JULES-INFERNO in the Fire Model Intercomparison Project

Model performance and process evaluation

Douglas Kelley, Stijn Hantson, Stephane Mangeon

FireMIP contributors: Almut Arneth, Sandy P. Harrison, Sam S. Rabin, Dominique M. Bachelet, Matthew Forrest, Silvia Kloster, Gitta Lasslop, Fang Li, Joe R. Melton, Tim Sheehan, Chao Yue

Fire Limitation Framework: Ioannis Bistinas, Rhys Whitley, Chantelle Burton, Toby Marthews

27th June 2017

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Met Office

UKESM

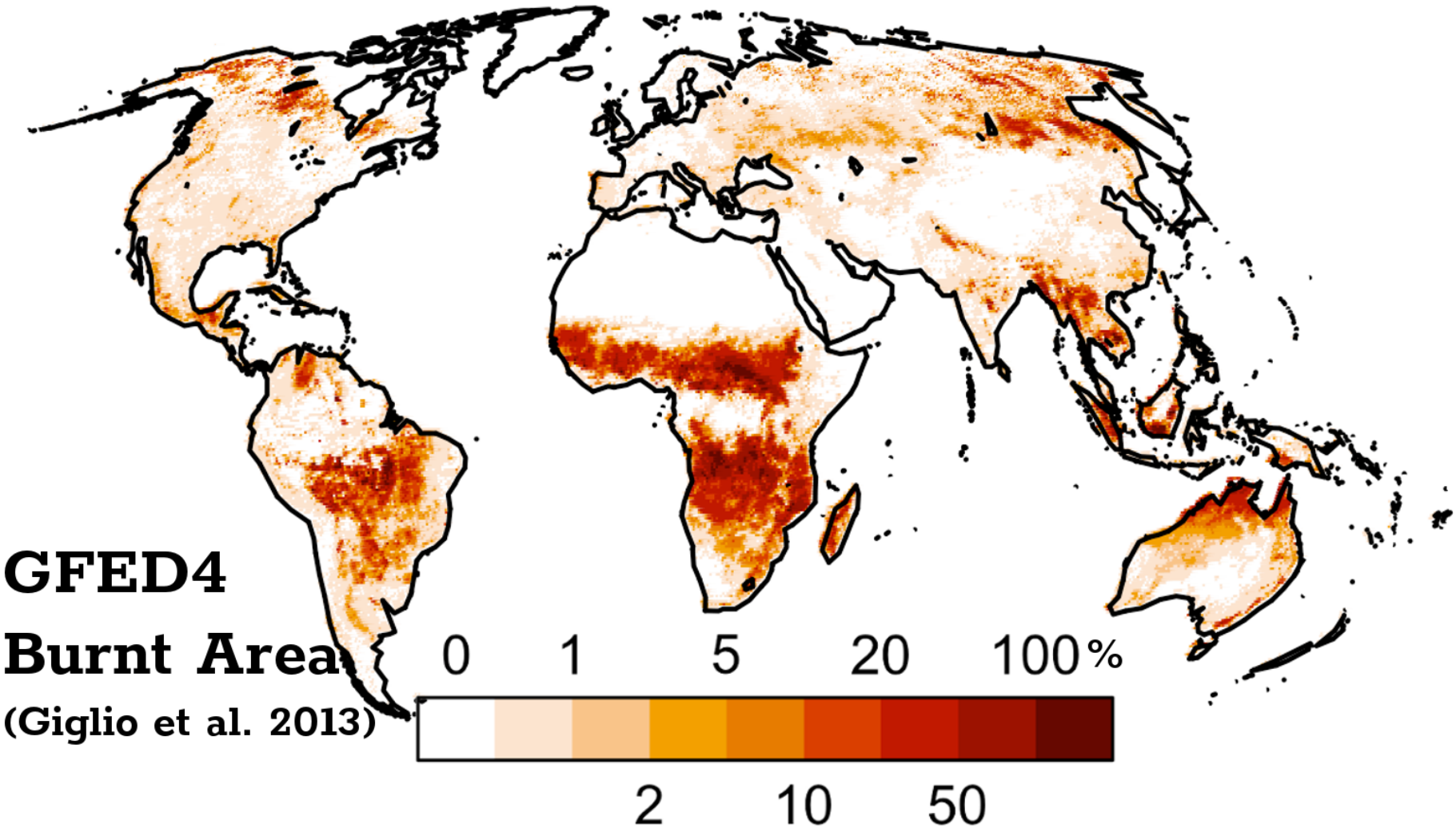
SUNCORP

KIT Karlsruhe Institute of Technology

NERC SCIENCE OF THE ENVIRONMENT

Fire In the Earth System

Areas affected

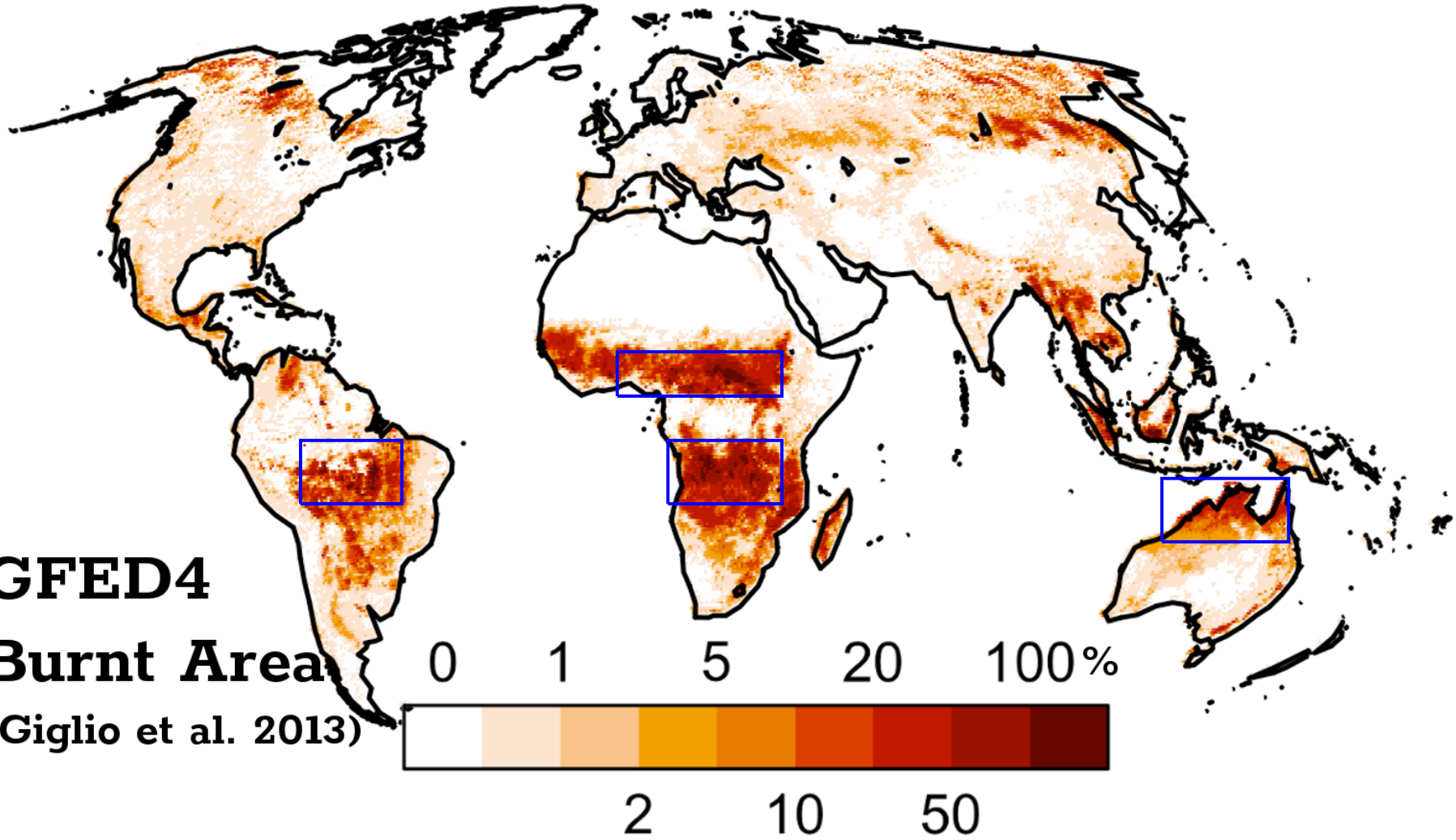


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Fire In the Earth System

Areas affected

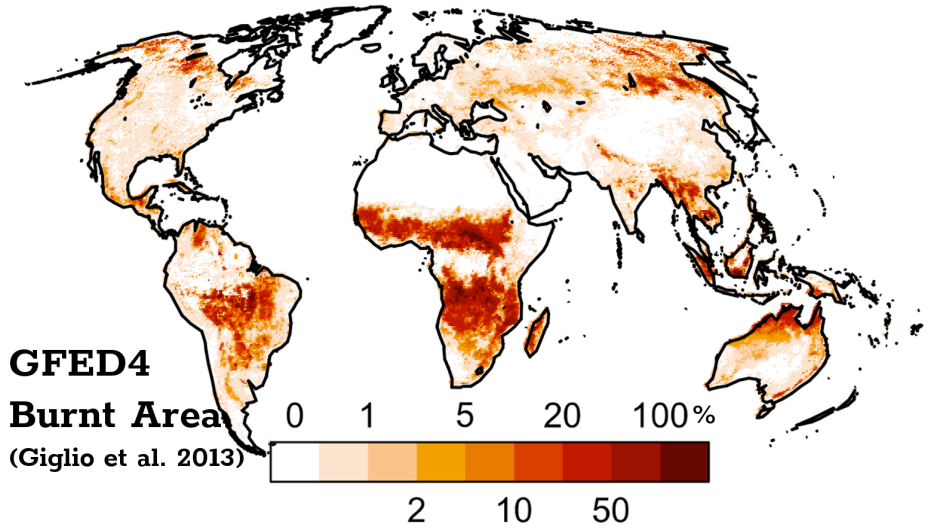


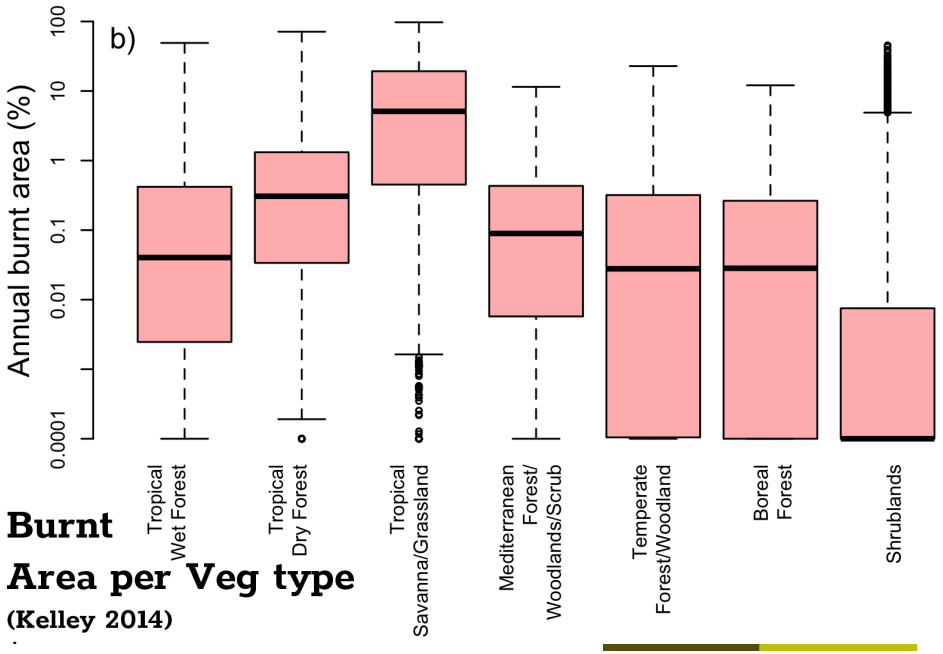
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Fire In the Earth System

