

# EISCAT space debris during the IPY

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- The IPY debris campaign
- Measurement issues
- The ASAT event
- Examples of data

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3 - 7 Aug 2009, Tromsø.*

# EISCAT's IPY measurement at Svalbard

March 2007 - March 2008 - March 2009

Latitude 78.15 N  
Longitude 16.0 E  
Altitude 440 m

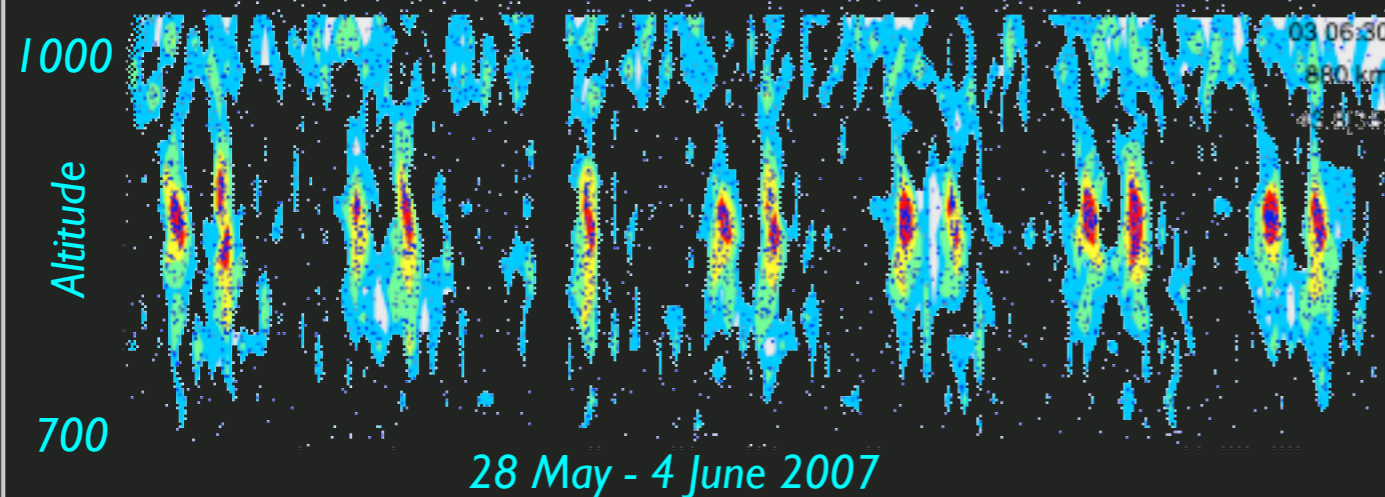
32m steerable  
dish

Space debris  
receiver

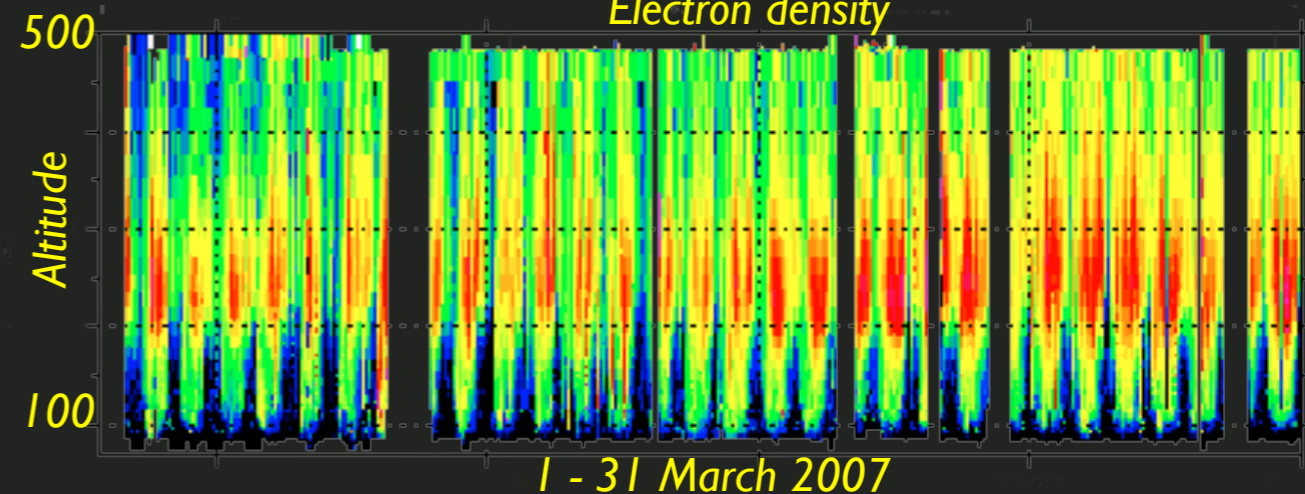
Standard  
receivers

42m fixed,  
elevation 82  
azimuth 181  
dish

Debris "density"



Electron density



# EISCAT space debris during the IPY

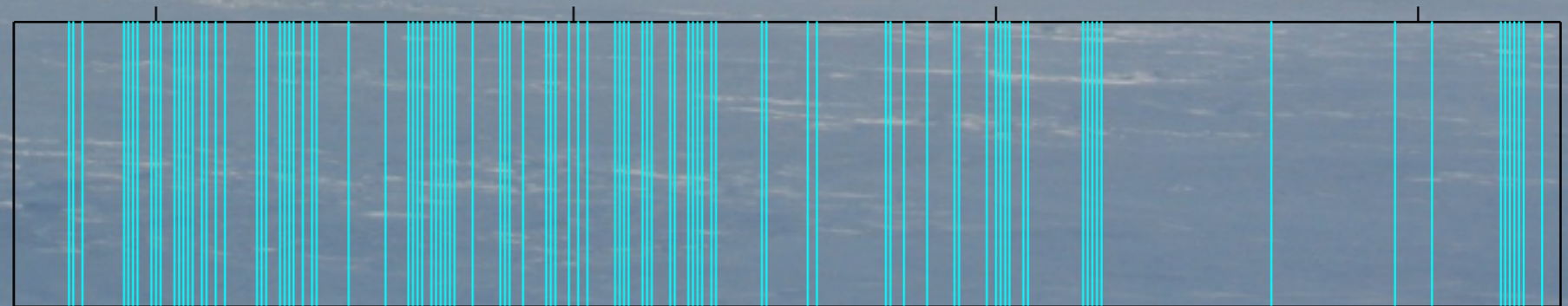
13 Mar 2007 - 10 Feb 2008

5060 h

239 000 unique events

203 000 “strong and long” events

**101** good days with  
**95 000** strong events



Apr

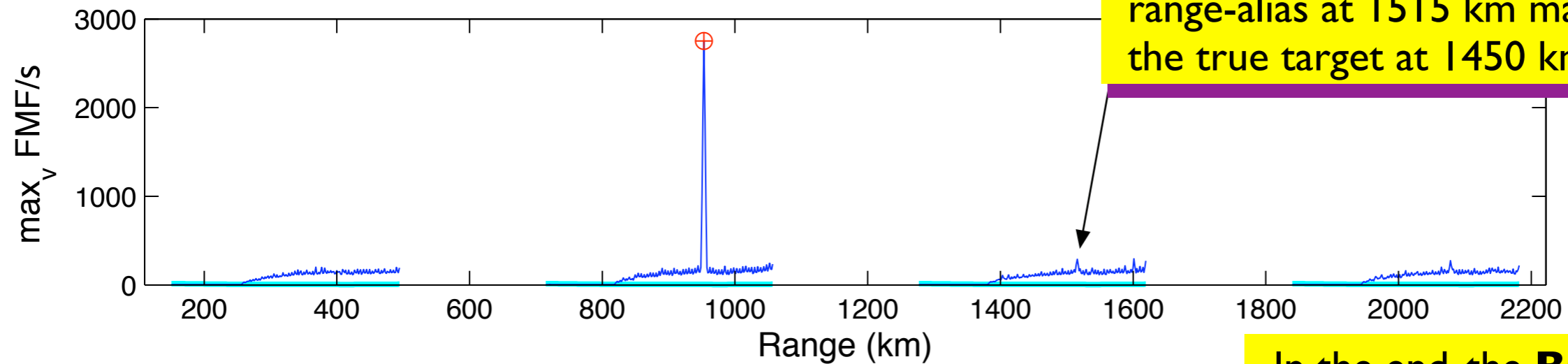
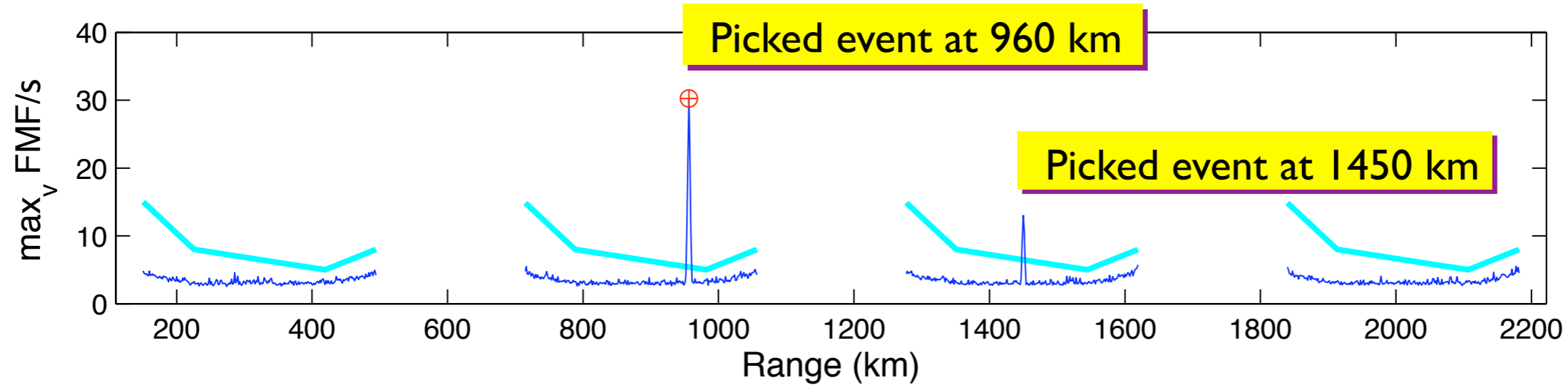
Jul

