EPSC 2012

Simulation of meteoroid impacts on Phobos and global crater distributions

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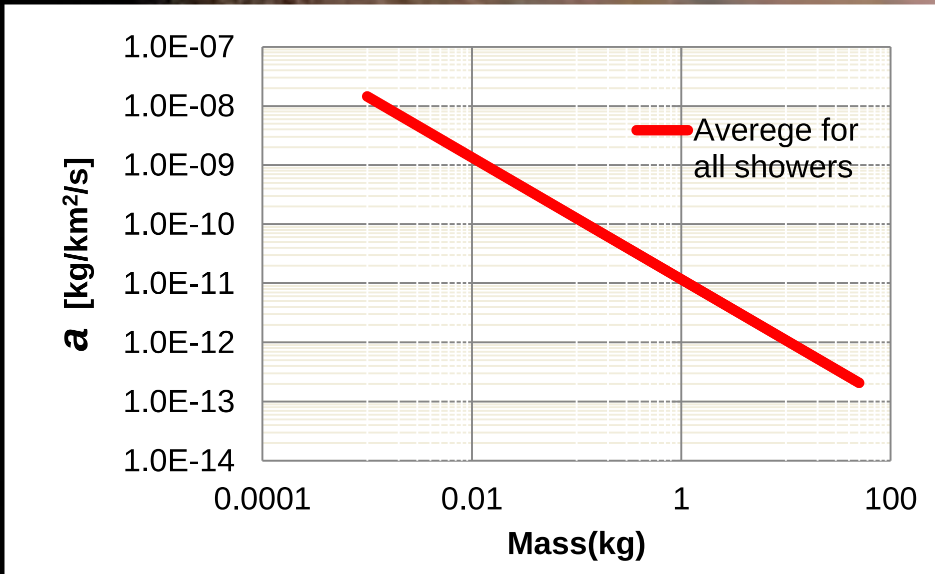
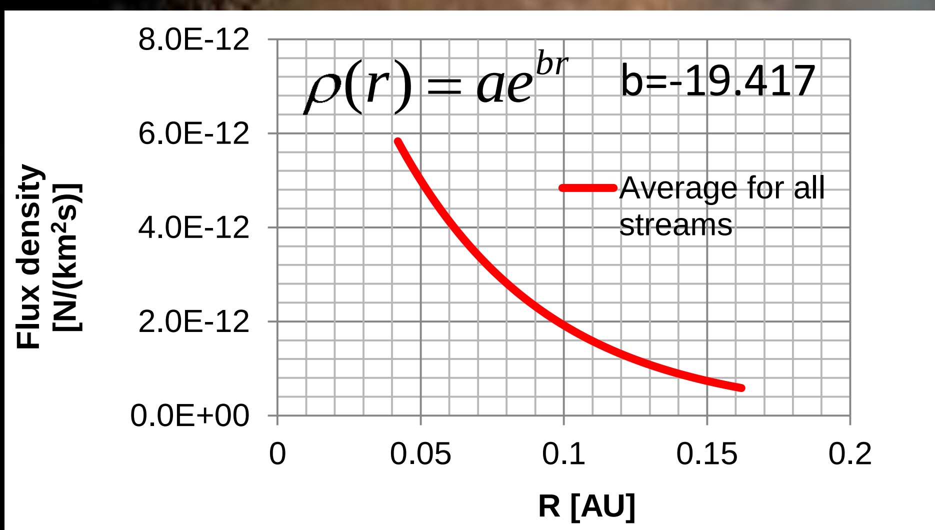
Earlier results



- A database [1] of 1037 periodical comets was analyzed, and 137 potential parent bodies of Martian meteor streams were identified.
- Time of their activity was obtained.
- A model of spatial distribution of meteoroid material was constructed.



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Estimation of probable number of impact events

1. Zone of meteoroid stream activity was limited by distance 0.15 AU.
2. The average integral flux density along the orbit of Mars:

$$\rho_{cp} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \rho(r(t))dt \quad \left[\frac{K_{particle}}{km^2 \cdot s} \right]$$

$r(t) -$ distance from the stream axis depends on the time;

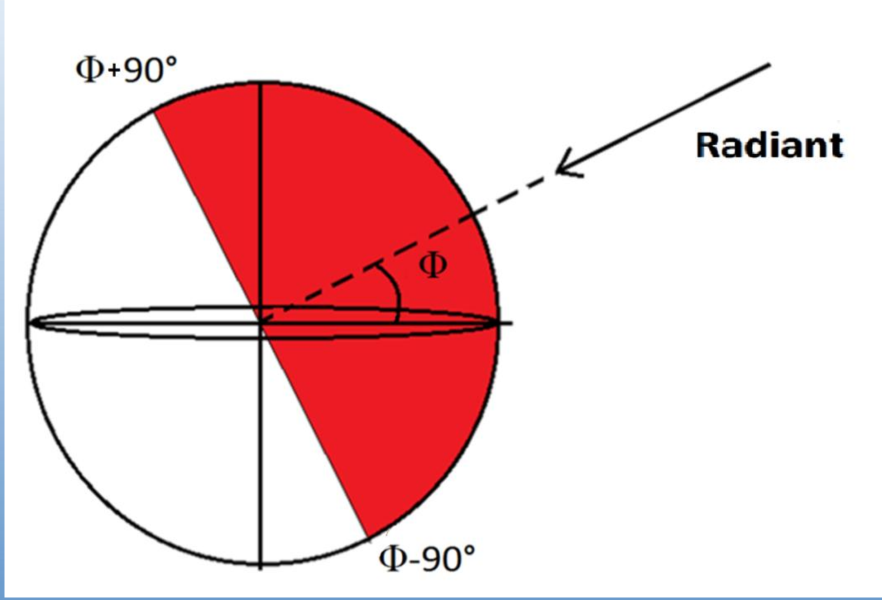
$\rho(r(t)) -$ flux density is presented as a function of distance from the stream axis. Implicitly depends on time.

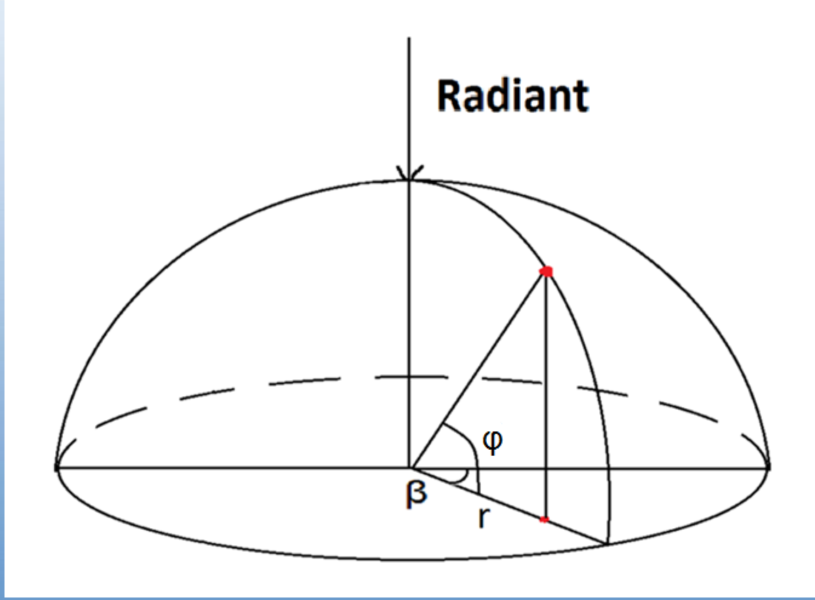
3. Probable number impacts of meteoroids on Phobos:

$$K = \rho_{cp} \cdot S \cdot (t_2 - t_1)$$

S - Phobos limb area, which corresponds to circle with R = 11 km.

