# Cloud Parameterisations
# - the Role of Observations -

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# Initial thoughts...

**Cloud parametersations** ...

... simulate sub-scale cloud effects (geometrical extensions+microphysics for radiation and precipitation.

... were never developed directly from observations,

... are derived from conceptual ideas about clouds (e.g. non-precipitating clouds exist; there are trigger mechanisms for convection, ...)

... are at best calibrated to very limited observations

**Clouds are different** (see classical cloud types)

... some simple clouds led to cloud parameterisation concepts ...

... cloud parameterisation relate to special cloud types

... and must be biased when used in a generalized manner, as they are.

**Clouds are an integral part of the state of the atmosphere**...

... but are treated as an added-on, re-acting phenomenon.

... instead cloud parameterisations should be two-way-coupled with large- scale state, turbulence, convection and radiation processes.

-> isolated cloud parameterisations are always incomplete (meaning they hard to validate).

# Contents

- What are cloud parameterisations?
- How can observations be used to calibrate cloud parameterisations?
- What kind of observations do we really need, to substantiate or calibrate cloud parameterisations?
- Are there other ways to use observations?

# What are cloud parameterisations?

... calibrated formalized conceptual models about cloud processes and structures at scales below the models grid and temporal resolutions ...

... in order to diagnose fractional cloud cover, cloud microphysical parameters (particle number concentrations, cloud bulk densities, particle size distributions,...)

... to allow calculation of radiative effects,

... to allow for microphysical processes, i.e. precipitation simulations.

# Connections between cloud and other parametersations (complete physics package)

Convection parametersation diagnose atmospheric motion effects, like energy, momentum, and mass fluxes on sub-grid scales

→ cloud and convection parameterisations must be physically very strongly related,

but they are traditionally treated independently.

The same holds for turbulence and radiation modules, and also includes the core model.

# Types of cloud parameterisations

- **Deterministic schemes**

  gridscale values lead to unique sets cloud parameters

- **probabilistic schemes**

  gridscale values lead to distributions of cloud parameters

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- What are cloud parameterisations?
- How are observations used to aid cloud parameterisations?
- What kind of observations do we really need, to substantiate or calibrate cloud parameterisations?
- Are there other ways to use observations?

# Ways to aid the development of cloud parameterisations

- Proof of concept

  ...needs dedicated experiment setups

- Calibration of formalized concepts

  ... can often be achieved with traditional experiment setups and long-term measurements (but you need to very careful)

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# Optimal measurements

- Continuous long term high temporal resolution measurements are indispensible for statistical reasons
- Surface radiation measurements (F)
- Temperature (T(z) ) and humidity profile (RH(z) ) from radiosondes (**RS**), radioacoustic sounding systems ( **RASS**), or microwave profilers (**MWP**)
- Passive microwaves (**MWR**) for total water vapour (W) and cloud liquid water path (LWP)
- Precipitation radar (**PR**) for in-cloud precipitation-size particles (RRty(z))
- FMCW-radar (**MRR**) for precipitation particle size distributions (N(DRRz))
- Cloud radar (**CR**) and laser-ceilometer (**LC**) for cloud cover (N(z))
- **MWR**+**CR**+**LC** for LWC(z), IWC(z)
- Aircraft measurements for cloud microphysisсs, water vapor variations, turbulence...
- Scanning water vapor lidar to detetct continuously spatial and temporal water vapor variations
- High temporal fields of cloud parameters from satellites
- High quality forcing fields (analysis)

**Similar to BBC(1)**

- + another aircraft
- + Raman lidar
- + micro rain radar(s)
- + (growing like ...)

