Analyses of CAPT simulations with CAM5.5 candidate schemes based on observations in the Azores

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Motivation:

To assess CAPT simulations of marine boundary layer (BL) clouds with the CAM5.5 candidate schemes:

- CAM5.3 with CLUBB/MG2
- CAM5.3 with UNICON

Methodology

- Three sets of 5-day hindcasts from June 2009 to April 2010: Day 2 at one grid column (39.1N, 27.5W)
  - CAM5.3 control; CAM5.3 CLUBB/MG2; CAM5.3 UNICON
- Observations: ~7600 hours of observations; ~2200 hours of low-cloud only condition (30%)
- Low cloud statistics: low-cloud-only hours in both model and observation
- Case study: a two-day time period experiencing open cell clouds and closed cell clouds
Averaged cloud fraction from observed low-cloud hours

- Control simulation has the highest cloud fraction
- CLUBBMG2 and UNICON are pretty close to each other except the lower BL
**Low cloud statistics: low cloud cover**

- Very low values in UNICON low cloud cover
- UNICON gets the best correlation
- CLUBBMG2 gets the best mean cloud cover
- Negative bias in cloud cover and all-sky LWP
Low cloud statistics: in-cloud LWP

- Median
- Mean
- 25%-75%
- 9%-91%

Too few clouds, too large in-cloud LWP
Low cloud statistic: surface radiative forcing

Weaker than Obs., consistent with cloud cover and LWP biases

**Thin clouds:** among the low clouds observed in the Azores, 40% have LWP < 60 g/m² and 1/3 are with a thickness < 250 m. >50% clouds are thinner than the model layer depth.
Case study: 11/21/2009 open cell clouds

MOD021KM.A2009325.1240.005.2009325214620.hdf
Terra MODIS Truecolor Scene
Case study: 11/22/2009 closed cell clouds

(Remillard et al. 2012)
Radar observation vs. modeled cloud fraction

Cloud oscillation in CLUBBMG2 scheme

Convective cloud fraction (~3%)
Cloud/BL oscillation in CLUBBMG2

subtime step = 5 min

Cloud fraction

Water vapor tendency X10^7 (g/kg/s)

Third Moment Vertical Velocity (m^3/s^3)

subtime step = 30 sec

~2 hrs

~4 hrs
Summary:

- All schemes produce too few low cloud cover and all-sky LWP.
- On Average, CLUBB/MG2 performs slightly better in-cloud LWP simulation. UNICON produces too few cloud cover and too much in-cloud LWP. Results are consistent with global satellite analyses and CAPT global analyses.
- Low clouds simulated with all three schemes have too weak surface radiative forcing. UNICON has the weakest surface longwave radiative forcing.
- In a case study, UNICON produces convective cloud fraction (~3%) throughout the whole BL layer continuously.
- CLUBB/MG2 produces unrealistic cloud/BL oscillation, whose frequency relates to the sub-time step.
Thanks!
Supplement slides
Radar observation vs. modeled cloud fraction

Obs. cloud fraction

Radar reflectivity (dBZ)

Control Convective CLD

UNICON Convective CLD

Cloud oscillation in CLUBBMG2 scheme
Cloud surface radiative forcing