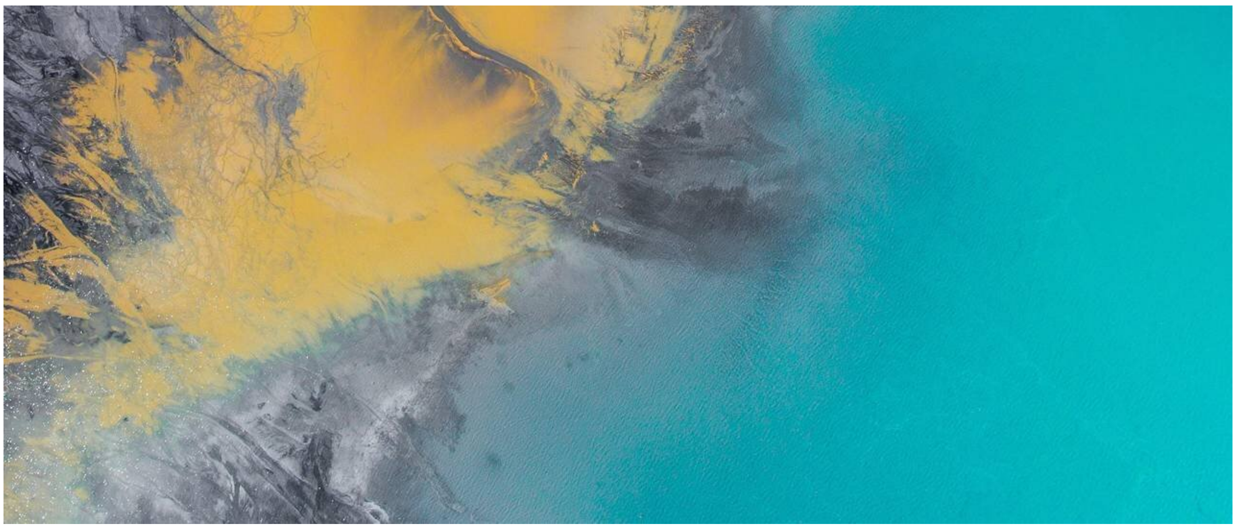
The same sea level for everyone

March 23 2021



With the help of satellite data, a hypothetical sea level can be calculated. Credit: Curioso Photography / pexels

Maps generally indicate elevation in meters above sea level. But sea level is not the same everywhere. A group of experts headed by the Technical University of Munich (TUM), has developed an International Height Reference System (IHRS) that will unify geodetic measurements worldwide.

How high is Mount Everest? 8848 meters? 8844 meters? Or 8850 meters? For years, China and Nepal could not agree. In 2019, Nepal sent a team of geodesists to measure the world's highest mountain. A year later a team from China climbed the peak. Last December the two governments jointly announced the outcome of the new measurement: 8848.86 meters.

The fact that both China and Nepal recognize this result must be seen as a diplomatic success. It was made possible by the new International Height Reference System (IHRS), used for the first time by the geodetic specialists conducting the new measurement. Scientists from TUM played a leading role in developing the new system. It establishes a generally agreed zero level as a basis for all future measurements. It thus replaces the mean sea level, which has traditionally served as the zero level for surveyors and thus for all topographical maps. A paper in the *Journal of Geodesy*, jointly authored by TUM scientists and international research groups, outlines the scientific background and theoretical concept of the IHRS as well as the strategy for implementing it.

When zero is not always zero

The standard used until now—the mean sea level—was flawed from the outset: There was never a fixed definition. Every country could use arbitrary tide gauges to define its own zero level. As a result, Germany's official sea level is 31 centimeters higher than Italy's, 50 cm higher than that used in Spain and actually 2.33 m higher than in Belgium, where the zero height is based on low water in Ostend.

When topographical maps are only used for hiking, no one is bothered by such differences. But for geodetics specialists trying to arrive at a universally agreed height—for Mount Everest, for example, half in Nepal and half in China—the inconsistent zero levels are a bigger problem. And it can be very costly when planners of cross-border structures such as bridges and tunnels forget to check the different coordinates used by the teams and convert them as needed. On the Hochrheinbrücke, a bridge connecting Germany and Switzerland, a discrepancy of this kind was noticed just in time.

Surveys from orbit

"The introduction of an internationally valid height reference system was long overdue," says TUM researcher Dr. Laura Sánchez of the Deutsches Geodätisches Forschungsinstitut (DGFI-TUM), who has headed working groups studying theoretical aspects and implementing the new global height reference system at the International Association of Geodesy for several years.

What is needed is obvious: a universally accepted zero level. The new International Height Reference System (IHRS) defines how it can be calculated: It takes into account the shape of the Earth—which is close to spherical, but flattened at the poles and bulging slightly at the equator due to its rotation—and the uneven distribution of masses in the interior and on the surface. The resulting irregularities in the gravity field are the basis for calculating the height system because the strength and direction of the force determine the distribution of water in the oceans. If we assume that the Earth's surface is completely covered with water, the height of a hypothetical sea level and thus the zero level for the entire globe can be calculated precisely.

In construction projects, even the smallest deviations can be crucial

"It became possible to realize the IHRS only with the availability of global data from satellite missions such as the ESA earth observation satellite GOCE (Gravity field and steady-state Ocean Circulation Explorer)," says Prof. Roland Pail of the TUM Chair of Astronomical and Physical Geodesy (APG). His team played an integral role in analyzing the GOCE measurements and using them to calculate global models of the Earth's gravity field. "The information gained in this way provides the basis to calculate the mean sea level for every point on

Earth with the new International Height Reference System, regardless of whether it is on a continent or in an ocean, and thus to compute the internationally accepted zero level," explains Sánchez.

Does every map have to be redrawn? "It won't be that dramatic," says Sánchez. "In the industrial countries, where they have been making gravity measurements for decades, the deviations are quite small—only in the decimeter range." But with construction projects, for example, even small deviations can cause serious troubles. Consequently, the scientist is confident that the new reference system will gain acceptance quickly.

More information: Laura Sánchez et al, Strategy for the realisation of the International Height Reference System (IHRS), *Journal of Geodesy* (2021). DOI: 10.1007/s00190-021-01481-0

Provided by Technical University Munich