WP3.2 Assessment and Quantification of the Aerosol [Indirect] Effect

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11) CNRS, France

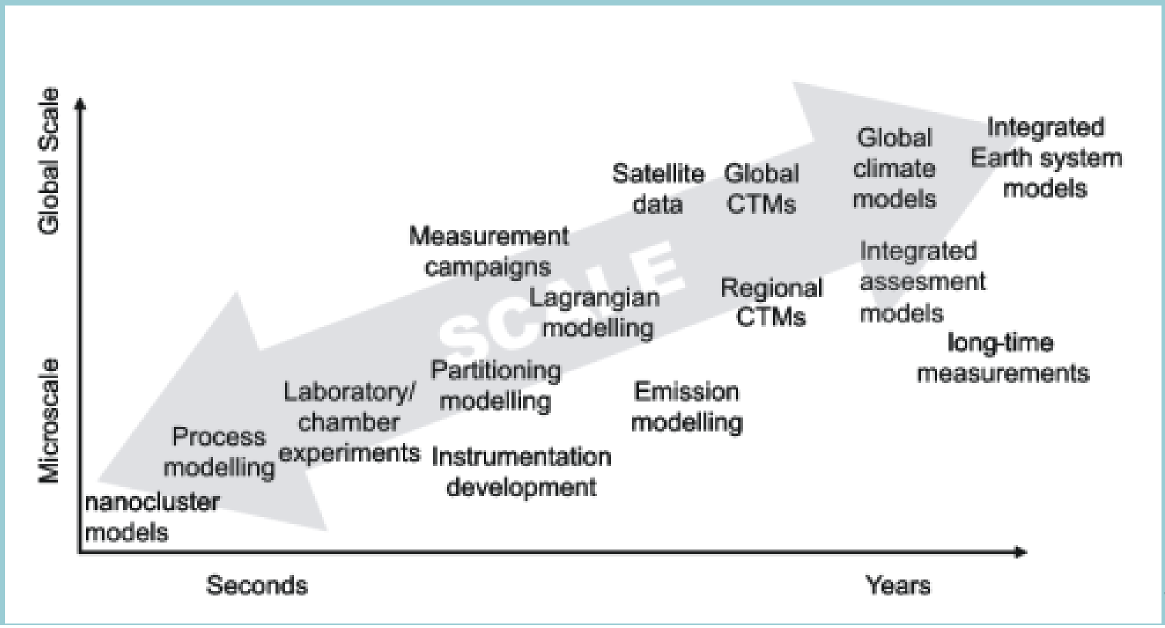
EUCAARI

European Integrated project on Aerosol Cloud Climate and Air Quality Interactions (EUCAARI) is a project within EU's Sixth Framework Program.

It's main goals are to:

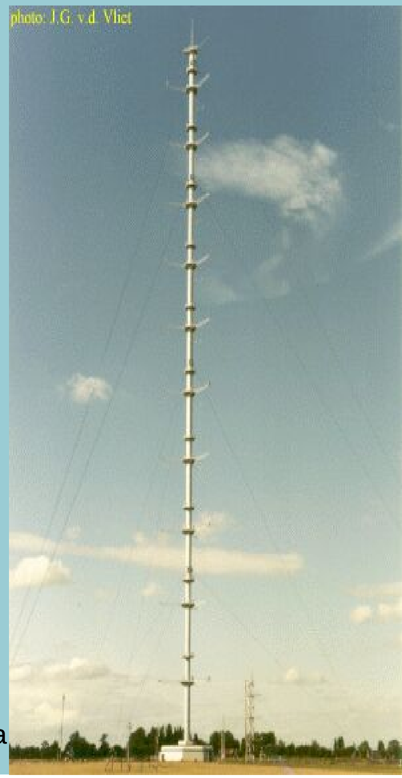
1) Reduce current uncertainity of impact of aerosol particles on climate by 50% and quantify the relationship between anthropogenic aerosol particles and regional air quality

2) Quantify the side-effects of Europen air quality directives on global an regional climate



Impact

Intensive Measurement Period at Cabauw Tower



Overall focus of observations during EUCAARI – IOP :
Intensive **M**easurement **P**eriod **A**t **C**abauw **T**ower: May 2008

Measure: Impact

a) ***Details*** of aerosol distribution (surface)

b) Vertical velocity distribution (remote, aircraft)

c) Cloud structure (remote, aircraft)

d) Cloud droplet microphysical and mixing structure (aircraft)

e) sub - adiabatic character of clouds

[Do not focus so much on cloud albedo observations]

Preparation at Cabauw:

a) Installation of drizzle radar on top of mast (TUDelft)

b) BSRN certification

c) Installation of aerosol inlet at 60 m

d) Expansion of laboratory space at central Cabauw laboratory

e) Installation of permanent PM2.5 observation site and incorporation in national PM-net (RIVM)

Scanning cloud radar (TUDelft)
10 GHz

TU Delft

At the tower: new and improved!!

Aerosol inlet at 60 m

At the tower: new and improved!!

Baseline Surface Radiation Network Now Certified!

