Latitudinal dependence of UV background in Tatiana-2 and ISUAL measurements

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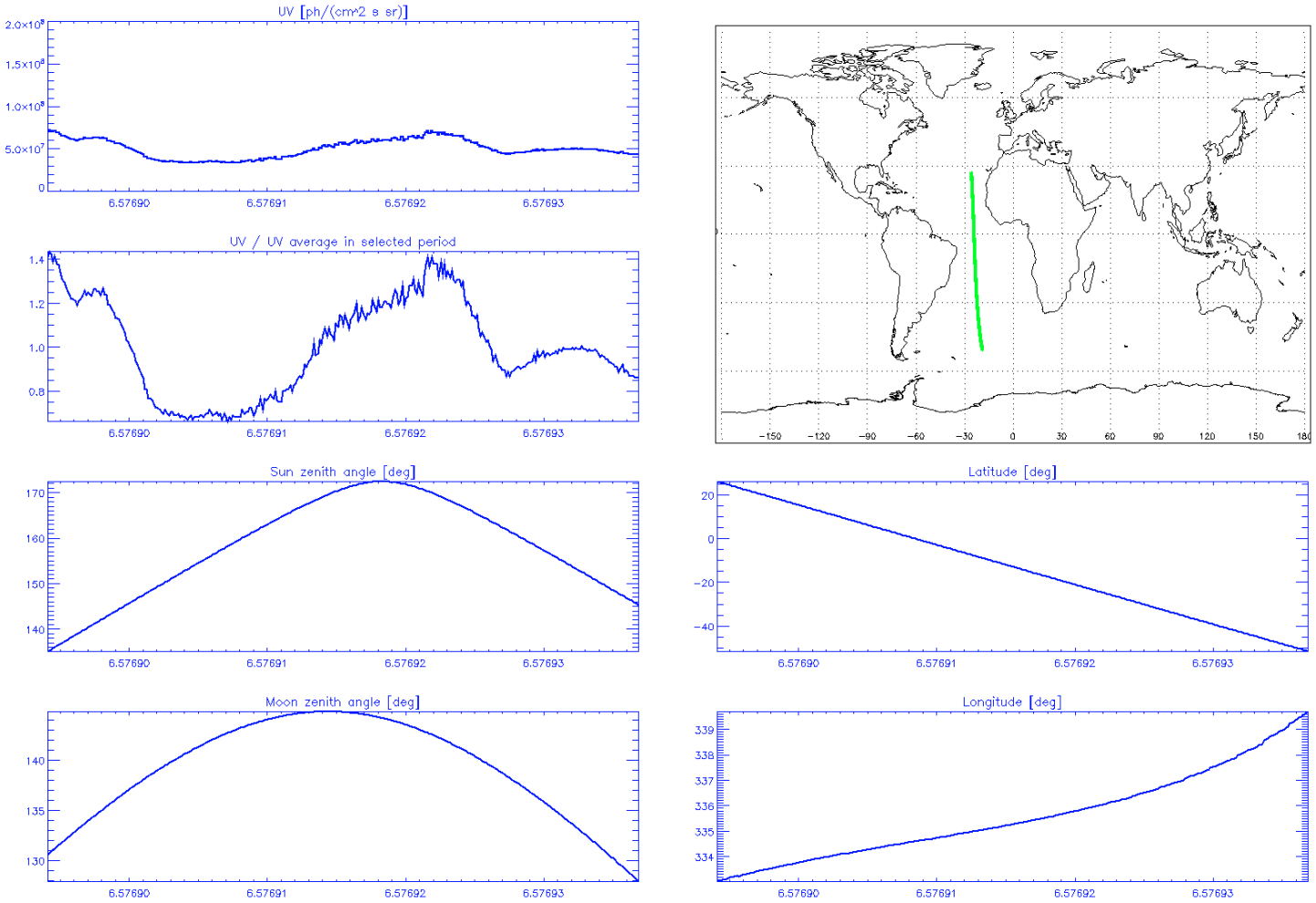
Motivation

- the systematic study of UV background is essential for the estimation of JEM-EUSO duty cycle and also for further data analysis
- In this preliminary analysis we focus on latitudinal dependence which is predicted by AURIC model
  - 1st part of presentation – observations of UV background
  - 2nd part of presentation – model AURIC (will be presented by Dr. Putiš)
- Tatiana-1 data have been processed, but it does not offer sufficient data for latitudinal dependence analysis
- Tatiana-2 data should show possible characteristic dependence, but provide low statistics
- ISUAL data contain high number of measurements, first preliminary results will be presented

1st part - OBSERVATIONS

Tatiana-1 data archive

Available on: http://space.saske.sk/JEM/tatiana.html (standard login & pwd)



Tatiana-2 data archive - in progress

Conditions of studied measurements:

- sun zenith angle $S_{ZA} > 132°$
- moon zenith angle $M_{ZA} > 90°$

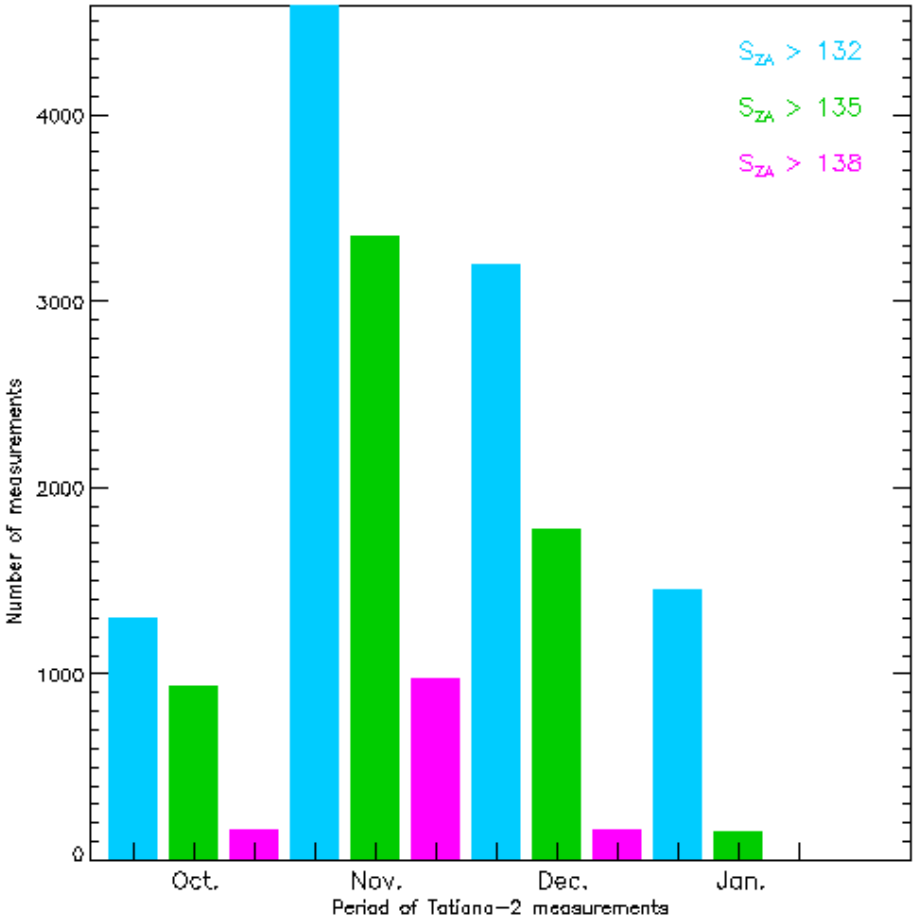
  => moon phase is not important
- satellite tracks over Atlantic and Pacific ocean
- unselected measurements of high peaks ~ TLE events

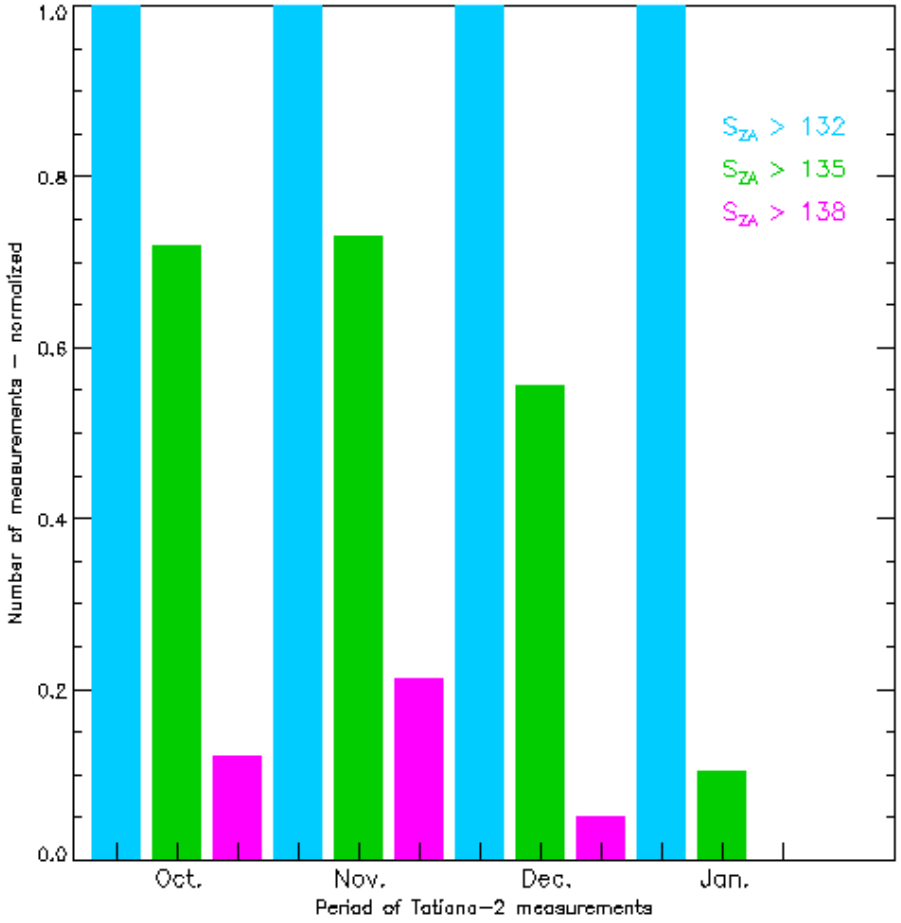
=> we try to find clear sky moonless situation -> low statistics

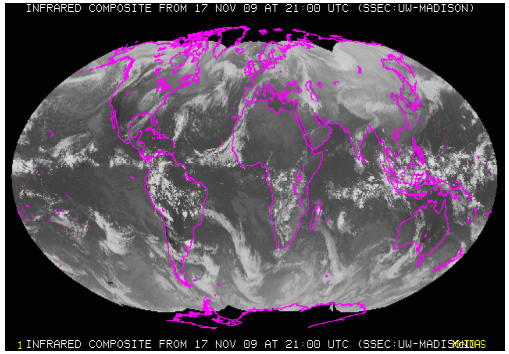
- index Kp < 2 for all presented data (solar minimum)

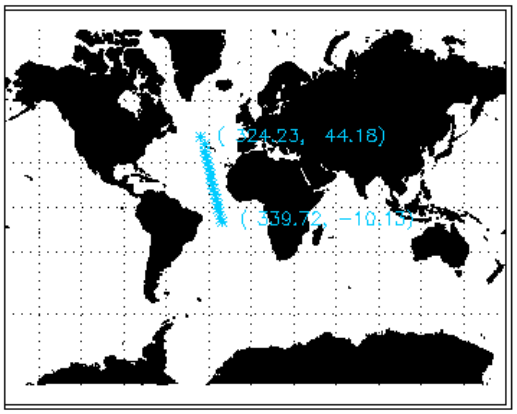
Literature: Sadovnichy et al. (2011, *SoSyR* 45, 3)
Garipov et al. (2011, arXiv:1112.0894)
Dmitriev et al. (2011, *P&SS* 59, 733)

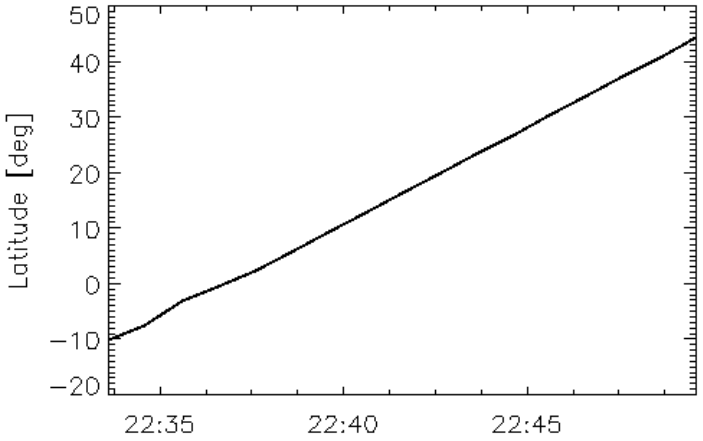
Tatiana-2: night measurements - statistics

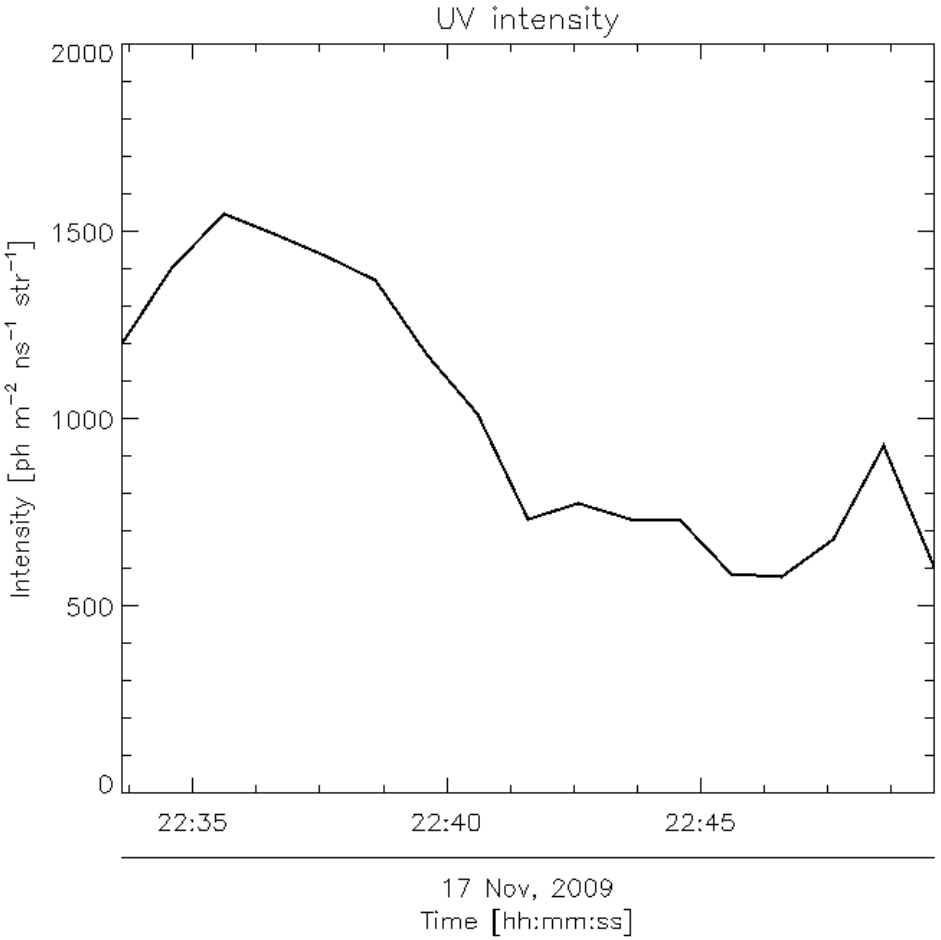


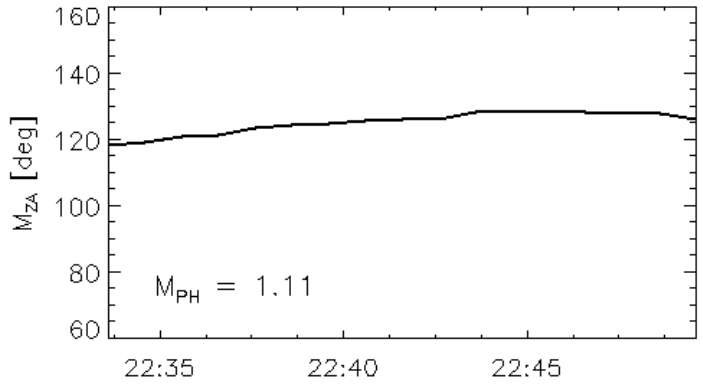


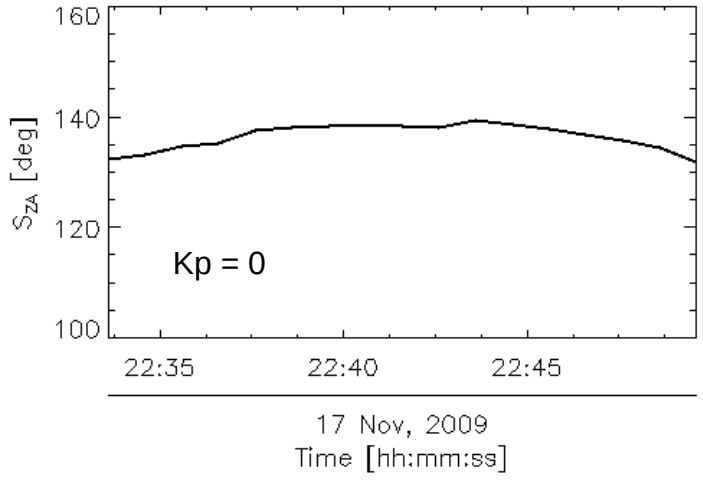

INFRARED COMPOSITE FROM 17 NOV 09 AT 21:00 UTC (SSEC:UW-MADISON)
1 INFRARED COMPOSITE FROM 17 NOV 09 AT 21:00 UTC (SSEC:UW-MADISON)

