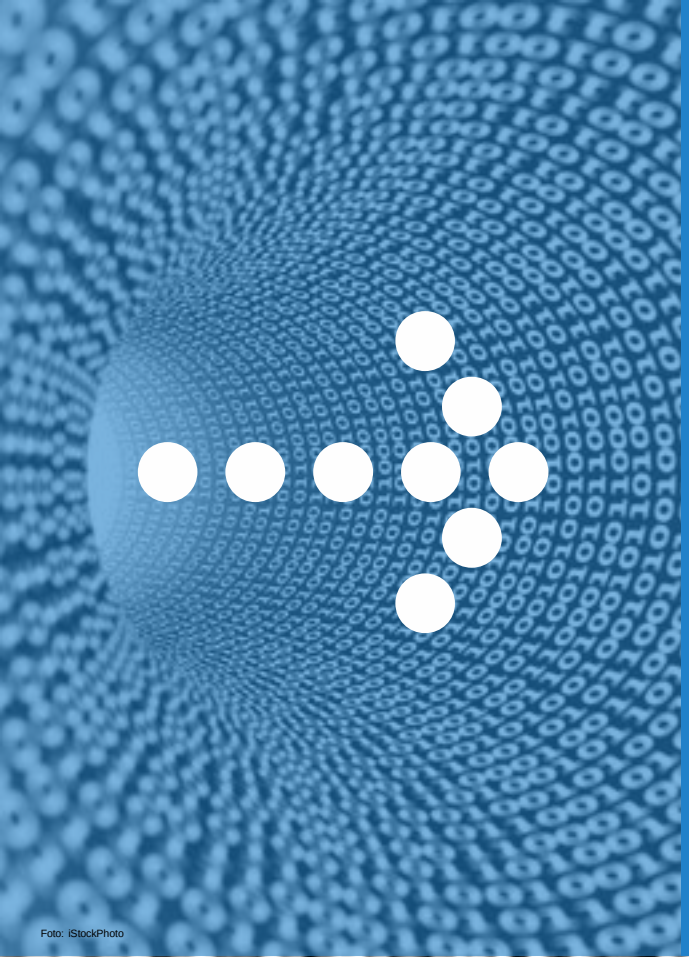

Foto: iStockPhoto

Aerosol dynamics in a random displacement dispersion model

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Outline

- Atmospheric dispersion modelling in radioactive emergency preparedness
- Aerosol dynamic processes
- Method
  - CALM – trajectory box model
  - Experiment setup
- Results
- Conclusions

Atmospheric dispersion modelling in radioactive emergency preparedness

- Decision support
  - First estimate of the outcome of an accident
  - Affected areas
  - Regulations with threshold values, internal and external doses
    - Mitigating measures
      - People, livestock and farmlands

