The Sea State Climate Change Initiative Project

the **Sea State CCI Team**[1]

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Sea states are the statistical properties of wind-waves : from the significant wave height (**swh**) to the full wavenumber-direction spectrum. Even without any long-term change, the **wave climate** is a key driver for the design of **ships**, offshore and coastal **structures**, and in the **implementation of sustainable coastal management programs.** Of particular interest are the **extremes** for design conditions. Waves are also an important geophysical quantity that affects **air-sea fluxes**, and **extreme sea levels** at the coast. Is the wave climate changing? What are the consequences for **low-lying islands** ? **Coral reefs**? **Sea ice**? For air-sea **gas fluxes** ? **Marine energy** ? What about corrections for other EO data ? Here is a summary of the main outcomes of the Sea State CCI project two years after its kick-off.

QUALITY ASSESSMENT OF THE SEA_STATE CCI DATASET V1.1

The first version of the sea state CCI dataset (CCI V1.1) was released in May 2019. This new product builds upon the Globwave effort and extends the time coverage up to 2018, including three recent altimeter missions (Jason-3, Saral, Cryosat-2), inter-calibrated against earlier reference missions. Data editing, uncertainty estimate and validation against in-situ measurements and model outputs have been carried out in a consistent manner for all altimeter missions. In addition, an adaptive filtering method based on Empirical Mode Decomposition (EMD) and wavelet thresholding has been implemented to swh in order to reduce noise at scales <100 km and to reveal important features of sea state variability. Comparisons against WW3 outputs forced with ERA5 wind fields highlight the good accuracy of the calibrated altimeter measurements, which still improves once denoising is applied (see Fig.1 and Dodet et al., 2020)

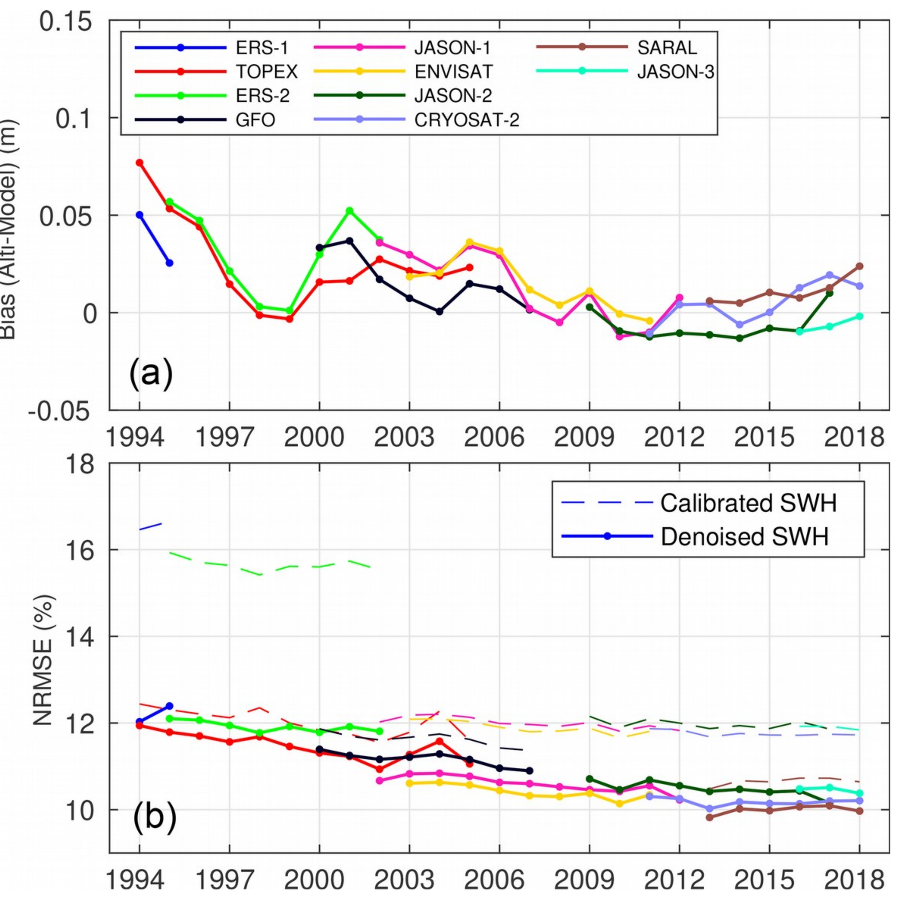

Figure 1. Time series of mean global bias (a) and mean global NRMSE (b) between Sea State CCI dataset v1 and WW3 model outputs forced with ERA5 wind fields. The thin dashed lines in (b) represent the results obtained for the calibrated SWH before denoising was applied.

