AeroCom Biomass Burning Experiment Phase 1: Fire source strength adjustment

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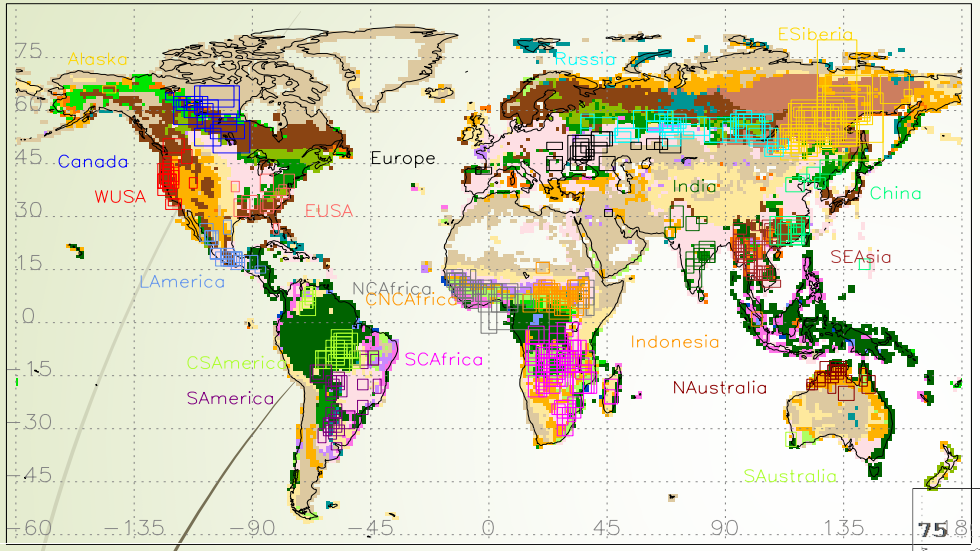
AeroCOM BB Experiment Design

- We are **providing satellite-based constraints** (globally, stratified by season and biome-related regions) and leading analysis of the results on
  - BB **source strength** (**Phase 1**, M. Petrenko, R. Kahn, M. Chin)
  - BB emission **injection height** (**Phase 2**, M. Val Martin, R. Kahn)
- Year 2008
- Runs: GLOFIR0 (no BB), GLOFIR1 (GFED3 daily), GLOFIR0p5 (GFED3*0.5), GLOFIR2, GLOFIR5
- 14 participating models
  - CAM5
  - ECHAM6.1_HAM2.2
  - ECHAM-SALSA
  - GEOS-Chem
  - GEOS5
  - GFDL
  - GISS-MATRIX
  - GISS-OMA
  - GOCART
  - HadGEM3
  - IFS (CAMS)
  - INCA
  - OsloCTM2
  - SPRINTARS

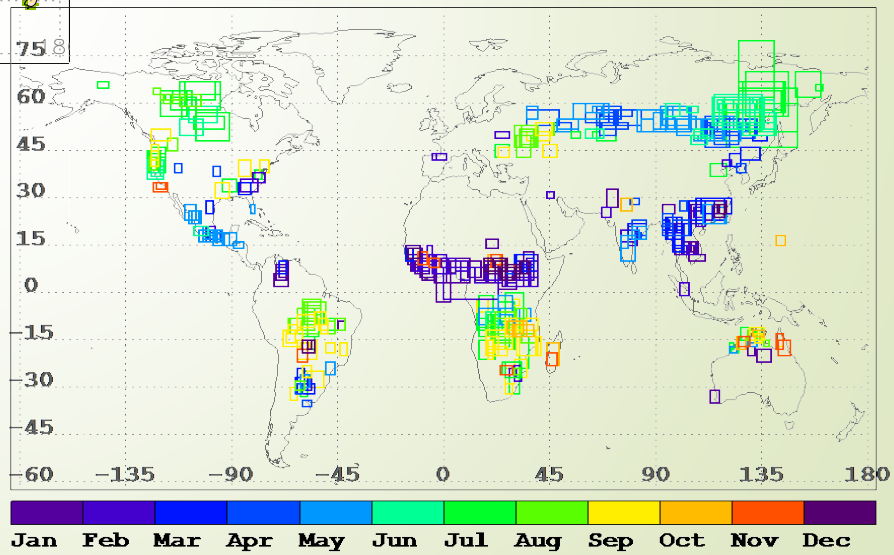
AeroCOM BB Experiment Objectives

- Inter-compare and **quantify model BB AOD accuracy and diversity**
- Evaluate factors that define **regional difference** between satellite and model AOD (Phase 1)
  - provide constructive summary to widely used GFED inventory
  - Identify modeling aspects to benefit from modification
- Develop and evaluate the use of measurement-based, statistical smoke injection height distributions, on simulated smoke climate and air quality effects (Phase 2)

