Modelling wet deposition with high resolution precipitation data

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Outline

- Wet deposition
- Modelling of wet deposition in NAME
- Advances in NWP data
- Compatibility of wet deposition schemes and high resolution precipitation data
- Closing thoughts

Met Office

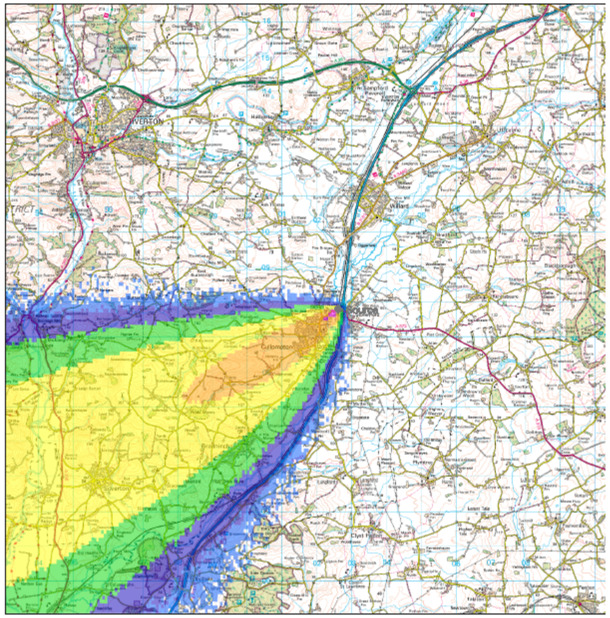
Wet deposition

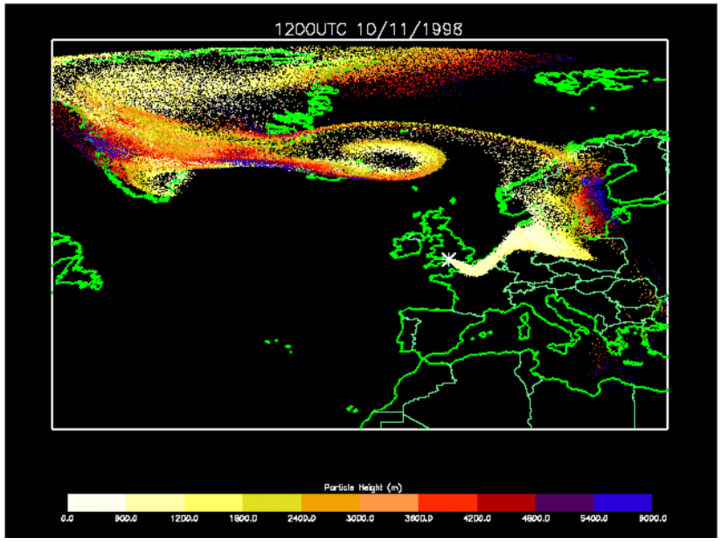
- Removal of material from the atmosphere within precipitation elements
  - Often the dominant loss process
  - Includes below-cloud (washout) and in-cloud (rainout) scavenging
  - Dependencies
    - Precipitation
      - amount, droplet size, type (rain, snow, etc.), intensity
    - Scavenged material
      - gases: solubility
      - aerosols: particle size, hydrophobic (water hating) / hydrophilic (water loving)

NAME (Numerical Atmospheric-dispersion Modelling Environment)

Met Office

- UK Met Office's Lagrangian dispersion model
  - Uses NWP 3-d flow fields or single site observations
  - Loss processes: radioactive decay, wet & dry deposition, chemical transformations
  - Wide range of applications
    - Emergency response: chemical, biological and nuclear
    - Air quality: forecasts and episode analysis
    - Disease spread (foot and mouth, bluetongue)
    - Identifying source locations and strengths
    - Volcanic ash
    - Dust forecasts
    - Policy support





