



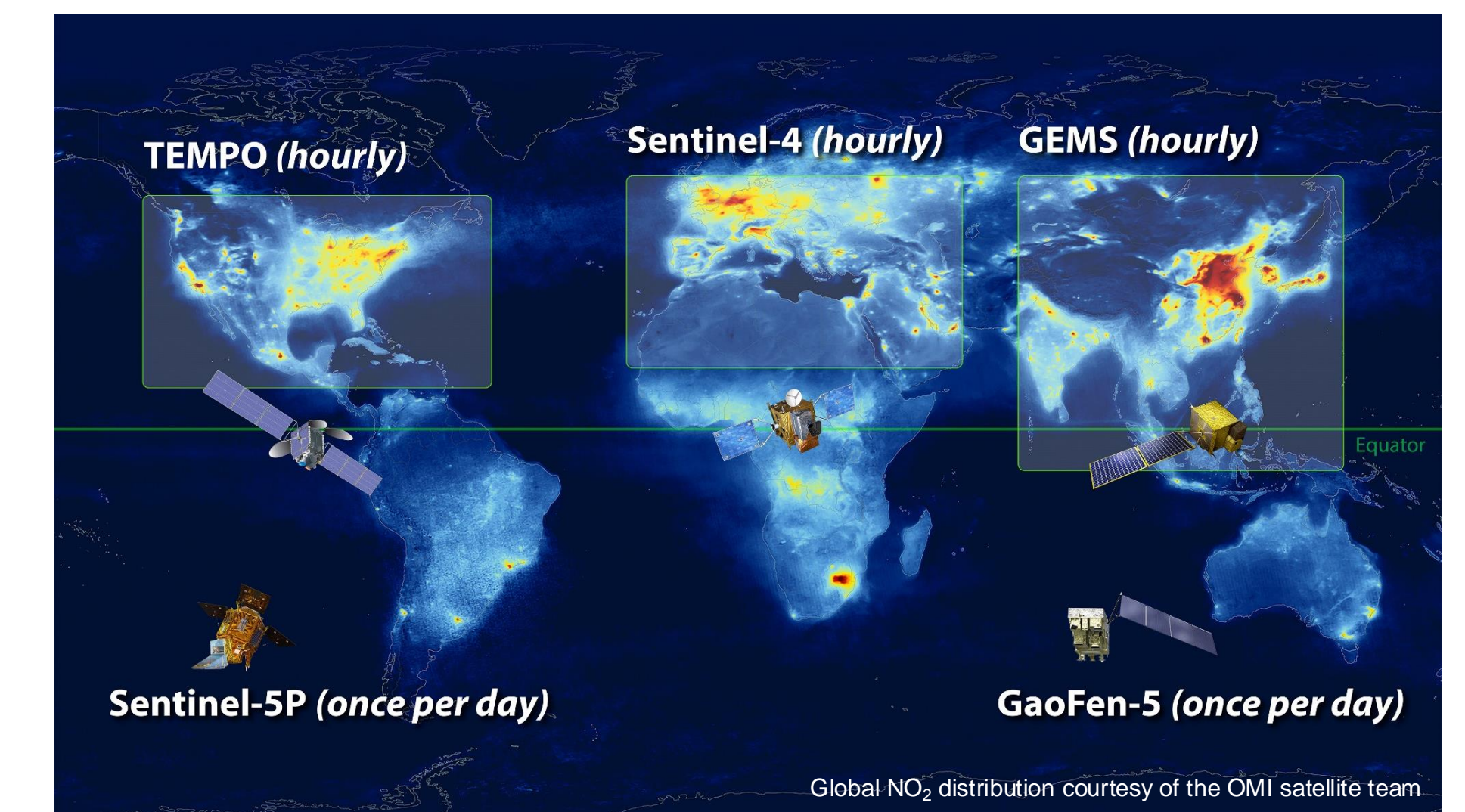
Hemispheric Airborne Measurements of Air Quality (HAMAQ)

Laura M. Judd¹, James H. Crawford¹, Brian C. McDonald², Luisa T. Molina³, Michel Grutter⁴, J. Victor Hugo Paramo Figueroa⁵, Daniel López Vicuña⁶, Sergio Zirath Hernández Villaseñor⁷, Salvador Landeros Ayala⁸, Laura Erika Guzmán Torres⁵, Hugo Landa Fonseca⁷, Armando Retama⁶, José Abraham Ortinez Alvarez⁹

