Observations of Southeast Asian Biomass Burning and Urban Trace Gas Enhancement Ratios: Insights into Regional Air Quality and Aerosol Composition

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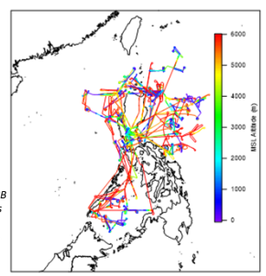
Overview

- Enhancement ratios of CH_4:CO used to apportion biomass burning and urban sources
- HYSPLIT backtrajectory analysis consistent with resulting regime assignment
- Organic aerosol dominate average biomass burning aerosol composition, while sulfates form the plurality of urban emissions
- Enhancement ratios of O_3:CO highly correlated in biomass burning and urban regimes respectively, though with different values

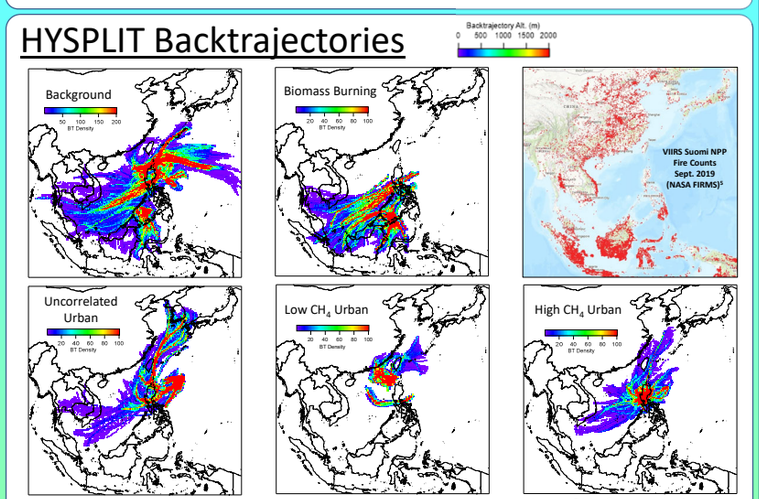
CAMP²Ex Flight Campaign

- Joint NASA/MO/NRL project: Aug-Oct 2019
- Measurements: NASA P-3B aircraft, SPEC Learjet
- Major science question: How do contrasting airmass composition and sources, such as biomass burning (BB) or urban, affect:
  - Aerosol properties
  - Air quality
  - Cloud nucleation & precipitation



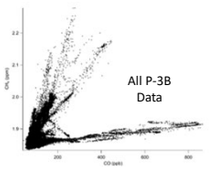
All NASA P-3B flight tracks near the Philippines during CAMP²Ex

HYSPLIT Backtrajectories



- 48 h BT along flight track[6,7]
  - 1 min intervals
  - GFS 0.25° meteorology
  - Only shown < 2 km
- Background flagged air most recently influenced by air over the Philippine and South China Seas
- Biomass burning flagged air influenced exclusively from SE Asia, primarily Borneo, Sumatra, and Sulawesi
- Low CH_4 flagged air influenced by mainland China, while high CH_4 flagged air influenced mostly by local Pilipino emissions
- Uncorrelated urban flagged air influenced predominantly by longer range transport from SE Asia, Korea, & Japan

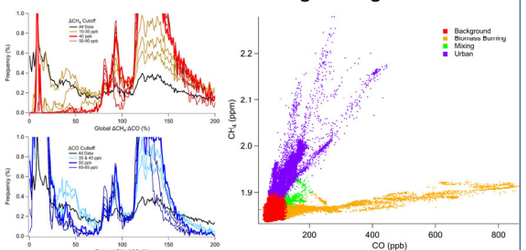
Chemical Influence Apportionment



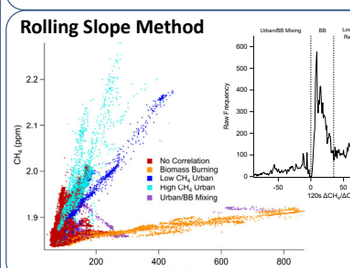
- Enhancement ratios (ER) of CH_4 and CO used to apportion different airmass source influences
  - Partitioned strongly between reported biomass burning[1,2] and urban[3] emission ratios
- Two methods used to separate regimes

