# Impact of fires on atmospheric CO, $CH_4$, and $CO_2$ and reactive nitrogen fluxes

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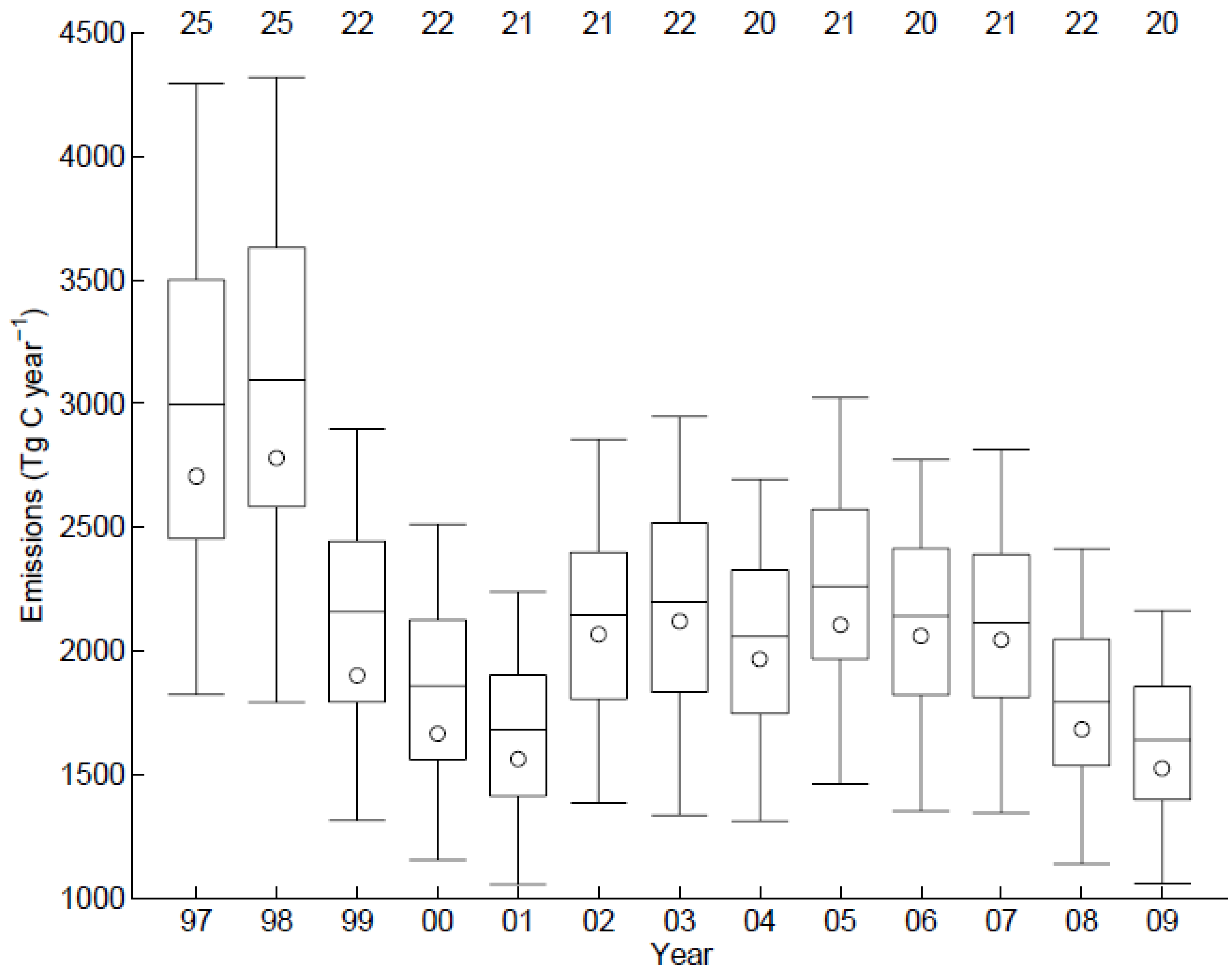
**Table 6.** Reported and best-guess uncertainties ($1\sigma$) for various parameters influencing fire emission estimates. We used a Monte Carlo simulation with 2000 runs to analyze the impact of uncertainties on estimated fire carbon emissions. Distributions for individual variables were truncated to avoid physically unrealistic scenarios, such as negative depth of burning values.

| Parameter | Uncertainty |
|---|---|
| Burned area | Reported standard deviation (Giglio et al., 2010) |
| Deforested area | Reported burned area standard deviation × 2 |
| Woody biomass | 22%[1] |
| Herbaceous biomass | 44%[2] |
| Tree mortality | 25% |
| Depth of soil burning | 50% of range |
| Combustion completeness | 50% of range |

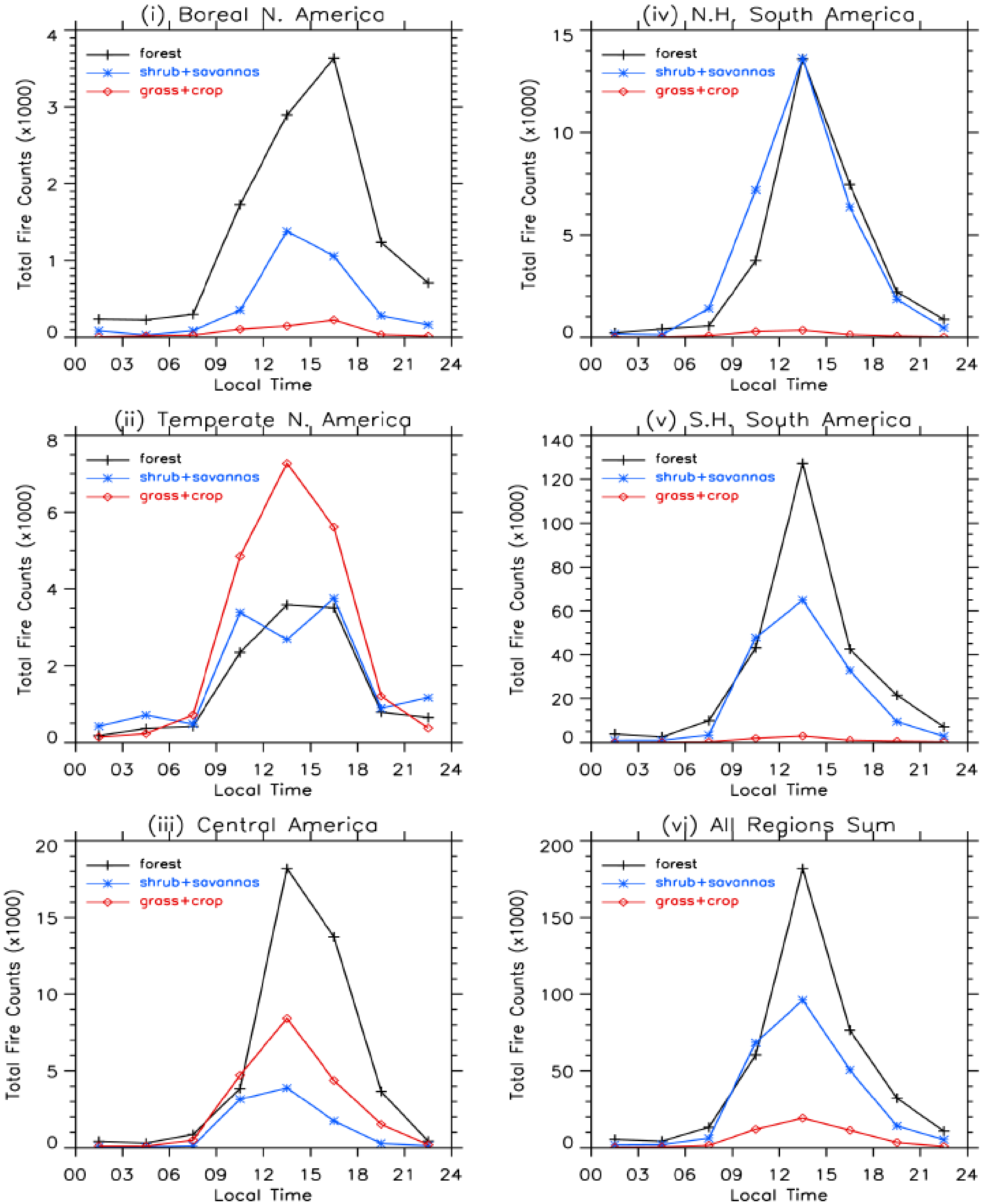
[1] Based on a comparison of Amazon biomass with data from Saatchi et al. (2007)
[2] Double the uncertainty of woody biomass due to more factors impacting herbaceous biomass that may not be accurately represented at high resolutions, such as time since last fire, grazing, etc.

