



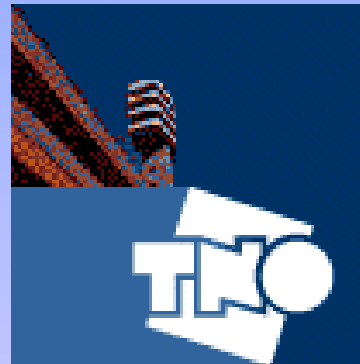
Recent results from the Cabauw  
Experimental Site for Atmospheric  
Research

R. Boers

KNMI

April 2004

# Collaboration between institutions



# Contributions by



- KNMI:

Arnout Feijt, Henk Klein Baltink,  
Wouter Knap, Erik v Meijgaard,  
Fred Bosveld, Piet Stammes, Pier  
Siebesma, Rob Roebeling, Gert-Jan  
Zadelhoff

- University Delft:

Herman Russchenberg, Hans v Marel

- Environmental Protection

- Agency Netherlands(RIVM):

Arnoud Apituley, Daan Swart

- Netherlands Technical

- Research Organisation:

Gerrit de Leeuw

- University Bonn:

Susanne Crewell, Clemens Simmer, Uli  
Loenert

- University of Leipzig

Manfred Wendich

- MeteoFrance

Jean-Louis Brenguier

- University of Berlin

J. Fischer

- GKSS

# Cabauw Site





# CESAR: A national observatory

Observations (remote sensing and *in situ*)

Land-Atmosphere transfer

Clouds

Aerosol

Radiation (BSRN)

Applications

Parameter retrieval

Model validation

Satellite validation

Process studies

Intensive observation periods (BBC)

Near future

Data access



# Motivation

the need for meaningful remote sensing data

- a) to address essential questions regarding climate change,
- b) to validate satellite observations,
- c) to validate models of the atmosphere, and
- d) to understand atmospheric processes

- the notion that this can only be accomplished with the synergetic use of multiple remote sensing instruments in combination with *in situ* data

the conviction that joined forces of the participating research institutes will add significant value to Dutch science



## The importance of Cabauw within Netherlands / Europe

A) Cabauw is within the centre of the Netherlands, therefore it is representative of the Netherlands.

B) Cabauw is within the heart of northwest Europe. A great variety of air masses come across this part of the world.

C) No orography to confuse you

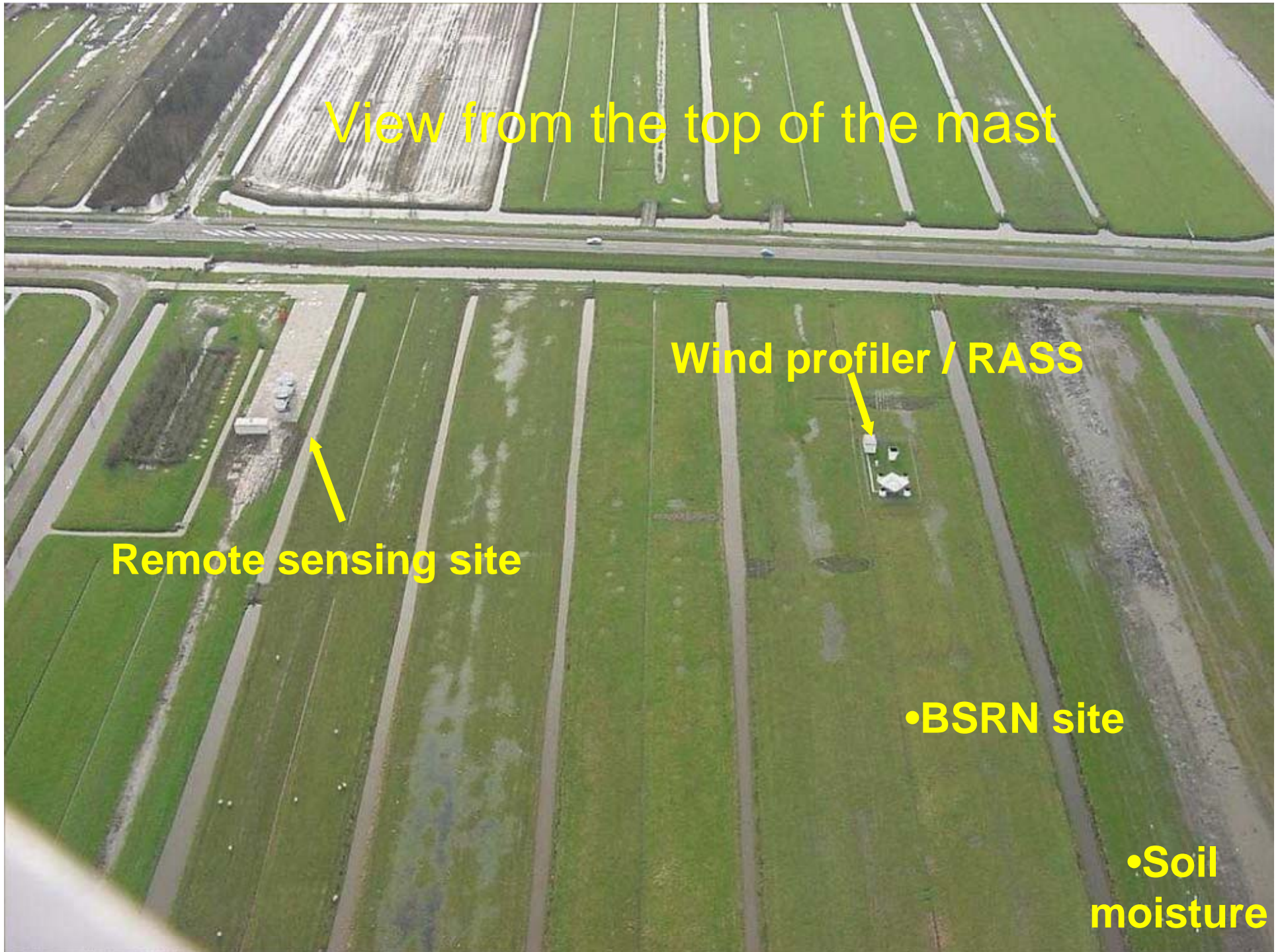
**View from the top of the mast**

**Wind profiler / RASS**

**Remote sensing site**

**•BSRN site**

**•Soil  
moisture**







# Remote sensing site



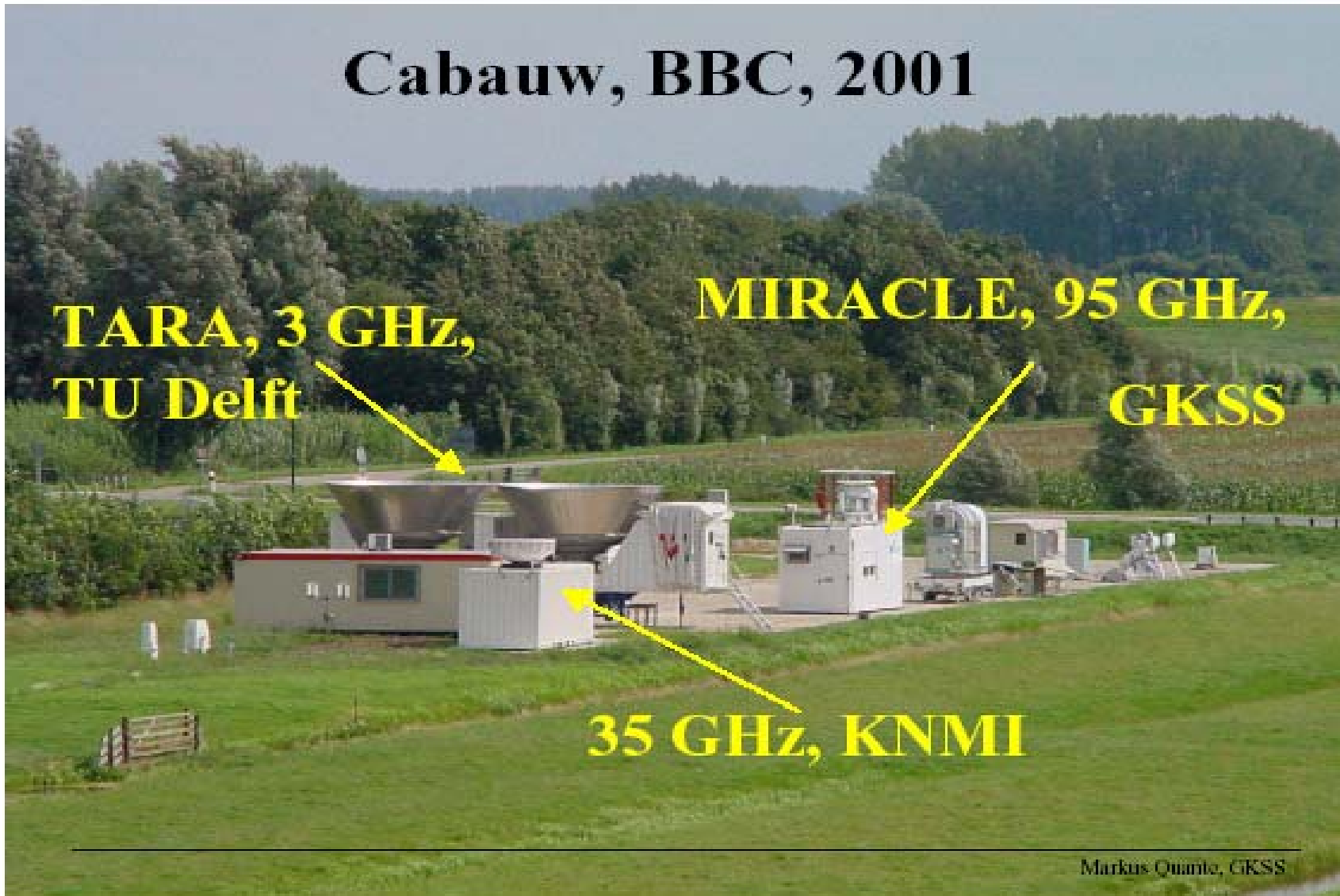
Koninkrijk der Nederlanden

## Cabauw, BBC, 2001

**TARA, 3 GHz,  
TU Delft**

**MIRACLE, 95 GHz,  
GKSS**

**35 GHz, KNMI**



# Cabauw water level /soil measurement system



25 11:25 AM



The 6 channel sun  
photometer SPUV

These channels are  
2-15 nm wide.



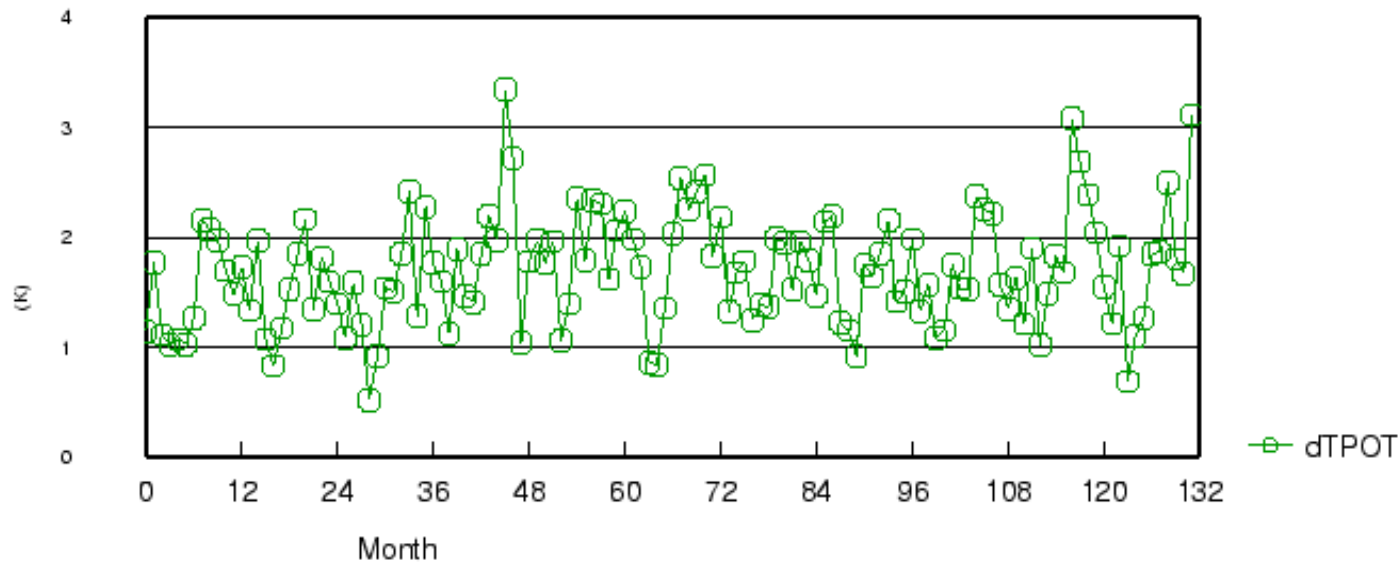


Observations: Radiation (pre-BSRN)

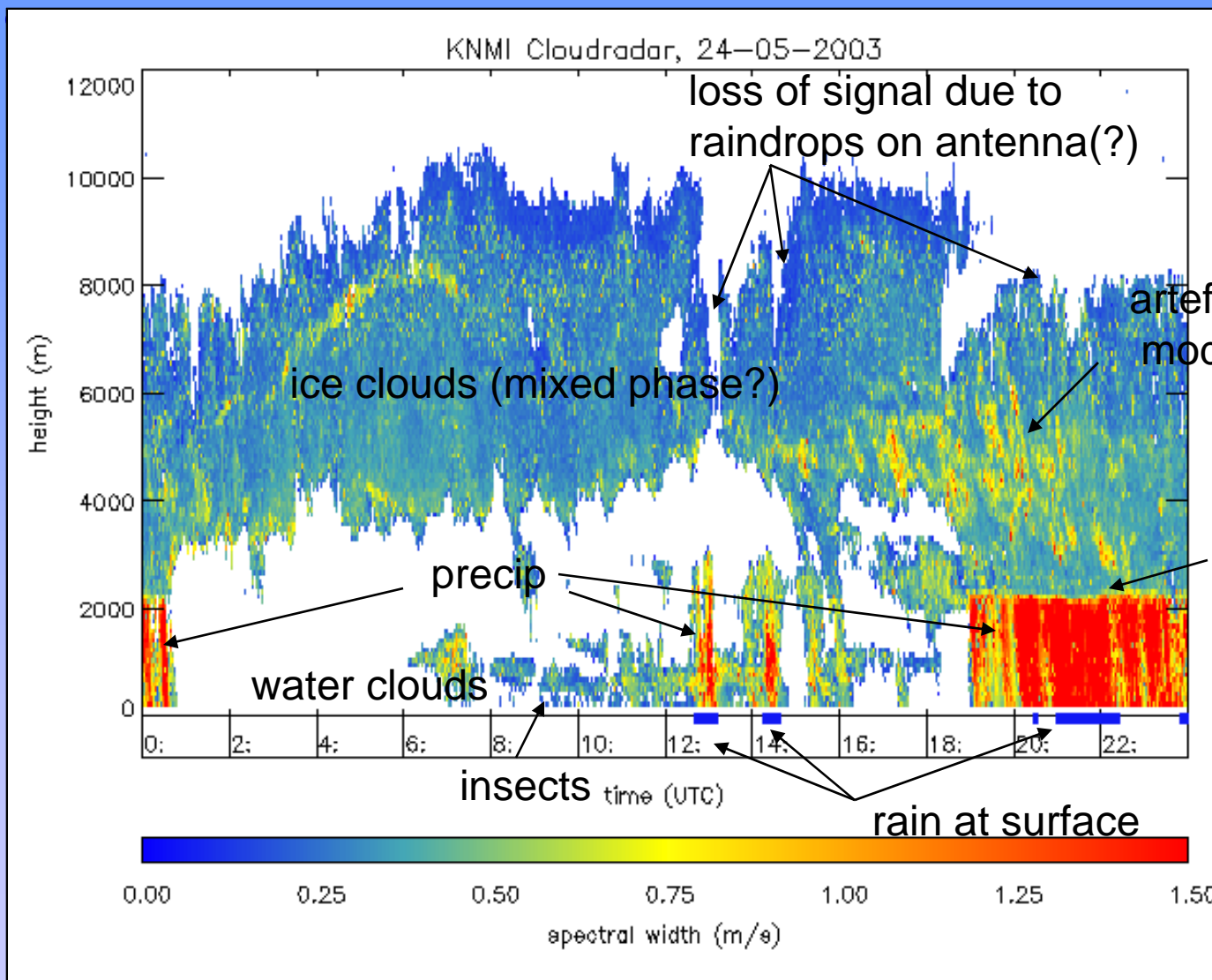
# Observations: Land-Atmosphere interactions :

## Cabauw potential temperature difference between 200 m and 2 m

Cabauw monthly values feb 1986-jan 1997  
Potential temperature difference between 200 and 2 m

