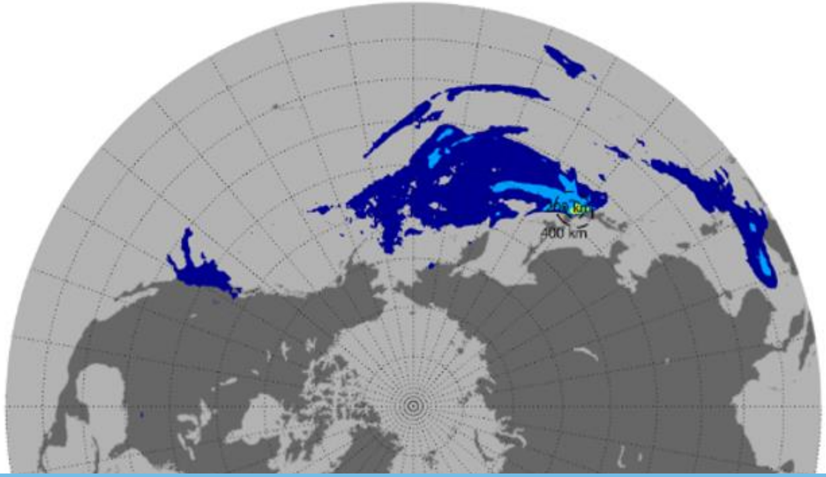

Evaluation of model performance using new deposition schemes in the Random displacement Particle model PELLO using Fukushima power plant accident data

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Content

- PELLO – dispersion model
  - Radiation preparedness system in Sweden
- Improved particle dynamics
  - Below cloud scavenging
  - In cloud scavenging
- Comparison with Fukushima NPP accident data
- Improved model

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PELLO – Stochastic particle model

- Dispersion model for regional to global scales
- Developed at Swedish Defense Research Institute, FOI
- Used in the Swedish radiation preparedness system at the Swedish radiation Authority, SSM
  - Run operationally at the Swedish meteorological and Hydrological institute, SMHI

FOI

PELLO – Stochastic particle model

- Lagrangian Random Displacement Model (RDM)
- The source is represented with model particles
- Each model particle have unique properties
  - Mass or amount of Becquerel
  - Size, sedimentation velocity,
  - Time from release (i.e. for radioactive decay etc.)
  - Each model particle represents a great number of real particles with the same properties (or an amount of gas)

