An inverse modeling estimate of the geoid height in the Atlantic

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INTRODUCTION

Several models of the geoid have been developped by the geodesy community which are based on the use of satellite tracking data, supplemented by crude information on the ocean circulation derived from low resolution climatologies of the ocean. An alternative approach to estimate the geoid height over the ocean is to subtract the dynamic topography estimated by a general circulation model from the sea surface height observed by satellite altimeters. This ocean modeling approach is known to yield improvements of geoid height estimates at small spatial scales but to result in inconsistencies with geopotential models at larger spatial scales. One way to overcome this problem is to combine the oceanographic information contained in general circulation models with the information contained in geopotential models using an inverse methodology. This approach, which differs from the approach of geodesists in its stronger emphasis on prior knowledge on the ocean circulation, is applied to the estimation of the geoid height in the Atlantic Ocean using the finite difference inverse model of the Laboratoire de Physique des Oceans (LPO).

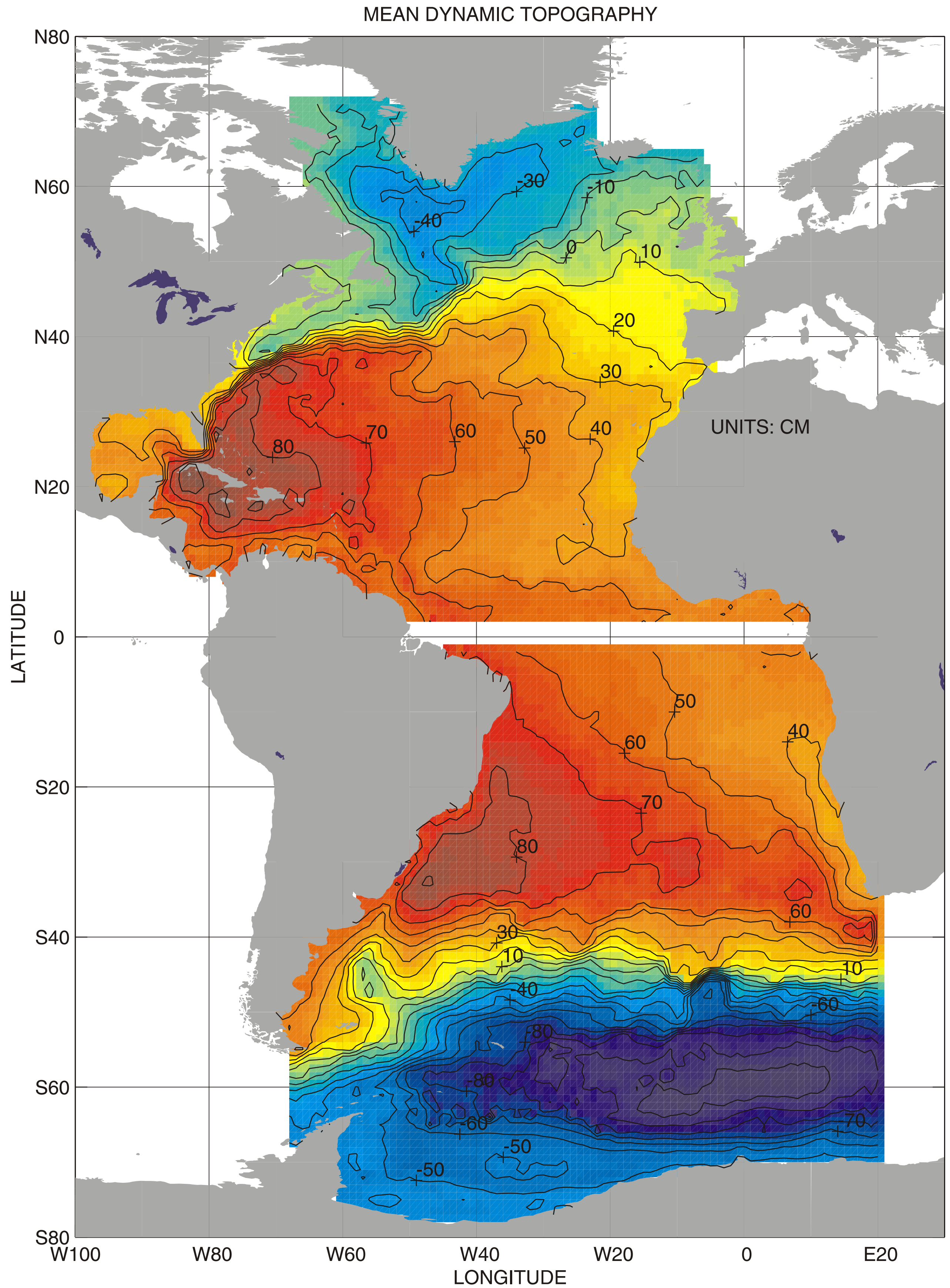

Figure 1: Mean dynamic topography estimated in the Atlantic with a 1 degree resolution version of the LPO inverse model based on a combination of in situ data and the EGM96-TOPEX/POSEIDON estimate of the mean dynamic topography.