Aircrafts associated with the IOP

F-ATR42

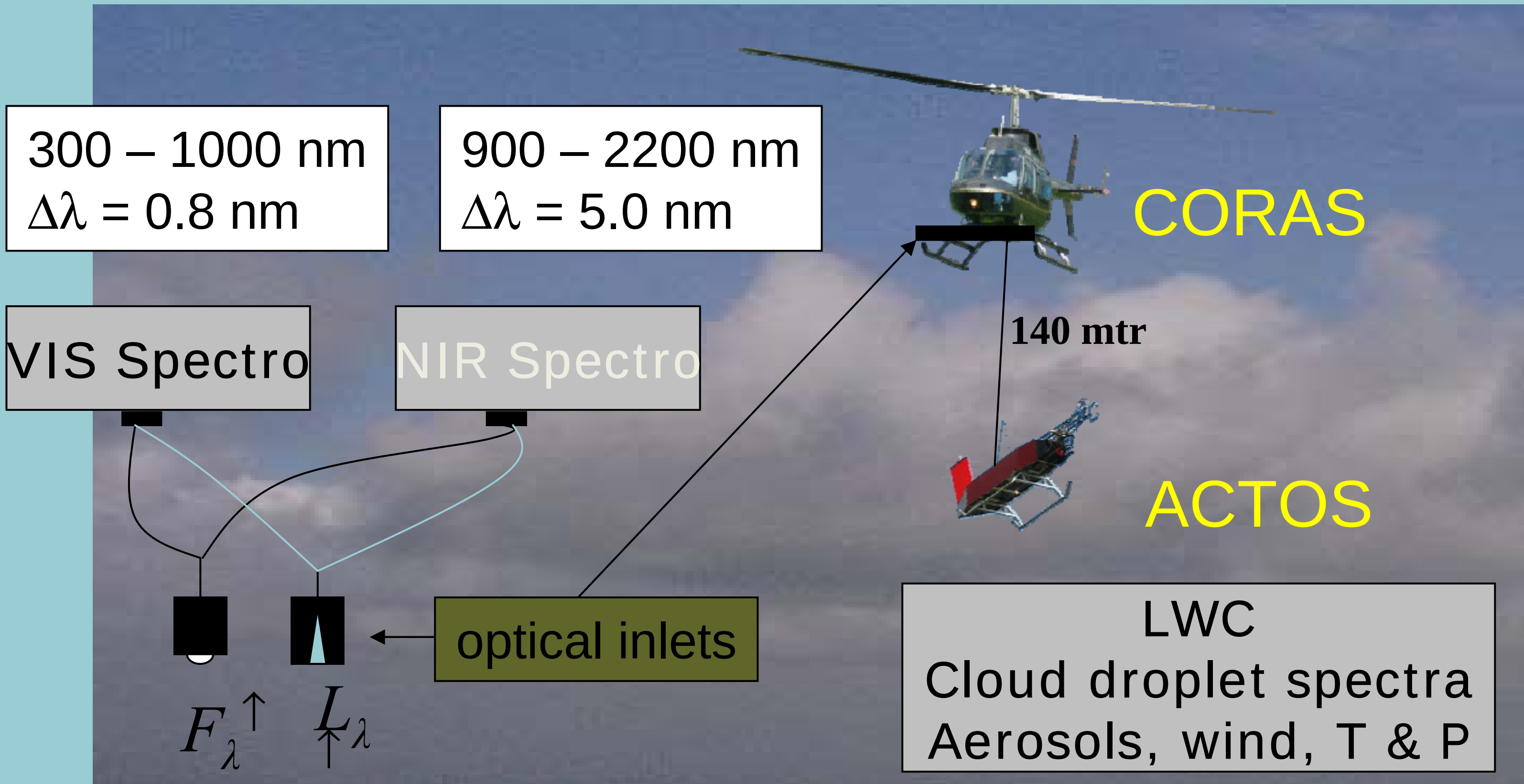
NERC Dornier 228: D-CALM

Focus on:
- Optical, physical, chemical and hygroscopic properties of aerosols (CN and CCN)
  - Cloud Microphysics (warm clouds)
  - Turbulence observation
  - Aerosol and cloud radiative properties
  - 60 hrs available (40 IOP, 20 langrangian), stationed at Rotterdam

Focus on:
Radiation measurements, collocated with the ATR42
30hrs available, stationed in the UK

Helicopter associated with the IOP

ACTOS: Airborne Cloud Turbulence Observation System CORAS: COmpacted RAdiation System



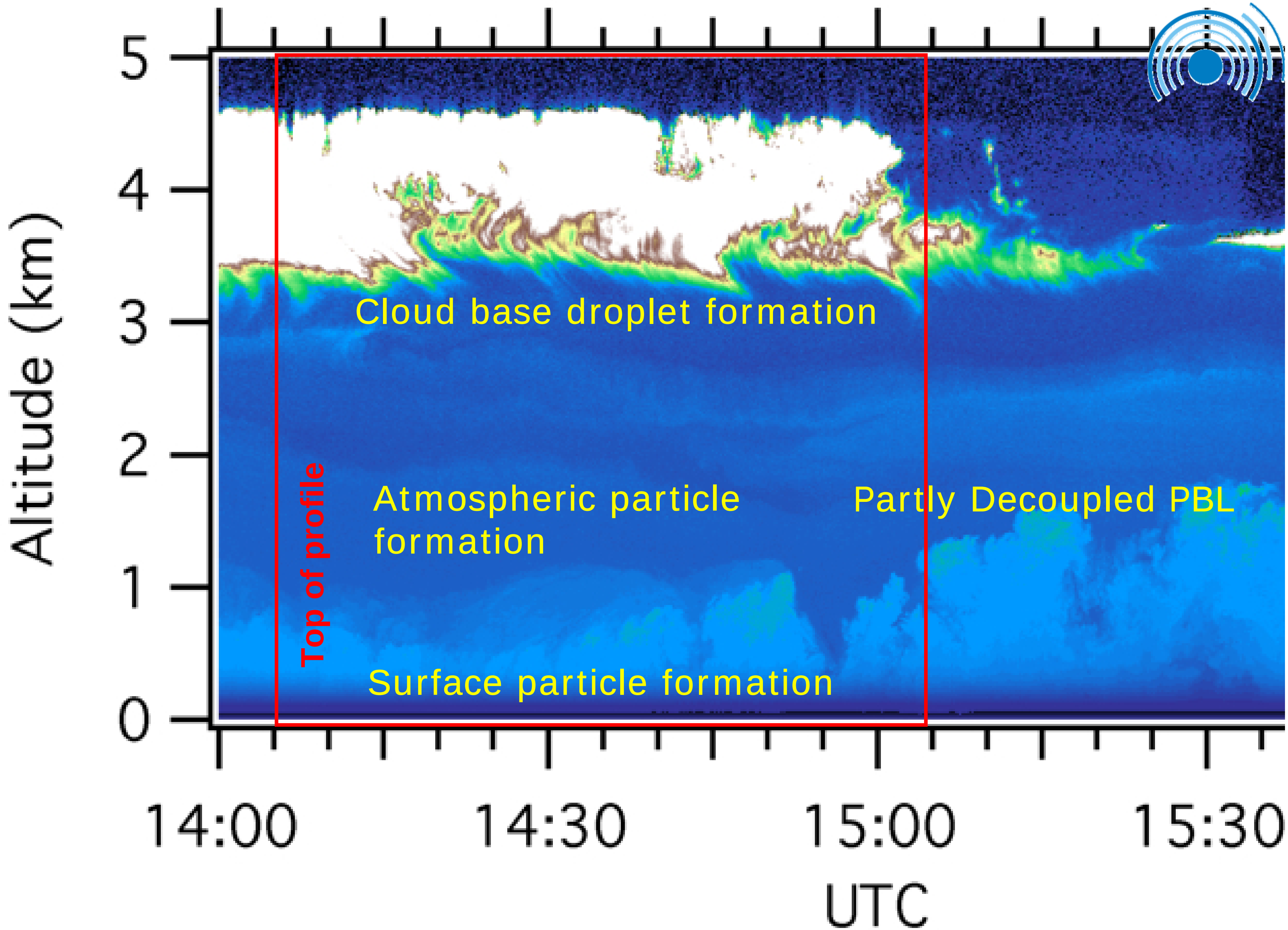
$F_\lambda\uparrow$: upwelling spectral irradiance
$L_\lambda\uparrow$: upwelling spectral radiance

