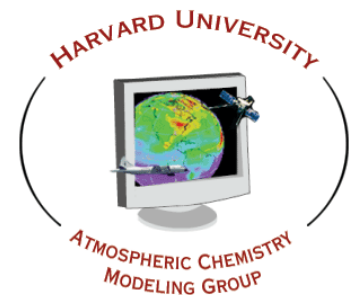


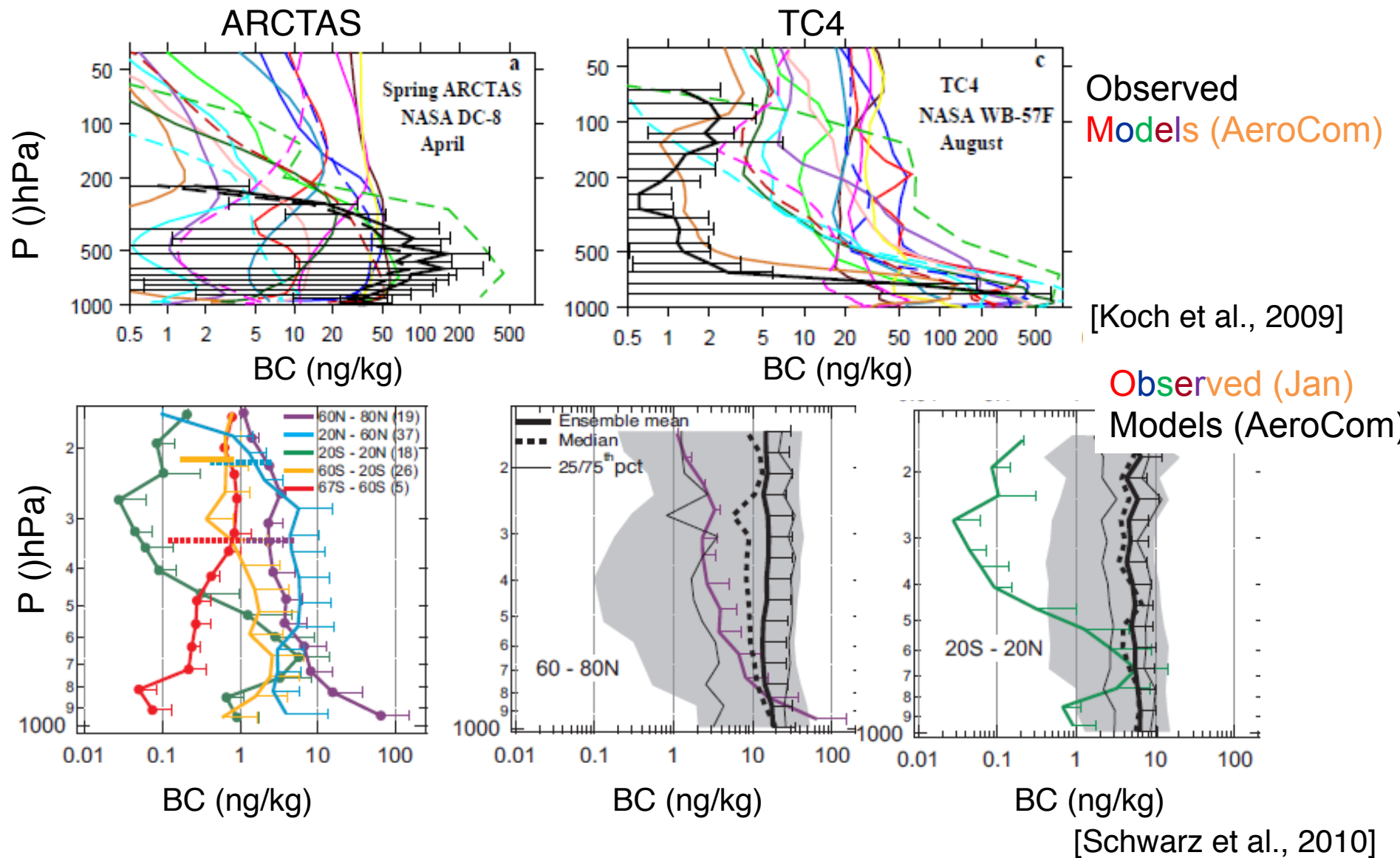
# Global budget of black carbon: constraints from HIPPO

Qiaoqiao Wang, Daniel Jacob, Ryan Spackman,  
Joshua Schwarz and HIPPO science team  
HIPPO Science Meeting, Mar 12<sup>th</sup>, 2012

Research funded by NSF



# Multimodel intercomparisons and comparisons to observations



- Models differ by order of magnitude, do not reproduce observed gradients
- Differences reflect treatment in scavenging

