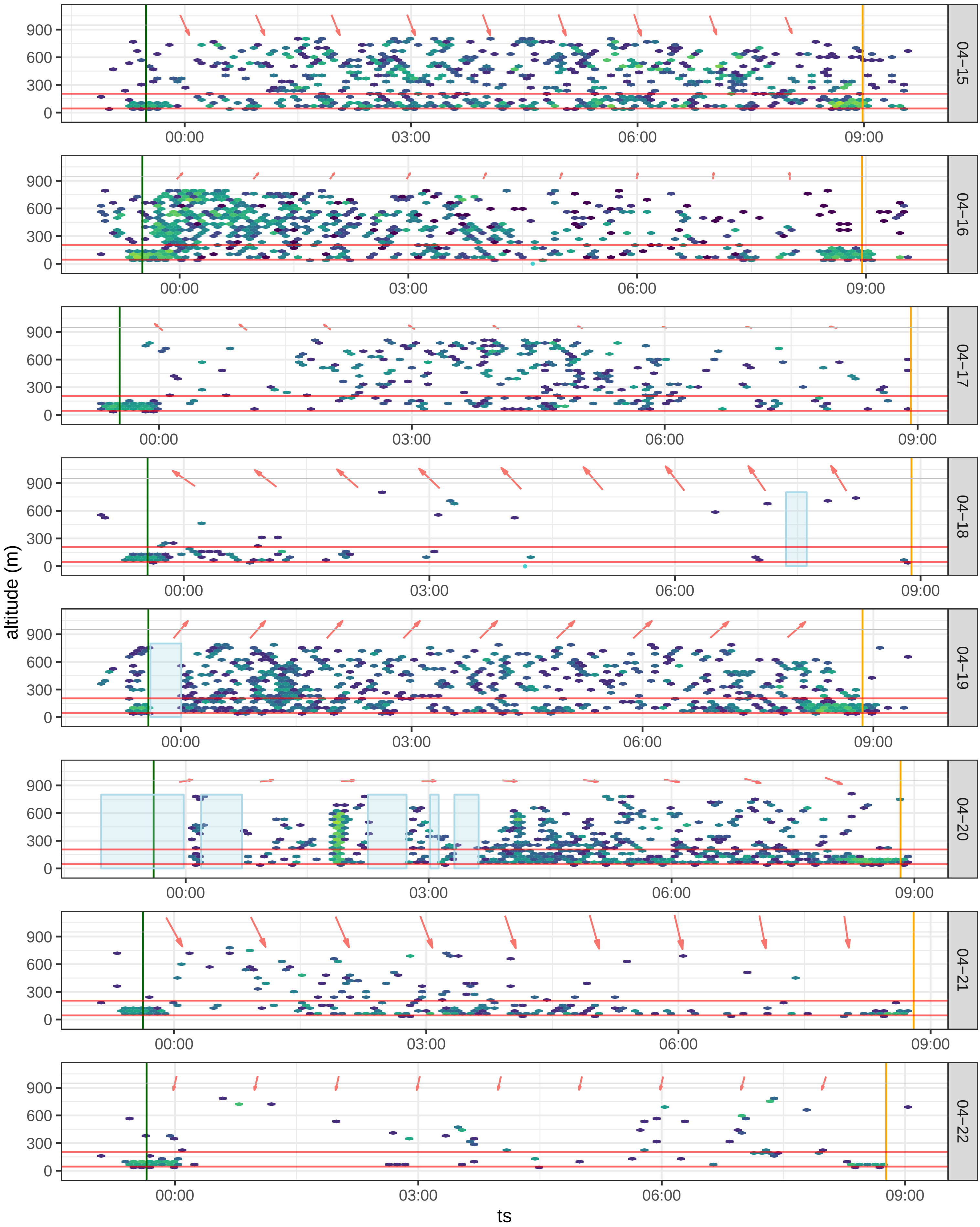
Appendix A
Complete Spring 2023 Radar Data

OVERVIEW

The entire radar and acoustic detections for the spring 2023 monitoring period are provided below. Each panel in the figures is a separate night. Time is indicated using Global Mean Time (GMT) on the x-axis with the beginning and end of civil twilight indicated by the vertical green and yellow lines, respectively. Target altitude is on the y-axis, including the proposed rotor swept zone (i.e.0-200 m) indicated with red horizontal lines. Data points are radar detections divided into hexagonal time and altitude bins, which 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 include insects, raindrops, or other noise). Wind direction (cardinal direction of red arrow) and wind strength (arrow size) at approximately 700 m agl is indicated for each hour at the top of each plot. The blue box represents a period of rain when raindrops could not be distinguished from bird detections.



altitude (m)
ts
04−15
04−16
04−17
04−18
04−19
04−20
04−21
04−22
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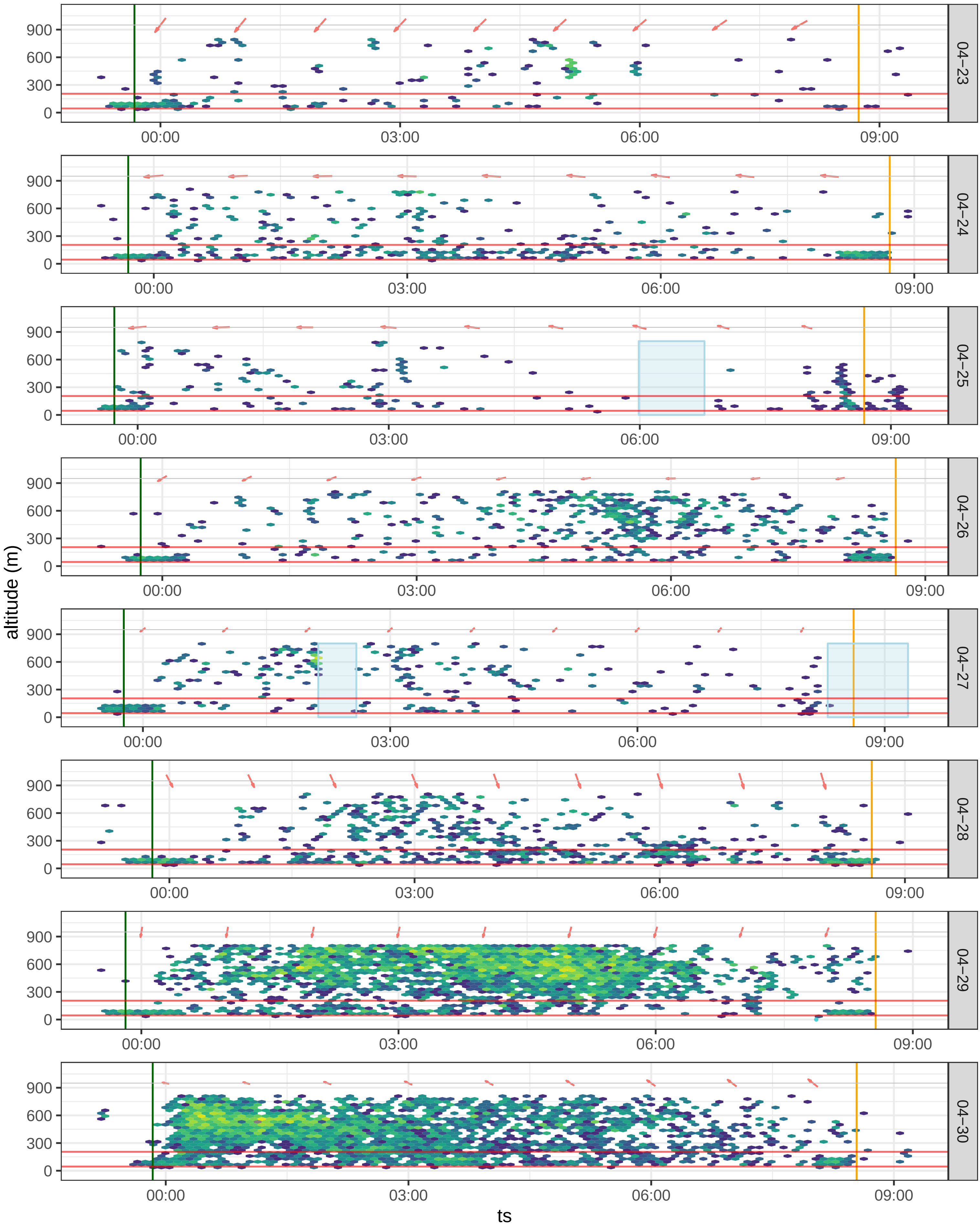
300
600
900
00:00
03:00
06:00
09:00



