Long-Term Dispersion Modelling of Atmospheric Pollution Transport and Deposition and Assessment for Middle and Northern Latitudes

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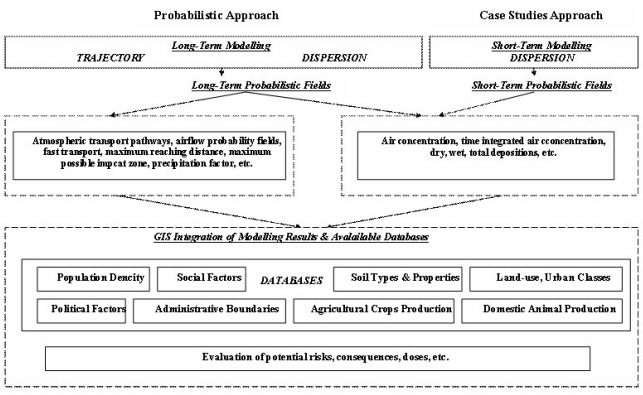
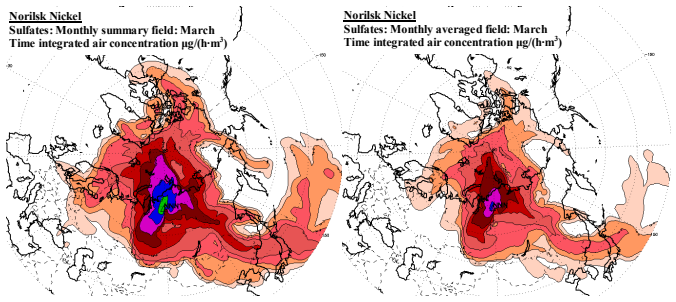
Abstract

The results of the long- and short-term trajectory and dispersion modelling of atmospheric transport, dispersion, and deposition of different pollutants from multiple sources of potential pollution in the Northern Hemisphere at hemispheric, regional, and meso-scales are presented and discussed. The potential impact of atmospheric pollution in middle and northern latitudes is evaluated.
The 3D meteorological fields used to drive simulations are based on outputs of the NCAR/NCEP (National Center for Atmospheric Research/ National Center for Environmental Prediction), ECMWF (European Center for Medium-range Weather Forecast), and HIRLAM (HIgh Resolution Limited Area Model) numerical weather prediction models. The fields have been used to calculate atmospheric transport, dispersion, and deposition of different pollutants from multiple sources of potential pollution in the Northern Hemisphere. Both the results of the trajectory (using the HYSPLIT model – HYbrid Single-Particle Lagrangian Integrated Trajectory model) and dispersion (using the DERMA model – Danish Emergency Response Model for Atmosphere) modelling are used for estimation of different levels of impact, consequences, risks, etc. on environment and population of the studied geographical regions.
The presented results are included as the Chapter 2 "*Long-term atmospheric transport and deposition of pollutants and evaluation of their impact in middle and high latitudes of the Northern Hemisphere*" (by Mahura A., Baklanov A., Rigina O.) into the monografia entitled "*Modelling of Atmospheric Transport and Deposition of Pollutants and Evaluation of Consequences for Arctic*".

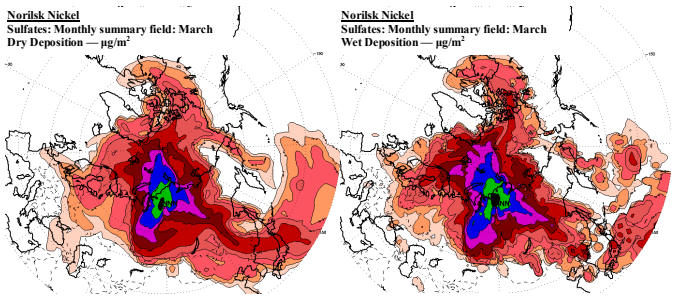


Evaluation of risks &consequences based on results of trajectory & dispersion modelling.



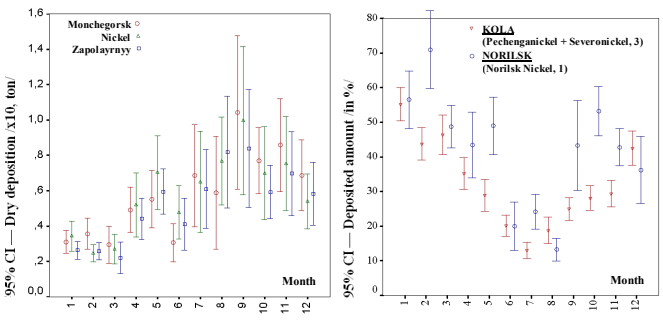
(a) *(b)*

March (a) summary and (b) average time integrated air concentration of sulphates due to continuous emissions from the Norilsk smelters (isolines are shown starting from 1e-4).



