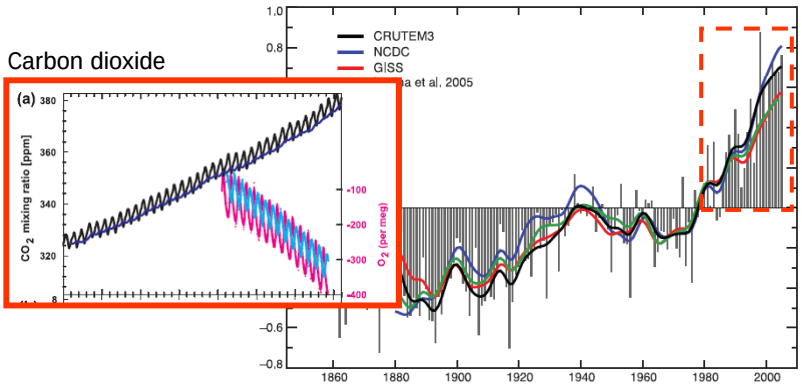
Can we understand climate change without quality measurements?

Herman Russchenberg
9 December, 2009

Observations of climate change

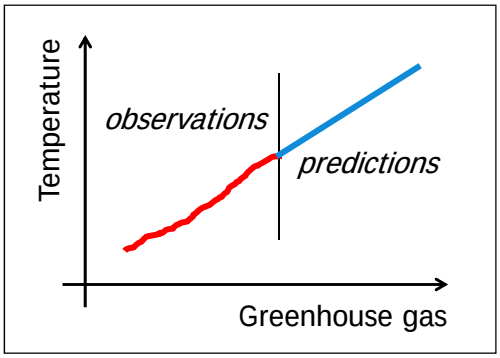
Temperature in the last 160 year

Carbon dioxide



Source: IPCC

About predictions

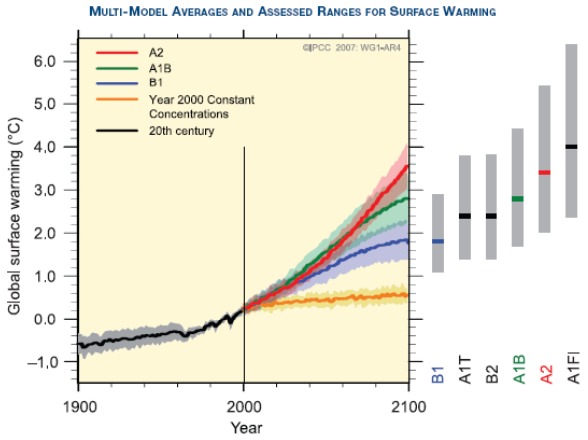


Is it that simple?