The calculation of the coordinates of meteoroids impacts using a random number generator





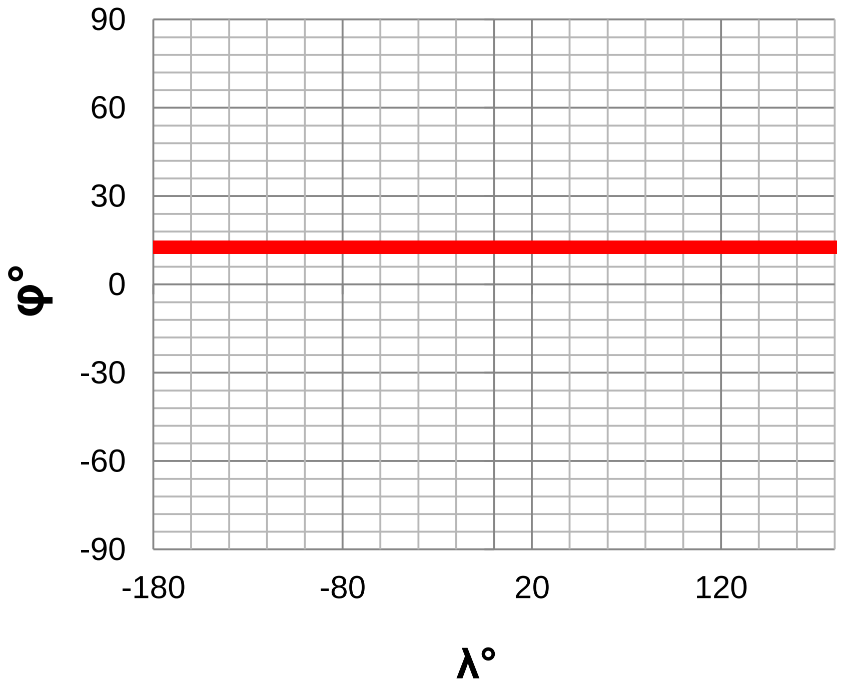
Coverage area of each meteor stream:

Latitude: (Φ-90° < φ < Φ +90°), where Φ is radiant latitude - the angle between the radiant and Phobos equator.

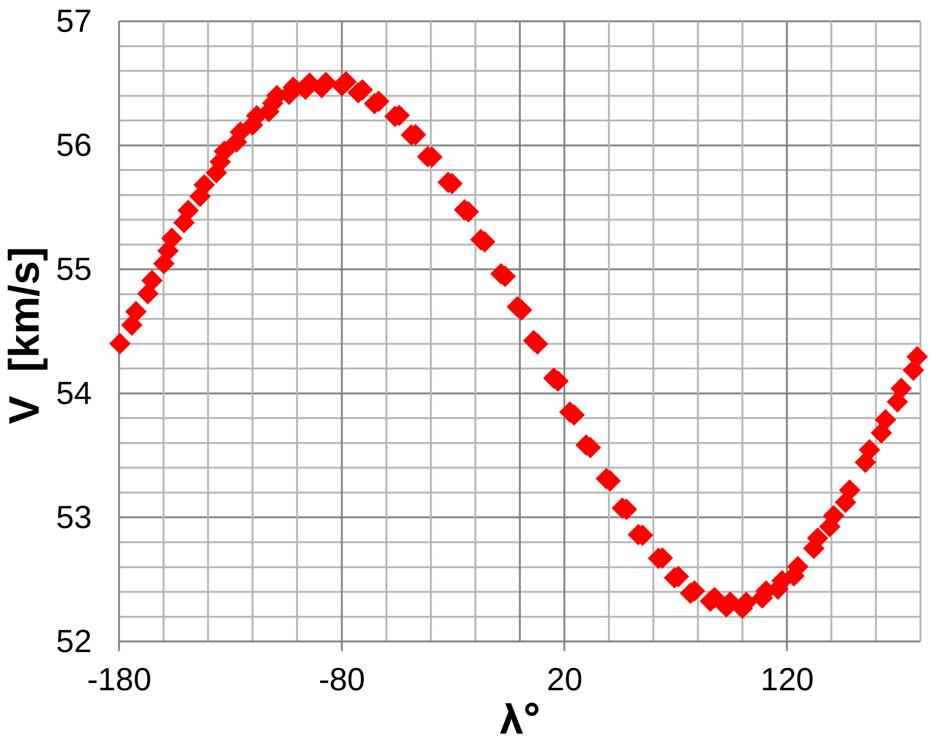
Longitude: 0° to 360°

Flux radiant in the Phobos-centric Phobos-fixed coordinate system

Phobos-centred Phobos-fixed spherical coordinates of the vector of the meteor stream direction (S/2007 D2)



Relative velocity for (S/2007 D2)



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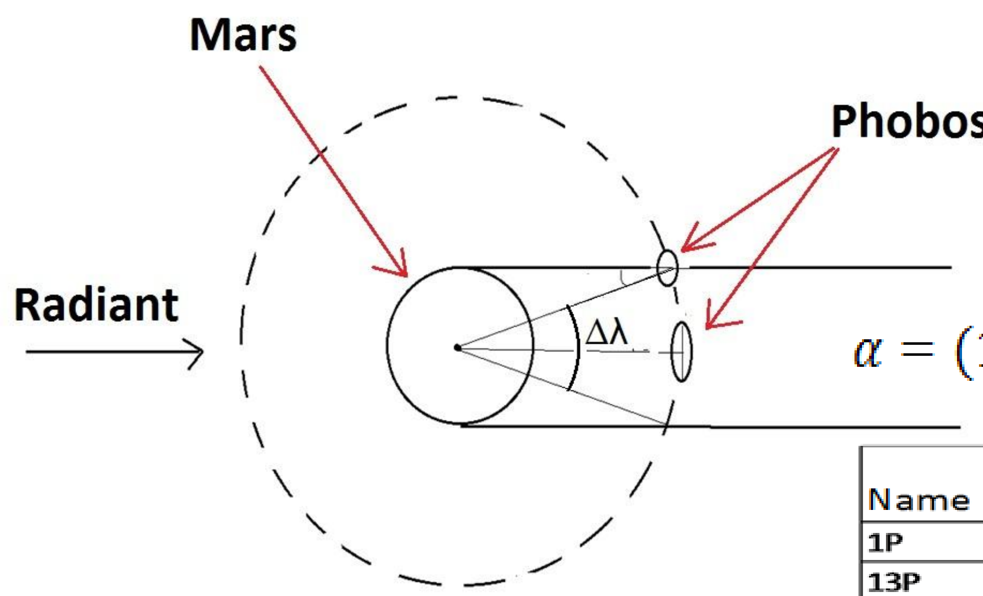
Screening of meteoroids by Mars

Effect of Mars effects may take place for streams with orbit inclination to Phobos orbit less than ~20 (the angle at which Mars is visible from Phobos).

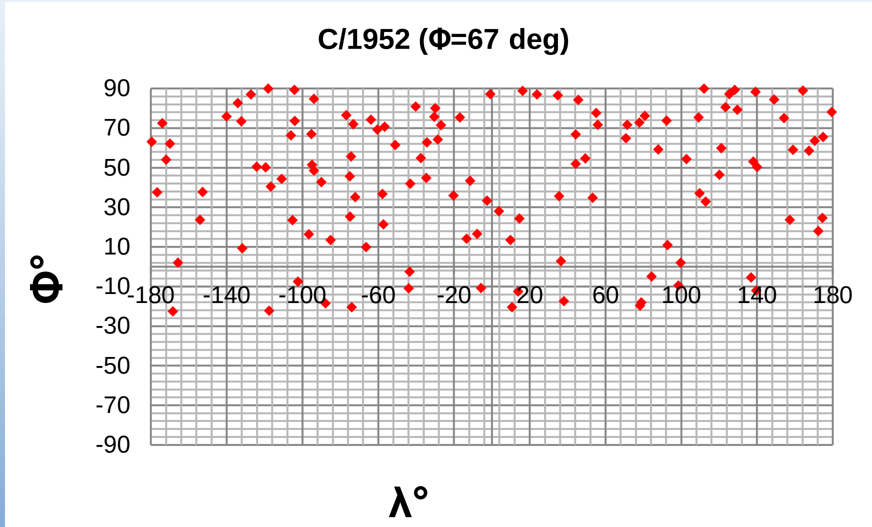


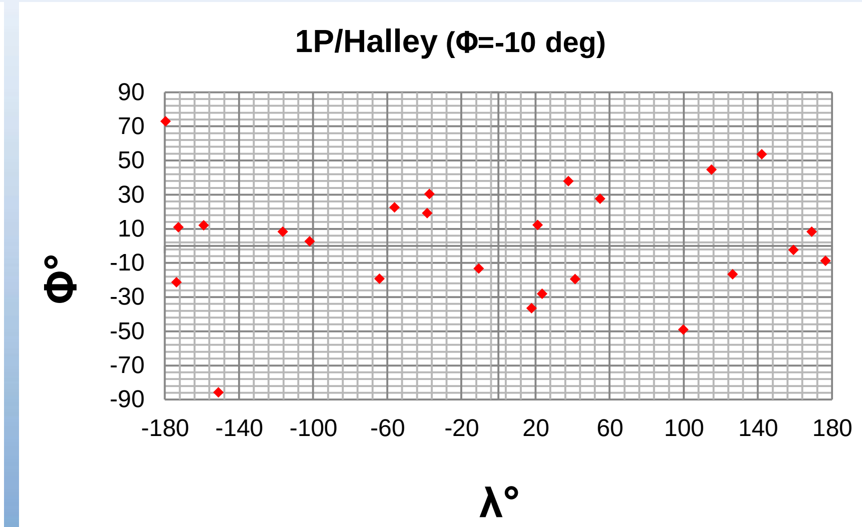
$$\alpha = \left(1 - \frac{\Delta\lambda}{360°}\right)$$

