# Aerosol Modeling and Forecasting at NRL: FLAMBE and NAAPS

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# Lingo: FLAMBE, NAAPS and NAVDAS

- FLAMBE: Fire Locating and Monitoring of Burning Emissions
  - NASA IDS project
  - PI: Jeff Reid (NRL)
  - PI: Elaine Prins (U. Wisconsin - CIMSS)
- NAAPS: Navy Aerosol Analysis and Prediction System
  - Supported by ONR
  - PI: Doug Westphal
- NAVDAS-AOD: Navy Variational Data Assimilation System – Aerosol Optical Depth
  - ONR, JCSDA
  - PI: Jianglong Zhang (U. North Dakota)

# Capabilities in Place at NRL

- Fire Monitoring from satellite
  - WF_ABBA Geostationary data within 2 hours
    - GOES 10,11,12,13 + Meteosat SEVIRI + MTSAT-1R
  - MODIS data within 6 hours
    - Terra + Aqua
  - Data repackaged for WWW delivery
    - current and archive
- Smoke source estimation
  - hourly smoke aerosol emission estimates
  - currently 1-degree (to support current NAAPS)
- Aerosol transport and evolution modeling
  - analysis + 72-hour forecast every 24 hours
  - AOD data assimilation (MODIS)
    - over ocean only for now

