The International Land Model Benchmarking Project

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- Meeting Co-organized by Forrest Hoffman (UC-Irvine and ORNL), Chris Jones (UK Met Office Hadley Centre), Pierre Friedlingstein (U. Exeter), and Jim Randerson (UC-Irvine).
- About 45 researchers participated from the United States, Canada, the United Kingdom, the Netherlands, France, Germany, Switzerland, China, Japan, and Australia.

International Land Model Benchmarking (ILAMB) Project Goals:

- Develop benchmarks for land model performance, with a focus on carbon cycle, ecosystem, surface energy, and hydrological processes. The benchmarks should be designed and accepted by the community.

- Apply these benchmarks to global models

- Support the design and development of a new, open-source, benchmarking software system for either diagnostic or model intercomparison purposes

- Strengthen linkages between experimental, monitoring, remote sensing, and climate modeling communities in the design of new model tests and new measurement programs

Key operational elements of ILAMB 1.0 benchmark

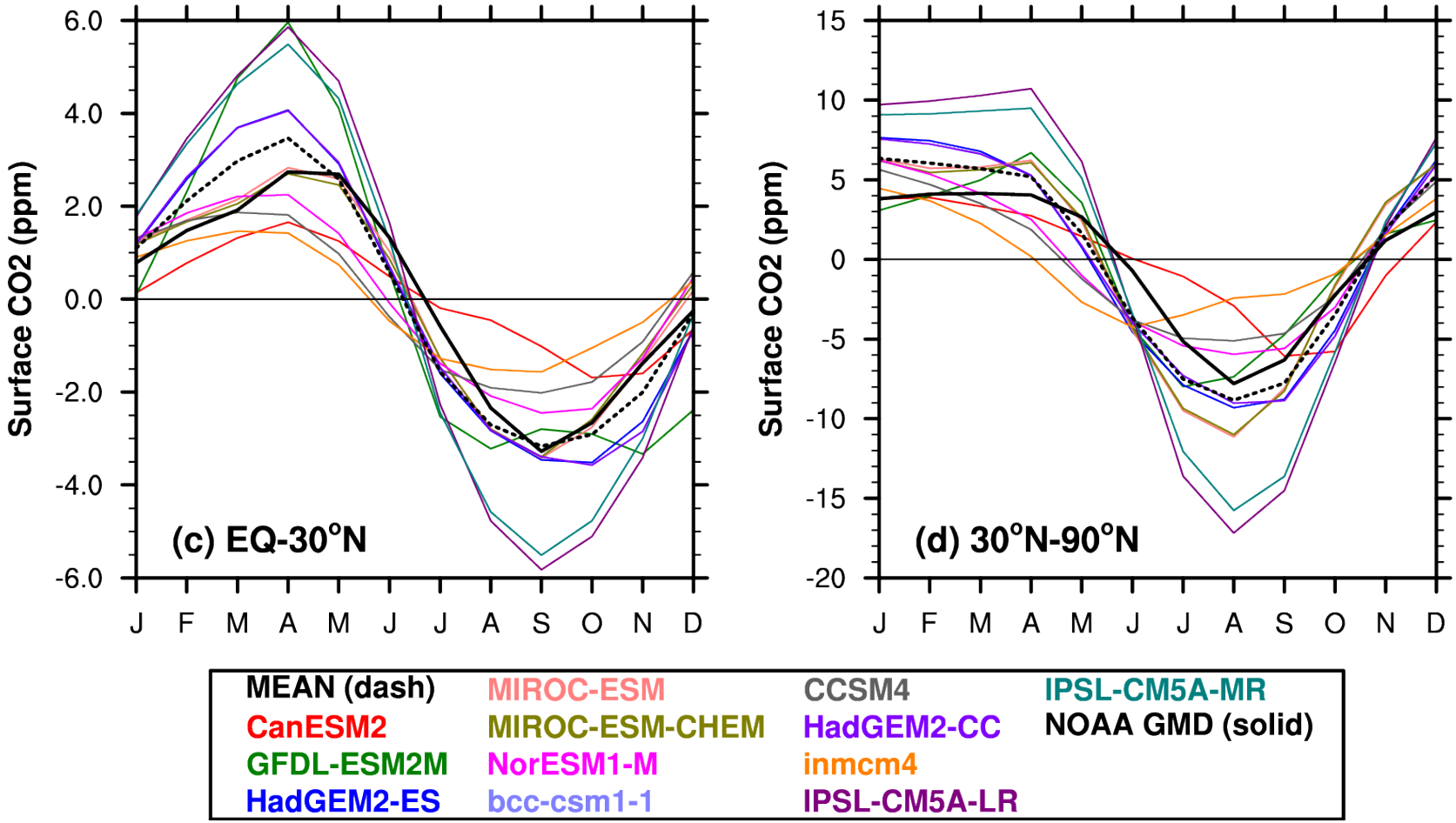
- Traceable lineage for data sets
  - Lineage, units, transformations documented in readme files
  - Datasets must be publicly available so that they can be distributed with ILAMB 1.0 system
- Clear documentation of model regridding and variable transformation
- A document describing the metrics used to score each dataset
  - For example, Taylor score, spatial correlation coefficient
- Community agreement on scoring metrics and weighting across datasets

Status Update

- Almost all CMIP5 output is available (some bugs still being fixed)
- Progress on model evaluation:
  - soil carbon (Todd Brown, Allison, Post, et al.)
  - soil temperatures (Koven and Riley)
  - hydrology (Dave Lawrence)
  - atmospheric CO_2 (Keppel Aleks, Hoffman, Stephens, et al.)
  - Ecosystem carbon fluxes (Randerson, Mu, et al.)
  - Turnover times and carbon stocks (Xia, Luo, Wang)
- Conceptual framework defined – Yiqi Luo synthesis paper submitted to BGD
- Next critical step is integration and standardization
  - At AGU we decided that UCI would be a central clearing house for collating obs. datasets and will take a first step at standardization of the different disciplines
  - We are in the process of detailing a metrics document that discusses how scoring system is designed, cost functions, data-model comparison approach

Example Analysis – Examination of Seasonal Dynamics of Ecosystem Carbon and Energy Fluxes

