Ausenco

ROA 2023 Radar and Acoustic Monitoring

Prepared for:

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Project No. 106536-02

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Disclaimer

This work was performed in accordance with Proposal 2202133 between Ausenco Sustainability ULC, a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and ABO Wind Canada LTD (Client), dated [March 7th 2023] (Contract). This report has been prepared by Ausenco, based on fieldwork conducted by Ausenco, for sole benefit and use by ABO Wind Canada LTD. 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

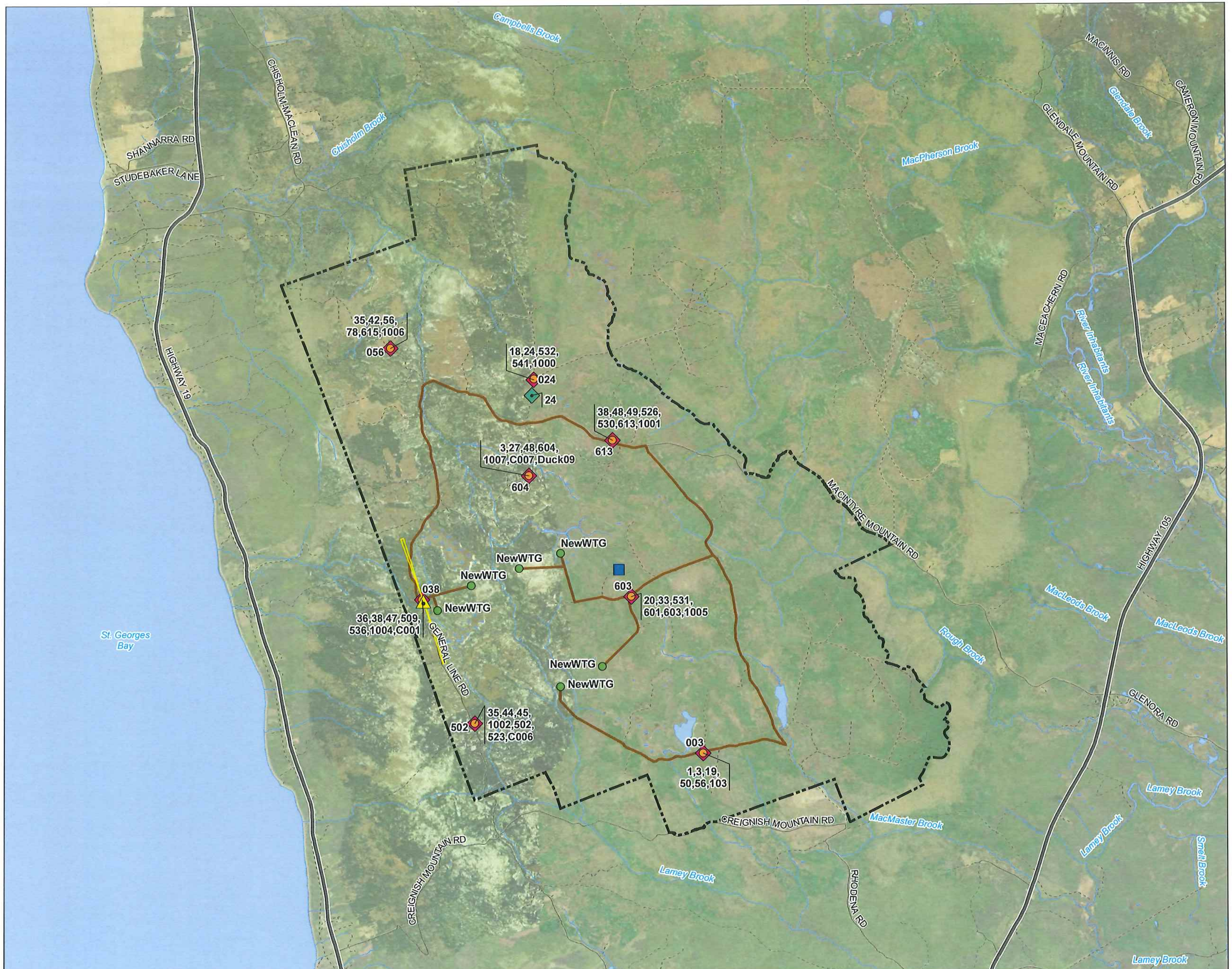
ABO Wind Canada LTD retained Ausenco Sustainability ULC (Ausenco), to conduct spring and fall radar and acoustic monitoring of nocturnally migrating birds at the proposed Rhodena Wind Project in 2023. Ausenco conducted this work with the technical support of Dr. Phil Taylor of Tabanid Consulting Ltd.

This report provides a summary of the data collected during spring and fall 2023 and an assessment of risk to nocturnally migrating birds at the Project as per Environment and Climate Change Canada (ECCC) 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 measured by radar surveys 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 to understand if collision risk increases under certain weather conditions.

1.1 Project Details

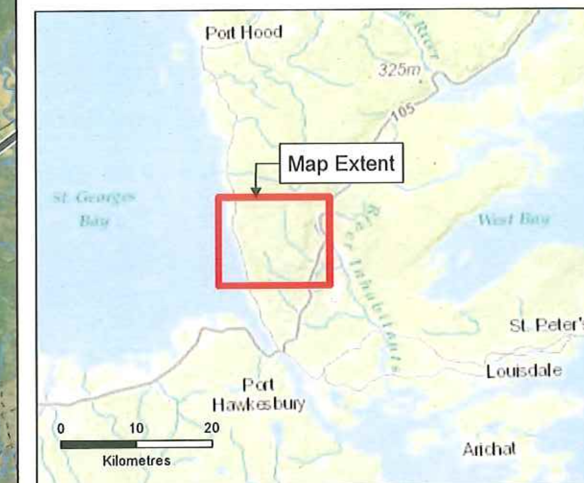
The Project area is located in Inverness County on the eastern side of St. Georges Bay, approximately 15 kilometres (km) north of the Town of Port Hastings (**Figure 1.1**). The Project includes several access routes with connector lines from Rhodena Road and General Line Road, and a substation with a connection line to the high-voltage lines approximately 200 metres (m) east from Highway 105 across Macintyre Road.

ABO Wind Canada LTD proposes to install and operate six Nordex N163 turbines, each with an individual energy capacity of 6.8 megawatts (MW). The total Project rated capacity will be up to 40.8 MW. Turbine models being considered have an approximate maximum height of 200 m above ground level (agl), which includes a tower height of 120 m and a blade length of approximately 80 m.



Rhodena Wind Power Project

Project Area



Legend

- Radar Location
- Radar Beam
- Acoustic Sensor (Fall Deployment)
- Acoustic Sensor (Spring and Fall Deployment)
- Wind Turbine Generator
- Wind Turbine Generator (Deployment 5 Fall 2023)
- Substation
- Access Road
- Project Area

Basemap Layers

- Highway
- Road
- Trail
- Mapped Watercourse
- Mapped Waterbody
- Mapped Wetland

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) - Nova Scotia
- Project Features: ABO Wind Canada Ltd, 2022
- Basemap: ESRI World Imagery
- Inset Basemap: ESRI World Topographic Map

N

1:45,000

0 500 1,000 1,500 2,000 2,500

Metres

NAD 1983 UTM Zone 20N

Page Size: 11" x 17"

106536-02	Production Date: Jan 16, 2024	Figure 1.1

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ABO Wind Canada Ltd

1.2 Regulatory Context

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 (NS Environment). 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).

Key federal legislation relevant to environmental aspects of wind energy development includes the *Migratory Birds Convention Act* [SC 1994, c 22] (MBCA), which protects nearly all migratory songbirds, the Migratory Birds 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 and assessment of impacts to multiple avian species groups which use coastal regions.

2.0 Methods

This study uses radar and acoustic monitoring to evaluate the number and species of birds 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 electromagnetic pulses (the radar beam) are recorded when the radar beam reflects off an 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 nocturnally migrating 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 in 2023. 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 sample as much of the airspace above the Project as possible. 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 346 degrees from true north, which meant that the radar beam was projecting 256 and 76 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.

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 passage rates and flight heights at other wind energy projects (Ausenco Sustainability ULC 2022; Hemmera Envirochem Inc. 2021).

Raw radar data (i.e. unprocessed radar scans) were stored locally on a solid-state drive (SSD) 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 have 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. These 'raw' data are stored locally on an SSD drive for backup. 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. Hourly files are uploaded automatically to a remote cloud-based server, where they can be downloaded at any time by analysts for further processing.

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 from 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 50 m agl are filtered out because they are often masked by ground clutter and are located below the RSZ of turbines. 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 as the birds fly through the sensor microphone's detection cone. These data are used in conjunction with the radar data to determine the avian species and species groups migrating through the area.

2.2.1 Acoustic Data Collection

AudioMoth™ full-spectrum acoustic recorders were deployed to detect migrating bird calls at 11 sampling locations in 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 in 2023. 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 digital) 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 make direct copies of those cards 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. These 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 second 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 species detected (and retained), along with estimated values of precision and recall used for each, are 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*) ▫ CommonYyellowthroat (*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 et al. (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 et al. 1950; Muller 1976; Åkesson & 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; Åkesson *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 40 and 200 m).

Targets below 70 m 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" (Pennycuick 1968), using flight direction, flight speed, wind direction and wind speed as input variables. Since the exact flight trajectories 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 was 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 46 nights between April 27 and June 15, 2023, and fall migration was observed for a total of 117 nights between July 13 and November 15, 2023. The radar functioned properly during all spring nights and approximately 94 percent of all nights during the fall. During spring migration eight Audiomoths recorded successfully during all nights between April 21 and June 15, and during the fall migration eight Audiomoths successfully recorded all nights between July 13 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 greatest flight volumes were observed between late April and early June, and greatest proportion of flights within the RSZ was observed in late April and late May (**Figure 3.1**).

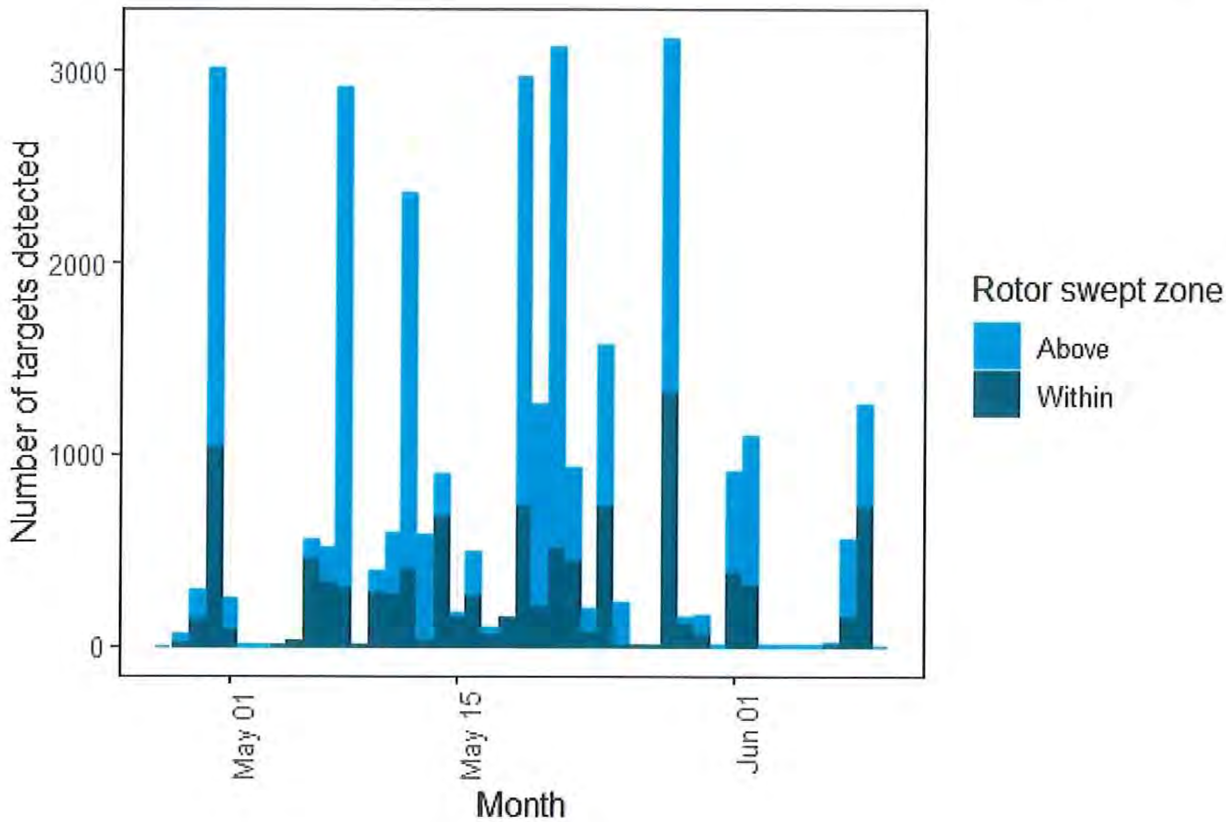


Figure 3.1 Radar detections per survey night during spring 2023

During the fall monitoring period the greatest flight volumes and greatest proportion of flights within the RSZ were observed in late September (**Figure 3.2**). 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. The radar data filters cannot remove all non-bird targets (see **Section 2.1.2**).

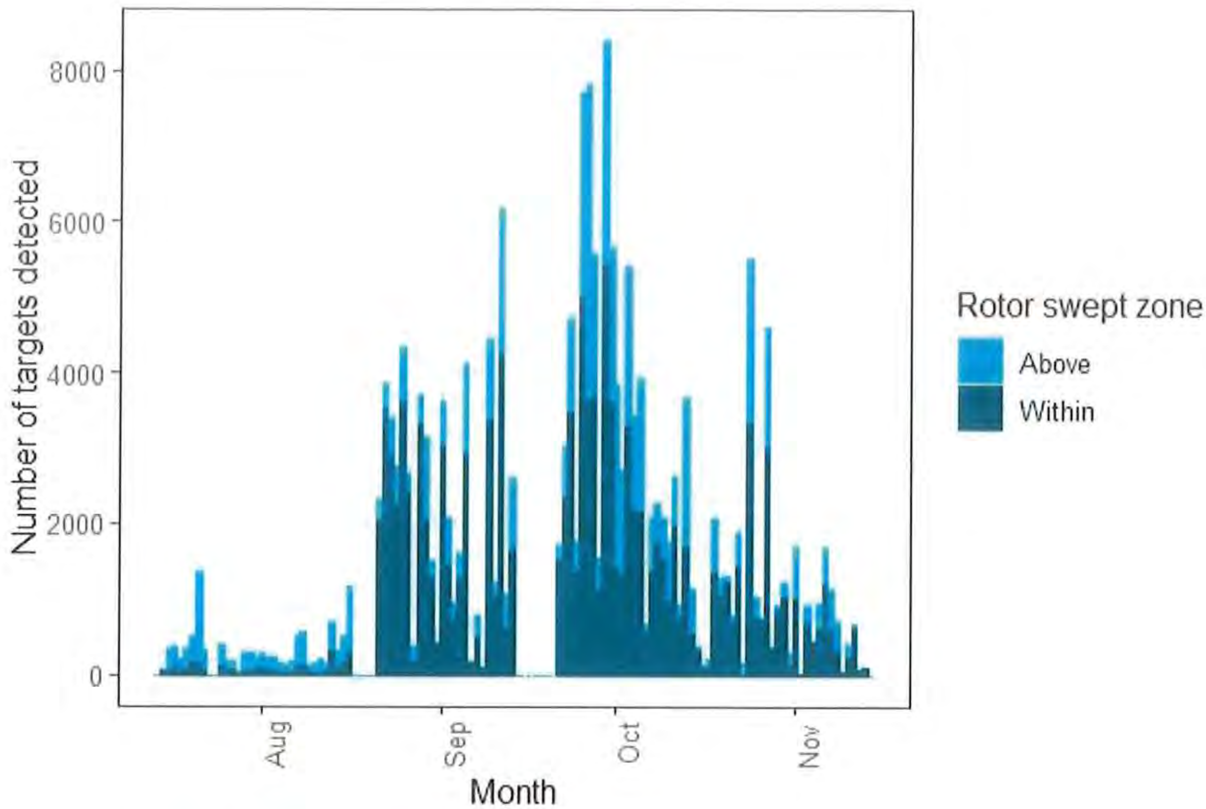
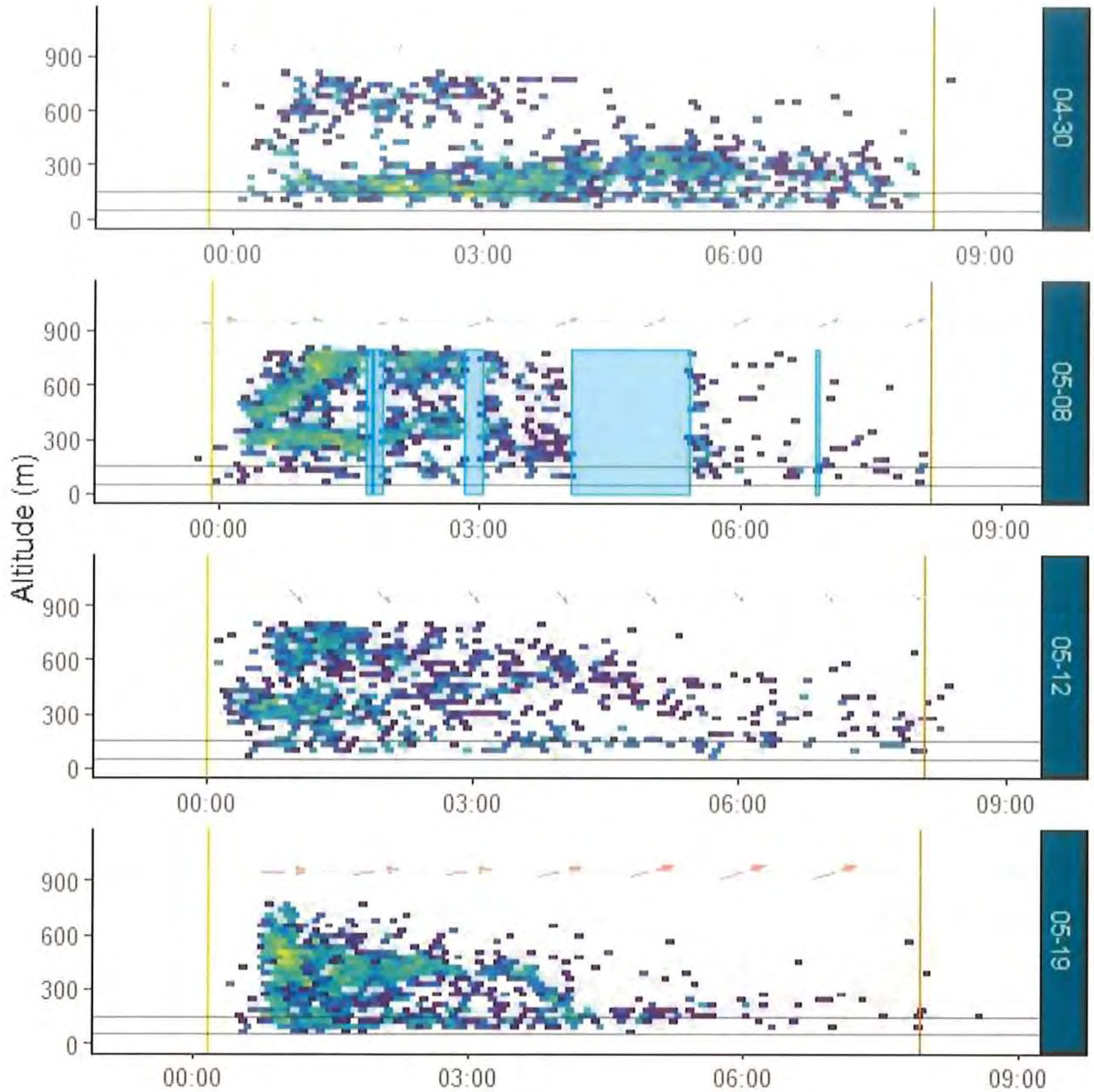


Figure 3.2 Radar detections per survey night during fall 2023

To illustrate how flight volumes can change throughout the night, radar data have been visualized for a subset of high-volume nights. For the spring migration these nights include April 30, May 8, 12, 19, 21 and 28 (**Figure 3.3**). During these selected nights, flight volumes were consistently higher at the start of the night. On May 8 migration was interrupted by four periods of rain as indicated by the blue boxes. The first period of rain was short and had little effect on the flight volumes, but flight volumes dropped noticeably after second and third period of rain. Flight volumes on May 21 were greatest at high altitude, which was likely caused by the strong tailwind as indicated by the red arrows. On May 28 the flight volumes were greatest at low altitude, which was likely caused by the strong headwind forcing the birds to fly low.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04-30
05-08
05-12
05-19

