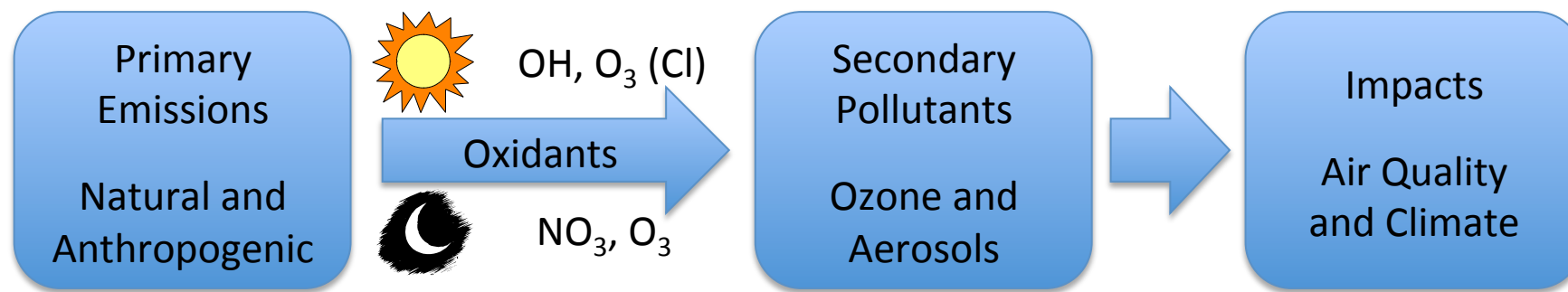


Atmospheric chemical transformation (oxidation) determines many of the impacts of primary emissions



- Cannot understand chemical transformation unless you understand the night
- CSD is a recognized leader in nighttime chemistry

CSD research topics for this review:

1. Nighttime oxidation of biogenic hydrocarbons

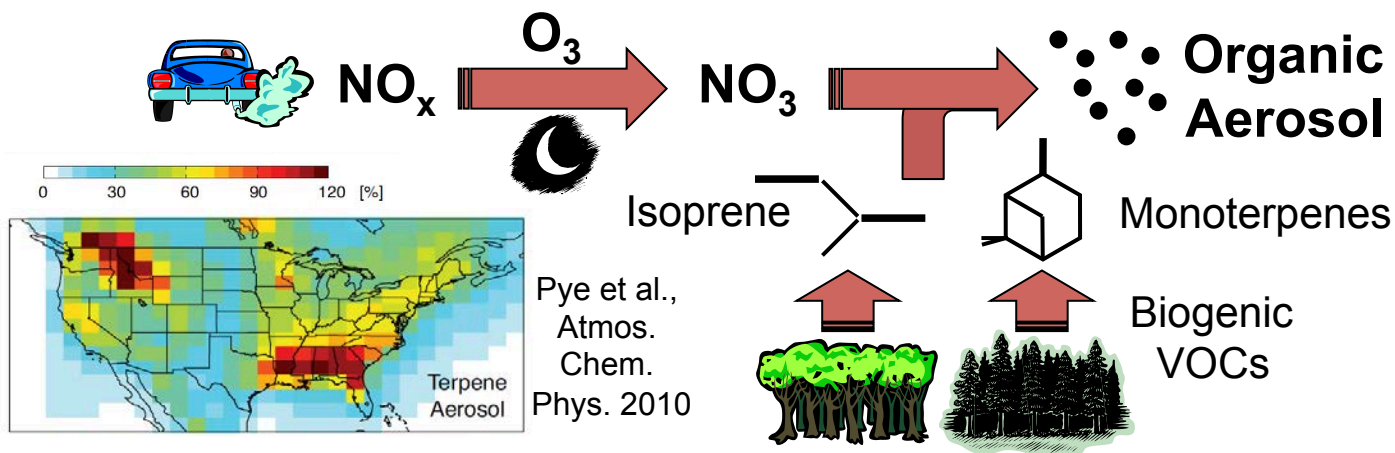
The influence of anthropogenic emissions on aerosol from biogenic emissions

