



Additional analysis TLE data of MSU satellite TATIANA-2 and SRI of RAS satellite CHIBIS-M

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**On behalf of the TATIANA2 science team
On behalf of the CHIBIS-M science team**



1.TATIANA2 microsatellite scientific instrument -principal investigator SINP MSU
Science team leader - Mikhail Panasyuk.

Co-executers

BUAP university, Mexico

EWHA university, Republic of Korea

2.CHIBIS-M microsatellite - principal investigator Space Research Institute of the Russian Academy of Sciences
Science team leaders - Alexander Gurevich & Lev Zeleny.

Co-executers

LPI RAS, Russia

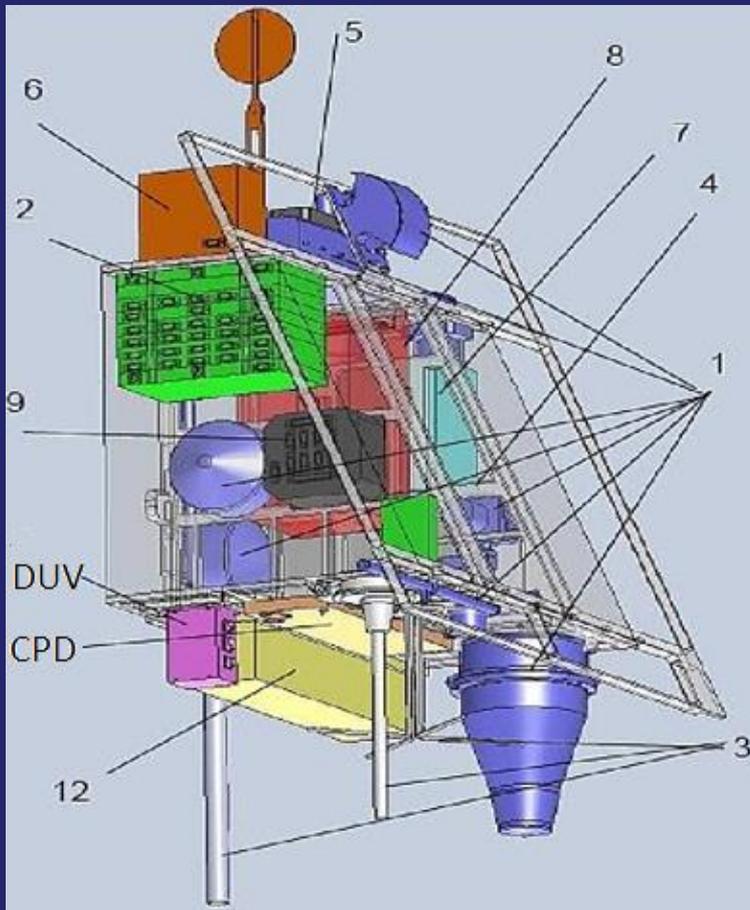
SINP MSU, Russia

Lvov Center of SRI, Ukraine

Etvosh university, Hungary

Speaker contribution to the science teams is design and manufacturing of detectors, the development of research methods, on-line data processing and analysis

TATIANA2 during design and integration time



Carrier rocket: "Souz-2"
Upper-stage rocket "Frigate"

Operating orbit:
Polar Sun synchronous
Altitude : 800 – 850km
Inclination 98.8⁰
Mass: 100kg
Power: 100W

CHIBIS-M at the time of separation from launch vehicle PROGRESS



Carrier rocket: PROGRESS -13M

Operating orbit:

Altitude : ~ 500km

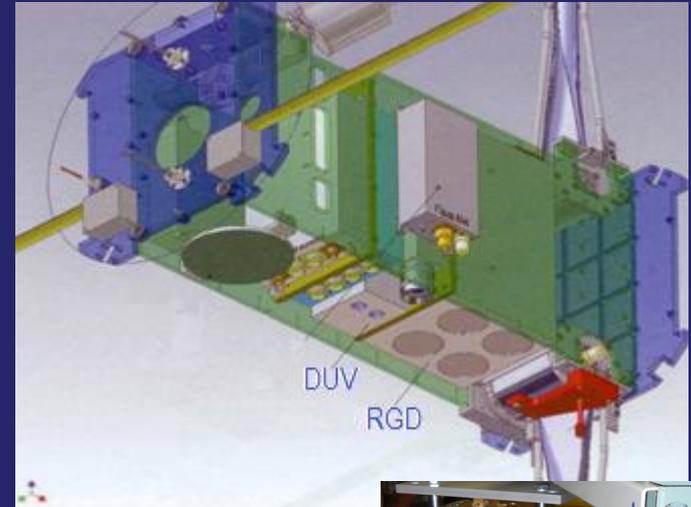
Inclination 51,6°

Mass: ~40kg

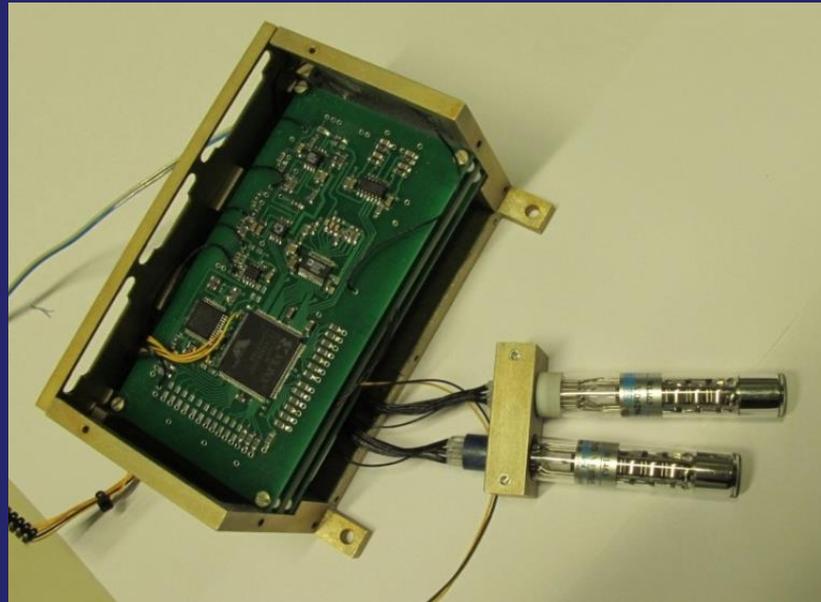
Power: ~ 50W

CHIBIS-M

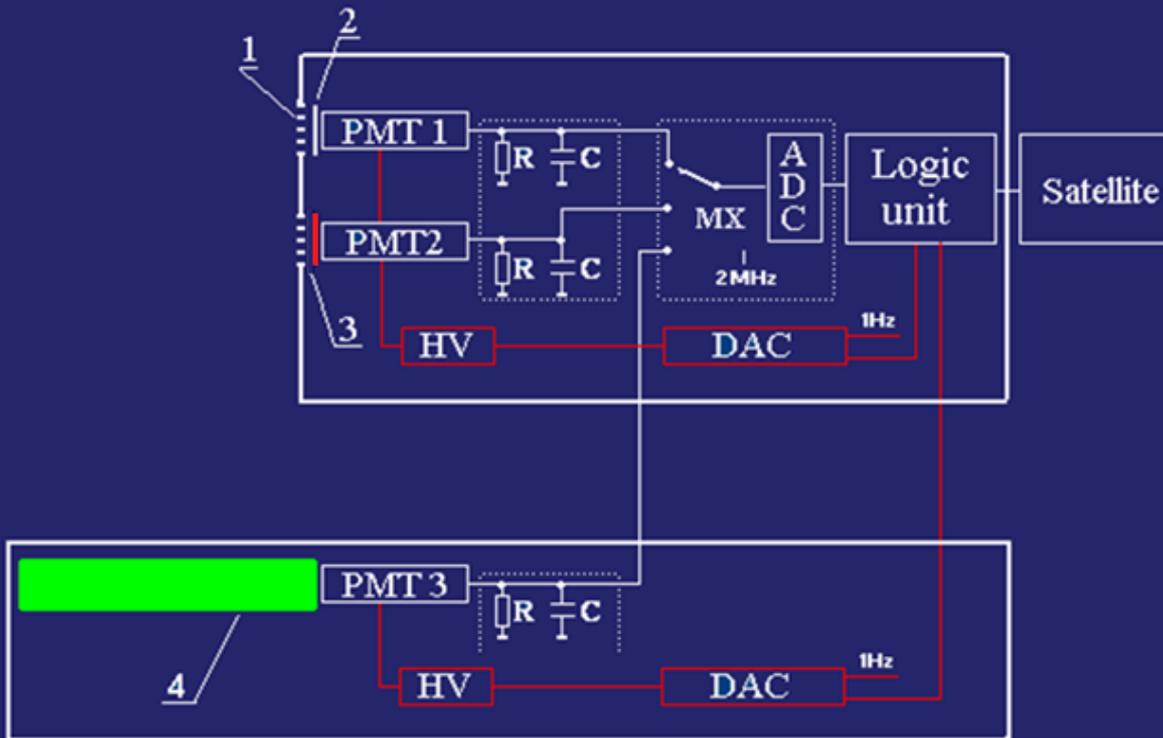
during design and integration time



UV 240-400nm
IR 610-800nm
Sensitive area ~ 0.5cm²
Field of view ~ 15°
Mass ~ 0.65kg
Power < 2.5Wt



Block-diagram of the UV detector



1. Signal finding algorithm of the brightest flashes in every 1min time interval.
2. Gain control algorithm to fix PMT anode current at a given level in the whole expected airglow range.
3. Interface algorithm for communication with the satellite board.

