Southeast US
Summer 2013 Science Coordination

SOAS
Southern Oxidant & Aerosol Study

REILLY: **RE**gional **I**nvestigation of **L**ocal and **L**ong-range Chemistr**Y**

GAMES: **G**as and **A**erosol **M**easurement **E**xperiment – **S**outheast U.S.

MASSIVE: **M**any **A**tmospheric **S**cience **S**ystems **I**nvestigating **V**olatile **E**missions

ACRONYM: **A**tmospheric **C**hemistry of **R**eactive **O**rganics, **N**itrogen **Y**ields and **M**ercury

Challenge to the group to come up with an over-arching acronym. Developer of successfully-picked acronym will receive a New Jersey-inspired prize. Here are some helpful letters: SOAS, SENEX, NOMADSS, NAMEX, TropHONO

Partners

SOAS
Southern Oxidant & Aerosol Study

Aerodyne
Atmospheric Research & Analysis
California Institute of Technology
Eidgenössiche Technische Hochschule Zürich
Electric Power Research Institute
Kent State University
Massachusetts Institute of Technology
National Science Foundation
National Center for Atmospheric Research
National Oceanic and Atmospheric Administration
National Park Service
North Carolina State University
Oakland University
Pennsylvania State University
Perdue University
Reed College
Research Triangle Institute
Rice University
Rutgers University
Stony Brook University
Tennessee Valley Authority
Texas A&M University
University of Colorado - Boulder
University of California –Berkeley
University of California – Irvine
University of California – Los Angeles
University of California – Riverside
University of California – San Diego
University of Eastern Finland
University of Iowa
University of Michigan
University of Washington - Bothell
University of Wisconsin – Madison
University of North Carolina – Chapel Hill
U.S. Environmental Protection Agency
Utrecht University, Netherlands
Washington University in St. Louis
West Chester University of Pennsylvania
Western Michigan University

Southern **O**xidant and **A**erosol **S**tudy

- SOAS is unique as a 'grass roots' field campaign based on SOS studies of the 1990s
- NOAA's commitment to fly the P3 for SENEX was an important impetus
- NSF funded an OFAP request, individual investigator proposals
- EPA originally planned to fund $3 million in STAR grants but increased that amount
- EPRI science and logistics partner
- One of my personal favorite SOAS facts:
  - ***EPA*** funded a ***university*** scientist to fly an instrument on ***NOAA***'s plane

Timeline

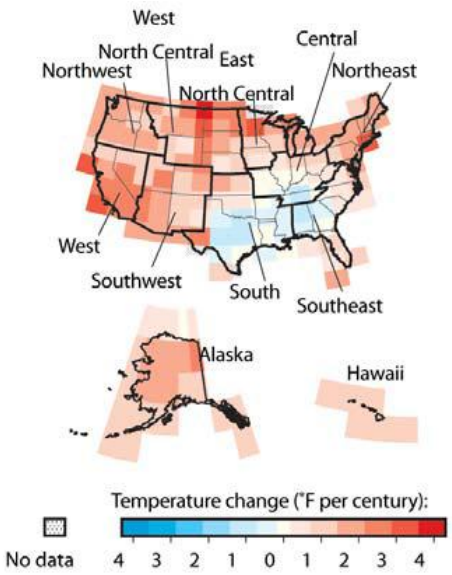
Pre SOAS discussions

December 2010	Ad Hoc Meeting at Fall 2010 AGU meeting (San Francisco, CA)
May 2011	First SOAS Workshop at Rutgers University (New Brunswick, NJ)
December 2011	Town Hall Meeting at Fall 2011 AGU meeting (San Francisco, CA)
March 13, 2013	Science Coordination Meeting at EPA Potomac Yard offices (Washington, DC)
June 1 – July 15, 2013	Official dates of SOAS
October 2013	Look out for us at future AAAR meetings
December 2013	Look out for us at future AGU meetings
October 2014	Look out for us at future AAAR meetings
December 2014	Look out for us at future AGU meetings

SOAS data and modeling workshops

SOAS and SENEX

SOAS
Southern Oxidant & Aerosol Study



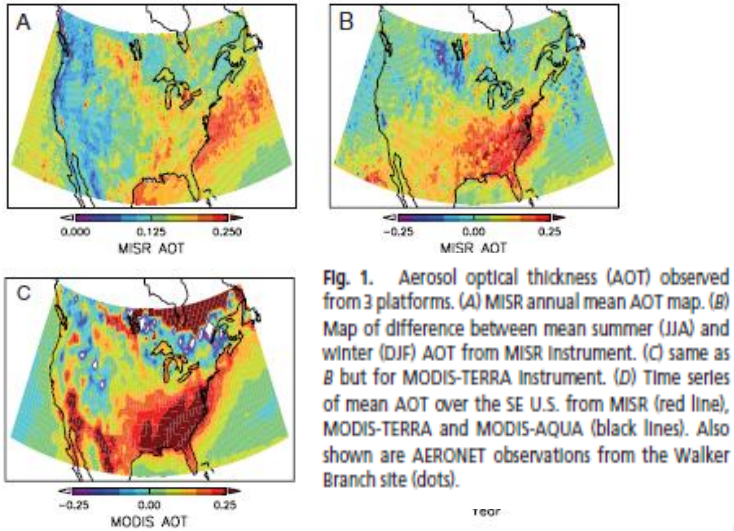
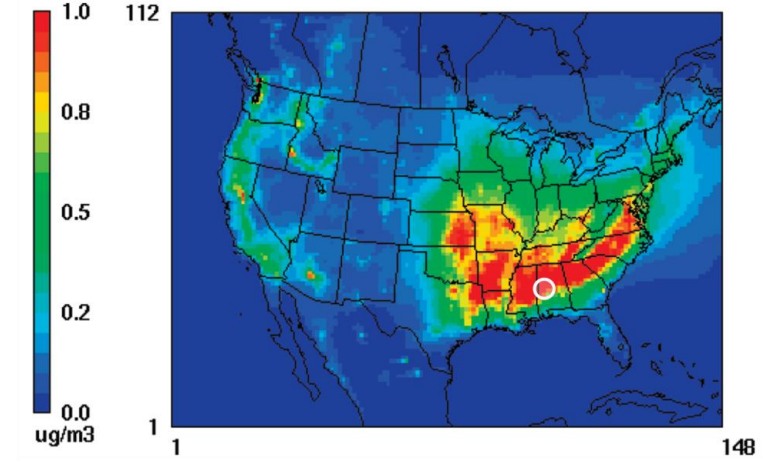


Fig. 1. Aerosol optical thickness (AOT) observed from 3 platforms. (A) MISR annual mean AOT map. (B) Map of difference between mean summer (JJA) and winter (DJF) AOT from MISR instrument. (C) same as B but for MODIS-TERRA instrument. (D) Time series of mean AOT over the SE U.S. from MISR (red line), MODIS-TERRA and MODIS-AQUA (black lines). Also shown are AERONET observations from the Walker Branch site (dots).