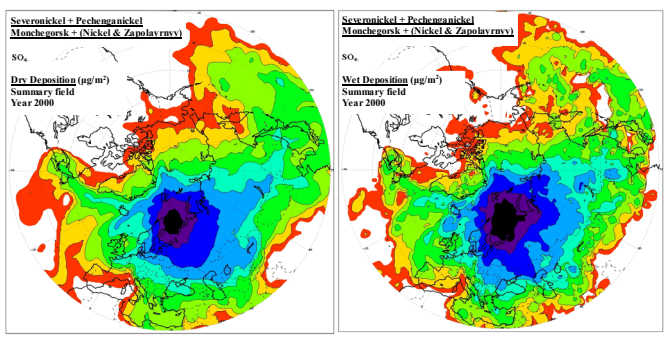
(a) *(b)*

March summary (a) dry deposition and (b) wet deposition of sulphates due to continuous emissions from the Norilsk smelters /isolines are shown starting from 1e-4/.



(a) *(b)*

Month-to-month variability of (a) dry deposition during atmospheric transport from the Severonickel (Monchegorsk) and Pechenganickel (Nickel and Zapolayrnyy) enterprizes; and (b) deposited amount of sulphates (in percentage of daily released) during atmospheric transport on regional scale from the Cu-Ni smelters of the Kola and Norilsk regions.



(a) *(b)*

Annual summary patterns of the (a) dry and (b) wet deposition as a result of continuous emissions from the Severonickel (Monchegorsk) and Pechenganickel (Nickel and Zapolayrnyy) smelters /isolines are shown starting from 0.01/.

DISPERSION MODELLING FOR PROBABILISTIC EVALUATION OF ATMOSPHERIC TRANSPORT AND DEPOSITION OF POLLUTANTS

1. General approach

2. Long-term dispersion modeling
   Dispersion model
   Meteorological model and meteorological data
   Modelling of atmospheric transport and deposition of pollutants

3. Probabilistic analysis based on results of dispersion modelling
   Summary and averaged time integrated air concentration
   Summary and averaged dry and wet deposition

LONG-TERM DISPERSION MODELLING AND ANALYSIS OF IMPACT FROM NUCLEAR AND CHEMICAL RISK SITES ON DIFFERENT GEOGRAPHICAL REGIONS

1. Nuclear and chemical risk sites

2. Evaluation of long-term atmospheric transport and deposition of pollutant from the Cu-Ni smelter of the Russian North
   Sources of emissions
   Local
   Regional

3. Evaluation of potential impact from the Cu-Ni smelters
   North-West Russia
   Arctic territories of Russia and Greenland
   Ural and Siberian federal districts

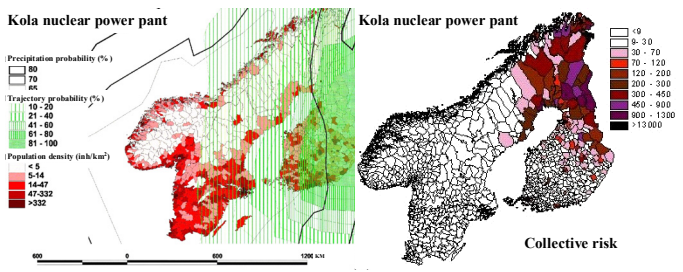
4. Evaluation of potential impact from the Semipalatinsk nuclear testing site and accidental oil spills in the Caspian Sea region

5. Evaluation of potential impact comparing DERMA vs. K-model

6. Evaluation of potential impact using sensitivity functions
   Combined analysis of probabilistic fields of atmospheric transport for estimation potential source-receptor relationship
   Estimation of sensitivity functions for regions with functionals

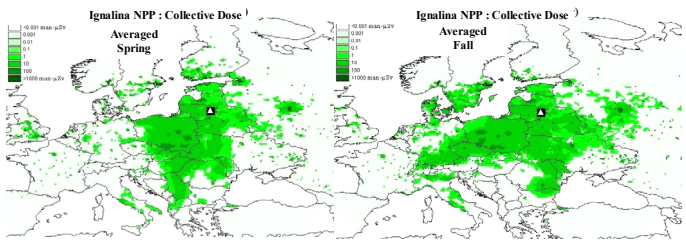
7. Evaluation of potential impact based on monitoring of the Kr and Xe radionuclides in the North-West Russia

GIS INTEGREATION OF DISPERION MODELLING RESULTS FOR EVALUATION OF POTENTIAL IMPACT



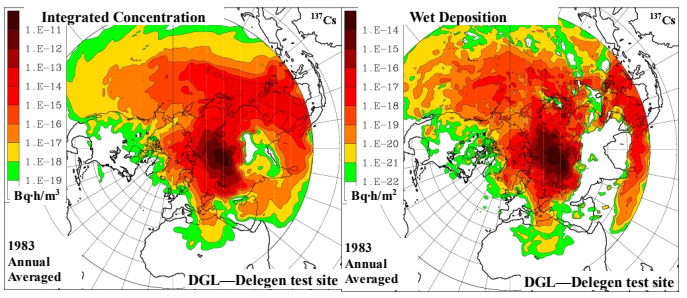
(a) *(b)*

Example of using results of (a) trajectory and (b) dispersion modeling through GIS integration for evaluation risks for the population and environment (from hypothetical accidental releases from the Kola nuclear power plant).



