

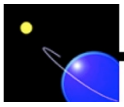
# Characterizing the global aviation radiation environment based on models and management databases

**CCMC Workshop**

**April 26, 2018**

**W. Kent Tobiska**

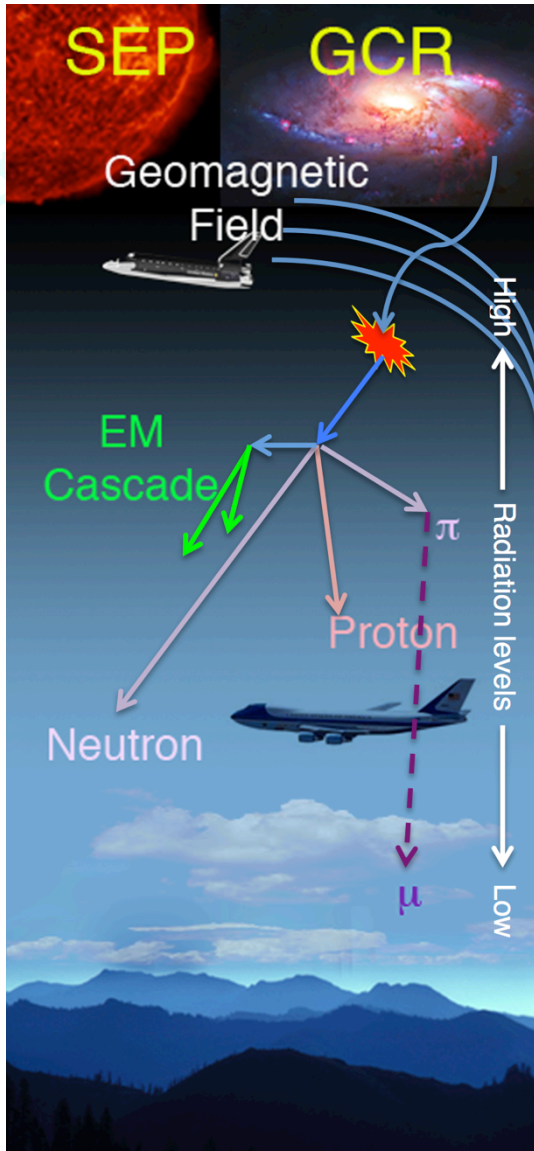
Space Environment Technologies

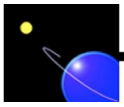


# Space weather creates a dynamic radiation environment at aviation altitudes

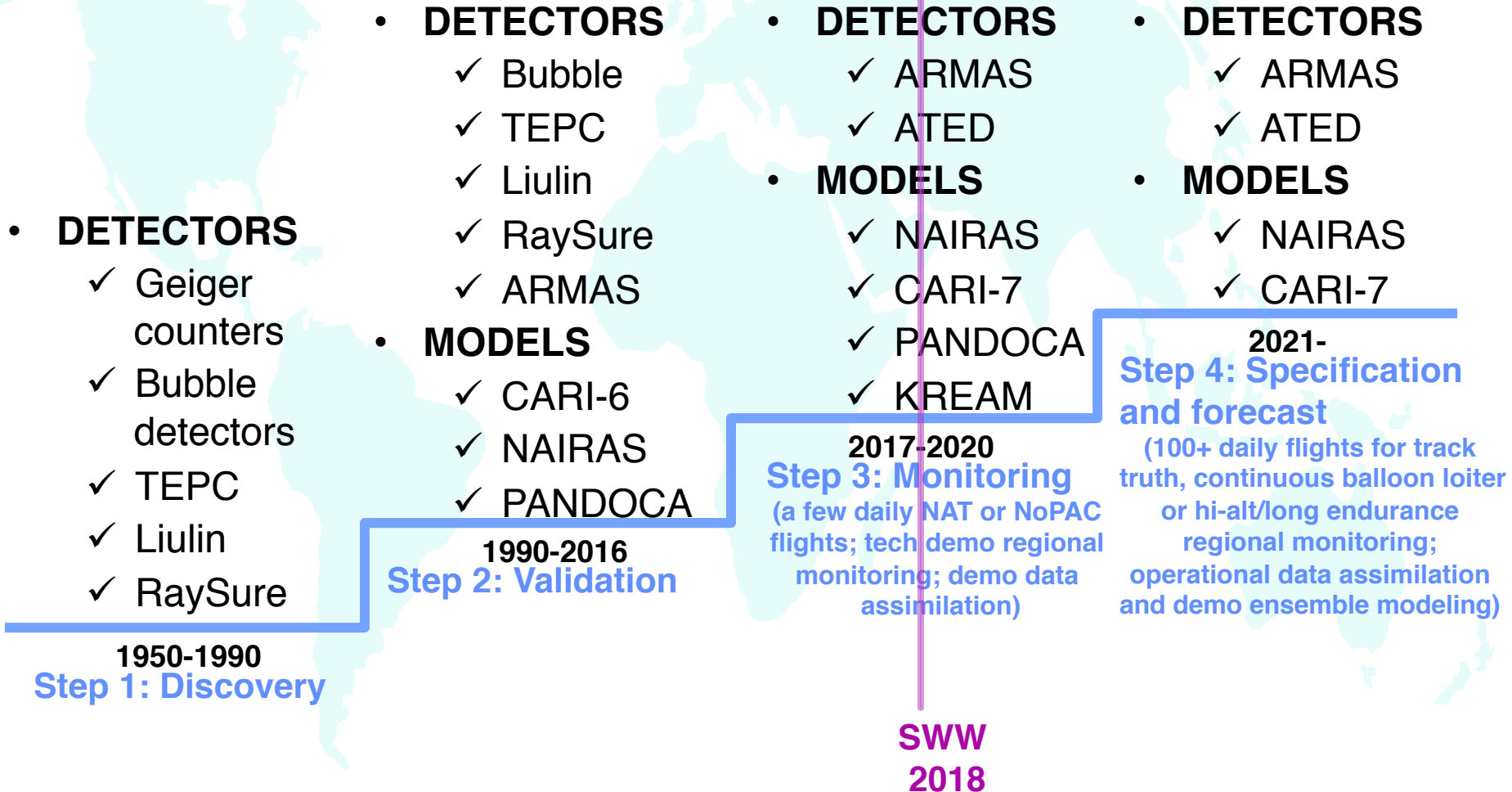
