Volcanic Aerosols as an Analog for Geoengineering, and GeoMIP

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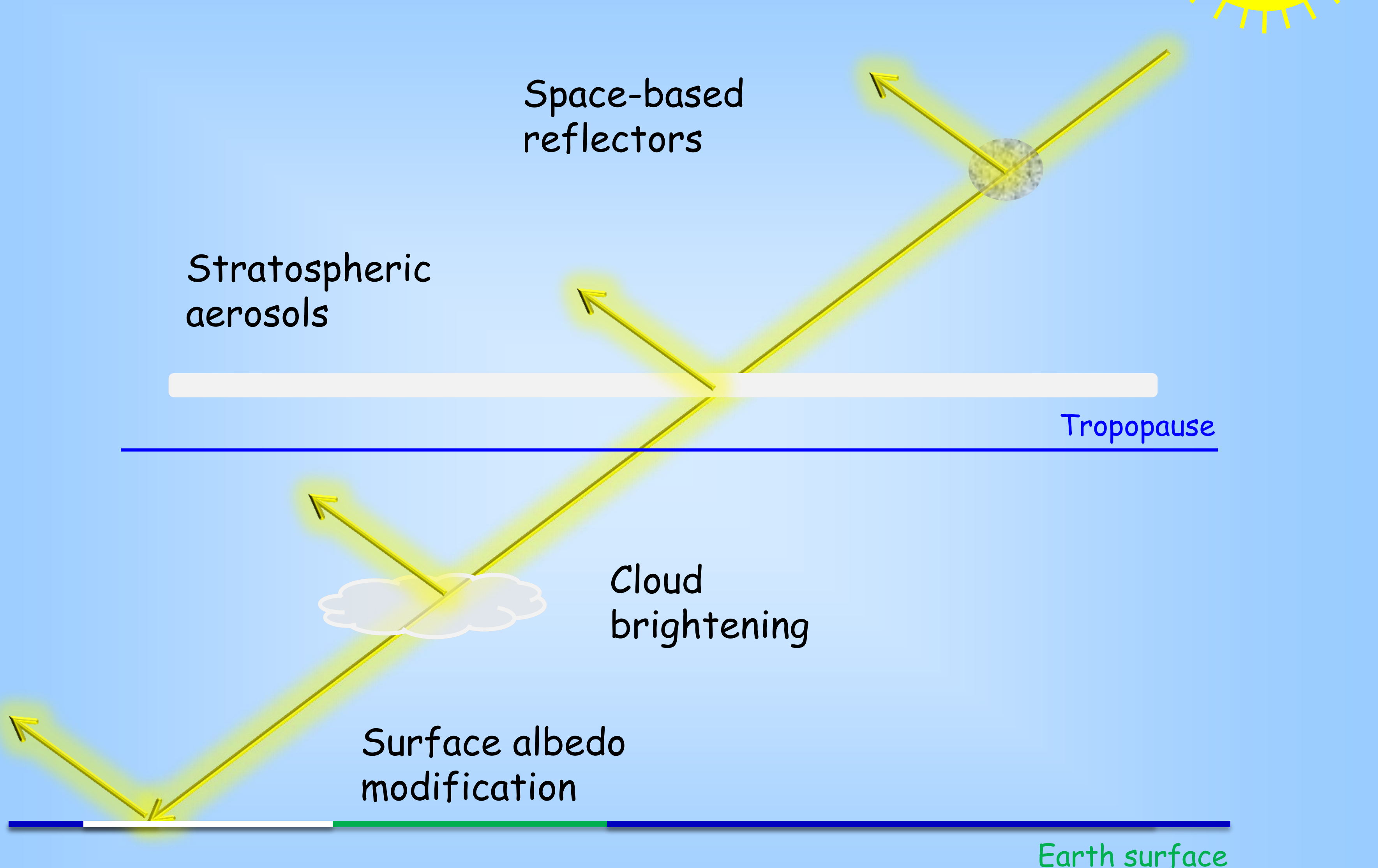
Solar Radiation Management



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Volcanic Analogs to Stratospheric Geoengineering

Aerosol growth, transport, and removal
Surface cooling
Regional climate changes
- Temperature
- Precipitation
- Atmospheric circulation (e.g., Northern Annular Mode)

Ozone depletion
Diffuse radiation effects on
- Vegetation and carbon sinks
- Solar energy generation (with direct solar)

Beautiful sunsets
Whiter skies
Degradation of astronomy and remote sensing
Effects on airplanes flying in stratosphere
Famine
Social unrest

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GeoMIP

We proposed standard experiments with the new GCMs being run as part of CMIP5 to use the same global warming and same geoengineering scenarios, to see whether our results are robust.