UV detector comprises 2 PMT tubes and electronics block.

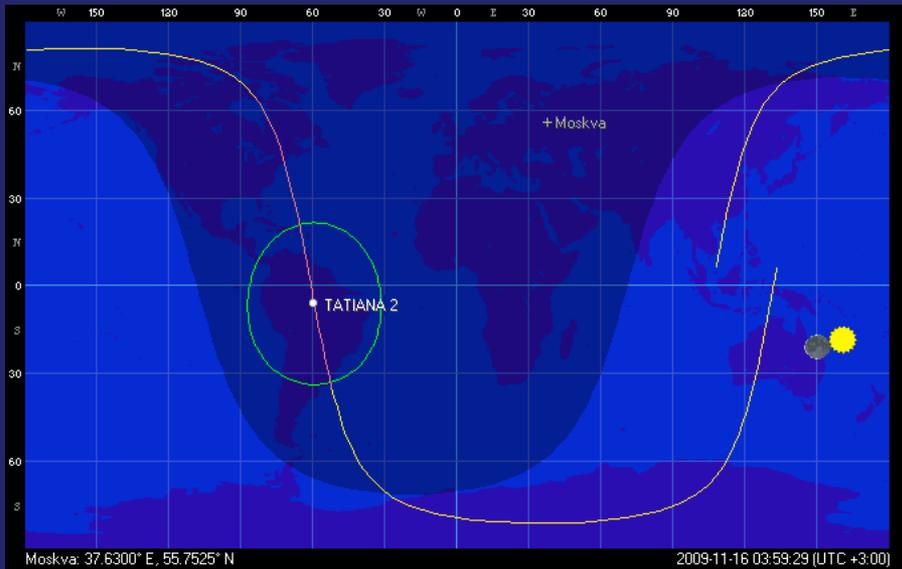
(first two tubes measure an optical radiation, third measures the charge particle background)

Two code are recorded and used in measurements:

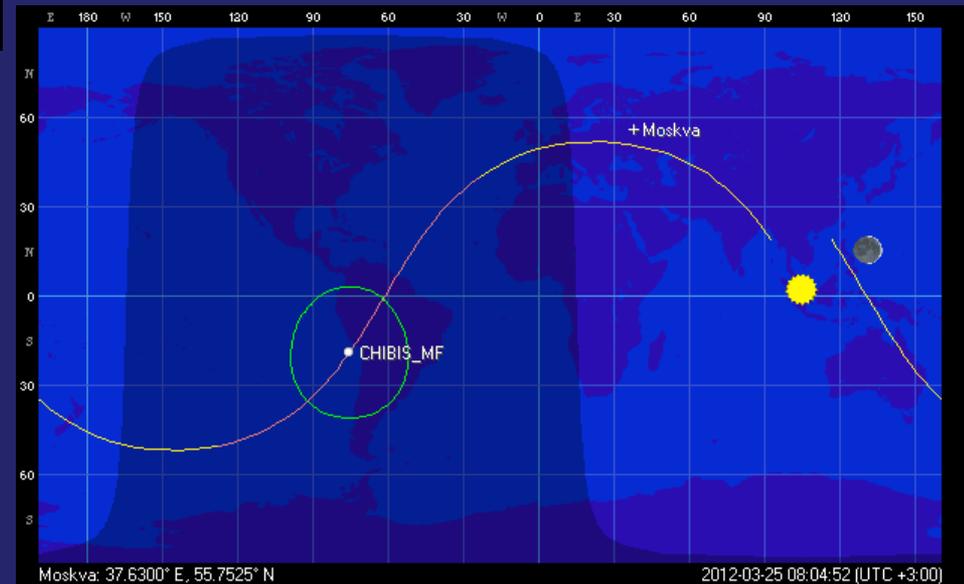
M- PMT gain DAC code and N- the PMT anode current ADC code

(1) collimator, (2) UV-1 filter, (3) IR filter, (4) scintillating plastic, MX—multiplexor, HV—voltage supply for PM tubes, ADC and DAC— analog-digital and digital-analog convertors, Logic Unit- FPGA.

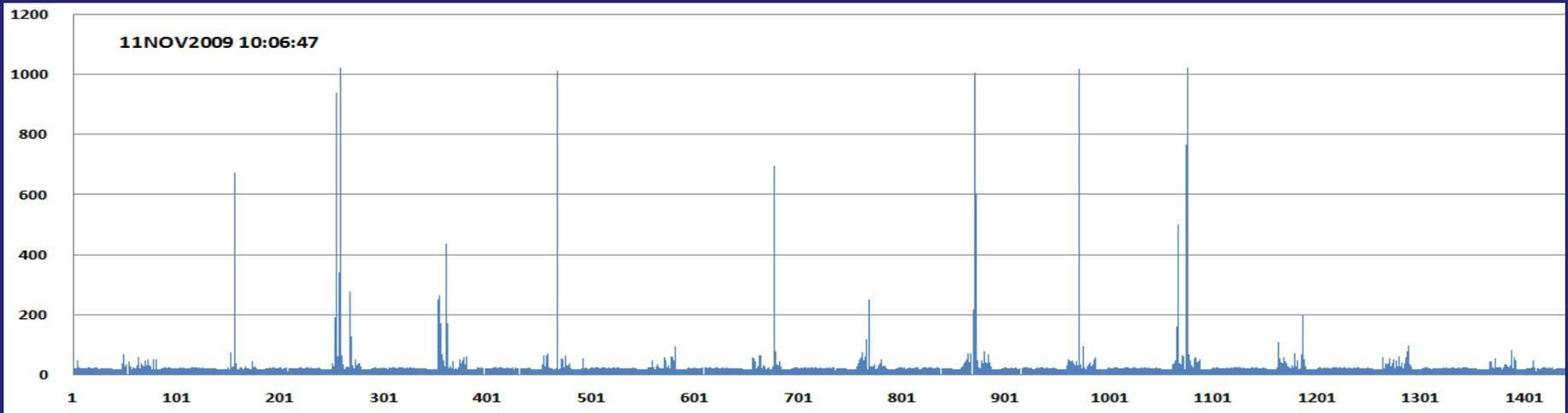
TATIANA-2 region and one orbit ground track on November 16 2009 which is discussed in this report



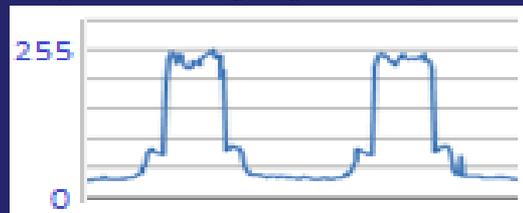
CHIBIS-M region and ground track of one orbit March 25 2013 which is discussed in this report



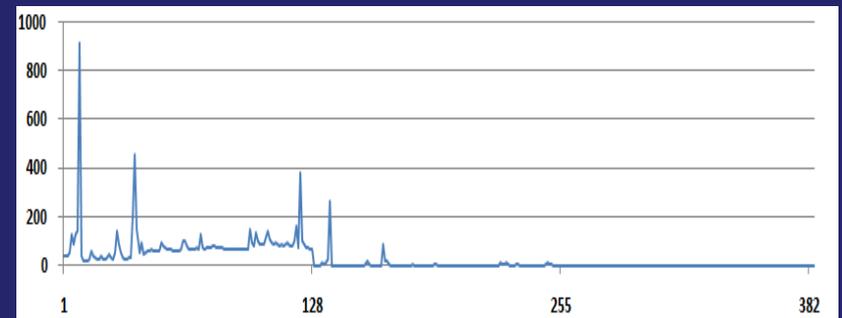
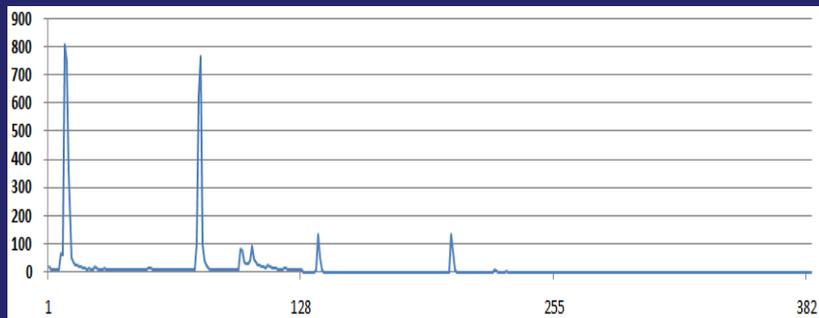
TLE altitudes distribution recorded during one day TATIANA2 (~14 orbits)



