Use of Small Unmanned Airplanes to Improve On-Demand Local Forecasts

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SARWeather – www.sarweather.com

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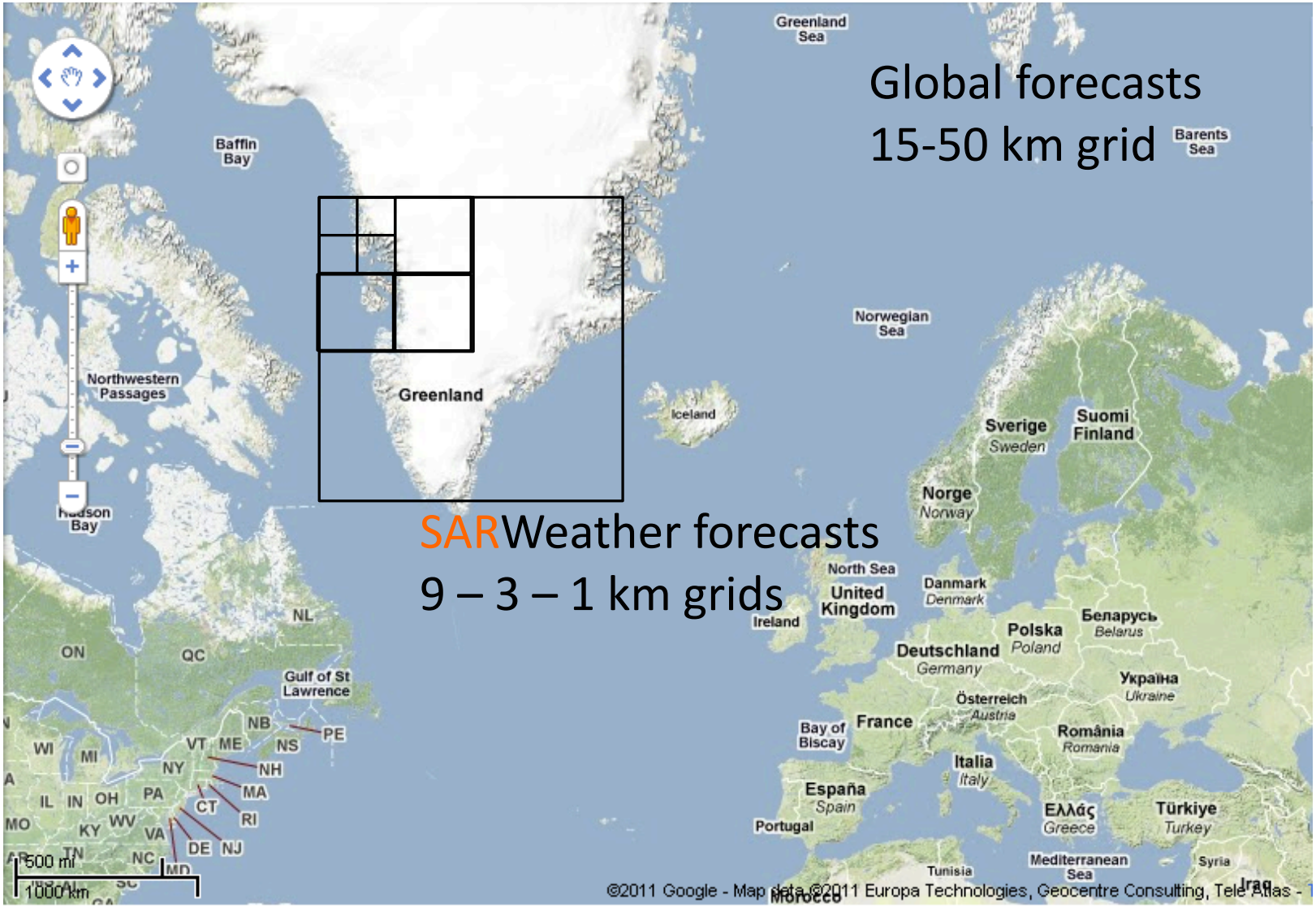
Overview

- Numerical Weather Models
  - Importance of resolution
- Current Crisis Response System
  - SARWeather demonstration
- Use of observations from UAS's
- On-going research
- Conclusions

Importance of high resolution



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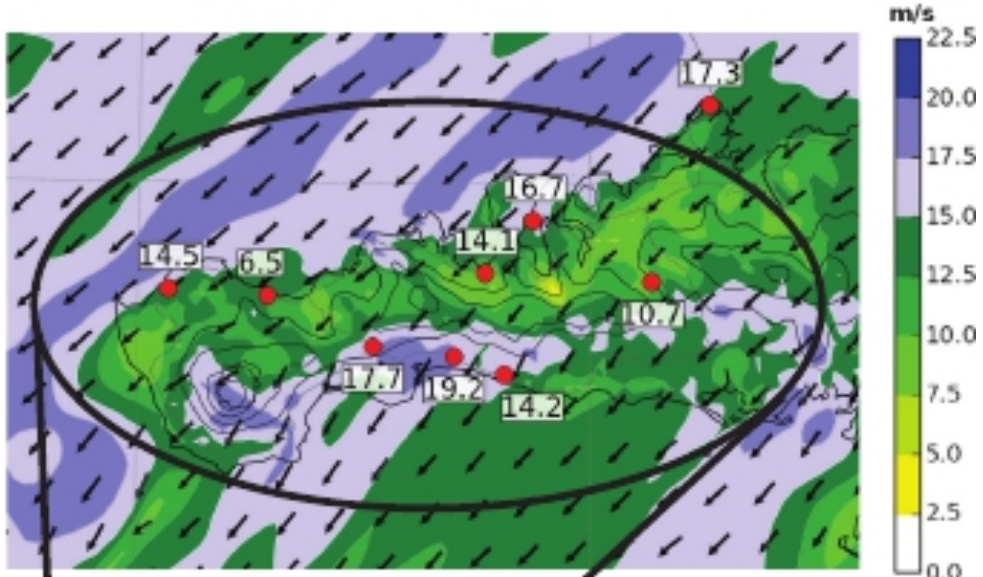
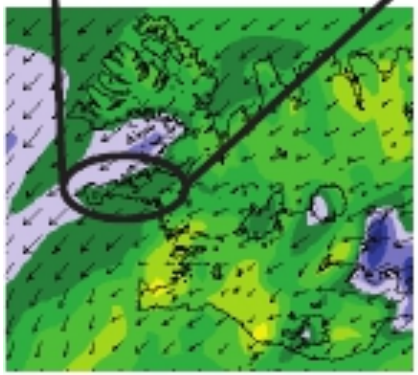
Importance of high resolution

Very high resolution – 1 km



High resolution (1 km.)