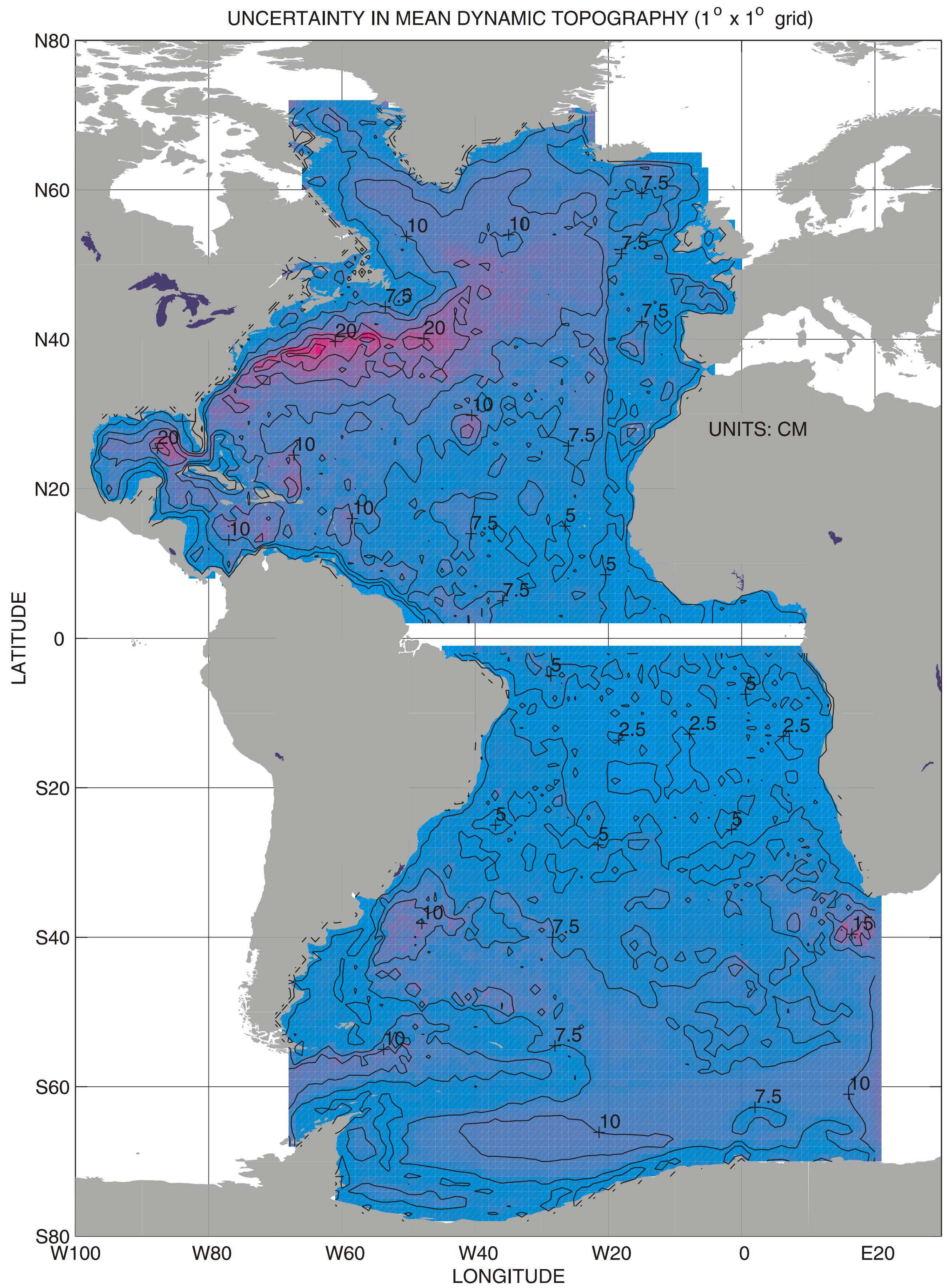

Figure 2 : Uncertainty in the inverse estimate of mean dynamic topography presented in Figure 1.

