

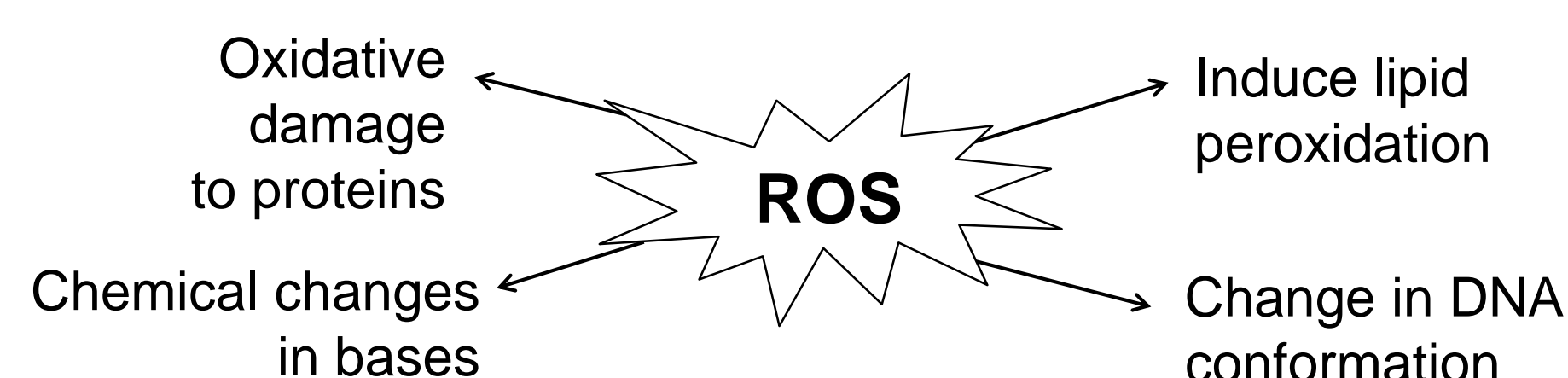


## Motivation

- Elevated particulate matter (PM) concentrations associated with increases in cardiopulmonary diseases
  - Asthma, chronic obstructive pulmonary disease (COPD), arrhythmia, heart failure
- Ambient PM exposure ranks in top ten global human health risks
- Organic aerosols (OA) constitute significant portion of fine PM
  - Field studies show secondary organic aerosols (SOA), formed from atmospheric oxidation of volatile organic compounds, often dominate over primary OA

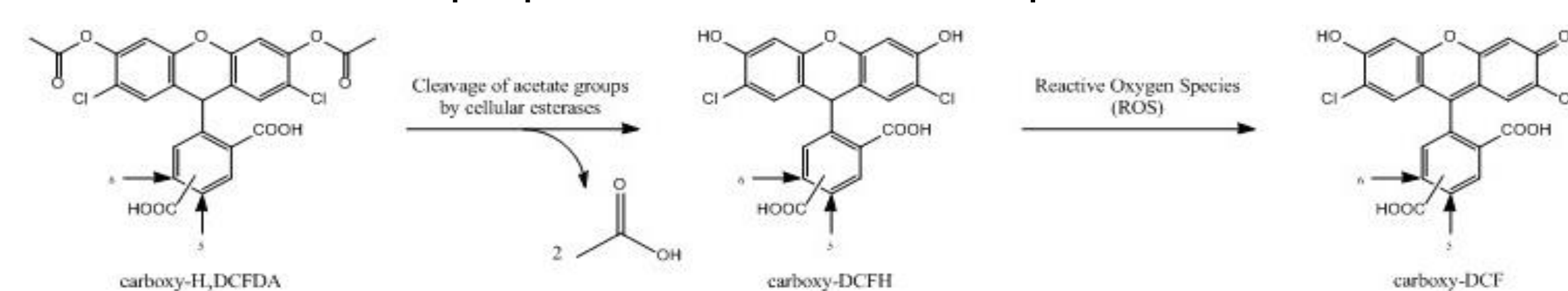
## Reactive oxygen and nitrogen species (ROS/RNS)

