General description of

Belgingur's Operational and On Demand Weather Forecasting System

With examples of deployment and usability

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BELGINGUR

Experts in high resolution weather forecasting

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Introduction

For over a decade Belgingur[1] has been dedicated to research in meteorology with special emphasis on numerical simulations of the effects of orography on atmospheric flow. With state of the art numerical weather prediction models, run on powerful computer clusters, our forecasts of precipitation, winds and temperature are becoming ever more detailed and reliable.

Belgingur has been a key player in research projects with universities, organizations and private companies in Norway, Finland, Faroe Islands, USA and other countries. This close collaboration is key to our ongoing success and commitment to provide our customers with the best weather forecasts possible.

Today, Belgingur is considered one of the technological leading companies in high-resolution weather forecasts, ensemble forecasting and dynamical downscaling of past, present, and future climate for any location worldwide.

In this document we give a short description of Belgingur's operational and On Demand weather forecasting system.

Background

Belgingur has been running operational high resolution forecasts[2] for Iceland and surrounding waters since 2004 and ensemble forecasts since 2009. Since 2008 Belgingur has further run operational forecasts for the Faroe Islands and W-Norway. In 2010 we started operating an On Demand forecasting system tailored to the needs of Search and Rescue operators worldwide. This system, called SARWeather[3], is operated on the Amazon EC2 cloud which insures both great scalability and operational reliability. SARWeather is used domestically by local SAR authorities as well as being used globally by the GDACS[4] consortium. GDACS is a cooperation framework between the United Nations, the European Commission and disaster managers worldwide to improve alerts, information exchange and coordination in the first phase after major sudden-onset disasters.

Research

Our main research focus has been on the effects terrain has on the local flow field and how we can improve flow simulations using atmospheric models. With regards to model improvements Belgingur collaborates with scientists at NOAA/ESRL in Boulder, mainly in the fields of planetary boundary layer physics, microphysics and

[1] http://www.belgingur.eu
[2] http://www.belgingur.is
[3] https://www.sarweather.com
[4] http://www.gdacs.org

Large Eddy Simulations (LES). We further have a good relationship with scientists at the University of Bergen, Norway, when it comes to the use of Unmanned Aerial Vechicles (UAV) in the lower boundary layer. Belgingur's research has shown that vertical profiles from UAVs can significantly improve the accuracy of the weather model[5].

Our most recent development is the installation of WRF-Chem to run operational forecasts for the dispersion of volcanic ash and SO_2 from an ongoing eruption in central Iceland (cf. Fig. 1). The model can also be used for general air-quality forecasts.

