Modeling of Space Debris in GEO @ CNUCE

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Software Tools Available

- SDM: Space Debris Mitigation long-term analysis program (Version 2.0)
- GEODAT: Geostationary Debris Analysis Tool

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SDM (1)

- Mainly used for LEO studies, but applicable up to 40,000 km of altitude
- Sources include launches (satellites, upper stages & mission related objects), explosions and collisions
- Sinks include re-orbiting to a user-defined graveyard orbit (e.g. IADC)

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SDM (2)

- Useful for long-term, statistical studies
- Very fast from a computational point of view
- Accuracy limited by the orbit propagator (luni-solar gravity, Earth's harmonics and solar radiation pressure are neglected)

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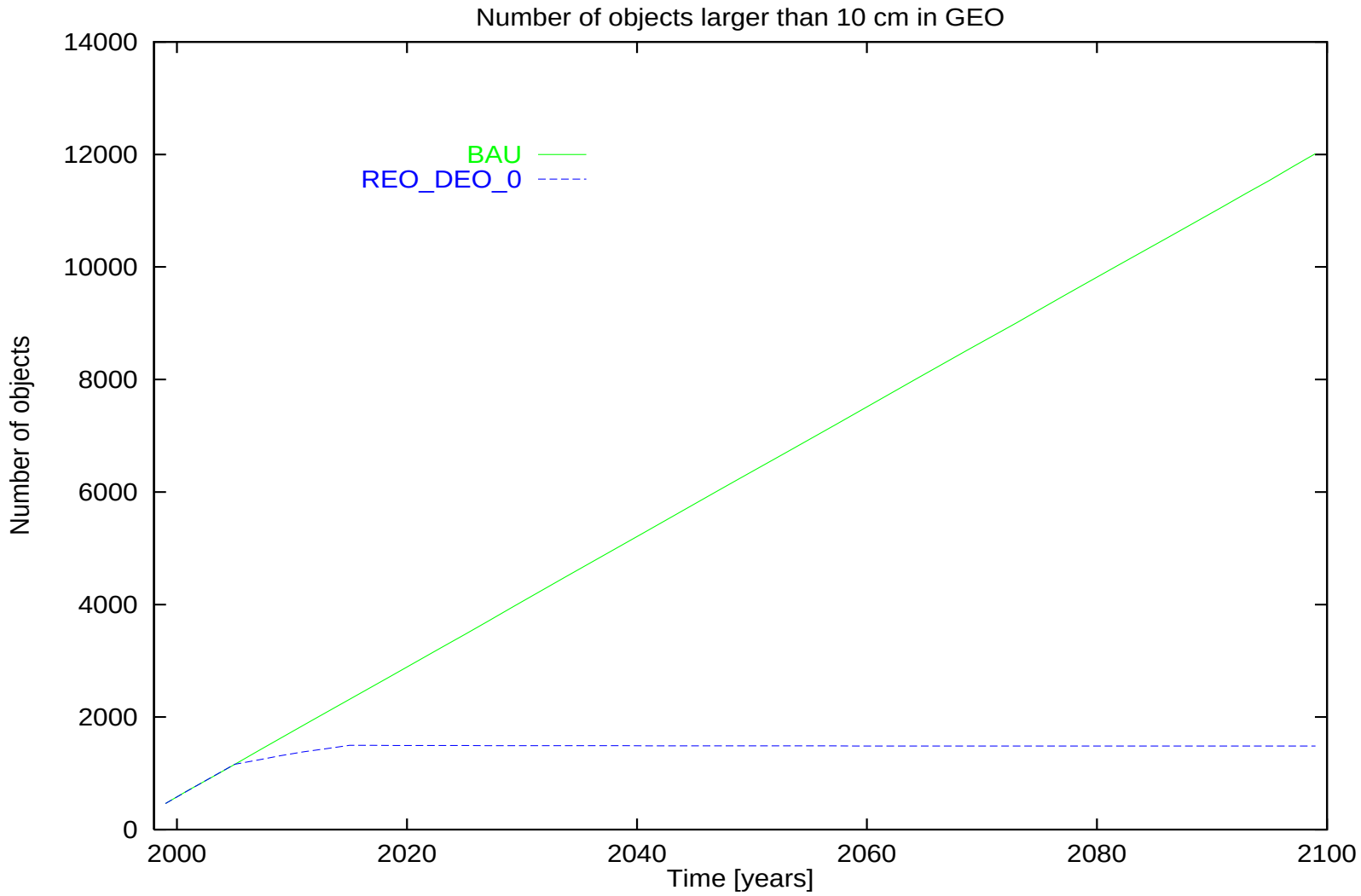
Number of objects larger than 10 cm in GEO
14000
12000
10000
8000
6000
4000
2000
0
Number of objects
BAU
REO_DEO_0
2000
2020
2040
2060
2080
2100
Time [years]

