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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The climatic effects of the direct injection of water vapour into the stratosphere by large volcanic eruptions" *by* M. M. Joshi and G. S. Jones

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Previous reviewers have covered many good points about this interesting paper on the idea that some eruptions may inject more water into the stratosphere than others, and that this may account for discrepancies in the effects of the resulting volcanic sulfate aerosols on temperatures. These points offer some explanations, such as seasonal differences between the eruptions, for the discrepancy noted by Joshi and Jones. I here introduce another possible explanation and elaborate on a couple of volcanologic aspects that I believe make the rigorous testing of this idea rather difficult with our current state of knowledge.

Relative size and nature of Krakatau eruption products and sulphur dioxide release:

As the other reviewers and the authors point out, Pinatubo 1991 is generally accepted to have been about half the size of the Krakatau 1883 eruption, based on volume or mass of magma erupted. In both cases this is rather poorly known due to the fact that Krakatau's deposits went mainly into the sea (Self and Rampino, 1981), and extensive ash-fall occurred at sea for the Pinatubo case. But eruptive size is not a first-order control on climatic response to eruptions, and, importantly, there is virtually no rigorous constraint on the amount of sulphur dioxide released by Krakatau. It may have been equivalent to, or only slightly larger than, the release by Pinatubo despite the bigger eruptive volume. The similarity in optical depths in 1992 and 1884 perhaps suggest this (see comment by F. Prata in these reviews). The discrepancies in climatic impact noted by the authors of the paper under discussion could simply be due to this? Both Pinatubo and Krakatau erupted dacite magma, and in each case, mixing-in of basaltic magma played a role in triggering the eruption and may have introduced some sulphur into the high-level magma chamber (Pallister et al., 1996; Self, 1992). Such magma systems are usually highly oxidized and susceptible to the "excess sulphur" phenomenon (e.g., Scaillet et al., 2003). This means that petrologic studies of the erupted dacitic products and estimates of the S content and release budget yield too little S in the case of Pinatubo and, perhaps, Krakatau (Gerlach et al., 1996; Mandeville et al., 1996). In detail, however, the history of sulphur concentration in the two magma batches may have been quite different. Thus, unfortunately, this aspect of the comparison of the effects of Pinatubo and Krakatau due the amount of aerosols generated from the released sulphur dioxide gas remains elusive.

Volcanic eruption columns and injection of water vapour to stratospheric altitudes:

If Krakatau did inject an anomalous amount of water vapour into the stratosphere, then the mechanism would be by co-ignimbrite ash clouds rising off the pyroclastic flows as they entered the shallow sea (thus including both magmatic and ocean water) and immediately after deposition by explosions in the hot material (parts of the shallow

Sunda Straits were filled with new ignimbrite deposits, see Self, 1992), as suggested by reviewer L. Glaze. How much "extra" water was vaporized and sent aloft has not been estimated, and we do not know whether Krakatau injected more water than Pinatubo, as commented upon by the other reviewers. F. Prata, in his review, quotes Guo et al. (2004a) in that 1000 Mt of water could have released from the Pinatubo magma alone. This is a high estimate for purely magmatic gas but not improbable as a total release from the Pinatubo magma system because Pinatubo's explosions disrupted an extensive hydrothermal system within the volcano. As F. Prata indicates in his referee comments, this figure does not take into account the tropospheric water entrained by the explosive eruption and injected into the stratosphere. Again, as with the amount of sulphur dioxide released, and unfortunately for the type of study undertaken by Joshi and Jones, our understanding of these processes during the Krakatau eruption, and, in fact, all eruptions, makes it difficult to provide firm estimates of aspects of eruptive activity such as masses of water vapour transported by eruption columns to the middle atmosphere.

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