KNMI
Parameterization
Testbed



Studying cumuliform cloud overlap and its impact on radiative transfer at Cabauw using continous SCM and LES

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* *A new boundary-layer scheme for EC-Earth / RACMO / ECMWF*

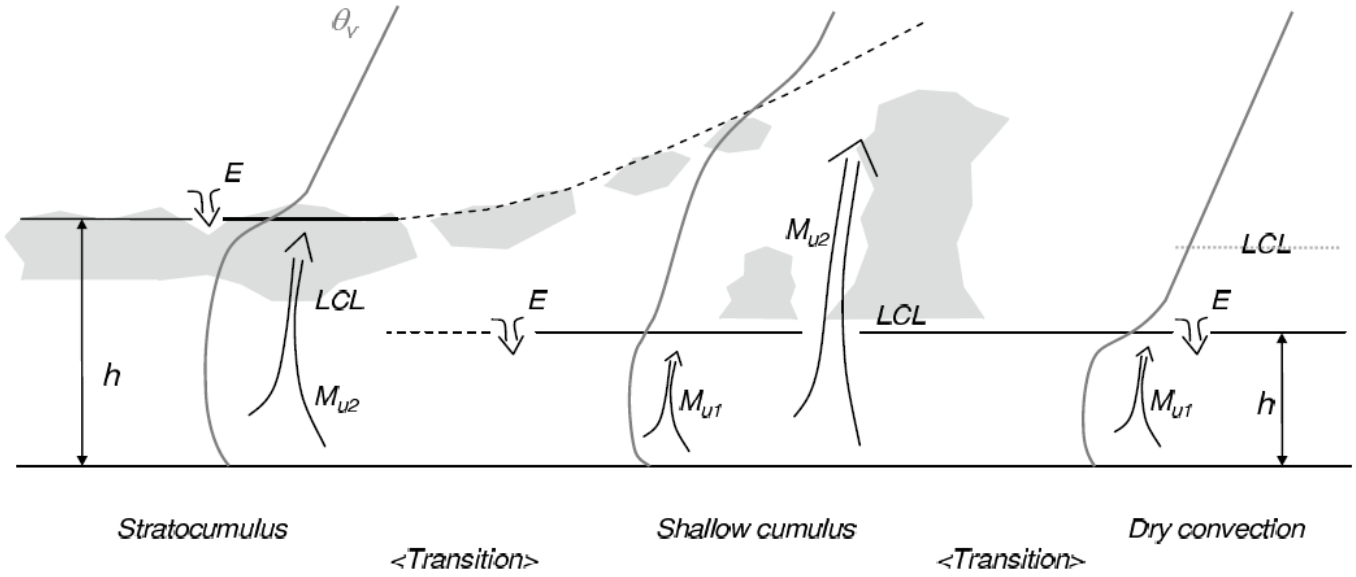
* *Evaluating the cloud-radiative model climate at Cabauw*

* *Cumuliform cloud overlap & radiative transfer*

A new boundary-layer scheme for EC-Earth / RACMO / ECMWF

EDMF-DualM *(Siebesma et al., JAS 2007; Neggers et al., JAS 2009)*

* *Scheme integration*
* *Accommodating all distinguished BL regimes into one "unified" framework*
* *Avoiding artificially discrete transitions in coding and behavior*

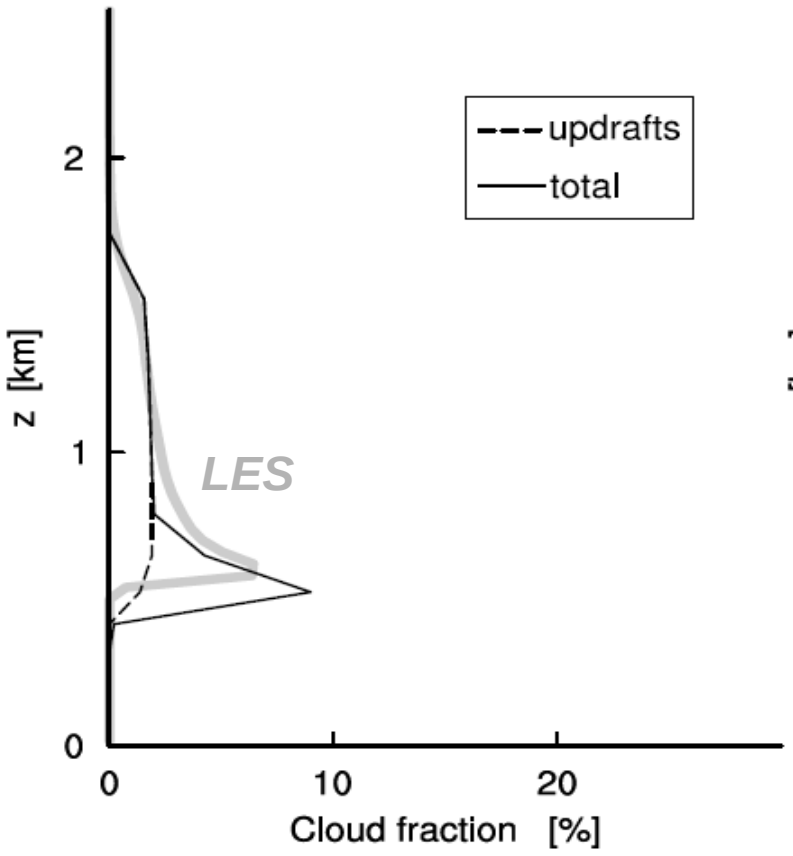


Key ingredients:

