The Cabauw Parameterization Testbed

Motivation

Configuration

Preliminary results

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pan-GCSS, Toulouse, 2-6 June 2008

KNMI

GCSS objectives

* Develop the scientific basis for the parameterization of cloud processes.

* Highlight key issues and encourage other relevant programs to address them.

* Promote the evaluation and intercomparison of parameterization schemes for cloud processes.

Evaluation of parameterizations

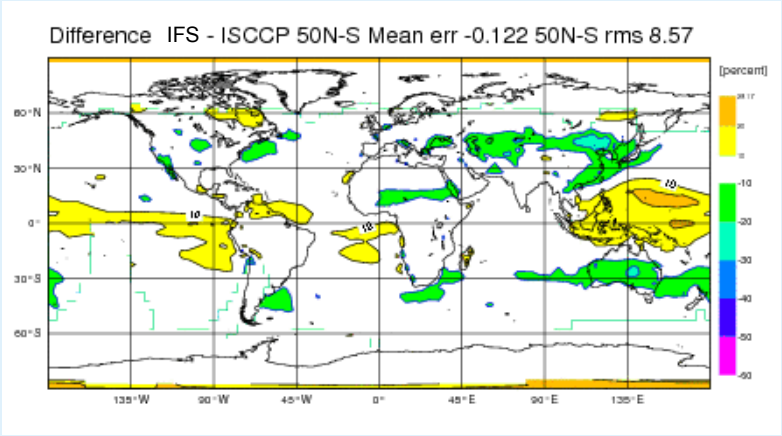
In general, two different methods are used:

In interactive mode	In isolated mode
Study physics as embedded in GCM	Study physics in controlled conditions
Feedbacks with the larger-scale circulation	No feedbacks; prescribed forcings

Interactive evaluation

Documents the typical location & frequency of occurrence of biases

AMIP ***GPCI***

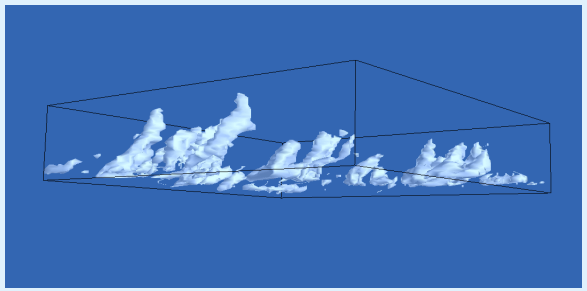


Acts as a first step towards model improvement

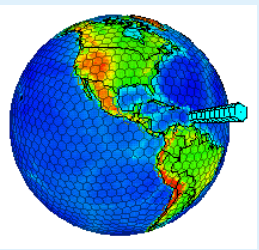
Problem: How to identify the responsible parameterizations?

Isolated evaluation

Study parameterizations in a known & controlled environment



CRM / LES / SCM



Reveals if parameterizations correctly reproduce sub-grid statistics

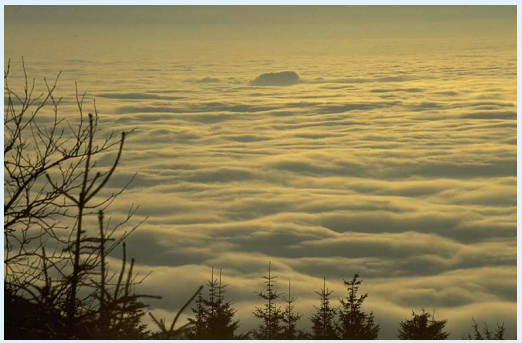
Gives insight into feedbacks at physics level

GCSS model intercomparison studies for CRM/LES/SCM

Idealized cases reflecting observed situations, considered (proto)typical regimes:

Dry CBL

Wangara



Stratocumulus

FIRE
ASTEX
DYCOMS
M-PACE

Shallow cumulus

BOMEX
ATEX
SCMS
RICO
ARM SGP

Deep cumulus

LBA
ARM SGP
TWP-ICE

Q: how representative are these "typical" situations?

Many situations still exist for which parameterizations remain untested.

The evaluation dilemma: Representativeness vs. Transparency

(Characterization vs. Understanding)

Interactive evaluation

Representativeness

Model transparency

Isolated evaluation

Can we find the middle ground?