- Toxicology studies suggest that PM-induced oxidant production may be a possible mechanism for health endpoints resulting from PM exposure
- ROS/RNS can lead to oxidative stress and damage cellular components
- Possible link between PM exposure and health effects
  - Generate ROS/RNS via redox reactions
  - Induce cellular pathways that produce ROS/RNS

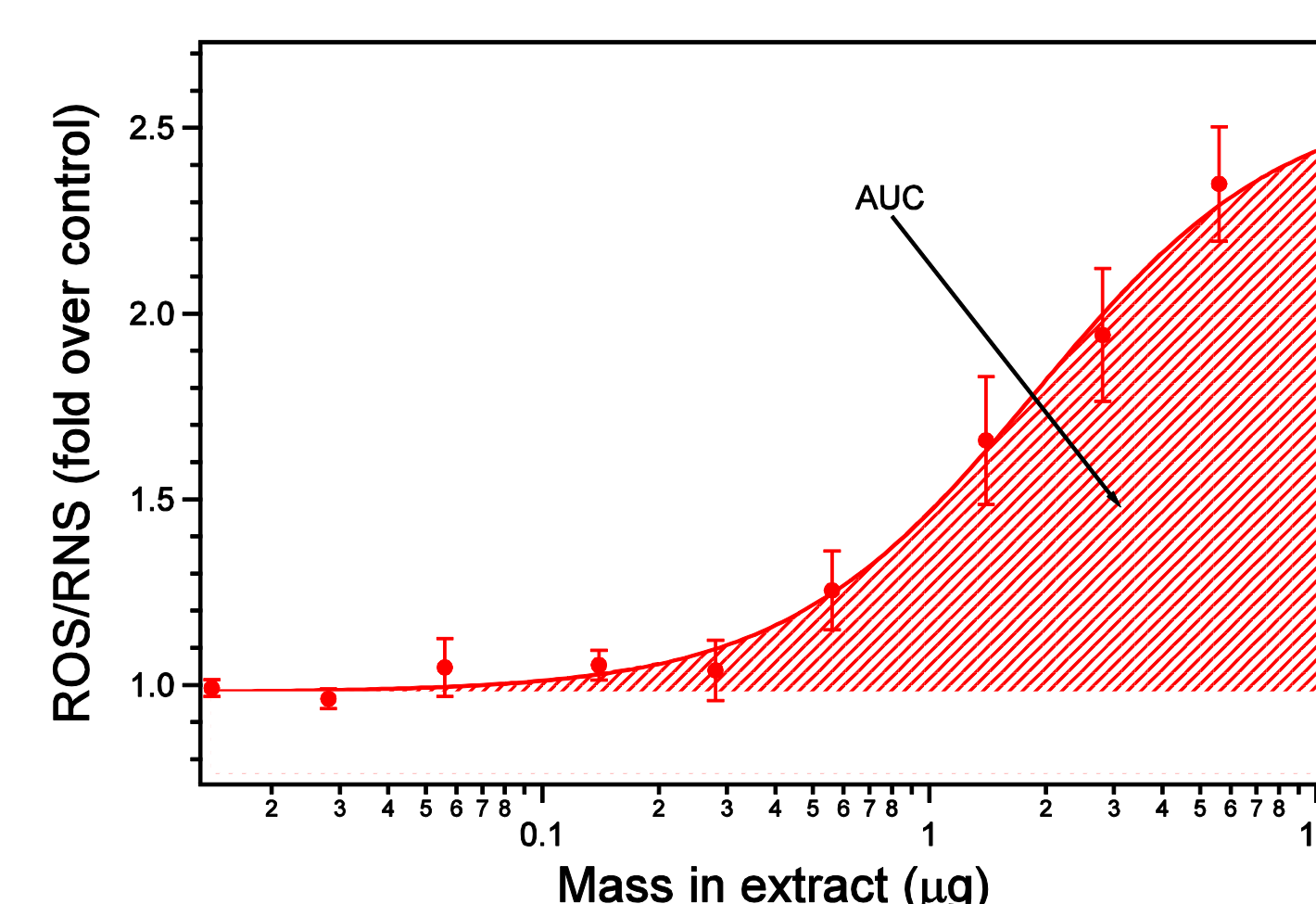


## Intracellular ROS/RNS production

- Murine alveolar macrophages (MHS cell line)
  - 1<sup>st</sup> line of defense against environmental insults
- Measures intracellular ROS/RNS production
  - ROS/RNS probe: carboxy-H<sub>2</sub>DCFDA
  - Non-fluorescent compound → intracellular deacetylation → reaction with ROS/RNS → fluorescent compound
  - Fluorescence proportional to ROS/RNS produced



