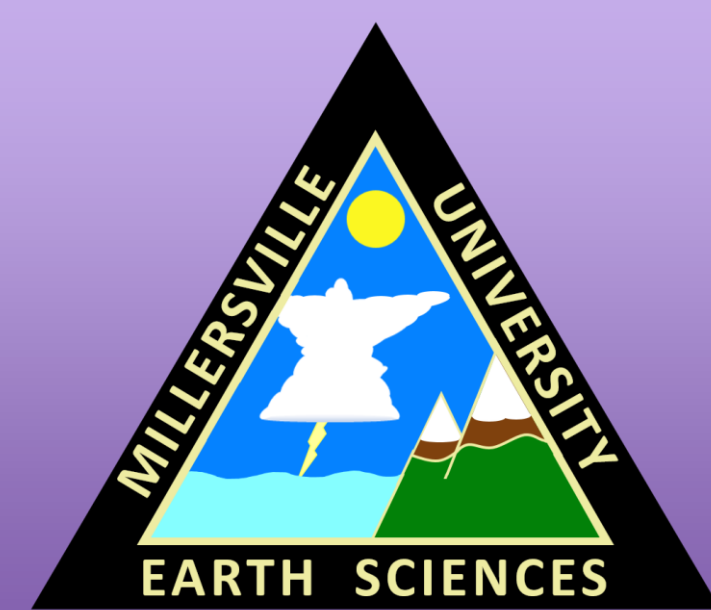




Model Improvements for the Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) Model

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NAIRAS Model

• LaRC's Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) Model

- Began model formulation and development in 2004
- Running in real-time at the LaRC/DAAC since April 2011

• Distinguishing Features

- Real-time physics-based, global model
- Real-time inclusion of SEP radiation
- Real-time solar-magnetospheric effects on radiation

• Public Website:

<http://sol.spacenvironment.net/~nairas/>

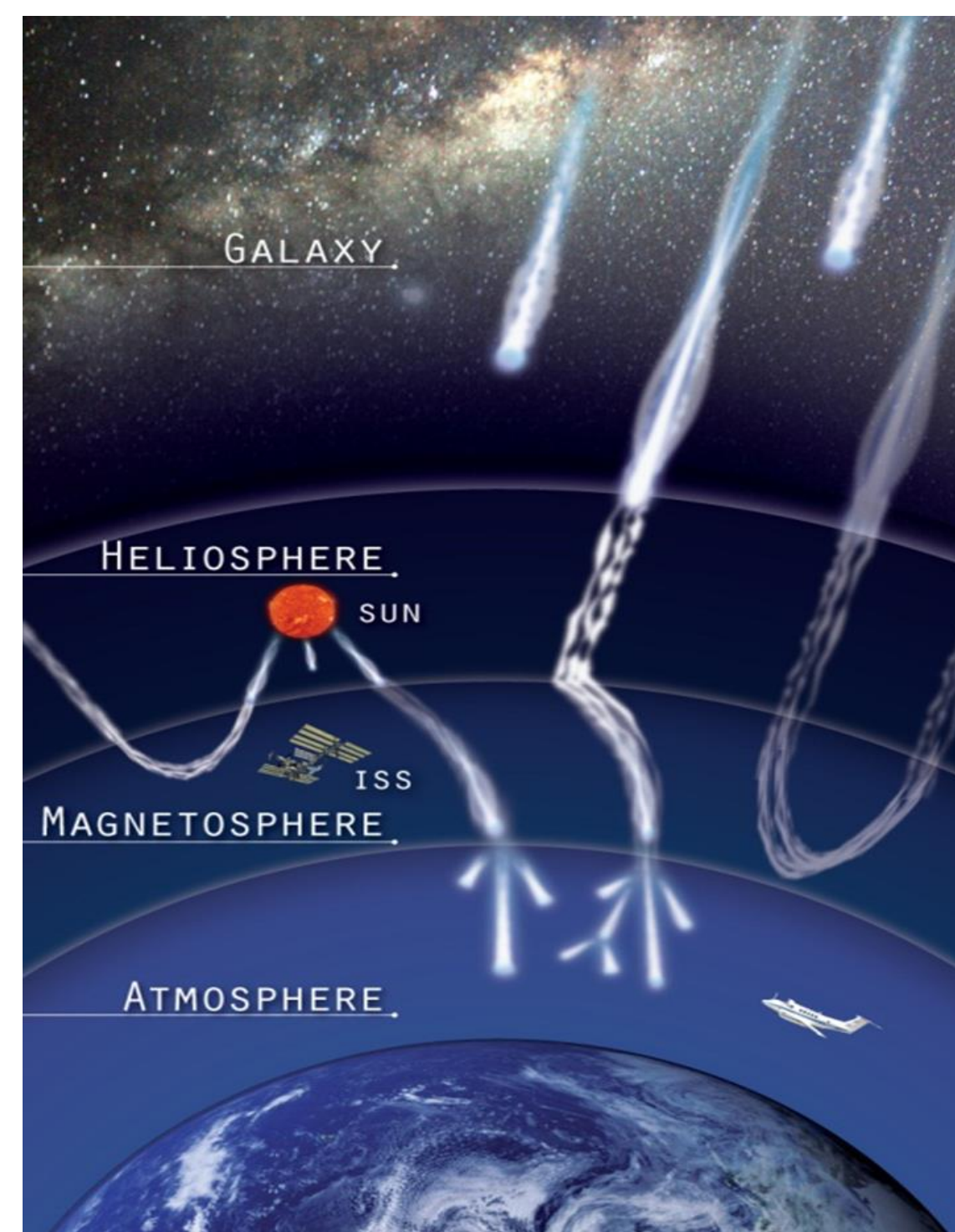


Photo Credit: NASA

Effective Dose Rate¹(E) for 2012-03-07 11:00-12:00 GMT

	lat	90S-60S	60S-40S	40S-20S	20S-0	0-20N	20N-40N	40N-60N	60-90N
avg	12.01	0.51	3.77	1.00	0.08	2.58	8.21	11.74	
max	13.07	12.35	8.81	3.03	3.64	8.71	12.45	13.61	

	lat	90S-60S	60S-40S	40S-20S	20S-0	0-20N	20N-40N	40N-60N	60-90N
avg	03.79	43.36	15.16	2.69	2.14	9.45	41.37	66.03	
max	09.41	66.18	47.22	10.15	13.08	45.58	67.88	72.08	

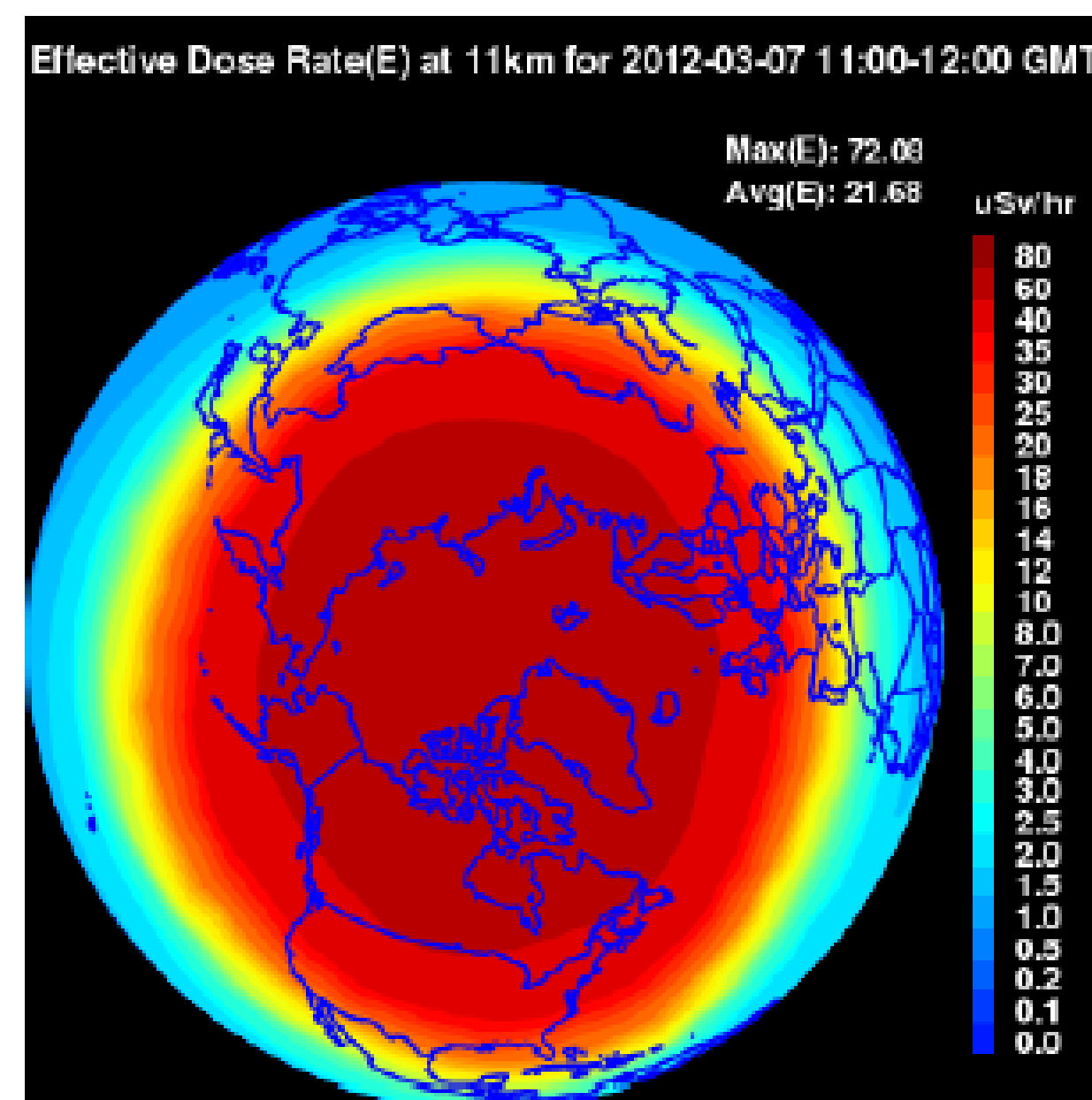
	lat	90S-60S	60S-40S	40S-20S	20S-0	0-20N	20N-40N	40N-60N	60-90N
avg	133.91	8.470	22.91	3.21	2.51	13.33	76.84	142.45	
max	144.85	120.65	94.88	13.45	17.59	90.36	147.34	182.19	

