Future Use of NASA Airborne Platforms to Advance Atmospheric Composition Priorities

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Glenn Wolfe, Rebecca Hornbrook, Lu Hu, Frank Flocke, Colette Heald,
Dylan Millet, Shane Murphy, and Jeffrey Pierce

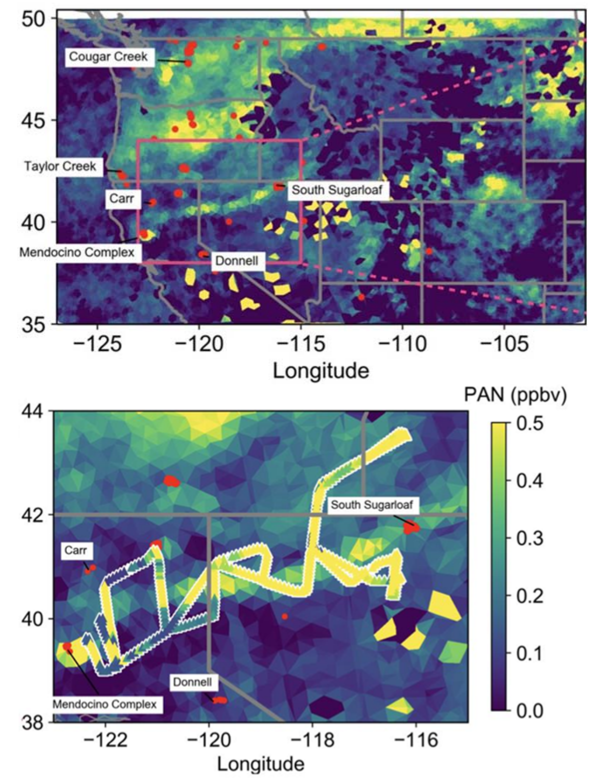
1) Aircraft observations will be essential to an overall composition measurement strategy, even with next-generation satellites/retrievals.

Development of usable next-gen satellite products requires gold-standard validation.

Clouds impact trace gas and aerosol retrievals.

Key species are either not measured by satellite or measured with *essentially no* vertical resolution.

Aircraft fill satellite observational gaps.



CrIS PAN / WE-CAN example courtesy of:
Julieta Juncosa Callahorano, Vivienne Payne, Susan Kulawick

2) To move atmospheric chemistry forward, future missions will require large complex payloads. We need to observe the system.

Instruments that reliably measure “targeted observables” in all environments <u>are large</u>.

New instruments should be paired with older technology to ensure continuous records.

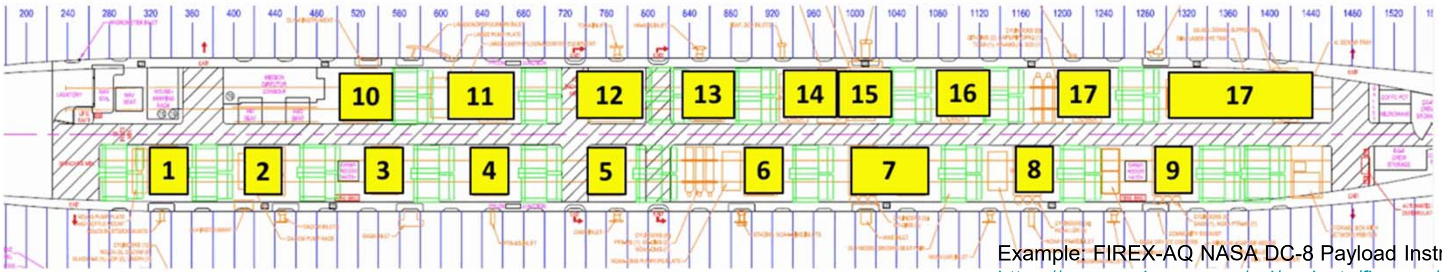
Redundancy is good. Mission-critical measurements should be duplicated.

Instrument-specific inlets/ports/modifications are often required.

New instruments provide insights into previously unmeasured species.

Other aircraft (e.g. C-130, GV, P3) lack altitude, payload or endurance capacity.

Recent missions have filled the DC8.



Example: FIREX-AQ NASA DC-8 Payload Instrument Layout
https://www.esrl.noaa.gov/csl/projects/firex-aq/dc8/payload.html

3a) ATom combined “tomography style” sampling and a comprehensive payload to produce important unplanned findings.

