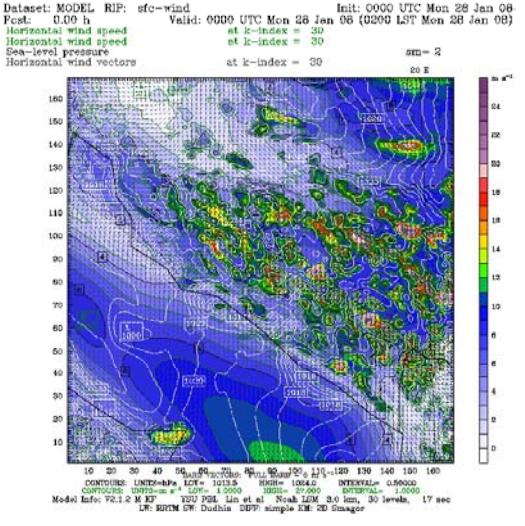
Wind Forecasts in Complex Terrain
Experiences with SODAR and LIDAR

René Cattin, Saskia Bourgeois, Silke Dierer, Markus Müller, Sara Koller
Meteotest, Switzerland



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Private company founded in 1981
28 employees
Any kind of meteorological service
- → weather forecast
- → wind and solar energy
- → climatology
- → air pollution
- → geoinformatics/webapplications

Wind energy (in complex terrain):
- → wind measurements with masts/SODAR/LIDAR
- → wind modelling with WindSim CFD
- → icing consultancy
- → energy yield assessments

FP6 project SEEWIND main objective:

To gain experience in wind measurement, site development and operation of large scale wind turbines at sites in complex terrain and especially under the specific geographic and climatic conditions in the West Balkan area with the aim of increasing efficiency and reliability of wind turbine technology.

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WP 4: Vertical wind profile in complex terrain

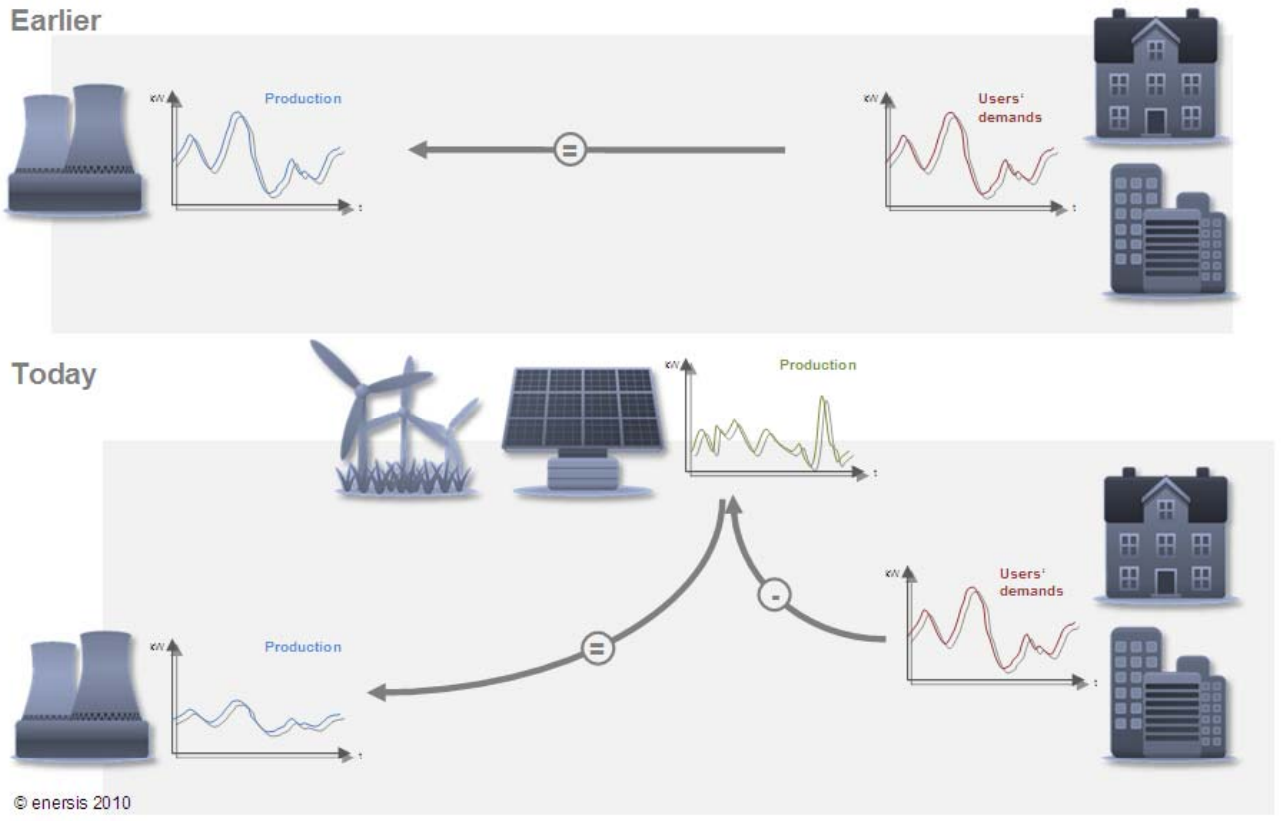
→ LIDAR and SODAR measurements

→ under harsh climatic conditions

WP 5: Local Wind Systems

→ Wind Forecasts in complex terrain

Why wind forecasts?