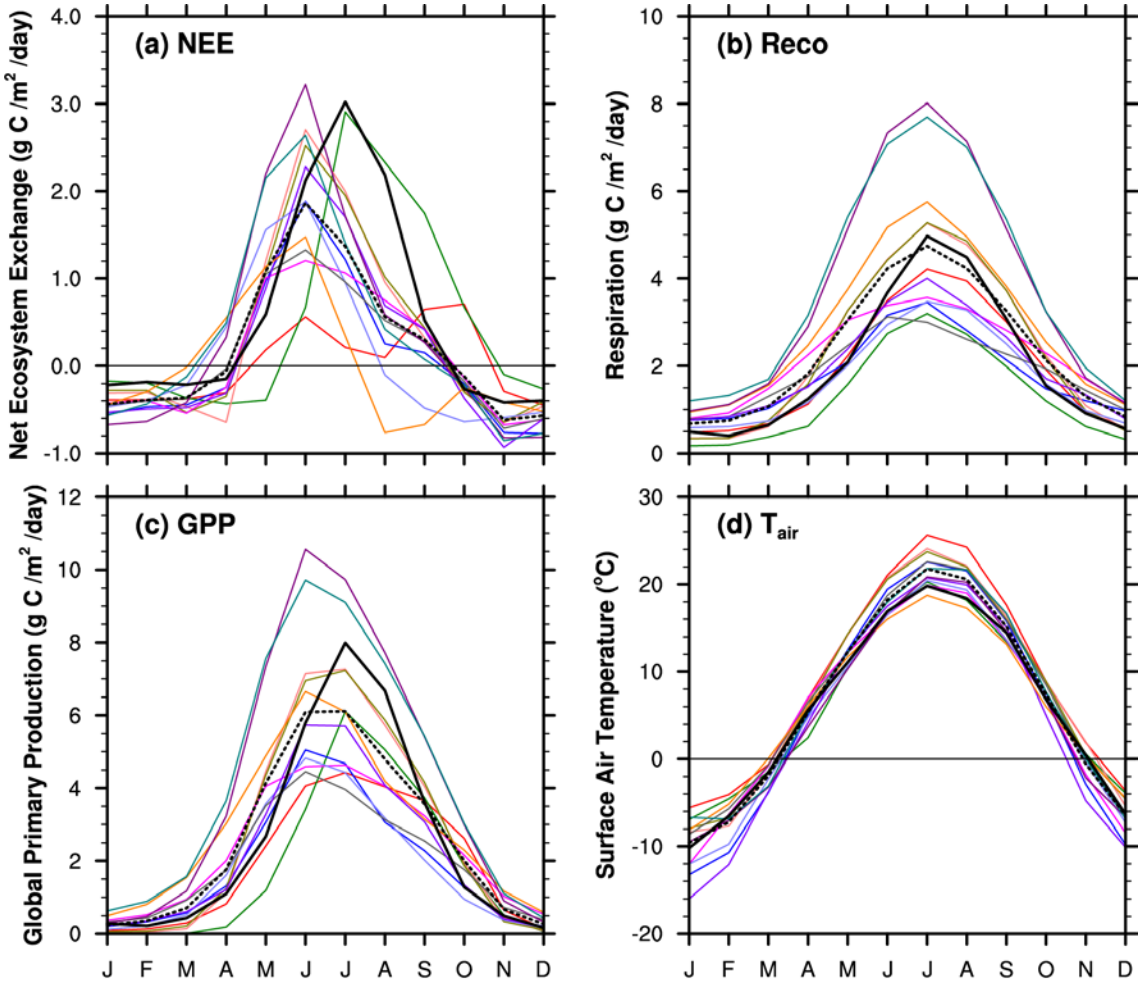
- Atmospheric CO_2 is drawn down too early in most CMIP5 models



What is causing the phase bias in atm. CO_2? Ameriflux observations provide some insight

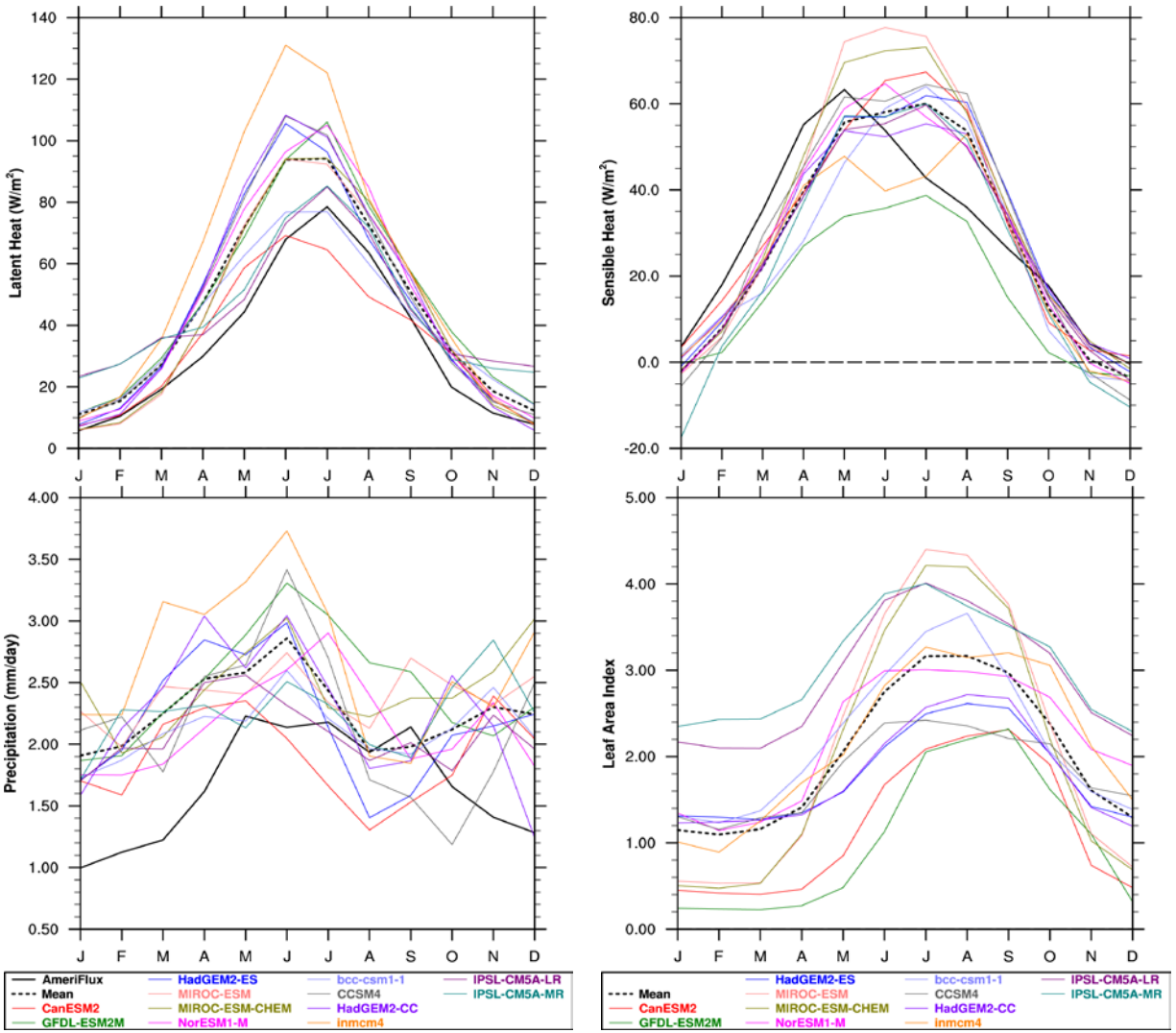
- GPP appears to be the primary culprit for the early NEE uptake and CO_2 drawdown