Leibniz institute, Leipzig, Germany

Synthesis

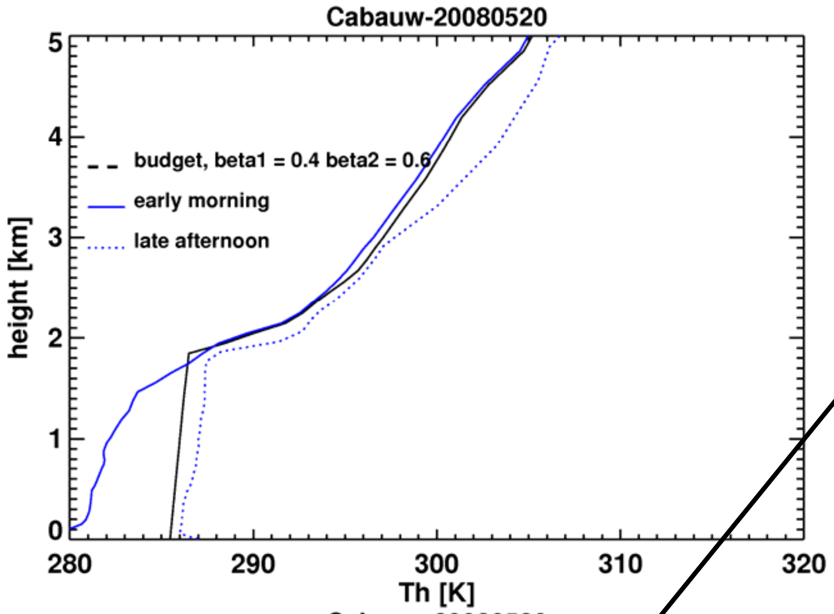
- Mixing state of the continental PBL.
- New particle formation.
- Nitrates and organic aerosols as potential CCN sources.
- Vertical velocity, CCN formation and chemistry.
- The importance of high resolution Large Eddy Simulation (LES) studies in the understanding cloud processes.
- Aerosols and the modeling of atmospheric radiation.
- The Integration 'Thing'

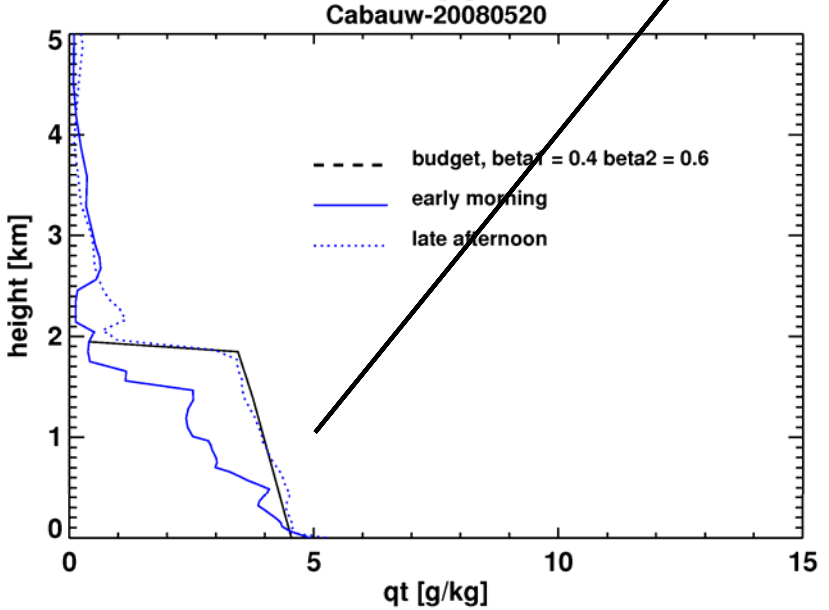

Site of North Sea
case study,
15 May 2008,
mostly clouds
Cabauw site mostly
aerosol studies



Altitude (km)
5
4
3
2
1
0
Cloud base droplet formation
Atmospheric particle formation
Partly Decoupled PBL
Top of profile
Surface particle formation
14:00
14:30
15:00
15:30
UTC

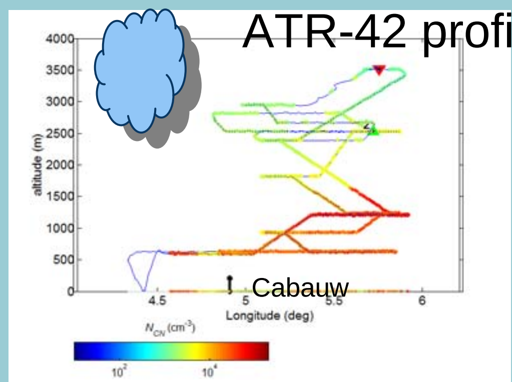
Aerosol mixing in PBL

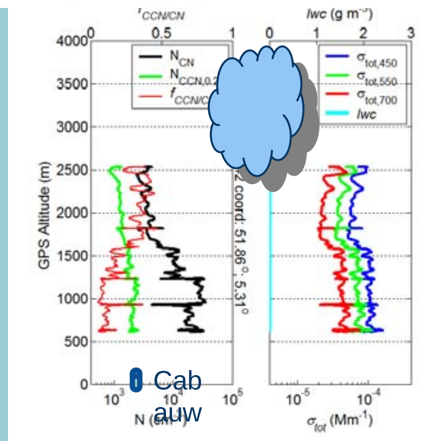




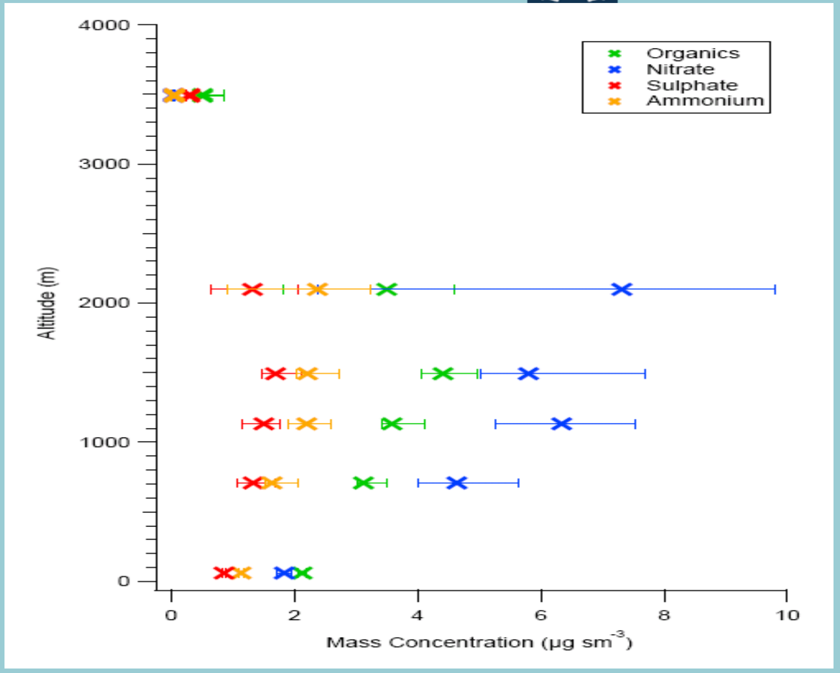
- Strong aerosol source near surface
- PBL not always well-mixed

