

Real-Time Atmospheric Radiation Exposure: NAIRAS Model Predictions and the ARMAS Measurement Program

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Hampton, VA

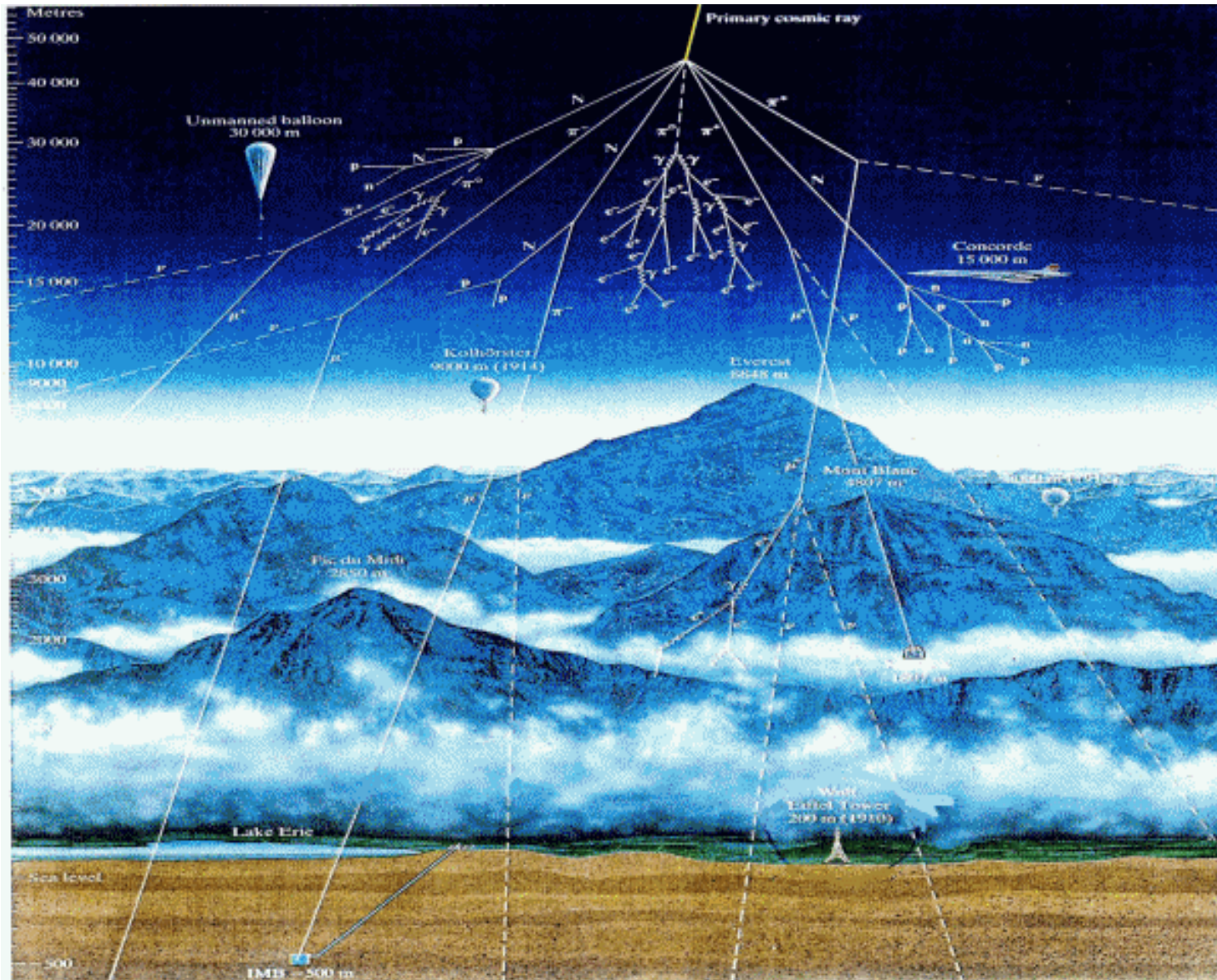
Nowcast of Atmospheric Ionizing Radiation for Aviation Safety

- **Chris Mertens (PI), NASA Langley Research Center, Hampton, VA**
 - Cosmic ray transport; integration of NAIRAS models and data; V&V
- **Kent Tobiska (Co-I; ARMAS PI), Space Environment Technologies, Inc, Pacific Palisades, CA**
 - Distributed data nerve center and conduit for input data – models – output data
- **Brian Kress (Co-I), Dartmouth College, Hanover, NH**
 - Real-time magnetospheric transport / geomagnetic shielding model
- **Mike Wiltberger and Stan Solomon (Co-I), NCAR/HAO, Boulder, CO**
 - Benchmark MHD magnetospheric magnetic fields
- **Brad Gersey (ARMAS Co-I), CRESSE, Prairie View A& M, Prairie View, TX**
 - Radiation measurements and instrumentation
- **Joe Kunches (Collaborator), NOAA/Space Environment Center, Boulder, CO**
 - Guidance on research-to-operations; interaction with commercial aviation industry
- **Barbara Grajewski (Collaborator), CDC/NIOSH, Cincinnati, OH**
 - Aircraft radiation measurement data for V&V; epidemiological studies
- **Steve Blattmig (Collaborator), NASA Langley Research Center, Hampton, VA**
 - Cosmic ray nuclear interactions; transport physics
- **Bill Atwell (ARMAS Collaborator), Boeing, Houston, TX**
 - Radiation measurement data analysis
- **Xiaoqing Xu (Collaborator), SSAI, Hampton, VA**
 - Scientific programming and data visualization tools
- **Ryan Norman (Post-Doc Fellow), NASA Langley Research Center, Hampton, VA**
 - Cosmic ray nuclear interactions; transport physics