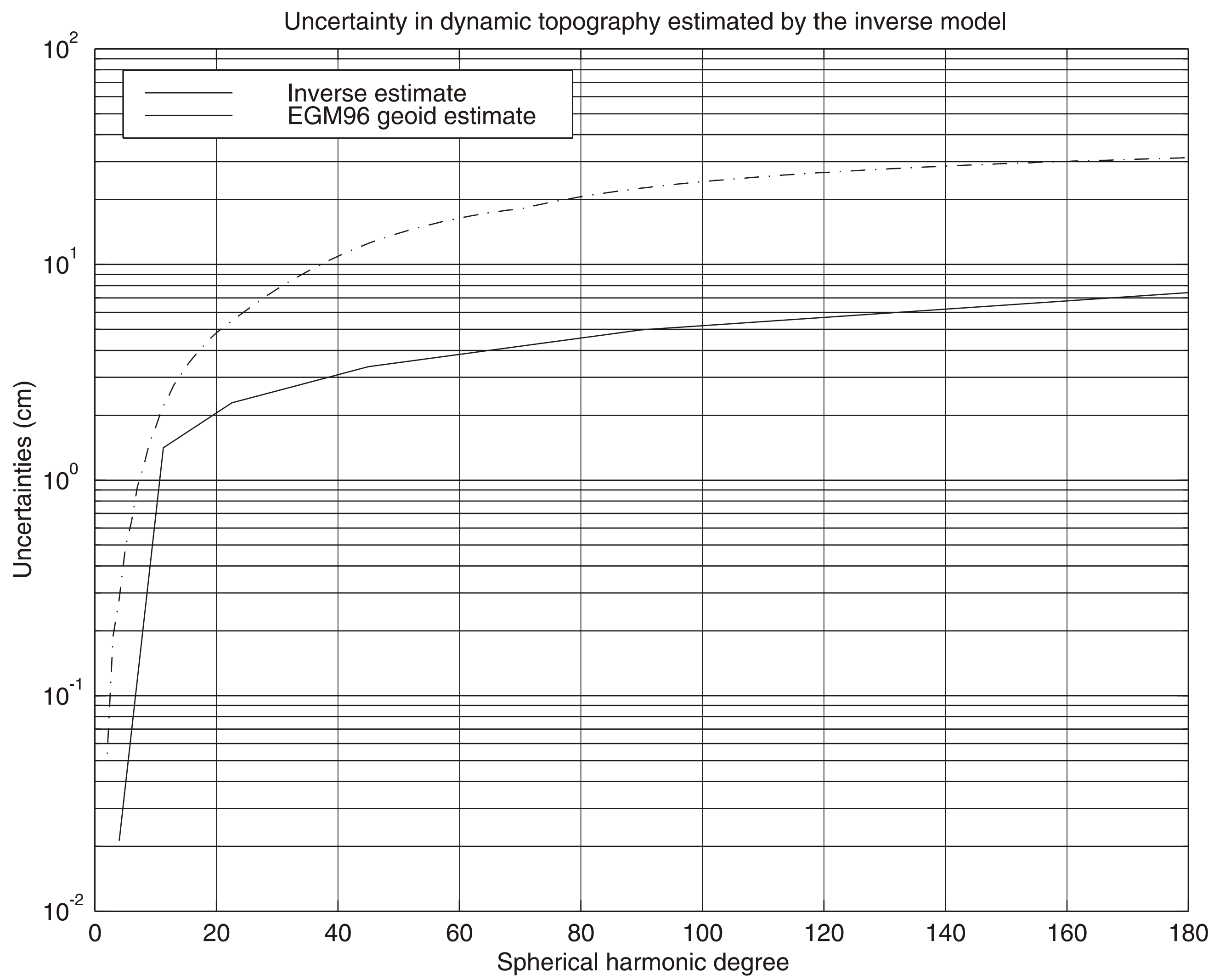

Figure 3: Uncertainty in the inverse estimate of mean dynamic topography as a function of spatial scale (presented in terms of spherical harmonic degree).