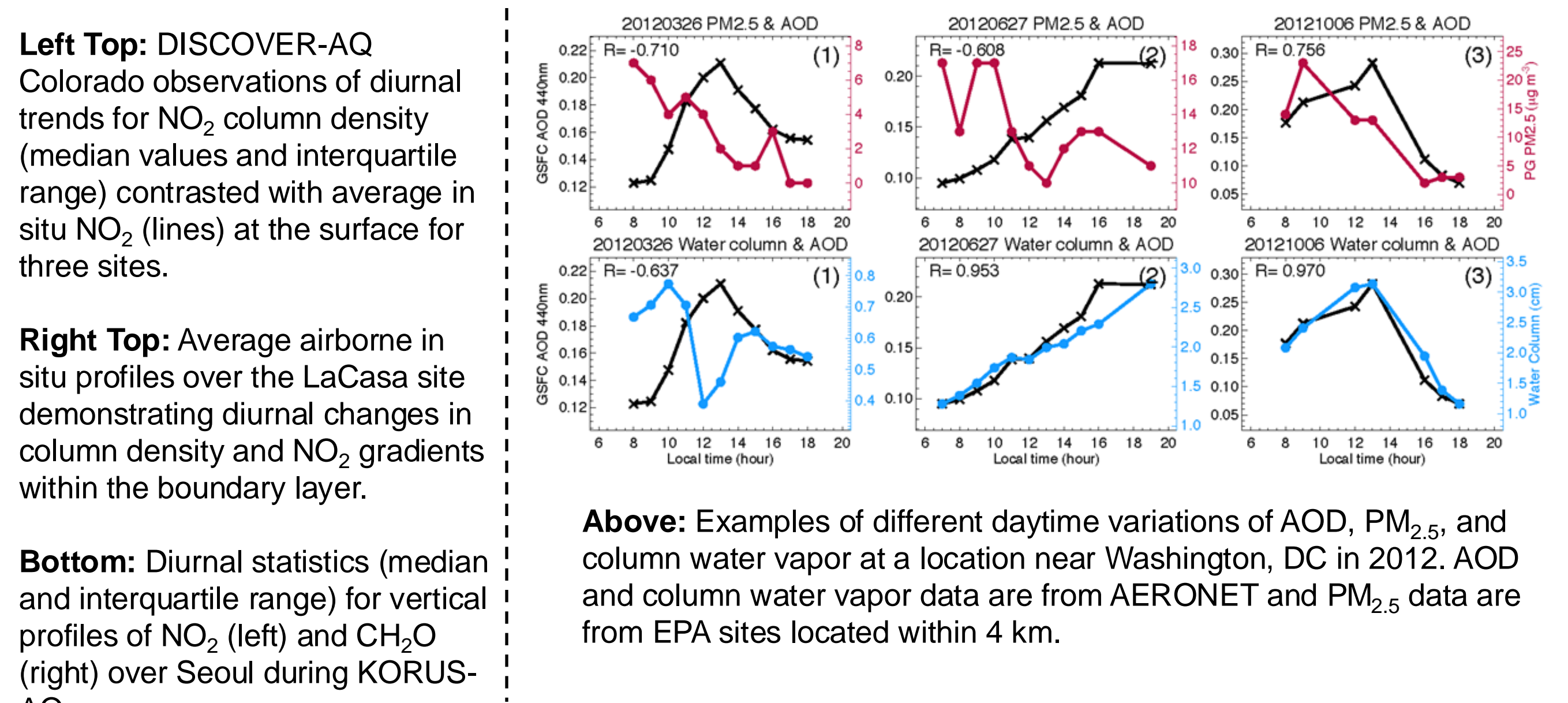
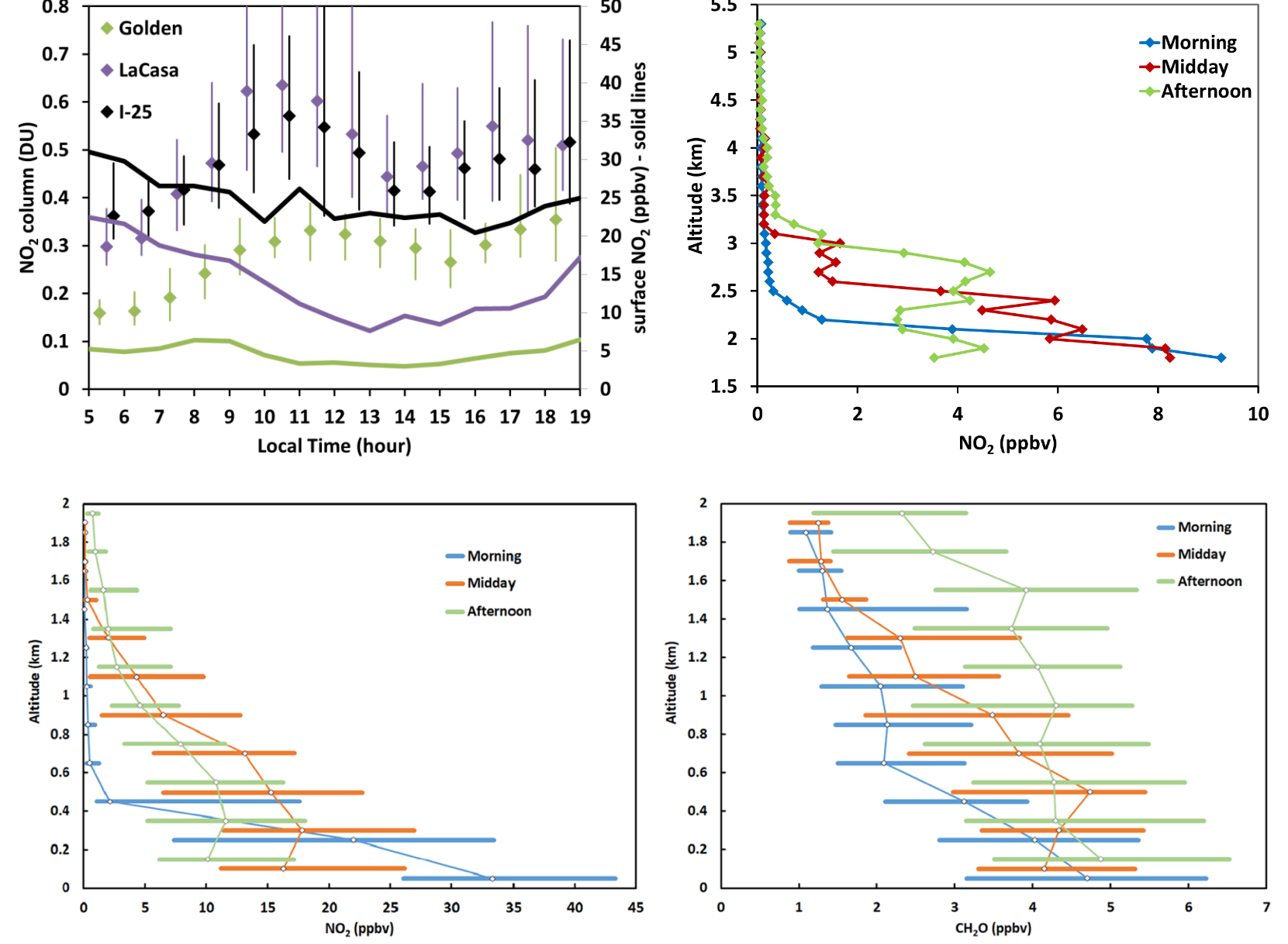
¹NASA Langley Research Center; ²NOAA Chemical Sciences Laboratory; ³Massachusetts Institute of Technology; ⁴Universidad Nacional Autónoma de México; ⁵Comisión Ambiental de la Megalópolis; ⁶Independent Research Scientist; ⁷Secretaría de Medio Ambiente y Recursos Naturales; ⁸Agencia Espacial Mexicana (AEM); ⁹Instituto Nacional de Ecología y Cambio Climático

