Present Mean Sea Level indetermination coming from ITRF Reference Frame uncertainties on TOPEX/DORIS orbits

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Summary:

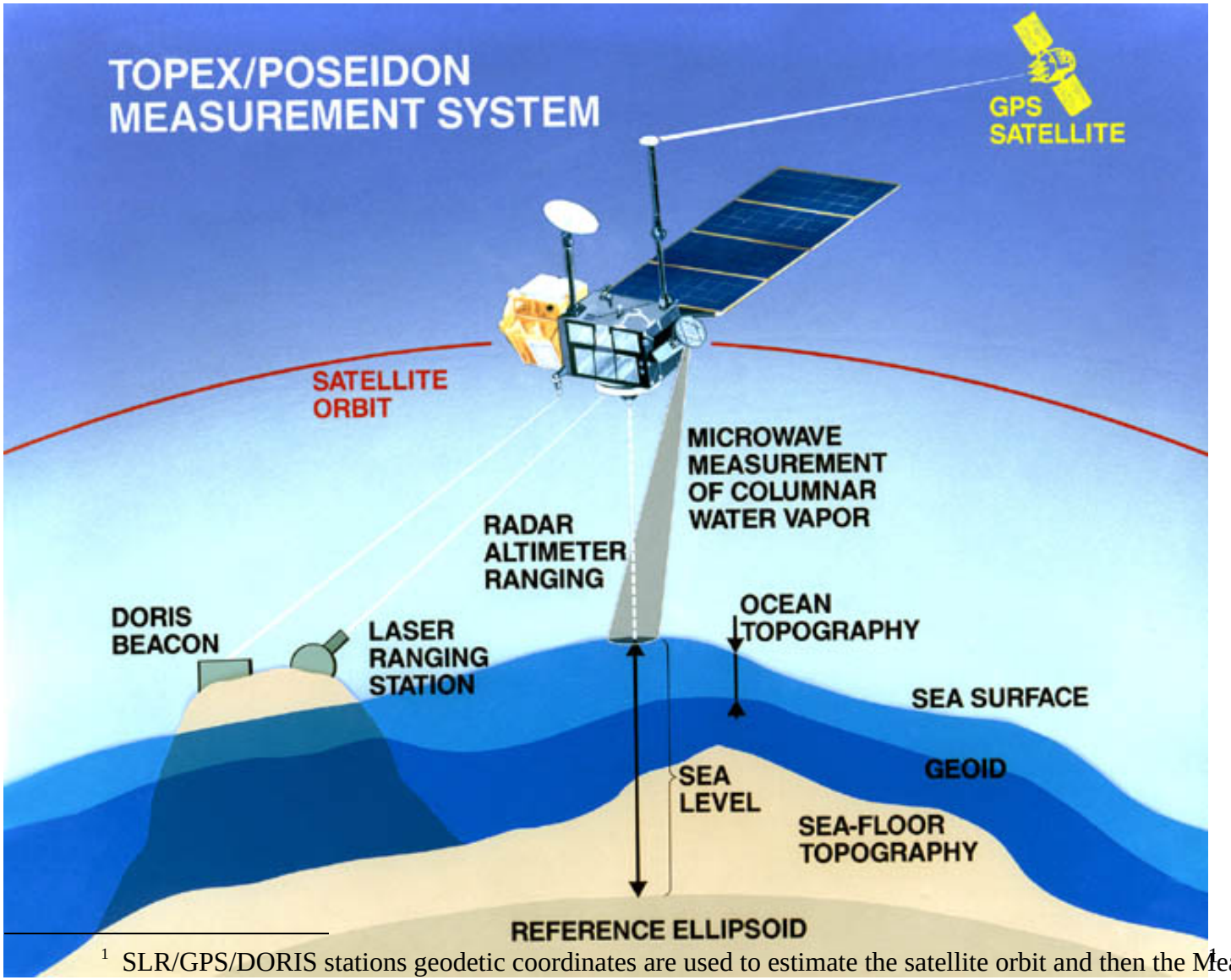
Satellite altimetry missions, such as TOPEX/Poseidon and JASON are key tools for monitoring global Mean Sea Level. Possible long-term rise of the Sea Level has drastic consequences on human activities as a large number of people are living close to the sea coasts. It is also important to evaluate precisely the related error budget.

