Wind Wildlife Research: Recent Advances in Understanding Bat Interactions with Wind Turbines Using Thermal Imagery and Acoustics

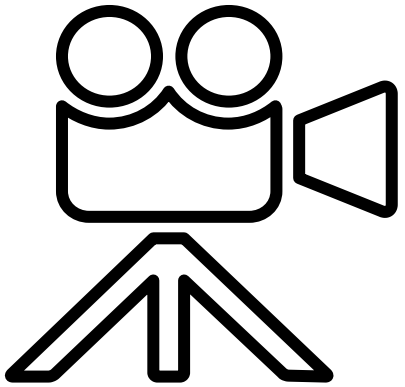
GENERATION

EPRI Hosted Webinar with Bowman Consulting and Stantec

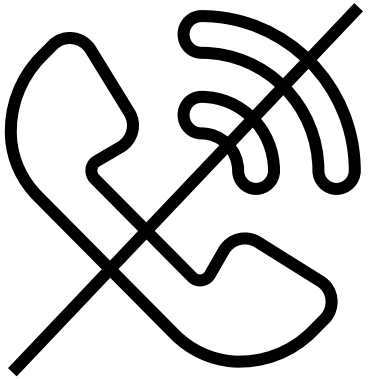
September 30, 2025

Welcome to today's Environmental Aspects of Wind
Wind Wildlife Research Webcast

We will begin at 11:00 am ET / 8:00 am PT



We will be recording this webcast



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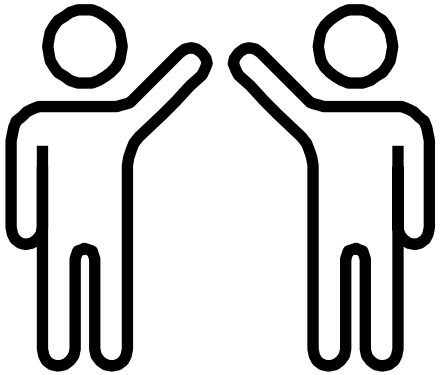
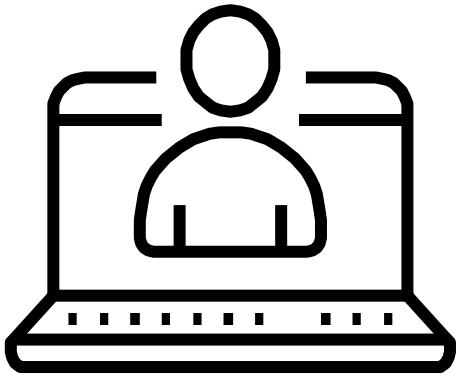
To un-mute, press *6 on your phone or push the un-mute icon in WebEx



Please ask any questions at any time by using the Chat panel or 'raise hand' during the Q&A session at the end



We will post the presentation materials on EPRI.com program pages

Your participation provides consent to the recording

Background

In 2021, three research projects began exploring how bats interact and behave around wind turbines to support more effective fatality reduction strategies at operating wind farms. All three advanced the collective understanding of bat-wind behavior using thermal imaging and acoustics.

Stantec: Quantifying bat presence, interactions with wind turbines, and risk of turbine-related impacts using ultrasonic acoustic detectors and thermal video cameras. Contributors: Seta Aghababian (Stantec), Caroline Byrne (Stantec), Sydney Edwards (Stantec), Brogan Morton (WIS), and Trevor Peterson (Stantec)

Bowman Consulting: Bat focal behavior at wind turbines in Texas. Contributors: Sara Weaver (Bowman), Brogan Morton (WIS)

EPRI: No evidence that bats are attracted to the wakes of wind turbines at an Iowa wind facility. Contributors: Donald Solick (EPRI), Aaron Corcoran (UCCS), Michael Whitby (BCI), Noah Myrent (EPRI), Praanjal Nasery (EPRI), Corey Markfort (UI), Tyler Bell (UI), Jesse Leckband (MidAmerican), and Christian Newman (EPRI)

Original 2021 Request for Proposal

Research topics of interest:

1) Conducting experimental studies to investigate potential hypotheses for why bats approach and interact with wind turbines.
2) Relating video observations and collisions with spatial, temporal, operational, and weather conditions.
3) Quantifying the response (e.g., flight behaviors and distances) of bats to wind turbines or wind energy facilities.

Stantec

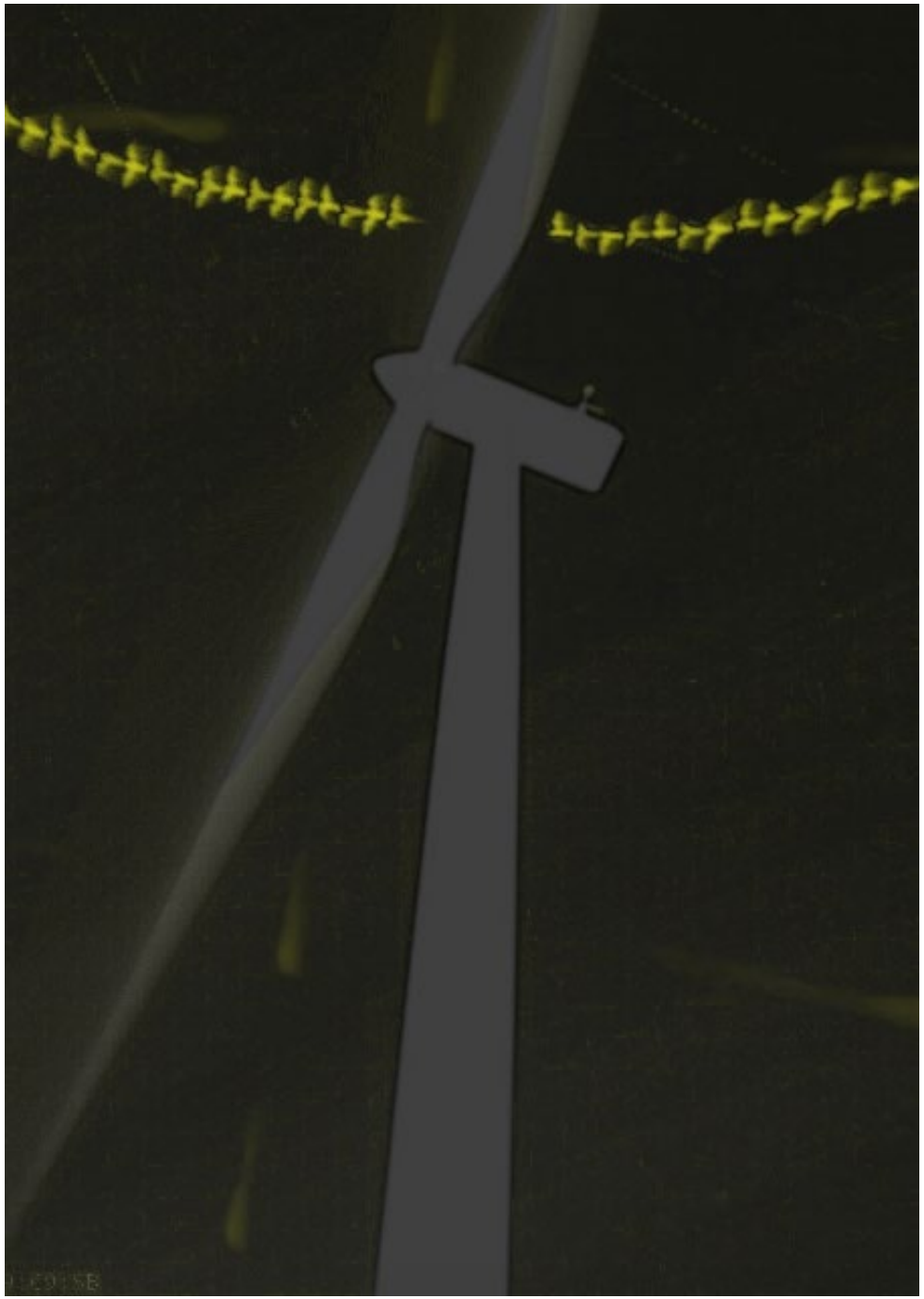
Quantifying bat presence, interactions with wind turbines, and risk of turbine-related impacts using ultrasonic acoustic detectors and thermal video cameras.

Contributors: Seta Aghababian (Stantec), Caroline Byrne (Stantec), Sydney Edwards (Stantec), Brogan Morton (WIS), and Trevor Peterson (Stantec)

Quantifying bat presence, interactions with wind turbines, and risk of turbine-related impacts using ultrasonic acoustic detectors and thermal video cameras

Presented by: Seta Aghababian

Authors: Caroline Byrne, Brogan Morton, and Trevor Peterson



The Problem

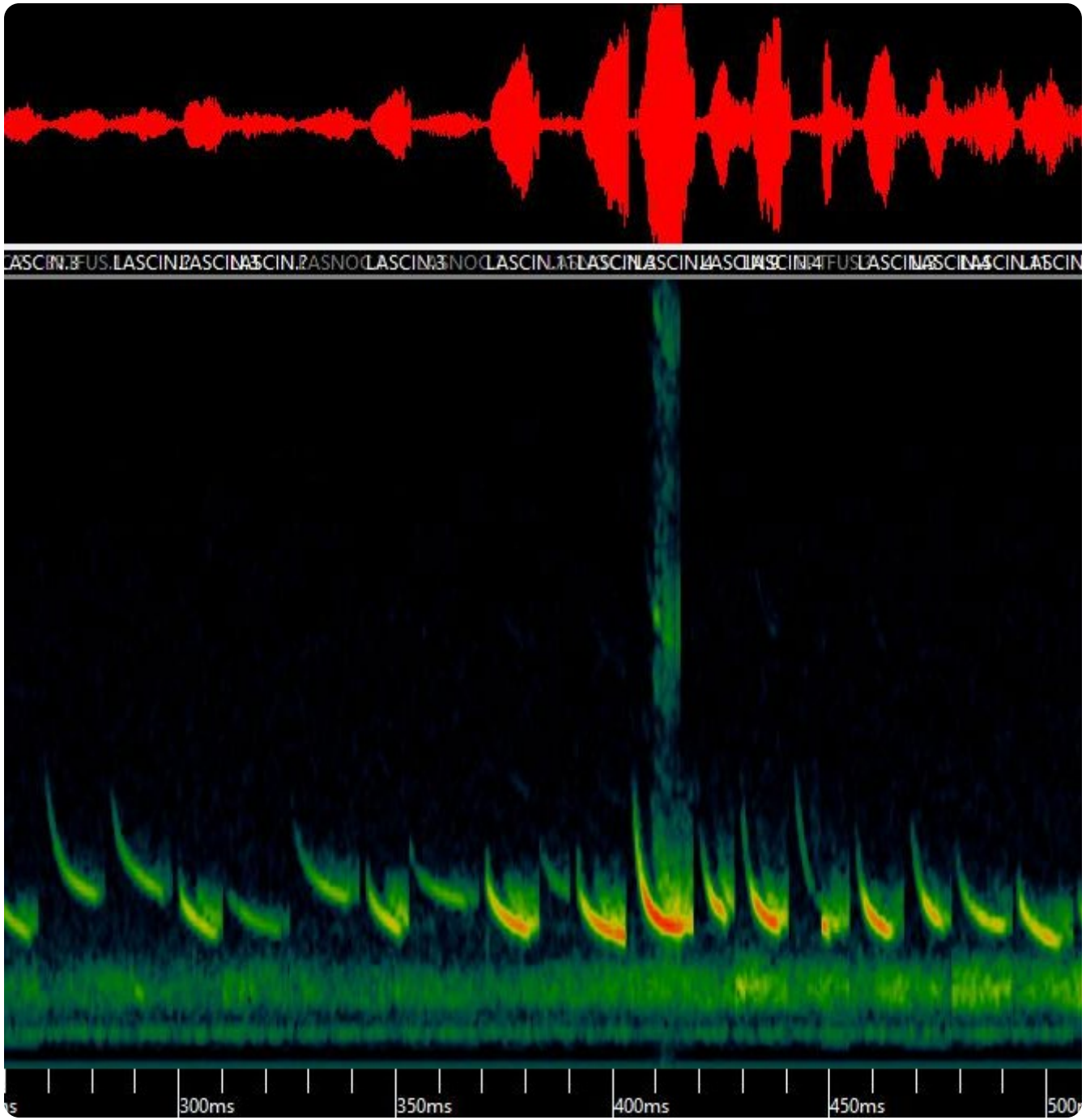
- Bats are at risk of colliding with turbines
- How can we improve our understanding monitoring?
- Implications for what we use to assess risk

BACKGROUND

Acoustic Monitoring

- Widespread and practical monitoring
- Approximate spatial location
- Species identifications
- Behavioral information from call patterns

❖ Limited sampling area and dependent on echolocation

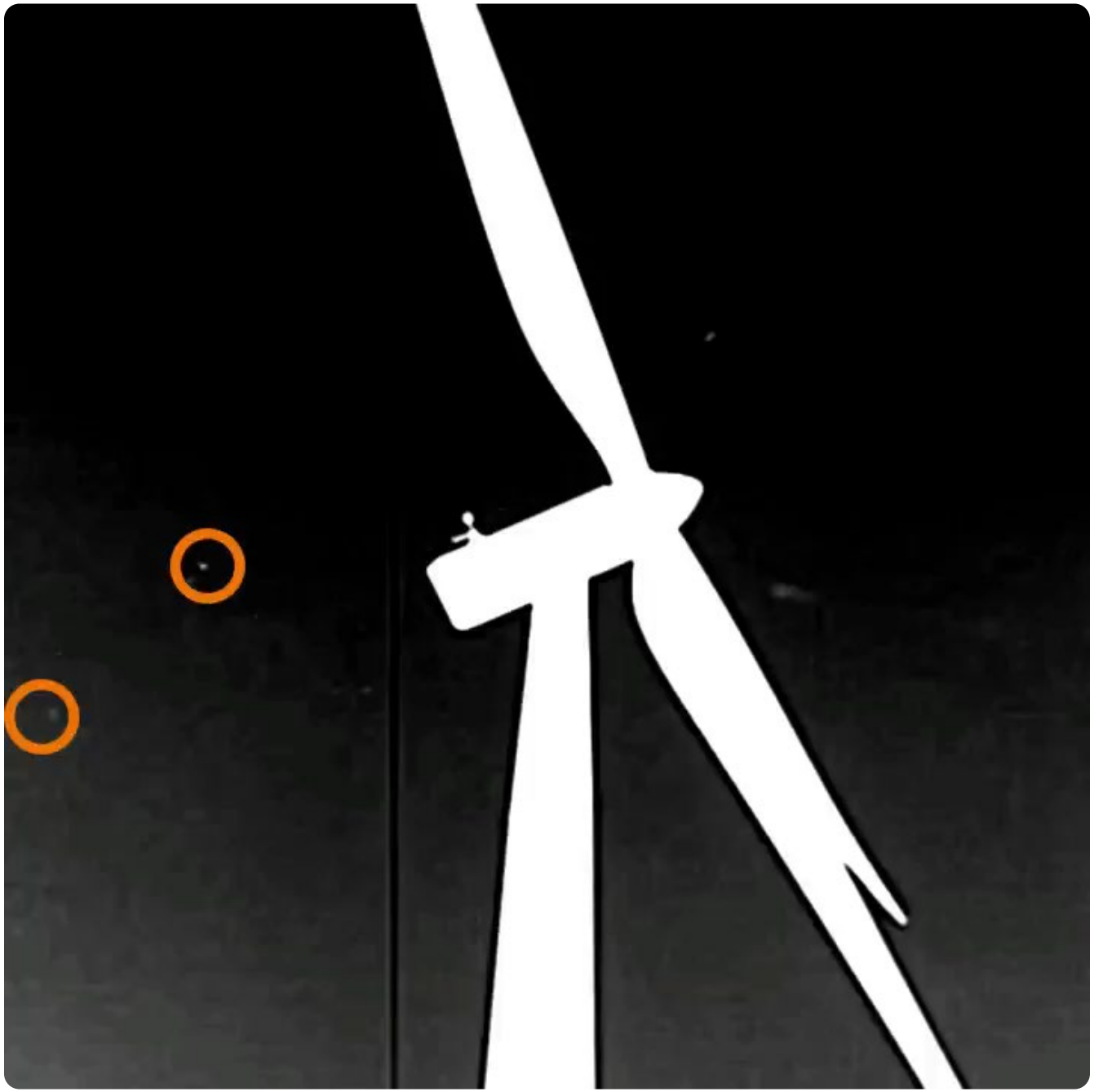


BACKGROUND

Camera Monitoring

- Less widespread than acoustic monitoring
- Detection independent of echolocation
- Larger sampling area
- Behavioral information from flight patterns

❖ No species identification and more limited spatial inference



Combined Methodology

1. **Spatial Inference:** Where do bats fly near wind turbines?