Phase 1: Satellite Reference Observational Dataset

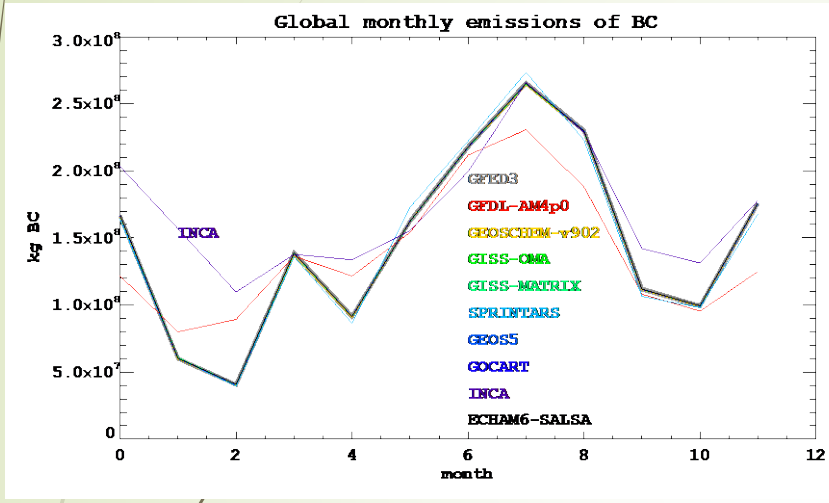


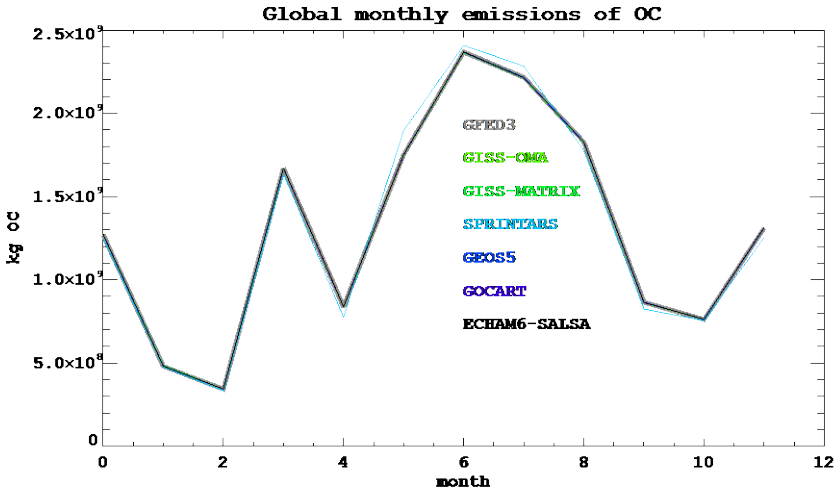
497 cases in 2008

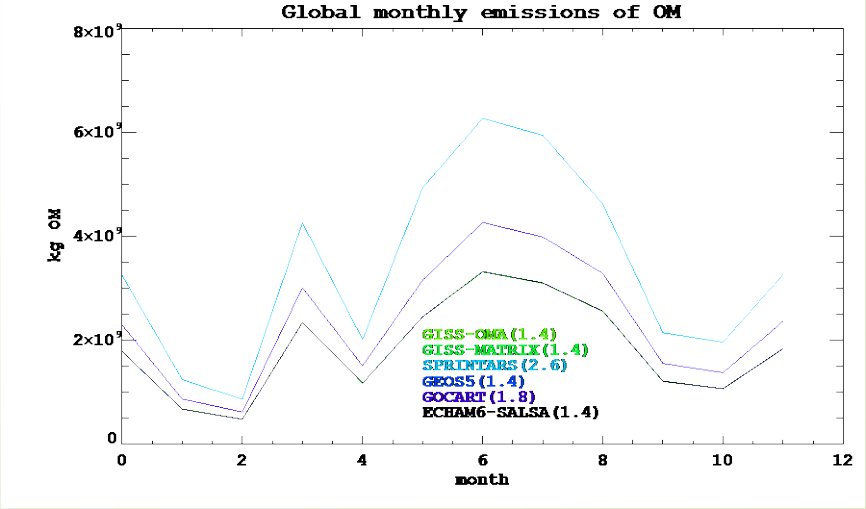


Month when case was observed by MODIS

Global Fire Emission Database version 3 (GFEDv3) aerosol emissions

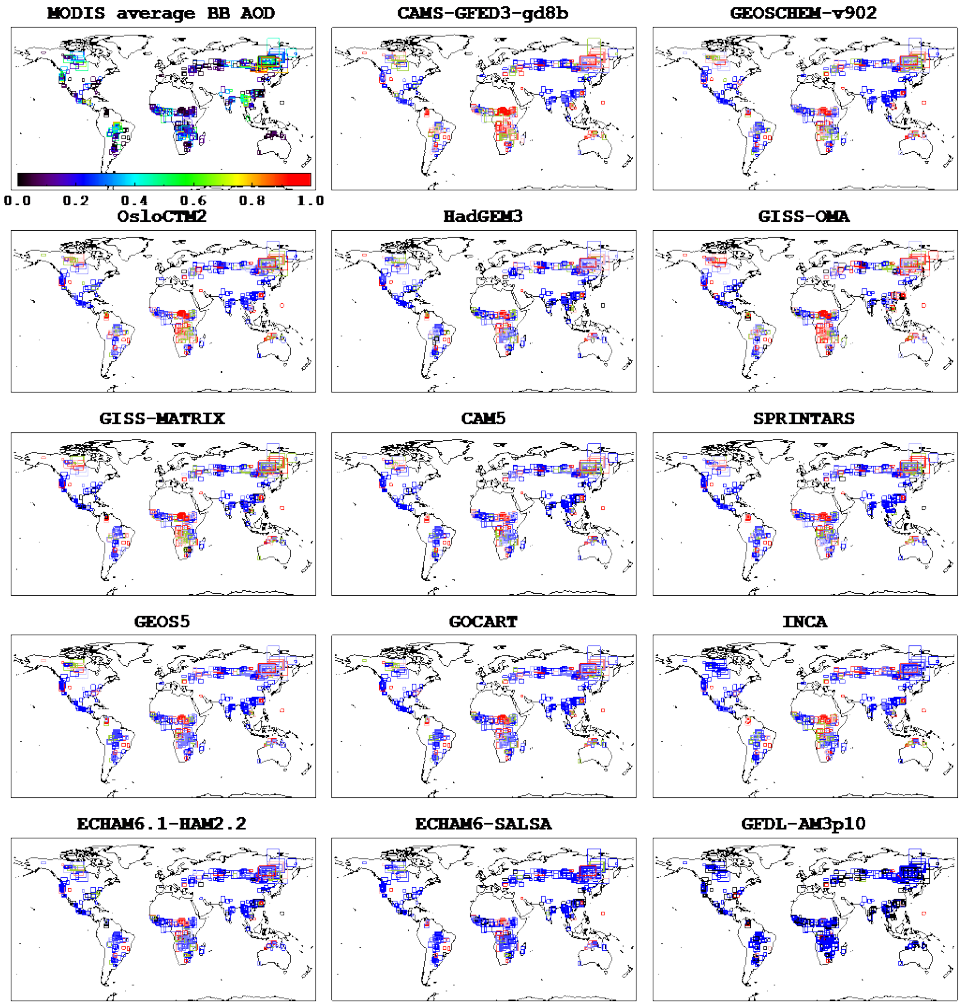


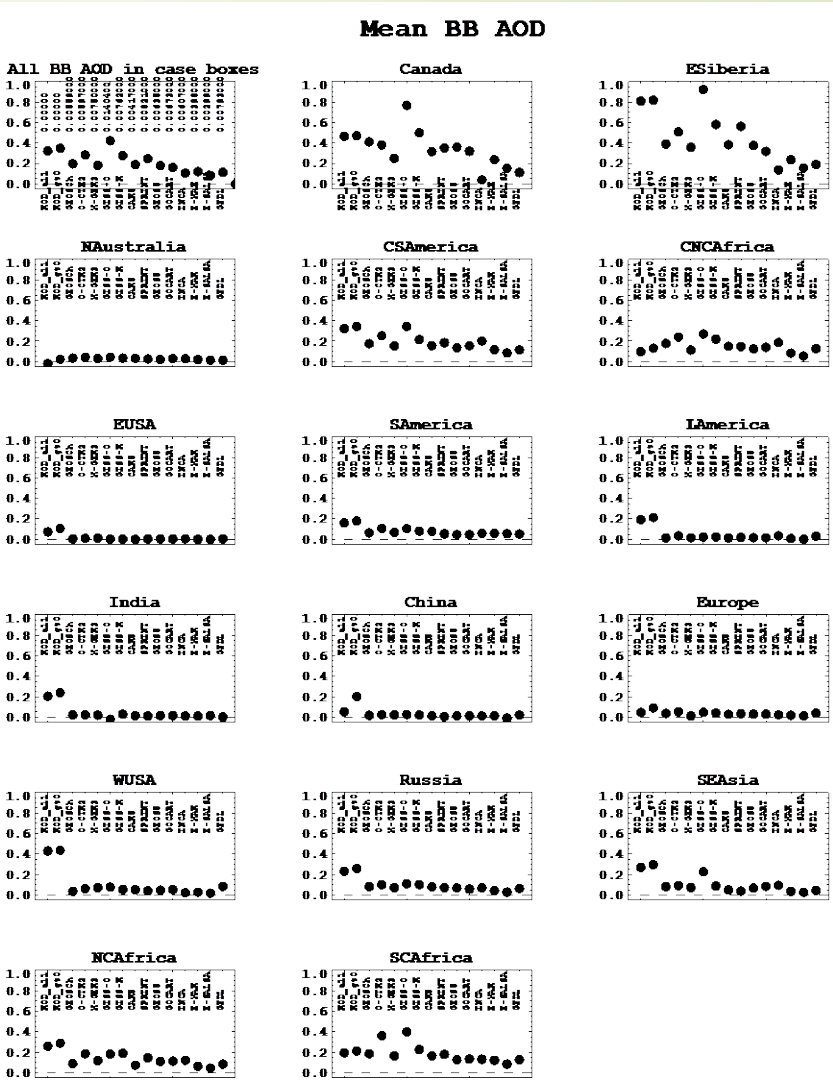




In models:
Var_BB = var_GLOFIR1 - var_GLOFIR0

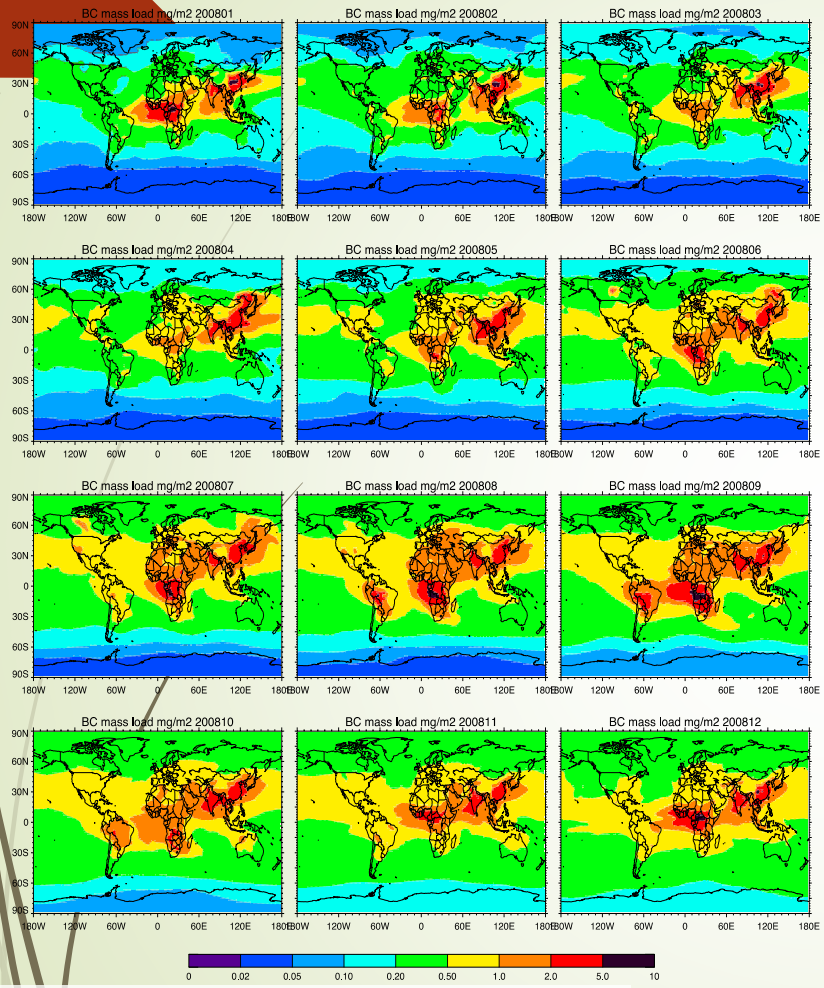
AOD comparison



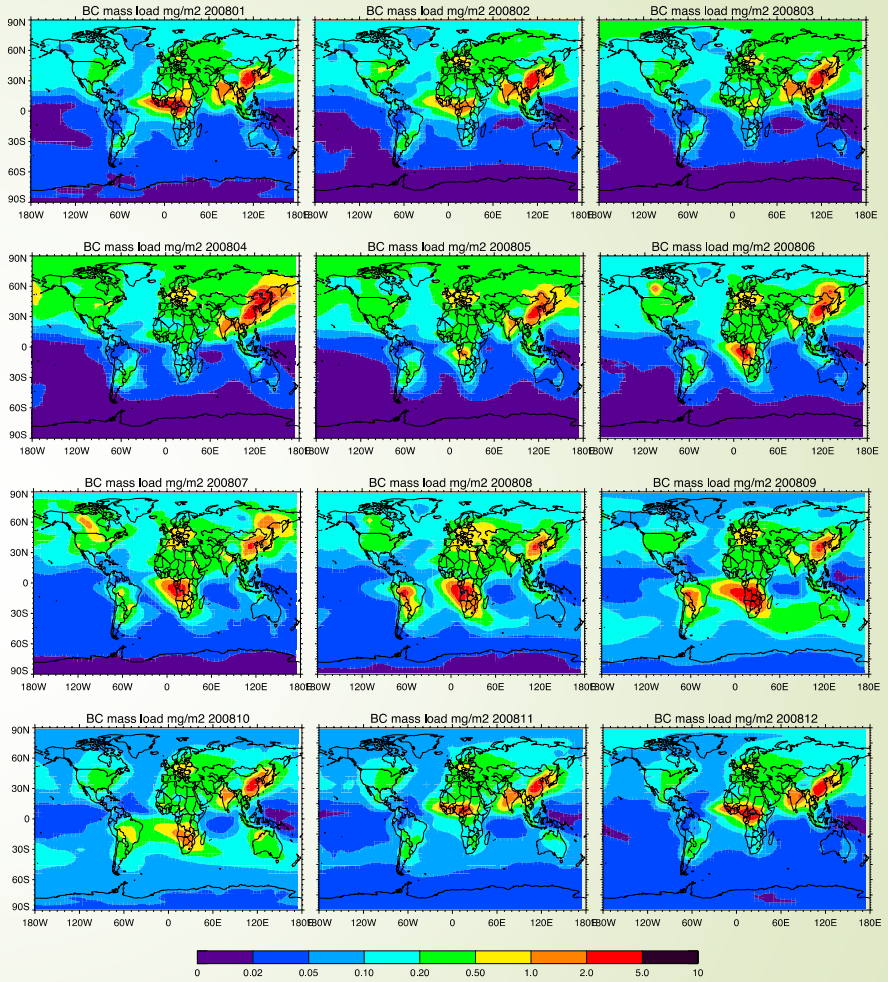


Monthly BC load

ECHAM6-SALSA GLOFIR1



GEOSCHEM-v902 GLOFIR1



GLOFIR1 BC load can be calculated for:

- CAM5
- ECHAM6-SALSA
- GEOS5