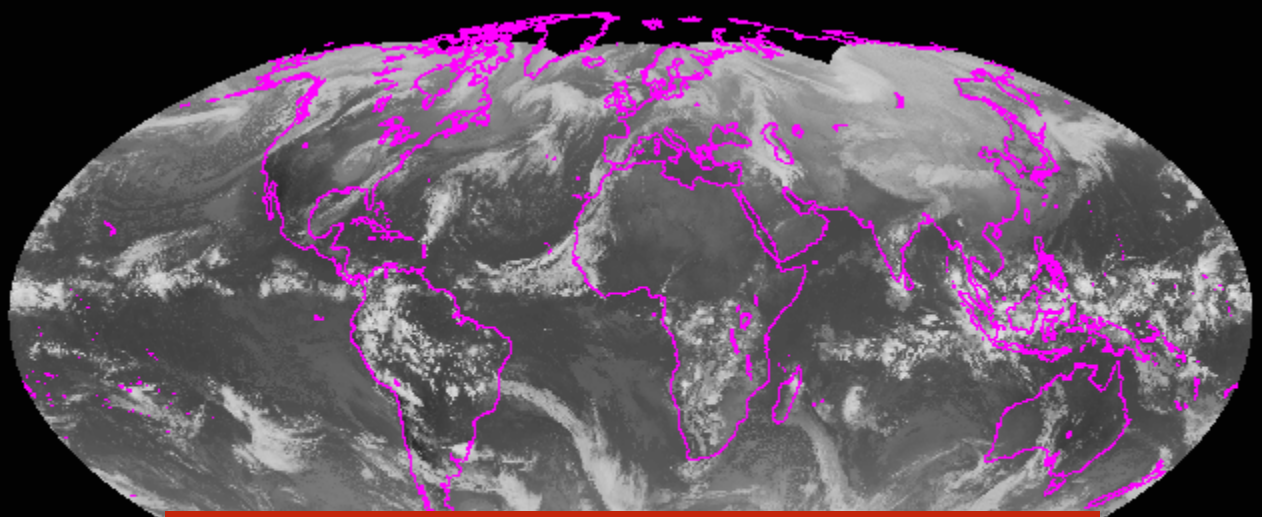

Tatiana 2 (longitude, latitude)
(324.23, 44.18)
(339.72, −10.15)


Latitude [deg]
50
40
30
20
10
0
−10
−20
22:35
22:40
22:45


UV intensity
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
22:35
22:40
22:45
17 Nov, 2009
Time [hh:mm:ss]


M_{ZA} [deg]
160
140
120
100
80
60
M_{PH} = 1.11
22:35
22:40
22:45


S_{ZA} [deg]
160
140
120
100
Kp = 0
22:35
22:40
22:45
17 Nov, 2009
Time [hh:mm:ss]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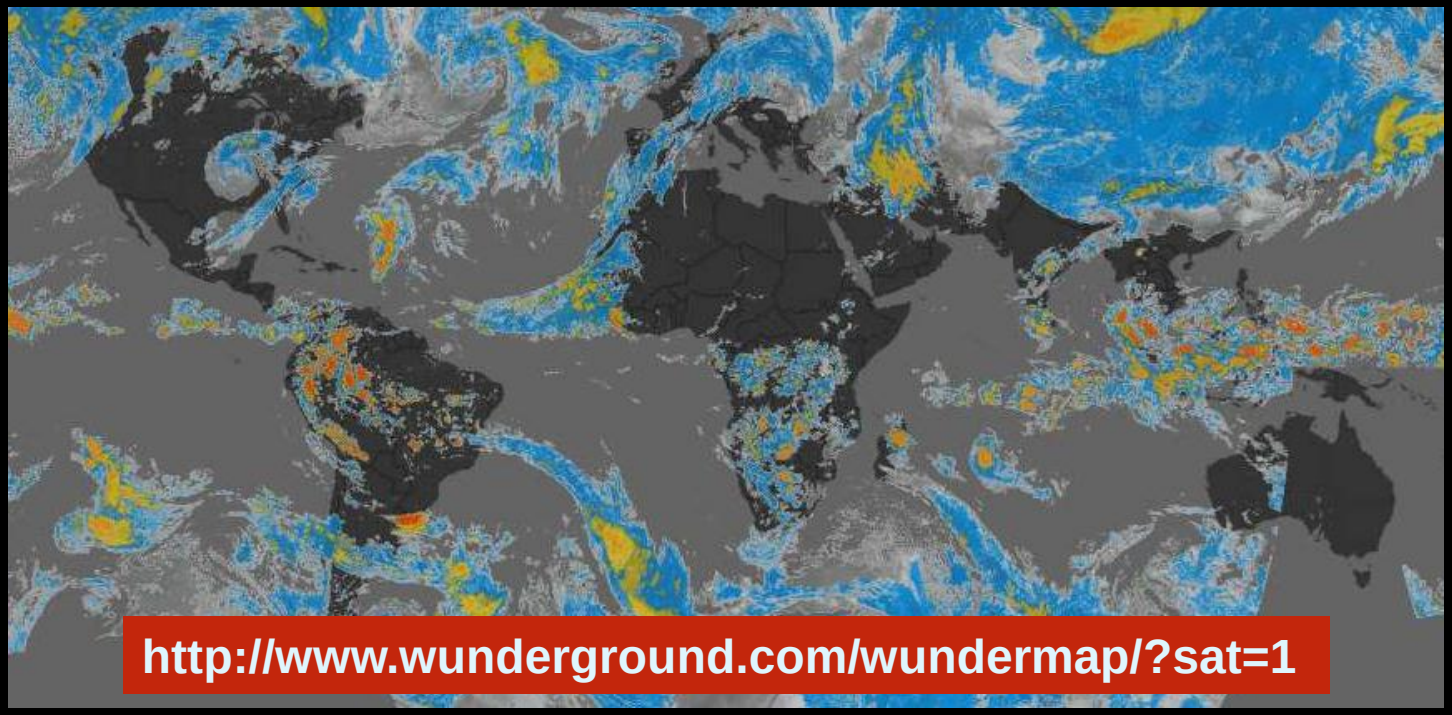
http://www.ssec.wisc.edu/data/comp/ir/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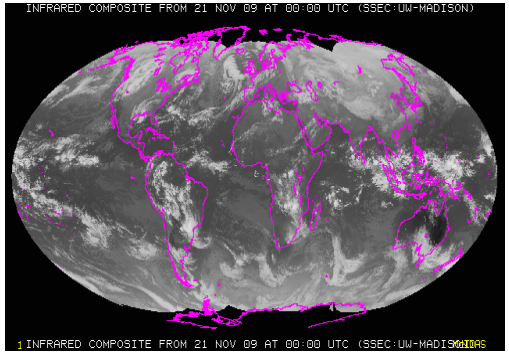
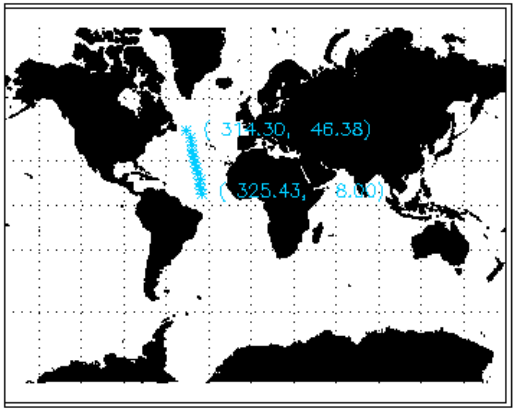
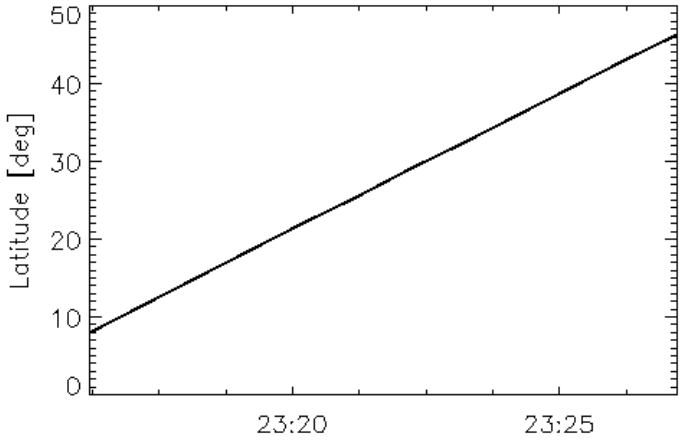
MIDAS
http://www.wunderground.com/wundermap/?sat=1

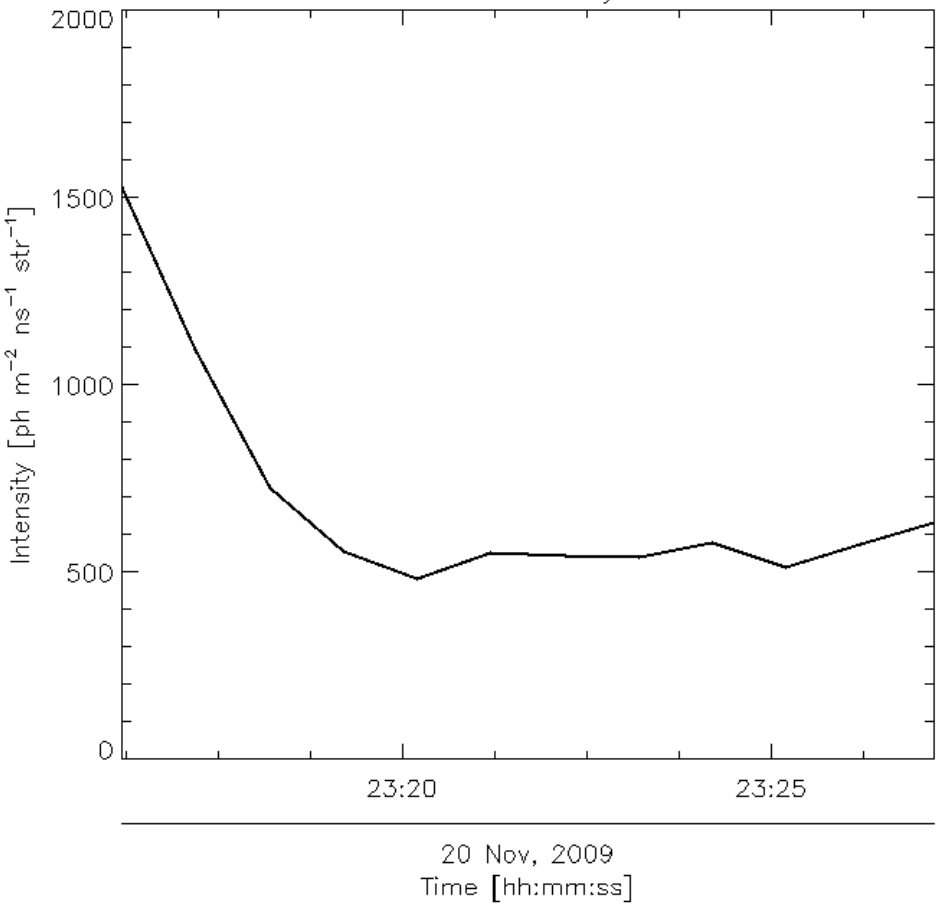


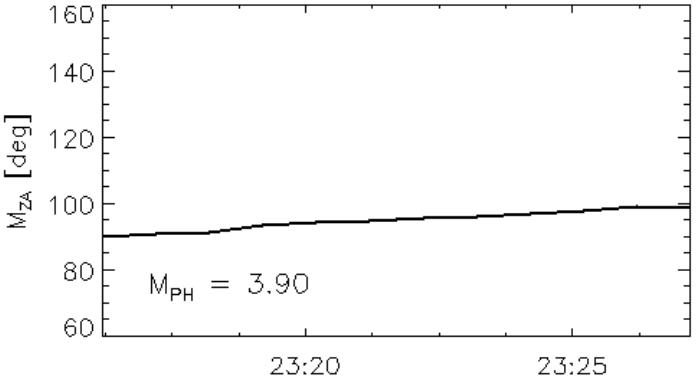
Tatiana 2 (longitude, latitude)

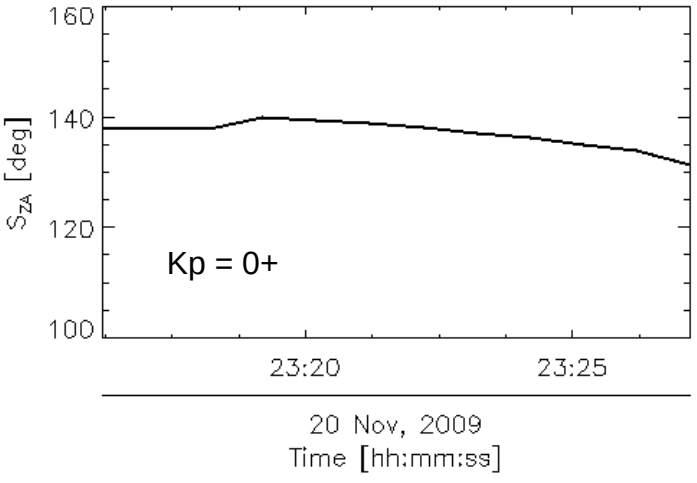


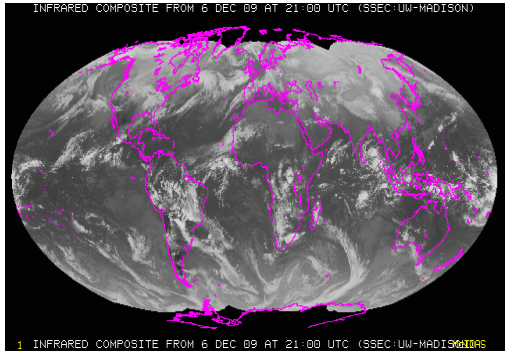


UV intensity

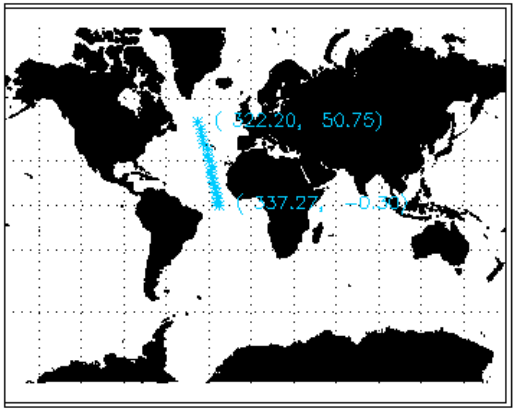


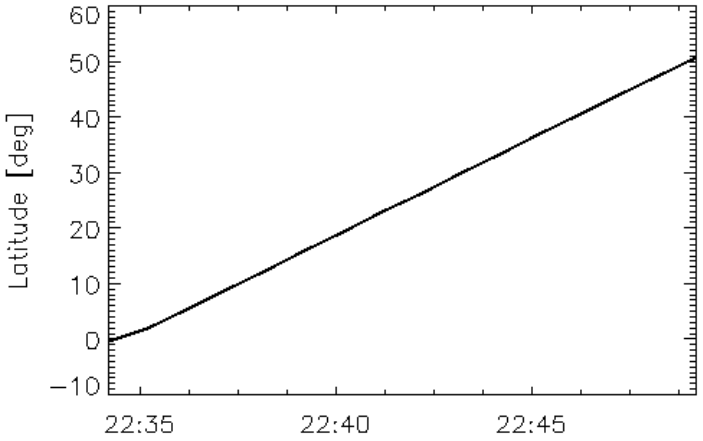




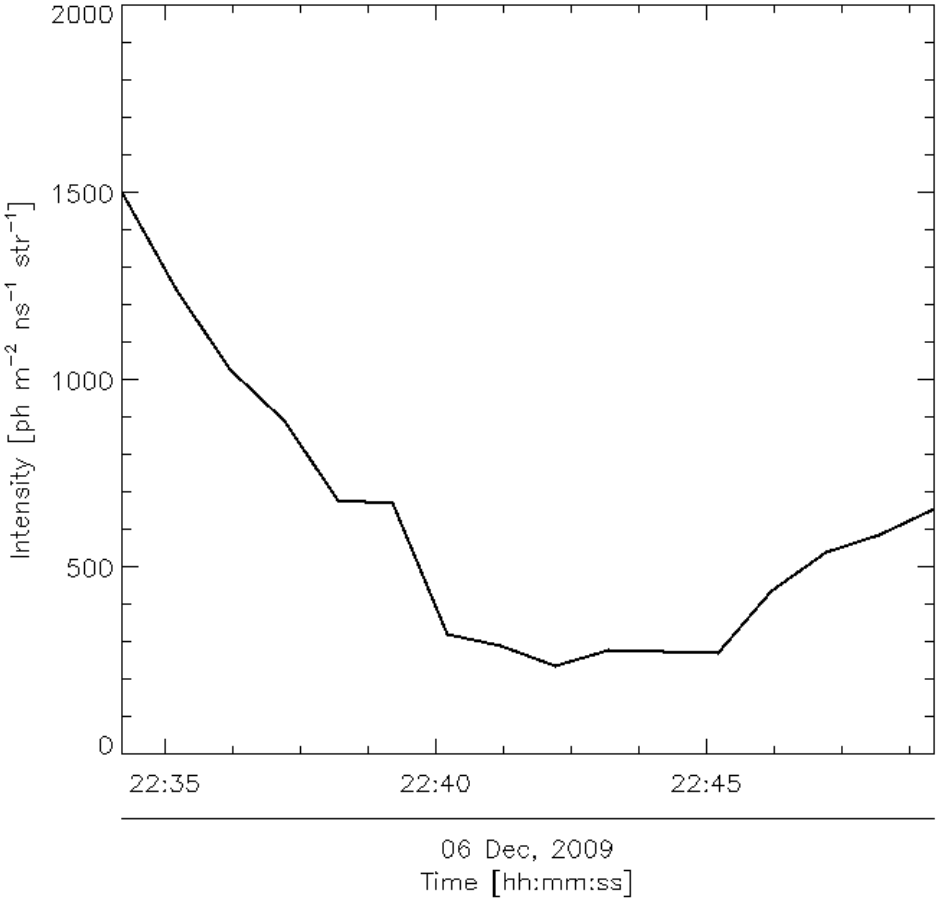


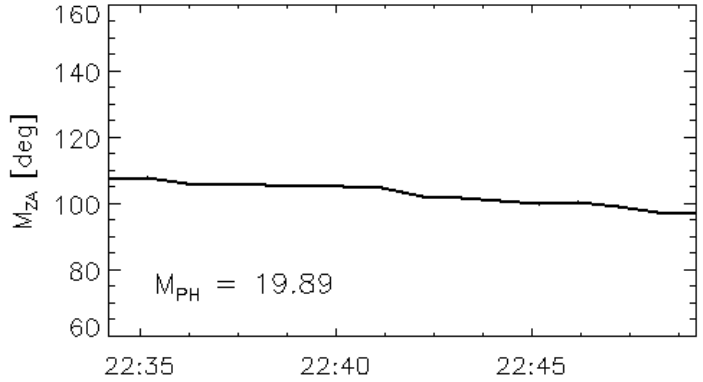
Tatiana 2 (longitude, latitude)

