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High-resolution wind forecasts: On-demand and operational forecasting and observational nudging

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Abstract

Wind turbine and power plant operators rely on accurate forecasts and mapping of the wind resource for safe and successful operation of the utilities.

We present a state-of-the-art operational forecasting system that utilizes the AR-WRF model to prepare high-resolution forecasts of wind and weather for any location in the world. The system can both be run in an operational setting (repeated forecasts) as well as in an On-Demand mode (called SARWeather) where individual forecasts can be ordered in an intuitive way at a short notice in a web-based interface. The system requires no prior knowledge on behalf of the user regarding atmospheric modeling and/or high performance computing. Specific post-processing modules tailored to end-user needs can be developed, and output from the system can easily be ingested into other decision support software, such as ArcGIS. The system has been actively and successfully used by Search-And-Rescue personnel in operations worldwide, but is currently being pushed towards the wind energy sector and other weather dependent operations.

The current research on the system includes development of post-processing modules specific to the needs of the wind energy sector, including filtered and corrected forecasts of wind speed and power and forecasts of atmospheric icing. Forecasts have been successfully improved based on nudging of in-situ observations from an unmanned aerial vehicle and similar work is being done for other observations platform, opening the way for using in-situ, as well as remote sensing, observations to improve operational forecasts of wind inside wind parks.

On-Demand Forecasts

The procedure to set up and run an on-demand weather forecast via the On-Demand SARWeather system is straight forward. Once logged on, the user simply chooses his/her region by clicking on a map (cf. Fig. 1).

