# Towards an increased understanding of icing conditions within a wind farm through visualisation of SCADA data in a topographic context



WeatherTech

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WinterWind
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# About WeatherTech

- Consultant firm based in Uppsala, Sweden
- Specialized in:
  - Mesoscale atmospheric modeling
  - Wind resource assessment
  - Atmospheric icing
- Other services:
  - Energy forecasts
  - Dispersion
  - Sailing
- R&D:
  - National and international projects

| | |
|---|---|
| Problem | Production losses due to icing |
| Motive | Increase understanding |
| Method | Visualisation |
| Analysis | Maps |
| Conclusions | Maybe… |

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# Problem

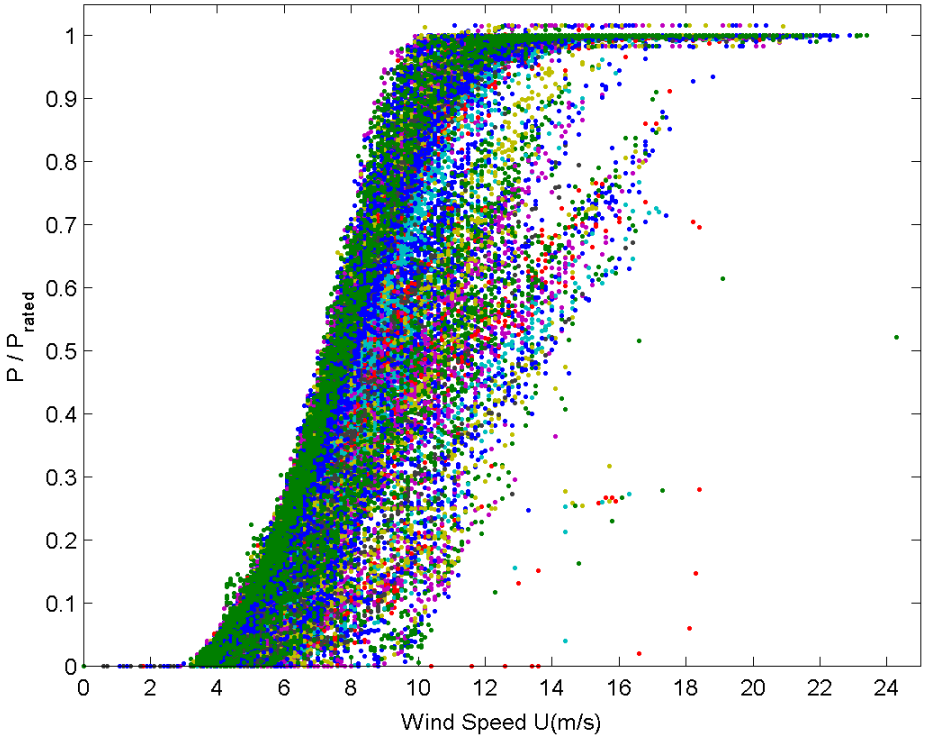
Production losses due to icing

# Production losses due to icing

Cloud water droplets & T< 0

Accretion of ice on turbine blade

Reduced efficiency of turbine




# Motive

Increase understanding

# Icing is complex but can we simplify?

- Describe icing climate with simple parameters? Hypothesis:
  - Spatial variation: Terrain height and geometry, open sea
  - Season variations: Temperature & Wind direction
- End result – Knowledge!
  - Siting
  - Layout

# Method

Visualisation

# Visualisation

- Many parameters
- Developed internal tool
  - Production loss from SCADA – careful data mining
  - Interactive crossfilters
  - Keep control over sample
  - Maps and distributions
- Case study
  - Wind farm in northern Scandinavia
  - Terrain height ~650-750 masl
  - Production loss numbers are normalised

# Analysis

Maps

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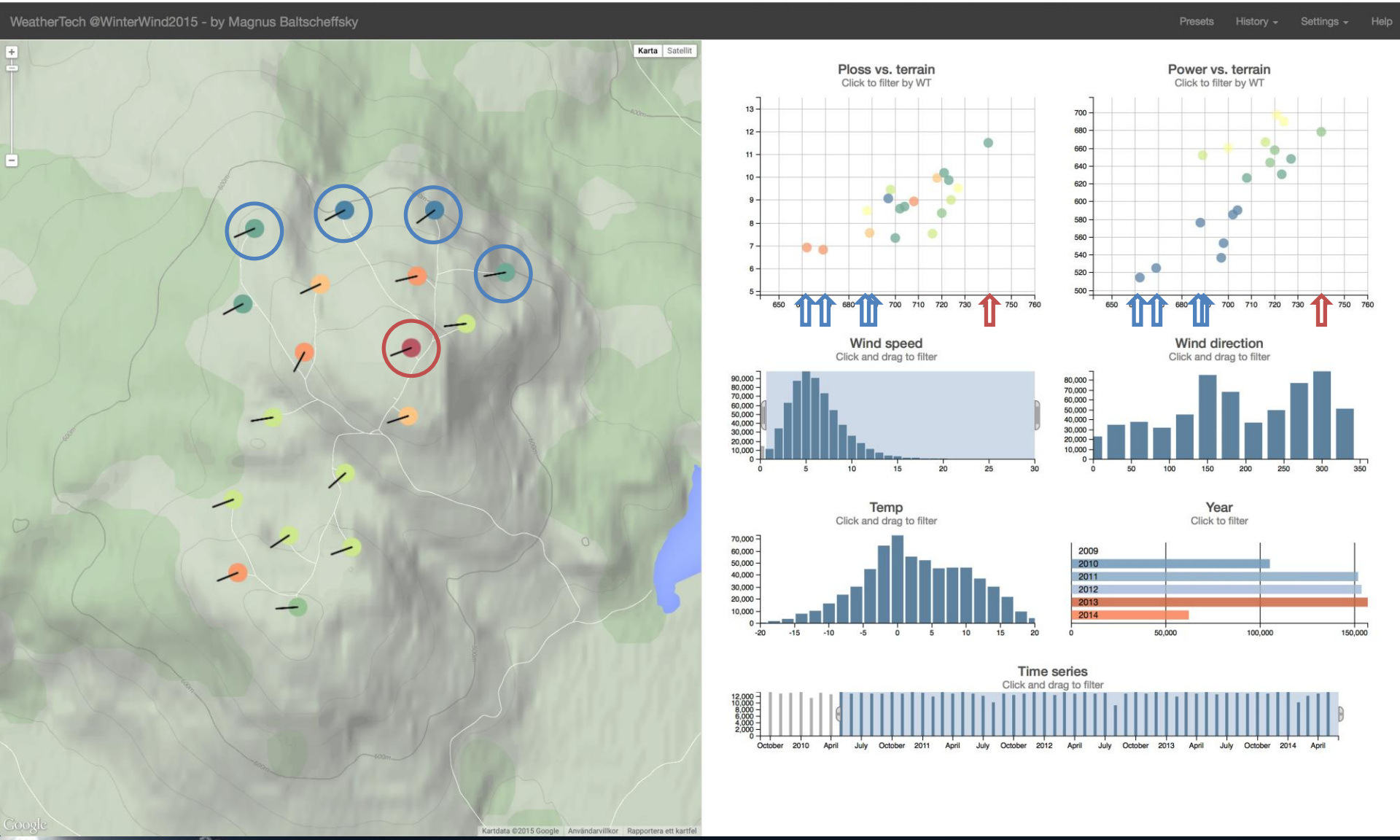
# 2010-2014