The Cabauw Parameterization Testbed

Objective: "GCSS-style" intercomparison studies of SCM/LES/CRM against observations on a continuous, daily basis

http://www.cesar-observatory.nl/

Method

- Run SCMs daily for a location where continuous measurements of many relevant parameters are made
- Models are driven by prescribed large-scale forcings, obtained from:
  - i) a GCM forecast
  - ii) a GCM analysis
- Evaluation against observational datastreams (near real-time in forecast mode)
- Supplementary LES runs provide info on small scale (50m-10km) variability

Required ingredients:

A workstation

Single column models

Large-scale forcings

A meteorological "supersite"

Advantages

Every day is a different case

Including many intermediate/transitional regimes

An archive of cases is automatically generated

Allows quantitative assessment of model performance

A first try-out arena for new parameterizations

Can act as an "early warning system" during model development

Allows close monitoring of model physics

Easy access to all possible model diagnostics

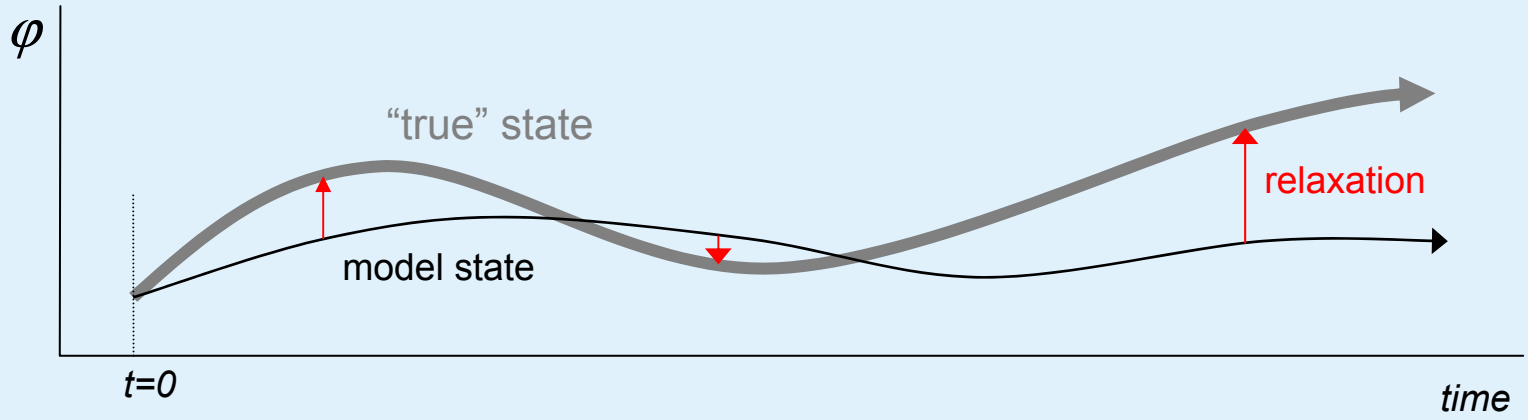
It's fast and cheap

"a testing ground for modellers"

SCM setup - relaxation

Continuous nudging towards a background state

$$\left(\frac{\partial \varphi}{\partial t}\right)_{relax} = \frac{\varphi_{bg} - \varphi}{\tau}$$



Background state: either
- Forecasted (GCM)
- Observed (integrated profiling technique)
- A combination of both (GCM analysis)

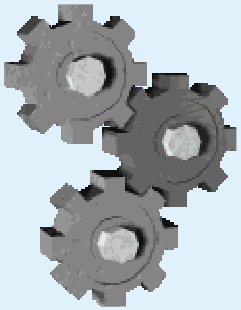
A 6hr relaxation timescale:

* if weather is driven by larger scales, SCM stays close to background state
* if weather is driven locally, SCM physics can create their own unique state

→ models will start to differ

2 configurations, reflecting two purposes:

A priori: Initialization with most recent ECMWF analysis,
time-integration goes into future



Operational

Relaxation towards a GCM forecast state

Purpose: Local 1D weather forecasts

Near real-time evaluation of current weather at physics level

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A posteriori: Initialization and integration both fall completely in the past

Relaxation towards observed state (IPT or ECMWF analysis)

Purpose: Scientific evaluation

Preliminary testbed results

Forecast (a priori) mode: Operational since september 2007

A ridiculously short demonstration of

* Cabauw observational datastreams

* PBL regimes

  which boundary layer regimes are common at Cabauw?

* Feasibility of method

  does using GCM derived large-scale forcings result in realistic PBLs?