## Aviation radiation sources

- ✓ **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

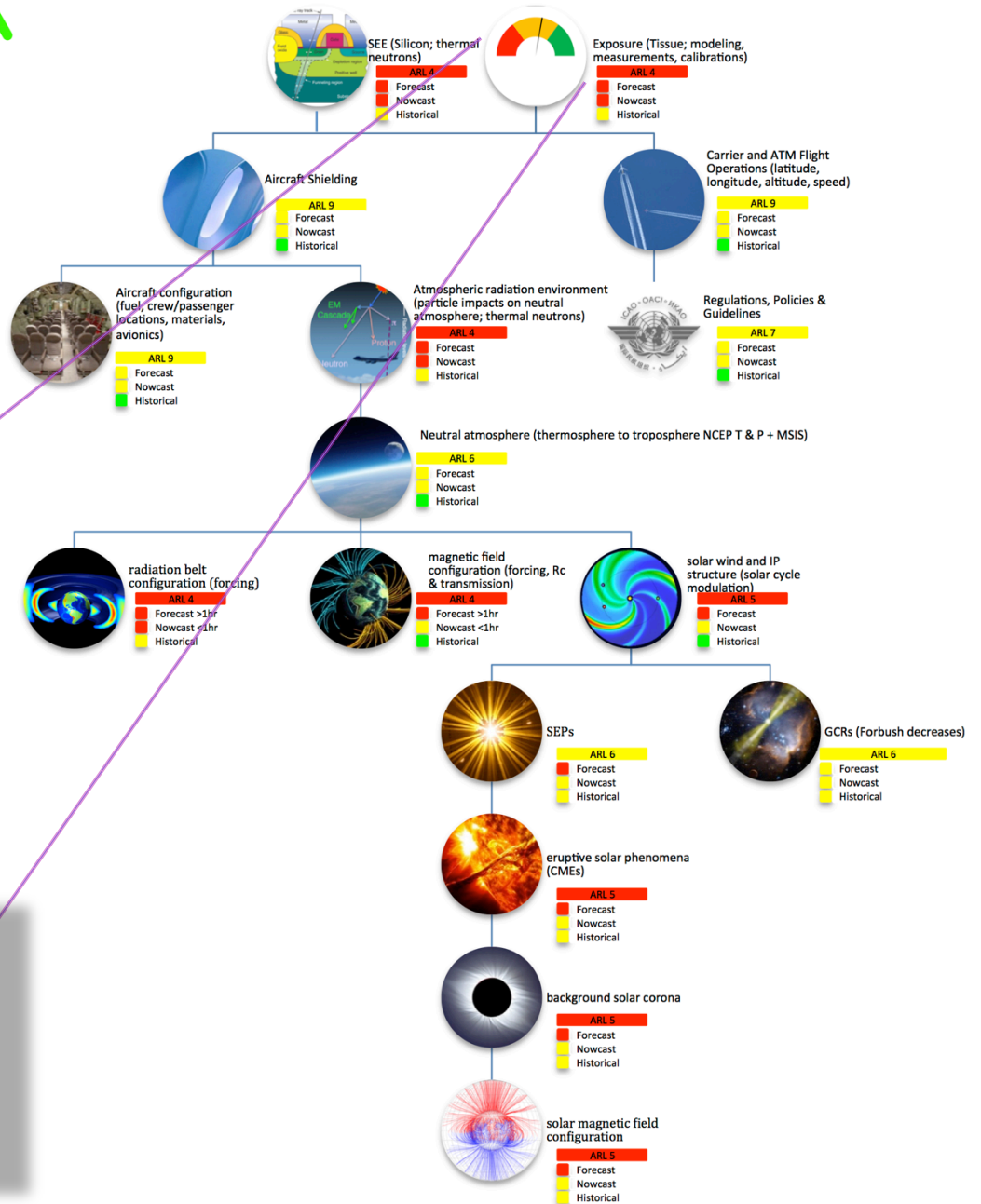


# SAFESKY ROADMAP

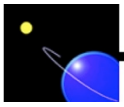
status: 5 papers in preparation for SWJ

PRIORITY

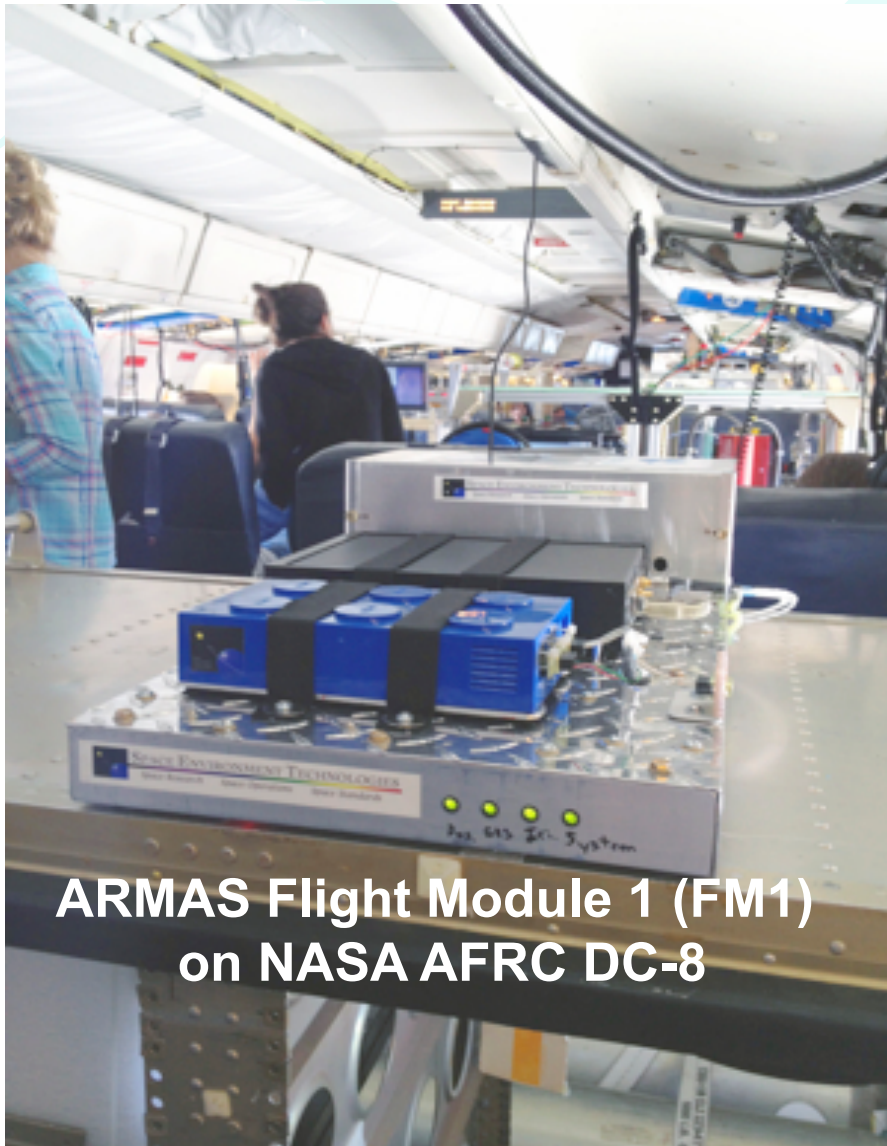
## Roadmap for Aviation Radiation Safety