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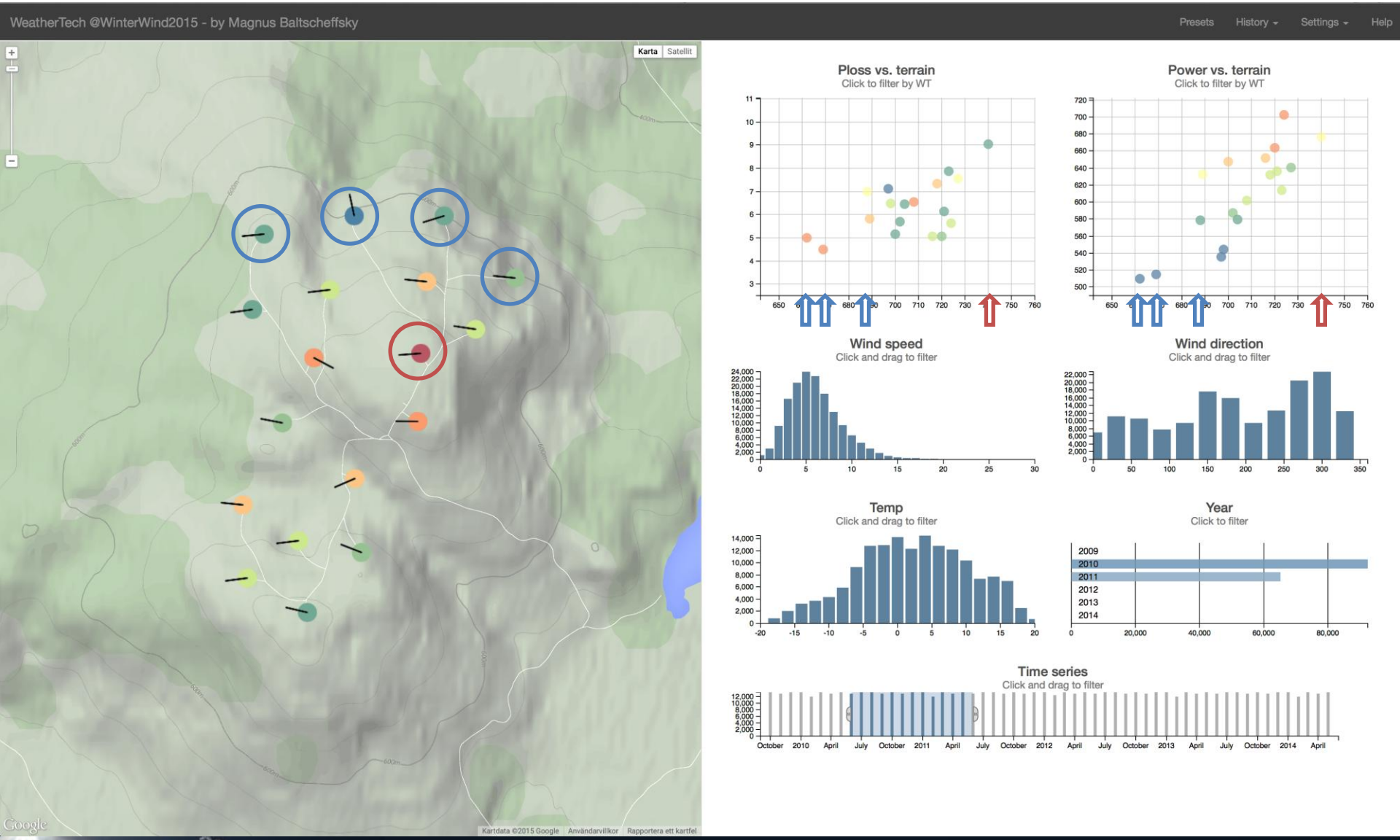
# 2010-2011



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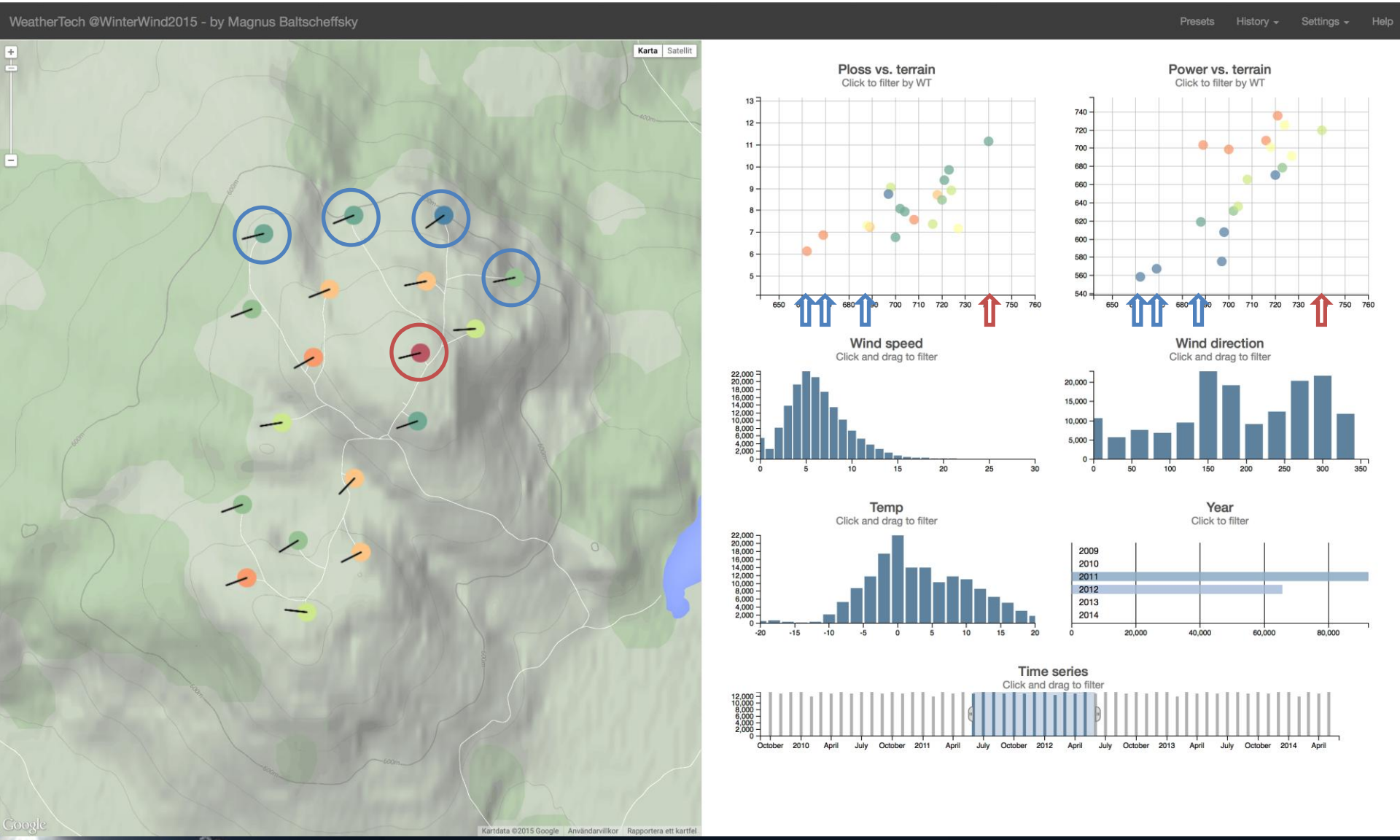
# 2011-2012