- Dose-response curve
  - Wide dose range
  - Response expressed as fold increase over cells exposed to stimulant-free media
- Area under the dose-response curve (AUC)
  - Used to represent overall toxicity
  - Most robust response parameter

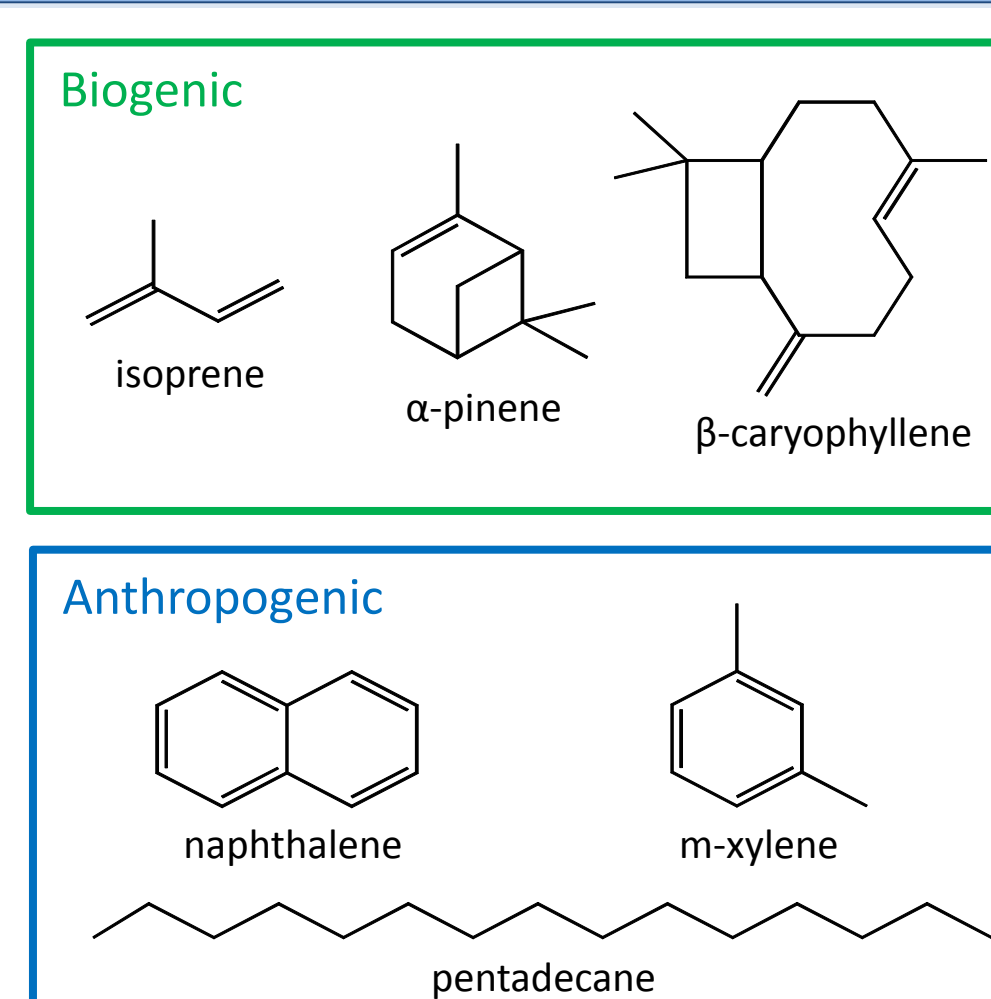


## Inflammatory cytokine secretion

- Tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6)
  - Pro-inflammatory cytokines
- Measured post-exposure (24 hrs) using enzyme-linked immunosorbent assay (ELISA)
  - Dose-response approach
  - AUC used to represent each endpoint for comparison

