Estimating the low cloud-radiative feedback in a perturbed climate from steady-states of Scu-topped boundary layers

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30 May 2012
EUCLIPSE/CFMIP meeting
A new framework

CGILS results:
A new framework

CGILS results:

Idea: new framework for mapping the entire phase space

1. Which are the conditions which arise marine boundary layer clouds deepening or breakup?
2. What is the effect of perturbed large scale conditions which are intended to mimic climate change?
Experiments set-up

Steady-states solution of Scu-topped BL

\[ w_0 \left(1 - e^{-\frac{z}{z_0}}\right) \]

Constant incoming SW radiation

SST = 19°C

Bellon and Stevens, 2011
Experiments set-up

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Constant incoming SW radiation

height (m)

\[
\begin{align*}
\text{θl} & \quad \text{qt} \\
\text{SST} = 19^\circ\text{C}
\end{align*}
\]
Experiments set-up

Steady-states solution of Scu-topped BL

\[ w_0 \left( 1 - e^{-\frac{z}{z_w}} \right) \]

SST = 19°C
Experiments set-up

Steady-states solution of Scu-topped BL

Bellon and Stevens, 2011
RACMO SCM results: cloud cover

Phase space definition:

\[ E_{\theta_i} = \theta_i(z = 3000m) - \theta_{i\text{surf}} \approx LTS \]
\[ E_{q_t} = q_t(z = 3000m) - q_{t\text{surf}} \]
Phase space definition:

\[ E_{\theta_i} = \theta_i(z = 3000m) - \theta_{i,\text{surf}} \approx LTS \quad E_{qt} = q_t(z = 3000m) - q_{t,\text{surf}} \]

Broken-clouds solutions: \[ \frac{\text{rms}(LWP)}{LWP} \geq 30\% \]
RACMO SCM results: liquid water path

Qualitative correspondence with CGILS cases.
MLM results: different entrainment parameterizations

How important is the entrainment parameterization in determining the model fingerprint?
MLM results: different entrainment parameterizations

How important is the entrainment parameterization in determining the model fingerprint?

Simplified Moeng:

Lock (as in the SCM):

Steady-states solution of Scu-topped BL
Perturbed climate (PC) set-up

Steady-states solution of Scu-topped BL

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RACMO SCM: PC results

Steady-states solution of Scu-topped BL
RACMO SCM: PC results

Steady-states solution of Scu-topped BL

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Conclusions and outlook

Conclusions:

▶ this framework is now ready to become a new intercomparison study for CMIP SCMs (more on Friday);
▶ specific results for RACMO SCM:
  ➔ fingerprint of the model, important role of entrainment parameterization;
  ➔ qualitative explanation with a MLM framework;
  ➔ negative cloud feedback in the Scu dominated region of the phase space;
  ➔ positive feedback in the broken-clouds region (earlier transition).
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  - fingerprint of the model, important role of entrainment parameterization;
  - qualitative explanation with a MLM framework;
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Outlook:

LESs for some of the considered experiments:
Thank you!