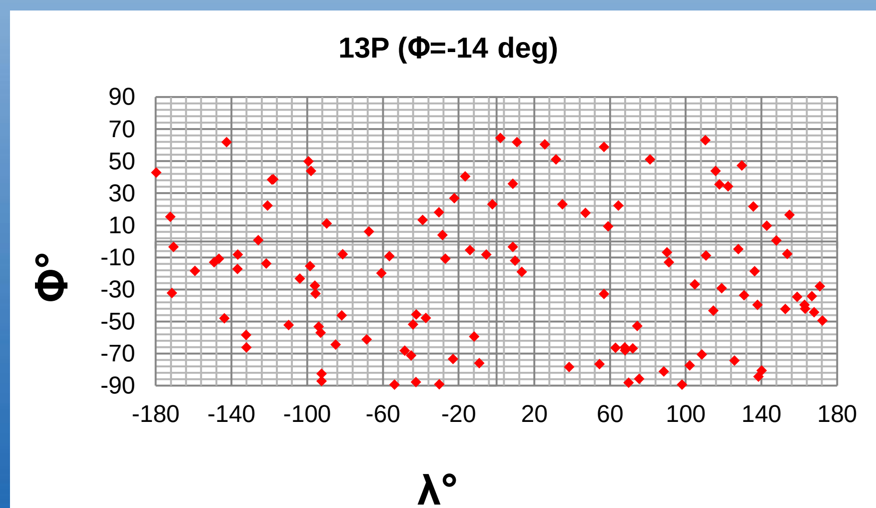
Name	α
1P	0.097222
13P	0.077778
38P	0.111111
C/1974	0.094444
C/2007 D2	0.094444

Example: Meteoroid showers, which are subject to screening and the screening coefficient **α** (part of meteoroids stopped by Mars).

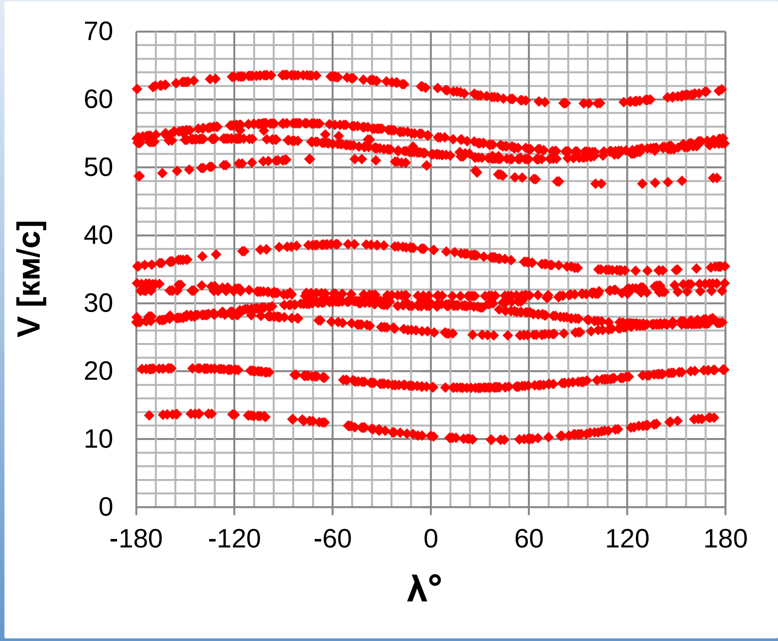
Areas of Phobos bombarded by meteoroids for different streams



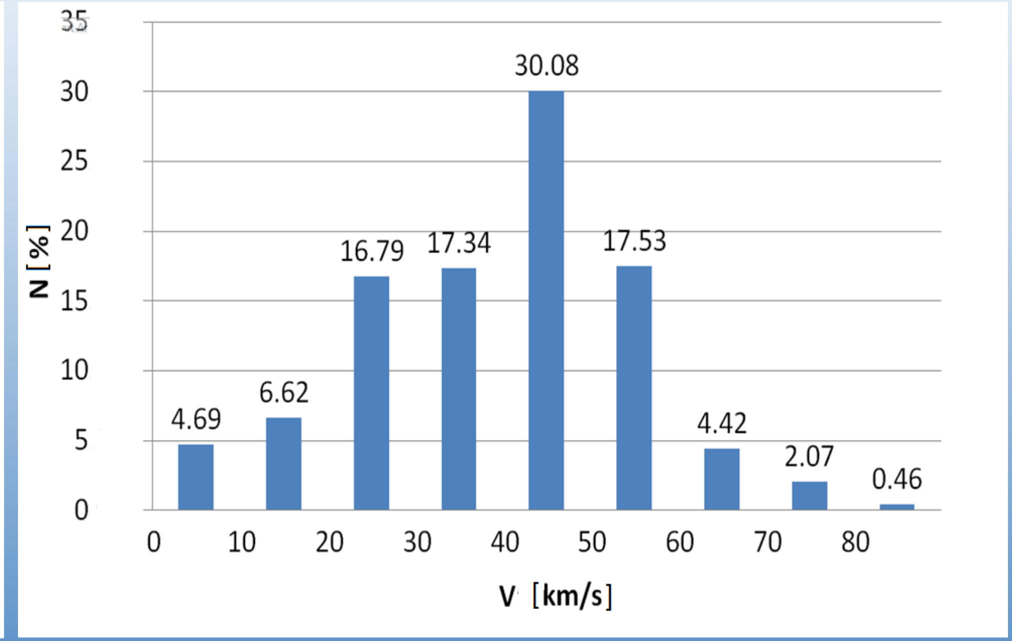




Impact velocity as a function of Phobos-fixed longitude of the radiant



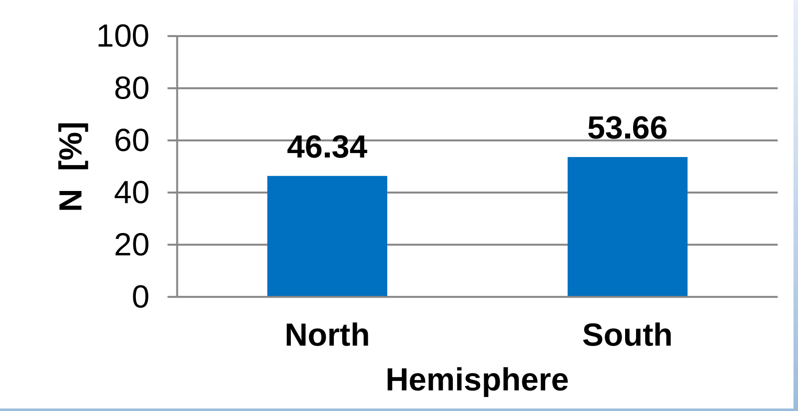
Impact velocity, depending on the longitude of the radiant in Phobos-fixed coordinate system



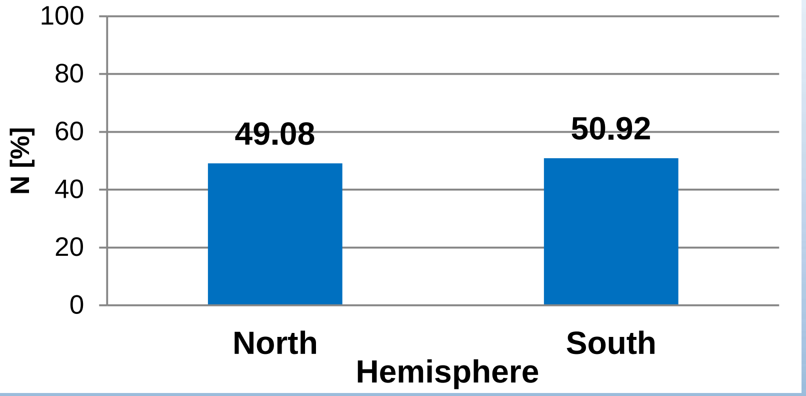
Distribution of the generated impacts by velocity