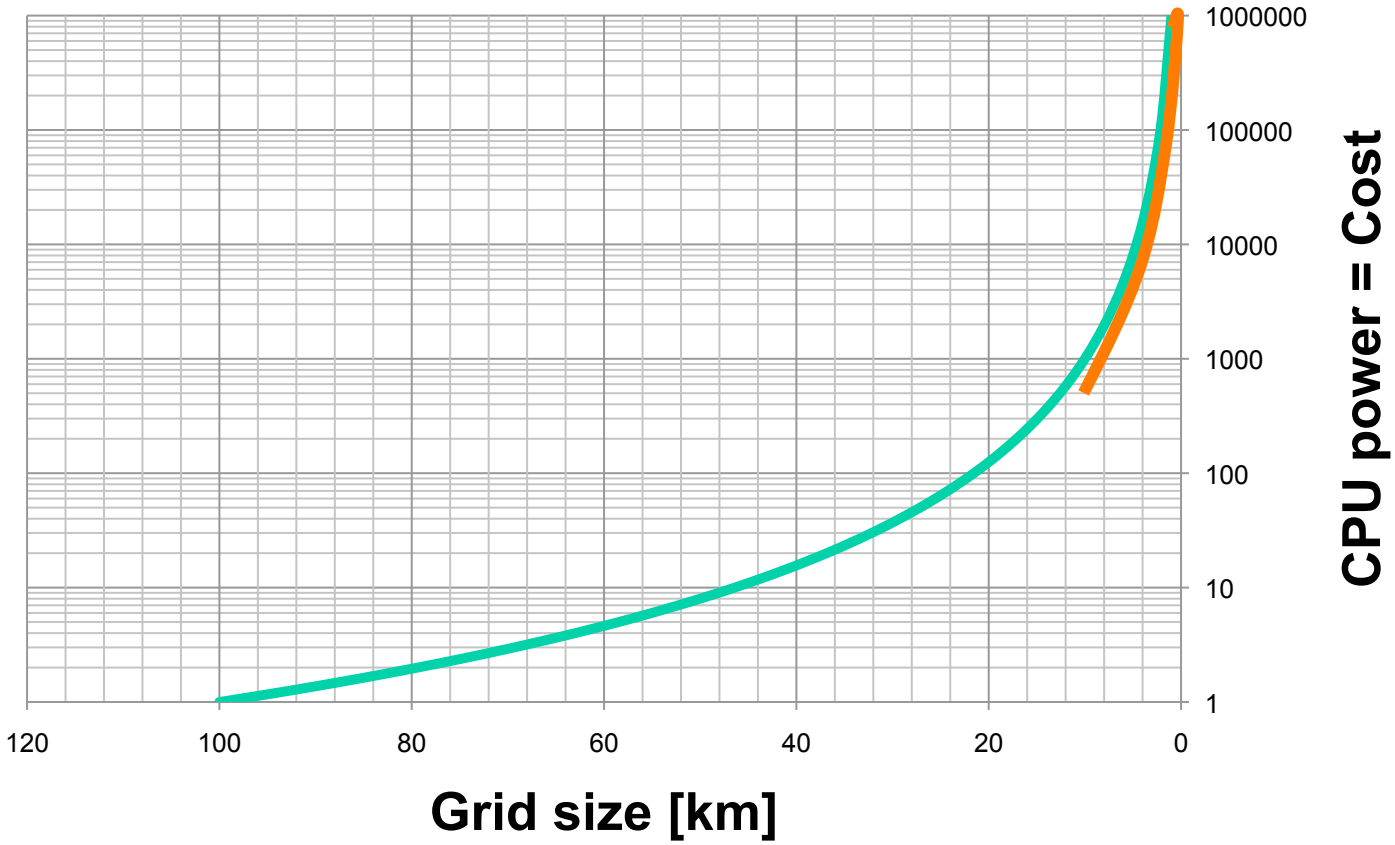
Medium resolution – 9 km



Medium resolution (9 km.)

When model resolution is increased to 1 km the true complexity and strength of the wind field becomes apparent

Why not always use 1km resolution?



Need 1000-times more CPU power to simulate a 1 km resolution forecast than a 10 km one for the same region!

What if

- You only need high very high resolution once in a while?
- Computer clouds (e.g. Azure, EC2 and GreenQloud) are starting to offer HPC service
- Offers great scalability
- Relatively cheap
- And there is already a solution out there ☺

Crisis Response System

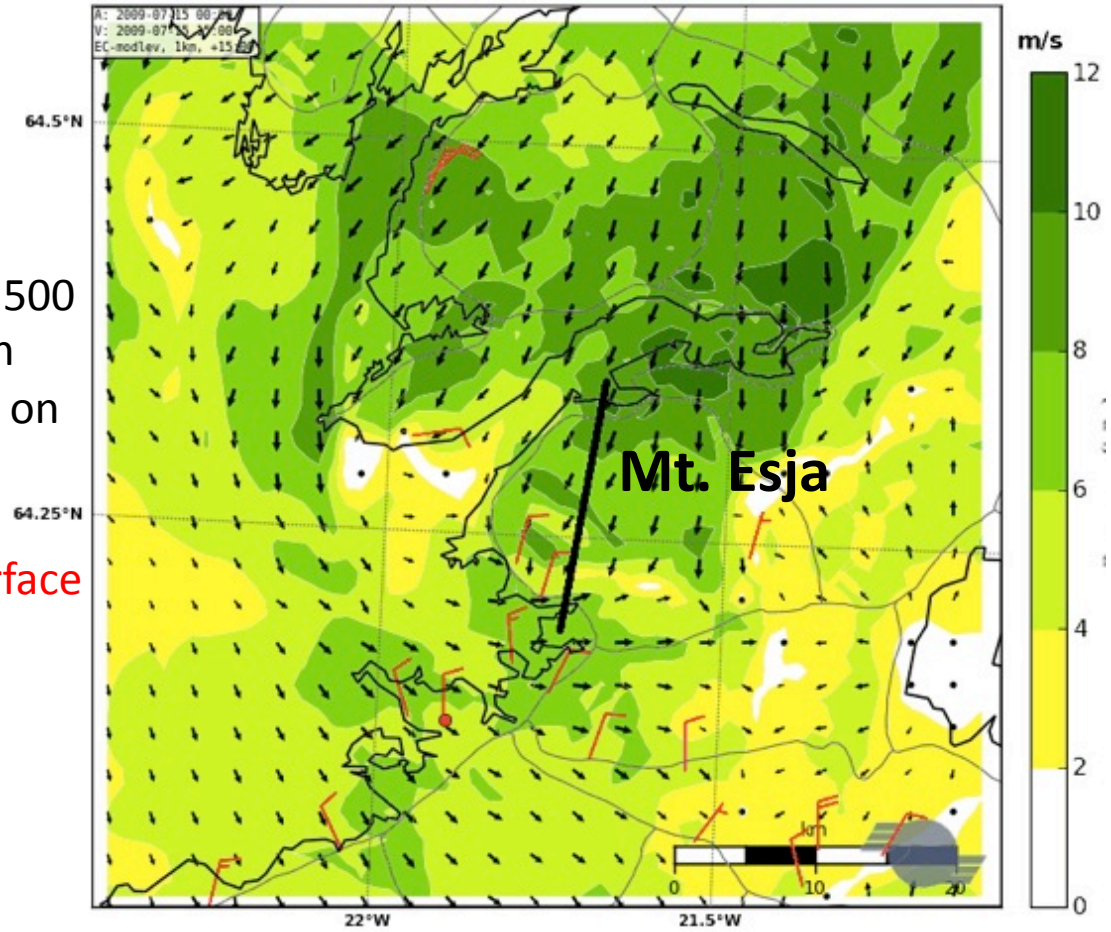
- Good weather information help improve decision making
- Current CRS uses the WRF model and consists of a
  - Backend and Frontend
- Frontend is called SARWeather
  - Easy to use
  - Fast
  - Flexible model output and presentation
    - CF and ArcGIS compliant output files
    - Interactive and static maps

High resolution not always sufficient

Simulated and observed surface winds on 15 July 2009 at 13 UTC

WRF at a resolution of 500 m forced with ECMWF-data on model levels.