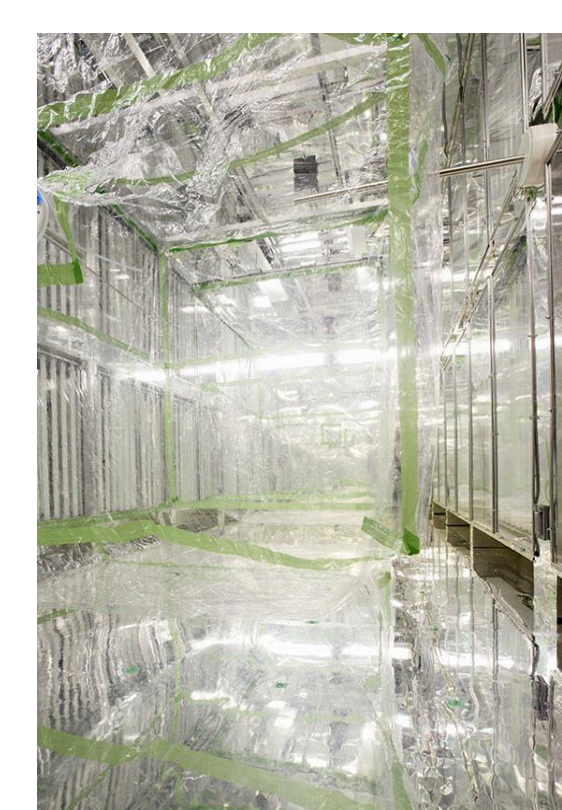
## Photooxidation SOA

- Volatile organic compound + hydroxyl radical → SOA
  - H<sub>2</sub>O<sub>2</sub> (OH precursor)
  - Ammonium sulfate seed
- Precursors of biogenic and anthropogenic origin
- Different formation conditions
  - Dry vs humid
  - RO<sub>2</sub> + HO<sub>2</sub> vs RO<sub>2</sub> + NO