* Evaluation techniques

Cabauw continuous observational datastreams

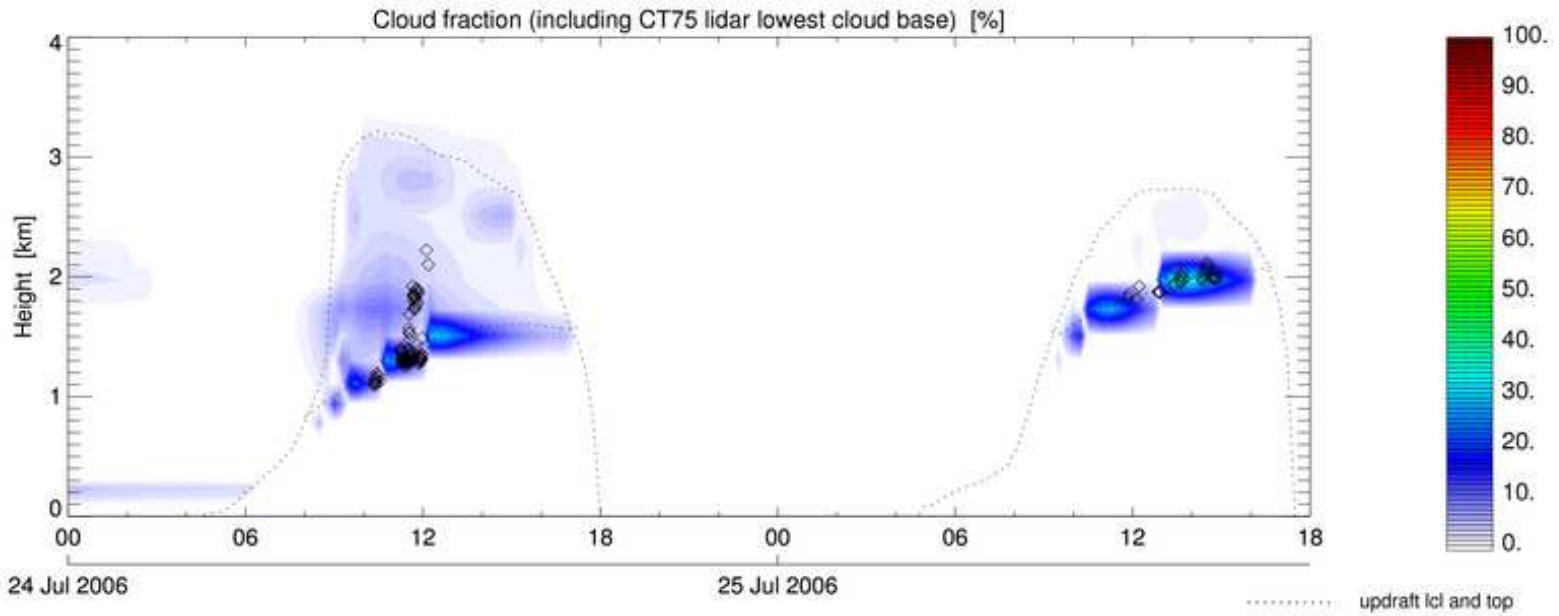
Class	Instrument	Data-stream	Unit	Testbed status
Surface meteorology		2m T	K	✓
		2m Td	K	✓
		10m wind	m s^{-1}	✓
		Surface precip	mm day^{-1}	✓
	CT75 ceilometer	Cloud cover	%	✓
Vertical structure	Cabauw tower (lowest 200m)	T	K	✓
		q	g kg^{-1}	✓
		U	m s^{-1}	✓
		wT	K m s^{-1}	✗
		wq	kg kg^{-1} m s^{-1}	✗
		wU	m^2 s^{-2}	✗
	Profiler			✗

Class	Instrument	Data-stream	Unit	Testbed status
Clouds	CT75 ceilometer	Cloud base height	m	✓
	HATPRO MWR	Liquid water path (LWP)	mm	✓
	35 GHz Cloud radar	Cloud top height (>10μm)	m	✗
Surface turbulent fluxes		Latent heat	W m^{-2}	✓
		Sensible heat	W m^{-2}	✓
Surface radiative fluxes		LW down	W m^{-2}	✓
		LW up	W m^{-2}	✓
		SW down	W m^{-2}	✓
		SW up	W m^{-2}	✓
Bulk humidity budget	HATPRO MWR	Water vapour path (WVP)	kg m^{-2}	✓