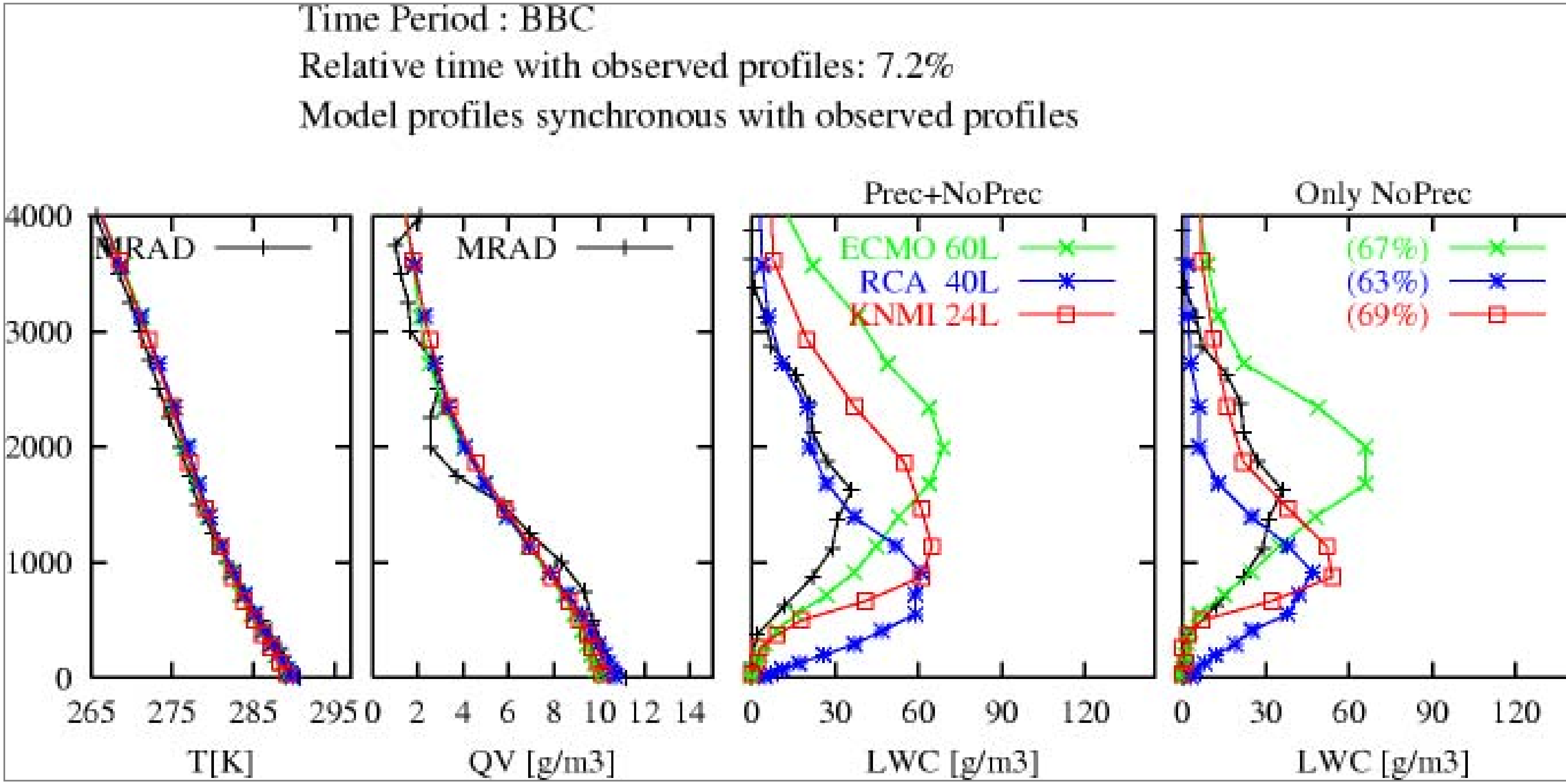
# What did we learn from CLIWA-Net

- Perception/assumptions of clouds from modellers and observers can be very different (e.g. LWP with/without drizzle or rain, what is a cloud, what is cloud cover).
- Modellers always think, that measurements have no errors, at least they assume, the are gaussian). When they learn about errors they tend to discard any measurements.
- Both models and observations are biased in very different ways (daily variations, precipitation) leading to differently biased statistics.
- The impact of measurements on parameterisations was nil, until confidence was established between modellers and observers (modellers need to understand measurements and vice versa).

# Specific results of CLIWA-Net

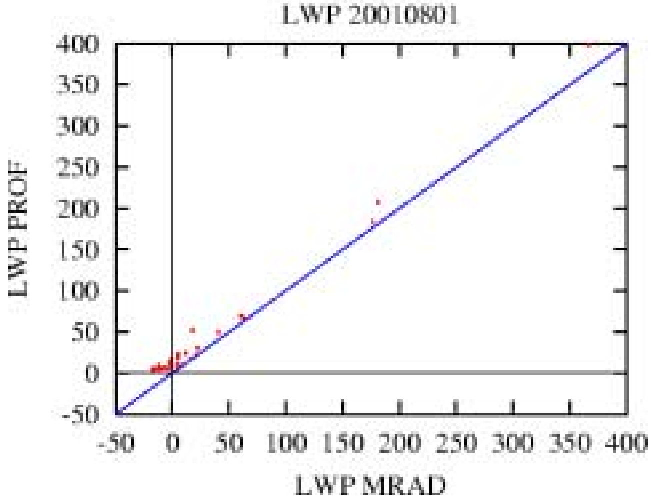
- LWP-fields with reasonable error (30%) from satellites available for model comparisons
- High-quality (Low-cost) profiler (radiometer) available for ground-based LWP network
- Algorithms for condensed water profiles from ground-based synergetic measurements (cloud radar + microwave profile + laser ceilometer)
- Assessment of cloud parameters from state-of-the–art atmospheric models
- Preliminary quantifications of model shortcomings and errors in assumptions in cloud parameterisations (e.g. cloud overlap assumptions)

