VALIDATING AN ICE THROW MODEL: A COLLABORATIVE APPROACH

DR GAIL HUTTON
SENIOR STATISTICAL ANALYST

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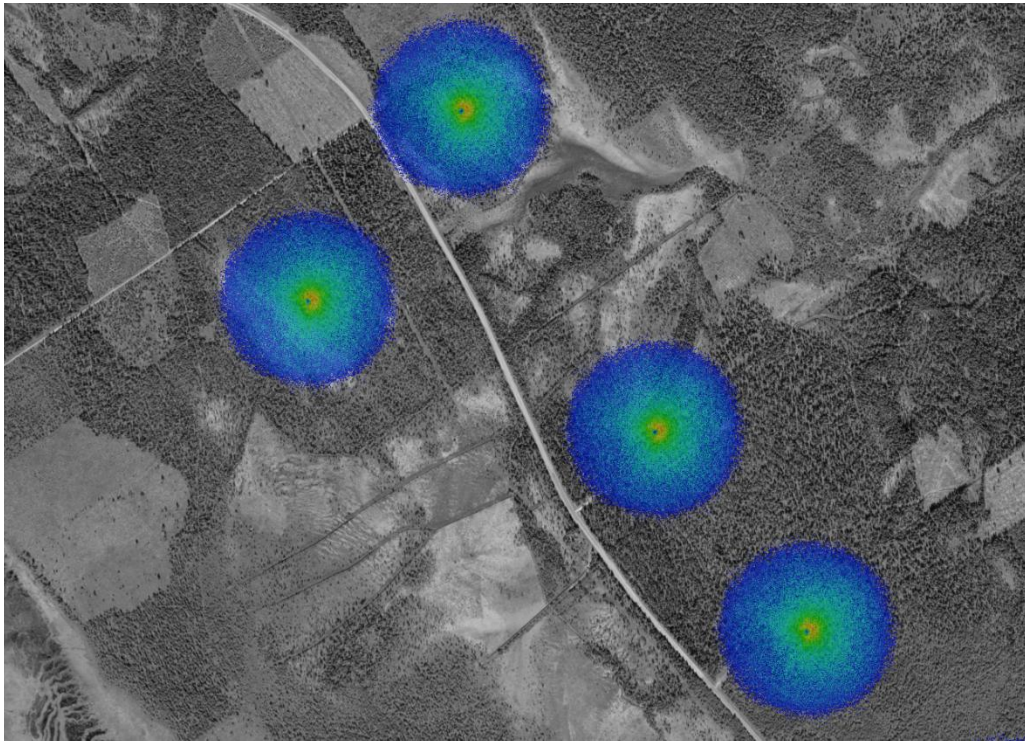
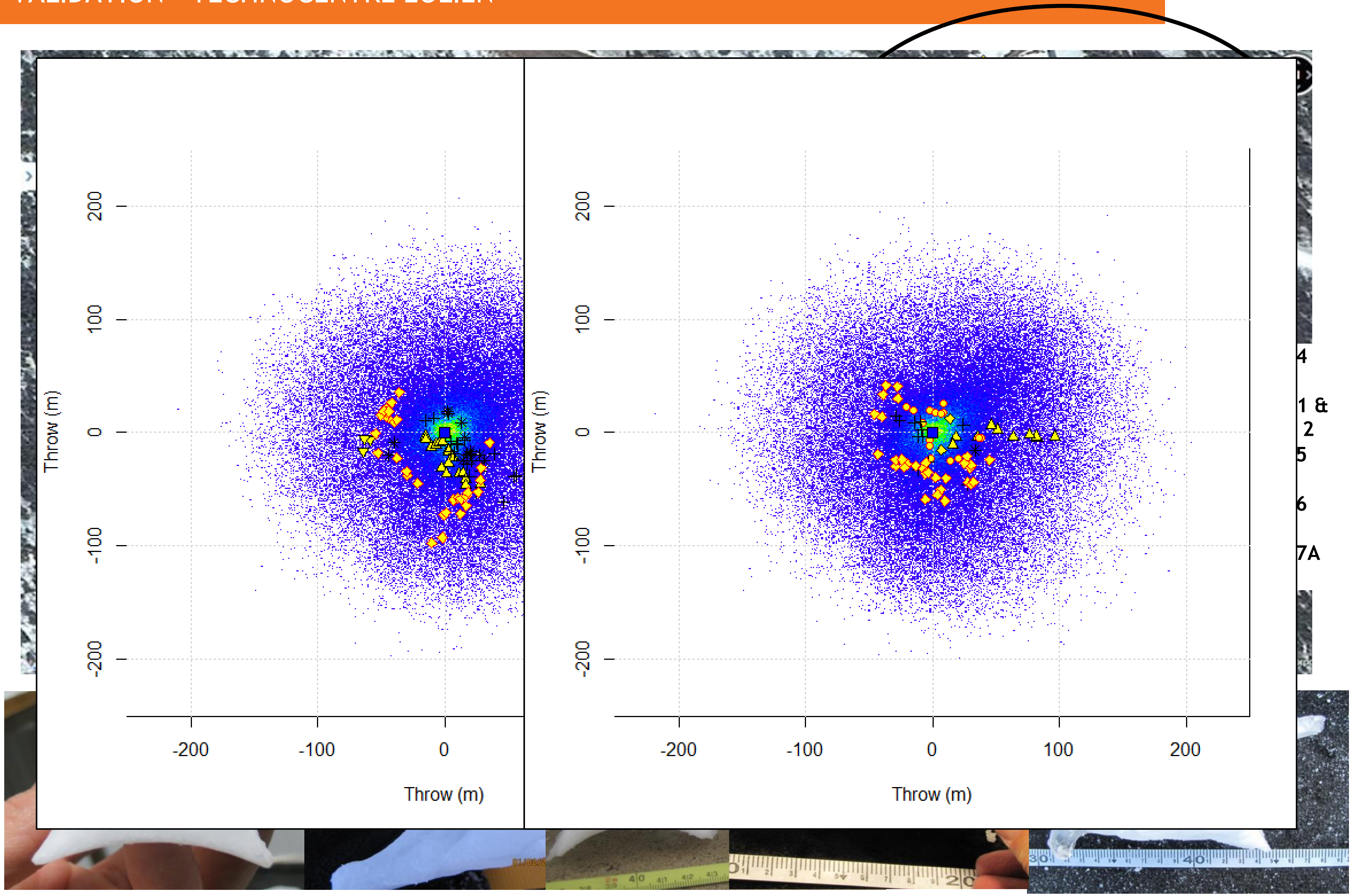
RES: Gail Hutton, Alan Derrick
TCE: Matthew Wadham-Gagnon, Dominic Bolduc

