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ATom: ARMAS Program Absorbed and Equivalent Radiation Dose Rates for ATom-1 Campaign

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Dataset Version: 1

Summary

This dataset contains Level 2 (L2) absorbed radiation dose rates in silicon from the Automated Radiation Measurements for Aerospace Safety (ARMAS) system along ATom flight paths for the ATom-1 campaign conducted in July and August 2016. Absorbed dose rates measure how much energy is deposited in matter by ionizing radiation per unit time. The radiation sources can be from galactic cosmic rays, solar energetic particles, or Van Allen radiation belt energetic particles. Radiation can have adverse effects on human tissue and aerospace electronics, as well as profound effects on chemical species in the atmosphere, making them important to consider in atmospheric modeling and analyses. In this context, the derived ambient equivalent dose rates are also provided and relate the absorbed dose in human tissue to the effective biological damage of the radiation through a radiation weighting factor. In addition, visualizations of absorbed radiation dose for ATom-1 flight paths are included. The visualizations show the absorbed dose rates in silicon in the upper panel and the 3D representation of the flight in the bottom panel.

This dataset includes 11 data files in ICARTT (*.ict) format and 11 data files in JPEG (*.jpg) format.

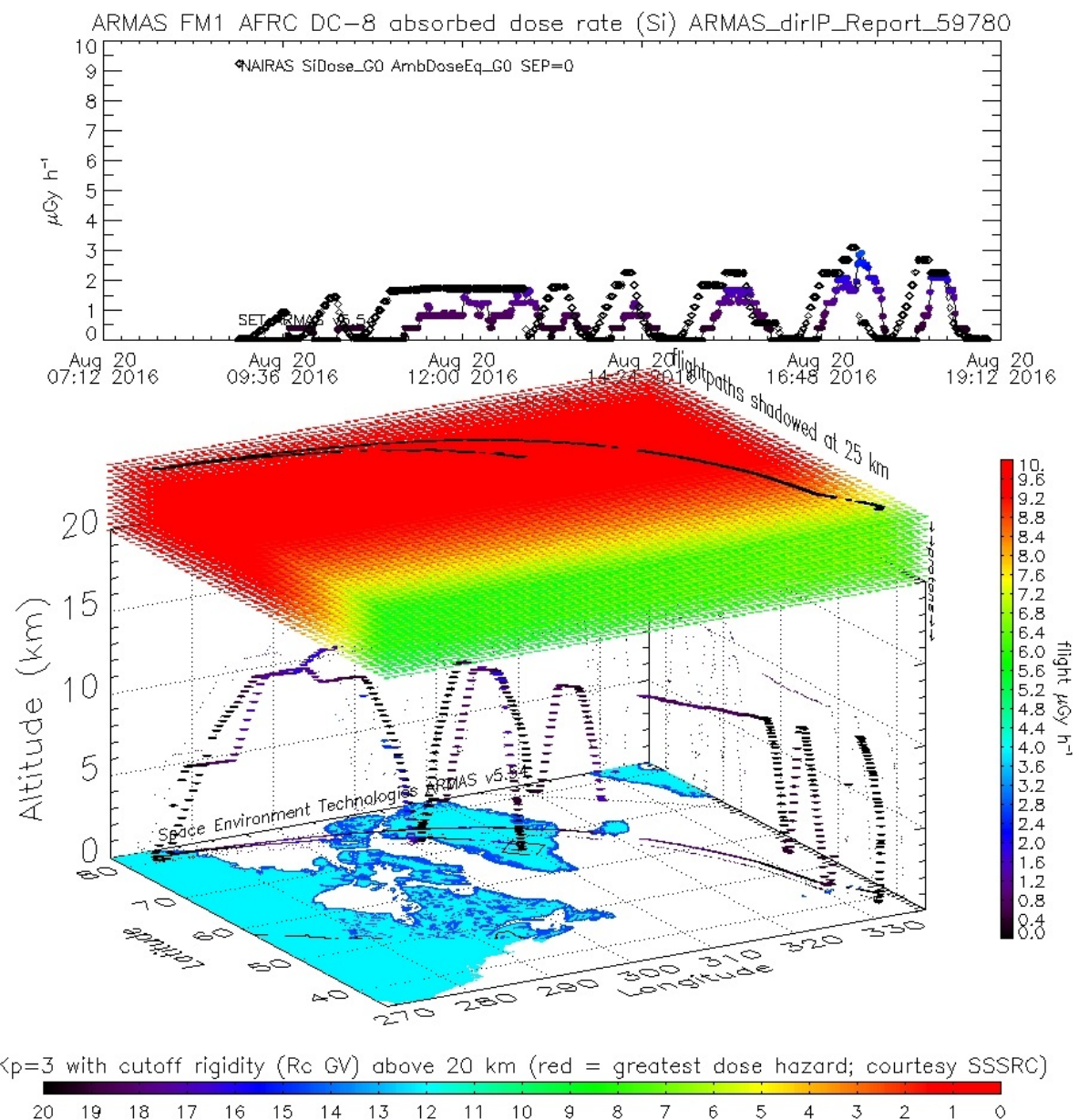


Figure 1. The Level 2 (L2) absorbed dose rate in silicon (top panel) and the 3D representation of the flight (bottom panel). The colored region above 20 km is the notional hazards of the incoming particle environment at the top of the atmosphere, where red indicates greater hazard (more particle flux) at the high latitudes while green represents lower hazard (lower particle flux and lower radiation exposure) in the equatorial region. Each dot is a 1-minute data record. Source: L2dose_rate_DC8_20160820_R0.jp