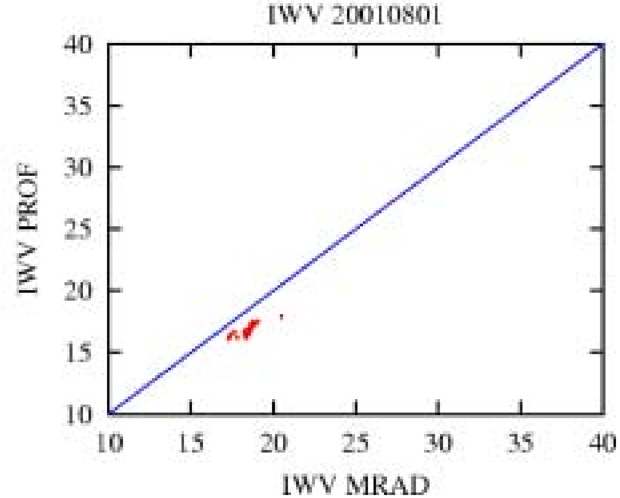
# BBC-Cabauw: Measured and model predicted vertical distribution of liquid water content, LWC(z)

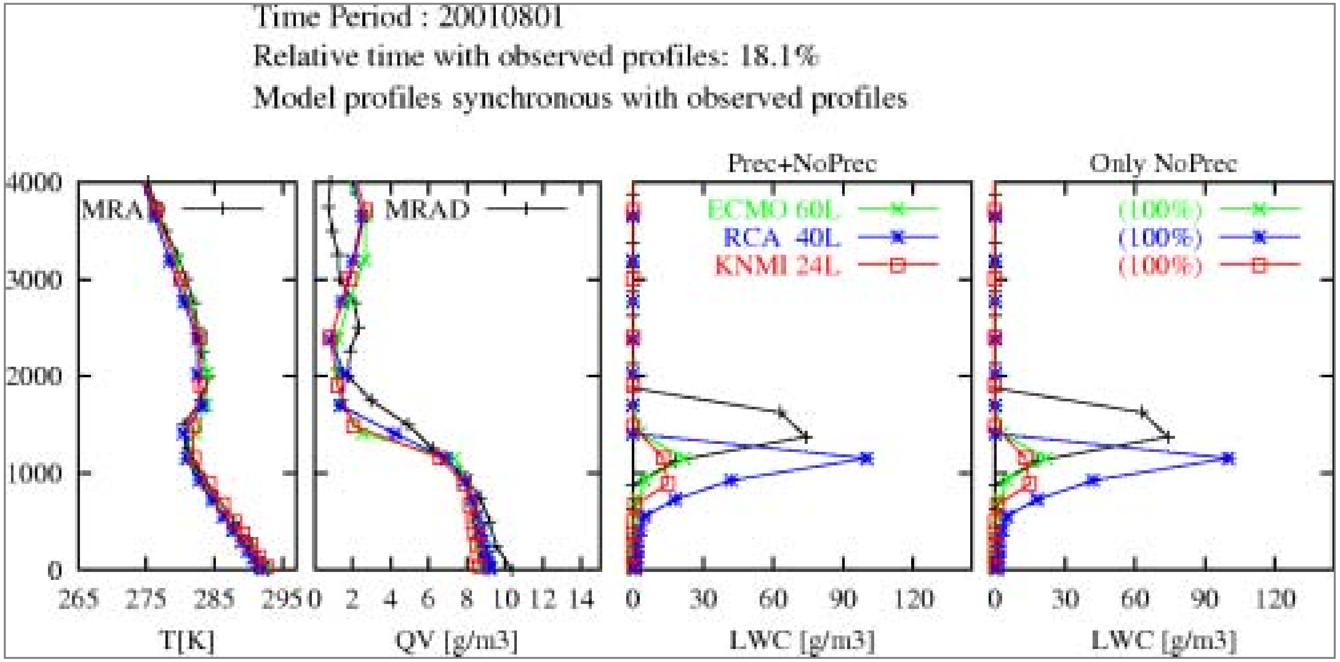


# 1 August 2001

Time Period : 20010801 ; Relative time with observed profiles: 18.1%