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Why wind forecasts?

Wind has a high spatial and temporal variability

→ especially in complex terrain
→ production even more decentralized

Wind Forecasts are needed:

→ Electrical grid management
→ Allocate balance energy
→ Sell electricity on the spot market
→ Prepare for extreme events
→ Plan maintenance activities

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SEEWIND: run wind forecasts for the pilot sites

→ Numerical weather prediction model WRF

National Center for Atmospheric Research (NCAR)
Freely available → highly flexible

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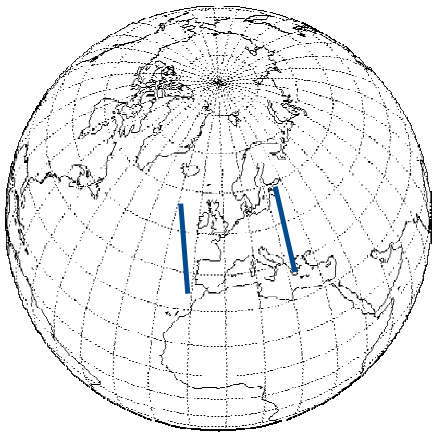

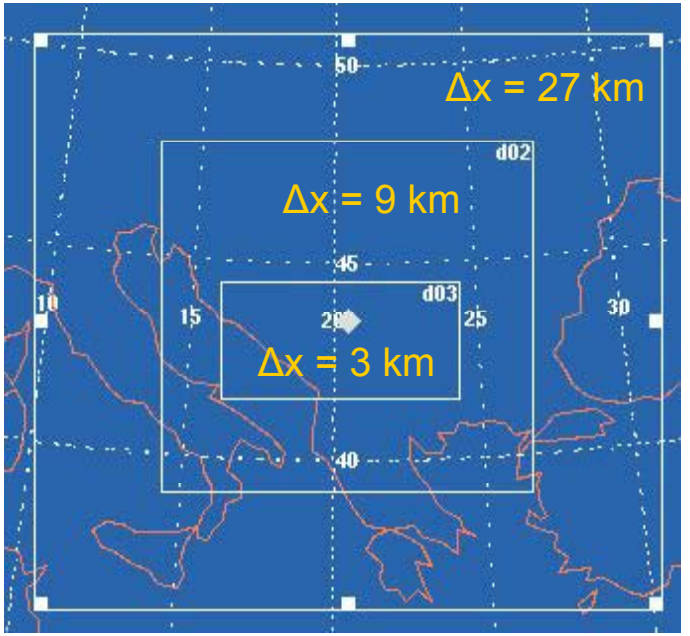

Global Forecast System GFS
Δx = 50 km

Local model WRF

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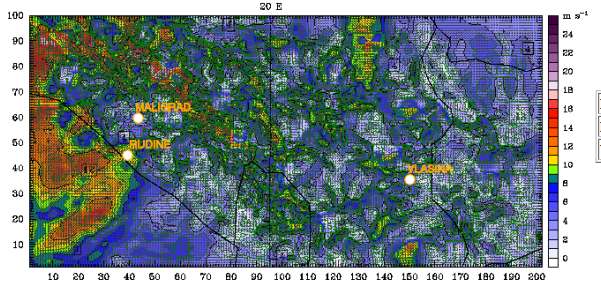
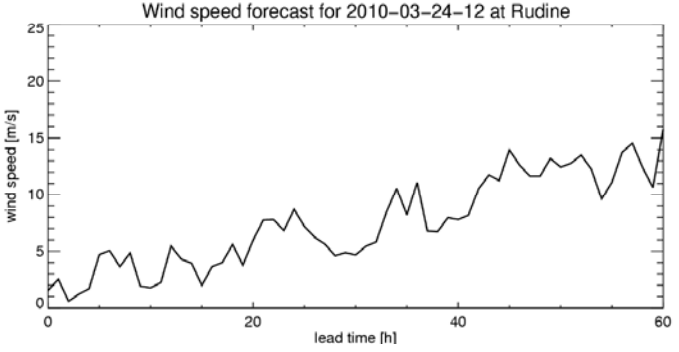
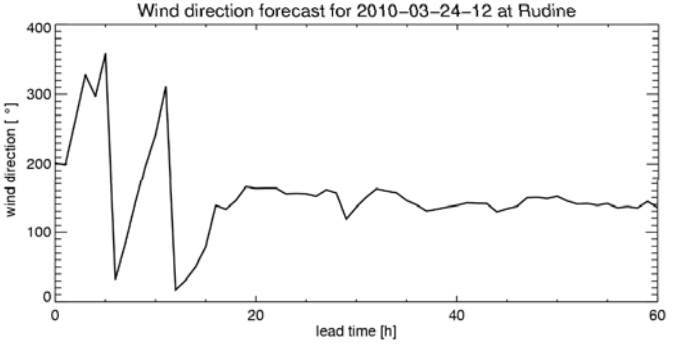
Time series of ff and dd at 80 m height at pilot wind parks