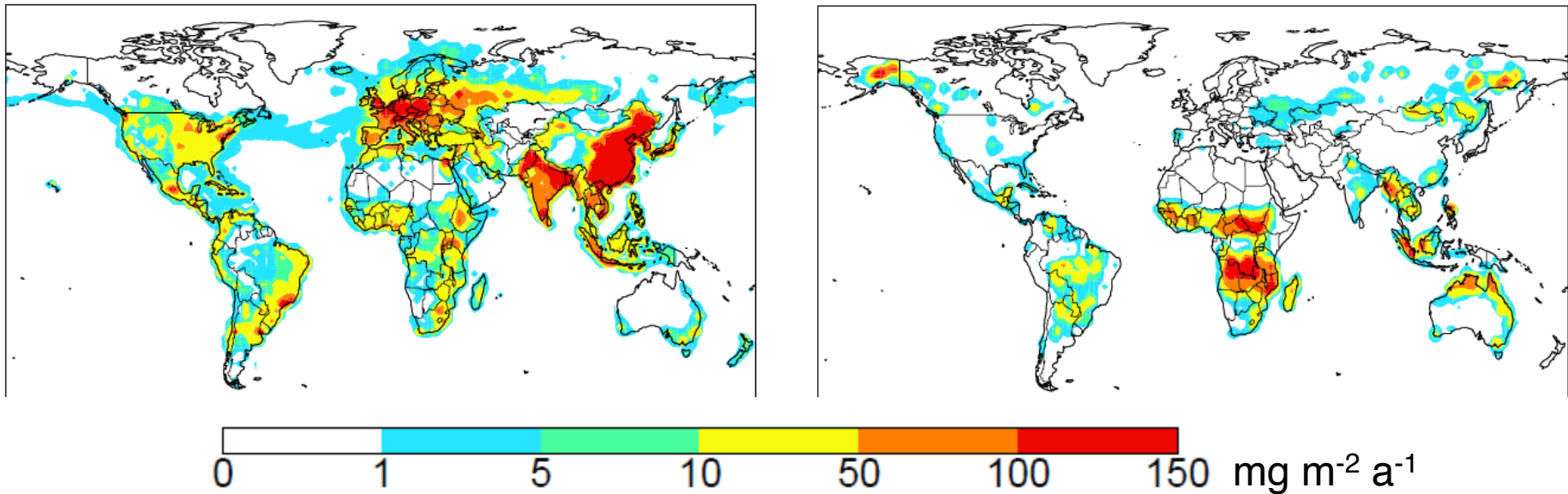
# Global BC simulation in GEOS-Chem

- $2^\circ \times 2.5^\circ$  resolution, 47 vertical levels, GEOS-5 meteorological data
- Anthropogenic and biomass burning (GFED3) emissions w/monthly resolution (aircraft emissions are not included yet)

## BC emissions in 2009

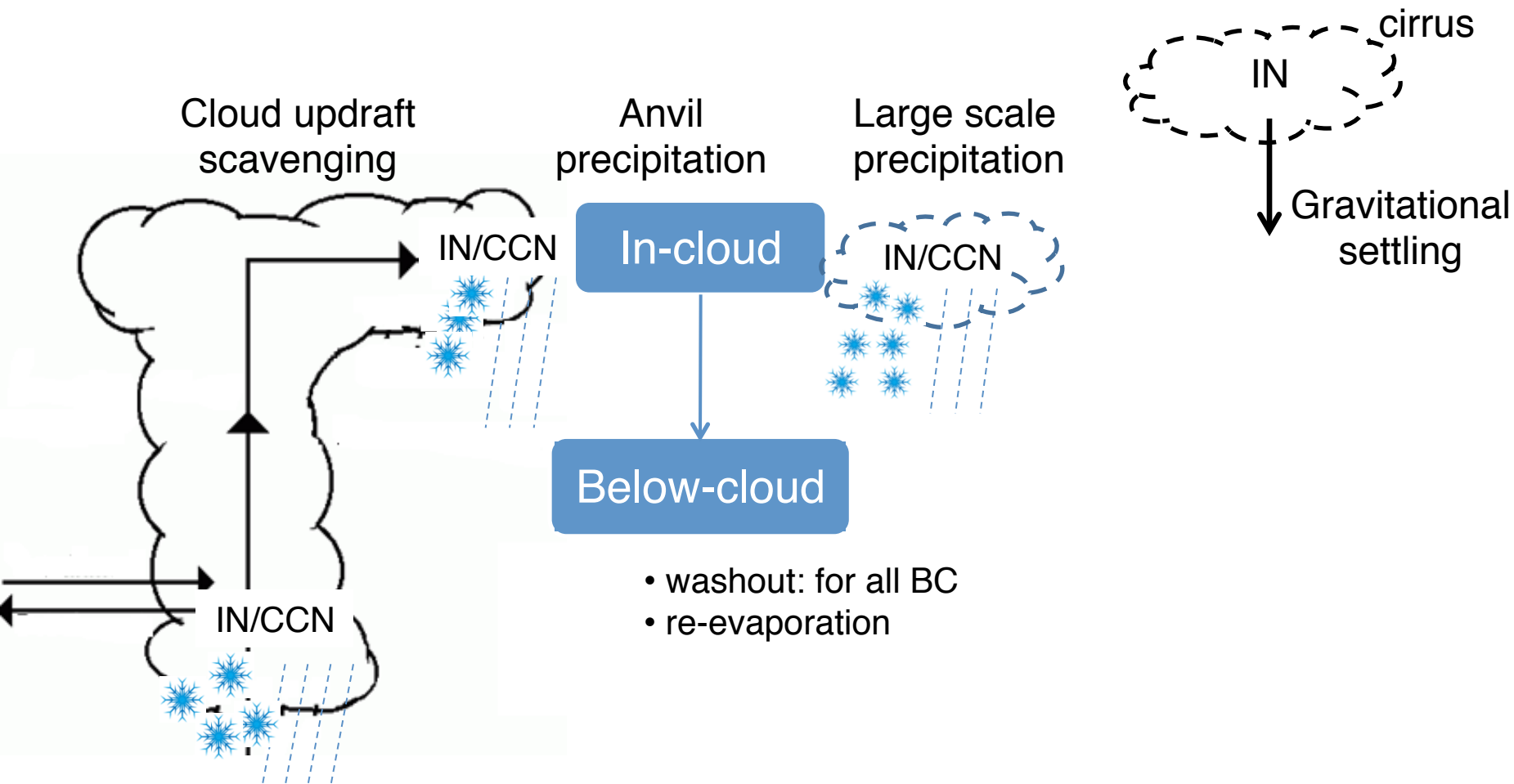
Anthropogenic ( $4.9 \text{ Tg a}^{-1}$ )