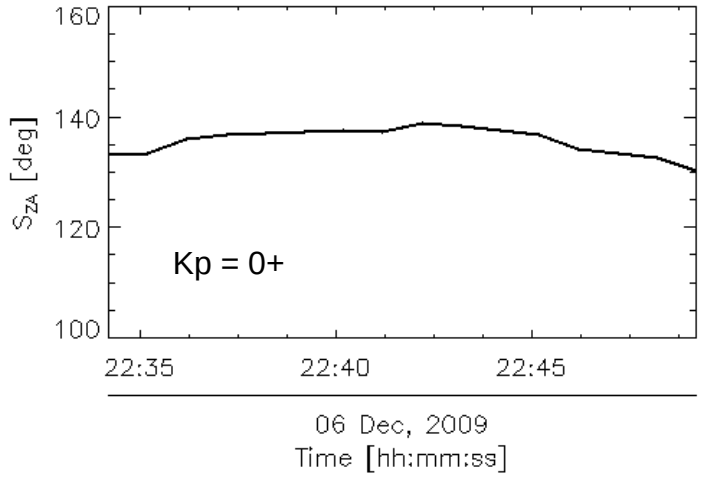


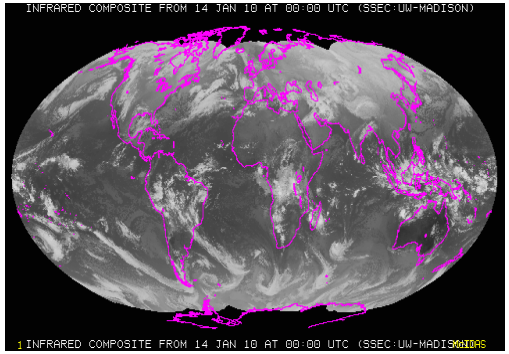


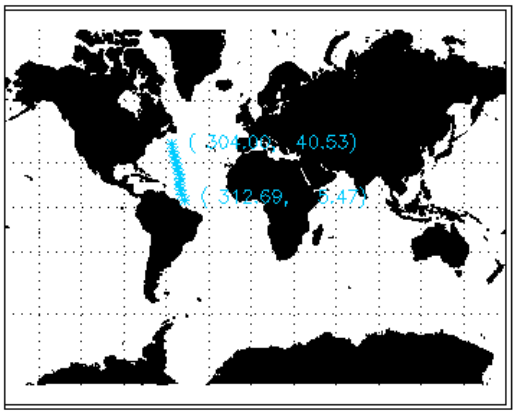
UV intensity

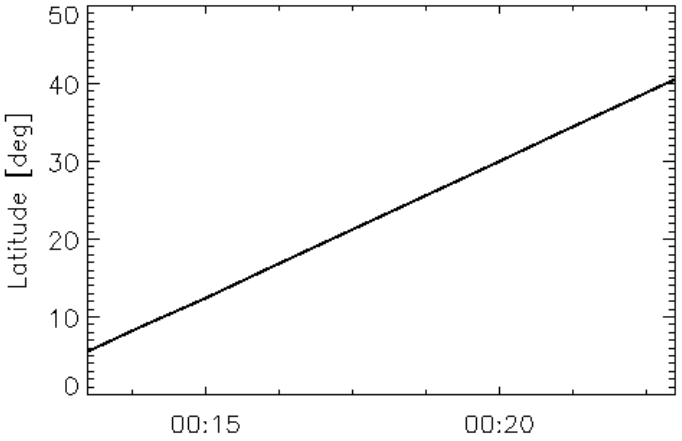


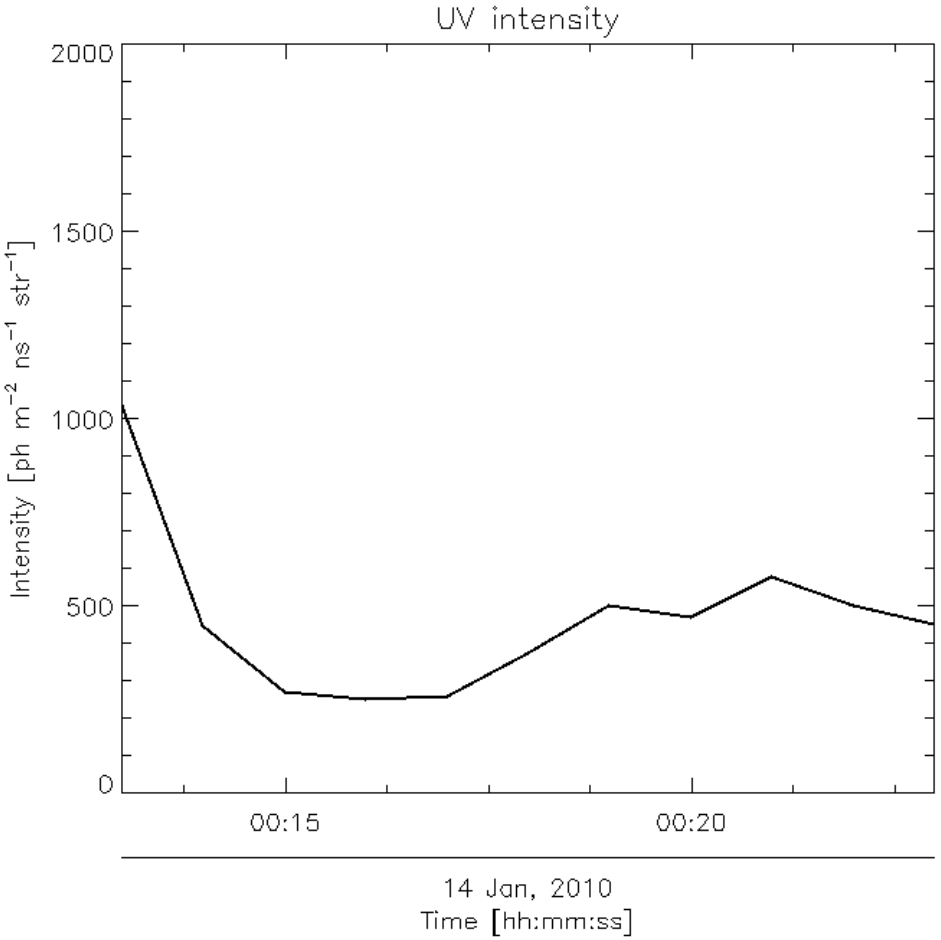


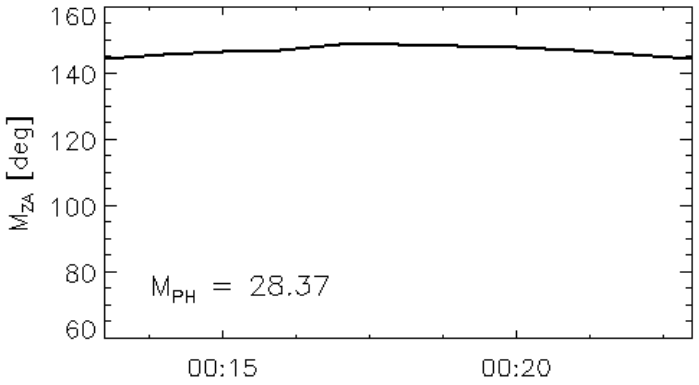


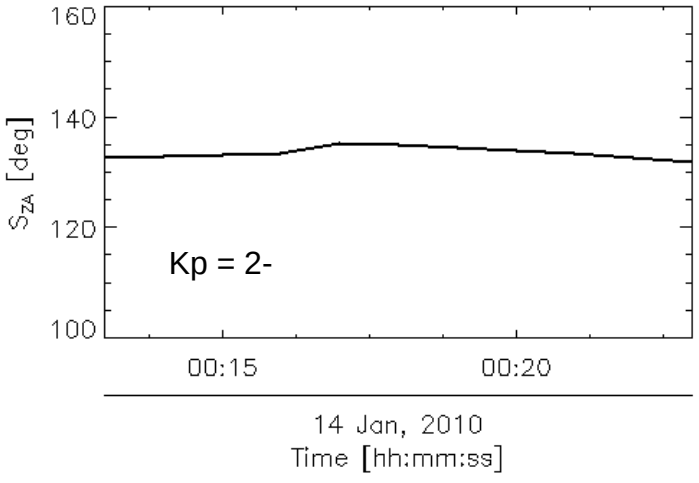

INFRARED COMPOSITE FROM 14 JAN 10 AT 00:00 UTC (SSEC:UW-MADISON)
1 INFRARED COMPOSITE FROM 14 JAN 10 AT 00:00 UTC (SSEC:UW-MADISON)

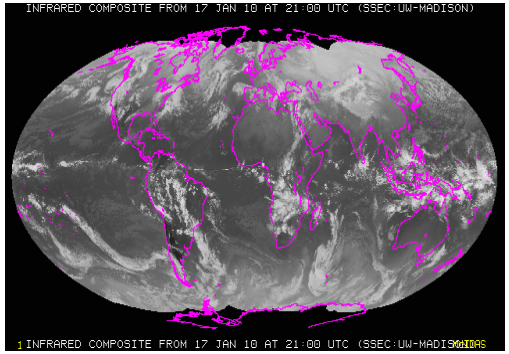

Tatiana 2 (longitude, latitude)
(304.09, 40.53)
(312.69, 5.47)

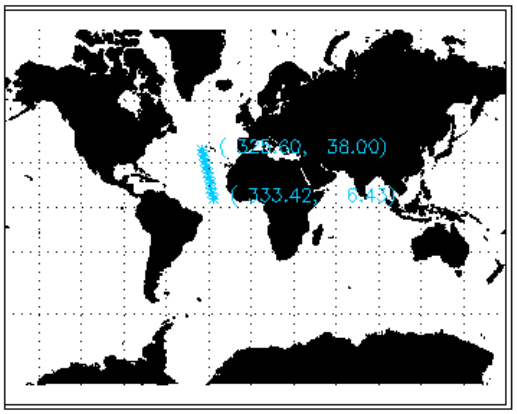

Latitude [deg]
50
40
30
20
10
0
00:15
00:20

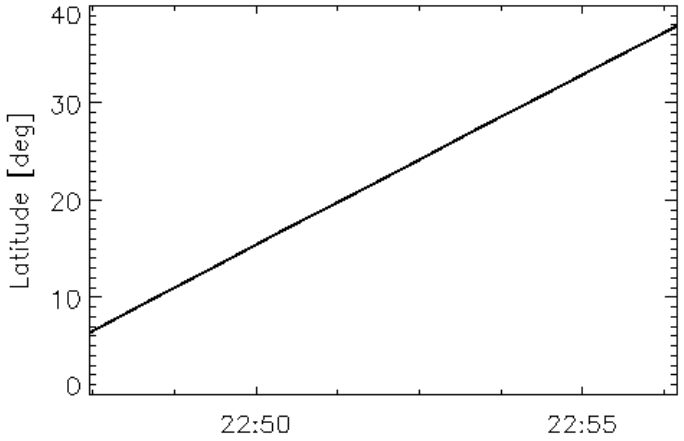

UV intensity
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
00:15
00:20
14 Jan, 2010
Time [hh:mm:ss]

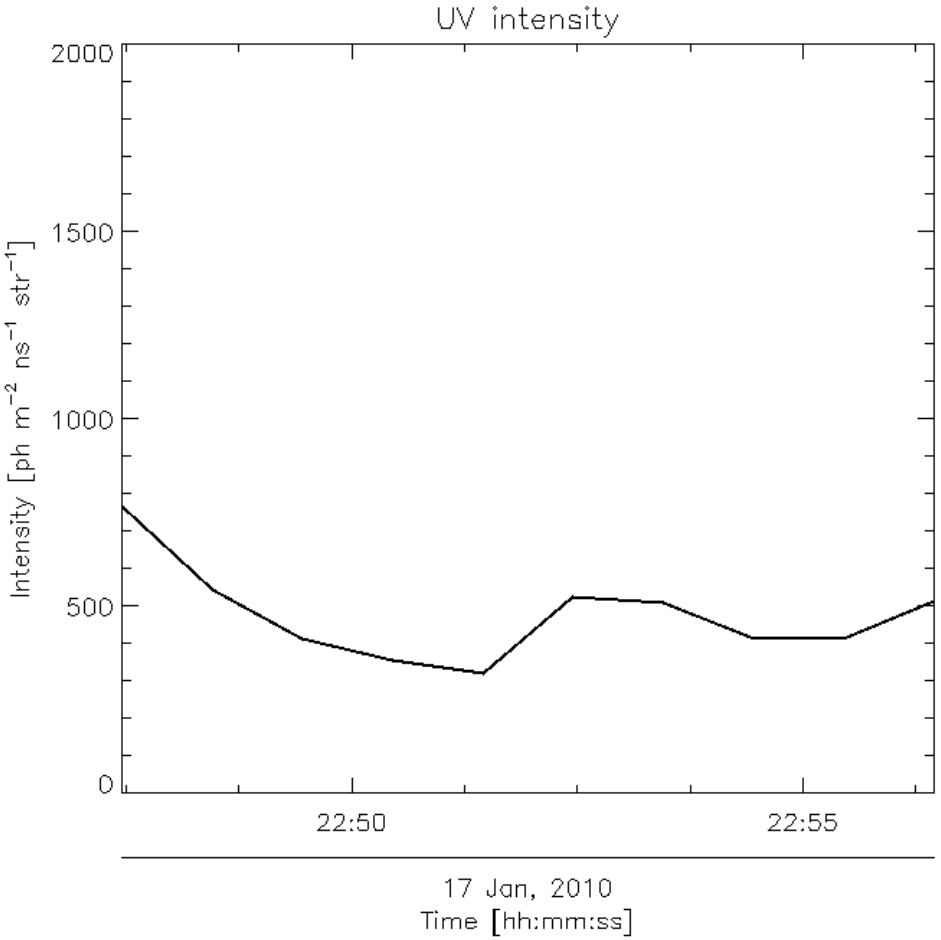

M_{ZA} [deg]
160
140
120
100
80
60
M_{PH} = 28.37
00:15
00:20

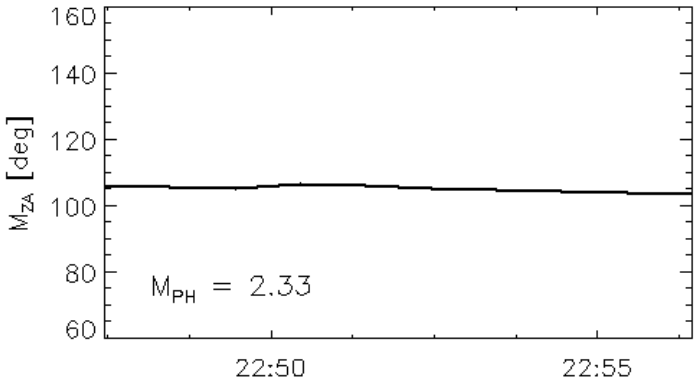

S_{ZA} [deg]
160
140
120
100
Kp = 2-
00:15
00:20
14 Jan, 2010
Time [hh:mm:ss]

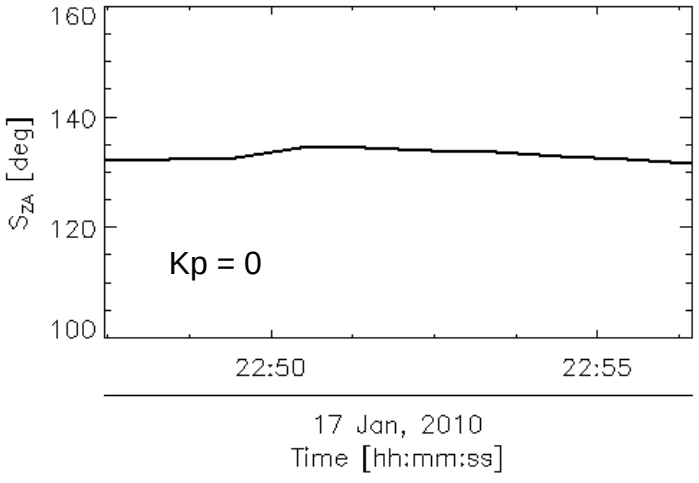

INFRARED COMPOSITE FROM 17 JAN 10 AT 21:00 UTC (SSEC:UW-MADISON)
1 INFRARED COMPOSITE FROM 17 JAN 10 AT 21:00 UTC (SSEC:UW-MADISON)


Tatiana 2 (longitude, latitude)
(38.00)


Latitude [deg]
40
30
20
10
0
22:50
22:55


UV intensity
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
22:50
22:55
17 Jan, 2010
Time [hh:mm:ss]