Hemispheric Airborne Measurements of Air Quality (HAMAQ, pronounced “hammock”) was selected for funding under NASA’s Earth Venture Suborbital (EVS-4) solicitation. As originally proposed, HAMAQ would have flown under each of the geostationary satellites in the Atmospheric Composition Virtual Constellation (AC-VC). Selected under a reduced budget (\$15M), HAMAQ has been descope to include only sampling under TEMPO. The science objectives and approach are still relevant to the broader constellation, and partnerships are still in place to continue the pursuit of the larger vision of HAMAQ to also sample in Asia and Europe. HAMAQ plans include two deployments in 2028, including the Mexico City megalopolis and a second North American site yet to be selected. The effort will include two aircraft, NASA’s B777 for in situ sampling and G-III for remote sensing. These aircraft will be used to complete the integrated observing system, combining satellite observations, ground-based monitoring, research observations, and air quality modeling. With the long lead time for deployments in 2028, HAMAQ leadership are soliciting feedback on the project white paper available for download at <https://science.larc.nasa.gov/HAMAQ>.

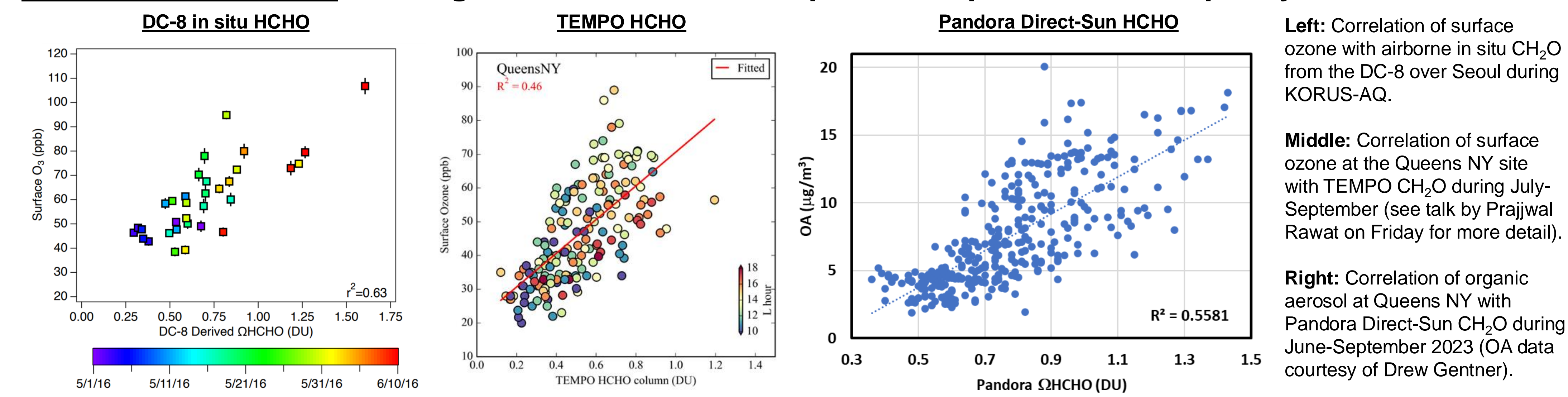
The goal of HAMAQ is to advance the integrated observing system for air quality through targeted airborne observations over priority areas in coordination with the geostationary air quality satellite constellation and local monitoring to improve forecasting and inform policy.



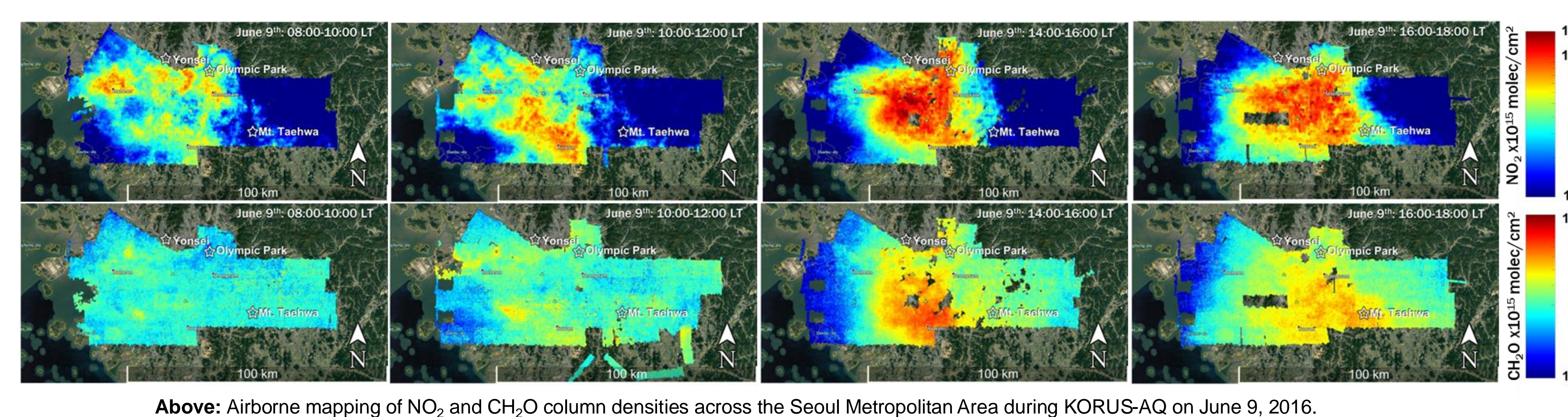
Science Objective 1: Improve connections between satellites and surface networks through chemically detailed, vertically- and diurnally-resolved measurements.