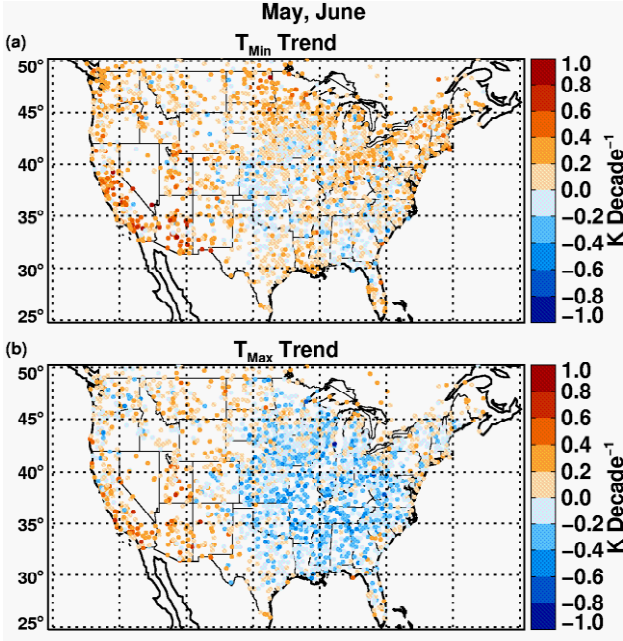
Goldstein et al., PNAS 2010

EPA with data courtesy of NOAA

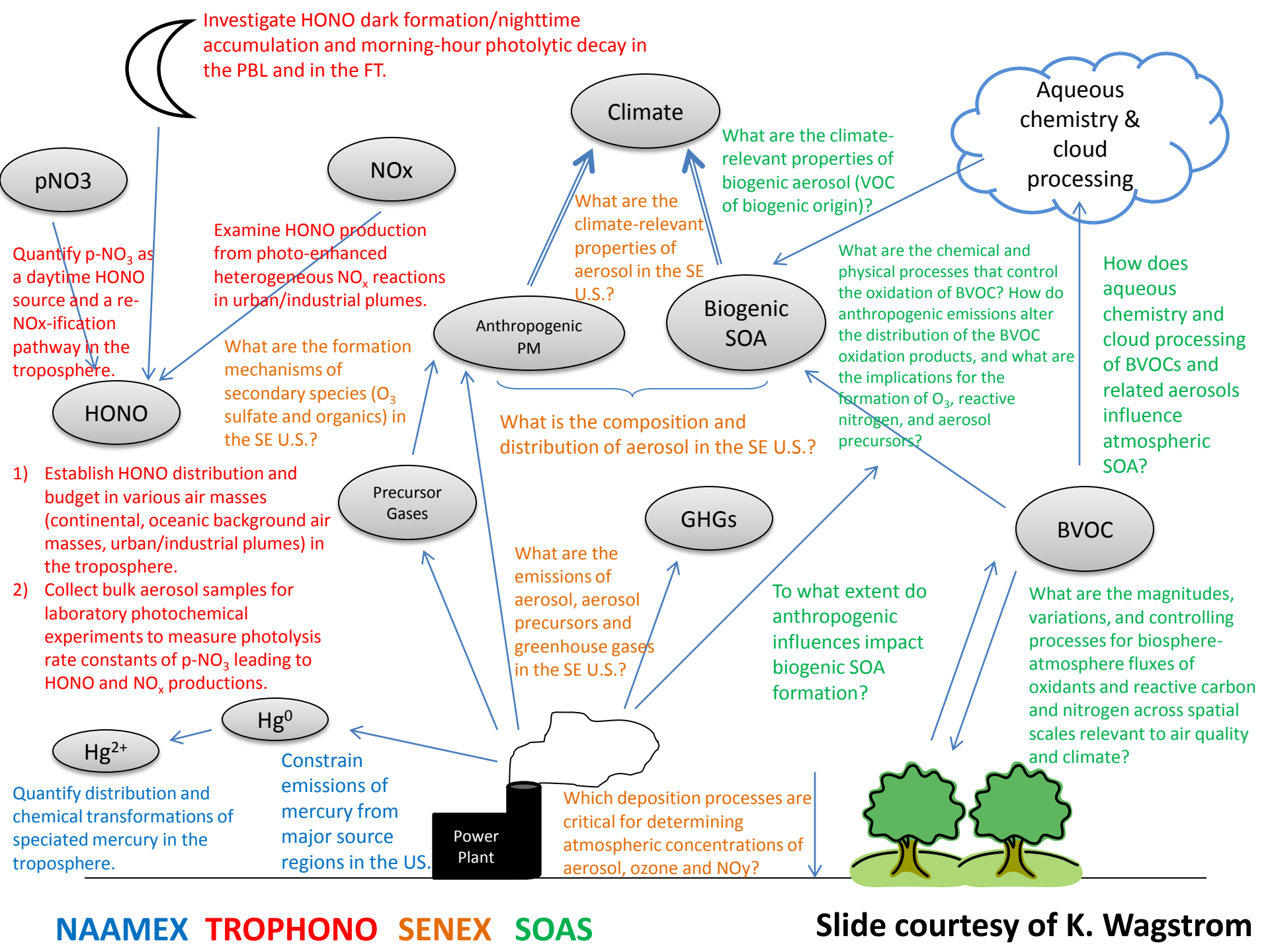
Enhancement in biogenic SOA due to controllable emissions



Carlton et al., ES&T 2010



Portmann et al., PNAS 2010


Investigate HONO dark formation/nighttime accumulation and morning-hour photolytic decay in the PBL and in the FT.
Climate
Aqueous chemistry & cloud processing
pNO3
NOx
What are the climate-relevant properties of biogenic aerosol (VOC of biogenic origin)?
What are the climate-relevant properties of aerosol in the SE U.S.?
Quantify p-NO3 as a daytime HONO source and a re-NOx-ification pathway in the troposphere.
Examine HONO production from photo-enhanced heterogeneous NOx reactions in urban/industrial plumes.
Anthropogenic PM
Biogenic SOA
What are the chemical and physical processes that control the oxidation of BVOC? How do anthropogenic emissions alter the distribution of the BVOC oxidation products, and what are the implications for the formation of O3, reactive nitrogen, and aerosol precursors?
How does aqueous chemistry and cloud processing of BVOCs and related aerosols influence atmospheric SOA?
HONO
What are the formation mechanisms of secondary species (O3 sulfate and organics) in the SE U.S.?
What is the composition and distribution of aerosol in the SE U.S.?
1) Establish HONO distribution and budget in various air masses (continental, oceanic background air masses, urban/industrial plumes) in the troposphere.
2) Collect bulk aerosol samples for laboratory photochemical experiments to measure photolysis rate constants of p-NO3 leading to HONO and NOx productions.
Precursor Gases
GHGs
BVOC
What are the emissions of aerosol, aerosol precursors and greenhouse gases in the SE U.S.?
To what extent do anthropogenic influences impact biogenic SOA formation?
What are the magnitudes, variations, and controlling processes for biosphere-atmosphere fluxes of oxidants and reactive carbon and nitrogen across spatial scales relevant to air quality and climate?
Hg0
Hg2+
Quantify distribution and chemical transformations of speciated mercury in the troposphere.
Constrain emissions of mercury from major source regions in the US.
Power Plant
Which deposition processes are critical for determining atmospheric concentrations of aerosol, ozone and NOy?
NAAMEX TROPHONO SENEX SOAS
Slide courtesy of K. Wagstrom

SOAS
Southern Oxidant & Aerosol Study

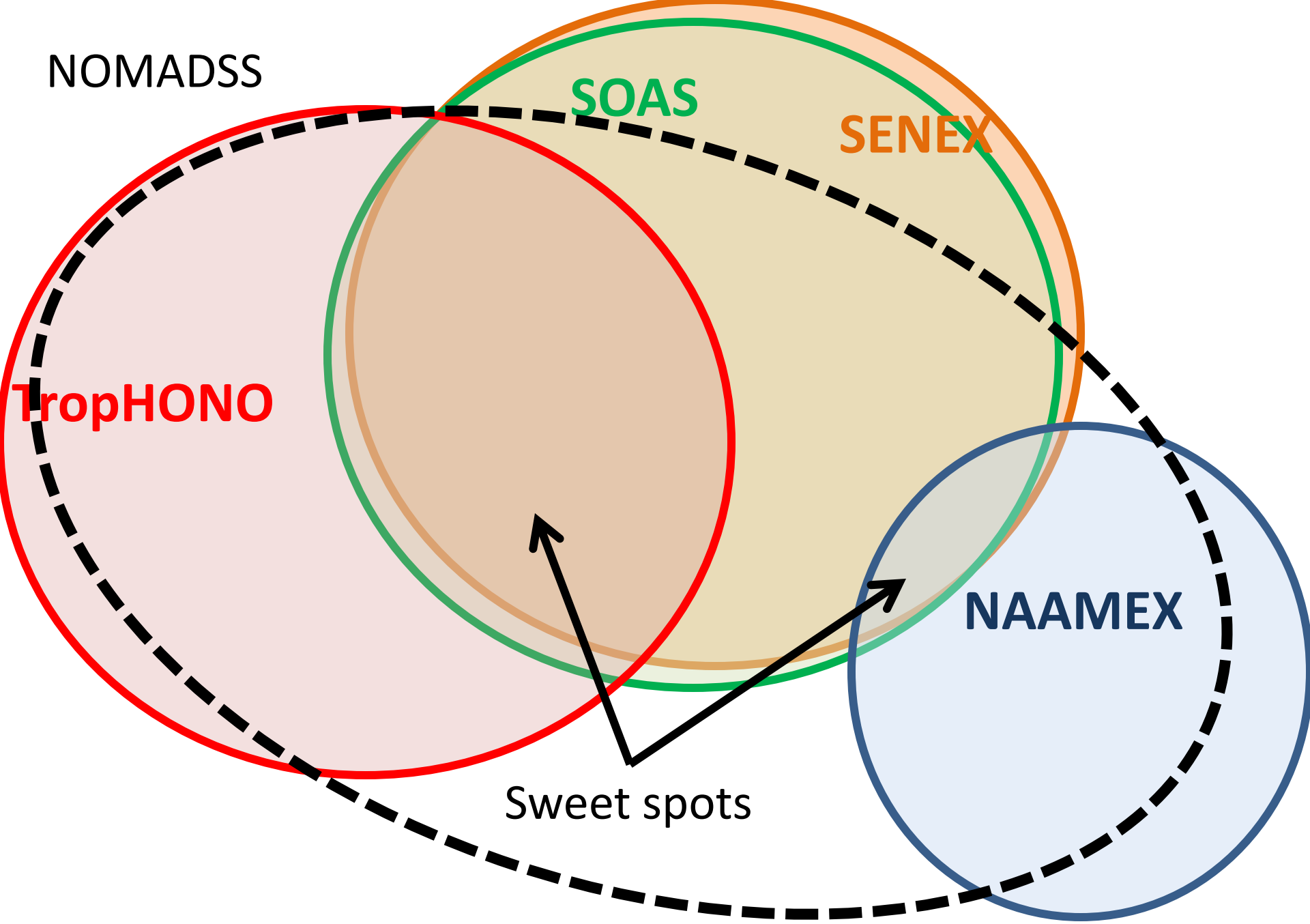
EPA STAR Call:

Anthropogenic Influences on Organic Aerosol Formation and Regional Climate Implications

1. How do anthropogenic emissions influence the oxidation of biogenic volatile organic compounds (BVOCs) and the subsequent formation of secondary organic aerosol, ozone, stable organic intermediates or reactive nitrogen compounds?

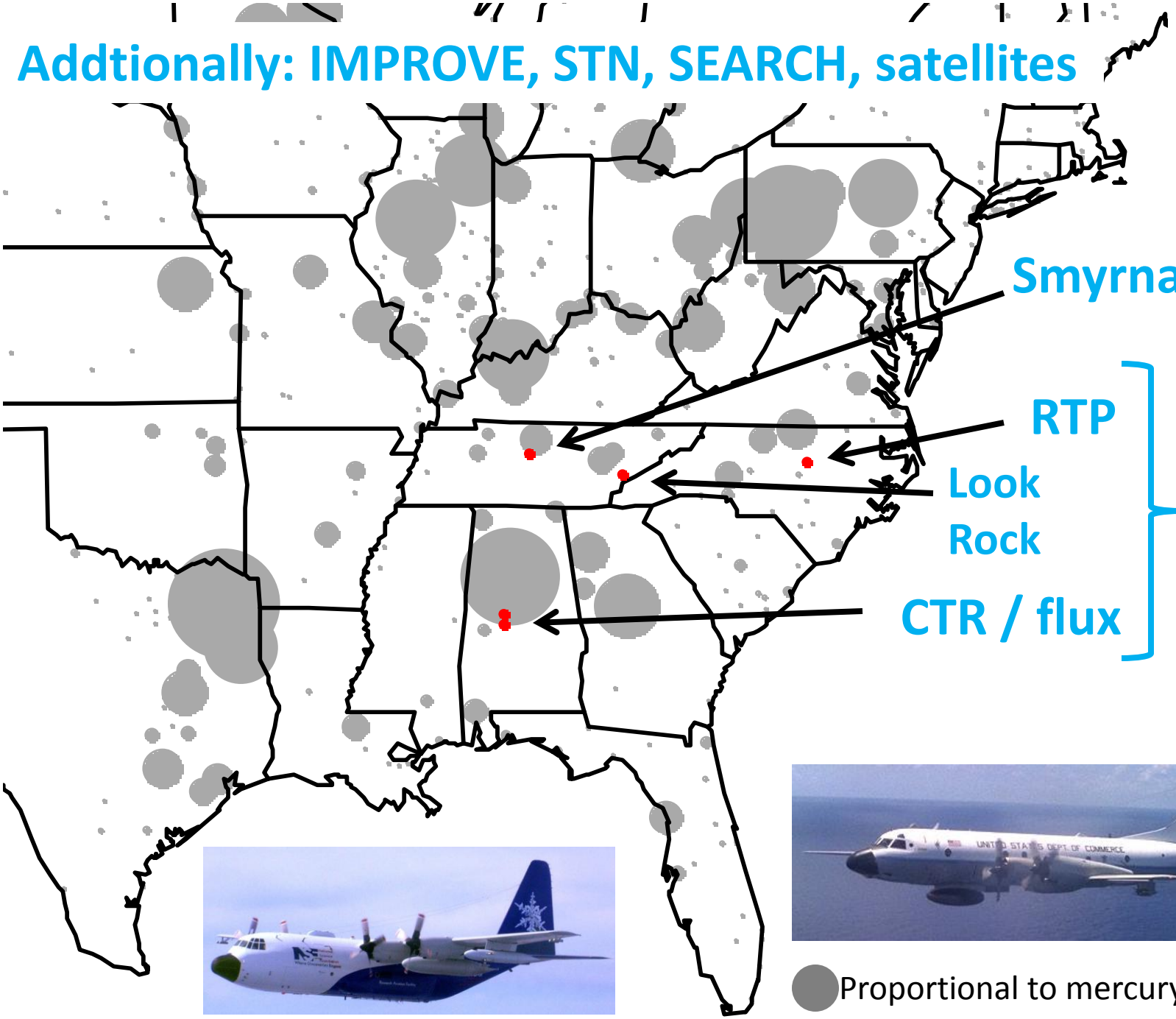
2. How can the linkages between gas phase chemistry and secondary organic aerosol formation be improved in air quality models using observations of gas and aerosol concentration and properties?

3. How are the climatically relevant properties of biogenic secondary organic aerosols (either optical properties or cloud interactions) impacted by anthropogenic emissions?