2. Heterogeneous reactions of nitrogen oxides

A better understanding of the influence of NO_x on tropospheric ozone

Nocturnal Biogenic VOC Oxidation

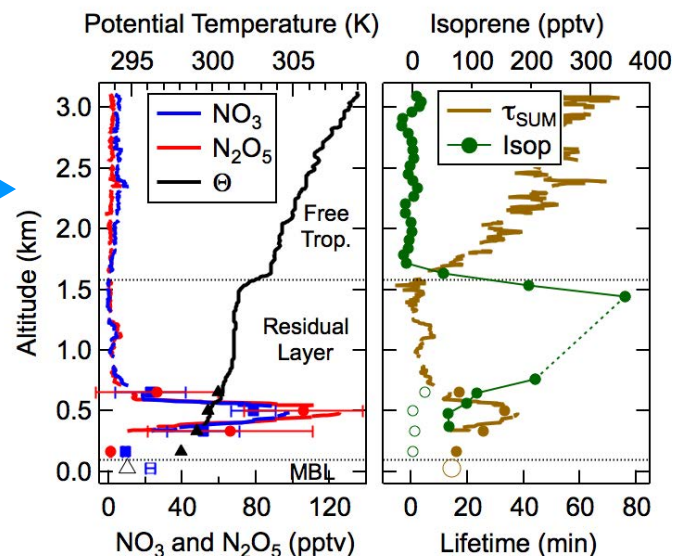
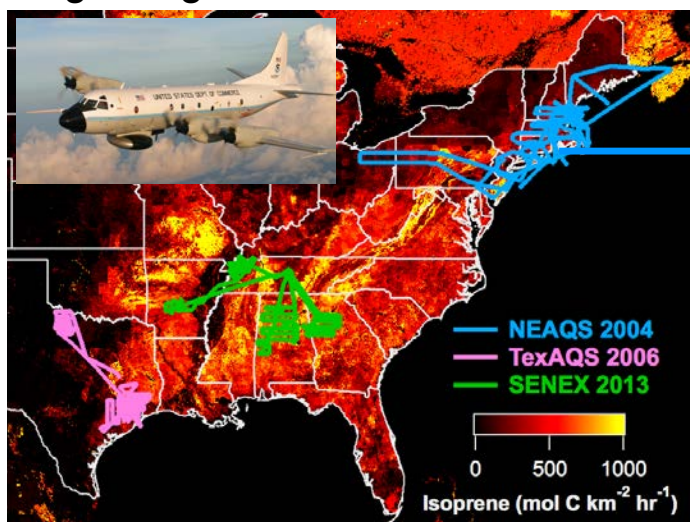
Scientific Problem: Enhanced organic aerosol of biogenic origin in regions of high anthropogenic emissions (Spracklen, ACP 2011; Xu, PNAS 2015)



Nighttime BVOC oxidation is one aerosol source that couples anthropogenic and biogenic emissions

CSD Approach: Extensive laboratory and field studies, including the most comprehensive current database of nighttime aircraft measurements

