CSL RESEARCH STRATEGIES OVERVIEW

Theme Lead: Dr. Patrick Veres

StoryMaps under this theme

- → *4.1 Innovative Instrumentation*
- → *4.2 Laboratory Studies*
- → *4.3 Field Campaigns*
- → *4.4 Model Development and Applications*

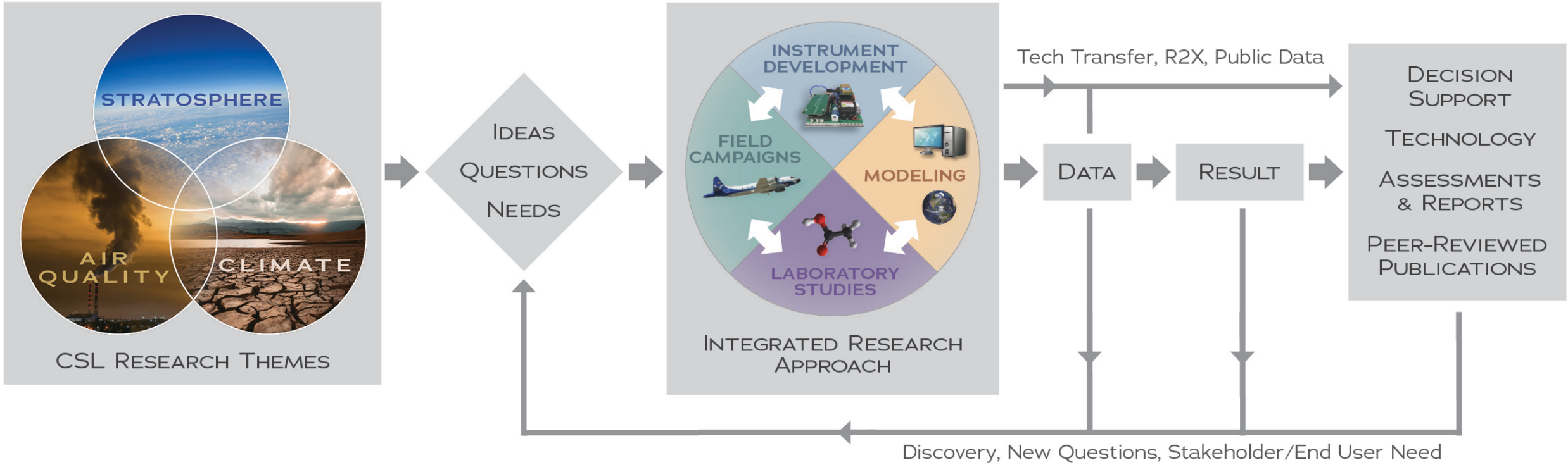
NOAA CHEMICAL SCIENCES LABORATORY

CIRES

RESEARCH

CSL uses a holistic approach to understanding the Earth System

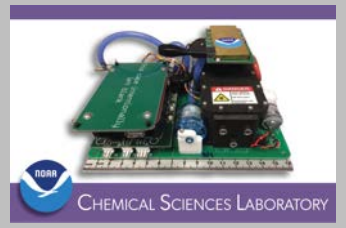
CSL's process is designed to address core scientific goals and capitalize on the unanticipated discoveries and deliver results.



CSL's strategy is designed to meet NOAA OAR goals to detect changes in the atmosphere, make better forecasts and drive innovative science.

CSL's diversity in research strategies is the key to its success

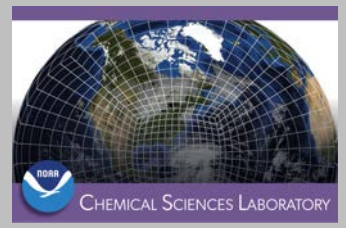
CSL leverages its state of the art instrumentation and modelling frameworks to conduct laboratory and field investigations that improve our understanding of an increasingly complex Earth–atmosphere system



