Table D-1: Science and Applications Traceability Matrix (SATM).

CarbonFOX will deliver novel, highly accurate and spatially resolved measurements that quantify the processes driving fluxes of CO_2 and CH_4 between natural and human systems and the atmosphere, providing actionable information for effective evaluation of climate-carbon feedbacks and supporting climate mitigation activities.

Science & Applications Objectives – SO & AO	Science Measurement Requirements		Instrument Requirements	Instrument Performance	Mission Requirements[1]
	Physical Parameters	**Observables**			
 ***SO1*** **NAS Decadal Survey 2017** **[E-2a (Global Land), C-3a, C-3c, C-3e, E-5a]** Measure changes in carbon dynamics over **natural terrestrial ecosystems** (boreal and tropical forests, grasslands and vegetated wetlands) over inter-annual, seasonal, and sub-seasonal temporal scales.  ***SO2*** **NAS Decadal Survey 2017** **[E-3 (Carbon Dynamics), E-5a,E-5b, E-5c]** Determine how **disturbances** (e.g., hurricanes, fires, and floods) impact carbon dynamics of terrestrial ecosystems, including those managed for agriculture and undergoing large-scale land-use change over inter-annual, seasonal, and sub-seasonal temporal scales.  ***SO3*** **NAS Decadal Survey 2017** **[C-3b]** Quantify natural and anthropogenic drivers of carbon dynamics of **coastal and inland urban area** at inter-annual, seasonal, and sub-seasonal temporal scales.  ***AO1*** Deliver low latency CO_2, CH_4 and SIF data products to support detection and mitigation of significant **anthropogenic** emission or disturbance events.	Column-averaged mixing ratios of CO_2 (XCO_2) and CH_4 (XCH_4) as well as SIF over terrestrial ecosystems with sub-monthly revisit globally for solar zenith angles up to 80 (degrees). **XCO_2 Error:** Random error < 2 ppm at 1 km x 1 km at reference of 25% surface reflectance and 45° solar zenith angle (better than 0.5 ppm at 4 km x 4 km). Systematic errors < 0.5 ppm. **XCH_4 Error:** Random error < 8 ppb at 1 km x 1 km at reference of 25% surface reflectance and 45° solar zenith angle (better than 2 ppb at 4 km x 4 km). Systematic error < 5 ppb. **SIF Error:** Random errors < 0.4 W/m²/µm/sr at 0.5 km x 0.5 km	Top of Atmosphere Spectral Radiance with high spectral resolution over CO_2, CH_4, and O_2 absorption bands **Spectral Resolution:** Adequate spectral resolving power to measure XCO_2, XCH_4 and SIF with sufficient sensitivity to meet random and systematic error specified in the NAS Decadal Survey **Spatial Resolution:** <0.2 km x <0.5 km GSD in order to retrieve close to water bodies and within urban regions, and resolve sources for applications objective *[Threshold = 2 km x 2 km]* **Spatial Coverage:** 250km swath width provides global coverage every 2 weeks and covers global land ecosystems for solar zenith angles < 80°, except Antarctica and Greenland *[Threshold <65°]* **Temporal Revisit:** ≤ 12 days at equator to measure sub-seasonal variations **Temporal Coverage:** 3 years to distinguish seasonal variations and climate related disturbances	CO_2, CH_4 Imaging Spectrometer • Spectral Range: 1596 - 1678 nm • Spectral Resolution: 0.24 nm (FWHM) • Spectral Sampling: 2.5 pixels per FWHM • Avg SNR (continuum) > 122 at reference of 25% surface reflectance and 45° solar zenith angle, single pixel • Dynamic Range: SNR of 8 to 312 for scene radiance of 0.36 to 64 W/m²/µm/sr O_2 Imaging Spectrometer • Spectral Range: 740 - 771 nm • Spectral Resolution: 0.12 nm (FWHM) • Spectral Sampling: 2.5 pixels per FWHM • Avg SNR (continuum) ≥ 146 at same reference as above, single pixel • Dynamic Range: SNR of 4 to 304 for scene radiance of 0.79 to 264 W/m²/µm/sr General • Straylight: < 1% • Polarization Sensitivity: ≤ 7% • Nadir GSD: 0.2 km x 0.5 km (cross-track x along-track) • Radiometric Accuracy: ≤ 5% • Radiometric Stability: ≤ 2 % • Sensor Co-alignment: ≥ 90% overlap across 1.5 km x 1.5 km spatially sampled areas for all wavelengths between CH_4/CO_2 and O_2 sensors	CO_2, CH_4 Imaging Spectrometer • Spectral Range: 1596 - 1678 nm • Spectral Resolution: 0.23 nm (FWHM) • Spectral Sampling: 3 pixels per FWHM • Avg SNR (continuum) > 152 at reference of 25% surface reflectance and 45° solar zenith angle, single pixel • Dynamic Range: SNR of 10.5 to 384 for scene radiance of 0.36 to 64 W/m²/µm/sr O_2 Imaging Spectrometer • Spectral Range: 734 - 773 nm • Spectral Resolution: 0.12 nm (FWHM) • Spectral Sampling: 3 pixels per FWHM • Avg SNR (continuum) ≥ 184 at same reference as above, single pixel • Dynamic Range: SNR of 5.6 to 378 for scene radiance of 0.79 to 264 W/m²/µm/sr General • FOV: 21° providing 250 km swath width at 676 km altitude • Straylight: < 0.5% • Polarization Sensitivity: ≤ 5% • Nadir GSD: 0.126 km x 0.382 km (cross-track x along-track) • Radiometric Accuracy: ≤ 4% • Radiometric Stability: ≤ 1.5 % • Sensor Co-alignment: ≥ 93% overlap across 1.5 km x 1.5 km spatially sampled areas for all wavelengths between CH_4/CO_2 and O_2 sensors	• Flying in sunsynchronous repeating ground track, with early afternoon descending equator crossing time (for consistent orbit-to-orbit solar viewing angle) • Orbit sufficient to meet spatial and temporal resolution & coverage • ≤12 day revisit at the equator to measure subseasonal variations • 500 m geolocation knowledge • Collect and return ≥95% global land data for SZA <80°, except Antarctica and Greenland • Archive global L0-L2 science data products within six months of collection • CarbonFOX shall support nadir and off nadir science operations, calibration, and validation • Mission Duration: 3 years + 3 month for commissioning

Threshold requirements provide design resiliency for future data collection and onboard processing optimization; descopes are related to calibration & validation for L4 products, therefore are not reflected in the SATM.

[1] Accommodate instrument requirements

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