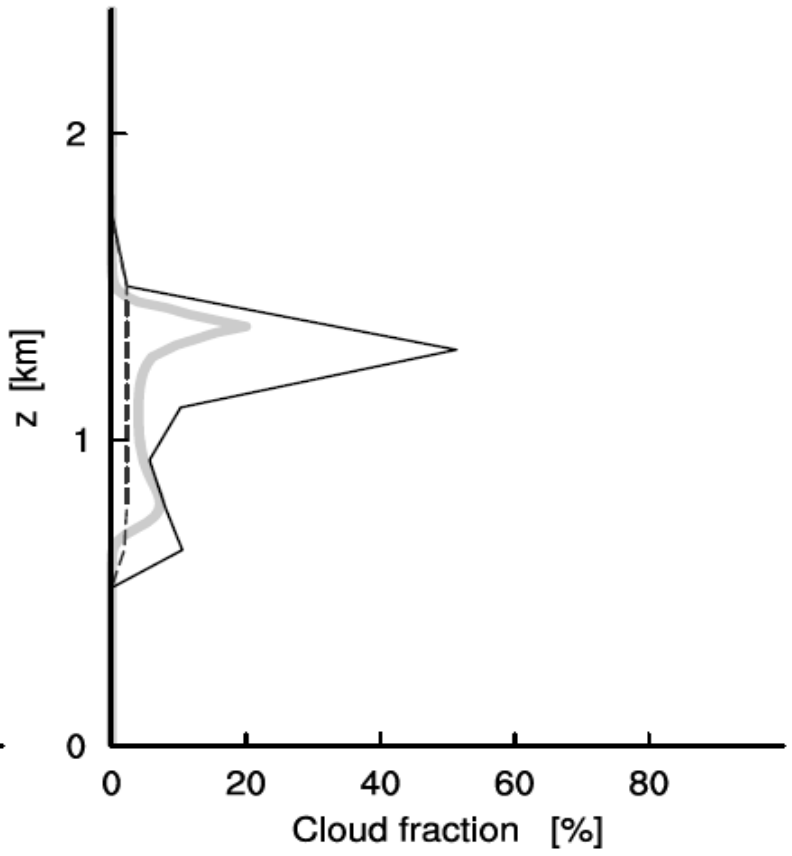
* *Apply the advection-diffusion decomposition to the turbulent joint-PDF within the BL* *(ED-MF)*
* *Reconstruct the advective part of this PDF using a limited number of resolved updrafts* *(Dual Mass-flux)*
* *Use this reconstructed bimodal PDF to model both transport and clouds* *(A bimodal statistical cloud scheme)*