Van der Werf et al. (2010) ACPD

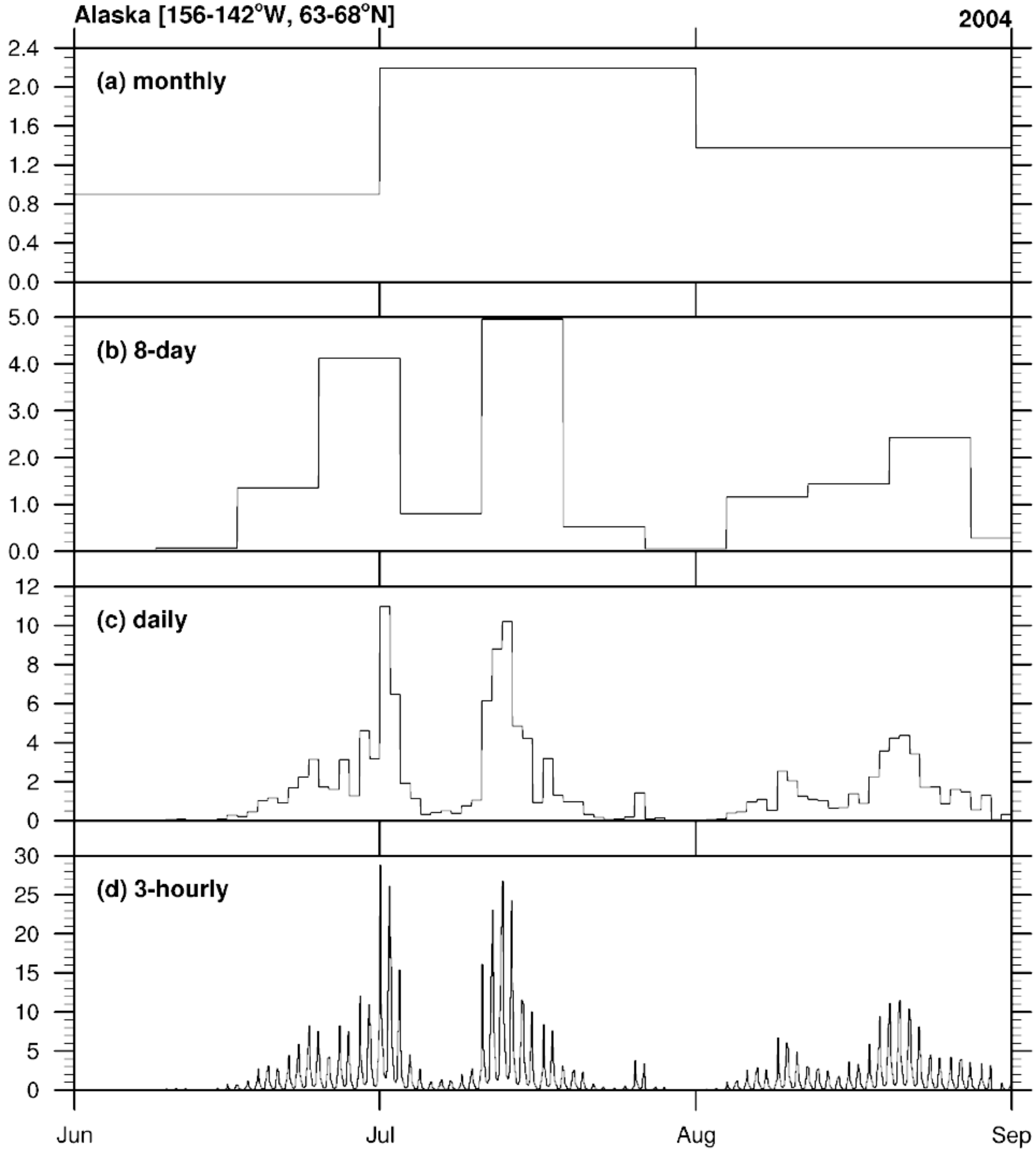
# Uncertainties remain substantial – spatial patterns and interannual variability probably more robust




Van der Werf et al. (2010) ACPD




# Using GOES data toward the development of a 3-hourly fire emissions product




Moving from monthly to hourly emissions, one approach

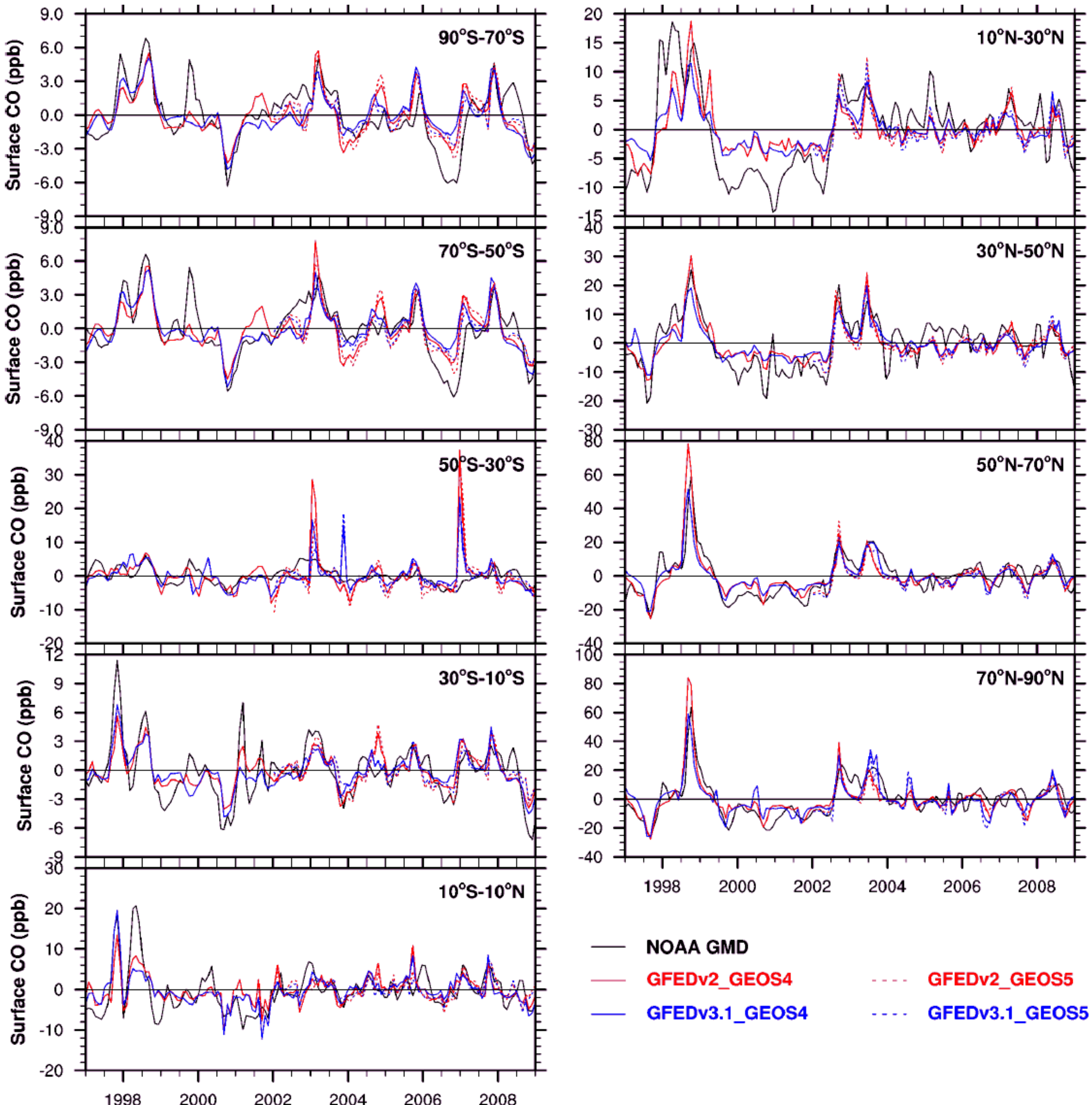
# Overview – fire contributions to interannual variability in CO, $CO_2$, and $CH_4$

- Most of the interannual CO variability measured by NOAA flask and from space can be attributed to fires
- Much of the increase of $CH_4$ during the 1998 event can be attributed to fires, but only a small part of the increase observed during 2007-2009
- Some of the interannual variability in $CO_2$, particularly in the NH, can be attributed to fires