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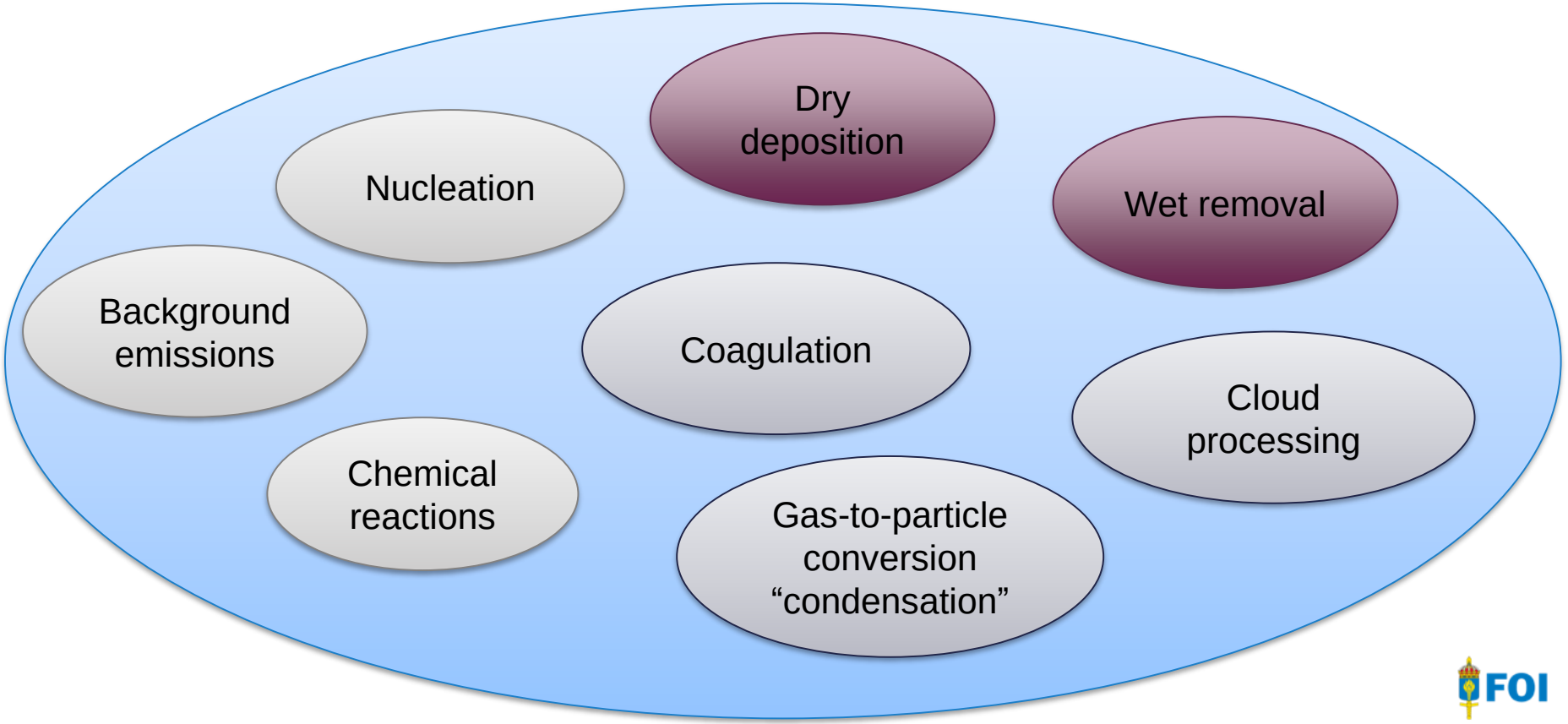
Modeling atmospheric aerosols



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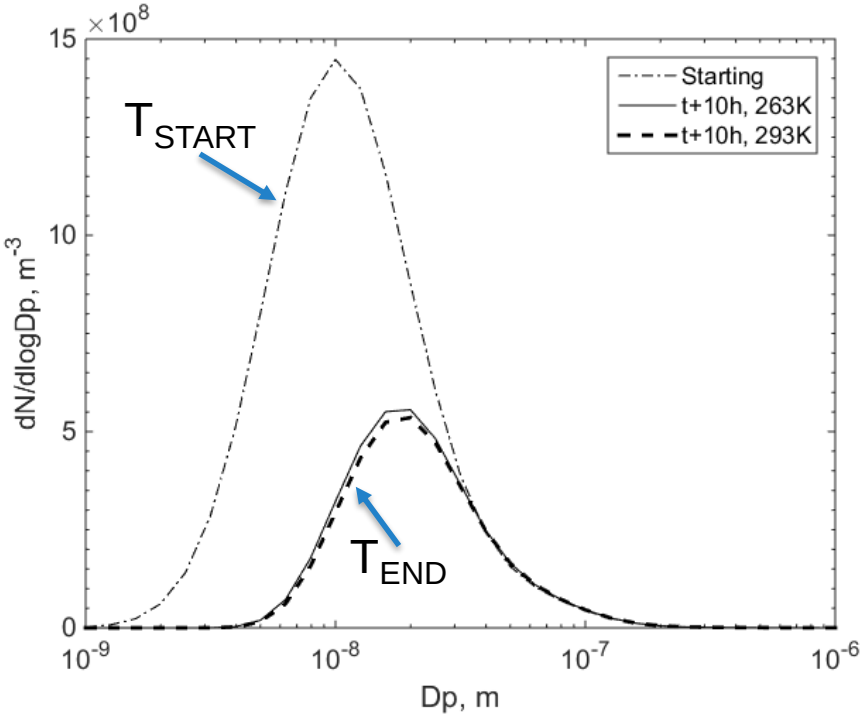
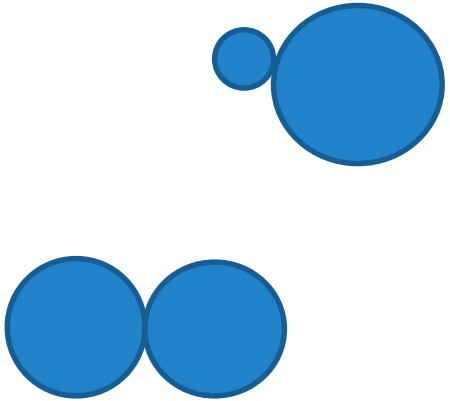
Coagulation

