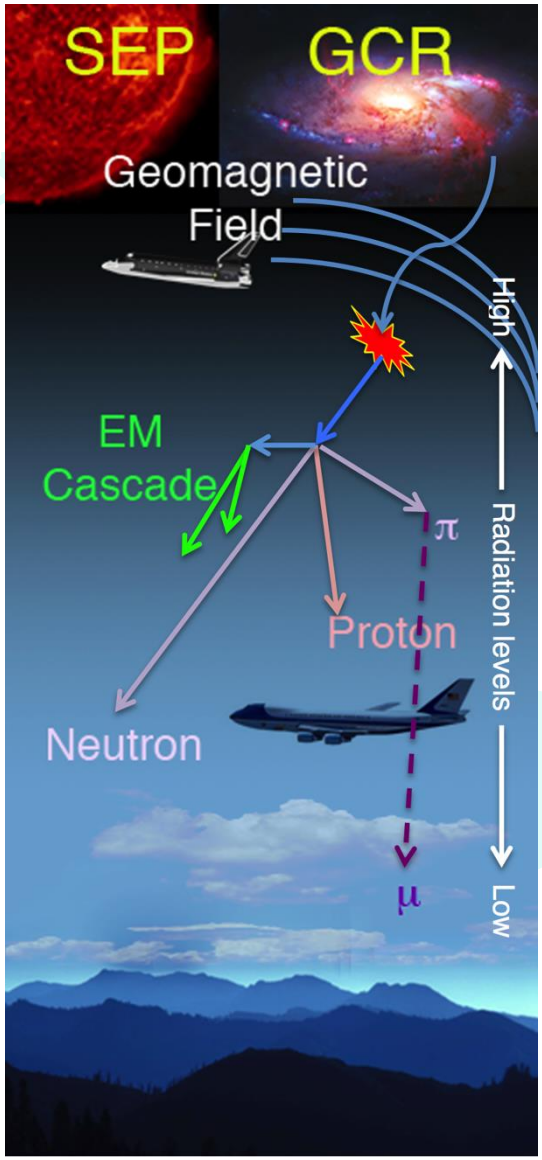
Real-time radiation weather for commercial aviation on the horizon

SWW Panel Space Weather and Aviation
April 18, 2018

W. Kent Tobiska

Space Environment Technologies and American Commercial Space Weather Association



Space weather creates a dynamic radiation environment at aviation altitudes

Aviation radiation sources

- ✓ **global phenomenon** GCRs (career health issue and avionics SEUs)
- ✓ **high latitude phenomenon**
  - ✓ **Extended major events** SEPs (fleet operations and aircrew/passenger safety issue)
  - ○ **Short-term minor events** precipitating outer radiation belt energetic electrons (career health issue)
  - ○ **Instantaneous minor events** terrestrial gamma-ray flashes (TGFs) (avionics EMI)

Where are we today? Progress towards aviation radiation specification & forecast

- **DETECTORS**
  - ✓ Geiger counters
  - ✓ Bubble detectors
  - ✓ TEPC
  - ✓ Liulin
  - ✓ RaySure

1950-1990
Step 1: Discovery

- **DETECTORS**
  - ✓ Bubble
  - ✓ TEPC
  - ✓ Liulin
  - ✓ RaySure
  - ✓ ARMAS
- **MODELS**
  - ✓ CARI-6
  - ✓ NAIRAS
  - ✓ PANDOCA

1990-2016
Step 2: Validation

- **DETECTORS**
  - ✓ ARMAS
  - ✓ ATED
- **MODELS**
  - ✓ NAIRAS
  - ✓ CARI-7
  - ✓ PANDOCA
  - ✓ KREAM

2017-2020
Step 3: Monitoring
(a few daily NAT or NoPAC flights; tech demo regional monitoring; demo data assimilation)

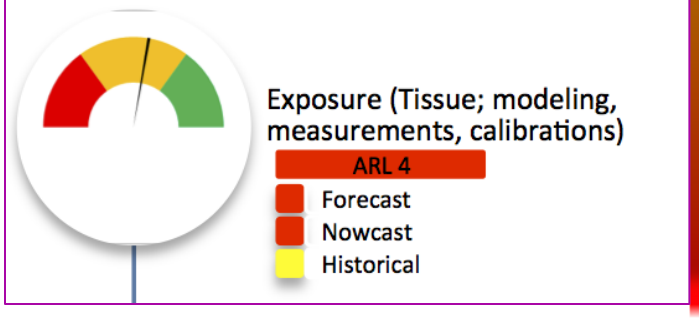
- **DETECTORS**
  - ✓ ARMAS
  - ✓ ATED
- **MODELS**
  - ✓ NAIRAS
  - ✓ CARI-7