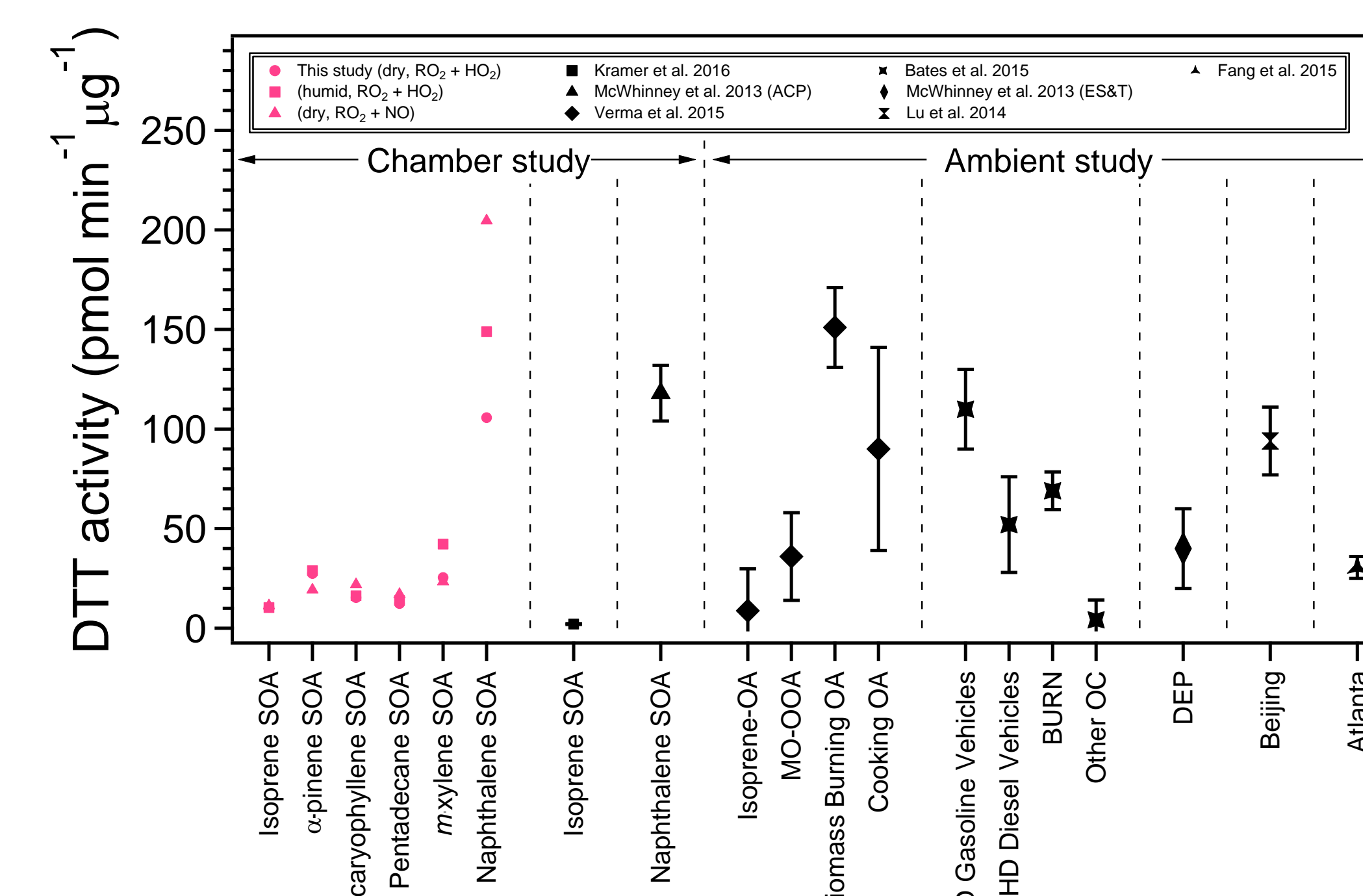


## Georgia Tech Environmental Chamber

- 21 x 12 ft temperature-controlled enclosure
  - UV and sunlight lamps
  - 4 – 40 °C temperature range
- Various instruments for measuring aerosol chemical and physical properties
  - High resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS)

