JEM-EUSO duty cycle estimation

Influence of auroral lights

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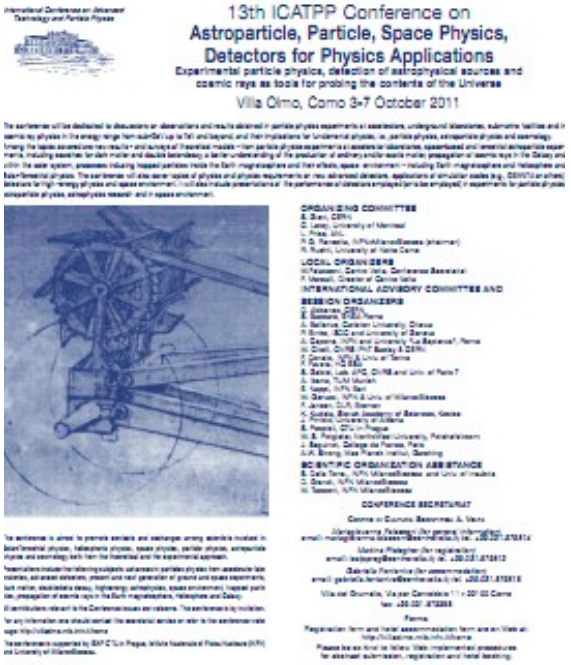
Observation efficiency – Como article

- 13th ICATPP Conference on Astroparticle, Particle, Space Physics and Detectors for Physics Applications, Villa Olmo, Como 3-7 October 2011 - http://villaolmo.mib.infn.it
- **Estimation of JEM-EUSO experiment OBSERVATION EFFICIENCY**
- **Deconvolution of effects**
- **... in Conclusion "**... at present stage, 1 bright pixel in the PDM is blinding the entire PDM. If the 1st trigger level could work at EC level (9 elementary cells in PDM), we could gain ~1% (from 18.51% back to 19%) in operational duty cycle.**"**

$I_{Allowed}$ [ph/(m² ns sr)]	I_{SUN} > 109.18°	I_{MOON} only [%]	Cities only [%]	I_{SUN} + I_{MOON} [%]	I_{SUN} + I_{EG} + I_{MOON} [%]	I_{SUN} + I_{EG} + I_{MOON} + Cities [%]
1		50.00	90.14	17.83	0.00	0.00
10		50.11	90.14	17.85	0.00	0.00
100		51.14	90.18	18.14	0.00	0.00
300		53.45	90.18	18.72	0.00	0.00
500		55.92	90.26	19.25	0.00	0.00
1000	34.84	62.06	90.26	20.41	19.25	17.46
1500		**68.08**	**91.06**	**21.43**	**20.41**	**18.51**
5000		89.73	95.97	26.73	26.07	23.61
10000		97.85	98.81	32.69	32.20	29.15
15000		99.99	100.00	34.83	34.80	31.55
30000		100.00	100.00	34.84	34.84	31.58



Aurora effect on JEM-EUSO operational efficiency

Start from **20.41%** from model presented in Como 2011

$$I = I_{SUN} + I_{MOON} + I_{BG}$$

I_{BG} is set to 500 UV photons / (m^2 sr ns)

To estimate auroras effect we evaluate for every position of ISS additional parameters

- **Kp index** to describe geomagnetic activity
- geomagnetic latitude and longitude of ISS

The K-index quantifies disturbances in the horizontal component of earth's magnetic field with an integer in the range 0-9 with 1 being calm and 5 or more indicating a geomagnetic storm. The official planetary Kp index is derived by calculating a weighted average of K-indices from a network of geomagnetic observatories.

Following a Table from NOAA

- http://www.swpc.noaa.gov/Aurora/index.html

we exclude from duty cycle (observation efficiency) moments when Kp index for ISS geomagnetic latitude was equal or higher than auroral boundary

Comparison of Auroral Boundaries from Kp and Auroral Activity Level at Local Midnight

Magnetic Latitude	Kp	Magnetic Latitude	NOAA POES Auroral Activity Level
66.5	0	67.5	1
64.5	1	66.5	2
62.4	2	65.6	3
60.4	3	63.9	4
58.3	4	62.5	5
56.3	5	60.7	6
54.2	6	58.6	7
52.2	7	56.7	8
50.1	8	54.6	9
48.1	9	51.0	10
		48.5	10+
		45.0	10++

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Aurora effect on JEM-EUSO operational efficiency

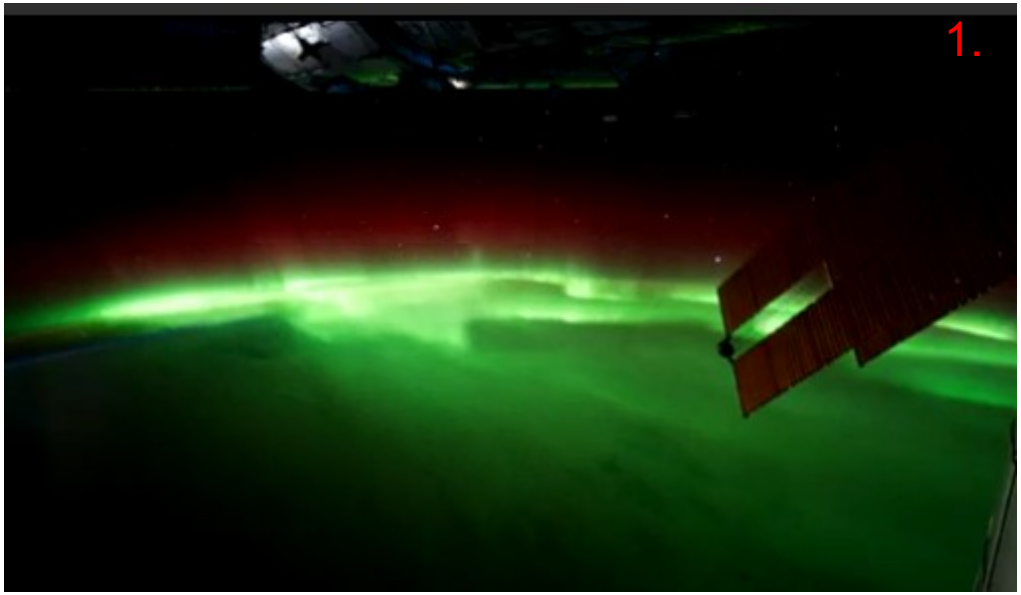
Simple verification of method

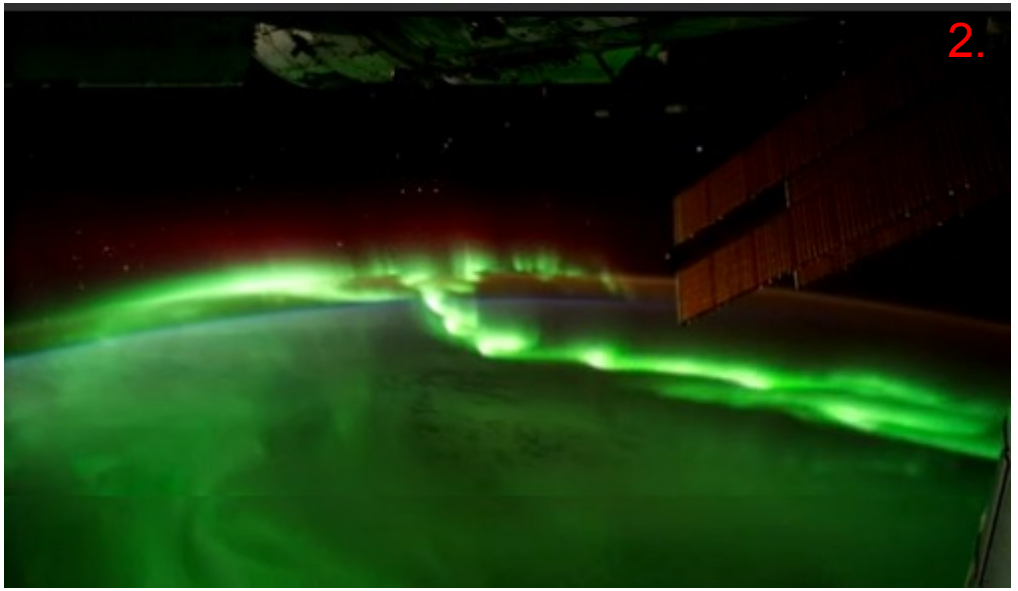
From few videos taken from ISS with auroras available at [1] we were able select one [2] in period 2000-2011 with clear aurora visible in nadir mode (directly under ISS).