altitude (m)
ts
04−23
04−24
04−25
04−26
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04−28
04−29
04−30
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300
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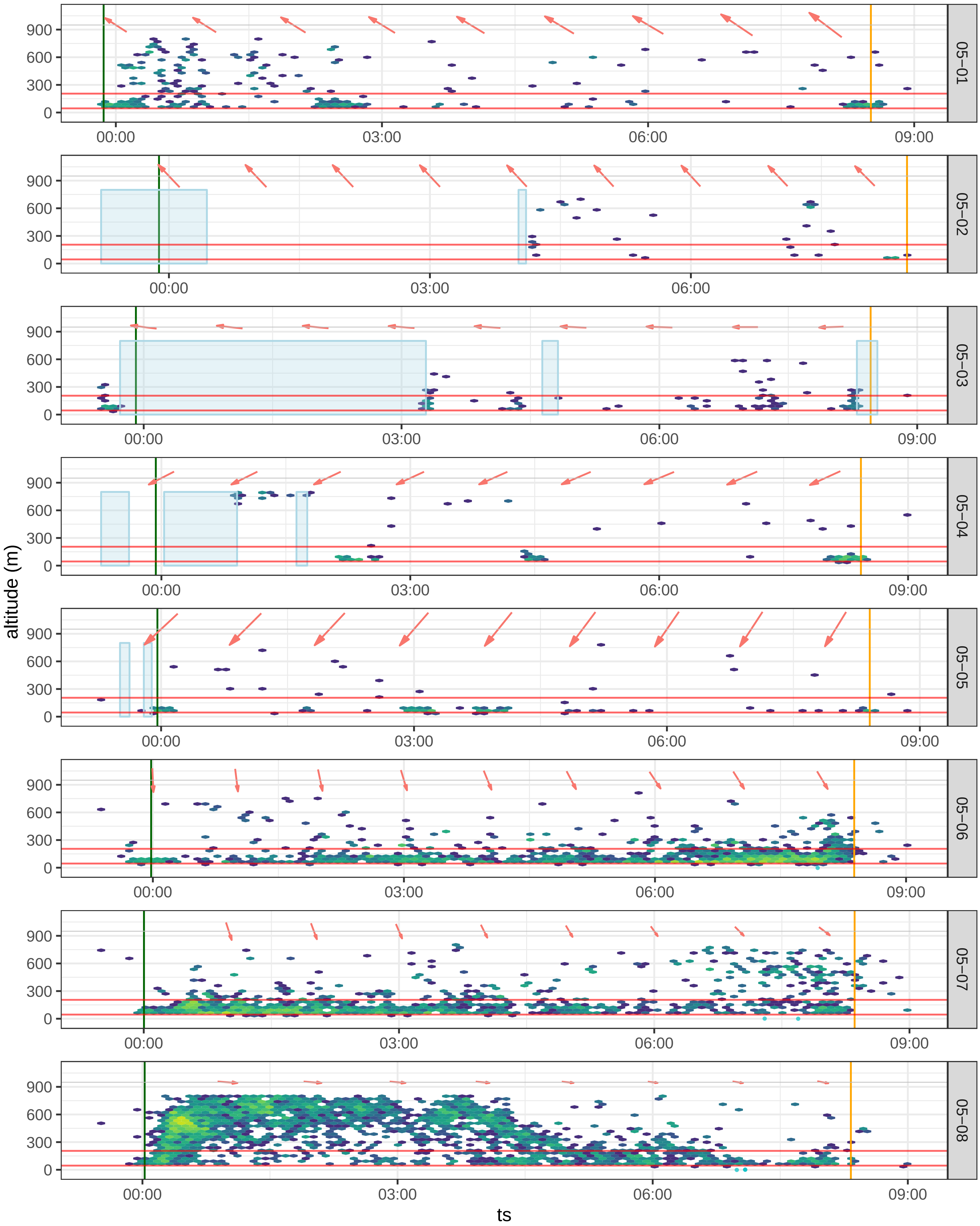
900
00:00
03:00
06:00
09:00



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05−01
05−02
05−03
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05−06
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05−08
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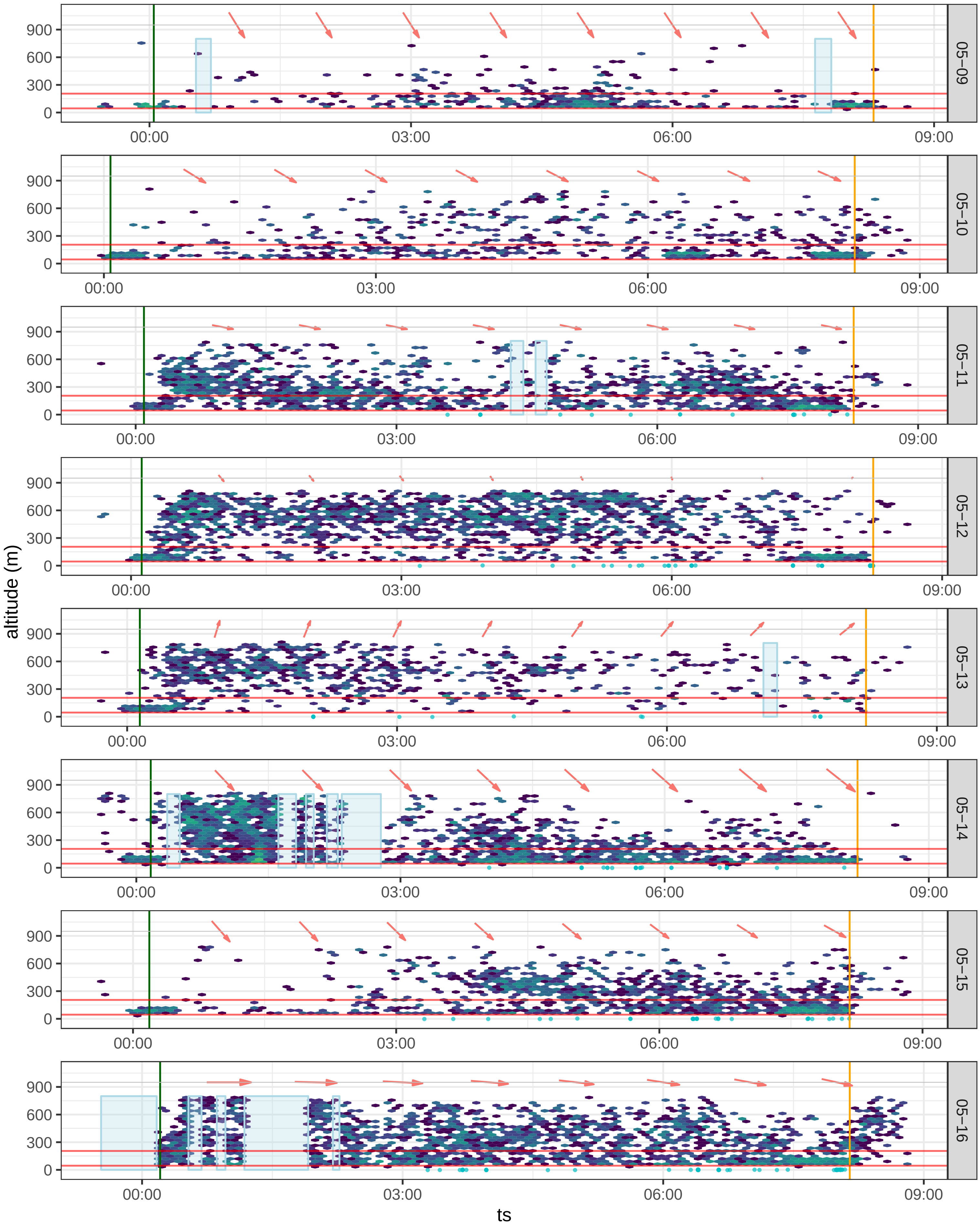
600
900
00:00
03:00
06:00
09:00