Areas affected





Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Fire and carbon

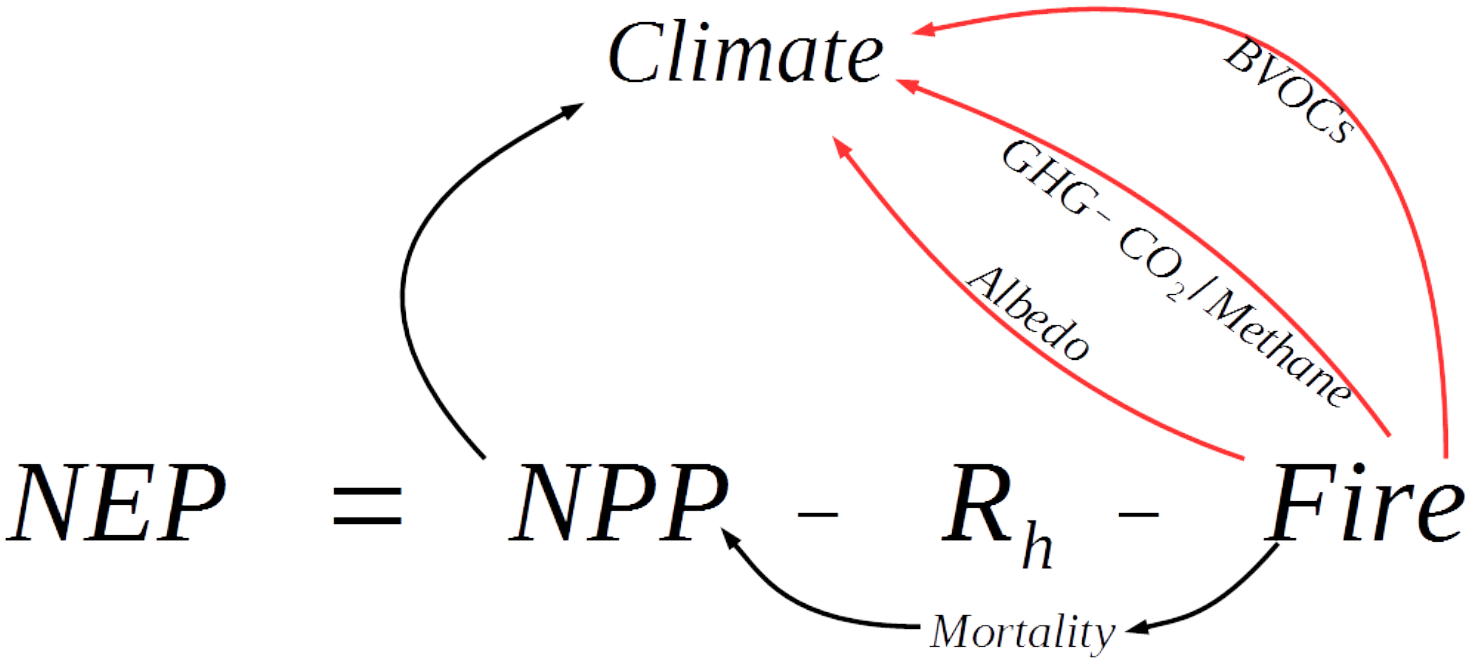
$$NEP = NPP - R_h - Fire$$

Fire and carbon

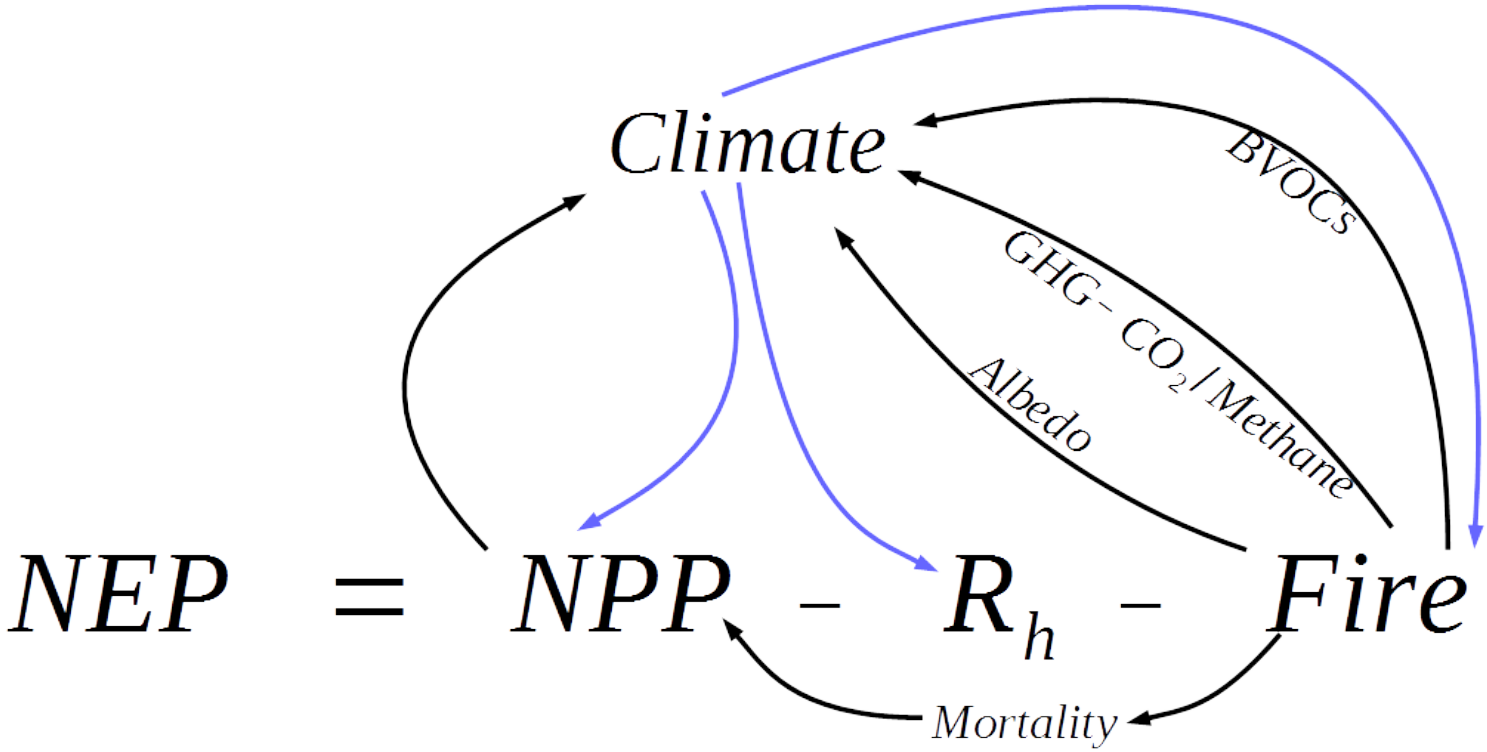
$$NEP = NPP - R_h - Fire$$

Mortality

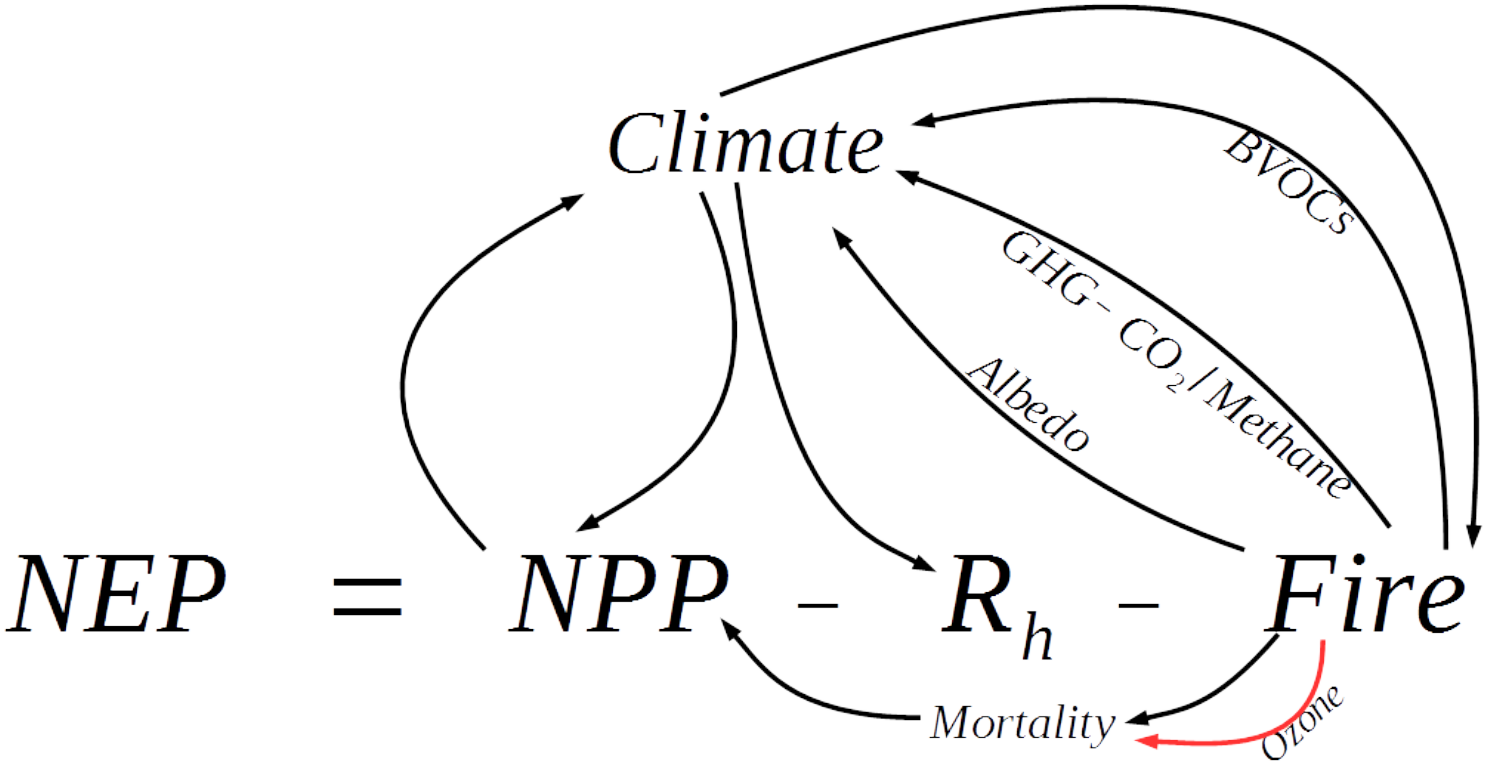
Fire and carbon



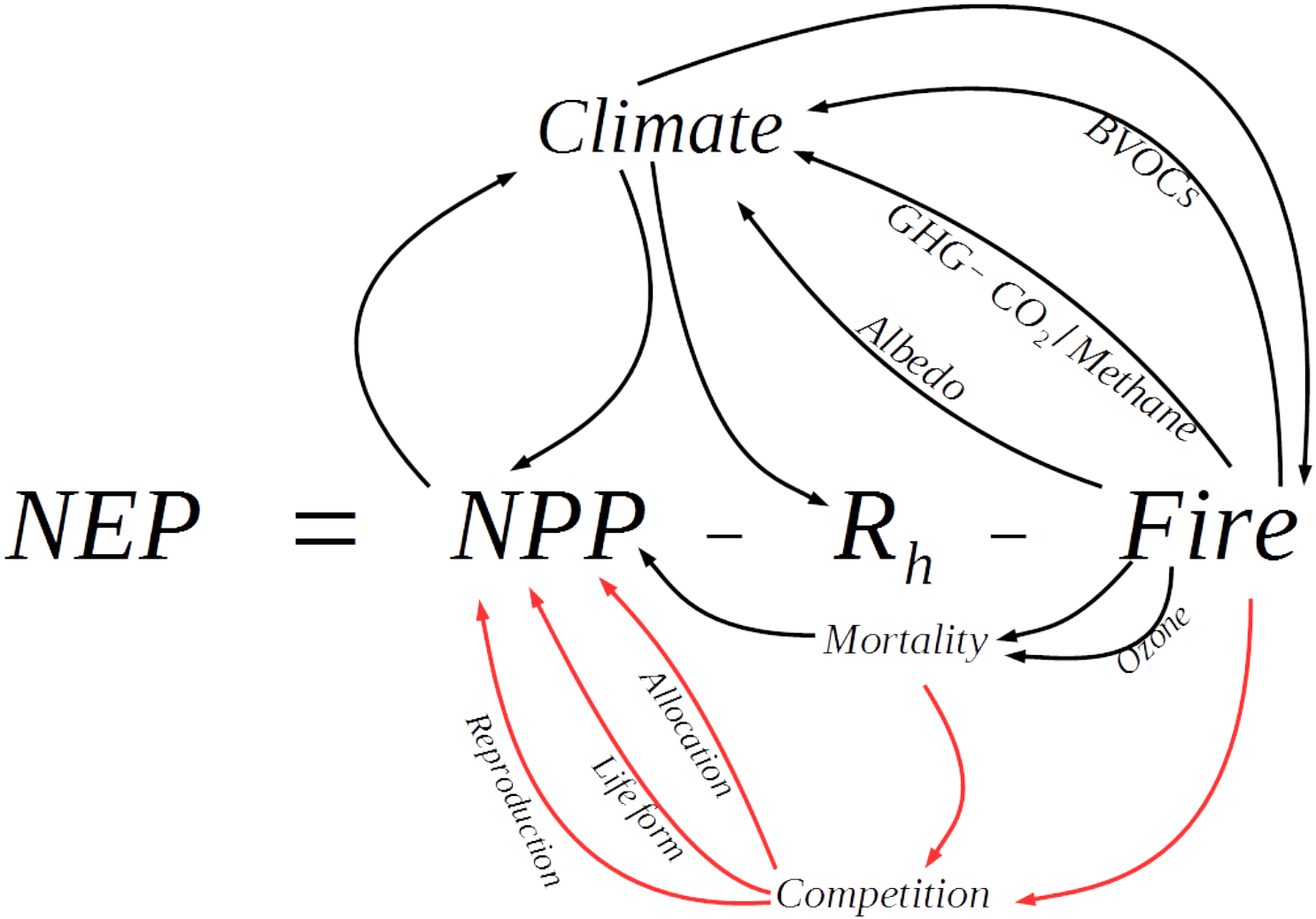
Fire and carbon



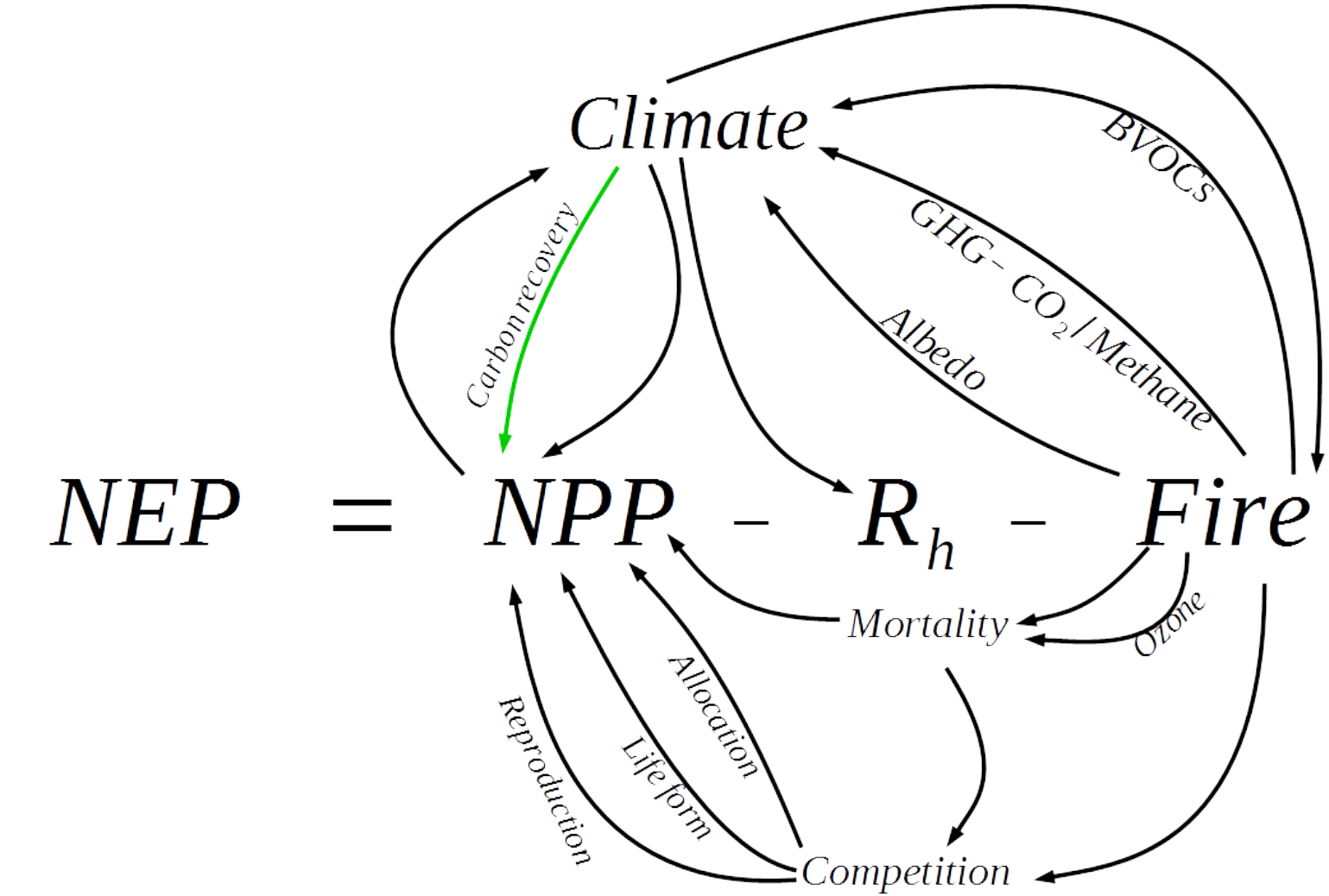
Fire and carbon



Fire and carbon

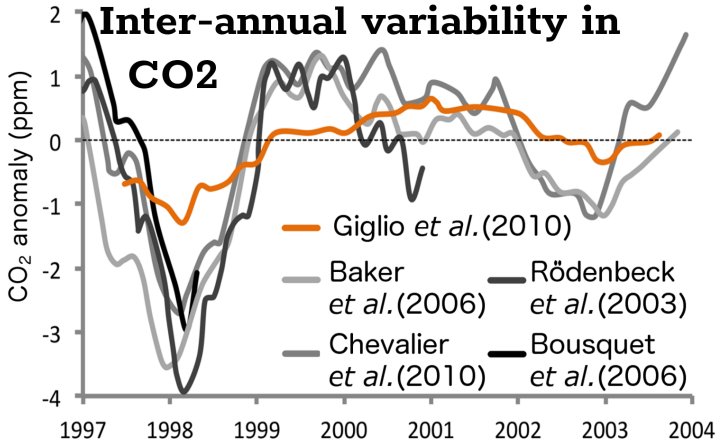


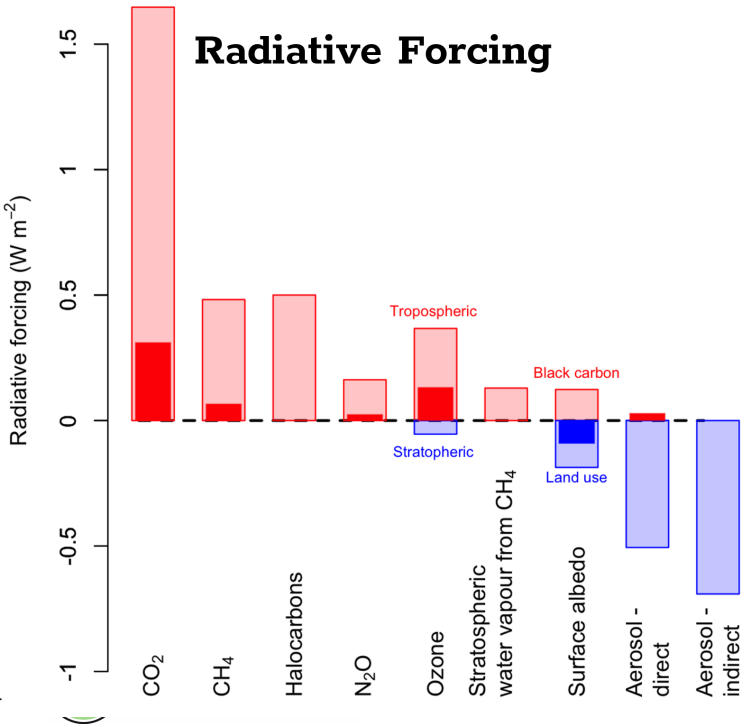
Fire and carbon

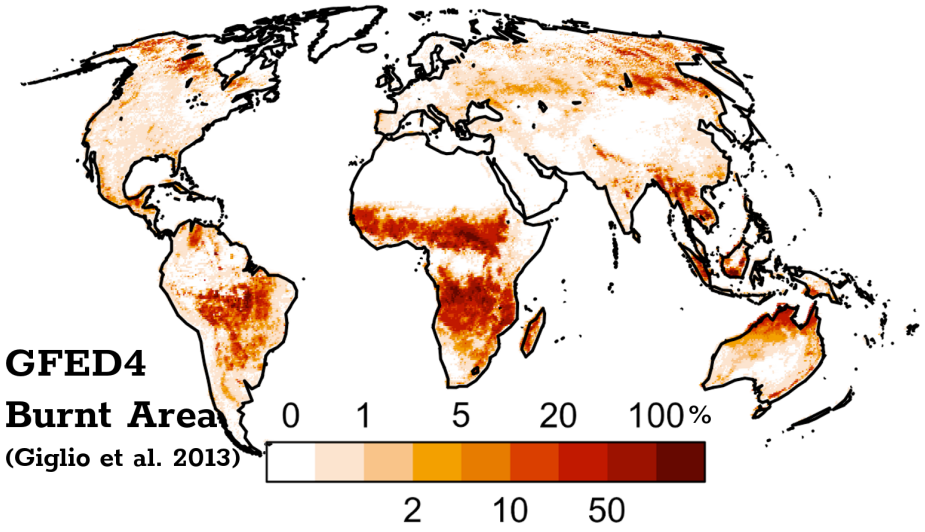


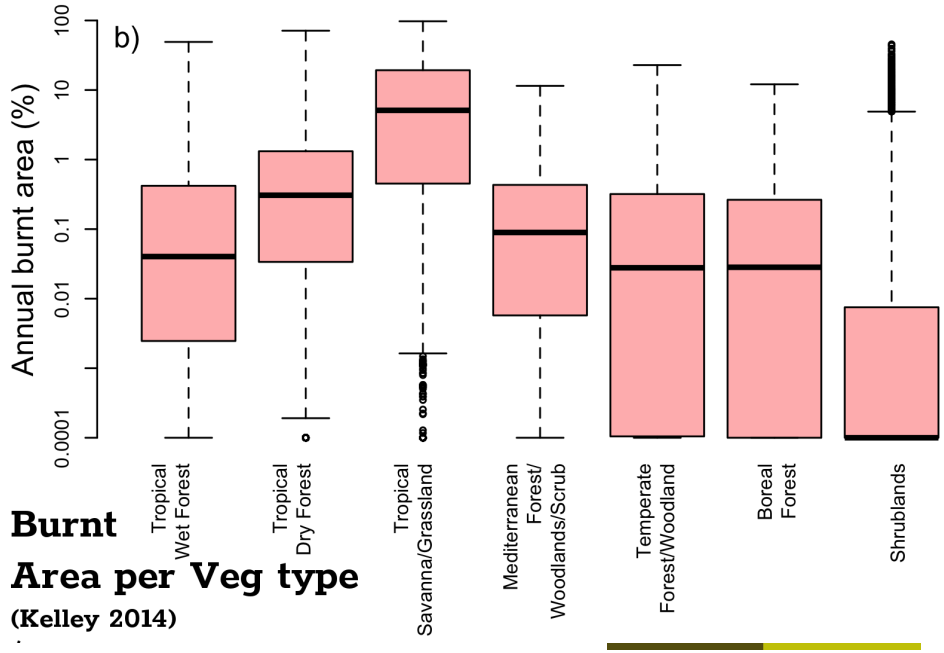
Fire In the Earth System

Carbon Cycle and Radiative Forcing









fireMIP
Fire Modelling Inter-comparison Project

fireMIP Models

CLM

CTEM

JSBACH

JULES-INFERNO

LPJ-GUESS-BLAZE

LPJ-GUESS-GLOBFIREM

LPJ-GUESS-SPITFIRE

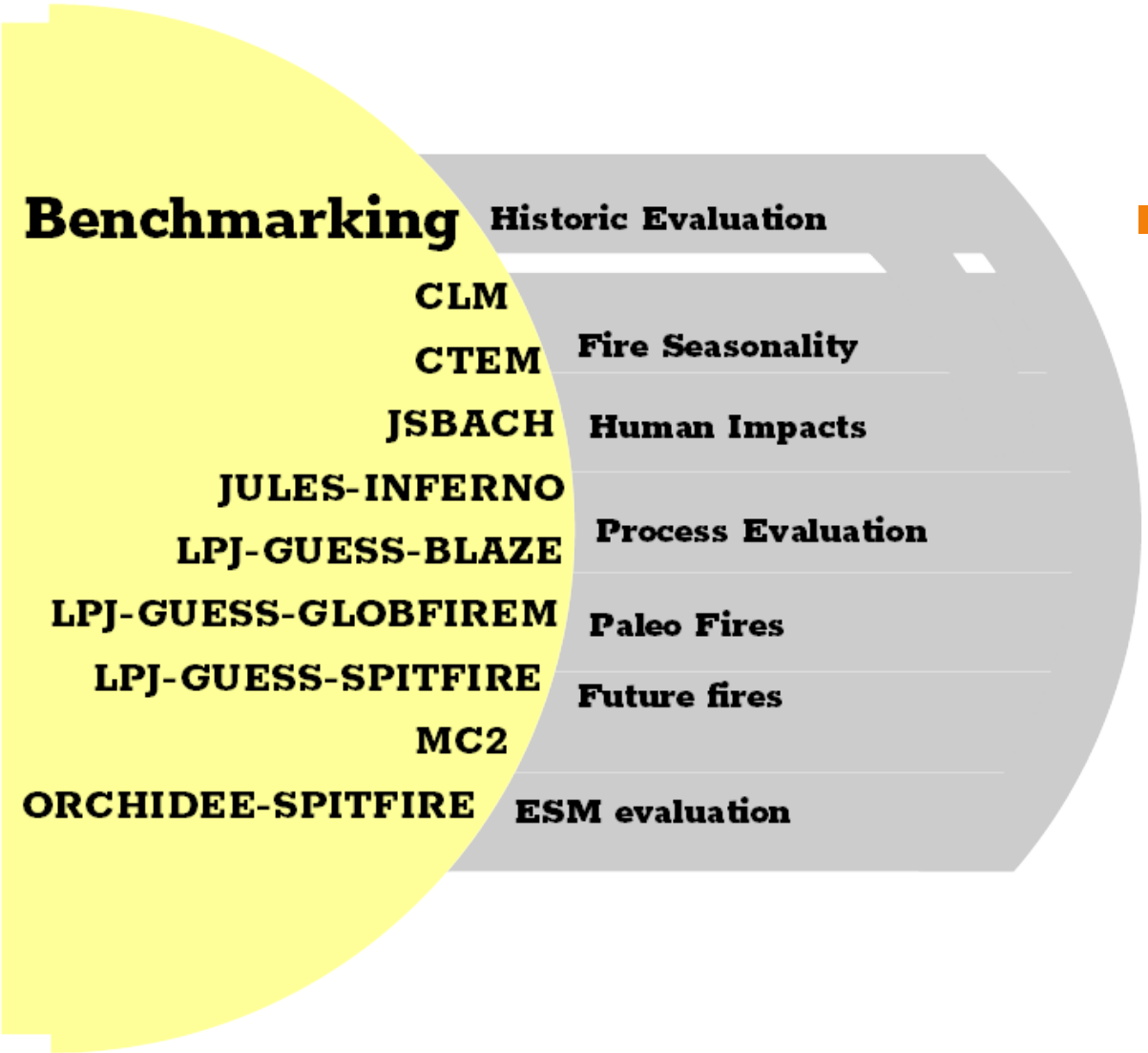
MC2

ORCHIDEE-SPITFIRE

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

fireMIP
Fire Modelling Inter-comparison Project

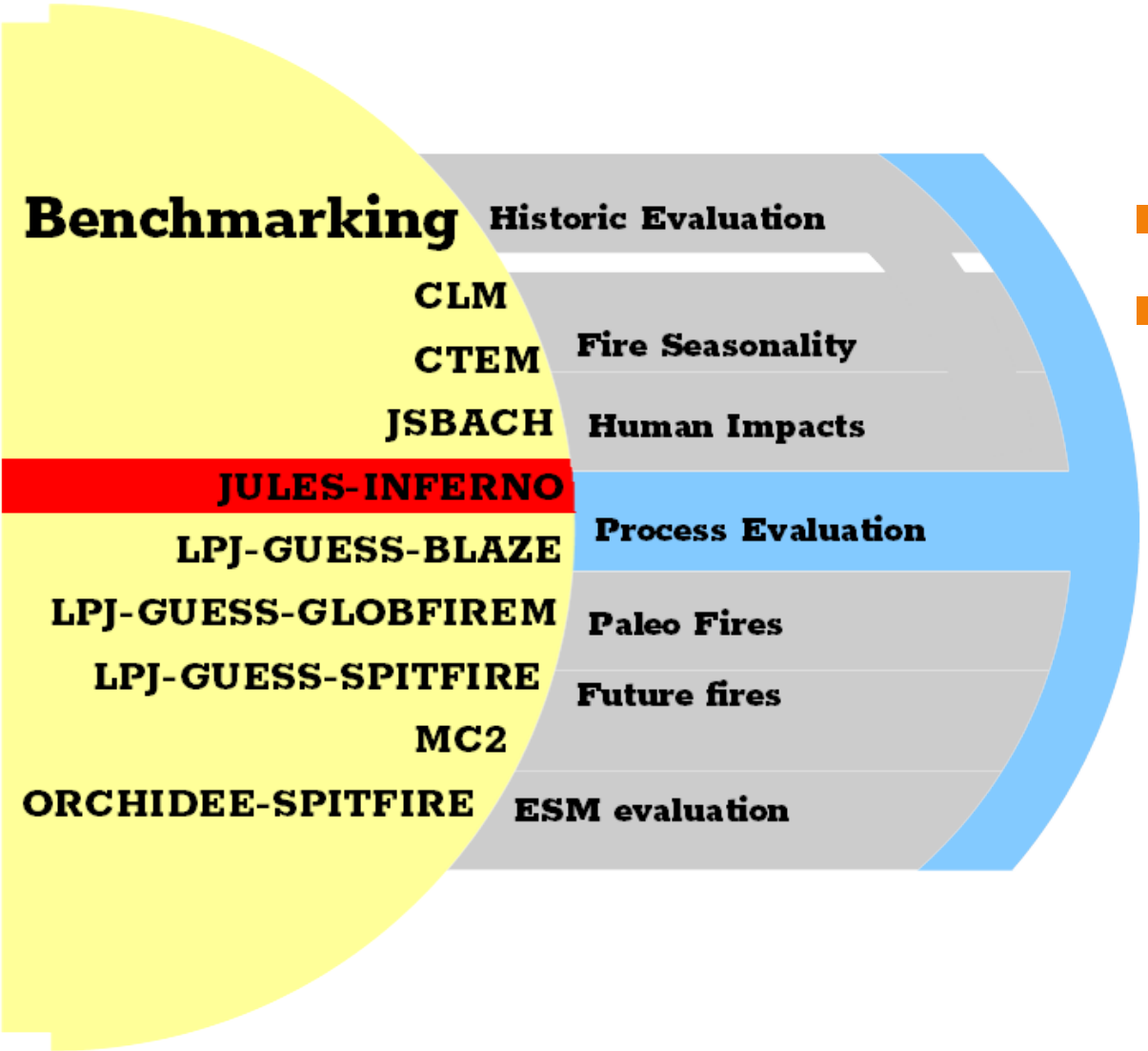


- Benchmark overview

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

fireMIP
Fire Modelling Inter-comparison Project

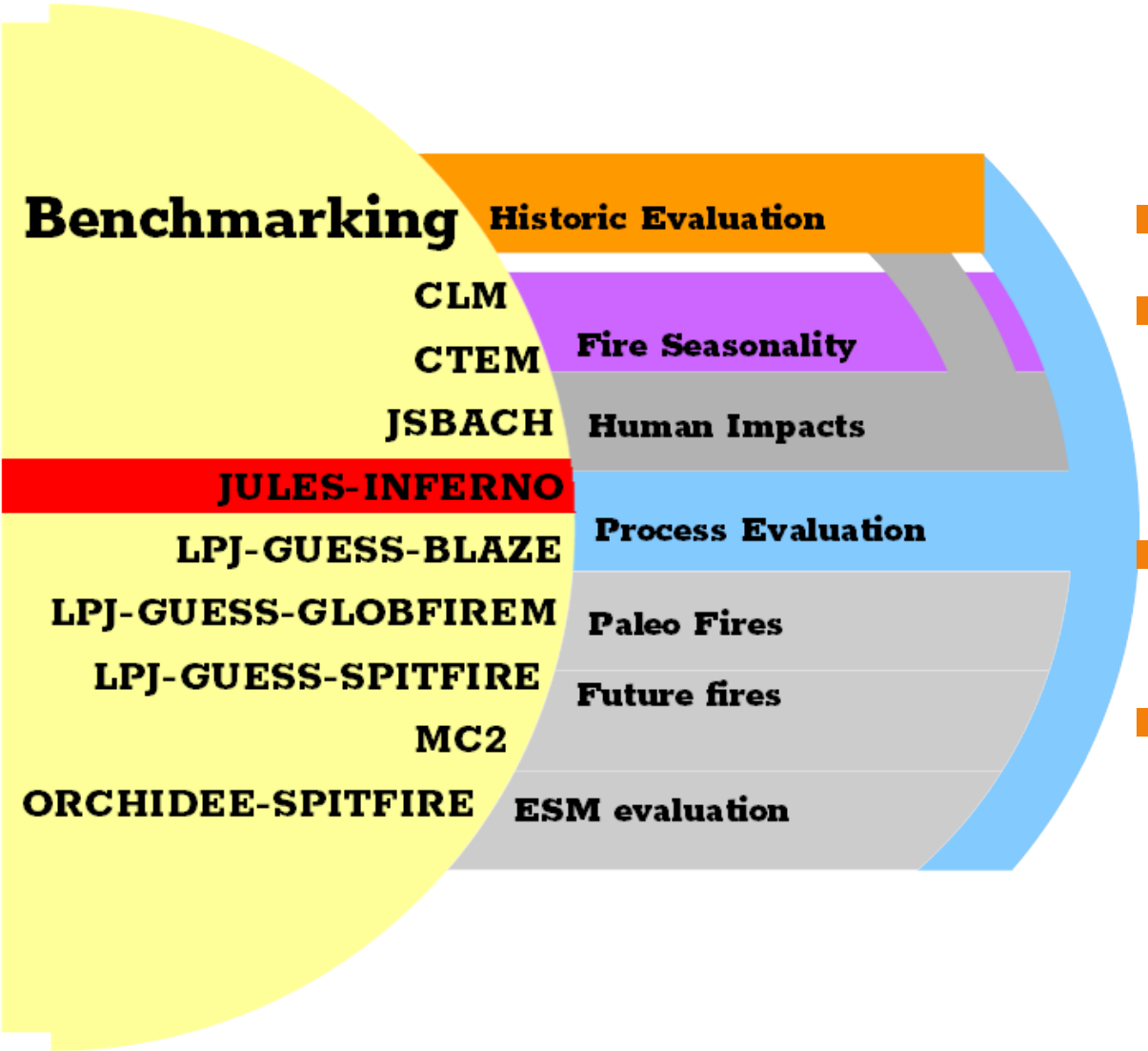