GEODAT (1)

- Specifically developed to study how space debris affect the GEO ring
- High precision propagator including all the relevant perturbations
- High resolution, high accuracy
- Useful to investigate the short, medium and long-term effects of breakups

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GEODAT (2)

- Analysis of the debris density evolution inside the GEO ring (as a function of right ascension) based on the actual transit times of the objects
- Slow from a computational point of view

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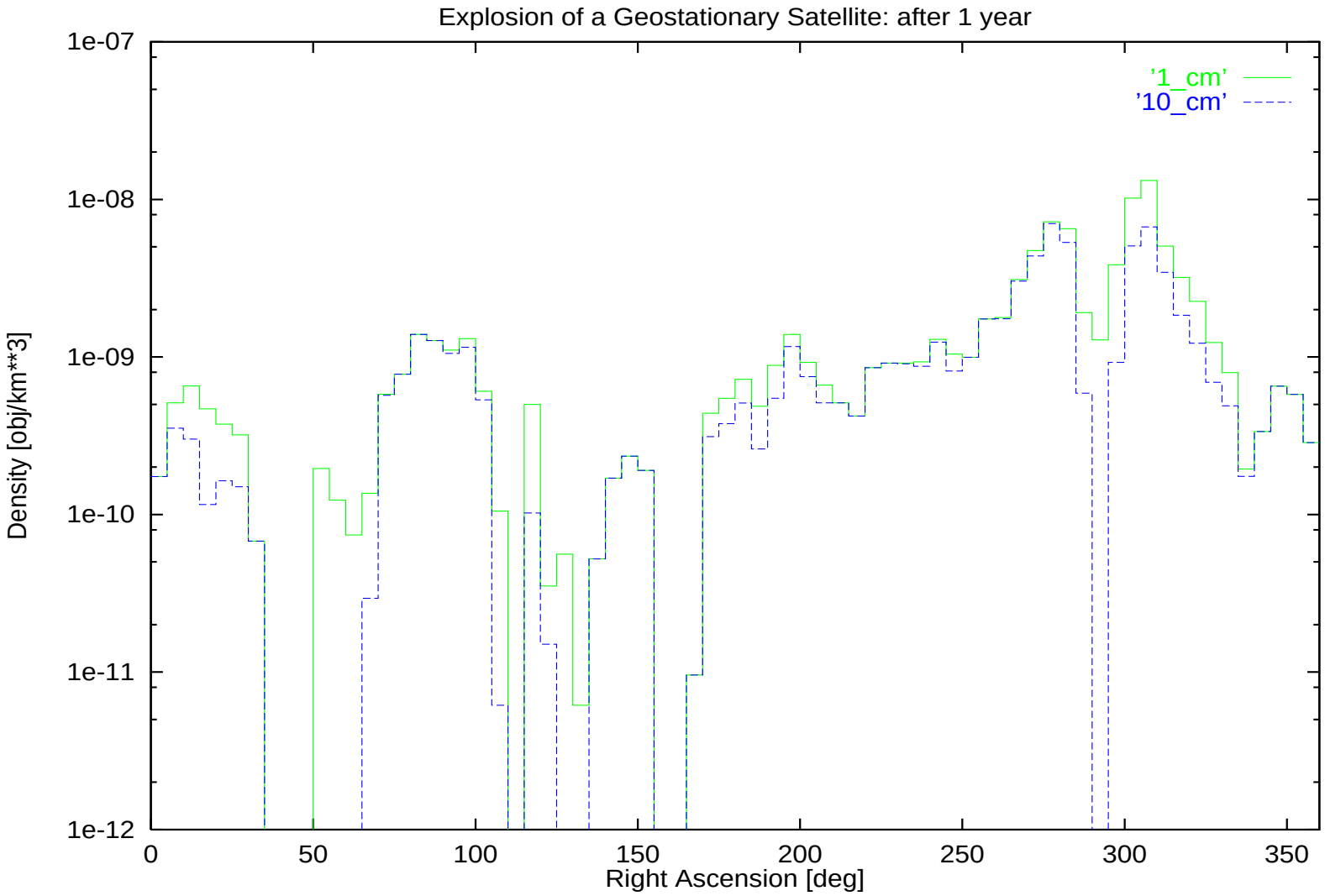
Explosion of a Geostationary Satellite: after 1 year
'1_cm'
'10_cm'
Density [obj/km**3]
1e-07
1e-08
1e-09
1e-10
1e-11
1e-12
0
50
100
150
200
250
300
350
Right Ascension [deg]