Venn Diagram of SE2013 Activities to find Synergies

Addtionally: IMPROVE, STN, SEARCH, satellites

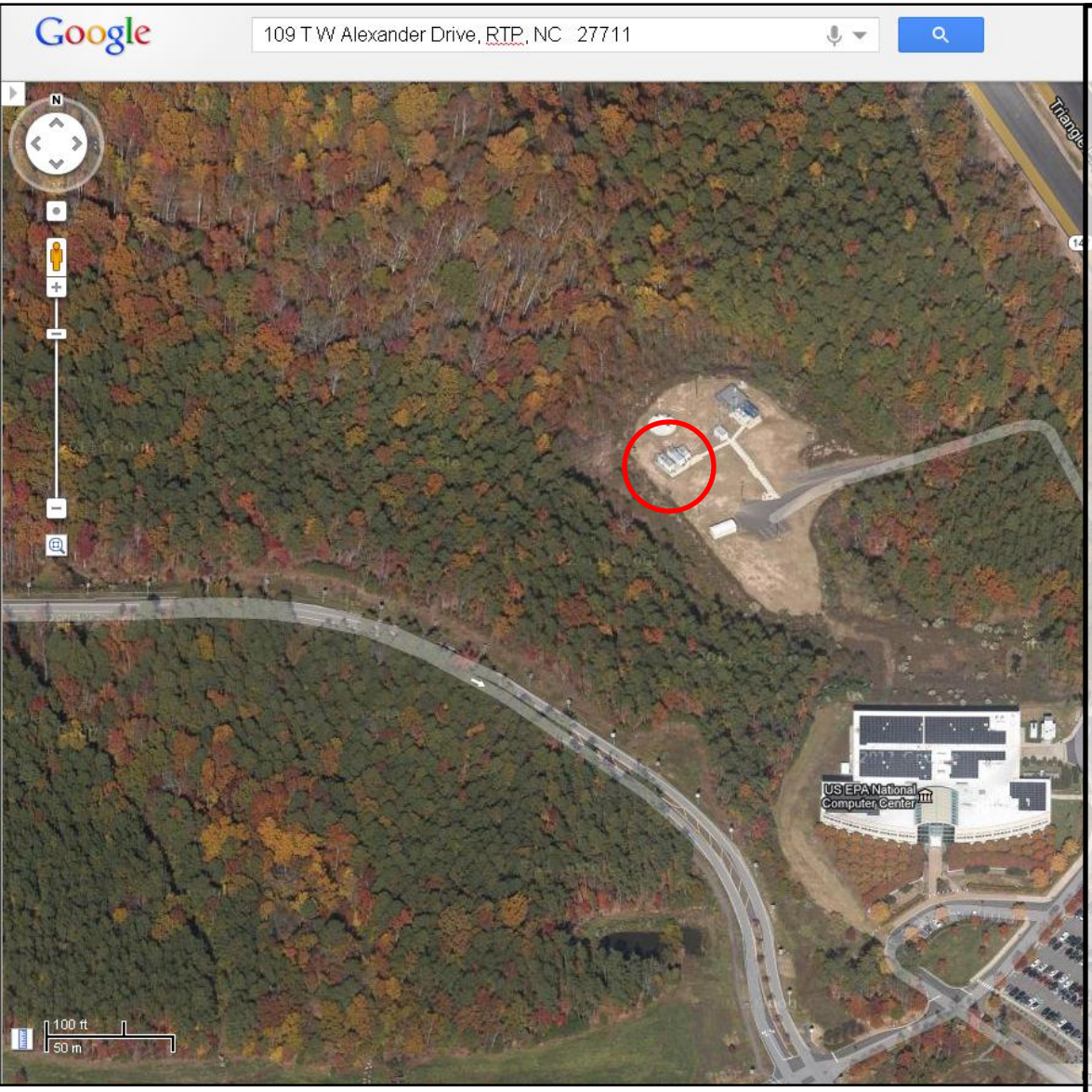


Proportional to mercury emissions

SOAS - RTP

Dates: 01 June - 15 July 2013

SOAS Southern Oxidant & Aerosol Study



01 June - 15 July 2013

- TD-HR-ToF AMS
- CIMS
- AIM
- Sunset OC/EC; SMPS
- SP2 & PASS
- 3 x Hi-Vol filter samplers
  SOA tracers, POA tracers & ^{14}C
- VOC canisters & DNPH tubes twice daily; PAN hourly
- Criteria Gases… plus

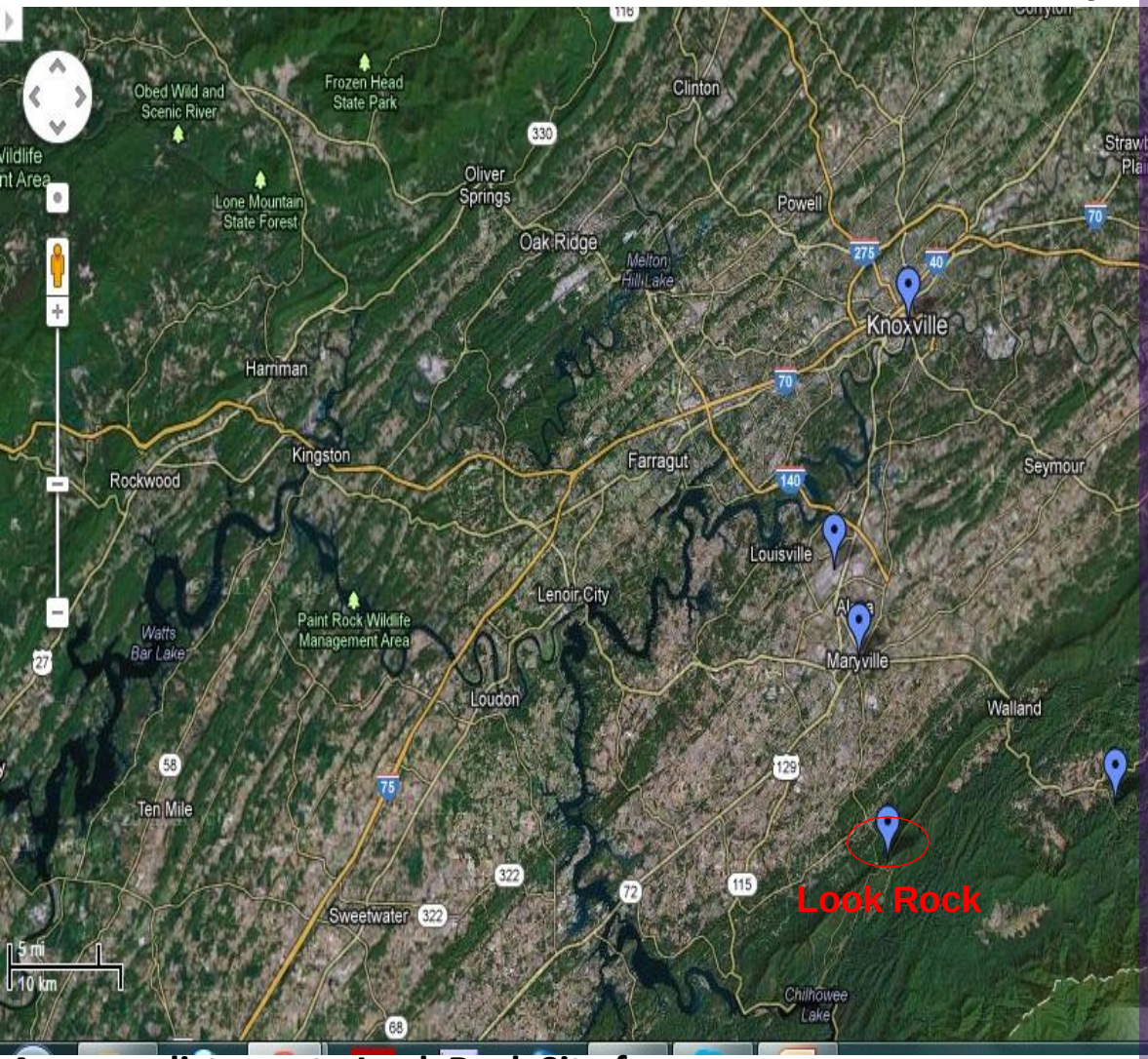
(e.g. NO_2 by CRDS; NO_x by FRM & FEM)

Slide courtesy of J. Offenberg

SOAS - Look Rock Site, TN

Dates: 01 June - 15 July 2013

SOAS Southern Oxidant & Aerosol Study



- **Aerodyne Acetate CIMS**
- **Aerodyne ACSM**
- **Aerodyne HR-TOF-AMS & SP2**
- **Low-Vol $PM_{2.5}$/PM_1 Filter Samplers**
  - FTIR; XRF
- **3 x High-Vol $PM_{2.5}$ Filter Samplers**
  - SOA Tracers by GC/MS & LC/ESI-HR-MS
- **3 x SMPS w/ CPCs**
- **Sunset OC/EC; TEOM**
- **Thermodenuder**
- **Cavity ringdown/photoacoustic spectrometer (CRD-PAS)**
- **CIMS for N_2O_5 reactivity**
- **CCN**
- **EPA NCore Site**
  - Criteria (e.g., NO_x, O_3, etc.) & particle data (e.g., BC, $PM_{2.5}$, etc.)
- **Continuous Meteorology**
- **Possibly PTR-MS??**

Average distance to Look Rock Site from:

- **Maryville, TN = 12.3 mi**
- **Knoxville McGhee Tyson Airport = 17.4 mi**
- **Knoxville, TN = 30.9 mi**

Collaborators: TVA, EPRI & NPS

Slide courtesy of J. Surratt

SOAS – Brent, AL

Dates: 01 June - 15 July 2013

SOAS
Southern Oxidant & Aerosol Study

Current Met Measurements at CTR

Variable	Z (magl)	Analyzer/Sensor	Time Resolution (min)
WS/WD	10	RMYoung 81000 sonic	5
T/RH/BP	9	Paroscientific Met4A	5
T/RH	2	Vaisala	5
PAR	2	Licor	5
precipitation	2	ETI-NOAH IV	5
aerosol/cloud layers	50-15,000	JenOptik CHM 15k	5

Current Chemical (gas) at CTR

Variable	Z (magl)	Analyzer/Sensor	Time (min)
CO	10	Thermo 48i	5
SO_2	10	Thermo 43i	5
NO	10	Thermo 42i	5
NO_2	10	photolysis/Thermo 49i	5
HNO_3	10	continuous denuder diff/Thermo 42i	5
NO_y	10	cat. reduction/Thermo 42i	5
NH_3	5	continuous denuder diff/Thermo 42i	5
Tot. PANs	5	thermophotolytic/Thermo 42i	5
Tot. Alkyl Nitrates	5	thermophotolytic/Thermo 42i	5