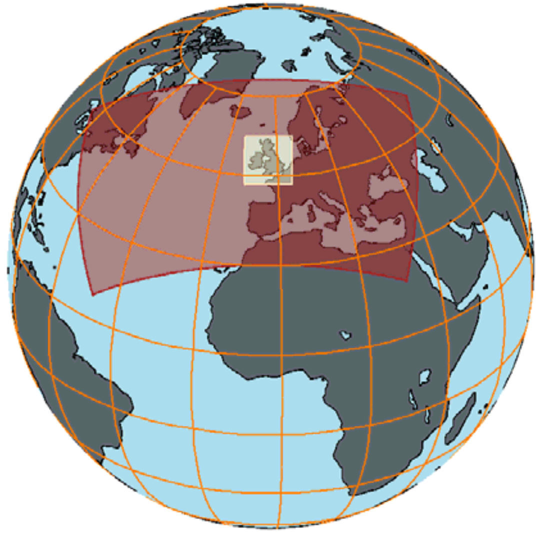
NAME's wet deposition scheme

- More than 20 years old
- Uses a bulk parameterisation
  - Λ is the scavenging coefficient ($\Lambda = Ar^B$)

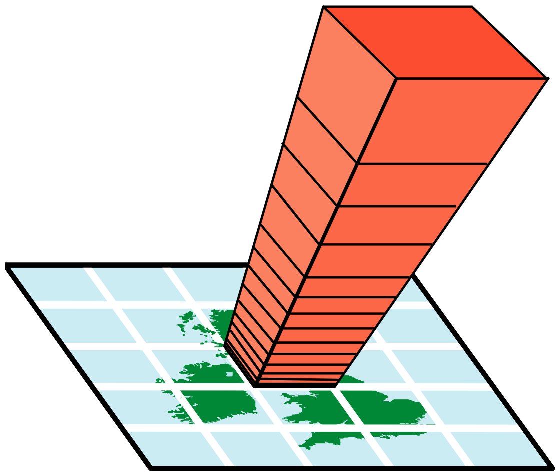
$$\frac{dC}{dt} = -\Lambda C$$

- Assumes input precipitation data (*r*) has two components
  - dynamic / large-scale (resolved by NWP model)
  - convective (parametrised within NWP model)
- Different scavenging parameters (*A* and *B*) for
  - rain / snow and ice
  - convective / dynamic precipitation
  - in-cloud / below-cloud scavenging
- Total wet deposition given by sum of wet deposition by dynamic and convective components

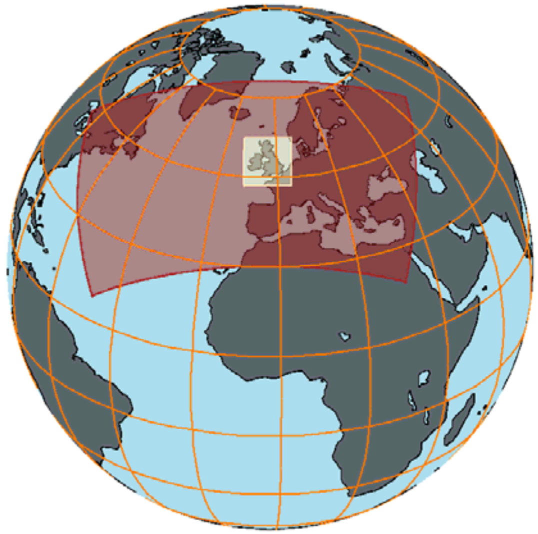
Numerical Weather Prediction (NWP) input data



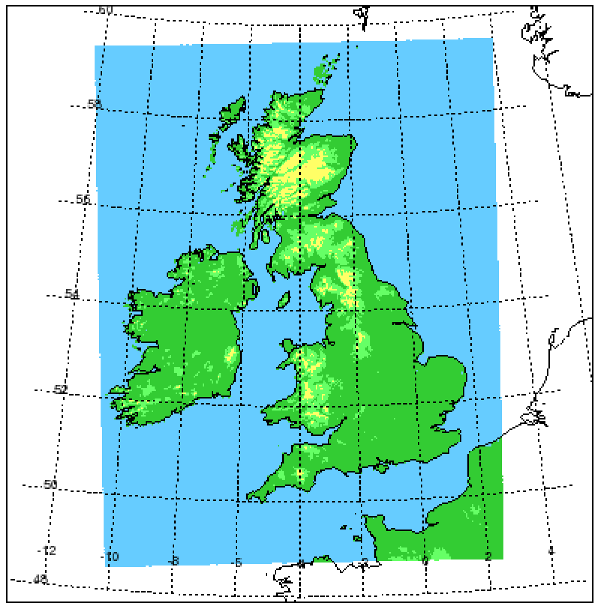
- gridded model data
- full 3-d structure
- advances in computing and science
  - ►increases in resolution
  - ►improvements in accuracy
  - ►large volumes of data
    - ►data storage / transfer issues
    - ►increased computing power / model run time