- Benchmark overview
- Focus on JULES performance & fire controls

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

fireMIP
Fire Modelling Inter-comparison Project

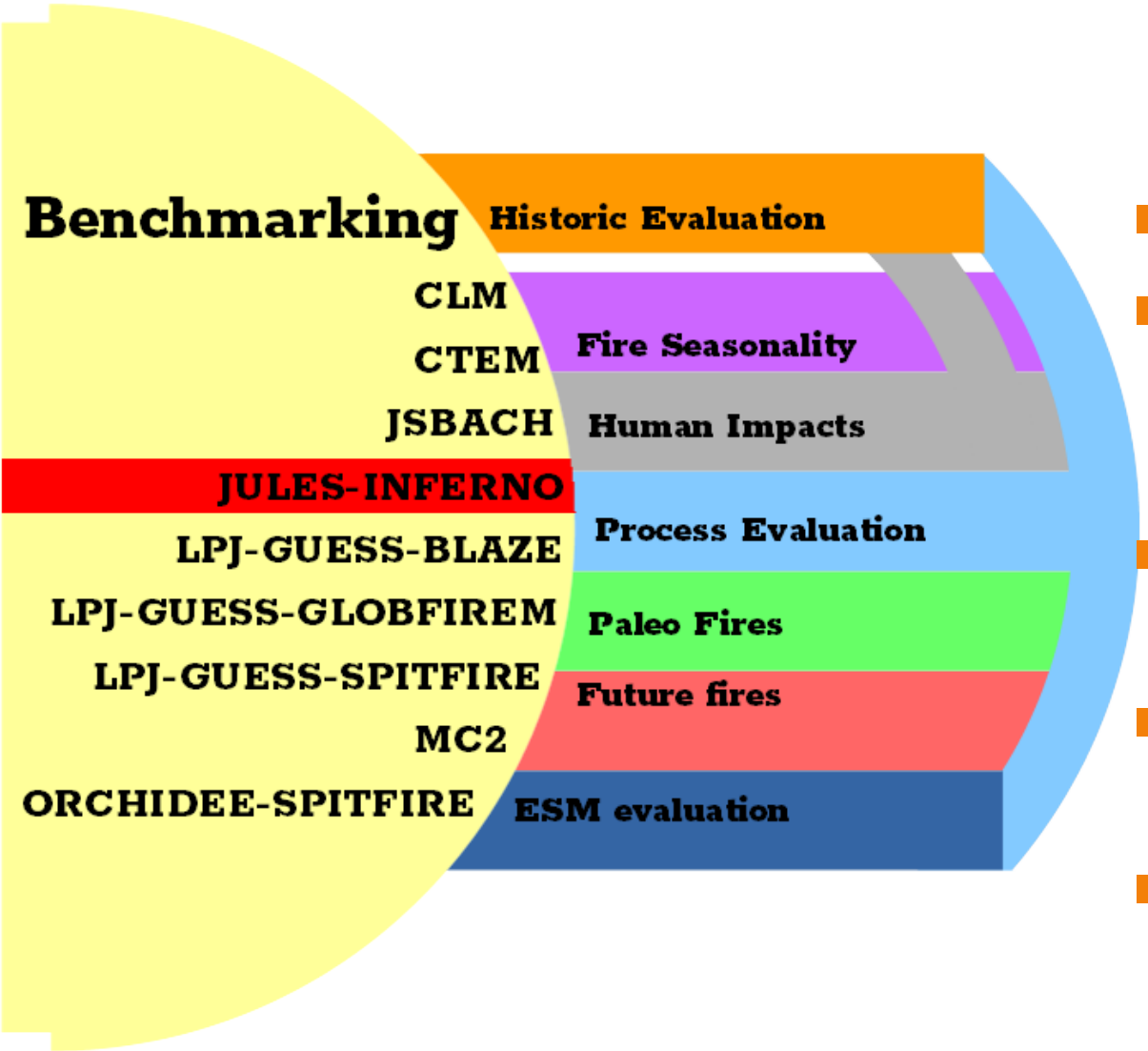


- Benchmark overview
- Focus on JULES performance & fire controls
- Diagnose seasonality performance
- Explore missing anthropogenic processes

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

fireMIP
Fire Modelling Inter-comparison Project

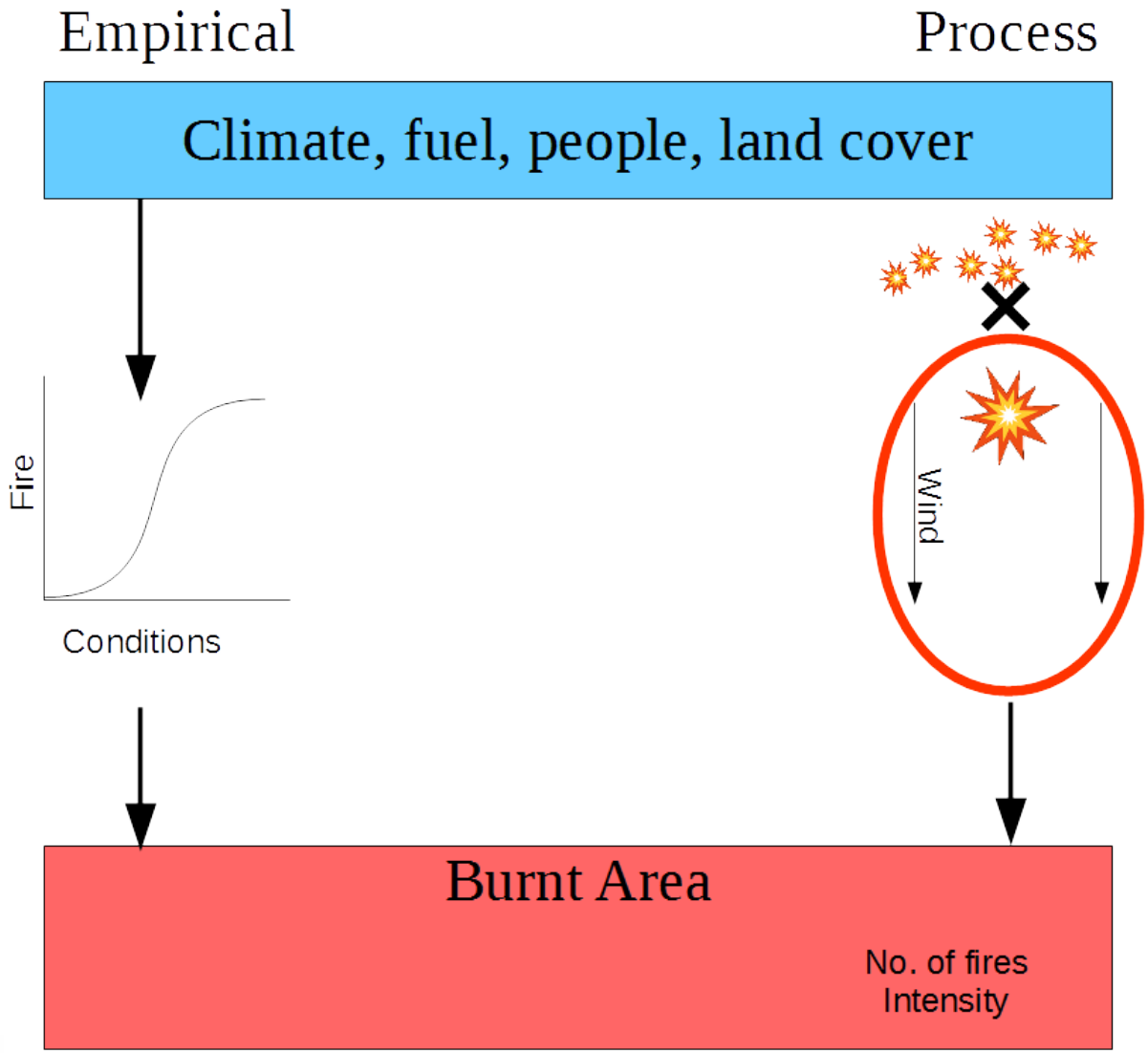


- Benchmark overview
- Focus on JULES performance & fire controls
- Diagnose seasonality performance
- Explore missing anthropogenic processes
- Future fireMIP evaluations

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

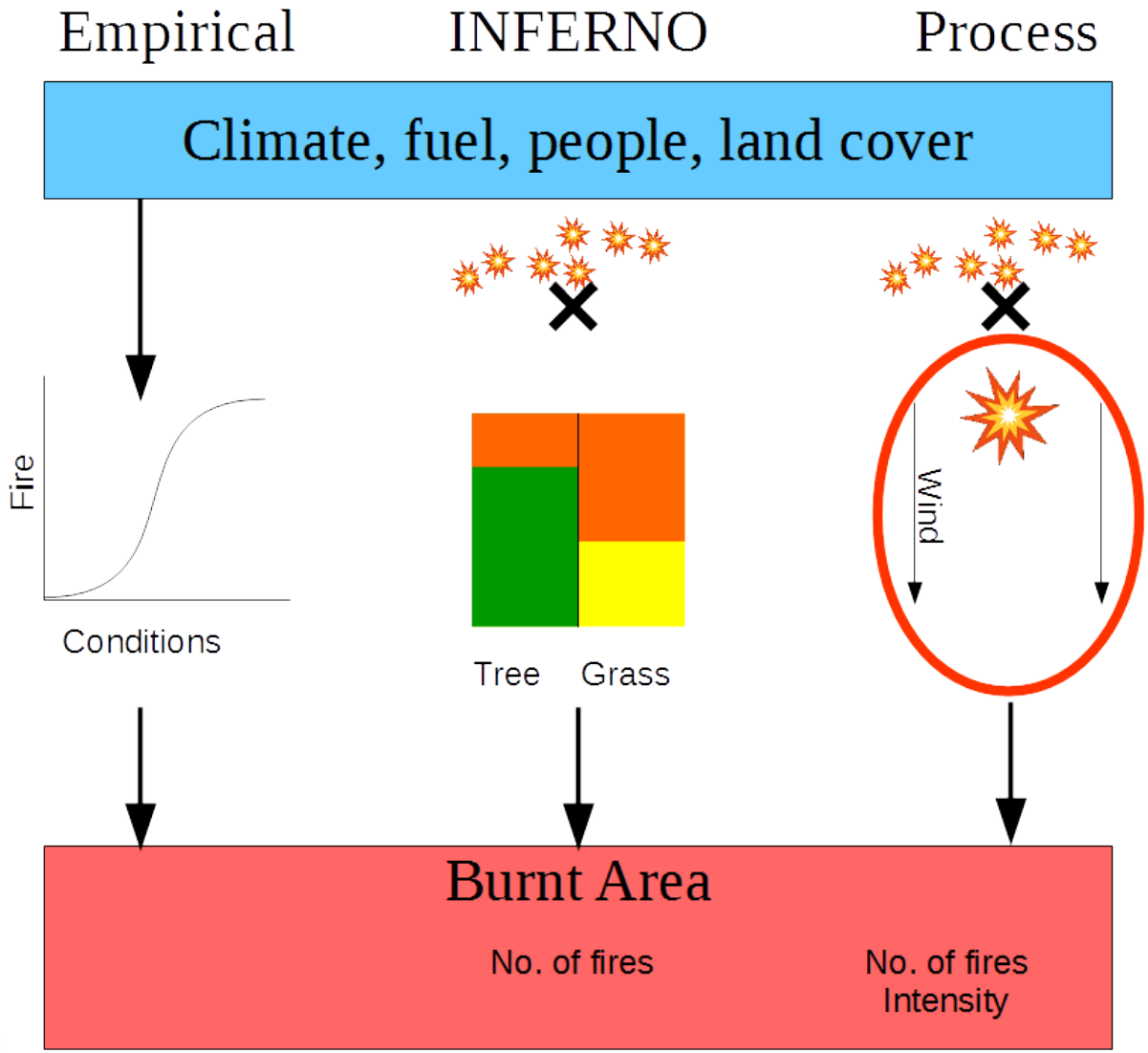
fire Models
Types



Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

fire Models
Types

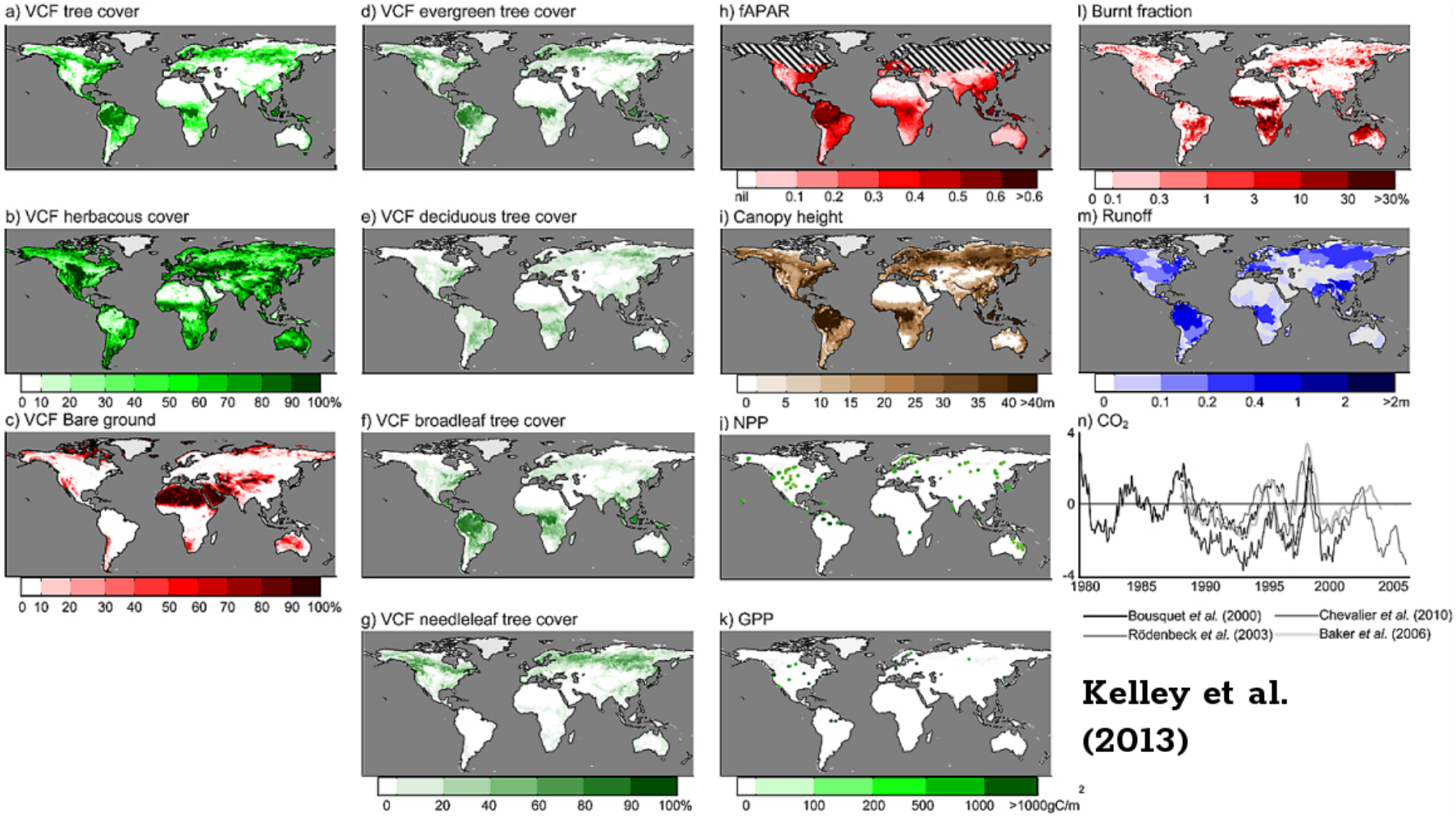


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

FireMIP benchmarking

Benchmark Datasets



Kelley et al. (2013)

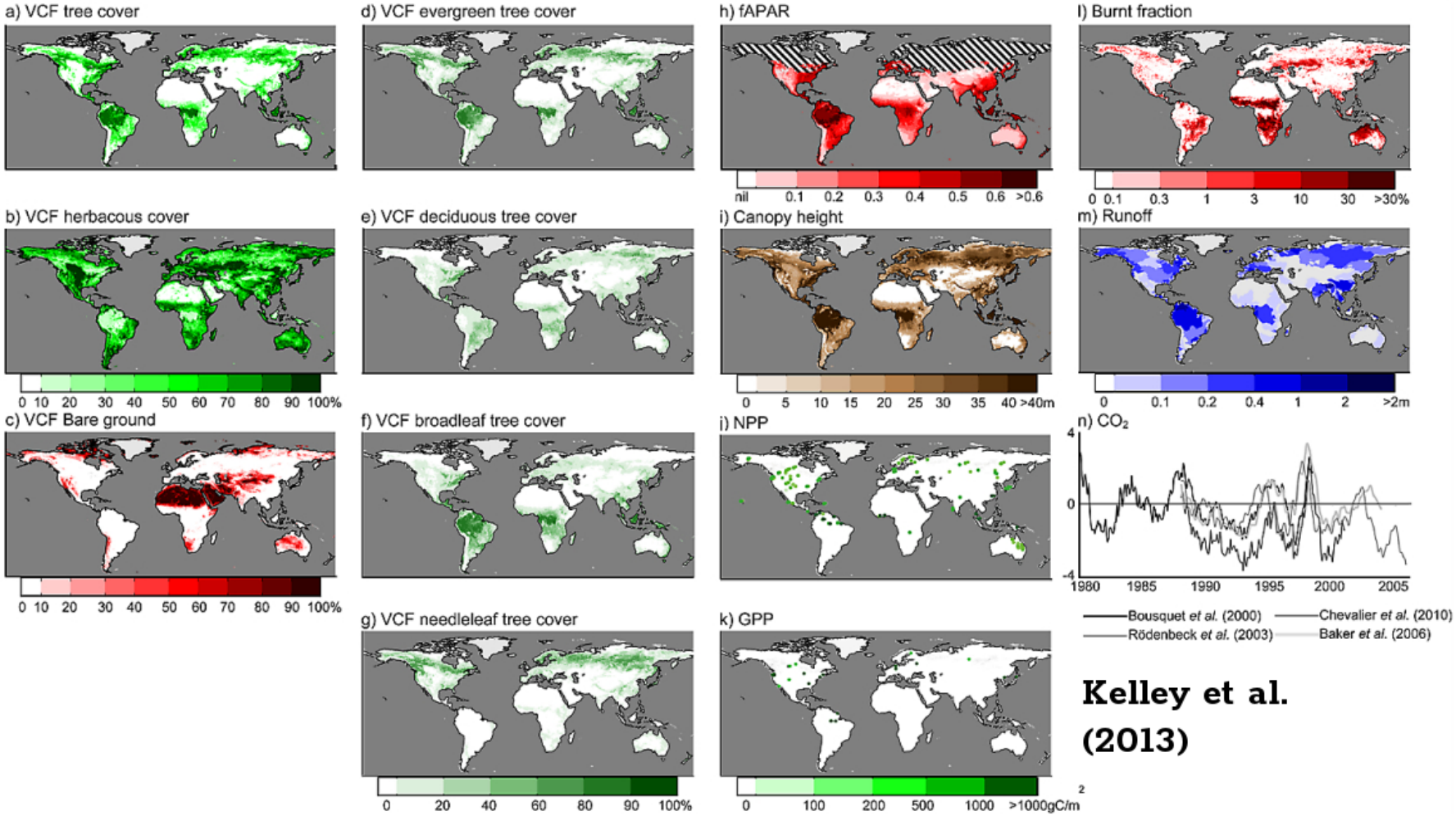
Plus some new ones

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

FireMIP benchmarking

Benchmark Datasets



Kelley et al. (2013)

