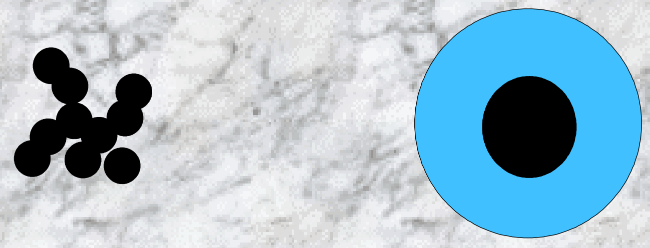
Modelling the Ageing Process of Soot



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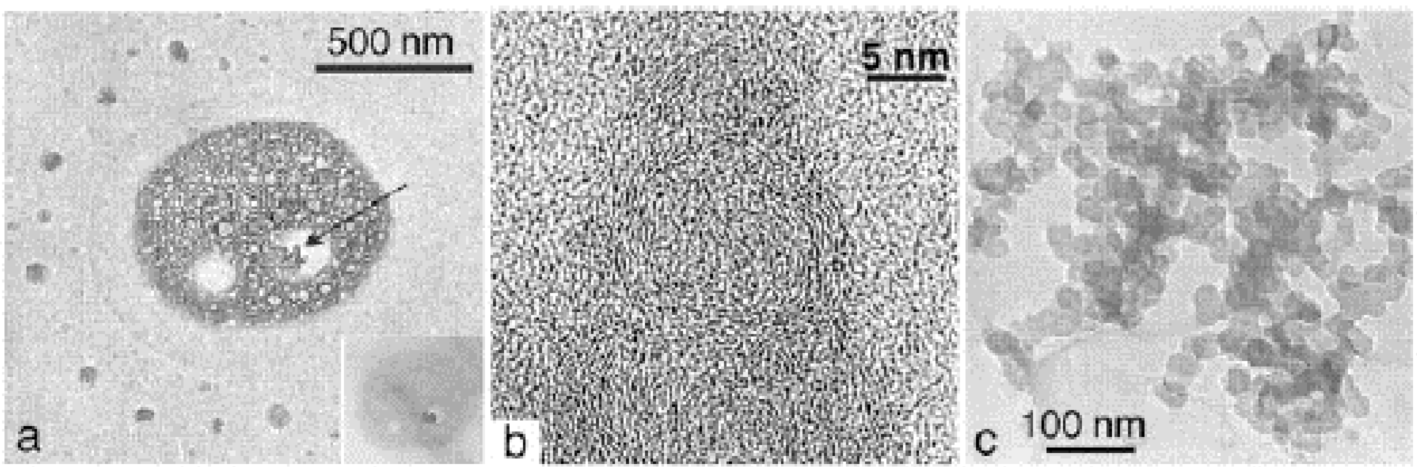
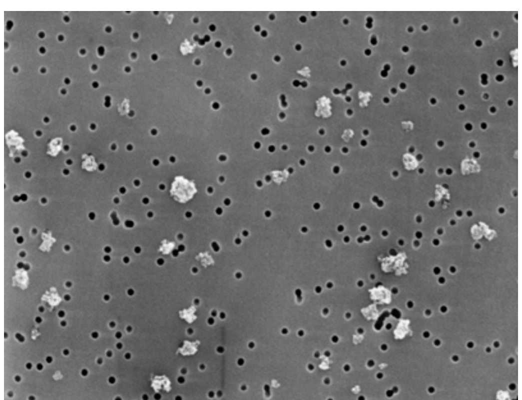
Venice, 25.10.2004

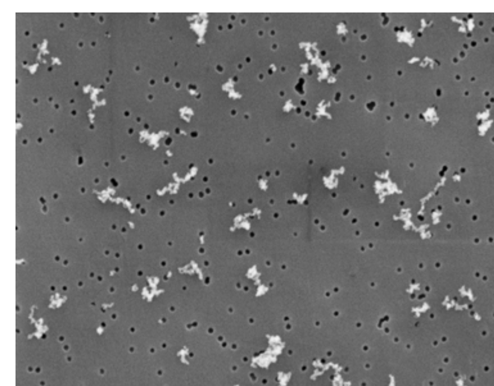
Aged soot

Freshly emitted soot



Buseck und Pósfai, (1999)



