Space-based HCHO Measurements as Constraints on VOC Emissions in Asia

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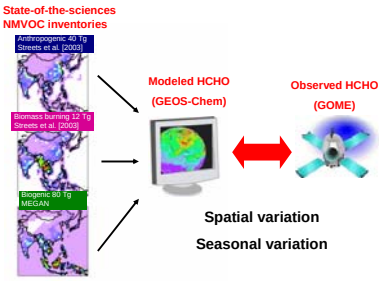
Formaldehyde (HCHO) columns measured from space by solar backscatter allow quantitative mapping of reactive volatile organic compound (VOC) emissions. We analyze measurements from the GOME satellite instrument between 1996 and 2001 over Asia and compare the resulting monthly constraints on VOC emissions with the latest emission inventories. We show that the current inventory for Chinese anthropogenic emissions is 25% too low in winter due to an underestimation of vehicular activities. The current biogenic inventory is a factor of 2 to 4 too low for China and a factor of 2 too high for Indonesia. Satellite-constrained Asian biomass burning emissions are 6 times larger than the current estimation. Large HCHO signals are consistently observed in early summer over the North China Plain, implying a large, previously unrecognized source from winter wheat harvesting and crop residual burning. We estimate 30 to 70% of crop residual is burned in field in China.

HCHO Columns as Top-down Constraints on VOC Emissions

HCHO is a high-yield intermediate oxidation product of VOCs, which are emitted through **anthropogenic**, **biomass burning**, and **biogenic** activities. Localized HCHO column signals observed from space indicate emissions of short-lived VOCs.

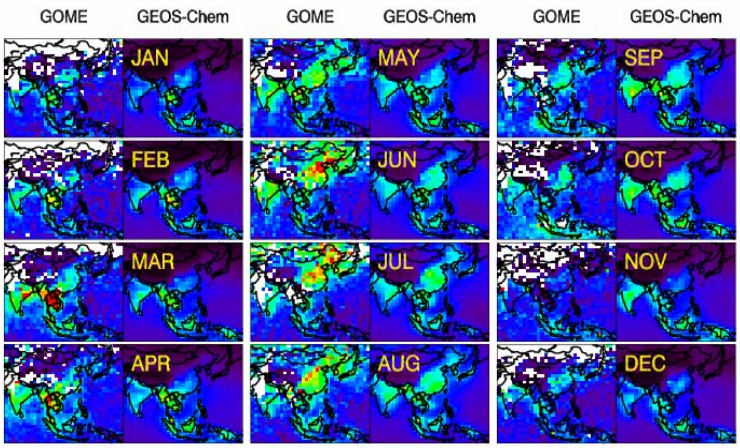


Comparing the spatial and seasonal variation between the observed and modeled HCHO allow quantitative assessments of the current inventories.

Previous studies have shown that over N. America and during the growing season, GOME-observed HCHO are dominated by biogenic isoprene emissions and agree well with the current inventory.

GOME HCHO Monthly Columns over Asia (1996-2001)

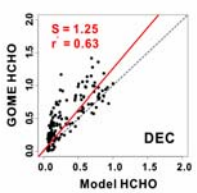
We analyze measurements from the GOME instrument between 1996 and 2001 over Asia. Diffuser plate bias is removed for each solarday. Vertical columns are calculated by applying the air mass factor (AMF).



Relationship to VOC emissions far more complex than for N. America; biomass burning, isoprene, anthropogenic VOCs, and direct HCHO emissions all contribute.

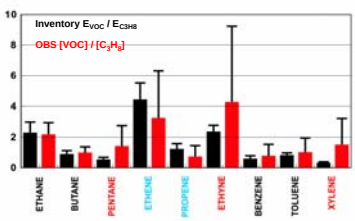
Excess winter HCHO in China due to VOCs from vehicles

Chinese grids w/ GOME > 0



In winter, observed Chinese HCHO is 25% higher than the model. We compare the Chinese urban VOC concentration ratios with the emission ratios. Species associated with vehicles are underestimated in the inventory.

