

ARMAS radiation monitoring first results from the surface to LEO

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November 23, 2022

Abstract

Radiation hazards at commercial aviation altitudes up to suborbital space have been known for decades including those from galactic cosmic rays (GCRs), solar energetic particles (SEPs), and more recently radiation belt particle precipitation (RBPP). The complex radiation field that derives from these primary particle sources creates safety concerns for aerospace crew and passengers. Because of this safety hazard, the Automated Radiation Measurements for Aerospace Safety (ARMAS) program was developed to provide global aerospace radiation environment monitoring. The ARMAS TRL 9 operational system has now achieved monitoring from the surface of the Earth into Low Earth Orbit (LEO) with aircraft, high altitude balloon, suborbital vehicle, satellite and ISS flights over the past year. We present the latest results from i) the various flight domains; ii) the calibrations of the ARMAS system with the Tissue Equivalent Proportional Counter (TEPC); and iii) the ongoing real-time data assimilation of ARMAS data into the RADIATION system using NAIRAS v2 baseline global fields and CARI-7 verifications. We also describe progress towards 24/7 atmospheric monitoring from both the perspective of new sensor development as well as new stratospheric monitoring platforms.



ARMAS radiation monitoring from the surface to LEO

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Activity	Support	Project
Science	NASA LWS	✓ RADIANT – data assimilation of ARMAS into NAIRAS; implemented
	SET IR&D	✓ CARI-7 validation; implemented
	NASA LWS	● ARMAS-ML: Machine-learning w/ data
Data collection	NASA SBIR	✓ ARMAS FM5, ATED, γ -ray spectromtr, Liulin-SET LET, thermal neutrons on WVE 30-day Stratollite balloon
	USAF SBIR	✓ ARGOS/ARMAS 20km, 1 year data
	NASA SBIR	✓ SWAP-E/ARMAS FM8B cubesats (3)
	NASA SBIR	✓ iSSI/ARMAS FM9+Liulin-SET on ISS
Instruments	NASA SBIR	✓ OPSRAD LET detector



ARMAS Dual Monitor will fly through multiple domains in 2022

Flight region

Date

Instrumentation

Troposphere

07/22

ARMAS FM7 in at least one of:

- ✓ ER-2
- ✓ Business jet
- ✓ Commercial flight

Stratosphere

07/22

ARMAS FM5, ATED, γ -ray spectrometer, Liulin, thermal neutron monitor

- ✓ WVE Stratollite balloon (30-days)
- UAV (concept development)

2022

ARMAS FM5 & FM7 WVE & ARGOS flights

Thermosphere

06/21

ARMAS FM8A

- ✓ TAGSAT2 (sun-syn, 97.5°, 550 km)

02/22

ARMAS FM9

- ISS (28.5°, 450 km)