Observed surface winds in red



Model simulates a see-breeze that is not seen in observations

SUMO and WRF

The SUMO (Small Unmanned Meteorological Observer) can measure winds, humidity, pressure, and temperature in a vertical profile up to a 4km height

Can be operated in cold climates

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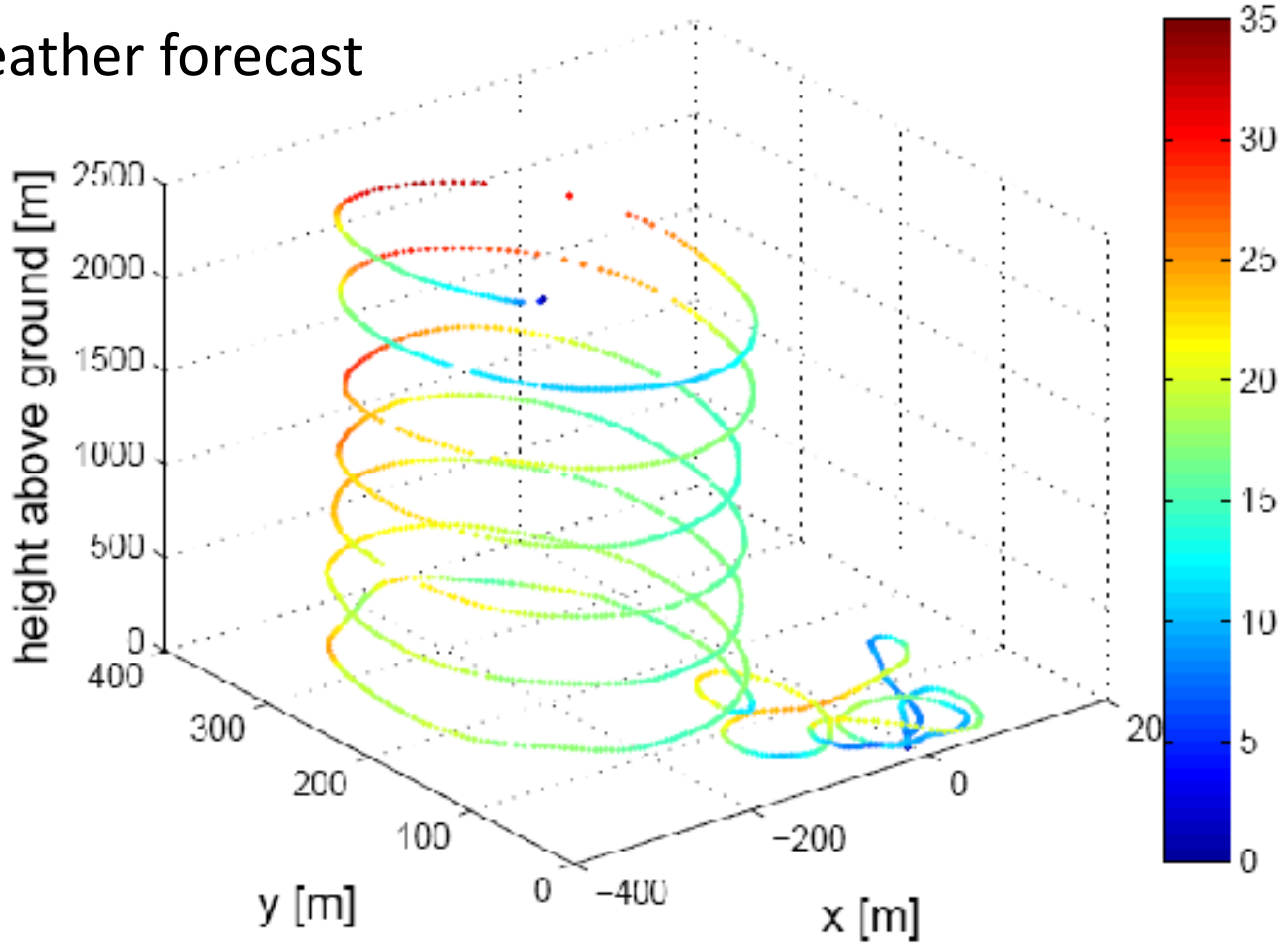
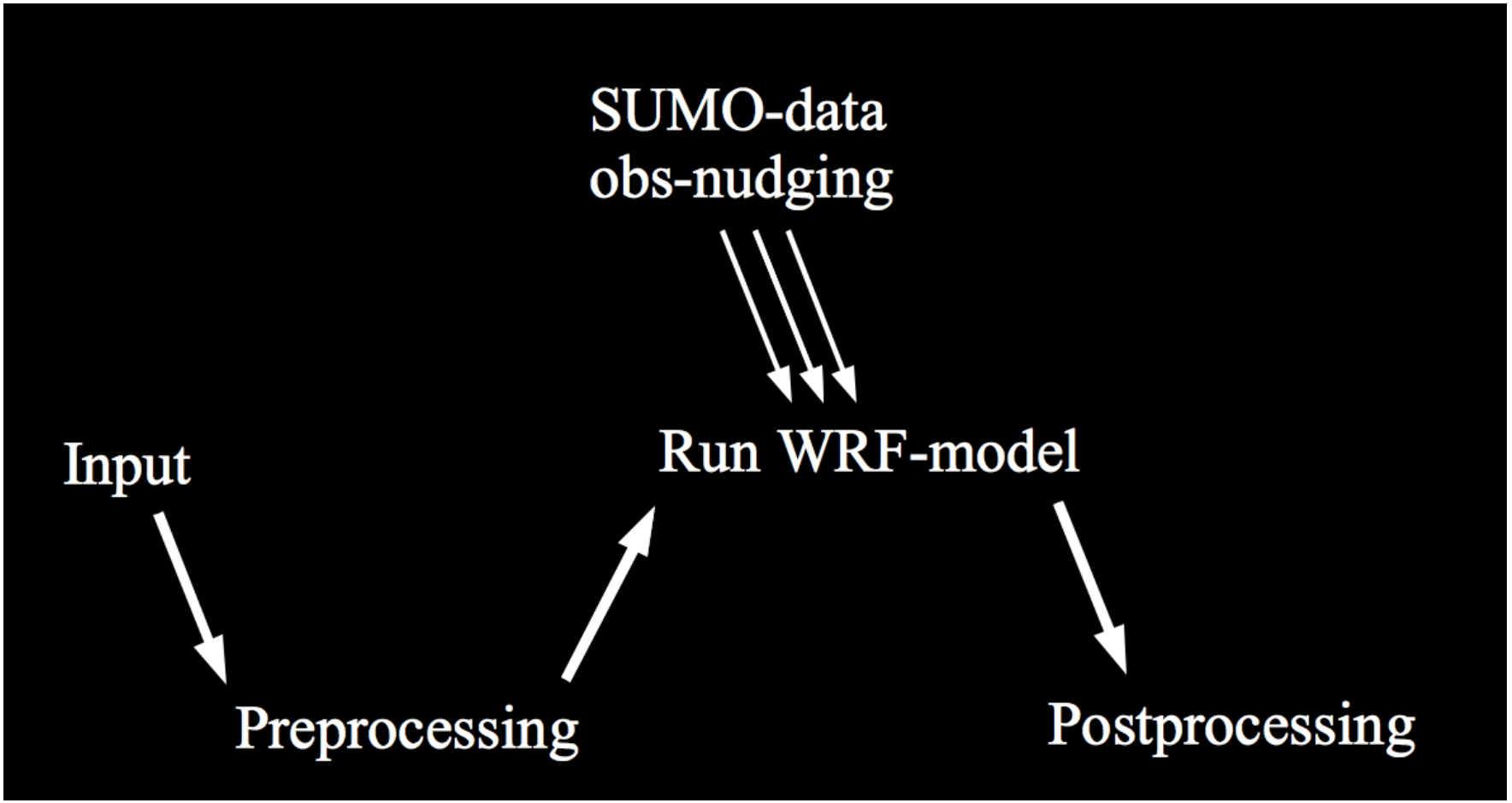
SUMO and WRF