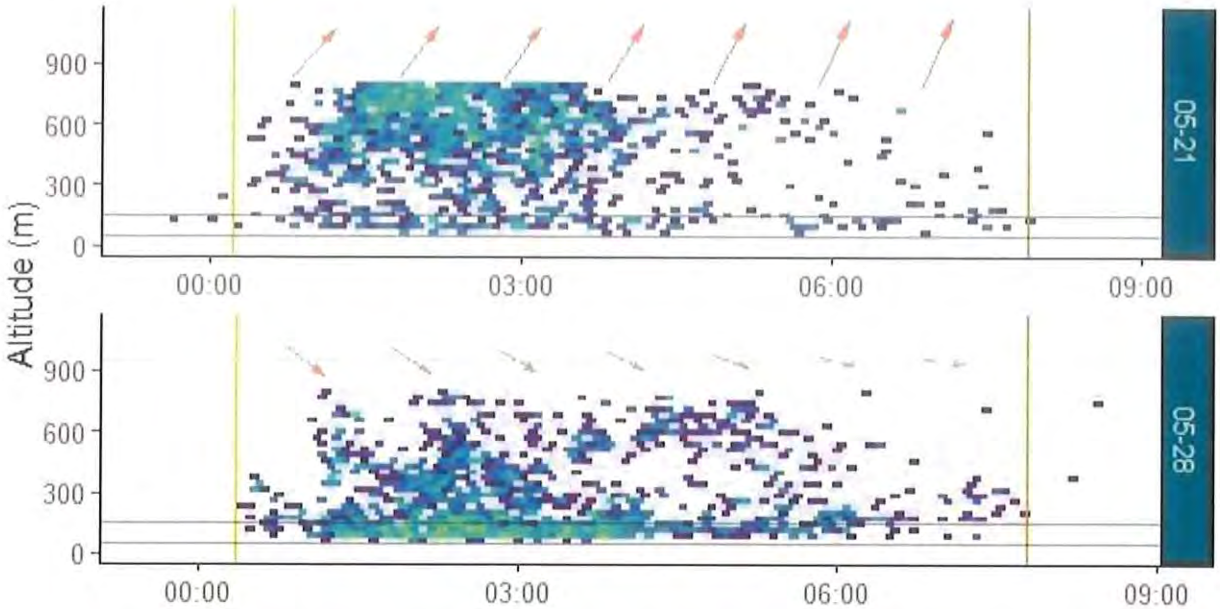
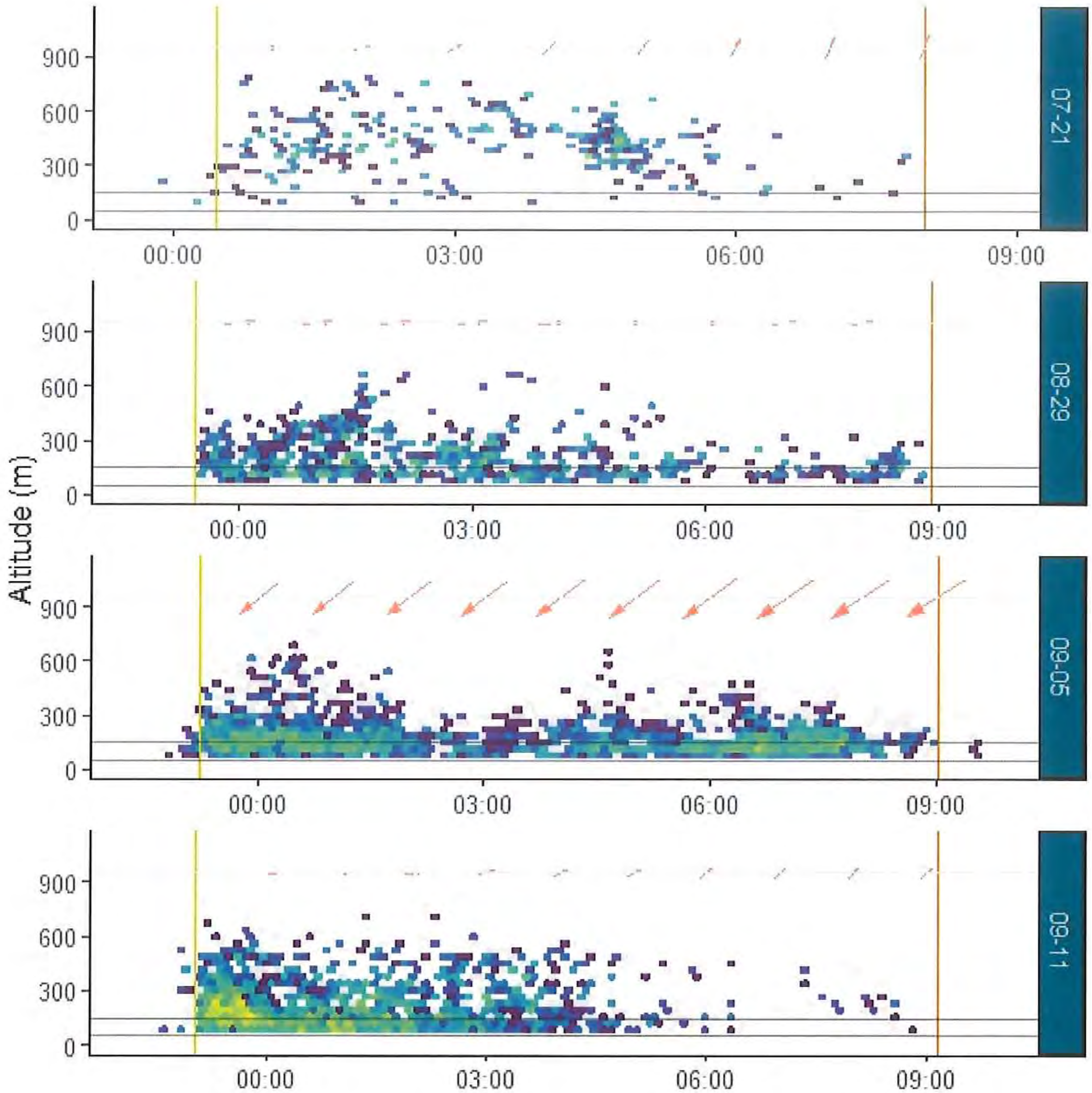


Figure 3.3 Targets detected by radar on April 30, May 8, 12, 19, 21 and 28

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 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 (arrow size) at approximately 700 m agl is indicated for each hour at the top of each plot.

For the fall migration, the nights of Jul 2, Aug 29, Sept 5, 11, 26, Oct 13, 24 and Nov 7 are presented (**Figure 3.4**). Flight volumes were consistently high at low altitude during most nights. Flight volumes on September 5 and 26 and on October 24 remained high at low altitude even though there was a strong tailwind on those days, during which birds usually benefit from flying at higher altitudes.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07-21
08-29
09-05
09-11

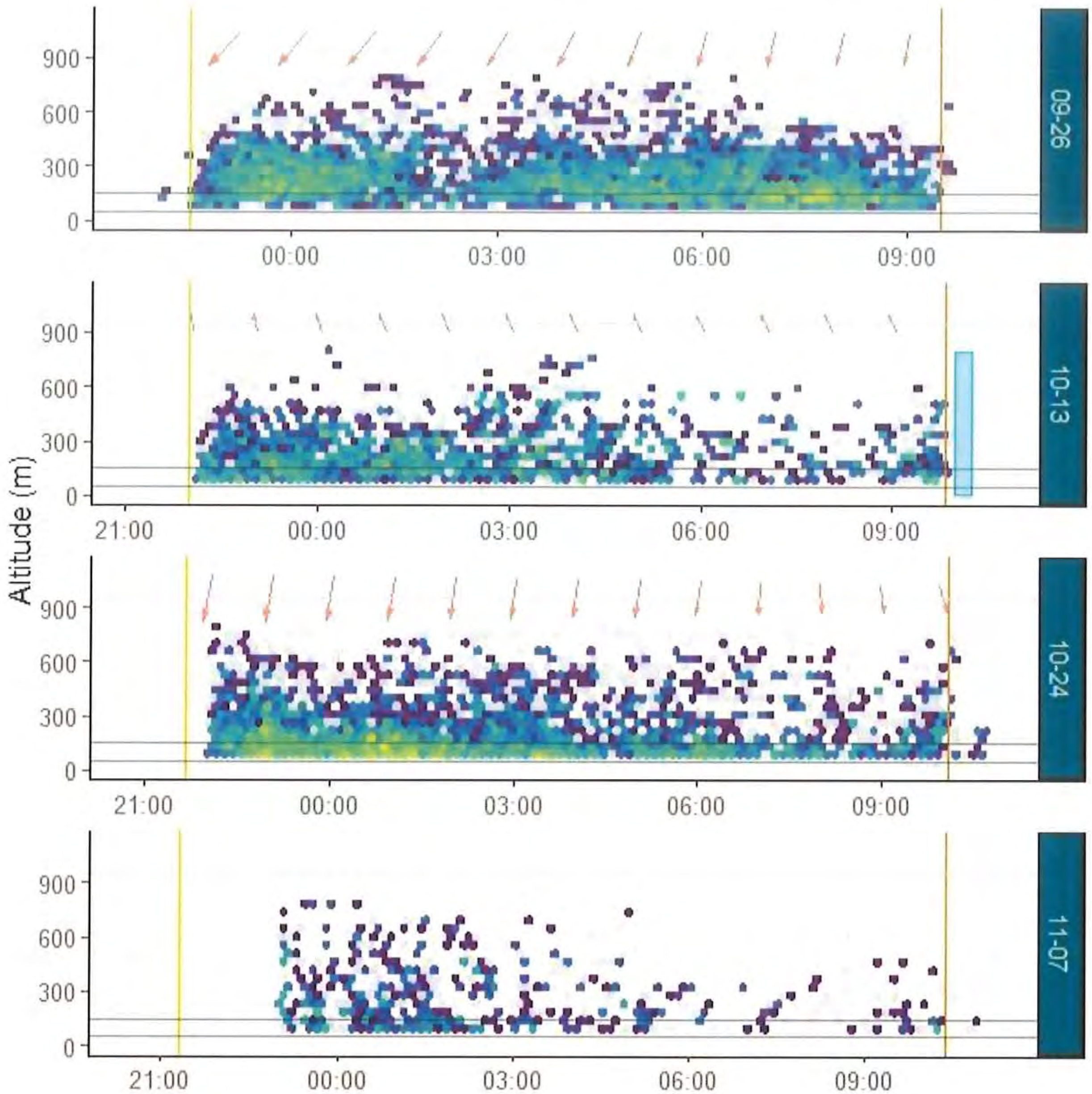

Figure 3.4 Targets detected by radar on Jul 21, Aug 29, Sept 5, 11, 26, Oct 13, 24 and Nov 7.

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. 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 (arrow size) at approximately 700 m agl is indicated for each hour at the top of each plot.

During the spring migration season flight volumes were greatest at altitudes between 100 and 200 m, with more than 4500 detections between 100 and 150 m (**Figure 3.5**). Although the flight volumes were greatest in these two 50 m altitude zones, flight volumes were cumulatively much greater above the RSZ than within the RSZ.

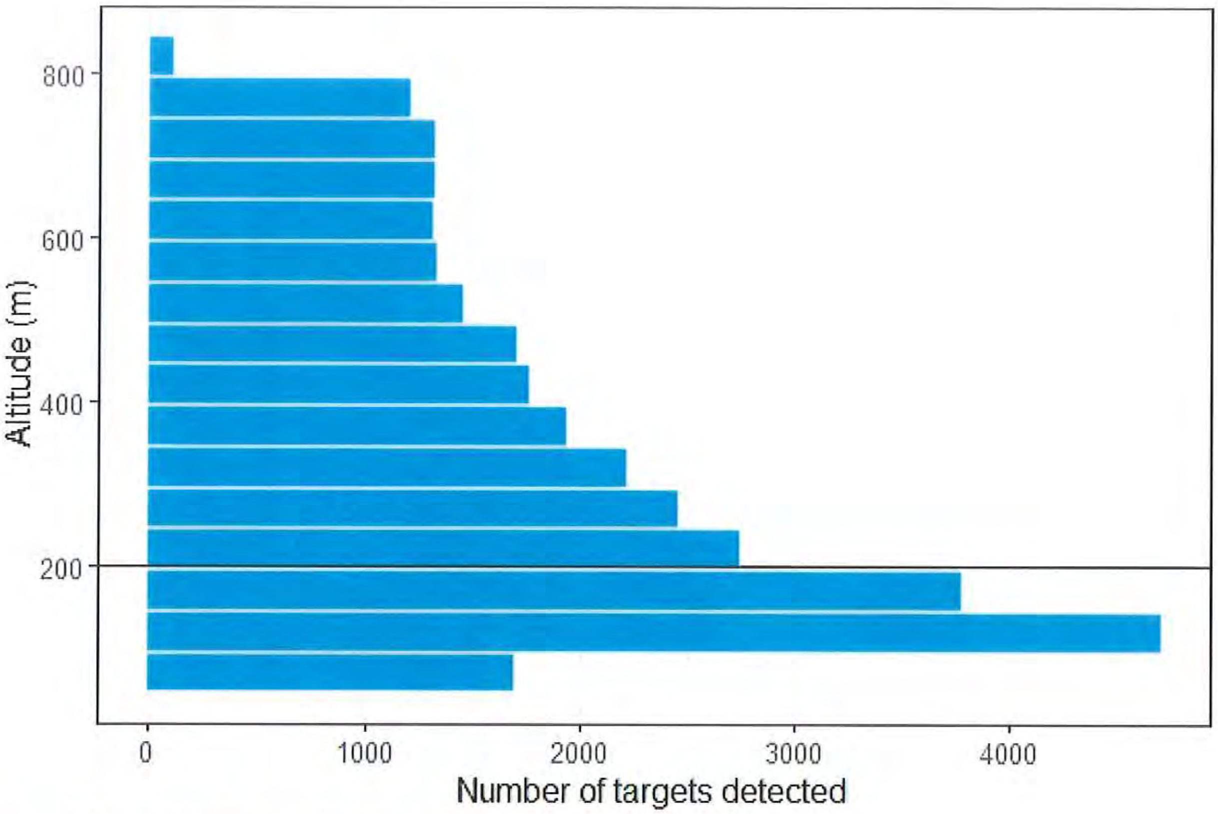

Figure 3.5 Altitudinal profile of targets detected in spring 2023

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

During the fall migration season flight volumes were greatest at altitudes between 70 and 150 m, with more than 60000 detections between 70 and 100 m (**Figure 3.6**). In contrast to the spring migration season the flight volumes above the RSZ are cumulatively not greater than flight volumes within the RSZ.

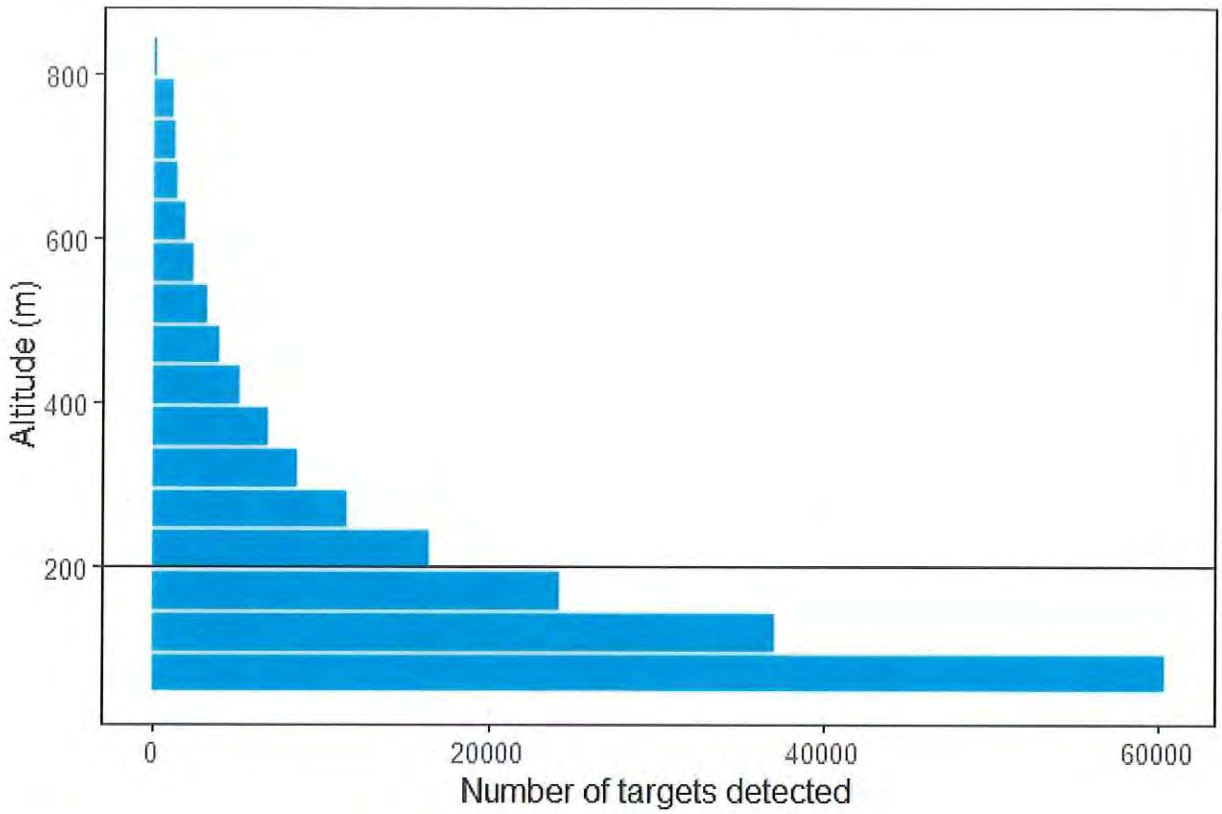

Figure 3.6 Altitudinal profile of targets detected in fall 2023

The x-axis shows the number of targets detected and the y-axis shows altitude bins measuring 50 m vertically. The maximum rotor sweep height of approximately 200 m is indicated with a black horizontal line.

The altitudinal profile of targets was observed to change from night to night, due to changing weather conditions. During most spring nights the flight volume is greater above the RSZ than below, except for May 28 where flight volumes within the RSZ are much greater than above the RSZ (**Figure 3.7**).

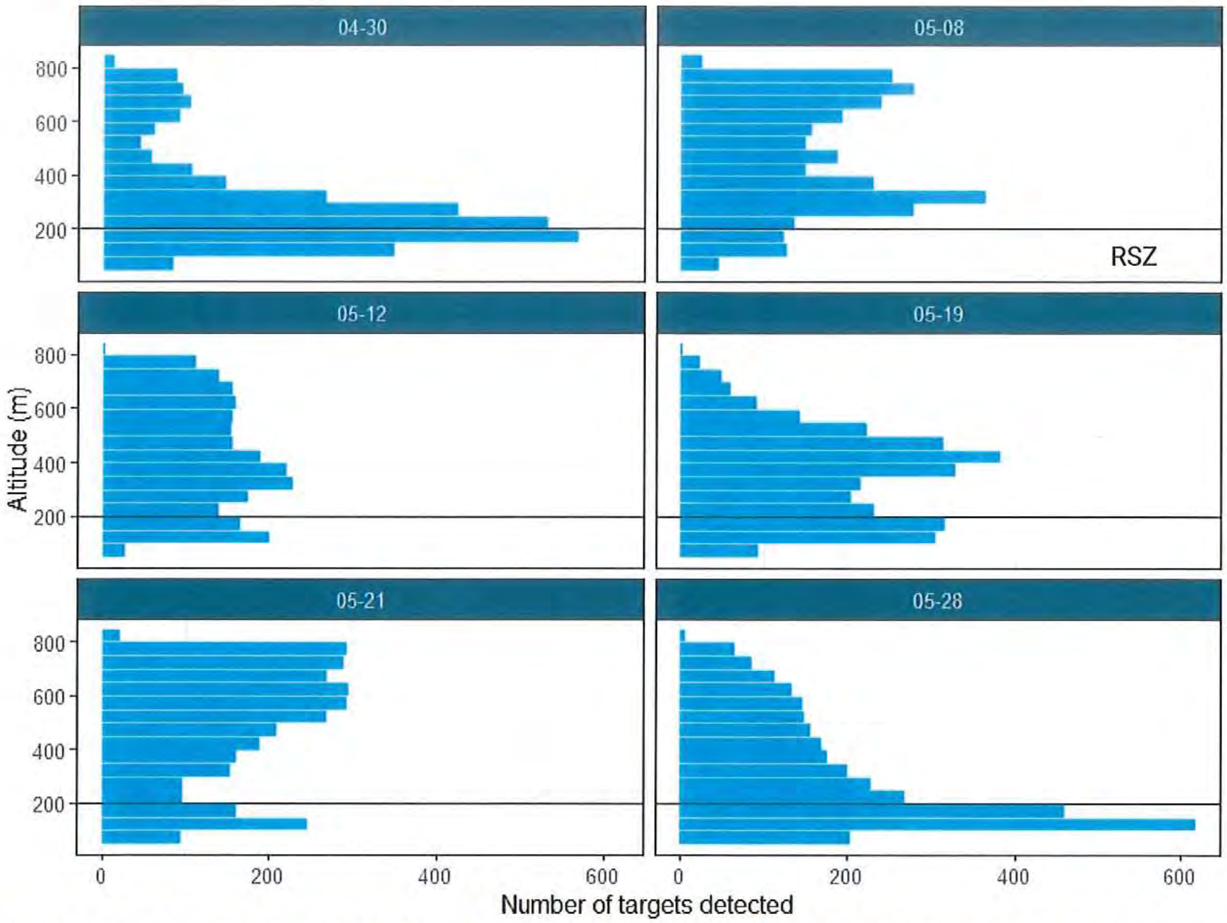

Figure 3.7 Altitudinal profiles of targets detected on April 30, May 8, 12, 19, 21 and 28, 2023

In contrast to the spring migration the flight volumes were greatest within the RSZ at most nights during the fall migration, except for July 21 (**Figure 3.8**).

