REGIONAL SEA LEVEL PREDICTION AND ITS RELATION TO EL NIÑO/SOUTHERN OSCILLATION

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ABSTRACT. The study focuses on forecasting sea level anomaly (SLA) data (the entire data span is 1993-2002) in the rectangular area: 20 S - 20 N, 70 W - 130 W covering the equatorial sections of west coasts of South, Middle, and North America. First, the polynomial-harmonic least-squares model (LS) consisted of annual, semiannual oscillations and the linear trend was extrapolated. Second, the above-mentioned extrapolation was combined with the autoregressive prediction (LS+AR) of stochastic SLA residuals. The second approach leads to more accurate SLA data predictions, both in ENSO conditions and in normal conditions. The LS+AR technique reveals the root mean square errors (RMSEs) of regional SLA 1-month predictions to be approx. three times smaller than the maximum amplitudes of the signal (El Niño 1997/1998 validation period). For La Niña 1998/1999, the 1-month RMSEs determined by the LS+AR technique are four times smaller than the amplitudes of the signal obtained from maximum amplitudes of the annual and semiannual cycles. In normal conditions, the corresponding ratio is of 1/6.

1. INTRODUCTION

The problems related to sea level fluctuations are in the scope of Global Geodetic Observing System (GGOS) project. The essential and highly unpredictable reason of regional sea level change in the equatorial Pacific is El Niño/Southern Osciallation (ENSO). El Niño event causes an increase in sea level in the vicinity of the east equatorial Pacific, whereas La Niña phenomenon leads to the decrease of the sea level in this region. The sea level may rise in the east equatorial Pacific even several tens of centimeters. For instance, the dynamic sea level change expressed by the sea level anomaly (SLA) recorded by TOPEX/Poseidon (T/P) altimetric satellite is shown to be of approx. 40 cm during El Niño 1997/1998. Thus, the predictions of SLA time series may be applied to forecast the ENSO signal.

The SLA gridded time series obtained from TOPEX/Poseidon and Jason-1 satelite altimetry provides the insight into the large-scale ocean circulation. Kosek (2001) detected several oscillations in SLA data with periods of 365 days, 183 days, 120 days, 90 days, 62 days, 37 days, and 30 days. The maxima of amplitudes corresponding to those oscillations may cause that - theoretically - the maximum amplitudes of entire SLA signal may be very high, especially during El Niño. Niedzielski & Kosek (2008) predicted the SLA time series in the east equatorial Pacific and discussed the accuracy of the predictions in respect to the maximum amplitudes of annual and semiannual terms. In this article, we discuss the results obtained by Niedzielski & Kosek (2008).

2. RESULTS

The SLA time series covering the area of the east equatorial Pacific (20 S - 20 N, 70 W - 130 W) and the period 1993-2003 were examined. The temporal resolution of these data is 9.9140625 days and the spatial resolution if of $1^{o} \times 1^{o}$.

The two prediction techniques were applied. First, the extrapolation of the polynomial-harmonic least-squares model (LS method) was utilized. This model was used to capture the annual and semiannual oscillations, and the linear inclining trend. Second, we combined the above mentioned extrapolation and the autoregressive prediction of SLA residuals (LS+AR method). The residuals, however, were computed as the difference between the data itself and the LS model. The accuracy of forecasts was evaluated by means of the root mean square error (RMSE) of predictions.

These two methods were used to determine the 1-month SLA predictions in the east equatorial Pacific. Three experiments were planned, i.e. forecasting SLA during El Niño 1997/1998, during La Niña 1998/1999, and during normal conditions. The T/P cycles which respectively correspond to these events are the following: 163-213, 213-263, 285-335. For instance, during El Niño 1997/1998 the maxima of amplitudes of the SLA oscillations in the considered region were of approximately 20 cm and 14 cm, for the annual and semiannual terms, respectively.

In the first experiment (Niño 1997/1998), the RMSE values of 1-month SLA predictions computed by the LS technique for the east equatorial Pacific reached even 19 cm in the vicinity of the Equator. The application of the LS+AR technique allowed us to reduce the prediction errors during El Niño 1997/1998, i.e. the RMSE values were smaller than 12 cm. Hence, the LS+AR method decreased the prediction errors due to the autoregressive modelling of the stochastic component of the signal.

In the second experiment (La Niña 1998/1999), the RMSE values of the 1-month forecasts obtained by the LS technique were smaller than 14 cm. The reduction of the prediction errors (LS vs. LS+AR techniques) was also noticed in the case of La Niña 1998/1999. Indeed, the RMSE values were not higher than 6 cm.

In the third experiment (normal conditions), for the LS-based predictions the maximum RMSE inaccuracy was smaller than 6 cm. The predictions determined by means of the LS+AR technique were more accurate, i.e. RMSE values were found to be smaller than 4 cm in the Pacific.

The overall satisfactory performance of the LS+AR method is enhanced by the comparison between the RMSE values and the maximum amplitudes of the most energetic annual and semiannual oscillations. In what follows, the ratios between the RMSE values and the sums of the two maxima (of annual and semiannual terms) justify a good performance of the LS+AR prediction approach (see conclusions).

3. CONCLUSIONS

The LS+AR technique was applied to predict SLA in the east equatorial Pacific. The performance of the method is acceptable, particulary in respect to the maximum amplitudes of the signal. Indeed, the LS+AR technique leads to the RMSE values of regional SLA 1-month predictions to be approx. three times smaller than the maximum amplitudes of the signal (El Niño 1997/1998 validation period). For La Niña 1998/1999, the RMSE values determined by the LS+AR technique were four times smaller than the amplitudes of the signal obtained from maximum amplitudes of the annual and semiannual cycles. In normal conditions, this ratio was of 1/6.

Acknowledgements. The research is supported by the Polish Ministry of Education and Science under the project No 4 T12E 039 29. Tomasz Niedzielski is supported by the Foundation for Polish Science within the Start Program (stipends for young researchers) and by the European Union within the Marie-Curie Actions. The authors thank the Center for Space Research, University of Texas at Austin, USA for providing the T/P and J-1 data. The authors of R 2.0.1., a Language and Environment 2004 and the additional packages are acknowledged. Wiesław Kosek are supported by the organizers of the Journées 2008 "Systèmes de référence spatio-temporels" and X. Lohrmann-Kolloquium, September 2008, Dresden, Germany.

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