NASA Dryden
Flight Research Center's
Space Weather Needs

Scott Wiley, Aerospace Meteorologist,
Tybrin Inc.

Space Weather Users Conference
Goddard Spaceflight Center

September 14-15, 2011

Global Hawk Flights are Polar and Equatorial

NAS Flight Summary

- 13 Flights
- 310 Hours
- ~100,000 nmi

2 Certificates of Authorization

- Pacific-Alaska-Arctic
- Western Atlantic-Caribbean-Gulf of Mexico


872
NASA
NORTHROP GRUMMAN
DRYDEN FLIGHT RESEARCH CENTER


06:53
PACIFIC
09:53
EASTERN
13:53
ZULU
SWEEPTIME
SWEEP
Gate
Control

Global Hawk Space Weather Concerns

- Developed by the GLOPAC and GRIP mission teams
- With assistance from Dr. Hal Maring
- Good start but addresses only Global Hawk
- What about other platforms and Crew?

Support of the Evaluation of Single Event Upset (SEU) Risk in the Global Hawk UAS from Increased Neutron Flux at High Latitudes

by

Dr. David Fahey (NOAA/ESRL) and Dr. Paul Newman (NASA/GSFC),
GloPac Project Scientists
Dr. Hal Maring (NASA/HQ), Radiation Sciences Program Manager

Background: In the GloPac Arctic Flight Tech Brief (20 April 2010) for the GloPac Arctic flight, additional risk was included for an SEU failure of the Global Hawk IMMC at high latitudes (up to 85° N). The analysis was based, in part, on the latitude dependence of the cosmic-ray neutron flux as analyzed by Normand and Baker and presented on Slide #11 of the Tech Brief (see next slide).

Objective: Evaluate the representativeness of the Normand and Baker results for neutron fluxes that are likely to be encountered during the Arctic flight at solar minimum conditions in April 2010 (See Appendix B).

Neutron flux dependence on latitude from Normand and Baker

(Slide #11 in Tech Brief)

