CCPP FASTER: Improving the representation of cloud macrophysics in the RACMO and the IFS

A short description of the models

Preliminary SCM results for 1999-2001 at ARM SGP. Two research topics:

* Evaluation of the impacts of the ice super-saturation function on high cloud occurrence

* Evaluation of the impact of the new EDMF-DualM boundary layer scheme on the vertical structure of low-level clouds

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DOE ASR meeting, 15-18 March 2010
**ECMWF IFS**

*Integrated forecasting System (IFS) of the European Centre for Medium-range Weather Forecasts (ECMWF)*

*Current physics version: Cycle 36 R<something>*

*ERA Interim (CY31R1)*

**KNMI RACMO**

*Regional Atmospheric Climate Model (RACMO)*

*Consists of HIRLAM dynamics and IFS physics (currently C31R1)*

*Used for*
  * Generation of future climate scenarios for Europe / The Netherlands*
  * Short-term forecasts (Initialization & domain boundaries: ECMWF analysis)*
  * Testing of experimental parameterization schemes (boundary layer)*
  * Provides forcings for the KNMI Parameterization Testbed (KPT)*

Two SCM versions participate in FASTER:

* **CY31R1** (also known as the “ECMWF SCM”)*

* **CY31R1 + EDMF-DualM**  
  
  *Eddy Diffusivity - Mass Flux scheme* (Seibesma et al, JAS 2007)

  *Dual Mass flux framework* (Neggers et al, JAS 2009)
* The SCM picks up the major cloud structures
* Smaller-scale events at high levels are underestimated – do other SCMs show this too?
**Topic I: Impact of the ice super-saturation function on the high cloud cover in the IFS**

A (new) routine for ice super-saturation above RH=100% was introduced into the IFS in 2005:

OLD (no super-saturation allowed)  NEW (allowing super-saturation)

Dotted grey arrow: behavior of RH when gridbox reaches saturation

*Tompkins et al., ECMWF Tech. Memo 481, 2005*
IFS GCM results: SuperSat – Control (no SuperSat)
yearly mean 200009-200109

Tompkins et al., ECMWF Tech. Memo 481, 2005

Figure 2: 12 month average difference in high cloud cover (p<450 hPa approximately) between two experiments using the new nucleation parametrisation and the control, respectively.

Q: Is this reduction of high clouds an improvement?
Can we evaluate against ARM SGP measurements using the SCM technique?
March 2000
monthly mean at 18 UTC

Sensitivity test on ice super-saturation: it reduces the cloud fraction by about 10% at 10km height

This is in agreement with the GCM results

According to ARSCL this is an improvement (at least for this month)

Also note: the CY31R1 SCM reproduces the cloud structure of ERA Interim (CY31R1 physics) reasonably well, even when driven by an independent forcings dataset
Better statistics:

Evaluation of the monthly mean cloud fraction at 10km height at 18 UTC against ARSCL for the period 1999-2001:

* The March 2000 result is representative of the longer-term

* The supersaturation function brings a statistically significant improvement

* Not accounting for super-saturation leads to too much high cloud occurrence
Topic II: Testing a new boundary layer scheme for RACMO / IFS

Results with the EDMF-DualM framework for the Rain In Cumulus over the Ocean (RICO) case of the Boundary Layer Working Group (BLWG) of the GCSS (http://www.knmi.nl/samenw/rico/RICO)

EDMF-DualM better reproduces the “bottom-heavy” profile of cloud-fraction as seen in LES

Q: This is an idealized case. Do these results carry over to the real world?
Spring/summer cloud fraction at SGP:
EDMF-DualM has its low-level maximum at a lower height compared to ERA Interim (CY31R1)
Process-level evaluation

Evaluation of the monthly mean height and time-development of the daytime maximum cloud fraction in the lowest 4 km

* The typical diurnal rise of the peak in PBL cloud fraction can be distinguished

* EDMF-DualM agrees better with ARSCL
Better statistics:

Evaluation of the monthly mean height of the maximum cloud fraction in the lowest 4 km at 18 UTC against ARSCL for the period 1999-2001:

* CY31R1 overestimates this height, reflecting that it overestimates the occurrence of shallow cumulus outflow at the top of the PBL (“ anvils”)

* EDMF-DualM agrees better with observations, reflecting that for fair-weather cumulus it typically puts the maximum cloud fraction at cloud base
Summary / conclusions

Long-term SCM evaluation against ARM SGP datasets reveals that:

* The ice super-saturation routine in RACMO / IFS brings a significant improvement in high cloud occurrence

* Typical results with EDMF-DualM on shallow cumulus cloud structure for the idealized GCSS RICO case also materialize in multi-year statistics at ARM SGP

A more general statement: It is well possible to reproduce typical GCM behavior due to fast-acting sub-grid physics by means of long-term continuous SCM simulation

see also our paper “Continuous single-column model evaluation at a permanent meteorological supersite”, to be submitted to BAMS, available for viewing online at http://www.knmi.nl/~neggers/index_publ.html