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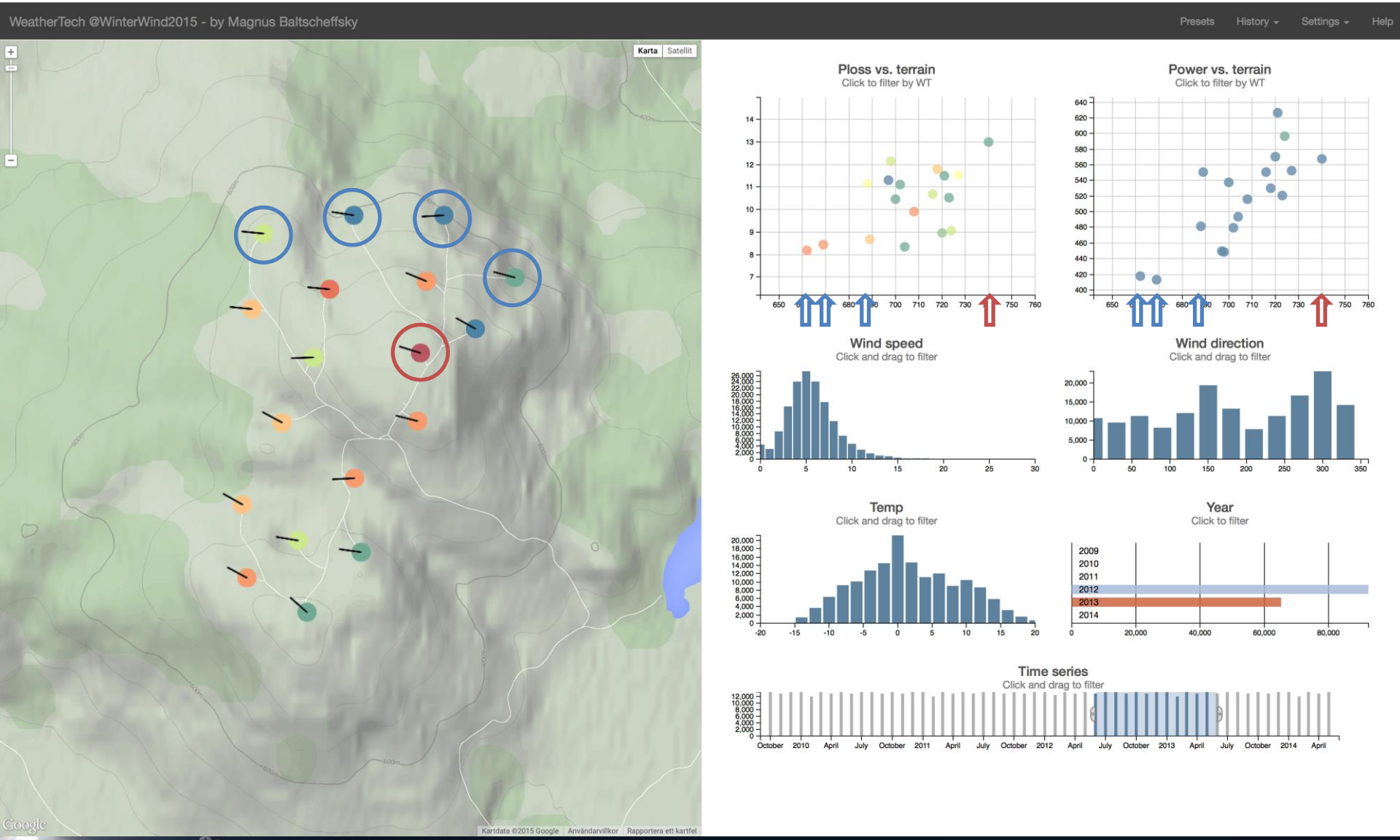
# 2012-2013



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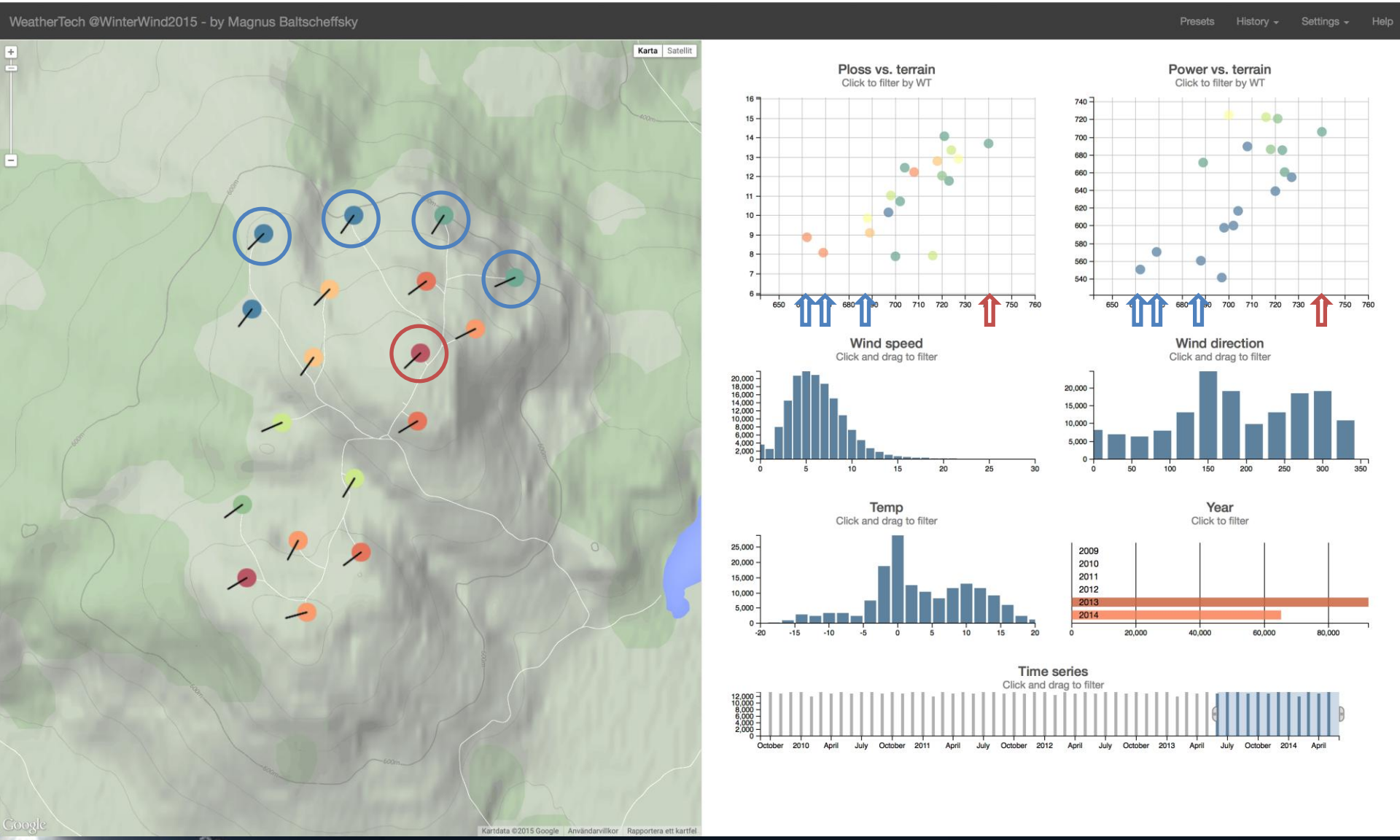
# 2013-2014