Models sampled at all sites north of 40N

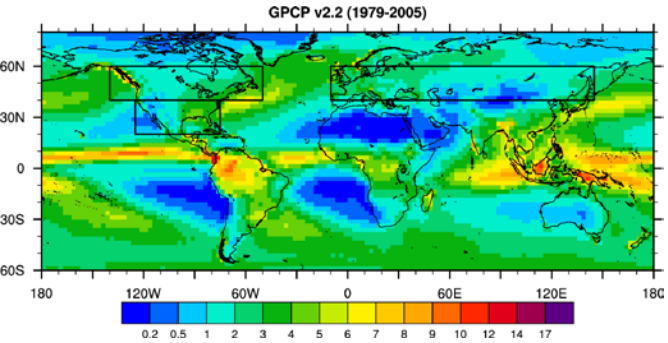


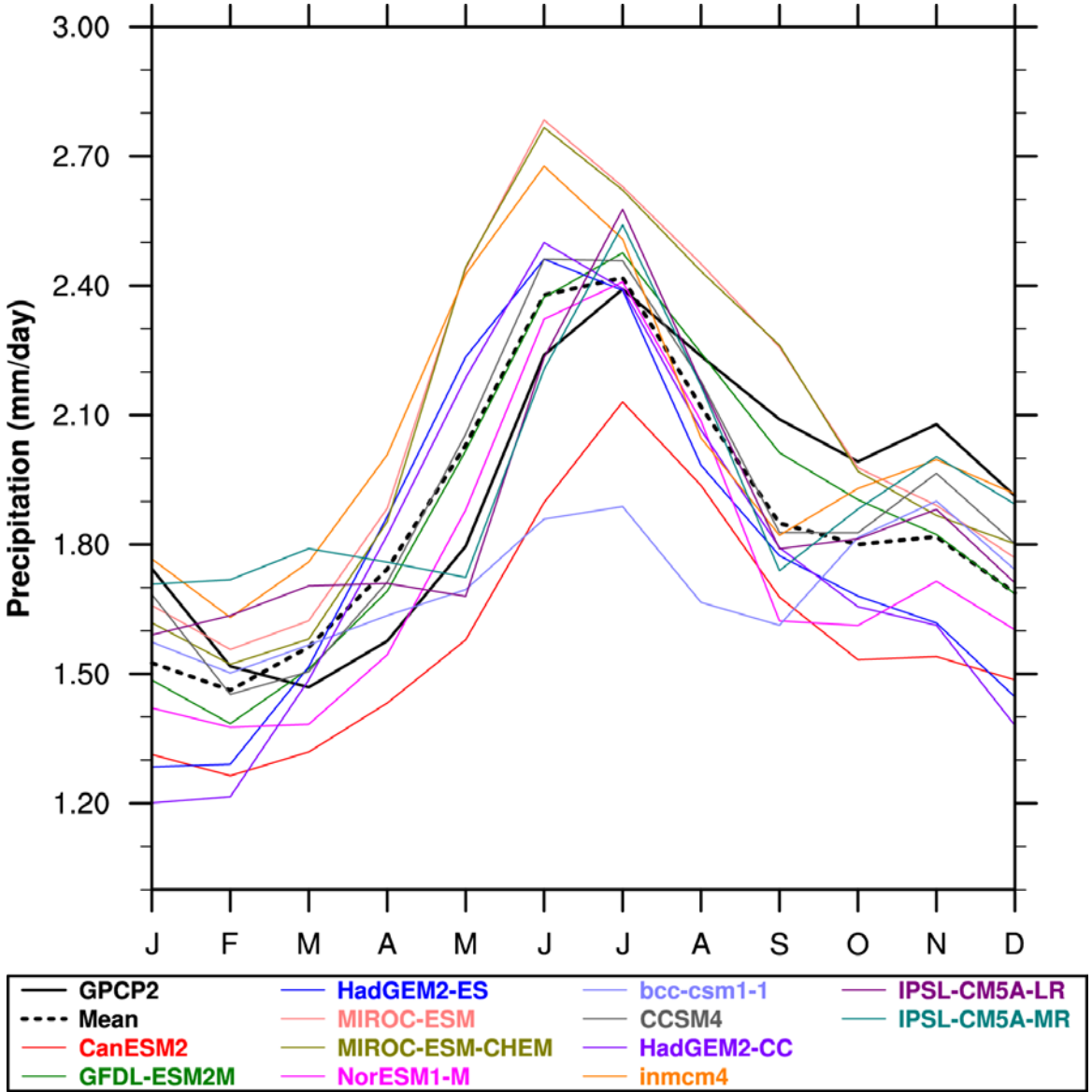
Early onset of photosynthesis has consequences for the seasonal dynamics of surface energy exchange

- Early use of snow melt may cause drought stress in late summer



Does the early onset of photosynthesis have a climate signature?