This data can be assimilated with the WRF weather forecast



SUMO and WRF

The SUMO-data is incorporated into the WRF-simulation, via obs-nudging

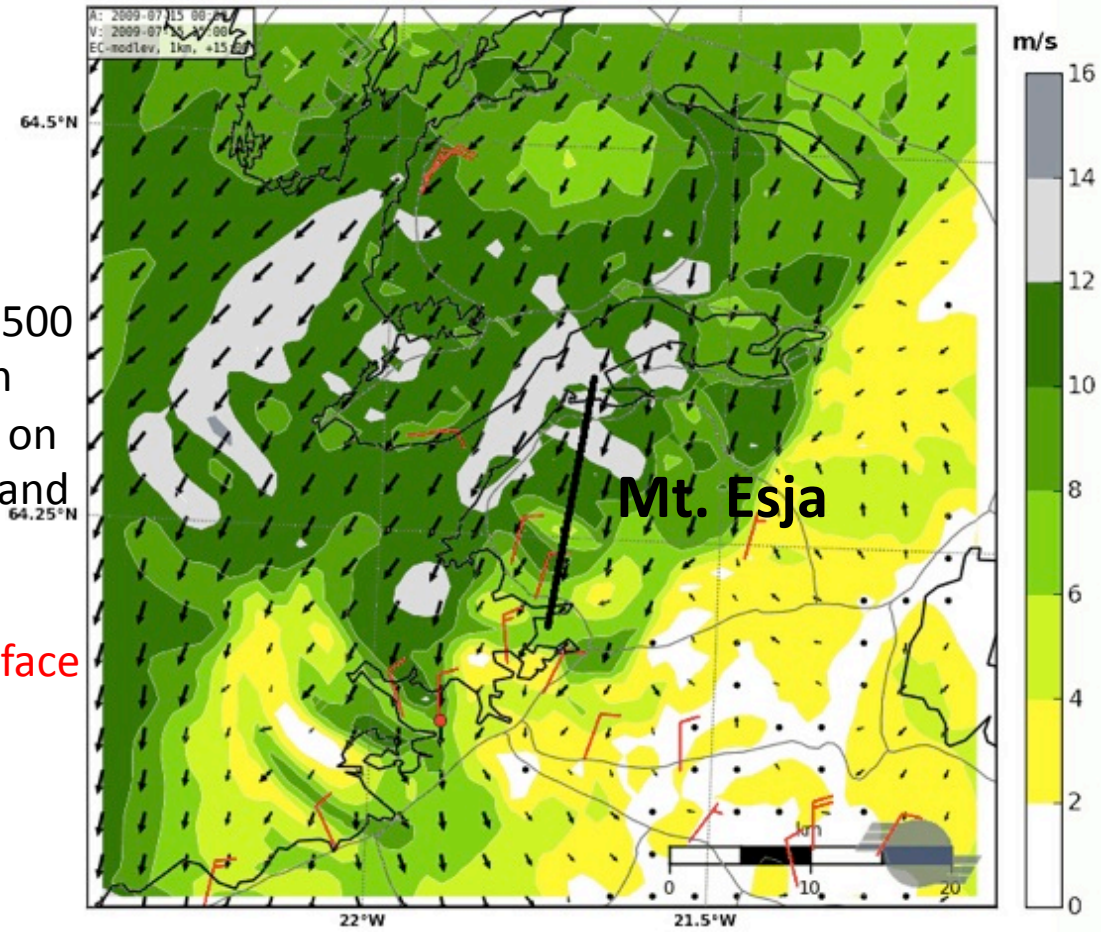


Effects of additional observations

Simulated and observed surface winds on 15 July 2009 at 13 UTC

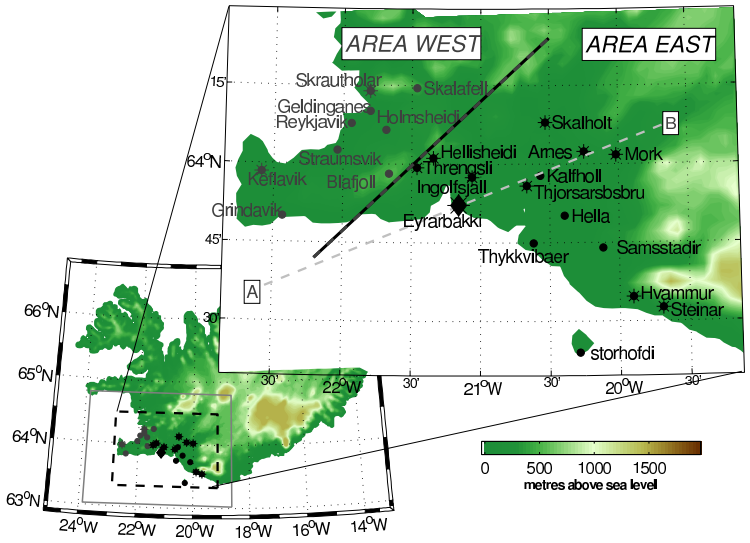
WRF at a resolution of 500 m forced with ECMWF-data on model levels and SUMO data

Observed surface winds in red

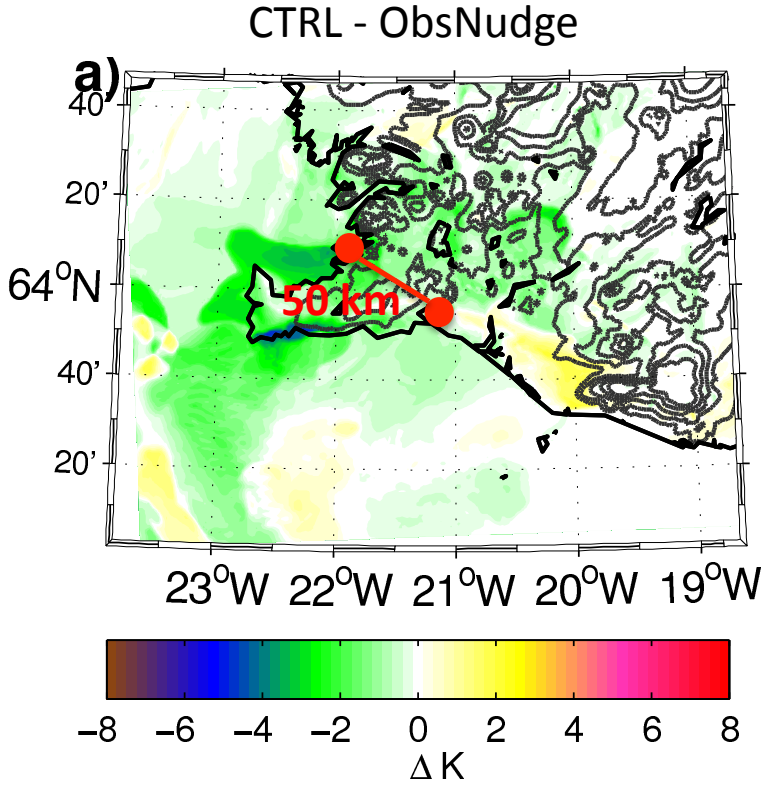


The flow structure is now in much better agreement with available observations

Effects can be far reaching

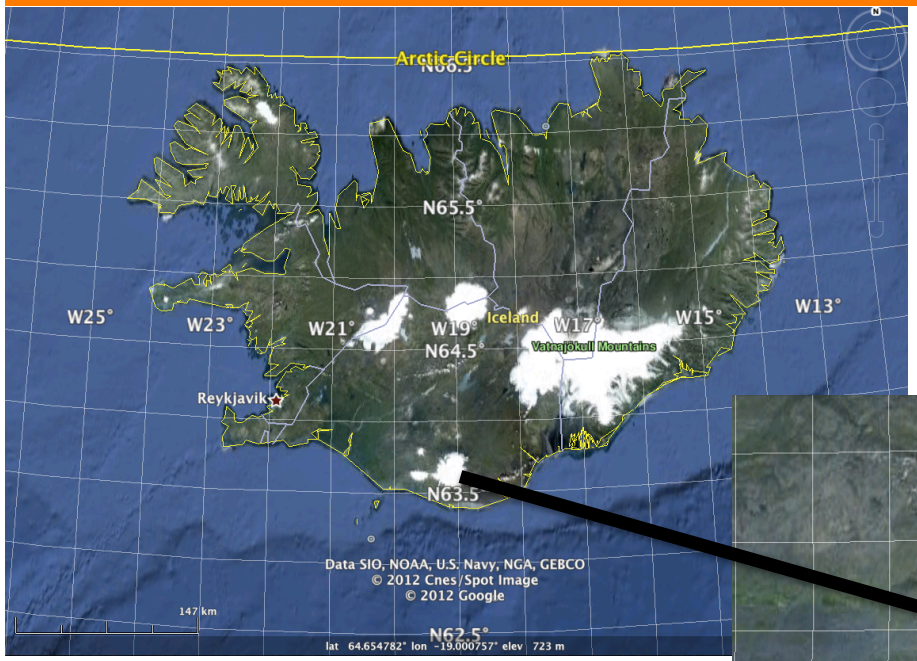


"Substantial improvements of winds, temperatures and humidity in the region are achieved"