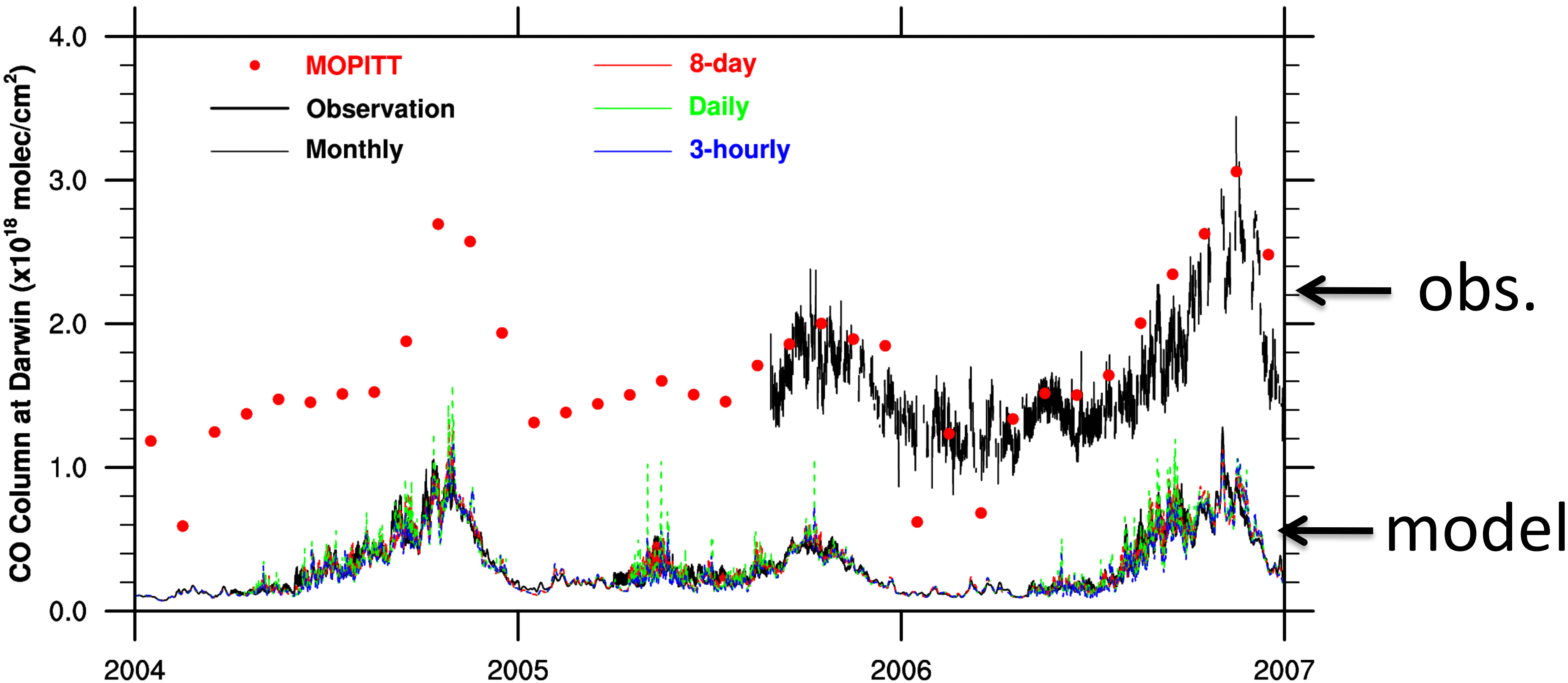
**Fire only**

**Sampled at 60 NOAA GMD sites**

**Annual cycle and Trend removed**



# Fire contributions to TCCON carbon monoxide at Darwin

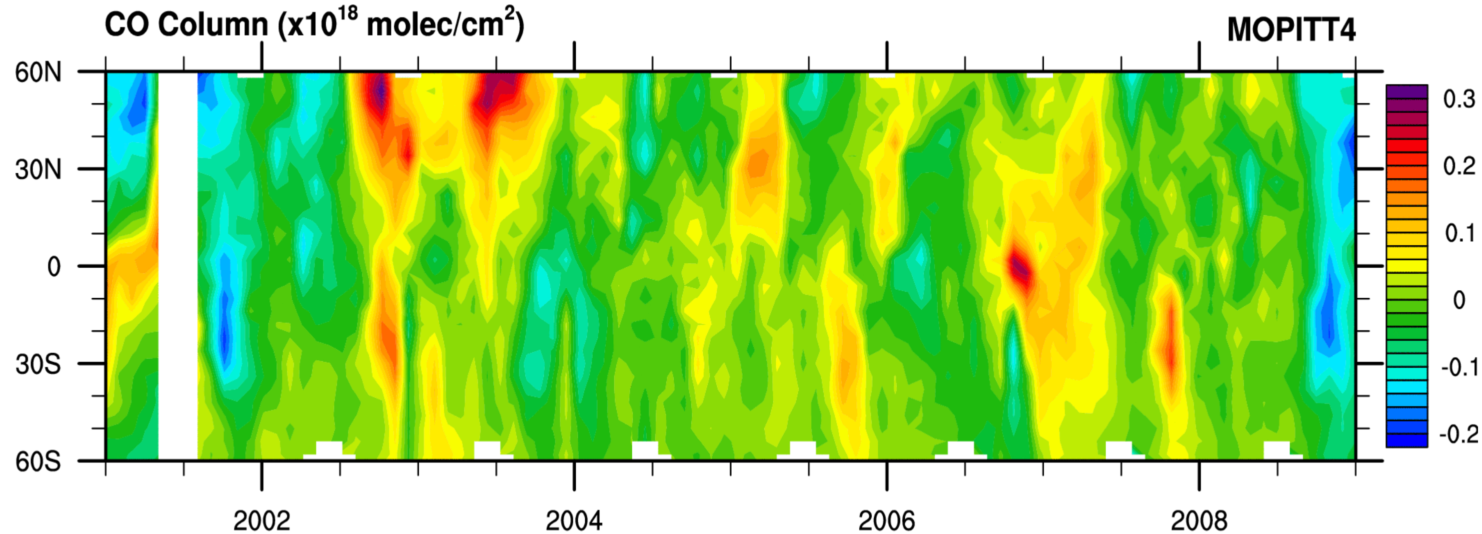



Obs. – upward looking FTIR measurements from Wennberg et al.

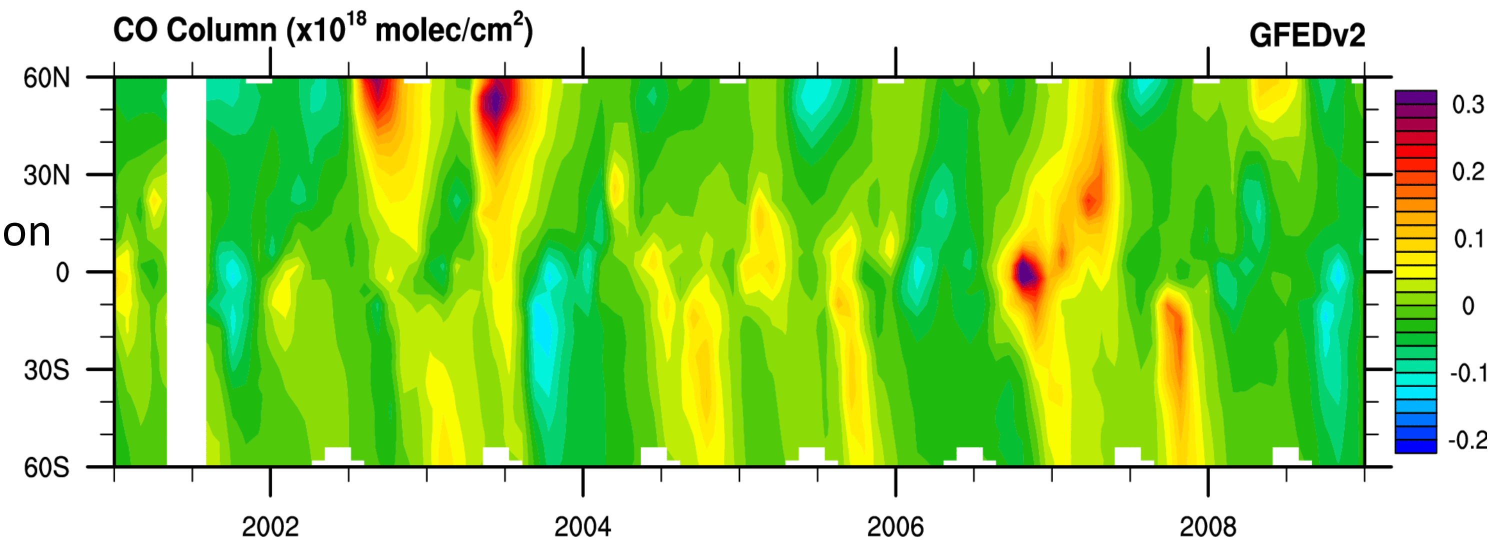
Model – fires emissions from GFEDv2 in GEOS-CHEM