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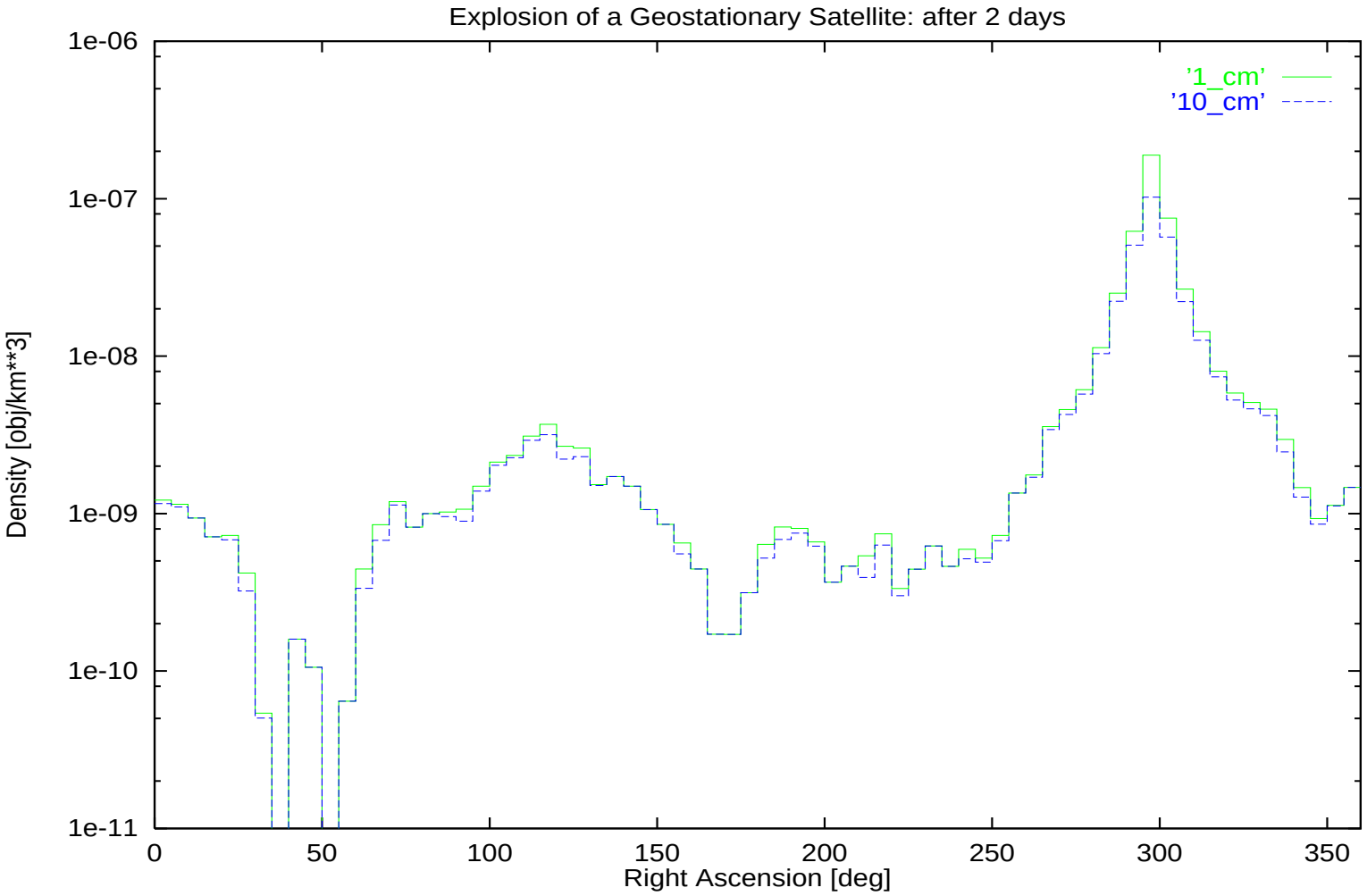
Explosion of a Geostationary Satellite: after 2 days
'1_cm'
'10_cm'
Density [obj/km**3]
1e-06
1e-07
1e-08
1e-09
1e-10
1e-11
0
50
100
150
200
250
300
350
Right Ascension [deg]

