<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Presentation Title</th>
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<tbody>
<tr>
<td>8:30 a.m.</td>
<td>Mike Mills</td>
<td>State of the WACCM</td>
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<tr>
<td>8:45 a.m.</td>
<td>Doug Kinnison</td>
<td>Status of chemistry for CMIP6</td>
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<tr>
<td>9:00 a.m.</td>
<td>Dan Marsh</td>
<td>Overview of solar forcing recommendations for CMIP6</td>
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<td>9:15 a.m.</td>
<td>Chuck Bardeen</td>
<td>Improvements in the representation of UTLS water vapor from changes to ice microphysics in WACCM5.5</td>
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<tr>
<td>9:30 a.m.</td>
<td>Yaga Richter</td>
<td>Simulations with high vertical resolution WACCM for QBO Intercomparison Project</td>
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<td>9:45 a.m.</td>
<td>Josh Pettit</td>
<td>WACCM studies in the CU Middle Atmosphere Group</td>
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<td>10:00 a.m.</td>
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<td>Break</td>
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<tr>
<td>10:30 a.m.</td>
<td>Sasha Glanville</td>
<td>Stratospheric transport and ozone fluxes resulting from different QBO widths in WACCM</td>
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<tr>
<td>10:45 a.m.</td>
<td>Drew Rollins</td>
<td>Constraining the stratospheric sulfur budget using in-situ SO2 measurements and WACCM</td>
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<tr>
<td>11:00 a.m.</td>
<td>Yunqian Zhu</td>
<td>The simulation of polar stratospheric clouds within WACCM / CARMA model</td>
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<tr>
<td>11:15 a.m.</td>
<td>Yunqian Zhu</td>
<td>WACCM studies in the CU Toon Aerosol Research Group</td>
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<tr>
<td>11:30 a.m.</td>
<td>Co-chairs</td>
<td>WACCM plans and discussion</td>
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<tr>
<td>12:00 p.m.</td>
<td></td>
<td>Adjourn</td>
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The State of WACCM (6)

Mike Mills: CESM WAWG Liaison
Andrew Gettelman: NCAR co-chair
Lorenzo Polvani: External co-chair
& the ‘WACCM Team’

Whole Atmosphere Working Group
CESM Workshop, Breckenridge
June 21, 2016
Summary of Current Work

• Overview and Current updates
  – WACCM6 Development
  – WACCM6 for CMIP6
• Stratospheric aerosol & volcanic eruptions
• CCMI Simulations (see Kinnison talk)
• Last Millennium WACCM with CAM5 simulation
  – Solar-only (850-2005CE) and 850CE control complete
• WACCM-DART (Data Assimilation)
• WACCM-X 2.0 Update
WACCM Updates since February

• Fully integrated WACCM and CAM physics
  – Updated to CAM6 physics (CLUBB, MG2)
  – Update to ice nucleation: corrected stratospheric humidity, better SAD ice in polar vortex
  – Working with new momentum forcing (orographic Gravity Waves, no TMS)

• Updated Chemistry
  – Vectorized: 5-10% speedup
  – Updating photochemical rates with JPL 2015

• Further tested volcanic aerosols for CESM2
  – Prognostic aerosols may require full chemistry (i.e. prescribe in CAM and SC-WACCM). Likely need interactive OH.

• WACCM-X updated, close to version 2.0
WACCM6 Status

- Integrated WACCM with CAM6 physics
- Currently running:
  - 1850 coupled, full chemistry
  - 1979-present, atmosphere only, specified chemistry
  - Climatology looks ‘okay’
  - Will need some gravity wave tuning before release: do with Specified Chemistry first.
- Also need to run with Specified Dynamics to check chemistry
- Then combine to do interactive. Will do soon.
- Good progress for CESM2
  - Aiming for code freeze by September.
Current WACCM6 Status (T)

Current WACCM6 Status (U)

Discussion: Issues

• What chemistry will we use?
  – E.g.: New SOA chemistry = +5%
  – Need to make a decision with Chemistry-Climate Group.

• Need to combine simulations to get to fully interactive
  – (SC = GW tuning, SD = Chemistry checks)
WACCM for CMIP6

WACCM6 will be part of several MIPs for CESM6

- DynVar (Dan Marsh Leading)
- VolMIP (Mike Mills)
- ISA-MIP: Interactive Strat Aerosols (Mike Mills)
- AerCOM (Simone, Mike, Andrew)
- Others?

Runs planned in 2017
Volcanic eruptions since 1990

- Volcanic eruptions increasingly well characterized (Satellite retrievals, in-situ measurements, geochem. & geophys. monitoring)
- 1979 first TOMS volcanic SO$_2$ retrievals
- Compiled volcanic emission dataset for use in climate models

Reported eruptions, Smithsonian Global Volcanism Program
Volcanic eruptions since 1990

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- 1979 first TOMS volcanic SO₂ retrievals
- Compiled volcanic emission dataset for use in climate models

Database: 42 volcanoes, 52 eruptions, 171 days of eruption

<table>
<thead>
<tr>
<th>Period</th>
<th>SO₂ Emission (Tg)</th>
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<tr>
<td>1990-1994</td>
<td>12.85</td>
</tr>
<tr>
<td>1995-1999</td>
<td>0.93</td>
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<tr>
<td>2000-2004</td>
<td>0.93</td>
</tr>
<tr>
<td>2005-2009</td>
<td>7.56</td>
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<tr>
<td>2010-2015</td>
<td>8.55</td>
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Northern mid-latitudes

Prognostic stratospheric aerosols with volcanic SO$_2$ database match lidar observations well.
Northern mid-latitudes

Prognostic stratospheric aerosols with volcanic SO$_2$ database match lidar observations much better than existing climatologies.
Data assimilation: WACCMM+DART Status

- WACCMM+DART assimilates standard lower atmosphere observations and SABER and MLS (up to ~100km)
- Completed one year (2007) WACCMM+DART run (40 members). Model results have been used to study tidal and planetary wave variability.
- WACCMM-X+DART is currently under development.
WACCM+DART can better capture aspects of the dynamical variability of the MLT compared to SD-WACCM. An example is the elevated stratopause after SSWs, which has impacts on NO descent.
Latest WACCM-X Results
Comparing Equatorial O and T @ Solar Max

Equatorial [O]

Equatorial T

Good agreement with observations and an empirical model

Observations
Empirical Model

WACCMX, Smax Noy (F107=200, kp=0.3)

WACCMX, Smax Noy
Observations
Empirical Model

1/cm3
Z(km)

K
Z(km)

1.72x468.png

Courtesy of Bob Meier
Comparison with COSMIC 2008 Jan-Feb

Peak ion density looks good compared to observations.

Courtesy of Jing Liu
WACCM-X Summary

• The WACCM-X thermosphere and ionosphere compare well with observations/climatology.

• WACCM-X 2.0 will be released in CESM2 with WACCM4 physics.
  — Try it out when it’s released.
Current WACCM-X Development

- Implementation and testing of Helium.
- Prepare for CESM2.0 release (scheduled for December 2016), which will include WACCM-X with the aforementioned features.
- WACCM-X/AMIE.
- WACCM-X Data Assimilation (DART).
Summary/Plans

• Release WACCM6 and WACCM-X2.0 with CESM2

• Perform CMIP6 experiments with WACCM

• Continue WACCM-X integration
  – Get consistent with WACCM6 physics.

• Do more good science!