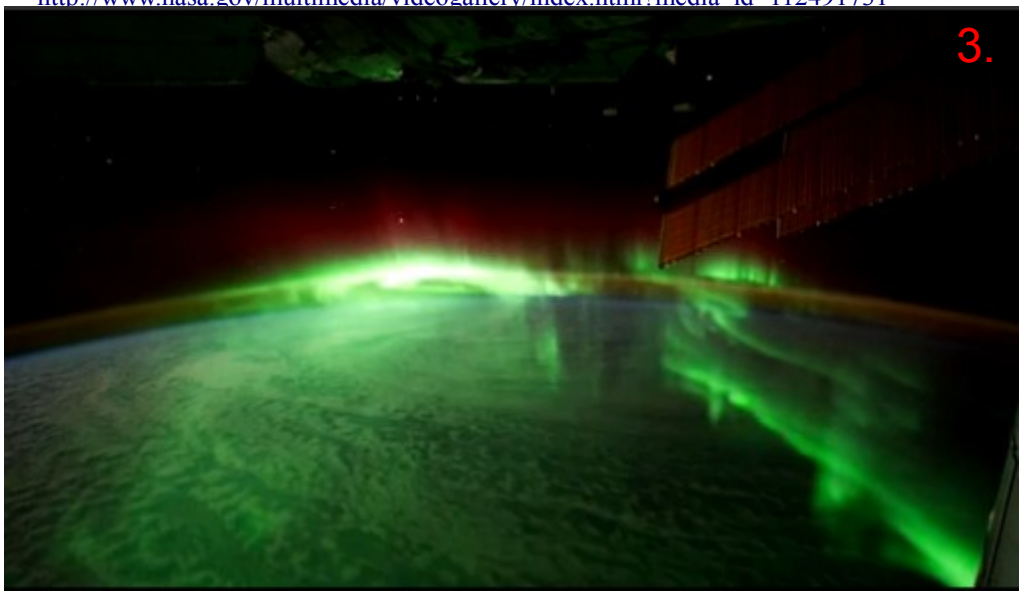
Video was taken when ISS flew from Madagascar to Australia between 17:22 and 17:45 GMT on 17. september 2011. Part of video shows ISS flight over aurora australis.

For same time, our method identifies appearance of aurora. During the year 2011 method identifies 433 minutes (50 minutes in september 2011) with aurora appearance.

Coincidence between movie appearance of aurora and method identification of aurora in same time is a supporting argument to method validity.







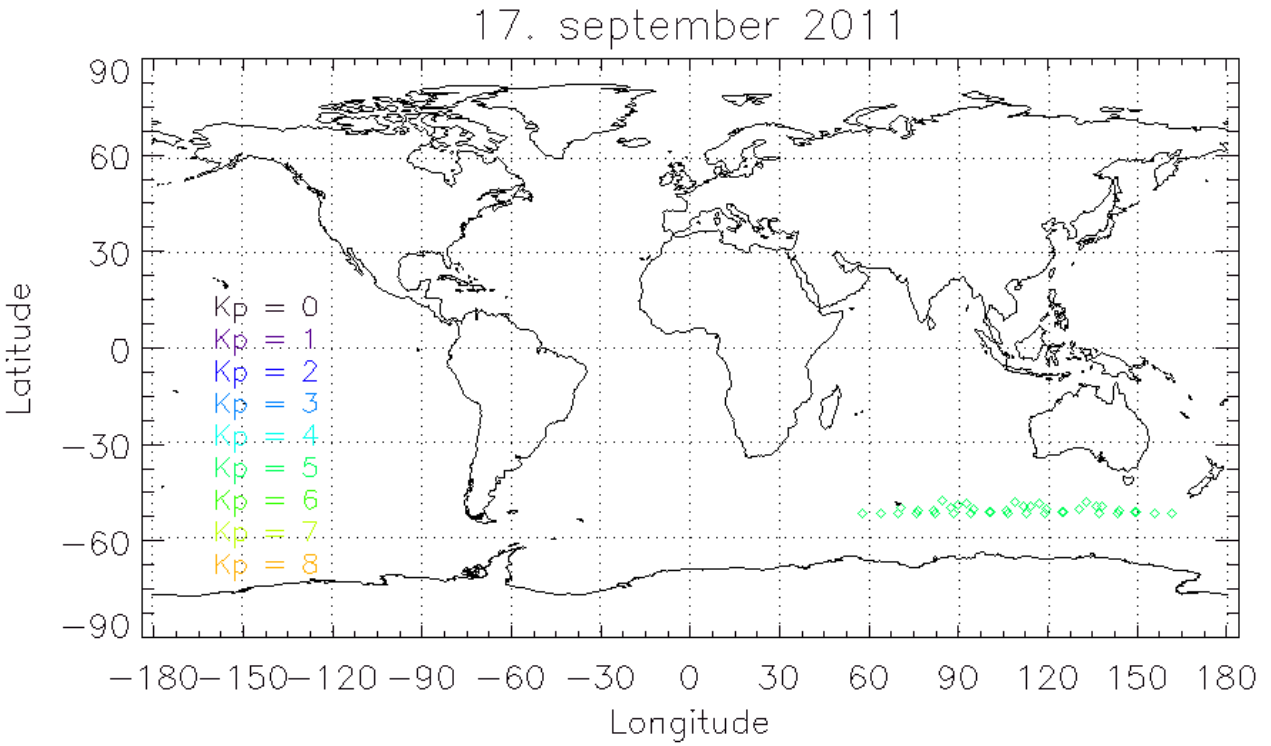
References:

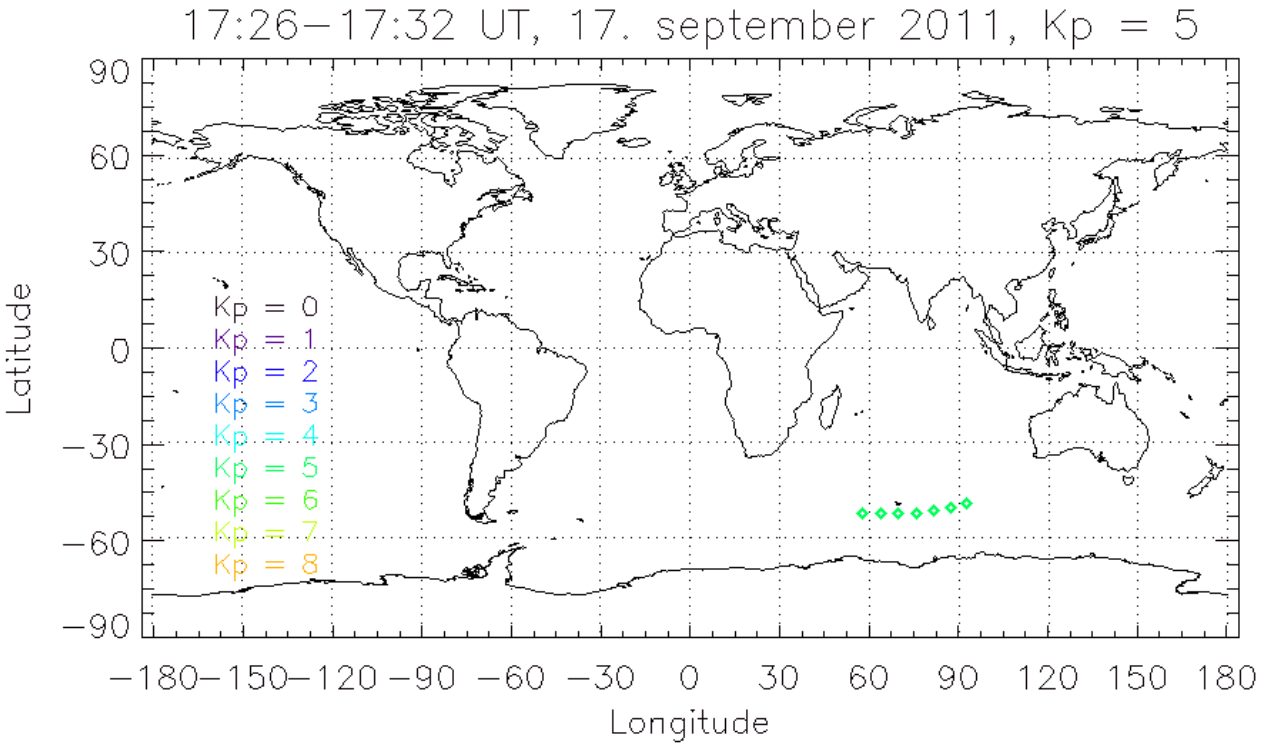
1. http://www.nasa.gov/multimedia/videogallery/index.html
2. http://www.nasa.gov/multimedia/videogallery/index.html?media_id=112491731

