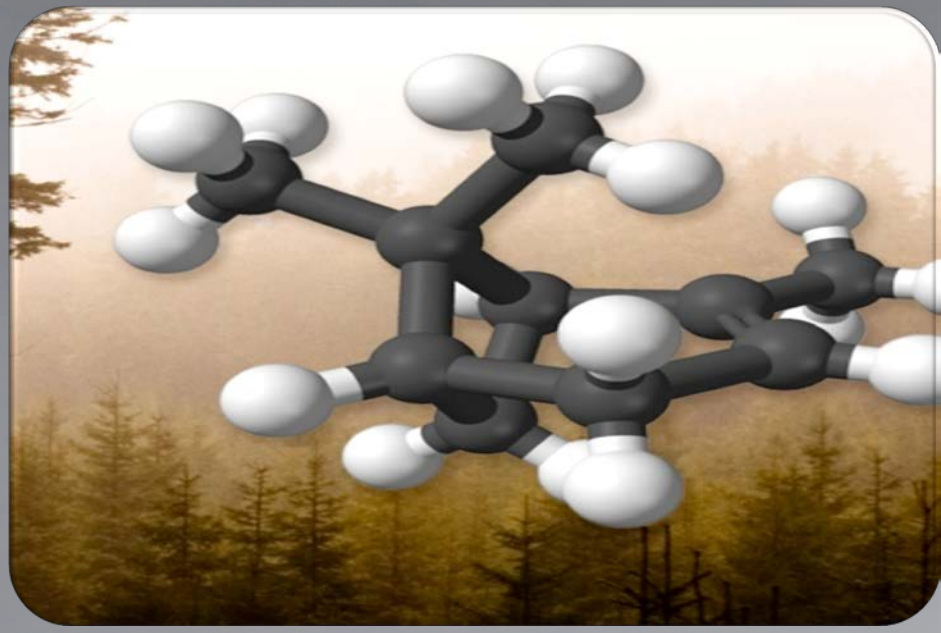
Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

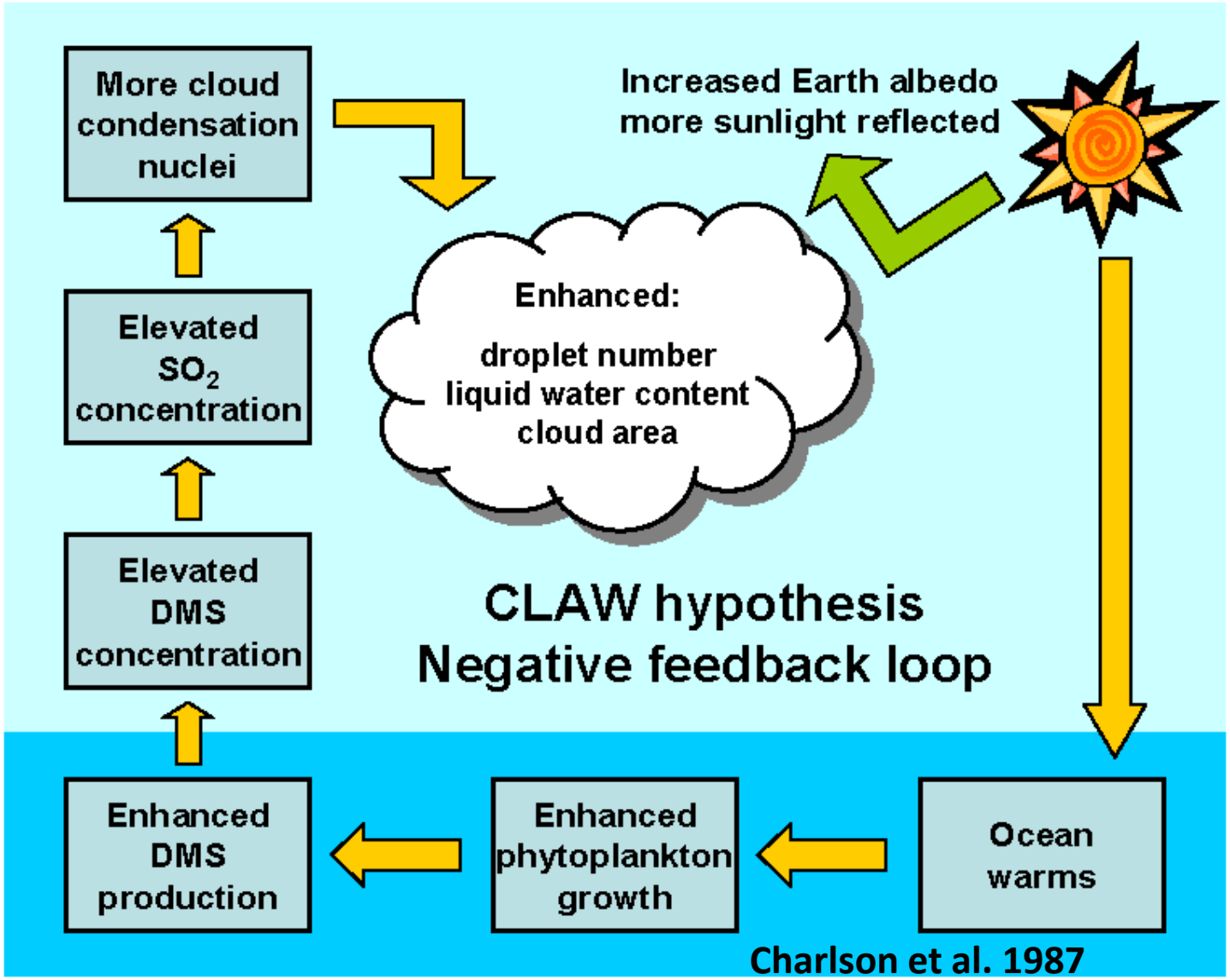
Feedbacks between biogenic emissions, SOA, boundary layer and clouds

