Advanced Atmospheric Modeling

SRNL's Atmospheric Technologies Group (ATG) develops, adapts and applies advanced atmospheric models of contaminant fate and transport in support of national security customers in emergency response and nuclear non-proliferation. These applications require versatile configurations, with model scales ranging from global (1000's of kilometers) to local (100's of meters). Resources include both the Regional Atmospheric Modeling System (RAMS) and the Weather Research and Forecasting Model (WRF), which predict the high resolution meteorological fields needed to simulate contaminant transport and dispersion with models such as the Hybrid Single-Particle Lagrangian Trajectory (HYSPLIT) model and the Lagrangian Particle Dispersion Model (LPDM). Additional models include HPAC, SCIPUFF, and FLEXPART. Global, real time data for model initialization is available through the National Weather Service's NOAAPort service.

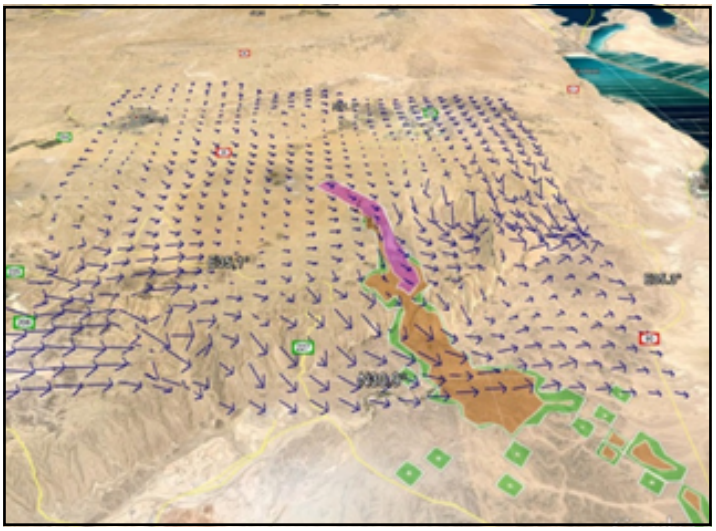
Ongoing Applications

Nuclear Nonproliferation

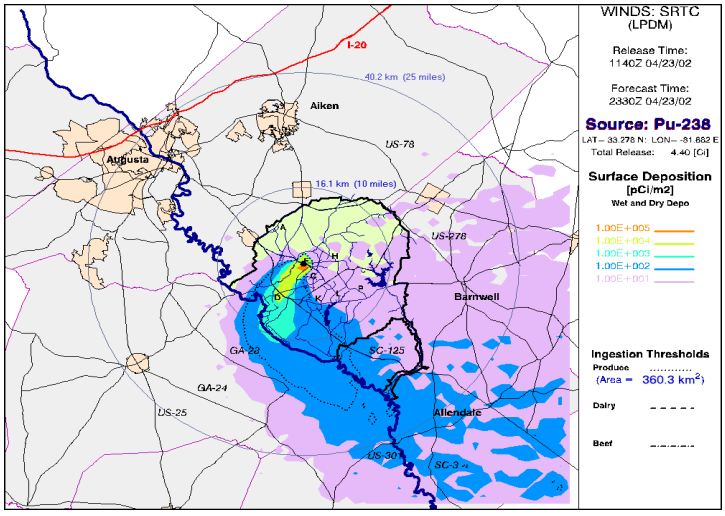
The ATG generates daily forecasts of contaminant transport for pre-defined regions worldwide. The results are used to develop collection strategies for detecting radiological signatures of interest using fixed or mobile samplers, and relate the observed signatures to emissions from nuclear facilities. ATG has streamlined operational protocols to quickly 'spin up' predictions for rapid deployment in other locations, sometimes with little notice, to support a customer's emerging needs. For example, our 2 day forecasts of noble gas transport produced immediately following the Fukushima-Daiichi nuclear power plant disaster in March 2011 enabled the successful deployment of test samplers more than 1000 km from the power plant. Predictions were later confirmed against measurements conducted by the Comprehensive Test Ban Treaty Organization (CTBTO), and Environmental Protection Agency (EPA).

Emergency Response

Model forecasts for the Savannah River region are run up to 8 times daily. Deterministic results from RAMS and WRF, or from a WRF ensemble mean, are used with LPDM to determine the regional consequences of an unplanned radiological release. Output used for emergency response includes the amount of contaminant deposited on exposed surfaces, which is used to identify areas where contaminated agricultural products exceed U. S. Food and Drug Administration (FDA) thresholds for ingestion.

