Ground-based remote sensing profiling and Numerical Weather Predicton model to manage nuclear power plants meteorological surveillance in Switzerland

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ABSTRACT

The meteorological surveillance of the four Swiss nuclear power plants is of first importance in such a densely populated country as Switzerland. The project "Centrales Nucléaires et Météorologie" CN-MET is providing a new security tool based on the development of a high resolution numerical weather prediction (NWP) model linked to a meteorological network instrumented with ground based remote sensing equipment. The NWP model is used to forecast the dynamics of the atmosphere in the planetary boundary layer over the Swiss Mittelland, using remote sensing instruments such as wind profilers and passive microwave radiometers for continuous wind and temperature profiling. The measuring sites of the network are located in such a way to generate the optimal database taken into account the topographical regional characteristics, to be assimilated in real time in the fine grid NWP model.

This decision making tool integrates the meteorological network and the fine grid NWP model and provides, at any time (e.g. starting from the initial time of a nuclear power plant accident), the best picture of the 24-hour evolution of air masses over the entire Swiss Mittelland. It is furthermore generating the necessary data input for the local dispersion model, the latter being specifically designed for each of the four nuclear power plants locations.

1. THE MEASUREMENT NETWORK

A combination of surface measurements and ground-based remote sensing techniques [1] constitutes the CN-MET observation network (see Figure 1).

The three low-tropospheric wind profilers combined with three microwave radiometers provide a continuous observation of the Planetary Boundary Layer dynamics over the Swiss Mittelland. These sites are located at three strategic locations within the region: at the two main boundary conditions of the domain, respectively corresponding to the in- and out-flow wind conditions over the Swiss Mittelland, and one in the center of the domain. The aerological radiosonde station in Payerne (the station located at the south western part of the domain) will furthermore provide the state of the atmosphere four times a day: twice with pressure, temperature, humidity and wind and twice with wind only. Four high towers in the surroundings of the nuclear sites are equipped with wind and temperature sensors, and bring an additional dataset for the validation of the model results.

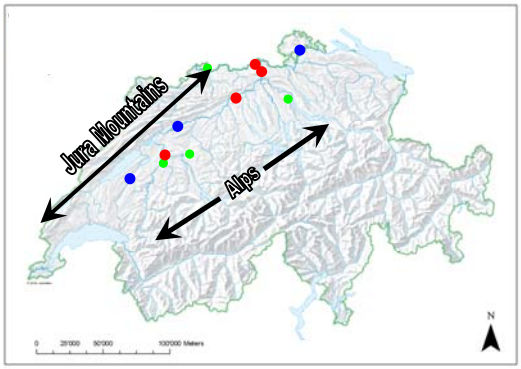

Figure 1. *CN-MET measurement network. Red dots correspond to the nuclear power plants locations with surface in-situ measurements, blue dots to the three upper-air ground-based remote sensing sites with low-tropospheric wind profiler and microwave radiometer, and green dots to in-situ measurements located on radio towers.*

2. THE MODELING PART

The COSMO model is the numerical weather prediction model of the Consortium for Small Scale Modelling (COSMO). MeteoSwiss uses this model in two configurations: COSMO-7 with a grid spacing of 6.6 km for the short-range forecasting over the next 72 hours, and COSMO-2 with a grid spacing of 2.2 km for nowcasting over the next 24 hours. The development of the higher resolution of COSMO-2 was in particular induced by the performance expected for the new CN-MET tool. Among many others, the Swiss COSMO-2 NWP model operationally assimilates wind profiler data from the strategic CN-MET observation network.

COSMO-7 uses the lateral boundary conditions from the Integrated Forecast System (IFS) provided operationally by the European Centre for Medium-Range Forecasts (ECMWF). A continuous assimilation cycle has been implemented, ingesting conventional surface observations as well as upper atmosphere soundings, aircrafts and wind profilers from the CN-MET and from the entire European network. Two daily 72 hours forecasts are calculated, based on the 00 and the 12 UTC analyses, with a 45 minutes cut-off time. At MeteoSwiss COSMO-7 is calculated on a 393×338 grid, with a grid size of about 6.6 km, on a domain covering most of Western Europe. COSMO-7 provides the lateral boundary conditions for COSMO-2 and has a grid size of about 2.2km. Its domain of 520×350 grid points

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is centered over the Alps. The operational configuration is described in Figure 2 and validation is presented in [2].

