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



# WeatherTech

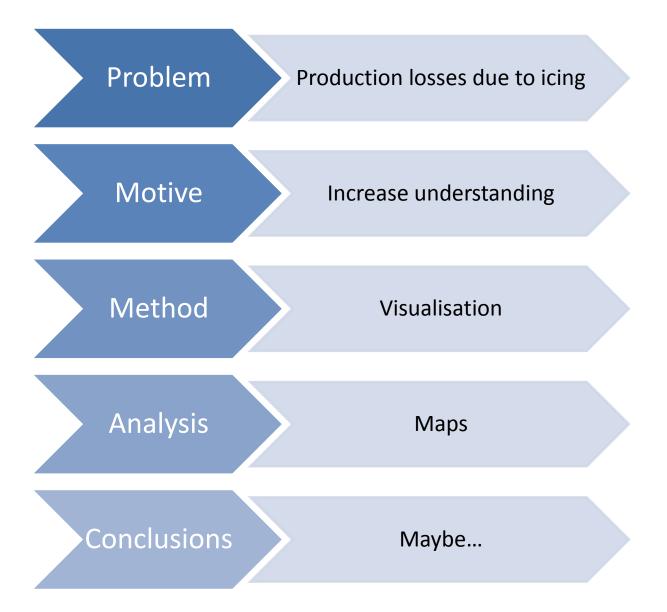
Magnus Baltscheffsky Stefan Söderberg

> WinterWind Piteå, 2015-02-03

# 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

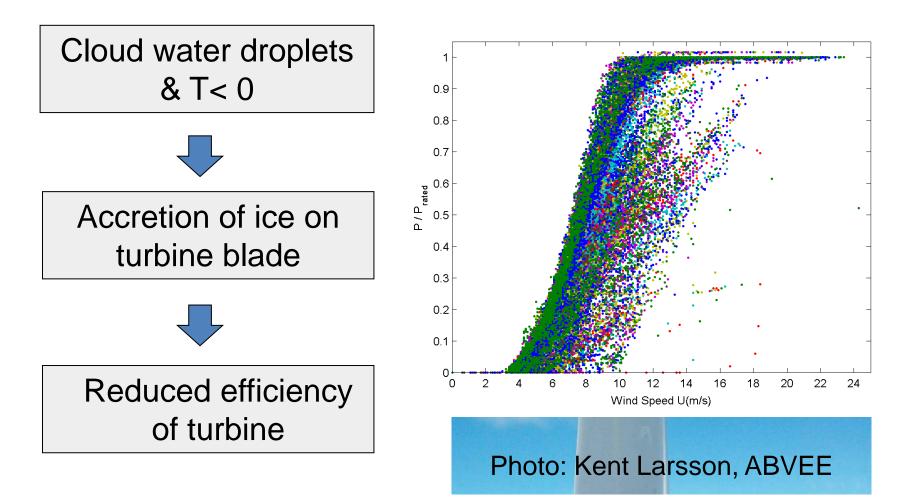






#### Production losses due to icing

# Production losses due to icing





#### 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





#### 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



Maps

2010-2014

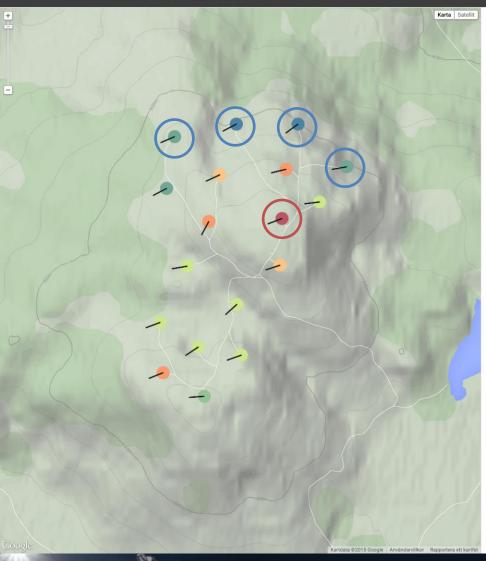
40,000 - 30,000 -

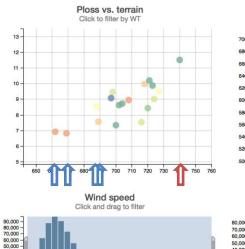
20,000 -

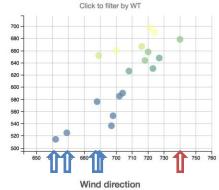
10,000 -

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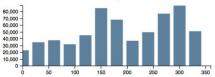