For example, how will the hydrological cycle respond to stratospheric geoengineering? Will there be a significant reduction of Asian monsoon precipitation? How will ozone and UV change?

Kravitz, Ben, Alan Robock, Olivier Boucher, Hauke Schmidt, Karl Taylor, Georgiy Stenchikov, and Michael Schulz, 2011: The Geoengineering Model Intercomparison Project (GeoMIP). *Atmospheric Science Letters*, **12**, 162-167, doi:10.1002/asl.316.

GeoMIP

GeoMIP is a CMIP Coordinated Experiment, as part of the Climate Model Intercomparison Project 5 (CMIP5).

GeoMIP is also a SPARC CCMVal Geoengineering Model Intercomparison Project.

GeoMIP is led by Ben Kravitz (Stanford University), Alan Robock (Rutgers University), and Olivier Boucher (Laboratoire de Météorologie Dynamique).

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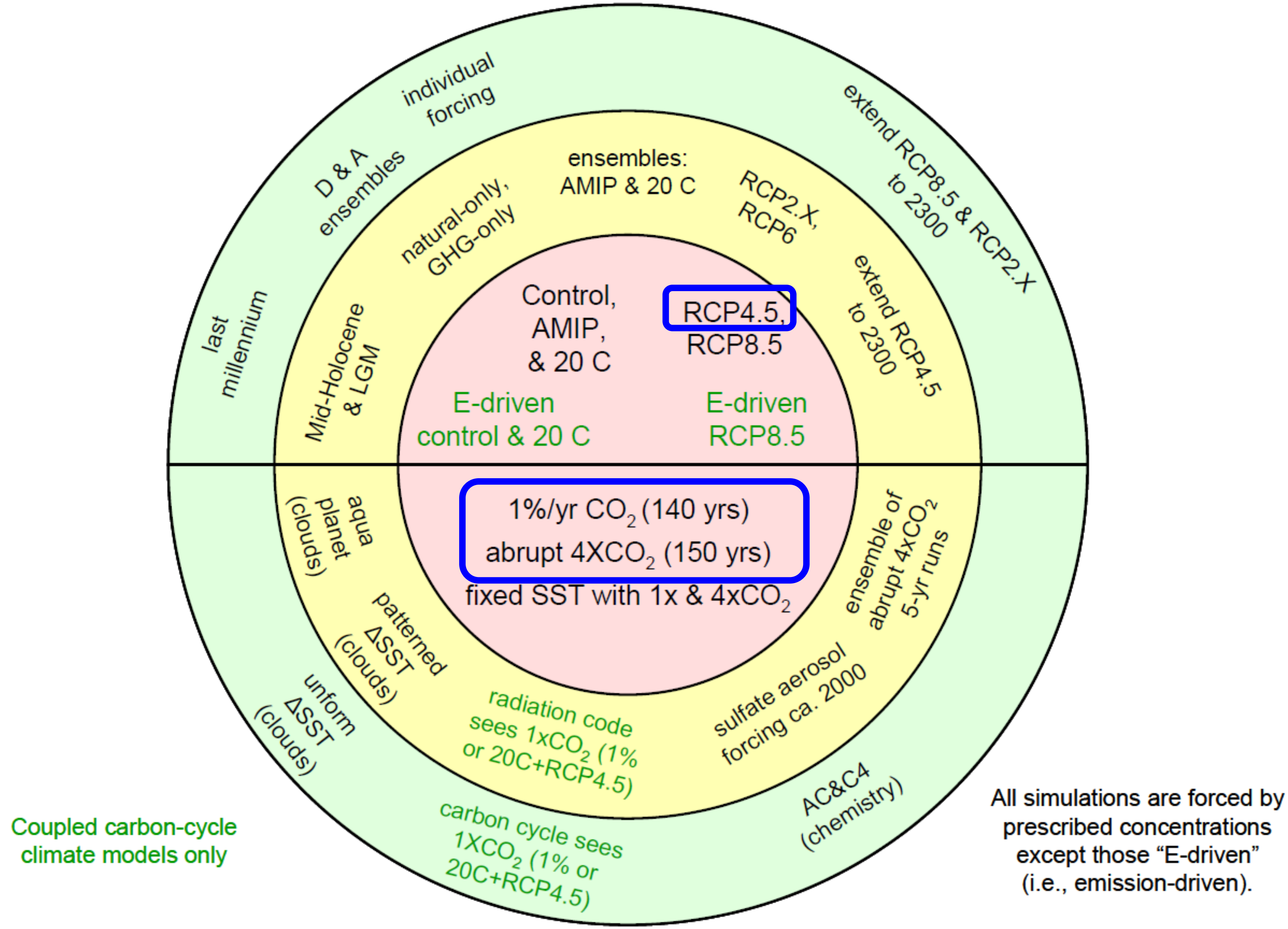
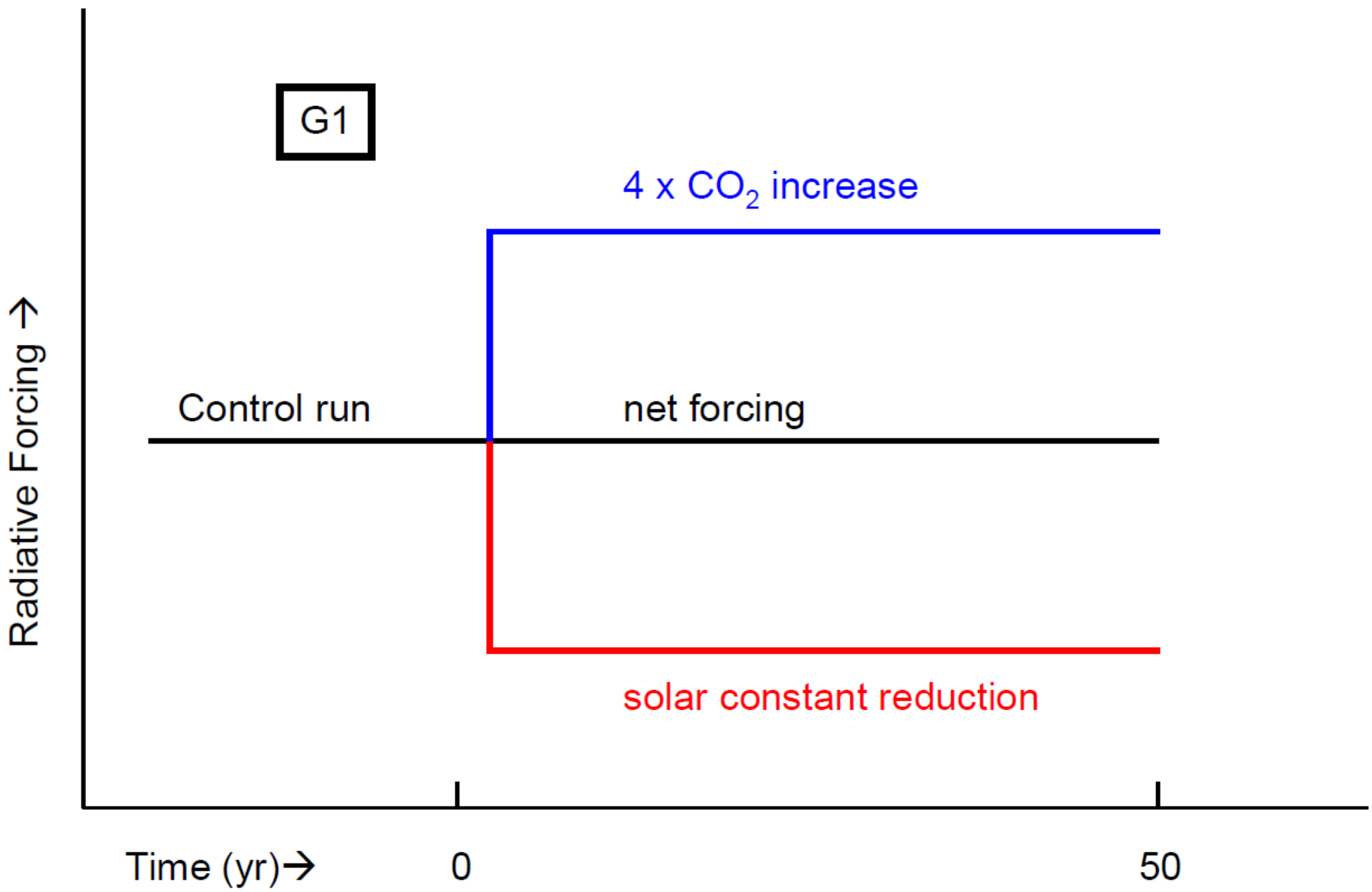
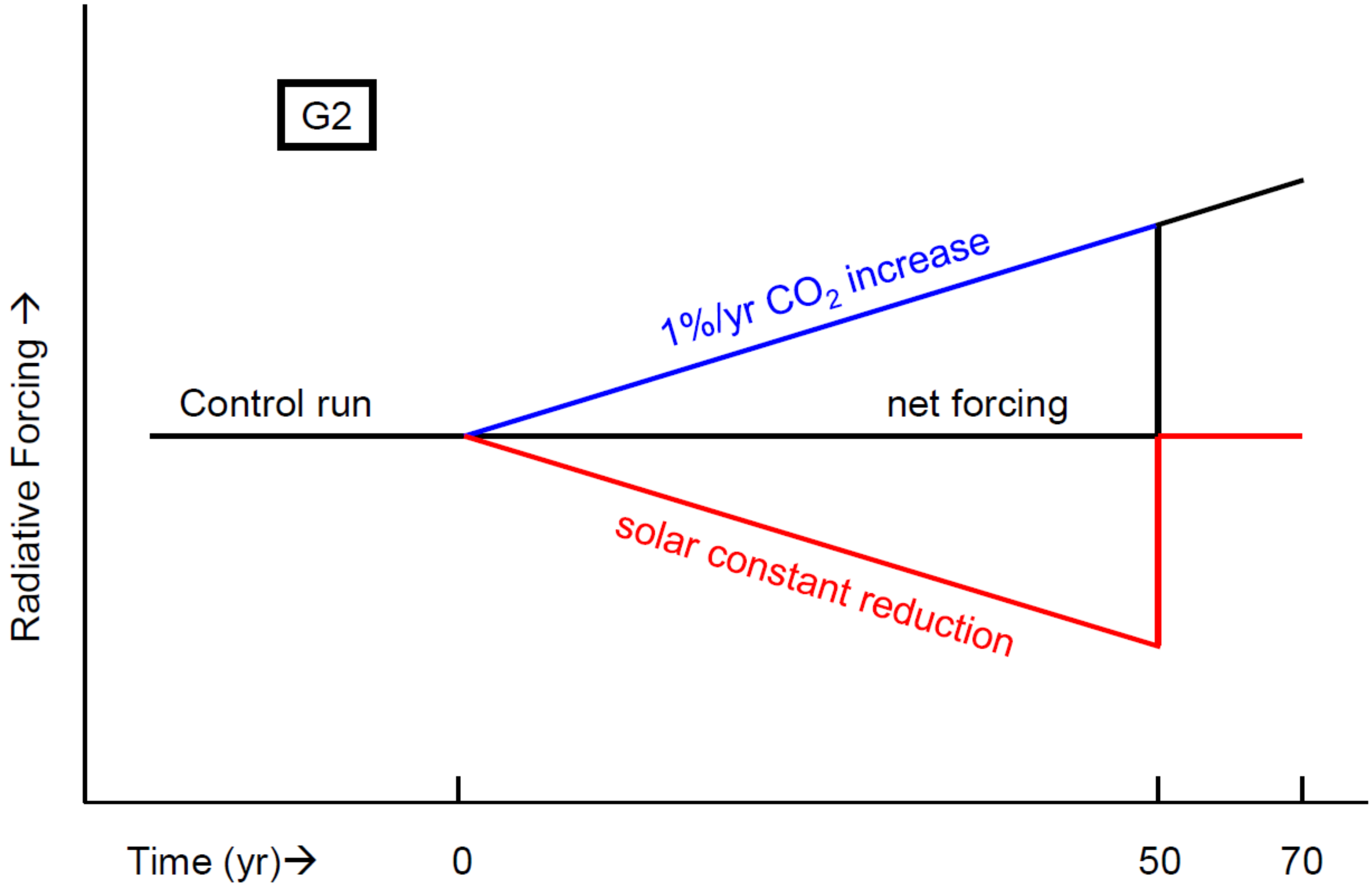


