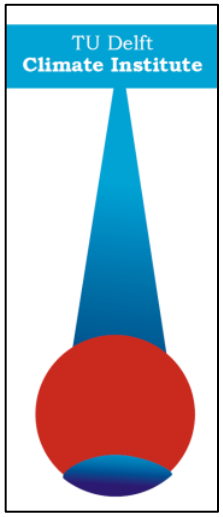
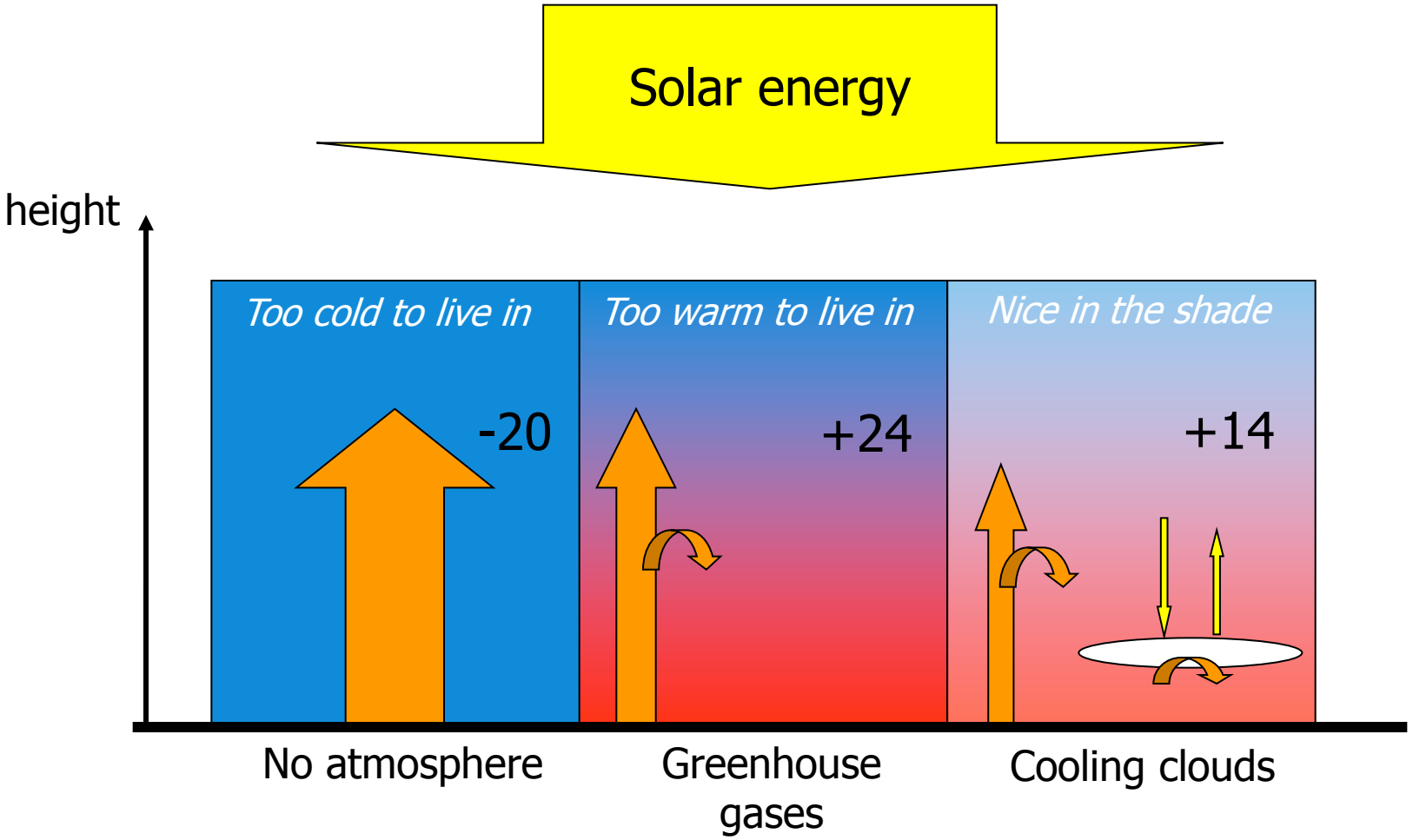
Clouds, climate, challenges