→ CCN concentrations at surface may be considerably higher than at cloud base (Roberts, Gomes, Schwarzenboeck, Pelon, Boers)





Semi-volatiles & gas-aerosol partitioning



-Rapid changes with height [even increases] because partitioning of nitrate and organics into particle phase at reduced T and enhanced RH aloft

-Figures from Morgan et al., published in ACP(D)

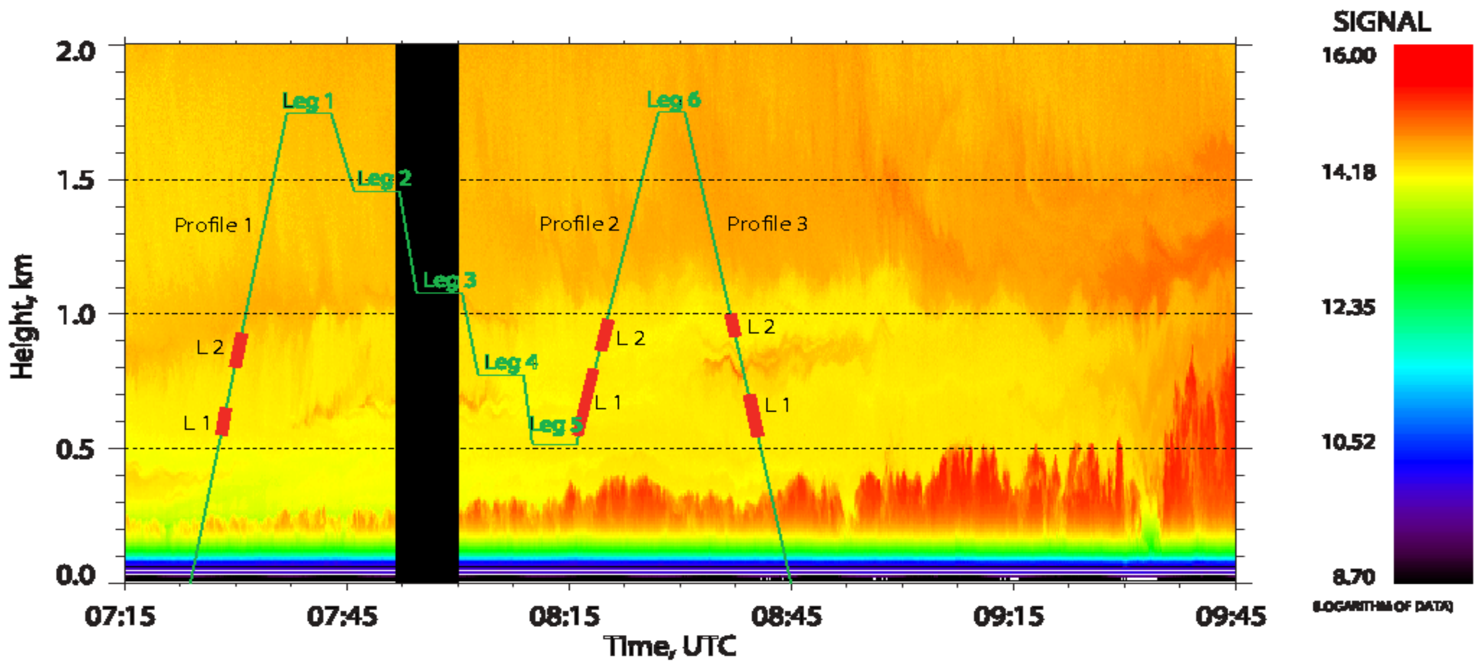
1) Mixing state of the continental PBL.

The observed PBL was often only partly mixed. This was particularly evident from the moisture gradients obtained from radiosondes.

Chemical reactions and strong temperature RH dependence of chemical balances can account for increases with height

These gradients should be taken into account in the modeling of CCN concentrations near cloud base.

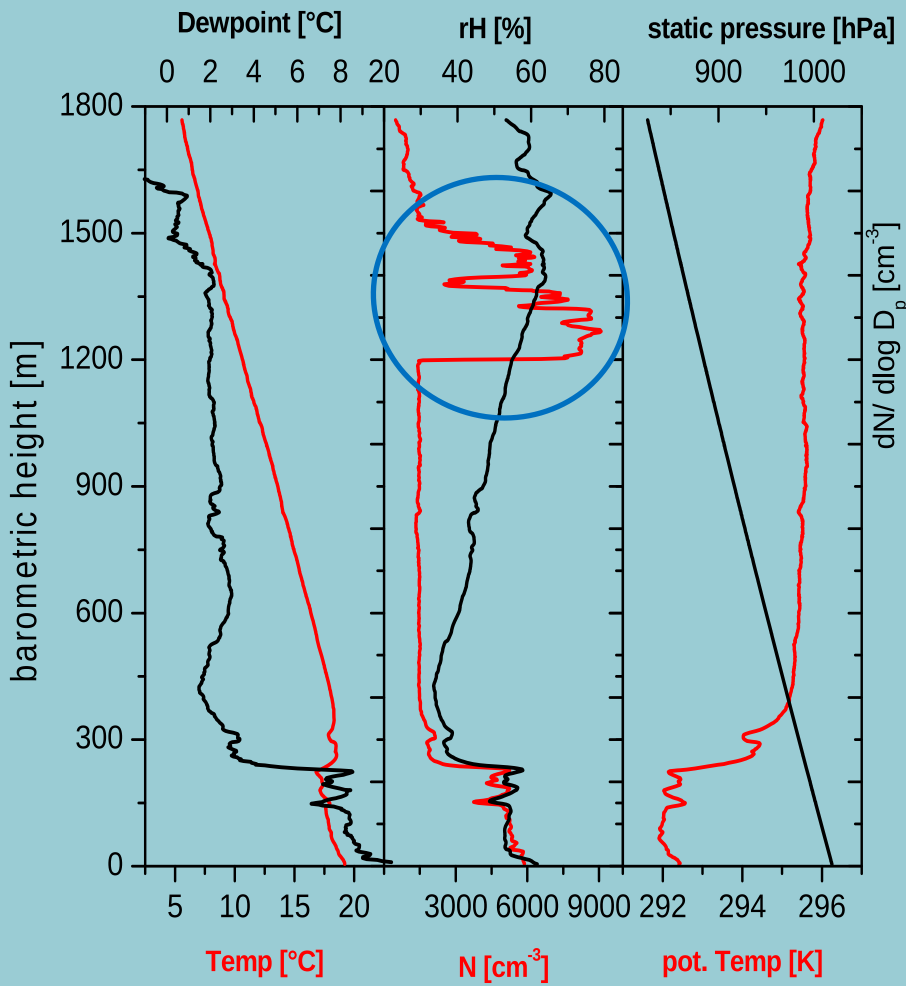
The importance of new particle formation in the PBL and in the residual layer (Wehner, Siebert et al., 2010, Manninen et al., 2010)