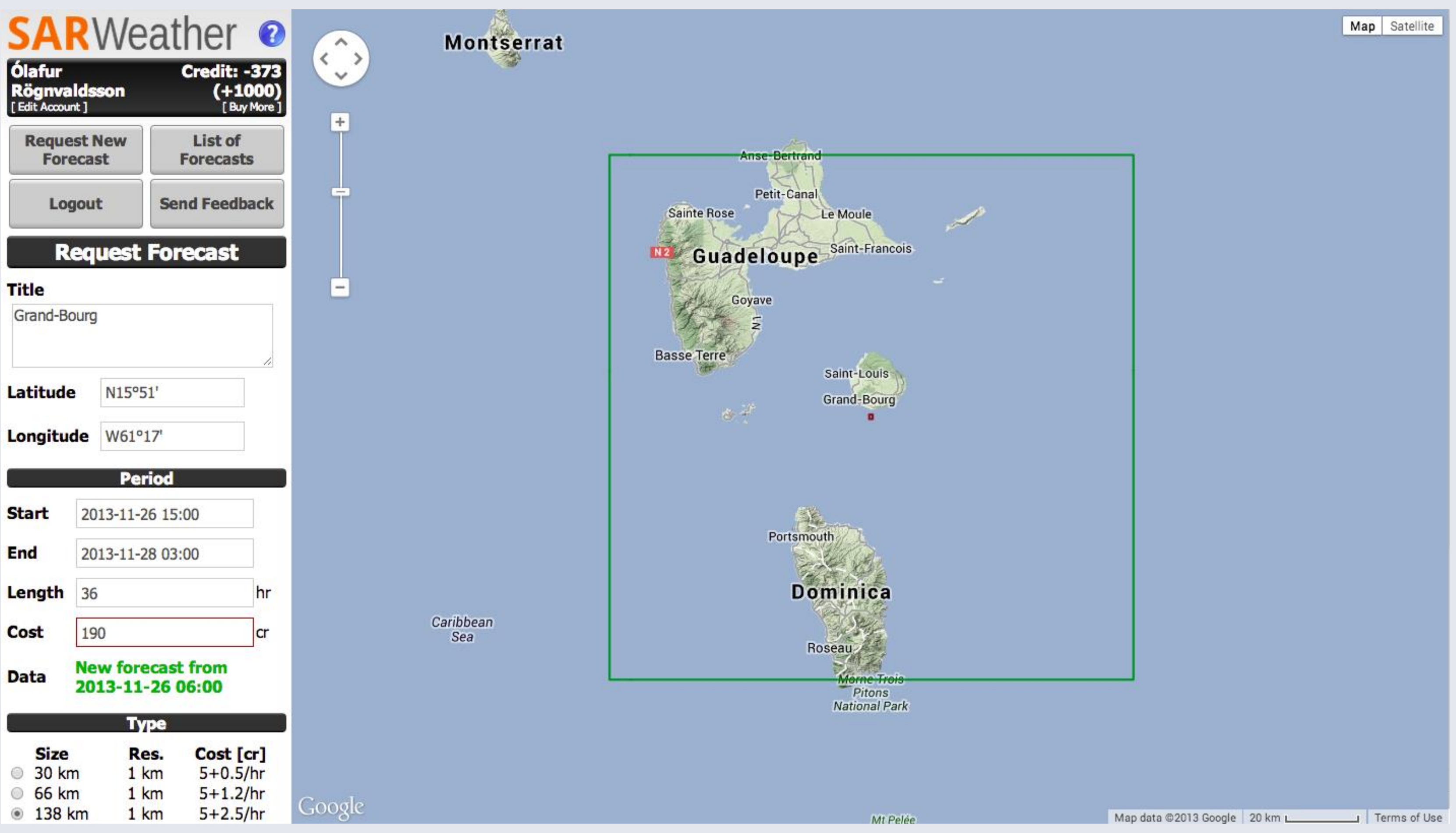

Figure 1: Domain for a 1 km resolution forecast, centred over the island of Saint-Louis, north of Venezuela.

In addition to choosing the location and size of the domain, the user can choose between three types of horizontal resolution and duration. Depending on forecast type, i.e. domain size, resolution and length, the total simulation time ranges between 20 and 120 minutes. Once the forecast is done, model output files can be downloaded, both in native AR-WRF netCDF format, as well as CF Compliant and ArcGIS Compliant netCDF files.

The forecasts of wind, and other primary and secondary weather parameters (e.g. precipitation, cloud cover, turbulence, wind gusts, and icing), can both be viewed as static PNG or SVG figures or on an interactive map (cf. Fig. 2). Currently, a more flexible method of overlaying scalable vector graphics figures on user-defined map underlays is being developed. Other post-processing modules are being prepared and can be tailored to the needs of the end-users, this includes but is not limited to online dissemination of csv-files of wind forecasts at given location and elevation.

The numerical weather prediction is done by using the state-of-the-art AR-WRF atmospheric model and global weather forecasts/analysis from the GFS-system. Simulations are either run in-house at Belgingur or outsourced to the Amazon Elastic Compute Cloud (Amazon EC2). Many individual forecasts can be run simultaneously for any region in the world, and the system allows for repeated forecasts (i.e. operatioal forecasts vs. on-demand forecasts).