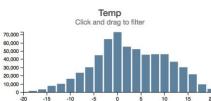




Power vs. terrain

Click and drag to filter

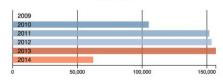


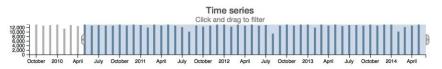


20

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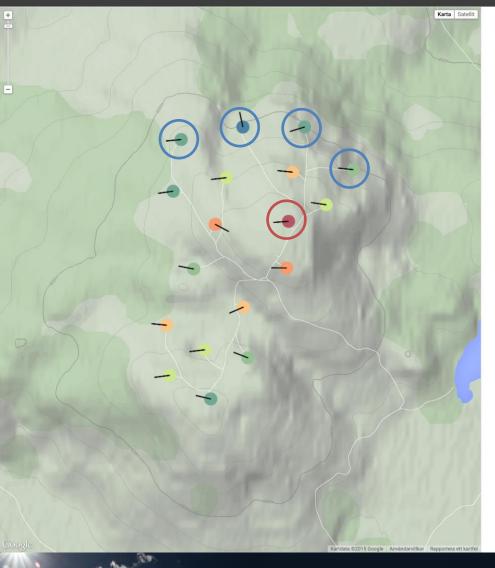
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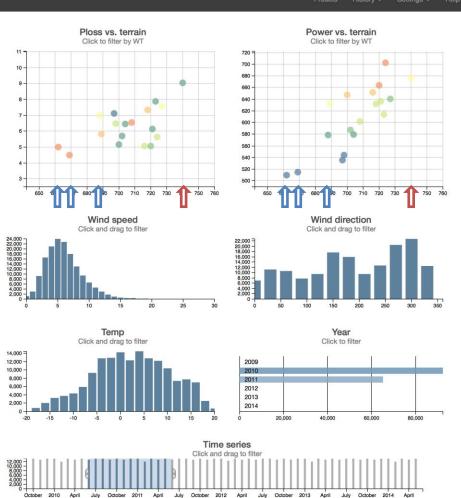




## 2010-2011



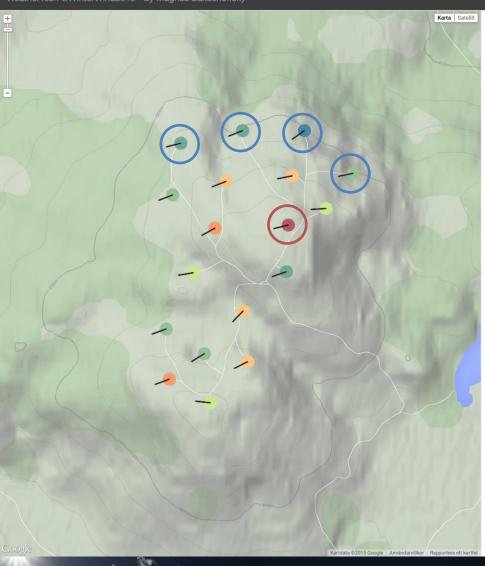


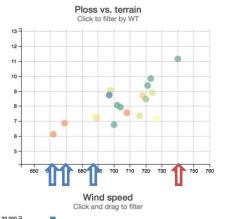


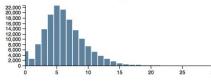
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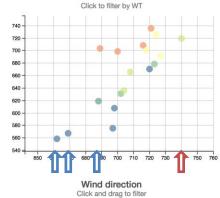
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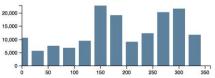