900
600
300
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00:00
03:00
06:00
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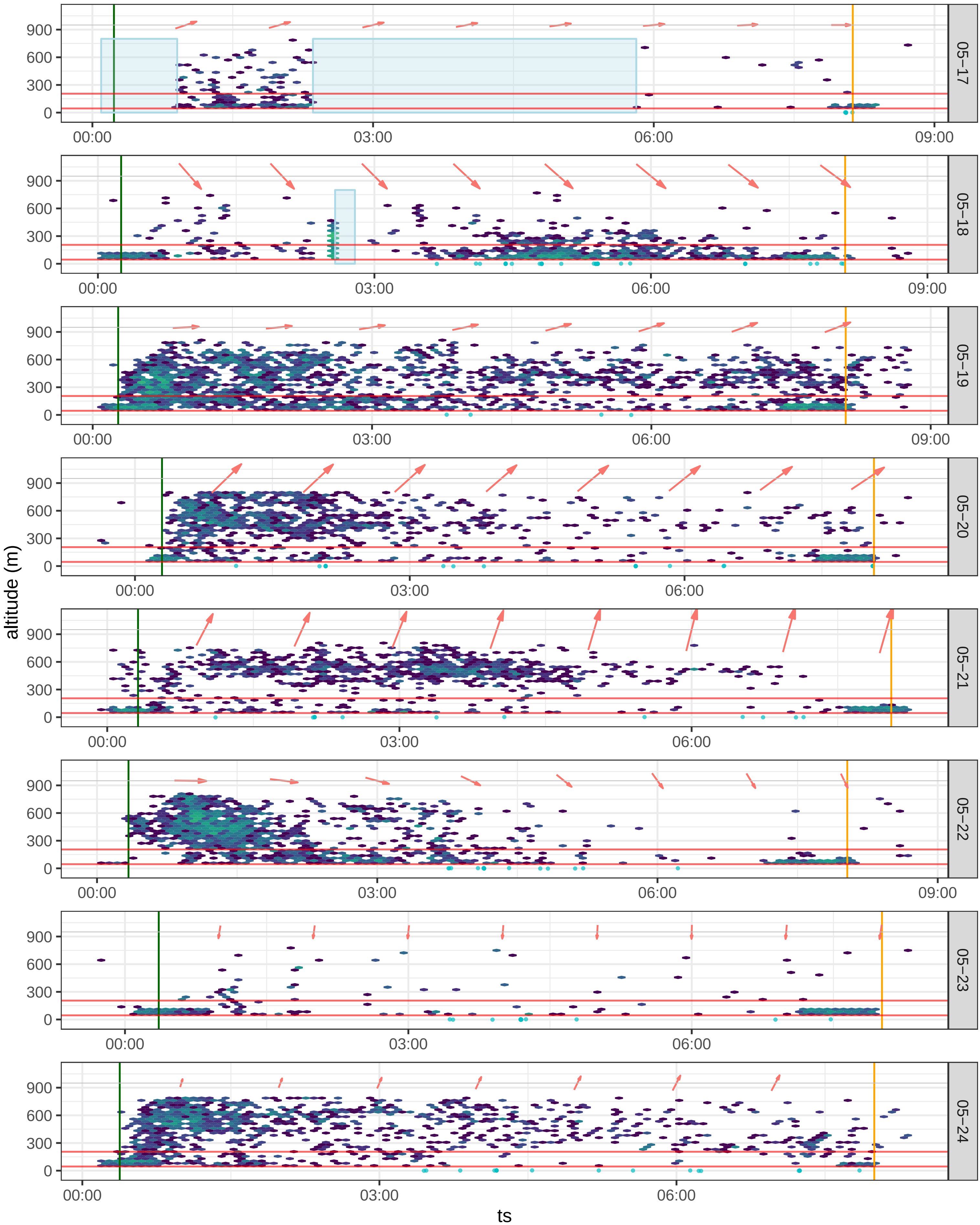
05−09
05−10
05−11
05−12
05−13
05−14
05−15
05−16
altitude (m)
ts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ts
05−17
05−18
05−19
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05−22
05−23
05−24
0
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03:00
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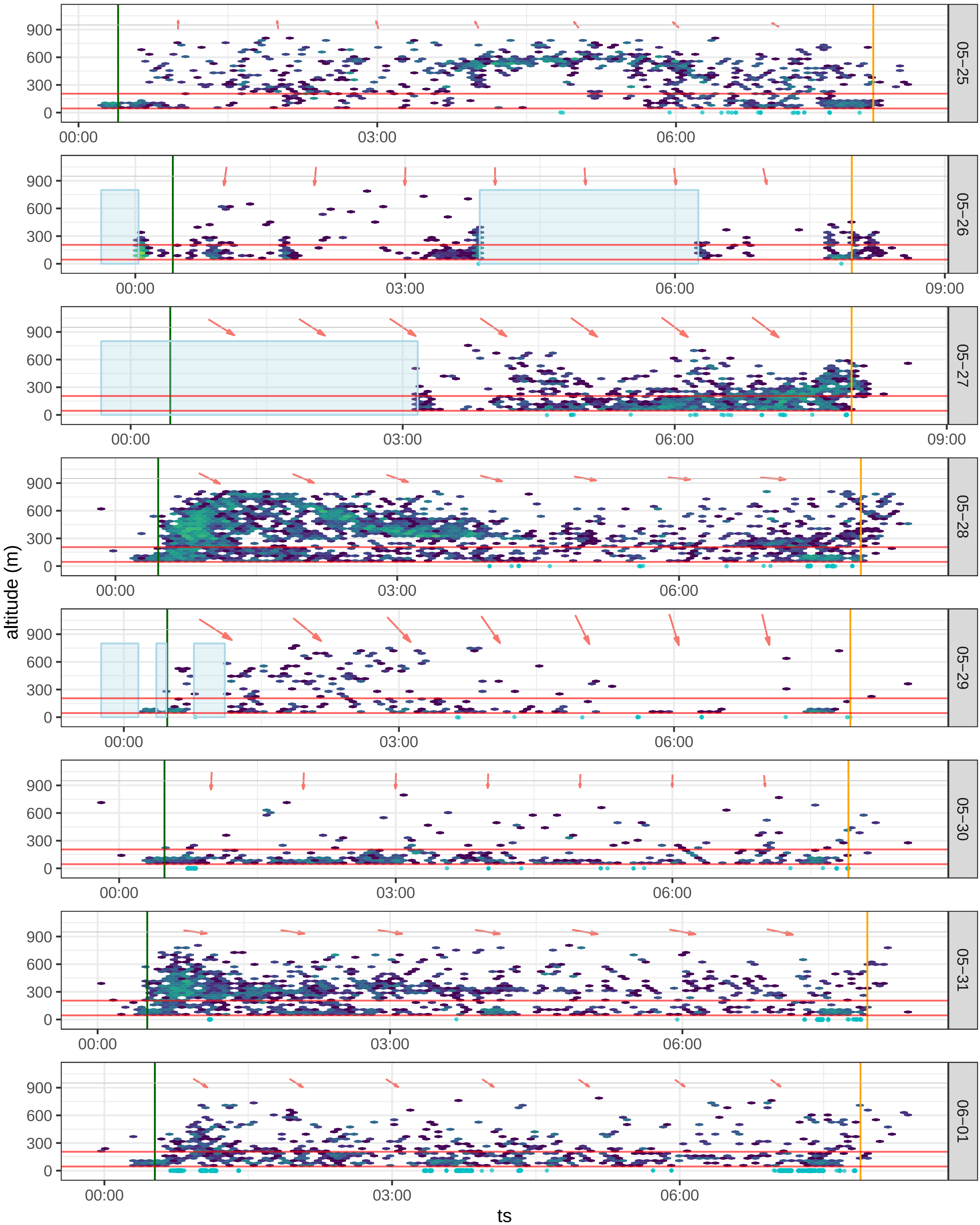
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05−30
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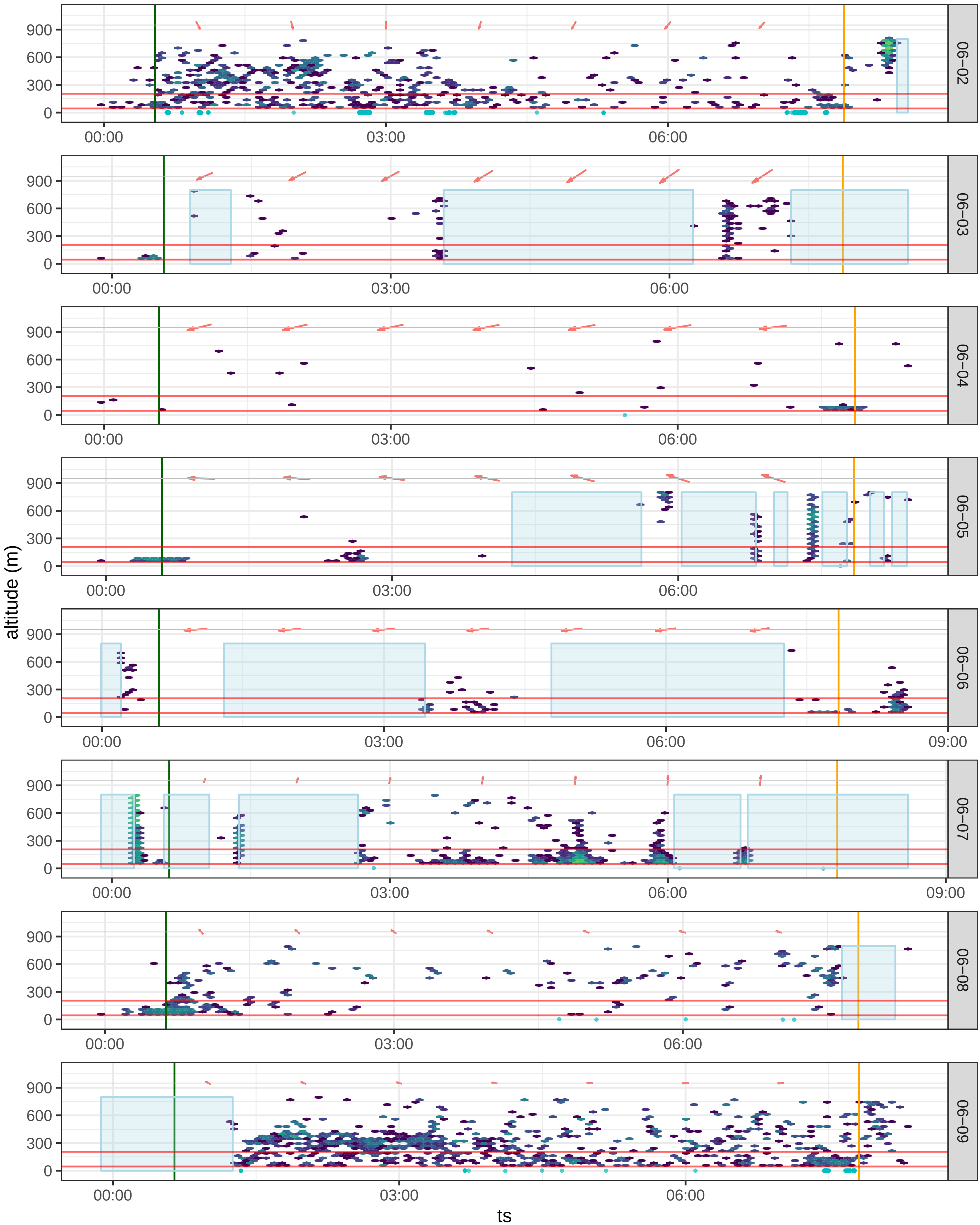
06−01



altitude (m)
ts
0
300
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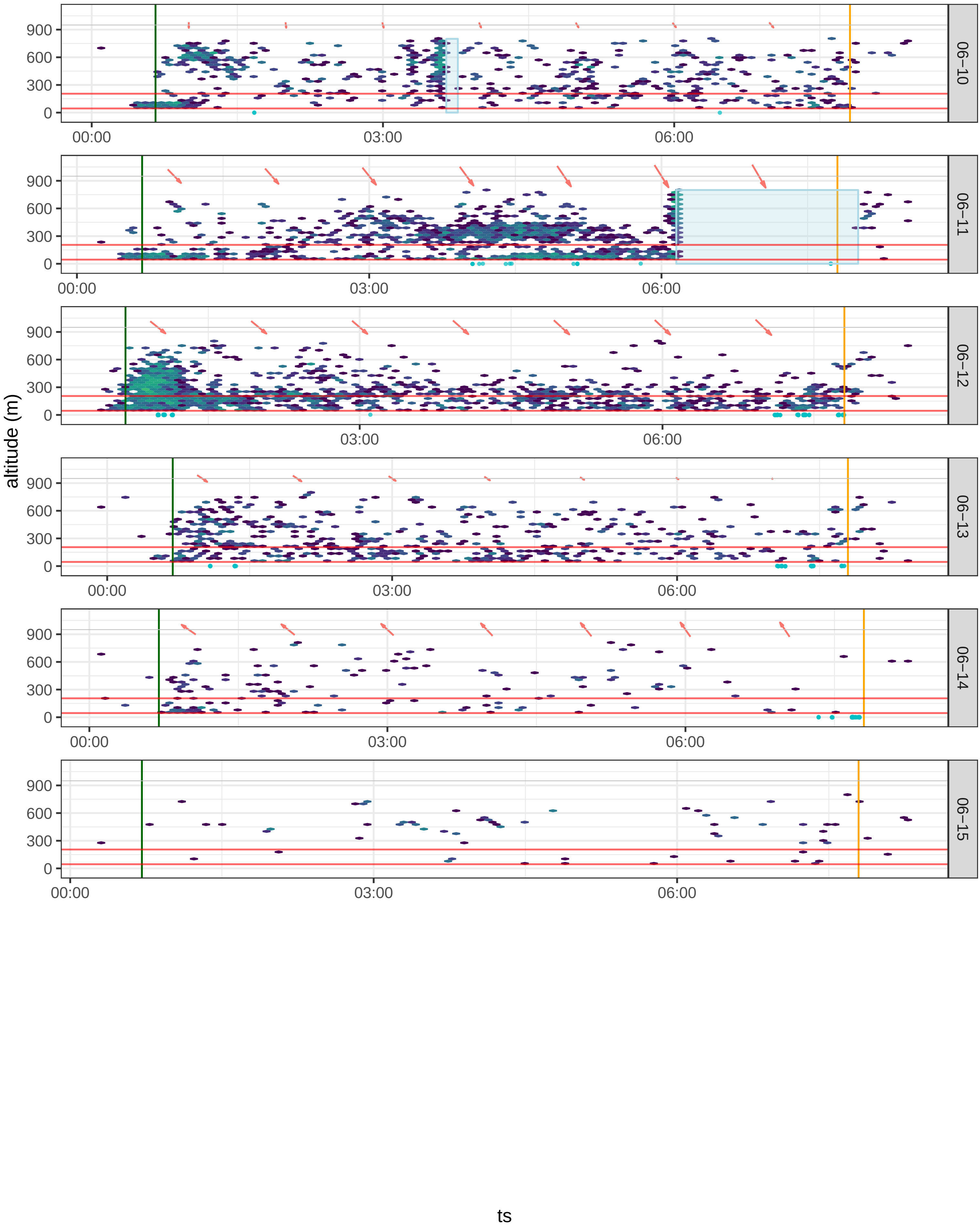