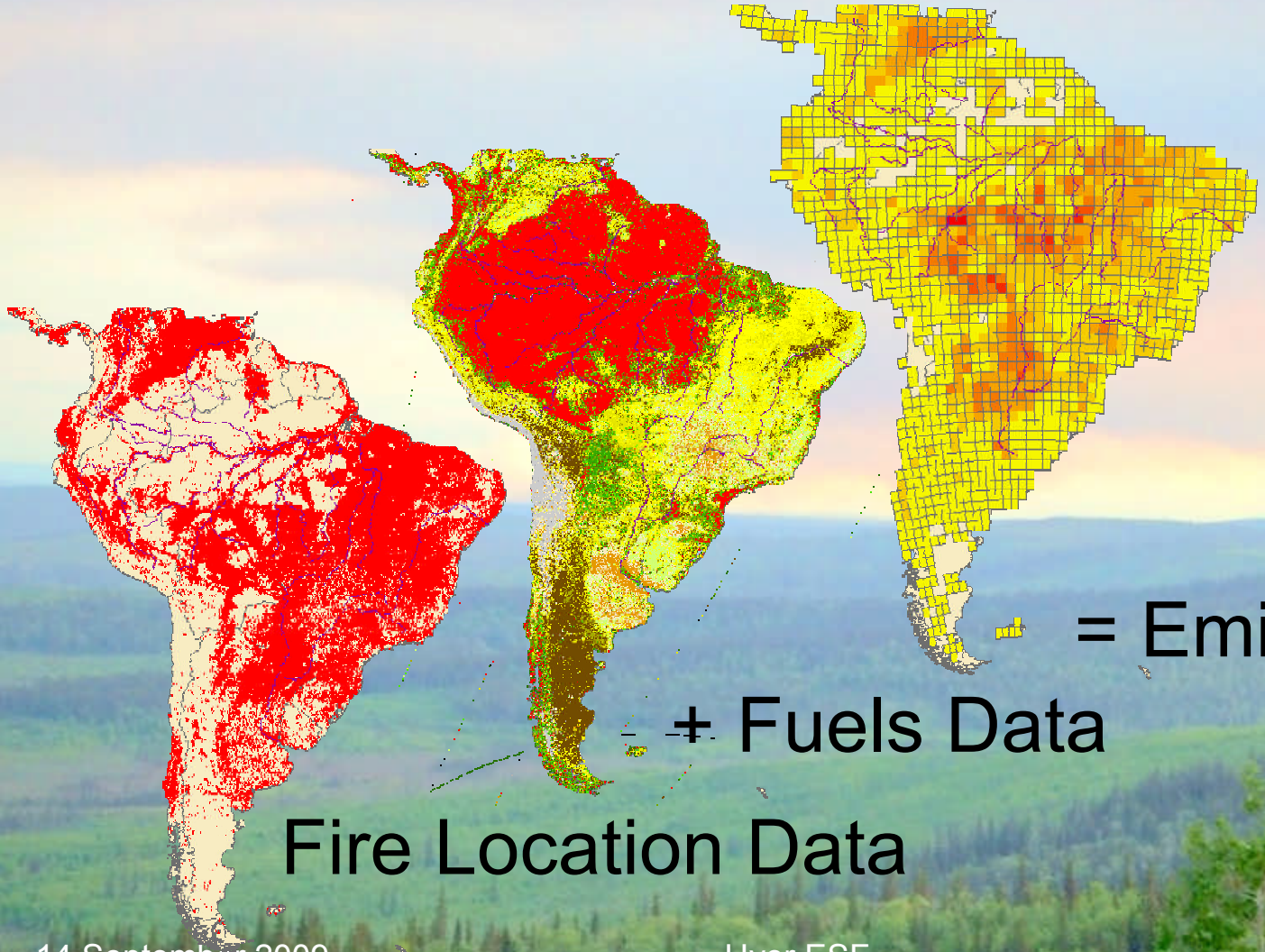
# Smoke Emissions Algorithm

- Fire location, and timing from active fire detections
  - MODIS fires used to fit simple diurnal curve
  - GOES fires emit at time of detection
- Emissions characteristics based on database of experimental fires compiled by Reid et al. (2005).
  - Tied to land cover type
    - Currently GLCC v2 (based on 1992-1993 AVHRR data)

**Reid et al., JSTARS, 2009 (in press).**

**Reid, J.S.; R. Koppman; T.F. Eck; D.P. Eleuterio, 2005. A review of biomass burning emissions part II: intensive physical properties of biomass burning particles. *Atmos. Chem. Phys.*, 5, 799–825, 2005**