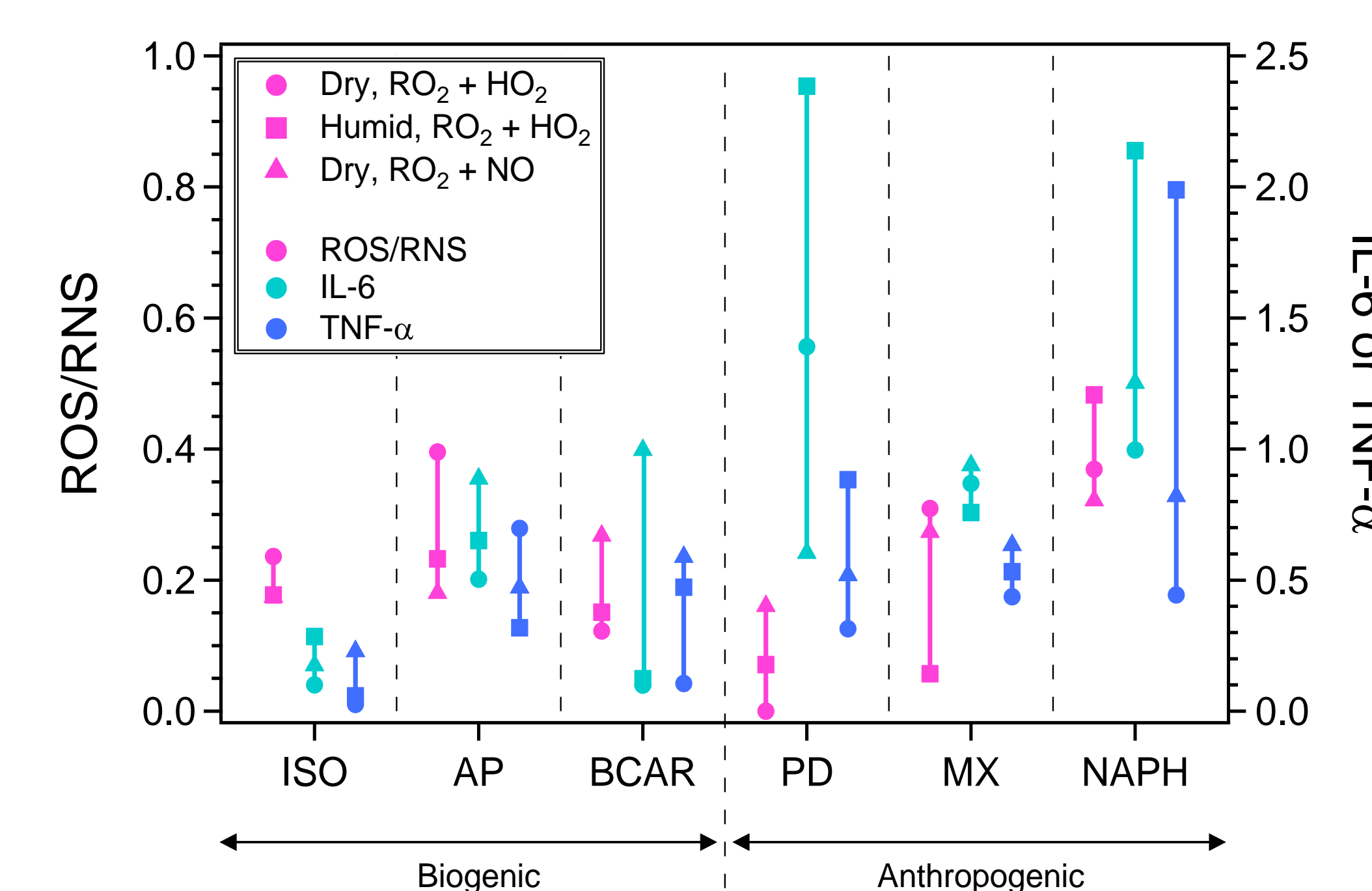


## Intrinsic DTT activity: the effect of SOA precursor and formation condition



- Isoprene, α-pinene, β-caryophyllene, pentadecane:
  - Low DTT activity across all reaction conditions
  - Organic peroxides and organic nitrates formed may have similar redox activity (all not highly redox active)
- m*-xylene:
  - Negligible difference between conditions that favor different RO<sub>2</sub> fates
  - Large portion of ring-breaking products
- Naphthalene:
  - Highest DTT activity, DTT activity strongly influenced by humidity and reaction condition
  - Importance of conjugated systems