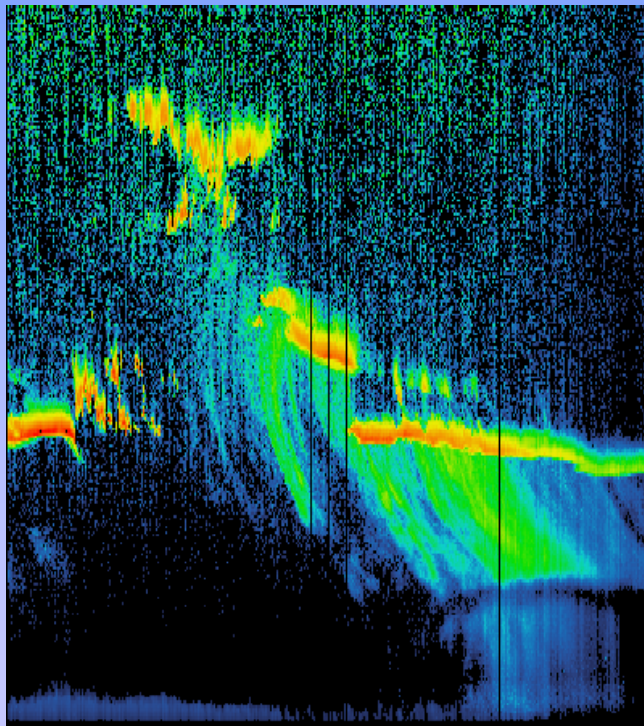


# Observations: Cloud radar data

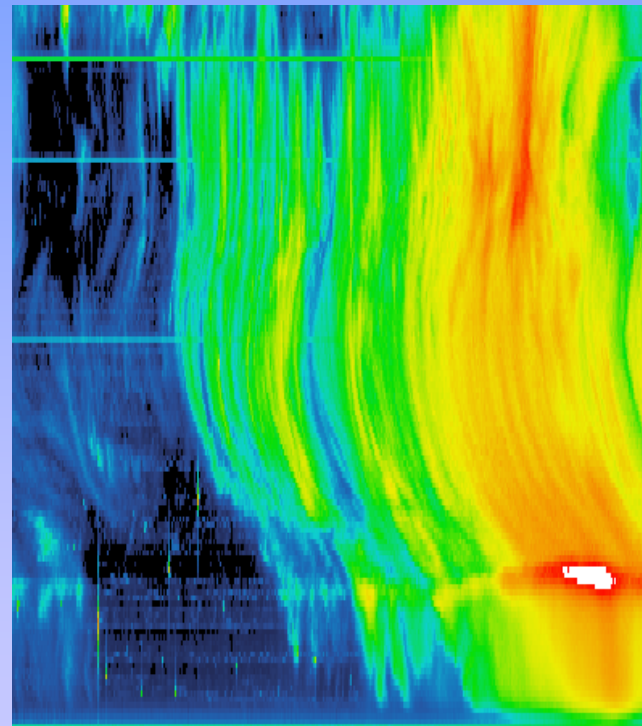


••••  
Observations: Light rain with lidar and radar

lidar



radar



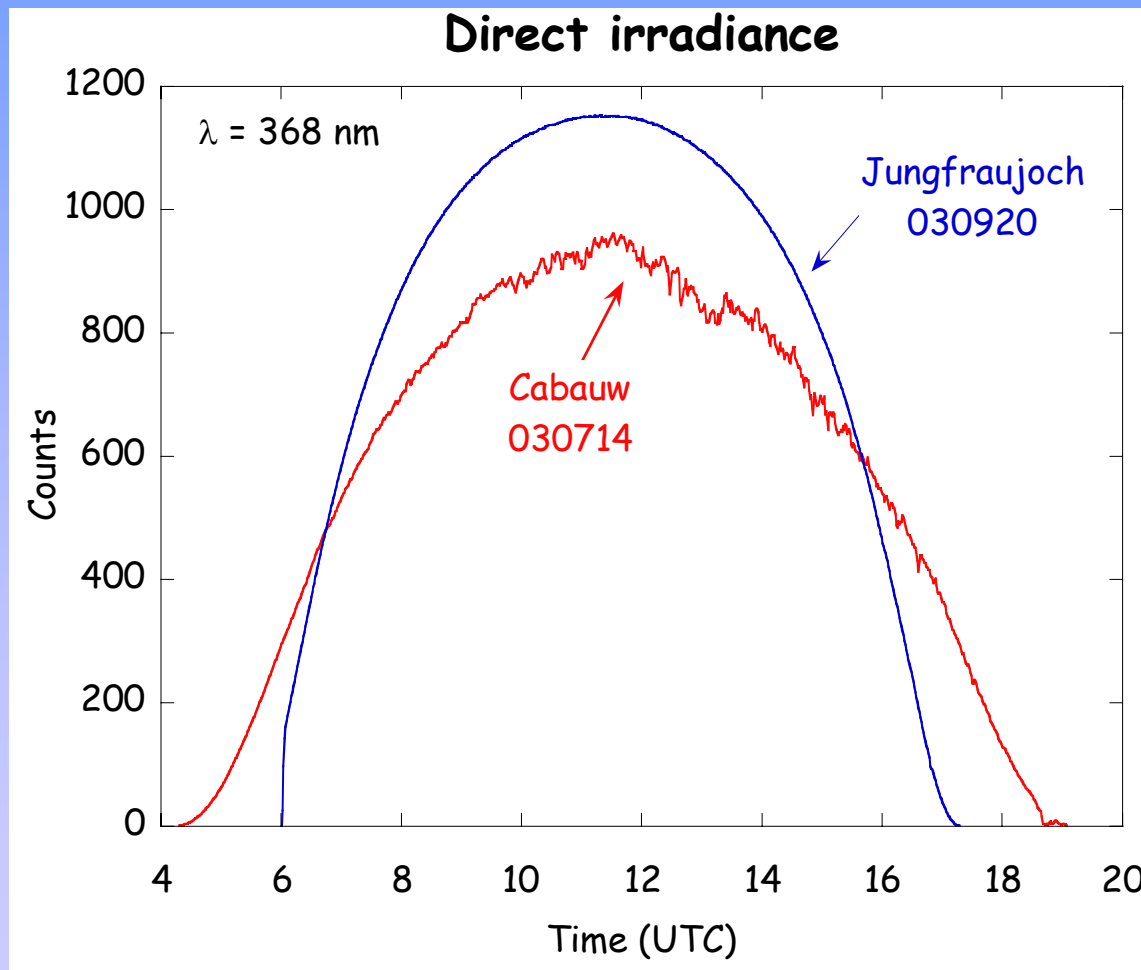
*height*

*time*

# Observations: Calibration of sun photometer

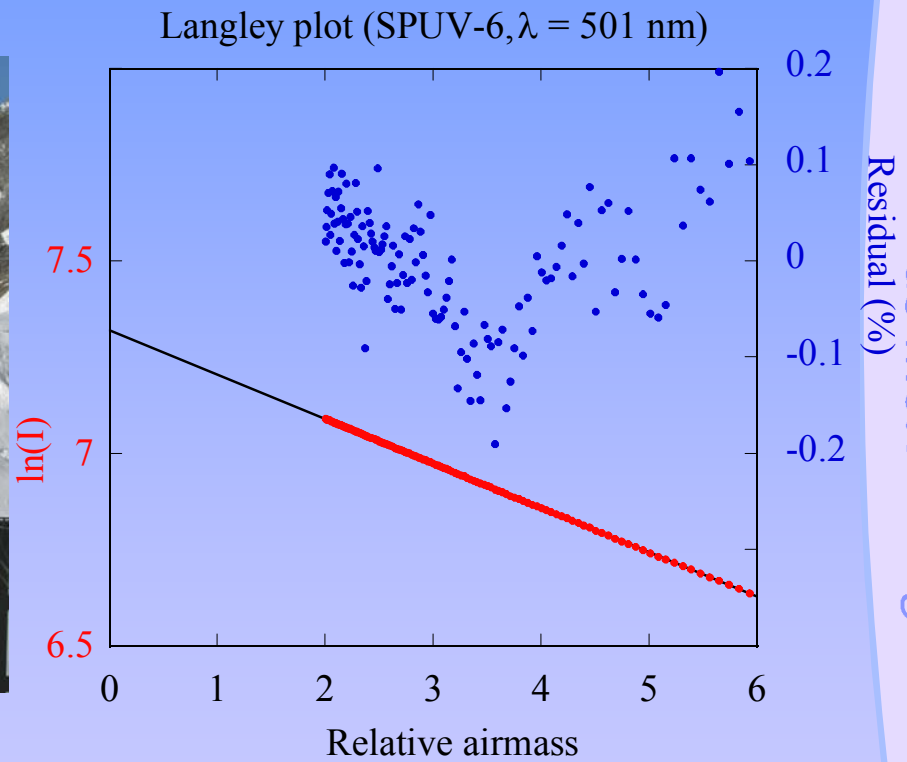


## Sea level versus high altitude: two “top” days



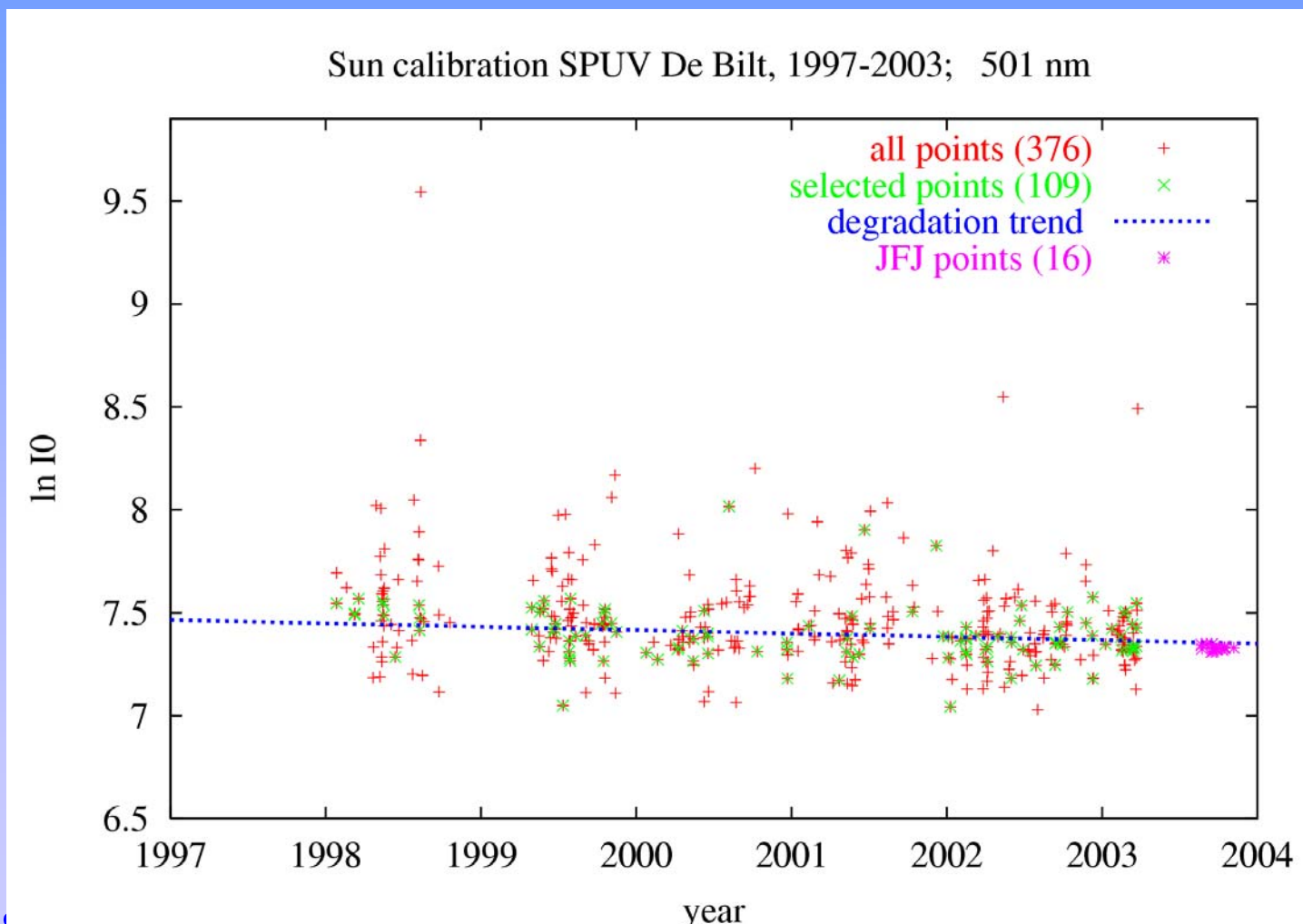


# Observations: Calibration of sun photometer at JungfrauJoch, autumn 2003



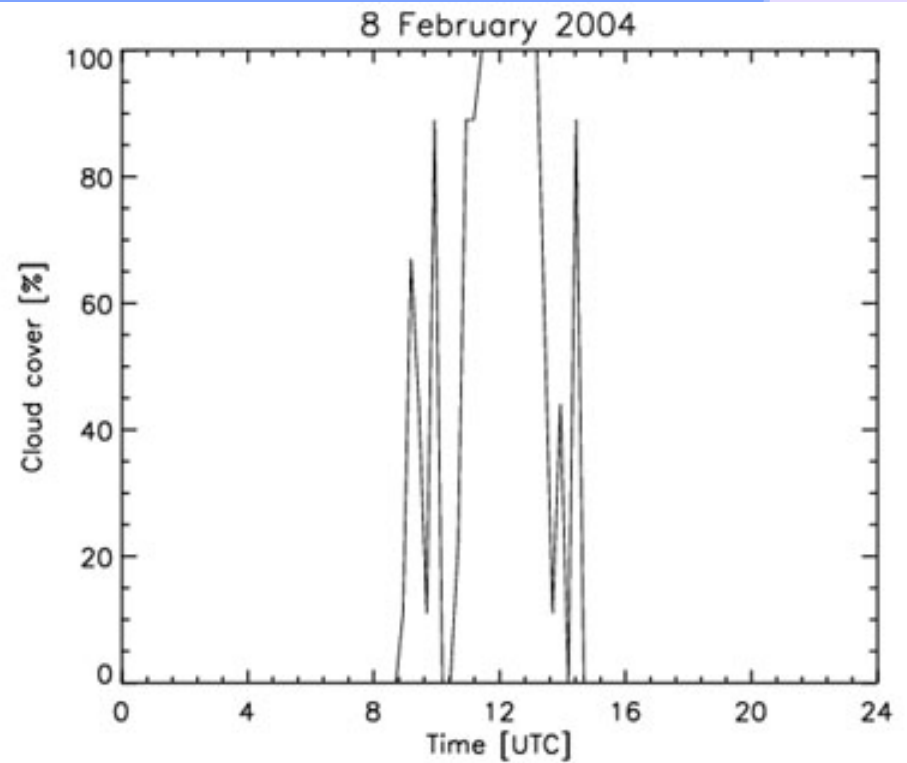
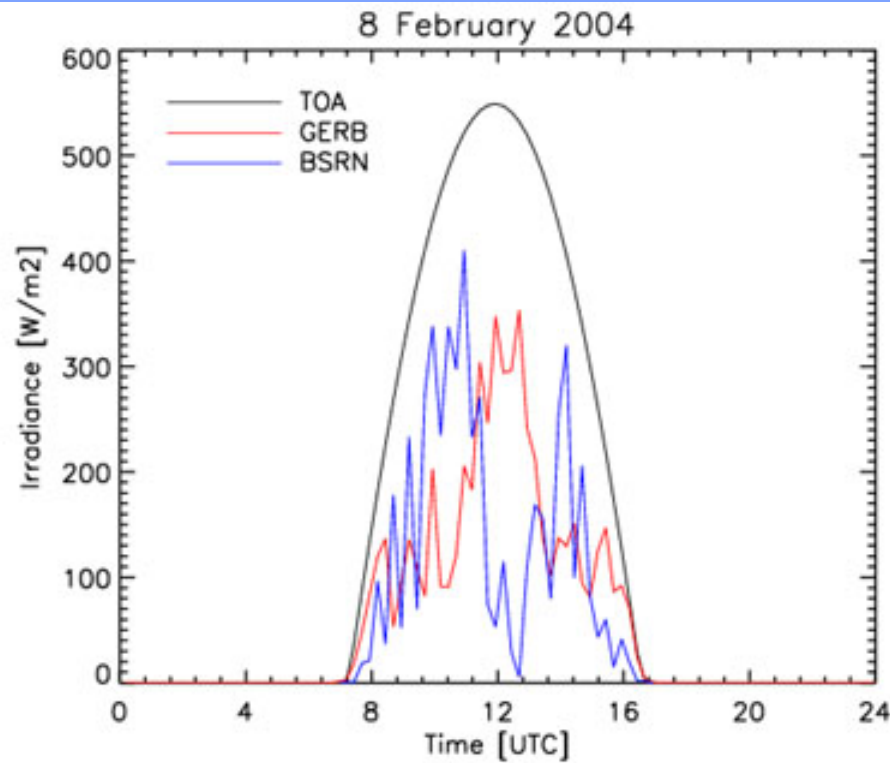


