Use of Satellite Data in Marine Early Warning System

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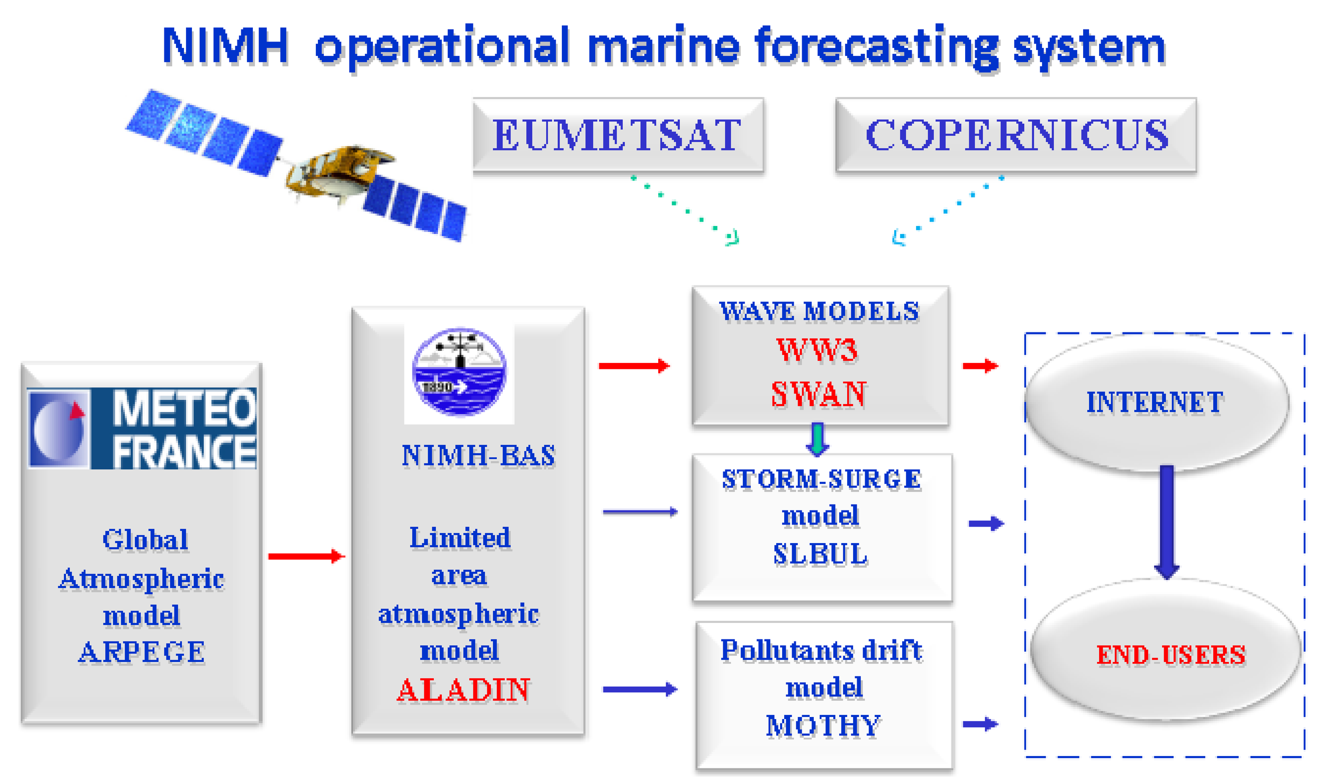
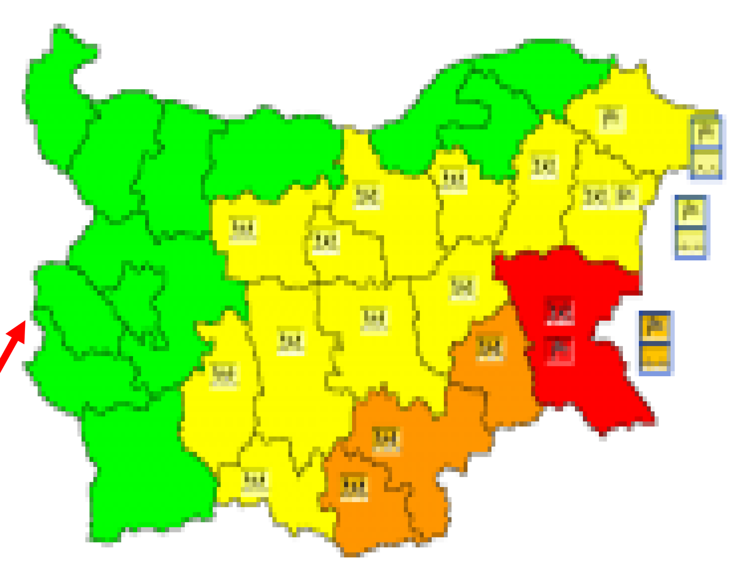
Accurate and timely prediction of extreme weather events is crucial for sea safety and for successful decision-making and planning of operations to combat potential pollution of coastal areas and to protect the environment. This paper shows the results of improving the performance of National Institute of Meteorology and Hydrology (NIMH) early warning marine forecasting system via use of remote sensing technology for verification of numerical wind and wave forecast in the Black Sea. Satellite altimeter wind and wave data from Jason-2, Jason-3, and SARAL AltiKa and scaterometer wind data from MetOP ASCAT-B are used for the statistical evaluation of the marine forecasts and calibration of the operational wave models. This approach minimizes errors in the wave data from deep waters, allowing better boundary wave conditions for high-resolution grids in coastal regions. Analysis of the statistical data shows that the SWAN model provides an effective framework for prediction of the wave conditions in the Black Sea area and the coastal environment. Further the advanced GIS and WEB-based technologies are highly effective in all phases of disaster management cycle. Capabilities of a WEB GIS are demonstrated by the visualization of the sea state forecast provided by the SWAN. The SWAN wave model produces its output (significant wave height) in a NetCDF format that allows import, further processing and dynamical visualization in GIS. The results of numerical simulation technologies used in marine forecasting will be applied during integrated training activities within the ECOPORTIL project.