Herman Russchenberg

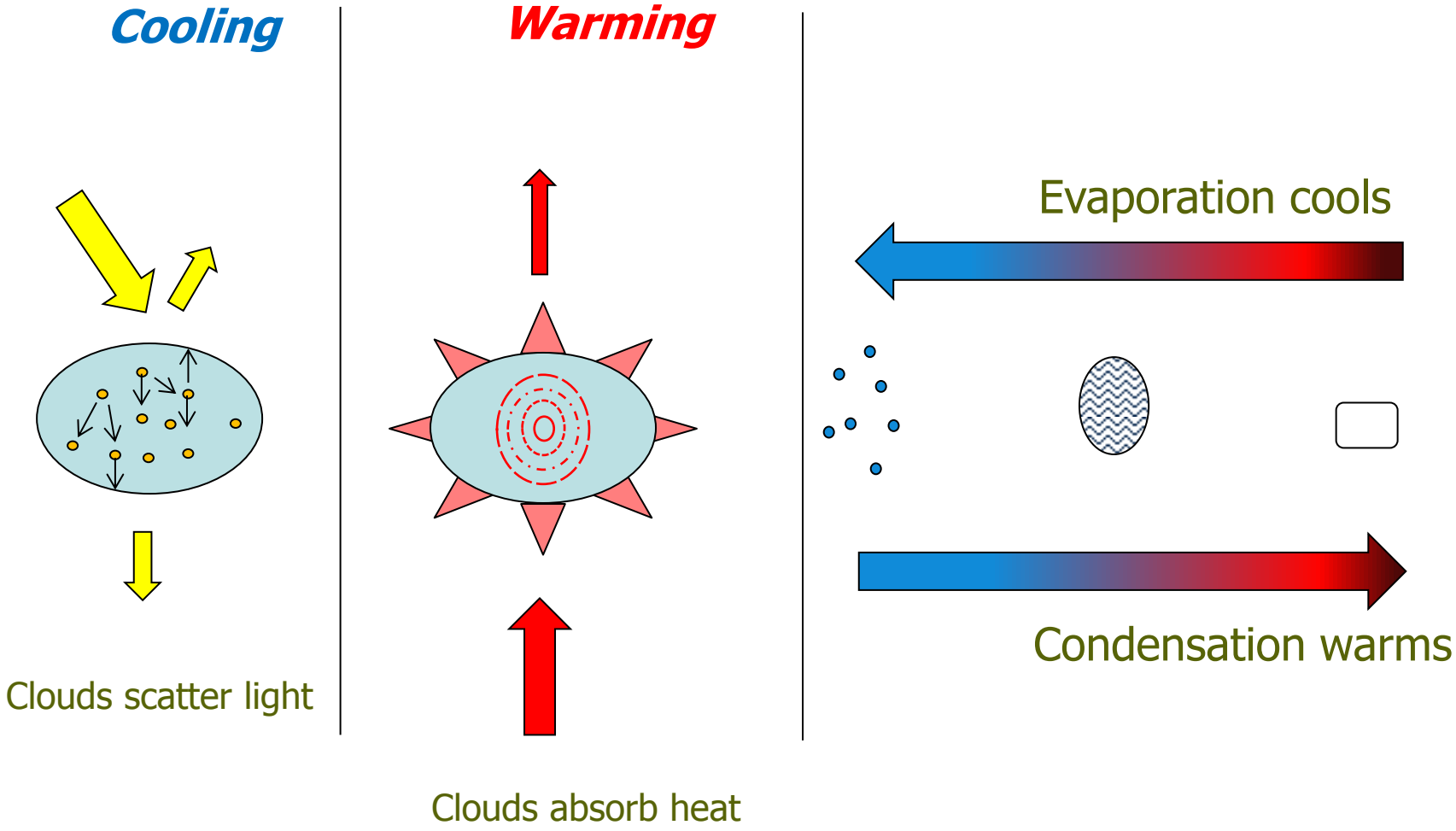
Remote Sensing of the Atmosphere



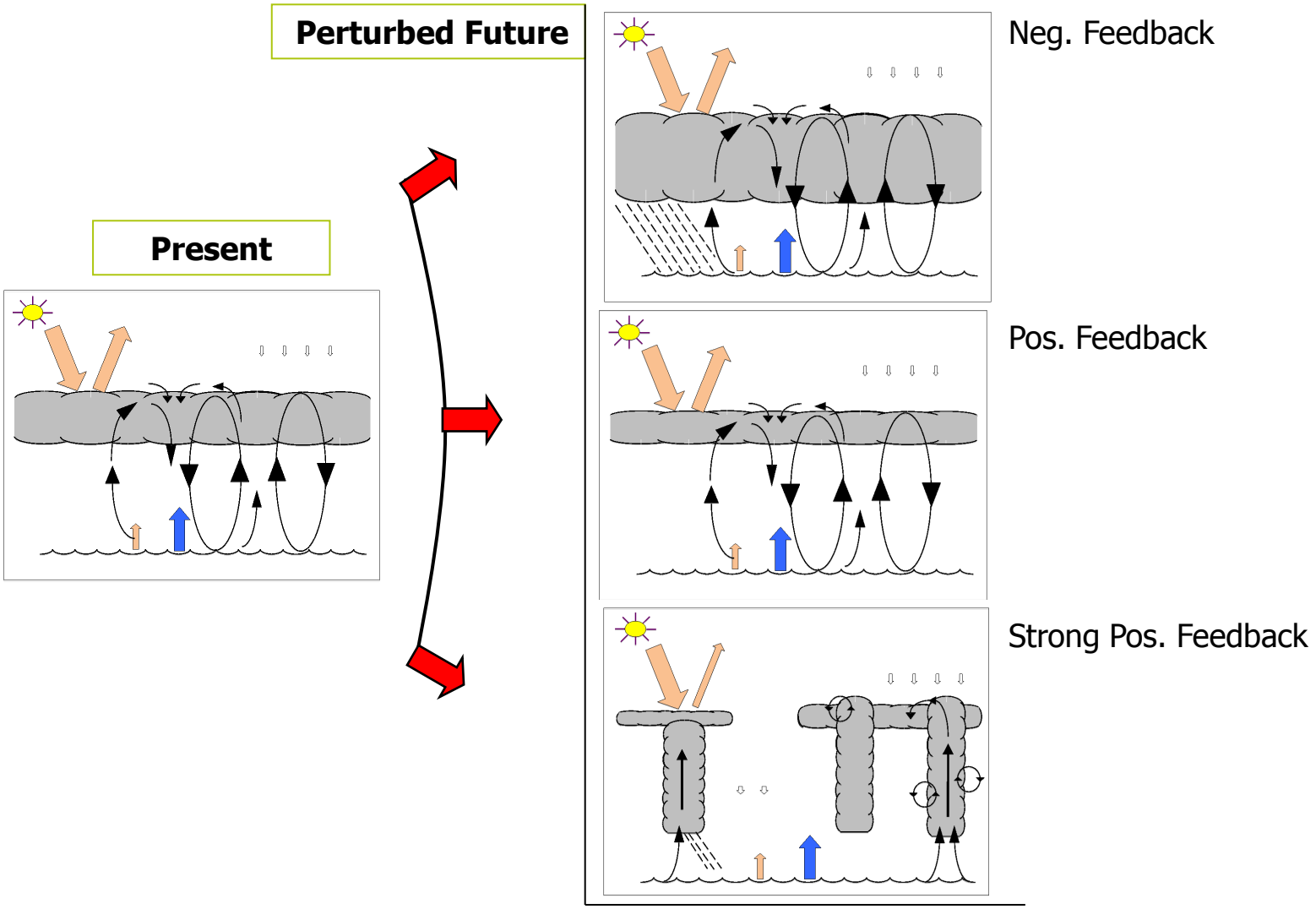
The radiation balance: a status quo

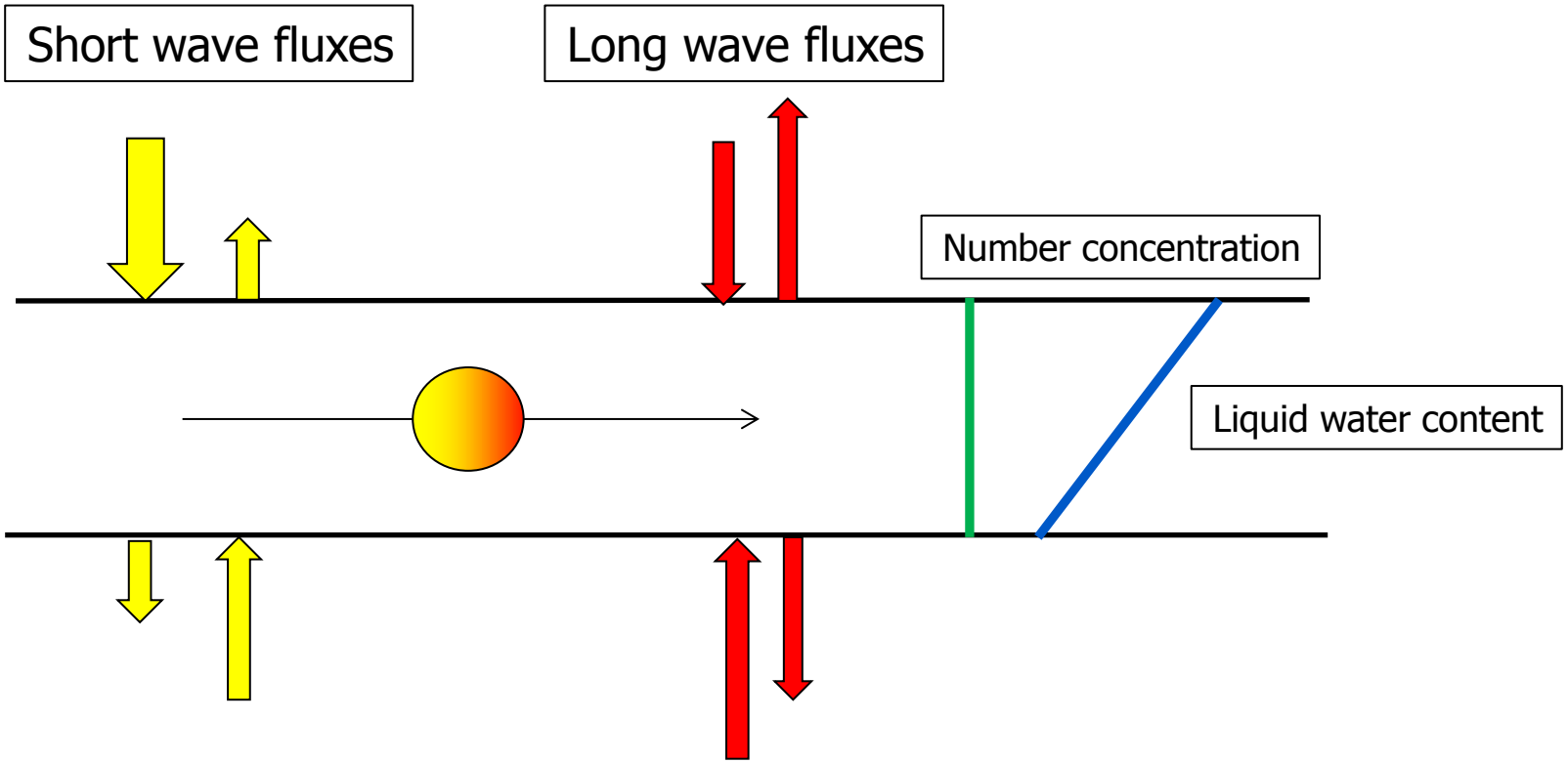


Clouds and climate



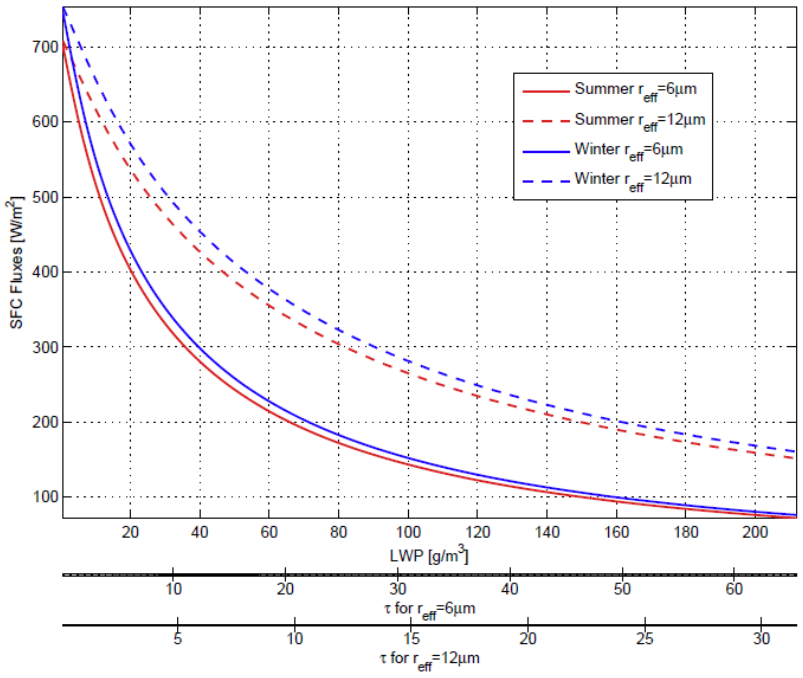
Possible cloud responses to warming

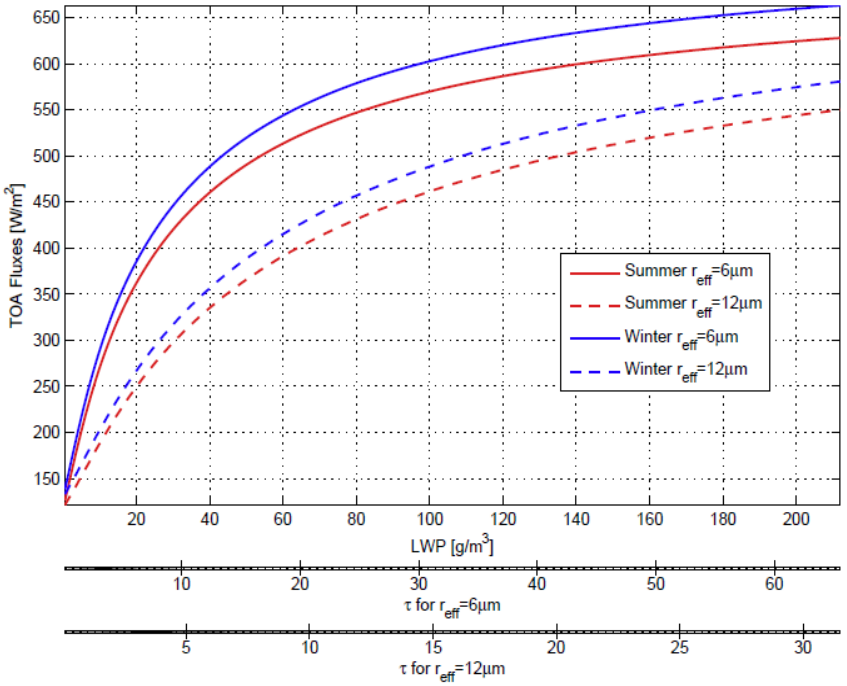




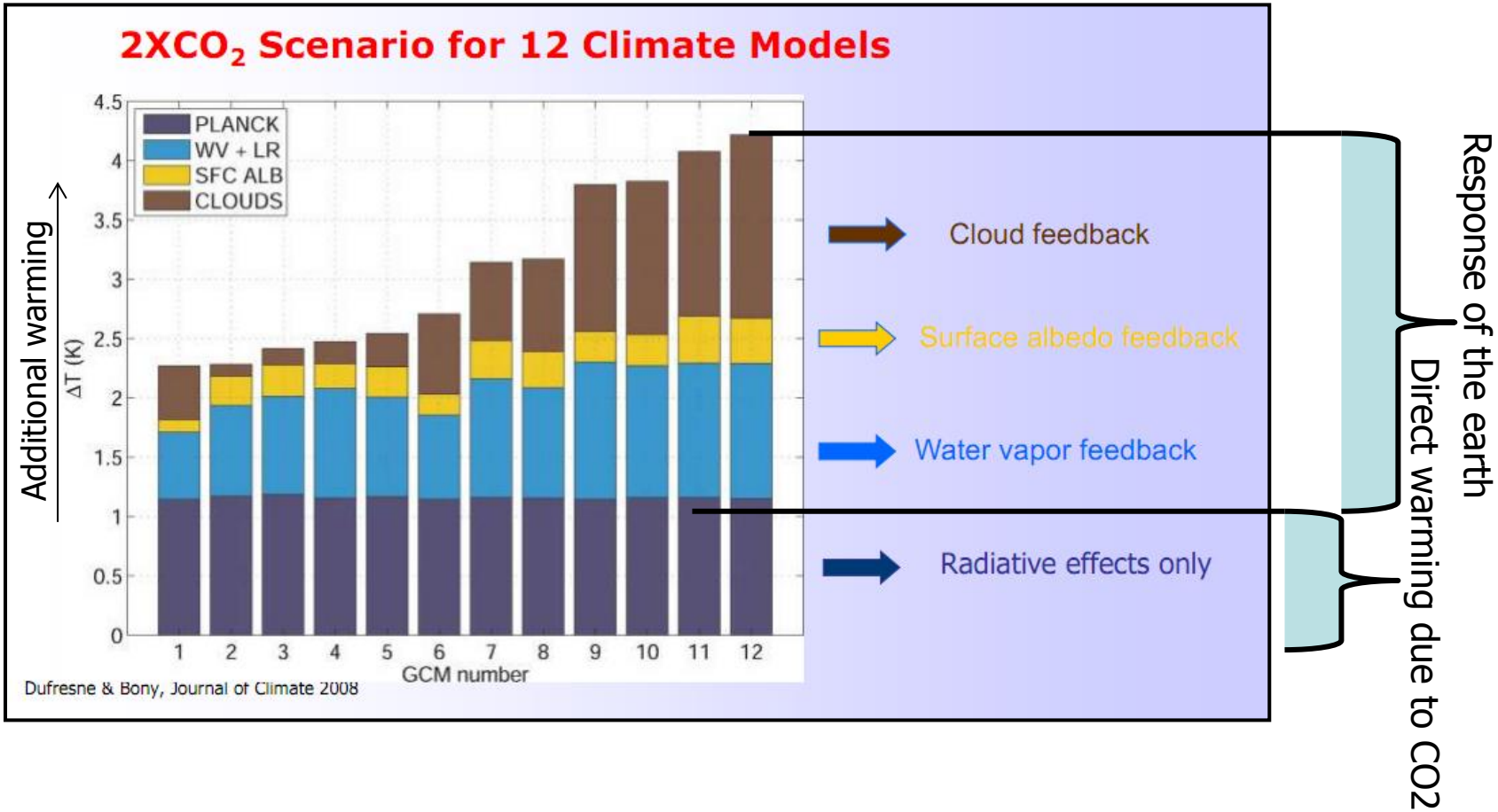
Optical depth = total extinction of radiation due to absorption and scattering

