



1 **New frontiers in geoenvironmental research**

2  
3 Ben Kravitz,<sup>1,2</sup> Alan Robock,<sup>3</sup> and John C. Moore<sup>4,5</sup>

4  
5 <sup>1</sup>Department of Earth and Atmospheric Sciences, Indiana University, Bloomington, IN, USA

6 <sup>2</sup>Atmospheric Sciences and Global Change Division, Pacific Northwest National Laboratory,  
7 Richland, WA, USA

8 <sup>3</sup>Department of Environmental Sciences, Rutgers University, New Brunswick, NJ, USA

9 <sup>4</sup>University of Lapland, Rovaniemi, Finland

10 <sup>5</sup>Beijing Normal University, Beijing, China

11  
12 Submitted to *Bulletin of the American Meteorological Society*

13 November 2019

14  
15 Corresponding Author:

16 Alan Robock

17 Department of Environmental Sciences

18 Rutgers University

19 New Brunswick, NJ 08901 USA

20 Email: [robock@envsci.rutgers.edu](mailto:robock@envsci.rutgers.edu)

21 Phone: +1-848-932-5751

**Early Online Release:** This preliminary version has been accepted for publication in *Bulletin of the American Meteorological Society*, may be fully cited, and has been assigned DOI 10.1175/BAMS-D-18-0327.1. The final typeset copyedited article will replace the EOR at the above DOI when it is published.

23 **Ninth Geoengineering Model Intercomparison Project (GeoMIP) Workshop**

24 **What:** This ninth workshop was held to review new GeoMIP6 and related climate model  
25 simulations, plan joint analysis of the results, and discuss new GeoMIP experiments.

26 **When:** 15-16 August 2019

27 **Where:** Beijing, China

28

29           In late summer 2019, the ninth annual workshop of the Geoengineering Model  
30 Intercomparison Project (GeoMIP; <http://climate.envsci.rutgers.edu/GeoMIP>) convened at  
31 Beijing Normal University (Figure 1). This meeting was held in conjunction with a summer  
32 school in which 89 participants from five continents learned about climate modeling of solar  
33 geoengineering, also known as climate engineering or climate intervention. The students at the  
34 summer school were mainly physical science majors, with many from China, but also included  
35 some social science people. The summer school was focused on impact modeling (e.g., on  
36 agriculture and the cryosphere) and consideration of extremes, rather than just looking at climate  
37 model output. There were also lectures on governance and economics. Solar geoengineering  
38 refers to “radiation management” methods, which involve deliberate manipulations of the  
39 radiation budget through potential technologies such as solar dimming, stratospheric sulfate  
40 aerosols, marine cloud brightening, and cirrus thinning, but not CO<sub>2</sub> removal. This event  
41 signifies the first major international geoengineering meeting held in Asia.

42           Attendees of the summer school participated in lectures and discussions about solar  
43 geoengineering modeling, including a workshop on how to download and analyze GeoMIP  
44 output. Twenty-four of the attendees were were from projects under the Developing Country  
45 Impacts Modeling Analysis for SRM (DECIMALS; <http://www.srmgi.org/decimals-fund/>) fund,  
46 a project aimed at building solar geoengineering research capacity in developing countries so  
47 that there is a diversity of well-informed voices at future climate negotiations.

48           At the GeoMIP meeting (Figure 2), numerous new results were highlighted, including the  
49 potential role of stratospheric heating in side effects of solar geoengineering, simulations of  
50 direct condensation of H<sub>2</sub>SO<sub>4</sub> into sulfate aerosols, and preliminary results from DECIMALS  
51 groups regarding downscaling solar geoengineering model output over different regions.

52 Preliminary results from the direct condensation experiments show that, as compared to SO<sub>2</sub>, less  
53 injection is needed to reach the same aerosol optical depth, but ozone impacts differ between the  
54 participating models, necessitating further study. Several presentations also discussed topics that  
55 have thus far received limited attention in solar geoengineering research, including health  
56 impacts and glacier melt's contribution to sea level rise. Participants also discussed plans and  
57 progress on the contributions to CMIP6, participation in an overshoot scenario in which solar  
58 geoengineering is applied upon exceeding a predetermined "dangerous" level, and plans for  
59 projects to isolate the role of stratospheric heating in multiple models; new results indicate that  
60 stratospheric heating appears to be important for surface climate, but we do not know whether  
61 those results are model-dependent. Participants planned out future papers to write with CMIP6  
62 output as it becomes available. We evaluated barriers to developing country participation in  
63 geoengineering research efforts and how GeoMIP and other major geoengineering projects can  
64 help remove some of those obstacles.

65 The meeting concluded with a Great Debate, a public event featuring different  
66 perspectives on key issues in solar geoengineering and outlooks toward the future. This send-off  
67 to the GeoMIP meeting was in conjunction with the conclusion of the Chinese Geoengineering  
68 Project (<http://www.china-geoengineering.org>), a five-year effort to link Chinese natural science  
69 and governance research in solar geoengineering.

70 At previous meetings, GeoMIP highlighted priorities of regional analyses, particularly of  
71 impacts. At this ninth meeting, we saw evidence that those aspects are beginning to be addressed  
72 by both experienced researchers and newcomers to the field. Many of the attendees of the  
73 summer school expressed interest in maintaining involvement in GeoMIP and the solar  
74 geoengineering research community.

75           The next GeoMIP meeting will be held in summer 2020 in Sunday River, Maine adjacent  
76 to the second Gordon Research Conference focused on the natural science study of solar  
77 geoengineering. Discussions held there will continue at the Climate Engineering Conference  
78 2020, to be held in Berlin a few months later in October.

79

80 **Acknowledgments.** This work was supported by NSF grant AGS-1617844.

81



82  
83

84 **Figure 1.** Beijing and the mountains to the North, as viewed from the Beijing Normal  
85 University campus.

86



87  
88  
89  
90

**Figure 2.** The attendees at the ninth GeoMIP Workshop. The authors are in the middle of the front row.