12-15-2011 DRAFT GEO-CAPE Atmosphere Science Traceability Matrix

Science Questions

1. What are the temporal and spatial variations of emissions of gases and aerosols important for air quality and climate?

2. How do physical, chemical, and dynamical processes determine tropospheric composition and air quality over scales ranging from urban to continental, diurnally to seasonally?

3. How does air pollution drive climate forcing and how does climate change affect air quality on a continental scale?

4. How can observations from space improve air quality forecasts and assessments for societal benefit?

5. How does intercontinental transport affect air quality?

6. How do episodic events, such as wild fires, dust outbreaks, and volcanic eruptions, affect atmospheric composition and air quality?

Measurement Objectives
(color flag maps to Science Questions)

Baseline measurements[1]:
O3, NO2, CO, SO2, HCHO, CH4, NH3, CHOCHO, different temporal sampling frequencies; AOD, AAOD, AI, aerosol optical centroid height (AOCH), hourly for SZA<70; all at 4 km x 4 km product horizontal spatial resolution at the center of the domain.

Descope options: degrade product horizontal spatial resolution to 8 km x 8 km. eliminate cloud camera. eliminate observations over the open ocean (>250 km from coast). eliminate AOCH. Eliminate HCHO, SO2, CH4, CHOCHO, NH3, AAOD, AI.

A. Measure the threshold or baseline species or properties with the temporal and spatial resolution specified (see next column) to quantify the underlying emissions, understand emission processes, and track transport and chemical evolution of air pollutants [1, 2, 3, 4, 5, 6]

B. Measure AOD, AAOD, and NH3 to quantify aerosol and nitrogen deposition to land and coastal regions [2, 4]

C. Measure AOD, AAOD, and AOCH to relate surface PM concentration, UV-B level and visibility to aerosol column loading [1, 2, 3, 4, 5, 6]

D. Determine the instantaneous radiative forcings associated with ozone and aerosols on the continental scale and relate them quantitatively to natural and anthropogenic emissions [3, 5, 6]

E. Observe pulses of CH4 emission from biogenic and anthropogenic releases; CO anthropogenic and wildfire emissions; AOD, AAOD, and AI from fires; AOD, AAOD, and AI from dust storms; SO2 and AOD from volcanic eruptions [1, 4, 6]

F. Quantify the inflows and outflows of O3, CO, SO2, and aerosols across continental boundaries to determine their impacts on surface air quality and on climate [2, 3, 5]

G. Characterize aerosol particle size and type from spectral dependence measurements of AOD and AAOD [1, 2, 3, 4, 5, 6]

H. Acquire measurements to improve representation of processes in air quality models and improve data assimilation in forecast and assessment models [4]

I. Synthesize the GEO-CAPE measurements with information from in-situ and ground-based remote sensing networks to construct an enhanced observing system [1, 2, 3, 4, 5, 6]

J. Leverage GEO-CAPE observations into an integrated observing system including geostationary satellites over Europe and Asia together with LEO satellites and suborbital platforms for assessing the hemispheric transport [1, 2, 3, 4, 5, 6]

K. Integrate observations from GEO-CAPE and other platforms into models to improve representation of processes in the models and to link the observed composition, deposition, and radiative forcing to the emissions from anthropogenic and natural sources [1, 2, 3, 4, 5, 6]

Measurement Requirements
(mapped to Measurement Objectives)

		Measurement Rationale
Geostationary Orbital Location: 100 W +/-10 Viewing North America from 10-60N		Provides optimal view of North American atmospheres over land, coastal waters, and open ocean in support of science questions.
Column measurements: [A to K]		Continue the current state of practice in vertical; add temporal resolution.
Cloud Camera *1 km x 1km horizontal spatial resolution, two spectral bands, baseline only*		Improve retrieval accuracy, provide diagnostics for gases and aerosol
Vertical information: [A to K]		
Two pieces of information in the troposphere in daylight with sensitivity to the lowest 2 km	O3, CO	Separate the lower-most troposphere from the free troposphere for O3, CO.
Altitude (+/- 1km)	AOCH	Detect aerosol plume height; improve retrieval accuracy.