Solutions – Can we fix this and change precipitation dynamics?

- Biochemistry
  - Is the Q10 on Vcmax to small?
  - Does Btran limit GPP in the spring the way we expect it to when soils are frozen?
- Physiology
  - Do we need to build in a frost avoidance strategy into the model?
  - Unpackaging membrane and protein systems increases vulnerability to late spring frost events
- Phenology
  - Compare APAR and LAI from satellite obs. with the model

ILAMB 1.0 benchmark is now under development

	Annual Mean	Seasonal Cycle	Interannual Variability	Trend	Data Source
Atmospheric CO_2					
Flask/conc. + transport		✓	✓	✓	NOAA, SIO, CSIRO
TCCON + transport		✓	✓	✓	Caltech
Fluxnet					
GPP, NEE, TER, LE, H, RN	✓	✓	✓		Fluxnet, MAST-DC
Gridded: GPP	✓	✓	?		MPI-BGC
Hydrology/Energy					
river flow	✓		✓		GRDC, Dai, GFDL
global runoff/ocean balance	✓				Syed/Famiglietti
albedo (multi-band)		✓	✓		MODIS, CERES
soil moisture		✓	✓		de Jeur, SMAP
column water		✓	✓		GRACE
snow cover	✓	✓	✓	✓	AVHRR, GlobSnow
snow depth/SWE	✓	✓	✓	✓	CMC (N. America)
T_{air} & P	✓	✓	✓	✓	CRU, GPCP and TRMM
Gridded: LE, H	✓	✓			MPI-BGC, dedicated ET
Ecosystem Processes & State					
soil C, N	✓				HWSD, MPI-BGC
litter C, N	✓				LIDET
soil respiration	✓	✓	✓	✓	Bond-Lamberty
FAPAR	✓	✓			MODIS, SeaWIFS
biomass & change	✓			✓	Saatchi, Pan, Blackard
canopy height	✓				Lefsky, Fisher
NPP	✓				EMDI, Luyssaert
Vegetation Dynamics					
fire — burned area	✓	✓	✓		GFED3
wood harvest	✓			✓	Hurtt
land cover	✓				MODIS PFT fraction

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Table Information for variables of Benchmark and CMIP5

Benchmark Component	CMIP5 Output Variable Name	CMIP5 Standard Name	Units of CMIP5	Dataset Name	Reference	Time Peridod	Units of Original Datasets
burntArea	burntArea	Burnt Area Fraction	%	GFED3	Giglio et al., Biogeosciences, 2010	1997-2005	Hectares/0.5° grid cell
albedo	rsds	surface downwelling shortwave flux in air	watt/m^2	CERES (surface downward and net shortwave radiations)	Young et al., J. Appl. Meteorol, 1998	2000-2005	watt/m^2
	rsus	surface upwelling shortwave flux in air					
	rsds	surface downwelling shortwave flux in air	watt/m^2	MODIS (white sky shortwave albedo)	Schaaf et al., Proc. Int. Geosci. Remote Sens. Symp. (IGASS'99), 1999	2000-2005	unitless
	rsus	surface upwelling shortwave flux in air					
nee	gpp	Gross primary productivity of carbon	Kg /m^2 /s	US Forest		1998-2005	Kg /m^2 /s
	ra	plant respiration carbon flux					

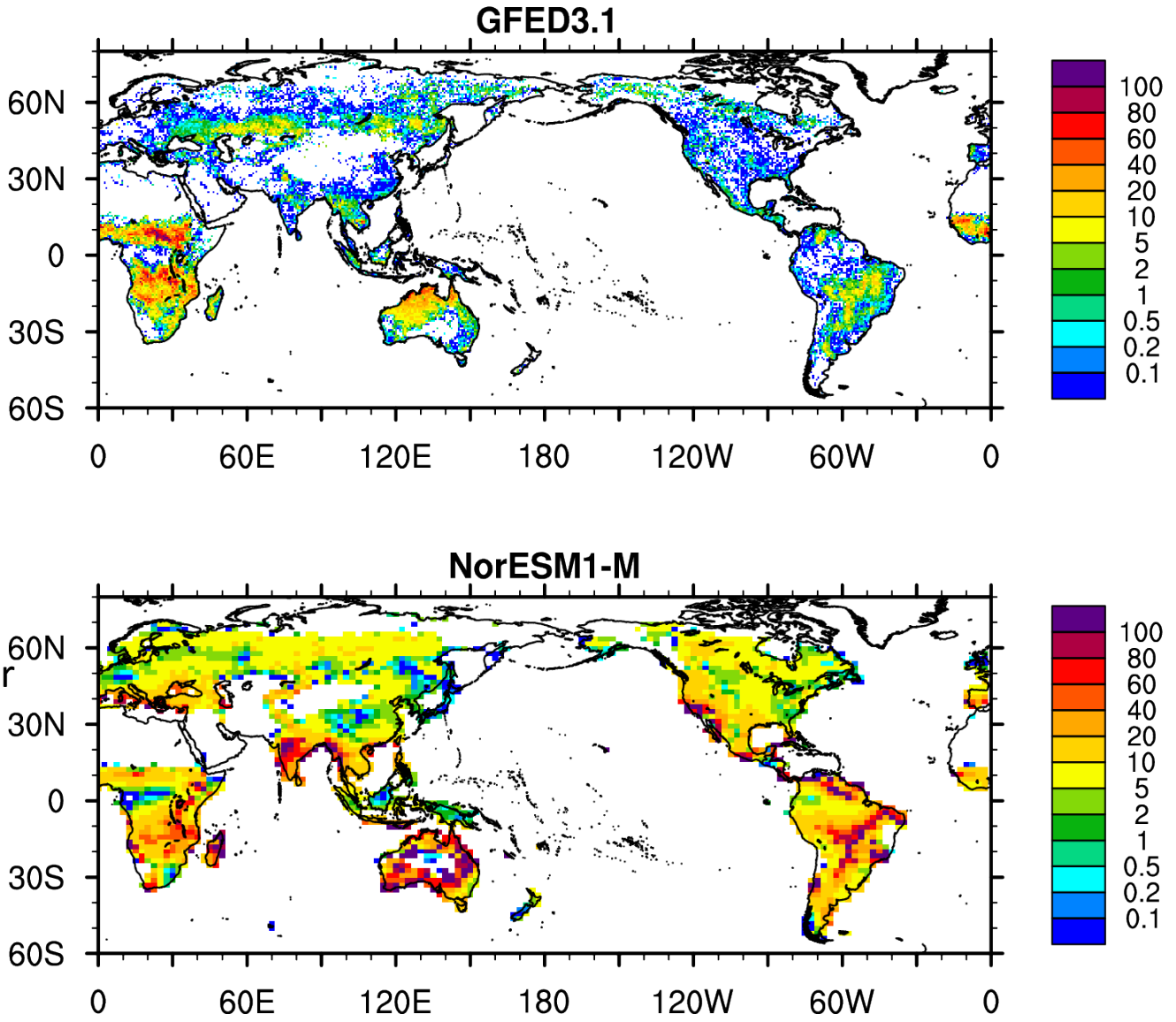
Annual mean of Global Burnt Area In 1997-2005