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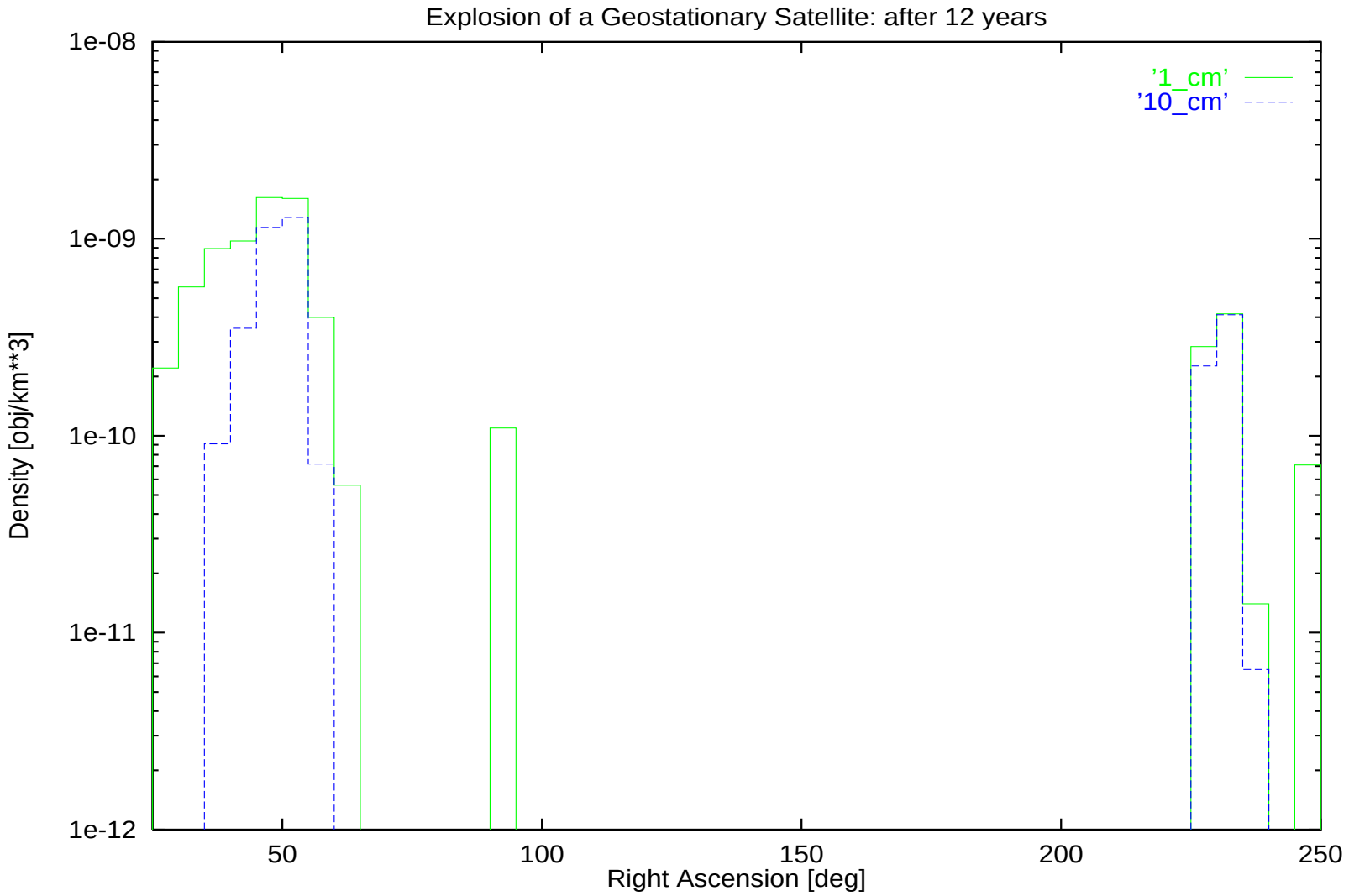
Explosion of a Geostationary Satellite: after 12 years
'1_cm'
'10_cm'
Density [obj/km**3]
1e-08
1e-09
1e-10
1e-11
1e-12
50
100
150
200
250
Right Ascension [deg]