Current Met Office NWP models



- Global
  - 25 km horizontal resolution
  - dynamic (resolved) and convective (parameterised) precipitation
  - 3 hourly time resolution
  - height ~80 km
  - 144 hour forecast
- UKV
  - UK region
  - 1.5 km horizontal resolution
  - convection permitting
  - hourly time resolution
  - height ~40 km
  - 36 hour forecast



NAME's wet deposition parametrisation

- NWP precipitation data
  - dynamic / large-scale – resolved
  - convective – parametrised
  - UKV precipitation
    - dynamic + convective – resolved
    - no parametrised

- Wet deposition scheme
  - different parametrisation for scavenging by dynamic (resolved) and convective (parametrised)
  - resolved convective precipitation uses dynamic parametrisation! ✗
  - predicted wet deposition dependent on ratio of resolved precipitation to parametrised precipitation! ✗

►modifications to wet deposition scheme

Remove dynamic / convective difference

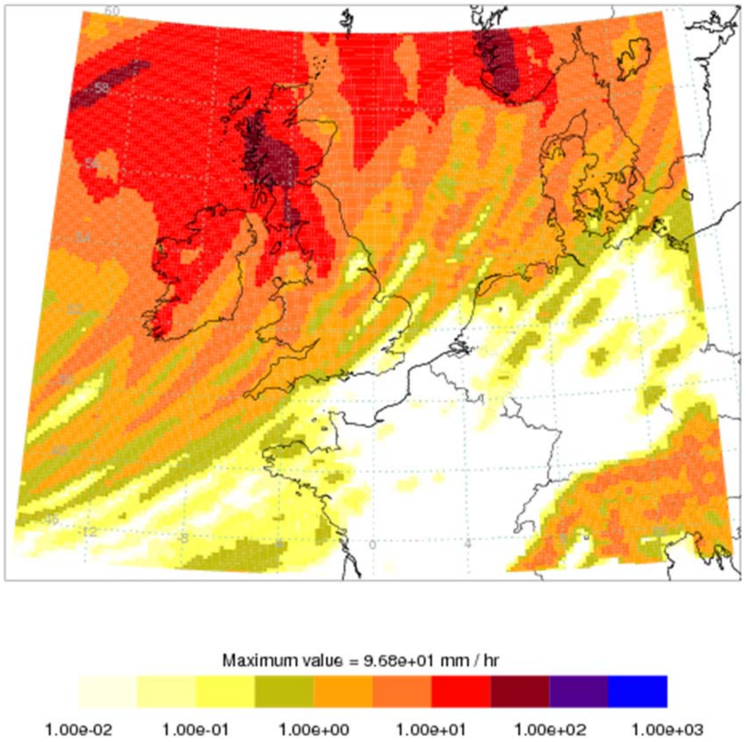
Calculate a total scavenging coefficient (Λ_{tot})

$$\Lambda_{tot} = (1 - C_f) A_1 r_{dyn}^{B_1} + C_f A_2 \left(r_{dyn} + \frac{r_{con}}{C_f} \right)^{B_2}$$