SEARCH Routine Measurements

SEARCH

Current Chemical (PM) CTR

Variable	Z	Analyzer/Sensor	Time
Continuous $PM_{2.5}$ Mass	5	TEOM	5
Continuous $PM_{2.5}$ SO_4	5	cat. reduction/Thermo 43i	5
Continuous $PM_{2.5}$ NO_3	5	cat. reduction/Thermo 42i	5
Continuous $PM_{2.5}$ NH_4	5	cat. oxidation/Thermo 42i	5
Continuous $PM_{2.5}$ TC/EC	5	Sunset	5
dry Babs (550 nm)	5	Radiance Research M903	5
dry Bsp	5	Magee 2ch. Aeth	5
ambient Bsp	5	Optec NGN-2a	5
Discrete $PM_{2.5}$ Mass	5	filter/gravimetry	1440, daily
Discrete $PM_{2.5}$ ions	5	filter/IC	1440, daily
Discrete $PM_{2.5}$ major/minor elements	5	filter/XRF	1440, daily
Discrete $PM_{2.5}$ water-soluble metals	5	filter/ICPMS	1440, daily
Discrete $PM_{2.5}$ OC/EC	5	filter/TOR	1440, 1 in 3
Discrete PM_{10} Mass	5	filter/gravimetry	1440, 1 in 3
Discrete PM_{10} ions	5	filter/IC	1440, 1 in 3
Discrete PM_{10} major/minor elements	5	filter/XRF	1440, 1 in 3
Discrete PM_{10} water-soluble metals	5	filter/ICPMS	1440, 1 in 3

Speciated deposition measurements at CTR

Variable	Z	Analyzer/Sensor	Time
wet deposition ions	2	bucket/IC	10080
wet deposition total-Hg	2	glass btl./CVAAS	10080
wet deposition trace elements	2	poly btl./ICPMS	10080

****Just became an official NADP site (March calendar picture)**

Confirmed Tower Inlet

Organic acids HRToF-CIMS
Flux of BVOC and oxidation products- PTR-TOFMS
BVOC flux, relaxed eddy accumulator – GCMS
Glyoxal gradient – LIP
HCHO flux, gradients – LIF
NO_2, PANS, ANs NO fluxes and gradients – TD-LIF
$NO/NO_2/NH_3$ – chemillumescence
NO_3/N_2O_5 – CRDS
N_2O_5 reactivity
Submicron NR aerosol composition and size distribution – HR-ToF-AMS
2 potential aerosol mass (PAM) flow reactors
- with OH, O_3, NO_3 oxidation + AMS&SMPS
Aerosol volatility – thermal denuder
Aerosol number size distribution - SMPS

CTR Ground Measurements (gases)

SOAS
Southern Oxidant & Aerosol Study

AVOC, BVOC, $RONO_2$ – 2DGC
PAN/MPAN, GC-ECD
RONO2 – CIMS
Vertical BL profile, HCHO, NO_x – MAX-DOAS
Sulfuric acid and amines – CIMS
$NO/NO_2/NH_3$ – Thermo
Ion clusters, Cl, NO_3 – APiToF
NO_3/corona – IMS-ToF
SVOCs - EI-HR-MS
Organic gases – PTRMS
Organic acids – CIMS
g+p inorganic ions, URG aerosol inorganic monitor
g+p SVOCs – hourly with SVTAG
g+p organic molecular composition – MOVI-HRToF-CIMS

Wind profiler radar, RASS, basic met

CTR Ground Measurements (particles)

SOAS
Southern Oxidant & Aerosol Study

Inorganic ion, tot. carbon, org. nitrogen light abs. by dissolved organics – $PM_{2.5}$ cyclone inlet

Hygroscopicity – SMPS

Single ptcl. optical properties – PAX, SP2

UV aerosol extinction by λ

Aerosol volatility – thermal denuder *2 different groups

Organic aq. Chemistry – mist chambers

SOA formation – CAGE chambers/ HRToF-AMS, PILS-IC, HDTMA, CCN, APS

Total ptcl phase liquid water, total ptcl volatiles – DMA

WSOC(g+p), aerosol extinction, OC/EC,NO_x/NO_2 , metals - PILS-BrwnC- TEOM, 7λ aeth., PILS-AMS-CCN, PILS-IC

f(RH) – nephelometers

Organic aerosol volatility and polarity – VAPS

Submicron NR aerosol comp. & size distribution – HR-ToF-AMS

Potential aerosol mass flow reactors w/ OH, O_3, NO_3 –AMS/SMPS/CIMS

Aerosol number size distribution and total particle number conc. – SMPS / CPC

Aerosol phase – “bouncing” by CPC

Single scattering albedo – CAPS

Nanoparticle molecular composition and size distribution 3-100 nm - TDCIMS

Outreach and Communication

2 student made documentaries for PBS' online learning

- not only conveys science to broad audience but trains next generation of journalists in scientific literacy and science communication skills

1 flight on the P3 (?)

Outreach and Communication

thesoasblog.wordpress.com

SOAS Southern Oxidant & Aerosol Study The Blog

HOME | ABOUT

SITE VISIT

Trailer at SEARCH site

Posted on February 13, 2013 • Leave a comment

Dennis (mayor) and Eric (ARA) talk with Stephanie Shaw (EPRI) about SOAS. Delphine (CSU) and Ann Marie (Rutgers) find the only shade and stay there.

LATEST ENTRIES

SITE VISIT / SOAS BRAINSTORMING

Flux tower

Posted on February 12, 2013 • Leave a comment

A flux tower will be situated near the study site to study in-canopy emissions, chemistry, and bi-directional surface exchange. Featured here is a picture of

RECENT POSTS

Trailer at SEARCH site
Flux tower
Why Alabama?
"If a tree falls in a forest and no one is around to see it, does it make a sound?"
Local residents

Google hangouts and tours

C130 has its own twitter account!

Synergies

SOAS
Southern Oxidant & Aerosol Study

- 3 super sites across SE U.S.
  - filter sharing/coordination (across time zones)
- Adding Hg monitor at surface site near SOAS
- Wingtip-to-wingtip comparisons
- TropHONO nitrogen measurements compliment SOAS/SENEX (reactive nitrogen fluxes/fate)
- Longer co-located flight times
- BNL potentially to have ‘leftover’ hours on the G1
  - Share data, fly over surface sites, repeat some flight track segments, extends SOAS/SENEX aircraft missions

Southeast 2013 Summer Field Campaigns

SOAS
Southern Oxidant & Aerosol Study

Coordination Team (SOAS/NOMADSS/SENEX)
A.G. Carlton (Rutgers) (SOAS)
J.L. Jimenez (CU – Boulder) (SOAS)
A.H. Goldstein (Cal – Berkeley) (SOAS)
A. Guenther (NCAR) (SOAS/NOMADSS)
J. deGouw (NOAA) (SENEX)

Program Management Coordination
S. Edgerton (NSF)
S. Hunt (U.S. EPA)
S. Shaw (EPRI)

Working Groups

Supersites and Surface Logistics
K. Bauman (ARA)
soas-ground@googlegroups.com

Operations Coordination
J. Moore (NCAR) SOAS
V. Salazar (NCAR) NOMADSS
E. Edgerton (ARA)

Aircraft
D. Jaffe (U. Wash)

