THE MISSING PIECE

PREDICTION MODELS TO COMPLEMENT A WILDLIFE STRIKE ADVISORY SYSTEM

Dr. Isabel C. Metz and Graciela de Cuba

German Aerospace Center DLR and University of Amsterdam

First Military Wildlife Hazard Management Conference 2025

UNIVERSITY OF AMSTERDAM

DLR

Motivation

Focus of Wildlife Hazard Management in Civil Aviation

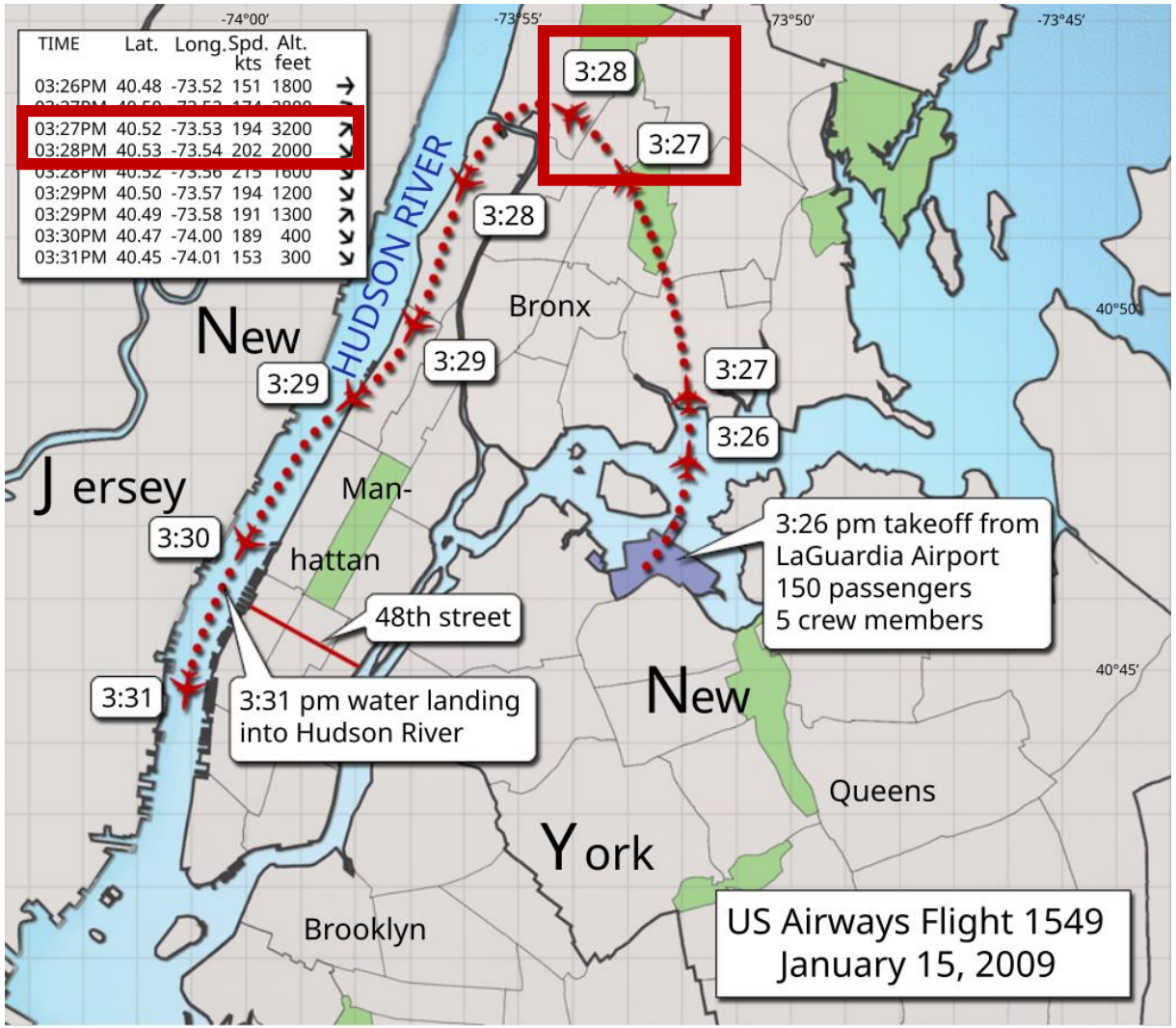
In reality, wildlife strike risk is not an aerodrome problem.

Wildlife strike is a below 3000' AGL airspace problem and thus the primary responsibility for managing the problem should reside with those managing and using the airspace.

Jeff McKee, Phillip Shaw, Arie Dekker, and Kylie Patrick (2016)

Motivation

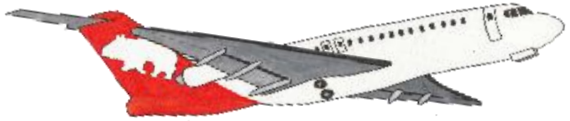
Focus on Wildlife Hazard Management in Civil Aviation

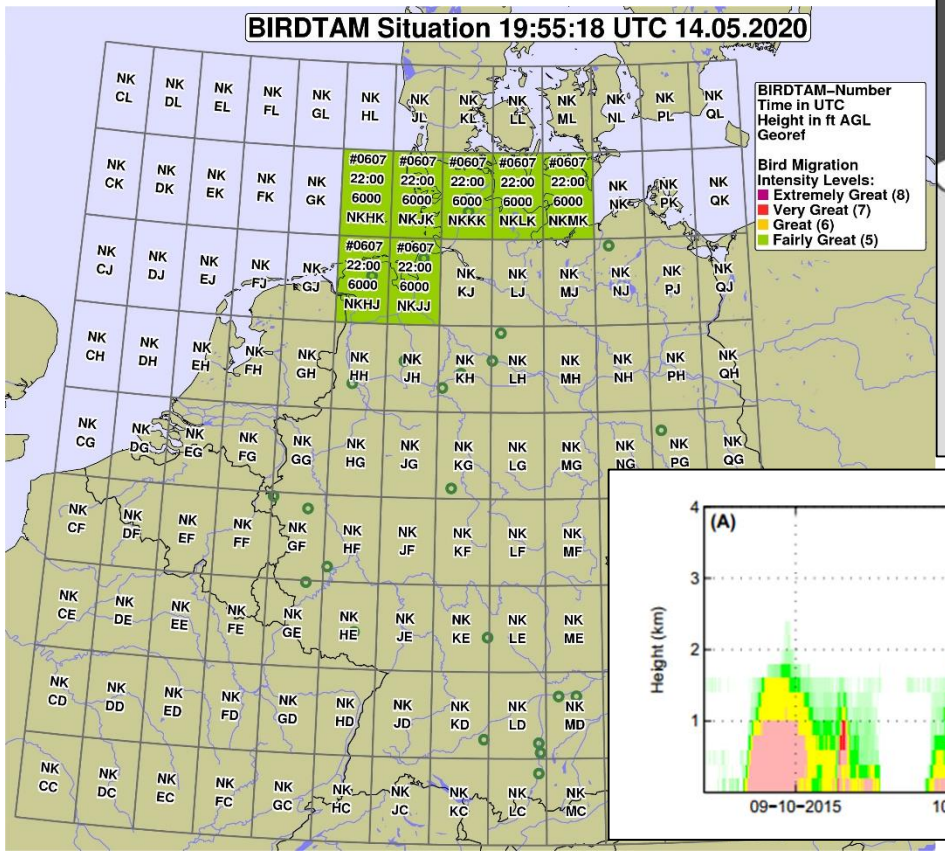


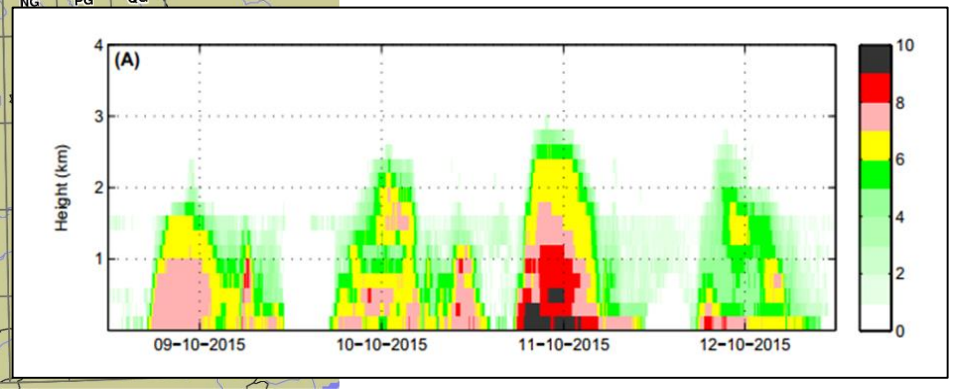
Source: S. Bollmann – own work and Image: Airports New York City Map Julius Schorzman with Floyd Bennett Field.jpg, Flight path data from www.flightaware.com, Grid from Google Earth., CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=5755002

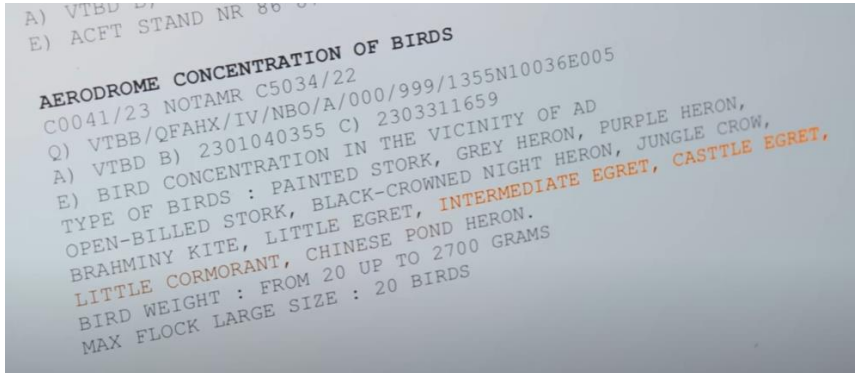
Where‘s the Problem?