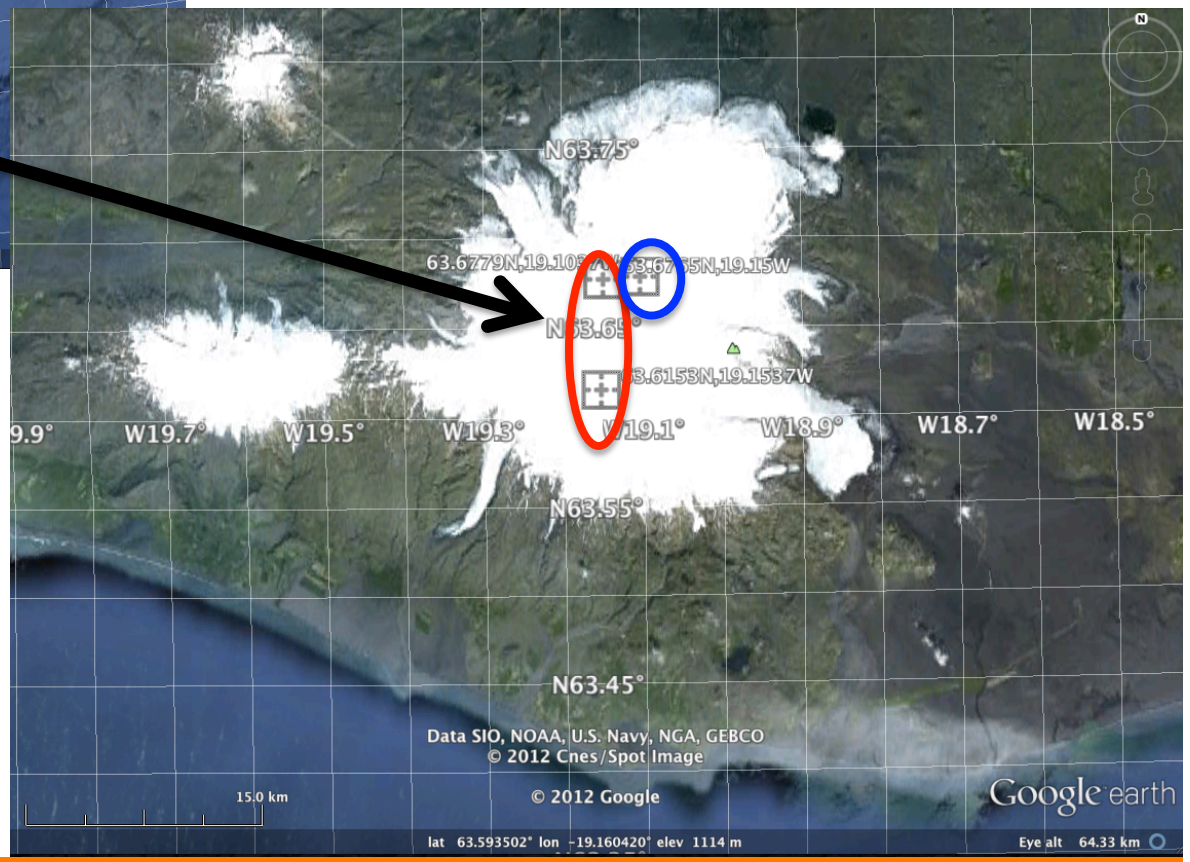
Marius O. Jonassen, Haraldur Ólafsson, Hálfdán Ágústsson, Ólafur Rögnvaldsson, and Joachim Reuder (2012). Improving a high resolution numerical weather simulation by assimilating data from an unmanned aerial system. Accepted for publication in *Monthly Weather Review*

Transmitting data from the field



Observations made over Myrdalsjokull ice cap in South Iceland on 17 May 2012
Data can be transmitted via 3G mobile connection

One profile used for comparison at 16:30 UTC



Three profiles used to nudge the forecast at times 11:55, 12:58 and 14:38 UTC
Site altitudes ~ 1300 m.a.s.l.
Profile heights ~ 2000 m.a.g.l.
From 860hPa to 650/680hPa

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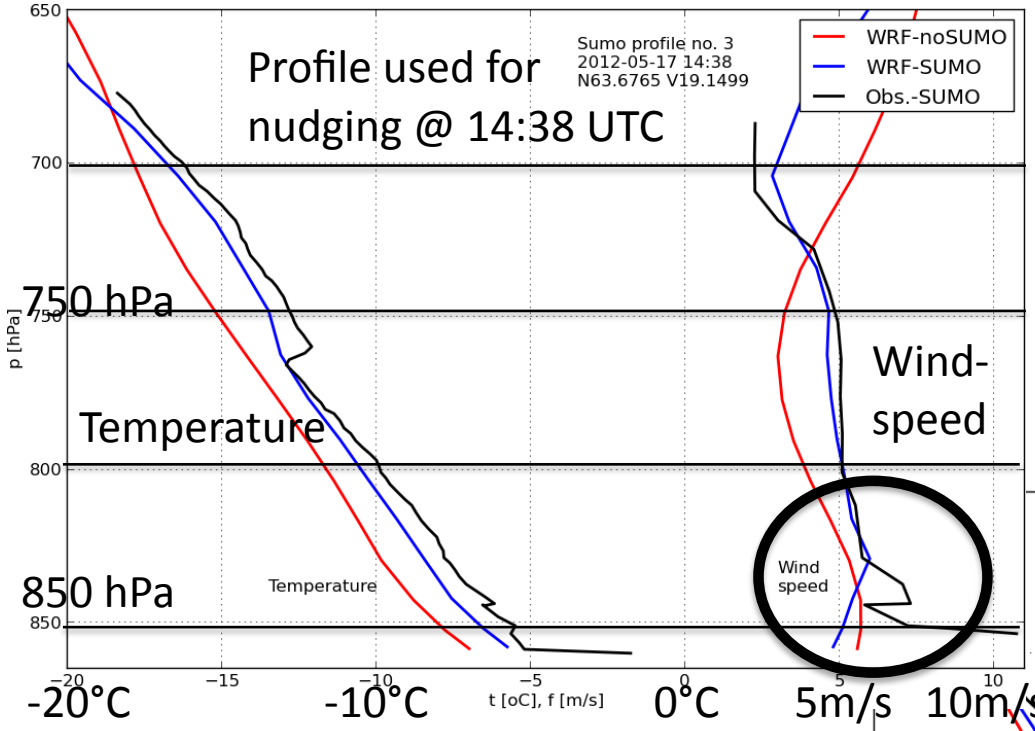
Transmitting data from the field

