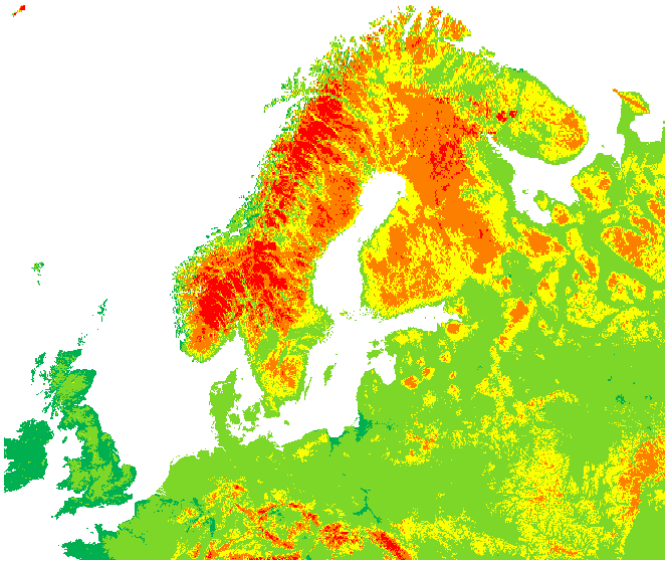
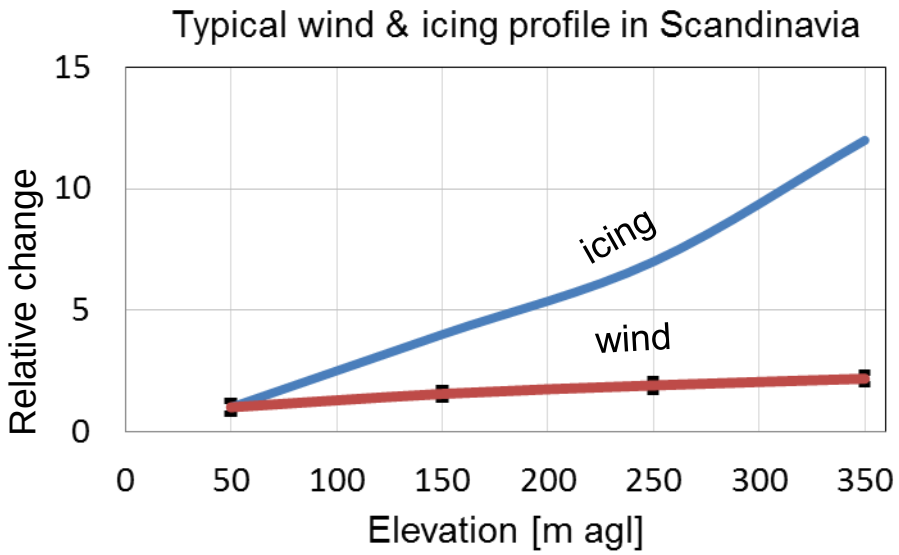


Global Wind and icing optimization atlas: case Finland

Winterwind 2016, Åre, Sweden
Simo Rissanen, Ville Lehtomäki
VTT Technical Research Centre of Finland Ltd

Motivation

At higher elevation both AEP and icing will be increased.
Where is optimal location for wind power?



Available atlases:

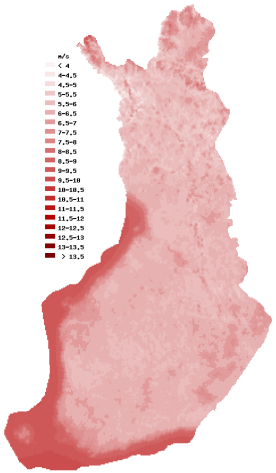
- WIceAtlas (Wind power Icing Atlas) by VTT ⇨ pwr loss
- Global Wind Atlas (GWA) by DTU ⇨ AEP
- Finnish Wind atlas (FWA) by FMI* ⇨ AEP
- Finnish Icing atlas (FIA) by FMI* ⇨ pwr loss

