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Solar Geoengineering

I have been thinking about geoengineering since the early 1990s, when I wrote one of the first assessments of the technology and its policy implicatons in the journal literature (#9), work that grew into a more systematic look at the technology and its historical roots that appeared in *Annual Review of Energy and the Environment* (#26) and in shorter form in *Nature* (#37). My current work on geoengineering includes:

- ***Assessments***. Member of the working group for UK Royal Society's 2009 report (#118), the first by a national science academy devoted to geoengineering. In 2010 I testified before committees of the US Congress (testimony) and the UK Parliament. I presented at US National Academy meetings in 2000 and 2009 (see presentation), served on the drafting committee for the American Meterological Society's statement (see AMS) and was co-author of the geoengineering sub-chapter (4.7) of the mitigation volume of the Third IPCC Report and serving on the IPCC AR5.

- ***Public engagement***. My 2007 TED talk has been widely viewed, see also a 2009 debate at the Royal Geographical Society and an op-ed in the New York Times. Recent media coverage includes a long interview in November 2011 on HARDtalk a flagship BBC program.

- ***Meetings on science and governance***. I co-organized a meeting a Harvard in November 2007 that brought together leaders in the geosciences with experts on public policy and governance (See articles in *Science* and the *New York Times*). In 2009 I co-organized a meeting in Lisbon that engaged European science and foreign policy experts to consider research and governance of geoengineering (see IRGC). More recently I helped to form the Solar Radiation Management Governance Initiative (SRMGI).

- ***Research***. I am working on the economics of decisions about geoengineering and abatement under uncertainty (#117), on public perception (#150), on engineered aerosols (#96), and on methods of delivering materials to the stratosphere (R1). In collaboration with Jim Anderson I have started a Harvard based project to develop in situ experiments to test the risk and efficacy of aerosols in the stratosphere. I also work on direct capture of CO_2 from air (see Air Capture).

- ***Research Funding***. My work has been funded by the US NSF and Canada's NSERC as well as by a grant from Bill Gates managed as FICER.

Selected Publications on Geoengineering

Some publications require a username and password to access. Contact Hollie Roberts **(hroberts(at)seas.harvard.edu)** to request this information.

R1. Aurora Flight Sciences report on Geoengineering Cost Analysis (PDF).
Note: This report was commissioned by the University of Calgary as a contract to Aurora. The project was managed by Jay Apt at Carnegie Mellon and David Keith. The report benefited from reviews and input by various experts in aerospace and atmospheric science. Jay Apt managed Aurora's response to review.

117. Juan B Moreno-Cruz and David W Keith. (under review). Climate Policy under Uncertainty: A Case for Geoengineering. *Climatic Change*. (PDF)

155. Katharine L. Ricke, Dan Rowlands, William J. Ingram, David W. Keith and M. Granger Morgan. (2011). Effectiveness of stratospheric solar radiation management as a function of climate sensitivity. *Nature Climate Change*, **2**: 92-96. (PDF) (SI)

150. A M Mercer, D W Keith and J D Sharp. (2011). Public understanding of Solar Radiation Management. *Environmental Research Letters*, doi: 10.1088/1748-9326/6/4/044006. (PDF) [Plain Language Communications Poster - PDF]

J. Long, S. Rademaker, J. G. Anderson, K. Caldeira, J. Chaisson, D. Goldston, S. Hamburg, D. Keith, R. Lehman, F. Loy, G. Morgan, D. Sarewitz, T. Schelling, J. Shepherd, D. Victor, D. Whelan, D. E. Winickoff, (2011). Task Force on Climate Remediation Research. Bipartisan Policy Center. 33 pages. (PDF)

131. Juan Moreno-Cruz, Katharine Ricke and David W. Keith. (2011). A simple model to account for regional inequalities in the effectiveness of solar radiation management. *Climatic Change*, doi: 10.1007/s10584-011-0103-z. (PDF)

128. Douglas G. MacMynowski, Ho-Jeong Shin, Ken Caldeira and David W. Keith. (2011). Can we test geoengineering? *Energy and Environmental Science*, **4**: 5044-5052. (PDF)

132. K. Caldeira and D. W. Keith. (2010). The Need for Climate Engineering Research. *Issues in Science and Technology*. **27**: 57-62. (PDF)

127. Jeffrey R. Pierce, Debra K. Weisenstein, Patricia Heckendorn, Thomas Peter and David W. Keith. (2010). Efficient formation of stratospheric aerosol for geoengineering by emission of condensible vapor from aircraft. *Geophysical Research Letters*, 37, L18805, doi:10.1029/2010GL043975. (PDF) (Aux Material)

125. David W. Keith, Edward Parson and M. Granger Morgan. (2010). Research on global sun block needed now. *Nature*, **463**: 426-427. (PDF)

96. D. W. Keith. (2010). Photophoretic levitation of engineered aerosols for geoengineering. *Proceedings of the National Academy of Sciences*, **107**: 16428-16431. (PDF)

89. David W. Keith. Engineering the Planet. (2010). *Climate Change Science and Policy*. S. Schneider and M. Mastrandrea eds. (PDF)

119. J. J. Blackstock, D. S. Battisti, K. Caldeira, D. M. Eardley, J. I. Katz, D. W. Keith, A. A. N. Patrinos, D. P. Schrag, R. H. Socolow and S. E. Koonin (2009). *Climate Engineering Responses to Climate Emergencies*, Novim. (PDF)

118. John Shepherd, Ken Caldeira, Joanna Haigh, David Keith, Brian Launder, Georgina Mace, Gordon MacKerron, John Pyle, Steve Rayner, Catherine Redgwell, Peter Cox and Andrew Watson (2009). *Geoengineering the climate - Science, governance and uncertainty*. The Royal Society. (PDF)

75. Stephens, J. C. and D. W. Keith (2008). Assessing Geochemical Carbon Management. *Climatic Change,* **90**: 217-242. (PDF)

50. David W. Keith (2002). Geoengineering - die technologische Gestaltung des Planeten Erde. Klima. Das Experiment mit dem Planeten Erde. W. Hauser ed., Deutsche Museum, Munich, Germany, p. 352-369. (PDF)

44. David W. Keith (2002). Geoengineering. Encyclopedia of Global Change. A. S. Goudie ed, Oxford University Press, New York, NY, p. 495-502. (PDF)

41. David W. Keith (2001). Geoengineering and carbon management: Is there a meaningful distinction? *Greenhouse Gas Control Technologies: Proceedings of the 5th International Conference*. D. Williams, B. Durie, P. McMullan, C. Paulson and A. Smith eds., CSIRO Publishing, Collingwood, Australia, p. 1192-1197. (PDF)

37. D. W. Keith (2001). Geoengineering. *Nature*, **409**: 420. (PDF)

28. David W. Keith (2000). The Earth is Not Yet an Artifact. *IEEE Technology and Society Magazine*, **19**: 25 -28. (PDF)

26. David W. Keith (2000). Geoengineering the Climate: History and Prospect. *Annual Review of Energy and the Environment*, **25**: 245-284. (PDF)

16. David W. Keith (1998). Geoengineering Climate. *Elements of Change 1998*. S. J. Hassol and J. Katzenberger eds., Aspen Global Change Institute, Aspen Colorado, p. 83-88. (PDF)

9. David W. Keith and Hadi Dowlatabadi (1992). A Serious Look at Geoengineering. *Eos, Transactions American Geophysical Union*, **73**: 289-293. (PDF)