Ozone, Aerosol and Carbon Gases at the Mt. Bachelor Observatory

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Mt. Bachelor, Oregon, (MBO) 2.8 km asl

- The only high elevation/free trop research site on west coast of U.S.
- Continuous observations of CO, O_3 and aerosols since 2004;
- Frequent detection of Asian pollution and biomass burning plumes;
- More than 40 papers since 2004 on O_3, PM. Hg, LRT, wildfires, etc.
- Key goal: Identify importance of background sources on US air quality.

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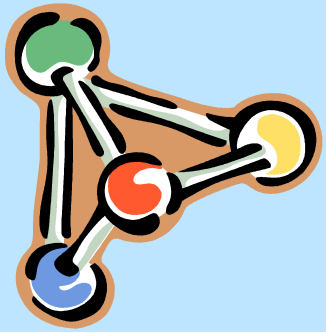
Chemical measurements at MBO



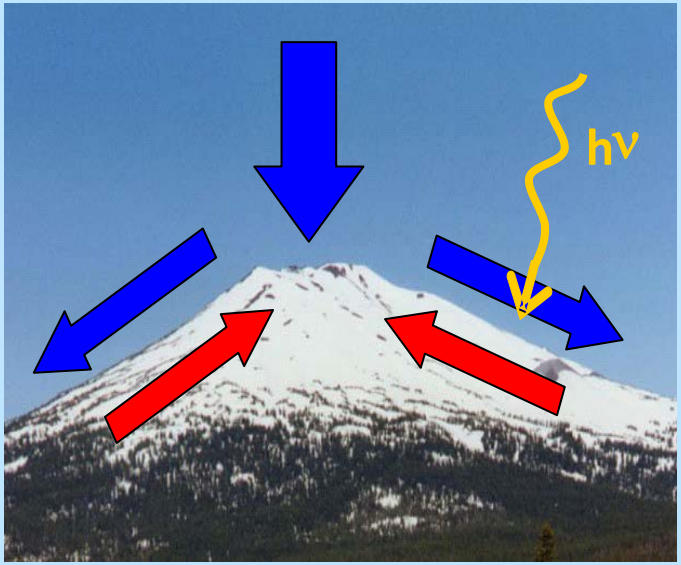
Continuous (most since 2004):

- CO and CO_2 Cavity Ring Down Spectroscopy
- O_3: UV spectroscopy
- Aerosol scattering (continuous PM1, PM2.5)
- Aerosol absorption (PSAP/TAP)

Campaigns:

- NOx/NOy: Chemiluminescence spectroscopy
- Peroxyacetyl nitrate (PAN): Gas chromatography, CIMS
- Mercury (Hg): Cold vapor atomic fluorescence (CVAFS)
- Hydrocarbons: Gas chromatography/mass spec.
- Acids (H_2SO_4, HNO_3): Ion chromatography, CIMS
- Aerosol chemistry: X-ray fluorescence, AMS (Zhang UCD)
- Aerosol size distribution (SMPS/nano-SMPS-Lee-UAH)
- Aerosol Black Carbon: SP2 (Sedlacek-BNL and UCD–Cappa-UCD)