1484 IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 40, NO. 6, DECEMBER 1993

Altitude and Latitude Variations in Avionics SEU and Atmospheric Neutron Flux

E. Normand and T. J. Baker

Boeing Defense & Space Group, Seattle, WA 98124-2499

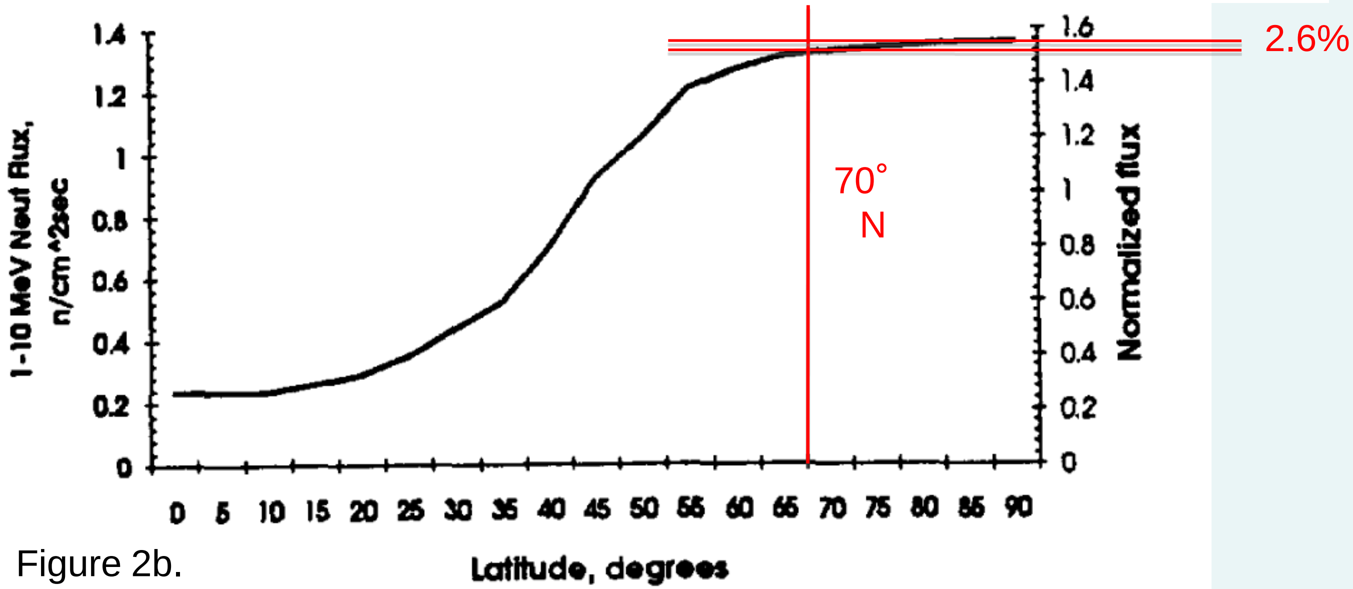


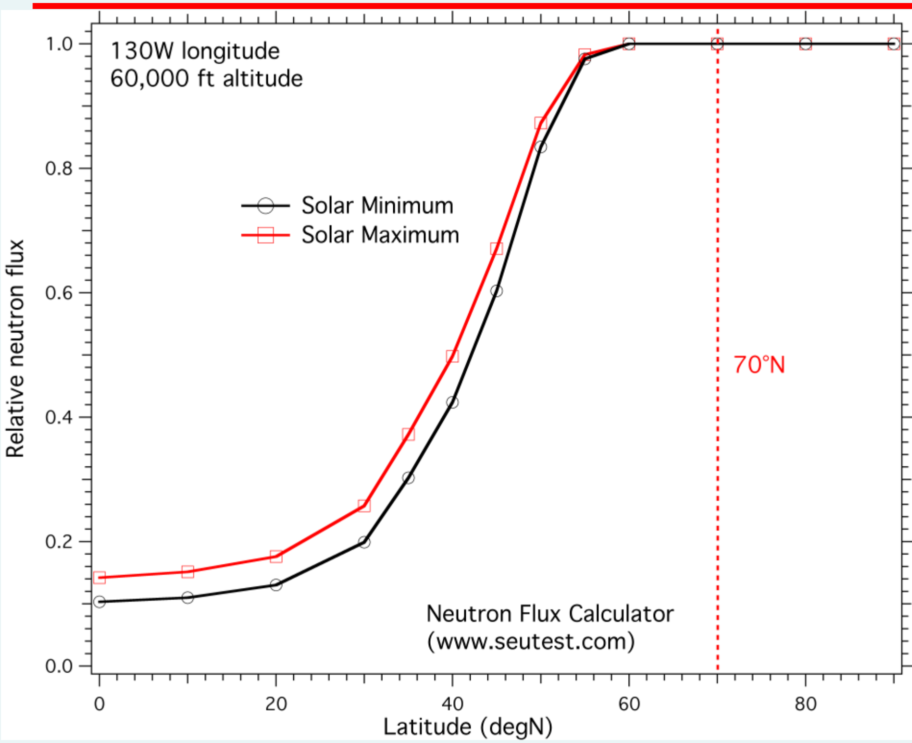
Figure 2b.

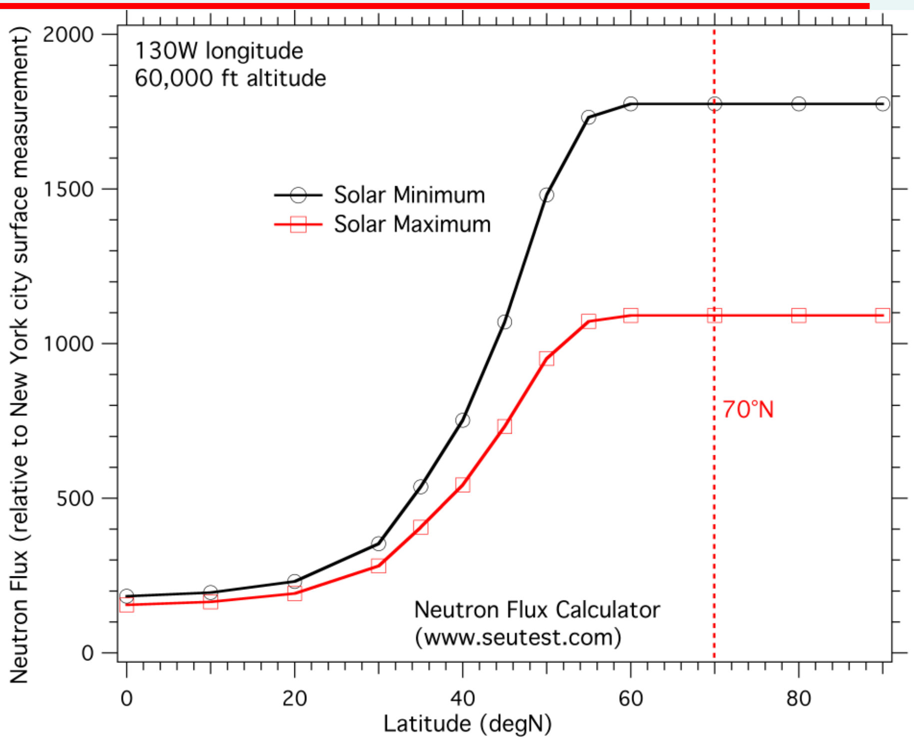
- Flux values are based on measurements from a few balloon and aircraft flights.
- Changes in flux values are small above 70° N (~ 2.6%)
- Solar conditions and altitudes of the measurements are not stated.
- No uncertainties are stated for these published values.

Calculations of the latitude dependence of neutron flux

Neutron flux normalized to 90˚ N

Neutron flux relative to NYC





- Flux values are normalized to the value at 90˚ latitude.
- The variation in latitude gradient is less than 10% between solar min and max.
- Normand and Baker results (Fig. 2) match the latitude dependence at solar maximum.
- No change in flux occurs above 70˚ N.

- Flux values are referenced to the value measured in New York City at the surface.
- The flux changes by a factor of 1.6 between solar minimum and solar maximum.
- No change in flux occurs above 70˚ N.

(www.seutest.com calculations represent the most current scientific understanding of the dependences of neutron flux on altitude, latitude, and solar cycle.)

