Storm Observations by Remote Sensing, Influences of organized Gusts on Ocean Waves and on Generation of Rogue Waves

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The impact of the gustiness on surface waves under storm conditions was investigated with focus on the appearance of wave groups with extreme high amplitude and wavelength. During many storms characterized by extremely high individual waves measured near the German coast especially in cold air outbreaks the moving atmospheric open cells are observed by optical and radar satellites. According to measurements the footprint of the cell produces a local increase in the wind field at sea surface, moving as a consistent system with a propagation speed near to swell wave traveling speed.

The optical and microwave satellite data are used to connect mesoscale atmospheric turbulences and the extreme waves measured. The parameters of open cells observed are used for numerical spectral wave simulations (North Sea with horizontal resolution of 2.5km). The wind field "storm-in-storm" including moving organized mesoscale eddies with increased wind speed was generated. To take into account the rapid moving gust structure the input wind field was updated each 5min. The test cases idealized with one, two, and four open individual cells and respectively with groups of open cells, with and without pre-existing sea state as well the real storm conditions are simulated.

The model results confirm that an individual moving open cell can cause the local significant wave height increase in order of meters within the cell area and especially in a narrow area of 1-2km at the footprint center of a cell (the cell's diameter is 40-90km). In a case of a traveling individual open cell with $15 m \cdot s^{-1}$ over a sea surface with a pre-existing wind-sea of and swell, a local significant wave height increase of 3.5m is produced. A group of cells for a real storm condition produces a local increase of significant wave height of more than 6m during a short time window of 10-20min (cell passing). The sea surface simulation from modeled wave spectra points out the appearance of wave groups including extreme individual waves with a period of about 25s and a wavelength of more than 350m under the cell's footprint. This corresponds well with measurement of a rogue wave group with length of about 400m and a period of near 25s. This has been registered at FiNO-1 research platform in the North Sea during Britta storm on November 1, 2006 at 04:00 UTC.

The results can explain the appearance of rogue waves in the German Bight and can be used for ship safety and coastal protection. Presently, the considered mesoscale gustiness cannot be incorporated in present operational wave forecasting systems, since it needs an update of the wind field at spatial and temporal scales, which is still not available for such applications. However, the scenario simulations for cell structures with appropriate travel speed, observed by optical and radar satellites can be done and applied for warning messages.