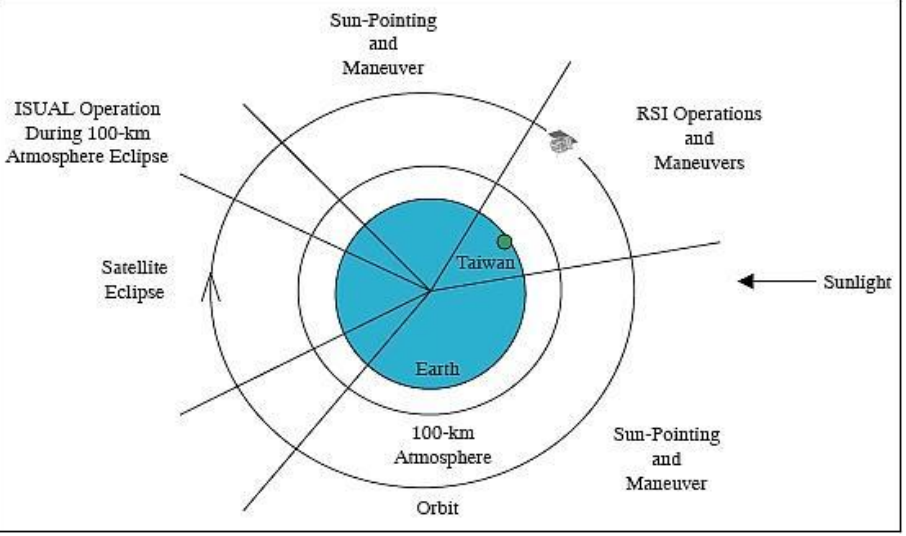

M_{ZA} [deg]
160
140
120
100
80
60
M_{PH} = 2.33
22:50
22:55


S_{ZA} [deg]
160
140
120
100
Kp = 0
22:50
22:55
17 Jan, 2010
Time [hh:mm:ss]

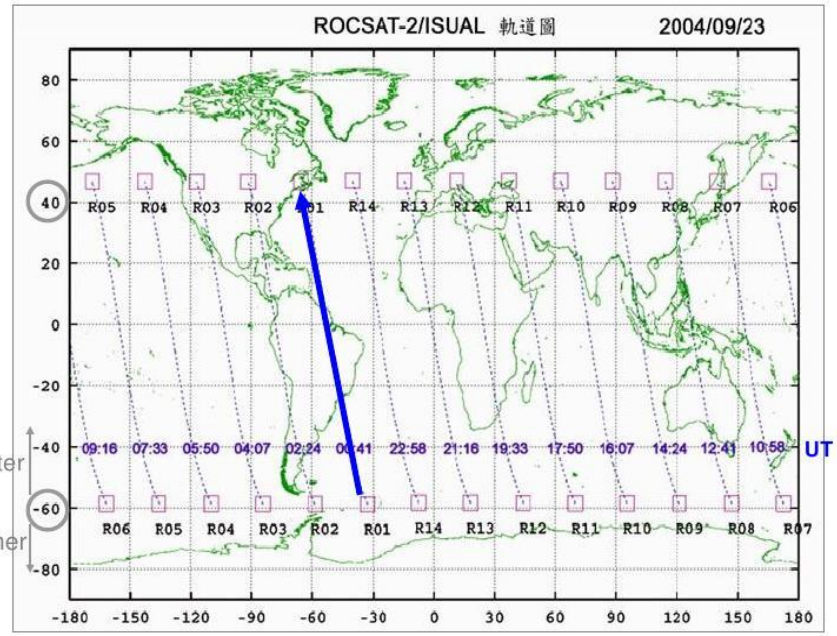
ISUAL

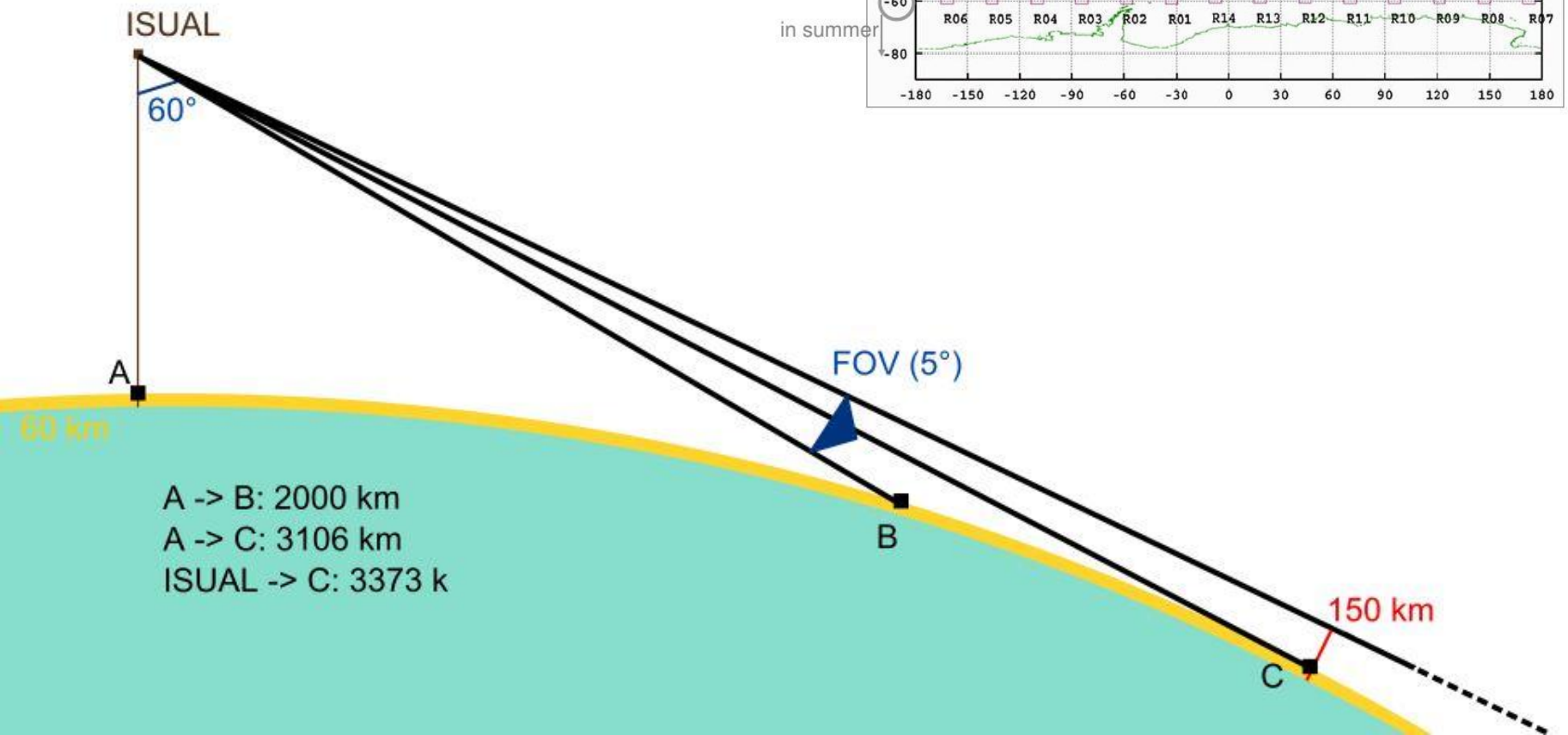
- Imager of Sprites and Upper Atmospheric Lightning
- Onboard Formosat-2 - satellite from Taiwan
- One of mission objective: To investigate the global distribution of the airglow intensity as a function of altitude
- Spectrophotometer with broadband UV filter 250-390 nm
- Aurora and airglow operation mode
- Available data since end of 2004 – 2013
- High statistical opportunity

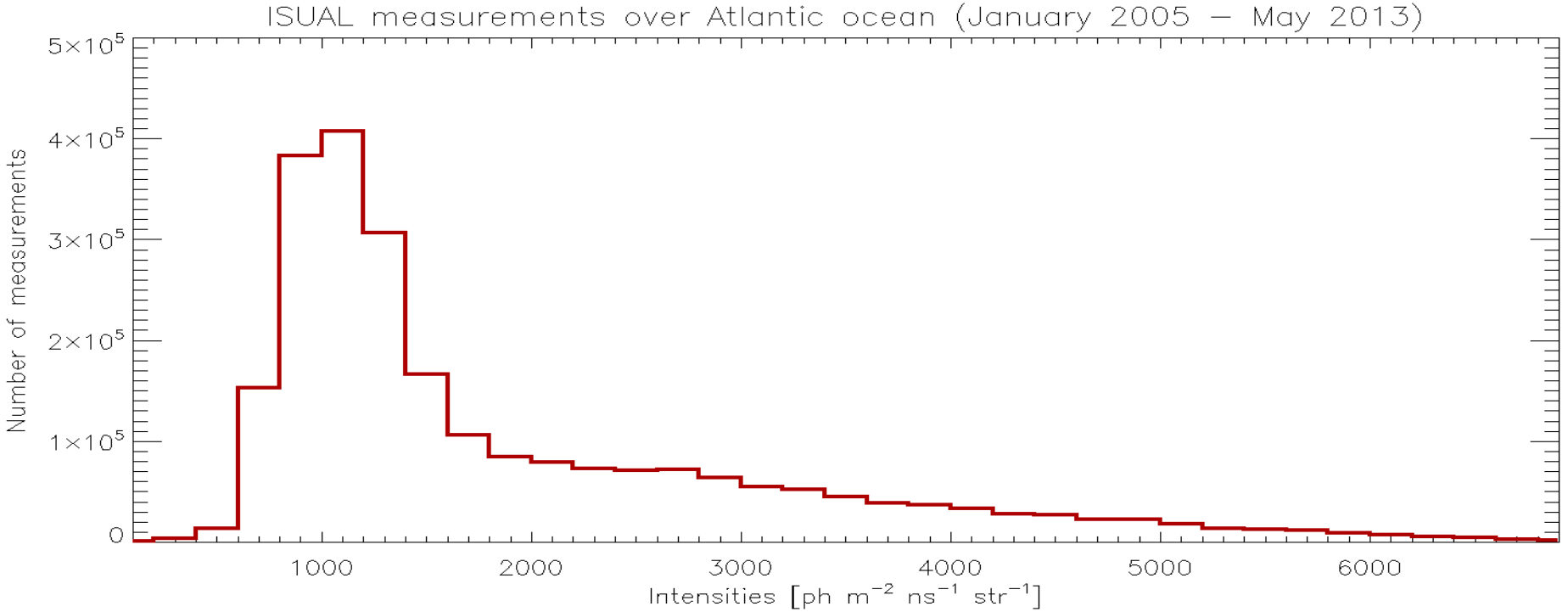
- http://sprite.phys.ncku.edu.tw/En/Eindex.html
- Chern et al. (2003), Chen et al. (2008), Rejesh et al. (2009), Adachi et al. (2010), …

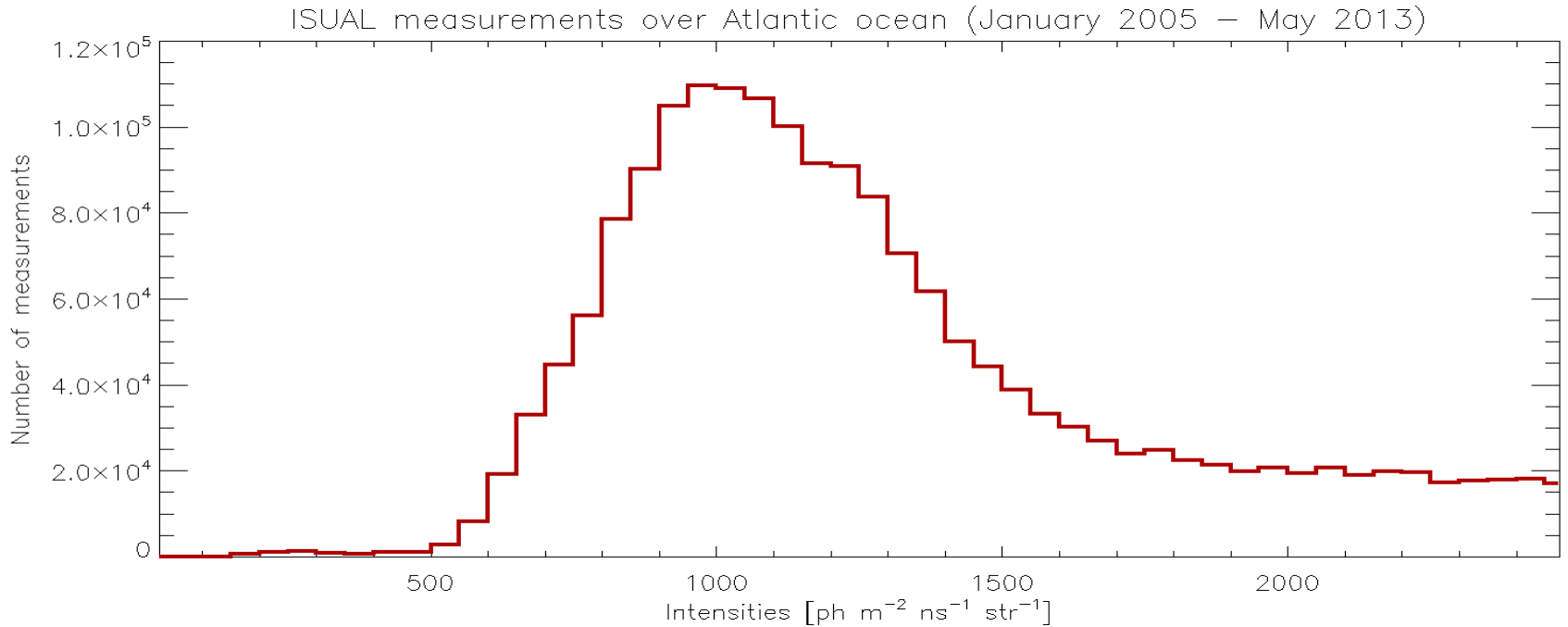


FORMOSAT-2/ISUAL night-region tracks





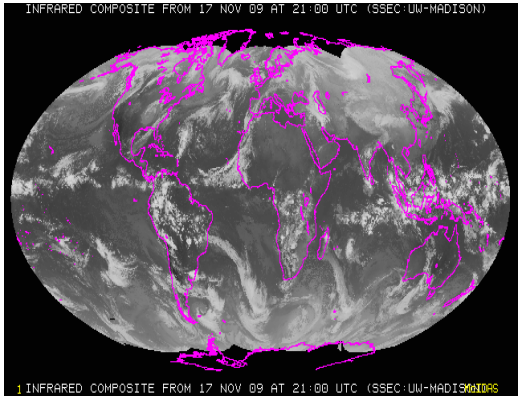

ISUAL measurements over Atlantic ocean (January 2005 – May 2013)
Number of measurements
5×10^5
4×10^5
3×10^5
2×10^5
1×10^5
0
1000
2000
3000
4000
5000
6000
Intensities [ph m^-2 ns^-1 str^-1]

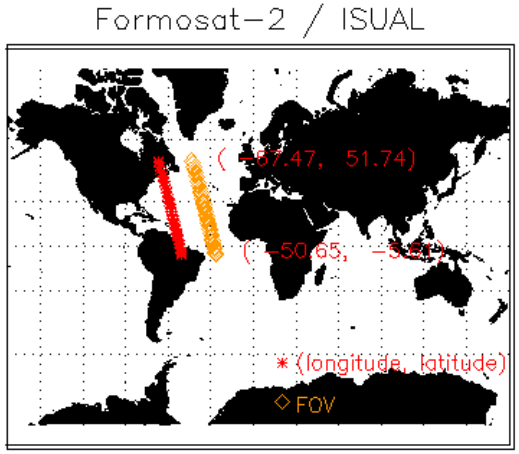

ISUAL measurements over Atlantic ocean (January 2005 – May 2013)
Number of measurements
1.2×10^5
1.0×10^5
8.0×10^4
6.0×10^4
4.0×10^4
2.0×10^4
0
500
1000
1500
2000
Intensities [ph m^-2 ns^-1 str^-1]

