National Aeronautics and Space Administration
Goddard Institute for Space Studies
New York, N.Y.

Columbia University
in the City of New York

Fire radiative forcing for preindustrial, present day and future conditions in an interactive Earth System Model

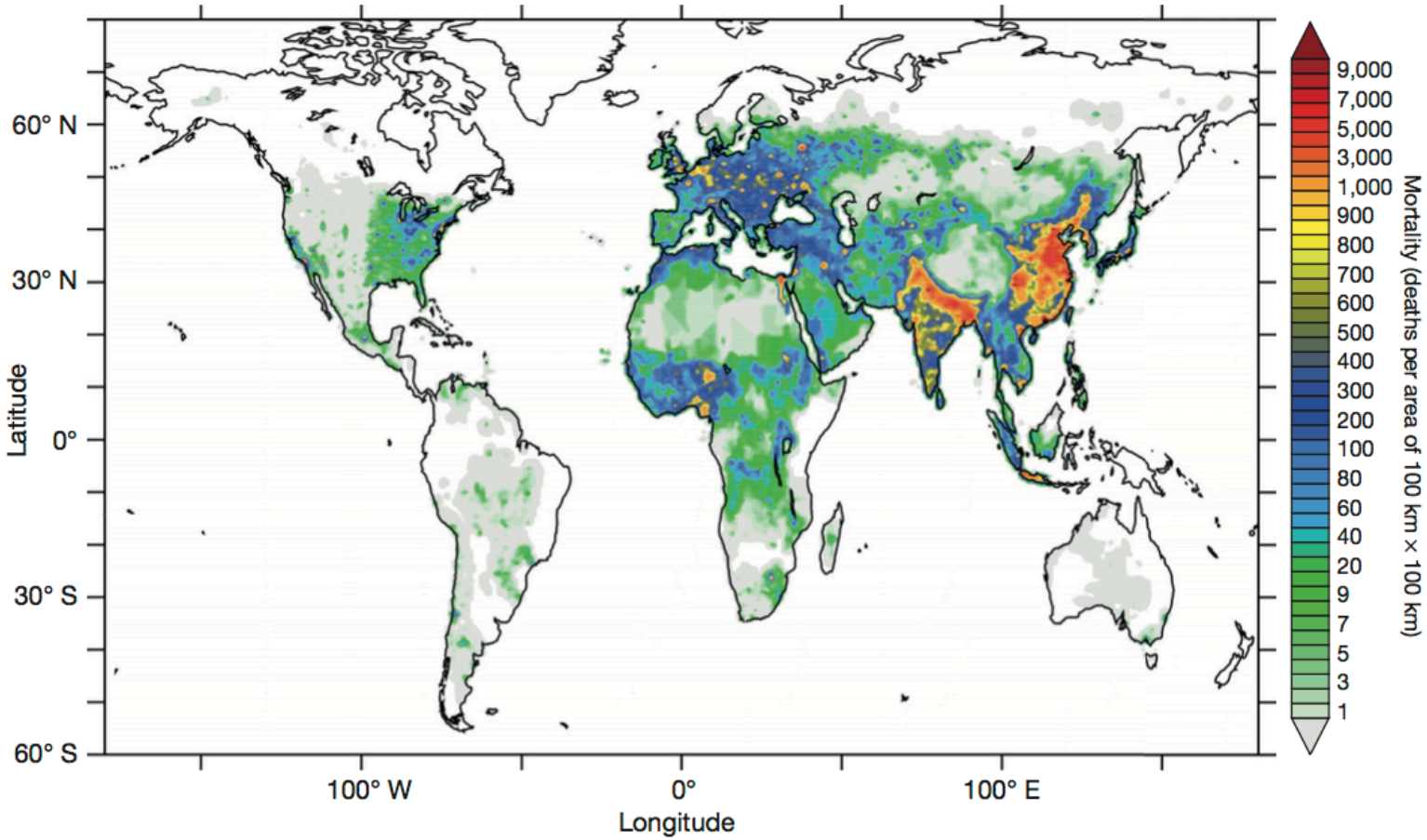
Keren Mezuman

NASA GISS lunch seminar
Nov 30th, 2016

Southeast E USA, Nov 7th 2016 – MODIS (Terra)

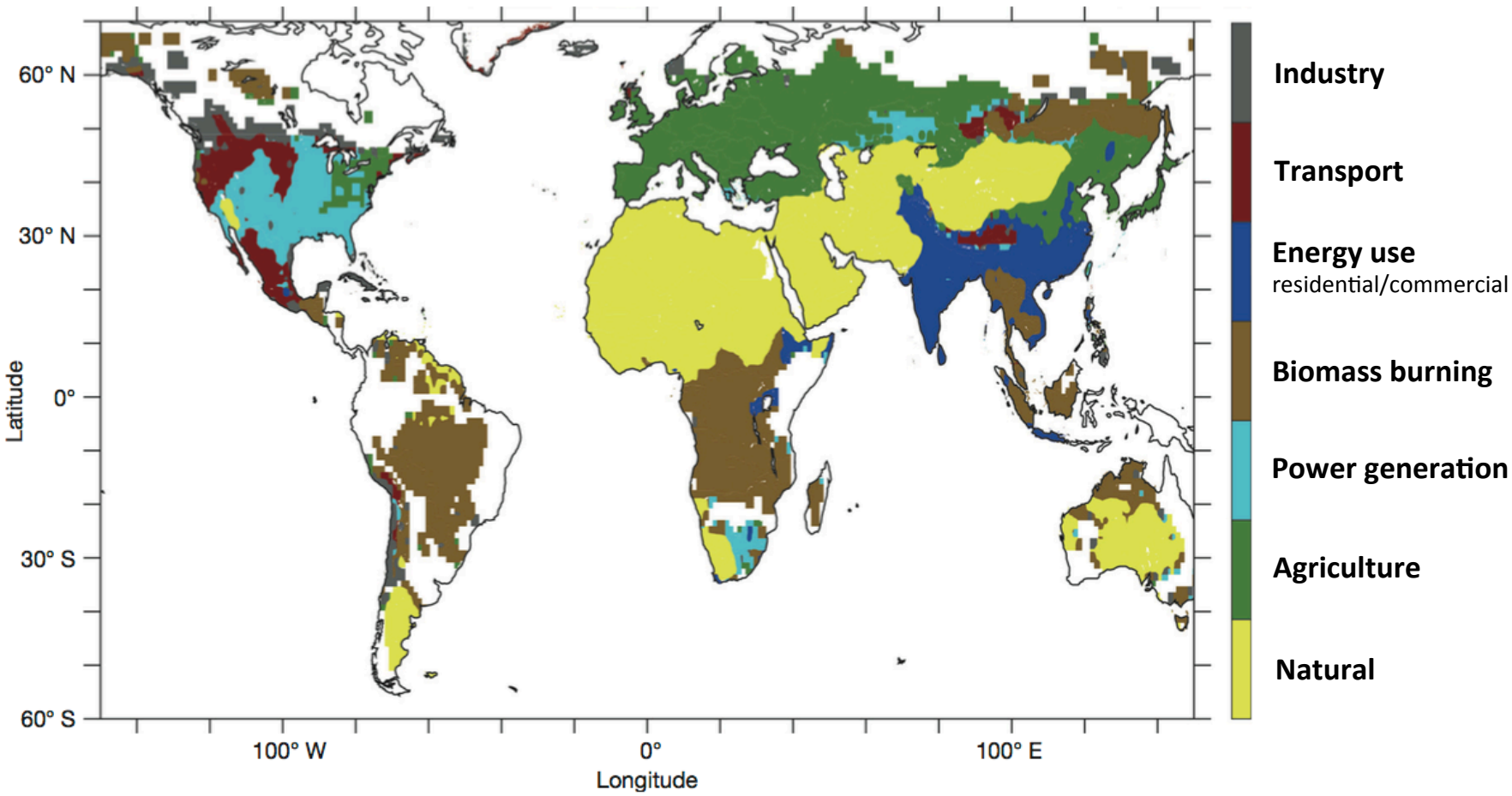
We care about air (and smoke) pollution because it is linked to higher mortality rates

Lelieveld et al., 2015: 2010 global outdoor PM2.5 related mortality was 3.15 million people



In the white areas, annual mean PM2.5 and O3 are below the concentration–response thresholds where no excess mortality is expected

Biomass burning is a major air pollution source, with the strongest impact over the tropical continental chimneys