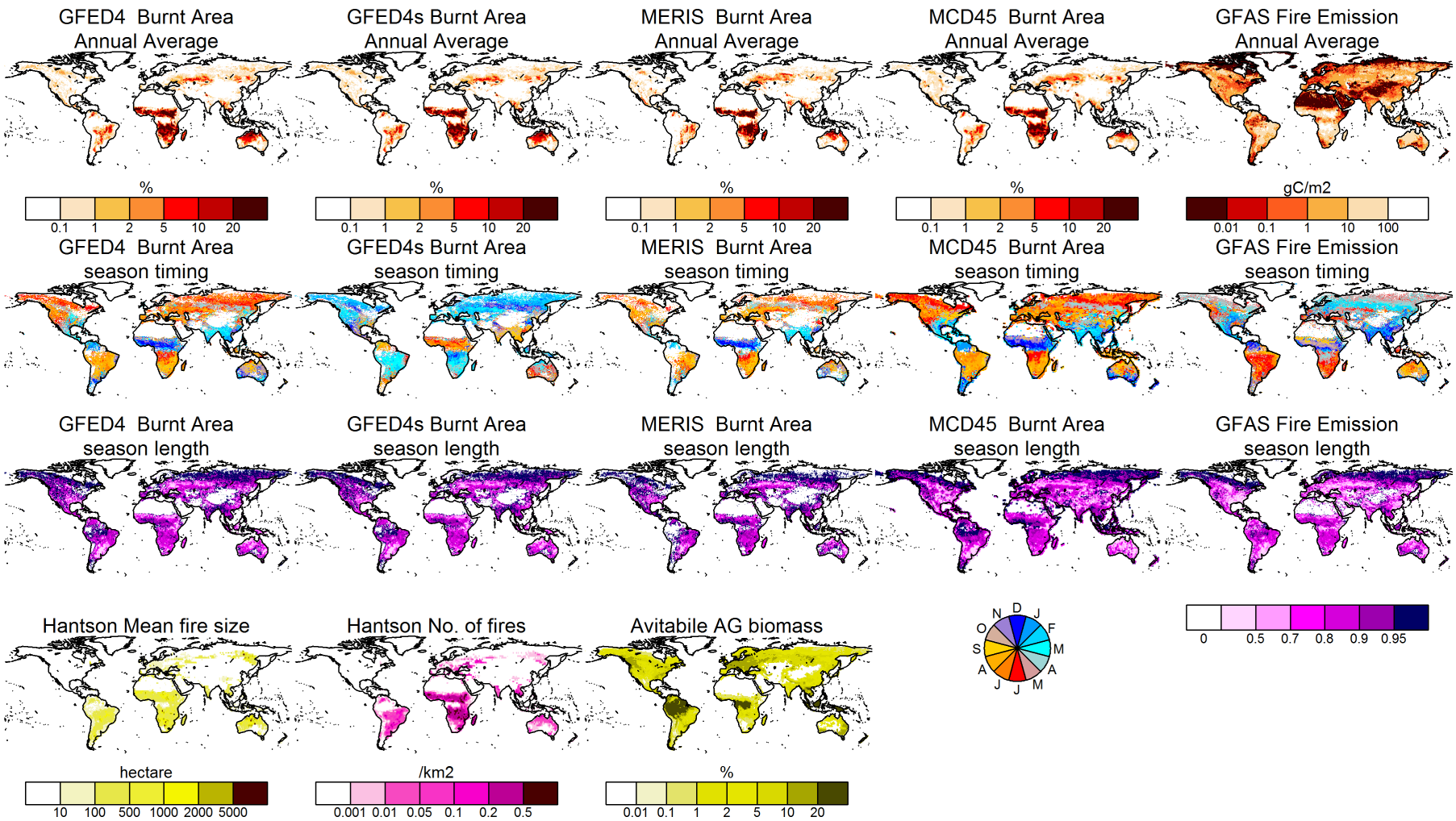
Plus some new ones

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

FireMIP benchmarking

Fire Benchmark Datasets

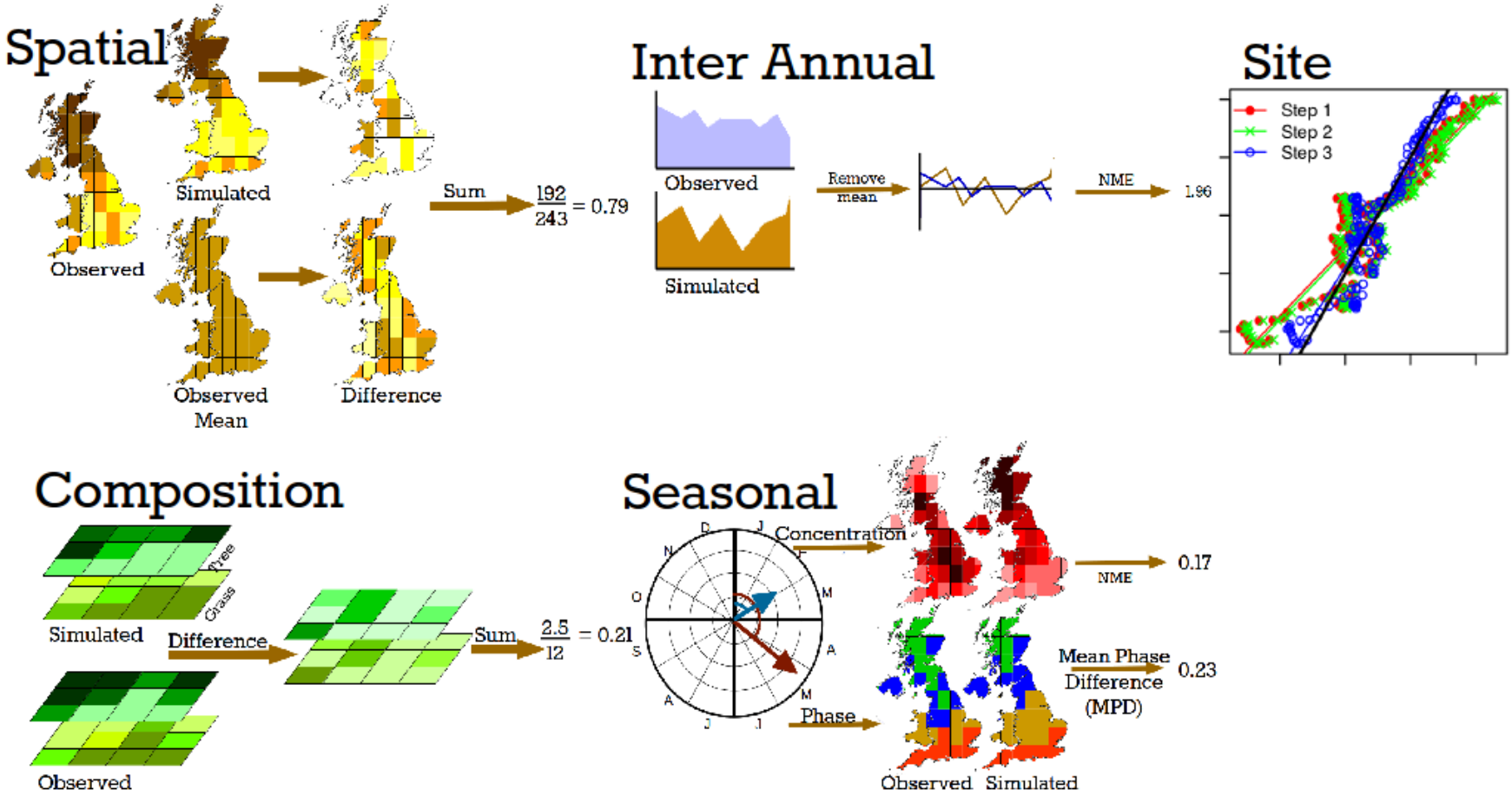


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

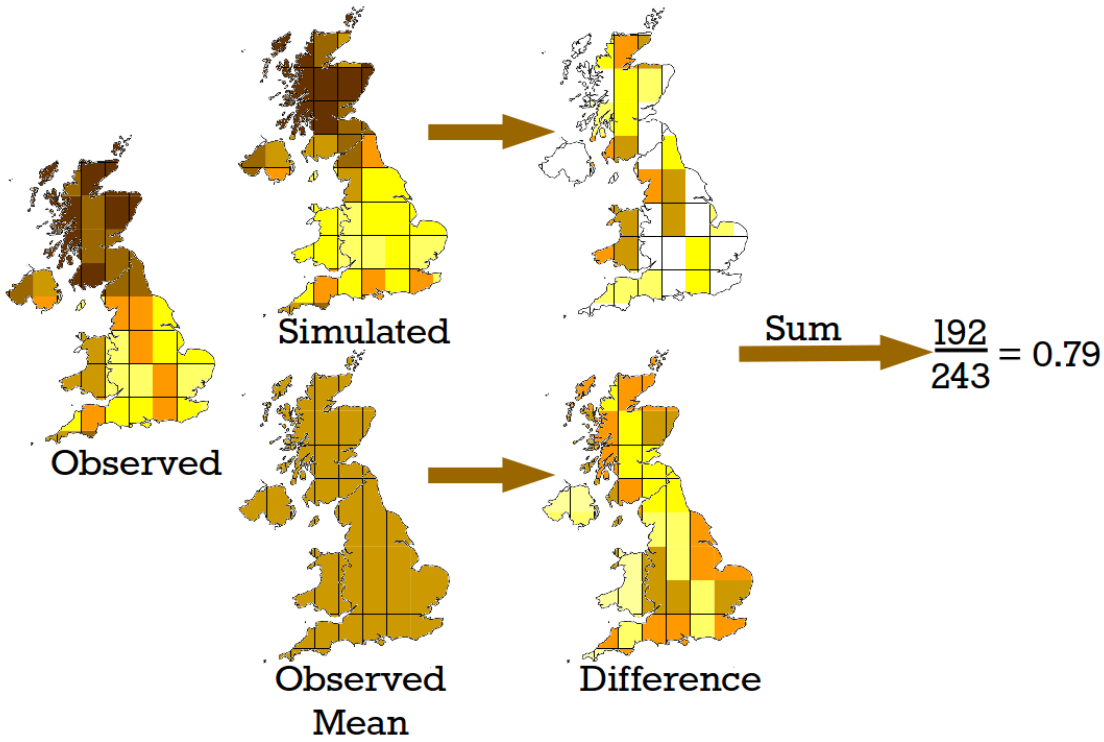
NERC SCIENCE OF THE ENVIRONMENT

FireMIP Metrics

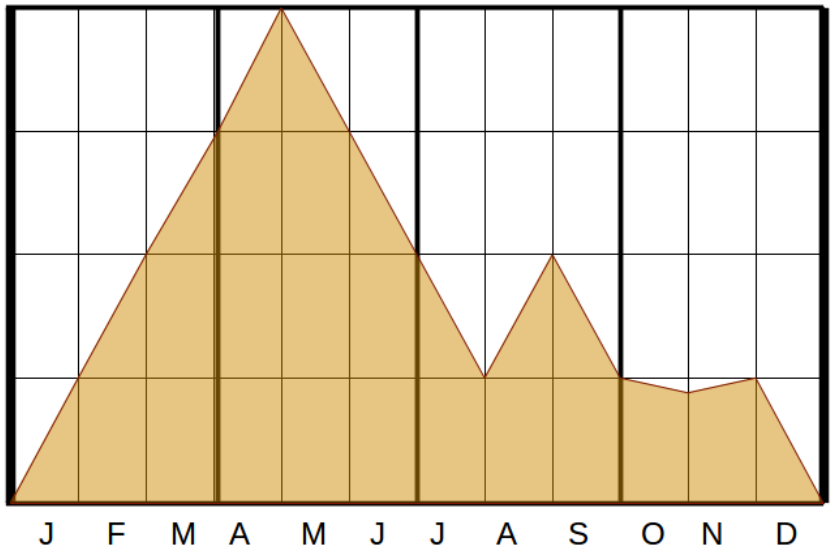
All Metrics

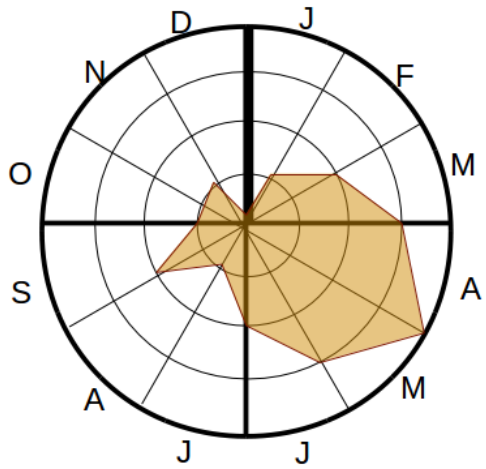


FireMIP Metrics
Normalised Mean Error

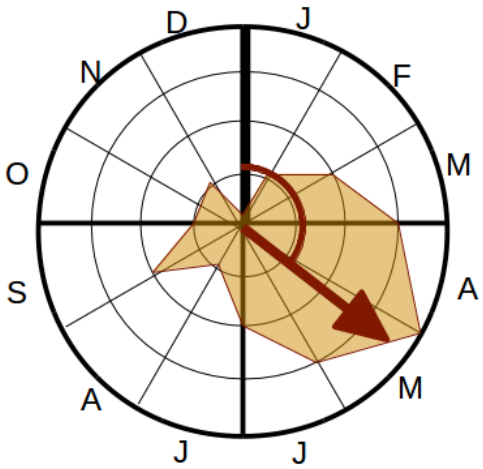


FireMIP Metrics
Seasonal Comparisons

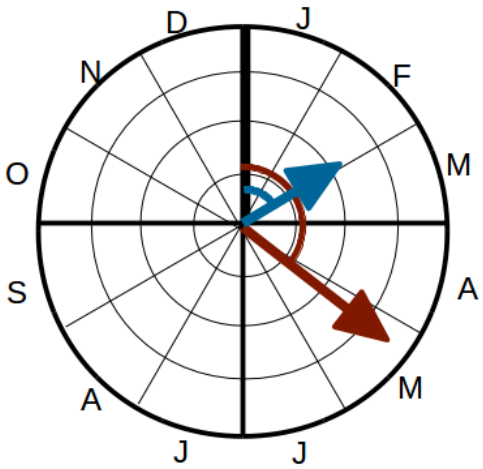




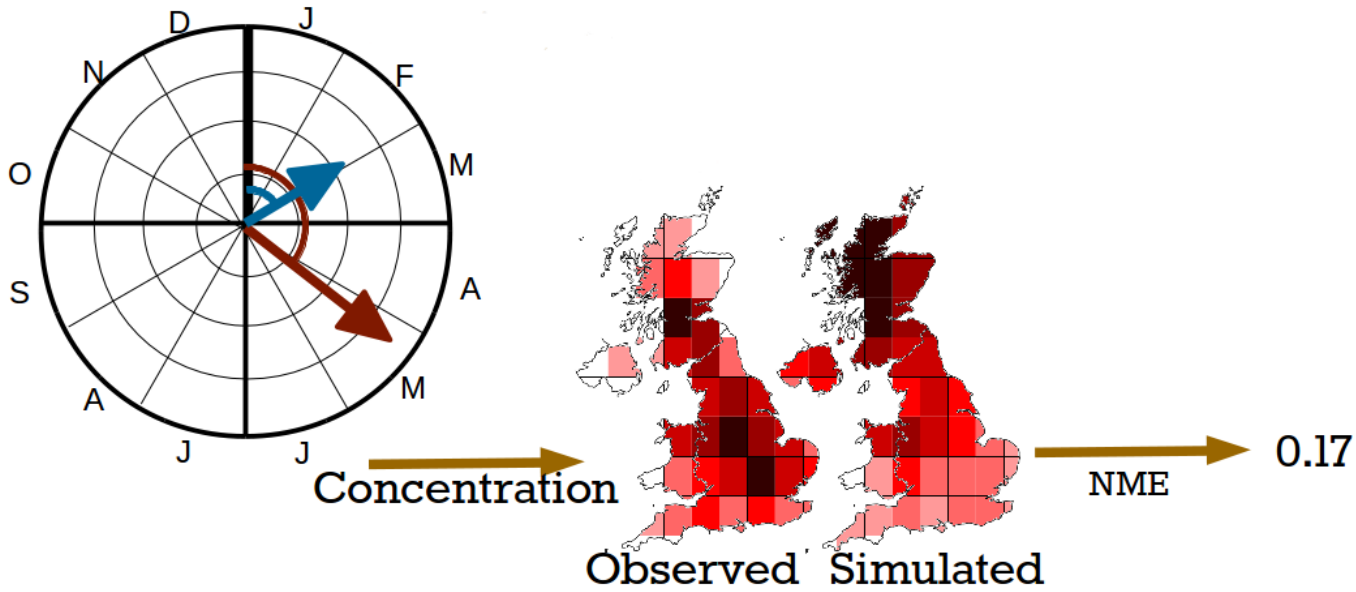
FireMIP Metrics
Seasonal Comparisons



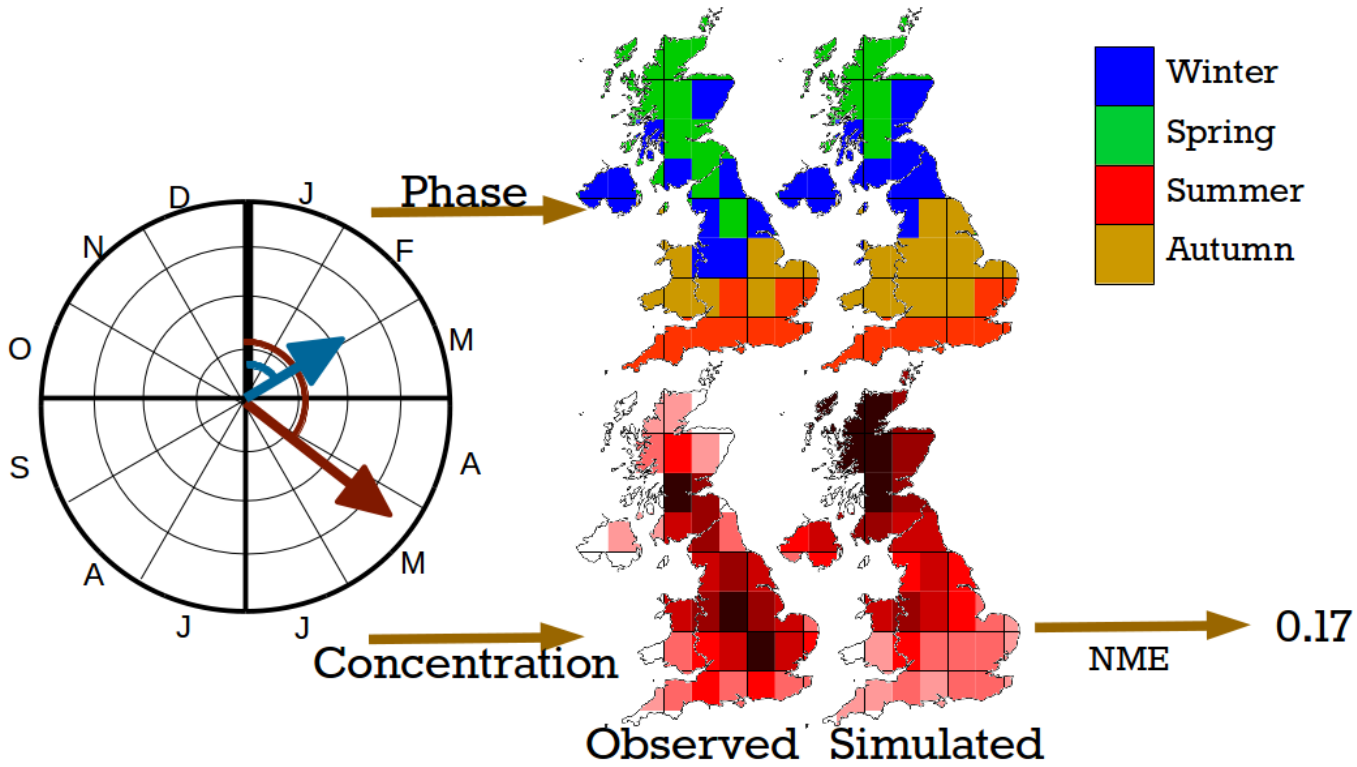
FireMIP Metrics
Seasonal Comparisons



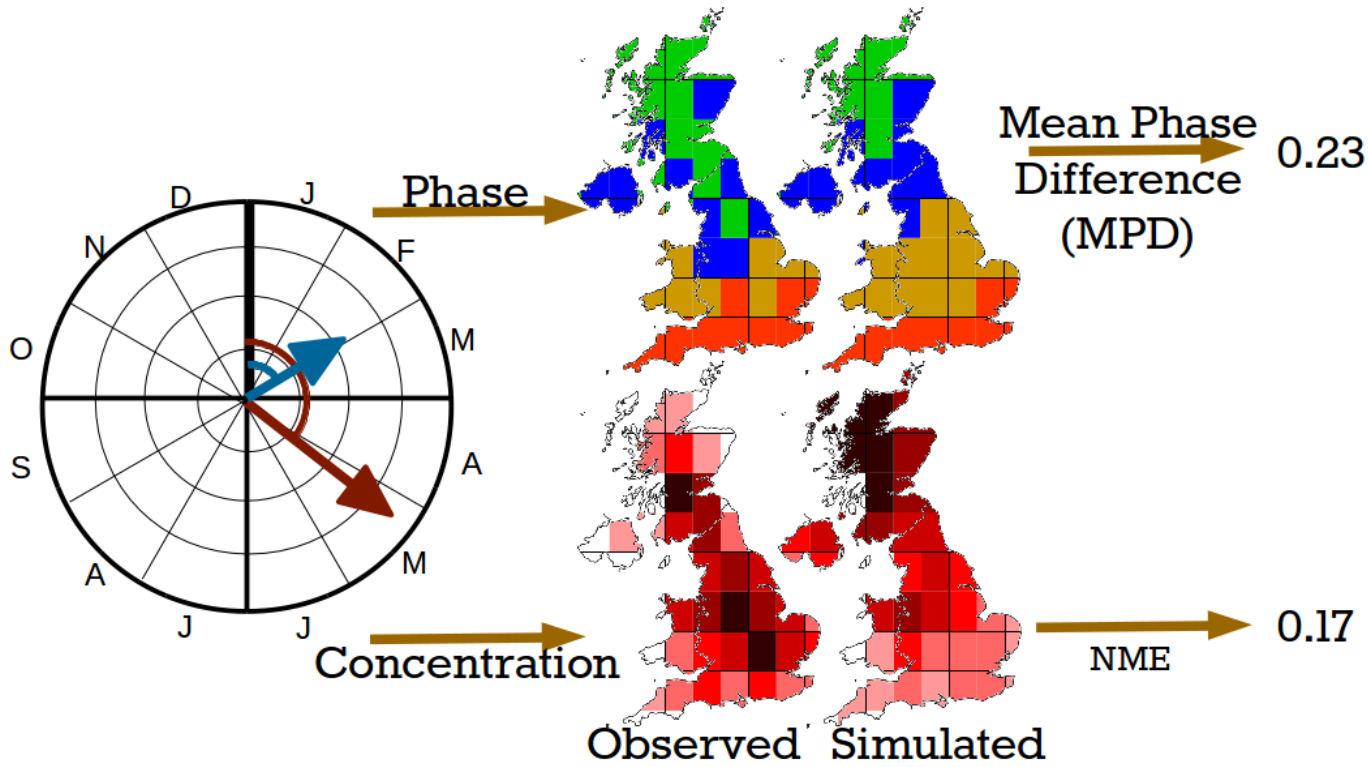
FireMIP Metrics
Seasonal Comparisons



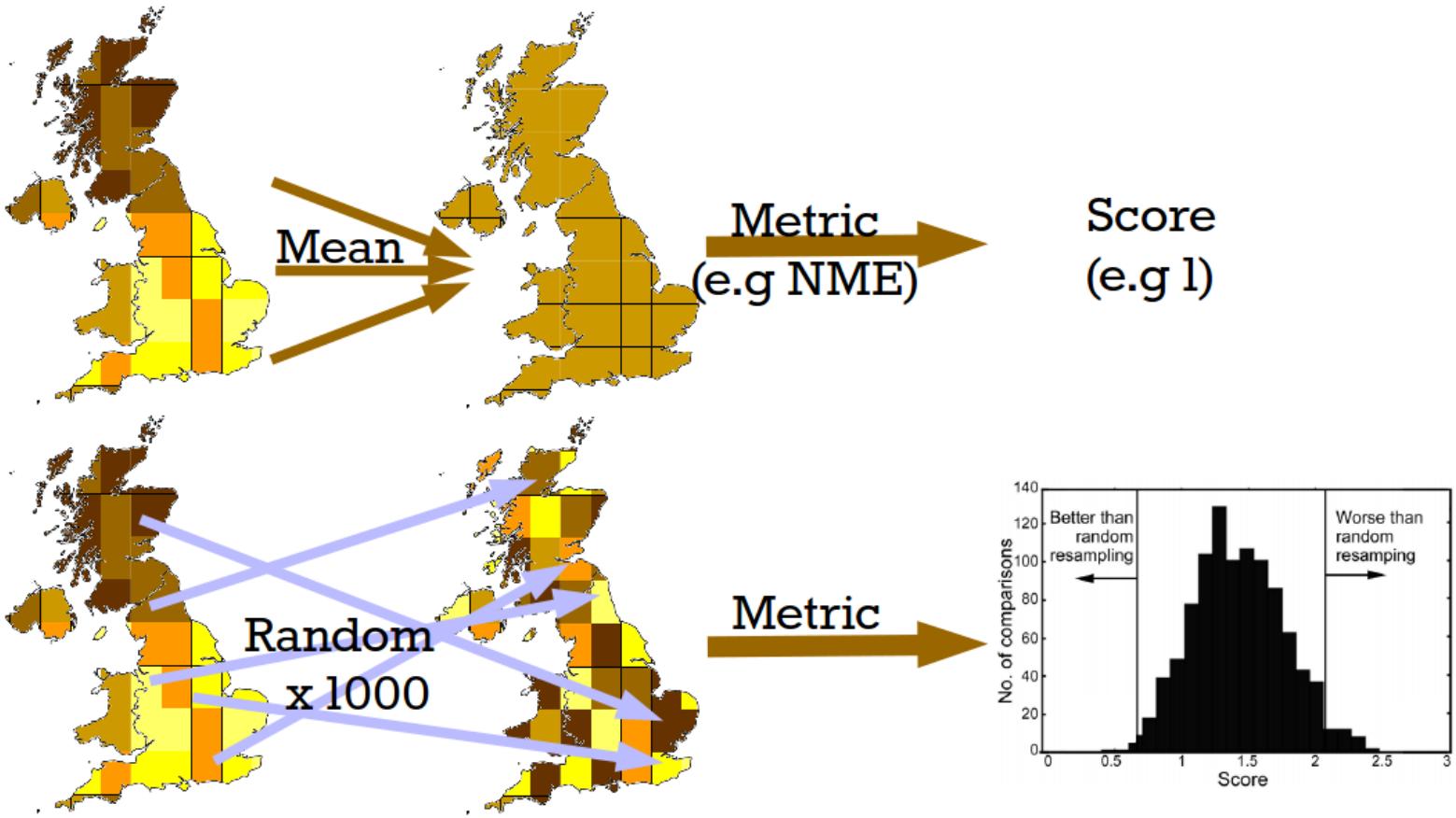
FireMIP Metrics
Seasonal Comparisons



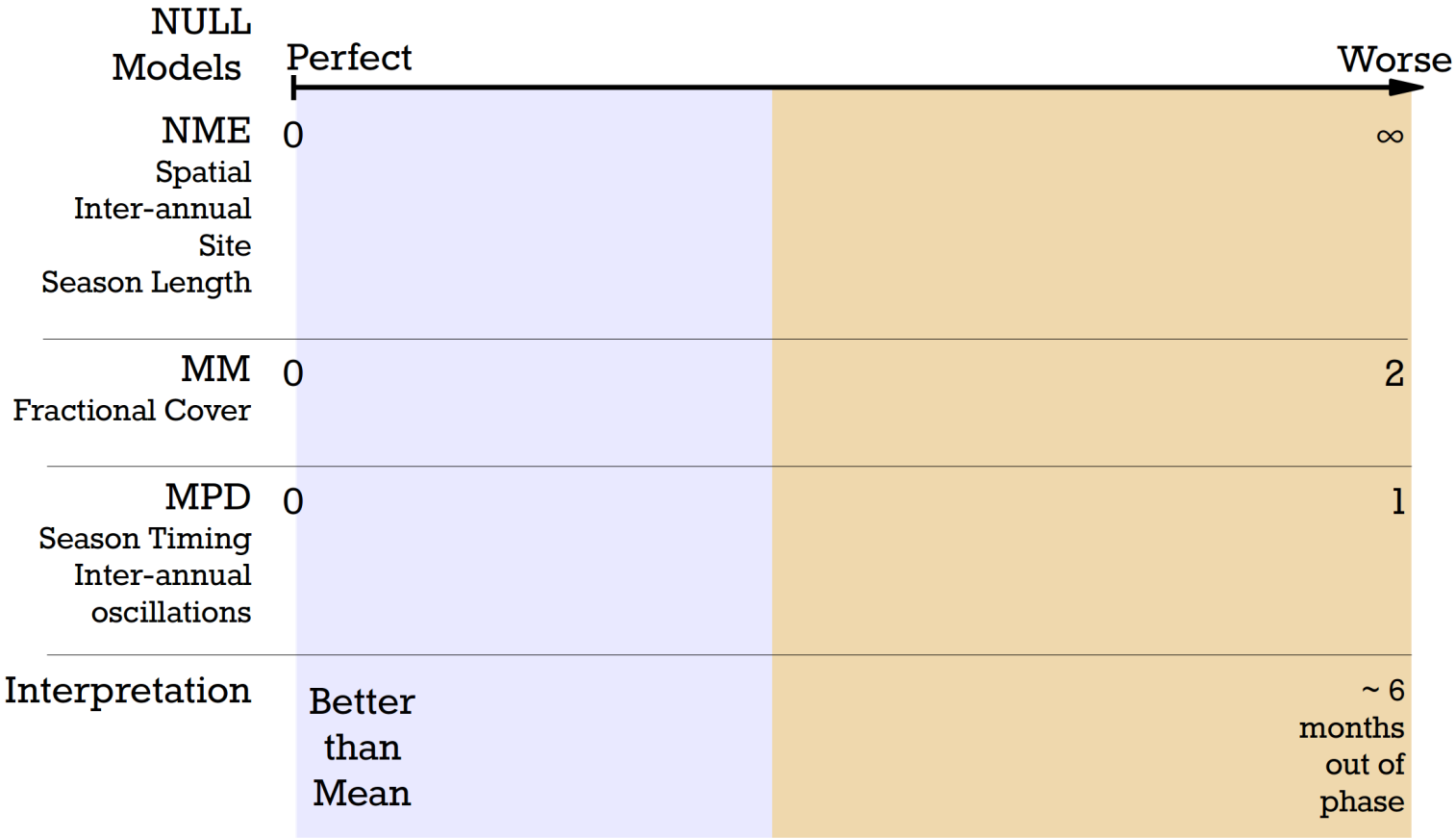
FireMIP Metrics
Seasonal Comparisons



FireMIP Null Models



FireMIP Null Models



FireMIP Null Models

NULL Models	Perfect	Mean	Random	Worse
NME Spatial Inter-annual Site Season Length	0	1	≈ 1.2-1.4 Data Dependant	∞
MM Fractional Cover	0	≈ 1 Data Dependant	≈ 1 Data Dependant	2
MPD Season Timing Inter-annual oscillations	0	Data Dependant	Data Dependant	1
Interpretation	Better than Mean	As Good as Mean / Better than Random	As Good as Random	Worse than Ramdom

Model Scores

			mean	RR	CLM	CTEM	JULES	JSBACH	LPJ	LPJ	LPJ	MC2	ORCHIDEE
							INFERNO	SPITFIRE	GLOBFIRM	SPITFIRE	BLAZE		SPITFIRE
	Burnt Area	GFED4 (s)	1	1.18	0.67	0.77	0.68	0.76	0.74	0.83	0.84	0.79	0.7
		GFED4	1	1.14	0.81	0.83	0.76	0.87	0.71	0.97	0.98	0.78	0.82
	Veg C		1	1.32	0.73	0.89	0.89	1.35	1.3	1.27	1.3	1.27	0.73
	Fire C	GFAS	1	1.2	0.82	0.93	0.77	0.96	0.75	0.94	0.95	0.77	1.07
Phase	Burnt Area	GFED4 (s)	0.49	0.5	0.30	0.34	0.37	0.38		0.31			0.32
Conc.			1	1.36	1.08	1.20	1.73	1.35		1.05			1.12
Phase	Fire C	GFAS	0.57	0.47	0.42	0.50	0.49	0.47		0.37			0.37
Conc.			1	1.36	1.15	1.78	1.81	1.45		1.21			1.15

Model Scores

			mean	RR	CLM	CTEM	JULES INFERNO	JSBACH SPITFIRE	LPJ GLOBFIRM	LPJ SPITFIRE	LPJ BLAZE	MC2	ORCHIDEE SPITFIRE
	Burnt Area	GFED4 (s)	1	1.18	0.67	0.77	0.68	0.76	0.74	0.83	0.84	0.79	0.7
		GFED4	1	1.14	0.81	0.83	0.76	0.87	0.71	0.97	0.98	0.78	0.82
	Veg C		1	1.32	0.73	0.89	0.89	1.35	1.3	1.27	1.3	1.27	0.73
	Fire C	GFAS	1	1.2	0.82	0.93	0.77	0.96	0.75	0.94	0.95	0.77	1.07
Phase	Burnt Area	GFED4 (s)	0.49	0.5	0.30	0.34	0.37	0.38		0.31			0.32
Conc.			1	1.36	1.08	1.20	1.73	1.35		1.05			1.12
Phase	Fire C	GFAS	0.57	0.47	0.42	0.50	0.49	0.47		0.37			0.37
Conc.			1	1.36	1.15	1.78	1.81	1.45		1.21			1.15

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Model Scores

			mean	RR	Model Ensemble	JULES INFERNO
	Burnt Area	GFED4(s)	1	1.18	0.67-0.84 (0.68-0.84)	0.68
		GFED4	1	1.14	0.71-0.98 (0.71-0.98)	0.76
	Vegetation Carbon		1	1.32	0.73-1.35 (0.89-1.35)	0.89
	Fire Carbon	GFAS	1	1.2	0.77-1.07 (0.77-0.95)	0.77
Phase	Burnt Area	GFED4(s)	0.49	0.5	0.30-0.38 (0.31-0.37)	0.37
Conc.			1	1.62	1.05-1.73 (1.05-1.73)	1.73
Phase	Fire Carbon	GFAS	0.57	0.47	0.42-0.50 (0.37-0.49)	0.49