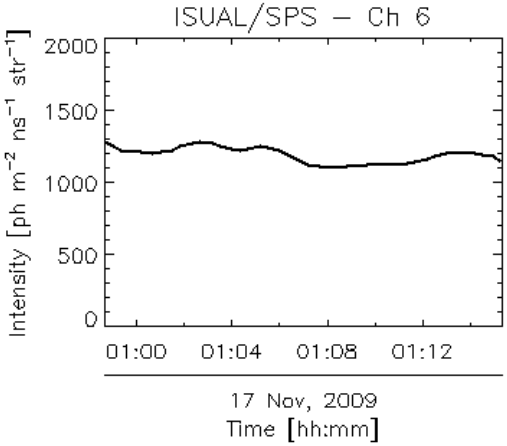
ISUAL measurements over Atlantic ocean

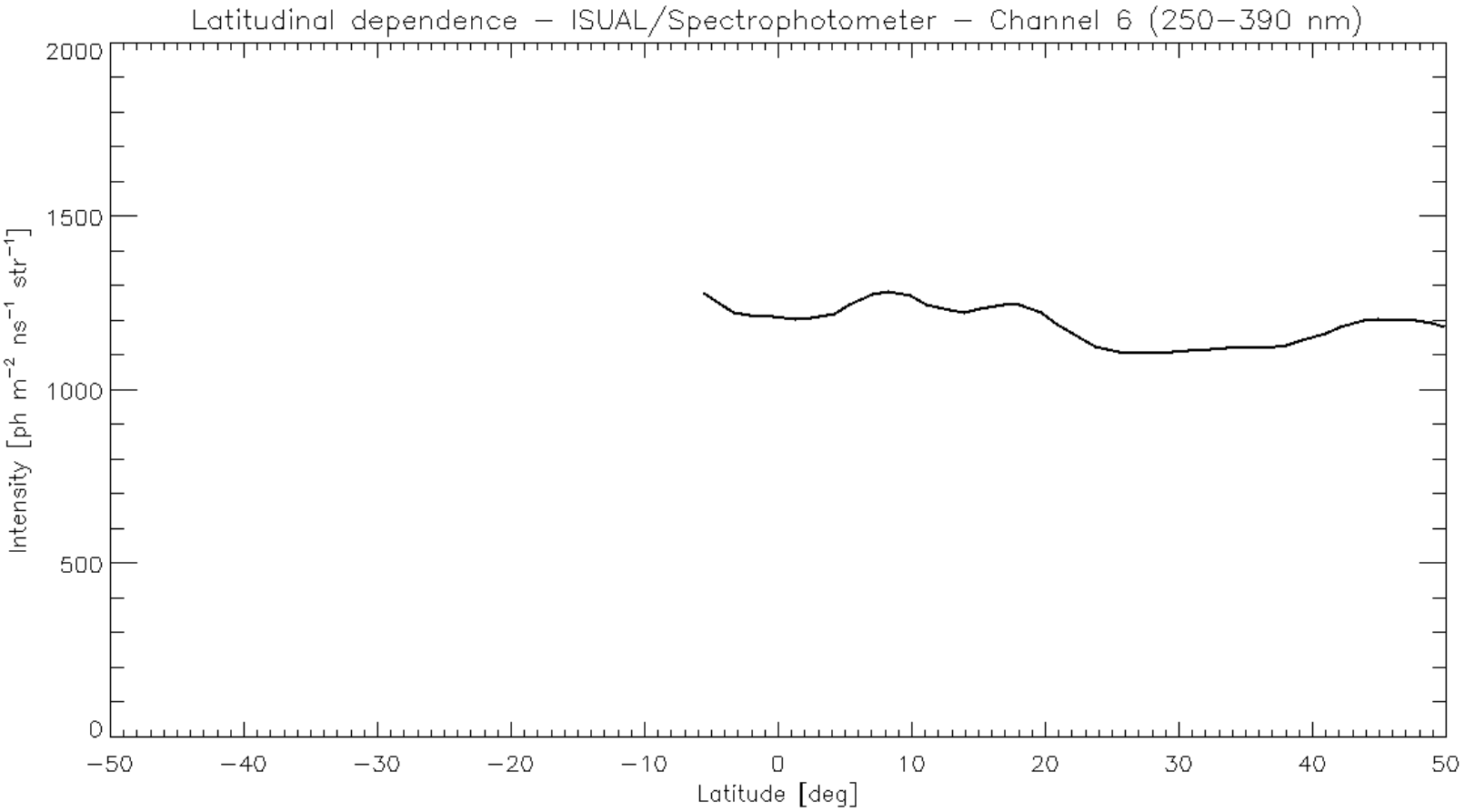
- influence of the Moon will be removed in short time
- one peak distribution of intensities with maximum about 1 000 ph m^{-2} ns^{-1} sr^{-1} (AURIC model predict two peaks distribution for whole Earth)
- observed intensities are higher than measurements by Tatiana-2 due to tilt mode (60°) and wider spectral range (250 – 390 nm)
- more complex analysis is ongoing

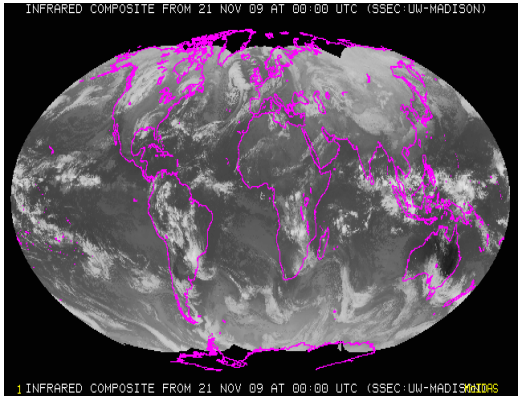
- on the next slides will be shown several examples of ISUAL measurements for the same dates as previous Tatiana-2 measurements

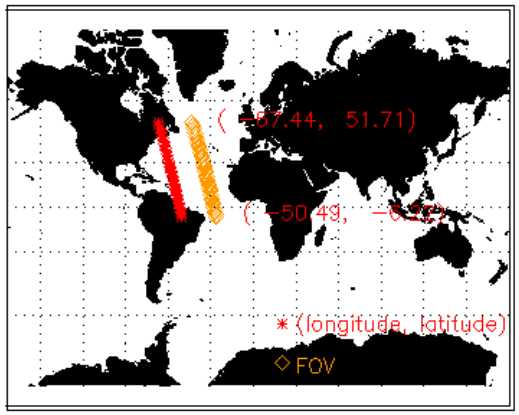

INFRARED COMPOSITE FROM 17 NOV 09 AT 21:00 UTC (SSEC:UW-MADISON)
1 INFRARED COMPOSITE FROM 17 NOV 09 AT 21:00 UTC (SSEC:UW-MADISON)


Formosat-2 / ISUAL
(-67.47, 51.74)
(-50.65, -3.81)
*(longitude, latitude)
◇FOV


ISUAL/SPS – Ch 6
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
01:00
01:04
01:08
01:12
17 Nov, 2009
Time [hh:mm]


Latitudinal dependence – ISUAL/Spectrophotometer – Channel 6 (250–390 nm)
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
−50
−40
−30
−20
−10
0
10
20
30
40
50
Latitude [deg]


INFRARED COMPOSITE FROM 21 NOV 09 AT 00:00 UTC (SSEC:UW-MADISON)
1 INFRARED COMPOSITE FROM 21 NOV 09 AT 00:00 UTC (SSEC:UW-MADISON)


Formosat-2 / ISUAL
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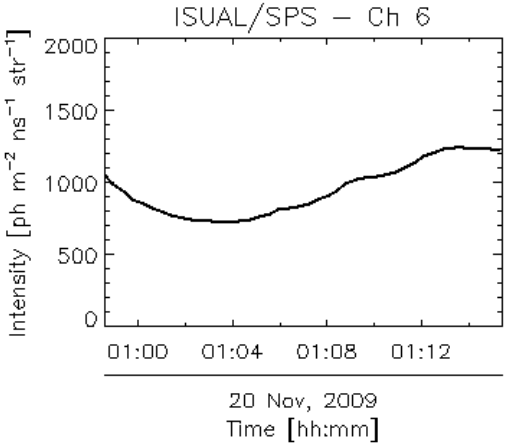
(-50.49, -6.76)
*(longitude, latitude)
◇FOV


ISUAL/SPS – Ch 6
Intensity [ph m^{-2} ns^{-1} str^{-1}]
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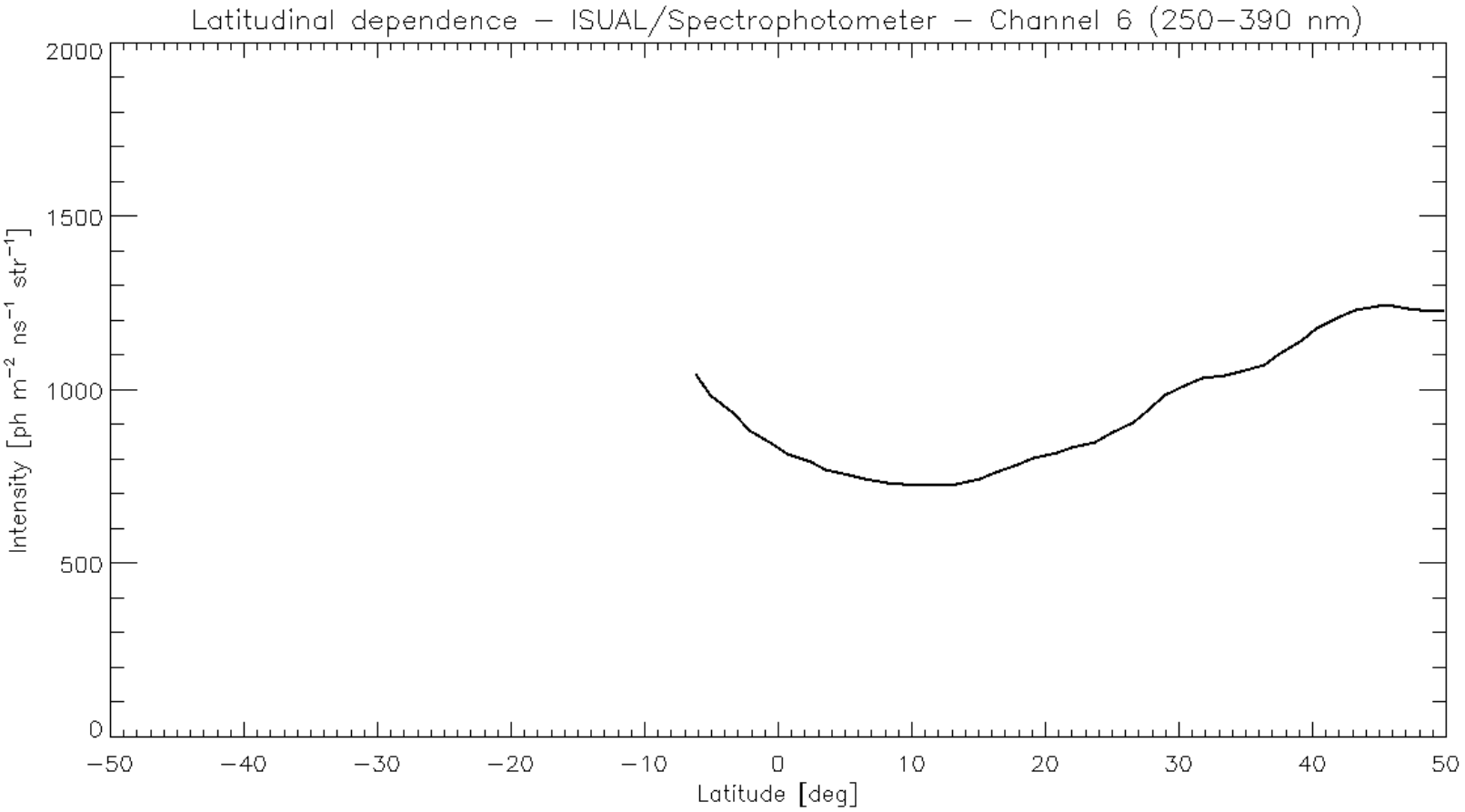
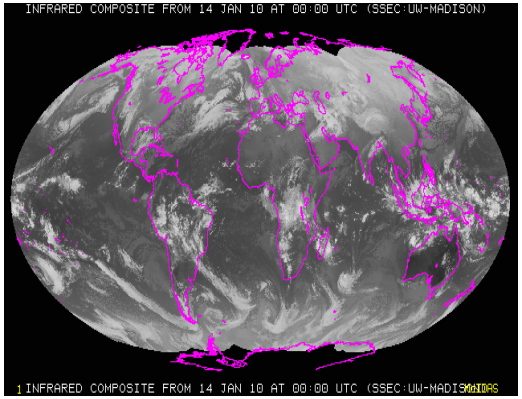
1500
1000
500
0
01:00
01:04
01:08
01:12
20 Nov, 2009
Time [hh:mm]


Latitudinal dependence – ISUAL/Spectrophotometer – Channel 6 (250–390 nm)
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
−50
−40
−30
−20
−10
0
10
20
30
40
50
Latitude [deg]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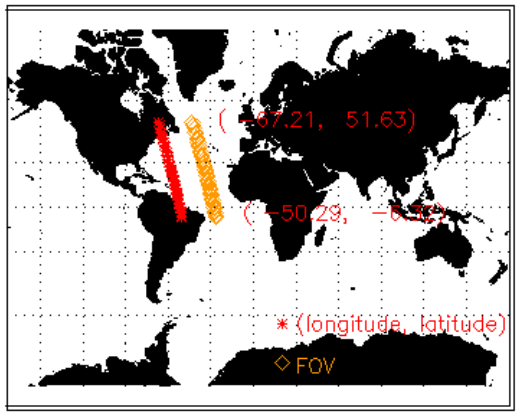
1 INFRARED COMPOSITE FROM 14 JAN 10 AT 00:00 UTC (SSEC:UW-MADISON)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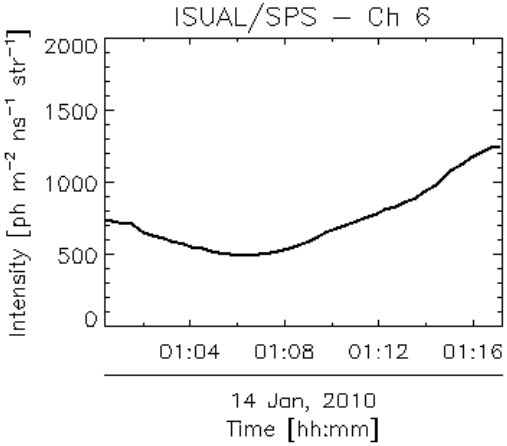
*(longitude, latitude)
◇FOV


ISUAL/SPS – Ch 6
Intensity [ph m^{-2} ns^{-1} str^{-1}]
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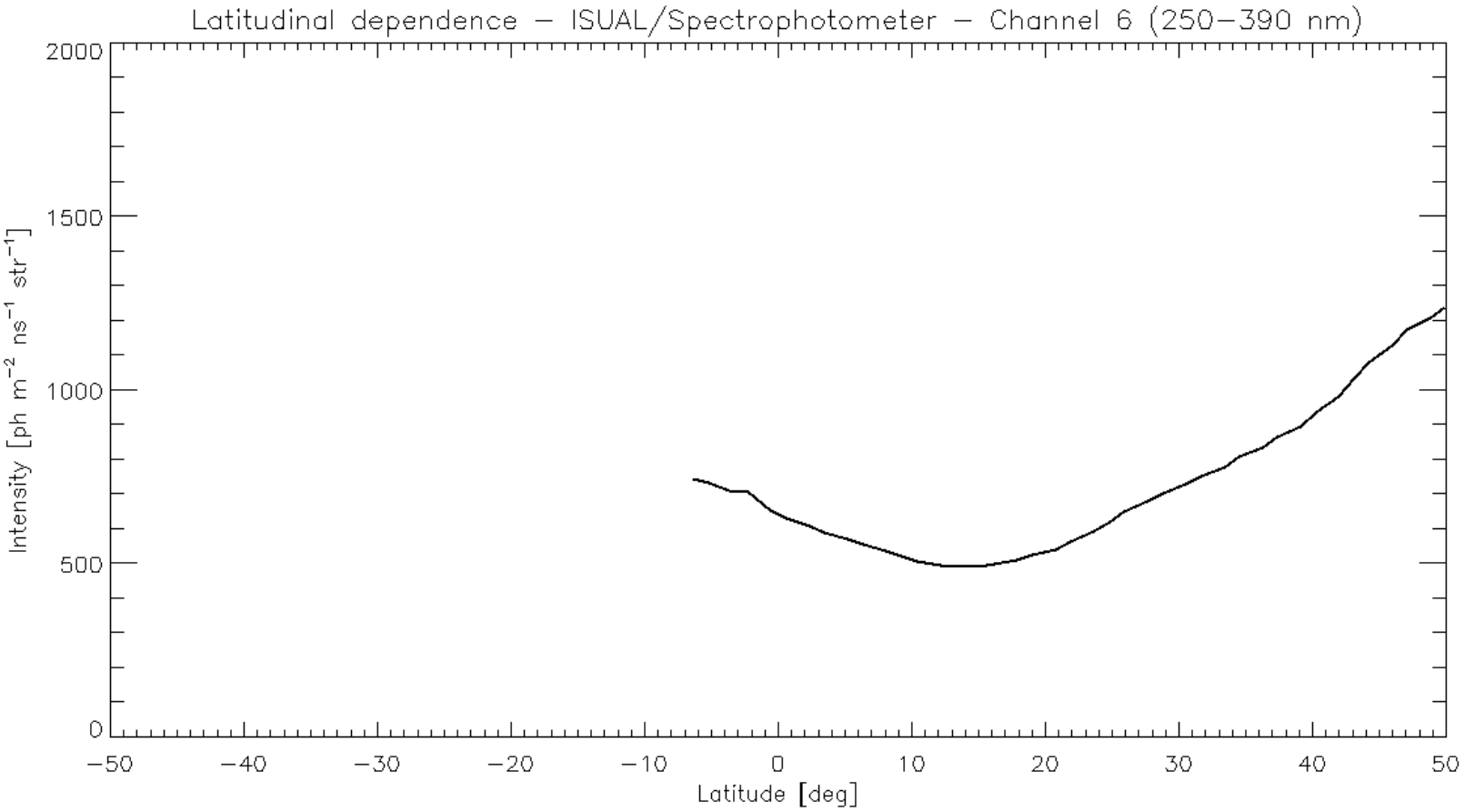
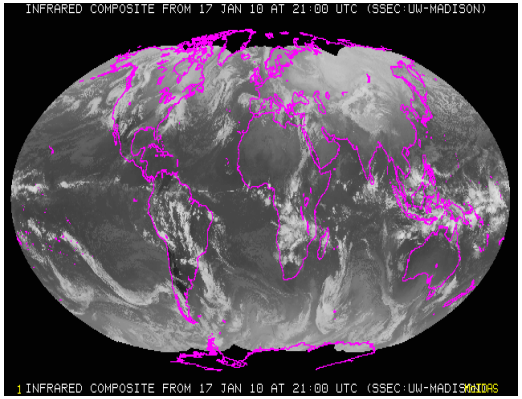
1500
1000
500
0
01:04
01:08
01:12
01:16
14 Jan, 2010
Time [hh:mm]