Example of broadband sw fluxes

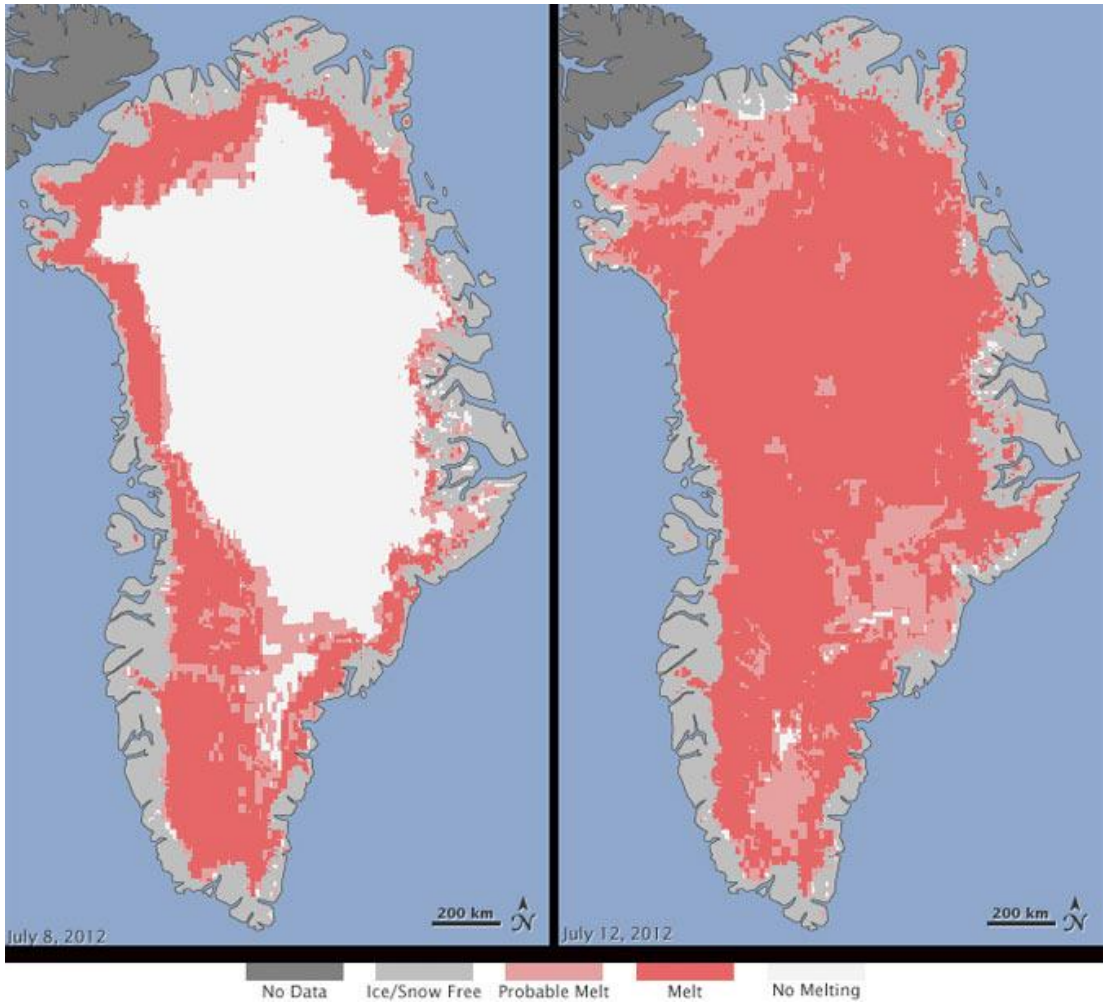




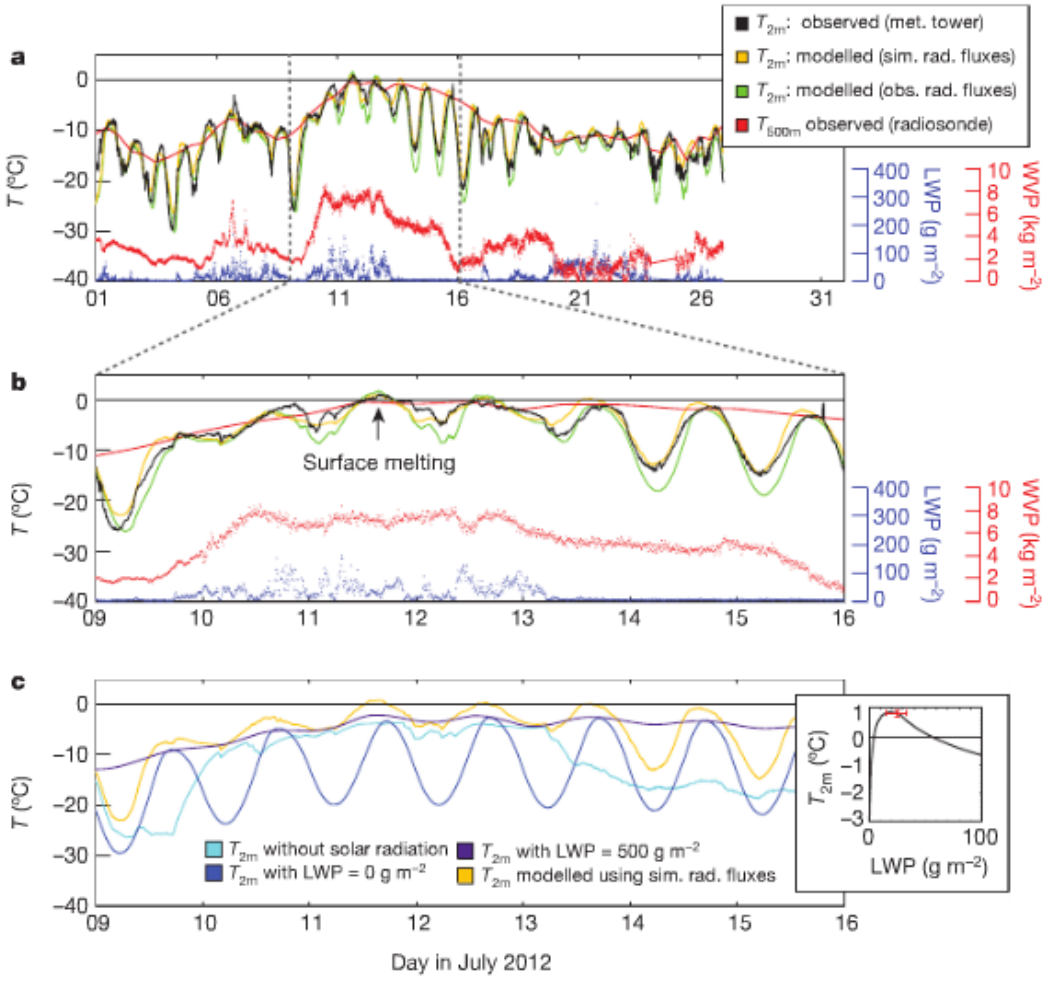
Global warming: state of the art



Greenland melt, July 2012

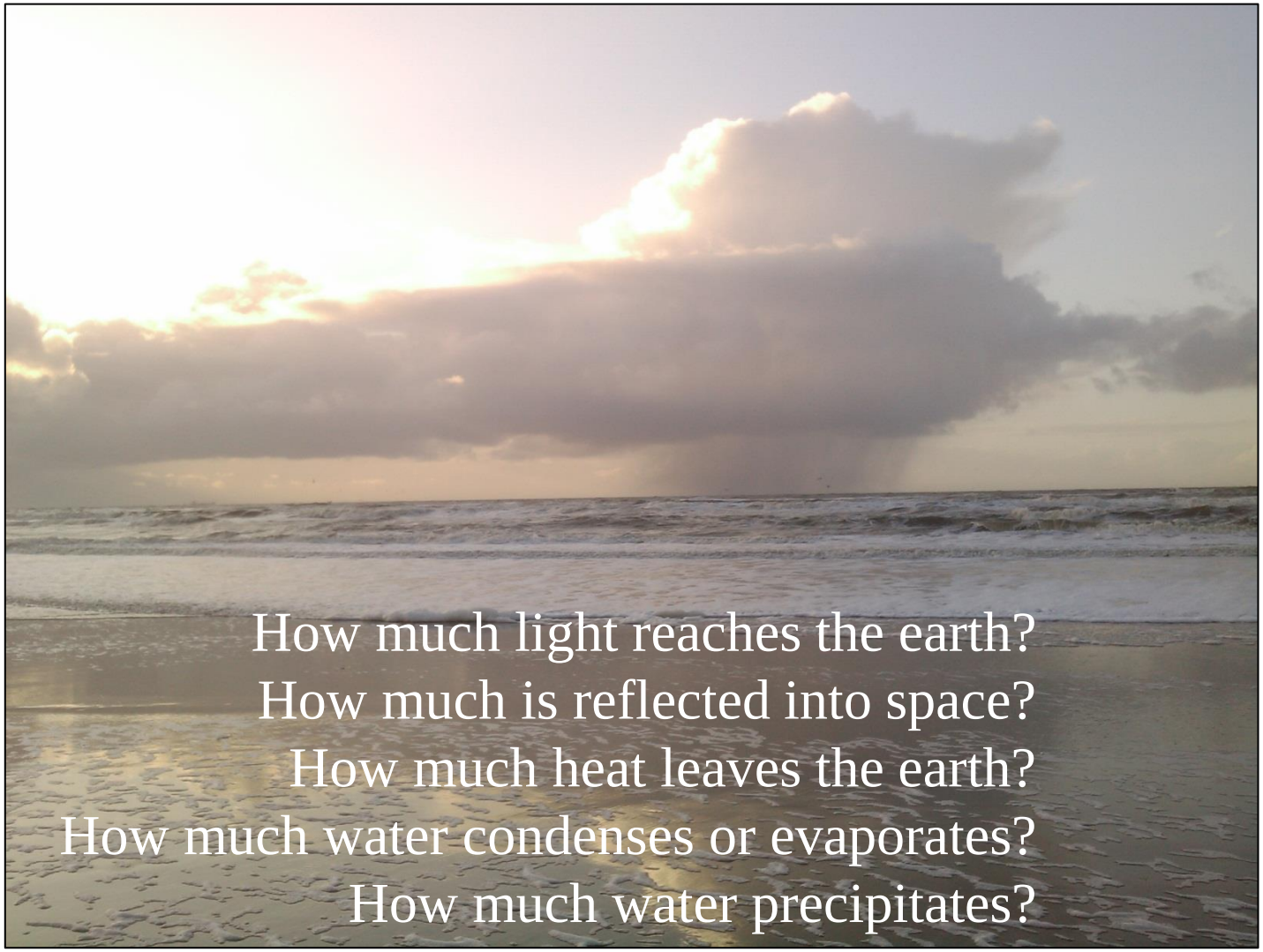


Impact of thin low level clouds on surface temperature

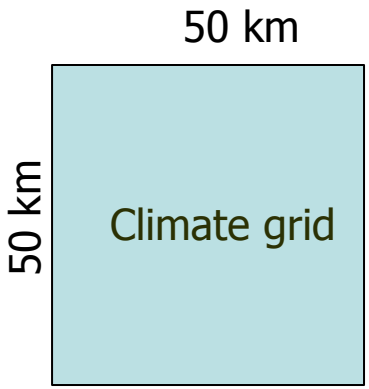


Bennartz et al, 2013, Nature

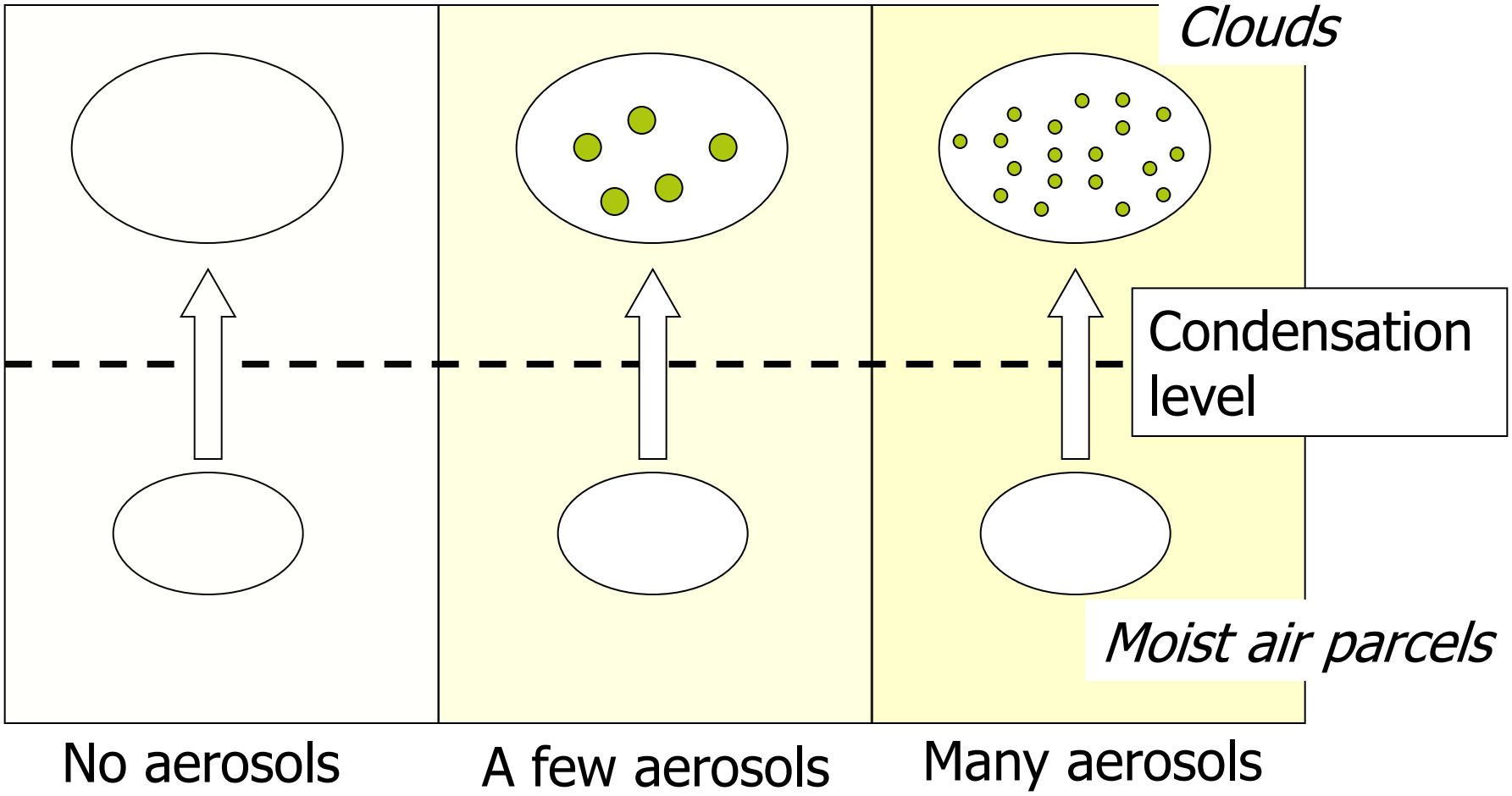
The cloud questions