Neutron flux dependence on altitude from Normand and Baker

1484 IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 40, NO. 6, DECEMBER 1993

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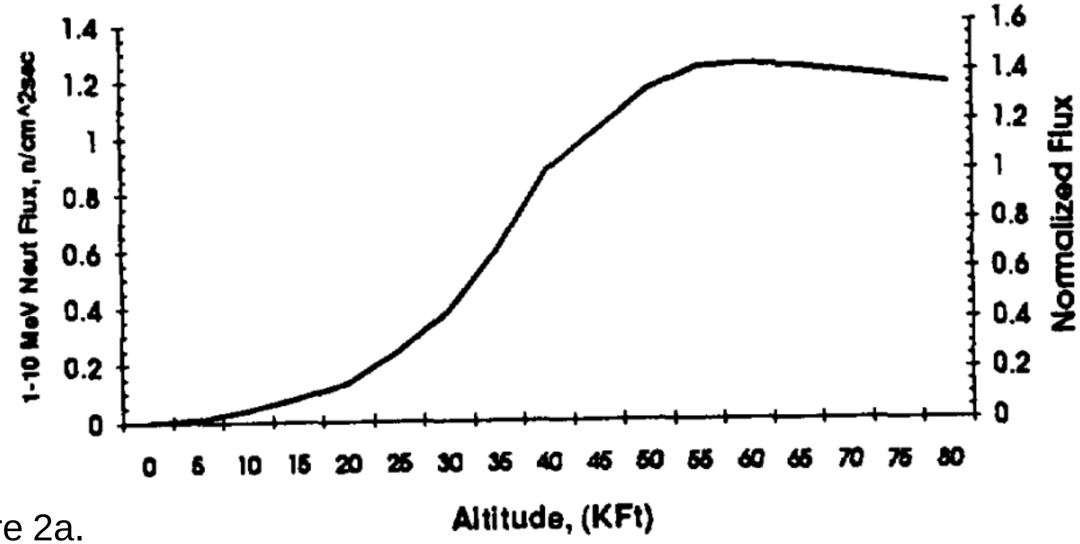
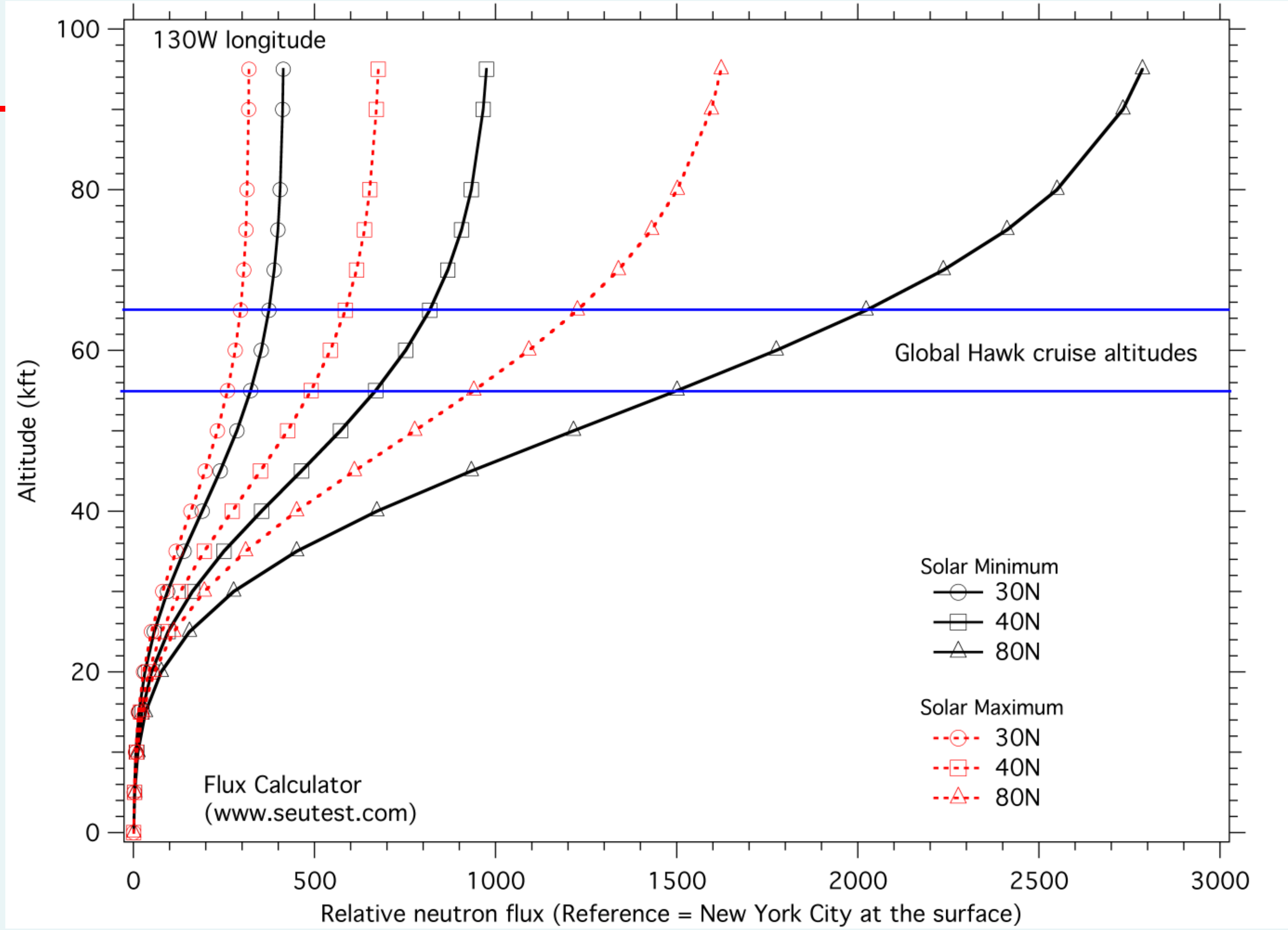


