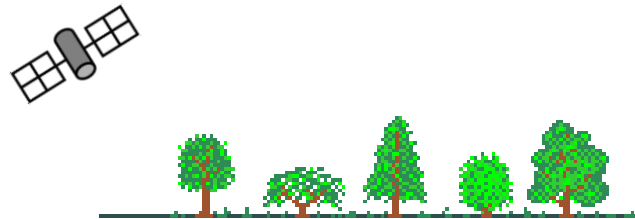


An updated biogenic soil NO_x model for GEOS-Chem

Rynda Hudman¹, Neil Moore^{2,3}, Randall Martin²,
Ashley Russell¹, Luke Valin¹, Ron Cohen¹



*GEOS-Chem Meeting
May 3, 2011*

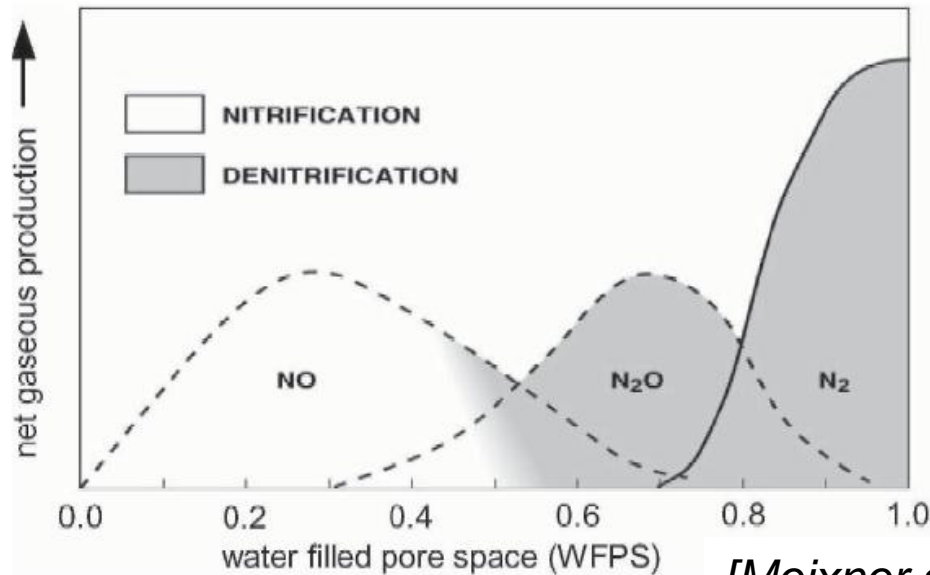
¹ *UC Berkeley, Dept of Chemistry*

² *Dalhousie University, Dept of Physics and Atmospheric*

³ *now at University of Manitoba, Dept of Physics & Astronomy*



NO IS A HIGHLY VARIABLE PRODUCT OF MICROBIAL ACTIVITY IN SOILS



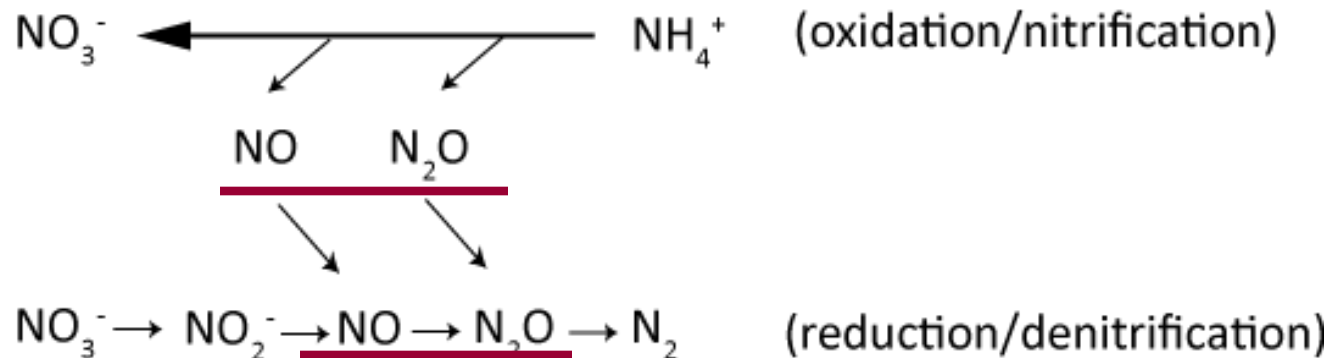
Processes not well understood, **HUGE** spatial variability, but best correlation w/ soil moisture, T, N avail.

[Meixner and Yang, 2006]

ATMOSPHERE

\uparrow N₂O(g), N₂(g), NO(g)