Open fires ( $1.6 \text{ Tg a}^{-1}$ )



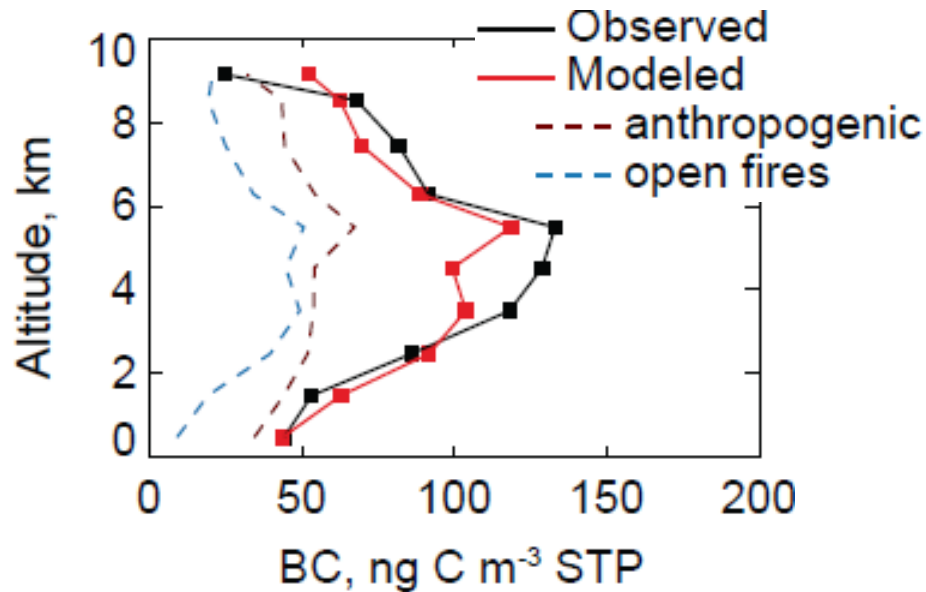
- Anthropogenic emission dominates globally, biomass burning may dominate regionally and seasonally
- Anthropogenic emissions previously evaluated with surface networks in US, Europe, East Asia; error is  $\pm 40\%$

# BC removal in GEOS-Chem

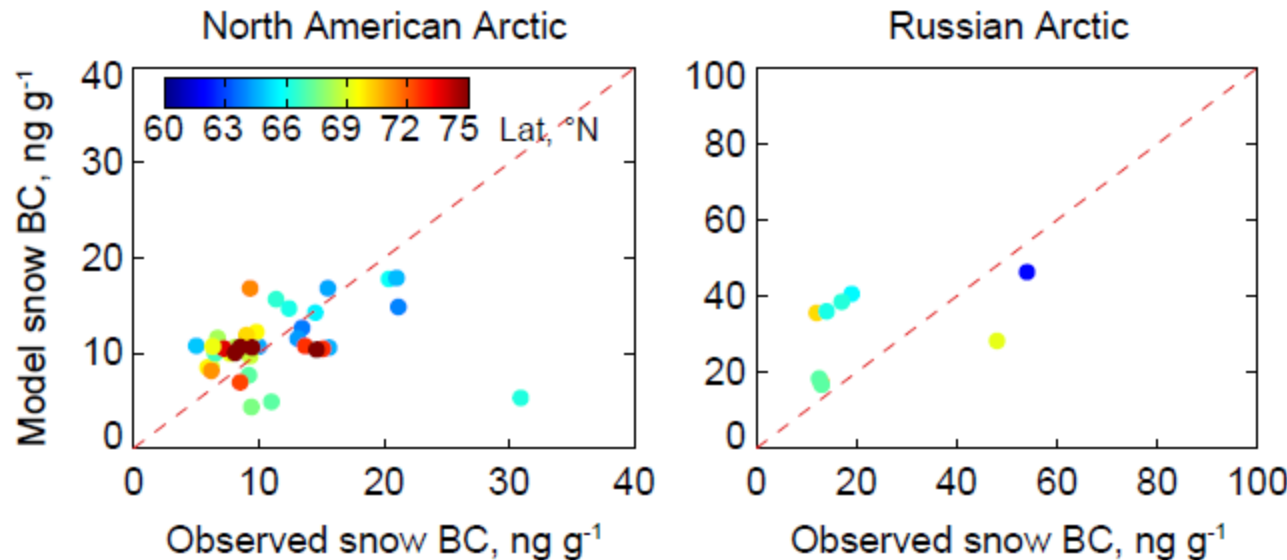


- BC removal is mainly by wet deposition with hydrophobic/hydrophilic distinction
- Scavenging scheme previously evaluated with aerosol surface/aircraft observations
- Use HIPPO to evaluate sensitivity to BC CCN/IN assumptions, cirrus precipitation