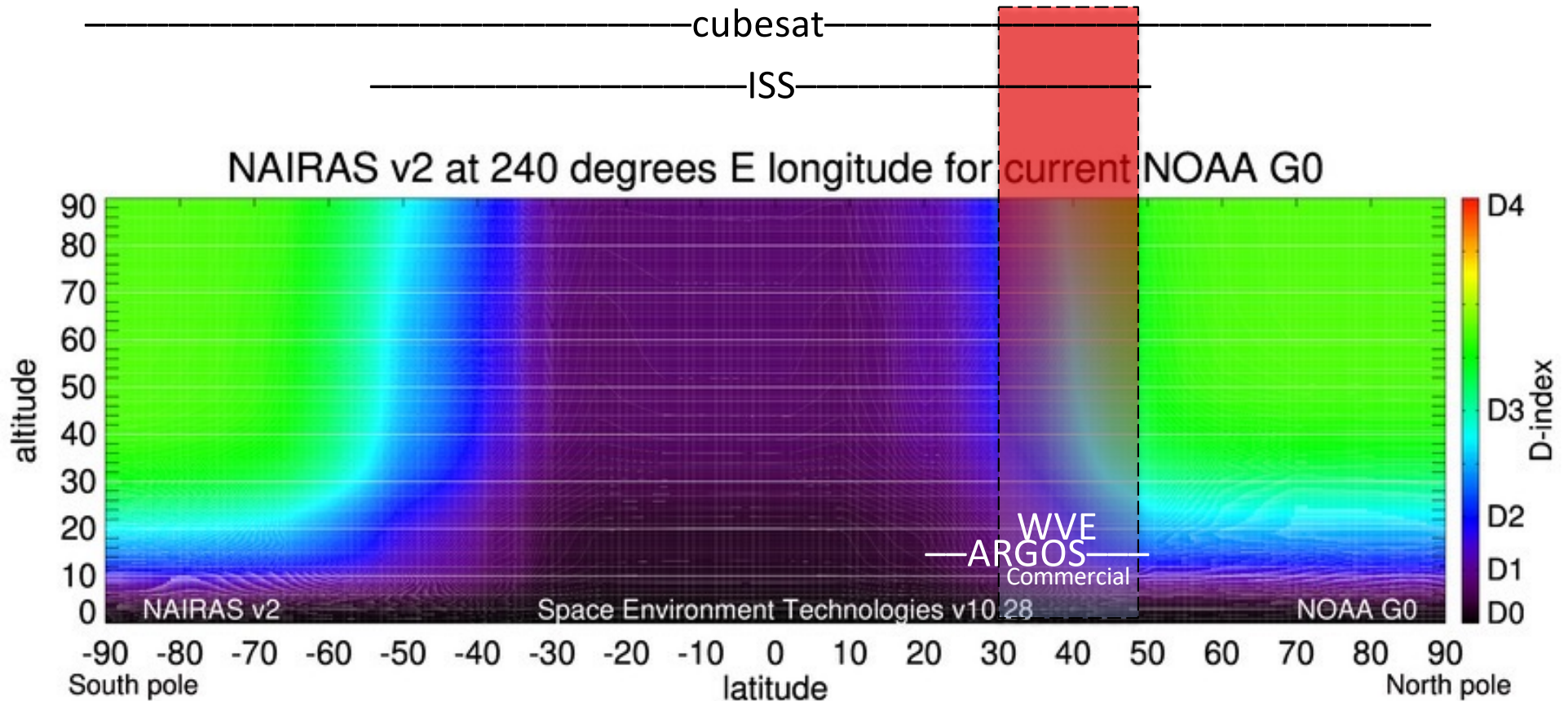
07/22

ARMAS FM8B

- SWAP-E (sun-syn, 97.5°, 550 km)

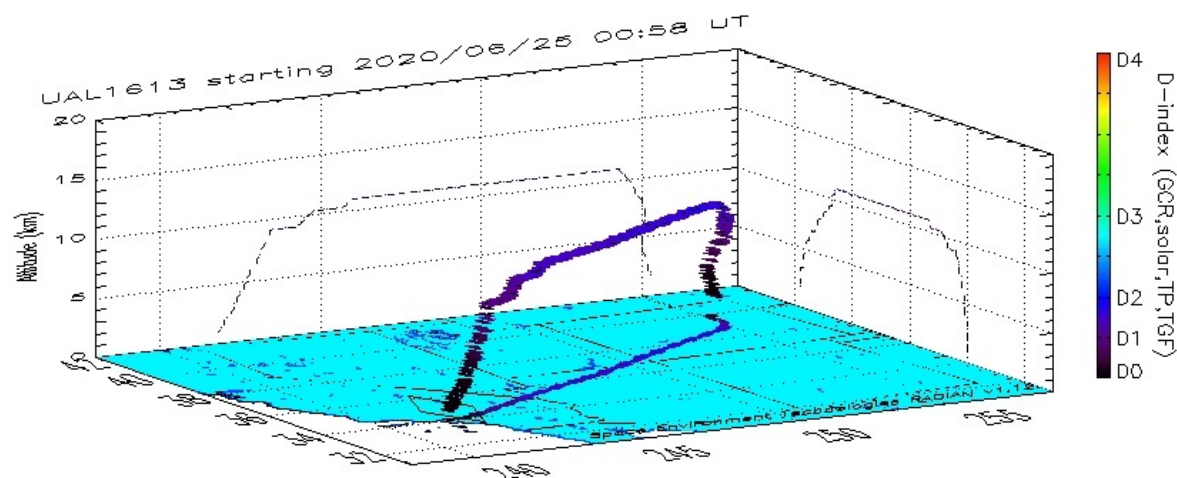
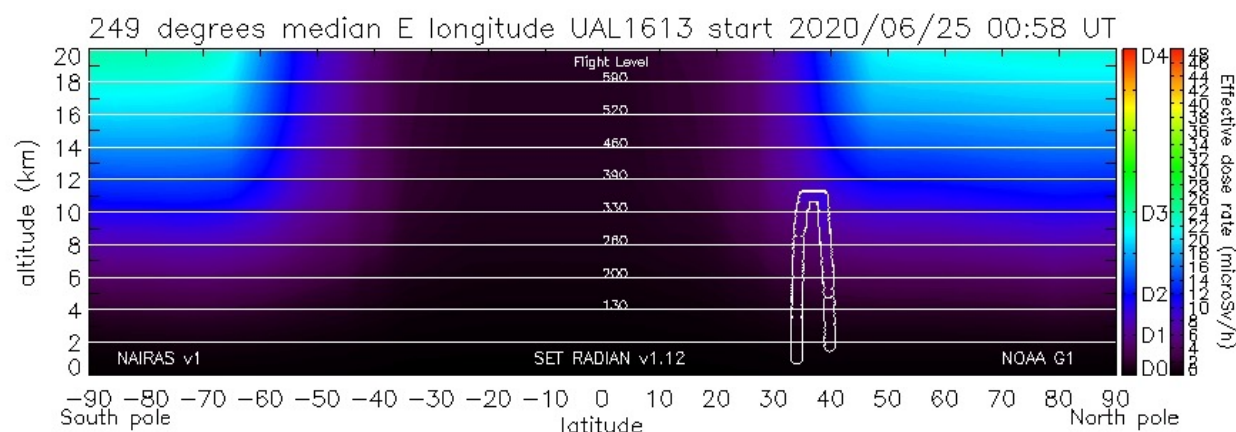


