Using Data to Improve a Global Fire Model for Use in Climate Models and ESMs

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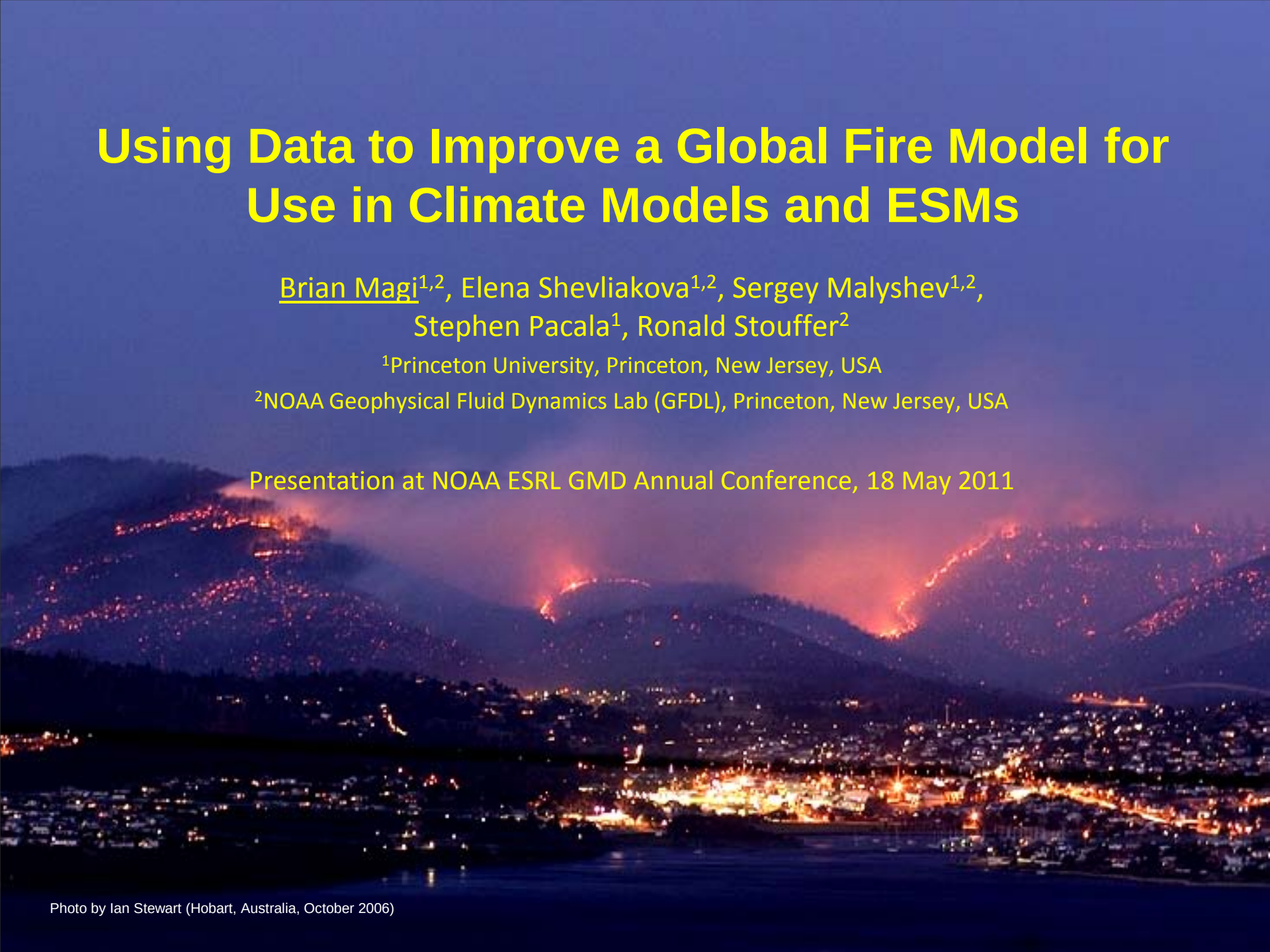
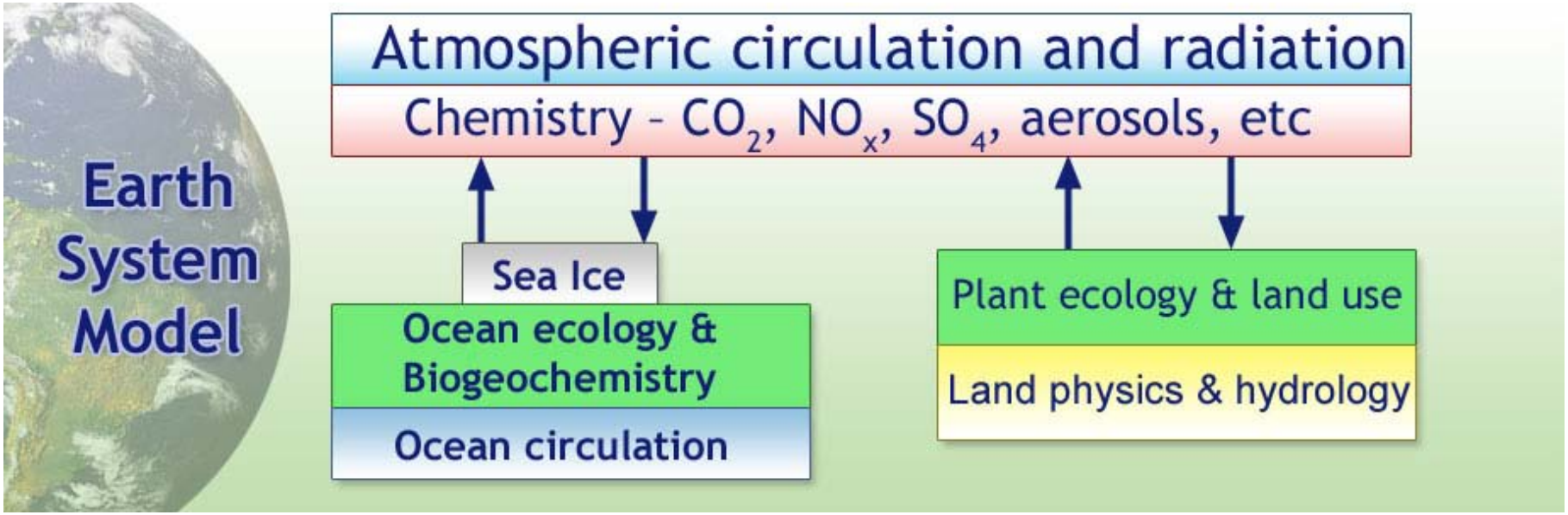


Photo by Ian Stewart (Hobart, Australia, October 2006)

NOAA GFDL Earth System Model



source: John Dunne et al., 2011, in preparation.