Maligrad:	ff	dd
Rudine:	ff	dd
Vlasina:	ff	dd





Horizontal cross-section of the temporal development of ff at 80 m height

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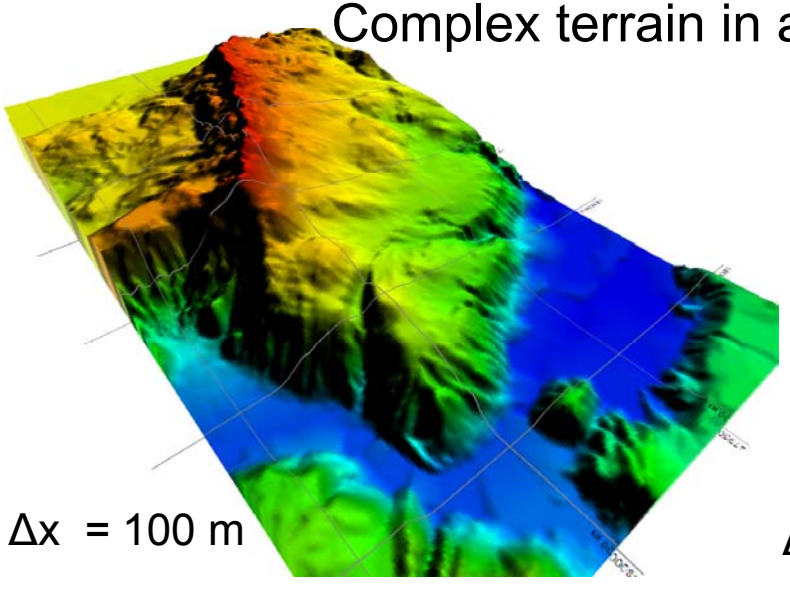
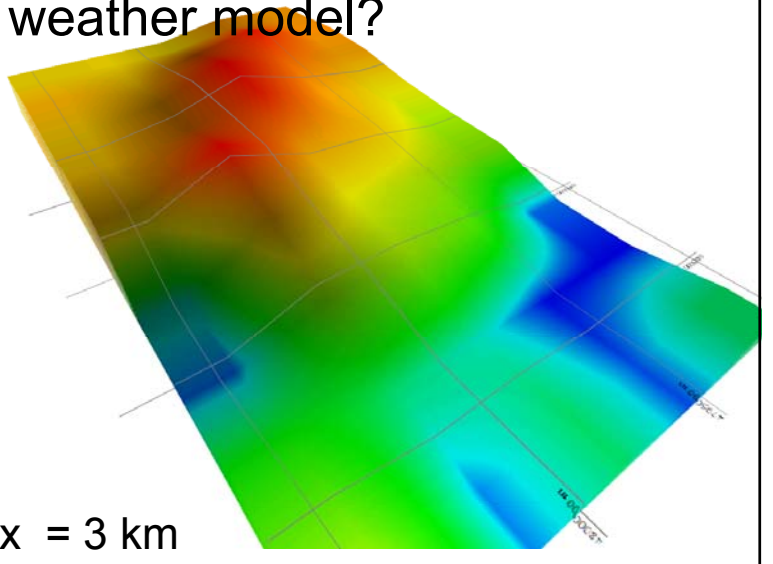
Complex terrain in a weather model?



Δx = 100 m



Δx = 3 km

Direct Model Output (DMO) of
numerical weather models does not fully represent the reality

→ post-processing can improve the results

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Basic principle:

evaluate a statistical relationship between the model output and the reality

MOS: model output statistics (based on historical data)

Kalman filter (online data needed)