- METEOALARM on 25.10.2017



The altimeter wind and wave data from Jason-2, Jason-3 and SARAL AltiKa satellites (Fig.1) is received at NIMH in near real time (NRT) through the World Meteorological Organization network GTS (Global Telecommunication System). The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) distributes the wind speed (WS) at 10m above the mean sea level and the significant wave height (SWH) as the operational geophysical data records (OGDR)-in BUFR format.

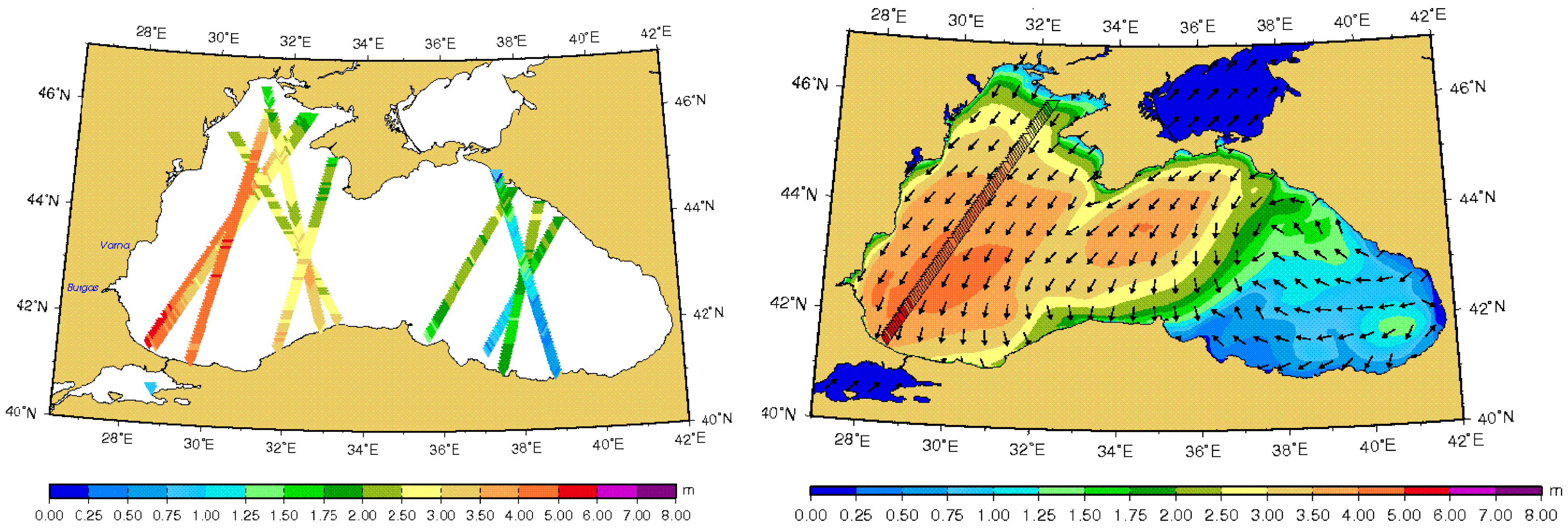
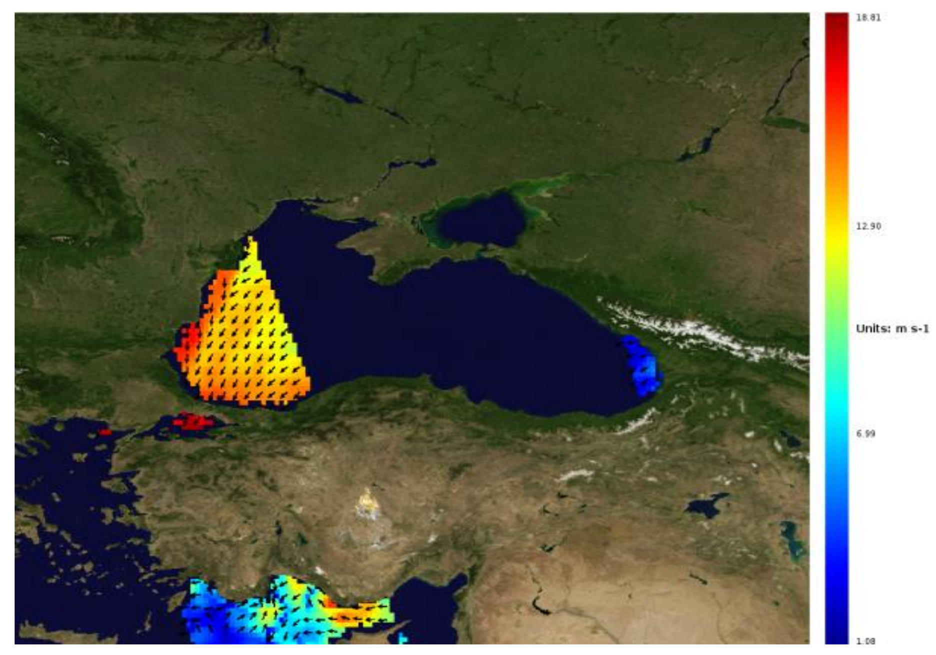


Fig.1. Satellite altimeter ground tracks over the Black Sea on 29-30 November 2018 (left) and Jason-3 along the track SWH on 29.11.2018 at 01 h 48min UTC (right).

The operational system of NIMH for wind wave forecast in the Black Sea area is based on the SWAN (Simulating Waves NearShore) numerical spectral model. SWAN is running operationally for the Black Sea twice a day at 06 and 18h UTC and produces main wave parameters 72 hours ahead with a grid spacing of 1/30°. The SWAN wave model is forced by the 3-hourly winds from the ALADIN model. The numerical weather prediction model ALADIN is a hydrostatic limited area numerical weather prediction model. The lateral boundary conditions are obtained from the global numerical weather prediction model ARPEGE of Meteo-France. The 0.125x0.125 degree ALADIN spatial latitude/longitude grid covers the whole Black Sea. The available data for marine forecasts are: wind speed and direction at 10 m above the sea surface and atmospheric pressure at the sea level.