# The Heart of the Process

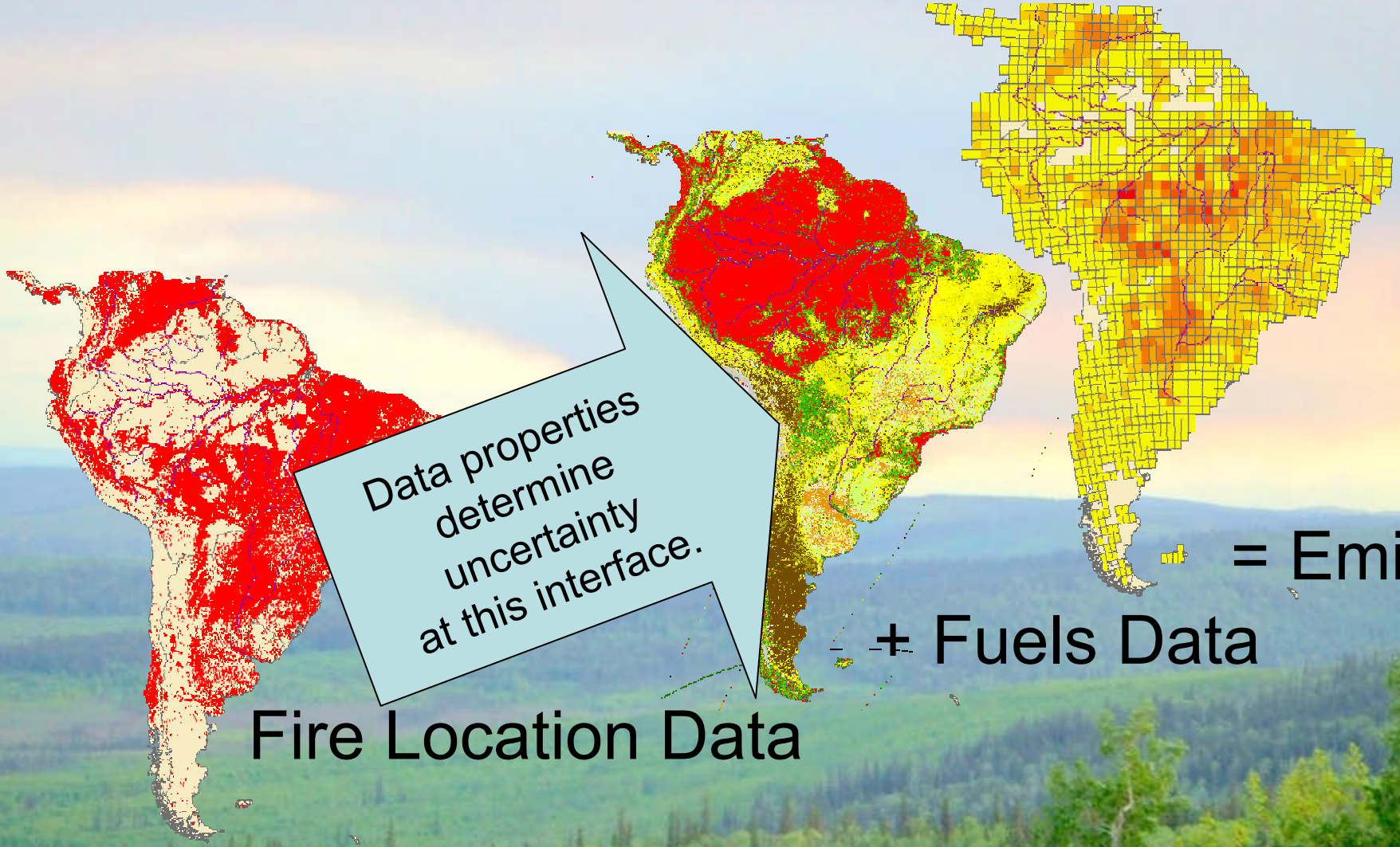


= Emissions

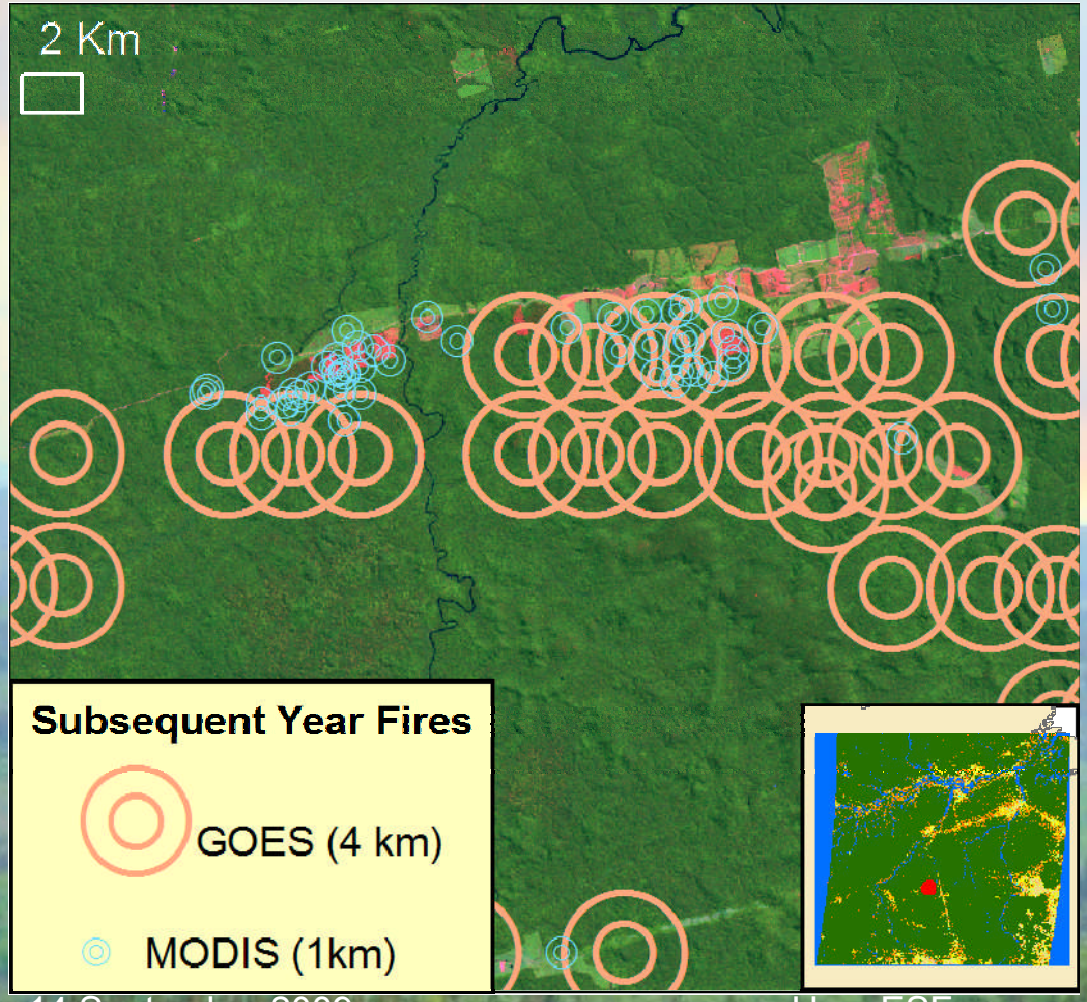
+ Fuels Data

Fire Location Data

# The Heart of the Process



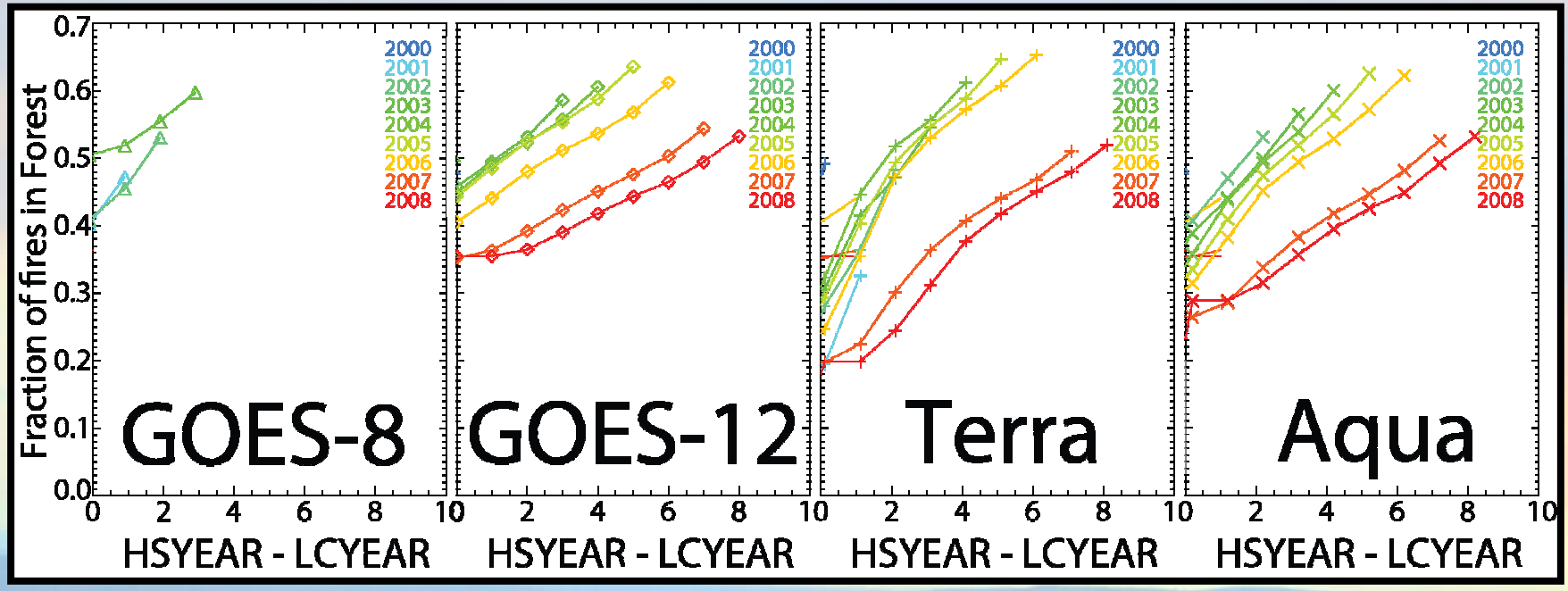
# For Instance, Spatial Resolution of Fire Location Data




- Bias and Random Error vary