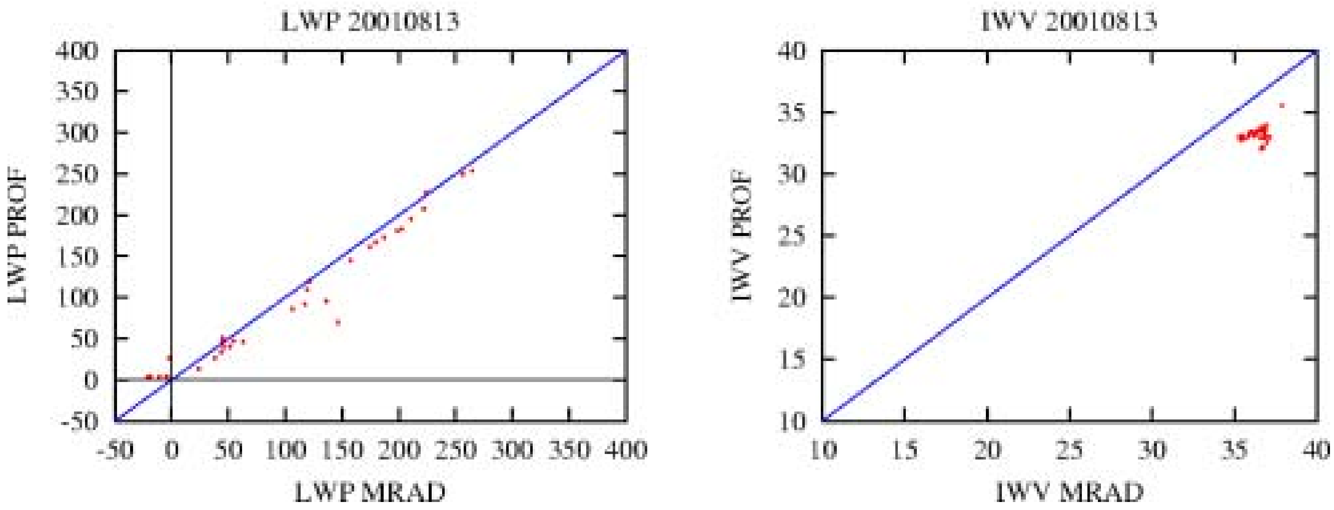


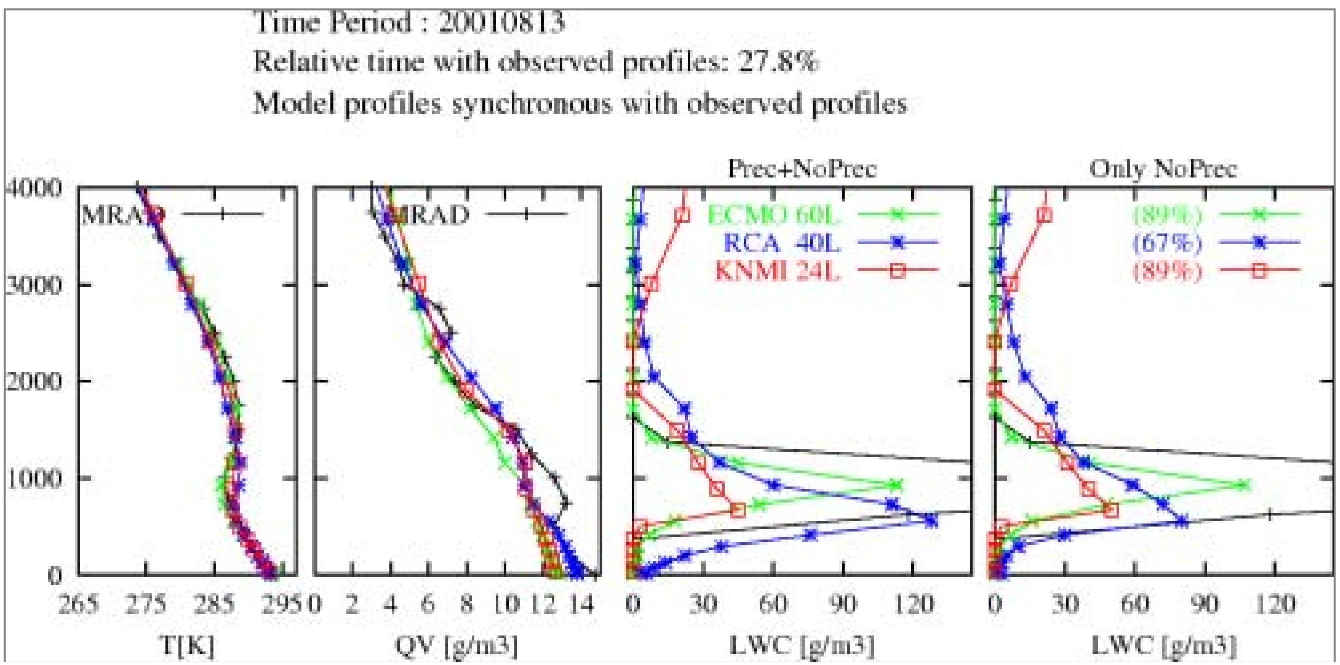



# 13 August 2001

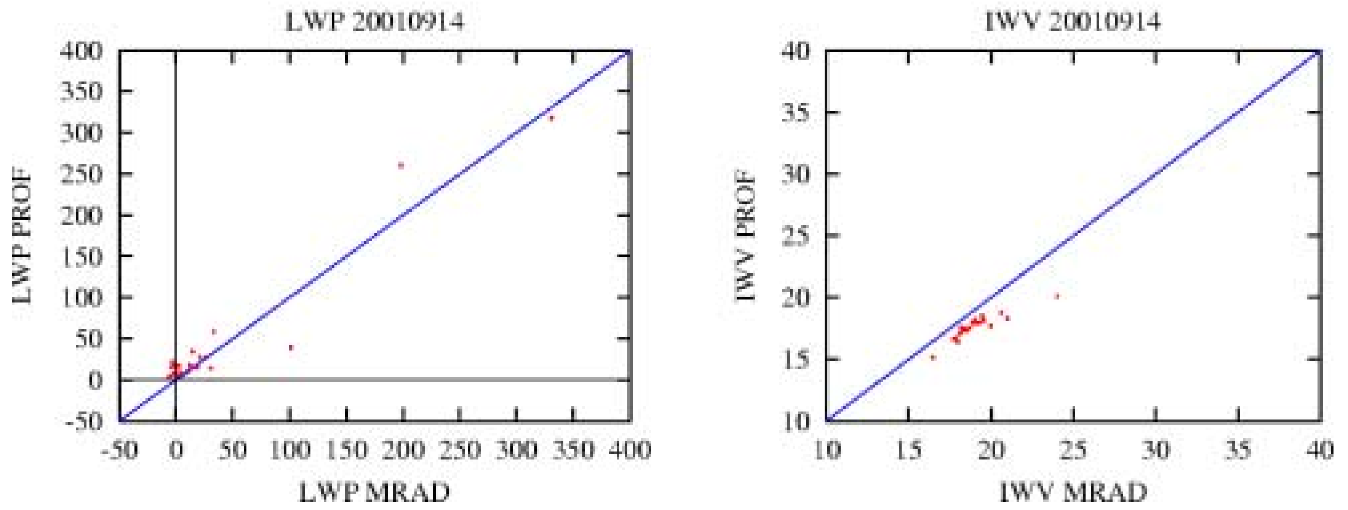
Time Period : 20010813 ; Relative time with observed profiles: 27.8%