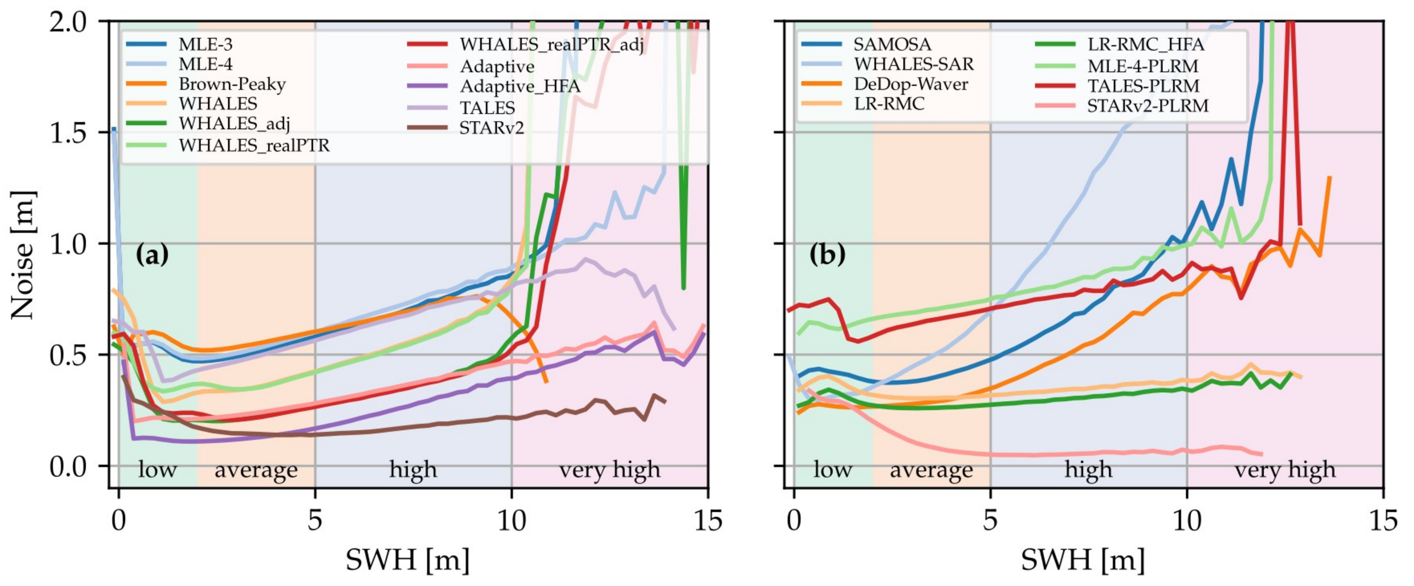

Figure 2. Noise level of the individual retrackers as a function of significant wave height (SWH) for (a) J3- and (b) S3A-retracking algorithms with the sea state noted at the bottom.

IMPROVED RETRACKING ALGORITHMS (LRM/DD)

In order to determine the best performing retracking algorithm for both Low Resolution Mode and Delay-Doppler altimetry, an objective assessment has been conducted in the framework of the Sea State CCI project (Fig. 2). Five different metrics are evaluated: percentage and types of outliers, level of measurement noise, wave spectral variability, comparison against wave models, and comparison against in-situ data. The metrics are evaluated as a function of the distance to the nearest coast and the sea state. The selected retracking algorithm for LRM and DD altimetry are currently implemented in the CCI system and the next release of the Sea State CCI dataset (V2) will include these new products. More information in Schlembach et al. (2020).

REFERENCE IN SITU DATASET FOR SEA STATE ALTIMETRY

Calibration and validation of satellite measurements require a high-quality reference in situ dataset. Nowadays, thousands of in situ stations are measuring wave parameters, mostly in the coastal zone of the northern hemisphere (Fig.3). However, not all stations are suitable for comparisons with satellite data. The distance to the coast, the depth of mooring, the measured quantities or the uncertainty on the positions are some of the parameters to be considered before selecting reference stations. Moreover, buoy hulls, payloads and data processing algorithms change over time, and often the changes through metadata are not well documented. The Sea State CCI project will therefore build up a reference dataset based on the large database constitued by the Copernicus Marine Environment Service In Situ Thematic Assembly Center.