Figure 3: Schematic summary of CMIP5 long-term experiments.

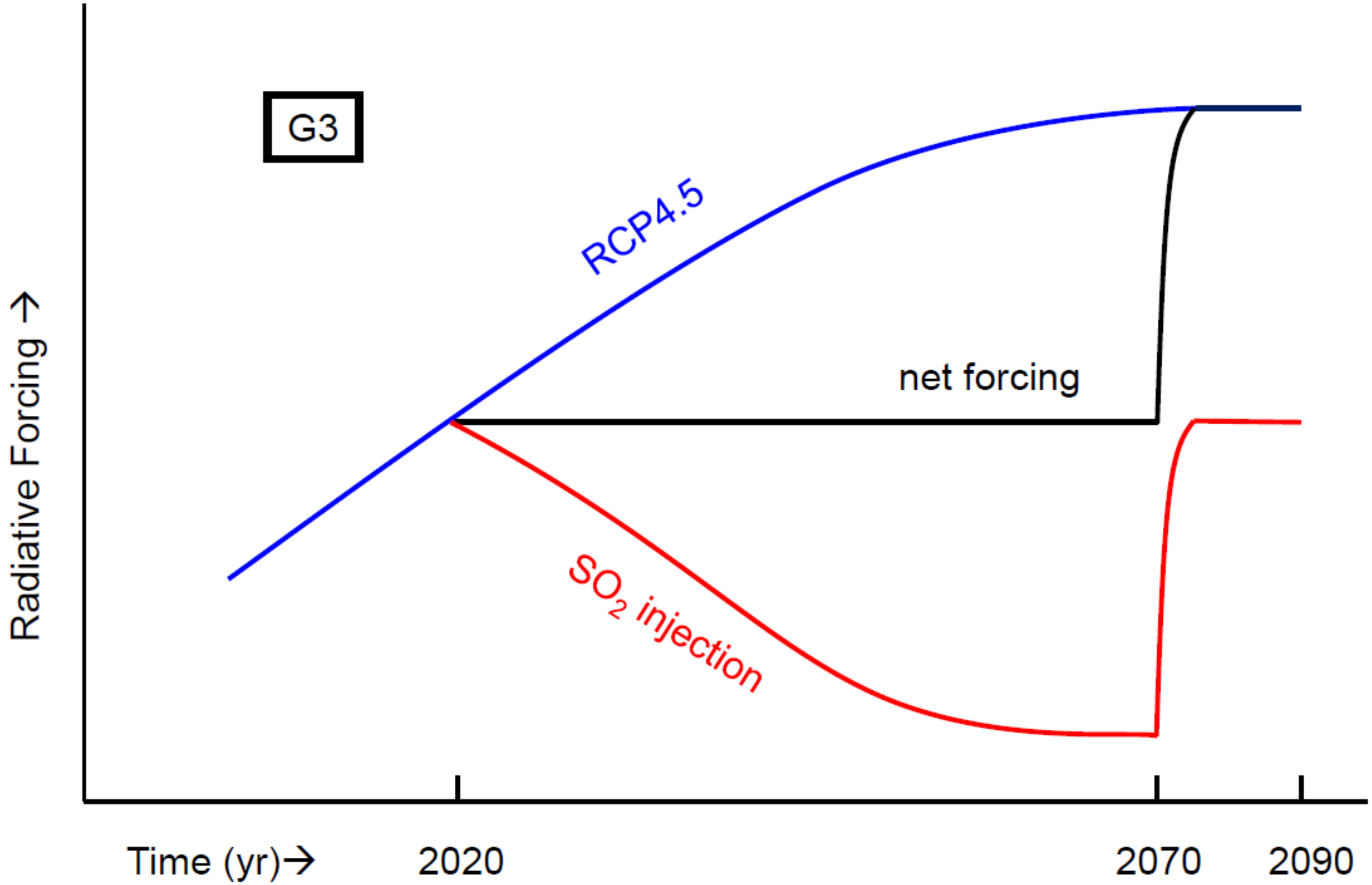
Taylor et al. (2008)