# Observations: Calibration results $\ln I_0$ in De Bilt at 501 nm



••••

# Observations: Surface and TOA irradiances





## Applications:

1) Parameter retrieval

2) Sensor synergy

3) Climate Model Validation

4) Process Studies

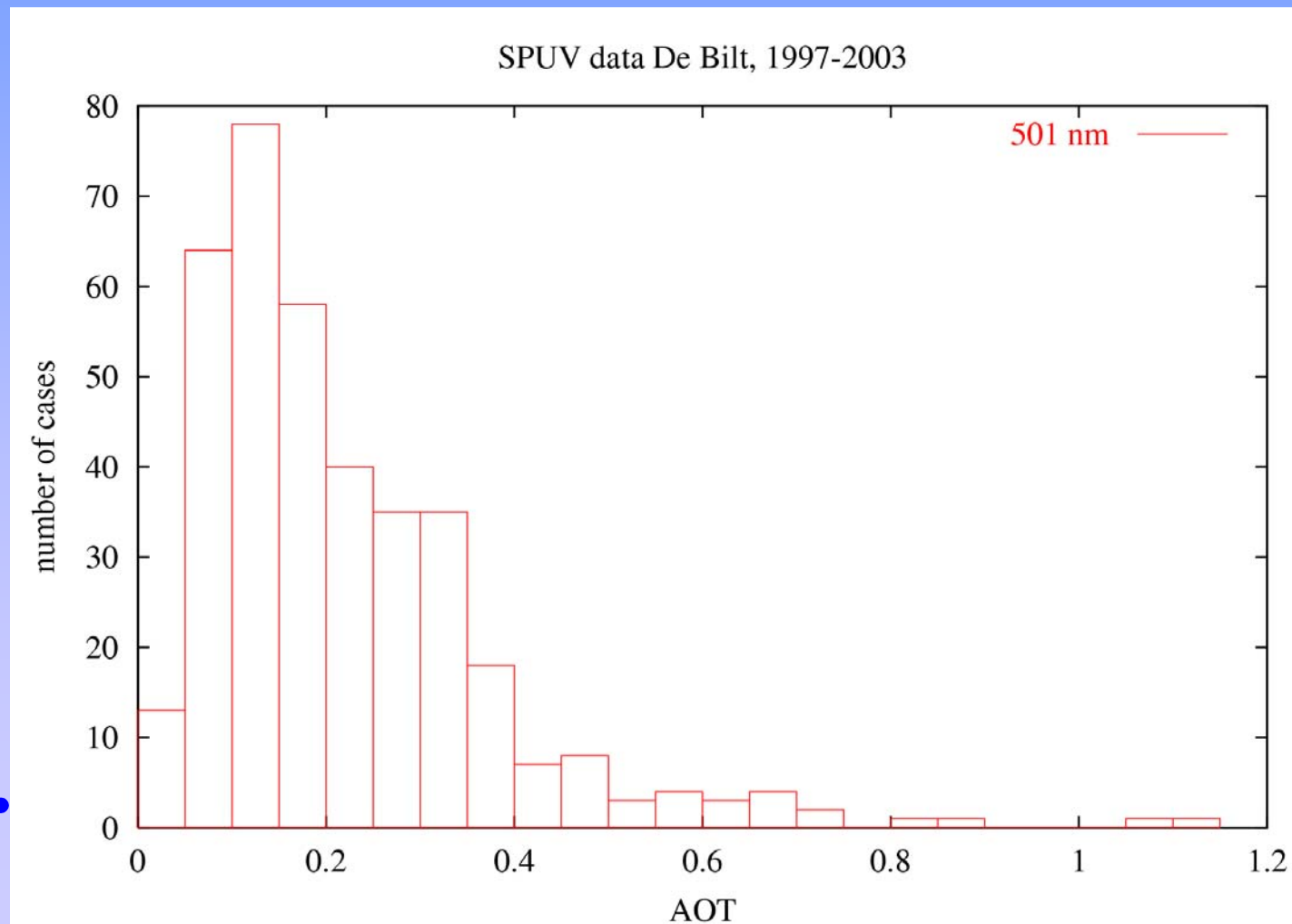
2001 8 13

# Applications: Parameter Retrieval; Aerosol optical depth; Histogram of $\tau_{\text{aer}}(501 \text{ nm})$

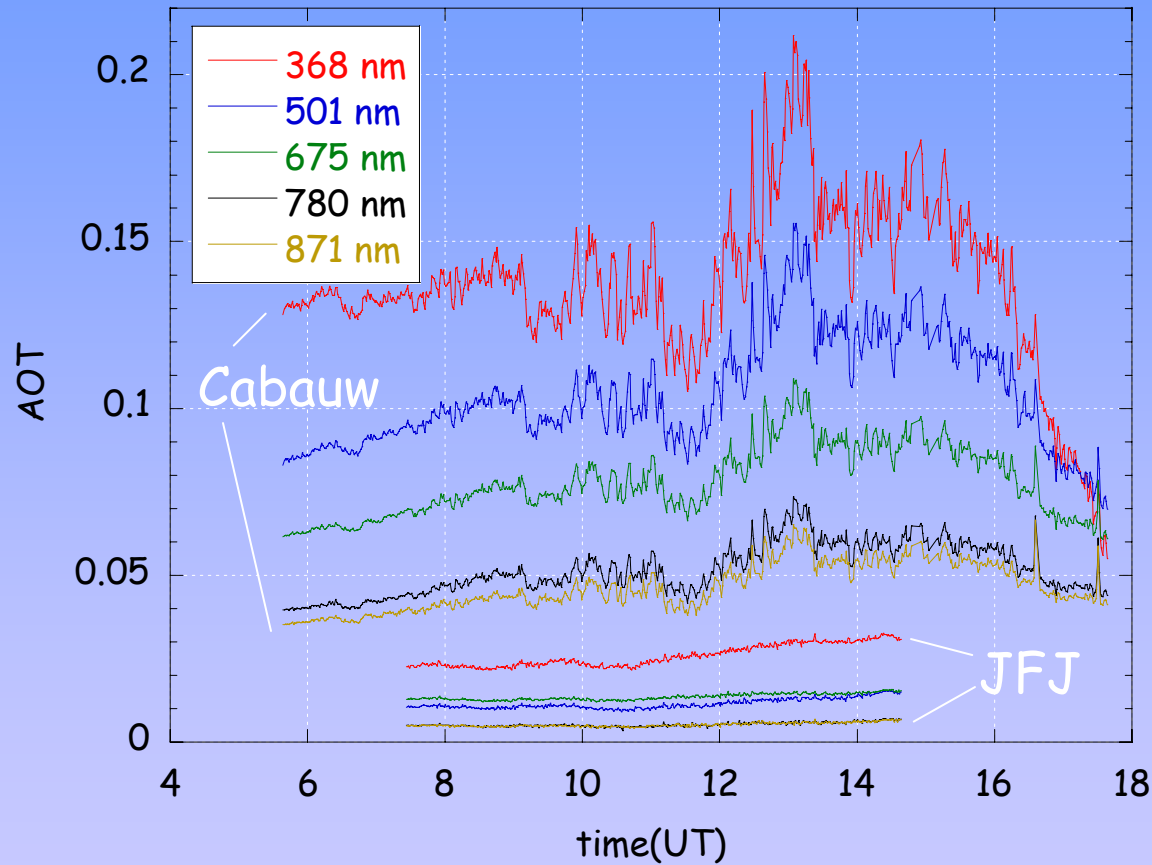


mean:  $0.22 \pm 0.16$ ; median 0.18

min.: 0.03, max.: 1.13



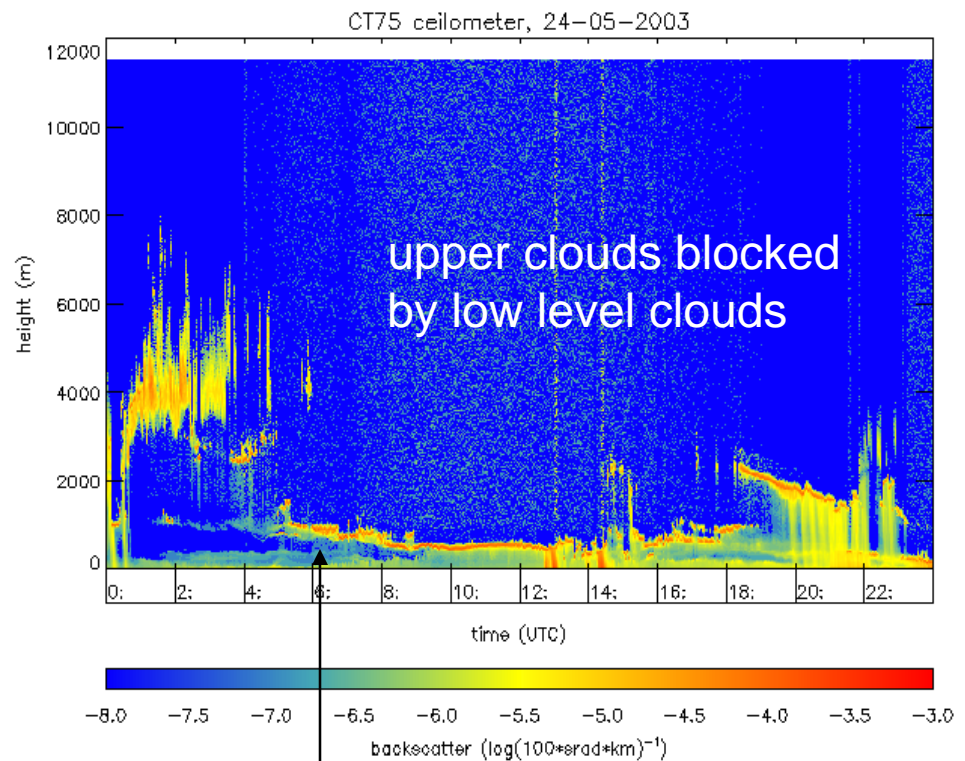
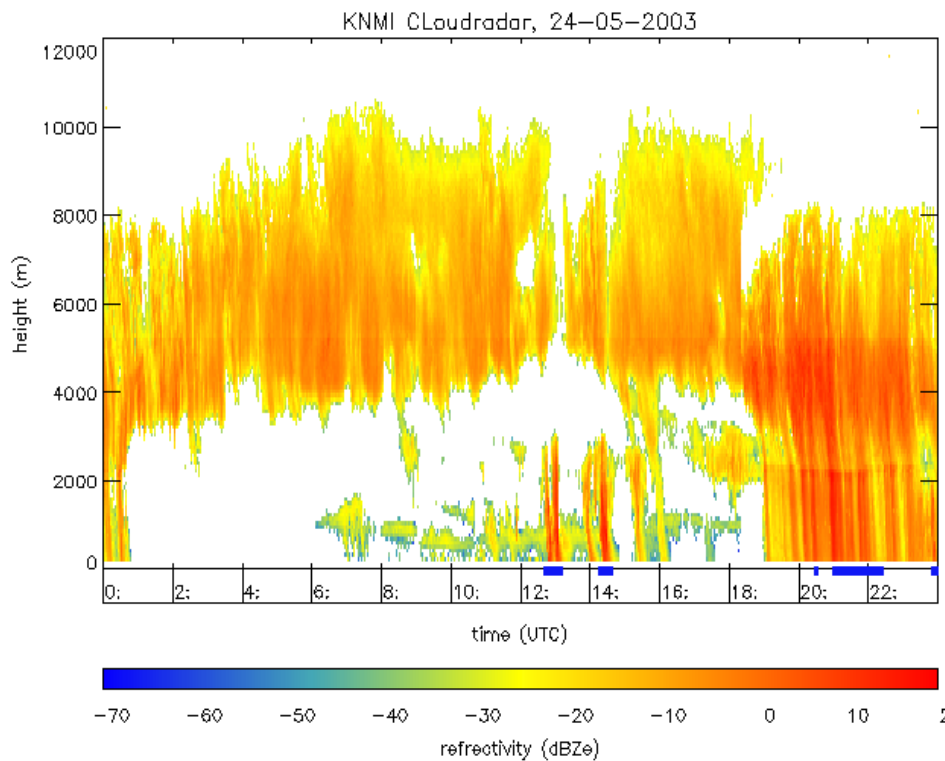
# Applications: Parameter retrieval: Aerosol optical thickness



# Applications: Sensor Synergy: Detection of clouds, Radar vs. Ceilometer



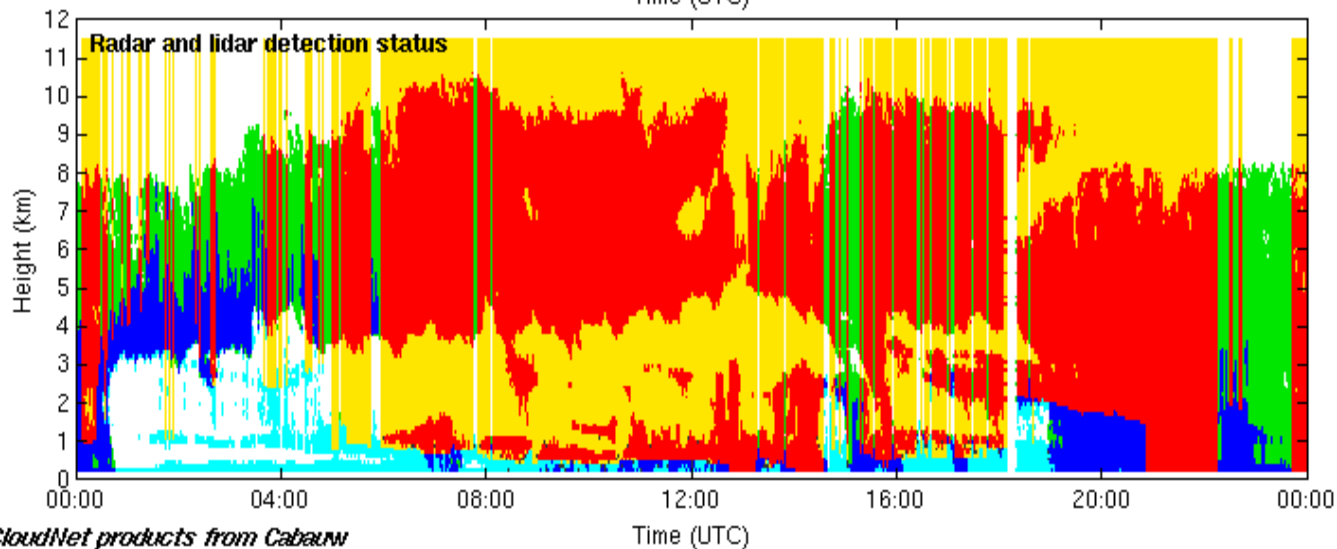
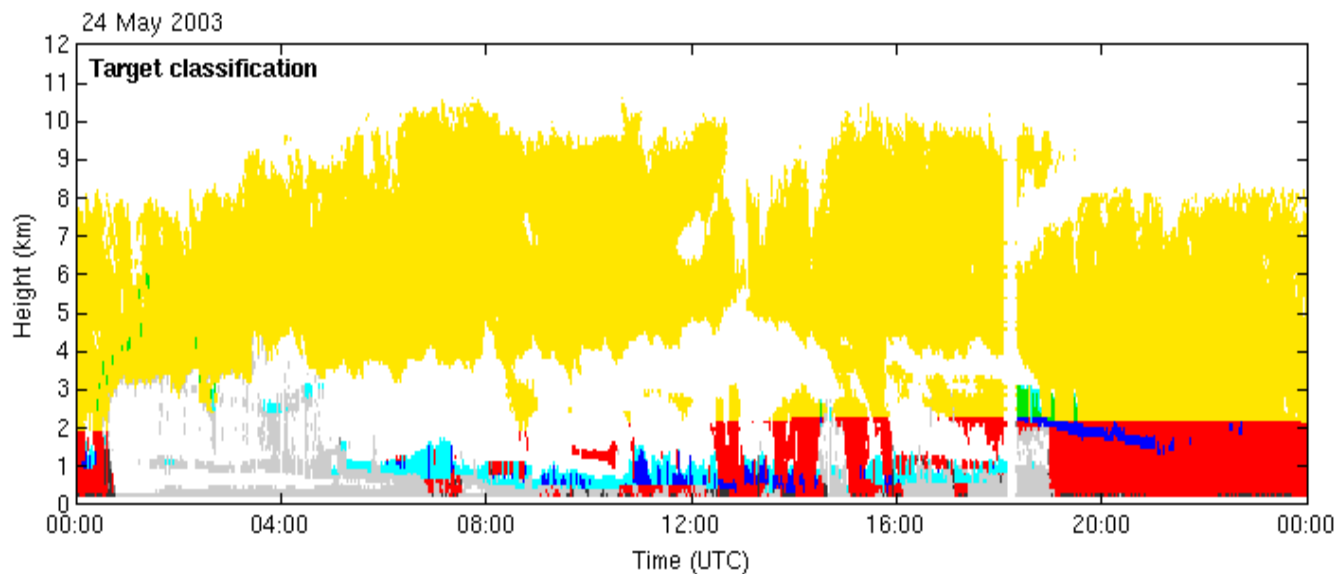
Konink