SCM results for GCSS BLWG idealized case studies – cloud structure

BOMEX
Shallow cumulus



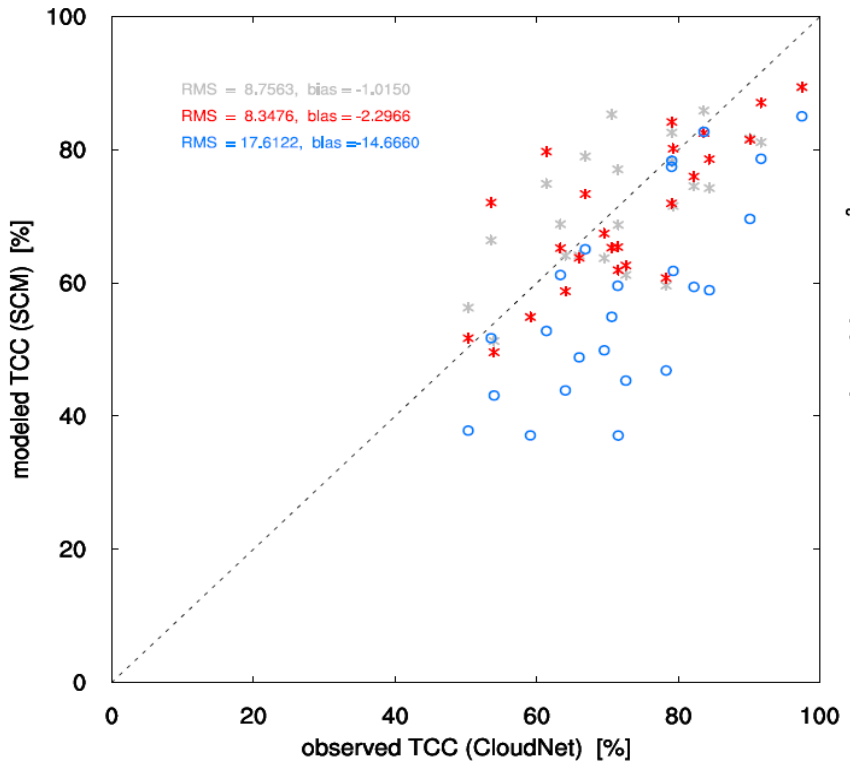
ATEX
Cumulus under a strong inverson

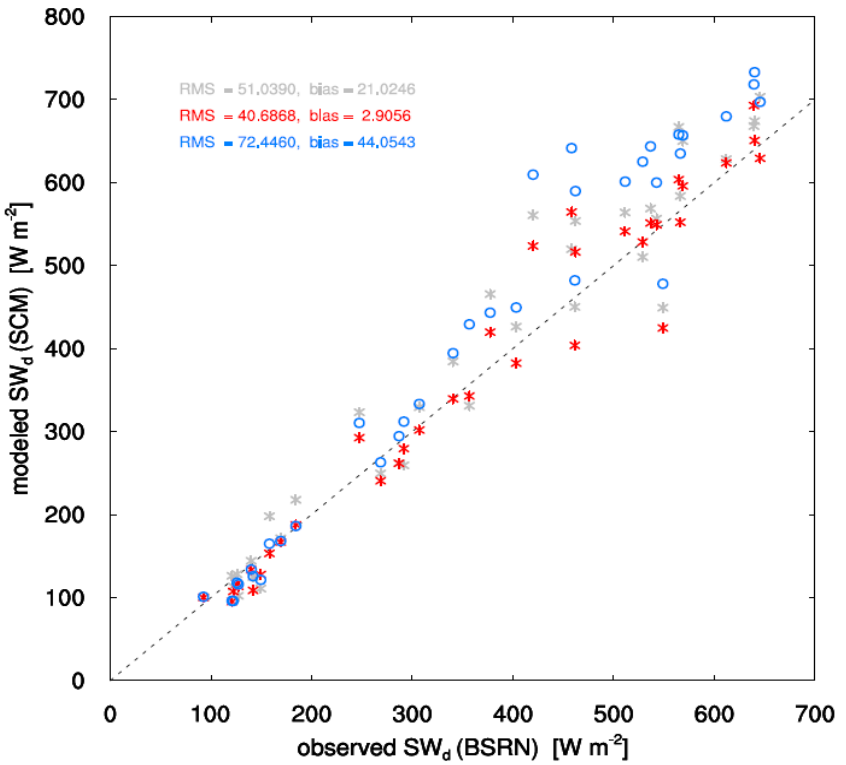


The real world - Long-term continuous SCM evaluation at Cabauw

Observed (x) versus modeled (y) monthly means at 12 UTC for 2007-2009

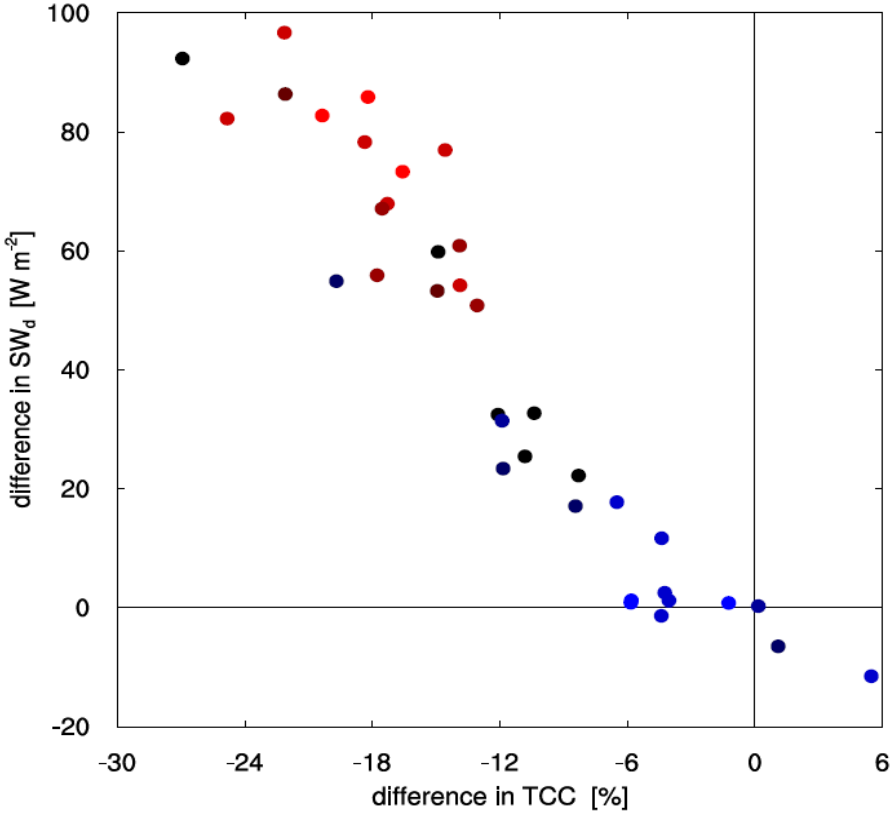
Grey: RACMO 3D	*(IFS physics)*
Red: SCM CY31R1	*(forced by RACMO)*
Blue: SCM CY31R1 + EDMF-DualM	*(forced by RACMO)*