Aurora effect on JEM-EUSO operational efficiency

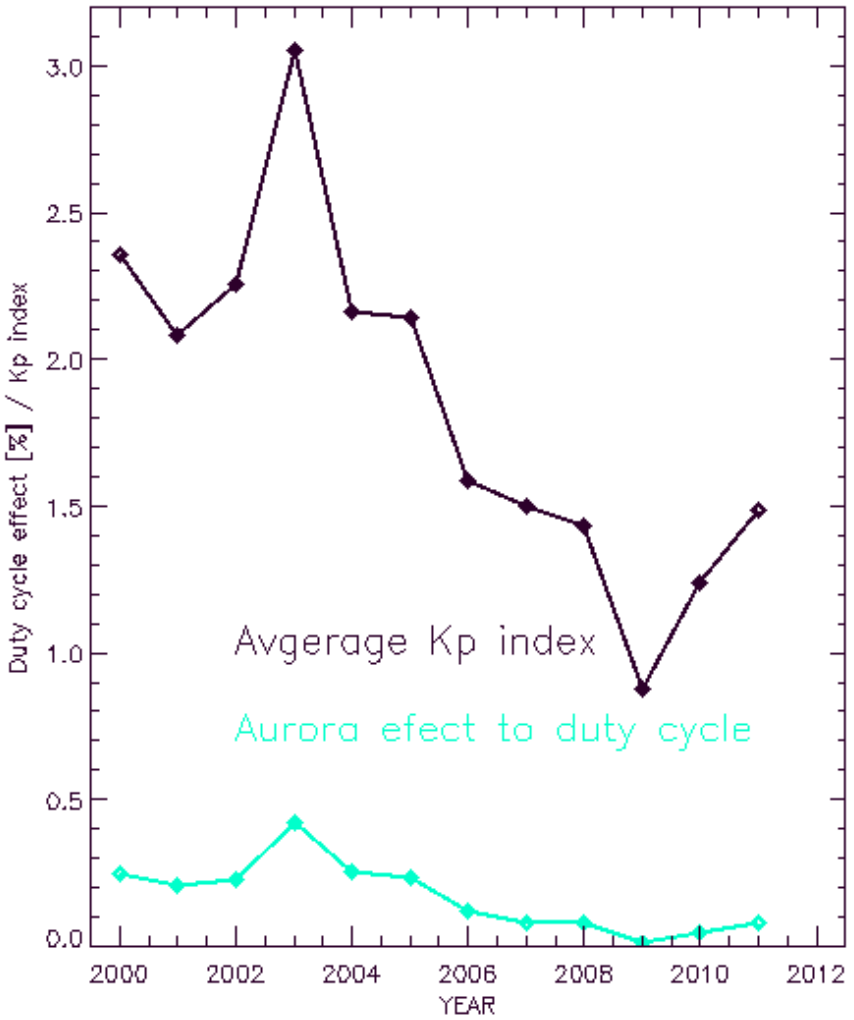
Simple verification of method

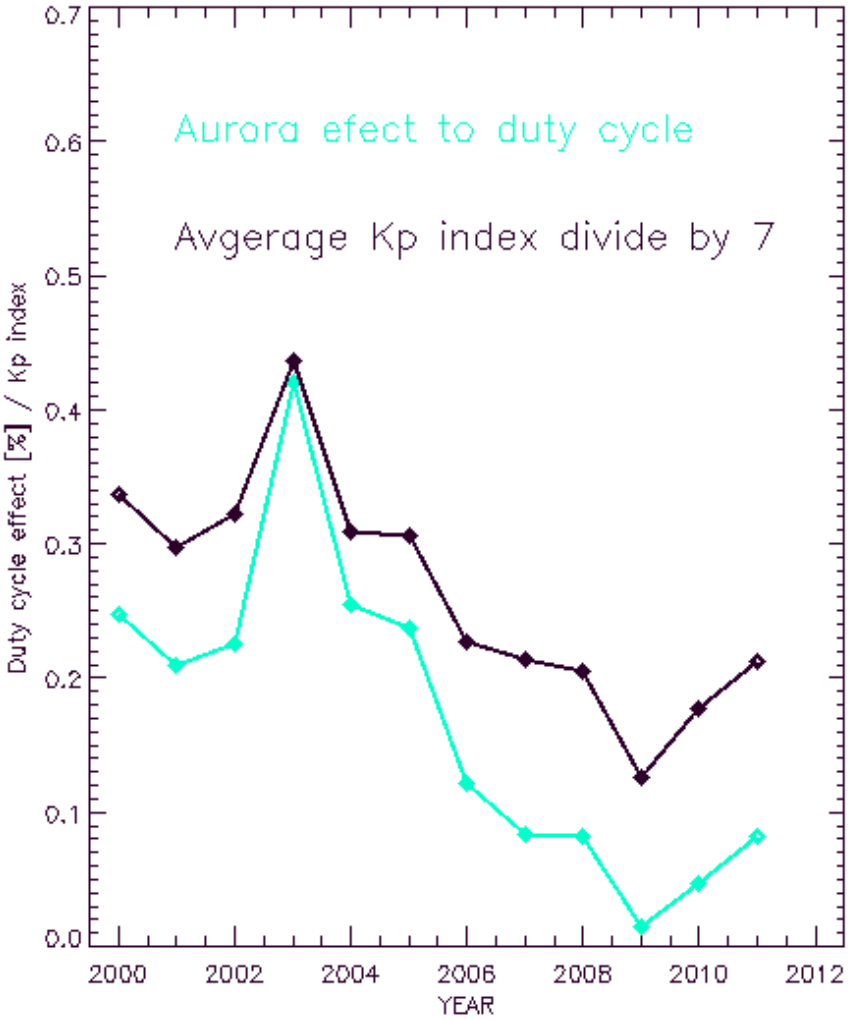
Positions of ISS with auroras visible in nadir mode detected by position of auroral oval and Kp index limits.