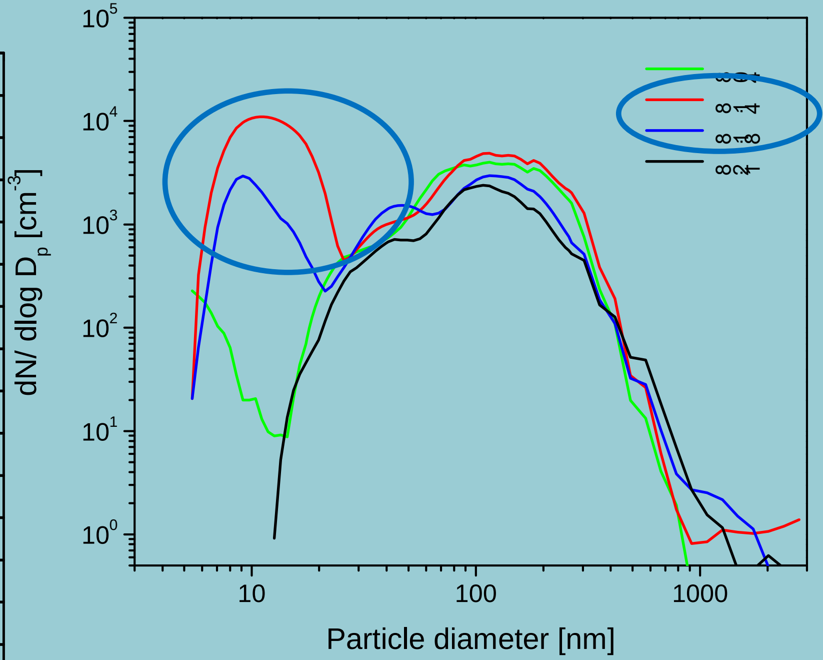


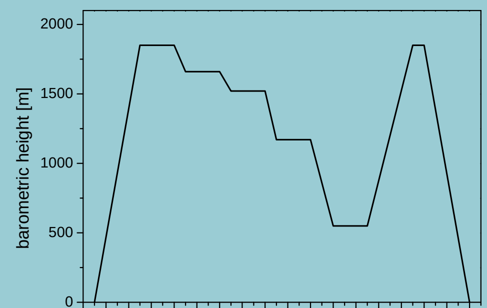
Combined measurements with helicopter-borne ACTOS
(green lines indicate flight pattern around Cabauw) and LIDAR CAELI

Clear sky period: May 8th [Helicopter view]

High total particle number concentration ⇔ High concentration of ultrafine particles







Vertical flight pattern

Birgit Wehner [IFT]

2) New particle formation.

New particle formation in the PBL and in the residual layer has been proven.

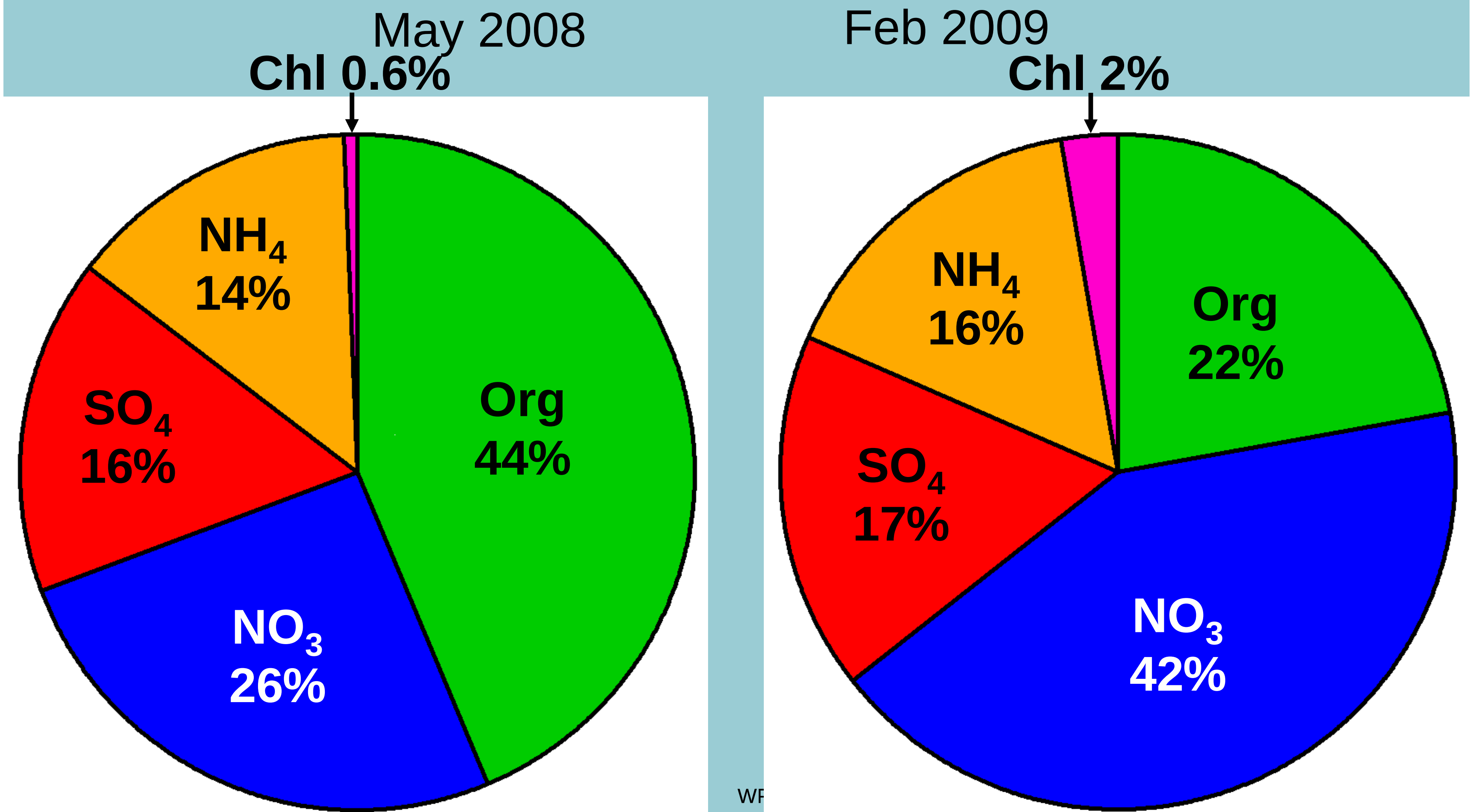
Relative contribution to total particles is unknown.

Challenging prospect for the parameterization of the AIE

Their impact on CCN formation may be quite large, but remains unsure from these observations

AMS measurements at Cabauw
Campaign Overview 2009, A.A. Mensah, A. Kiendler-Scharr, A. Trimborn and T. Mentel, FZ Jülich

Average particle composition



WF

3) Nitrates and organic aerosols as potential CCN sources.