Clouds – vertical structure

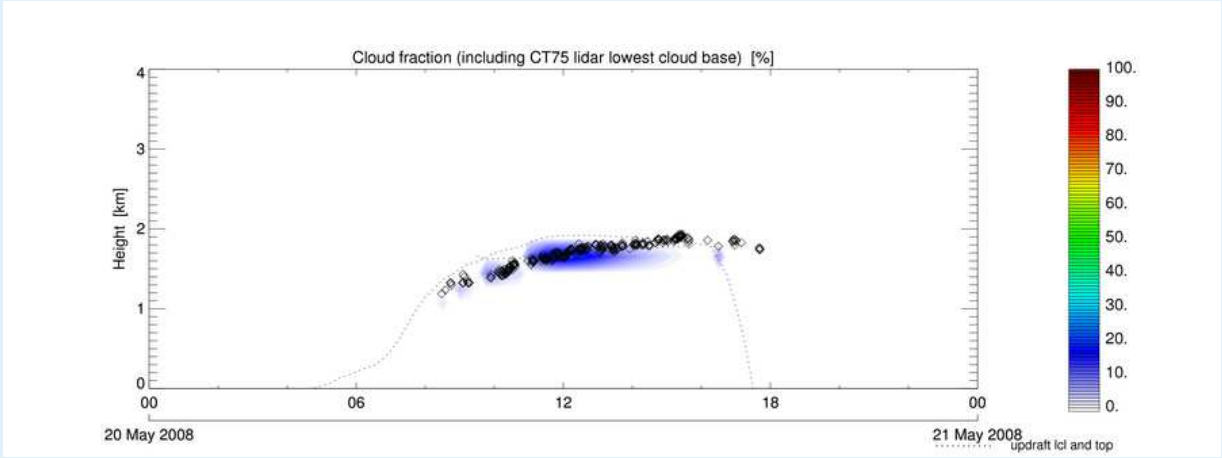
Cabauw, 24 July 2006

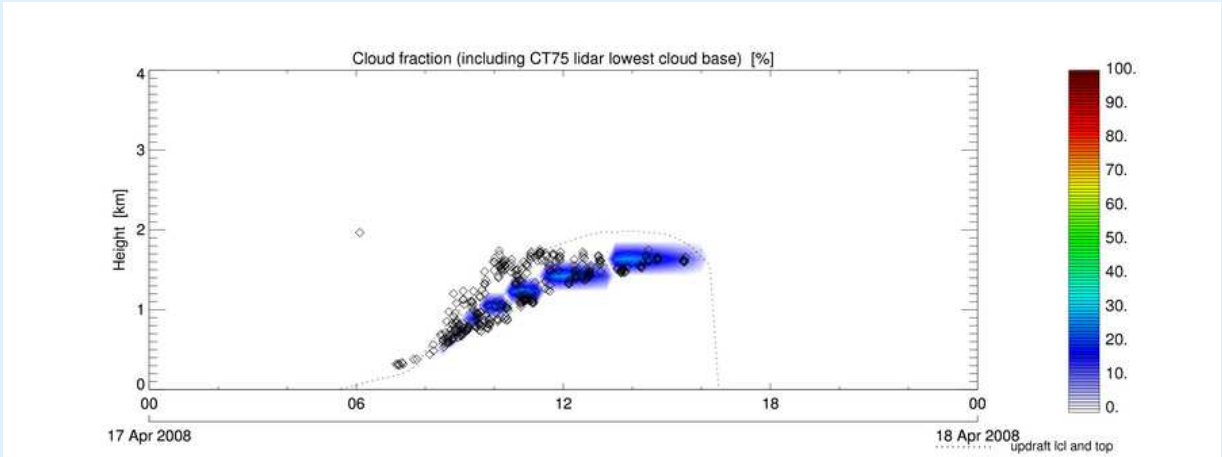
Shallow cumulus

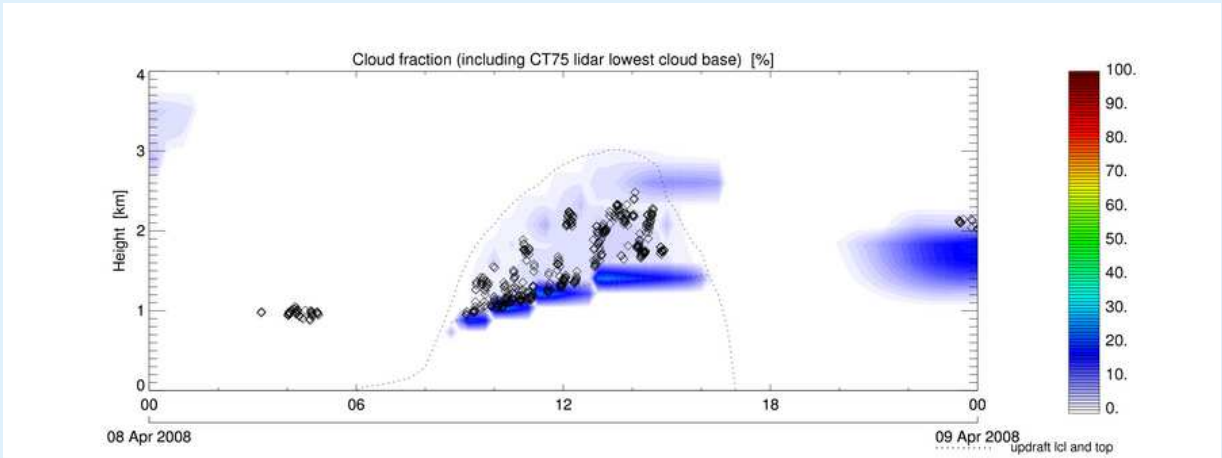