No, we have to understand the physical processes in the climate system

TUDelft

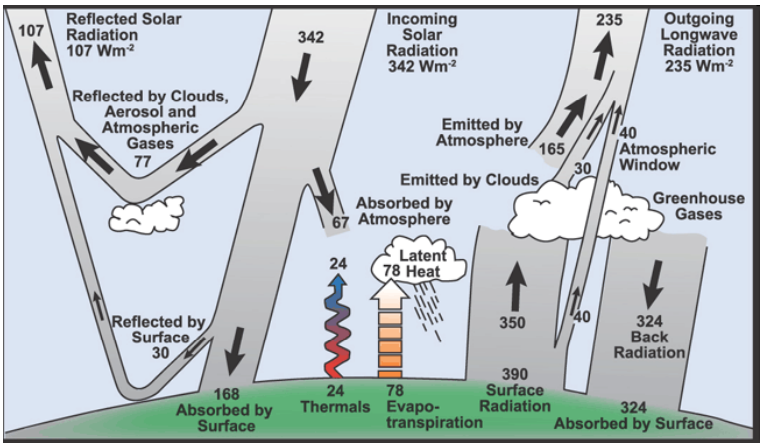
IPCC climate scenarios



TUDelft

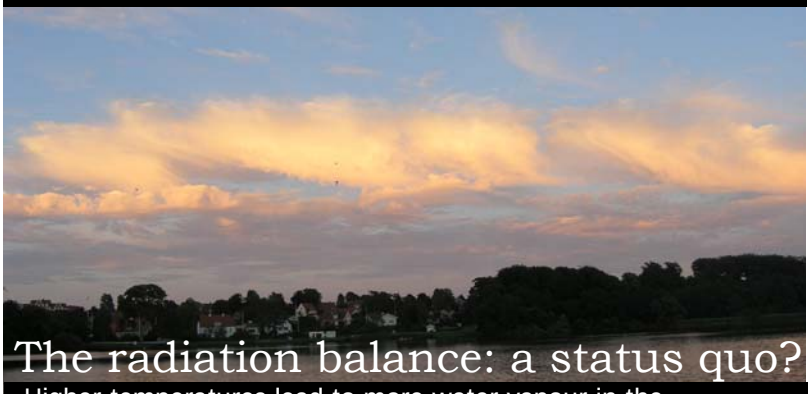
Source: IPCC

The atmospheric radiation balance



TUDelft

- Higher temperatures lead to more water vapour in the atmosphere leads to more clouds lead to trapping of heat from the earth leads to higher temperatures: **warming**



The radiation balance: a status quo?

- Higher temperatures lead to more water vapour in the atmosphere leads to more clouds lead to more reflection of sun light: **cooling**

TUDelft

WMO, Bali 2007

Adequate high-quality observations of climate and climate-related variables are essential if adaptation to climate change is to be based on deliberate planning leading to better adaptation policies.

Good observations acquired over extended periods make it possible to get an understanding of the frequency of extreme events as well as average climate conditions.

They thereby contribute to better planning and decision making related to agriculture, coastal zone management, water resources management, health, tourism, and disaster risk management.

TU Delft

WMO, Bali 2007, continued

At the present time, in many countries neither the quality nor quantity of observations needed by global and regional models is adequate to support and verify climate models so as to allow the reliable projections needed for adaptation purposes.

In order to meet adaptation needs, models will need to be improved and observation networks and data use will need to be strengthened, especially in vulnerable areas.

TU Delft

Why do we need observations?

- The description of the climate
- The detection of climate change
- Improvements of climate models and the development of climate scenarios, both on global and regional scales
- Assessment of adaptation measures
- Increasing understanding via process studies
- Fundamental research

TUDelft

More specifically: what is monitoring?

Long term uninterrupted measurement, archiving and value adding of all relevant parameters of the global climate system

- No interruptions in the measurements
- Fixed representative location
- No discontinuities when measurement methods are changed
- Archiving of metadata
- Quality control
- Free and unrestricted exchange of data

TUDelft

What to measure?
Essential climate variables

Domain	Essential Climate Variables
Atmospheric (over land, sea and ice)	**Surface:** Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour. **Upper-air:** Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties. **Composition:** Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties.
Oceanic	**Surface:** Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure. **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Biomass, Fire disturbance.

TUDelft

Nature, Editorial

(Vol 450, Issue no. 7171, 6.12.2007)

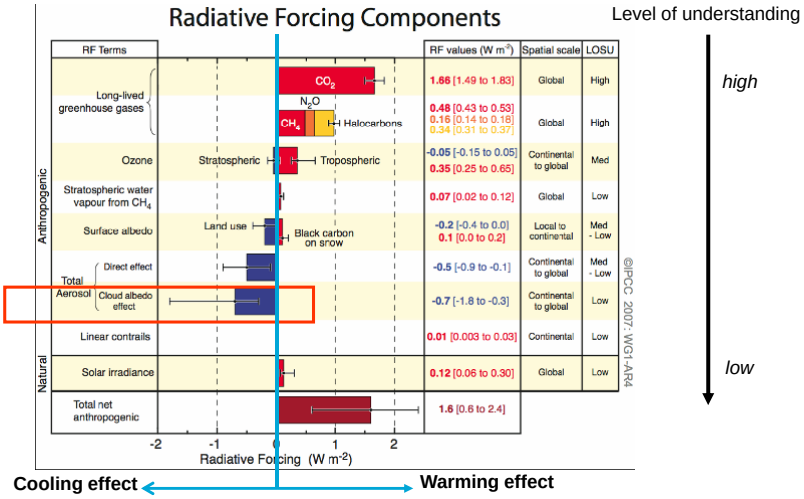
Monitoring the Earth system requires great expertise, not just to build the instruments but to use them properly and interpret their output.