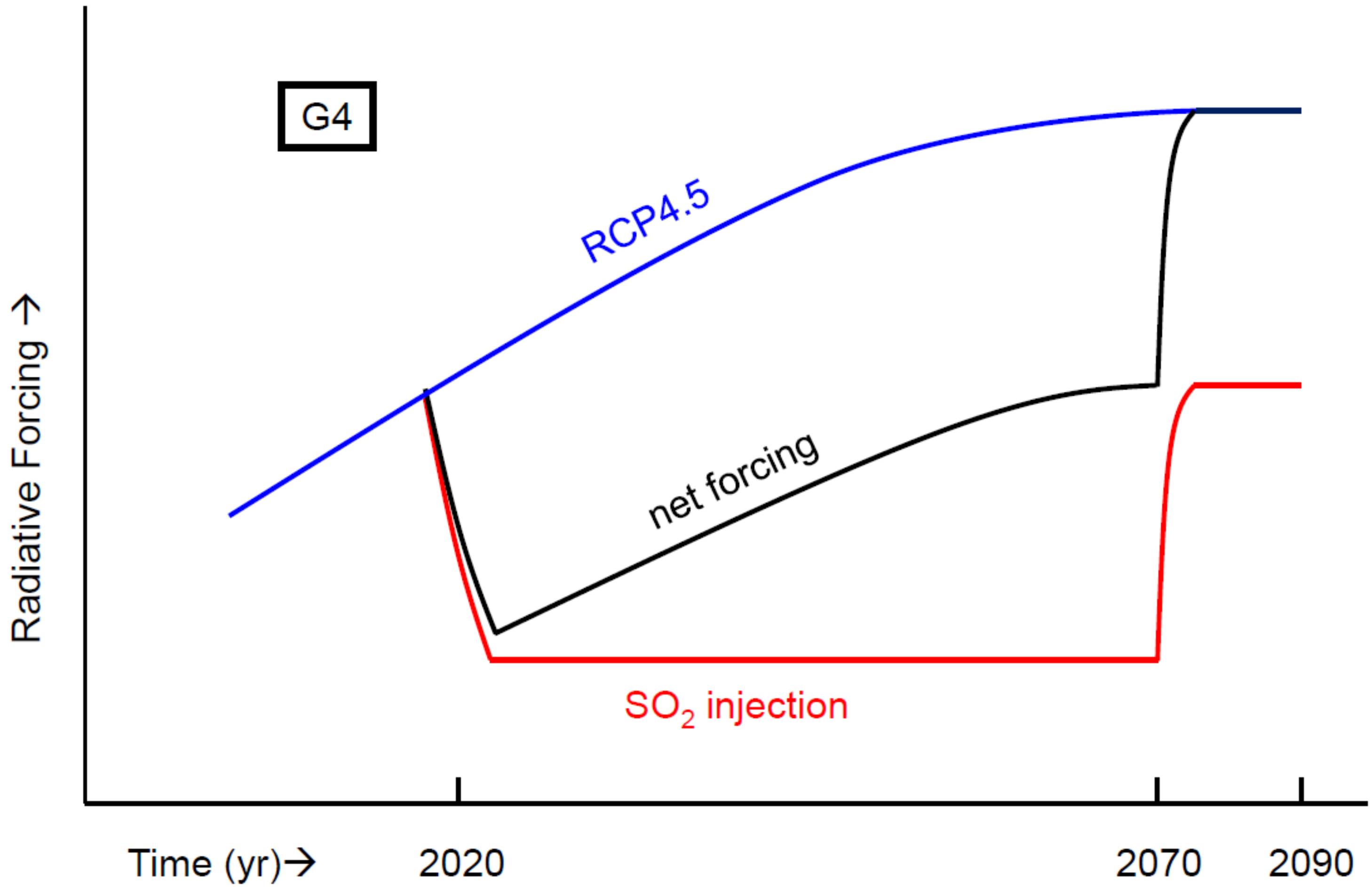
G1: Instantaneously quadruple CO_2 concentrations (as measured from preindustrial levels) while simultaneously reducing the solar constant to counteract this forcing.



G2: In combination with 1% CO_2 increase per year, gradually reduce the solar constant to balance the changing radiative forcing.