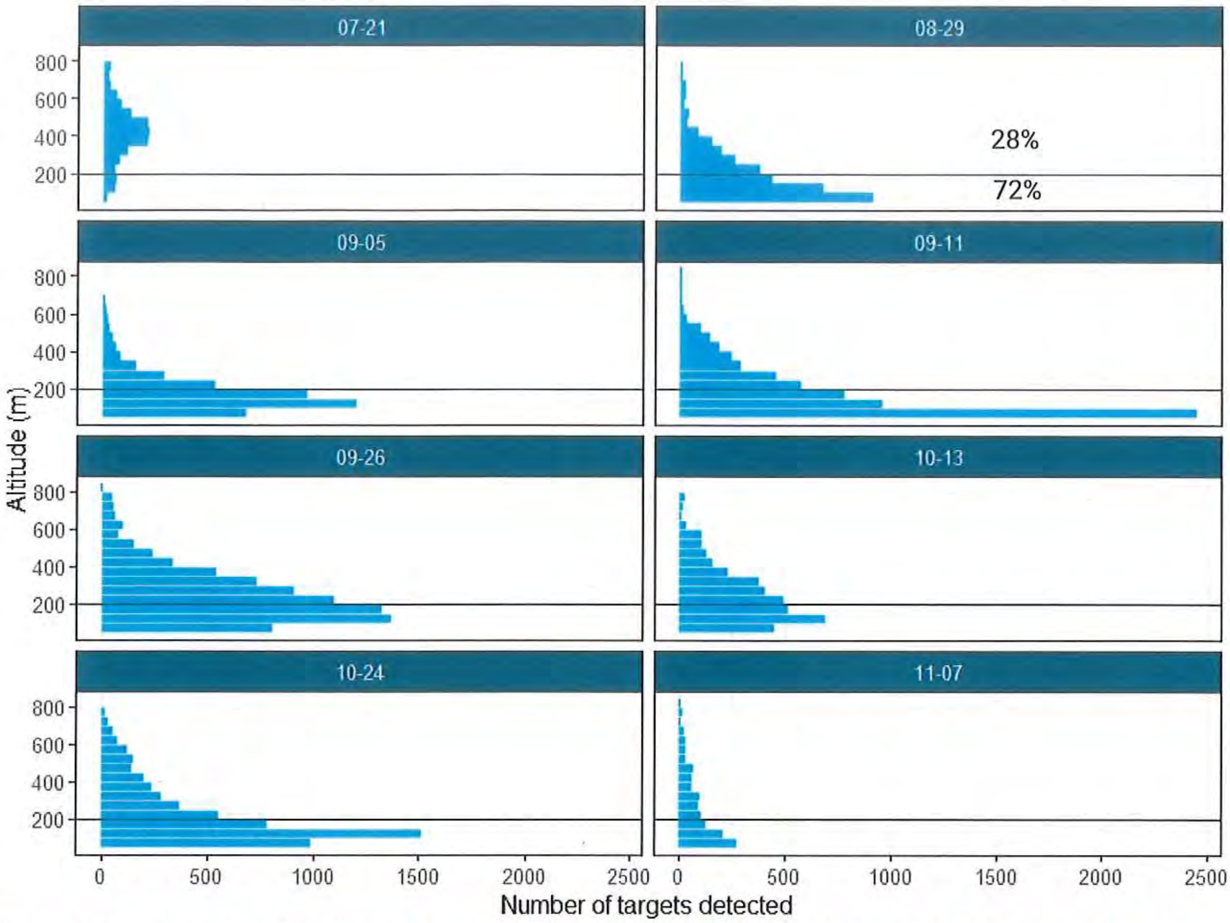

Figure 3.8 Elevational profiles of targets detected on Jul 21, Aug 29, Sept 5,11,26, Oct 13, 24 and Nov 7, 2023

During spring migration flight volumes increase steeply with tailwind during all periods of the night in May, during the middle of the night and sunrise in April, and no increase can be observed in June (**Figure 3.9**). During fall migration target detections increased steeply during all periods of the night in all months, except for sunrise in July (**Figure 3.10**).

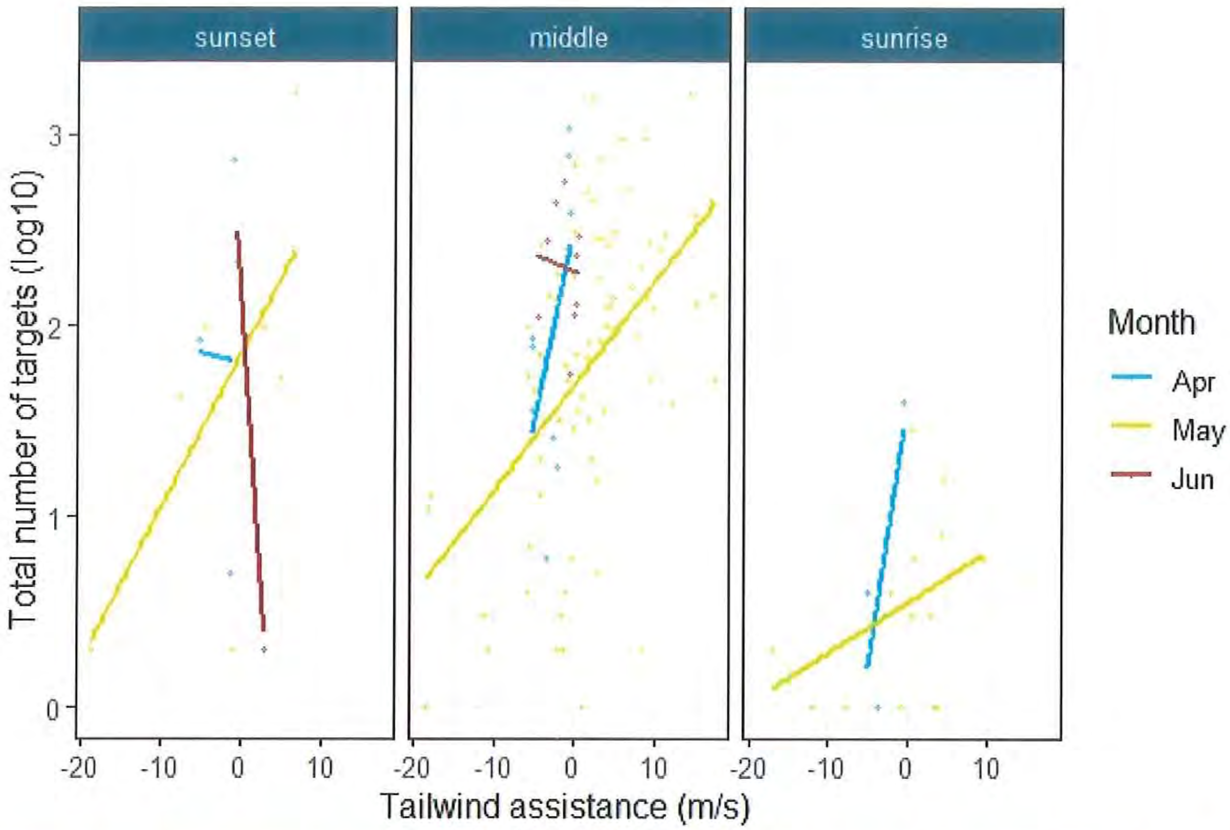

Figure 3.9 Relationship between tailwind assistance and the total number of targets across time of night and season during spring 2023

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 in metres per second (m/s). Horizontal lines indicate no effect from tailwind assistance on total number of targets and inclining lines mean a positive effect from tailwind assistance on total number of targets.

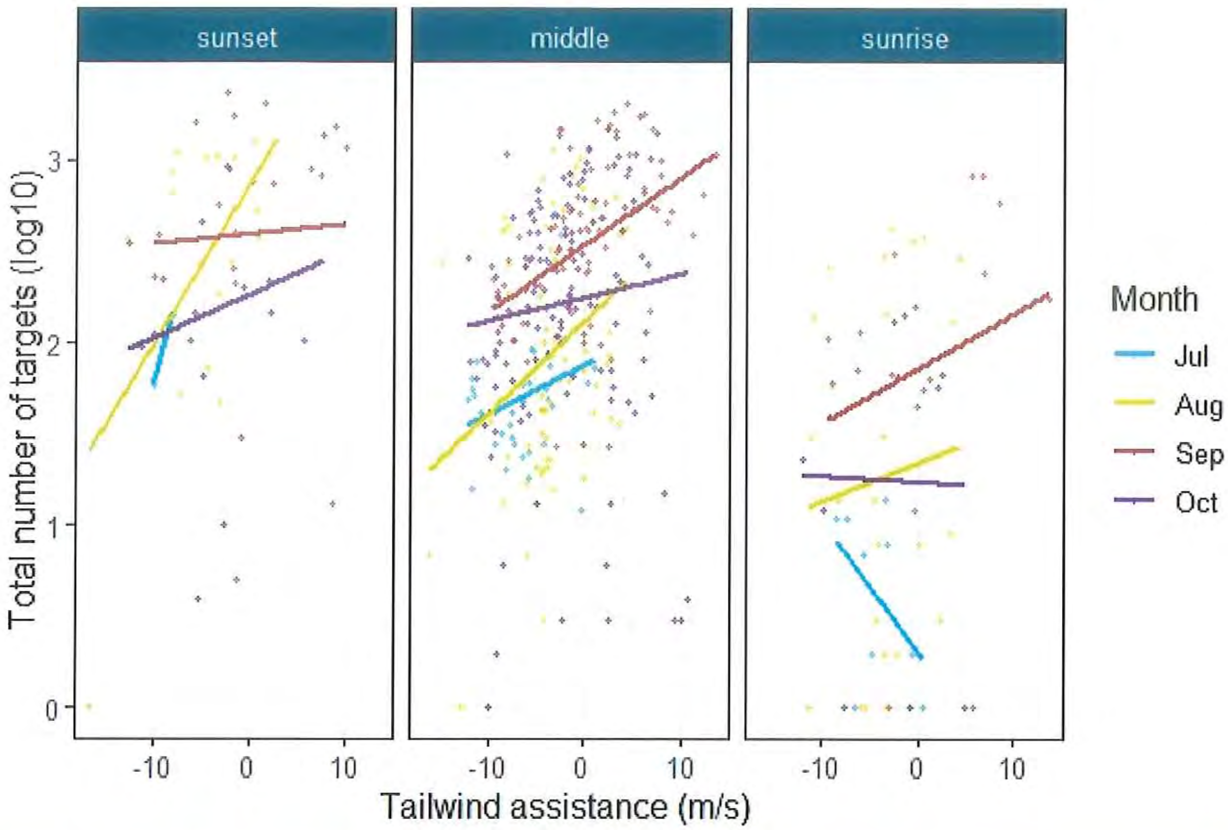

Figure 3.10 Relationship between tailwind assistance and the total number of targets across time of night and season during fall 2023

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 in metres per second (m/s). 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 RSZ increases with headwinds, which is especially noticeable during sunset (**Figure 3.11**). This matches with the patterns observed on May 28 where most of the targets were detected within the RSZ during strong headwinds (**Figure 3.3**). A similar pattern is observed during the fall migration, although the proportion of targets within RSZ is generally much greater (**Figure 3.12**).

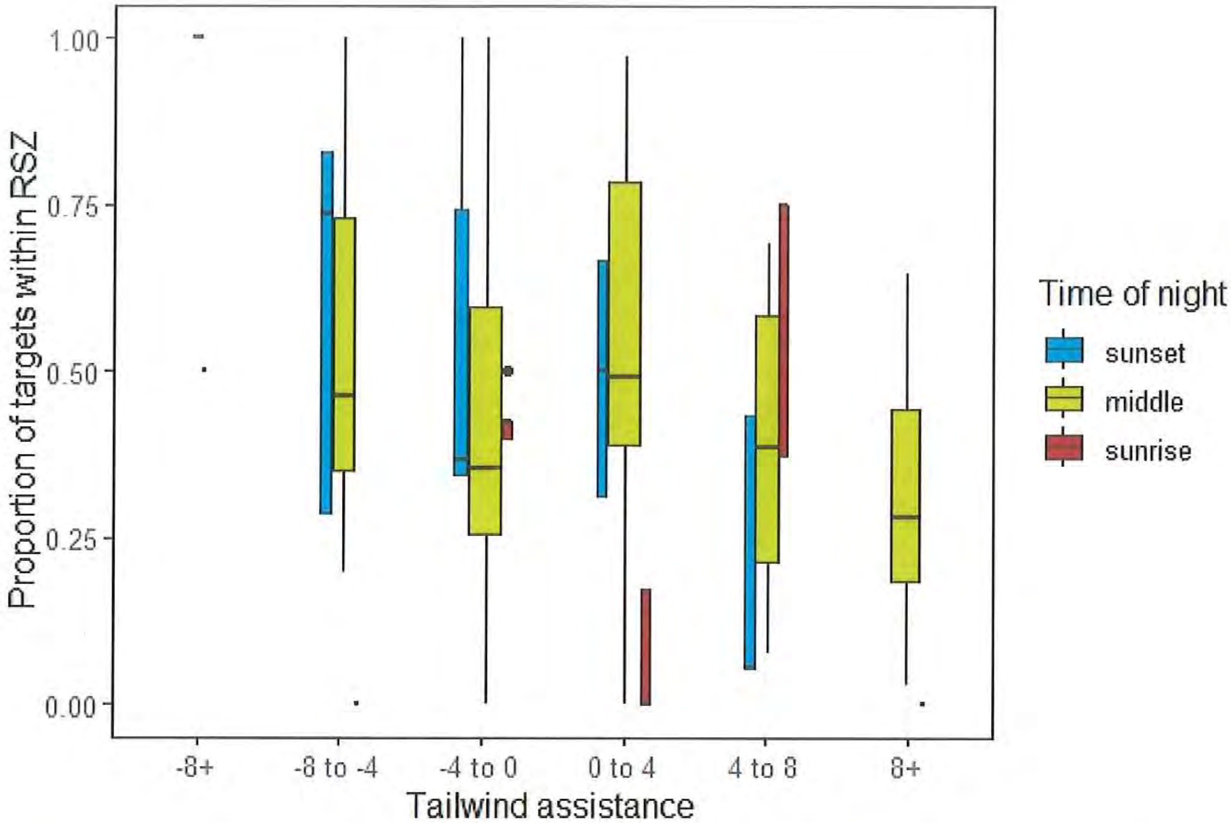

Figure 3.11 Relationship between tailwind assistance and the proportion of targets within RSZ across time of night during spring 2023

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 blue, green, and red. Each boxplot shows 50 percent of the data 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 is shown with black vertical lines, and outliers are shown as black points. The total number of targets is illustrated by the width of the boxplot, a wider boxplot means a greater number of targets.

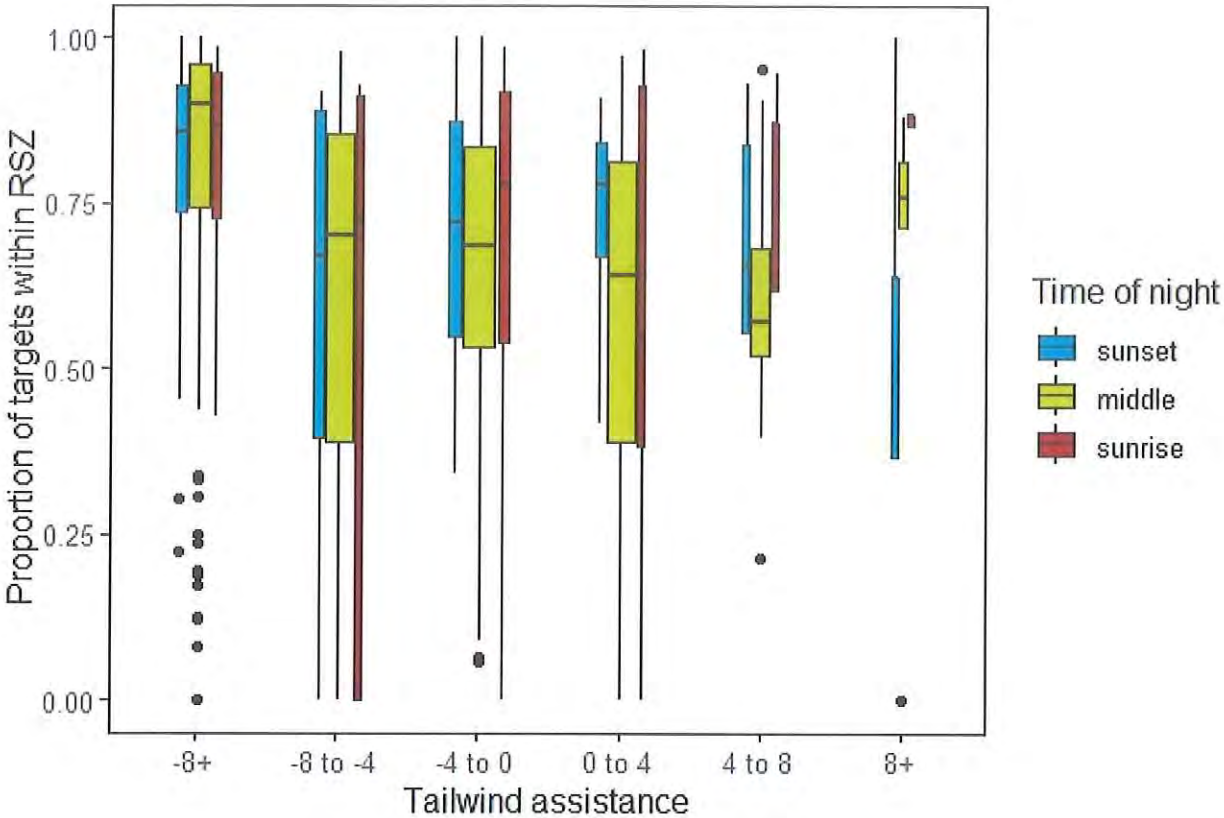

Figure 3.12 Relationship between tailwind assistance and the proportion of targets within RSZ across time of night during fall 2023

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

3.2 Nocturnal Migration Species Composition

Acoustic data were used to determine the avian community using the Project area during migration. During spring 2023 a total of 9 distinct species and 1 species group were identified with the nocturnal flight call recordings. Swainson's Thrush was the species that was most commonly detected and comprised 47.3 percent of the total detections. The second most common detected species was the Common Nighthawk which comprised 28.4 percent of all detections. A summary of all nocturnally migrating species detected in spring 2023 is provided in **Table 3.1**. The species listed in the table represent nocturnal migratory activity below approximately 200 m in agl.

Table 3.1 Spring nocturnal flight call detections by species and species group

Species or Species Group(a)	Total Number of Calls Detected	Proportion of Calls Detected
Swainson's Thrush	105	47.3
Common Nighthawk	63	28.4
Northern Waterthrush	10	4.5
Black-and-white Warbler	8	3.6
Ovenbird	8	3.6
Zeep[a]	8	3.6
Canada Warbler	6	2.7
American Redstart	4	1.8
Mourning Warbler	4	1.8
Unknown	4	1.8
Northern Parula	2	0.9
Total	**222**	**100**

Note: a) "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. Swainson's Thrush was the species most commonly detected, comprising 18.7 percent of the total detections. The second most commonly detected species was the Black-and-white Warbler, which comprised 12.2 percent of the total detections, followed by the American Redstart which comprised 10 percent of total detections. The species group Zeep represents 14 percent of the total flight call detections. A summary of all nocturnally migrating species detected in fall 2023 is provided in **Table 3.1**.