Aurora effect on JEM-EUSO operational efficiency





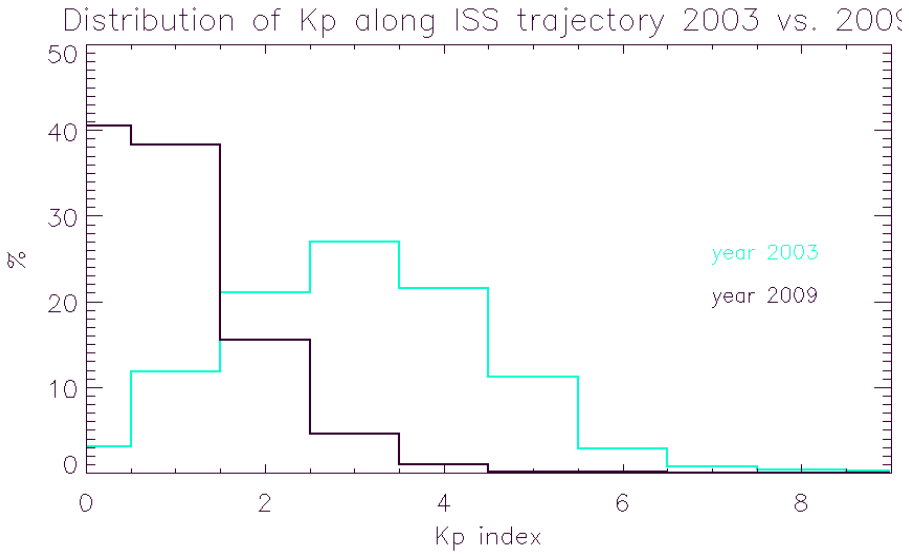
Effect of auroras to JEM-EUSO operational efficiency for one year long periods from 2000 to 2011

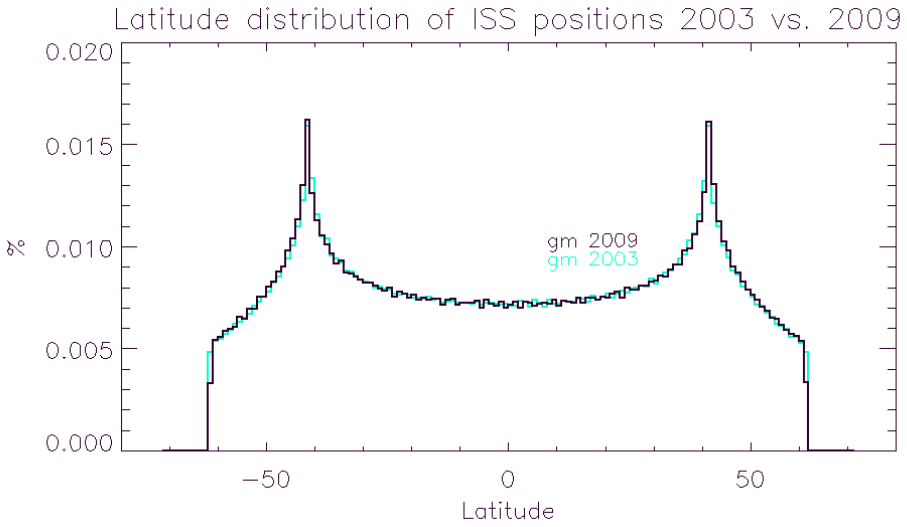
The value of duty cycle reduction vary from 0.42% in year 2003 to 0.01% in year 2009.

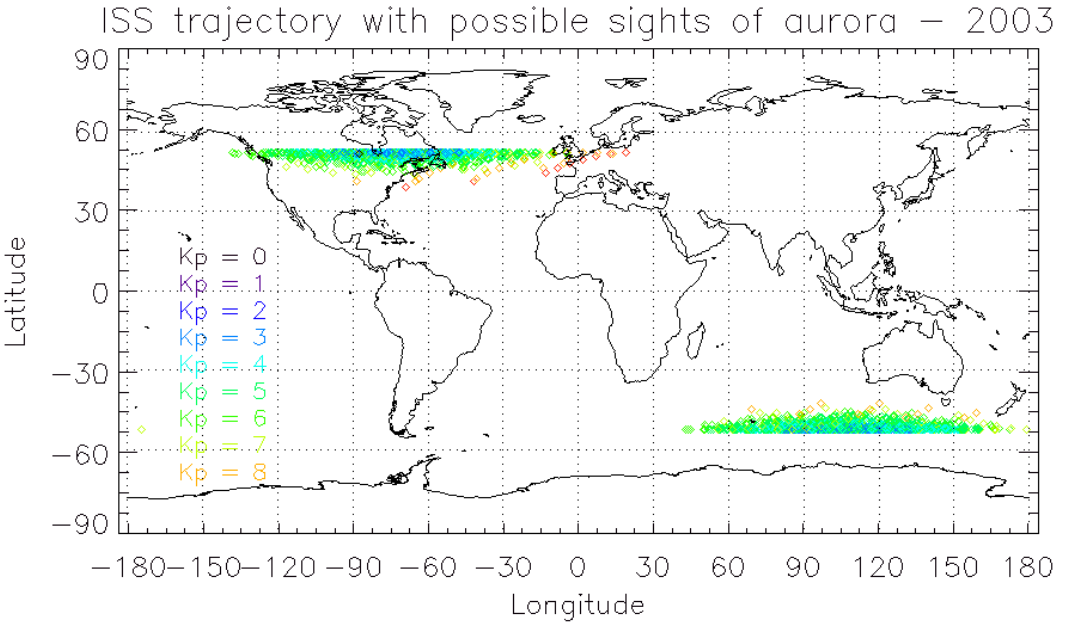
Aurora effect on JEM-EUSO operational efficiency