Testing hypotheses about how the world works requires not just information on the current state of the three-dimensional globe, but on its progress through the fourth dimension of time.

And continuous data sets are going to be vital to the validation of the ever more informative models of the Earth system that we need. This is why operational systems for data collection in which scientists play key roles are so important.

TUDelft

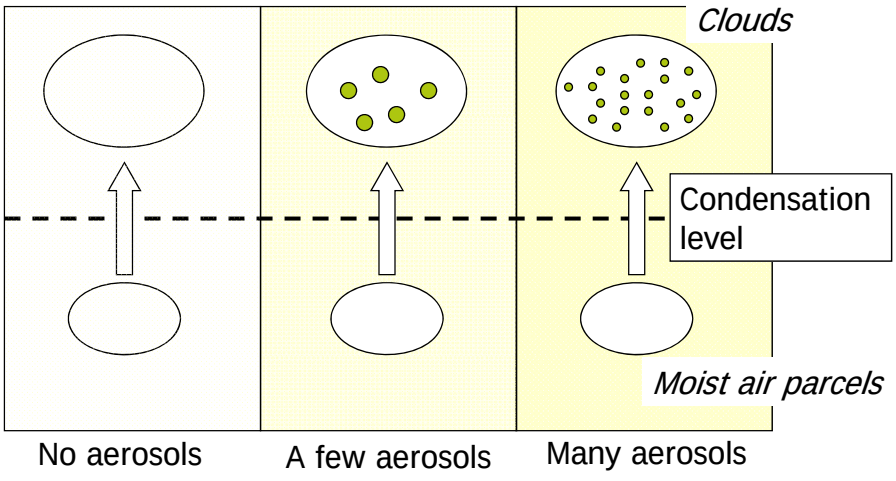
State of the atmospheric art in climate research