Table 3.2 Fall nocturnal flight call detections by species and species group

Species or Species Group(a)	Total Number of Calls Detected	Proportion of Calls Detected
Swainson's Thrush	759	18.7
Zeep[a]	566	14.0
Black-and-white Warbler	496	12.2
American Redstart	403	10.0
Ovenbird	381	9.4
Northern Waterthrush	281	6.9
Veery	266	6.6
Dark-eyed Junco	258	6.4
Mourning Warbler	211	5.2
Northern Parula	117	2.9
Canada Warbler	115	2.8
Chestnut-sided Warbler	70	1.7

Species or Species Group[(a)]	Total Number of Calls Detected	Proportion of Calls Detected
Common Nighthawk	57	1.4
Unknown	36	0.9
Savannah Sparrow	32	0.8
White-throated Sparrow	1	0.1
Total	**4049**	**100**

Note: 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 Swainson's Thrush. This species was first detected in early May, and detections peaked at the end of May with over 40 detections per night. The Swainson's Thrush is the only thrush species detected in both spring and fall. This species (Thrushes) was most detected at midnight with only a few detections at dawn (**Figure 3.13** and **Figure 3.14**). The Common Nighthawk was first detected in early May and this species was detected throughout the night. Detections of the Common Nighthawk peaked at 10 detections per night in late May.

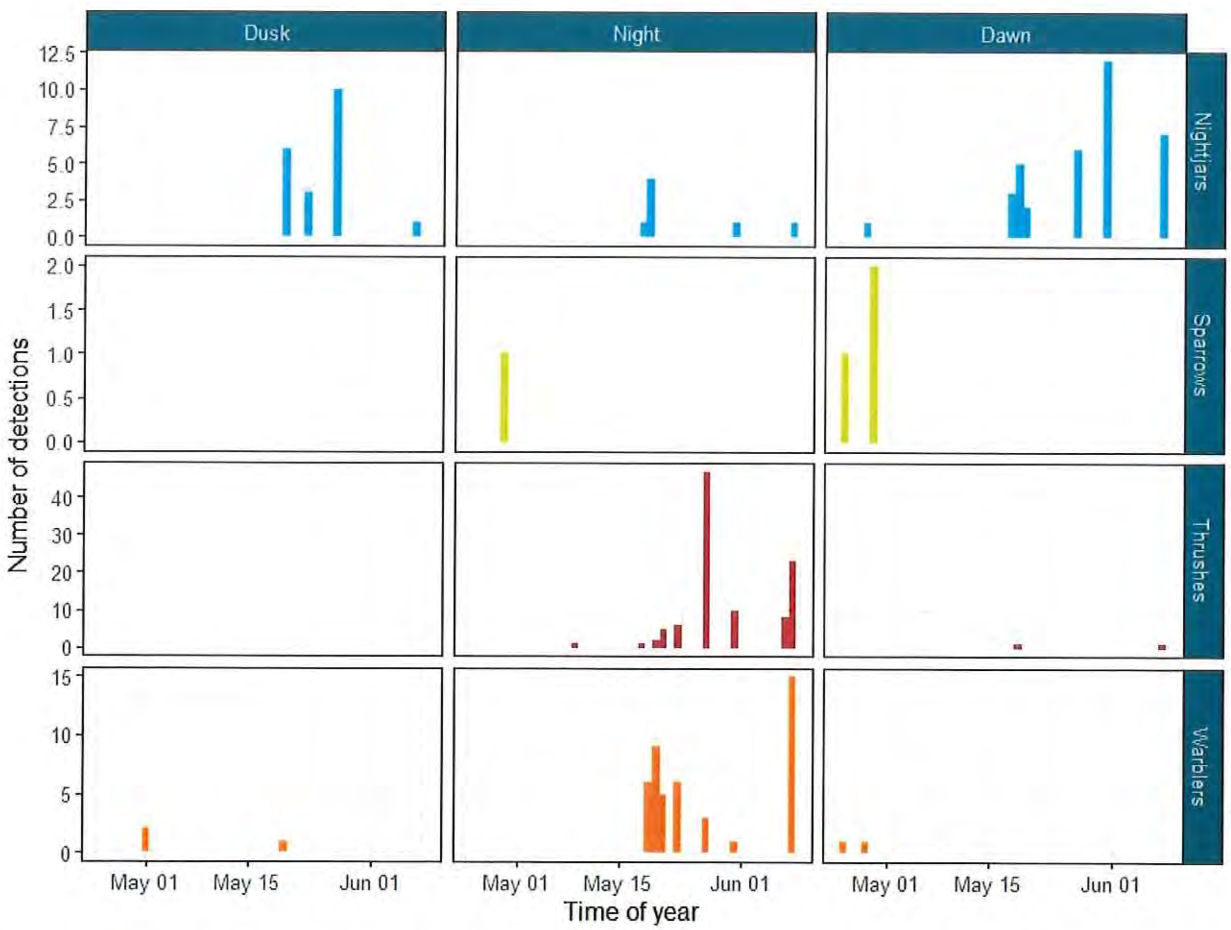

Figure 3.13 Acoustic detections by species groups during spring 2023

Detections are grouped by time of night in panels and displayed as detections per month, note that the y-axis are different between the species groups.

Although Swainson's Thrush was the most-commonly detected species during fall migration, cumulatively there were many more detections of the warblers species group with close to 300 detections per night in late August and early September (**Figure 3.14** and **Figure 3.15**). Both warblers and Swainson's Thrush were most detected at midnight. Sparrow detections peaked briefly in late September with over 100 detections per night, but then diminished to fewer than 25 detections per night for the rest of the migration period. Common Nighthawk detections peaked in late September (**Figure 3.14**).

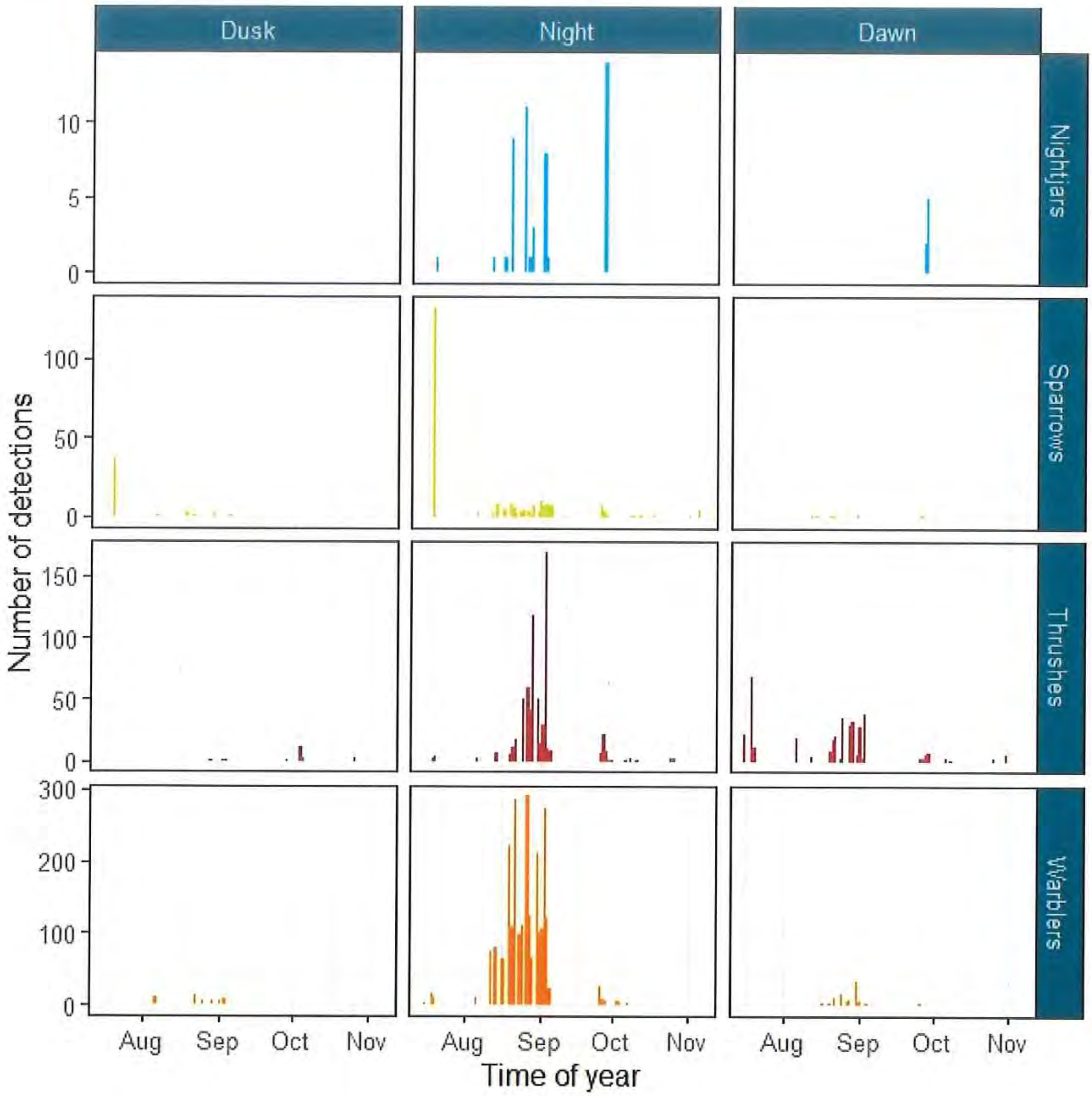

Figure 3.14 Acoustic detections by species groups during fall 2023

Detections are grouped by time of night in panels and displayed as detections per month, note that the y-axis are different between the species groups.

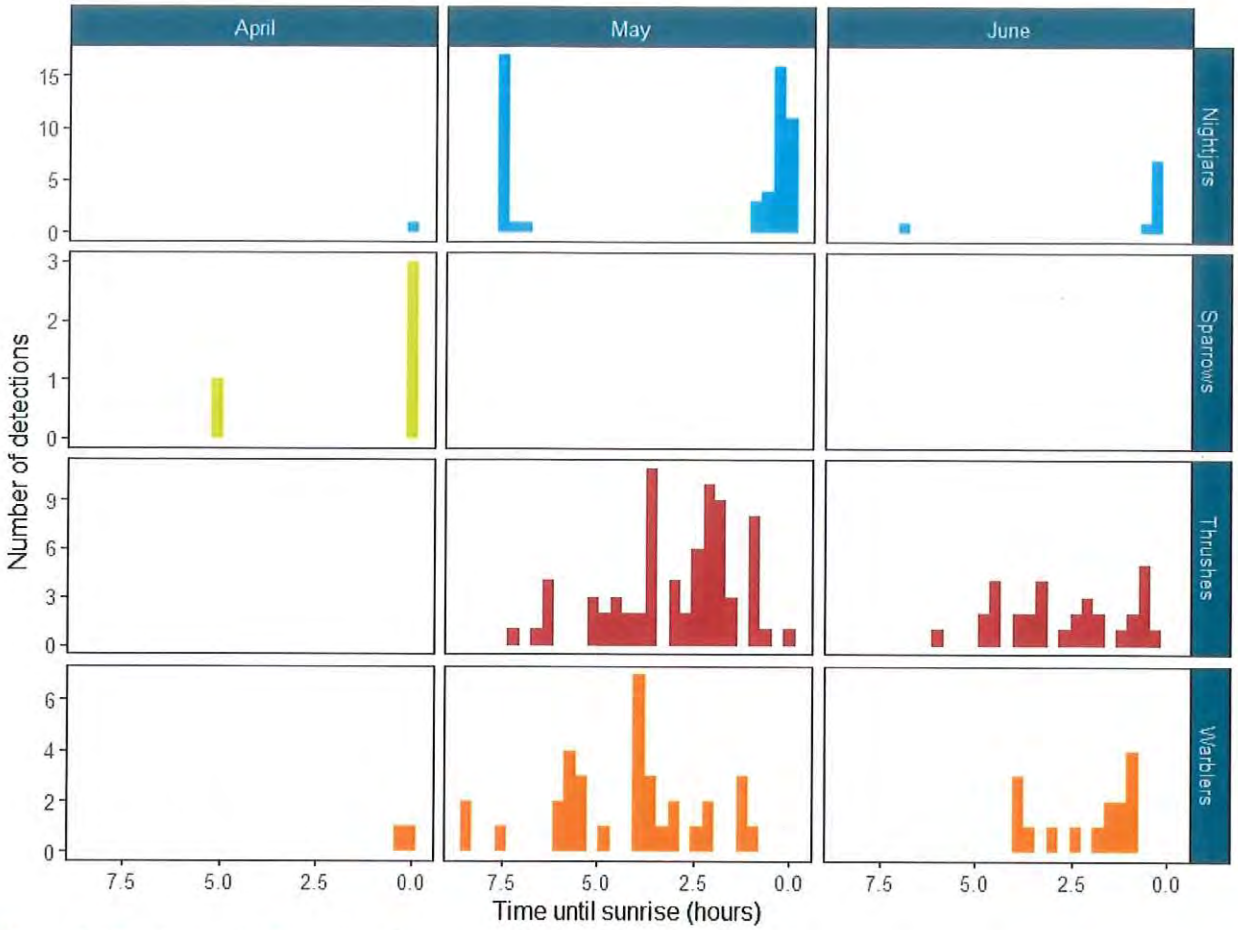

Figure 3.15 Acoustic detections by species groups during spring 2023

Detections are grouped by time of night in panels and displayed as detections per hour of the night, note that the y-axis are different between the species groups.

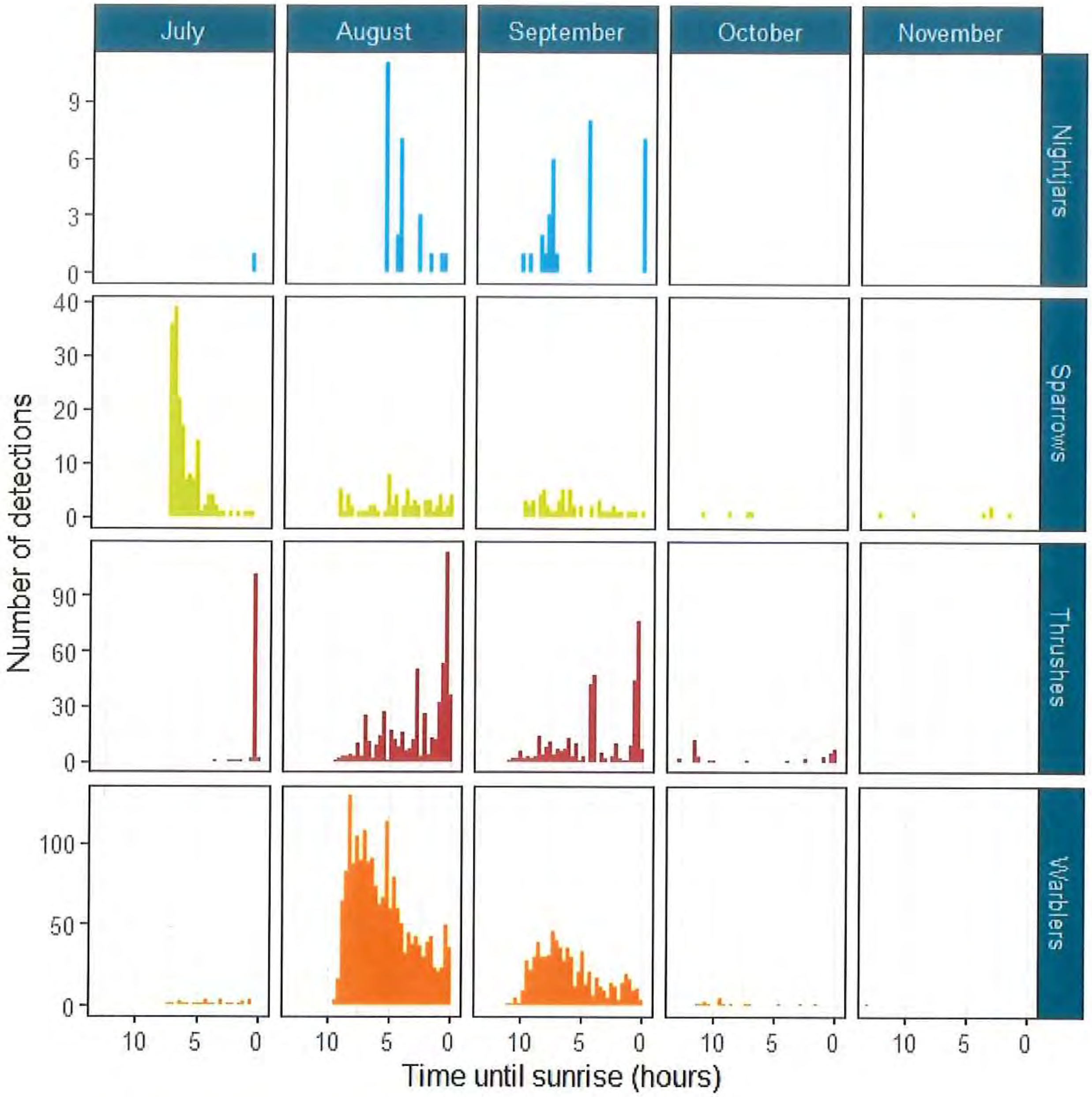

Figure 3.16 Acoustic detections by species groups during spring 2023

Detections are grouped by time of night in panels and displayed as detections per hour of the night, note that the y-axis are different between the species groups.

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

Common nighthawk

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 Lands and Forestry (NSDLF) developed a recovery plan for the Common Nighthawk in Nova Scotia (NSDLF 2021a). 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 the 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 and breeding takes place elsewhere outside of the Project area.

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 Nova Scotia Department of Lands and Forestry (NSDLF) 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 the 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 migratory bird activity in the Project area during spring and fall 2023 and inform potential impacts to migratory birds resulting from operation of a wind facility in the Project area.

The radar data show that most targets were detected above the RSZ in the spring, but some targets were also detected within the RSZ, particularly during nights with strong headwinds, such as on May 28 (**Figure 3.3** and **Figure 3.7**). The effect from headwinds on proportion of flights within RSZ was further supported by plotting the proportion of targets within RSZ against the tailwind assistance (**Figure 3.11**). Therefore, periods with strong headwinds may increase risk of avian collision with turbines.

In contrast to the spring data the radar data collected during fall migration shows that most targets were detected within the RSZ (**Figure 3.6**). It is interesting to note that flight volumes remained high at low altitude on days with a strong tailwind, such as on September 5, 26 and October 24, when birds are generally expected to fly at higher altitudes. It is unclear exactly why so many targets were detected at low altitudes. A potential explanation may be periods of rain as birds are known to fly at lower altitudes during rain (Kennedy 1970; Richardson 1978). There have been many periods of rain during the fall migration period potentially forcing the birds to fly at low altitudes (**Appendix B**), though there were also many periods of rain during the spring and here it did not seem to increase target detection within RSZ (**Appendix A**). Another potential explanation is activity from insects or nocturnal aerial foragers like the Common Nighthawk or bats, though the nocturnal flight call detections of Common Nighthawk were not particularly numerous in the fall (**Table 3.3**). Periods of low overcast may also cause birds to have flown at low altitudes during the fall (Richardson 1978).

The Common Nighthawk call was detected frequently in the spring, and less often in the fall (**Table 3.2** and **Table 3.3**). 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 in the spring suggests that this species is using this area for foraging rather than simply passing through on migration. So, although the detection rate is quite high in the spring, these may only be a few individuals foraging in the Project area. Although the Common Nighthawk is a species of concern, studies show that wind turbines are generally no threat to this species (COSIWIC 2018). Compared to other species Common Nighthawks have among the lowest reported collision rates with vehicles, buildings, and wind turbines (Bishop and Brogan 2013; Longcore et al. 2013; 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 3.2** and **Table 3.3**). Because the Canada Warbler was only detected a few times, the collision risk for Canada Warbler is judged to be low. Post-construction monitoring will be required to accurately predict potential mortality for the Canada Warbler in the Project area.

It is important to note that prediction of collision risk of migratory 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 and 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 collected that should be considered when drawing conclusions from the data presented within this report.

5.1 Radar Data

Radar data can provide a good understanding of nocturnal avian migration trends at proposed wind energy projects. However, there are limitations to how the data are collected and can be interpreted, such as:

- 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, direct comparison of passage rates across sites can be difficult.
- Targets at very low altitudes (i.e. below the RSZ) are difficult to detect with a radar due to ground clutter and background noise from vegetation.

5.2 Acoustic Data

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

- Microphone sensitivity may cause detection rates to change due to rainfall, background noise, vegetation cover, and technology (microphones need to be calibrated frequently).
- Because the acoustic microphones have a limited range of approximately 200 m, birds flying at elevations higher than 200 m 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. Because acoustic detection rates of the Common Nighthawk were the highest of all recorded species, this species is also expected to have an increased risk. To determine whether mitigation measures are needed, Ausenco recommends 2-year post-construction monitoring to determine collision risk at the Project as per federal recommendations (Government of Canada 2007b). Post-construction monitoring will also help determine what type of mitigation is best suited for the Project. The post-construction monitoring should include carcass searches in combination with radar and acoustic data, as per federal recommendations (Government of Canada 2022), as well as collection of weather data to predict what species are most at risk, and the weather events associated with the greatest risk of collision. The findings of this study will inform development of a project-specific curtailment plan.