- GesChem
- GOCART
- GISS-MATRIX
- GISS-OMA

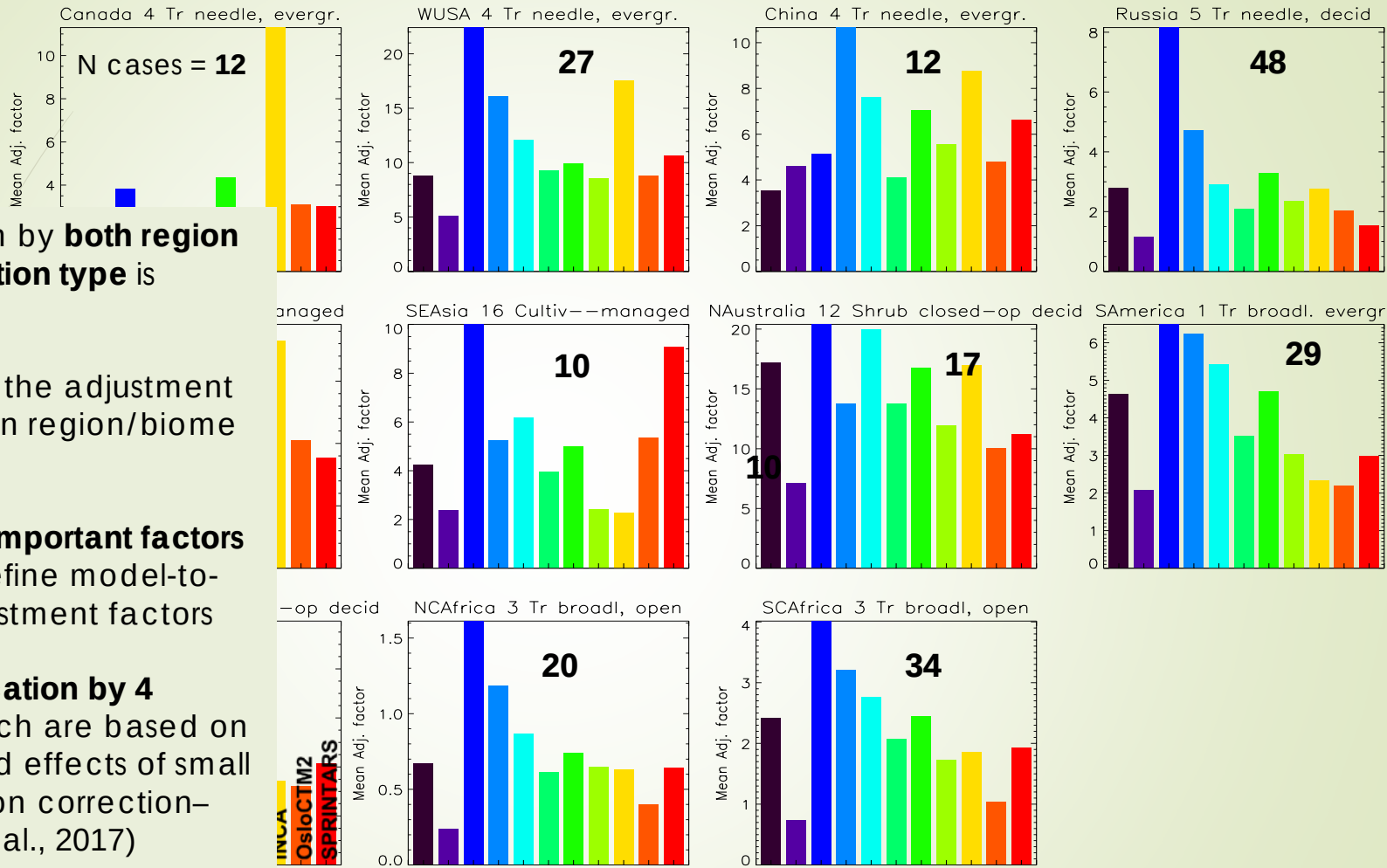
BB BC load for:

- CAM5
- ECHAM6-SALSA
- GEOS5
- GOCART
- GISS-MATRIX
- GISS-OMA

In progress comparison of :

- loads,
- extinction,
- BB BC & OC lifetime,
- deposition.

BB model/sat AOD ratio in [some] regions and veg. types



- Stratification by **both region and vegetation type** is important
- Variation of the adjustment factors within region/biome is high
- **Regionally important factors** exist that define model-to-MODIS adjustment factors
- **New stratification by 4 groups** (which are based on location and effects of small fire + emission correction– Petrenko et al., 2017)