Alex Guenther

Pacific Northwest National Laboratory
Richland WA, USA



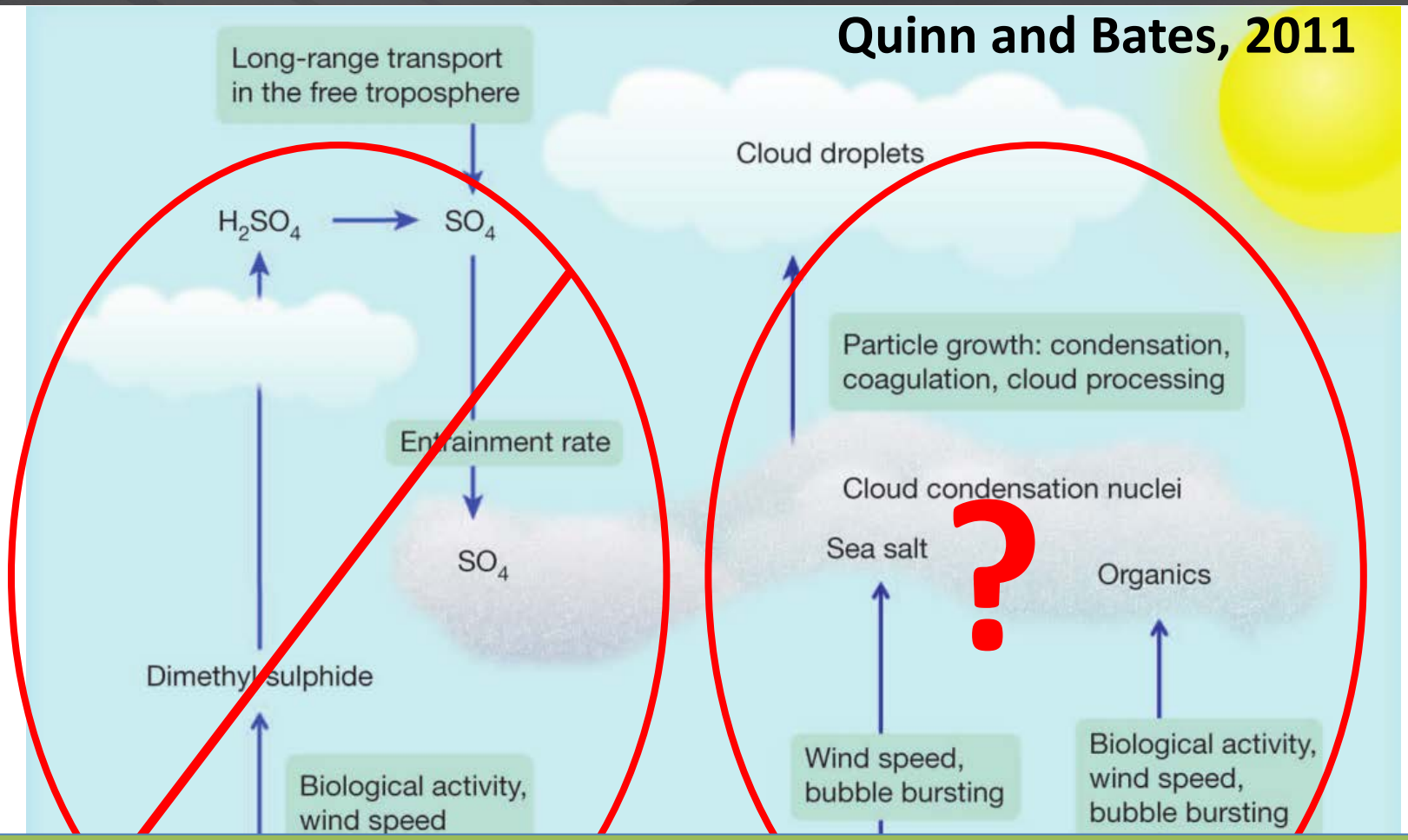
Climate regulation via marine biogenic sulfur