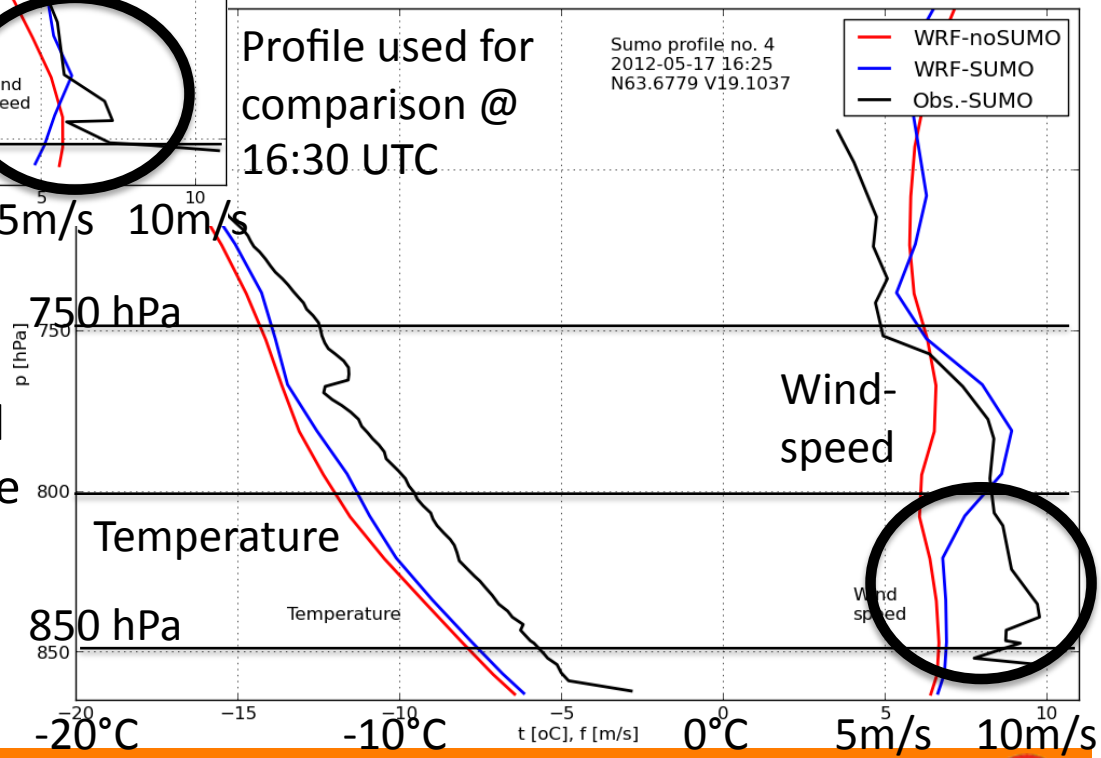


Observations made over Myrdalsjokull ice cap in South Iceland on 17 May 2012

Obs in black

WRF - noSUMO in red

WRF - withSUMO in blue



Problems with low-level windspeed and a cold bias 2hrs after last profile

Additional sensors

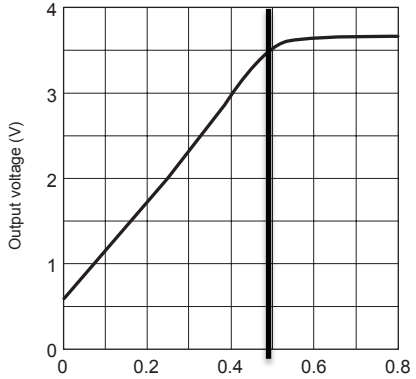
The SUMO has been equipped with an optical dust sensor

GP2Y1010AU0F is a dust sensor by optical sensing system:

- An infrared emitting diode (IRED) and an phototransistor are diagonally arranged into the device
- It detects the reflected light of dust in air
- Especially effective to detect very fine particle
- In addition it can distinguish smoke from house dust by pulse pattern of output voltage