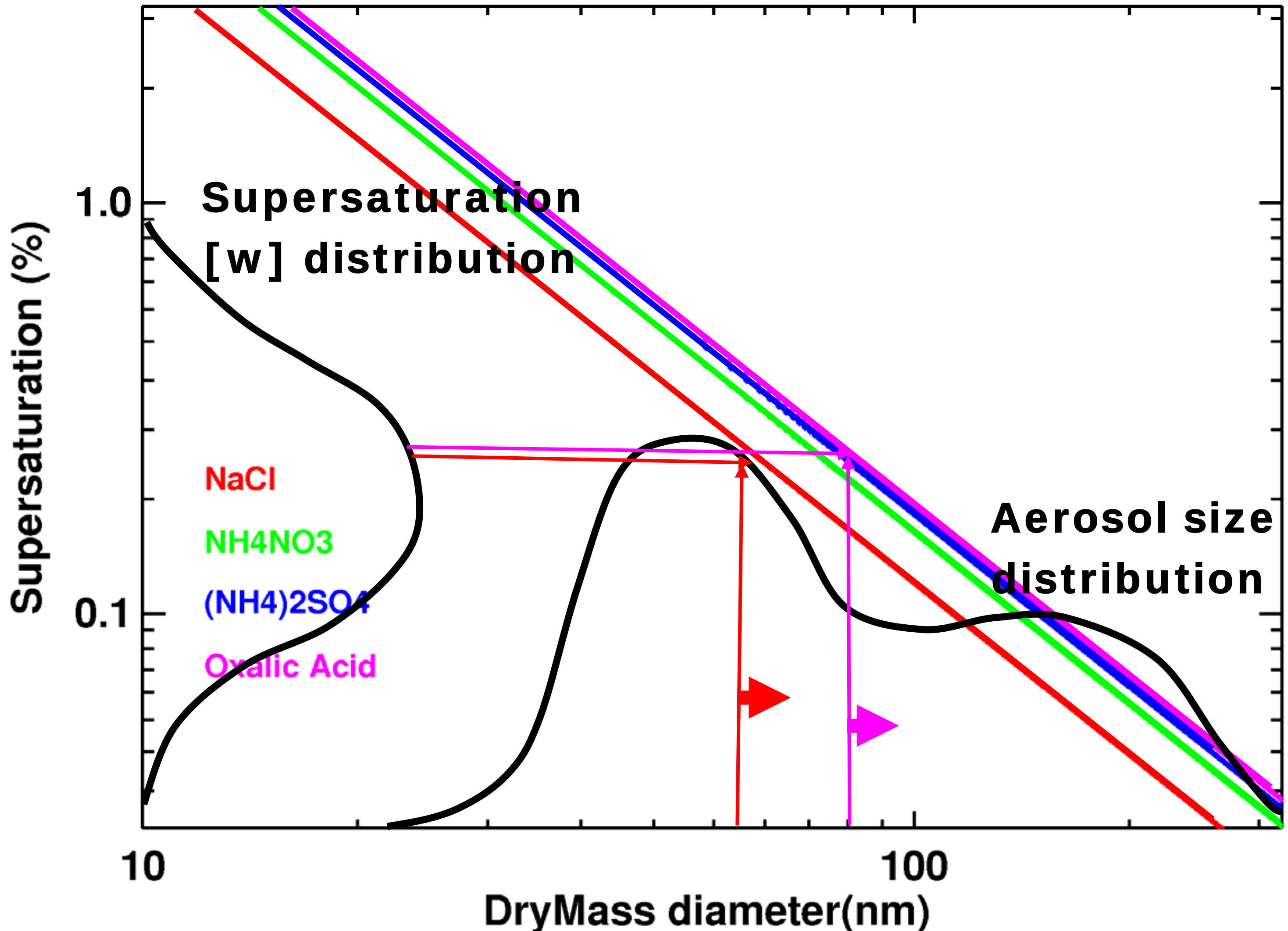
For CCN formation:

Water chemistry is controlled by

1) chloride
2) nitrate
3) sulphate
4) ammonium
5) AND ORGANICS (HOW MANY…….)

Conclusion: influence of organics on CCN formation should be bulk-parameterized

The importance of vertical velocity and chemical composition

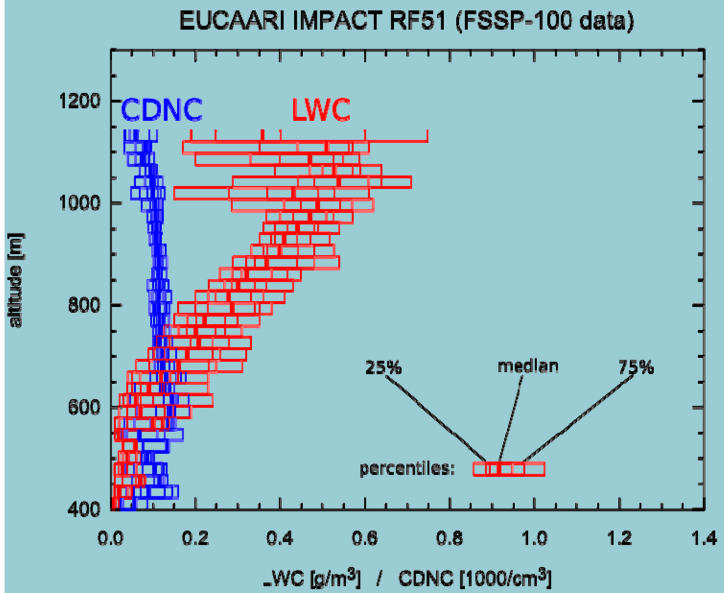


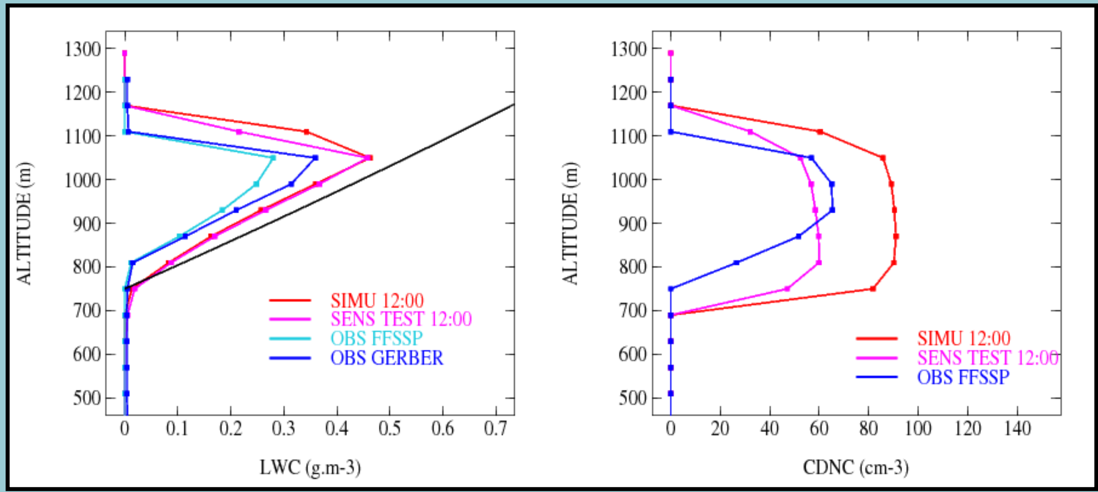
4) Vertical velocity, CCN formation and aerosol chemistry.