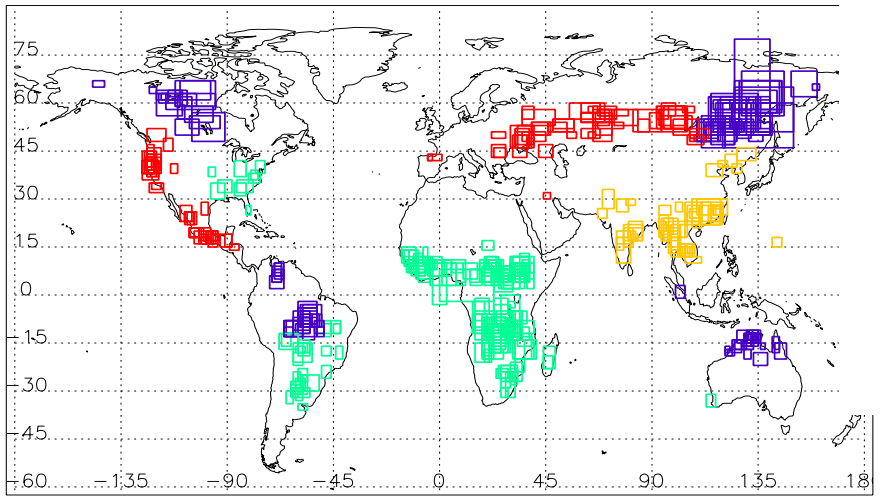
CAM5 **GEOS5** **INCA**

CAMS **GEOSChem** **OsloCTM2**

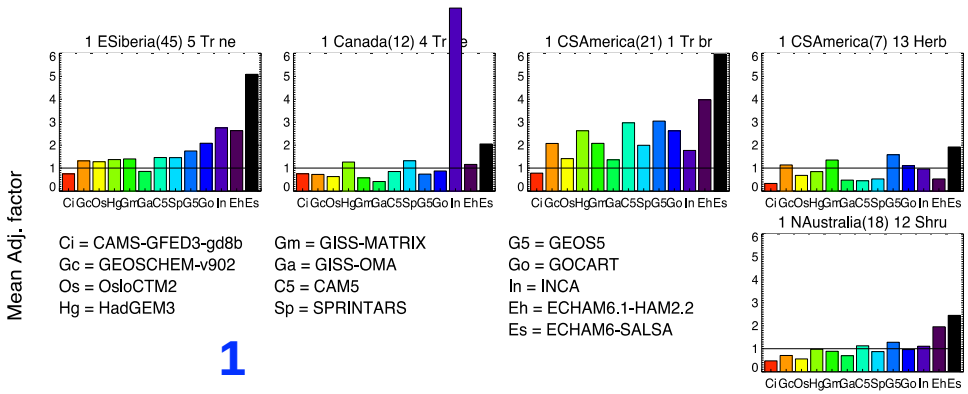
ECHAM6-SALSA **GOCART** **SPRINTARS**

ECHAM6-Ham2 **HadGEM3**

BB model/sat AOD ratio in 4 groups of regions

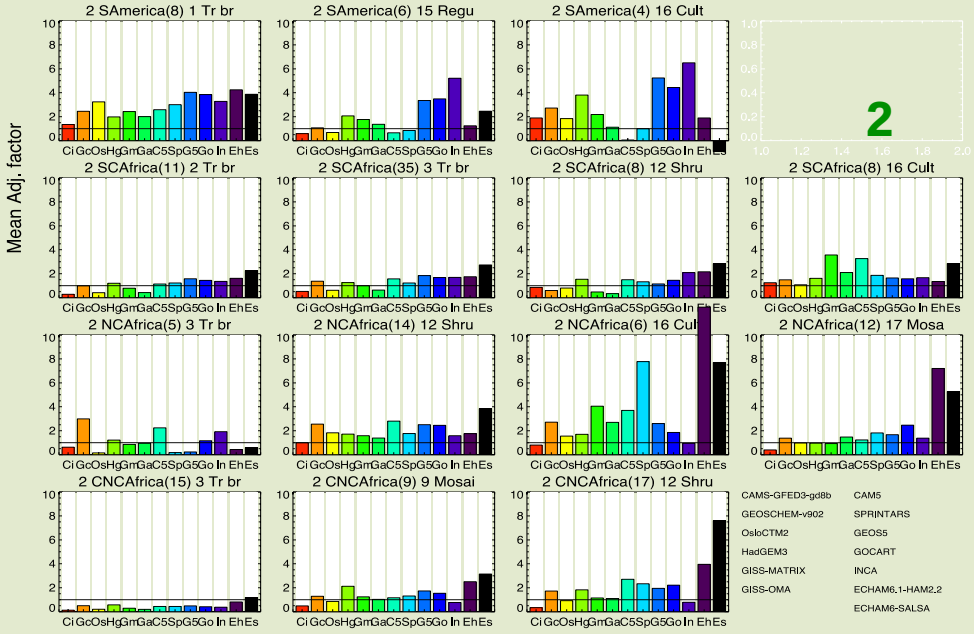


Group 1: Large defined fires, minimal adjustment
Group 2: Intermediate fires, emission adjustment required
Group 3: Polluted regions, analysis inconclusive
Group 4: Need some emission and large SF adjustment



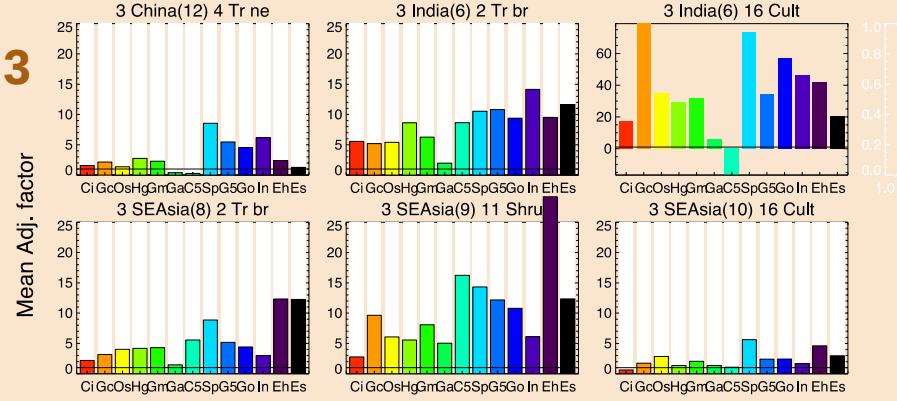
Ci = CAMS-GFED3-gd8b
Gc = GEOSCHEM-v902
Os = OsloCTM2
Hg = HadGEM3
Gm = GISS-MATRIX
Ga = GISS-OMA
C5 = CAM5
Sp = SPRINTARS
G5 = GEOS5
Go = GOCART
In = INCA
Eh = ECHAM6.1-HAM2.2
Es = ECHAM6-SALSA

1



2

CAMS-GFED3-gd8b
GEOSCHEM-v902
OsloCTM2
HadGEM3
GISS-MATRIX
GISS-OMA
CAM5
SPRINTARS
GEOS5
GOCART
INCA
ECHAM6.1-HAM2.2
ECHAM6-SALSA



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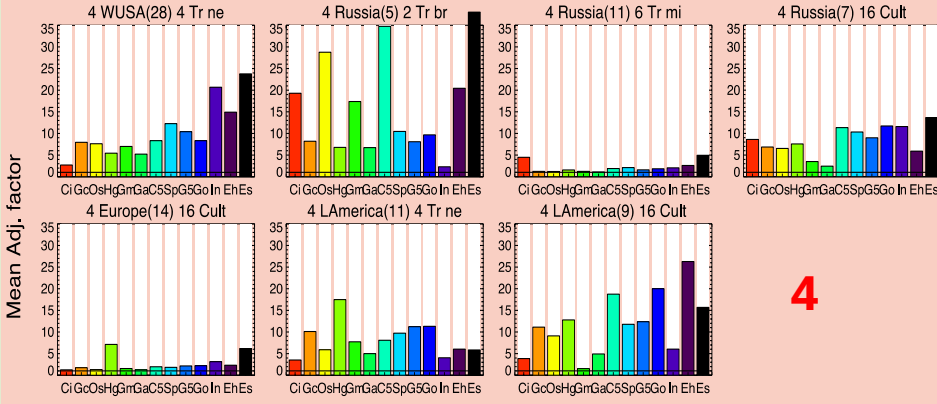

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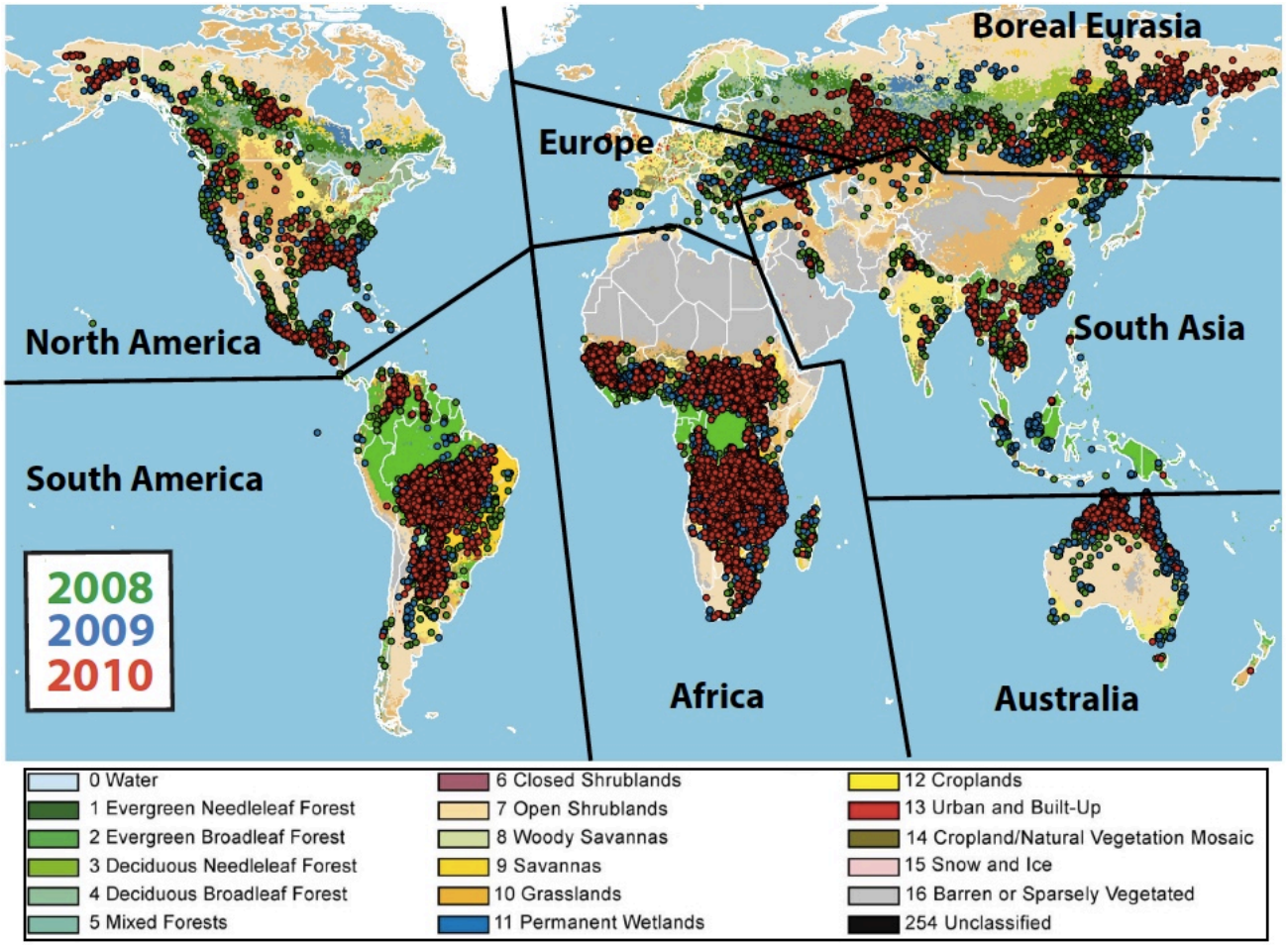
Thank you!