aerosol

Instituut

# Applications: Sensor Synergy; Target Classification

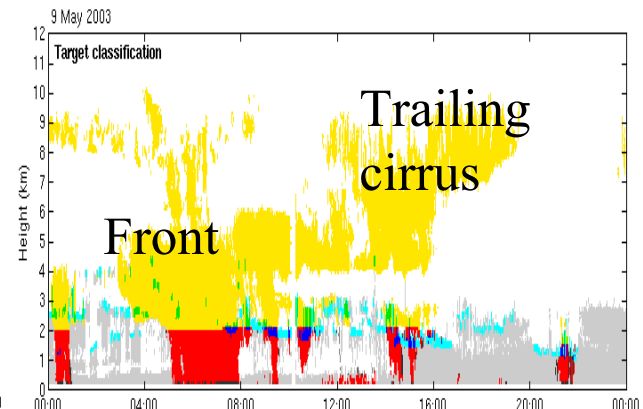
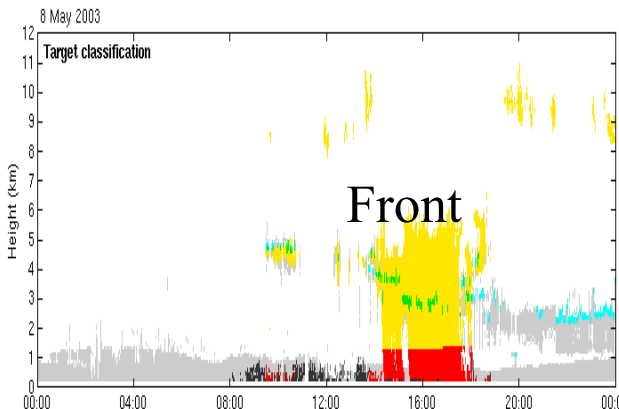
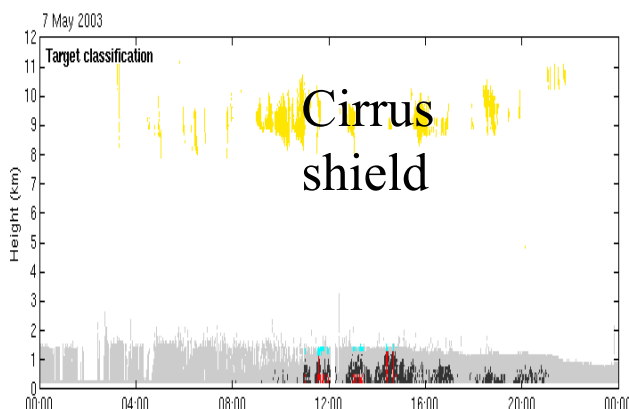
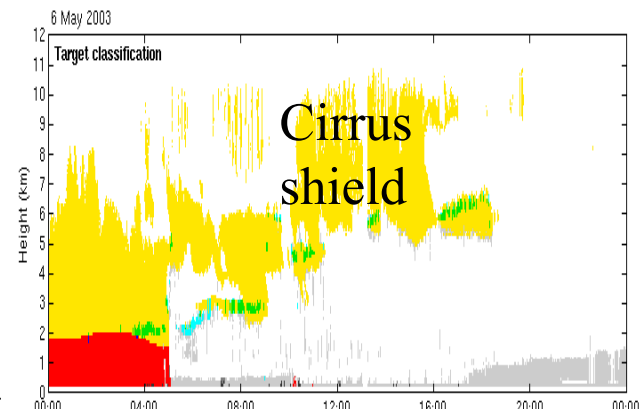
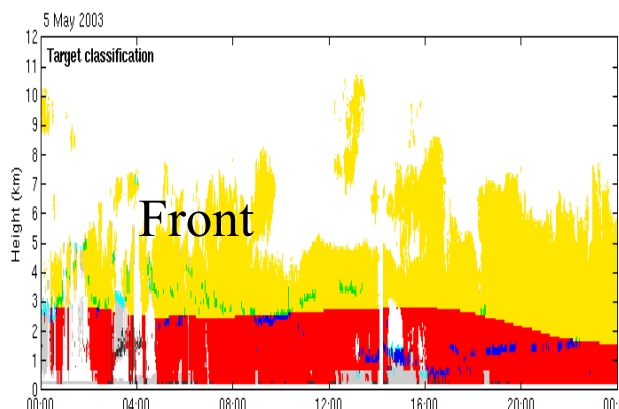
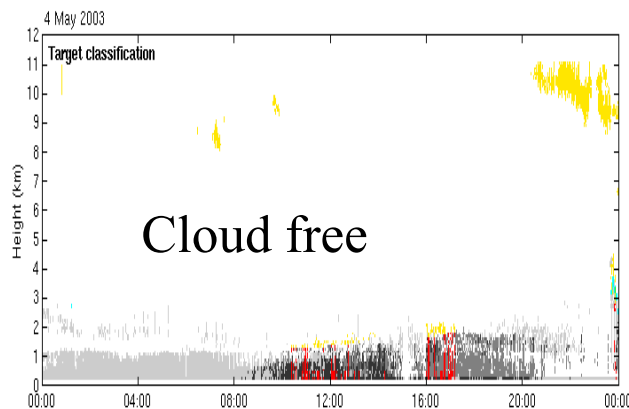
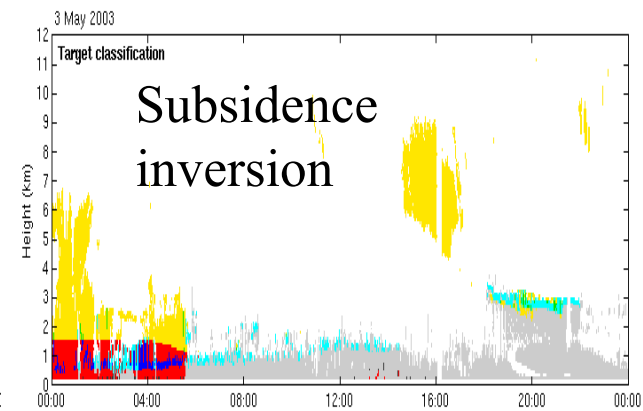
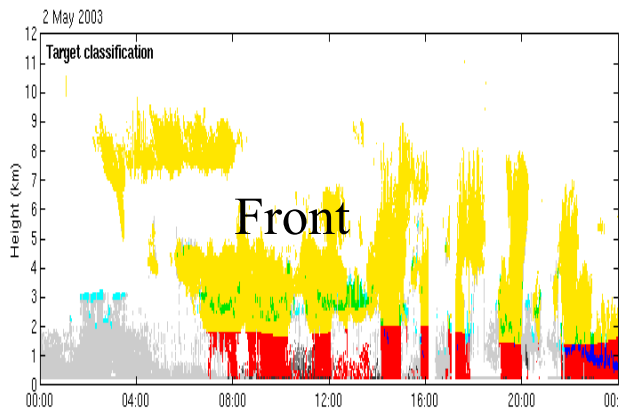




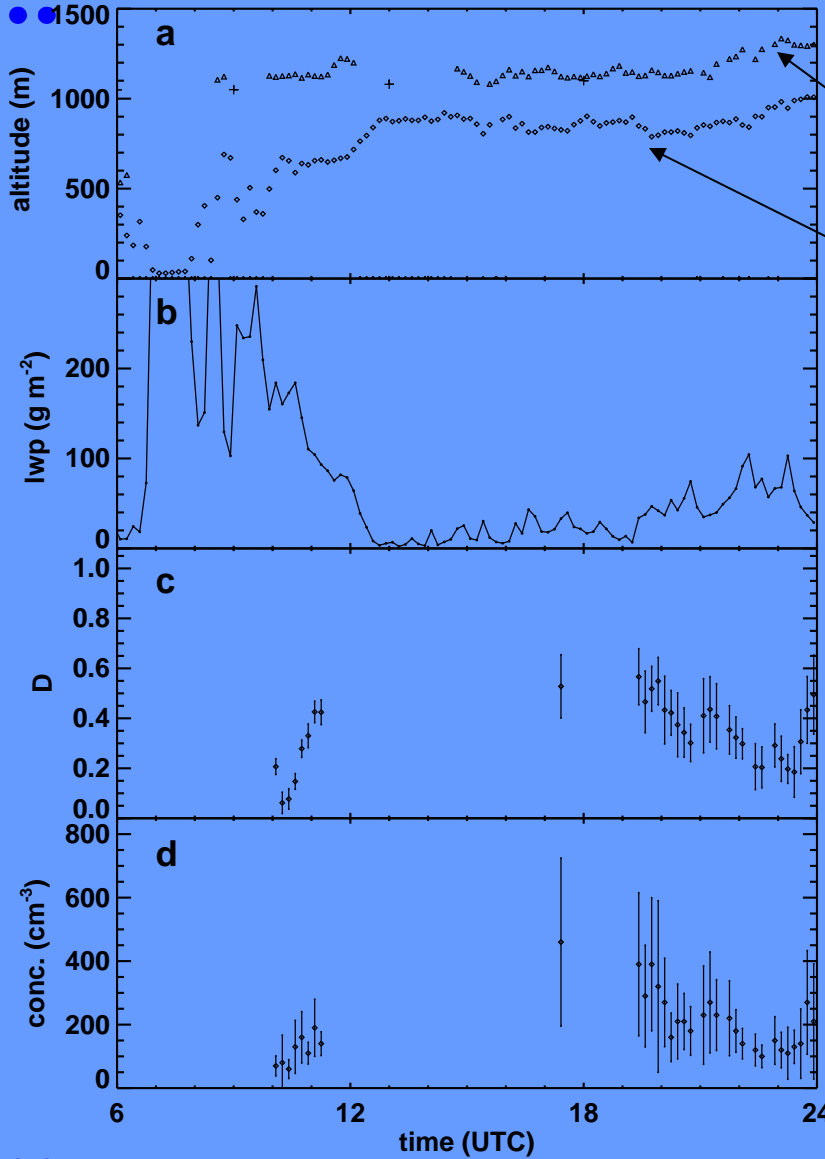
# Cloud types at Cabauw during BBC2

- Ice and supercooled droplets
- Ice
- Drizzle/rain & cloud droplets
- Drizzle or rain
- Cloud droplets only
- Clear sky

2km = 0°C



# Applications: Sensor Synergy; The retrieval of cloud microparameters



Radar cloud top  
Lidar cloud base

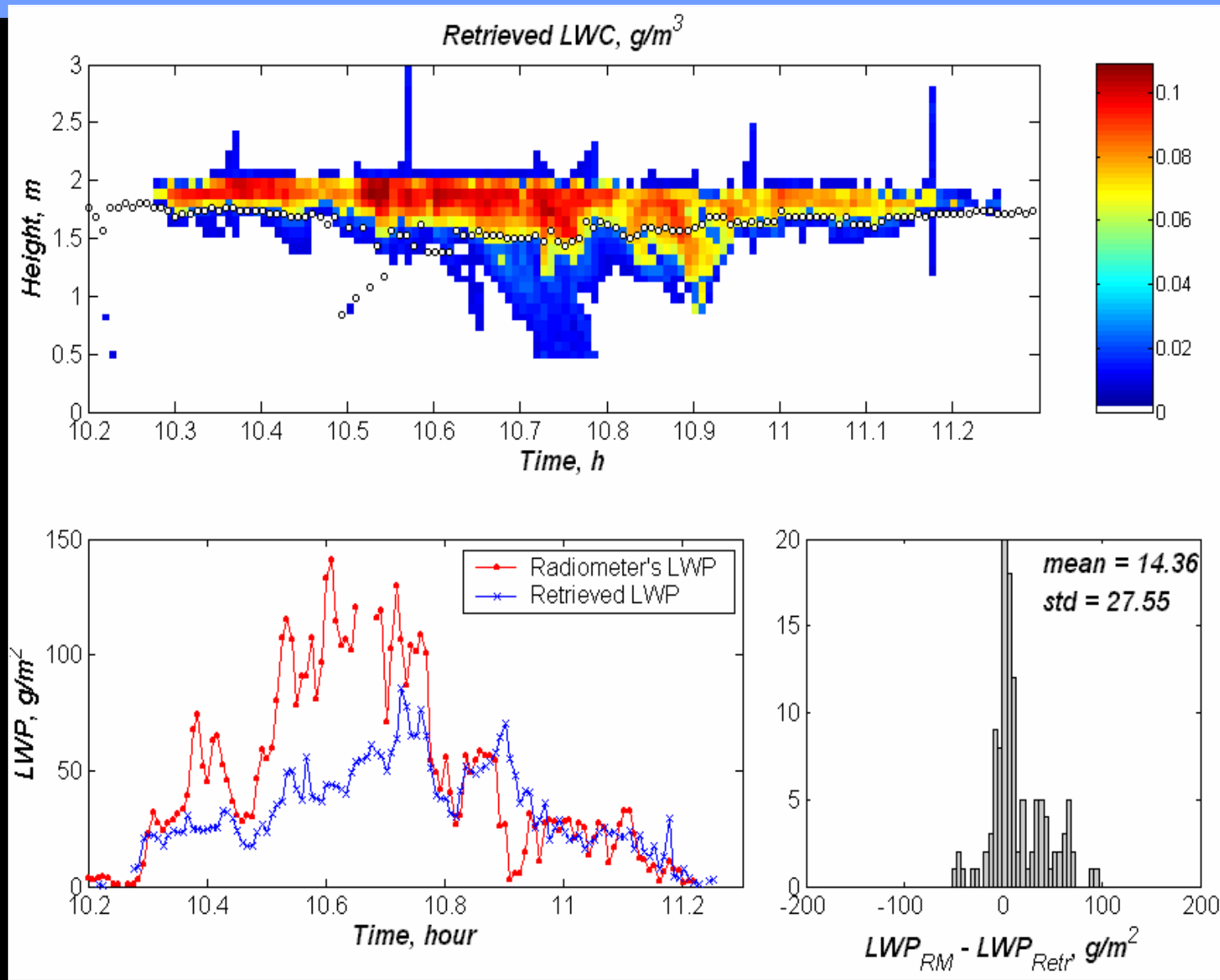
Liquid water path  
from microwave radiometer

Retrieved adiabaticity  
parameter

Retrieved number  
concentration



# Applications: Sensor synergy: Case study: August 28, 2001, Cabauw, Retrieval Results (classification using radar and lidar data)

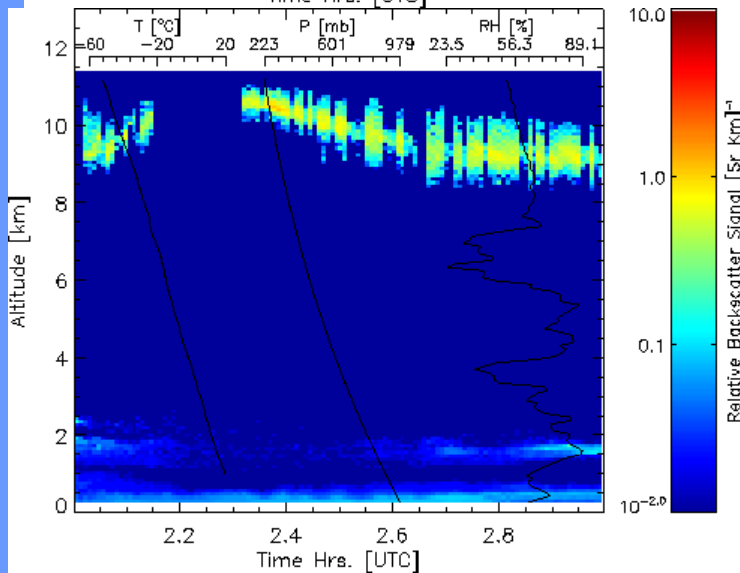
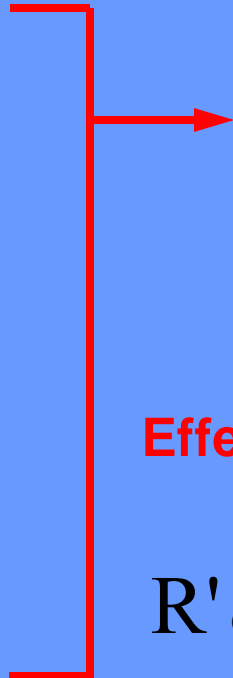
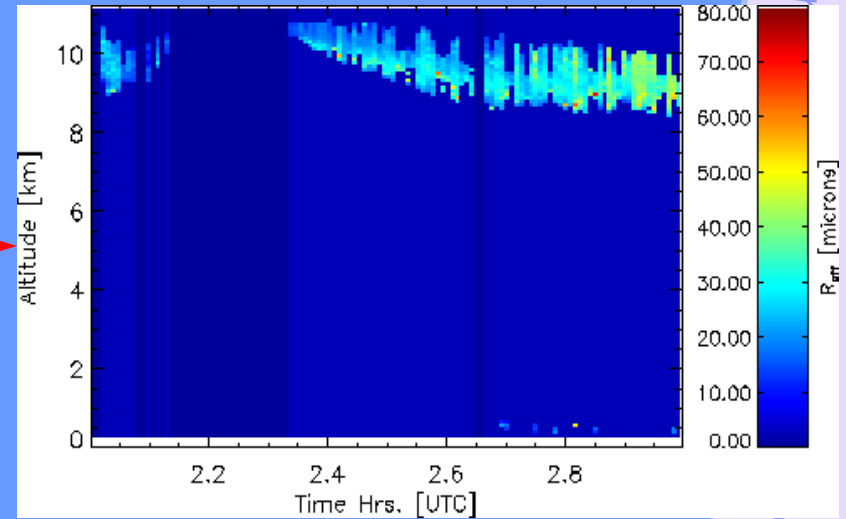
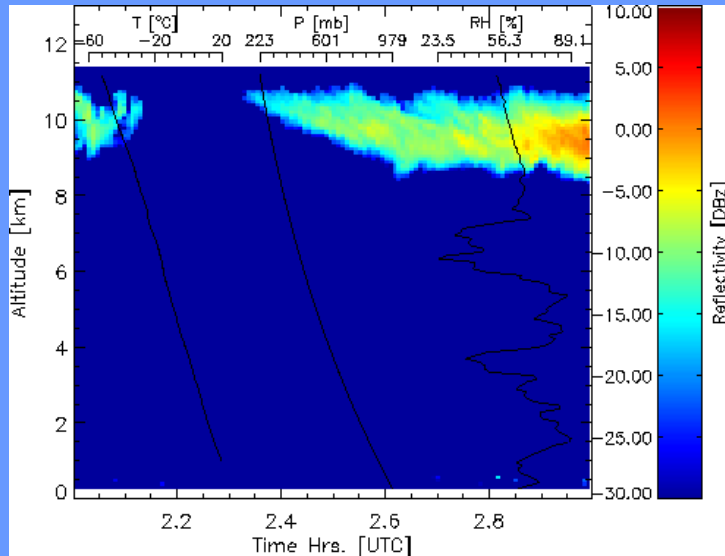


# Applications: Sensor Synergy; Calculating ice cloud microphysics using Lidar and Radar

## Radar Reflectivity [KNMI 35 GHz]



Koninkrijk



## Effective radius of the particles [ $R'_{eff}$ ]

$$R'_{eff} \propto \sqrt[4]{Z_e / \alpha} \quad (\text{Robust parameter})$$

$R'_{eff}$  to  $R_{eff}$  relationship is a function of:

1. Ice crystal Habit
2. Degree of multi-modality

$R'_{eff}$  can be over 2x  $R_{eff}$

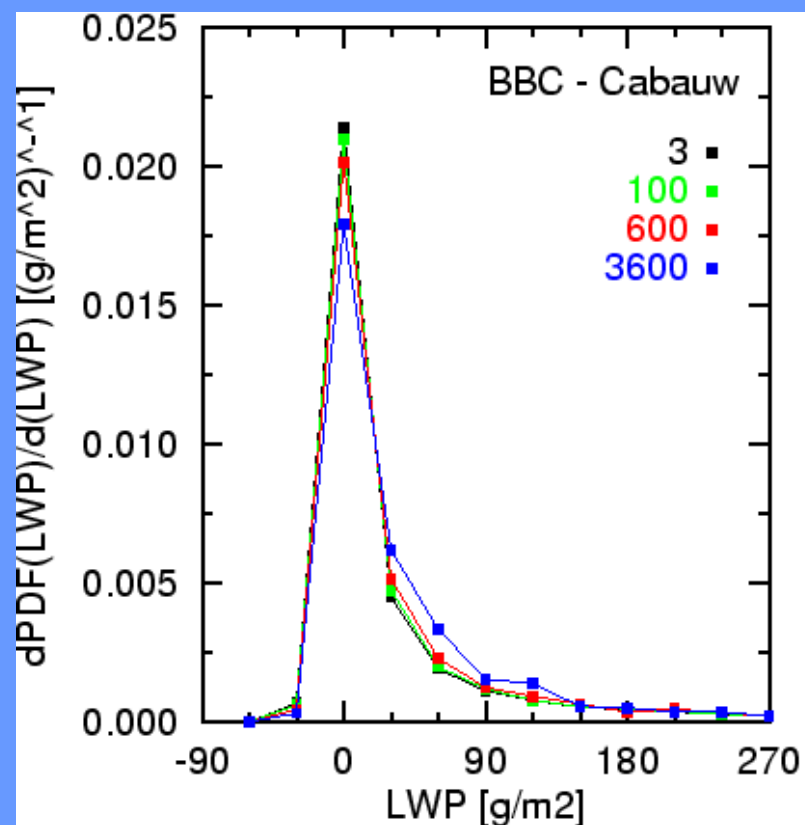
## Relative Backscatter [KNMI CT-75]