Diurnal circulation pattern at Mt. Bachelor



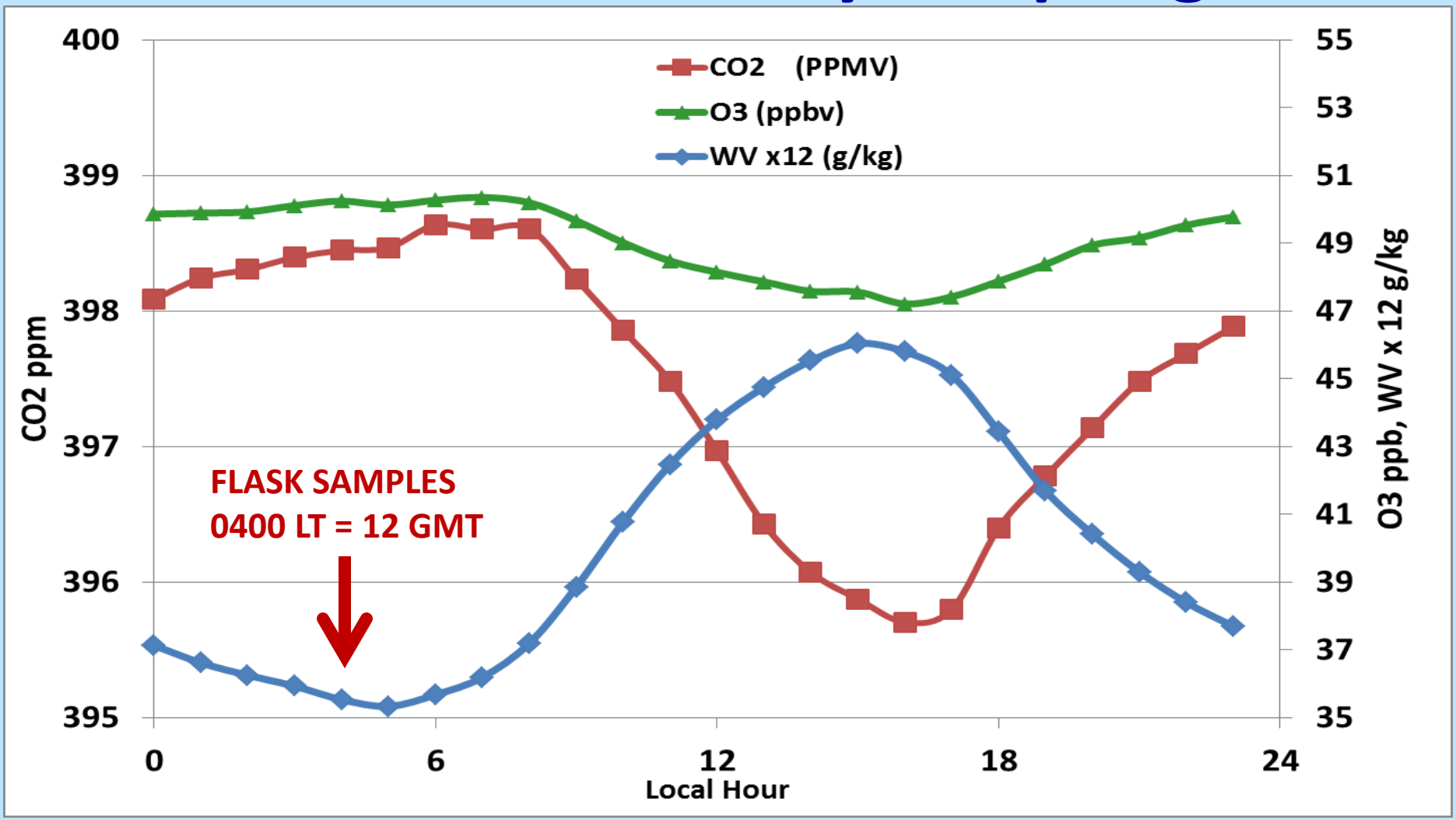
Day: upslope flow brings modified BL air to summit. This air is more humid and usually low in O_3.

Night: downslope flows brings Free Tropospheric (FT) air to the summit. This air is dry and usually high in O_3.

ID of Free Tropospheric Air

- Time of day.
- Water vapor mixing ratio.
- Chairlift soundings.
- Observations of NOx
- Weiss 2006, 2007; Fischer 2009; 2010; Reidmiller 2011

