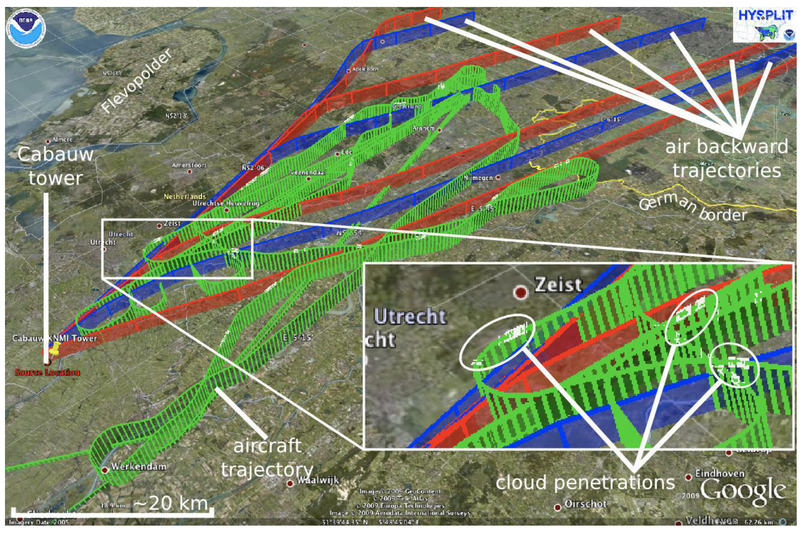
Cloud droplet formation by water vapour condensation on aerosol

EUCAARI-IMPACT observations vs. parcel model results

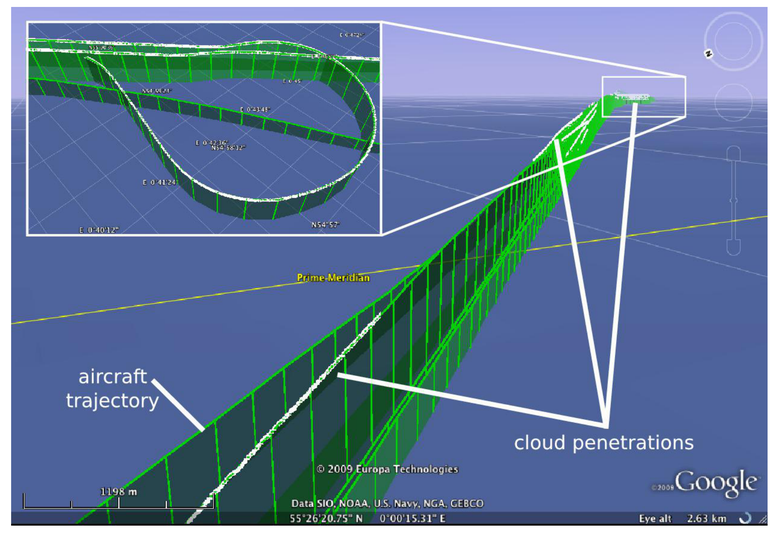
Sylwester Arabas, Hanna Pawlowska
Institute of Geophysics, Faculty of Physics,
University of Warsaw, Poland

observational data courtesy of:
S. Crumeyrolle, A. Schwarzenboek, et al. (CNRS-LaMP, Clermont-Ferrand, France)
L. Gomes, G. Roberts, et al. (CNRM/Meteo-France, Toulouse, France)