06−10
06−11
06−12
06−13
06−14
06−15
altitude (m)
ts
00:00
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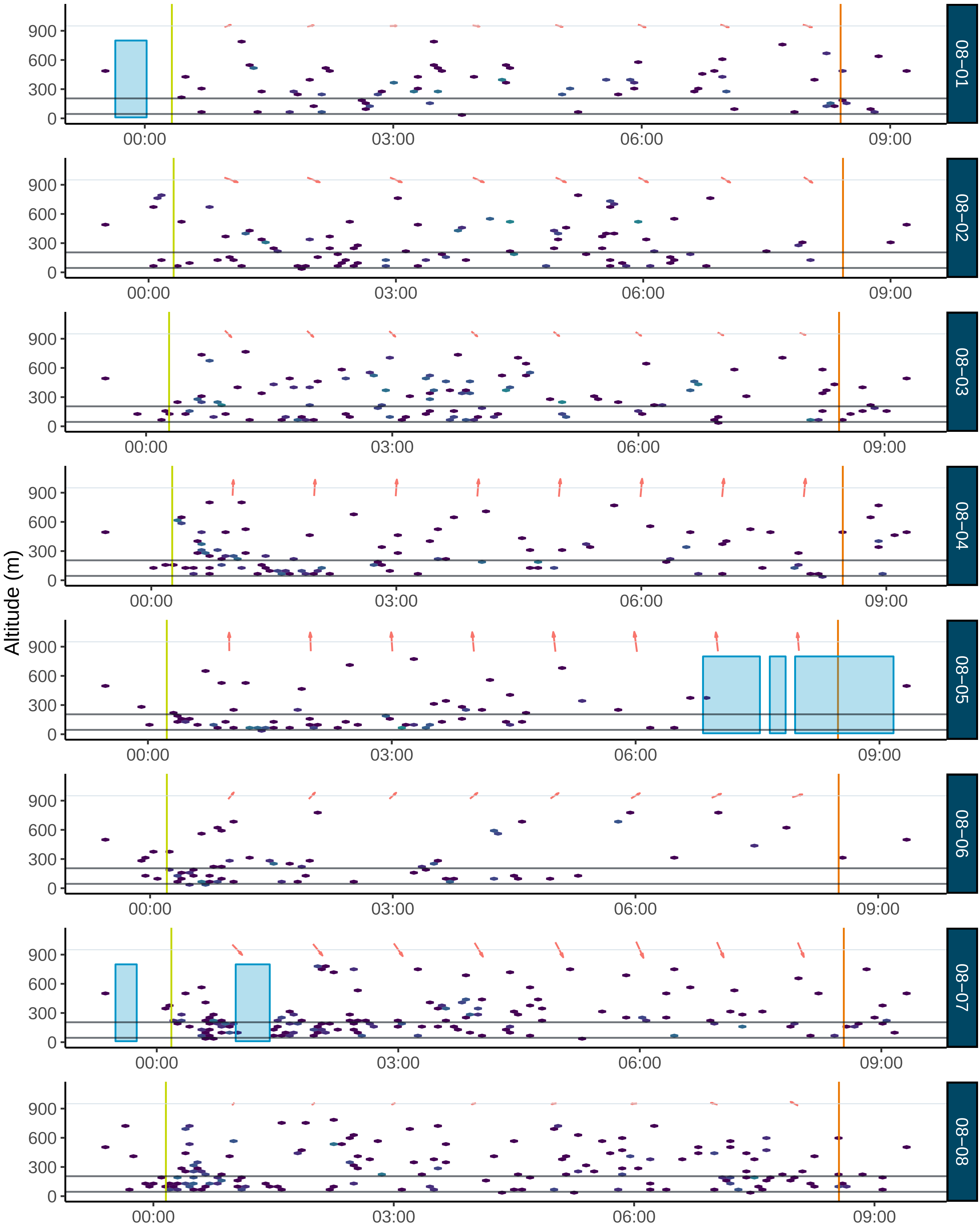
0
300
600
900

Appendix B

Complete fall 2023 Radar Data



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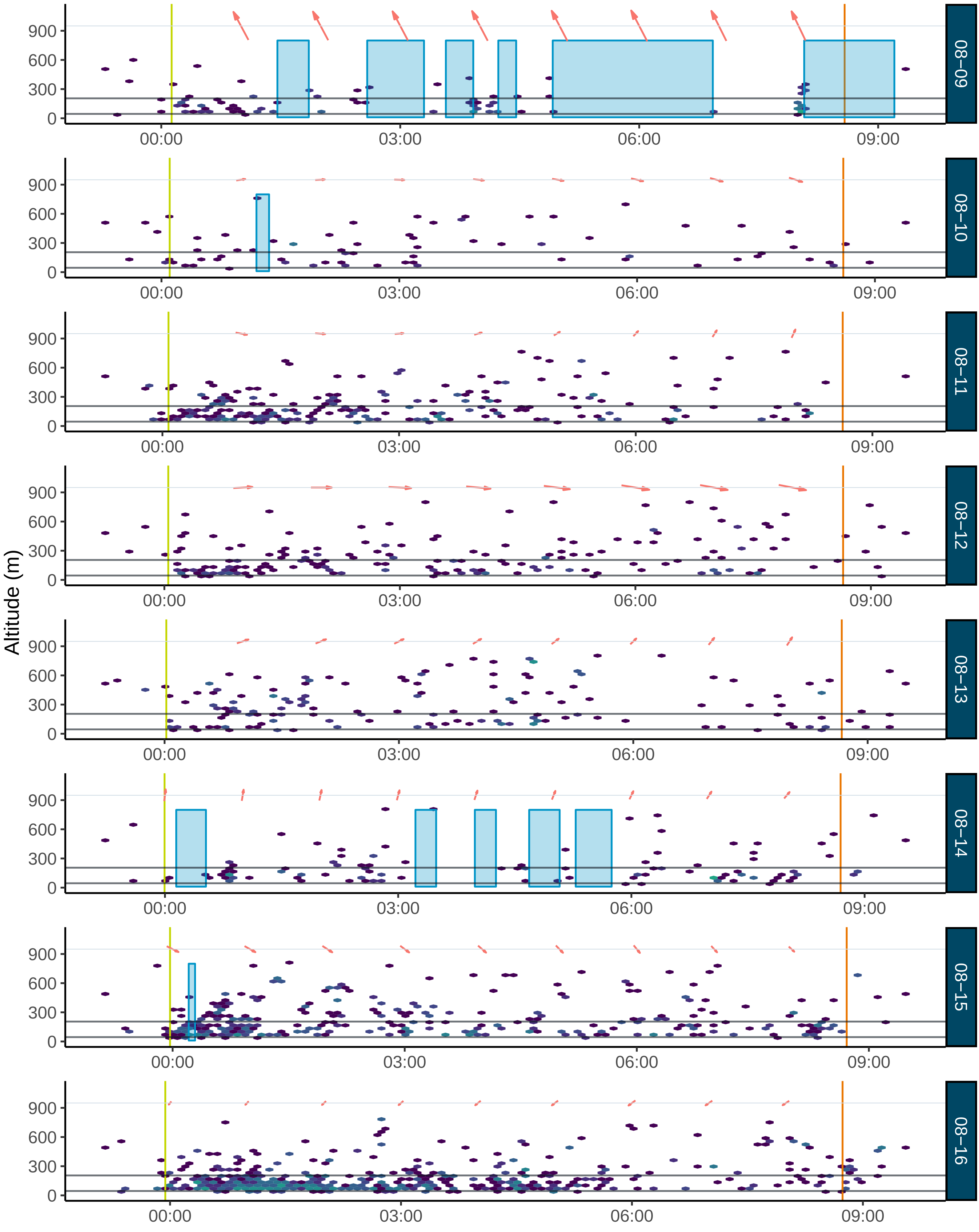

