CARTOGRAPHIC STUDY OF THE MEO PHASE SPACE FOR PASSIVE DEBRIS REMOVAL

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Introduction

Recently, it has been realized that lunisolar secular resonances are of particular importance in the MEO regime, which may provide a substantial perigee boost for the satellite under properly chosen circumstances [1, 2, 3, 4]. Additionally, solar radiation pressure (SRP) plays crucial role in the motion of satellites, especially at large altitudes [5, 6]. We use a suitably modified version of the SWIFT symplectic integration package [7], to integrate the trajectories of $\sim$ 7.5 m initial conditions in the GNSS and GTO regions for 120 yr, assuming nominal and enhanced SRP (e.g. solar sail).

Model & Initial conditions

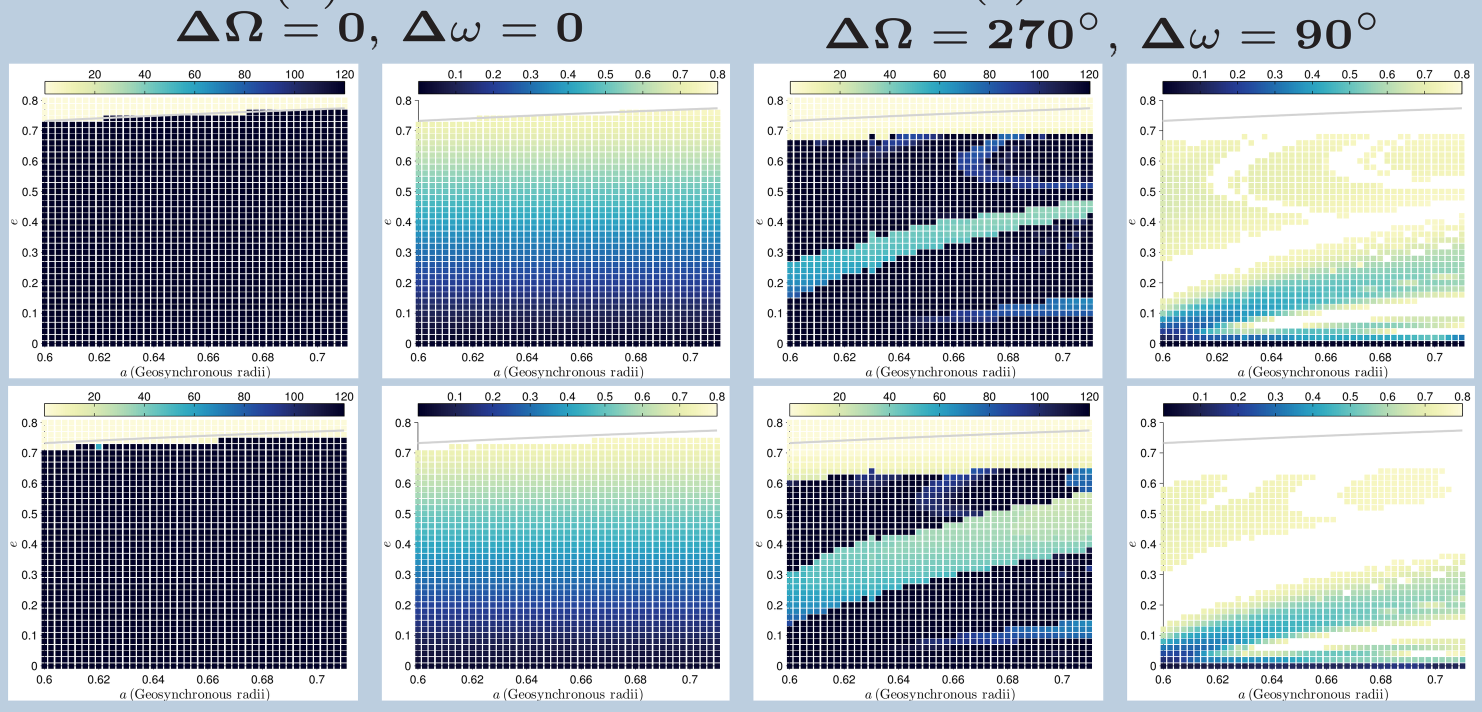
- Earth (J_2, C_{22}, S_{22}) + Moon + Sun (no expansion)
- Nominal $C_R\,(A/m) = 0.015\ m^2/kg$ (SRP$_1$) and enhanced $C_R\,(A/m) = 1\ m^2/kg$ (SRP$_2$)
- Two initial epochs (in 2018 and 2020)
- $t_{max} = 120\ yr$ & Re-entry limit $h_R = 400\ km$
- code: SWIFT-SAT, symplectic integrator, non-averaged equations of motion