- Many thanks to everyone who ran models, formatted, submitted (and re-submitted ;) output) participated in the telecon, commented on drafts and provided suggestions!
- Final draft of the paper will be sent to co-authors soon

Biomass Burning Experiment *PHASE 2*: *Fire Emission Injection Heights*

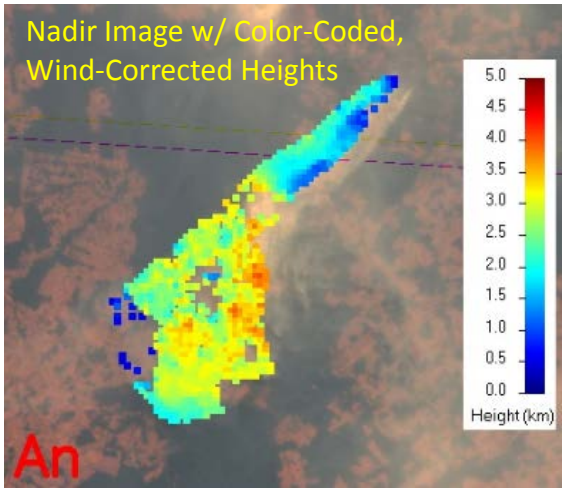


- About ***23,000 smoke plumes*** digitized 2008-2010 (~13,000 for 2008)
- Each plume is Operator-Processed using ***MINXv4.0***, and Quality Controlled
- For N America, ≥ ***4% - 12%*** of plumes are injected above the PBL; Boreal Forest **18%**
- Raw, graphics and summary files, and documentation are ***available on-line:***

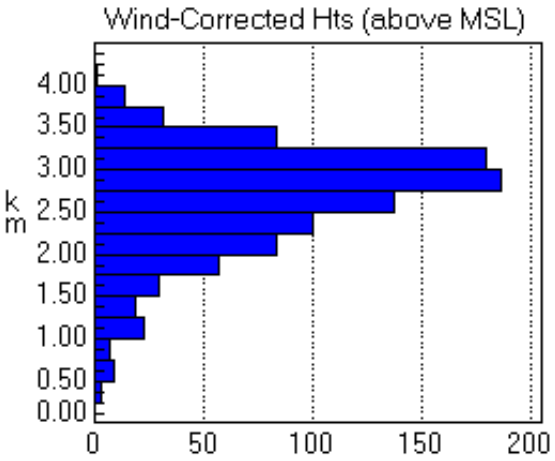
https://misr.jpl.nasa.gov/getData/accessData/MisrMinxPlumes2/

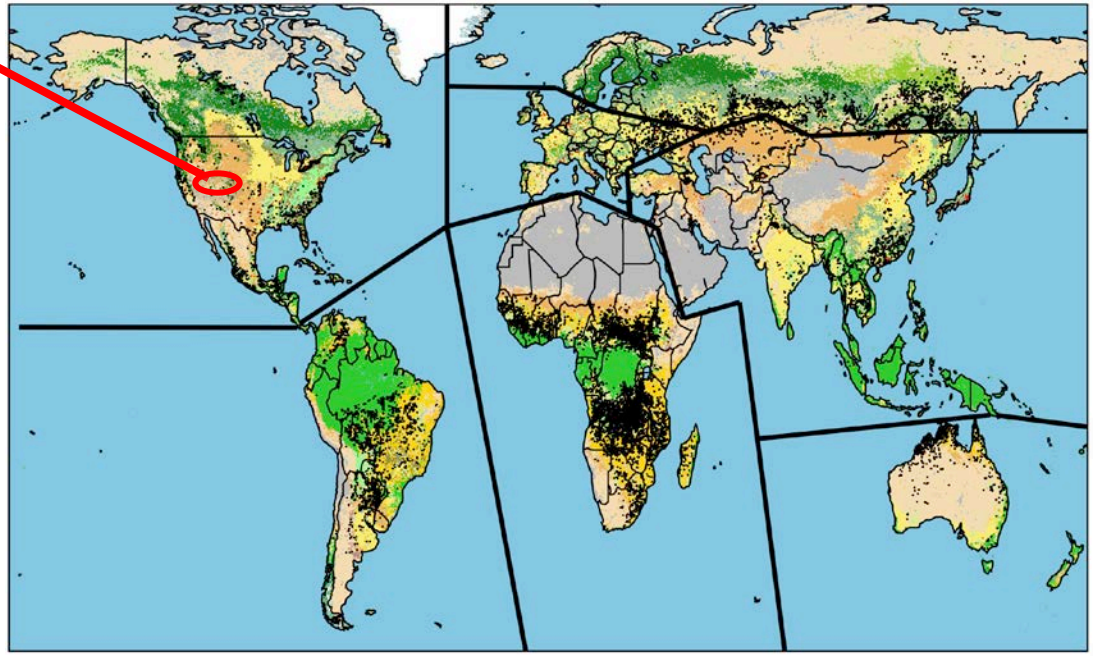
Val Martin et al., Remt. Sens.2018

Biomass Burning Experiment *PHASE 2*: *Fire Emission Injection Heights*



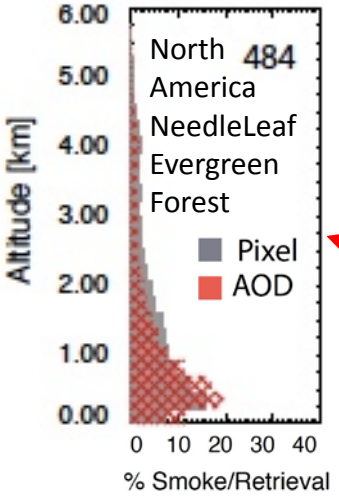
- Heights at ***1.1 km Horizontal*** res., ***~250-500 m Vertical*** res.
- Keyed to the ***Elevation of Maximum Spatial Contrast***
- Parallax is corrected for proper motion (***Wind Correction***)
- Missing AOD filled w/ ***max***; missing height w/***statistical dist***.
- Both ***Pixel-weighted*** and ***AOD-weighted*** profiles derived
- Height histogram gives some ***Indication of Vertical Extent***

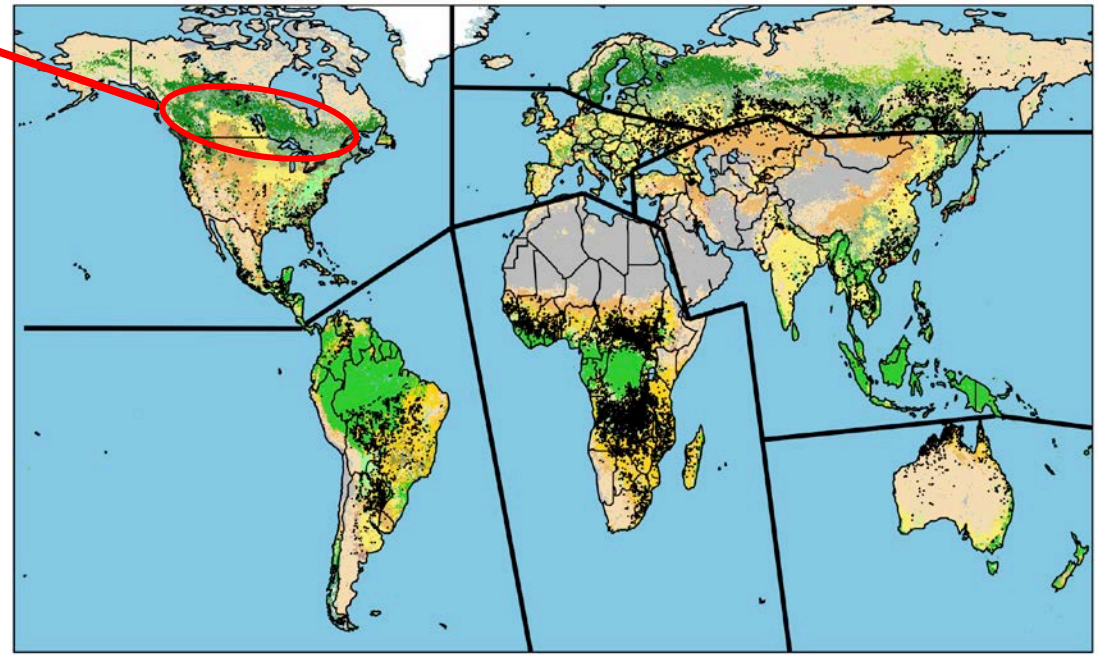




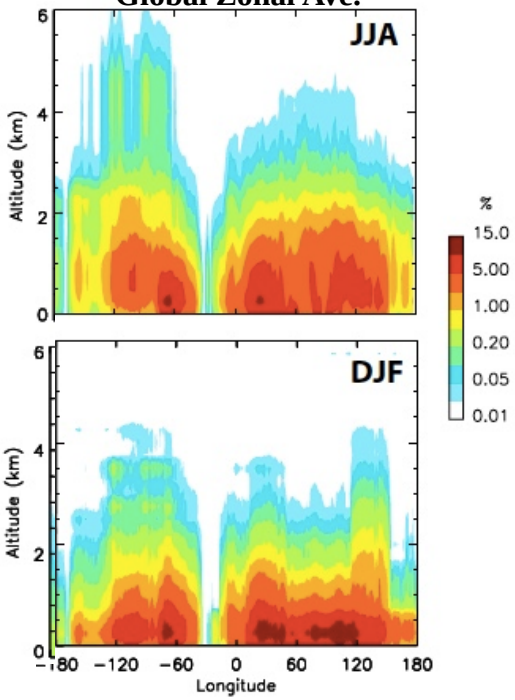
Val Martin et al., Remt. Sens. 2018

Biomass Burning Experiment *PHASE 2*: *Fire Emission Injection Heights*





Global Zonal Ave.