Impact statistics for the North and South hemispheres

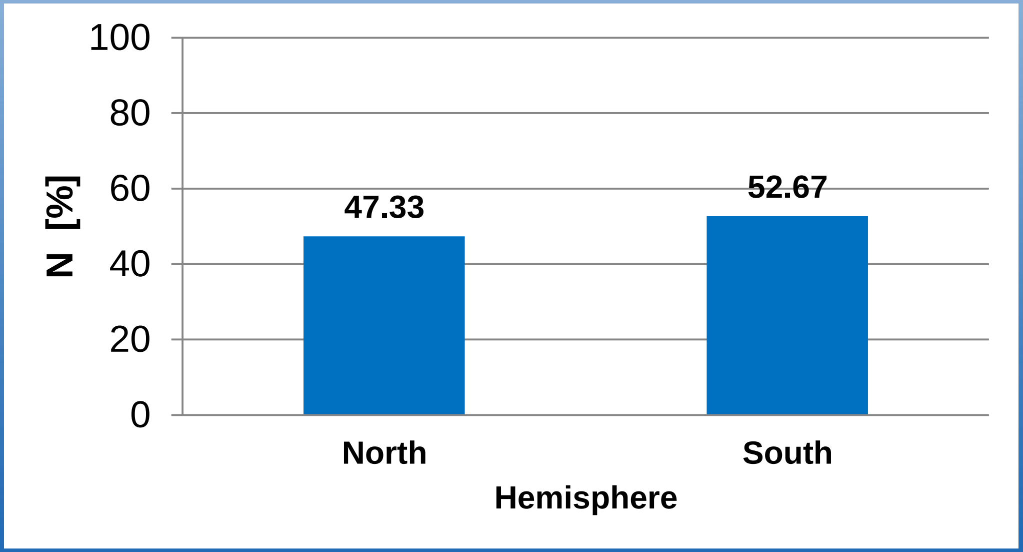
With Jupiter-family comets



Without Jupiter-family comets



Observations (for craters with diameter 80-150m)



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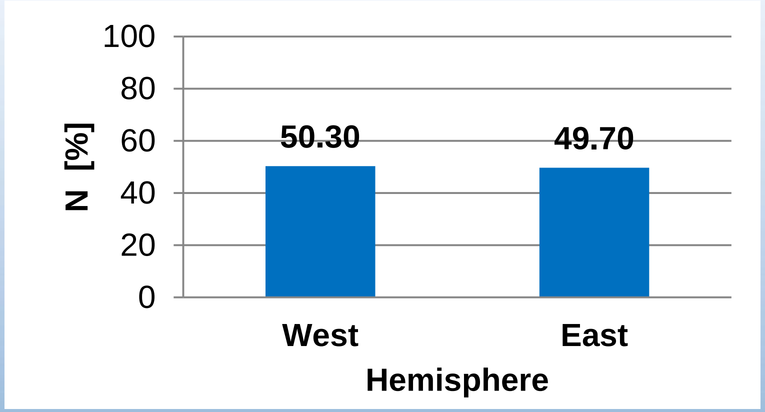
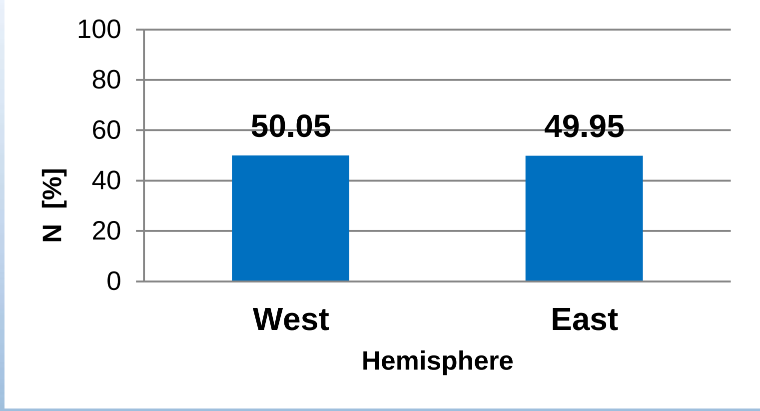
Impact statistics for the West and East hemispheres

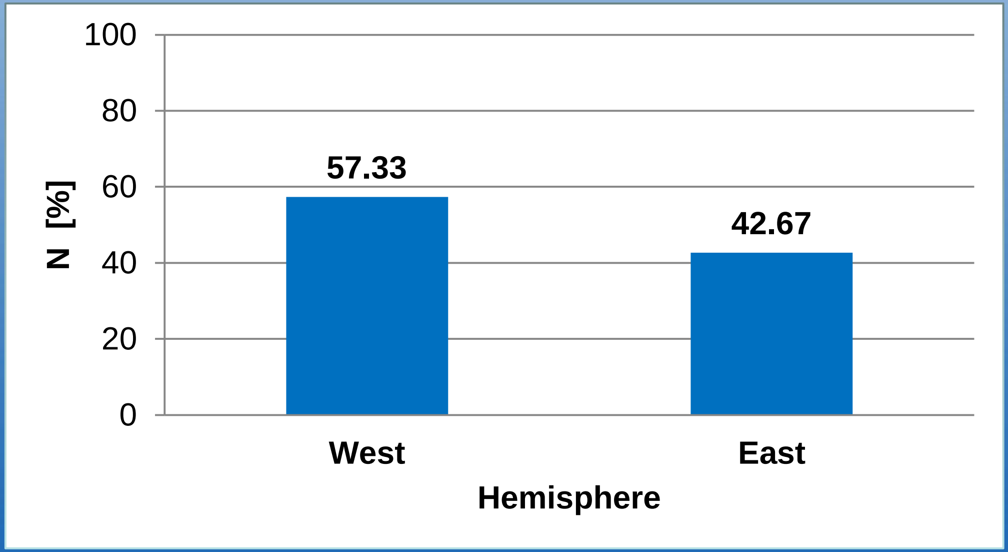
With Jupiter-family comets



Without Jupiter-family comets



Observations (for craters with diameter 80-150m)