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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8.0 References

Åkesson S., and A. Hedenström. 2000. Wind selectivity of migratory flight departures in birds. Behav. Ecol. and Sociobiol. 47: 140-144.

Åkesson S. G., L. Walinder, L. Karlsson and S. Ehnbom. 2001. Reed warbler orientation: initiation of nocturnal migratory flights in relation to visibility of celestial cues at dusk. Anim. Behav. 61: 181-189.

Alerstam, T., G. Gudmundsson, P. Jönsson, J. Karlsson, and Å. Lindström. 1990. Orientation, migration routes and flight behaviour of knots, turnstones and brant geese departing from Iceland in spring. Arctic 43 (3): 201–214. DOI: 10.2307/40511259.

Aishwarya, K. J. K. Christina, and R. B. Lakshmi. 2016. A survey on bird activity monitoring and collision avoidance techniques in windmill turbines. In: 2016 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR). Tiar. IEEE, July 2016, pages 188–193.

Ausenco Sustainability Inc.. 2022. Westchester Wind Project – Radar and Acoustic Monitoring.

Bagg, A. M. W. H. Gunn, D. S. Miller, J. T. Nichols, W. Smith, and F. P. Wolfarth. 1950. Barometric pressure-patterns and spring bird migration. Wilson Bull. 62: 5-19.

Band, W. Madders, M. Whitfield, D.P. 2007. Developing Field and Analytical Methods to Assess Avian Collision Risk at Wind Farms. In: M. De Lucas, G. Janss, and M. Ferrer. (Eds.) Birds and Wind Power. Quercus, Madrid.

Barton, K. 2012. MuMIn: multi-model inference: R package. See: http://cran. R-project. Org/web/packages. MuMIn/index. Html.

Bates, D. M. Maechler, B. Bolker, and S. Walker. 2015. Fitting linear mixed-effects models using lme4. Journal of Statistical Software 67(1): 1-48. DOI: 10.18637/jss.v067.i01.

Bird Studies Canada, Canadian Wind Energy Association, Environment Canada and Ontario Ministry of Natural Resources 2016. Wind Energy Bird and Bat Monitoring Database Summary of the Findings from Post-construction Monitoring Reports.

Bishop, C.A. and J.M. Brogan. 2013. Estimates of avian mortality attributed to vehicle collisions in Canada. Avian Conservation and Ecology 8(2): 2.

Campbell, R.W. M.K. McNicholl, R.M. Brigham, and J. Ng. 2006. Wildlife Data Centre featured species: Common Nighthawk. Wildlife Afield 3:32-71.

COSEWIC. 2018. COSEWIC assessment and status report on the Common Nighthawk *Chordeiles minor* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 50 pp.

COSEWIC. 2021. Species at Risk Public Registry. Committee on the Status of Endangered Wildlife in Canada. Government of Canada. Available online at http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm.

Environment Canada. 2015. Recovery Strategy for Canada Warbler (*Cardellina canadensis*) in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. Vi + 55 pp.

Environment Canada. 2016. Recovery Strategy for the Common Nighthawk (*Chordeiles minor*) in Canada. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. vii + 49 pp.

Erni, B., F. Liechti, L.G. Underhill and B. Bruderer. 2002. Wind and rain govern the intensity of nocturnal bird migration in central Europe – a log-linear regression analysis. Ardea 90 (1): 155-166.

Evans, W.R., and M. O'Brien. 2002. Flight Calls of Migratory Birds. Old Bird, Inc. Available: http://oldbird.org/pubs/fcmb/start.htm.

Evans, W.R. 2005. Monitoring Avian Night Flight Calls – The New Century Ahead. The Passenger Pigeon 67(1):15-24.

Fense, S.A.H., R.M. Brigham, and E.F. Baerwald. Submitted. A comparison of fatality rates of bats and Common Nighthawks (*Chordeiles minor*) at wind turbines in Canada and the United States.

Ferrer, M,, De Lucas, M., Janss, GFE. et al. 2012. Weak relationship between risk assessment studies and recorded mortality in wind farms. J Appl Ecol. 49:38–46.

Government of Canada. 2007a. Wind Turbines and Birds: A Guidance Document for Environmental Assessment. Canadian Wildlife Service (CWS); Environment Canada (EC). Available: https://publications.gc.ca/site/eng/458437/publication.html.

Government of Canada, 2007b. Recommended Protocols for Monitoring Impacts of Wind Turbines on Birds. Canadian Wildlife Service (CWS); Environment Canada (EC).

Government of Canada. 2020. Birds Protected Under the *Migratory Birds Convention Act*. Available online at https://www.canada.ca/en/environment-climate-change/services/migratory-birds-legal-protection/convention-act.html.

Government of Canada. 2022. Wind Energy & Birds Environmental Assessment Guidance Update.

Gradolewski, D., D. Dziak, and D. Kaniecki. 2021. Comprehensive bird preservation at wind farms. Sensors 21 (1): 267.

Haché, S. P. Solymos, T. Fontaine, E. Bayne. S. Cumming, F. Schmiegelow, and D. Stralberg. 2014. Critical habitat of Olive-sided Flycatcher, Canada Warbler, and Common Nighthawk in Canada (Project K4B20-13-0367) [DRAFT]. Boreal Avian Modelling Project.

Hemmera Envirochem Inc. 2021. Benjamins Mill Wind Project – Radar and Acoustic Monitoring.

Kemp, M., E. van Loon, E. Emile, J. Shamoun-Baranes, and W. Bouten. 2011. RNCEP: global weather and climate data at your fingertips. Methods in Ecology and Evolution 3(1): 65–70.

Kennedy, R. J. 1970. Direct effects of rain on birds: a review. Brit. Birds 63: 401-414.

Kleyheeg-Hartman, J.C., K. L. Krijgsveld, M. P. Collier, M. J. Poot, A. R. Boon, T. A. Troost, and S. Dirksen. 2018. Predicting bird collisions with wind turbines: comparison of the New Empirical Flux Collision Model with the SOSS Band Model. Ecol. Model. 2018 (387): 144–153.

Longcore, T. C. Rich, P. Mineau, B. MacDonald, D.G. Bert, L.M. Sullivan, E. Mutrie, S.A. Gauthreaux Jr, M.L. Avery, R.L. Crawford, A.M. Manville II, E.R. Travis, and D. Drake. 2013. Avian mortality at communication towers in the United States and Canada: which species, how many, and where? Biological Conservation 158: 410-419.

Masden, E. and A. Cook. 2016. Avian collision risk models for wind energy impact assessments. In Environmental Impact Assessment Review 56: 43–49.

Muller, R. E. 1976. Effects of weather on the nocturnal activity of White-throated Sparrows. Condor 78: 186-194.

Natural Forces Developments Inc. 2022. Westchester Wind Project Environmental Assessment Registration. Available: https://www.novascotia.ca/nse/ea/Westchester-Wind-Project/

Nova Scotia Department of Lands and Forestry. 2021a. Recovery Plan for the Canada Warbler (*Cardellina canadensis*) in Nova Scotia [Final]. *Nova Scotia Endangered Species Act Recovery Plan Series*.

Nova Scotia Department of Lands and Forestry (NSDLF). 2021b. Recovery Plan for the Common Nighthawk (*Chordeiles minor*) in Nova Scotia [Final]. Nova Scotia Endangered Species Act Recovery Plan Series.

Nova Scotia Government. 2021. Guide to Preparing an EA Registration Document for Wind Power Projects in Nova Scotia. Environmental Assessment Branch. URL EA.Guide-Proponents-WindPowerProjects.pdf (novascotia.ca)

Nova Scotia Environmental Assessment Branch (NSEAB). 2021. Guide to preparing an EA registration document for wind power projects in Nova Scotia. Available: https://novascotia.ca/nse/ea/docs/EA.Guide-Proponents-WindPowerProjects.pdf.

Parslow, J. L. F. 1969. The migration of passerine night migrants across the English Channel studied by radar. Ibis 111: 48-79.

Pennycuick, C.J. 1968. Power requirements for horizontal flight in the pigeon *Columba livia*. Journal of Experimental Biology 49 (3):527–555.

Peckford, M. 2006. Wind drift and the use of radar, acoustics, and Canadian Migration Monitoring Network methods for monitoring nocturnal passerine migration. M.Sc. Thesis, Acadia University.

Peckford, M.L. and Taylor, P.D. 2008. Within night correlations between radar and groundcounts of migrating songbirds. J Field Ornithol. 79:207–214. DOI: 10.1111/j.1557-9263.2008.00165.

R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Rhinehart, T.A., J. Kearney, P. Taylor, L. Chronister, L. Freeland-Haynes, and J. Kitzes. 2022. Nocturnal Bird Flight Calls of North America v0.1. Available: https://nocturnalflightcalls.com. doi:10.5281/zenodo.7054404

Richardson, W.J. 1978. Timing and amount of bird migration in relation to weather: a review. OIKOS 30: 224-272.

Richardson W.J. 1990. Timing and amount of bird migration in relation to weather: updated review. Pages 78-101 In: Gwinner E. (ed.) Bird Migration: The Physiology and Ecophysiology. Springer, Berlin.

Saunders, W.E. 1907. A migration disaster in western Ontario. The Auk 24 (1):108–110.

Schippers, P., R. Buij, A. Schotman, J. Verboom, H. van der Jeugd, and E. Jongejans. 2020. Mortality limits used in wind energy impact assessment underestimate impact of wind farms on bird populations. Ecology and Evolution 10: 6274-6287.

Smith, A.D, P.W. Paton, and S.R. McWilliams. 2014. Using nocturnal flight calls to assess the fall migration of warblers and sparrows along a coastal ecological barrier. PloS One 9 (3).

Taylor, P. D., J. M. Brzustowski, C. Matkovich, M. Peckford, and D. Wilson. 2010. radR: an open-source platform for acquiring and analysing data on biological targets observed by surveillance radar. BMC Ecol 10 (1):22. DOI: 10.1186/1472-6785-10-22.

Taylor, P.D., S. Neima, and J. Walker. 2020. Burchill Energy Project Radar and Acoustic Monitoring Interim Report.

Tyler, W. M. 1940. Chimney Swift. Pages 271-293 in A. C. Bent, ed. Life histories of North American Cuckoos, Goatsuckers, Hummingbirds and Their Allies. U.S. Natl. Mus. Bull. 176.

Tomé, Ricardo, F. Canário, A. Leitão, N. Pires, and M. Repas. 2017. Radar-assisted Shutdown on Demand Ensures Zero Soaring Bird Mortality at a Wind Farm Located in a Migratory Flyway. Pp. 119-133 In J. Köppel (Ed.). Wind Energy and Wildlife Interactions: Presentations from the CWW2015 Conference. Springer, Cham. https://doi.org/10.1007/978-3-319-51272-3_7

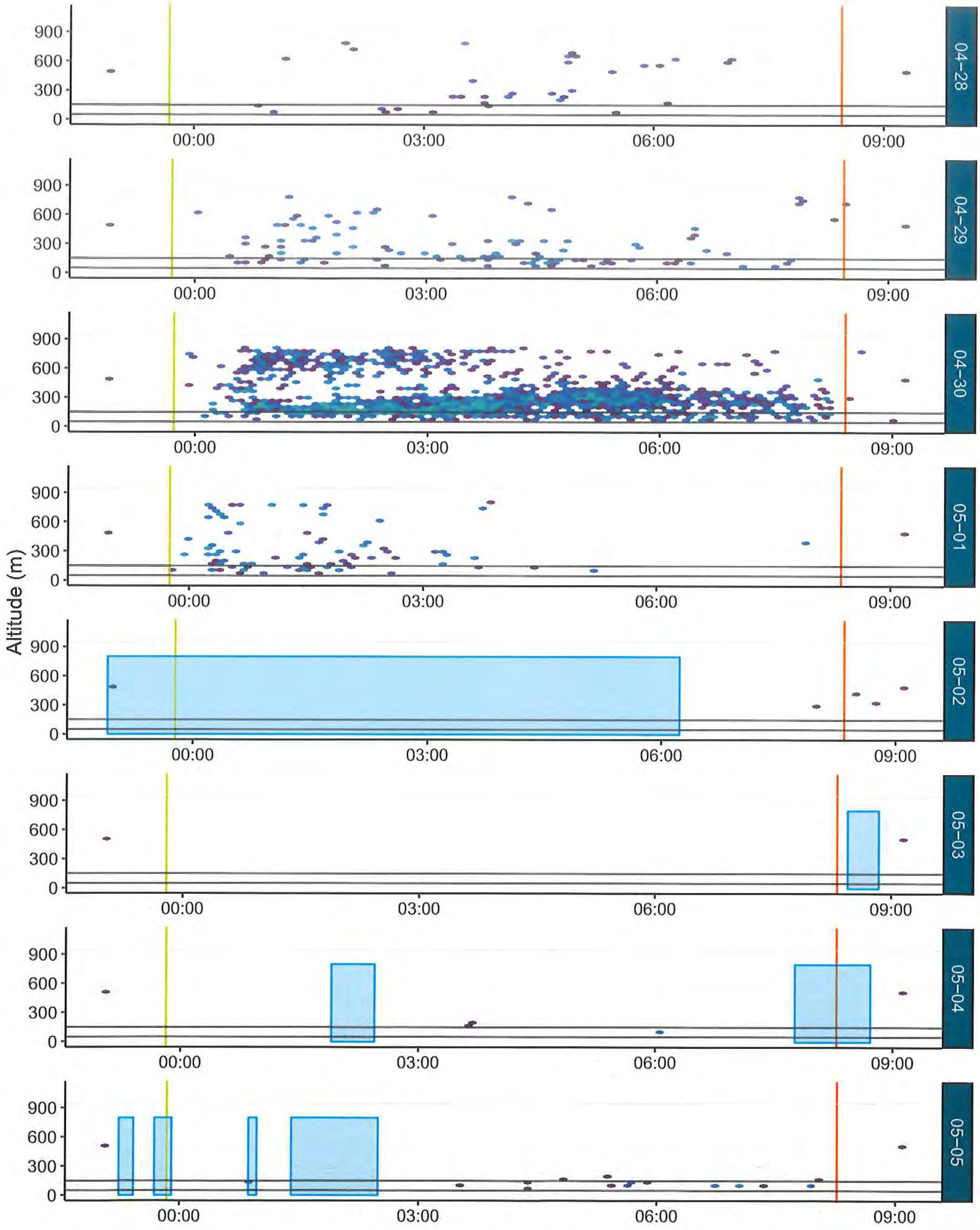
Wickham, H. et al. 2019. Welcome to the tidyverse. Journal of Open Source Software 4(43):1686. DOI: 10.21105/joss.01686

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 (i.e. few detections) through dark purple to yellow (i.e. many detections). Acoustic detections are red dots along the base of each plot. Wind direction (i.e. cardinal direction of red arrow) and wind strength (i.e. 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)
900
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300
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00:00
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04–28
04–29
04–30
05–01
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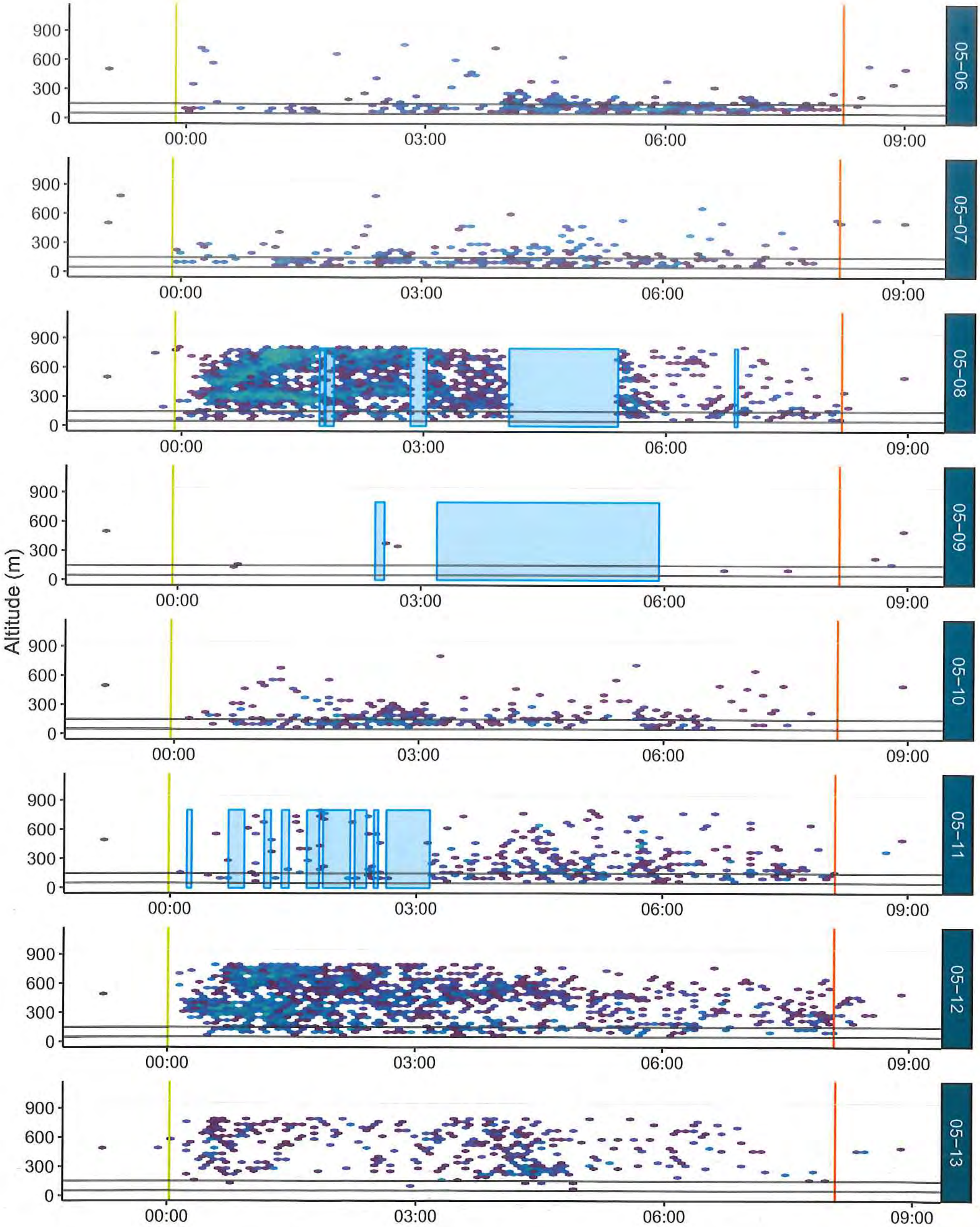
05–03
05–04
05–05