Product horizontal spatial resolution at the center of the domain, (nominally 100W, 35 N): [A to H]

4km x 4 km	Gases and Aerosols	Capture spatial/temporal variability; obtain better yields of products.
16 km x 16 km	Over open ocean	Inherently larger spatial scales, sufficient to link to LEO observations

Spectral region : [A to H]		Typical use
UV, Vis, TIR	O3	Provide multispectral retrieval information in daylight
SWIR, MWIR	CO	
UV	SO2, HCHO	Retrieve gas species from their atmospheric spectral signatures (typical)
SWIR,TIR	CH4	
TIR	NH3	
Vis	AOD, NO2, CHOCHO	Obtain spectral-dependence of AOD for particle size and type information
UV-deep blue	AAOD	Obtain spectral-dependence of AAOD for aerosol type information
UV-deep blue	AI	Provide absorbing aerosol information
Vis-NIR	AOCH	Retrieve aerosol height [3]

Atmospheric measurements over Land/Coastal areas: [A to K]

Species	***Time resolution***	*Typical value* [2]	*Precision* [2]	Description
O3	Hourly, SZA<70	9×10^{18}	0-2 km: 10 ppbv 2km–tropopause: 15 ppbv Stratosphere: 5%	Observe O3 with two pieces of information in the troposphere with sensitivity to the lowest 2 km for surface AQ; also transport, climate forcing
CO	Hourly, day and night	2×10^{18}	0-2 km: 20ppbv 2km–tropopause: 20 ppbv	Track anthropogenic and biomass burning plumes; observe CO with two pieces of information in the vertical with sensitivity to the lowest 2 km in daylight
AOD	Hourly, SZA<70	0.1 – 1	0.05	Observe total aerosol; aerosol sources and transport; climate forcing
NO2	Hourly, SZA<70	6×10^{15}	1×10^{15}	Distinguish background from enhanced/ polluted scenes; atmospheric chemistry

Additional atmospheric measurements over Land/Coastal areas, total column: [A to K]

Species	***Time resolution***	*Typical value* [2]	*Precision* [2]	Description
HCHO*	3/day, SZA<50	1.0×10^{16}	1×10^{16}	Observe biogenic VOC emissions, expected to peak at midday; chemistry
SO2*	3/day, SZA<50	1×10^{16}	1×10^{16}	Identify major pollution and volcanic emissions; atmospheric chemistry
CH4	2/day	4×10^{19}	20 ppbv	Observe anthropogenic and natural emissions sources
NH3	2/day	2×10^{16}	0-2 km: 2ppbv	Observe agricultural emissions
CHOCHO*	2/day	2×10^{14}	4×10^{14}	Detect VOC emissions, aerosol formation, atmospheric chemistry
AAOD	Hourly, SZA<70	0 – 0.05	0.02	Distinguish smoke and dust from non-UV absorbing aerosols; climate forcing
AI	Hourly, SZA<70	-1 – +5	0.1	Detect aerosols near/above clouds and over snow/ice; aerosol events
AOCH	Hourly, SZA<70	Variable	1 km	Determine plume height; large scale transport, conversions from AOD to PM

Open ocean measurements: [F, H, I, J, K] *16 km x 16 km*

O3	1/day	Over open oceans, capture long-range transport of pollution, dust, and smoke into/out of North America; establish boundary conditions for North America
CO	1/day	
AOD, AAOD, AI	1/day	

AOD=Aerosol optical depth, AAOD=Aerosol absorption optical depth, AI=Aerosol index.

The mixing ratio [mole fraction], ppb, of a target gas is number of moles of that gas/mole of air, invariant with temperature and pressure. The number density is the number of molecules of the target gas/unit volume of air; the total column concentrations in the table above are the integral of the number density from the surface to space.

[1] Baseline: Measured quantities deliver the full science requirements for GEO-CAPE.

[2] Typical column amount. Units are molecules cm^{-2} for gases and unitless for aerosols, unless specified. Typical AOD and AAOD values are provided for mid-visible wavelengths over North America.

[3] Retrieval aerosol height from different techniques, e.g. O2-O2 band at 477 nm, O2-A band at 760 nm, O2-B band at 680 nm.

* = background value. Pollution is higher, and in starred constituents, the precision is applied to polluted cases.