Mean diurnal cycle-Spring



Use WV mixing ratio as a criteria to separate FT/BL Influenced (BLI) air

McClure et al 2016-
AAQR Mtn top special issue

Some past and current work at MBO

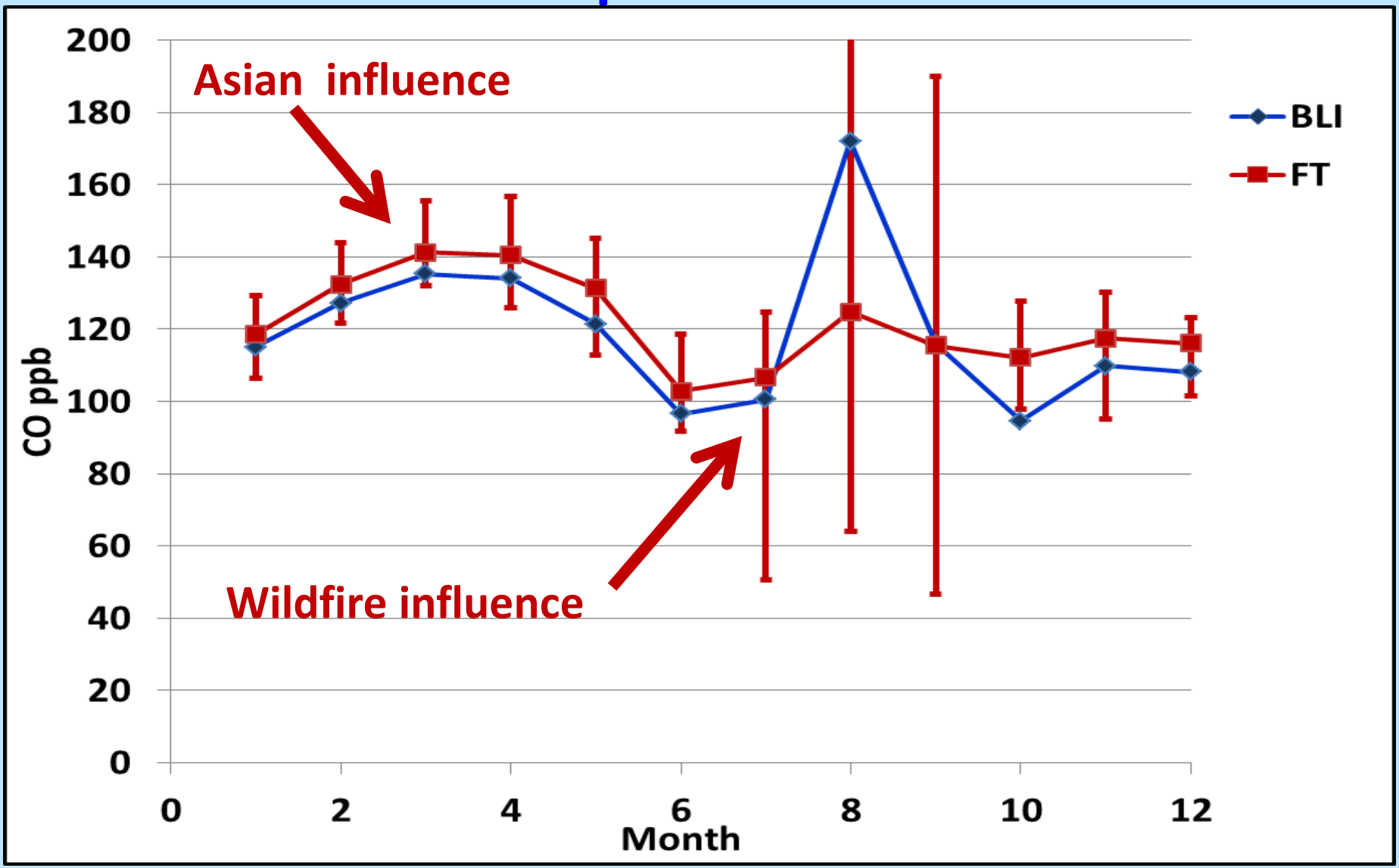
- Identification of long-range transport of CO, O_3, aerosols and Hg from Asia to the US; Identification of a significant under-estimate in Asian emissions of Hg;
- Identification of a significant source of Hg^{2+} in the free troposphere;
- Identification of micro-organisms in free troposphere.
- Use of MBO observations to understand NOy, PAN, O_3 and PM chemistry in wildfire plumes.
- Positive trend in spring and summer O_3 and negative trend in CO over past decade. Sources of O_3 in the free trop.
- Aerosol properties, SSA, Å, size distributions in Asian and fire plumes.
- Constraints on the inflow of background O_3 to the US.
- Look at consistency of multiple methods to measure BC.
- Examination BC/CO ratios in LRT to constrain BC lifetime.

Collaboration with more than 20 diff. groups (Universities, Gov labs, etc)

Collaboration with NOAA-GMD

- Prior to 2012 CO measurements with a Thermo 48CTL;
- Starting in April 2012, we installed a CRDS from Picarro for higher precision CO, CO_2 and WV.
- NOAA (Kofler) has provided invaluable support for maintenance and calibration of the Picarro.
- GMD flask samples started in October 2011, now doing daily samples at 12Z, which is most likely time for free trop air.
- 940 samples to date; 55% Free trop, 41% Boundary Layer Influenced (BLI) using WV criteria.