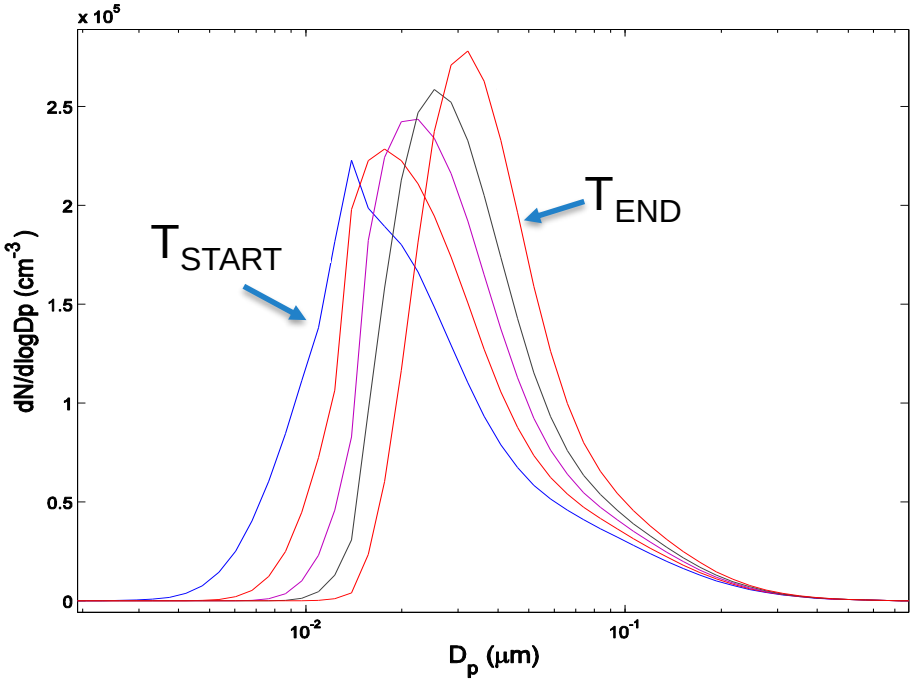


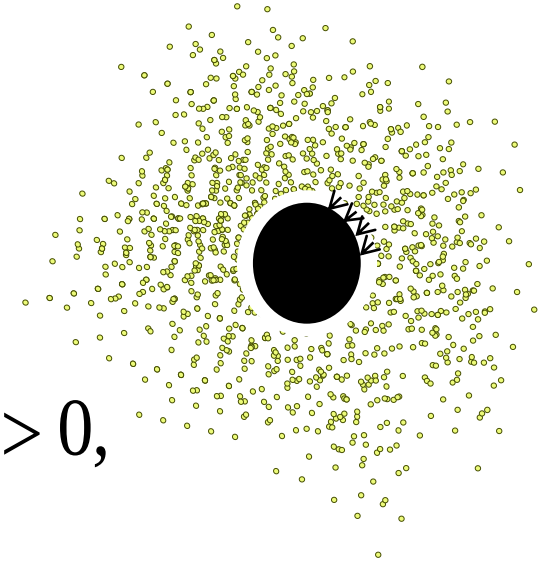
$$\frac{dM}{dt} = 0,$$

$$\frac{dN}{dt} < 0$$



Condensation



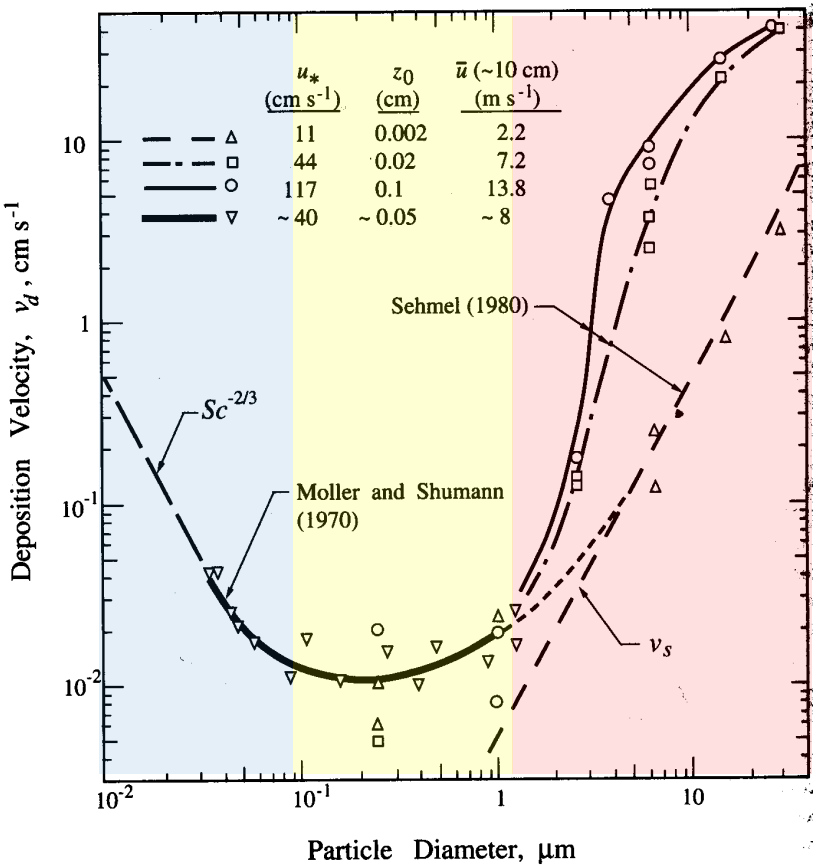


$$\frac{dM}{dt} > 0,$$

$$\frac{dN}{dt} = 0$$

Dry deposition

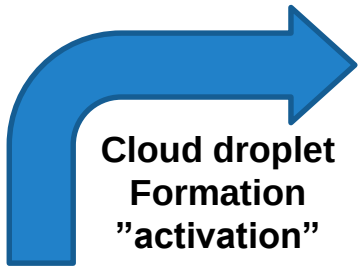
Accumulation mode

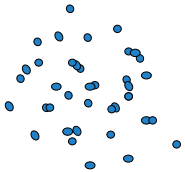


(Ref: Seinfeld and Pandis 1997)