Citation

Tobiska, W.K. 2021. ATom: ARMAS Program Absorbed and Equivalent Radiation Dose Rates for ATom-1 Campaign. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1906>

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1. Dataset Overview

This dataset contains Level 2 (L2) absorbed radiation dose rates in silicon from the Automated Radiation Measurements for Aerospace Safety (ARMAS) system along ATom flight paths for the ATom-1 campaign conducted in July and August 2016. Absorbed dose rates measure how much energy is deposited in matter by ionizing radiation per unit time. The radiation sources can be from galactic cosmic rays, solar energetic particles, or Van Allen radiation belt energetic particles. Radiation can have adverse effects on human tissue and aerospace electronics, as well as profound effects on chemical species in the atmosphere, making them important to consider in atmospheric modeling and analyses. In this context, the derived ambient equivalent dose rates are also provided and relate the absorbed dose in human tissue to the effective biological damage of the radiation through a radiation weighting factor. In addition, visualizations of absorbed radiation dose for ATom-1 flight paths are included. The visualizations show the absorbed dose rates in silicon in the upper panel and the 3D representation of the flight in the bottom panel.

The Atmospheric Tomography Mission (ATom) was a NASA Earth Venture Suborbital-2 mission. It studied the impact of human-produced air pollution on greenhouse gases and on chemically reactive gases in the atmosphere. ATom deployed an extensive gas and aerosol payload on the NASA DC-8 aircraft for a systematic, global-scale sampling of the atmosphere, profiling continuously from 0.2 to 12 km altitude. Flights occurred in each of four seasons over a 4-year period.

Related Datasets

Wofsy, S.C., et al. 2018. ATom: Merged Atmospheric Chemistry, Trace Gases, and Aerosols. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1581>

- Data from all ATom instruments and all four flight campaigns, including aircraft location and navigation data, merged to several different time bases.

Wofsy, S.C., and ATom Science Team. 2018. ATom: Aircraft Flight Track and Navigational Data. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAC/1613>

- Flight path (i.e., location and altitude) data for each of the four campaigns provided in KML and CSV formats.

Acknowledgments

This work was supported by NASA's NAIRAS DECISION project (grant NNL07AA00C), NASA's SBIR Phase I and Phase II program (grants NNX11CH03P, NNX12CA78C), NASA's AFRC Phase III (grants NND14SA64P, NND15SA55C), NASA's Airborne Sciences Program, Armstrong Flight Research Center, and the South Korean Space Weather Center matching funds for SBIR Phase IIE.

2. Data Characteristics

Spatial Coverage: Global; flights circumnavigate the globe, primarily over the oceans

Spatial Resolution: Point measurements

Temporal Coverage: Periodic flights occurred during the ATom-1 campaign only.

Deployment	Date Range
ATom-1	July 29 - August 23, 2016
ATom-2	January 26 - February 21, 2017
ATom-3	September 28 - October 28, 2017
ATom-4	April 24 - May 21, 2018

Temporal Resolution: 1 minute

Data File Information

This dataset includes 11 data files in ICARTT (*.ict) format and 11 data files in JPEG (*.jpg) format. Files are associated with the ATom-1 campaign. ICARTT data files conform to the [ICARTT File Format Standards V1.1](#).

DOSE_* files contain absorbed and equivalent dose rate measurements and L2doserate_* files contain visualizations of dose rates. DOSE_* files are named DOSE_DC8_YYYYMMDD_R#.ict (e.g., DOSE_DC8_20160729_R1.ict), and L2doserate_* files are named L2doserate_DC8_YYYYMMDD_R#.jpg (e.g., L2doserate_DC8_20160729_R1.jpg), where YYYYMMDD is the start date (in UTC time) of the flight and R# is the file version or revision number.

Data File Details

Missing data are indicated by -9999.000.

Table 2. Variable names and descriptions in the data file DOSE_DC8_YYYYMMDD_R#.ict.