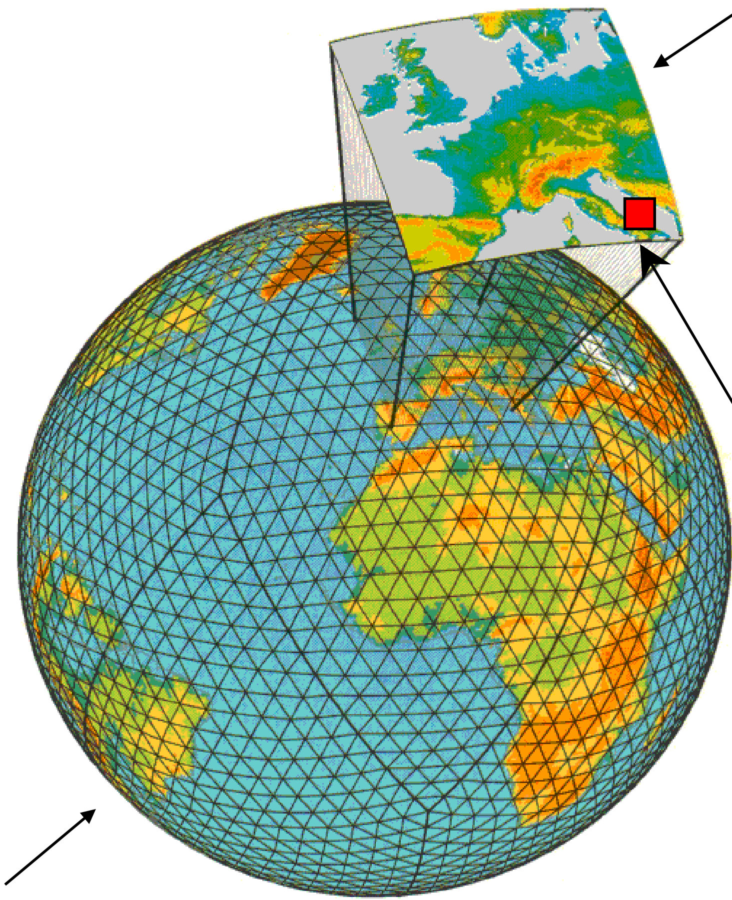


Motivation:

- Freshly emitted soot is hydrophobic and externally mixed.
- It is transferred into internally mixture by different processes.
- Optical properties, growth behaviour, lifetime and health effects are effected by the ageing process.
- Global models often use a first order parameterisations to describe the transfer from the external into the internal mixture. Lifetimes found in literature differ between 0 and 80 hours.

⇨ **Simulations with a non-hydrostatic model to parameterise the ageing process of soot.**

LM - Model of the German Weather Service



KAMM/DRAIS model domain

≅ 1 Grid cell of a global model

GME - Model of the German Weather Service

Mesoscale Model:

$$\frac{\partial m_s(\vec{x},t)}{\partial t} = A(\vec{x},t) + S(\vec{x},t) + D(\vec{x},t) + E(\vec{x},t) - T(\vec{x},t)$$

$$T(\vec{x},t) = Coa(\vec{x},t) + Con(\vec{x},t)$$

Global Scale Model:

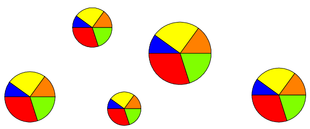
$$\frac{\partial \hat{m}_s(\vec{x},t)}{\partial t} = \hat{A}(\vec{x},t) + \hat{S}(\vec{x},t) + \hat{D}(\vec{x},t) + \hat{E}(\vec{x},t) - \hat{k} \cdot \hat{m}_s$$

Parameterization:

$$\hat{k}(z,t) = \frac{\sum T(x,y,z,t)}{\sum m_s(x,y,z,t)} \quad \Rightarrow \quad \tau = \frac{1}{\hat{k}}$$

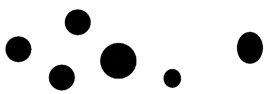
The Aerosol Model MADE$_{SOOT}$

- **Five** modes represent the aerosol population:

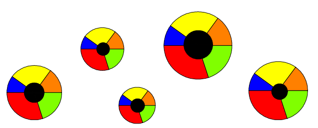


Two modes for SO_4^{2-}, NO_3^-, NH_4^+, H_2O, SOA, internally mixed

One mode for **pure soot**

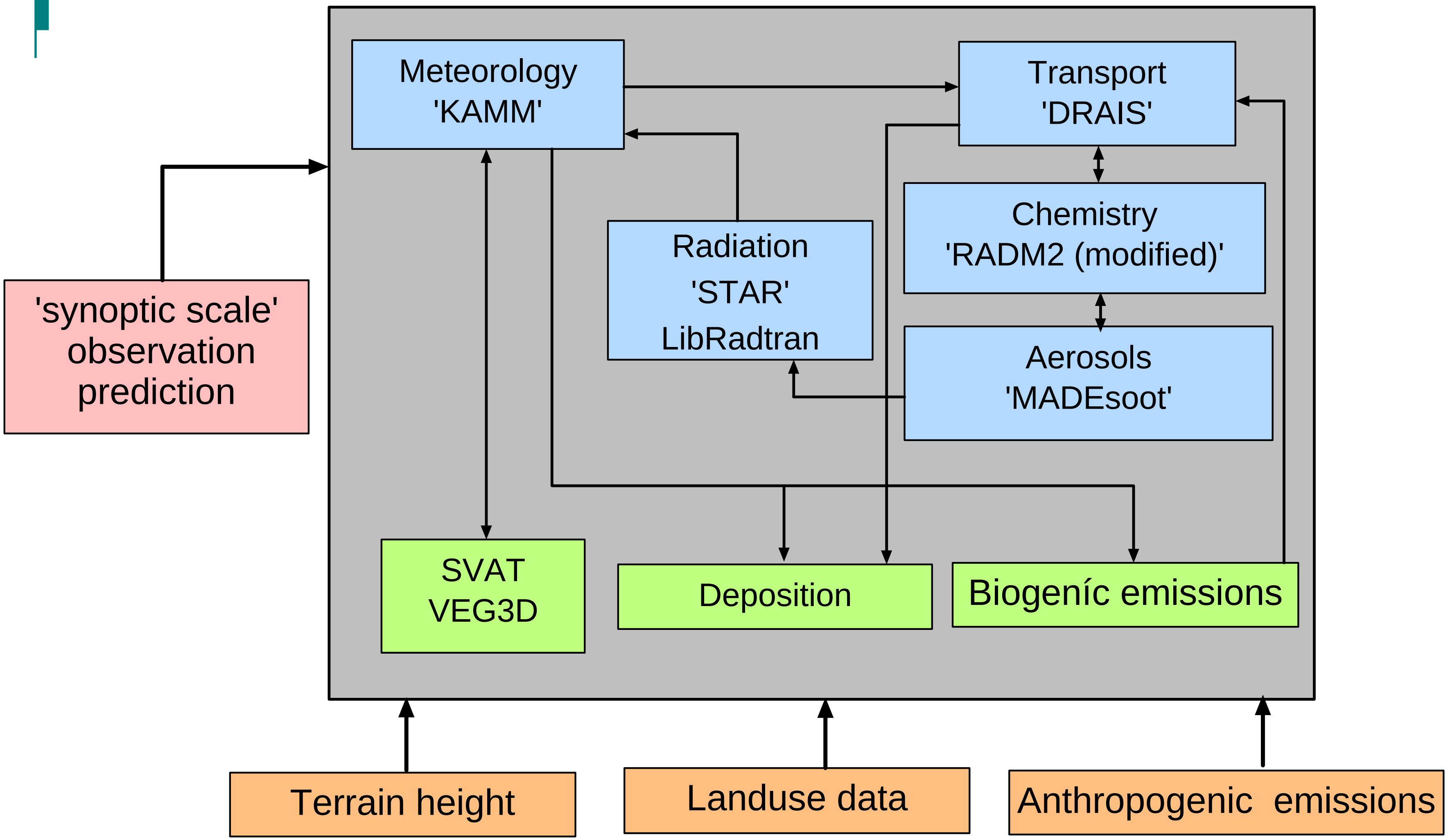


Two modes for SO_4^{2-}, NO_3^-, NH_4^+, H_2O, SOA, **soot**, internally mixed

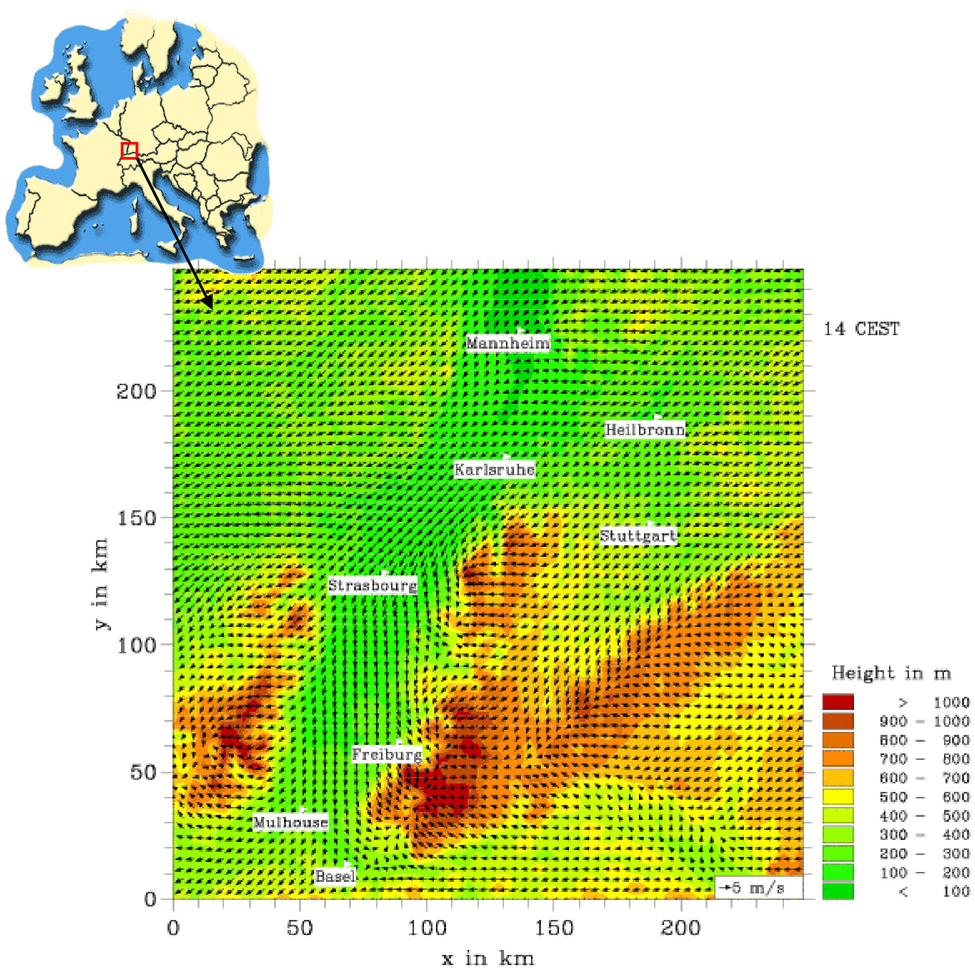


Each mode is represented by a log-normal distribution.

