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Monitoring the Ocean Heat Content and the Earth Energy imbalance from space altimetry and space gravimetry: the MOHeaCAN product

Marti Florence[1], Ablain Michaël[1], Fraudeau Robin[1], Jugier Rémi[1], Meyssignac Benoît[2], Blazquez Alejandro[2], Restano Marco[3], and Benveniste Jérôme[4]
[1]Magellium, Ramonville St Agne, France
[2]LEGOS, Toulouse, France
[3]SERCO-ESRIN, Italy
[4]ESA/ESRIN, Italy

The Earth Energy Imbalance (EEI) is a key indicator to understand climate change. However, measuring this indicator is challenging since it is a globally integrated variable whose variations are small, of the order of several tenth of $W.m^{-2}$, compared to the amount of energy entering and leaving the climate system of ~340 $W.m^{-2}$. Recent studies suggest that the EEI response to anthropogenic GHG and aerosols emissions is 0.5-1 $W.m^{-2}$. It implies that an accuracy of <0.3 $W.m^{-2}$ at decadal time scales is necessary to evaluate the long term mean EEI associated with anthropogenic forcing. Ideally an accuracy of <0.1 $W.m^{-2}$ at decadal time scales is desirable if we want to monitor future changes in EEI.

In the frame of the MOHeaCAN project supported by ESA, the EEI indicator is deduced from the global change in Ocean Heat Content (OHC) which is a very good proxy of the EEI since the ocean stores 93% of the excess of heat gained by the Earth in response to EEI. The OHC is estimated from space altimetry and gravimetry missions (GRACE). This “Altimetry-Gravimetry'' approach is promising because it provides consistent spatial and temporal sampling of the ocean, it samples nearly the entire global ocean, except for polar regions, and it provides estimates of the OHC over the ocean’s entire depth. Consequently, it complements the OHC estimation from the ARGO network.

The MOHeaCAN product contains monthly time series (between August 2002 and June 2017) of several variables, the main ones being the regional OHC (3°x3° spatial resolution grids), the global OHC and the EEI indicator. Uncertainties are provided for variables at global scale, by propagating errors from sea level measurements (altimetry) and ocean mass content (gravimetry). In order to calculate OHC at regional and global scales, a new estimate of the expansion efficiency of heat at global and regional scales have been performed based on the global ARGO network.

A scientific validation of the MOHeaCAN product has also been carried out performing thorough comparisons against independent estimates based on ARGO data and on the Clouds and the

Earth's Radiant energy System (CERES) measurements at the top of the atmosphere. The mean EEI derived from MOHeaCAN product is 0.84 $W.m^{-2}$ over the whole period within an uncertainty of ±0.12 $W.m^{-2}$ (68% confidence level - 0.20 $W.m^{-2}$ at the 90% CL). This figure is in agreement (within error bars at the 90% CL) with other EEI indicators based on ARGO data (e.g. OHC-OMI from CMEMS) although the best estimate is slightly higher. Differences from annual to inter-annual scales have also been observed with ARGO and CERES data. Investigations have been conducted to improve our understanding of the benefits and limitations of each data set to measure EEI at different time scales.

The MOHeaCAN product from "altimetry-gravimetry" is now available and can be downloaded at https://doi.org/10.24400/527896/a01-2020.003. Feedback from interested users on this product are welcome.