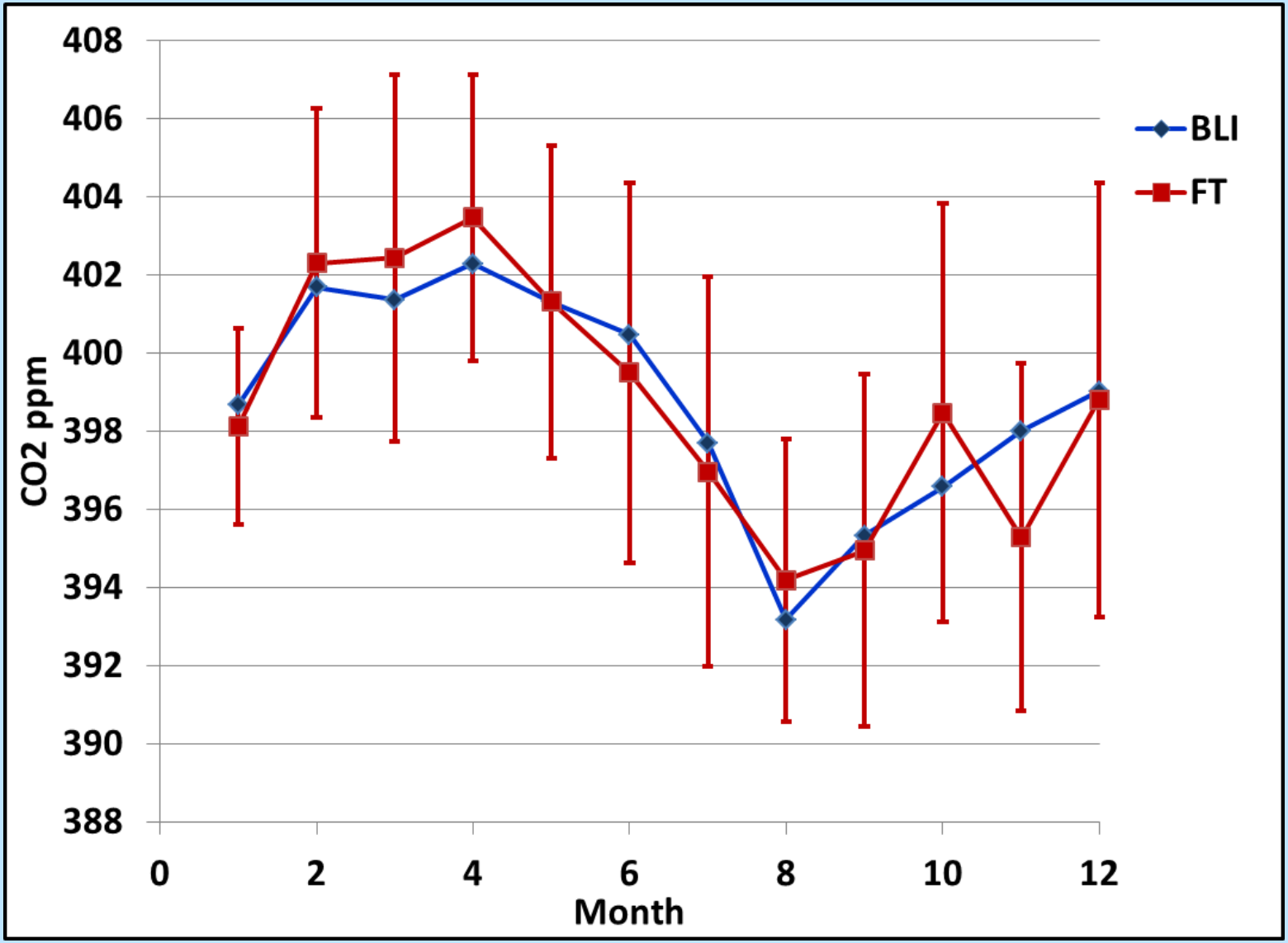
CO in the Free Trop and "BL Influenced" Air



