Development of the MethaneSAT L0-1B processor

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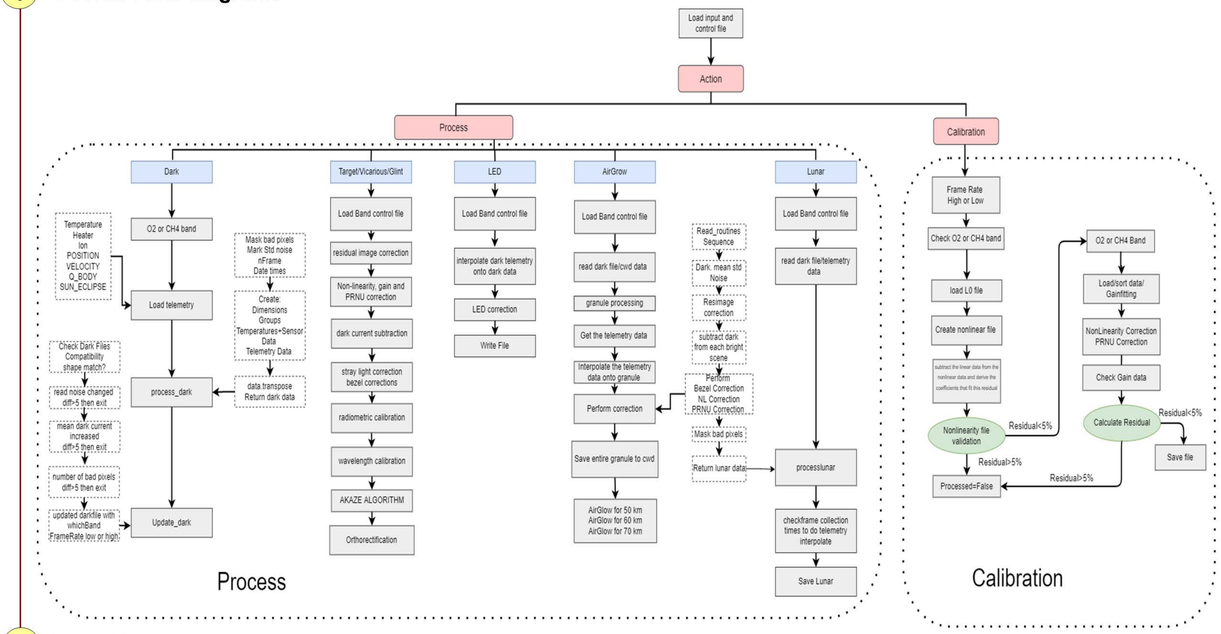
Introduction

MethaneSAT is an Environmental Defense Fund (EDF) satellite mission set to launch in mid-2023 to monitor methane emission from over 80% of the oil and gas industry and other sources with high precision and fine spatial resolution. The MethaneSAT instrument consists of two push-broom imaging spectrometers: the CH4 spectrometer (1.598-1.676 µm) to detect CH4 and CO2 absorption near 1.65 and 1.61 µm, and the O2 spectrometer (1.249-1.305µm) to detect O2 absorption near 1.27 µm. It is currently being built by Ball Aerospace and under sensor-level testing. Integration with the spacecraft bus by Blue Canyon Technologies will occur in Q3 2022 followed by flight-system level testing. MethaneAIR is the airborne simulator for MethaneSAT. It was successfully deployed in July/August 2021 aboard the NSF/NCAR Gulfstream V and produced ~50 hours of observations. A L0-1b processor has been developed for MethaneAIR to convert digital counts to radiometrically, spectrally, and geometrically calibrated L1b radiance spectra. The MethaneSAT L0-1b processor is being developed leveraging that the MethaneAIR L0-1b processor and analysis of MethaneSAT instrument calibration test data.

1 Overall Flow diagrams



2 Input Maps

1. Snow/Ice and Earth Orientation Parameters - Northern hemisphere: 1 km resolution data from U.S. National Ice Center Southern hemisphere: NOAA Global Multisensor Automated Snow/Ice Cover Map (GMASI) global snow/ice/land mask.
2. Digital Elevation Map - Fixed Map
The digital elevation map (DEM) includes ALOS World 3D-30m (AW3D30) global digital surface model (DSM)
3. MODIS Land Type Tagging - Terra and Aqua combined Moderate Resolution Imaging Spectroradiometer (MODIS) Land Cover Type (MCD12Q1) Version 6 data product provides global land cover types at yearly intervals

3 Five major parts

This design assumes that the system will be running in Flyte, which will be responsible for the orchestration and triggering as well as managing various specific aspects.

1. Sorting - between calibration and science target L0 files
2. L0 to L1a processing - Apply corrections to the data (e.g. bad pixels, dark current subtraction, stray light, residual image correction, non-linearity, gain and PRNU correction after Bezel correction, etc).
3. L1a to L1b processing - Apply orthorectification algorithms, do the wavelength Calibration
4. GeoAkaze Adjustment/Correction - Retry frames that failed orthorectification using successful, neighboring frames as input.
5. GeoTagging & Output collection - Tag the L1b with relevant information such as surface conditions using L1b geo data as reference.

4 On-orbit calibration algorithms

The On-oribit calibration algorithms :
1. Dark current measurements: update bad pixel map, random telegram signal (RTS) map, monitor dark current level and its temperature dependence
2. LED measurements: apply photon transfer to monitor gain, non-linearity, and PRNU.
3. Radiometric calibration trending: use vicarious calibration and/or lunar measurements
4. Wavelength shift and ISRF monitoring: using wavelength calibration & airglow results

5 Outputs

1. Geolocation info: Longitude, Latitude, CornerLongitude/Latitude, ViewingZenithAngle, , ViewingAzimuthAngle, RelativeAzimuthAngle, Surface/ObservationAltitude, Time, AircraftLongitude/Latitude, Aircraft Altitude and PixelBore

2. LandType, SnowIceTag, EclipseFlags

3. Band: Wavelength, Radiance, Signal to noise ratio, RadianceFlag

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IWGGMS-18

3-P05

July 12 and 13 9 AM -10 AM JST