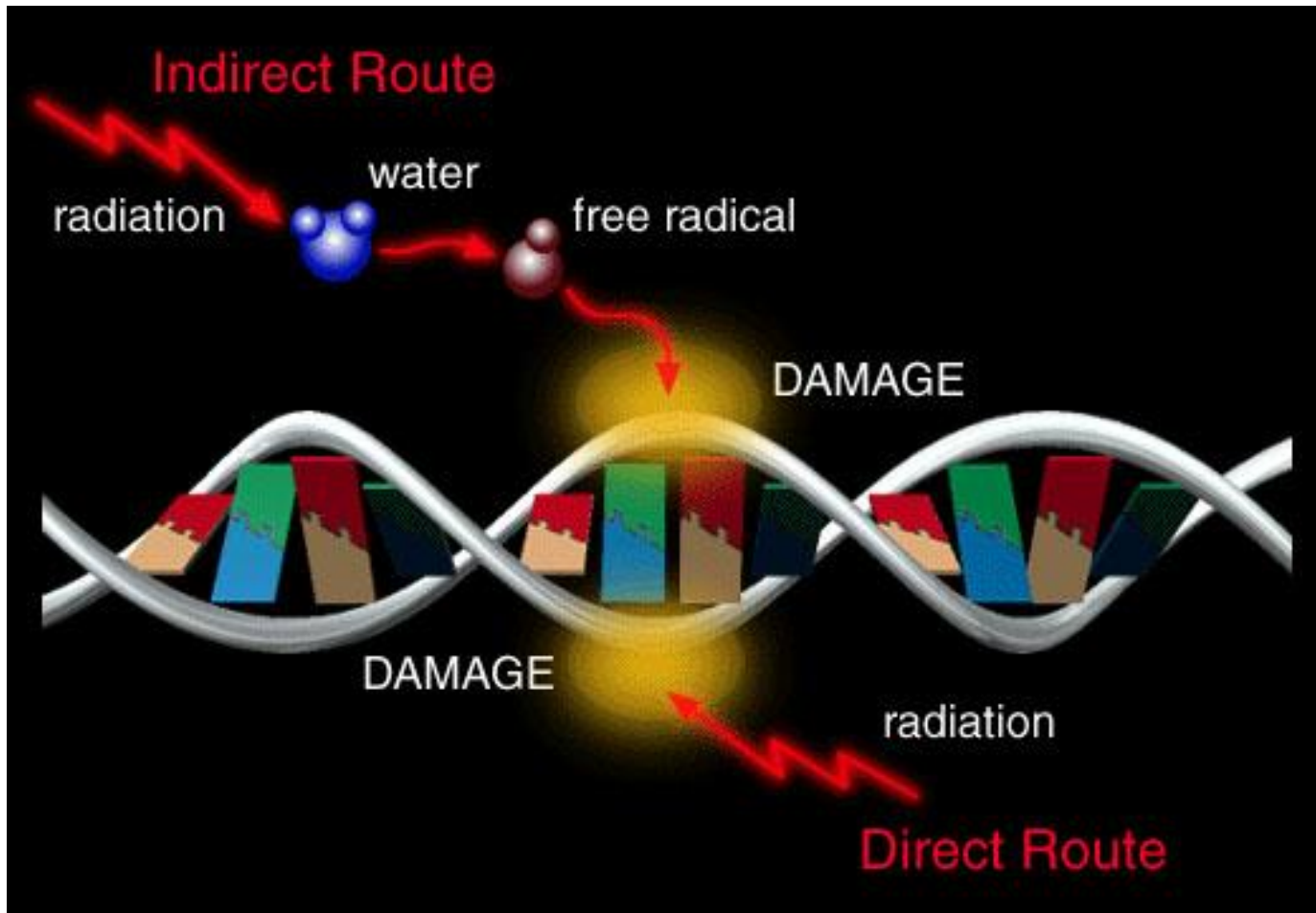
Outline

- **Motivation**
- **NAIRAS Model Description and Results**
- **NAIRAS Real-Time Products**
- **NAIRAS V&V Roadmap and ARMAS Program**
- **Wrap-Up Discussion**