Conc.			1	1.36	1.15-1.81 (1.21-1.81)	1.81

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Model Scores

			mean	RR	Model Ensemble	JULES INFERNO
	Burnt Area	GFED4(s)	1	1.18	0.67-0.84 (0.68-0.84)	0.68
		GFED4	1	1.14	0.71-0.98 (0.71-0.98)	0.76
	Vegetation Carbon		1	1.32	0.73-1.35 (0.89-1.35)	0.89
	Fire Carbon	GFAS	1	1.2	0.77-1.07 (0.77-0.95)	0.77
Phase	Burnt Area	GFED4(s)	0.49	0.5	0.30-0.38 (0.31-0.37)	0.37
Conc.			1	1.62	1.05-1.73 (1.05-1.73)	1.73
Phase	Fire Carbon	GFAS	0.57	0.47	0.42-0.50 (0.37-0.49)	0.49
Conc.			1	1.36	1.15-1.81 (1.21-1.81)	1.81

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Model Scores

			mean	RR	Model Ensemble	JULES INFERNO
	Burnt Area	GFED4(s)	1	1.18	0.67-0.84 (0.68-0.84)	
		GFED4	1	1.14	0.71-0.98 (0.71-0.98)	
	Vegetation Carbon		1	1.32	0.73-1.35 (0.89-1.35)	0.89
	Fire Carbon	GFAS	1	1.2	0.77-1.07 (0.77-0.95)	0.77
Phase	Burnt Area	GFED4(s)	0.49	0.5	0.30-0.38 (0.31-0.37)	0.37
Conc.			1	1.62	1.05-1.73 (1.05-1.73)	1.73
Phase	Fire Carbon	GFAS	0.57	0.47	0.42-0.50 (0.37-0.49)	0.49
Conc.			1	1.36	1.15-1.81 (1.21-1.81)	1.81

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Model Scores

			mean	RR	Model Ensemble	JULES INFERNO
	Burnt Area	GFED4(s)	1	1.18	0.67-0.84 (0.68-0.84)	
		GFED4	1	1.14	0.71-0.98 (0.71-0.98)	
	Vegetation Carbon		1	1.32	0.73-1.35 (0.89-1.35)	
	Fire Carbon	GFAS	1	1.2	0.77-1.07 (0.77-0.95)	
Phase	Burnt Area	GFED4(s)	0.49	0.5	0.30-0.38 (0.31-0.37)	0.37
Conc.			1	1.62	1.05-1.73 (1.05-1.73)	1.73
Phase	Fire Carbon	GFAS	0.57	0.47	0.42-0.50 (0.37-0.49)	0.49
Conc.			1	1.36	1.15-1.81 (1.21-1.81)	1.81

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Model Scores

			mean	RR	Model Ensemble	JULES INFERNO
	Burnt Area	GFED4(s)	1	1.18	0.67-0.84 (0.68-0.84)	
		GFED4	1	1.14	0.71-0.98 (0.71-0.98)	
	Vegetation Carbon		1	1.32	0.73-1.35 (0.89-1.35)	
	Fire Carbon	GFAS	1	1.2	0.77-1.07 (0.77-0.95)	
Phase	Burnt Area	GFED4(s)	0.49	0.5	0.30-0.38 (0.31-0.37)	
Conc.			1	1.62	1.05-1.73 (1.05-1.73)	1.73
Phase	Fire Carbon	GFAS	0.57	0.47	0.42-0.50 (0.37-0.49)	
Conc.			1	1.36	1.15-1.81 (1.21-1.81)	1.81

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Model Scores

			mean	RR	Model Ensemble	JULES INFERNO
	Burnt Area	GFED4(s)	1	1.18	0.67-0.84 (0.68-0.84)	
		GFED4	1	1.14	0.71-0.98 (0.71-0.98)	
	Vegetation Carbon		1	1.32	0.73-1.35 (0.89-1.35)	
	Fire Carbon	GFAS	1	1.2	0.77-1.07 (0.77-0.95)	
Phase	Burnt Area	GFED4(s)	0.49	0.5	0.30-0.38 (0.31-0.37)	
Conc.			1	1.62	1.05-1.73 (1.05-1.73)	
Phase	Fire Carbon	GFAS	0.57	0.47	0.42-0.50 (0.37-0.49)	
Conc.			1	1.36	1.15-1.81 (1.21-1.81)	

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

JULES-INFERNO v obs

Overall fire performance

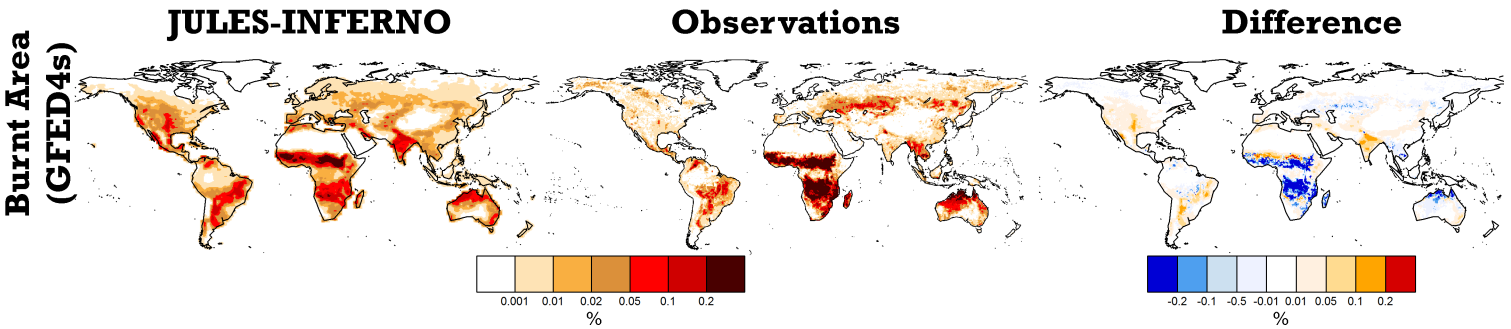
Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

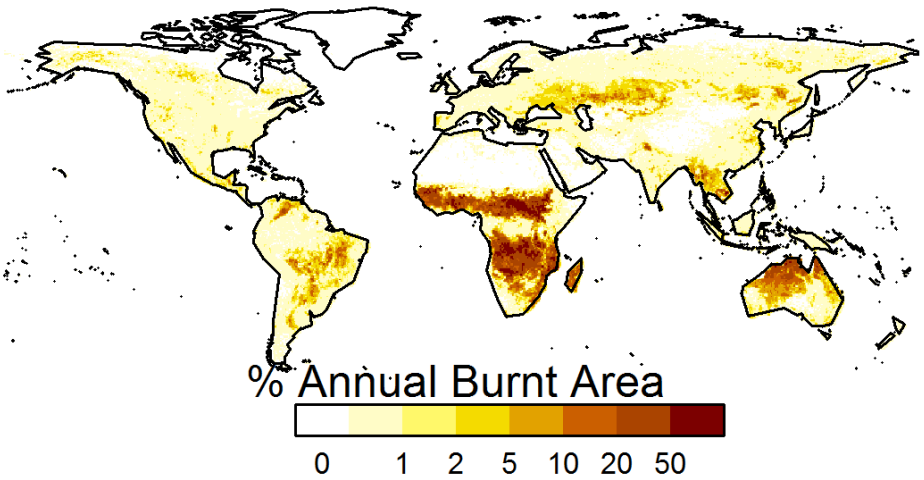
JULES-INFERNO v obs

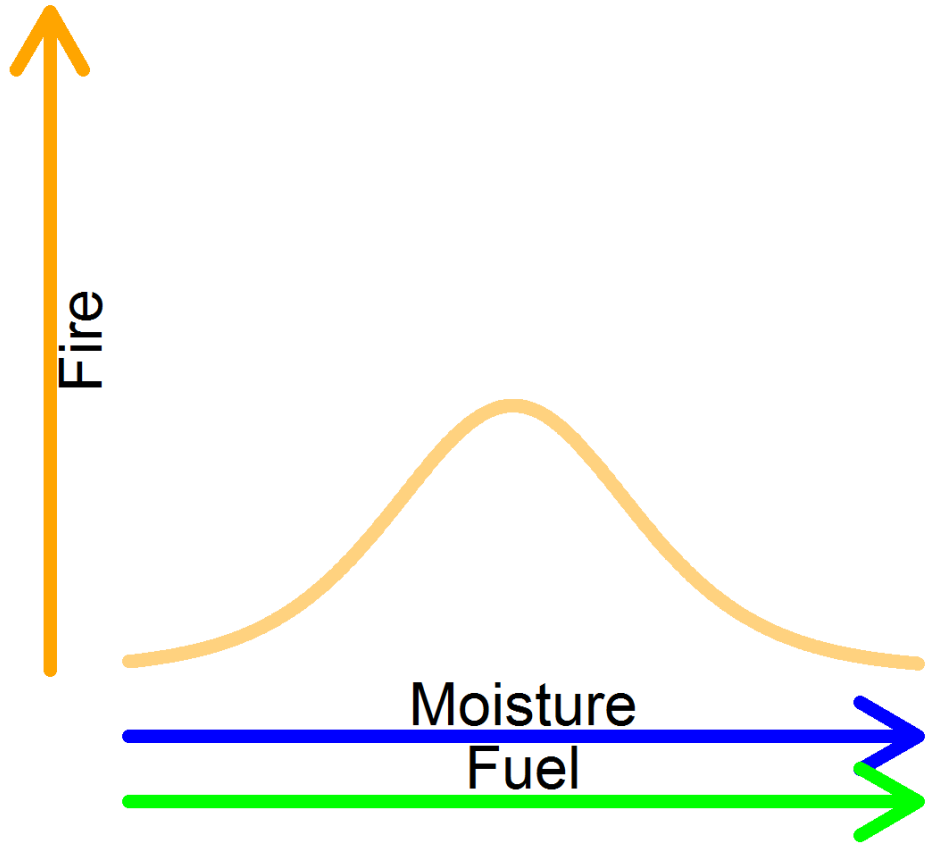
Overall fire performance



Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

It burns where it rains (a bit)
Uni-modal relationship with moisture



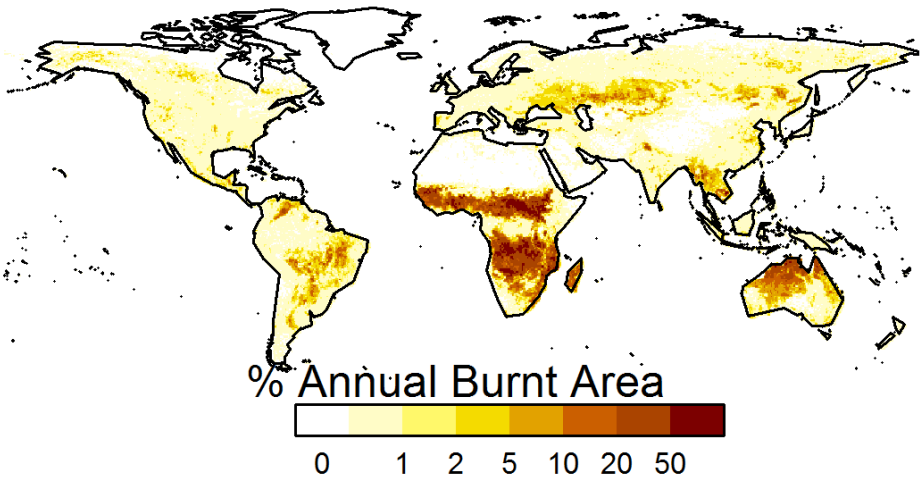


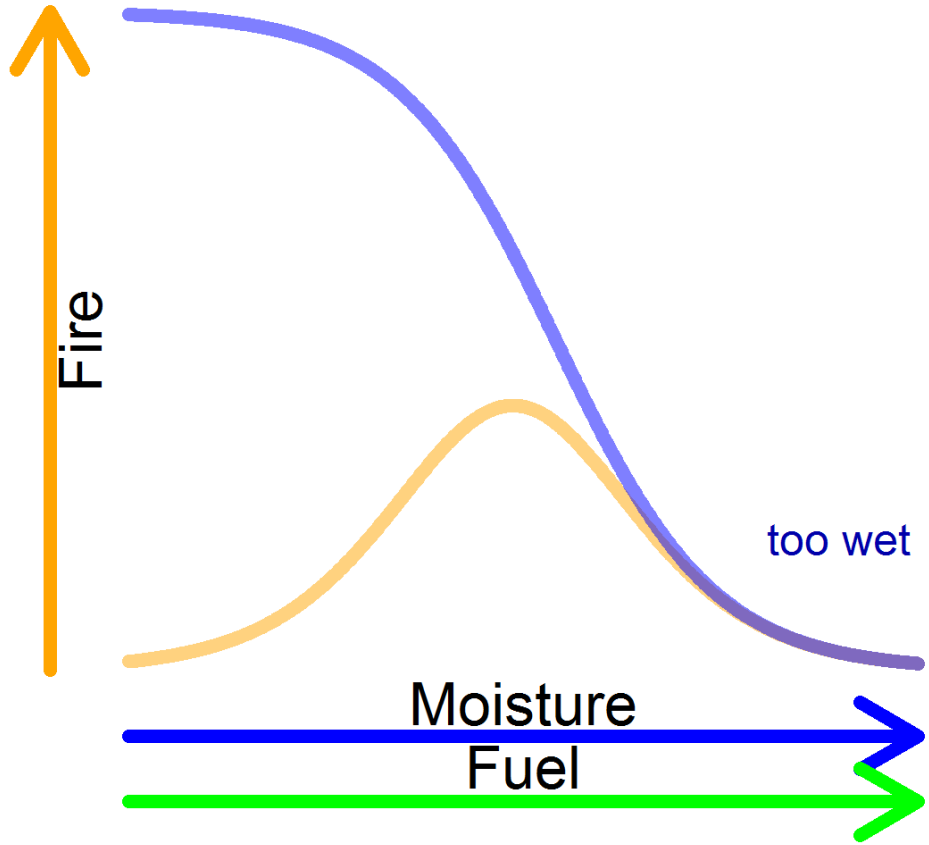
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