Innovative Instrumentation
StoryMap 4.1

Laboratory Studies
StoryMap 4.2

Field Campaigns
StoryMap 4.3



Model Development & Application
StoryMap 4.4

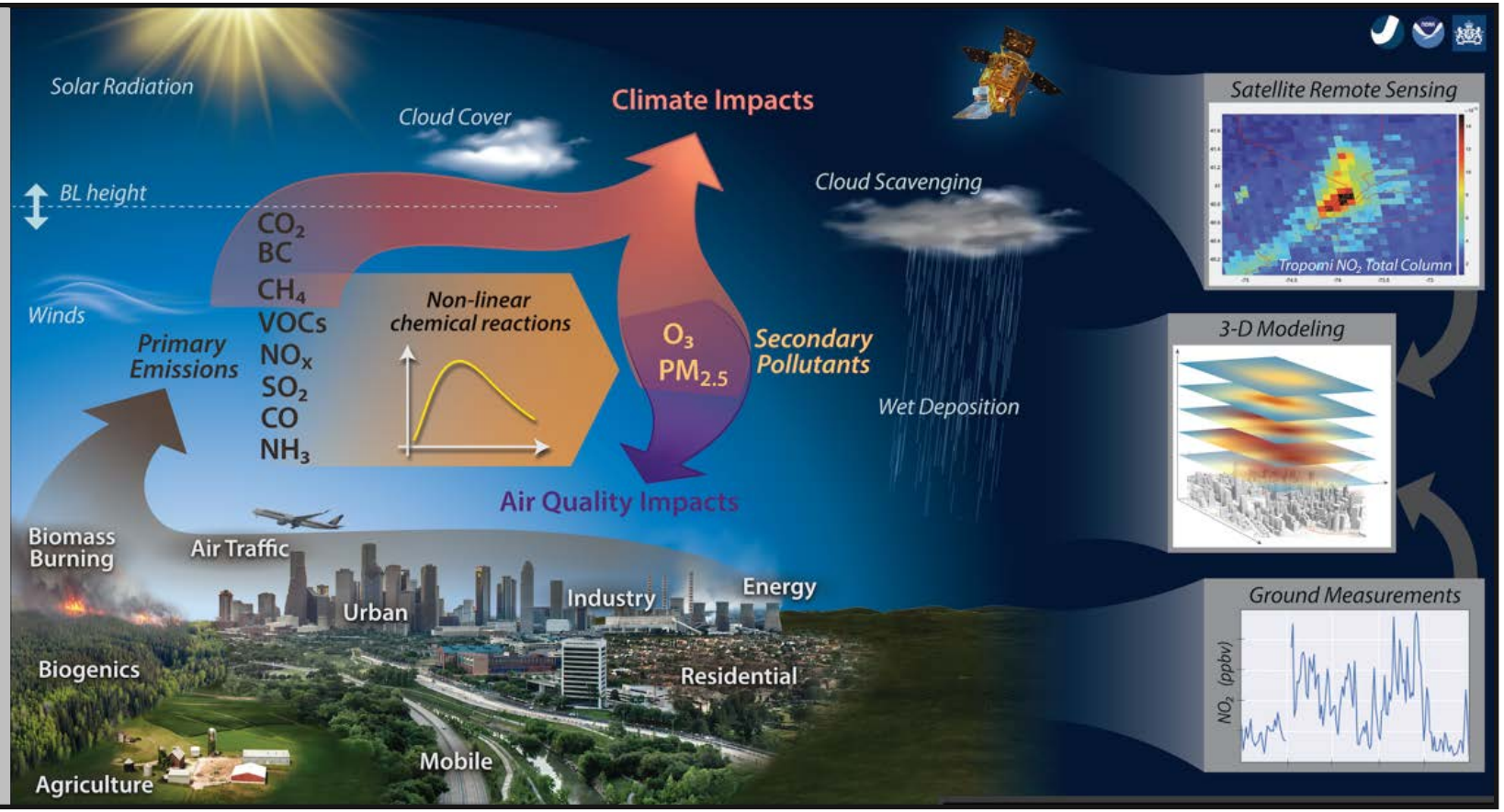


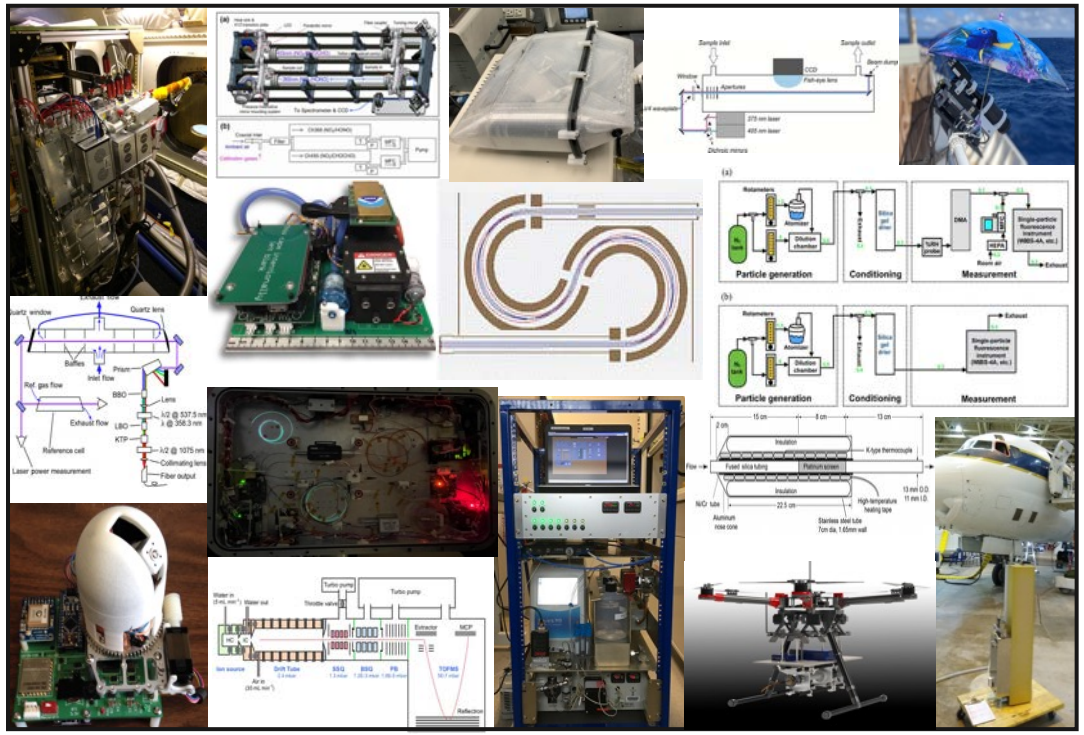
Figure by C. Thompson from Gkatzelis et al., 2021

Instrument Development - Innovation, Evolution, and Adaptation

StoryMap 4.1

CSL prioritizes sustained investment in R&D to drive innovative research to develop new tools relevant to societal needs and provide information when and where it is needed.

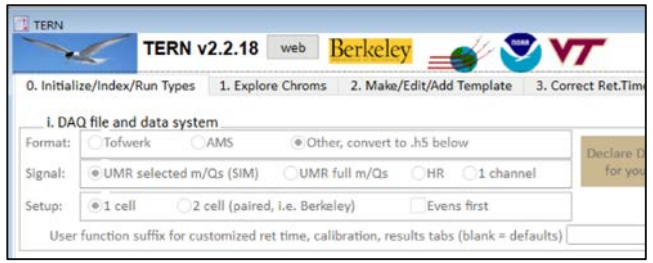
CSL has produced 21 new/custom instruments since 2015



e.g. PALMS sTOF, Nitric Oxide Laser Induced Fluorescence (NO-LIF), Micro Doppler Lidar (MICRO DOP), Miniature Sun Photometer

Partnerships help direct development efforts

TERN is an open-source non-proprietary, highly adaptable data analysis tool developed in CSL and available to the community at no cost.