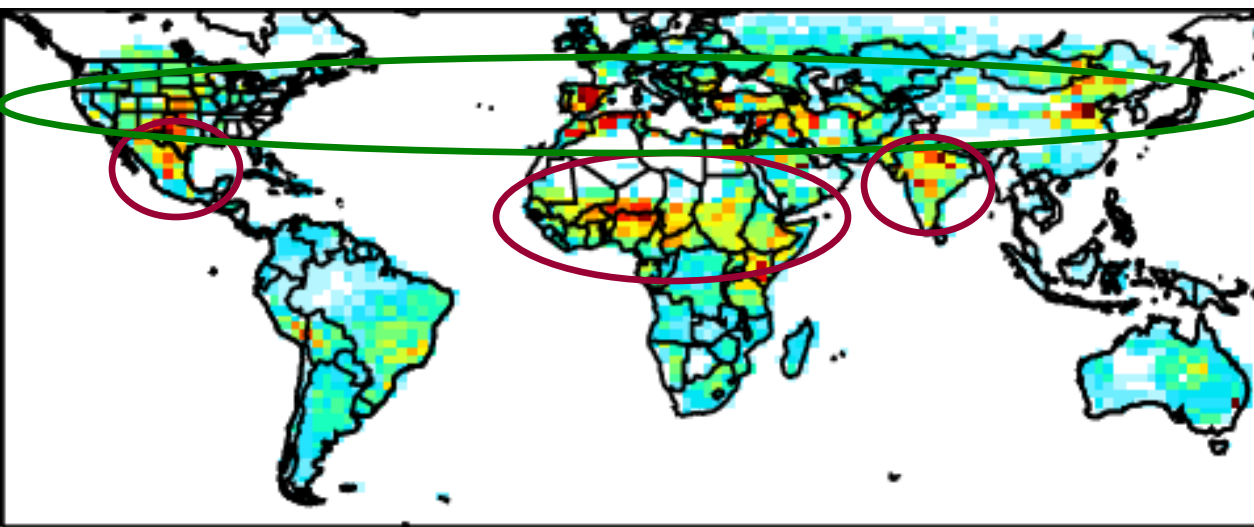
BIOSPHERE



LARGEST EMISSIONS OVER N. MIDLAT & MONSOONAL REGIONS

Satellite-based inferred emissions >> GEOS-Chem emissions

GOME Constraints on Natural Soil and Agriculture



0.0 2.5 5.0 7.5 10 [ng N m² s⁻¹]

GLOBAL: 8.9 Tg N/yr
N. MIDLAT: 3.5 Tg N/yr
TROPICS: 5.3 Tg N/yr

• ~22% of global NO_x source

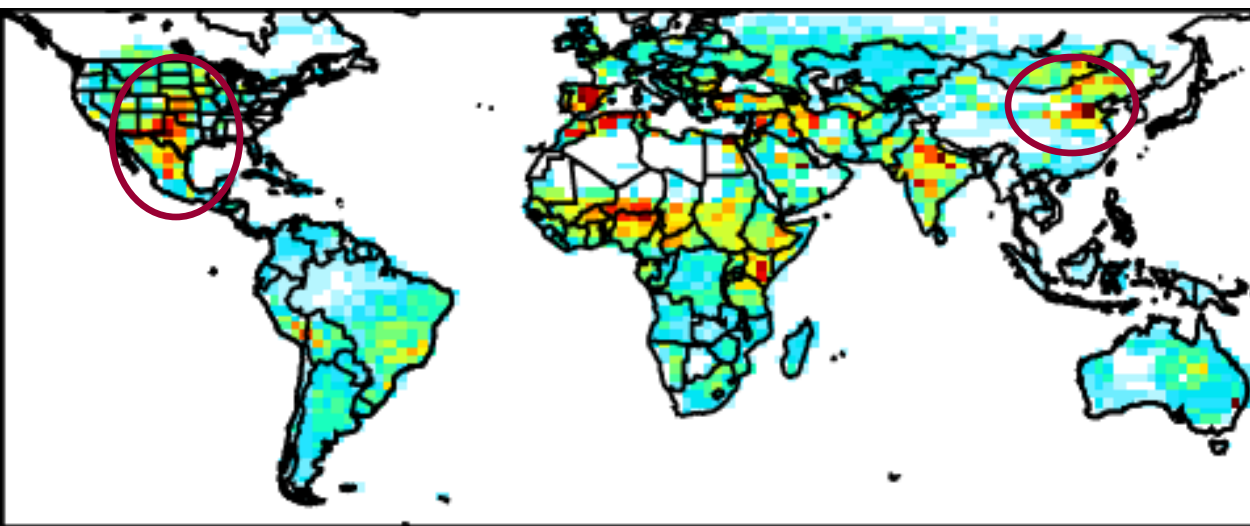
• 60% higher than GEOS-Chem

[Jaeglé *et al.*, 2005]

LARGEST EMISSIONS OVER N. MIDLAT & MONSOONAL REGIONS

Satellite-based inferred emissions >> GEOS-Chem emissions

GOME Constraints on Natural Soil and Agriculture



0.0 2.5 5.0 7.5 10 $[\text{ng N m}^2 \text{s}^{-1}]$

[Jaeglé et al., 2005]

Add'l studies citing soil source as too small: Boersma et al., [2008] – X2 increase needed over Mexico, Wang et al., [2007] – X3 over Eastern China
Hudman et al., [2010] – importance of fertilizer pulsing