TUDelft

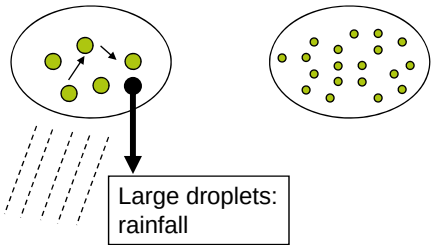
Source: IPCC

A bit about cloud formation



TUDelft

rainfall formation



More aerosols

↓

Delayed rainfall

↓

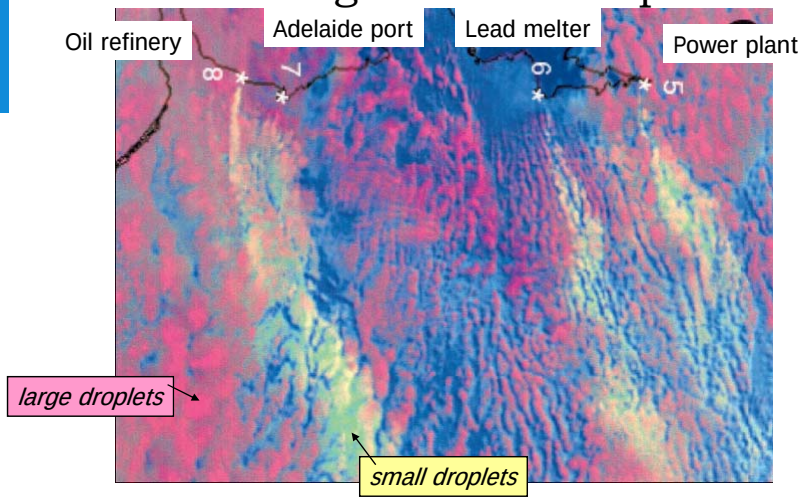
Longer cloud lifetime

↓

Sustained impact on radiation

TUDelft

Cloud changes due to air pollution



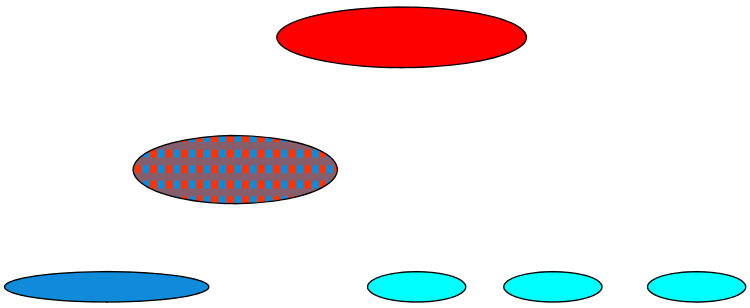
TUDelft

Source: NASA

Clouds are clouds are everywhere

TU Delft

What will happen to the clouds?



TU Delft

Complexity of the problem

Large variety of cloud types

Global information needed

A large range of temporal and spatial scales

A multitude of different physical parameters

TU Delft

How to tackle this problem?

Observations to understand the processes

Improve the atmosphere models

Observations to monitor long term trends

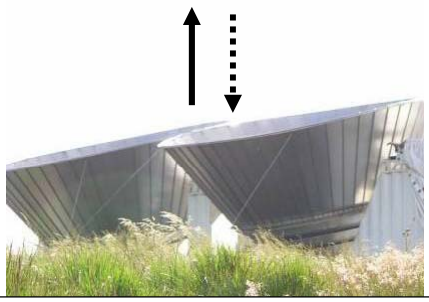
→ Not all observation techniques are available yet

TU Delft

The principle of atmospheric remote sensing

Atmospheric properties: gases, aerosols clouds, rain, wind, thermo-dynamics, radiation

Dielectric properties of the atmosphere as function of time and place



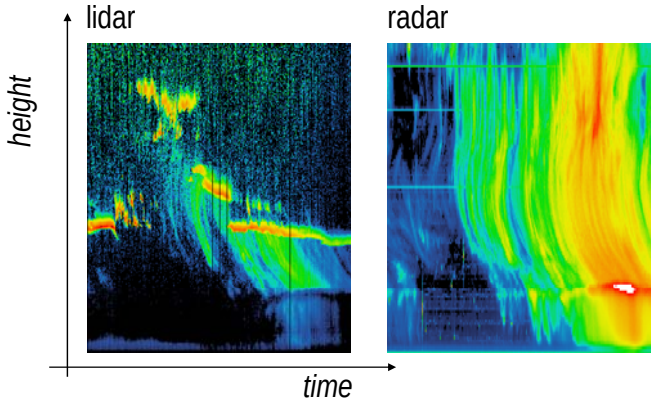
TU Delft

The field laboratory: CESAR

TU Delft

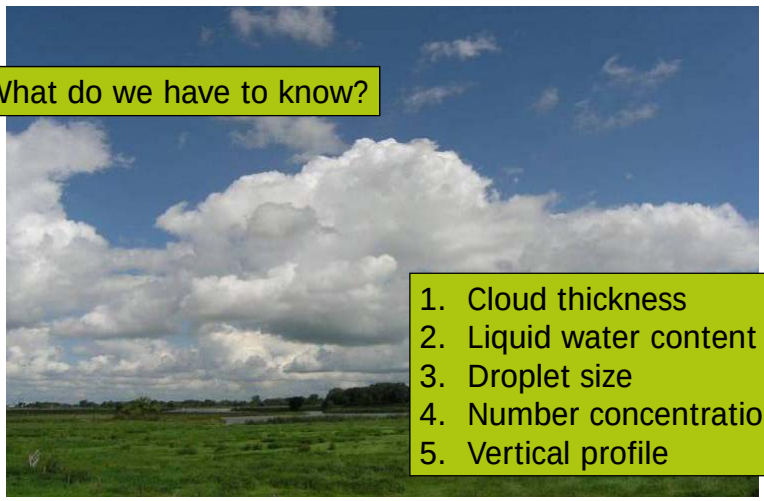
Why multi-sensor strategies?