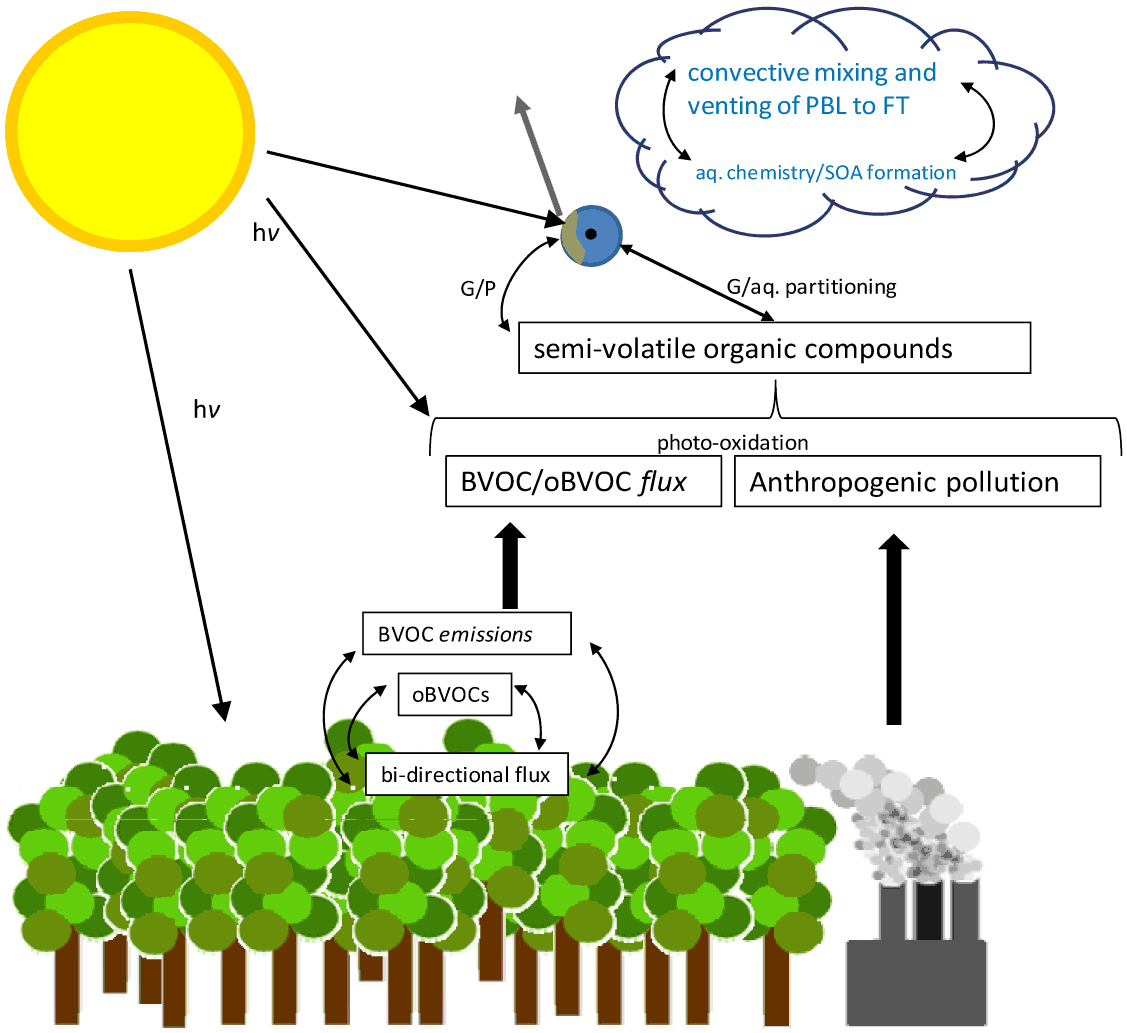
Modeling and Forecasting
R.W. Pinder (EPA)
soas-modeling@googlegroups.com

Tower
P. Wennberg (CalTech)
soas-ground@googlegroups.com

Data Management
K. Aiken (NOAA) (SOAS/SENEX)
G. Stossmeister (NCAR) field catalog
S. Williams (NCAR) archiving

Communications and Outreach
K. Nguyen (Rutgers)

Sampler Coordination
L. Yee (Berkeley), J. Surratt (UNC)
soas-samplers@googlegroups.com



Biogenic emissions and anthropogenic pollution interact and affect atmospheric photo- oxidation chemistry and subsequently air quality and climate.

http://tinyurl.com/SOAS-logistics

- EXTRA SLIDES

SOAS

1. What are the controlling processes for biosphere-atmosphere fluxes of oxidants and reactive carbon and nitrogen across spatial scales relevant to air quality and climate?
2. What are the processes that control BVOC oxidation? How do anthropogenic emissions alter distribution of BVOC oxidation products, and what are the implications for ozone, reactive nitrogen, and aerosol precursors?
3. To what extent do anthropogenic influences impact biogenic SOA formation?
4. How does aqueous chemistry and cloud processing of BVOCs and related aerosols influence atmospheric SOA?
5. What are the climate-relevant properties of biogenic aerosol (VOC of biogenic origin)?

SENEX

1. What are the emissions of aerosol, aerosol precursors and greenhouse gases in the SE U.S.?
2. What is the composition and distribution of aerosol in the SE U.S.?
3. What are the formation mechanisms of secondary species (ozone, sulfate and organics) in the SE U.S.?
4. Which deposition processes are critical for determining atmospheric concentrations of aerosol, ozone and NOy?
5. What are the climate-relevant properties of aerosol in the SE U.S.?

TROPosphersic **HONO**

1) establish HONO distribution and budget in various tropospheric air masses (continental, oceanic, and urban/industrial plumes)
2) collect bulk aerosol samples for laboratory photochemical experiments to measure photolysis rate constants of p-NO_3 leading to HONO and NO_x production
3) quantify p-NO_3 as a daytime HONO source and a re-NO_x-ification pathway in the troposphere
4) examine HONO production from photo-enhanced heterogeneous NO_x reactions in urban/industrial plumes
5) investigate HONO dark formation/nighttime accumulation and morning-hour photolytic decay in the PBL and in the FT.

North **A**merican **A**irborne **M**ercury **EX**periment (NAAMEX)

- **Constrain emissions of mercury from major source regions in the United States.** What is the spatial distribution of mercury in the boundary layer in the western US, Midwest, and Eastern USA? Are observations consistent with bottom-up emissions inventories? Can we separate US sources from global sources?
- **Quantify the distribution and chemical transformations of speciated mercury in the FT.** How does the speciation of mercury change with increasing height in the FT over the US? How is this speciation affected by atmospheric oxidation, precipitation, cloud-processing, and stratospheric intrusions? How does the partitioning of mercury evolve in the outflow of emission regions?

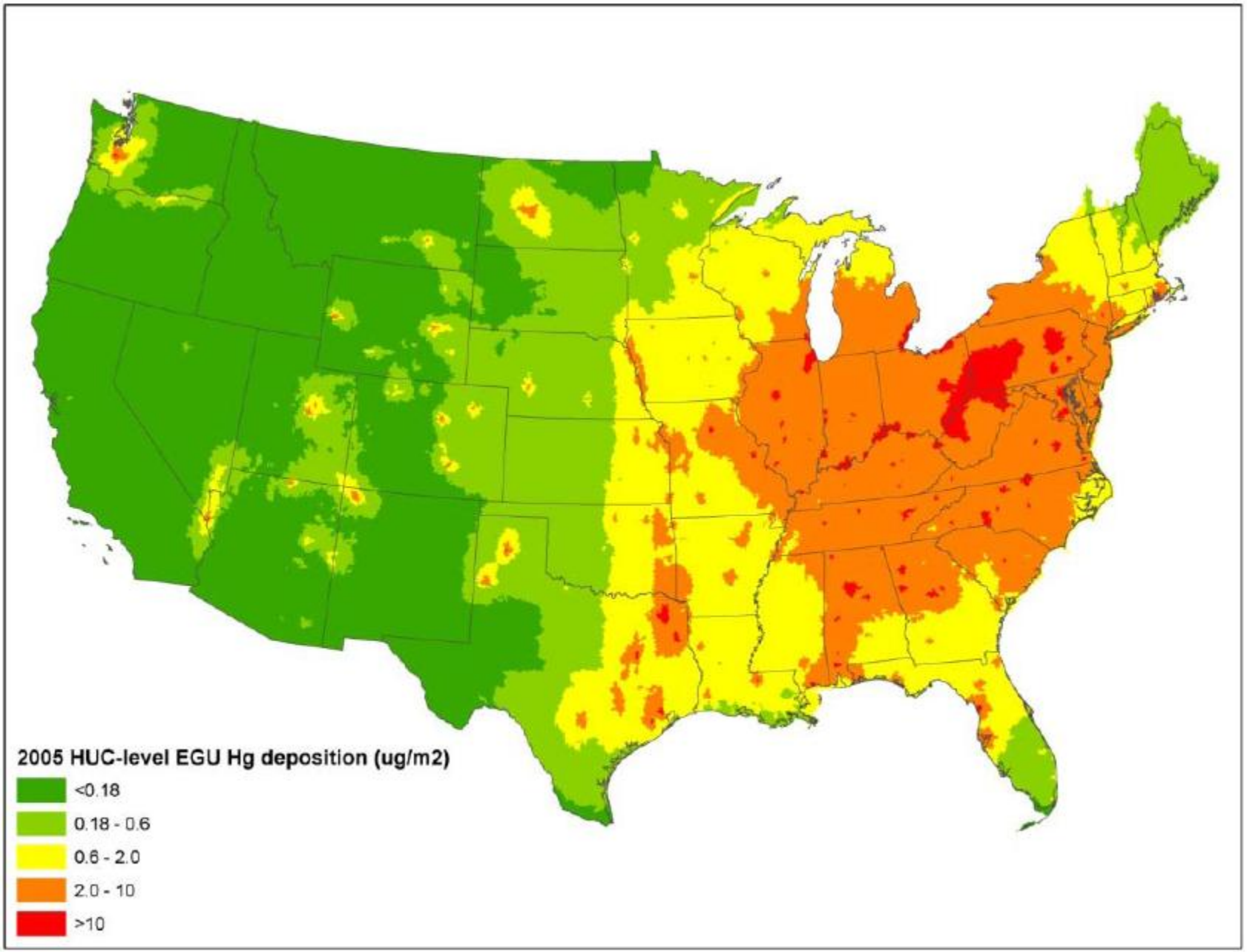


Figure 2-3 U.S EGU-Attributable Mercury Deposition by HUC ($\mu g/m^2$) for the 2005 Scenario

