OBSERVING SEA LEVEL AND CLIMATE CHANGE AT THE COAST AND THE POLAR LATITUDES WITH REPROCESSED SATELLITE ALTIMETRY: A REVIEW

Marcello Passaro

Being Geodesy the science of the Earth's shape and size, satellite altimetry is the perfect example of a practical application of this discipline, in its effort to study the shape of the oceans in terms of sea level. In order to observe climate-related variability in sea level, it is essential to consider long time series. Satellite altimetry has been providing almost three decades of continuous global observations of sea level, but the quality of the data was problematic in areas of key importance, such as the polar latitudes and the coastal zone. While the advent of new technologies and the rising number of altimetry missions in orbit is a great promise for the future of sea level observations from space, the urgency of the matter reminds us that it is at least as much important to improve processing methods in order to evaluate all the data already collected and which were disregarded until recently.

This talk is a partial review of the progresses in sea level climate research driven by the use of improved signal processing techniques to enhance quality and quantity of sea level retrievals in the coastal zone and at the polar latitudes. The objective is to review the science applications based on the adoption of the ALES-suit of algorithms (Passaro et al., 2014; Passaro et al., 2018), which is used in combination with other techniques to produce new dataset of historic and present altimetry missions in the context of several international studies, including the European Space Agency's Sea Level Climate Change Initiative, Sea State Climate Change Initiative and Baltic+ SEAL.

To improve our understanding and prepare to rising sea levels in the wider context of climate change is fundamental to take a regional and local perspective of sea level variability. This will be highlighted through examples of key findings. In the Arctic Ocean (Rose et al., 2018), the availability of reprocessed altimetry allowed the observations of the sea level drop along the Greenland coast, linked to the missing gravity pull from the melting glaciers. At the same time, sea level trends much higher than the global mean are observed in the Beaufort Gyre, where disappearing sea ice has enhanced the wind-related water transport. In the coastal zone, we are now able to observe trends up the last 0 to 5 km from the coastline (Benveniste et al., 2020). In the vast majority of the studied cases, coastal trends do not differ from neighboring offshore observations, with important implications for coastal planners that have to rely on models that do not resolve the coastal scales when projecting sea level rise. Increasingly, we are able to evaluate sea level variability at a sub-regional scale in connection with large-scale atmospheric variability, as in the Baltic Sea (Passaro et al., 2021), where gradients in sea level variability between the extremes of the basins are related to shifts of wind regimes in winter.

In perspective, the importance of coupled observations of wave height in conjunction with sea level will be considered. The impact of sea level rise at the coast is strictly connected with the height of the waves. This is particularly significant in the case of extreme events such as storm surges. The recent and future efforts are therefore dedicated to couple the improvements in sea level observations from altimeters with similar progresses in sea state estimations (Dodet et al., 2020), aiming at a full picture of the total water level reaching the coasts, where infrastructures, important ecosystems and the largest amount of the human population is located.

REFERENCES

Passaro M., Cipollini P., Vignudelli S., Quartly G., Snaith H.: ALES: A multi-mission subwaveform retracker for coastal and open ocean altimetry. Remote Sensing of Environment 145, 173-189, 10.1016/j.rse.2014.02.008, 2014

Passaro M., Rose S.K., Andersen O.B., Boergens E., Calafat F.M., Dettmering D., Benveniste J.: ALES+: Adapting a homogenous ocean retracker for satellite altimetry to sea ice leads, coastal and inland waters. Remote Sensing of Environment, 211, 456-471, 10.1016/j.rse.2018.02.074, 2018

Rose S.K., Andersen O.B., Passaro M., Ludwigsen C.A., Schwatke C.: Arctic Ocean Sea Level Record from the Complete Radar Altimetry Era: 1991–2018. Remote Sensing, 11(14), 1672, 10.3390/rs11141672, 2019

Benveniste J., Birol F., Calafat F., Cazenave A., Dieng H., Gouzenes Y., Legeais J.F., Léger F., Niño F., Passaro M., Schwatke C., Shaw A. (The Climate Change Initiative Coastal Sea Level Team): Coastal sea level anomalies and associated trends from Jason satellite altimetry over 2002–2018. Nature Scientific Data, 7, 357, 10.1038/s41597-020-00694-w, 2020

Passaro M., Müller F.L., Oelsmann J., Rautiainen L., Dettmering D., Hart-Davis M.G., Abulaitijiang A., Andersen O.B., Høyer J.L., Madsen K.S., Ringgaard I.M., Särkkä J., Scarrott R., Schwatke S., Seitz F., Tuomi L., Restano M., Benveniste J.: Absolute Baltic Sea Level Trends in the Satellite Altimetry Era: A Revisit, Frontiers in Marine Science, Under Review

Dodet G., Piolle, J.-F., Quilfen Y., Abdalla S., Accensi M., Ardhuin F., Ash E., Bidlot J.-R., Gommenginger C., Marechal G., Passaro M., Quartly G., Stopa J., Timmermans B., Young I., Cipollini P., Donlon C.: The Sea State CCI dataset v1: towards a sea state climate data record based on satellite observations. Earth System Science Data, 12(3), 1929-1951, 10.5194/essd-12-1929-2020, 2020

SHORT VERSION (2500 words):

Being Geodesy the science of the Earth's shape and size, satellite altimetry is the perfect example of a practical application of this discipline, in its effort to study the shape of the oceans in terms of sea level. In order to observe climate-related variability in sea level, it is essential to consider long time series. Satellite altimetry provides almost three decades of continuous global observations of sea level, but the quality of the data was problematic in areas of key importance, such as the polar latitudes and the coastal zone.

This talk is a partial review of the progresses driven by the use of improved signal processing techniques to enhance quality and quantity of sea level retrievals in the coastal zone and at the polar latitudes. The objective is to review the science applications based on the adoption of the ALES-suit of algorithms, which is used in combination with other techniques in the context of several international studies, including the European Space Agency's Sea Level Climate Change Initiative, Sea State Climate Change Initiative and Baltic+ SEAL.

To improve our understanding and prepare to rising sea levels in the wider context of climate change is fundamental to take a regional and local perspective of sea level variability. This will be highlighted through examples of key findings. In the Arctic Ocean, the availability of reprocessed altimetry allowed the observations of the sea level drop along the Greenland coast, linked to the missing gravity pull from the melting glaciers. In the coastal zone, we are now able to observe trends up the last 0 to 5 km from the coastline. In the vast majority of the studied cases, coastal trends do not differ from neighboring offshore observations, with important implications for coastal planners. Increasingly, we are able to evaluate sea level variability at a sub-regional scale in connection with large-scale atmospheric variability, as in the Baltic Sea, where gradients in sea level variability between the extremes of the basins are related to shifts of wind regimes in winter.

In perspective, the importance the observations of coastal wave height will be considered. This is particularly significant in the case of extreme events such as storm surges. The recent and future efforts aim therefore at a full picture of the total water level reaching the coasts, where infrastructures, important ecosystems and the largest amount of the human population is located.