- *Fig. 2: Surface wind fields from Metop-B/ASCAT-descending swath measurements over the Black Sea on 29.11.2018 at 07.00UTC*

Scatterometer observations are widely used in the Numerical Weather Prediction NWP for wind monitoring over the oceans, validation, assimilation and re-calibration of the NWP models. The Royal Netherlands Meteorological Institute (KNMI) Global Wind Level-3 ASCAT 12 km coastal wind product was selected for this study and was downloaded from the Copernicus Marine Environment Monitoring Service (CMEMS) website. The ASCAT observations over the Black Sea are taken two times daily due to ascending swaths (between 17.00 and 20.00) and descending swaths between 06.00 and 09.00 UTC, (Fig. 2). The near real time daily and reprocessing L3 wind products contains gridded L2 scatterometer wind vector observations and allows for direct use without preliminary manipulation

The ASCAT wind product represents an equivalent neutral wind speed at 10 m. We compare the scatterometer wind fields directly with the ALADIN model results and assume the neutral atmospheric stability. The scatterometer data were chosen with a minimal time difference (less than one hour) between the ALADIN model and ASCAT winds. The atmospheric model wind components were interpolated to the scatterometer observation locations using the bilinear interpolation method. Fig.3 shows the ALADIN wind field over the Black Sea on 29.11.2018 and comparison between the ALADIN and scatterometer data.