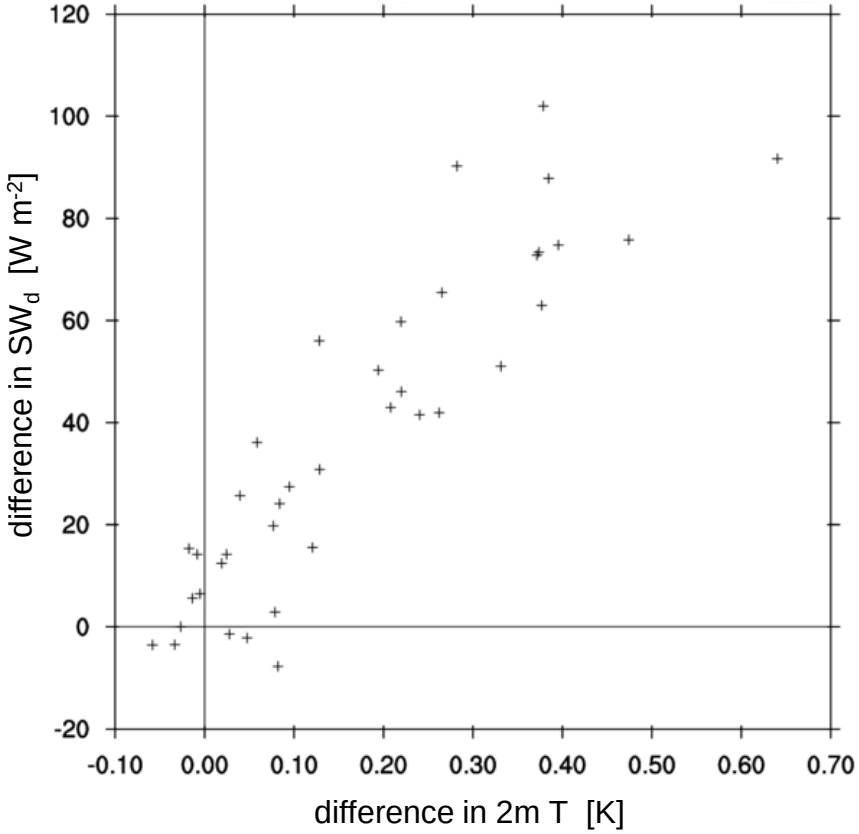




* *The control SCM (red) more or less reproduces the behavior of its native GCM (grey)*
* *PBL physics can have big impact on summertime cloud-radiative climate*
* *Consistent bias against different measures of cloud presence*

Correlated model differences (new – old)





Coloring (in this plot only): seasonality, from red (summer) through black (equinox) to blue (winter)

