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FOR EARTH SYSTEM RESEARCH
AND SUSTAINABILITY (CEN)

EFFECTS OF VOLCANIC FORCING ON SURFACE TEMPERATURE IN 0D-EBM WITH ADJUSTMENT FROM ONE CLOUD LAYER

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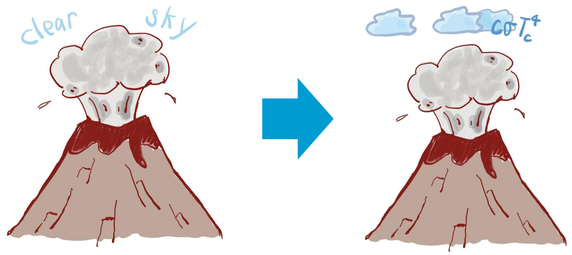
Motivation

Previous group showed effects of volcanic forcing on surface temperature without considering cloud effects. The temperature change is much smaller compared to the findings in literatures.

$$c_e \frac{dT_s}{dt} = \frac{S_0(t)(1-\alpha)}{4} - \varepsilon\sigma T_s^4$$

Being motivated from here we want to see the adjustment from cloud layer in 0D-EBM and compare it with historical simulation from MPI-ESM.



Methods

model: Effects of volcanic forcing are modeled in 0D-EBM through changes in solar constant with respect to time.

$$c_e \frac{dT_s}{dt} = \frac{S_0(t)(1-\alpha)}{4} - \varepsilon\sigma T_s^4 + c\sigma T_c^4$$

assumptions:

- ❑ planetary albedo: α = 0.3
- ❑ mixed layer depth: H = 70 m
- ❑ emissivity: ε = [0.41,0.51,0.61]
- ❑ cloud layer interacts with longwave radiation: c = 0.2 at 10 km; lapse rate = -6 K/km

run 0D-EBM without forcing, get the equilibrium temperature

start from equilibrium temperature, run 0D-EBM with forcing

loop over different value of emissivity

consider two cases: with clouds VS without clouds

Results

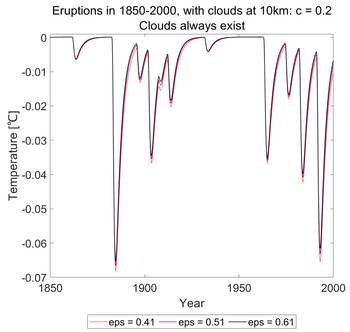


Fig. 1. Surface temperature anomaly due to 11 modelled eruptions in 1850-2000. 0D-EBM starts from equilibrium, with cloud term.

❖ **1. decreasing ε**
- ➢ more severe decrease of temperature
- ➢ same amount of time for a fully recovery of T_s
- ➢ a slower recover rate at the beginning stage

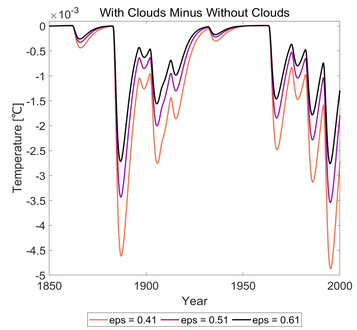


Fig. 2. Difference of surface temperature anomaly between with cloud term and without cloud term.

❖ **2. with clouds** vs. no clouds
- ➢ a slightly more severe T_s decrease ~ $O(10^{-3})$

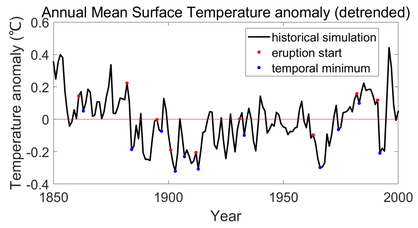


Fig. 3. Annual mean surface temperature anomaly (detrended)

❖ **3. historical simulation** from MPI-ESM model
- ➢ T_s decreases and reaches a trough after the eruptions except in 1907 and in 1974

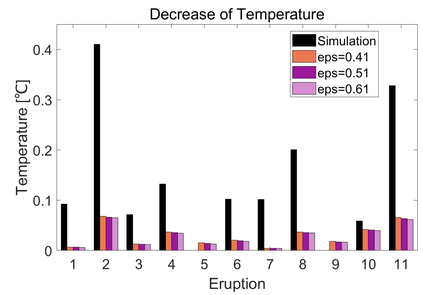
Conclusions

Volcanic forcing has a cooling effect on surface temperature. The strength of this effect can be modified about 2% by adding cloud term in the model.

Discussion

Limitation

- ❑ Only consider one cloud layer at a certain altitude with fixed cloud fraction. Changes of atmospheric composition (especially the volcanic ashes and aerosols) are not taken into account.
- ❑ Neglect the atmospheric response and seasonal variability
- ❑ Emissivity change is not considered as a result from cooling at the surface.



8 out of 11 represents 4%-27% of T_s decrease

Fig. 4. Decrease of temperature after eruptions in 1850-2000, comparison between historical simulation in MPI-ESM and 0D-EBM (cloud term included).

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