# CO column comparisons with MOPITT

Observed anomalies



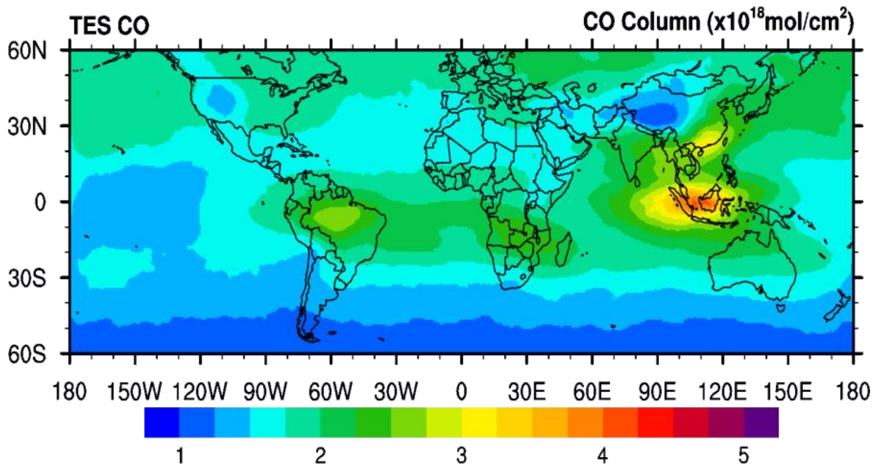

Fire contribution from GFED and GEOS-CHEM



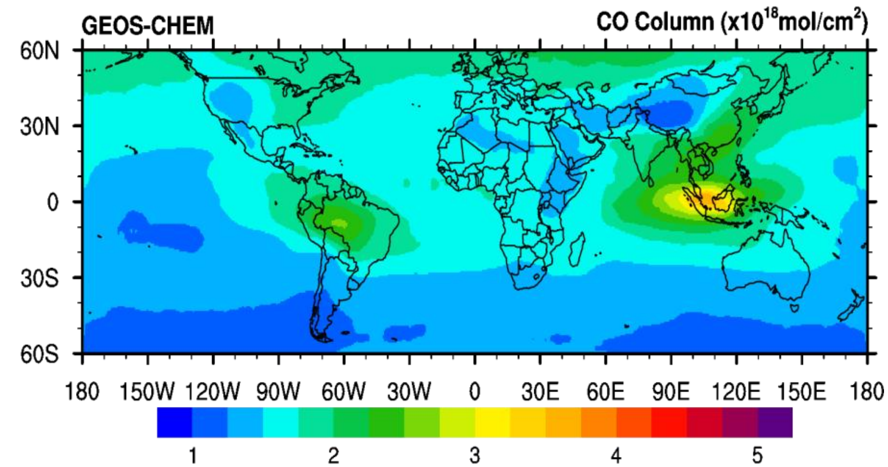

MOPITT - Measurements of Pollution in The Troposphere

# CO Column in October 2006

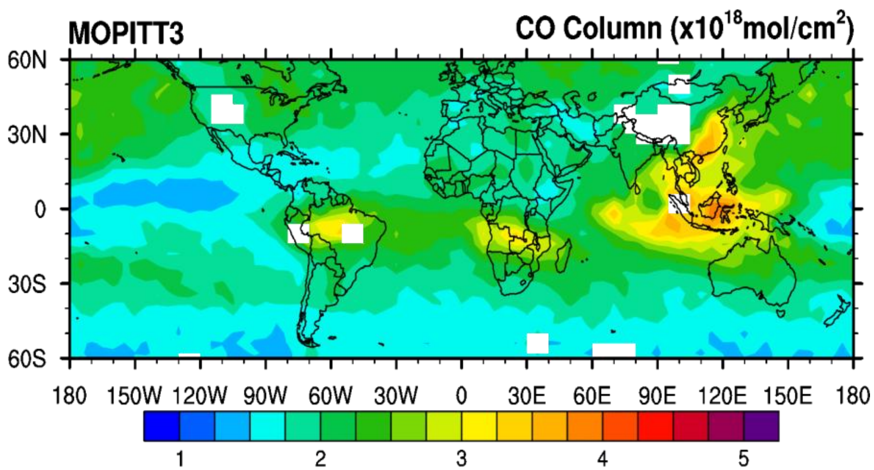
## TES CO



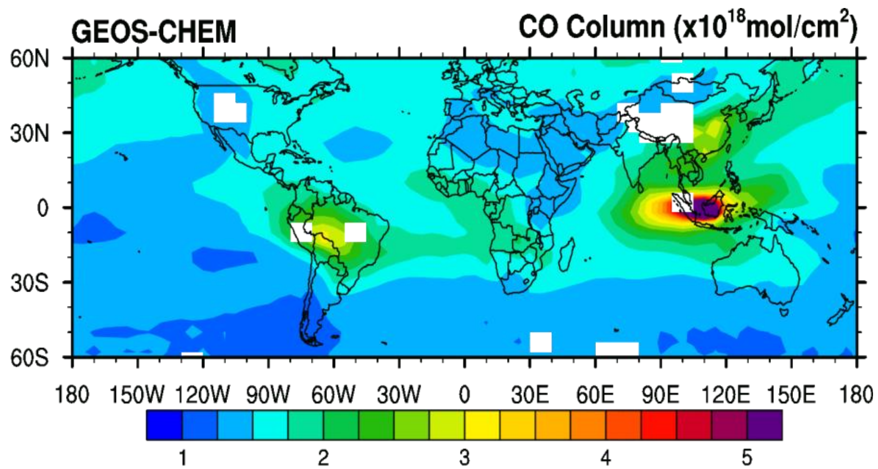

## Model CO based on TES




## MOPITT3 CO




## Model CO based on MOPITT3

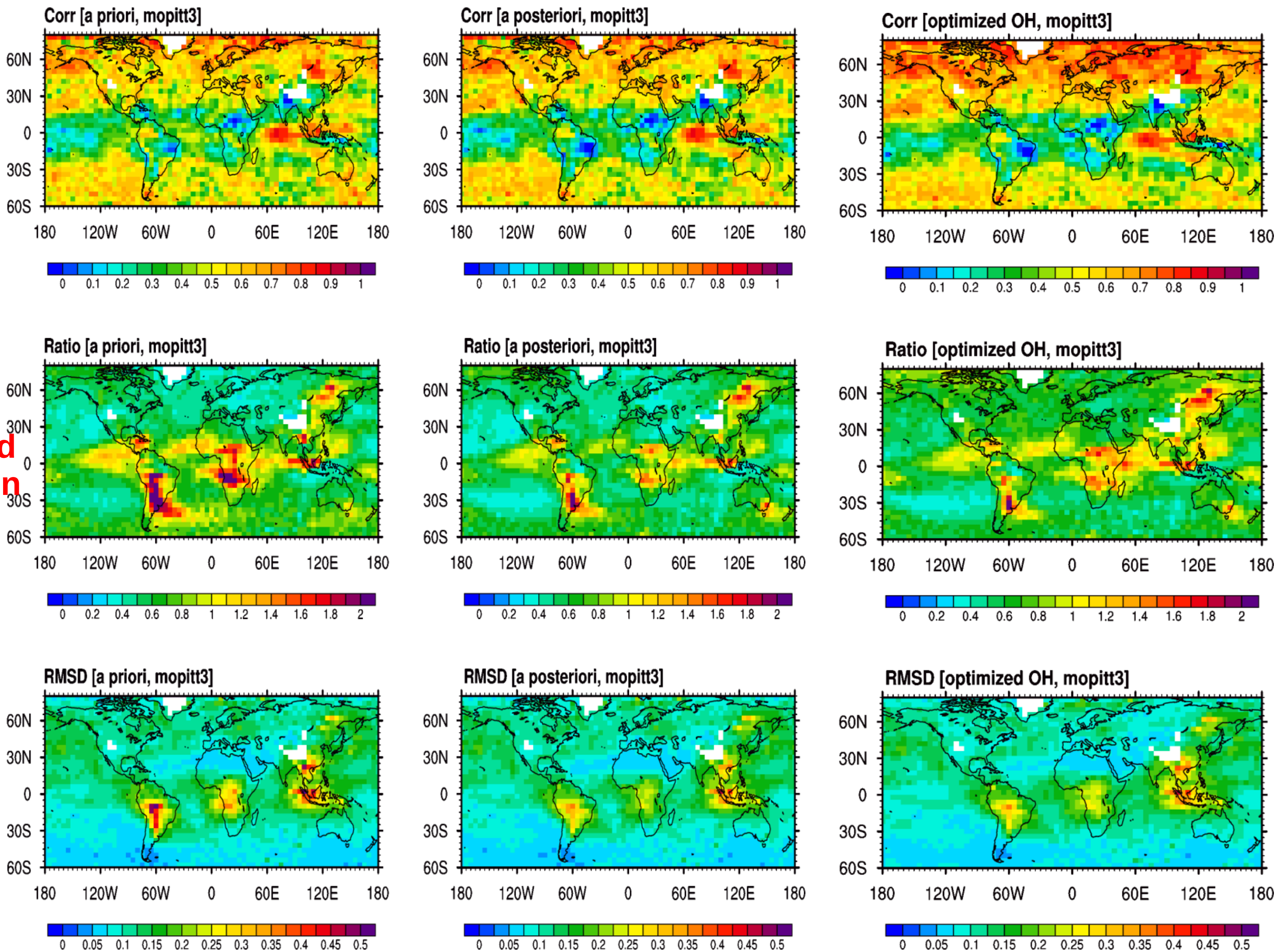


A priori | A posteriori | Optimized OH