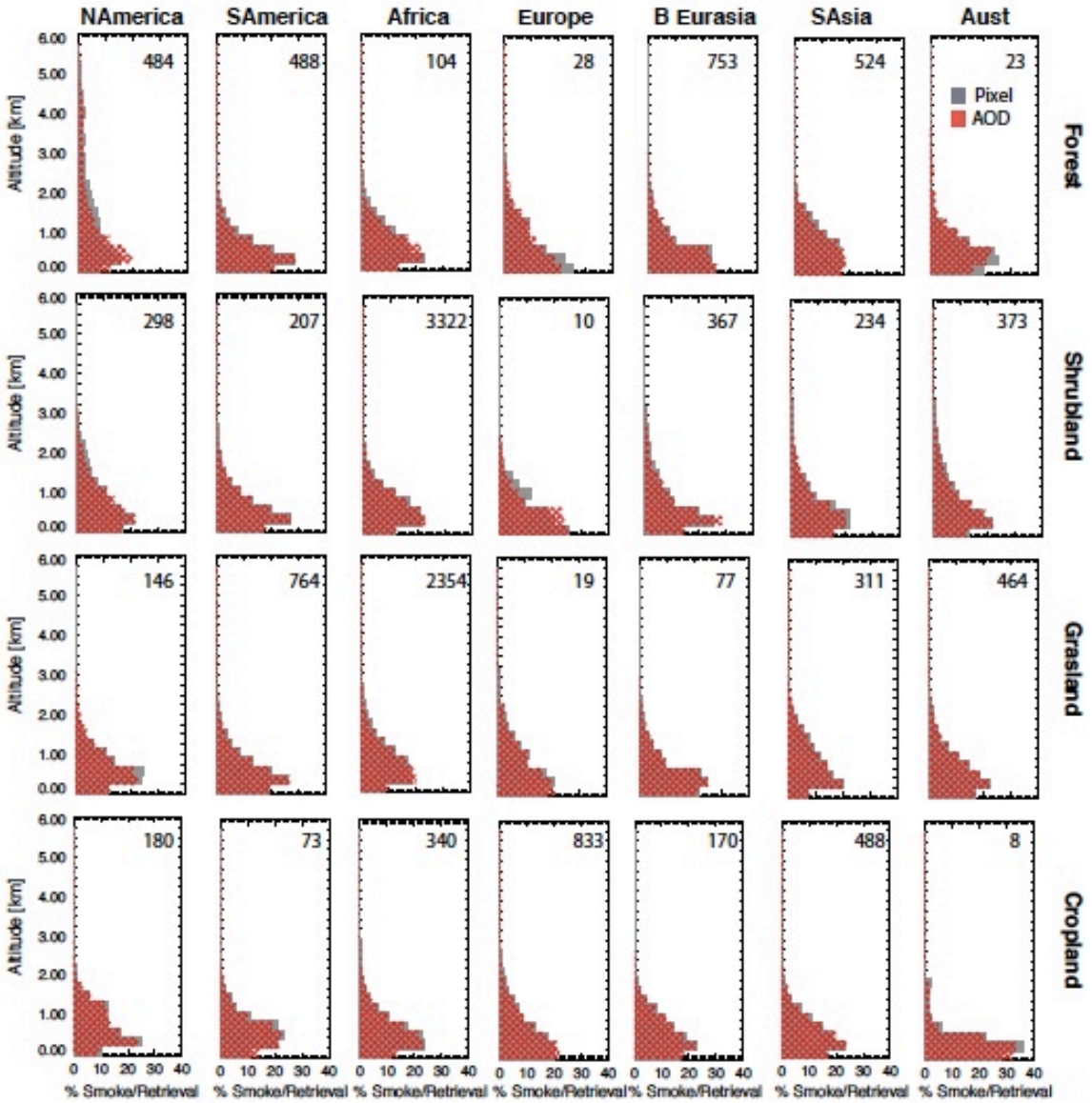


- Fire emissions are ***Stratified by Altitude***, ***Region***, ***Ecosystem***, & ***Season***
- The cases in each stratum are ***Averaged*** to produce a statistical summary
- Inter-annual and/or sub-seasonal ***temporal resolution*** might be needed in some cases; requires detailed, regional study (e.g., Amazon)