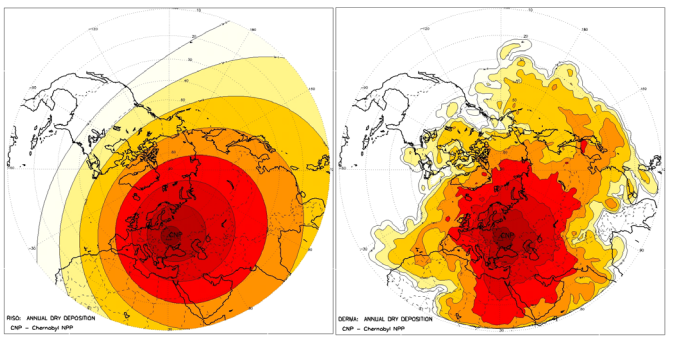
(a) *(b)*

Seasonally - (a) spring and (b) fall - averaged collective doses resulted from the hypothetical accidental releases from the Ignalina nuclear plant (Lithuania) /estimated based on GIS/.



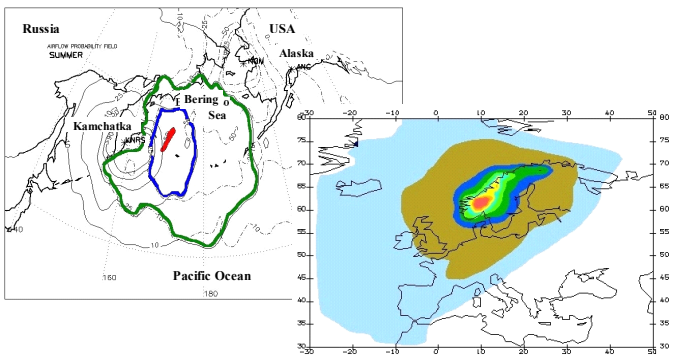
(a) *(b)*

Annual (year of 1983) averaged (a) time integrated air concentration and (b) wet deposition of ^{137}Cs for the Delegen test site (Semipalatinsk polygon, Republic of Kazakhstan).



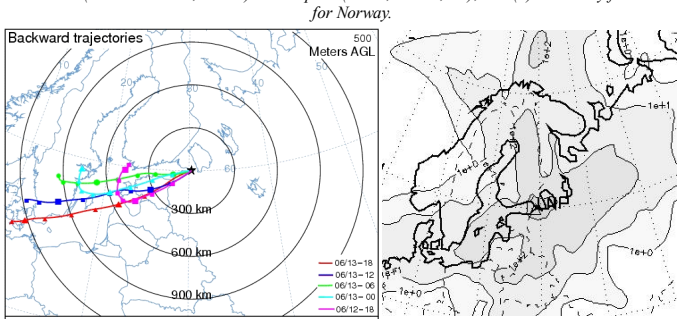
(a) *(b)*

Annual averaged dry deposition of ^{137}Cs from the Chernobyl nuclear plant (Ukraine) simulated using (a) K-model and (b) DERMA model.



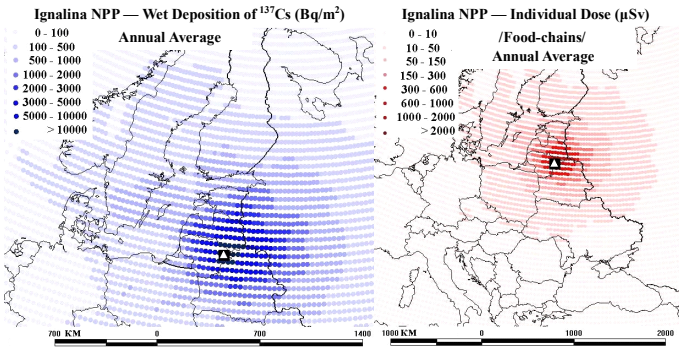
(a) *(b)*

(a) Combined seasonal (summer) probabilistic fields of airflow patterns or sensitivity functions for source (Kamchatka site, Russia) vs. receptor (Nome, Alaska, US); and (b) Sensitivity functions for Norway.



(a) *(b)*

(a) Backward trajectories for elevated concentrations of ^{133}Xe at the St. Petersburg (Russia) measurement site /60.01°N, 30.33°E/ on 13 Jun 2007, 06 UTC (±6 and ±12 h); and (b) April dominating patterns of time integrated air concentration resulted from unit hypothetical accidental release at the Leningrad nuclear plant.



(a) *(b)*

(a) Results of GIS integration of annual averaged wet deposition of ^{137}Cs; and (b) calculation (using GIS) individual doses for food-chains resulted from the hypothetical accidental releases from the Ignalina nuclear plant (Lithuania).

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