Variable	Units	Description
Start.UTC	seconds	Measurement start time. Number of seconds since 0000 UTC
Stop.UTC	seconds	Measurement stop time. Number of seconds since 0000 UTC
Mid.UTC	seconds	Mid-point of measurement. Number of seconds since 0000 UTC
Julian_date	numeric	Julian date of measurement
latitude	decimal degrees	Degrees North
longitude	decimal degrees	Degrees East
altitude	m ASL	Altitude of aircraft
ARML2dr	microGy_per_hour	ARMAS absorbed dose rate in silicon
NAIL2dr	microGy_per_hour	NAIRAS absorbed dose rate in silicon
ARML3dr	microSv_per_hour	ARMAS ambient dose equivalent rate
NAIL3dr	microSv_per_hour	NAIRAS ambient dose equivalent rate
Rc	GV	Cutoff rigidity
Q		Estimated quality factor at location
Mag_lat	decimal degrees	Degrees North in magnetic latitude (2015)
Mag_log	decimal degrees	Degrees East in magnetic longitude (2015)
Lshell		Magnetospheric L-shell parameter
P01	protons_per_cm2_s_sr	>1 MeV GOES protons

E06	electrons_per_cm2_s_sr	>600 keV GOES electrons
Dst	nT	Disturbance storm time index of magnetospheric ring current
flag		Flag for each parameter, where 0 = verified data 1 = unreliable dose rate 2 = Rc undetermined 3 = Q undetermined

3. Application and Derivation

ATom builds the scientific foundation for mitigation of short-lived climate forcers, in particular, methane (CH₄), tropospheric ozone (O₃), and Black Carbon aerosols (BC).

ATom Science Questions

Tier 1

- What are chemical processes that control the short-lived climate forcing agents CH₄, O₃, and BC in the atmosphere? How is the chemical reactivity of the atmosphere on a global scale affected by anthropogenic emissions? How can we improve chemistry-climate modeling of these processes?

Tier 2

- Over large, remote regions, what are the distributions of BC and other aerosols important as short-lived climate forcers? What are the sources of new particles? How rapidly do aerosols grow to CCN-active sizes? How well are these processes represented in models?
- What type of variability and spatial gradients occurs over remote ocean regions for greenhouse gases (GHGs) and ozone-depleting substances (ODSs)? How do the variations among air parcels help identify anthropogenic influences on photochemical reactivity, validate satellite data for these gases, and refine knowledge of sources and sinks?

Significance

ATom delivers unique data and analysis to address the Science Mission Directorate objectives of acquiring “datasets that identify and characterize important phenomena in the changing Earth system” and “measurements that address weaknesses in current Earth system models leading to improvement in modeling capabilities.” ATom will provide unprecedented challenges to the CCMs used as policy tools for climate change assessments, with comprehensive data on atmospheric chemical reactivity at global scales, and will work closely with modeling teams to translate ATom data to better, more reliable CCMs. ATom provides extraordinary validation data for remote sensing.

4. Quality Assessment

Extensive measurement uncertainty quantification is described in Tobiska et al. (2016) and results are provided in the ICT data files. In each data file, an estimated quality factor, Q, is provided for each observation. The quality assessment results are summarized in the “flag” variable, where 0 = verified data, 1 = unreliable dose rate, 2 = Rc undetermined, and 3 = Q undetermined.

5. Data Acquisition, Materials, and Methods

Project Overview

ATom made global-scale measurements of the chemistry of the atmosphere using the NASA DC-8 aircraft. Flights spanned the Pacific and Atlantic Oceans, nearly pole-to-pole, in continuous profiling mode, covering remote regions that receive long-range inputs of pollution from expanding industrial economies. The payload had proven instruments for in situ measurements of reactive and long-lived gases, diagnostic chemical tracers, and aerosol size, number, and composition, plus spectrally resolved solar radiation and meteorological parameters.

Combining distributions of aerosols and reactive gases with long-lived GHGs and ODSs enables disentangling of the processes that regulate atmospheric chemistry: emissions, transport, cloud processes, and chemical transformations. ATom analyzes measurements using customized modeling tools to derive daily averaged chemical rates for key atmospheric processes and to critically evaluate Chemistry-Climate Models (CCMs). ATom also differentiates between hypotheses for the formation and growth of aerosols over the remote oceans.

ARMAS Program

The Automated Radiation Measurements for Aerospace Safety (ARMAS) program originated with NASA funding. General information on the ARMAS program can be found on the Space Environment Technologies website (<https://spacewx.com/radiation-decision-aids/>). Its goal is to improve aviation and commercial aerospace safety for crew and the flying public by providing direct monitoring, in real-time, of the radiation environment above 8 km that comes from space weather. The radiation sources can be from galactic cosmic rays, solar energetic particles, or even Van Allen radiation belt energetic particles. These sources cause secondary radiation when they impact atmospheric molecules and vehicle materials. It is this secondary radiation environment that can have adverse effects on human tissue and aerospace electronics.

Measurements were taken with the silicon detector IMEI 59780. Specific characteristics of the device and other details on data processing and quality assessment can be found in Tobiska et al. (2016).

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[ATom: ARMAS Program Absorbed and Equivalent Radiation Dose Rates for ATom-1 Campaign](#)

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Tobiska, W.K., D. Bouwer, D. Smart, M. Shea, J. Bailey, L. Didkovsky, K. Judge, H. Garrett, W. Atwell, B. Gersey, R. Wilkins, D. Rice, R. Schunk, D.



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