Unit: %/yr

Global mean: 378 Mhayr

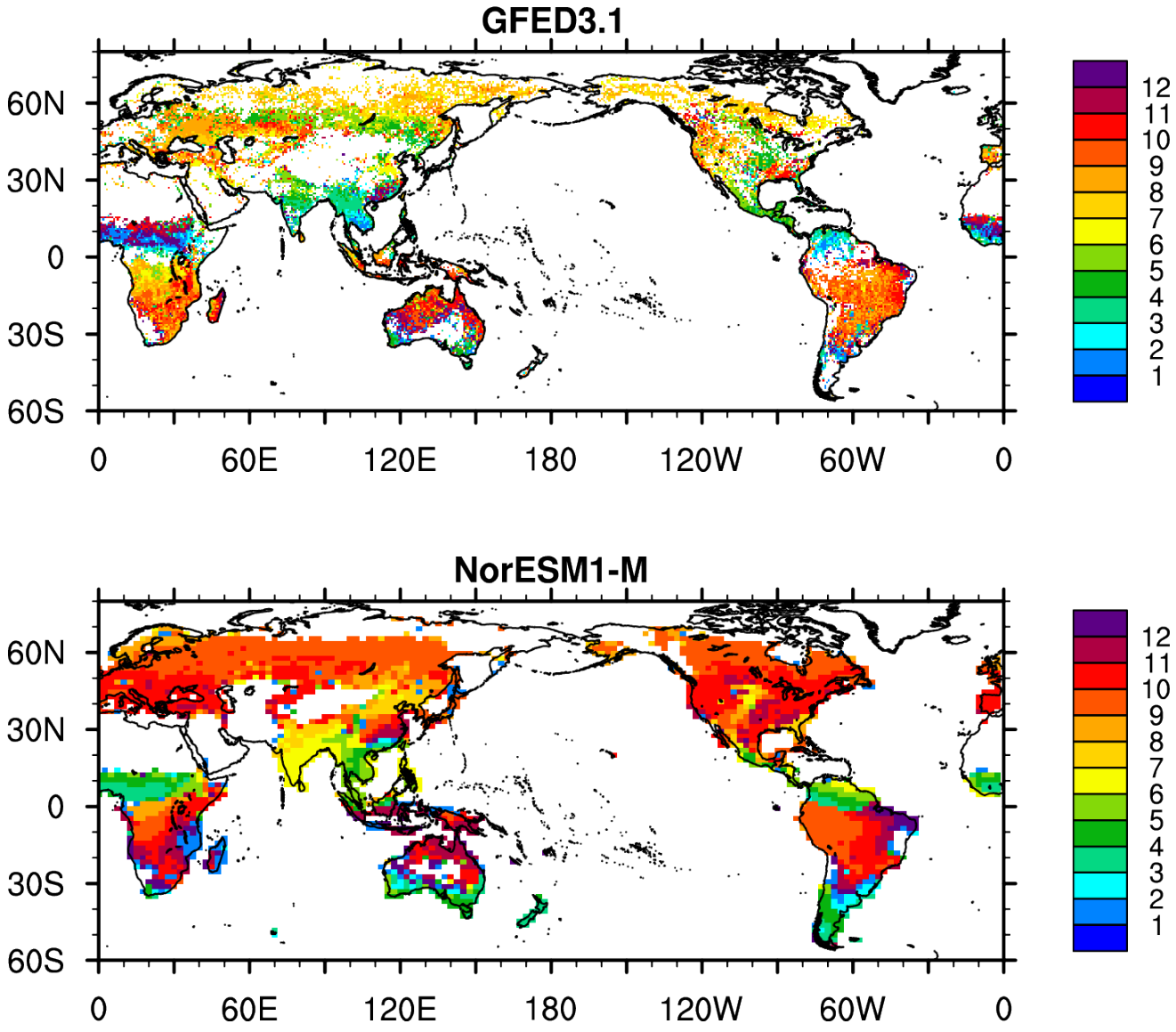
Global mean: 2768 Mha/yr

NorESM1-M vs GFED3.1



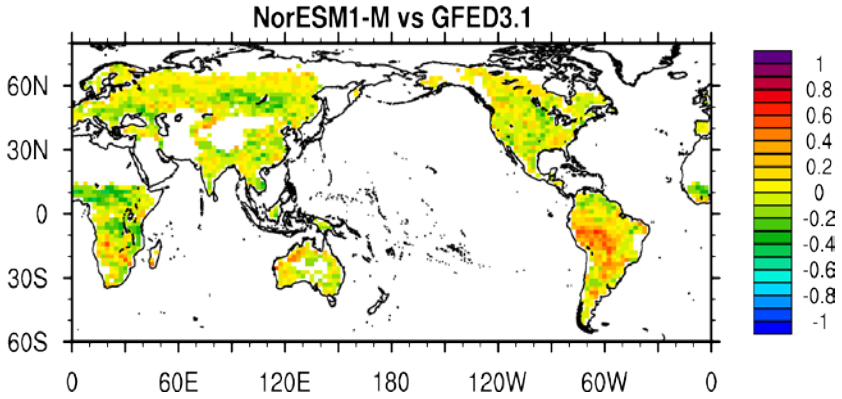
Peak fire season