RES has a theoretical model of ice throw (presented at WinterWind 2013)

- Used to predict impact position of ice fragment given characteristics of throw
- This takes into account
  - a physical model of the trajectory of an ice fragment
  - Stochastic/statistical models Of wind characteristics on-site
  - Turbine characteristics
  - Hub height
- Theoretical only
- **Validation needed**

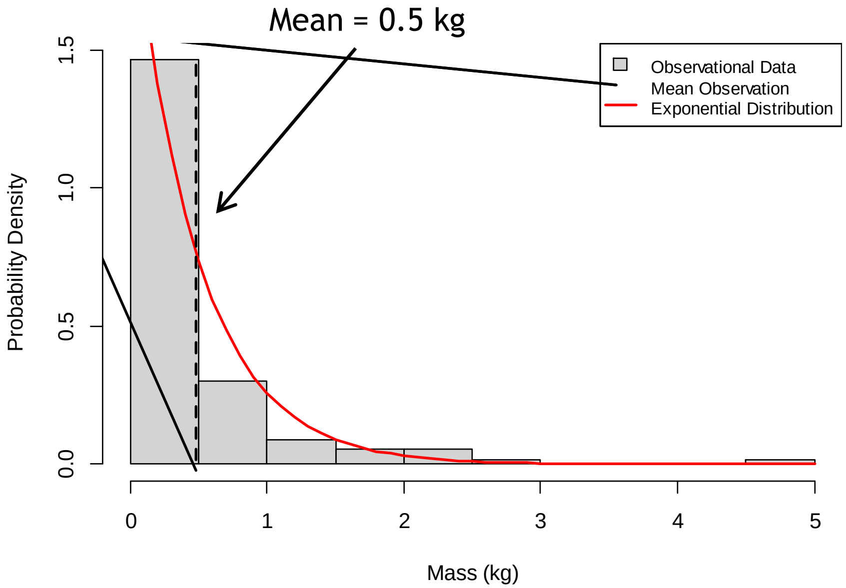


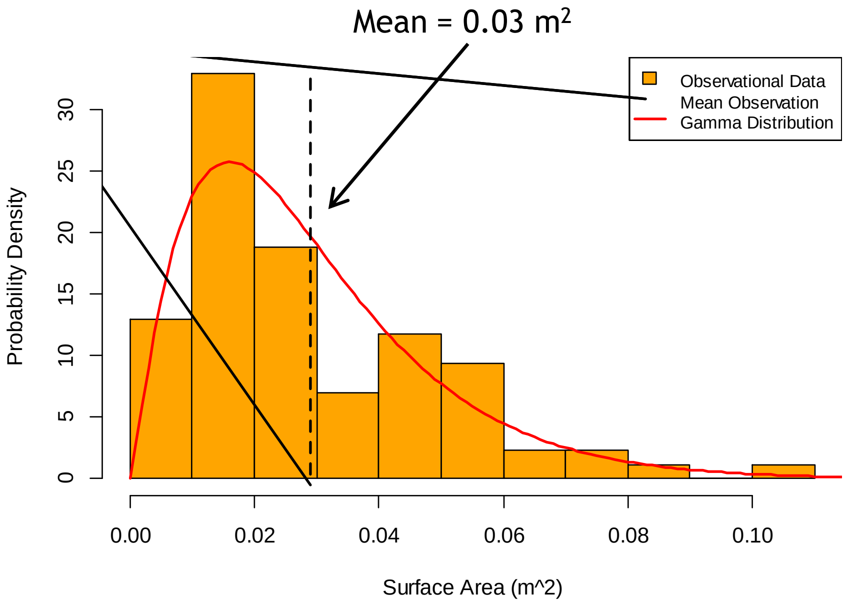
VALIDATION - TECHNOCENTRE EOLIEN



1. Introduction

- Model assumptions
  - Mass of ice fragment assumed constant at 1 kg
  - Frontal area assumed constant at 0.02 m^2
  - Drag coefficient assumed constant at 1





- New sampling distributions for mass and frontal area
- Drag coefficient probably higher than 1
- Observed fragments released per icing event in the range from 1-33