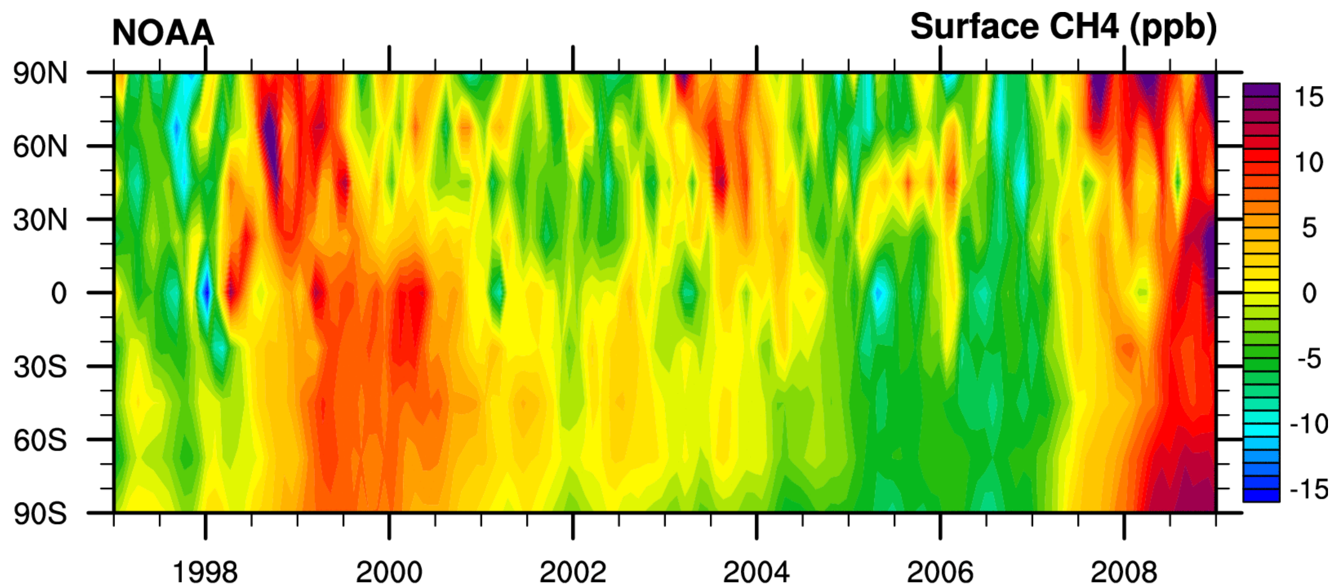
Corre

Standard Deviation Ratio

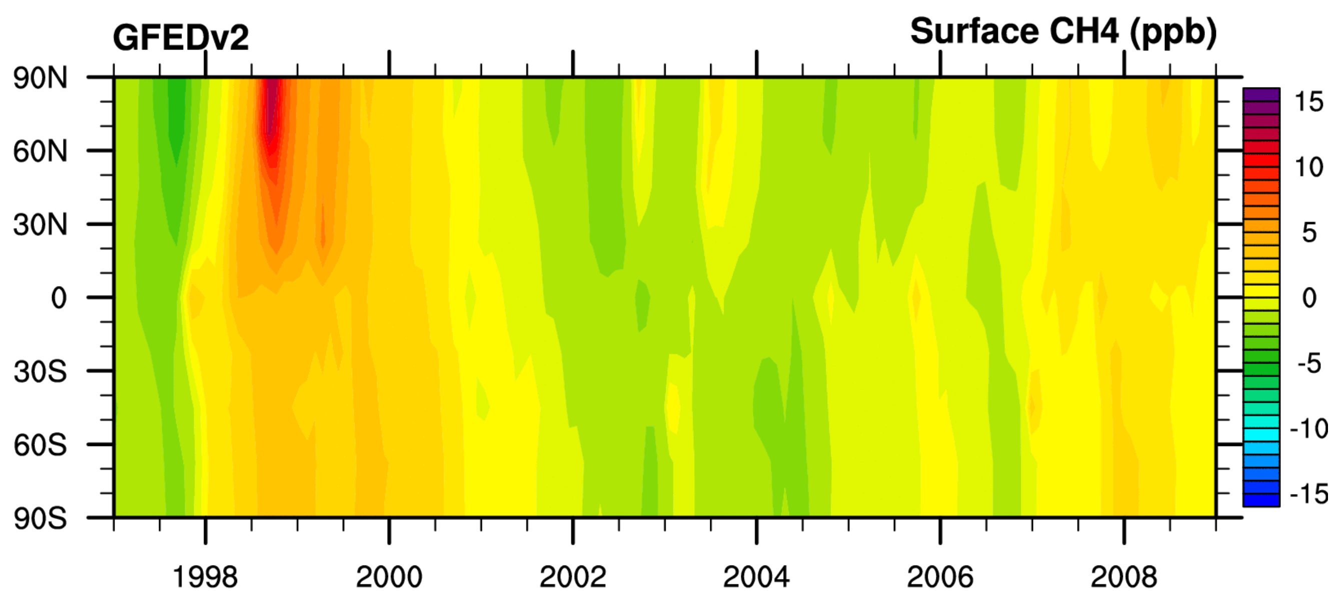
RMSD



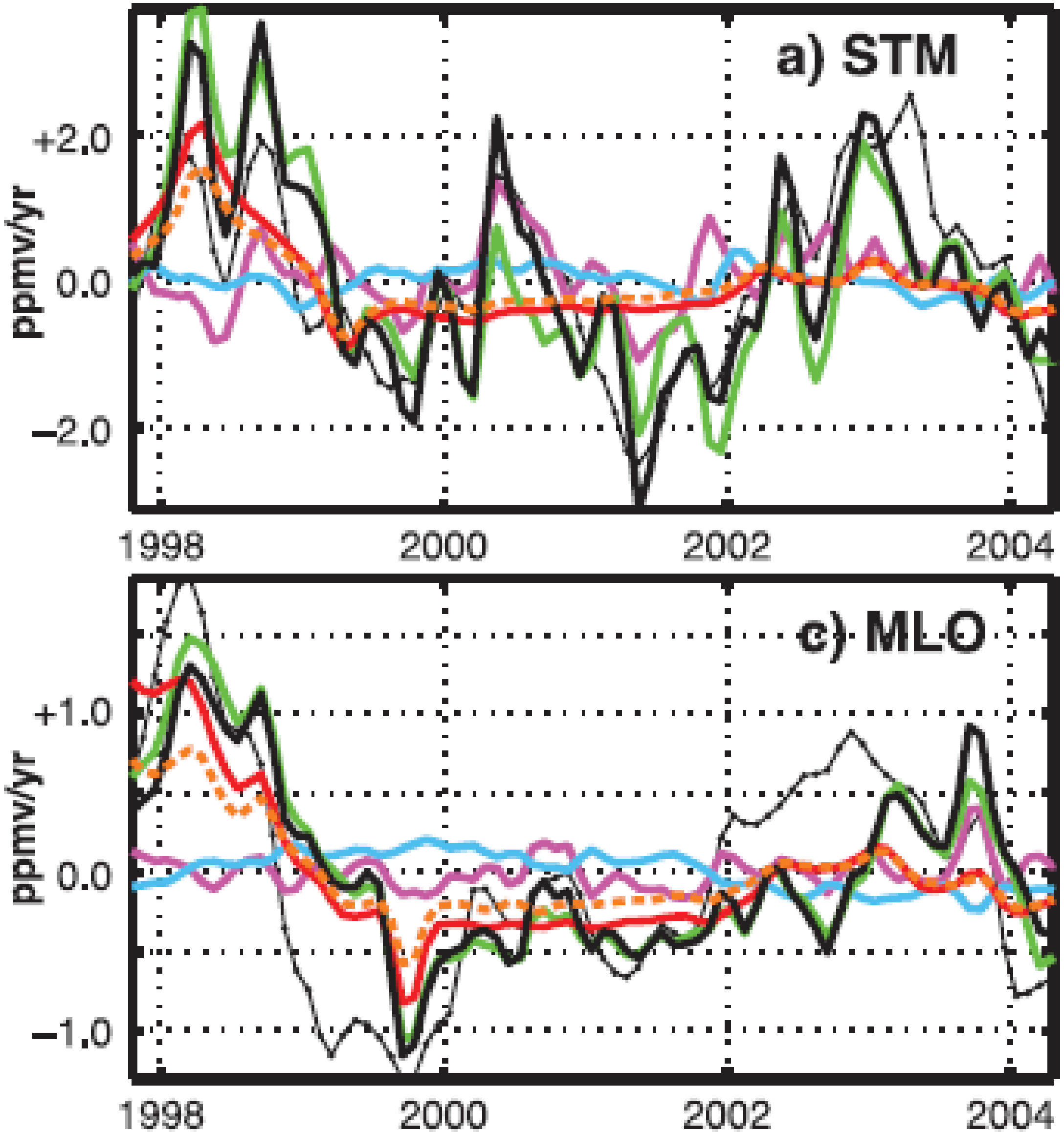
# $CH_4$ comparisons with NOAA GMD stations




Only direct $CH_4$ emissions



# Fire contribution to $CO_2$ variability




Thin black : Globalview

Red: fire component

Green: total land flux

Blue: ocean

**Thick black: Total model**

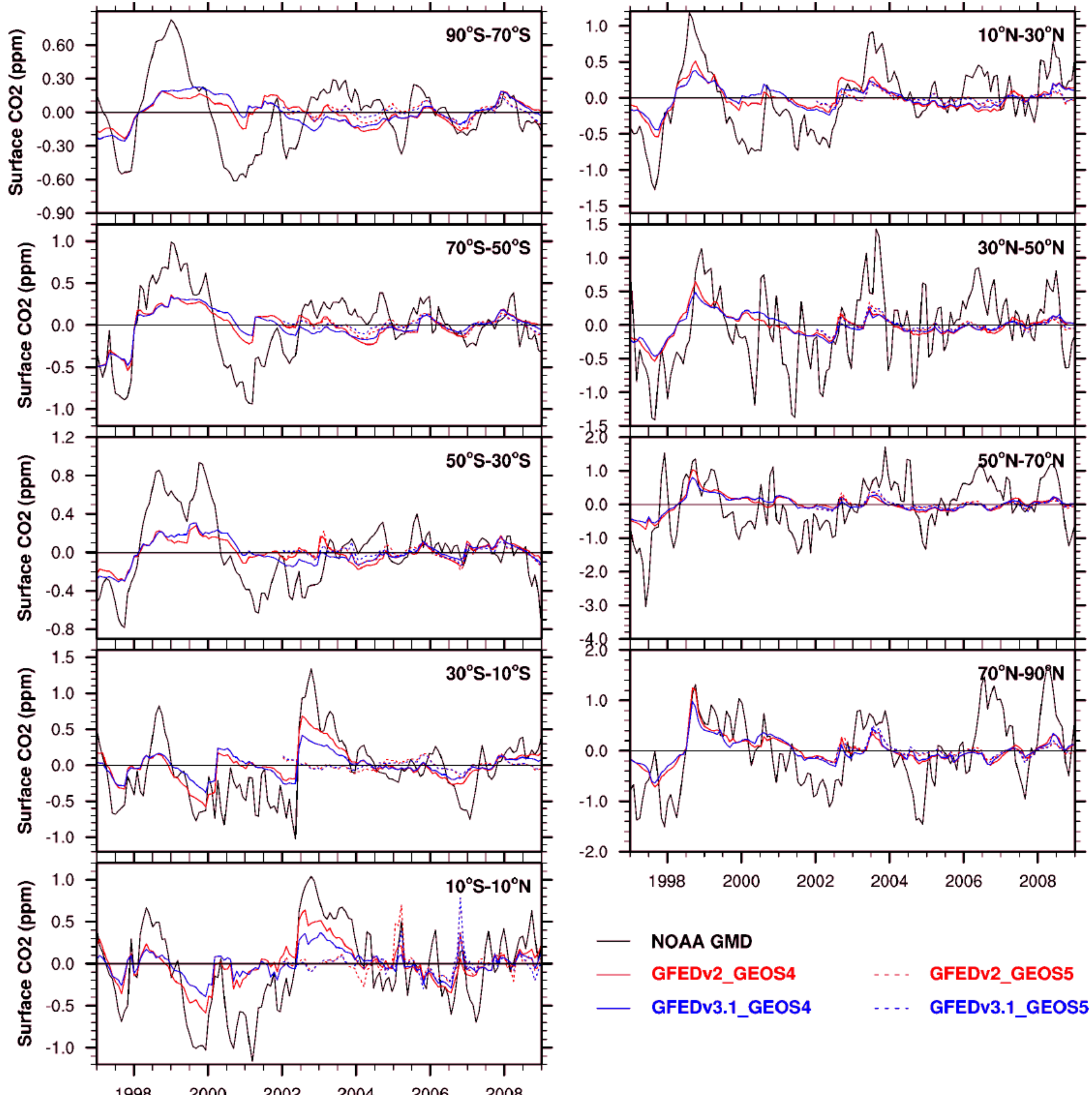
MATCH with
CO-optimized GFED

Nevison et al. (2008)