# Applications: Climate Model Validation

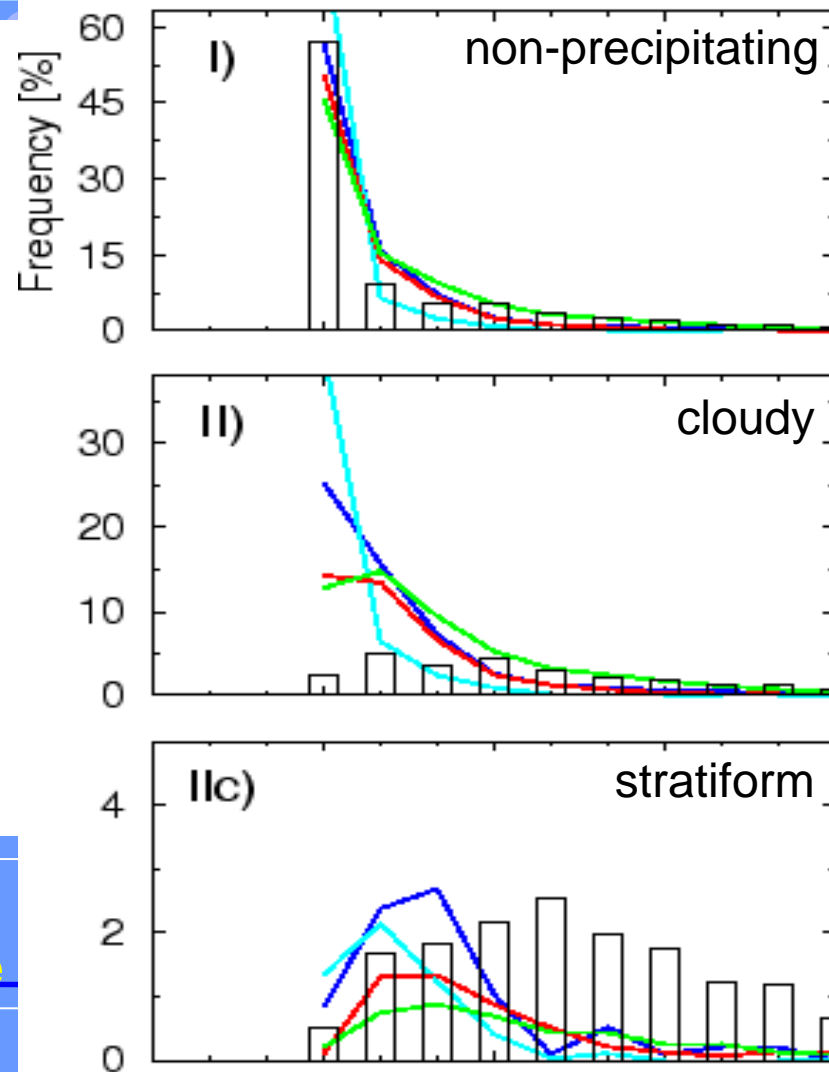


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# Applications: Model validation; Observed and model predicted LWP distributions



LWP distribution depends on aggregation time

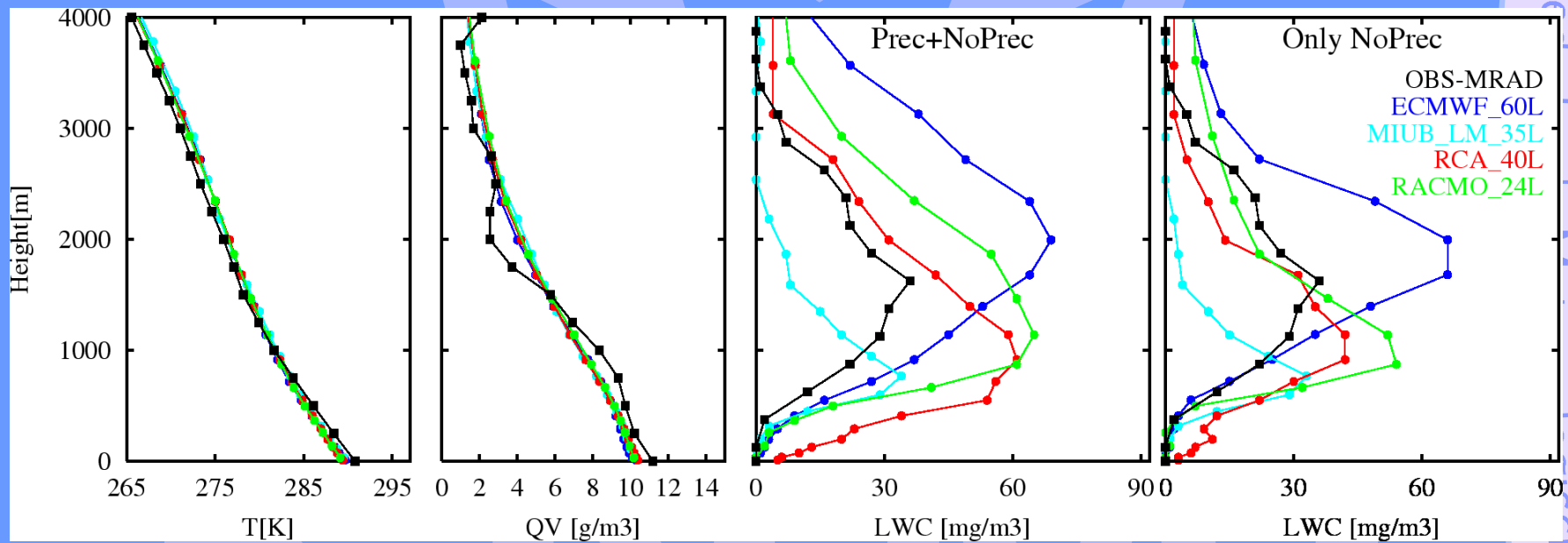


# Applications: Model evaluation;

## Evaluation of Liquid Water Content vertical profile

Comparison over whole BBC

- Integrated Profiling Technique is applicable in 7.2 %

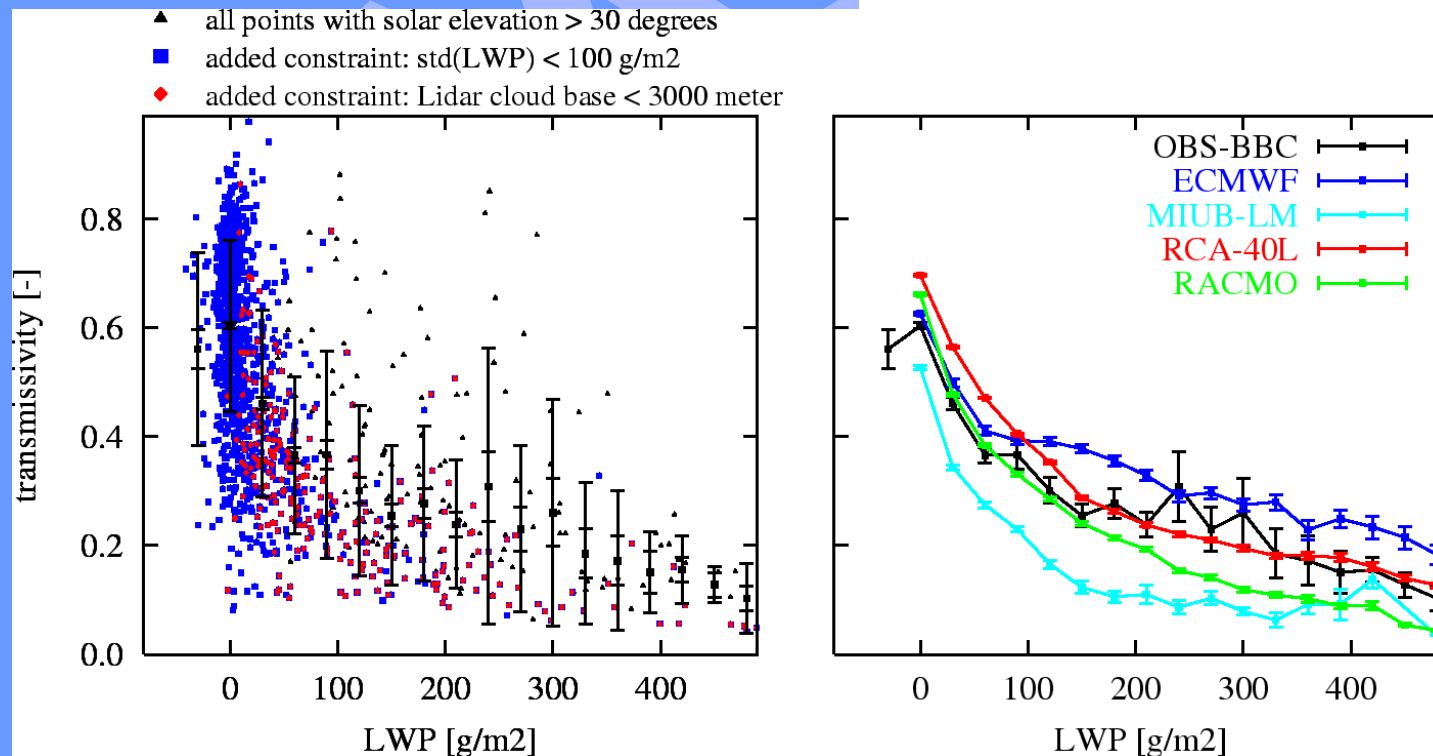


Useful validation data for the improvement of clouds in models  
- needs cloud monitoring -



# Applications: Model evaluation; Clouds and Solar Radiation

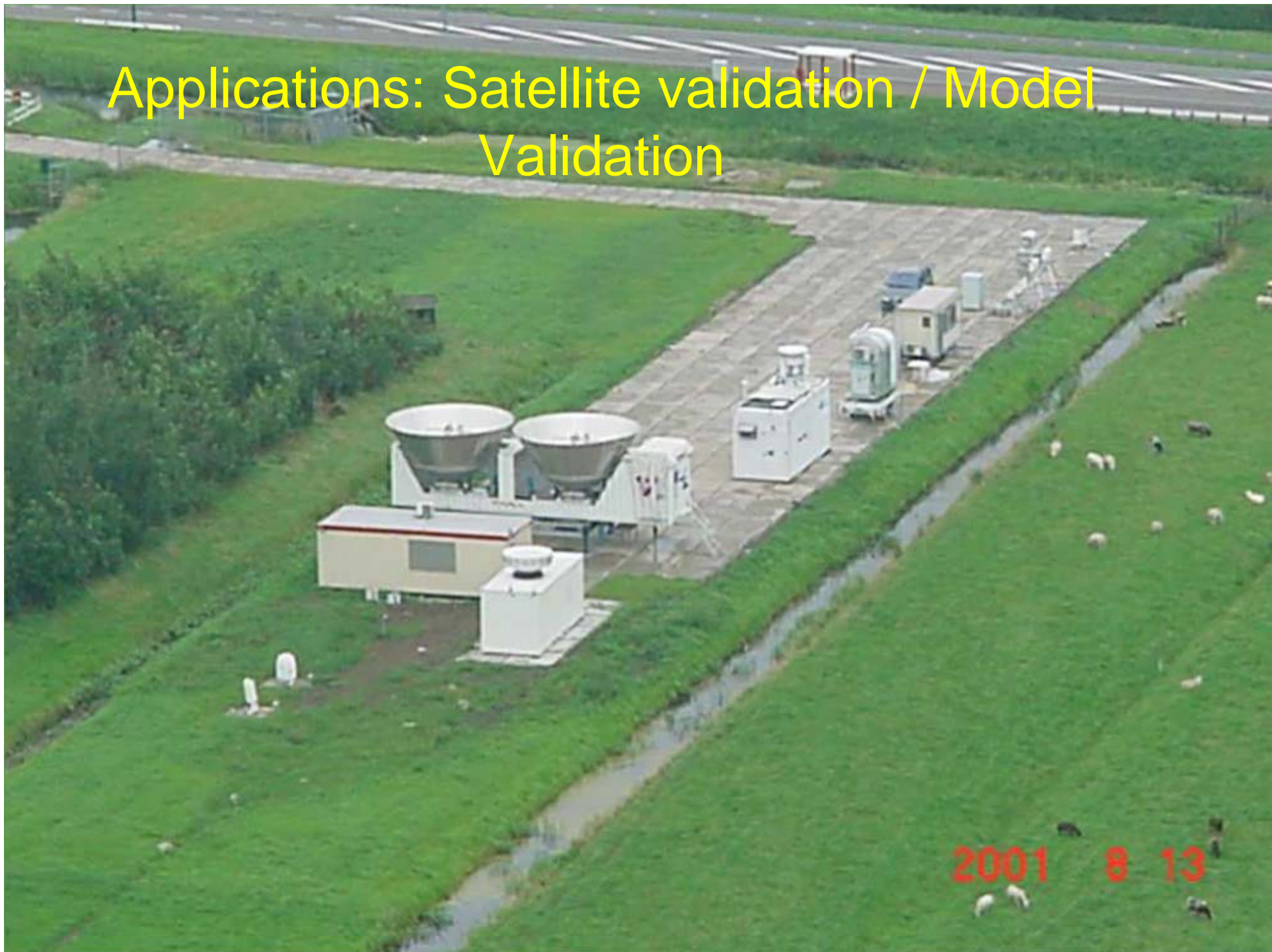
## Relationship between LWP and solar transmission



Liquid water clouds absorb solar radiation  
→ absolute LWP accuracy is very important

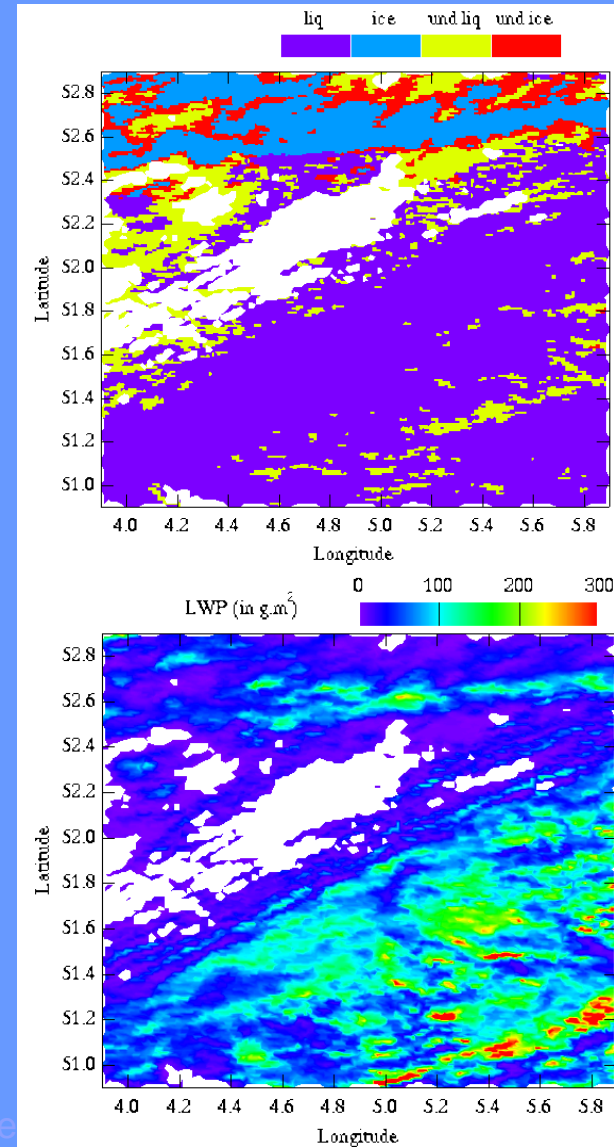
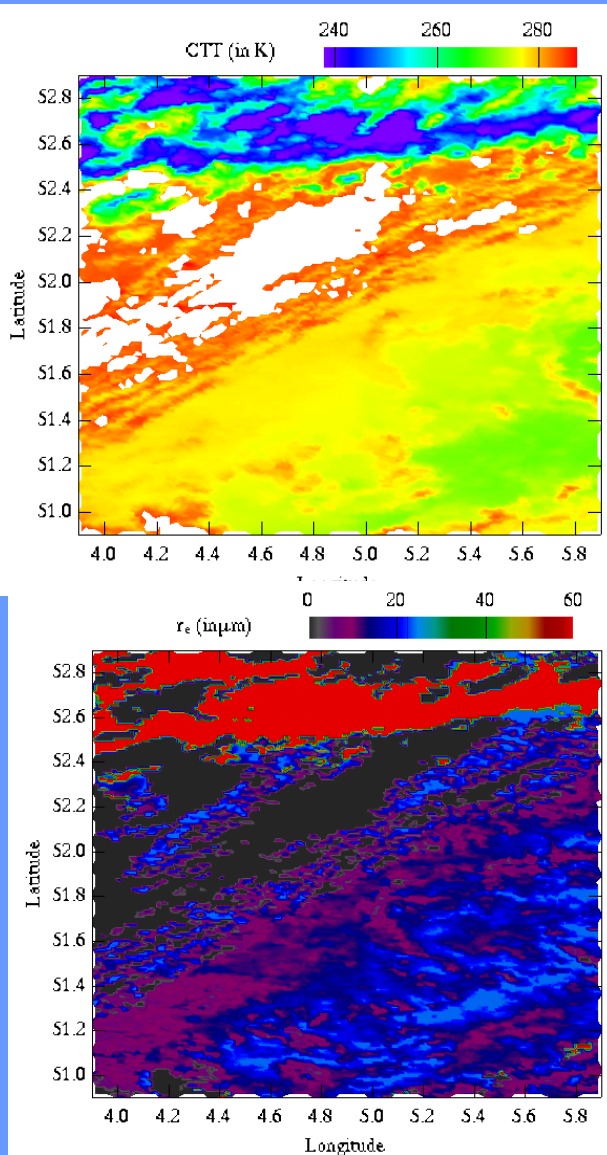