Further study: Comparing SCM cloud properties with LES

EDMF-DualM: Good vertical cloud structure, not so good projected cloud cover

→ *Could it be the cloud overlap?*

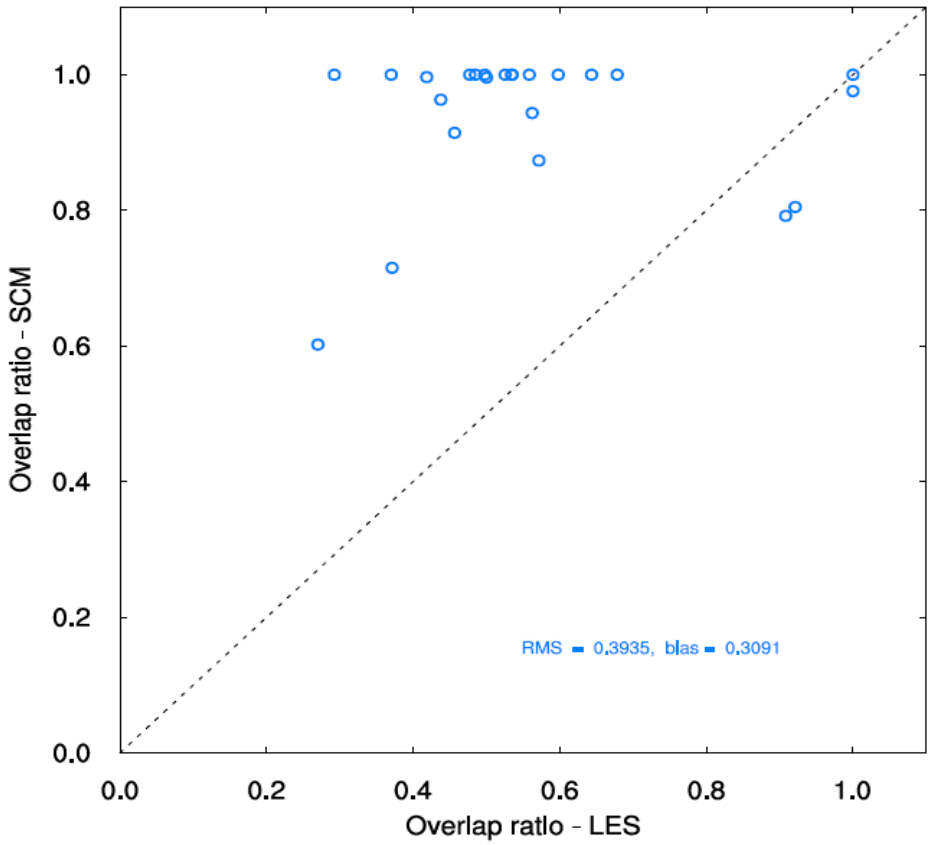
$$r = \frac{a_{\max}}{a_p}$$

maximum cloud fraction

TCC

*By default the **maximum-random*** overlap function is applied in the SCM*

Daily LES vs SCM results at 12 UTC for June 2008 at Cabauw

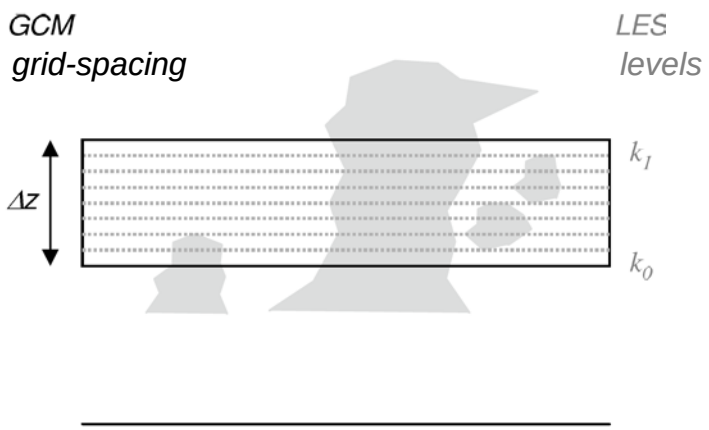


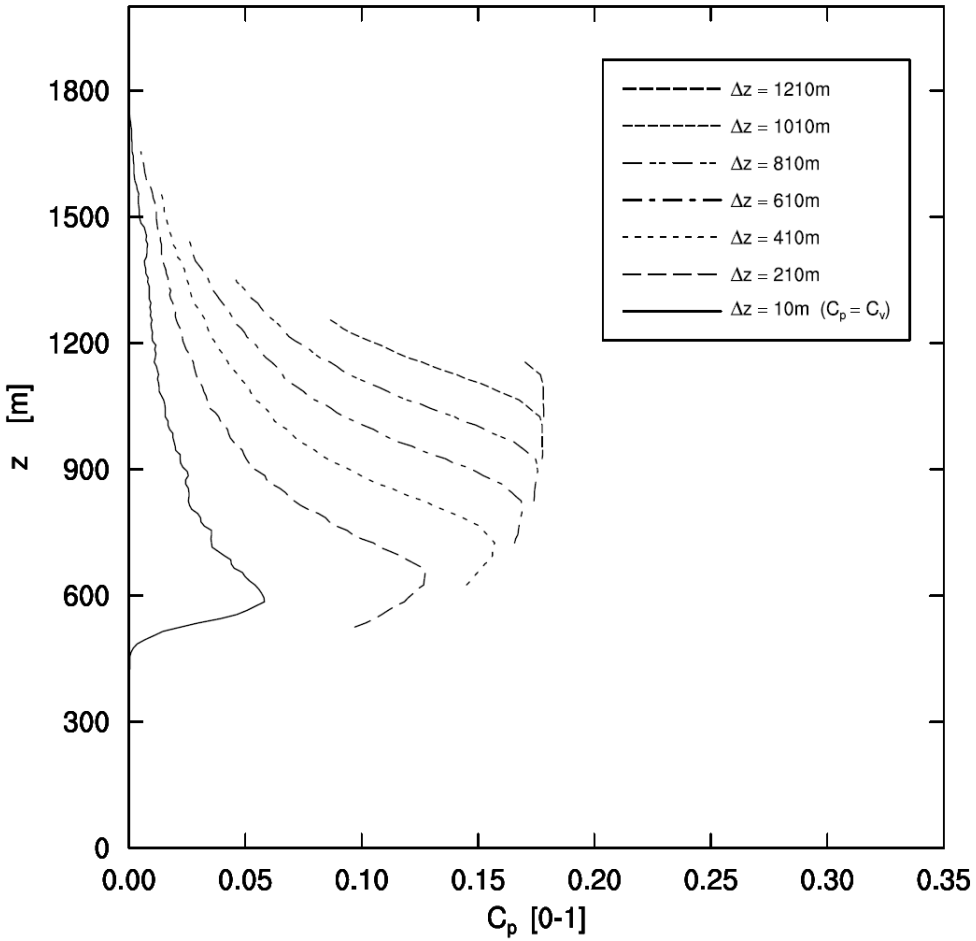
Cloud overlap efficiency in LES at high vertical resolutions

Diagnosing the effective overlap over multiple adjacent cloudy LES levels in a 3D snapshot of BOMEX

Ratio = C_v / C_p : volume-averaged / area-averaged cloud fraction *(Brooks, JAS, 2004)*

Input for radiative transfer model





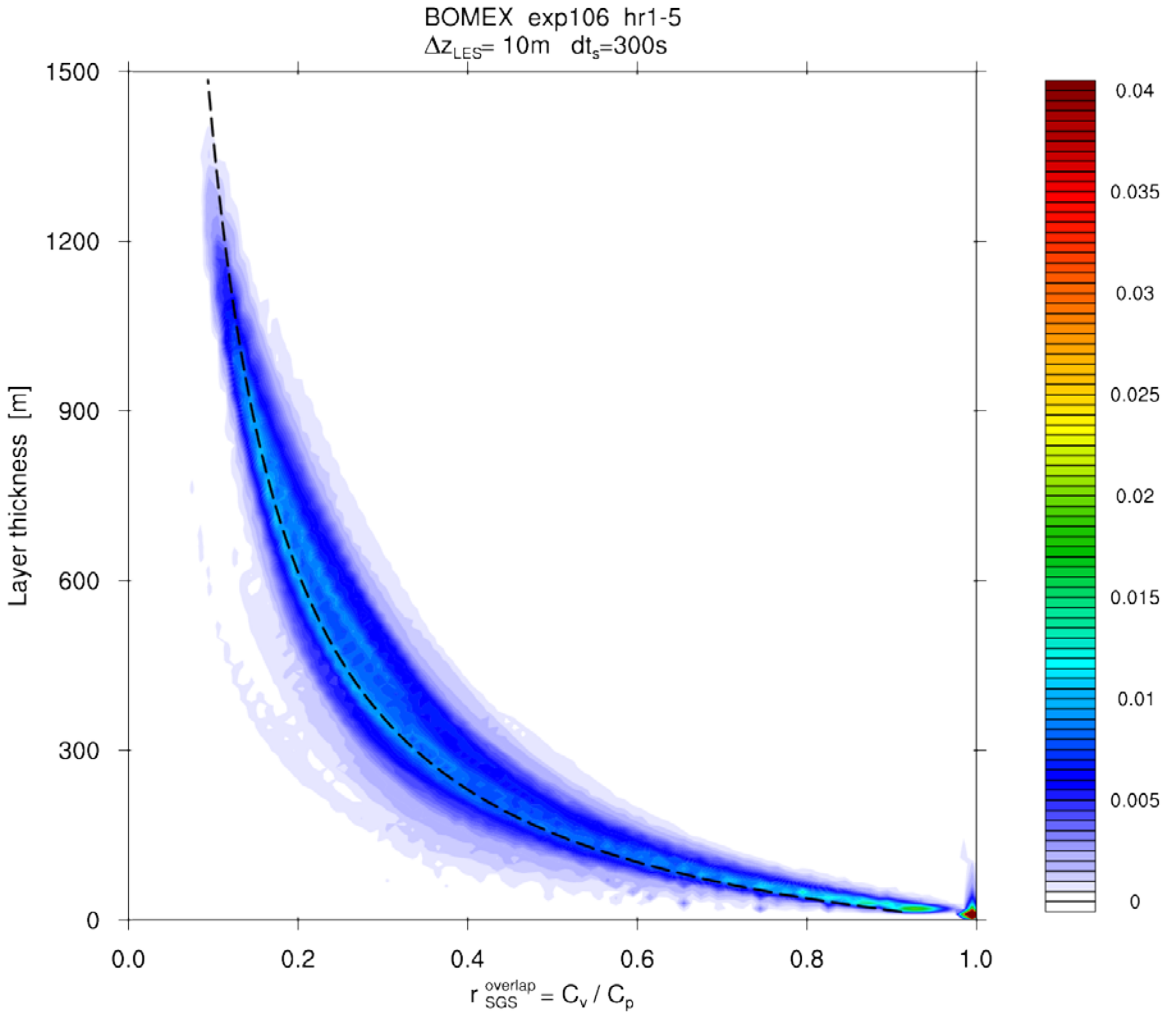
Vertical overlap in cumuliform boundary-layer cloud fields appears to be very inefficient at depth-scales that are sub-grid scale (SGS) at typical vertical resolutions in GCMs (~100-300m in the PBL cloud layer)