Latitudinal dependence – ISUAL/Spectrophotometer – Channel 6 (250–390 nm)
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
−50
−40
−30
−20
−10
0
10
20
30
40
50
Latitude [deg]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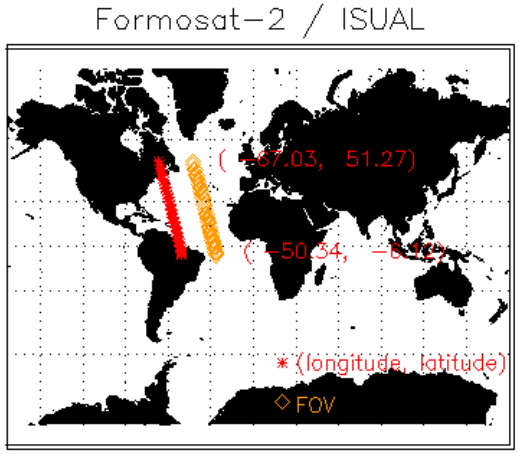
Formosat-2 / ISUAL
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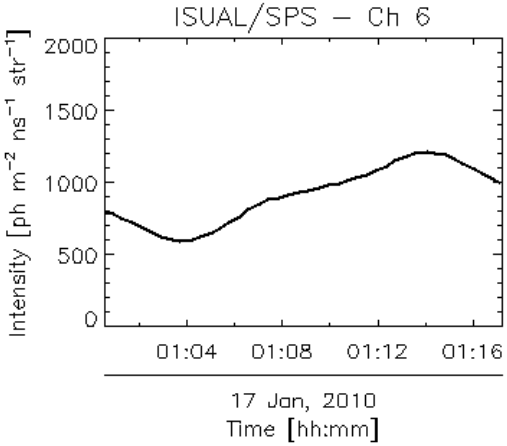
* (longitude, latitude)
◇ FOV


ISUAL/SPS – Ch 6
Intensity [ph m^{-2} ns^{-1} str^{-1}]
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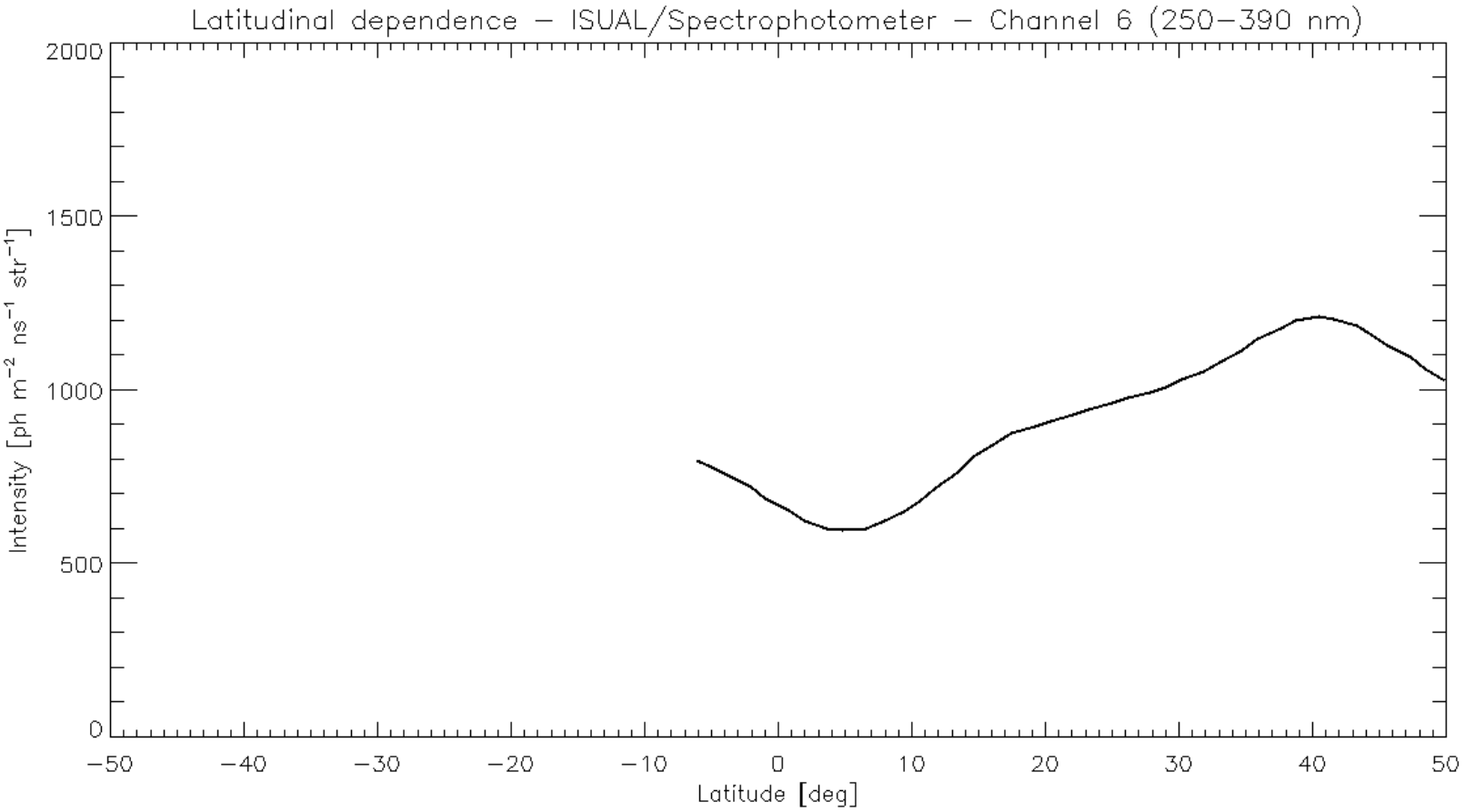
1500
1000
500
0
01:04
01:08
01:12
01:16
17 Jan, 2010
Time [hh:mm]


Latitudinal dependence – ISUAL/Spectrophotometer – Channel 6 (250–390 nm)
Intensity [ph m^{-2} ns^{-1} str^{-1}]
2000
1500
1000
500
0
−50
−40
−30
−20
−10
0
10
20
30
40
50
Latitude [deg]

Conclusions of 1st part

- archive of Tatiana-2 and ISUAL measurements was established
- interpretation of the UV BG sources is in progress
- first preliminary analysis of Tatiana-2 data do not show clear pattern (characteristic latitudinal dependence) – the result will be concluded latter
- Tatiana-2 data offer low statistics -> ISUAL is needed and preliminary results were presented
- accurate data (from JEM-EUSO precursor missions) will help to verify the future conclusions -> UV BG model

Acknowledgements

Authors are grateful to Tatiana 2 team from D.V. Skobeltsyn Institute of Nuclear Physics of M.V. Lomonosov Moscow State University for UV data.

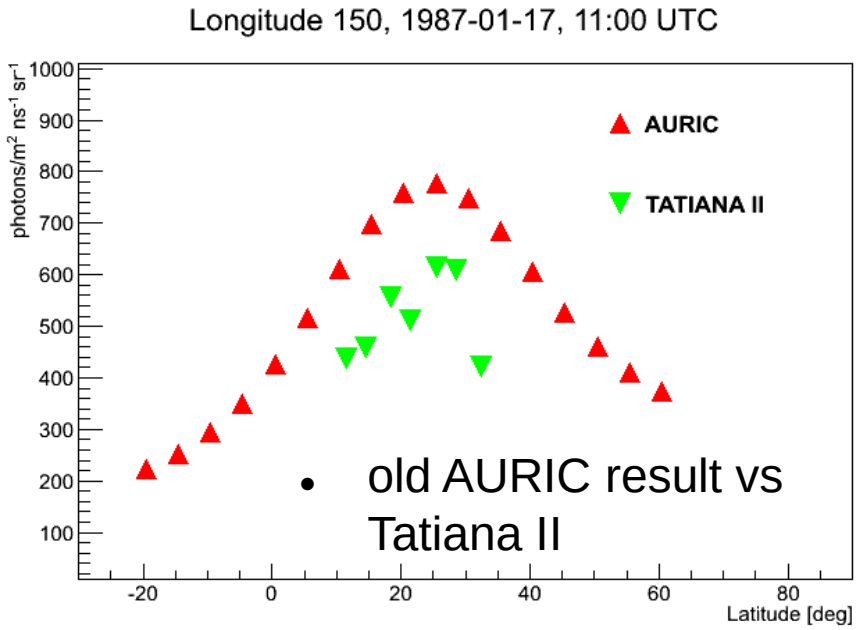
2nd part – Theoretical model

Comparison of AURIC and Tatiana II data

- Tatiana II data: October 2009 – January 2010
- AURIC – database for years 1970 -1994
- AURIC 1986 ~ Tatiana II 2009
- AURIC 1987 ~ Tatiana II 2010

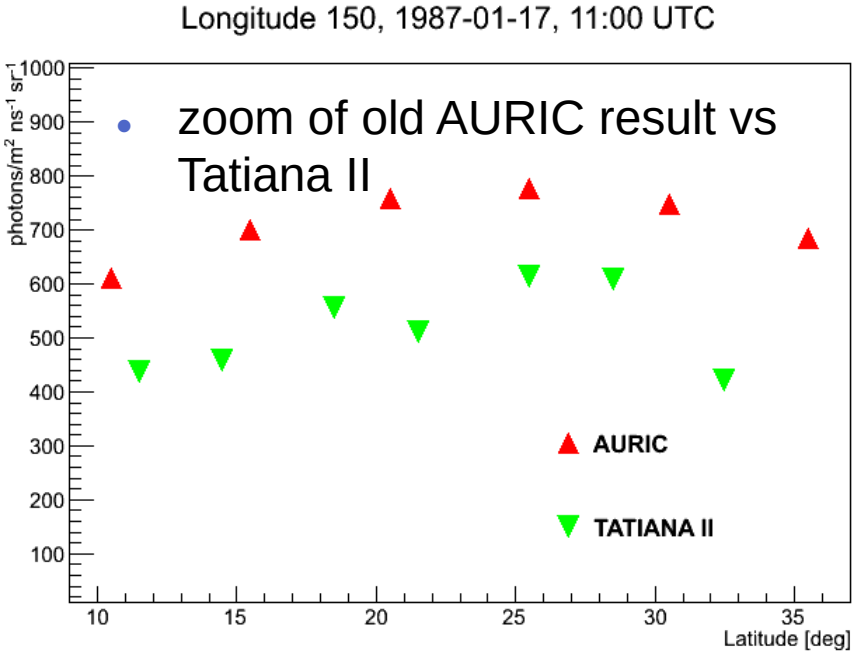
- AURIC calculate only upward radiation of Airglow layer
- Tatiana II measure upward radiation of all sources and reflected radiation of all sources
- Tatiana II should measure bigger intensities than AURIC

Old and new AURIC data vs. Tatiana II

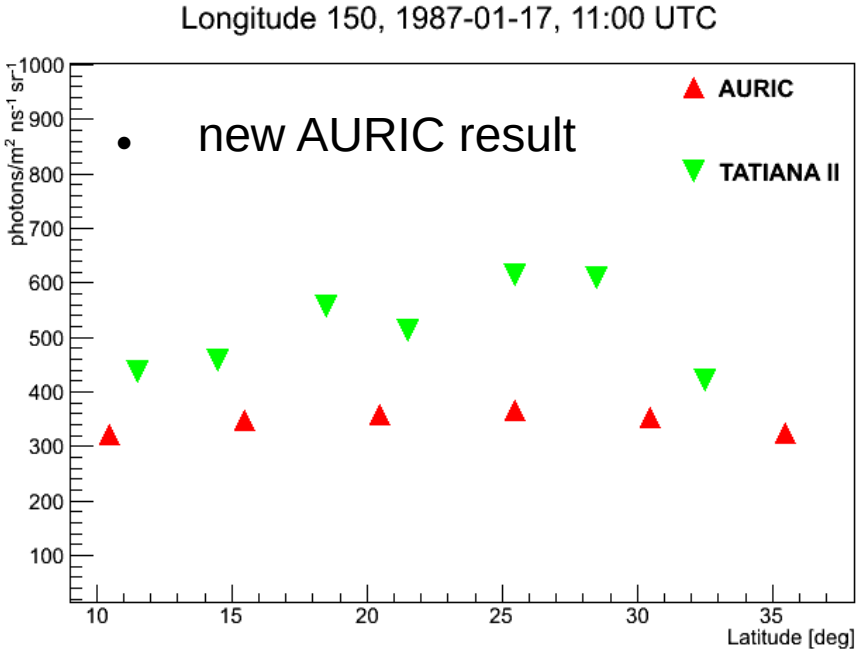


- old AURIC result vs Tatiana II

- Left side - old AURIC result compared to Tatiana II – AURIC produce bigger values than Tatiana II – wrong result
- Right side – new AURIC result vs Tatiana II – better result



- zoom of old AURIC result vs Tatiana II



- new AURIC result

What was changed?

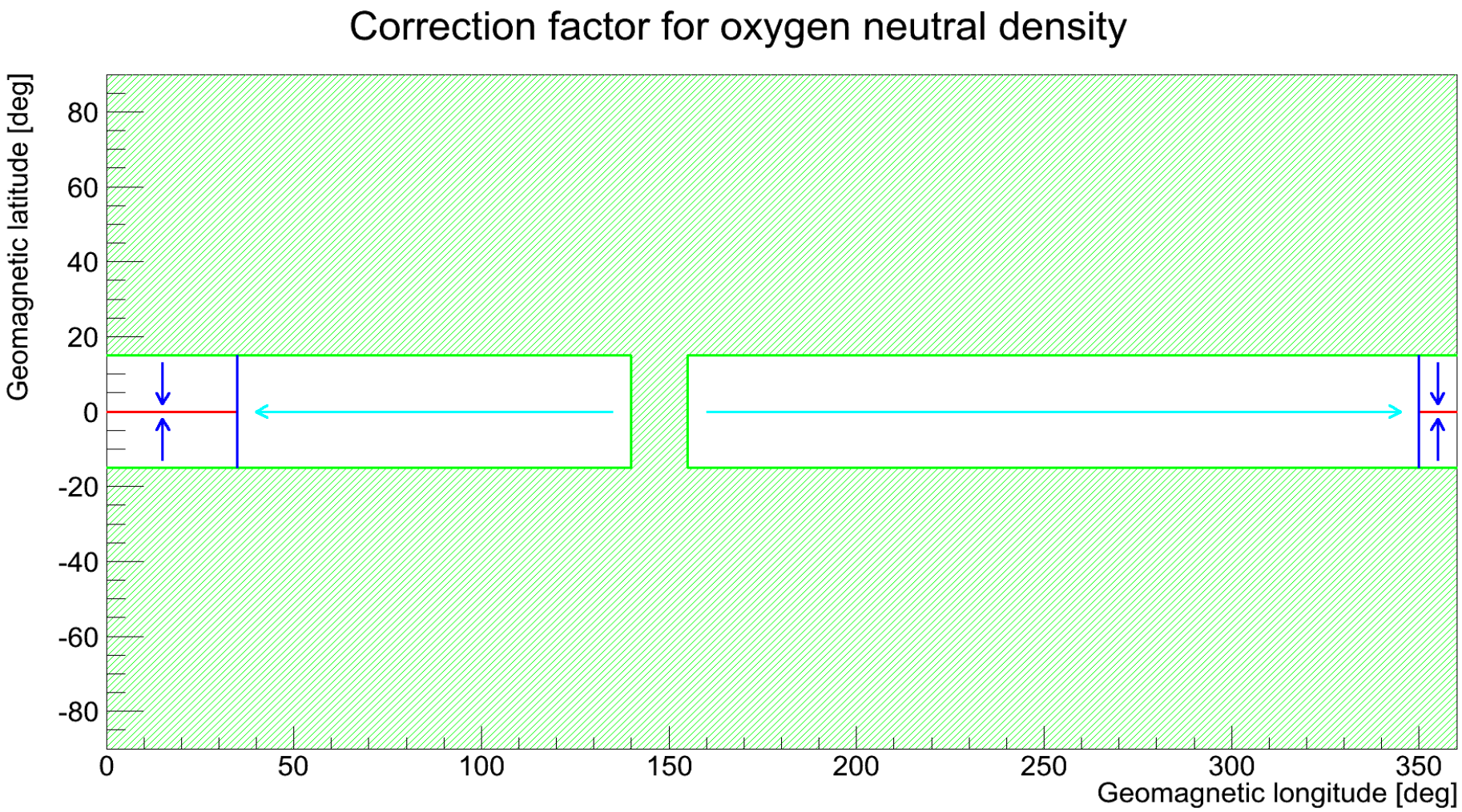
- We have found in several publications that authors need to change neutral density of atomic oxygen to fit they measurements in NRLMSISE-00 atmosphere model.
- Article:
  - The role of the zonal E×B plasma drift in the low-latitude ionosphere at high solar activity near equinox from a new three-dimensional theoretical model, doi:10.5194/angeo-24-2553-2006
  - Atmospheric Ultraviolet Radiance Integrated Code (AURIC): theory, software architecture, inputs, and selected results, http://dx.doi.org/10.1016/S0022-4073(98)00098-3 (fig.17)
- AURIC use this model to calculate neutral density of atoms and molecules for this reaction:

$$O + O + M \rightarrow O_2^* + M$$

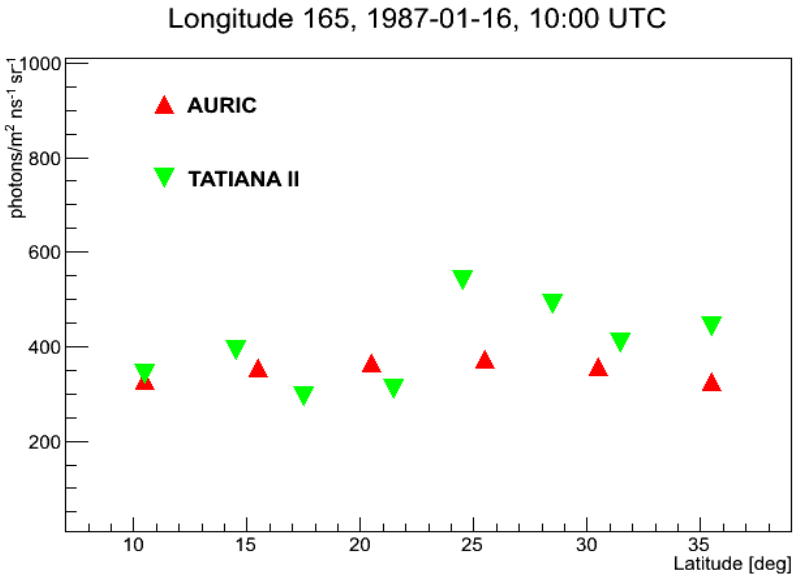
- M – O, O_2, N_2
- We use parameter C to divide NRLMSISE-00 model neutral density of atomic oxygen from article: “The role of the zonal E×B plasma drift in the low-latitude ionosphere at high solar activity near equinox from a new three-dimensional theoretical model”