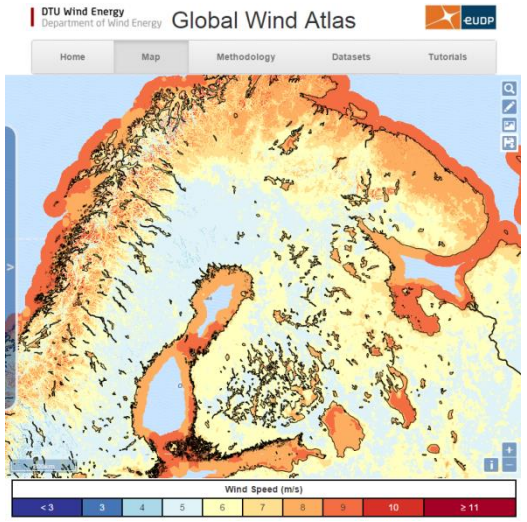
*Finnish Meteorological Institute

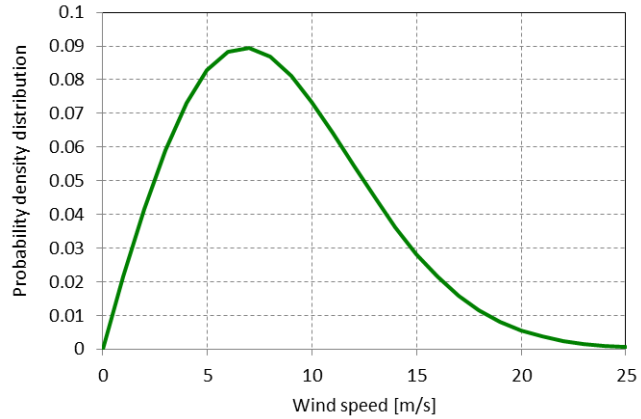
Methods (1/2)

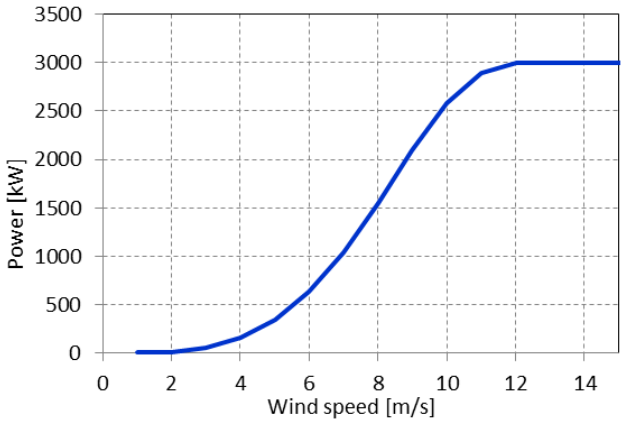
AEP calculated using:

- Weibull wind speed distribution with k = 2.0
- typical class IIA 3 MW turbine power curve
- GWA (Global Wind atlas) Wind speed at 100 m height and FI wind atlas for comparison



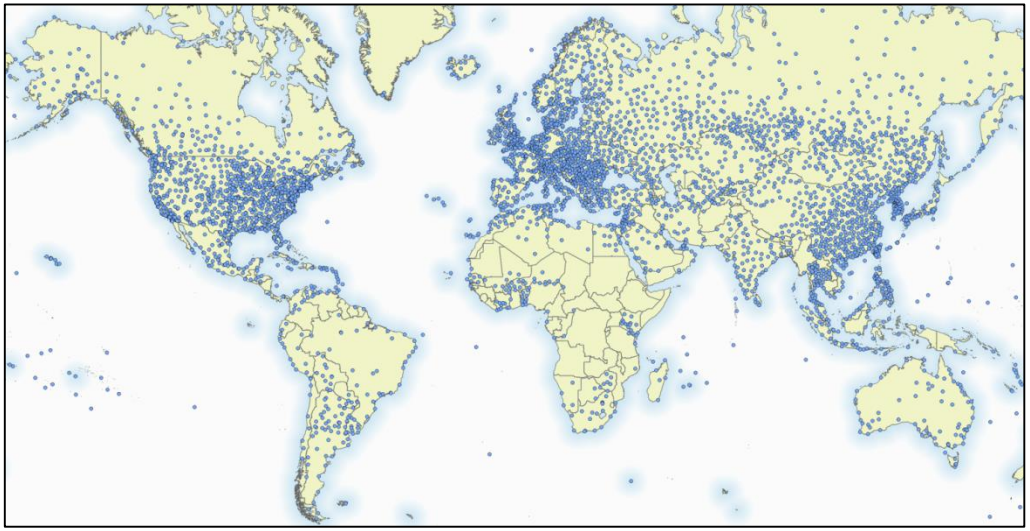






Methods (2/2)

- AEP loss from WIceAtlas using:
  - Met icing calibration factor from 2 sites (FI & CAN)
  - interpolated weather data from 3-10 meteorological stations
  - data at 100 m agl
  - IEA class from calibrated met icing and AEP loss from IEA table
- Weather data from ~4500 stations globally >20 yr/station