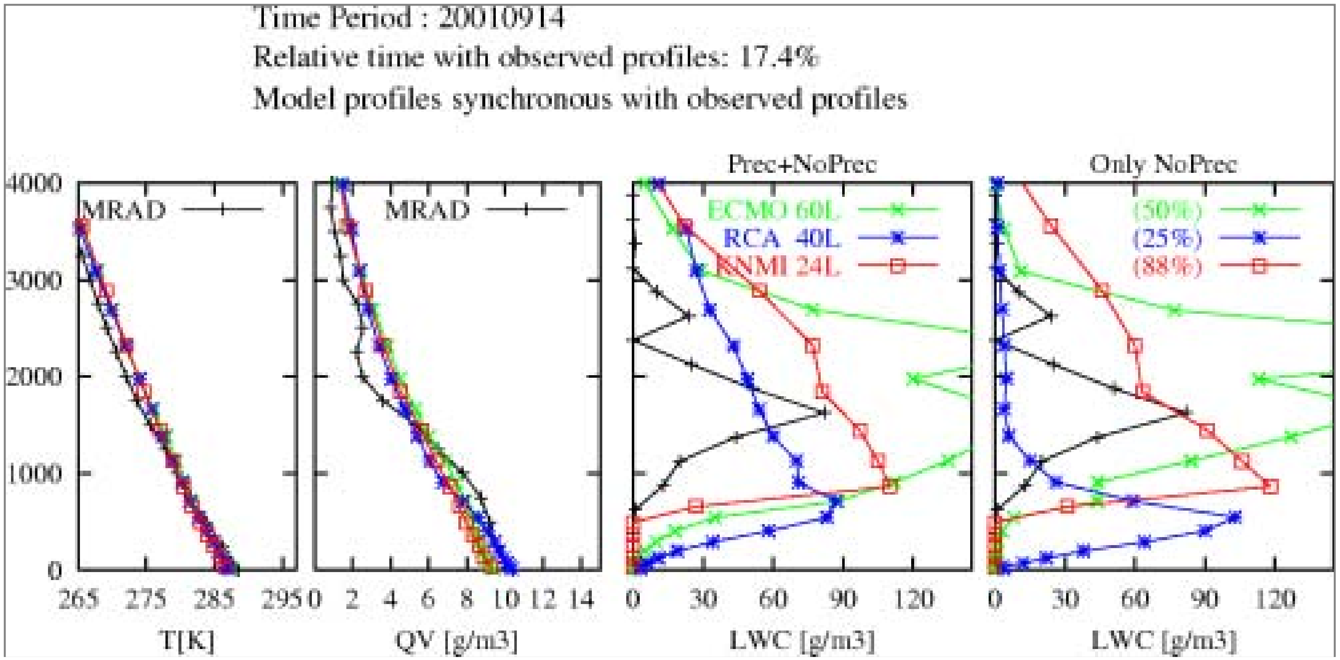


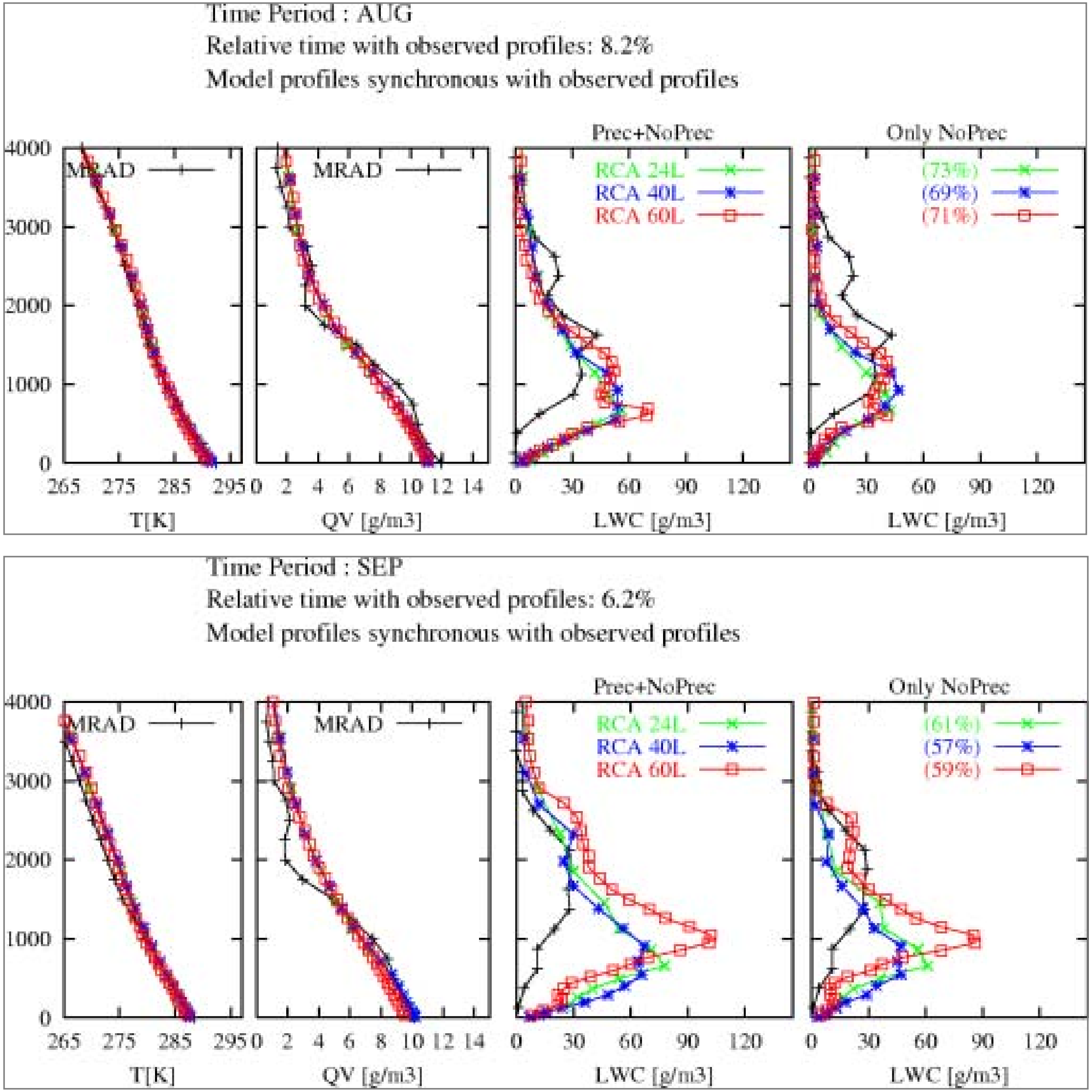



# 14 September 2001

Time Period : 20010914 ; Relative time with observed profiles: 17.4%






RCA model: Impact of vertical model resolution:

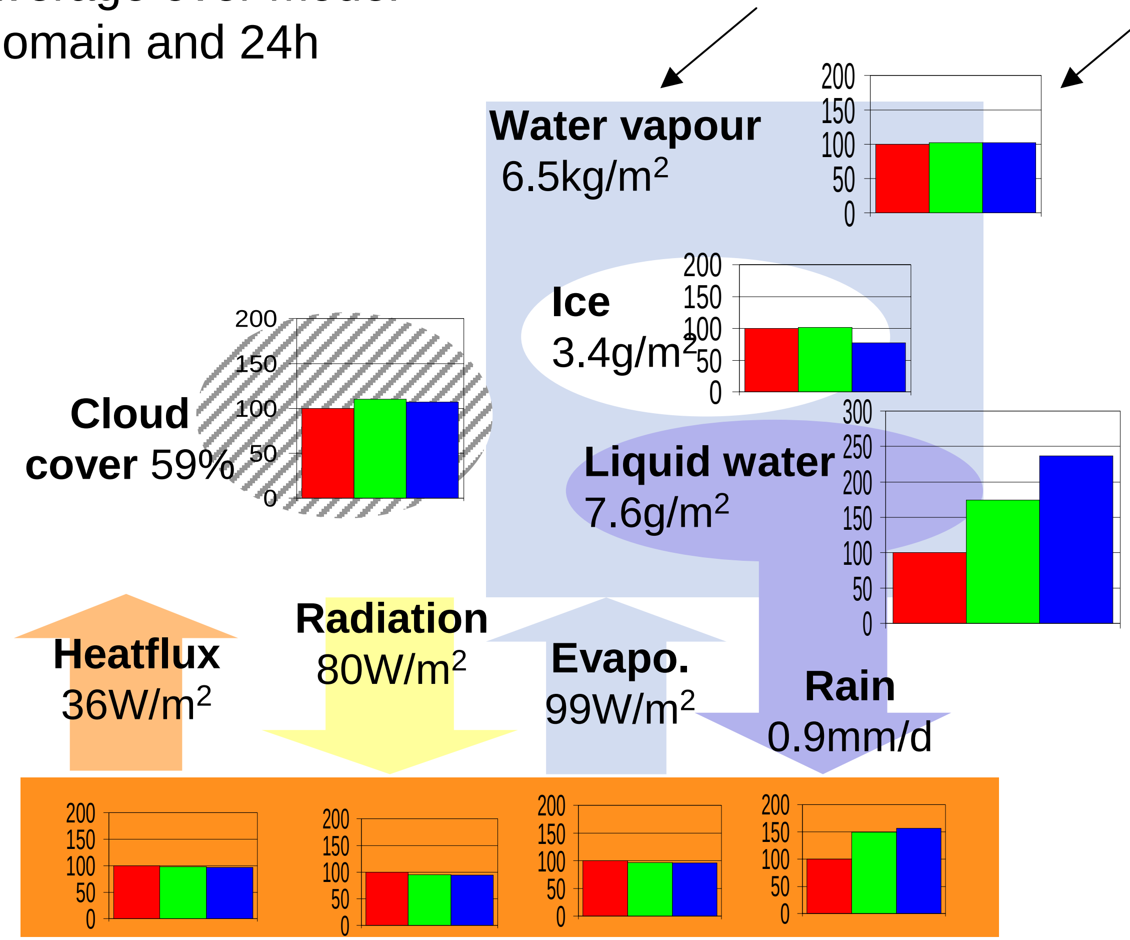
24Levels
40Levels
60Levels

# Budgets and fluxes I

Example: 13. April 2001
average over model
domain and 24h

Reference values:
7km run without
convection scheme

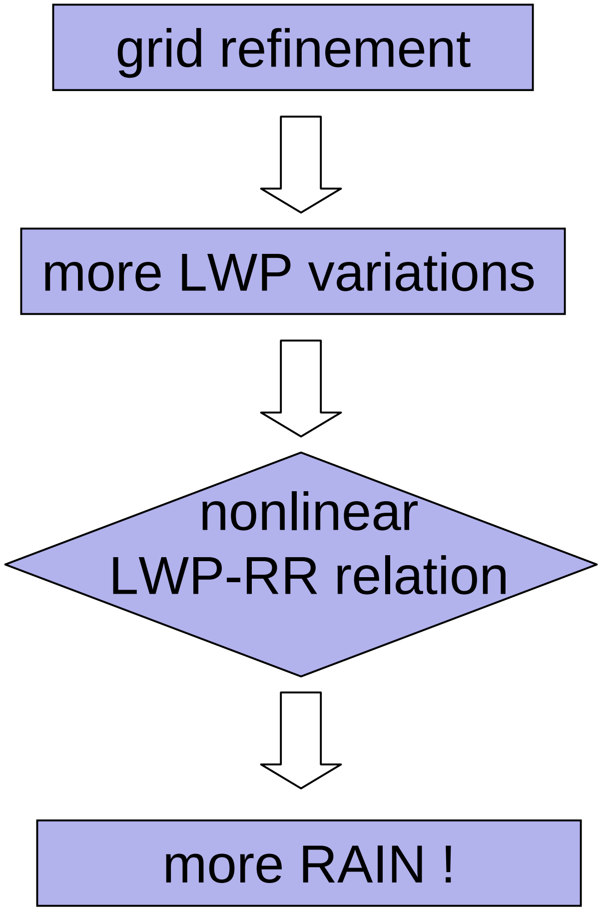
