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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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This paper presents an interesting new hypothesis that may account for part of the discrepancy between modeling of volcanically forced cooling and observations, following some eruptions. However, while some of the modeling results are intriguing, the results for Krakatau (1883) are not particularly convincing (it is not clear that the results are statistically significant).

One of my biggest issues with the paper as written is that I cannot tell which types of eruptions may provide the needed excess water to the stratosphere. The hypothesis states that because Krakatau is closer to the ocean than Pinatubo, it may have trans-

ported more water vapor into the stratosphere. Indeed, the eruption of 1883 resulted in the entire island of Krakatau being swallowed up by the sea. However, Pinatubo is also relatively "near" the ocean ($\sim$ 30 km). No mechanism is identified for how or why close proximity to the ocean would result in more water vapor within the rising ash plume. The paper talks about co-ignimbrite ash plumes, and perhaps the authors really mean this, but the mechanism is not explained. If the authors really mean that the excess water vapor requires a co-ignimbrite plume, then perhaps there IS an implicit assumption that pyroclastic flows traveling across the ocean may have evaporated water that then rose in the associated co-ignimbrite plume. If this is the case, then the paper should explain this assumption. Or, perhaps, the hypothesis simply requires that more water vapor be available in the lower troposphere to be entrained by a plinian eruption plume. If the mechanism is simply entrained atmospheric water vapor, both Pinatubo and Krakatau are "tropical" volcanoes and ash plumes would likely have risen through water rich air. Further, a typhoon provided ample atmospheric water for entrainment to the Pinatubo eruption column. Finally, the introduction of this manuscript indicates that Pinatubo may have ejected water vapor in excess of 500 Mt directly into the stratosphere; analogous to the 500 Mt modeled for Krakatau. Why would this amount of water result in an anomaly following Krakatau, but not Pinatubo? Without understanding what mechanism provides the extra water vapor, it is not possible to conjecture what other eruptions may also provide the necessary excess water vapor.

Some specific comments:

1. Several instances occur in the manuscript where the term "co-ignimbrite" is used. This is a specific volcanologic term referring to plumes made up of elutriated fines rising from pyroclastic flows. They are distinct from Plinian eruption columns. If there is something unique to co-ignimbrite plumes that is required for this hypothesis to be valid, then the paper should discuss these requirements explicitly.

2. First full paragraph on page 5449: The paragraph refers to "this mechanism" and "this case", but it is not totally clear whether the authors are referring to the mechanism

described in this paper (I think they are), or whether they are referring to the mechanism described in Joshi and Shine (2003). Additional clarification would be helpful.

3. Page 5449, paragraph beginning with line 10: what mechanisms have these previous studies assumed for direct injection of water vapor into the stratosphere. I know that Glaze et al. (1997) assumed a Plinian eruption column transporting magmatic water vapor plus entrained atmospheric water vapor.

4. Page 5449, Line 21: Perhaps use the word “plausible” instead of “possible”?

5. Page 5450, Line 10: “. . .as the baseline eruption, as our. . .” –> “. . .as the baseline eruption, because our. . .”

6. Page 5450, Line 11: “However, the parameterisation. . .” –> “The parameterisation. . .”

7. Page 5450, Line13: “. . . many characteristics to other. . .” –> “. . . many characteristics similar to other. . .”

8. Page 5450, Line 19: Is the assumption of a constant mixing ratio of water vapor between 0 – 40 km reasonable? Wouldn’t there be some kind of vertical gradient after 10 days? If this assumption is required as a starting condition for the model, perhaps another sentence could help explain why this is OK even if it is not realistic.

9. Some additional clarification would be helpful in the descriptions of the cases run. It is not clear what the difference is between the control (page 5450, line 2) and “V”. What are the assumptions of the V cases? What are the differences in the 4 members of each ensemble?

10. Page 5452, Line 3: SW is not defined (I don’t think). Is it short wave?

11. Page 5452, Line 15: What is “1.5m temperature”? There is no definition of what this phrase means.

12. Page 5452, Line 17: Sentence states “...warm the climate. . .”. Is this an accurate

statement? Does this really mean “. . .warming of the near surface temperature. . . ”?

13. Page 5452, Lines 18 & 21: Please indicate whether the stated p values indicate statistically significant differences or not. Just giving the p values is not very helpful.

14. Page 5454, Line 6: Is the stated temperature anomaly of 0.1 K + or -?

15. Page 5454, Line 11: “. . .the increase in Arctic. . .” –> “. . .the increase in the Arctic. . .”

16. Page 5455, Line 3: According to the introduction of this paper, 500 Mt is also a reasonable number for the Pinatubo eruption. Why do the existing models work well for Pinatubo but not Krakatau if they both injected the same amount of water vapor into the stratosphere? Why is a near ocean location required if both eruptions injected similar amounts of water vapor?

17. Page 5455, Discussion of Figure 6: It is not at all clear that these results support the hypothesis that inclusion of excess stratospheric water vapor provides a better fit to the observations. In all cases, the V and VSW cases are statistically indistinguishable. It is inappropriate to state that the VSW provides a closer fit to the observational data in the Southern Hemisphere. Within uncertainty, both the V and VSW solutions are acceptable. In order to see the small excursions where the observational data exceed the error bars for V but not for VSW in the 2 years following the eruption in 1883, the authors may want to zoom in on just those years in plots 6a and 6b. However, even then, I’m not sure the results are convincing.

18. Page 5455, Line 23: “hypothesis” –> “hypothesize”

19. Page 5456, Lines 1 & 2: There is a statement referring to “..what is known about eruptions near large bodies of water”. What might that be? Are there some references? Is there any evidence that eruptions near large bodies of water transported more water to the stratosphere? I can logically see that pyroclastic flows flowing over water might entrain more water, however, I do not know of any specific studies that have quantified

such entrainment (if they're out there, I'd like to know the references).

20. Page 5456, Line 9: "cancel" –> maybe "counterbalance"?

21. Page 5456, Line 9: "volcanoes" –> "eruptions"

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 5447, 2009.