Atmospheric Variability in CESM1.5 at Daily and Higher Time Frequencies

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Simulations and output

- **Simulations (1850 controls)**
  - Large-ensemble *(CESM1-LENS)*
  - Simulation ’28’ of **CESM1.5** development

- **Analysis**
  - 10 years of output
  - 3-hourly, 6-hourly and daily analyses
  - Atmosphere, single level variables only

- **New model version**
  - LENS + (CLUBB, Microphysics (MG2), Aerosols (MAM4))
What are we looking at?

- **Precipitation statistics**
  - Variance/standard deviation
  - PDFs (frequency, rate contribution)
  - Diurnal cycle (phase and amplitude)

- **Equatorial wave modes**
  - Madden Julian Oscillation (MJO)
  - Equatorial wave mode variance
  - Power, frequency
  - Regional characteristics

- **Blocking**
  - Frequency, location
Mean Precipitation (DJF, mm/day)

- Strong rainfall
- Double ITCZ
- Weak Amazon
- Orographic precip. large
Precipitation Standard Deviation (DJF, mm/day)

- Weak variance
- Locally high
- ITCZ better
Mean Precipitation (JJA)

- Strong rainfall
- Better SPCZ
- W Pacific maxima gone
- Better E. Pac ITCZ
- Monsoon maxima
- Worse Atlantic
- Venezuela max!
Precipitation Standard Deviation (JJA)

- Weak variability
- Particularly in Monsoon region
- Better in E. Pac
- Tibetan maximum
Mean Outgoing LW Radiation (DJF, mm/day)

- Strong OLR in oceanic dry and descending regions
- Too moist?
OLR Standard Deviation (DJF, mm/day)

Standard deviation - TOA Outgoing Long-Wave (W/m²) - DJF

- Stronger variability
- Opposite to precip.
- Cloud field and convection linkages
- Surprising, given different cloud schemes
OLR Standard Deviation (JJA, mm/day)

Standard deviation - TOA Outgoing Long-Wave (W/m²) - JJA

- Stronger variability
- Very high over India
US Precipitation %gps PDF (DJF) - Daily

CESM1.5

Mean = 2.41 mm/day
45.6% 57.3%

CESM1 (LENS)

Mean = 2.16 mm/day
Mean = 2.21 mm/day
45.6% 39.0%
US Precipitation % rain PDF (DJF) - Daily

**CESM1.5**

- Mean = 2.41 mm/day
- Mean = 2.16 mm/day

**CESM1 (LENS)**

- Mean = 2.41 mm/day
- Mean = 2.21 mm/day

Rainfall rate bins (mm/day)

- CESM1.5
- TRMM (1 deg)

Rainfall rate bins (mm/day)

- CESM1 (LENS)
- TRMM (1 deg)
US Precipitation %gps PDF (JJA) - Daily

**CESM1.5**

- 44.6%
- 62.4%
- Mean = 2.39 mm/day

**CESM1 (LENS)**

- 44.6%
- 40.8%
- Mean = 2.37 mm/day

Rainfall rate bins (mm/day)

% of total gridpoints.

- CESM1.5
- TRMM (1 deg)

- CESM1 (LENS)
- TRMM (1 deg)
US Precipitation % rain PDF (JJA) - Daily

CESM1.5

Mean = 2.39 mm/day
Mean = 2.04 mm/day

CESM1 (LENS)

Mean = 2.39 mm/day
Mean = 2.37 mm/day

% of total rainfall

Rainfall rate bins (mm/day)

CESM1_5
TRMM (1 deg)

Rainfall rate bins (mm/day)

CESM1 (LENS)
TRMM (1 deg)
Precipitation Diurnal Cycle (DJF)

TRMM (2001-2010)

CESM1_5 (1-10)

CESM1 (LENS) (1-10)
Precipitation Diurnal Cycle (JJA)
US Precipitation Diurnal Cycle (JJA)

(a) TRMM (2001-2010)

(b) CESM1_5 (1-10)