Neural networks

…

→ No online production data / limited budget

→ MOS will be applied within SEEWIND project

→ reanalysis of 1 year ongoing

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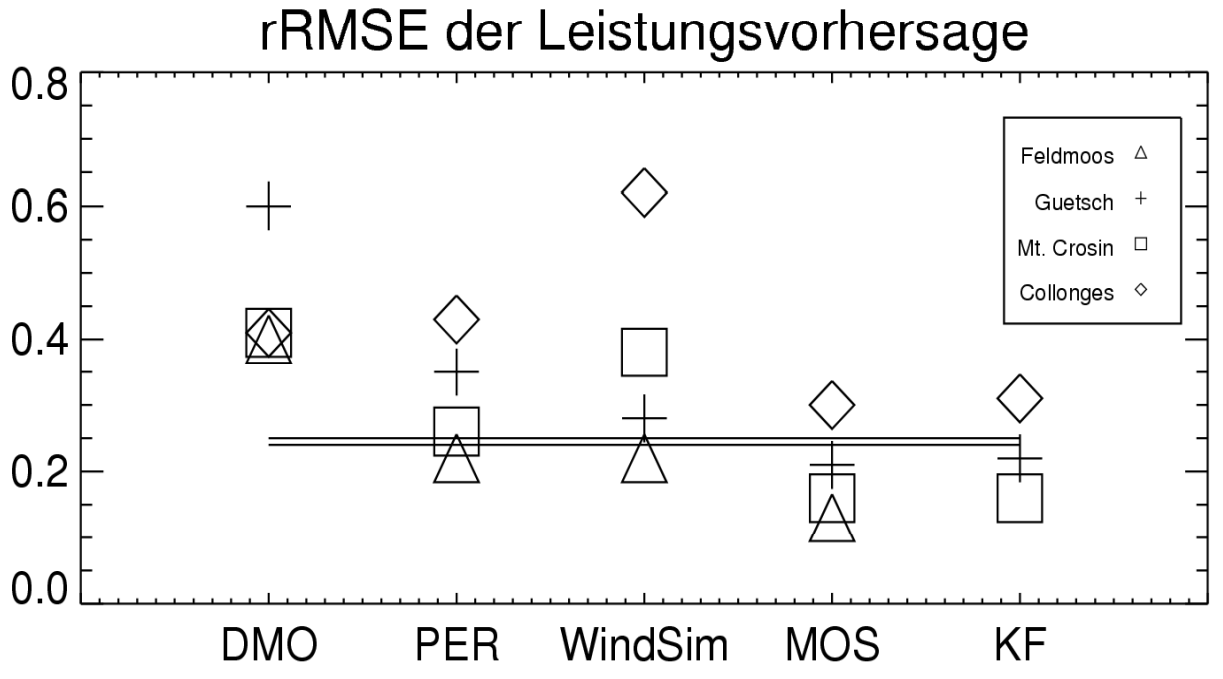
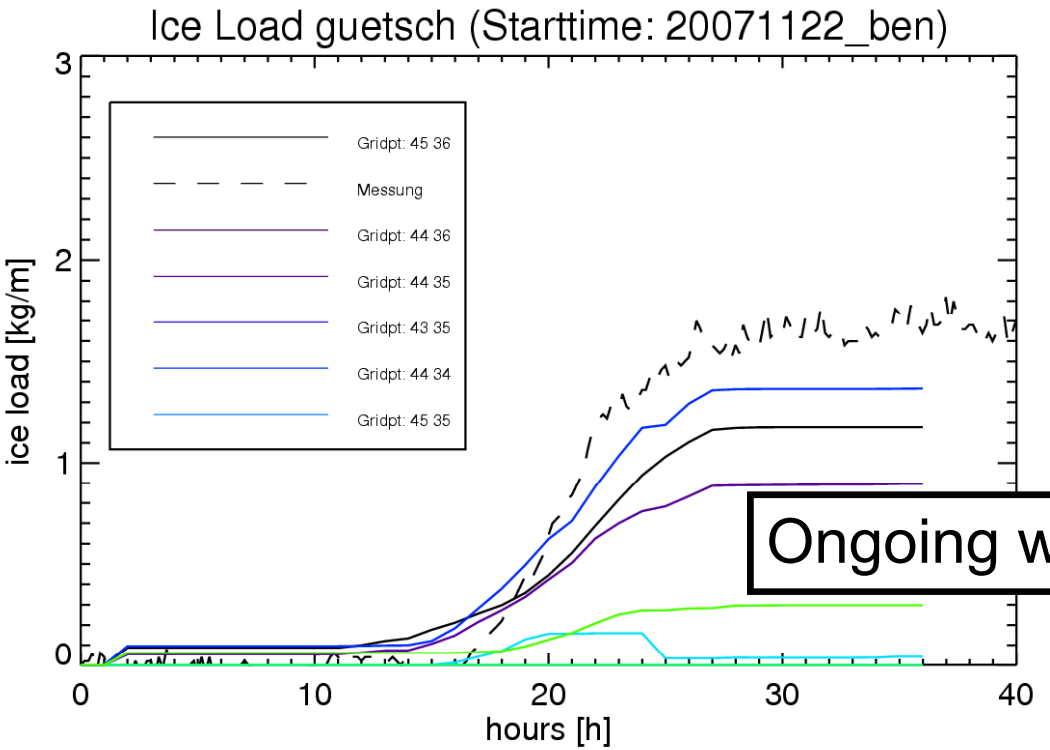


→WRF also allows prediction of icing events



Ongoing work…

In summary:

wind forecasts in complex terrain

→ will become more important in the near future
→ will raise new challenges
→ will require specific post-processing methods

→new COST Action about to be approved (wind and solar)

LIDAR and SODAR measurements

SEEWIND: All pilot sites are located in complex terrain
→ vertical wind profile is very important
→ high masts difficult to erect (costs, space, extreme events, ice)

→ remote sensing offers alternatives
→ in combintation with shorter masts
→ to be investigated within SEEWIND project