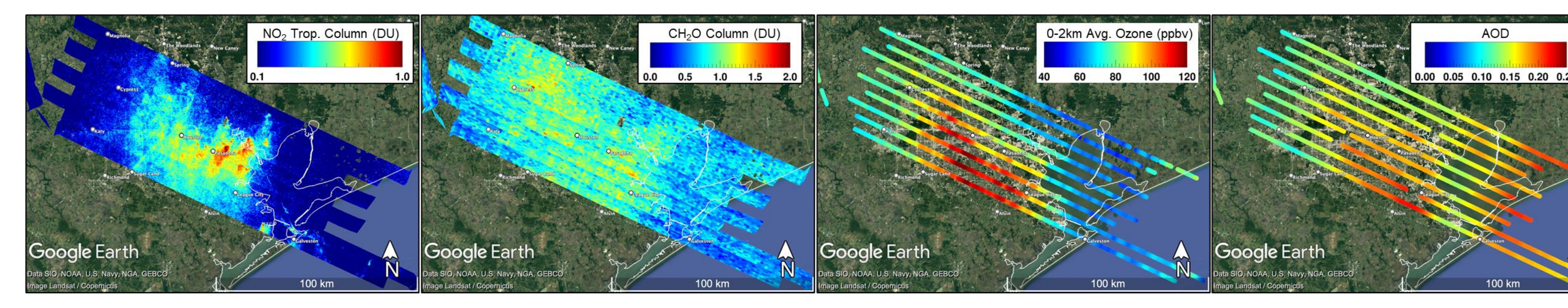
Science Objective 3: Investigate and further develop satellite proxies for air quality.



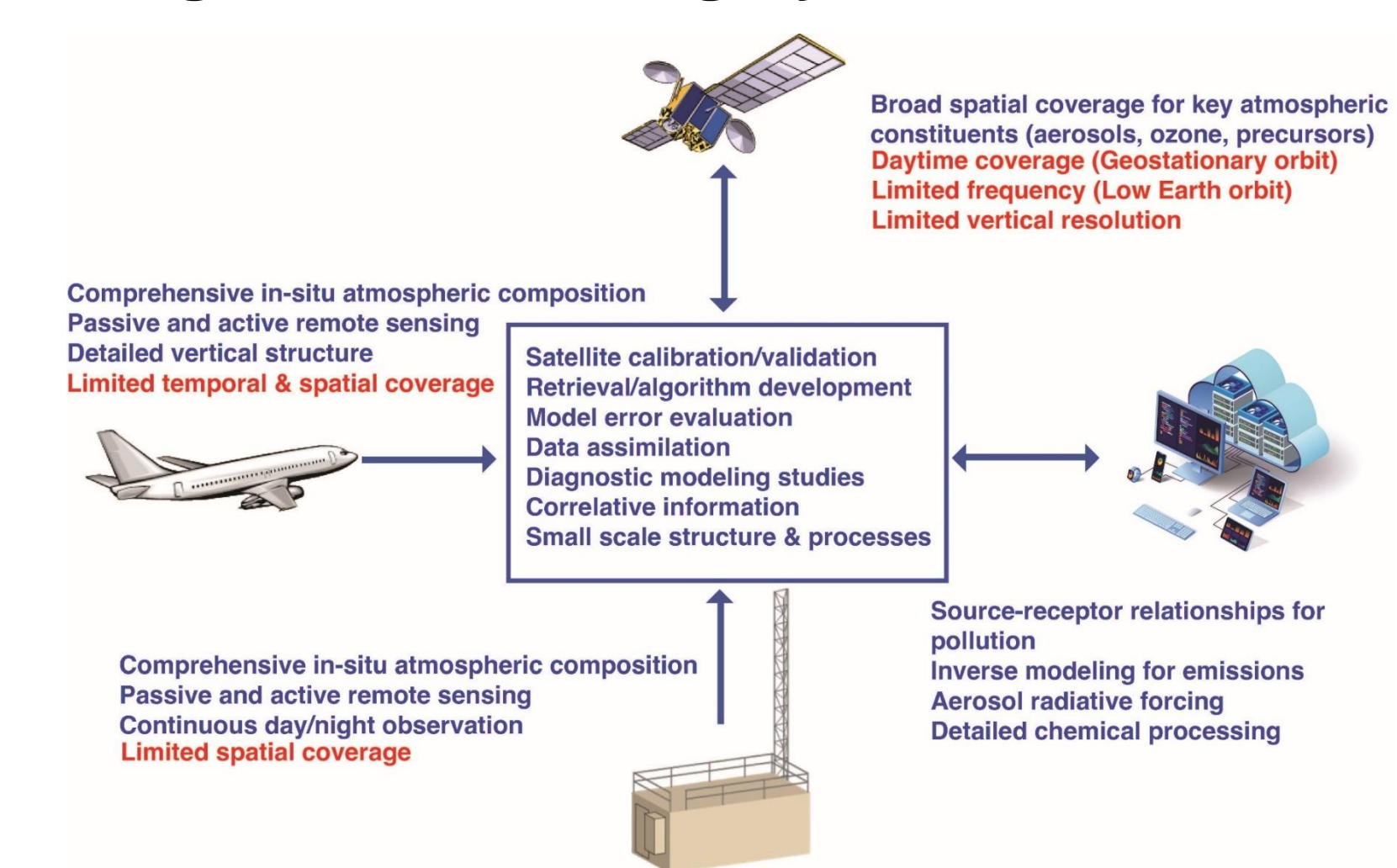
Science Objective 2: Evaluate the magnitude and timing of emissions and their source apportionment to inform inventories and their relationship to satellite column observations.