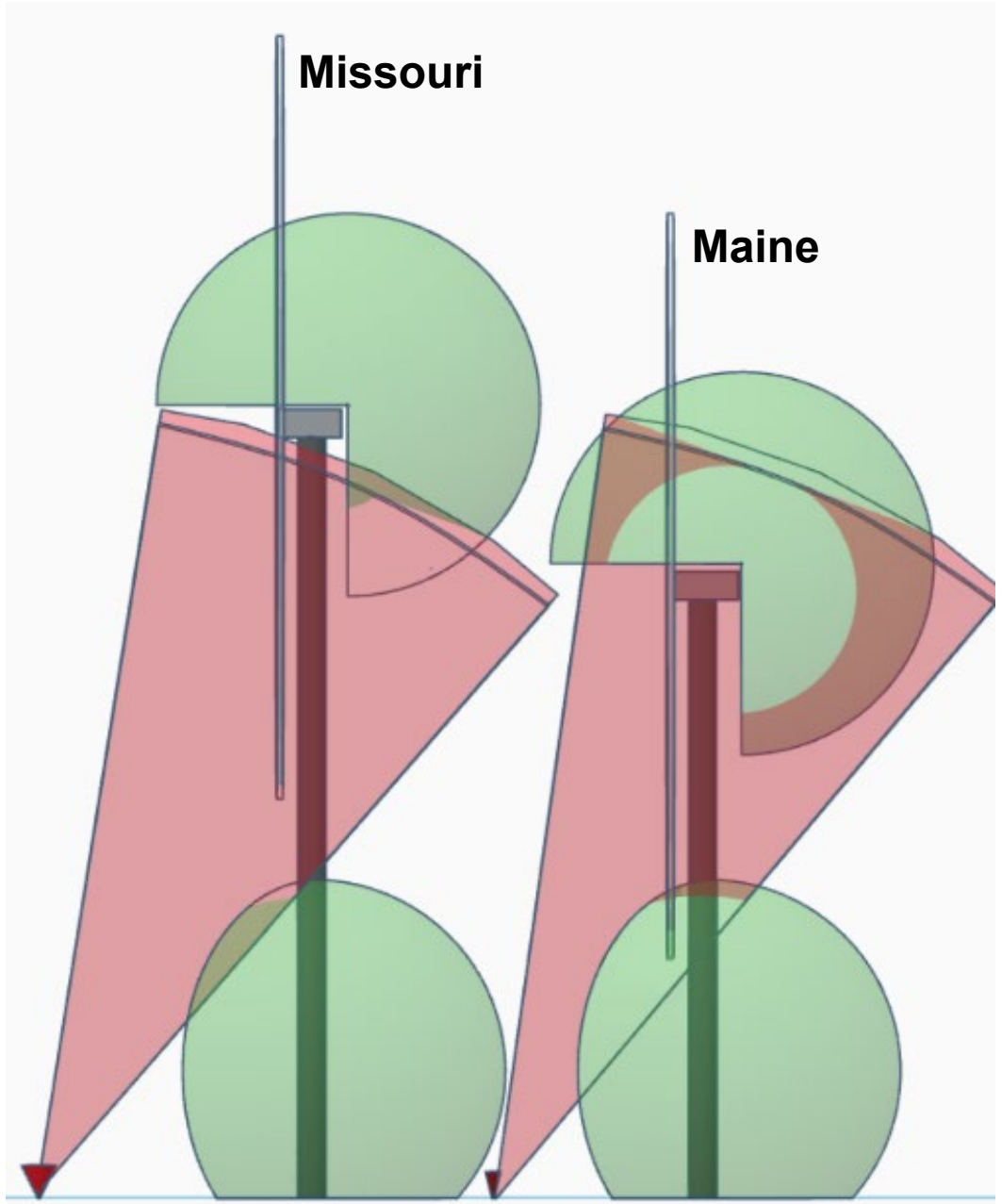
2. **Detection Influence:** Do certain environmental conditions change our characterization of bat activity?

3. **Risk Assessment:** Does risk characterization vary by detector method?

BACKGROUND

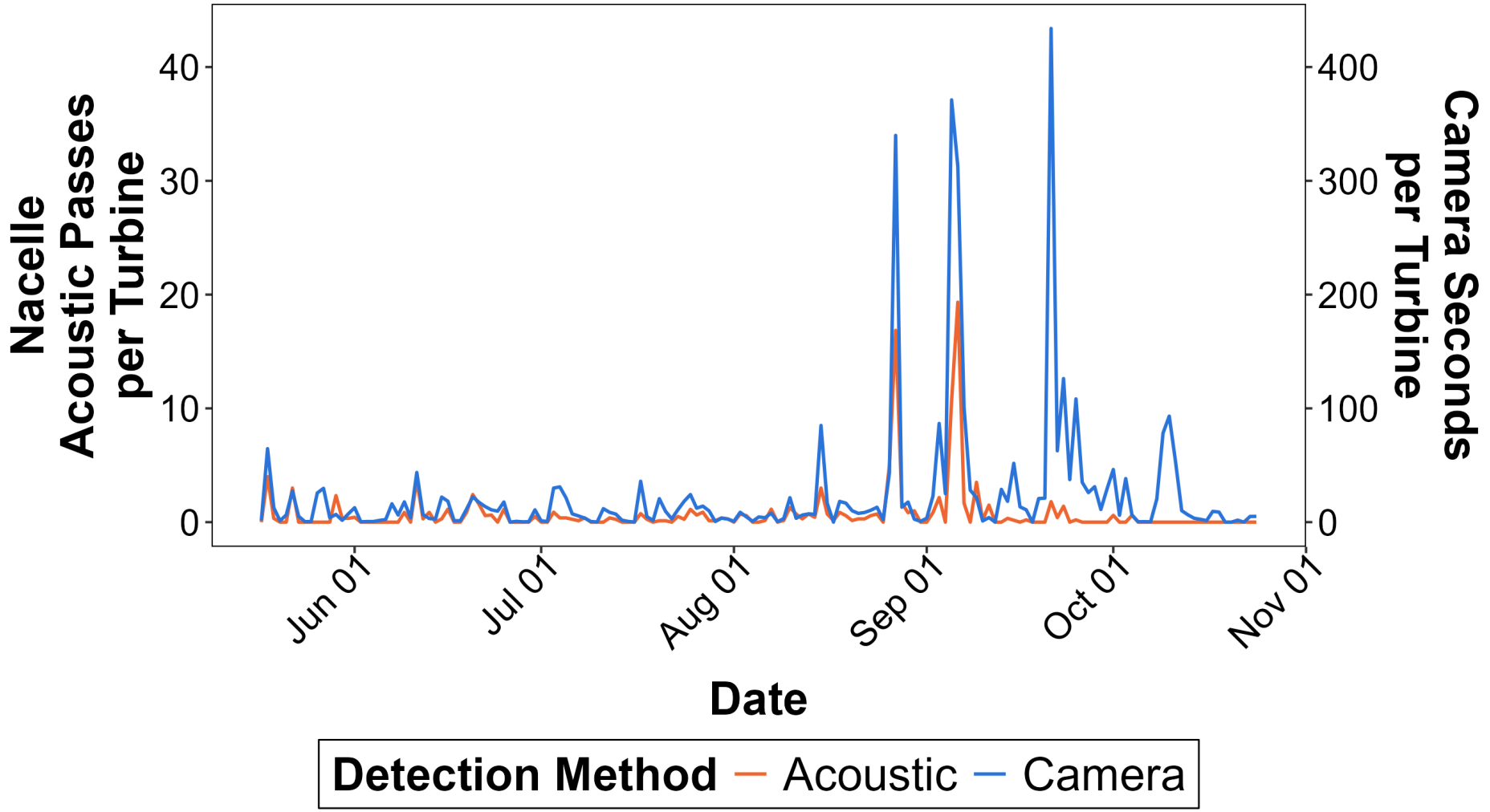
Study Design

- Monitored two wind facilities in summer and fall of 2023
  - Maine: 8 turbines 94-meter nacelle height
  - Missouri: 8 turbines 120-meter nacelle height
- Paired acoustics at **nacelle height** and **mid-tower** (~20m) with ground level (~1.5m) **thermal cameras**
- Compared bat activity across time, space, and detection method



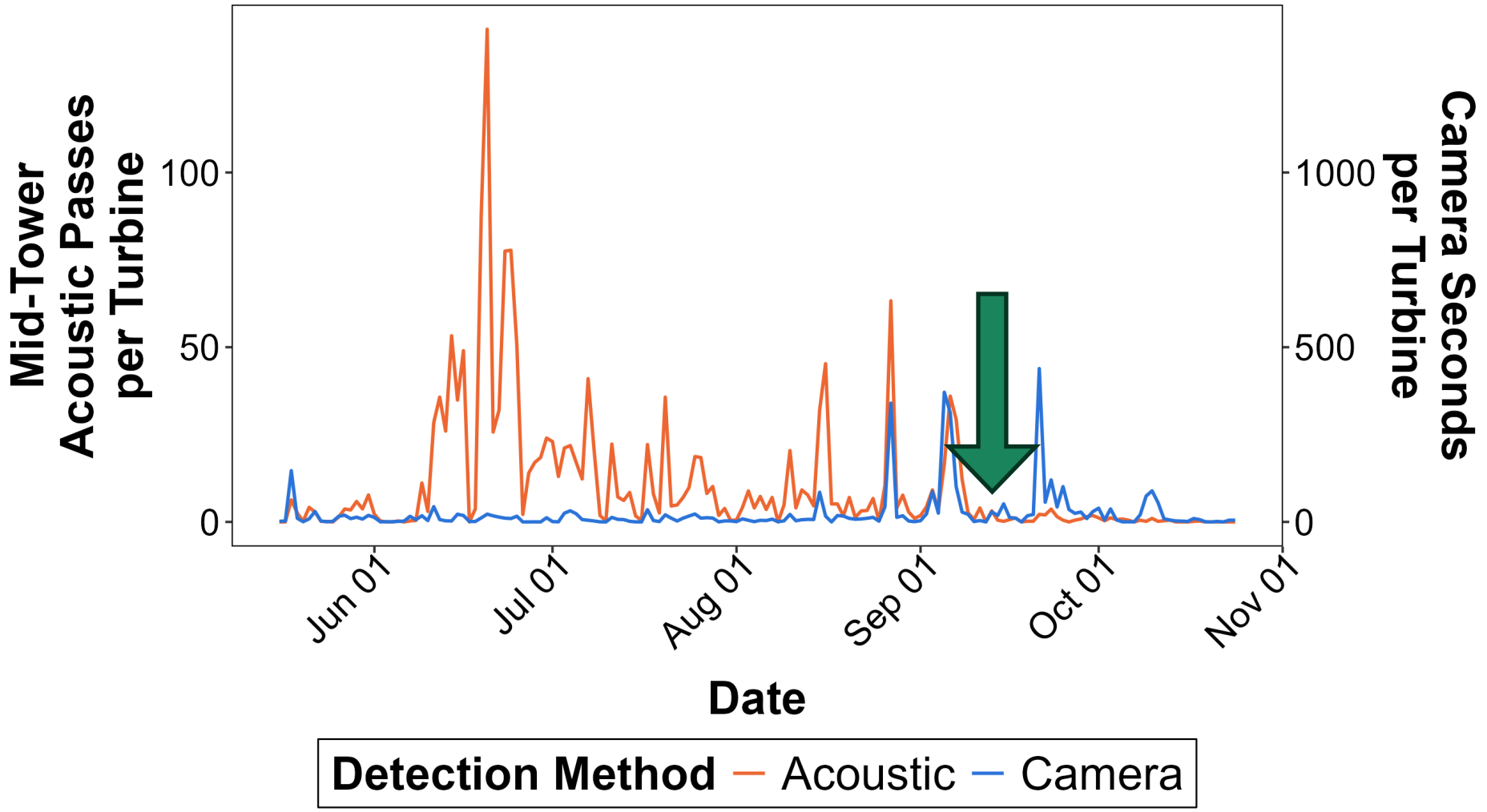
SPATIAL INFERENCE

Nacelle-height acoustics and cameras align nightly



SPATIAL INFERENCE

Mid-tower acoustics explain most other activity



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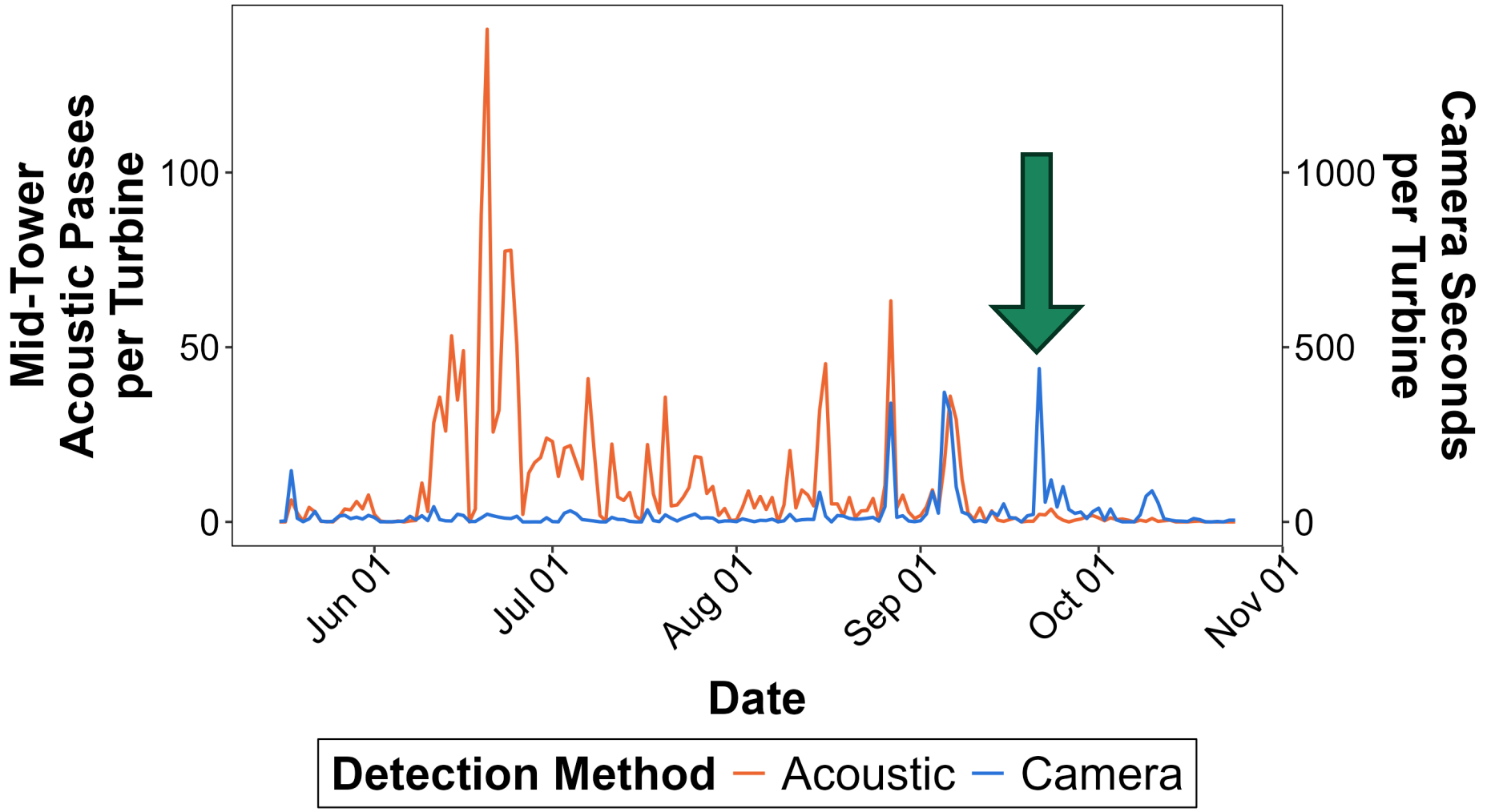
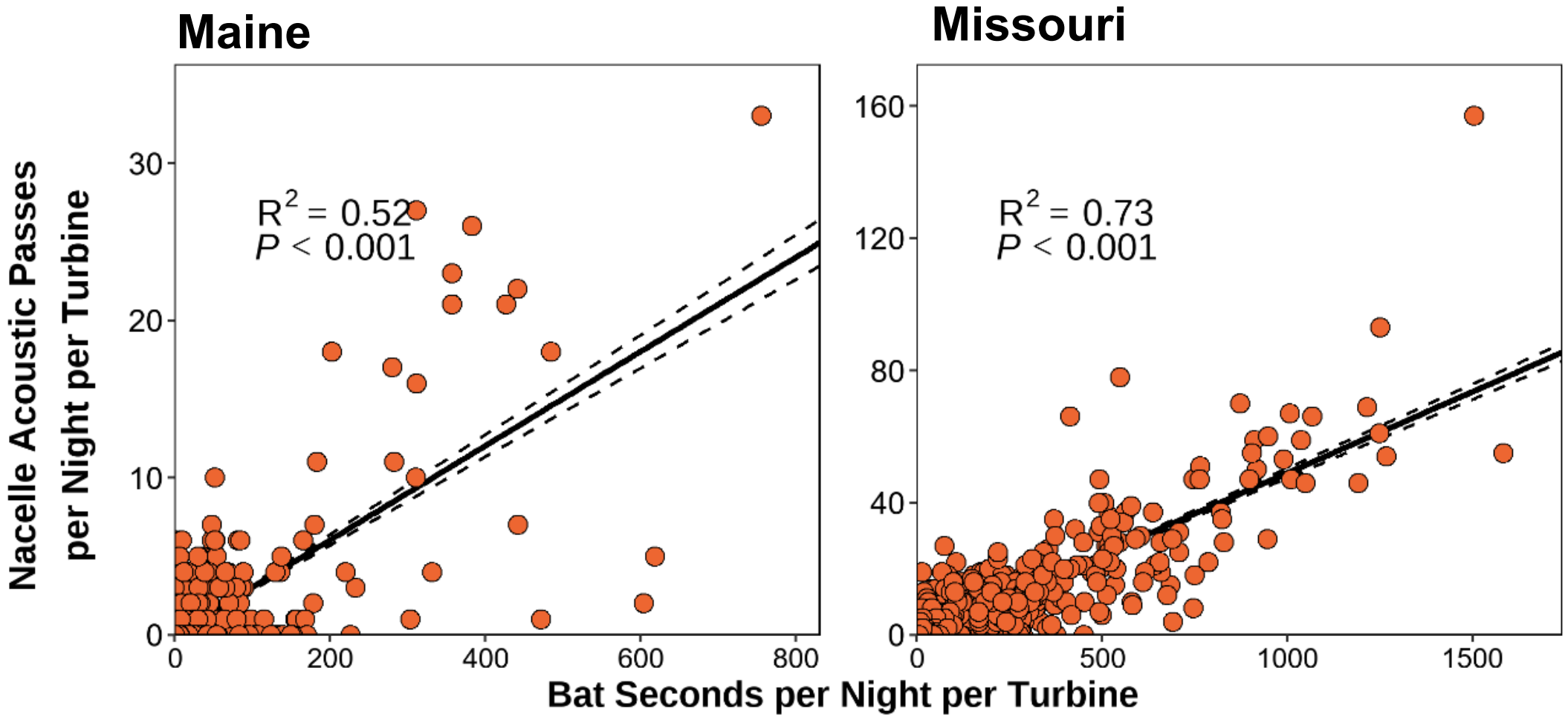
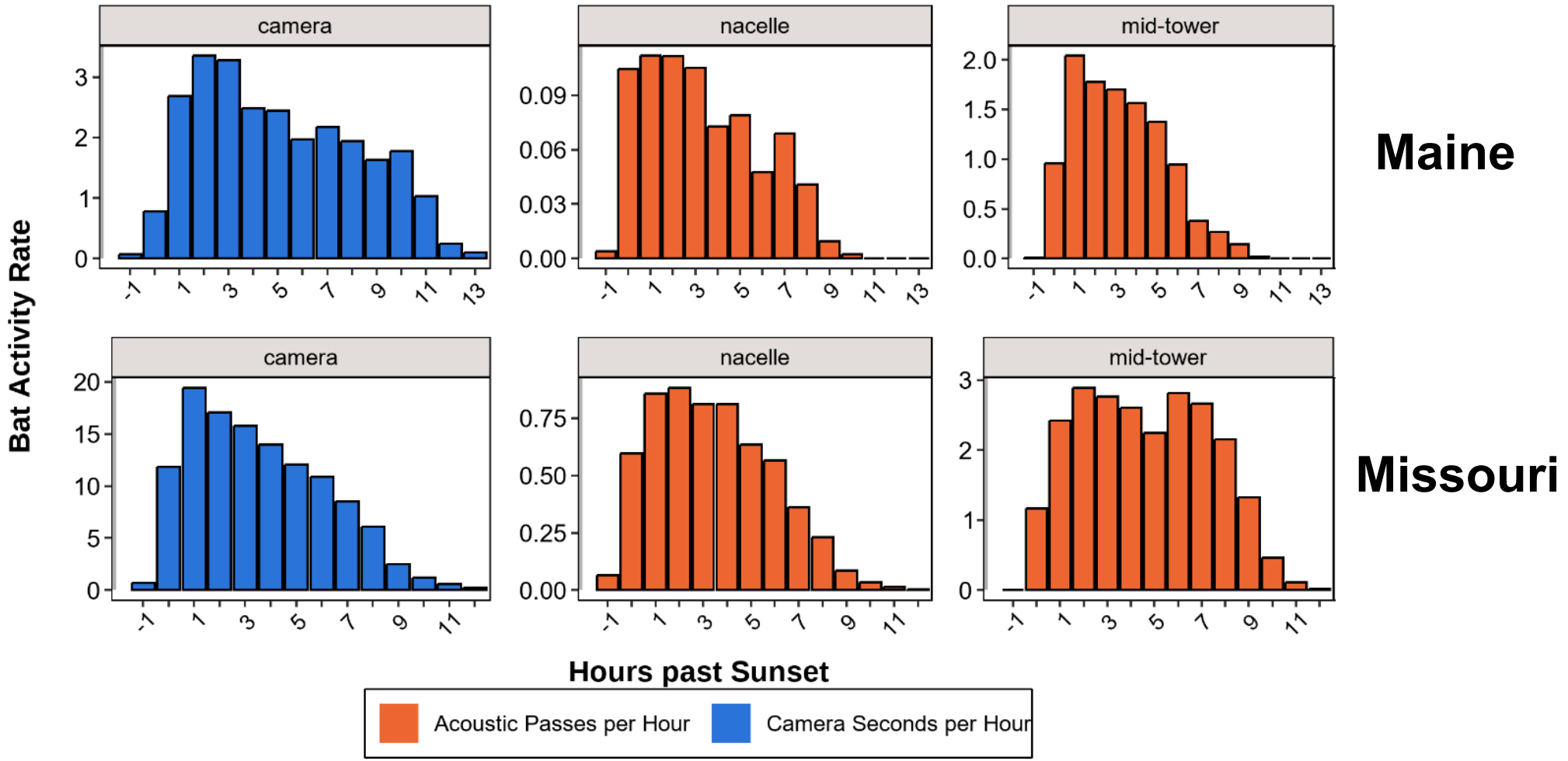