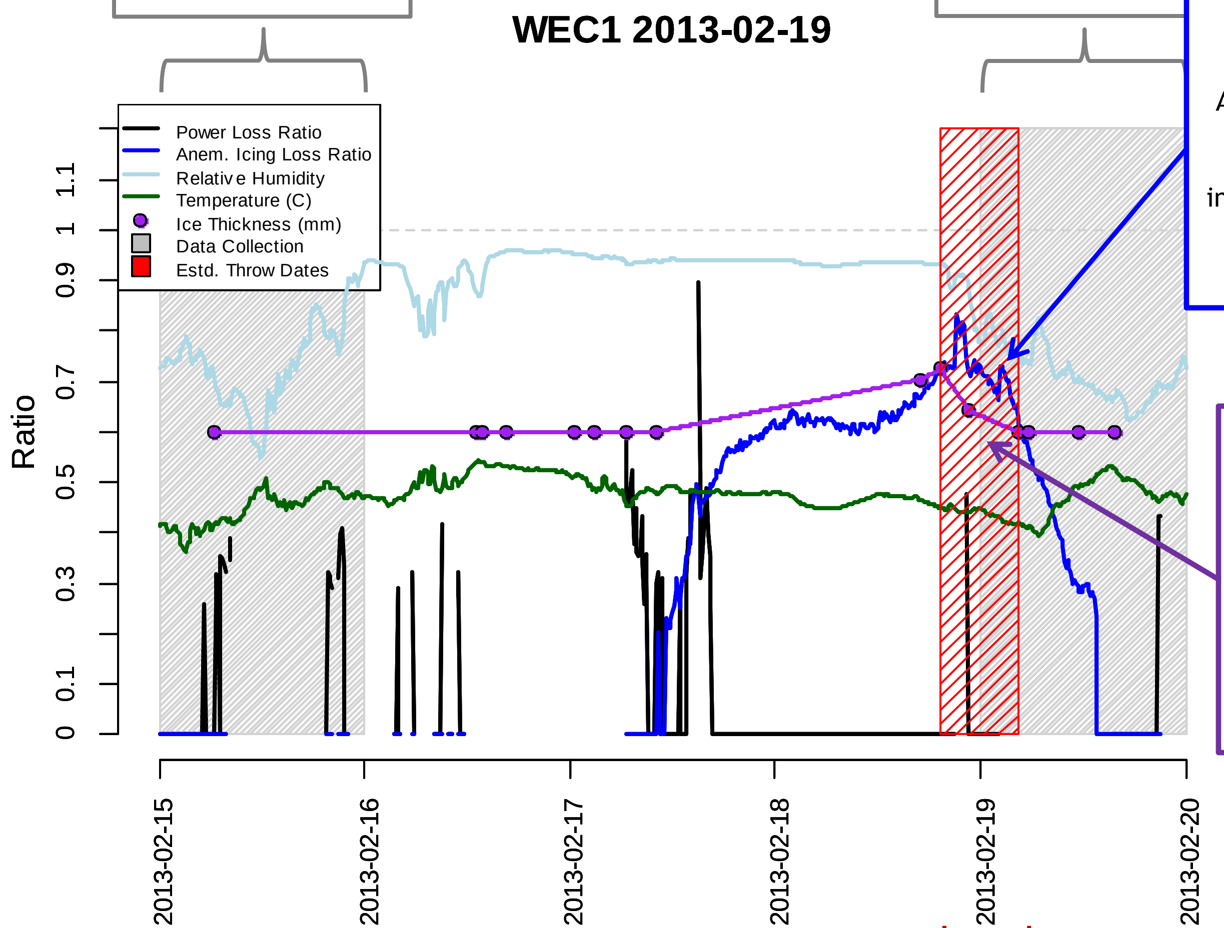
MODEL ACCURACY EXAMINED: ISOLATING THE TIME OF ICE THROW

Temperature consistently below zero -> not a good indicator of time of ice throw

Consistently high relative humidity and low temperatures - good indicator of icing conditions