Oct

Jan

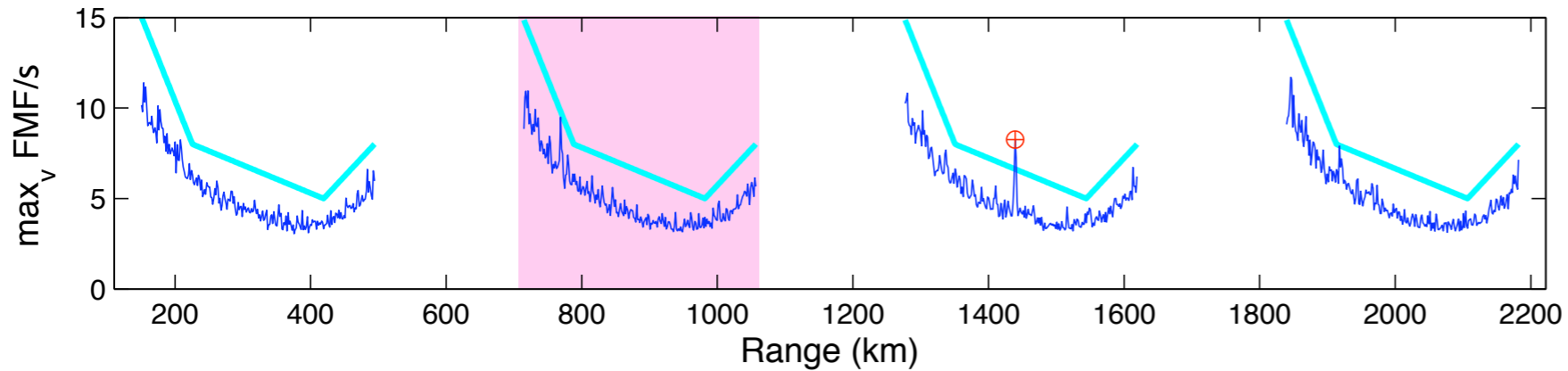
1-Mar-2007 -- 1-Mar-2008

## Range-aliases, gap-effects, and multiple targets



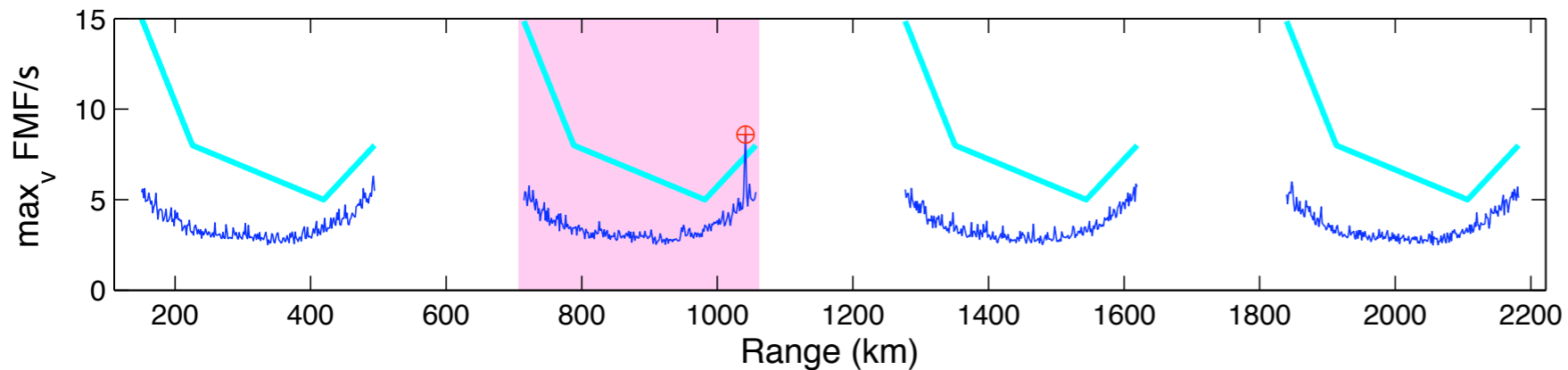
In the end, the **BOGUS** target got to the published results, while the **TRUE** target was lost.

**Highly variable, and often strong, ionospheric clutter**



Summer

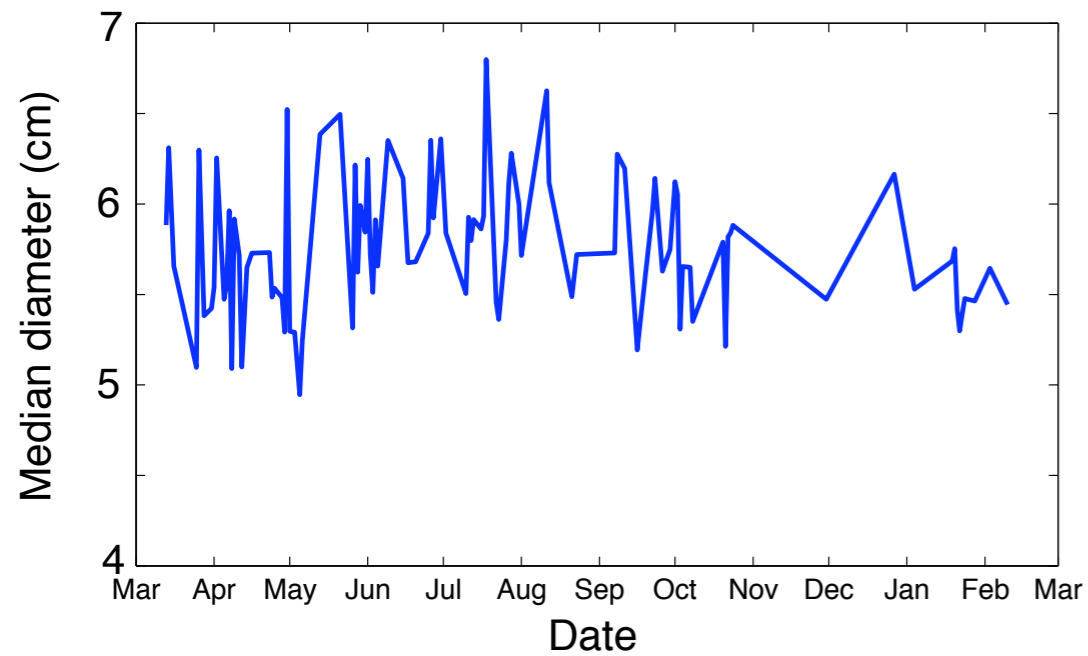
2007-Jun-26 13 LT



Winter

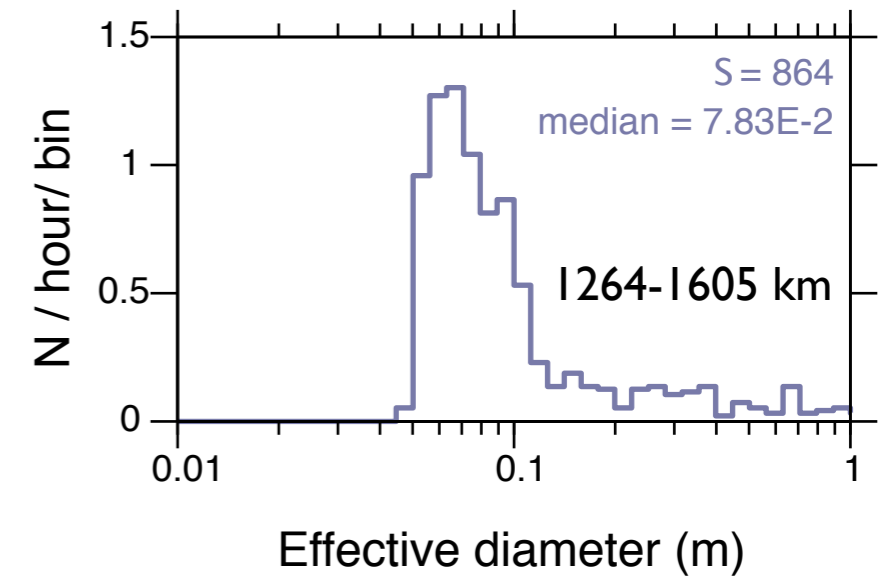
2007-Dec-27 13 LT

Range-dependent detection threshold was set according to worst-case conditions and was kept fixed for the whole campaign.