IEA ice class	Duration of Meteorological icing [% of year]	Duration of Instrumental icing [% of year]	Production loss [% of AEP]
5	>10	>20	>20
4	5-10	10-30	10-25
3	3-5	6-15	3-12
2	0.5-3	1-9	0.5-5
1	0-0.5	<1.5	0-0.5

Source: IEA Wind Recommended Practices for wind energy projects in cold climates edition 2011

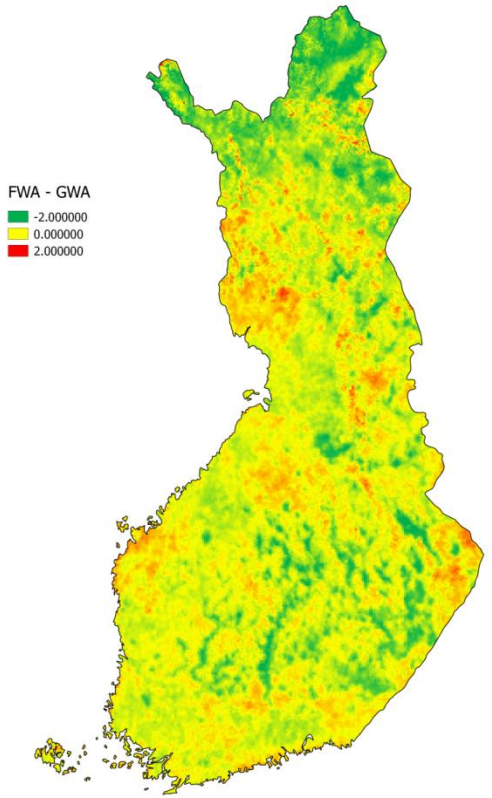
Wind and icing atlas comparison, case FI

Wind:
Huge (±2m/s) difference between FWA and GWA!

Icing:
Wiceatlas underestimates icing at Northern Finland and overestimates at central finland compared to FIA

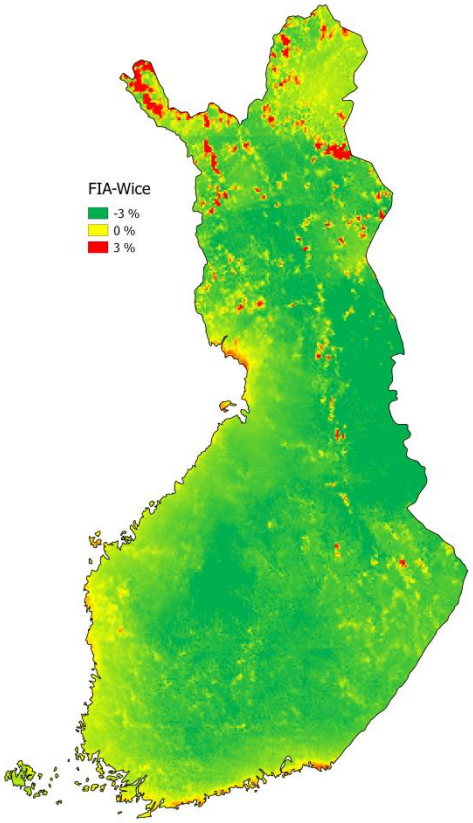
GWA = Global Wind Atlas
FWA = Finnish Wind Atlas
FIA = Finnish Icing Atlas

Wind difference (GWA-FWA)