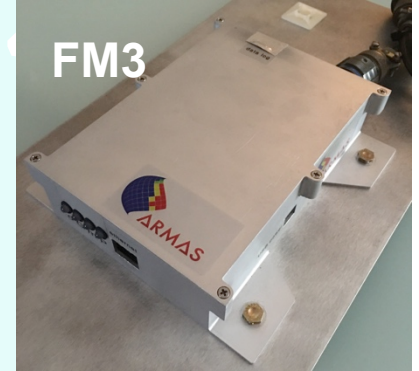
Exposure (Tissue; modeling, measurements, calibrations)  
ARL 4  
Forecast  
Nowcast  
Historical

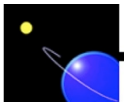


# ARMAS real-time measurements demonstrated



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





## Features:

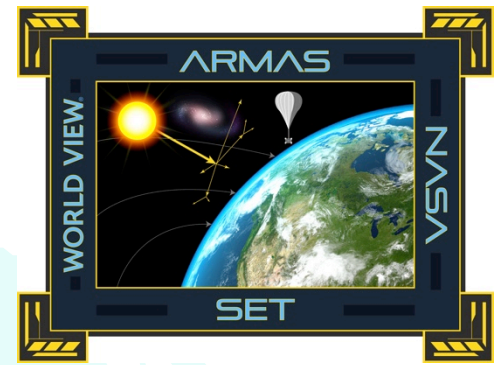
- ◆ Measurement of absorbed dose in silicon
- ◆ Small size and mass
- ◆ Data retrieval via Bluetooth pairing with smartphone or tablet app
  - Display current status on app
  - use plane's WiFi to transmit to ground as needed
- ◆ Level 4 real-time dose rates provided (effective dose rate)

## Status:

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

# ARMAS FM6

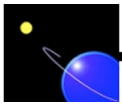




# ARMAS World View

## SUCCESS!

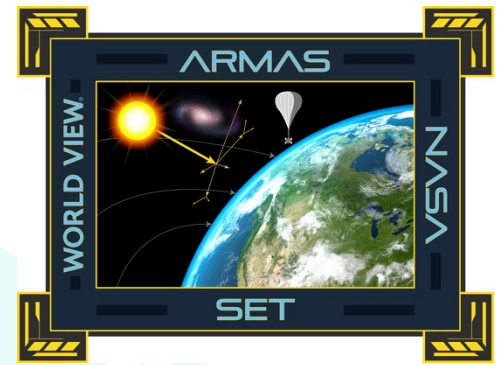
- Stratospheric balloon flight 29  
March 2018
- Real-time data  
extended to 35 km
- Highly dynamic  
environment found



SPACE ENVIRONMENT TECHNOLOGIES

Space Weather Division

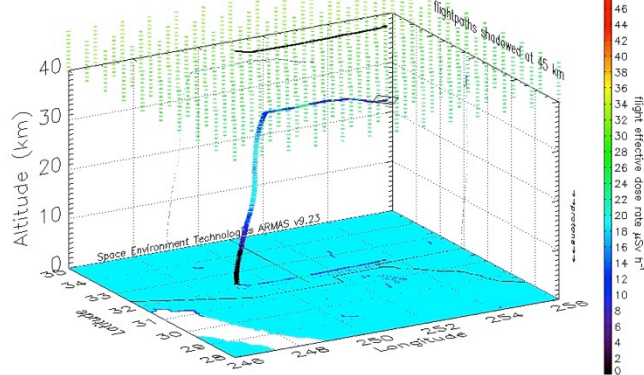
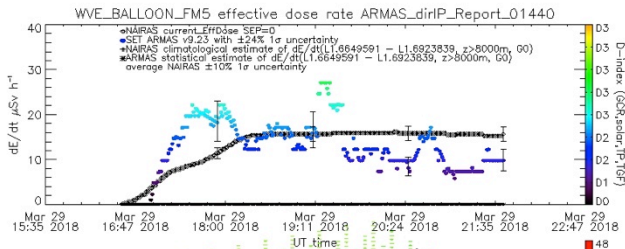
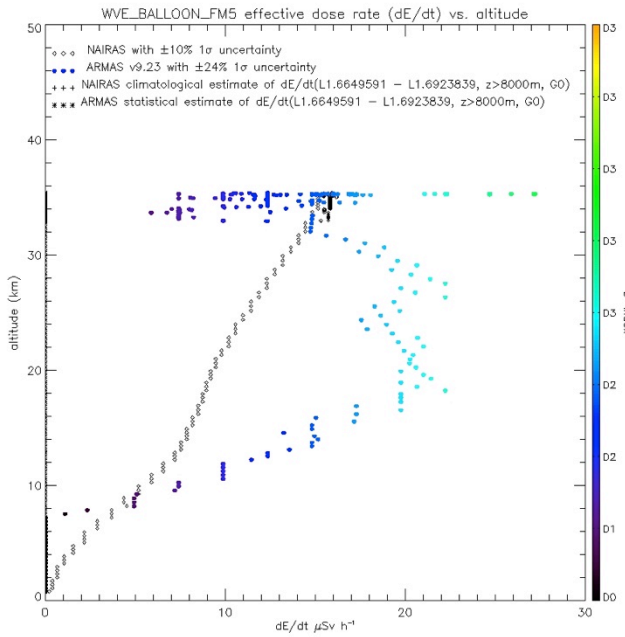
# ARMAS World View