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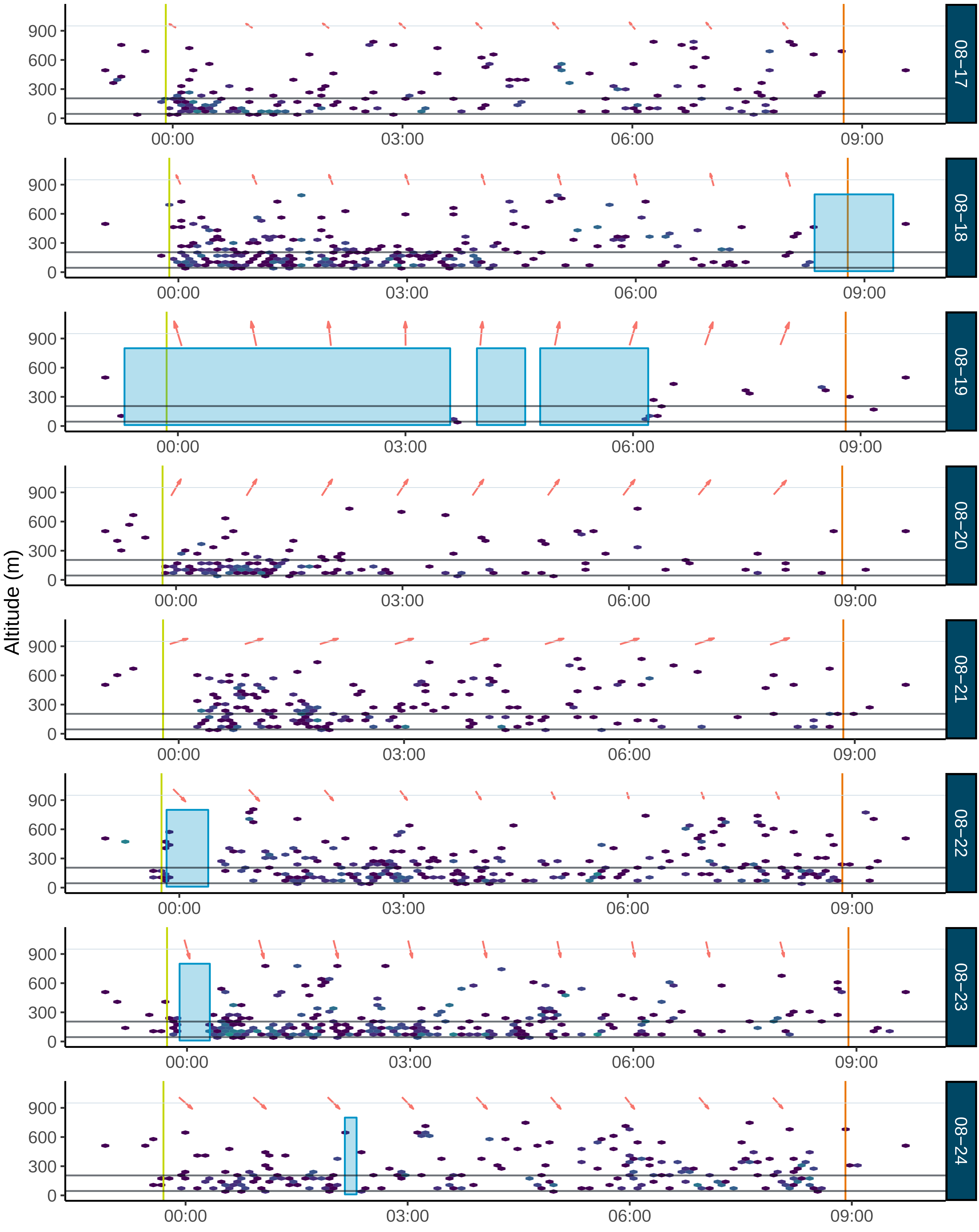
08–14
08–15
08–16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08–17
08–18
08–19
08–20
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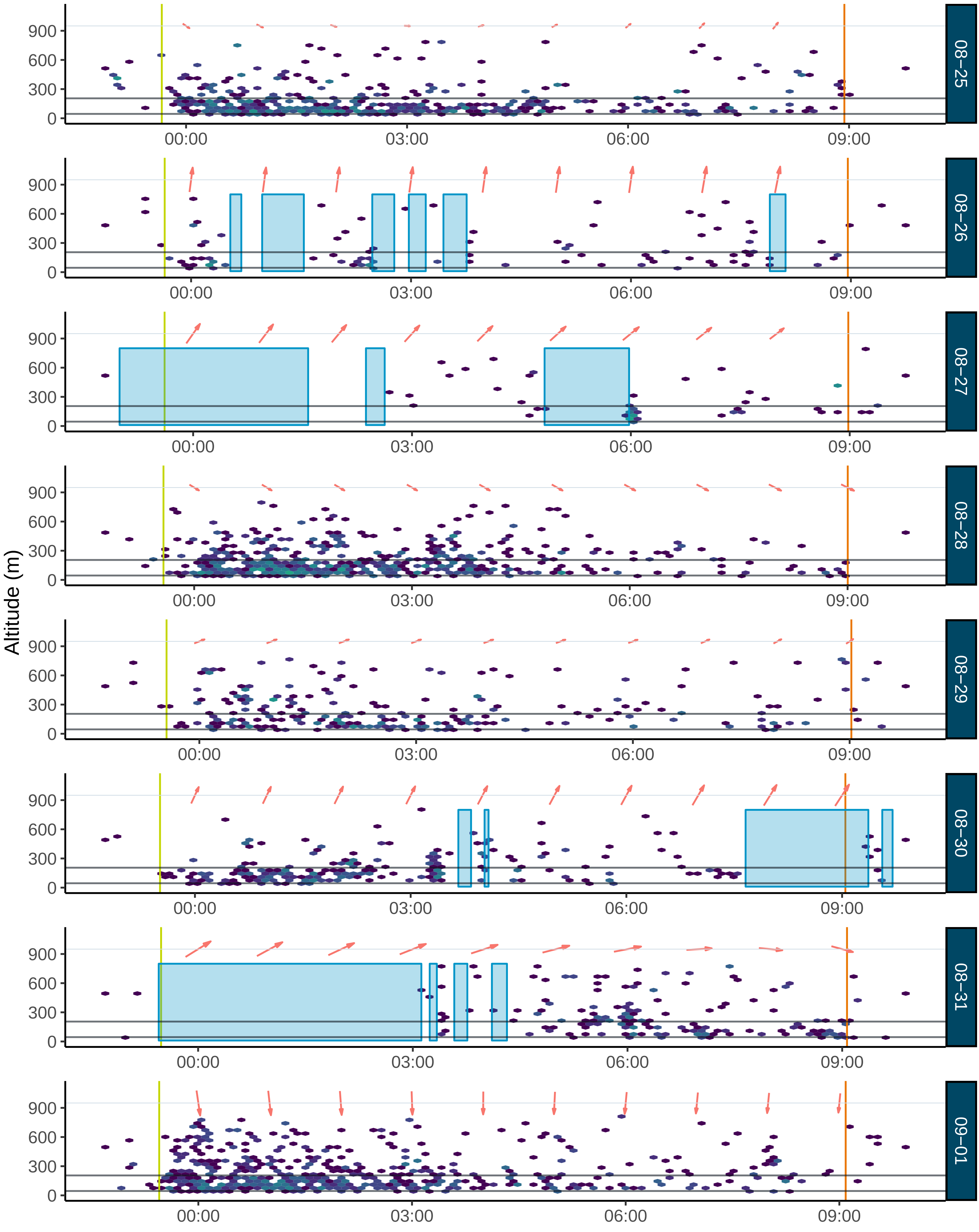
600
900



Altitude (m)
900
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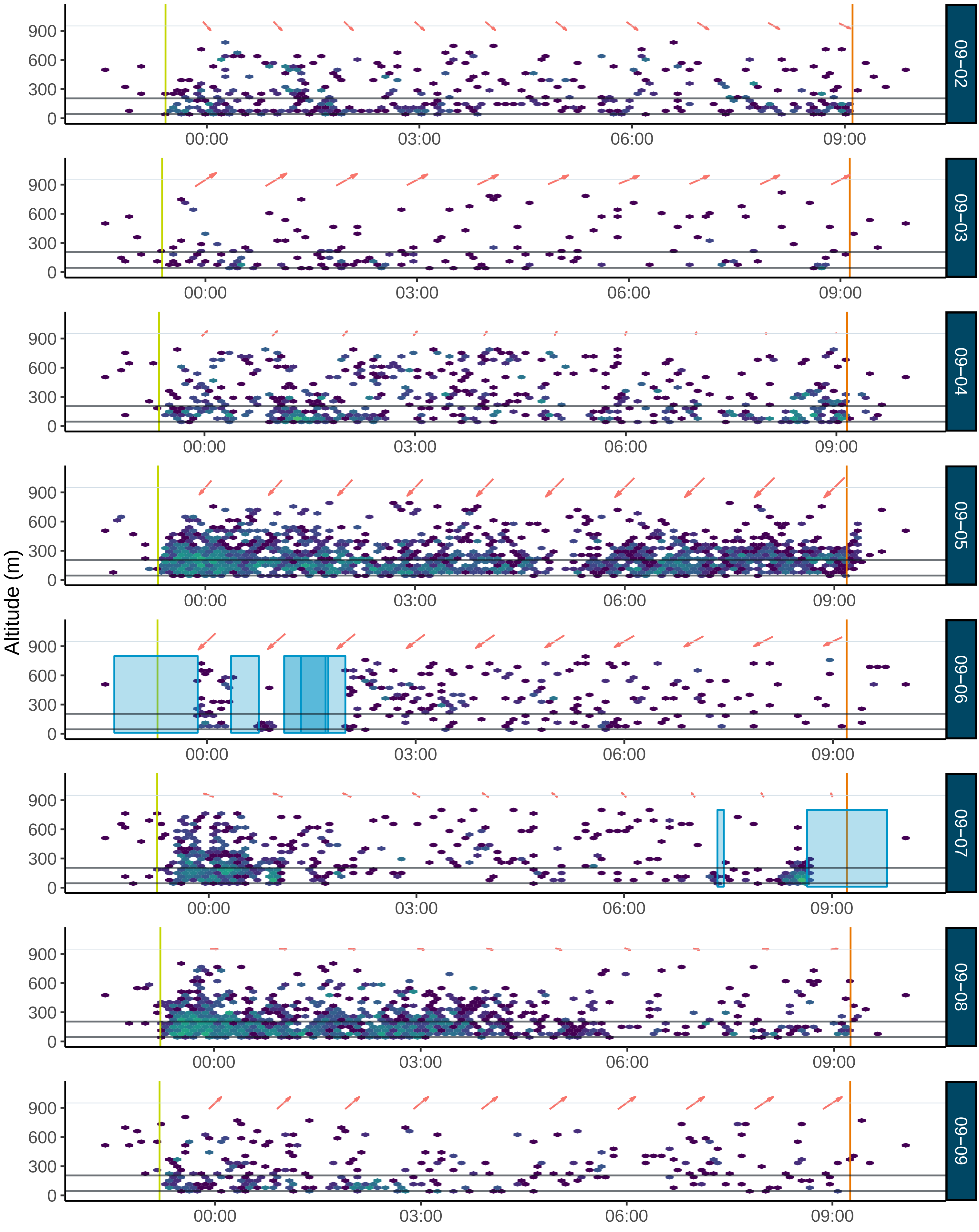
08−30
08−31
09−01