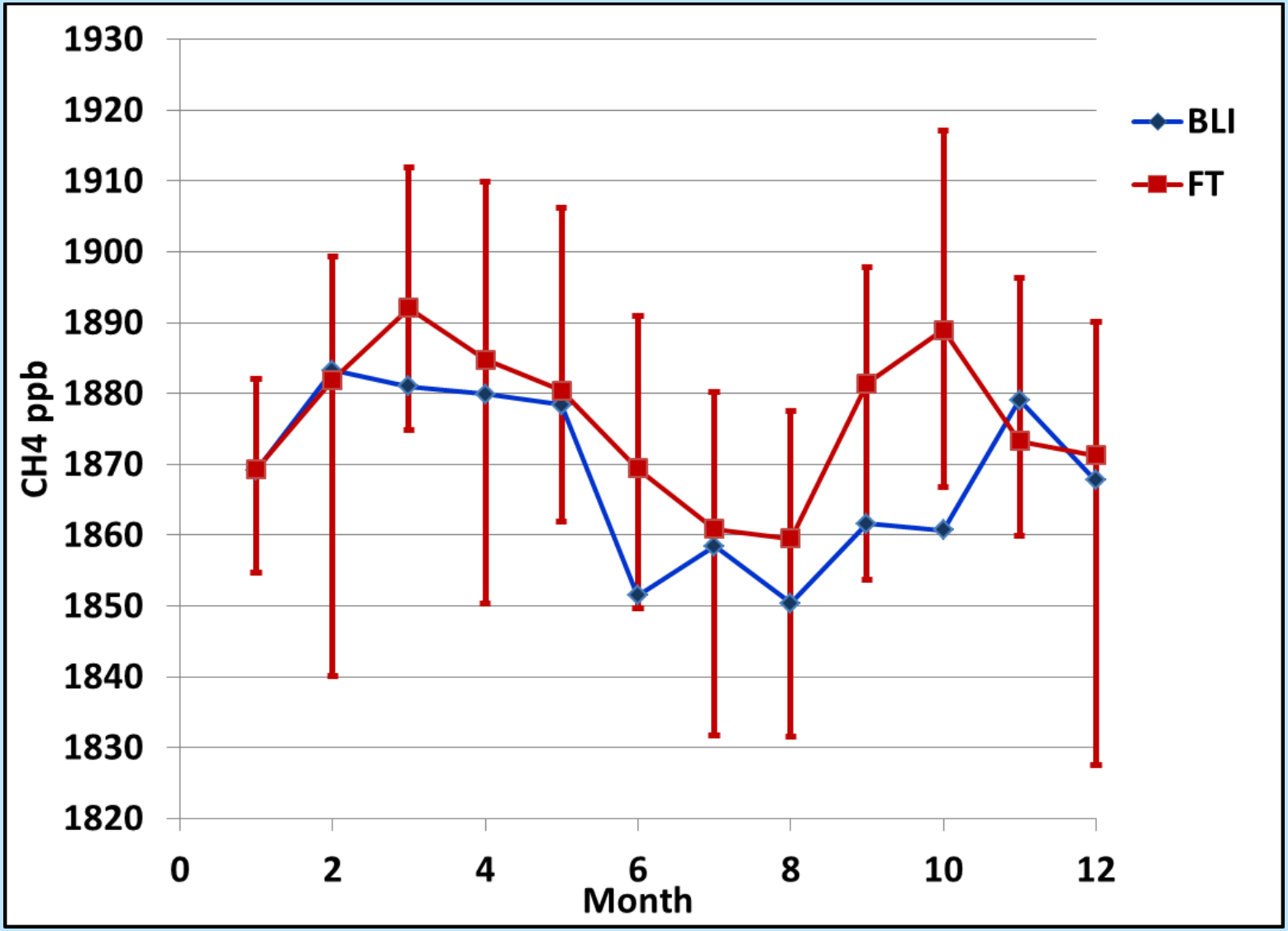
Asian influence seen mostly in FT

Wildfire influence seen in BL and FT

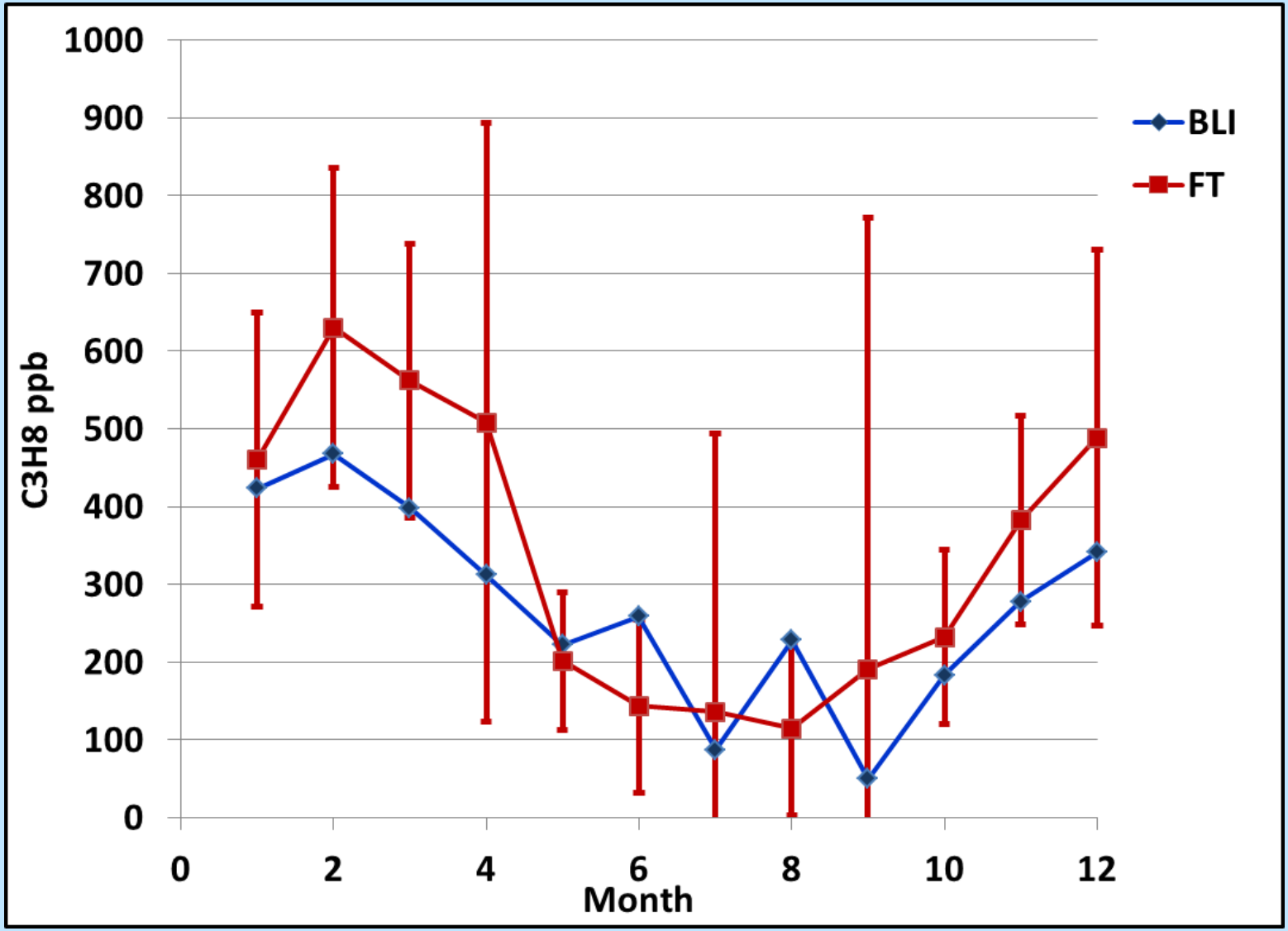
CO_2 in the Free Trop and "BL Influenced" Air