Green = GWA wind speed is larger
Red = FWA wind speed is larger

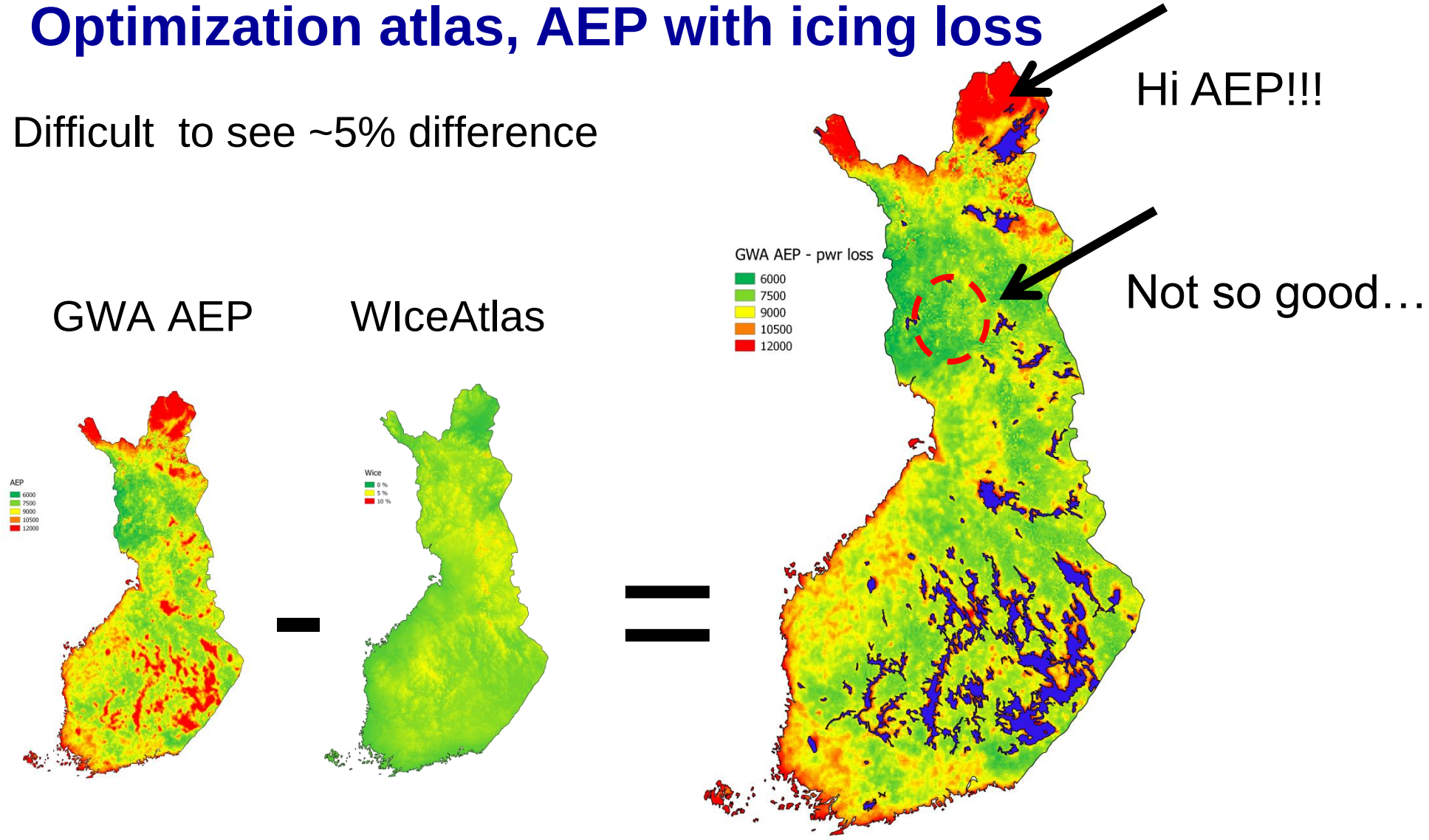
Icing difference(FIA-WIceAtlas)