Cameras explain nacelle-height and mid-tower acoustics



SPATIAL INFERENCE

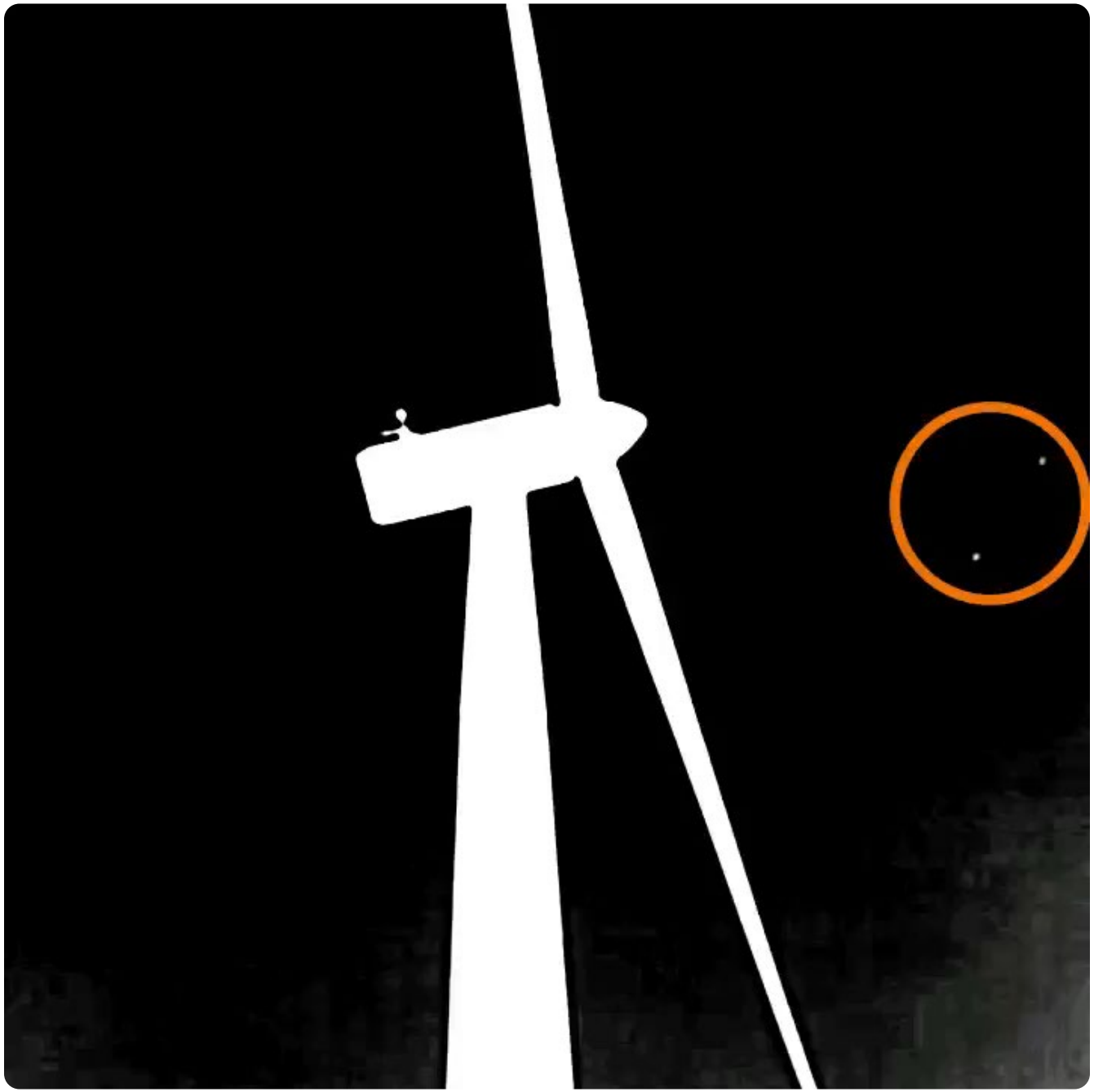
Hourly activity patterns are similar among detectors



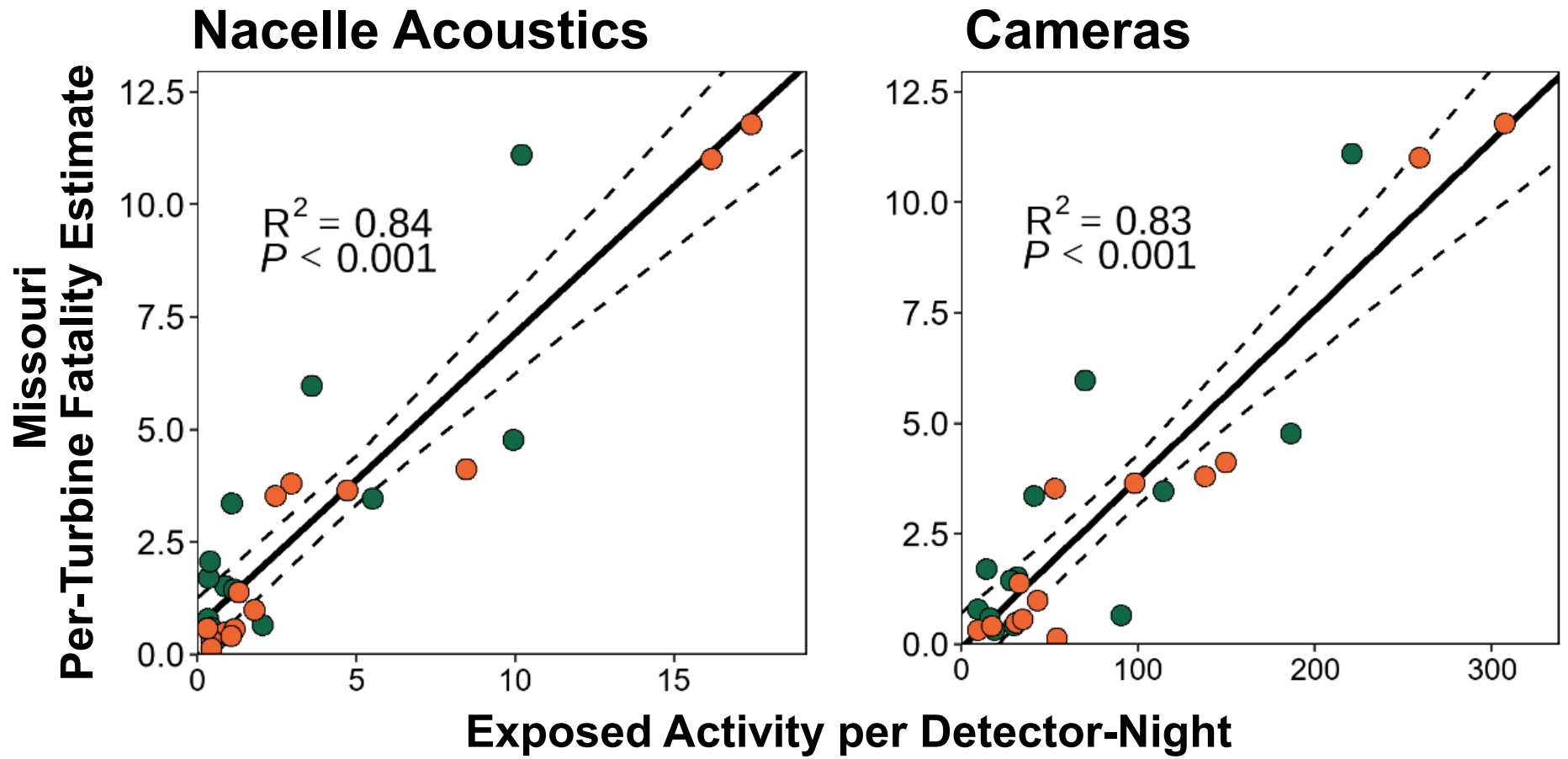
DETECTION INFLUENCE

Environmental Conditions

- No noticeable affect:
  - Temperature
  - Turbine Operation
  - Acoustic Attenuation
- Nacelle-height activity more sensitive to higher wind speeds

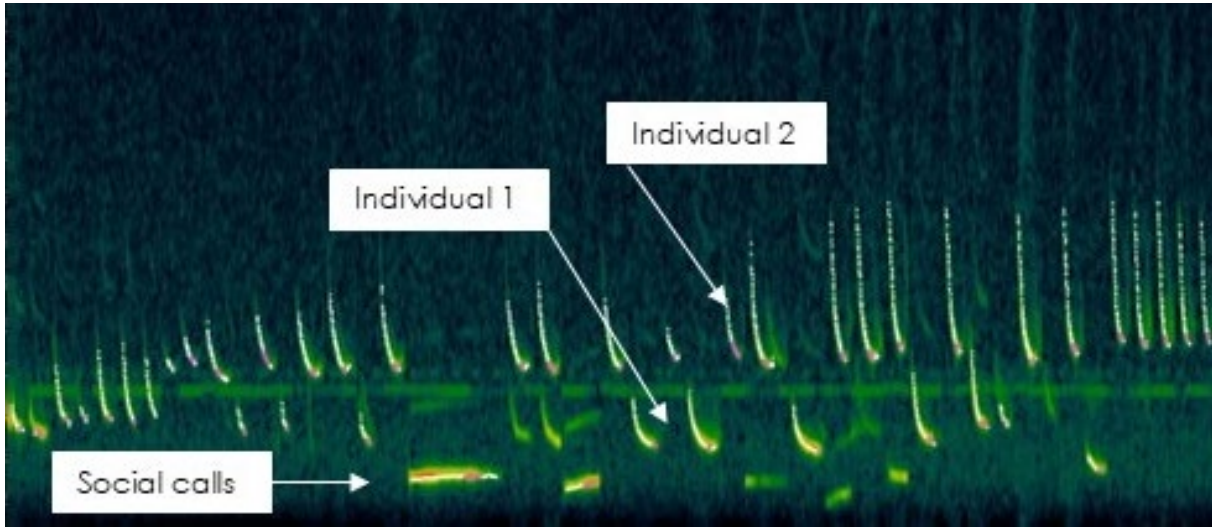


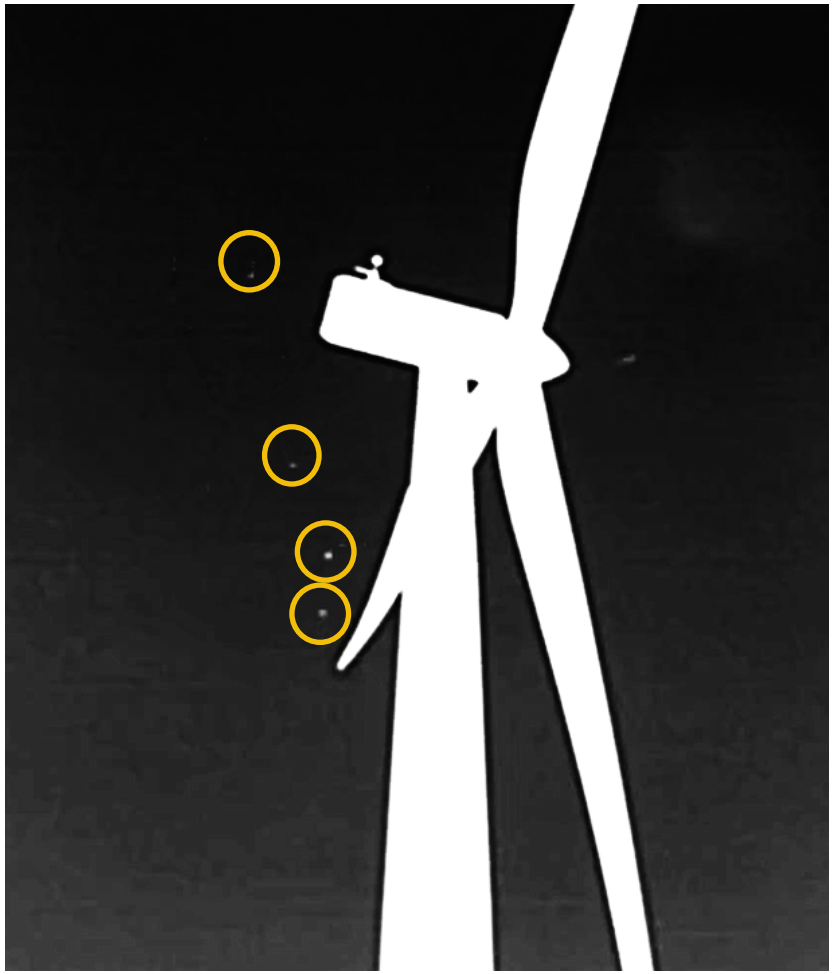
Cameras and acoustics correlate with fatality