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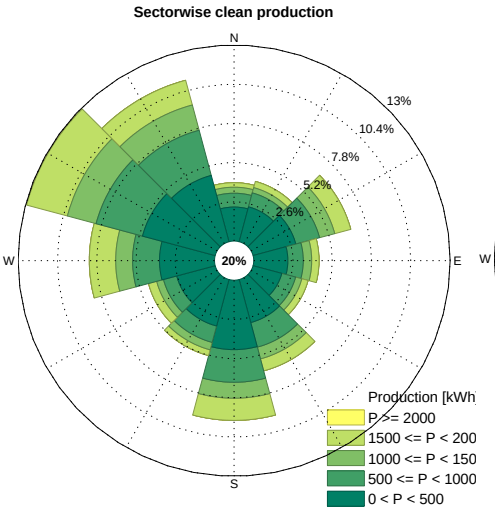
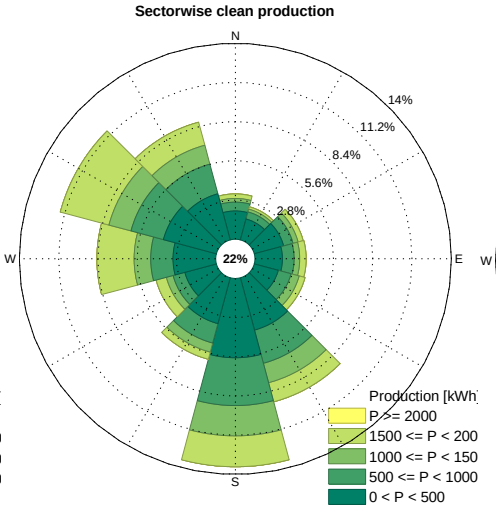
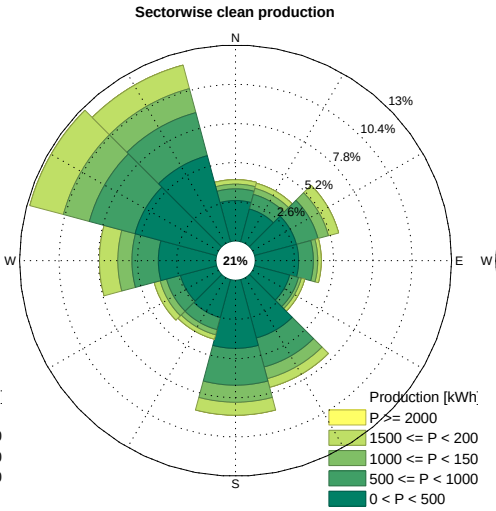
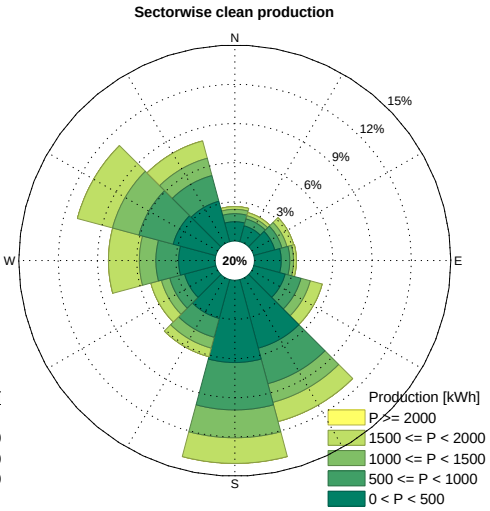
| 2010-2011 | 2011-2012 | 2012-2013 | 2013-2014 |
|---|---|---|---|
|  |  |  |  |
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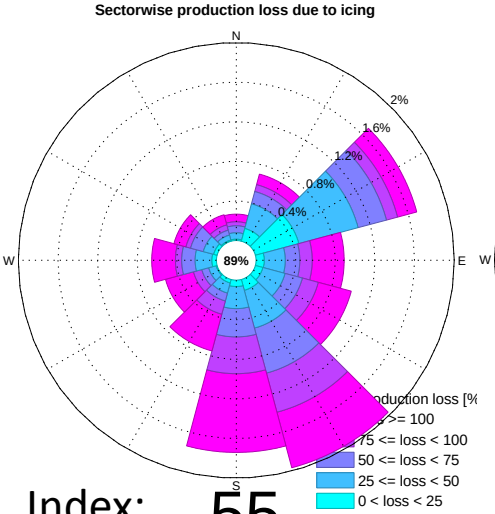
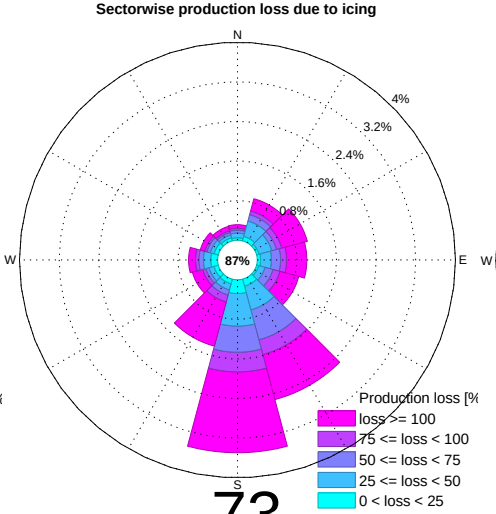
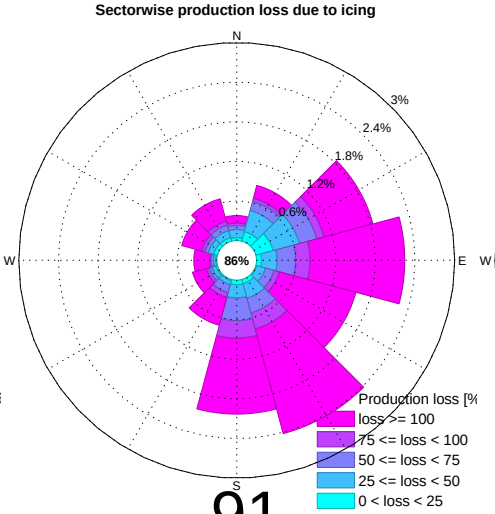
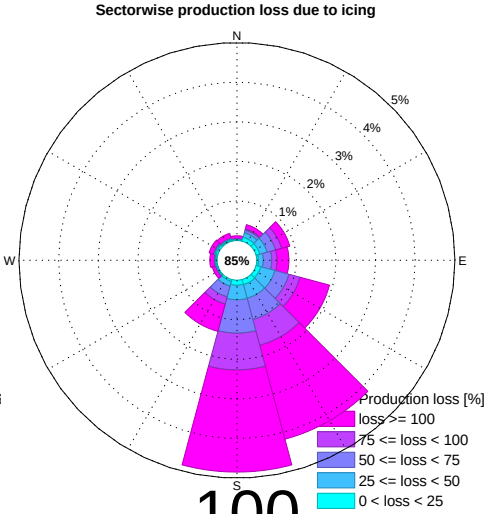
| Index: 85 | 90 | 83 | 87 |
|  |  |  |  |
|  |  |  |  |
| Index: 55 | 73 | 91 | 100 |