To determine Mean Sea Level, scientists use radar altimetry measurements in connection with precise knowledge of the orbit of the satellites in a global terrestrial reference frame. These satellites orbits are obtained using different tracking measurements (SLR, DORIS and GPS in the case of TOPEX/Poseidon and JASON) as well as precise knowledge of tracking stations geodetic coordinates.

However, these stations coordinates are not perfectly known. Current accuracies are usually assumed to be of the order of a few millimeters to a couple of centimeters. The goal of this poster is to investigate the effect of present indetermination of each individual tracking stations coordinates on the derived Mean Sea Level. This is only a part of the total error budget as other errors come from radar measurements noise and also orbital error sources.

Main results:

Present indetermination of Mean Sea level coming from best estimate of station geodetic coordinates (ITRF2000) is about **0.2 millimeter**. However, this indetermination will slowly grow in the future (0.7 millimeter in 2010), unless a new ITRF realization is used for precise orbit computation.



[1] SLR/GPS/DORIS stations geodetic coordinates are used to estimate the satellite orbit and then the Mean Sea Level

International Terrestrial Reference Frame (ITRF)

ITRF stations

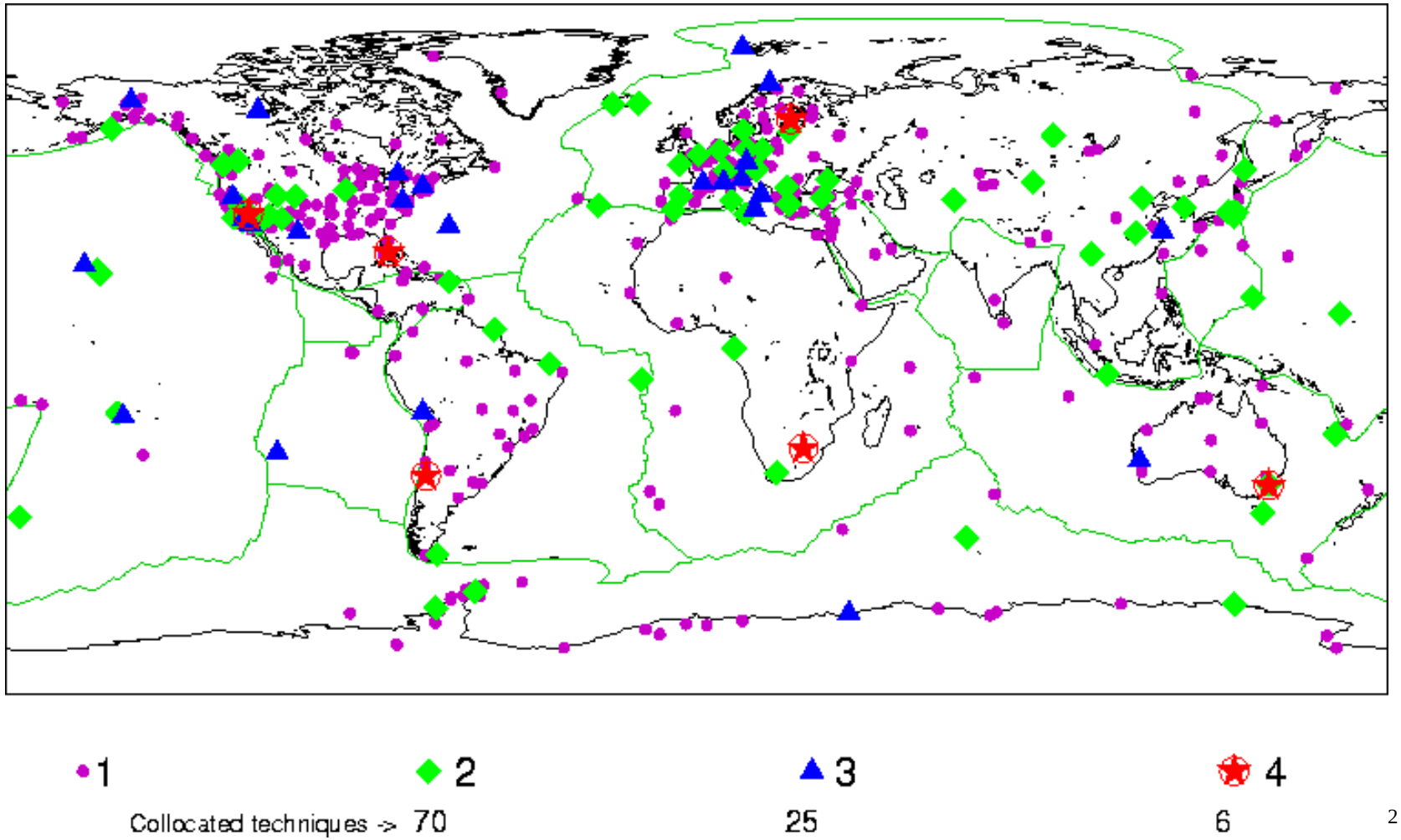
ITRF stations are fundamental geodetic stations equipped with specific instruments of observation (VLBI antenna, Laser Observatory, GPS or DORIS permanent tracking stations). The figure above describes the current ITRF network, distinguishing the number of geodetic instruments per site (called collocations). More observing techniques provide a better accuracy as well as a better integrity.