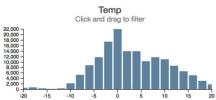




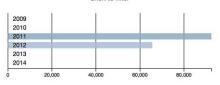


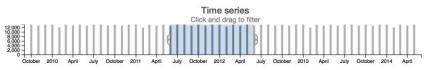
Power vs. terrain











2012-2013



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0

700 710 720 730

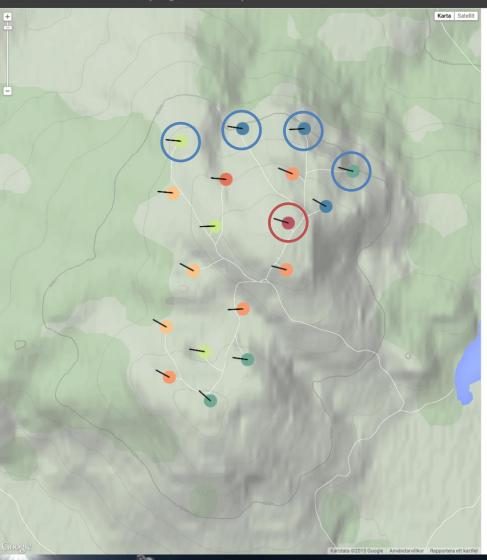
750 760

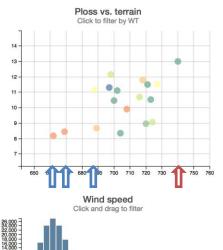
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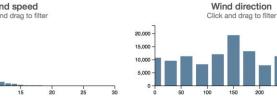
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Click to filter by WT







640 7

620 -

600 -

580 -

560 -

540 -

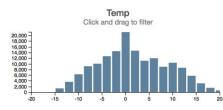
520 -

500 -480 -

460 -

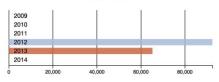
440 -420 -400 -

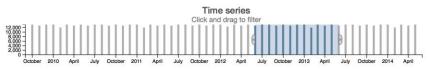
650



10

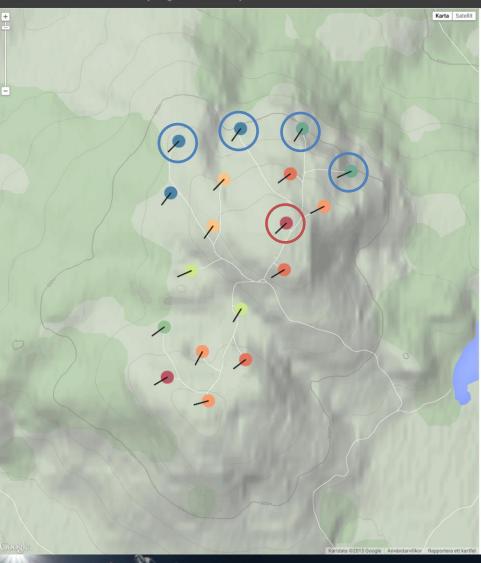
Year Click to filter

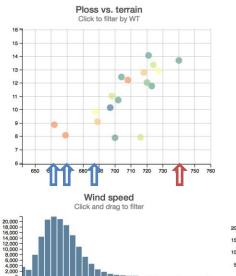


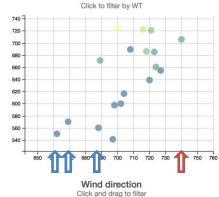


2013-2014

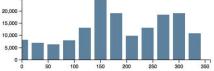
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Power vs. terrain