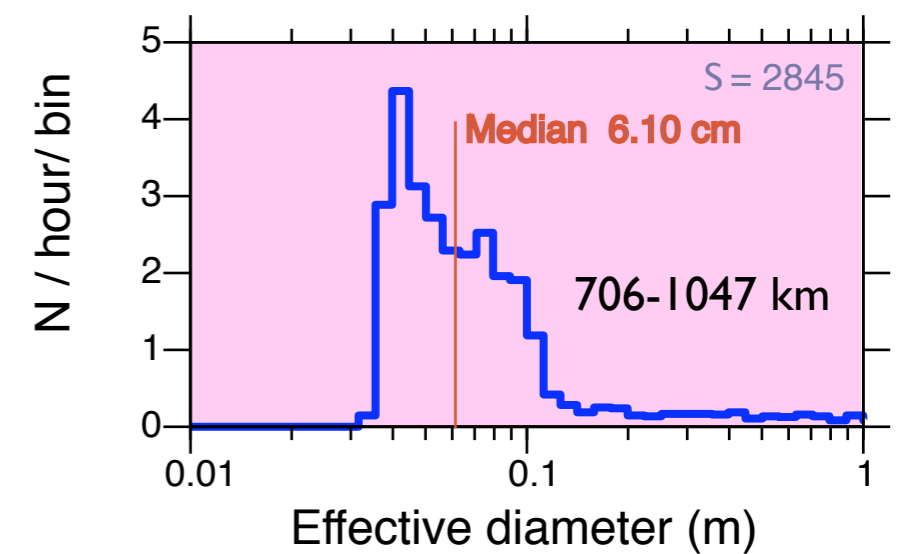


Zone 3

## Event rate v eff. diameter



Zone 2

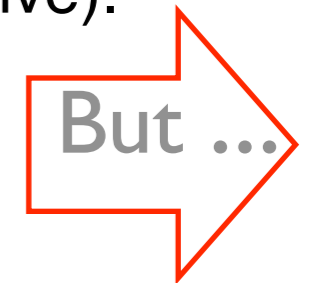


For week 23-29 Jul 2007

The daily and weekly summary plots generated during the campaign are on the page

<http://www.sgo.fi/~jussi/spade/ipy/index.html>

Also the daily numerical results for the 101 “quality days” are now **freely available** via the above page as ASCII text files (6 MB zip archive).



## The data come with a health warning



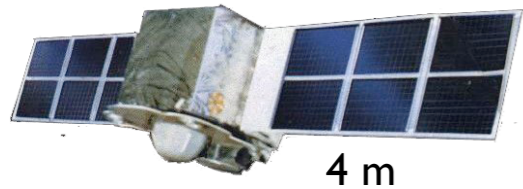
1. A largish data set was produced, analysed, and published to web automatically.
2. Strong post-detection (post-analysis) selection was done to get the final result set.
3. **Bogus targets remain, and strong targets may be missing. Even strong targets can have quite wrong parameters.**



# The ASAT fragmentation event

11-Jan-2007 22 UT

Feng Yun 1C (860 km altitude, 98.6° inclination, Sun-synchronous orbit)



