Guidelines for climate forecasts after sudden volcanic eruption

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Introduction:

Past large volcanic eruptions have shown significant climate impacts on continental scales and in the oceans years after (e.g. Stenchikov et al 2009; Otterå et al 2010; Maher et al 2015; Fischer et al 2007). Volcanic eruptions have also been identified to play a major role for climate predictions and can affect forecast skill on a global and regional scale (Timmreck et al., 2016; Bellucci et al 2015; Meehl et al., 2015). Given the current threat of a sudden volcanic eruption such as Mt. Agung, we propose a coordinated multi-model effort to predict the climate evolution five years ahead following the next major eruption. This will use measurements of volcanic aerosols coordinated by WCRP SPARC SSiRC (Stratospheric Sulphur and its Role in Climate) together with multi-model multi-year climate forecasts developed by the WCRP Grand Challenge on Near-Term Climate Prediction (GC-NTCP) and by the WCRP Decadal Climate Prediction Panel (DCPP) (Smith et al., 2013, Boer et al., 2016).

1.) Provision of Emission Profiles

The WCRP SPARC SSiRC activity (http://www.sparc-ssirc.org/) has started an initiative called VolRes "Volcano response plan after the next major eruption" to prepare a plan for the next major volcanic eruption[1]. This plan aims to raise the science questions behind the chemical and climate impacts of large volcanic eruptions to define measurement and modeling strategies which will augment our knowledge and can be used to forecast and mitigate their impacts. The activity is lead by Jean Paul Vernier (jeanpaul.vernier@nasa.gov) and Claudia Timmreck (claudia.timmreck@mpimet.mpg.de). Email list: ssircvolcano@mpimet.mpg.de. At present a wiki domain to post info and enhance interaction regarding VolRes is currently under construction https://wiki.earthdata.nasa.gov/display/volres.

VolRes includes members from several observational groups all-around the world encompassing remote and in situ measurements of aerosols and aerosol precursor gases. VolRes will collect and gather all available information to generate a comprehensive dataset of the volcanic aerosol forcing and provide the best possible estimate of the volcanic emission profile (SO_2 and injection height) after a major volcanic eruption.

[1] Also : https://www.researchgate.net/project/Response-Plan-to-a-Major-Volcanic-Eruption

2.) Generation of Input Files for Global Climate Models

Emission profiles (amount of SO_2, injection height) need to be fed into global aerosol models to generate the input forcing files for global climate models, such as aerosol optical depth. One possibility is to use the EVA (Easy Volcanic Aerosol) module (Mathew Toohey, et al, 2016), which is freely available and can be easily adapted for climate models. EVA is tuned to a tropical Pinatubo like (or larger) eruption. Smaller and extratropical eruptions might therefore be overestimated but probably in the range of uncertainties. Alternatively, individual global aerosol models can be used, which allow a more realistic aerosol distribution with respect to e.g., the height of the eruption or the QBO. The modelling groups are encouraged to generate the forcing files after the following priorities:

Priority 1: Using EVA, aerosol models or idealized alternatives. This it to give the modelling groups maximum flexibility and being ready for operation

Priority 2: Using EVA (in case not used before). This is to have a common as possible experiment design and to reduce uncertainties due to the production of the forcing data

3.) Multi-year Multi-model Forecasts after a Volcanic Eruption

Multi-year multi-model forecasts will be run following a sudden volcanic eruption using the volcanic measurements described in section 2. Forecasts should be run with and without the new forcing files to examine the volcanic impacts. For the initial dates of the forecasts the following priorities should be considered:

Priority 1: The initial date is the same as the last forecast (e.g. Nov). This is to be as close as possible to the current setup of operational forecasts, and to be able to use hindcasts for post-processing (e.g. bias correction)

Priority 2: The initial date should be no longer than one month before the onset of the volcano. This is to stay as close as possible to the current observed basic state, but leaves enough time to prepare initial conditions (e.g. by waiting for reanalyse and performing assimilation experiment). This does not necessarily need a full hindcast set since the volcanic response can be diagnosed from forecasts with and without the volcano.

The same initial conditions should be used for the forecasts with and without the new forcing files. Ideally atmosphere and ocean initial conditions should be used.

A minimum of 10 ensemble members with 5 year forecast length should be performed. However, we encourage modelling groups to increase the ensemble size to account for the internal variability which can easily overwhelm the dynamical responses (Khodri et al., 2017, Ménégoz et al., 2017). We suggest multiples of 10 members (20, 30, …) dependent on the available computing resources.

Currently, groups that are interested in running the experiments are: MetOffice, MPG, BSC, CCCma. The recommended output variables should be stored as the standard DCPP variables (Boer et al 2016).

In practice, DCPP in collaboration with SPARC SSiRC Volres will undertake to decide when a coordinated volcano experiment is likely to be rewarding and will communicate to the community via email.

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