60,000

80,000



10

25,000 -

20,000 -

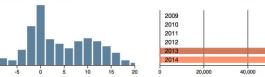
15,000 -

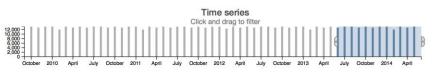
10,000 -

5,000 -

0--20 -15 -10

Year Click to filter





#### WeatherTech 2010-2011 2011-2012 2012-2013 2013-2014 Sectorwise clean production Sectorwise clean production Sectorwise clean production Sectorwise clean production Ν 1.3% 13% 15% .10.4% 11.2% 10.4% .12% 8 4% 7.8% .7.8% 9% 5.6% 60/ 20% 22% 21% 20% Production [kWh Production [kWh] Production [kWh Production [kWh] P/>= 2000 P/>= 2000 P/>= 2000 P/>= 2000 1500 <= P < 200 1500 <= P < 200 1500 <= P < 200 1500 <= P < 2000 1000 <= P < 150 1000 <= P < 150 1000 <= P < 150 1000 <= P < 1500 500 <= P < 1000 0 < P < 500 0 < P < 5000 < P < 5000 < P < 500Index: 85 87 83 Sectorwise production loss due to icing N .3.2% .2.4% .4% 2 4% 1.8% 3% 1.6% 2% 89% 87% 86% 85% dugtion loss [% Production loss [% Production loss [% Production loss [%] S = 100loss >= 100 loss >= 100 loss >= 100 75 <= loss < 100