with true distribution of clearing vs. non-clearing fires
- Assuming clearing fires are 35-50% of total
  - MODIS net emissions bias: **+3% to +11%**
  - GOES net emissions bias: **+5% to +22%**
- **Relative to other uncertainties, this is small**
- **However, it applies even with perfect fuel map data**

**Hyer and Reid, *GRL*, 2009**

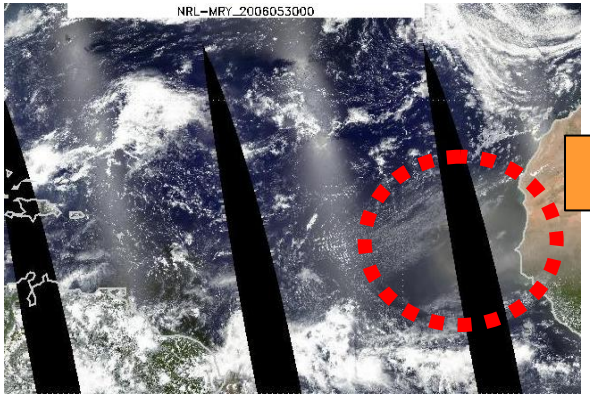
# For Instance, LC Expiration



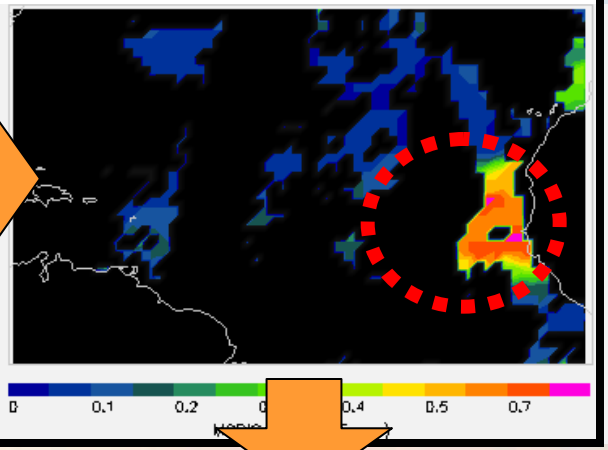

- **PRODES Land cover data from Amazon Basin**
- **X-axis: time lag between LC data and fire data**
  - **0 = LC data from 2000, fires from 2001**
- **Y-axis: Fraction of fires in forest**