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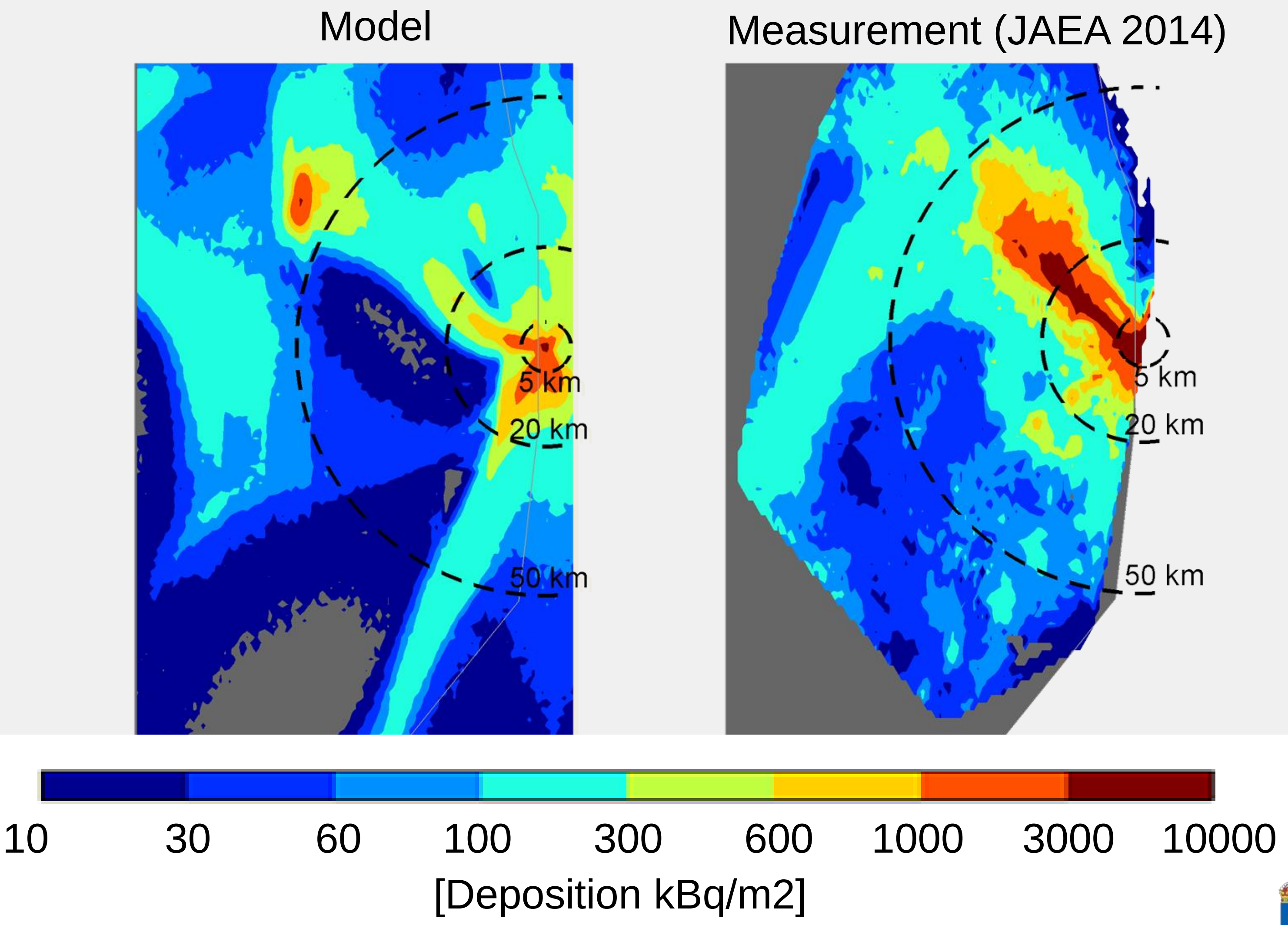
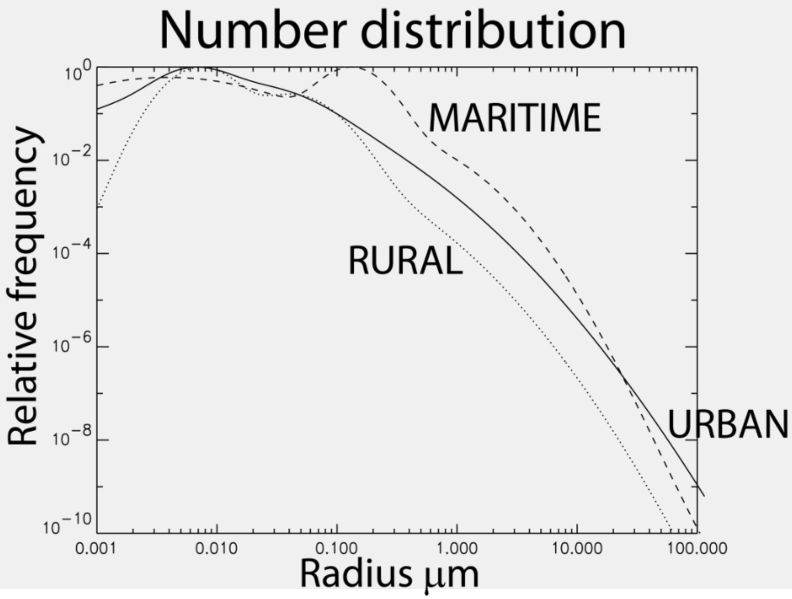
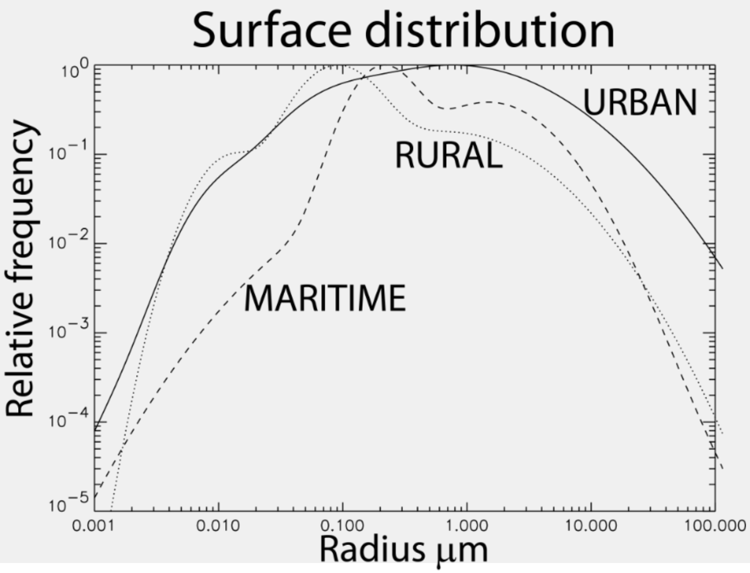
Fukushima accident comparison