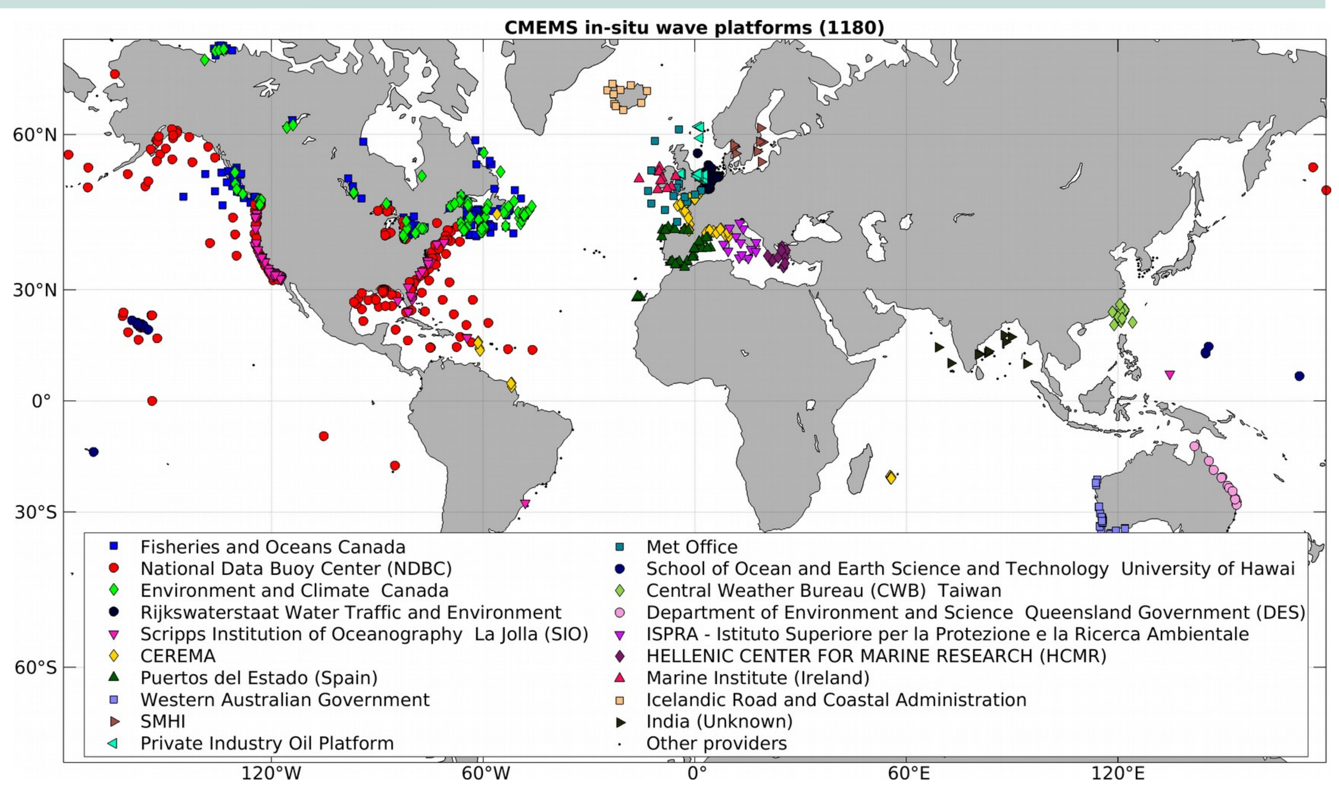

Figure 3. Location of the in situ wave measurements collected by the CMEMS in situ Thematic Assembly Center. The ranked 19 major data providers are indicated with symbols.