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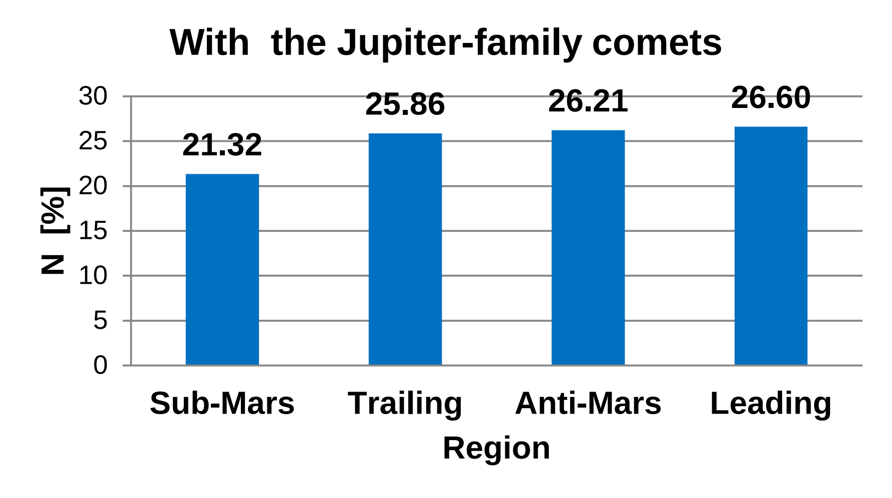
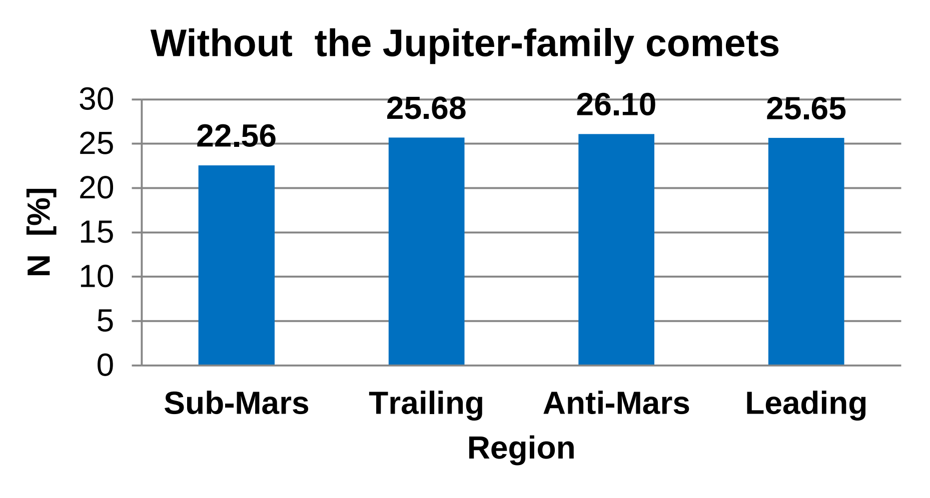
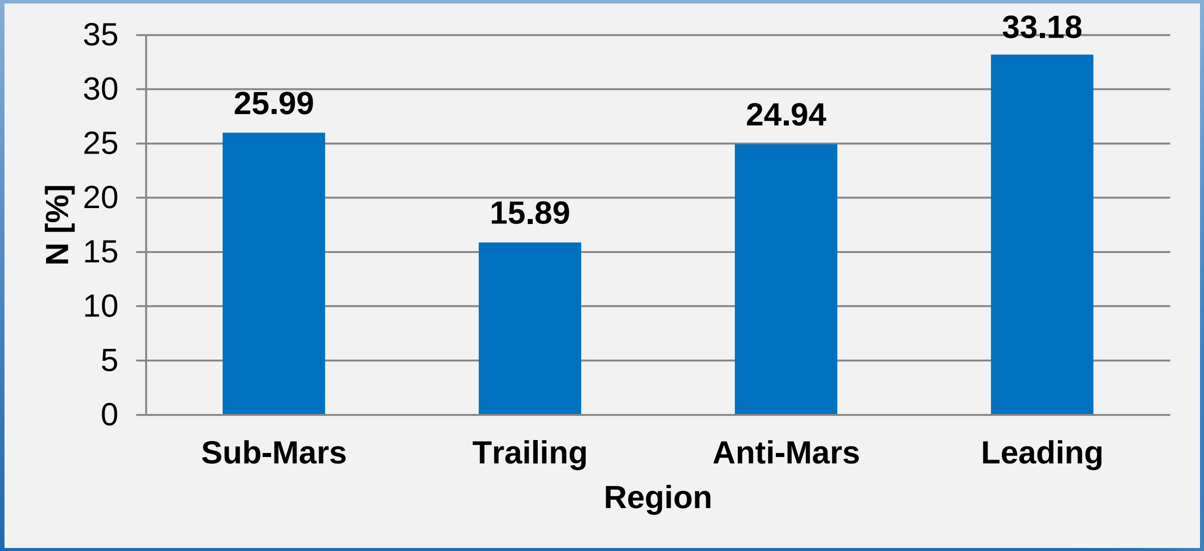
Impact statistics for the 90 degrees longitude zones





Observations (for craters with diameter 80-150m)



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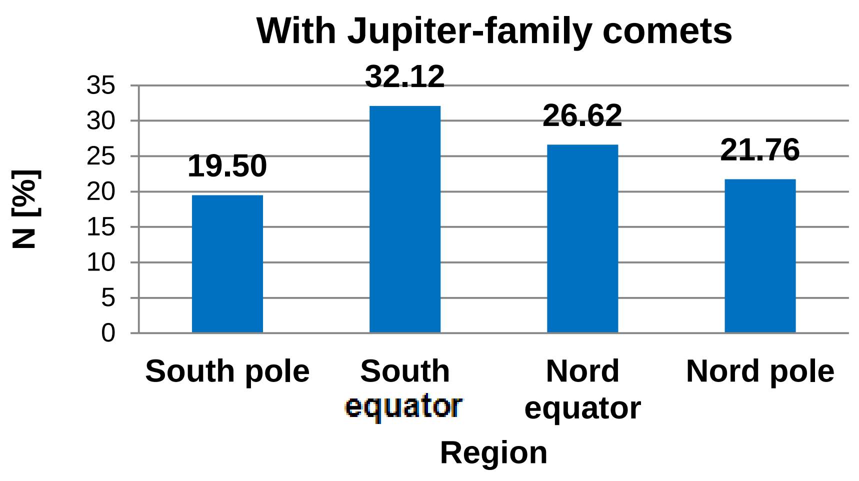
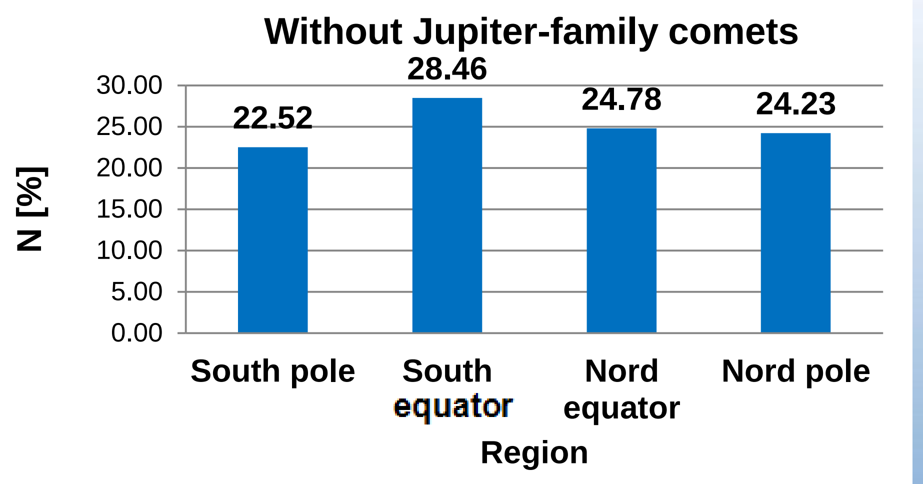
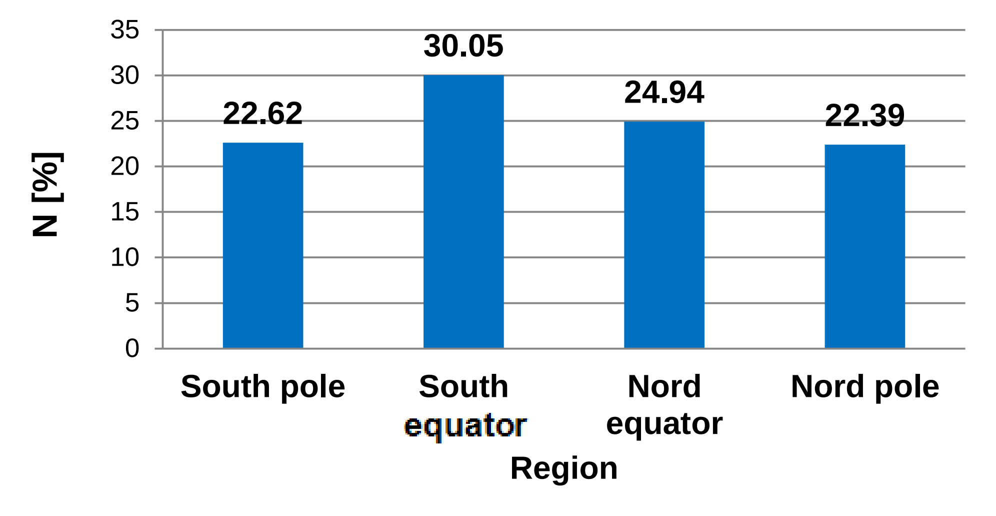
Impact statistics for equal-area latitude zones





Observations (for craters with diameter 80-150m)