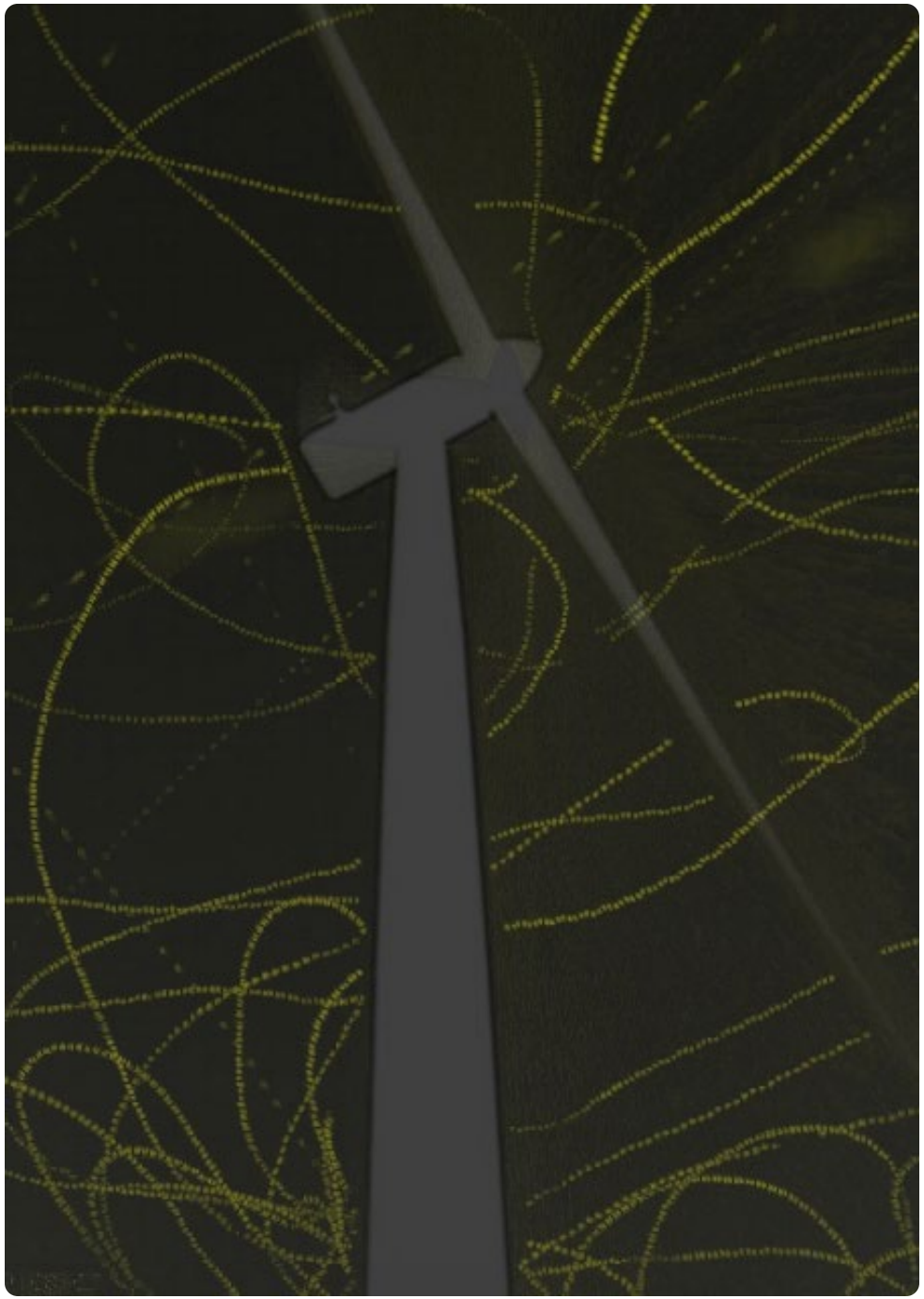


Species and Behavior

- Paired acoustics and video assist with identifying and characterizing events of interest
- Multiple species, individuals, and behaviors can be confirmed







Application and Future Work

- Applications in answering species-specific behavioral questions
- Nacelle-height acoustics and cameras characterize activity and risk similarly
- Strong seasonal and temporal signals highlight applications for refined curtailment
- Better information on flight height could improve minimization options

Thank you!

Caroline Byrne, Brogan Morton, and Trevor Peterson

Stantec

Wildlife Imaging Systems

Scan to learn more about Stantec's wind-wildlife work

Bowman Consulting

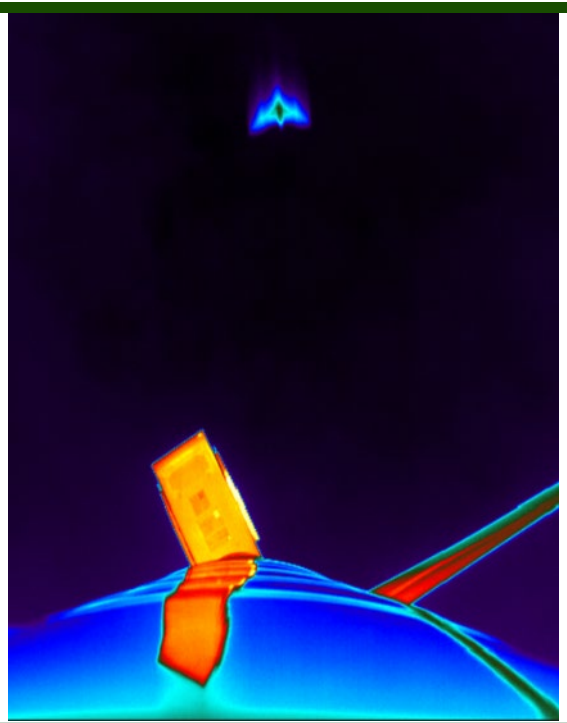
Bat focal behavior at wind turbines in Texas.

Contributors: Sara Weaver (Bowman), Brogan Morton (WIS)

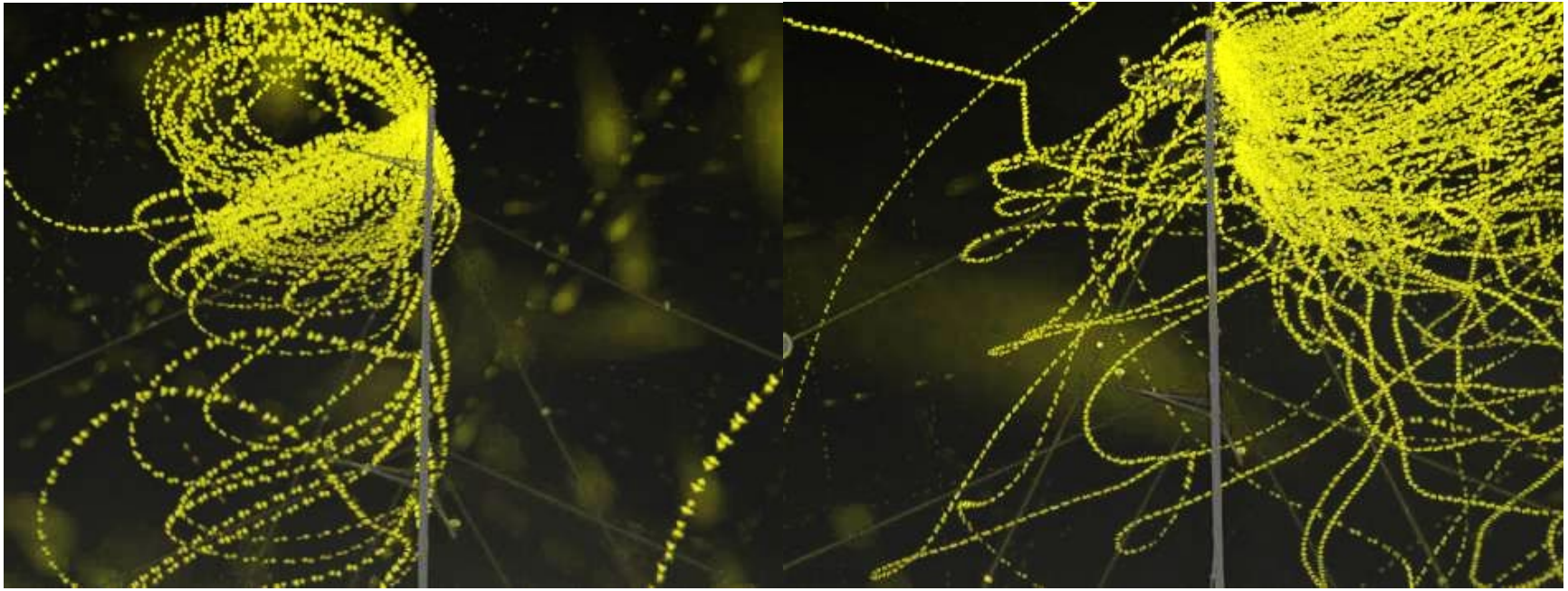
Bat Focal Behavior at Wind Turbines in Texas

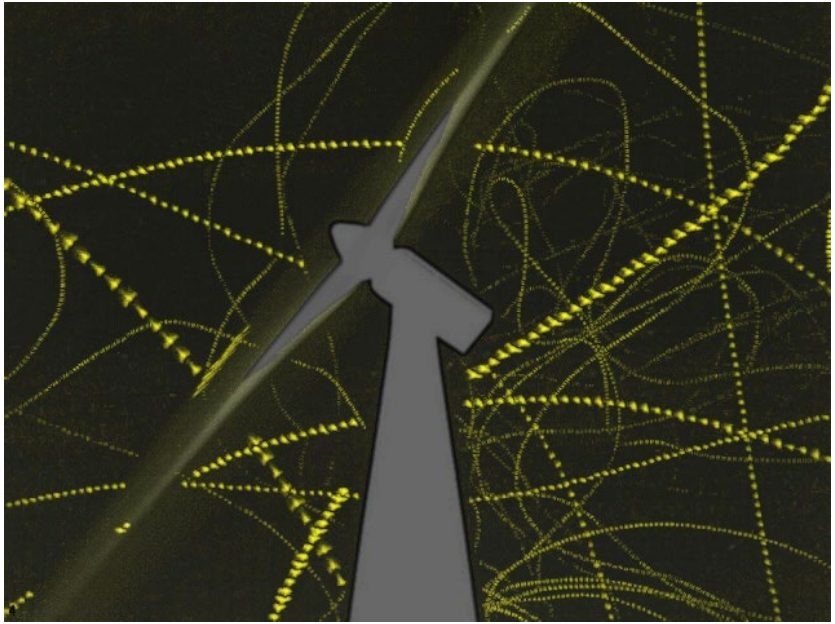
Sara Weaver*, Jon Ritter, Brittney Oliver, Juan Garcia, Brogan Morton*

*Principal Investigators



Background – Focal Behavior



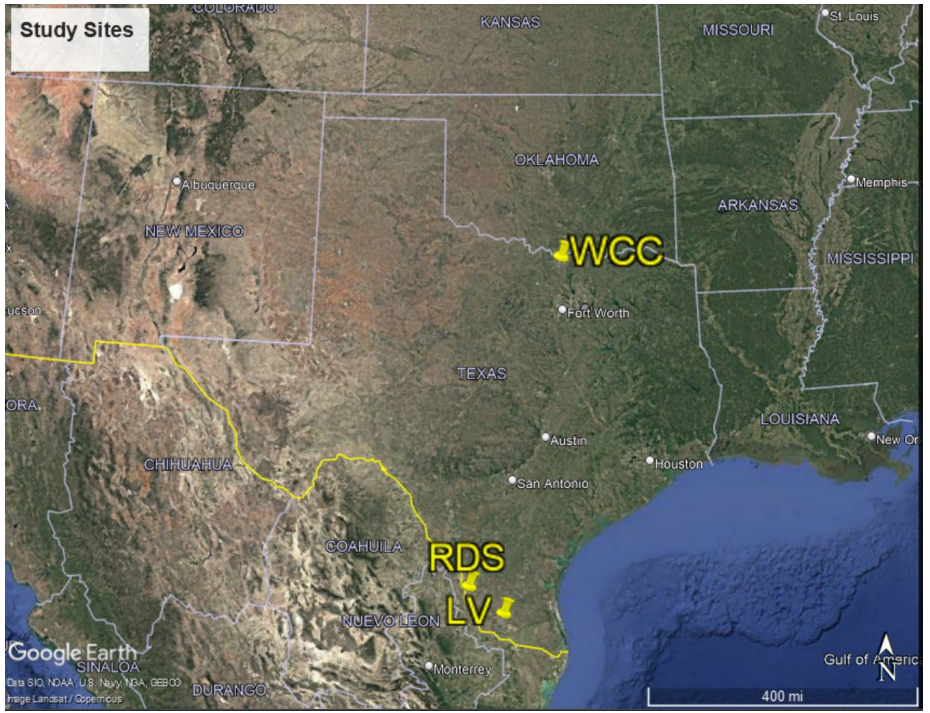


Study Objectives

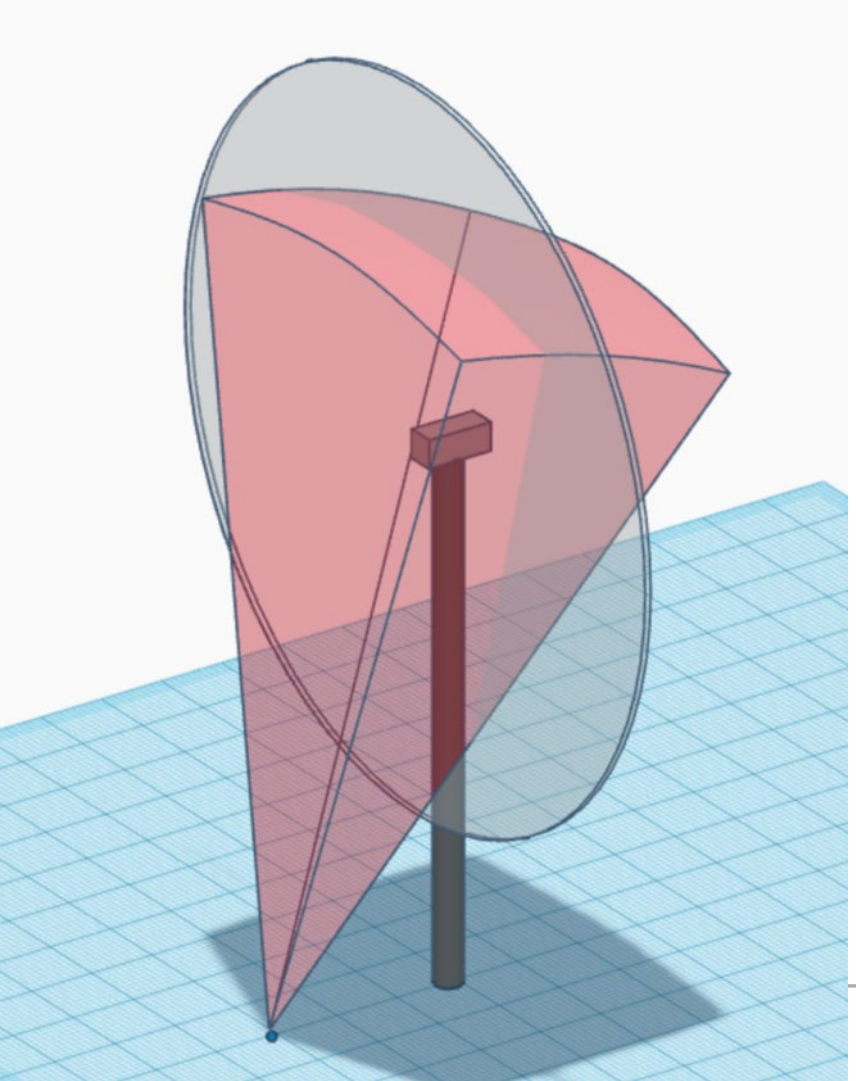
- Document focal behaviors at wind turbines opportunistically
- Quantify frequency of focal behaviors
- Describe behaviors occurring before and after focal behavior occurs
- Determine if focal behavior increases following collisions

Study Areas

- Wildcat Creek (WCC)
  - 6 Cameras
  - July 15 to October 31, 2023
- Reloj Del Sol (RDS)
  - 2 Cameras
  - July 15 to October 31, 2022
- Los Vientos (LV)
  - 3 cameras
  - August 15 to October 15, 2017

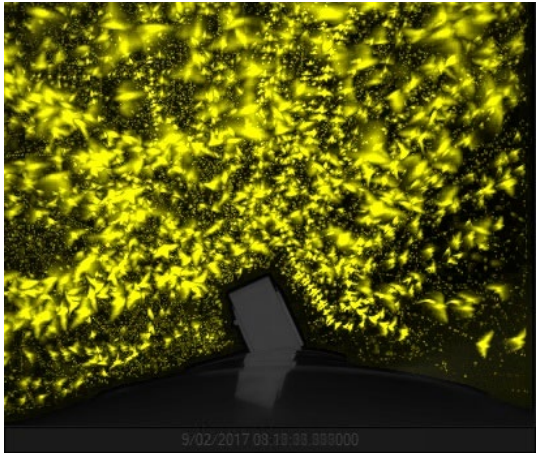


Bowman



System Design

- RDS and WCC
  - Axis Thermal Camera
  - Solar powered
  - Survey tripod
- LV
  - FLIR Thermal Camera
  - Turbine tower magnetic mount
  - Powered by wind turbine