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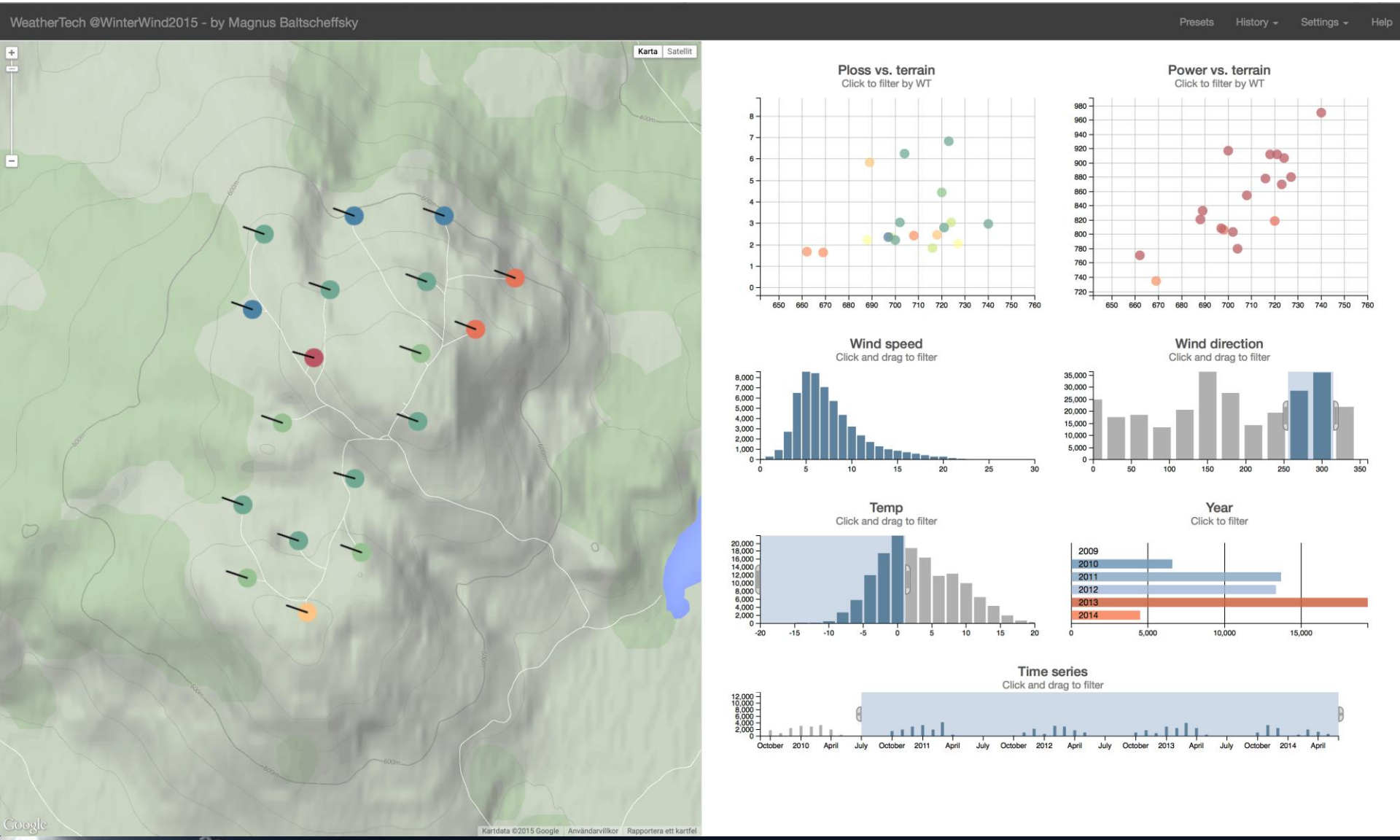
# 2010-2014 & WNW & T<0



