Satellite observations of peroxyacetyl nitrate (PAN) in the tropical troposphere:
New insights into the seasonal and interannual variability of the reactive nitrogen budget

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Acknowledgements:

Matt Alvarado, Karen Cady-Pereira (AER)

ROSES Aura Science Team funding

PAN is the route for NO_x to reach the remote troposphere.

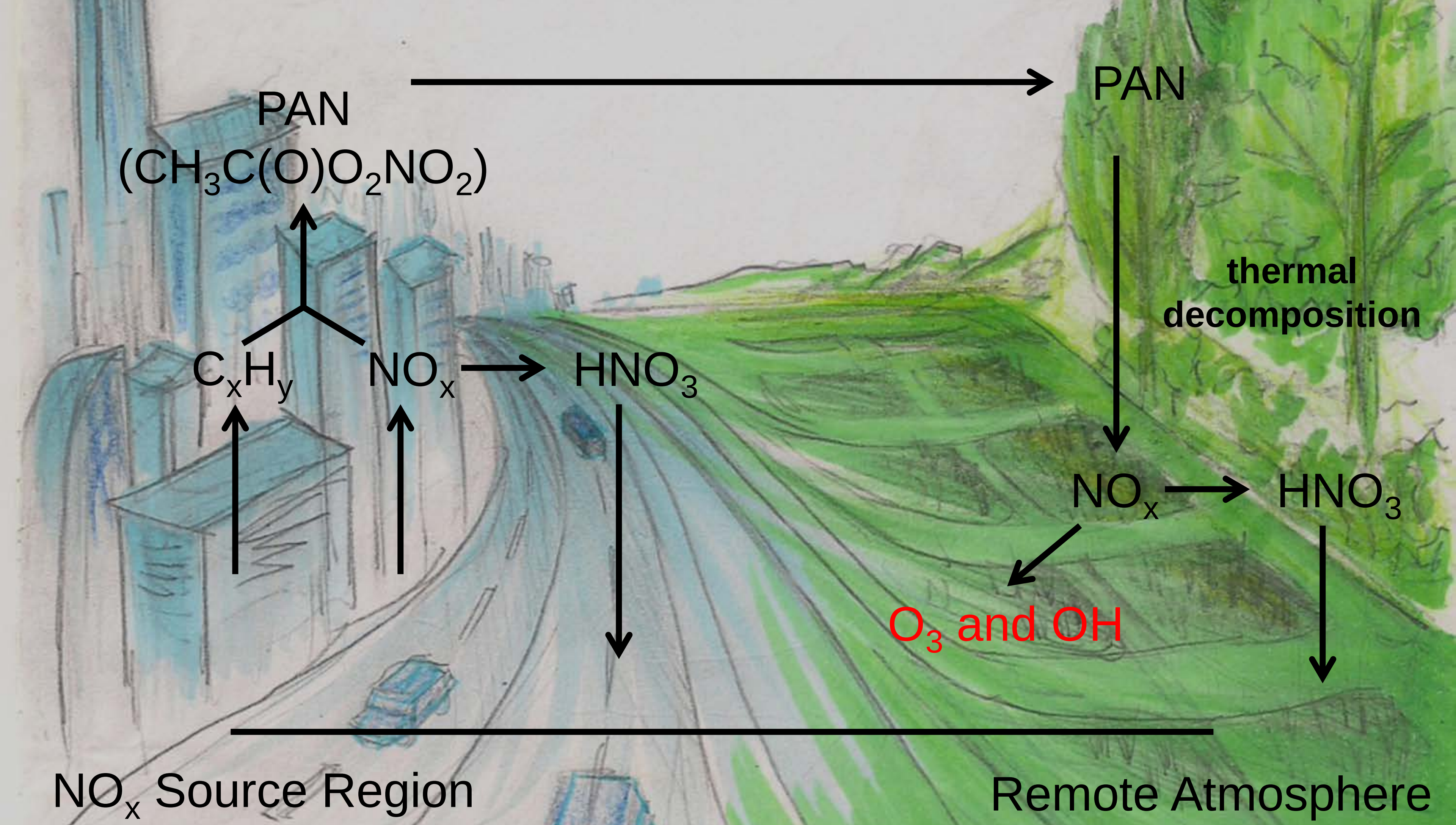
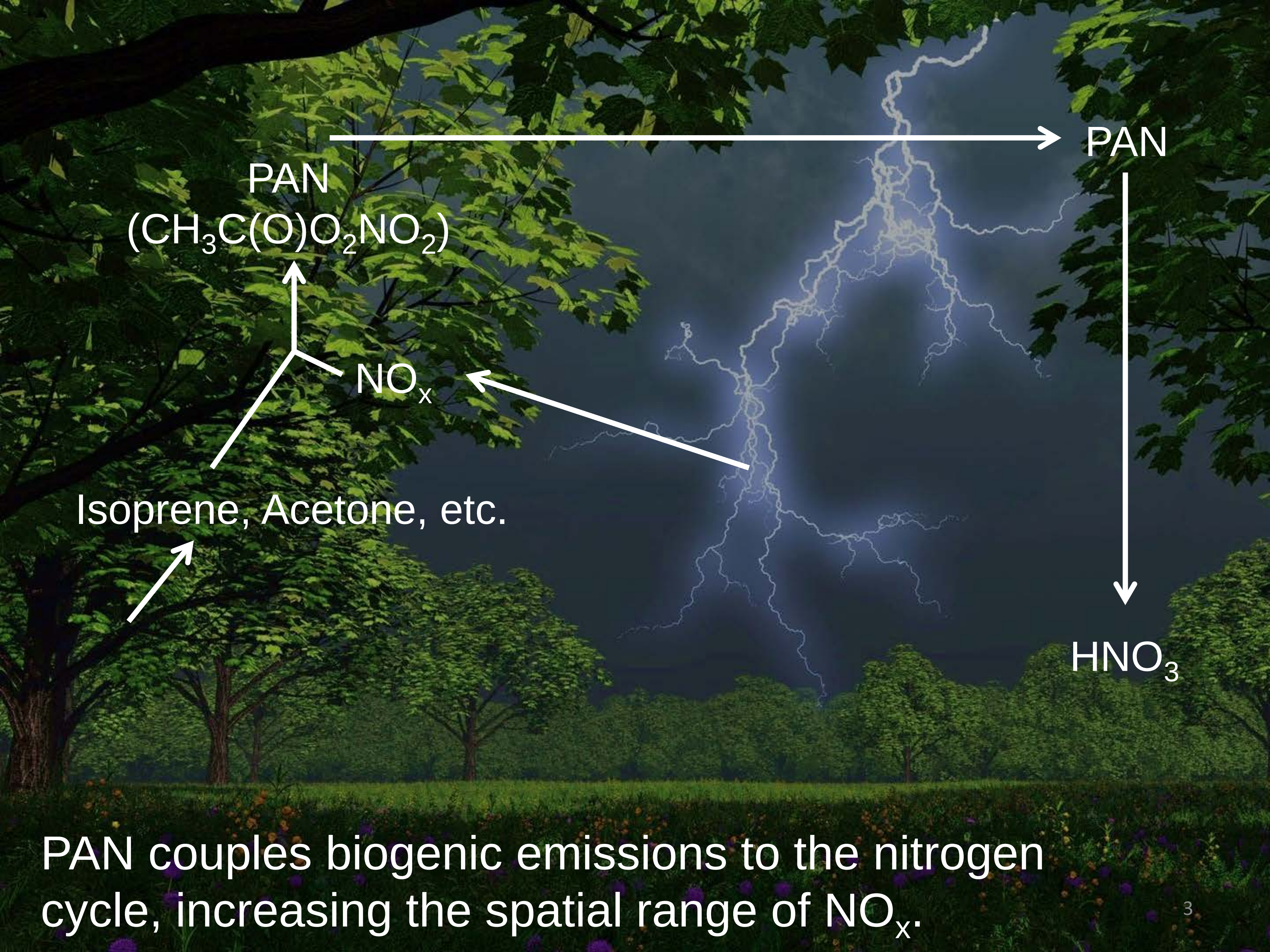