PELLO - size distribution

- Each model particle are randomly given a radius
- All model particles fill up the prescribed distribution
- 1M – 100M model particles used normally





Ref: Guide to Global Aerosol Models, 1999
AIAA (American Institute for Aeronautics and Astronautics)

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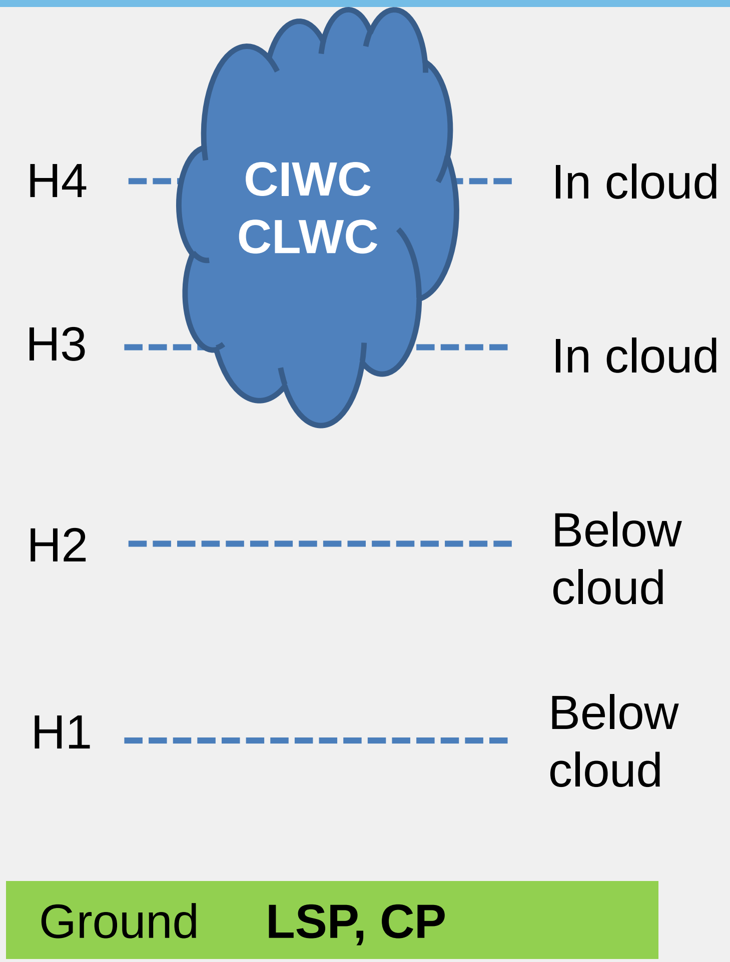
PELLO – Stochastic particle model

- The weather (wind, turbulence, precipitation etc.) controls the particle movements
  - Moved with the average wind (transport)
  - Random displacement step representing the turbulent diffusion (dilution)
- NWP – Numerical Weather Prediction models are used
- ECMWF – European Centre for Medium-Range Weather Forecasts

NWP – Deposition parameters



Height parameters:

CIWC, Specific Cloud Ice Water Content [kg/kg]
CLWC, Specific Cloud Liquid Water Content [kg/kg]

Ground level parameters:

LSP, Large Scale Precipitation, [m]
CP, Convective Scale Precipitation, [m]

- Cloud location is calculated
- **LSP** and **CP** is distributed in height with aid of **CIWC and CIWC** Into *Height parameters:*
- **LSP** $_{\textbf{in cloud}}$**,** **LSP** $_{\textbf{below cloud}}$
- **CP** $_{\textbf{in cloud}}$**,** **CP** $_{\textbf{below cloud}}$

PELLO – Particle dynamics considered

- **Dry deposition**
- **Wet deposition**
  - Height above ground
  - Particle size
- Is this sufficient?