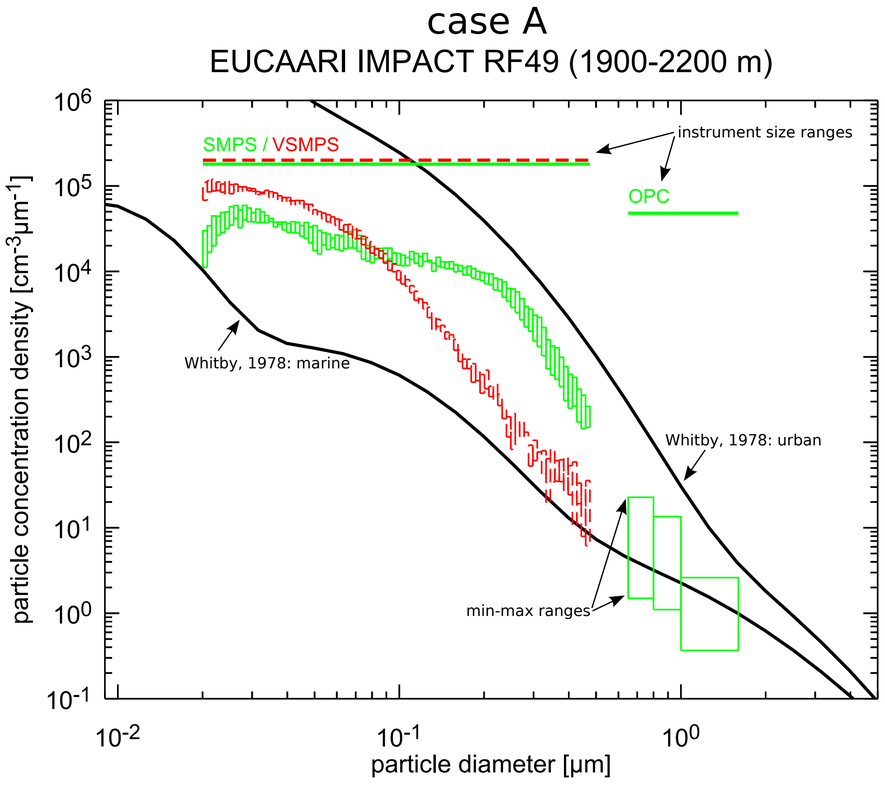


EUCAARI-IMPACT
Intensive Measurement Period
at Cabauw Tower
(May 2008, The Netherlands)

IMPACT



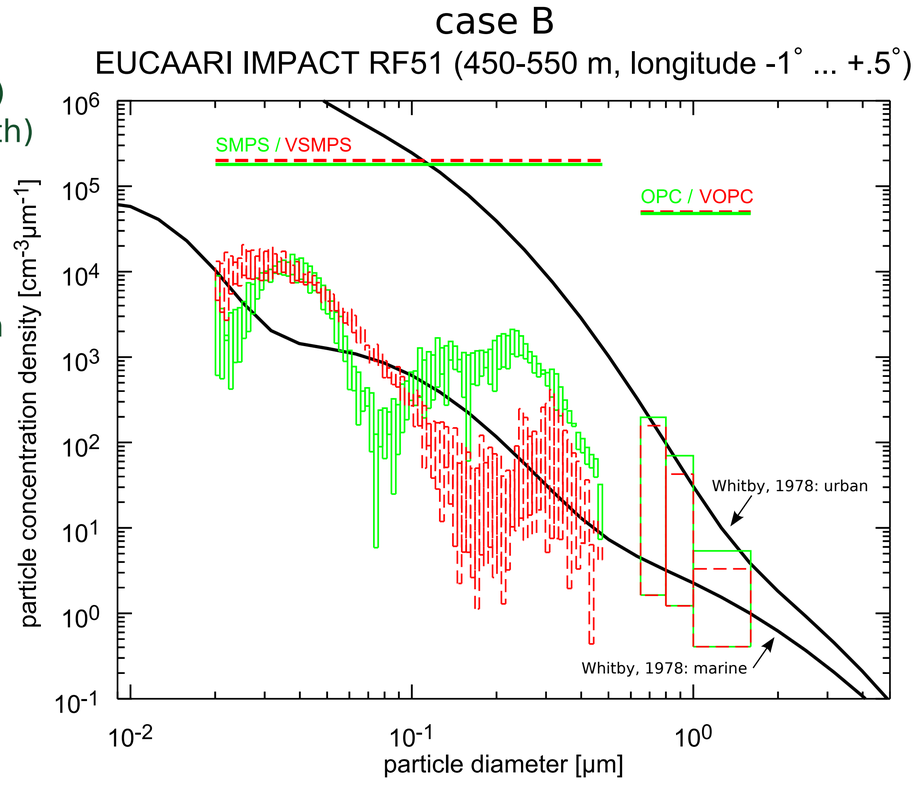
SAFIRE ATR-42 aerosol measurements
(see e.g. Crumeyrolle et al. 2010):
- SMPS: electrical mobility spectrometer (10-250 nm)
  (+one connected through a heater - VSMPS)
- OPC: optical spectrometer (0.29-0.95 μm)
  (+ one connected through a heater - VOPC)
- CCNC: DMT cloud condensation nuclei counter
  (operated at single supersaturation: 0.21%)
- aerosol mass spectrometer, nephelometer, ...