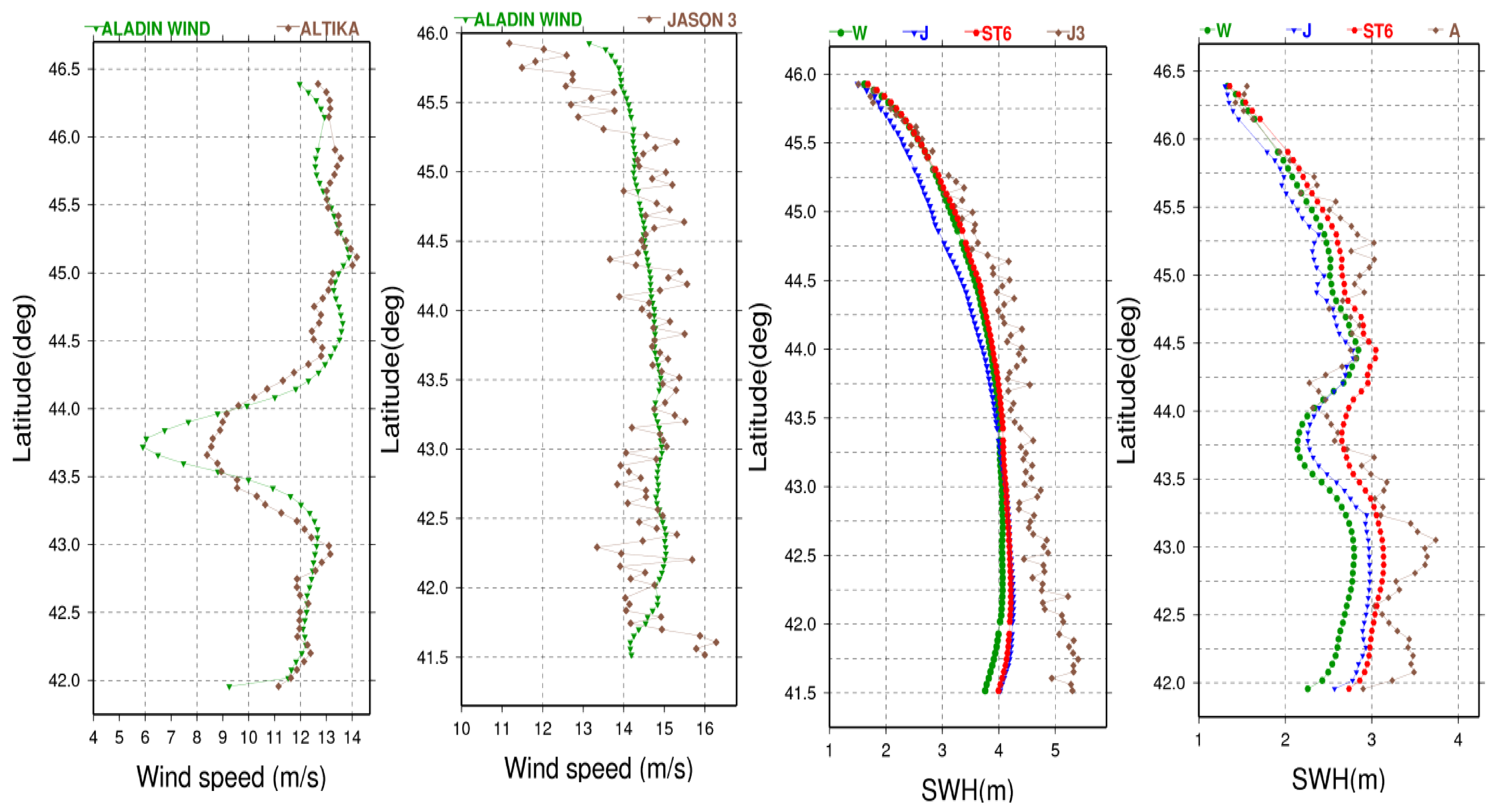
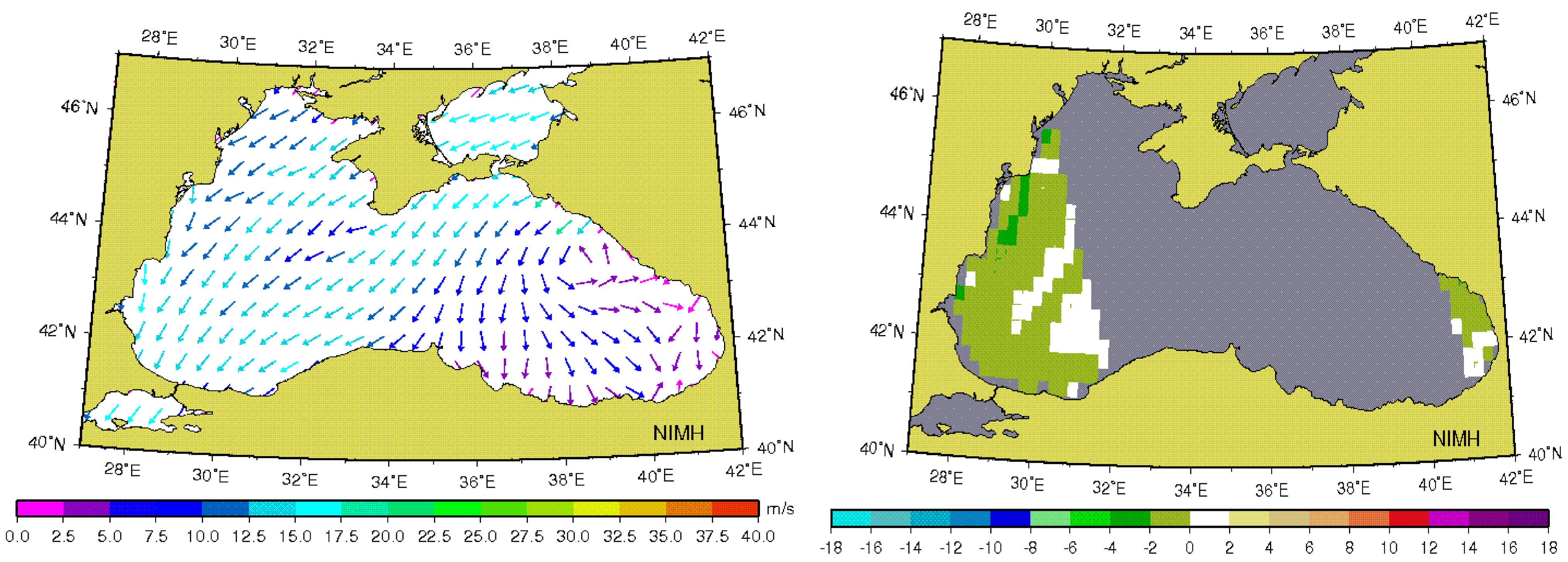