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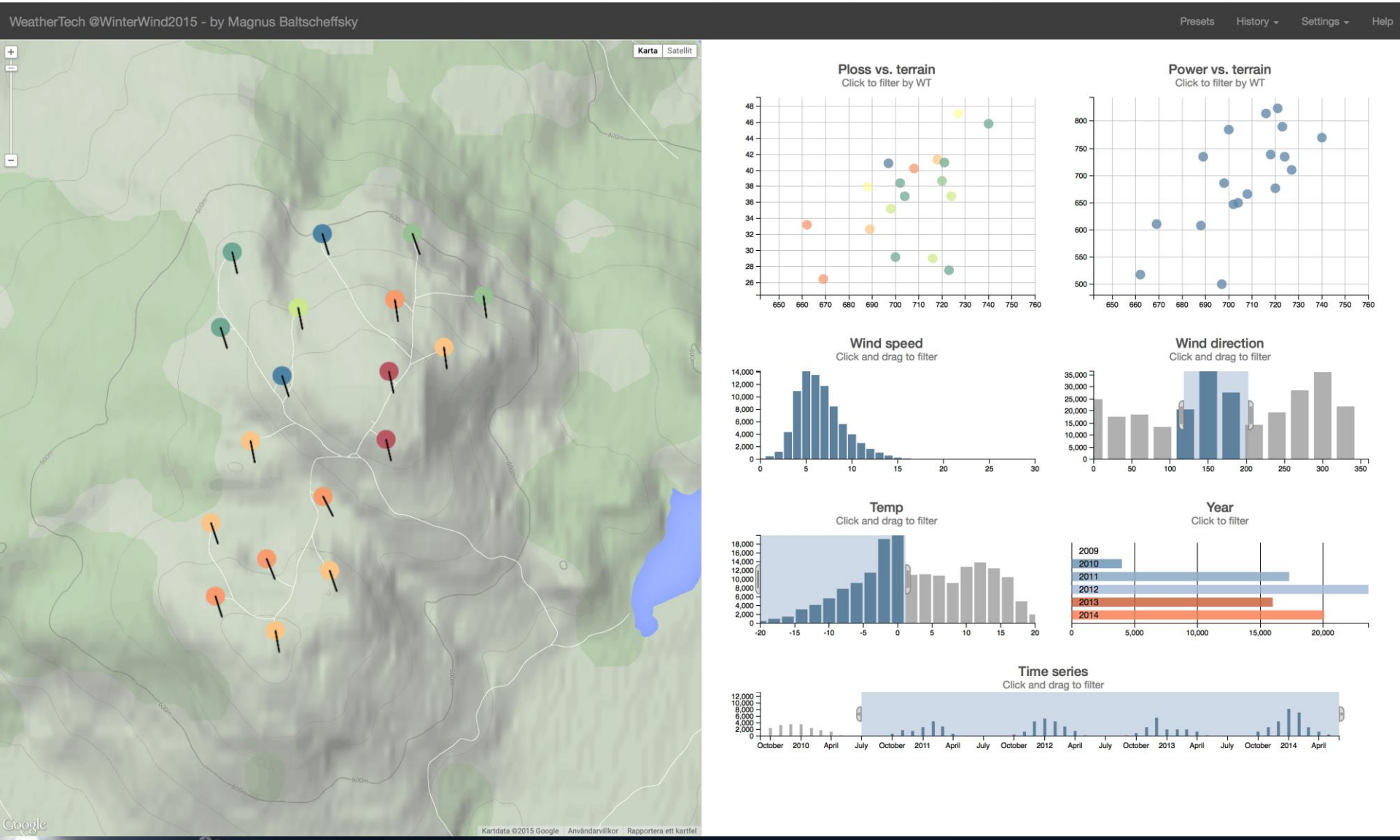
# 2010-2014 & S & T<0



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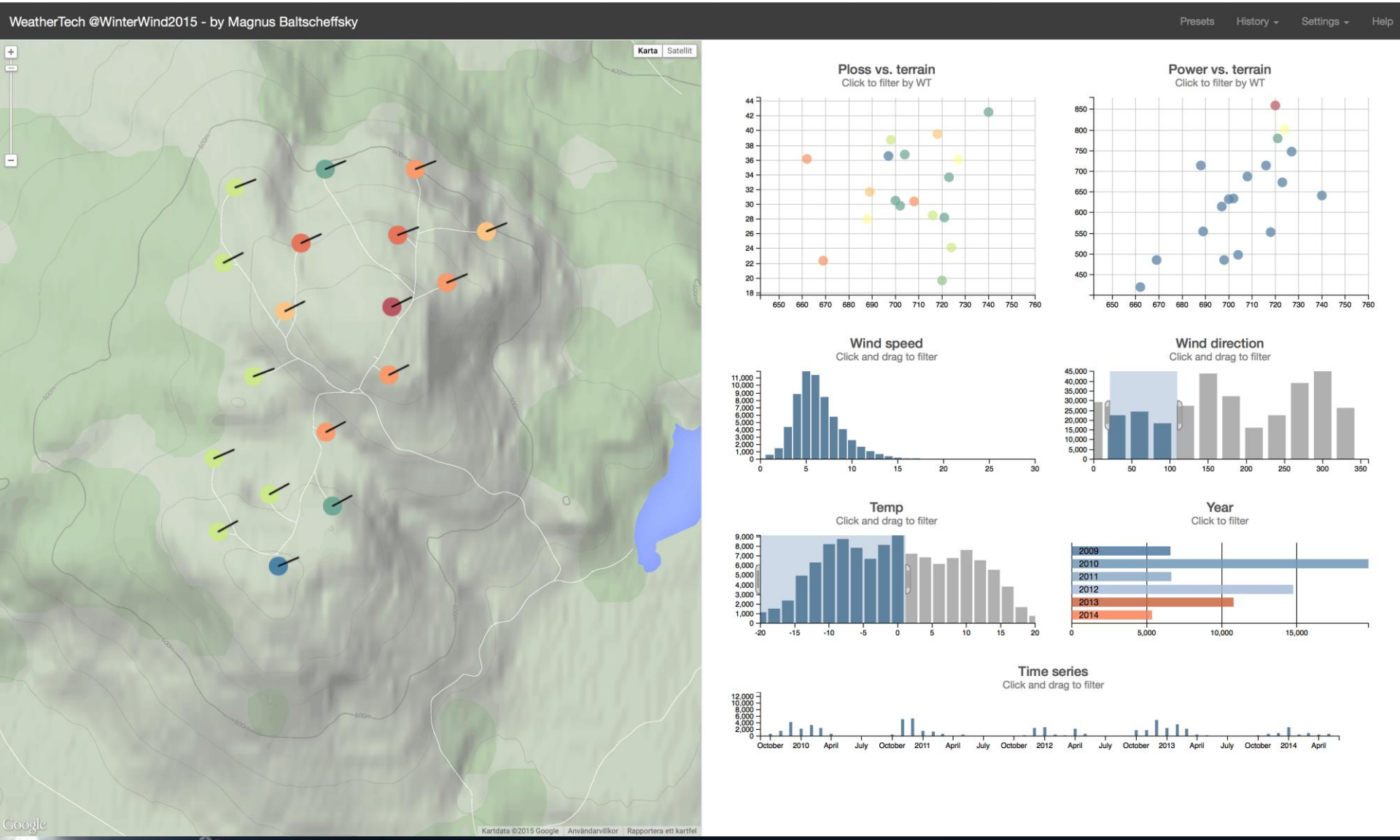
# 2010-2014 & NE & T<0



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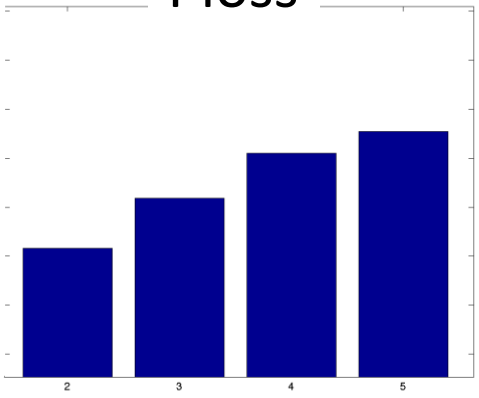
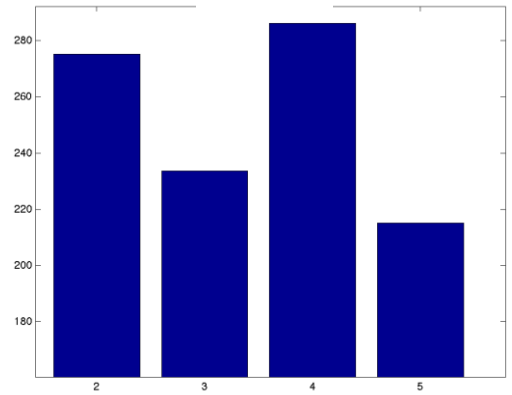
# How to correct for season variation?