# Previous application to Arctic spring (ARCTAS)

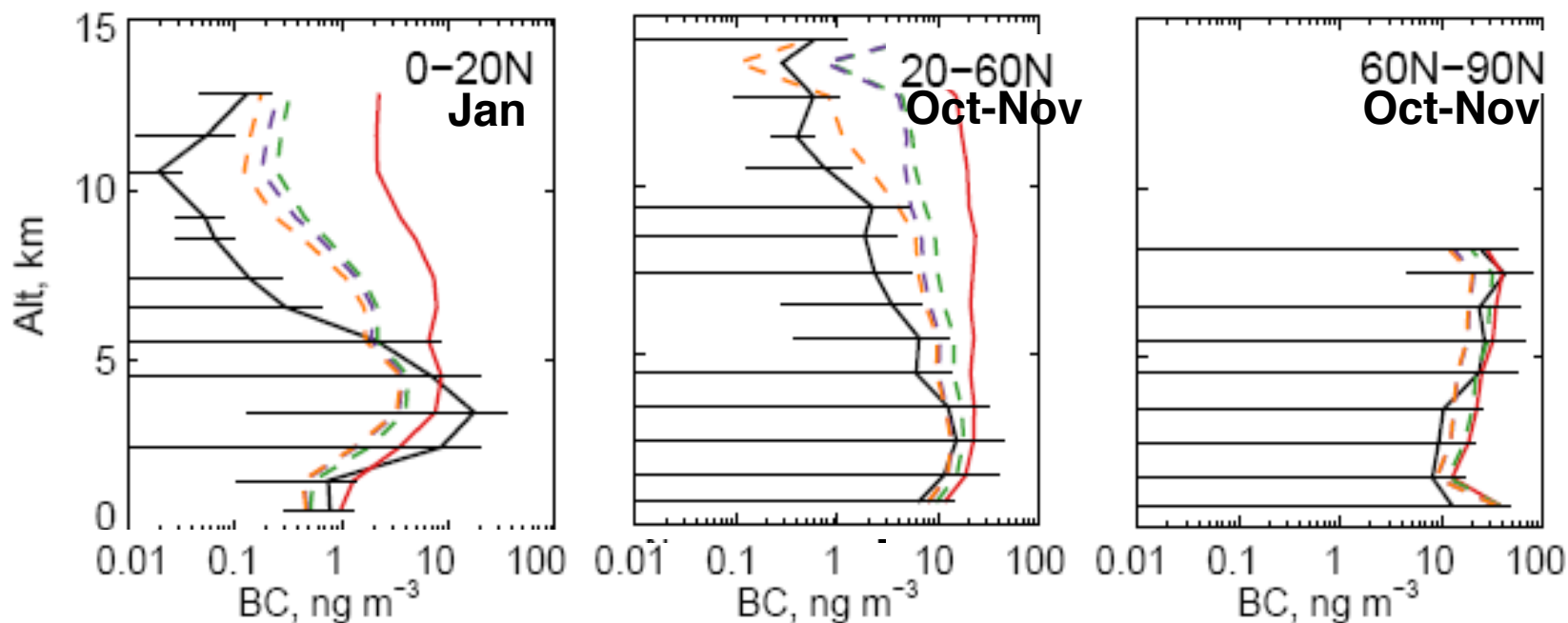


- Model was unbiased in reproducing vertical profiles, deposition to snow
- HIPPO provides far more extensive test of model scavenging and implications for global transport



[Wang et al., 2011]

# Using HIPPO data to test/improve BC removal in GEOS-Chem



— Observed

— Standard GEOS-Chem

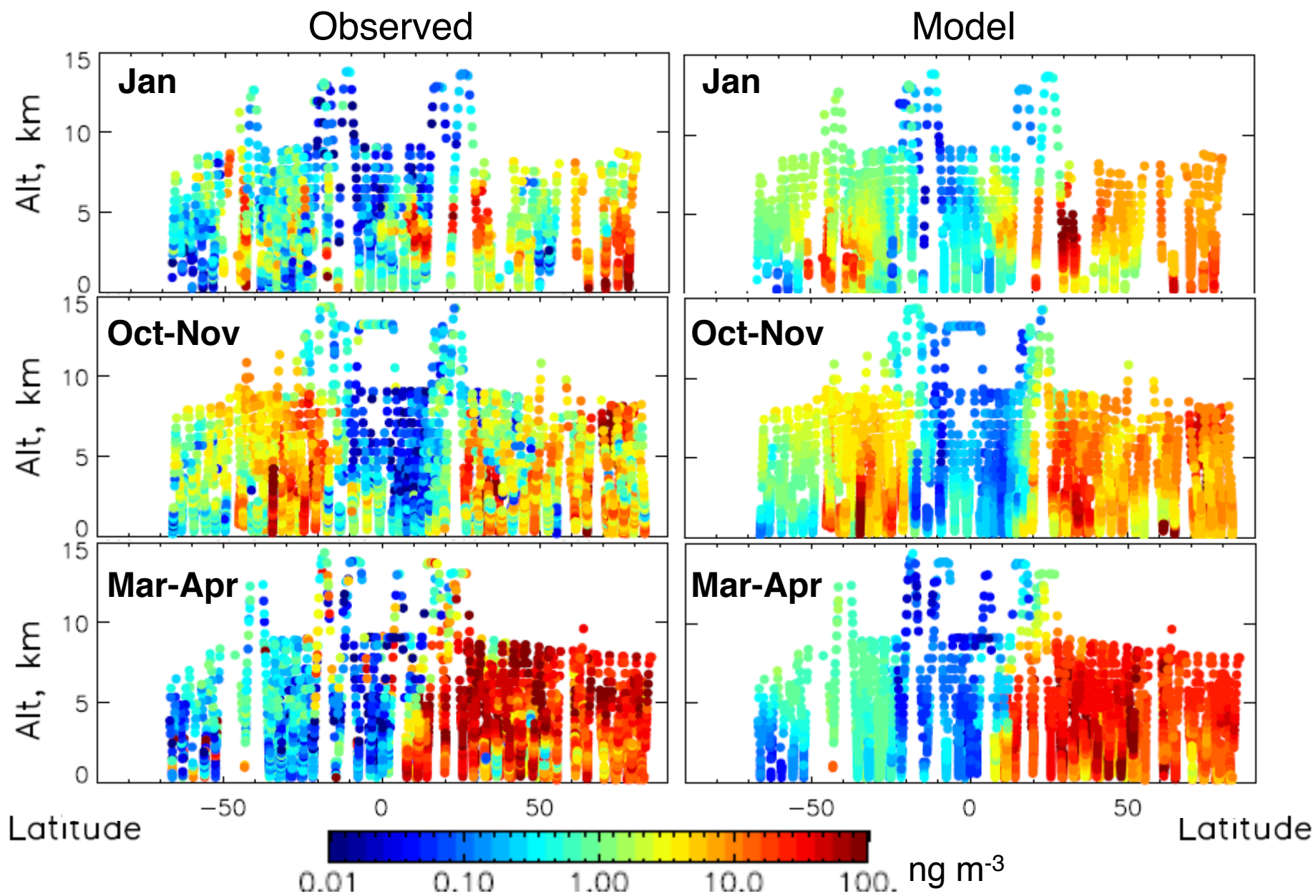
— + scavenging by impaction in convective updrafts and other precipitating clouds