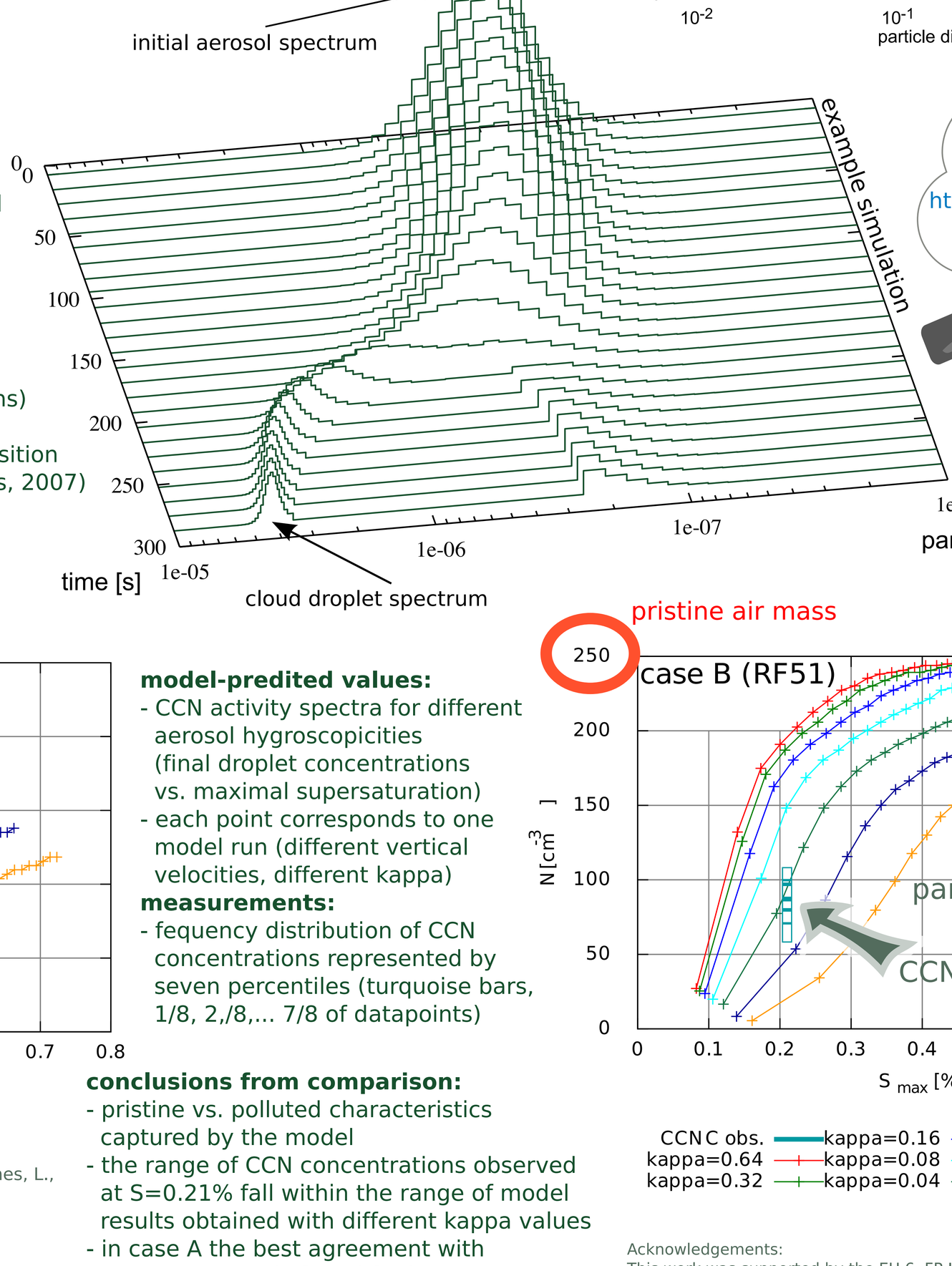


Case studies:
A: Cu clouds over The Netherlands (May 13th)
B: Sc cloud deck over The North Sea (May 15th)

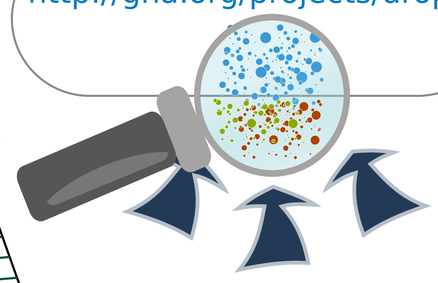
Initial values for the parcel model:
average values measured below cloud base,
ca. 200 samples (1 Hz):
- SMPS+OPC data as initial aerosol spectrum
- temperature, pressure, humidity

Model parameters:
- vertical velocity, aerosol composition
  (hygroscopicity parameter kappa)





