Effects of aerosols on SW radiation through aerosol-cloud-radiation interactions (ACRI) in a changing climate – a proposal for AeroCom model experiment

Mian Chin et al., NASA Goddard Space Flight Center, USA   *Updated 2019-01-21*

Objectives:
- To assess the effect of climate change/climate variability on multidecadal trends in cloud cover and aerosol levels;
- To estimate the role of aerosols on multidecadal variations in cloud cover through ACRI under different aerosol and cloud regimes; and
- To identify the roles of aerosols, clouds, and climate variability on SW downwelling radiation at the surface in recent decades

Background:
Our previous study has shown that cloud plays much more important roles on the surface dimming/brightening trends. Aerosol direct radiative effects is only obvious under clear sky conditions. Big questions need to be addressed:
- What causes the cloud trend?
- How much is the change of cloud mediated by aerosols through aerosol-radiation interaction and aerosol-cloud interaction?
- How does climate change affect the cloud and aerosol trends and their interactions?

Therefore, model experiments are desired that include realistic ACRI in a climate change environment.

Proposed model experiment:
GCM or AGCM simulation of ACRI, 1985-2015 (31 years)

Model experiment:				
Name	**SST**	**Aerosol**	**Aer-rad. Coupling**	**Aer-cloud coupling**
BASE	Time varying	Time varying	Dynamic aerosol	Dynamic aerosol
FIXSST	Fixed at 1985 level	Time varying	Dynamic aerosol	Dynamic aerosol
FIXAER	Time varying	Fixed at 1985 level	Dynamic aerosol	Dynamic aerosol

Analysis:	
Effect	**Method obtaining the signal of effect relative to the state of 1985**
CLIM	Climate change/climate variability effect – difference between BASE and FIXSST
ACRI	ACRI effect – difference between BASE and FIXAER

Model output:	
Fields	**Variables**
Aerosol	3-D solar spectral aerosol extinction, single scattering albedo, asymmetry factor, and dry mass concentration of each species
Cloud	Cloud fraction, optical depth, liquid and ice water path, droplet and ice crystal number concentrations and effective radii, cloud top and bottom height
Radiation-related	3-D shortwave downward and upward total, direct, and diffuse fluxes at UV, visible, and near-IR wavelength, atmospheric heating rates
Other	Atmospheric water vapor concentration, temperature profile

Observations:
Surface network observations of SW downwelling radiation at the surface – GEBA and BSRN site locations and data records:

	GEBA	BSRN
Location of long-term sites		
# long-term sites	323 sites with data record > 20 years	26 sites with data record > 10 years (1992-)
Variables used in this study	Monthly average total *rsds* under all sky condition	Monthly average total, direct, diffuse under all sky and cloud-free conditions (*rsds, rsdsdir, rsdsdif, rsdscsdir, rsdscs, rsdscsdir, rsdscsdif*)
Info website	http://www.geba.ethz.ch/	http://bsrn.awi.de/
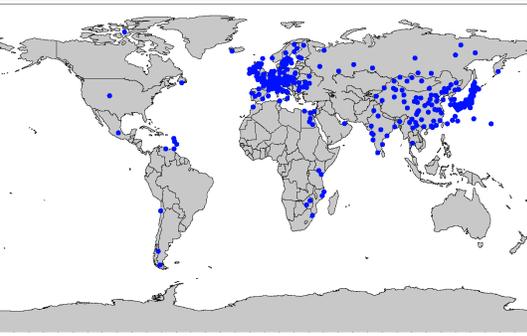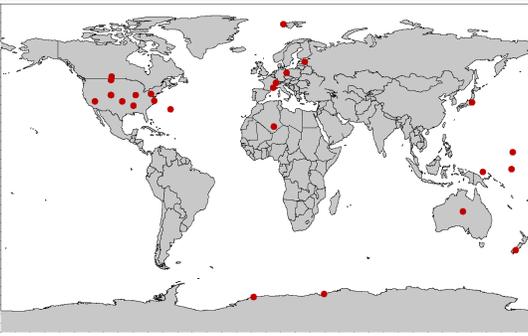
Satellite-derived R_{SFC} products[#]:

	ISCCP-FD	GEWEX-SRB	UMD-SRB	CERES-EBAF
Time period*	1983 – 2009	1983 – 2007	1983 – 2014	2000 – 2015
Relevant product	Total and cloud-free (*rsds, rsdscs*)	Total and cloud-free (*rsds, rsdscs*)	Total and cloud-free (*rsds, rsdscs*[&])	Total and cloud-free (*rsds, rsdscs*)
Spatial resolution	2.5°×2.5°	1°×1°	1°×1°	1°×1°
Cloud fields used	ISCCP-D1	ISCCP-D1	ISCCP-DX	CALIPSO, CloudSat, CERES, MODIS (CCCM)
Aerosol fields used	Trop: GISS model climatology. Strat: SAGEII climatology	AeroCom climatology with variability from ECHAM model	LUT built with information from MODIS, AERONET, and other sources	AERONET/MODIS validation-based estimates
Reference	Zhang et al., 2004	Zhang et al., 2013	Ma and Pinker, 2012	Kato et al., 2013

[#]Permission for using the data for AeroCom is needed.

*Time period listed here are data availability as of the end of 2016. The data teams will continue processing the R_{SFC} products under separate projects.

[&]The UMD-SRB rsdscs is available from 200307 to the end of 2014 as of the end of 2016.

Emissions (need discussion)**:**
- Anthropogenic: CMIP6
- Biomass burning: CMIP6
- Volcanic: Carns (TOMS+OMI)
- Dust, sea salt, DMS, POA, and lightning NO: Model-dependent (?)
- NH_3 from ocean: GEIA