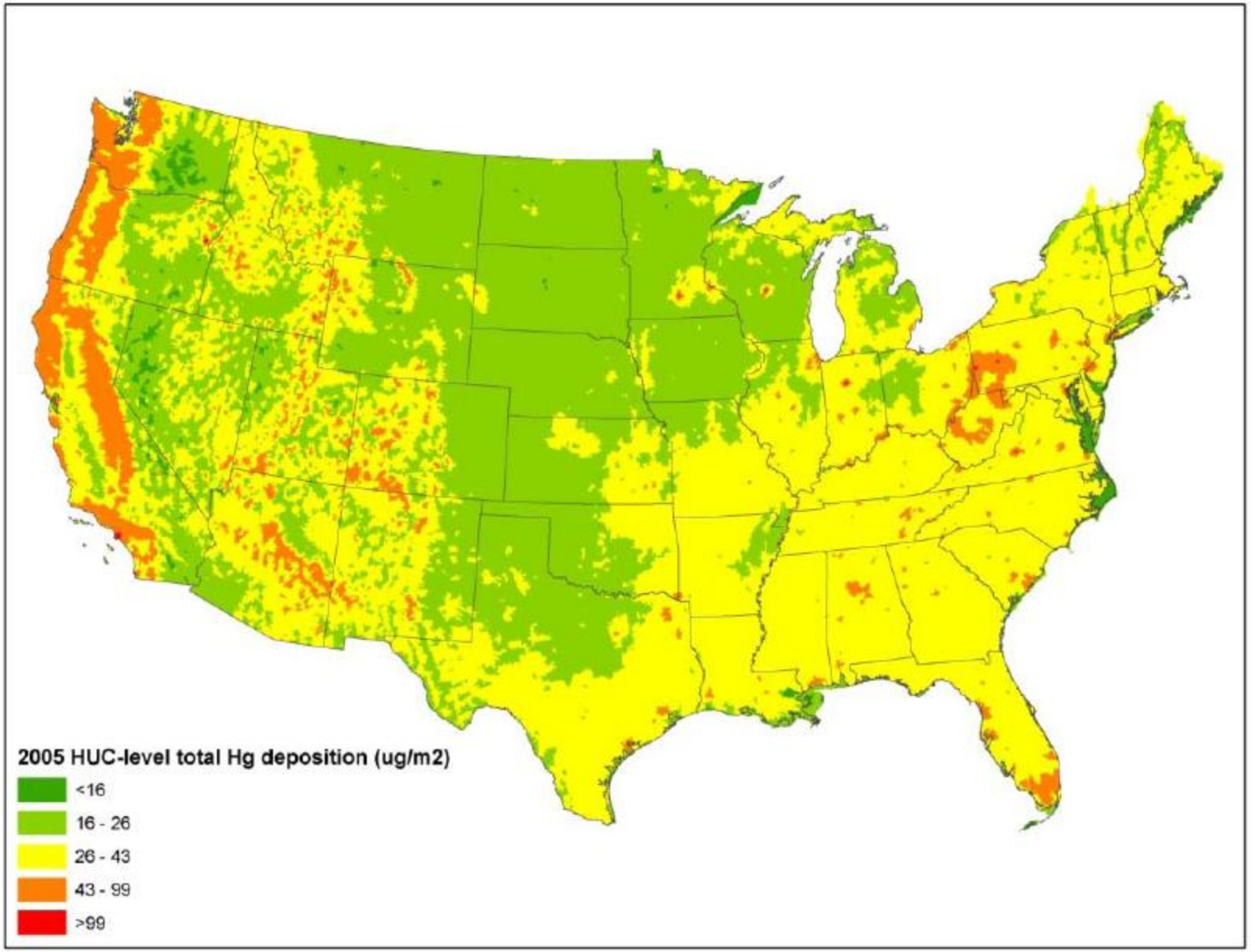
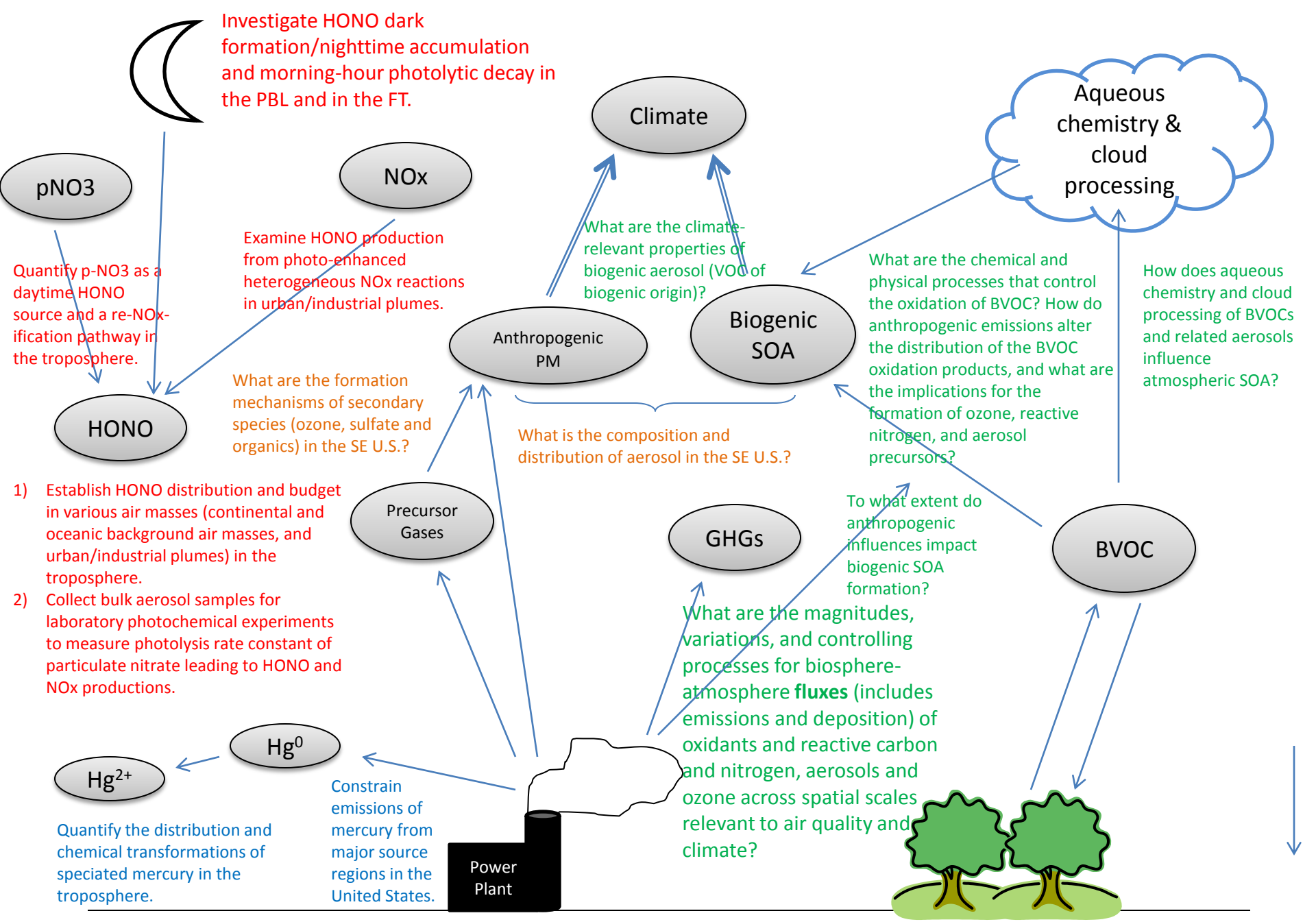