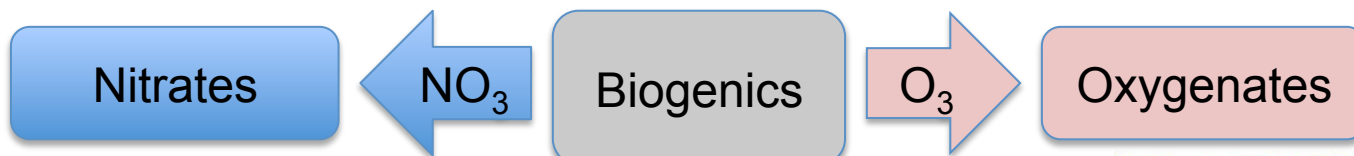
Night Flights of NOAA P-3 Aircraft



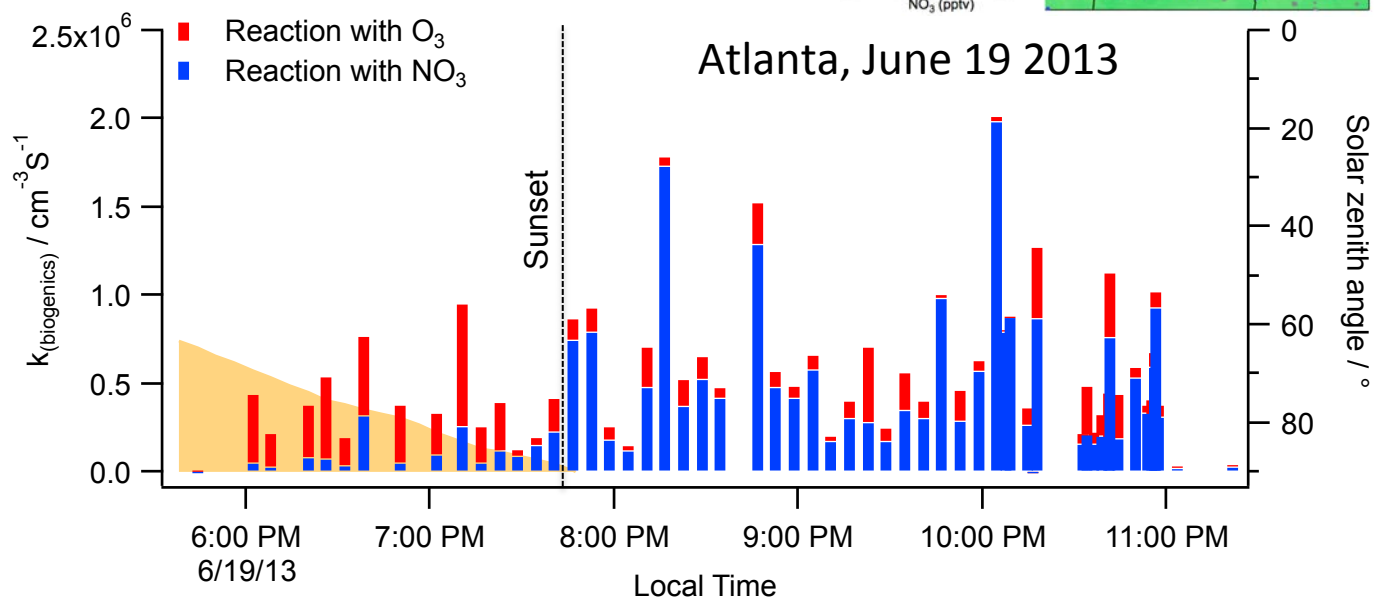
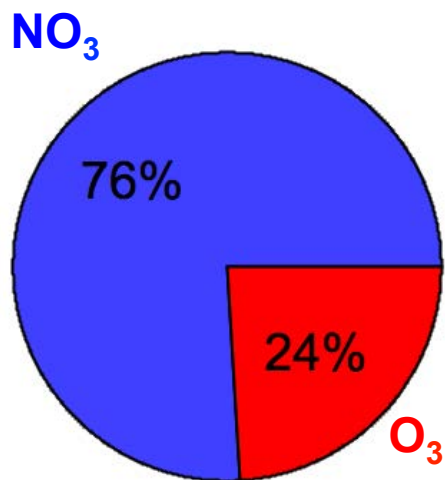
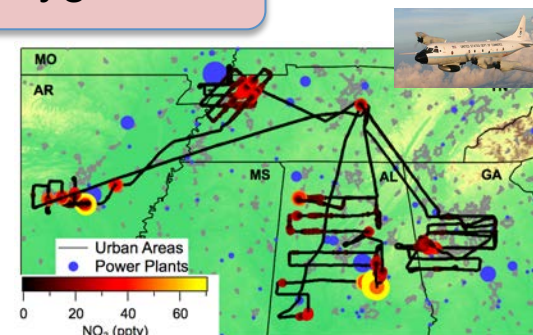
Aircraft probes vertical structure in stratified nighttime atmosphere for complete picture of nighttime oxidation

Nocturnal Biogenic VOC Oxidation

Key Scientific Result: Quantitative measure of the competition between NO_3 (anthropogenic) and O_3 (natural, background) oxidation of biogenics at night