Figure 2a.

- Flux values are based on measurements from a few balloon and aircraft flights.
- Changes in flux values are small above 55 kft.
- Solar conditions and latitudes of the measurements are not stated.
- No uncertainties are stated for these published values.

Calculations of the altitude dependence of neutron flux



- Flux values at Global Hawk cruise increase with altitude below 70 kft at all latitudes.
- Solar cycle variations in flux at Global Hawk cruise altitudes are less than a factor of 2.
- Normand and Baker altitude dependence matches the 30-40° N results.

Conclusions

1) The Normand and Baker relative latitude dependence (*equator to pole*) matches flux calculations for solar maximum conditions. The latitude dependence of neutron flux varies about 10% between solar minimum and solar maximum.

2) The Normand and Baker absolute value of neutron flux at high latitudes (60 - 90° N) is consistent (within ±70%) with the most current neutron flux estimates based on the calculated variation between solar minimum and maximum conditions.

3) The combination of these factors (10% + 70%) represent our best estimate of the uncertainty in the Normand and Baker results for representing neutron flux at high latitudes during the Arctic flight.

4) Neutron fluxes in the Normand and Baker results and from the *seutest.com* calculations show small latitude dependences above 60° N latitude.

5) In the altitude profiles at all latitudes above 30° N, the maximum flux value occurs above Global Hawk cruise altitudes (55-65 kft).

Appendix A: Neutron Flux Calculator: www. seutest.com

Soft-error Testing Resources

Home | News | Flux Calculation | Accelerator Facilities | Links | Feedback

Seutest.com is a cooperatively managed website providing links and support for soft-error testing compatible with the JEDEC standard JESD89 - "Measurement and Reporting of Alpha Particles and Terrestrial Cosmic Ray-Induced Soft Errors in Semiconductor Devices." Jeff Wilkinson is currently maintaining the content of this site with support from a number of others. Please direct e-mail to the address below and I will try to respond in a timely manner.

This is a non-commercial site, intended as a resource. There are no products or services offered through this site. Links to other sites should not be considered an endorsement of their products or services.

Update to news on September 15, 2006.

Contact Information

General questions and comments may be directed to the webmaster.

Webmaster: webmaster@seutest.com

Appendix A: Neutron Flux Calculator: www. seutest.com

Use this calculator to determine the relative neutron flux at a particular location. The output value is relative to the sea-level flux in New York City, New York, USA. This point has historically been the reference point for neutron flux measurements.

Instructions for use are here (opens a new window) and summarized at the bottom of this page.

Location

Latitude	40.7	(•) N degrees ( ) S degrees
Longitude	74	( ) E degrees (•) W degrees

Elevation, Pressure or Depth - Enter a single value and check the appropriate box

Elevation	(•)	0	(•) feet ( ) meters
Station pressure	( )		(•) mm Hg ( ) inches Hg ( ) millibar (hPa)
Atmospheric depth	( )		g/cm^2