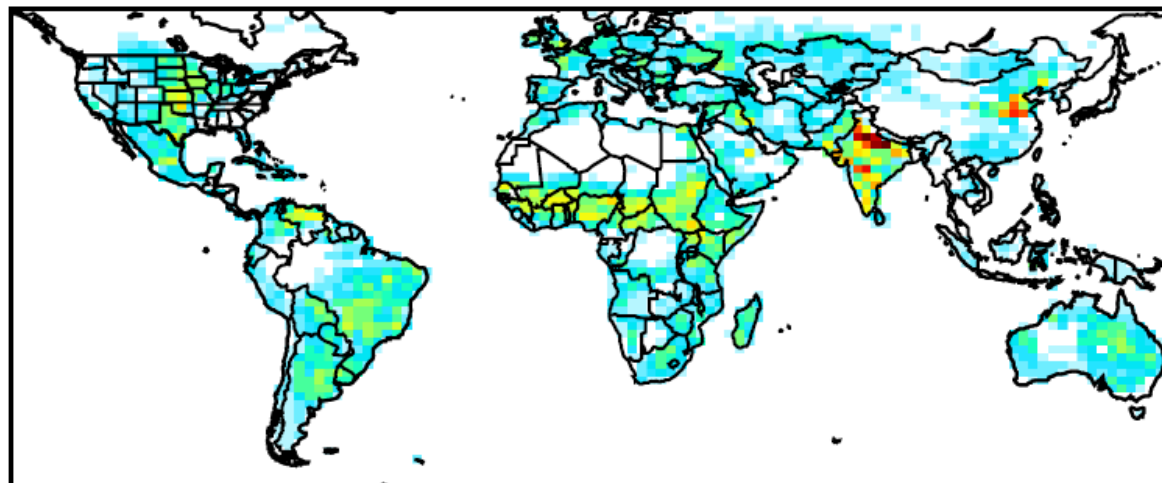
...suggests misrepresentation of soil-moisture response and of fertilizer source

WHAT IS IN THE MODEL NOW

The current model lacks some important physical processes

$$E_{\text{NOx}} = f(\text{T, biome, wet/dry}) \times \text{Pulse (precip)} \times \text{canopy uptake} + \text{FERT}$$

- **Soil Moisture/Temperature**: Discrete wet/dry states based on climatological precipitation [Yienger and Levy, 1995]
- **Pulsing**: Pulsing ~ to precipitation amount [Yienger and Levy, 1995]
- **Canopy Uptake**: based on LAI/SAI [Jacob and Bakwin, 1991]
- **Fertilizer**: Country-wide, distributed evenly over crudely defined growing season [Wang et al., 1998]



0.0 2.5 5.0 7.5 10 [ng N m² s⁻¹]

2006 Total =
6.2 Tg N yr⁻¹

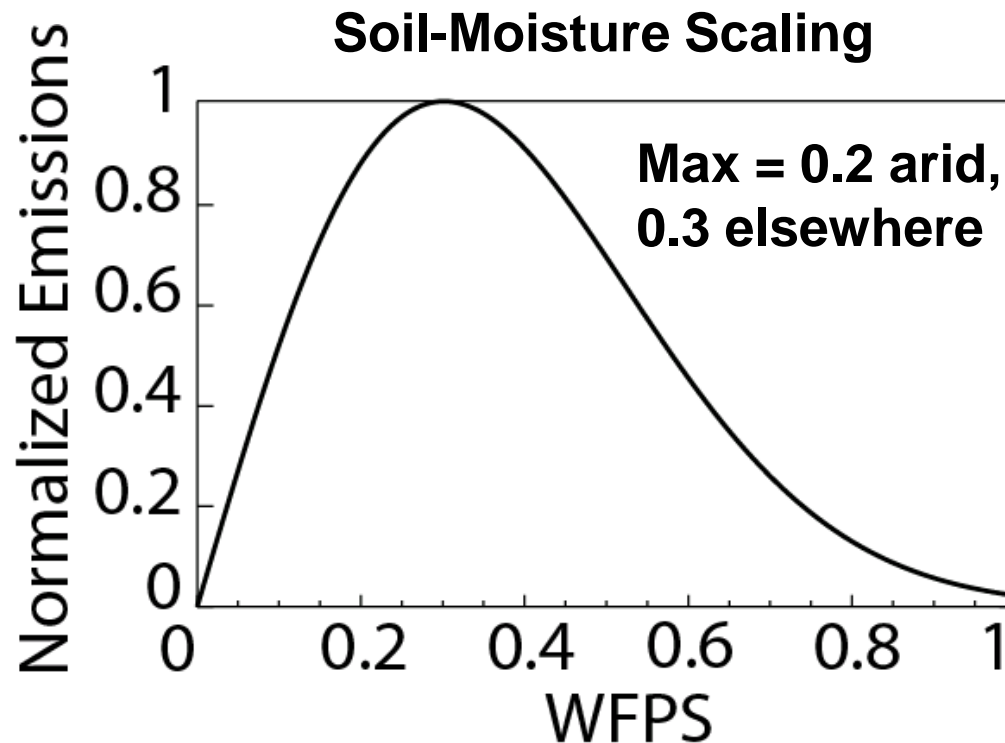
SOIL MOISTURE/TEMPERATURE:

soil moisture as a continuous variable

Old: $A_{\text{WET/DRY}}(\text{landtype}) * \text{linear or exponential } f(T)$

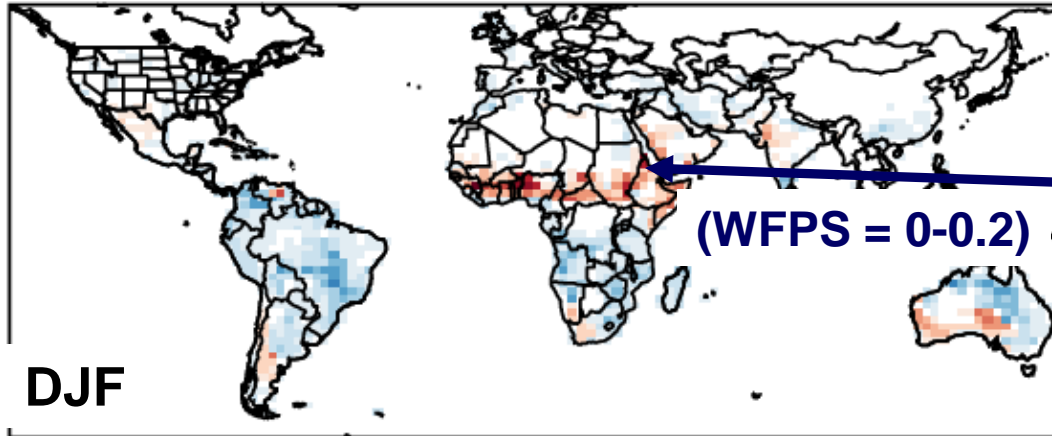
$A_{\text{WET}} \gg A_{\text{DRY}}$ (emissions essentially shut off when soils dry)

New: $A_{\text{WET}}(\text{landtype}) * \text{exponential } (T) * \text{Soil-Moisture Scaling}$



SOIL MOISTURE/TEMPERATURE:

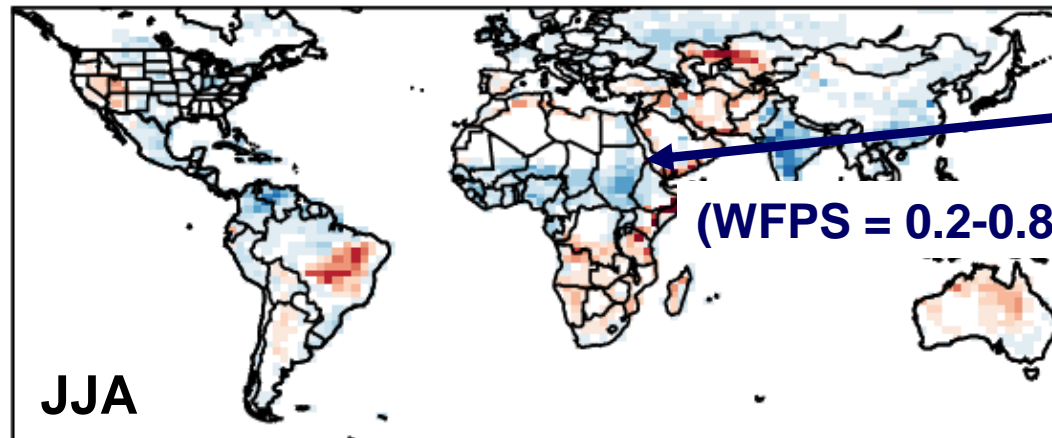
Seasonal Mean Changes in Emissions



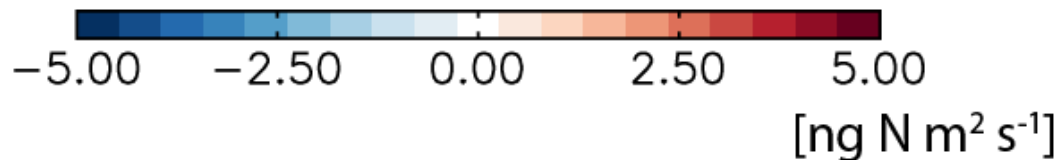
- Increases during dry season

- Little change during transitions (not shown)

- Shutting of emissions as soils inundate as wet season progresses



Impact: -1 Tg N yr⁻¹



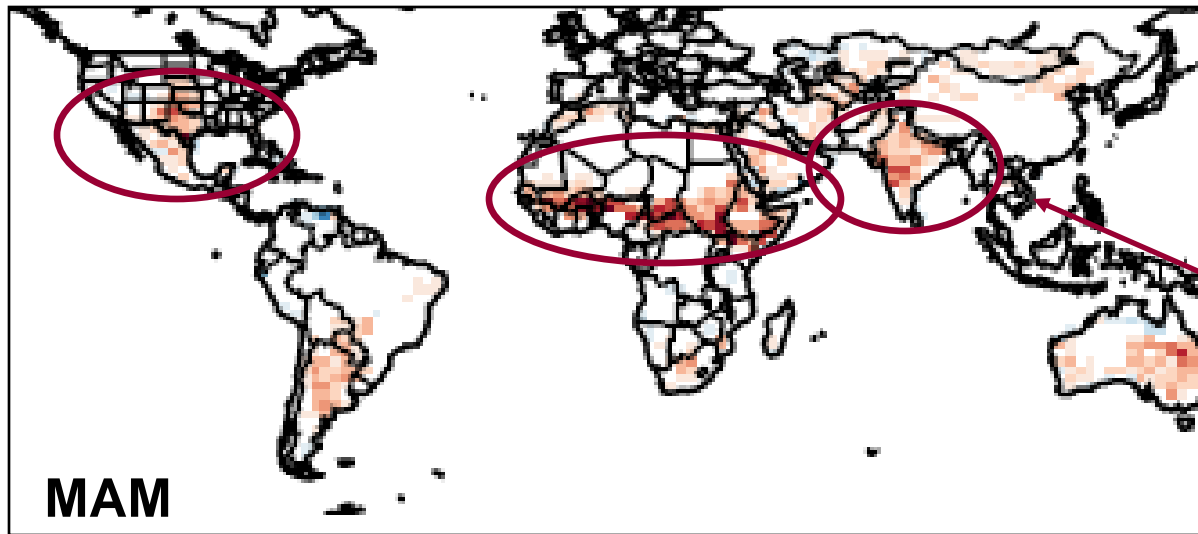
PULSING: Shorter, stronger pulses more consistent with observations [e.g., Hudman et al., 2010 over U.S.]