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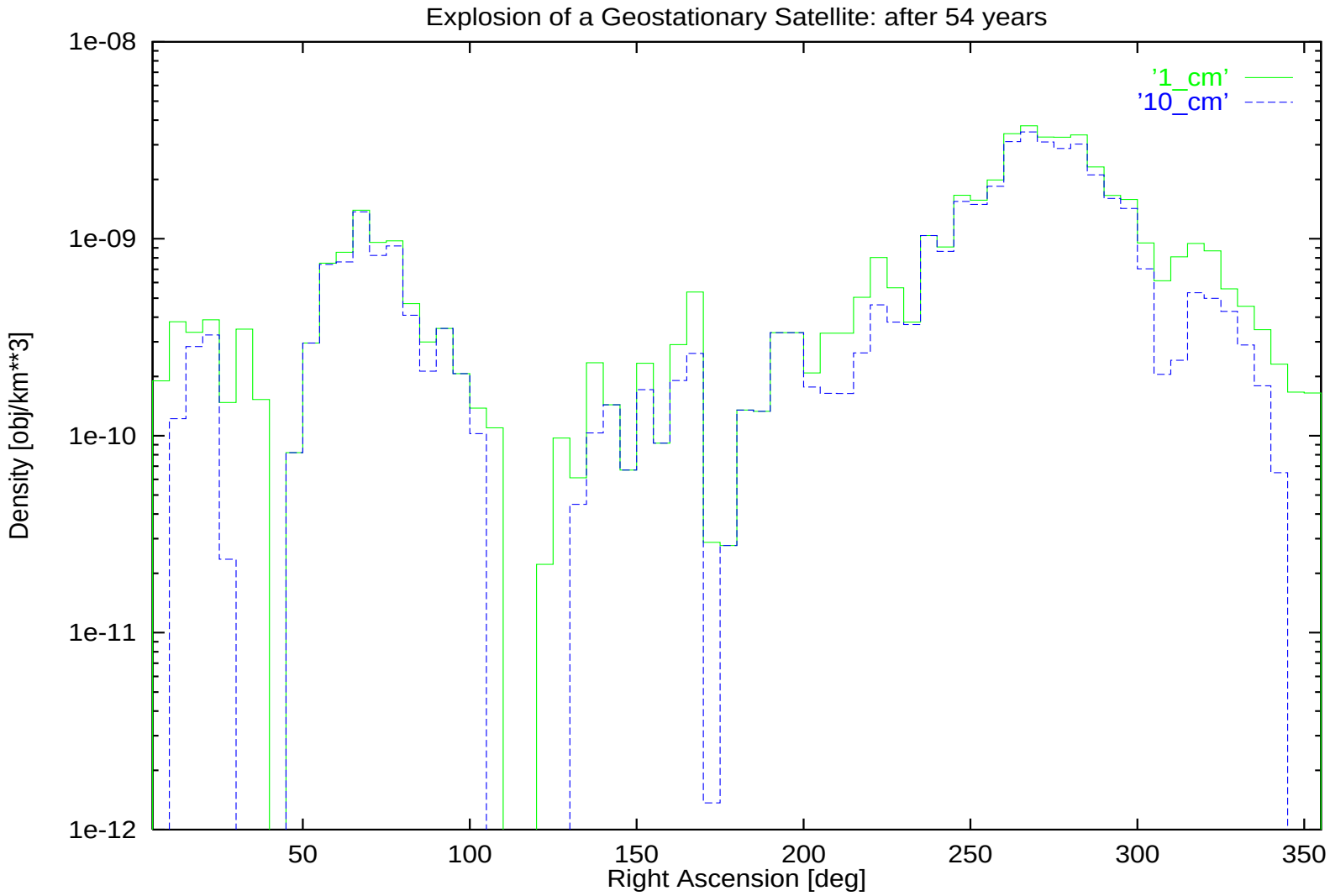
Explosion of a Geostationary Satellite: after 54 years
'1_cm'
'10_cm'
Density [obj/km**3]
1e-08
1e-09
1e-10
1e-11
1e-12
50
100
150
200
250
300
350
Right Ascension [deg]

