Preliminary Accident Simulations with NAME

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Brief Description of NAME model setup for Fukushima Accident Simulations

- Meterological model 1: Met Office Unified Model - Global
  - Type of data: Analysis
  - Horizontal Resolution: $0.3515625°$ longitude by $0.234375°$ latitude
  - Vertical Resolution: 70 levels up to $80km$
  - Temporal Resolution: 3 hourly
- Meterological model 2: European Centre for Medium-range Weather Forecasting (ECMWF) Operational Meteorology
  - Type of data: Analysis
  - Horizontal Resolution: $0.125°$ longitude by $0.125°$ latitude
  - Vertical Resolution: 55 levels up to $\sim 90hPa$
  - Temporal Resolution: 3 hourly
- ATDM: NAME (Numerical Atmospheric-dispersion Modelling Environment)
  - Number of Lagrangian particles: 100k/hr
  - Number of species: 3 (NGAS, LPAR, DGAS)
  - Source strength: 1 Bq/hr
  - Release location: $37.4206°$N $141.0329°$W
  - Release height: 0-100 m AGL for Met Office model and 100m AGL for ECMWF model
  - Vertical distribution: Uniform
  - NAME model time step: 10 minutes

Type	Species Name	Dry Deposition	Wet Deposition	Radioactive Decay	Gravitational Settling	Surrogate for
Gas	NGAS	No	No	No	No	Noble gases
Gas, depositing	DGAS	$R_c = 150$, $R_B = \frac{8}{u*}$	Yes	No	No	^{131}I
Light Particle	LPAR	$R_c = 0$, $R_B = \frac{300}{u*}$	Yes	No	No	^{131}I, ^{137}Cs

Table 1: Species used in NAME model runs. R_c is surface resistance and R_B is laminar resistance. a longer description of the dry deposition scheme is given in the second half of this document.

- Output Details
  - Output time step: 3 hourly
  - Forecast time : 72 hours from each 3 hour release
  - Output 1: Air concentration averaged between 0 and 100m agl and averaged over each 3-hour time period
  - Output 2: Total deposition (wet and dry) integrated over each 3-hour time period

	X	Y
Grid Origin	$125.0250°$ E	$28.02500°$ N
Number grid cells	600	400
Resolution	0.05	0.05

Table 2: Output Grid Details

Short overview and description of NAME and physical removal processes

NAME (Numerical Atmospheric-dispersion Modelling Environment) is a Lagrangian particle dispersion model used to model the atmospheric transport and dispersion of a range of gases and particles [2, 1]. It was originally developed to model the transport of radioactive material following the Chernobyl accident but now has a wide range of applications including simulating releases of hazardous materials (chemical, biological, radiological and nuclear), modelling the transport of ash clouds from volcanic eruptions, disease spread, air quality forecasting, analysis of air pollution episodes and identifying source locations and source strengths.

In NAME, large numbers of model particles are released into the model atmosphere and each model particle represents a certain mass of the material (gases or aerosols) being modelled. Model particles are advected within the model atmosphere by input three-dimensional winds from numerical weather prediction models and turbulent dispersion is simulated by random walk techniques. Gravitational settling of heavy particles and loss processes, such as wet and dry deposition processes, radioactive decay and chemical transformations, are included if appropriate.

Dry Deposition

Dry deposition is modelled in NAME using the concept of the deposition velocity, v_d [5]. The flux of pollutant to the ground, F, is proportional to the concentration, C, of pollutant and is given by

$$F = v_d C,$$

where v_d is the constant of proportionality. The deposition velocity can either be specified by the user or is calculated using a resistance analogy

$$v_d = \frac{1}{R_a + R_b + R_c},$$

where R_a is the aerodynamic resistance, R_b is the laminar layer resistance and R_c is the surface resistance. The aerodynamic resistance represents the efficiency with which material is transported to the ground by turbulence and is independent of the material. The laminar layer resistance is used to specify the resistance to transport by diffusion across the thin quasi-laminar layer adjacent to the surface. Different parameterisations for R_b are used for gases and particles. The surface resistance characterises the resistance to capture by the surface and is dependent on both the pollutant and the underlying surface. For particles, the surface resistance is taken to be zero. For gases, a fixed surface resistance can be specified by the user or, for a selection of gases, a complex land use dependent surface resistance parametrisation can be invoked.

Wet Deposition

The removal of material from the atmosphere by wet deposition is based on the depletion equation

$$\frac{\mathrm{dC}}{\mathrm{dt}} = \Lambda C,$$

where C is the air concentration and Λ is the scavenging coefficient. The scavenging coefficient is given by

$$\Lambda = Ar^B,$$

where r is the rainfall rate (in mm hr^{-1}) and A and B are coefficients which vary for different types of precipitation (i.e., large-scale, convective, rain or snow) and for different wet deposition processes (i.e., rainout, washout and the seeder-feeder process) (see Table 3) [2]. Within NAME, wet deposition due to convective and large-scale precipitation are computed separately and summed to give total wet deposition. Material located above the cloud top is not subject to wet deposition. Enhanced wet deposition (due to the seeder-feeder process) is applied to material close to the ground in elevated orographic regions. Meteorological data (cloud, precipitation, etc.) was taken in this study from the global version of the Met Office's numerical weather prediction model (the Unified Model) with a horizontal resolution of about 25 km in mid-latitudes and the operational version of the European Centre for Medium-range Weather Forecasting model with a horizontal resolution of 0.125 degrees.

	Rain		Snow/Ice	
	Large-scale	Convective	Large-scale	Convective
Orographic enhancement (seeder-feeder)	$A = 3.36 \times 10^{-4}$ $B = 0.79$	$A = 3.36 \times 10^{-4}$ $B = 0.79$	$A = 1.0 \times 10^{-3}$ $B = 0.79$	$A = 1.0 \times 10^{-3}$ $B = 0.79$
Below-cloud (washout)	$A = 8.4 \times 10^{-5}$ $B = 0.79$	$A = 8.4 \times 10^{-5}$ $B = 0.79$	$A = 8.0 \times 10^{-5}$ $B = 0.305$	$A = 8.0 \times 10^{-5}$ $B = 0.305$
In-cloud (rainout)	$A = 8.4 \times 10^{-5}$ $B = 0.79$	$A = 3.36 \times 10^{-4}$ $B = 0.79$	$A = 8.0 \times 10^{-5}$ $B = 0.305$	$A = 3.36 \times 10^{-4}$ $B = 0.79$

Table 3: Scavenging coefficients used in NAME

Gravitational settling

Gravitational settling of heavy particles is modelled in NAME using the concept of a sedimentation velocity, w_{sed}. The sedimentation velocity is dependent on the particle's diameter and density and a distribution of particle sizes can be represented within NAME with a corresponding distribution of sedimentation velocities. The sedimentation velocity is calculated using the Reynolds number dependent drag coefficient given by Maryon et al. [2] with the Cunningham correction applied for small particle sizes [3] and is combined with the dry deposition velocity in the absence of sedimentation v_d to give a total dry deposition velocity v_d' using the method given by Underwood [4] as described in Webster and Thomson [5],

$$v_d' = \frac{w_{sed}}{1 - \exp\left(-\frac{w_{sed}}{v_d}\right)}.$$

References

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[3] Pruppacher, H.R. and J.D. Klett (1999). Microphysics of clouds and precipitation. *2nd edition*. Kluwer, Dordrecht.

[4] Underwood, B.Y. (1999). A review of dry and wet deposition, *AEAT-5382*, AEA Technology plc, UK.

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