Representative High-Latitude Flights

2012-03-07 11:00-12:00 GMT

Flight Name	Time	Rate ¹	Dose ¹	Safety Signal		
	hours	uSv/hr	mSv	Aircraft ²	Public ³	Prenatal ⁴
London,GBR - New York,USA	5.50	51.52	0.283			
Chicago,USA - Stockholm,SWE	8.50	83.09	0.536			
Chicago,USA - Munich,DEU	8.50	56.35	0.479			
Chicago,USA - Beijing,CHN	13.50	60.34	0.815			

Signal	Aircraft ²	Public ³	Prenatal ⁴
Max Annual(60hrs)	0-6.6mSv	0-0.33mSv	0-0.167mSv
	6.6-12.0mSv	0.33-0.67mSv	0.167-0.333mSv
	>12.0mSv	>0.67mSv	>0.333mSv



Model Improvements:

A) Updating to HZETRN2015

- Pion-initiated electromagnetic (EM) cascade process

B) Correcting GCR primary proton and alpha flux based on PAMELA satellite measurements

Pion-Initiated EM Cascade

Pi-Meson Production ($m_2c^2 \sim 140$ MeV)

$$A + A' \rightarrow \pi^\pm + x$$
$$A + A' \rightarrow \pi^0 + x$$

Pi-Meson Decay + Muon Production

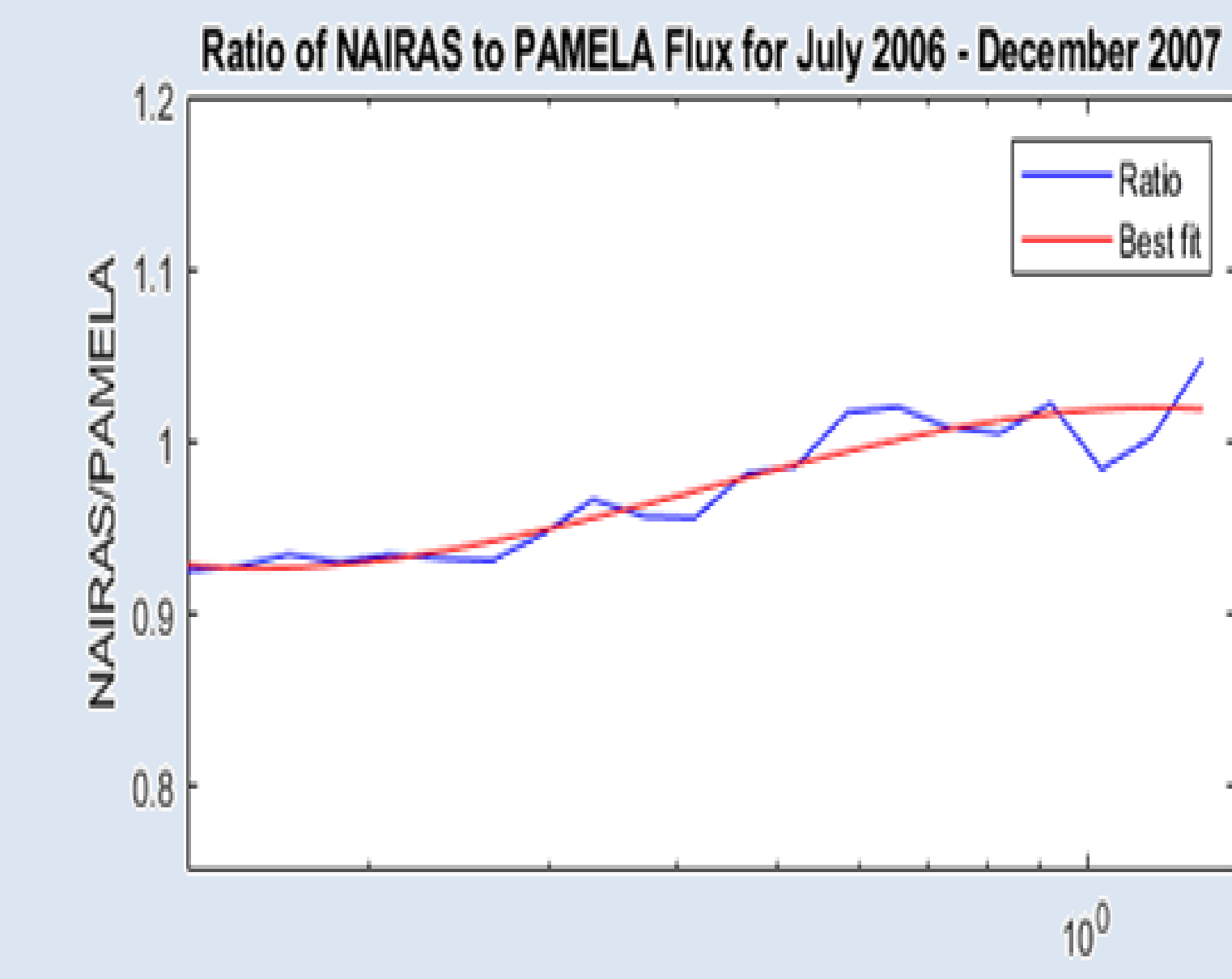
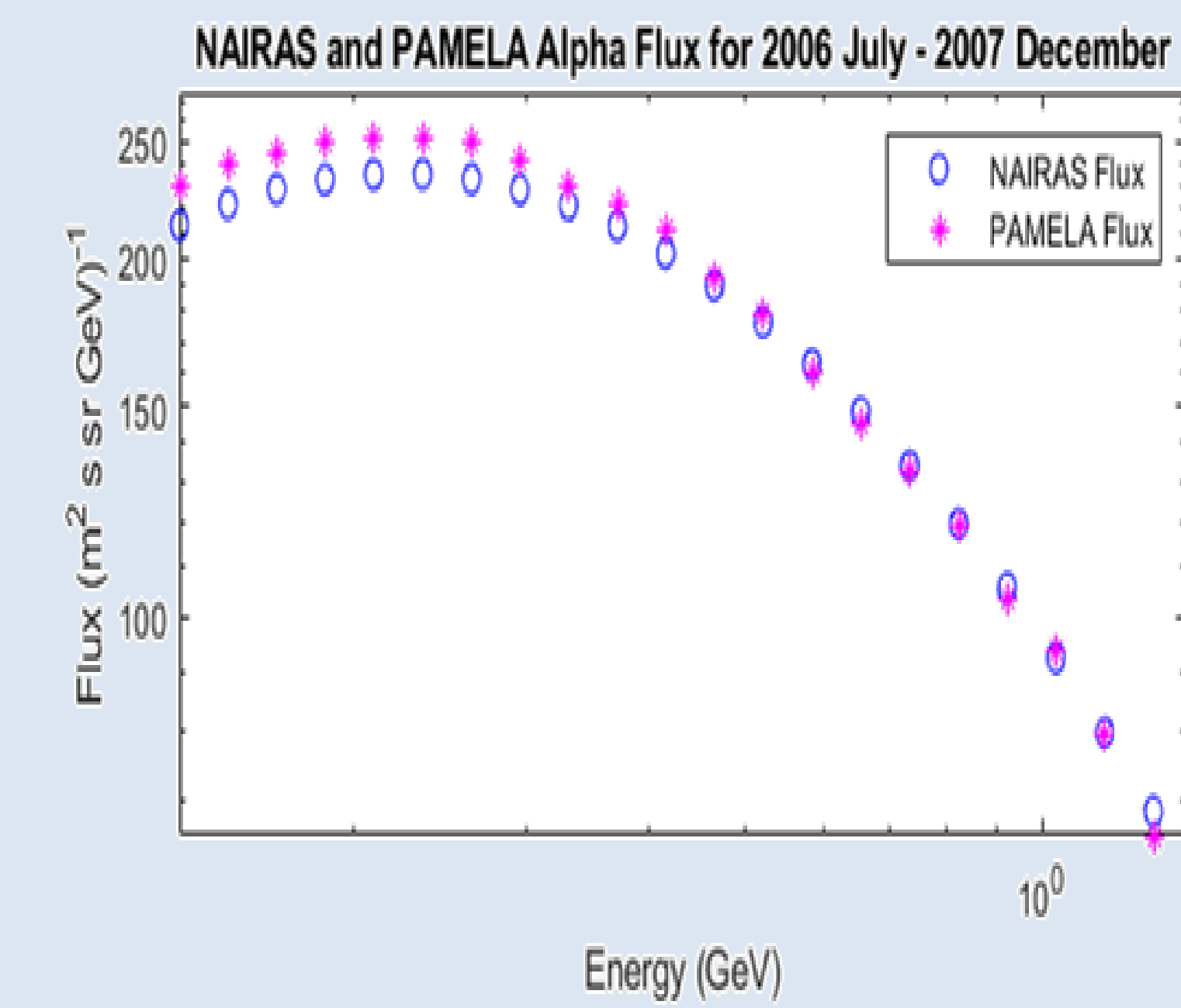
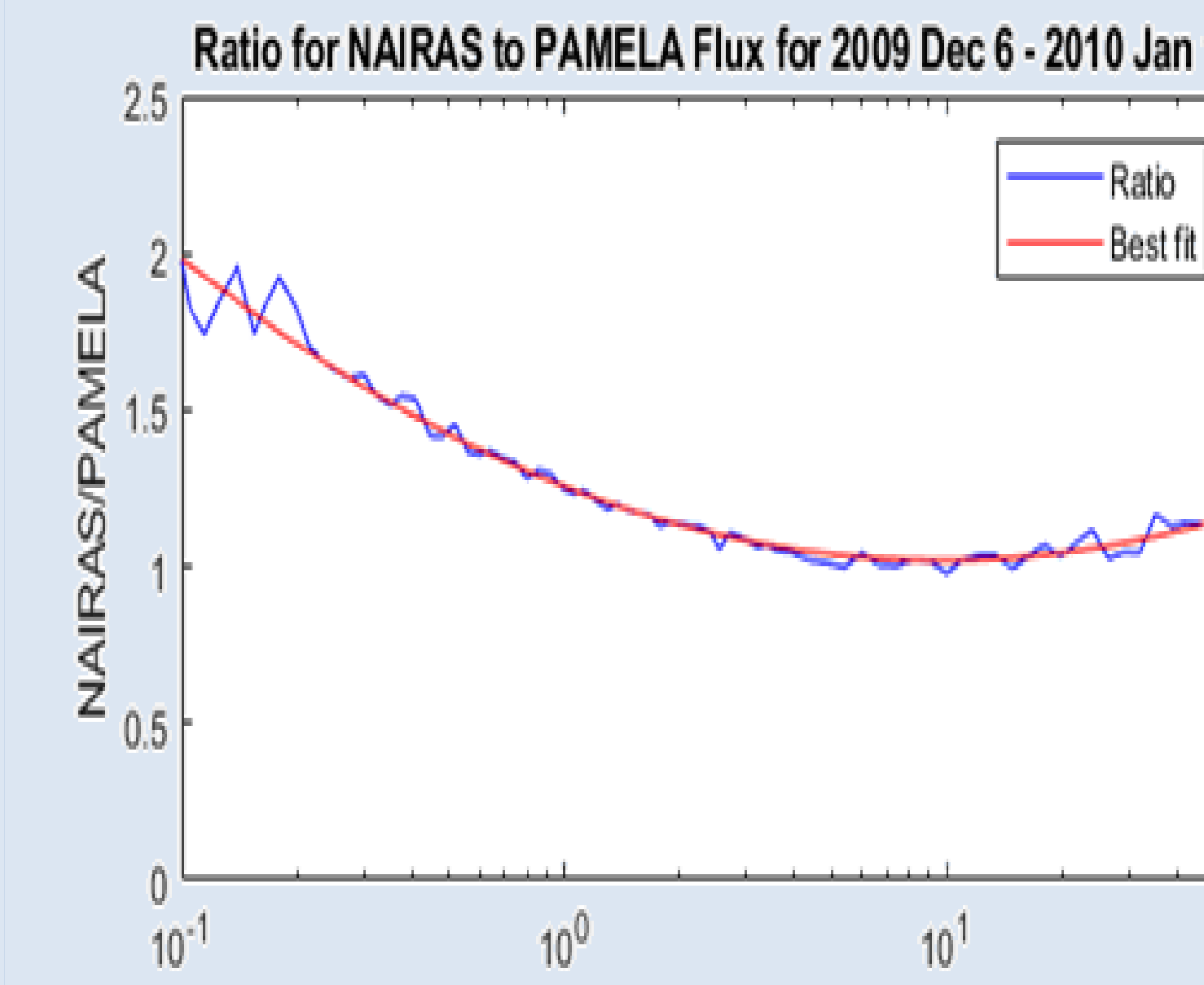