Bowman

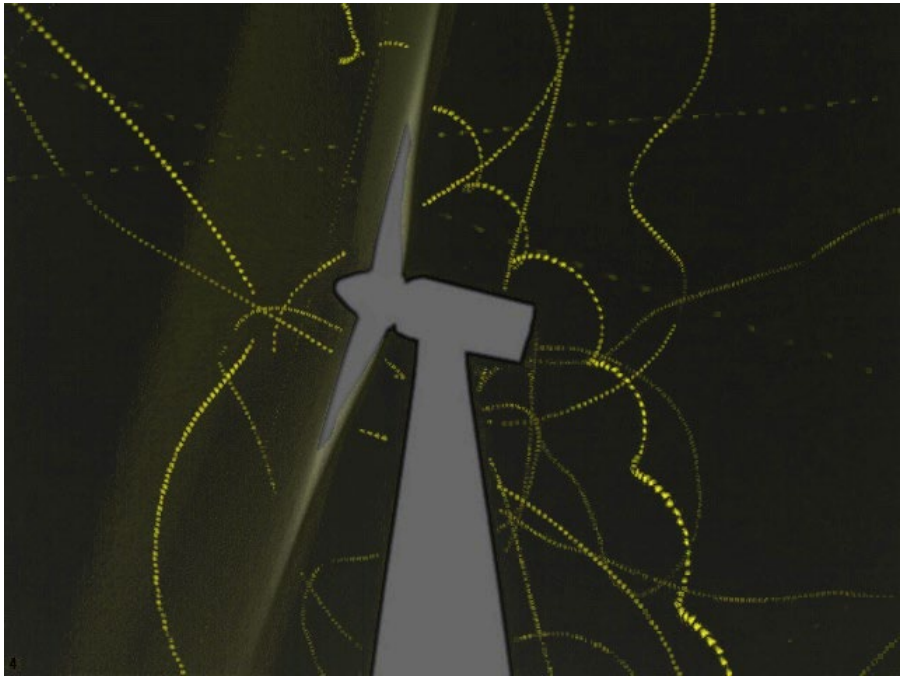
Analysis Methods

- WIS machine learning algorithm previously established
  - 10-minute summary images of bat activity across night
- Bowman reviewers manually identified images with bats
  - Focal
  - Non-focal
  - Collision
  - Confirmed Fatality
- Reviewed associated videos to confirm
- Confirmed fatalities (RDS and WCC only)
  - Behavior and fatality camera video, as well as found carcass, all aligned
- Focal behavior, looked at 30 min before and after and labeled
  - Added no activity if no bats present

Analysis Methods

- Descriptive statistics
- Heat maps of focal activity by night and site
- GLMM comparing focal behavior across sites
  - Night as random effect
  - Does focal behavior differ between sites?
- GLMM on 30-min after a collision/fatality
  - Night and site as random effects
  - Does focal activity increase after?
- Fine-scale timing, splitting the 30 min into 10-min bins
  - Does focal activity differ over the 30 min following a collision/fatality

Example

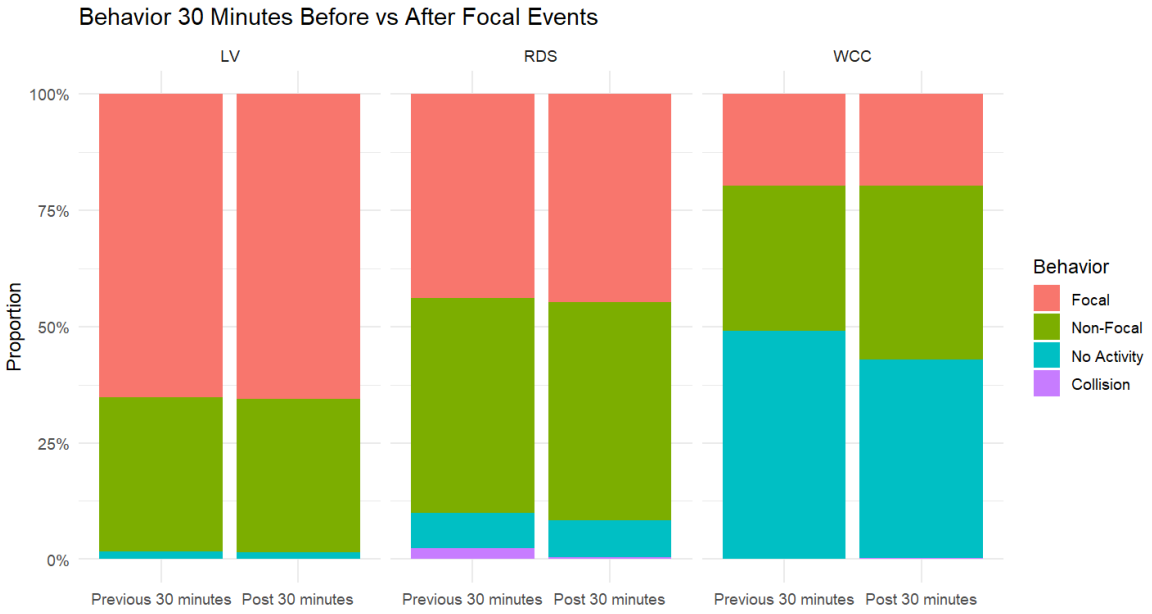


Descriptive Results

- Focal activity more common at LV and RDS, lower at WCC
  - 657 focal bins/79 nights LV, 219 focal bins/210 nights RDS, 151 focal bins/151 nights WCC
  - LV: 7.9 focal bins per night
  - RDS: 1.2 focal bins per night
  - WCC: 0.25 focal bins per night
- Collision events are rare
  - 0 at LV, 1 WCC, 9 RDS

Descriptive Results

- Behavior before and after a focal event varies by site



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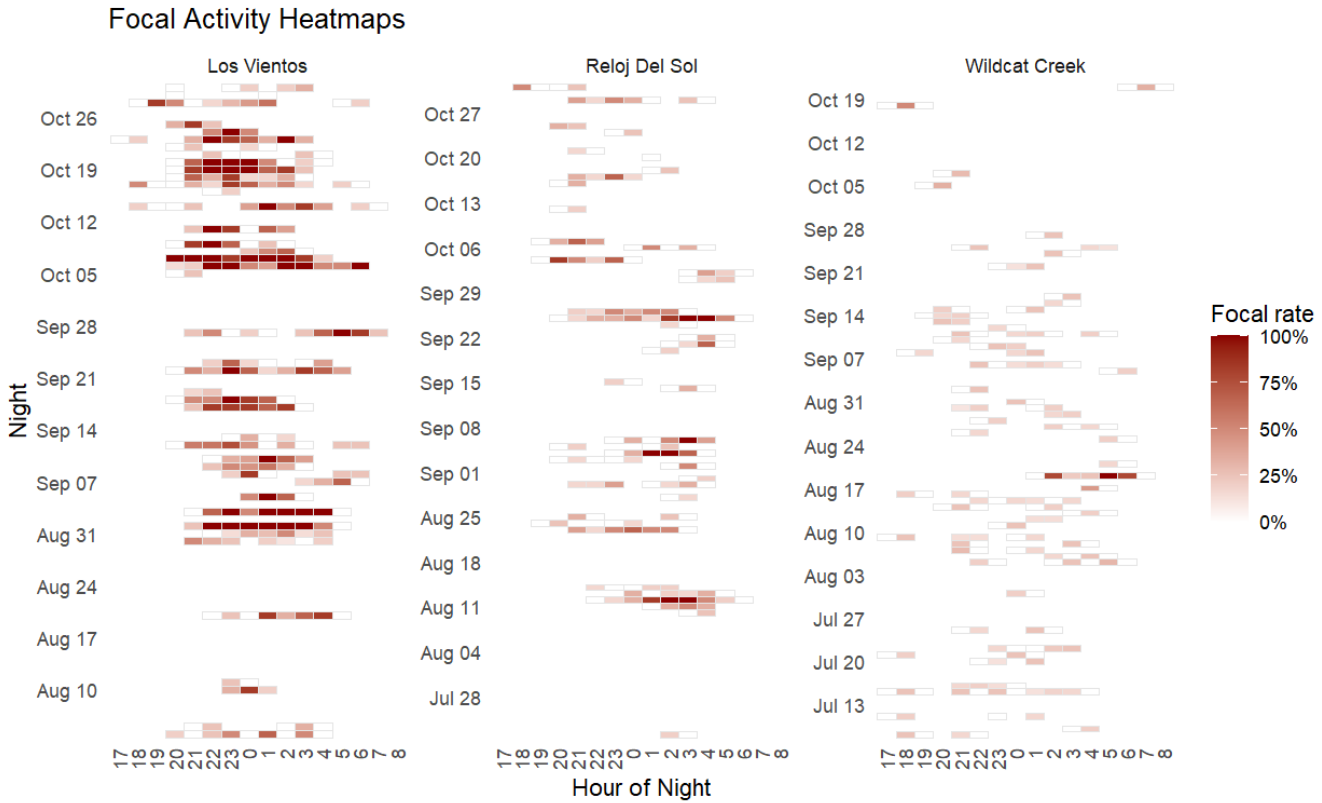
Heat Map Results



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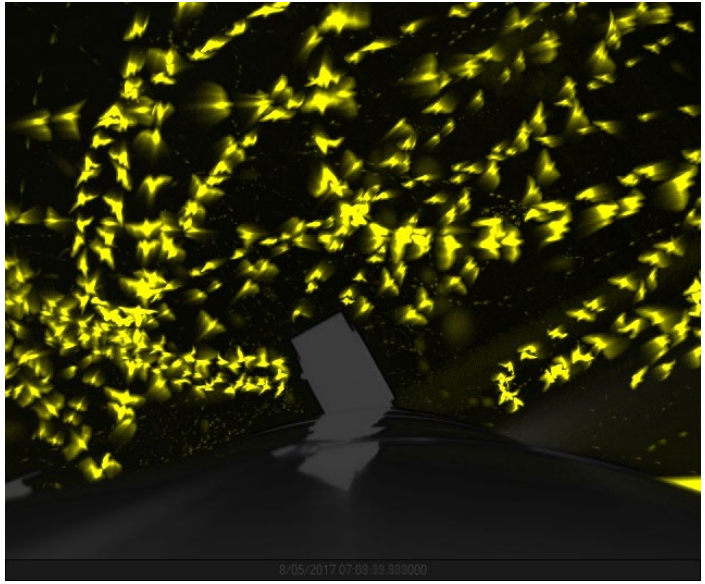
Modeling Results

- Does focal behavior differ between sites? Yes
  - 46%*** probability at LV
  - 27%*** probability at RDS
  - 16%*** probability at WCC

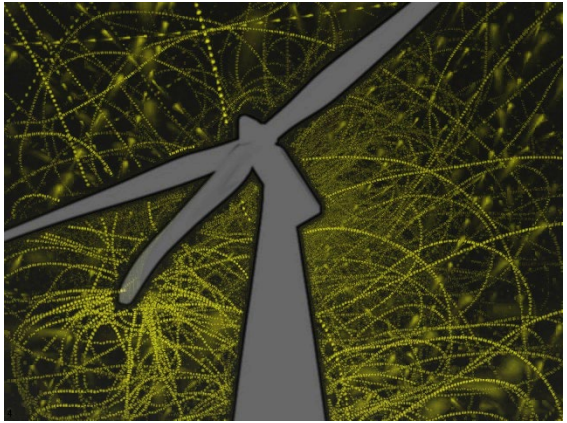


Modeling Results

Model type	Predictor(s)	Baseline Probability (no event)	Post-event Probability	Effect Size (odds ratio)	*p*-value	Interpretation
Overall (no time split)	After Event (Yes/No)	~28%	~48%	~2.3× higher	0.043	Significant increase in focal activity after collisions.
Fine-scale timing (10-min bins)	After Event Bins (10-, 20-, 30-min)	~28%	10-min: ~47% 20-min: ~39% 30-min: ~35%	10-min ≈ 3.3× 20-min ≈ 2.1× 30-min ≈ 1.7×	10-min: 0.08 20-min: 0.26 30-min: 0.46	Suggests strongest spike in first 10 min, then decreases, but only marginally supported due to small sample size.

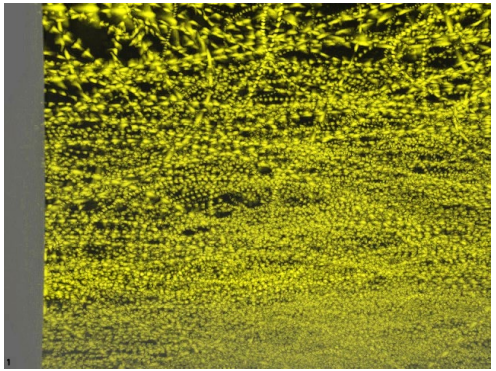
Discussion

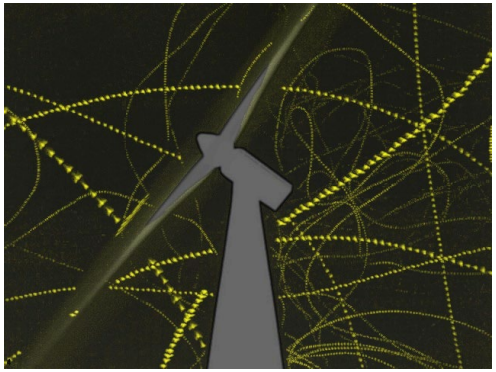
- Evidence of focal behavior at all 3 sites
- Difference between sites and apparent difference across season
- Focal behavior more common southern locations
- Species differences
- Collisions rare events
  - Focal behavior increases after
- Implications?



Other Aspects of Project

- Comparing weather variables and insect activity with focal behaviors
- Is focal behavior risky?
- Activity below vs above RSA for RDS and WCC
- Comparing all activity
  - Not focused on focal
- Expand to other areas





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EPRI

No evidence that bats are attracted to the wakes of wind turbines at an Iowa wind facility.

Contributors: Donald Solick (EPRI), Aaron Corcoran (UCCS), Michael Whitby (BCI), Noah Myrent (EPRI), Praanjal Nasery (EPRI), Corey Markfort (UI), Tyler Bell (UI), Jesse Leckband (MidAmerican), and Christian Newman (EPRI)

No evidence that bats are attracted to the wakes of wind turbines at an Iowa Wind Facility

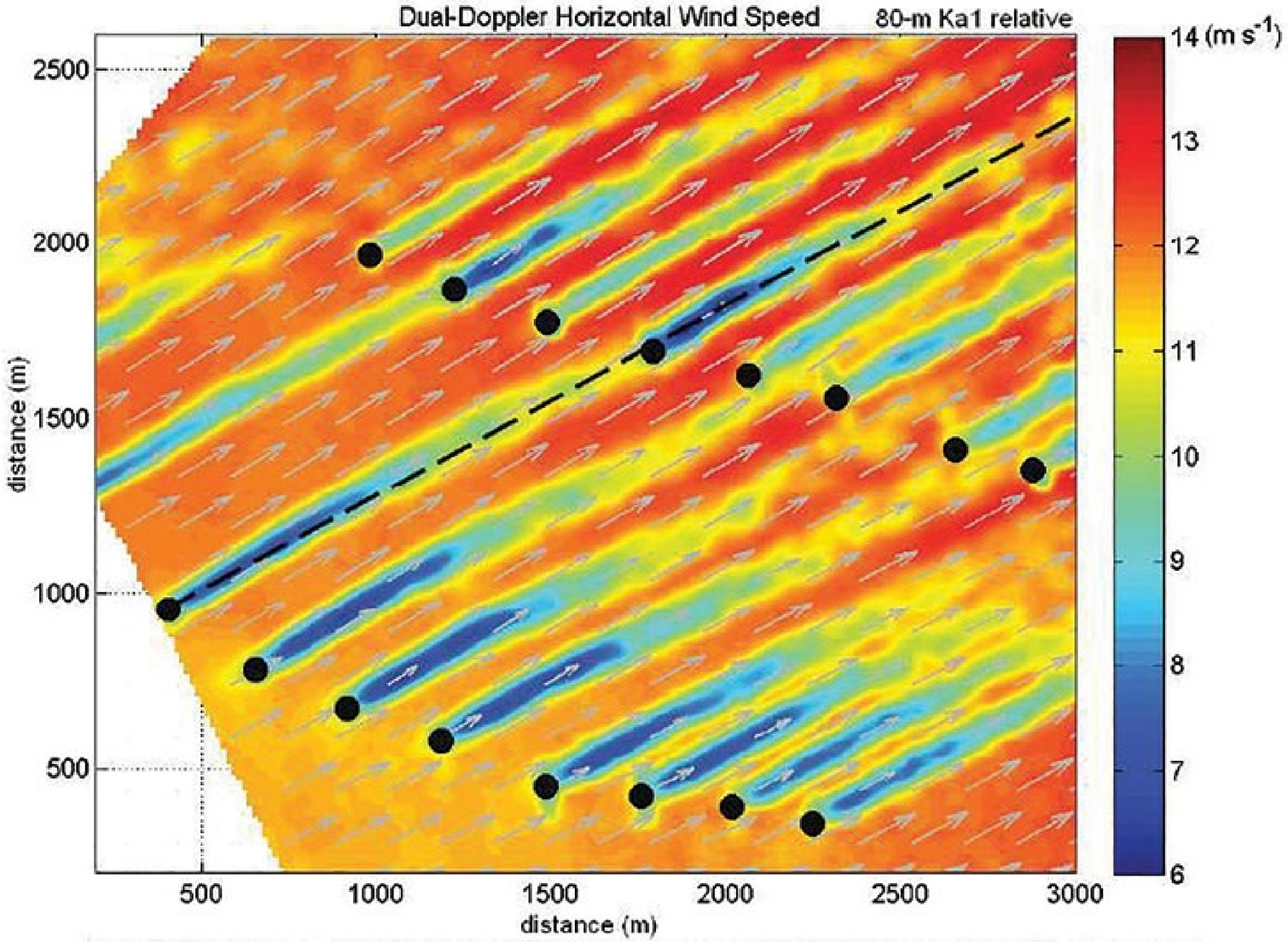
Conference on Wind energy and Wildlife impacts

