The VOCALS Assessment (VOCA)

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VOCA modeling groups (without which there’s nothing to say)
Pre-VOCA compared 15 regional, weather forecast, and climate models (in forecast mode) for October 2006 in the VOCALS region.

- Many models had large errors in distribution of low cloud cover, though ECMWF and UKMO performed well.
- Most models produced a marine BL too shallow near the coast at 20°S.
- Most models qualitatively captured diurnal and day-to-day variability of the cloud and BL despite mean biases.
- Global models outperformed most regional models.
The VOCALS Assessment (VOCA): Motivations

• Make use of extensive REx in-situ aircraft/ship datasets
• Emphasize chemical/aerosol transport, cloud-aerosol interaction.
• Do models simulate the variation of droplet concentration $N_d$ along 20S?
• Is anthropogenic sulfate the main contributor to geographic $N_d$ variation?
• What controls $N_d$ in remote ocean regions?
• What is the simulated indirect effect due to anthropogenic aerosols perturbing clouds and net TOA radiative flux in the VOCALS domain?
VOCA Overview

- Similar protocol to PreVOCA.
- Aerosol Species: \( \text{SO}_4 \), sea salt, dust, black carbon, organic carbon
- Gas Species: \( \text{SO}_2 \), DMS, CO, \( \text{O}_3 \)
- Emissions of aerosol and gas species are specified in a standard protocol for regional models.
- Compare aerosol and gas concentrations to in-situ measurements.
- Compare cloud-top effective radius with satellite.
- Geoengineering experiment: Set \( N_d = 375 \text{ cm}^{-3} \) everywhere.
- Initial results are coming in now.
## Participating Models

<table>
<thead>
<tr>
<th>Center or Group</th>
<th>Model</th>
<th>(Regional or Global)</th>
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<tbody>
<tr>
<td>PNNL</td>
<td>WRF-Chem</td>
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<tr>
<td>U. Iowa</td>
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<td>ECMWF</td>
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<td>UK Met Office</td>
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<td>CAM4 and CAM5</td>
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<td>UWiscM</td>
<td>WRF-CLUBB</td>
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Monthly-mean results (16 Oct – 15 Nov 2008)

Low cloud fraction

[Various models' data visualizations showing cloud fraction maps across different regions]
Liquid water path [g m$^{-2}$]
In-situ on 20S: 0.1-0.5 mm/d at 80-85W, negligible at 70-75W (Breth et al. 2010).
Specified aerosols

ECMWF1 Low Cloud

Interactive aerosols

ECMWF2 Low Cloud

ECMWF1 LWP [g m\(^{-2}\)]

ECMWF2 LWP [g m\(^{-2}\)]
Mean 20S cloud fraction cross-section

Bretherton et al. 2010

Inv too low at coast: CAM5, GFDL, UKMO

Inv somewhat low offshore: GFDL, CAM5
Mean 20S sulfate cross-sections

PNNL AERO SO4, kg/kg

UKMO AERO SO4, kg/kg

ECMWF 2 outer SO4, kg/kg

GFDL AERO SO4, kg/kg

CAM5 SO4, kg/kg

Boundary layer

PNNL, ECMWF good

FT obs

Allen 2011
Mean 20S sea-salt cross-sections

- Do we have suitable VOCALS observations?
- Caveat: number is as important as mass.
Mean 20S DMS cross-sections

PNNL AERO DMS, kg/kg

GFDL AERO DMS, kg/kg

CAM5 DMS, kg/kg

PNNL much too high, CAM5 and GFDL somewhat high
Caveat: observations don’t cover the diurnal cycle
Mean 20S CCN (0.1\%) cross-sections

Model CCNs mostly too low near coast (except UKMO). GFDL too low everywhere.
Mean 20S $N_d$ cross-sections

Huge differences
- GFDL very low,
- CAM and PNNL have strange profiles,
- UKMO may include clear air

Surprisingly different from CCN fields

Is model output really the mean in-cloud $N_d$?
Temporal variability

Models pick up pollution peaks associated with offshore flow, but mean biases are overwhelming (except PNNL).
Conclusions

• VOCA is a stringent observational test of model-simulated clouds and aerosol-cloud interaction in SE Pacific.
• Results presented here are still preliminary!
• The comprehensive REx dataset indicates a diverse set of parameterization issues in all models, hopefully pointing the way to an intensive phase of model improvement.
Emissions Inventory (Scott Spak)

- SO$_2$, VOCs, CO
- CONAMA Chilean Inventory point sources, municipal mobile, residential sources
- SO$_2$ Peruvian smelters and volcano estimates from OMI PBL SO$_2$
- Inclusion of daily biomass emissions using MODIS detection of fires from C. Wiedinmyer is being investigated.
SO$_2$ Point Sources

mt/year

- $10^6$
- $10^5$
- $10^4$
- $10^3$
- $10^2$
- 10
VOCALS: A CLIVAR study of SE Pacific cool ocean/Sc region.

REx: Large field expt off N Chile - Oct.-Nov. 2008
- cloud/aerosol/land interactions
- role of mesoscale ocean eddies