The impact of high time resolution meteorology on dispersion models

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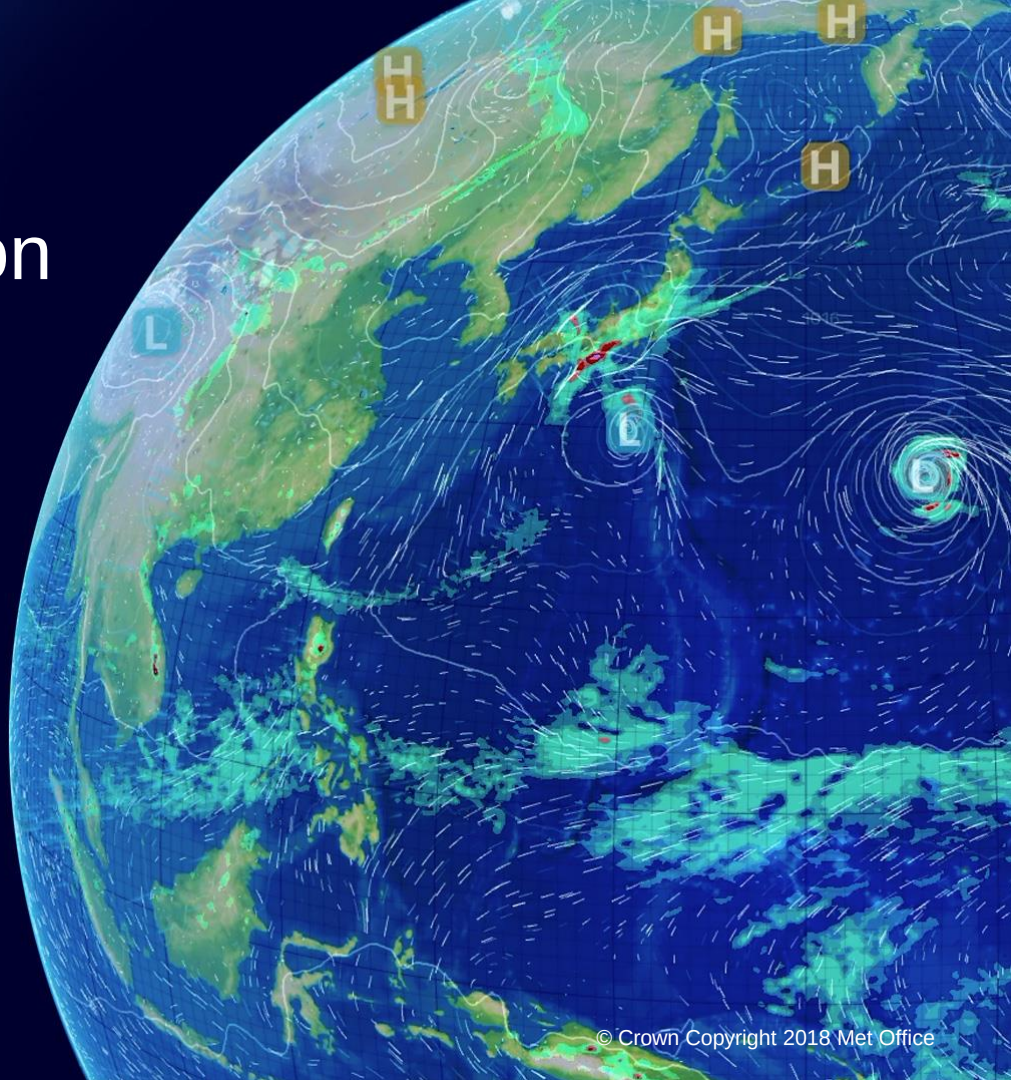

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The Models

Atmospheric dispersion model: NAME

- **N**umerical **A**tmospheric dispersion **M**odelling **E**nvironment
- Lagrangian particle dispersion model
- Offline model that reads in meteorological data
- Uses meteorological data on its native grid

NWP model: UM

- Met Office's **U**nified **M**odel
- Global and limited area
- Global: currently ~10km
- UK: currently ~1.5km