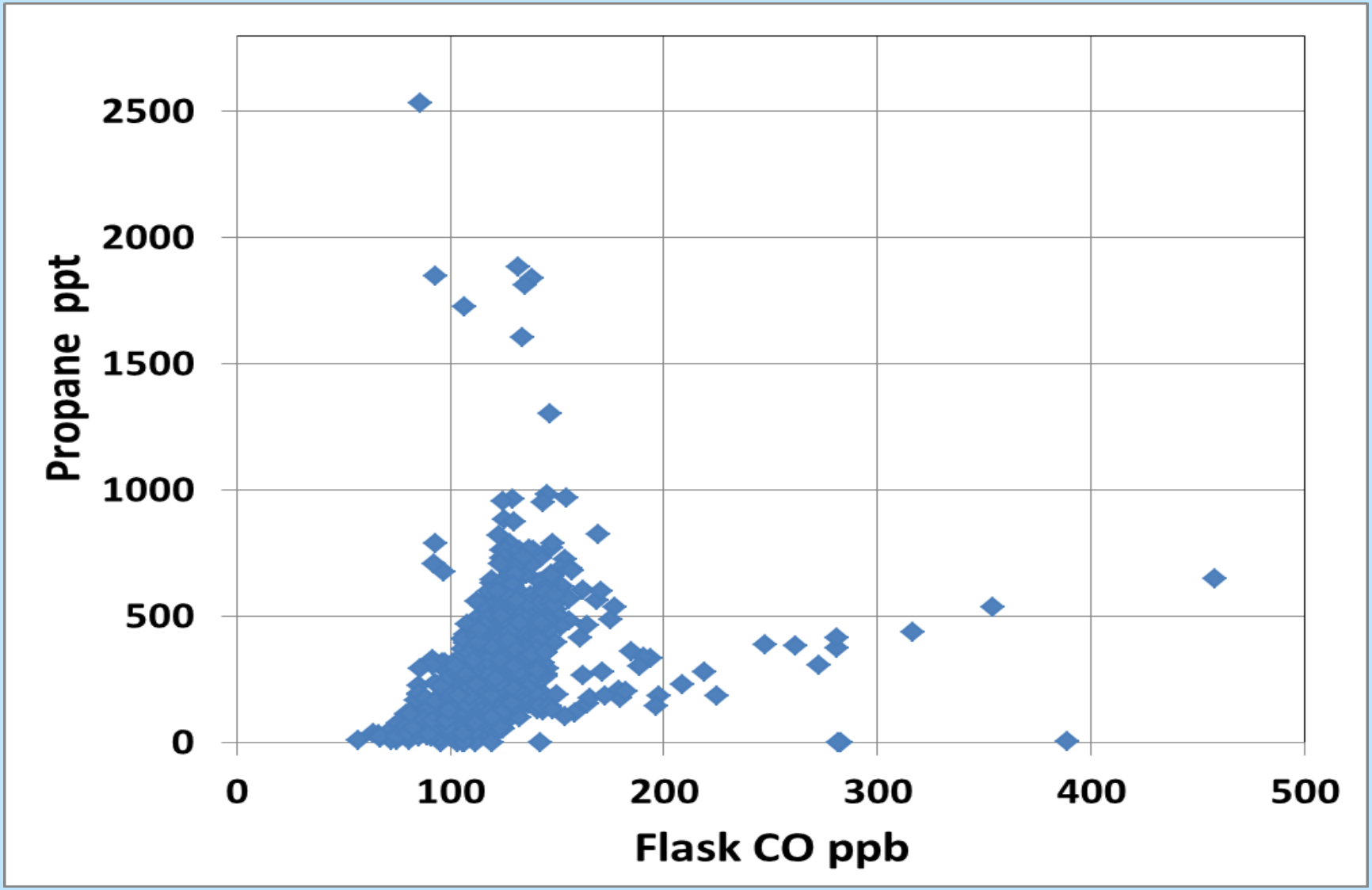
CH_4 in the Free Trop and "BL Influenced" Air