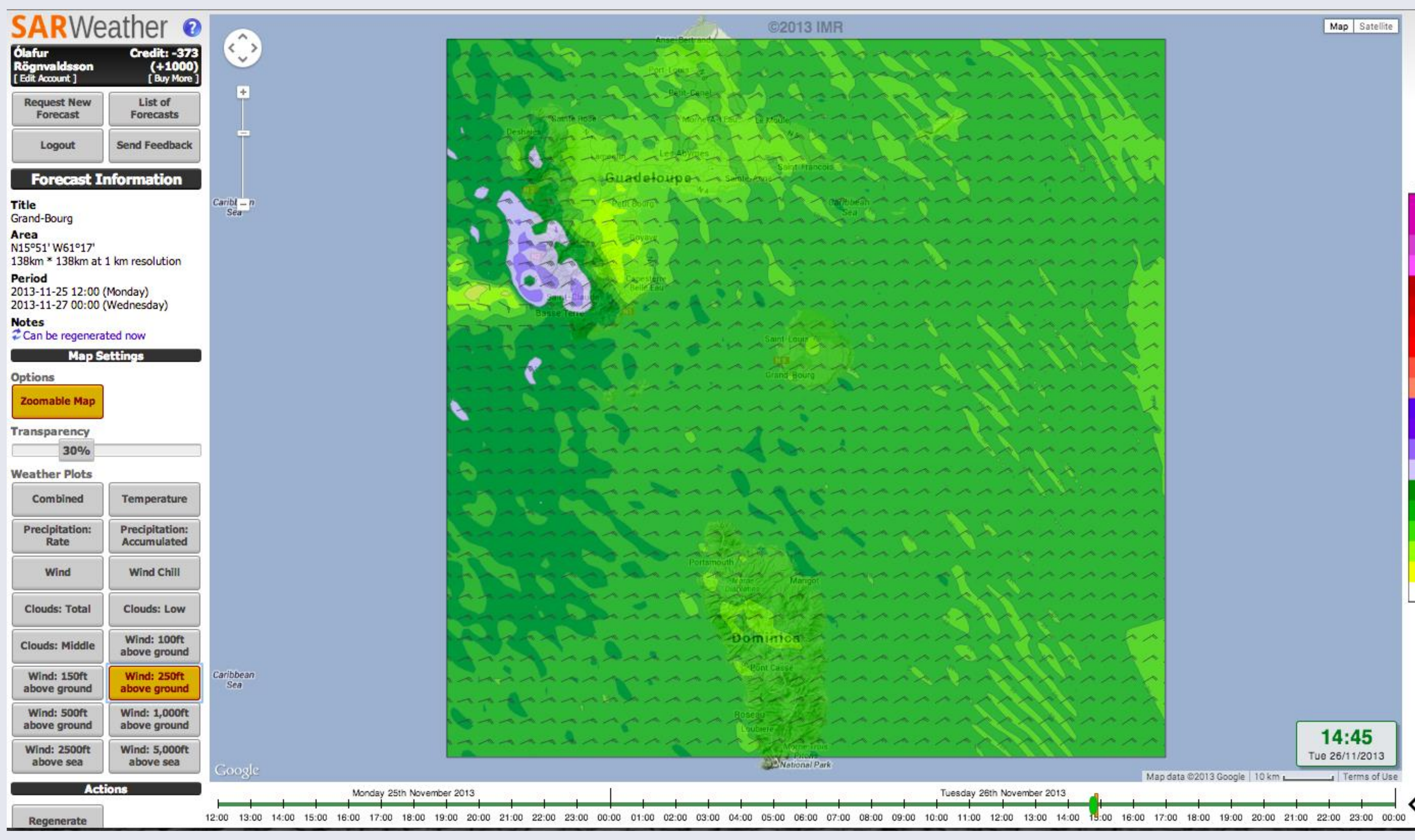

Figure 2: Simulated wind at 80 metres, in a 1 km resolution forecast, centred over the island of Saint-Louis, north of Venezuela.

Current Research

The current research includes, but is not limited to, the integration of in-situ, as well as remote sensing, observations into the forecasting system, which then are used to improve local, short-range forecasts (cf. Fig. 3).