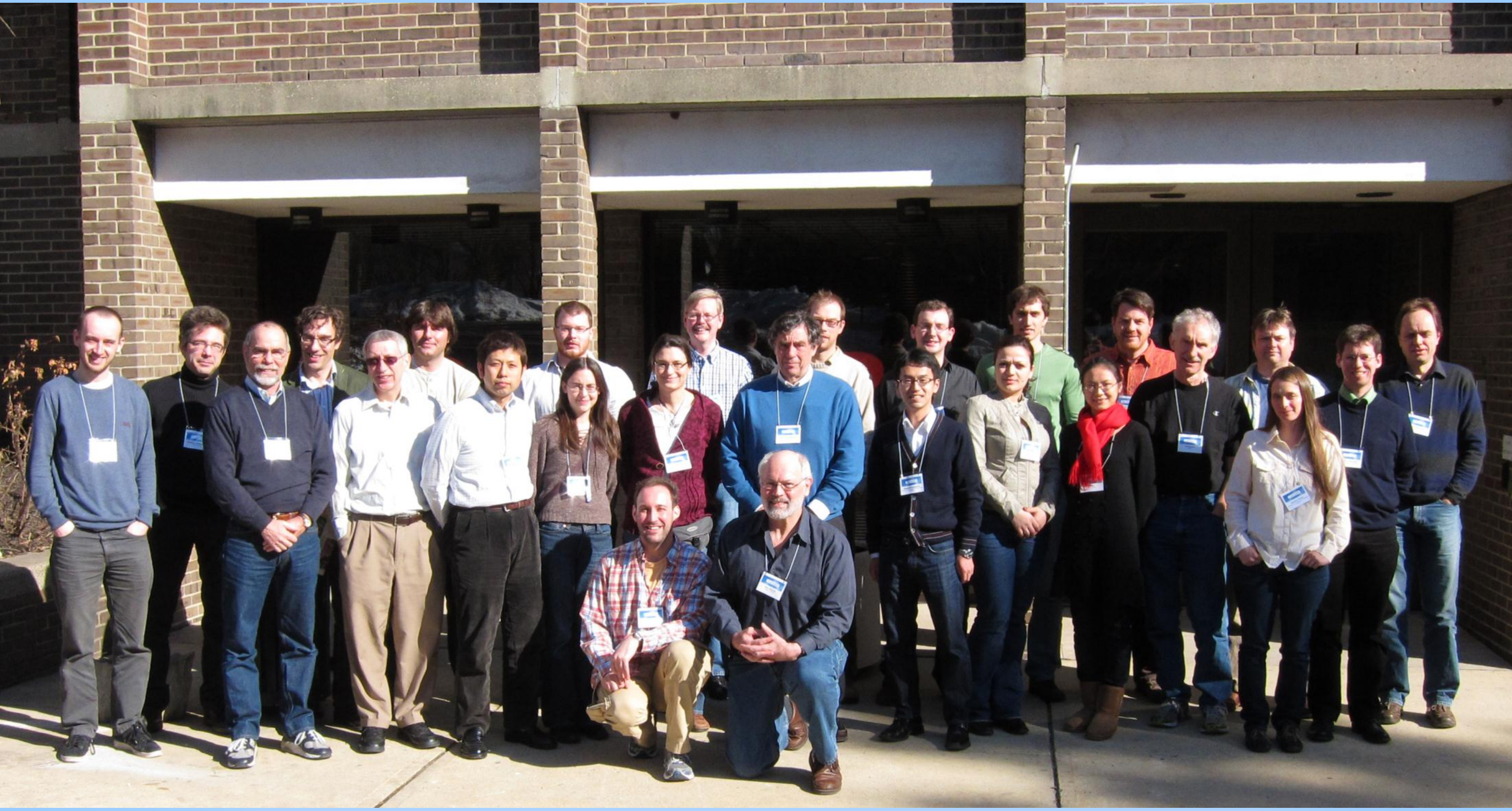
G3: In combination with RCP4.5 forcing, starting in 2020, gradual ramp-up the amount of SO_2 or sulfate aerosol injected, with the purpose of keeping global average temperature nearly constant. Injection will be done at one point on the Equator or uniformly globally.



G4: (optional) In combination with RCP4.5 forcing, starting in 2020, daily injections of a constant amount of SO_2 at a rate of 5 Tg SO_2 per year at one point on the Equator through the lower stratosphere (approximately 16-25 km in altitude).

GeoMIP Workshop, Rutgers University, February 10-12, 2011

http://climate.envsci.rutgers.edu/GeoMIP/events/rutgersfeb2011.html



Workshop was sponsored by the United Kingdom embassy in the United States.

Robock, Alan, Ben Kravitz, and Olivier Boucher, 2011: Standardizing Experiments in Geoengineering; GeoMIP Stratospheric Aerosol Geoengineering Workshop; New Brunswick, New Jersey, 10-12 February 2011, *EOS*, **92**, 197, doi:10.1029/ 2011ES003424.