- Treament of the ageing process of soot:
  Transfer of soot from external mixture into internal mixture due to
  coagulation and condensation of sulfuric acid and organics.

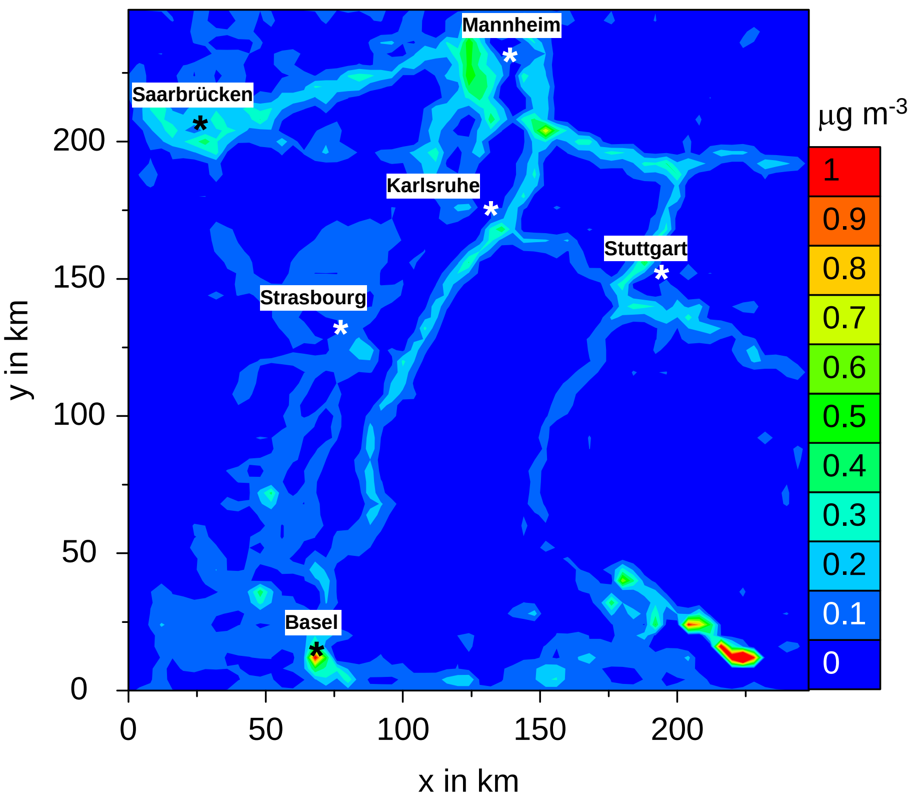

Meteorology
'KAMM'
Transport
'DRAIS'
Chemistry
'RADM2 (modified)'
Radiation
'STAR'
LibRadtran
Aerosols
'MADEsoot'
'synoptic scale'
observation
prediction
SVAT
VEG3D
Deposition
Biogenic emissions
Terrain height
Landuse data
Anthropogenic emissions

3D-Simulations with KAMM/DRAIS:

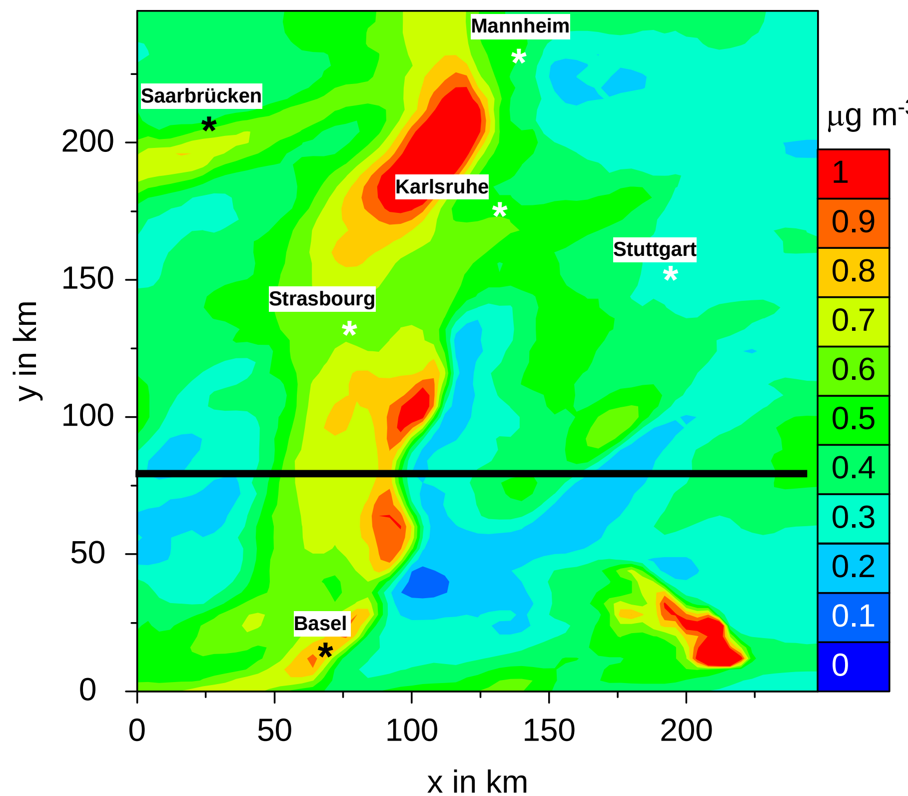


- Model domain:
  250 km x 250 km
  $\Delta x = \Delta y = 4$ km
  25 layers in the vertical direction
- $\Delta t \approx 10$ s
- No clouds
- Simulations:
  - typical summer day
  - typical winter day