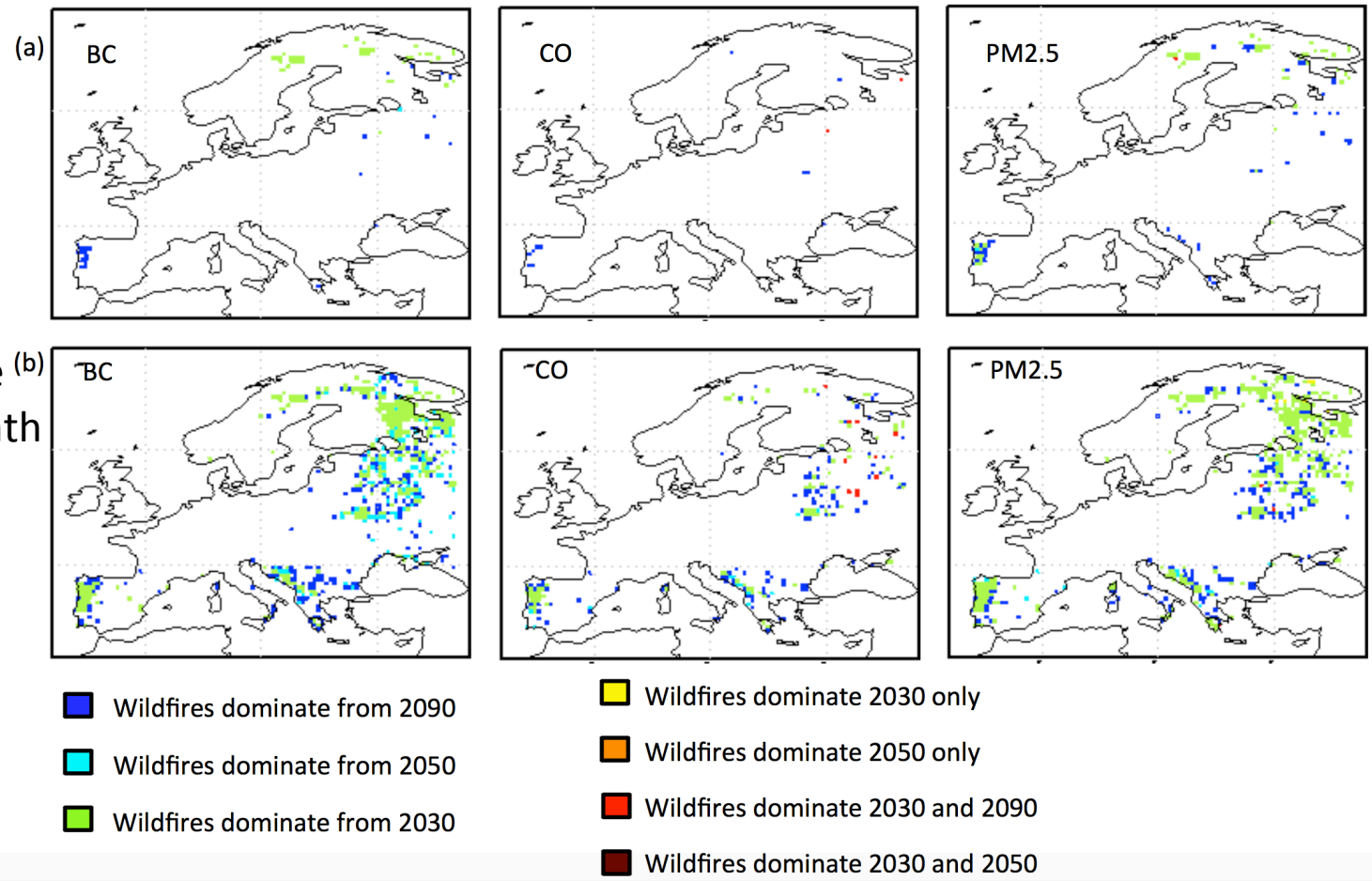


Lelieveld et al., 2015

In the future, European wildfire emissions could exceed anthropogenic emissions in some areas

(a) Annual

(b) Peak fire season month



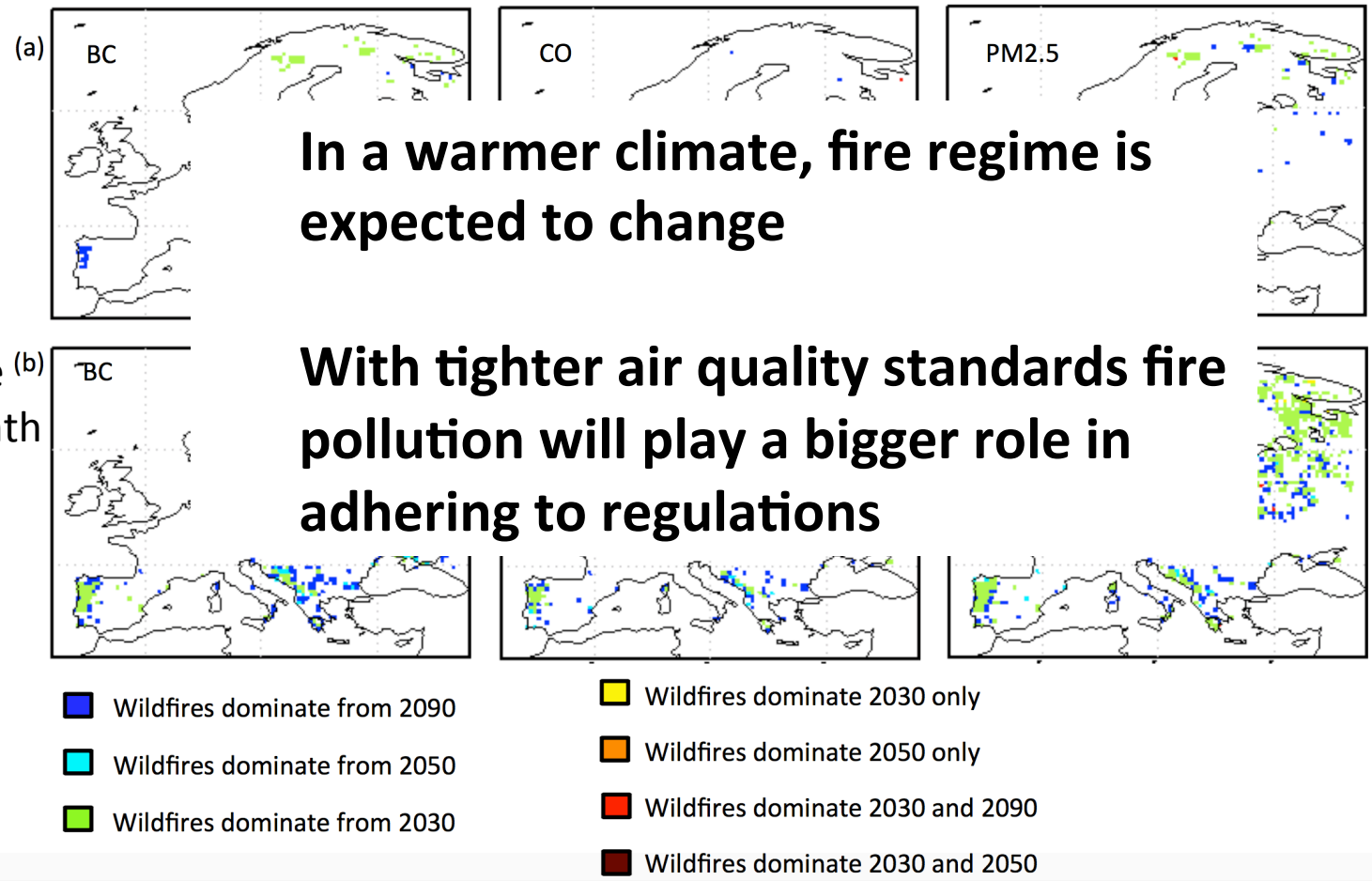
Knorr et al., 2016

LPJ-GUESS-SIMFIRE driven by eight-ESM ensemble mean (CMIP5)

In the future, European wildfire emissions are projected to exceed anthropogenic emissions in some areas

(a) Annual

(b) Peak fire season month



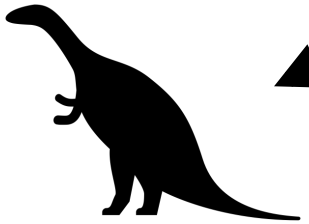
In a warmer climate, fire regime is expected to change

With tighter air quality standards fire pollution will play a bigger role in adhering to regulations

Knorr et al., 2016
LPJ-GUESS-SIMFIRE driven by eight-ESM ensemble mean (CMIP5)

Fire emission inventories are useful for the period of satellite coverage (present day)