2021-
Step 4: Specification and forecast
(100+ daily flights for track truth, continuous balloon loiter or hi-alt/long endurance regional monitoring; operational data assimilation and demo ensemble modeling)

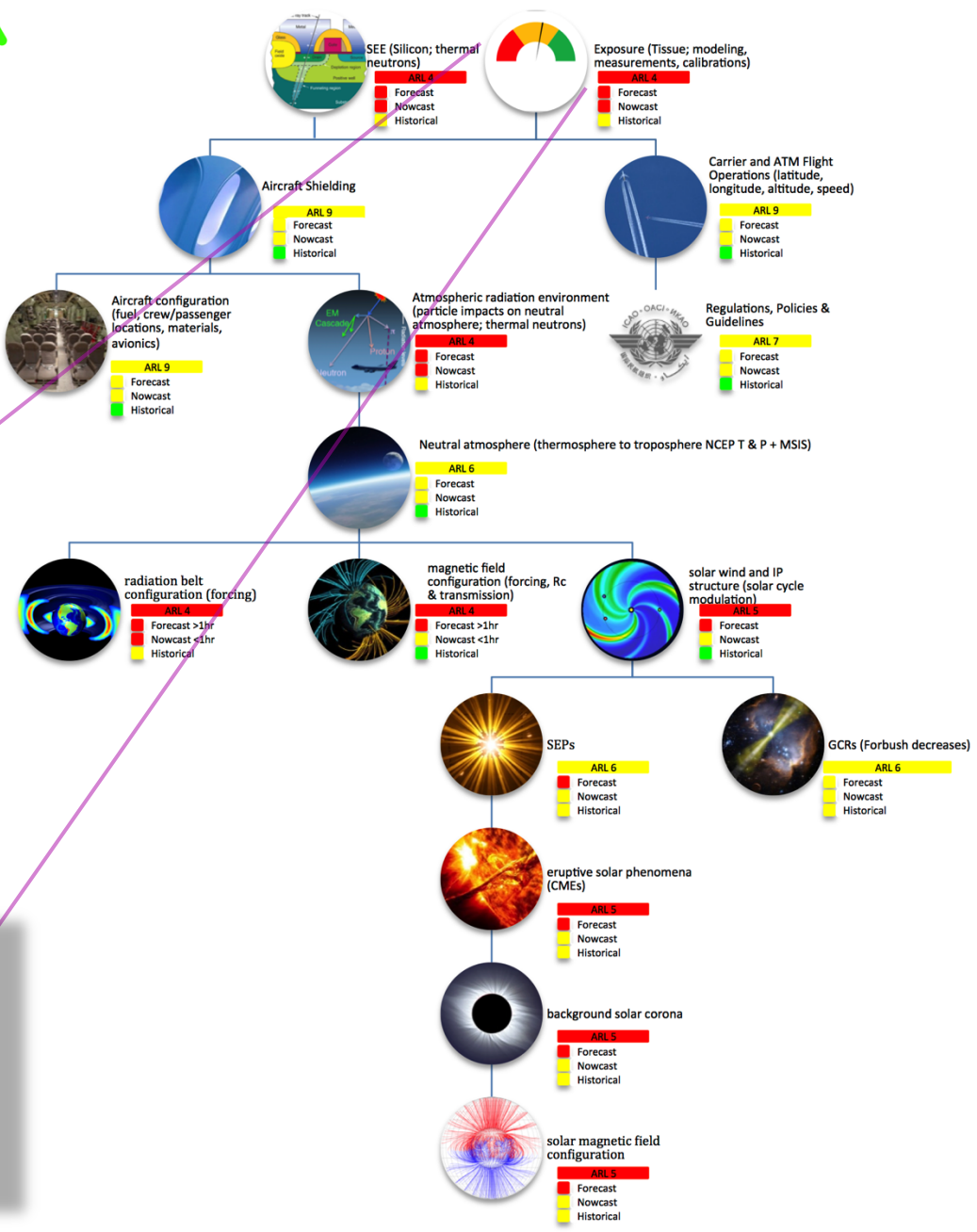
SWW 2018

SAFESKY ROADMAP

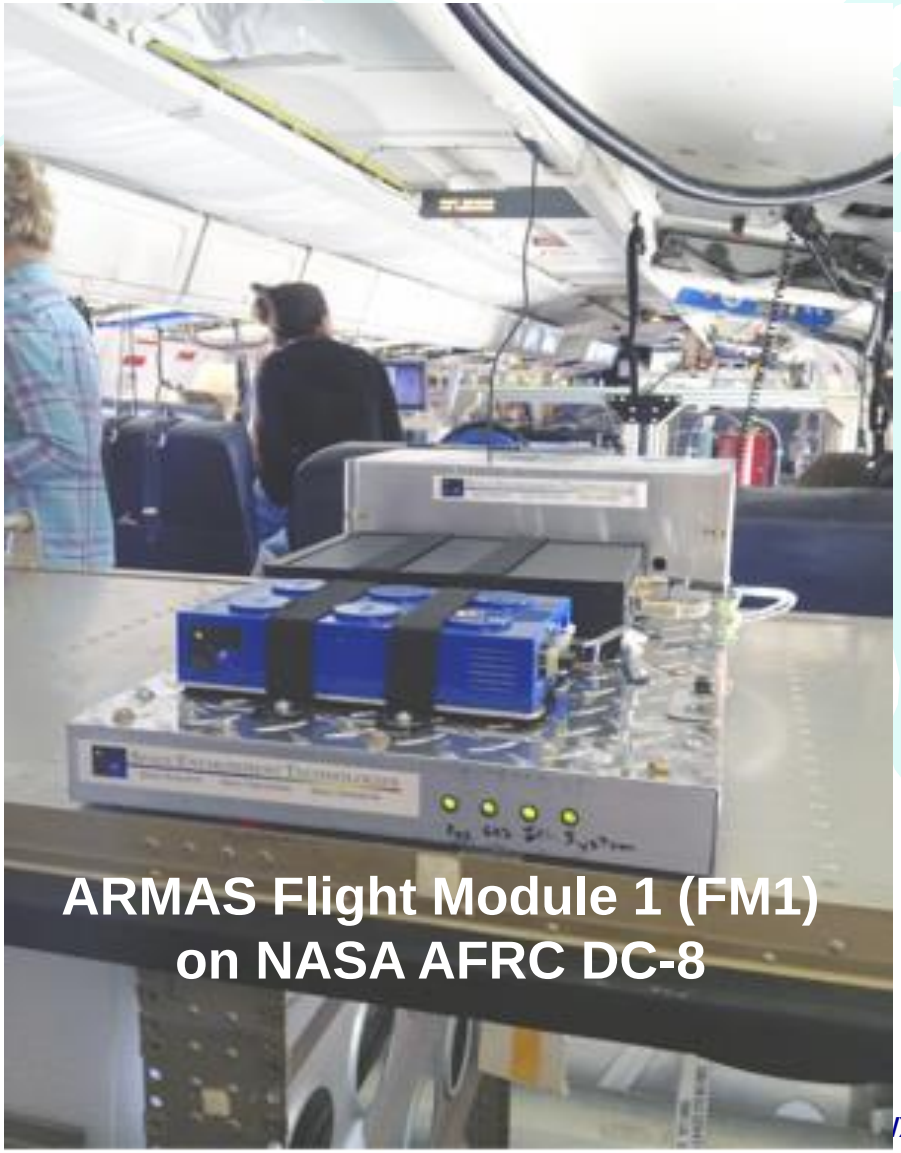
status: 5 papers in preparation for SWJ

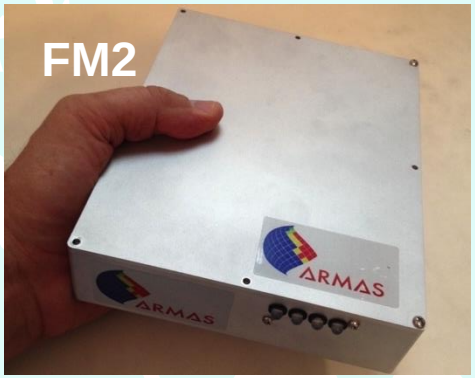


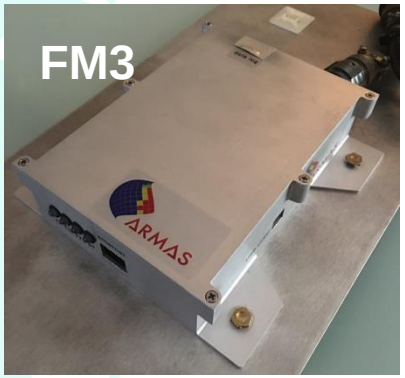
PRIORITY



ARMAS real-time measurements demonstrated