ARMAS Dual Monitor will measure first ever radiation column in 2022

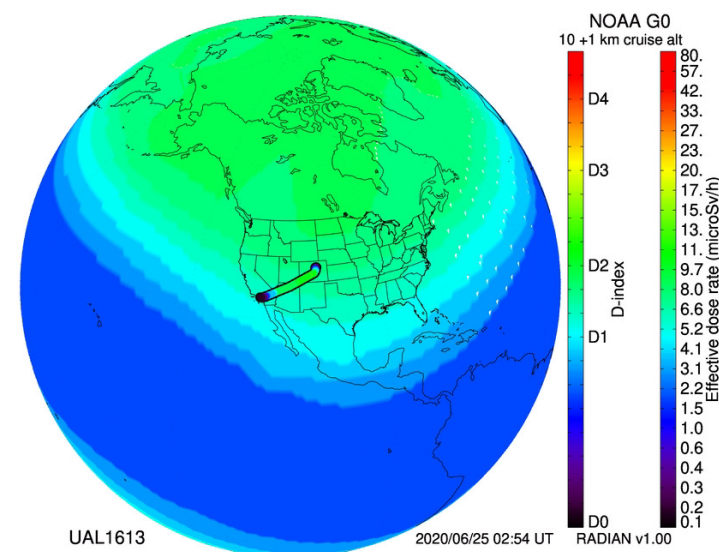




Providing global data: ARMAS measurements integrated with NAIRAS v2 form the RADIAN data cube