History and Goals of ITRF

Since 1988, the International Earth Rotation Service has been computing stations coordinates and velocities (to take into account global plate tectonics) of ITRF sites on a yearly basis. This is only possible through a world-wide international scientific cooperation of fundamental geodetic observatories, geodetic archiving data centers and a large number of analysis groups to make full profit of all exiting satellite geodetic data present and past.

Current precision of ITRF coordinates

The latest version of ITRF is ITRF-2000, which is used for a wide variety of applications: from coordinates of satellite altimetry tracking stations to national primary geodetic networks. The present estimated accuracy of ITRF coordinates is about 2 to 5 millimeter for the best stations in position and 1 to 2 millimeter per year in velocity. However, due to the uncertainty in the velocity determination, coordinates error will tend to grow in the future (as it will be an extrapolation using data from the past).



(current ITRF2000 map was obtained courtesy of Zuheir Altamimi –IGN/France, http://lareg.ensg.ign.fr/ITRF)

[2] International Terrestrial Reference Frame (ITRF) network showing collocations of VLBI, SLR, GPS, DORIS techniques

Description of the study

1) estimate the effect of 1 station error on derived Mean Sea Level

For each DORIS station and each component (longitude, latitude, height), we have estimated a transfer function f_i in the case of TOPEX/Poseidon, by looking at the effect of a station error on the orbit first and then on the derived Mean Sea Level:

$$\text{Mean Sea Level error} = \sqrt{\sum_{i=1}^{n} (\text{f\_latitude}_i * \text{latitude\_error}_i)^2 + (\text{f\_longitude}_i * \text{longitude\_error}_i)^2 + (\text{f\_height}_i * \text{height\_error}_i)^2}$$