Better statistics

Average over 60 independent 3D snapshots

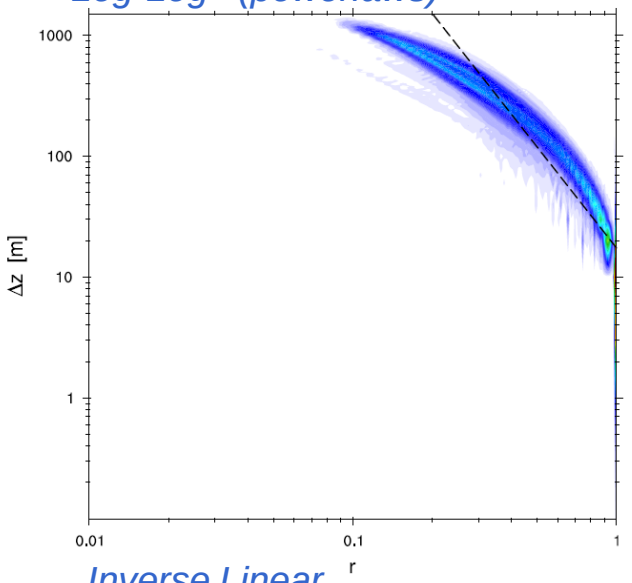
Plot overlap ratio as a function of layer depth

Functional form?

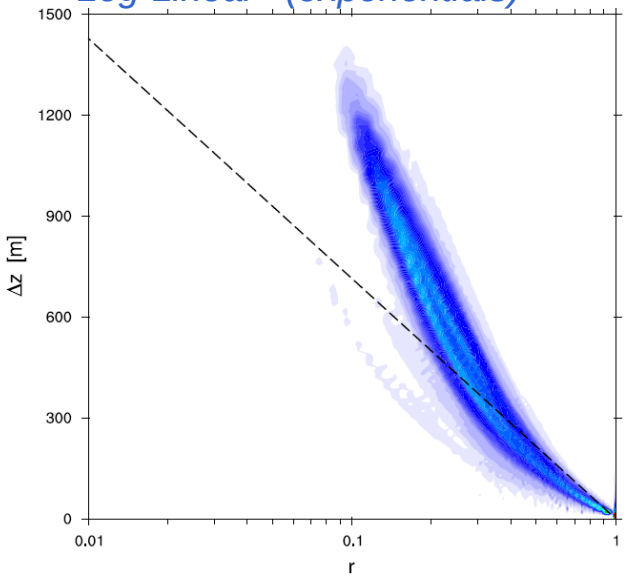


Axis transformations

Log-Log (powerlaws)



Log-Linear (exponentials)



Inverse Linear

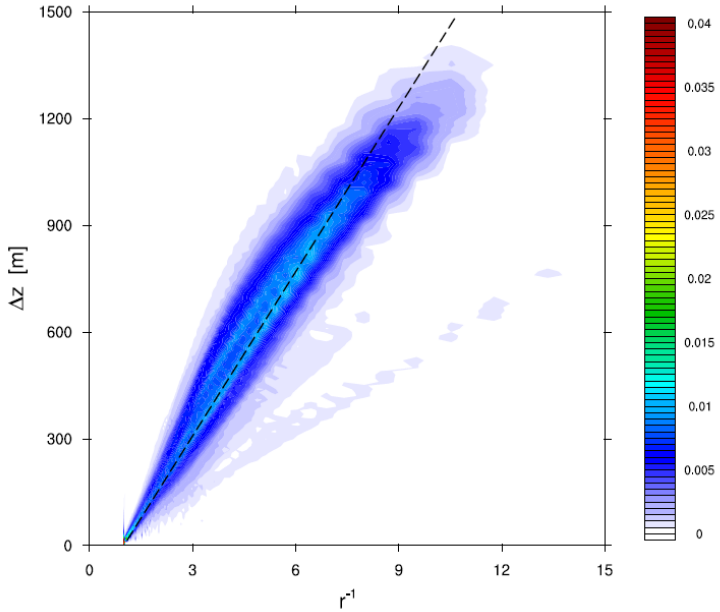


Table 1. Candidate Functional Forms[a]