— ++ allow fraction of hydrophilic BC to serve as IN

— +++ cirrus precipitation

- How reliable are the observations of  $BC < 0.1 \text{ ng m}^{-3}$ ?

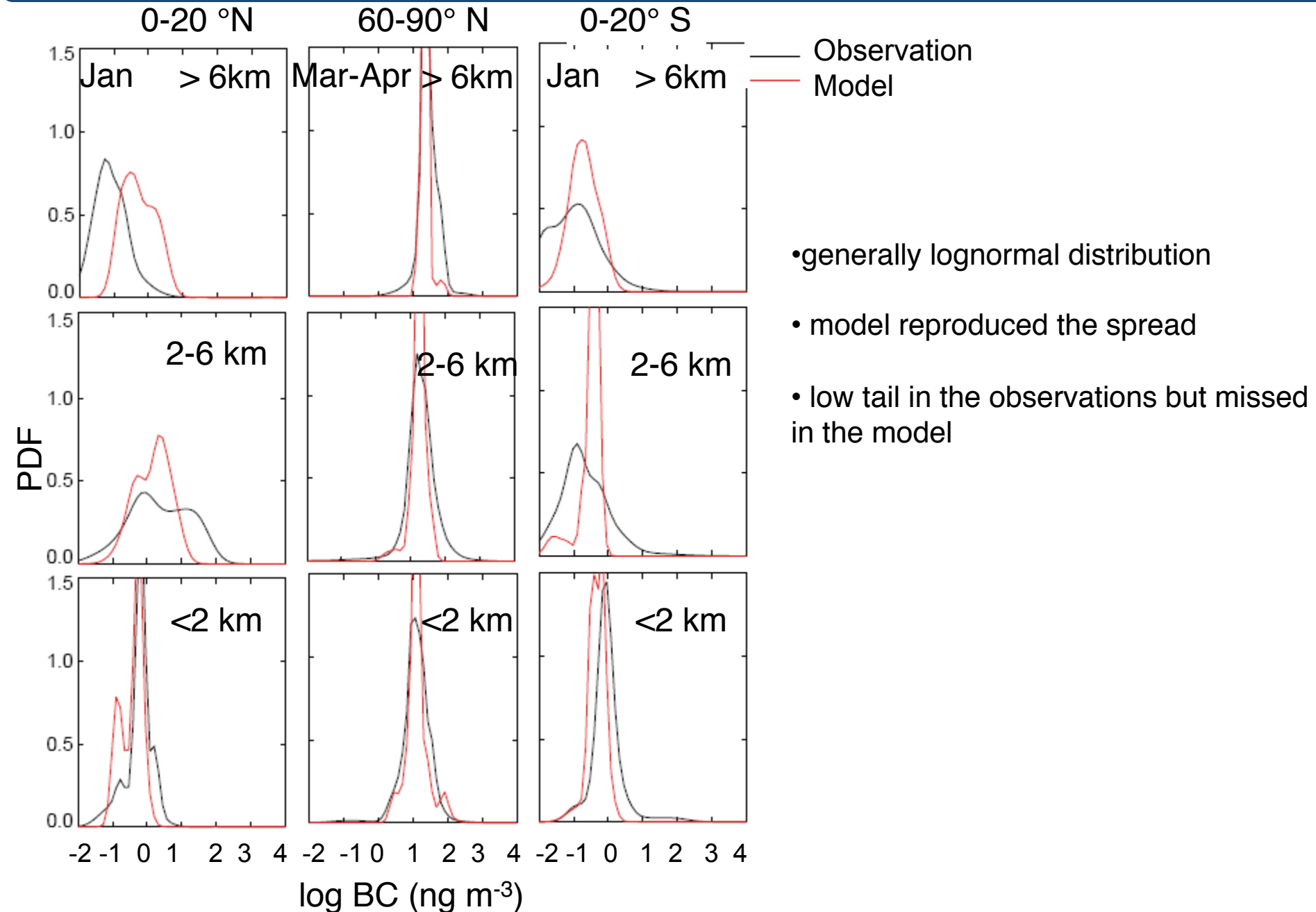
# Observed vs. model curtains for HIPPO BC (West Pacific)