Used to build a complete dynamical map of circumterrestrial space (check presentation by A. Rossi)

Maps of the MEO phase space

- $a \in [0.6 - 0.71]$ (a_{GEO}), $e \in [0 : 0.88]$, $i \in [0 : 90°]$
- $\Delta\Omega$, $\Delta\omega = \{0, 90°, 180°, 270°\}$ w.r.t. equatorial values of Moon

(*a*) **i = 0**, **ΔΩ = 0, Δω = 0** (*b*) **i = 56°**, **ΔΩ = 270°, Δω = 90°**



(*c*) **i = 64°**, **ΔΩ = 90°, Δω = 180°** (*d*) **i = 90°**, **ΔΩ = 180°, Δω = 90°**

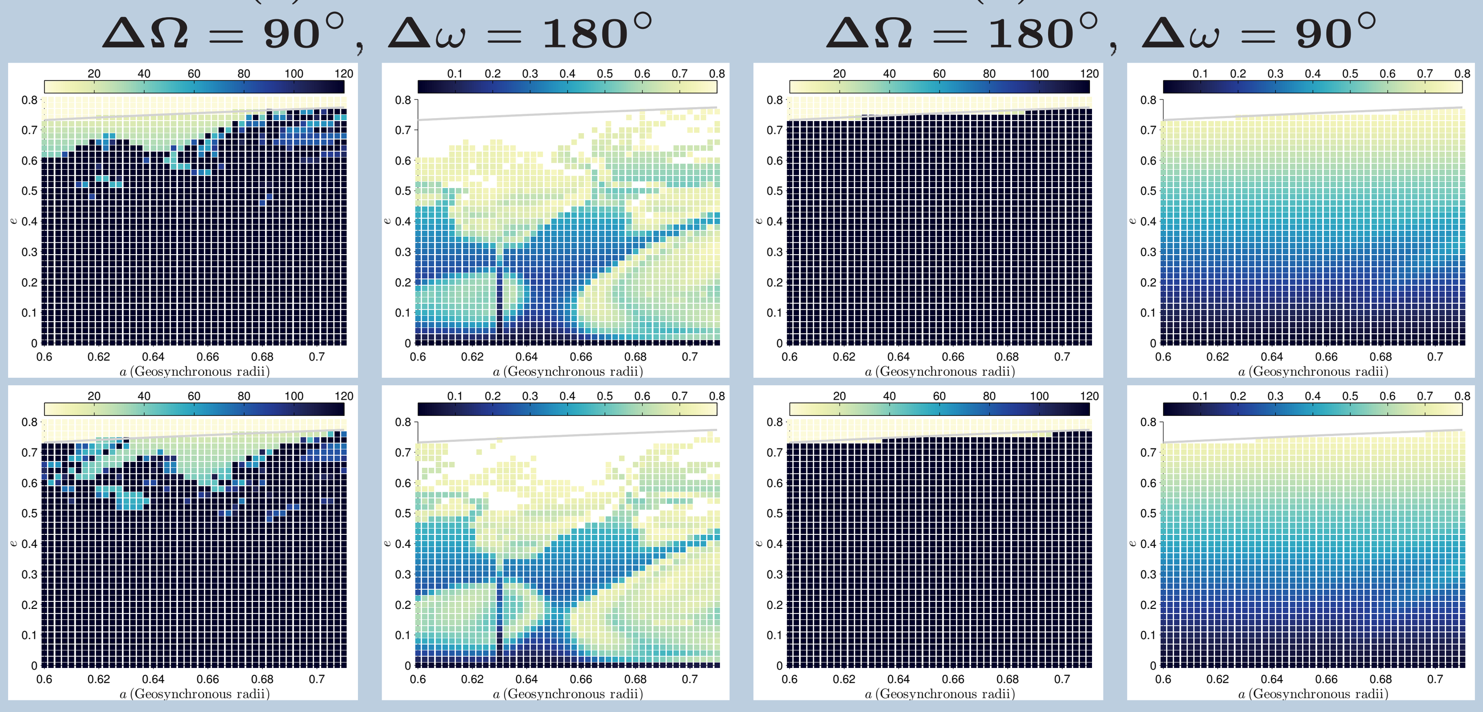


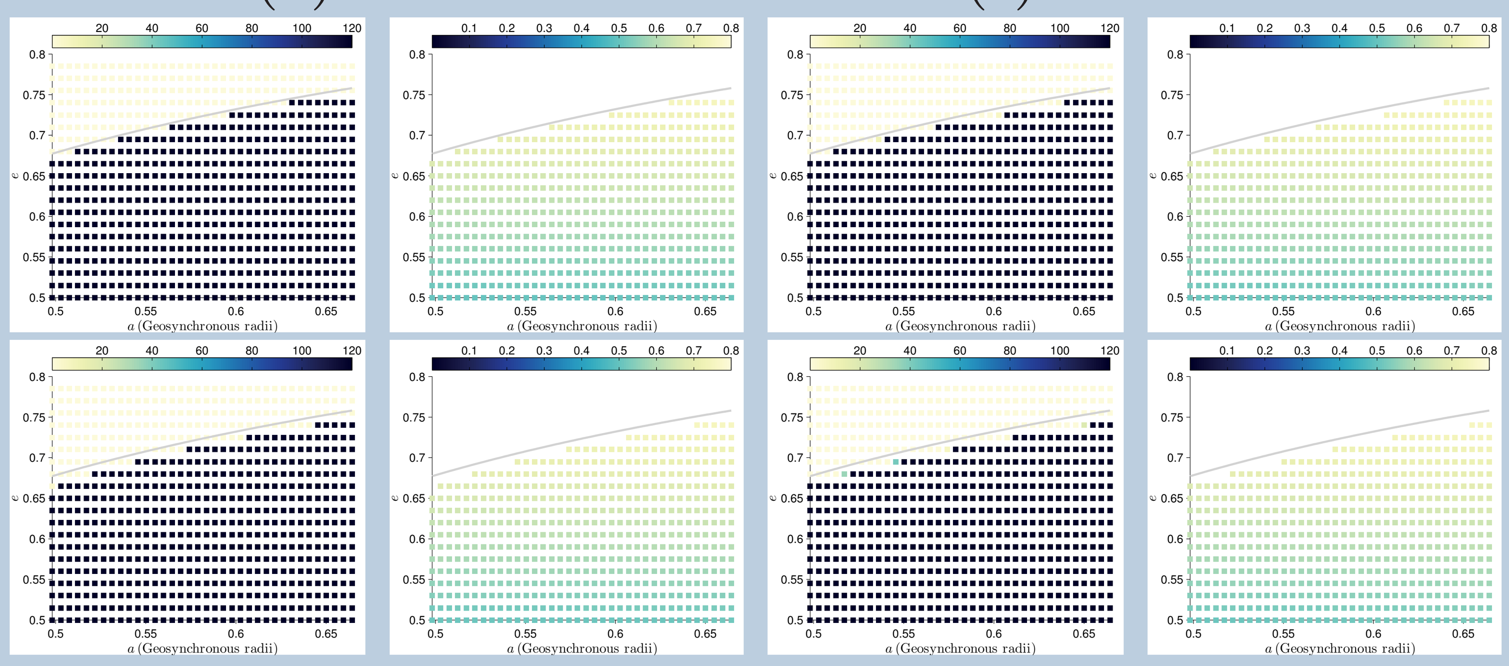
Figure 1: Lifetime (left) and sup-e maps (right) for SRP$_1$ (top) & SRP$_2$ (bottom).