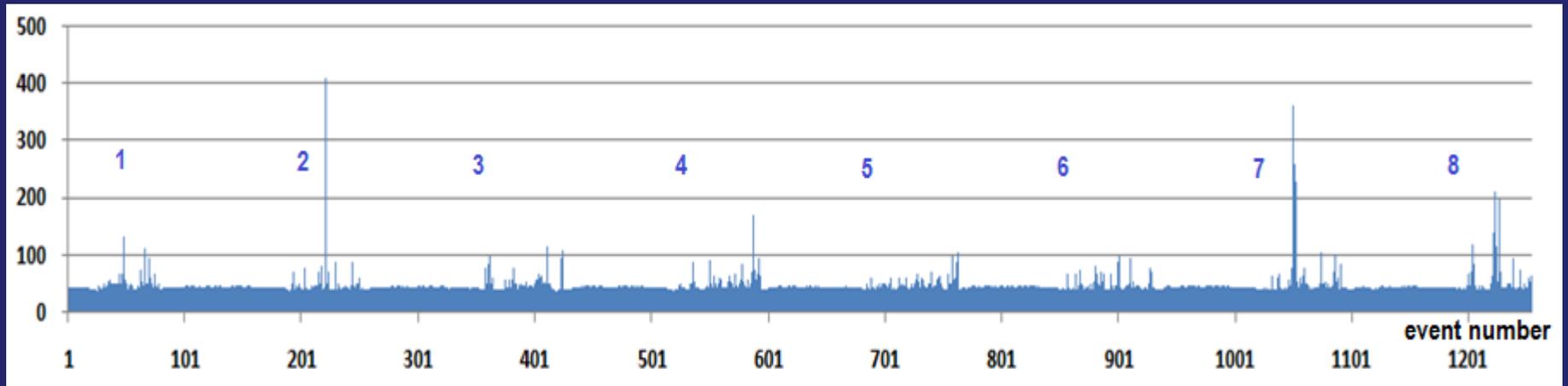
Example of gain changing during two orbits



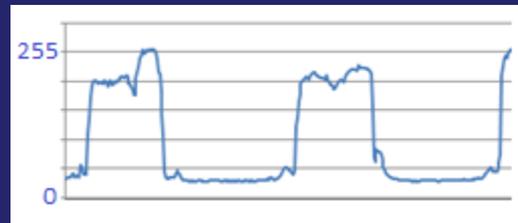
Examples of two temporal profile recoded TLE



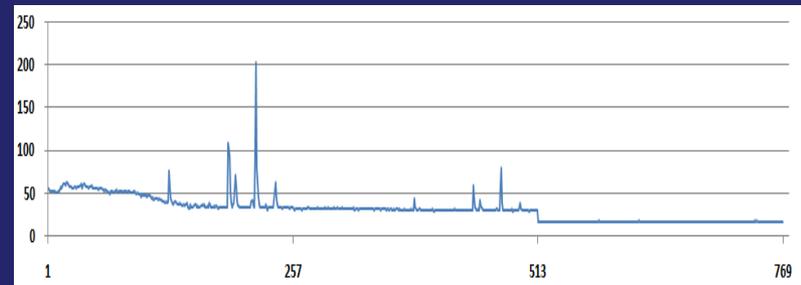
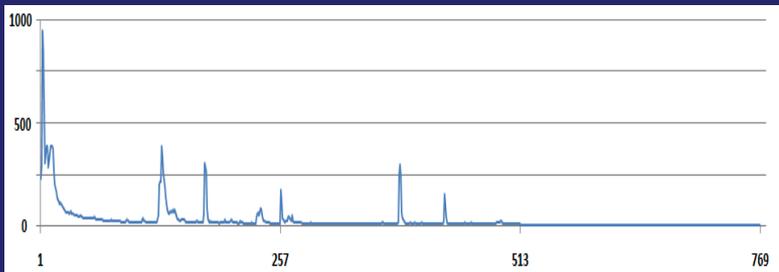
TLE altitudes distribution recorded during one exposition time CHIBIS-M (~8 orbits)



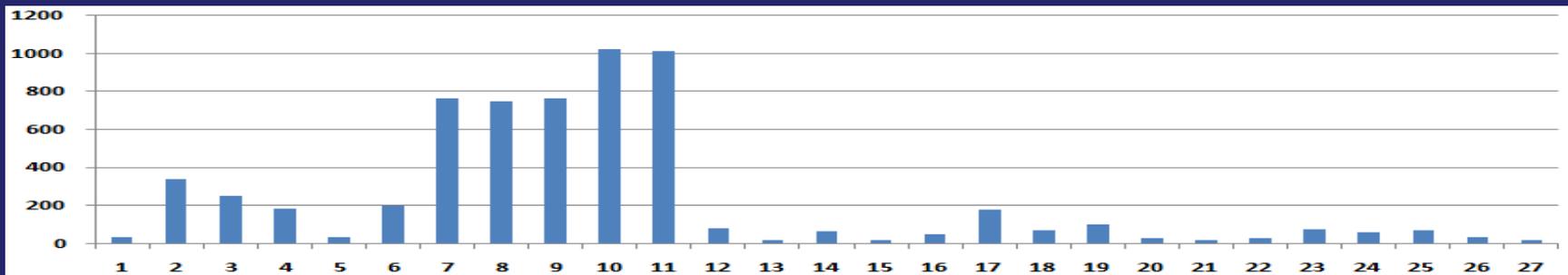
Example of gain changing during two orbits



Examples of two temporal profile recoded TLE

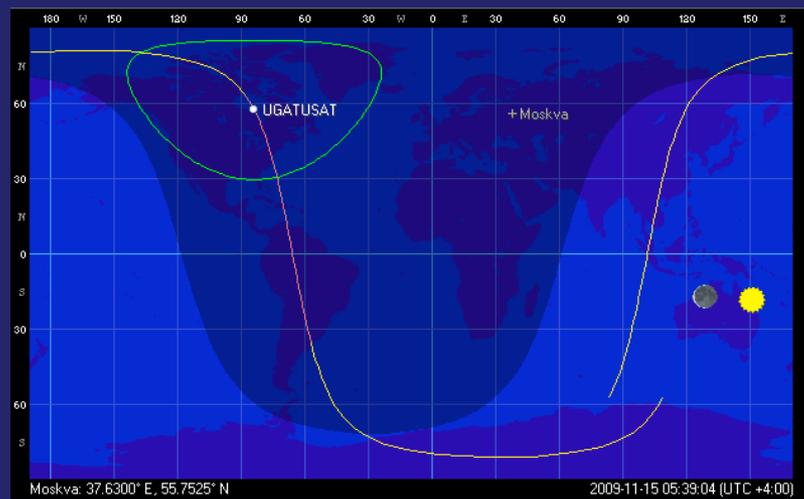
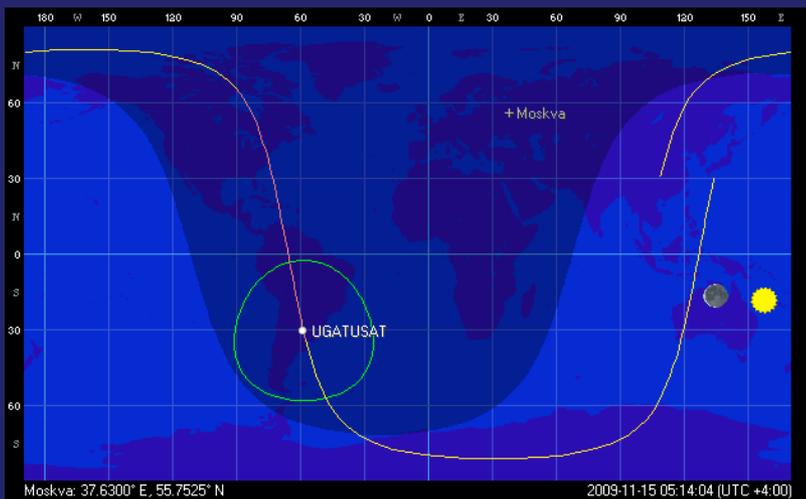
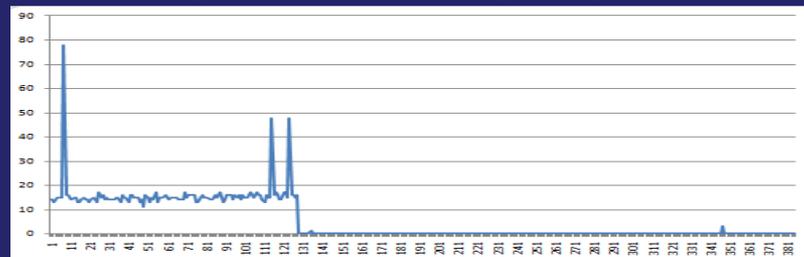
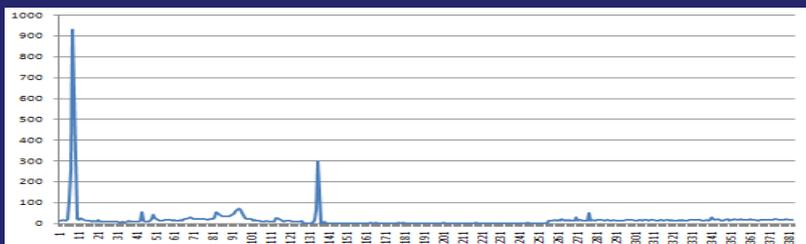


TLE altitudes distribution recorded by TATIANA-2 above South & North America



Example of temporal profile of TLE recorded at south age of trajectory

Example of temporal profile of TLE recoded at north age of the same trajectory



Книга5 - Microsoft Excel

Работа с диаграммами

Главная Вставка Разметка страницы Формулы Данные Рецензирование Вид Разработчик Конструктор Макет Формат