Network pressure!









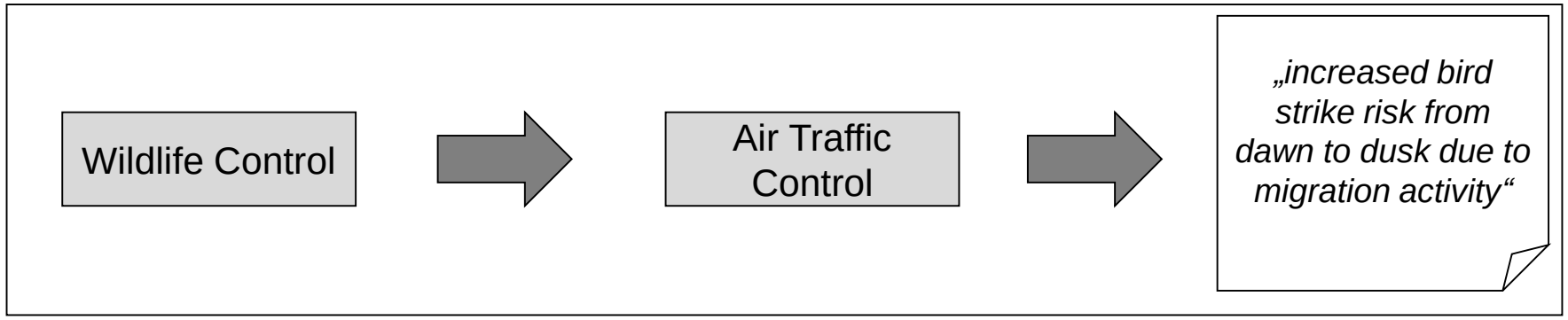
Source: ZGeoBW

Source: www.flysafe-birdtam.eu

Quelle: https://www.youtube.com/watch?v=499kGRS81dg
NOTAMS: The Majestic, Endangered Species on the Verge of Collapse

Concept

Involving Air Traffic Control and Pilots



Concept

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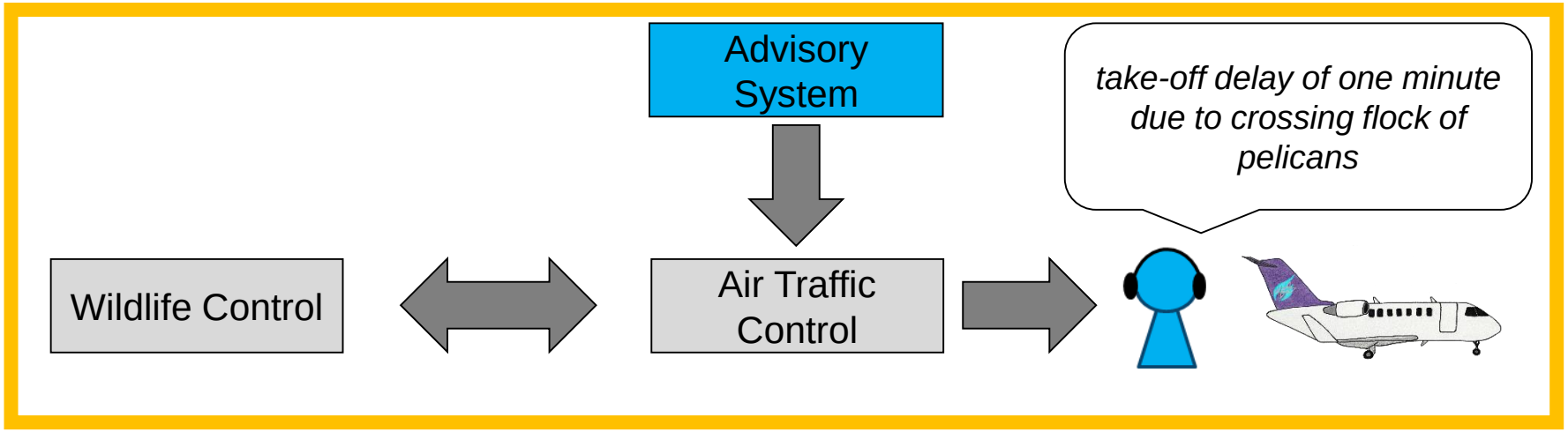


Process and Research Questions

Wildlife Strike Risk Advisory System

Track Prediction → Risk Assessment → Visualization

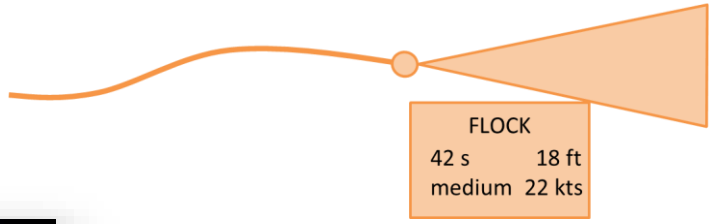
take-off delay of one minute due to crossing flock of pelicans