It burns where it rains (a bit)

Uni-modal relationship with moisture

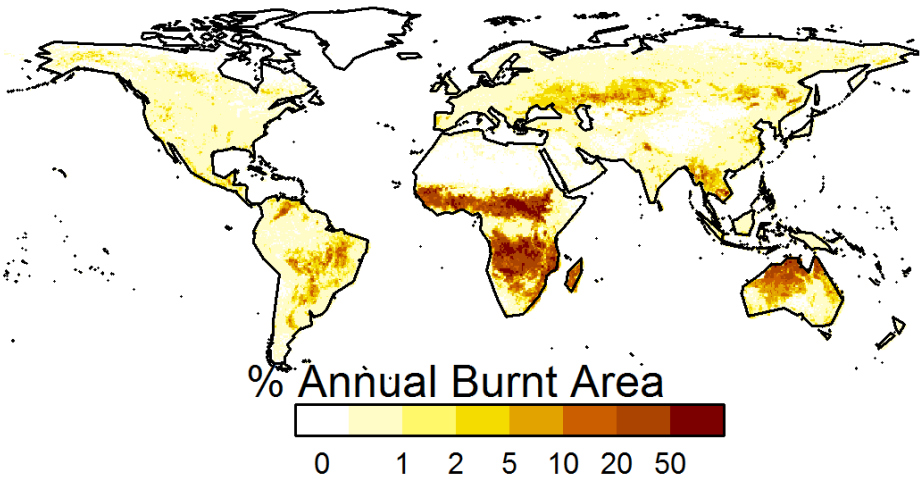


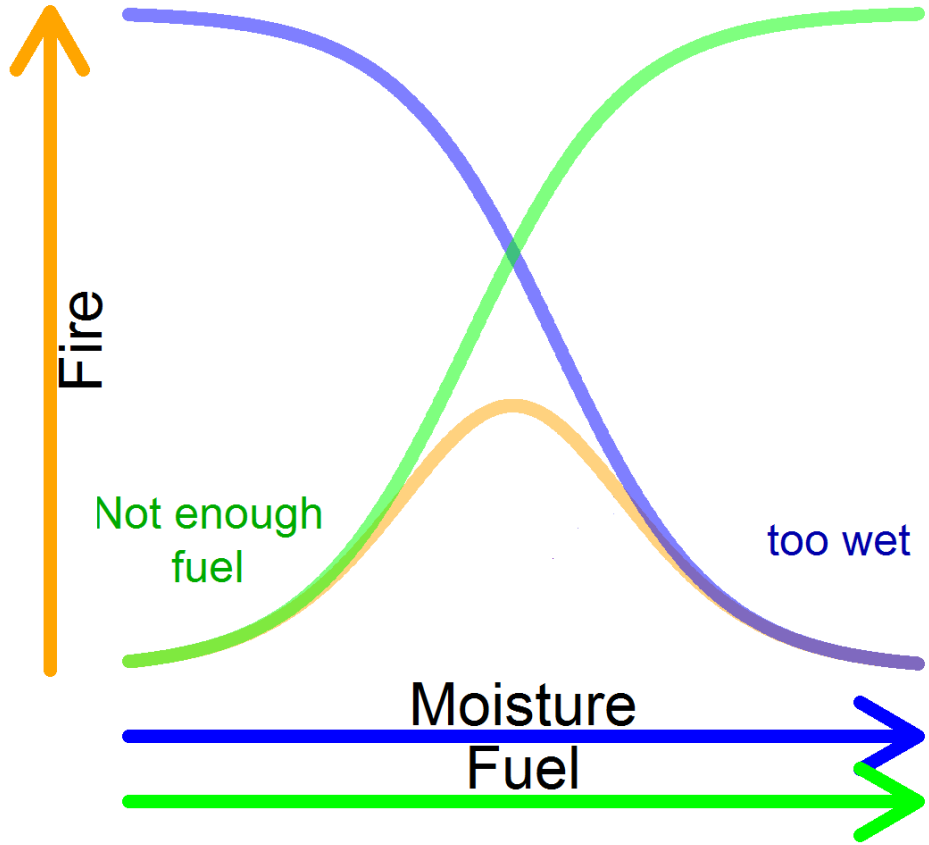


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

It burns where it rains (a bit)
Uni-modal relationship with moisture



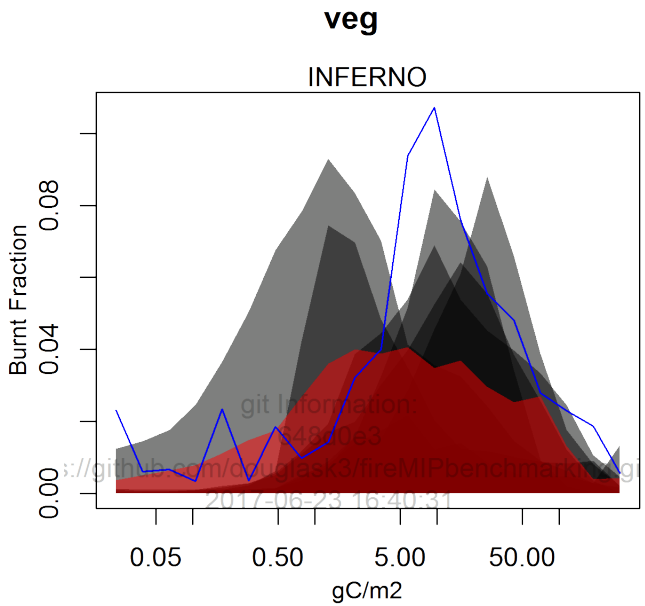


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

INFERNO Fire Controls

Vegetation



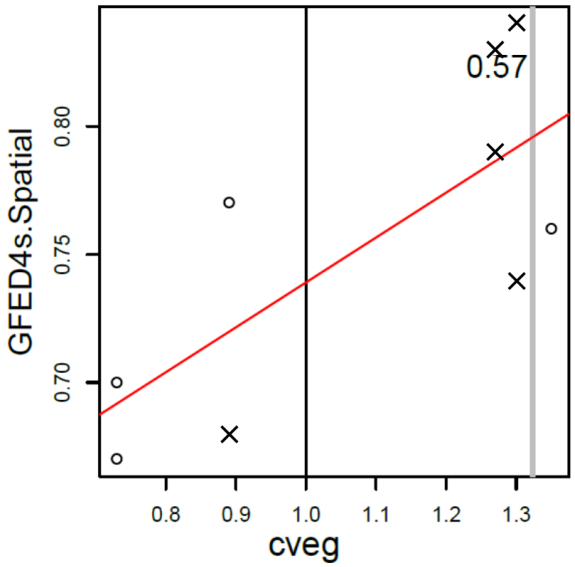
Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

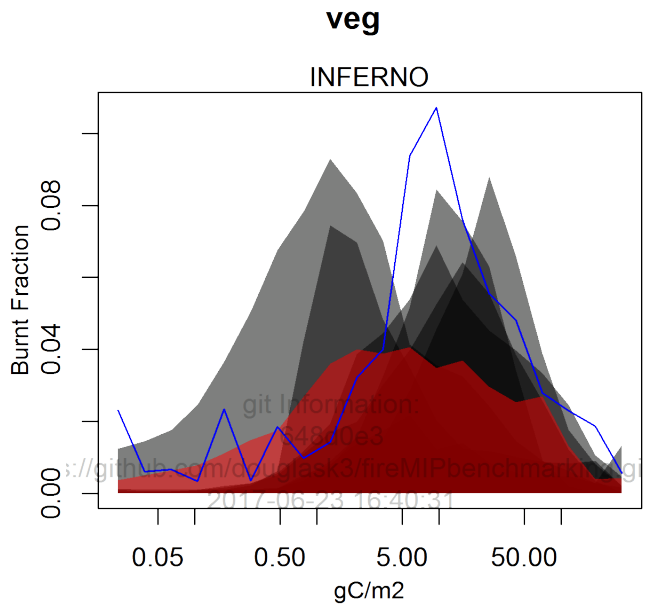
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

INFERNO Fire Controls

Vegetation

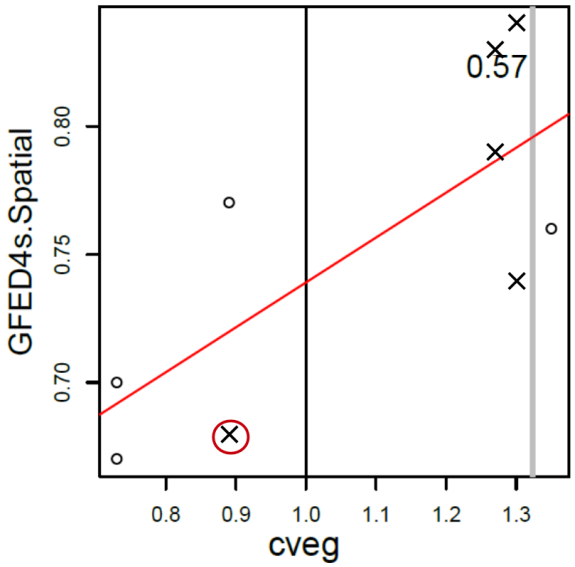


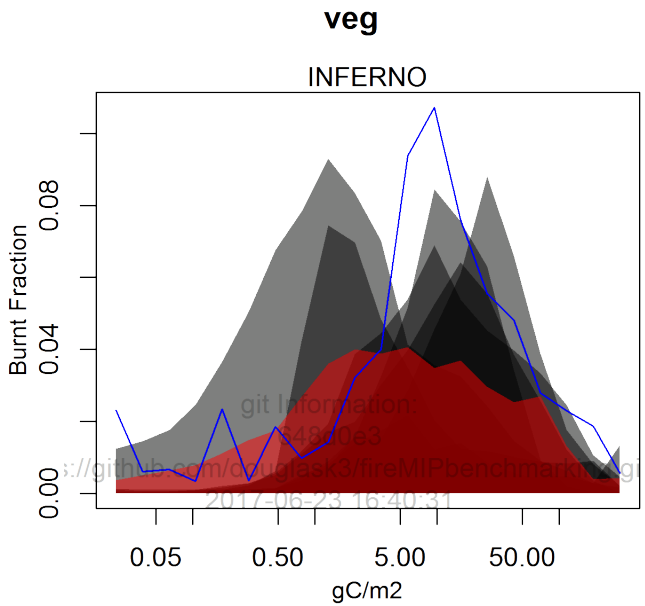


Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

INFERNO Fire Controls

Vegetation



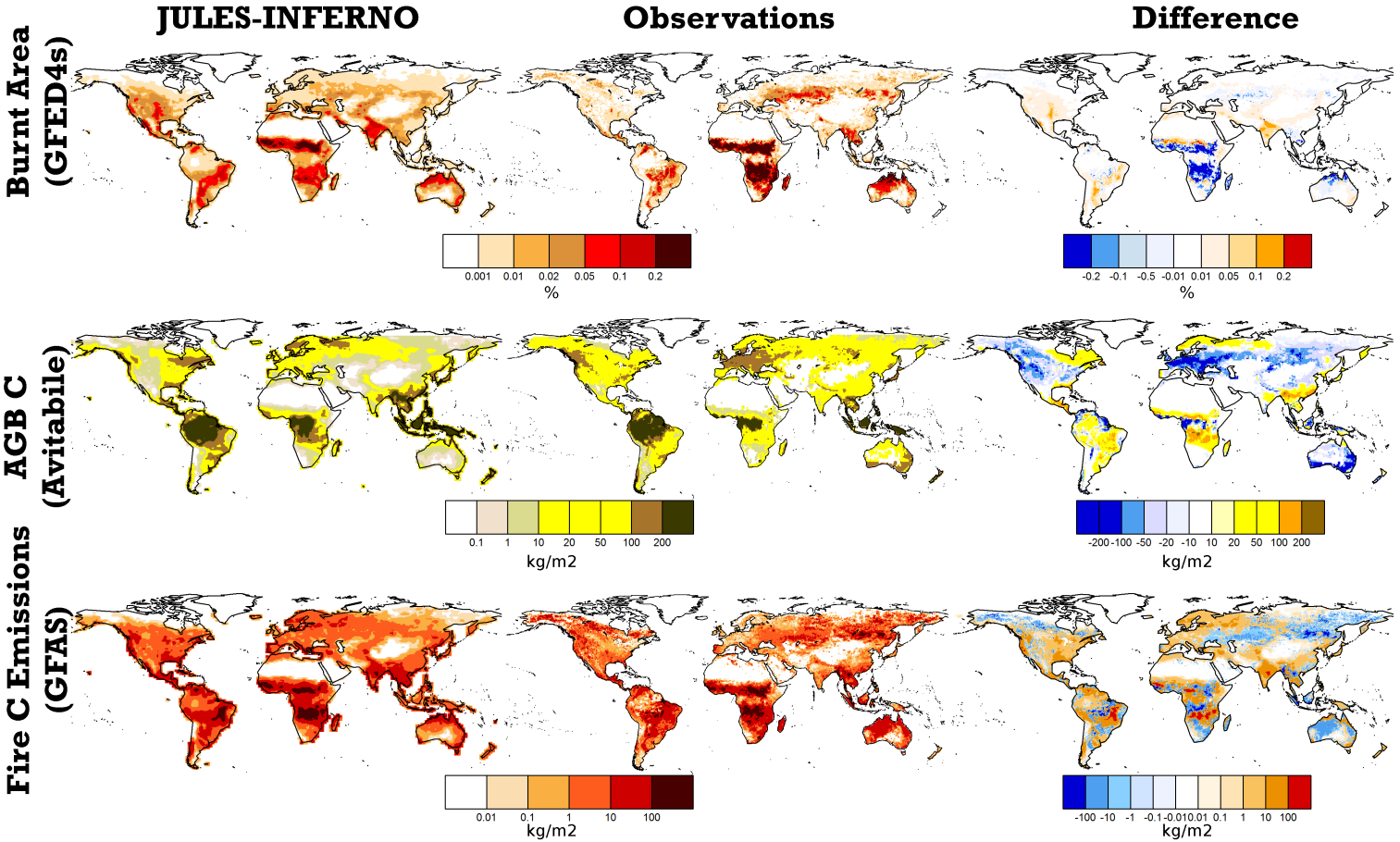


Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

JULES-INFERNO v obs

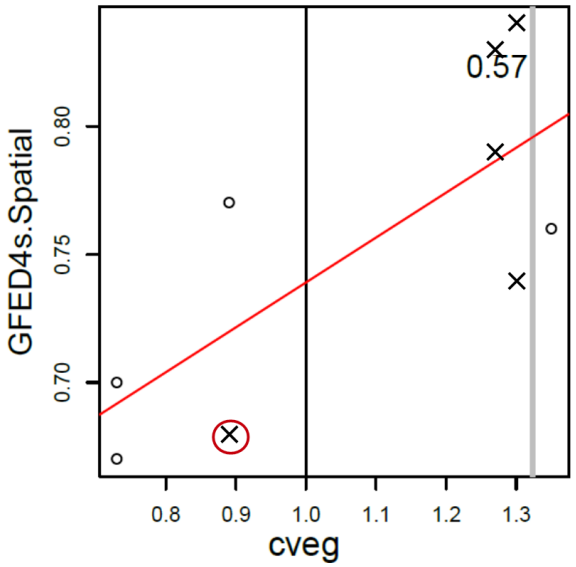
Fire Emissions

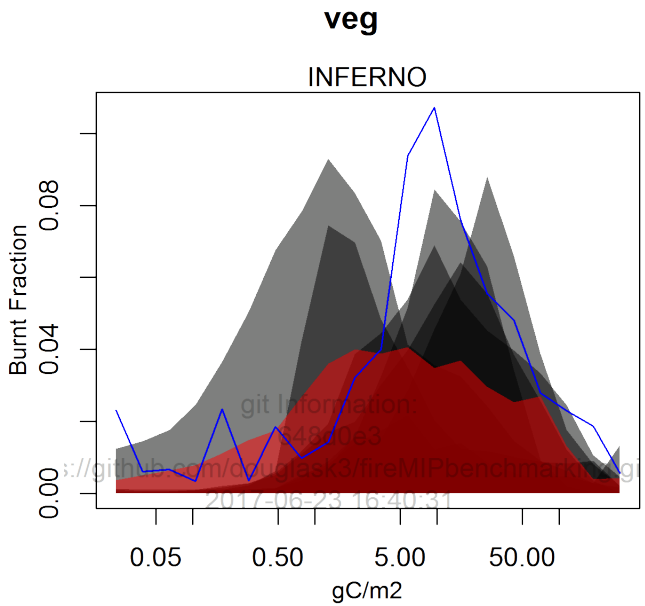
Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	



INFERNO Fire Controls

Vegetation

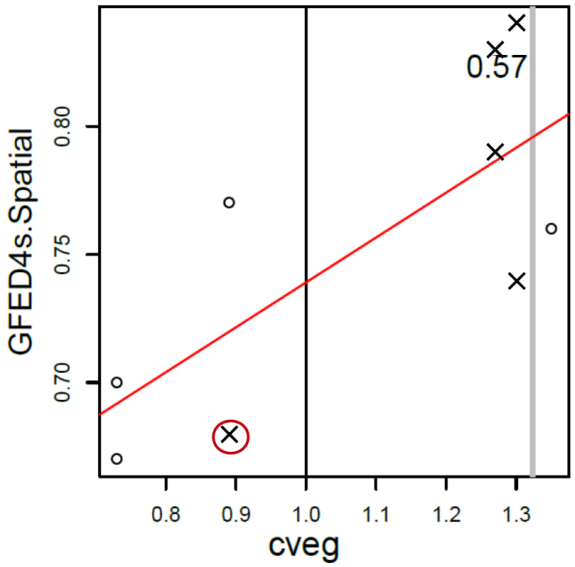




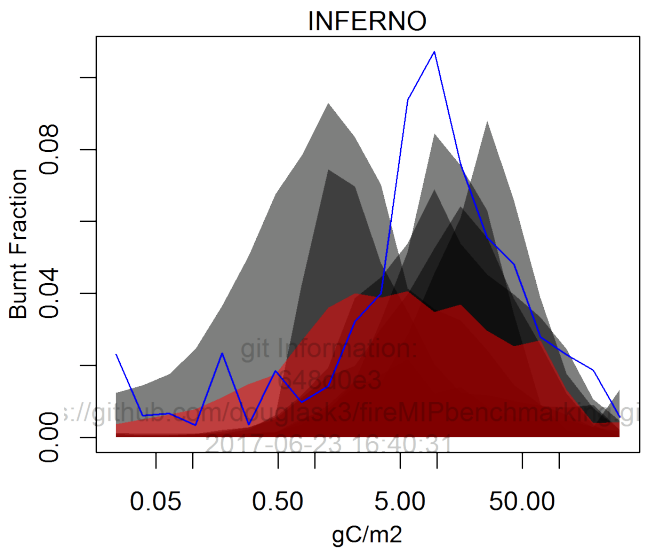
Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

INFERNO Fire Controls

Moisture

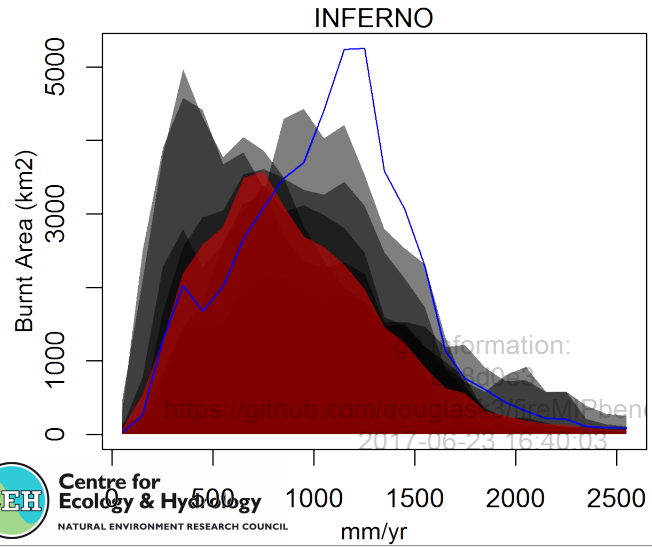


veg



Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

MAP

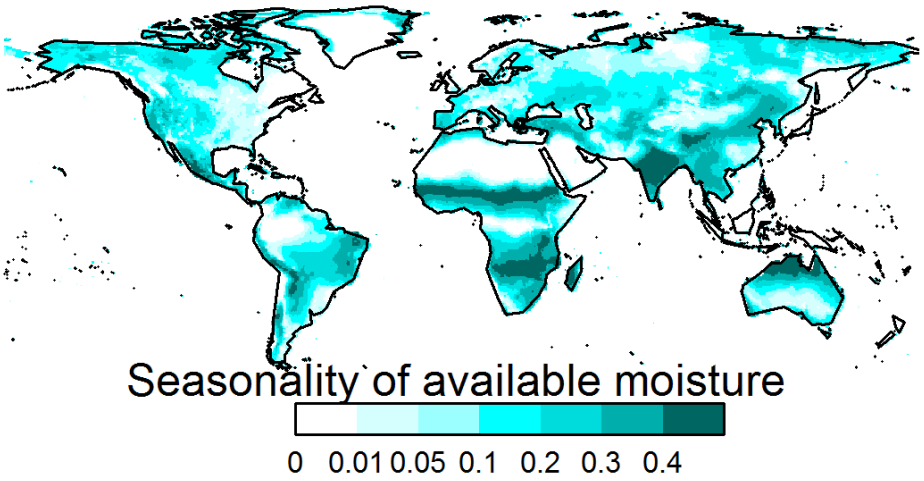


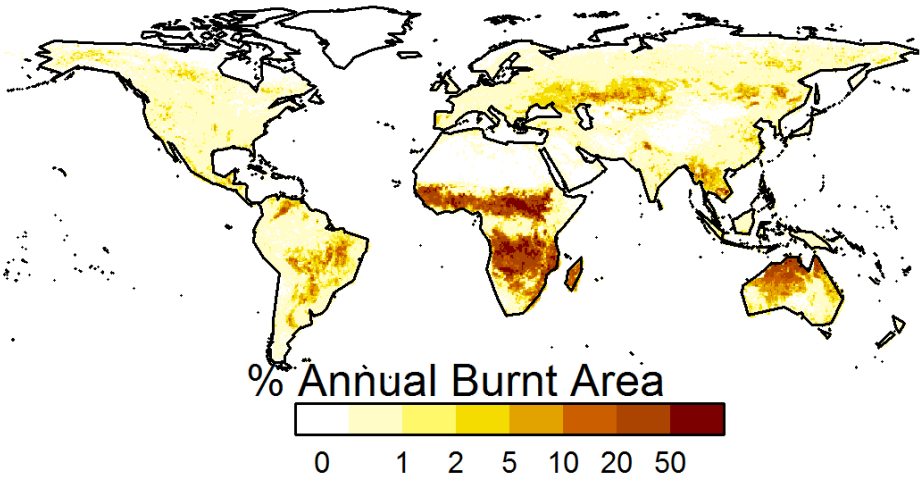
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