Изменить тип диаграммы Сохранить как шаблон

Строка/столбец Выбрать данные

Макеты диаграмм

Стили диаграмм

Переместить диаграмму Расположение

Диаграмма 3

	RJ	RK	RL	RM	RN	RO	RP	RQ	RR	RS	RT	RU	RV	RW	RX	RY	RZ	SA	SB	SC	SD	SE	SF	SG	SH	SI	SJ	SK	SL	SM
1	04.11.29.	04.12.29.	04.13.29.	04.14.29.	04.15.29.	04.16.29.	04.17.29.	04.18.29.	04.19.29.	04.20.29.	04.21.29.	04.22.29.	04.23.29.	04.24.29.	04.25.29.	04.26.29.	04.27.29.	04.28.29.	04.29.29.	04.30.29.	04.31.29.	04.32.29.	04.33.29.	04.34.29.	04.35.29.	04.36.29.	04.37.29.	04.38.29.	04.39.29.	04.40.29.
2	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.	09.11.15.
3	73	72	72	211	220	210	232	234	225	229	234	240	245	236	219	241	241	234	242	247	245	244	216	212	225	235	233	228	212	
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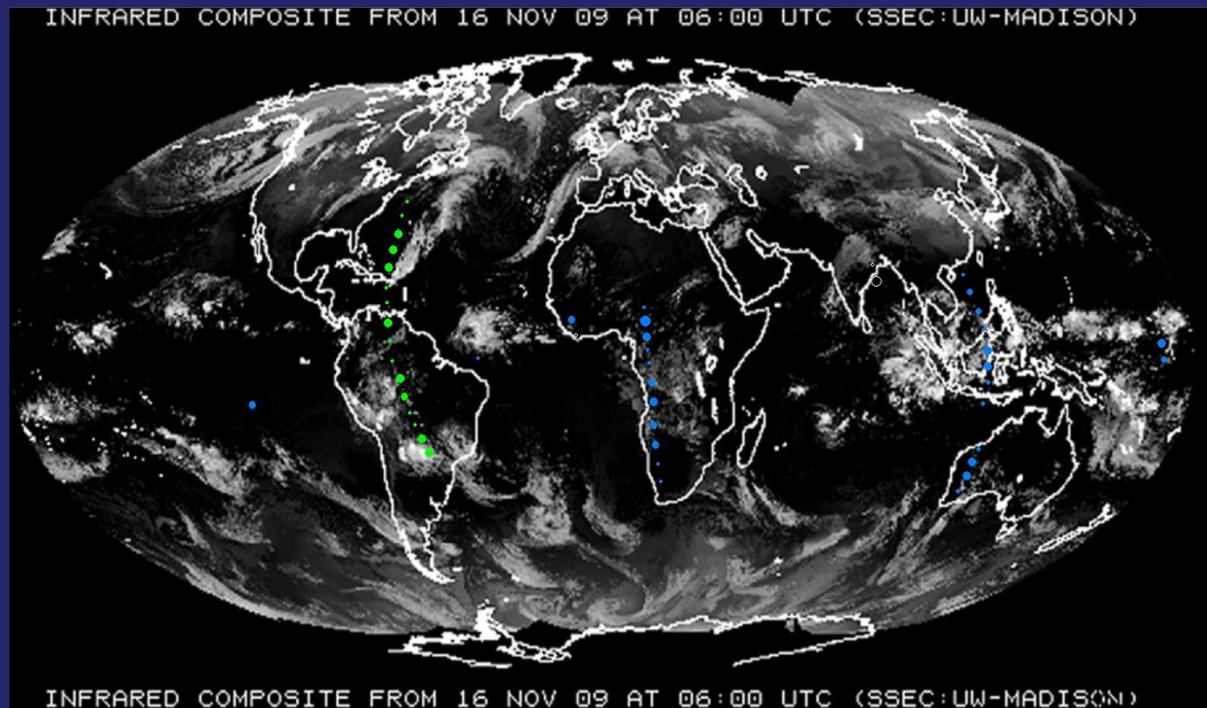
Лист1 Лист2 Лист3

Готово

70%

18:04 05.02.2013

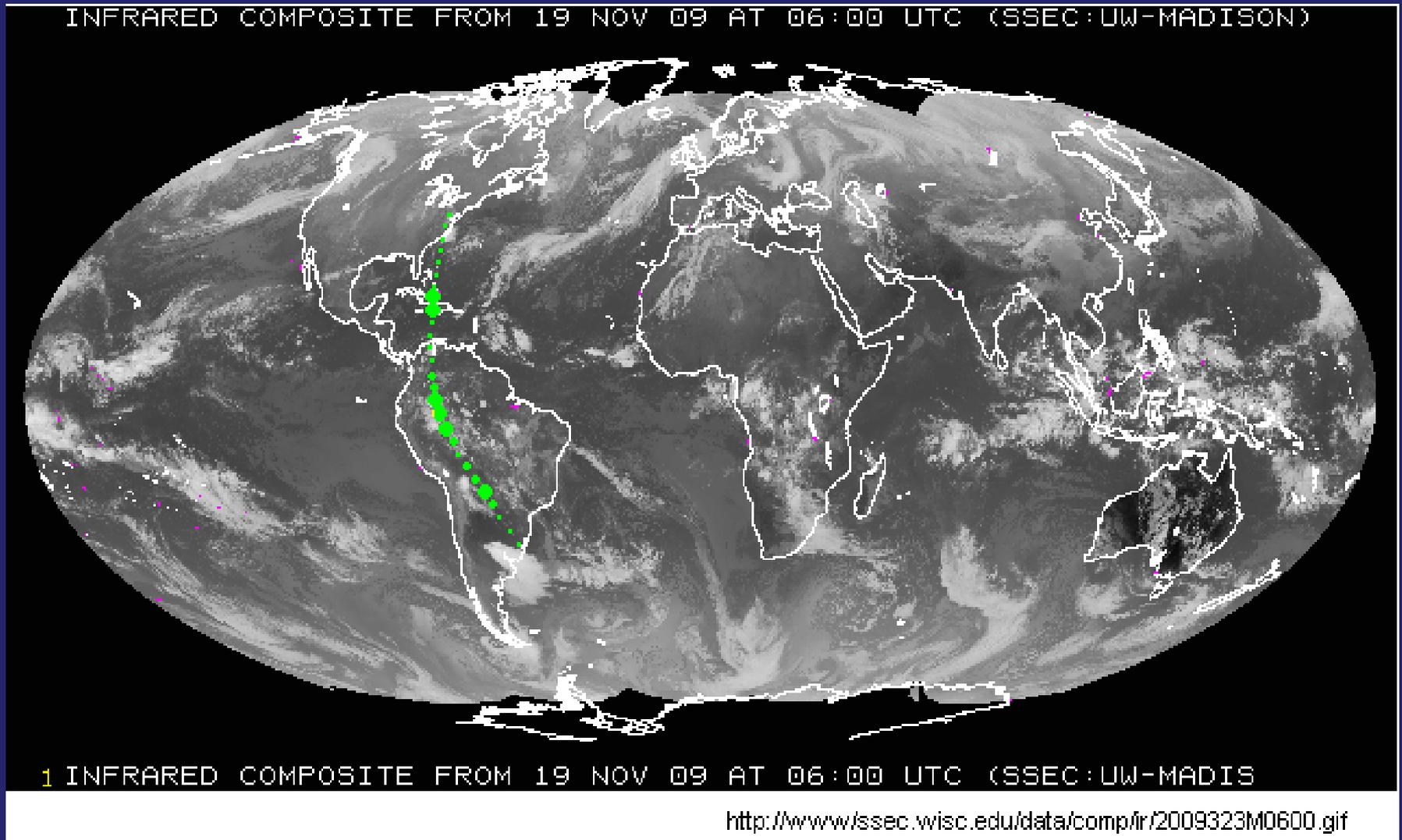
One day TLE distribution recorded by TATIANA-2 above clouds map



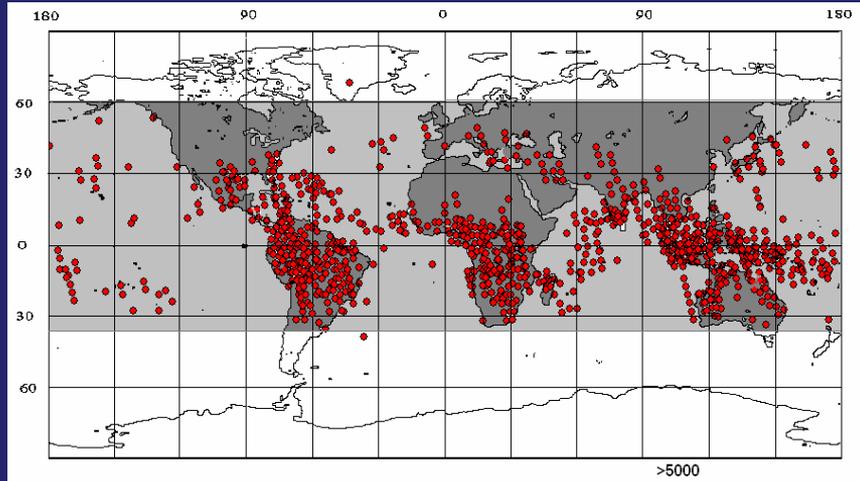
Some of the flashes are observed in cloudless regions were not detected by WWLLN
There are a lot of clouds above oceans but there are no registered events above them
Length of such series reach 10 thousand kilometers which is much more longer then expected thunderstorm or clouds area crossed by satellite

Efficiency of WWLLN is less then 30% so to miss 7 events which are out of clouds regions will be $(1-0.3)^7 \approx 0.08$.
At the same time in accordance to WWLLN data efficiency to detect event in cloud less regions is less then 10^{-2} per min per detector field of view, so probability to detect 7 of the same kind events is about $(10^{-2})^7$