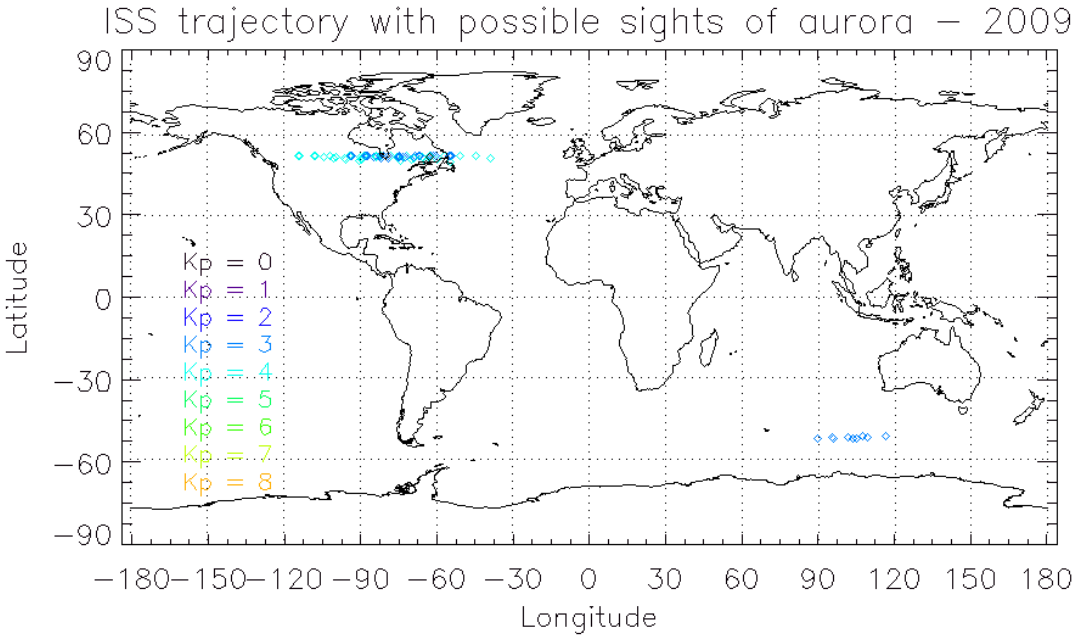
2003 vs. 2009

- duty cycle reduction 0.42% in year 2003 and 0.01% in year 2009



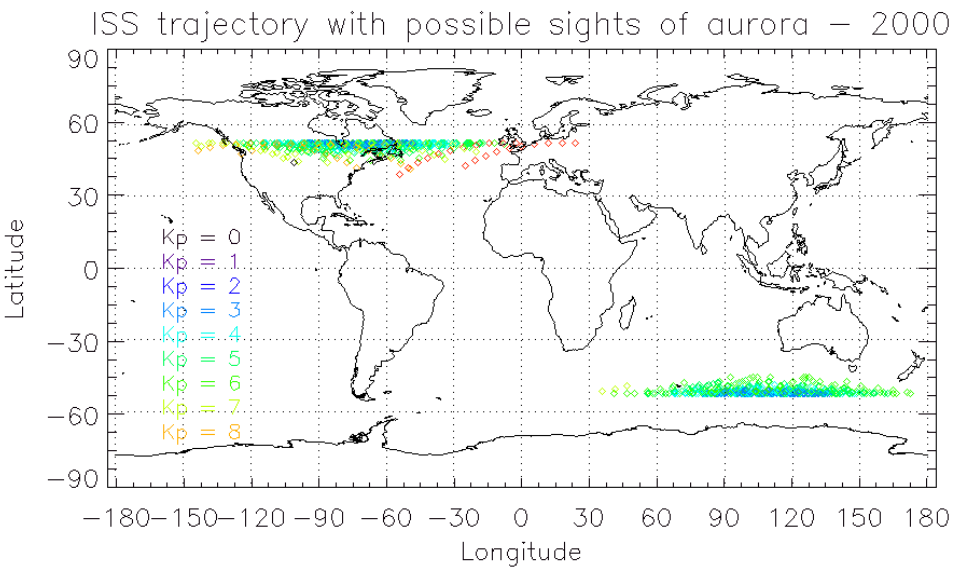


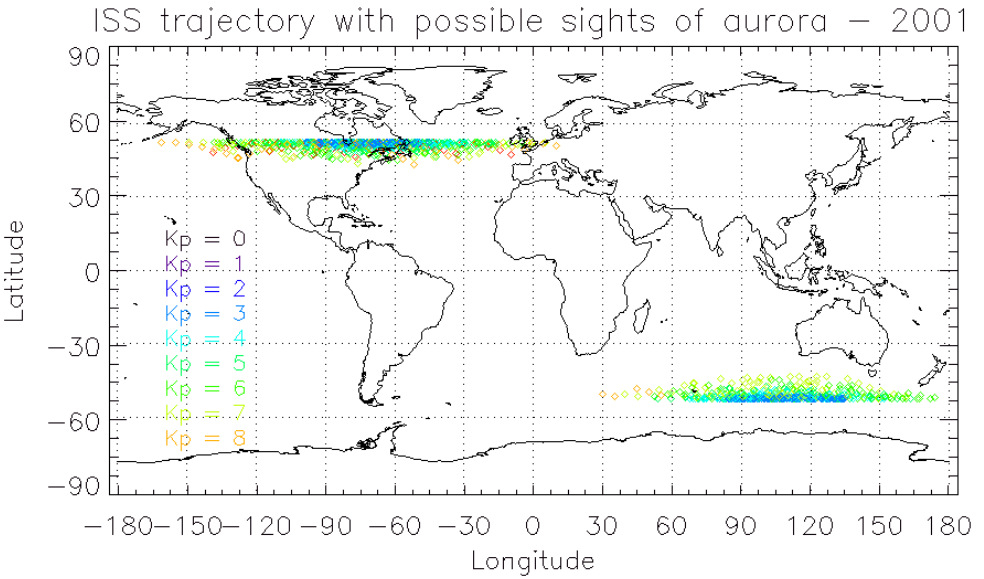


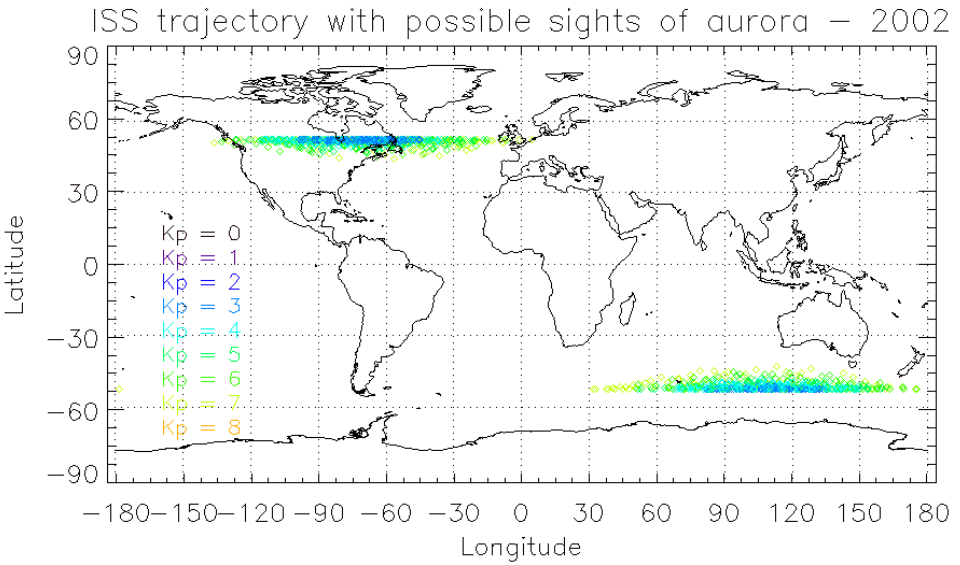


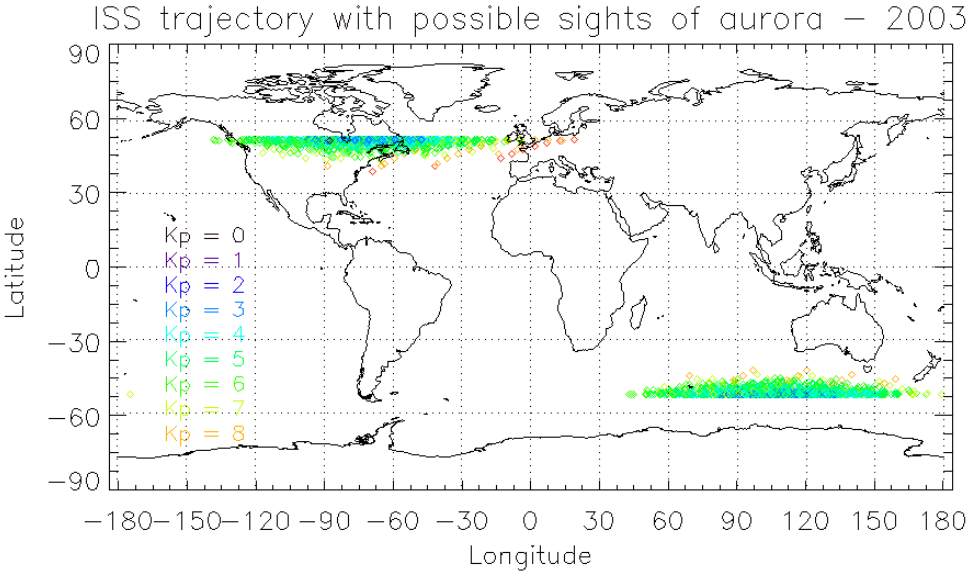
Aurora effect on JEM-EUSO operational efficiency