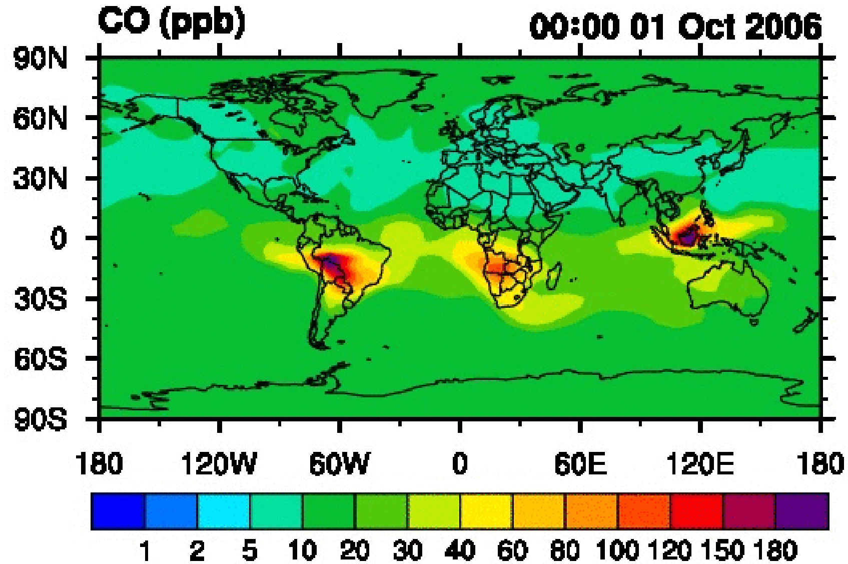
## Fire only

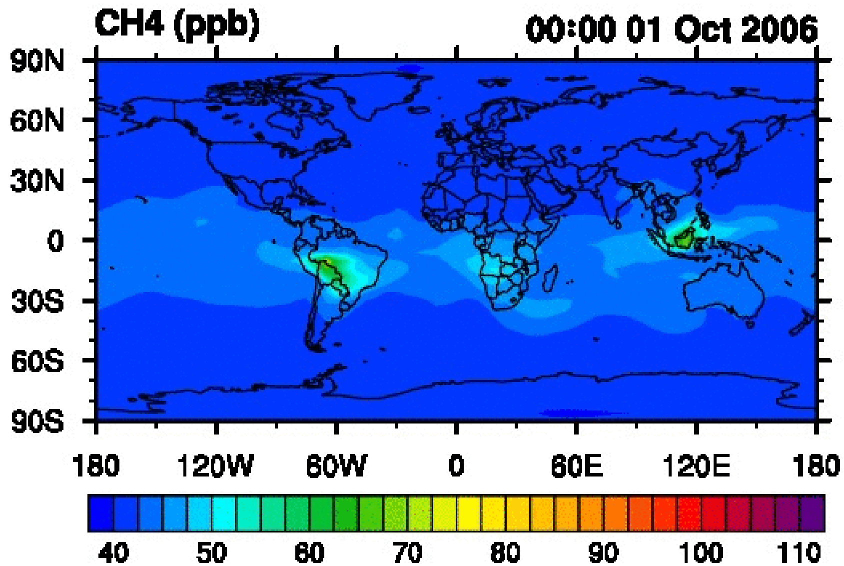
## Sampled at 67 NOAA GMD sites

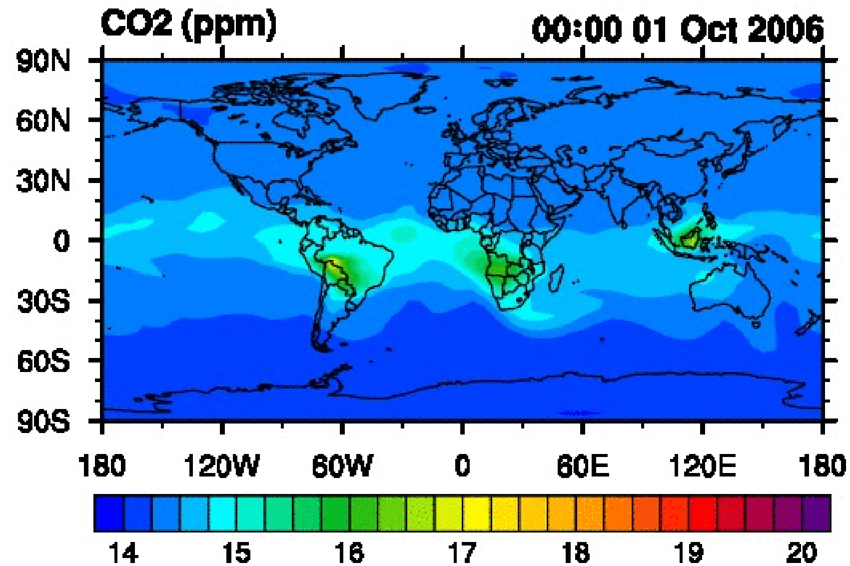
## Annual cycle and Trend removed



# Simultaneous impacts of fires on CO, $CH_4$, and $CO_2$

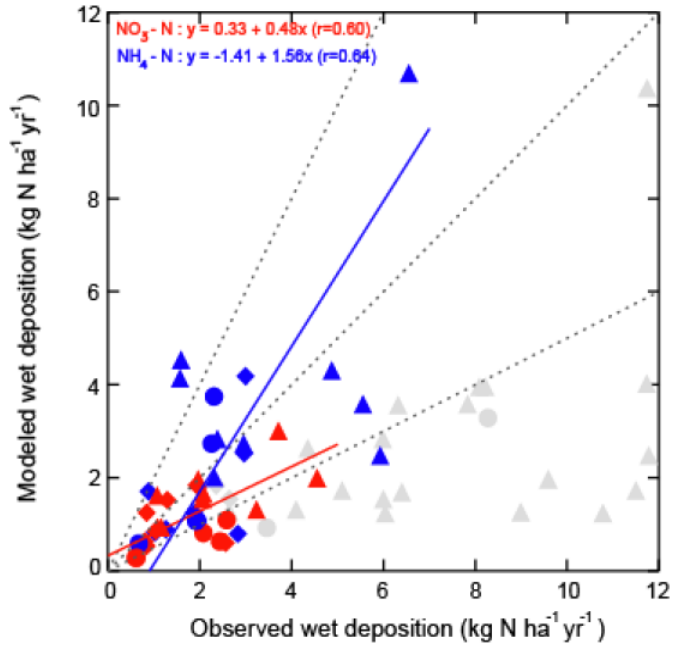


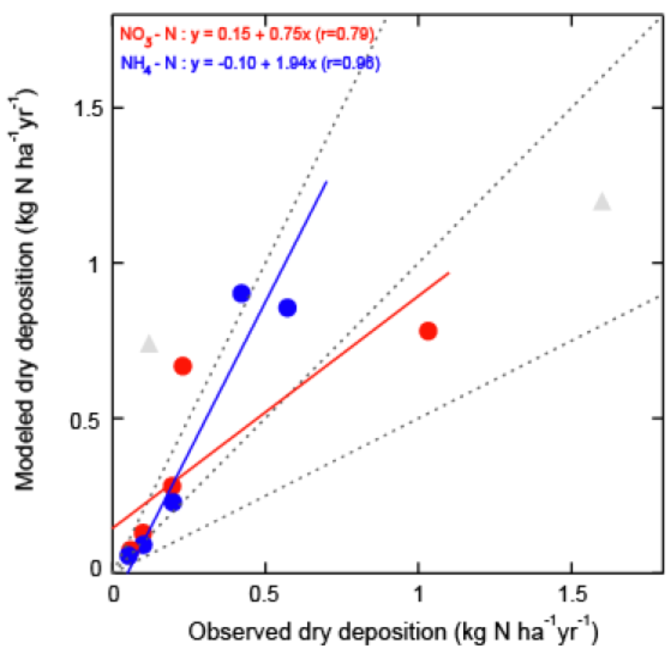



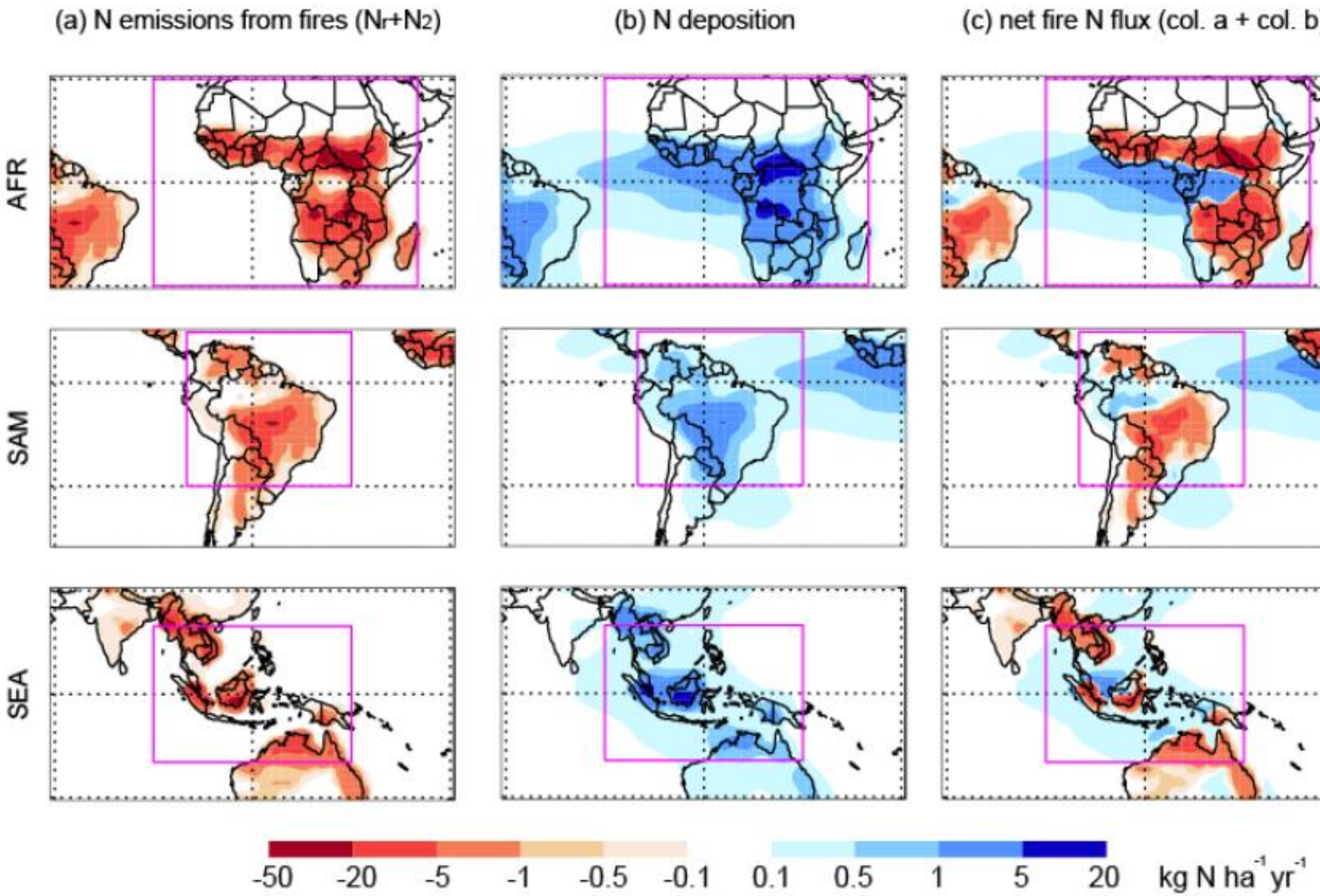
# N deposition and losses from tropical fires

- GEOS-CHEM chemical transport model (Bey et al. 2001)
  - 2.5° resolution
  - Fire emissions from GFEDv2
- Assumed that half of volatized N lost directly to $N_2$ following *Kuhlbusch et al.* (1991)
- Considered losses of N to $NH_3$ and NO using emission factors from Andreae and Merlet (2001)
  - equal to C/N ratio of fuels of ~100
- Model includes both dry and wet deposition