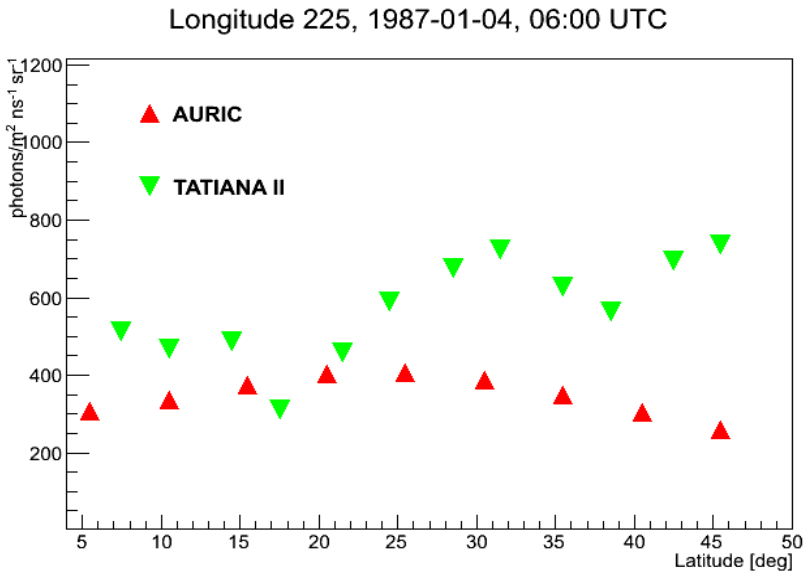
Map of parameter C

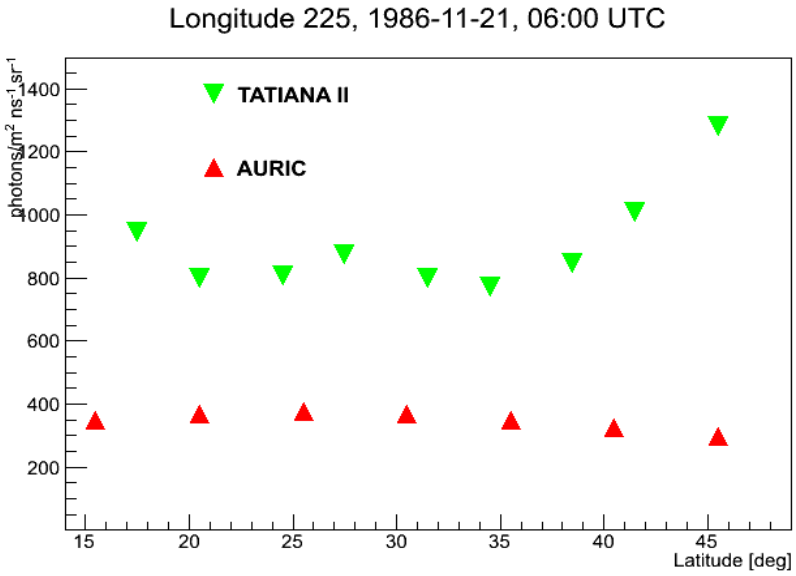
- C=1.5
- C=1.2
- C – linear decrease in arrow direction
- C – linear decrease in arrow direction

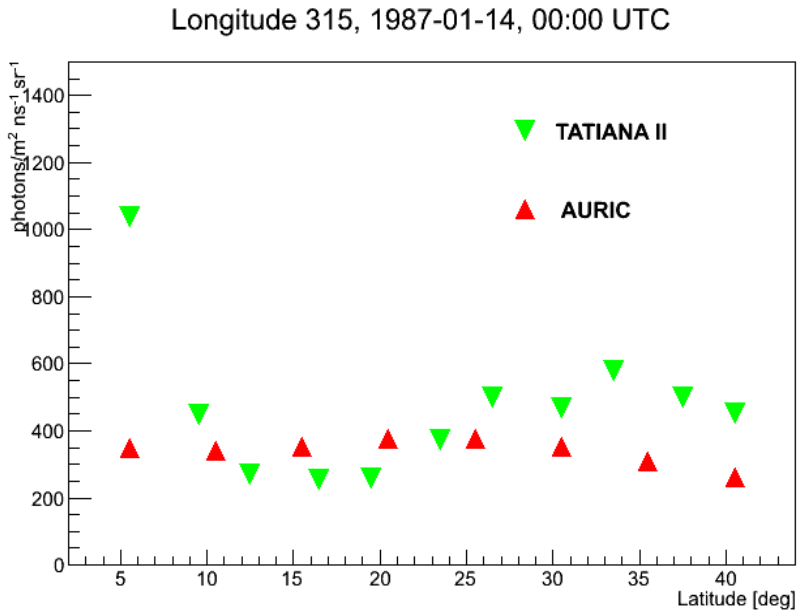


AURIC - modified neutral density of atomic oxygen

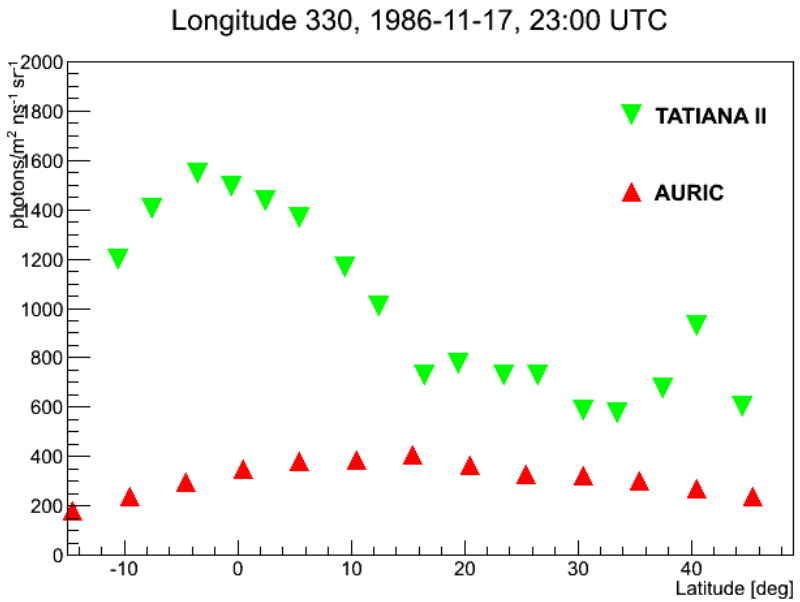


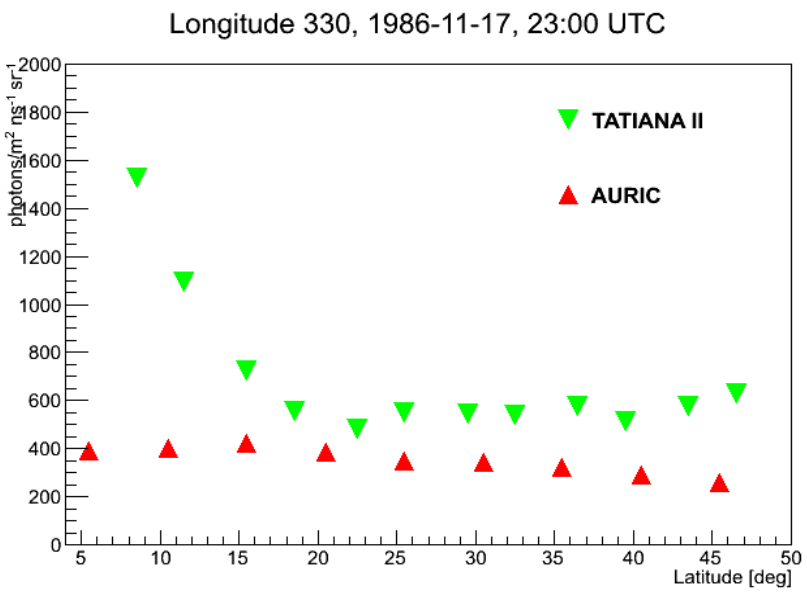


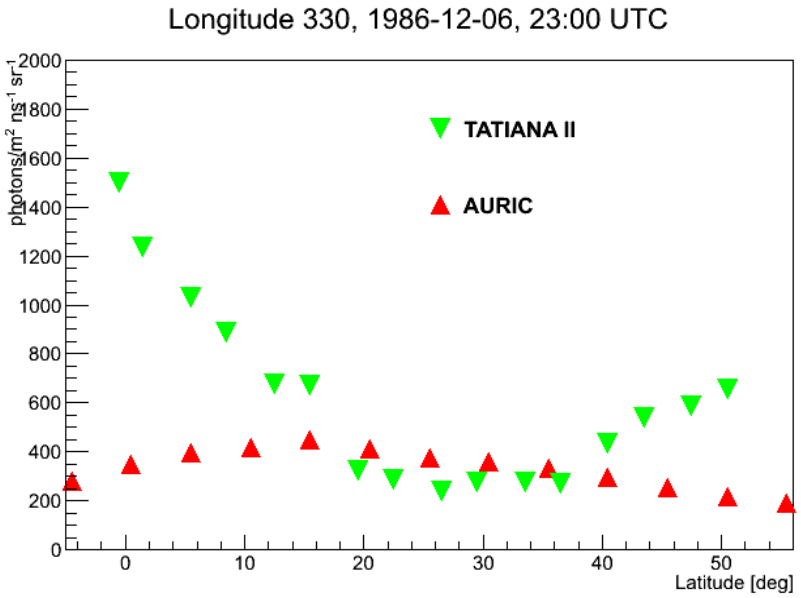


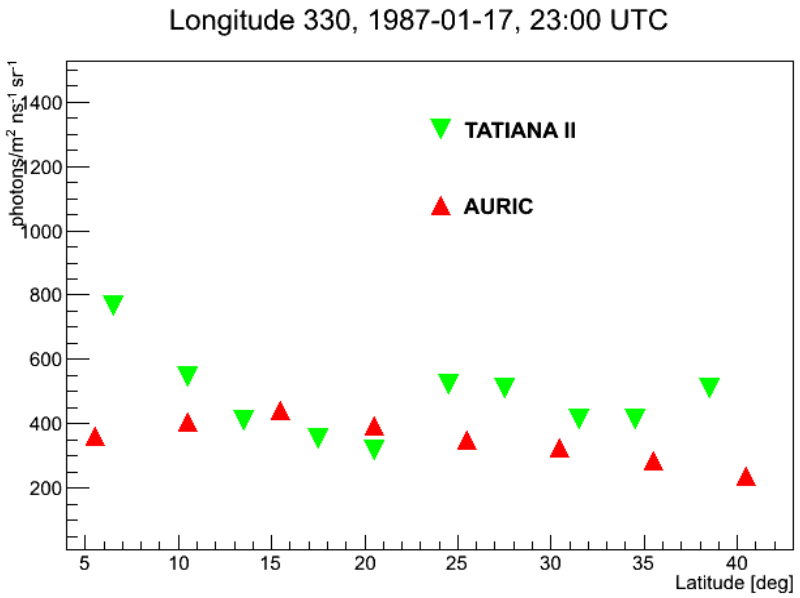


AURIC - modified neutral density of atomic oxygen







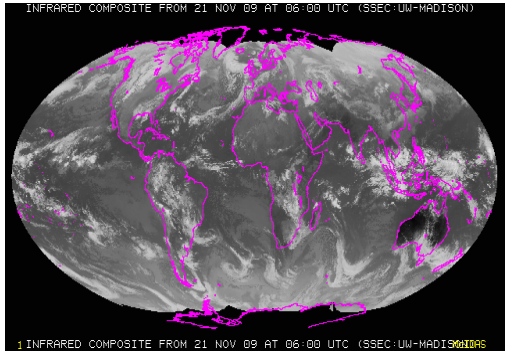


Conclusions of 2nd part

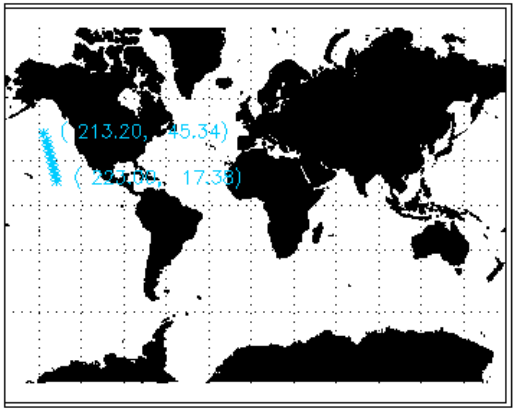
- AURIC produce result which are in better agreement with Tatiana II data after correction of atomic oxygen neutral densities from NRLMSISE-00 model – still not ideal
- we need more experimental data to understand how NRLMSISE-00 model (and AURIC) is out of real situation
- ISUAL can by very helpful
- corrected AURIC can calculate BG for situations for which we don't have experimental data

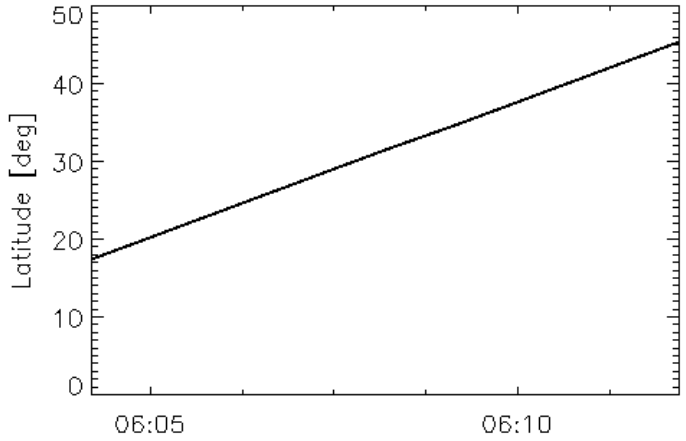
Appendix

Additional figures for Pacific ocean

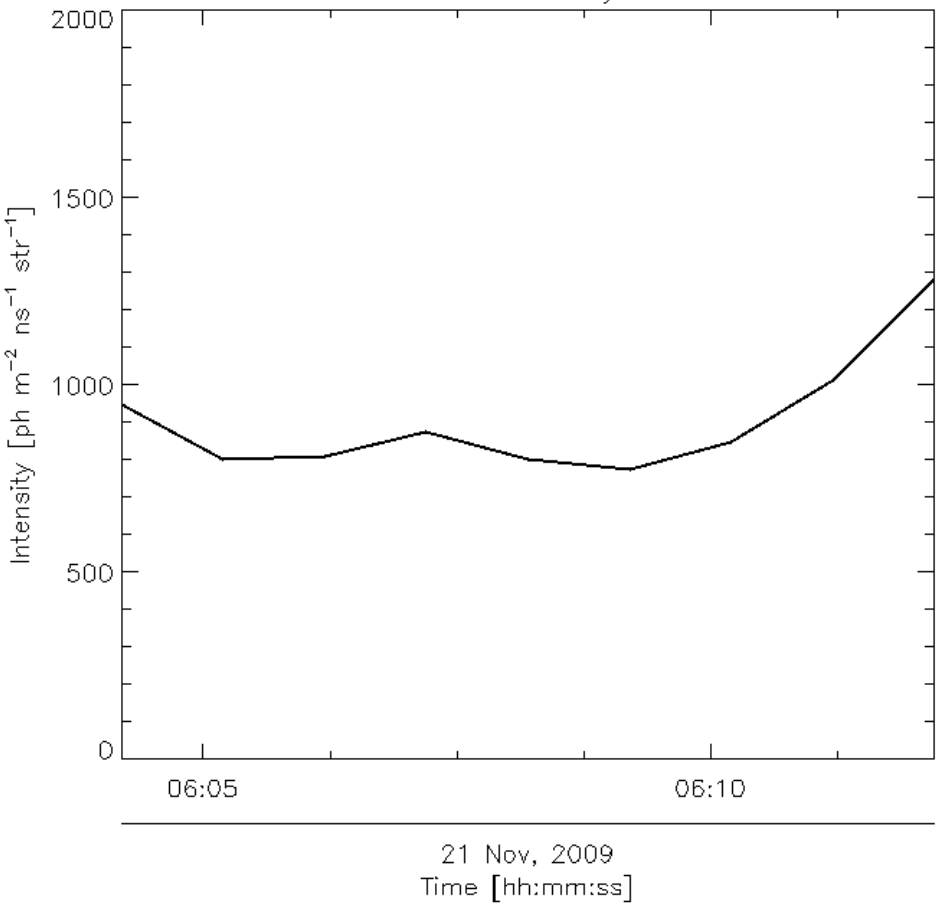


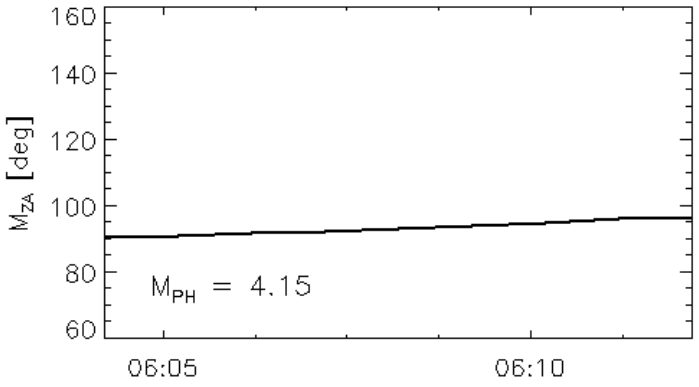
Tatiana 2 (longitude, latitude)