Observation of light rain with different instruments



TU Delft

Case study: water clouds

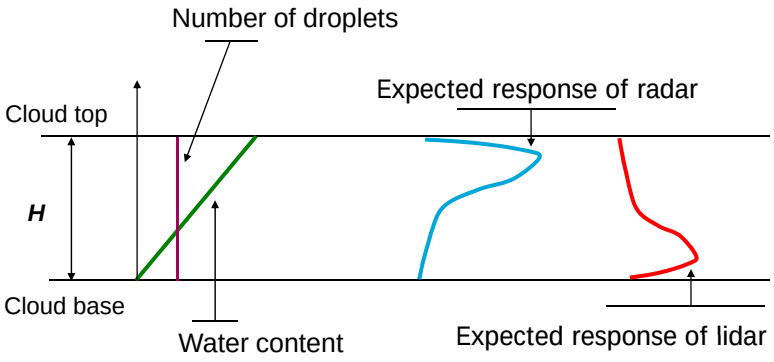


What do we have to know?

1. Cloud thickness
2. Liquid water content
3. Droplet size
4. Number concentration
5. Vertical profile

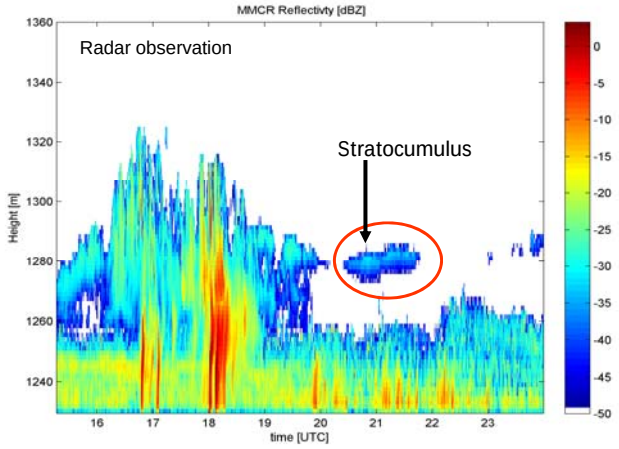
TU Delft

Assume a cloud model,



TUDelft

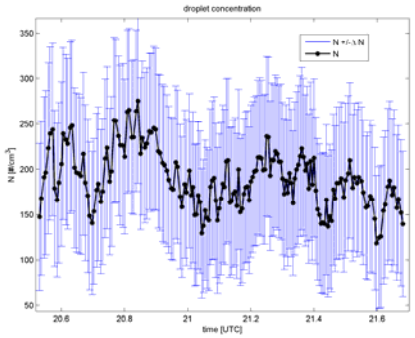
make the observations,



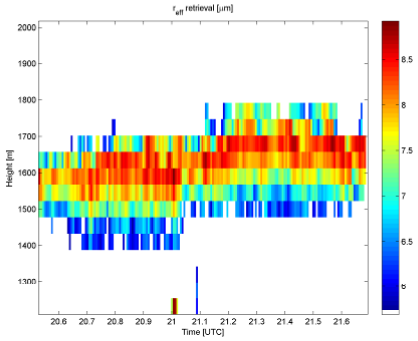
TUDelft

...estimate cloud parameters

Droplet concentration



Profile particle size

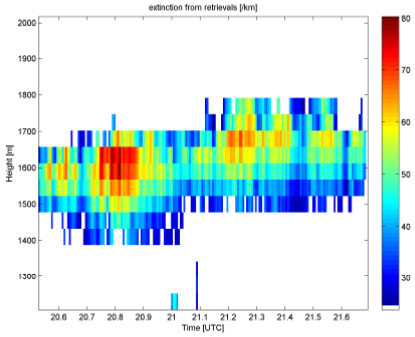


Courtesy: Christine Brandau

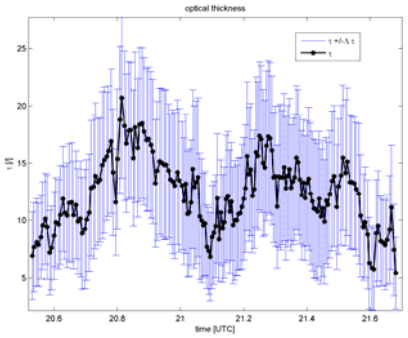
TUDelft

...and the radiative properties

Extinction

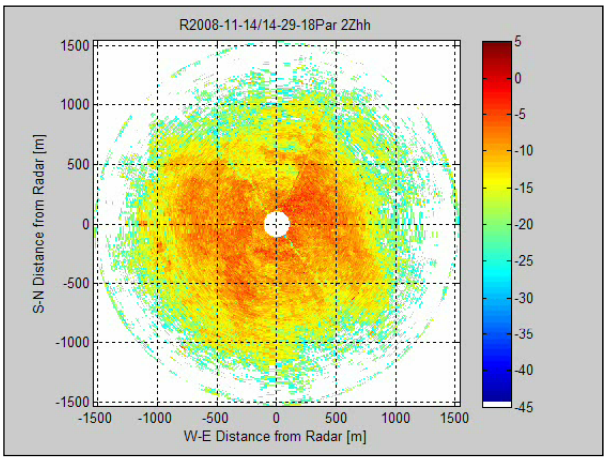