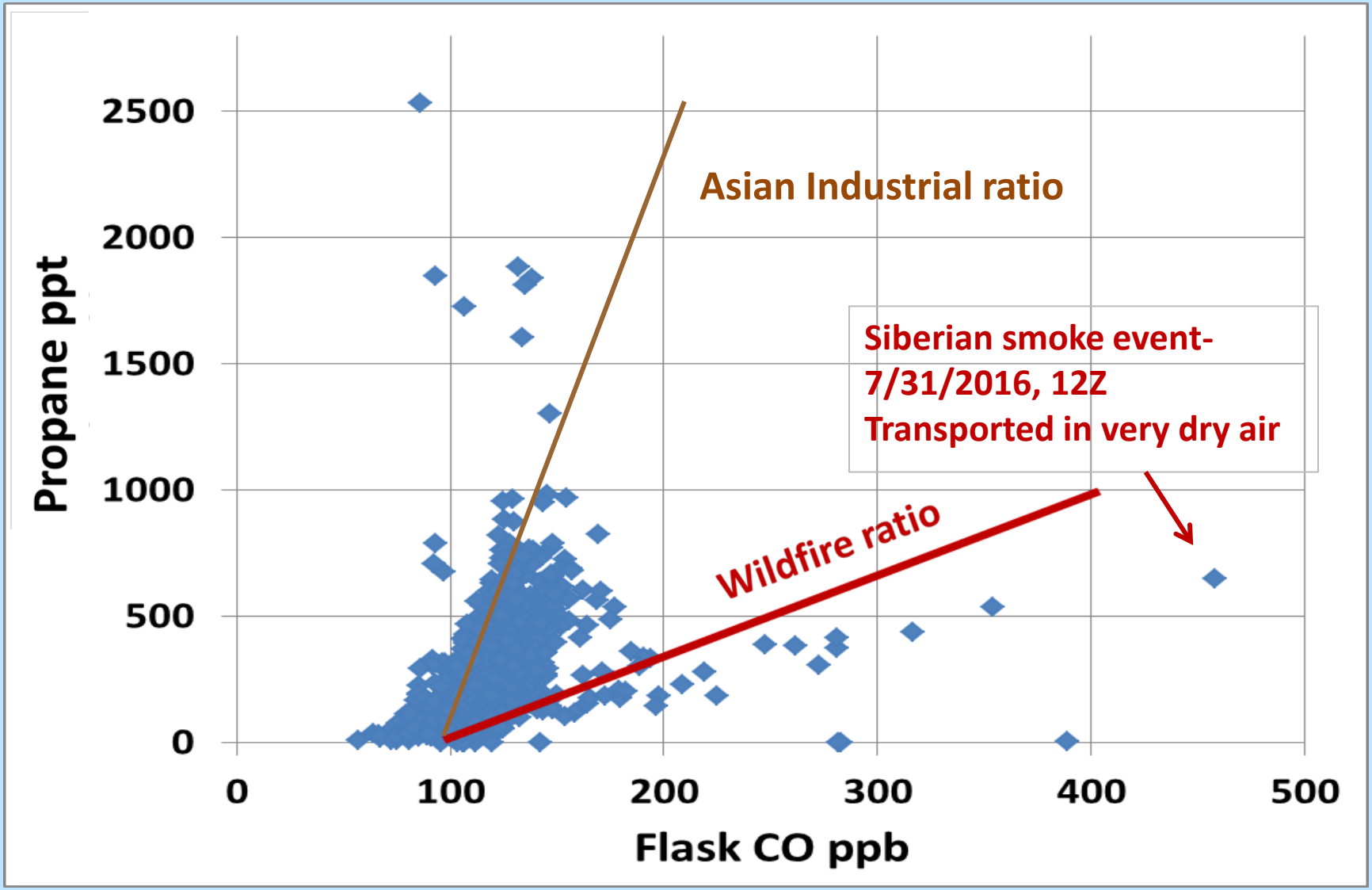
C_3H_8 in the Free Trop and "BL Influenced" Air