- *Mechanism based wet deposition*

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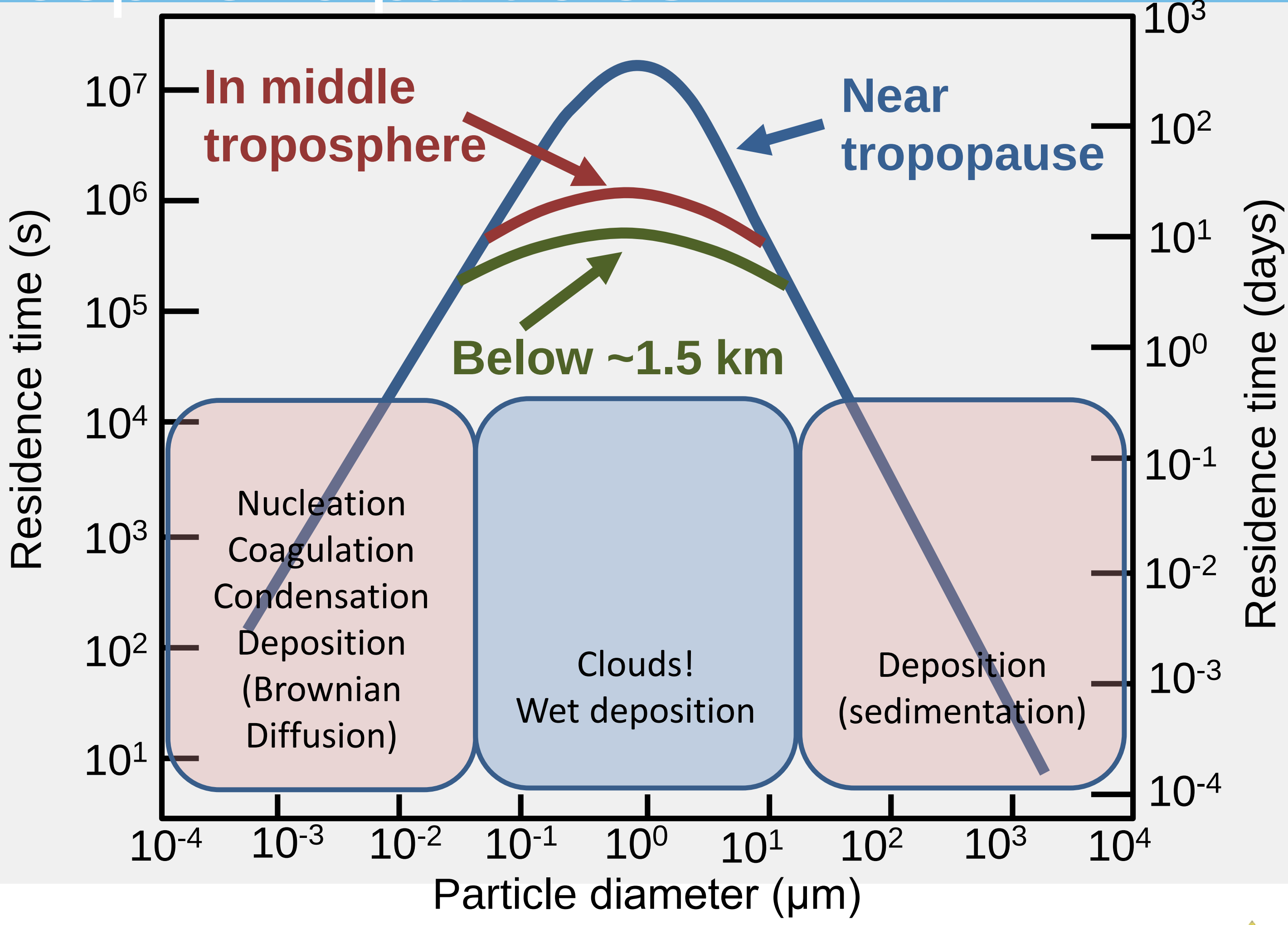
Residence time as a function of size for atmospheric particles