Optical thickness



TUDelft

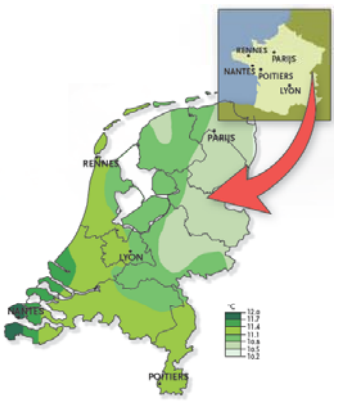
...and their spatial spreading



TU Delft

Courtesy: Jordi Figueras

What to expect in The Netherlands?



TU Delft

Source: KNMI

Rainfall in a changing climate

Higher temperature > more water vapour

More rainfall and severe weather

Observations during the 20th century: **an increase of 20 %**

Predictions for the 21st century:
more extreme rainfall in the summer
more rainfall in the winter

TU Delft

Extreme rainfall in a metropolis

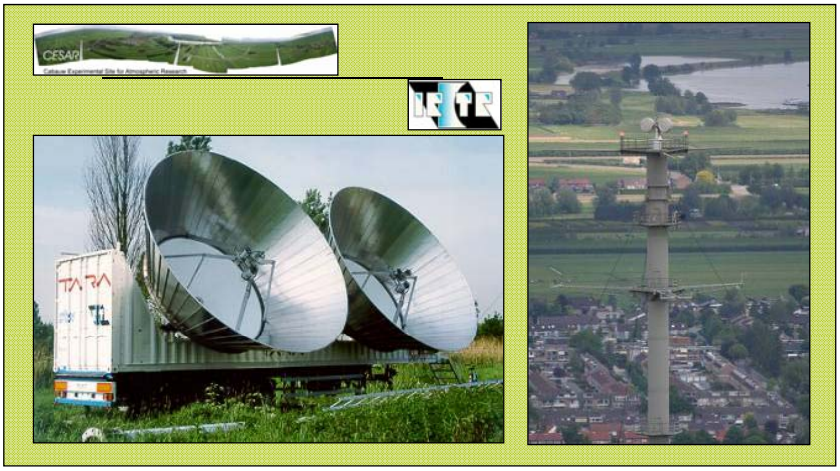
Larger vulnerability modern society

Accurate information needed

Better understanding rainfall formation
Detailed observations of microphysics needed
Integrated model-observation warning systems