Old: Pulse = f(precipitation amount)

Pulse-Factor \uparrow precip amount \rightarrow X5, 10 15, decays over 3, 7, 14 days

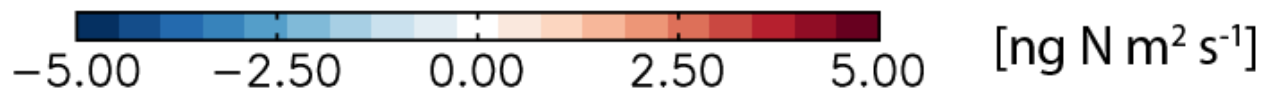
New: Pulse = f(dry-spell length); pulse, dryspell saved in restart file

Pulse-Factor \uparrow with dry spell length (continuous) \rightarrow X 0 – 50 over 1-3 days

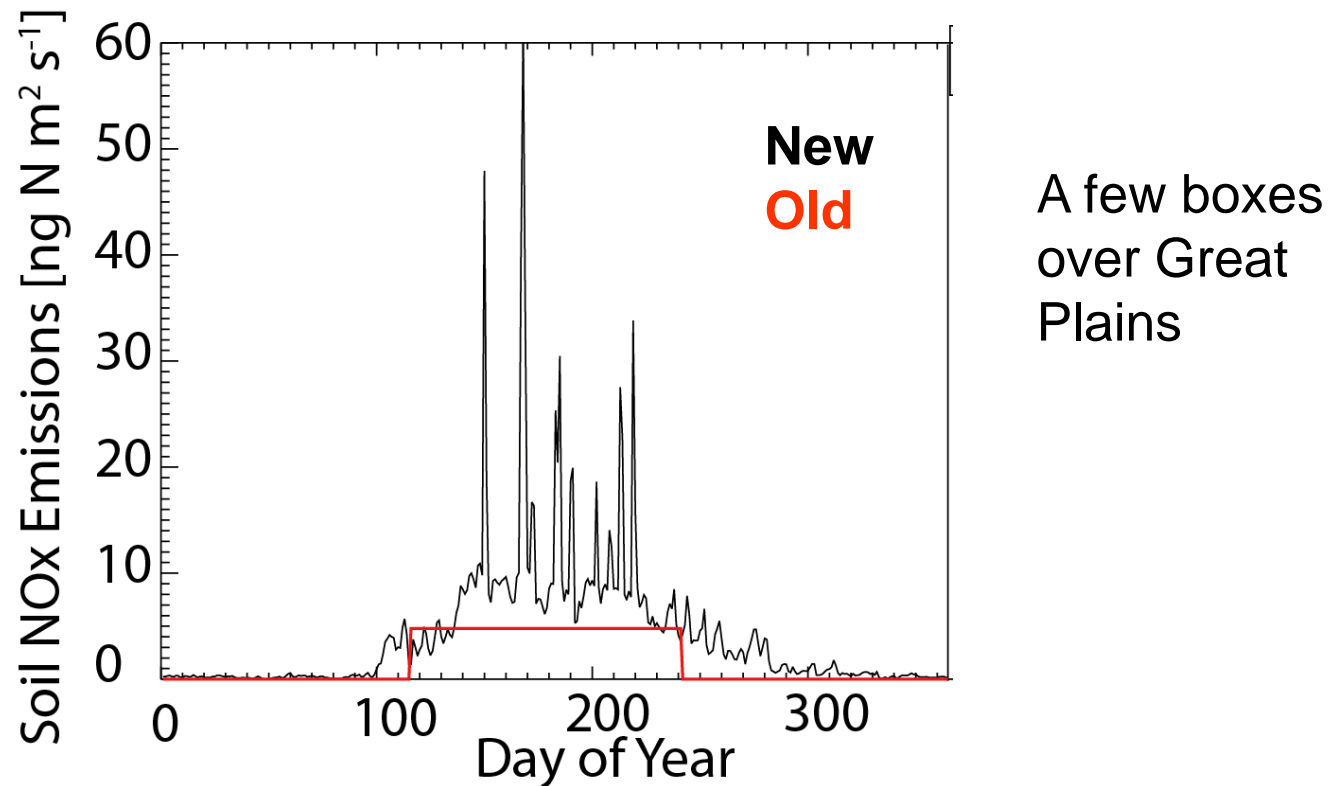


\rightarrow Impact: +1 Tg N yr⁻¹

More realistic representation of monsoon onset



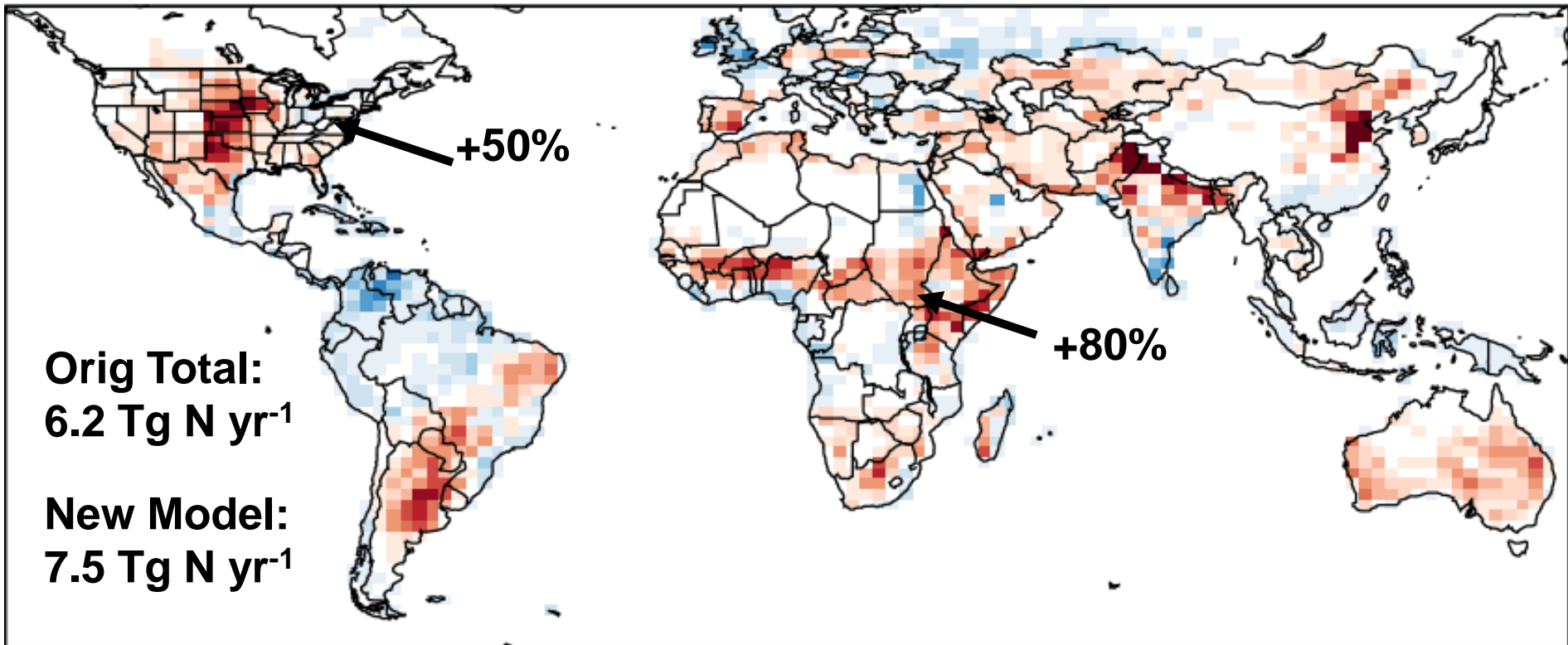
FERTILIZER: Updated and treated like all other N