NorESM1-M vs GFED3.1

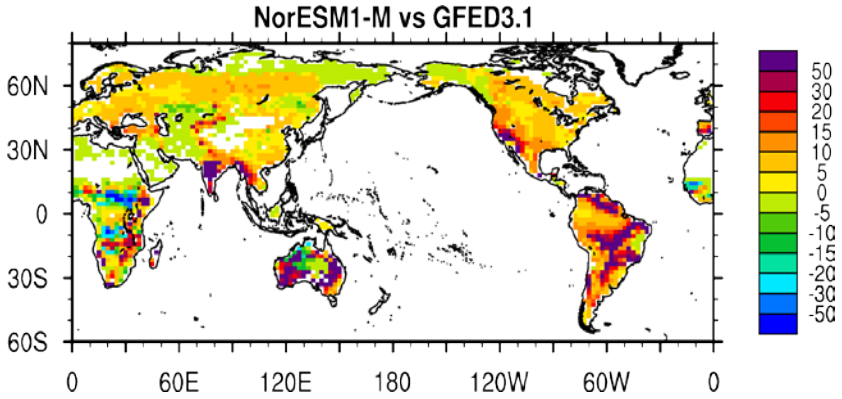


NorESM1-M vs GFED3.1

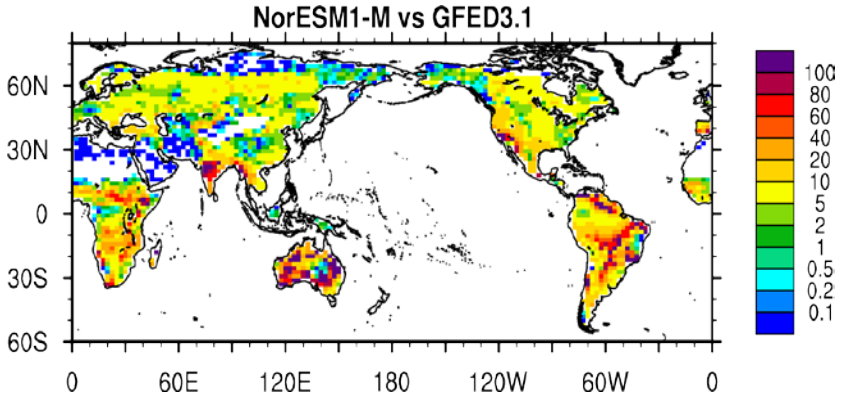
Correlation



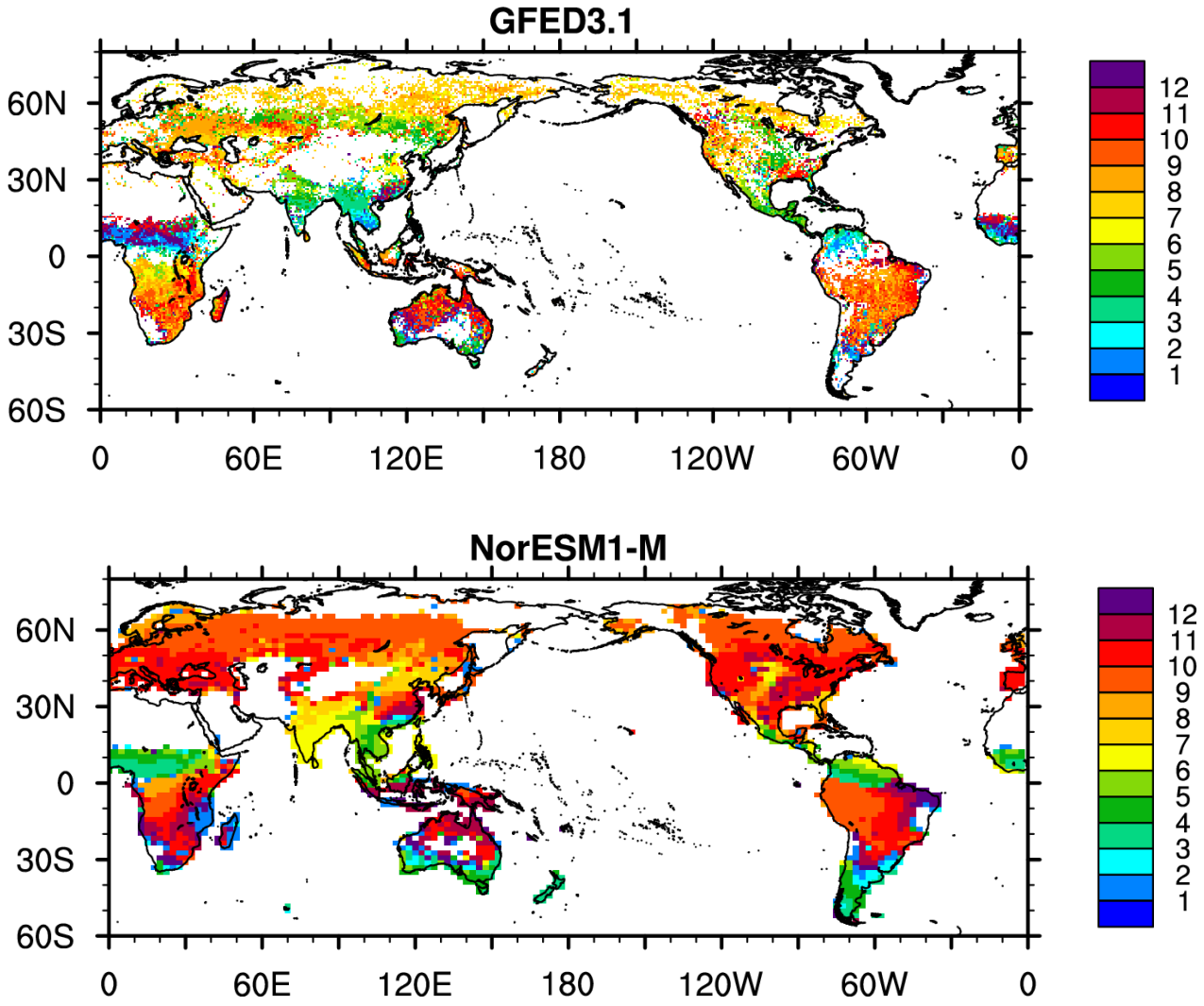
Bias
(%/yr)