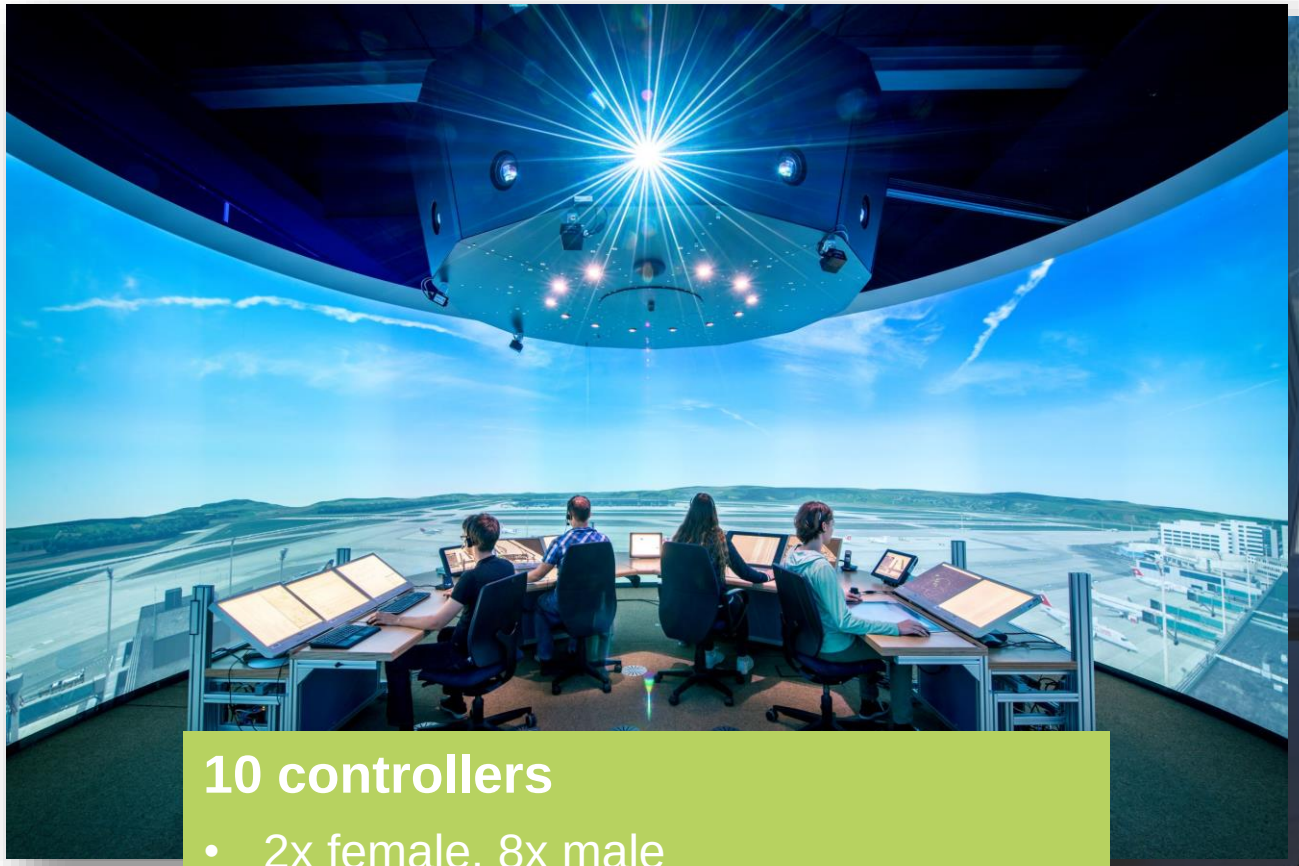
Operational Feasibility

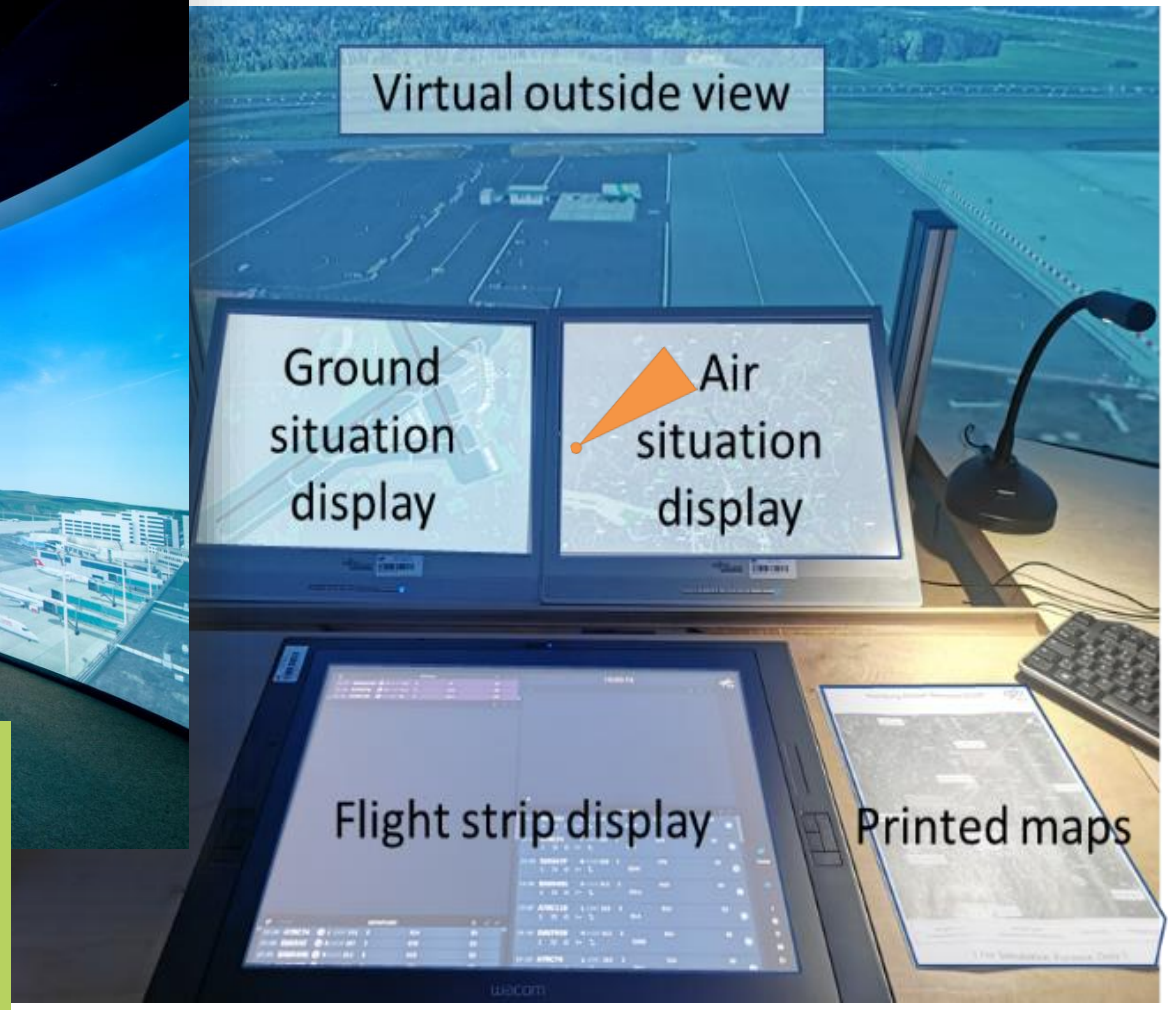
Real-time Human-in-the-Loop simulations

Operational Feasibility

Human-in-the-Loop Simulations







10 controllers

- 2x female, 8x male
- average age 35.1 years, std 7.2 years
- 9x civil, 1x military

from Germany, Austria and Poland

Operational Feasibility

Human-in-the-Loop Simulations

- High reported acceptance and usability
- Increased situational awareness
- Reduced workload

- Reasonable departure delays
- Increased throughput

Process and Research Questions

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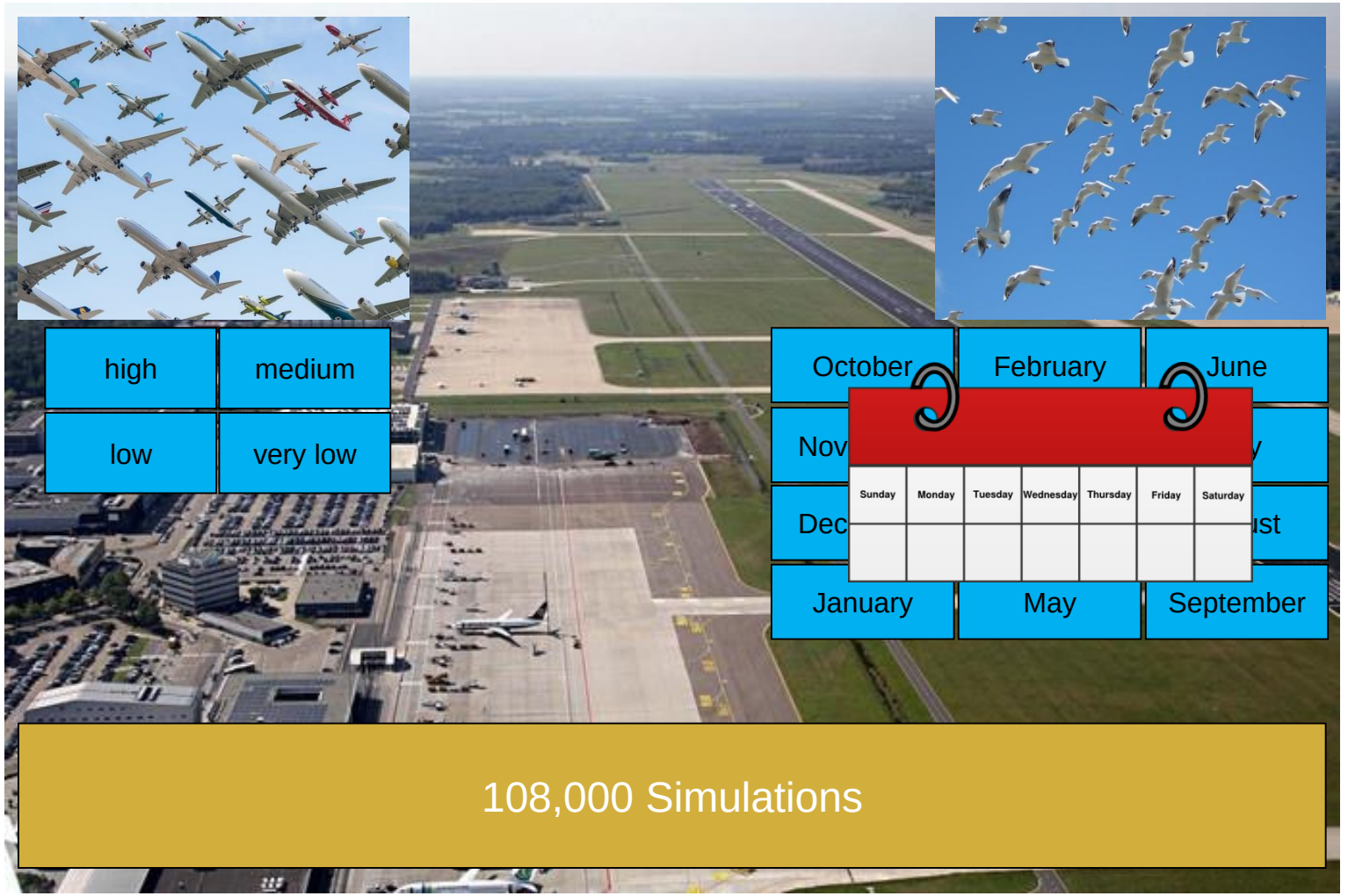
Theoretical Feasibility

