Status of WACCMM
CESM2 (WACCM6)

- High-top atmospheric component of CESM2 (0.95° x 1.25° horizontal resolution, 70L)
- Orographic, frontal and convective GW parameterizations (orographic parameterization completely updated). New PBL drag
- Prognostic aerosol parameterization (MAM4)
- 2° version now available as part of CESM2.1.1 release (paleo simulations; basis for building WACCM-X, etc.)
- New boundary layer physics; shallow convection scheme (CLUBB)
- JPL-15 chemistry; updated TSMLT scheme; other chemistry options available (MA, MA-D)
- Volcanic aerosols from Neely and Schmidt (2016) database
- SOA from Tilmes et al. (JAMES, 2019) Volatility Basis Set (VBS) scheme
- CMIP6 wavelength resolved solar variability specification
- Can generate a QBO internally (with some caveats; see later)

details: Gettelman et al., 2019: *JGR* 124, 12,380-12,403, https://doi.org/10.1029/2019JD030943
# WACCM6 configurations and cost

## Table 2

<table>
<thead>
<tr>
<th>Name</th>
<th>WACCM6</th>
<th>WACCM6-SD</th>
<th>CESM2-WACCM6 Coupled</th>
<th>CESM2-WACCM6 Coupled</th>
<th>WACCM6-SC Specified Chemistry</th>
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<td>Specified Dynamics</td>
<td>1850 Control</td>
<td>Historical</td>
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<td>FWsCHIST</td>
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<td>21,000</td>
<td>27,000</td>
<td>30,000</td>
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</table>

Gettelman et al. (JGR 2019)
Climatological fields

Gettelman et al. (JGR 2019)
SSW climatology

- Annual frequency is good; seasonal distribution has **too many late SSW**

Gettelman et al. (JGR 2019)
long-term $O_3$ evolution

- Excellent simulation of $O_3$ hole development and incipient recovery
- Overestimates tropical $O_3$ by about 6-8%

Gettelman et al. (JGR 2019)
H$_2$O “tape recorder” signal

- Tape recorder a bit too fast
Stratospheric volcanic aerosols

Gettelman et al. (JGR 2019)
global-mean T vs. observations

WACCM6 AMIP vs. satellite data

• Note good volcanic response and solar-cycle signal

Gettelman et al. (JGR 2019)
WACCM6 historical simulations

Gettelman et al. (JGR 2019) referenced to 1950-1980
WACCM6 small-ensemble scenarios

- Completed members 3, 4, & 5 for SSP5-8.5 and SSP2-4.5, 2015-2100
- 003: initialized from historical 003, 2015-01-01
- 004: historical 002 atmosphere, 001 other components
- 005: historical 003 atmosphere, 002 other components

- SSP5-3.4OS members 3, 4, & 5, 2040-2100
  - Branched from SSP5-8.5 members, 2040-01-01.
  - 003, 004 & 005: completed

Results from NSC project: SSP5-8.5, SSP2-4.5 and SSP5-3.4OS now available.

Plot by M. Mills
2° version of CESM2 (WACCM6)

- 2° version of WACCM6 now available
- DECK simulations performed
- Historical Tₜ consistent with 1° models
climate sensitivity vs. CAM6

plot by M. Mills
QBO and standard vertical resolution (70L)

Gettelman et al, (JGR 2019)
QBO and high-vertical resolution (110L)

- Results from WACCM5.4, 110L
- Similar results can now be obtained with WACCM6
more on vertical resolution

- Fine vertical resolution makes a difference outside the Tropics in the Japanese model
Future choices

• WACCM6 is expensive to run (~ 10 x CAM6)
• Most of the expense is due to chemistry (~ 5 x); the rest (~ 2 x) is due to additional levels in WACCM (32L vs. 70L standard)
• Chemistry is necessary to provides radiative and oxidant fields for CAM (or for SC-WACCM); this expense cannot be avoided unless CESM wants to outsource these calculations
• Higher vertical resolution is required to address stratospheric physics (→ more levels; a linear in crease in cost)
• Higher resolution above the tropopause may not be of interest to CAM ...
• It might be desirable not to have to maintain multiple CESM models. Is it possible to do so given the above considerations?