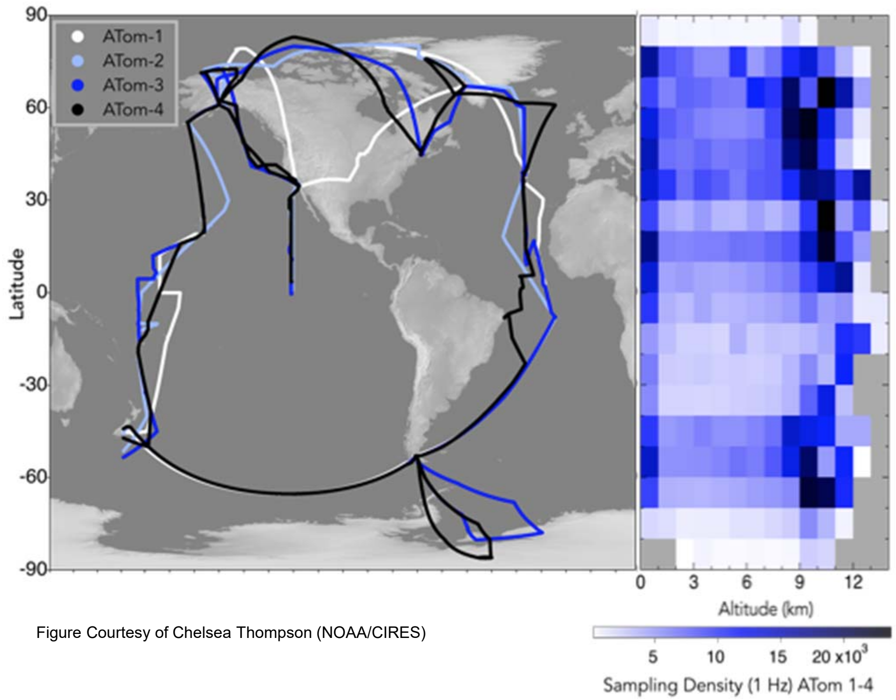


Figure Courtesy of Chelsea Thompson (NOAA/CIRES)

New sulfur oxidation mechanisms.
(e.g., *Veres et al.*, 2020)

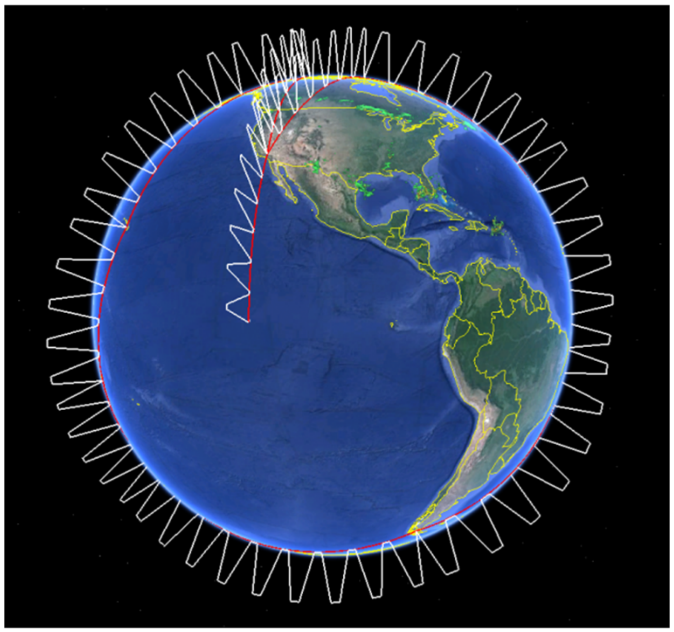
Constraints on OH abundances.
(e.g., *Wolfe et al.*, 2019)

New oceanic OVOC emissions.
(e.g., *Brewer et al.*, 2020)

….there are many more!
https://esdpubs.nasa.gov/pubs_by_mission/ATom?page=1

The DC8 capabilities were critical to this successful approach.

3b) ATom was a dream mission for satellite validation and for modelers.



https://espo.nasa.gov/atom/content/ATom_Science_Overview

An unbiased sampling approach is valuable.
Plume sampling is great for untangling processes, but terrible for model exploration/ evaluation.

Repeated profiles of the troposphere.
Essential for satellite validation.
Provides a mix of polluted versus remote conditions.

ATom should be repeated, perhaps over smaller target regions as well.

4) A large airborne platform that can access the remote atmosphere is essential for many research priorities including:

- Top-down constraints on emissions.
  - Including understudied sources (e.g. agriculture)
- Narrowing major gaps in the global oxidant budget
  - O_3 deposition flux and precursor measurements needed.
  - Precursors are dynamic in remote & polluted environments.
- Satellite and model validation will continue to be required.
  - Essential for new geostationary missions
  - Vertical profiles across different environments
- Satellites remain inadequate for critical health and climate parameters.
  - Aerosol size distribution and composition are poorly observed.
- Fast track deployment mechanisms could enable rapid health-centric deployments
  - In response to natural disasters, accidents, etc.

5) Human capital is as important as airborne platforms. Deploy intentional inclusive mentoring / onboarding efforts with new infrastructure.

Invest in logistical/engineering support and take risks on new PIs/teams.

Smaller missions may increase use of fleet, and “branch out” the research suite.

Expand training opportunities mentor early career researchers in mission scientist responsibilities, payload design, etc.

Science teams do not mirror the U.S. population. *Find and fix the bottleneck.*
- They will miss key societal applications.
- This also severely compromises creativity and problem solving.

Better data-sharing infrastructure will increase the data use.
- We still need **consistent labeling, metadata, and clear uncertainties.**