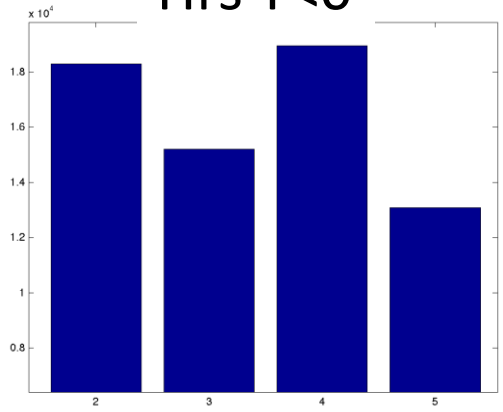
Ploss



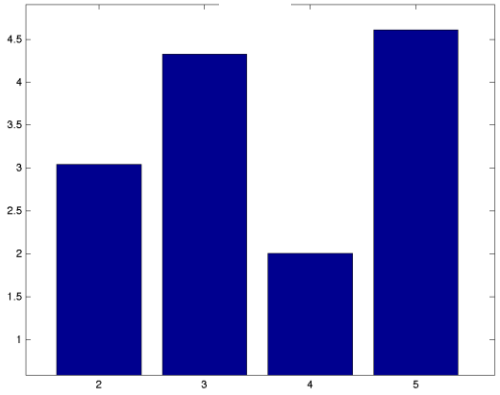

WD



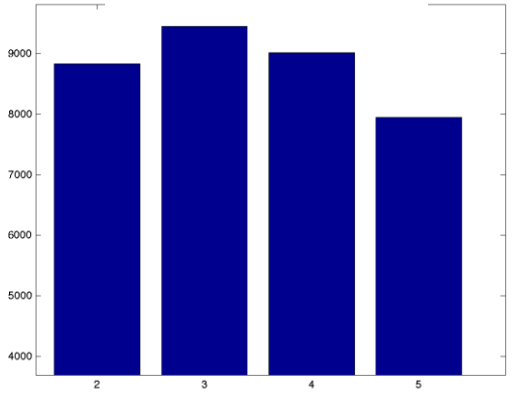

Hrs T<0



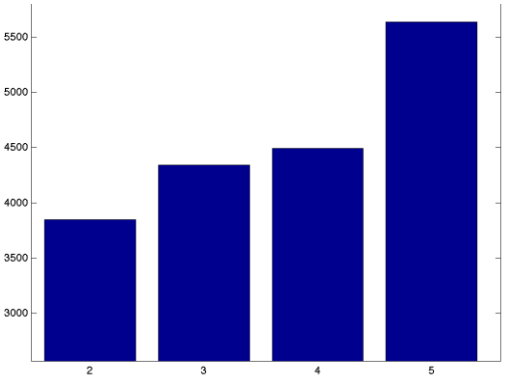

T




Hrs -5<T<0




Hrs T<0 & 90<WD<180



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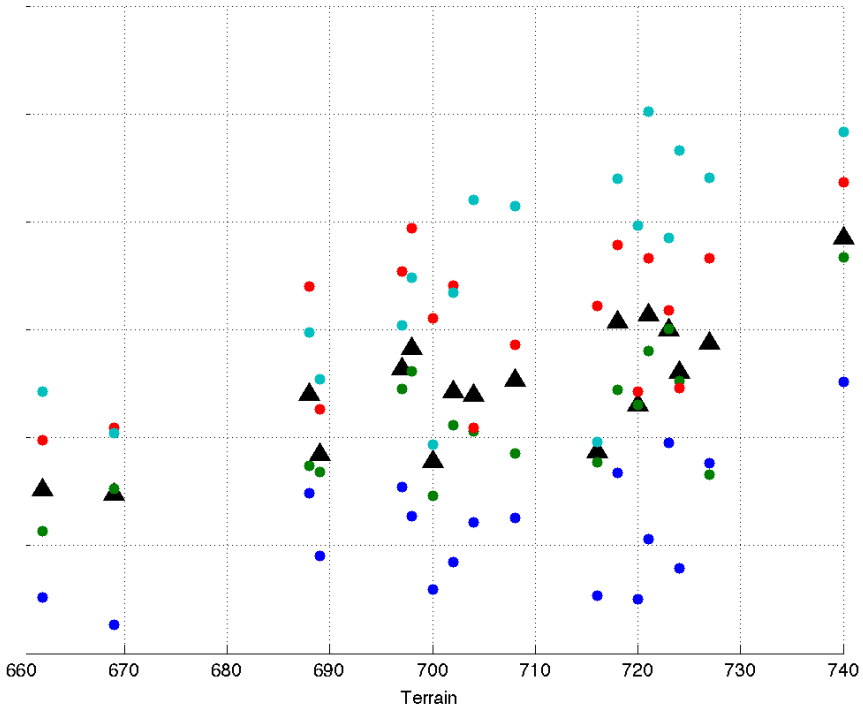
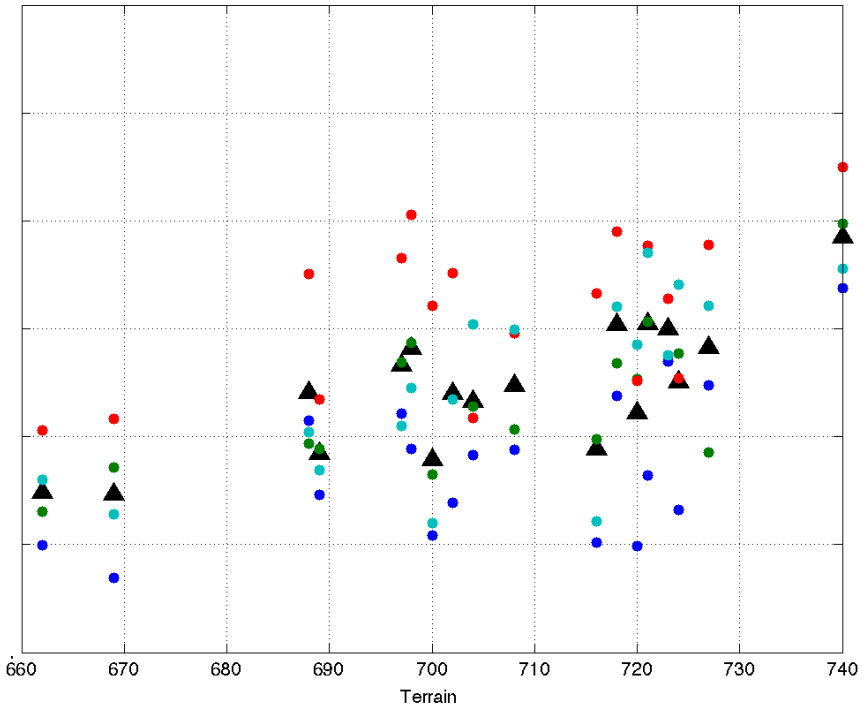
# How to correct for season variation?