- New chemical and manure fertilizer N maps (0.5 degree) (+0.8 Tg N yr⁻¹)
 - Distributed around growing season based on MODIS EVI
 - Fertilizer N subject to runoff and exponential loss in soils ($\tau = 4\text{mos}$)
- Online dry/wet deposition of N species addt'l source (+0.4 Tg N yr⁻¹)
- All fertilizer now allowed to respond to soil moisture/Temp/Pulsing

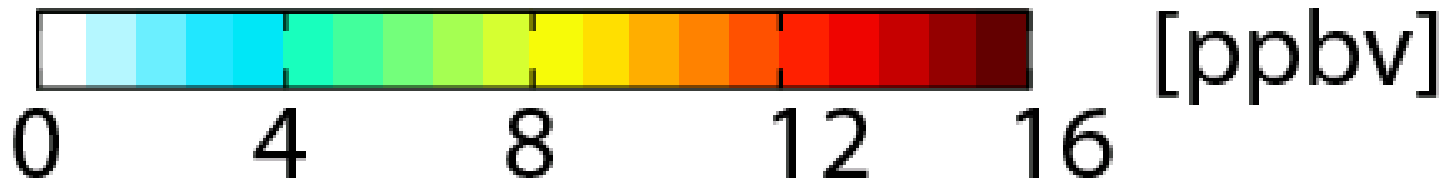
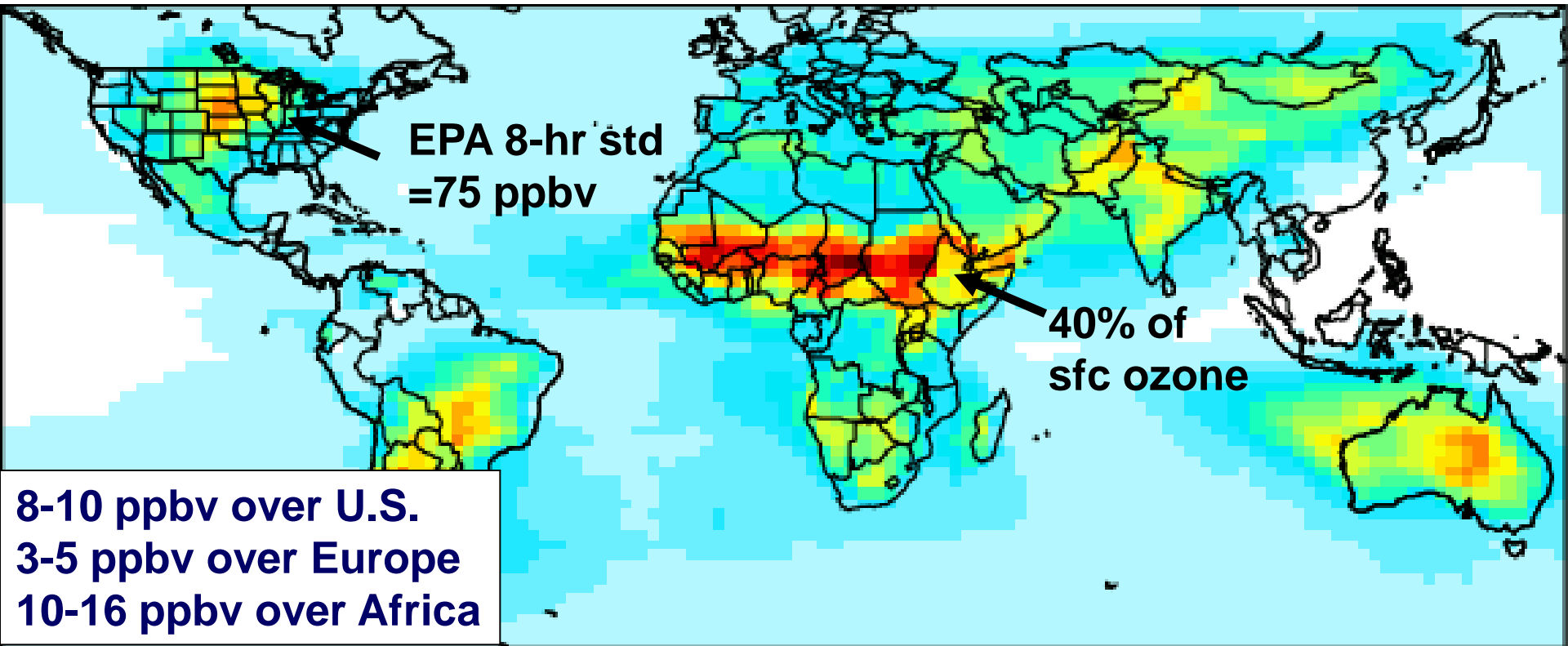
NEW MODEL INCREASES EMISSIONS WHERE WE THINK THEY SHOULD INCREASE