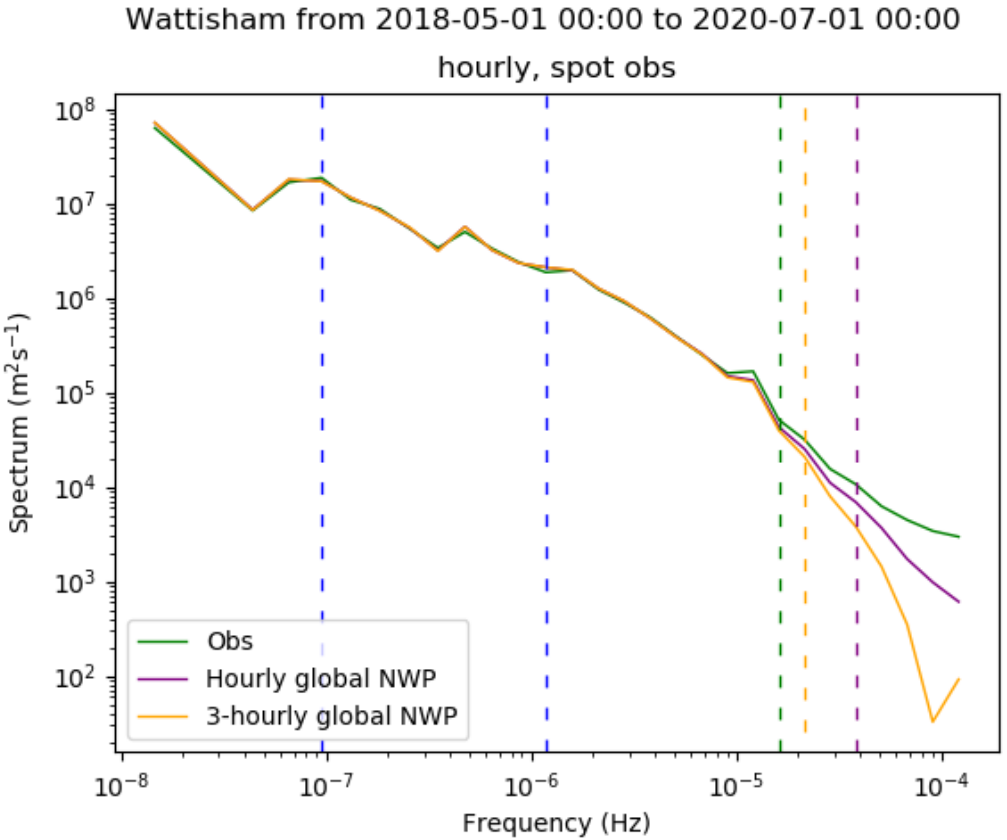
um | Unified Model

Motivation

- Motions resolved by the NWP model, and those unresolved
- Atmospheric dispersion model parametrizes the effects of unresolved motions
  - Turbulence (3D)
  - Unresolved mesoscale motions (2D)
- Scale of unresolved mesoscale motions depends on the resolution of the NWP data
- Spatial resolution of NWP data has increased over the years, but temporal resolution of the input fields has not increased in line.
  - Global:
    40km (2005) →10km
    3-hourly → hourly?
  - UK:
    4km (2007) → 1.5km
    hourly → 15 minute?