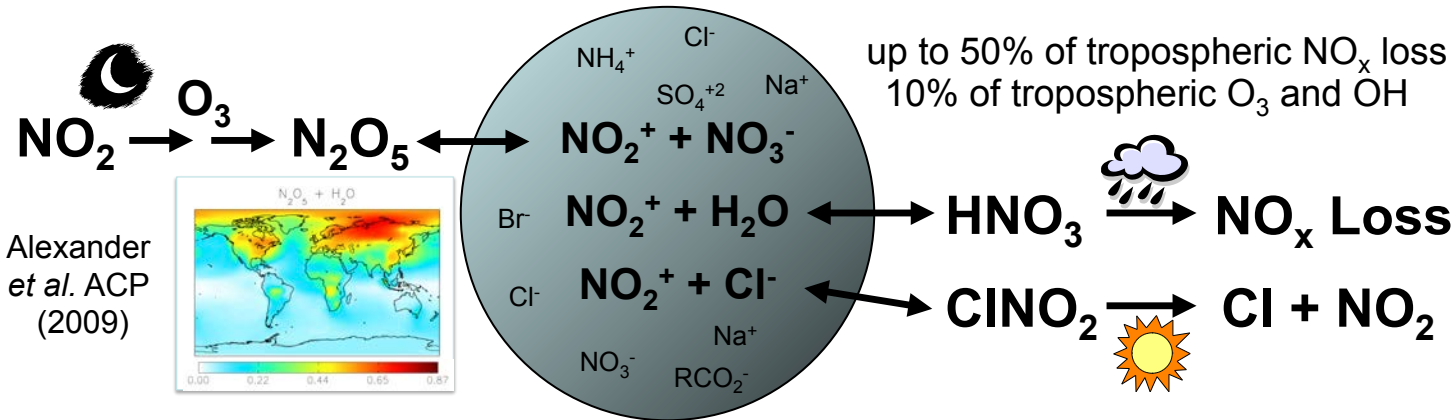
SENEX 2013: A CSD aircraft campaign in the southeast U.S. designed to understand anthropogenic – biogenic interactions



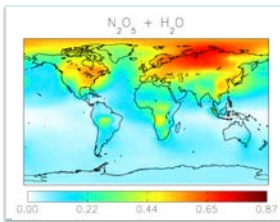
Despite recent reductions in U.S. emissions, NO_x still dominates nighttime oxidation in the summertime residual layer in the Southeast

Heterogeneous Reactions of Nitrogen Oxides

Scientific Problem: Nitrogen oxide reactions on aerosols are complex and uncertain, but important to understanding regional and global tropospheric ozone



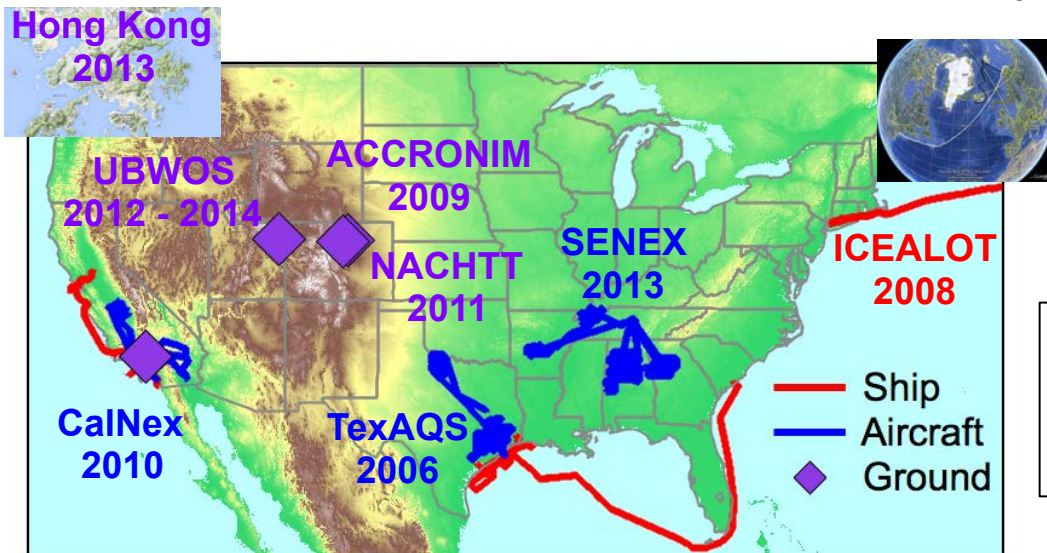
Alexander
et al. ACP
(2009)



N_2O_5 uptake is variable

ClNO_2 recently discovered, highly uncertain yield

CSD Approach: Laboratory, field and model studies, including the largest current database for paired measurements of N_2O_5 and ClNO_2