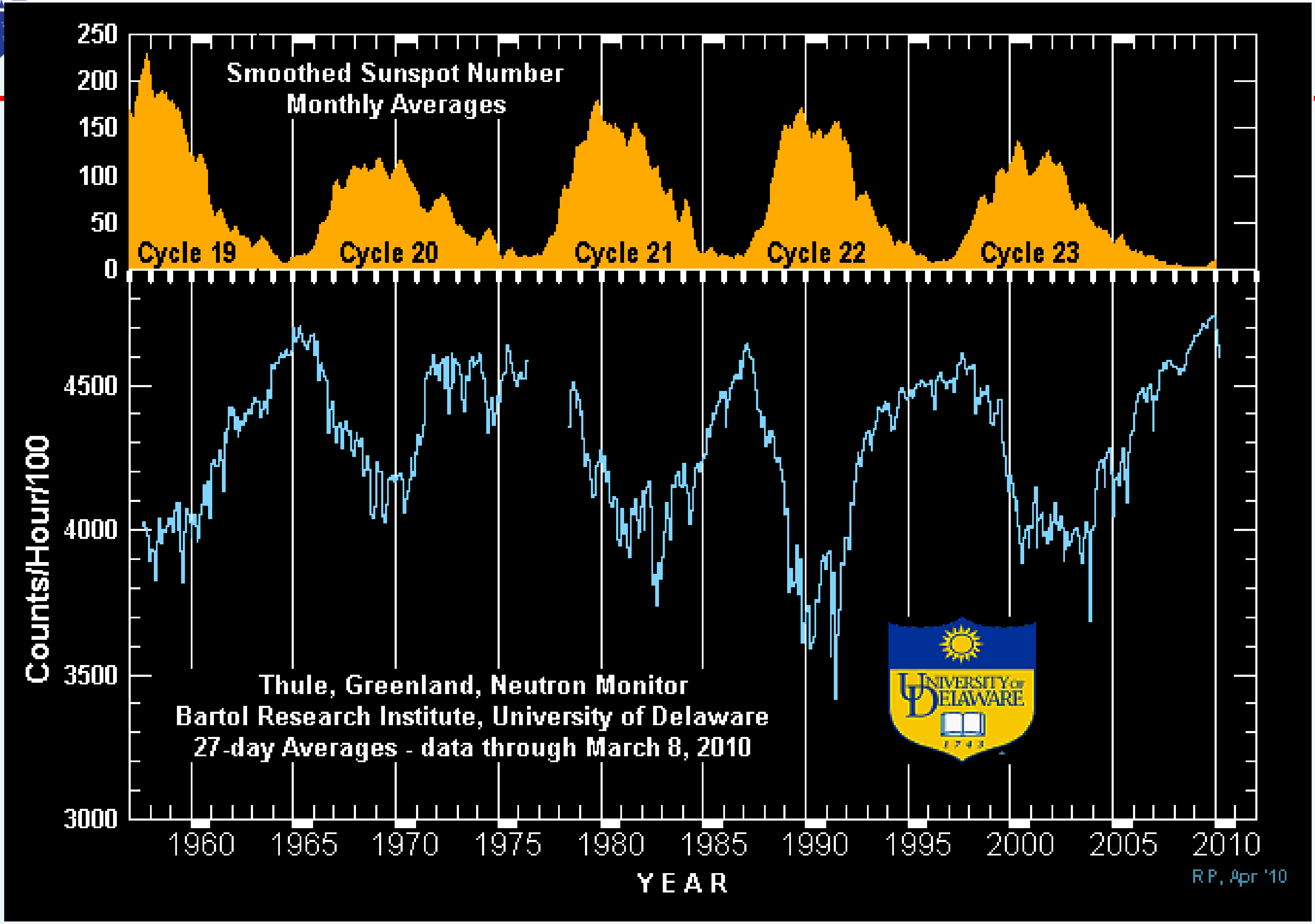
Solar Modulation

Solar modulation	50	% (0 is minimum flux / active sun, 100 is maximum flux / quiet sun)

Submit

Relative flux	**1.00**	(NYC, NY, USA = 1.00)

Appendix B: Solar cycle sunspot and neutron flux time series



Neutron flux peaks in solar minimum. The variation at the surface is ±7%. The variation at 60000 ft is a factor of ~ 1.6. The solar cycle is at a minimum in April 2010.

