Towards isoprene measurements from CrIS: Gaining space-based information on key biogenic VOCs

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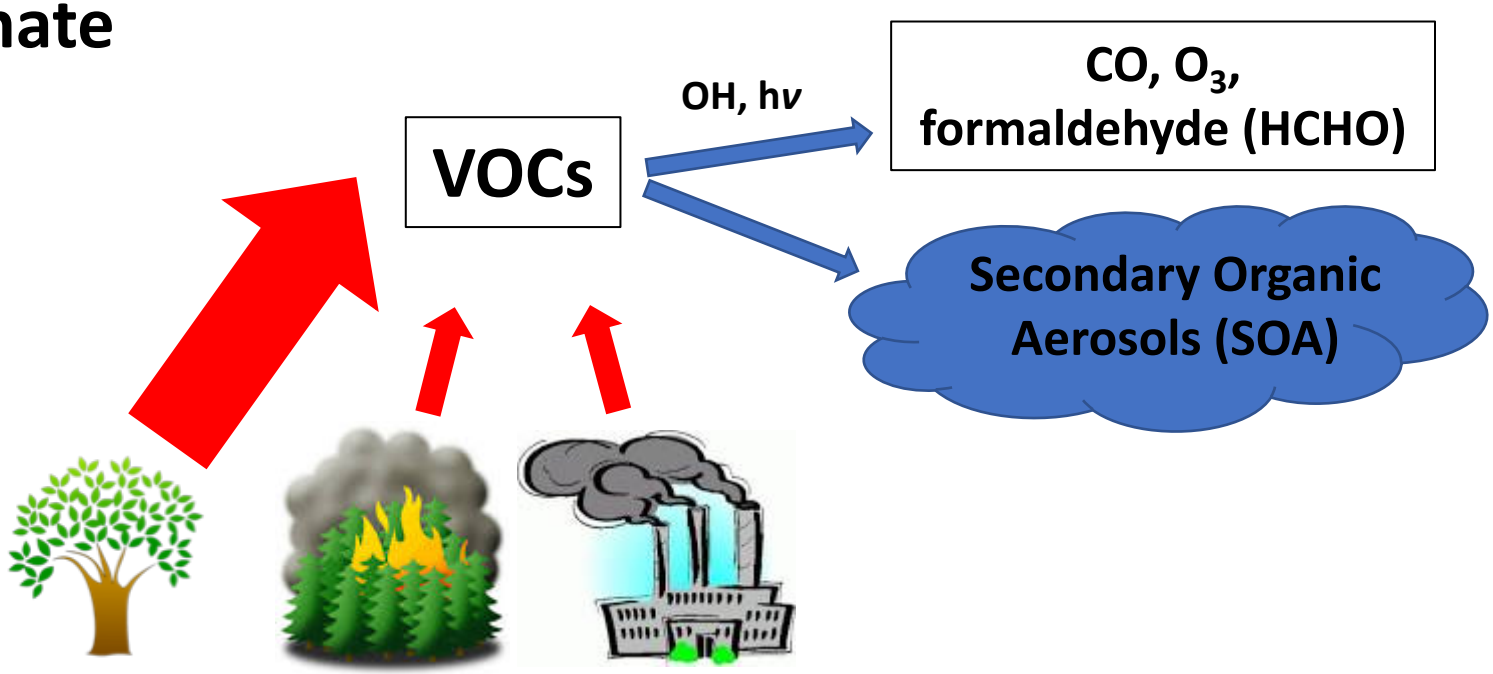
Karen Cady-Pereira (AER), Sree Chaliyakunnel (UMN), Xin Chen (UMN)

UNIVERSITY OF MINNESOTA

Biogenic volatile organic compounds impact air quality and climate

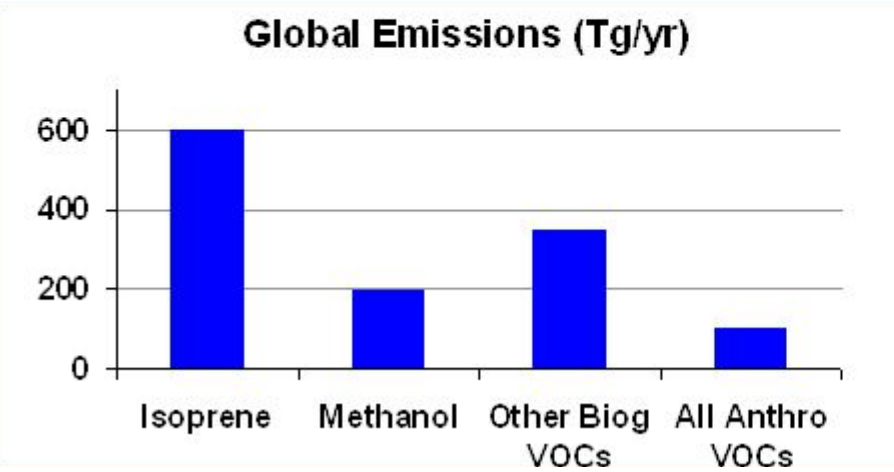


Isoprene: highest emitted BVOC

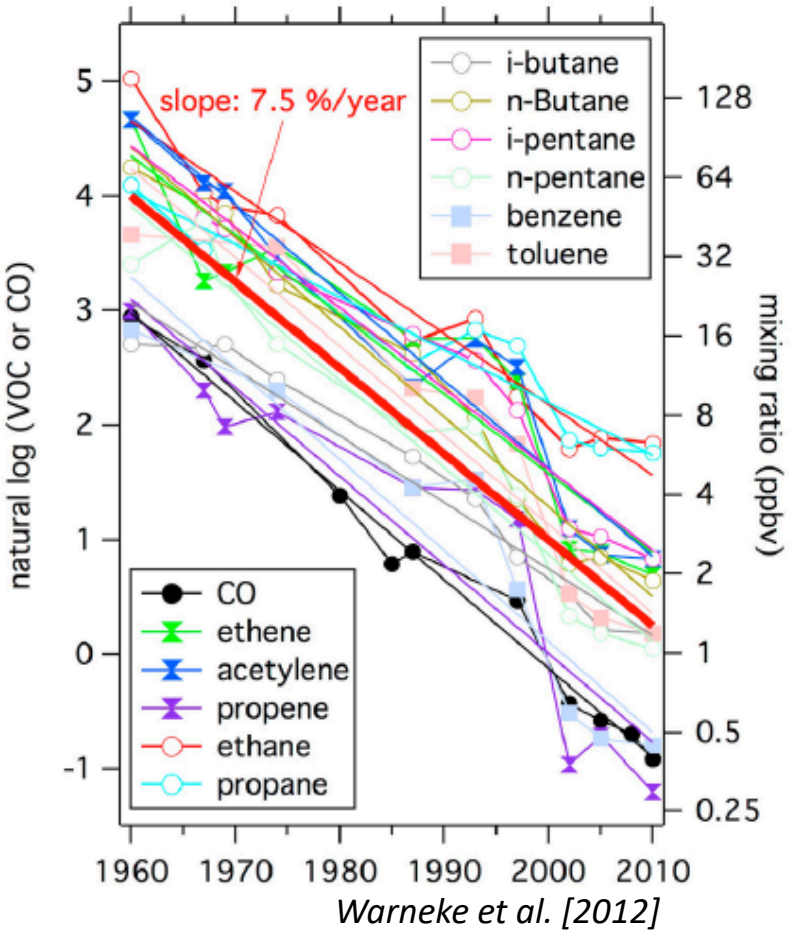
- Short lifetime (~1 hr)
- Source of HCHO, O_3, SOA
- Key player in atmos oxidation and Nitrogen cycling