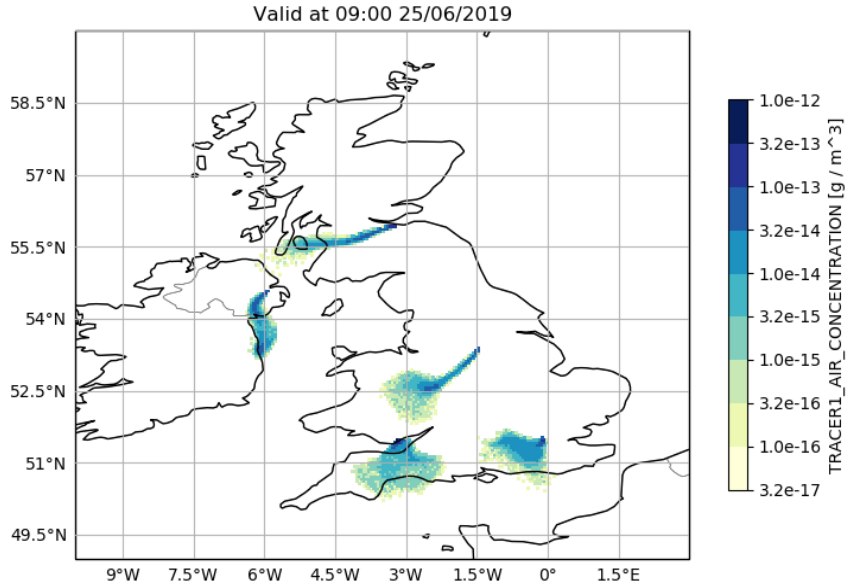
Spectral analysis

- Time series of observed 10m winds (high time resolution)
- NWP data for the same location
  - High time resolution
  - Low time resolution, linearly interpolated
- Spectral curve for each time series
- “Block averaging” to smooth noisy curve
- Scale model to match observations at low frequencies
- To calculate parameter values to use with the unresolved mesoscale motions parametrization:
  - Frequency that model curve diverges from observation curve
  - Area between the two curves

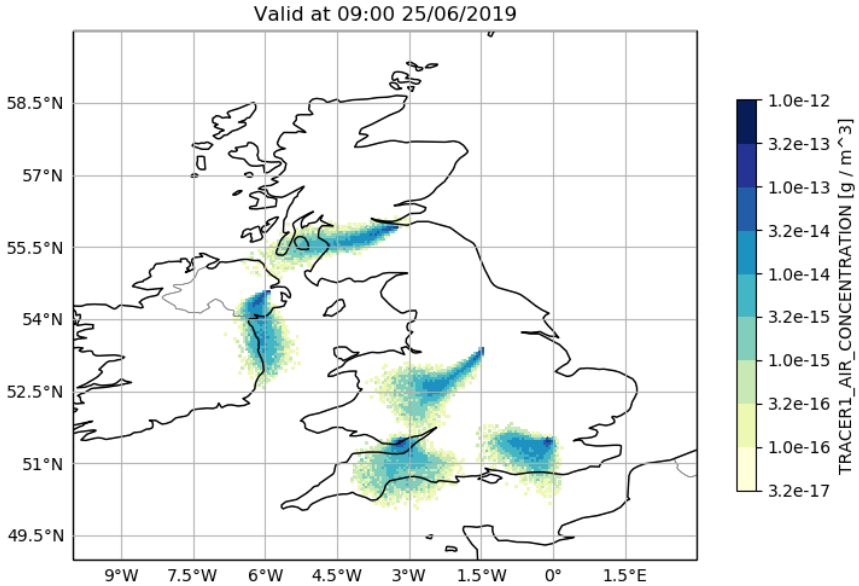


Unresolved mesoscale motions parametrization

Parametrization off

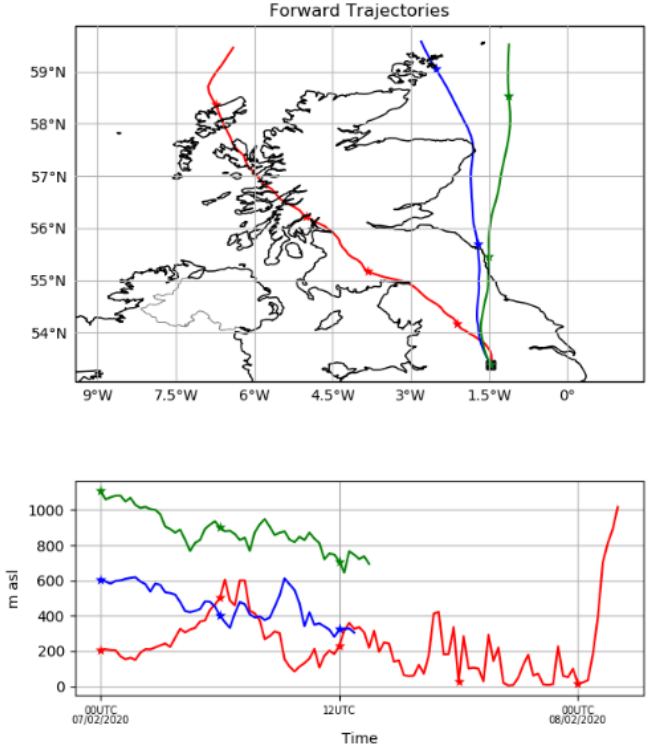


Parametrization on (K~3500m^{2}s^{-1})