Image from dwellingintheword.wordpress.com

Adapted from Jacob's Intro to Atmos Chem



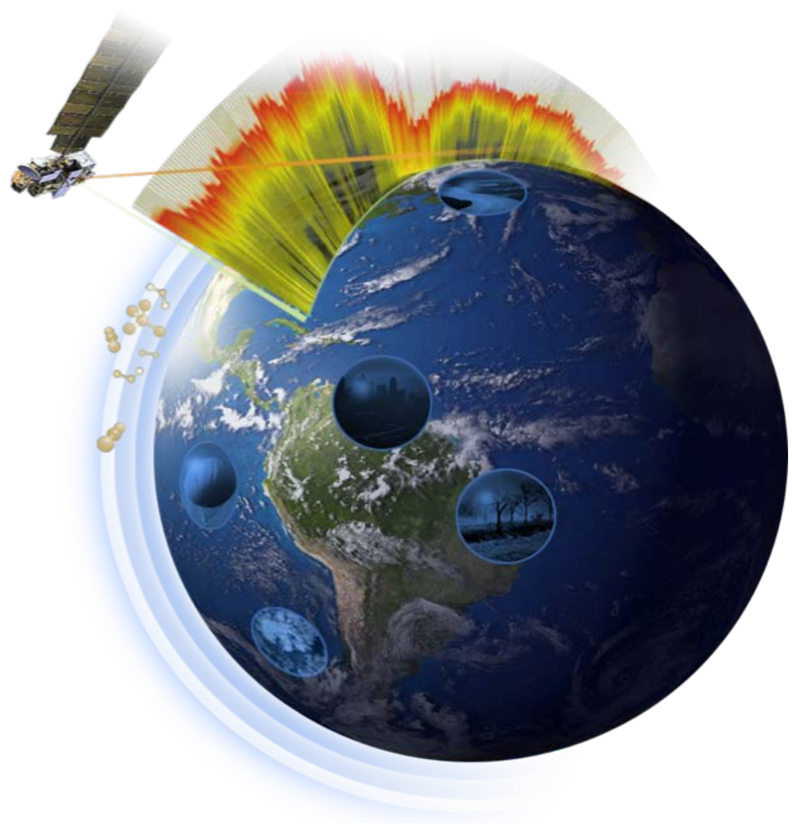
PAN couples biogenic emissions to the nitrogen cycle, increasing the spatial range of NO_x.

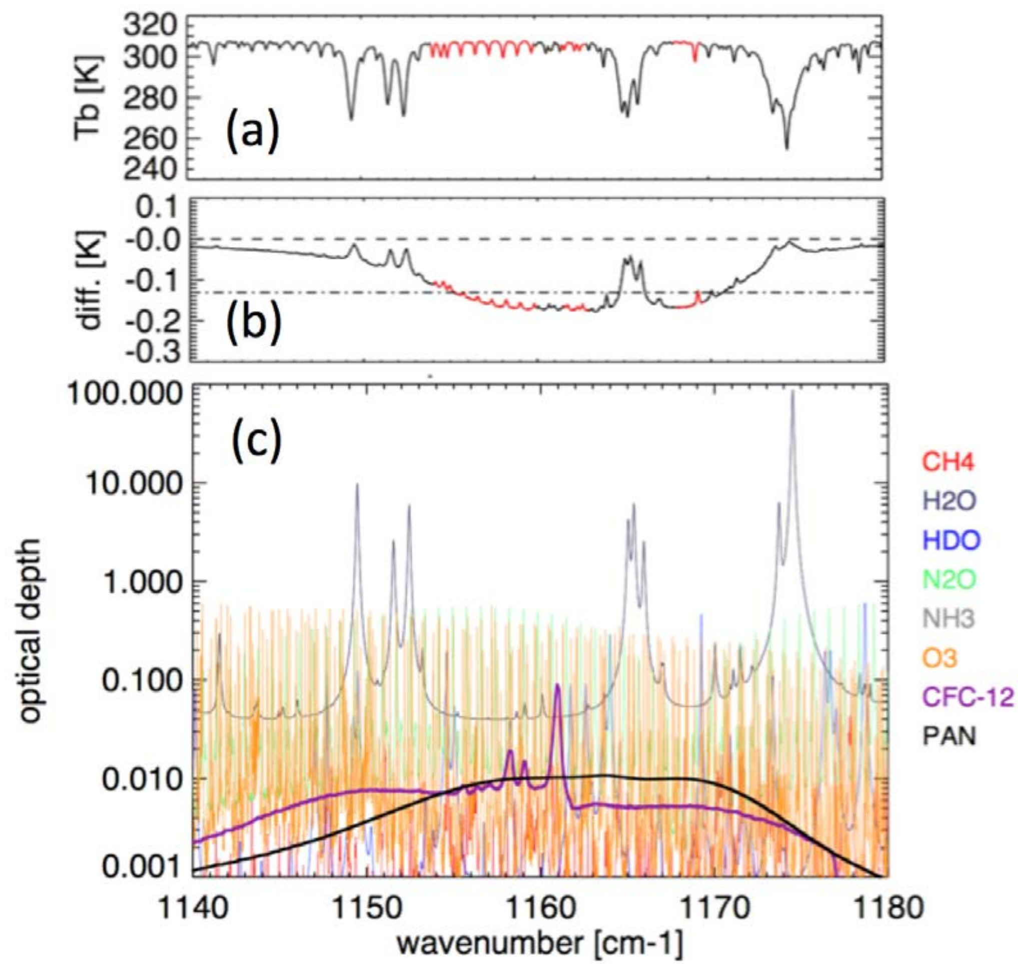
PAN extends the air quality impacts of fires.

