How much water does the ocean have?

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The calculation of variations in the sea level is relatively simple. It is by far more complicated to then determine the change in the water mass. A team of geodesists and oceanographers from the University of Bonn, as well as from the GFZ German Research Centre for Geosciences and the Alfred-Wegener Institute for Polar and Marine Sciences, two centres of the Helmholtz Association, have now, for the first time succeeded in doing this. The researchers were able to observe short-term fluctuations in the spatial distribution of the ocean water masses. Their results are, amongst others, important for improved climate models.

In order to determine the ocean volume in a certain region, one only needs to know, in addition to the topography of the seabed, the height of the sea level. For this purpose, researchers have long been resorting to gauging stations and satellite altimetric procedures. The ocean mass depends, however, not only on the volume, but also on the temperature and on the salt content. Water expands when heated. Warm water, thus, weighs less than the same quantity of cold water.

For the calculation of the ocean mass it is, therefore, necessary to know the temperature and salt content profiles. However, this is not easy to quantify. "For our study we, therefore, combined different procedures so as to be able to judge changes in mass", explains Professor Dr. Juergen Kusche. The geodesist from Bonn is co-author of a scientific paper, which has just been published in the Journal of Geophysical Research.

On the one hand the researchers used data from the German-American satellite mission GRACE where the distance between two satellites

(popularly known as Tom and Jerry as one chases the other in the same orbit) are measured exactly to thousandths of millimetres. The larger the ocean mass at a certain point of the Earth, the stronger the gravitational strength. This influences the flight altitude of the satellites and thus the distance from each other. The gravitation and, hence, the mass distribution can be calculated from the change in distance between the two satellites.

The seabed bends under the weight of the water

In addition, the scientists put to use an effect which frequent book readers will have perceived. The ocean floor bends similarly to that of the shelves of an overfilled bookshelf. Thus, stationary GPS-gauging stations on land drop by up to one centimetre and move closer by a few millimetres. The heavier the water, the stronger is this movement.

"We combined these data with numerical models of the ocean" explains Kusche. "In this way we were able to prove, for the first time, that in particular in the higher latitudes, significant fluctuations of the water mass occur, and that this takes place within a time period of only one to two weeks".

So far one only knew that the mass of the world-wide ocean water varies seasonally by on average approximately three quadrillion kilogrammes (a quadrillion equals to 1 followed by 15 zeroes) - that implies a sea level variation of approx. seven to eight millimetres. This effect is brought about, among others, by variations in precipitation and evaporation as well as by the storage of water as snow. But, also, the melting of the glaciers and the ice masses in Greenland and in the Antarctic play a role.

By comparing the variation in volume and in mass the researchers want to determine changes in the amount of heat stored in the ocean. Therefore, in the near future, the long term changes are to be examined.

The results will contribute to improved climatic models.

An urgent wish of the scientists is the realisation of a punctual follow-up mission for the satellite tandem GRACE. Otherwise the valuable information, particular in the registration of trends in the Earth system, obtained through GRACE, cannot be used to its full potential for Earth System and climate research.

Source: Helmholtz Association of German Research Centres (news : web)