Fire as a Land-Atmosphere Process

fire

- meteorological conditions
- availability of vegetation
- ignition source

land

- carbon cycle
- surface albedo
- vegetation cover
- soil and sediment

climate

- land cover change
- vegetation type
- radiative forcing
- atmospheric circulation

atmosphere

- trace gases
- aerosol
- air quality
- thermodynamics

Global Distribution of Fires As Seen From Satellite

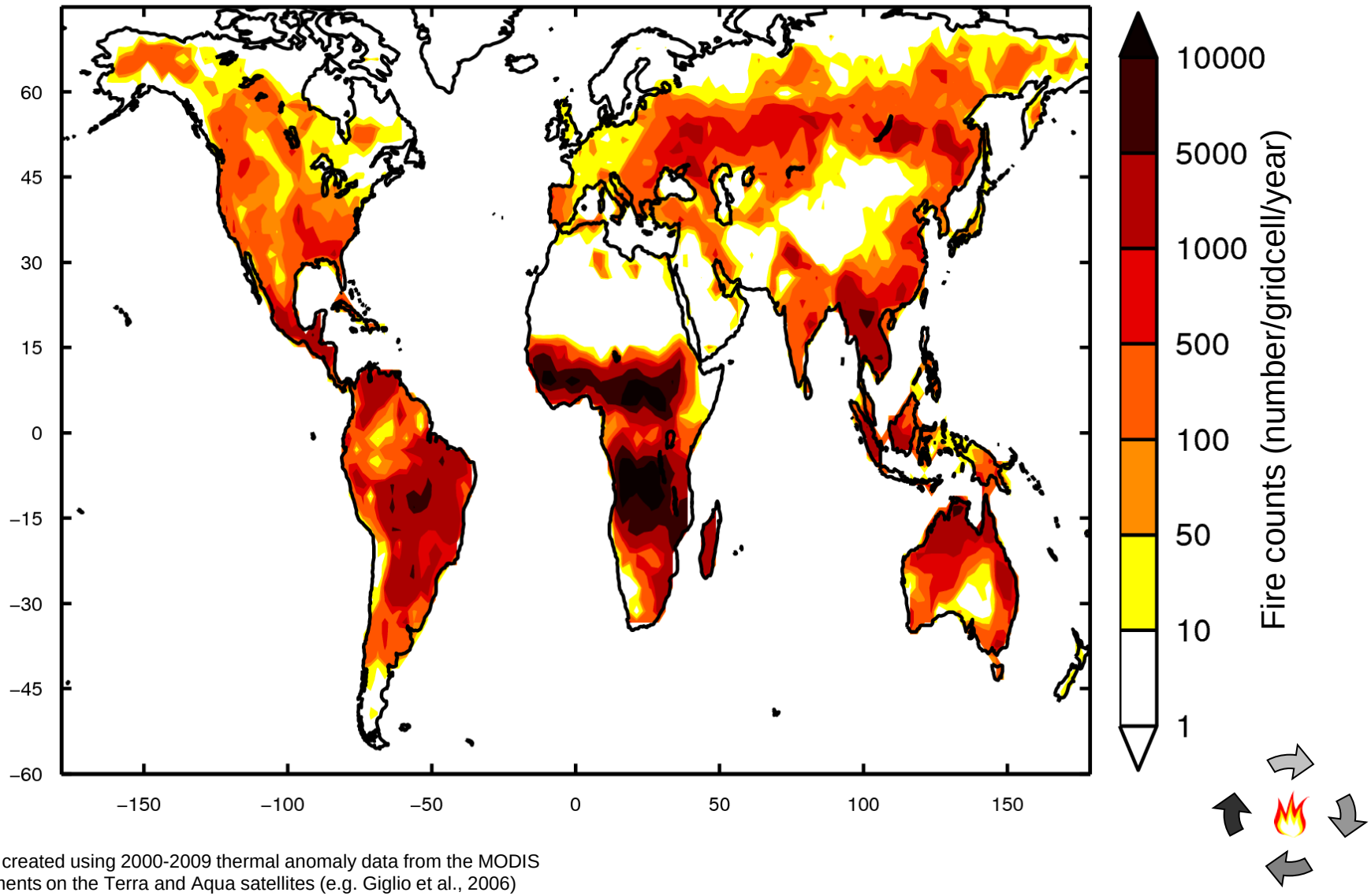
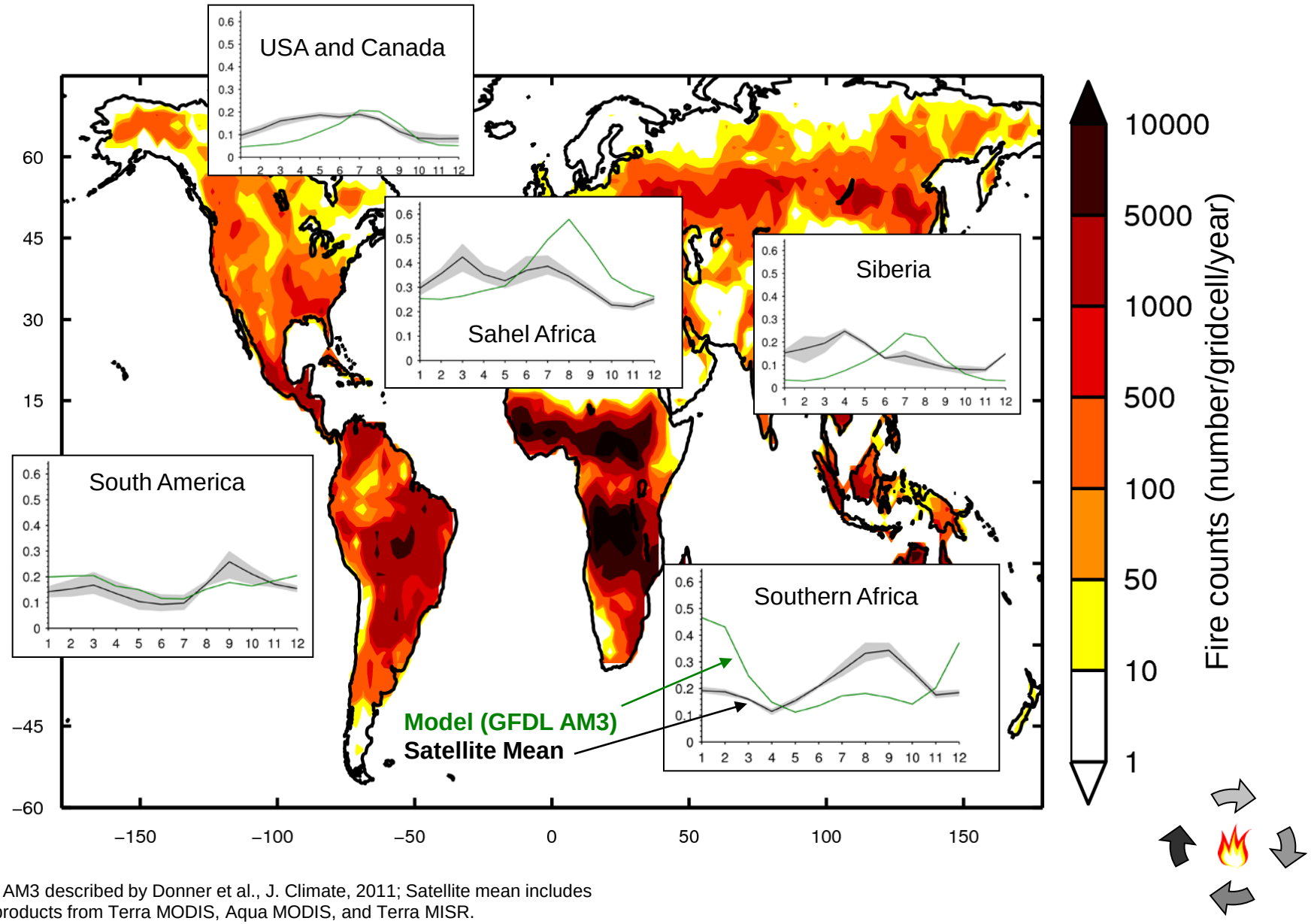