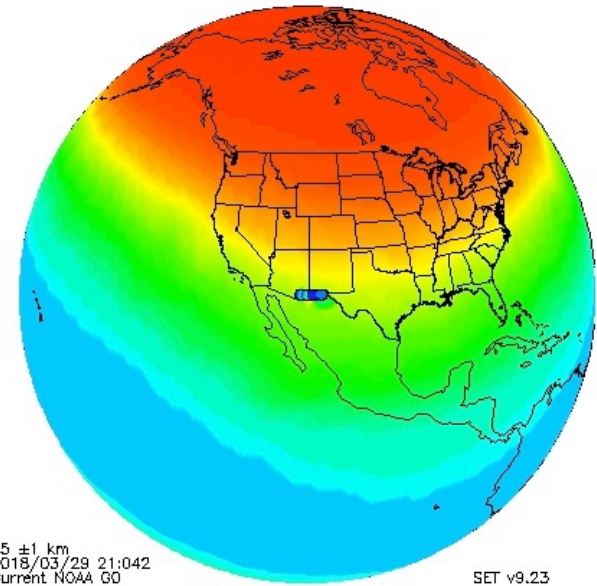
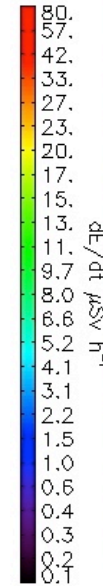
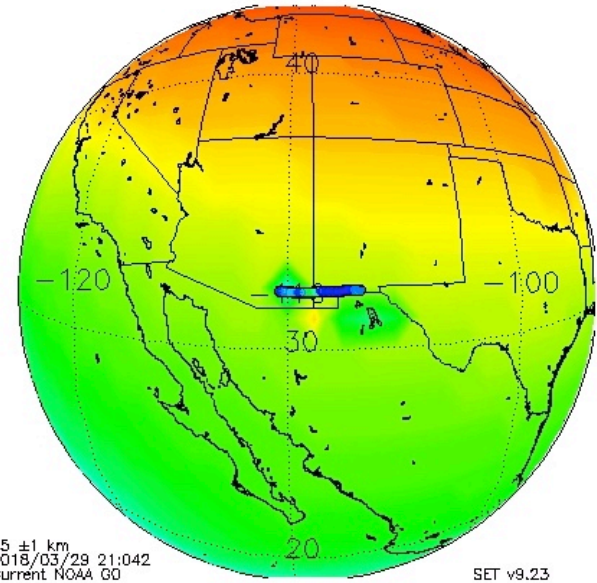
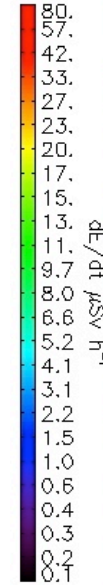




# ARMAS World View Results

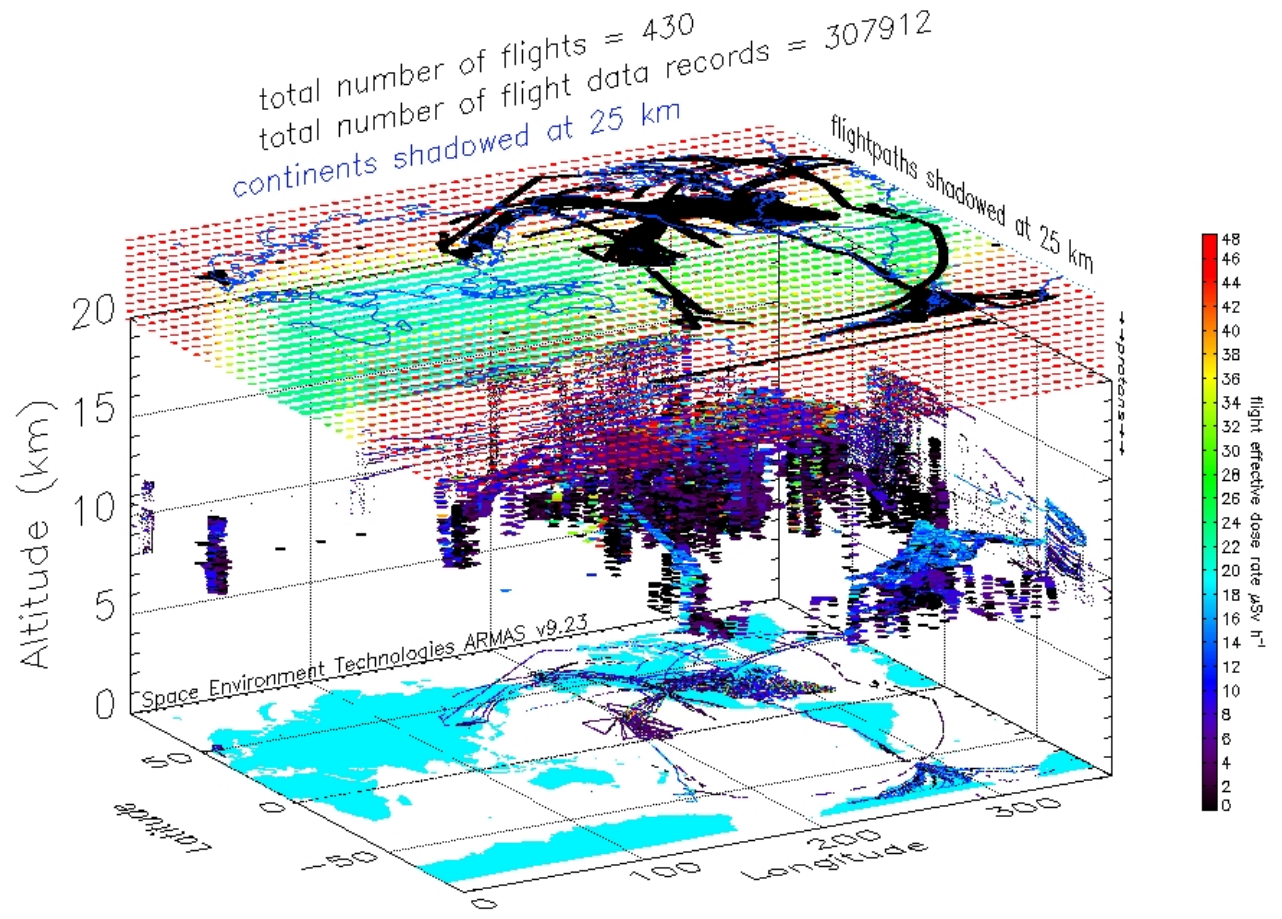
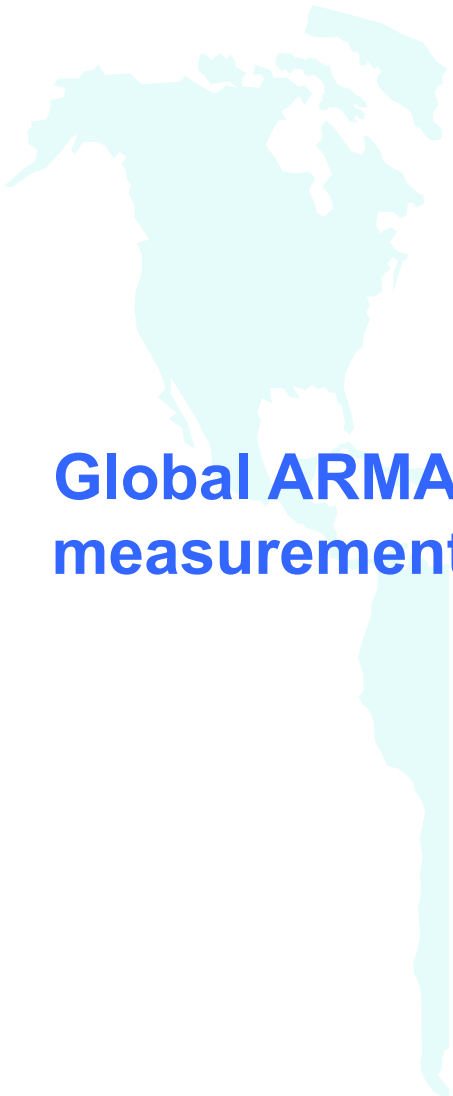