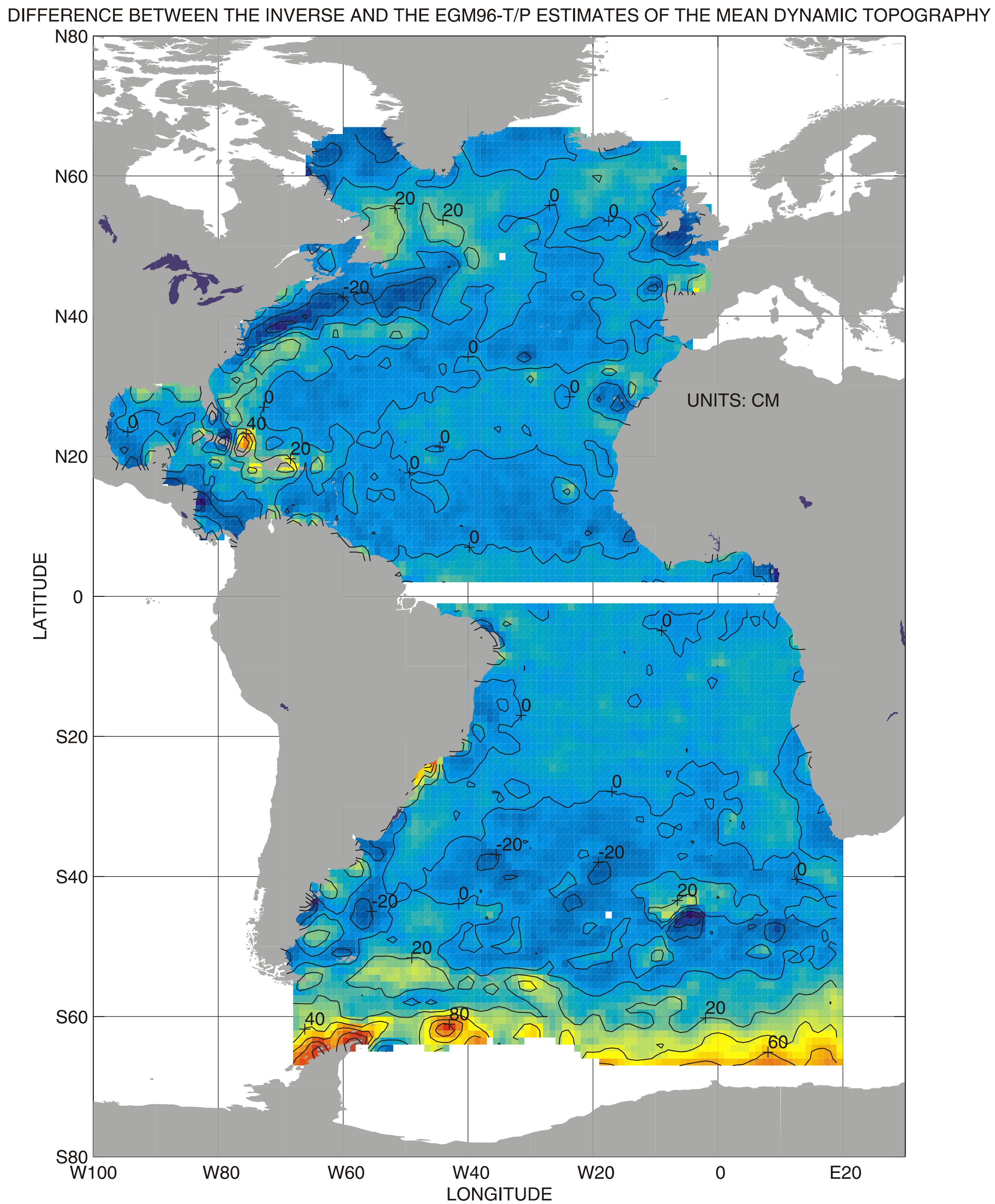

Figure 4: Difference between the inverse estimate of mean dynamic topography and an estimate based on EGM-96 and T/P altimetric data.

RESULTS

The mean dynamic topography of the surface of the Atlantic is estimated by the inverse model constrained by hydrographic observations and a prior estimate of the mean dynamic topography derived from altimetry and the EGM-96 geoid model. The inverse topography estimate is consistent with oceanographic observations and ocean dynamics. It is also consistent with the EGM-96 geoid model everywhere except in the Circumpolar Current. Indeed, the contraint provided by the EGM-96 model produces transports that are too small in the Drake Passage. Except for this local discrepancy, which may be due to a local underestimate of the errors in the EGM-96 model, the solution estimated by the inverse model is consistent with the geopotential model at all spatial scales, including large spatial scales. The uncertainty in the inverse estimate of the mean dynamic topography is of the order of 10 cm at spatial scales of 1 degree, 3 cm to 4 cm at spatial scales of 4 degrees, and tends to the very small uncertainties of EGM-96 at larger spatial scales. The uncertainty of the geoid model which can be derived by subtracting the inverse estimate of dynamic topography from an altimetric estimate of the sea surface height would be limited by the uncertainty in the inverse estimate of dynamic topography, but also by the uncertainty in the altimetric mean sea surface height.