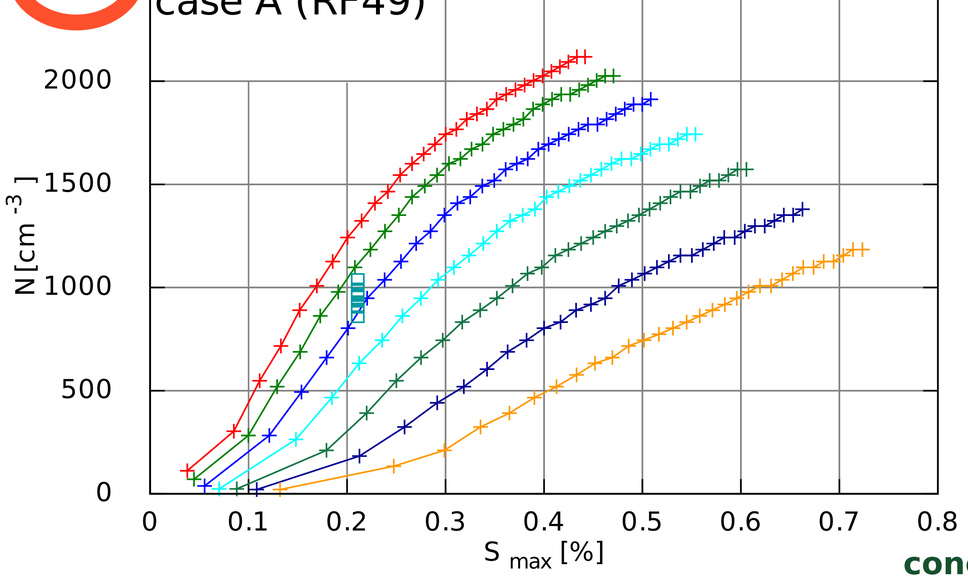
written in C++
using SUNDIALS, GSL
and Boost.Units
http://gna.org/projects/drops/



CCN activation model:
(Arabas & Pawlowska 2011)

- water vapour condensation on an ensamble of aerosol particles in a rising adiabatic air-parcel
- moving-sectional scheme for solving condensational growth of aerosol (position and width of bins change in time)
- fully adaptive numerics (time-step adjustments, adaptive grid refinement - variable number of bins)
- kappa-Koehler parametrisation of aerosol composition (hygroscopicity parameter, Petters & Kreidenweis, 2007)
- model code under GPL in supplement of the paper (+ public CVS @ gna.org)

polluted air mass



model-predited values:
- CCN activity spectra for different aerosol hygroscopicities (final droplet concentrations vs. maximal supersaturation)
- each point corresponds to one model run (different vertical velocities, different kappa)

measurements:
- fequency distribution of CCN concentrations represented by seven percentiles (turquoise bars, 1/8, 2,/8,... 7/8 of datapoints)

pristine air mass

conclusions from comparison:
- pristine vs. polluted characteristics captured by the model
- the range of CCN concentrations observed at S=0.21% fall within the range of model results obtained with different kappa values
- in case A the best agreement with measurements is found for kappa between 0.16 and 0.32 - typical values for continental Europe (Pringle et al. 2010)

CCNC obs. kappa=0.64 kappa=0.32 kappa=0.16 kappa=0.08 kappa=0.04 kappa=0.02 kappa=0.01

References:
- Arabas, S. and Pawlowska, H.: Geosci. Model Dev., 4, 15-31, 2011.
- Crumeyrolle, S., Manninen, H. E., Sellegri, K., Roberts, G., Gomes, L., Kulmala, M., Weigel, R., Laj, P., and Schwarzenboeck, A.: Atmos. Chem. Phys., 10, 6721-6735, 2010
- Petters, M. D. and Kreidenweis, S. M.: Atmos. Chem. Phys., 7, 1961–1971, 2007.
- Pringle, K. J., Tost, H., Pozzer, A., Poeschl, U., and Lelieveld, J.: Atmos. Chem. Phys., 10, 5241–5255, 2010
- Whitby, K.: Atmos. Environ., 12, 135–159, 1978

Acknowledgements:
This work was supported by the EU 6. FP IP EUCAARI (European Integrated Project on Aerosol Cloud Climate and Air Quality interactions) No. 036833-2 and the Polish MNiSW grant 396/6/PR UE/2007/7.
SA participation in WaVaCS school supported by COST Action ES0604

EUCAARI

Poster presented at the "Atmospheric Water Vapour in the Climate System" (WaVaCS) COST school in Venice, Italy (February 2011)