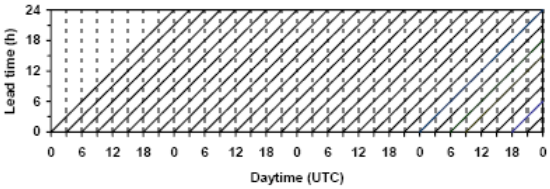

Figure 2.*Operational configuration of the COSMO-2 forecasts; each oblique line represents one forecast run. A new 24 hour forecast is started every three hours.*

3. EXAMPLE

The effect of continuously assimilating measurements and in particular wind profilers from the CN-MET network is improving the quality of the forecasts. An example of a cycle is shown in Figure 3. One can observe the progressive improvement of the forecast as time is going on. Finally, analysis fits very well wind profiler measurements. The effect of a specific system on the assimilation seems to have an increasing impact on the quality as we tend to go towards smaller spatial scales.

4. SUMMARY

The project CN-MET is in its final stage and the combination of a measurement network including three ground-based remote sensing stations (equipped with a low-tropospheric wind profiler and a microwave radiometer) and a fine-scale NWP model will ensure the meteorological surveillance of the Swiss territory for the unlikely case of a nuclear power plant accident. Assimilation of upper-air information improved substantially the quality of the forecasts, especially at the regional and local spatial scales.

Future work includes the model assimilation of temperature and water vapor measured with microwave radiometers as well as the passage to an even finer spatial scale (COSMO-1) to improve the forecasts in such a complex topography.

REFERENCES

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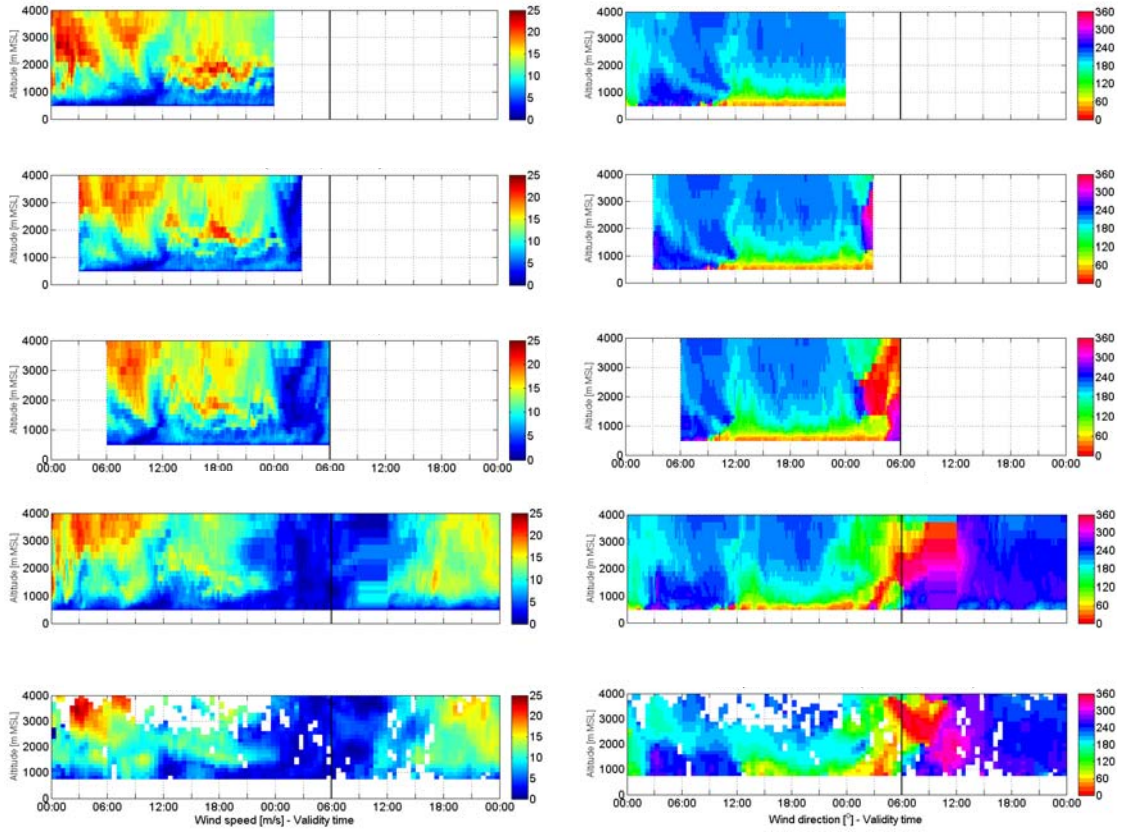

Figure 3.*COSMO 2 wind speed (left, in ms^{-1}) and wind direction (right, degrees) forecast for 30 November – 1 December, 2008. Three upper panels: 24h forecast initiated every 3 hours; fourth panels: analysis with wind profiler assimilation; fifth panels: wind profiler measurements.*