StoryMap 4.1.4

Developed by CSL in collaboration with Aerodyne Research Inc, Virginia Tech University, and UC Berkeley funded in part by a NOAA Small Business Innovative Research Grant (2017-2021).

The development of technology to measure and model atmospheric properties is necessary to address the Nation's need to understand air quality, climate, and the stratosphere

Portable Optical Particle Spectrometer (POPS) Case Study

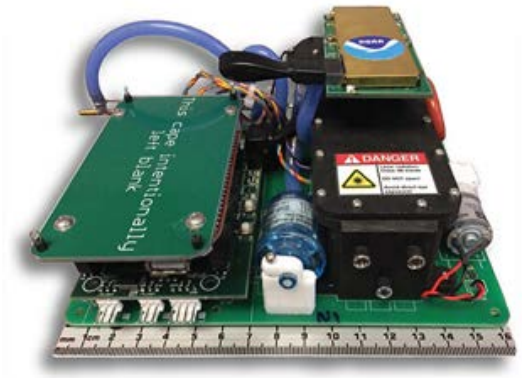
StoryMap 4.1.2

POPS prototype

Gao et al., 2016

CSL scientists recognize a need for small, light weight, and relatively inexpensive instruments while maintaining the precision and accuracy needed for science.

CSL POPS Instrument



2020 NOAA Technology Transfer Award

Handix POPS #100

Transferred to Handix Scientific and successfully commercialized.

