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TECHNICAL NOTE [1]

NUMERICAL MODELING OF SURFACE WAVES BASED ON PRINCIPAL EQUATIONS OF POTENTIAL WAVE DYNAMICS

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OPC CONTRIBUTIONS

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No. 2. Richardson, W. S., D. J. Schwab, Y. Y. Chao, and D. M. Wright, 1986: Lake Erie Wave Height Forecasts Generated by Empirical and Dynamical Methods -- Comparison and Verification. Technical Note, 23pp.

No. 3. Auer, S. J., 1986: Determination of Errors in LFM Forecasts Surface Lows Over the Northwest Atlantic Ocean. Technical Note/NMC Office Note No. 313, 17pp.

No. 4. Rao, D. B., S. D. Steenrod, and B. V. Sanchez, 1987: A Method of Calculating the Total Flow from A Given Sea Surface Topography. NASA Technical Memorandum 87799., 19pp.

No. 5. Feit, D. M., 1986: Compendium of Marine Meteorological and Oceanographic Products of the Ocean Products Center. NOAA Technical Memorandum NWS NMC 68, 93pp.

No. 6. Auer, S. J., 1986: A Comparison of the LFM, Spectral, and ECMWF Numerical Model Forecasts of Deepening Oceanic Cyclones During One Cool Season. Technical Note/NMC Office Note No. 312, 20pp.

No. 7. Burroughs, L. D., 1987: Development of Open Fog Forecasting Regions. Technical Note/NMC Office Note. No. 323., 36pp.

No. 8. Yu, T. W., 1987: A Technique of Deducing Wind Direction from Satellite Measurements of Wind Speed. Monthly Weather Review, 115, 1929-1939.

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No. 16. Yu, T. W., 1988: A Method for Determining Equivalent Depths of the Atmospheric Boundary Layer Over the Oceans. Journal of Geophysical Research. 93, 3655-3661.

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No. 18. Feit, D. M., 1987: An Operational Forecast System for Superstructure Icing. Proceedings Fourth Conference Meteorology and Oceanography of the Coastal Zone. 4pp.

No. 19. Esteva, D. C., 1988: Evaluation of Priliminary Experiments Assimilating Seasat Significant Wave Height into a Spectral Wave Model. Journal of Geophysical Research. 93, 14,099-14,105.

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Numerical modeling of surface waves based on principal equations of potential wave dynamics[2]

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Abstract

A method for numerical investigation of nonlinear wave dynamics based on direct hydrodynamical modeling of 1-D potential periodic surface waves is presented. By a nonstationary conformal mapping, the principal equations are rewritten in a surface-following coordinate system and reduced to two simple evolutionary equations for the elevation and the velocity potential of the surface. For stationary equations, the proposed approach coincides with the conventional complex variable method. For this case, numerical algorithms for solution of gravity (Stokes) and gravity-capillary wave equations are proposed, and examples of numerical solutions are given. The results imply that gravity-capillary waves do not approach Stokes waves as the capillarity coefficient decreases. Both stationary and nonstationary schemes use Fourier series representation for spatial approximation and the Fourier transform method to calculate nonlinearities. The nonstationary model was validated by simulation of propagating waves with initial conditions obtained as numerical (for gravity and gravity-capillary waves) or analytical (for pure capillary, or Crapper's waves) solutions of the stationary problem. The simulated progressive waves did not change their shape during long-term time integration, which indicates high accuracy of the scheme. Another criterion used for model validation was conservation of integral invariants of simulated multi-mode wave fields. A number of long-term model simulations of gravity, gravity-capillary, and pure capillary waves, with various initial conditions, were performed; for the simulated wave fields, distributions of energy and phase speed over spectra were analyzed. It was found that the wavenumber-frequency spectra are well separated into patterns lying along regularly located curves, with most of the energy concentrated along the curves corresponding to free and bound waves. This set of curves can be described by the equation $D(\omega/n, k/n) = 0$ $(n = 1, 2, 3, \ldots)$, where

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