Photos of High Park Fire from CNN

PAN signal in thermal-IR radiances

Aura Tropospheric Emission Spectrometer (TES): High spectral resolution infrared spectrometer





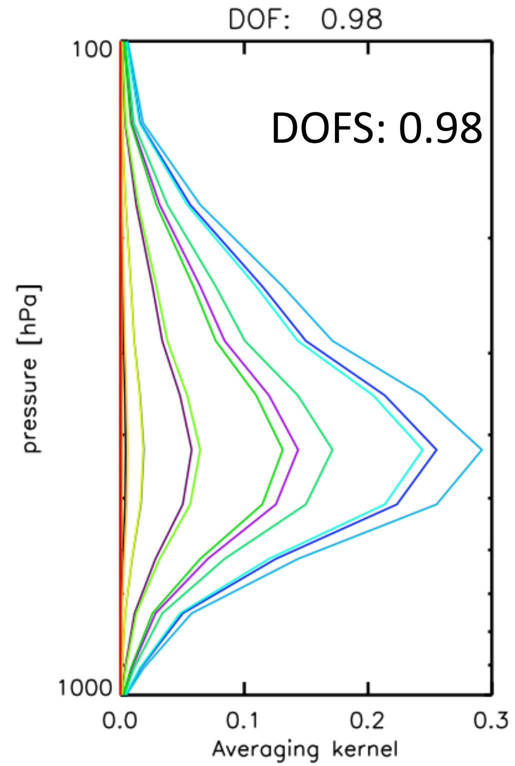
<u>Other satellite observations of PAN:</u>

Limb-sounding observations: MIPAS, ACE (Uppermost troposphere and stratosphere)

Nadir-sounding observations: IASI (PAN observed in fire plumes)

TES PAN retrievals

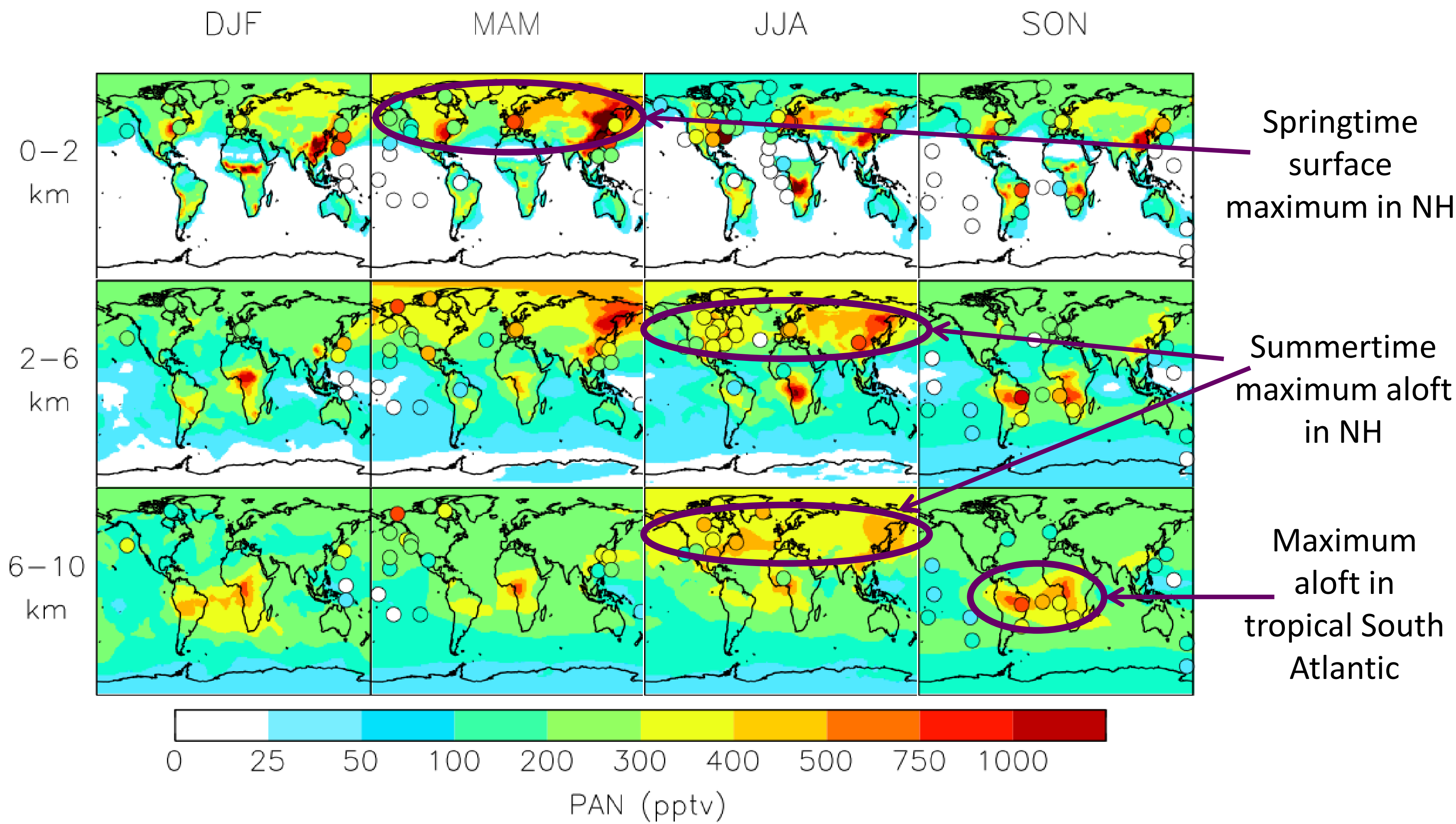
- Algorithm description:
  - **Payne et al., AMT, 2014**
- **Sensitivity:**
  - Mid-upper troposphere
  - **DOFS < 1.0**
- Limit of detectability:
  - ~0.2 ppbv
  - **TES only sees elevated PAN**
- **Estimated errors: 30-50 %**