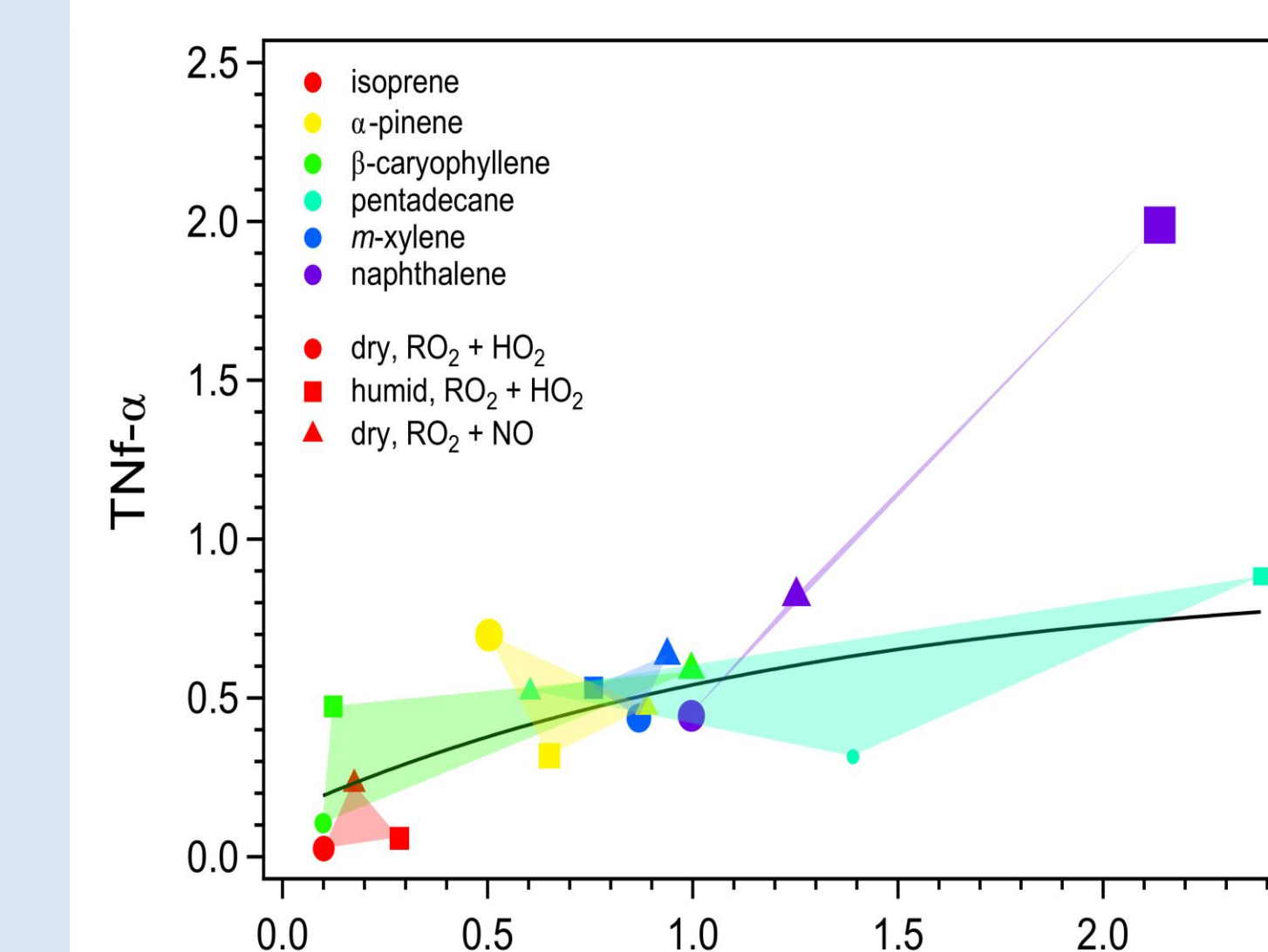
## SOA-induced inflammatory responses



- Isoprene
  - Low inflammatory response regardless of formation condition
- α-pinene, *m*-xylene:
  - Similar inflammatory response for all three formations conditions
  - Ring-breaking products with similar carbon chain length
- β-caryophyllene, pentadecane:
  - Large response range for IL-6
  - Products with long carbon chain (possible membrane insertion)
- Naphthalene:
  - Large response range for TNF-α and IL-6, higher levels of ROS/RNS
  - Aromatic ring-containing products