# Applications: Satellite validation / Model Validation

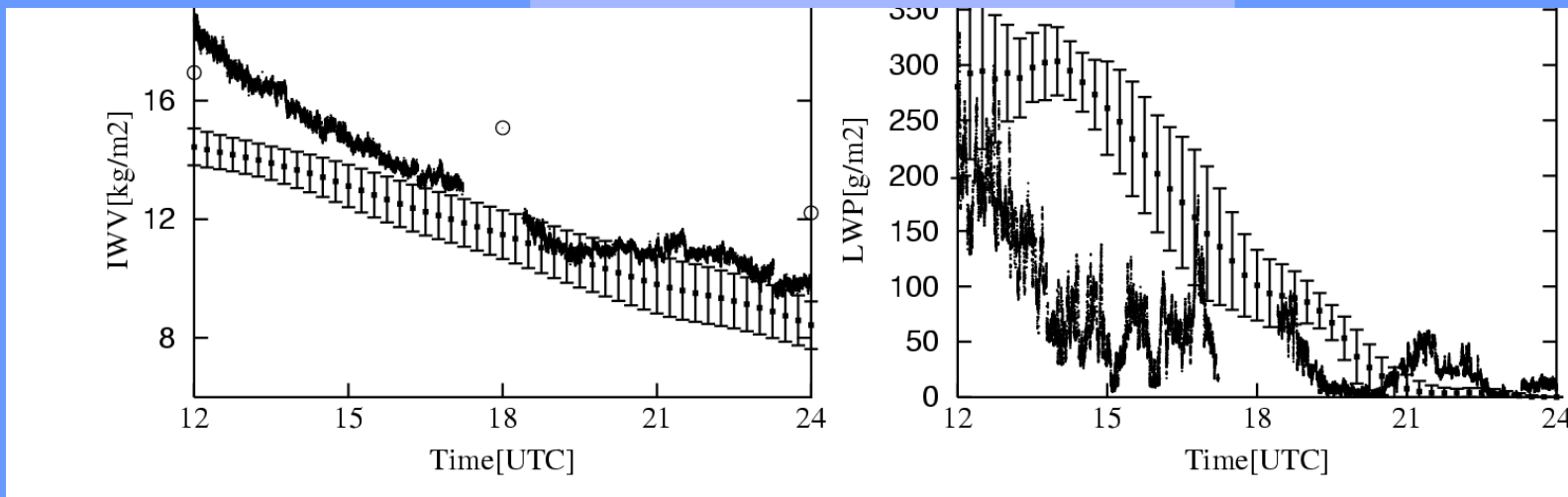
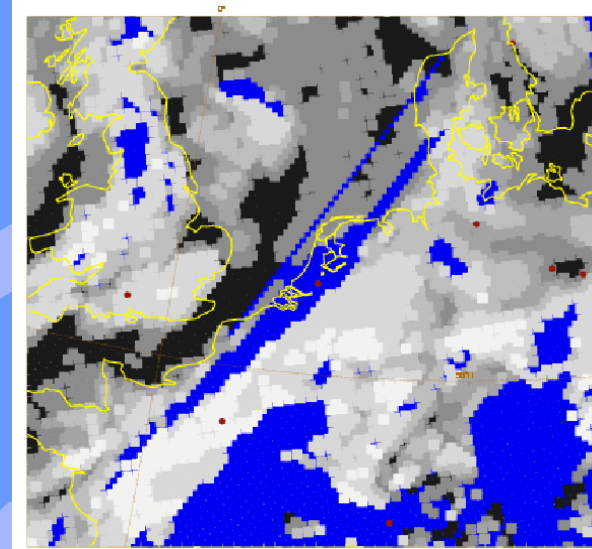


2001 8 13

# Application: Satellite / model validation using consistent quantitative cloud analysis from AVHRR / MSG

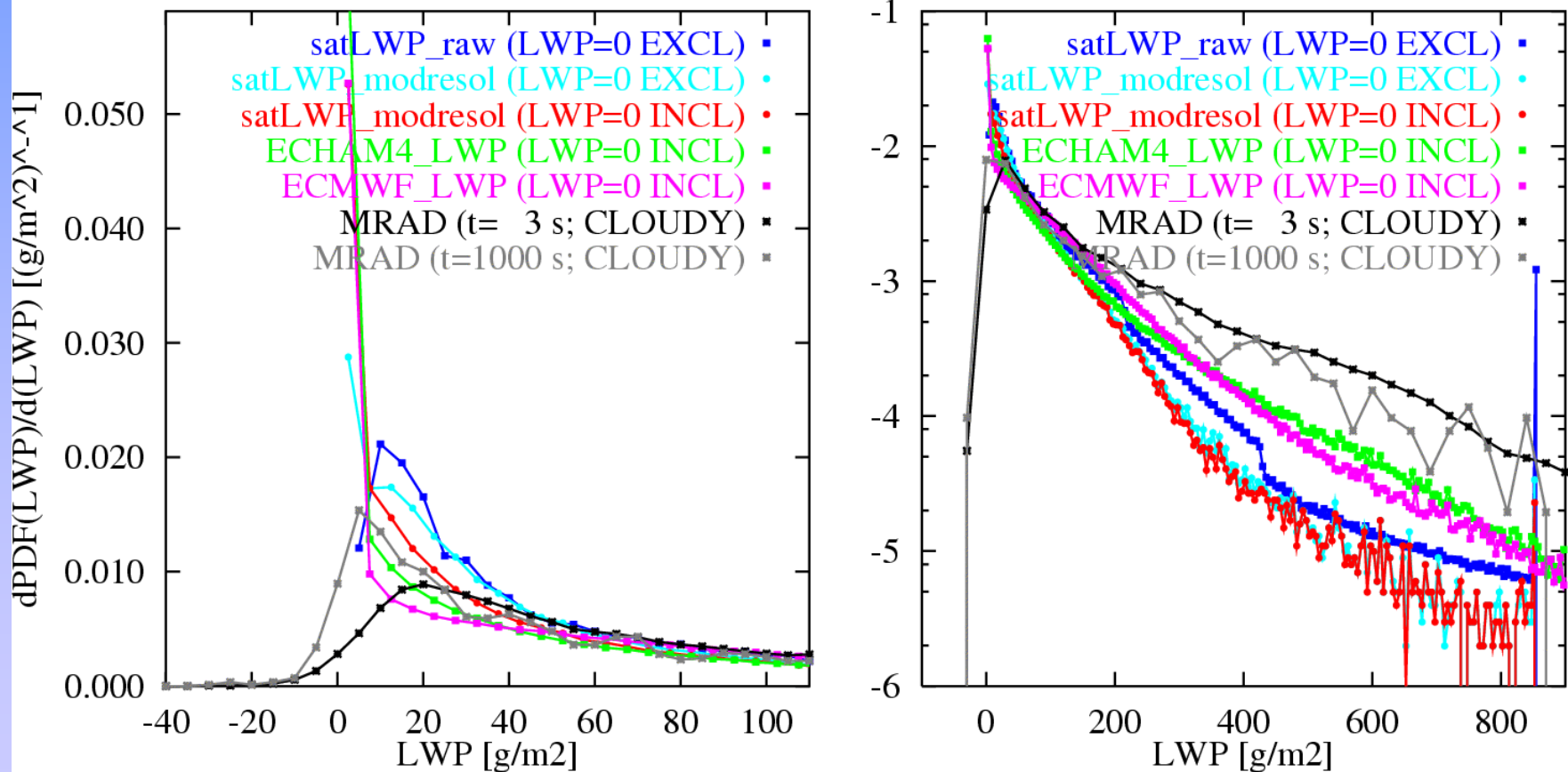


•••• Example of case study with AVHRR and RACMO LWP fields

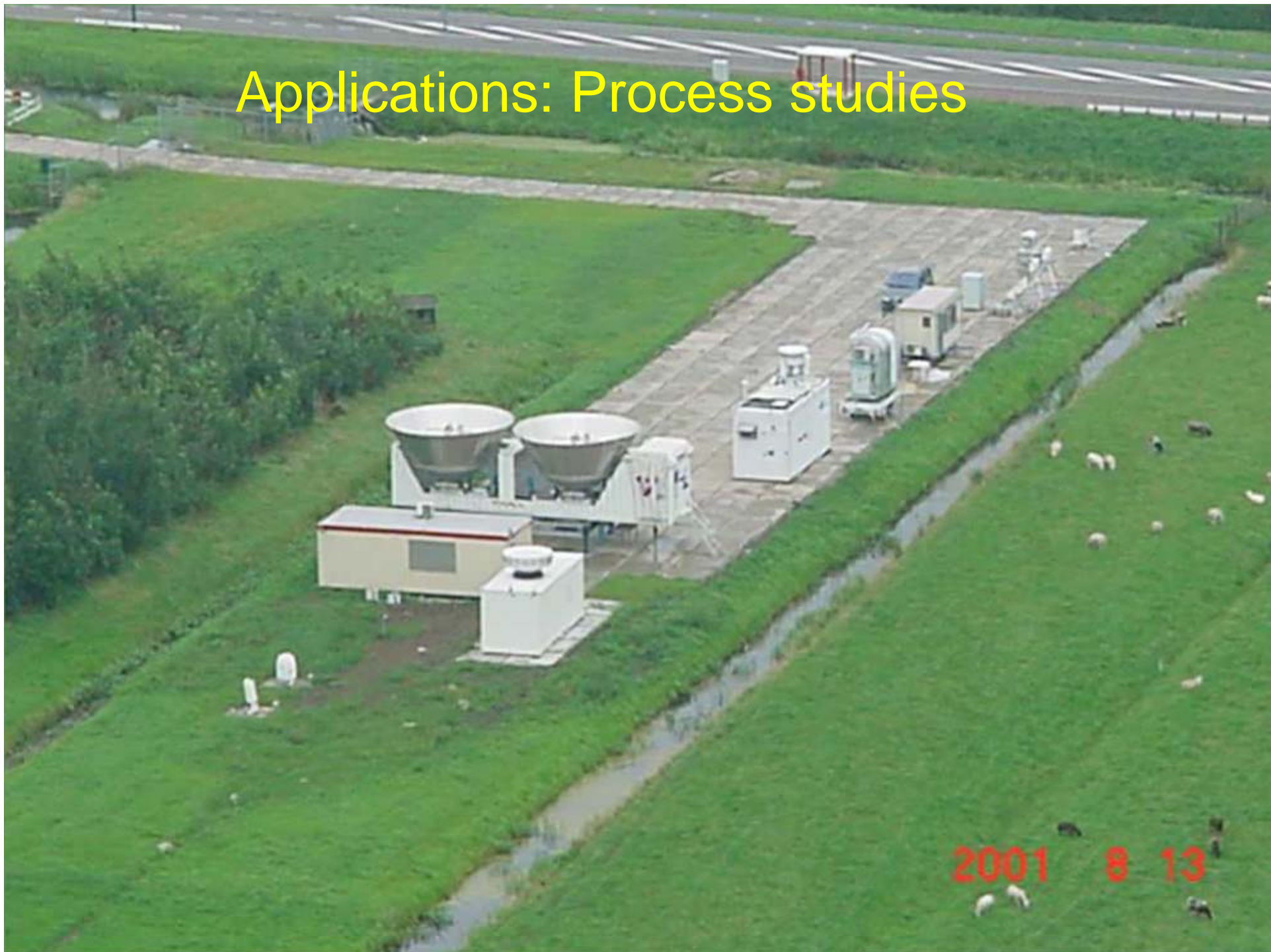


# Applications: Comparing model, satellite and ground-based observations of LWP

Probability Density LWP inferred  
from Microwave Radiometer (3 and 1000 second resolution)  
from Satellite (pixel and model resolution) and from Model  
linear scale logarithmic scale