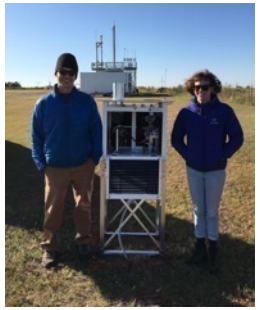
This transfer catalyzed > $1M in sales

Launch to ISS, Oct. 2020

POPSnet – Aerosol Microphysics Network

13-sites across the U.S. Department of Energy ARM, Southern Great Plains (SGP) domain

NOAA CSL, CIRES, University of Leeds, Yale University, and Brookhaven National Laboratory.



CSL scientists Franz Erdesz (left) and Lizzy Asher (right)

CSL provides an environment that promotes innovation and long-term development maximizing high payoff projects.

Laboratory Studies – Providing insight into atmospheric processes

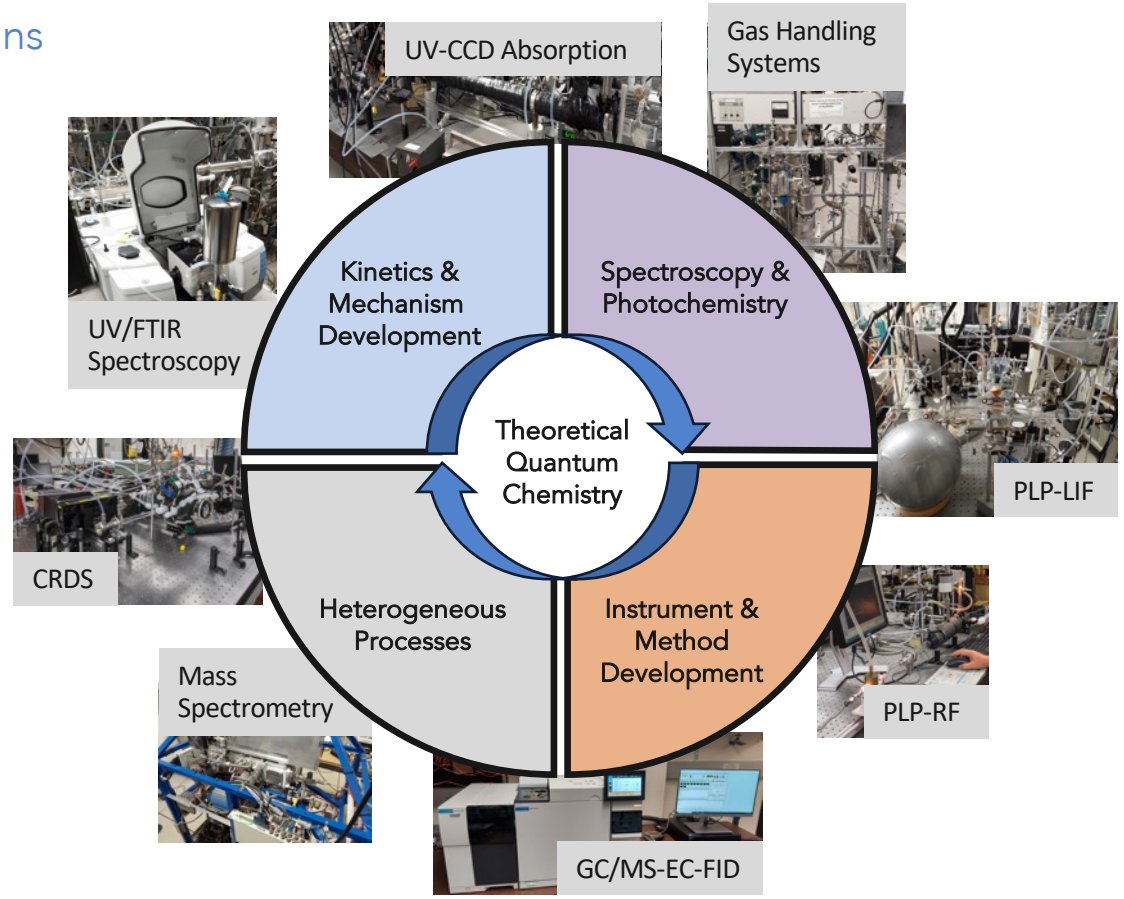
StoryMap 4.2

CSL laboratories provide the foundation for the investigation of atmospheric processes, the basis for the interpretation of observations and forecast models, and science to inform policy decisions.