Fast-Time Simulations

Fast-Time Simulations

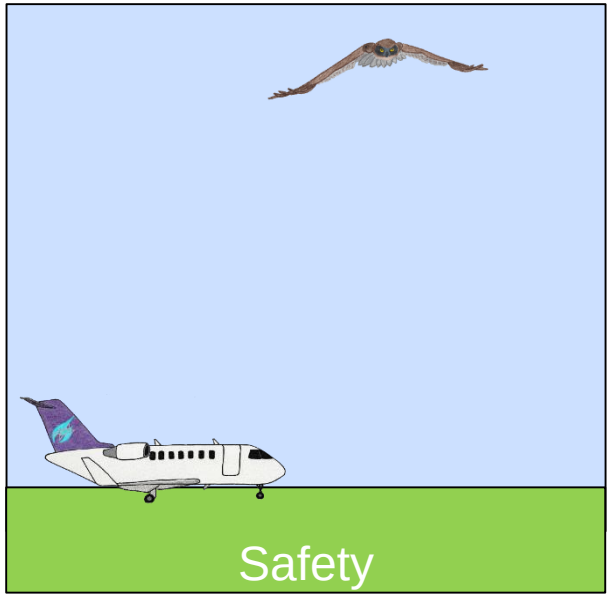
Scope



Fast-Time Simulations

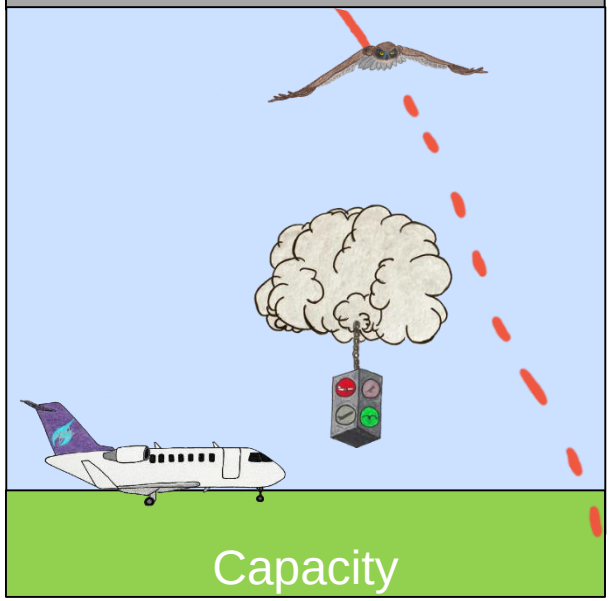
Scope

No system



ATC advisory system

Collision avoidance

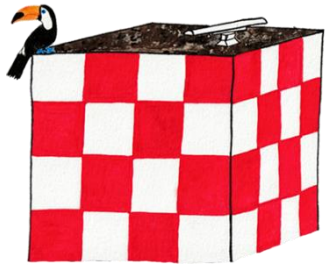


Risk avoidance

maintaining of capacity achieved by risk-based approach

more sophisticated model required to increase safety

Process and Research Questions



Wildlife Strike Risk Advisory System

Track Prediction → Risk Assessment → Visualization

take-off delay of one minute due to crossing flock of pelicans

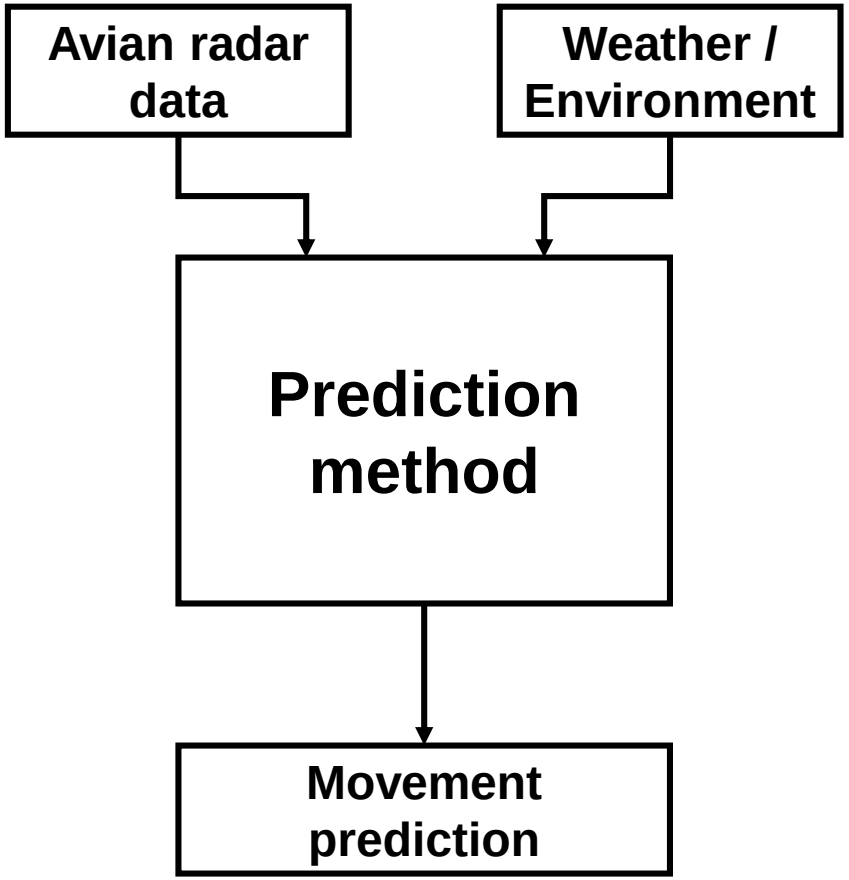
Increase accuracy of prediction

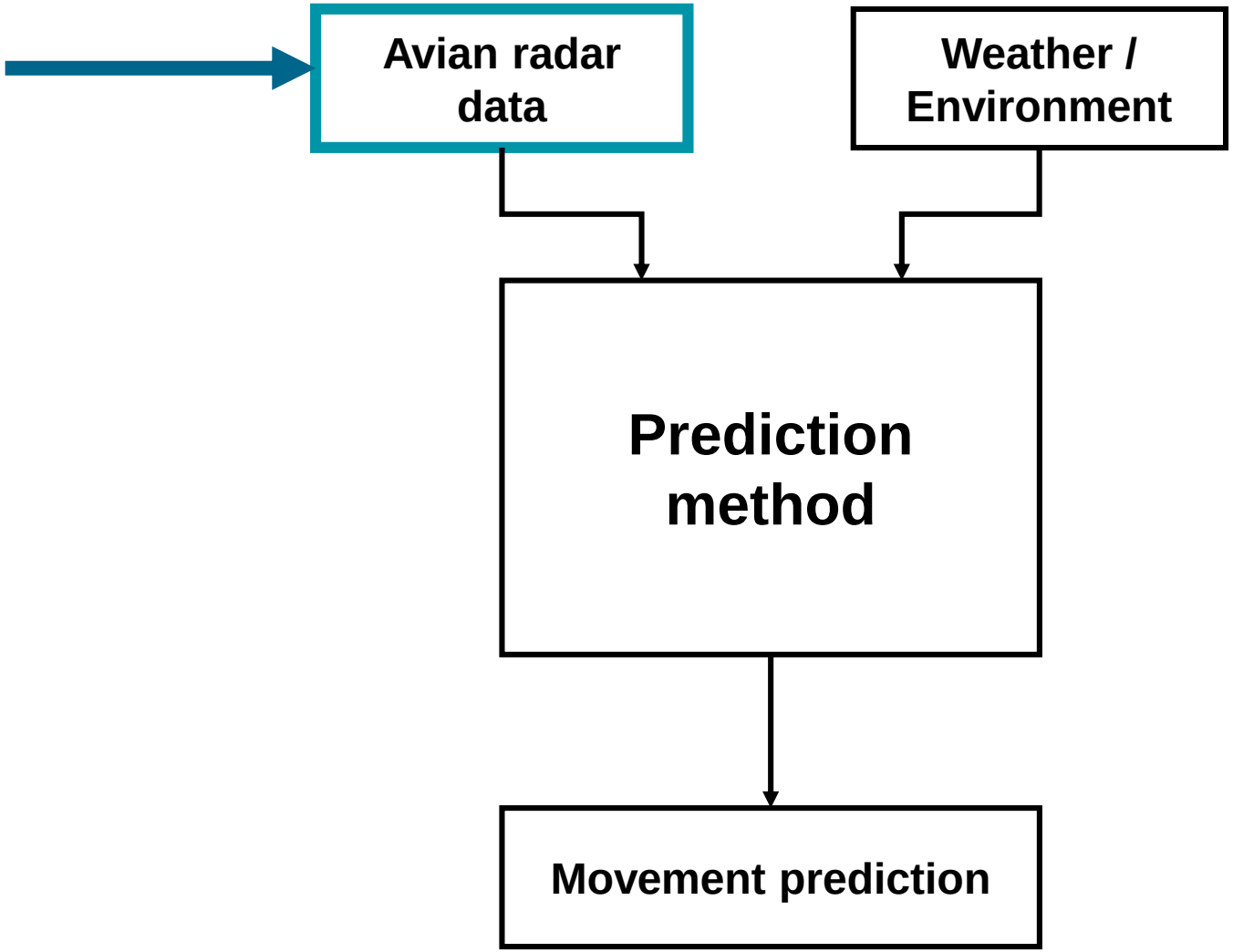
Prediction model

Developing a model to predict bird trajectories

- More accurate track predictions → more precise aircraft delays possible

- Predicting local bird movement
- Avian radar tracks as input for the model
- Possible effects of weather / environment on bird movement




Avian radar data
Weather / Environment
Prediction method
Movement prediction

Why use avian radar data?