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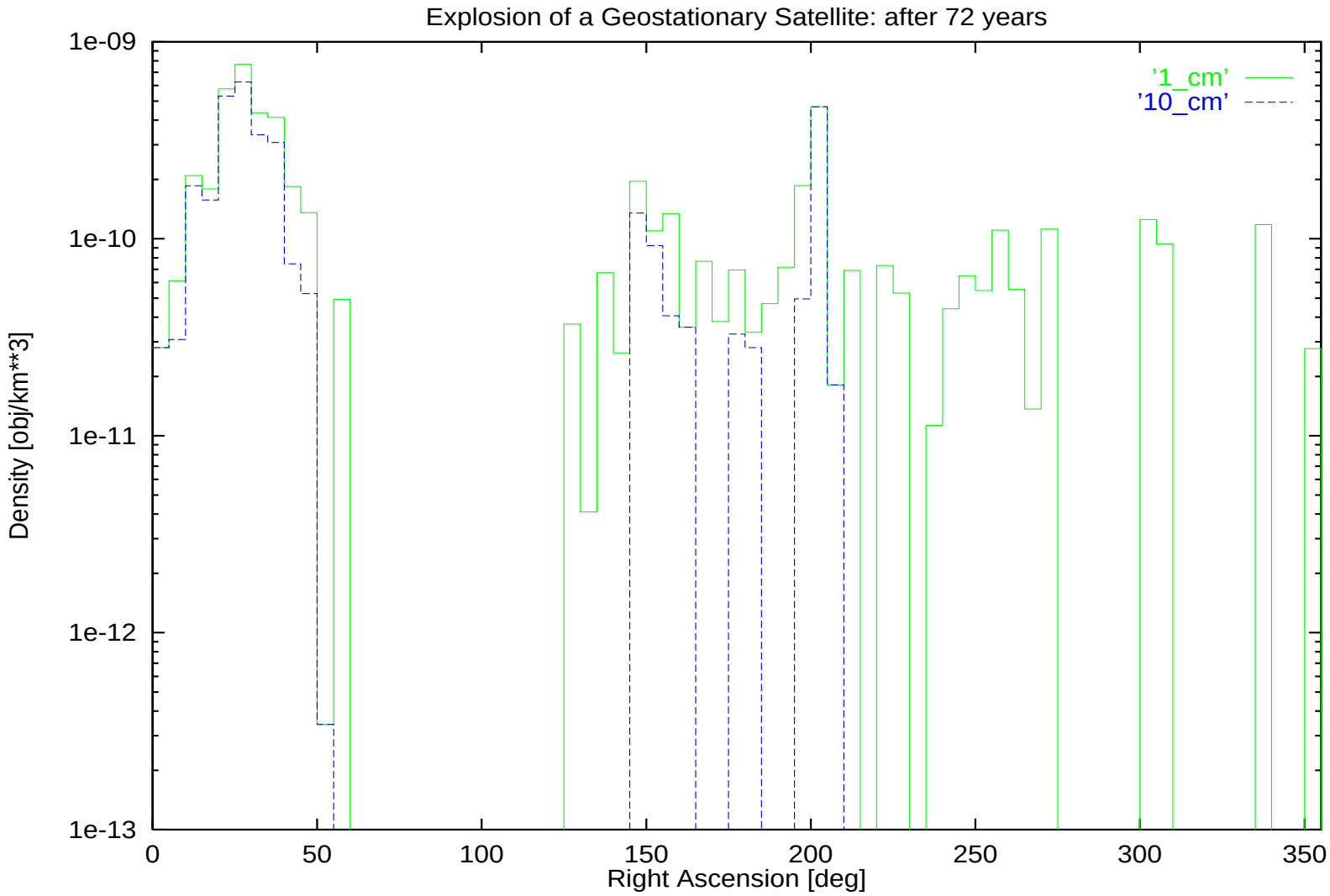
Explosion of a Geostationary Satellite: after 72 years
'1_cm'
'10_cm'
Density [obj/km**3]
1e-09
1e-10
1e-11
1e-12
1e-13
0
50
100
150
200
250
300
350
Right Ascension [deg]