Single Background Method

- Single concentration for each species chosen as background lower limit
- Background upper limit chosen by finding minimum in slope distribution at different ER cutoffs (left panels)
- Regime in middle assigned as mixing due to presence of mixing lines

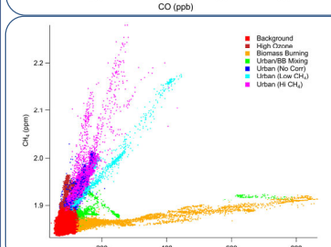


Rolling Slope Method



- ER determined by slope of CH_4:CO fit of 120 s rolling window[4]
- Slopes filtered for only those with strong correlations ($r^2 > 0.5$)
- Minima in distribution of slope distribution identified different regimes (right panel)
  - Negative slopes implied mixing regime
  - Urban regime separated into two regimes, one with lower CH_4:CO ER (low CH_4) and the other with higher CH_4:CO ER (high CH_4)

Final Combined Flag



- Final flag merges regimes from both methods
- Includes "high ozone" regime: evidence of stratospheric influence
- Isolates data within 1 km of takeoff/landing (not shown due to scale)

Acknowledgements

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James Geiger, Mario Rana

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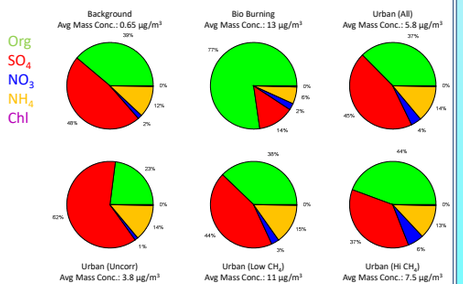
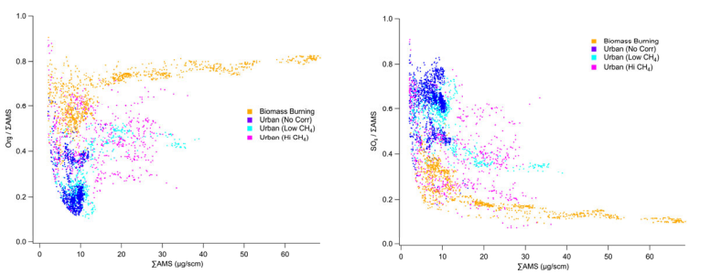
Aerosol Chemical Composition

Relative Mass Contributions by Regime

- Average relative composition from NASA LaRC Aerosol Mass Spectrometer
- Biomass burning apportioned airmasses dominated by organic aerosol contributions
- Urban regimes exhibited higher average sulfate contributions, with the uncorrelated regime exhibiting the highest sulfate proportion



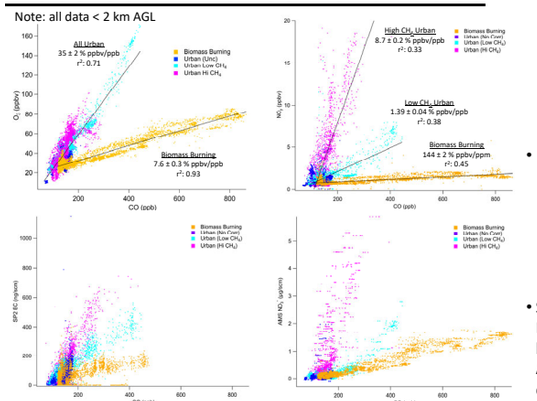
Contributions as Function of Total Mass



- Bio burning and low CH_4 regimes each approach narrow mass contribution range
- Larger spread at high aerosol mass implies higher variety of sources in high CH_4 regime

Trace Gas Enhancement Ratios

Note: all data < 2 km AGL



- Distinct O_3 and CO correlated relationships between Urban and BB regimes
  - Persistent correlation in BB regime despite different relative airmass ages
- NO_y weakly dependent on CO in correlated urban regimes
  - High CH_4 regime clearly exhibits much higher NO_y enhancements compared to Low CH_4 regime
- Similar separation as with NO_y:CO by regime seen in black carbon (BC):CO and AMS nitrate (NO_3^-):CO enhancements