# N emissions and deposition from tropical fires

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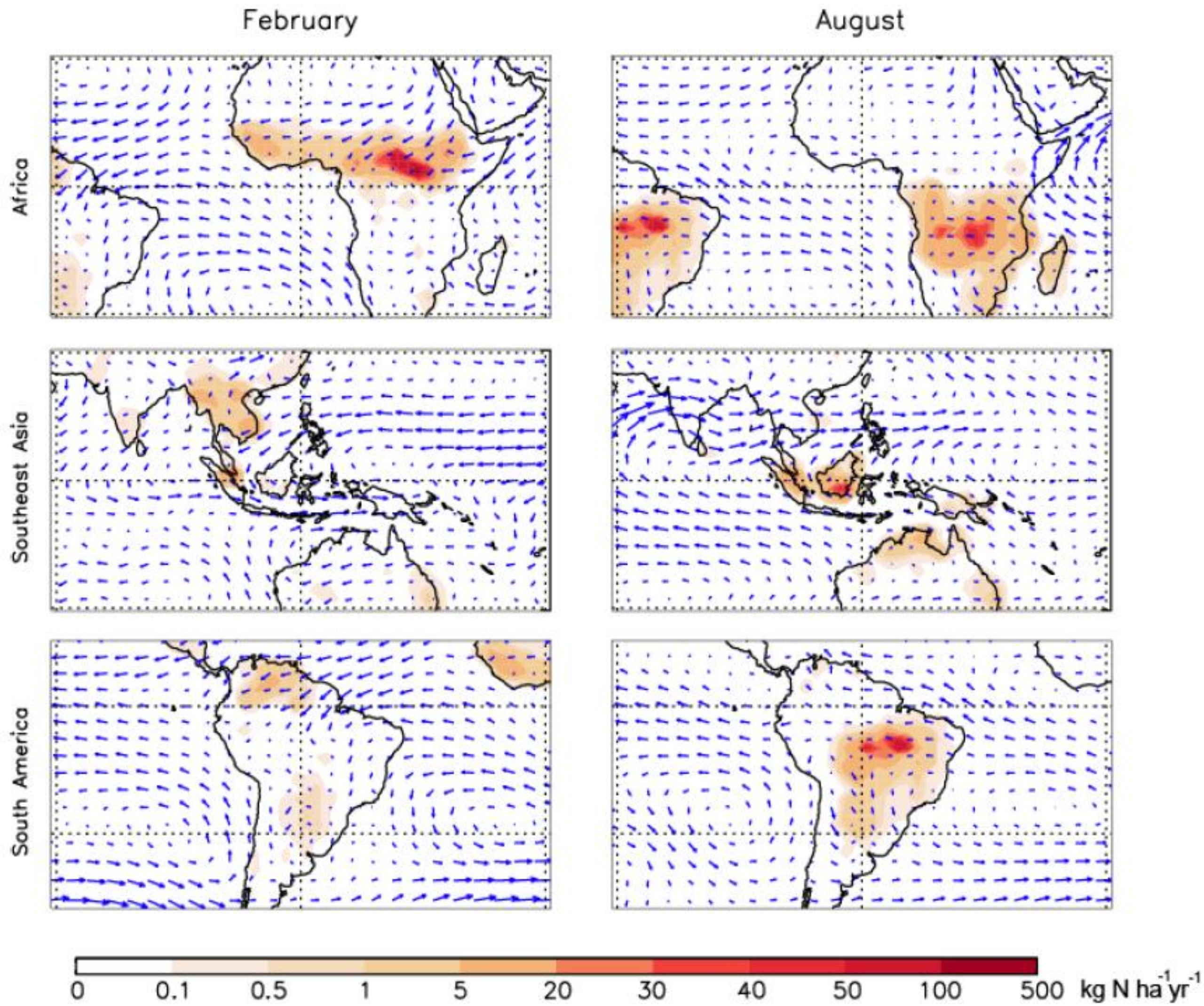
# Winds during the dry season transport fire emissions equatorward

Winds at 850 kPa

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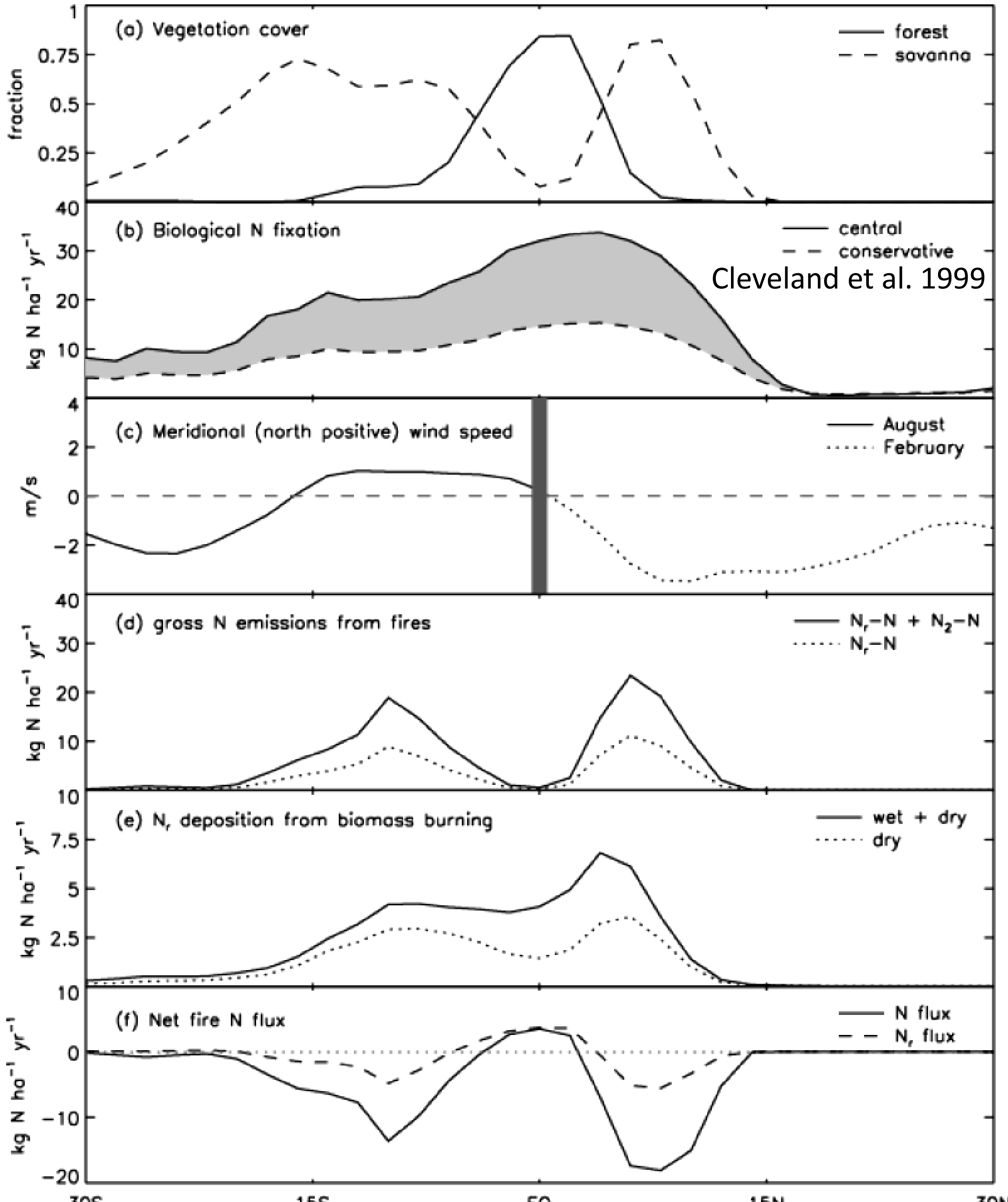


# Africa North-South Transect

Mean over

10°E-30°E

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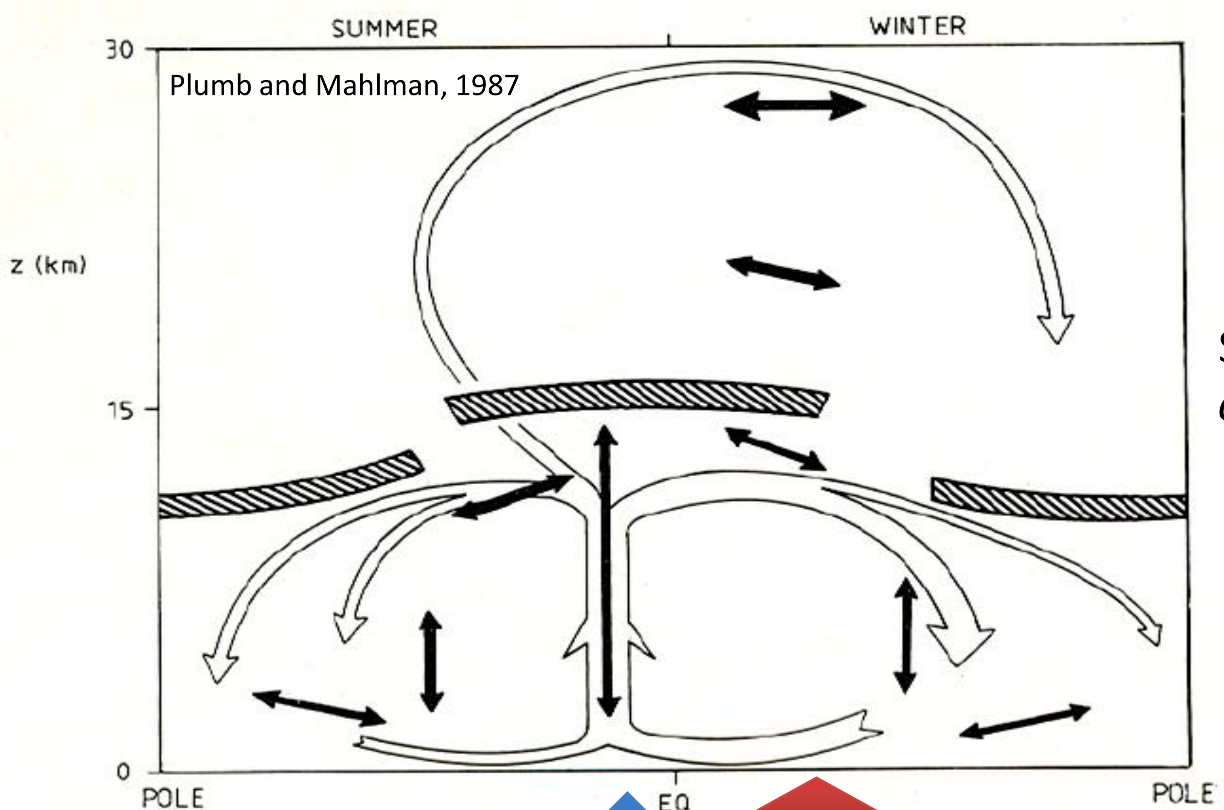
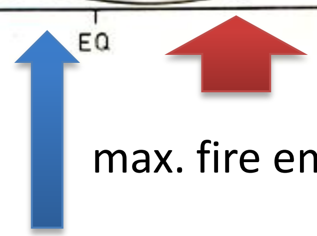
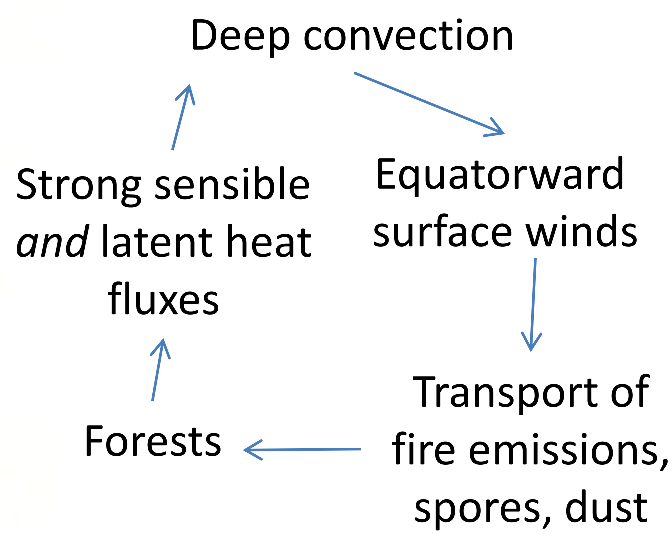
# BGC – Hadley Circulation Interactions