simulating fires at present day will allow us to study other time periods

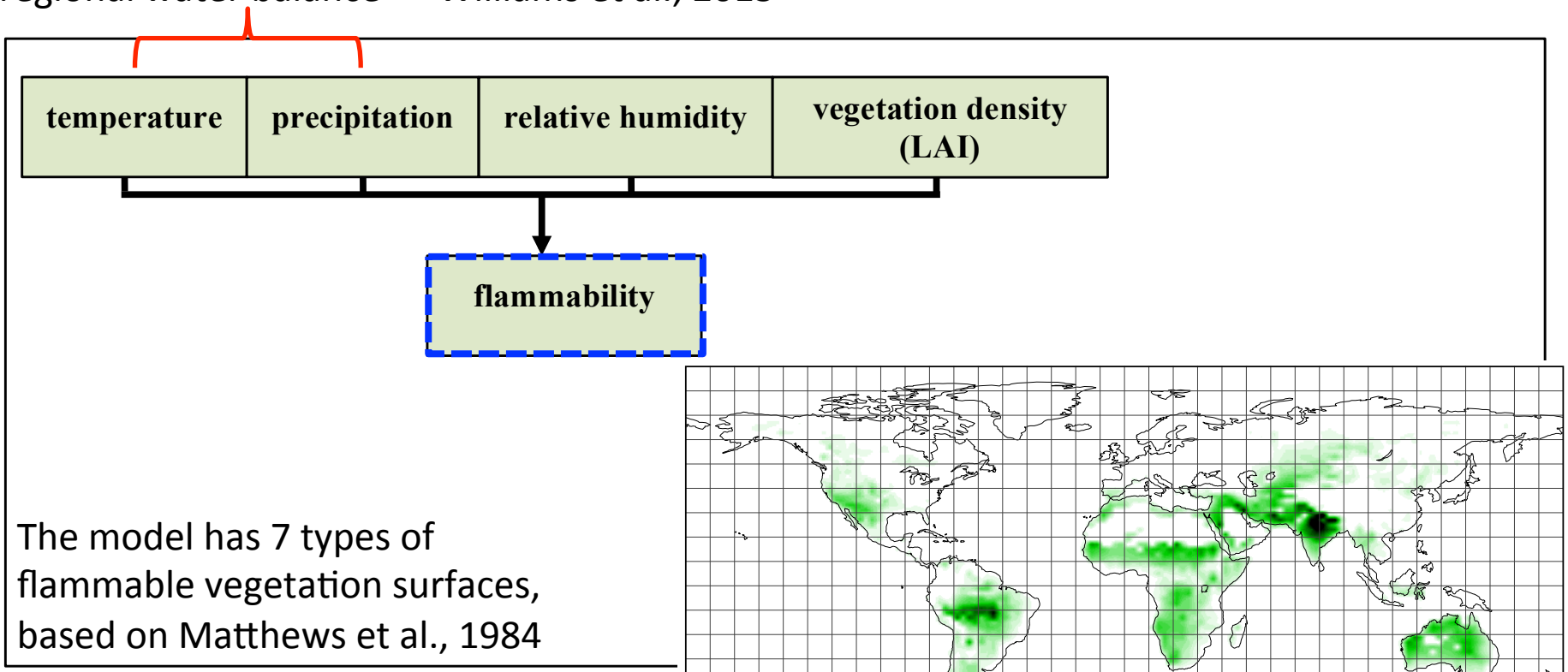


past

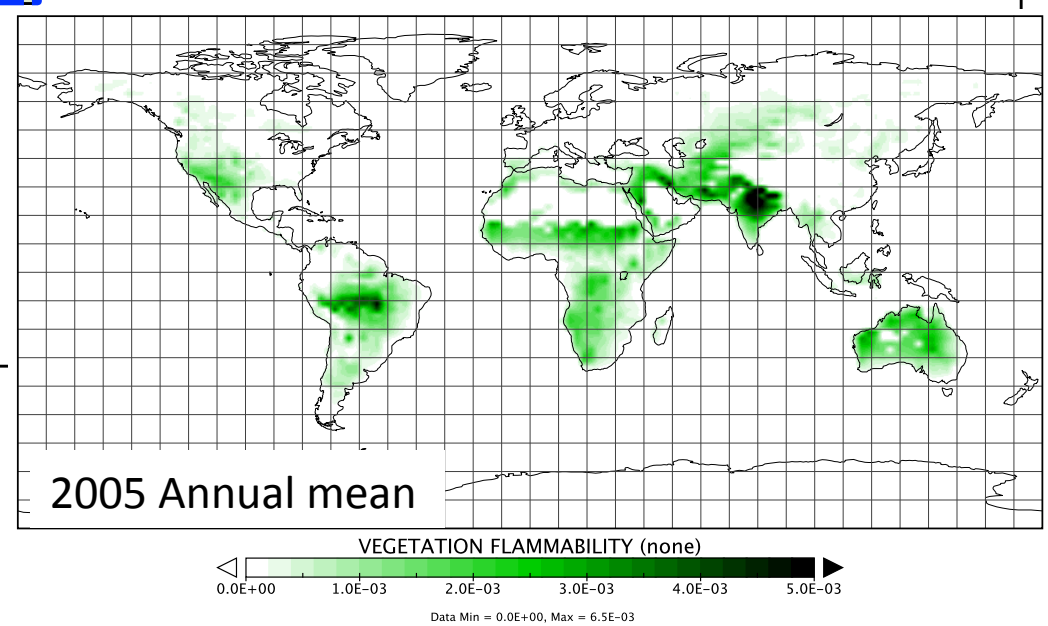
future

NASA-GISSFireE
Initial fire conditions set by flammability

"VPD appears to be a simple and holistic indicator of regional water balance" – Williams et al., 2015

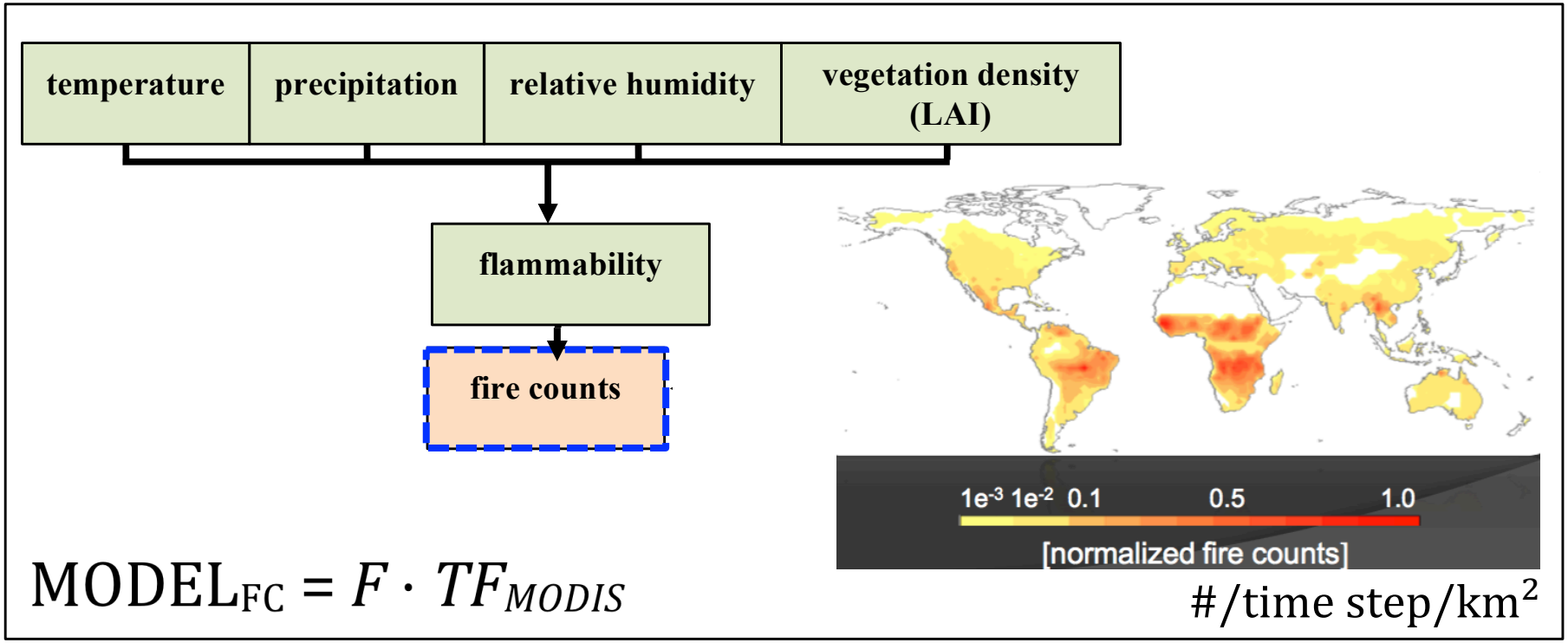


The model has 7 types of flammable vegetation surfaces, based on Matthews et al., 1984



Pechony and Shindell (2009, 2010)
Pechony, Shindell and Faluvegi (2013)

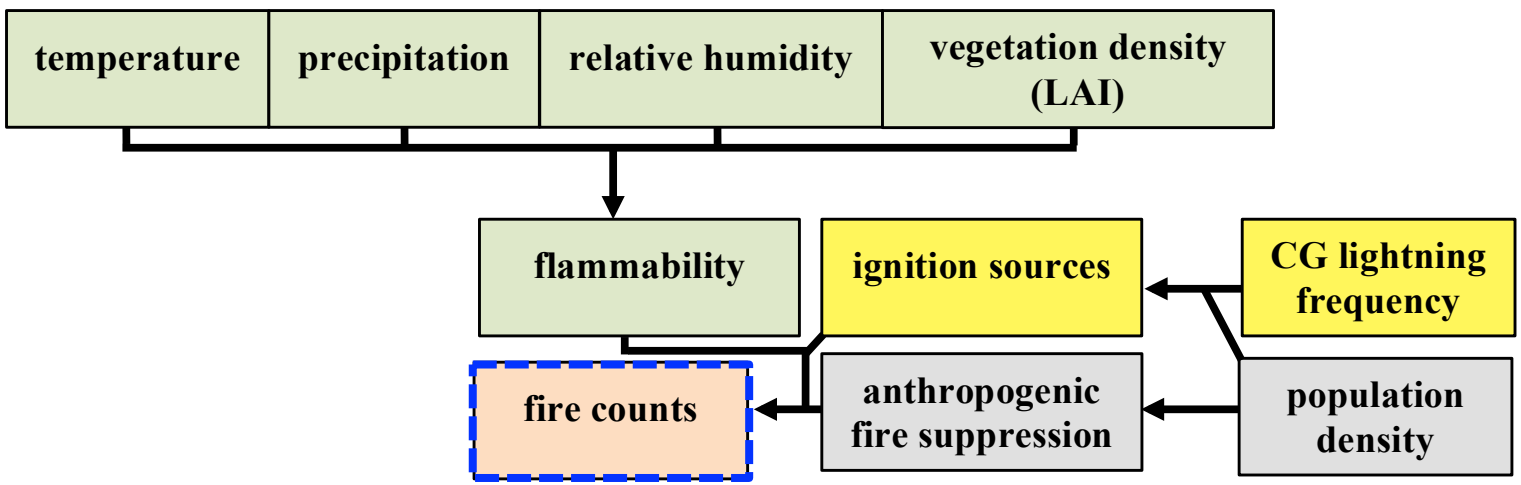
1st model flavor: tuned against MODIS



Tuning factor based on MODIS fire counts

Pechony and Shindell (2009, 2010)
Pechony, Shindell and Faluvegi (2013)