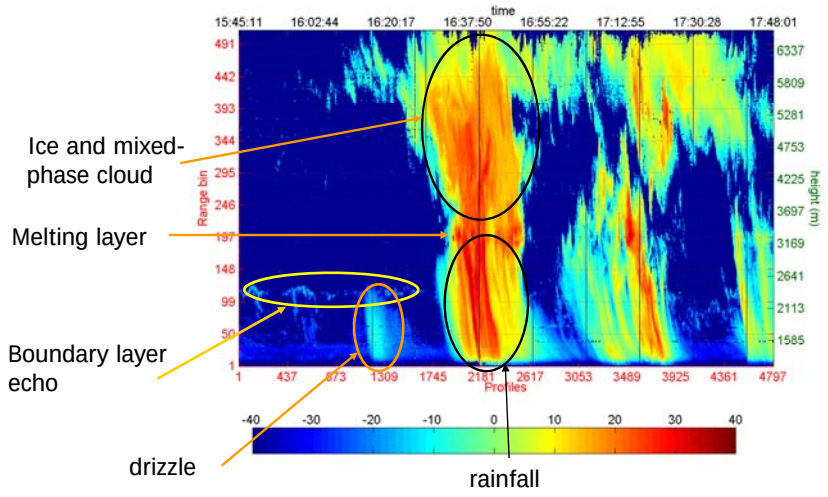
TU Delft

Rainfall radars at CESAR Observatory



TUDelft

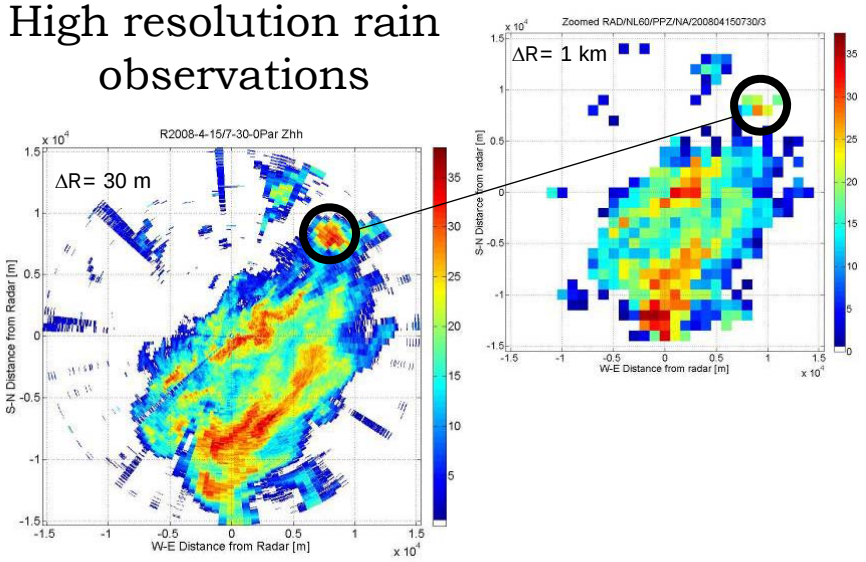
Rain through radar eyes



TUDelft

Courtesy: Yann Dufournet

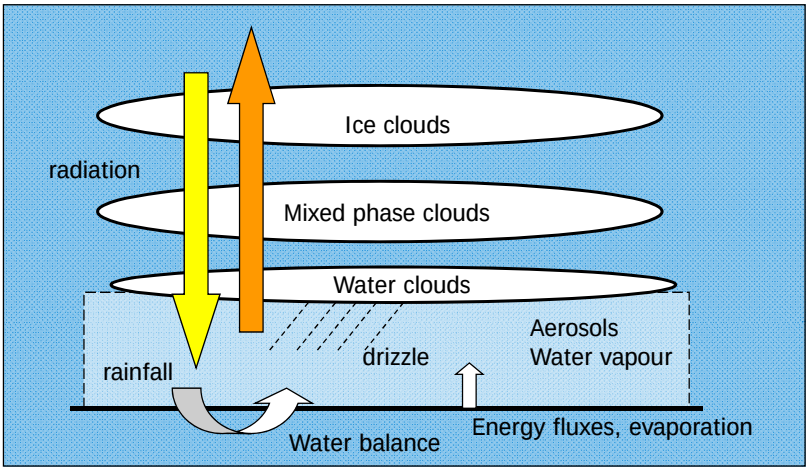
High resolution rain observations



TUDelft

Courtesy: KNMI

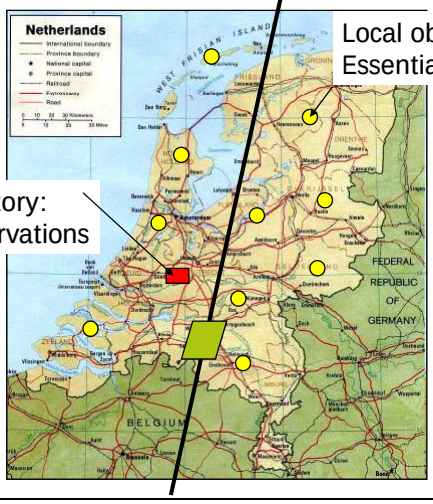
Way of the future: put the content into its context



TUDelft

Observations in The Netherlands?

satellite



Local observations of Essential climate variables