Altitude (m)
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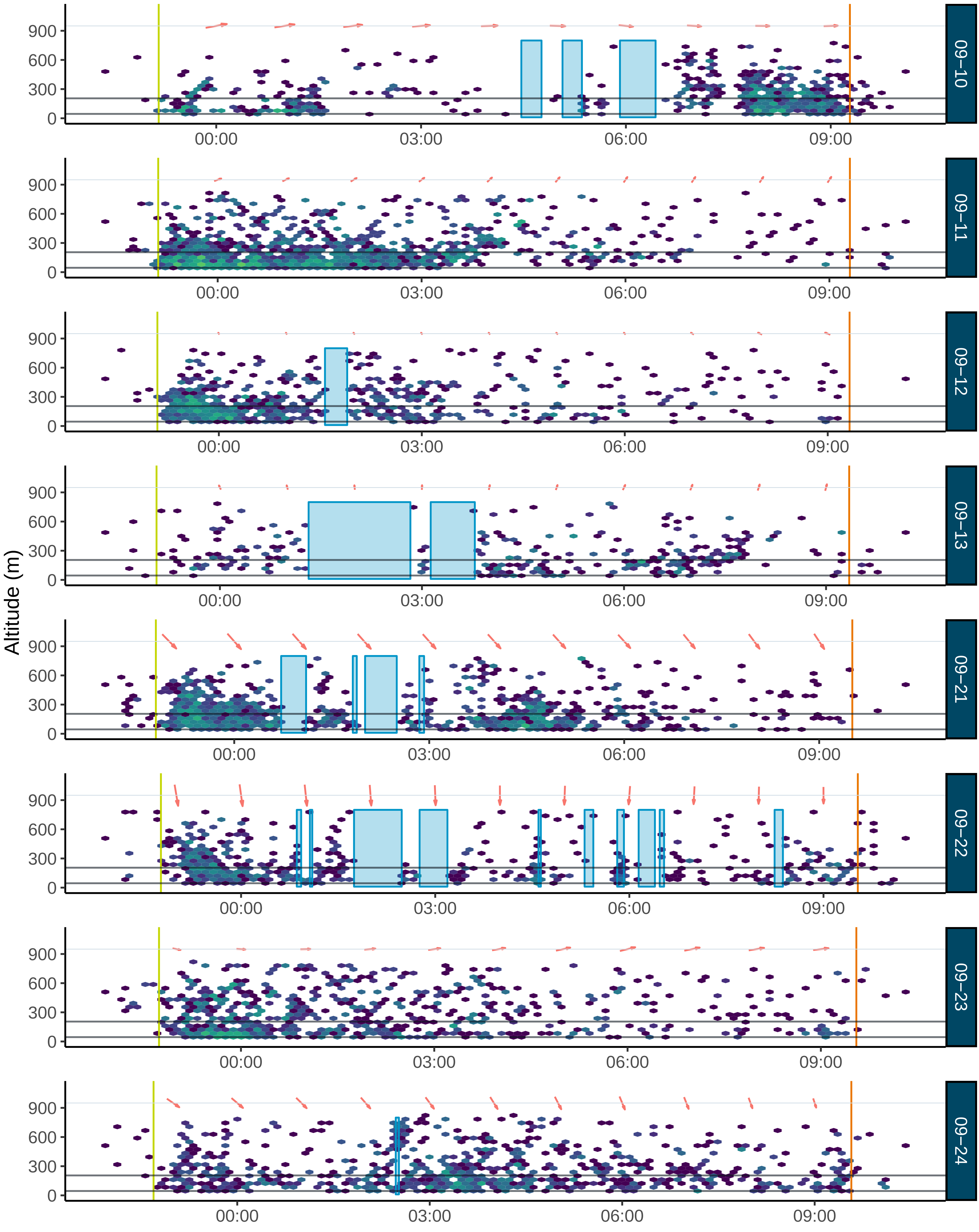
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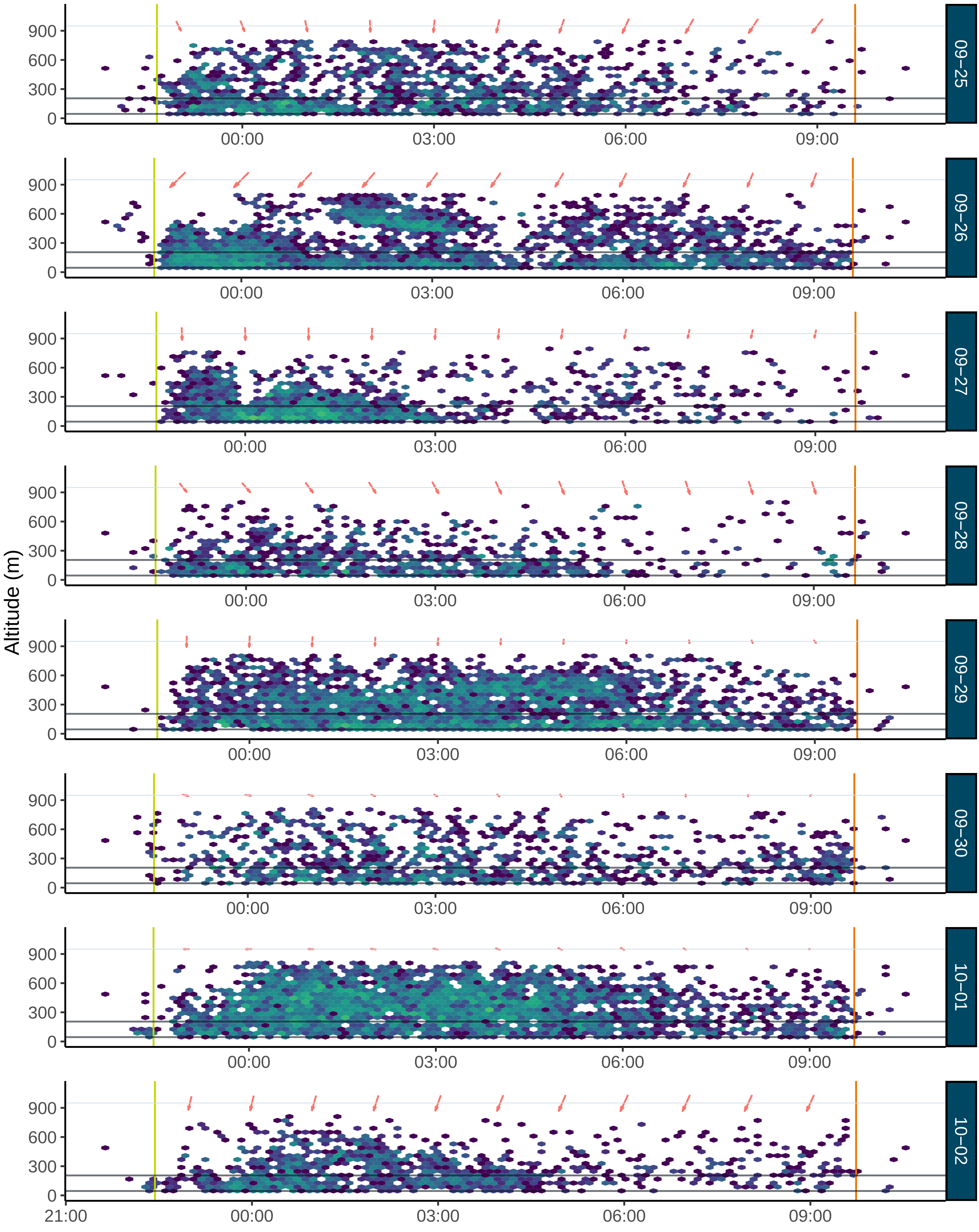