time-step independent

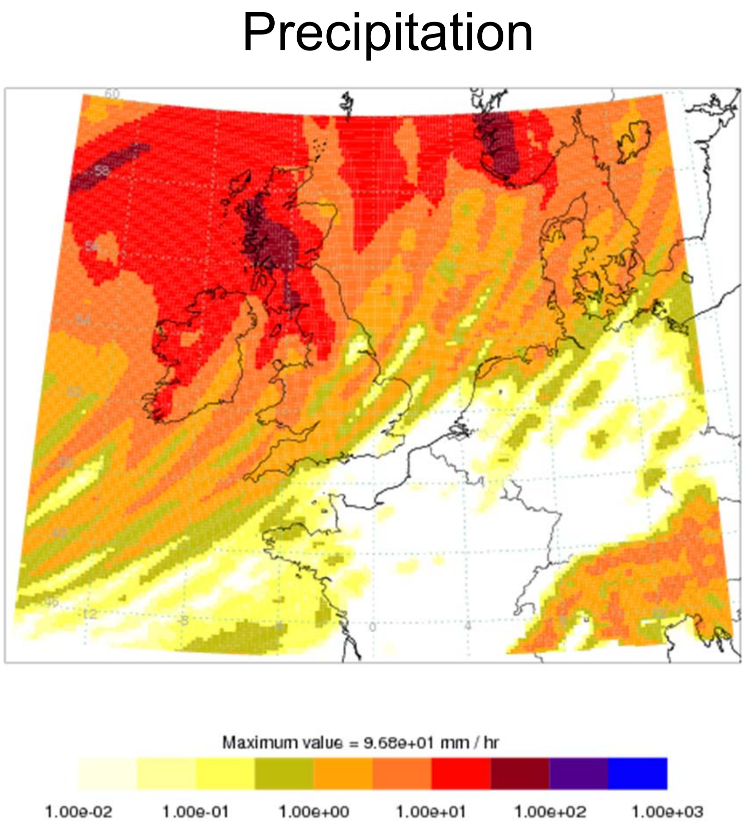
Rain hopping – instantaneous precipitation fields