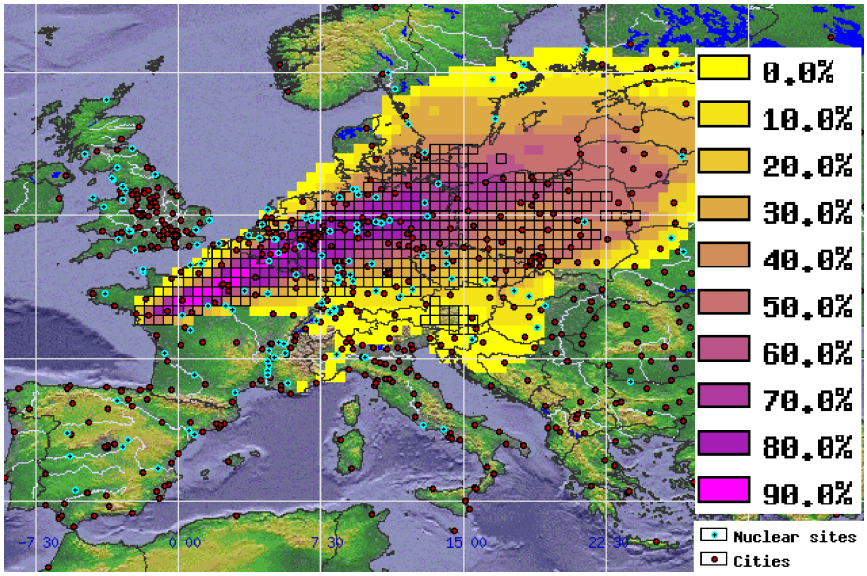


Wind field and plume predictions over an area of complex terrain

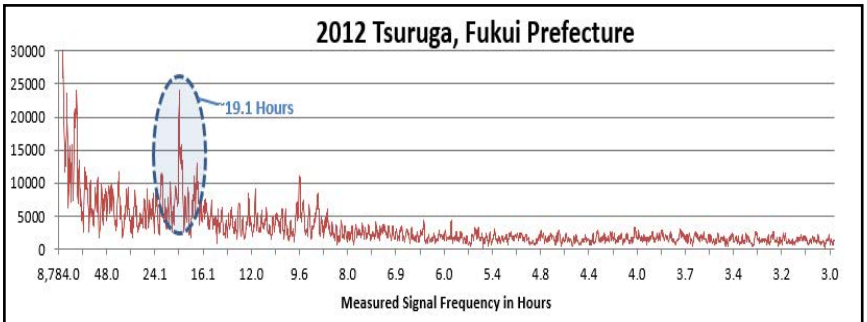


Model predicted ground level contamination annotated with areas exceeding FDA intervention levels.

For many years, ATG's advanced modeling system has participated in the European Union's ENSEMBLE program. EMSEMBLE provides a web-based framework for reconciling natural variability in model predictions through statistical methods. For example the figure, directly below, depicts ensemble results from modeling a tracer release in northeastern France, expressed as the percent agreement among models for surface concentrations exceeding a threshold concentration 4 days after the initial release (The SRNL results are shown as the cross-hatched area). ATG continues to increase utilization of model ensembles to improve quantification of model uncertainties in customer applications.



Percent of models predicting air concentrations above threshold during ENSEMBLE. SRNL's RAMS/LPDM prediction shown by hatched area.



Results from a Fourier analysis of radiological measurements collected an air monitoring station in Japan. The strong spectral peak at 19.1 hours signifies the detection of a plume from a South Korean nuclear power plant.

Advanced Research and Development

Ongoing research has resulted in the application of advanced statistical analyses of air monitoring data, combined with atmospheric transport modeling, to reduce ambiguity in identifying signatures of nuclear facility effluents. Fourier analysis, wavelet analysis and Bayesian statistics can exploit the general temporal and spatial behaviors of an effluent plume to successfully isolate signatures in measurement time series, and identify likely source locations and amounts. In addition, ATG is actively involved in field studies that are, in part, intended to optimize field measurement protocols (i.e, sample locations and duration) in a way that improves the harmonization of measurements with high resolution simulations of facility effluent to improve confidence in source estimates for national security customers.

For more information contact:

Dr. Robert Buckley, Senior Fellow Scientist
SRNL Atmospheric Technologies Group
robert.buckley@srnl.doe.gov
(803) 725-1926

January 2020 SRNL-IM-2020-00014