Before




After



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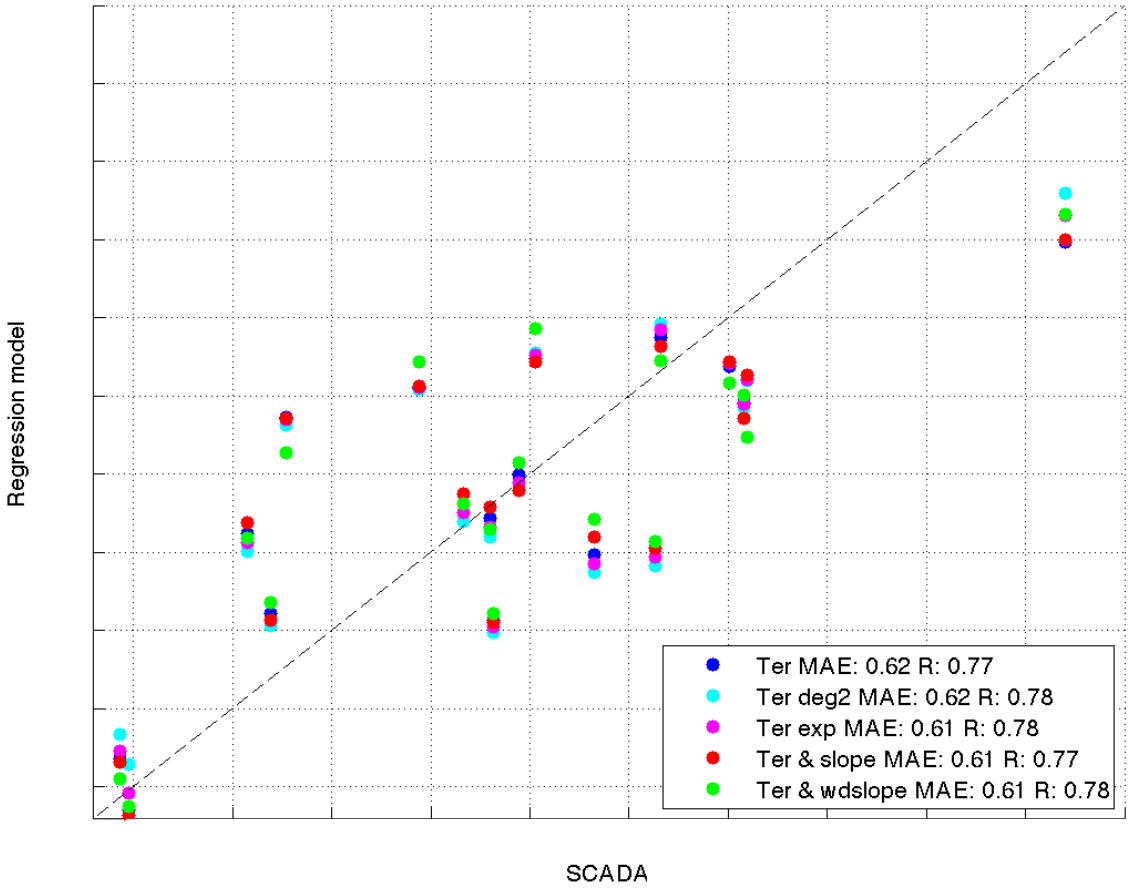
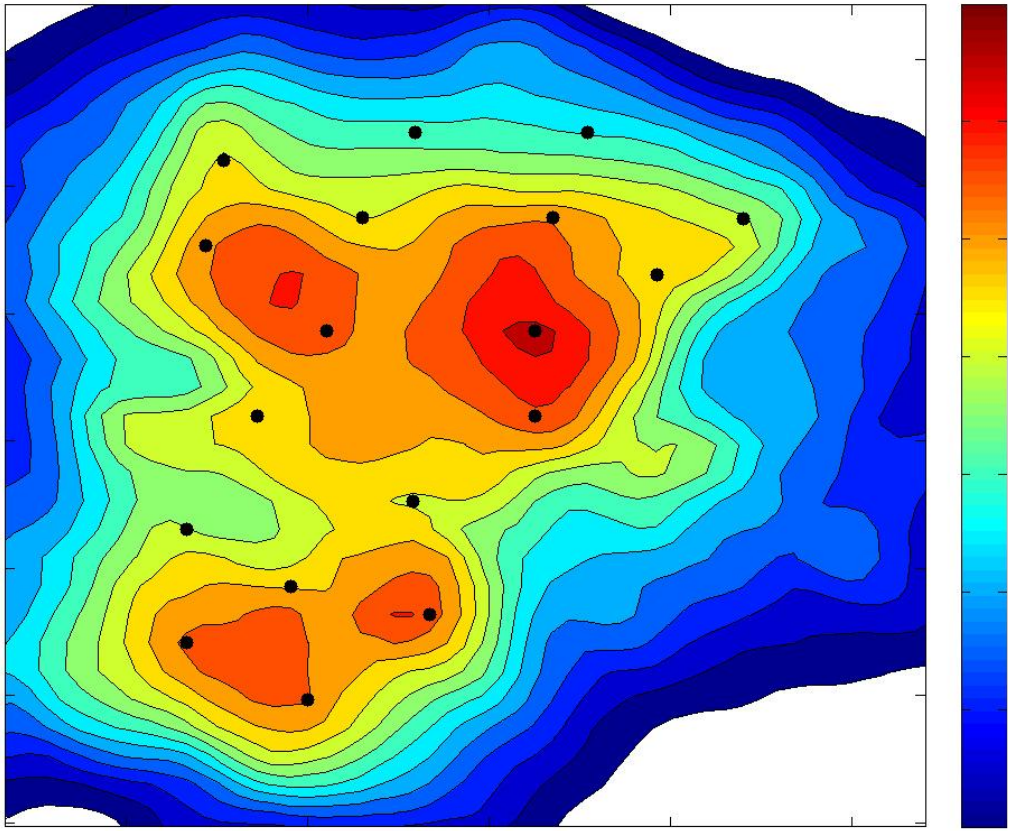
# Simple curve fitting…



# …gives a map



## Conclusions

Maybe…

# Conclusions & Summary

- Local production loss may be dependent on terrain height but
  - Dependency varies with wind regime
- Icing seasons may be characterised by wind direction or large scale weather patterns during winter
- Need to extend analysis to several wind farms to find what is only local and what is general
- Much can be learned by careful analysis of SCADA data from existing wind farms

**Thank you for your attention**

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**email: magnus@weathertech.se**