



Greenhouse gas And Air Pollutants Emissions System (GRA²PES)

Objective

Developing a joint activity between [NOAA Chemical Science Laboratory \(NOAA CSL\)](#) and [NIST's Greenhouse Gas \(GHG\) Measurement Program](#) is consistent with the missions of both NOAA and NIST. This activity will enhance the Department of Commerce's capability to model and map greenhouse gas and air pollutant emissions and their associated uncertainties. These approaches use, for example, activity-based data, socio-economic data, and energy statistics along with emission factors – commonly referred to as "bottom-up" GHG emission estimation. At present, the estimation of GHG emissions and air pollutants are largely independent exercises but their inter-dependence, especially at urban scales, are increasingly gaining attention. For example, there are potential co-benefits from reducing GHGs that improve air quality while mitigating climate impacts.

The joint activity will enhance the development of authoritative referenced "bottom-up" emission data and uncertainty evaluation at spatial and temporal resolutions relevant to both improving air quality (AQ) and mitigating greenhouse gas (GHG) emissions including city, State, and regional scales. Such spatial and temporal mapping enables data assimilation systems or "top-down" methods, such as those that combine atmospheric observations (e.g., surface, aircraft, satellite) and meteorological models, to better constrain emission estimates. This information will have low latency and be publicly available at disaggregate spatial and temporal resolutions. Systems can be developed for nowcasting, forecasting, or hindcasting. Uncertainty methodologies will be developed giving capabilities to map regions where improvements to data and models will be most beneficial and include estimation and novel combinations of different emission information. It is anticipated that statistical analysis methods developed for pollutant emissions will transfer, to a large degree, to GHG emissions.

Future work will include data assimilation of observations from multiple platforms and various species to estimate emissions. This may include ground based in-situ measurement, remote sensing, etc. Such a system will be able to ingest multi-species data from satellite constellations

like NOAA's [Geostationary Extended Observations \(GeoXO\)](#) in the future, and potentially GHGs if they are included within the mission. Assimilation of multiple data will help evaluate satellite retrievals while improving the quantification of flux estimates.

Organizational Structure

The Greenhouse gas And Air Pollutants Emissions System (GRA²PES) initiative is a joint activity managed by both NIST's Greenhouse Gas (GHG) Measurement Program and NOAA Chemical Science Laboratory (CSL). A core group of scientists and practitioners from each organization will discuss objectives, challenges, preliminary work on a regular basis (e.g., quarterly), culminating in a yearly activity review involving Directors from both programs and other interested parties from government, academia, and the private sector. Annual meetings will also incorporate a planning component to better shape future directions and promote engagement with the stakeholder community. The core group of scientists will produce and revise yearly goals and future objectives within a planning documentation.

Current Capabilities

NOAA Chemical Science Laboratory (CSL)

At present, NOAA CSL performs emissions and chemical transport modeling to support development of NOAA's weather-chemistry models, and provide timely emissions information to stakeholder groups (e.g., State and local air quality agencies, U.S. EPA, and industry). This research is largely performed in-house by NOAA CSL scientists and affiliates for the Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado Boulder. At present, NOAA CSL does not perform extensive GHG modeling and seeks to partner with the NIST GHG Measurement Program to create an emission modeling system that fully integrates greenhouse gas and air quality species.

NOAA modeling personnel include:

- [Brian McDonald](#), NOAA emissions and air quality modeling lead – will provide guidance
- Meng Li, NOAA affiliate – will provide guidance on merging air quality and GHG bottom-up emission inventories
- Colin Harkins, NOAA affiliate – primary person responsible for software development of emissions modeling at NOAA
- Congmeng (Trammell) Lyu, NOAA affiliate – primary person responsible for evaluating emissions modeling at NOAA with atmospheric observations

NIST Greenhouse Gas (GHG) Measurement Program

To date, NIST funds academic research on modeling of GHG emissions and has an active atmospheric observation and modeling research program. Several peer-reviewed articles have demonstrated that NIST-funded research has created the base knowledge for modeling GHG

emissions that can be used/evaluated with atmospheric observations. The NIST GHG Measurement Program intends to expand aspects of the academically funded research into the NIST Program with an emphasis on development of uncertainty analyses of these relatively complex models. At present, the NIST Program does not have emission modeling expertise, but its Statistical Engineering Division has extensive knowledge and expertise in analyzing measurement systems to develop methodologies for estimating their uncertainties.

NIST statistical personnel include:

- [Antonio Possolo](#), NIST Chief Statistician and expert in uncertainty methods – will provide guidance
- Jack Prothero, NIST statistician – primary person responsible for emission modeling at NIST
- Mikela Waldman, NIST associate – engaged in emission modelling at NIST

Tangential Work

At present, NOAA Air Resources Laboratory (ARL) is developing a near real-time (NRT) data assimilation system using NIST / NOAA Global Monitoring Laboratory (GML) in-situ observations and resources developed in NOAA GML and NOAA ARL. The inventory developed as part of the GRA²PES initiative will be used within this system. It is assumed that both GRA²PES and the NRT data assimilation system will converge within 5 to 10 years once both projects reach more maturity.

In the meantime, NOAA CSL continues to use satellite data and aircraft measurements to estimate fluxes for the purposes of evaluating inventories including criteria pollutants and methane. This includes data from recent and future flight campaigns as well current and upcoming satellite missions.

Workflow

Year 1 - Migrate/transfer emission modeling capabilities in consultation with academic researchers to establish a NIST program and coordinate it between NIST and NOAA CSL to include liaison with academic researchers in the field where appropriate. Specific tasks may include:

- Porting of some academic methods (e.g., Vulcan/Hestia methods, data sources, and perhaps code) for NIST usage. Code developed by NIST and NOAA CSL in this research effort will eventually be placed in the public domain.
- NIST personnel will learn and use NOAA CSL emissions modeling framework for pollutants and develop additional capability migrated from academic (or any other GHG method) sources.
- NOAA CSL emission modelers will work with NIST staff to develop/adapt uncertainty approaches that can be applied to non-GHG emission estimates.

- Identify a specific sector/problem to begin as a test-case relevant to both NOAA CSL and NIST.
- Compile and review literature.
- Identifying and collate key datasets.
- Given the significant rise in interest in these methods by non-governmental interests and in consultation with CSL, NIST will utilize its private sector relationships to work toward improving understanding of the boundary between governmental and non-governmental activities for this activity.

To accomplish task and overall objectives, NIST personnel will travel to NOAA CSL (Boulder) to work with CSL emission modelers. In addition, NIST personnel will work with Northern Arizona University (NAU) academic researchers, and others as the opportunity arises, to learn and transition elements to GRA²PES codebase with the purpose of generating a fully integrated GHG and AQ emissions modeling system. The code base will be made transparent, publicly available, and held in a repository (e.g., GitHub) allowing for version control. This will likely happen in Year 2 or 3.

After Year 1, the joint activity will be assessed by both NIST and NOAA CSL to determine future activities, etc. Such future activities could include evaluating the jointly developed emissions modeling system with atmospheric observations from the [NIST Urban Test Bed](#) program, NOAA CSL field campaigns (e.g., [AEROMMA](#), [SUNVEx](#), [LISTOS](#)), and satellite data, as well as data assimilation of atmospheric observations for improving emission inventories.

Given that GRA²PES is at a nascent stage, NIST and NOAA CSL plan on convening a workgroup in early 2023 to entrain other agencies (e.g., NASA, EPA, DOE) into the program to help shape its future and scope.