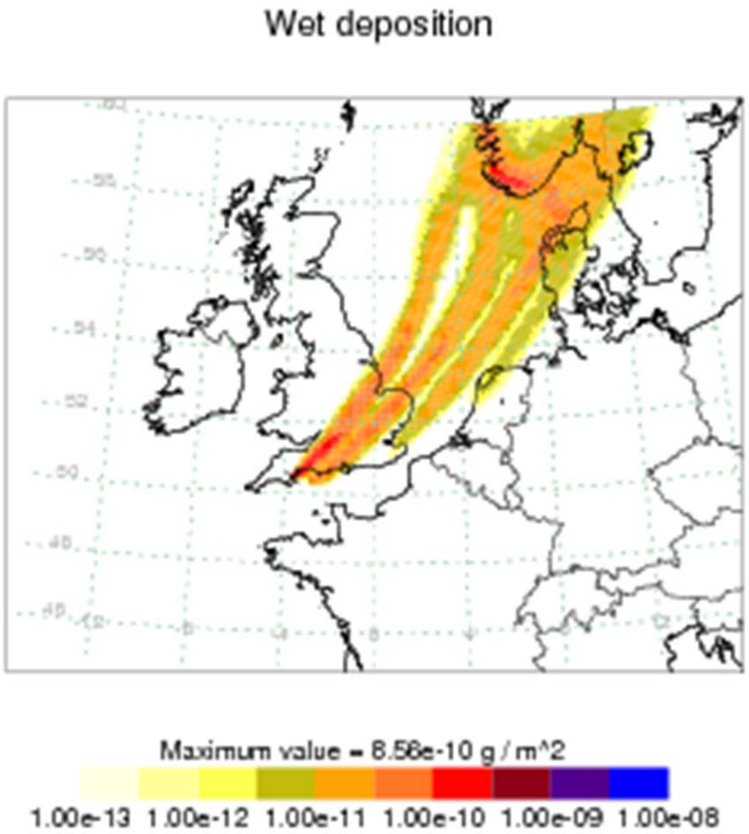
Precipitation



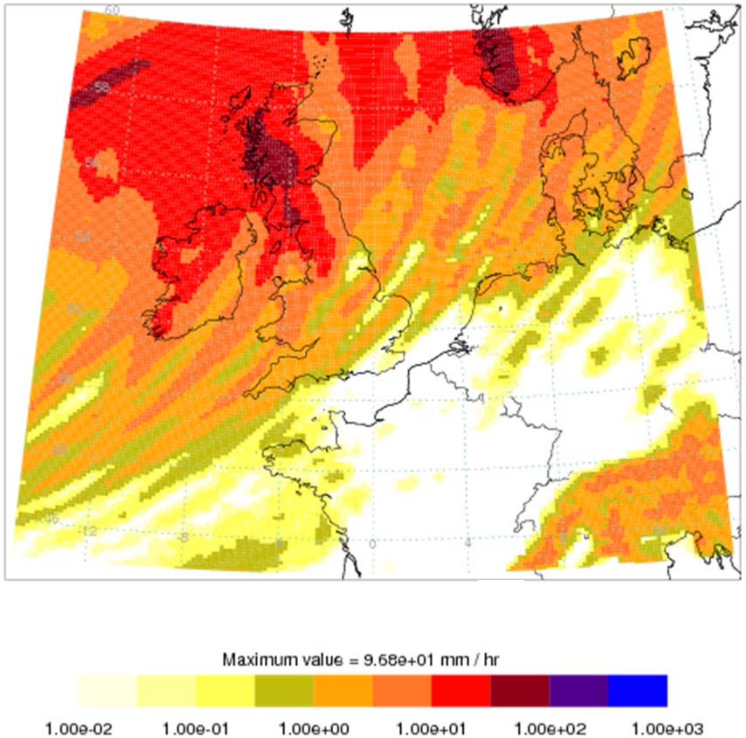
- 3 hourly instantaneous fields
- Thin band of precipitation (front)
- Precipitation (as seen by the dispersion model) appears to hop from one location to another
- Problem caused by mismatch between high spatial resolution and comparatively low temporal resolution