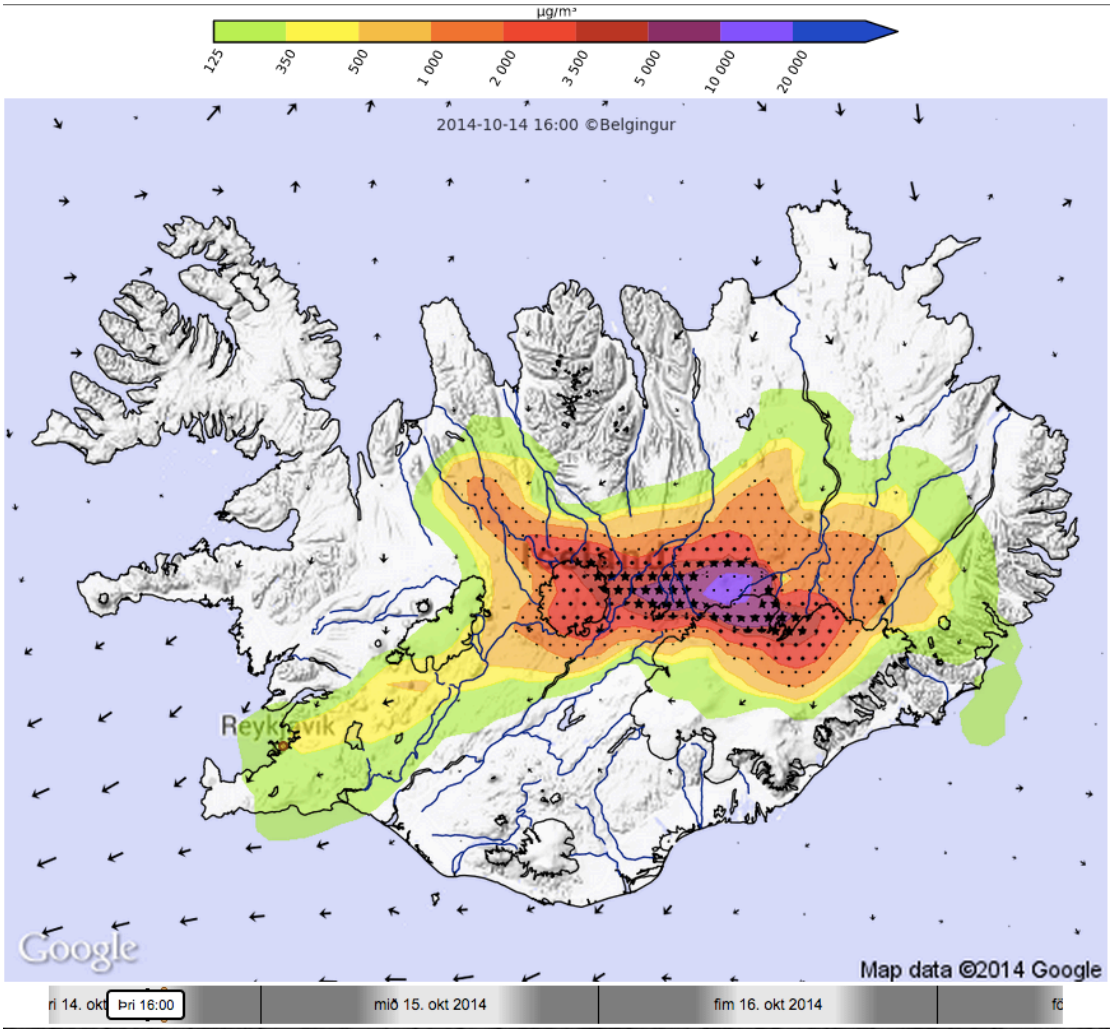

Figure 1: Estimated surface strength of SO_2 in µg/m3 (for values, see color bar on top of the graph) and distribution of volcanic ash (black stars and dots) from the Holuhraun eruption in central Iceland.

Belgingur is also involved with a volcanic research group consisting of scientists from Iceland, Germany, and Japan.

[5] http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-11-00344.1

System Description

The back-bone of Belgingur's forecasting suite is the latest version (currently V3.6.1) of the WRF-Chem atmospheric model, with a number of in-house customisations. Initial and boundary data are taken from the Global Forecasting System (GFS) operated by the National Oceanic and Atmospheric Administration (NOAA) in USA. Operational forecasts use cycling of a number of parameters, mainly deep soil and surface fields. This is done to minimize spinup effects and to ensure proper book-keeping of hydrological fields such as snow accumulation and runoff, as well as the constituents of various chemical parameters.

There are REST APIs[6] for launching forecasts similar to those created with SARWeather. This method can also be used for setting up recurring forecasts and explicitly triggering inactive recurrence rules. Forecasts can be viewed on-line[7] with an interface similar to SARWeather, forecasts can be embedded[8] in associated web applications, or the full model output data can be downloaded for custom processing. These APIs are constantly extended to support customer requirements as well as those of our internal systems.

Post-processing bias reduction solution

Belgingur has developed a linear regression method to improve point forecasts from a dynamical weather model using available observations of near-surface wind speed and temperature. The method identifies the best combination of nearby model grid cells to minimize the mean square difference of the forecast value with observations. Results from the Faroe Islands (for location, see Fig. 2) show that the Root Mean Square (RMS) error, for a forecast with a one day lead time, can be reduced by 38% for temperature and 45% for wind speed, (cf. Fig. 3). The Faroe Islands, with their rich and complex terrain, are located in the North Atlantic storm track. This combination gives rise to a very demanding environment for numerical weather models, an ideal ground to truly test the potential of Belgingur's forecast capabilities.