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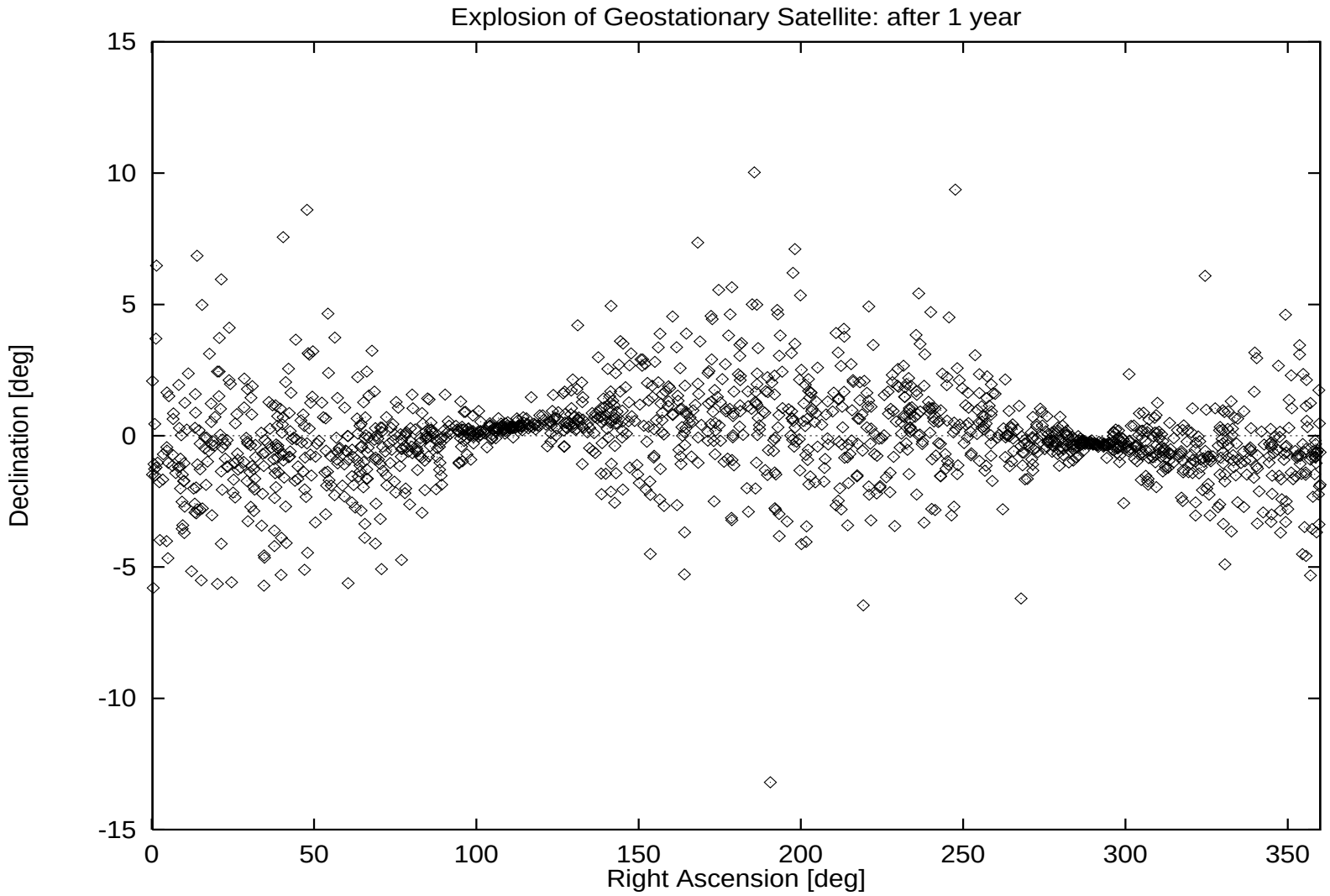
Explosion of Geostationary Satellite: after 1 year
Declination [deg]
Right Ascension [deg]
15
10
5
0
-5
-10
-15
0
50
100
150
200
250
300
350