Pure soot

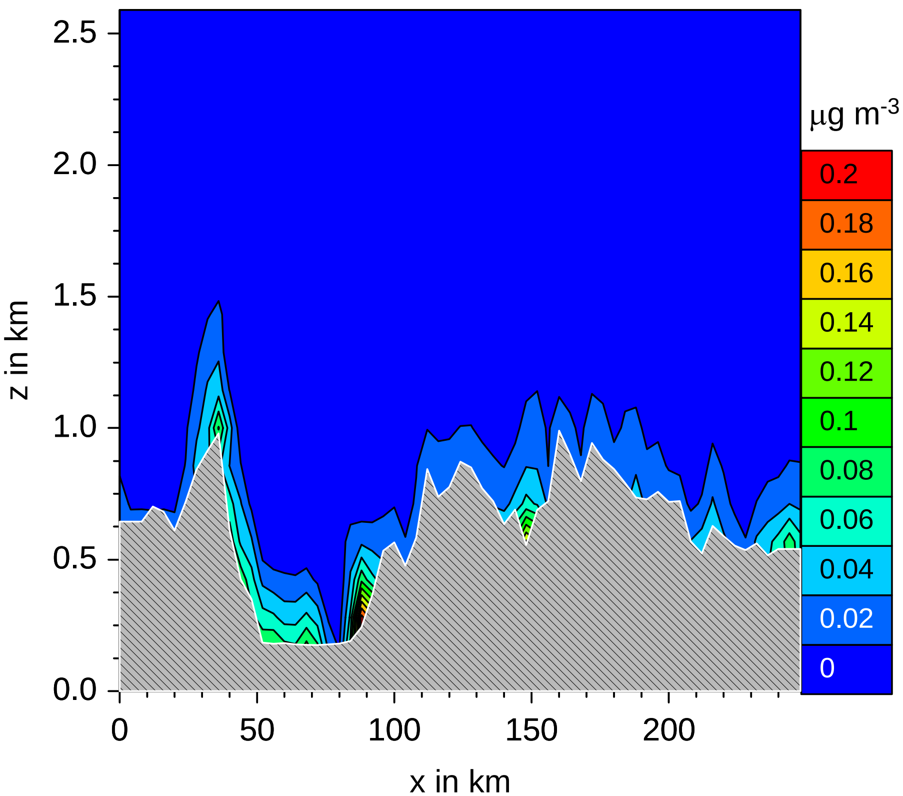


Soot internally mixed

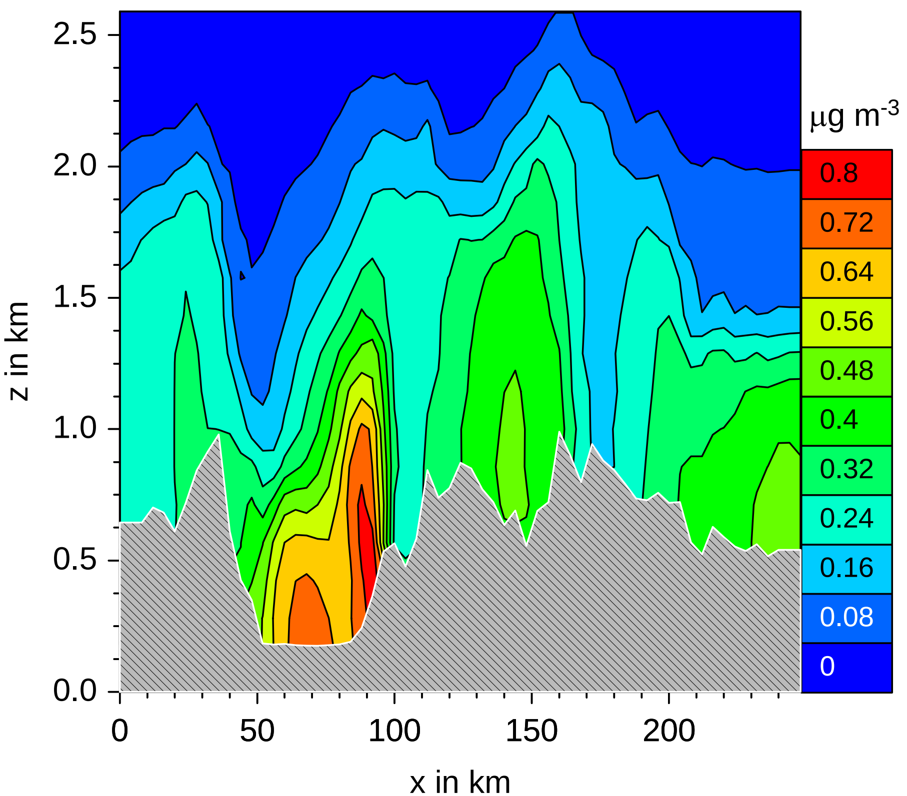


Summer day, 12:00 CET, 25 m above surface

Pure soot

