Emissions and dispersion from Nikel smelter

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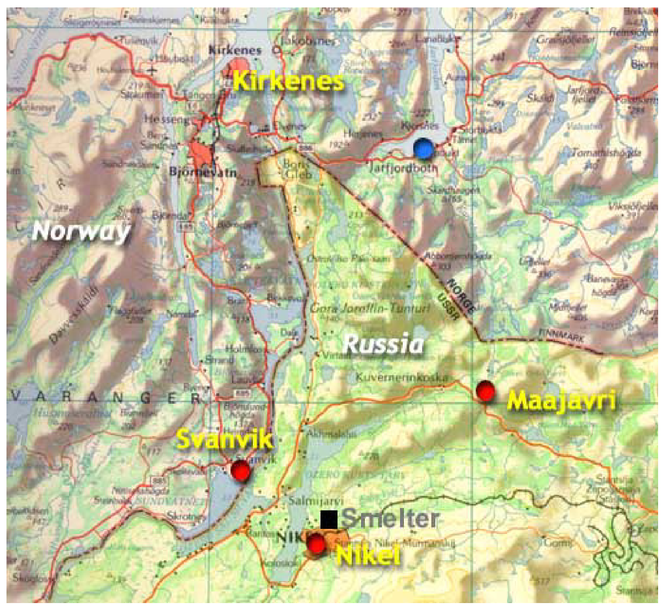
Introduction and motivation:

The soil in the Paz valley at the Norwegian-Russian border contains large amounts of valuable heavy metals, especially nickel. Since the 1930s there are substantial mining and metallurgical activities taking place in the area, especially in the Russian cities of Nikel and Zapolyarny. These activities will inevitably emit pollution to air. Due to high sulphur content in the soil there are substantial emissions of sulphur dioxide (SO_2), in addition to emissions of heavy metals. Although the emissions have been reduced considerably since the 1970s, the smelter in the city of Nikel still emits about 100,000 tonnes of SO_2 per year. A large proportion of the pollutants are emitted from the buildings (diffusive emissions).

Map showing the Norwegian-Russian border areas. The locations of the city of Nikel and the smelter, Svanvik monitoring station (Norway), city of Kirkenes (Norway) and the Russian monitoring station Maajärvi, are indicated. The NILU monitoring station in the city of Nikel is closed at the moment.



The Nikel smelter and the city of Nikel seen from Height 96 (Norway) 19 June 2008. Plumes from stacks as well as diffuse emissions from the buildings are clearly seen. Northerly wind brings the flue gas from the smelter towards the city. Hourly concentrations of SO_2 in the city of Nikel were about 1500 µg/m^3 when the photo was taken.

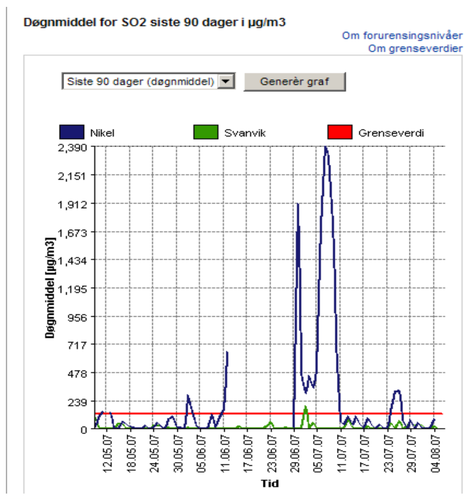
WRF-Chem model setup:

In this study, the WRF-Chem model (**W**eather **R**esearch and **F**orecast model with chemistry scheme included) has been used to investigate the emissions and dispersion from the Nikel smelter and its environmental impact. As a first test the model was run in a multiple nesting mode with grid resolutions at 1×1 km^2, 5×5 km^2, 25×25 km^2 respectively, the grid being cantered around the Nikel smelter. Both SO_2 and nickel were studied, and concentrations and deposition were sampled.