Charlson et al. 1987

Climate regulation in the marine environment

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965



WHAT ABOUT LAND?

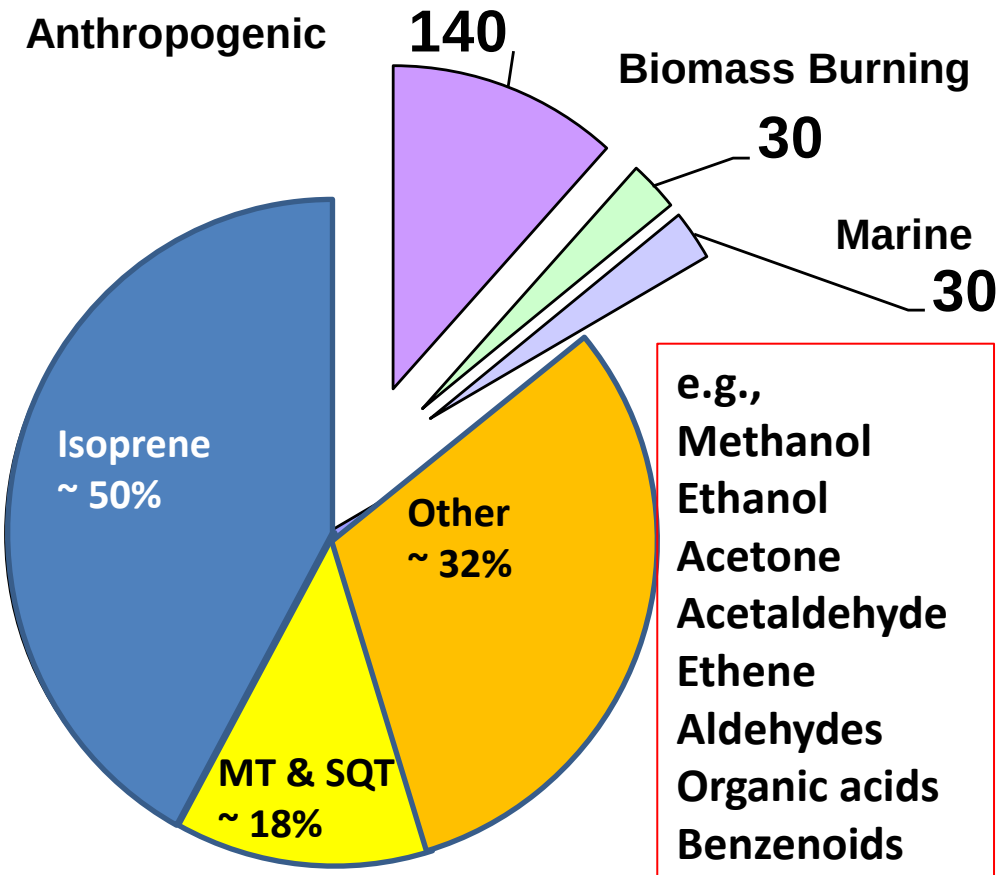
Biogenic organic flux from land is far greater than from marine