Consistently realistic PBLs

when weather is locally driven

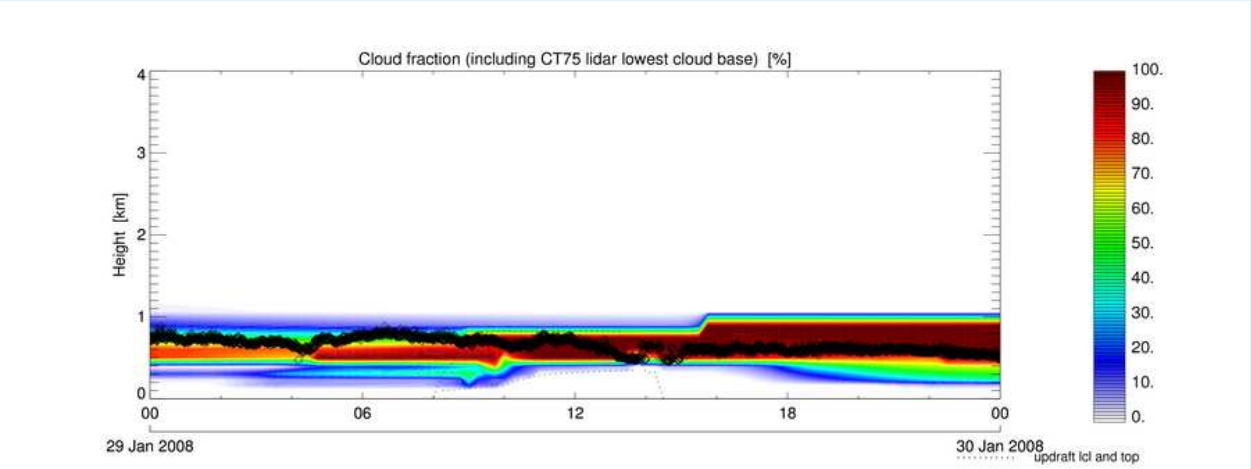




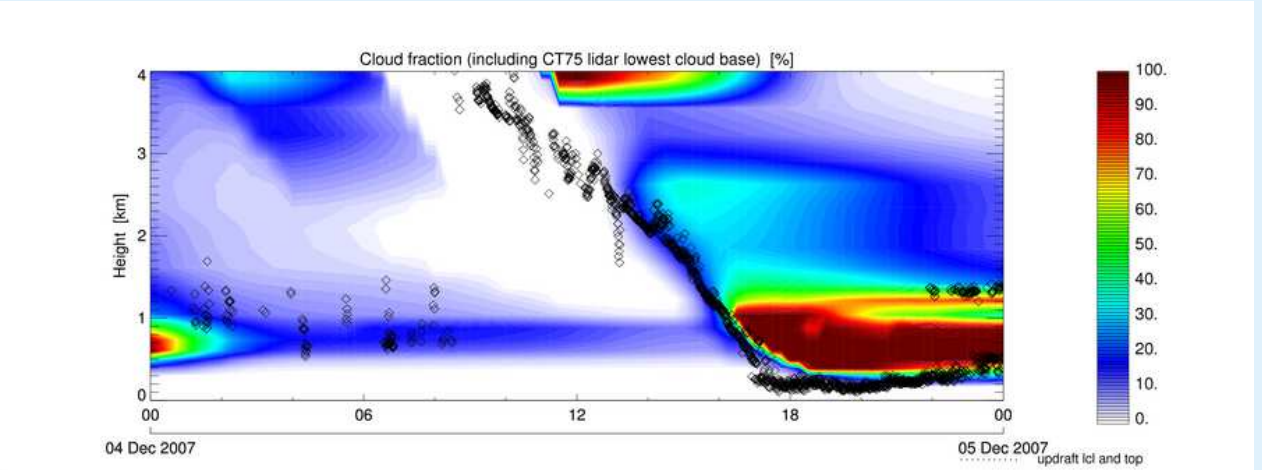


Other common regimes at Cabauw

29 january 2008