# Findings – Hadley-BGC Interactions

- More than 25% of annual BNF in global savannas is lost to fire
- Equatorward transport of reactive nitrogen from savanna and deforestation fires may increase NPP and carbon storage in intact tropical forests
  - Long term carbon storage increasing in both Amazonian (Phillips et al., 2009) and African (Lewis et al., 2009) forests
  - P deposition in interior Amazon also enhanced by fires (Mahowald et al., 2005)
  - Nutrient loading from fires & land use change at the perimeter provides an alternate mechanism for fueling tropical C sinks
- Provides a basis for speculating that the Hadley Circulation may be sustained by coupled biogeochemical cycles

# Acknowledgements

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- CCSM Biogeochemistry Working Group
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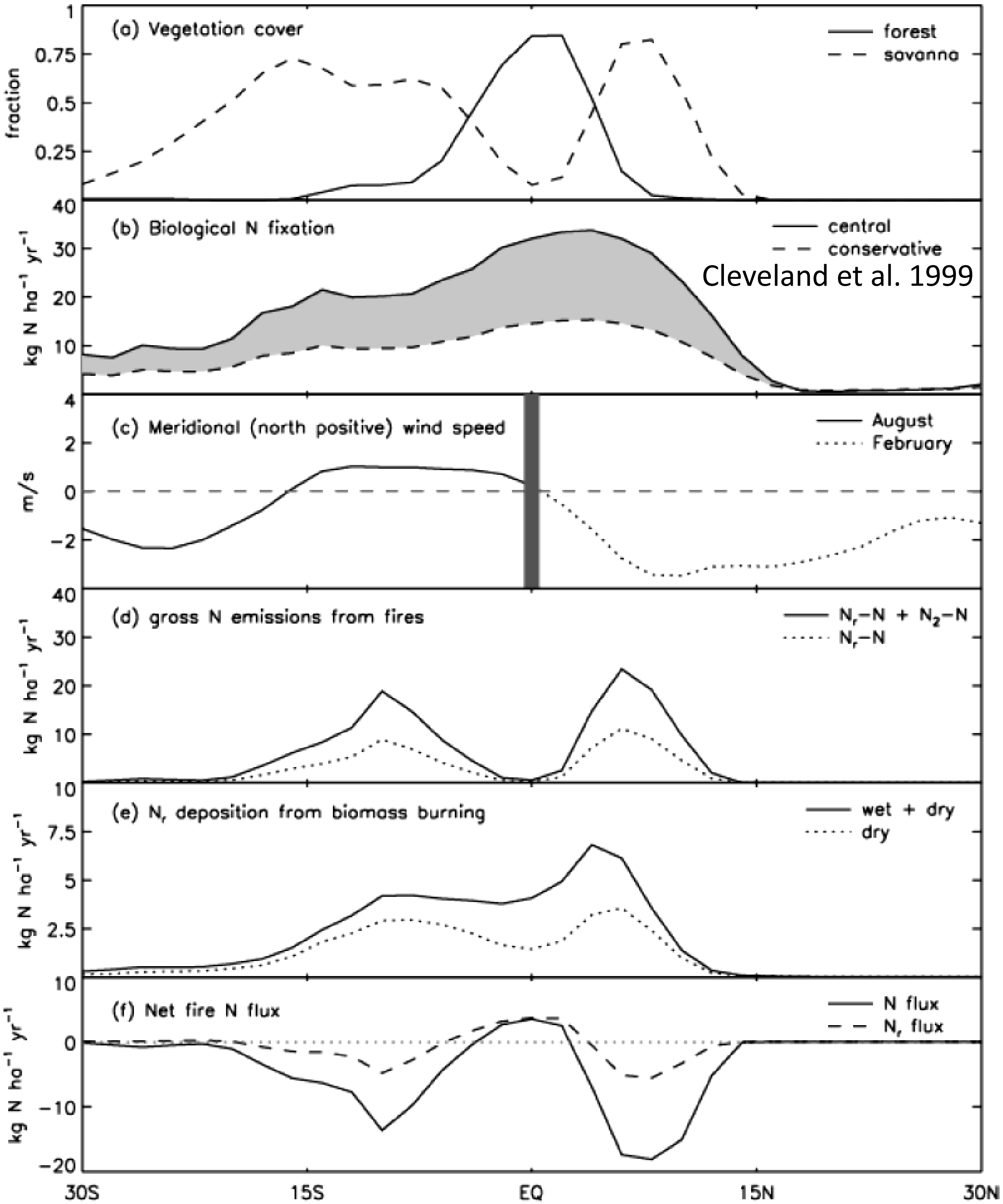
Comments or questions: please email me: *jranders@uci.edu*

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Chen et al. submitted to GCB

# Findings – Atmospheric N transport

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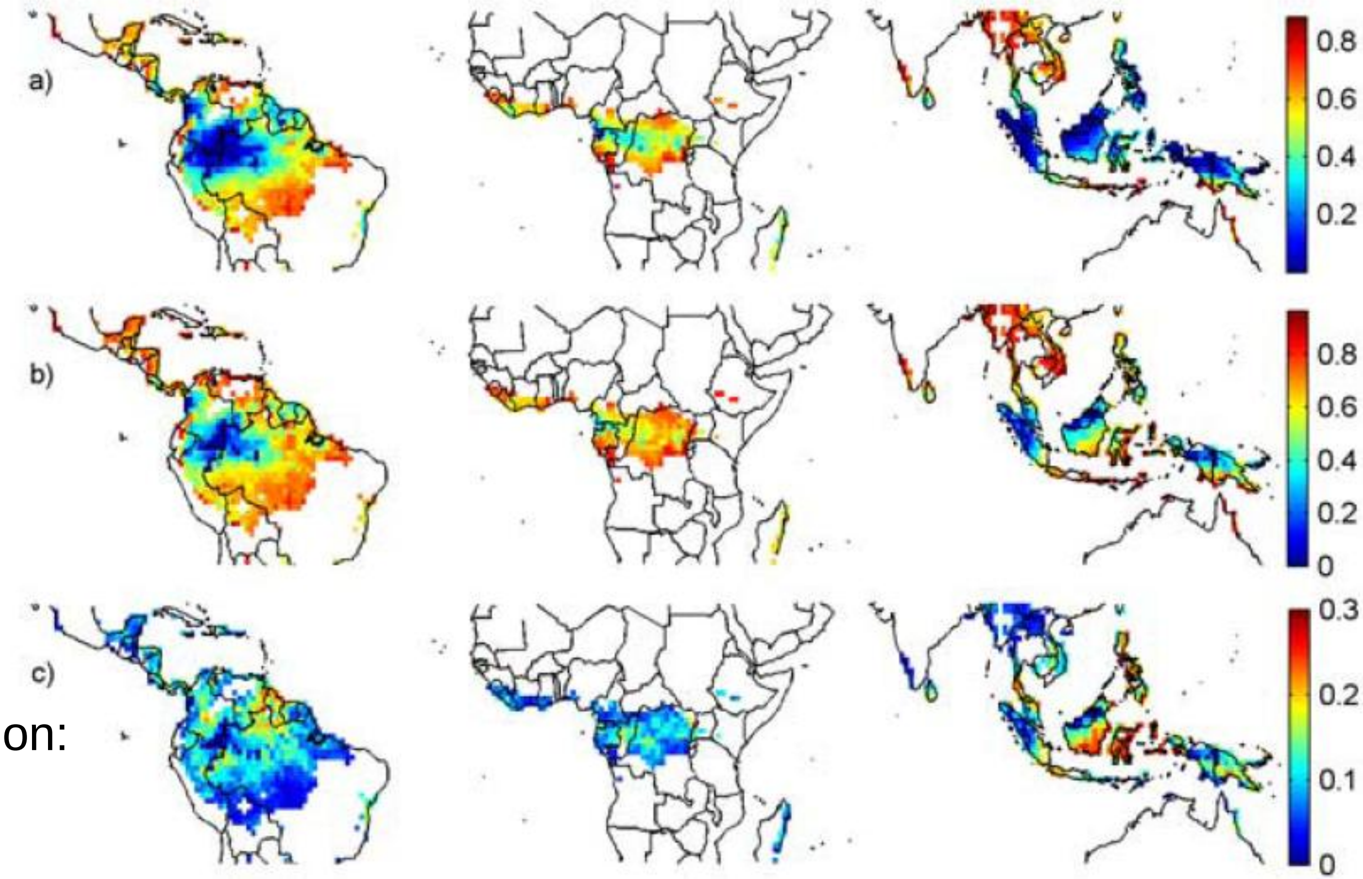
# Vulnerability of tropical forests to fire use varies considerably by continent

Fire-driven Deforestation Potential (FDP) scalar combines information about the length and intensity of the dry season

Mean (98-06):

Minimum:

Standard deviation:




Van der Werf et al. (2008) GBC