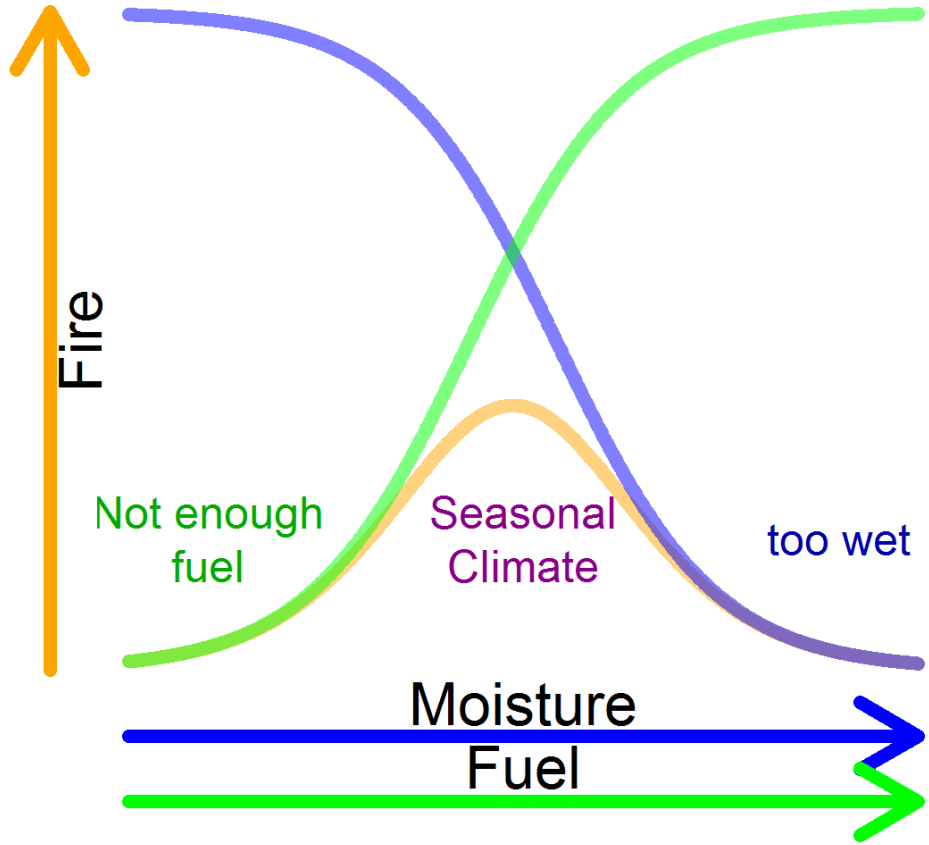
NERC SCIENCE OF THE ENVIRONMENT

It burns where it rains (a bit)

Uni-modal relationship with moisture





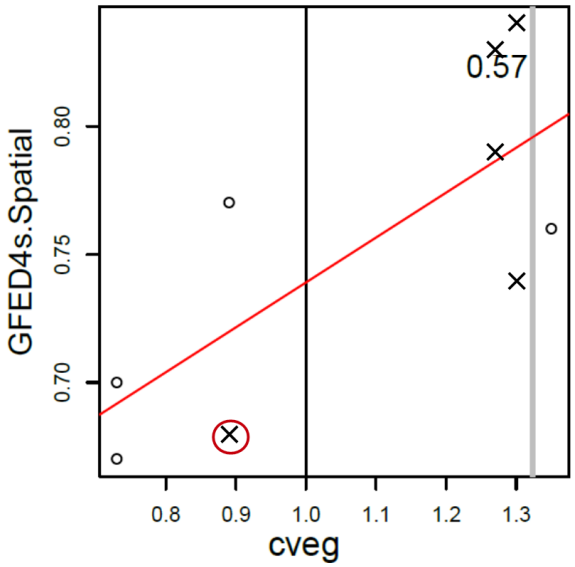


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

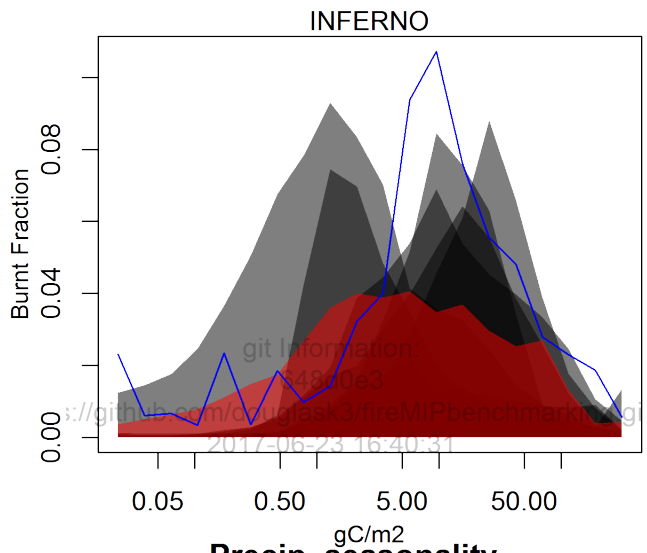
NERC SCIENCE OF THE ENVIRONMENT

INFERNO Fire Controls

Moisture

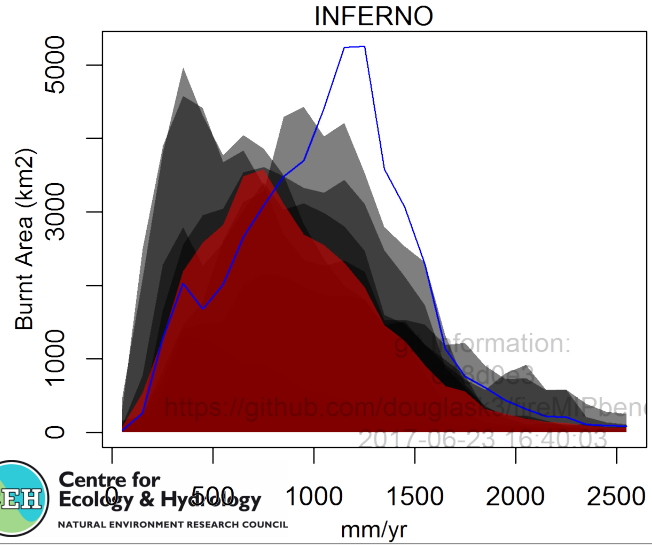


veg

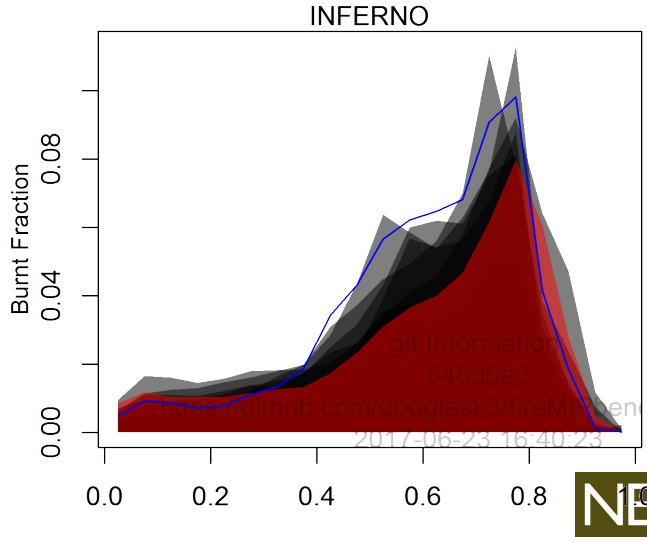


Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

MAP



Precip_seasonality

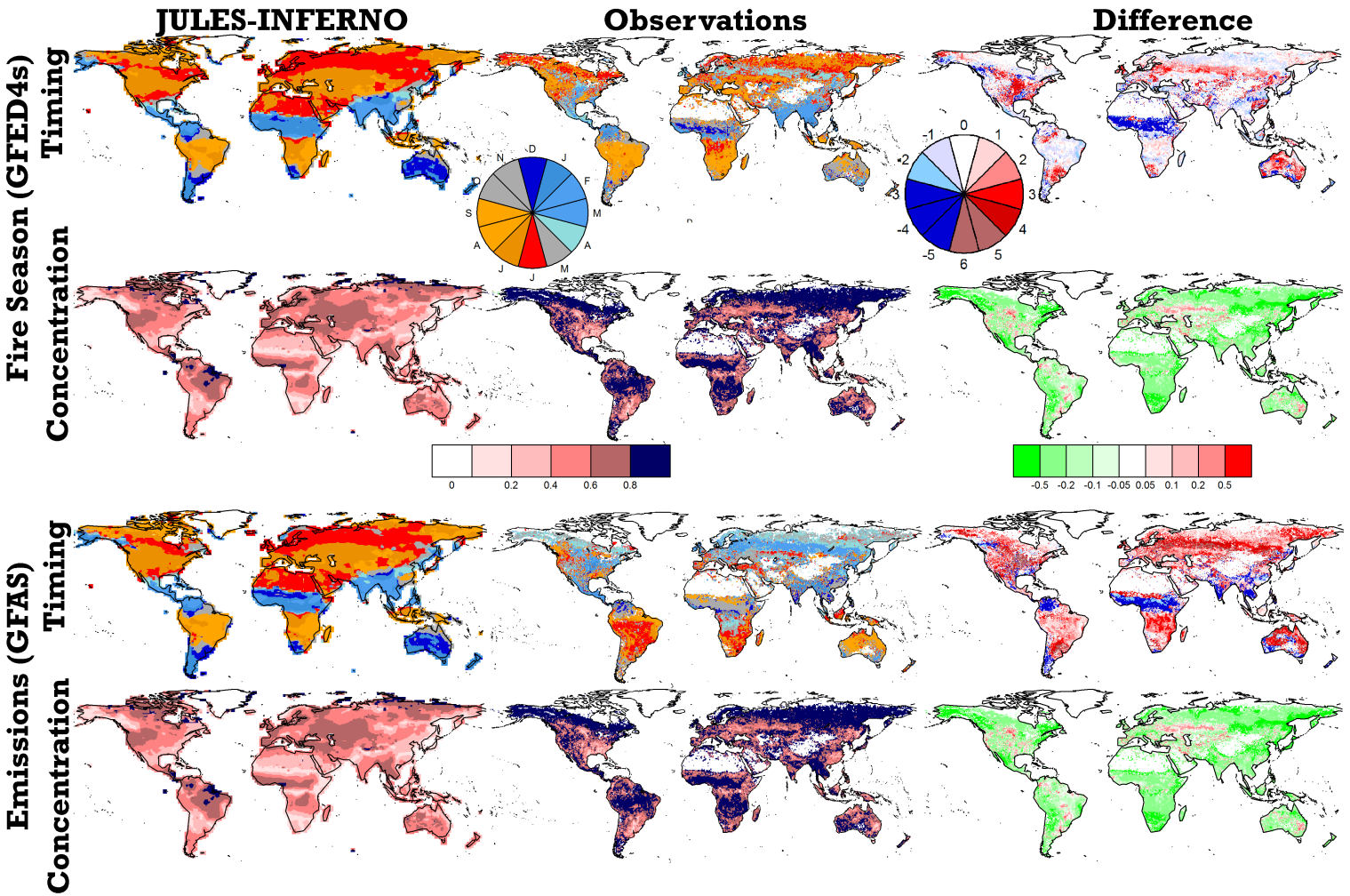


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

JULES-INFERNO v obs

Seasonality



Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

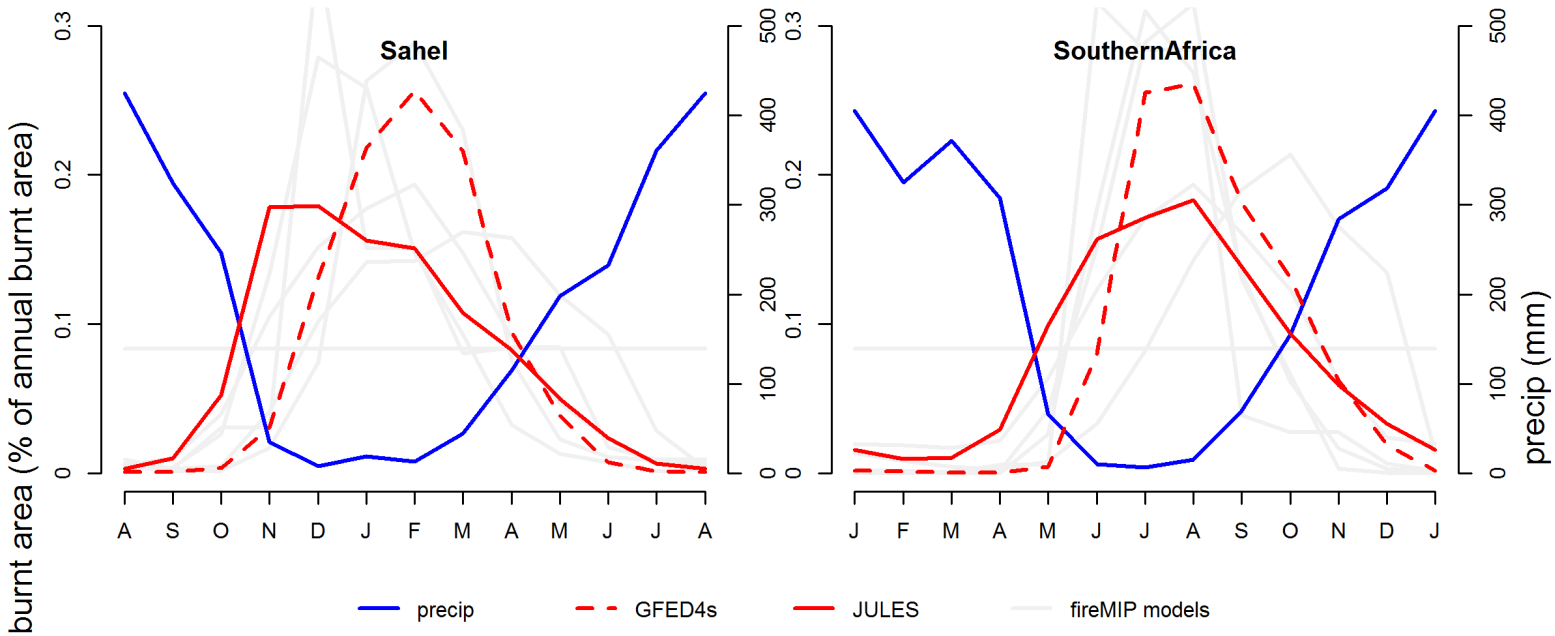
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

JULES-INFERNO v obs

Seasonality

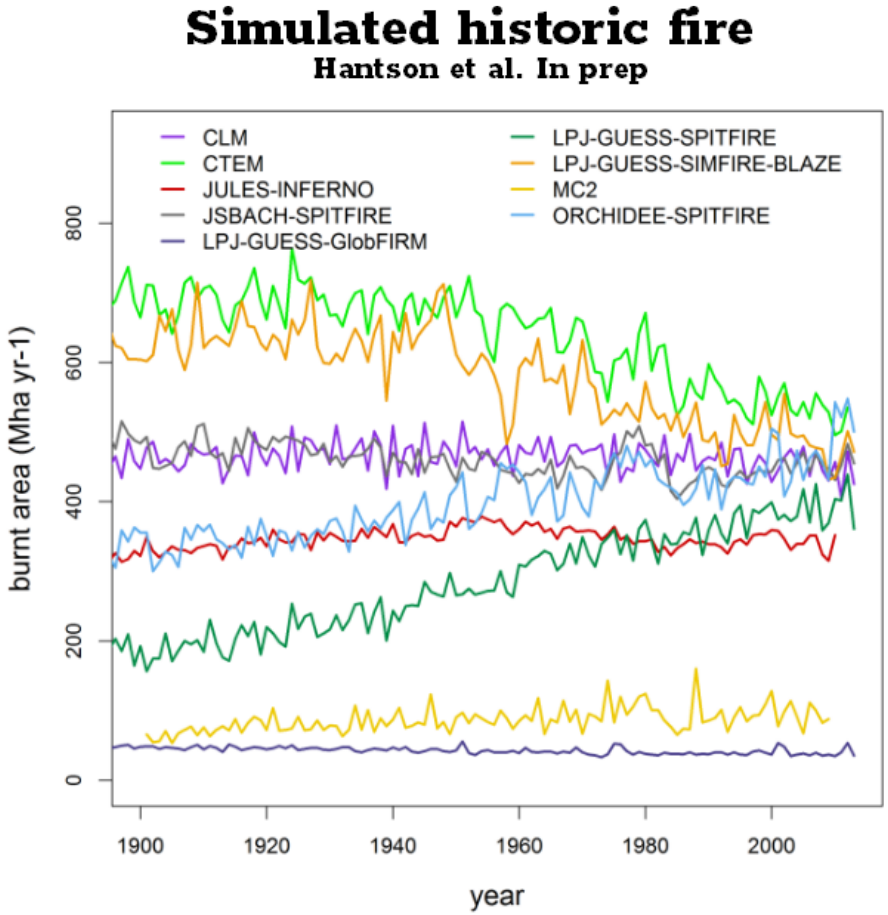
Burnt Area	😁
Veg C	🙂
Fire C	😁
Burnt Area Season	🙁
Fire C. Season	😢



Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

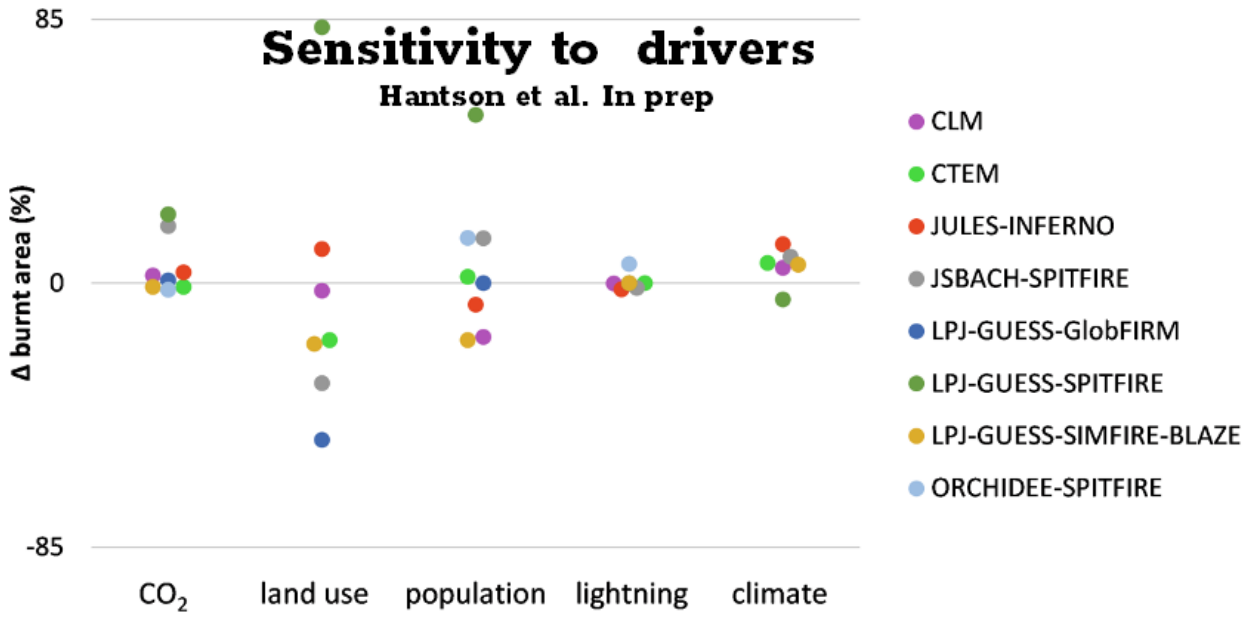
Human Impact



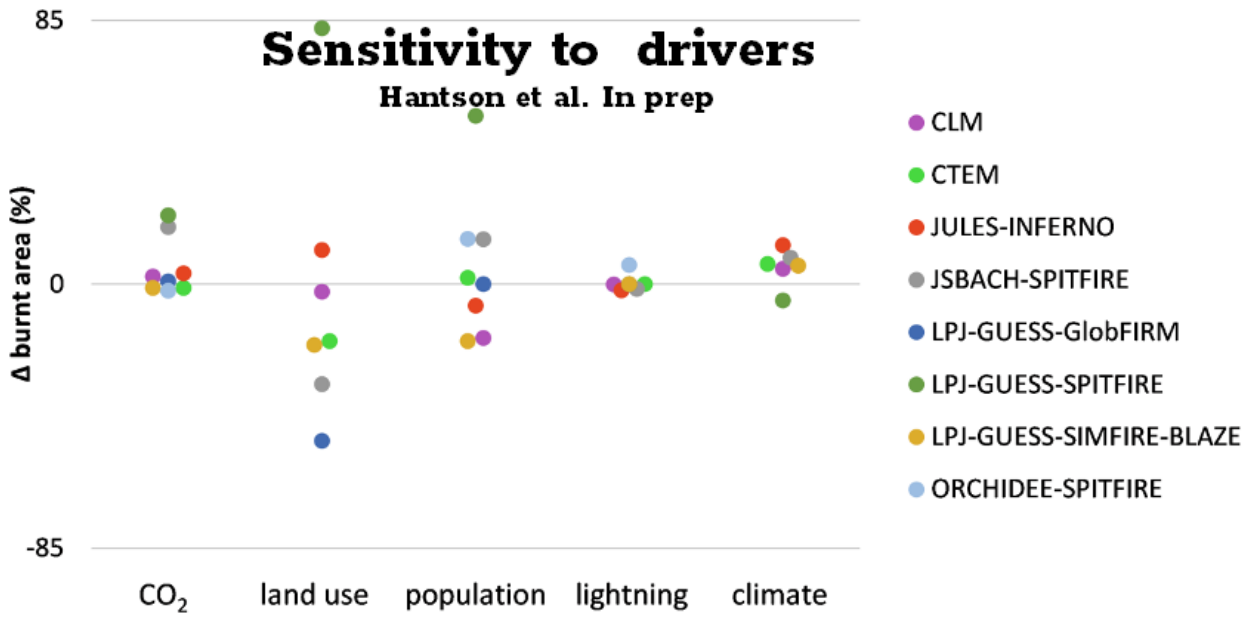
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