http://neutronm.bartol.udel.edu/


IKHANA
NASA
870

Western States Fire Missions 2007

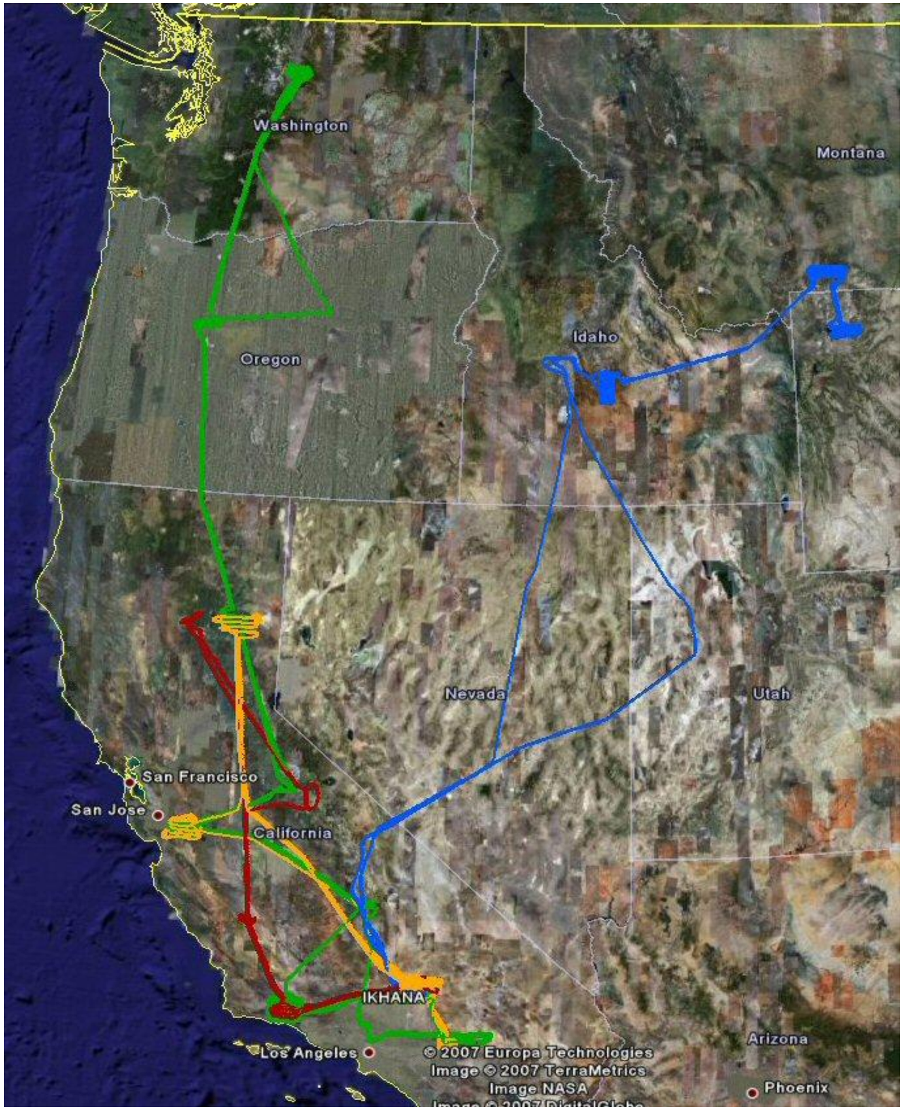
IKHANA

WSFM 1 Aug. 16
4 Fires, 1400 nm, 9.5 hrs

WSFM 2 Aug. 29 – 30
7 Fires, 2500 nm, 16.1 hrs

WSFM 3 Sept. 7 – 8
12 Fires, 3200 nm, 20.0 hrs

WSFM 4 Sept. 27
BAER, 3 Fires, 1800 nm,
9.9 hrs



WSFM Achievements

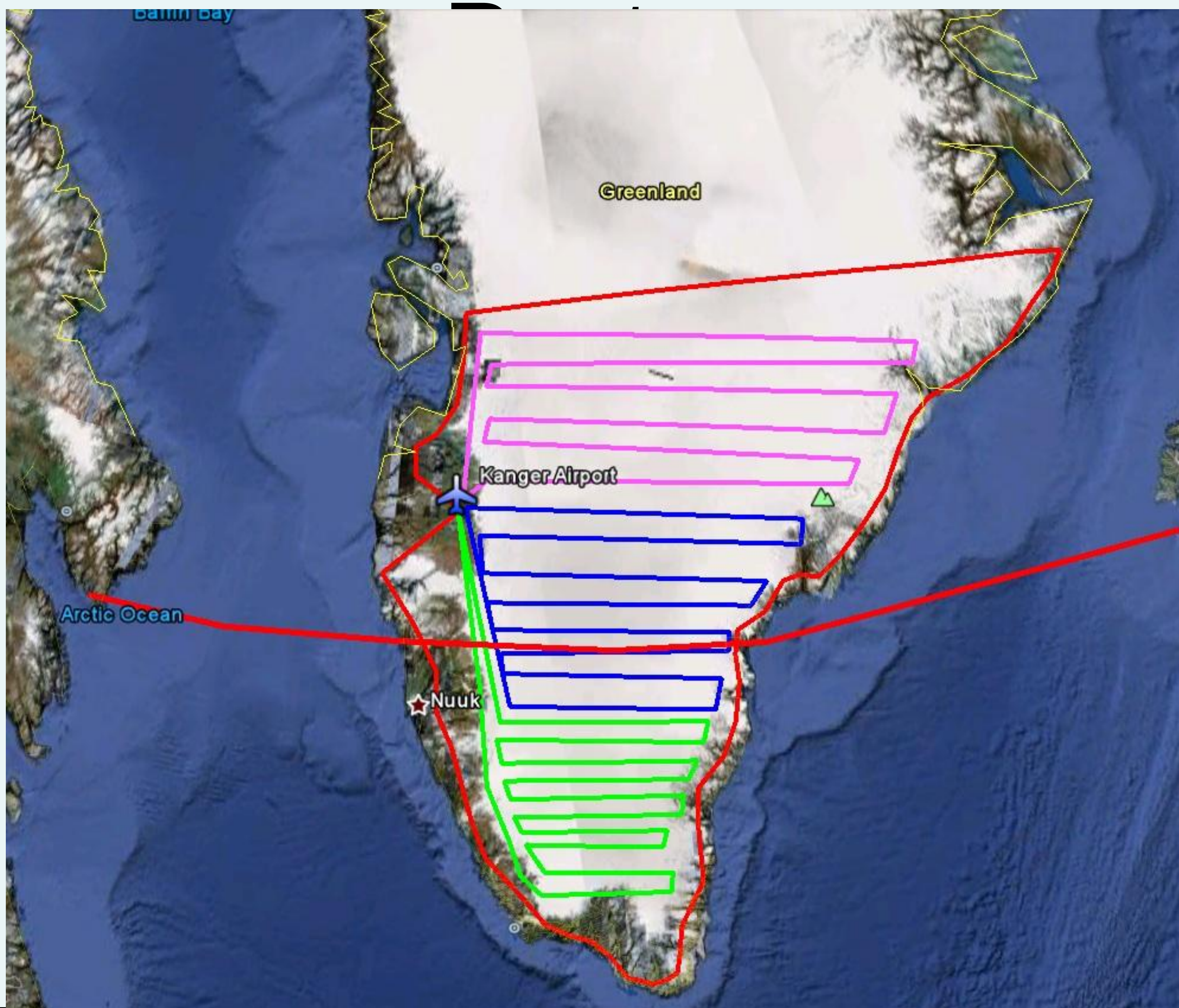
IKHANA

	Flight Date	Flight Duration	Fires Flown	Mileage NM
WSFM 1	16 Aug	9.5 hrs	4	1400
WSFM 2	29 Aug	16.1	5	2500
WSFM 3	7 Sept	20	11	3200
WSFM 4	27 Sept	9.9	4	1800
WSFM 5	24 Oct	9	9	~1350
WSFM 6	25 Oct	8.7	8	~1350
WSFM 7	26 Oct	7.8	8	~1350
WSFM 8	28 Oct	7.1	11	~1350