Altitude (m)
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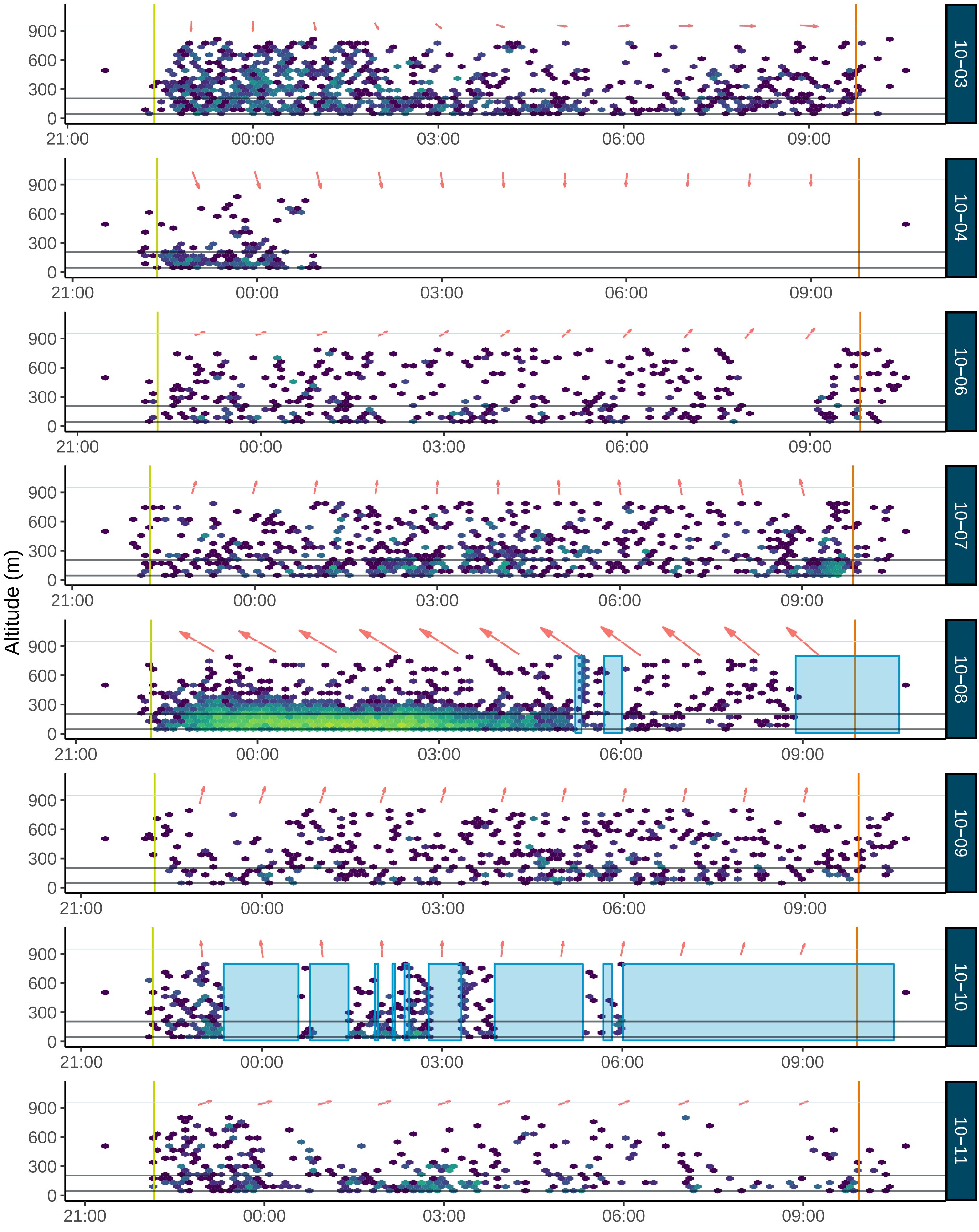
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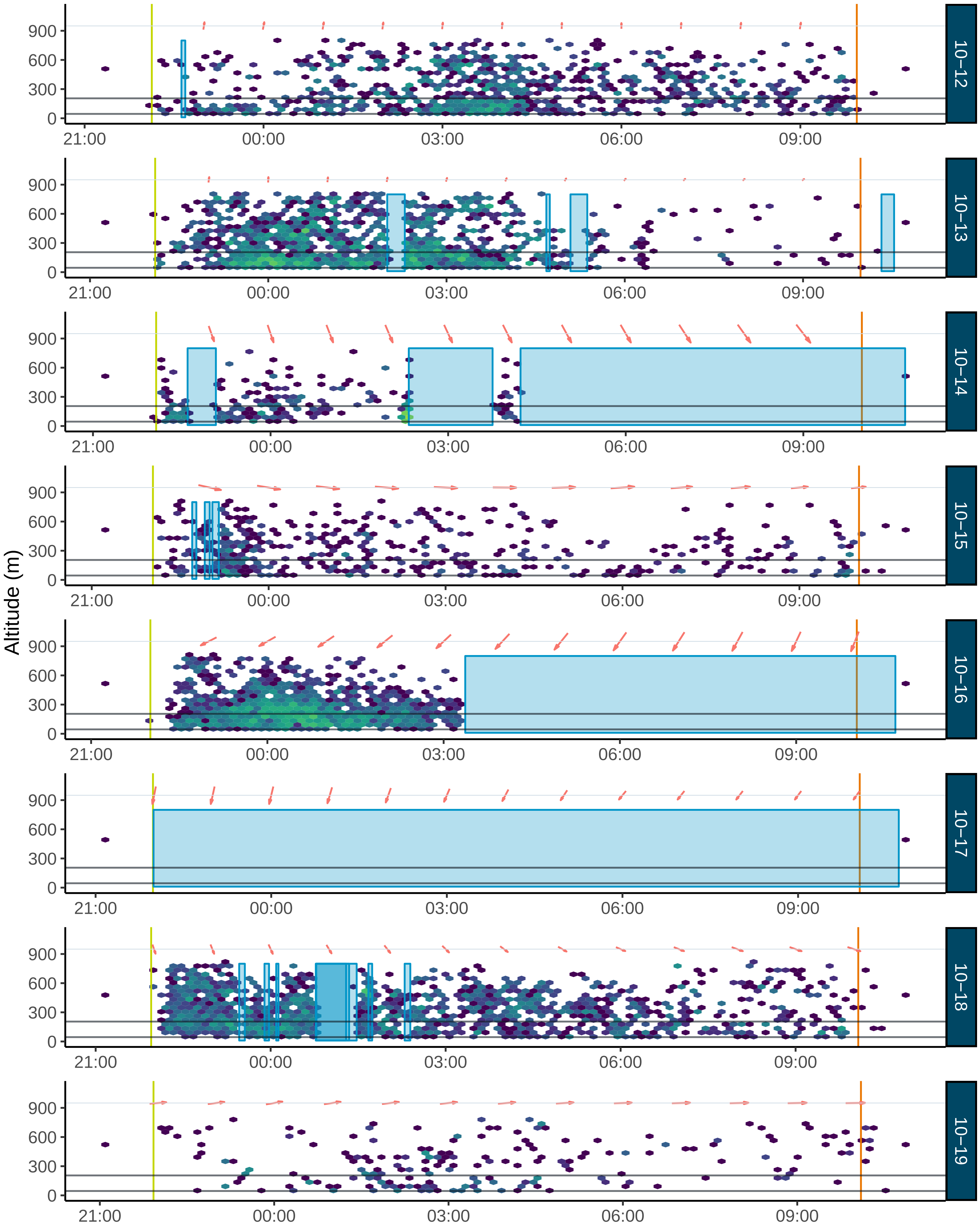
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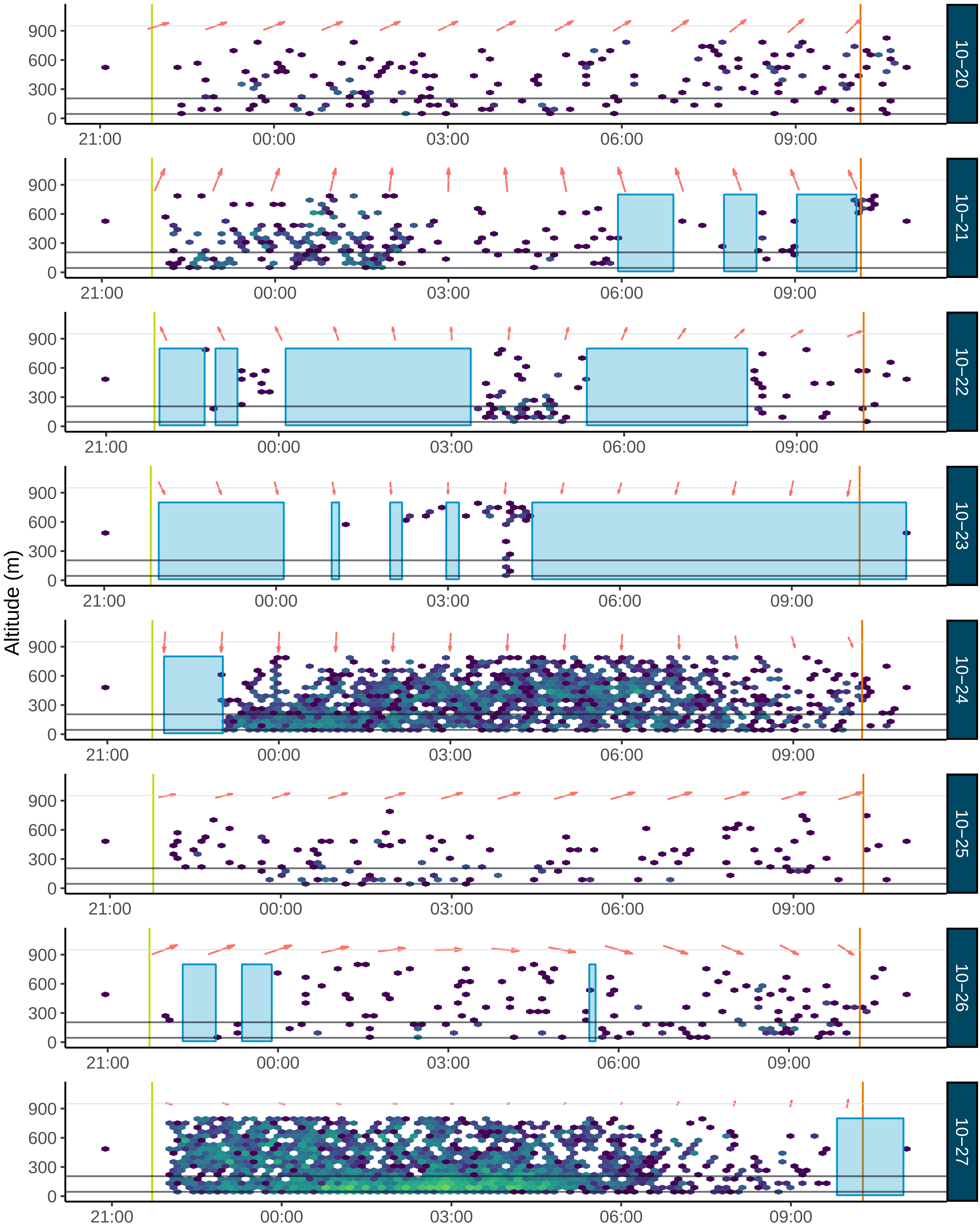