- data averaged over the model grid

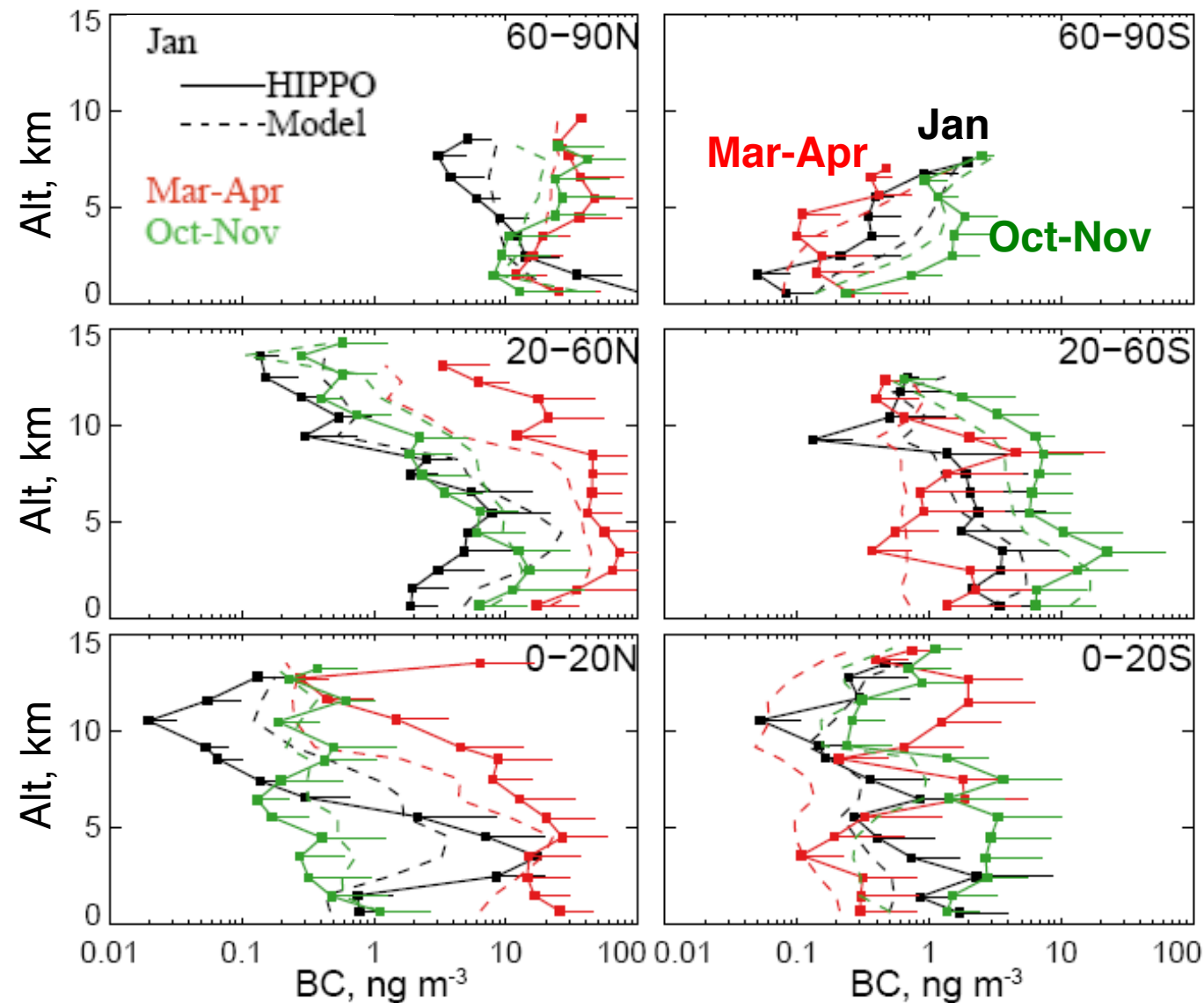


# Probability density function for BC





# Comparison of vertical profiles



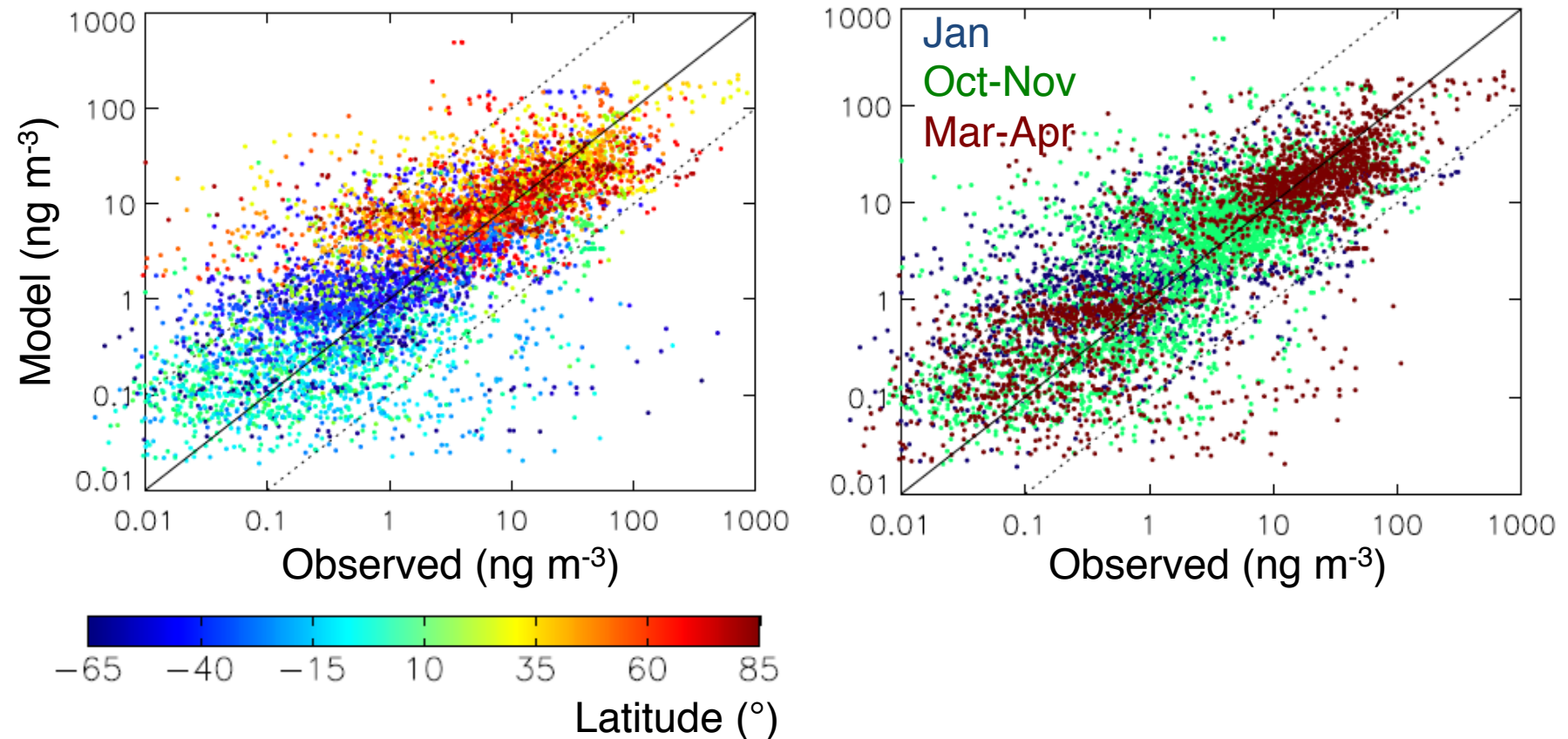