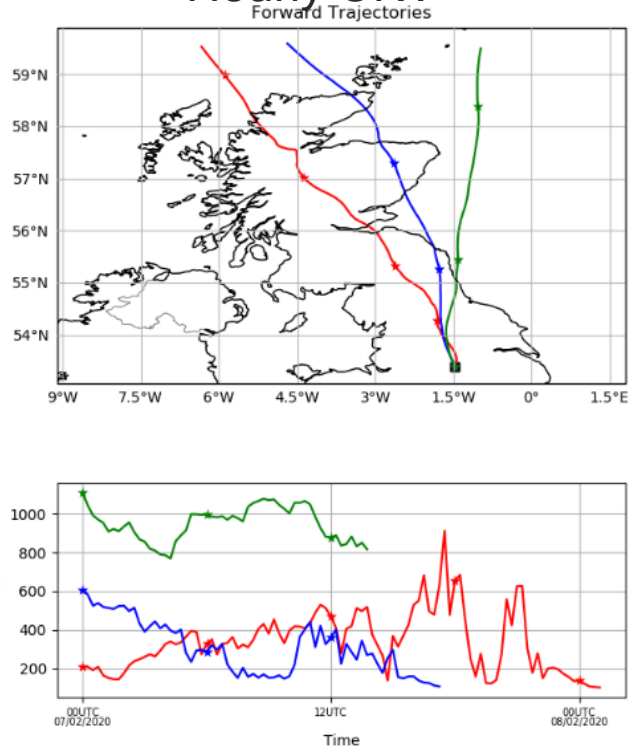


Trajectories with higher temporal resolution met

15 minute UKV

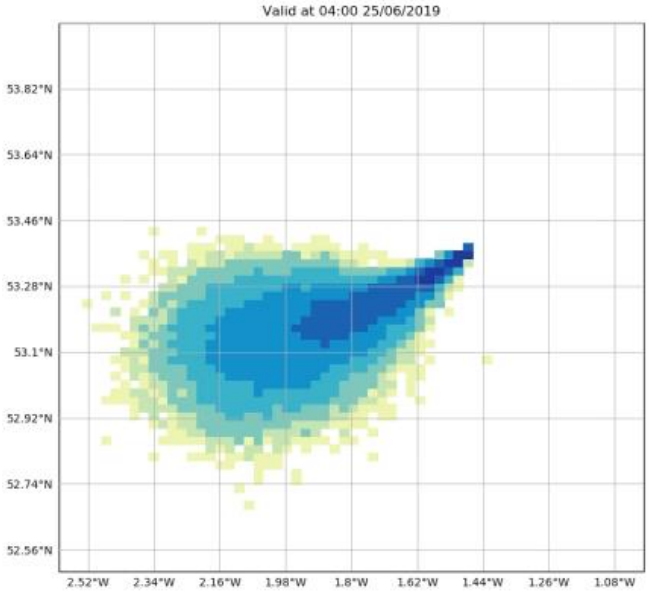


Hourly UKV

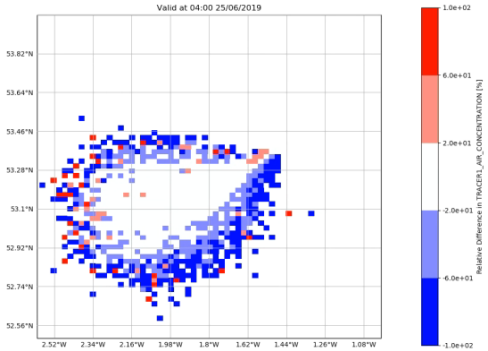


Dispersion model output

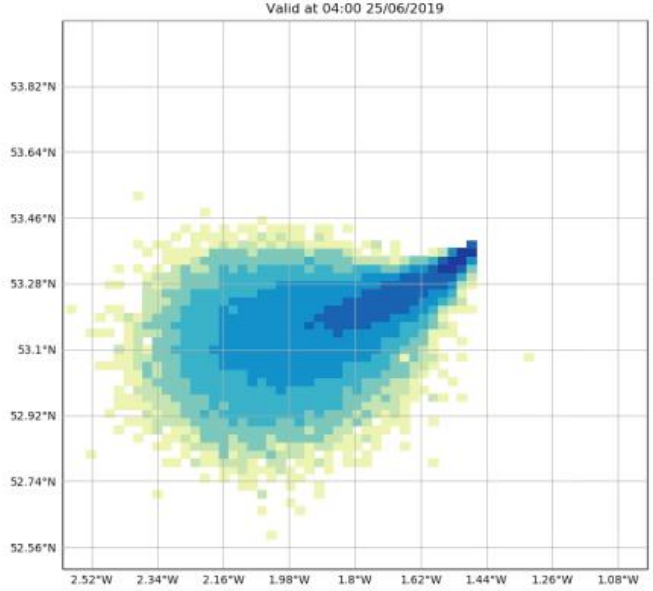
Global hourly



Relative difference (hourly – 3hourly)