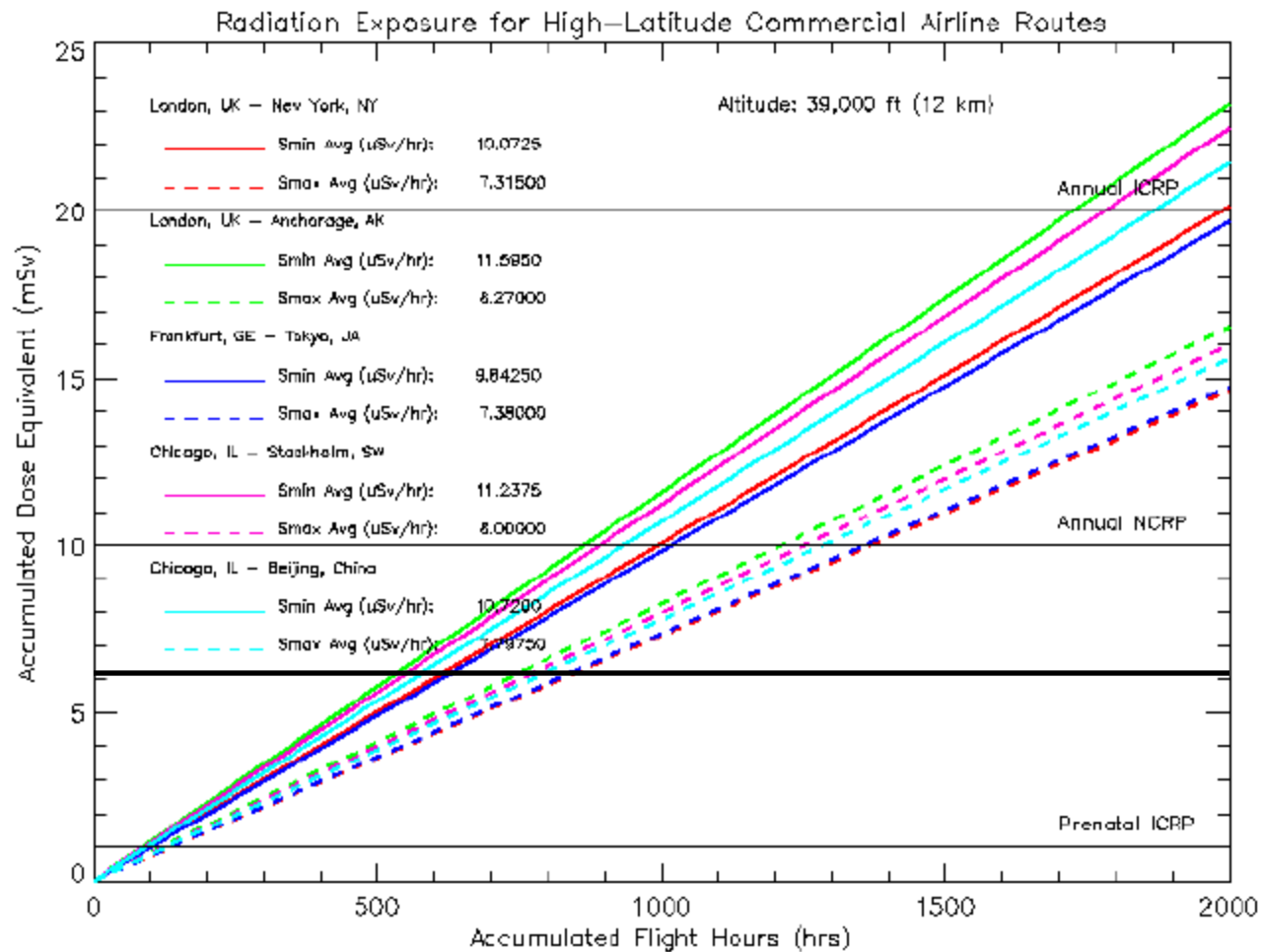
Cosmic Ray Interactions



Ways to damage DNA



GCR Exposure



EU Action Level

ICRP Public/Prenatal

Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS)

Earth System Models

Radiation Dose Rates:

AIR (parametric)
HZETRN (physics-based)

Near-Earth Space Environment

- Badhwar/O'Neill GCR Model
- Empirical Cutoff Rigidity
(IGRF+TS05)
- Physics-based Cutoff Rigidity
(LFM/CMIT+SEP-trajectory)



Earth Observations

Near-Earth Space Environment

NASA/ACE
NASA/HEAO-3
NOAA/GOES

Assimilated Atmospheric

Atmospheric Depth (NCEP/GFS)

Ground-Based

Neutron Count Monitors

Predictions/Forecasts

Ionizing Radiation Nowcast

4-D Effective Dose
4-D Ambient Dose Equiv.
4-D Differential Flux

NAIRAS Distributed Network System

High-Performance
Computer Systems
Server Interface
Operational and Archival
Databases

Differential Particle Flux

HZE Particles (A=5-56)
Light-Ions (A=1-4)
Neutrons
Pions and Muons
Electromagnetic
Cascade Particles

Observations, Parameters & Products

Decision Support Systems, Assessments, Management Actions

NAIRAS decision support tool
for NOAA/SWPC space
weather forecasts, warnings,
and advisories

NAIRAS available at public
website

Specific analyses to support the decision making

Predict real-time radiation
exposure at airline altitudes
(includes background GCR
and SEP events)

Provide accumulated radiation
exposures for representative
set of domestic, international,
and polar routes

Specific Decisions / Actions

Limit aircrew flight hours to
within recommended annual
and career limits

Alter route and/or altitude
during SEP events

Value & Benefits to Society

Improvements in the decision- making, decisions, and actions

First-ever, data-driven, real-time
prediction of biologically harmful
radiation exposure levels at
airline altitudes

Quantitative and qualitative benefits from the improved decisions

Comprehensive database of
radiation exposure rates to
formulate recommended annual
and career limits to ionizing
radiation exposure

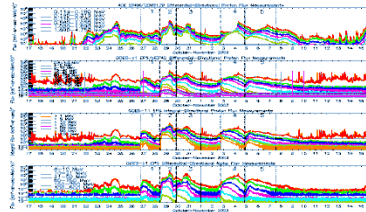
Comprehensive database of
radiation exposure rates for
airlines to assess cost/risk of
polar routes

Real-time prediction of
radiation exposure levels to
enable optimal balance
between airline cost and air
traveler health risk during
solar storm (SEP) events

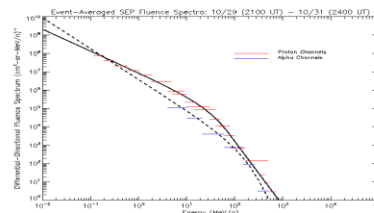
Improve understanding of
biological effects of
atmospheric ionizing radiation
on aircrew and passengers
through collaboration of
epidemiological studies by
NIOSH

Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) Model

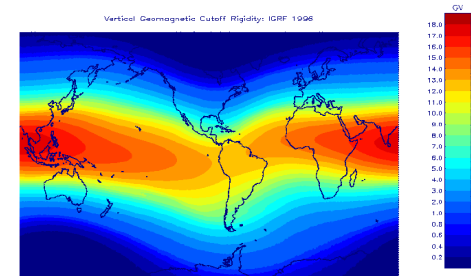
NOAA/GOES + NASA/ACE Data



Spectral Fitting



Cutoff Rigidity (IGRF)

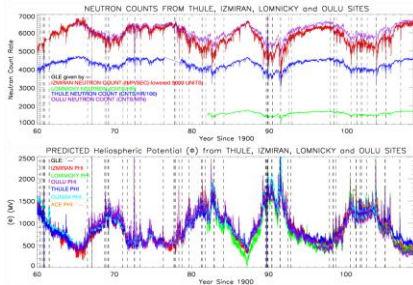


Magnetospheric
Magnetic Field
(e.g., T05)
Effects on
Cutoff Rigidity

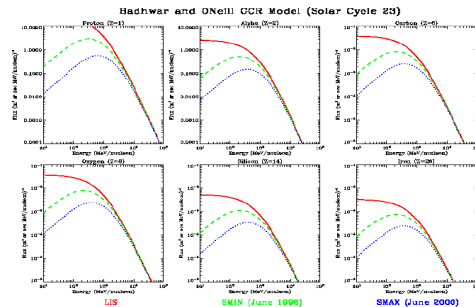
NASA/ACE Solar
Wind and IMF Data

Real-time Neutron
Monitor Data
(e.g., IZMIRAN and
LOMNICKY)