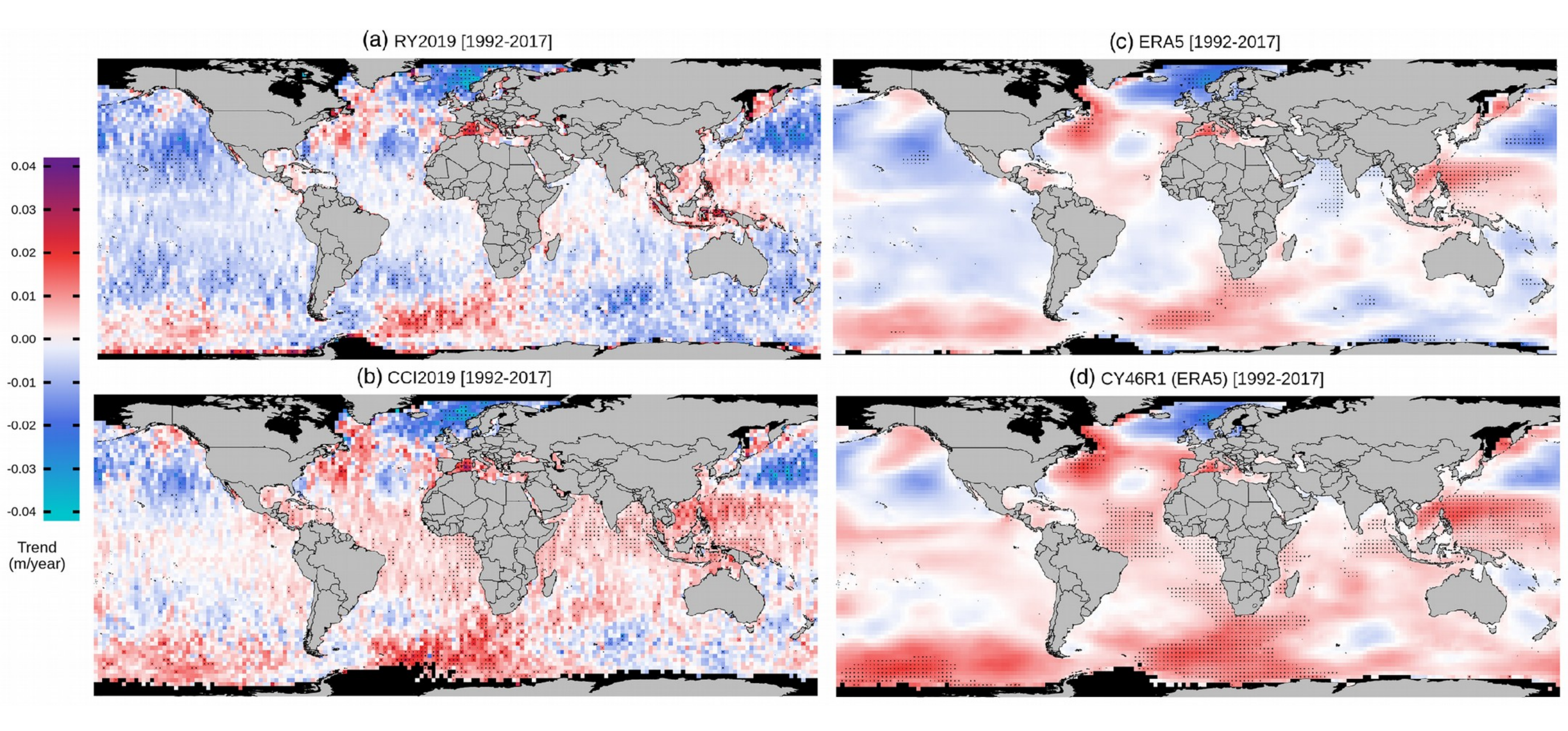

Figure 4. Figure 3. Global distribution of JFM mean Hs trend estimates on a 2 ◦ × 2 ◦ grid over 1992–2017 for (a) RY2019, (b) CCI2019, (c) ERA5, and (d) CY46R1. Dots indicate grid cells where the trend coefficient is significant at the 5% level..

COMPARISONS OF GLOBAL WAVE HEIGHT TRENDS

Figure 4 represents long-term global JFM swh trends from the CCI Level 4 dataset, intercompared with other high-quality sea state records. Overall, there is remarkable variability across datasets, although in all cases intra-dataset variability shows a high degree of spatial coherence. Trends from the CCI L4 appear to be substantially more positive than those from the Ribal and Young and in better agreement with the CY46R1 ERA5 hindcast. CCI L4 contrasts with Ribal and Young with positive trends in the central Atlantic and eastern Pacific, although there is qualitative agreement on (negative) sign in the northern and southern Pacific. Differences in source missions and calibration approaches likely explain some of these differences. More details in Timmermans et al. (2020).

COOL PAPERS

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