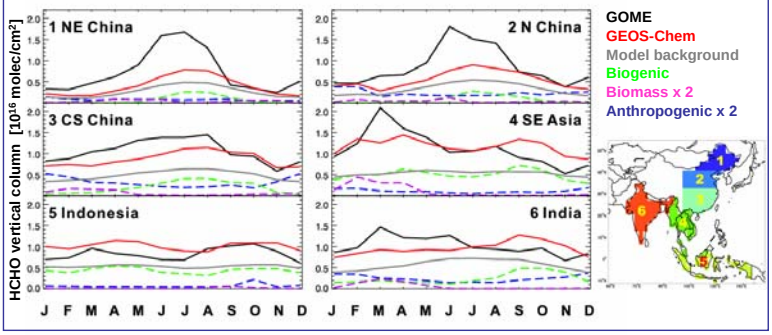
$$\text{Local } \frac{[\text{VOC}_i]}{[\text{C}_3\text{H}_8]} \approx \frac{E_i}{E_{\text{C}_3\text{H}_8}}$$



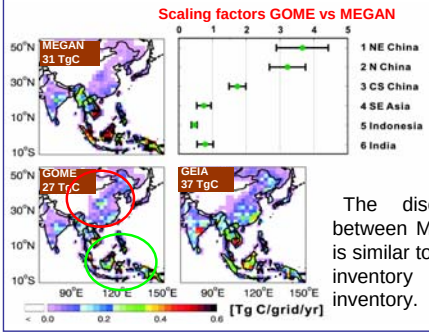
Adjusting for vehicular VOC emissions results in +9% HCHO column. Further considering direct HCHO emission from vehicles leads to +10-60% HCHO.

Large Seasonal Variations due to Biomass Burning and Biogenic Emissions

We conduct sensitivity simulations to test the response of HCHO columns to each emission type. We found that the seasonal variation of HCHO is mainly due to biomass burning and biogenic emissions. Current inventories capture the timing of the emission events, but the resulting HCHO amplitude is too low.



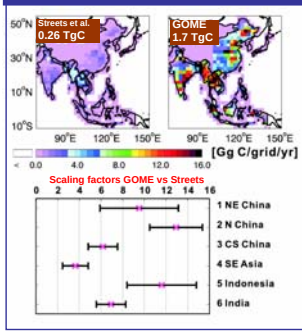
Biogenic Isoprene Differently Distributed



GOME observations indicate a general larger emission associated with the deciduous broadleaf trees in China and smaller emission associated with the evergreen broadleaf trees over Indonesia compared to MEGAN.

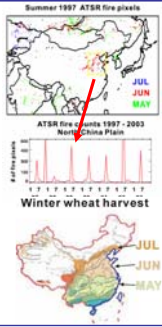
The discrepancy in spatial distribution between MEGAN and the results from GOME is similar to the difference between the MEGAN inventory and its predecessor the GEIA inventory.

Biomass Burning Emissions Largely Underestimated



GOME observations indicate a factor of 6 enhancement across the Asian domain compared to the Streets et al. inventory.

Over N China Plain, there is a factor of 13 enhancement associated with the recurring hot-spots of HCHO in June. We attribute this to 30 to 70% of crop residual being burned in field following winter wheat harvest.

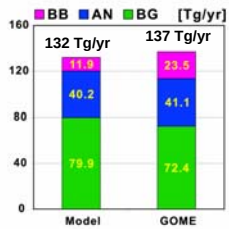


Spatial and seasonal variation of HCHO column can be use to constrain anthropogenic, biomass burning, and biogenic VOC emissions.

Previously unrecognized burning associated with winter wheat harvesting in June over N China Plains, equivalent to 30% to 70% percent of crop residual burned in field.

Total NMVOC emission inferred from GOME is 137 Tg/yr.

ΣNMVOC Emis



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