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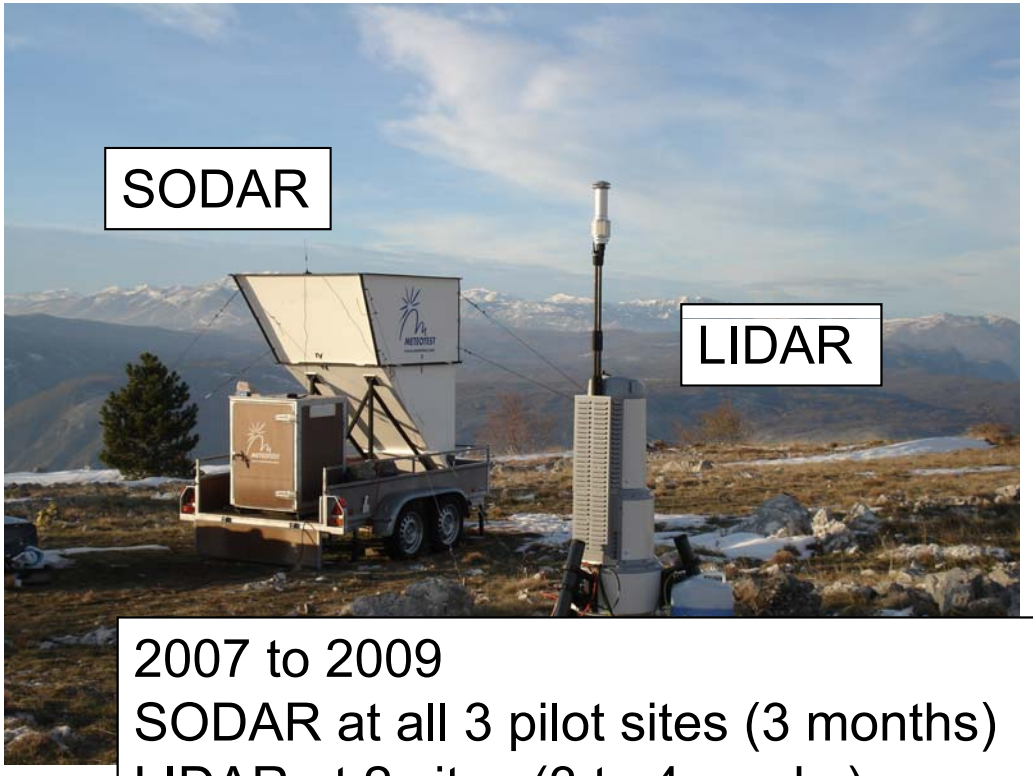

2007 to 2009
SODAR at all 3 pilot sites (3 months)
LIDAR at 2 sites (3 to 4 weeks)
In combination with met masts from 30 to 50 m

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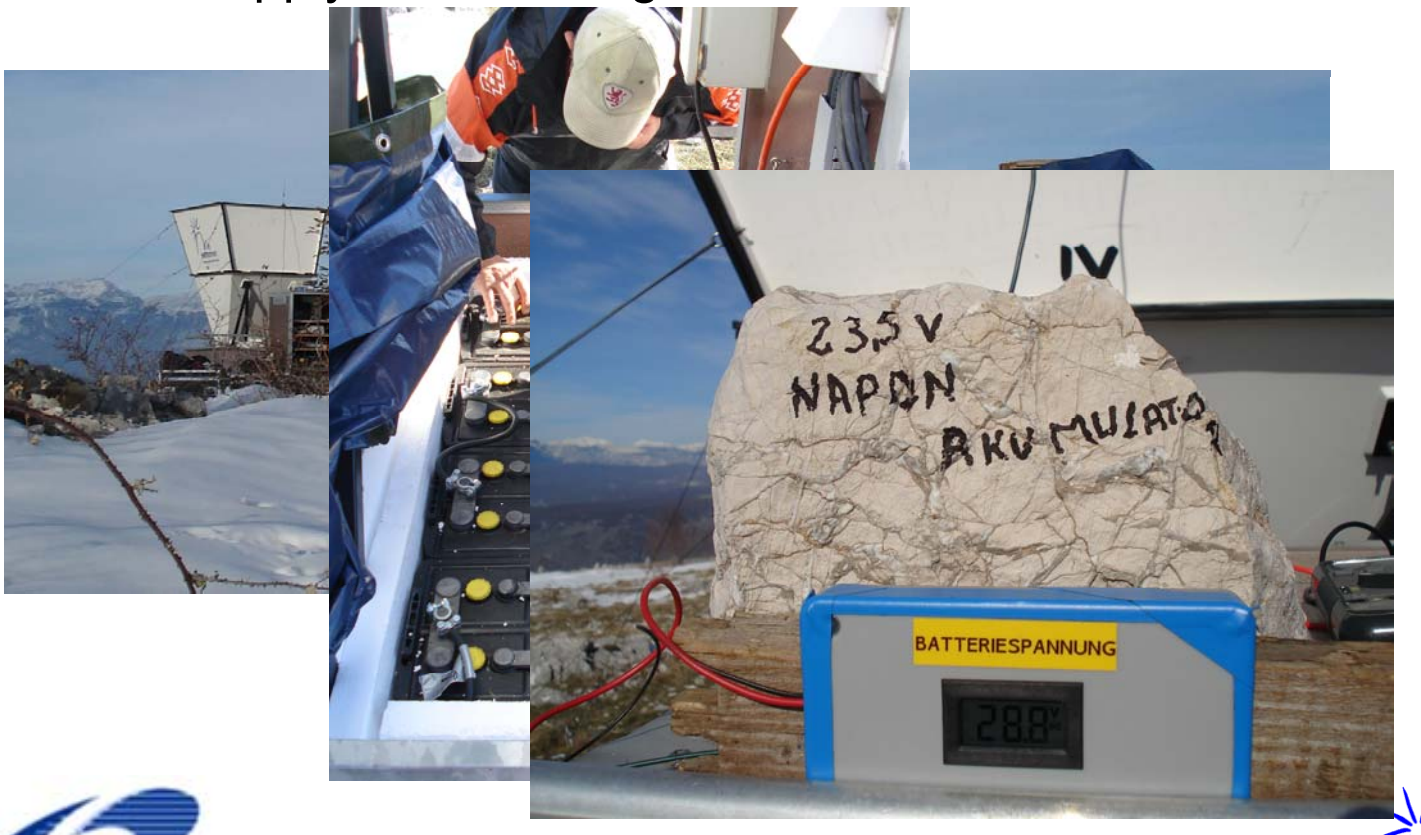
Transport is a challenge (customs, site access)