2000 - 2003









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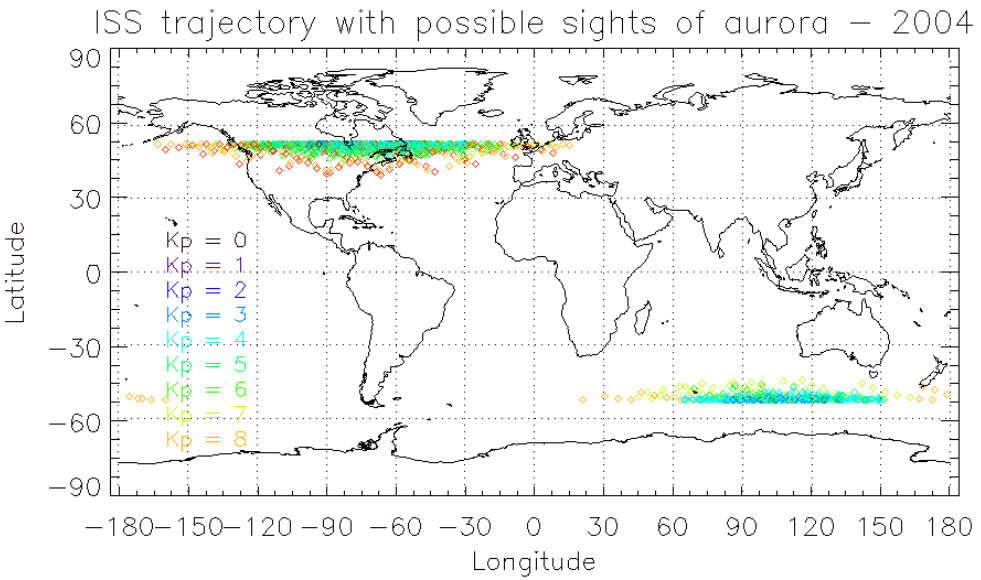
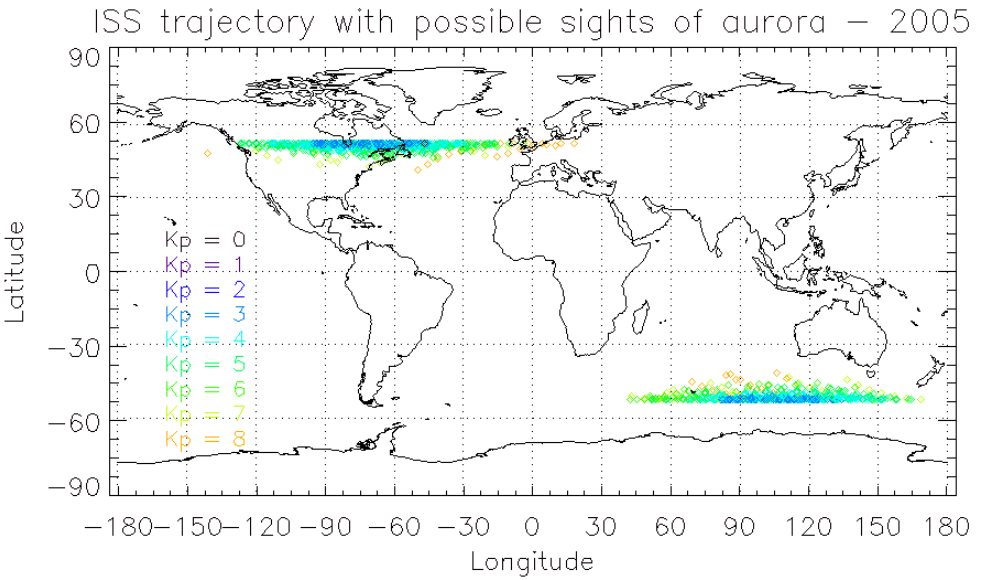
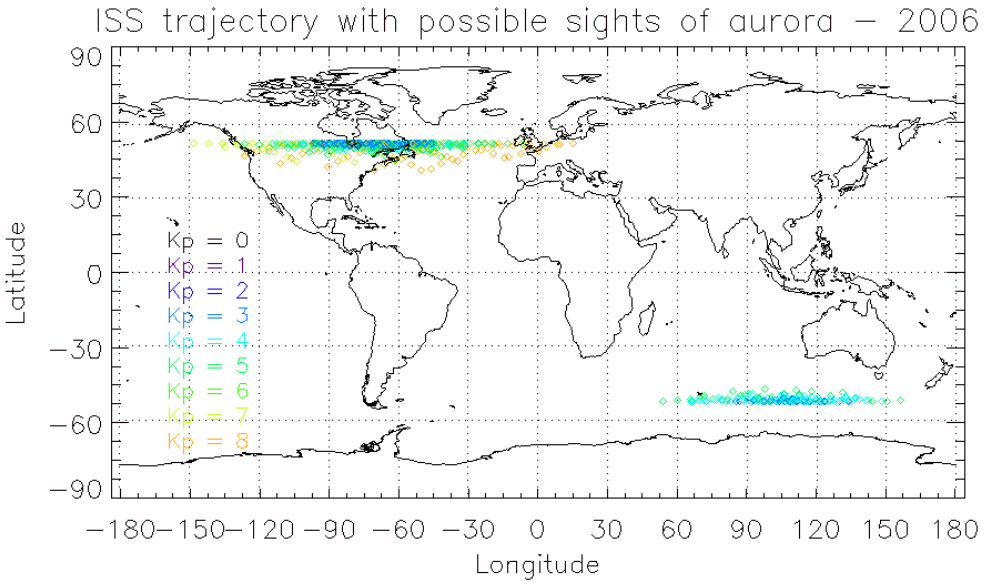
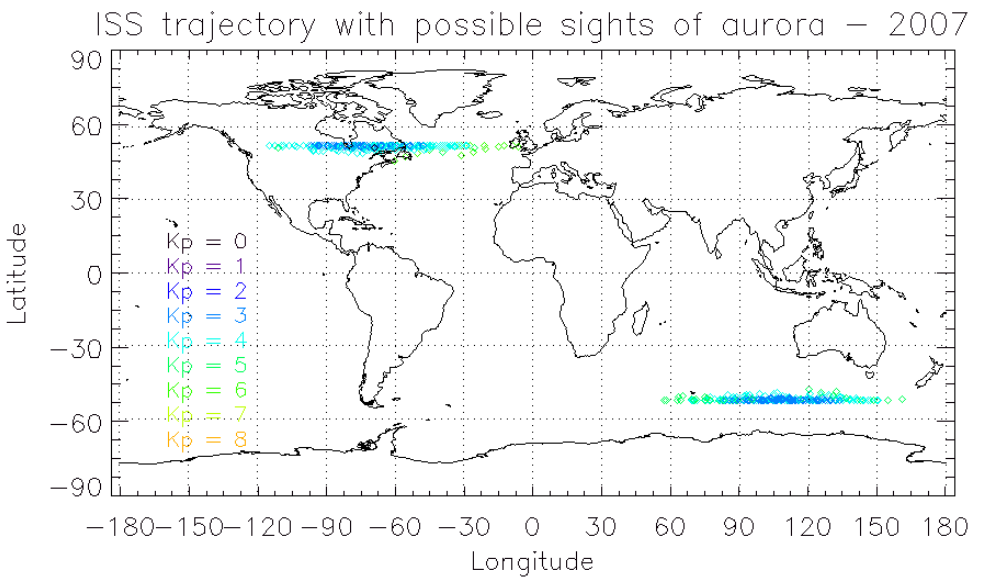
2004 - 2007