Some specific model modifications and parameterisations had to be made:
Emissions:}
1/3 of the flue gas was emitted from layer 1 (0-57 m) to account for diffusive emissions, and 2/3 from layer 3 (138-245 m) to account for emissions from the tall stacks.
Oxidation of SO_2 to H_2SO_4:
To account for the oxidation of SO_2 to H_2SO_4 a lifetime of 10^5 s was assumed. A lifetime for SO_2 of about a day is in accordance with our previous model results using the OsloCTM2 model.
Wet deposition:
From the WRF model the Liquid Water Content (QCLOUD) and precipitation rate (PRECR) are known. Using these two parameters and the concentrations of SO_2 and H_2SO_4 the wet deposition of sulphur was parameterised.
Modelling of nickel:
Nickel was included as a tracer, assuming some nickel is hydrophobic and some is hydrophilic. A lifetime of 10^5 s for conversion from hydrophobic to hydrophilic nickel was assumed.
Test run:
WRF-Chem is computationally very demanding. We present here results from a test run covering the period from 3. -13 July 2007.

Summer episode 2007:

In 2007 there wsa period during summer (11 June to 11 July) with very strong emissions and stable meteorological conditions. Maximum daily concentration of SO_2 in Nikel was 2390 µg/m^3 during this particular period. For the test run the period from 3 -13 July 2007 was investigated. This was at the end of the summer episode.



Observations from the NILU monitoring station in Nikel (now closed), daily mean concentrations of SO_2, June-July 2007.

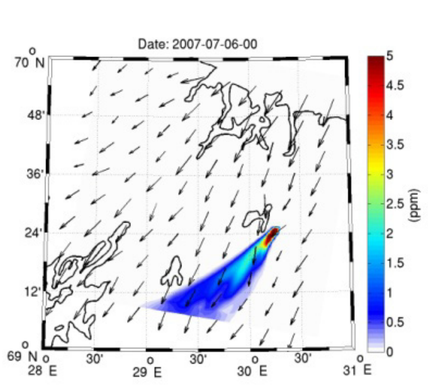
Results:

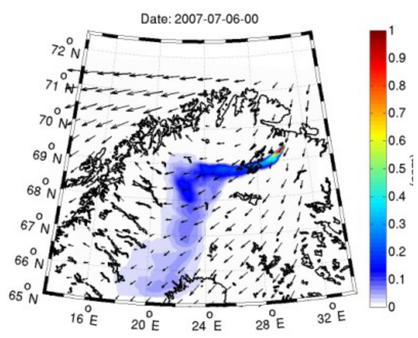
Here the results for WRF-Chem 5 July 2007 at midnight are shown. The plots show total sulphur, i.e. the sum of SO_2 and H_2SO_4 for the 11 lowermost layers (unit ppm). Results for the three different grid resolutions are displayed. The arrows indicate wind direction at the ground. Please note different scale for the different plots.

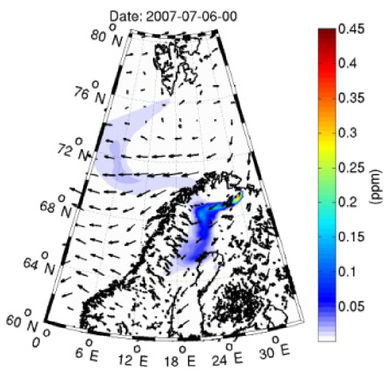
Innermost grid (1×1 km^2 grid boxes, left panel)
This is the local grid covering 100×100 km^2. These results will be compared with the Norwegian monitoring station at Svanvik, and with the station in the city of Nikel (still in operation in 2007). Preliminary analysis shows that the model is able to reproduce the overall level and specific episodes, although somewhat shifted in time and space.

Second grid (5×5 km^2 grid boxes, mid panel)
This is the regional grid covering the North Calotte. These results show that emissions from the Nikel smelter are transported several hundred kilometres away before it is deposited.

Outermost grid (25×25 km^2 grid boxes, right panel)
The outermost grid covers the Northern countries plus the Norwegian Sea and Barents Sea up to Svalbard. The regional dispersion is seen, but also some transport into the Arctic occurs.







These results are also presented as movies showing clearly the dispersion from Nikel. The movies can be downloaded from:
http://folk.uio.no/torefl/WRF-Chem/Domene1_SO2-SO4_delay10.gif
http://folk.uio.no/torefl/WRF-Chem/Domene2_SO2-SO4_delay10.gif
http://folk.uio.no/torefl/WRF-Chem/Domene3_SO2-SO4_delay10.gif

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