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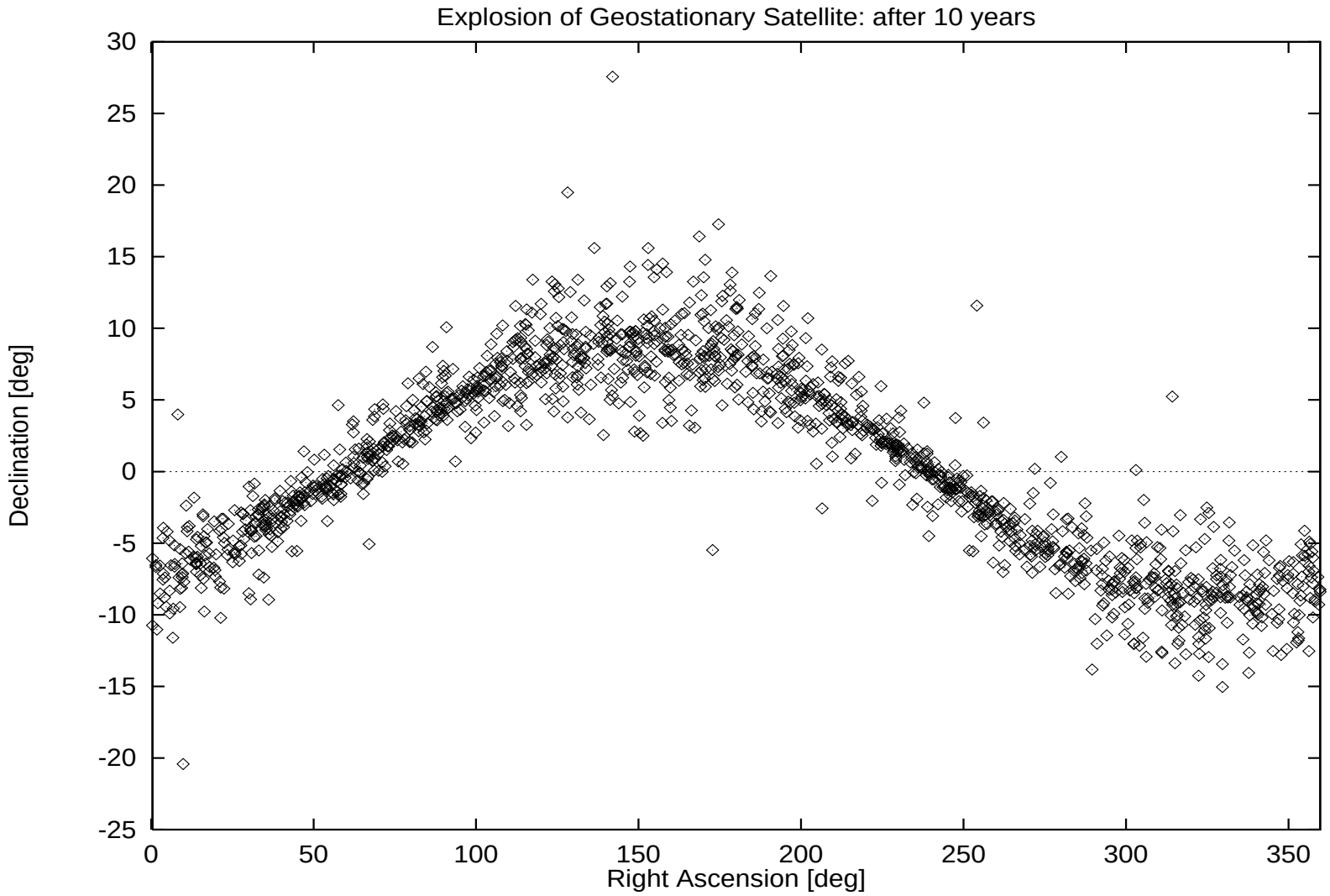
Explosion of Geostationary Satellite: after 10 years
Declination [deg]
Right Ascension [deg]
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
0
50
100
150
200
250
300
350

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GEO-SDM (?)

- Version of SDM tailored for GEO studies
- Maintain actual program structure
- Consider only objects above LEO
- Use of new orbit propagator including Earth's gravity harmonics, luni-solar attraction and solar radiation pressure
- Debris diameter $\geq$ 1 mm

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CONCLUSION

- SDM and GEODAT already available for specific studies and analyses, both short and long-term
- GEO-SDM could be developed if really needed and if adequate *human* (and funding) resources are available

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