relative deviations
runs with 7, 2.8 and
1.1 km grid spacings

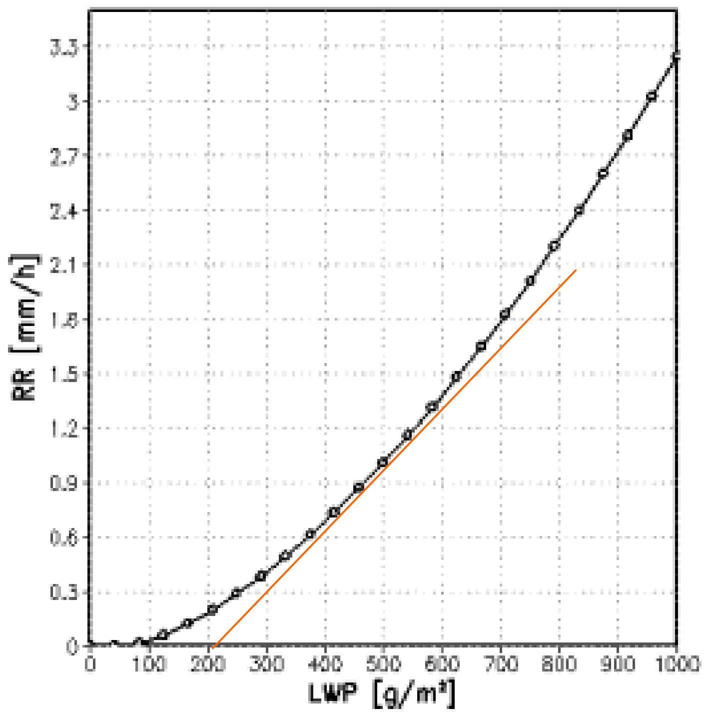



## Results:

- water vapour, cloud cover and surface fluxes remain unchanged
- LWP and rain rate increase due to refinement