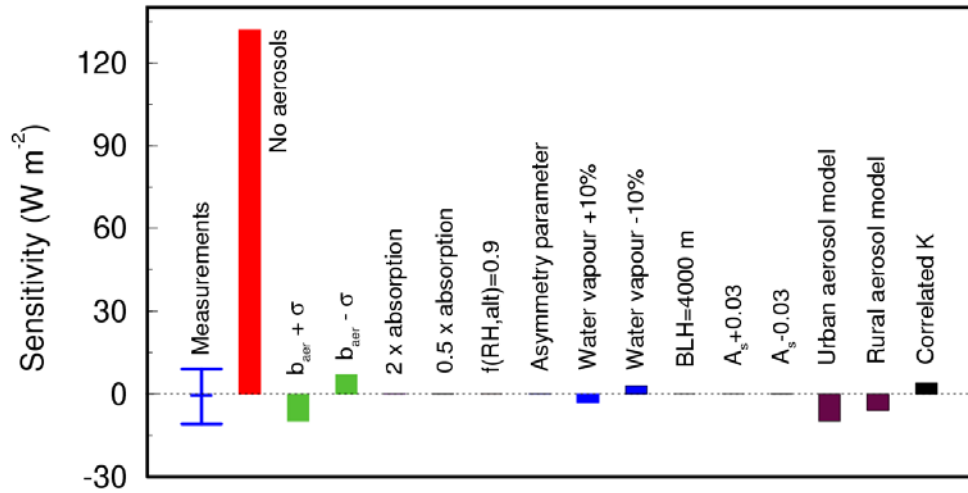


# Applications: Process studies

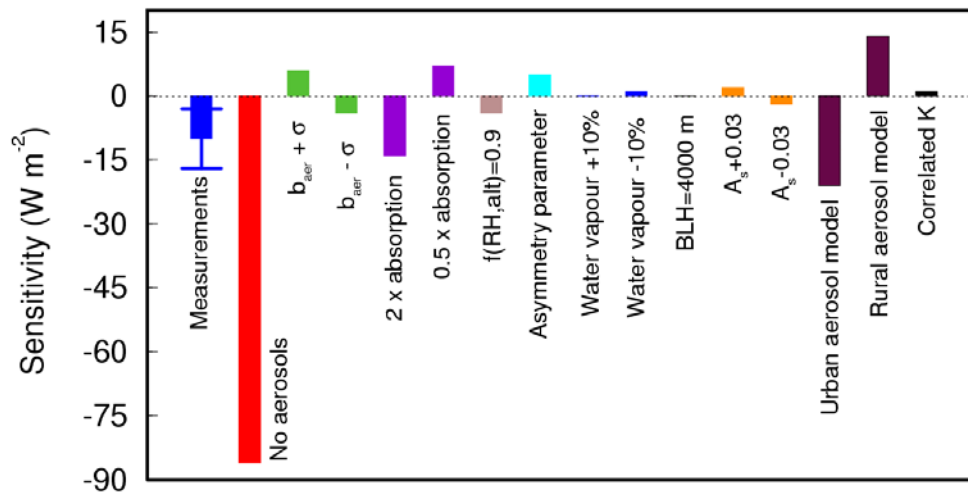


2001 8 13

# Applications: Process studies: The effect of aerosols on $I \downarrow$

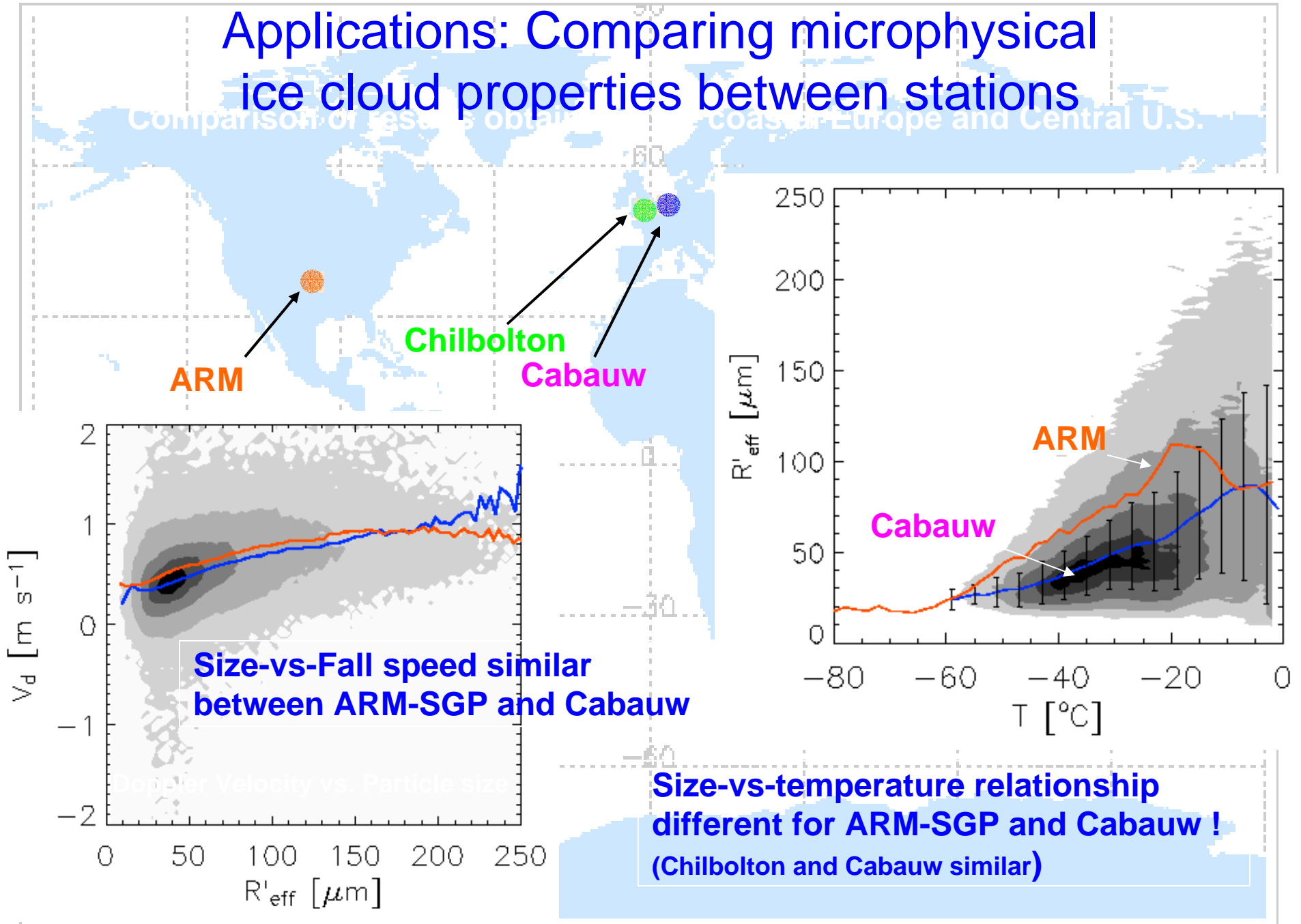


Direct irradiance



Diffuse irradiance

# Applications: Comparing microphysical ice cloud properties between stations

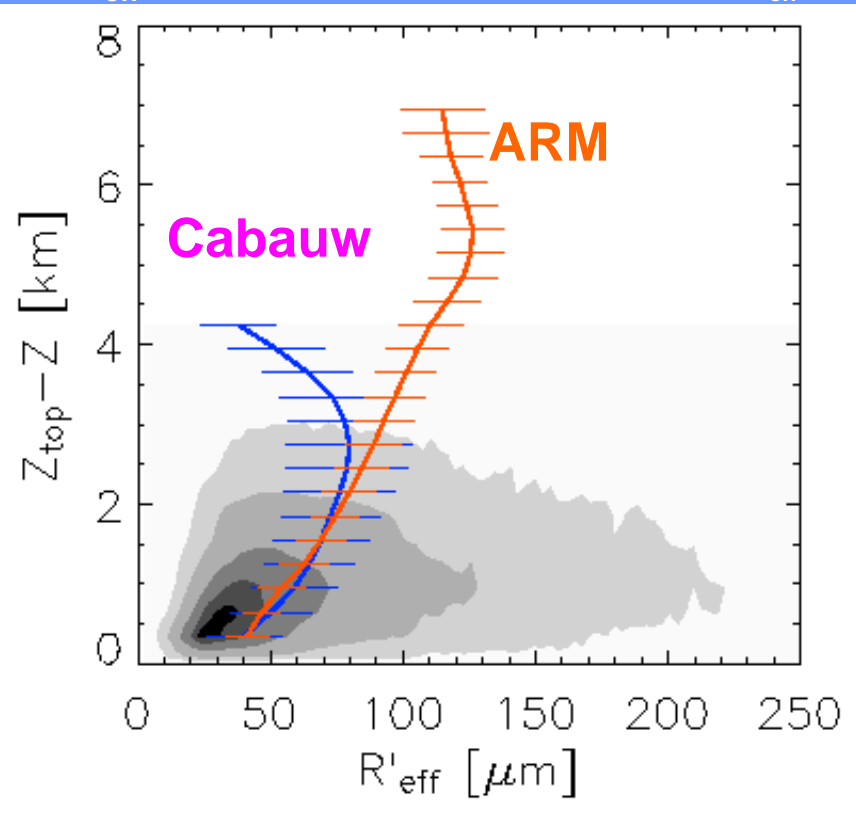


# Applications: Process Studies; Relating particle size to cloud depth

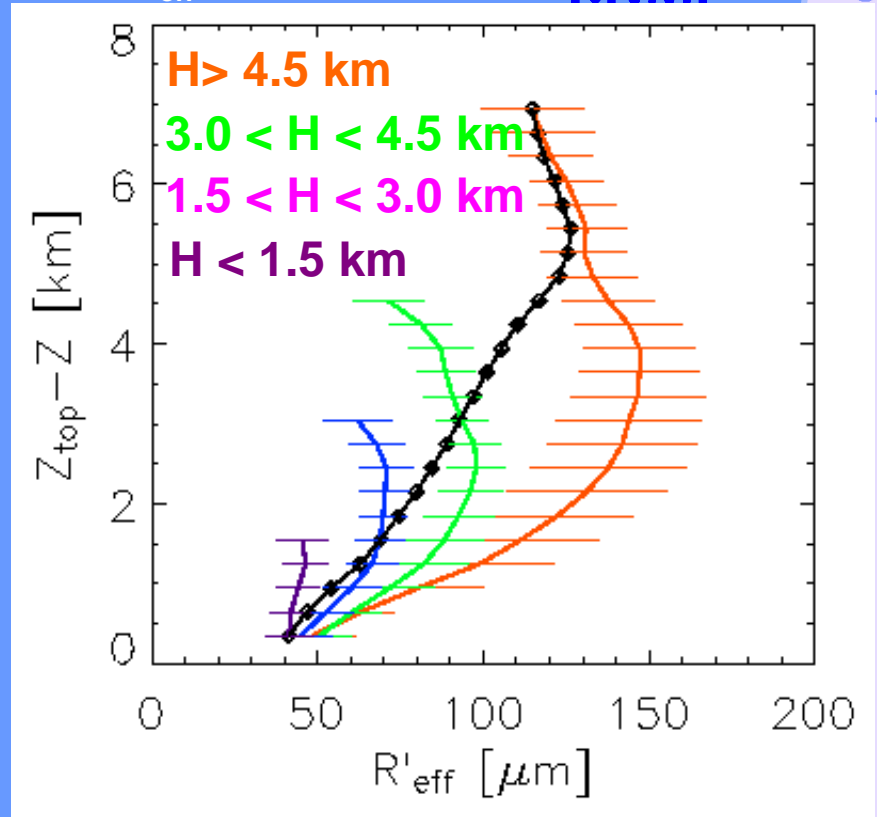


KO

$R'_{eff}$  vs-distance from cloud-top [ $R'_{eff}(dz)$ ]



$R'_{eff}(dz)$  vs. total cloud thickness (H)



- There is no global particle size-Temperature parameterization.
- However, A global  $R'_{eff}$  vs. ( $Z_{top}-Z$ ) parameterization may be possible.
- Sensitivity of results to instrument differences has been addressed
- Future satellite missions (CloudSAT/Calipso, EarthCARE) will give global coverage.

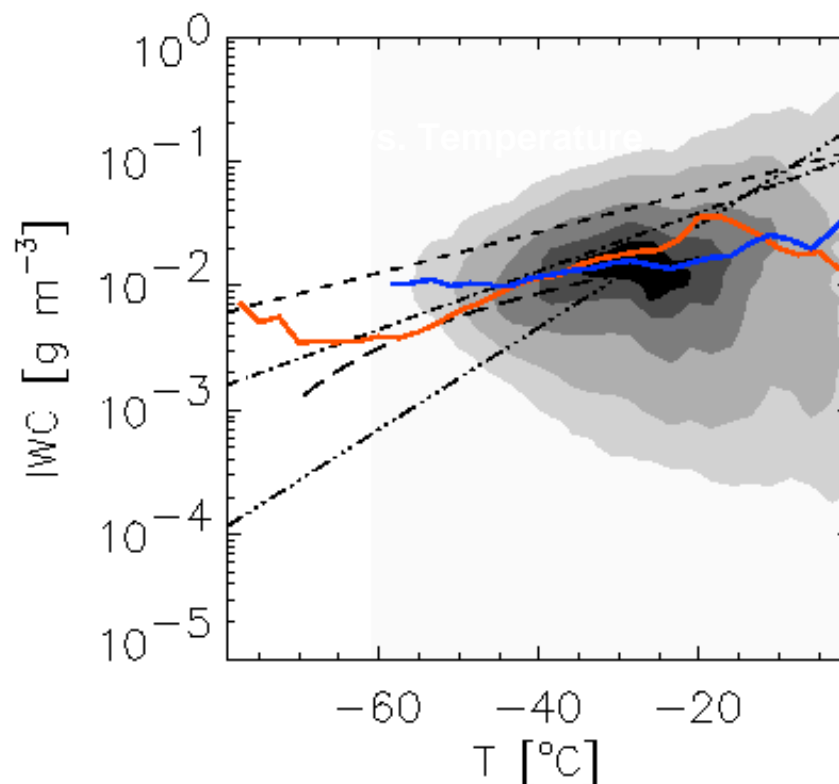
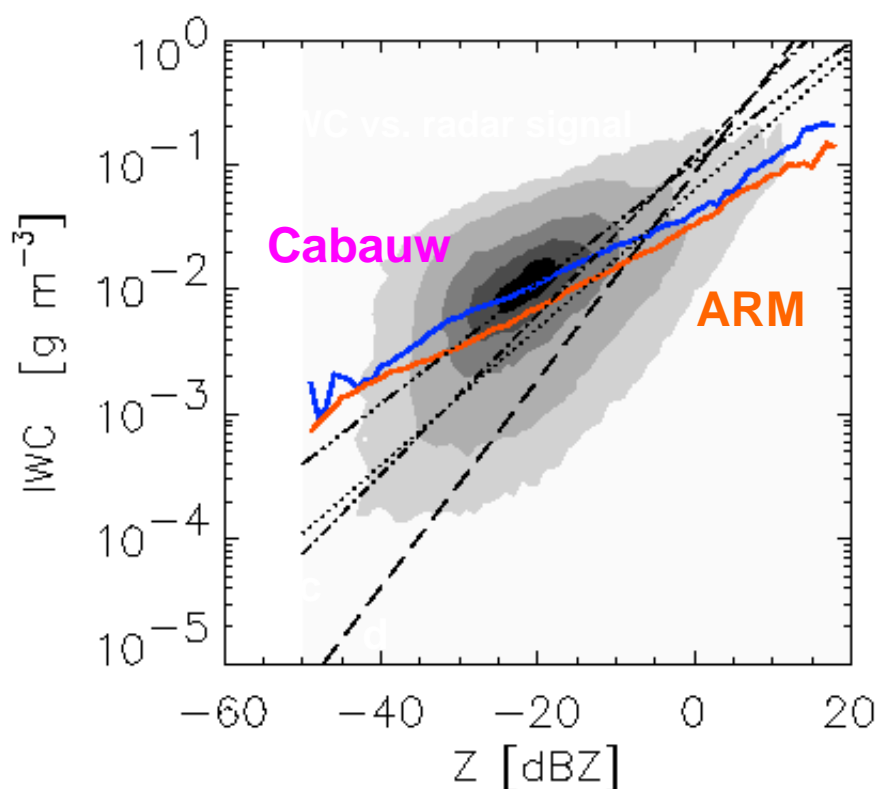
ARM-science meeting NM April 2004

ch Institut



# Applications: Comparing ice water content to literature relationships

- Adopt complex polycrystals as ice-habit



Lidar/Radar results consistent with range of previous mainly in-situ based results

- a) Aydin and Tang (1997)
- b) Norquist and D'Entremont (2003)
- c) Matrosov 2003
- d) Sassen and Liao (1996)

- e) Boudala et al. 2002 ( f incl. Small part.)
- g) Wang and Sassen (2002)
- h) Stephens et al. (1990)

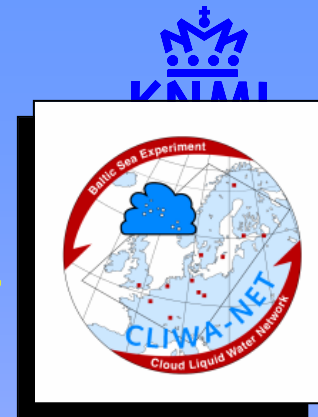
ARM-science meeting, NM, April 2004



The Baltex Bridge Cloud (BBC) campaign  
August 1- September 30, 2001, Cabauw, NL

## Aircrafts

- the Meteo France Merlin aircraft
- the Partenavia P68B aircraft from the Institute for Tropospheric Research, Leipzig
- the Cessna C207T aircraft from the Free University of Berlin.



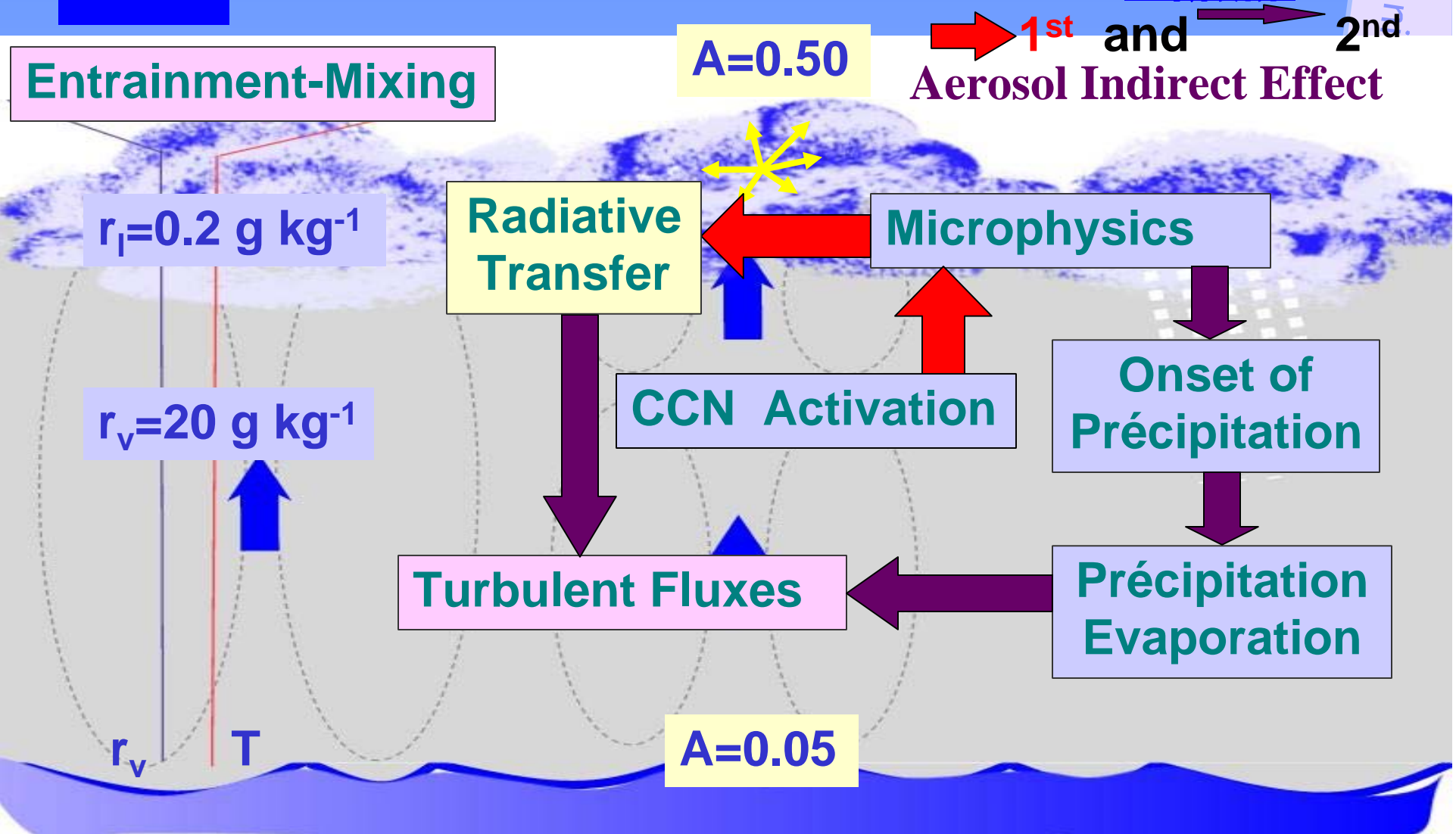
pril 2004

## BBC2 main topics

- Radiative transport in inhomogeneous cloud fields
- Improvement of cloud representation in models
  - Focus on boundary layer clouds
- Improvement measurement techniques
  - Synergy: Lidars, radars, microwave radiometers, ..
  - Satellite retrievals (MSG, AVHRR, SCIAMACHY)
- Aerosol - radiation interaction

# Boundary Layer Clouds

Kor.





# Impressions

## Building-up



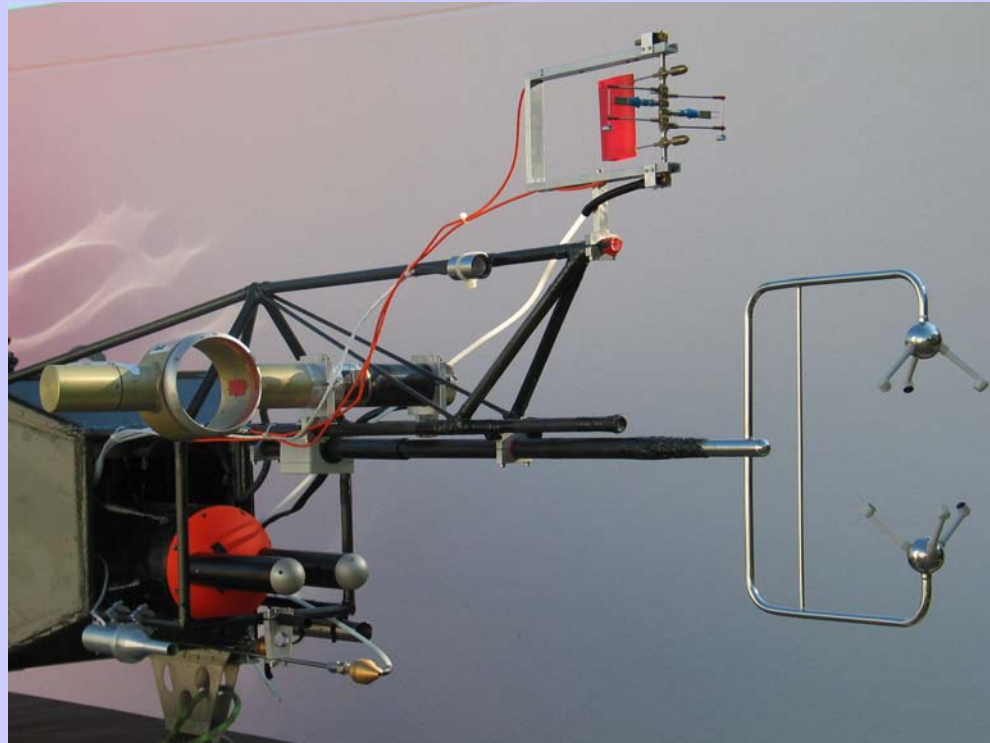
Koninklijk Nederland  
Wetenschappelijk Instituut