Kp=2 with cutoff rigidity (Rc) >45 km (GV: red = greatest dose hazard; courtesy SSSRC)



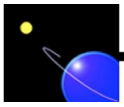
ARMAS global dose rates >8 km

# Global ARMAS measurements



Tobiska

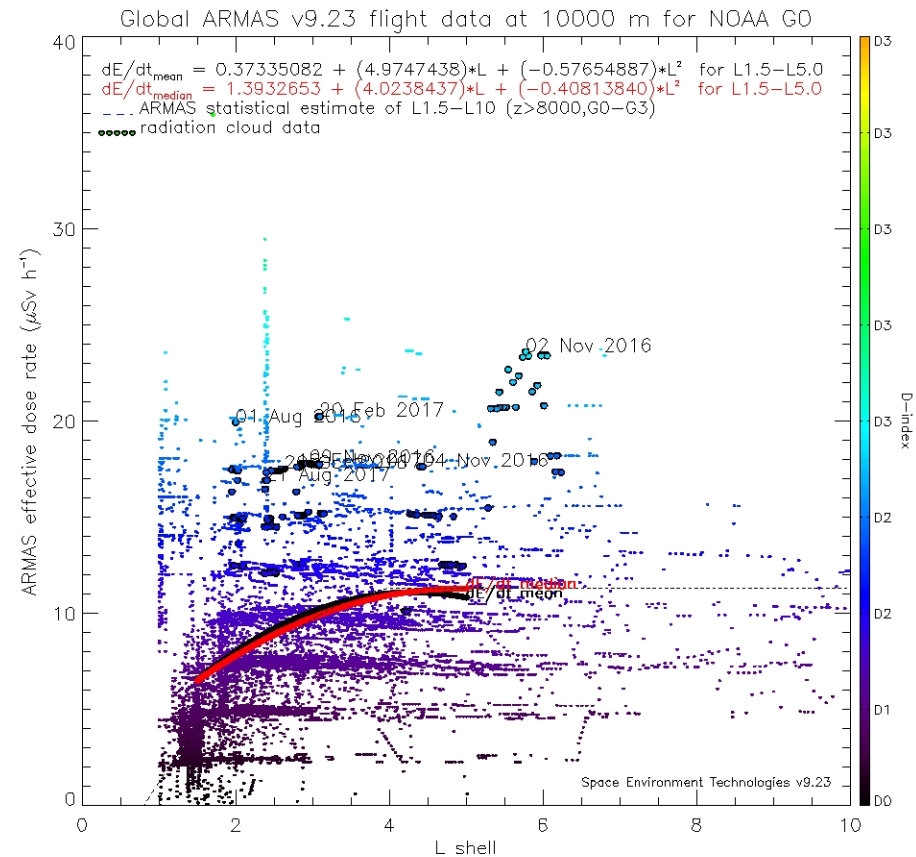
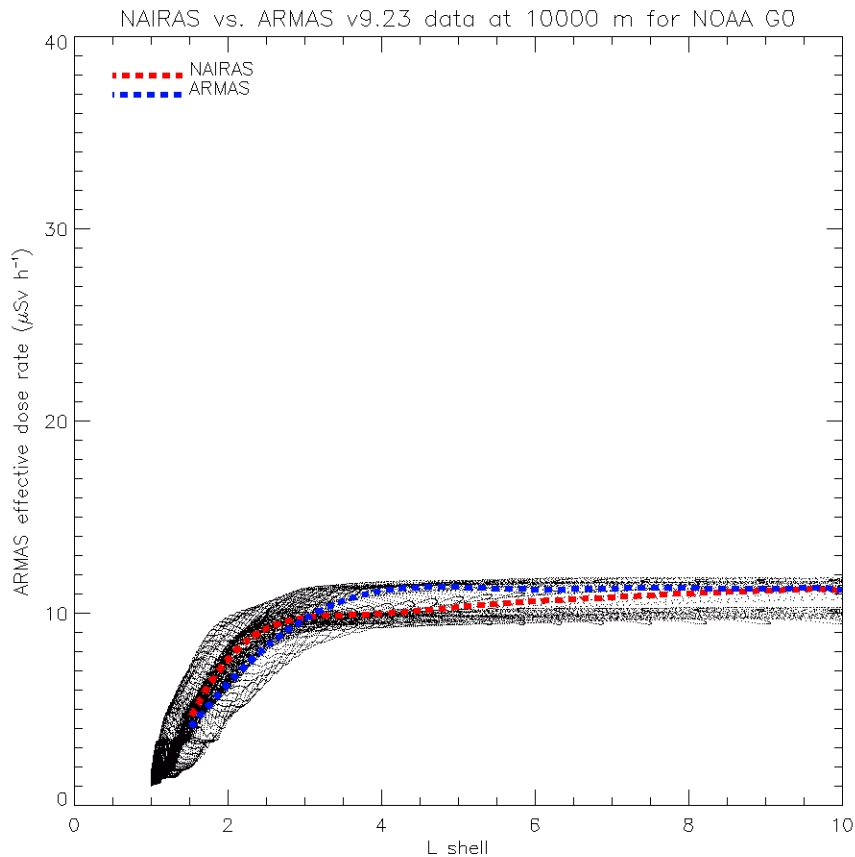