Name	Function	Constants	RMS
Exponential	$r = \exp\left(-\frac{\Delta z}{\Delta z_0}\right)$	$\Delta z_0 = 310$ m	0.10105
Powerlaw	$r = a\Delta z^b$	$a = 2.8$ $b = -0.36$	0.08053
Inverse linear	$r = \frac{1}{1+\beta\Delta z}$	$\beta = 0.0064$ m^{-1}	0.04229

Accepted by JGR pending revisions, March 2011

Impacts on radiative transfer

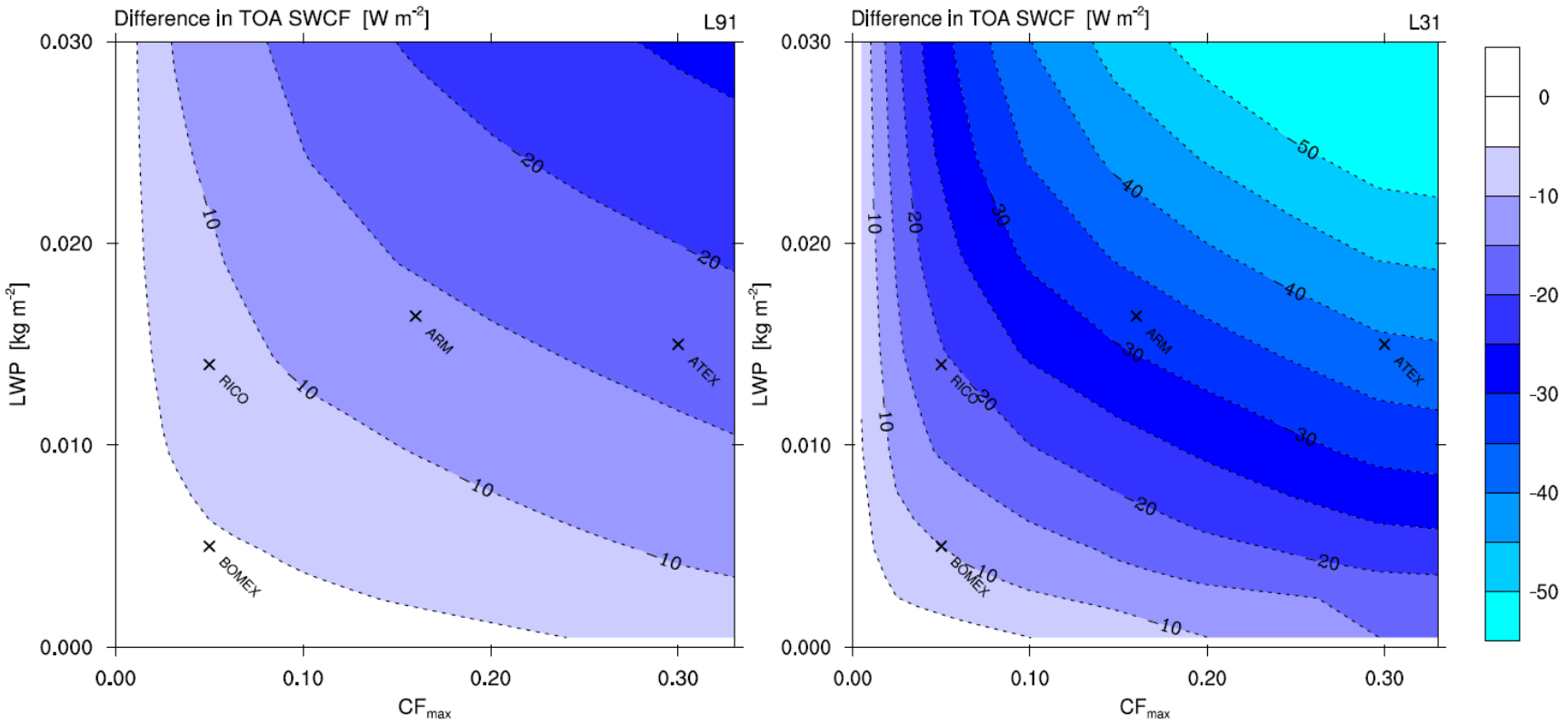
Offline calculations with a GCM radiation scheme

Acting on the cloud and condensate profiles as obtained from LES BOMEX

Explore cloud-condensate phase-space by performing calculations on hypothetical 2D matrix, created by scaling these profiles while preserving vertical structure