Fit to Climax HP

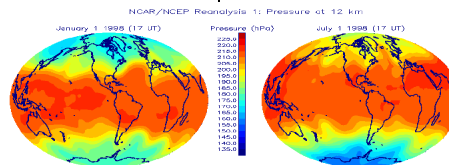


Badhwar+O'Neill GCR Model

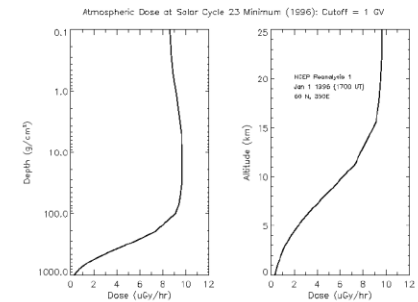


HZETRAN
+
Dosimetry

Atmospheric Density

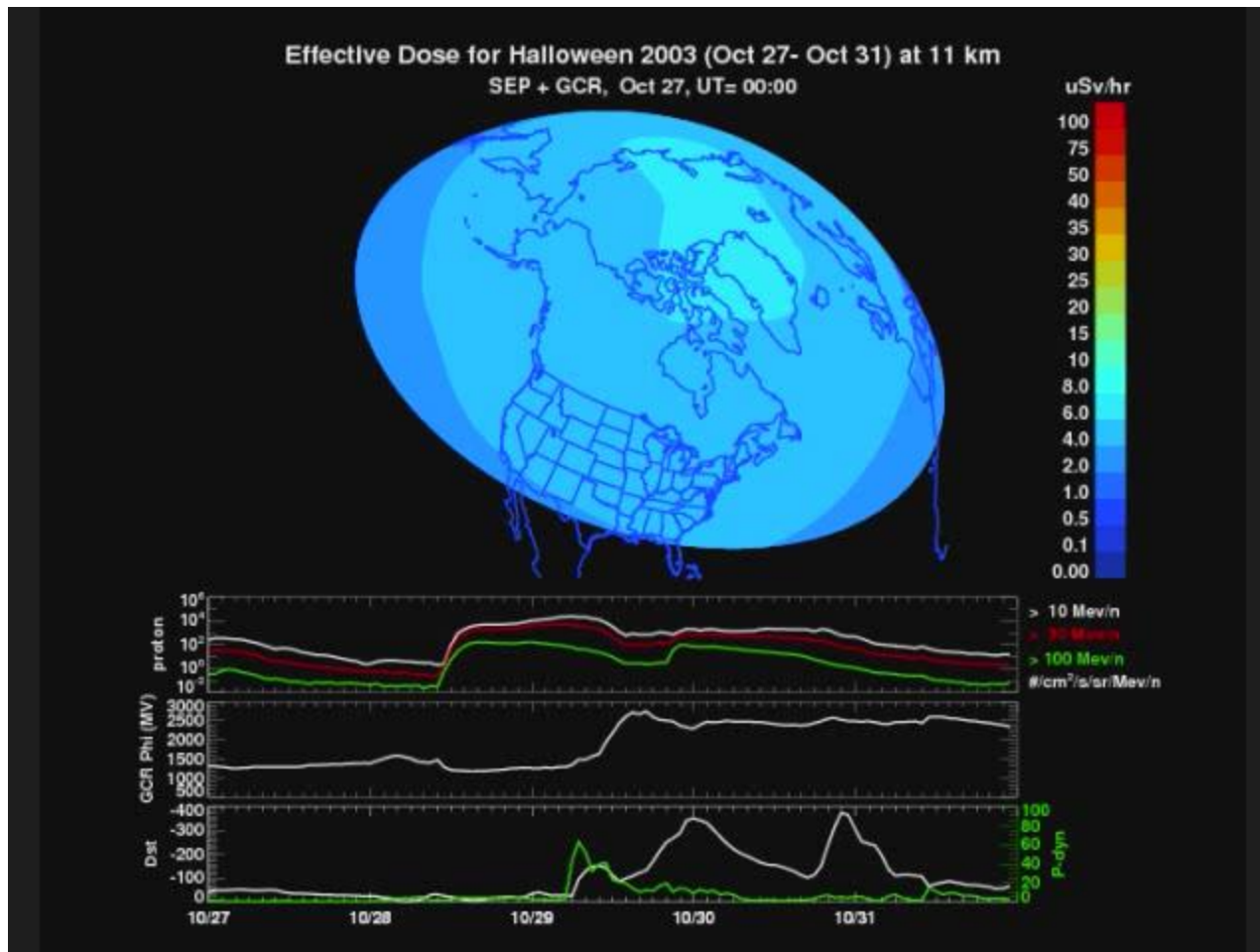


NCEP/GFS

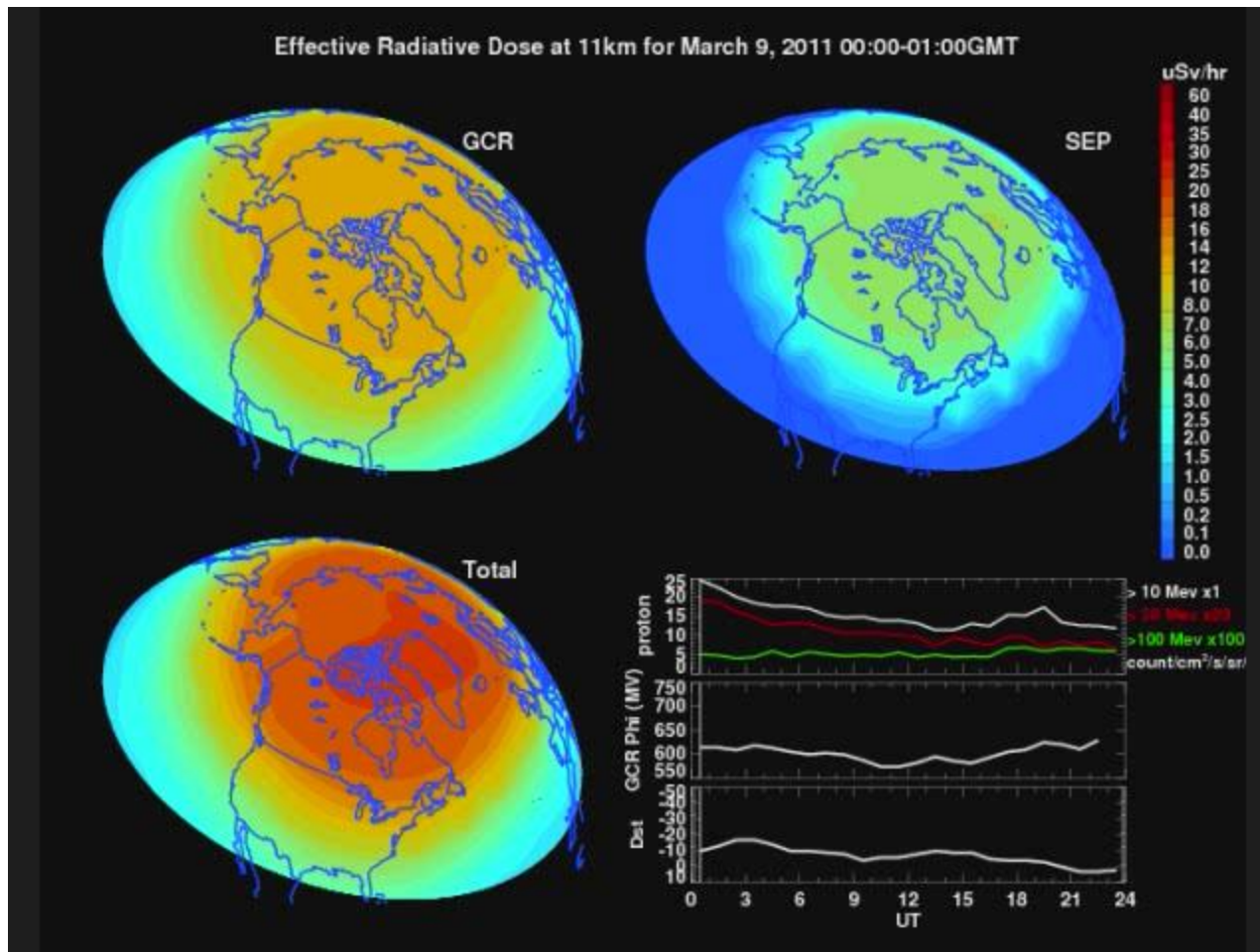