Averaging kernel for an elevated PAN case

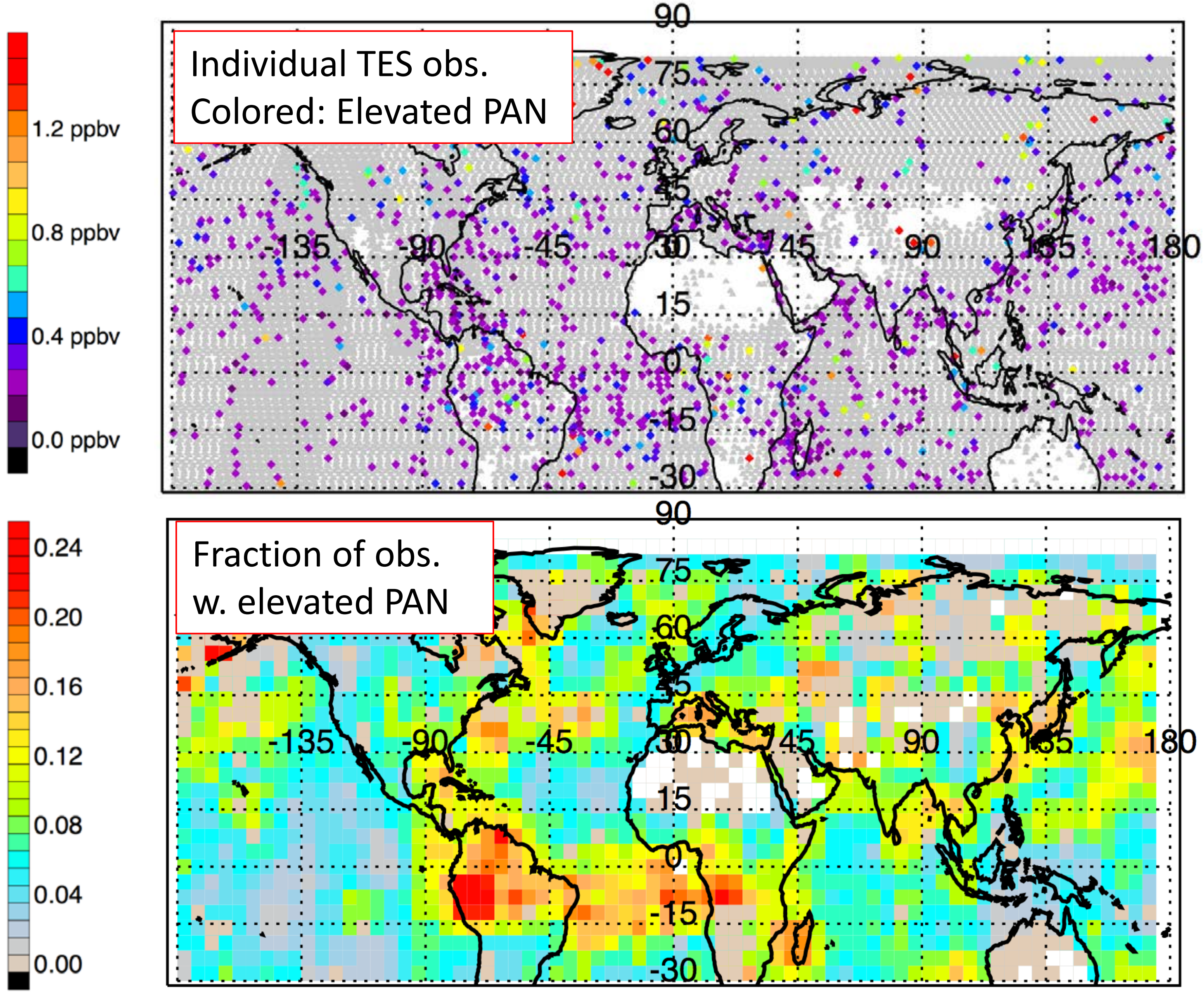
PAN will be an official product in the TES v07 product release