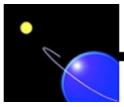


# Dose rates vs. L shell at 10 km during NOAA G0 conditions

## CLIMATOLOGY

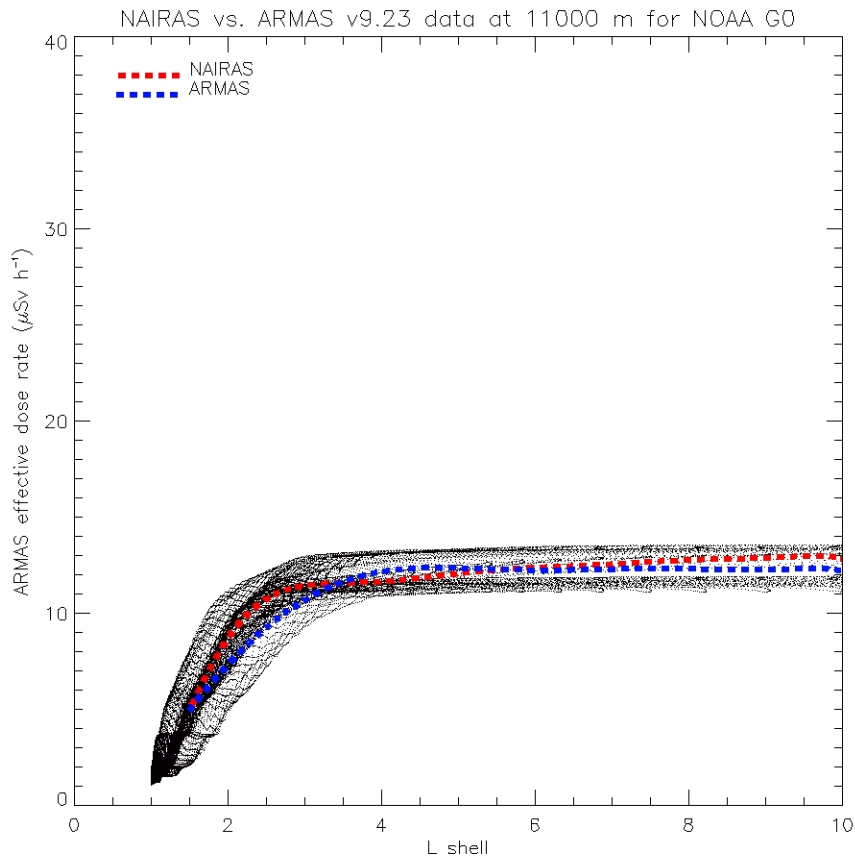
## STATISTICAL DATABASE



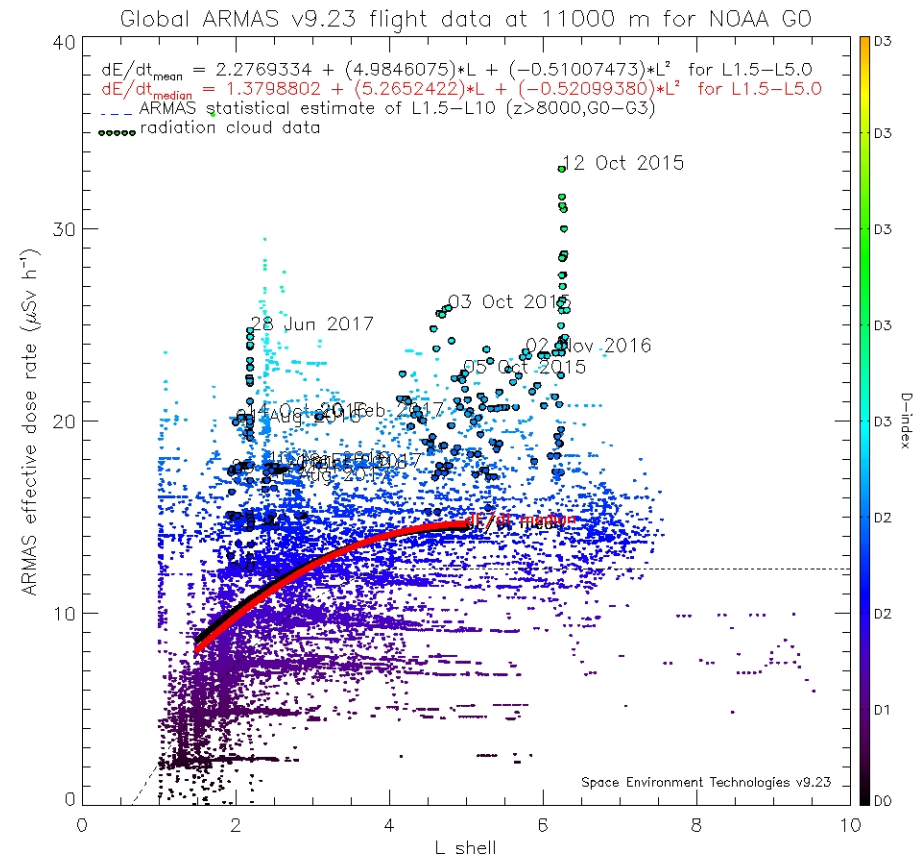


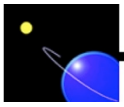
# Dose rates vs. L shell at 11 km during NOAA G0 conditions