Ref: Hobbs 2000

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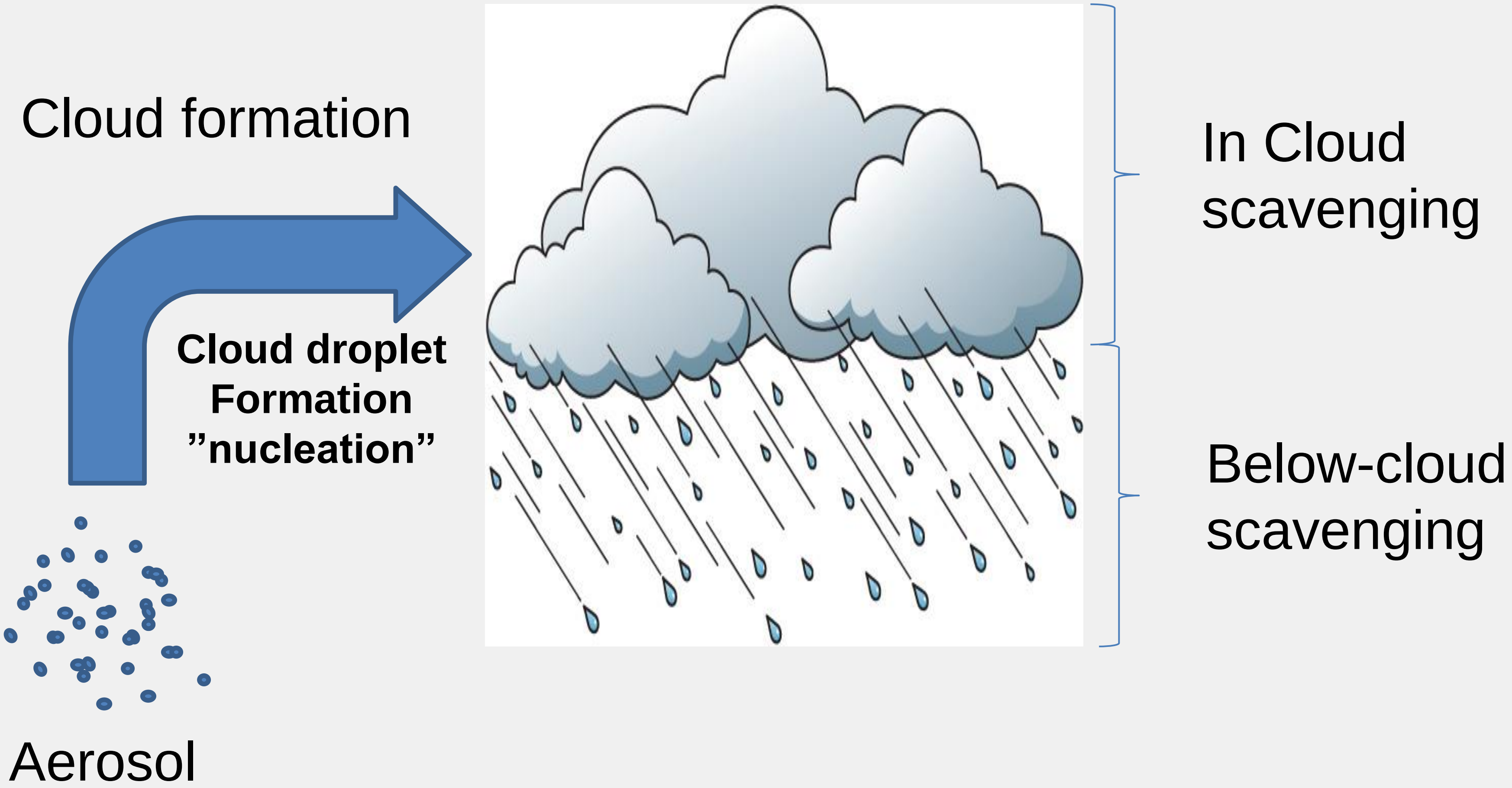
Wet deposition