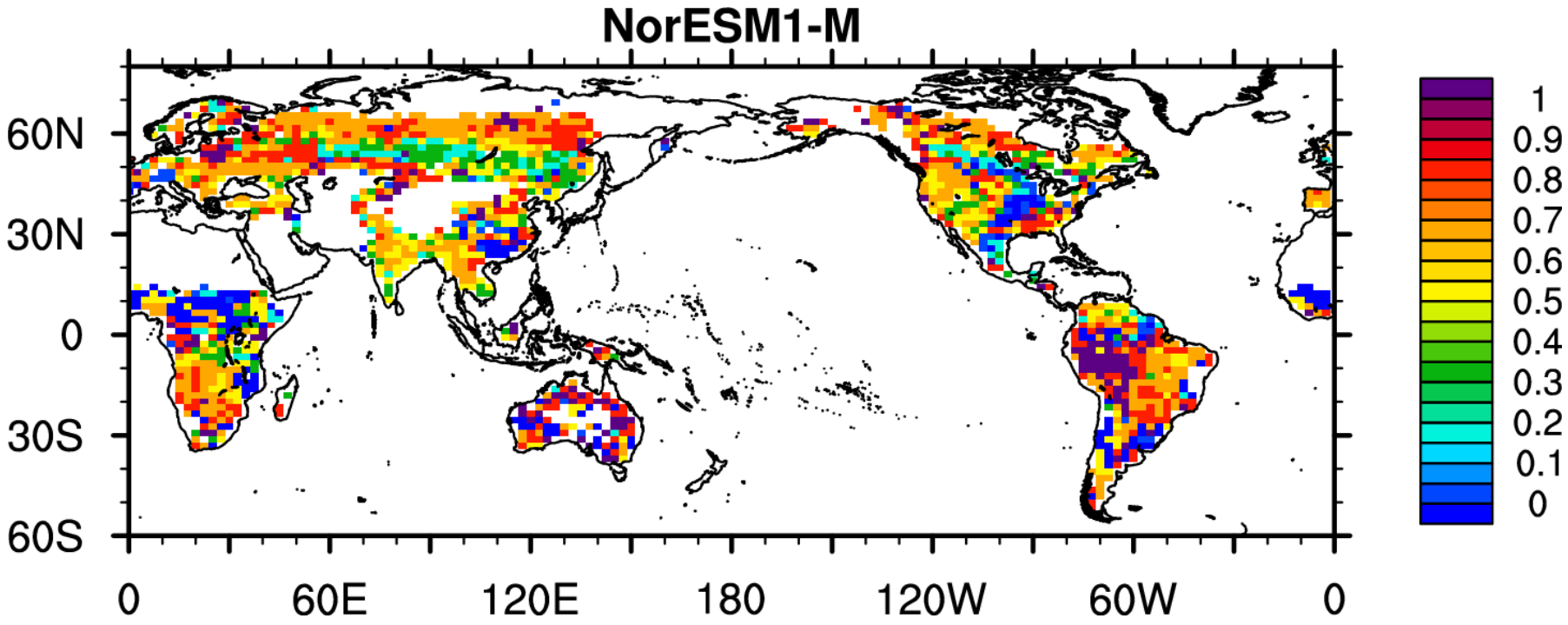
Root mean square error
(%/yr)



Burned Area Fraction
Peak Fire Month (PFM)



Burned Area Fraction
Seasonal Cycle Score (OPS)



Dataset Name: original GFED3 (MCD64A1) Burned Area

Variable Names: BurntArea, LandCoverDist

Reference of Original Data:
Giglio, L., J.T. Randerson, G.R. van der Werf, P.S. Kasibhatla, G.J. Collatz,D.C. Morton, and R.S. DeFries. Assessing variability and long-term trends in burned area by merging multiple satellite fire products. Biogeosciences. 6: 1171~S1186, 2010.

Downloaded Date and Person:
By M. Mu (ESS, University of California Irvine) on Apr. 20, 2010

Name and Version of Original source: MCD64A1, GFED3.1

Temporal Resolution: monthly from 1997 till 2005

Spatial Resolution: 0.5x0.5 degree

Unit: hectares per grid cell

Data Format: hdf

Readme for original GFED3 Burned Area

Dataset Name: derived GFED3 Burned Area

Variable Name: burntArea

General Info: This product was derived from GFED3 (MCD64A1) dataset.

Approach:

Derived Data Code: ~/CODES/conversion-ba-gfed3.ncl

Temporal Resolution: monthly from 1997 till 2005

Spatial Resolution: 0.5x0.5 degree

Unit: unitless

Data Format: netCDF 3

Data File Structure: burntArea_YearMonth.nc

Readme for derived GFED3 Burned Area

Dataset Name: original CERES radiation

Variable Names: Total_sky_Sfc_Net_SW_Flux_Mod_B__1,
Total_sky_Sfc_Down_SW_Flux_Mod_B__1

Reference of Original Data:
Young, D. F., P. Minnis, D. R. Doelling, G. G. Gibson, T. Wong, Temporal Interpolation Methods for the Clouds and the Earth Radiant Energy System (CERES) Experiment. Journal of Applied Meteorology, Vol 37(6), 572-590, 1998.

Downloaded Date and Person:
By M. Mu (ESS, University of California Irvine) on Oct. 22, 2011

Name and Version of Original source:
CERES (The Clouds and the Earth Radiant Energy System), SRBAVG1 Terra

Temporal Resolution: monthly from 2000 till 2005

Spatial Resolution: 1.0x1.0 degree

Unit: watt/m^2

Data Format: hdf

Readme for original CERES radiations

Dataset Name: derived CERES albedo

Variable Name: albedo

General Info: This product was derived from CERES SRBAVG1 Terra radiation dataset.

Approach: Net downward surface shortwave divided by total sky downward surface shortwave from CERES SRBAVG1 Terra product.