Compact Optical Dust Sensor

Output Voltage vs. Dust Density



Saturation at about 500µg/m^3

Preliminary results

The SUMO dust sensor has been tested in France and Iceland

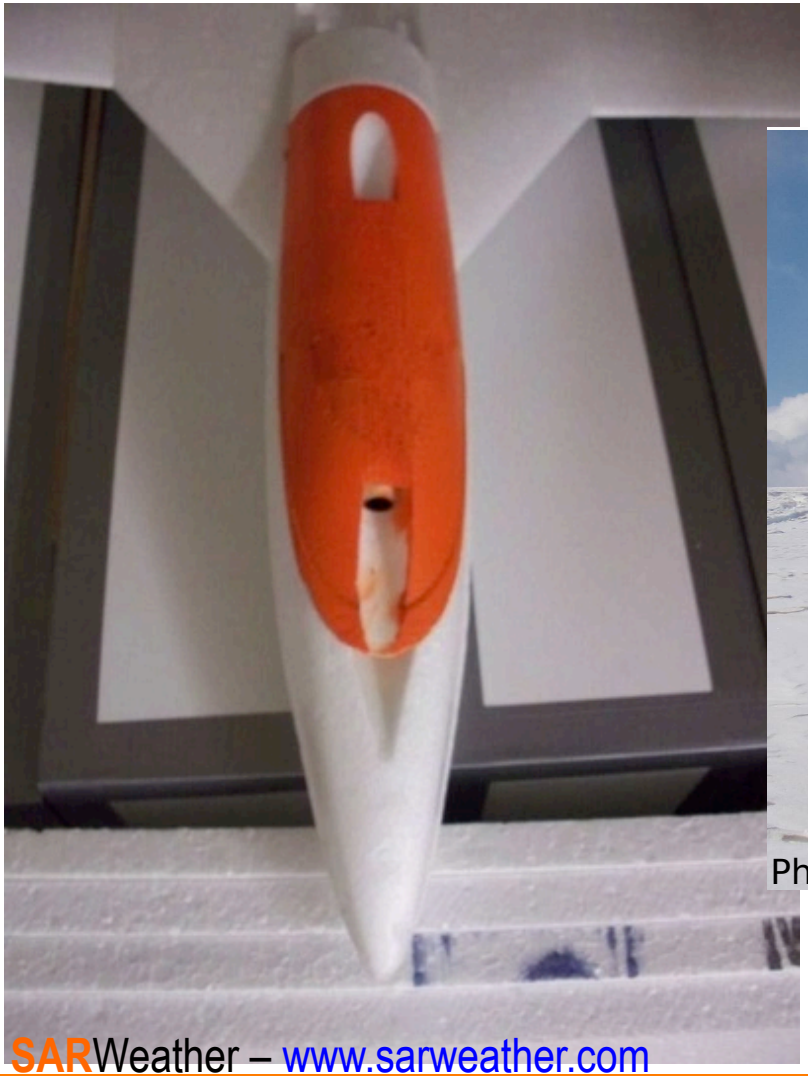


Photo: Birta Líf Kristinsdóttir

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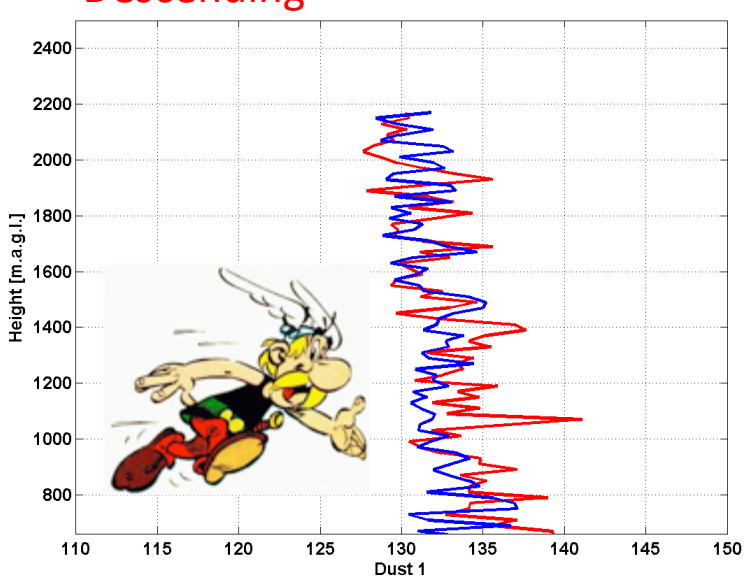
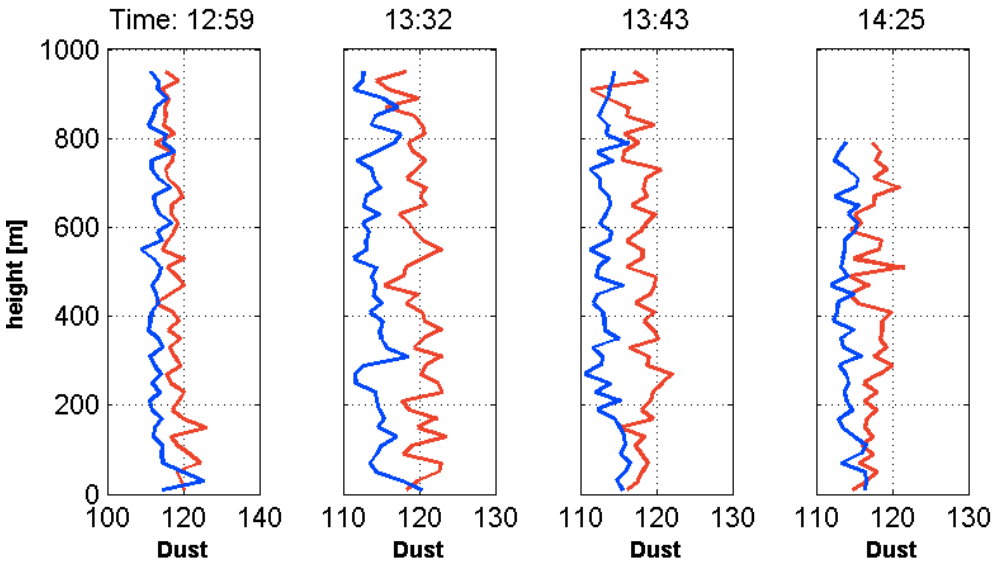
Preliminary results