- Designed to capture bird movement
- Automatically and continuously detect and store bird tracks
- A lot of data is collected throughout the years

Focus on predicting movement of larger birds and flocks

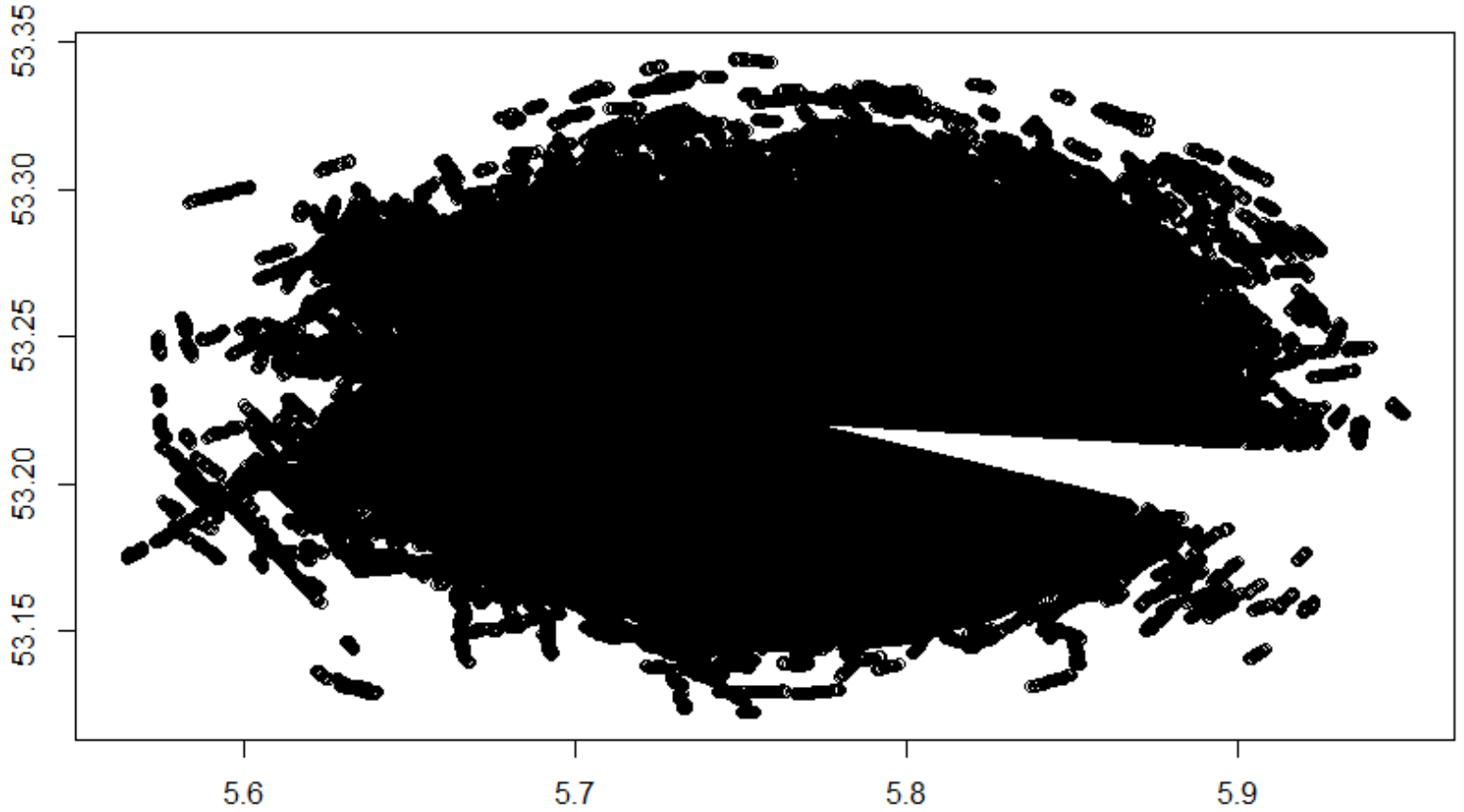
- Collisions with larger birds cause more damage

- Flocking birds pose a great risk for aircraft

Selection of avian radar tracks

- Tracks that are classified as medium/large birds or flocks
- Tracks that are long enough to use for prediction → sensitivity analysis
- Tracks within a certain range of the avian radar

Examples of bird tracks captured by the radar at Leeuwarden Airport



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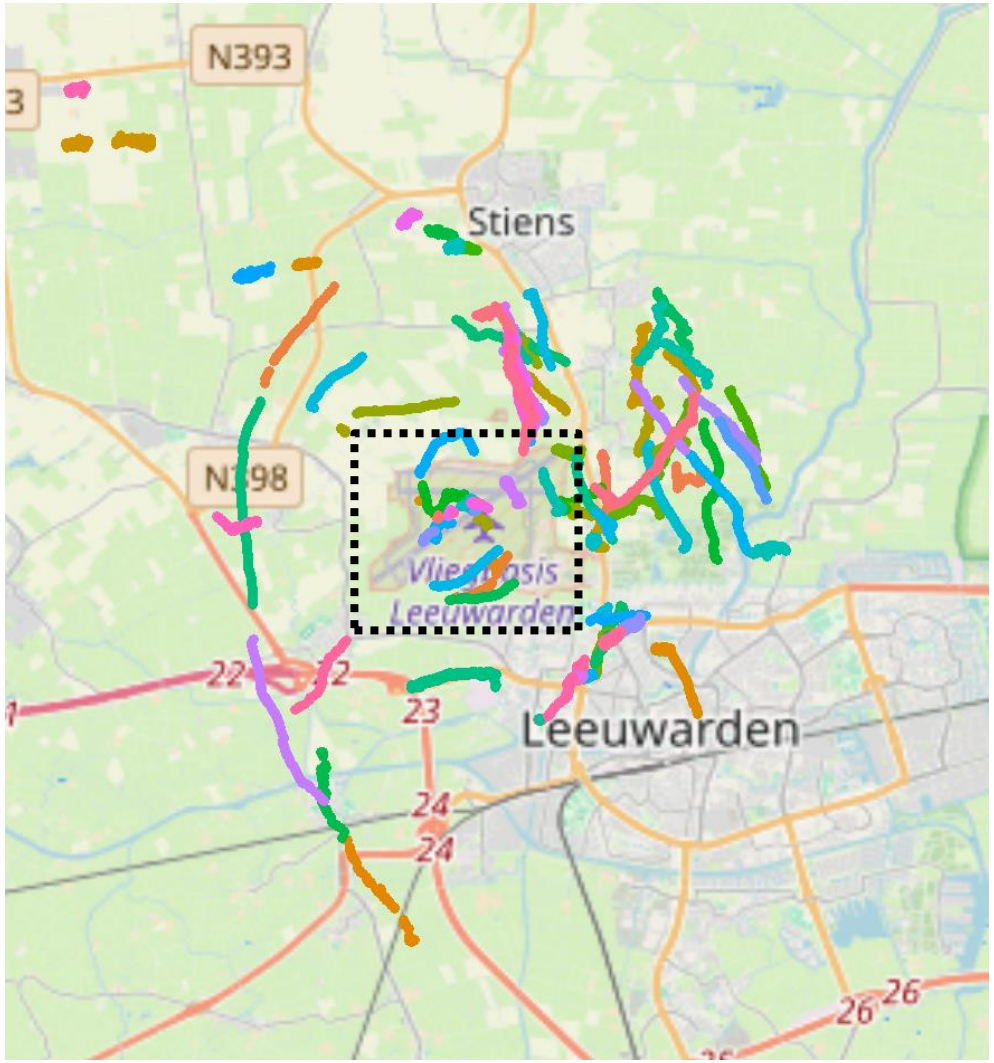