Methanol: most abundant BVOC

- 5-7 day lifetime
- Source of CO, HCHO, O_3

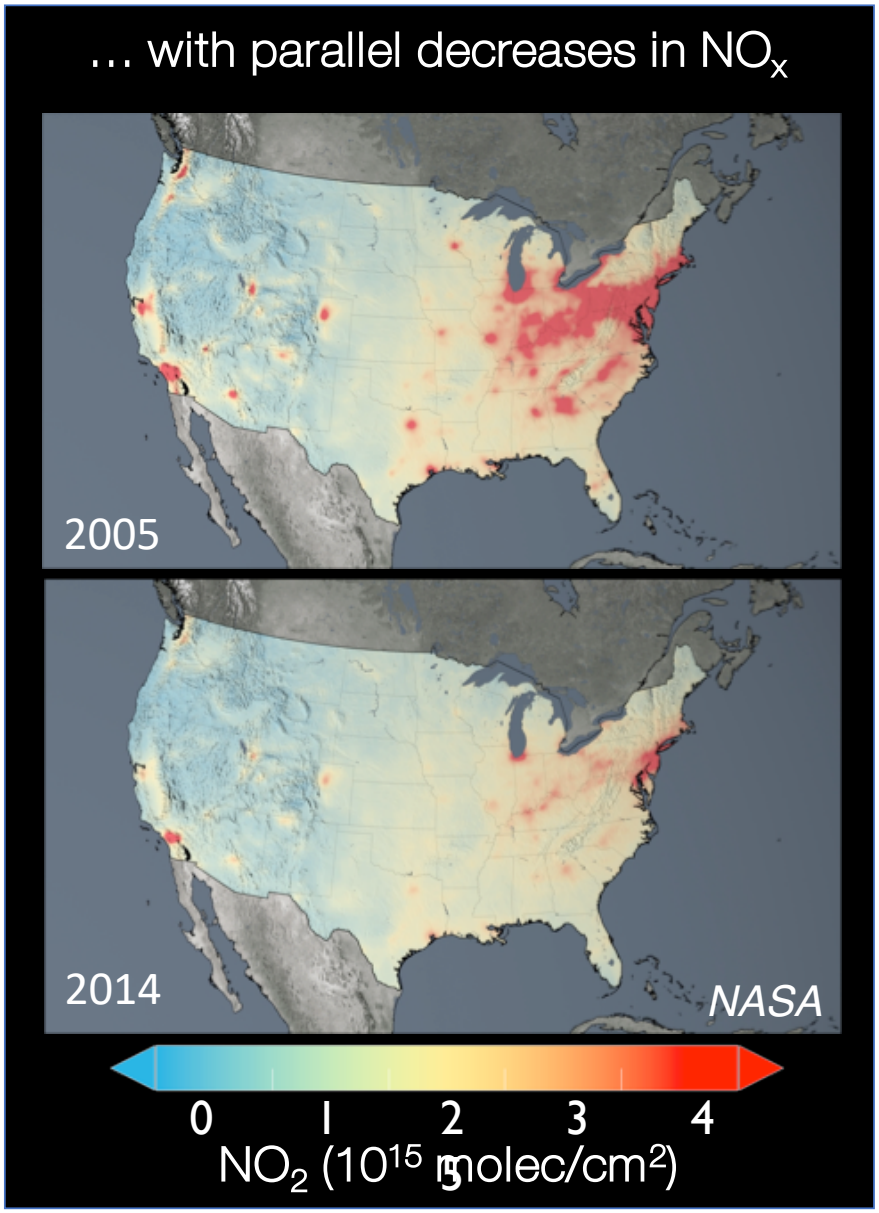


As anthropogenic emissions decline in the US, the relative importance of biogenic VOCs increases

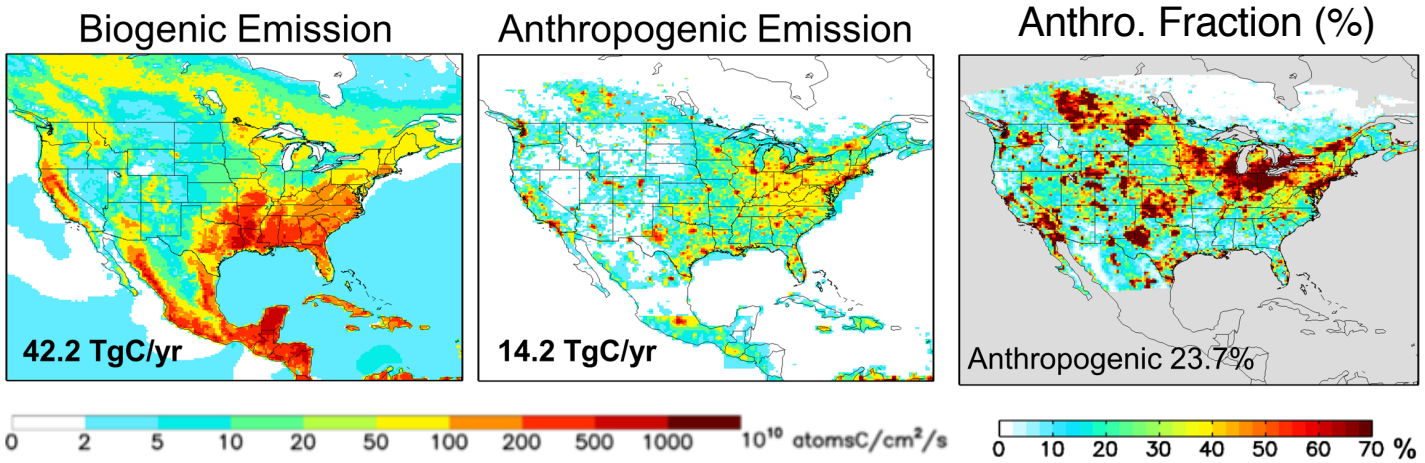


Warneke et al. [2012]

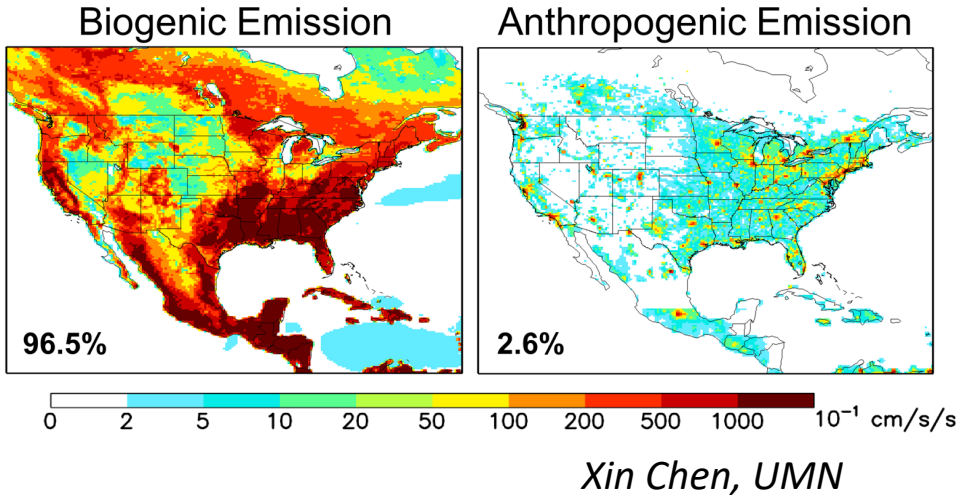
50× decrease in anthropogenic VOCs in LA since 1960, despite fuel use tripling over same time



Biogenic VOCs dominate chemical reactivity everywhere outside of major urban centers



Emissions weighted by their OH-reactivity:

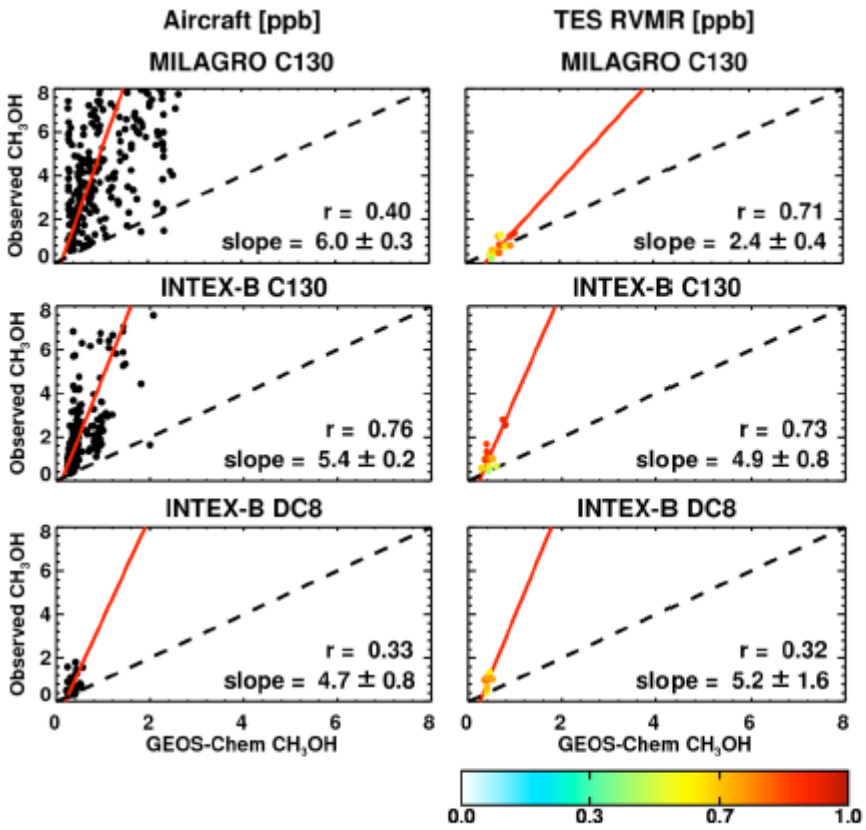


Xin Chen, UMN

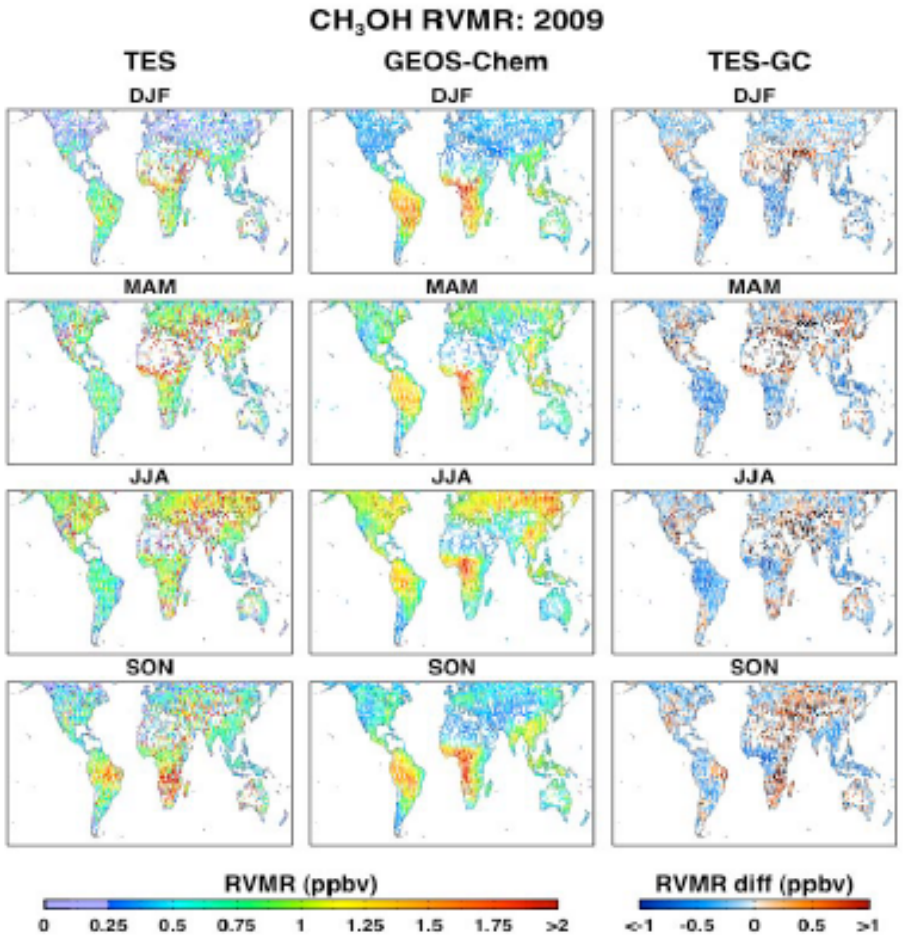
<u>Large emission uncertainties due to</u>:

- **Sparse in-situ constraints on emission rates**
- **Uncertainties in land cover, meteorological data, stress effects in plants**
- **e.g., recent estimates for global isoprene emissions range from ~270-1000 Tg yr^{-1}**

Aura TES methanol provides constraints on regional to continental-scale methanol emissions and seasonality



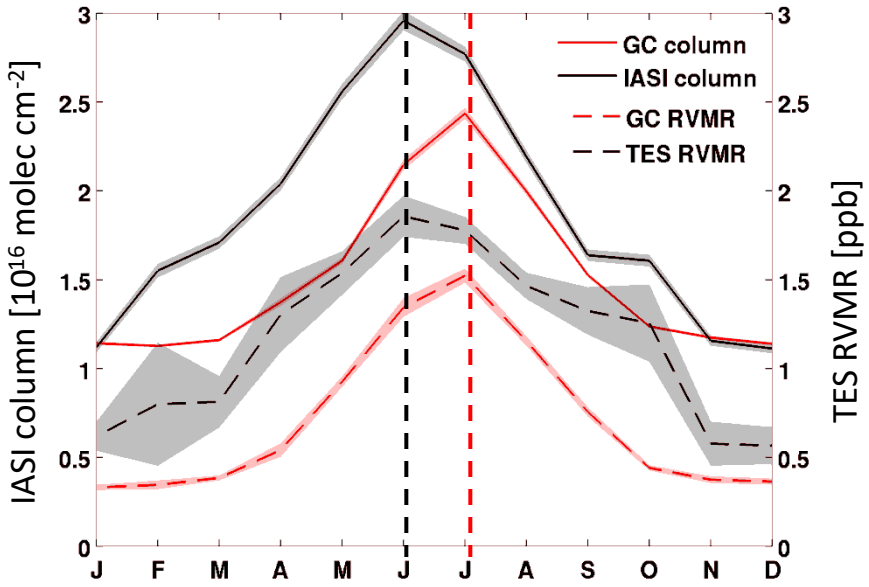
Wells et al. [2012]



Cady-Pereira et al. [2012]

- **Validated using aircraft data and GEOS-Chem model indirect comparison**
- **Comparison to TES revealed model overestimate in tropics, underestimate from arid regions**

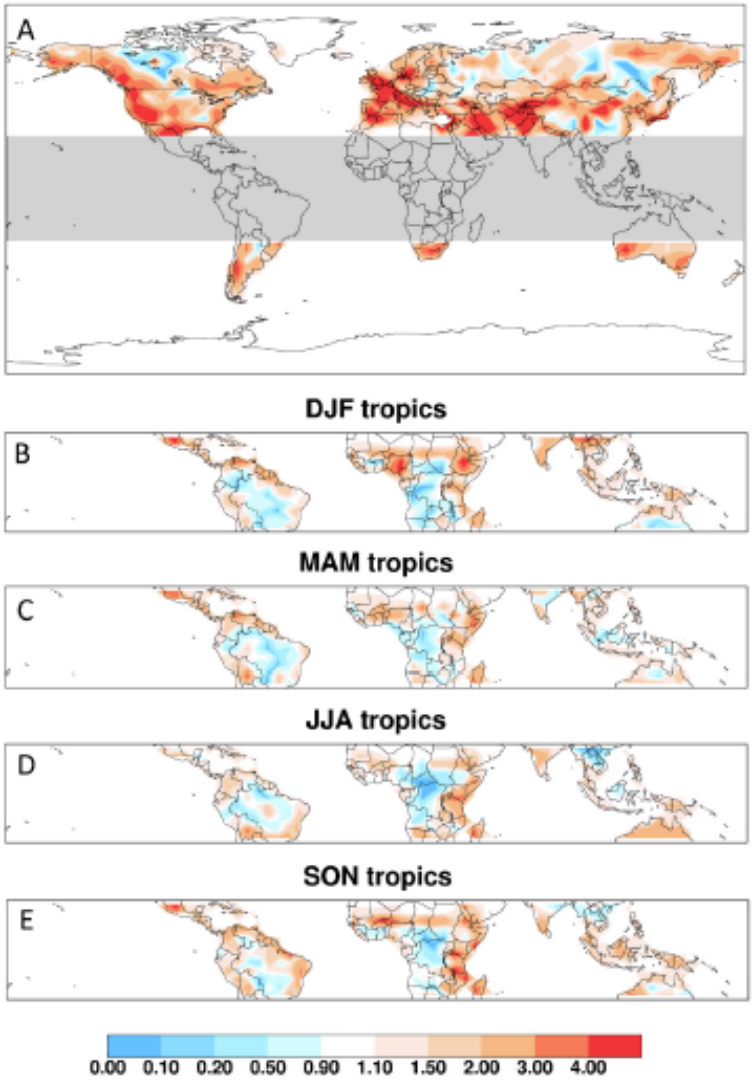
Aura TES methanol provides constraints on regional to continental-scale methanol emissions and seasonality



Wells et al. [2012]

- **Seasonal bias in comparison to TES and IASI revealed underestimation of emissions from young, new leaves**
- **Terrestrial flux increased 60% in 4D-Var inversion: from 76 to 122 Tg yr^{-1}**