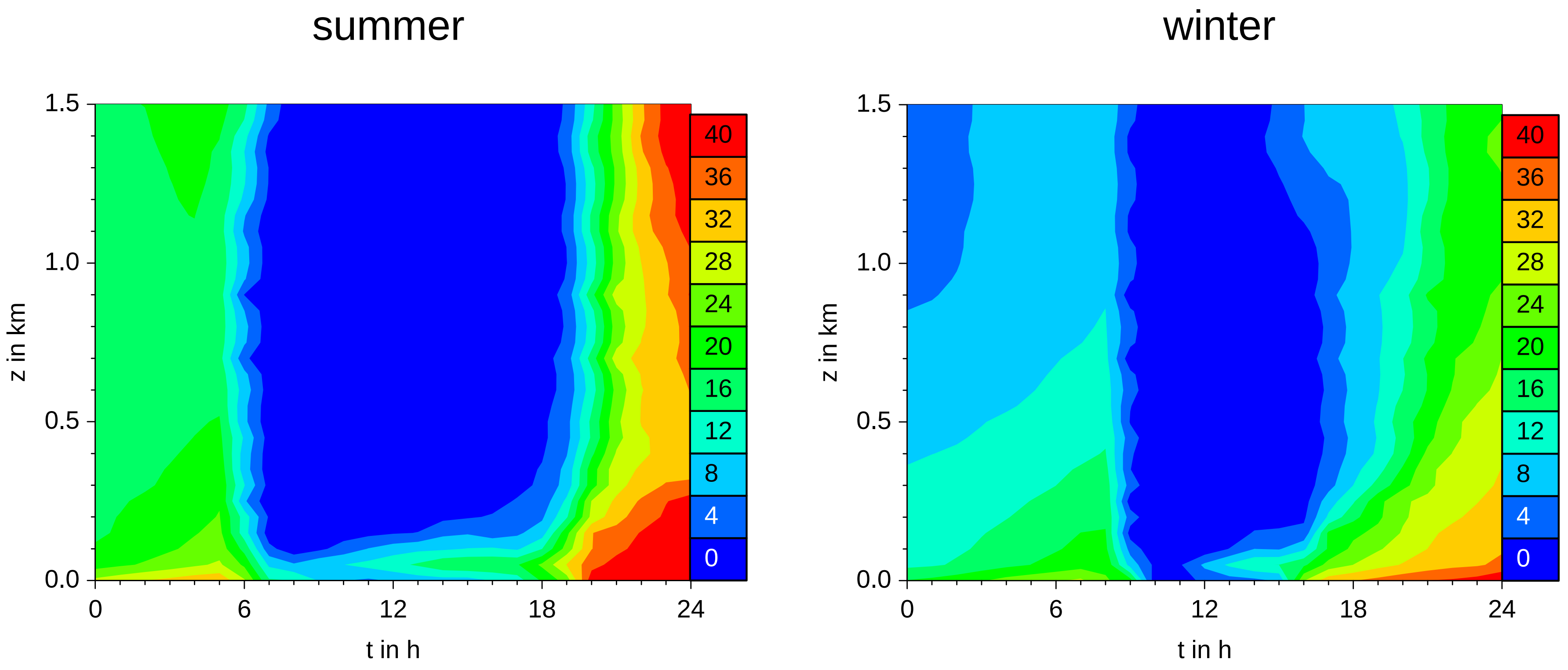


Soot internally mixed

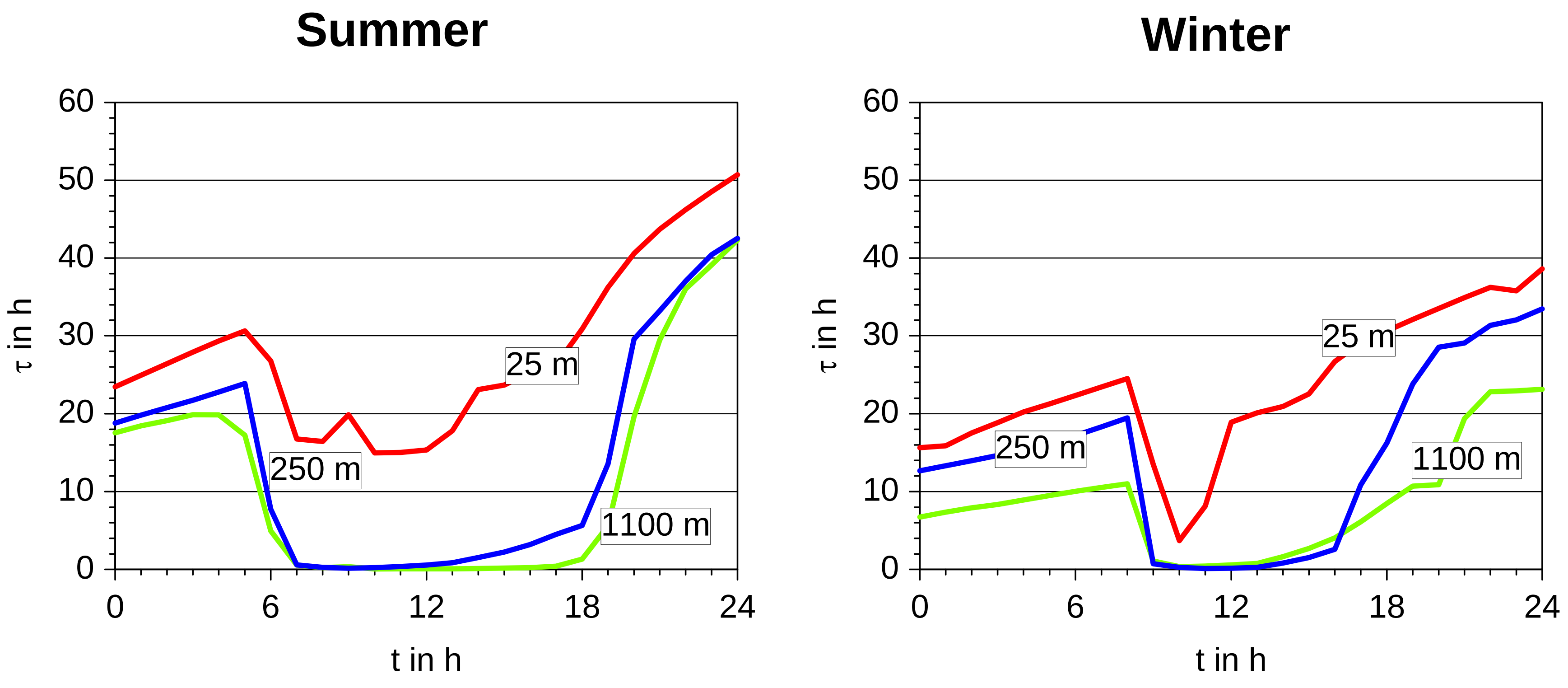


12:00 CET

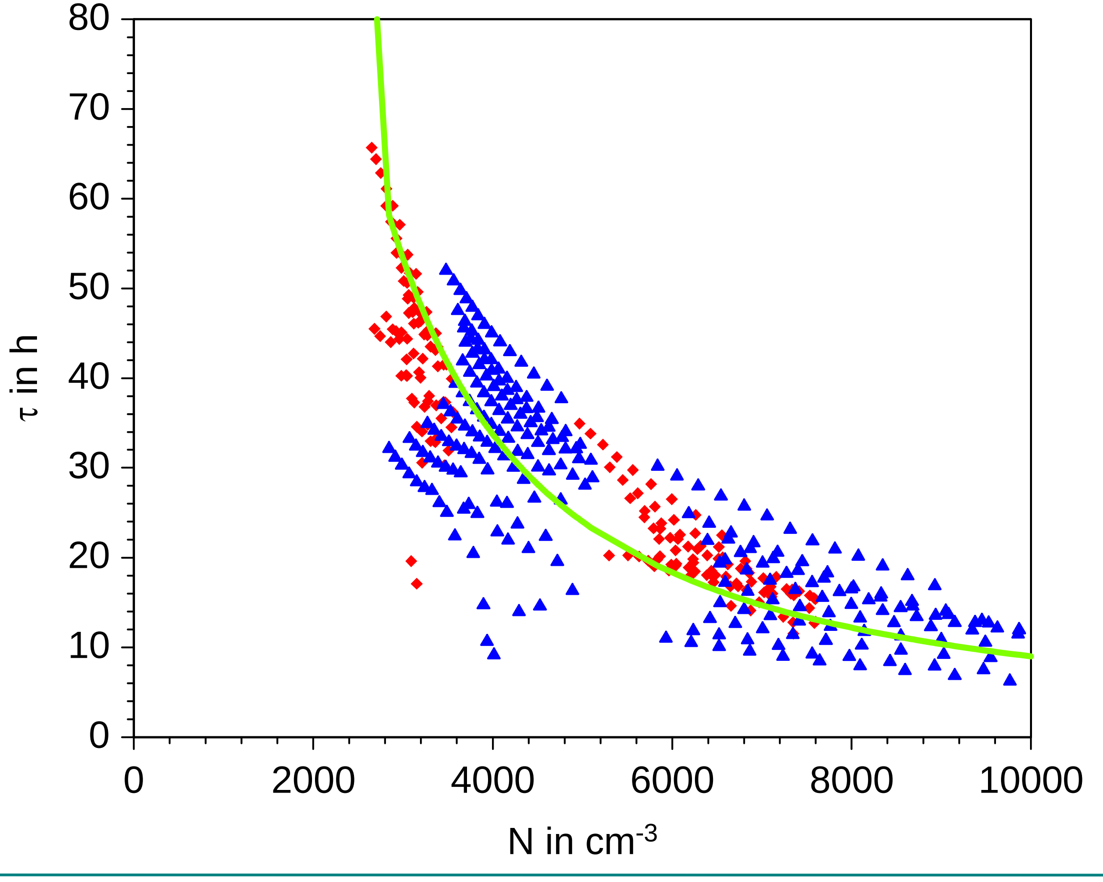
Vertical profiles of the ageing timescale