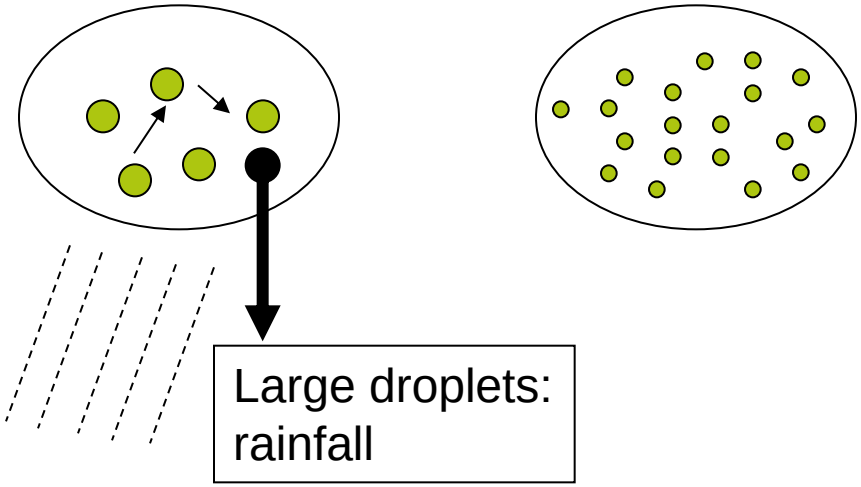
Why are clouds so difficult?



A bit about cloud formation



rainfall formation



More aerosols

↓

Delayed rainfall

↓

Longer cloud lifetime

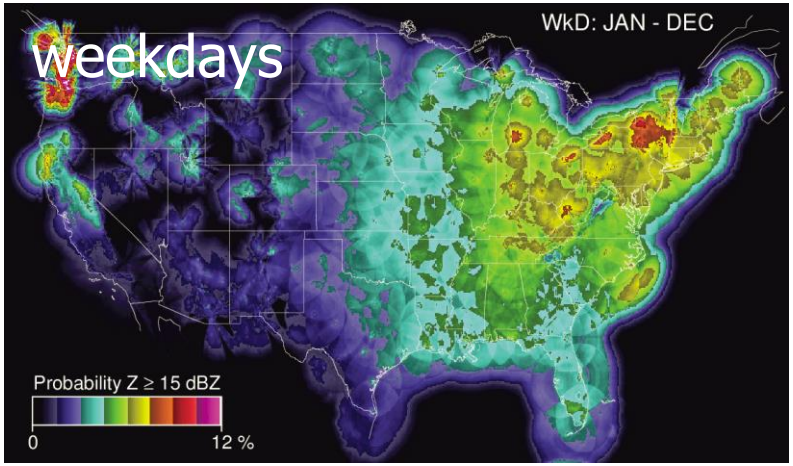
↓

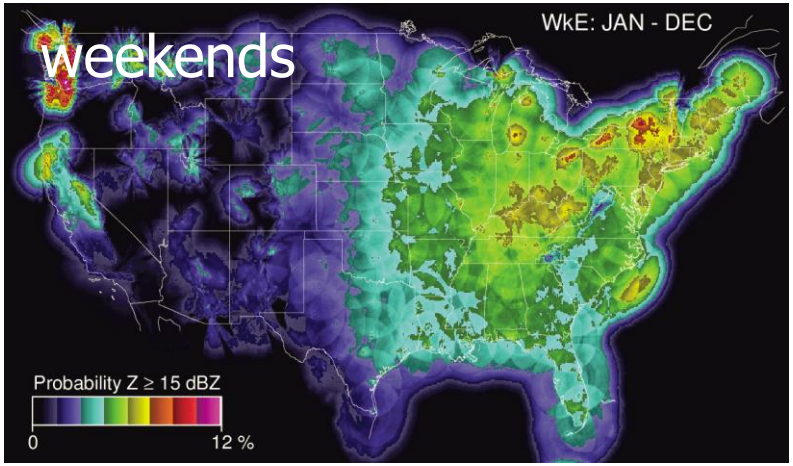
Sustained impact
on radiation

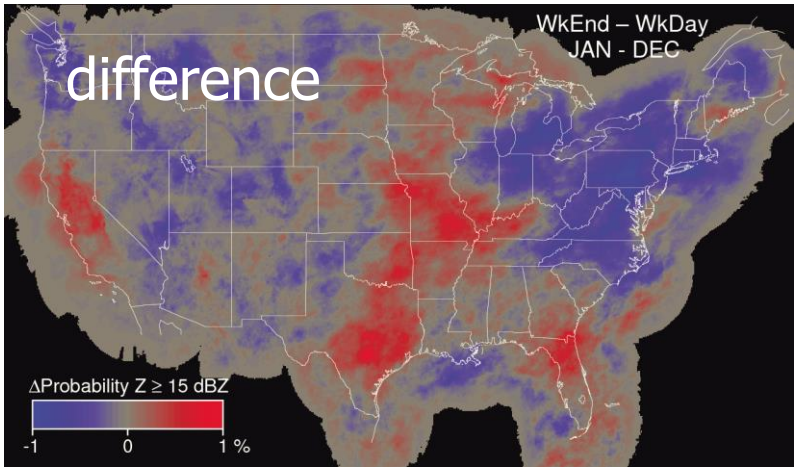
$$\tau_{cloud} = k \cdot \frac{LWP}{r_{eff,cloud}}$$

Influenced by aerosol background?