Figure 2: The geographical location and complex terrain of the Faroe Islands make it an ideal test bed for our forecast software suite.

[6] https://wod-int.belgingur.is/wod/api/1.0
[7] http://www.belgingur.is/map/island-gos.1.full/volcanic/2015-01-09T07:00+00:00
[8] http://demo.belgingur.is/embed-simple.html

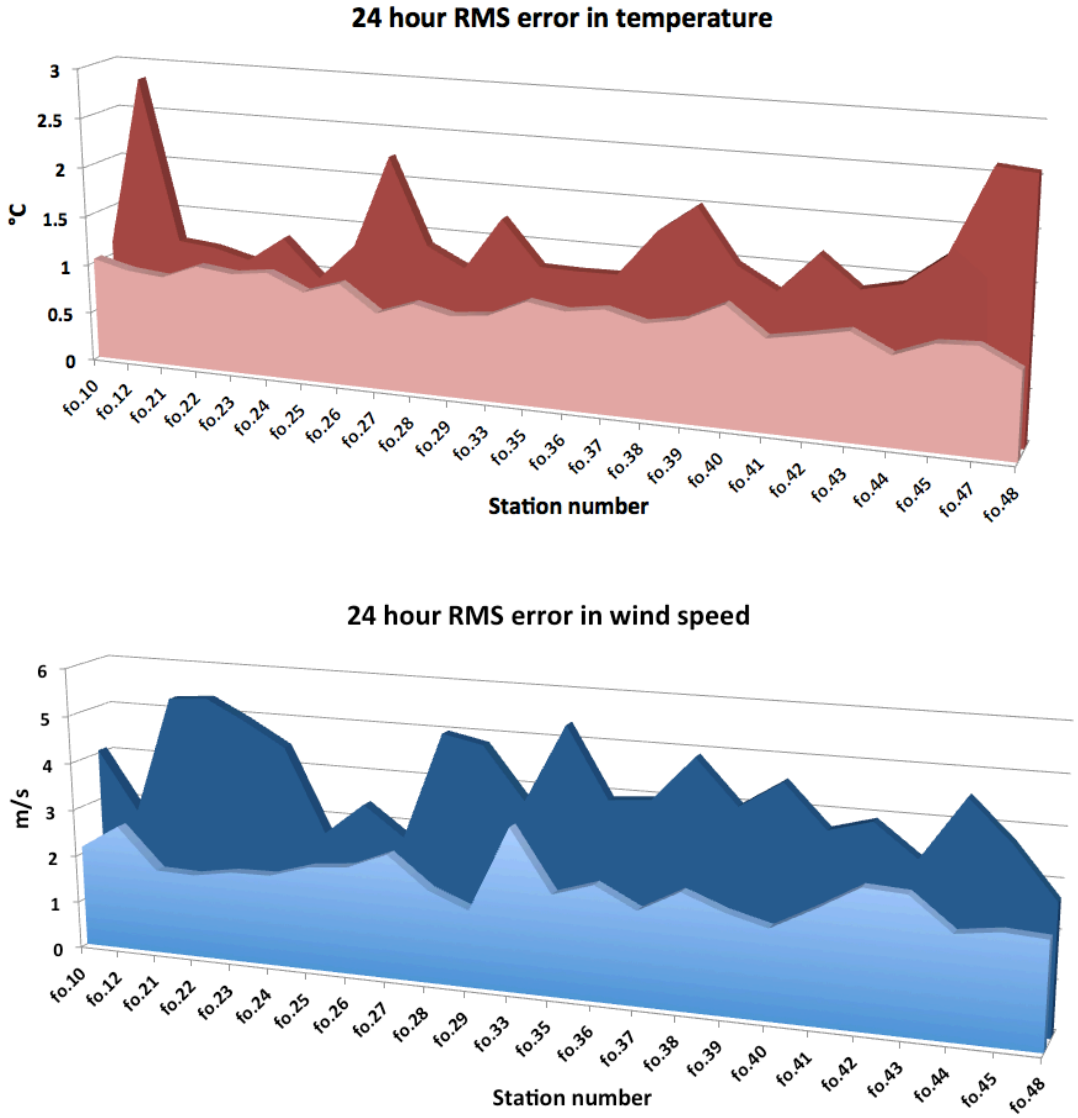

Figure 3: RMS error of a 24 hour forecast for temperature (top) and wind speed (bottom) for twenty-five weather stations in the Faroe Islands. On average, temperature bias is reduced from 1.6°C, using bilinear interpolation to the station location, to about 1°C when using the regression correction. For wind speed, the average error is reduced from 4 m/s to 2.2 m/s.

Wind Farm Forecasts and Optimization

