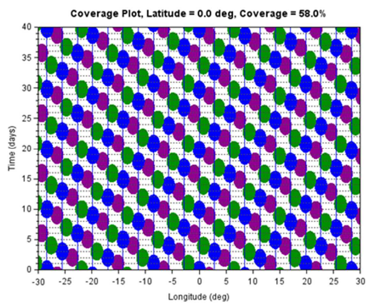
Satellite Constellations for Altimetry

Alain Lamy[1], Josiane Costeraste[1]
[1]*CNES (Centre National d'Etudes Spatiales), Toulouse, France*
Alain.Lamy@cnes.fr

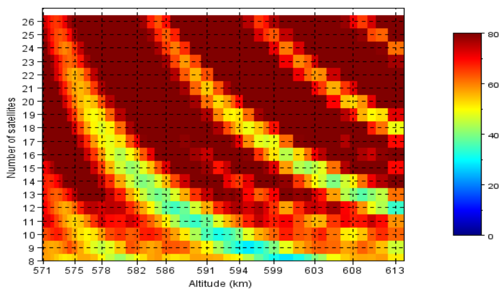
Keyword : satellite constellations, coverage, revisit time, altimetry

The framework of the analysis presented in this paper is the improvement of altimetry services in the 2020-2025 time frame by a better time and space coverage of the Earth (or rather ocean) surface. The typical expected revisit time is 3 days for ocean structures of size typically equal to 50 or 100 km.
Two possible instrument types are considered: nadir altimeter (Jason-like) or swath interferometry (SWOT-like). Both are treated in the same way through an "equivalent swath", so that the methods developed are not limited to only altimetry.
This paper focusses on the definition of satellite constellations that meet the requirements (maximizing coverage), while minimizing the number of satellites and orbit planes. The orbits that are considered are circular repeat orbits, sun-synchronous or not, possibly the same as used by some of the current altimetry missions.

The first step consists in calculating the performance of the constellation.
The criterion is based on a coverage map in the longitude-time plane (at a fixed latitude). Each pass is represented as an ellipse of (minor and major) axes DL and DT, with DL= "equivalent swath" size and DT = desired revisit time.
The criterion is obtained from the empirical distribution function considering all weighted results (at all considered latitudes). The aim is to have a coverage value of 80% with a "probability" of at least 0.8.



One major difficulty is the number of parameters that have to be determined. However, simpler problems can be more easily solved. For instance, for only one plane and equally spaced satellite positions, the performance is function of altitude (or repeat orbit parameters) as shown in the right figure. So by choosing altitude adequately, the number of satellites can be minimized. But this solution may not be the optimal one.



The paper details the sensitivity analysis that was conducted to assess the effects of various factors: position of ground tracks, number of orbit planes, variation of the results over time, etc... One interesting result concerns the number of different inclinations. As a matter of fact, an orbit with a smaller inclination is more efficient to cover low latitudes. But a simple evaluation based on the number of passes shows that a gain of about 10% only is to be expected on the number of satellites with several planes compared to only one. This was also proved by a more realistic simulation.

In order to find the best satellite configuration, optimization of the geometry is done using genetic algorithms. The optimization works quite well thanks to the simple enough criterion used, even with a population of limited size. The way the algorithms have been implemented (using Scilab) will be shown, as well as the results that have been obtained.