2nd model flavor: adding ignition and suppression

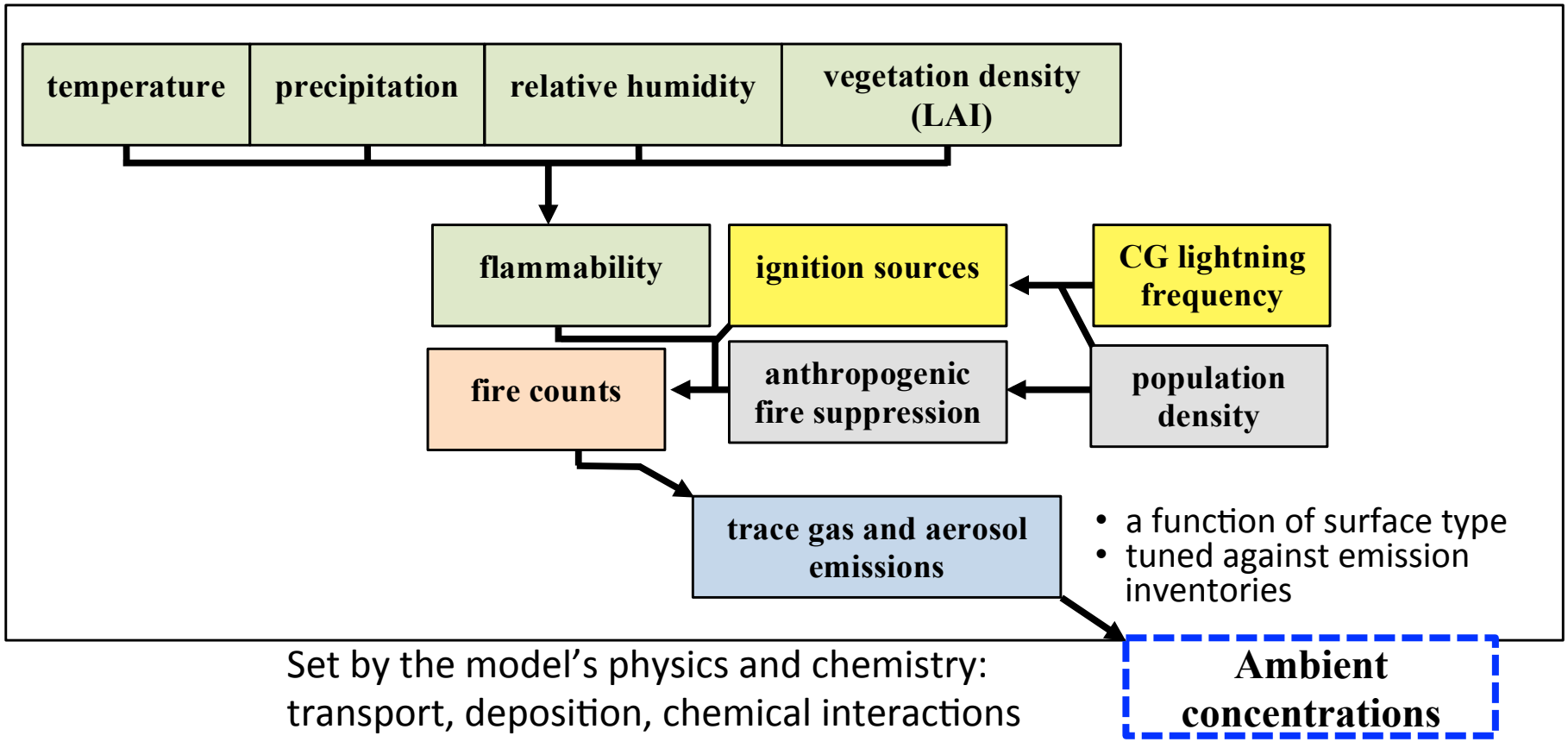


$$\mathrm{MODEL_{FC}} = F \cdot TF_{MODIS} \cdot (I_N + I_A) \cdot f_{NS}$$

#/time step/km^2

Pechony and Shindell (2009, 2010)
Pechony, Shindell and Faluvegi (2013)

Fires affect atmospheric composition through emissions



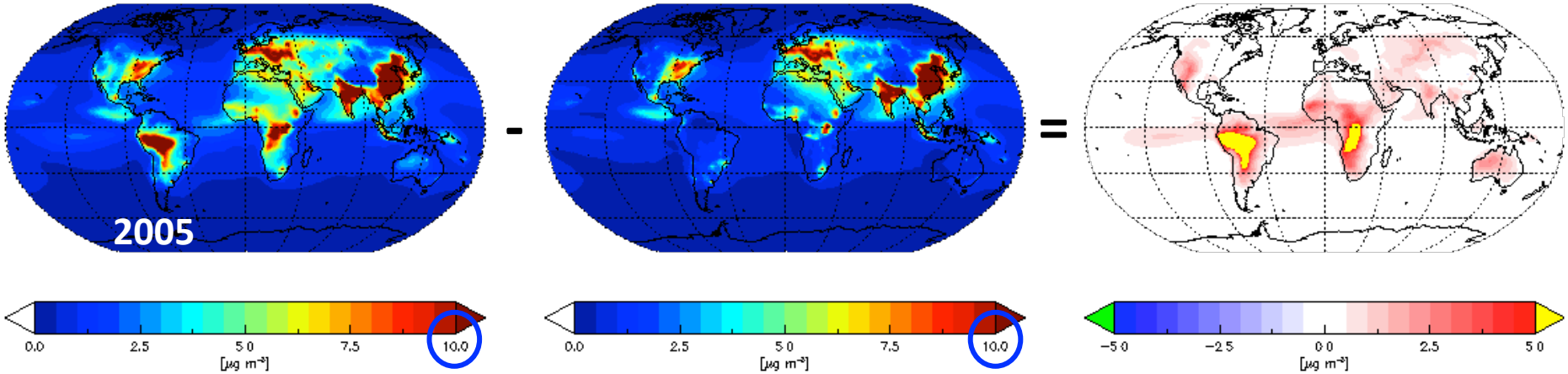
Set by the model's physics and chemistry: transport, deposition, chemical interactions

Pechony and Shindell (2009, 2010)
Pechony, Shindell and Faluvegi (2013)

Fire pollution (surface PM2.5) is dominating in the tropical continental chimneys