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

>25,000 organic compounds identified in plants, but many are not volatile

146 Biogenic VOC are included in MEGAN2.1

10 Biogenic VOC comprise ~80% of the total VOC flux estimated with MEGAN2.1



e.g.,
Methanol
Ethanol
Acetone
Acetaldehyde
Ethene
Aldehydes
Organic acids
Benzenoids
Alkenes

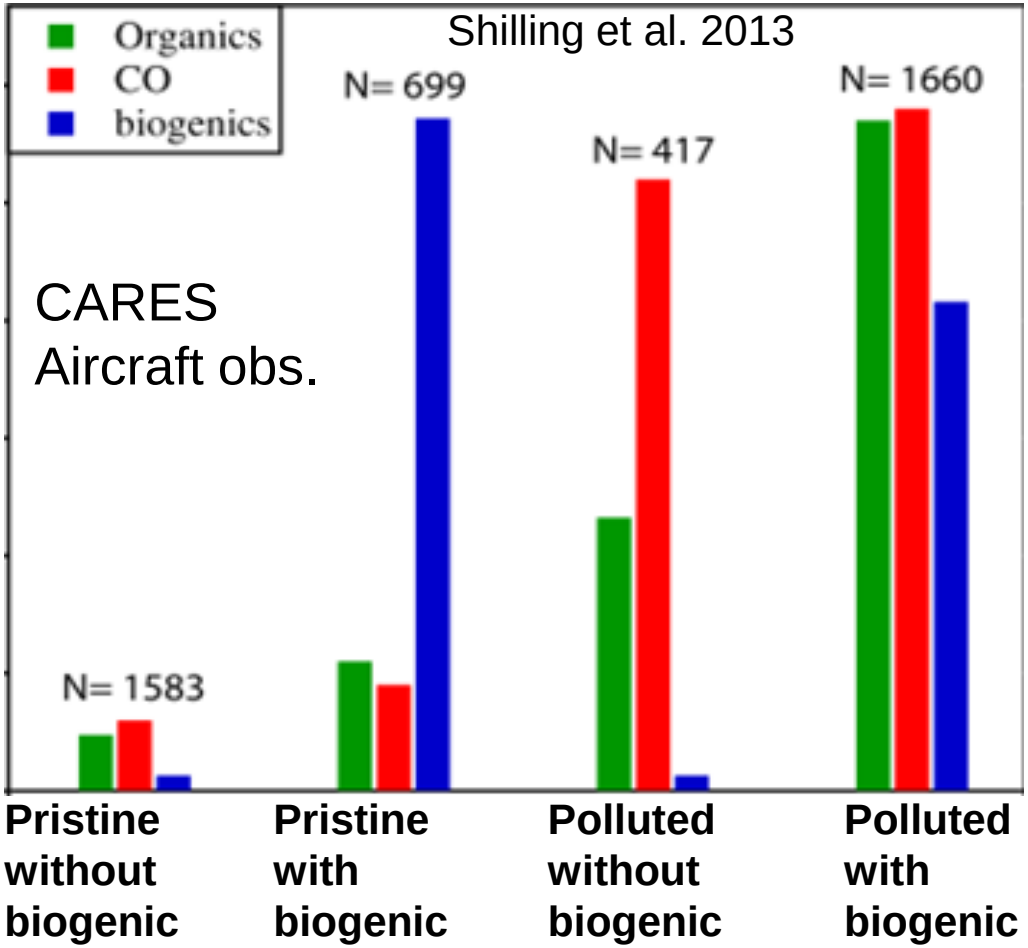
BiogenicTerrestrial
1000

Sources: Guenther et al. 2012 and EDGAR database

Organic aerosol is now recognized as abundant especially in polluted regions

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

….but it now appears that most organic aerosol (>80%?) is from interactions between biogenic VOC and anthropogenic pollution