Combination of ground, ship and aircraft measurements

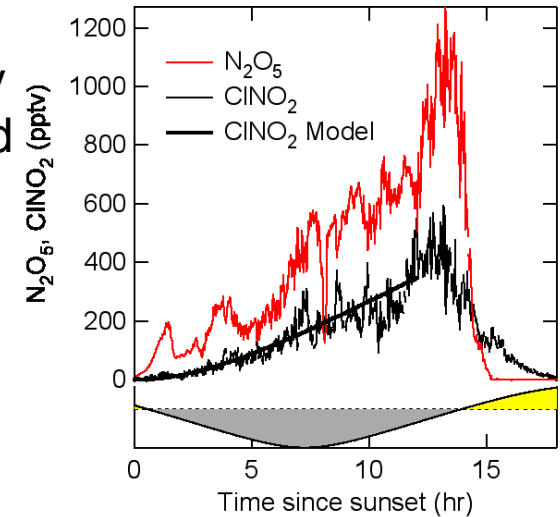
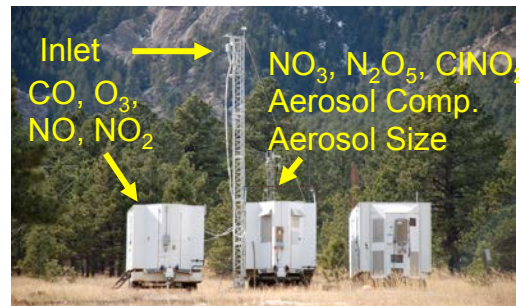
Domestic and international partnerships



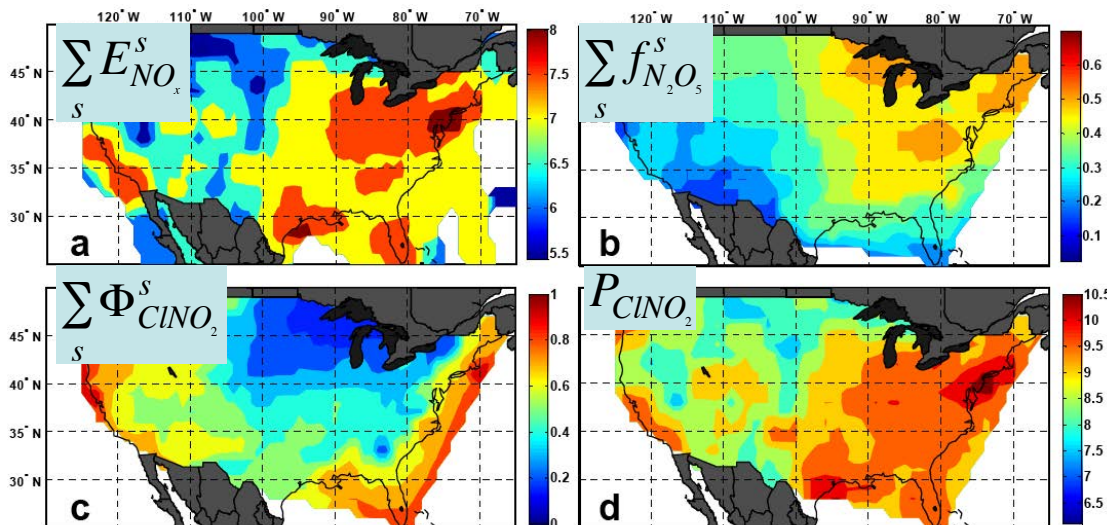
Heterogeneous Reactions of Nitrogen Oxides

Key Scientific Result: Demonstration of ubiquitous production of ClNO_2 from N_2O_5 , even in continental interior regions

ACCRONiM 2009: Activation of Continental Chloride by Reactive Oxides of Nitrogen in Midwinter, A CSD ground based intensive



17% yield of ClNO_2 from N_2O_5



Thornton *Nature*, 464, 271-274

Continental U.S. Cl production
3 - 8 Tg yr⁻¹

Global Cl production
8 - 22 Tg yr⁻¹
30 - 90% of *total*
tropospheric budget

New paradigm for tropospheric
halogens & NO_x