# NAVDAS-AOD Data Assimilation

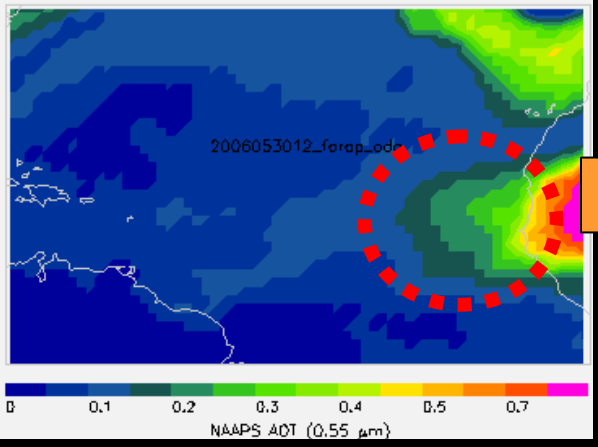
MODIS RGB



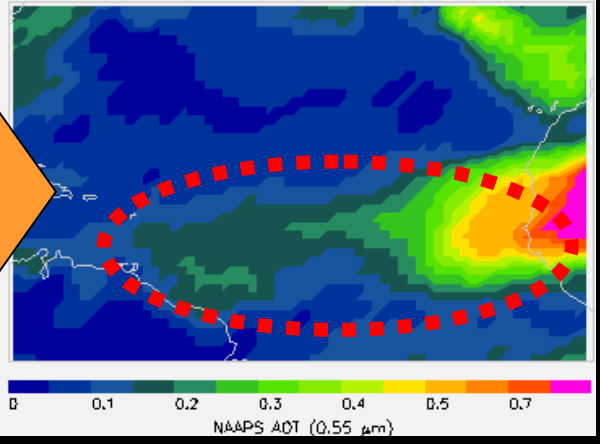

MODIS AOD




NAAPS "Natural"




NAAPS + NAVDAS




**J.L. Zhang et al., "A System for Operational Aerosol Optical Depth Data Assimilation over Global Oceans", *JGR* 2008.**

- **Now operational at Navy**
- **Coming soon: over-land AOD**

# With DA, what must the Forward Model Do?

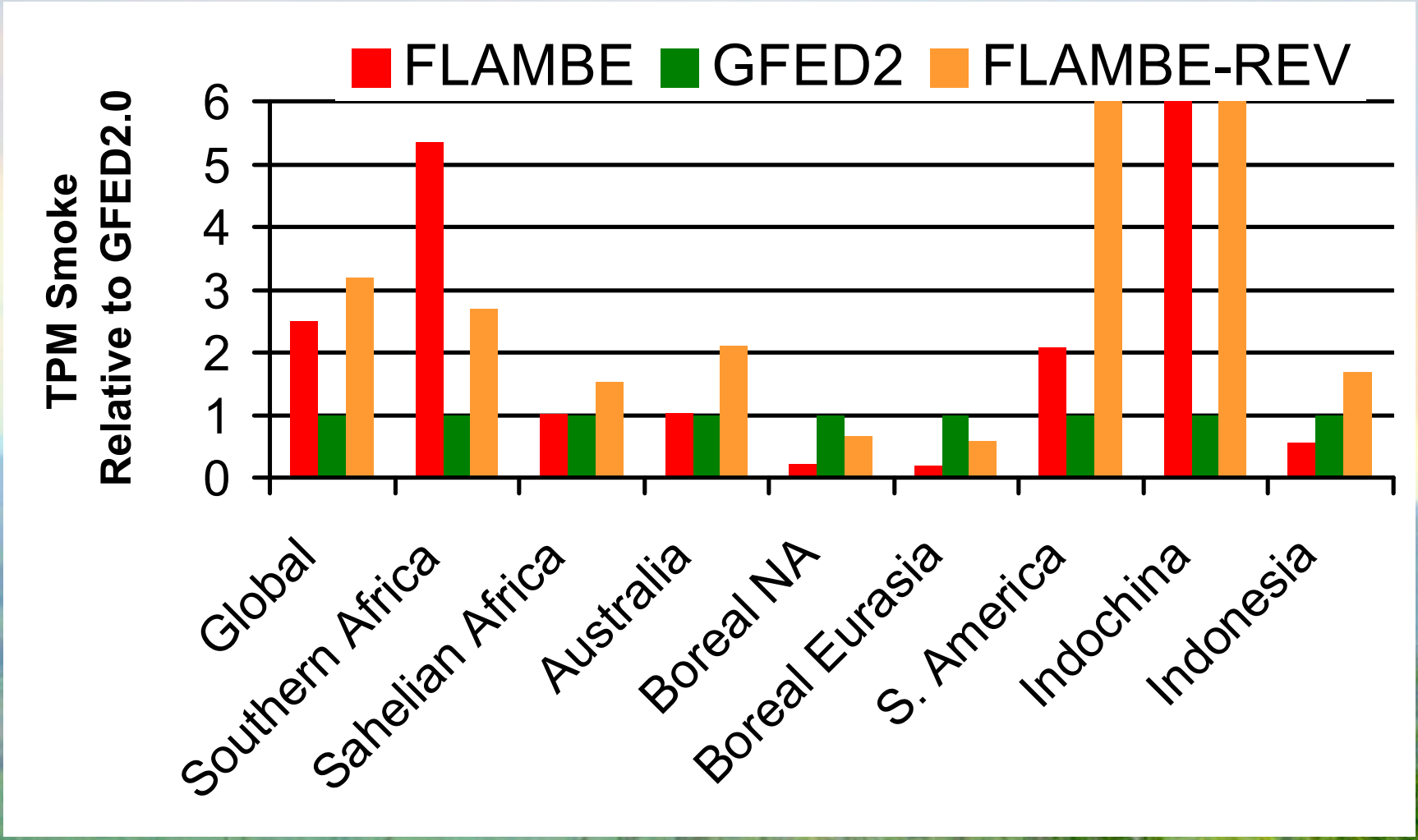
1. Do not miss fire events!
2. Get injection right
3. Get fire timing right
4. Separate “high-emission” and “low-emission” events
5. Use DA systems to provide feedback to emission models
    1. ***Directly*: use innovations to modify source terms at each timestep**
    2. ***Indirectly:* use DA to test emission hypotheses**