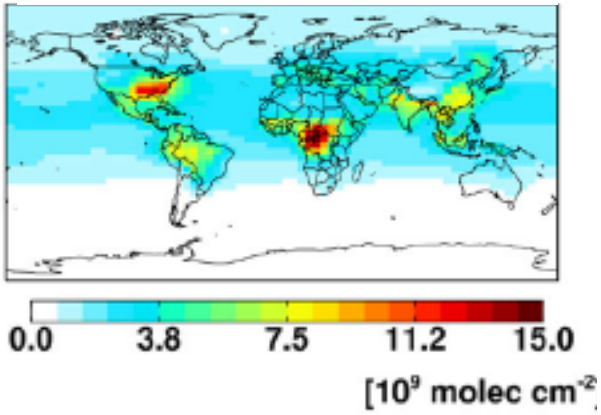
Methanol emission scaling factors



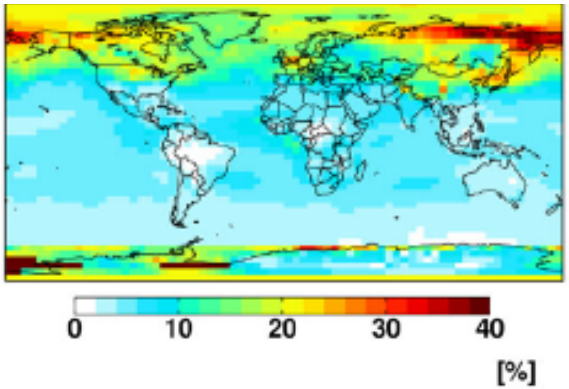
Wells et al. [2014]

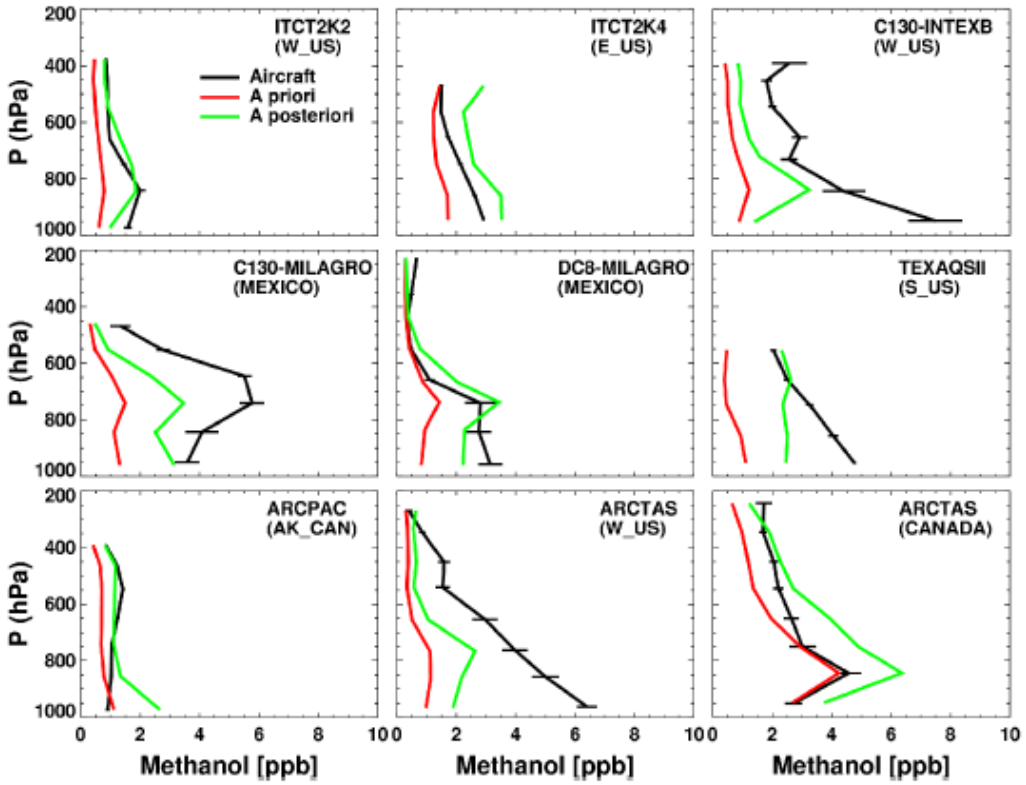
Optimized emissions highlight role of methanol in spring photochemistry, improve agreement with aircraft obs

June total CO production



June methanol loss:CO prod

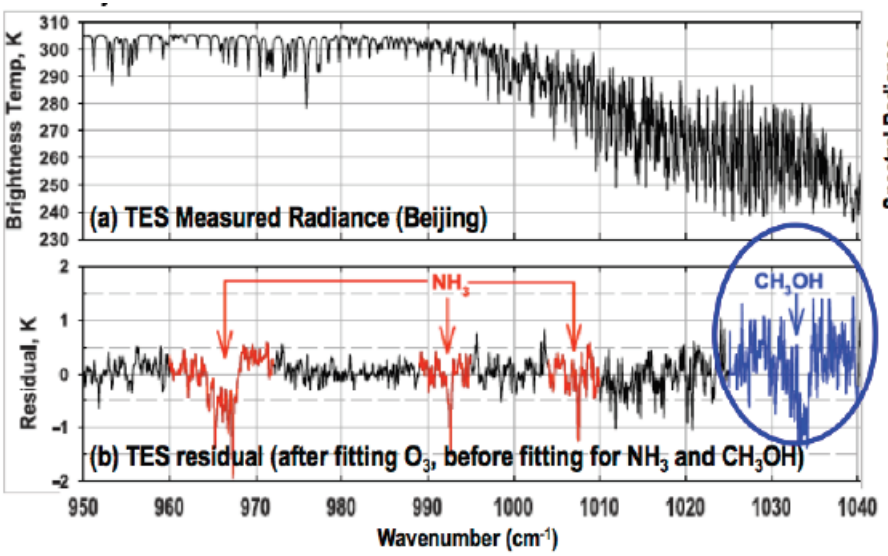


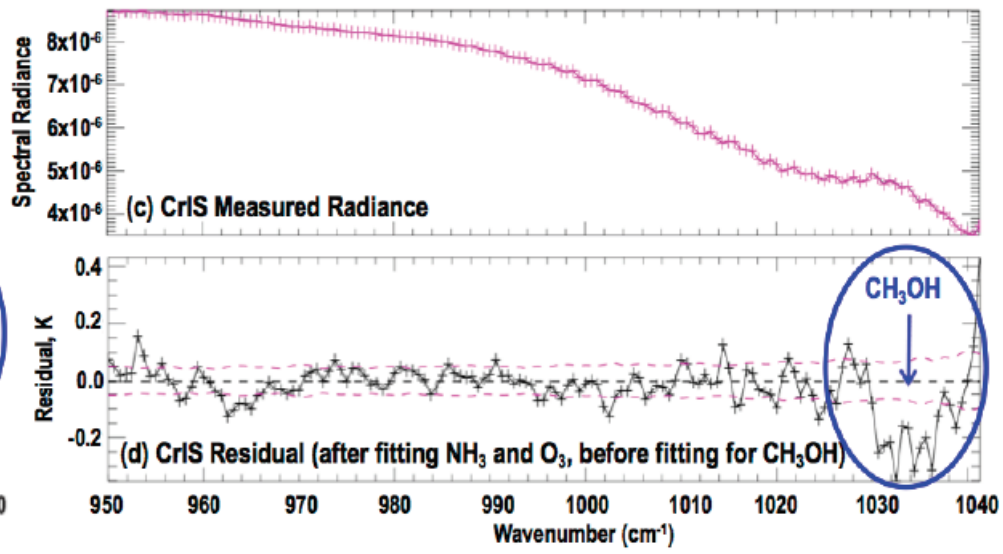


Wells et al. [2014]

- **Methanol contributes up to 50% of secondary CO, HCHO April-June**
- **Missing sources (desert plants, agricultural sources?) still apparent in the western US-- more work to do!**

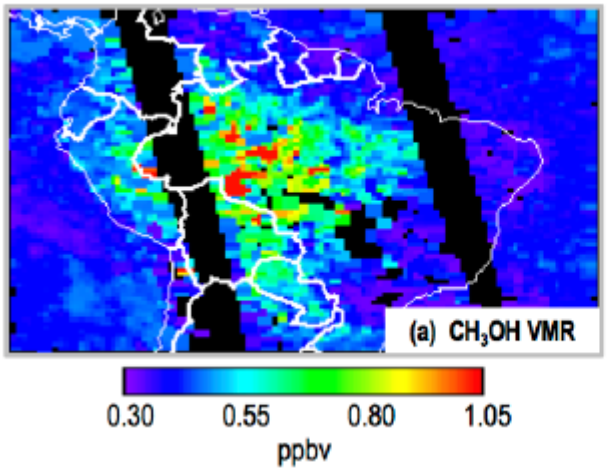
Methanol from SNPP-CrIS gives us the chance to extend Aura TES record with enhanced spatial resolution

