Lessons from Tambora

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In April 1815, the Indonesian volcano Tambora awakened. The main eruption phase starting on 10 April was one of the strongest in recent history. It devastated the island of Sumbawa and killed thousands of people. In the following year, the eruption led to global cooling and to climatic changes in the tropics, Europe, and North America. Disease and famine claimed tens of thousands of lives (Oppenheimer 2003).

Among the most affected regions was Switzerland, where the cold and rainy summer of 1816 contributed to the last famine. Two hundred years later, on 7-10 April 2015, about 130 scientists gathered in Bern, Switzerland, at an international conference co-funded by PAGES. Even after 200 years, science can learn from analyzing the Tambora eruption and its climatic and societal consequences. However, this requires a comprehensive Earth System perspective (Fig. 1). Correspondingly, the participants came from a broad range of fields, encompassing volcanology, atmospheric physics and chemistry, biogeochemistry, dynamical climatology, paleoclimatology, history, ethnology, and the arts. Only with such combined expertise can the event and all its consequences be understood.

The individual sessions touched on all these aspects. During the 1815 eruption, 30-50 km^3 equivalent of dense-rock material was ejected (Self et al. 2004). Around 60 Tg of SO_2 reached the stratosphere and formed sulphate aerosols; the cause of the subsequent climatic changes (see SPARC Newsletter 45, 2015, for a conference summary focusing on stratospheric aspects). The hemispheric distribution of aerosols is poorly constrained, although the time of year suggests that the major part went to the Southern Hemisphere. Globally, the top-of-atmosphere radiative forcing of the eruption equaled 5 Wm^{-2} (Timmreck 2012). The sulphate ultimately entered the troposphere and can be traced in ice cores. The dating of the cores as well as the quantification of sulphur deposition are areas of substantial recent methodological improvement. As to the ability of tree rings to capture volcanic cooling, several contributions showed a clear signal over northern Eurasia. However, it remains unknown why a cooling signature, although well documented in the Northern Hemisphere, is not seen in proxies from the Southern Hemisphere (Neukom et al. 2014).

Several speakers highlighted the Tambora eruption in the context of other strong eruptions of the past millennium. Hubertus Fischer, PAGES Co-chair, explored the interest in the community to engage in a PAGES volcanic forcing working group (PAGES has subsequently launched the VICS working group - www.pages-igbp.org/ini/wg/vics).

Reconstructions allow the climate in Europe (and increasingly also other regions) in 1816 to be analyzed. The strongest cooling is found in Western Europe, while data sources disagree on temperatures in Eastern Europe. In the North Atlantic-European sector, sub-daily instrumental observations suffice to address changes in weather and atmospheric circulation. For instance, a dynamical reanalysis of 1815-1817 within the "Twentieth Century Reanalysis" framework was presented (Gilbert Compo, Univ. Colorado/CIRES-NOAA, USA; Philip Brohan, Met Office, UK). Low-pressure weather types and increased cyclonic activity dominated over western France and Switzerland (Auchmann et al. 2012) and caused increased precipitation. For the tropics, information is scant and the effects on the Asian monsoon remain unclear.

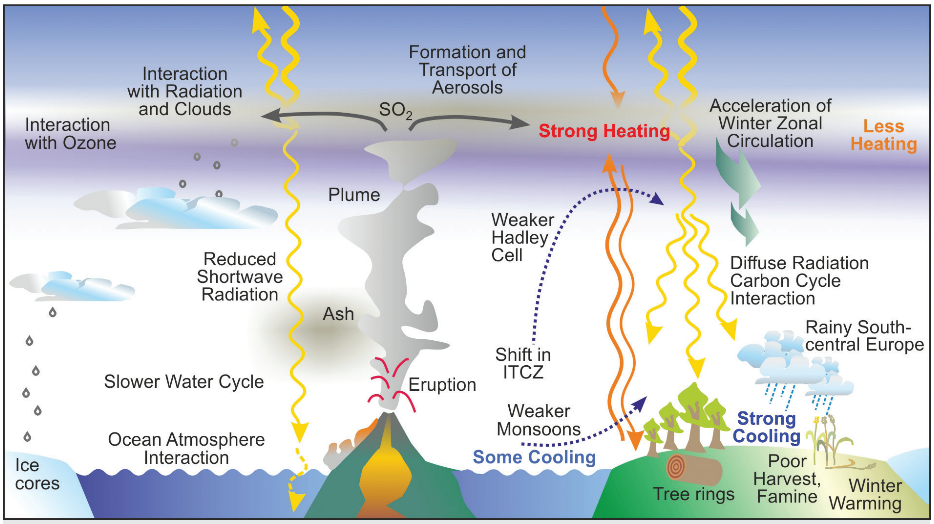

Figure 1: An Earth system perspective of the 1815 Tambora eruption and its consequences.

In Europe, the summer of 1816 fell into a period of declining temperatures, perhaps in part due to the unknown eruption of 1808 (but solar activity was also weak). Several presentations highlighted the particularly strong effect of double eruptions. In this context, the role of the ocean was also addressed.

Model studies find strong global cooling and stratospheric warming as well as a weakening of the monsoons after Tambora (Kandlbauer et al. 2013). In fact, the weakened African monsoon is a possible cause of rainy summers in South-Central Europe following strong eruptions due to a weakened Hadley circulation, weak subtropical highs, and an altered North Atlantic storm track (Wegmann et al. 2014). Proxies also reveal changes in tropical precipitation after volcanic eruptions, which are interpreted as changes in the Intertropical Convergence Zone.

Tambora also affected the carbon cycle; however, the relative roles of changes in precipitation, temperature, and diffuse radiation (increasing photosynthesis) on carbon stocks remain unclear. The effect of volcanic eruptions on the carbon cycle is an interesting test of our system understanding. The conference also addressed the historical and social aspects as well as the effects on culture and arts. The combination of these aspects is attractive also for a wider audience as evidence by the extensive media coverage of our conference and the bicentenary.

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REFERENCES

Auchmann R et al. (2012) Clim Past 8: 325-335

Kandlbauer J et al. (2013) J Geophys Res 118: 12497-12507

Neukom R et al. (2014) Nat Clim Chan 4: 362-367

Oppenheimer C (2003) Prog Phys Geogr 27: 230-259

Self S et al. (2004) Geophys Res Lett 31, doi:10.1029/2004GL020925

Timmreck C et al. (2012) Quat Int 258: 30-44

Wegmann M et al. (2014) J Clim 27: 3683-3691