4 m

880 kg

600 kg

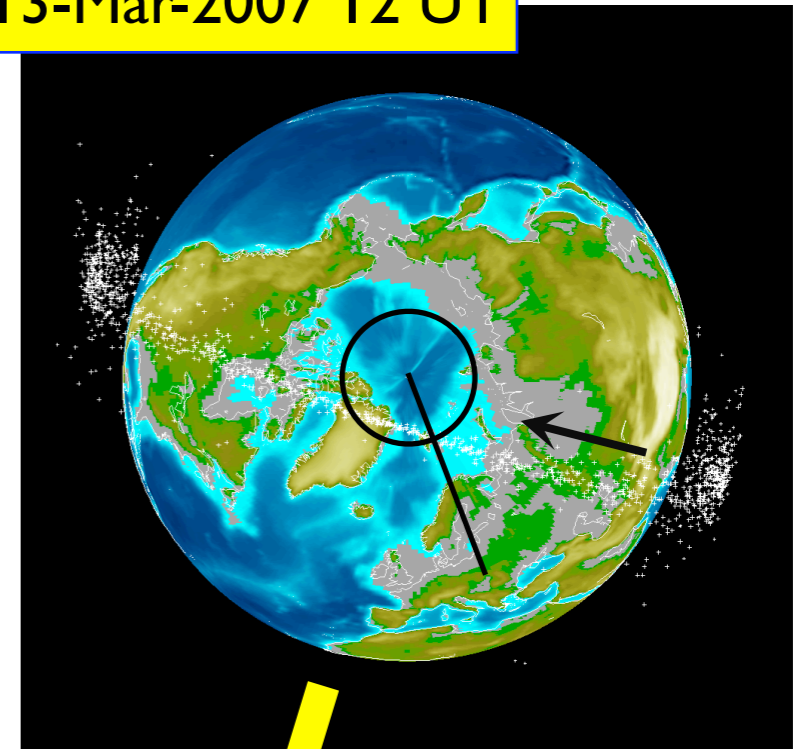
350 J/g

2700 >10 cm  
150 000 >1 cm

DongFeng-21

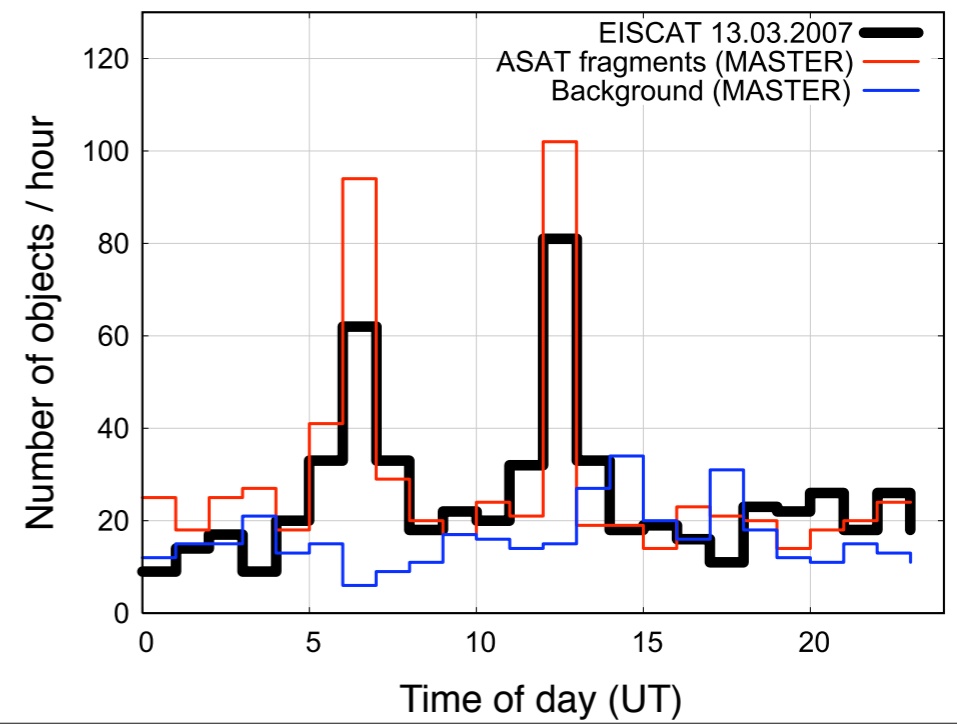


13-Mar-2007 12 UT



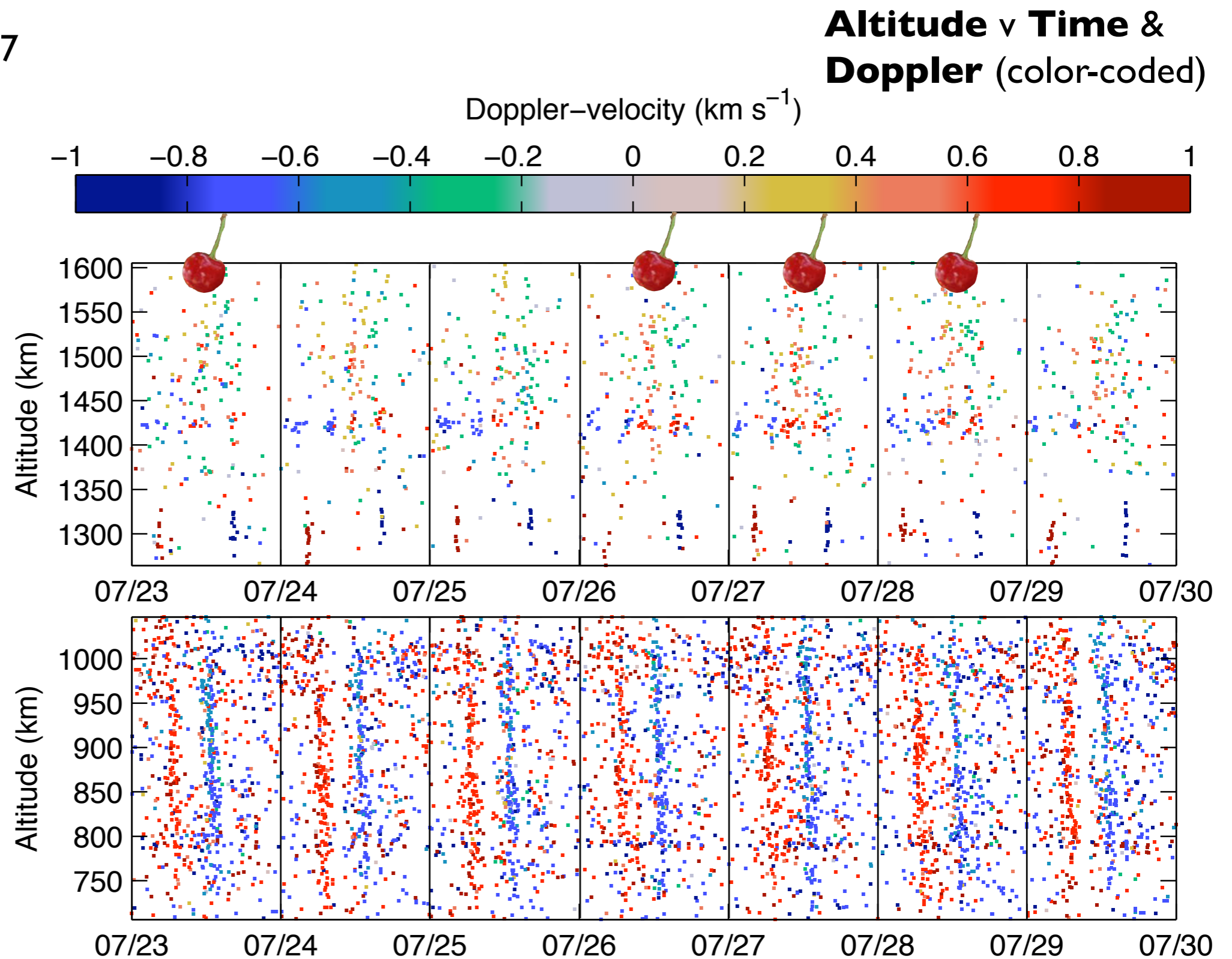
Sun

Krag et al, 2007



## ASAT in the weekly IPY plots

23-29 Jul 2007

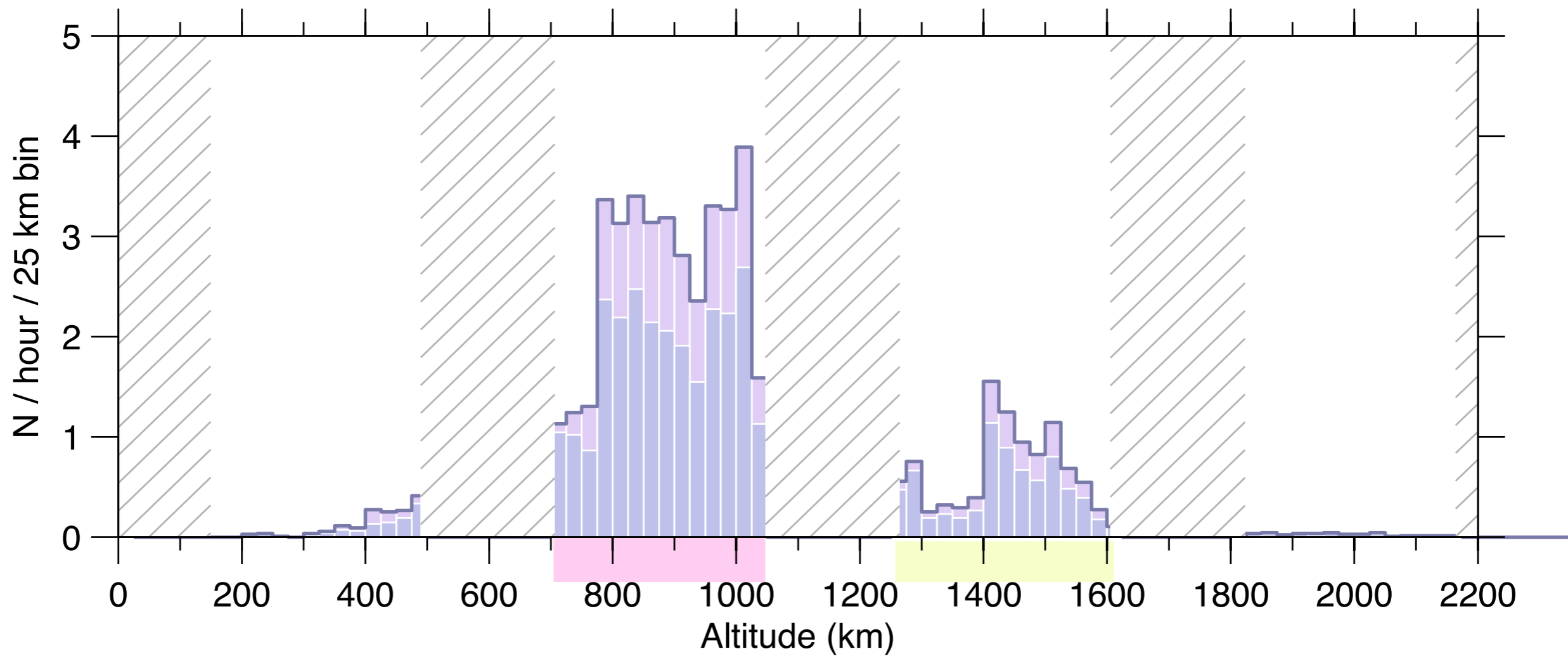