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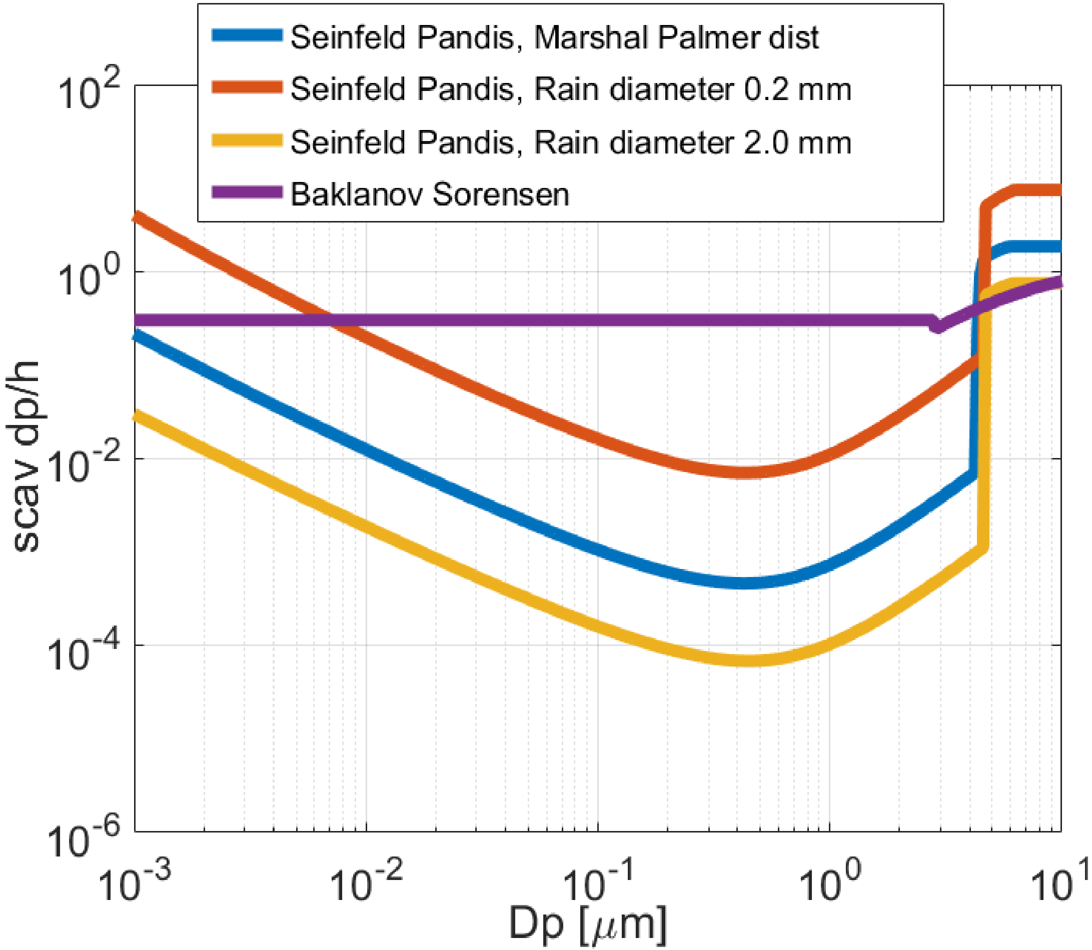
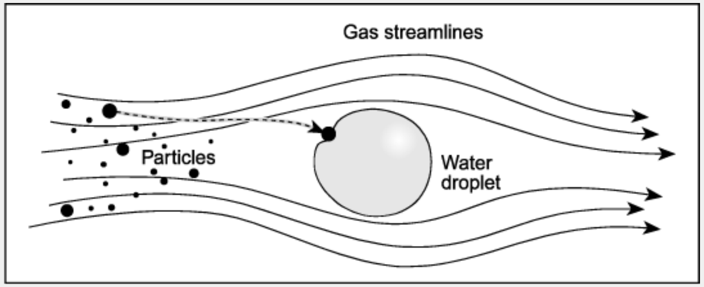
Wet deposition – below cloud

- Washout (below cloud scavenging)
- Current scheme
  - Baklanov and Sørensen 2001
- New scheme
  - Seinfeld and Pandis 1997

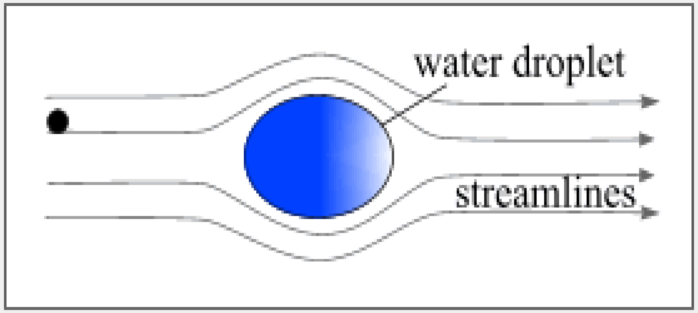


New scheme - below cloud
Seinfeld & Pandis

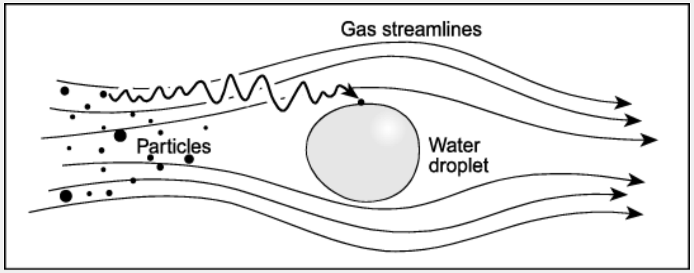
- Impaction



- Interception



- Brownian diffusion



Wet deposition – In cloud

- In cloud scavenging (rainout)
  - Calculate the amount of water (kg) in the cloud
    - from clwc and ciwc
  - Calculate the amount of rain (kg) from the cloud
  - Calculate fraction of cloud that is rained out (%), **FoC**
- Particles
  - Calculate how many real radioactive particles that the model particle represent
  - Calculate the fraction of radioactive particles compared to background aerosol within the cloud (%), **FoR**
  - Assume that all particles with diameter > 100 nm within the cloud was there to create the water droplets forming the cloud
  - Number of all radioactive particles, **NoR**
- Assume coalesces is the only process for precipitation
  - Washout = **FoC*FoR*NoR**