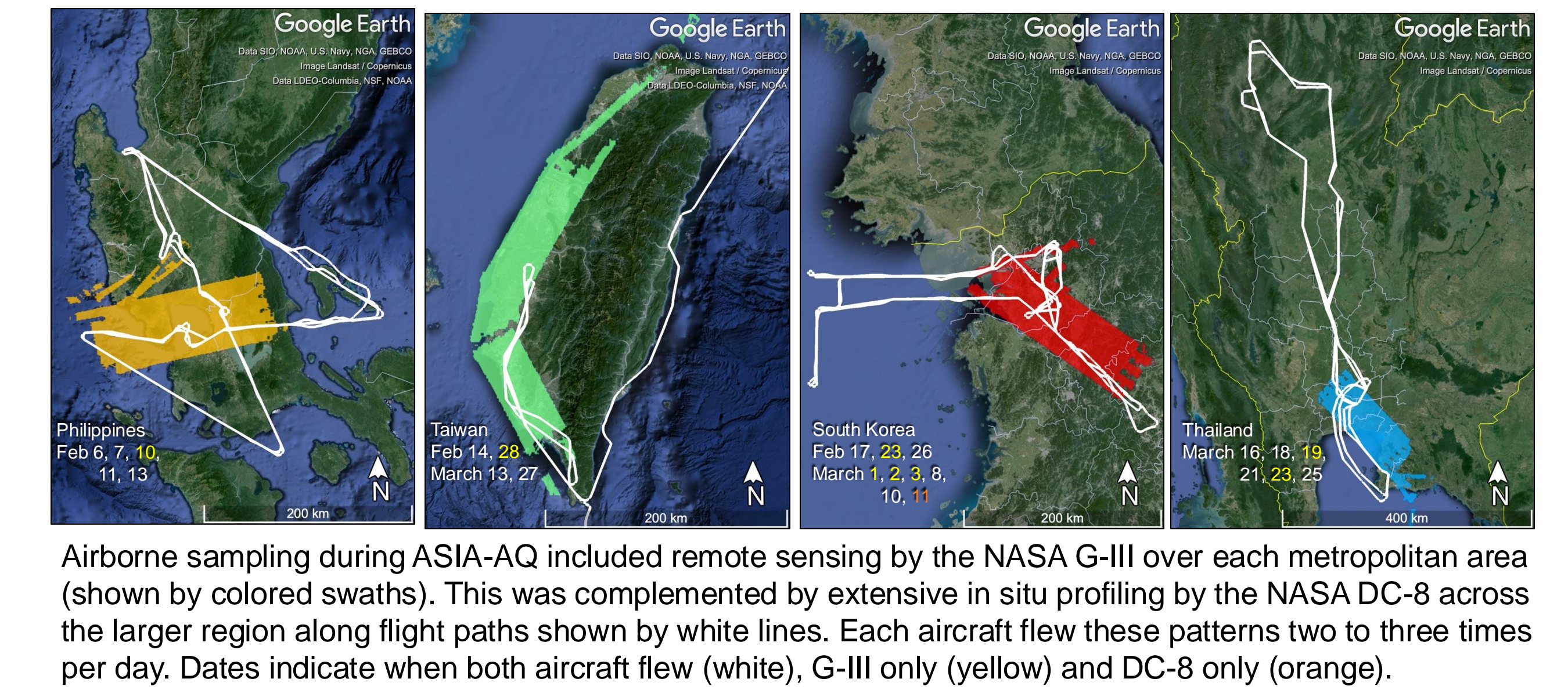
Science Objective 4: Investigate the diversity of factors controlling air quality across multiple urban areas.