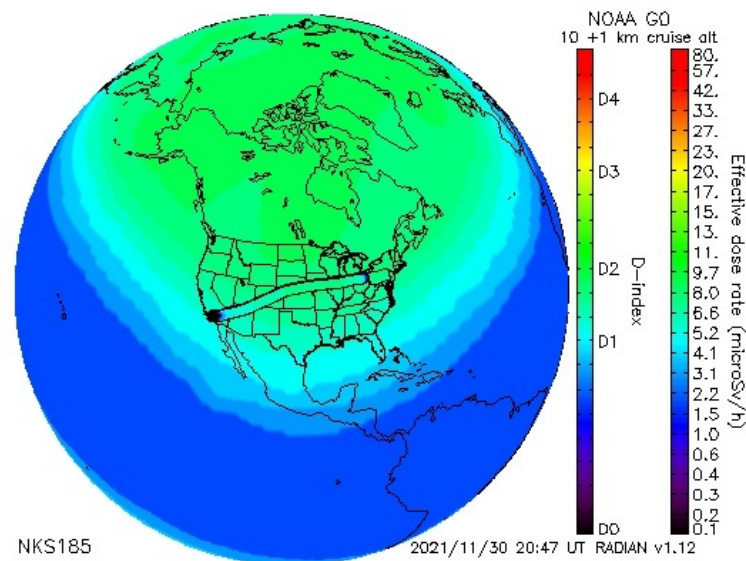
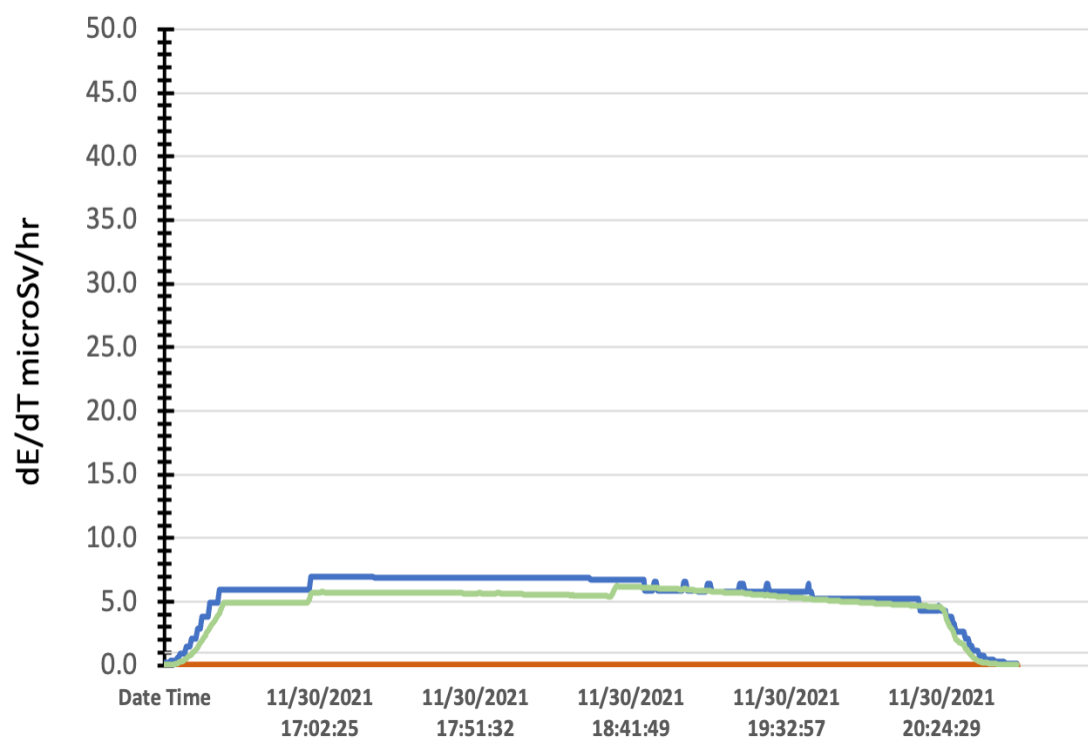
RADIAN now provides
flight tracks for any
aircraft in the world
(via ARMAS iOS app)