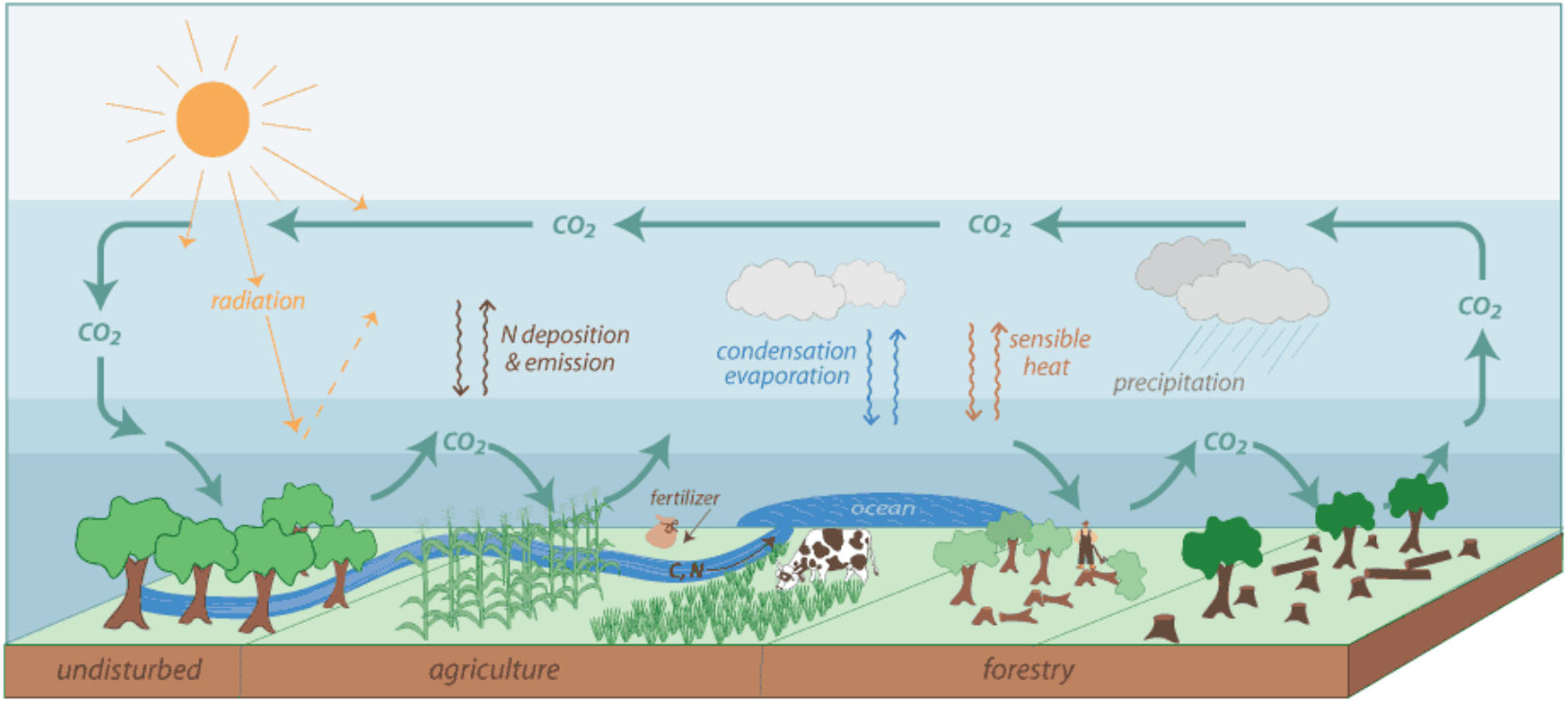
Figure created using 2000-2009 thermal anomaly data from the MODIS instruments on the Terra and Aqua satellites (e.g. Giglio et al., 2006)

Regional Aerosol Optical Depths from Model and Satellites



Model AM3 described by Donner et al., J. Climate, 2011; Satellite mean includes AOD products from Terra MODIS, Aqua MODIS, and Terra MISR.