Power supply is a challenge



Security is a challenge

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Local weather is a challenge

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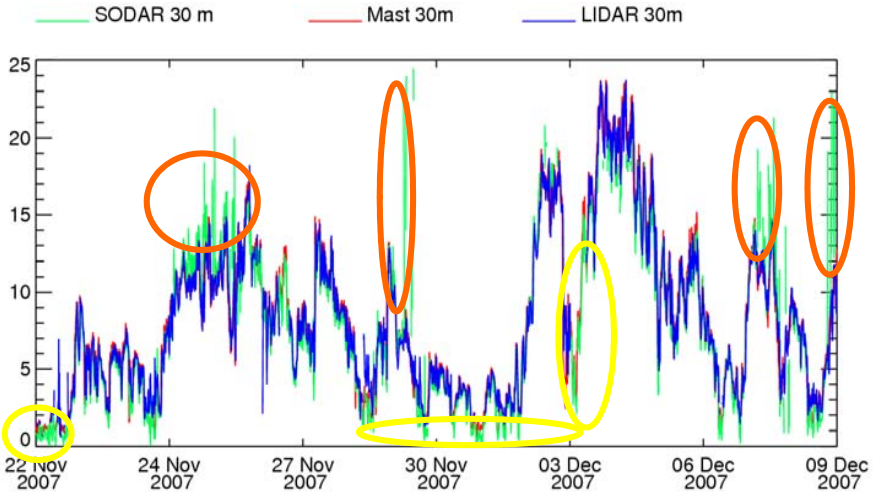
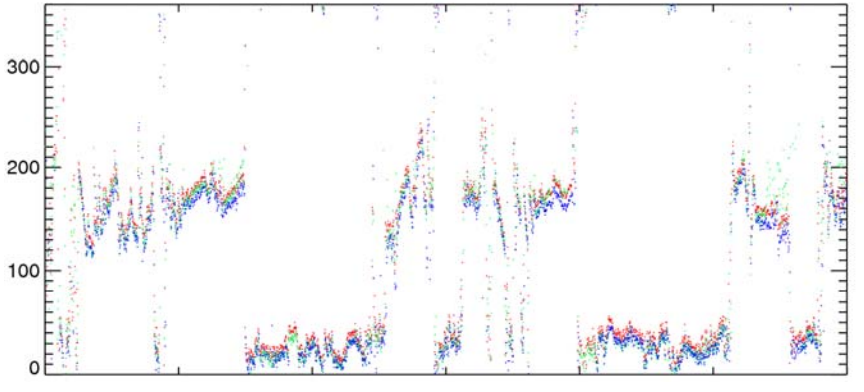
Data analysis is a cha

wind speed [m/s]



wind direction [°]



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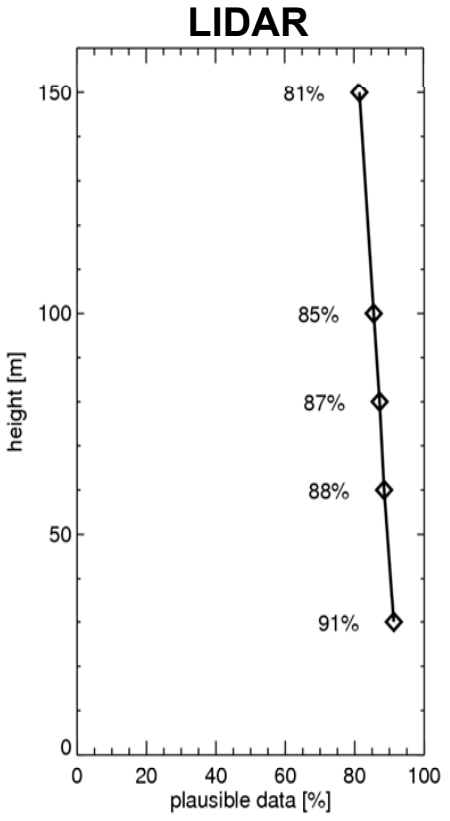
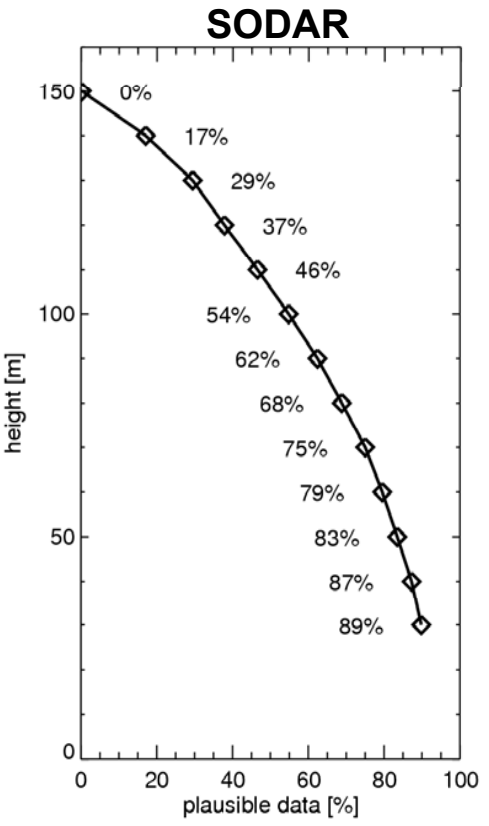
Data availability