City effect on winter precipitation?







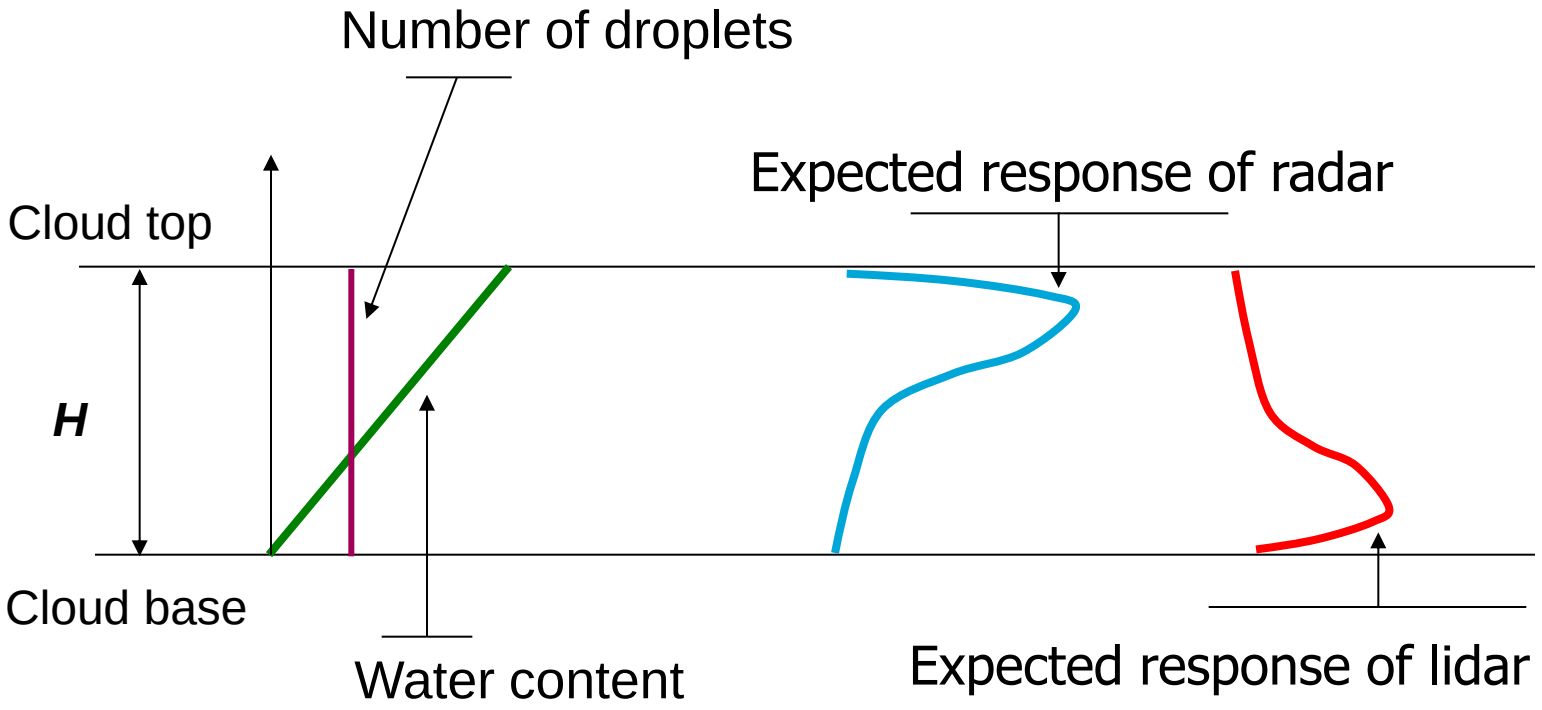
Analysis of 17 years
of weather radar data

Fabry et al, AMS Radar conference 2013

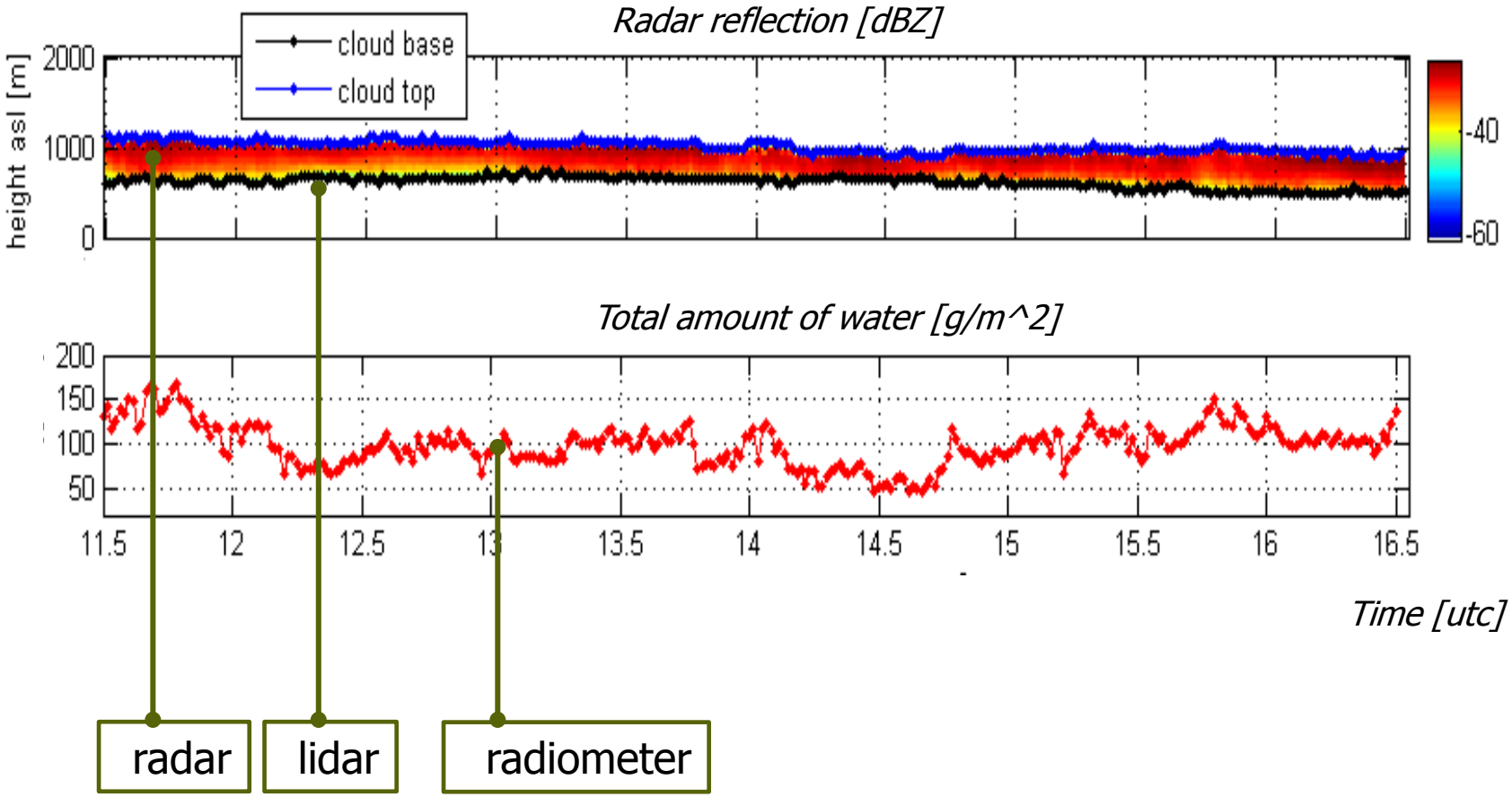
Cesar Observatory

Delft University of Technology, KNMI, Wageningen University and Research
Utrecht University, RIVM, ECN, TNO , European Space Agency