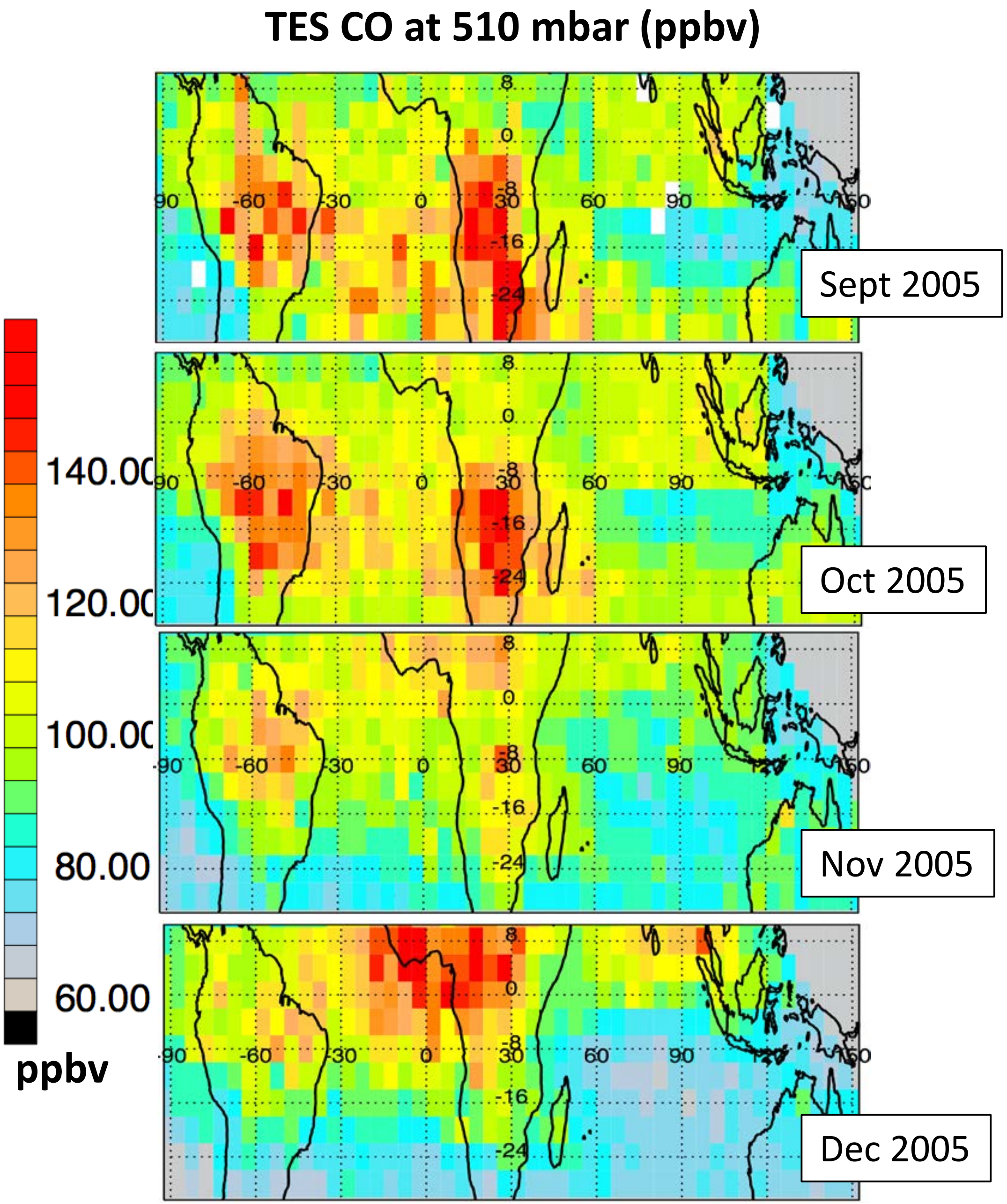
PAN: Expected Distribution

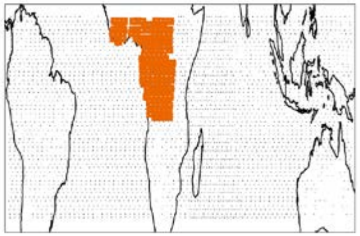


GEOS-Chem model with recently updated PAN scheme: **Fischer et al., 2014, ACP**

TES PAN observations: October 2006

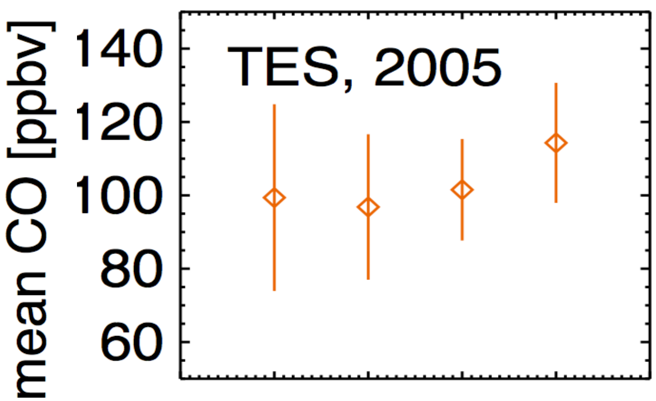


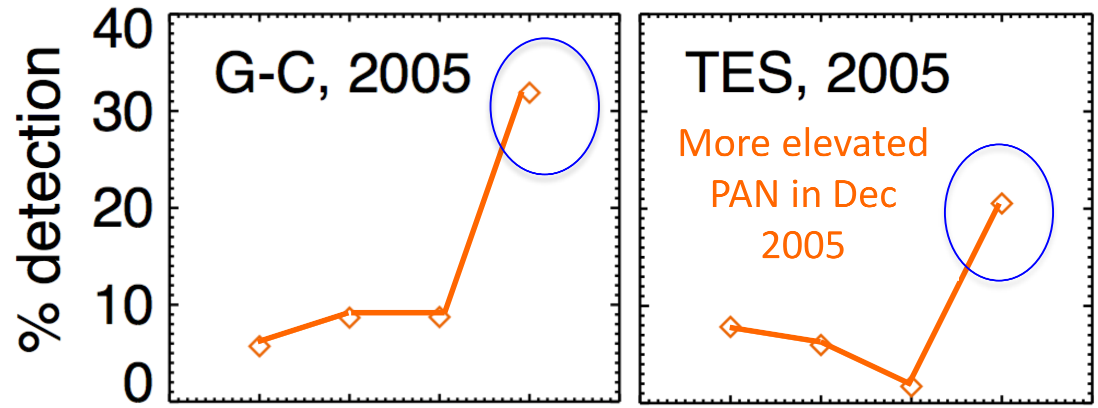

TES CO at 510 mbar (ppbv)
140.00
120.00
100.00
80.00
60.00
ppbv
Sept 2005
Oct 2005
Nov 2005
Dec 2005



December African burning

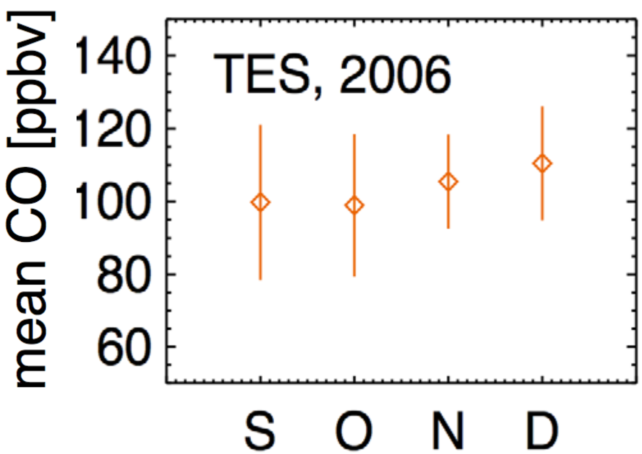
TES PAN compared to GEOS-Chem, a global chemical transport model

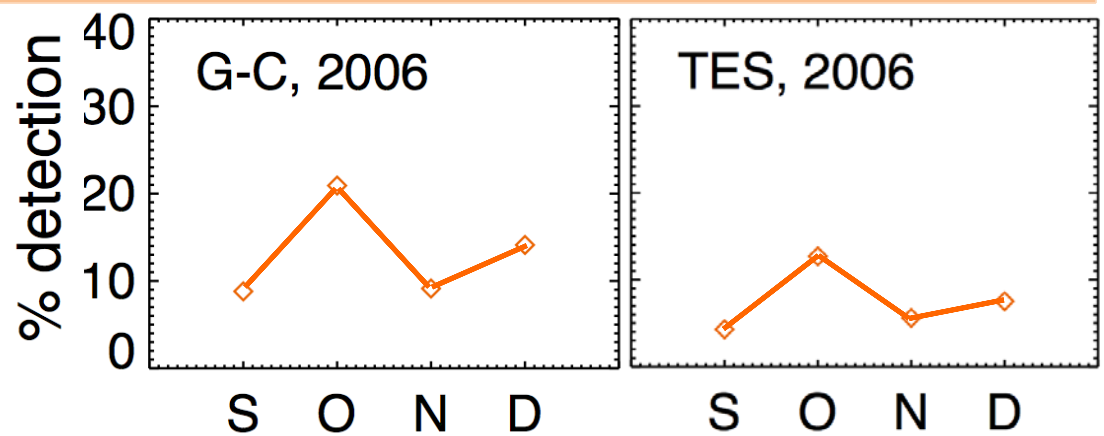




CO similar between 2005,2006

PAN: GEOS-Chem, TES show similar temporal variation





Dec '05: Stronger convection, faster vertical transport of fire products than Dec '06