Altitude (m)
900
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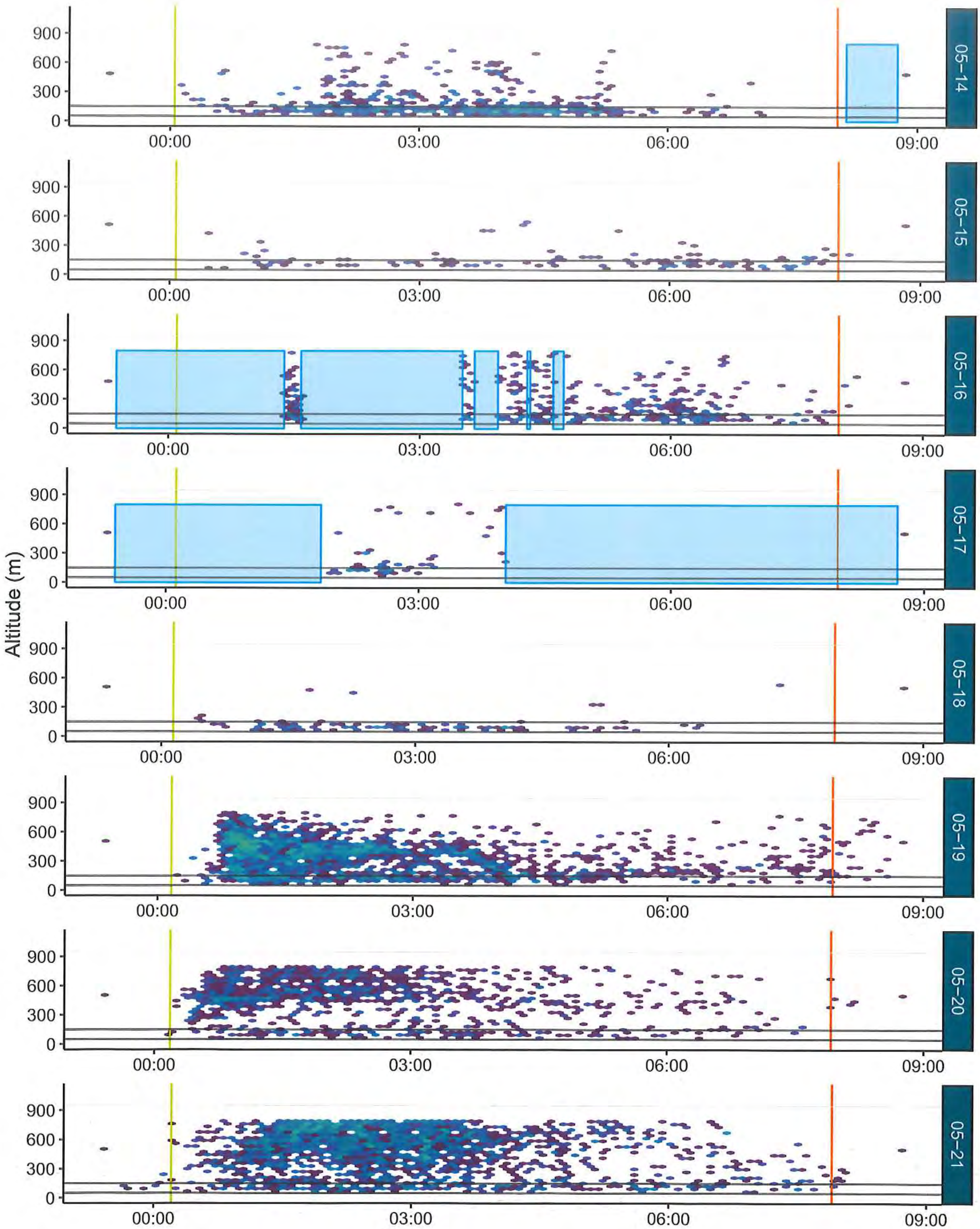
05–11
05–12
05–13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05–18
05–19
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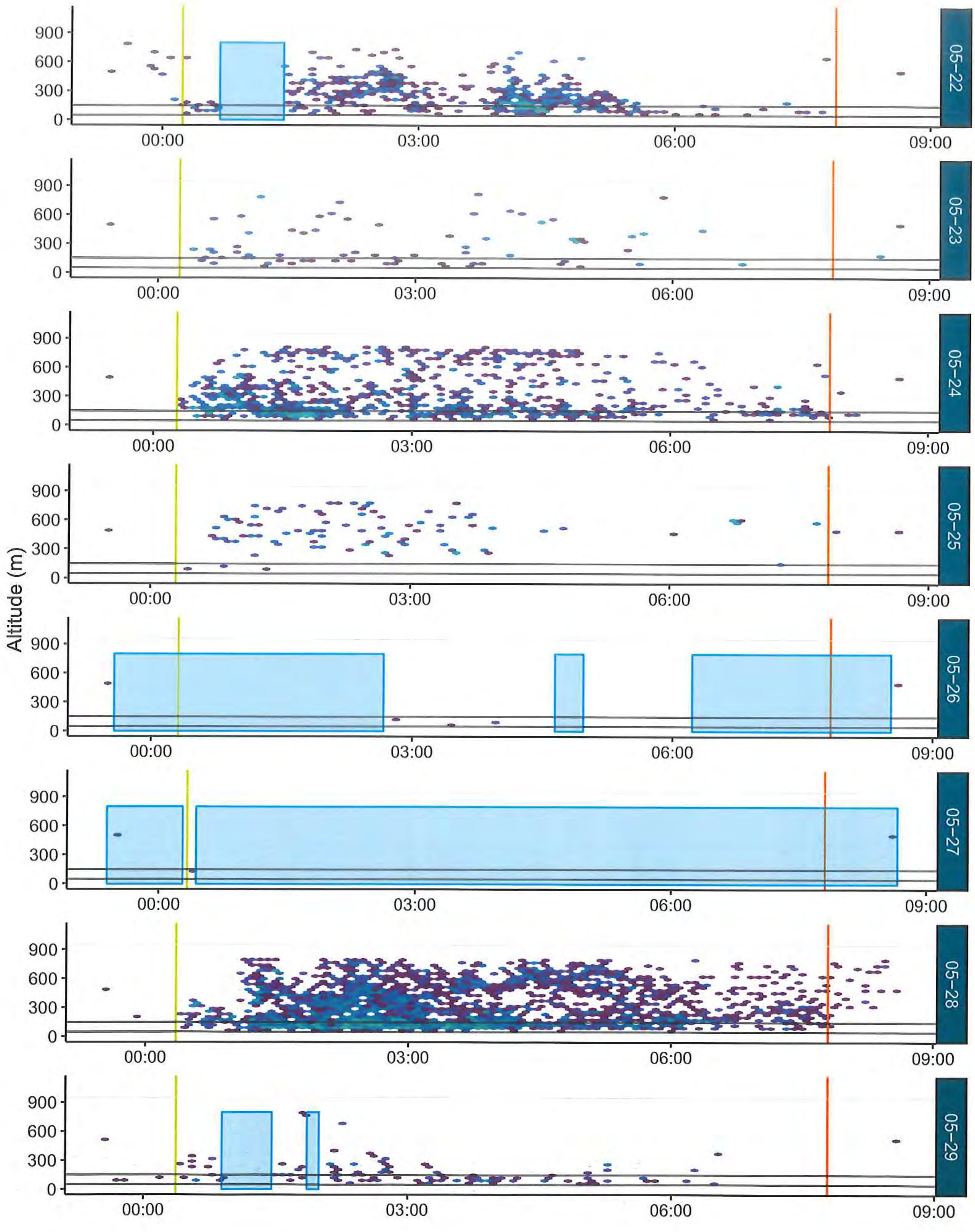
05–21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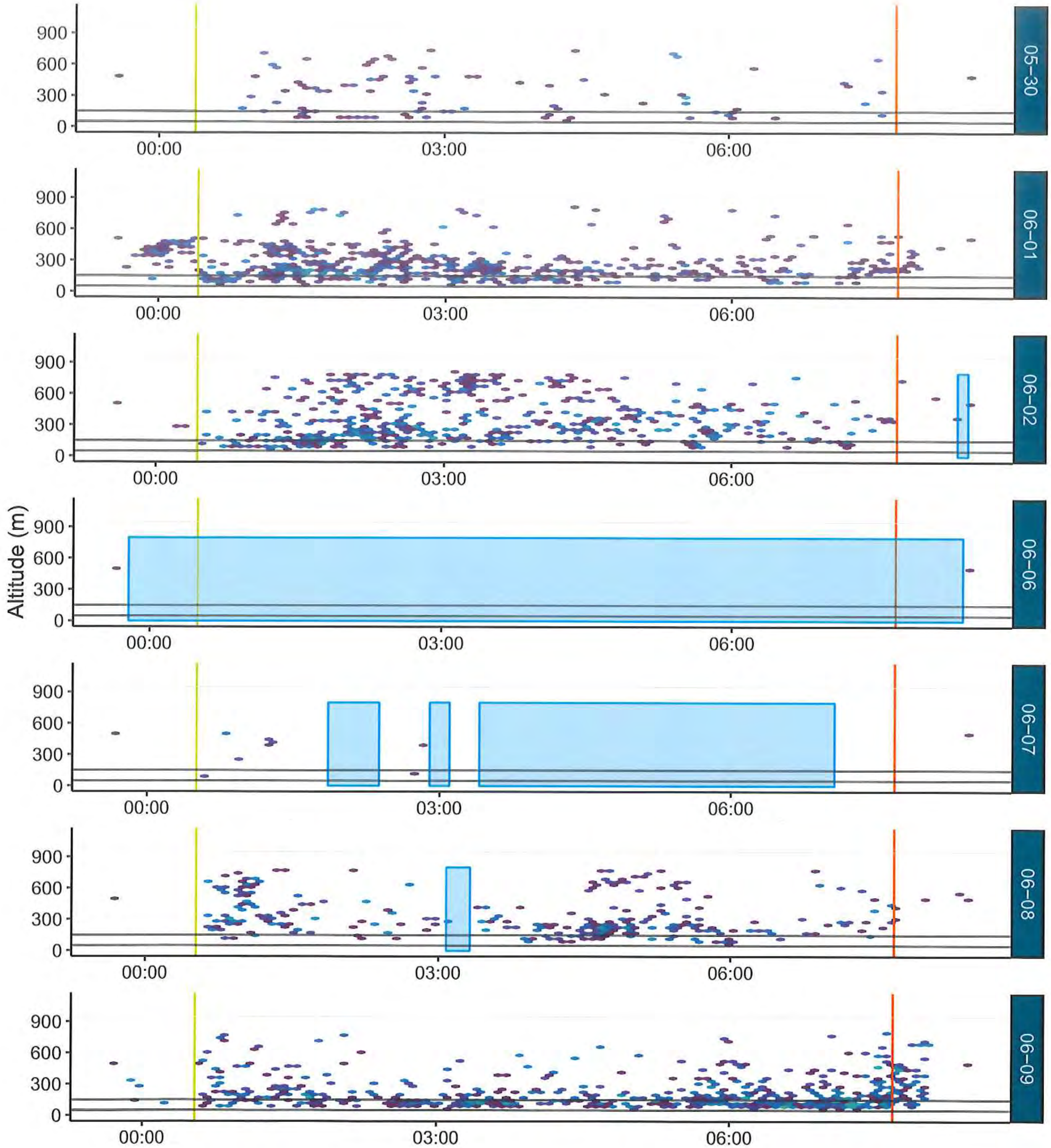
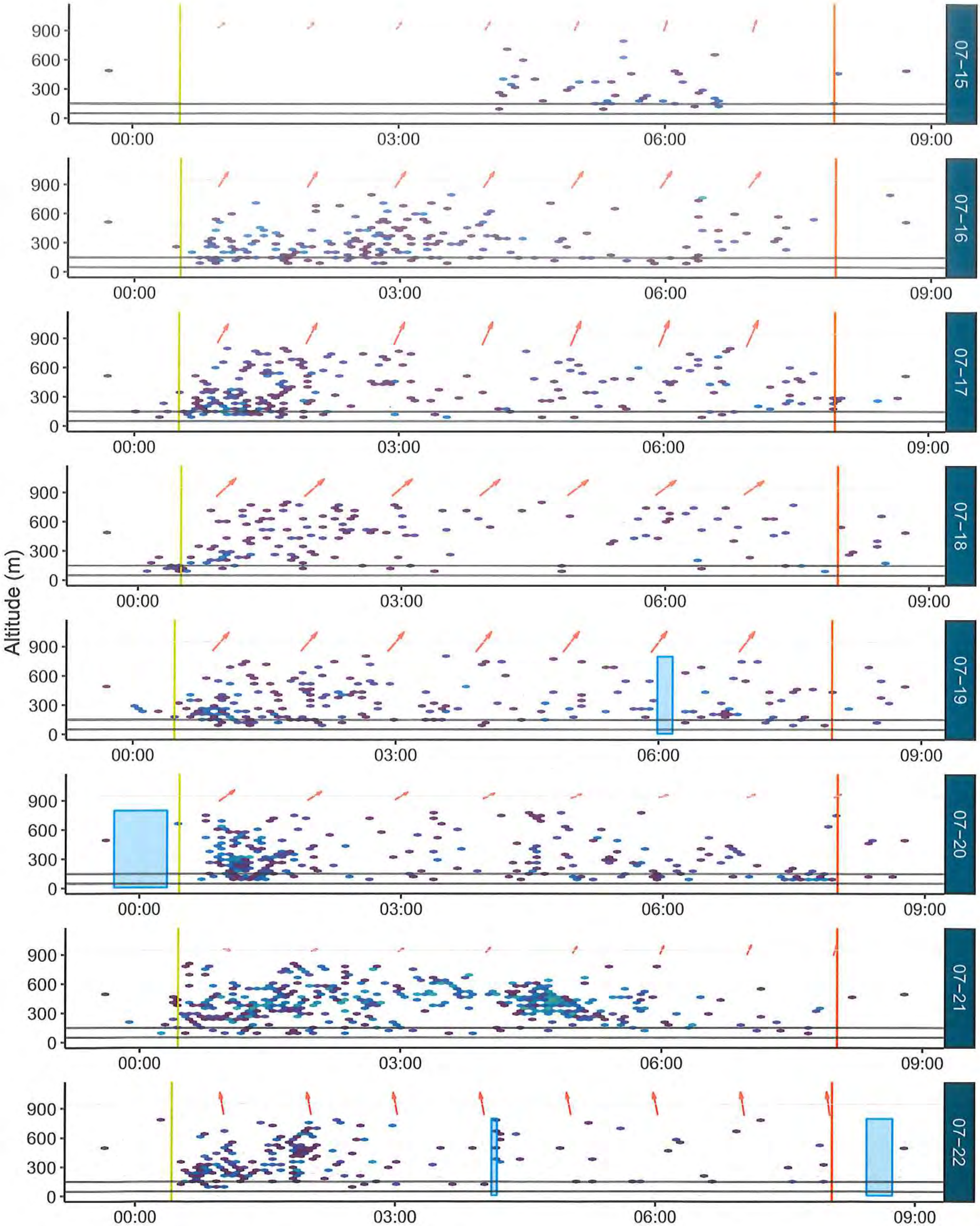


Altitude (m)
900
600
300
0
00:00
03:00
06:00
05–30
06–01
06–02
06–06
06–07
06–08
06–09

Appendix B
Complete Fall 2023 Radar Data

OVERVIEW

The entire radar and acoustic detections for the fall 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 (i.e. few detections) through dark purple to yellow (i.e. many detections). Acoustic detections are red dots along the base of each plot. Wind direction (i.e. cardinal direction of red arrow) and wind strength (i.e. 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)
07–15
07–16
07–17
07–18
07–19
07–20
07–21
07–22
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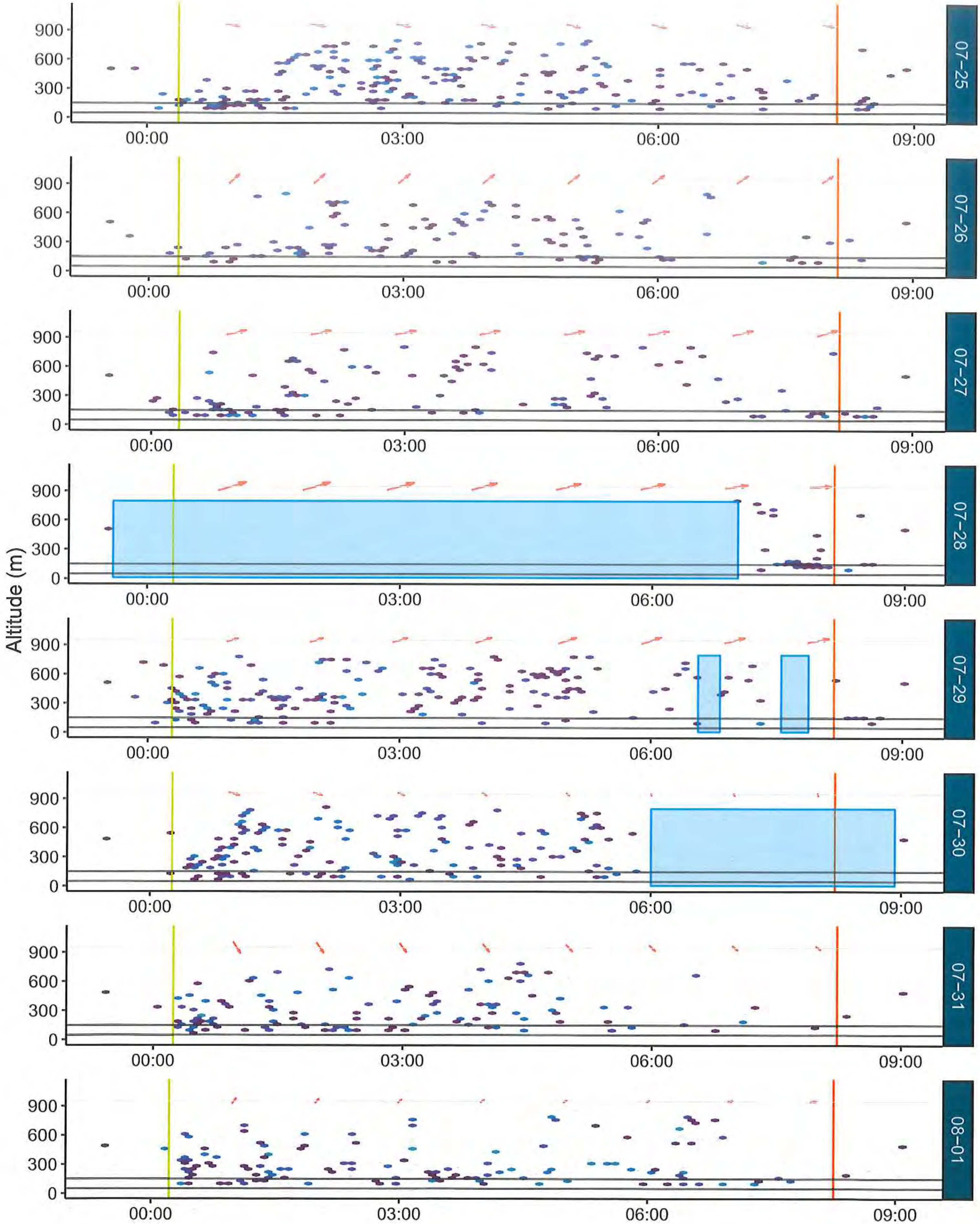
300
600
900
00:00
03:00
06:00
09:00


Altitude (m)
900
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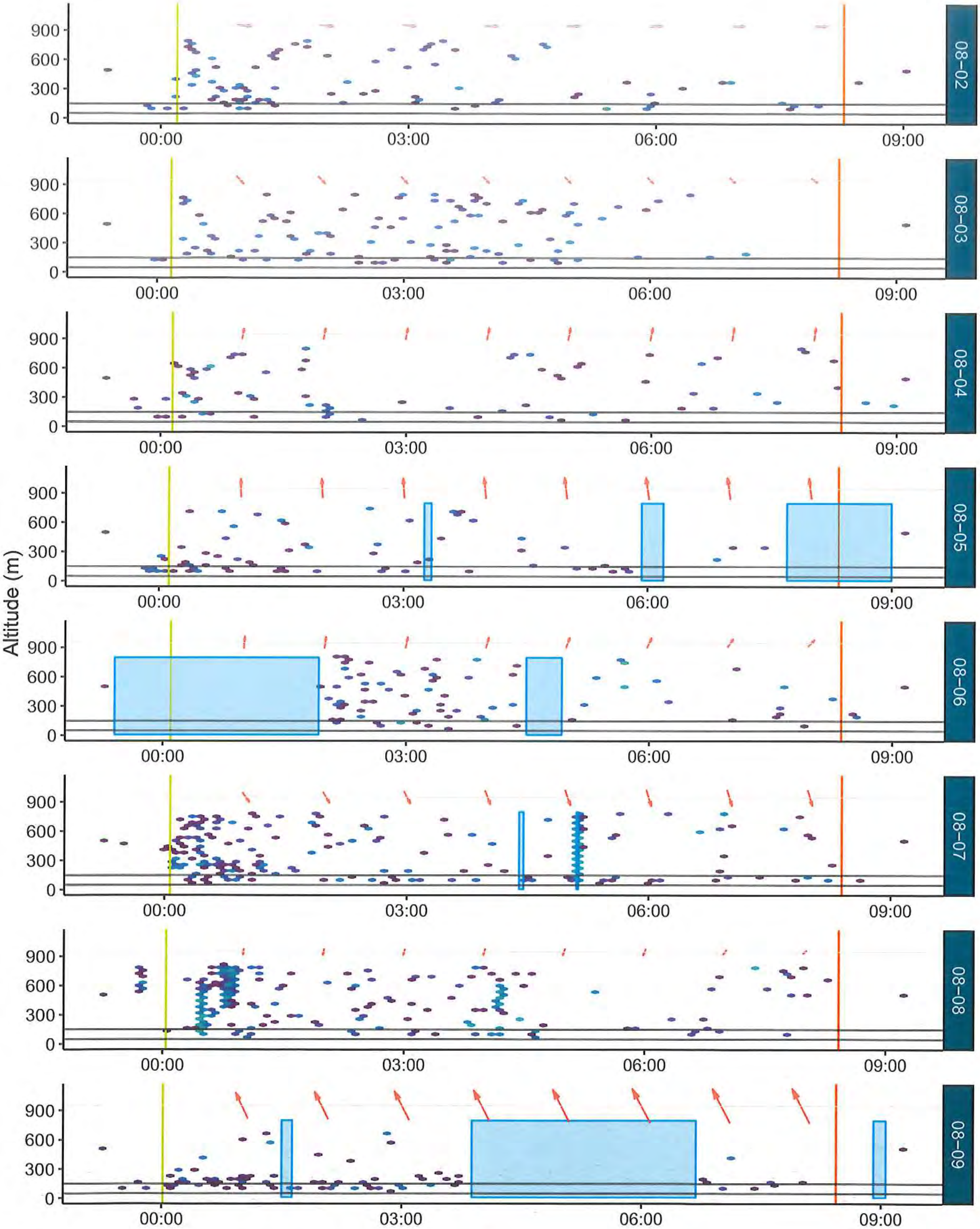
07-30
07-31
08-01