- Re-entry solutions feasible, but not for $t < 25\ yrs$
- Enhanced A/m can widen the re-entry regions
- Results depend on secular orientation angles and epoch

Maps for GTO phase space

- $a \in [0.498 - 0.664]$ (a_{GEO}), $e \in [0.5 : 0.8]$
- $i = i_o \pm 10°$, $i_o \sim 5°$ (Kourou), $\sim 28°$ (KSC), $\sim 46°$ (Baikonur)
- $\Delta\Omega$, $\Delta\omega = \{0, 90°, 180°, 270°\}$ w.r.t. ecliptic values of Moon

(*a*) **i = 5°** (*b*) **i = 28°**



(*a*) **i = 46°** (*b*) **i = 56°**

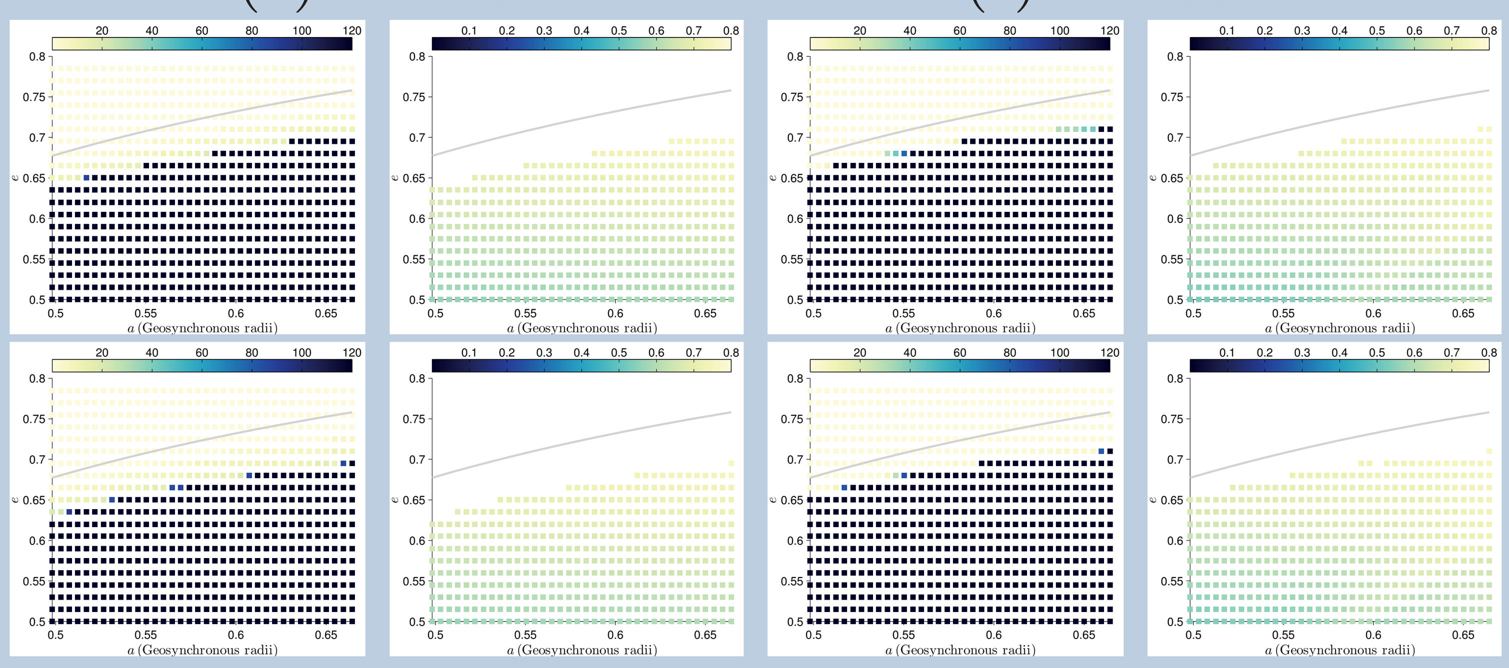


Figure 2: Lifetime (left) and sup-e maps (right) for **ΔΩ = 90°**, **Δω = 0** and SRP$_1$ (top) & SRP$_2$ (bottom).

- SRP is not very important, but helps
- Re-entry is easier at high inclinations

Conclusions - Future work

GNSS:

- Re-entry times of 40 − 60 yr feasible
- Design of maneuvers to reach the optimal diposal orbit for each initial operational orbit

GTO:

- Enhanced SPR is not enough for natural re-entry
- Atmospheric drag may help - need to check

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http://redshift-h2020.eu/