Year-to-year differences: 2006-2005

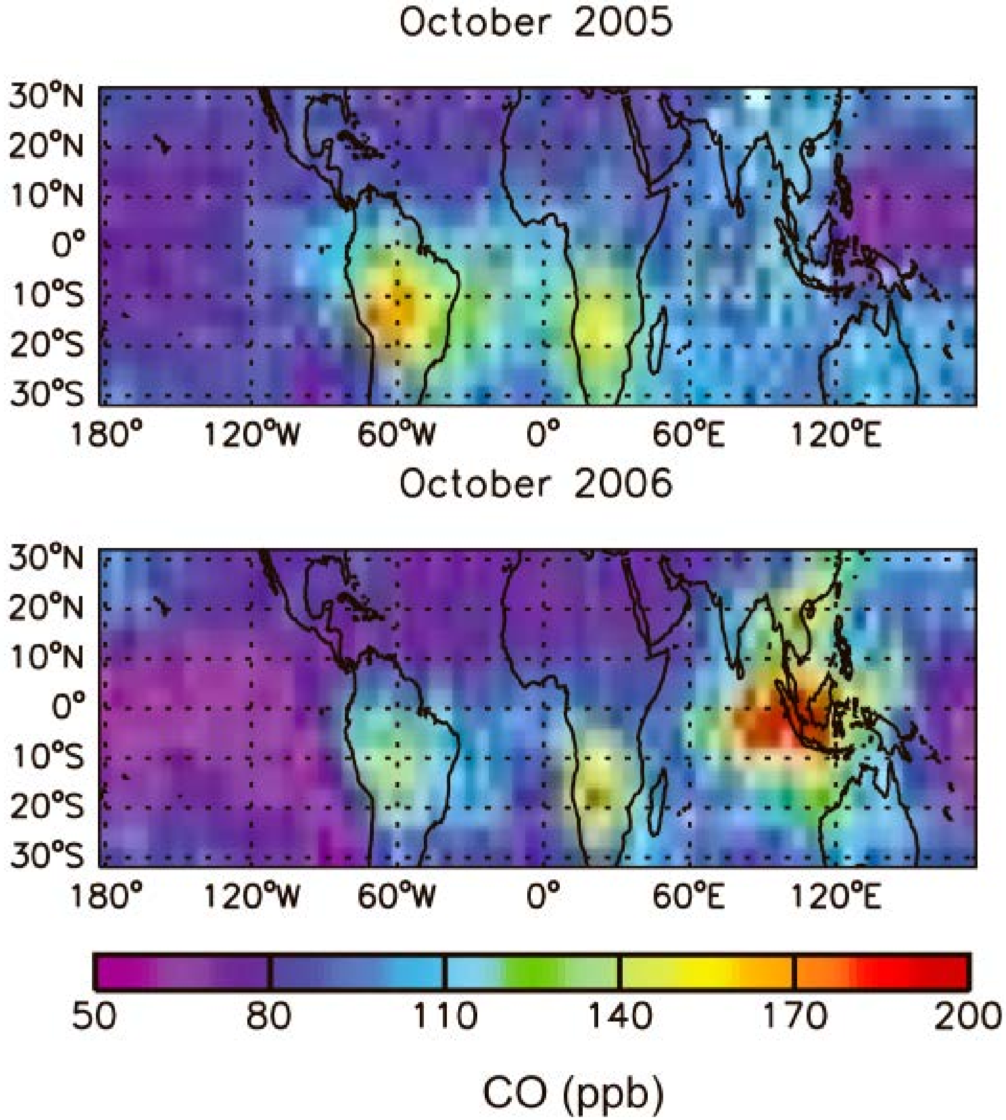
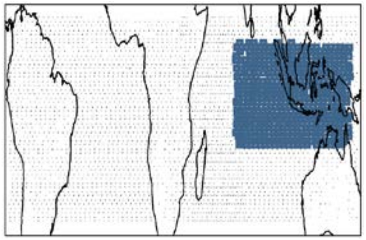


Figure from Logan et al. (2008)

TES publications documenting effects of 2006 El Nino:

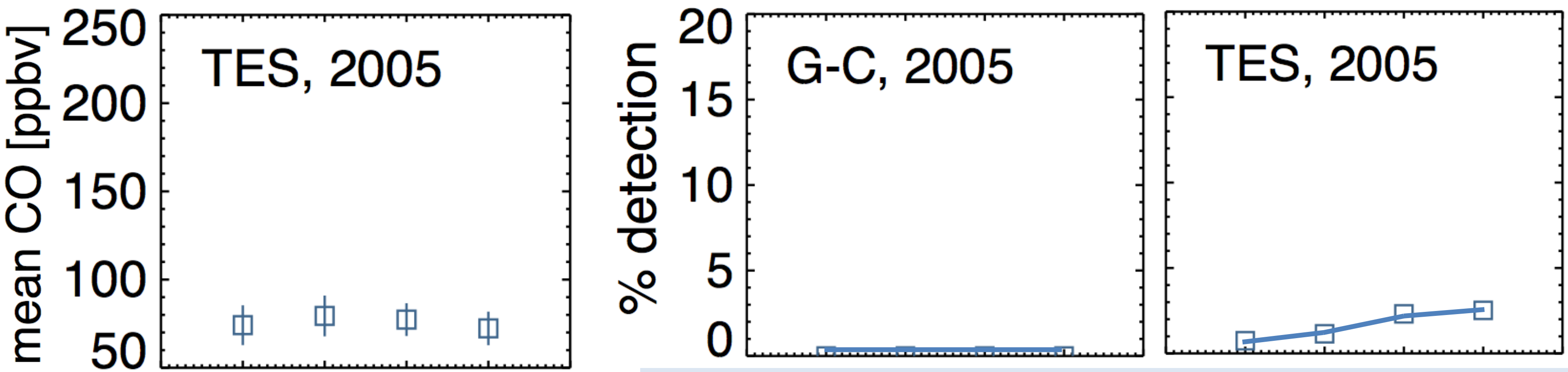
CO, O_3, H_2O:
Logan et al. (2008),
Nassar et al. (2009)

CH_4:
Payne et al. (2009),
Worden et al. (2013)



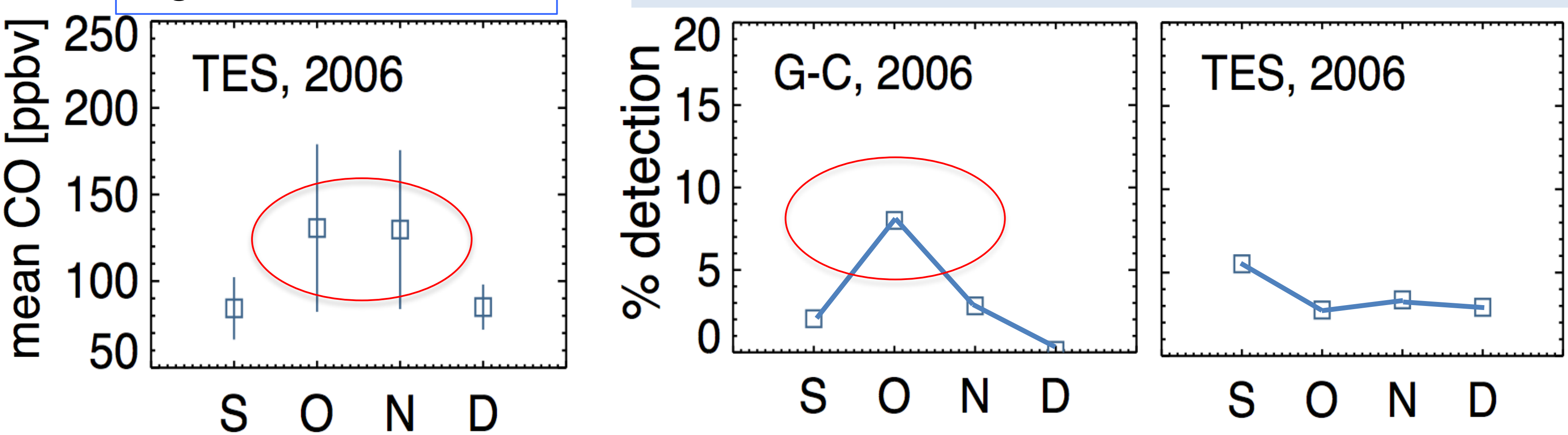
October 2006 Indonesian Fires

TES PAN compared to GEOS-Chem, a global chemical transport model



High **CO** in Oct/Nov '06

GEOS-Chem predicts high **PAN** assoc. with Oct '06 fires



Oct 2006: TES does not see the high PAN predicted by the model

Summary

- **New TES PAN satellite retrieval product**
  - Algorithm description in Payne et al., AMT, 2014
  - **Primarily sensitive in free troposphere**
  - Global scale, multi-year dataset (eventually!)
  - PAN will be included in TES v07 product release