*excluding mineral dust and sea salt, 2005 annual climatological mean

(Ignition & suppression) - (0 fire) = fire pollution

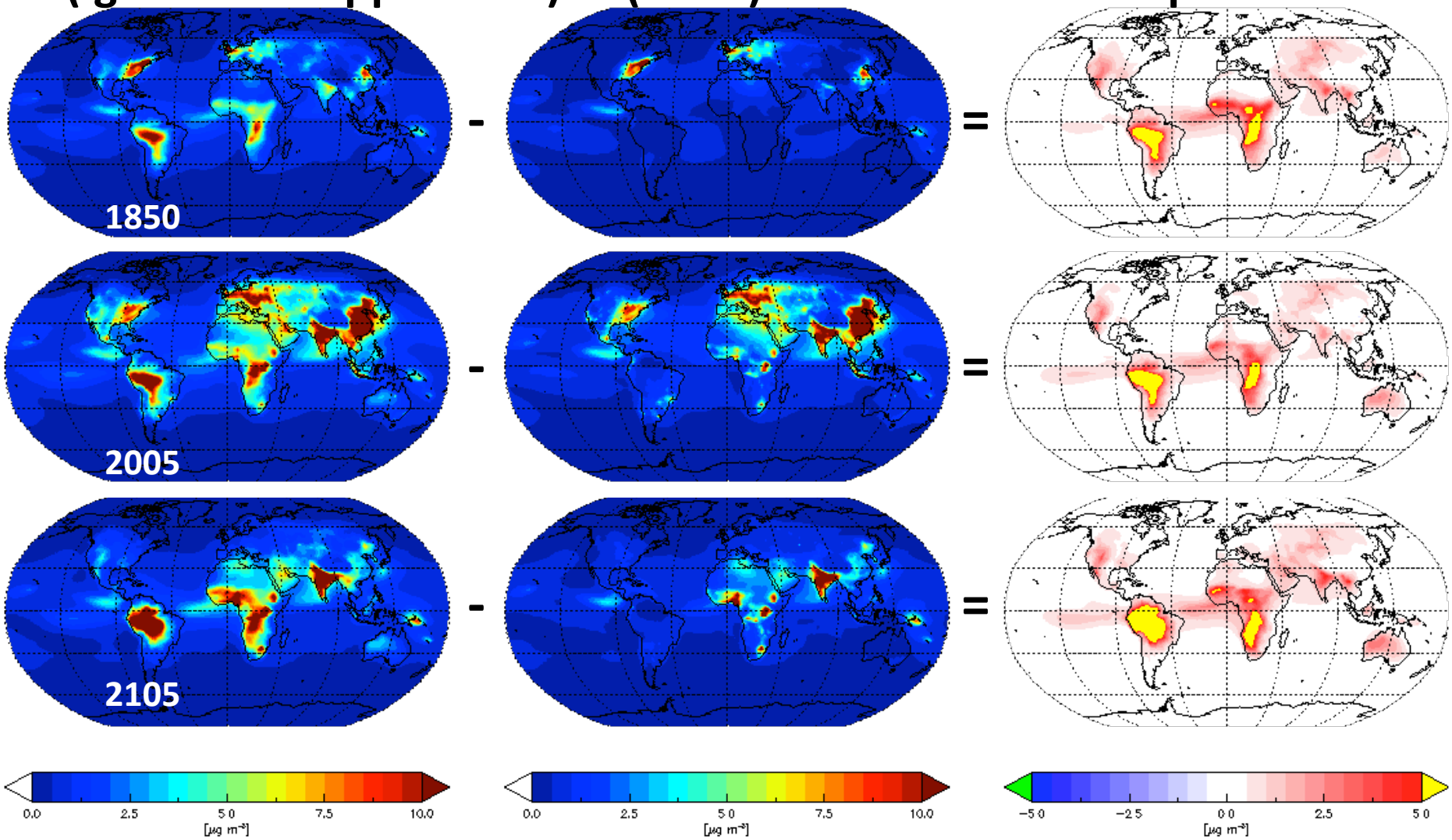


WHO annual mean standard for PM2.5

Consistent (annual) fire pollution (surface PM2.5) in the past and future

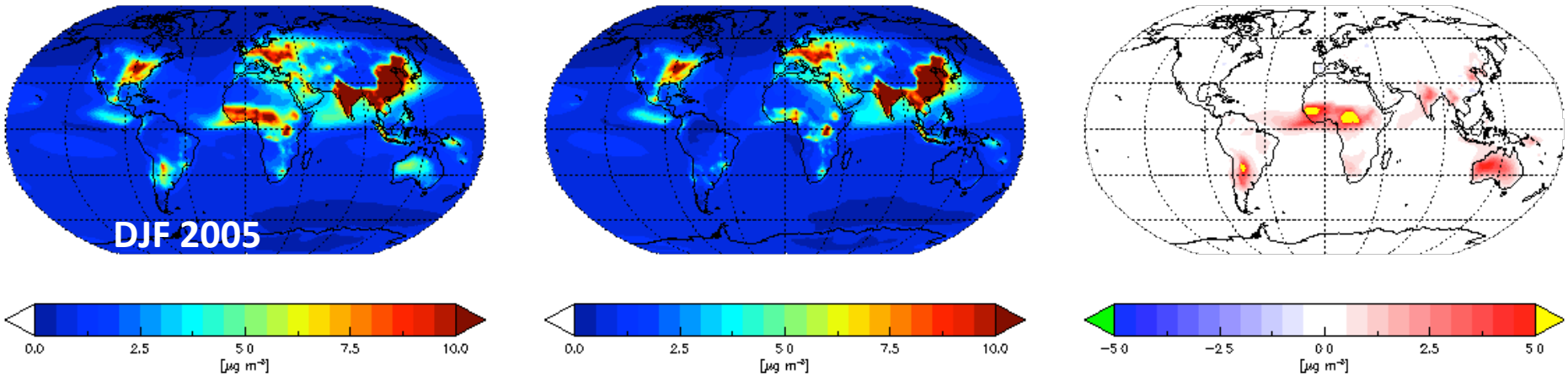
*excluding mineral dust and sea salt

(Ignition & suppression) - (0 fire) = fire pollution



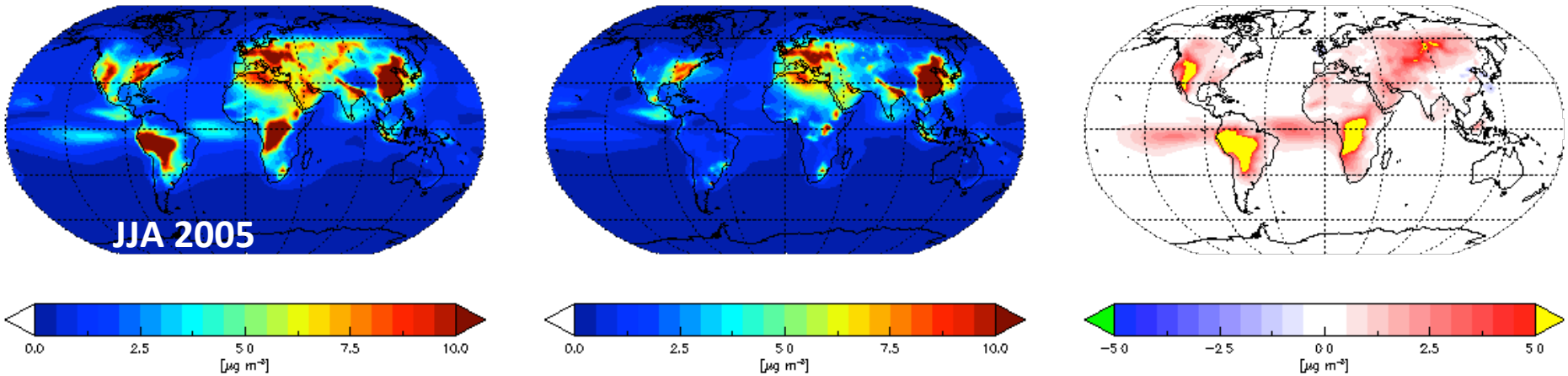
Seasonally (DJF), significant increases in surface PM2.5 due to fires in Argentina, sub-Saharan Africa, India, and Australia

(Ignition & suppression) - (0 fire) = fire pollution



Seasonally (JJA), BB pollution has a strong signal in WUSA, central south America, central Africa and Russia

(Ignition & suppression) - (0 fire) = fire pollution



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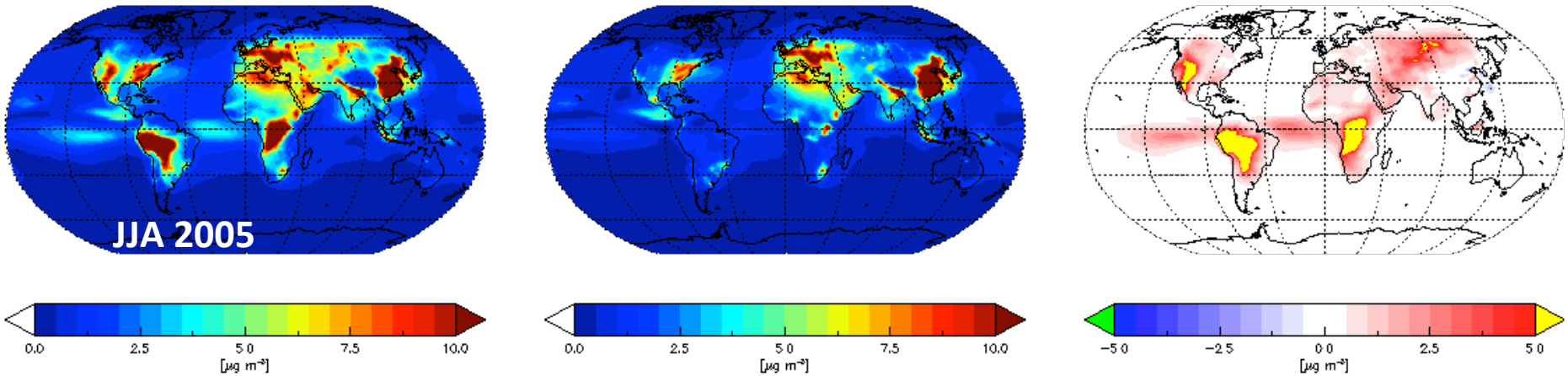