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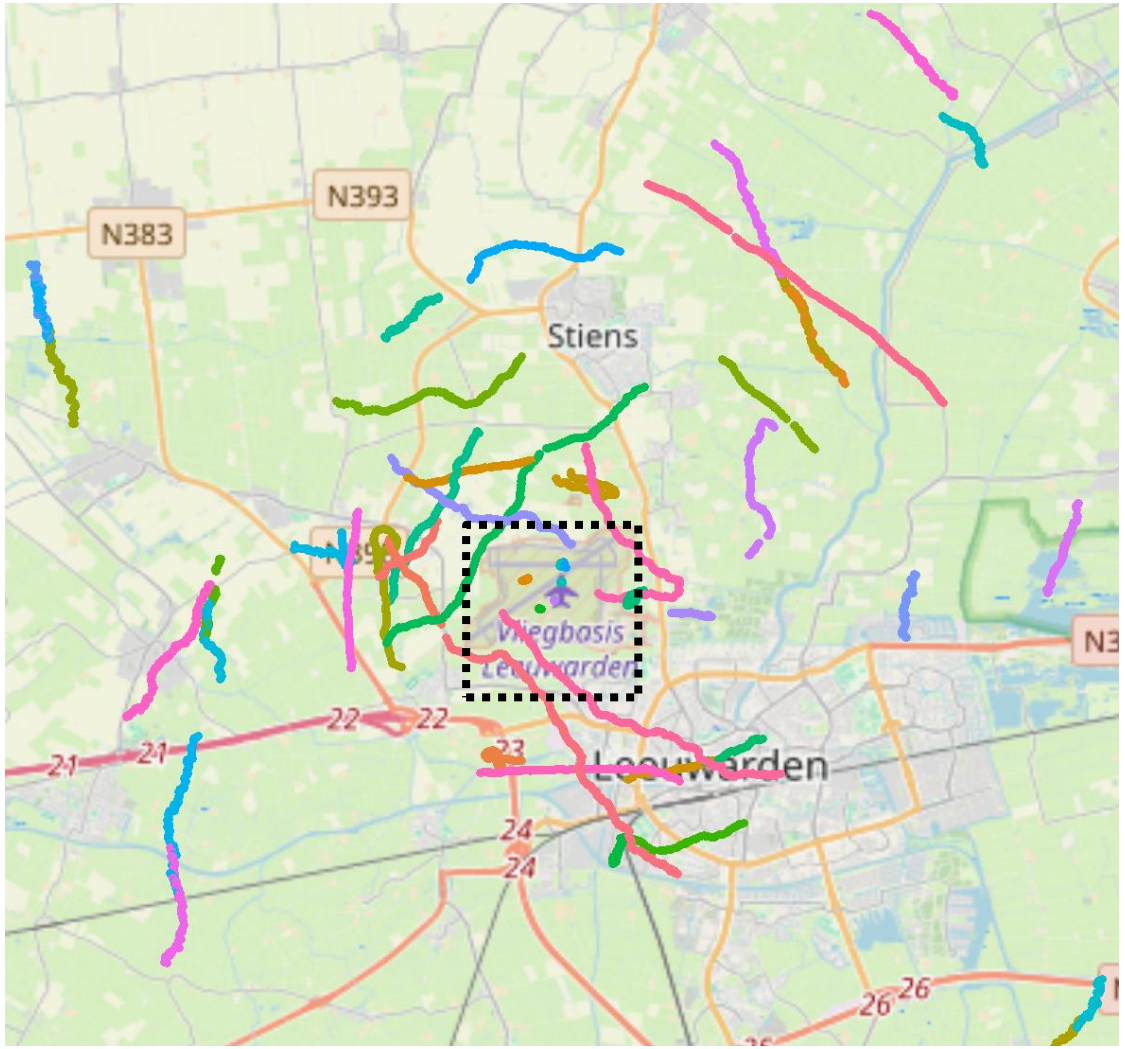

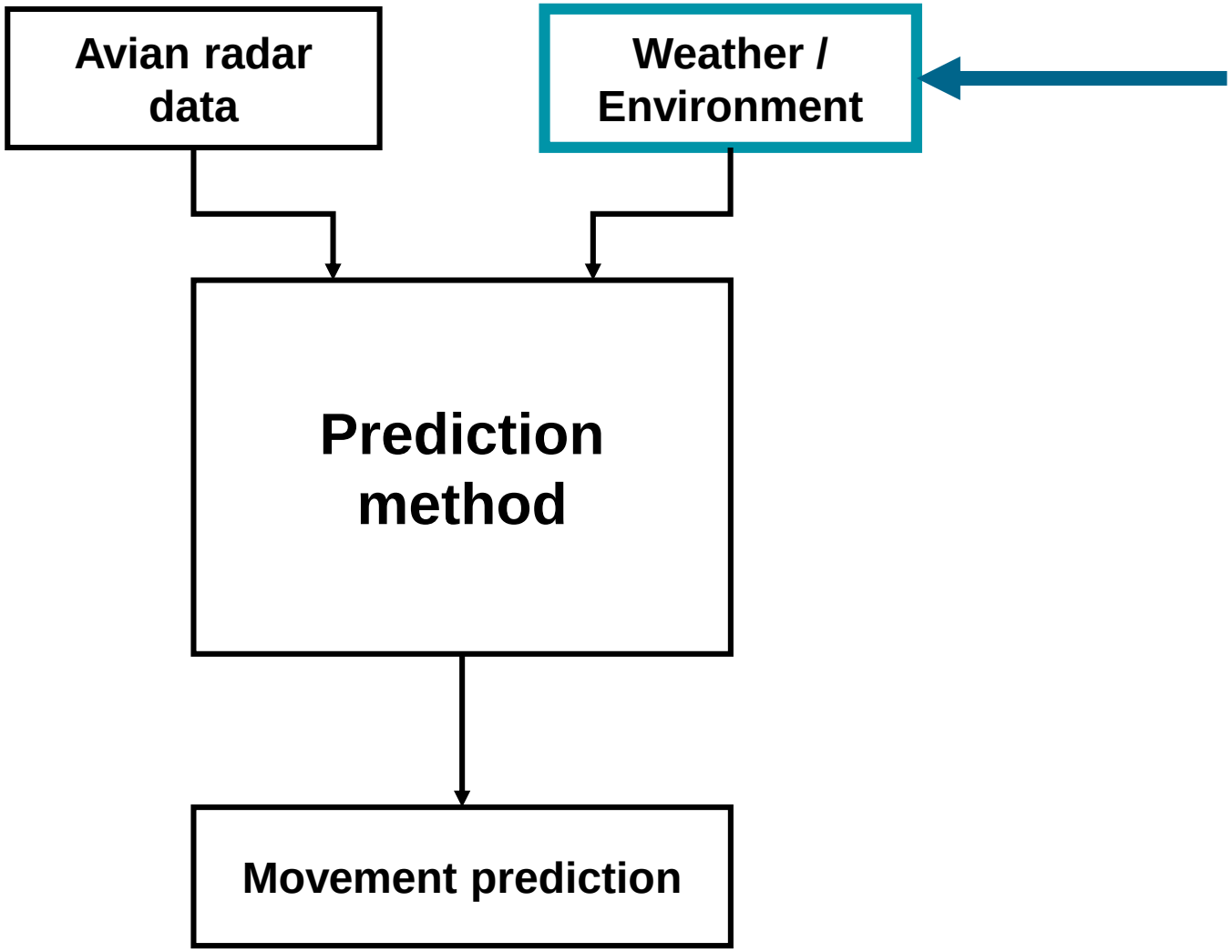
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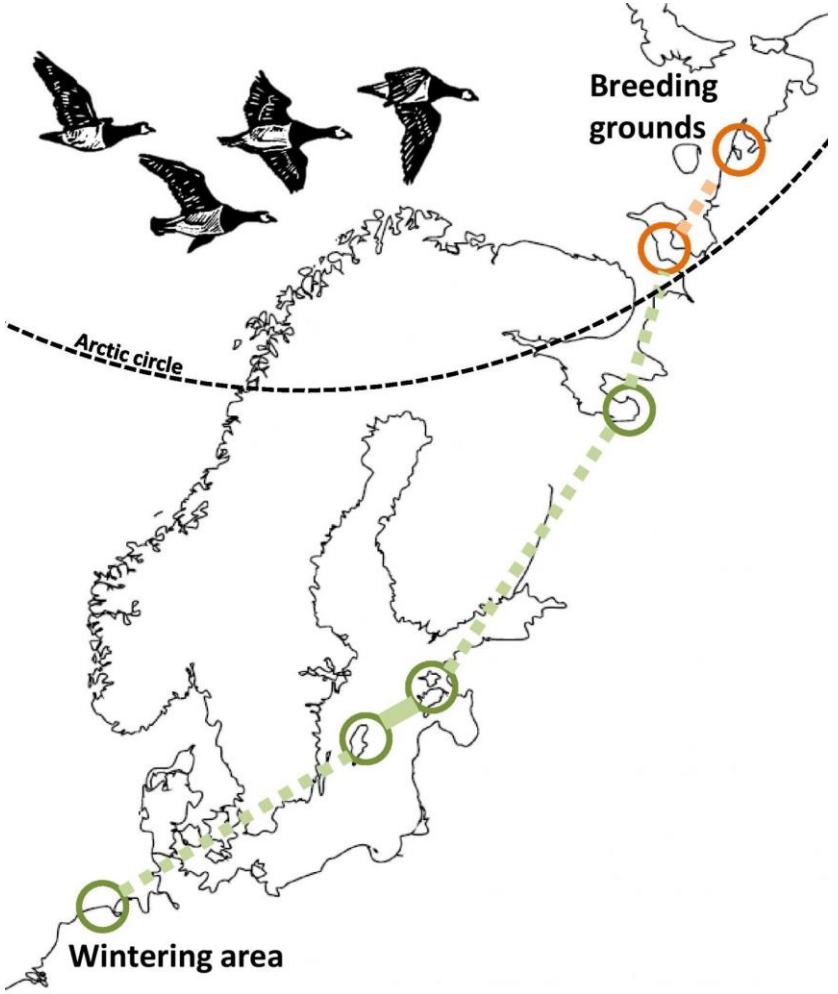
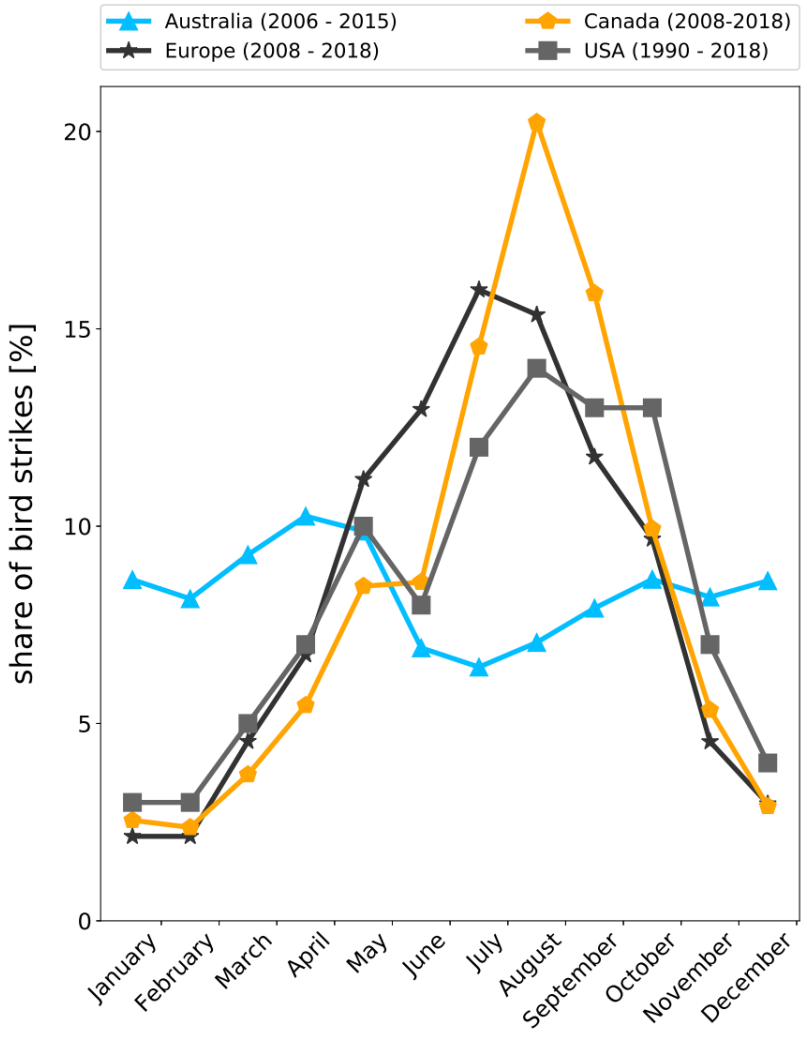
Weather, environment and daily and seasonal influences on bird movement