Data collection

Data collection

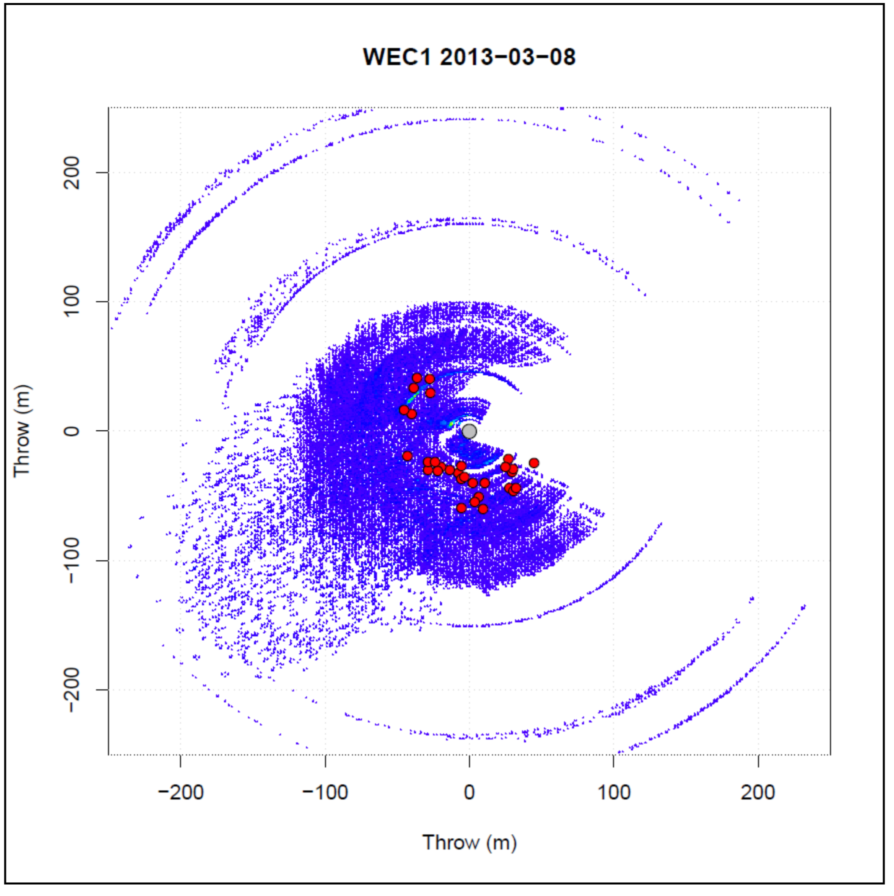


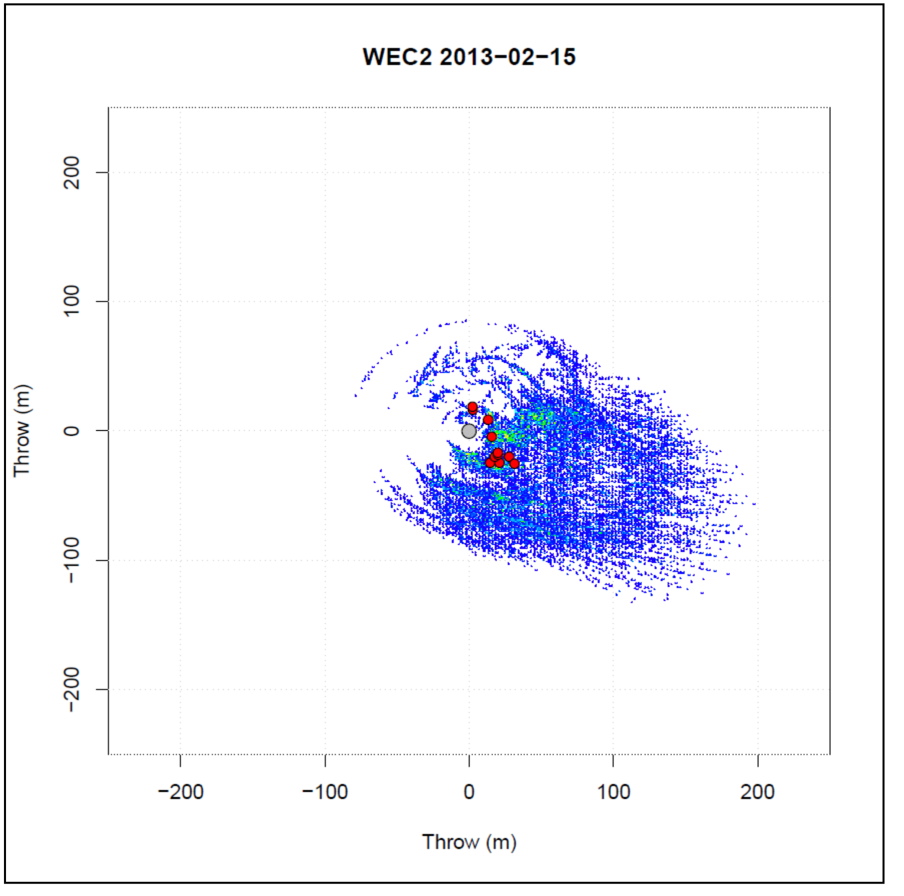
Anemometer slow then increasing in speed -> good indicator of instrumental ice melting