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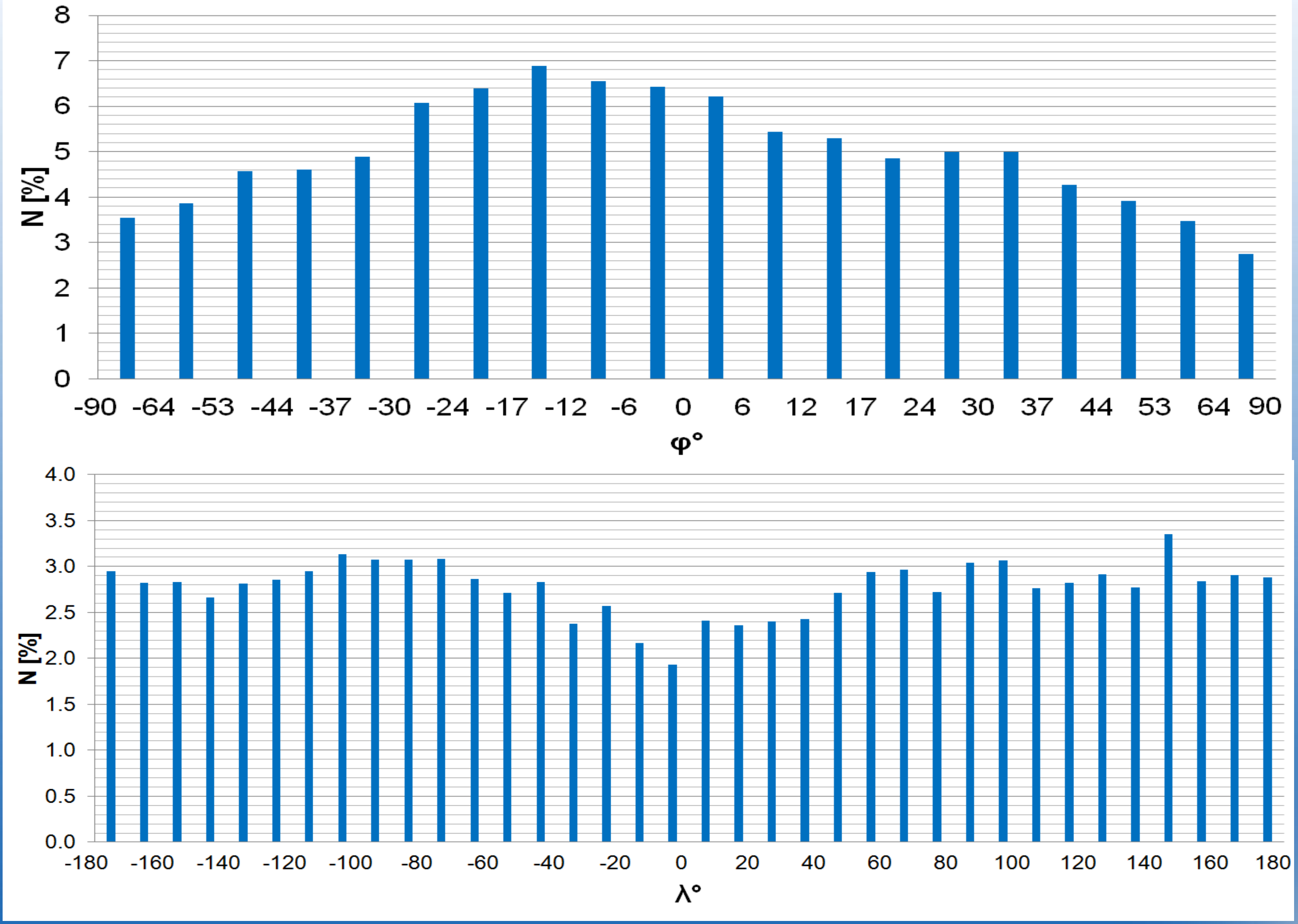
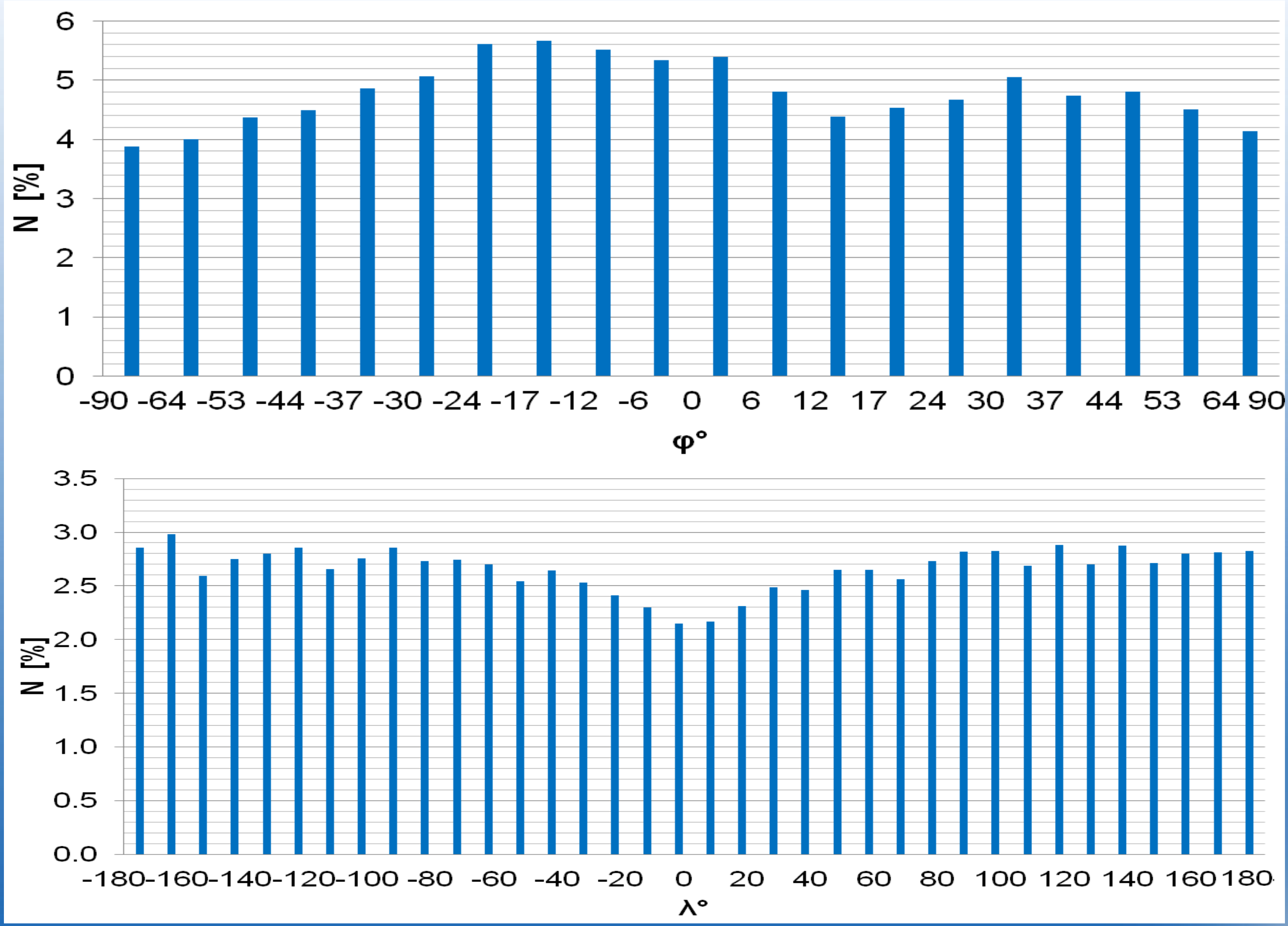
Detailed impact statistics with respect to surface areas (with Jupiter-family comets)



Detailed impact statistics with respect to surface areas (without Jupiter-family comets)