50 <= loss < 75

25 <= loss < 50

0 < loss < 25

50 <= loss < 75

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0 < loss < 25

9

50 <= loss < 75

25 <= loss < 50

0 < loss < 25

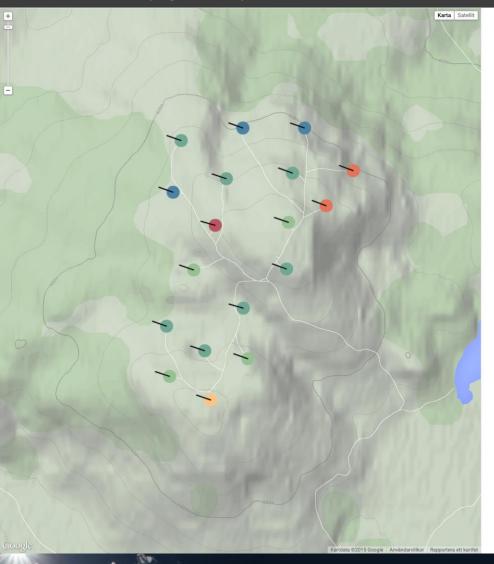
Index: 55

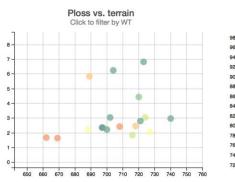
<u>0 < loss < 25</u> <u>73</u>

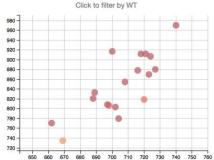
# WeatherTech 2010-2014 & WNW & T<0

#### VeatherTech @WinterWind2015 - by Magnus Baltscheffsk

Presets History - Settings - Hel

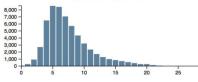




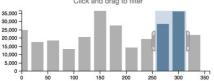


Power vs. terrain

Wind speed Click and drag to filter



Wind direction Click and drag to filter

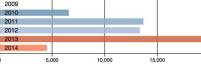




20,000 18,000 16,000 14,000 12,000 8,000 6,000 4,000 2,000 0 -

-20 -15





Year

Click to filter

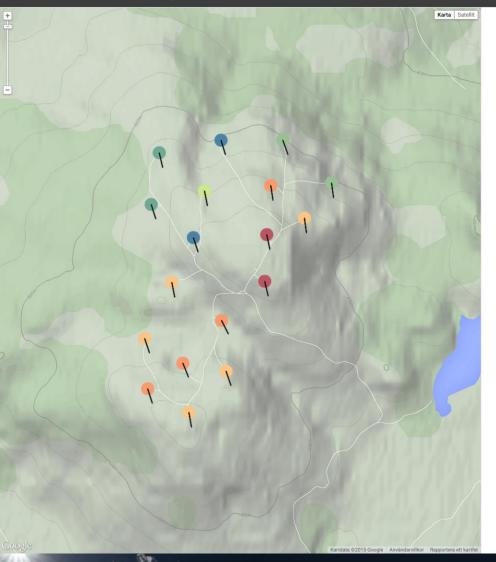
Time series Click and drag to filter

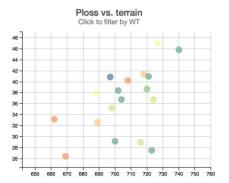


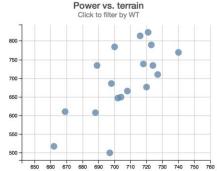
# WeatherTech 2010-2014 & S & T<0

#### WeatherTech @WinterWind2015 - by Magnus Baltscheffsky

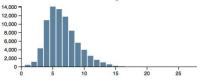
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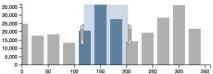




Wind speed Click and drag to filter









18,000

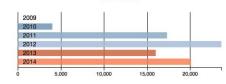
16,000 14,000 12,000 10,000 8,000

6.000

4,000

-15





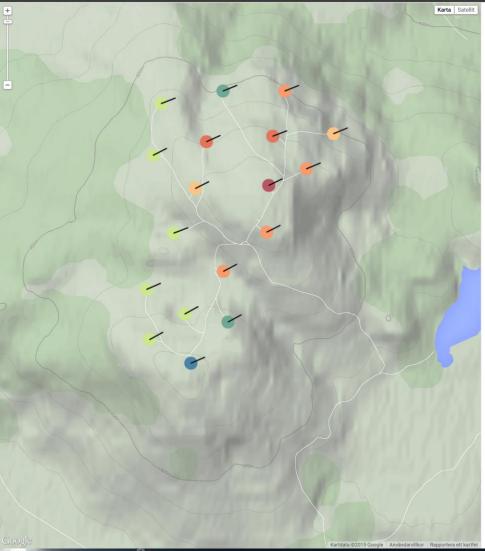


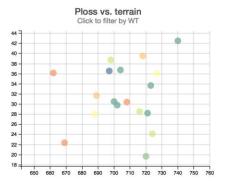


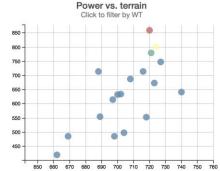
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# WeatherTech 2010-2014 & NE & T<0

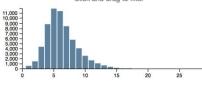
#### WeatherTech @WinterWind2015 - by Magnus Baltscheffsky





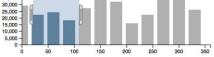


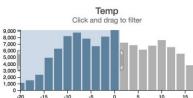
Wind speed Click and drag to filter



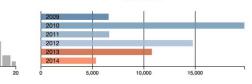


Wind direction





Year Click to filter



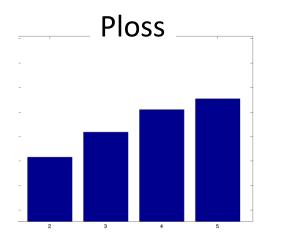
Time series Click and drag to filter

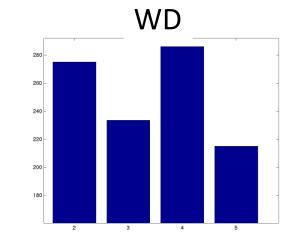
45,000 -

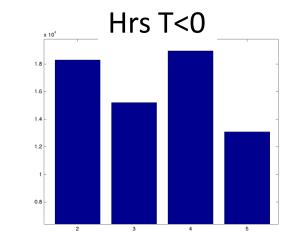
40,000 -35.000 -

 $\substack{\substack{12,000\\10,000\\8,000\\6,000\\4,000\\2,000}$ October 2010 April July October 2011 April July October 2012 April July October 2013 April July October 2014