Continental stratocumulus

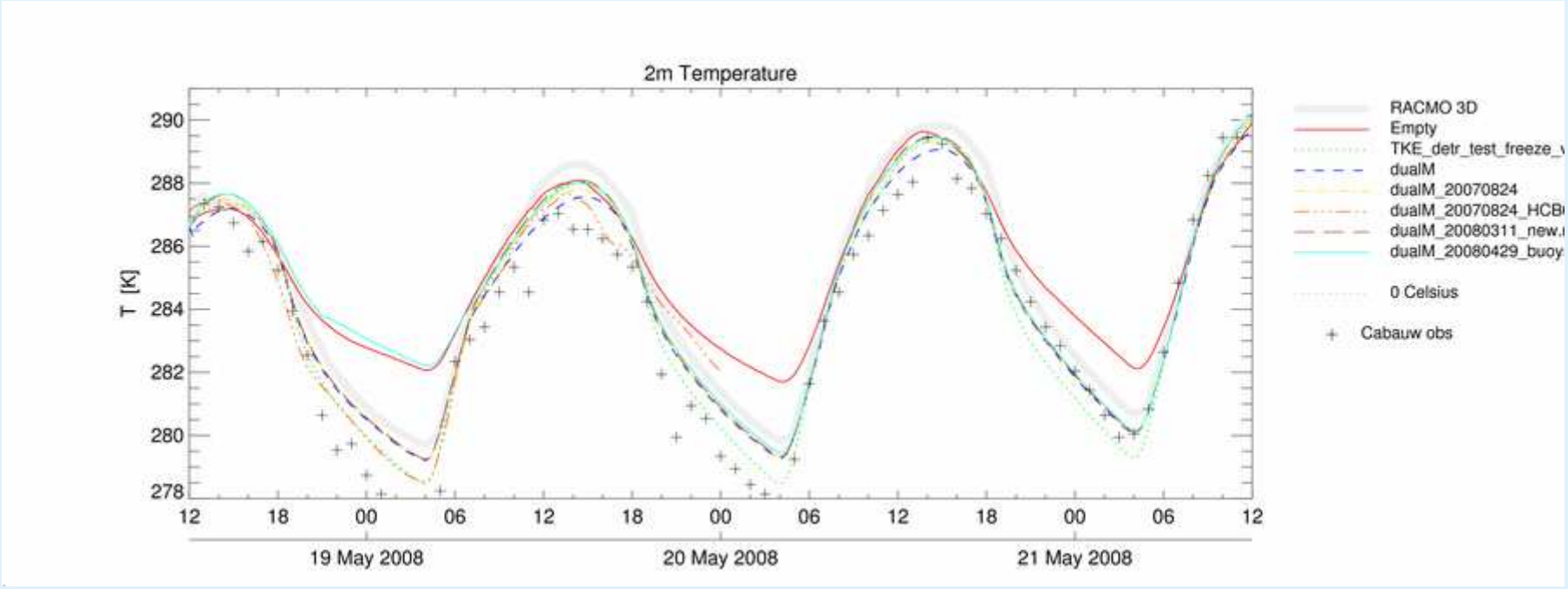


4 december 2007
Passage of a warm front



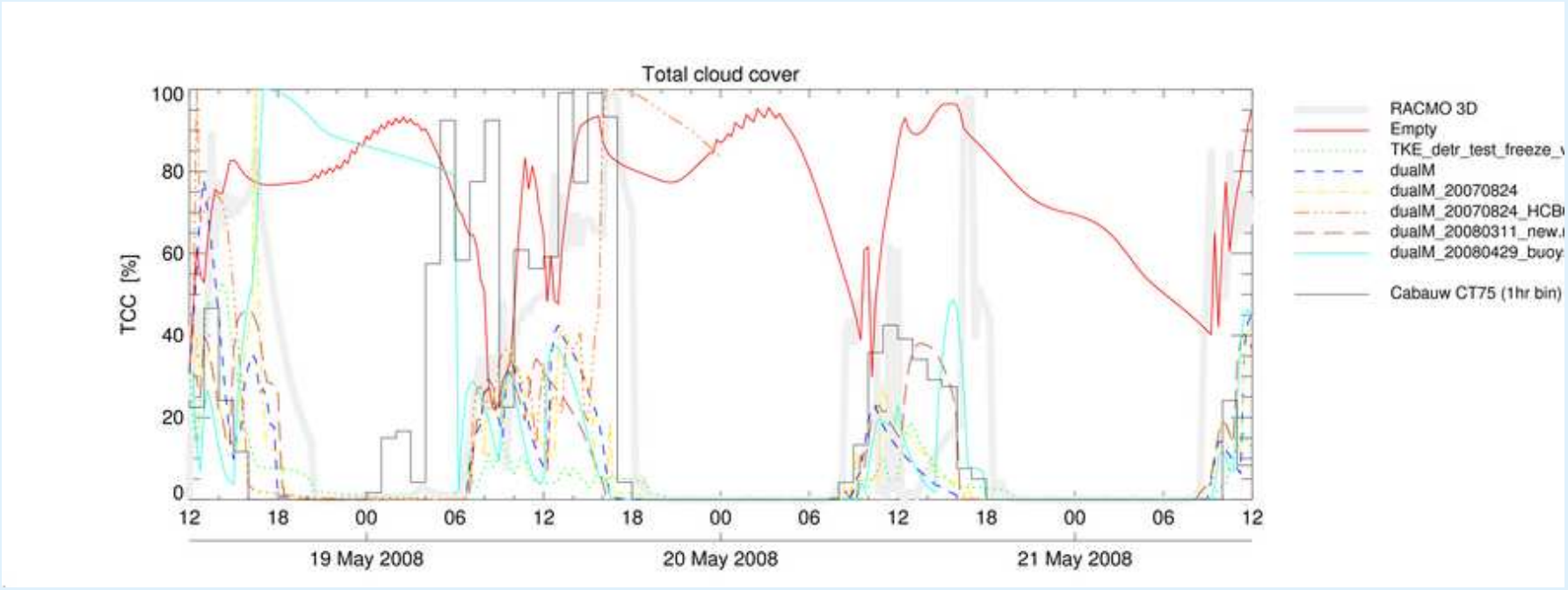
Evaluation techniques: direct comparison