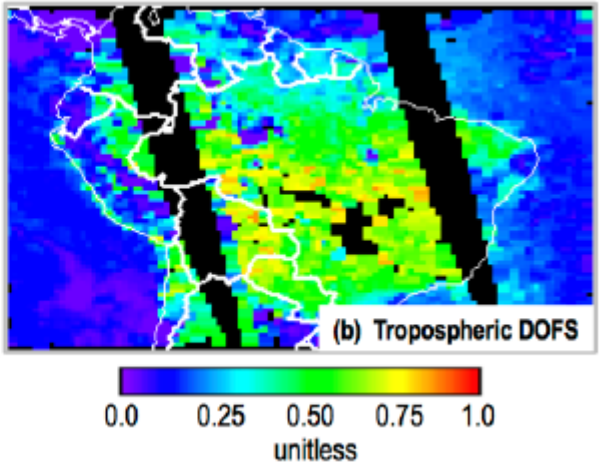




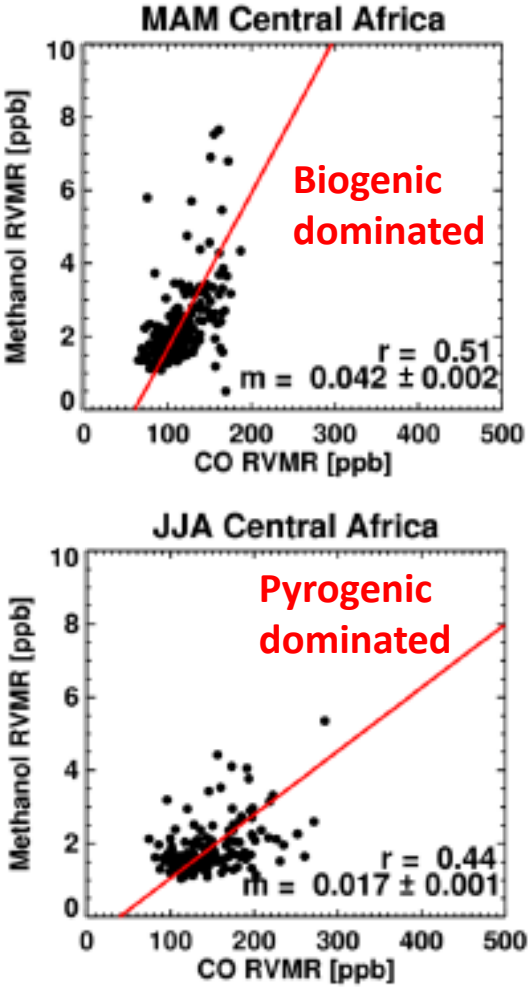
Preliminary retrieval for 12 Sept 2014 over Amazon

DOFS generally > 0.5

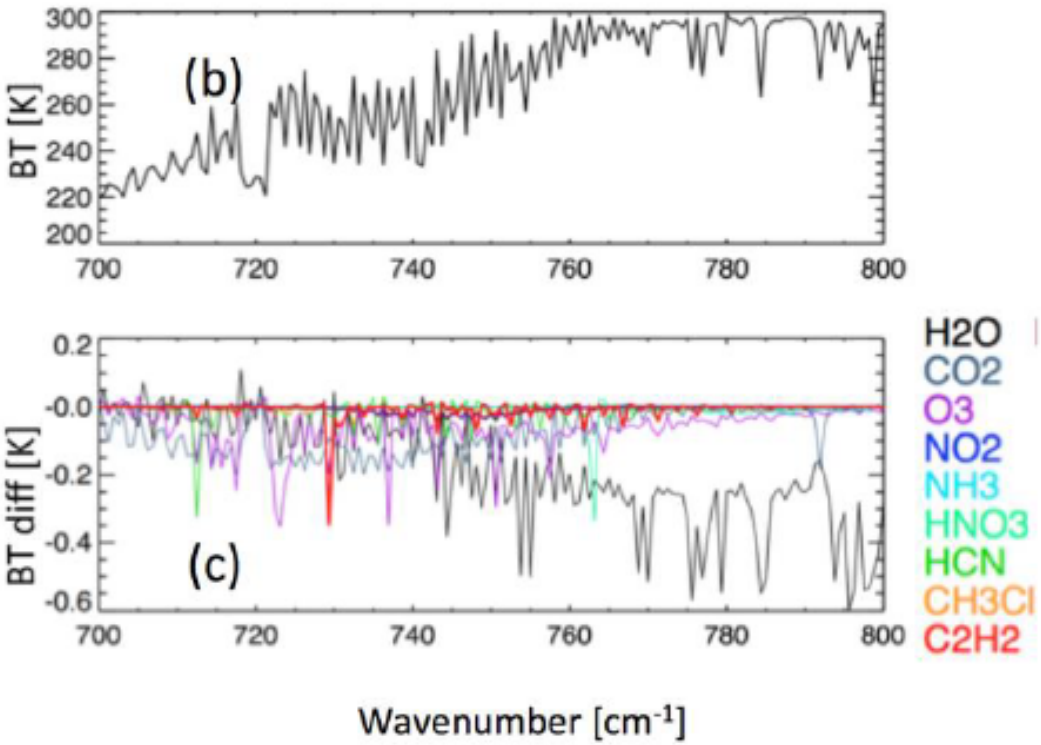




Potential SNPP-CrIS measurements of acetylene (C_2H_2) will help us further separate methanol sources



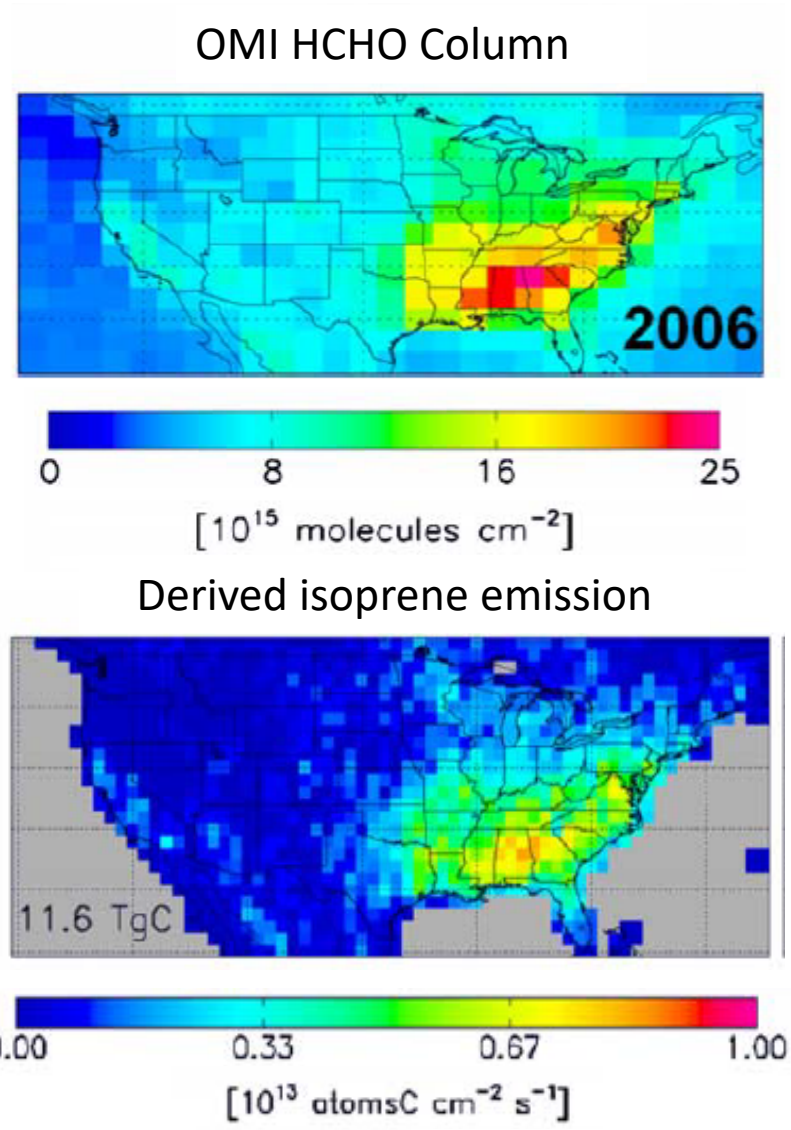
Wells et al. [2014]