# Day-to-day variation ?

19-24 Jan 2008



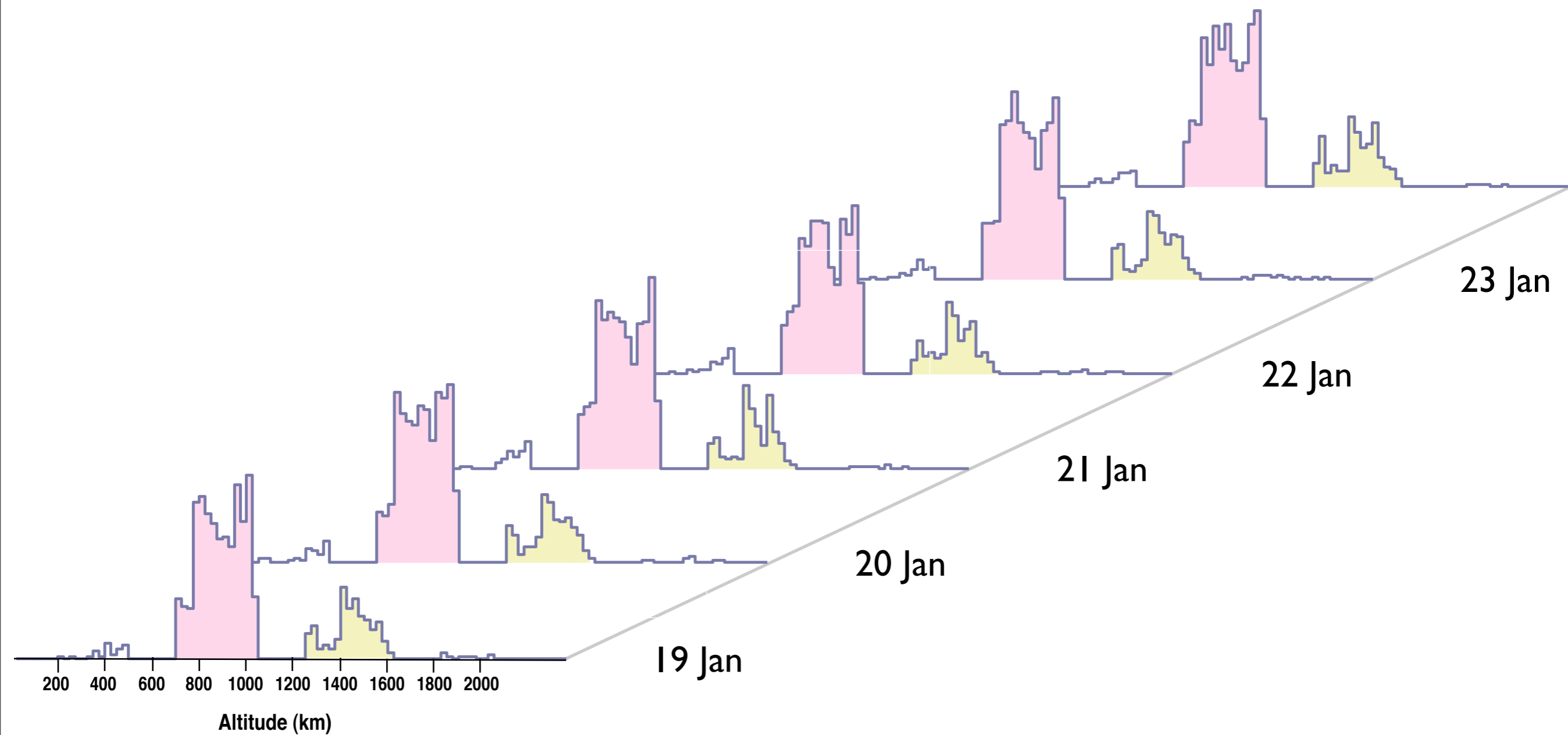
## Mean daily event rate v altitude



## Day-to-day variation ?

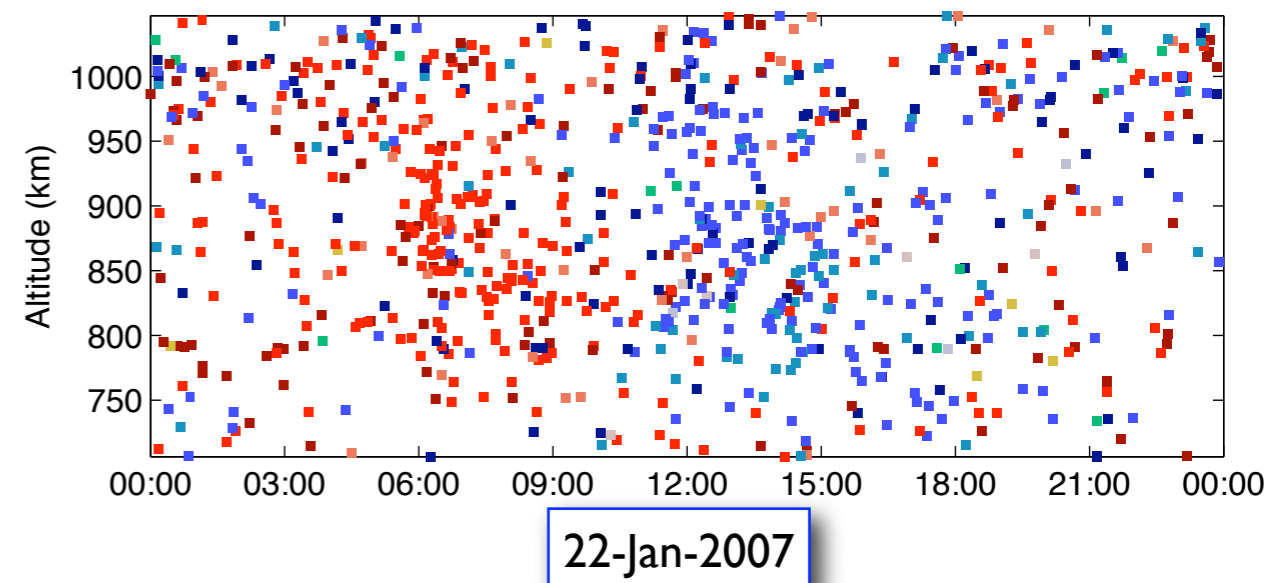
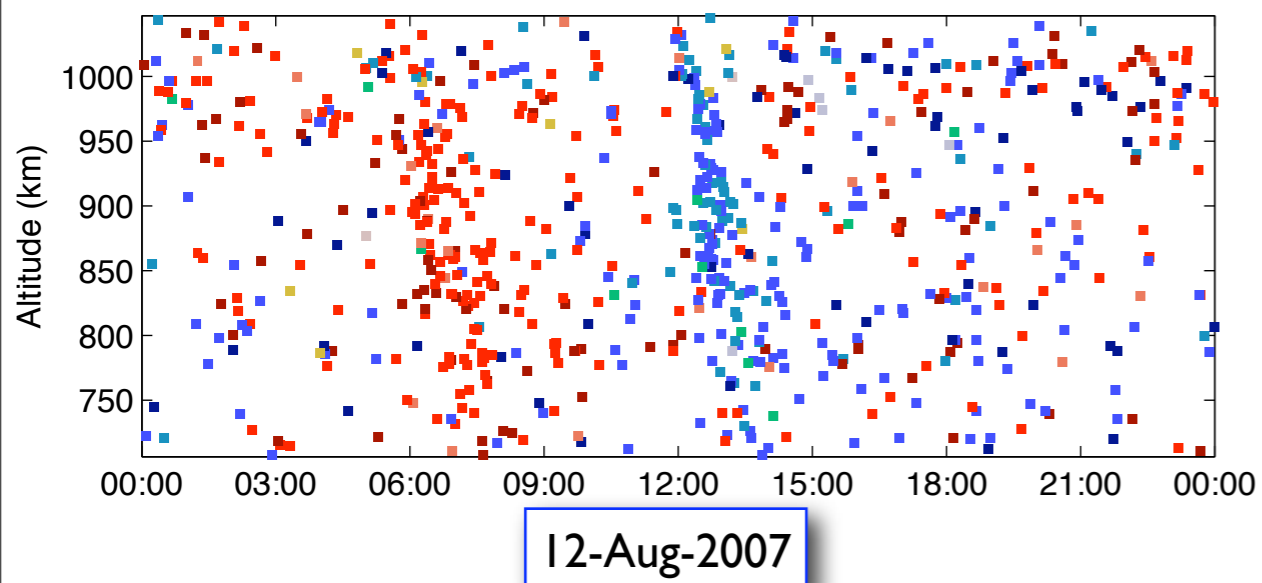
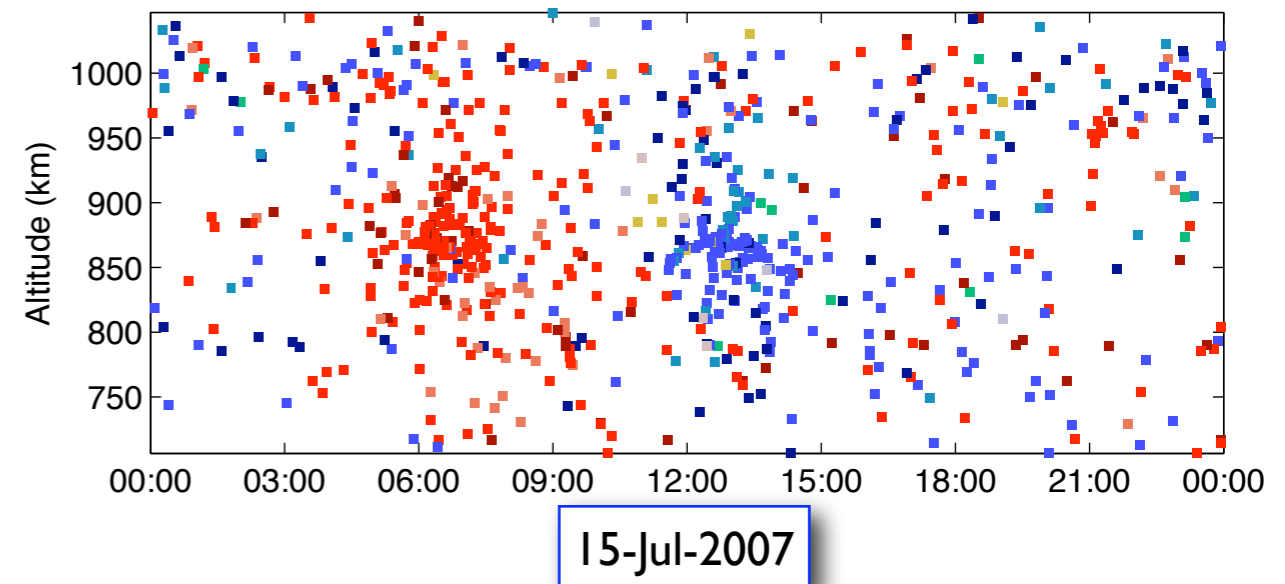
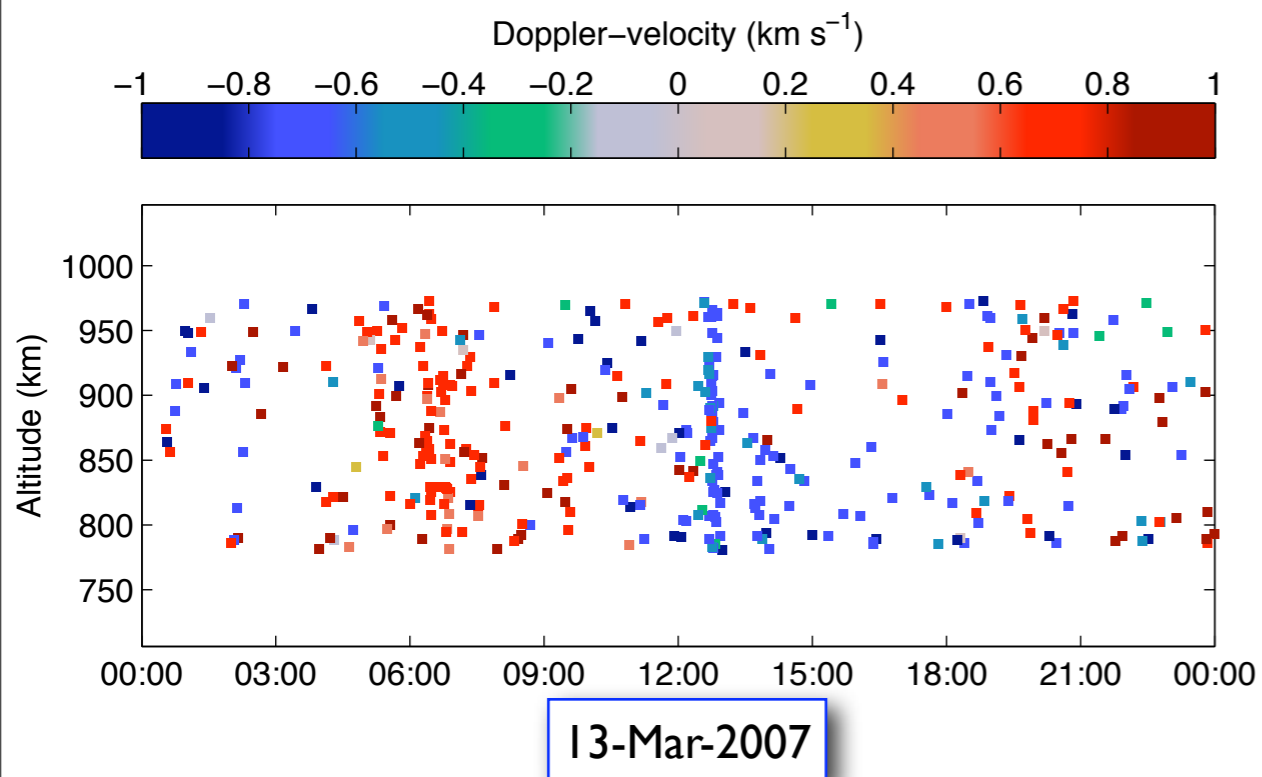
19-24 Jan 2008