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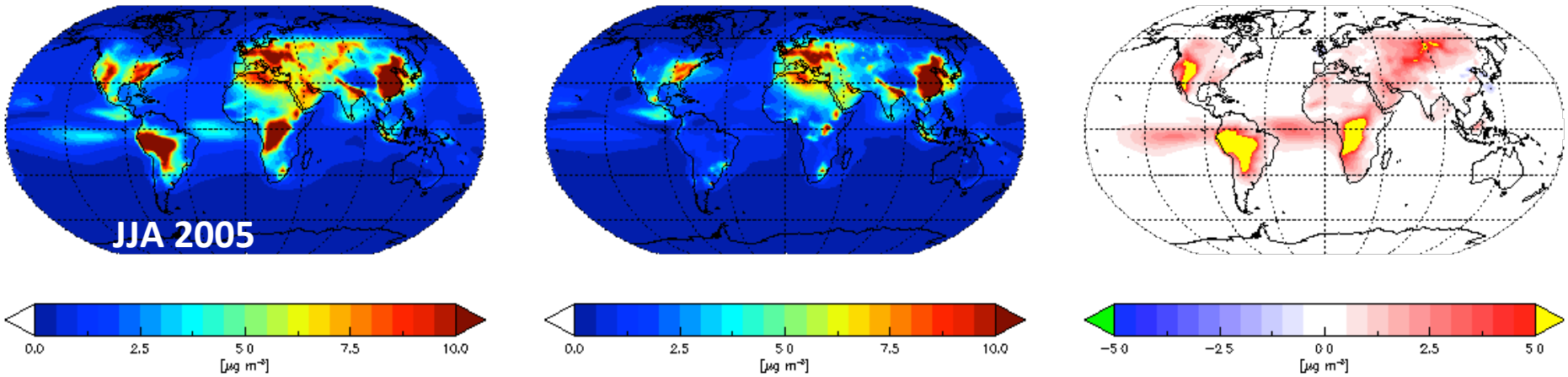
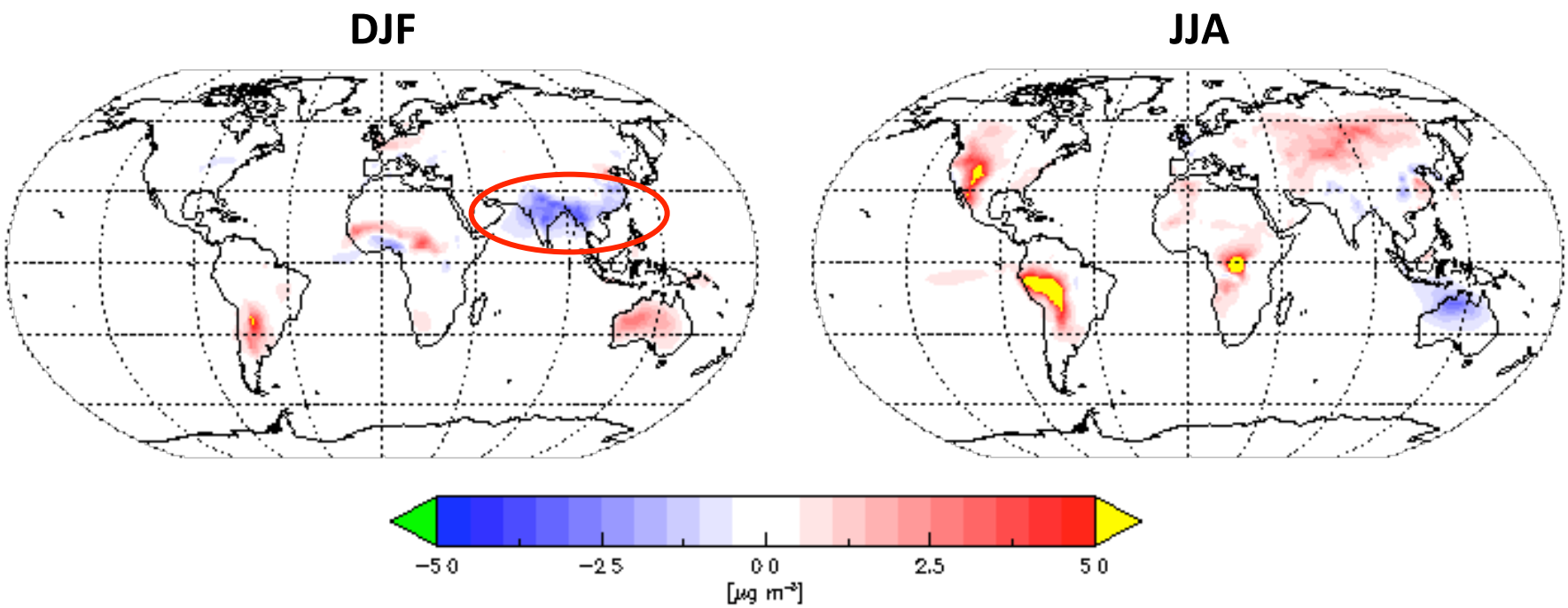


What else can we learn about fire pollution?

Differences b/t the two flavors of the model reflect anthropogenic fire pollution as well as differences in lightning activity

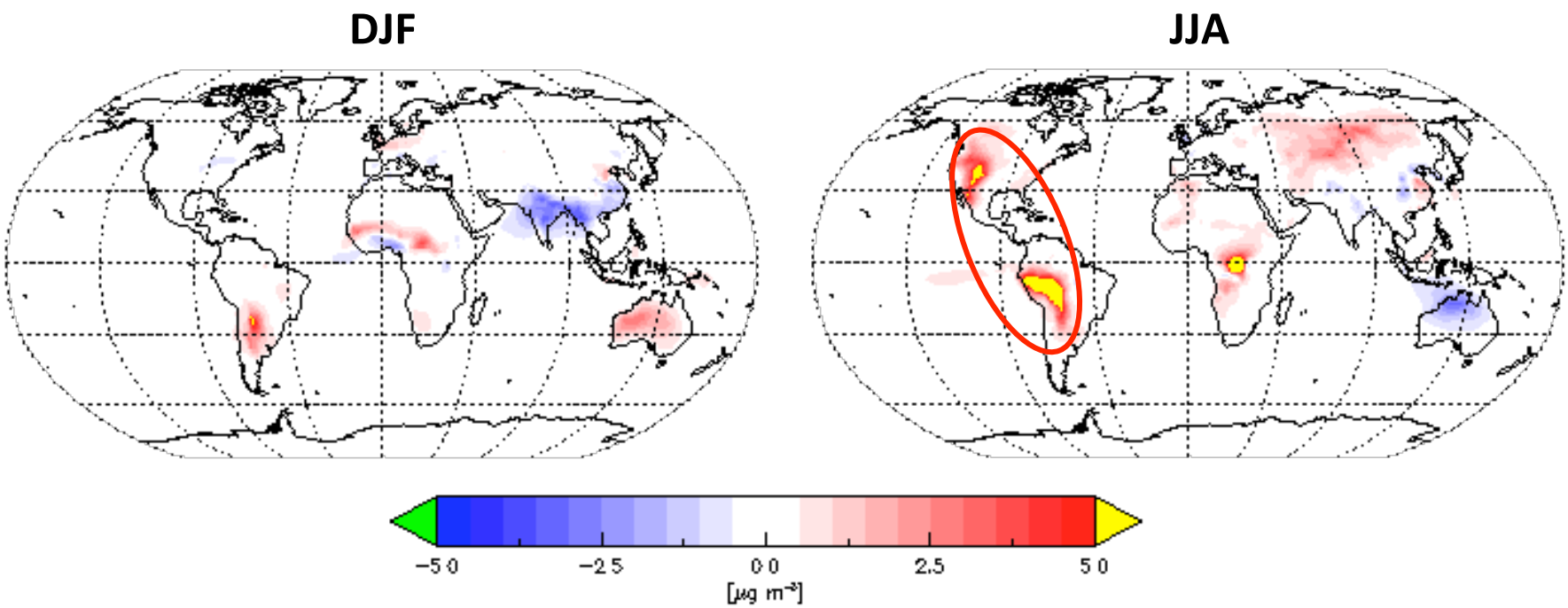
***Surface PM2.5 excluding mineral dust and sea salt, 2005 seasonal climatological mean**



Less pollution over SE Asia due to <u>fire suppression</u>

Differences b/t the two flavors of the model reflect anthropogenic fire pollution as well as differences in lightning activity

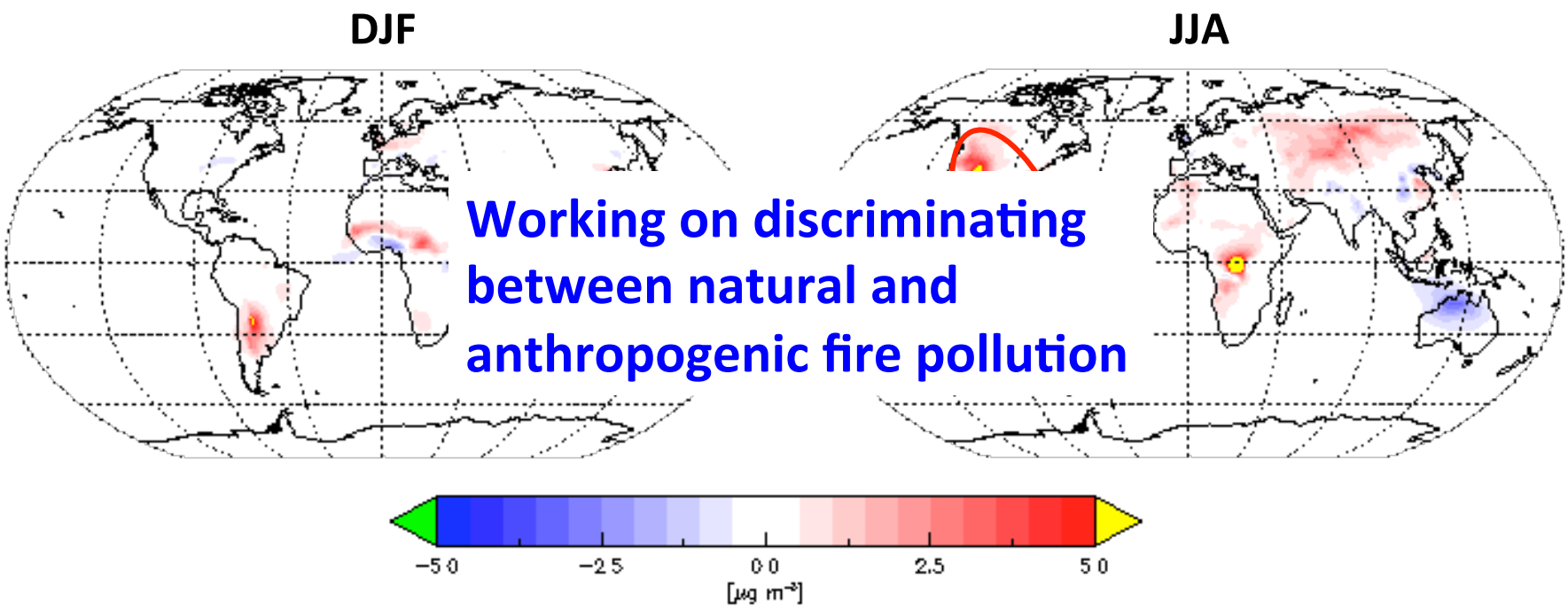
***Surface PM2.5 excluding mineral dust and sea salt, 2005 seasonal climatological mean**