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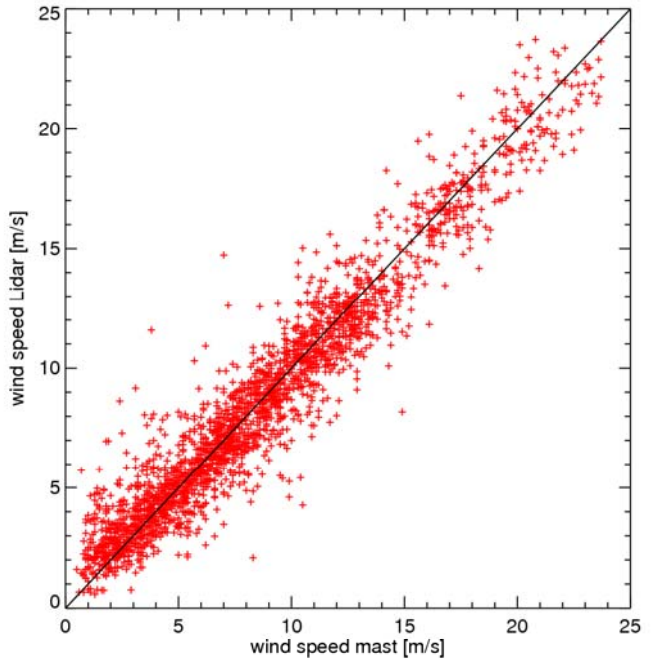
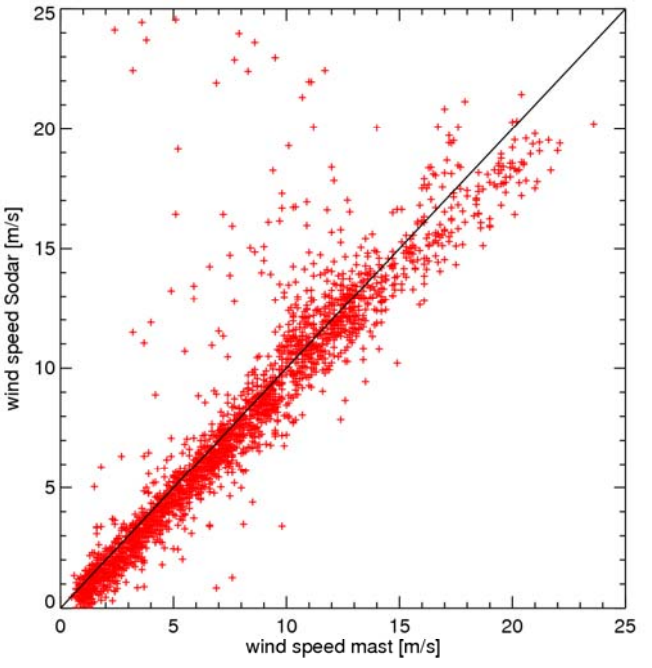
Met Mast – LIDAR: 30m



Met Mast – SODAR: 30m



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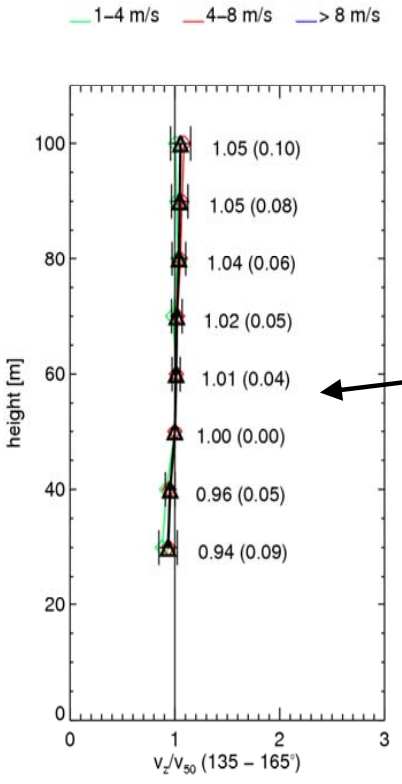
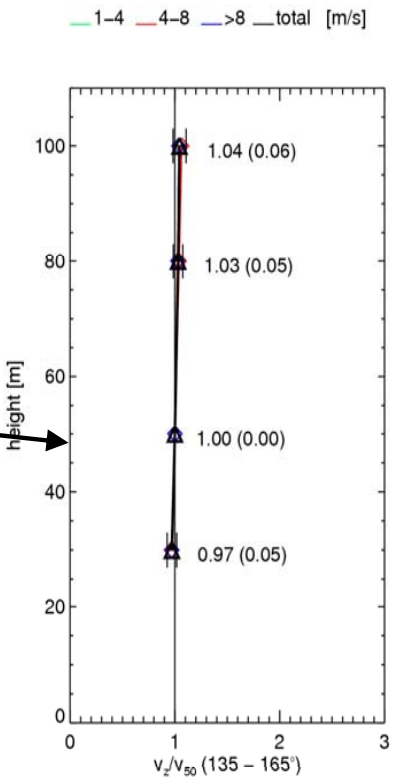