CSL laboratory research stakeholders:

- Climate/Chemistry Assessments (IPCC and WMO)
- Policy Makers (e.g. Montreal Protocol)
- Chemical Data Evaluations (NASA/JPL Data Evaluation)
- Government Agencies (e.g. EPA)
- Industry (e.g. Chemours, Honeywell, Zeon)

CSL laboratories are equipped with state-of-the-art instrumentation, expertise, and flexibility to address emerging research questions.

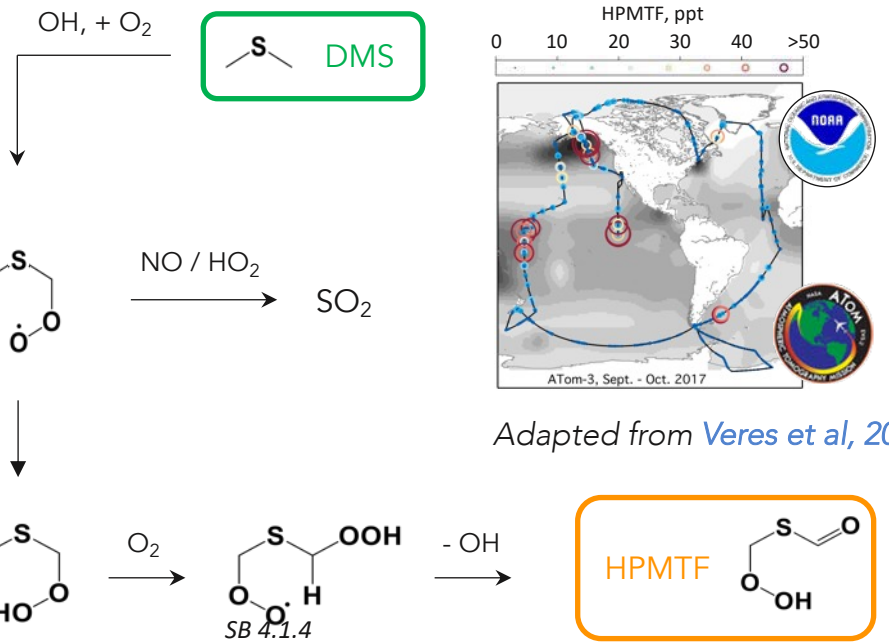


CSL laboratories provide context to discovery

StoryMap 4.2.5

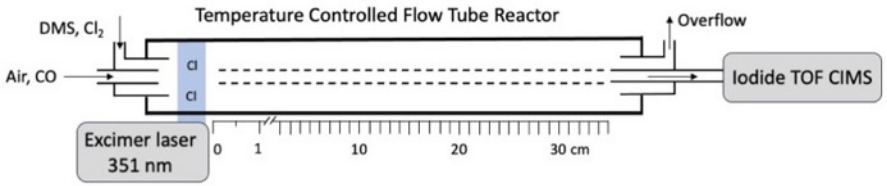
CSL scientists rapidly responded to the unexpected discovery of a new dimethyl sulfide (DMS) oxidation product, hydroperoxymethyl thioformate (HPMTF, Veres et al., 2020) to provide:

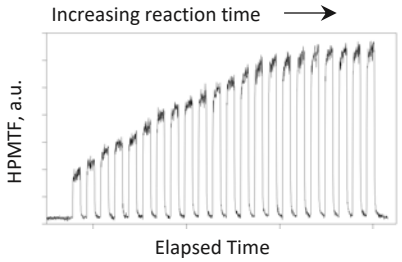
- Laboratory methods for identity verification
- Robust calibration technique
- Direct, quantitative measurement rates and yields