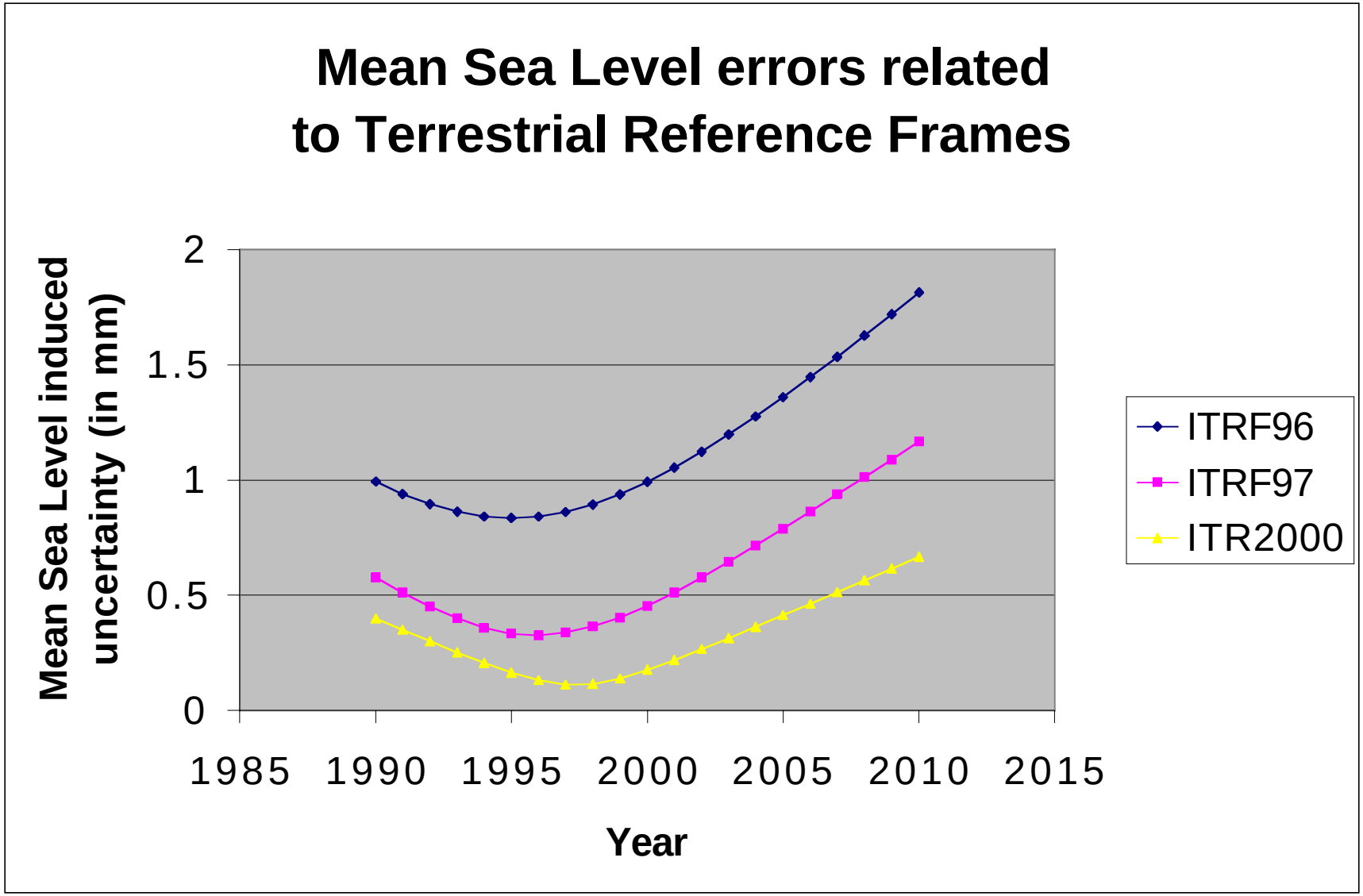
In the case of DORIS, stations whose latitude were closer to the TOPEX inclinaison had larger transfer functions. These stations provide the larger amount of observations due to their specific geometry towards the satellite and have a larger influence of the satellite orbit errors.

2) estimate the accuracy of ITRF2000 at different epoch (from 1990 to 2010)

The ITRF coordinates and velocities are given with a full variance matrix. It is then easy to predict the uncertainty in position at any different epoch by propagating the variance matrix.

3) estimate the Mean Sea Level uncertainty due to ITRF2000 coordinates at different epochs

Apply the above formula to errors estimated in step 2 and quadratically sum the effects of each individual station.


Mean Sea Level errors related to Terrestrial Reference Frames
Mean Sea Level induced uncertainty (in mm)
2
1.5
1
0.5
0
1985
1990
1995
2000
2005
2010
2015
Year
ITRF96
ITRF97
ITR2000