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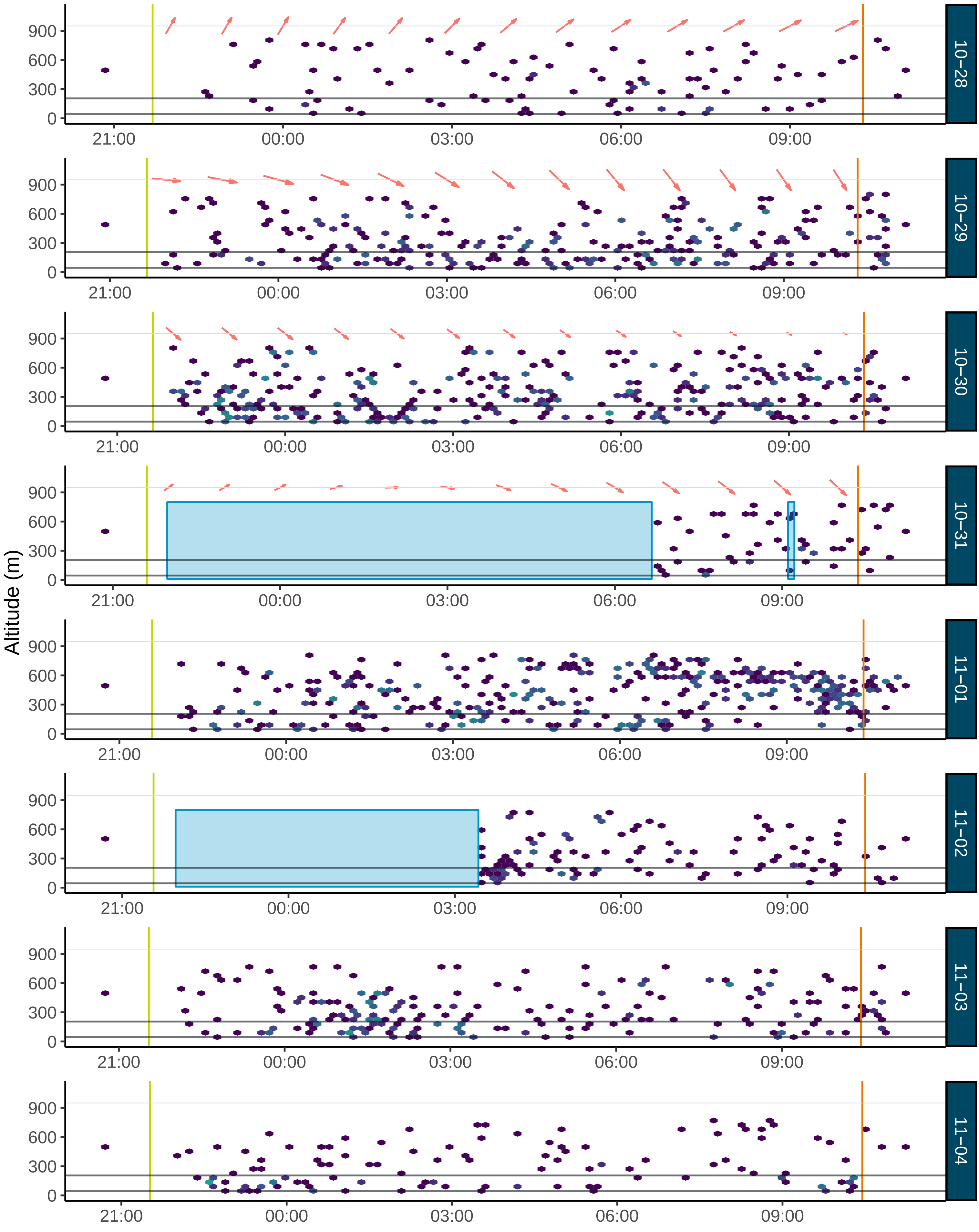

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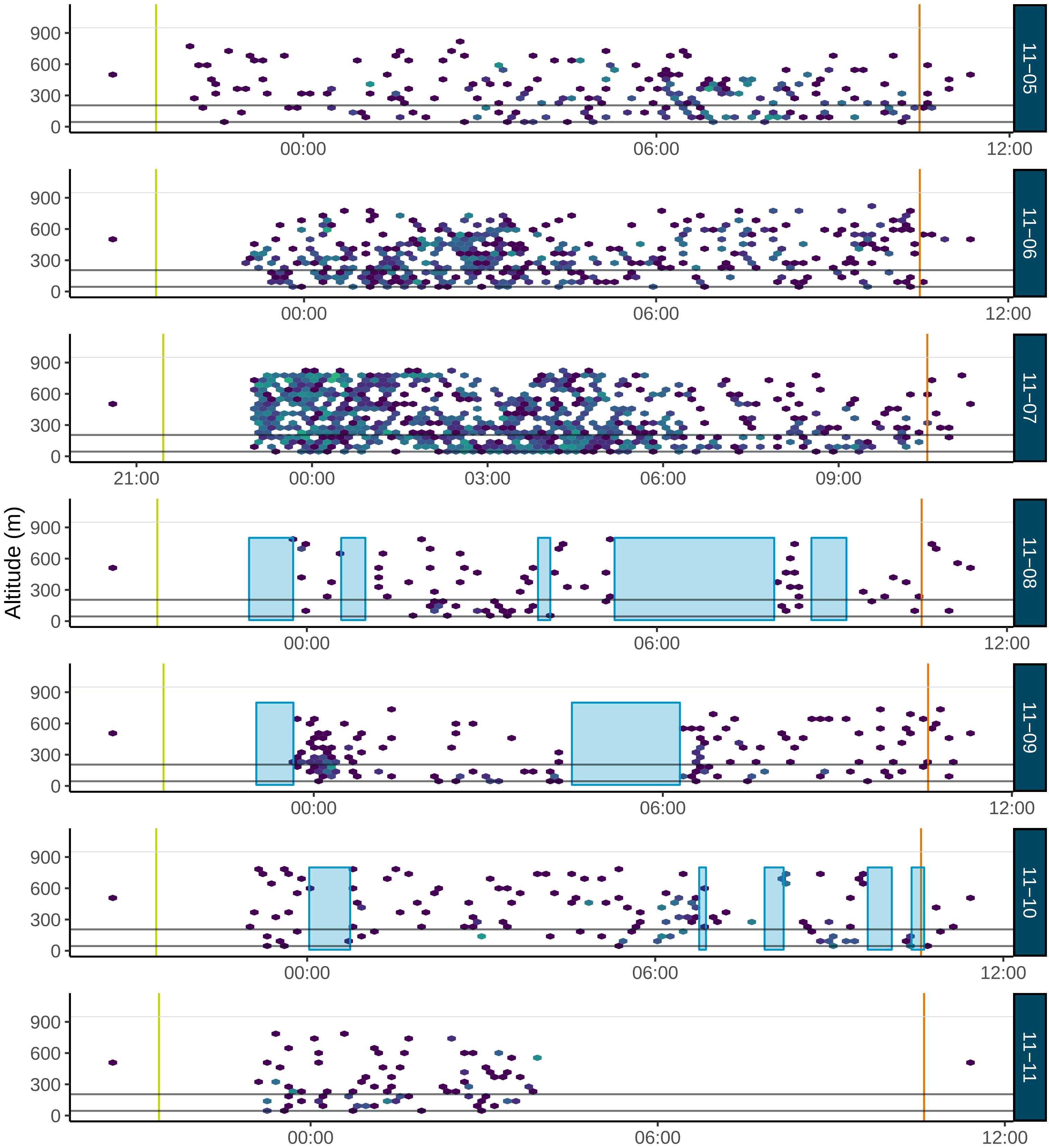

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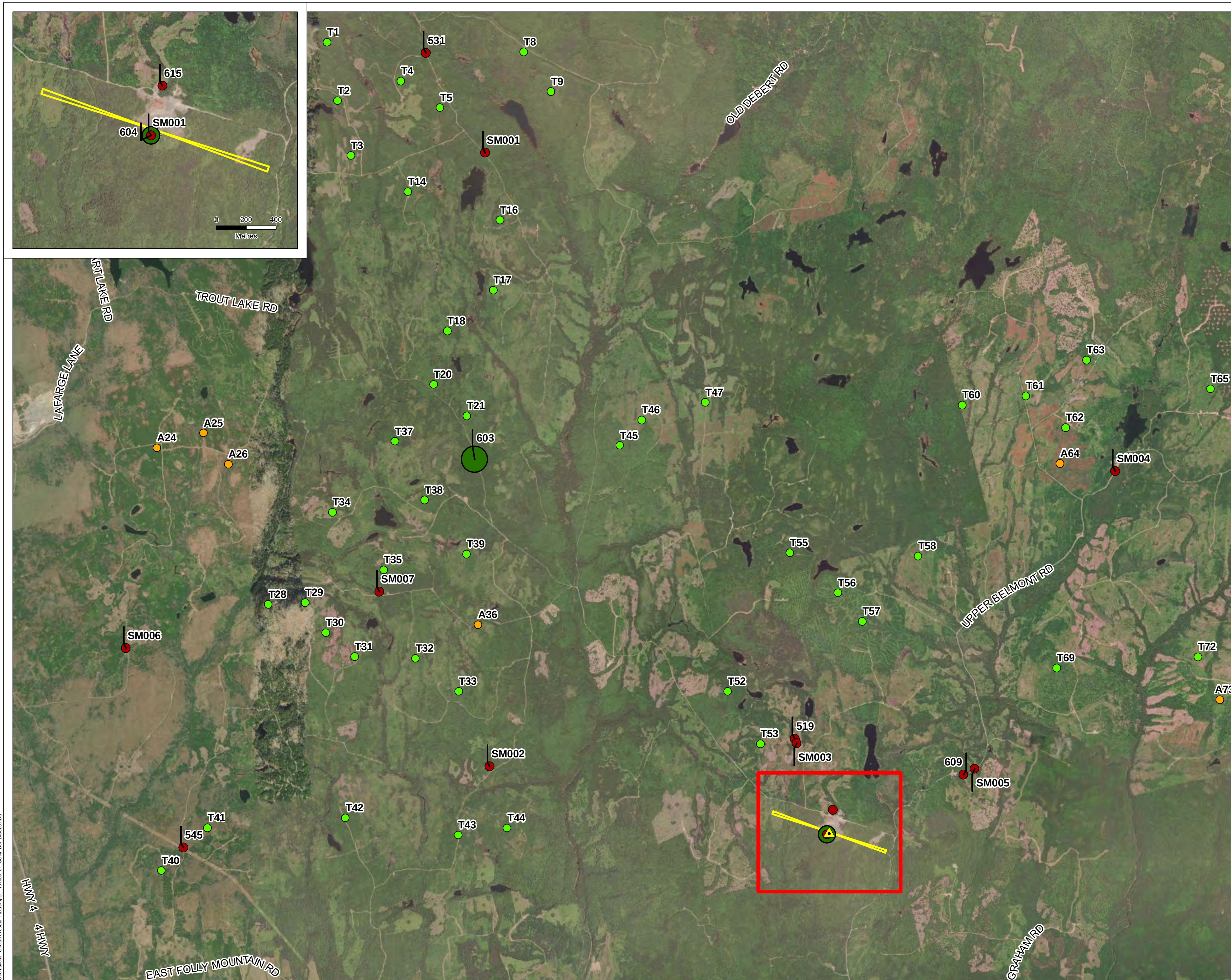
Appendix C

Common Nighthawk Detections Spring 2023



Windy Ridge Wind Project
Nova Scotia, Canada

Common Nighthawk Detections

Legend

- Alternative Turbine Location
- Turbine Location
- Radar Location
- Radar Beam

Common Nighthawk Detections

- Not Detected
- Few Detections
- Many Detections

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(s) - Prince Edward Island
- Aerial Image: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

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Windy Ridge Wind Limited

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