Thickness of ice peaks at ~5 mm and then decreases to zero -> good indicator of Met Mast ice melting

Most likely period for ice throw from turbine blades

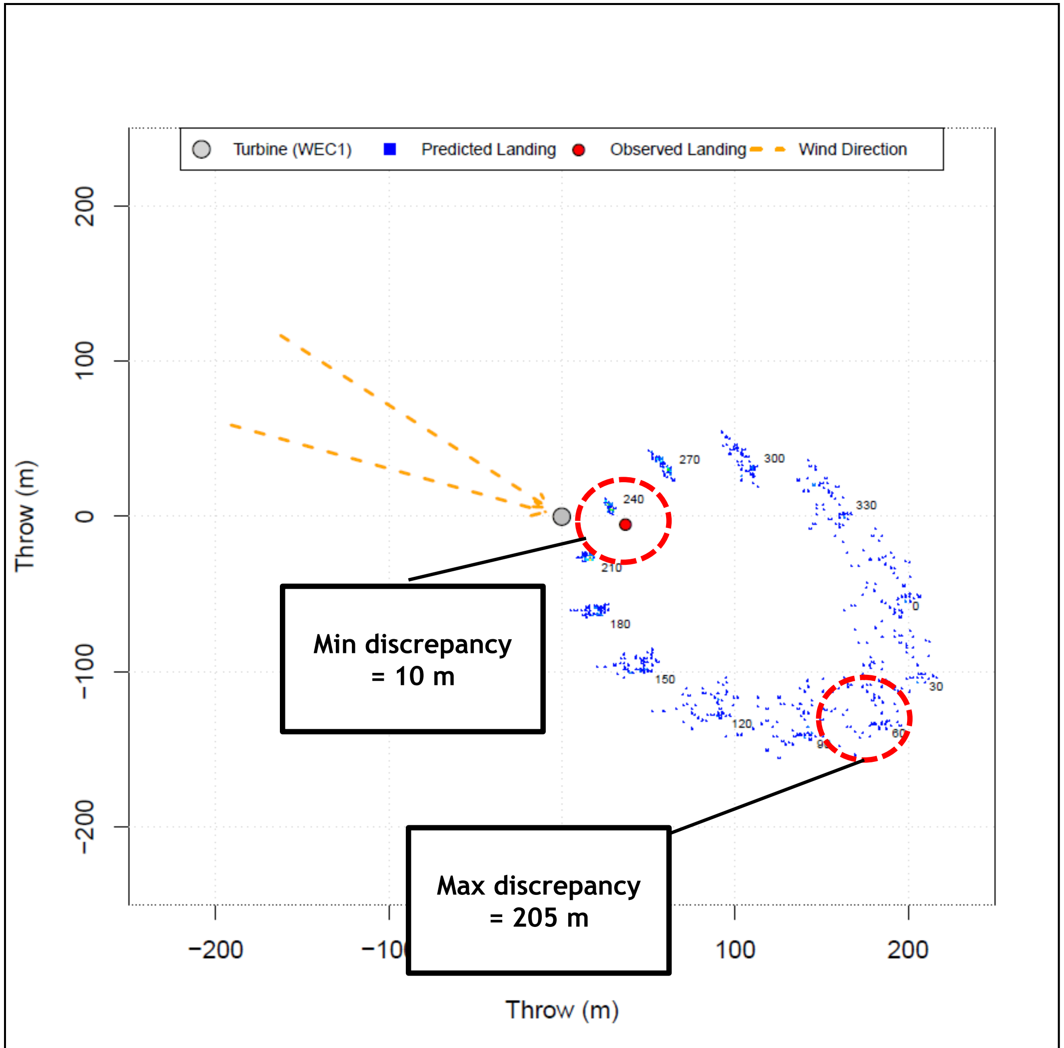