An analysis of the vertical velocity statistics demonstrate the importance of vertical velocity in the CCN-activation process.

CCN activation is also a function of the chemistry of aerosol particles.

Observations >>>>>>>>>>>>>>>>>LES models

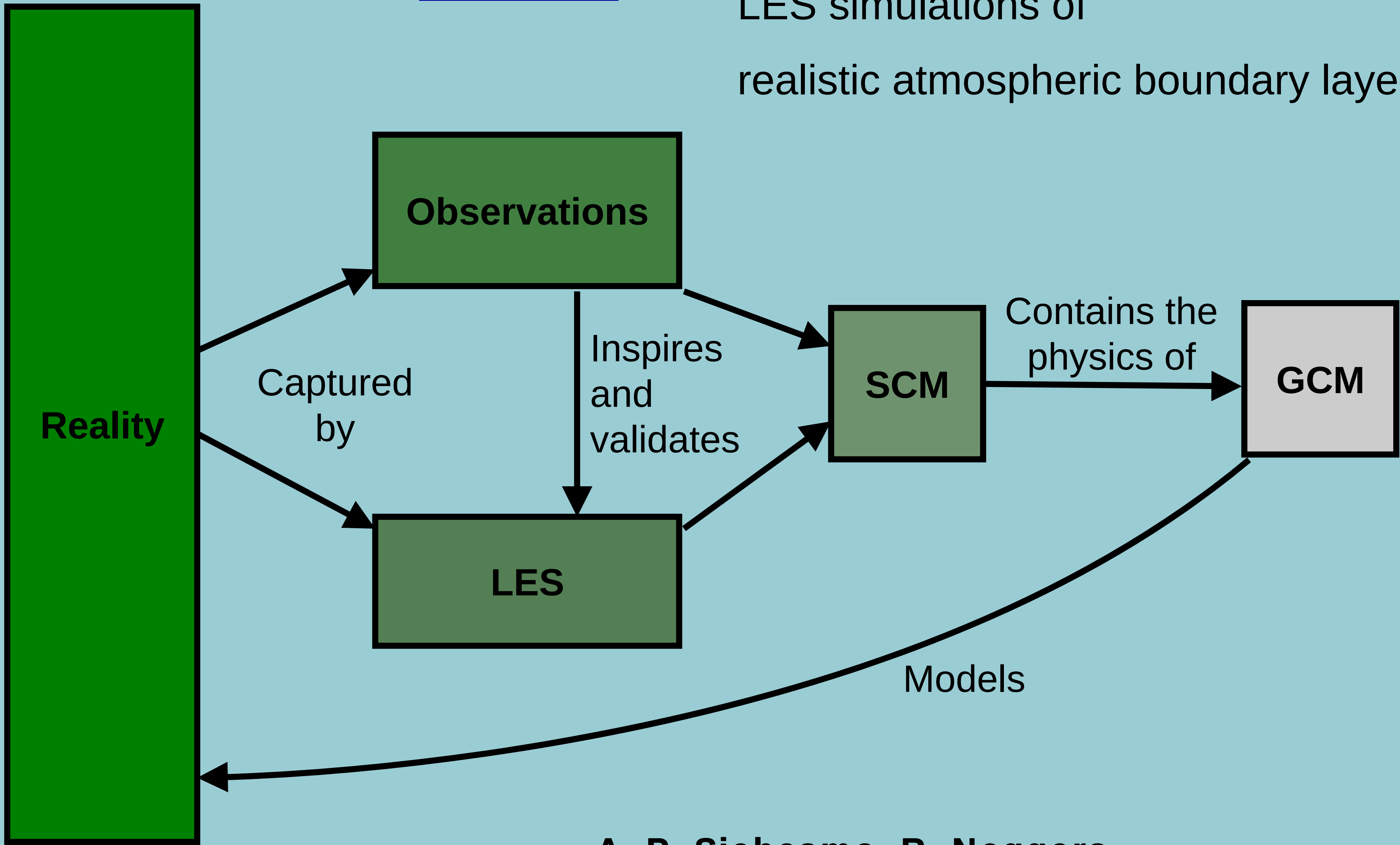




Development of these models now include

1) CCN parameterization,
2) the option to study in-depth the various mixing scenario's of the clouds with ambient [overlying air],
3) inclusion of the observed aerosol chemical and physical properties.

