# Lab 2: Altimetry over the oceans

The **Ocean Surface Topography Mission/Jason-2** satellite was a NASA/CNES/NOAA/ EUMETSAT altimetry mission designed to take over and continue the sea surface height (hereafter SSH) measurement of the TOPEX/Poseidon and Jason-1 missions. The satellite was launched on 06/20/2008 and ended its science mission on 10/01/2019. To ease the data flow continuity, Jason-2 has been transferred on the same nominal orbit as Jason-1 and TOPEX/Poseidon, with an altitude of 1336km and an inclination of 66.15°, leading to a **repeat cycle** of 9.9156 days. During each repeat cycle, the satellite makes 127 revolutions around the earth, each being divided into an **ascending pass** and a **descending pass**. The passes are numbered from 1 to 254 representing a full repeat cycle of Jason-2 ground-track. In other words, the satellite revisits the same ground-track within a margin of ±1km every 9.9156 days. In this lab, we will examine and process data collected along the same pass off the coast of Japan for cycle 92 to 103.

## Part I: determination of the SSH along-track

a) Download the MATLAB files `J2_data.mat` and `J2_header.mat` from *Ilias*. All the heights and correction in `J2_data.mat` are given in meter.

b) For each pass, compute the corrected range given by:

$$\begin{aligned}\text{corrected range} = \text{range} &+ \text{wet troposphere correction}\\ &+ \text{dry troposphere correction}\\ &+ \text{ionosphere correction}\\ &+ \text{sea state bias correction}\end{aligned}$$

What is the typical order of magnitude of the whole range correction?

c) What is the equation defining the SSH (see Fig.1)? Compute the SSH accordingly and remove all the obvious outliers by `NaN`.

d) In order to obtain a SSH independent of geophysical effects such as the tides, atmospheric pressure variations and wind, their contribution to SSH must be removed. Apply therefore the following correction:

$$\begin{aligned}\text{corrected SSH} = \text{SSH} &- \text{solid earth tide height}\\ &- \text{geocentric ocean tide height}\\ &- \text{pole tide height}\\ &- \text{inverted barometer height correction}\\ &- \text{HF fluctuations of the sea surface topography}\end{aligned}$$

Plot one corrected SSH along-track with the function `plot_along_trak`.

e) As mentioned earlier, the ground-tracks of successive cycles do not exactly overlapp. It is therefore necessary to "align" the different ground-tracks on the same reference track if the SSH successively estimated are to be compared. Here, we take the ground-track of cycle 102 as the reference ground-track. Use the MATLAB function `spline` to interpolate on this reference track the longitude of the aligned points, associated to each measurement point on the other ground-tracks as illustrated on Fig.2.

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f) We define a curvilinear coordinate $u$ as the distance along the reference ground-track from the first measurement point to a given point. For the sake of simplicity, we assume that the ground-track follows a geodesic between 2 successive measurement points. Use the function `distance` to compute the curvilinear coordinate of all the measurement points.

g) Plot on the same graphic the SSH of all cycles as a function of $u$

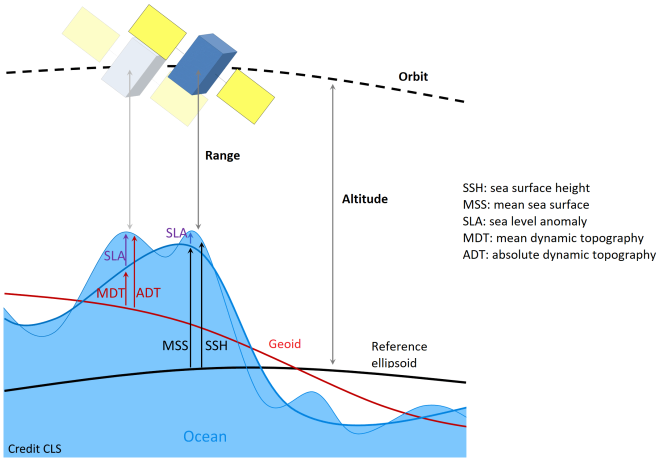


Abbildung 1: illustration of the different heights encountered in oceanography and altimetry.

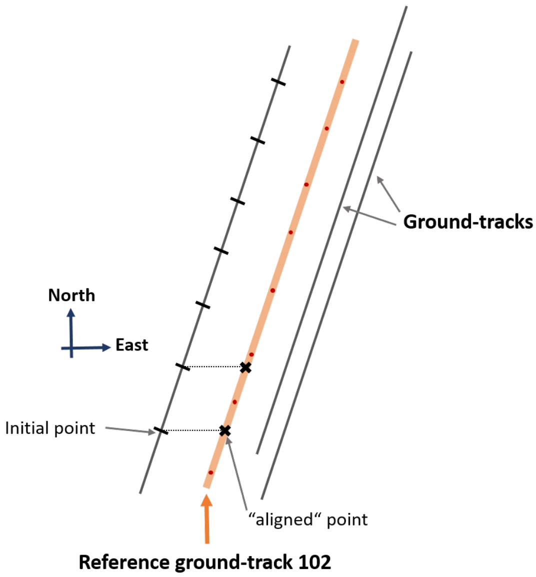


Abbildung 2: Principle of the ground-track "alignment".

## Part II: computation of the along-track gravity anomaly

a) If the absolute dynamic topography is negligible (e.g. no wind on the surface, no oceanic currents), what quantity is then represented by the SSH?

b) Compare the SSH to the bathymetry along the ground-track of cycle 102. Comments?

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c) To compute the gravity anomaly in the along-track direction $T_u = \frac{\partial T}{\partial u}$, we will use Brun's formula:

$$T = N\gamma \tag{1}$$

where $T$ is the disturbing potential, $N$ the geoid height and $\gamma$ the normal gravity. To simplify the computation, we will assume $\gamma = 9.795\mathrm{m/s}^2$ is a constant. Give the expression of $T_u$.

d) Compute for all cycles the gravity anomaly component in the along-track direction. Use in particular the function `SGF_smoothdiff` with order $= 3$, framelen $= 19$ to compute smoothed version of the SSH and its derivatives.

## Parameter

| | |
|---|---|
| semi-major axis | $a = 63781363\,\mathrm{m}$ |
| flattening | $f = 1/298.257$ |

Date of issue: *28 . 11 . 2019* Due date: ***12 . 12 . 2019***

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