Figure 2-1 Total Mercury Deposition by HUC (µg/m^2) for the 2005 Scenario


Investigate HONO dark formation/nighttime accumulation and morning-hour photolytic decay in the PBL and in the FT.
Climate
Aqueous chemistry & cloud processing
pNO3
NOx
Examine HONO production from photo-enhanced heterogeneous NOx reactions in urban/industrial plumes.
What are the climate-relevant properties of biogenic aerosol (VOC of biogenic origin)?
What are the chemical and physical processes that control the oxidation of BVOC? How do anthropogenic emissions alter the distribution of the BVOC oxidation products, and what are the implications for the formation of ozone, reactive nitrogen, and aerosol precursors?
How does aqueous chemistry and cloud processing of BVOCs and related aerosols influence atmospheric SOA?
Quantify p-NO3 as a daytime HONO source and a re-NOx-ification pathway in the troposphere.
Anthropogenic PM
Biogenic SOA
What are the formation mechanisms of secondary species (ozone, sulfate and organics) in the SE U.S.?
What is the composition and distribution of aerosol in the SE U.S.?
HONO
1) Establish HONO distribution and budget in various air masses (continental and oceanic background air masses, and urban/industrial plumes) in the troposphere.
2) Collect bulk aerosol samples for laboratory photochemical experiments to measure photolysis rate constant of particulate nitrate leading to HONO and NOx productions.
Precursor Gases
GHGs
To what extent do anthropogenic influences impact biogenic SOA formation?
BVOC
What are the magnitudes, variations, and controlling processes for biosphere-atmosphere fluxes (includes emissions and deposition) of oxidants and reactive carbon and nitrogen, aerosols and ozone across spatial scales relevant to air quality and climate?
Hg0
Hg2+
Quantify the distribution and chemical transformations of speciated mercury in the troposphere.
Constrain emissions of mercury from major source regions in the United States.
Power Plant
NAAMEX
TROPHONO
SENEX
SOAS
Slide courtesy of K. Wagstrom

Confirmed Flux Tower Measurements

OH, HO_2+RO_2, H_2SO_4 – CIMS

OH reactivity – comparative reactivity method

NO_x – CRDS

Peroxides, o-acids –CIMS

OH, HO_2, RO_2 - GTHOS

OH reactivity – OHR

O_3, NO, NO_2 - Thermo

Confirmed Ground Measurements

ISFS and ISS

AVOC, BVOC, $RONO_2$ – 2DGC
PAN/MPAN, GC-ECD
RONO2 – CIMS
Hi-vol filter samples …. SOA tracers
14C TC, EC, OC
TD-GCxGC-VUV/EI-HTOFMS w/ and w/o derivitization
PM_1 and $PM_{2.5}$ – with offline chem. Analysis
NO_3-API-ToF-CIMS
EI-HR-MS for I/SVOCs
Mist chambers
PILS-AMS-CCN
HTDMA
Hourly speciation of org. aerosols and semi-volatiles by SVTAG
Hygroscopicity SMPS +OPS (similar to DAASS)
Inorganic ions + TC, Org.N, light absorption spectra of dissolved organics (SJAC-TC/ON)
Inorg. Ions in gas+ptcl. (URG)
Organic Aerosol Volatility and Polarity Separator (VAPS)
CAPS PMex SSA
GIT SCAPE trailer with PILS-BrnC-WSOC, OCEC, O_3, NO_x, NO_2, TEOM, 7λ aetholometer,
PILS-IC online metals

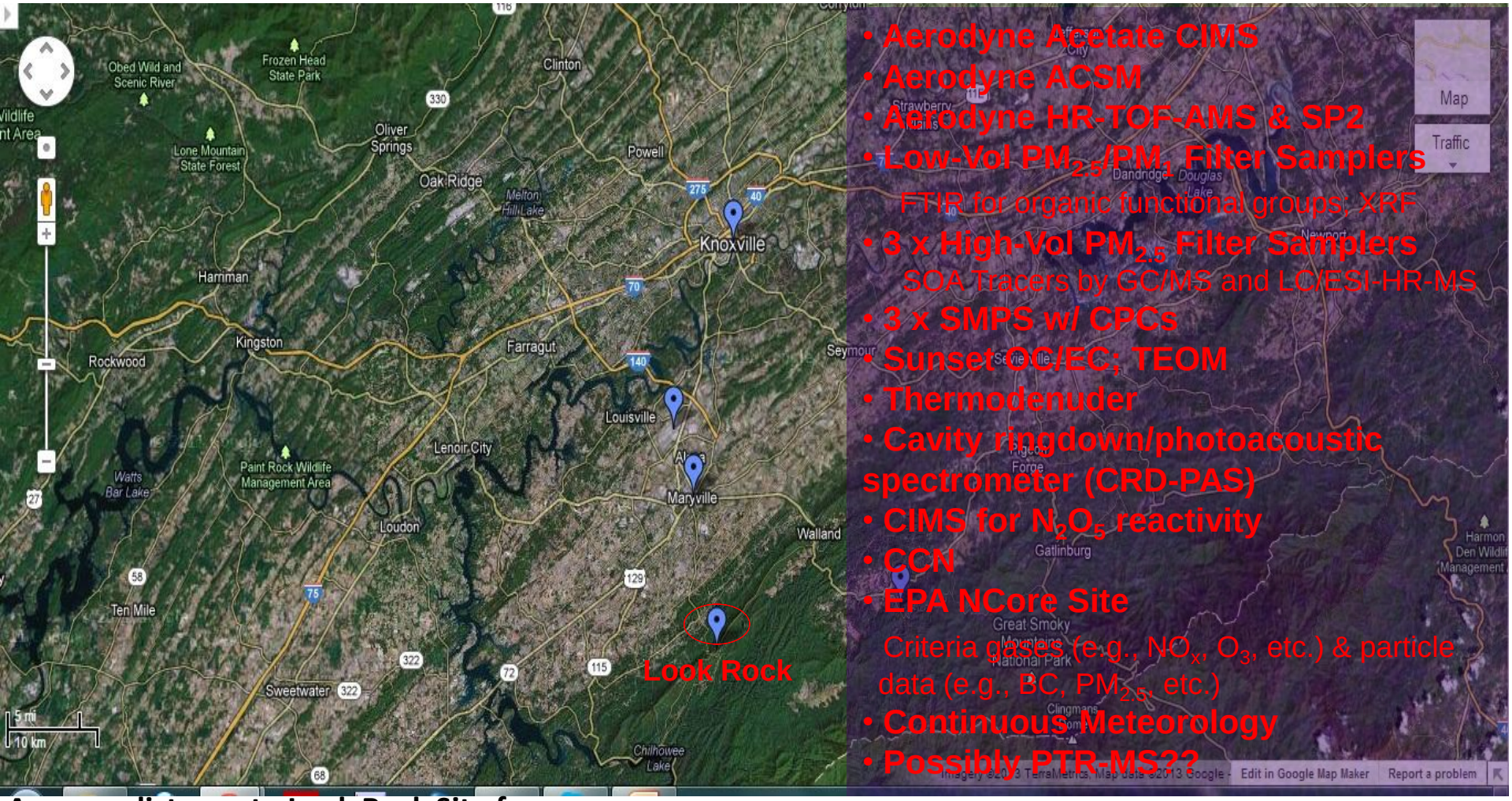
hygroscopicity SMPS + OPS + computer (similar to DAASS; Stanier et al., 2004)
Aerosol optical properties, absorption, single particle soot with temperature and RH conditioning (2 PAXs, SP2)
Aerosol extinction as a function of wavelength (360 - 420 nm) using cavity enhanced absorption spectroscopy
Aerosol volatility, Thermal Denuder and Condenser
Mist chambers for water soluble gas experiments
Aerosol Phase
SEMS particle size distribution
MARGA gas/aerosol ion chromatography
PSM
TSI CPC
CAGE chambers w/ HR-Tof-AMS, PILS-IC, SMPS, HTDMA, CCNc, APS
ROS-HiVol(1) and PCM (2) filters
f(RH) dry/ambient nephs

SOAS - Look Rock Site, TN

Dates: 01 June - 15 July 2013

SOAS Southern Oxidant & Aerosol Study

PIs: Surratt (UNC), Russell (UCSD), Bertram (UCSD), Cappa (UCD), & Ziemann (UCR)



Average distance to Look Rock Site from:

- **Maryville, TN = 12.3 mi**
- **Knoxville McGhee Tyson Airport = 17.4 mi**
- **Knoxville, TN = 30.9 mi**

Collaborators: TVA, EPRI & NPS

Slide courtesy of J. Surratt