CUMULATIVE PLOTS PER EVENT

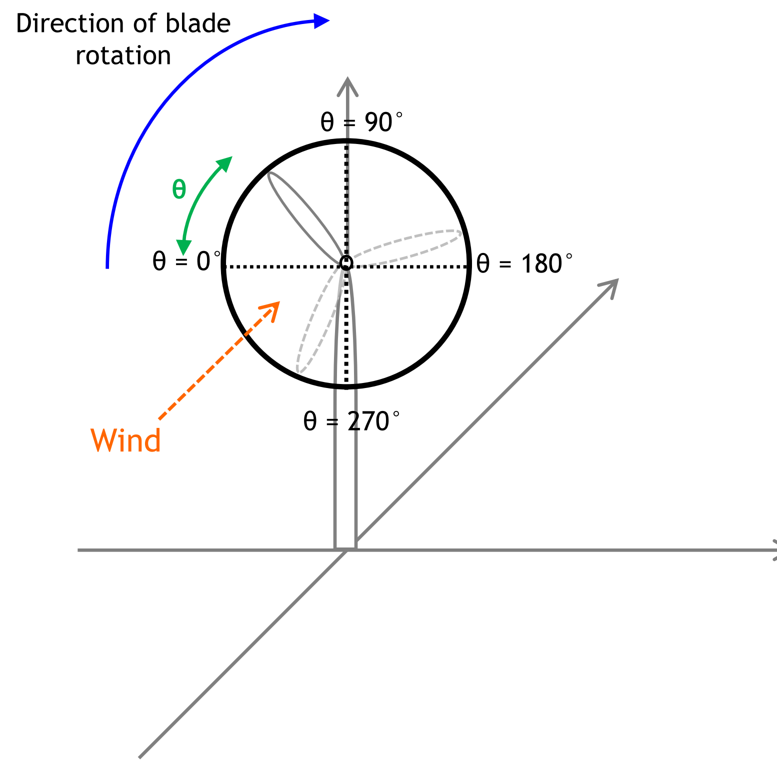




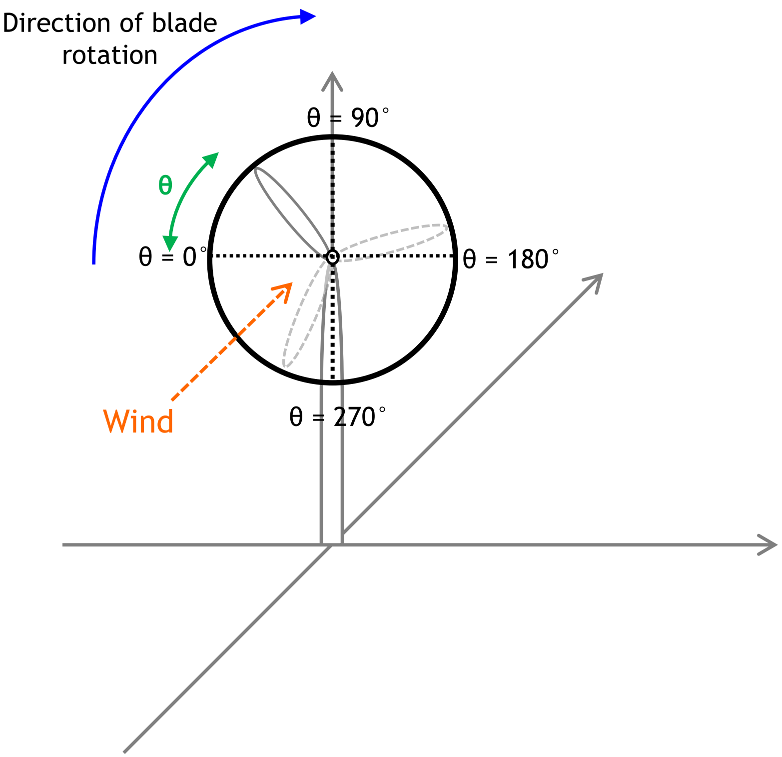
- Observed landing positions typically within range of expected/predicted landing positions