Green = WiceAtlas icing is larger
Red = FIA icing is larger

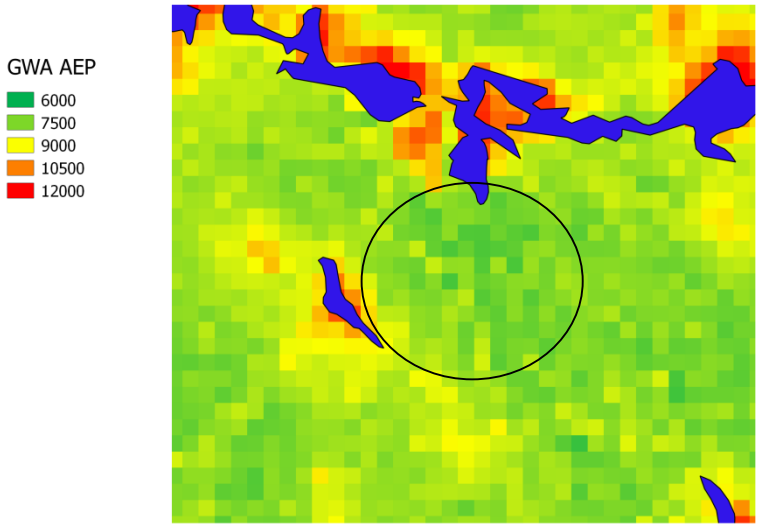
Optimization atlas, AEP with icing loss

- Difficult to see ~5% difference



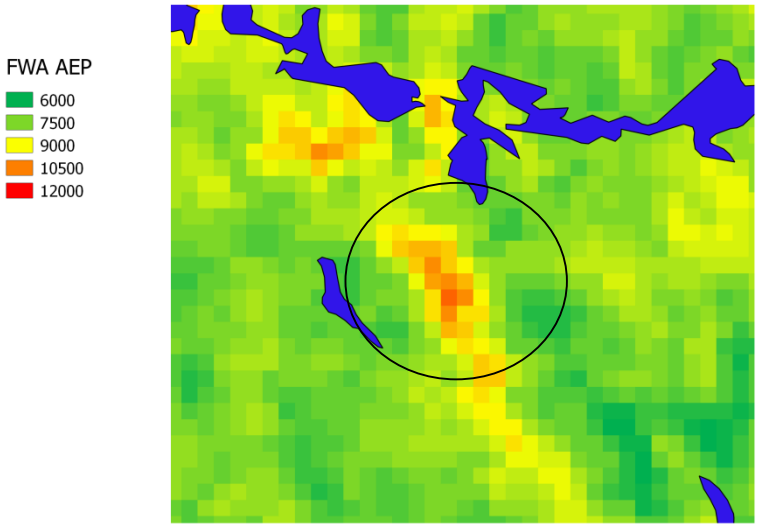
Example Naulavaara 330 m asl (1/2)

Global Wind Atlas



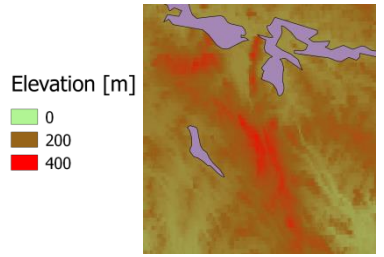
Do not build here

Finnish Wind Atlas



Best place in the area!

Finnish Wind Atlas selected for optimization!



Example Naulavaara 330 m asl (2/2)

FWA AEP

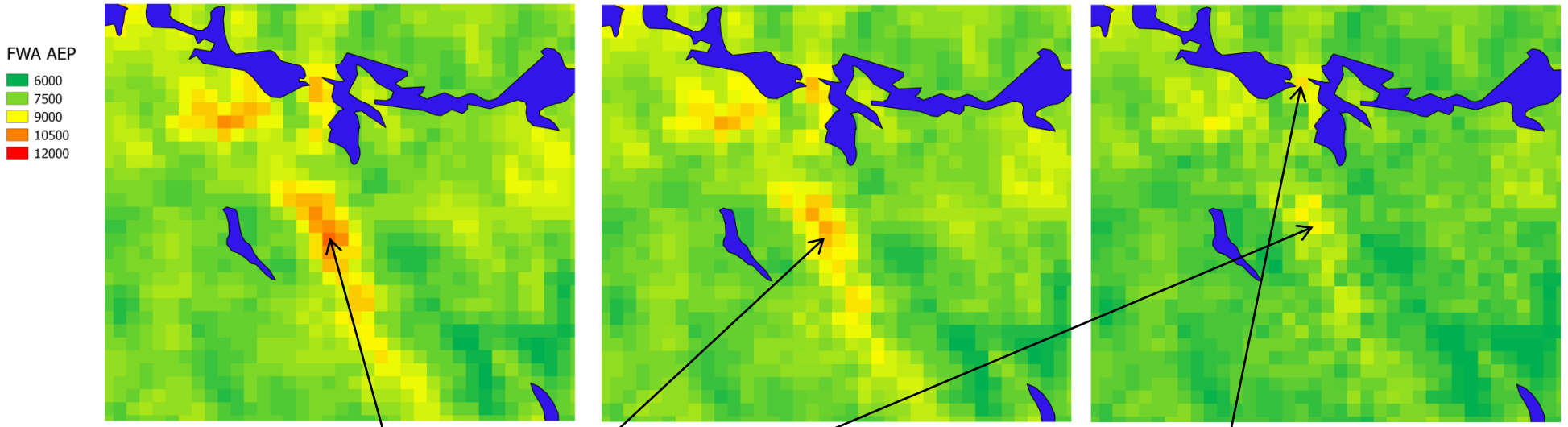
FWA AEP - WIceAtlas & IEA loss

Min (IEA class lower limit)

turbines with robust control during icing conditions

Max (IEA class upper limit)

turbines with sensitive control during icing conditions



- FWA AEP: 10.8 GWh
- Reduced AEP: 10.0 – 8.1 GWh (top of the hill)

Robust control: still the best place to build in this area!

Sensitive control: not the best place, between the lakes 9.4 GWh

Conclusions

1. Need more reliable global wind speed map in forested areas
2. Turbine ice operation strategy critical for AEP analyses
3. **ALWAYS USE MORE THAN ONE ICING & WIND MAP FOR AEP ASSESSMENT!!**

Next steps:

- launch open access global WiceAtlas GIS at VTT website in Q2/2016
- Verify GWA further in forested areas to define wind speed uncertainties