Derived Data Code: ~/CODES/conversion-albedo-ceres.ncl

Temporal Resolution: monthly from 2000 till 2005

Spatial Resolution: 0.5x0.5 degree

Unit: unitless

Data Format: netCDF 3

Data File Structure: albedo_YearMonth.nc
~

Readme for derived CERES albedo

Dataset Name: original MODIS albedo

Varialbe Name: Albedo_WSA_shortwave

Reference of Original Data:
Schaaf, C. B., W. Lucht, T. Tsang, F. Gao, N. Strugnell, L. Chen, Y. Liu, and A.H. Strahler , Prototyping the MODerate Resolution Imaging Spectroradiometer (MODIS) BRDF and Albedo Product, Proc. Int. Geosci. Remote Sens. Symp. (IGARSS'99), Hamburg, Germany, 28 June - 2 July, 1506-1508, 1999.

Downloaded Date and Person:
By M. Mu (ESS, University of California Irvine) on Oct. 22, 2011

Name and Version of Original source:
MODIS MCD43C3 16-day 0.05 degree CMG L3, version 5

Temporal Resolution: monthly from 2000 till 2005

Spatial Resolution: 0.05x0.05 degree

Unit: unitless

Data Format: hdf

Readme for original MODIS albedo

Dataset Name: derived MODIS albedo

Variable Name: albedo

General Info: This product was derived from MODIS MCD43C3 16-day 0.05 degree CMG dataset.

Approach: see conversion code for detail

Derived Data Code: ~/CODES/conversion-albedo-modis.ncl

Temporal Resolution: monthly from 2000 till 2005

Spatial Resolution: 0.5x0.5 degree

Unit: unitless

Data Format: netCDF 3

Data File Structure: albedo_YearMonth.nc

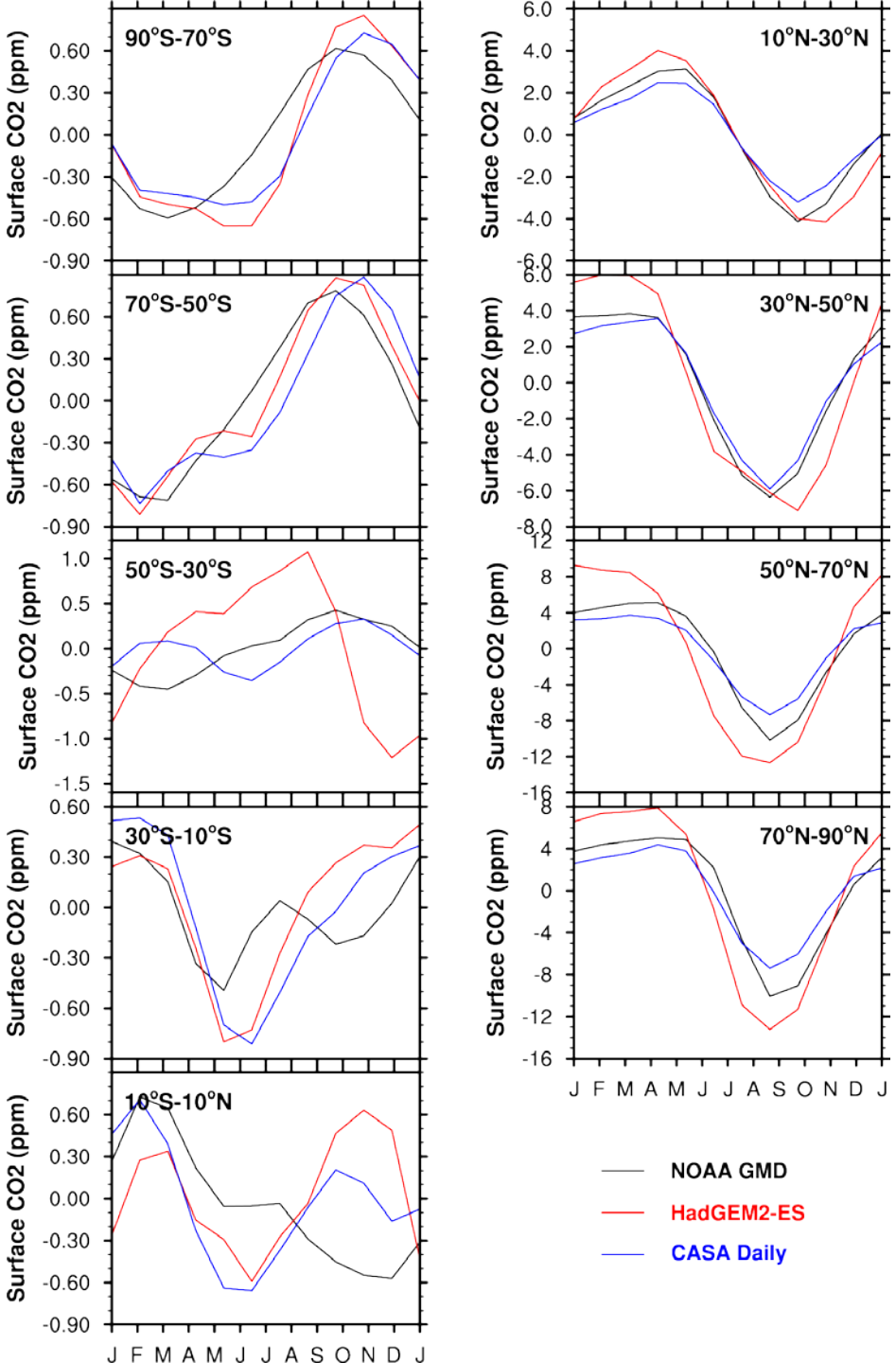
Readme for derived MODIS albedo

Total annual CO2

Sampled at NOAA sites

2001-2005 mean

Year	HadGEM2-ES (Tg/yr)
2001	-1170
2002	-3367
2003	-776
2004	-2780
2005	-1181
mean	-1855



Questions for ILAMB 1.0 benchmark development

- For models with ensembles, should we take the mean response?
- For comparing with observations at finer spatial resolution, do we:
  - 1) regrid the models to the observations (this will penalize models with coarser spatial resolution)
  - 2) regrid the observations to the model resolution (this will not penalize models with a coarser resolution)
- How do we reach a consensus regarding metrics and cost functions over the next two months for a given variable?
- For atmospheric CO2 comparisons, we will run the CMIP5 set of NBP from 1990-2005 through GEOS-Chem with MERRA reanalysis and use observed fossil fuel and data assimilation ocean fluxes. Are there other atmospheric models that would like to participate?
- Should we reorganize the approach for publishing the different components?
- Can individuals help procure their favorite datasets for ILAMB?