CWW 2025
8-12 SEPTEMBER

Co-organisers:

biotope

FRANCE renouvelables
système électrique pilotable



Credit: Paul Dvorak


Credit: Michael Durham


Credit: Merlin Tuttle

Hypothesis: Bats are attracted to wakes created by wind turbines

Predictions: Bats would be most active in wake areas

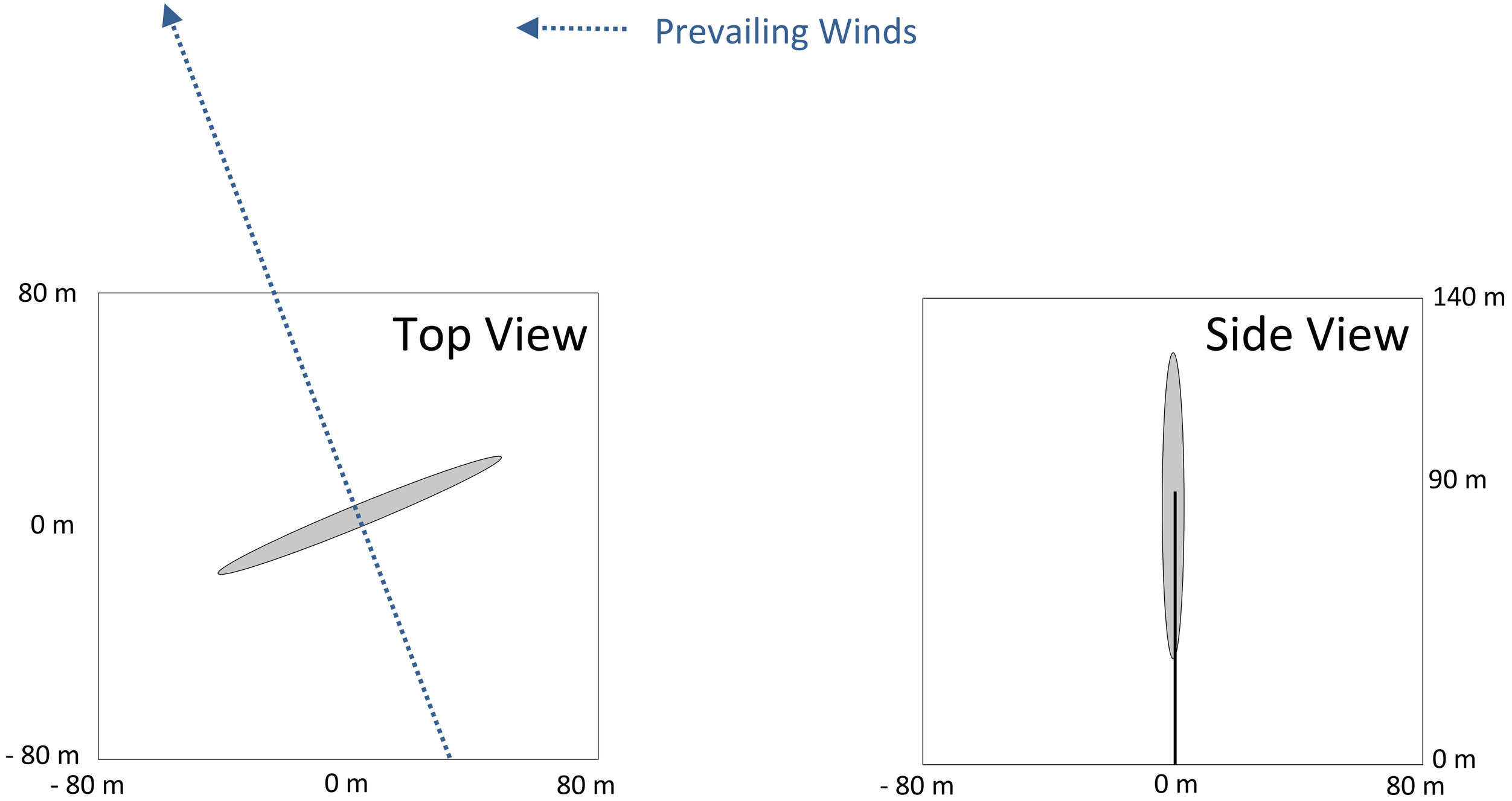
Bats would move toward the turbine using the wake

Approach: 3-D thermal videography, acoustics, wake modelling

Orient Wind Farm, Iowa

August and September 2022

MidAmerican ENERGY®


Prevailing Winds
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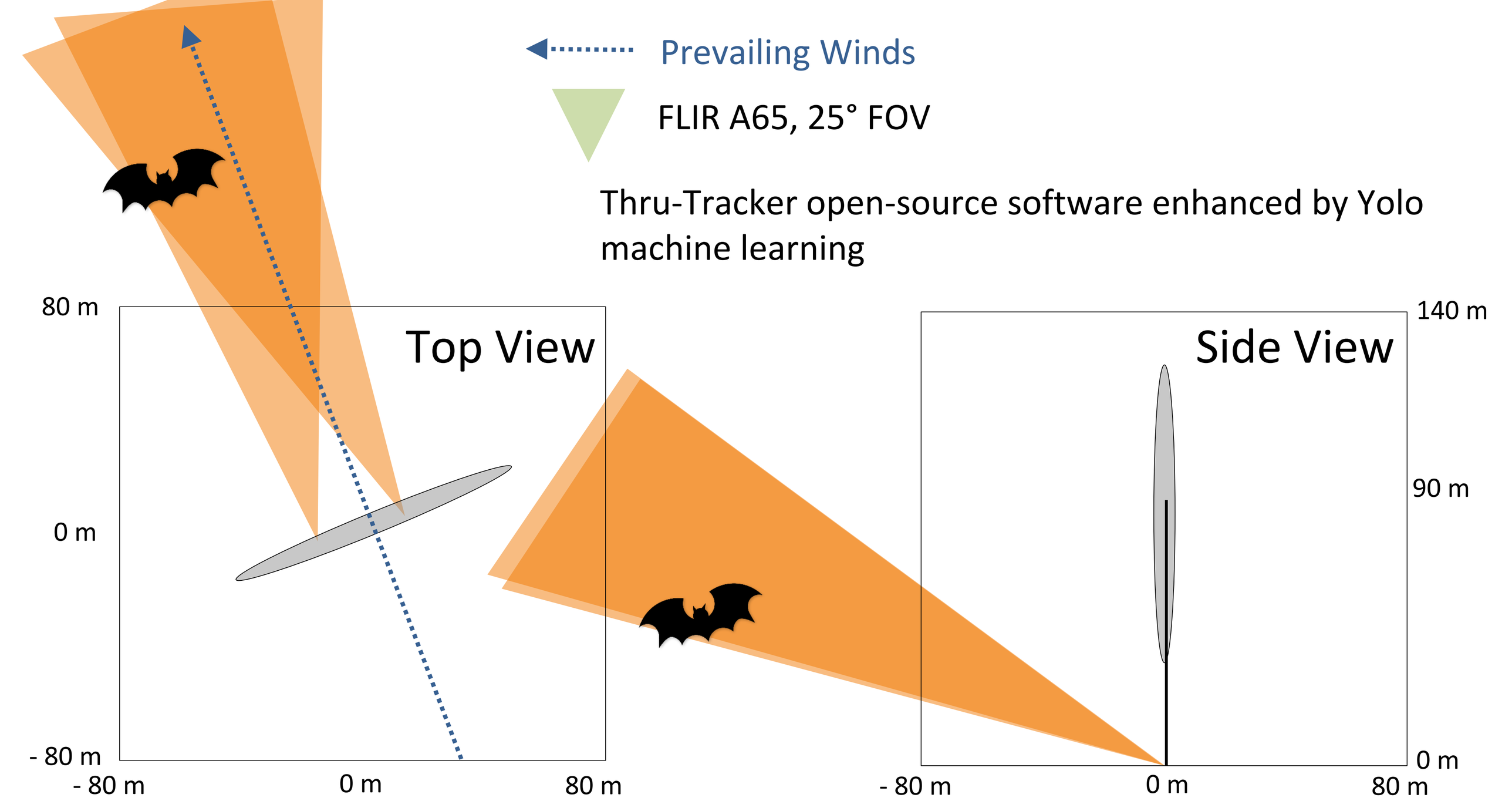
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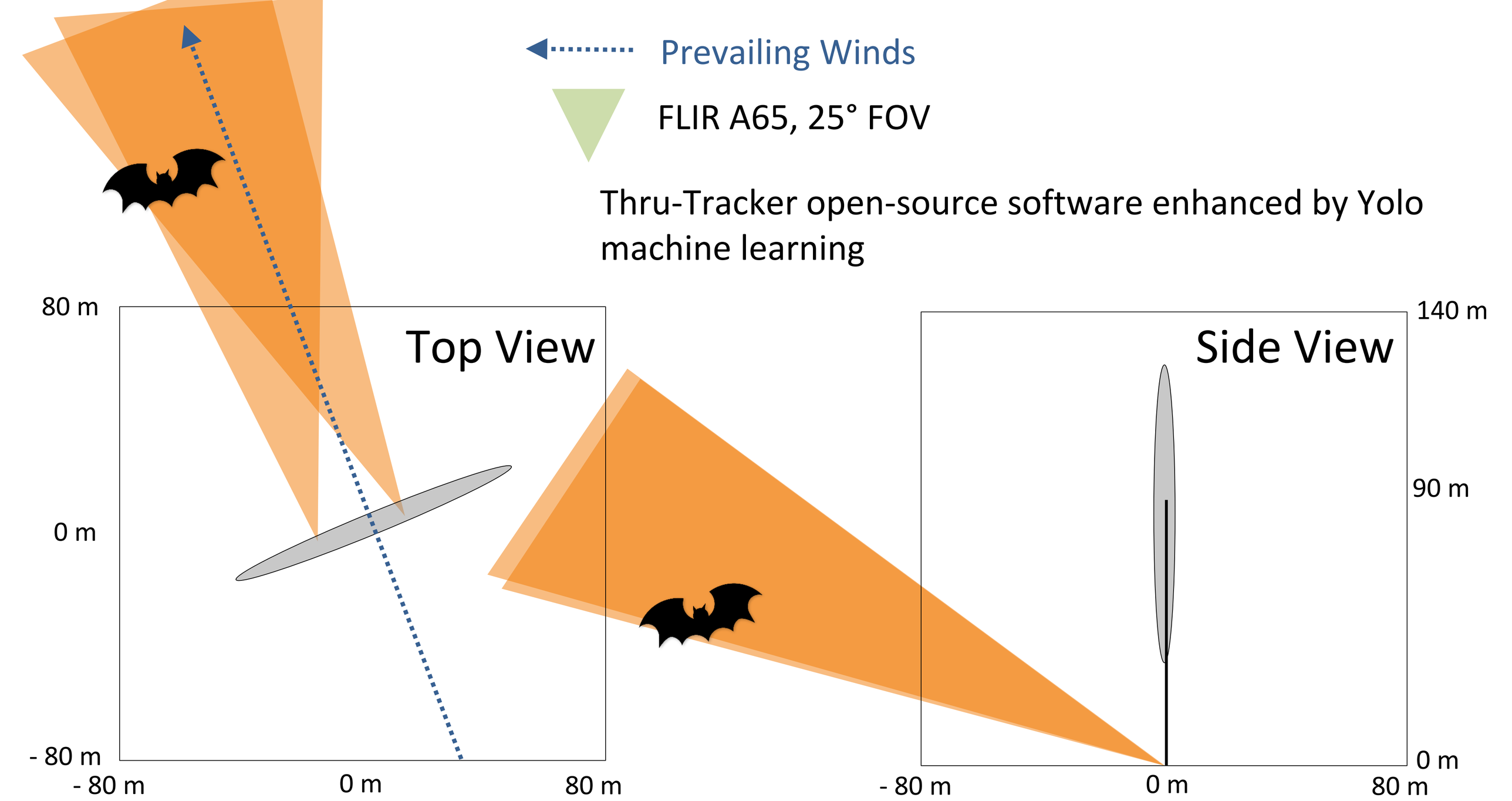
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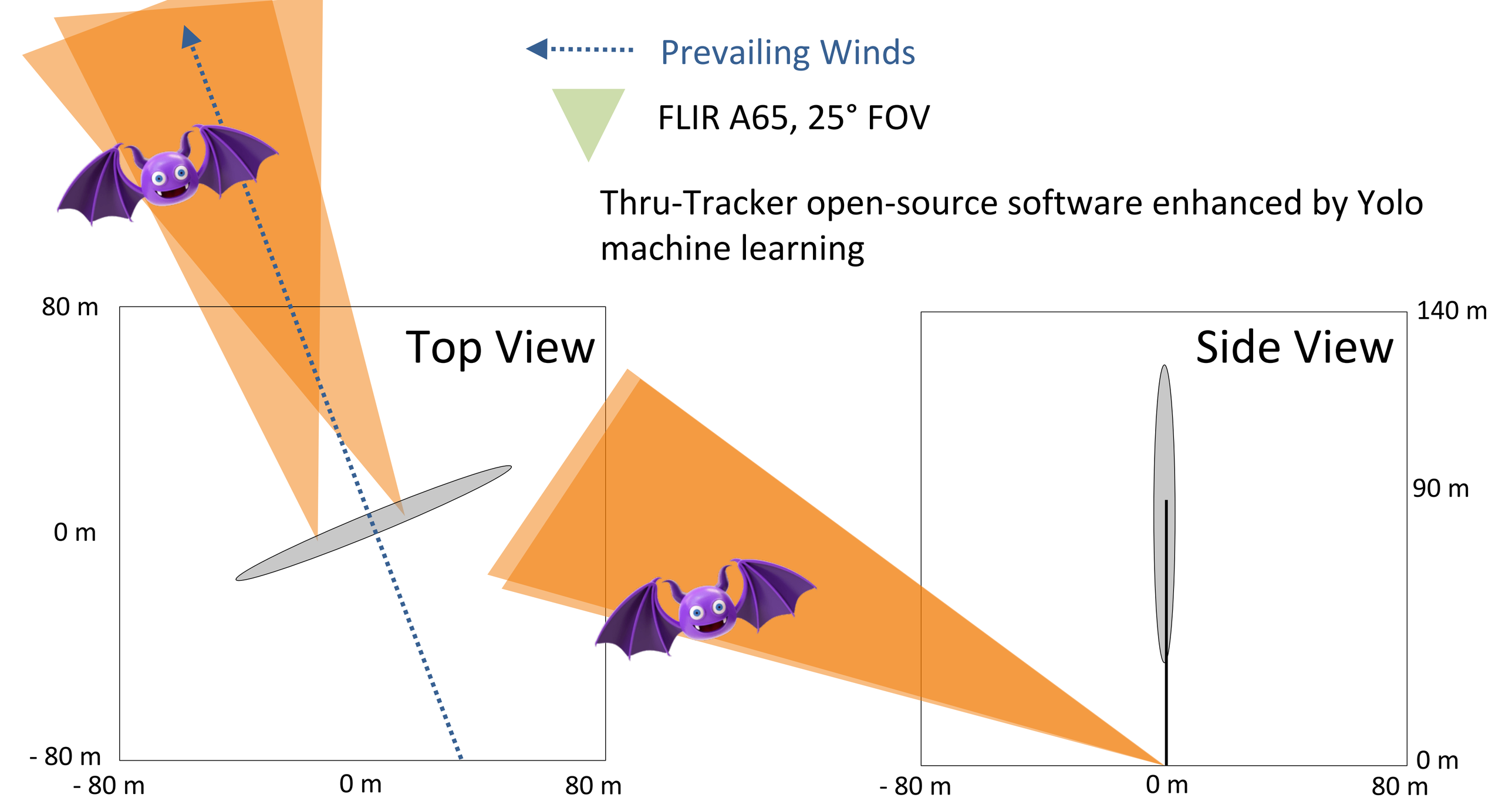
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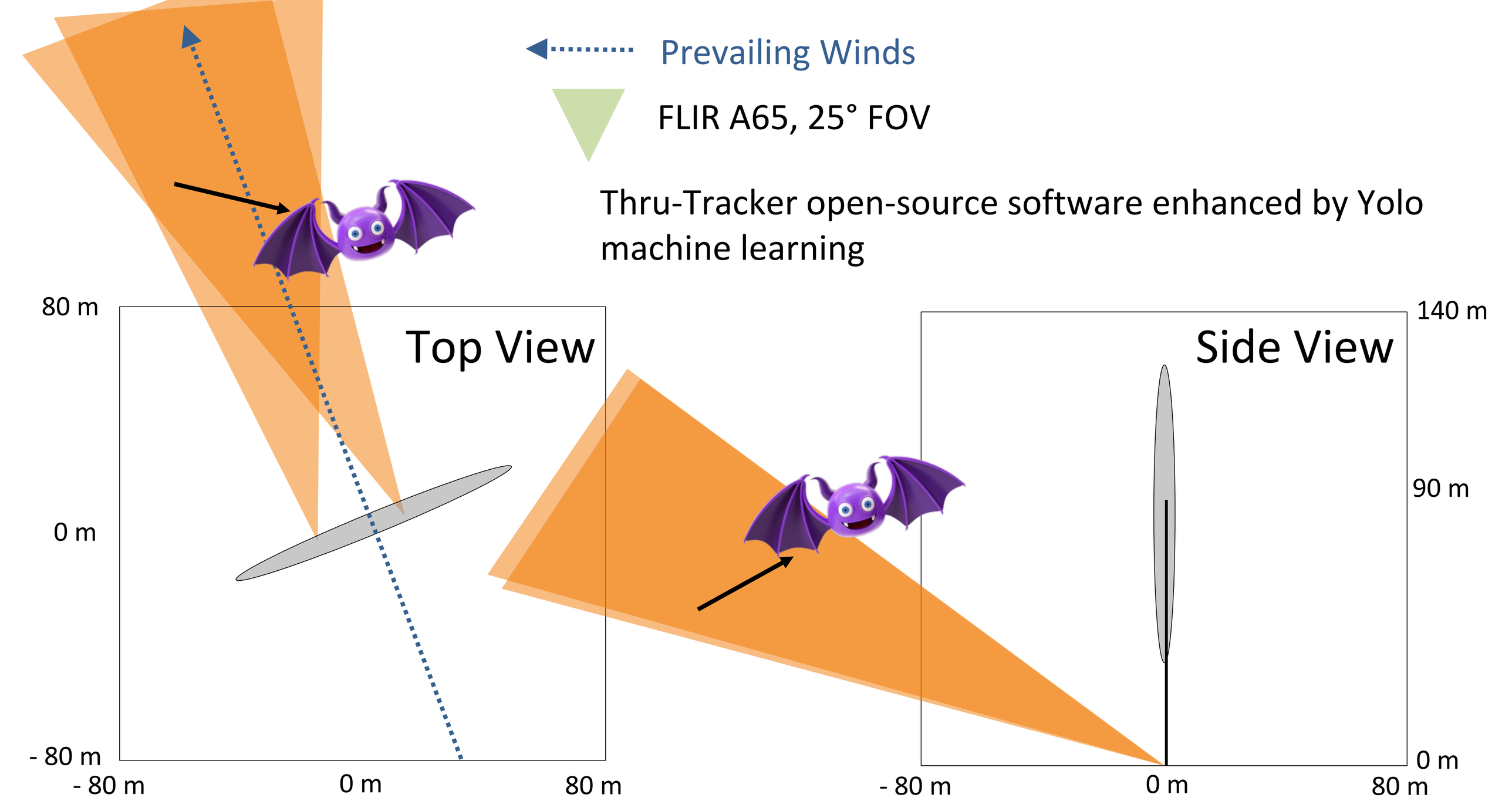
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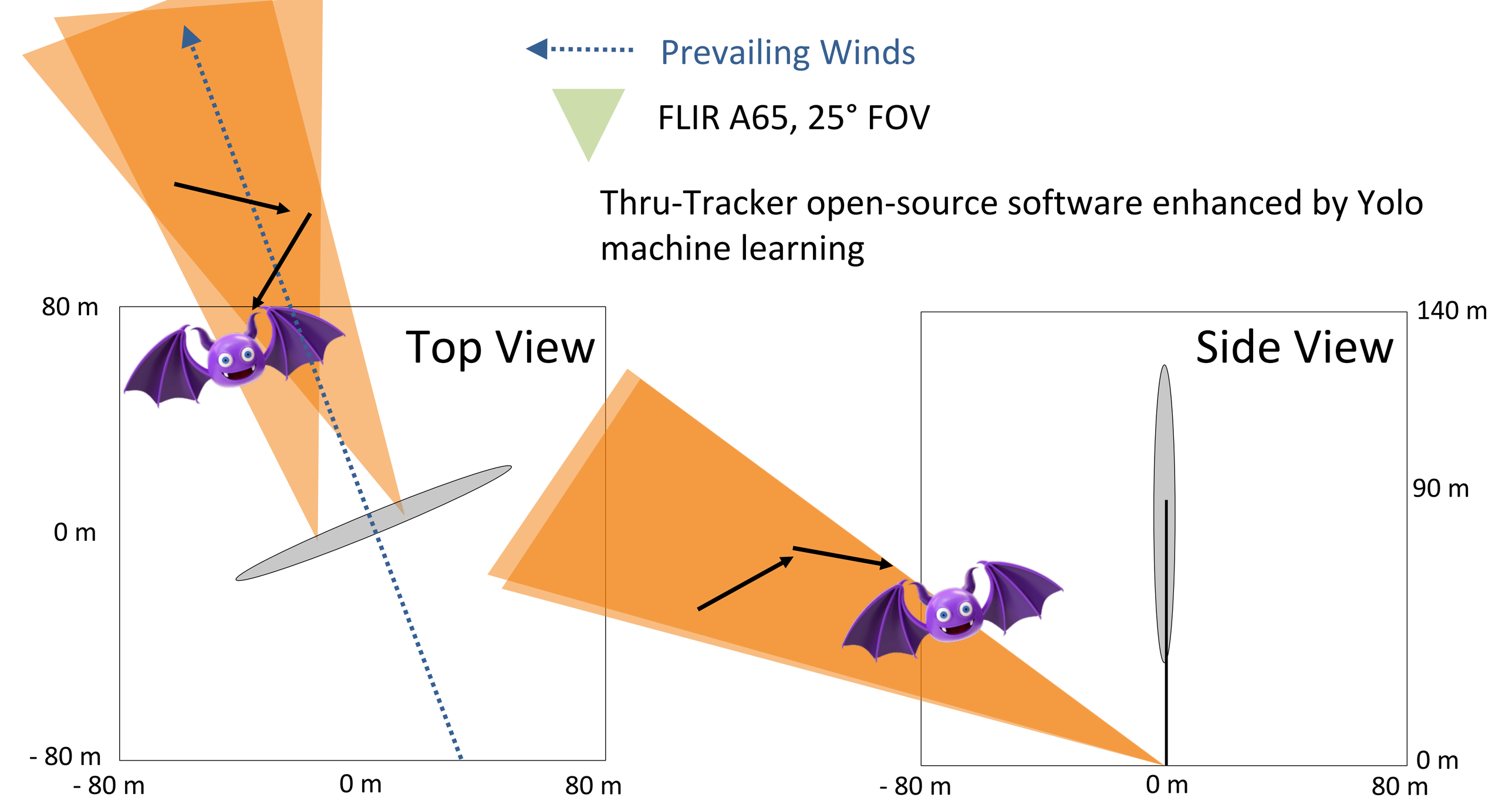
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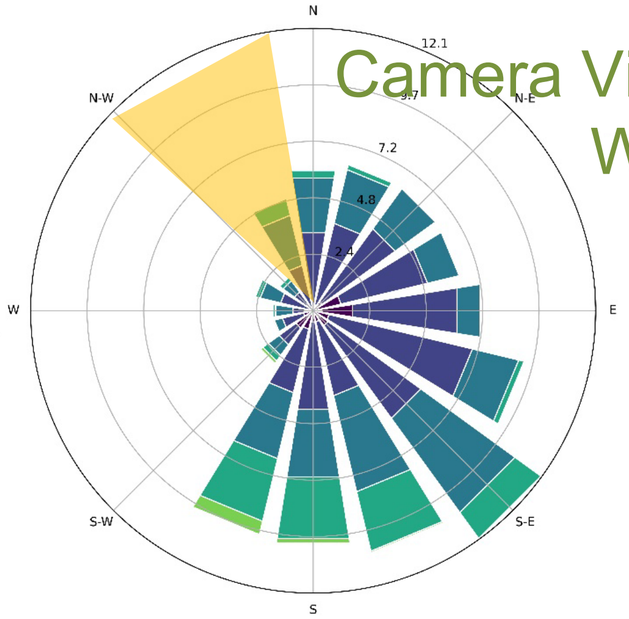
Methods: Weather Stations