Fukushima accident comparison

- Particulate ^{137}Cs
- Cesium assumed to attach on the surface of the ambient aerosol – Surface distribution
- Source term from Katata et. al (2014)
  - Source strength variations in time
- Compared with
  - Ground deposition measurements from JAEA
  - Filter measurements in Sweden

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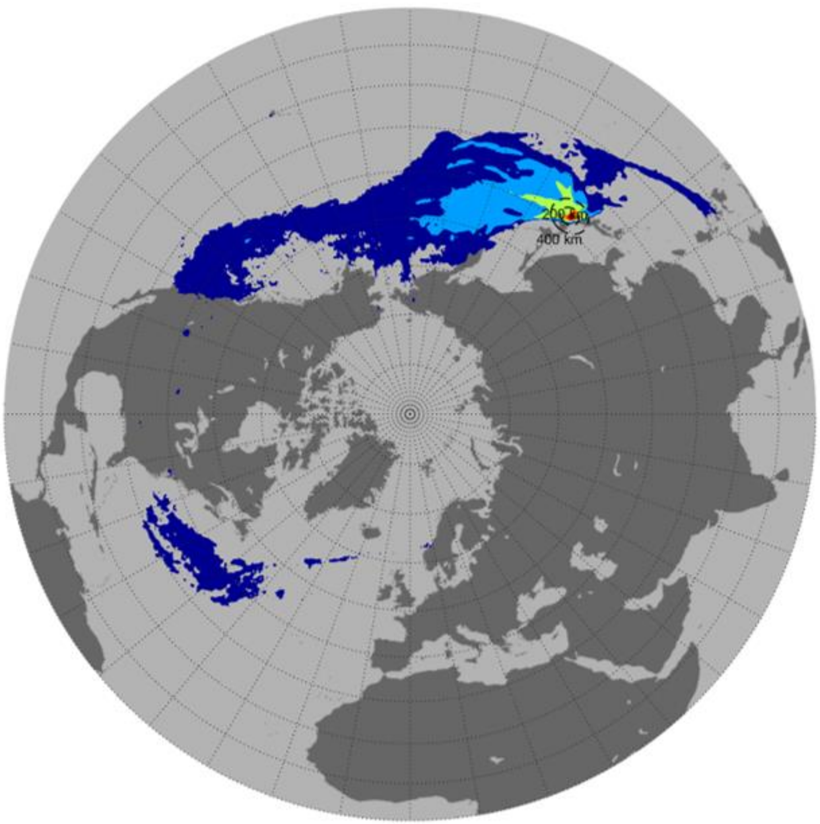
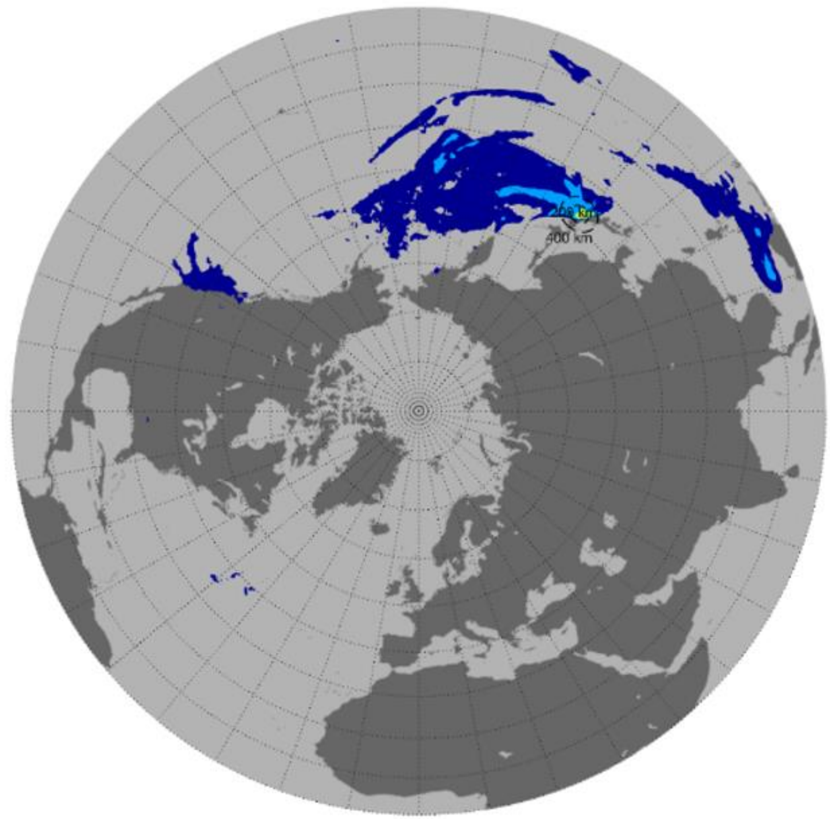
Fukushima accident comparison
All deposition (wet and dry)