ARMAS Flight Module 1 (FM1)
on NASA AFRC DC-8





ARMAS FM6

Features:

- Measurement of absorbed dose in silicon
- Small size and mass
- Data retrieval via Bluetooth pairing with smartphone or tablet app
  - Display current status on app
  - use plane's WiFi to transmit to ground as needed
- Level 4 real-time dose rates provided (effective dose rate)

Status:

- First 6 units in production for specific customers
- FM6A delivered Jan 2018
- FM6B-F deliveries in June 2018

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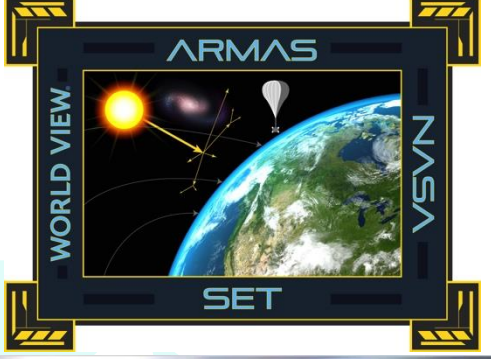
ARMAS World View



SUCCESS!

- Stratospheric balloon flight 29 March 2018
- Real-time data extended to 35 km
- Highly dynamic environment found

WORLD VIEW

2018/03/29 15:38:35

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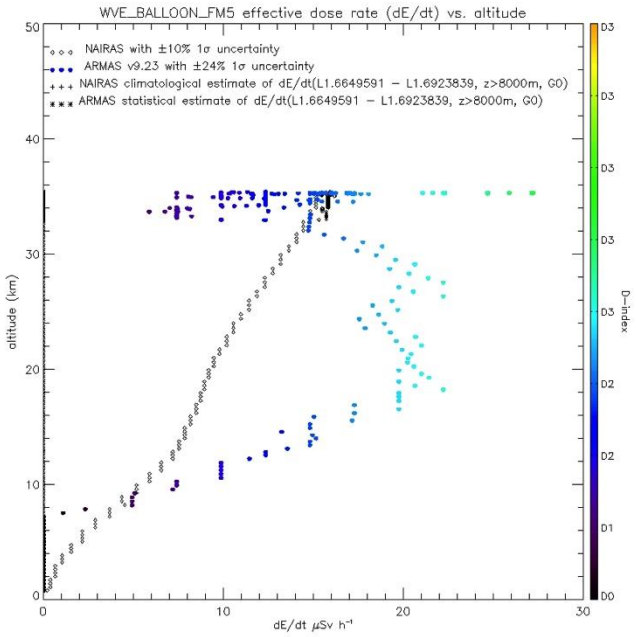
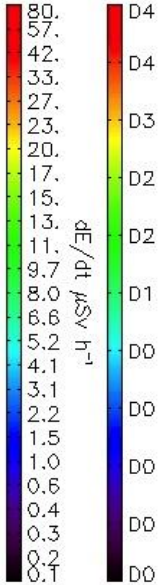
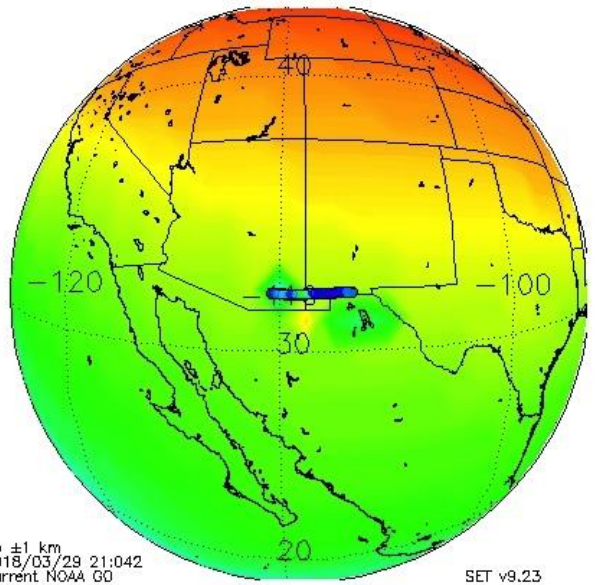
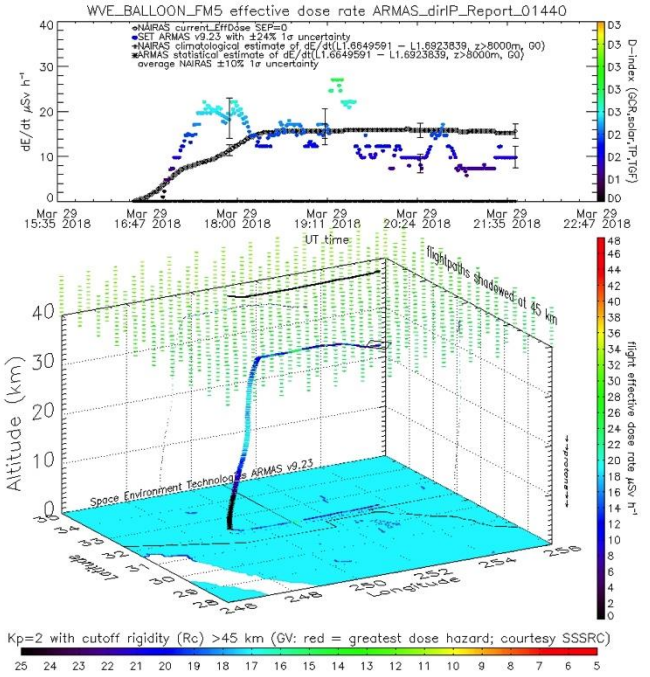
ARMAS World View