Daily event rate v altitude



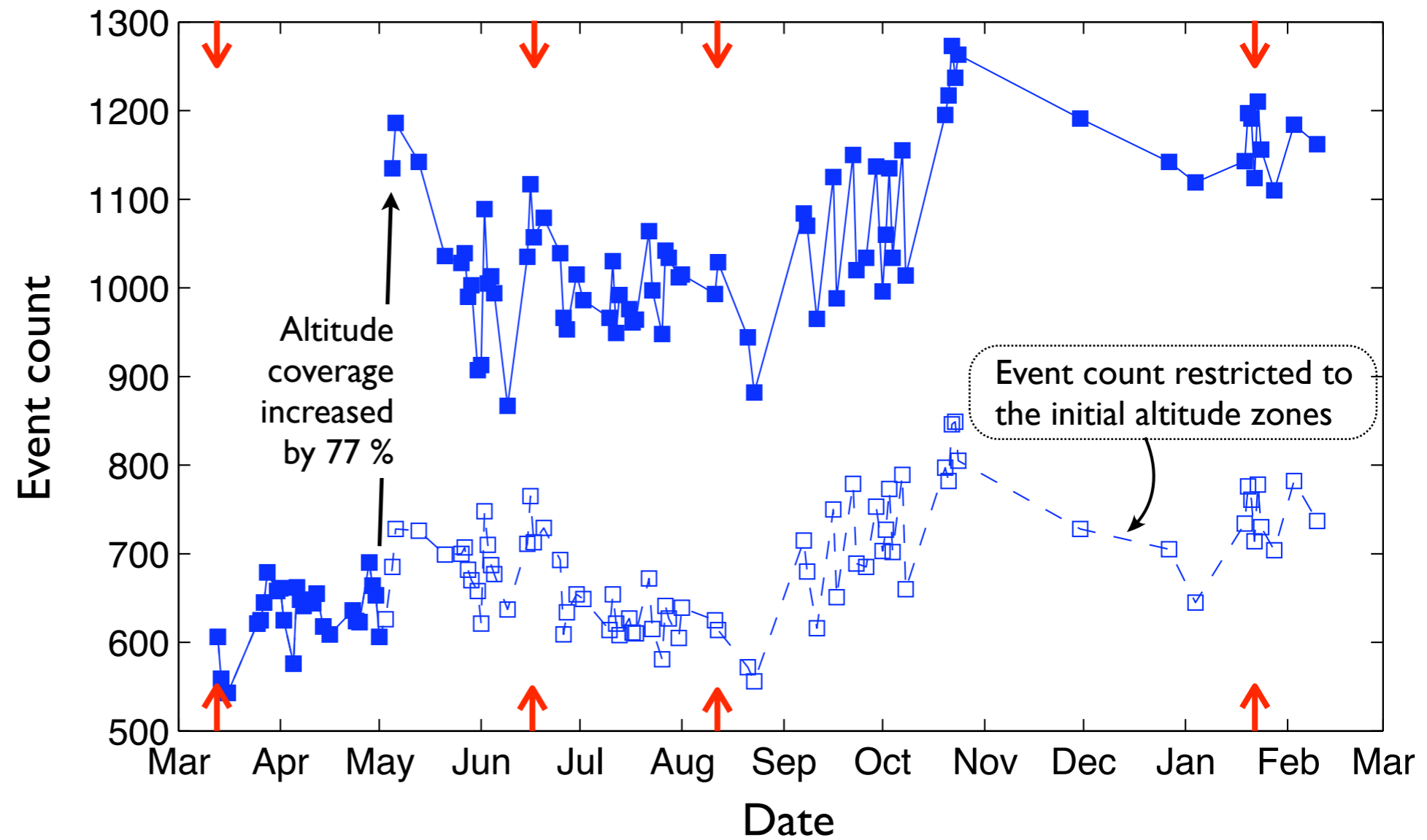
## Longer-term variation ?

## Altitude v Time



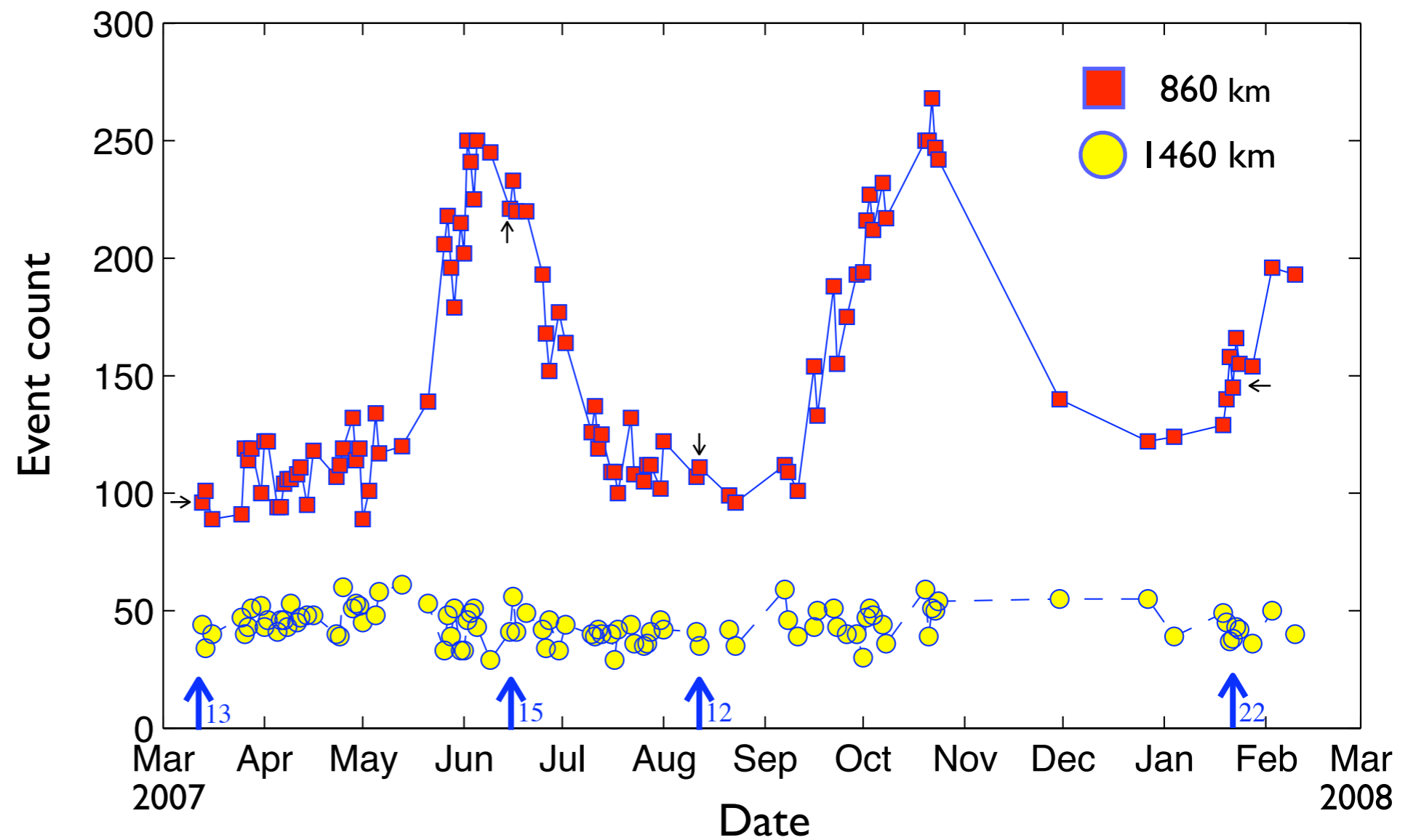
## Longer-term variation ?

13 Mar 2007-10 Feb 2008

**Daily event count**

## Longer-term variation

13 Mar 2007-10 Feb 2008

**Daily event count**  
in two 50 km wide altitude zones

## Data v ESA Debris Model (1/2)

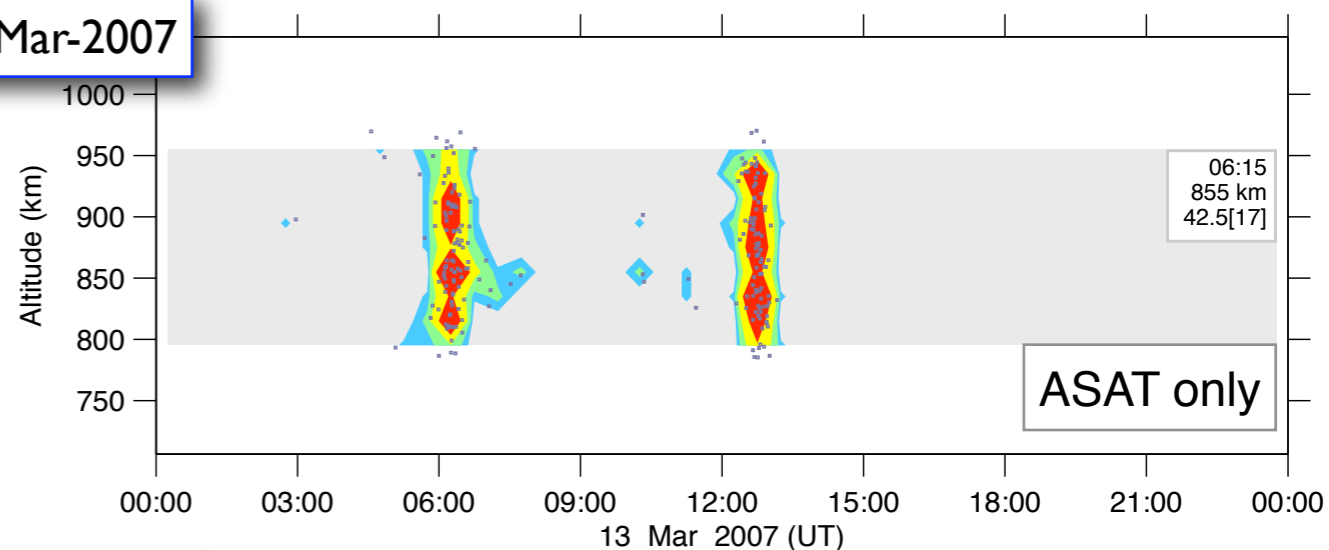
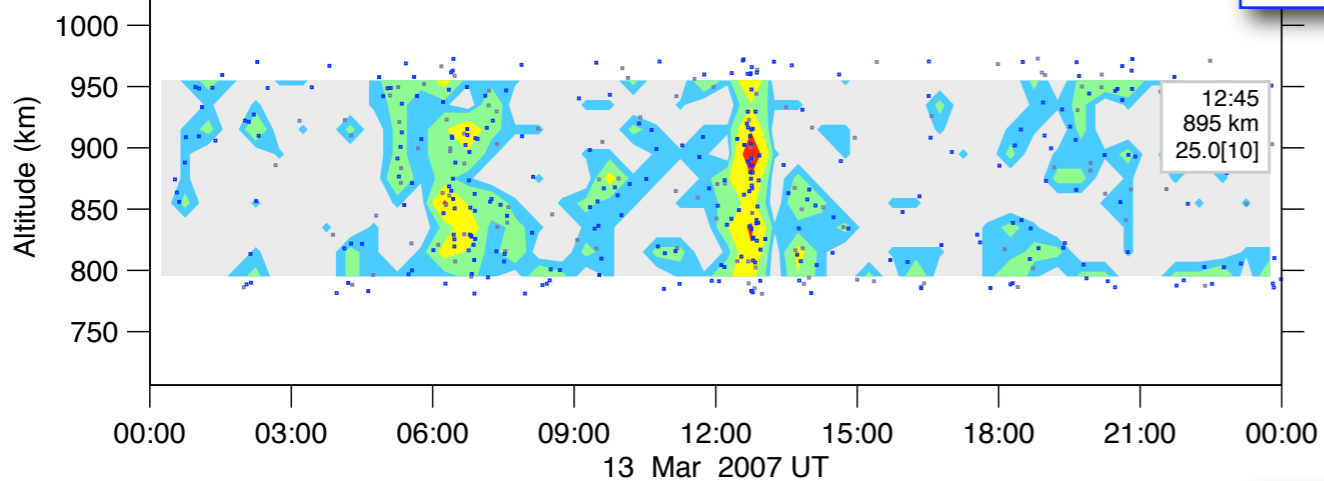
## Altitude v Time