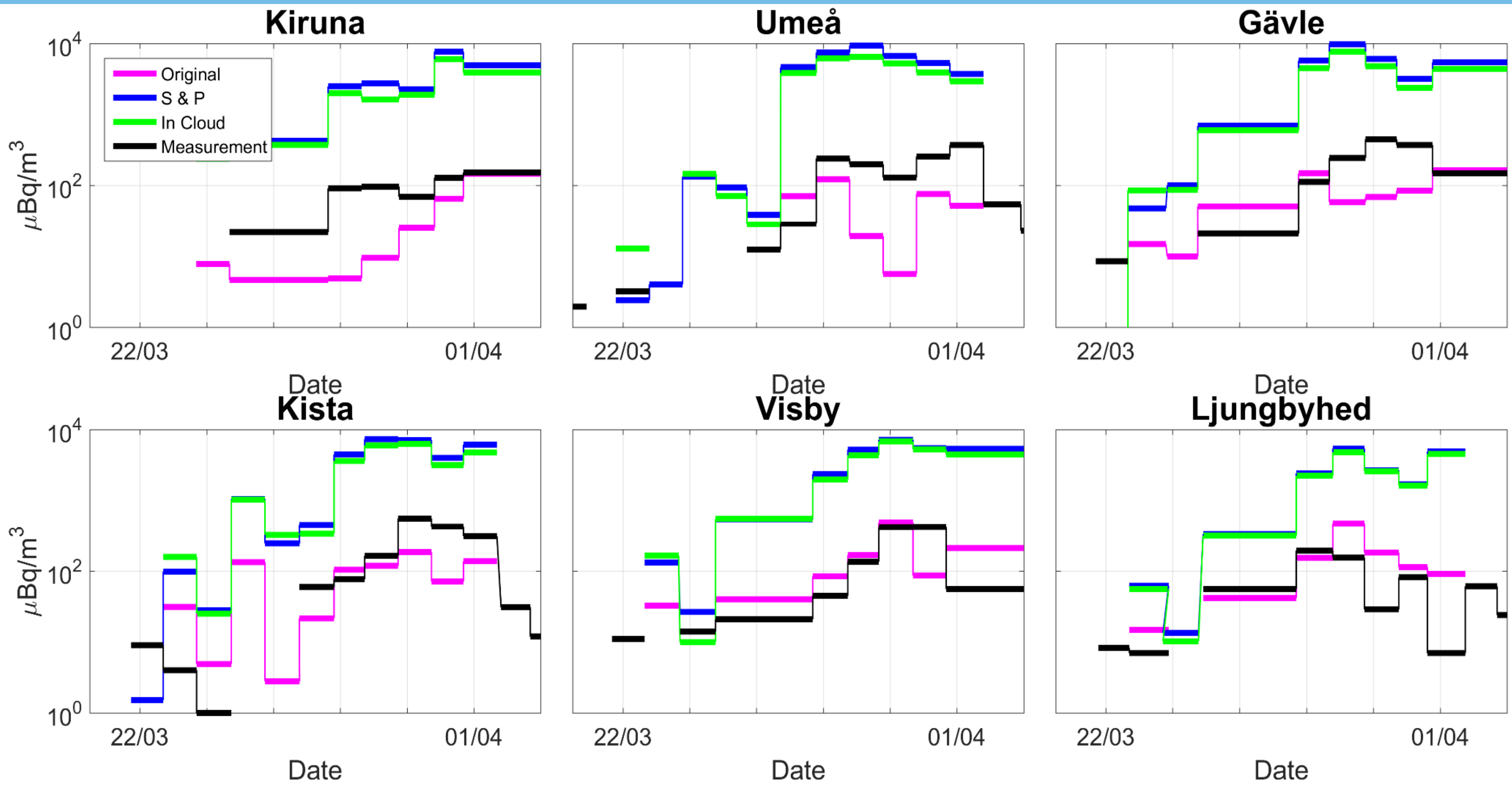
Baklanov and Sørensen 2001



Seinfeld and Pandis 1997



Preliminary results



Conclusions

- Altitude dependent wet removal scheme
  - In cloud and below cloud scavenging
- Parameterization still needs improvement
  - Representation of emitted particles
- Dynamical change of emitted particles
  - Coagulation, condensational growth
- Particles insensitive to wet removal moves into size ranges where they act as condensation nuclei
- Include information about and interaction with background aerosol
- *New ways of describing both wet removal and interaction in the dry atmosphere is required*

Thank you for your attention