Assume a cloud model

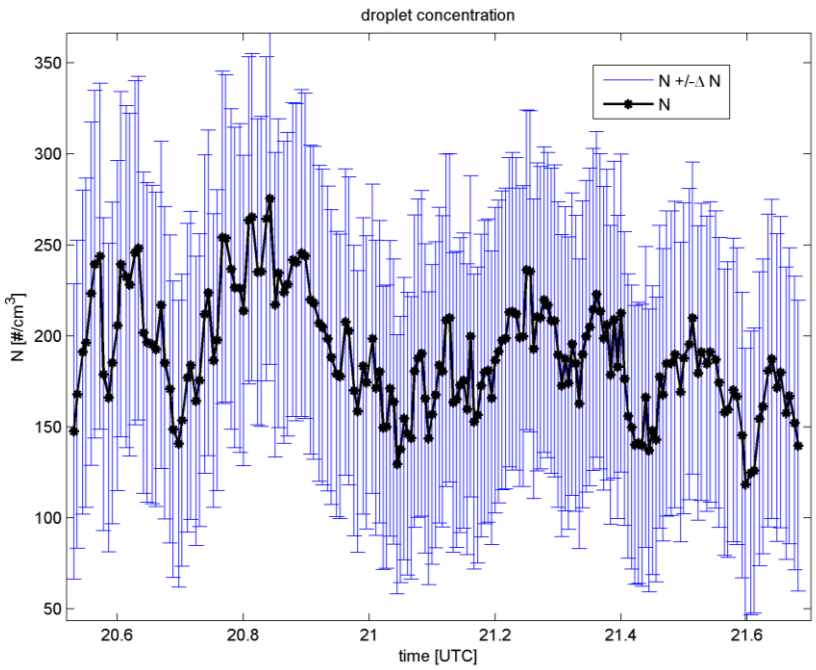


Inside stratocumulus

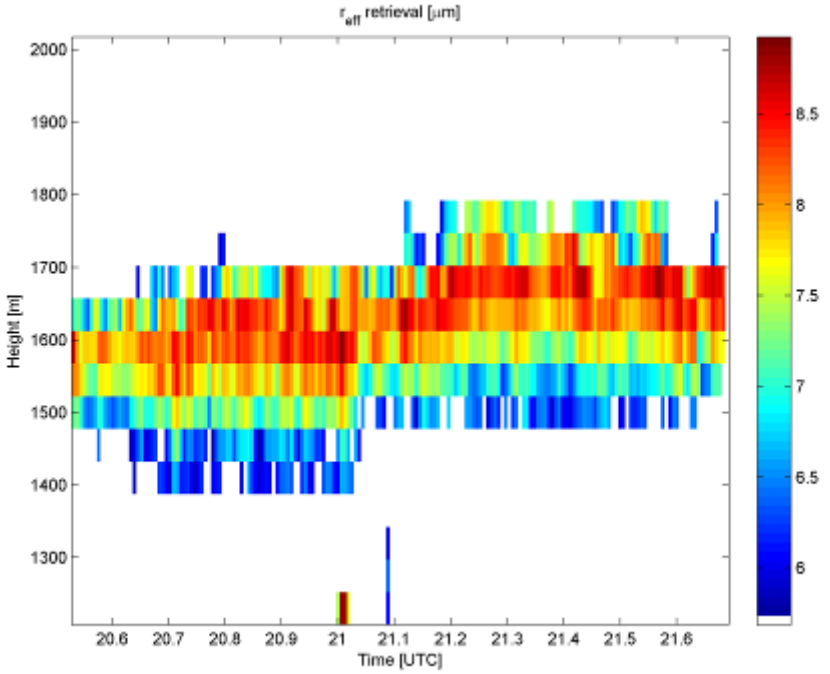


estimate cloud parameters

Droplet concentration



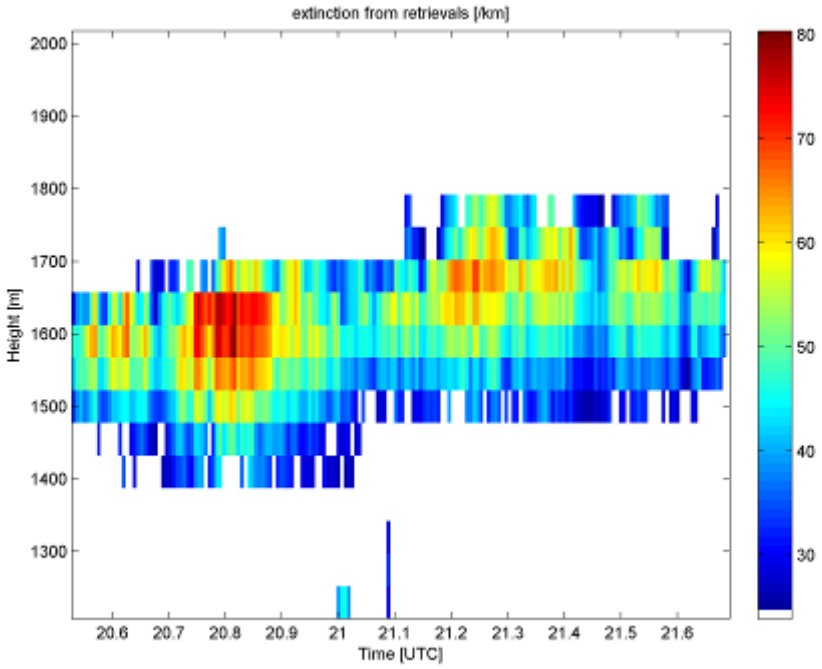
Profile particle size



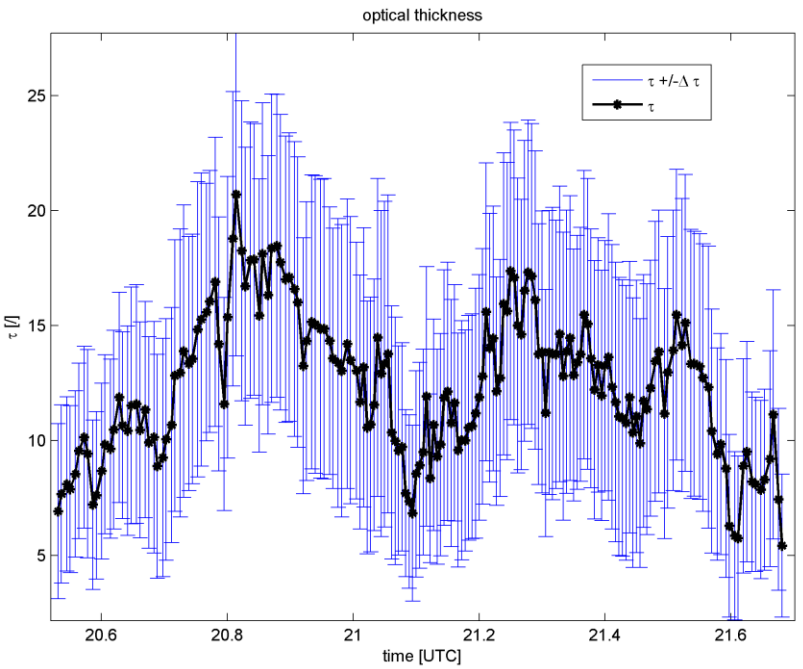
Courtesy: Christine Brandau

radiative properties

Extinction



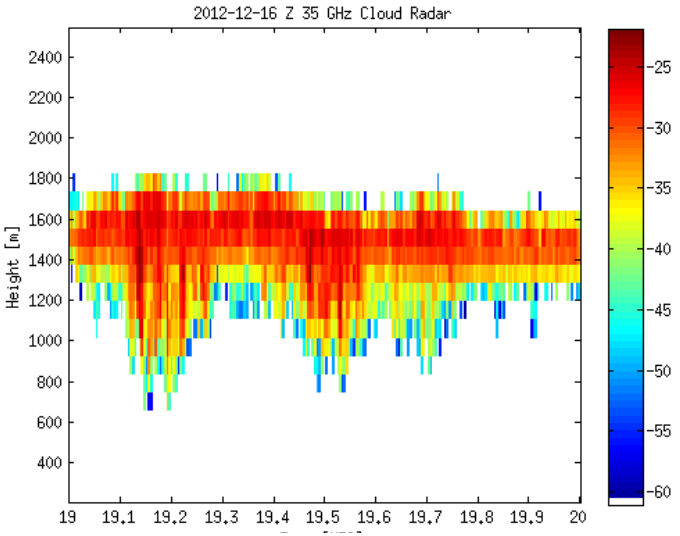
Optical thickness

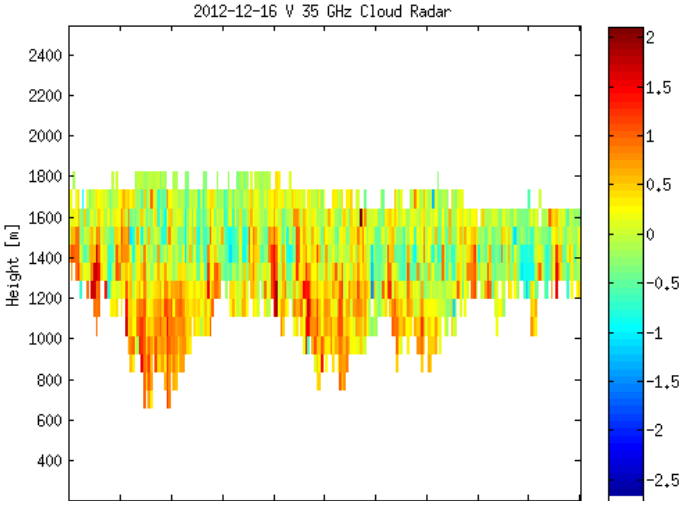


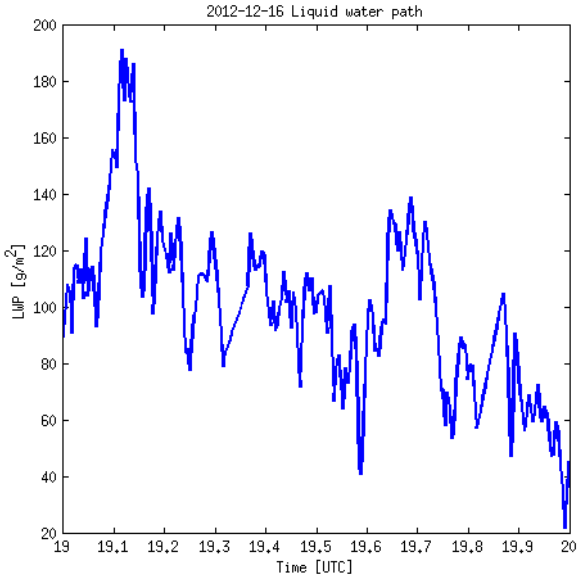
What about the link with aerosols?

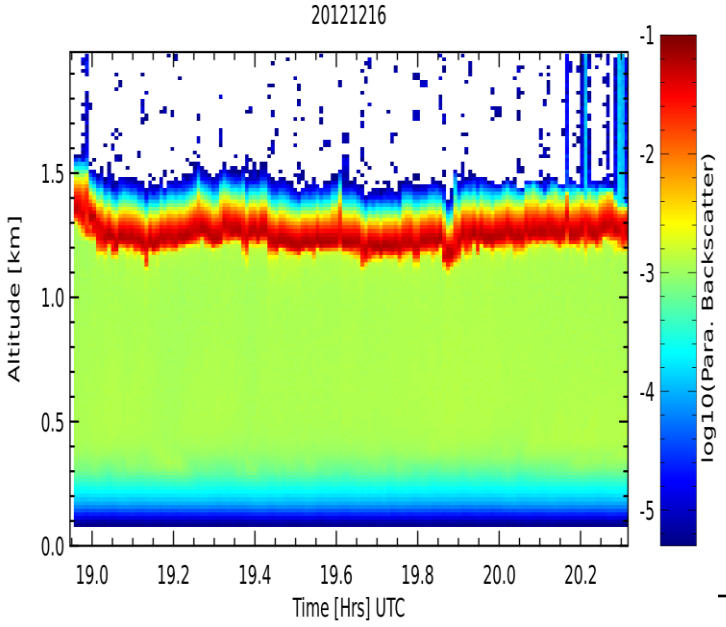
- Lidar extinction coefficient was measured 300 m below the cloud base
- Radar reflectivity and cloud droplet effective radius were measured 100 m above the cloud base
- Radar range is 90 m (we need better resolution!)
- Extinction range is 15 m – for these preliminary results it was integrated over 6 bins