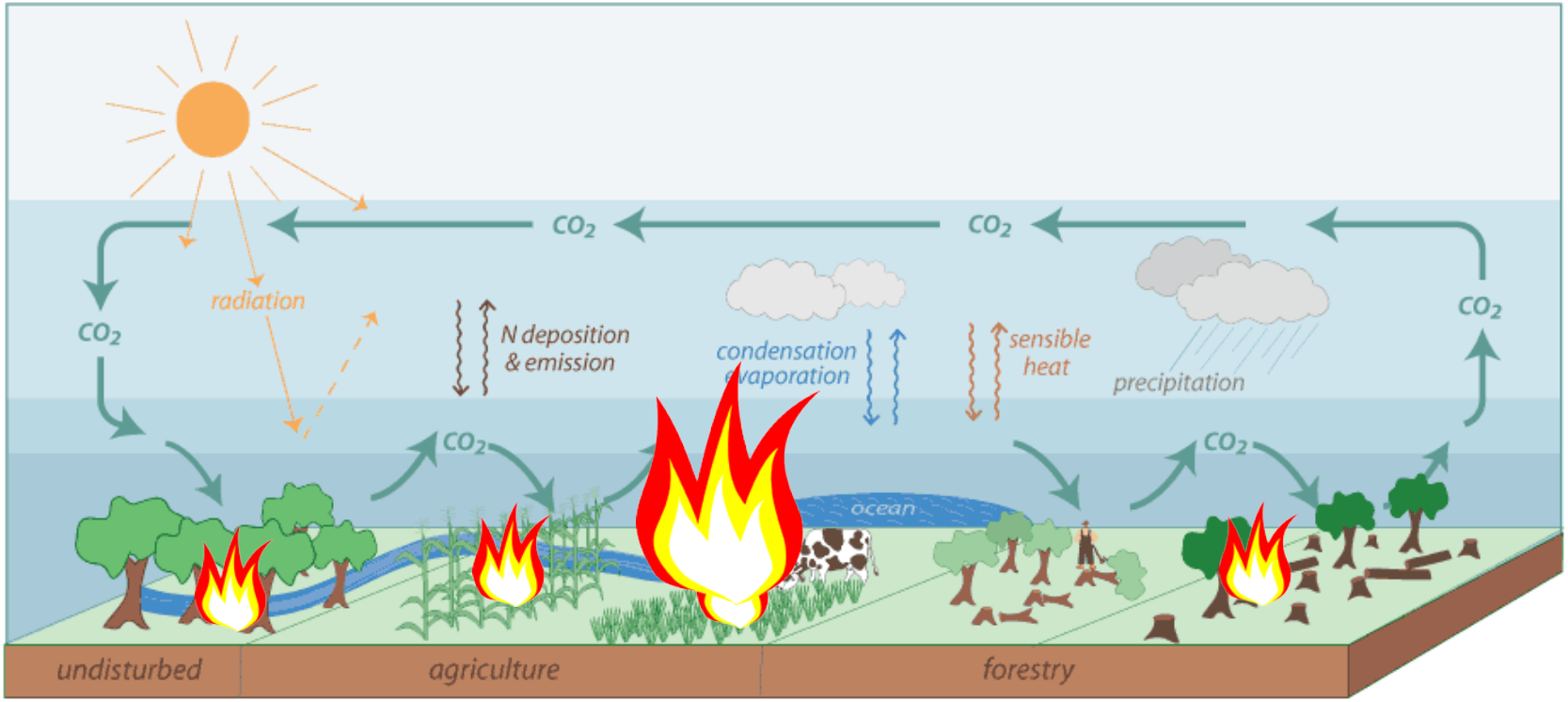
NOAA GFDL Land Model



primary crop, pasture secondary

Reference: Elena Shevliakova et al., 2009.

Improving the Simulation of Fire in the Land Model

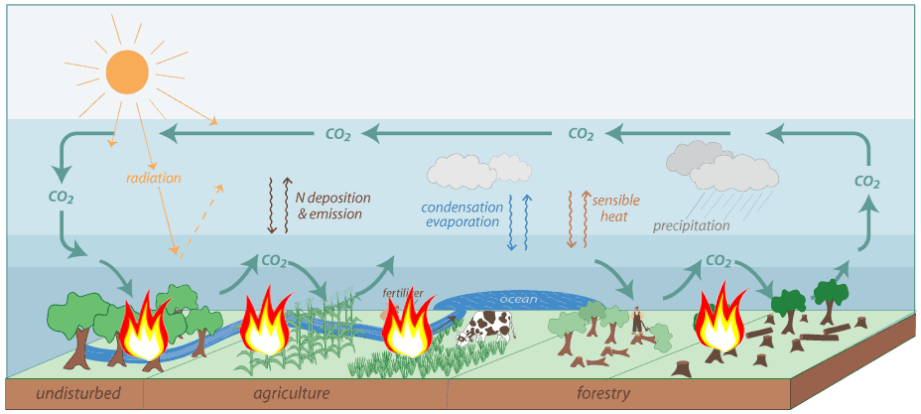


primary crop, pasture secondary

Reference: Elena Shevliakova et al., 2009.

Fire Model Schematic

inputs
-lightning (OTD/LIS)
-population density (HYDE)
-meteorology (T, q, precip)
-crop residue burning (YL2003)
-land use (H2006)