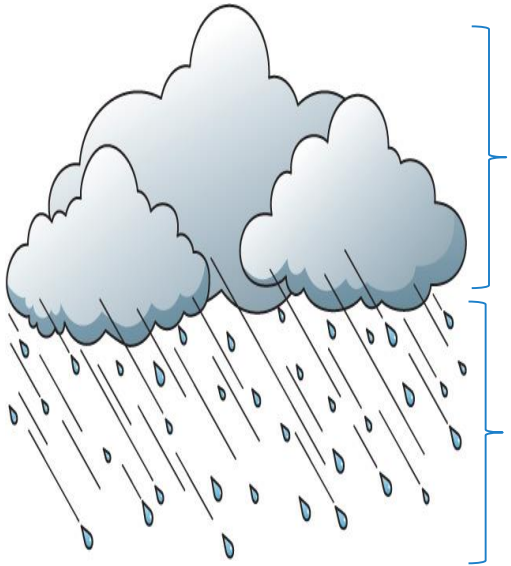
Wet deposition

Cloud formation





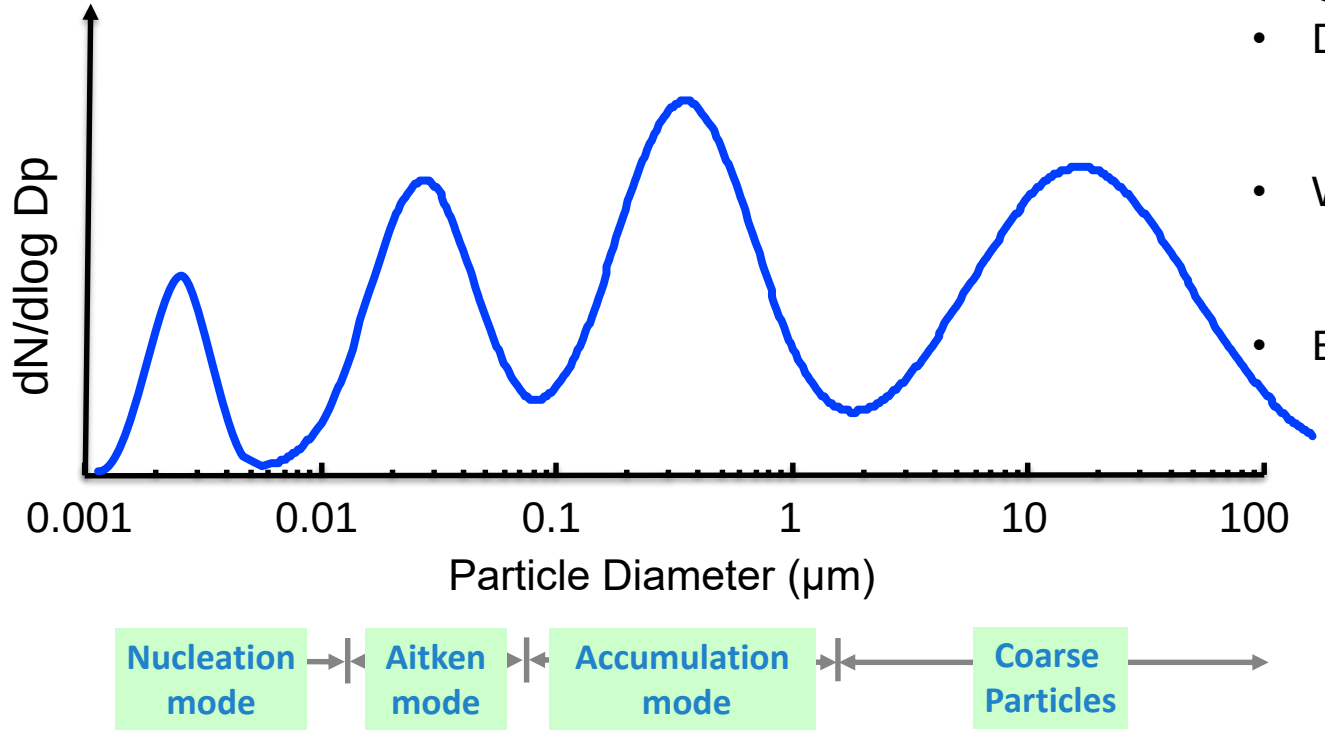
Aerosol



Cloud formation, precipitation
In-Cloud scavenging

Falling raindrops
Below-Cloud scavenging

Aerosol size distribution



- Nucleation
- Condensation
- Coagulation
- Chemical transformation
- Dry deposition
  - Sedimentation
  - Diffusion
- Wet deposition
  - In-Cloud
  - Below-Cloud
- Background sources

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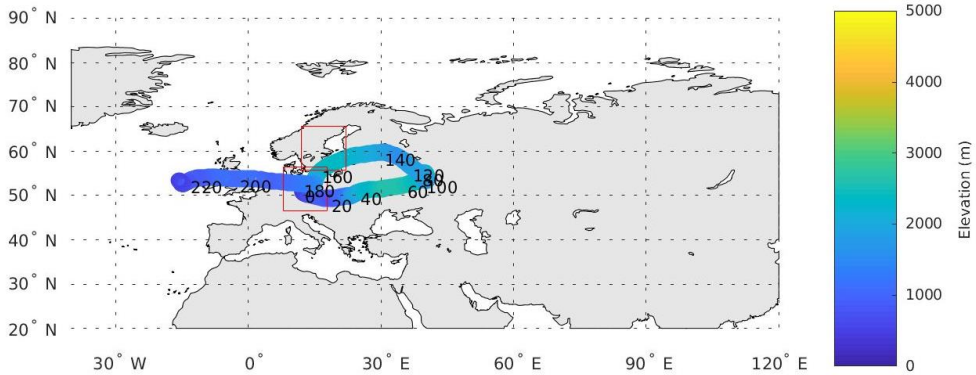
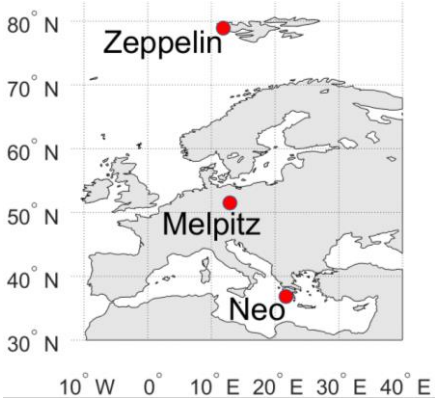
CALM

- Trajectory box model
  - Follow an air parcel along one trajectory in the air flow during 10 days
- Condensation, coagulation, chemical interactions, new sources
- Aerosol cloud interactions
  - Activation
  - Wet deposition
  - Cutoff
- Radioactive particles – source
- Tracking the change in aerosol size distribution



Experiment setup

- Starting each trajectory with a real measurement of ambient particle number distribution
- Measurement stations:
  - Zeppelin
  - Melpitz
  - NEO
- One 10 day simulation starts each hour during one year
  (except when measurements were not available)
- Caesium-137 released during one hour
  - Condensation on ambient particles



Stations and initial data

	Melpitz	NEO	Zeppelin
Year	2008	2012	2010
Latitude	51.50	36.83	78.90
Longitude	12.90	21.70	11.86
Number of simulations per experiment (out of possible start times in the current year)	8012/8784	7873/8784	7206/8760
Total number of simulations (5 experiments)	40060	39365	36030
Type of chemical background	Near City Urban	Natural Rural	Natural Rural
sulphuric acid	47 %	45 %	45 %
insoluble organic vapour	38 %	42 %	42 %
Non-condensable insoluble compounds	15 %	13 %	13 %