Normalized vertical wind profile at Rudine for 135°-165°

SODAR

LIDAR



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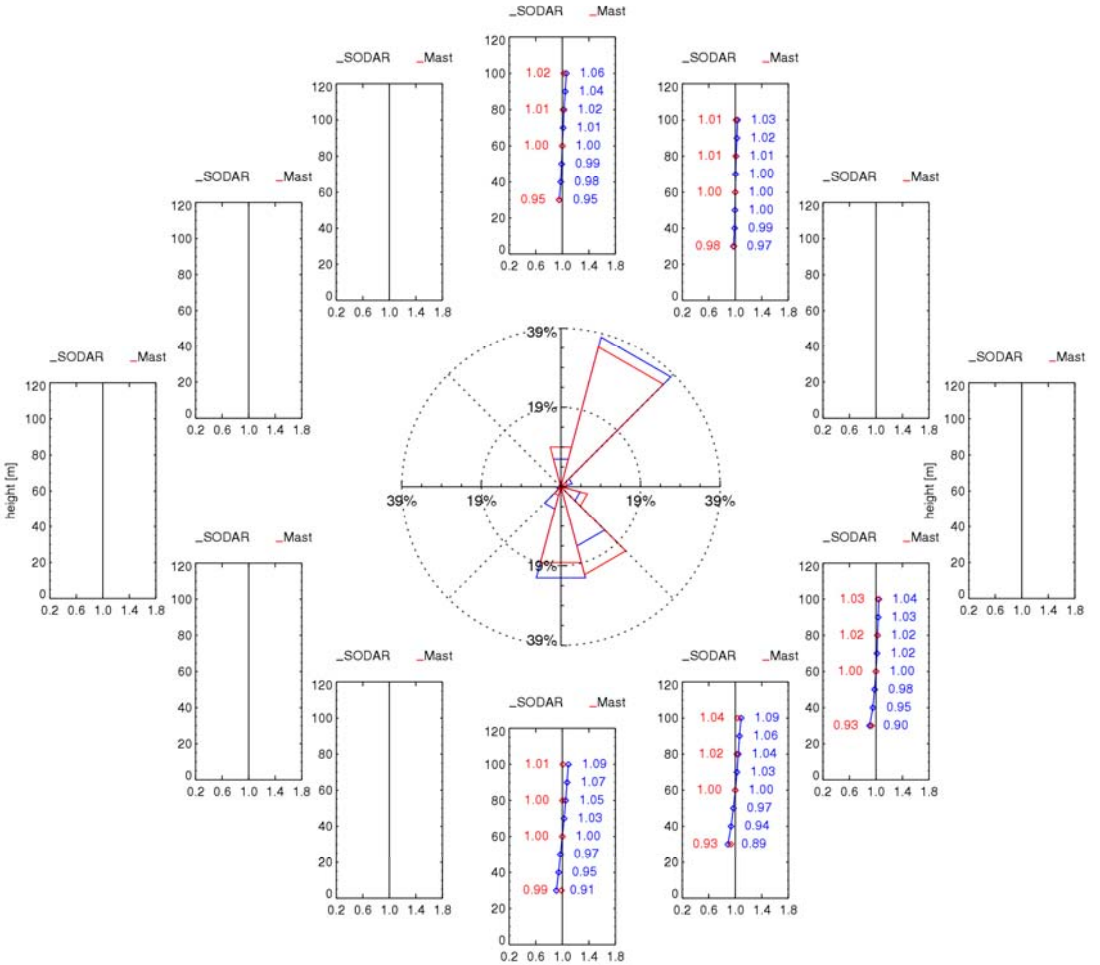

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Conclusions I

SODAR

- \- Decreasing data availability with height
- \+ Good data availability for low winds
- \- Low data availability for winds >20m/s
- \- Careful post-processing needed
- \- Careful use of absolute values
- \+ High vertical resolution (10m)
- \+ Fast GSM download
- \- Moderate transport and installation
- \- High energy consumption
- \- Sound Emission
- \+ Moderate Costs

LIDAR - ZephIR

- \+ High data availability until 150m
- \- Low data availability for winds <4m/s
- \+ High data availability for winds >20m/s
- \+ Little post-processing needed
- \+ Absolute values seem ok?
- \- Only five height levels
- \- Very slow (expensive!!) GSM download
- \+ Relatively easy transport and installation
- \+ Moderate energy consumption
- \+ No sound emission
- \- High costs

Conclusions II

→ Good performance of both, SODAR and LIDAR under harsh climatic conditions

→Good agreement between vertical wind profiles of SODAR and LIDAR

→Power supply difficult (costly!) in regions without grid connection

→ can deliver valuable additional information in complex terrain

→ should only be used in parallel with a met mast
(mast = reference) <-> data availability

→ very fast development

→ *maybe not the final answer*
but at the moment one of the best answers

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Thank you for your attention!

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