Adapted from Veres et al, 2020

Direct measurement of the HPMTF formation rate





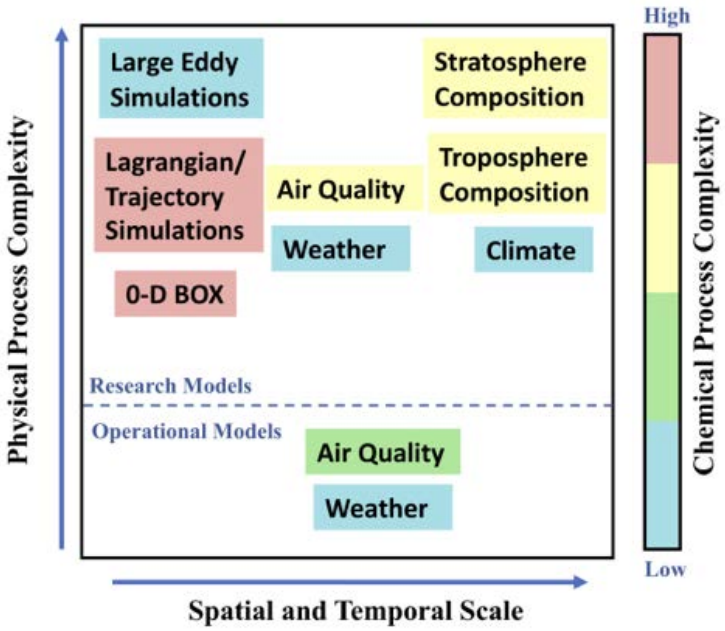
HPMTF and its role in marine sulfur oxidation would remain uncertain in the absence of novel laboratory studies. *Assaf et al., 2021 (in prep.)*

CSL's laboratory studies are necessary to improve model accuracy and interpret new observations.

Model Development & Application - Improving forecasting of Earth's Atmosphere

StoryMap 4.4

CSL aims to advance scientific understanding and improve weather, air quality, and climate projections and forecasts through model development.



Collaborations play a prominent role in the development of air quality research models to improve NOAA operational air quality forecast models

- NOAA Global Systems Laboratory (GSL)
- NOAA Air Resources Laboratory (ARL)
- NOAA National Environmental Satellite, Data, and Information Service (NESDIS)
- NOAA National Weather Service (NWS)
- Department of Energy (DOE)
- National Center for Atmospheric Research (NCAR)

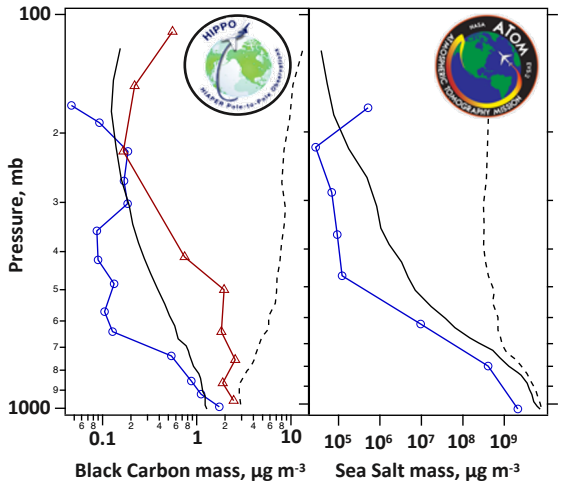
CSL generates process- and system-level understanding of Earth's atmosphere by developing and applying models at fine, regional, and global scales.

Model developments advance understanding and predictive capability

StoryMap 4.4.3

CSL evaluates simulations against observations, to generate understanding, approaches and solutions required to improve global and climate models.

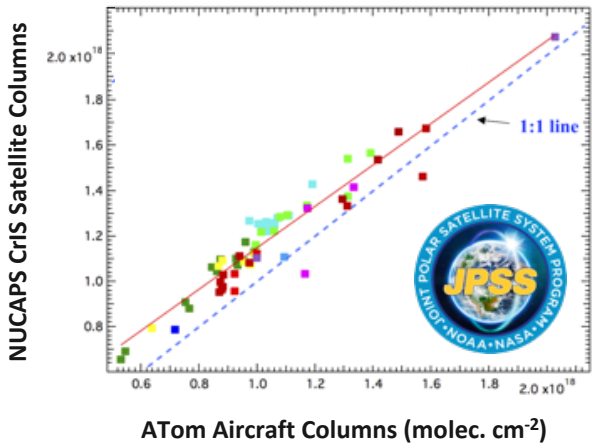
CESM/CARMA Improvements from revised aerosol scavenging