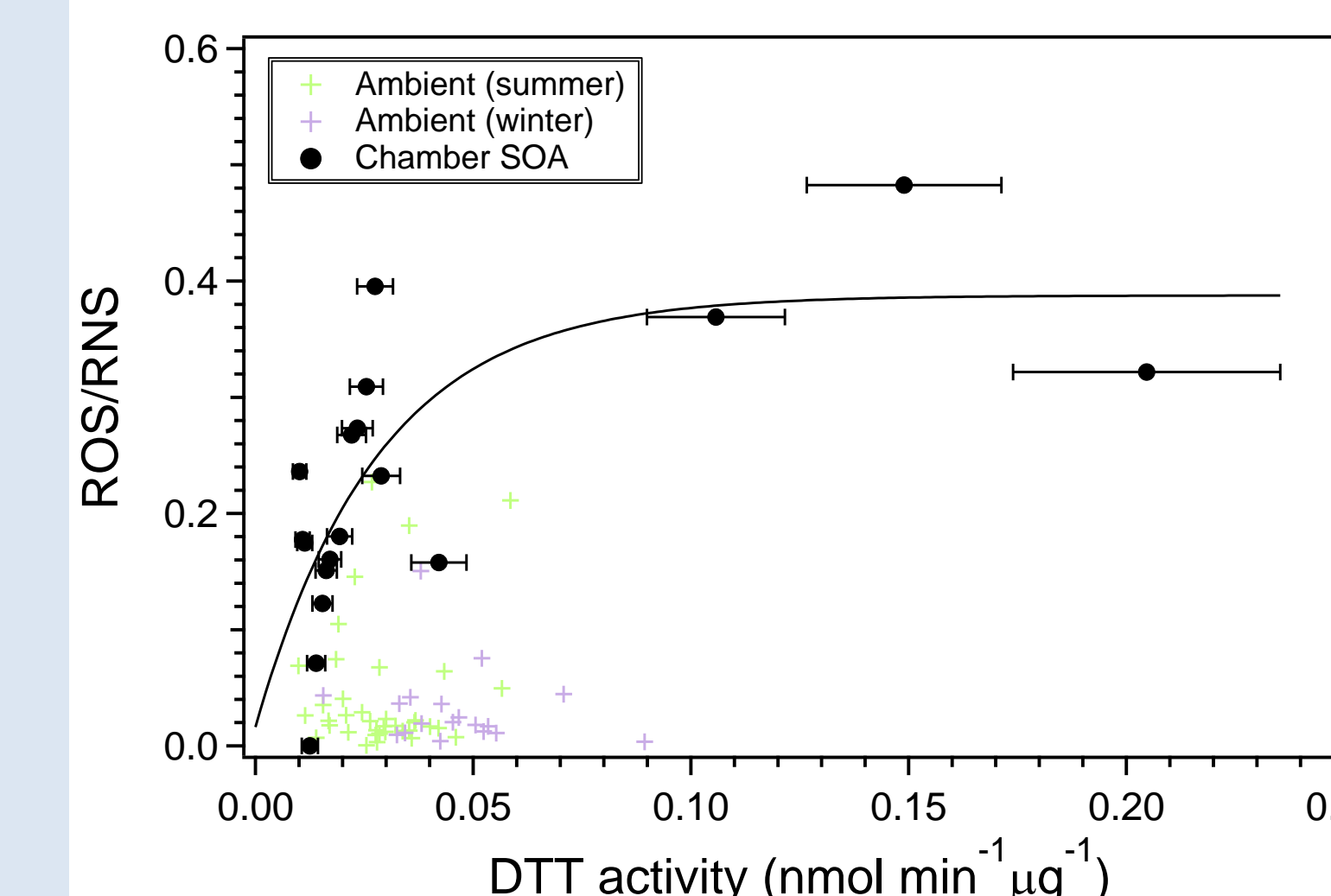
## Relationship between inflammatory responses

- Secreted levels of TNF-α and IL-6 follow an exponential curve with a TNF-α plateau
  - Interconnected cytokine pathways, stimulation and inhibition loops
  - IL-6 can directly inhibit TNF-α production
- ROS/RNS levels have increasing then decreasing trend
  - Balance between pro-inflammatory and anti-inflammatory effects
  - IL-6 exhibits some anti-inflammatory functions
- Naphthalene SOA is an exception
  - Likely due to aromatic products that may induce different cellular pathways
  - For example, nitroaromatics have mutagenic properties



## Comparison with ambient samples

- Positive association between ROS/RNS production and intrinsic DTT activity for laboratory-generated SOA
- Ambient context
  - Ambient samples collected around the greater Atlanta area
  - Analyzed using same methods for DTT and ROS/RNS



- DTT
  - SOA oxidative potential comparable to that observed in ambient samples
  - Naphthalene SOA is an exception; higher oxidative potential due to aromatic ring-retaining products

- ROS/RNS:
  - Similar or higher levels of ROS/RNS compared to ambient samples
  - Possible ambient species that do not contribute to ROS/RNS
  - Different formation conditions
  - Multiple precursors

## References

- Tuet, W. Y., Fok, S., Verma, V., Tagle Rodriguez, M. S., Grosberg, A., Champion, J. A., Ng, N. L., *Atmos. Environ.*, 2016. doi:10.1016/j.atmosenv.2016.09.005
- Tuet, W. Y., Chen, Y., Xu, L., Fok, S., Gao, D., Weber, R. J., Ng, N. L., *Atmos. Chem. Phys.*, 2017. doi:10.5194/acp-17-839-2017
- Tuet, W. Y., Chen, Y., Fok, S., Champion, J. A., Ng, N. L., *Atmos. Chem. Phys. Discuss*, in review. doi:10.5194/acp-2017-262

## Acknowledgement

We acknowledge support by HEI research agreement #4943-FRA13-2/14-4, EPA grant R834799, and NSF graduate research fellowship grant DGE-1650044.