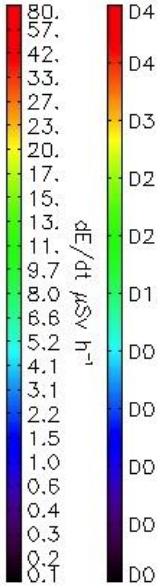
ARMAS World View Results

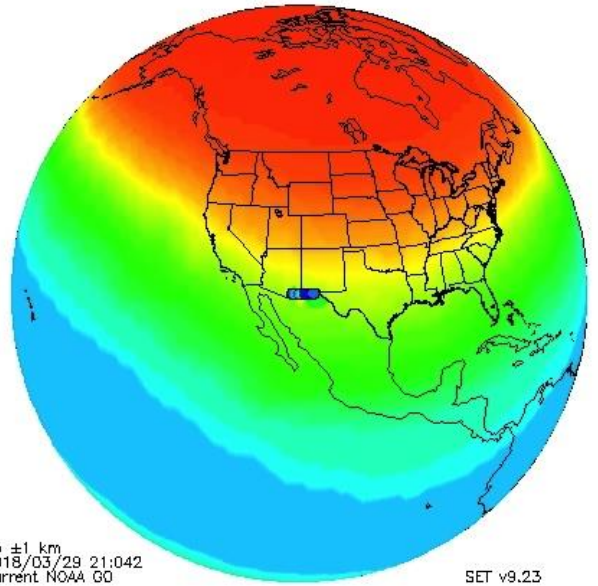












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