Val Martin et al., Remt. Sens. 2018

Injection Height Vertical Distributions

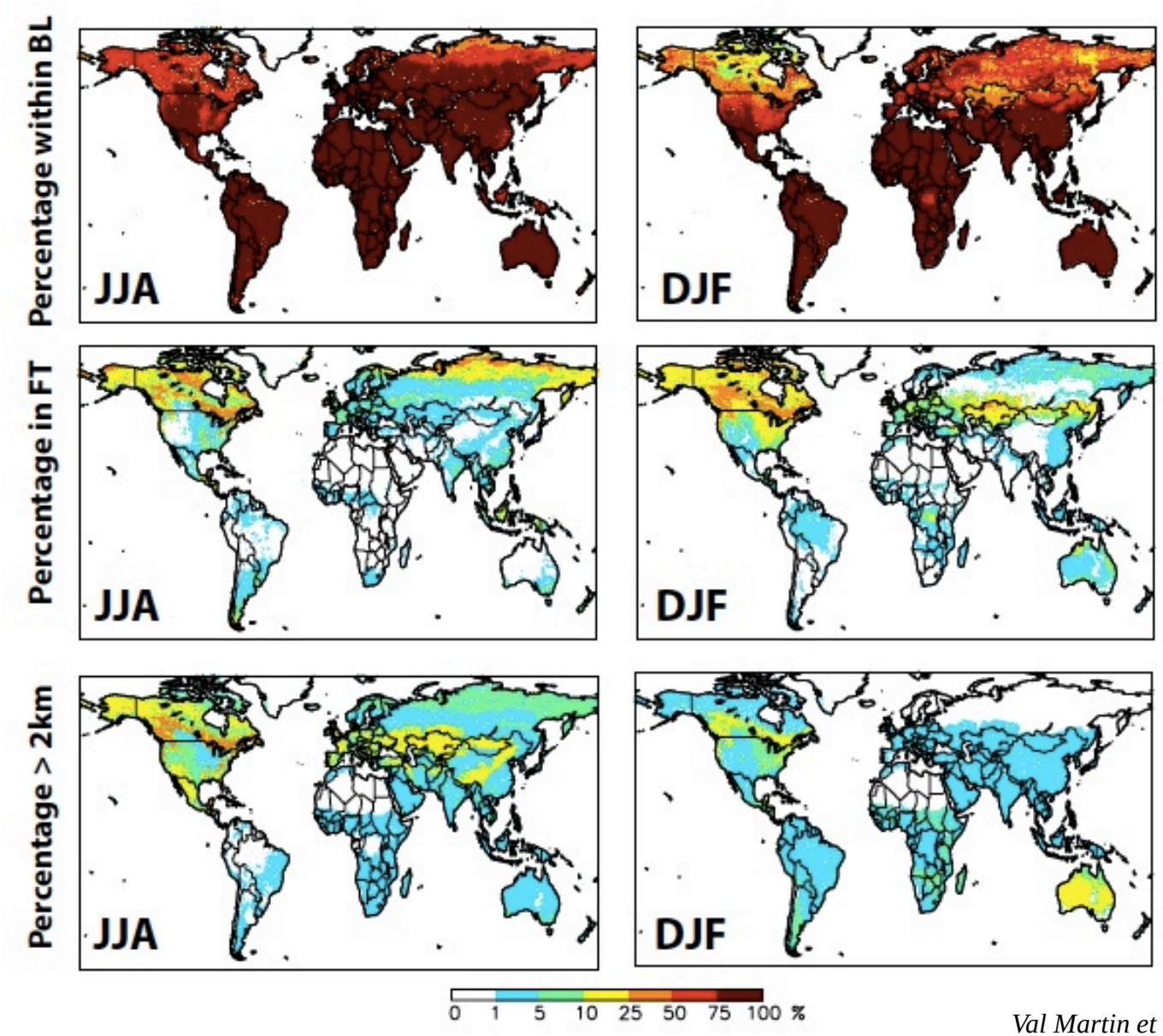
Stratified by Region and Biome



Val Martin et al., Remt. Sens. 2018

Global Distribution of Percent Injected Within/Above the PBL

Based on MERRA-2 Hourly PBL 10:00-13:00 LT



Accounting for uncertainty
FT = PBL + 500 m

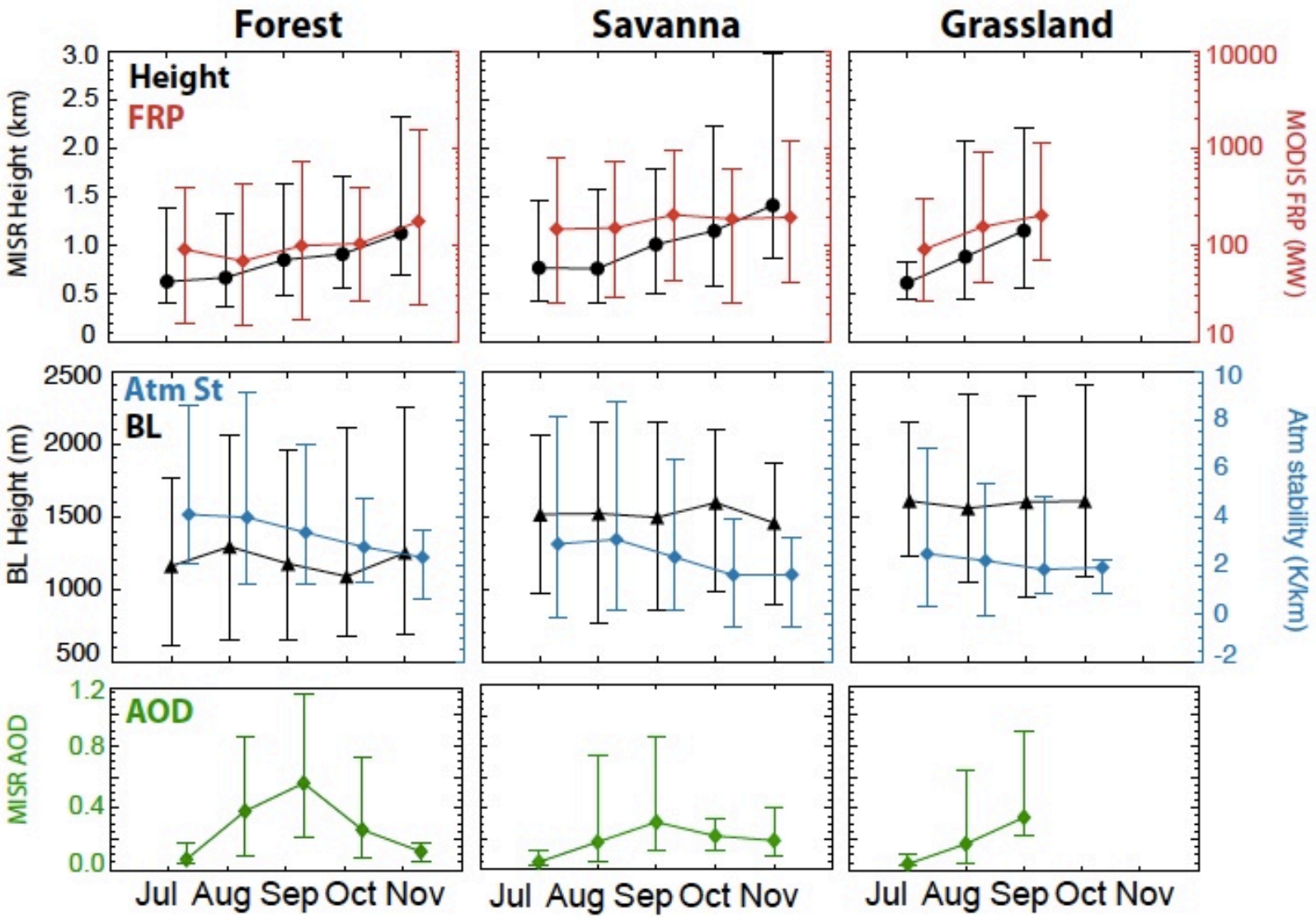
[PBL from MERRA-2}

2 km threshold avoids dependence on PBL height estimate

Val Martin et al., Remt. Sens. 2018

Amazon Plume-Height Climatology, 2005-2012

Seasonal Cycle

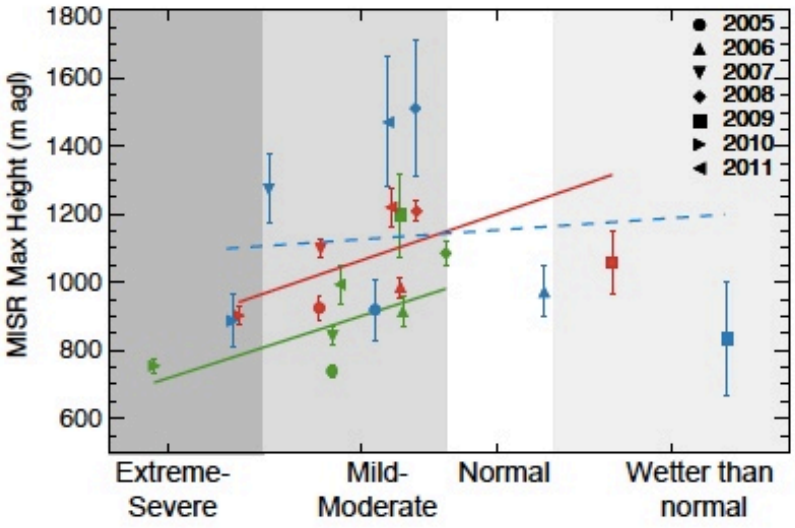


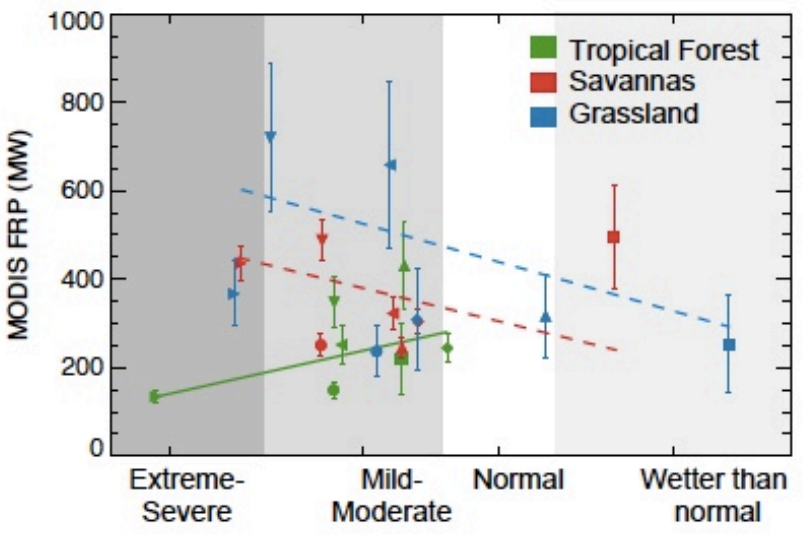
FRP **and *Height* tend to *increase* as the fire season progresses, for all major Amazon biomes**

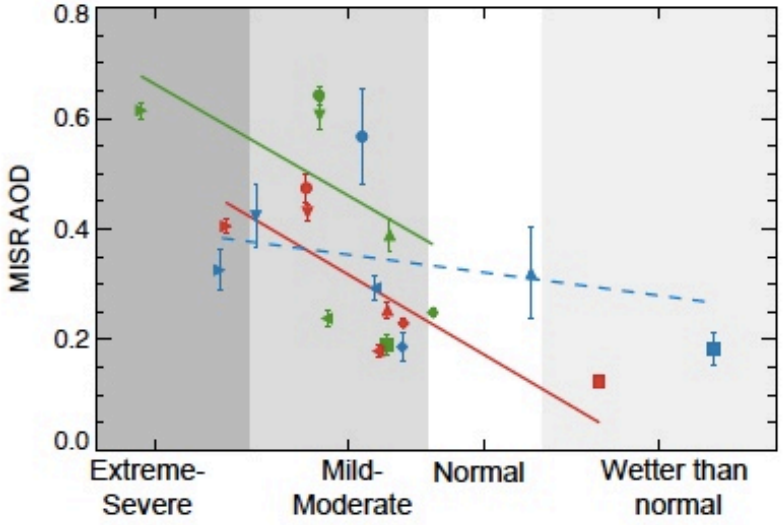
Gonzalez-Alonso et al., ACPD 2018

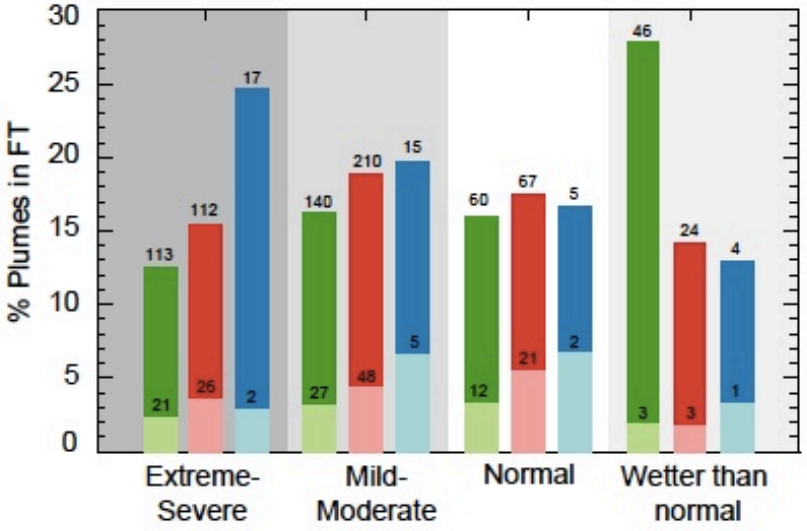
Amazon Plume-Height Climatology, 2005-2012