Observed event rate (1/h/25 km)

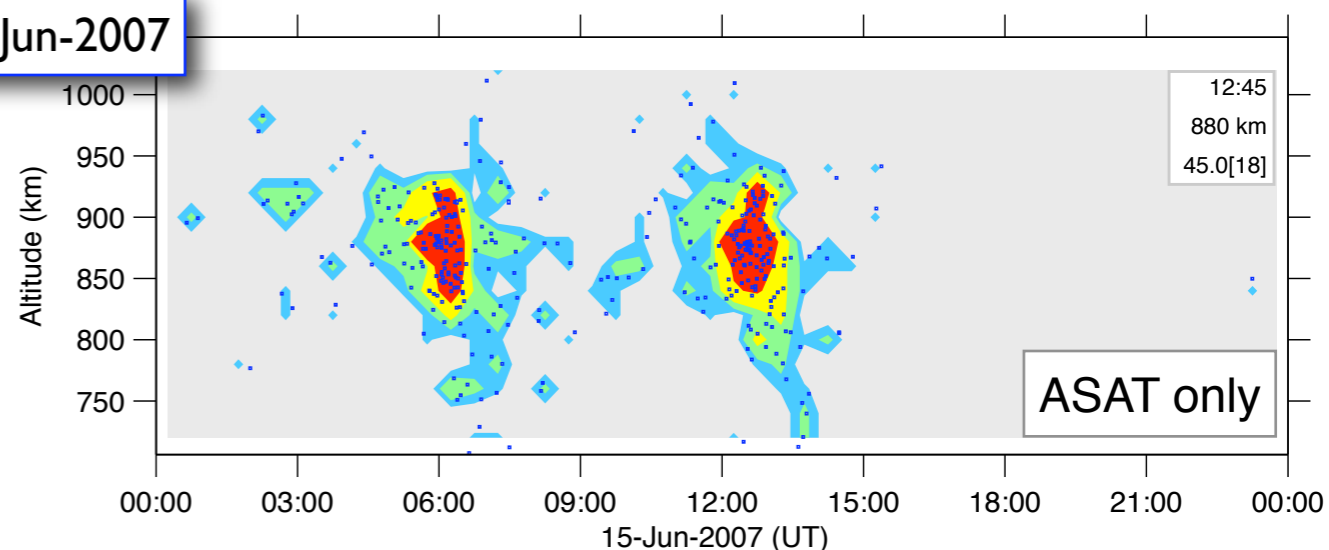
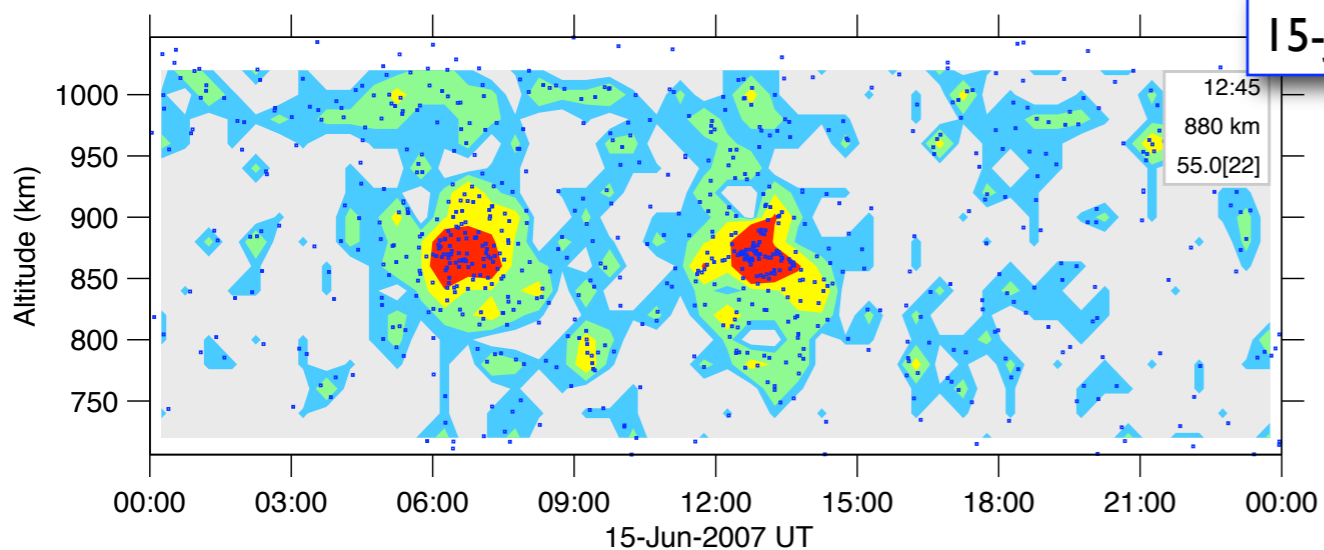
Simulated event rate (1/h/25 km)



13-Mar-2007



15-Jun-2007





## Data v ESA Debris Model (2/2)

## Altitude v Time

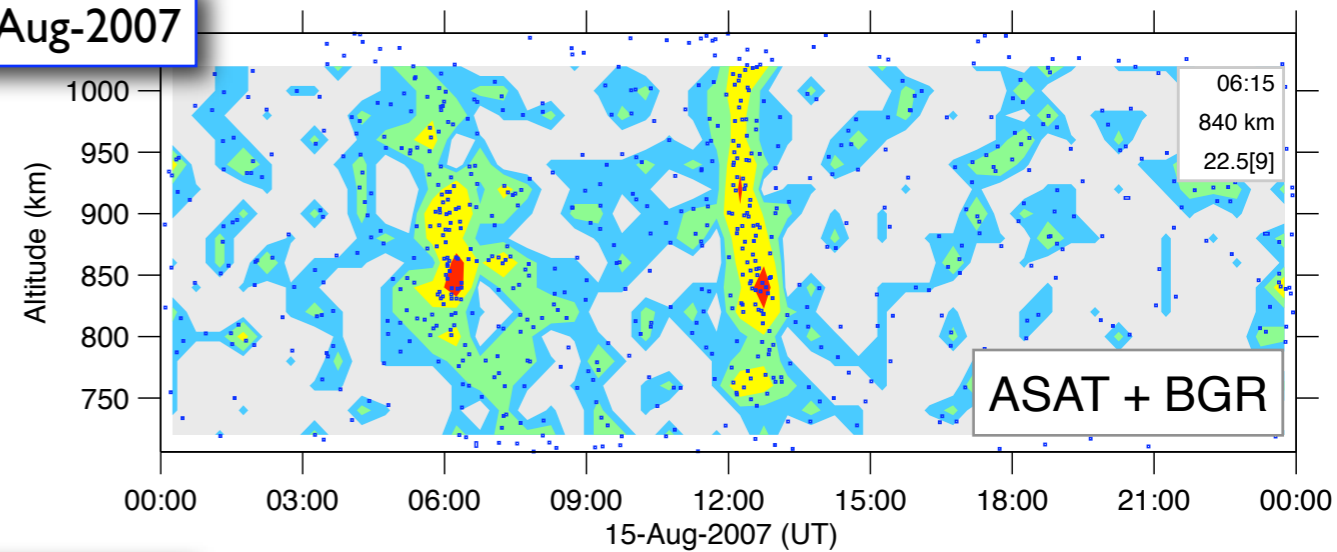
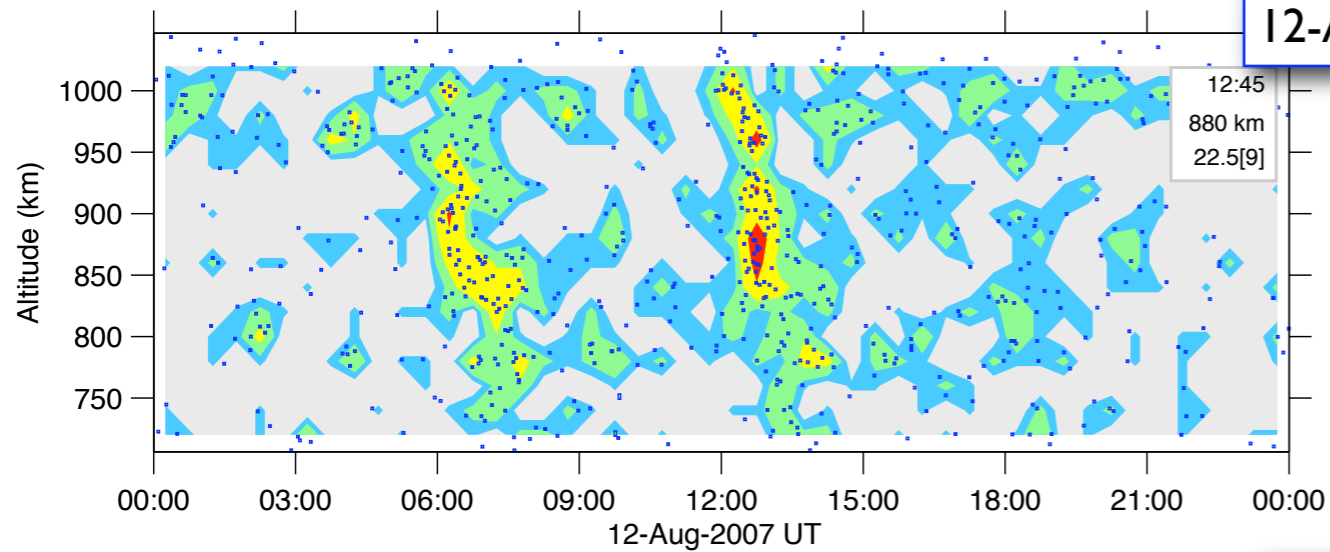
N / hour / 25 km bin



