

Emission Ratios for NH₃ and HC(O)OH and Observations of PAN in Biomass Burning Smoke As Seen By TES

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Atmospheric and Environmental Research

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1. Measuring biomass burning emissions and secondary products with TES

TES has previously looked at biomass burning CO (Kopacz et al., 2010) and secondary O₃ production in smoke plumes (Verma et al., 2009; Alvarado et al., 2010; DuPont et al., 2010).

We focus on three new gases:

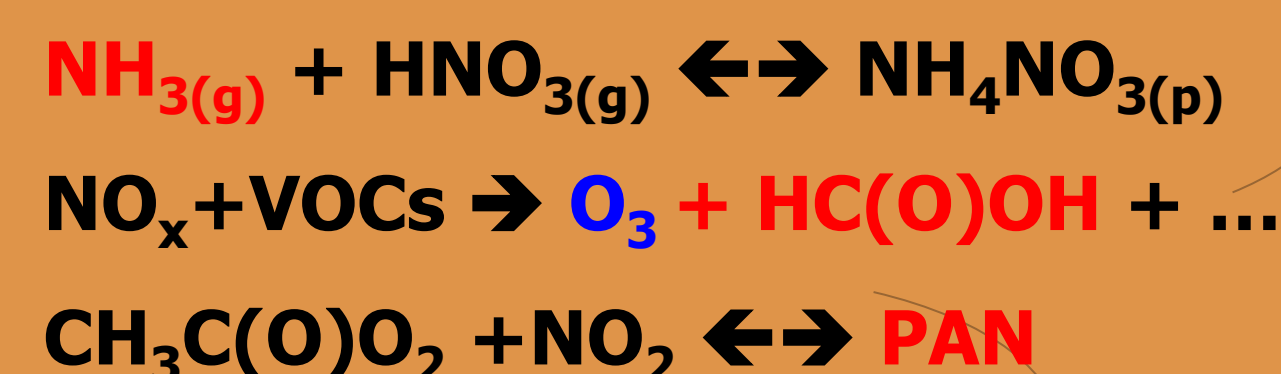
- NH₃ combines with H₂SO₄ and HNO₃ to make secondary aerosol.
- HC(O)OH is underestimated in global models due to uncertainties in its sources and chemical production.
- PAN is a reservoir of NO_x and can impact O₃ concentrations far downwind.



Primary Emissions

CO
NH₃
HC(O)OH
NO_x
VOCs

Secondary Chemistry



CO, O₃: operational, validated TES products

NH₃: operational in V005, validated using in situ data

HC(O)OH: prototype retrieval

PAN (peroxy acetyl nitrate): first detection by TES

2. Instrument and Methods

2(a) Tropospheric Emission Spectrometer (TES)

- FTIR instrument aboard Aura
 - Range 650-3050 cm⁻¹
 - Spectral resolution 0.06 cm⁻¹
 - Nadir footprint 5.3 km x 8.3 km

2(b) ARCTAS-B Special Observations

- June 15 to July 15, 2008
- ~0.4° latitude resolution over eastern Siberia, the North Pacific, and North America.
- Identified 22 boreal biomass burning plumes
 - 17 from Siberia, 5 from Canada
- Little O₃ formation in these plumes (Alvarado et al., 2010)

2(c) Emission and enhancement ratios (e.g., ΔNH₃/ΔCO)

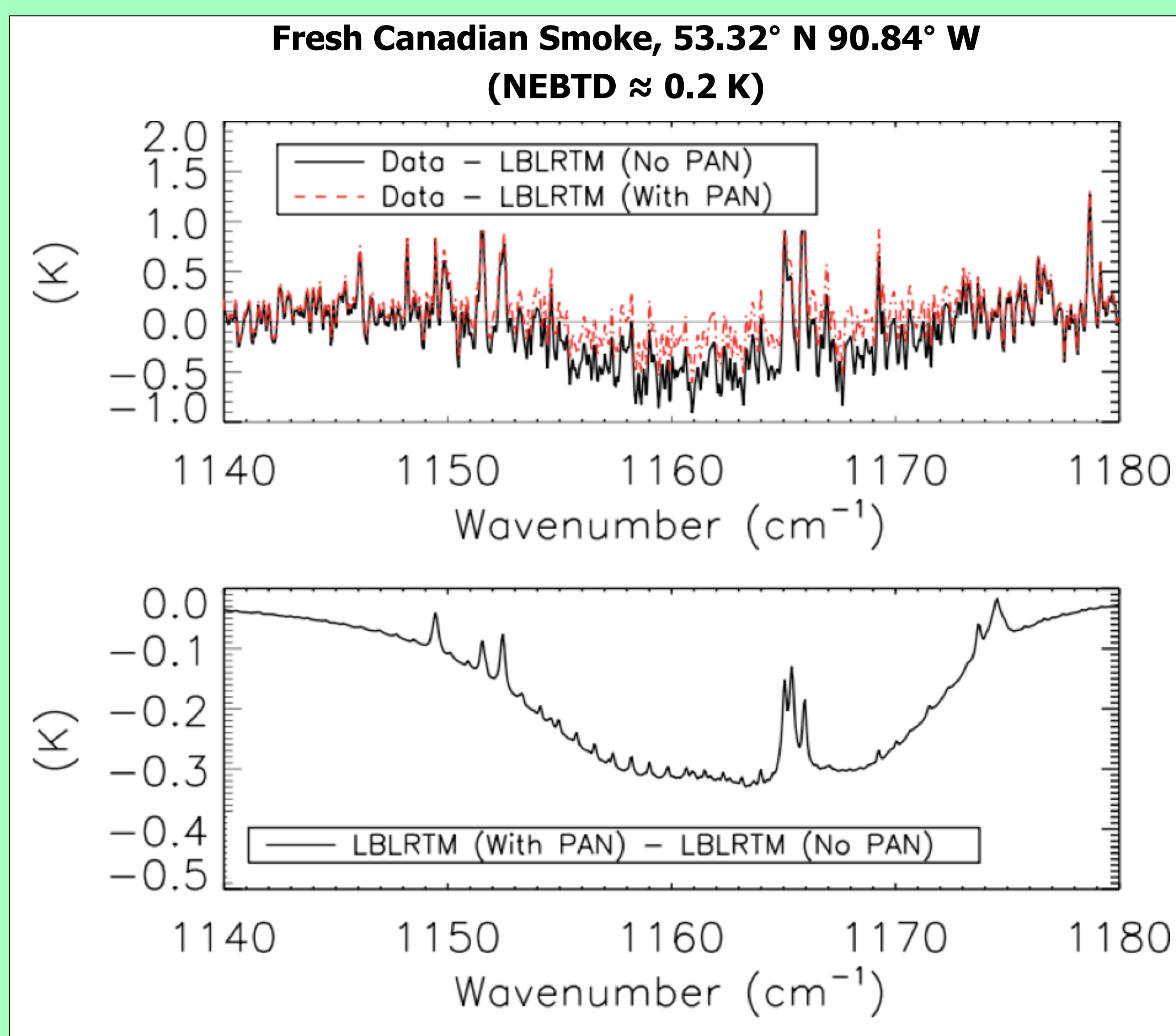
- TES NH₃ retrievals described in Shephard et al. (2011) and Pinder et al. (2011)
- Map NH₃ retrieval to a single representative volume mixing ratio (RVMR) similar to Payne et al. (2009)
- CO pseudo-RVMR calculated by mapping CO profile to same grid as NH₃ RVMR
- Slope of regression gives ΔNH₃/ΔCO

3. First detection of PAN using TES

- Detected in fresh Canadian and aging Siberian smoke
 - CO > 250 ppb at 510 hPa
 - Cloud OD < 0.1
- Shape of negative residuals matches shape of PAN absorption.
- PAN profile with peak of 960 ppt at 560 hPa moves residuals near 0.

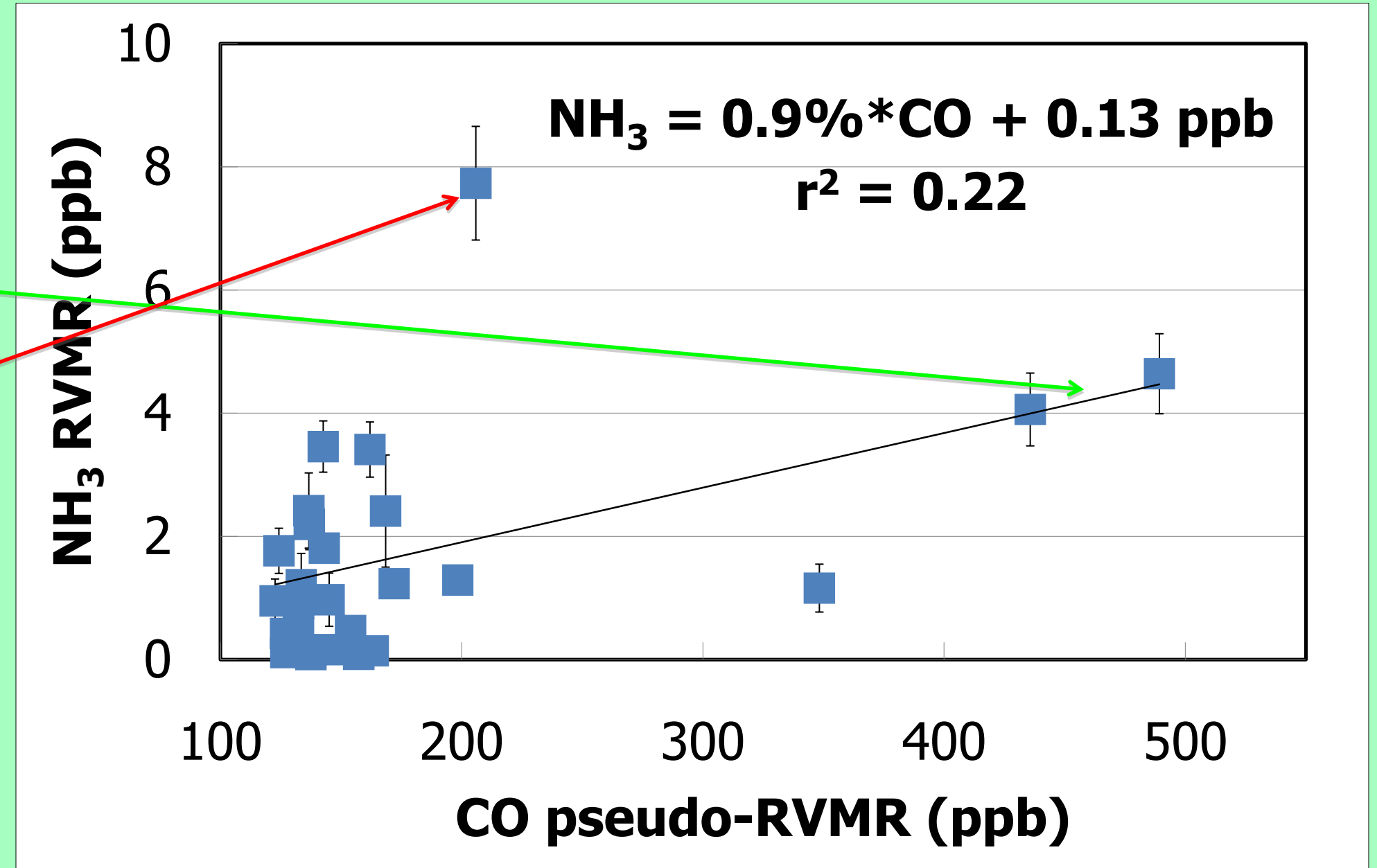
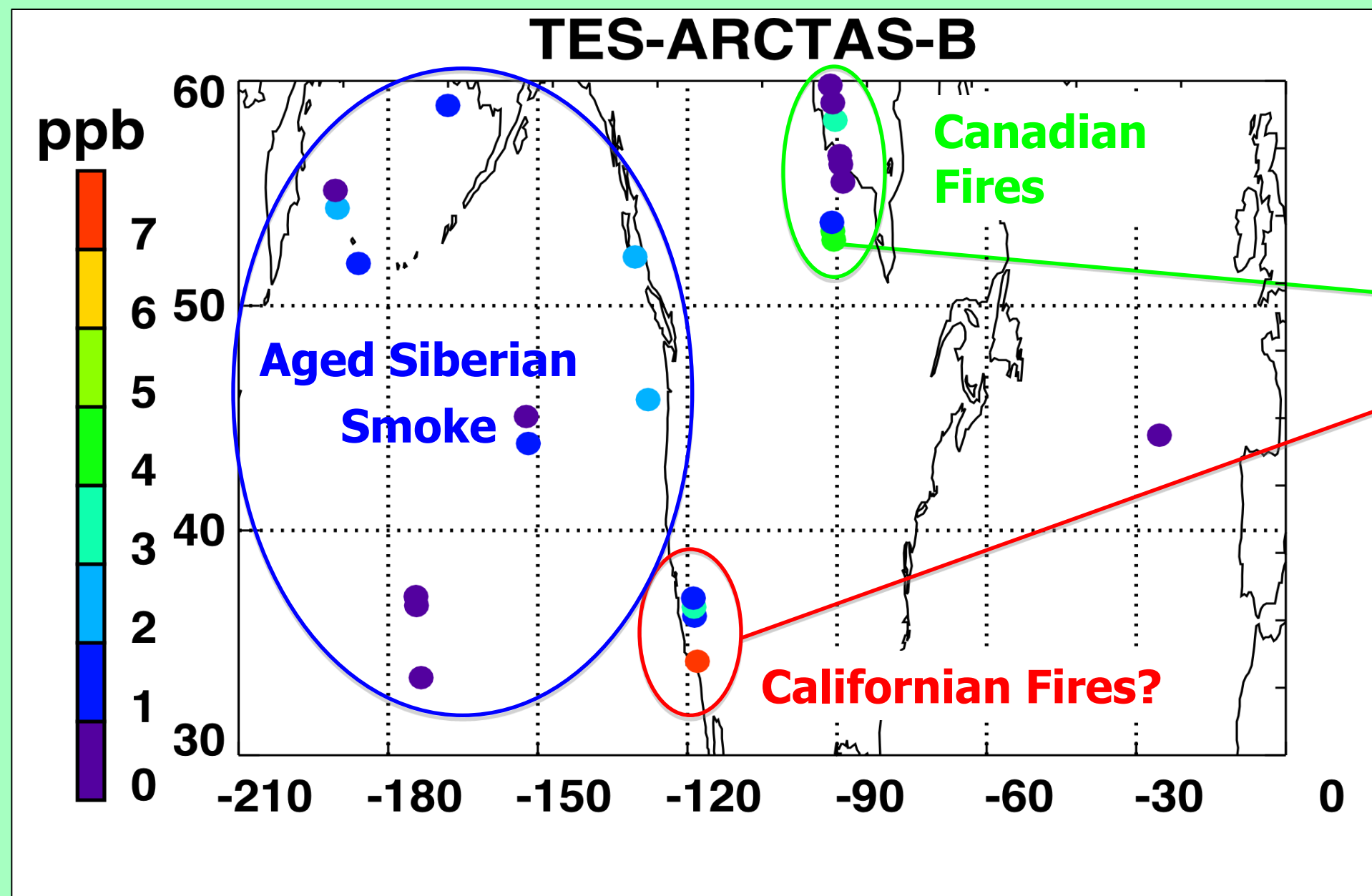
References:

Alvarado et al., ACP, 10, 9739-9760, 2010.
Dupont et al., ACPD, 10, 26751-26812, 2010.
Kopacz et al., ACP, 10, 855-876, 2010.
Pinder et al., GRL, 38, L04802, 2011.
Payne et al., JGR, doi:10.1029/2008JD010155, 2009.
Shephard et al., in prep., 2011.
Verma et al., JGR, D23S60, 2009.

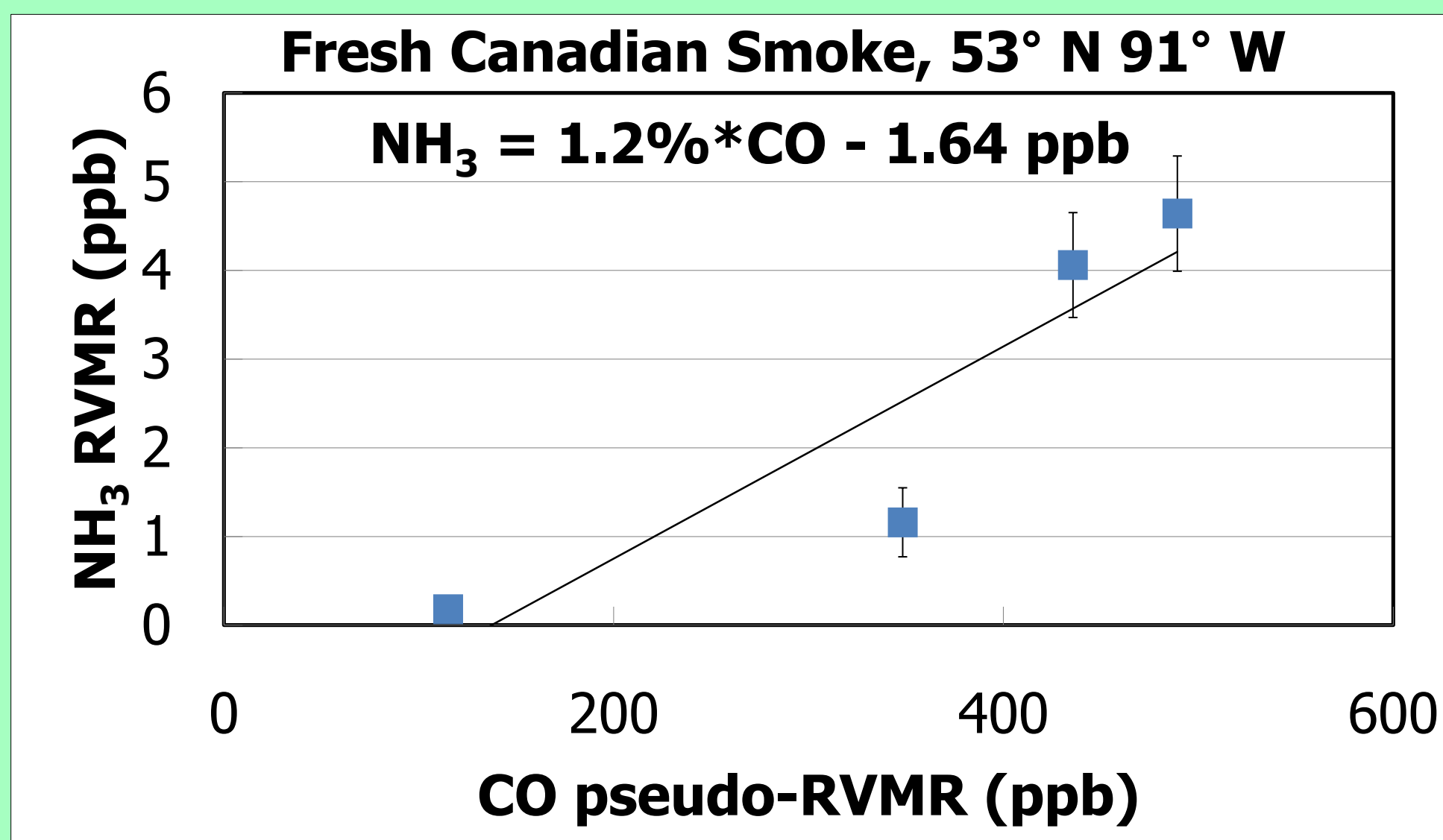


4(a) NH₃ retrievals show weak correlation with biomass burning CO

Removed retrievals with bad quality flags and low CO



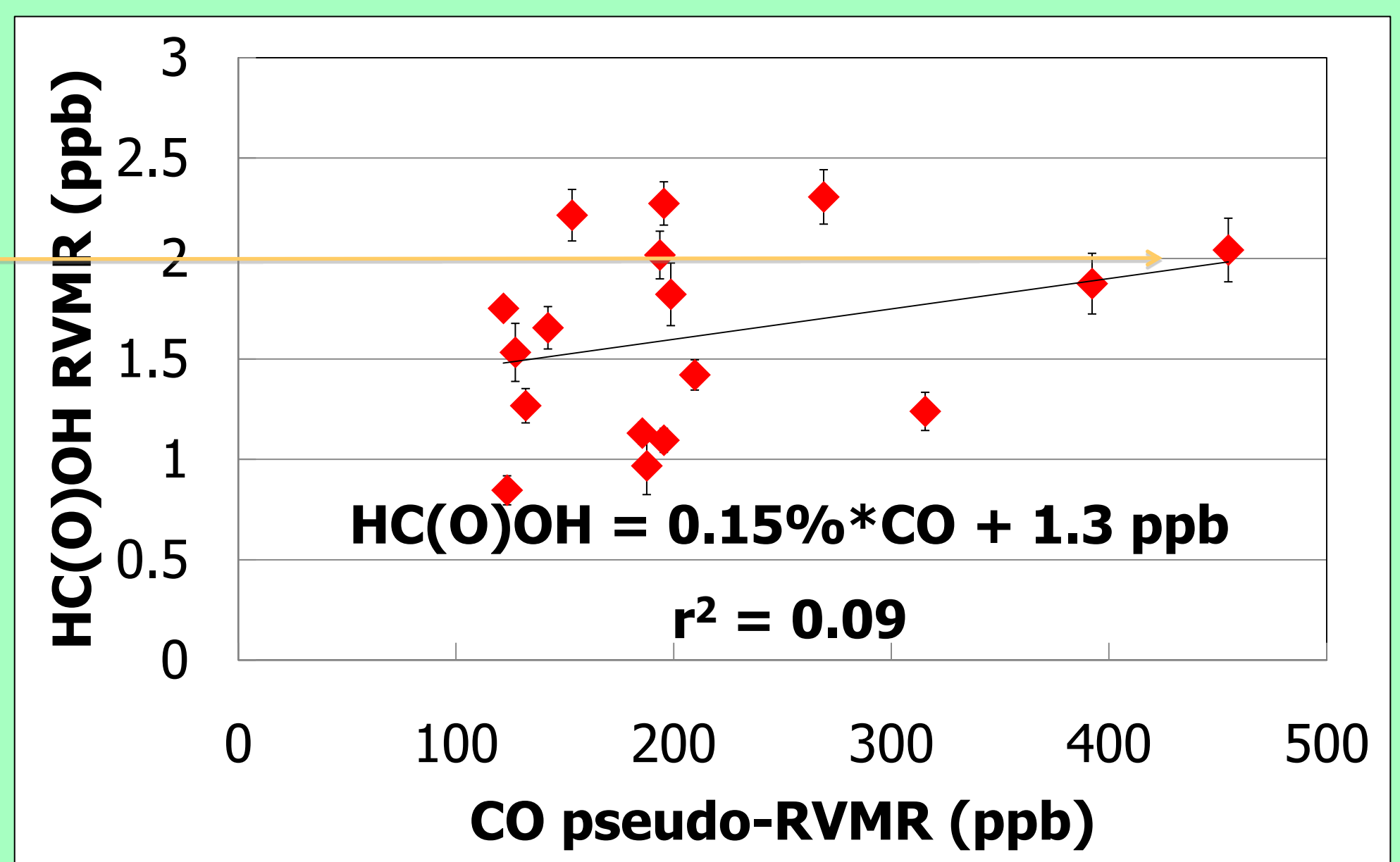
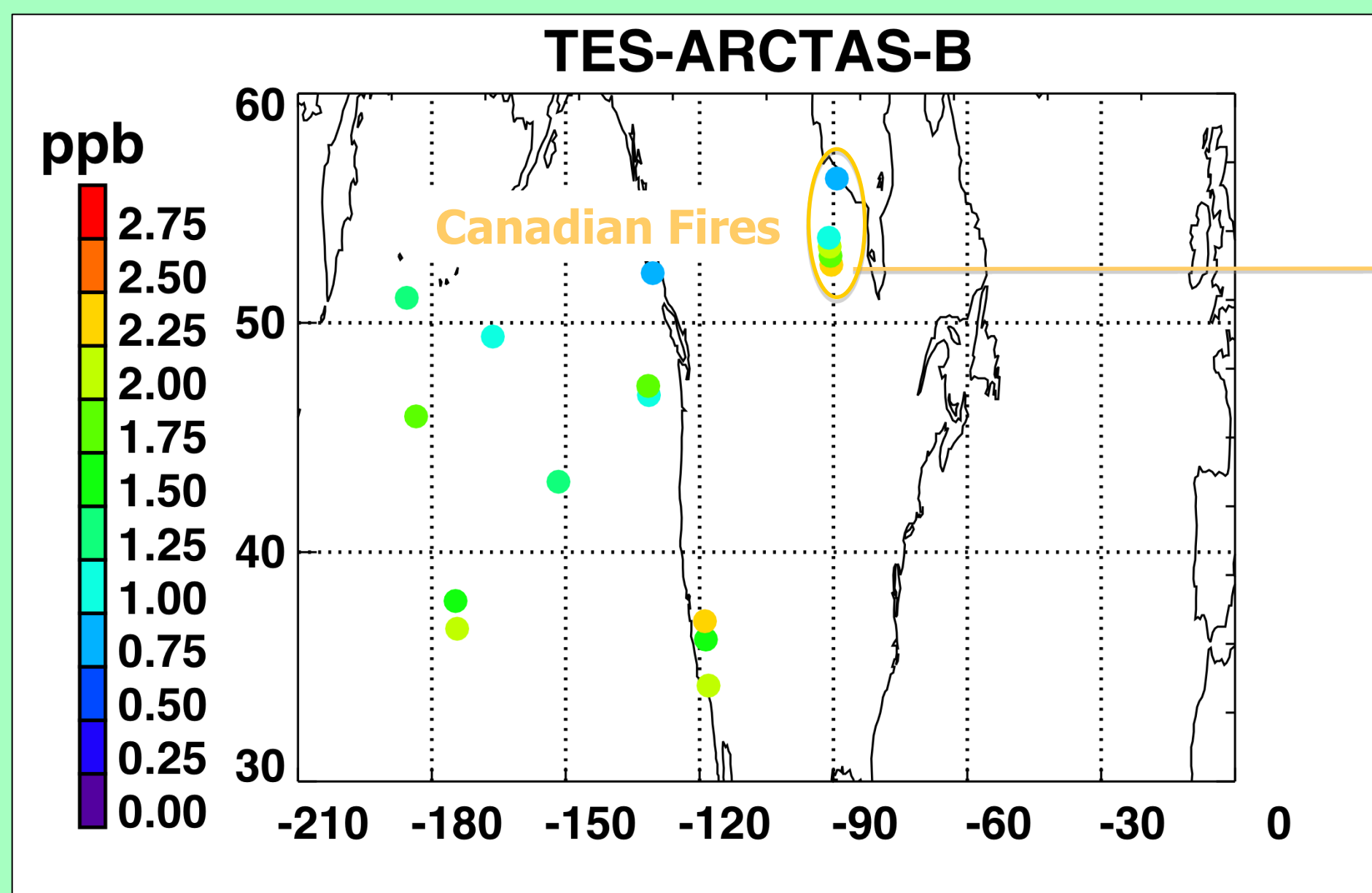
4(b) TES derived NH₃ emission ratio consistent with aircraft studies



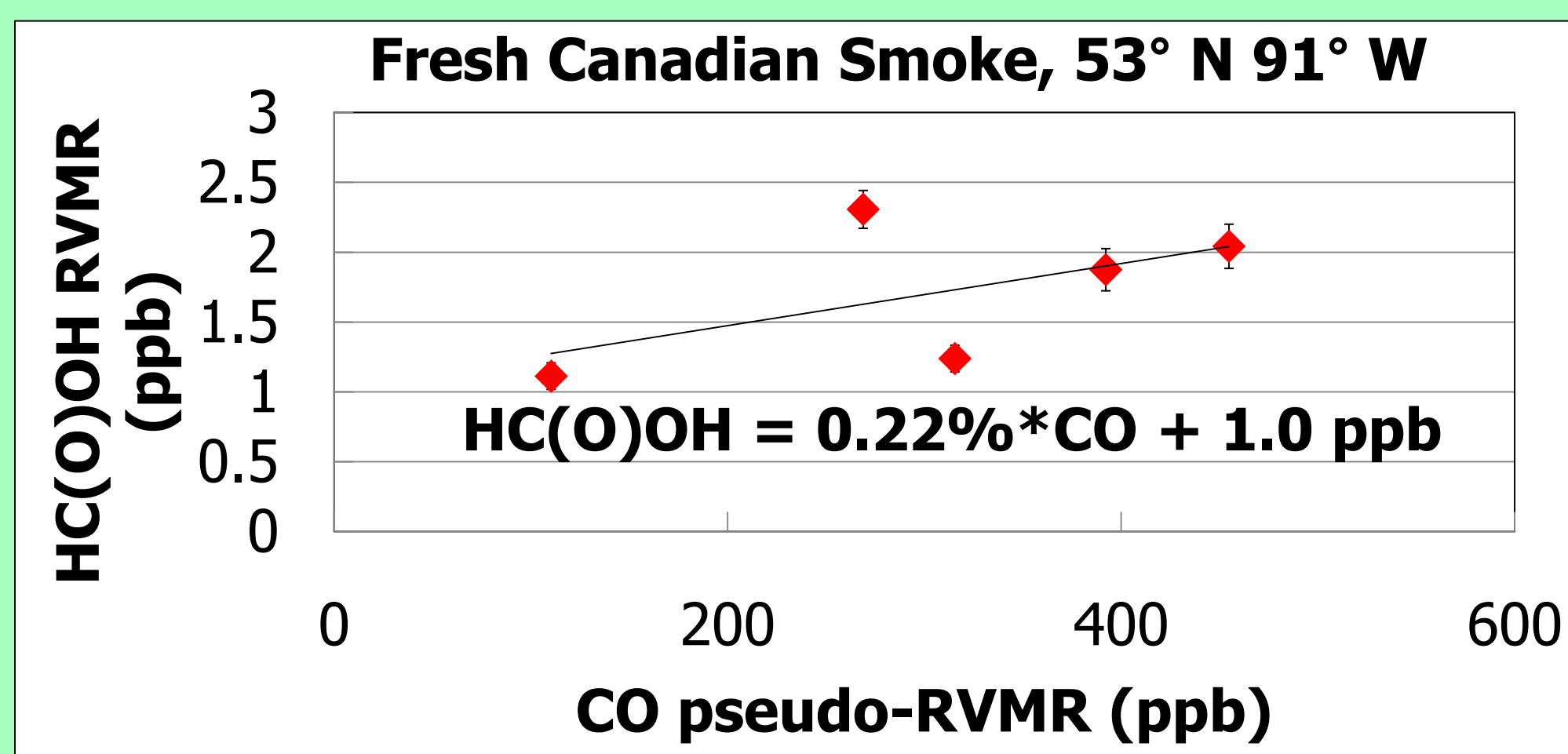
$\Delta\text{NH}_3/\Delta\text{CO}$	Source
1.2%	This Study
1.2% to 2.6%	Goode et al. (2000)
3.5% \pm 3.2%	Akagi et al. (2010)
2.6% \pm 2.2%	Andreae & Merlet (2001)

5(a) HC(O)OH shows little correlation with biomass burning CO

Removed retrievals with DOFS < 0.5 and low CO



5(b) TES derived HC(O)OH emission ratio in line with aircraft studies



$\Delta\text{HC(O)OH}/\Delta\text{CO}$	Source
0.22%	This Study
0.52% to 1.16%	Goode et al. (2000)
0.28% \pm 0.25%	Akagi et al. (2010)
1.4% \pm 1.4%	Andreae & Merlet (2001)

6. Summary and Conclusions

- PAN detected by TES for the first time
 - Seen in both fresh Canadian and aging Siberian smoke
- TES derived emission ratios for NH₃ (1.2%) and HC(O)OH (0.22%) are consistent with previous studies
- NH₃ and HC(O)OH RVMRs are weakly correlated with biomass burning CO ($r^2 < 0.3$)