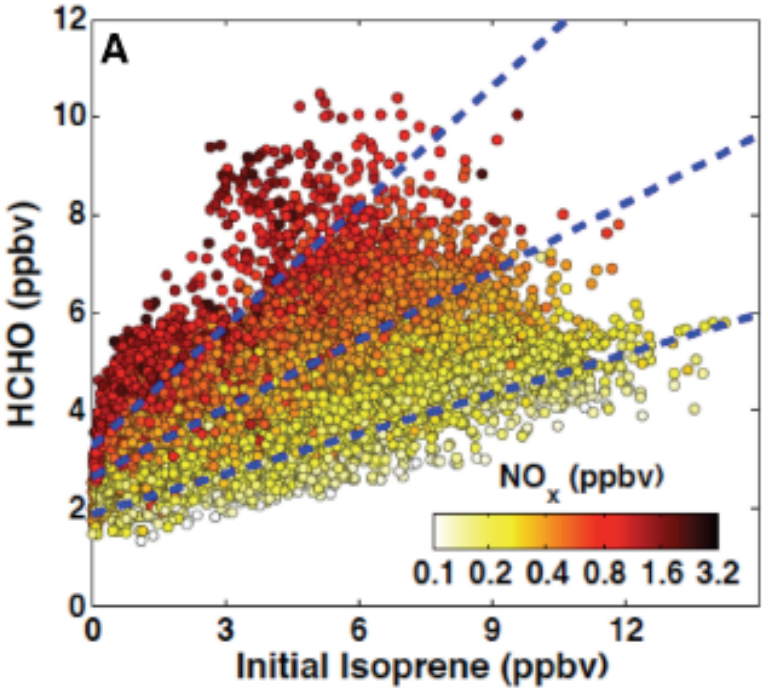
Calculated with LBLRTM

Previous work relied on methanol-CO correlations to estimate seasonality of biogenic vs. pyrogenic sources

Space-based HCHO often used as a proxy for isoprene emissions, but some limitations exist



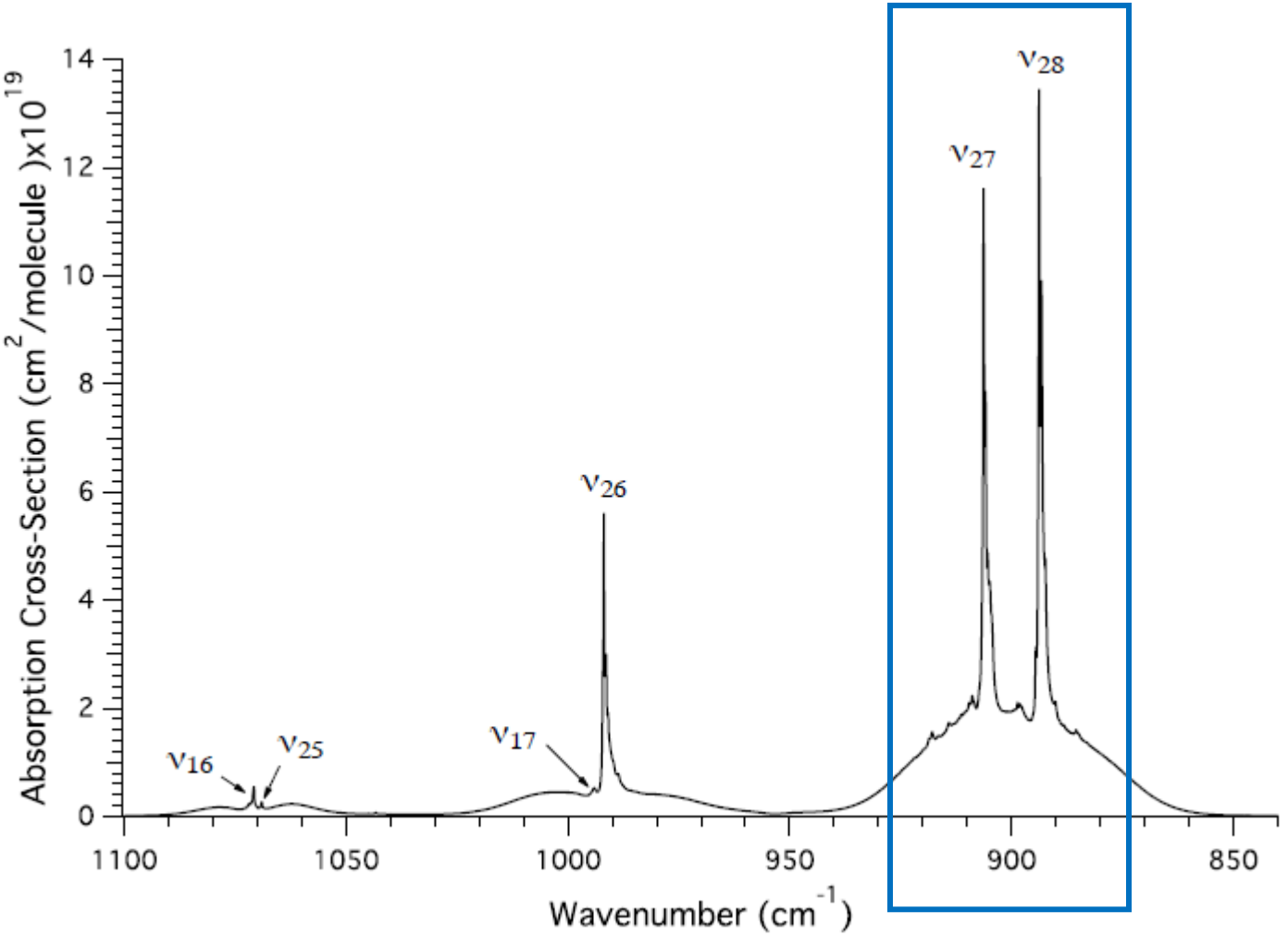
Millet et al. [2008]



Wolfe et al. [2016]

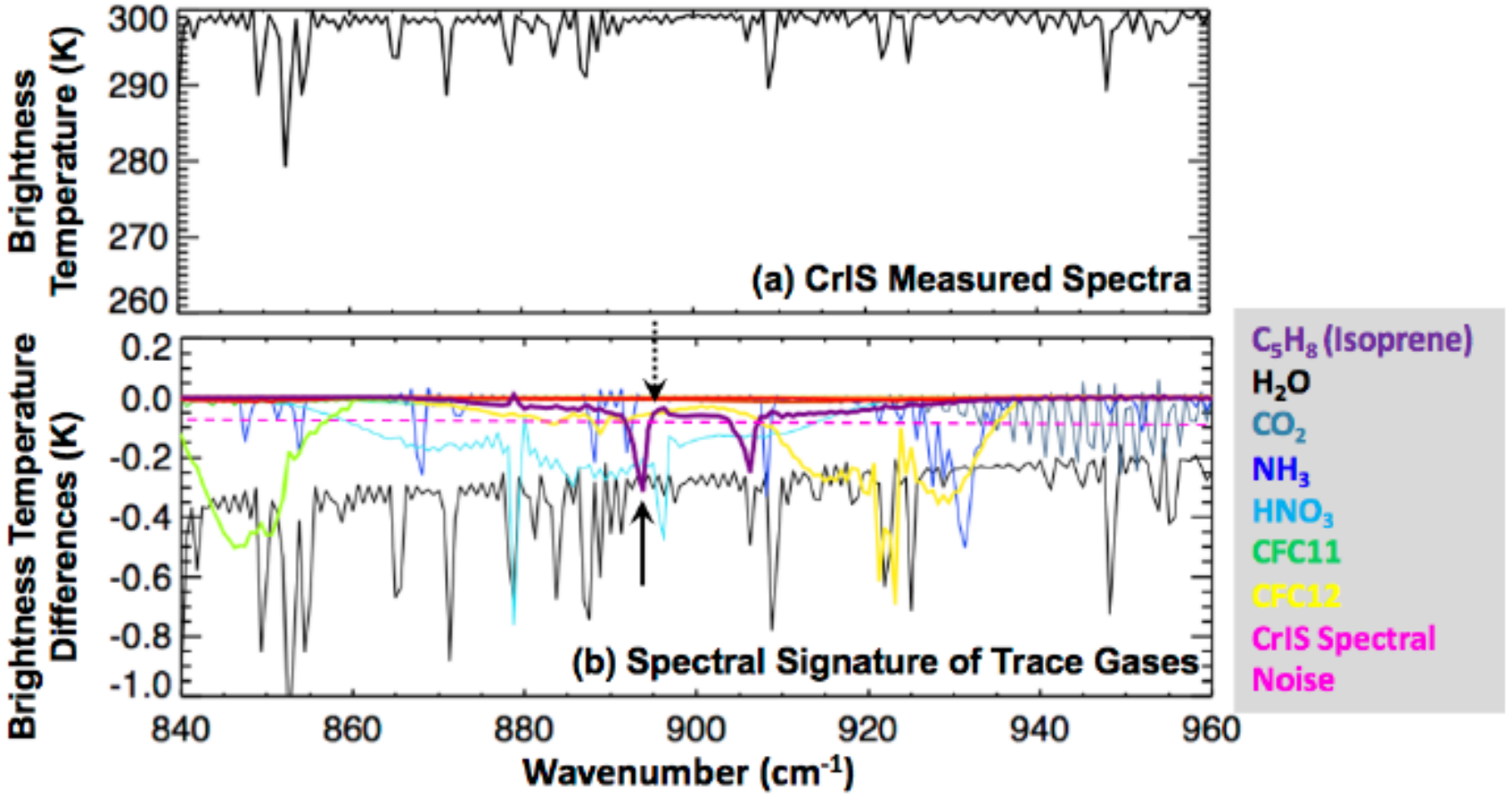
- **HCHO-isoprene relationship is a non-linear function of NO_x ($NO + NO_2$)**
- **HCHO is NOT a unique marker for isoprene emissions**