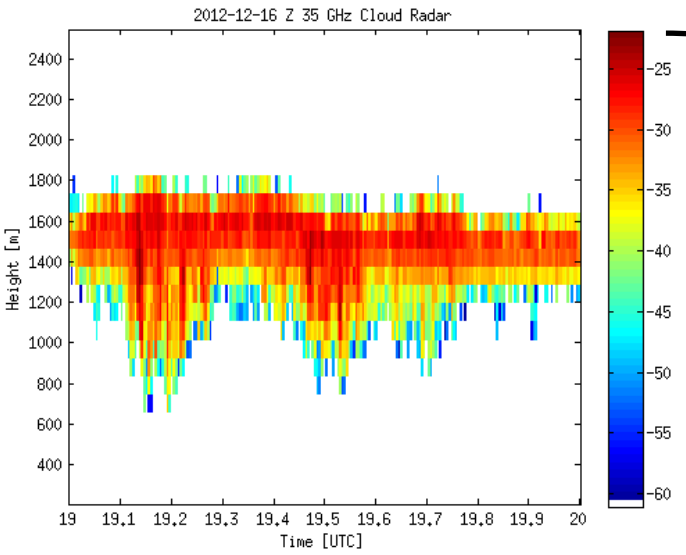
2012 – 12 – 16

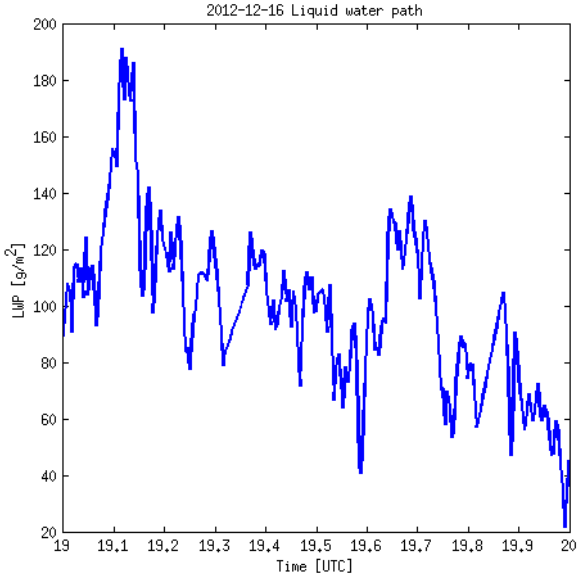

2012-12-16 Z 35 GHz Cloud Radar
Height [m]
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
19
19.1
19.2
19.3
19.4
19.5
19.6
19.7
19.8
19.9
20
-25
-30
-35
-40
-45
-50
-55
-60

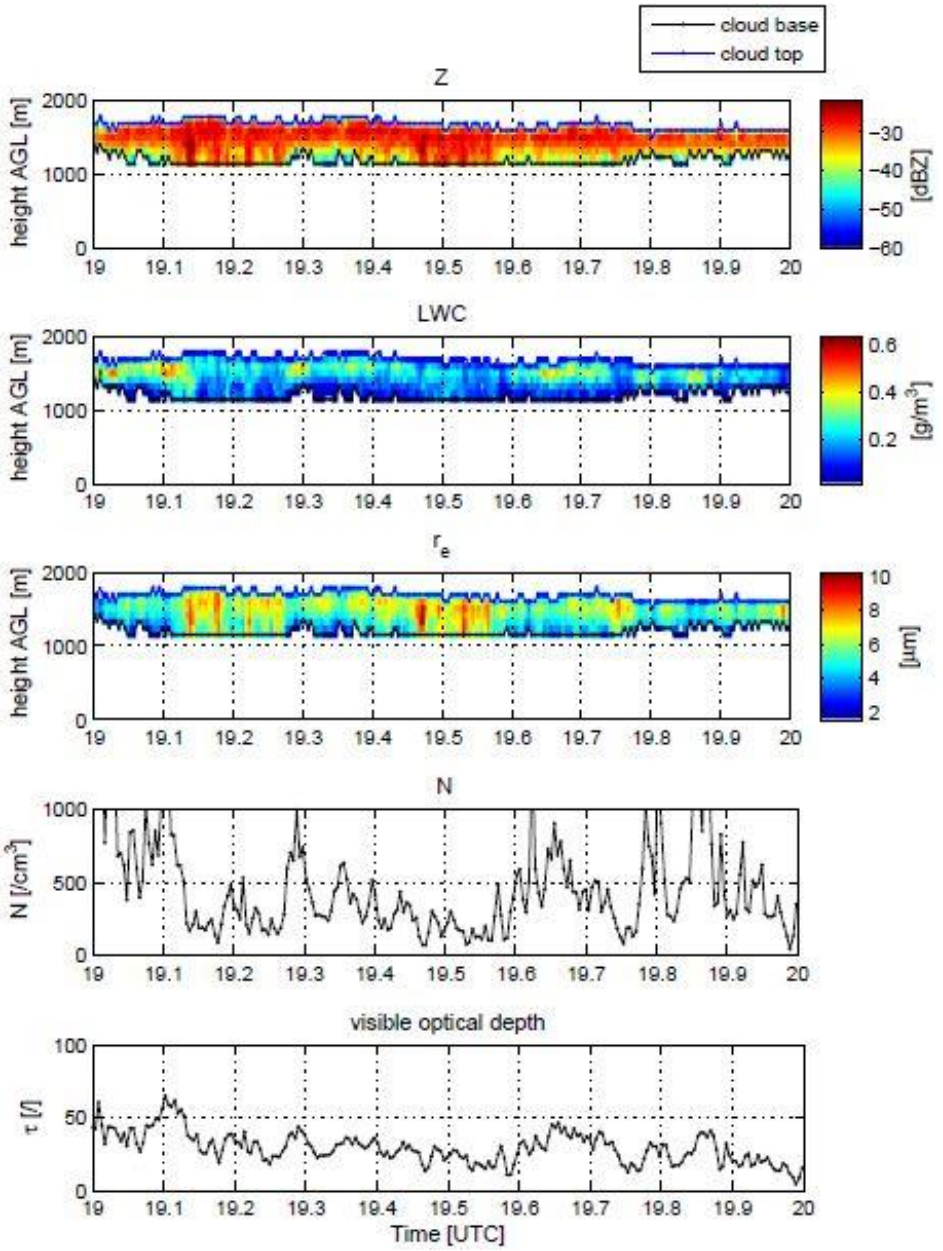

2012-12-16 V 35 GHz Cloud Radar
Height [m]
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5


2012-12-16 Liquid water path
LWP [g/m^2]
200
180
160
140
120
100
80
60
40
20
19
19.1
19.2
19.3
19.4
19.5
19.6
19.7
19.8
19.9
20
Time [UTC]


20121216
Altitude [km]
1.5
1.0
0.5
0.0
19.0
19.2
19.4
19.6
19.8
20.0
20.2
Time [Hrs] UTC
-1
-2
-3
-4
-5
log10(Para. Backscatter)

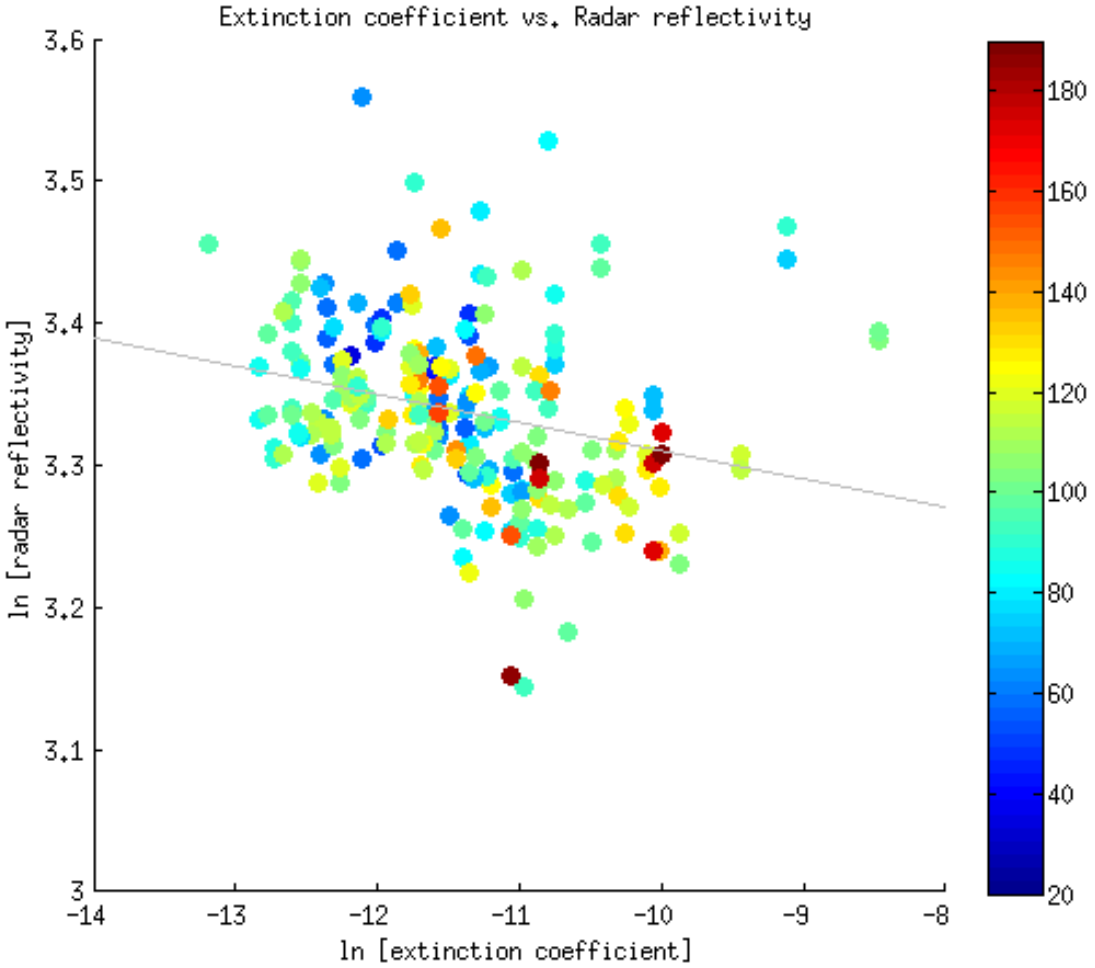

2012-12-16 Z 35 GHz Cloud Radar
Height [m]
Time [UTC]


2012-12-16 Liquid water path
LWP [g/m2]
Time [UTC]


cloud base
cloud top
Z
height AGL [m]
[dBZ]
LWC
[g/m3]
re
[µm]
N
N [/cm3]
visible optical depth
τ [/]
Time [UTC]