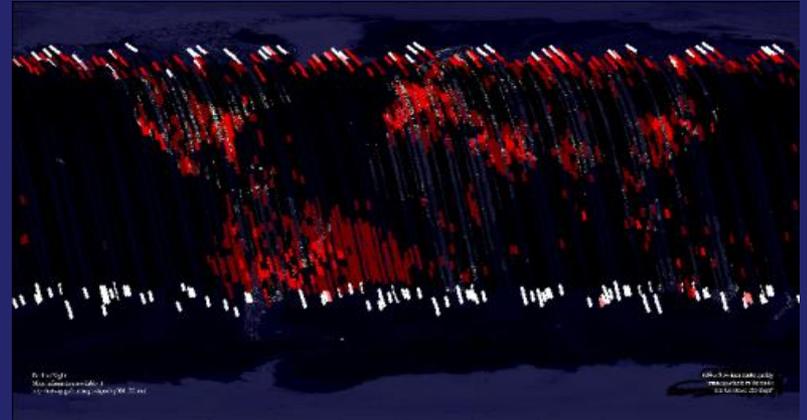
One orbit TLE distribution recorded by TATIANA-2 micro satellite
above clouds map



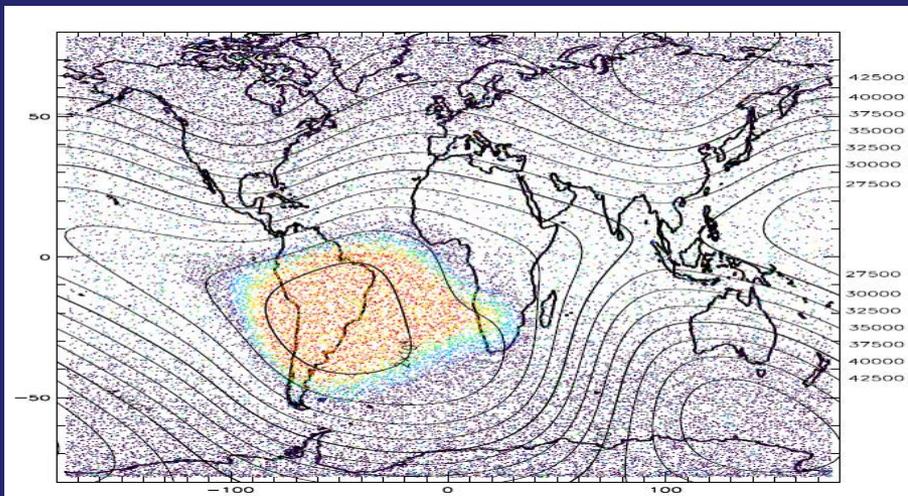
Global distribution of the TLE recorded by TATIANA -2



IR Earth night glow and light produced by charged particles in SAA region recorded by TATIANA -2



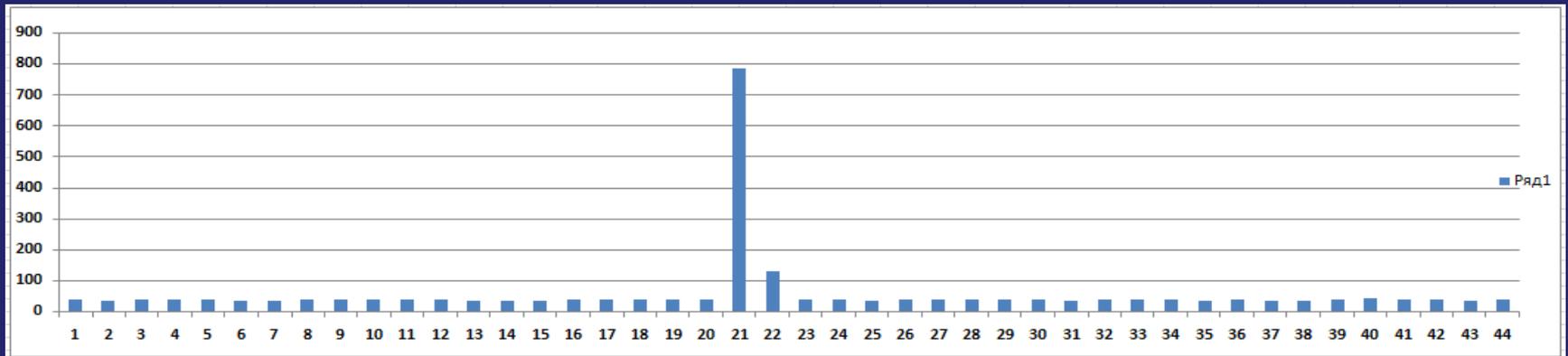
Charged particles global distribution recorded by TATIANA -2



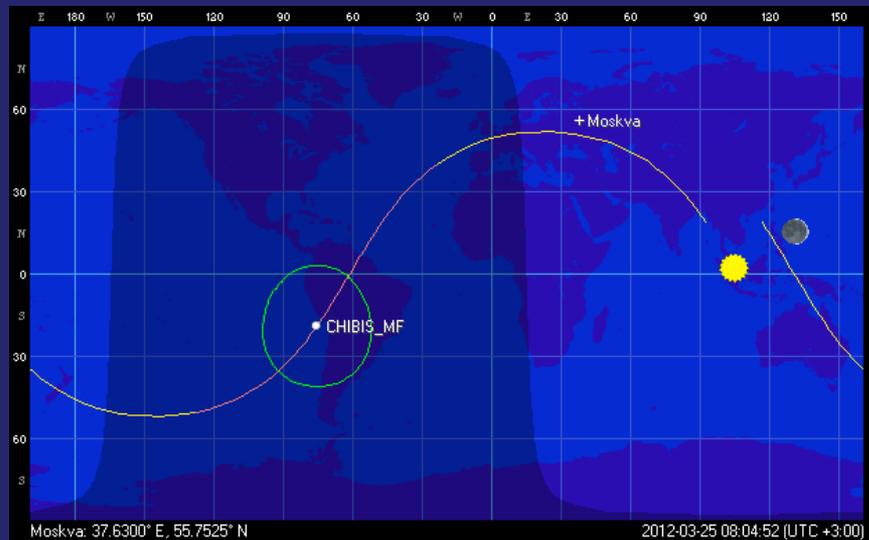
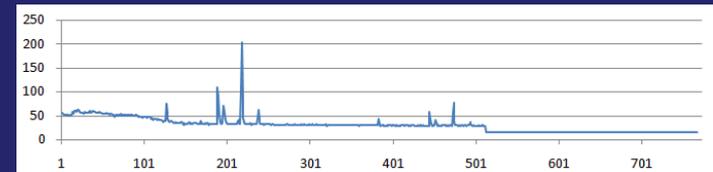
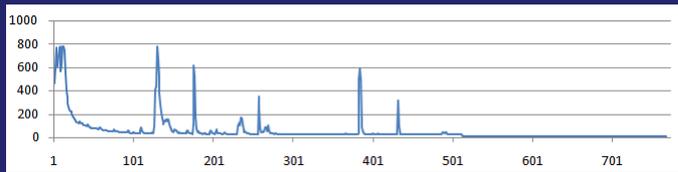
Distribution in number of flashes N_s in one series for various number of photons Q_a

Q_a/N_s	1	2	3	4	>4	Total number of flashes
$10^{20}-10^{22}$	202	59	48	18	49	372
$10^{22}-10^{23}$	118	146	128	85	222	699
$>10^{23}$	44	58	56	37	103	298

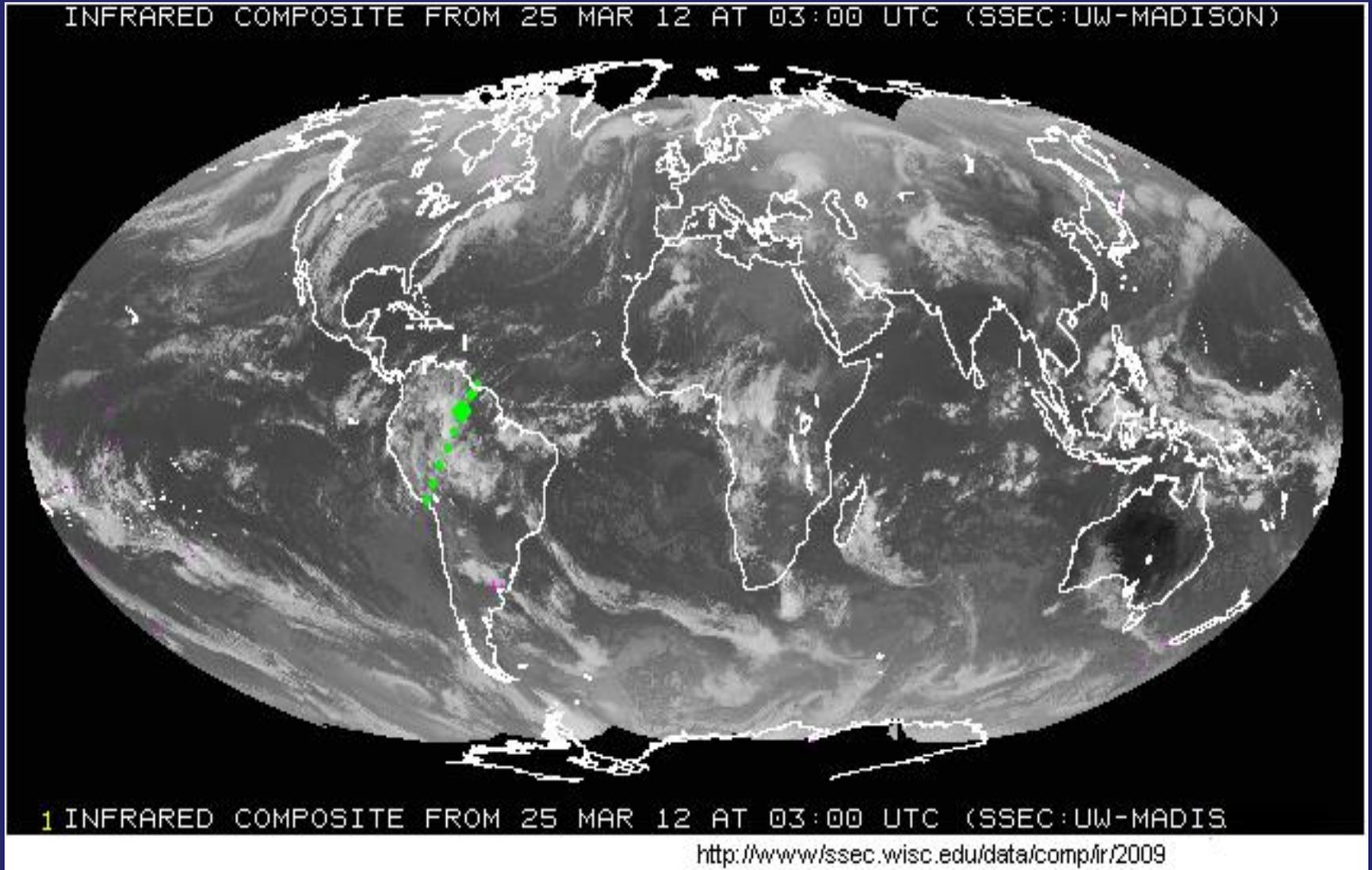
TLE altitudes distribution recorded by TATIANA-2 above South America