(c) CESM1 (LENS) (1-10)

mm/day

0 0.25 0.5 0.75 1 1.25 1.5 1.75 2 2.25 2.5 3 3.5 4 4.5 5 7.5
US Precipitation Diurnal Cycle (JJA)

(a) TRMM (2001-2010)

(b) CESM1_5 (1-10)

(c) CESM1 (LENS) (1-10)
Equatorially trapped wave modes (symmetric)

Kelvin Waves
Rossby Waves
Inertio-Gravity Waves
Madden Julian Oscillation
Topical Wave-Number Frequency Variance - Rainfall

CESM1.5

CESM1 (LENS)

Frequency (cpd)

Zonal Wave Number

Westward
Symmetric/Background
Eastward

0.5
0.4375
0.4375

0.375
0.375

0.3125
0.3125

0.25
0.25

0.1875
0.1875

0.125
0.125

0.0625
0.0625

0
0

15
10
5
0
-5
-10
-15
-30 days
-30 days

h=12
n=1 IG
Kelvin

h=12
n=1 IG
Kelvin

3 days
3 days

6 days
6 days

30 days
30 days

1.6
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.0
0.9
0.8
0.7
0.6
Equatorially trapped wave modes

Rainfall (TRMM)

Kelvin Waves
Eq. Rossby Waves
Inertio-Gravity Waves
Madden Julian Oscillation

Community Earth System Model
CESM Joint Working Groups 2016
Topical Wave-Mode Variance (OLR) – MJO (DJF)
Topical Wave-Mode Variance (OLR) – Kelvin (DJF)

NOAA

CESM1.5

CESM1 (LENS)
TRMM  

Rainfall

CESM1/CAM5.5

dmpdz/10

dmpdz*10

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Community Earth System Model

CESM Joint Working Groups 2016
Blocking Frequency (daily 500mb height, 50N)

DJF Blocking frequency

MAM Blocking frequency

W. Europe  N. Pacific

Blocking frequency (%)
Summary

- **Overall sub-seasonal variability weak (weaker in CESM1.5)**
- **Tropical variability:** Weak rainfall, strong OLR (Clouds)
  - Wave mode variance lower in CESM1.5
  - Kelvin waves and MJO have reduced strength in CESM1.5
  - Known deep convection sensitivities: Negative impacts on mean/dcycle
- **Rainfall PDF**
  - Good distribution in DJF; JJA too many weak and too few intense events
  - Indonesia: Too few dry days, CESM1.5 more dry days
- **Diurnal cycle**
  - Timing over land later everywhere (12pm -> 5pm, obs. 8pm)
  - Amplitude weakens
  - JJA US MCSs still absent
- **Atmospheric Blocking**
  - Similar behavior: CESM1.5 some Greenland increases
  - Updates to surface drag formulation may provide changes
Questions?
Precipitation Diurnal Cycle (DJF)

TRMM (2001-2010)

CESM1_5 (1-10)

CESM1 (LENS) (1-10)

mm/day
Precipitation Diurnal Cycle (JJA)

TRMM (2001-2010)

CESM1_5 (1-10)

CESM1 (LENS) (1-10)
Maritime Continent Precipitation PDF (DJF) - Daily

**CESM1.5**

- Mean = 2.41 mm/day
- Mean = 6.36 mm/day

**CESM1 (LENS)**

- Mean = 2.41 mm/day
- Mean = 6.37 mm/day
'Maritime Continent Precipitation PDF (DJF) - Daily'

**CESM1.5**

- 45.6% of grid points: 2.41 mm/day
- 25.7% of grid points: 6.36 mm/day

**CESM1 (LENS)**

- 45.6% of grid points: 2.41 mm/day
- 8.9% of grid points: 6.37 mm/day

Rainfall rate bins (mm/day)

- CESM1.5
- TRMM (1 deg)

- CESM1 (LENS)
- TRMM (1 deg)
Blocking Frequency (DJF, daily 500mb height, 50N)
Topical Wave-Number Frequency Variance - OLR

CESM1.5

CESM1 (LENS)
Topical Wave-Number Frequency Variance

Rainfall

Outgoing LW Radiation (TOA)