Altitude (m)
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08-07
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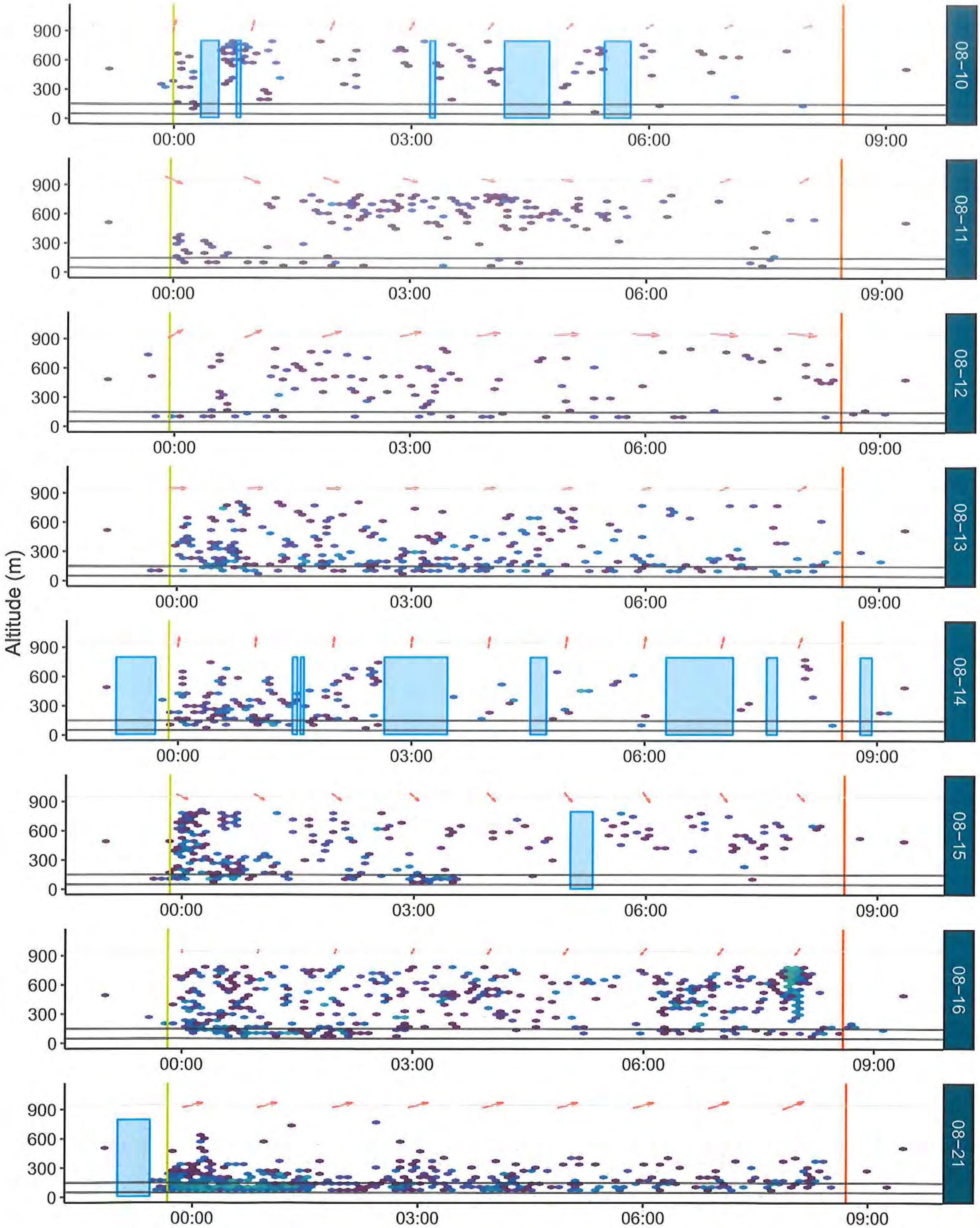

Altitude (m)
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08-14
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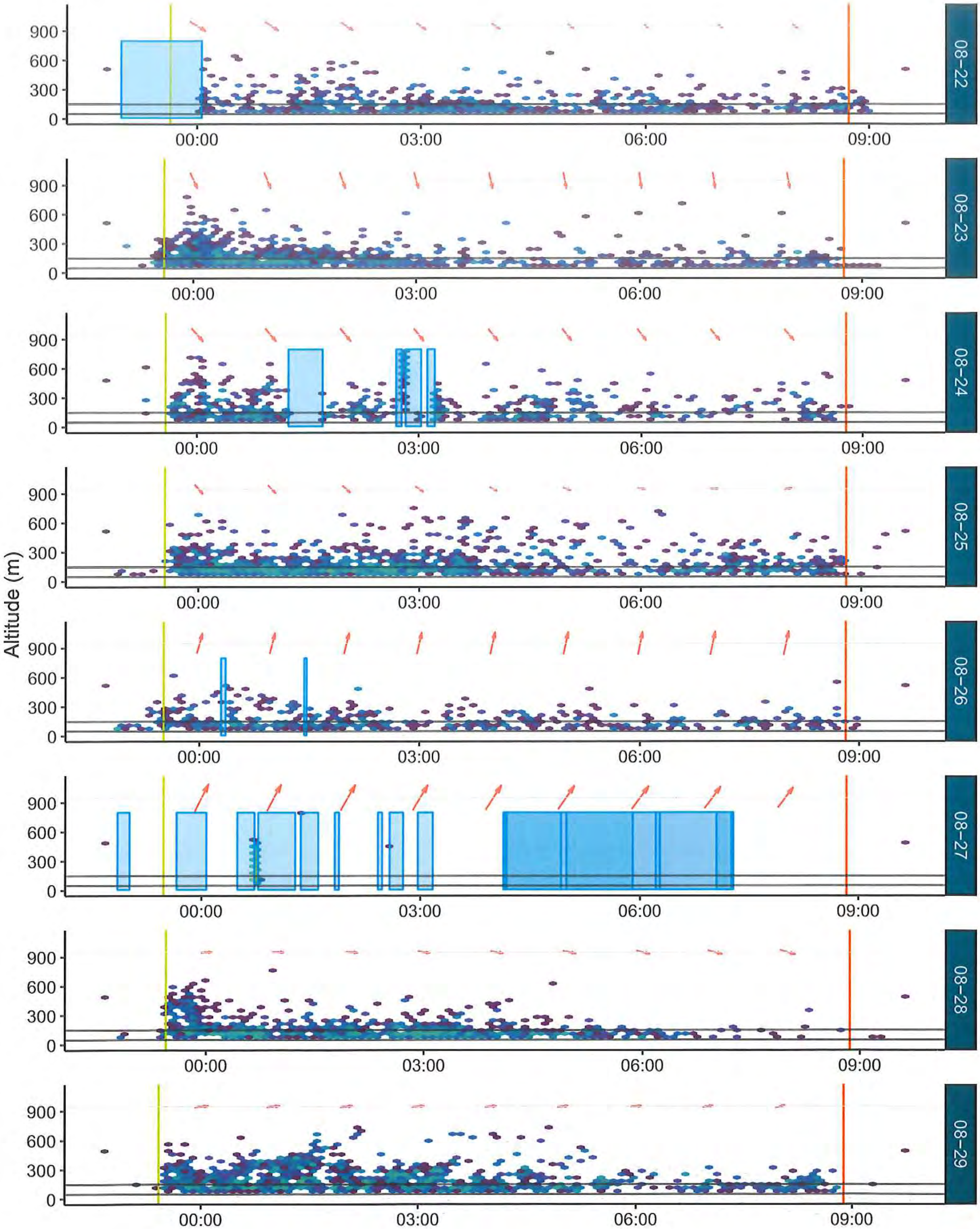
08-16
08-21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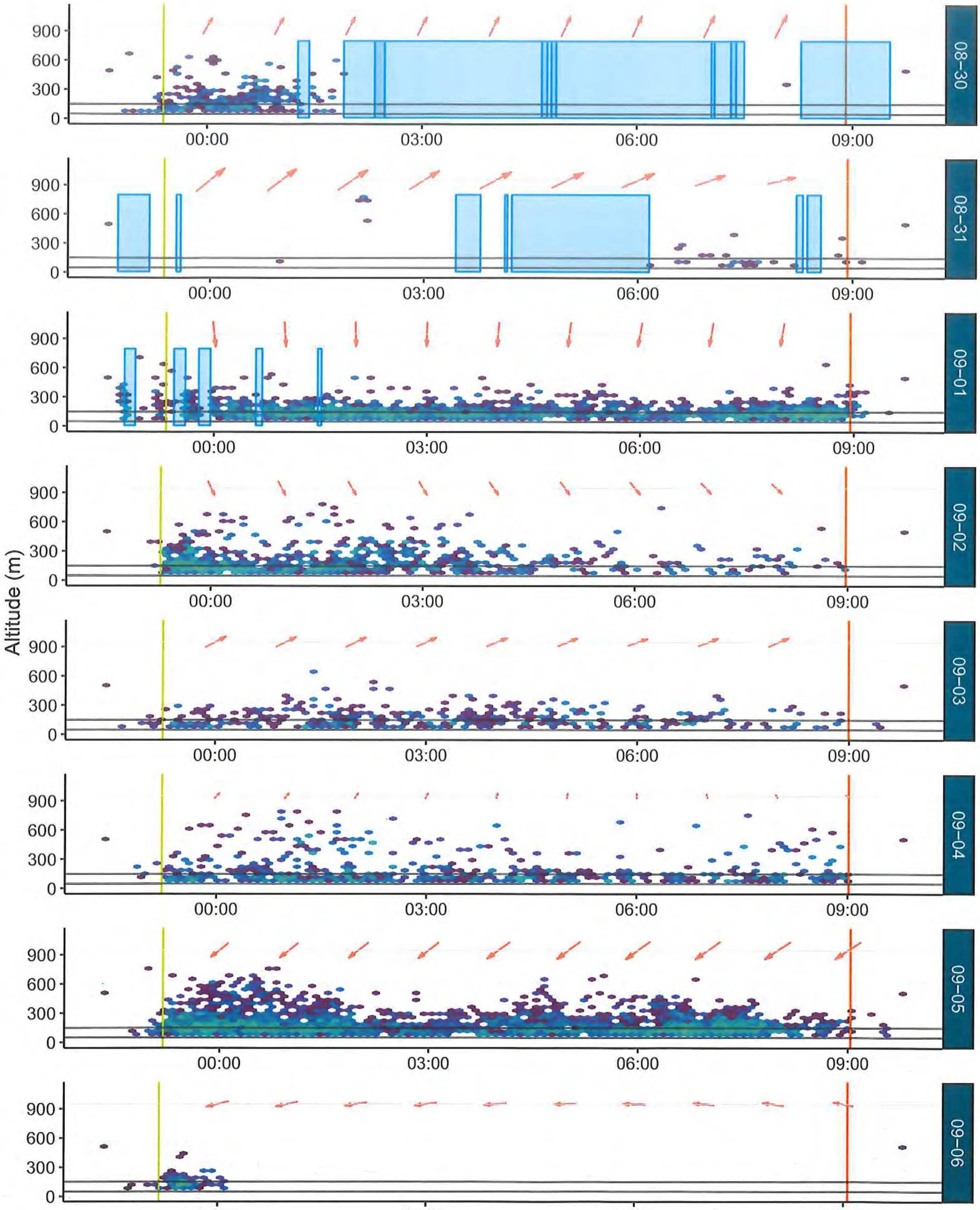
Altitude (m)
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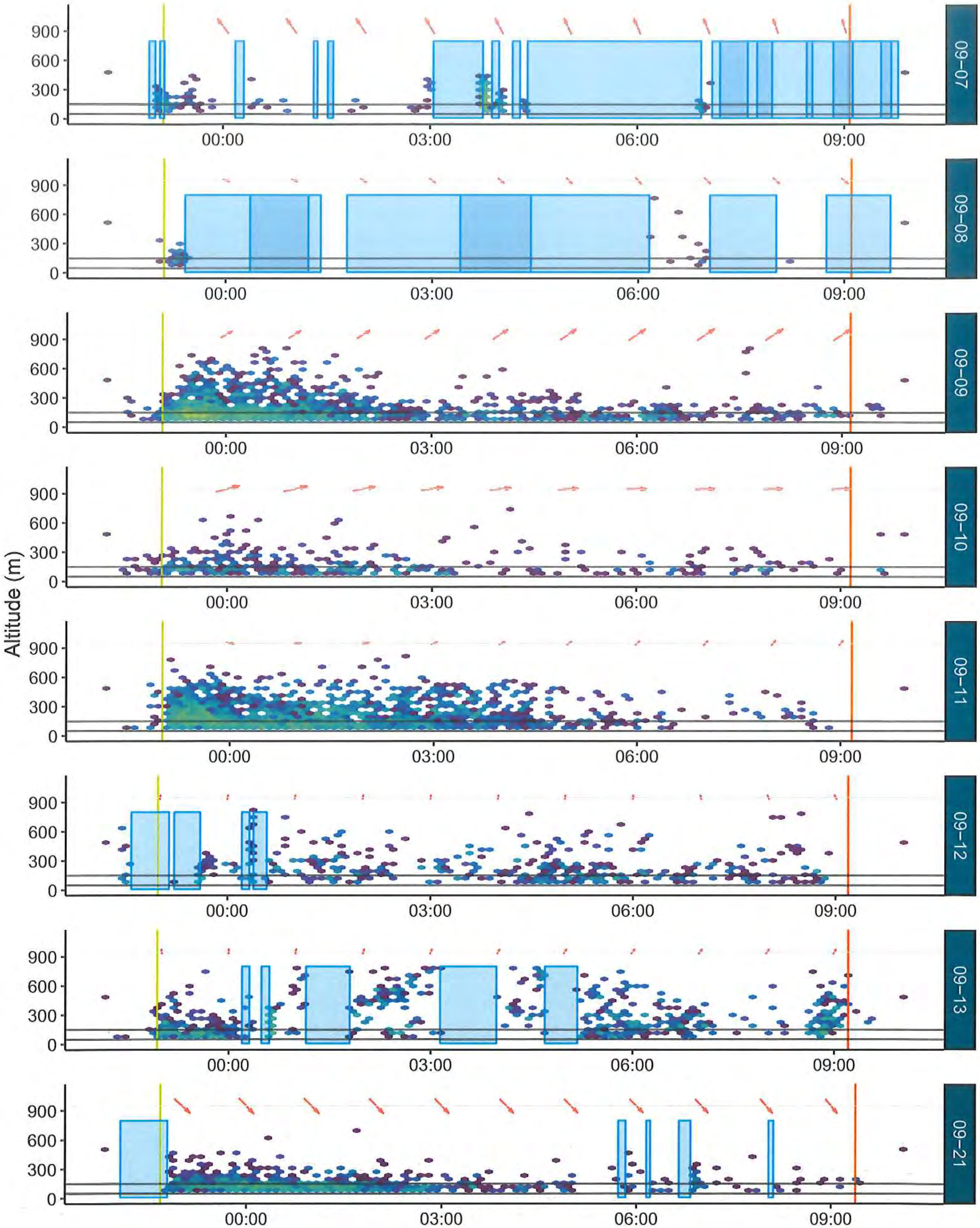

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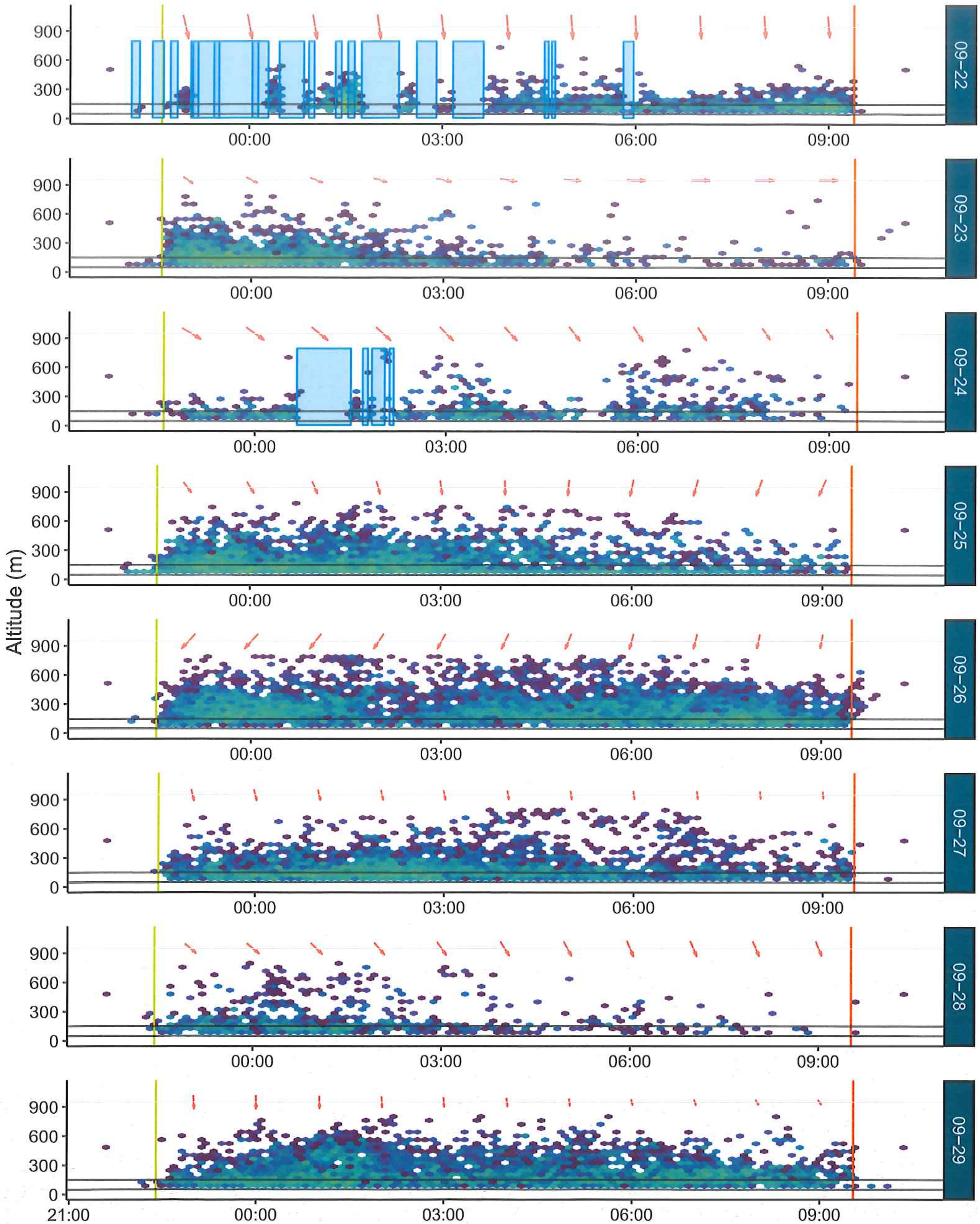