Example of temporal profile of TLE recoded above South America



One orbit TLE distribution recorded by CHIBIS-M micro satellite
above cloud map



Главная Вставка Разметка страницы Формулы Данные Рецензирование Вид Разработчик

Visual Basic Макросы Запись макроса Относительные ссылки Безопасность макросов Код

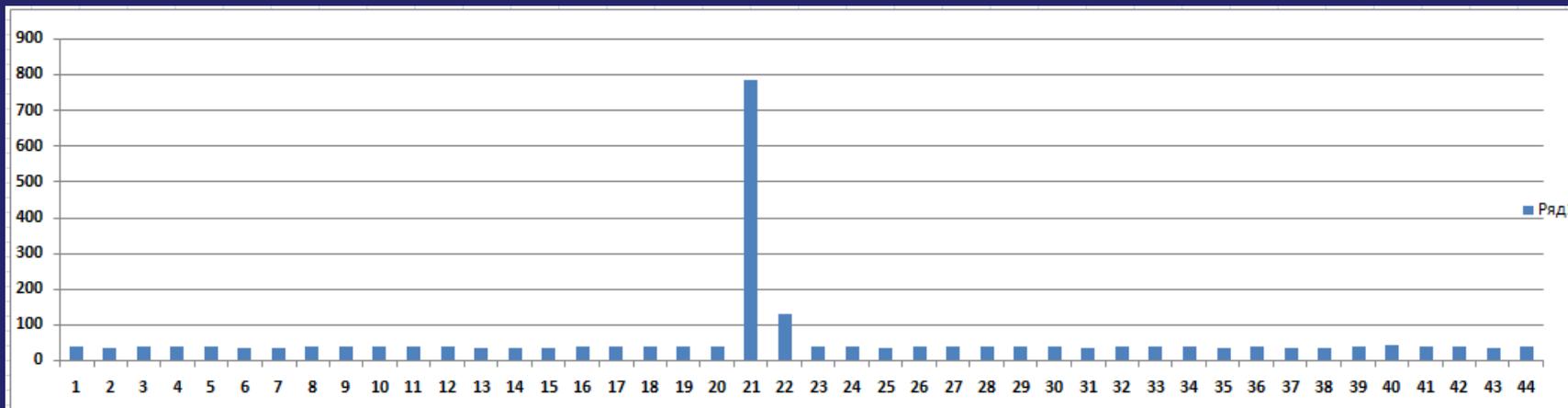
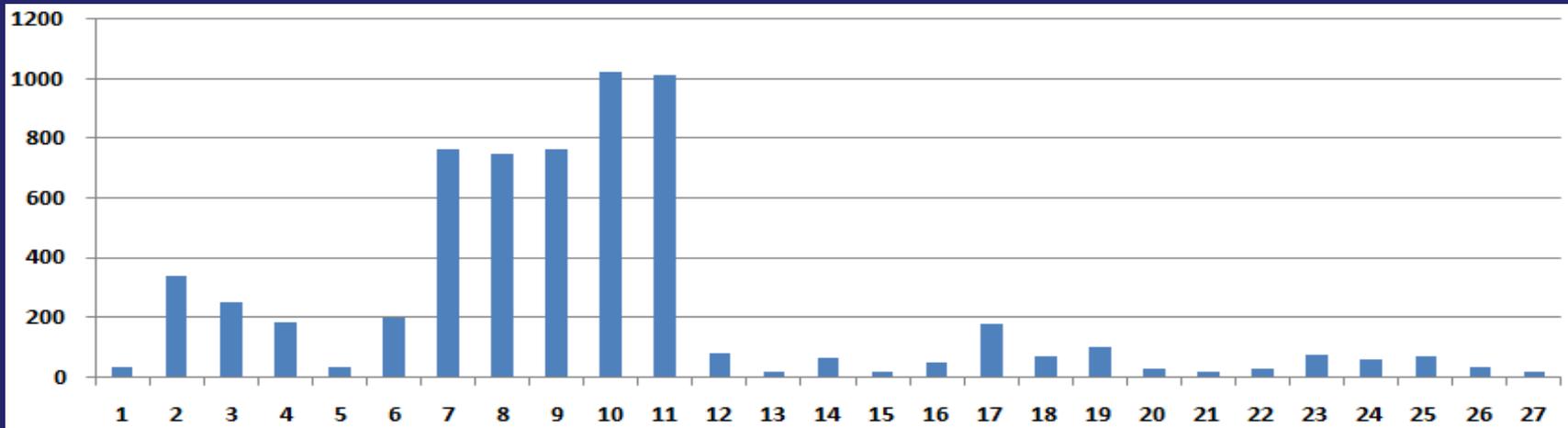
Вставить Режим конструктора Свойства Просмотр кода Отобразить окно Элементы управления

Источник Свойства карты Импорт Экспорт Пакеты расширения Обновить данные XML

Область документа Изменить

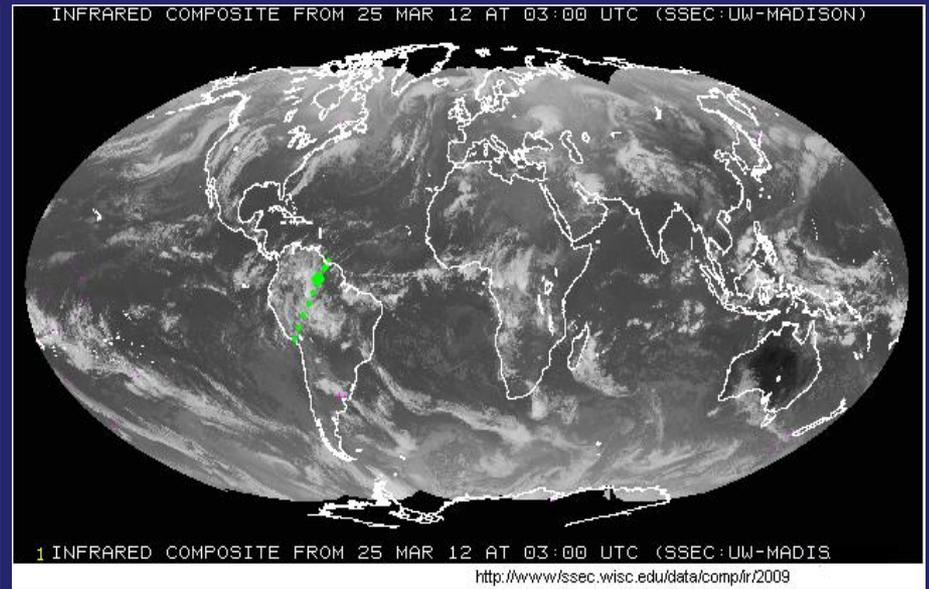
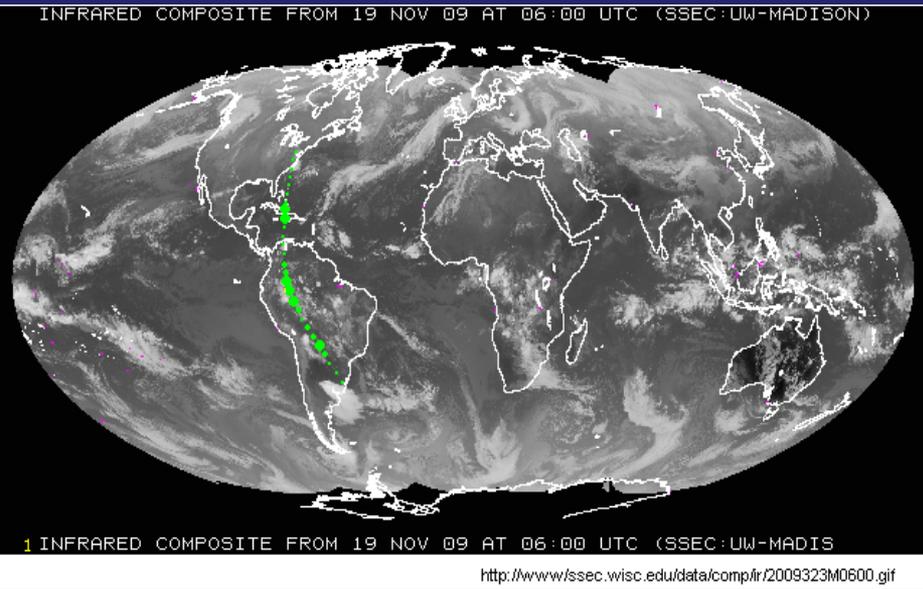
R1C1 6