Increased pollution over the Amazon and WUSA due to <u>ignition</u>

Differences b/t the two flavors of the model reflect anthropogenic fire pollution as well as differences in lightning activity

***Surface PM2.5 excluding mineral dust and sea salt, 2005 seasonal climatological mean**



More pollution over the Amazon and WUSA due to <u>ignition</u>

Conclusions

- In a future world we expect:
  - Warmer climate -> More fires
  - **Tighter air quality standards -> fires play a bigger role**
- Fire pollution is **dominating in the tropical continental chimneys**, consistent over the PI, PD and future, and with Lelieveld et al., 2015
- Seasonally, **BB is a major source of pollution** in the NH and sub-Saharan Africa.
- Fire **suppression decreases air pollution** over India.
  - **Discriminating b/t natural and anthropogenic fires** is important for studying air pollution

AGU FALL MEETING

San Francisco | 12–16 December 2016

SESSION

GC42C: The Role of Fire in the Earth System: Understanding Drivers, Feedbacks, and Interactions with the Land, Atmosphere, and Society II

Thursday, 15 December 2016 **10:20 - 12:20**

Moscone West - 3001

12:05

GC42C-08 Fire radiative forcing for preindustrial, present day and future conditions in an interactive Earth System Model

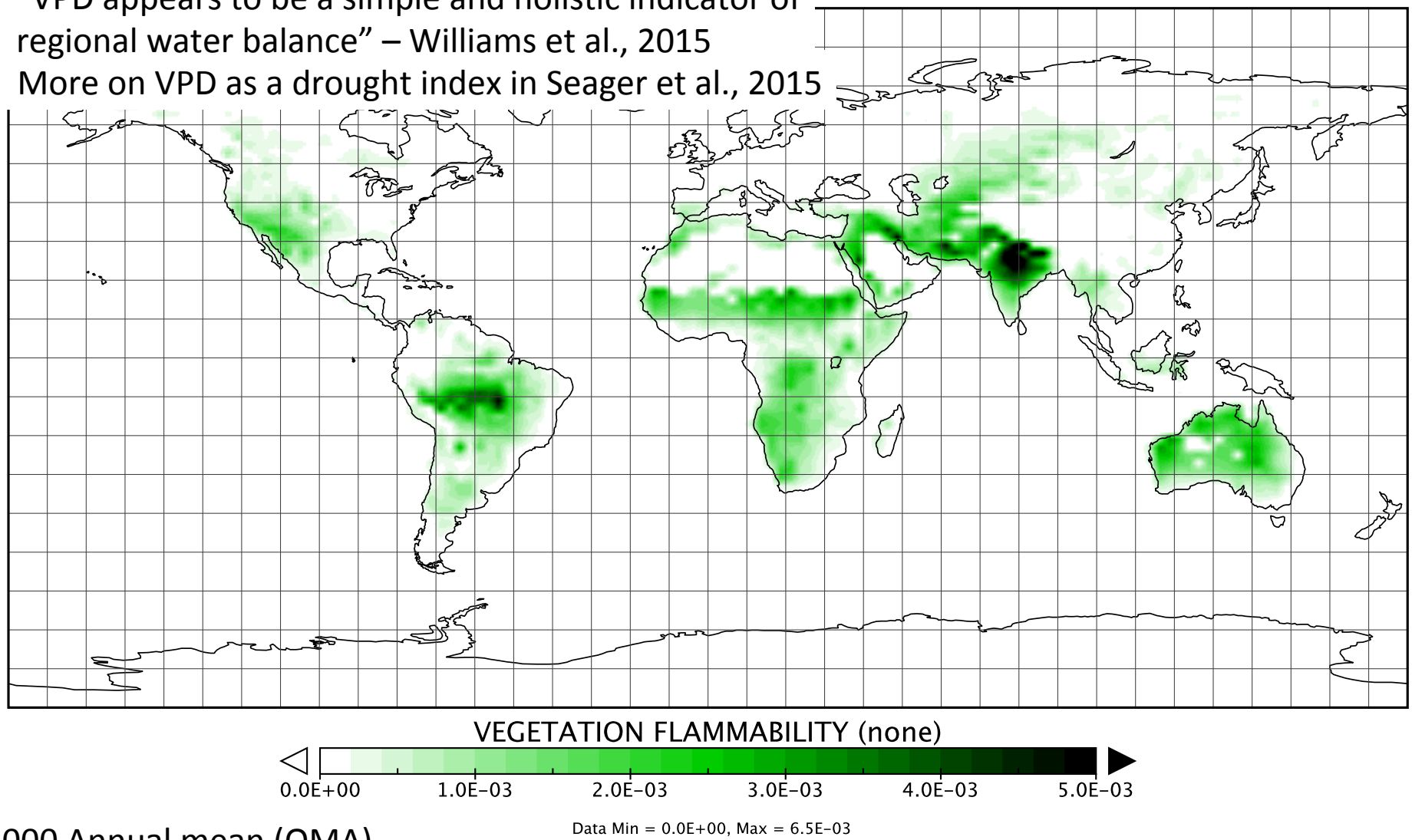
Keren Mezuman[1,2], *Susanne Bauer*[2,3] *and Kostas Tsigaridis*[2,3], *(1)Columbia University of New York, Palisades, NY, United States, (2)NASA Goddard Institute for Space Studies, New York, NY, United States, (3)Center for Climate Systems Research, Columbia University, New York, NY, United States*

Extra Slides

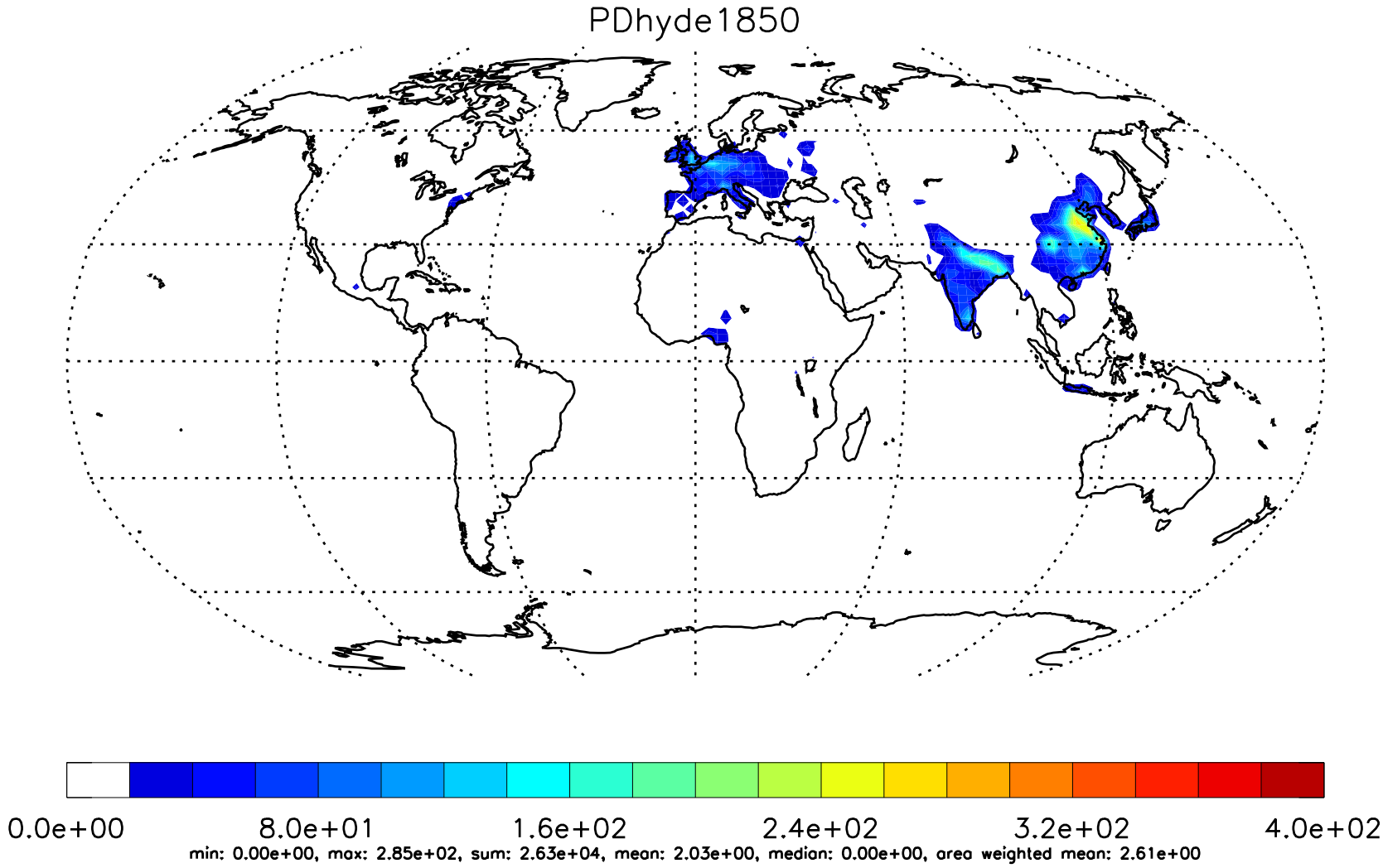
$$F(t)_{i,j} = \overbrace{\underbrace{10^{Z(\boldsymbol{T}(t)_{i,j})}}_{Goff-Gratch:\, e_s} \left(1 - \frac{\boldsymbol{RH}(t)_{i,j}}{100}\right)}^{vapor\ pressure\ deficit = e_s - e} \overbrace{\boldsymbol{VD}(t)_{i,j}}^{vegetation\ density} \exp\left(-c_R \overbrace{\boldsymbol{R}(t)_{i,j}}^{surface\ rain\ rate}\right)$$