Wet – Dry Year Interannual Behavior









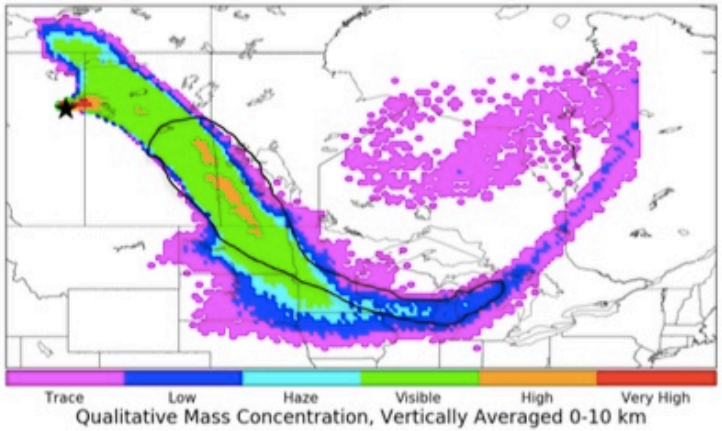
Forest and Savanna -- **Lower plume height, *Higher* AOD in drier years, due to deeper, smoldering fires**

Gonzalez-Alonso et al., ACPD 2018

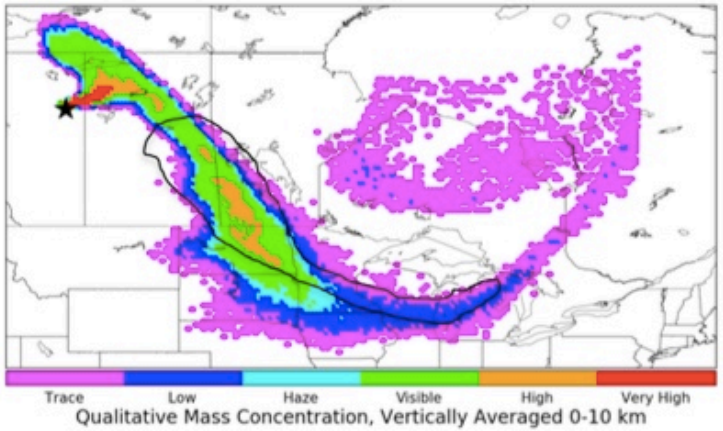
Ft. McMurray Wildfire, Alberta Canada

May 07, 2016 (Day 2) NOAA HySPLIT Model

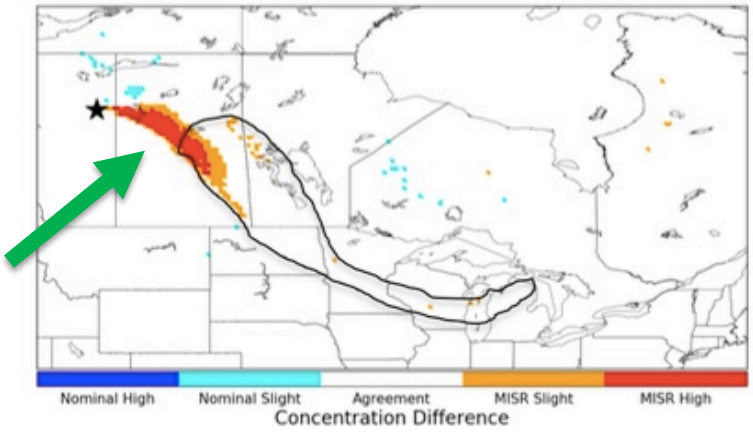
a) MISR-Initialized HYSPLIT



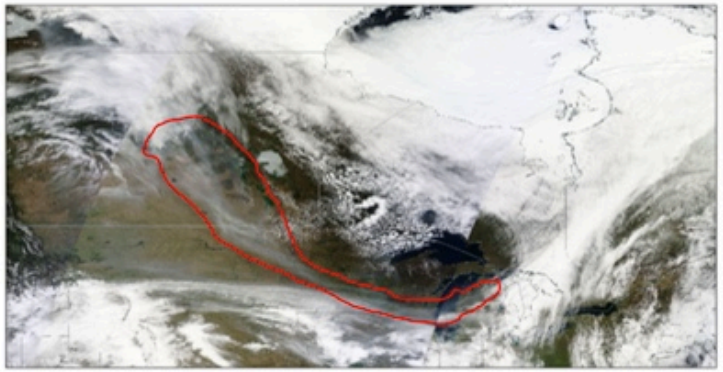
b) Nominal HYSPLIT



c) MISR - Nominal Difference



d) Terra MODIS Truecolor Scene



When the injection height is above the PBL in regions with significant wind shear, MINX-initiated simulations better represent satellite observations.

Vernon et al., AMT 2018

Implementation of MISR BB Injection Height in *GEOS-Chem* Model

MINX-derived global plume height database in 2008
Val Martin et al. (2018)

↓

Statistically derived profiles (%) based on altitude, land cover unit, region, and season

↓

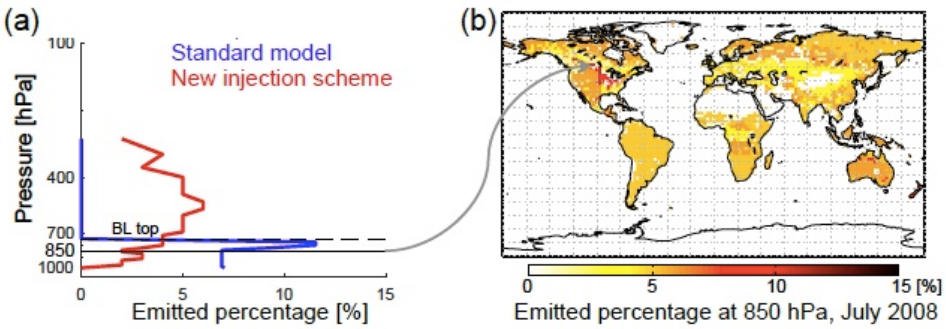
Map native MISR injection altitude distribution (0–8 km, 250 m) to GMAO 47-layer reduced vertical grid (hPa)

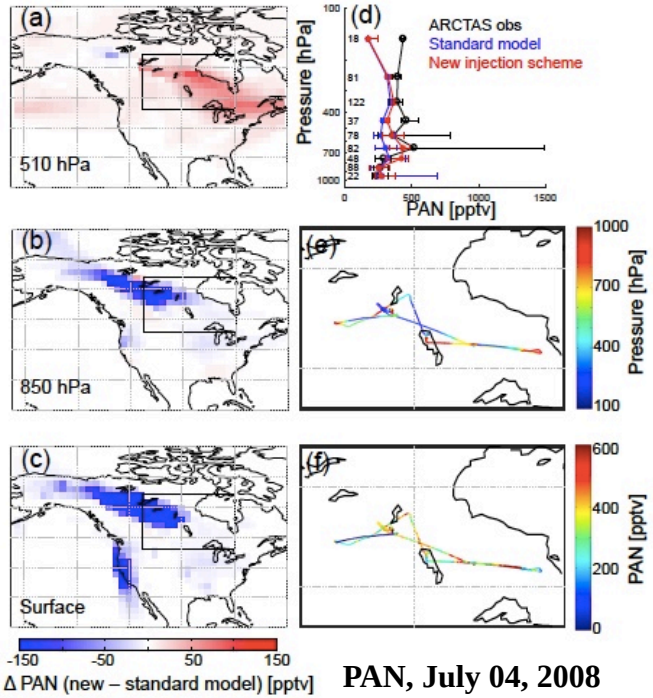
↓

Assign a smoke injection height altitude distribution to GEOS-Chem grid box (2° latitude x 2.5° longitude)

↓

Modify setemis.F in GEOS-Chem (v9.01.01) to distribute biomass burning emissions according to 3-D matrix





PAN, July 04, 2008

Better PAN and CO agreement with ARCTAS aircraft using MISR injection heights

Zhu et al., Geosci. Mdl. Dev. 2018

Key References

Val Martin, M. R.A. Kahn, and M. Tosca, 2018. A Global Climatology of Wildfire Smoke Injection Height Derived from Space-based Multi-angle Imaging. *Remote Sensing 10,* 1609; doi:10.3390/rs10101609.

Gonzalez-Alonso, L., M. Val Martin, and R.A. Kahn, 2018. Biomass burning smoke heights over the Amazon observed from the space. *Atmosph. Chem. Phys*. (*in review*)

Vernon, C.J., R. Bolt, T. Canty, and R.A. Kahn, 2018. The impact of MISR-derived injection-height initialization on wildfire and volcanic plume dispersion in the HySPLIT model. *Atmosph. Meas. Tech.* (*in press*)

Zhu, L., M. Val Martin, A. Hecobian, M.N. Deeter, L.V. Gatti, R.A. Kahn, and E.V. Fischer, 2018. Development and implementation of a new biomass burning emissions injection height scheme for the GEOS-Chem model. *Geosci. Model Develop*. *11*, 4103–4116, doi:10.5194/gmd-11-4103-2018.

https://misr.jpl.nasa.gov/getData/accessData/MisrMinxPlumes2/