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133	49	49	72	47	51	83	42	44	412	76	53	71	41	41	41	41	42	88	42	44	52	43	42	46	43	42	
134	37	36	36	37	39	39	37	38	443	57	40	66	38	39	37	39	39	39	37	38	39	37	38	40	35	37	
135	37	38	37	38	37	37	37	37	443	44	38	40	36	38	38	36	36	38	38	38	36	38	36	34	35	37	
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137	36	36	35	36	37	39	38	37	672	37	37	36	36	38	40	38	34	36	37	36	36	38	37	37	36	38	
138	36	37	36	36	37	36	38	38	521	39	37	37	36	37	37	37	35	35	36	39	37	38	35	36	36	39	
139	37	38	35	36	38	37	38	37	382	40	37	37	36	39	36	38	36	36	39	37	38	37	39	37	35	37	
140	36	35	34	36	40	36	36	37	289	40	36	36	36	37	38	37	35	36	37	36	37	37	39	37	38	36	
141	36	37	36	38	38	37	37	37	217	38	38	36	36	36	37	37	37	34	37	38	36	36	37	37	35	38	
142	38	38	35	36	37	36	37	36	170	36	36	35	36	39	36	39	35	36	35	36	36	38	37	38	35	40	
143	36	36	34	37	38	35	37	37	133	36	37	37	35	37	37	40	36	36	37	36	37	38	36	39	35	39	
144	37	36	35	37	37	36	39	36	120	38	36	36	34	39	37	36	34	36	37	38	38	36	38	37	34	37	
145	37	37	35	37	38	36	38	37	149	36	36	37	37	37	37	39	35	36	37	36	37	36	36	35	38	35	34
146	38	36	35	38	37	35	39	37	141	36	36	36	36	38	37	38	35	35	36	37	39	37	37	36	34	37	



One orbit TLE distribution recorded by TATIANA-2 micro satellite

One orbit TLE distribution recorded by CHIBIS-M micro satellite



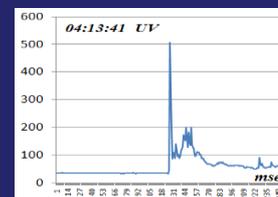
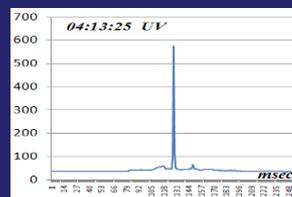
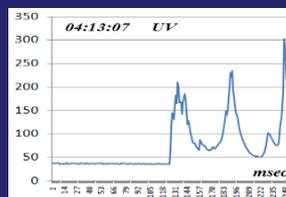
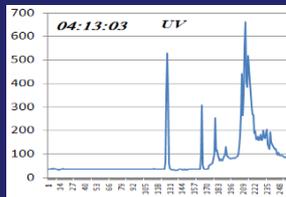
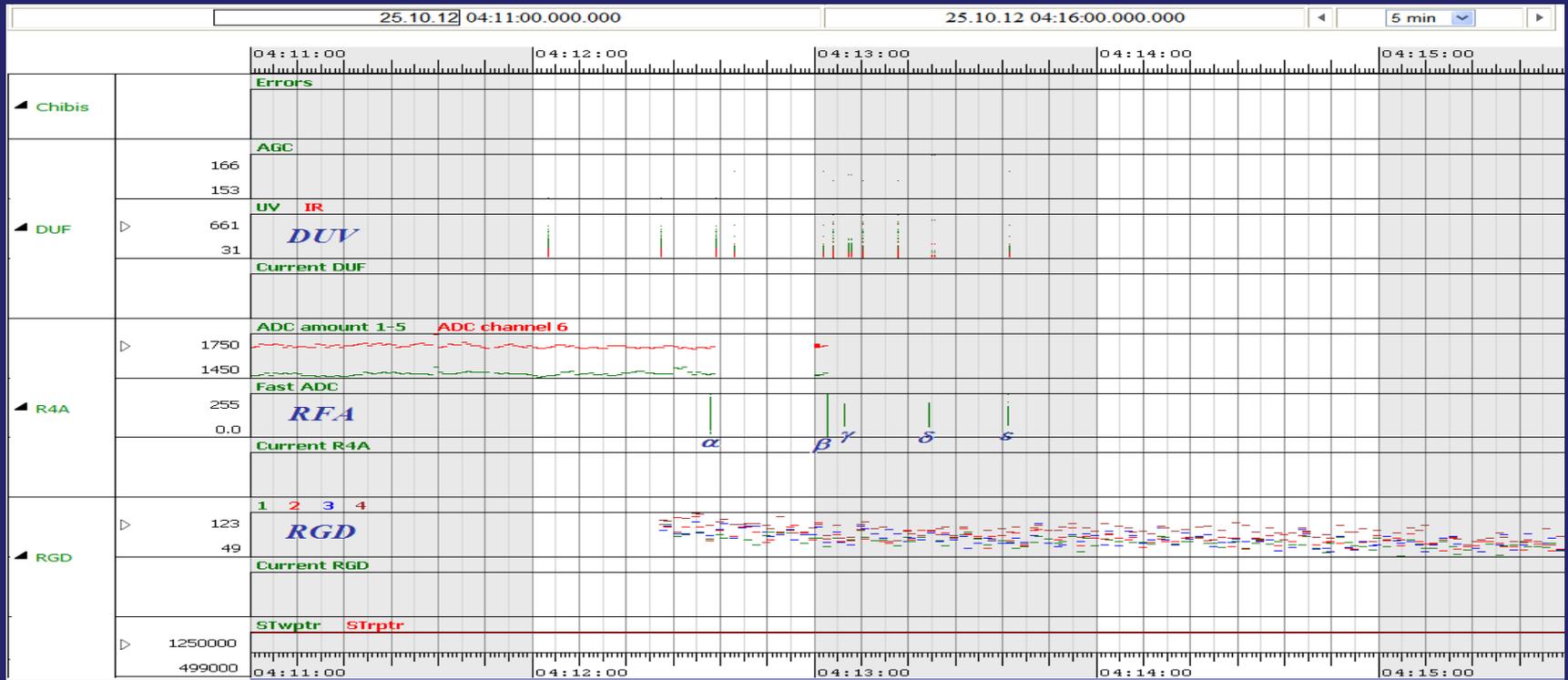
14 TLE registered with energy exceeded 0,1MJ from 25 recorded events

1 TLE registered with energy exceeded 0,1MJ from 25 recorded events

What is the reason of such distinguish difference ?

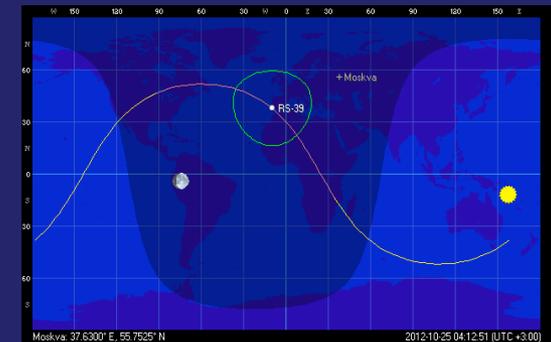
1. season?
2. local time?
3. direction of magnetic field relative to satellite ground track?

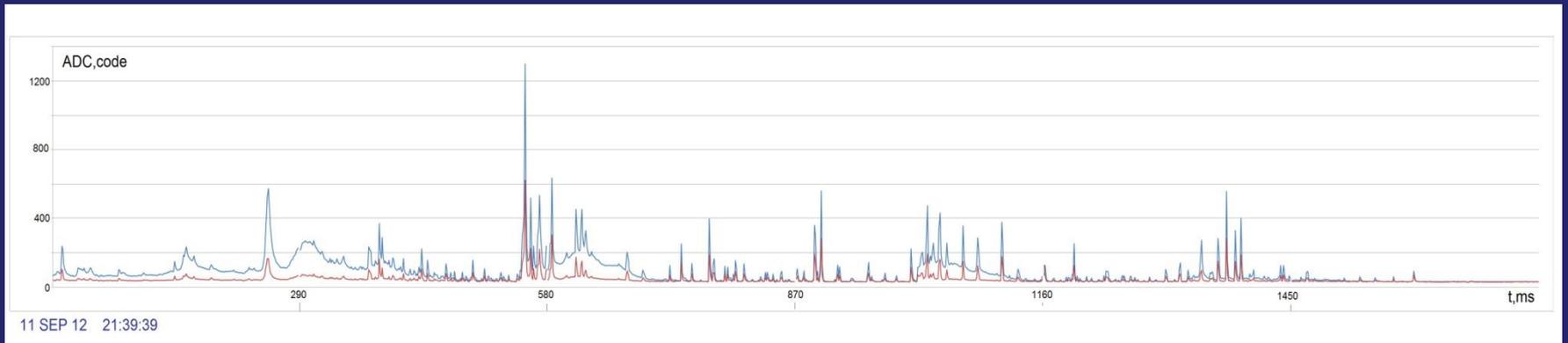
Example of joint operating DUV, RFA and RGD during 4 minutes. RFA signals $\beta, \gamma, \delta, \epsilon$ are coincide with UV&IR signals.