CESAR Observatory: Integrated observations

TUDelft

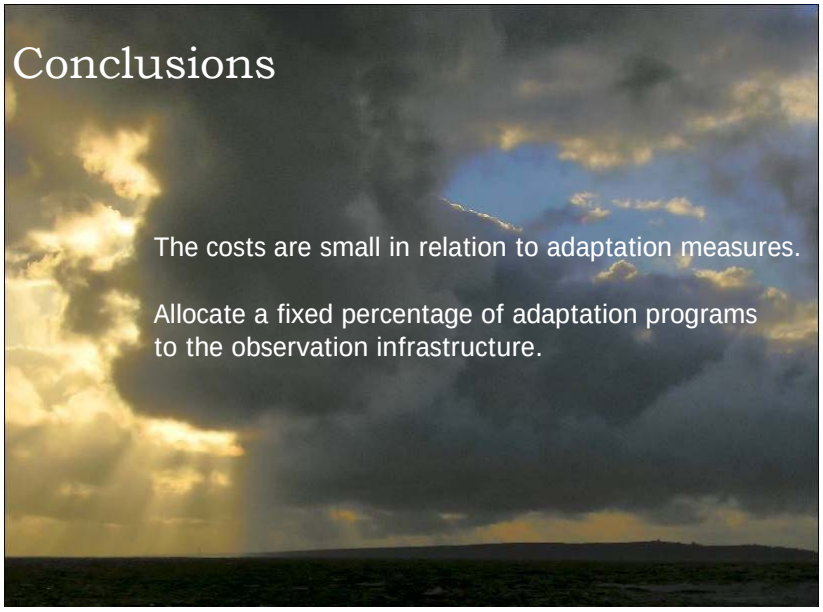
Conclusions

If we want to understand climate change, and
If we want make to correct climate projections, and
If we want to adapt society efficiently, and
If we want to convince the public,

we need long term observations.

TUDelft

Conclusions



The costs are small in relation to adaptation measures.

Allocate a fixed percentage of adaptation programs to the observation infrastructure.

TU Delft