Atmospheric Dose
and Dose Equivalent

Halloween 2003 Storm



March 9 2011 SEP Event

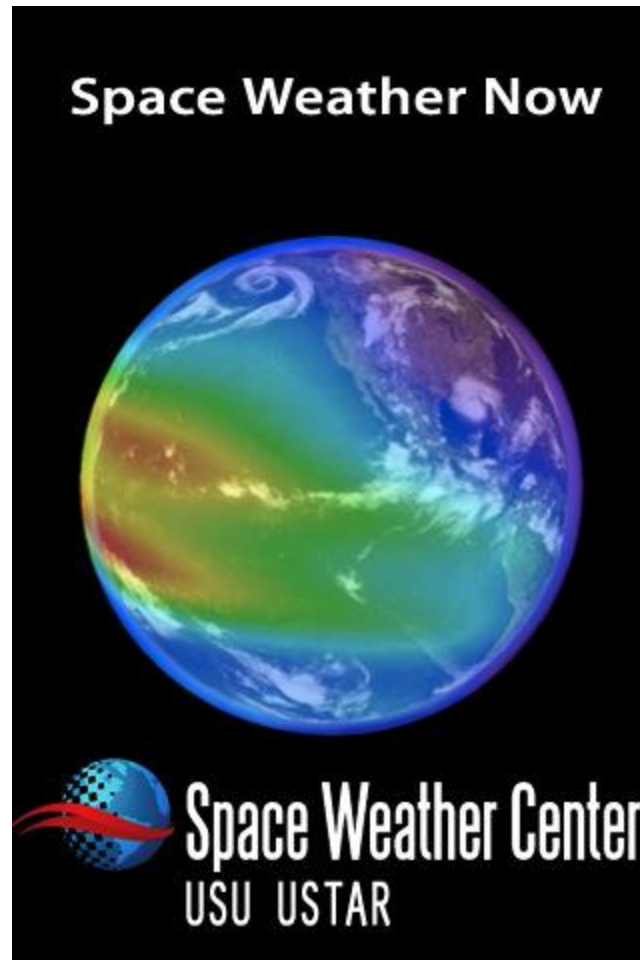


NAIRAS Real-Time Tabular/Graphics Products

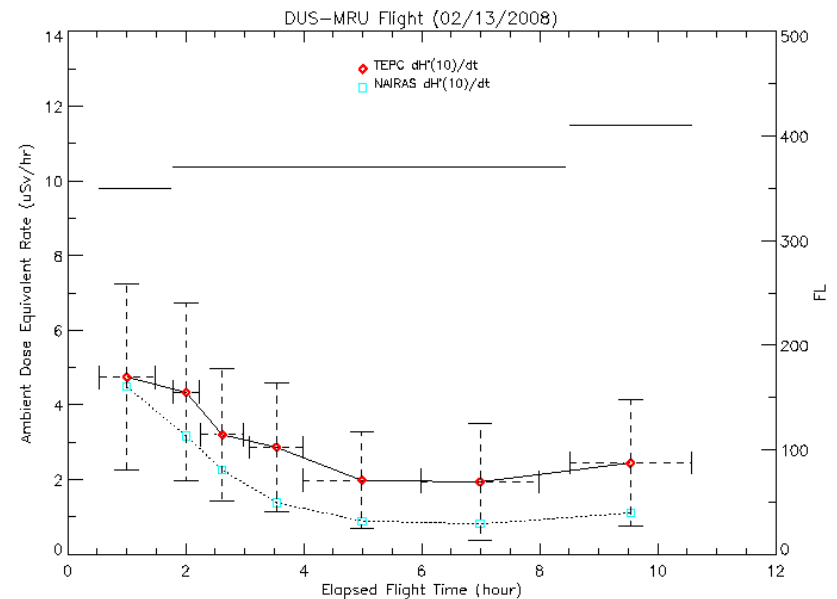
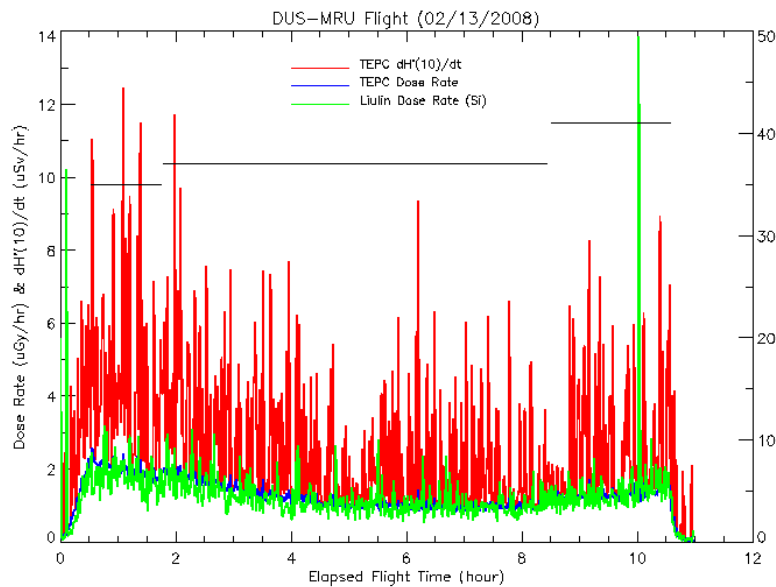
[web\index.html](#)