deforestation

primary

climate
ignition
fire size

burned area

crop, pasture

climate
ignition
fire size
residue

burned area

secondary

climate
ignition
fire size

burned area

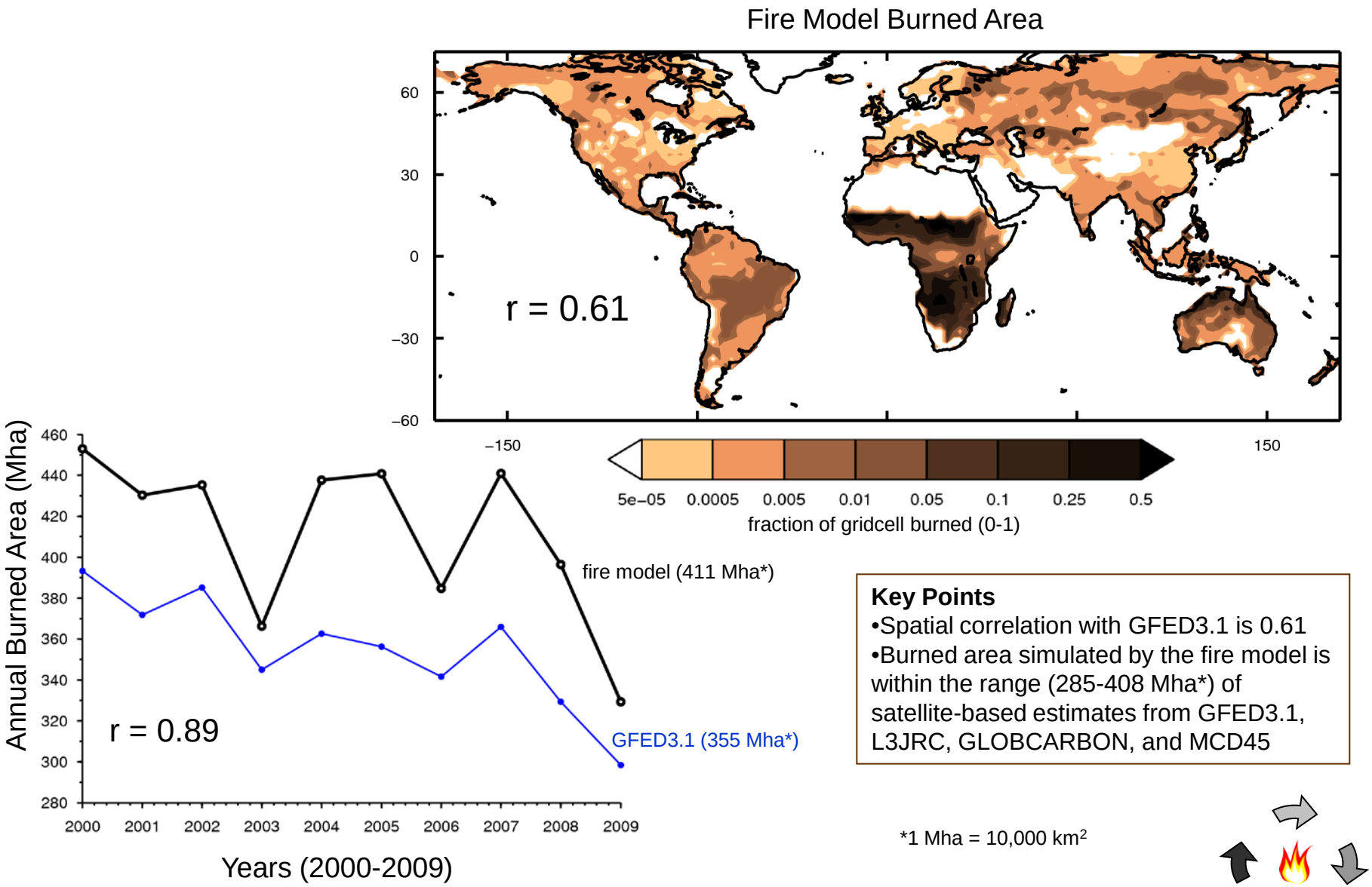
burned area

constraints
-satellite products
-ground-based data
- fire agency reports

total burned area

References: Magi et al., in preparation, 2011; OTD/LIS from NASA; HYDE3.1 described by Klein Goldewijk et al. 2010; YL2003 is Yevich and Logan, 2003; H2006 is Hurtt et al., 2006.

Annual Burned Area Simulated by the Fire Model



Key Points

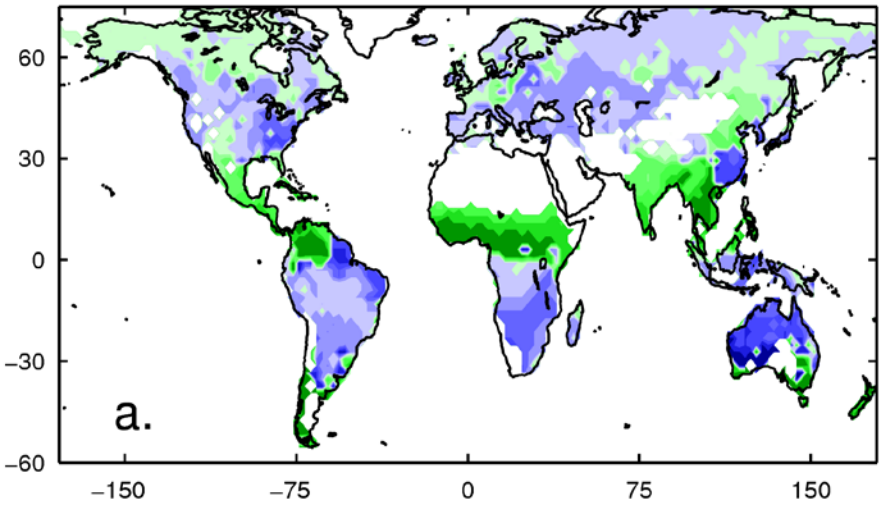
- Spatial correlation with GFED3.1 is 0.61
- Burned area simulated by the fire model is within the range (285-408 Mha*) of satellite-based estimates from GFED3.1, L3JRC, GLOBCARBON, and MCD45

*1 Mha = 10,000 km^2

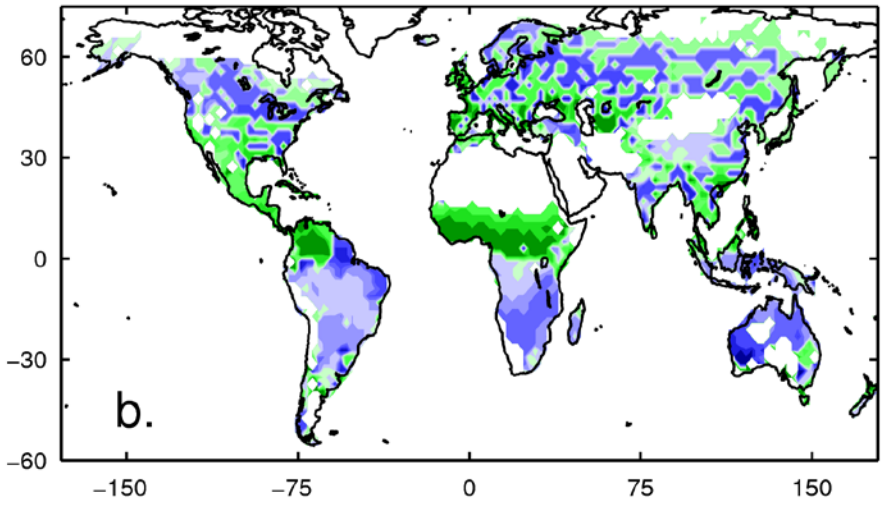
References: Fire Model described in Magi et al., in preparation, 2011; GFED3.1 burned area from Giglio et al., 2010. Other burned area products are L3JRC (Tansey et al., 2008), MODIS MCD45 (Roy et al., 2008), and GLOBCARBON (Plummer et al., 2006).