ATom 1 Pacific
HIPPO 20S – 20N
CARMA old convection
CARMA new convection

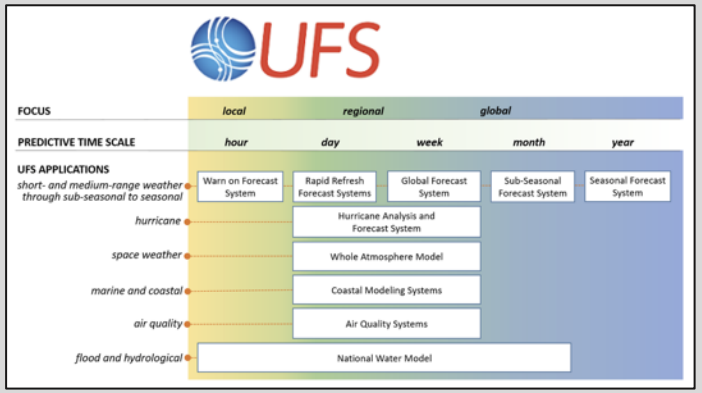
Adapted from Yu et al., 2019

CO Tropospheric Columns



Model improvements, correcting for overestimations of aerosols by climate models (left) and improvements to satellite retrievals (right), were informed by ATom global observations.

Unified Forecasting System (UFS)



UFS is a community-based Earth modeling system that provides a framework to efficiently incorporate research advances into NOAA's state-of-the-art operational forecasts.

CSL incorporates research level advances into NOAA's operational forecasts.

Atmospheric Field Campaigns – An essential part of CSL's science portfolio

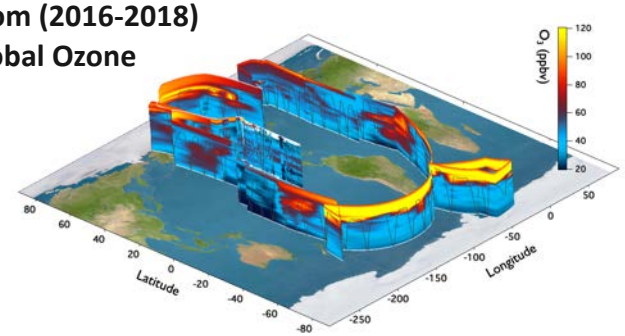
StoryMap 4.3

CSL engages in field observations all over the globe, providing essential data that drives model development, promotes scientific understanding, and emerging air quality concerns.

CSL's field campaigns are driven by:

- CSL core science objectives (Air Quality, Climate, Stratosphere)
- Stakeholders needs (policy makers, industry, data evaluation)
- Timely issues, current events (e.g. COVID-19, Aliso canyon)

ATom (2016-2018)
Global Ozone



Thompson et al., 2021 (in prep.), StoryMap 4.3.2

CSL adapts and responds quickly to provide the science stakeholders and partner agencies need.

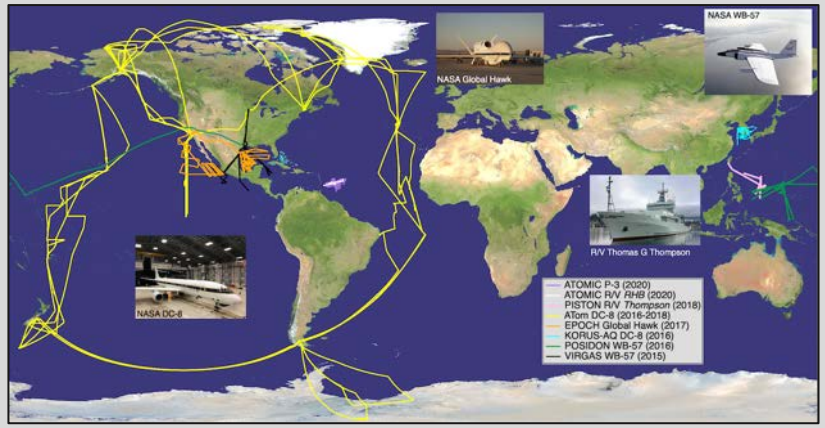
CSL Field Campaigns
(2015 – 2020)

7 aircraft missions
(261,182 km!)

3 mobile studies

2 research vessel cruises

15 ground-based campaigns



Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ)

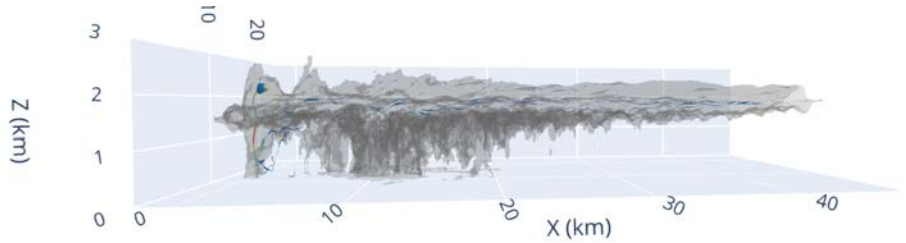
StoryMap 4.3.2

CSL initiated multi-year, multi-agency mission that produced the most comprehensive data set on wildfires and agricultural fires to date