NAIRAS Real-Time Predictions Available on iPhone app

News Release today at nasa.gov

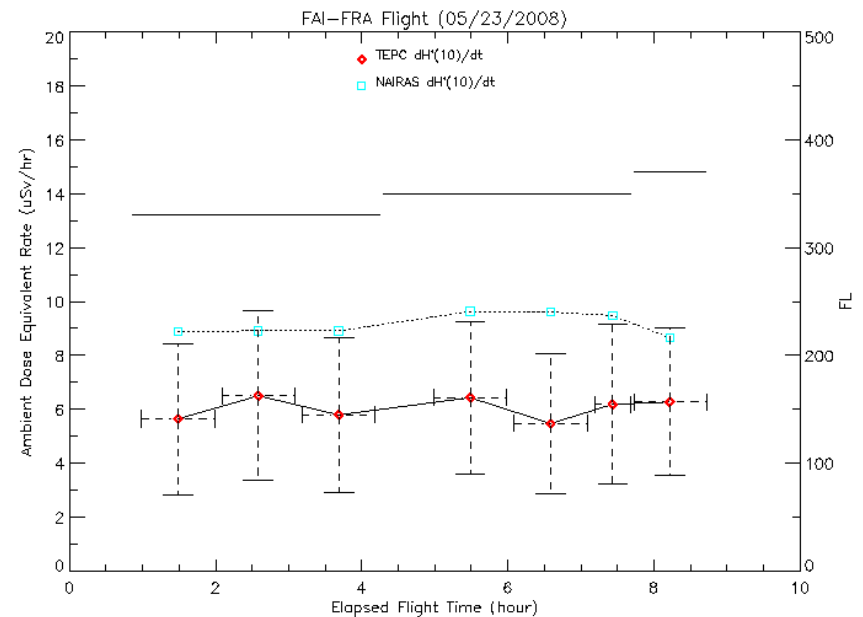
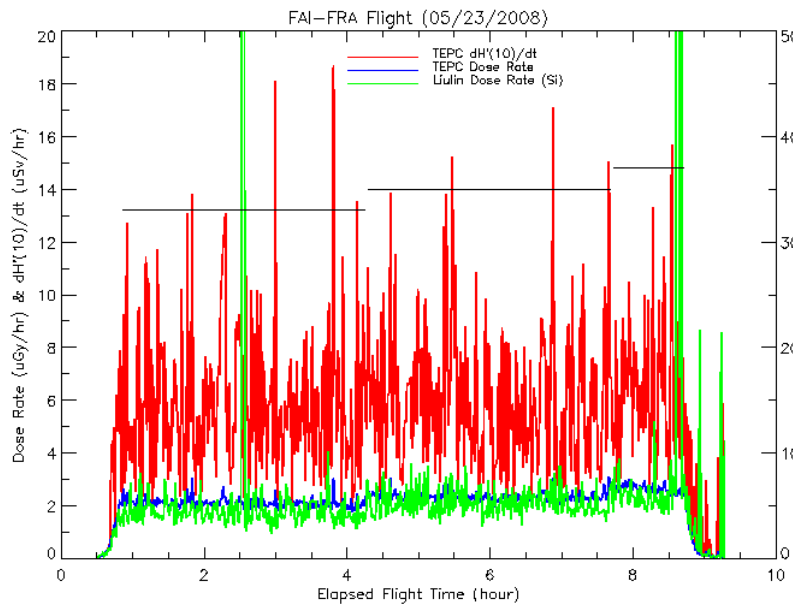