UAV components

Southern Greenland

Each Route is approx same distance



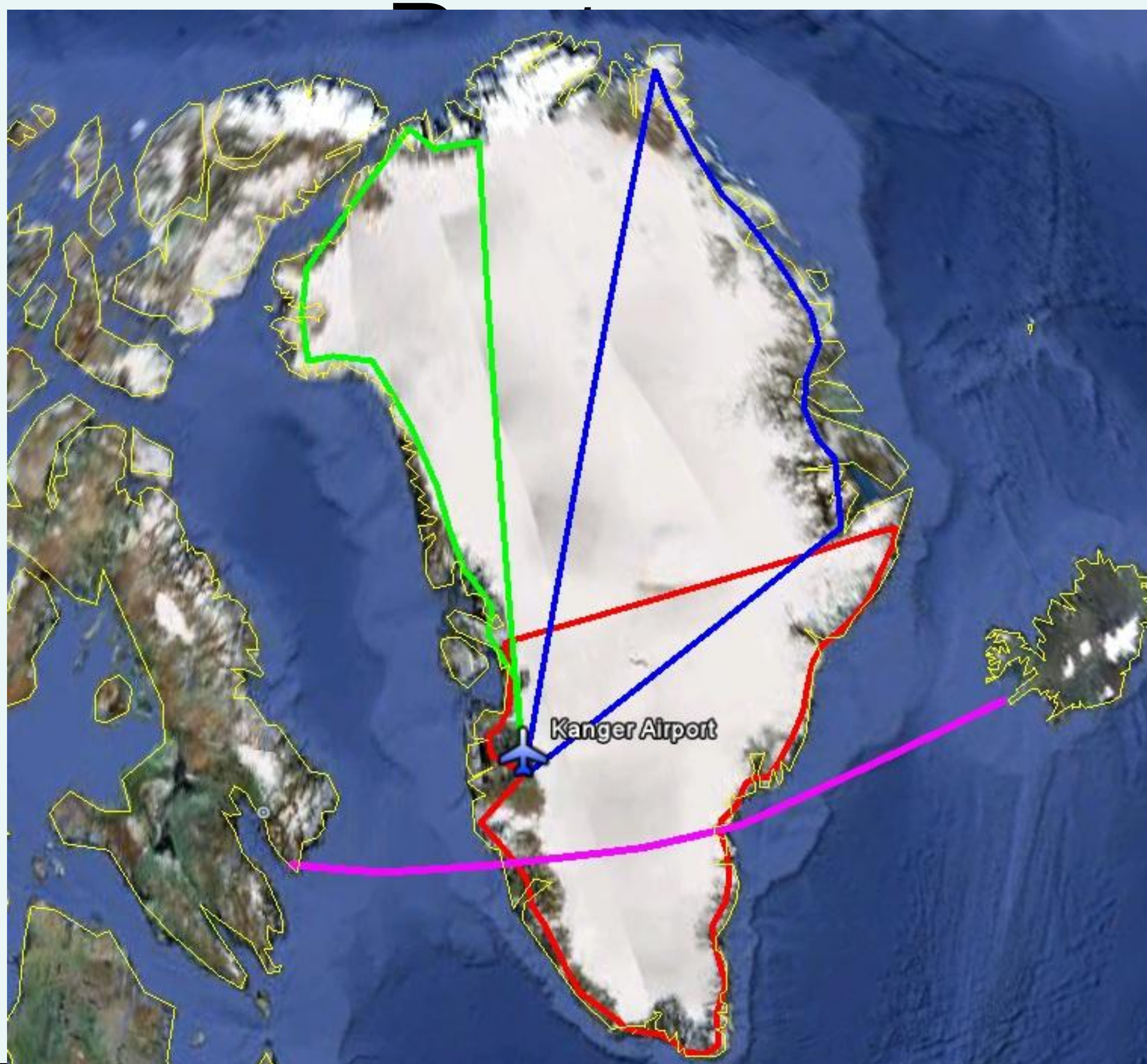
Red Line is 65° N Line

Greenland Perimeter

All Flights are out of Kanger

Each Route is approx same distance

Pink Line is the 65º N Line

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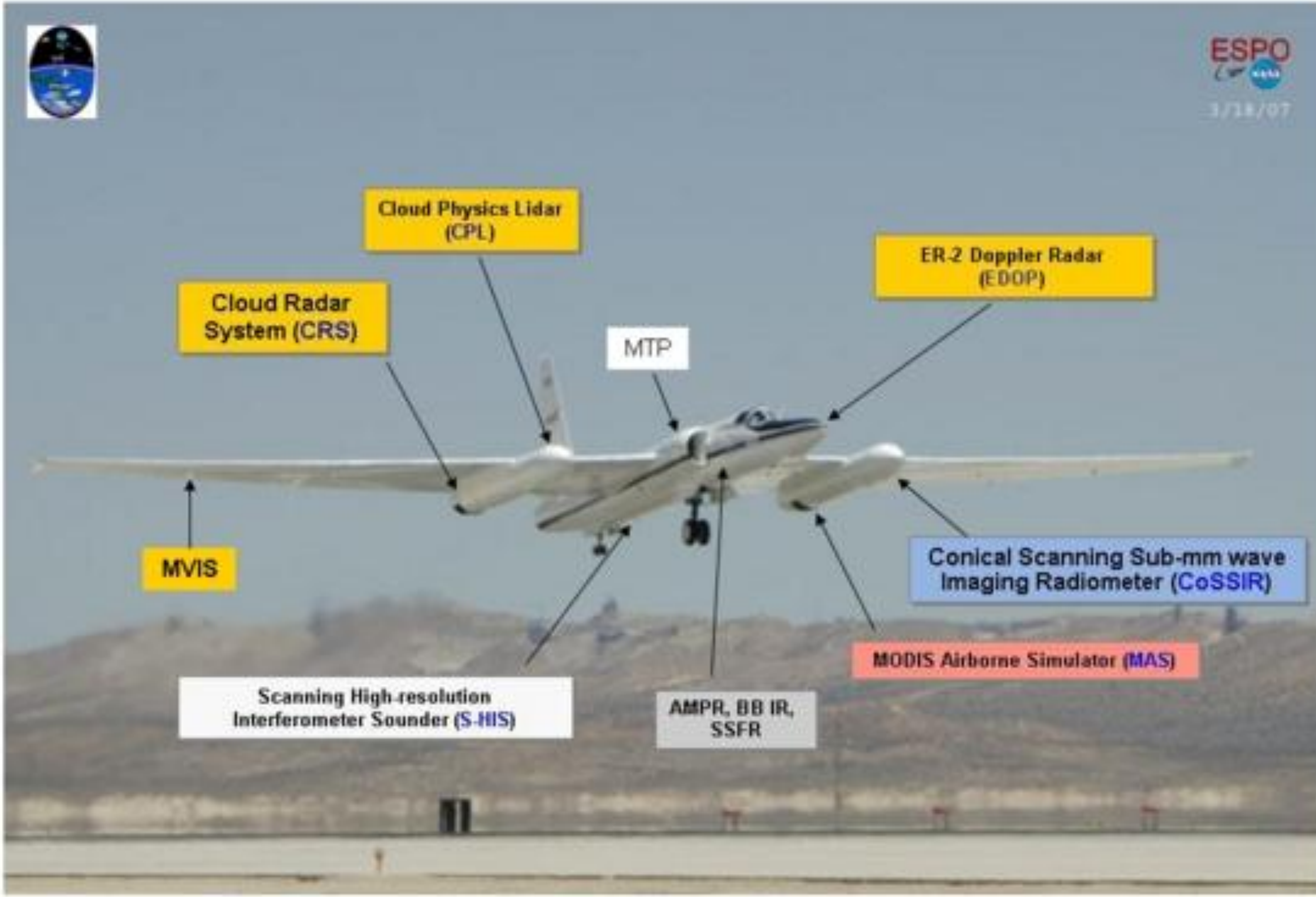
ESPO
3/18/07
Cloud Physics Lidar
(CPL)
ER-2 Doppler Radar
(EDOP)
Cloud Radar
System (CRS)
MTP
MVIS
Conical Scanning Sub-mm wave
Imaging Radiometer (CoSSIR)
MODIS Airborne Simulator (MAS)
Scanning High-resolution
Interferometer Sounder (S-HIS)
AMPR, BB IR,
SSFR

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/Gallery/Photo/index.html
NASA Photo: ED07-0027-54 Date: February 26, 2007 Photo By: Tom Tschida

An eight-foot-long pod designed to carry a synthetic aperture radar hangs from the underbelly of NASA's Gulfstream-III research testbed.

SOFIA

high altitude + Latitude & Equatorial


DROID 3
NASA

X-48B
X-48B
Boeing Phantom Works
Boeing Phantom Works
NASA
NASA

Potential for study

- Dosimeters could be installed in DFRC flight assets to baseline studies
- Develop strategies for altitude changes to minimize radiation exposure to crew/aircraft during solar events
- Model space weather along a route and verify results against modeling to refine and improve the model.
- Develop modeling for typical GA and airline routings (possible FAA nexgen inclusion)

Sensitivities at DFRC in Space Weather

- Radiated pilots may be identified as employable due to documented exposures
- U.S. Airlines do not want info released to their flightcrew’s lawyers fear of lawsuits
- May be viewed as a potential project killer if radiation is observed and documented as a normal part of flight operations (crewmembers and scientists refuse to fly mission based on space weather etc.)

Questions?