Integrated Observing System for Air Quality

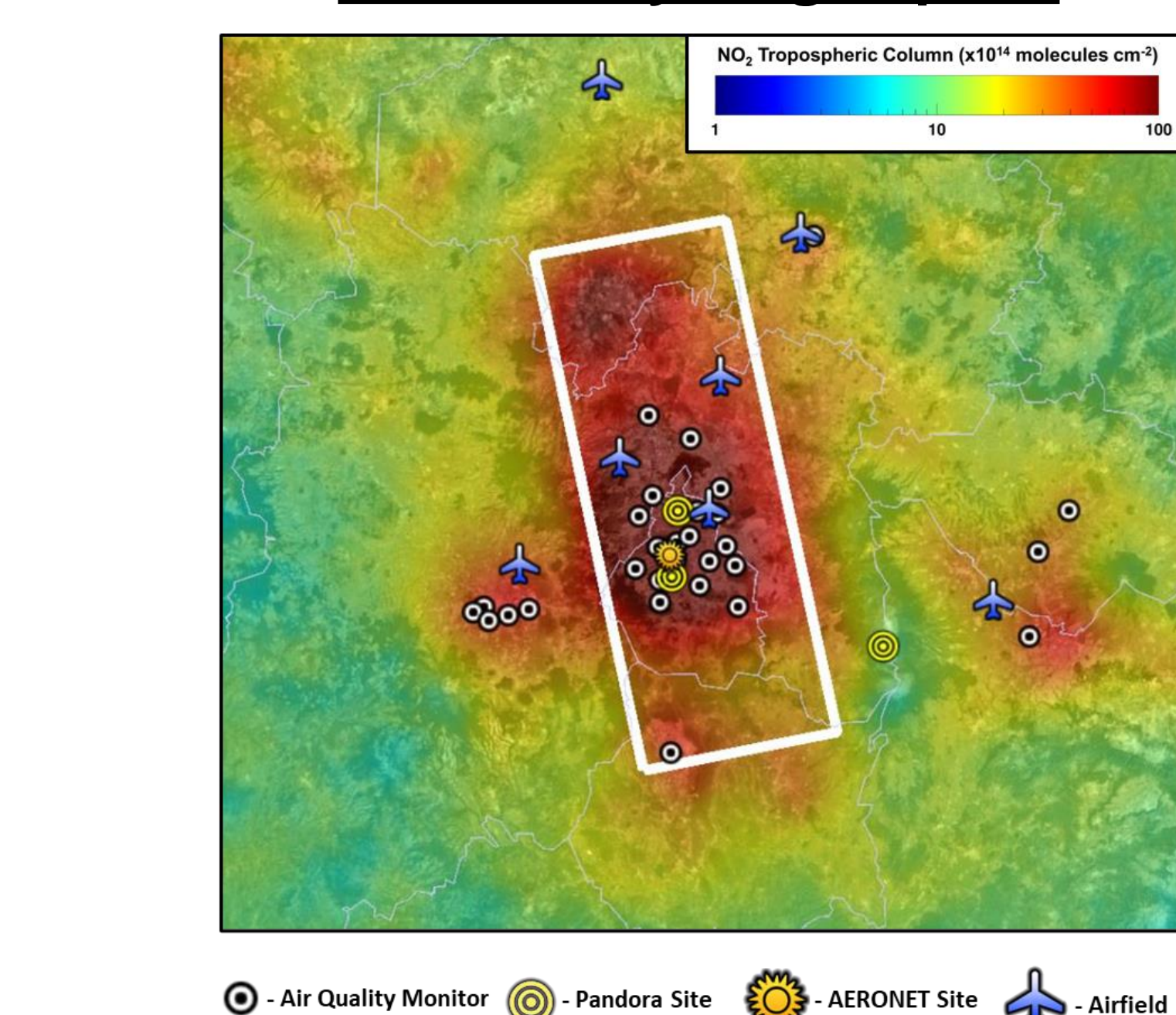


HAMAQ will employ the same airborne sampling strategy as ASIA-AQ



Airborne sampling during ASIA-AQ included remote sensing by the NASA G-III over each metropolitan area (shown by colored swaths). This was complemented by extensive in situ profiling by the NASA DC-8 across the larger region along flight paths shown by white lines. Each aircraft flew these patterns two to three times per day. Dates indicate when both aircraft flew (white), G-III only (yellow) and DC-8 only (orange).

Mexico City megalopolis



HAMAQ Approach

Aircraft: Similar to previous studies (DISCOVER-AQ, KORUS-AQ, ASIA-AQ), HAMAQ will use two aircraft, the G-III for remote sensing and the B777 for in situ profiling.

Remote Sensing: The NASA G-III is capable of sampling an area of 135x50 km² three times per day (two sorties required)

In Situ Profiling: The B777 can sample throughout the day using low approaches on airports to descend below 1000 feet and sample as low as 50 feet over runways.

The graphic showing the Mexico City megalopolis to the left depicts the size of the G-III sampling area (white box), current distribution of ground observations, and candidate airfields for low approaches by the B777.

Community input on the second deployment site is needed!