# Simple Correction Based on NAVDAS results

- 2-year run of NAAPS+NAVDAS, using Ocean and (experimental) Land AOD
- Evaluate AOD data biases based on AERONET comparison
- Calculate source function correction based on how much NAVDAS increases aerosol loading

***Reid et al., JSTARS 2009 (in press)***

# Correction Results vs. GFEDv2



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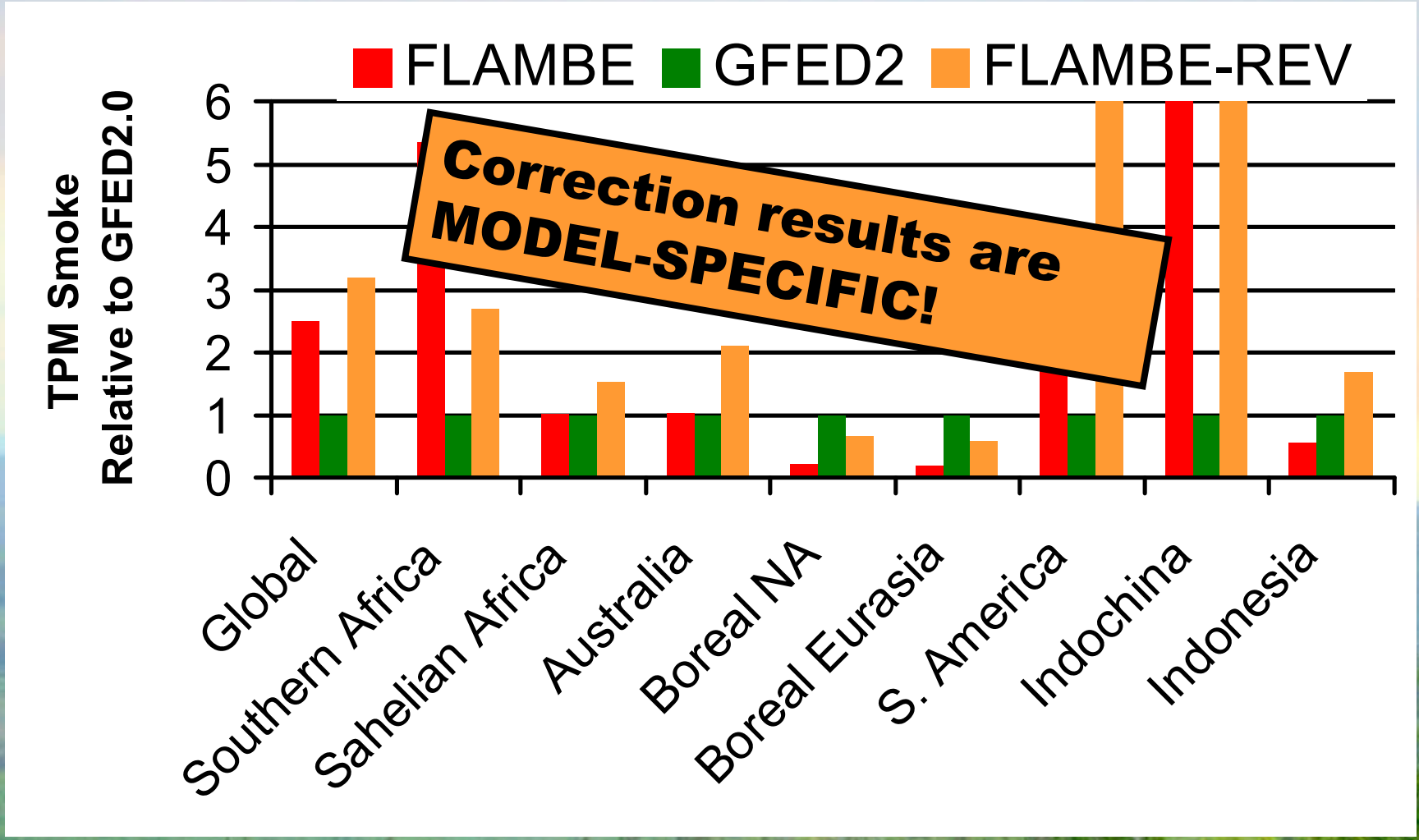
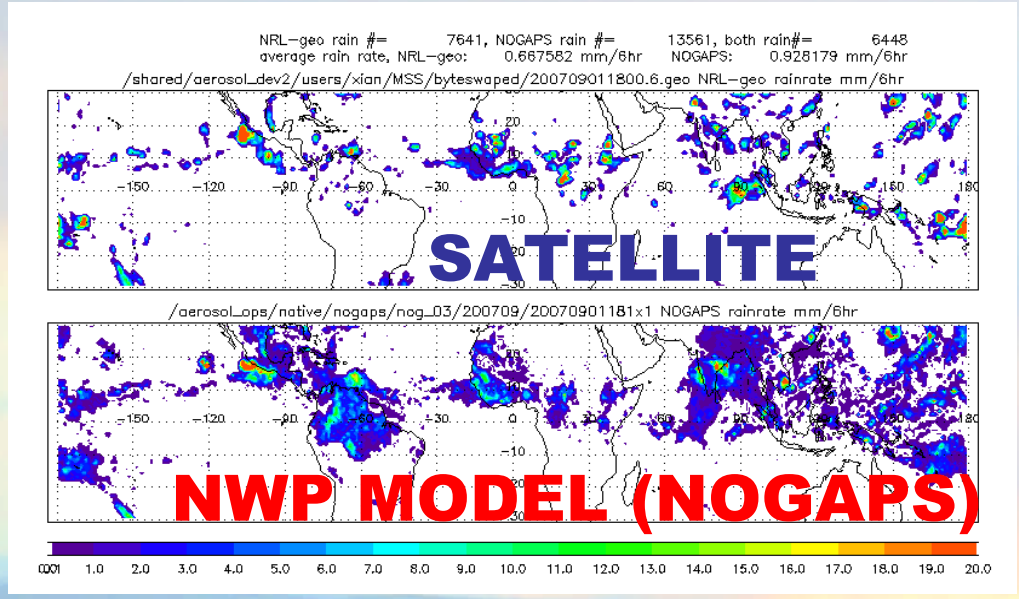
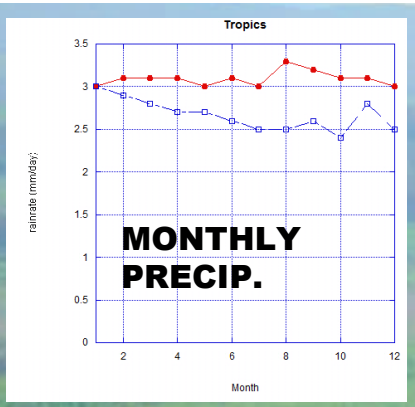
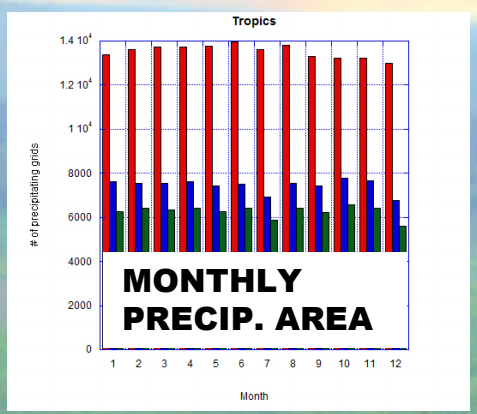