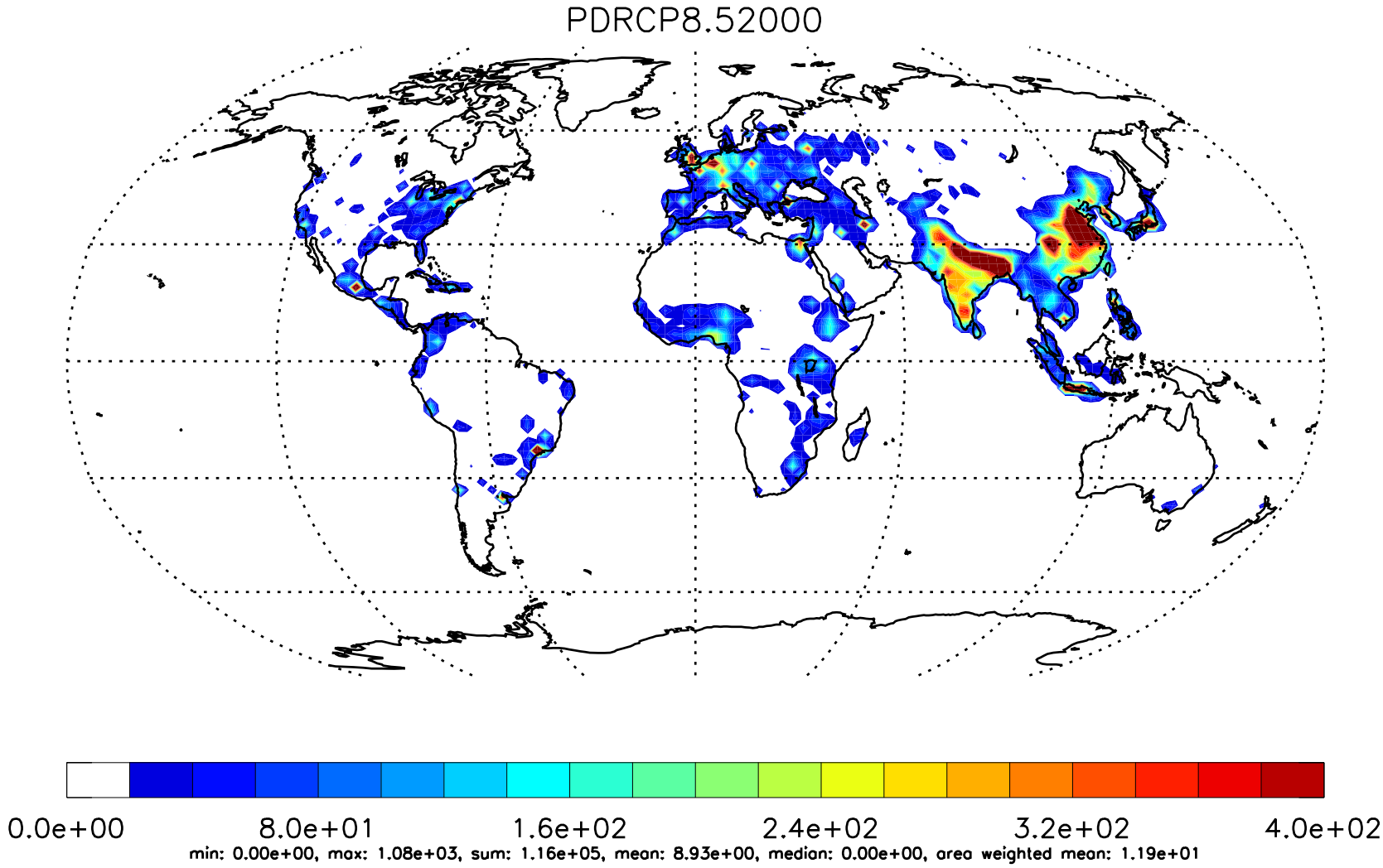
"VPD appears to be a simple and holistic indicator of regional water balance" – Williams et al., 2015

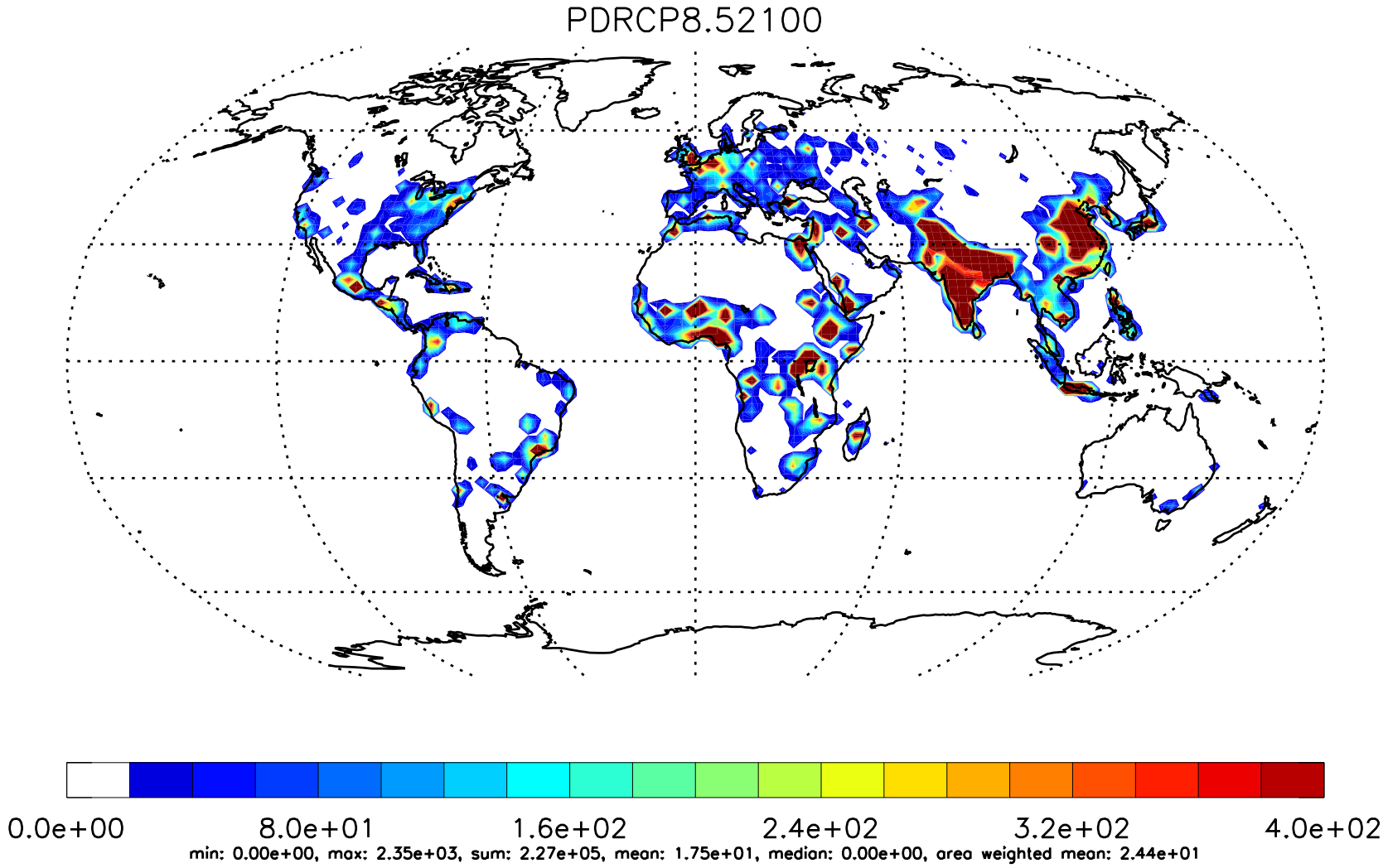
More on VPD as a drought index in Seager et al., 2015



2000 Annual mean (OMA)


PDhyde1850
0.0e+00
8.0e+01
1.6e+02
2.4e+02
3.2e+02
4.0e+02
min: 0.00e+00, max: 2.85e+02, sum: 2.63e+04, mean: 2.03e+00, median: 0.00e+00, area weighted mean: 2.61e+00


PDRCP8.52000
0.0e+00
8.0e+01
1.6e+02
2.4e+02
3.2e+02
4.0e+02
min: 0.00e+00, max: 1.08e+03, sum: 1.16e+05, mean: 8.93e+00, median: 0.00e+00, area weighted mean: 1.19e+01


PDRCP8.52100
0.0e+00
8.0e+01
1.6e+02
2.4e+02
3.2e+02
4.0e+02
min: 0.00e+00, max: 2.35e+03, sum: 2.27e+05, mean: 1.75e+01, median: 0.00e+00, area weighted mean: 2.44e+01