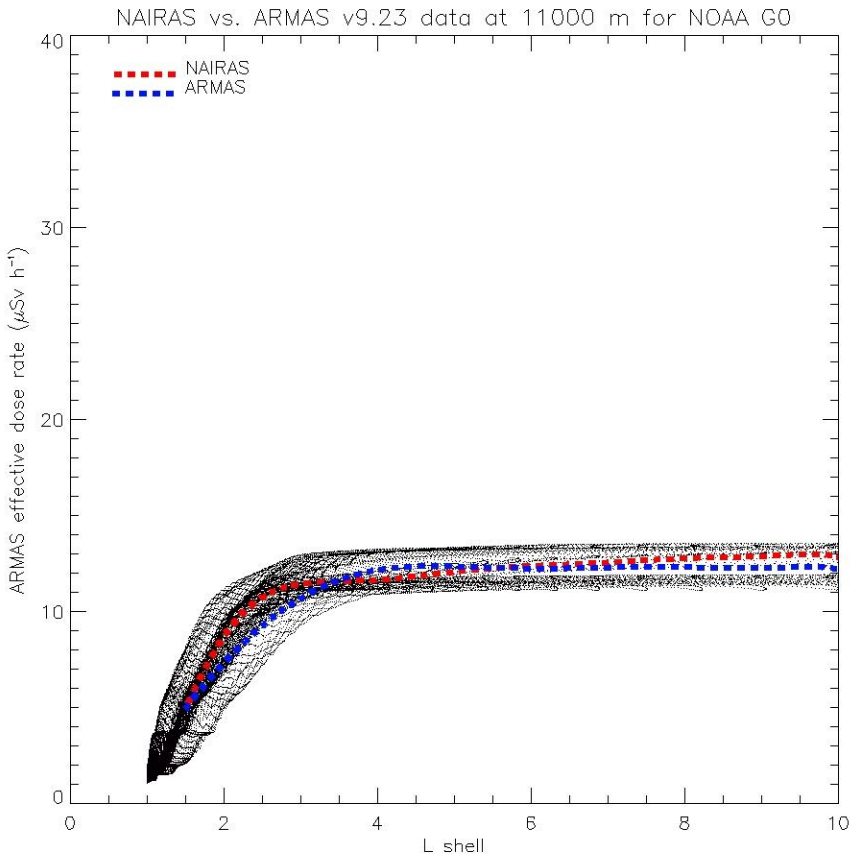
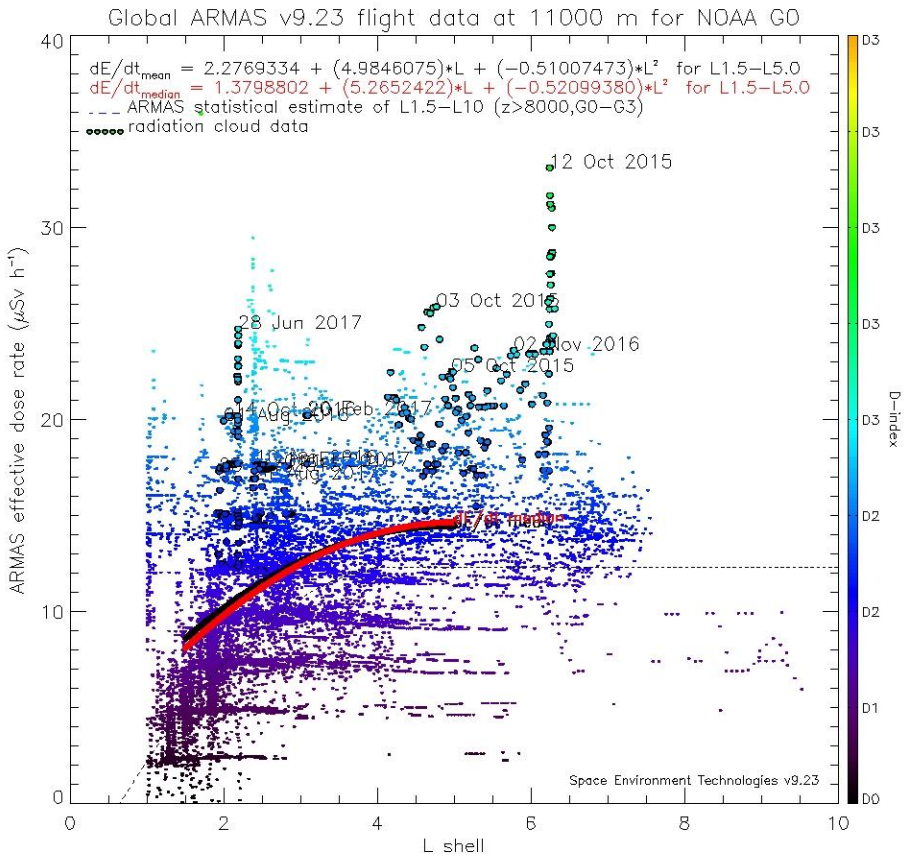
Dose rates vs. L shell at 11 km during NOAA G0 conditions