# Model-specific effects, for instance, NWP vs Satellite Precipitation

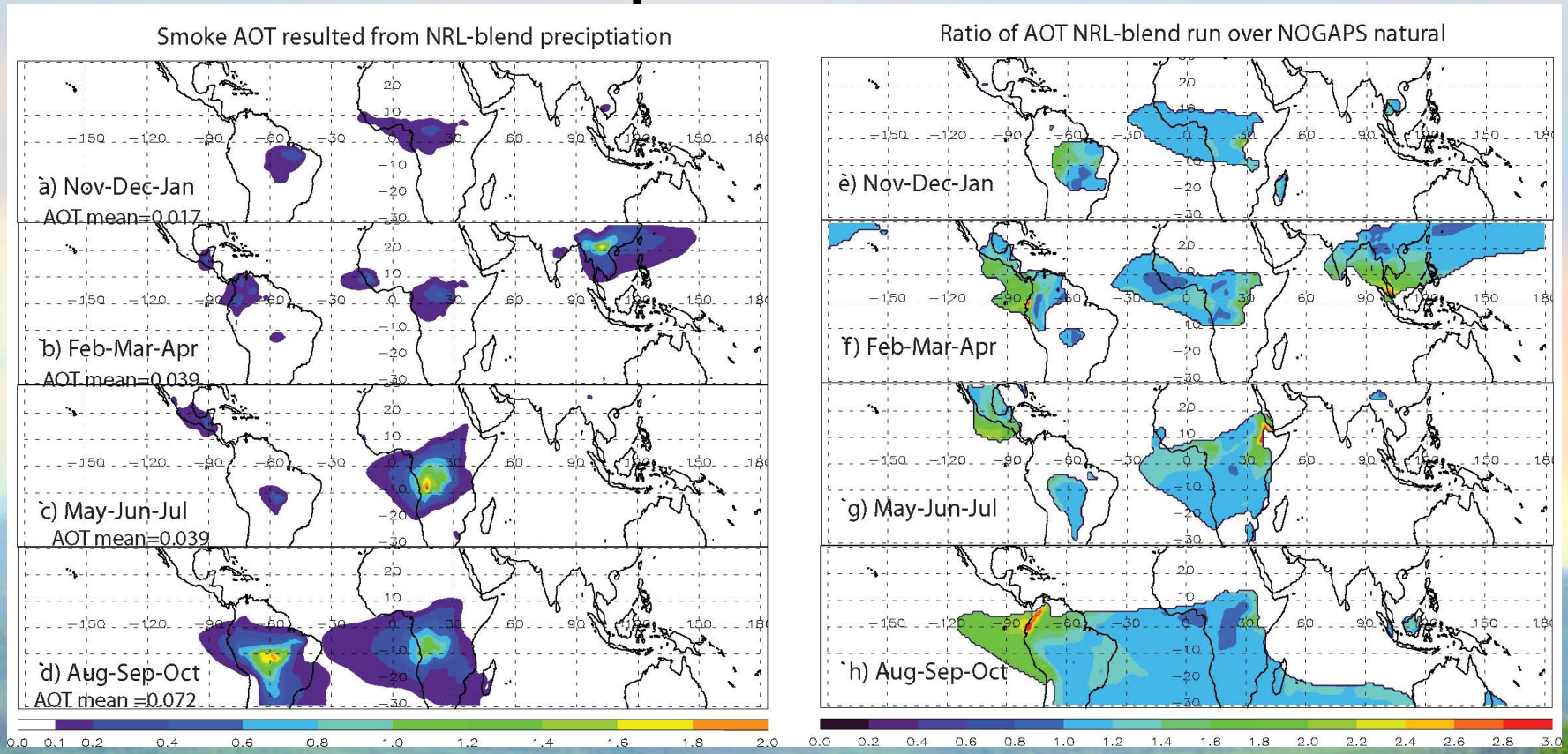



- Left: 6-hour rain rates, from blended satellite product (Turk et al., TOP), and from NOGAPS analysis (BOTTOM)
- Lower Left: Total Monthly Precip., SAT vs. MODEL
- Lower Right: Total area with precipitation, SAT vs. MODEL
- NWP models all do this, to some degree

# What is the impact on NAAPS AOD?




## Xian et al., GRL 2009

**Impact of modeled versus satellite measured tropical precipitation on regional smoke optical thickness in an aerosol transport model**

# Conclusions

- Simple inversion of model can improve model results, but may not improve understanding of sources
- Confidence in inversion results requires confidence in sink terms
- **FLAMBE smoke aerosol and carbon emissions are freely available**
  - **1 degree, hourly**
  - **2003-present**
- Thank you!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