Rain hopping – instantaneous precipitation fields

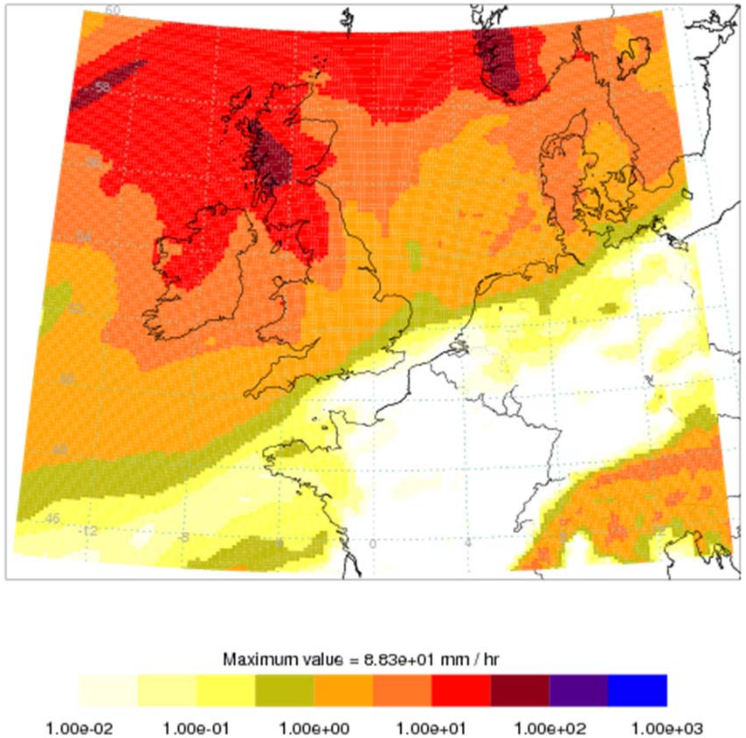




Instantaneous vs mean precipitation

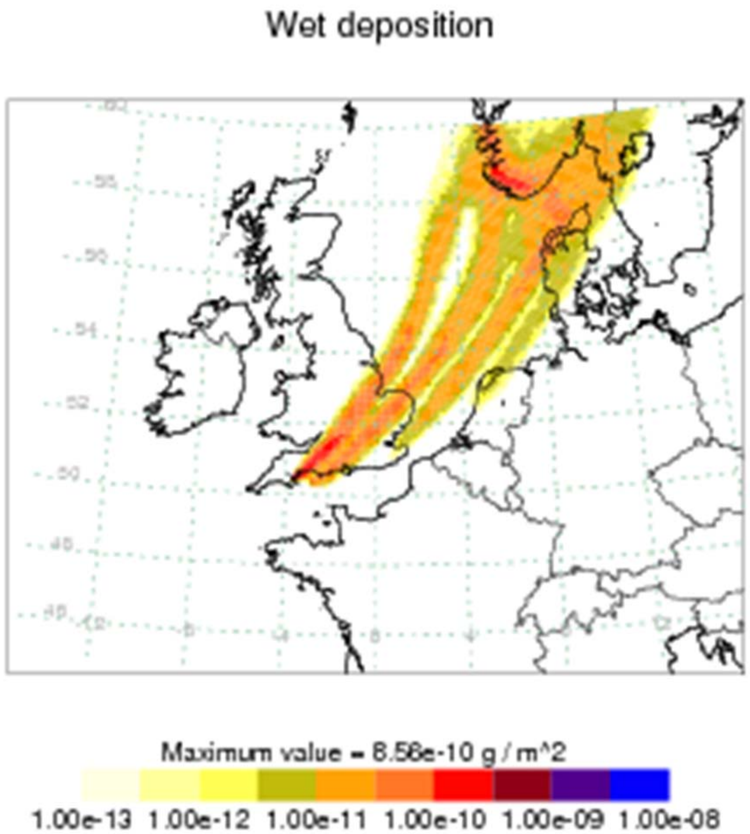


Instantaneous

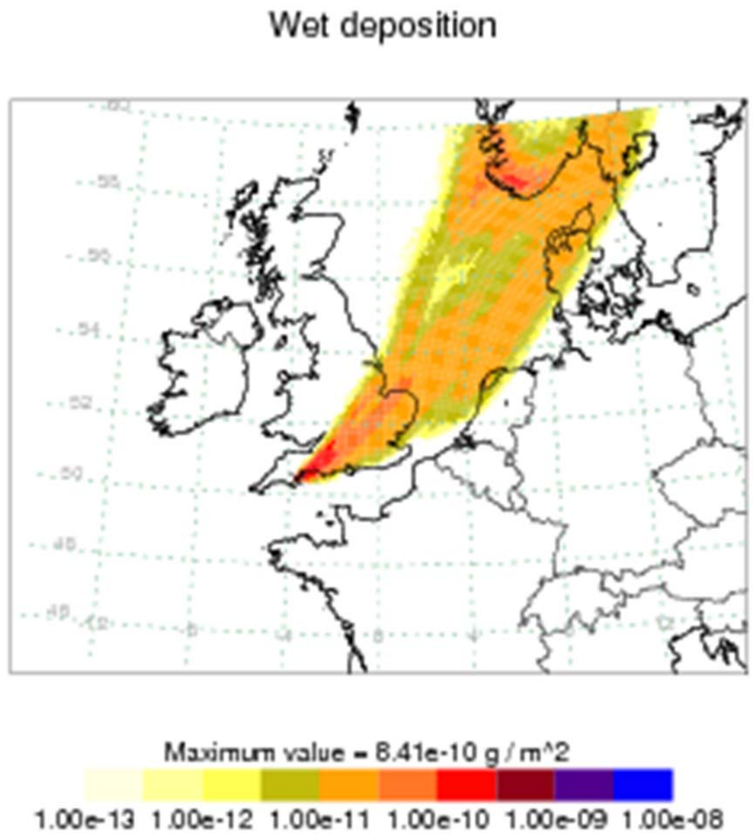


Mean

Wet deposition – instantaneous vs mean precipitation



Instantaneous



Mean

Summary

- Advances in NWP
  - advances in dispersion modelling capability
    - improved accuracy
  - dispersion modelling challenges
    - data volume
    - revisions to modelling approaches
- Highlights
  - Regular reviewing of model parametrisations is good practice
  - Helpful to have an understanding of the model parametrisations
  - Importance of model testing when using new input data sets