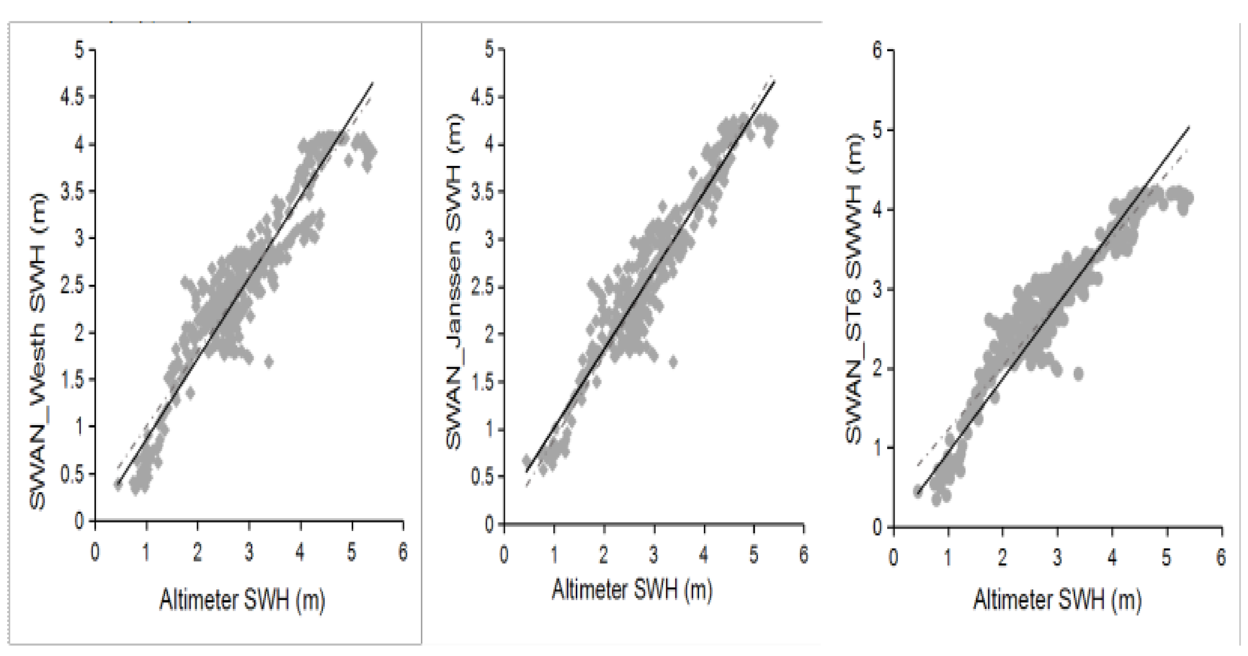
Fig 4. Comparison of modeled and satellite wind and wave data along the satelite tracks