Belgingur offers a range of medium to very high resolution wind forecasts that can be transformed into energy production estimates (cf. Fig. 4). These estimates can be optimized by using operational data through our linear regression method. The wind forecasts can also be adapted for direct use as input to existing wind power prediction software.

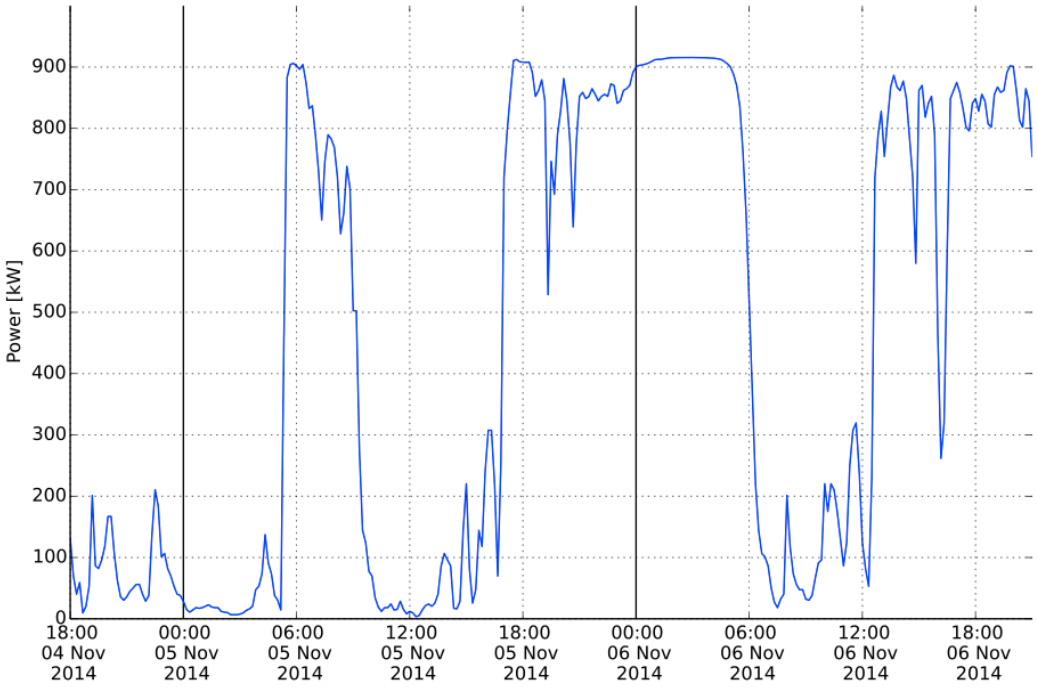

Figure 4: Example of a power production forecast for a 900kW Enercon wind-turbine.

As model resolution is increased, processes governed by the interaction of the large scale flow and the terrain become better resolved by Belgingur forecast models. This is of particular importance for wind farms located in complex topography or in the vicinity of water bodies and/or varying vegetation.

For even greater optimization and increased accuracy, the Belgingur forecasting system allows for the improvement of local wind forecasts by the use of remote sensing profiles, and/or in situ weather measurements from masts or UAVs.