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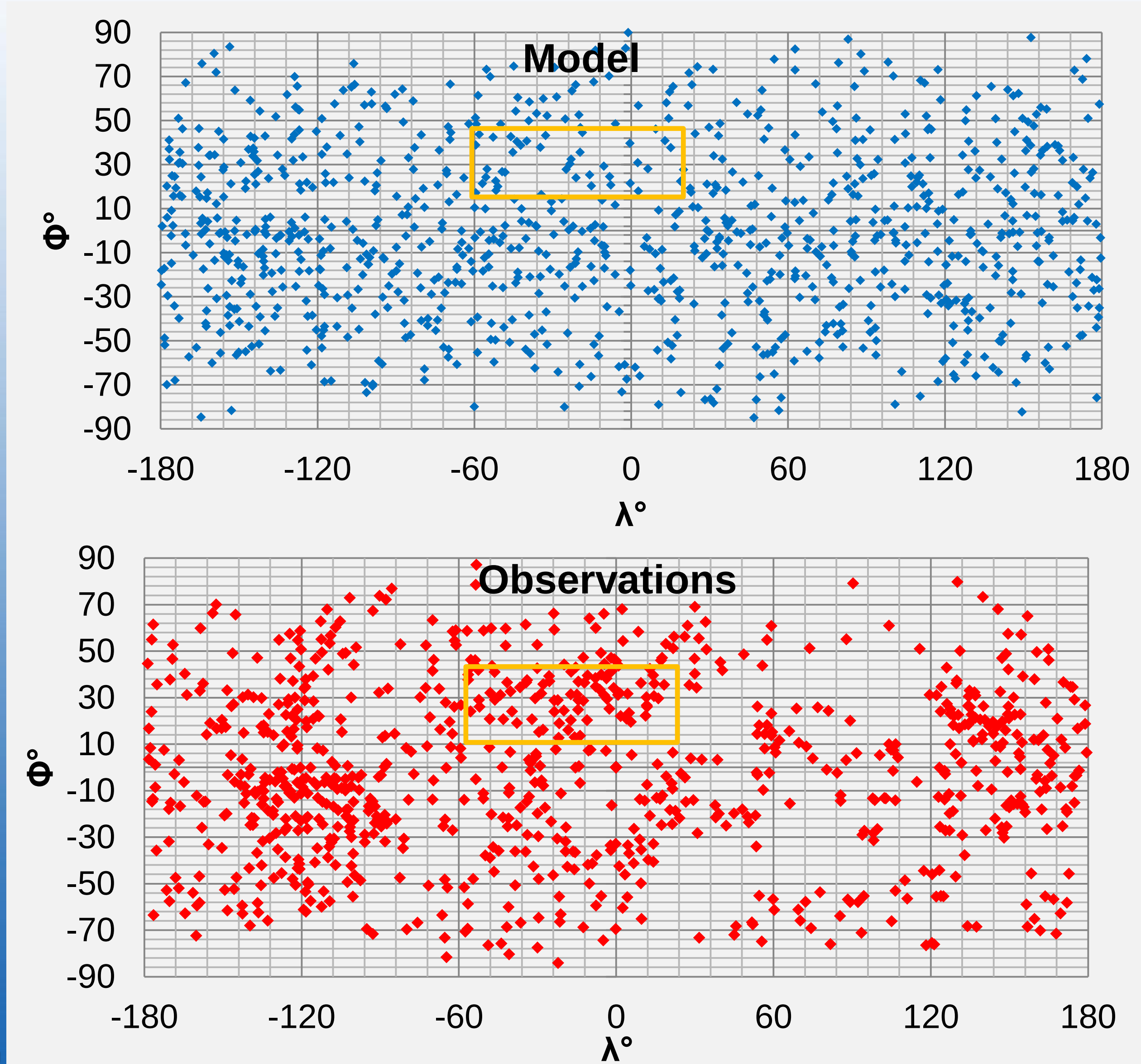
Comparison of observed and simulated crater distribution



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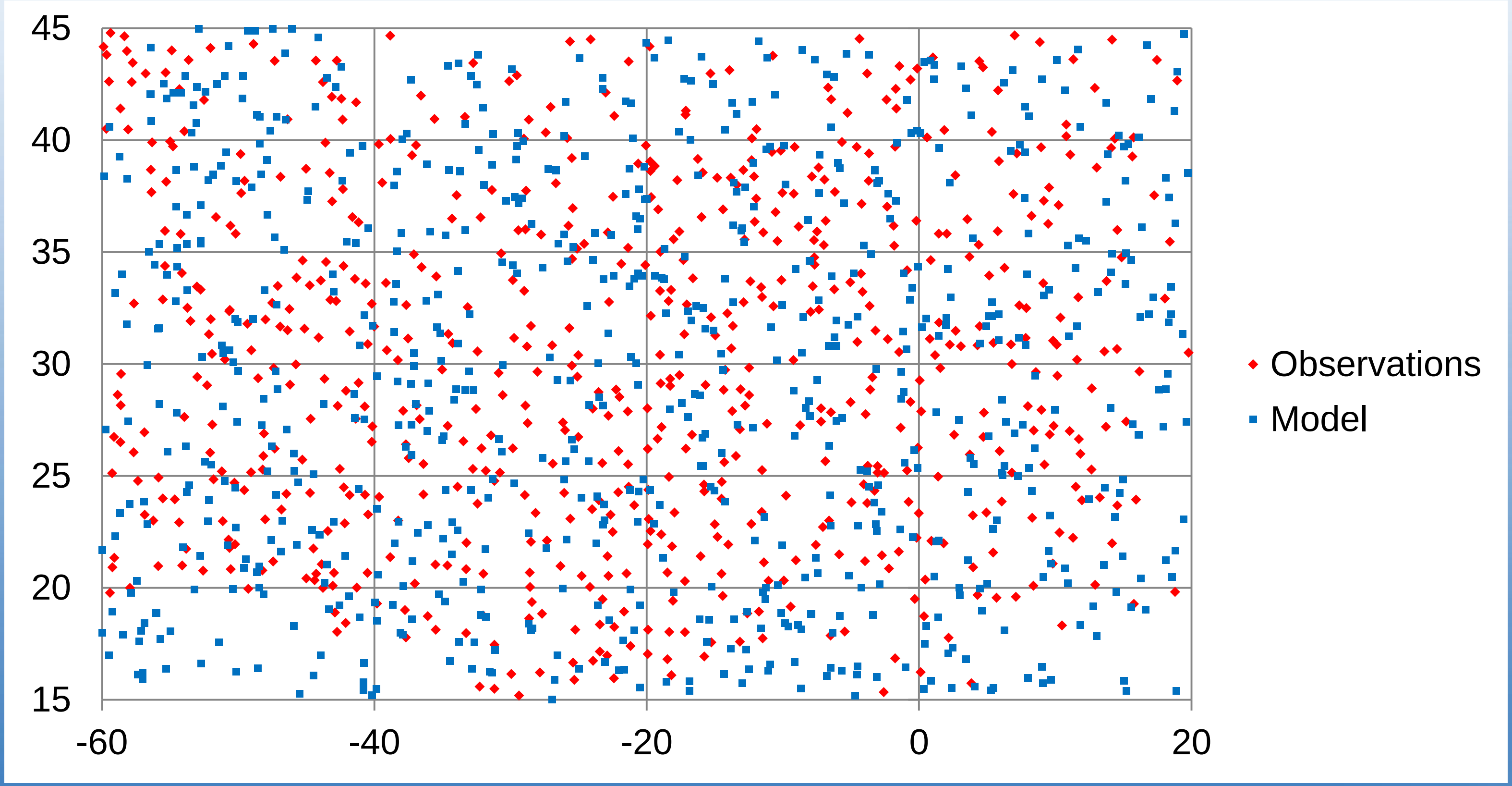
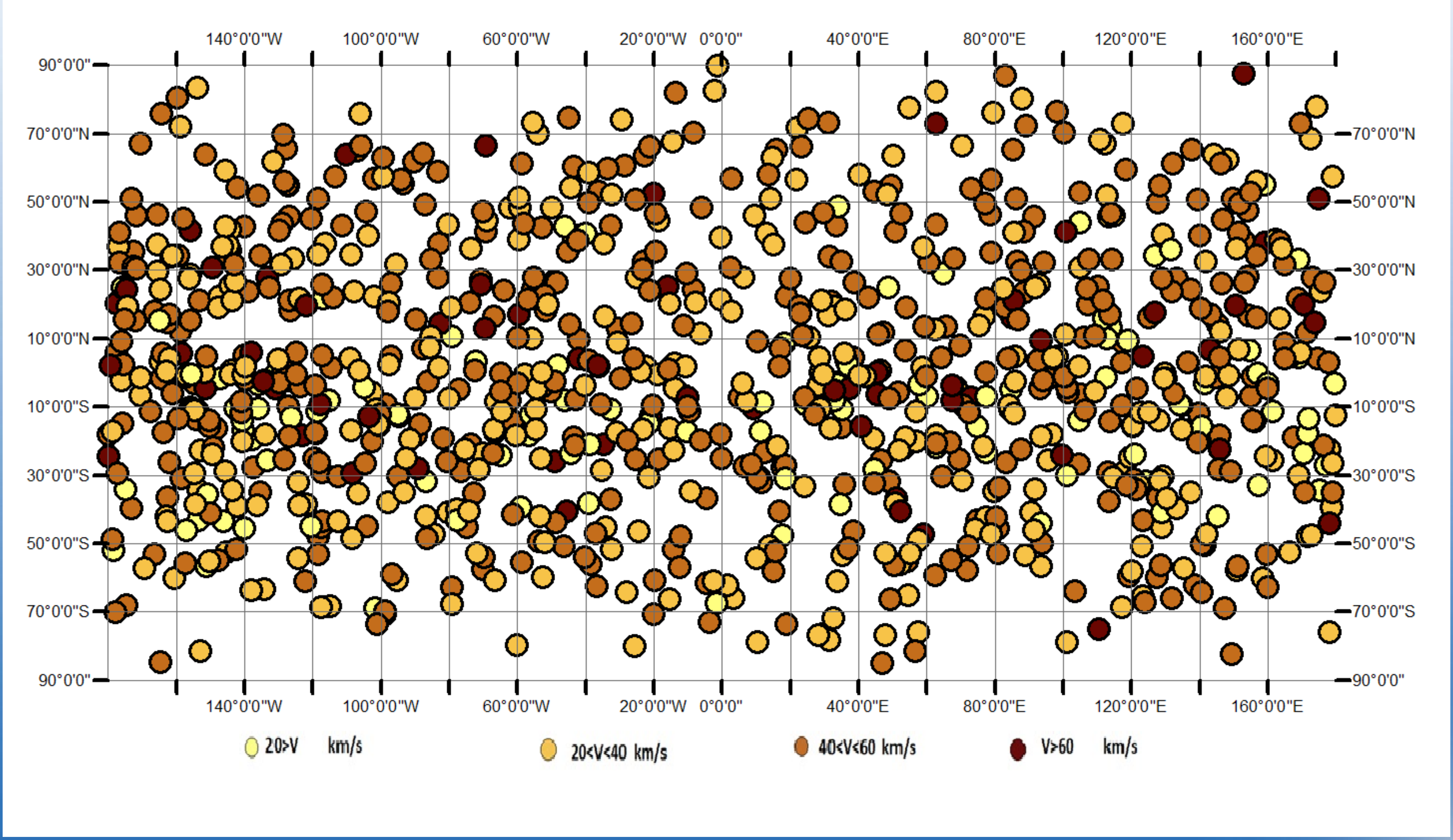
Comparison of observed and simulated crater distribution on local area