Lameris et al. 2017

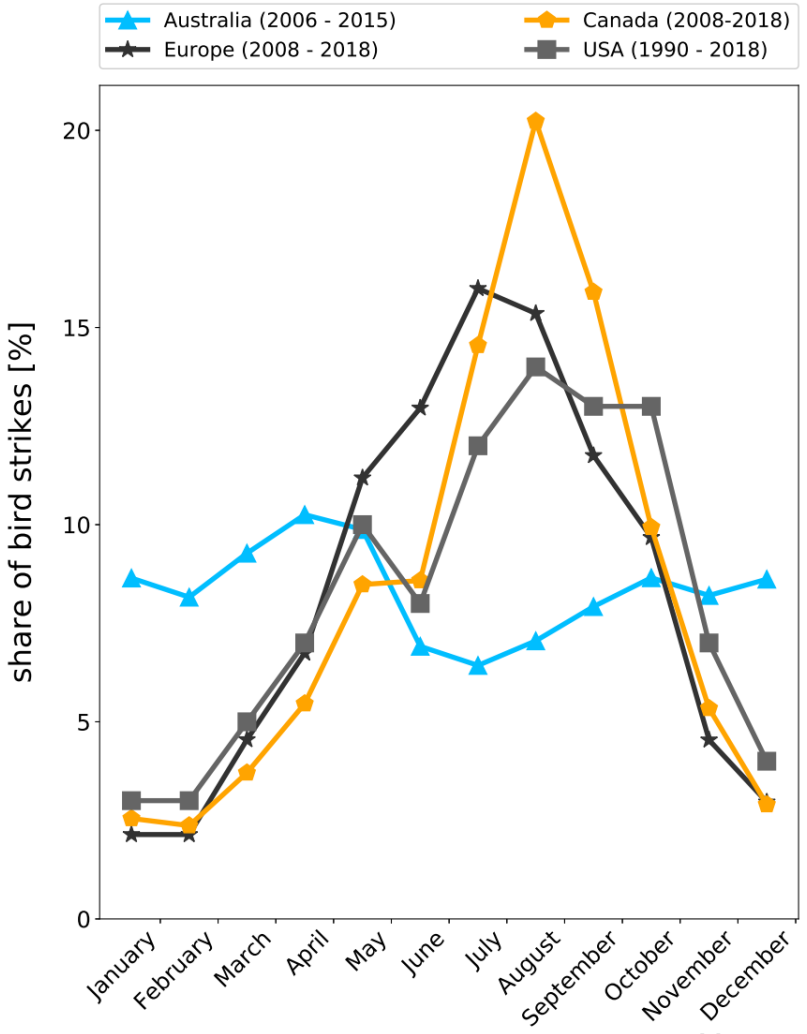
Peaks in bird strikes during summer



Metz et al. 2020

Peaks in bird strikes during summer

- More fledglings flying in summer
- Fledglings are inexperienced
- Possibly leading to more strikes



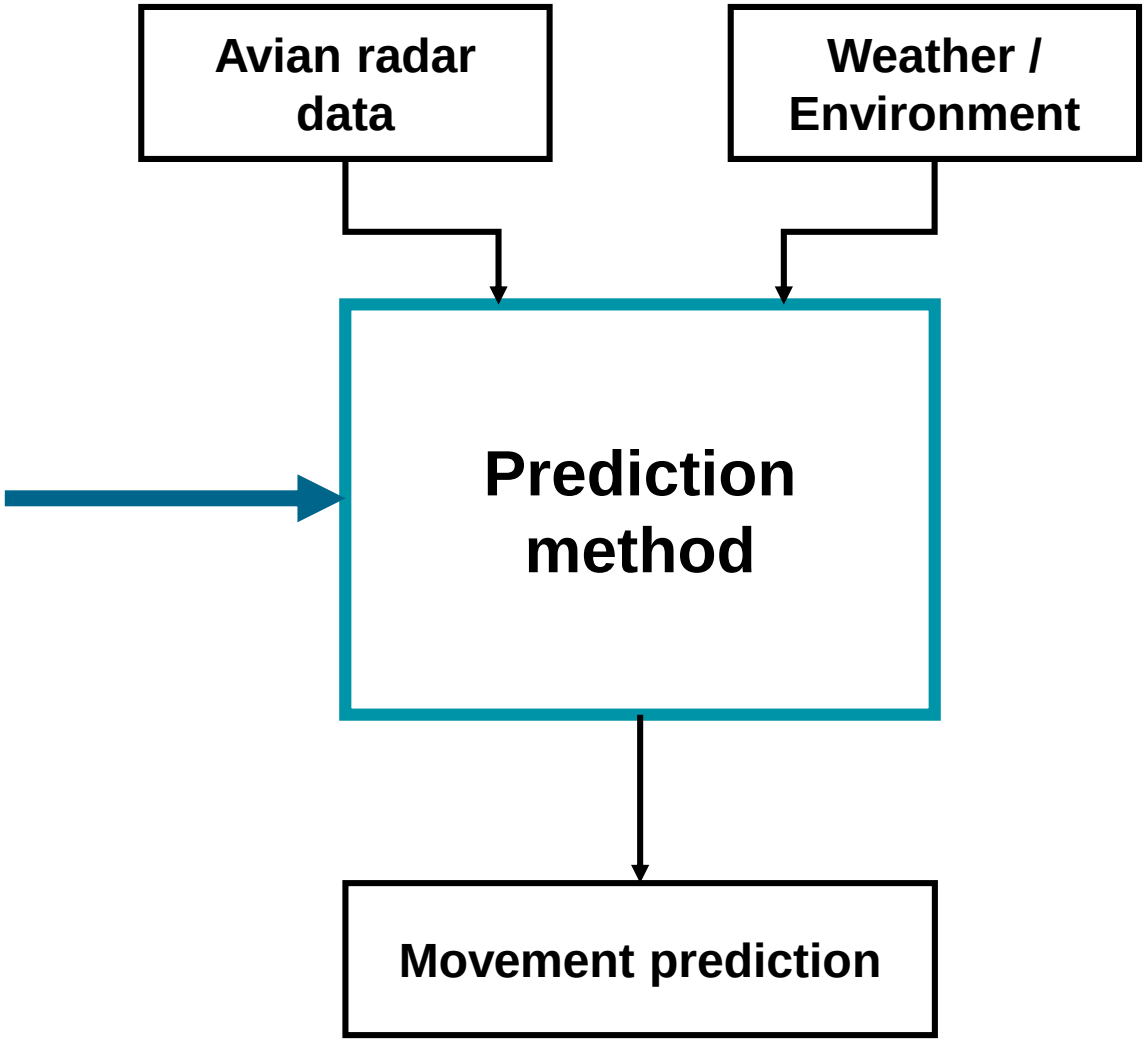
Metz et al. 2020

Daily movements may be predictable to some extent

2009 documentary on development of King Shaka airport, MERLIN radar installed for risk assessment of barn swallow movements