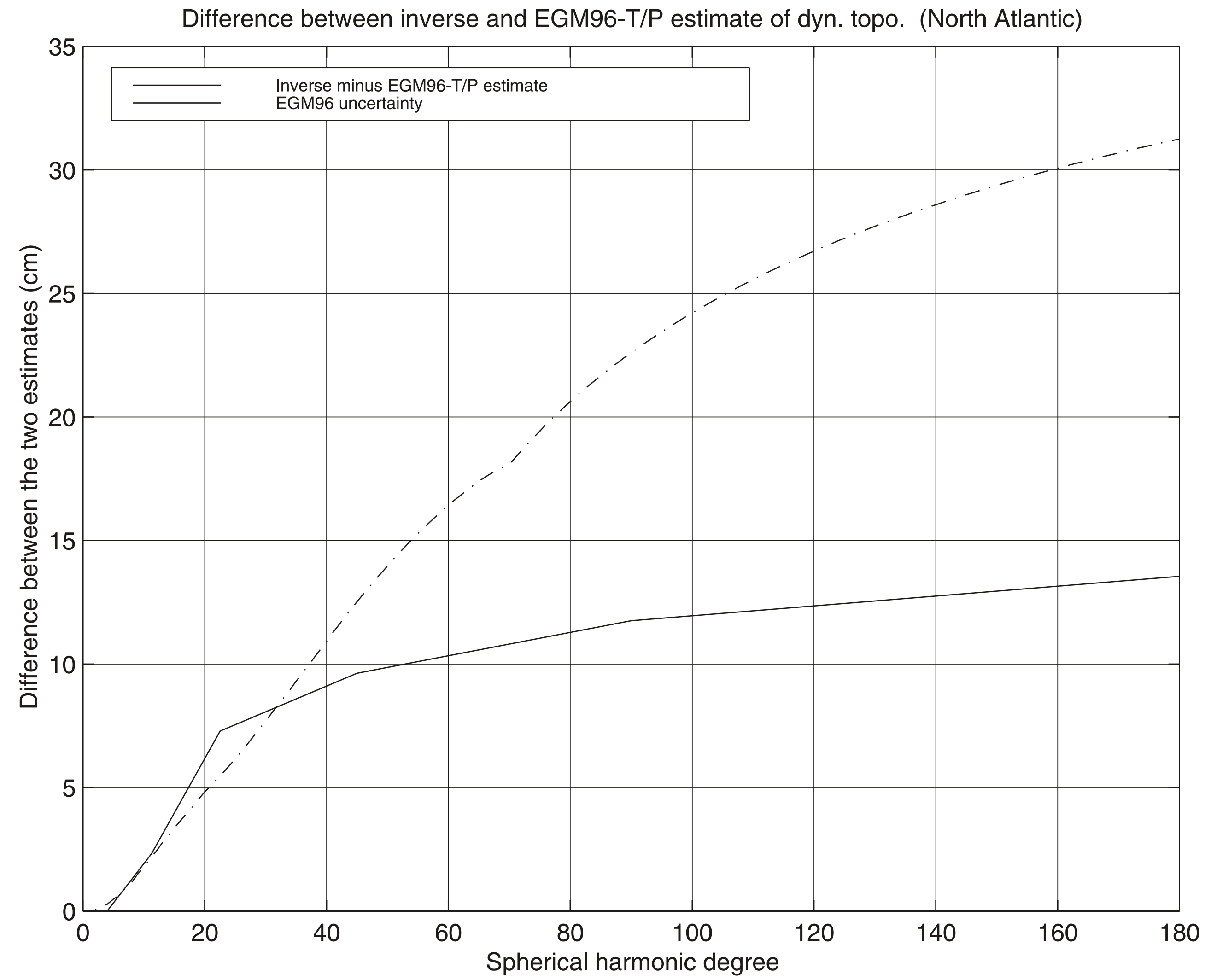

Figure 5: Difference between the inverse estimate of mean dynamic topography and an estimate based on EGM-96 and T/P altimetric data as a function of spatial scale.