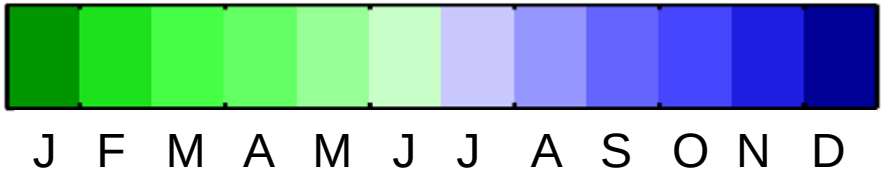
Month of Maximum Burned Area

Climate Driven Fires



Agricultural Fires

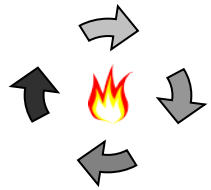




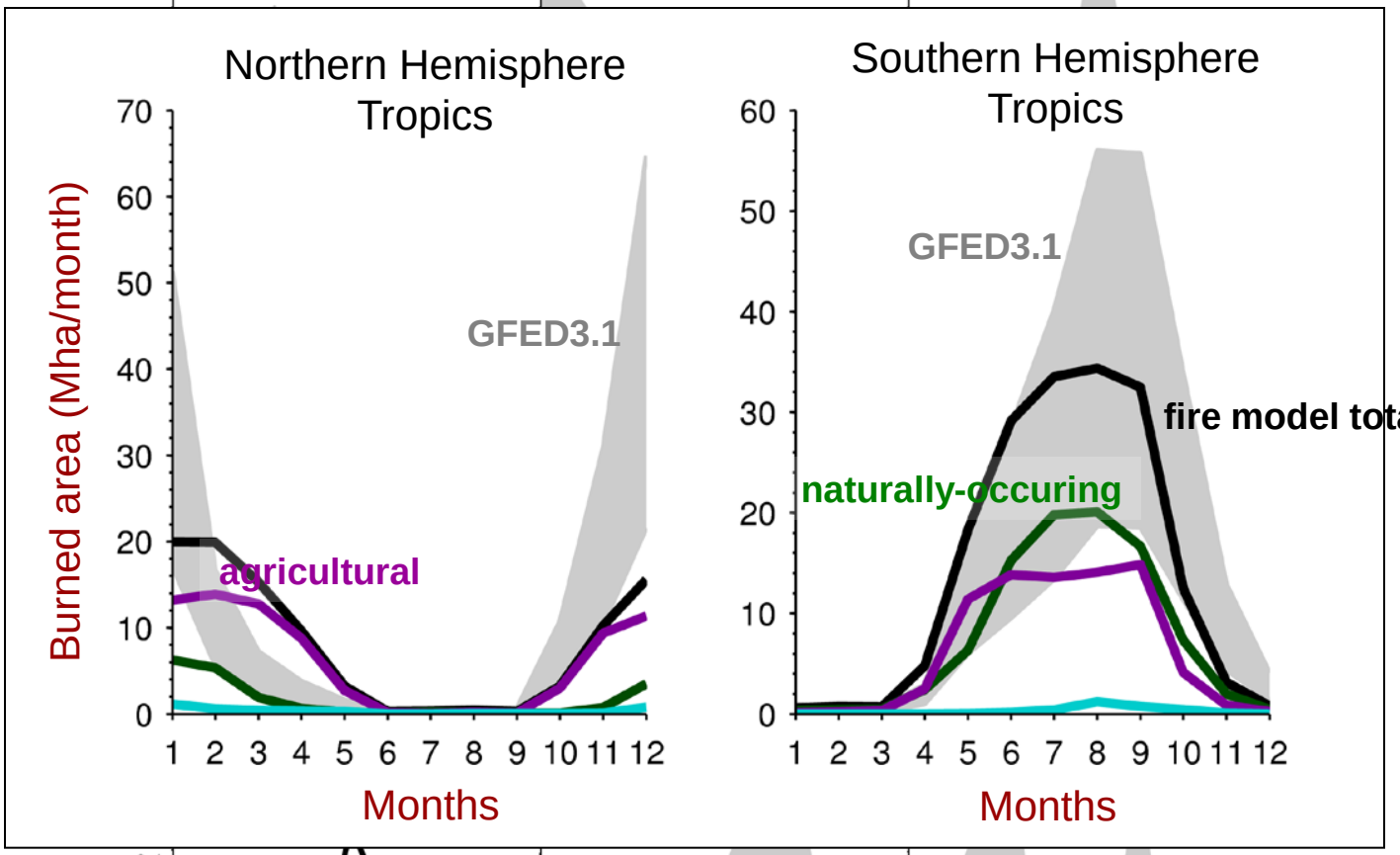
Key Points

- Tropical fire season peaks during the dry season, extratropical fire season during the hottest months
- Agricultural fire season in the tropics peaks close to the peak of the dry season
- Agricultural fire season in the extratropics peaks prior to and following the growing season

References: Magi et al., in preparation, 2011.