Recent lab measurements of isoprene TIR cross section will allow direct isoprene retrievals from SNPP-CrIS



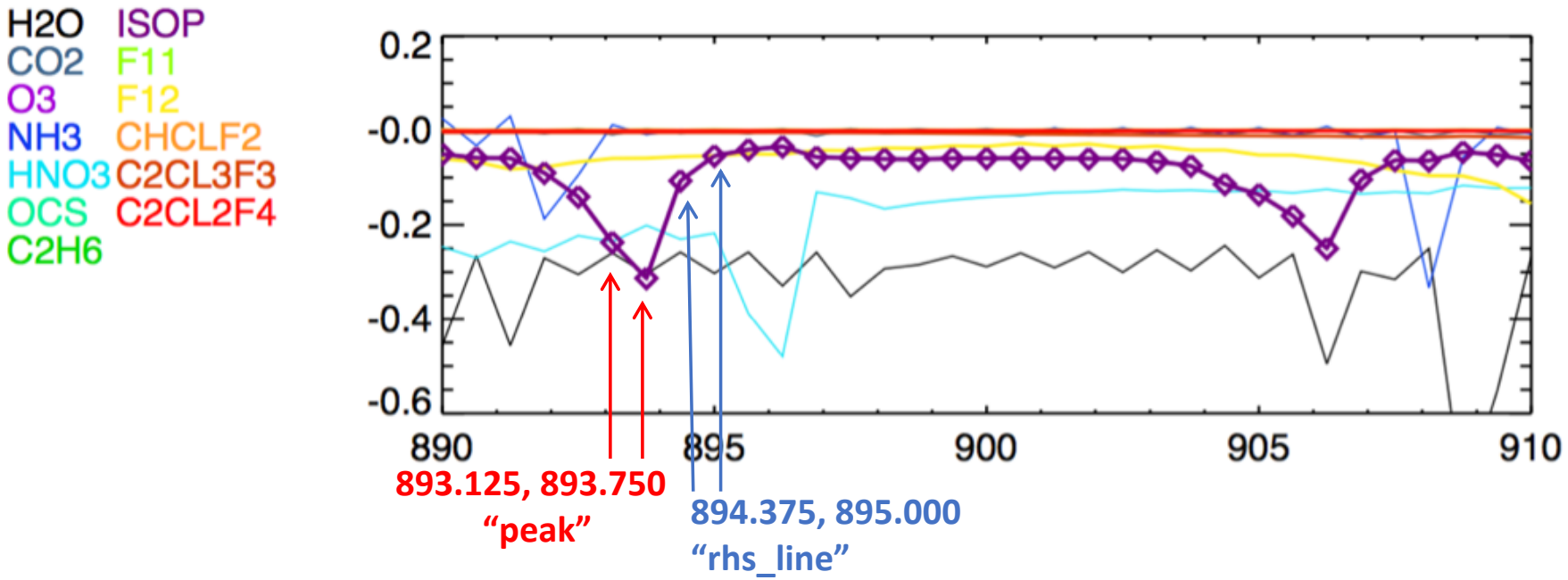
Brauer et al. [2014]

Recent lab measurements of isoprene TIR cross section will allow direct isoprene retrievals from SNPP-CrIS



Calculated with LBLRTM

As a first step we have employed a brightness temperature difference approach

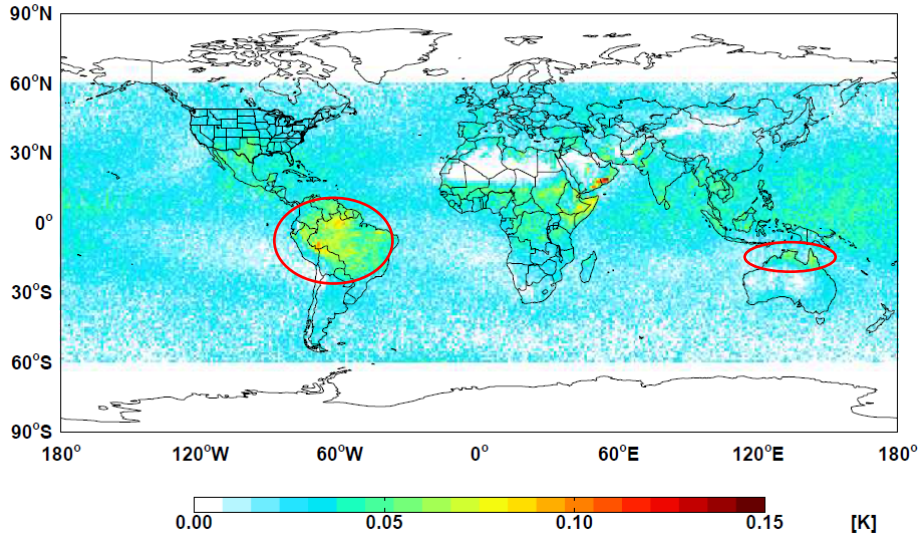


BT difference approach: $\Delta BT = BT_{rhs} - BT_{peak}$

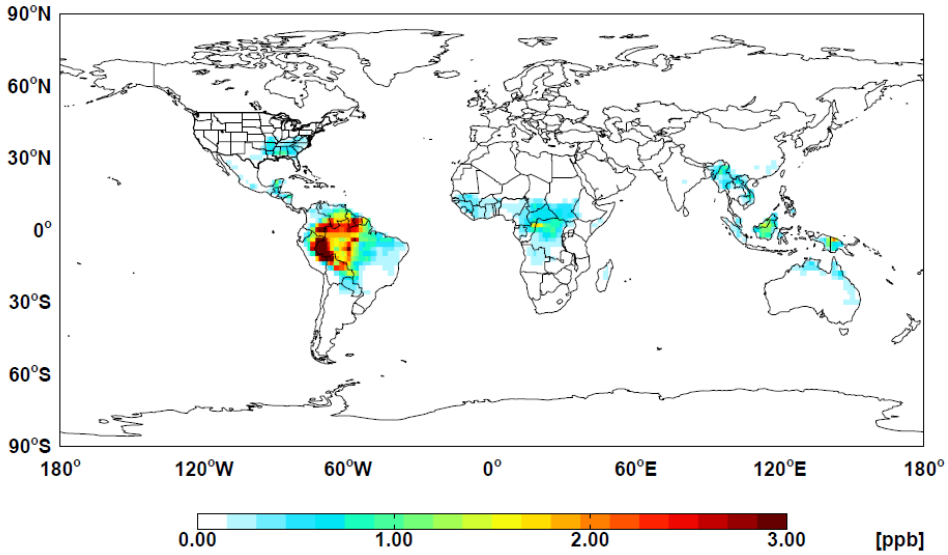
- e.g., for IASI NH_3 (Clarisse et al., 2009), methanol and formic acid (Razavi et al., 2011)
- Start from single footprint Level 1B radiances
- Pro: relatively quick way to look to a large dataset
- Con: does not provide any sensitivity information