## CLIMATOLOGY



## STATISTICAL DATABASE

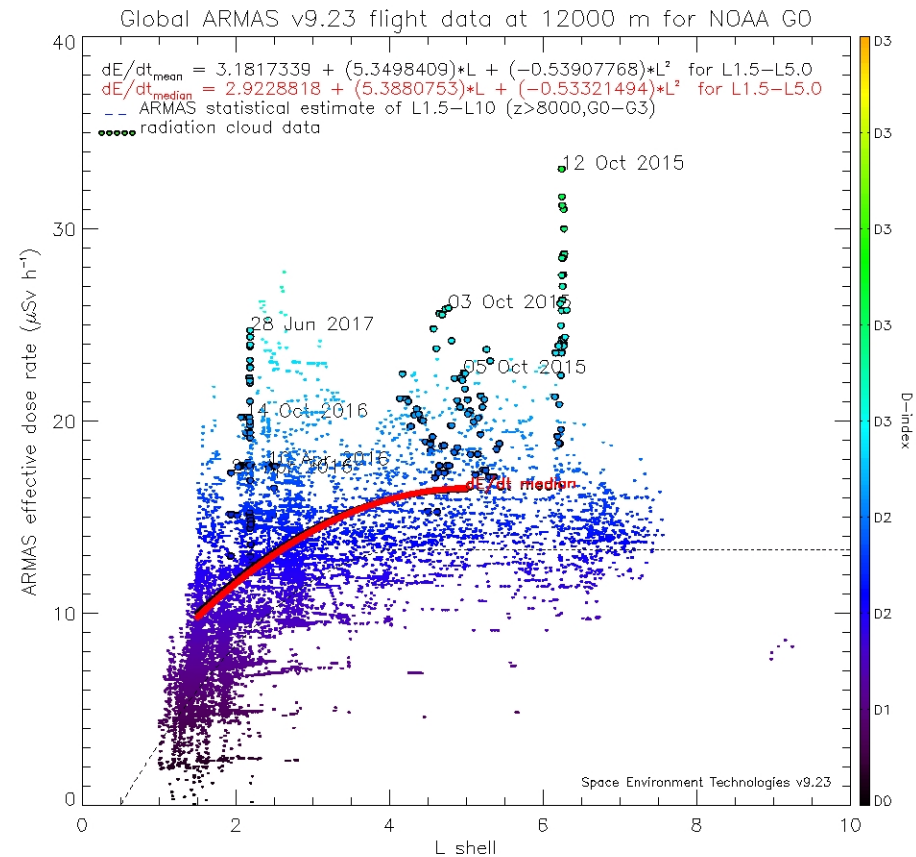
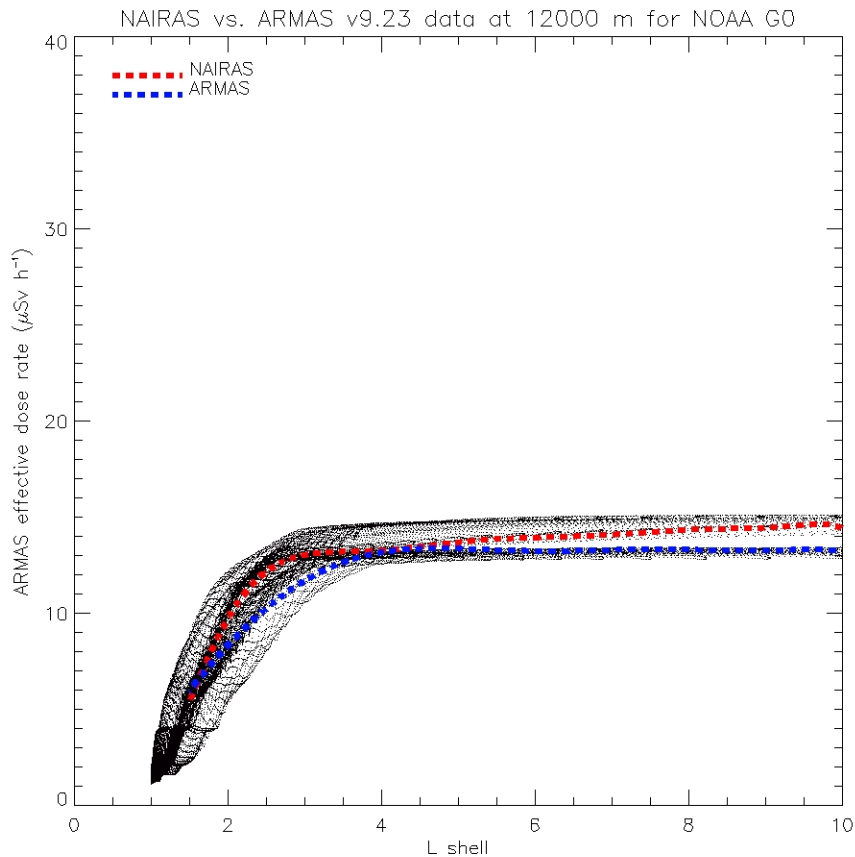


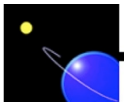


# Dose rates vs. L shell at 12 km during NOAA G0 conditions

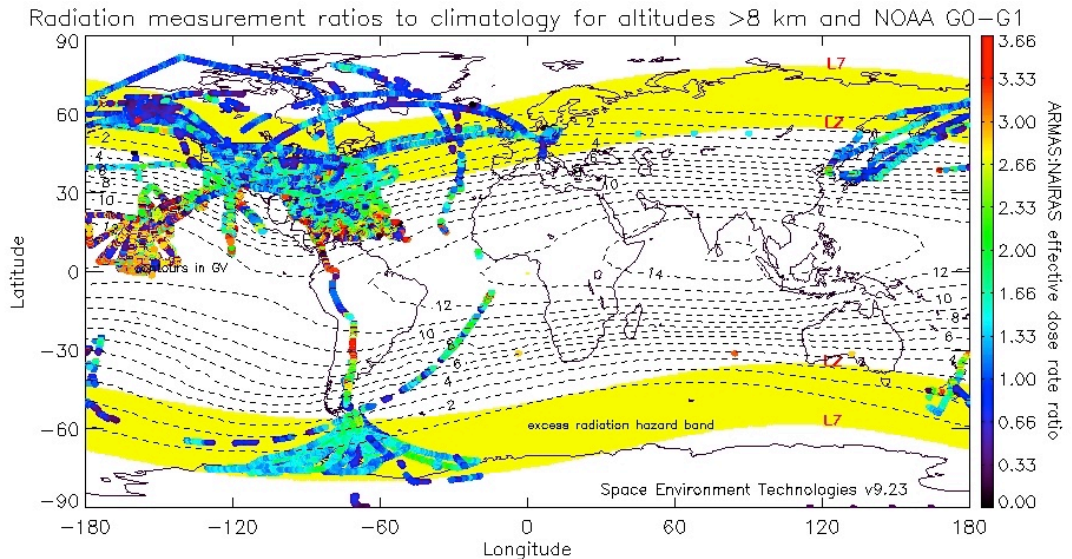
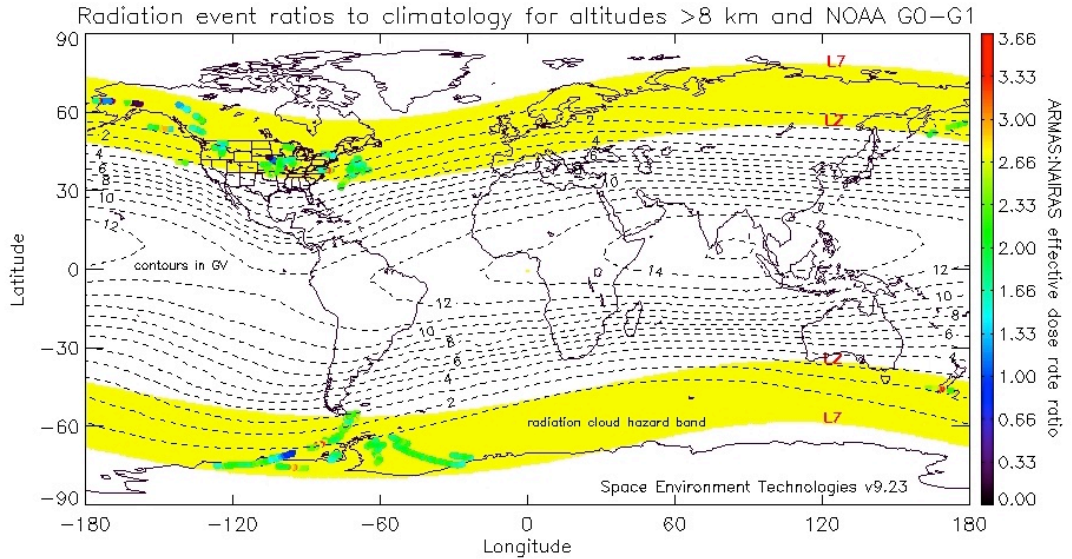
## CLIMATOLOGY