HAMAQ Measurement Priorities

Science Measurement Requirement Matrix (P=Priority, v=vertical, h=horizontal, a,t=along track)	P ¹	Uncertainty ²	Resolution ³	Sci. Obj.
Remote Sensing Aircraft				
Column densities:				
Nitrogen Dioxide (NO ₂)	1	1x10 ¹⁰ molec. cm ⁻² (slant column)	h, 500 m	1,2,3,4
Formaldehyde (CH ₂ O)	1	1x10 ¹⁰ molec. cm ⁻² (slant column)	h, 500 m	1,2,3,4
Sulfur Dioxide (SO ₂)	2	4x10 ¹⁰ molec. cm ⁻² (slant column)	h, 500 m	1,2,3,4
Glyoxal (CHOCHO)	3	5x10 ¹⁰ molec. cm ⁻² (slant column)	h, 500 m	1,2,3,4
Profiles:				
Aerosol backscatter	1	0.2 Mm ⁻¹ sr ⁻¹	v, 30 m, a.t. 2 km	1,2,4
Aerosol extinction	1	0.01 km ⁻¹	v, 300 m, a.t. 12 km	1,2,4
Aerosol depolarization	1	1%	v, 30 m, a.t. 2 m	1,2,4
Ozone (O ₃)	1	5 ppb or 15%	v, 300 m, a.t. 12 km	1,2,3,4
Surface variables:				
Surface Temperature Gradient	2	<1 C	a.t. 400 m	1,2,4
In situ Aircraft				
Trace Gases:				
Ozone (O ₃)	1	5 ppb or 10%	1 s	1,2,3,4
Nitric Oxide (NO)	1	30 ppt or 20%	1 s	2,4
Nitrogen Dioxide (NO ₂)	1	50 ppt or 30%	1 s	1,2,3,4
Total Reactive Nitrogen (NO _y)	1	100 ppt or 30%	1 s	2,4
Formaldehyde (CH ₂ O)	1	60 ppt or 10%	1 s	1,2,3,4
Sulfur Dioxide (SO ₂)	1	20 ppt or 30%	1 s	1,2,3,4
Water Vapor (H ₂ O)	1	5%	1 s	1,4
Carbon Monoxide (CO)	1	2 ppb or 2%	1 s	2,4
Carbon Dioxide (CO ₂)	1	0.25 ppm	1 s	2,4
Methane (CH ₄)	1	1%	1 s	2,4
Speciated hydrocarbons ⁴	1	variable (1-10 ppt or 10%)	variable (s to min)	2,4
Nitrous Oxide (N ₂ O)	2	1%	1 s	2,4
Ethane (C ₂ H ₆)	2	50 ppt or 5%	1 s	2,4
Speciated reactive nitrogen ⁵	2	variable (10-30%)	1 s	2,4
Ammonia (NH ₃)	2	20%	1 s	2,4
Tracer compounds ⁶	2	variable (1-10 ppt or 10%)	variable (s to min)	2,4
Peroxides (H ₂ O ₂ and ROOH)	3	50 ppt or 30%	1 s	2,4
Glyoxal (CHOCHO)	3	50 ppt or 10%	1 s	2,3,4
Aerosols:				
Number	1	10%	1 s	2,4
Size Distribution (10 nm - 5 μm)	1	20%	1 s	2,4
Scattering (multi-wavelength)	1	0.5 Mm ⁻¹	1 s	2,4
Absorption (multi-wavelength)	1	0.5 Mm ⁻¹	1 s	2,4
Hygroscopicity, f(RH)	1	20%	1 s	2,4
Nonrefractory mass composition	1	35%	1 s	2,3,4
Black Carbon mass	1	20%	1 s	2,4
BIC absorption	2	20%	1 s	2,4
Radiation and Met:				
Spectral Actinic Flux (4x sr)	1	10%	3 s	4
Met (T, P, RH, 2-D winds)	1	0.3 K, 0.3 mb, 15%, 1 m/s	1 s	1,2,4

HAMAQ Modeling Priorities

Science Modeling Requirement Matrix (P=Priority, v=vertical, h=horizontal, a,t=along track)	P ¹	Modeling Requirements	Sci. Obj.
Scientific Modeling			
Global model	1	h, 0.25 deg. v, 60m in the boundary layer; with ability to nest targeted domains, implement tagged tracers, provide 2-day hourly forecasting, real time visualization and comparison with observations	1,2,3,4
Regional model	1	h, 4 km, v, 30m in the boundary layer; with same abilities as listed above for the global model	1,2,3,4
0-D photochemical box model	2	Photochemical modeling based on in situ observed quantities with choice of mechanism (e.g., MCM, SAPRC, RADM, etc.)	3,4

HAMAQ Nominal Timeline and Next Steps

- 2024: Solicit community input on second deployment site and white paper
- 2025: Select second deployment location and finalize white paper
- 2026: ROSES solicitation released
- 2027: Science Team selections announced
- 2028: Deployments
- 2029: Rapid Science Synthesis Reports
- 2030: Peer Reviewed Publications

The HAMAQ white paper is public!
Please send comments to James.H.Crawford@nasa.gov

<https://science.larc.nasa.gov/HAMAQ>