Preliminary SNPP-CrIS BT difference maps reveal some features consistent with known isoprene sources

201409 monthly CrIS BTdiff

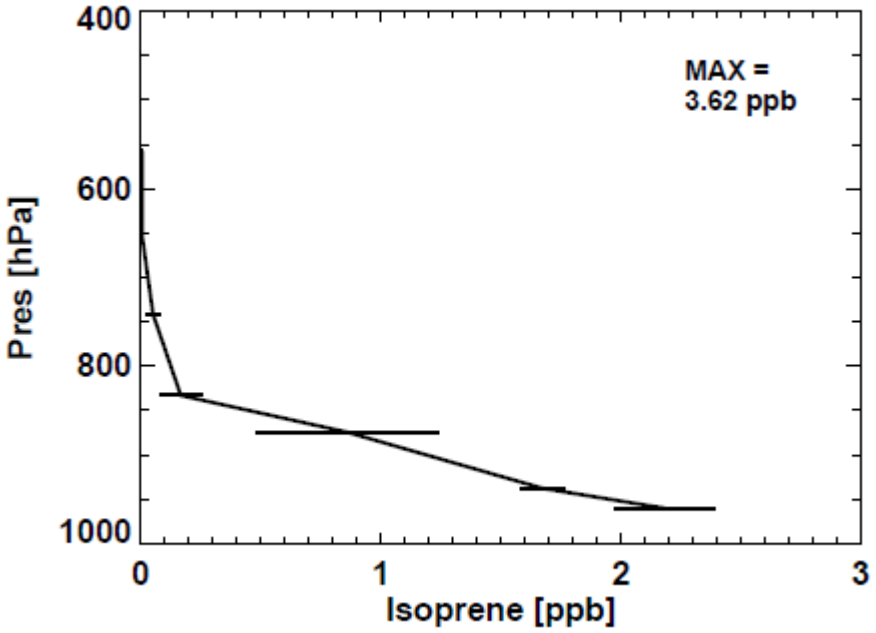


201409 GEOS-Chem isoprene

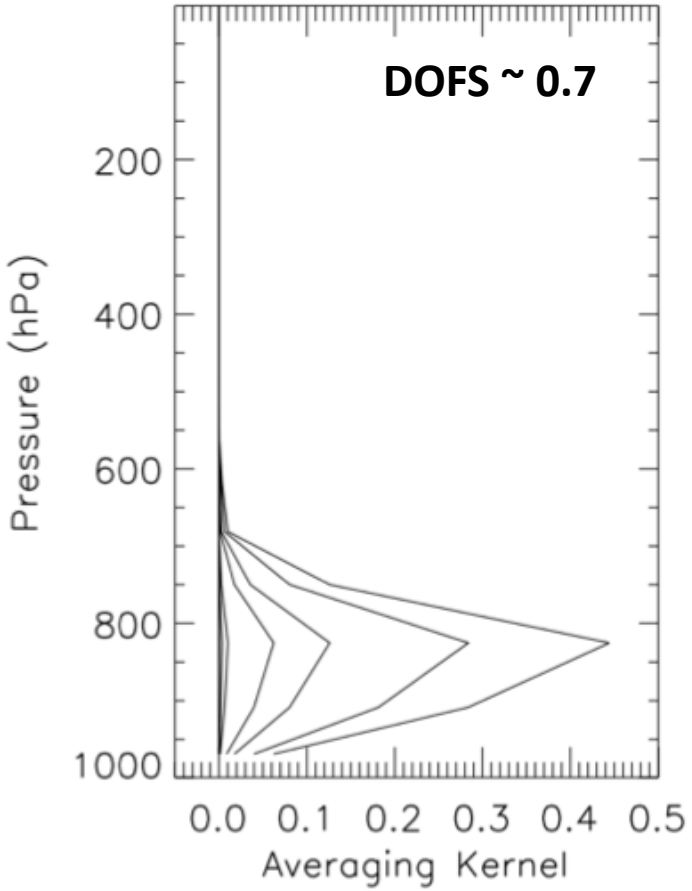


Next steps

20130611 SE US vertical profile



Simulated CrIS isoprene AK



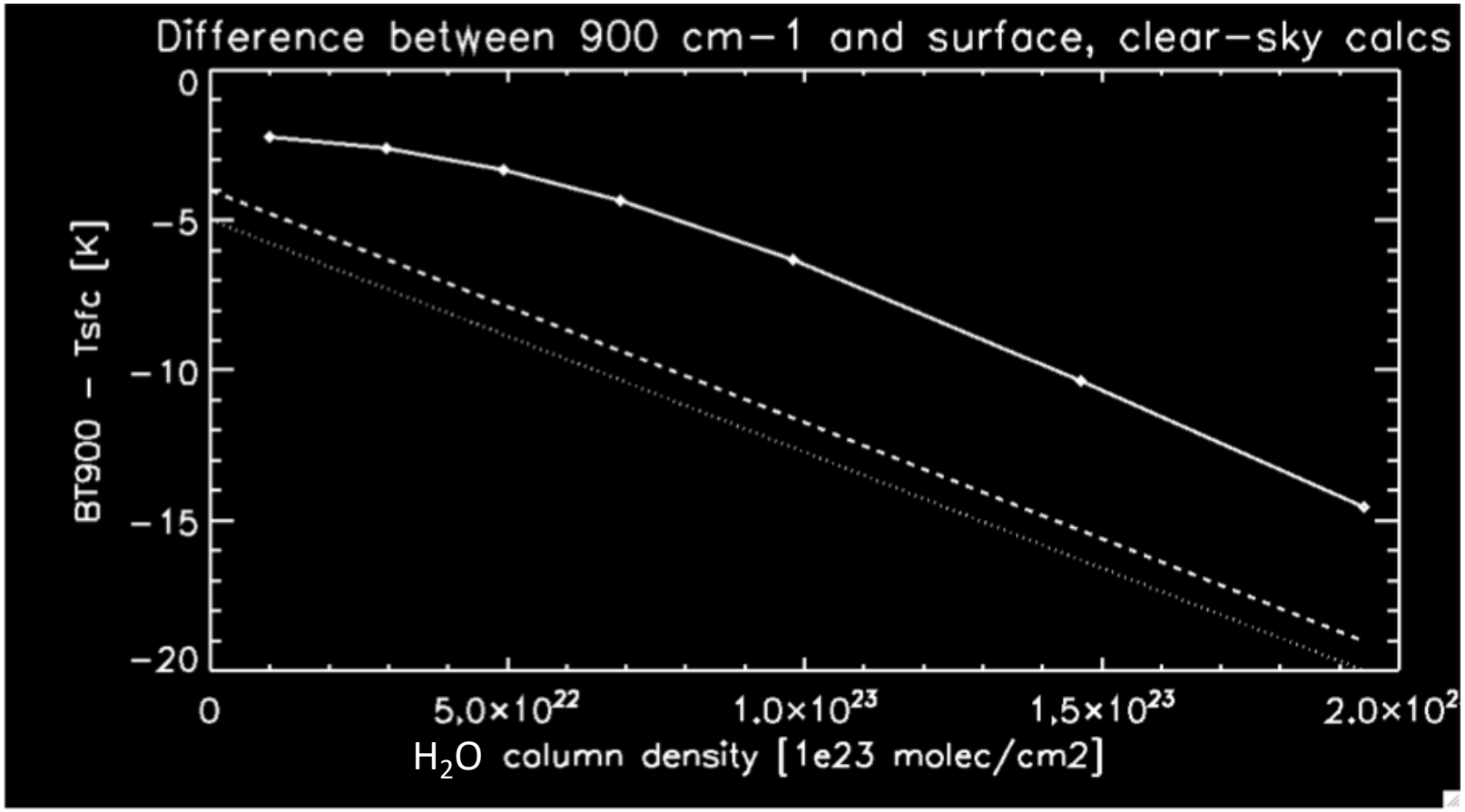
- **OE retrievals**
- **Validation against available aircraft data**
- **Inverse modeling in combination with concurrent HCHO and NO_x measurements**

Summary

- **TIR measurements of biogenic VOCs provide powerful information to constrain emission processes and associated impacts on atmospheric chemistry**
- **Measurements from SNPP-CrIS will allow us to extend the data record at higher spatial resolution and further refine emission quantification and source characterization**
- **Initial work on SNPP-CrIS shows promise in providing retrievals of methanol and isoprene**

Thank you!

Cloud screening based on BT900 cm^{-1} – Tsfc difference



Representative Volume Mixing Ratio, RVMR