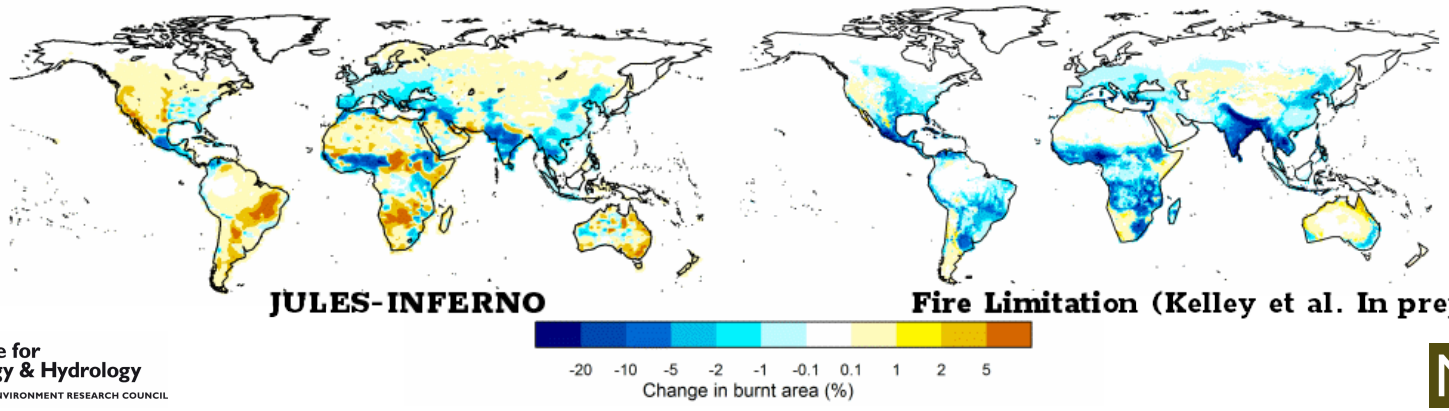
Human Impact



Human Impact



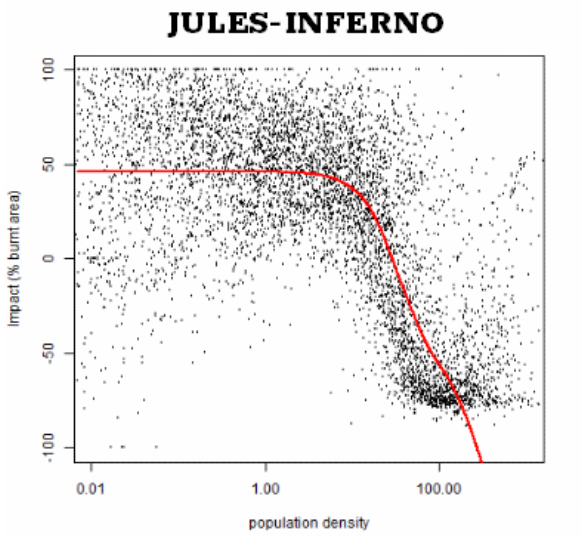
Impact of Humans

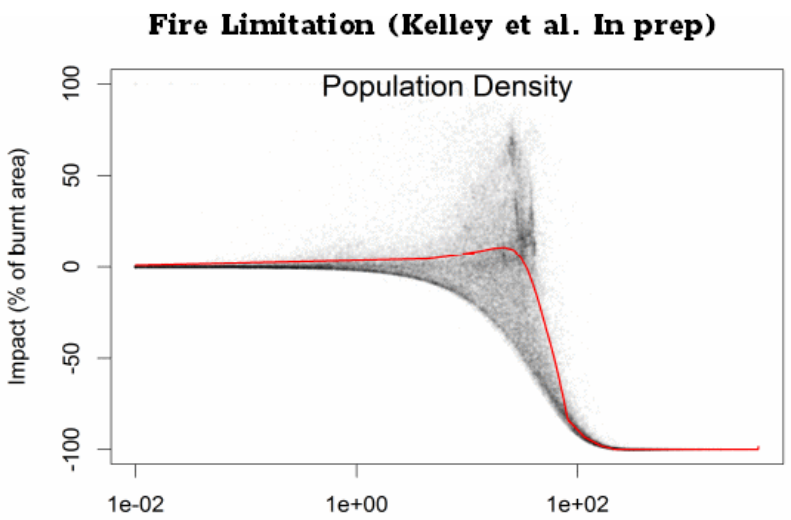


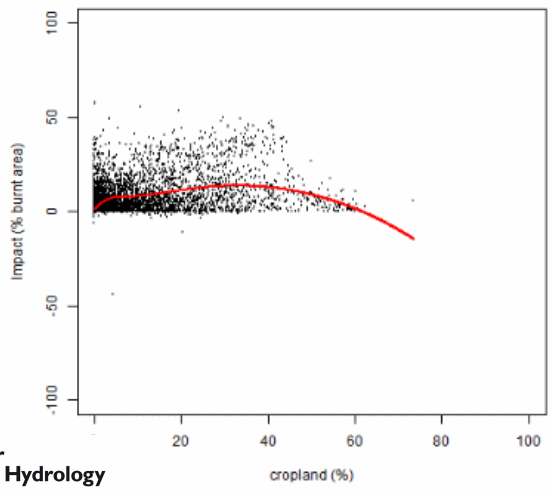
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

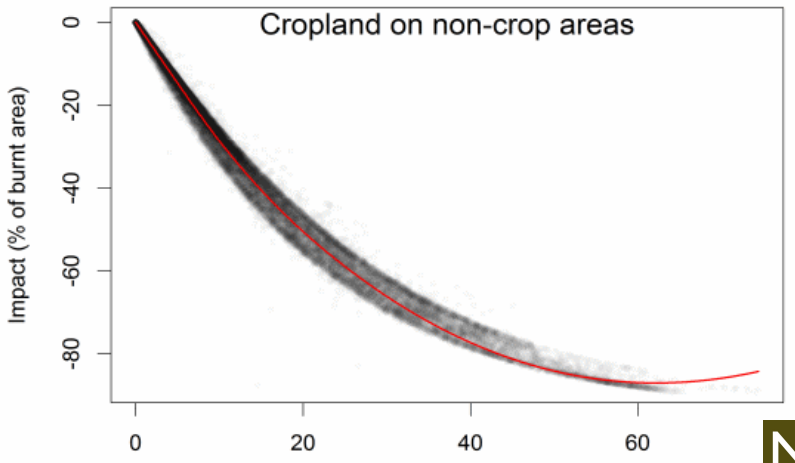
NERC SCIENCE OF THE ENVIRONMENT

Human Impact









Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Some things to work on...
Areas for JULES-INFERNO to improve on

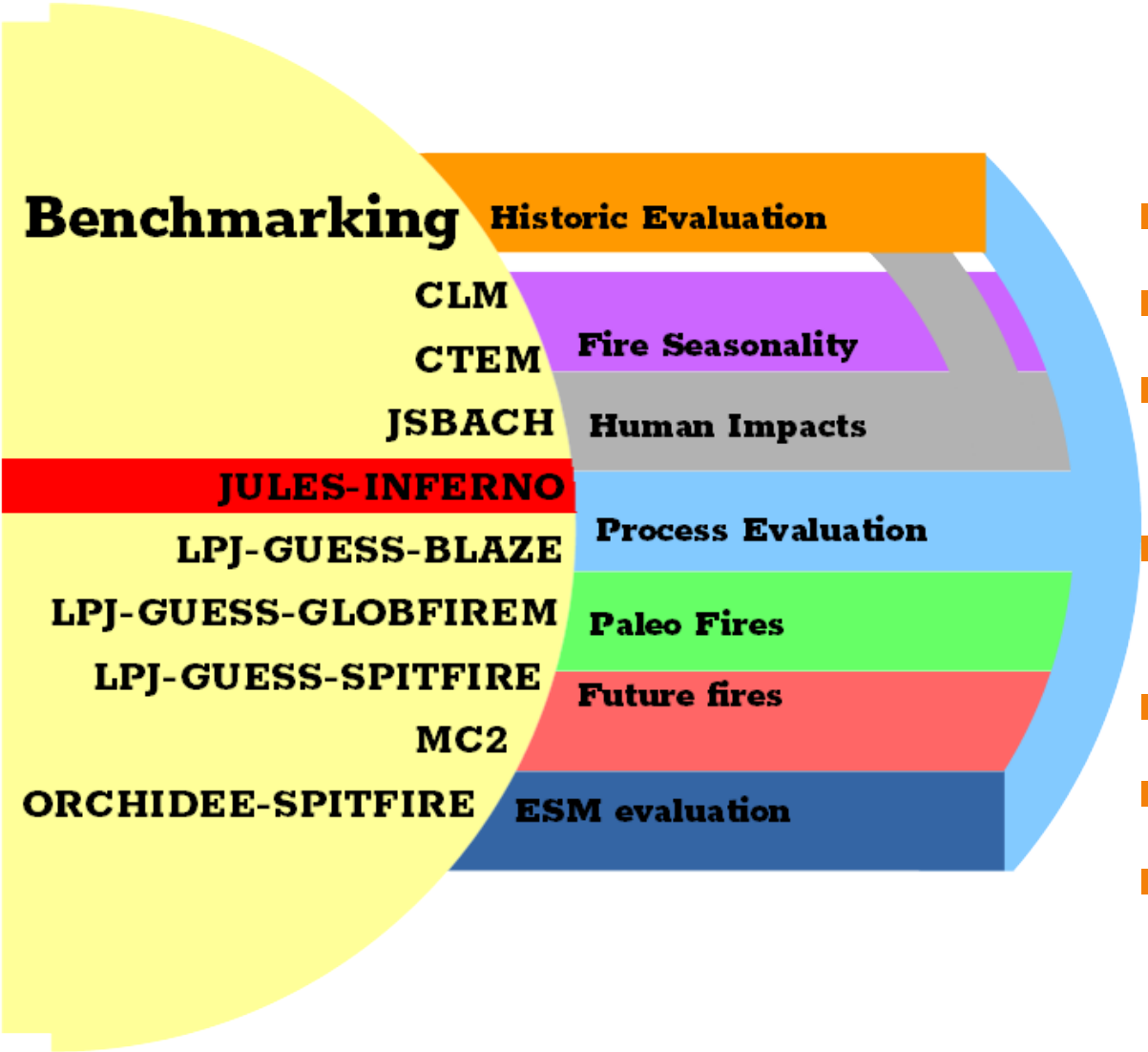
Burnt Area	
Veg C	
Fire C	
Burnt Area Season	
Fire C. Season	

- Burnt area in seasonal humid areas.
- Delay fire season onset
- Include land use fragmentation

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

fireMIP
Fire Modelling Inter-comparison Project

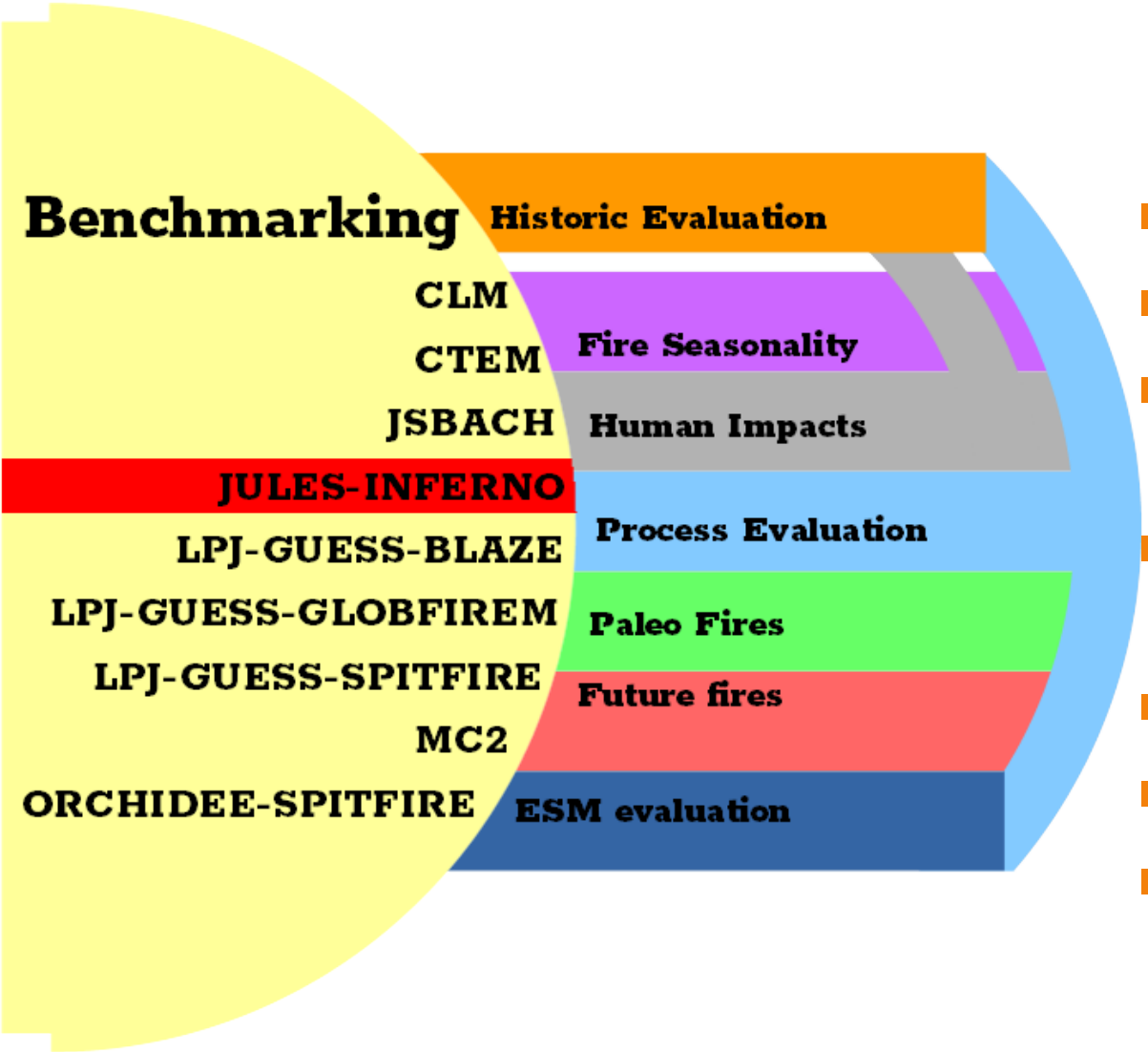


- World without fire.
- Pre-industrial fire regime.
- Pre-industrial atmospheric CO2.
- Fixed 1700 human population density.
- Fixed 1901-1920 lightning.
- Fixed 1901-1920 climate.
- Fixed 1700 land use.

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

fireMIP
Fire Modelling Inter-comparison Project

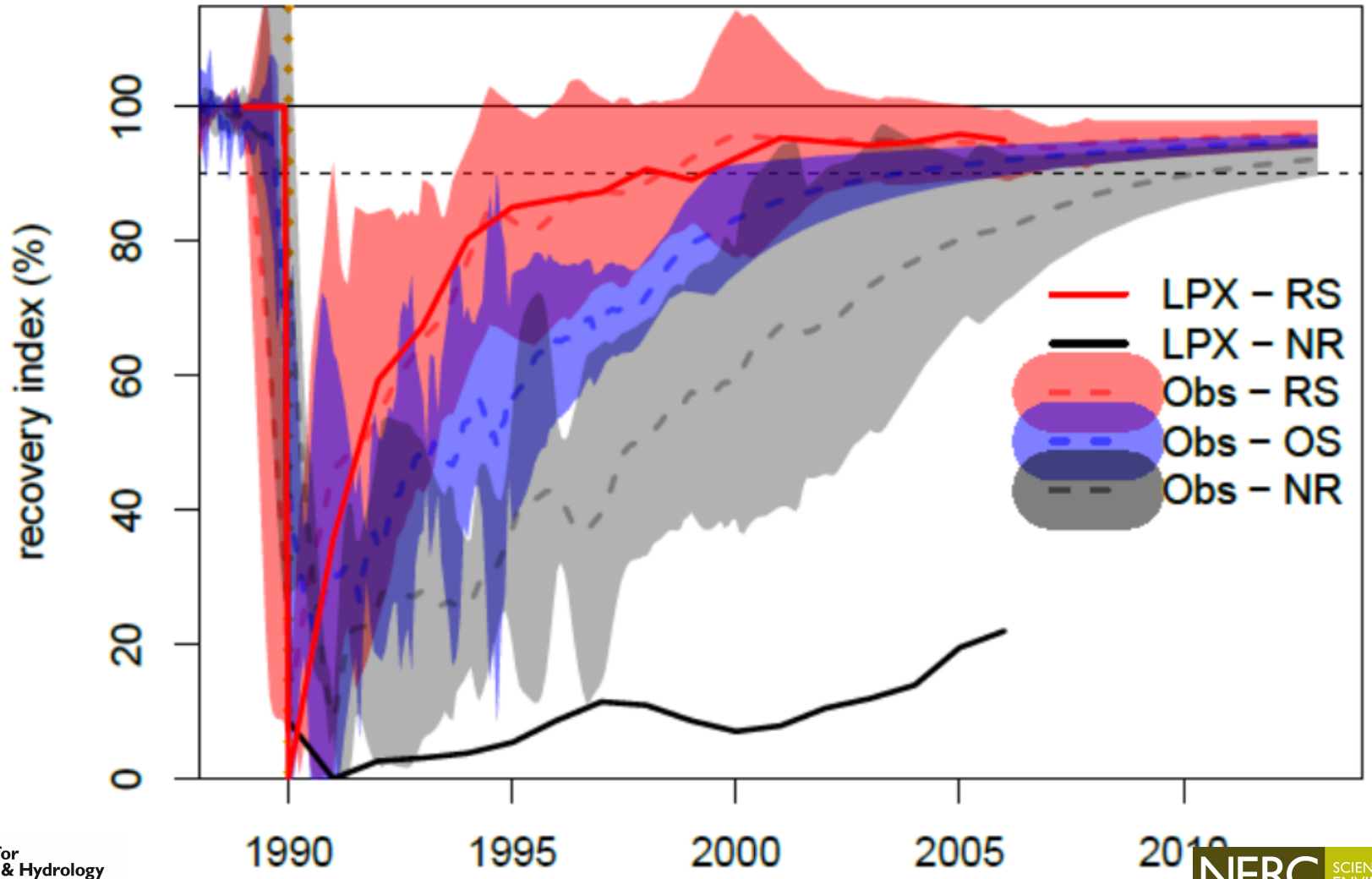


- World without fire.
- Pre-industrial fire regime.
- Pre-industrial atmospheric CO2.
- Fixed 1700 human population density.
- Fixed 1901-1920 lightning.
- Fixed 1901-1920 climate.
- Fixed 1700 land use.

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

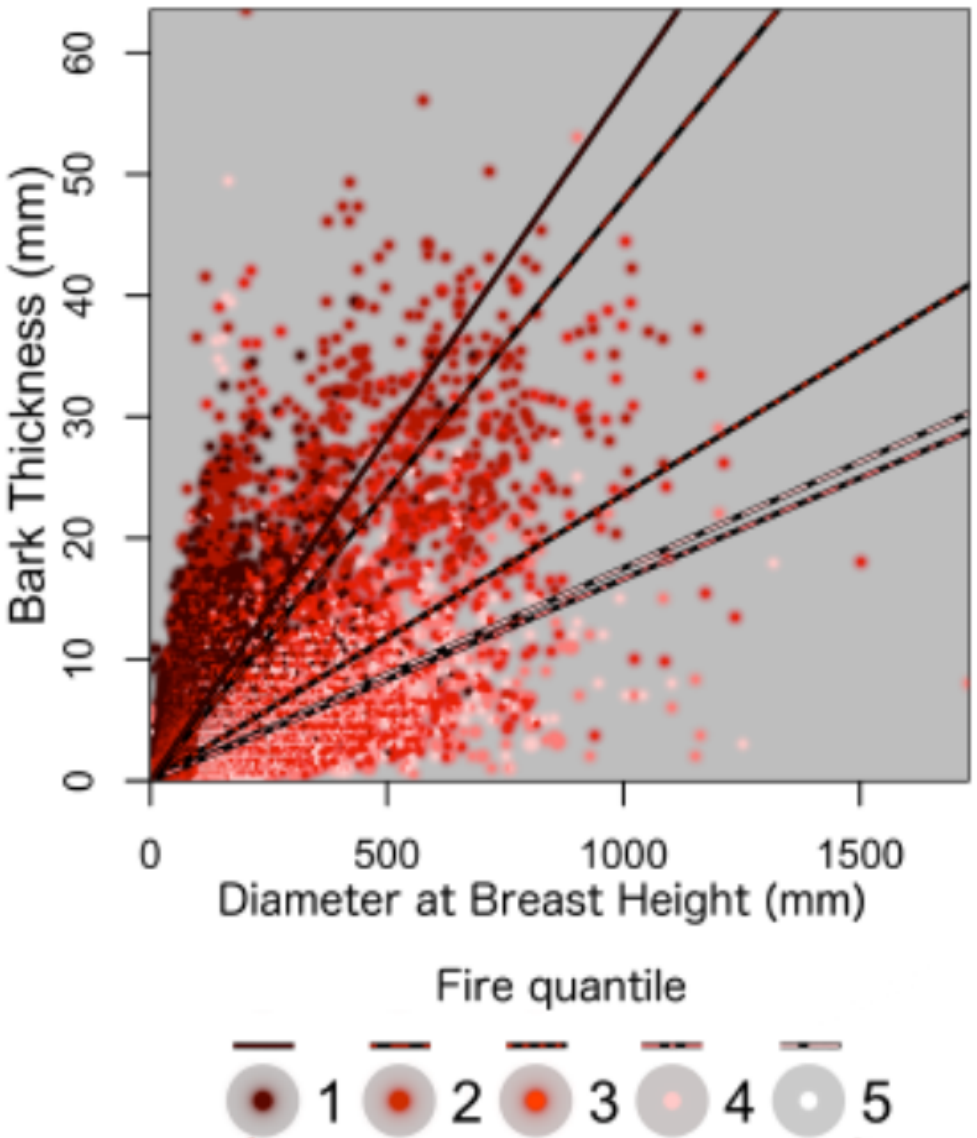
Post-fire recovery



Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Pre-fire resilience



Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT