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ON THE ORBIT CONTROL OF NEAR REPEAT CYCLE ORBITS: THE CASE OF THE BIOMASS MISSION

Abstract

Repeat cycle orbits are orbits characterised by a fixed ground-track, i.e, spacecraft in these orbits, after a fixed number of revolutions, fly over the same location on Earth. By comparison, near repeat cycle orbits are orbits whose ascending node at the end of the cycle does not exactly match the location of the ascending node at the beginning of the cycle. Since the difference between the initial and final ascending nodes accumulate with each cycle, we can say that these orbits have a drifting ascending node. This work addresses the particular characteristics of near repeat cycle orbits and discusses the unexpected consequences for the orbit control of BIOMASS.

BIOMASS is a mission from the European Space Agency (ESA) that will measure the amount of biomass and carbon stored in the forest. This mission will provide key information about the carbon cycle and will allow to better understand the impact of human activity on the Earth system. BIOMASS will be the first spacecraft equipped with a P-band synthetic aperture radar (SAR) and will provide the backscattering coefficients for each of the different linear polarizations. By observing the same area of forest from different angles (i.e. baselines), the interferometric correlation between each of the acquisitions can be computed and used to derived accurate quantification of the biomass. Moreover, tomography methodologies will be applied to the SAR measurements to derive complete information about the vertical structure of the forest. To satisfy the different science needs during the mission, two nominal phases are defined: i) tomographic phase (TOM) used to build a baseline stack of interferometric observations and reconstruct the scattering of the vegetation as a function of height; and ii) interferometric phase (INT) used to compute the forests biomass.

BIOMASS will fly in a frozen eccentricity, dawn-dusk, near repeat cycle orbit and it will take advantage of the resulting ascending node drift to generate the observation baselines with the geometry necessary for the P-band interferometric calculations. The reference orbit is characterized by a repeat cycle of 3 days and a cycle length of 44 orbits, which corresponds to 14+2/3 revolutions per day. To reach global coverage, BIOMASS combines measurements of three sub-swaths. During the TOM phase, seven measurements are performed using sub-swath 1, followed by seven using sub-swath 2, and another seven using sub-swath 3. Since the repeat cycle of the reference orbit is 3 days, 3 days after an observation, approximately the same scene is observed but from a position slightly drifted westwards. After the measurements using the 3 sub-swaths, a satellite repositioning manoeuvre (SRM) is performed, so that, the next measurement cycle uses sub-swath 1 to observe the areas adjacent to the last measurements with sub-swath 3. While the measurement stack during the TOM phase is comprised of seven observations, in the INT phase, the measurement stack is composed of three observations with each sub-swath.

In this paper, we demonstrate that, after a full cycle, the distances between the ascending nodes consecutive in longitude of a near repeat cycle orbit are not constant. For this reason, the total equatorial

distance to be observed by the instrument needs to be larger than the Earth's circumference divided by the cycle length of the reference orbit (in this case 44 orbits). Moreover, we show that, by performing orbit maintenance manoeuvres with the same periodicity as the orbit cycle, we can achieve a much tighter ground-track control than using a classical approach. Finally, the necessity of performing SRMs with a duration that is a multiple of the repeat cycle is discussed and its advantages are highlighted.