Extinction vs. Radar Reflectivity (ln scale)

for the whole cloud

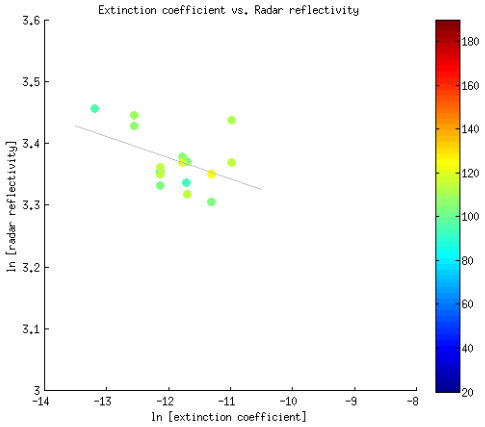


More aerosol exctinction:

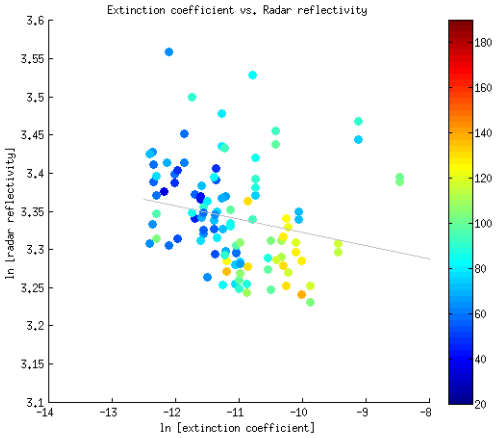
Stronger radar reflection

Extinction vs. Radar reflectivity for different time intervals

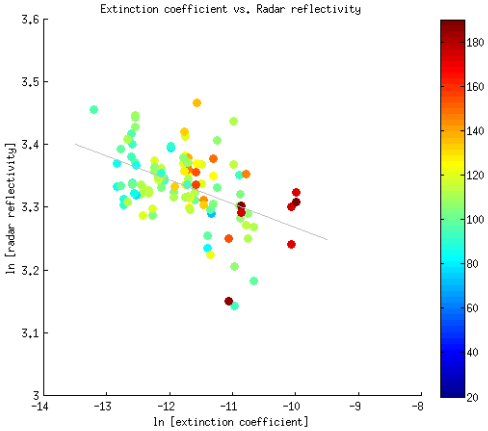
- from 19:00 to 19:05



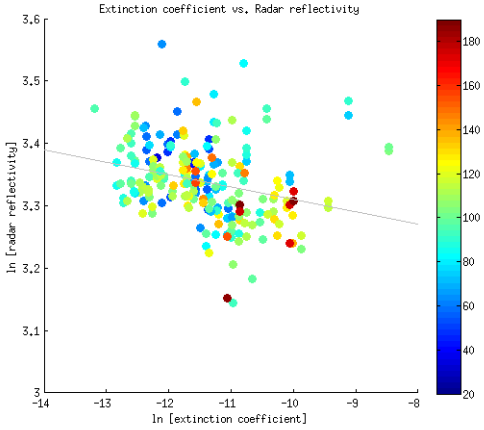
- from 19:00 to 19:30



- from 19:30 to 20:00

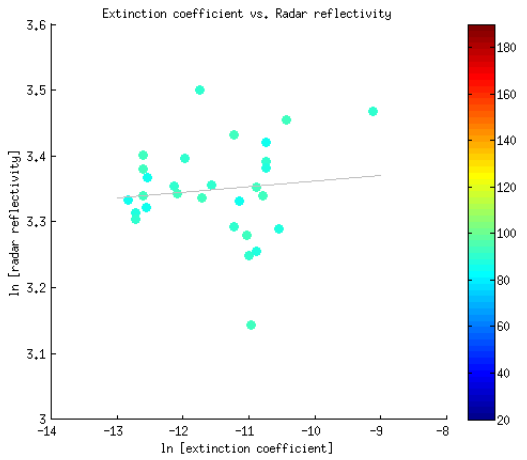


- from 19:00 to 20:00

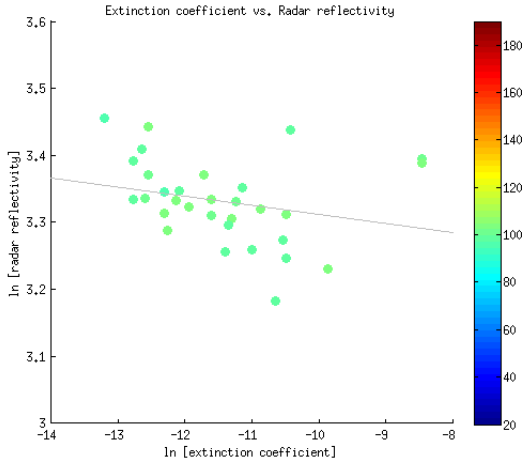


Extinction vs. Radar Reflectivity for smaller LWP intervals (ln scale)

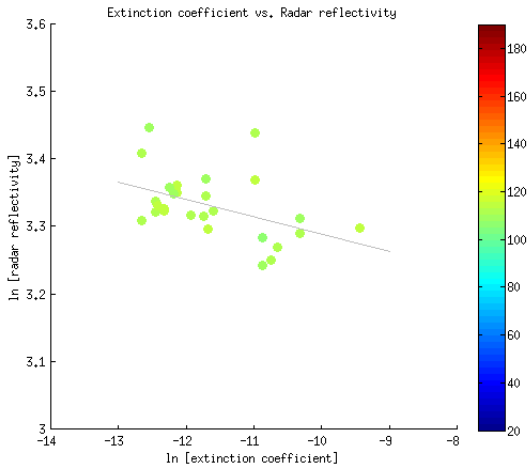
- for LWP 85 – 95 g/m^3



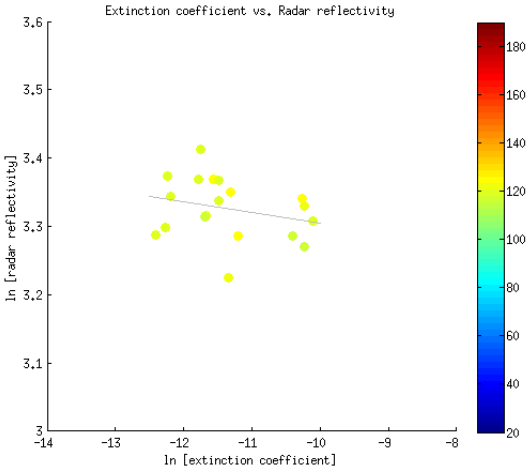
- for LWP 96 – 105 g/m^3



- for LWP 106 – 115 g/m^3



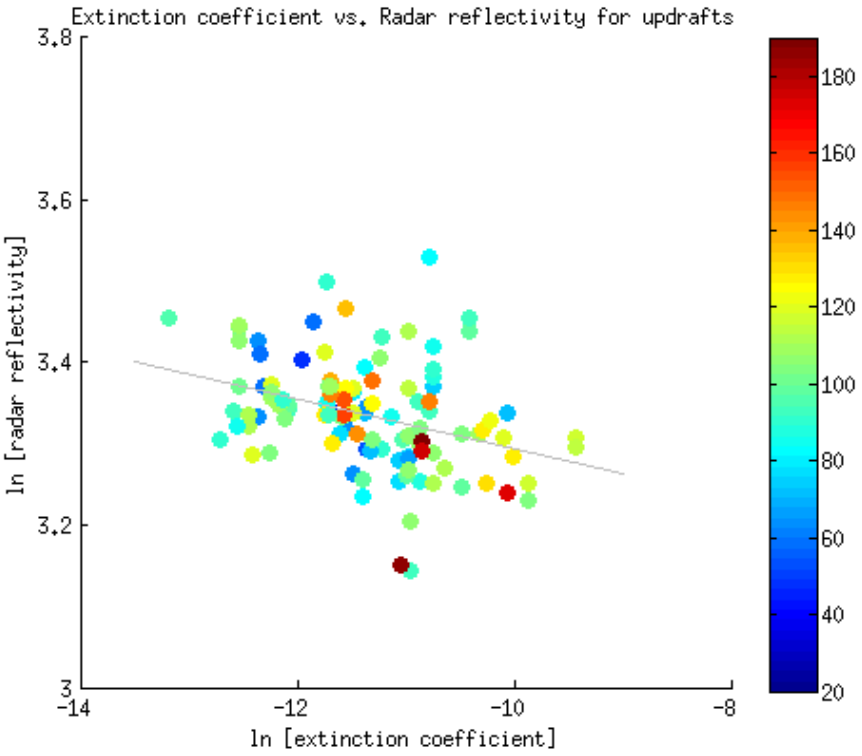
- for LWP 116 – 125 g/m^3



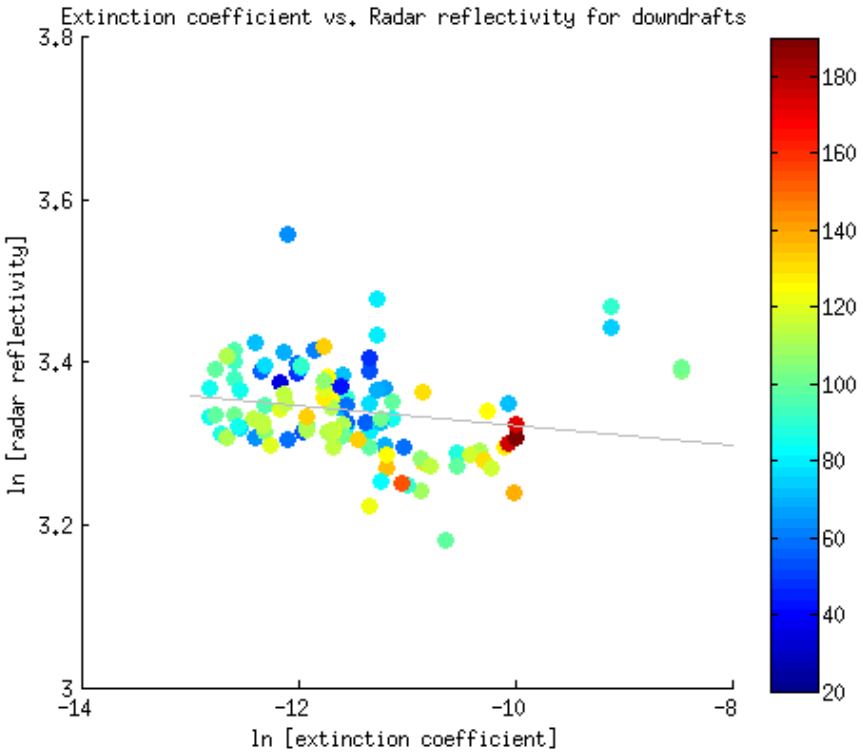
TU Delft

Lidar extinction vs. Radar reflectivity

- updrafts



- downdrafts



The effect seems(!!) a bit stronger in updrafts

Needed

Sources
Anthropogenic vs natural aerosol
Back trajectories
Relate ground-based in situ observations to cloud base:
Vertical transport obs and mod