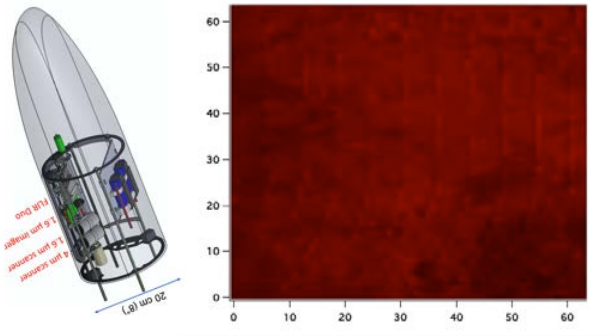
- Emissions
- Chemical Processes
- Air Quality and Climate Modeling
- Improvements for Operational Forecasting

WRF-LES model, chemical evolution in fire plumes

Siyuan Wang, StoryMap 4.4.1



NightFOX - Fire Radiative Power



Gao et al, 2018, StoryMap 4.4.1

CSL excels at designing field campaigns to address research themes, respond to stakeholder requests, and react to current events.

FIREX-AQ 2019 platforms

- NASA DC-8
- NASA ER-2
- Satellite support
- NOAA Met Twin Otter
- Mobile AERONET sites
- NOAA Chem Twin Otter
- Smoke forecast models
- Regional to global models
- Aerodyne mobile laboratory
- NASA LARGE mobile laboratory
- Boise, Missoula, McCall ground sites
- Ground fuel consumption, carbon emission

CSL evaluation of CMAQ, RRFS-CMAQ, and CSL research models (HRRR-Smoke and WRF-Chem)

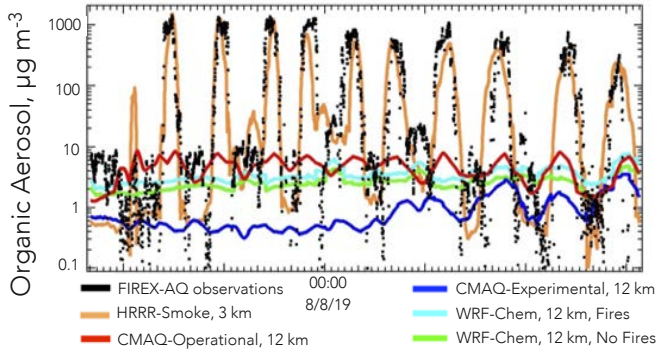
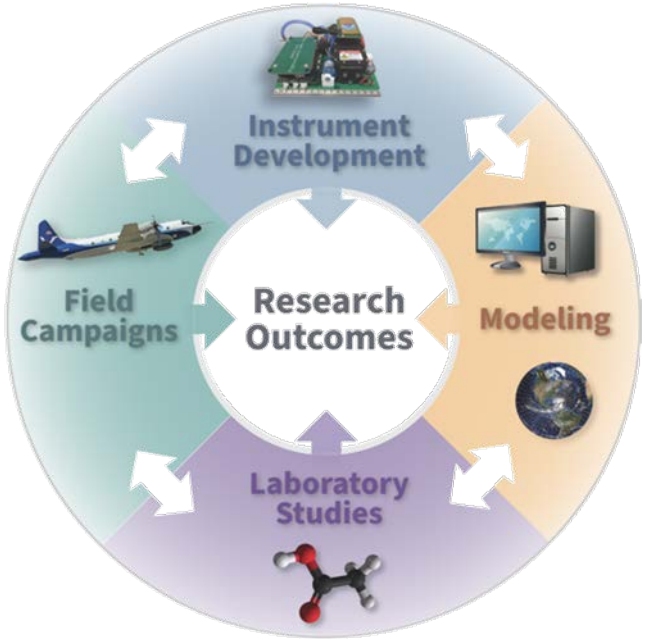


Figure by Stuart Mckeen, StoryMap 4.4.3

CSL's balance is designed to meet immediate & emerging needs

CSL meets the Nation's need to address issues related to air quality, climate, and the stratosphere by leveraging our strategic research plan.



Perpetual Development & Innovation

Institutional Knowledge

Robust Collaborations

Responsiveness & Adaptability

Integrity & Reliability

CSL's strategic research plan produces results that exceed OAR standards of quality, performance and relevance