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Experiments

Nr	Description	Coagulation, condensation, emissions, nucleation	CUTOFF	Drydep	Clouds and Wetdep
1	All processes turned on	YES	NO	YES	YES
2	Only Dry Deposition is turned on (no other processes)	NO	NO	YES	NO
3	Only Dry Deposition and Clouds (including wet deposition) is turned on (no other processes)	NO	NO	YES	YES
4	All Processes is turned on and wet deposition has a cutoff	YES	YES	YES	YES
5	Only Dry deposition and Clouds, including wet deposition with a cutoff (no other processes)	NO	YES	YES	YES

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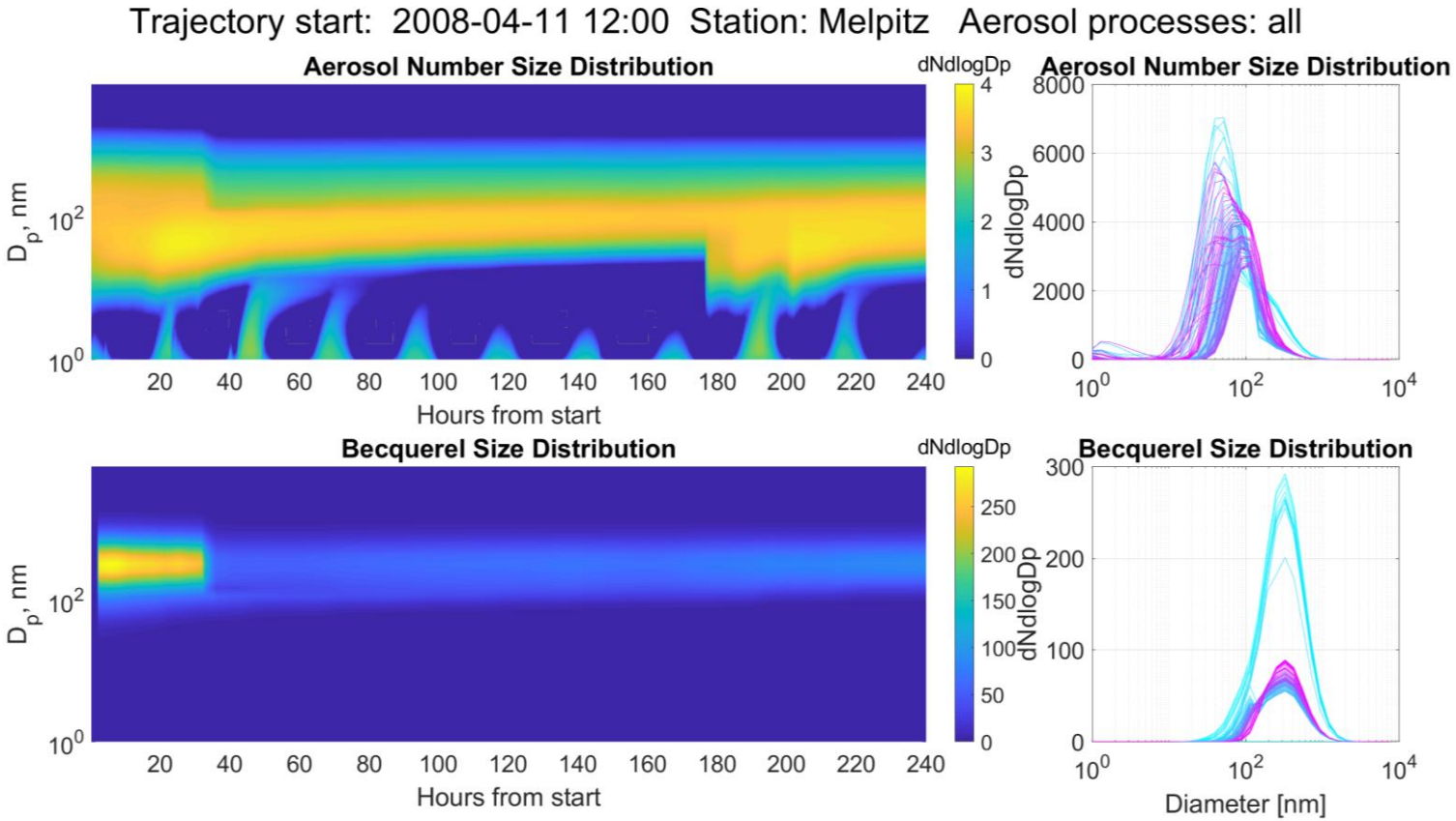
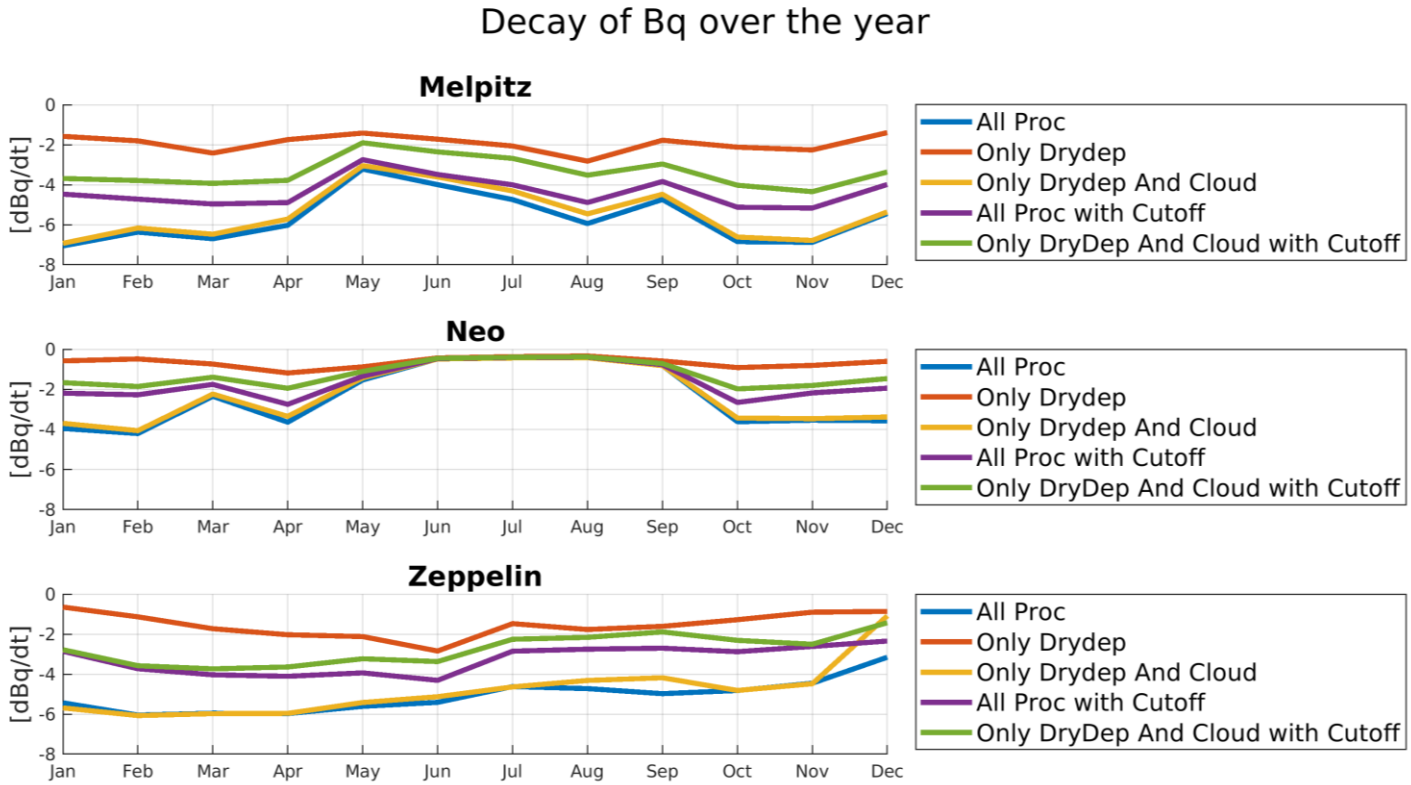
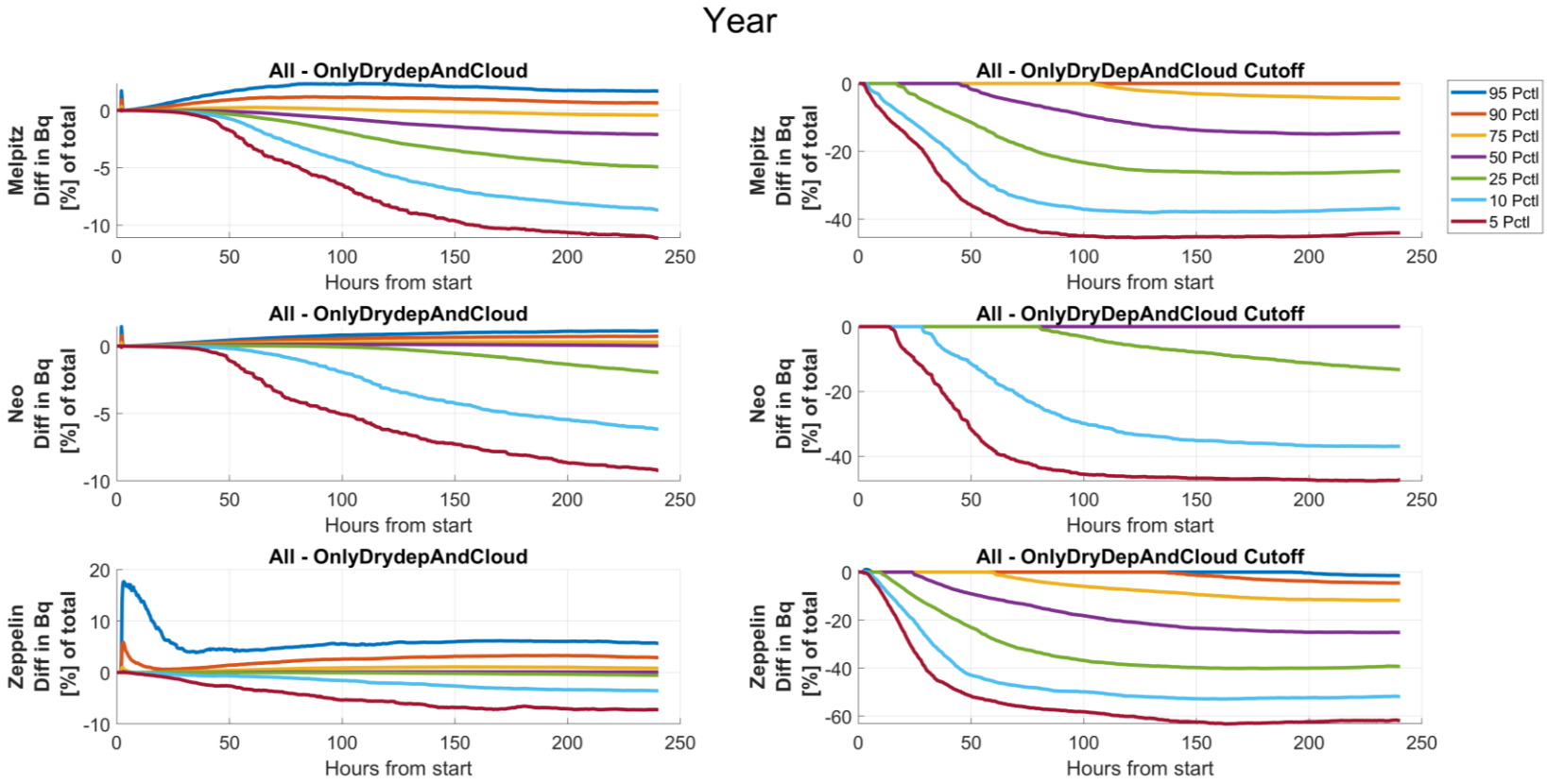
Example trajectory



