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SAFE-WEATHER: User Specified, Rapidly Produced, On-Demand, Very High-Resolution Numerical Weather Forecasts

Additional paper 2

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Safe-Weather

Safe-Weather is a system for producing user specified, on-demand, very high-resolution numerical weather forecasts for a small region and a short duration. Using just a single personal computer, Safe-Weather will produce forecasts quickly enough for an interactive user experience. Safe-Weather uses a publicly available version of the WRF model, and standard background meteorological data from the meteorological services.

Large Region Weather Forecasts

- National meteorological services collect diverse observational weather data from a distributed set of sources.
- The data sets are centrally stored. After processing for quality assurance and filtering, sets are routinely made available over the Internet to a large number of diverse users.
- Meteorological services have one or a few large data centers for computing numerical meteorological and oceanographic forecasts.
- A pre-selected set of result parameters from the forecasts are made available, either as standardized data files, or as ready made images for visualization.
- The spatial resolution of the most detailed forecasts are determined by the size of the forecast region, the forecast duration and the available compute resources.

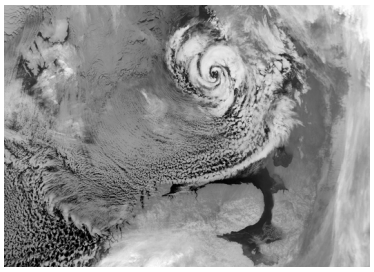

Figure 1. A Polar Low in the eastern Barents Sea. Photo NOAA.

Small Region High Resolution Weather Forecasts

- Weather and environmental conditions are challenging in northern areas.
- Operating in or near the sea ice edge will benefit from very high resolution models of both sea, atmosphere and sea-ice. Figure 1 is a picture of an actual Polar Low in the eastern Barents Sea, showing several small scale potentially challenging, features. Rapidly computing local very high resolution forecasts on-demand can be critical for safety and control of activities when operating in extreme environments.

Figure 5. The 22 Mpixel Tromsø Display Wall used to visualize the Earth

The HPDS research group

The High Performance Distributed Systems (HPDS) group is located at the Department of Computer Science at the University of Tromsø. The display wall laboratory is the cornerstone of the HPDS-group. The group's display wall is a wall-sized, high-resolution tiled display built using 28 projectors driven by a 28-node display cluster for a total resolution of 22 Mpixels.

http://hpds.cs.uit.no/

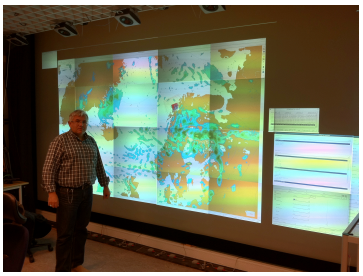

Figure 4. Using the 22 Mpixel tiled display wall for meteorological visualizations.

Drawbacks of todays approach

- The user is limited to the data collected by the national meteorological service which may not include locally observed data.
- Both access to observational and forecast data demands that the user must have Internet access whenever the data is needed.
- The user only has access to parameters and visualization determined by the meteorological services.
- The user is limited to the numerical models used by the meteorological services.
- All users receive the same spatial resolution.
- The spatial resolution is too coarse for some users.

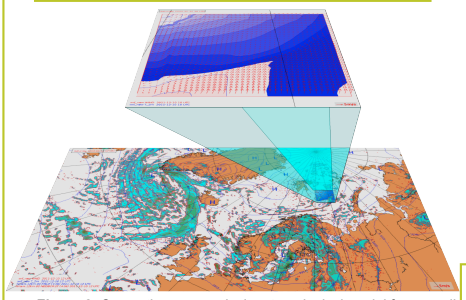

Figure 2. Computing a numerical meteorological model for a small area in the Barents Sea

Safe-Weather

- An extension to todays meteorological services
- A system for producing on-demand numerical weather forecasts. Using available background meteorological and geographical data.
- A prototype that produces a numerical forecast for any small area in 2-3 minutes.
- Area is selected by specifying the geographical center, and also the wanted spatial resolution. A typical scenario is illustrated in Figure 2.
- Position can be specified with a mouse click on a map, using the built-in GPS on a handheld device like the iPad, or using a simple web page form.

The Weather Research and Forecasting model, WRF.

The WRF model, *http://wrf-model.org,* is the current state-of-the-art numerical meteorological model. It is used extensively in national and private weather services for a range of operational and research purposes. The model provides multiple dynamical cores, a huge selection of possible physical modules and 3-dimensional (3DVAR) data assimilation system. WRF is fully parallelized for use multi-core and/or multi-node computers. WRF is suitable across scales ranging from meters to thousands of kilometers.

Safe-Weather, cont.

- A high end, multi-core, desktop computer will compute a numerical weather forecast. This is a typical current desktop computer
- The computations includes post-processing of the background meteorological and geographical data, computing the WRF model, and post-processing using the model output
- Current setup does not include local assimilation of observations. This is possible using the WRF model
- A locally computed numerical meteorological models provides access to a larger set of parameters.

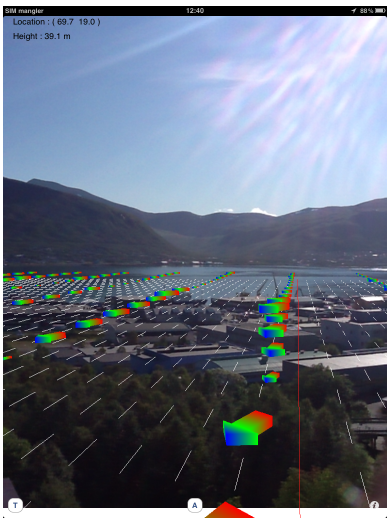

Figure 3. Meteorologcal data visualized on an iPad using augmented reality techniques.

Visualization in Safe-Weather

- Meteorological visualizations can be customized to the specific need of each user and each situation
- Safe-Weather prototypes use displays with size and resolution spanning several orders of magnitude
  - 0.6 Mpixel Smart-phone (iPhone)
  - 0.8 Mpixel Tablet (iPad)
  - 2 Mpixel personal computer
  - The 22 Mpixel tiled Tromsø Display Wall. Illustrated in Figure 4 and 5.
- On the iPad we can use both the built-in GPS for position and the camera for augmented reality type visualization of the model data. Figure 3.

Main results

We have created a prototype for running meteorological numerical models on-demand for a small user-selected area and timespan on Laptops or desktop computers. We have also created prototypes supporting visualization on two very different devices:

i. Visualizations produced for the Tromsø Display Wall, a wall sized 22 megapixel tiled display, enables both a regional overview and a high level of details at the same time.
ii. Meteorological and other data is visualized on a tablet with built-in GPS, compass and accelerometers. Safe-Weather overlays the camera image with the relevant weather visualization.