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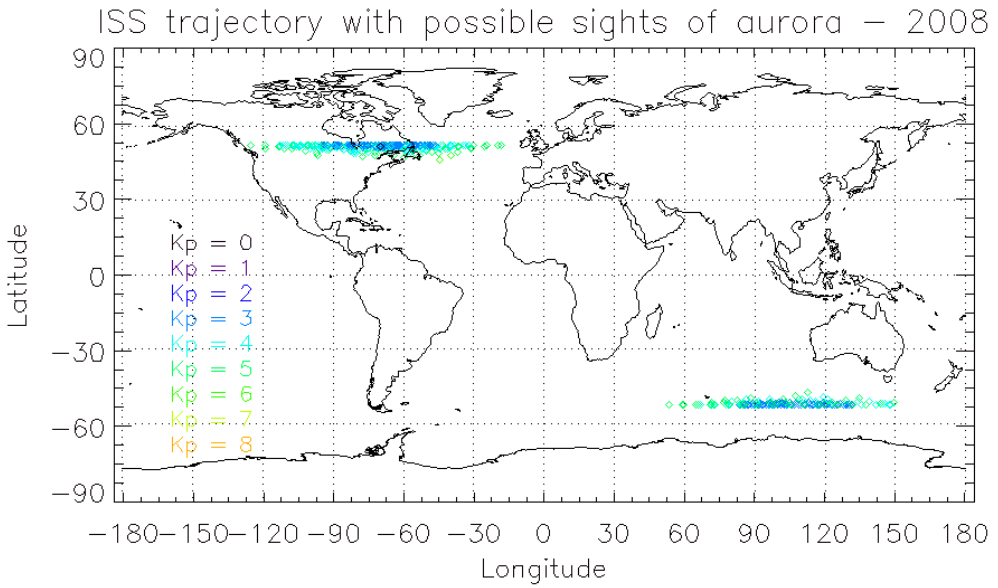
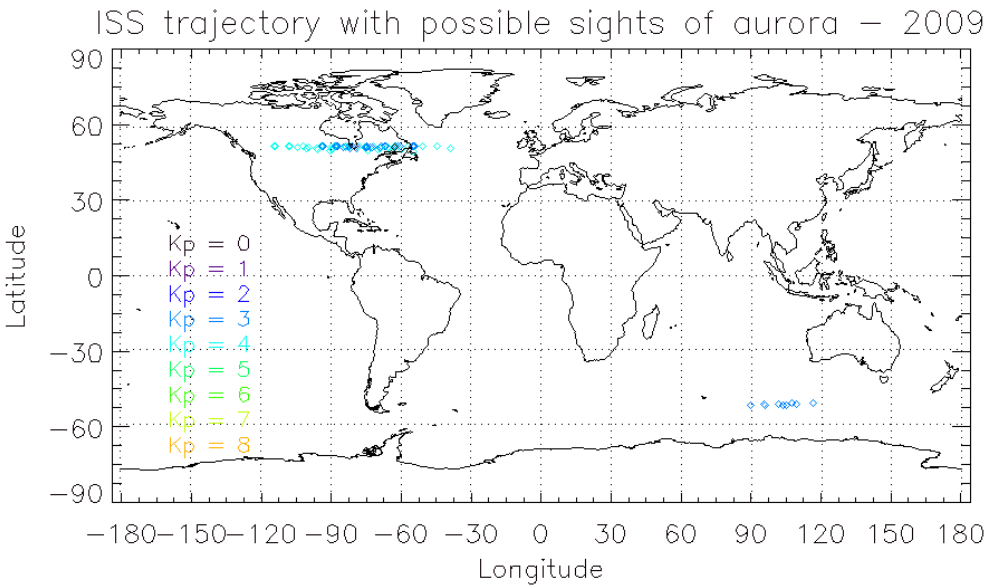
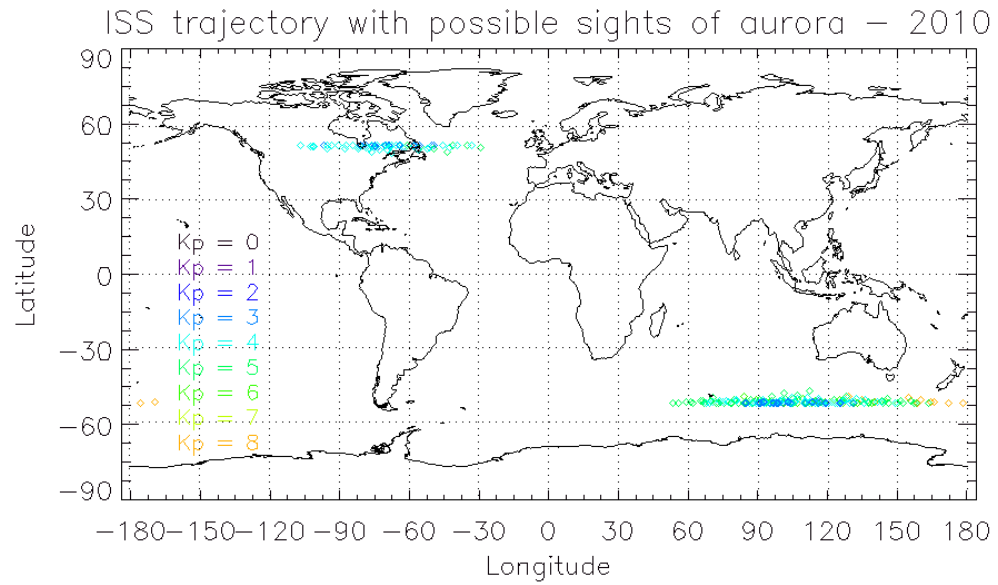
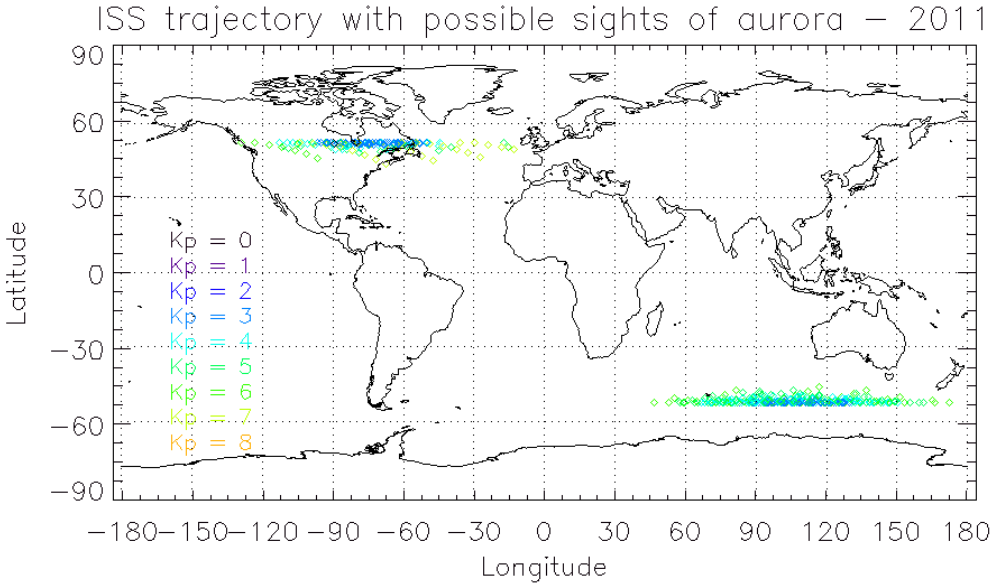
2008 - 2011









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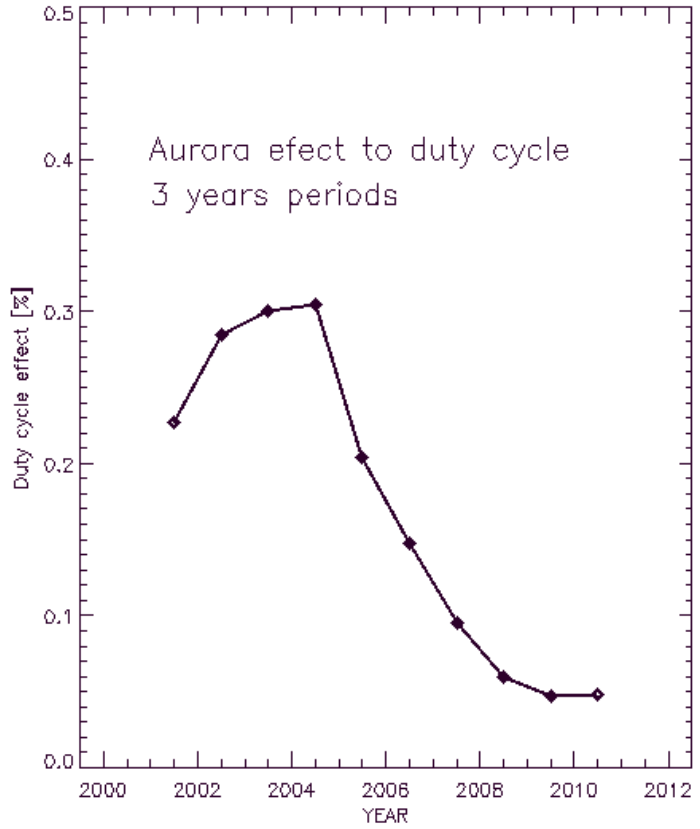
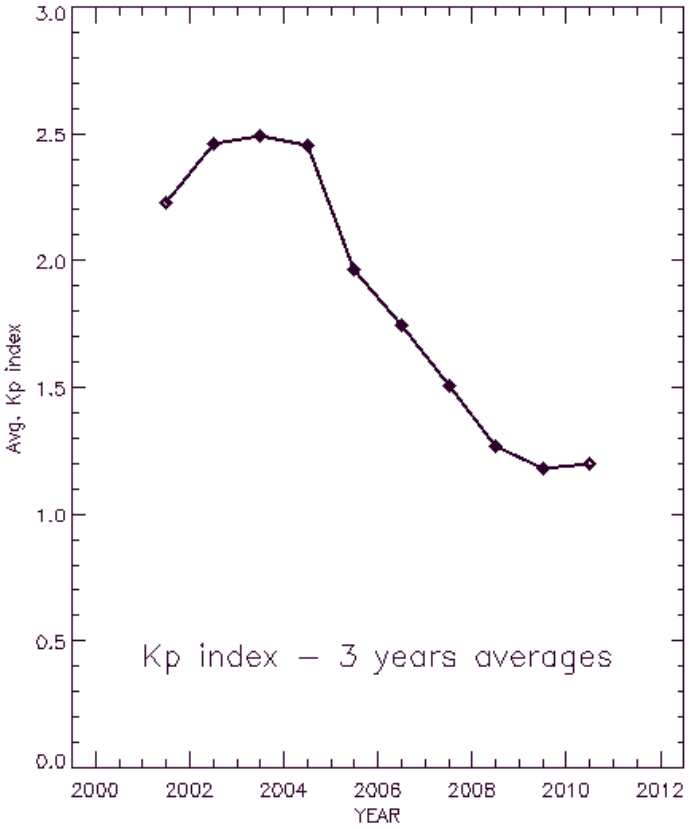
Aurora effect on JEM-EUSO operational efficiency