Organic Aerosol

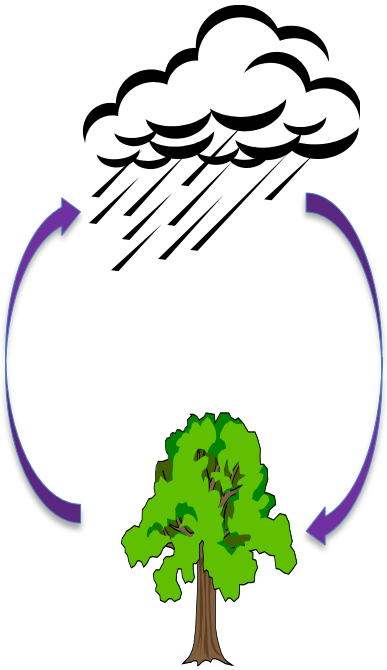
CO (pollution)

Biogenic VOC

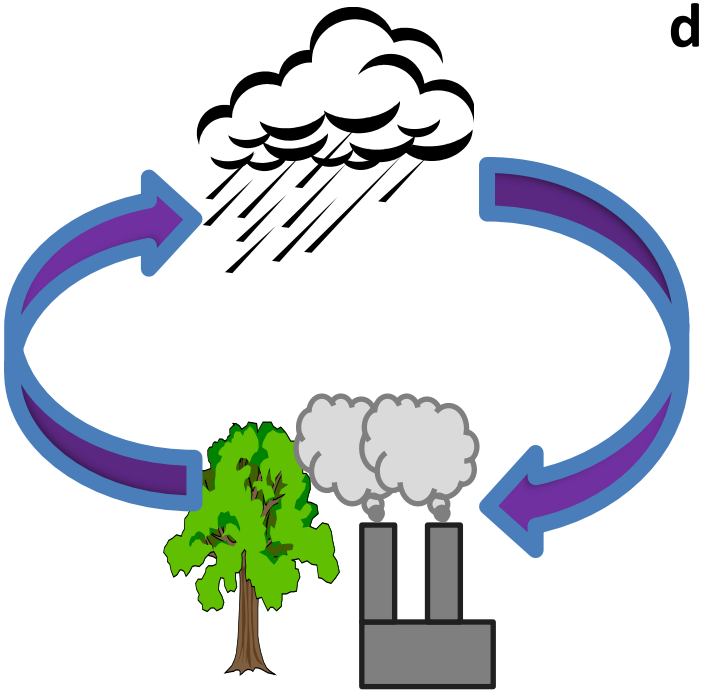
Is the BVOC/BSOA/climate feedback cycle enhanced in polluted regions?