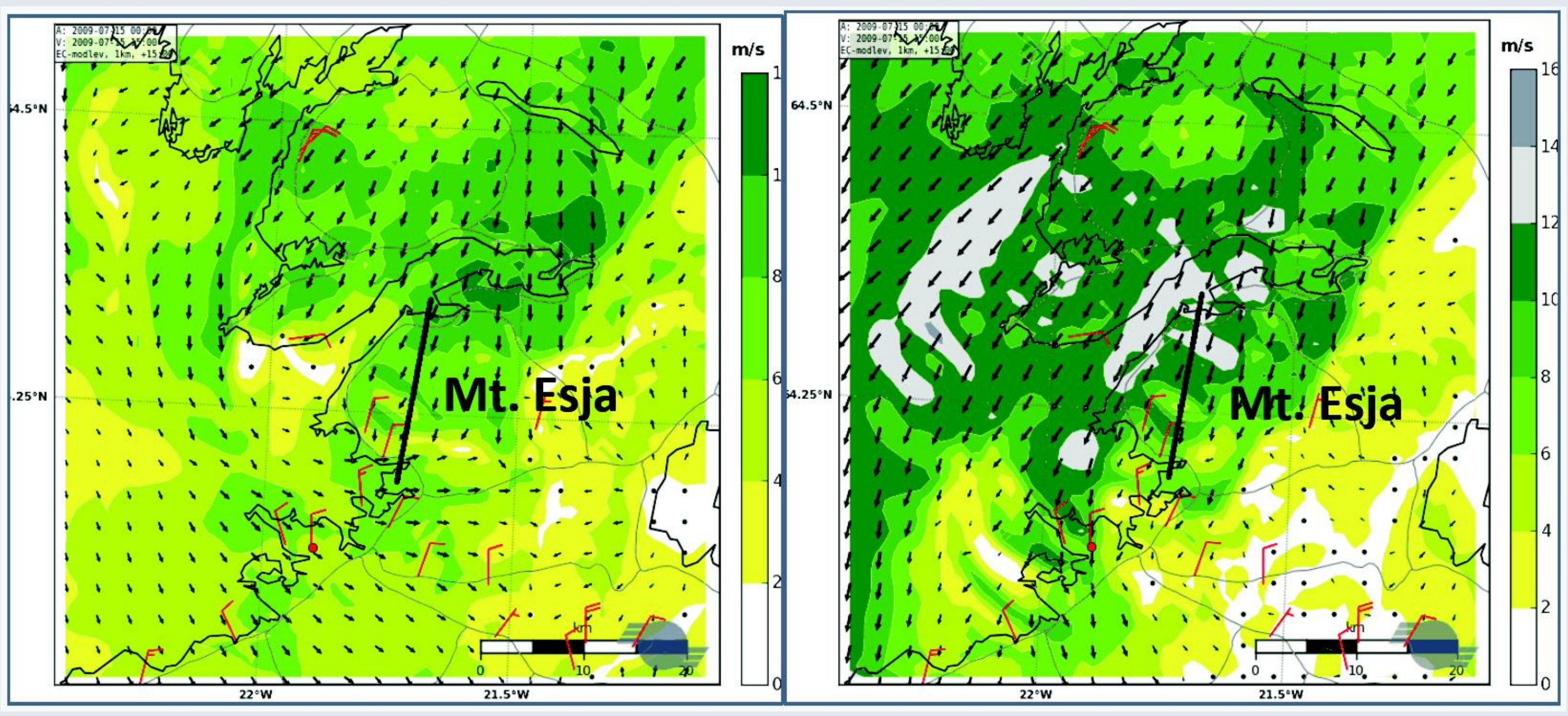

Figure 3: Simulated wind 10 metres, in a 1 km resolution forecast, centred over Reykjavík, Iceland. To the left is control forecast and to the right is a significantly improved forecast based on observational nudging (FDDA) from an unmanned aerial vehicle (UAV).

In view of the very promising improvements on high resolution simulations when combining observed profiles with the FDDA method, work is now being carried out to integrate this method with the SARWeather On-Demand forecasting system. A recent breakthrough was made when data from an UAV was successfully sent from the field via 3G modem (cf Fig. 4).

Figure 4: At 17 May 2012, during a field trip with the Icelandic Glaciological Society to the Mýrdalsjökull ice cap in South Iceland, four vertical profiles were taken. Photo B. L. Kristinsdóttir (left) and V. Leifsson (right)

Significant effort has also gone into preparing post-processing software to improve forecasts of primary weather parameters, including wind, based on observations from automatic weather stations. This includes software for statistical corrections of simulated winds.

Acknowledgements

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