Integration with third party software

One of the many strengths of Belgingur forecast solutions is how easily they can be integrated with existing decision support software. An example of this is shown in Fig. 5 where our forecasts are used by the SiteWatch™ tracking application system.

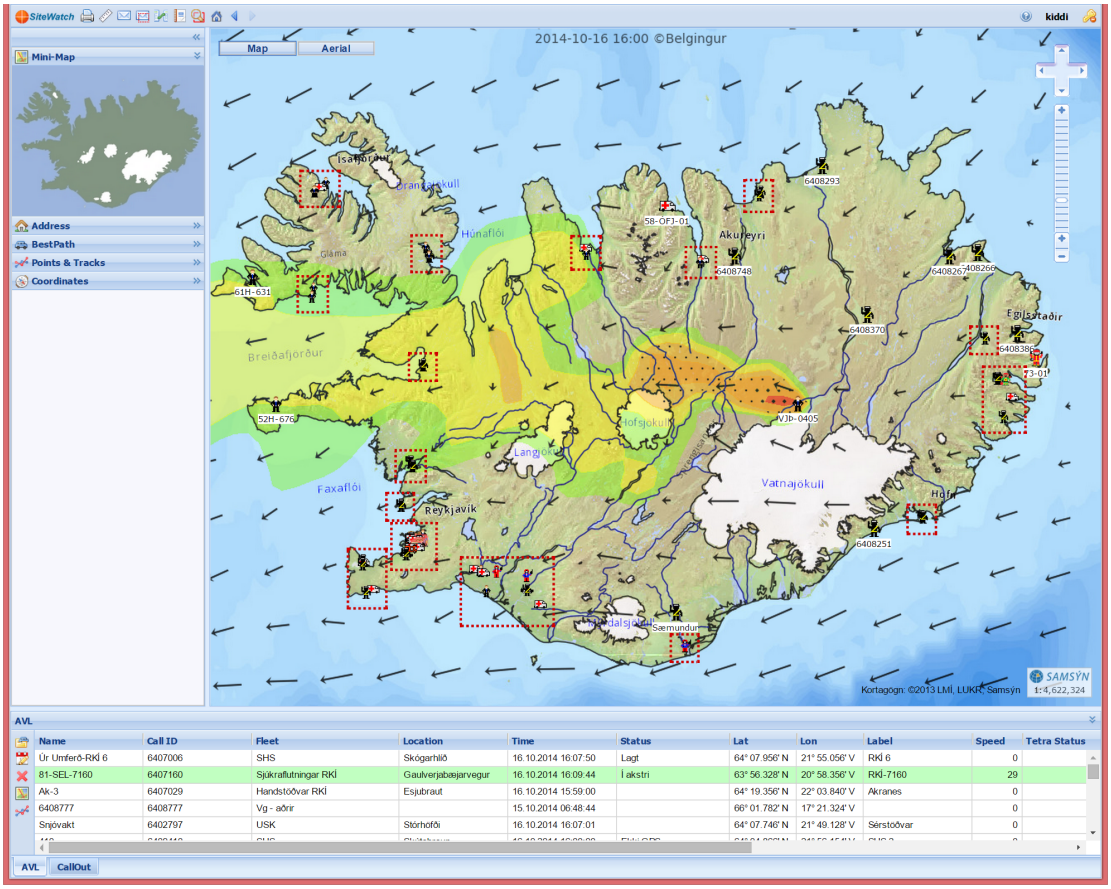

Figure 5: Example of how Belgingur forecasts are being visualized with the SiteWatch™ system.

SiteWatch™, developed by Samsýn Ltd.[9], is a fleet management system targeted for users operating in mission-critical environment. SiteWatch is a feature rich, multi-user and geographically enhanced (GIS) tracking application for any object on the move. It is designed especially for use in mission critical environment, an ideal match to Belgingur's operational and On Demand forecast solutions.

Way ahead

Belgingur is currently seeking new collaborators to further develop the companies forecast solutions, either as end-users or, preferably, as active co-developers.

[9] http://en.samsyn.is/