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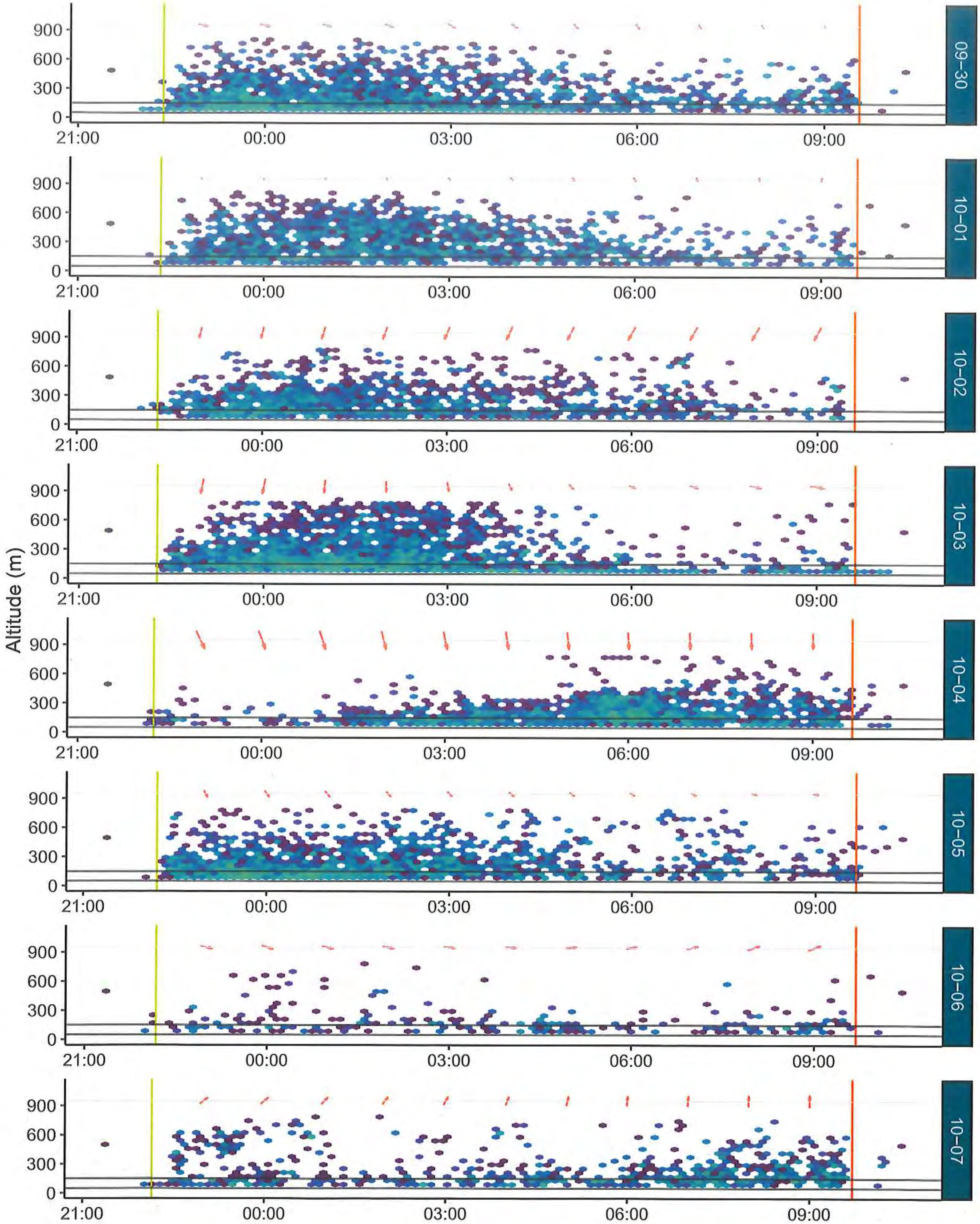

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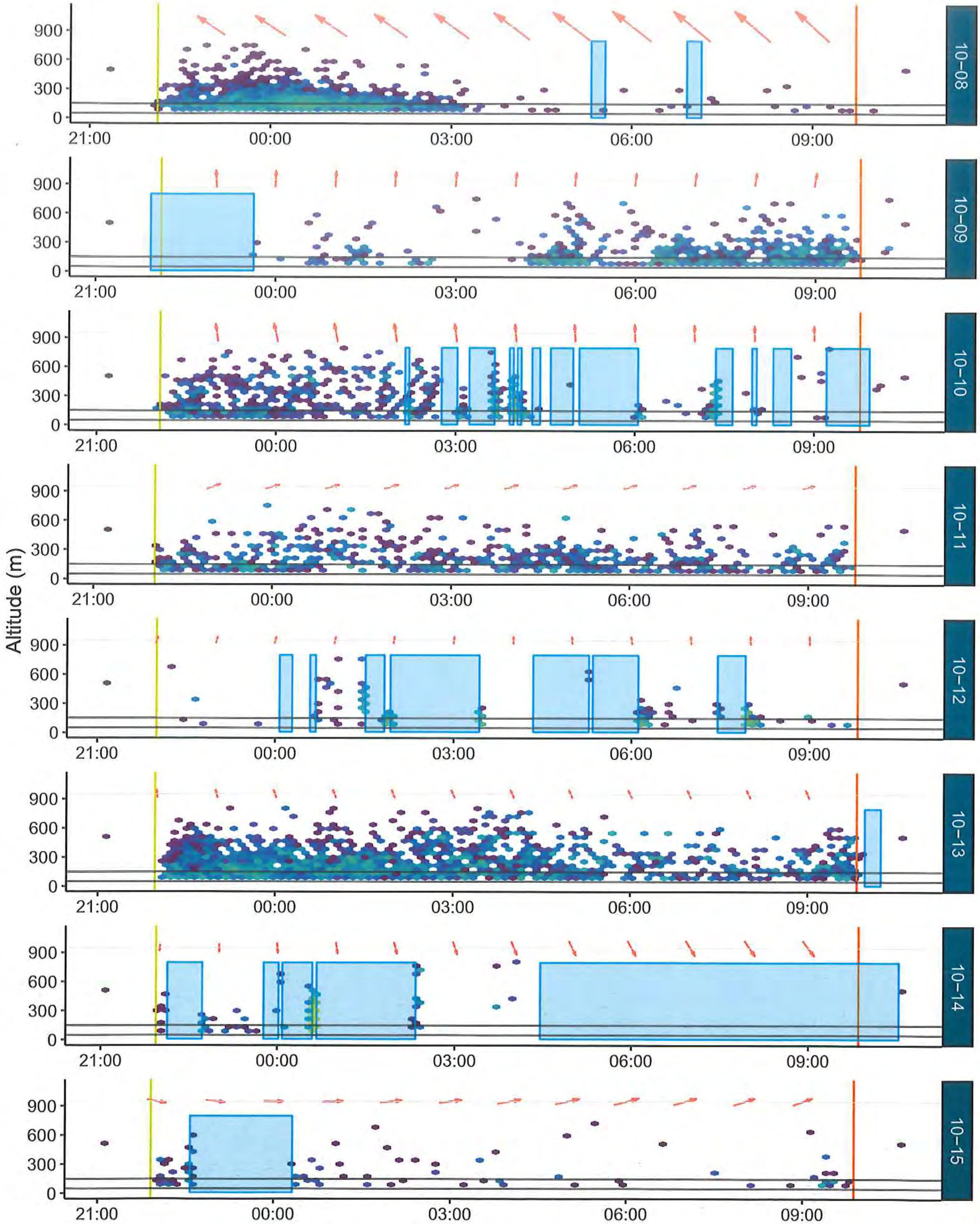

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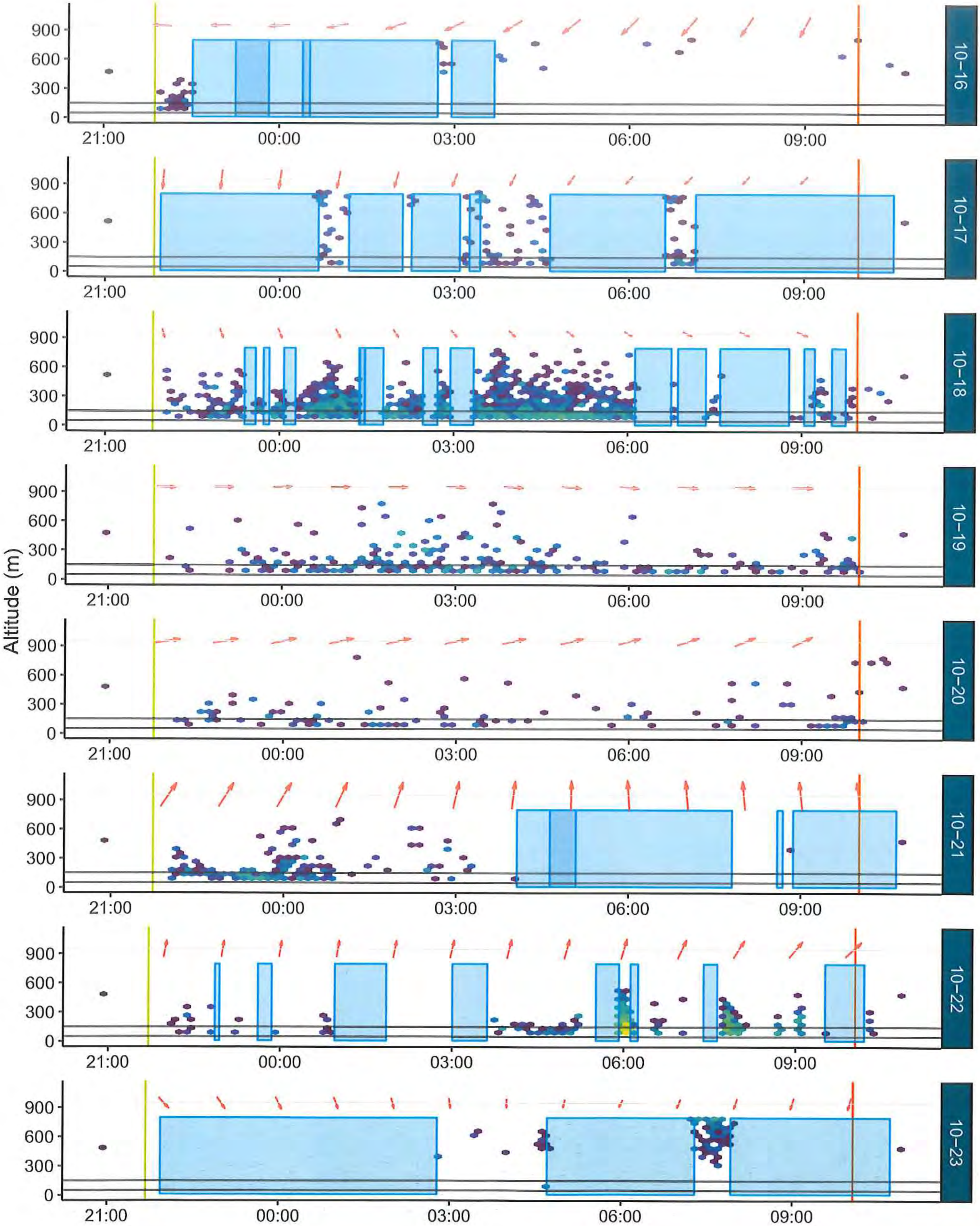

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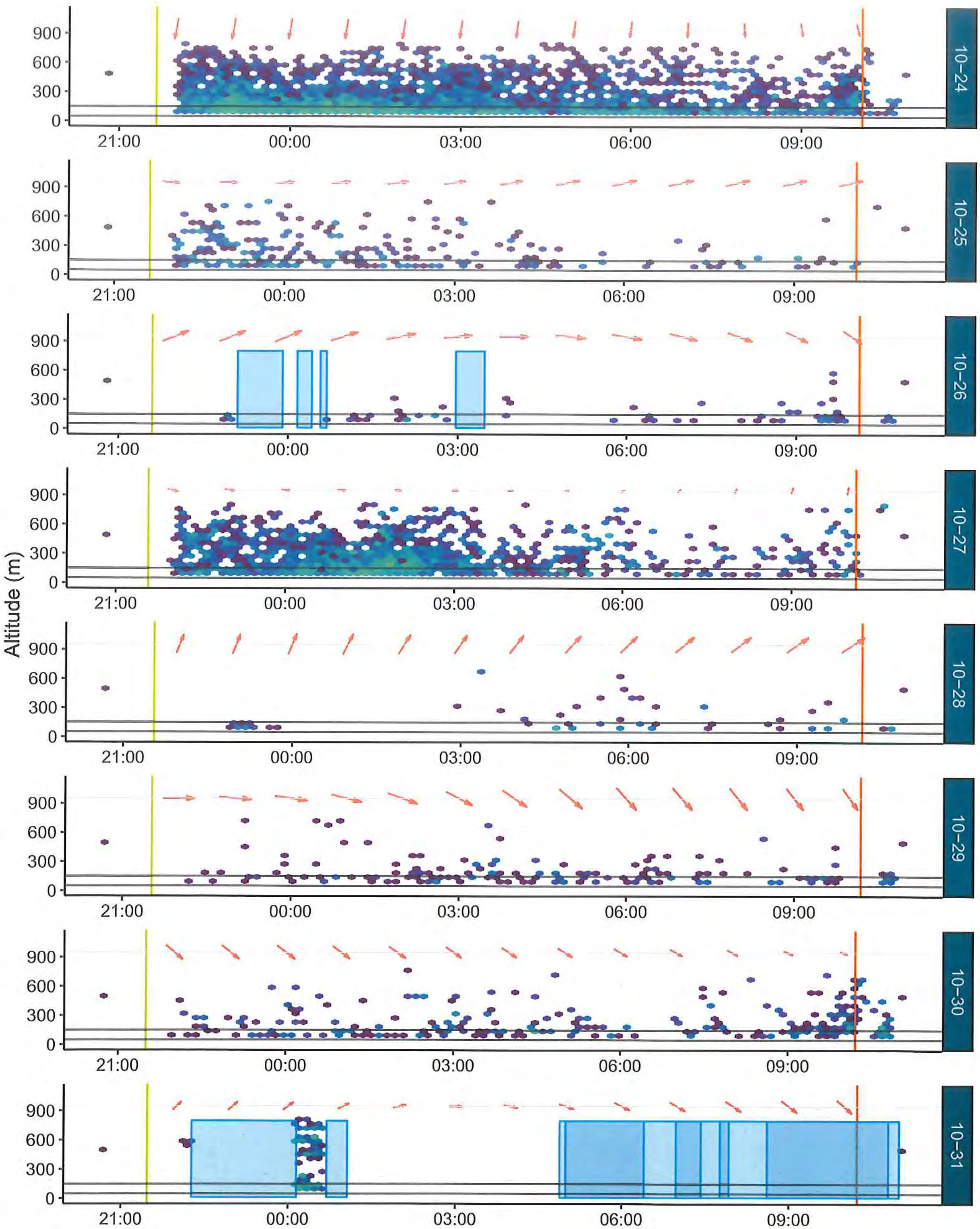

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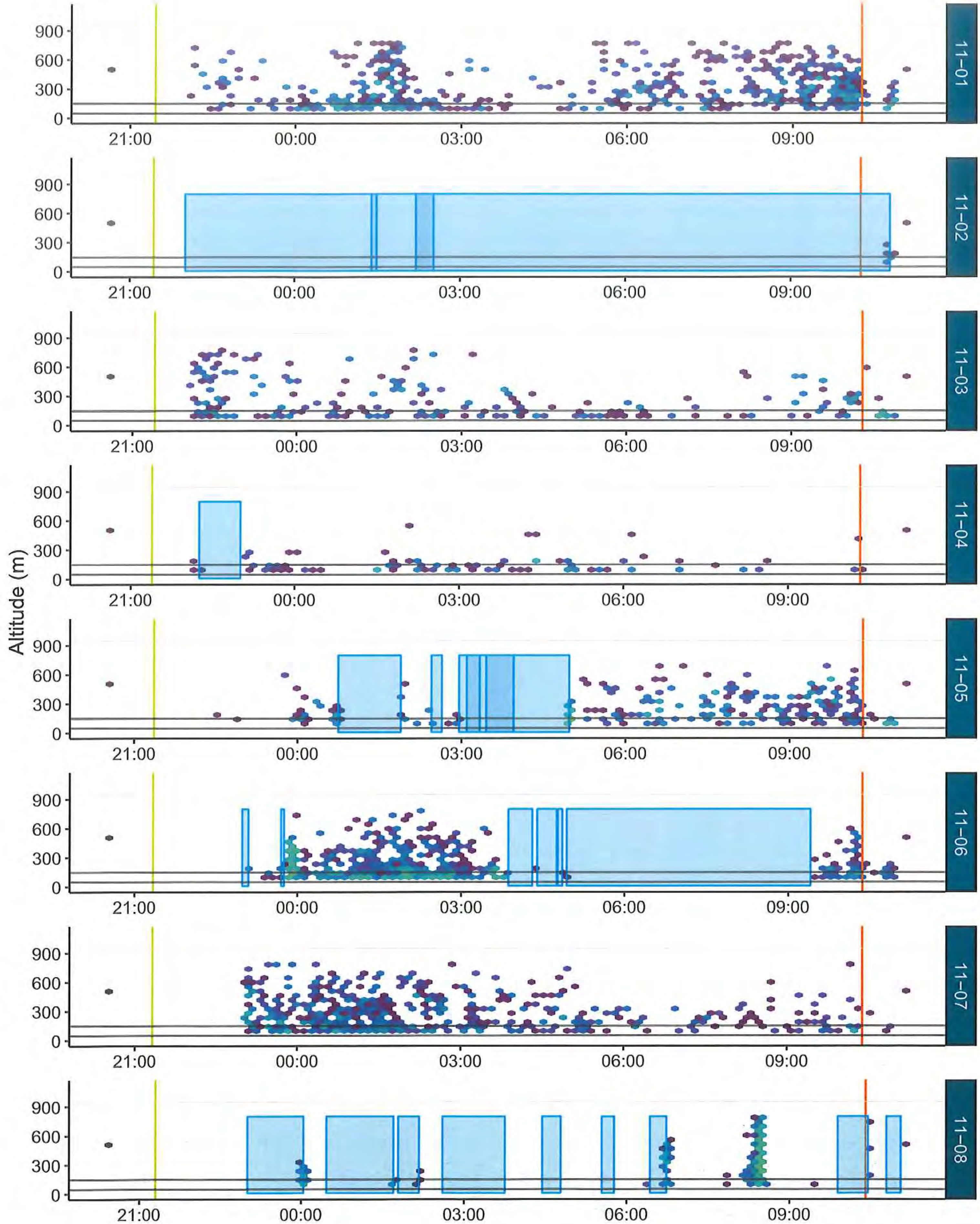

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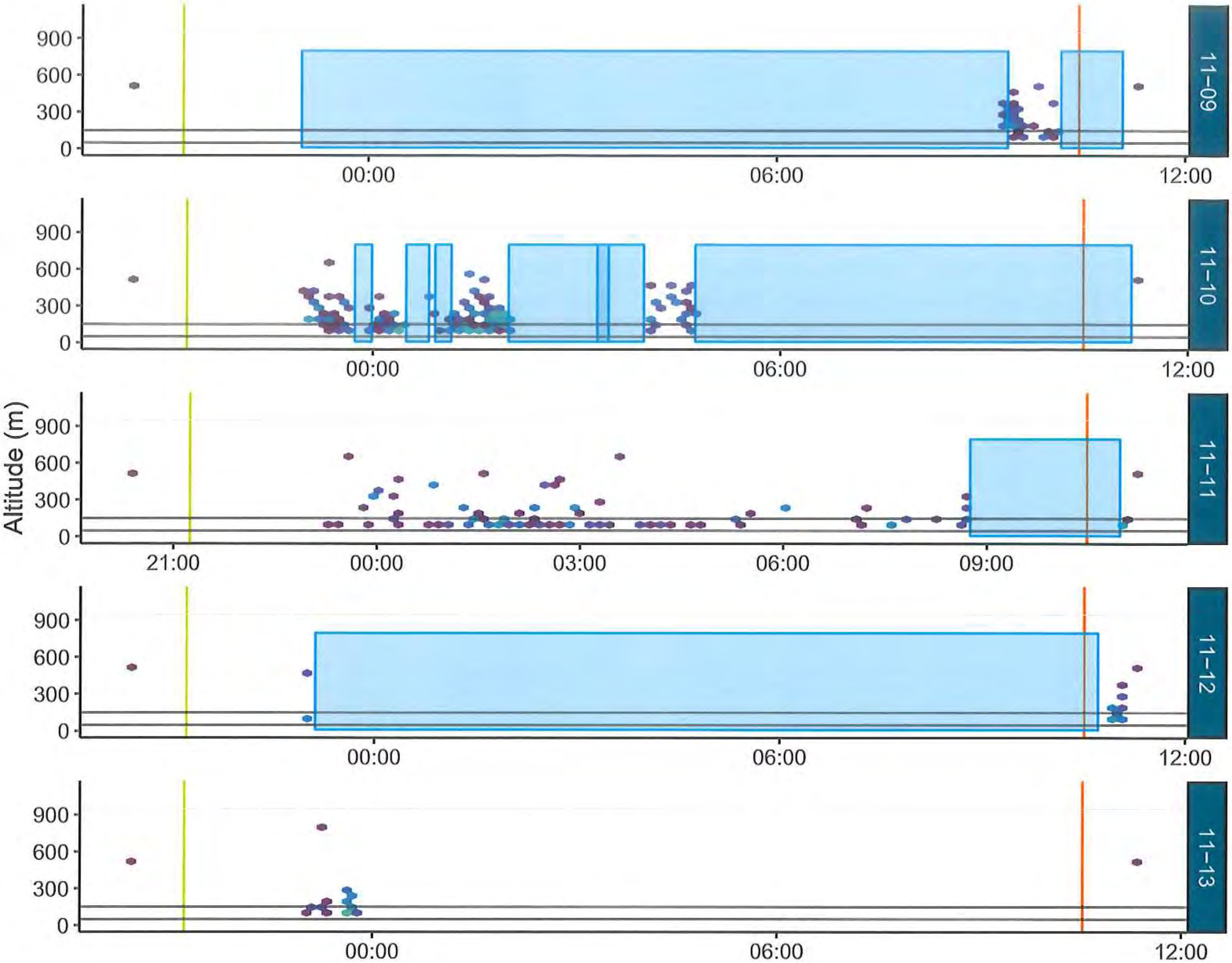

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