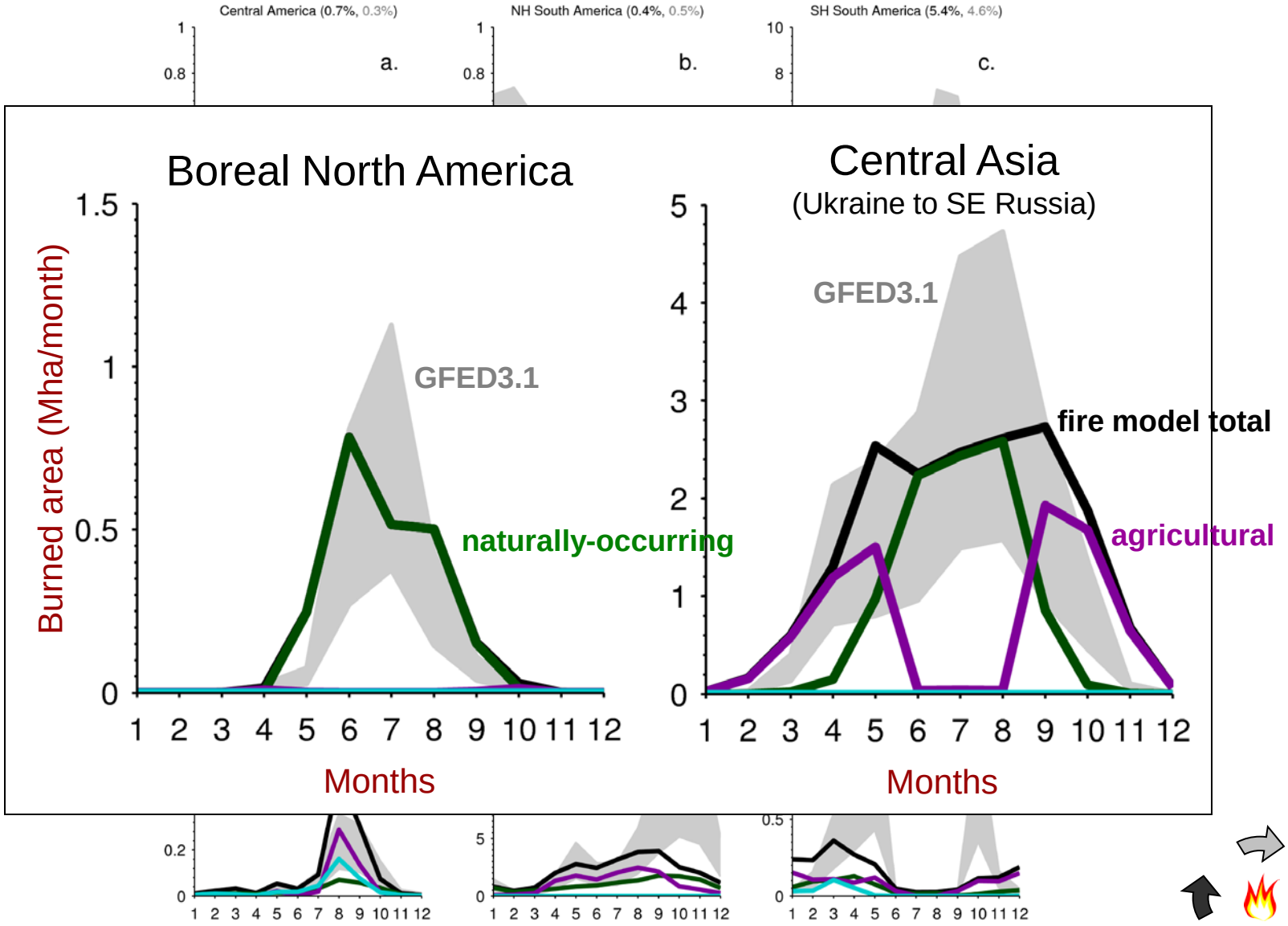


Mean Monthly Burned Area Simulated by the Fire Model



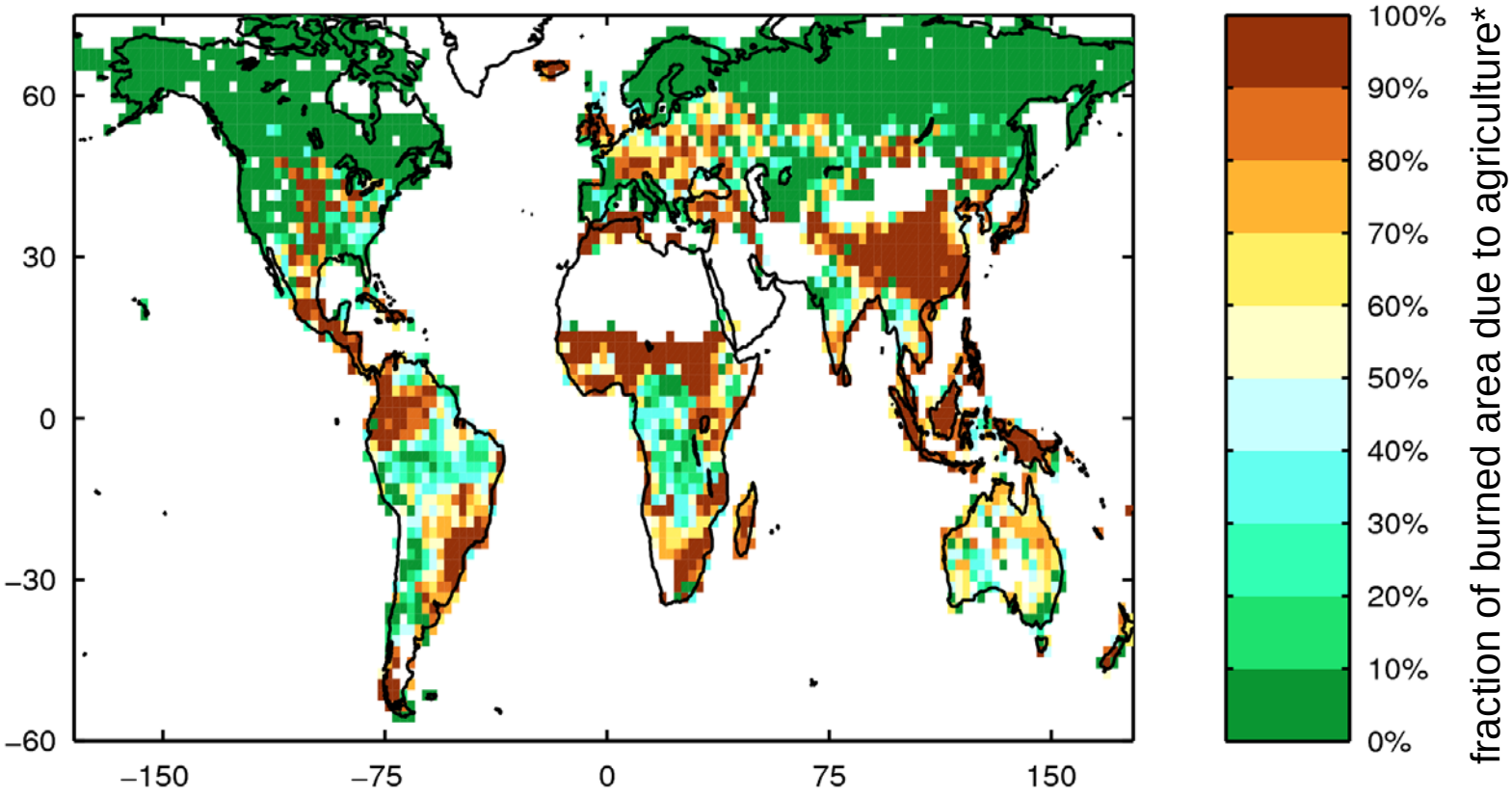
References: Fire Model described in Magi et al., in preparation, 2011; GFED3.1 burned area from Giglio et al., 2010.

Mean Monthly Burned Area Simulated by the Fire Model



References: Fire Model described in Magi et al., in preparation, 2011; GFED3.1 burned area from Giglio et al., 2010.