# How to correct for season variation?

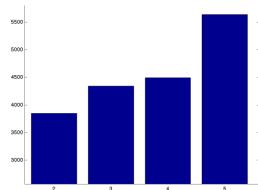


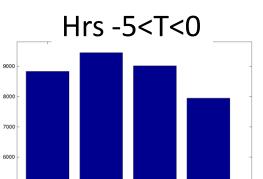




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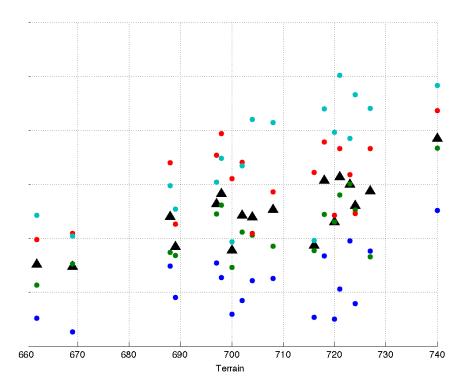


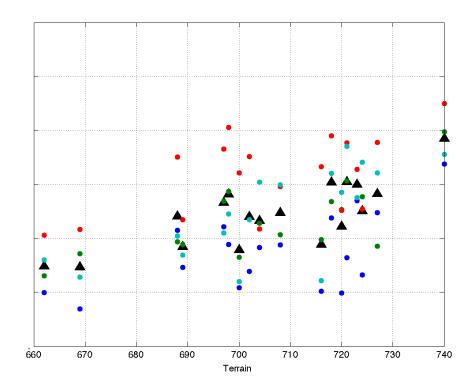
5000

4000

## WeatherTech How to correct for season variation?

Before

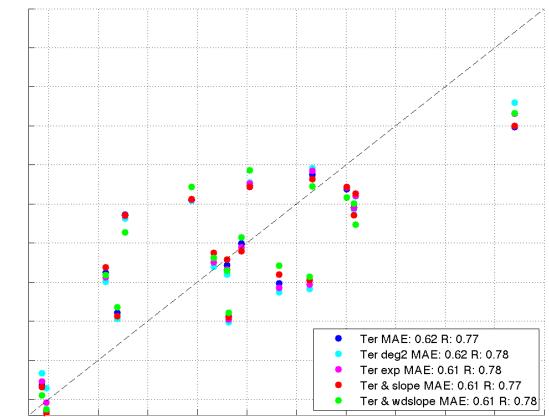




After



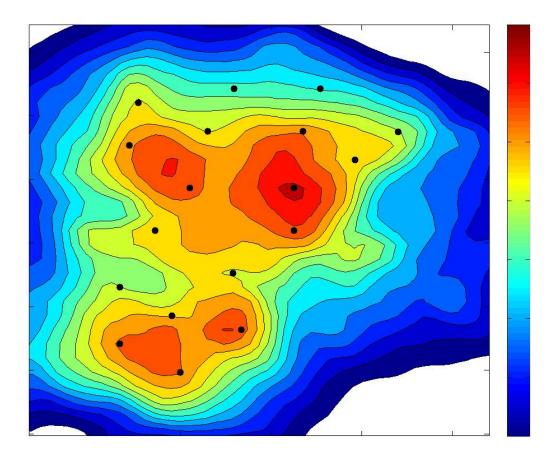
## WeatherTech Simple curve fitting...



Regression model

SCADA

# ... gives a map







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

Magnus Baltscheffsky mobile: +46 (0)70 863 19 63 email: magnus@weathertech.se