Modelling wet deposition with high resolution precipitation data

Helen Webster, David Thomson and Andrew Jones
Met Office, UK
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
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)

- 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
  - $\Lambda$ is the scavenging coefficient ($\Lambda=Ar^B$)
- 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

\[ \frac{dC}{dt} = -\Lambda C \]
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 ($\Lambda_{tot}$)

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

time-step independent
Rain hopping – instantaneous precipitation fields

- 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

Precipitation

Wet deposition

© Crown copyright  Met Office
Instantaneous vs mean precipitation

![Instantaneous precipitation map](image1)

![Mean precipitation map](image2)

© Crown copyright   Met Office
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