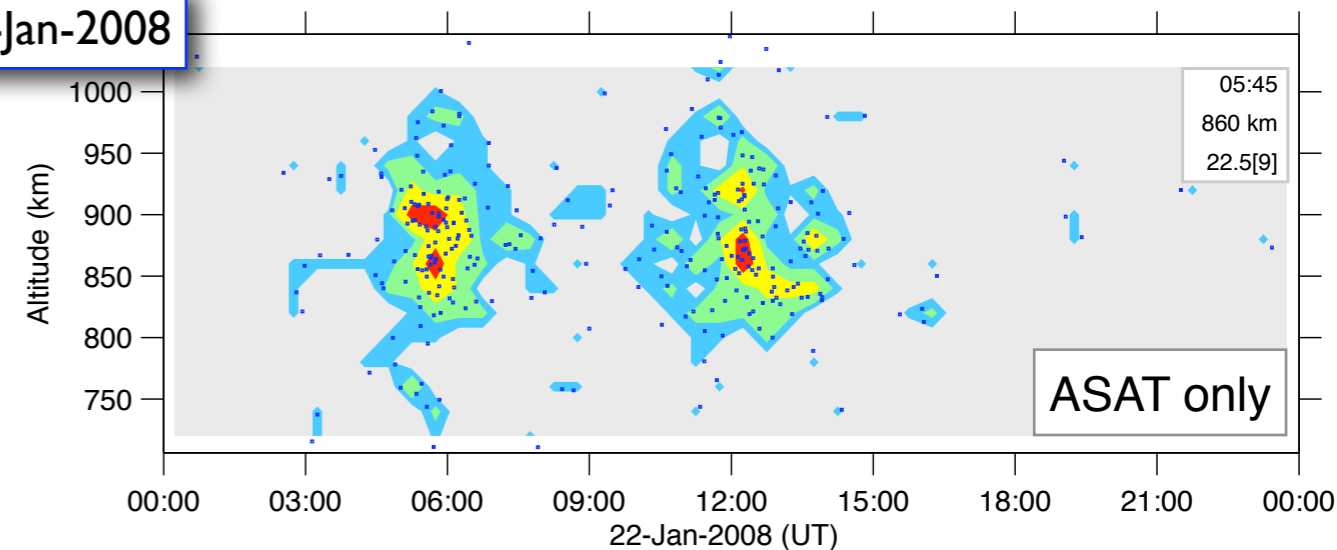
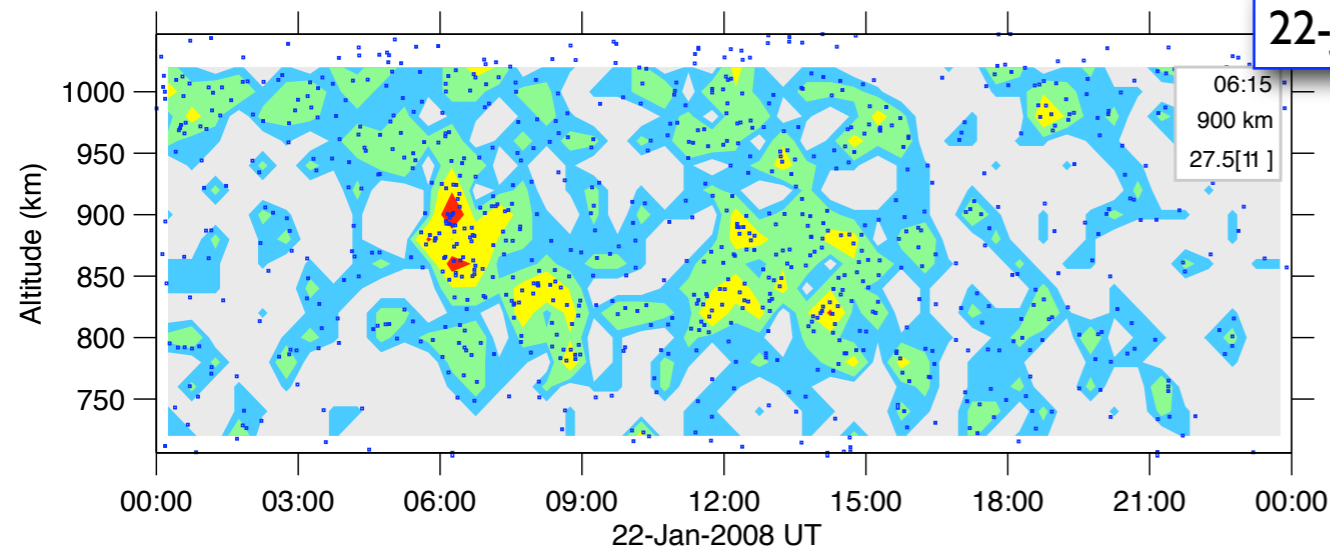
Observed

Simulated

12-Aug-2007



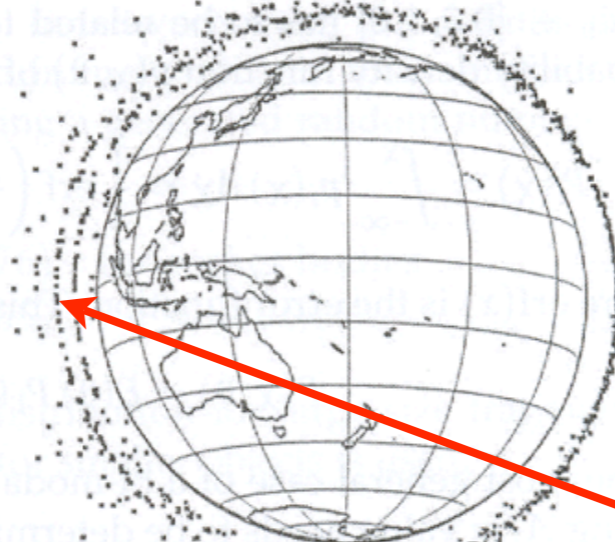
22-Jan-2008



# What is happening ?



after 1 orbit



after 20 orbits

Model of fragmentation at 800 km altitude, inclination  $98.7^\circ$

From H.Klinkrad,  
Space debris, Models and Risk Analysis,  
Springer, 2006, p. 72.

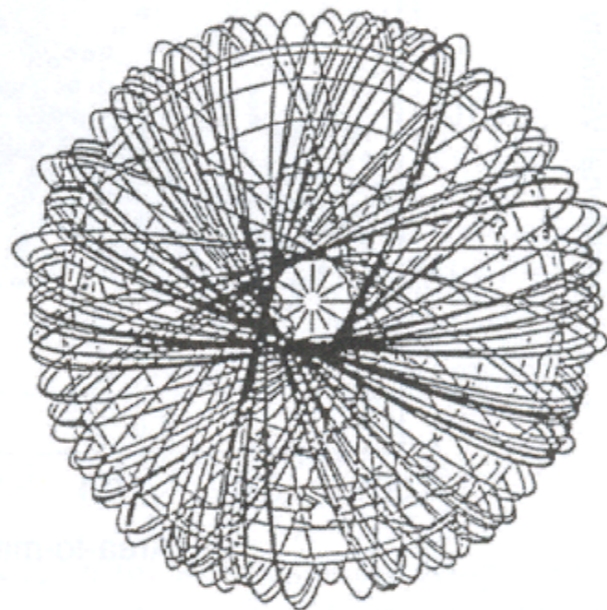
(FY 863 km,  $98.65^\circ$ )

Cloud is concentrated at the Pinch Point & the Pinch Line.

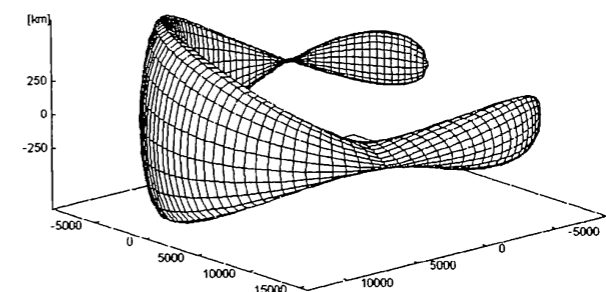
These precess along orbital plane at a speed of about  $30^\circ$  per month due to the oblateness perturbation of Earth's gravity field.



after 3 months



after 4 years



- ☹️ Gaps in altitude coverage
- ☹️ Selection bias against small targets
- ☹️ Inaccurate parameter estimates; but can't reanalyze
  - 😊 ~101 × 24 h “ESA beam-park”
  - 😊 Includes a major debris event
  - 😊 Results are in public domain