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Pristine region



Polluted region

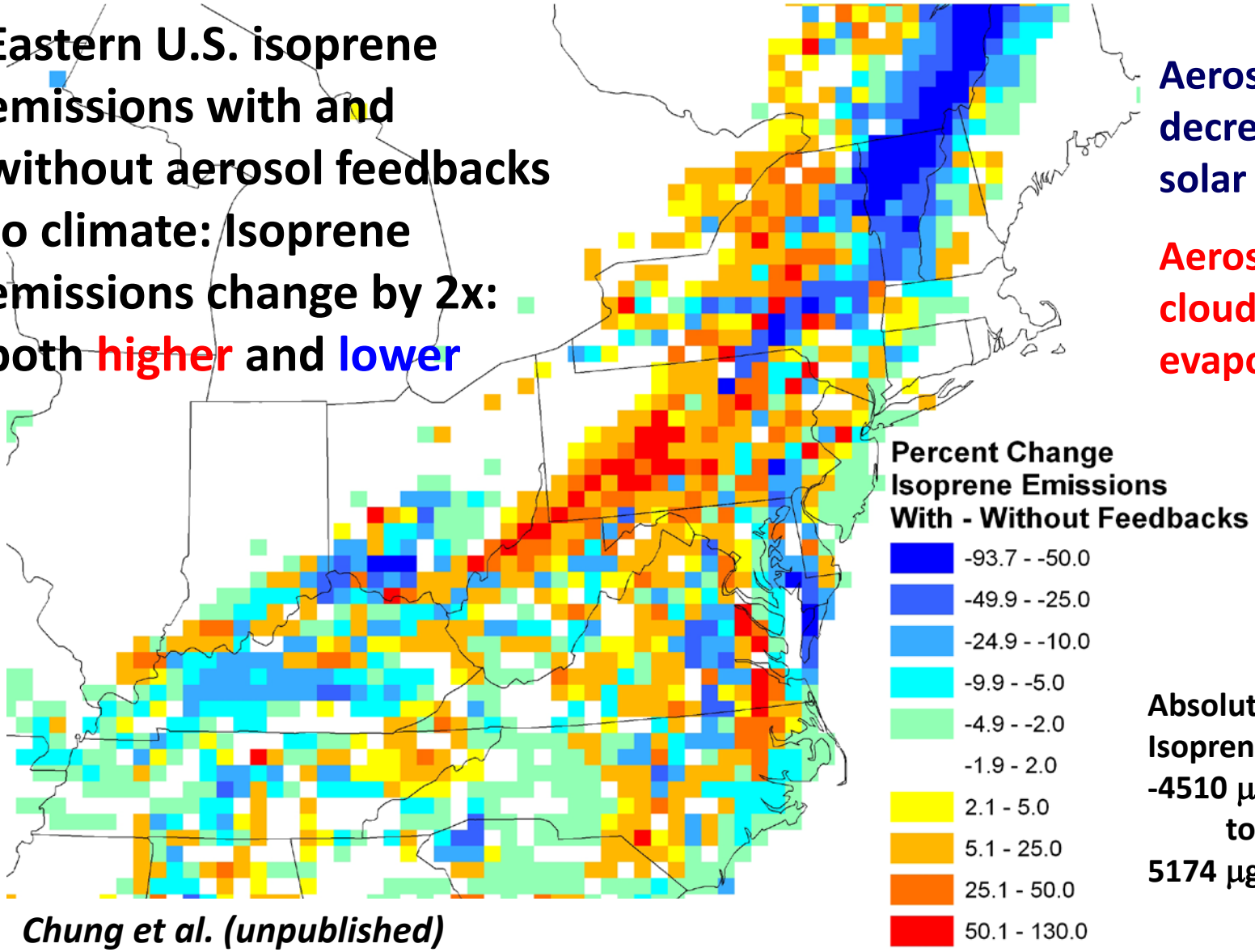


More biogenic organic aerosol is produced in polluted regions BUT the impact may be smaller due to existing aerosol

WRF-CHEM simulations indicate potential for BVOC-BSOA-climate feedback

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Eastern U.S. isoprene emissions with and without aerosol feedbacks to climate: Isoprene emissions change by 2x: both higher and lower