GeoMIP Participants

							# of ensemble members (* in progress)				
Model (CMIP5 or CCMVal participant)	**Contact**	**Atmospheric Model Resolution**	**Atmospheric Model Top**	**Oceanic Model Resolution**	**Stratospheric Aerosols**	**Ozone**	**G1**	**G2**	**G3**	**G3 solar**	**G4**
MPI-ESM (ECHAM6)	Hauke Schmidt, Ulrike Niemeier	T63L47	0.01 mb	GR15 L40	Prescribed AOD and surface area	Prescribed	1	1	3		
IPSLCM5A	Michael Schulz, Diana Karam, Olivier Boucher	2.5° lat x 3.75° lon L39	0.1 mb (80 km)	2° lat X 2° lon	Prescribed AOD	Calculated	1	1	*		
GISS ModelE2	Ben Kravitz	2° lat X 2.5° lon L40	0.1 mb (80 km)	1° lat X 1.25° lon L32	Generated from SO_2 injection (Koch scheme)	Calculated	*	*	*		*
NorESM1-M	Jón Egill Kristjánsson, Kari Alterskjær	1.9° lat x 2.5° lon	42 km	~0.5° lat x ~1° lon, 1.125 degrees along the equator	Prescribed	Prescribed	1	1			
CESM-CAM5	Phil Rasch, Jin-Ho Yoon	1.9° lat x 2.5° lon L30	3.5 mb	gx1v6 (displaced pole)	Prescribed	Prescribed	1	1	*		
CESM-CAM4 (G1, G2, G3 solar)	Simone Tilmes, Jean-Francois Lamarque	0.9° lat x 1.25° lon	42 km	~1° lat x ~1° lon	Prescribed	Prescribed	3	3		3	
CESM-CAM4 Chem (G3 solar, G3, G4)	Simone Tilmes, Jean-Francois Lamarque	1.9° lat x 2.5° lon	42 km	~1° lat x ~1° lon	Generated from SO_2 injection (bulk aerosol scheme)	Calculated				*	
CESM-WACCM4	Michael Mills	1.9° lat x 2.5° lon	5.9603E-6 hPa (~145 km)	~1° lat x ~1° lon	Prescribed from SAGE, prognostic PSC growth	Calculated					
MIROC-ESM	Michio Kawamiya, Shingo Watanabe	2.8° x 2.8° (T42)	~85 km (80 levels)	0.56° ~1.4° lat x ~1.4° lon (44 levels)	Prescribed AOD	Prescribed	1	1			1
MIROC-ESM-CHEM	Michio Kawamiya, Shingo Watanabe	2.8° x 2.8° (T42)	~85 km (80 levels)	0.56° ~1.4° lat x ~1.4° lon (44 levels)	Prescribed AOD --> sulfate SAD	Calculated					4
HadGEM2-ES	Andy Jones	1.25° lat x 1.875° lon	39.3 km	30°N-S: 1/3°, 30°-90°N/S: 1°x1°	Generated from SO_2 injection	Prescribed	1	3	3		3
CanESM2	Jason Cole, Charles Curry	~ 2.81° x 2.81° (T63)	~1 hPa (35 layers)	0.94° lat x 1.4° lon	Prescribed	Prescribed	3	3			3
CMCC-CMS	Chiara Cagnazzo	~1.8° x 1.8° (T63)	0.01 hPa (95 levels)	2° lat X 2° lon (31 levels)	Prescribed SO_2 or AOD	Prescribed					
UMUKCA (future HadGEM3-ES)	Peter Braesicke, Luke Abraham	2.5° lat x 3.75° lon (N48) L60	~84 km (60 levels)	~2° L31	Prescribed	Calculated	*	*			
CCSRNIES / MIROC3.2	Hideharu Akiyoshi	T42	0.012 mb		Prescribed	Calculated					1
EMAC2 (DLR)	Martin Dameris, Patrick Jöckel, Veronika Eyring	T42L90MA	0.01 mb		Prescribed	Calculated					
LMDzrepro	Bekki/Marchand	2.5° lat x 3.75° lon)	0.07 mb		Prescribed	Calculated					
SOCOL	Eugene Rozanov	T30	0.01 mb		Prescribed	Calculated					
ULAQ	Pitari	R6/11.5° lat x 22.5° lon	0.04 mb		Prescribed	Calculated					
UMSLIMCAT	Martin Chipperfield	2.5° lat x 3.75° lon	0.01 mb		Prescribed	Calculated					
EMAC (ECHAM5/MESSy)	Mark Lawrence	ca. 2.8° X 2.8° (T42)	~80 km (1 Pa), 90 levels		Generated from SO_2 injection	Calculated					
HadCM3	Peter Irvine	2.5° lat X 3.75° lon L19	5 mb (28 km)	1.25° lat X 1.875° Lon L20	Prescribed SO_2 or AOD	Fixed	1	1			
HadCM3 [27-member perturbed physics ensemble]	Peter Irvine	2.5° lat X 3.75° lon L19	5 mb (28 km)	1.25° lat X 1.875° Lon L20	Prescribed						
IAPRASCM	Alexander Chernokulsky	4.5° lat X 6° lon L8	80 km	4.5° lat X 6° lon L3	Prescribed lifetime	Prescribed					
GCCESM	John Moore	2.8° x 2.8° (T42)	42 km	200 lat x 360 lon, 30°-90°N/S: 1°x1°	Prescribed	Prescribed					
				1.6° lat x 2.8° lon (21							

Status as of Oct. 15, 2011

Next Workshop

Hadley Centre

Exeter, UK

March 30-31, 2012

http://climate.envsci.rutgers.edu/GeoMIP/