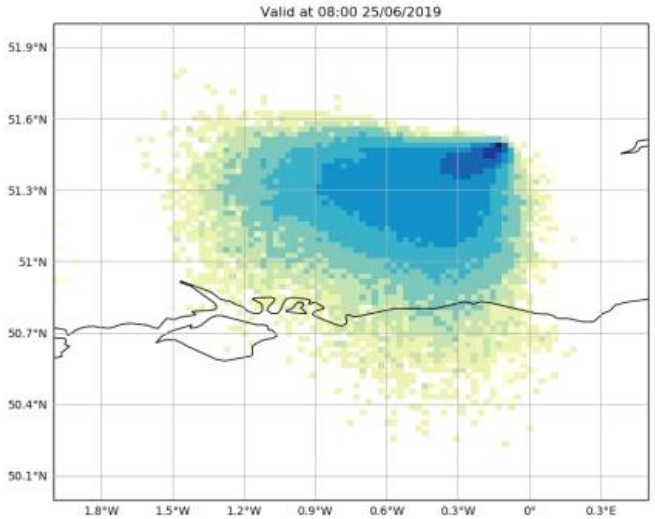


Global 3-hourly

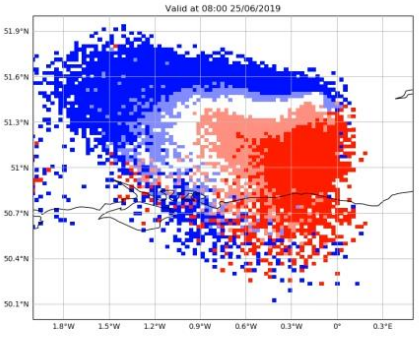


Dispersion model output

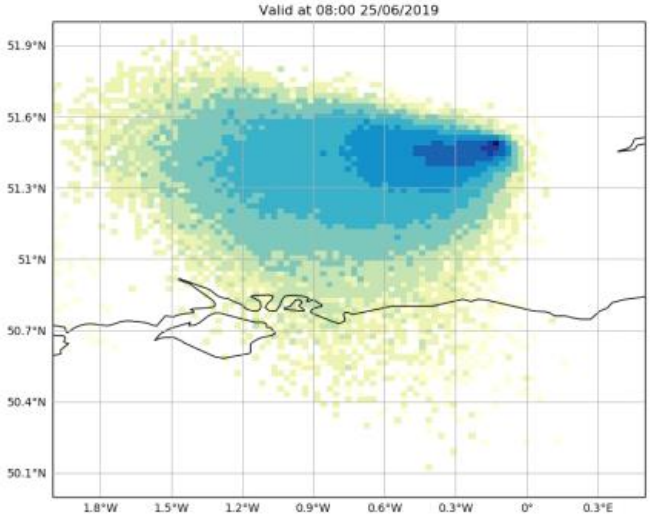
Global hourly



Relative difference
(hourly – 3hourly)



Global 3-hourly



Model run times

- Only the part of the run time for reading and processing meteorology is affected
  - 3-hourly to hourly → 3x increase
  - Hourly to 15-minute → 4x increase
- Proportion of run time on meteorology input depends on run type. As an example, the run time for a 24 hour volcanic run with global (10km) meteorology:
  - 3-hourly met ~2 minutes 40 seconds (met ~20 seconds)
  - Hourly met ~3 minutes 15 seconds (met ~60 seconds)
- Parallel met read/process not currently implemented in NAME, but would lead to significant speed ups

Summary

- Temporal resolution of NWP met driving dispersion models is often relatively coarse compared to the spatial resolution
- Increased resolution of NWP data changes the scales of motion that need to be parametrized by the dispersion model
- Spectral analysis of winds can be used to determine the scales resolved by the NWP data
- Changing the temporal resolution of the driving met can have a clear effect on mean particle trajectories
- Increased temporal resolution can reduce the spread and increase concentrations of the predicted plume due to more motions being resolved
- Only the run time for reading and processing the meteorological data is affected, with increases in line with the increase in resolution

Thank you for listening

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