# Nonlinear LWP-rain relation

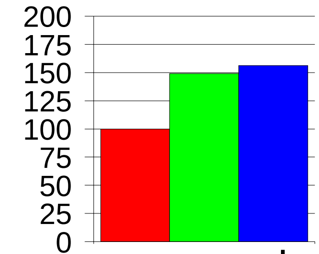



Result of LM cloud scheme
using idealized cloud profiles

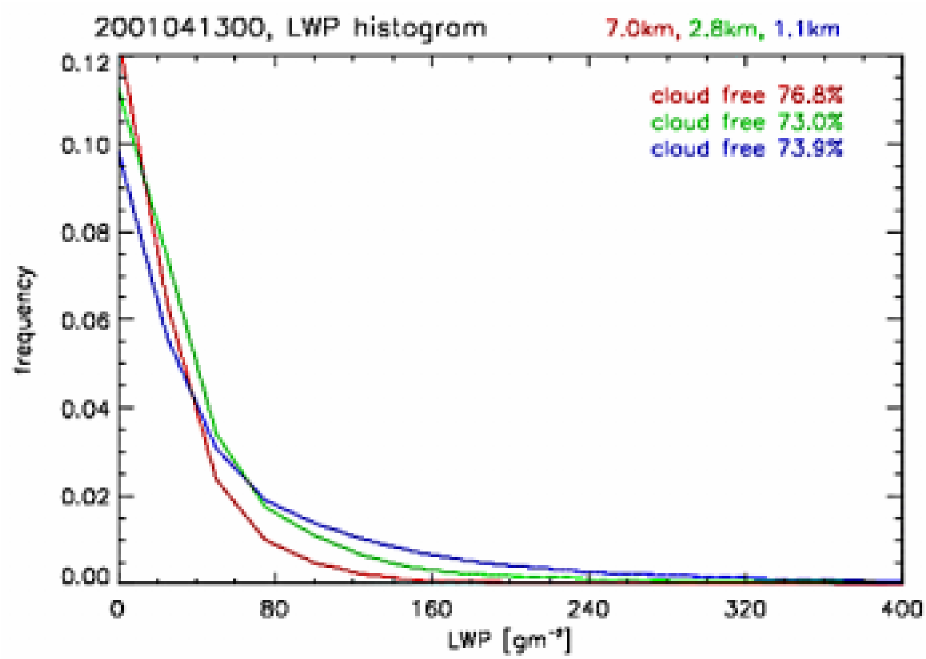
# LWP histograms

Example 13 April 01

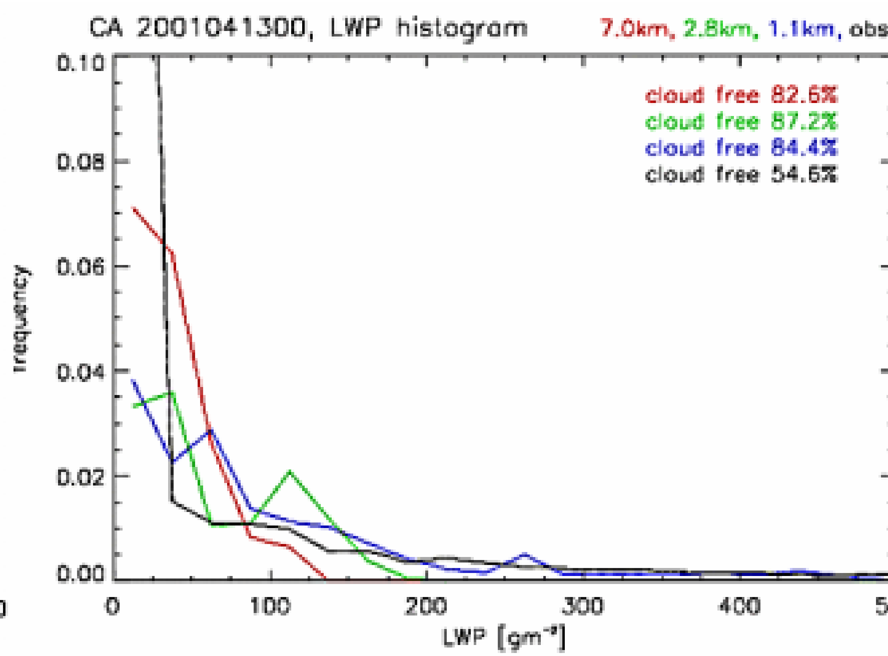



averaged rainfall

## Domain average




## Cabauw




⚠ Probably poor statistic!

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# Are there other ways...?

- **Proof of existing concepts**

  -> dedicated experiments (or dedicated analysis of existing experiments) for clearly defined cloud type concepts in order to prove or even better to falsify the concept

- **Statistical-probabilistic approach**
  (e.g. neural networks) without initial concepts

  -> very many data, very long time series, analysis might, or might not lead to new (or old) concepts