Geophysical Research Abstracts
Vol. 21, EGU2019-9177, 2019
EGU General Assembly 2019

Mediterranean sea-level changes from tide gauge and satellite altimetry data

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The Fifth Assessment Report (AR5) of the IPCC has established that the warming of the climate system is unequivocal, and that anthropogenic activities contribute to it. Sea level change is one of the essential indicators of global warming since the thermal expansion of the sea water is caused by the increase of the ocean heat content, and the melting of the ice sheets and glaciers turns into mass being added to the oceans. Indeed, sea level has been recognized by the Global Climate Observing System (GCOS) as one of the 50 Essential Climate Variables (ECVs) which are key for advancing climate research and for supporting decision makers in the public and private sectors. Therefore, monitoring trends and understanding the causes of sea-level change and variability are an issue of paramount importance for advancing contemporary scientific research. We have focused our study on the Mediterranean Basin, an area of major interest for historical and cultural reasons, prone to natural hazards, with a total length of coastline of about 46.000 km and 130 million residents living along the coast which might be endangered by rising sea level. There are mainly two techniques allowing to measure sea-level elevation, namely tide gauges and satellite radar altimetry. Tide gauges measure sea level relatively to a benchmark on land, hence these observations are affected by the vertical motions of the Earth's crust. Satellite radar altimetry provides absolute sea-level data which are referred to the Earth's center of mass and are independent of vertical movements of the land. To compare the outcomes of the analyses of these two different data sets, the vertical movements of the ground need to be removed from the tide gauge observations. We have retrieved, mainly from the Permanent Service for Mean Sea Level (PSMSL) the data of over 60 tide gauges distributed all over the Mediterranean. The minimum length of the sea-level time series is 16 years, starting from 1993 when also the satellite altimetry data became available. Vertical land motions, in close proximity of the tide gauge stations, were estimated from time series of GNSS data publicly available on the Nevada Geodetic Laboratory (NGL) Archive and from those of the DIFA network of the University of Bologna. The multi-satellite altimetry data analyzed are the gridded sea-level anomalies provided by the ESA's Climate Change Initiative (CCI) and the regional Duacs grids provided by the Copernicus Marine Environment Monitoring Service (CMEMS). The results of the two techniques indicate that, over the last couple of decades, the sea level in the Mediterranean has been rising between 2 and 4 mm/year.