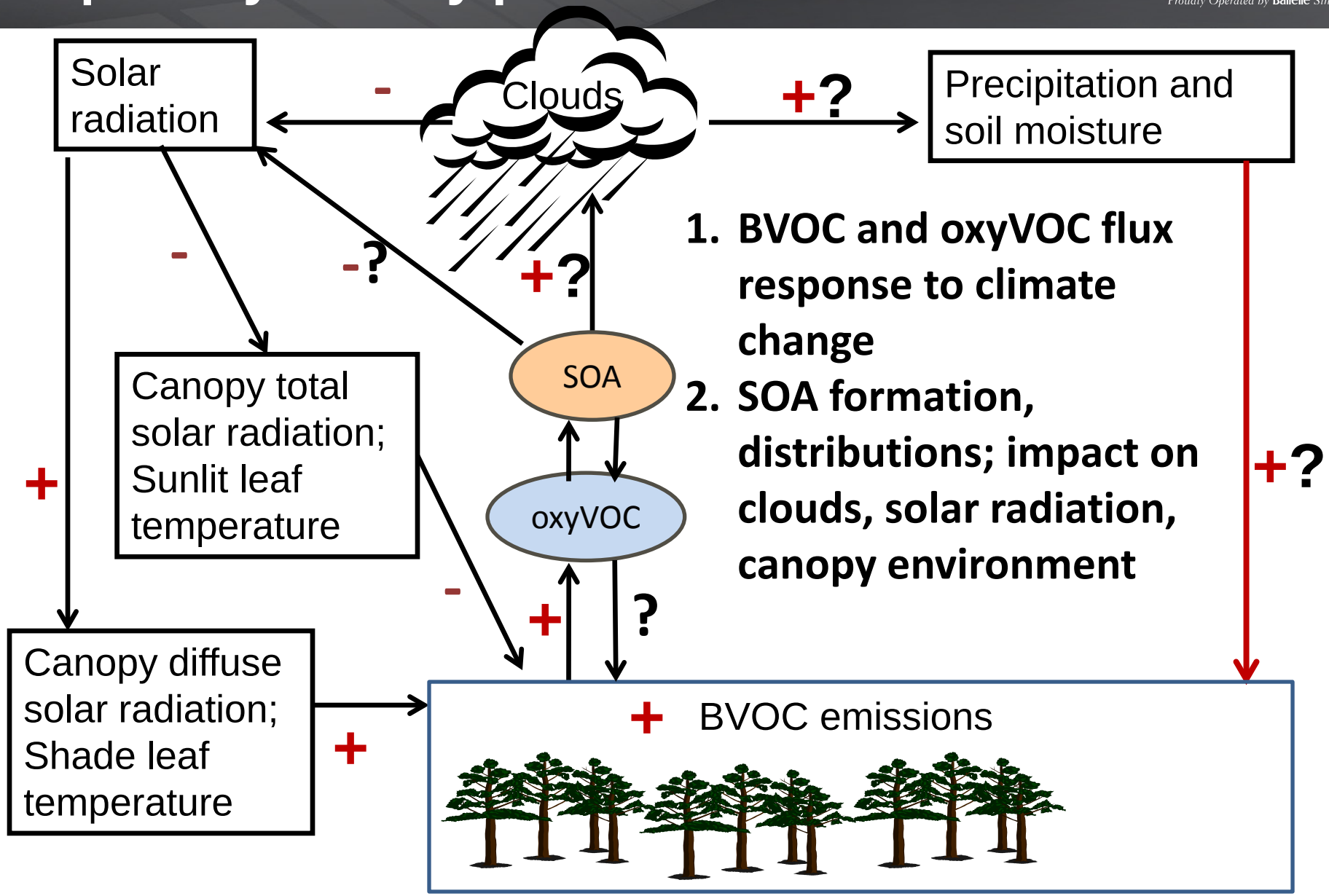
Aerosol decreases surface solar radiation

Aerosol warms clouds and they evaporate

Absolute Change in Isoprene Emissions: -4510 $\mu g\ m^{-2}\ h^{-1}$ to 5174 $\mu g\ m^{-2}\ h^{-1}$

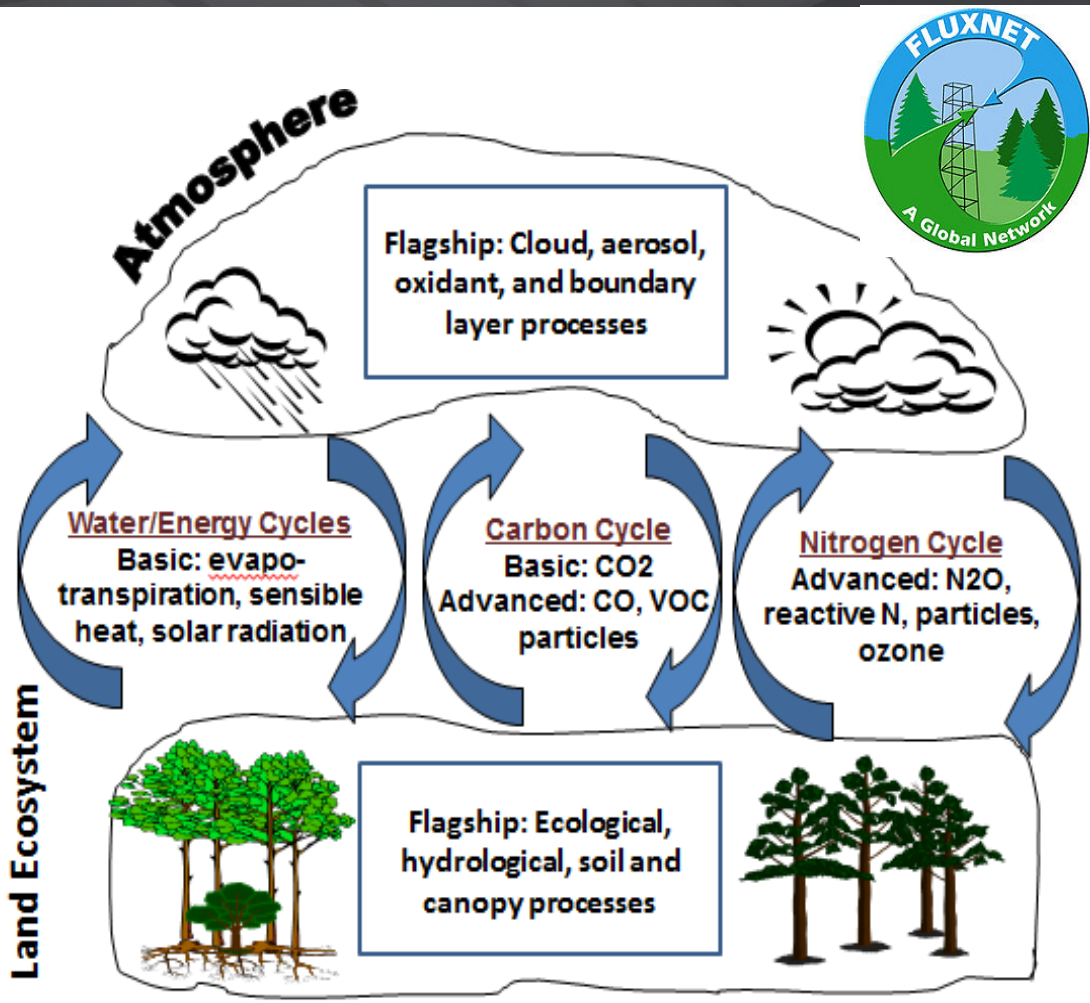
Chung et al. (unpublished)