Daily cycles of the ageing timescale



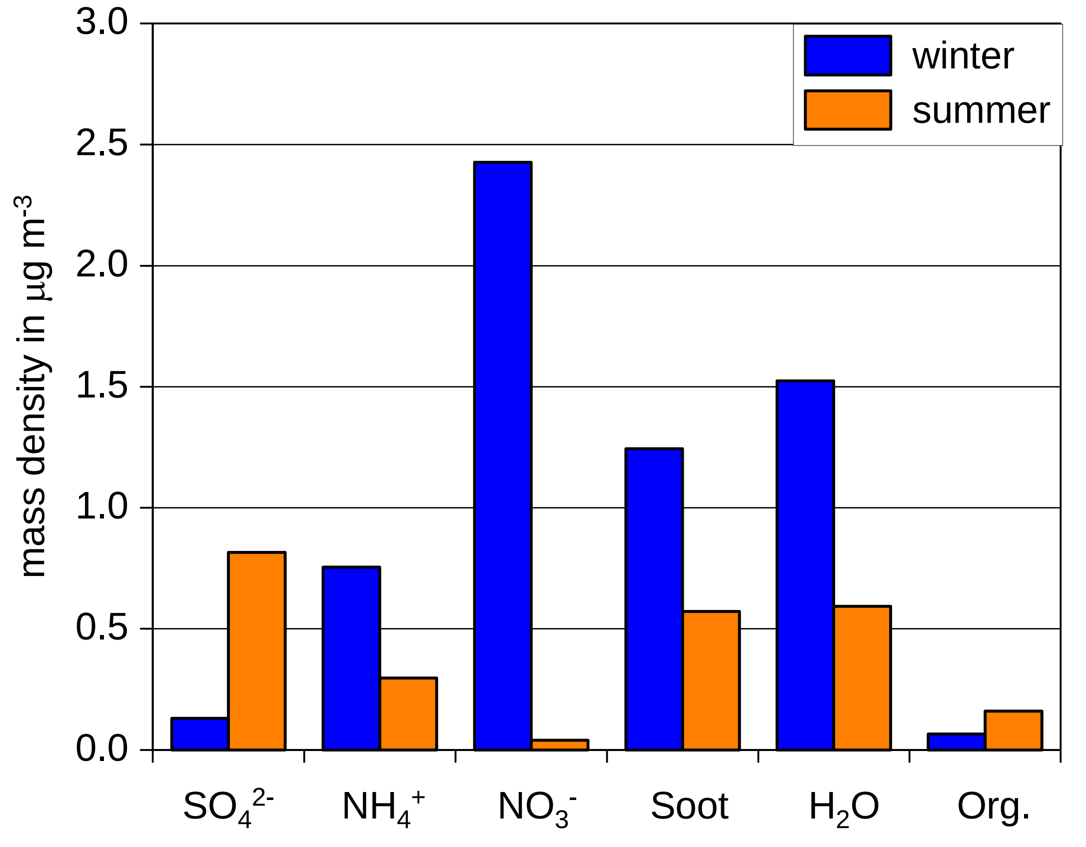
Approximation von τ



$$\tau = -a \cdot N^{-1} + b \cdot N^{-2}$$

$a = 6 \cdot 10^4 \text{ h cm}^{-3}$
$b = 3 \cdot 10^8 \text{ h cm}^{-6}$

Composition of internally mixed particles at 12 CET



Conclusions:

A tool to improve the parameterisation for global models.

The aging time scales that we derived are smaller than most of the values that are currently used in global climate models.

They show a considerable variability in space and time.

During daytime in summer, condensation of sulphuric acid is the governing process for the aging of soot. In wintertime, the formation of ammonium nitrate gains in importance.

During night time,condensation stops being the important process. Instead, Coagulation becomes more significant, acting very slowly.