# BBC - impressions



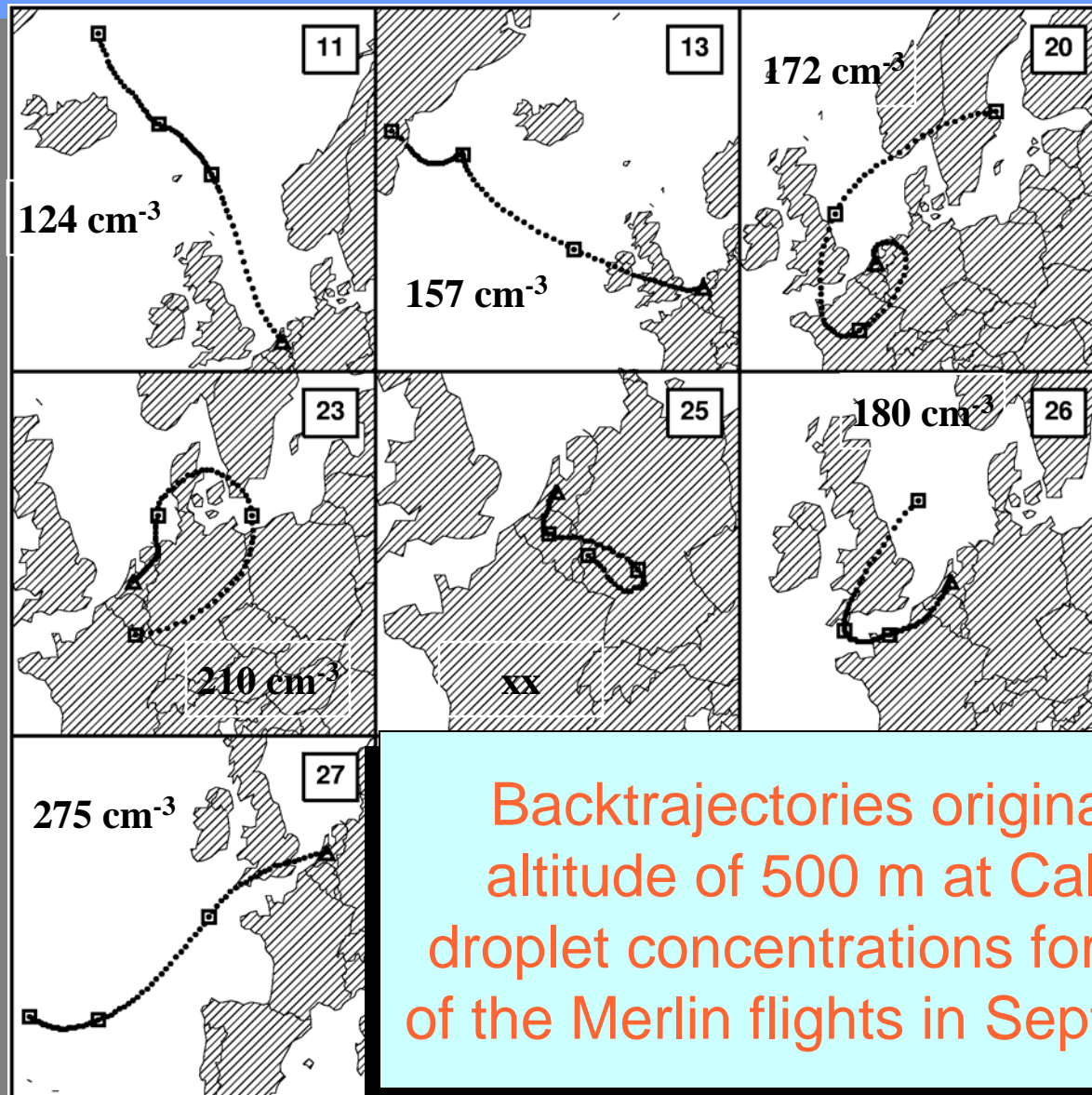
MAPSY Balloon  
Uni. Leipzig



Koninklijk Nederlands Meteorologisch Instituut



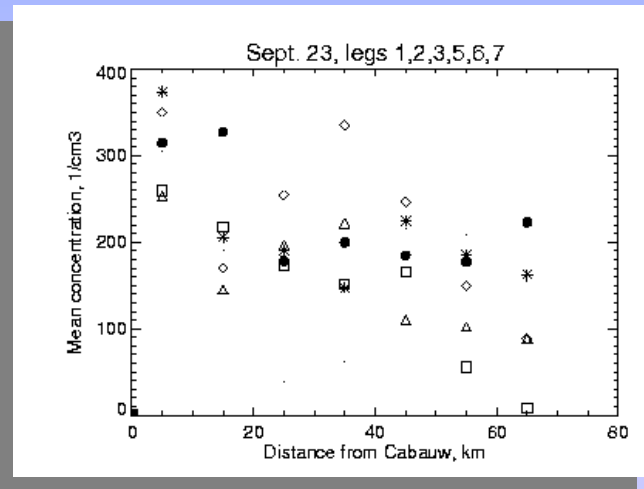
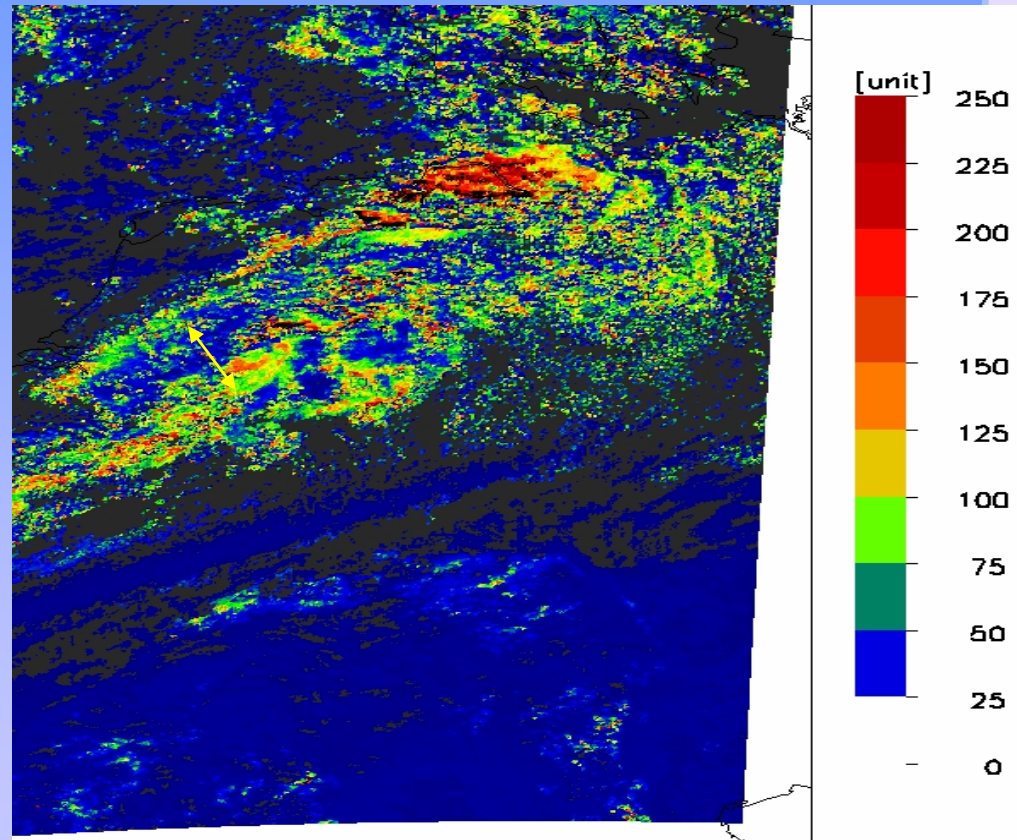
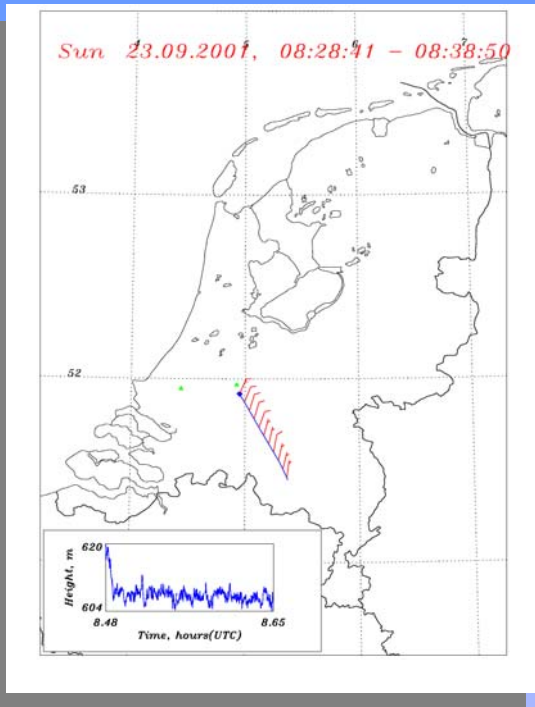
ARM-science meeting NM April 2004



- ▲ Cabauw
- -1 hour
- -1 day (24 hours)

Backtrajectories originating at an altitude of 500 m at Cabauw, and droplet concentrations for seven days of the Merlin flights in September 2001,

# Droplet concentration from passive imager



## Cloud Droplet Concentration

23 September 2003, 11:57 UTC.





# Near Future

## Observations: expansion

Raman lidar  
Cemel sun photometer  
cloud / rain radar  
permanent microwave radiometer  
CCN counter/ aerosol samplers  
Spectral sun photometer

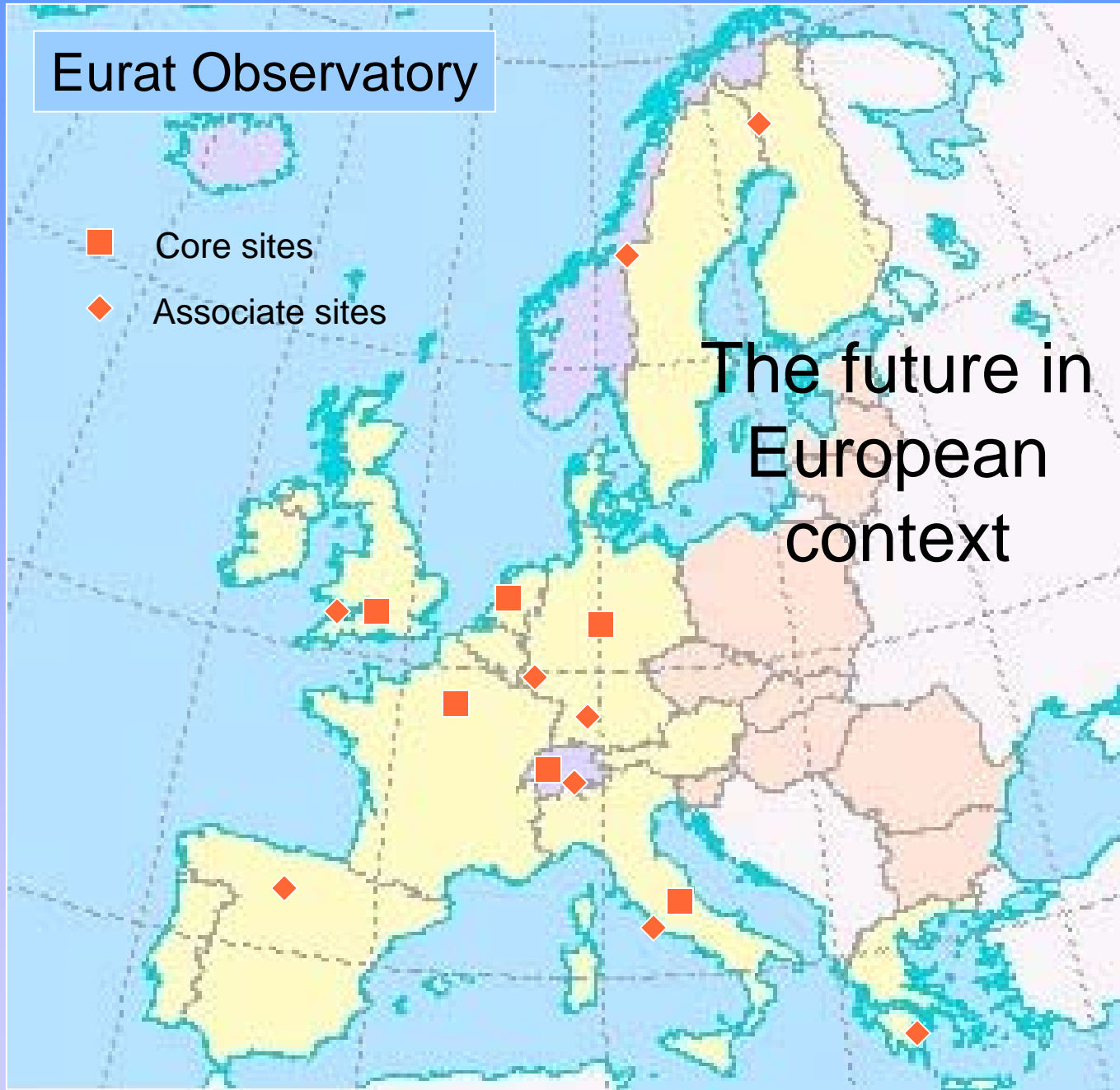
## Programs

KNMI >> automatization instruments, intake  
Netherlands >> Infrastructure program , CESAR,  
various collaborative research projects  
Europe >> embedding in cloud / aerosol  
programs (B2B, CLOUDNET, CLIWANET)  
Global >> GEWEX (GCSS, GBLS, APS)  
GEOSEC >> monitoring site ?

## Eurat Observatory

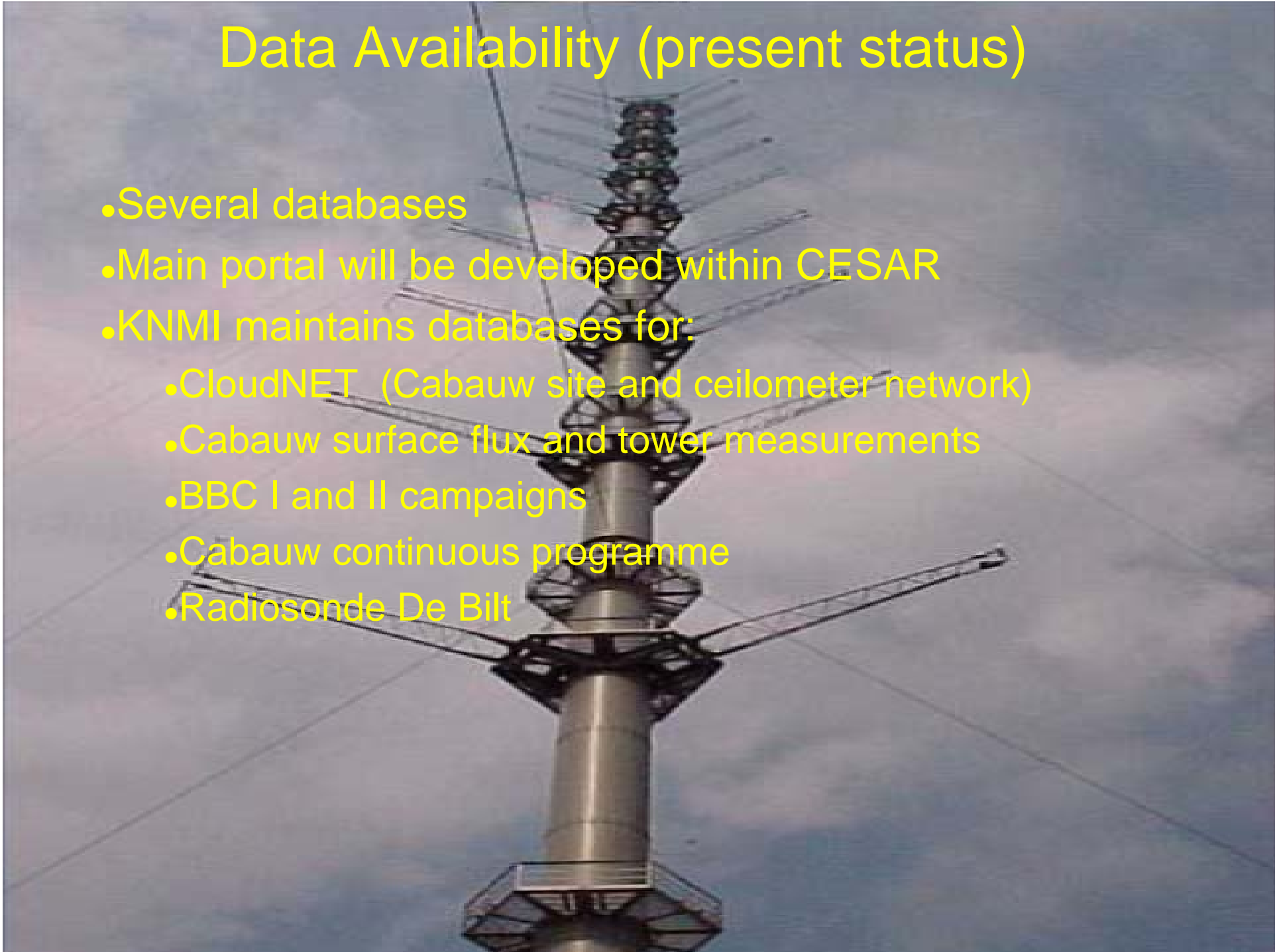
- Core sites
- ◆ Associate sites

The future in  
European  
context



# Data Availability (present status)

- Several databases
- Main portal will be developed within CESAR
- KNMI maintains databases for:
  - CloudNET (Cabauw site and ceilometer network)
  - Cabauw surface flux and tower measurements
  - BBC I and II campaigns
  - Cabauw continuous programme
  - Radiosonde De Bilt



## Related web sites (present status)

- <http://www.knmi.nl/samenw/bbc2>
- <http://www.knmi.nl/samenw/cloudnet>
  - (near realtime images: cloudradar, TSI)
- <http://www.knmi.nl/samenw/cesar>
- <http://www.cesar-observatory.nl>

## Help and instructions for access:

- General remote sensing: Henk Klein Baltink ([baltink@knmi.nl](mailto:baltink@knmi.nl))
- Land-Atmosphere: Fred Bosveld ([bosveld@knmi.nl](mailto:bosveld@knmi.nl))
- Radiation: Wouter Knap ([knap@knmi.nl](mailto:knap@knmi.nl))