Results

Wind Roses

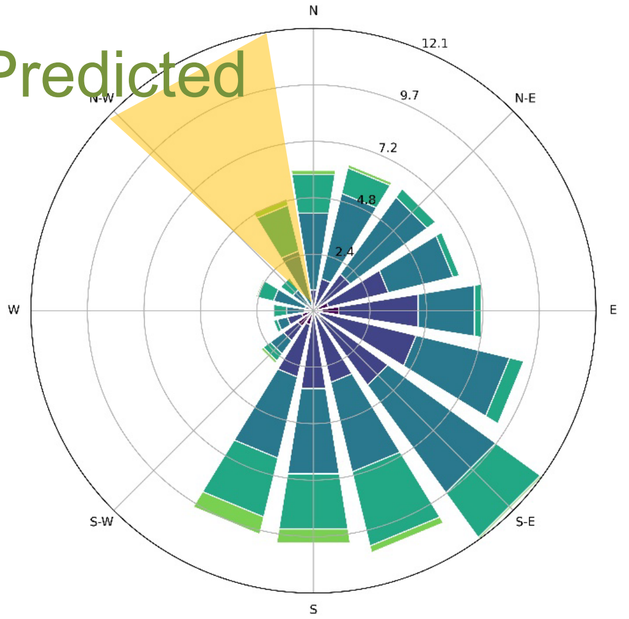
Wind direction during study period (from SE)

Camera View/Predicted Wake



Turbine 85

N



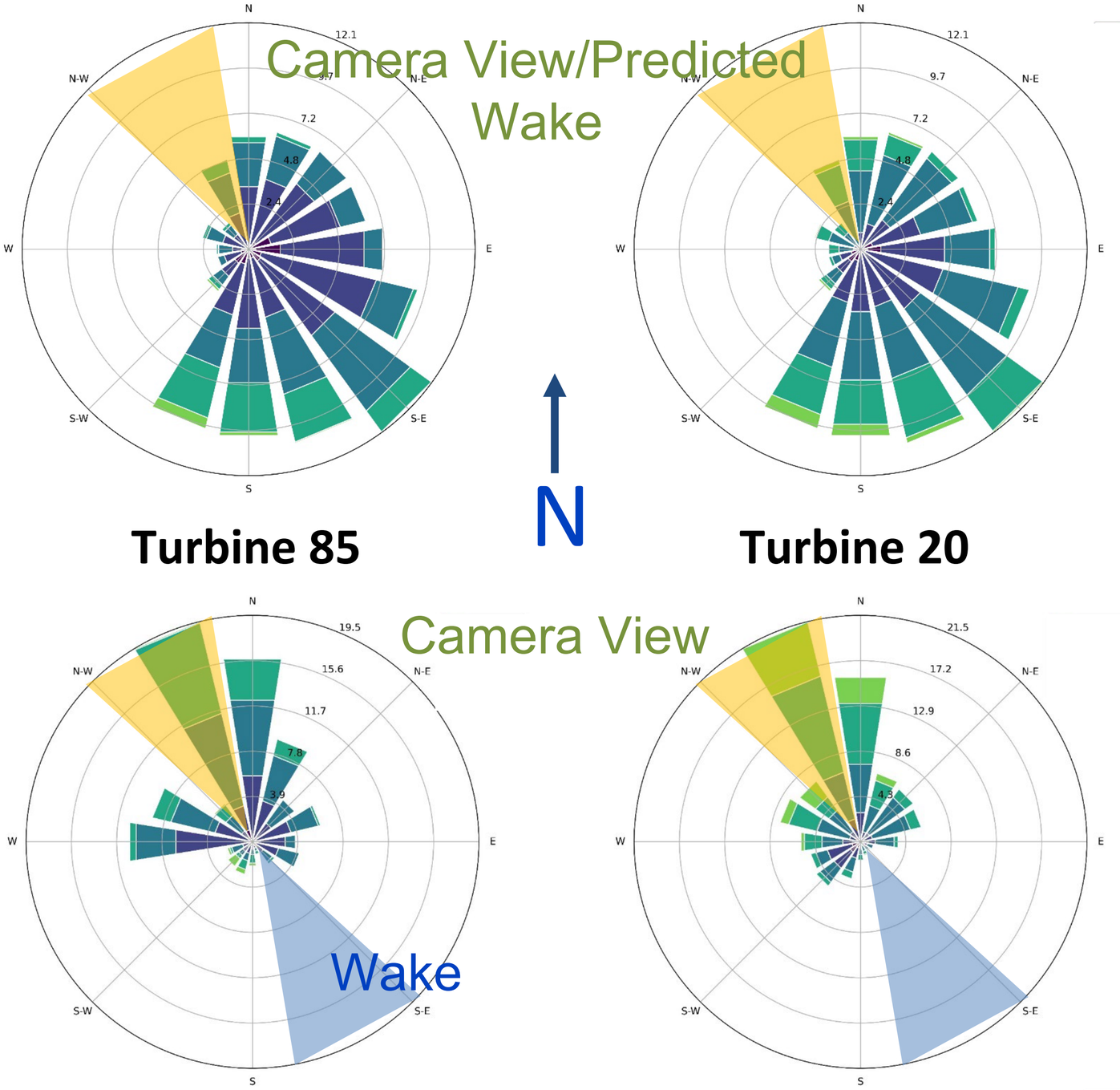
Turbine 20

Wind Roses

Wind direction during study period (from SE)

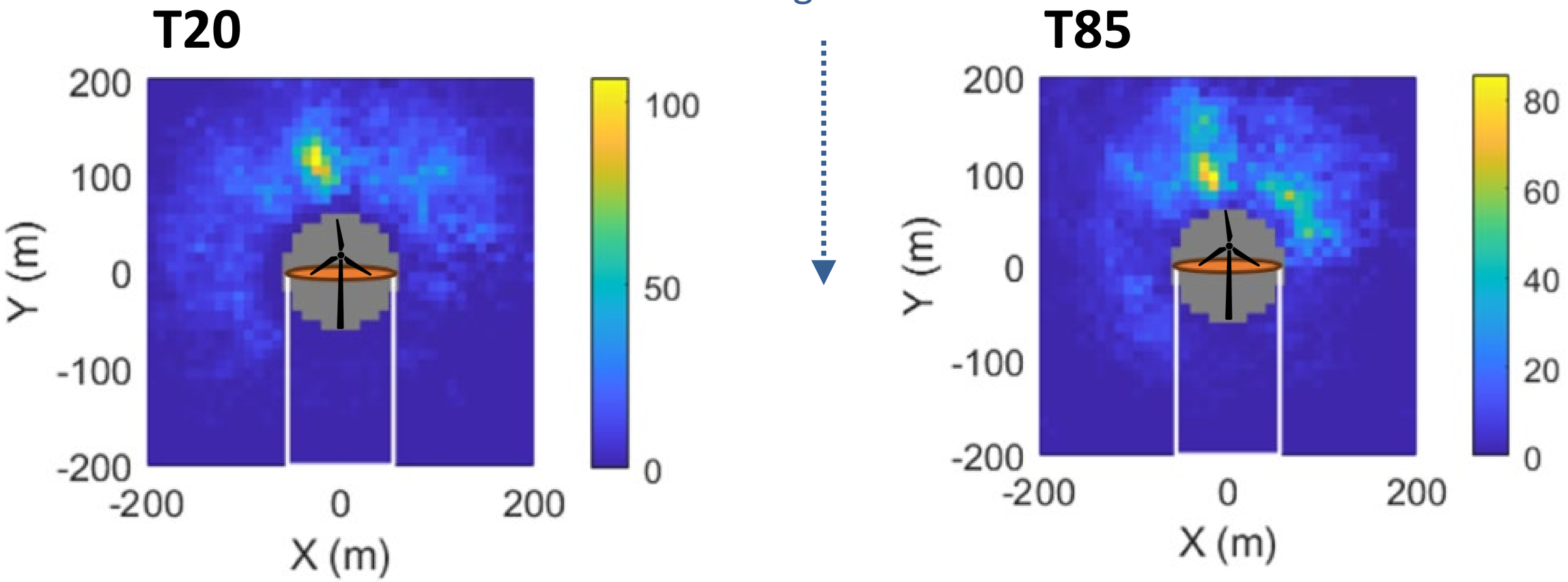
Detected 13,298 targets!

Wind direction when targets detected (from NW)



Target activity was low in turbine wakes

Prevailing Winds



Only 3% of 13,298 targets recorded in wakes

Hypothesis: Bats are attracted to wakes created by wind turbines

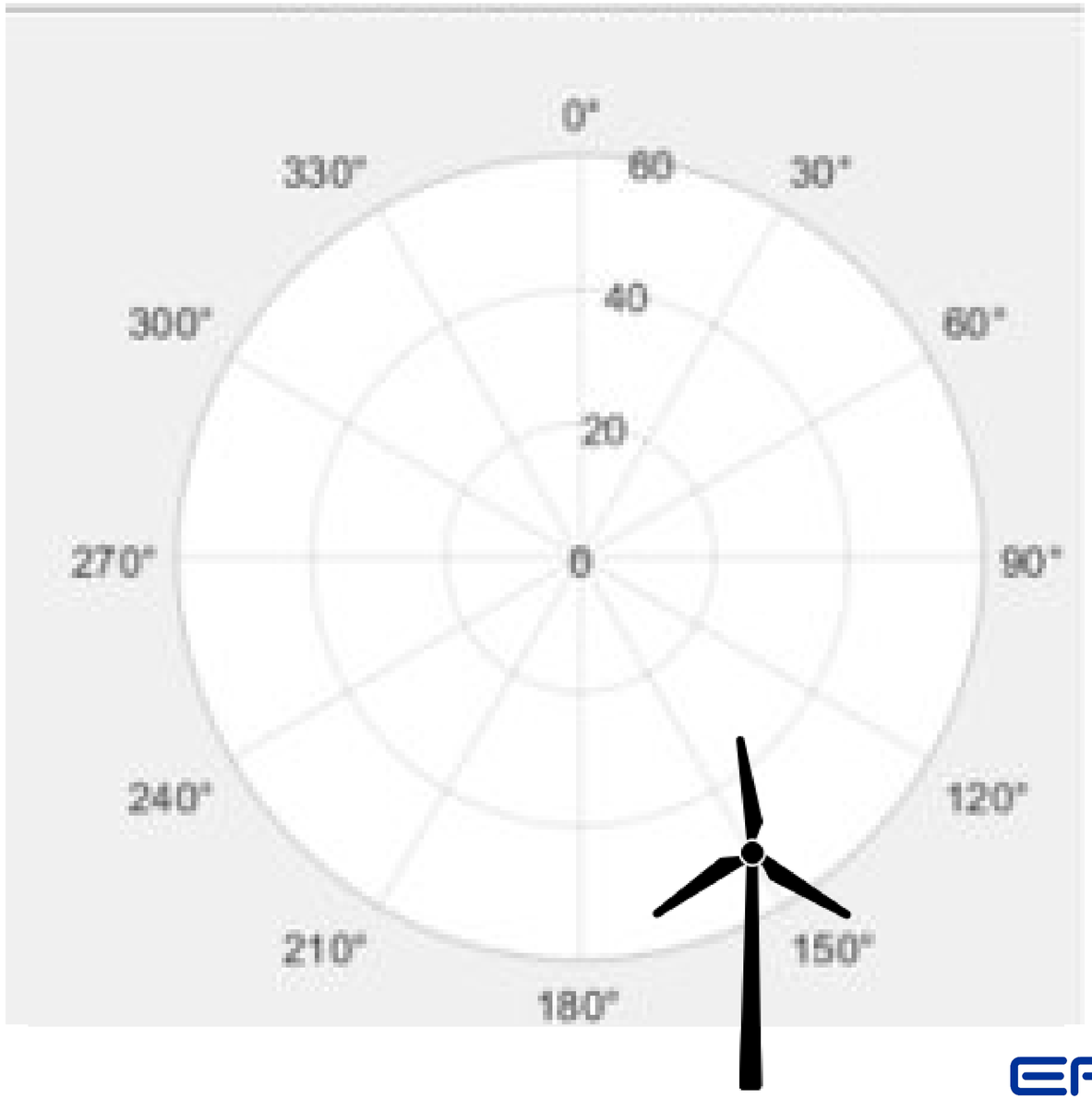
Predictions: Bats would be most active in wake areas **NO**