UPDATED MODEL – ORIGINAL MODEL



SOIL NO_x IMPACT

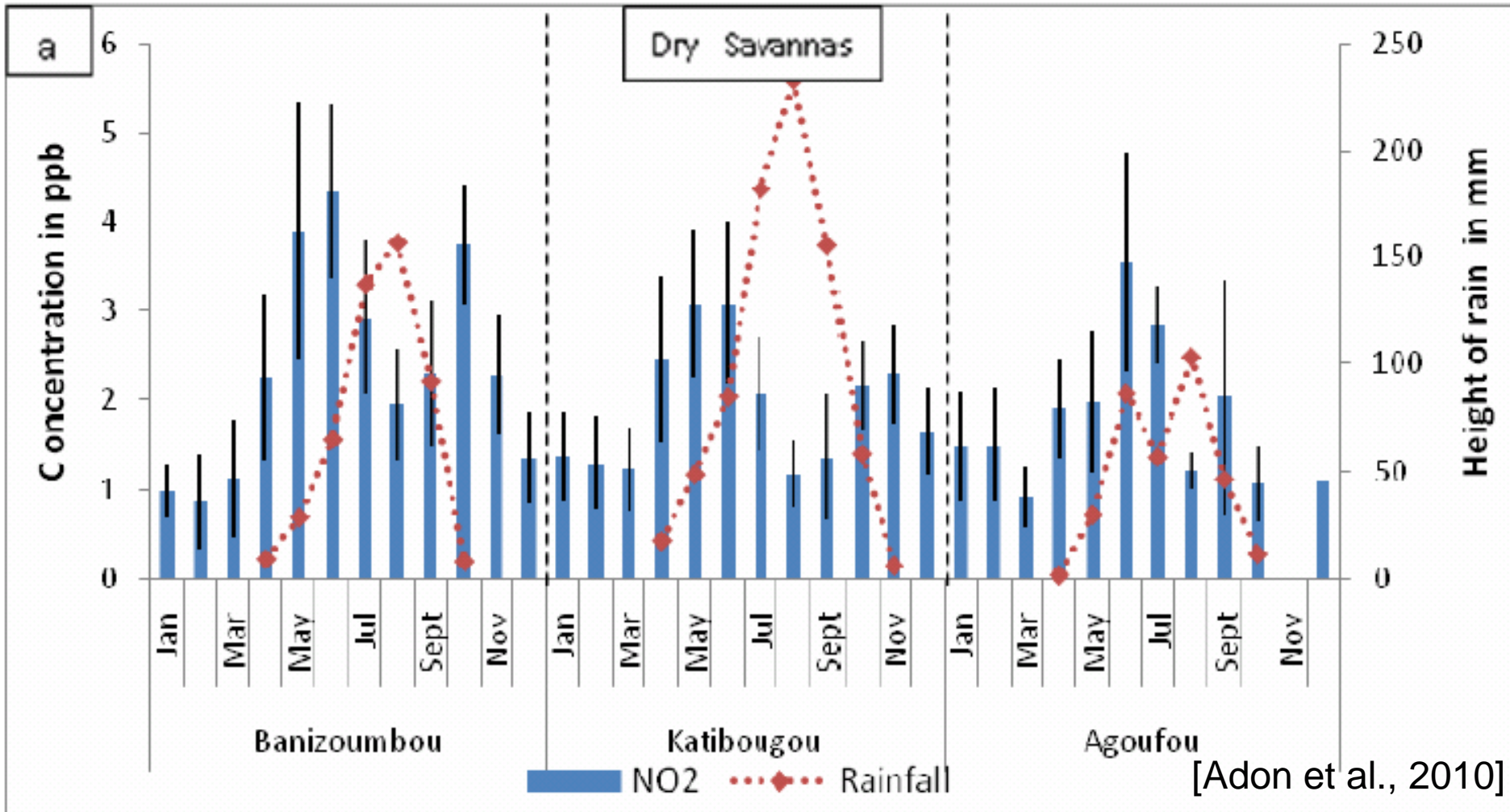
MAXIMUM MONTHLY MEAN SOIL NO_x OZONE ENHANCEMENT 2006



EXTRAS

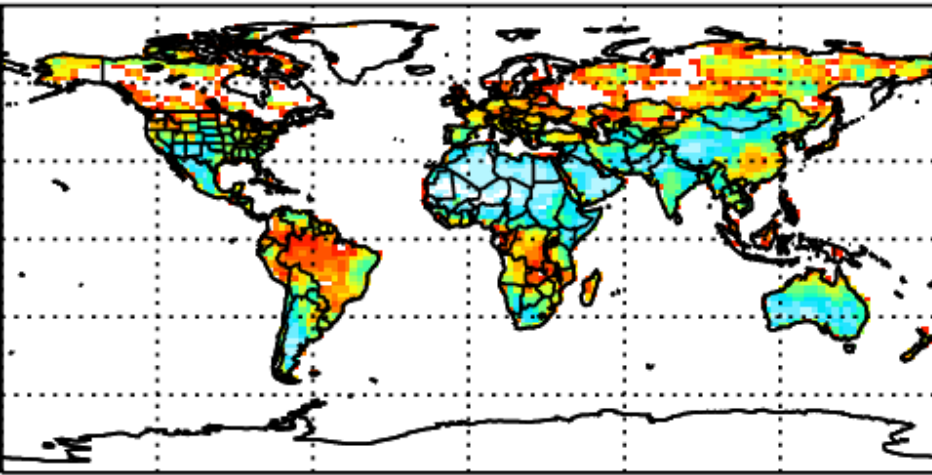
SURFACE OBSERVATIONS OVER AFRICA SHOW