Using TOA fluxes by cloud type to evaluate the CanAM4

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Zonal annual mean cloud fractions

- ISCCP high cloud (1986-2005)
- ISCCP middle cloud (1986-2005)
- ISCCP low cloud (1986-2005)
- CALIPSO high cloud (2006-2009)
- CALIPSO middle cloud (2006-2009)
- CALIPSO low cloud (2006-2009)
Top of atmos. cloud radiative effect (CRE) (2000-2009)

CRE = clear-sky flux – all-sky flux

Dataset: CERES EBAF

CanAM4 Net CRE

CERES Net CRE

CanAM4 SW CRE

CERES SW CRE

CanAM4 LW CRE

CERES LW CRE

-95 W/m^2 95 W/m^2
Is TOA cloud rad. effect consistent with liq. water path?


CanAM4 is much larger in mid-lat storm tracks. Why isn't reflected solar too large?

Dataset: O'Dell, J. Climate, 2008
Compensating biases in clouds

Zhang et. al., 2005; 60S-60N
DJF, 2001-2002

$\text{CRE} = A(F_{\text{clr}} - F_{\text{cld}})$
Radiative effects by cloud type

Hartmann et. al., 1992 => ERBE and ISCCP

“We believe it will be important to verify that the net cloud radiative forcing by individual cloud types (simulated in GCMs) is as observed, as well as to verify that the total cloud forcing is realistic.”
Radiative effects by cloud type

Hartmann et. al., 1992 => ERBE and ISCCP
Chen et. al., 2000 => ISCCP + radiative transfer calculations
Webb et. al., 2001 => daily ERBE and ISCCP (July 98)
Radiative effects by cloud type: CERES and MODIS

Clear-sky

\[
\langle F \rangle = (1 - A_c) \sum_{j=\lambda_1}^{j=\lambda_2} w(j) F(j) + A_c \left( \frac{1}{N_{cl,d}} \right) \sum_{i=1}^{i=N_{cl,d}} \sum_{j=\lambda_1}^{j=\lambda_2} w(j) F(i, j)
\]

Cloudy-sky

Variables observable from CERES+MODIS

\[
F_{cl,d} = \sum_{m=1}^{m=M} A_{c,m} F_{cl,d,m}; F_{cl,d,m} = \frac{1}{N_{cl,d,m}} \sum_{i=1}^{N_{cl,d,m}} \sum_{j=\lambda_1}^{j=\lambda_2} w(j) F(i, j)
\]

Case of M=3 with vertical boundaries matching ISCCP
An example from a CloudSat/CALIPSO cross-section

Complete dataset (cloud props + radiation) give more information
Uncertainty about underlying clouds due to passive observations
- active observations are needed for profile info
Compensating biases in clouds: CanAM4 Results

July 2001-2005 60°S-60°N

Cole et. al., *J. Climate*, 2011
Relation between albedo and cloud fraction (July 1998)

\[ \alpha = (1 - A_c)\alpha_{clr} + A_c\alpha_{cld} \]

ERBE and ISCCP

ECMWF (Cycle 16r2)

Hadley Centre (HadAM4)

LMD (LMDZ 2.0)
Daily mean variations in albedo and cloud fraction

July 2001-2005 60°S-60°N
Summary

• Time mean cloud and radiation properties are similar to observations
  - Use of simulators aid in comparisons
  - Several of the biases are known and some are similar to other models

• Supplement passive cloud properties with TOA radiative fluxes by cloud-type
  - There are time-mean biases that are consistent with our expectations
  - Time means are realized in rather different ways wrt observations

• Fuller evaluation of CanAM4 using the new flux by cloud type dataset