Comparison of actual and simulated craters distribution for average size of craters is 110 m

Modeled velocities distribution of meteoroid impacts on the Phobos surface



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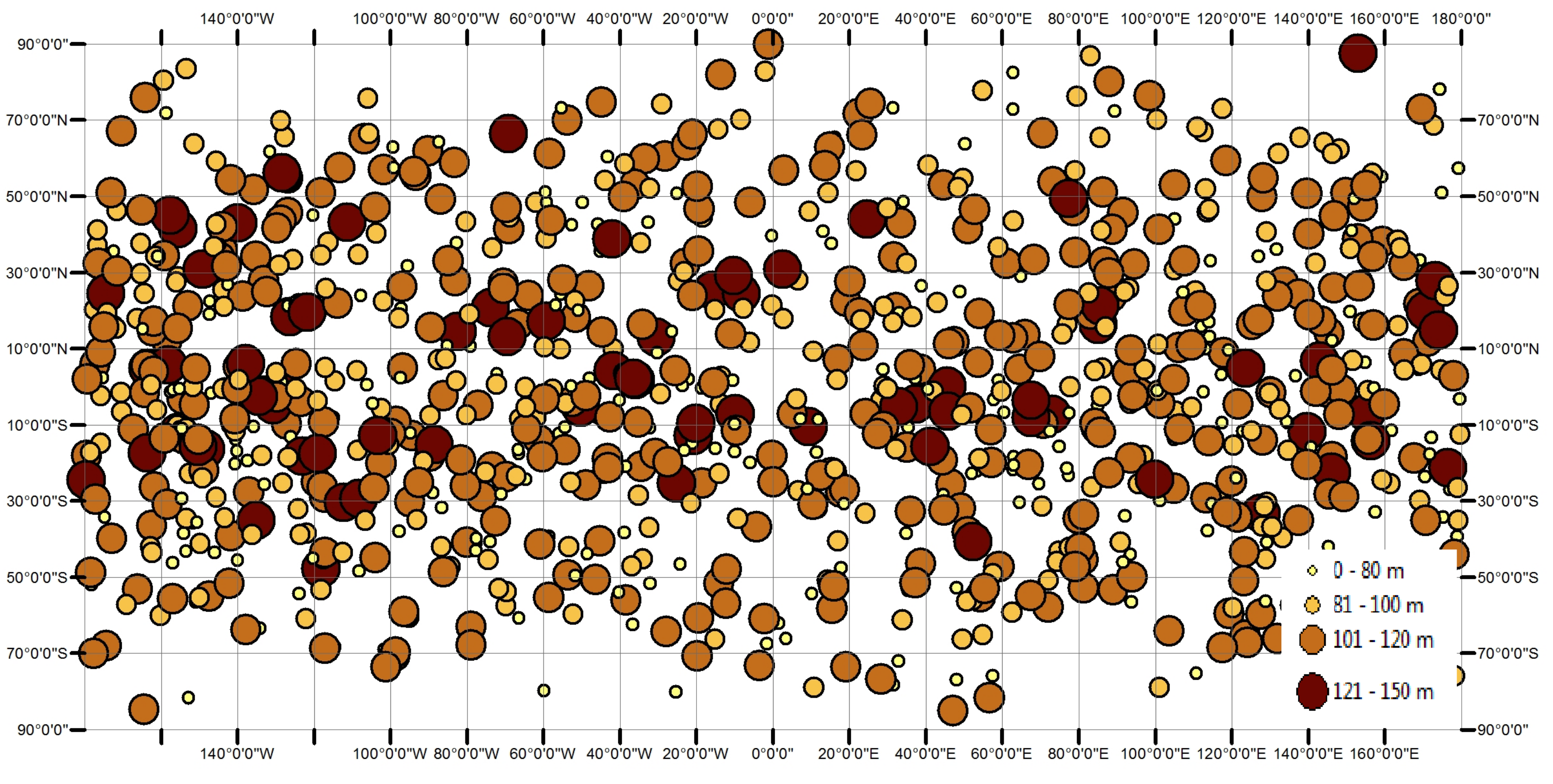
Modeled crater distribution of meteoroid impacts on the Phobos surface

$$D_c = 1.25\left(\frac{M}{\rho_t}\right)^{1/3}\left(\frac{1.61 g d_p}{V^2}\right)^{-\beta}$$ [2]



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Summary

	With Jupiter-family comets	Without Jupiter-family comets	Observations
Zone on Phobos	**N[%]**	**N[%]**	**N[%]**
-45° < λ < 45°	22.41	22.30	25.99
45° < λ < 135°	25.70	25.55	15.89
135°< λ < 225°	26.26	26.50	24.94
225°< λ <315°	25.63	25.65	33.18
ϕ>30°	21.76	24.23	22.39
0°<ϕ<30°	26.62	24.78	24.94
-30°<ϕ<0°	32.12	28.46	30.05
ϕ<-30°	22.54	22.30	19.50
North hemisphere	49.08	46.34	47.33
South hemisphere	50.92	53.66	52.67
West hemisphere	50.05	50.30	57.33
East hemisphere	49.95	49.70	42.67

- Simulation of Phobos bombardment by meteoroid particles of all potential meteoroid streams was performed.
- Simulated crater distributions was compared with observed one.
- Average effect of the meteoroid screening by Mars is about 5.5% for whole Phobos surface and about 11% for sub-Mars hemisphere.
- Average impact velocity for the leading hemisphere is 39.5 km/s and 37.17 km/s for the trailing hemisphere, the majority of attacks occur at velocities from 30 to 60 km/s.

References

[1] http://ssd.jpl.nasa.gov/ - JPL solar system dynamics.

[2] William F. Bottke, Stanley G. Love, David Tytell, Timothy Glotch – "Interpreting the Elliptical Crater Populations on Mars, Venus, and the Moon", Icarus 145, 2000.

[3] Karachevtseva I.P., J.Oberst, K.B. Shingareva, A.A. Konopikhin, E.V. Cherepanova, M. Wählisch, K. Willner "Development of a Global Crater Catalog of Phobos, and GIS-analysis of the Distribution of Craters" The second Moscow Solar System Symposium (2M-S3) Moons of planets, Moscow, 2011.

Thank You !

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