Fraction of Total Burned Area due to Agriculture

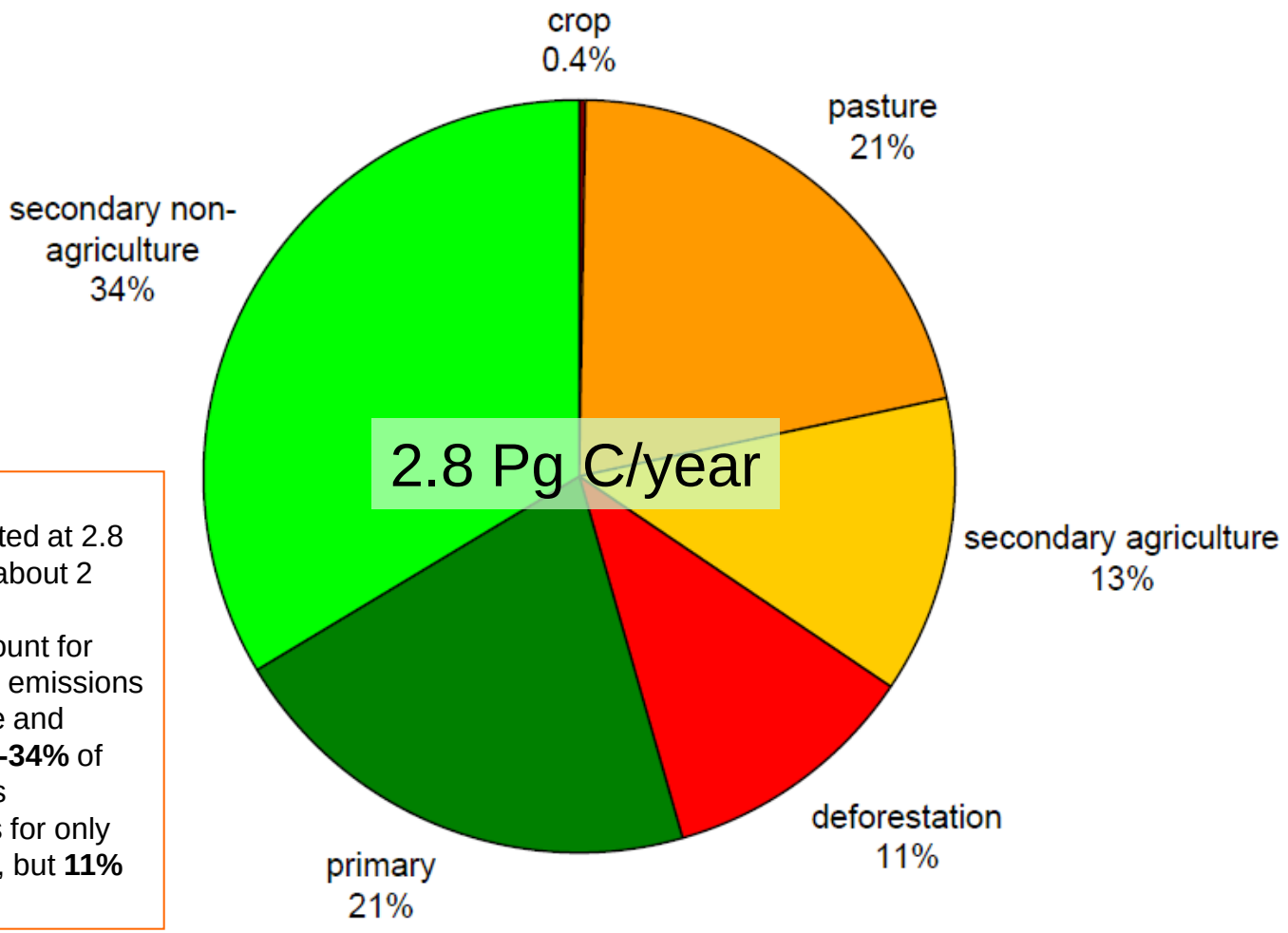


* agriculture includes burned area from fires on **cropland, pasture, and deforestation**

Key Point
•Agricultural burning practices account for **69%** of the total burned area

References: Magi et al., in preparation, 2011.

Apportionment of Global Carbon Emissions from Fires



Key Points

- Total emissions estimated at 2.8 PgC/year (GFED3.1 is about 2 PgC/year)
- Unintentional fires account for **over 50%** of the carbon emissions
- Burning of crop residue and pastures account for **21-34%** of global carbon emissions
- Deforestation accounts for only 2% of total burned area, but **11%** of carbon emissions

References: Fire Model described in Magi et al., in preparation, 2011;
GFED3.1 emissions from Van der Werf et al., 2010.

Conclusions

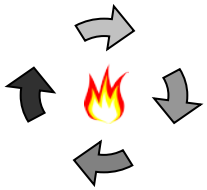
Summary: The improved fire model simulates seasonal fire as a mixture using empirical relationships, literature-based estimates, and parameter estimation

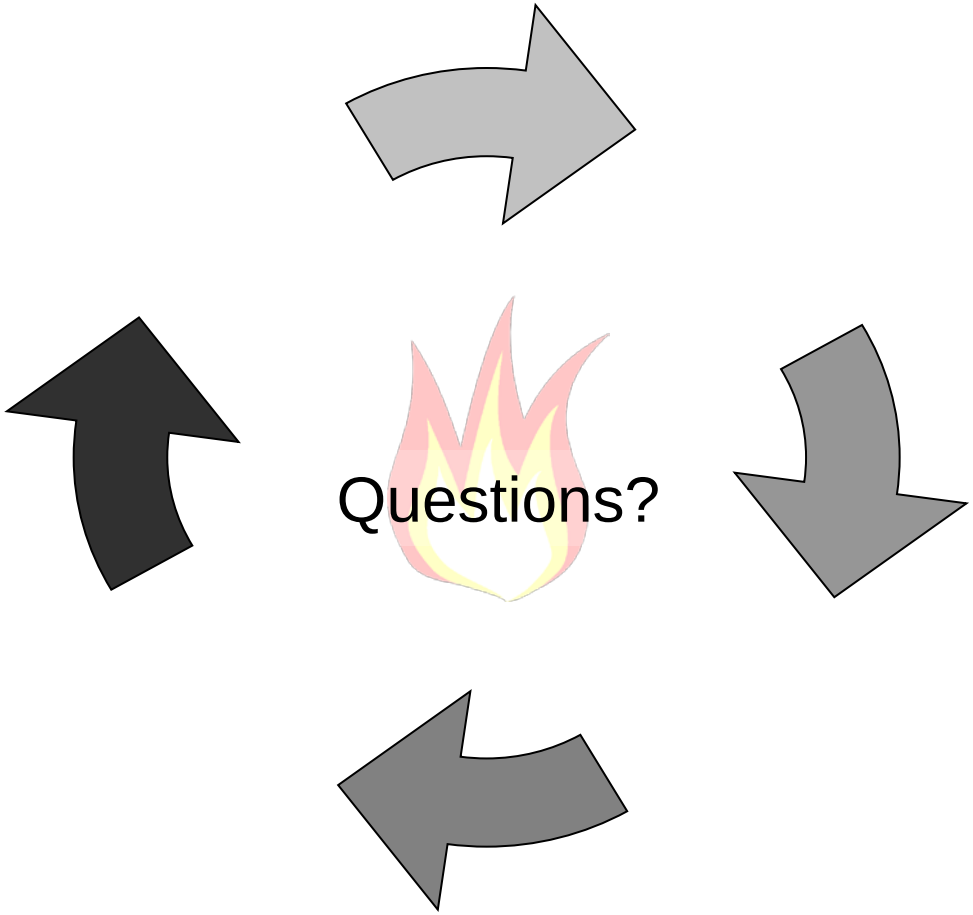
Results from our mixture model

1. Present day fires are driven by climate, but are nearly entirely anthropogenic
2. Most of the anthropogenic burned area is due to agricultural practices
3. Agricultural fraction of total global **burned area** is 69%, while the fraction of total global **emissions** is about 45%
4. 11% of global **emissions** is from deforestation

Future work on the fire model

1. Incorporation of the fire model as an interactive component in the GFDL Land Model and Earth System Model
2. Simulations of historical and future fire using land use scenarios and IPCC AR5 model output
3. Improve model of seasonal agricultural burning in different regions (China, India, southern Russia, Ukraine, Sub-Sahara Africa)
4. Improve model of deforestation




Questions?

Input and Datasets Used in the Fire Model

T, q, snow	GFDL ESM2M	Dunne et al., in prep, 2011
land use	HYDE, SAGE	Hurtt et al., 2006
precipitation	GPCP, rain gauges, TRMM	Sheffield et al., 2006
lightning	OTD, LIS on TRMM	LIS website
population	HYDE 3.1	Klein Goldewijk et al., 2010
crop use	bottom-up analysis	Yevich and Logan, 2003
burned area	GFED 3.1	Giglio et al., 2010
fire reports	NIFC, CIFFC, RFF	agency reports on internet
fire counts	Terra and Aqua MODIS	Giglio et al., 2006