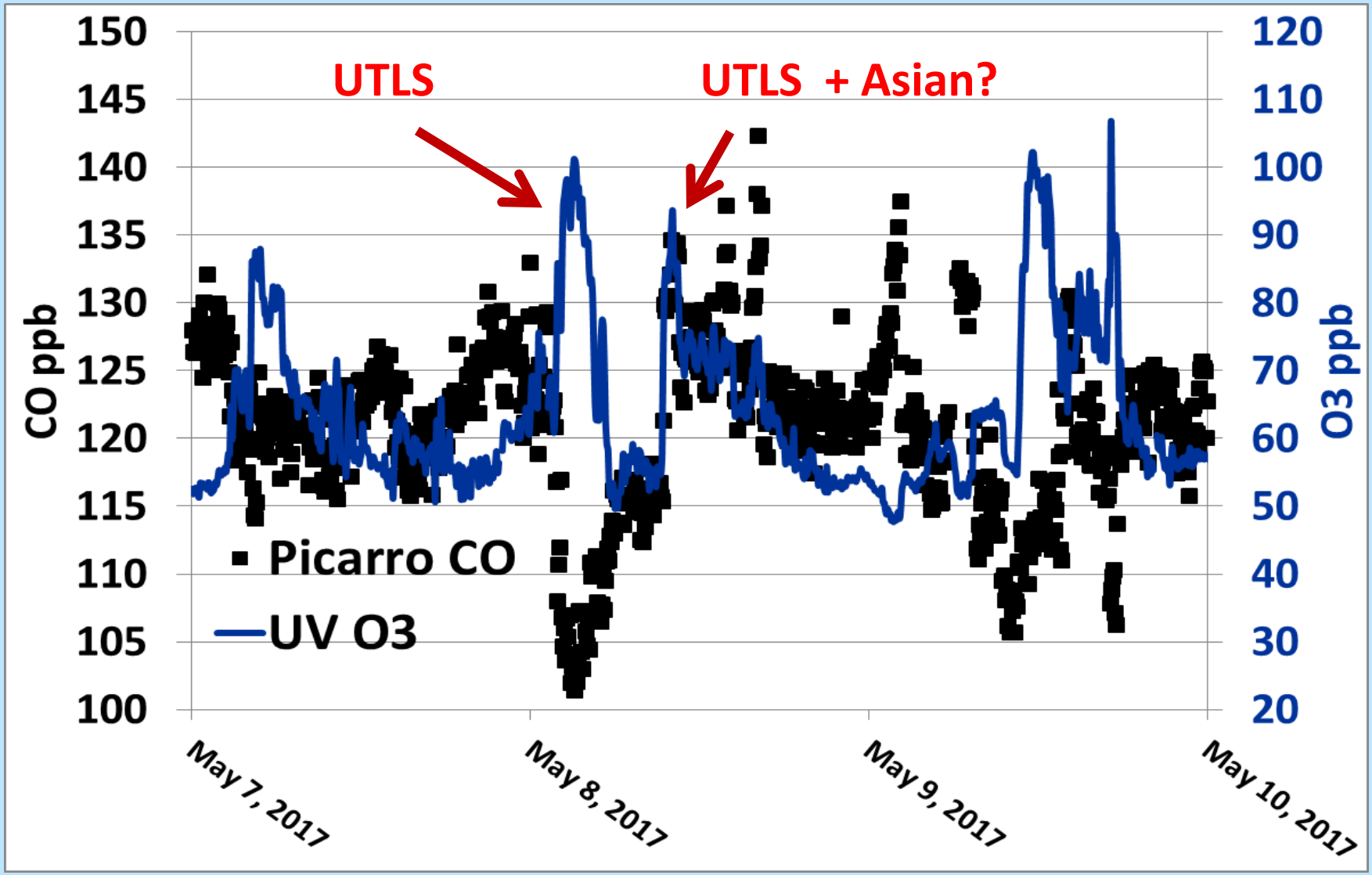
C_3H_8 (propane) vs Flask CO



C_3H_8 (propane) vs Flask CO- all data



Value in real time data



Summary

- MBO is an excellent site to observe free tropospheric inflow into North America, Asian and wildfire plumes. Observations of CO_2, CH_4, etc can give information on NA boundary conditions and help constrain global fluxes;
- In spring, CO, CO_2, CH_4, C_3H_8, O_3, etc are all higher in FT air compared to the BL.
- Enhancement ratios with CO provide key information on source type and processing enroute. (ERs with CO_2 more challenging to interpret).
- Daily flask obs at 12Z is ideal sampling time to sample FT inflow.
- O_3 is a key pollutant at MBO since US standard now 70 ppb. We see many days at MBO with O_3 in excess of this value and identifying source is important for understanding US air quality. Since 2004, we see positive trends in O_3 in spring, summer and fall.

Collaborations welcome!

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In-situ CO vs Flask CO