HAQAST Year 2 Tiger Team Proposal
Supporting the use of satellite data in regional haze planning

Lead PI: Arlene Fiore (Columbia/LDEO)
Other HAQAST participants: Bryan Duncan (NASA GSFC), Daven Henze (University of Colorado-Boulder), Patrick Kinney (Boston University), Talat Odman and Ted Russell (Georgia Tech), Daniel Tong (GMU), Jason West (UNC), Mark Zondlo (Princeton)
Stakeholder partners: Barron Henderson and Brett Gantt (U.S. EPA OAQPS), Gail Tonnesen (U.S. EPA Region 8), Julie McDill (MARAMA), Paul Miller (NESCAUM), Stephanie Shirley (TCEQ), Tom Downs (ME DEP), Michael Geigert and Kate Knight (CT DEEP). If selected, other interested agencies are welcome to join.

Stakeholder Needs: Under the Regional Haze Rule, states are responsible for developing plans that will meet a national goal of natural visibility conditions by 2064 in 156 mandatory "Class I" areas (national parks and wilderness areas). Planning is done in 10-year periods, with the next set of State Implementation Plans (SIPs) due by July 31, 2021[1]. This process involves attributing natural and anthropogenic sources of visibility-impairing $PM_{2.5}$ observed at IMPROVE monitoring sites, based on analysis of chemical composition and models. Satellite data can provide additional evidence for haze transport from specific sources (e.g., dust, fires, international, agricultural) in a weight-of-evidence approach to demonstrate progress towards attainment of natural visibility conditions. Satellite products can also provide top-down constraints on emission changes in upwind countries, needed to underpin accurate assessments of temporal trends in international transport. Satellite ammonia products can support relative assessments of spatial and temporal variability in agricultural ammonia emission inventories, which are highly uncertain yet needed for haze planning where ammonium sulfate and ammonium nitrate are typically the dominant haze components[2].

Project Overview: We propose to work with stakeholders to address three applications of satellite data of direct relevance to regional haze SIPs. First, we will identify a few case studies of natural events (e.g., dust, wildfire) and transport events from upwind agricultural and/or international (e.g., anthropogenic, agricultural or wild fires) sources for analysis with satellite data. Second, we will select an upwind nation or two (e.g., Mexico, China) and estimate emissions trends, over at least the past decade, in trace gas precursors to haze: nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) from the OMI instrument aboard the Aura platform, and ammonia (NH_3) from the CrIS instrument aboard JPSS, and IASI instruments on MetOp/A/B. Trends in global NO_x and SO_2 emissions as determined via inverse methods in a multi-year GEOS-Chem simulation that incorporates satellite data are also available for this project. Third, we will examine NH_3 from agricultural sources in the eastern US, both their spatial (pigs in NC; poultry in eastern Chesapeake; dairy in SE PA) and temporal (seasonal) trends and associated top-down patterns from satellite with bottom-up inventories. We will develop technical guidance documents that describe our approaches to using satellite data for regional haze applications. We anticipate that the guidance developed under this project will also be relevant to health agencies seeking to assess health burdens due to natural events (e.g., dust, wildfires) associated with severe health effects[3,4].

Relevant HAQAST Experience: Duncan has experience providing visualizations and quantitative information on trends in OMI NO_2 products and oversees the NASA Air Quality from Space website[5], which features trends in NO_2 in cities around the world since 2005. Trends in SO_2 derived from satellite are also available[6]. Tong has developed a satellite-aided algorithm to pinpoint dust events from the IMPROVE network, and also developed the dust emission model used for NOAA $PM_{2.5}$ forecasting. Henze has experience developing constraints on emissions of trace gases and aerosols using remote sensing data and atmospheric modeling. Zondlo has experience examining spatial and temporal patterns of ammonia abundances through CrIS and IASI satellite measurements, particularly

at short/local scales for identifying episodic emissions. Odman and Russell have experience with regional haze assessments and wildland fire impact analyses, particularly in the Southeastern U.S.A. Fiore has experience developing technical guidance documents and facilitating regular communication with stakeholder partners, in addition to analysis of international transport and identifying sources contributing to pollution episodes. West has experience in modeling and data analyses useful for air quality management.

Deliverables and *Participants:*

- **Describe at least two case studies using satellite data to identify wildfire and/or international transport events** (international events may occur due to natural or anthropogenic emissions) **in technical guidance documents** that include detailed instructions for how to obtain and visualize the specific satellite products being showcased alongside the standard IMPROVE and/or model data used in regional haze planning (*Odman*, *Russell, Fiore*).
- **Quantify the contribution of windblown dust emission to local air quality and describe the approach** to using satellite, ground observations and CMAQ modeling (one new simulation with dust relative to an existing baseline simulation) in a technical guidance document (*Tong*).
- **Produce a summary report describing trends in international emissions** inferred from space for 1-2 upwind countries, with the methods described sufficiently for others to repeat the approach in future applications. Where possible, these top-down trends will be compared with trends in available emission inventories. (*Duncan, Henze, Zondlo, Fiore, West*).
- **Analyze temporal** (seasonal) **and spatial patterns** (e.g. by animal type) **of NH_3 over the eastern US region** and compare patterns in satellite products and existing inventories (*Zondlo*).
- **Address emerging questions (**when possible) about using satellite data that arise in our regular meetings with stakeholder partners (*entire team*).
- **Post all technical guidance documents on** NASA Air Quality from Space Website[5] (*Duncan*).

Communication Plan:

- **Initial Phone meetings** between all HAQAST participants and each stakeholder partner to clarify specific needs of each agency during summer 2018.
- **Monthly team-wide phone calls** to ensure efficient sharing of progress and to facilitate "cross-pollination" of approaches and applications. Meeting notes will be taken and shared via e-mail for editing, followed by posting on our public website (e.g.,[7])
- **Disseminate guidance documents and case studies** via HAQAST and the NASA air quality website[5] and in-person and teleconference meeting presentations (e.g., with a broader set of regional air quality and health stakeholder groups).

Expected outcomes:

- Aid air quality managers in the use of satellite data in the Regional Haze SIP process.
- Provide tangible examples, via technical guidance documents from each case study, of the value of satellite data for addressing air quality and related health applications, to aid stakeholders who wish to conduct their own analyses.
- Lower the barrier for new health and air quality stakeholder agencies to apply satellite data.

References: [1]Fed. Reg. Vol. 82, pp. 3078-3129 (Jan. 10, 2017); see also https://www.epa.gov/visibility/final-rulemaking-amendments-regulatory-requirements-state-regional-haze-plans;
[2]e.g., http://www.maine.gov/dep/ftp/MVTSC/RH_METRICS_TRENDS/MANE-VU 2000-16 RHII & III Speciation plots 1-20-2018.xlsx compiled by Maine DEP; [3]Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT: Critical Review of Health Impacts of Wildfire Smoke Exposure. *Environmental Health Perspectives* 2016, **124**(9):1334-1343;
[4]Crooks JL, Cascio WE, Percy MS, Reyes J, Neas LM, Hilborn ED: The Association between Dust Storms and Daily Non-Accidental Mortality in the United States, 1993-2005. *Environmental Health Perspectives* 2016, **124**(11):1735-1743;
[5]https://airquality.gsfc.nasa.gov/; [6]https://airquality.gsfc.nasa.gov/news; [7]http://blog.ldeo.columbia.edu/atmoschem/haqast-tt-satellite-sips/