Temporal profile of the UV signals for events $\beta, \gamma, \delta, \epsilon$

Satellite track and flashes position for events $\beta, \gamma, \delta, \epsilon$





CHIBIS_M3

Lon	20.8718° E
Lat	6.2853° S
Alt (km)	498.822
Azm	198.7°
Elv	-28.2°
RA	19h 18m 50s
Decl	-59° 23' 39"
Range (km)	6 965.435
RRt (km/s)	4.143
Vel (km/s)	7.511
Direction	Descending
Eclipse	Umbral
MA (phase)	177.6° (128)
TA	177.6°
Orbit #	3 518
Mag (lum)	Not visible
Constellation	Pav

Sun Pav

Satellites Data

Load TLE Show next

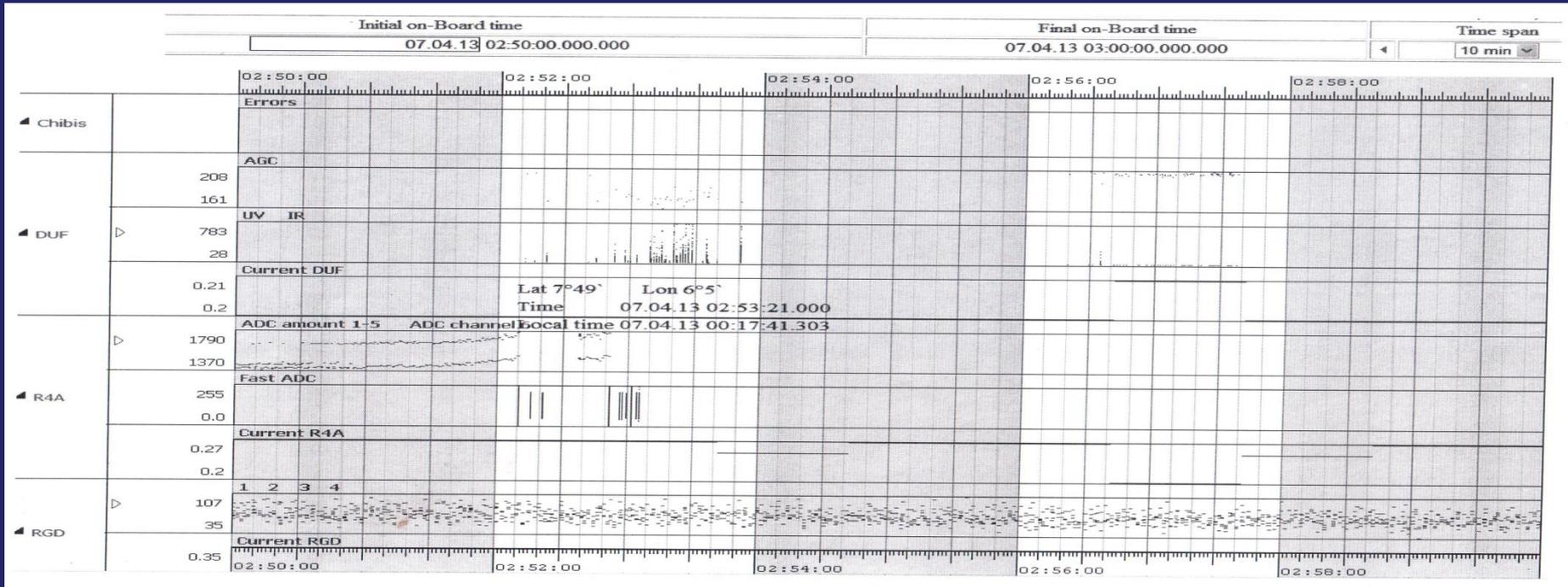
SIM AUTO-OFF LOC

21:38:40
2012-09-11

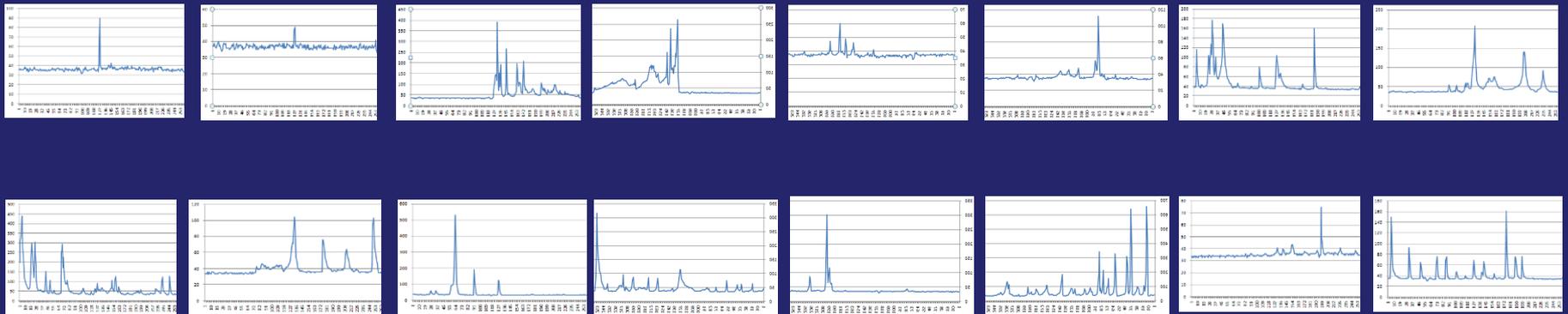
Mode: Real time Simulation
 Time: Local UTC
 2012-09 21:38:40
 1 seconds
 <<< < > >>>

Main Visualisation Location Sat/Orbit info Prediction setup Prediction Rotor/Radio About

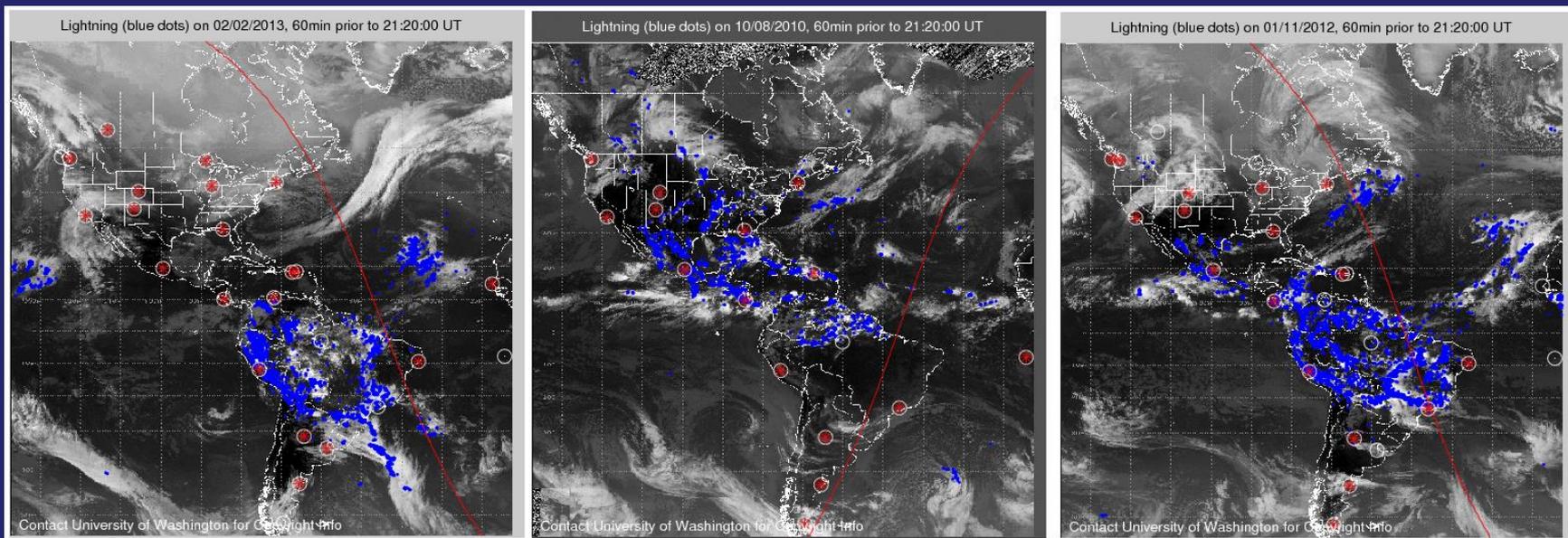
Example of local series of flashes recoded by CHIBIS-M above Africa.



Temporal profile of first 16 flashes



Typically only about 15 to 30% of strokes detected. These strokes are usually the stronger ones. Recent research indicates our detection efficiency for strokes about 30 kA is approximately 30% globally.



In these examples to be found less than 10 events out of clouds locations. Exposition time is 60 min, considering area is about $S=10^8 \text{ km}^2$

lightning detecting probability out of cloud region is less than $10^{-8} \text{ min}^{-1} \times \text{km}^2$

UV detector field of view $s=10^5 \text{ km}^2$

Probability to detect one lightning out of cloud region by UV detector less than 10^{-3} per min