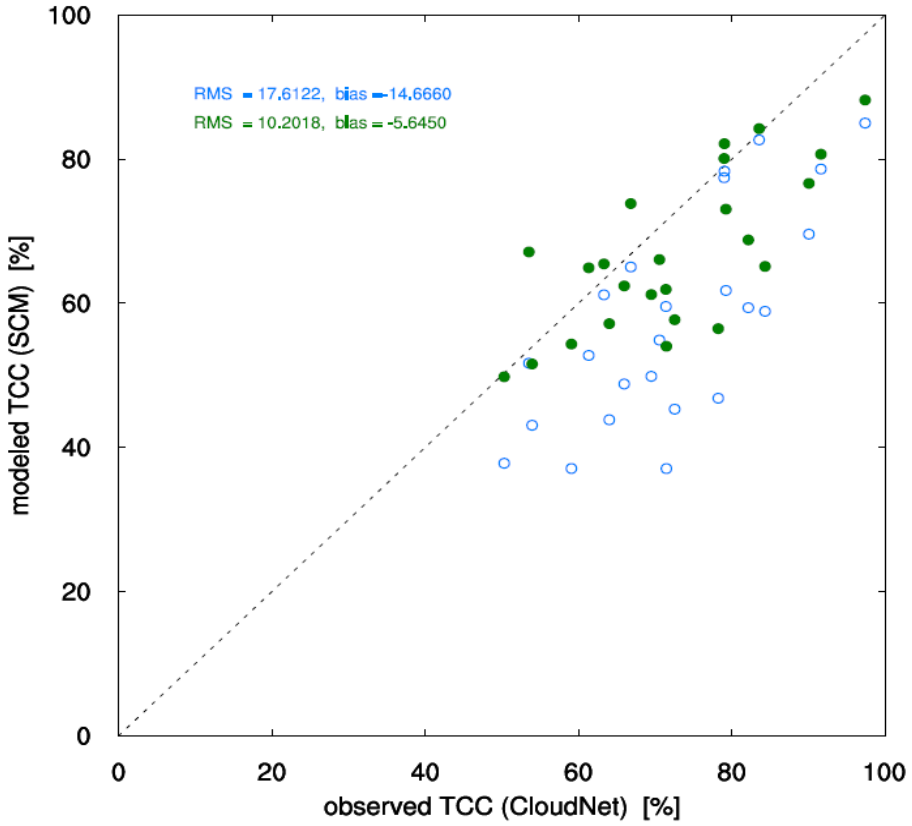
Plotted: Difference in TOA SWCF between calculations with and without a SGS cloud overlap function

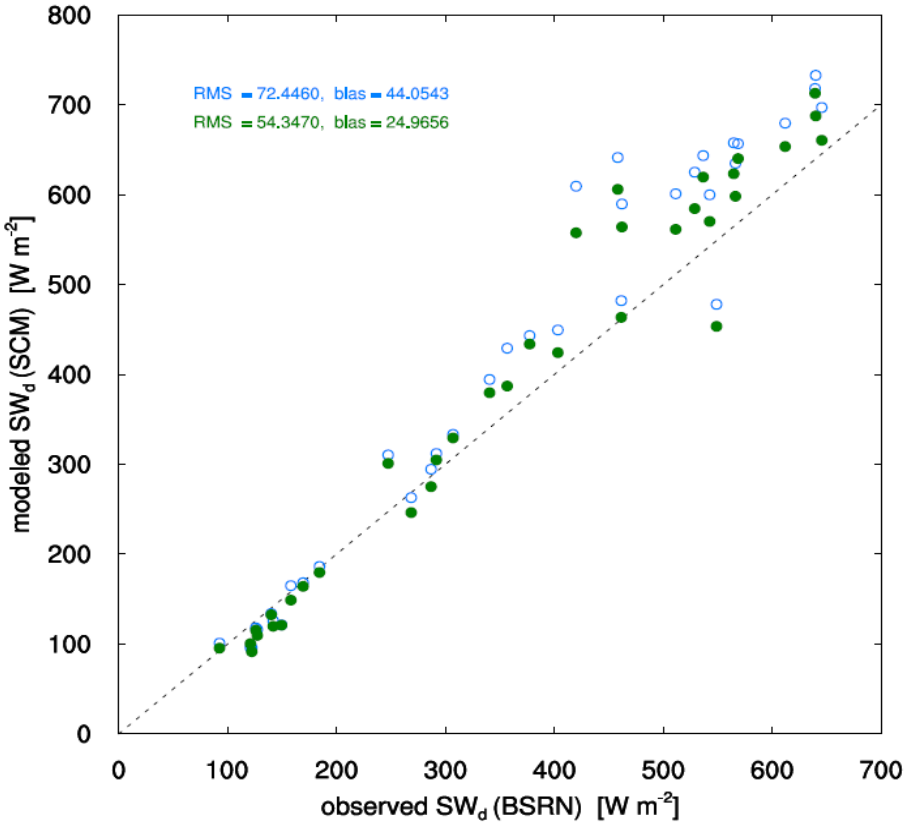
For two different GCM vertical discretizations; L91 (fine) and L31 (coarse)



Rerunning the SCM at Cabauw with improved physics

Monthly mean results at 12 UTC for the period 2007-2009





Blue: SCM CY31R1 + EDMF-DualM

Green: SCM CY31R1 + EDMF-DualM including SGS overlap

Impact on monthly mean daytime SW$_d$: up to 50 W/m^2 !!

Conclusions and Outlook

Continuous SCM at Cabauw was used to evaluate the cloud-radiative climate of a preliminary version of a new boundary-layer scheme

This revealed that this version of the scheme underestimated low-level cloud presence in summertime

Closer investigation using LES revealed that the absence of a SGS overlap function in the associated statistical cloud scheme was the cause

Implementation of such a function into the SCM then removed most of the bias

Next step: To repeat this analysis at other (ARM) sites ← *FASTER*

More LES-research is in progress to fully understand the found cumuliform overlap statistics

ARM data? Volume-scanning?