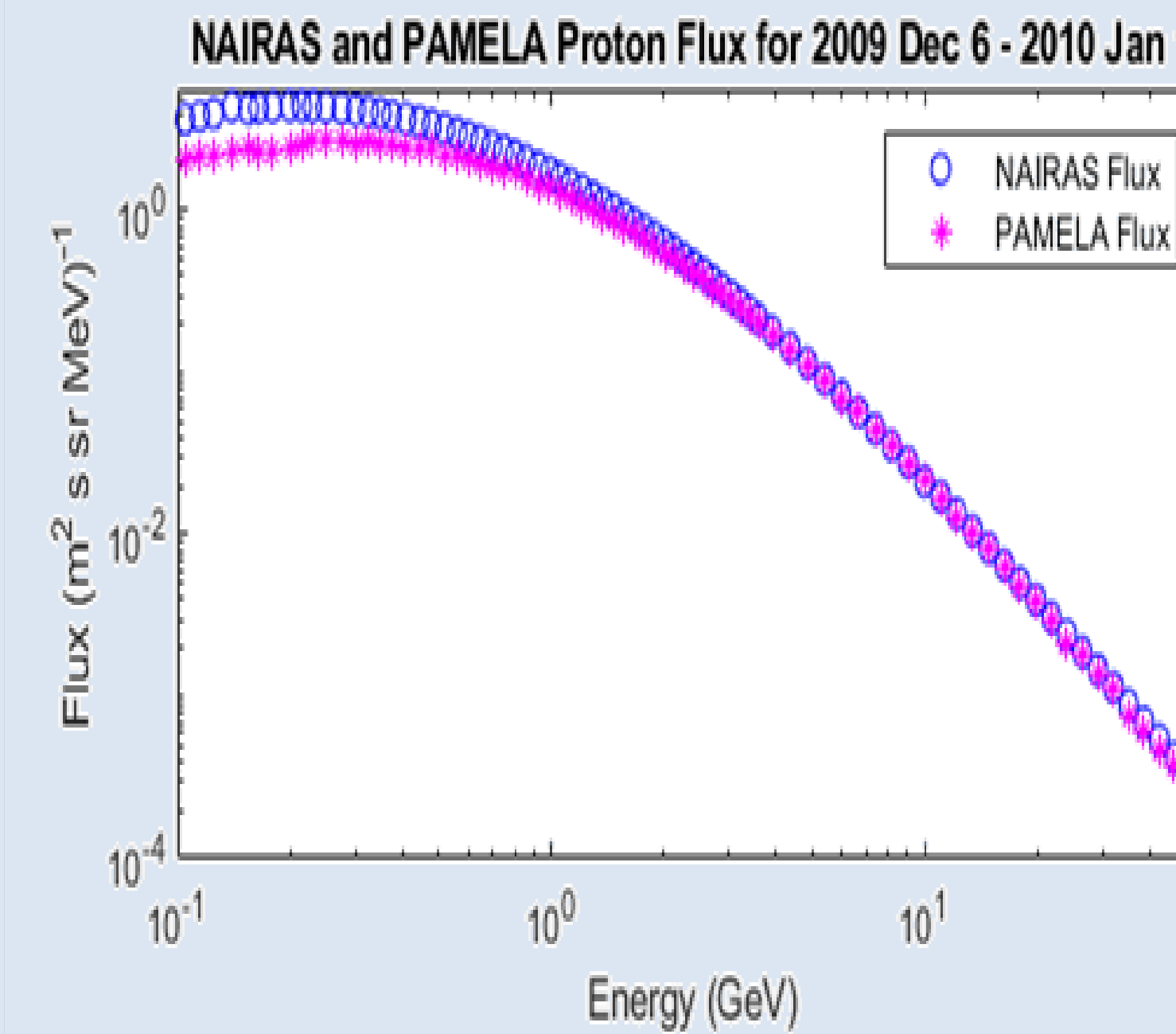
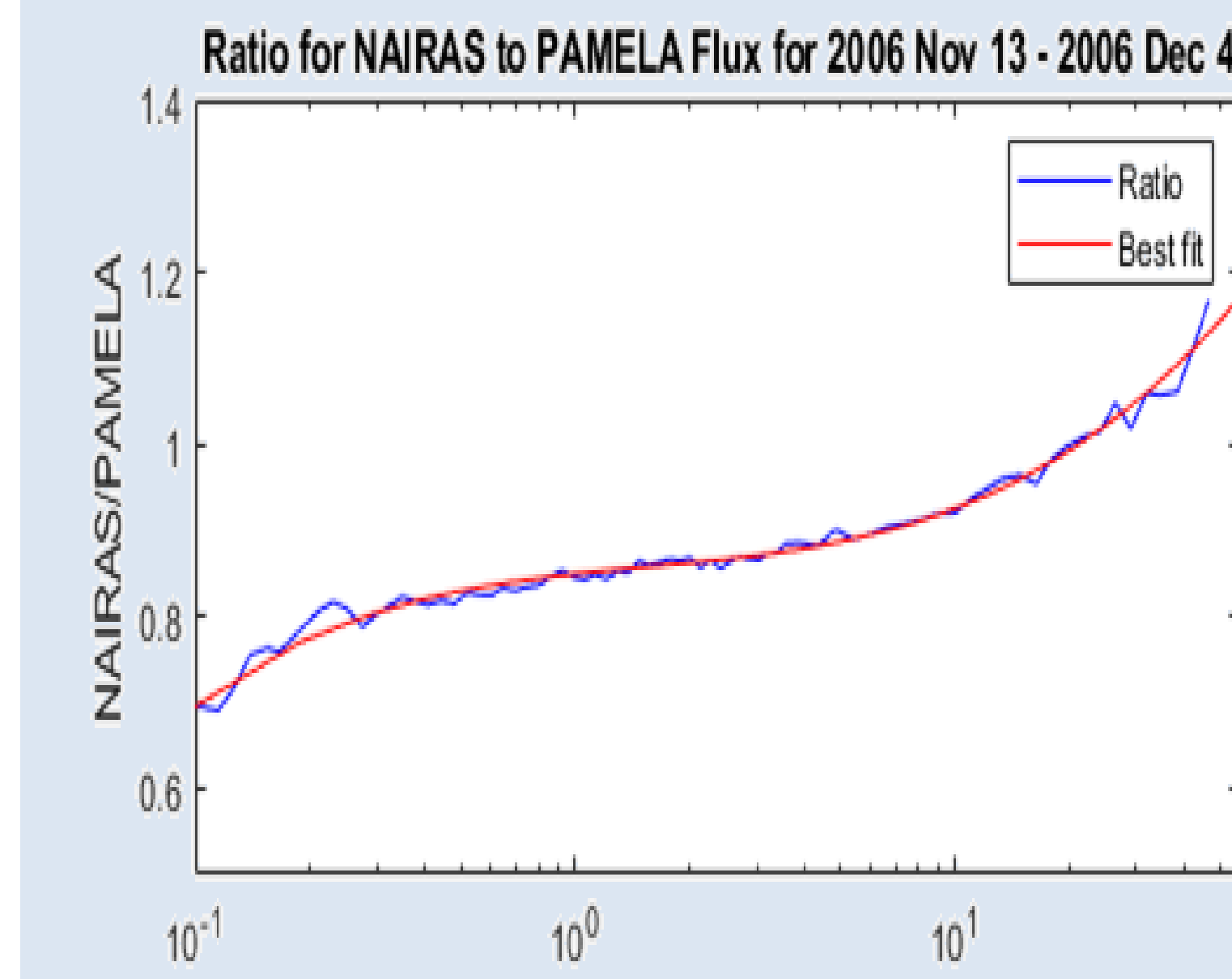
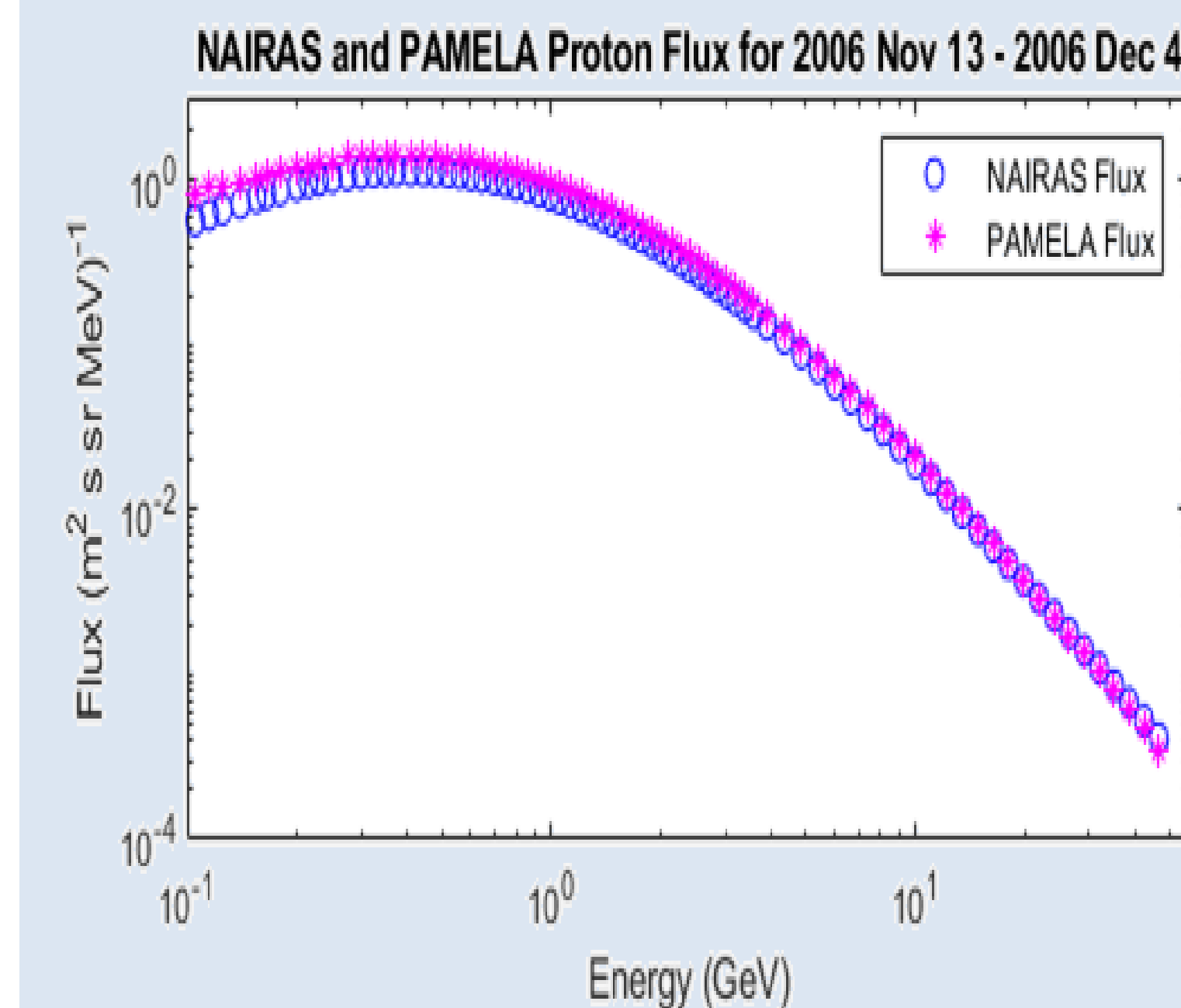
$$\pi^\pm \rightarrow \mu^\pm + \nu \quad (2.6 \times 10^{-8} \text{ sec})$$
$$\pi^0 \rightarrow \gamma + \gamma \quad (\sim 10^{-16} \text{ sec})$$