The idea of Automated LES simulations of realistic atmospheric boundary layers



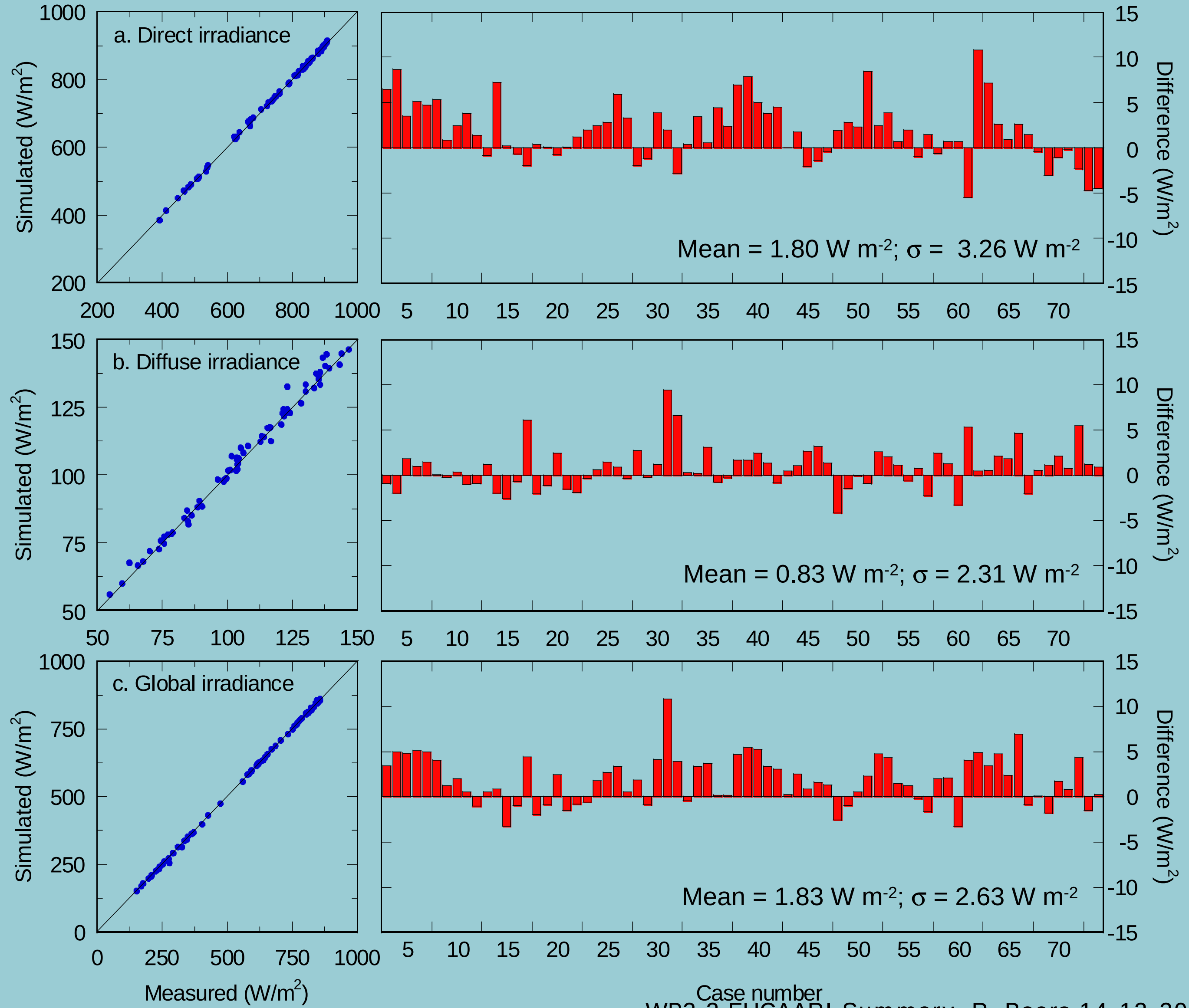
A. P. Siebesma, R. Neggers,

5) **The importance of high resolution Large Eddy Simulation (LES) studies in the understanding cloud processes.**

Data derived from the North Sea case studies are used to initialize LES models that are used to simulate the PBL-cloud formation and evolution.

A parameterization testbed is now being used to compare the output from LES models to that from larger scale Single Column Models that are reduced versions of full scale 3D regional / global climate models.

Clear-sky closure: May 2008
P. Wang, W. Knap

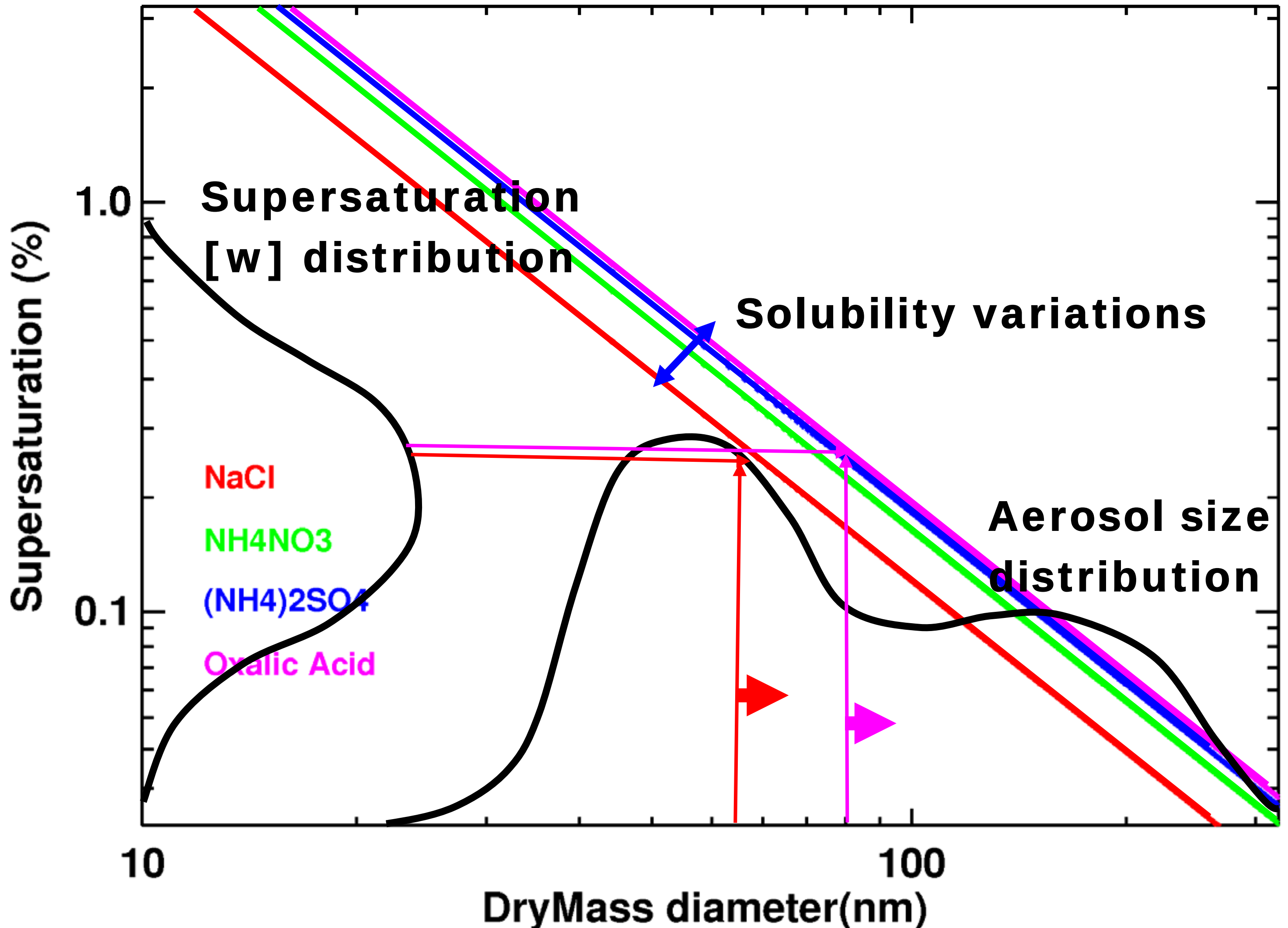


6) Aerosols and the modeling of atmospheric radiation.

A detailed model of the effects of aerosols on atmospheric radiation is able to capture the observed radiative signatures at the surface with a high degree of accuracy.

This suggests that an accurate modeling of the direct aerosol radiative effect in global climate models is within reach provided that the global and regional distribution of aerosols are known.

The integration thing……………….....this could be a key figure
Quatifying the uncertainty in estimating the Aerosol Indirect Effect



Constraining the Aerosol Indirect Effect

a) Even though there are many organics [20000], their solubility only has small uncertainty [this constrains the positioning of the slope of the slanted line

b) The influence of vertical velocity on droplet activation has a feedback(!), this seems to be a novel concept

W large | S large | Tendency to activate large # of droplets | S quickly drops | Activation stops rapidly, constraining # droplets

W small | S small | Tencency to activate small # of droplets | S drops only slowly | Weaker constraint on activation, so more #droplet

So with large w, activation quickly stops
with small w, activation keeps on going longer