The SUMO dust sensor has been tested in France and Iceland

Ascending

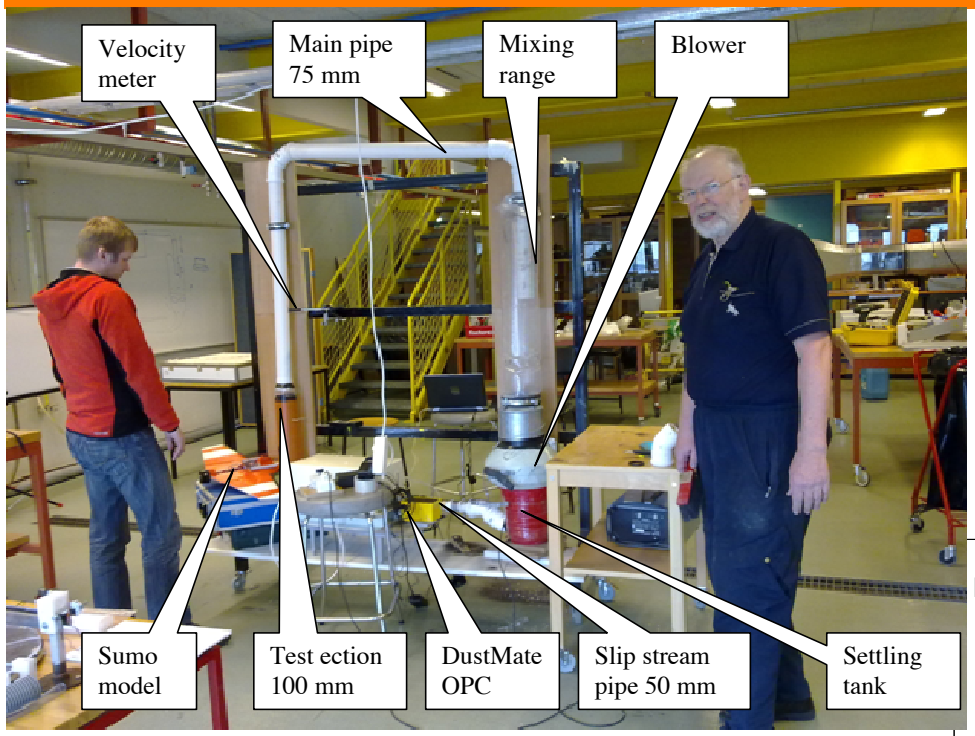
Descending



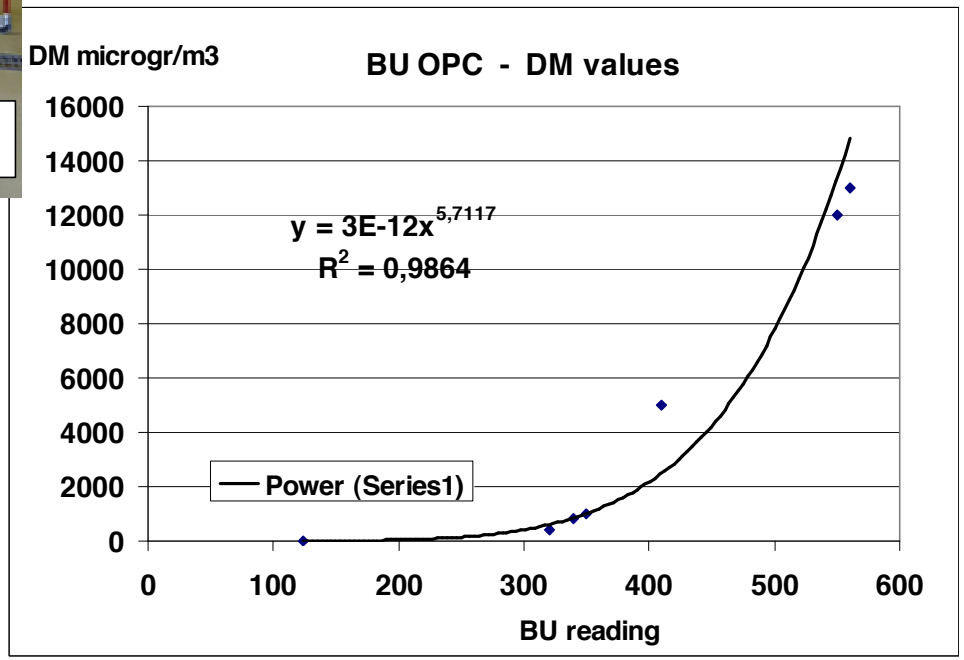


Sensor is now being calibrated and tested with ash from Mt. Eyjafjallajökull

Calibration – preliminary results

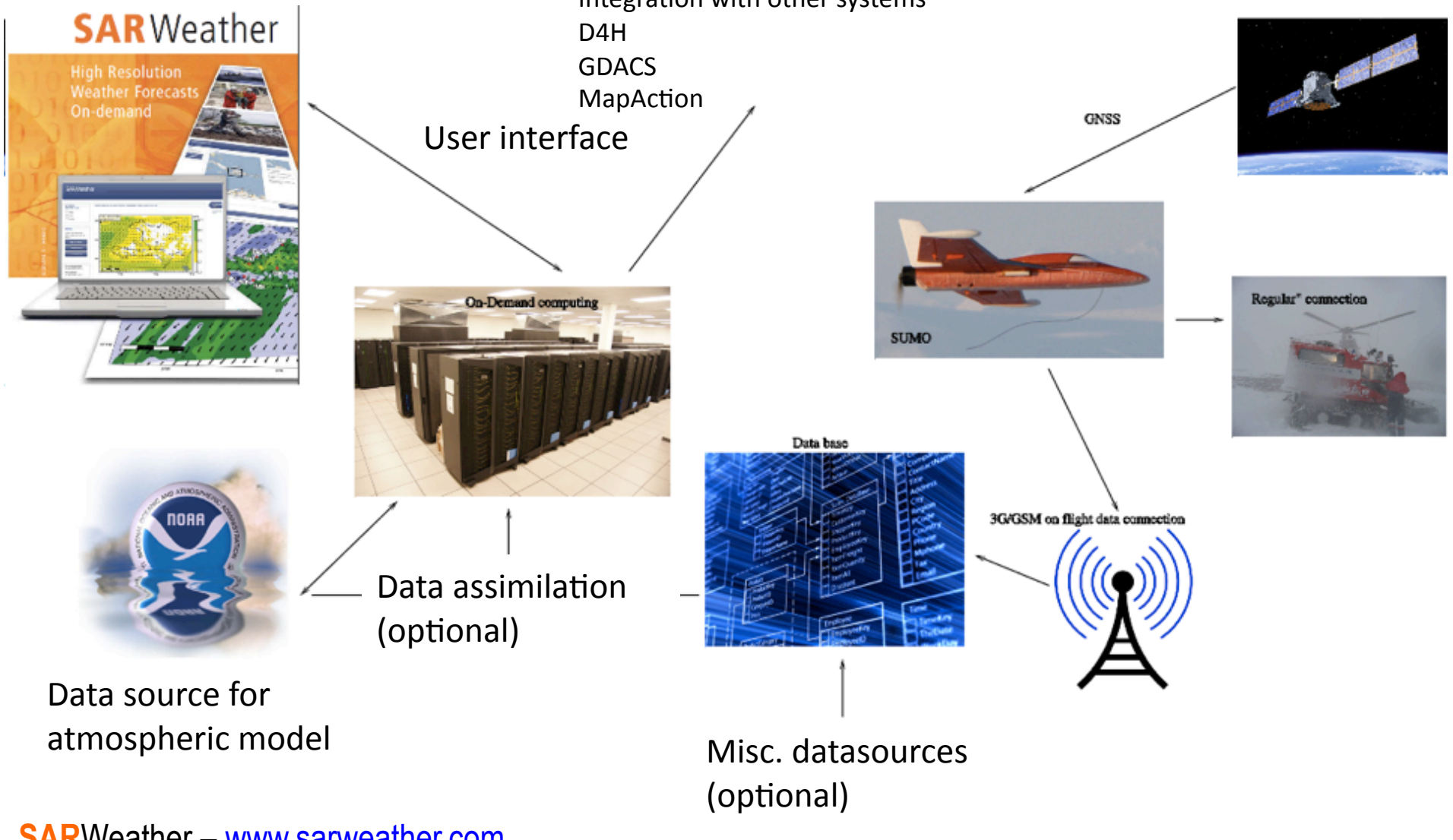


- The sensor (BU) readings show high sensitivity in the range 125 – 300. After that the sensitivity is rather low in the range 350 to 700.
- Using the meter for ash surveillance for jet aircrafts, the best thing would be to designate below 300 as “safe” but above 400 as “unsafe”



Current research and development

System schematics



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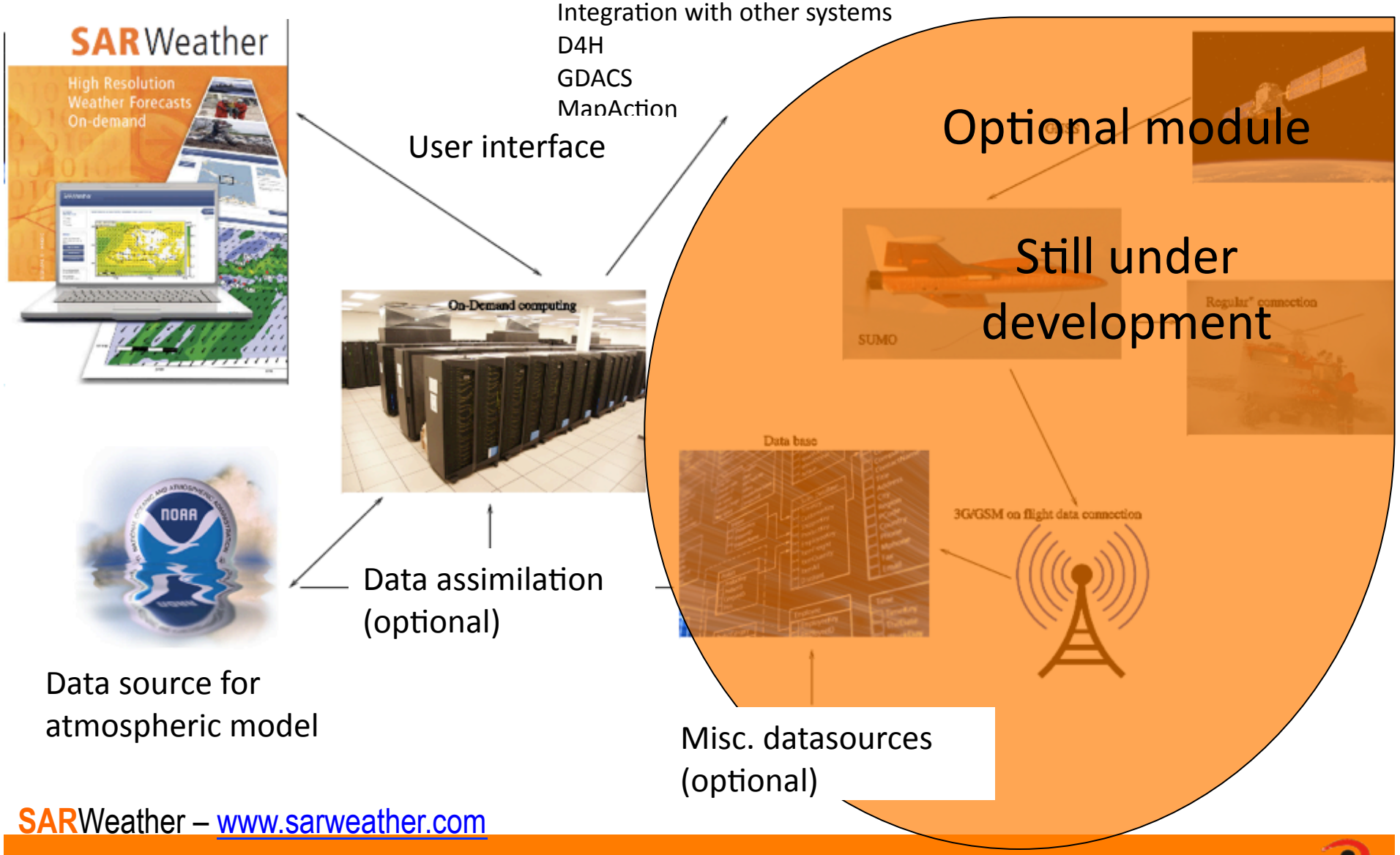

Conclusions

- Model resolution is important
  - Especially in the vicinity of complex terrain
- On-Demand CR system has been developed
  - Called SARWeather – www.sarweather.com
- Additional observations can improve the simulation
  - Vertical profiles made by the SUMO, radiosondes or other means
- The SUMO is a low-cost system with many advantages
  - Proof of concept before investing in a more durable and expensive UAS
  - Additional sensors are being added to the system
  - Is currently being integrated to the SARWeather CR system

Acknowledgement

- SARWeather is a joint research project led by IMR/Belgingur, in collaboration with NOAA/ESRL, the University of Bergen, and the private companies GreenQloud and DataMarket. To ensure maximum usability for SAR operators, SARWeather is developed in close collaboration with ICE-SAR and the Civil Protection Department of the Icelandic Police.
- SARWeather was initially funded in part by grant number 550-025 (Vejrtjeneste for Søberedskab) from NORA and by the European Commission under the 7th Community Framework Programme for Research and Technological Development (GalileoCast). GalileoCast is managed by GSA, the European GNSS Supervisory Authority.
- Current development of SARWeather is funded in part by the Icelandic Technical Development Fund – RANNÍS
- Development related to the SUMO has in part been funded by the COST project ES0802