Muon Decay + EM Cascade

$$\mu^\pm \rightarrow e^\pm + \nu + \nu' \quad (2.2 \times 10^{-6} \text{ sec})$$
$$e^\pm + A \rightarrow \gamma + e^\pm + A$$
$$\gamma + A \rightarrow e^+ + e^- + A$$
$$e^+ + A \rightarrow \gamma + \gamma + A^+$$

Uncertainty Assessment

Model Improvements



Summary & Conclusions

- For the proton and alpha corrections, the flux values were compared to PAMELA data, and then the correction factor was determined by finding the best fit of the ratio of NAIAS to PAMELA flux values.
- The NAIAS/PAMELA proton flux ratios were computed for two time periods: (1) 2009 Dec 6 – 2010 Jan 1, which represents solar minimum conditions, and (2) 2006 Nov 13 – 2006 Dec 4, which represents a solar cycle transition between minimum and maximum activity. The NAIAS/PAMELA proton flux correction ratios are assumed to vary linearly with respect to solar activity phase between these two fitting periods.
- The NAIAS/PAMELA alpha ratios were computed for one time period (2006 July – 2007 Dec). The alpha flux correction ratio is applied for all solar cycle phases until additional measurements are available.
- NAIAS uncertainty is assessed by comparing model predictions of ambient dose equivalent rate to ICRU (International Commission on Radiological Units and Measurements) reference measurements tabulated as a function of geomagnetic cutoff rigidity for January 1998 (Solar Minimum), January 2000 (Solar Transition), and January 2002 (Solar Maximum).
 - Ambient dose equivalent is an operational proxy for total biological detriment from radiation exposure.
- NAIAS percent differences were computed with respect to the ICRU reference data as well. (tables to the left)
- HZETRN2015, proton, and alpha corrections improved the reliability and accuracy of the NAIRAS model for January 1998 (solar minimum), January 2000 (solar transition), and January 2002 (solar maximum).

Percent Difference Table Before Updates

Time Period	FL310	FL350	FL390	Overall
Jan 1998	-10.54 %	-27.63 %	-37.73 %	-25.30 %
Jan 2000	-24.09 %	-36.42 %	-44.41 %	-34.97 %
Jan 2002	-32.44 %	-43.08 %	-50.06 %	-41.86 %

Percent Difference Table After Updates

Time Period	FL310	FL350	FL390	Overall
Jan 1998	1.67 %	-18.6 %	-30.88 %	-15.9 %
Jan 2000	6.2 %	-11.63 %	-22.90 %	-9.44 %
Jan 2002	-4.25 %	-19.84 %	-30.07 %	-18.10 %