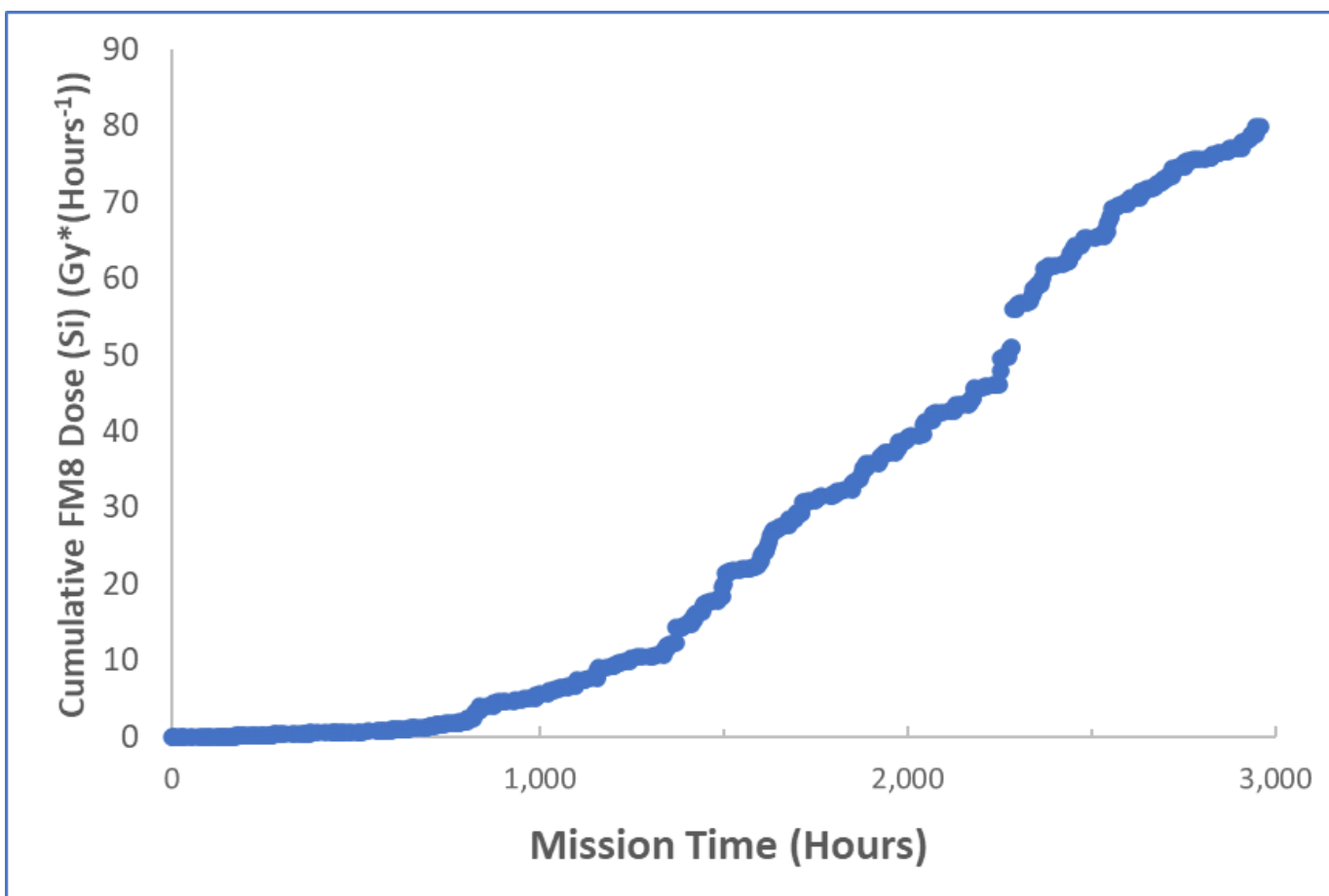
RADIAN data cube validation: NAIRAS v2 vs. CARI-7 for Spirit Airlines commercial flight NK185 on November 30, 2021