NAIRAS/DLR-TEPC Comparisons



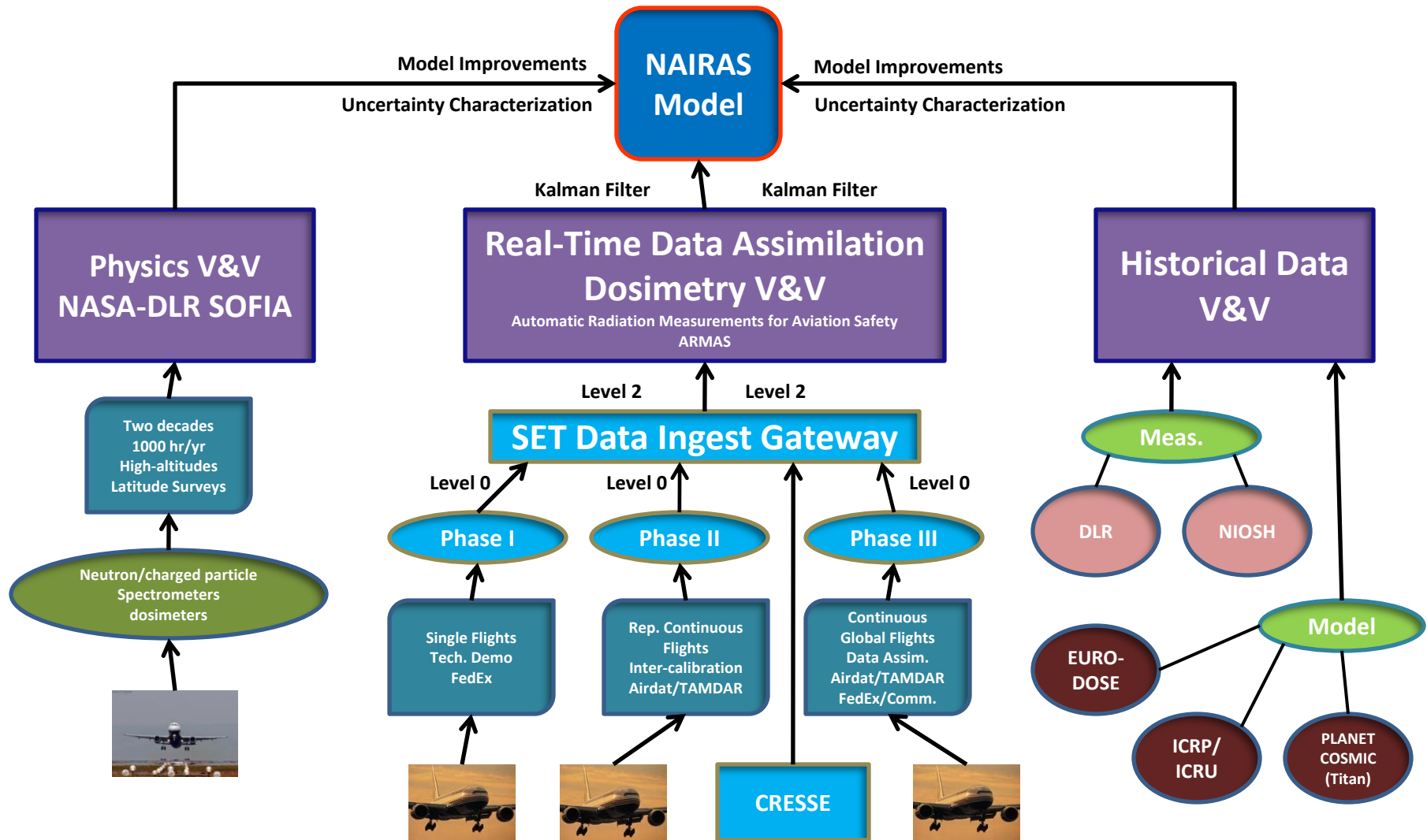
TEPC data courtesy of Matthias Meier

NAIRAS/DLR-TEPC Comparisons



TEPC data courtesy of Matthias Meier

NAIRAS V&V and Data Assimilation Plan



ARMAS Program

- **ARMAS**
 - Automated Radiation Measurements for Aviation Safety
- **NASA/SBIR project lead by Space Environment Technologies**
 - Phase I selected for funding to address Phase I of NAIRAS Decadal Roadmap for V&V and Data Assimilation of Radiation Measurements
- **ARMAS Team**
 - Kent Tobiska (PI), Space Environment Technologies
 - Brad Gersey (Co-I), CRESSE, Prairie View A & M
 - Bill Atwell (Collaborator), Boeing
 - Chris Mertens (Collaborator/Customer), NASA LaRC

Wrap-Up Discussion

- **Main Summary**

- NAIRAS is now streaming live from our public website and available as an iPhone app!
- Real-time, global, physics-based predictions of aircraft radiation exposure is now a reality!
- Google NAIRAS to find public website

- **Next Steps**

- Extensive, robust V&V effort
- R2O: Transition NAIRAS model to operations
- Transition NAIRAS data/graphics products from website to dispatcher/cockpit products
- O2R: Address science questions that emerged from R2O

Wrap-Up Discussion

- **Grand Challenges**
 - **Continued NAIRAS funding**
 - **NASA Applied Science Aviation Weather Program Budget Zeroed Out!**
 - **This is the NASA Program that funded the NAIRAS prototype development**
 - **Looking into creative ways to fund different elements of NAIRAS through multiple sources**
 - **ARMAS Program is an example**
 - **Integrate NAIRAS predictions into flight plans / cockpit data / and company records**
 - **NASA is interested in seeking commercial solutions through the SBIR Program**

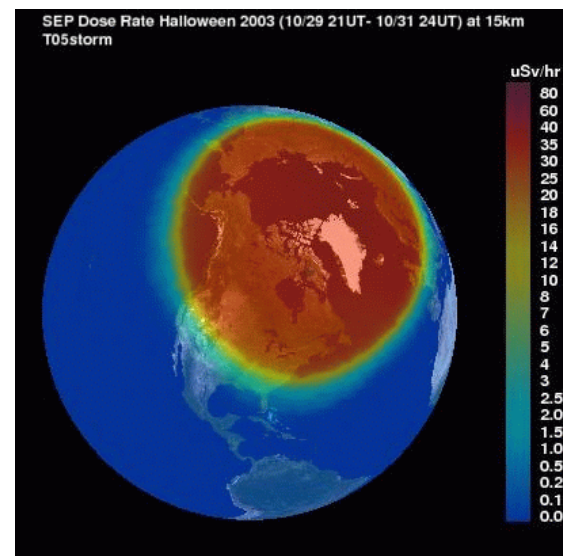
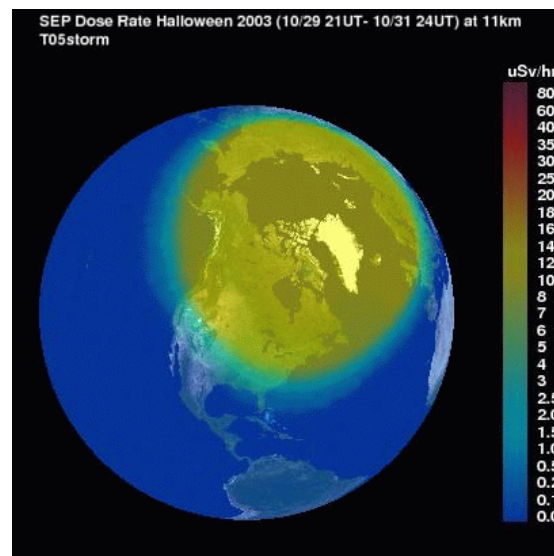
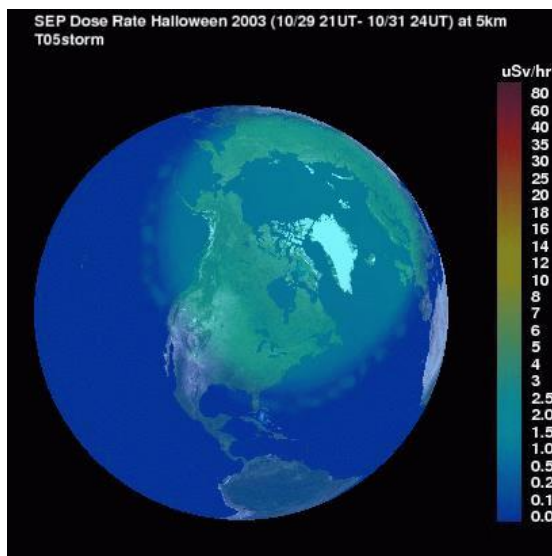
Backup Slides

Halloween, 2003 10/29 UT21- 10/31 UT24

11km (35,000feet) SEP radiative Dose Rate(uSv/hr)