Annual variations of decrease of radioactivity



Trajectory difference between “all processes” and “only drydep and cloud”



Discussion and Conclusions

- Particle radioactivity size distribution changes over the trajectory and moves particles mainly into the accumulation mode
  - Different sizes changes the physics for:
    - dry deposition, cloud formation, wet deposition => air concentration and deposition field
- Radioactive emergency preparedness
  - Gauged by action thresholds – exceeding or not exceeding certain threshold levels
  - Correct air concentration and deposition fields are important
  - Determines the mitigating actions when it comes to: the food chain, recommendation of iodine tablets, evacuating people,

Discussion and Conclusions

- Mean values over time works well without advanced aerosol dynamics
- Including aerosol dynamics transform the particle size spectra so that the particles can be activated and rain out
- When simulating individual events including and excluding advanced aerosol dynamics can make a difference
  - In 5% of the cases there is roughly a factor of 2 difference in air concentration with the simplified wet deposition scheme
- When having an advanced description of clouds and wet deposition, the difference in including and excluding advanced aerosol dynamics is less (10% difference)
- Future work:
  - How to include advanced aerosol dynamics in a particle dispersion model. Weighing computational cost against benefits of more accurate result.
  - Analysing the data set with different perspective
    - Comparing similar trajectories (clustering), over land, over sea, close to the surface etc.

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