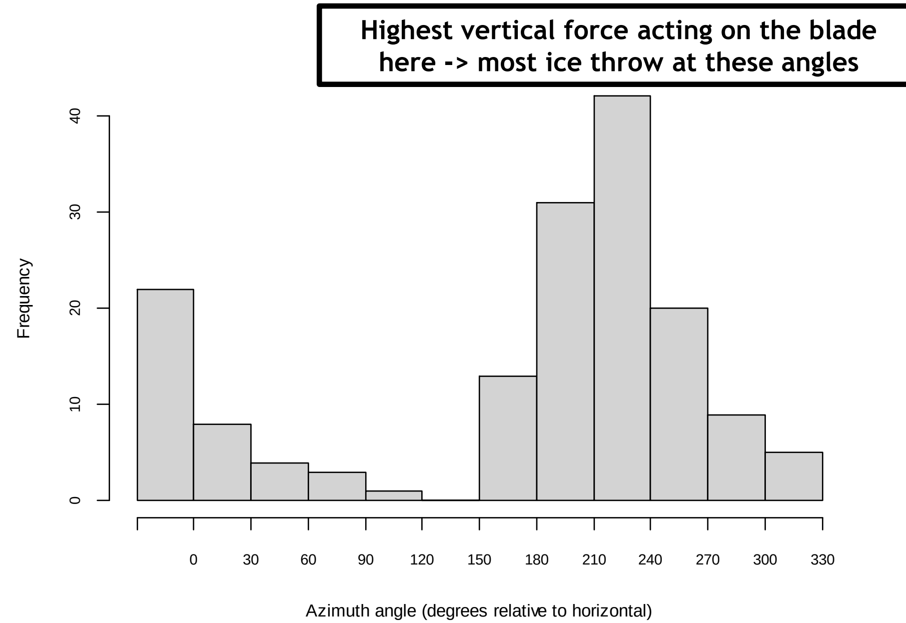
PREDICTED VS. OBSERVED

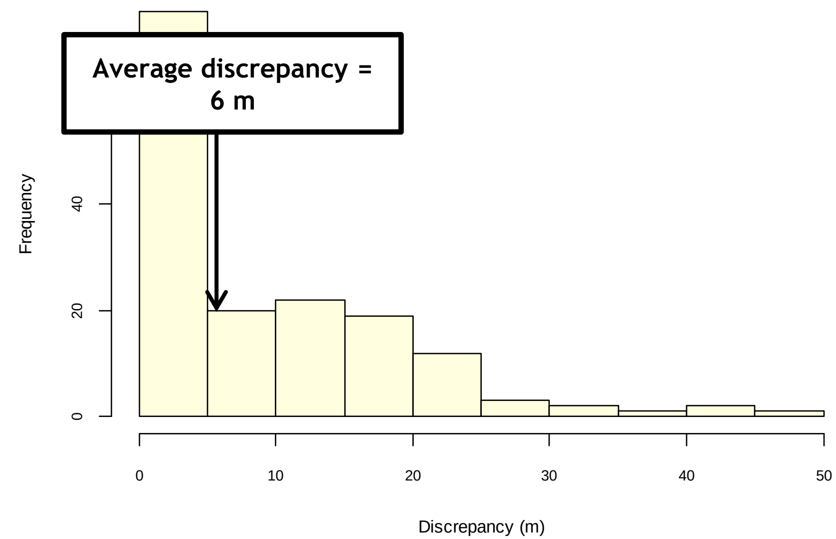




MODEL ACCURACY EXAMINED: DISTRIBUTION OF ERRORS







CONCLUSIONS AND FURTHER WORK

- Initial results are promising
  - Observed landing positions of ice fragments are in the range predicted by the model
  - Model improvements relating to mass, frontal area and drag can be made as a result of this research

- Identifying the blade azimuth at the time of ice throw is crucial to model validation
  - Smallest discrepancies weighted towards fragments being released from 180° - 270° azimuth angles
  - But model errors cannot be defined well without additional information

- Future validation should make use of turbine-mounted cameras to identify azimuth angle res

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