To accurately simulate feedbacks we need to quantify the key processes



1. **BVOC and oxyVOC flux response to climate change**
2. **SOA formation, distributions; impact on clouds, solar radiation, canopy environment**

with long-term flux measurements



Guenther et al. 2011
iLEAPS assessment

Basic (hundreds of sites): CO_2, water, energy fluxes.

Advanced (tens of sites): VOC, CO, particles, N_2O, NO_y, and NH_3 fluxes

Flagship (~10 sites): All the above plus comprehensive ecological, hydrological, canopy and atmospheric observations

and multi-scale regional observations

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

June/July 2013

- Controlled environment leaf enclosures
- Total VOC branch enclosures
- Broadleaf and mixed forest flux tower
- Needleaf and mixed forest flux tower
- Stonybrook light aircraft for vertical profiles
- Comprehensive BVOC, products and SOA measurements at groud sites
- Fluxes and concentrations on NSF/NCAR C130 and NOAA P3 research aircraft
- Satellite data

Leaf scale: carbon uptake, enzyme and substrate production

Enclosures

SAS Southeast Atmosphere Study

Canopy and boundary layer scale:
Radiative transfer, energy balance, vertical transport

Towers and light aircraft

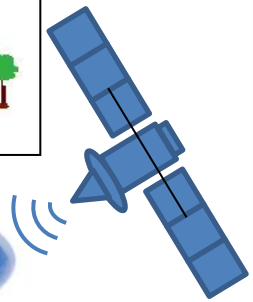
Landscape scale:

Landcover (LAI, vegetation types), weather patterns

Aircraft and multiple ground sites

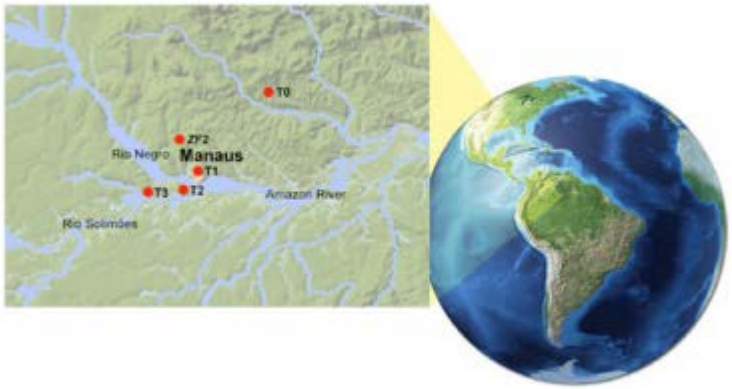
Regional to global scale:

Landcover (biomes, vegetation types)



Satellites

DOE ASR could combine long term measurements with multi-scale regional observations

Pacific Northwest NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

SGP: Southern Great Plains