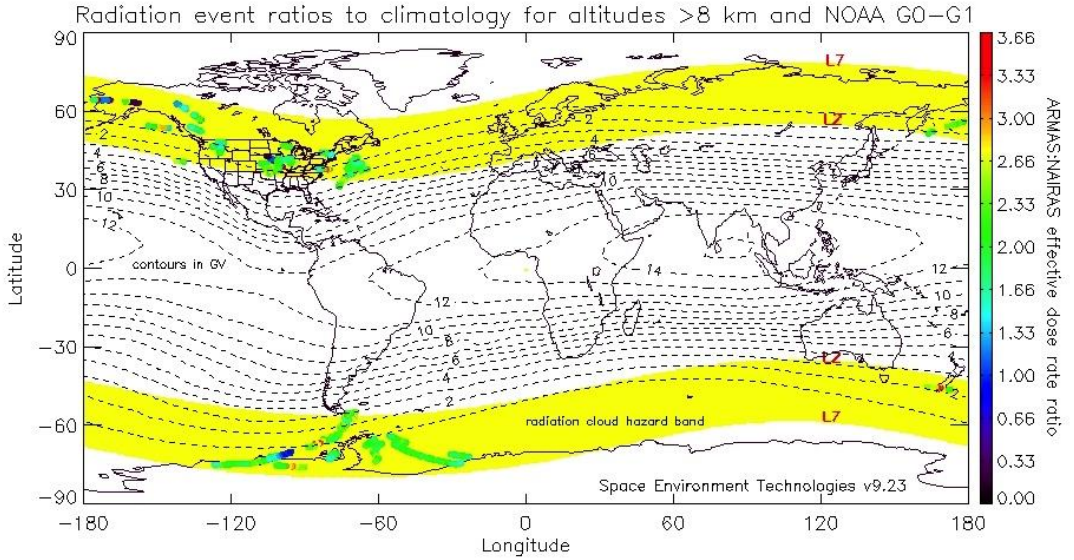
CLIMATOLOGY

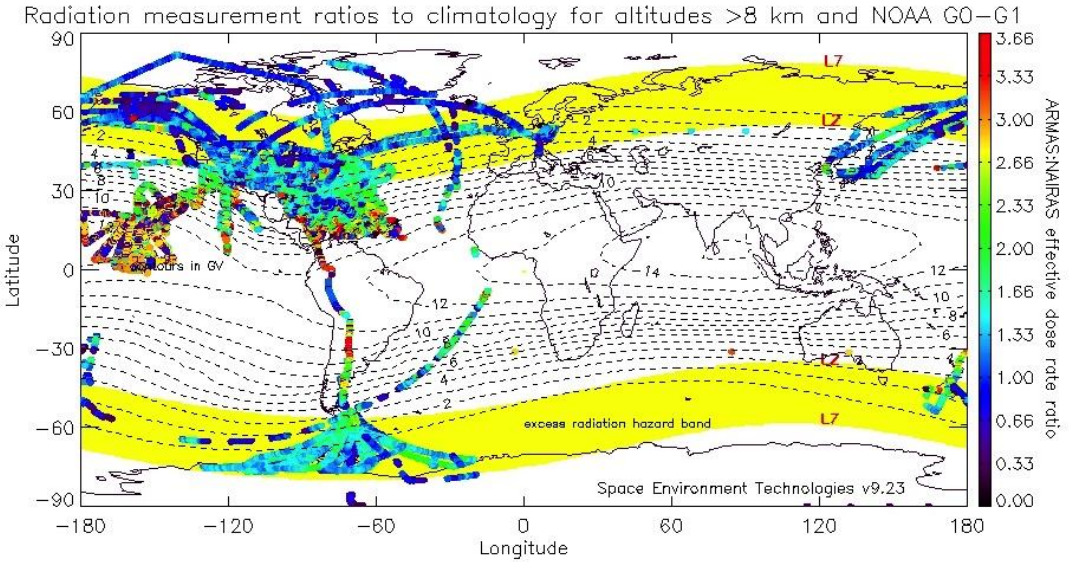


STATISTICAL DATABASE

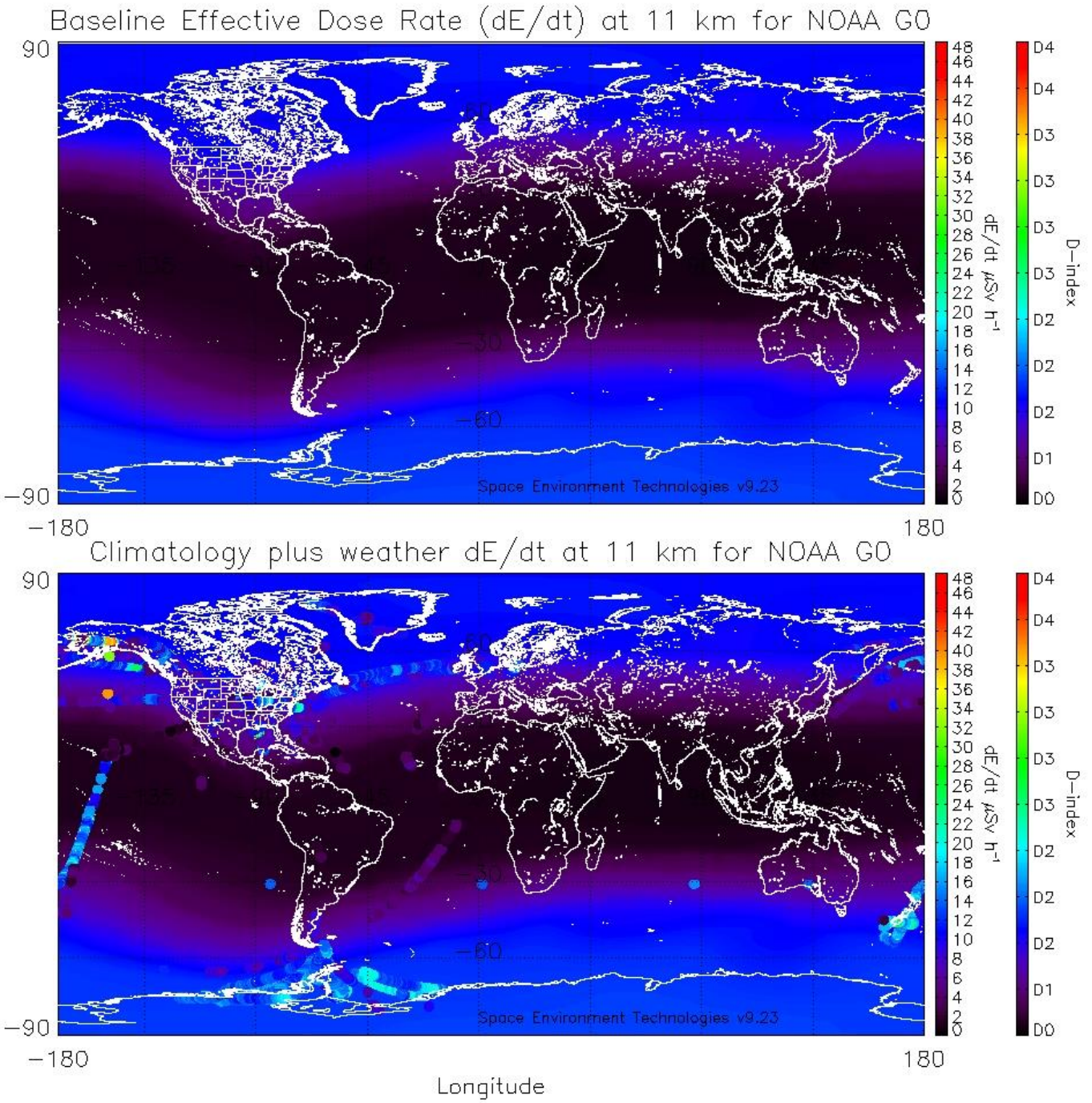


Event and database ratios to NAIRAS in preparation for data assimilation





Dose rate climatology and weather at 11 km during NOAA G0 conditions



Tobiska

Specification and forecasting

Users: air traffic management, company operations, pilots

- 24-hour forecast (climatology, top left)
- Current epoch (specification, bottom left)
- Flight track (due diligence archive, top right)
- Regional track (situational awareness, bottom right)