Daily movements may be predictable to some extent

- Movement to and from feeding grounds
- Flight timing around sunrise and sunset
- However, bird flight is still unpredictable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Weather / Environment
Prediction method
Movement prediction

Current methods used to model animal movement

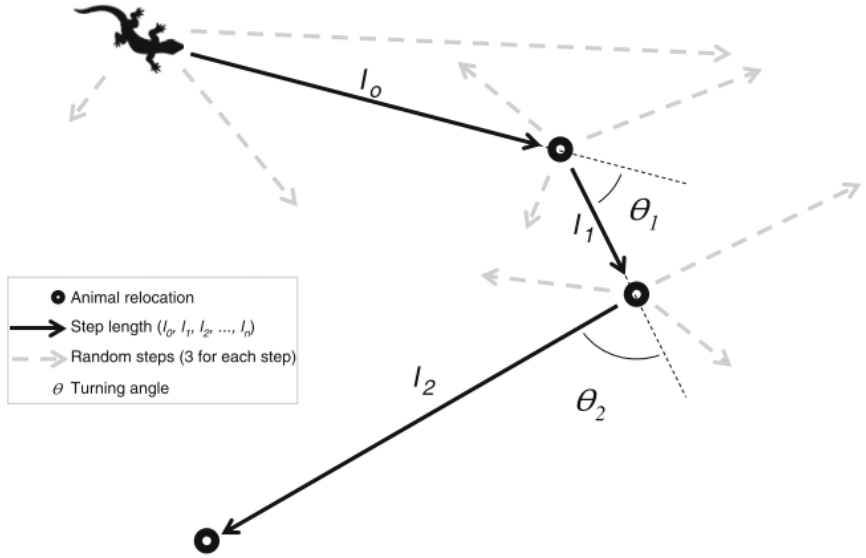
- Agent-based modelling
- Step selection analysis
- Machine-learning
- Deep-learning

Simulating animal movement using agent-based modelling

- Modelling dynamics of complex systems
- Individuals have behavior rules
- Behavior can have effect on environment

Modelling animal movement with step selection analysis

- Animal movement broken down into step length and turning angle
- Comparing selected step with set of random steps
- Understanding how animals use habitat



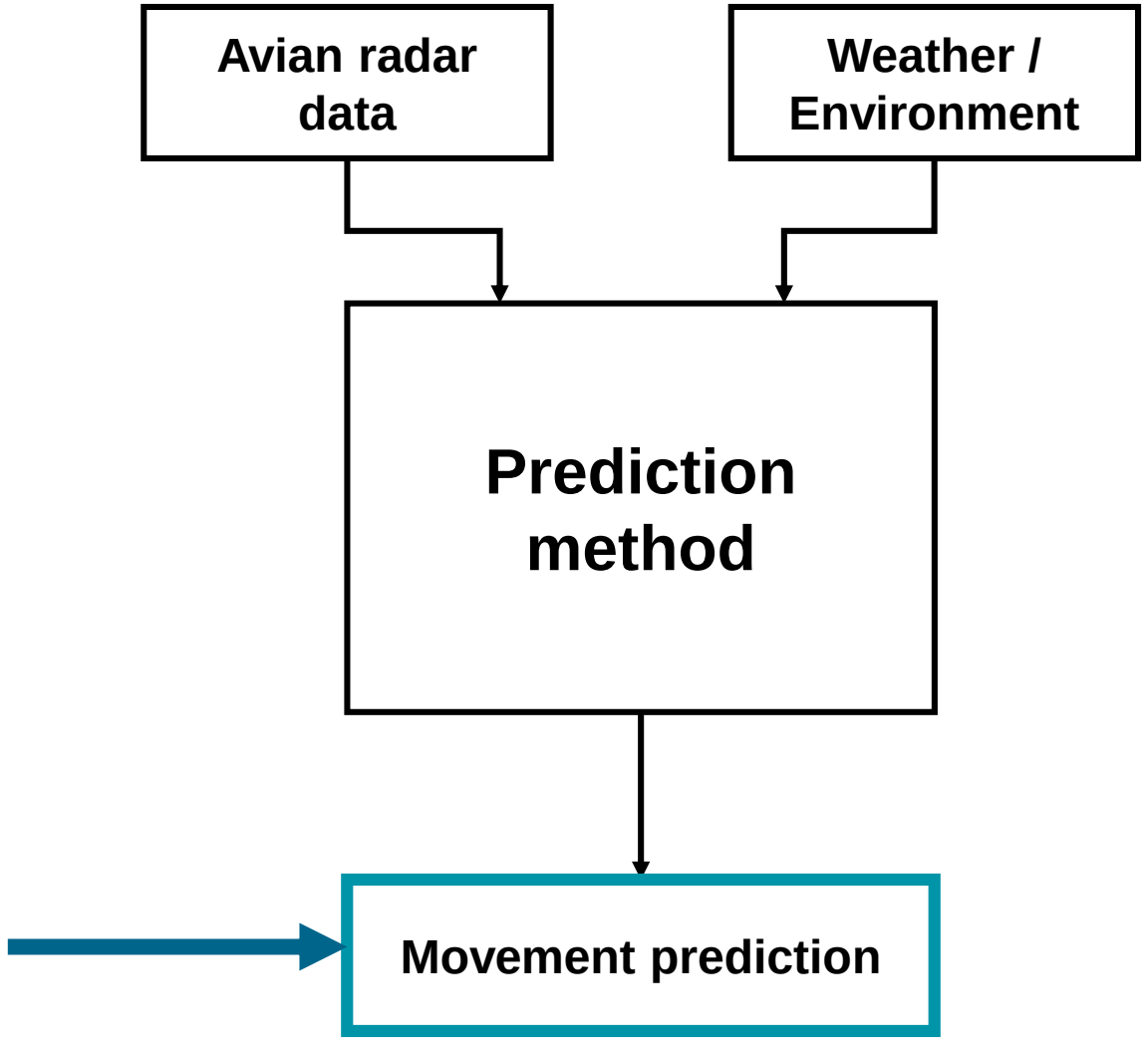
Thurfjell et al. 2014

Use of machine-learning has been increasing in recent years

- Supervised learning vs unsupervised learning
- Training model to make predictions
- Behavior classification and trajectory predictions

Deep-learning as a next step from machine-learning

- Deep-learning models can learn patterns in data
- Multi-layered neural networks allow for complex calculations
- Identification of animals from images and trajectory predictions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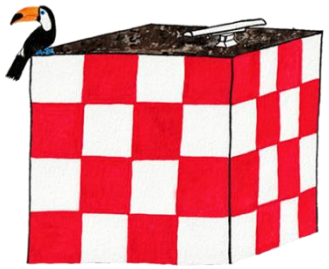
Goals for the bird movement prediction

- Accurately predict local bird movement
- Prediction of bird track up to 5 minutes in the future
- Identify patterns in bird movement

From movement prediction to risk assessment

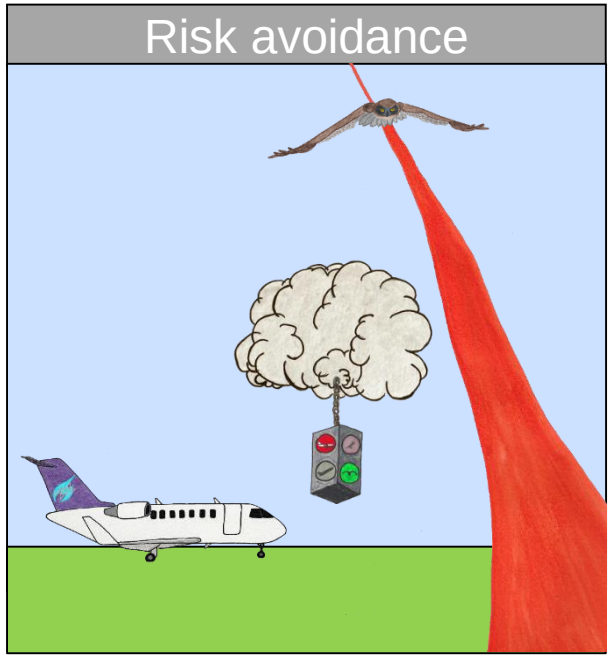
- Take into account the uncertainty in predicted bird track
- Calculate the probability of collision
- Calculate potential damage that could be caused by a collision
- Set threshold for probability and potential damage where delay is needed



take-off delay of one minute due to crossing flock of pelicans

Assessing impact of imposed delays on airport capacity

- Fast-time simulations
- Check whether predicted bird tracks are accurate enough
- Further improve prediction model if needed



Testing the model at different airport locations

- Applying prediction model at two airport locations

- Investigating in what way the model needs to be adapted for the location

Leeuwarden airport vs Woensdrecht airport

Adapting model to each airport location

- Develop a workflow to adapt the model to a specific airport
- Take into account environmental differences
- Compare model performance for two locations

Visualization of model outputs

- Clear and easy to use interface
- Show bird tracks in immediate area around the airport
- Send alert when risk of a bird strike is high

Improvement of visualization for use by ATC

- Initial evaluation of visualization by controllers
- Process feedback from evaluation and improve visualization

Conclusions

- Improving avian and aviation safety further
- More awareness of bird movements around airport