- *Fig. 3: ALADIN wind fields over the Black Sea on 29.11.2018 at 07 UTC (left) and differences between ALADIN and wind speeds from ASCAT Metop-B (right).*

	n	Mean WS ALADIN	Mean WS Altimeters	Bias	RMS error	Scatter index
All	48570	8.08	7.91	0.17	1.80	0.23
5-10m/s	40936	7.35	7.10	0.25	1.80	0.25
10-15m/s	7034	11.74	11.88	-0.14	1.72	0.14
15-20m/s	640	14.48	16.12	-1.64	2.44	0.15

- *Comparison of WS (m/s) between ALADIN model results and altimeter data for the Black Sea, for the period January-December 2018*



- *Fig. 5. Scatter diagrams of the model SWH(different parametrizations) against the Jason-3 altimeter data for the storm situation in the Black sea 28-30.11.2018.*

	N	Mean SWH SWAN (m)	Mean SWH satel-lite (m)	Bias (m)	RMS error (m)	Scatter index
Janssen						
All	392	2.61	2.94	-0.33	0.46	0.16
> 3 m	160	3.42	3.92	-0.50	0.58	0.15
Westhuysen						
All	392	2.54	2.94	-0.39	0.54	0.16
> 3 m	160	3.29	3.92	-0.63	0.72	0.15
ST6						
All	392	2.78	2.94	-0.16	0.38	0.13
> 3 m	160	3.53	3.92	-0.39	0.50	0.13

- *Comparison of SWH between SWAN model results (different parametrisations) and altimeter data for the storm event in the Black Sea 28-30.11.2018.*

	n	mean SWH SWAN	mean SWH altimeters	Bias	RMS error	Scatter index
All	36265	0.95	122	-0.27	0.43	0.35
0.5-1 m	17479	0.55	0.74	-0.19	0.29	0.40
1-2m	14924	1.09	1.37	-0.28	0.43	0.31
2-3 m	2777	1.91	2.39	-0.48	0.64	0.27
>3 m	1085	3.08	3.92	-0.84	1.05	0.27

- *Comparison of SWH between the operational implementation of the SWAN model results and altimeter data for the Black Sea, January-December 2018.*

Conclusions

Early warning system of coastal storms needs to provide timely, accurate and clear information on the potential severe weather conditions, so that the responsible authorities can take action to avoid or minimize disaster risk for coastal and sea ports infrastructure. Remote-sensed data are becoming very important source of information in the verification of wave models and improvement the accuracy of the operational numerical wind-wave forecasts and hindcast in the Black Sea area. Available satellite-derived altimeter and scatterometer data help improve model results and reduce forecast errors by accompanying model verification and calibration in general and more specifically for stormy conditions.

The implementation of Early Warning forecast systems will benefit the sustainable management of coastal regions. The ability to predict the evolution of extreme events constitutes an indispensable tool for risk assessment, sea safety.

Acknowledgements

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