SPARC/DCPP Volcanic Response Readiness Exercise

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Motivation

- A major volcanic eruption like Pinatubo in 1991 would invalidate WMO’s current annual to decadal forecasts.

- DCPP has drawn up Guidelines for climate forecasts after sudden volcanic eruption describing two potential response protocols.

- Responding to a hypothetical volcanic eruption will increase readiness of LC-ADCP contributors and support more durable documentation via a journal paper.

- By going through exercise, will confront any unanticipated issues not covered in Guidelines.

- Potentially could select one of two proposed response protocols.

- Will highlight any major disagreements between prediction systems and motivate efforts to reconcile them.

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**1990 mean temperature**

**before Pinatubo**

**after Pinatubo**

**1992 mean temperature**

*1991-2020 percentile, ERA5*
1) Provision of Emission Profiles
   • SPARC/SSiRC VolRes initiative will gather available data to provide best estimate of volcanic emission profile (SO$_2$ and injection height) after a major eruption

2) Generation of Input Files for Global Climate Models
   • Easy Volcanic Aerosol (EVA) module (Toohey et al., GMD 2016) can generate input model forcing inputs e.g. for aerosol optical depth

3) Multi-year Multi-model Forecasts after a Volcanic Eruption
   • Rerun forecasts with new forcing files to represent the volcanic impacts
Experiments

- Centres will repeat 2022-2026 forecasts two protocols outlined in DCPP Guidelines:

  **Protocol 1:** Rerun 2022-2026 (or 2022-2031) forecast from normal initial date with volcanic forcing inserted

  **Protocol 2:** Run pair of forecasts (with and without forcing) from start of month of eruption, consider difference (don’t need corresponding hindcasts)

- Data request same as for LC-ADCP submissions: monthly tas, pr, psl (ts, siconc, AMOC optional)

- Total simulation time = 15 (or 30) years x ensemble size
The hypothetical eruption

- Eruption occurs in **April 2022** in southern Mexico
- ~2× stratospheric sulfur injection of Pinatubo (16 TgS)
- Impacts weighted in Northern Hemisphere

## Participation

- Currently, 9 models have contributed Protocol 1 forecasts, 7 have contributed Protocol 2 forecasts:

<table>
<thead>
<tr>
<th>Centre</th>
<th>Model</th>
<th>Init time** P1(P2)</th>
<th>Range (y)</th>
<th>Ens size (H/F)</th>
<th>Fcst type</th>
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<tbody>
<tr>
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<td>CanCM4i</td>
<td>2022-01(2022-04)</td>
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<td>10/10</td>
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<td>MRI*</td>
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*Contributed to LC-ADCP 2022-2026 forecast    **All systems initialized on 1st day of indicated month
Protocol 1 results – 2022-2026 tas

Multi-model average

Anomalies from 1991-2020 (°C)
Next steps

- Assess content and value of Protocol 2 forecasts
- Analyses of SST, sea ice, AMOC
- Follow up with centres about lessons learned and/or suggestions for improving the process
- Incorporate MRI results when available
- Develop BAMS article, with co-authors from all participating groups
  - Background, motivation and description
  - Model results
  - Lessons learned and recommendations for operational response
Extra slides
Protocol 1 results – global mean tas 2022-2026

Multi-model average
Protocol 1 results – 2022 tas

Multi-model average

Anomalies from 1991-2020 (°C)
The hypothetical eruption

- Eruption occurs in **April 2022** in southern Mexico
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**Comparison to CMIP6 historical forcing**

**Comparison to Mt Pinatubo**

Lessons learned (preliminary)

• **EVA vs EVA_H**: EVA_H has height-dependent injection (unlike EVA) and performs better for recent smaller eruptions (Aubry et al. JGR 2019). However, the associated Volc2Clim webtool as configured could not provide forcings for IR wavelengths.

• **Impediments**: Models whose representation of volcanic aerosols does not align with CMIP practices could not readily ingest EVA-generated forcings. This precluded NCAR and CMCC (which uses CAM5) from participating.

• **Volcanic forcing expertise**: Participating centres had little difficulty generating and implementing forcings from EVA. However, these centres mostly applied their own models and were CMIP contributors. Centres using “borrowed” atmospheric components or not having CMIP expertise may find implementing volcanic forcings less straightforward.

• **“Practice”**: By undertaking this (nearly) end-to-end exercise, various minor glitches, e.g. in provided forcings and running from a modified start date were identified and ironed out, increasing readiness to respond to a real event.