NK185 effective dose rate starting 11/30/2021 16:14 UT





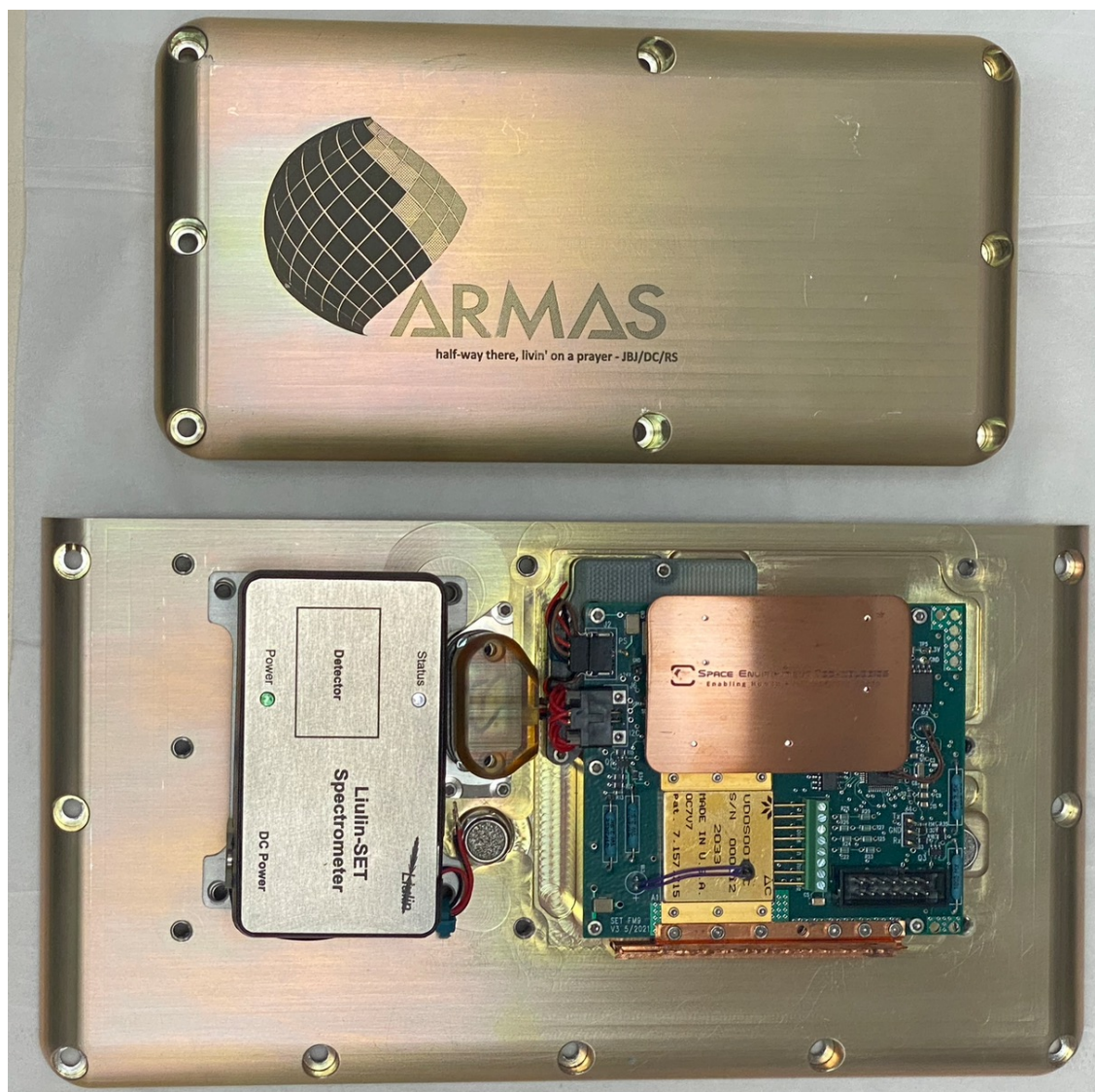
ARMAS FM8 total absorbed dose from
primary particles at top of
atmosphere in polar sun-synchronous
orbit at 550 km
July 1–September 18, 2021





Expanding radiation measurements to the top of the atmosphere: ISS

- ARMAS FM9 and Luilin-SET delivered for launch on December 10, 2021
- Measures total ionizing dose, semiconductor LET values, and energy spectrum
- ARMAS FM9 (right side) measures total ionizing dose by integrating the energy deposited in silicon across the nominal range of 100 keV to 15 MeV, including energy deposited from penetrating heavy ions, protons, and neutrons as well as from electrons, gamma-rays
- Liulin-SET (left side) measures ionizing radiation with LET between 0.1-40 keV/micron



<https://spacewx.com/radiation-decision-aids/>



Providing global data: ARMAS measurements using the ARGOS UAV

The Opportunity

ARGOS is a lightweight UAV designed to fly autonomously for up to a year at 20 km altitude. ARGOS will open a new market for lightweight payloads (≤ 5 kg) by dramatically reducing the cost for access to the stratosphere. In addition to the primary use for ARMAS radiation measurements, we are conducting a feasibility study to deploy a fleet for the Air Force and DoD as well as commercial payloads.

The Method

Above the clouds, sunlight is unobstructed and abundant. Collected energy will power flight during the day while storing excess for the night. We are building a low-cost prototype for a series of test flights from December 2021 to increasingly higher altitudes targeting June 2022 for the first high altitude, long endurance (HALE) attempt.

The Foundation

ARGOS will include Automated Radiation Measurements for Aerospace Safety (ARMAS) instrumentation for operations.

<https://spacewx.com/radiation-decision-aids/>



ARGOS UAV build