HIGH NO₂ DURING MONSOON ONSET (AMJ)

IDAF program 1998-2007 monthly surface NO₂ & precip

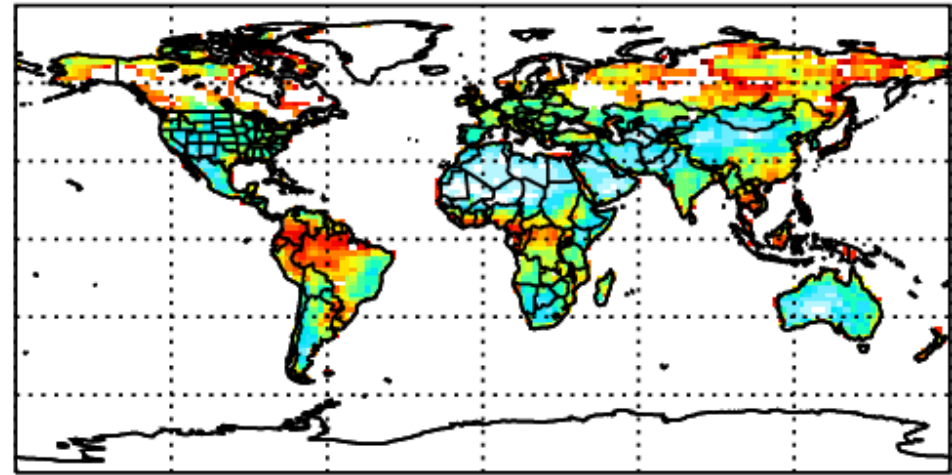


1 . SEASONAL SOIL MOISTURE MAPS

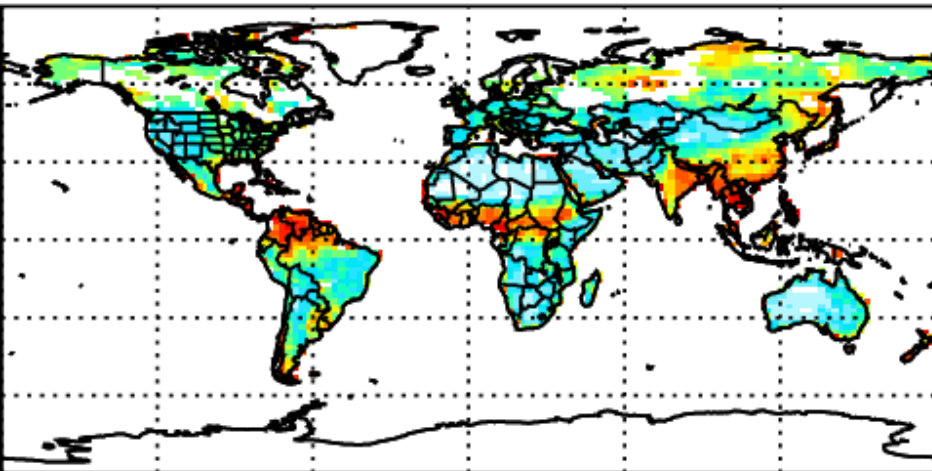
DJF



MAM



JJA



SON