## STATISTICAL DATABASE



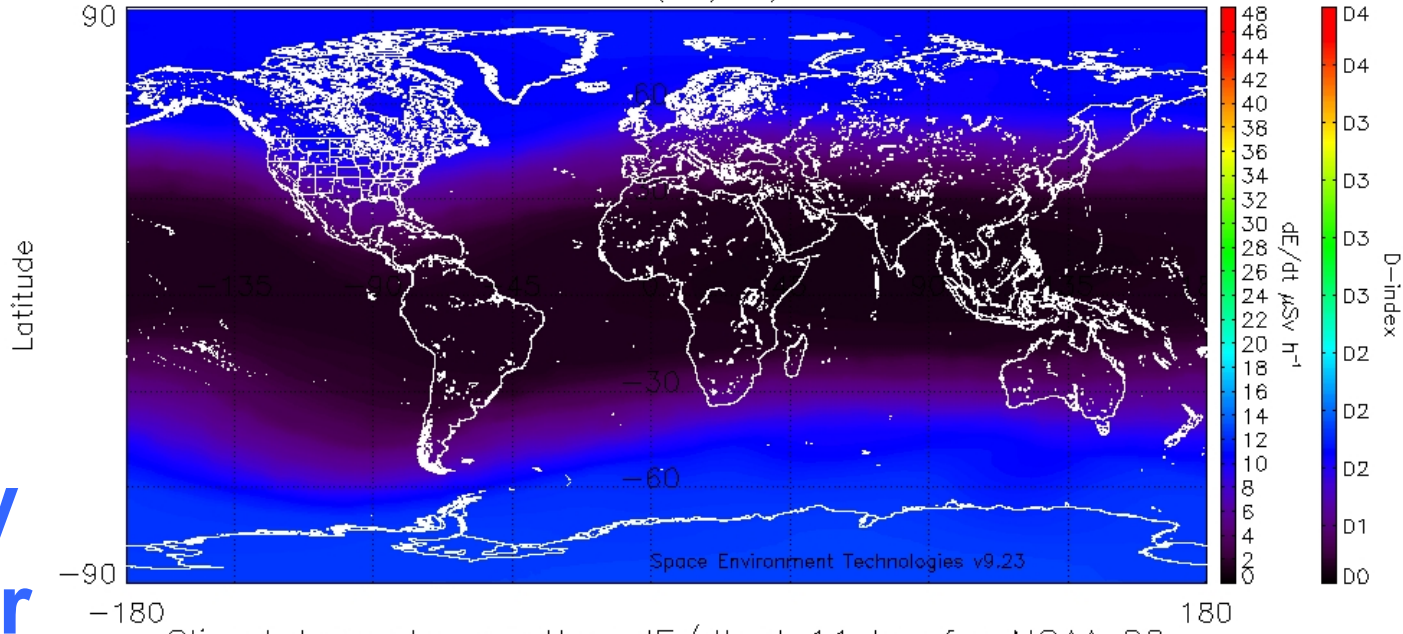


Event and database ratios to NAIRAS in preparation for data assimilation

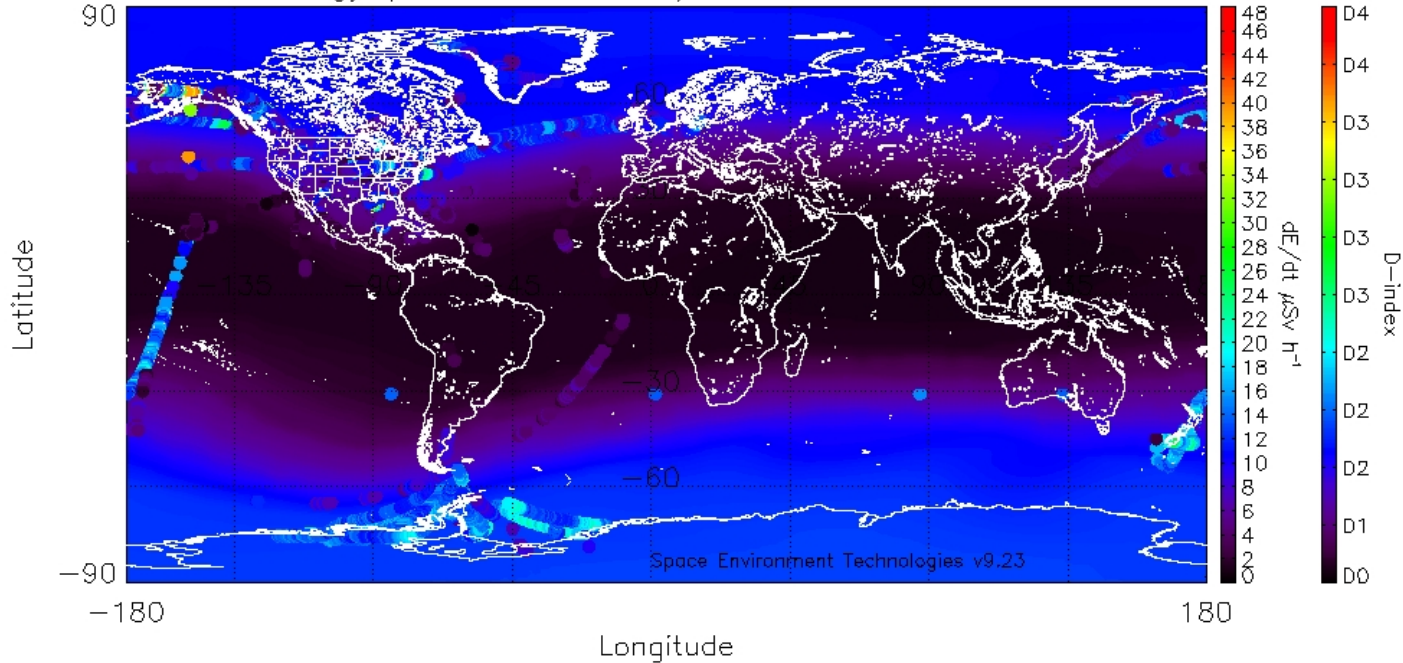


# Dose rate climatology and weather at 11 km during NOAA G0 conditions

Baseline Effective Dose Rate (dE/dt) at 11 km for NOAA G0

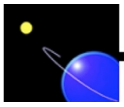


Climatology plus weather dE/dt at 11 km for NOAA G0









# 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)