## vertical gradients

- decrease with altitudes by orders of magnitude

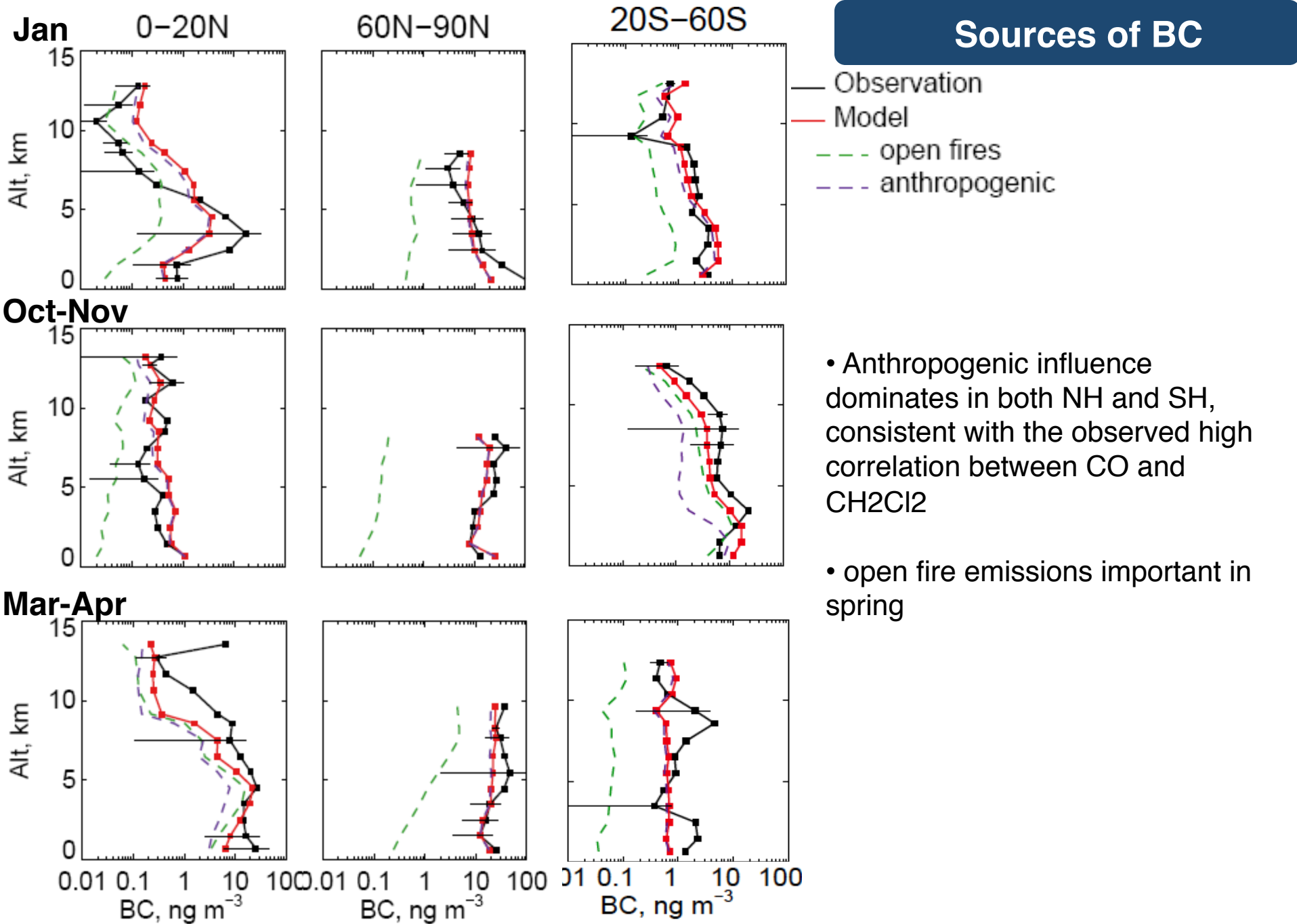
## seasonality

- higher concentrations in spring in both NH and SH

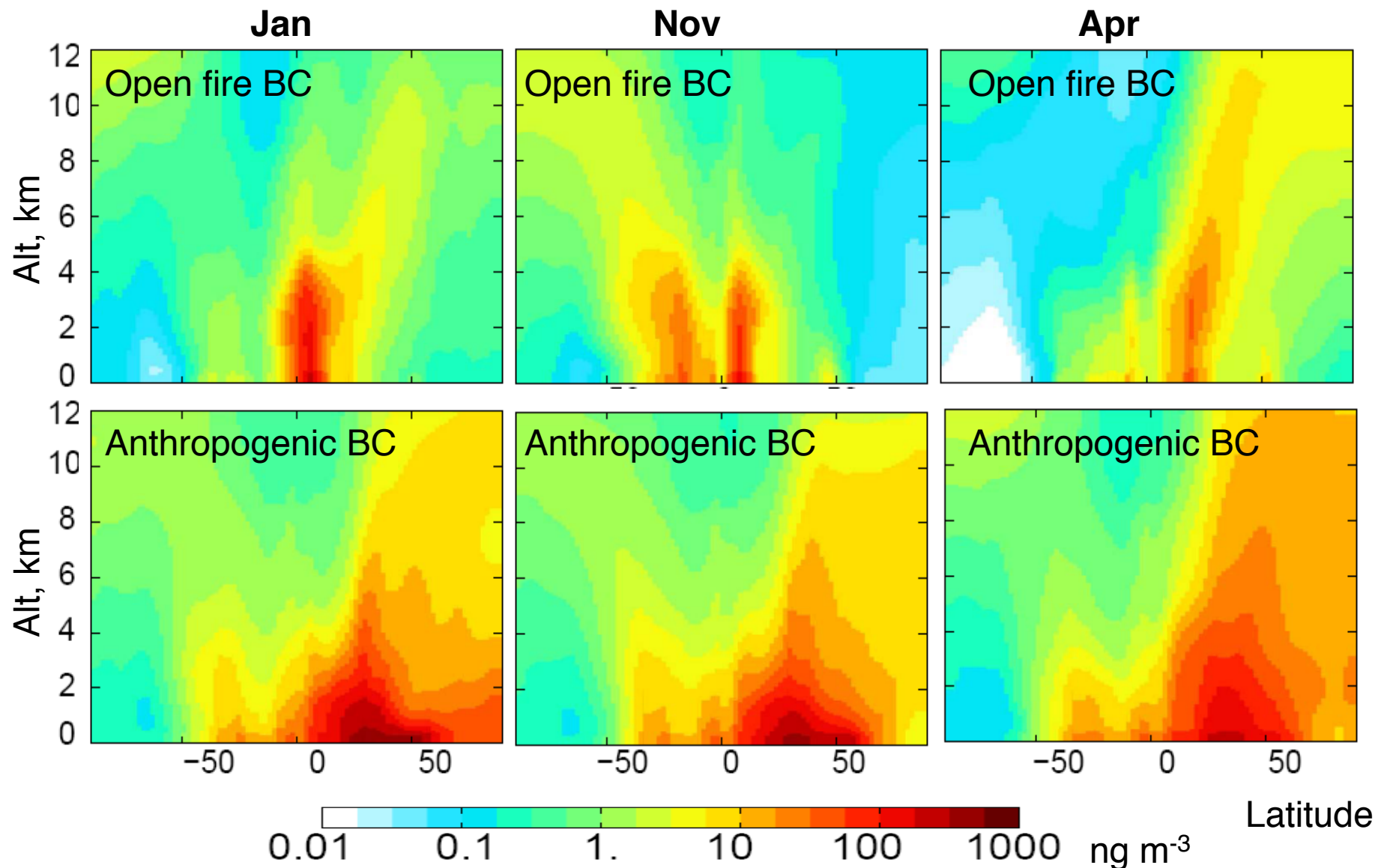
# Model bias



Normalized mean bias ( $NMB = \frac{\sum(M_i - O_i)}{\sum O_i}$ )  
-14% in all (-10% in Jan; 10% in Oct-Nov; -25% in Mar-Apr)



# Zonal mean BC in GEOS-Chem 'educated by HIPPO'



Global tropospheric BC lifetime in model is 4-5 days depending on season