Profiles and timeseries



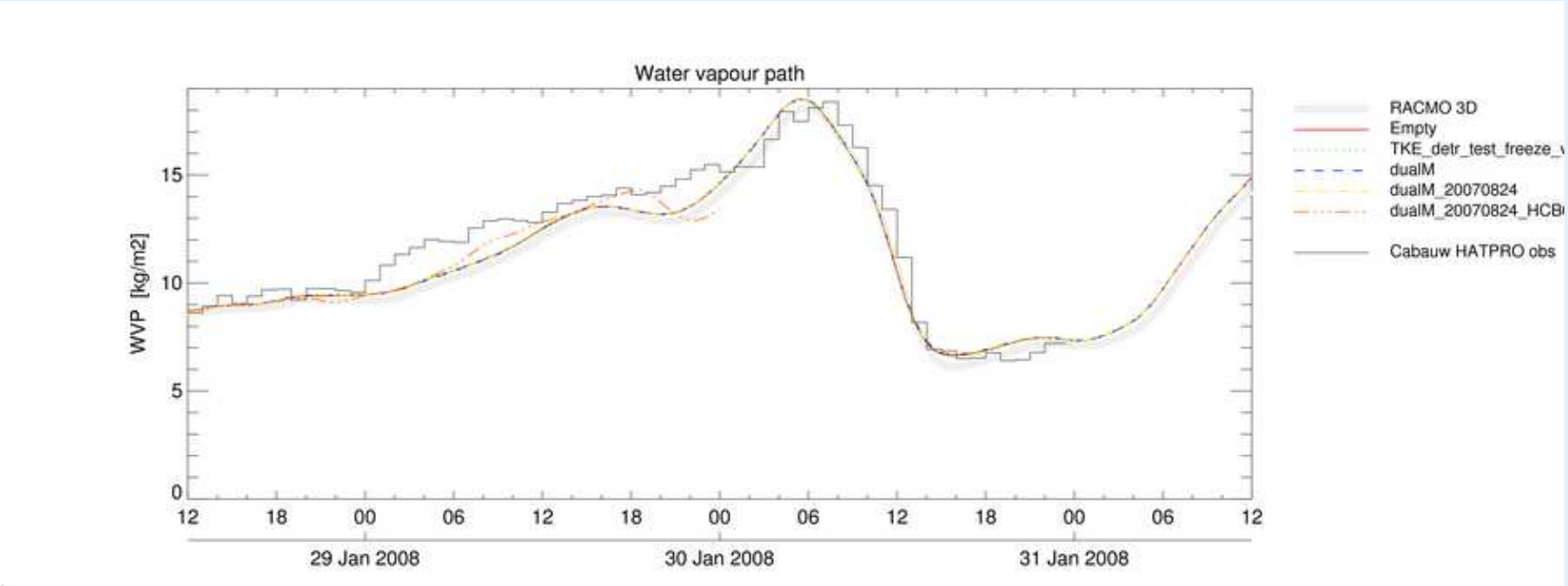
Models can differ despite relaxation

Cloud properties



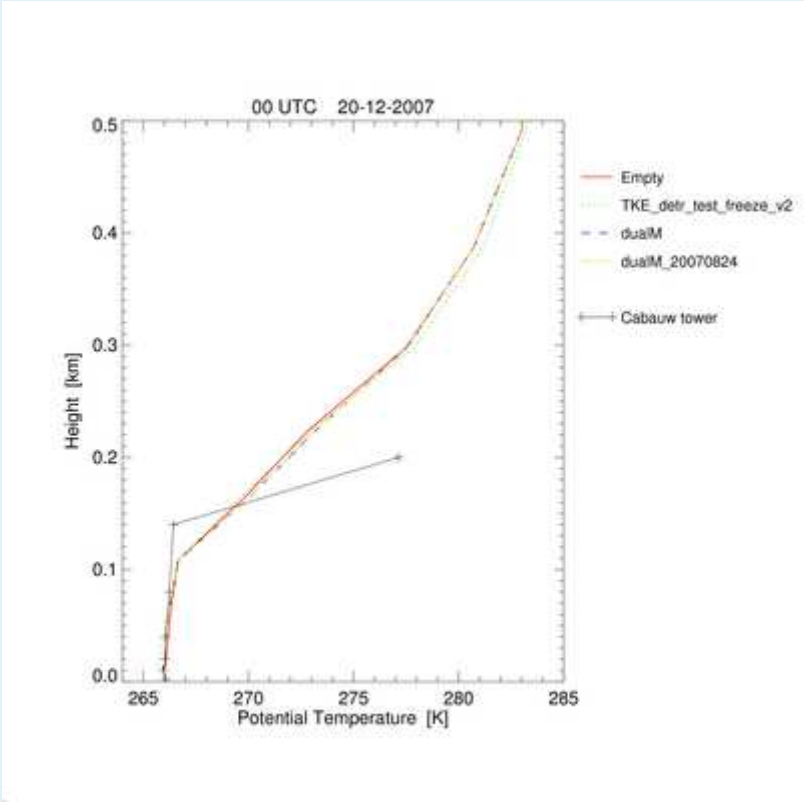
Spread among models is considerable

Integrated humidity budget

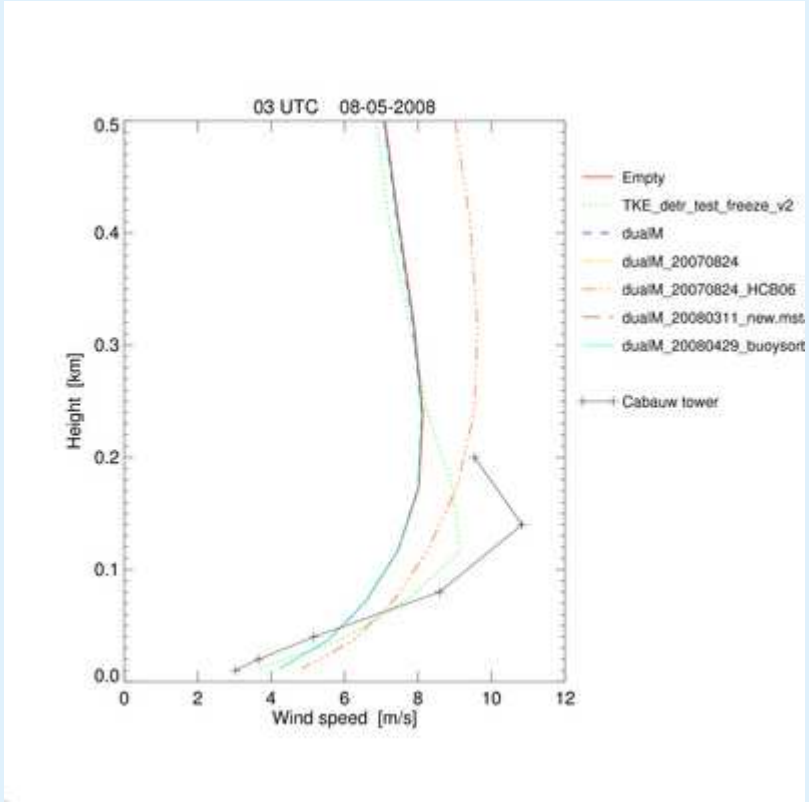


WVP: a good indicator if GCM forcings & background state are realistic

Vertical structure in lowest 200m – Cabauw tower measurements



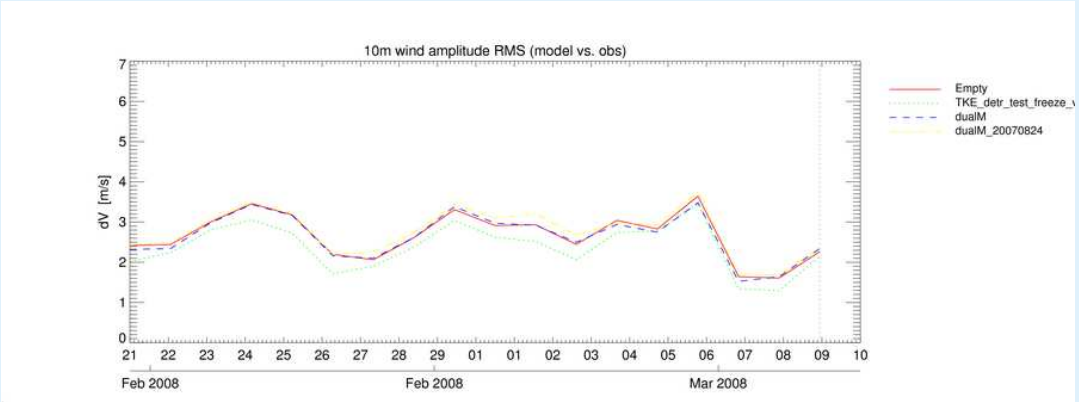
strong inversion



nocturnal jet

Daily RMS scores

Reveals performance consistency



The Cabauw Index

The combined RMS scores of groups of variables (e.g. surface, clouds, humidity budget, etc)

$$CI = \sum_{n=1}^{N} \frac{RMS_n}{RMS_n^{ref}}$$

Scatterplots

Establishing the effective parametric relations in models

Mixing diagram vectors (2m T, q)

Using bulk mixed layer arguments to establish the effective PBL top-entrainment in models

(Betts, JGR, 1992)

Outlook

The testbed is open for more participants

ECHAM, HIRLAM, WRF-1D

Under construction: an interactive interface

Bringing models and observations together

Integration of research

Method can be applied at other observational supersites

Other CloudNet sites? ARM sites?

Towards a GCSS testbed?

Detailed assessment of current, developing weather at physics level

Nowcasting (for aviation, severe weather warnings)

Field experiments (IMPACT EUCAARI, May 2008)

Cabauw Testbed location

http://www.knmi.nl/~neggers/KPT/

Demonstration at pan GCSS

During poster session