Latitude	60-90N	40-60N	20-40N	0-20N	0-20S	20-40S	40-60S	60-90S
average	10.80	4.87	0.25	<1e-2	<1e-2	0.49	6.14	11.78
maximum	11.57	11.06	8.26	0.01	<1e-2	8.68	11.86	13.67

Flight Name	Flight Time (hours)	Dose Rate (uSv/hr)	Dose (mSv)	Safety Signal	
				0.05<	>0.1
Chicago,IL-Beijing, China	13.50	9.133	0.123	⬜	⬜
New York, NY - London, UK	5.75	9.198	0.053	⬜	⬜
Chicago, IL - Stockholm, SW	8.42	10.302	0.087	⬜	⬜
Chicago, IL - Munich, GE	8.75	9.085	0.079	⬜	⬜
Nominal North Pole	10.00	11.570	0.116	⬜	⬜



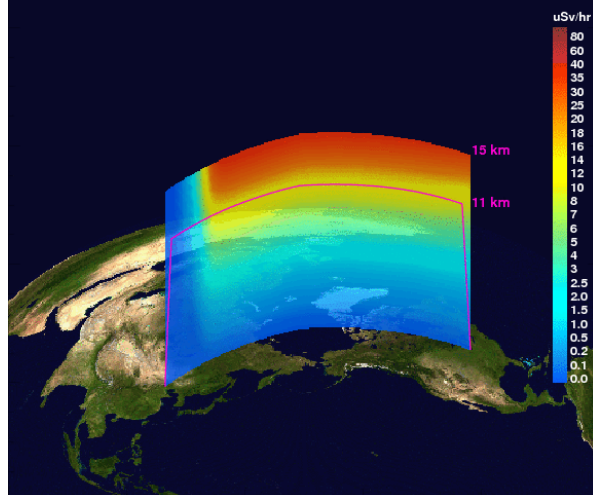
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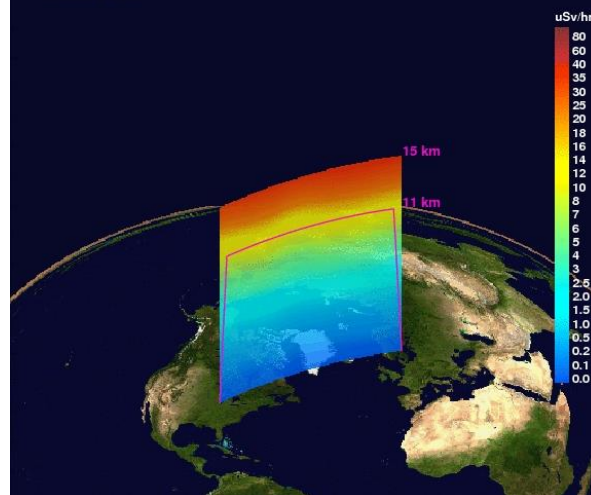
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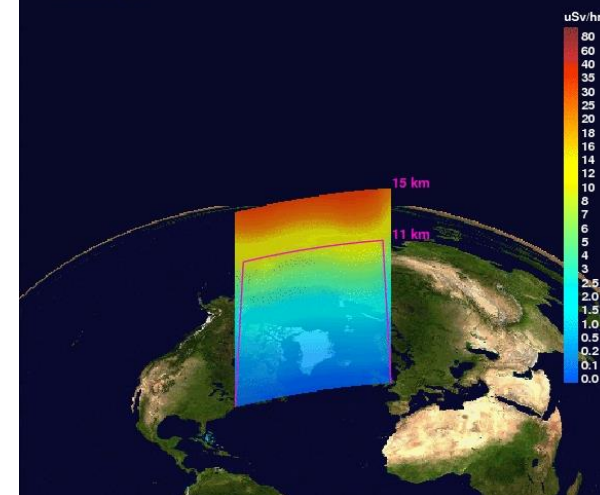
SEP dose rate, Halloween 2003, 10/29/21UT - 10/31/24UT
Chicago,IL-Beijing, China
T05storm field



SEP dose rate, Halloween 2003, 10/29/21UT - 10/31/24UT
Chicago, IL - Stockholm, SW
T05storm field



SEP dose rate, Halloween 2003, 10/29/21UT - 10/31/24UT
New York, NY - London, UK
T05storm field



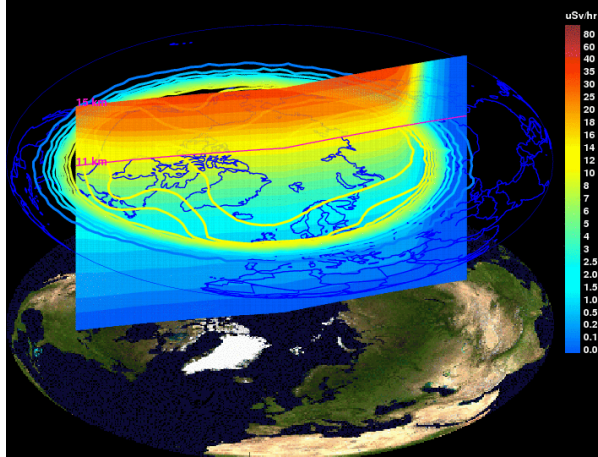
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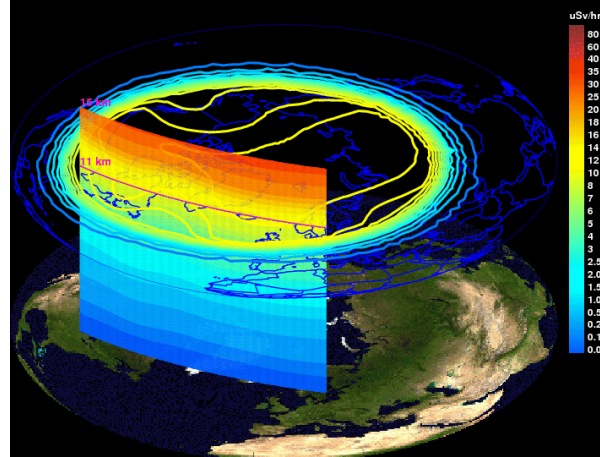
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Chicago,IL-Beijing, China



SEP dose rate, Halloween 2003, 10/29/21UT - 10/31/24UT
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SEP dose rate, Halloween 2003, 10/29/21UT - 10/31/24UT
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