Bats would move toward the turbine using the wake

Target trajectories in the turbine wake

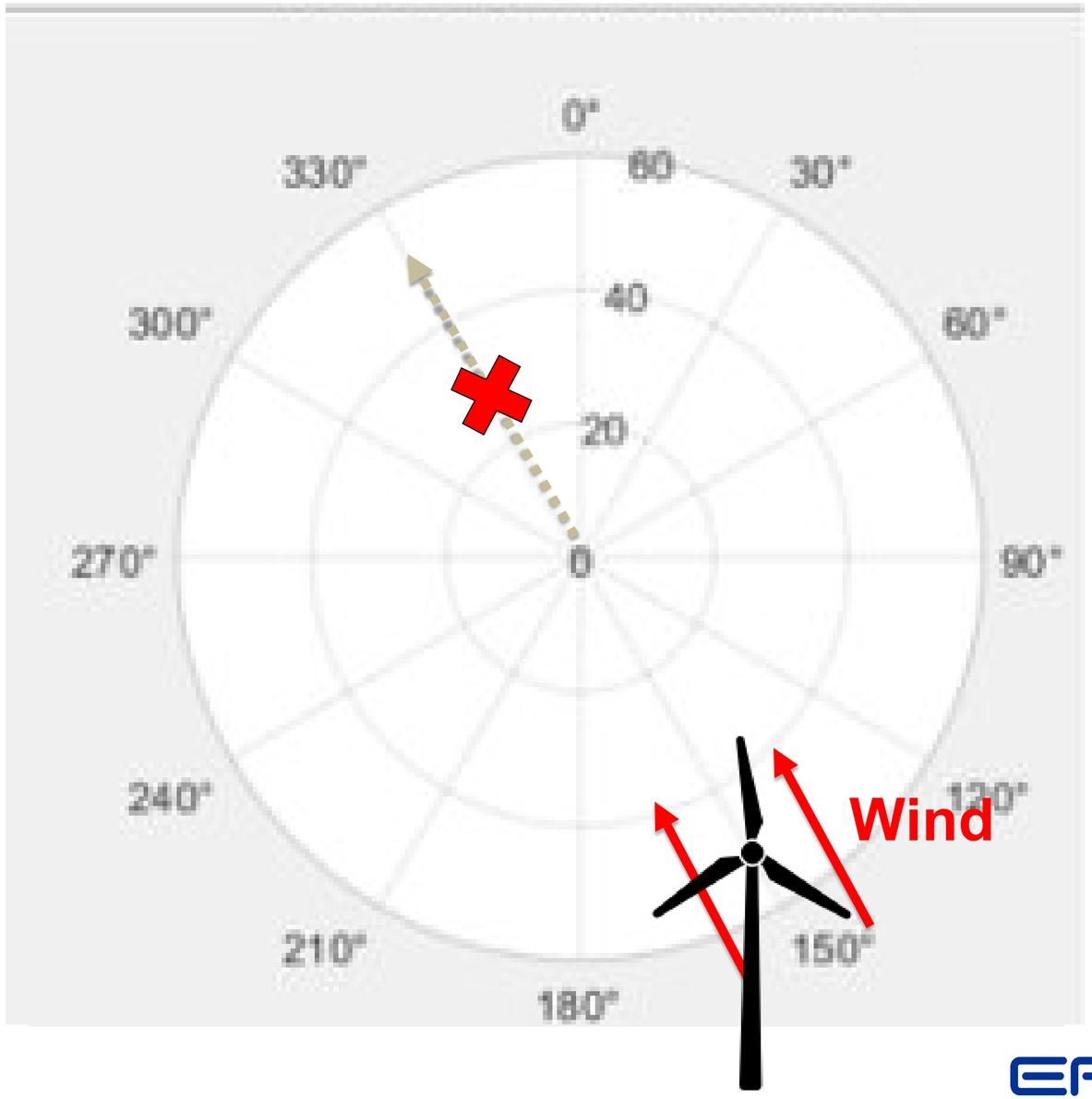
385 target tracks were detected

within wake



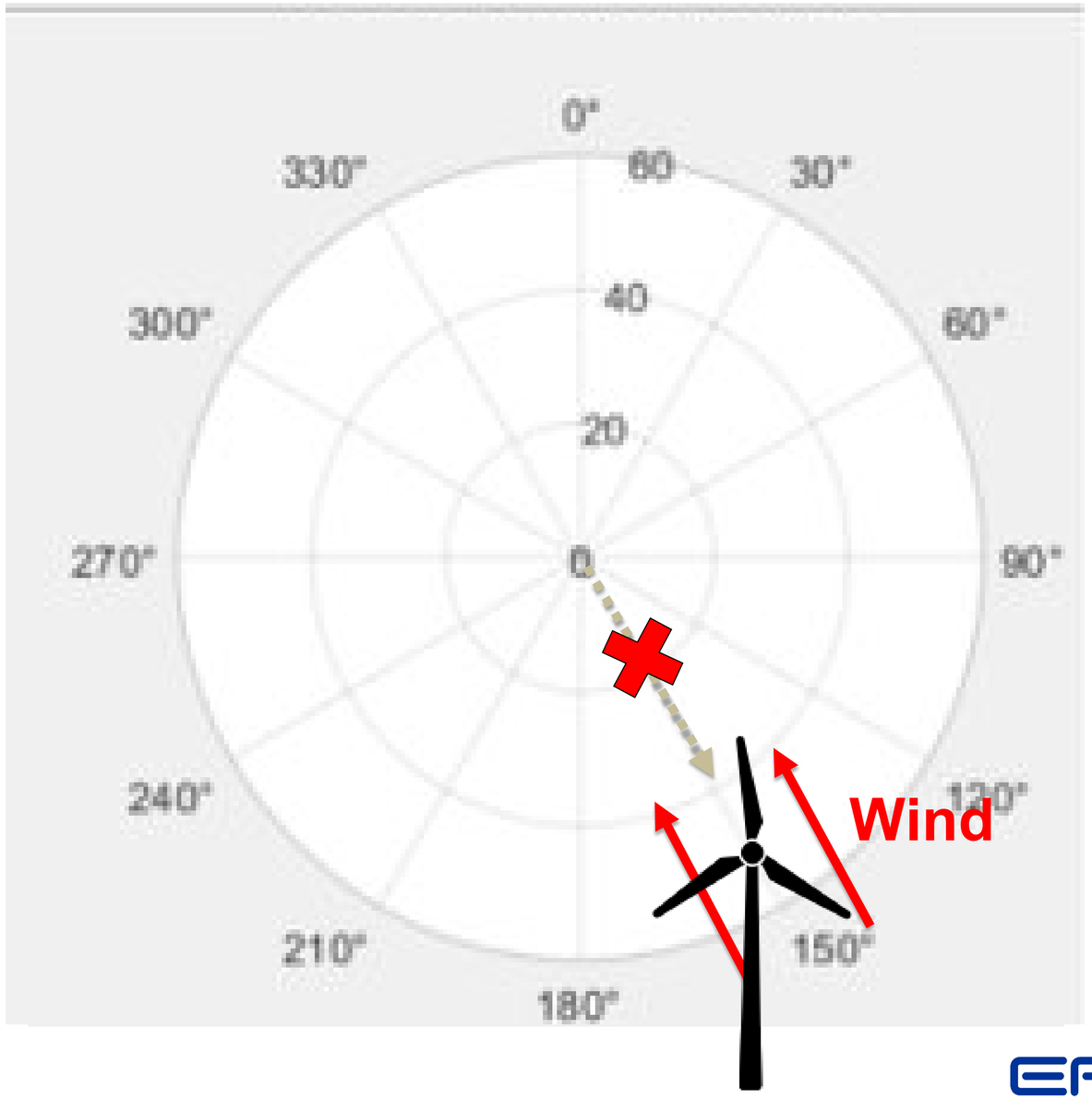
Target trajectories in the turbine wake

If targets flying with wind, we would expect NW flights



Target trajectories in the turbine wake

If targets using the wake, or were attracted to turbine, we would expect SE flights

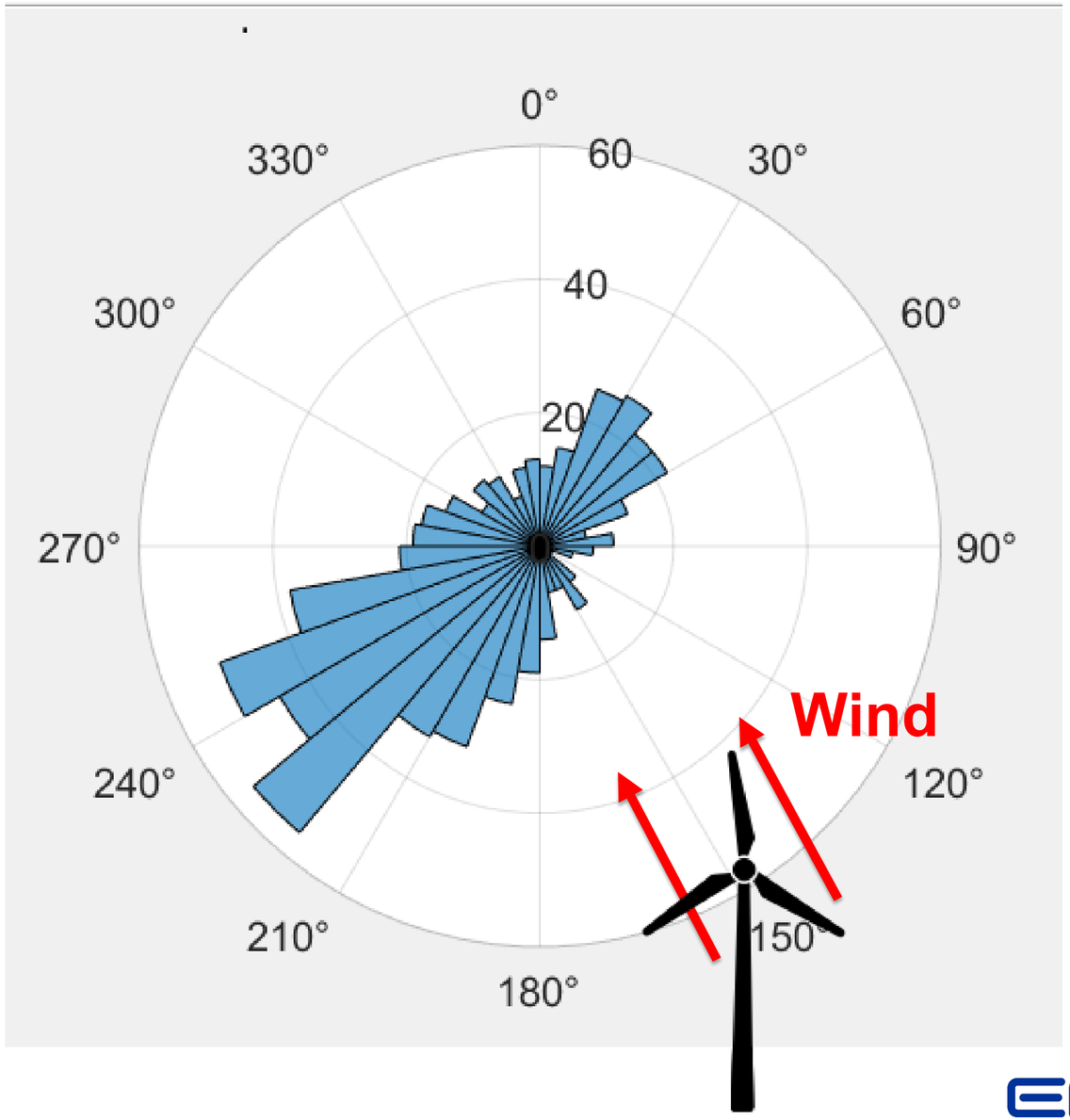


Target trajectories in the turbine wake

Targets flew SW and NE;

perpendicular to air currents

Could be simply migrating in a preferred direction. No evidence that targets approached turbine using wake.



Hypothesis: Bats are attracted to wakes created by wind turbines

Predictions: Bats would be most active in wake areas **NO**

Bats would move toward the turbine using the wake **NO**

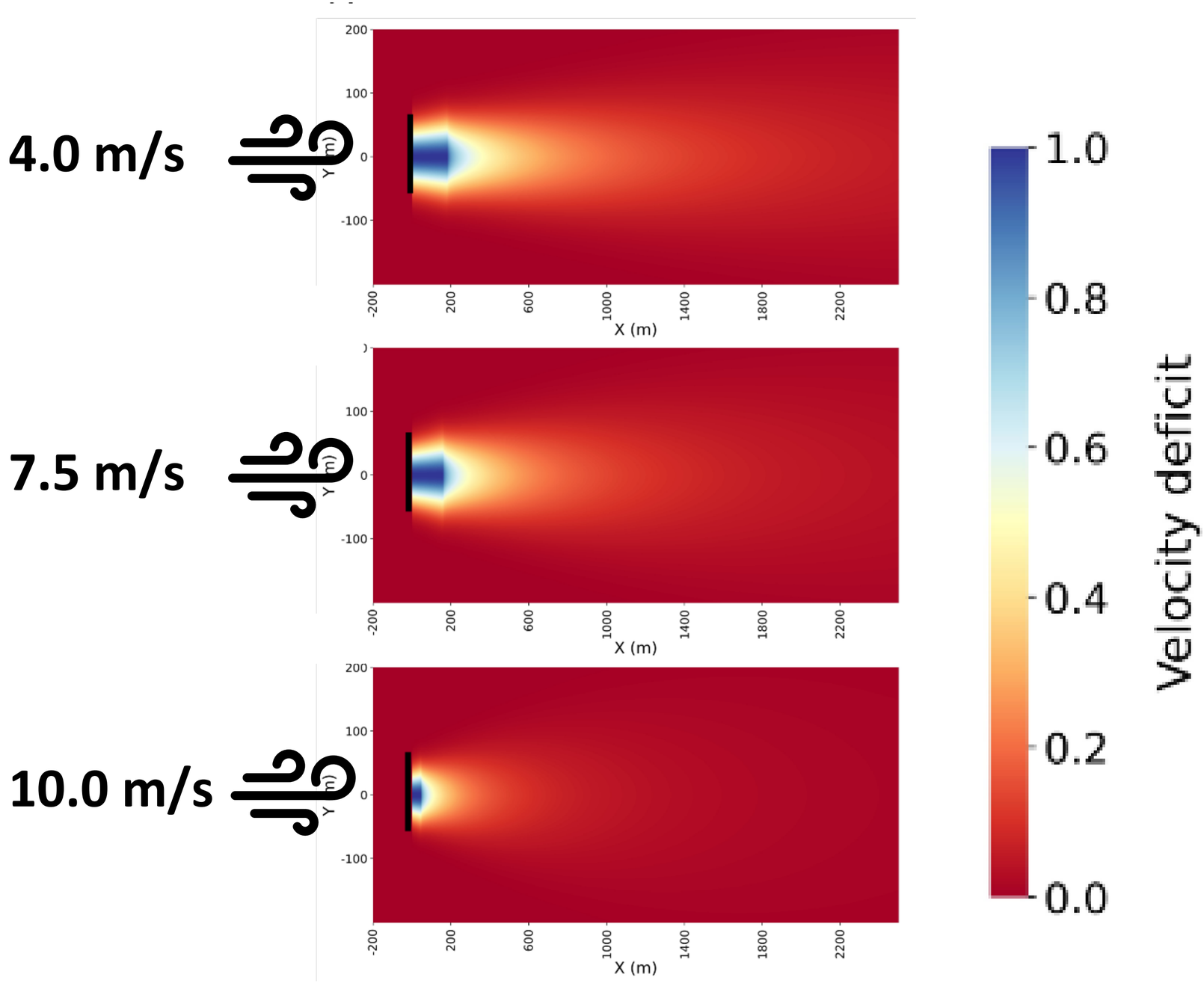
Wake modelling

110 m wide

600 - 1400 m long

Maximum velocity deficit was 1 m/s

- Width 50 m
- Length 50-200 m



Summary

Bats did not use turbine wakes as expected

- Wakes to NW present on 22% of nights
- Only 3% of target tracks (including bats) within wake
- Targets in wake flew perpendicular to air flow

No evidence to support attraction of bats to the wakes of wind turbines

Consistent with bats and turbine wakes in France (Leroux et al. 2024)

3D Thermal Videography and Wind

We need more studies of bat behavior at wind turbines using 3D thermal videography

- Refine curtailment and minimization strategies
- Evaluate effect of deterrents on bats
- Optimal placement of detectors/deterrents
- Quantifying exposure risk
- Detecting fatalities

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