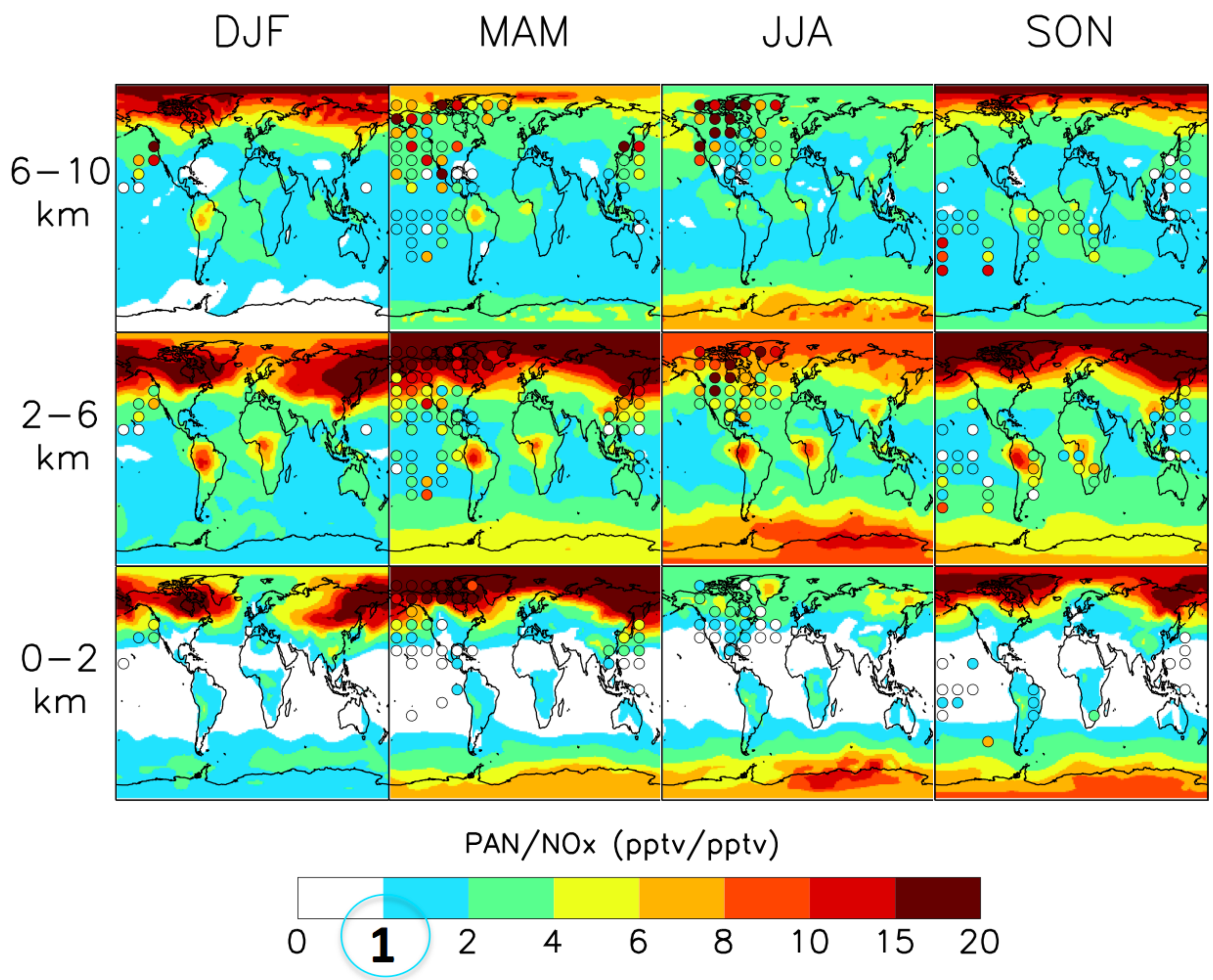
- This work: **PAN in the tropical troposphere**
  - **December over Central Africa:**
    - **Large year-to-year differences in PAN**
      - **driven by differences in convective transport rather than emissions**
  - **October over Indonesia region:**
    - **Small year-to-year difference in PAN**
      - **despite enormous difference in fire emissions**
  - **Payne et al., GRL, in review 2015**
- **High latitude springtime fires**
  - **Zhu et al., GRL, in review 2015**
- **Seasonality in export of Asian pollution**
  - **Jiang et al., in prep., 2015**

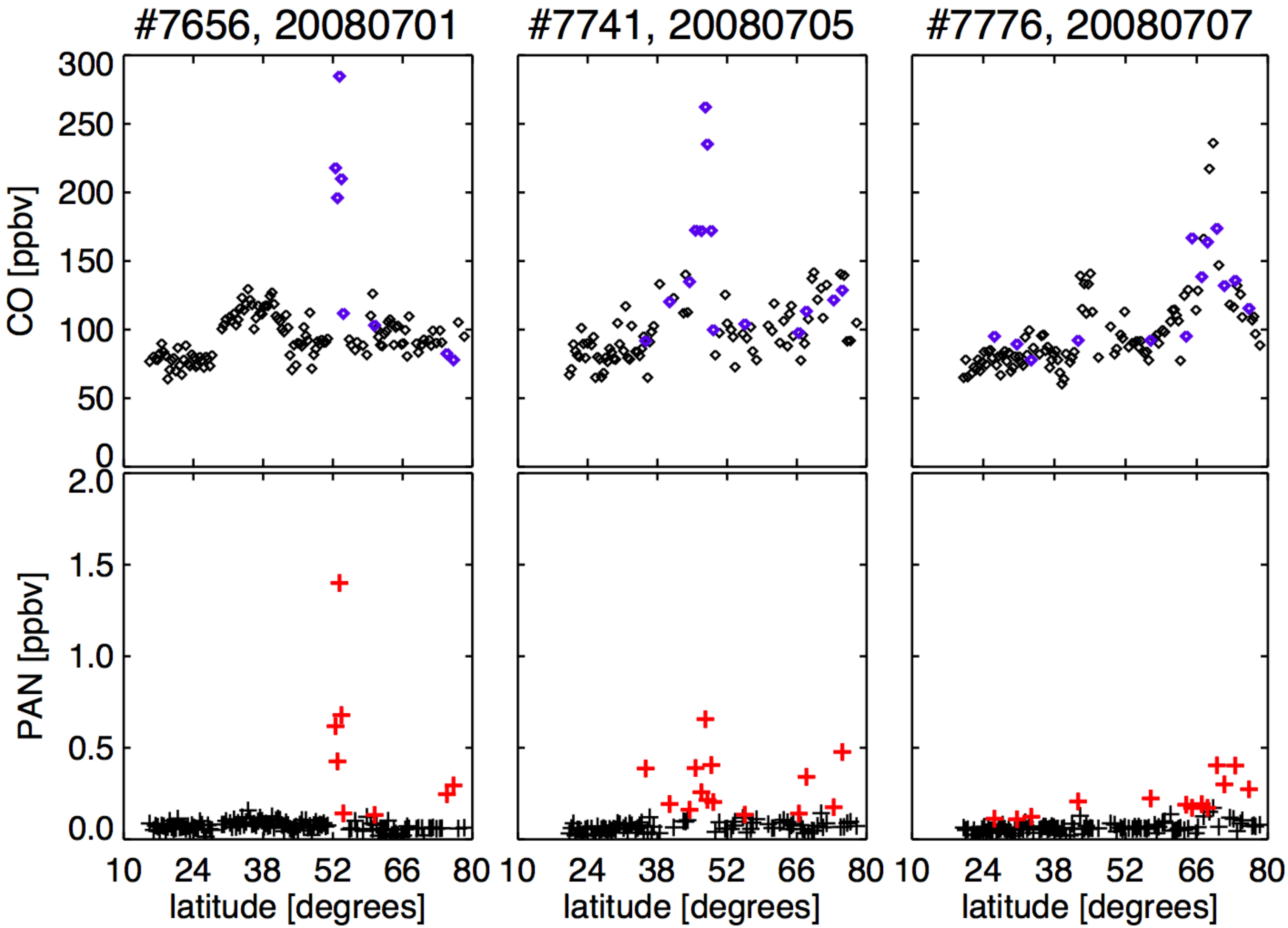
Questions?

Back-up slides

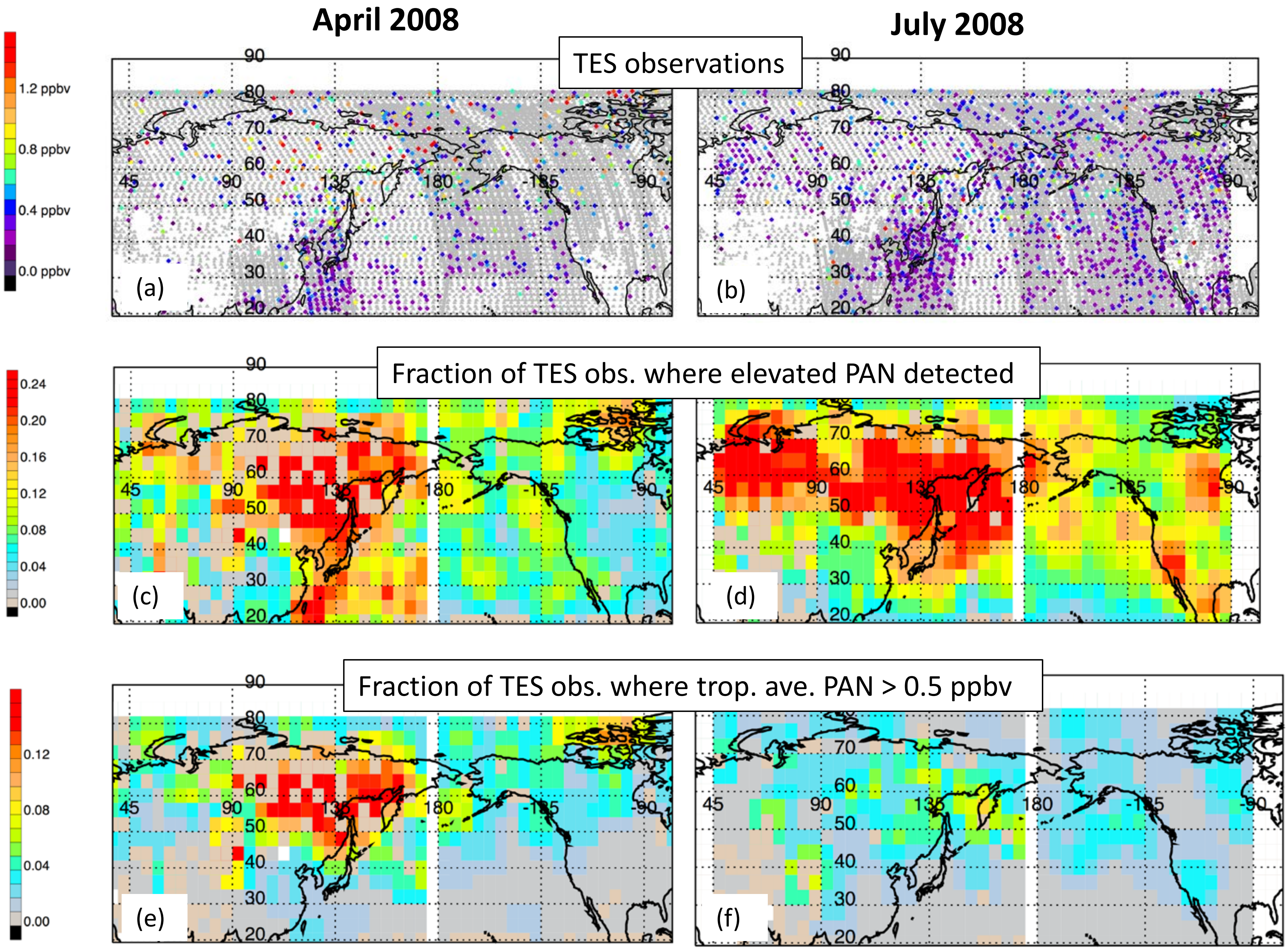
Fischer et al., 2013 AGU presentation

PAN is more abundant than NO_x *except* in the tropical and sub-tropical lower troposphere.





- **Examples of elevated CO and PAN in boreal burning plumes (previously identified by Alvarado et al. (2010)) seen in TES special observations made during the July 2008 phase of the ARCTAS campaign. Colored points show the cases where the DOFS was greater than 0.6 for the PAN retrieval.**



April 2008
July 2008
TES observations
1.2 ppbv
0.8 ppbv
0.4 ppbv
0.0 ppbv
(a)
(b)
Fraction of TES obs. where elevated PAN detected
0.24
0.20
0.16
0.12
0.08
0.04
0.00
(c)
(d)
Fraction of TES obs. where trop. ave. PAN > 0.5 ppbv
0.12
0.08
0.04
0.00
(e)
(f)