3 years long periods





To evaluate effect of auroras during 3 year long period of JEM-EUSO mission, we use a 3 years moving time window i.e. Periods 2000-2002, 2001-2003, ... , 2009-2011. The effect of auroras is the highest for periods 2002-2004 and 2003-2005 when decreasing duty cycle by 0.3% and lowest in periods 2008-2010 and 2009-2011 with value 0.05%.

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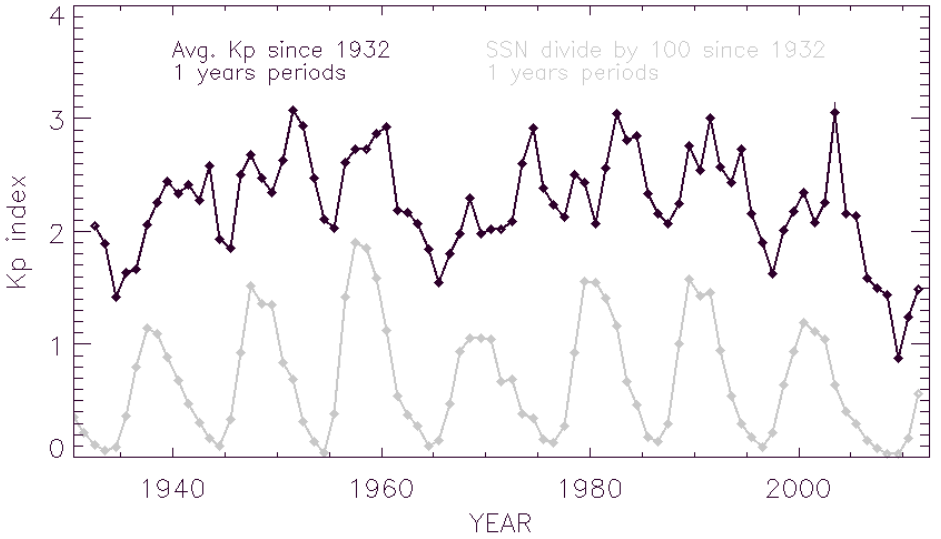
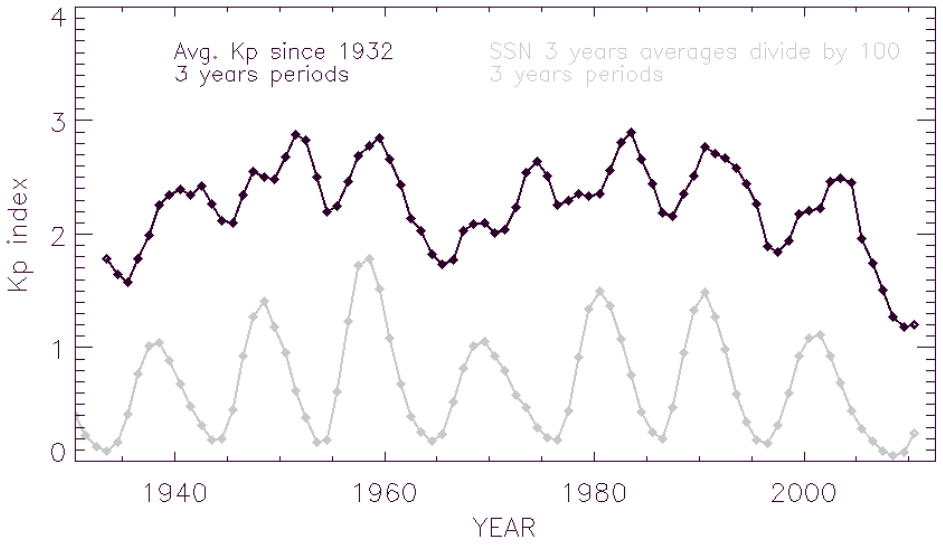
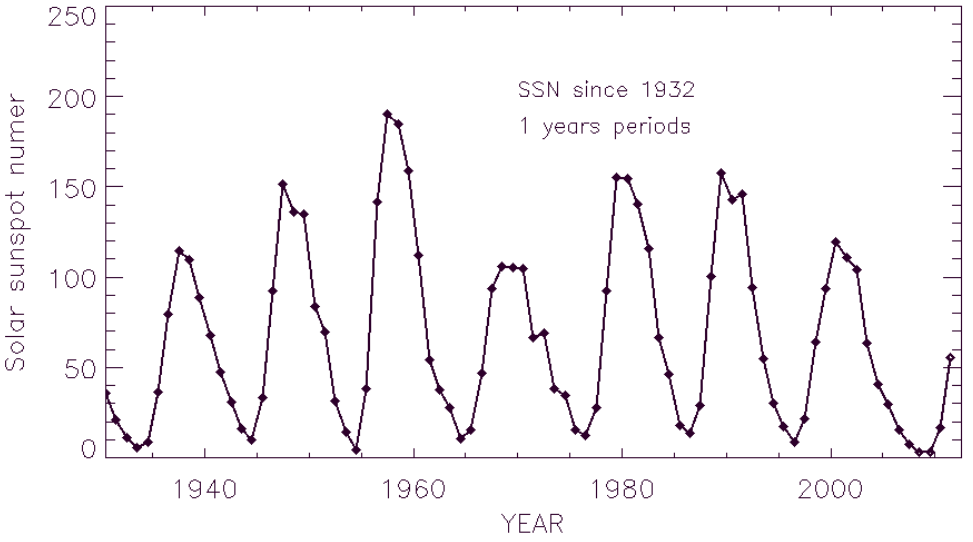
Aurora effect on JEM-EUSO operational efficiency

Evolution of yearly averaged Kp index in last decades since 1932 (upper panel) an Solar sunspot number (bottom panel).

3 year averages for Kp index and solar sunspot number (moving time window i.e. periods 1932-1934, 1933-1935, ..., 2009-2011)







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Conclusions

In time of expected JEM-EUSO mission in years 2017-2019 we will be in solar minimum, possible again in very quiet deep solar minimum like conditions. In that period we estimated an auroras effect to JEM-EUSO operational efficiency to be less than 0.2%.

Let us note that in years with expected tilt observation mode of JEM-EUSO detector when measurements can be more sensitive to auroras we expect a smaller auroras effect due to more quiet geomagnetic condition than in nadir period time. More precise estimation depend on next solar maximum time, in other words on length of time from next solar maximum to JEM-EUSO mission.