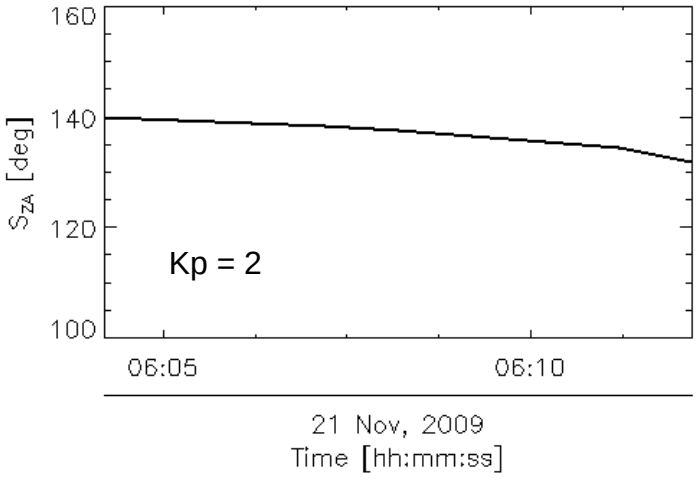


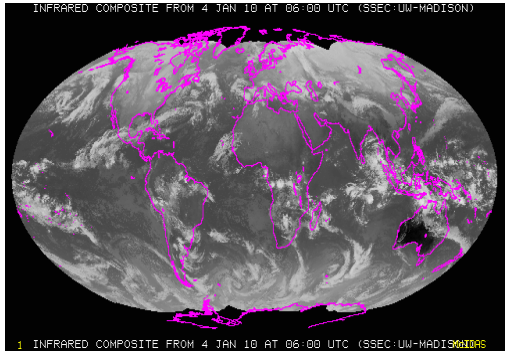


UV intensity

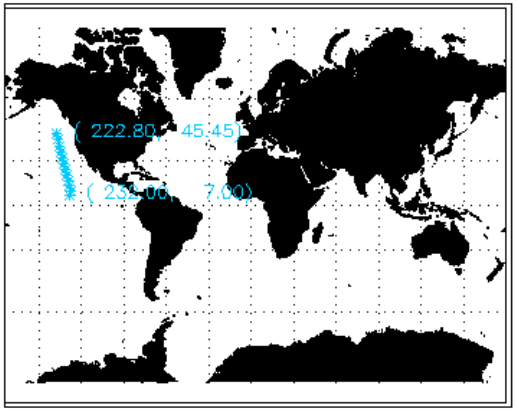


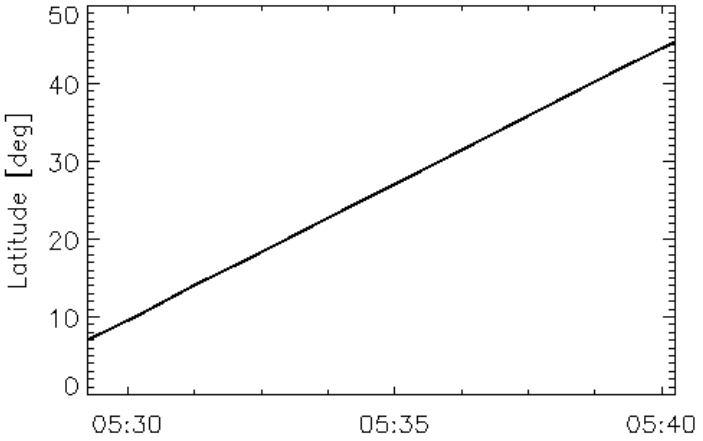




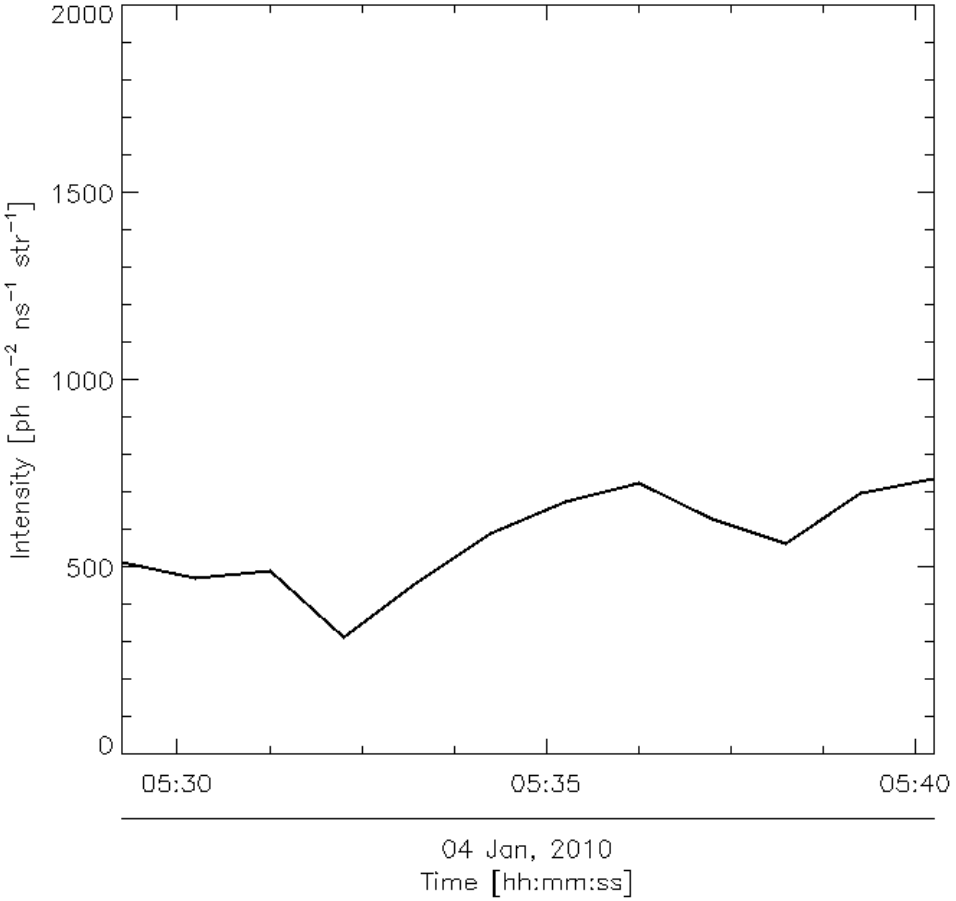


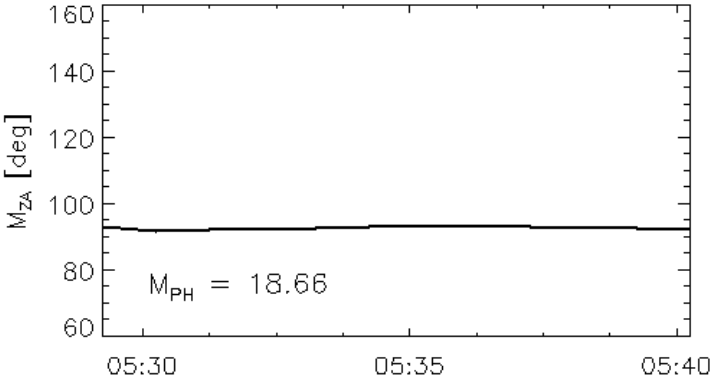
Tatiana 2 (longitude, latitude)

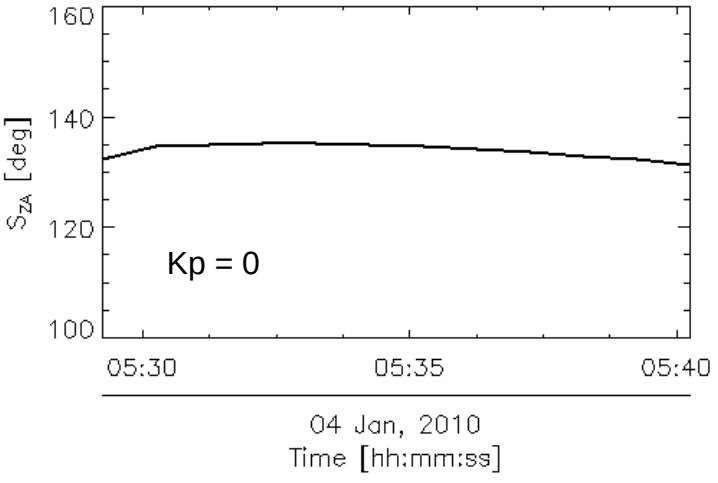


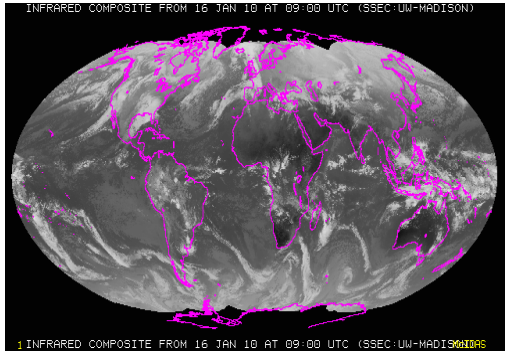


UV intensity

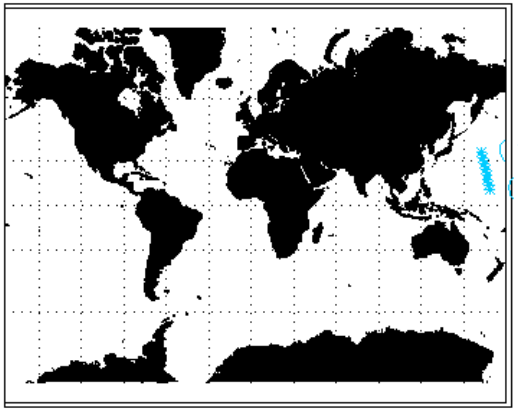


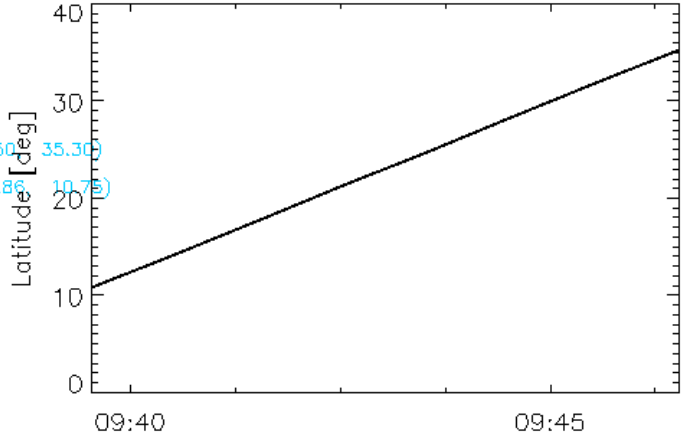




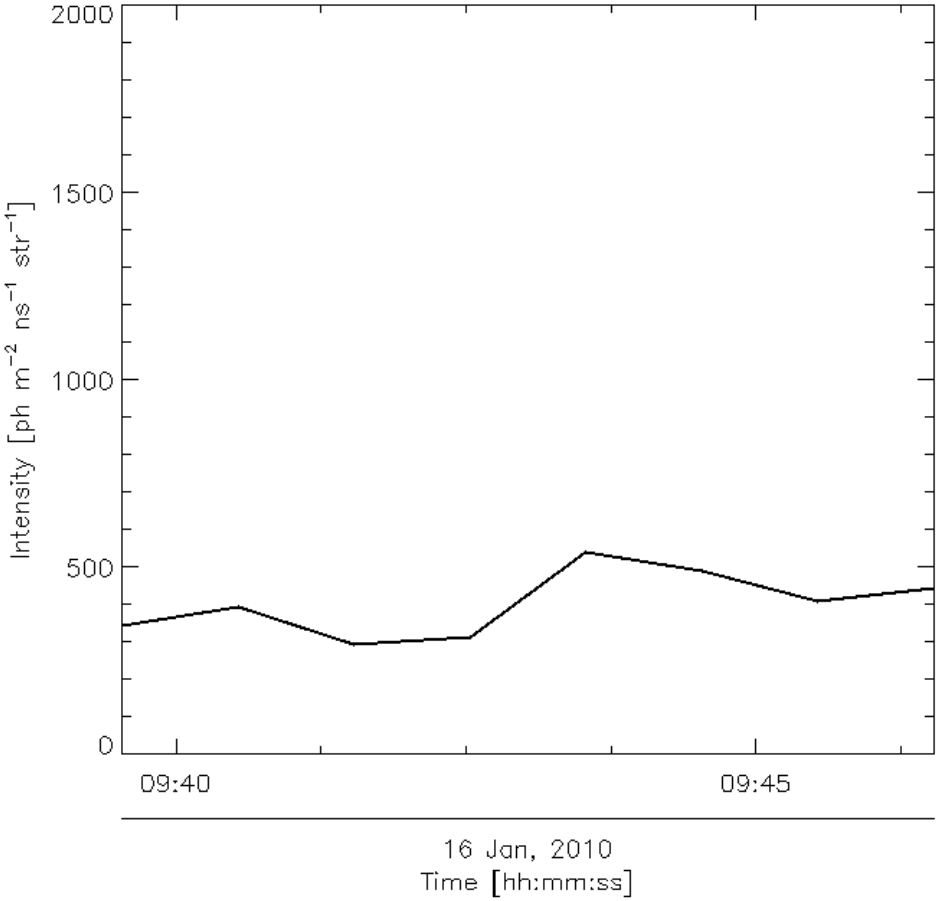


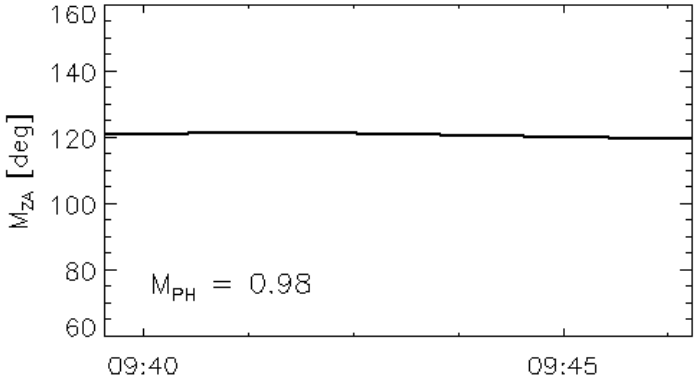
Tatiana 2 (longitude, latitude)

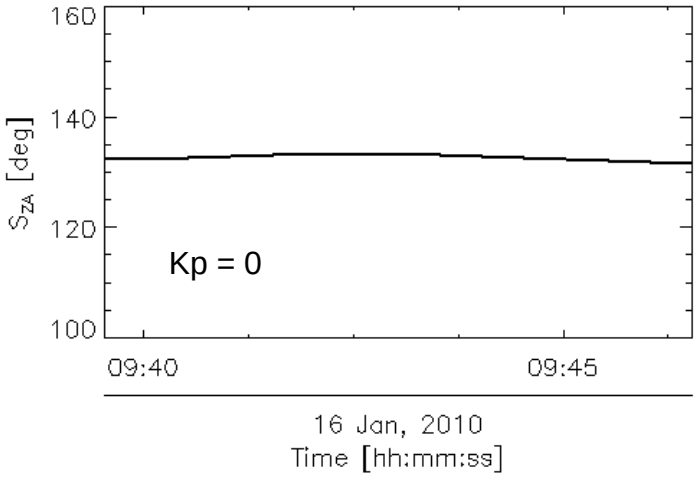


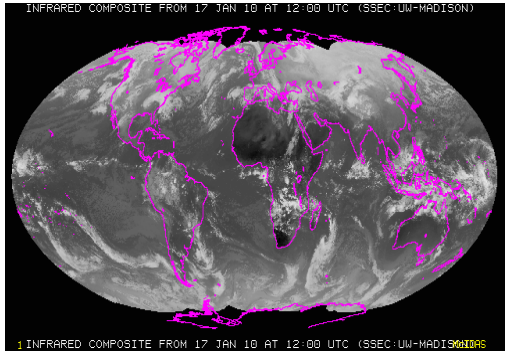


UV intensity

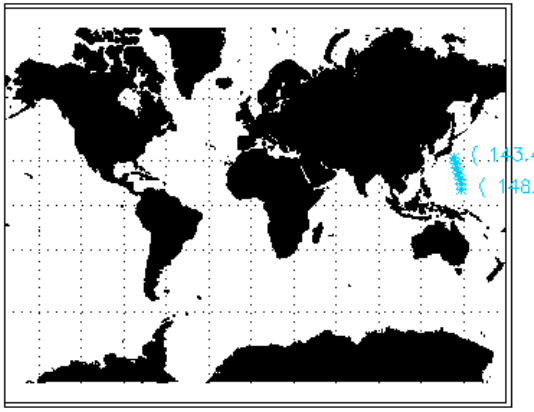


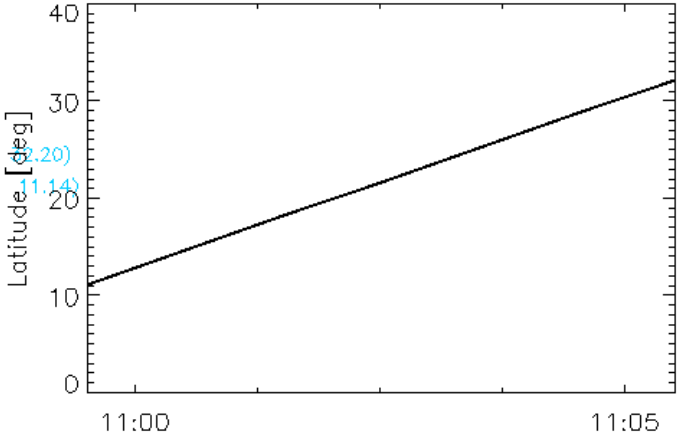






Tatiana 2 (longitude, latitude)





UV intensity