REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
24-08-2018	NRL Publication	

4. TITLE AND SUBTITLE
Rogue Wave Probability Estimator for WAVEWATCH III

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
0602435N

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
73-5A51-07-5

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Research Laboratory
Oceanography Division
Stennis Space Center, MS 39529-5004

8. PERFORMING ORGANIZATION REPORT NUMBER
NRL/PU/7320--17-3674

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
One Liberty Center
875 North Randolph Street, Suite 1425
Arlington, VA 22203-1995

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Overall objective is to develop a configurable module for WAVEWATCH III to forecast the likelihood of rogue waves around the world. The probability estimation system will operate in a broad range of wave environments, using metrics to account for multiple extreme-wave contributors based on established theory and extensive analysis of representative sea states. FYI 7 objectives are (1) to confirm that the models NHWAVE and OpenFOAM correctly simulate the development of rogue waves under appropriate conditions, and (2) use simulations to begin identifying critical values of causal metrics required for rogue wave formation.

15. SUBJECT TERMS
rogue waves, WAVEWATCH III, wave contributors

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Mark Orzech
Unclassified	Unclassified	Unclassified	UU	02	19b. TELEPHONE NUMBER *(Include area code)* (228) 688-5974

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Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Title: Rogue Wave Probability Estimator for WAVEWATCH III
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CTA: CWO

Computer Resources: Cray XC40 [ARL, MD]; Cray XE6m, Cray XE6 [ERDC, MS]; Cray XC40 [NAVY, MS]

Research Objectives: Overall objective is to develop a configurable module for WAVEWATCH III to forecast the likelihood of rogue waves around the world. The probability estimation system will operate in a broad range of wave environments, using metrics to account for multiple extreme-wave contributors based on established theory and extensive analysis of representative sea states. FY17 objectives are (1) to confirm that the models NHWAVE and OpenFOAM correctly simulate the development of rogue waves under appropriate conditions, and (2) use simulations to begin identifying critical values of causal metrics required for rogue wave formation.

Methodology: Conduct a series of simulations under increasingly complex wave and current conditions, aiming to foster the development of nonlinear modulation and rogue waves in each case. First, specify only an optimized wave triad (i.e., single carrier wave with two optimally-spaced side band waves) in a 2D wave flume. Then augment this with waves of different frequencies, roughly approximating a spectrum. Add a constant current (using several different magnitudes), and then add a current gradient (using several different slopes). Generate multiple carrier waves that converge from different principal directions. When rogue waves develop, adjust conditions to identify causal metric "boundaries" below which rogue waves do not develop. These boundaries will ultimately define the edges of the rogue wave probability distribution.

Results: We simulated rogue wave development with NHWAVE under several sets of conditions, ranging from the basic wave triad to a more complete spectrum. Incorporating currents and current gradients, we found that nonlinear modulation was often enhanced, resulting in more rapid development of rogue waves than obtained for the non-current cases. Initial investigation of multi-directional wave states revealed that NHWAVE will require a larger domain with greater cross-flume resolution in order to properly represent converging waves with only small differences in direction.

DoD Impact/Significance: Accurate prediction of environmental hazards is very important to tactical and strategic operations in the world's oceans. The potentially very destructive rogue wave is a significant environmental hazard that is not presently accounted for in any Navy operational models. The results obtained from these simulations will form the core of the configurable WAVEWATCH III prediction module, which will enhance the safety of Naval missions and reduce the potential for damage or loss of Navy assets in rogue wave events.

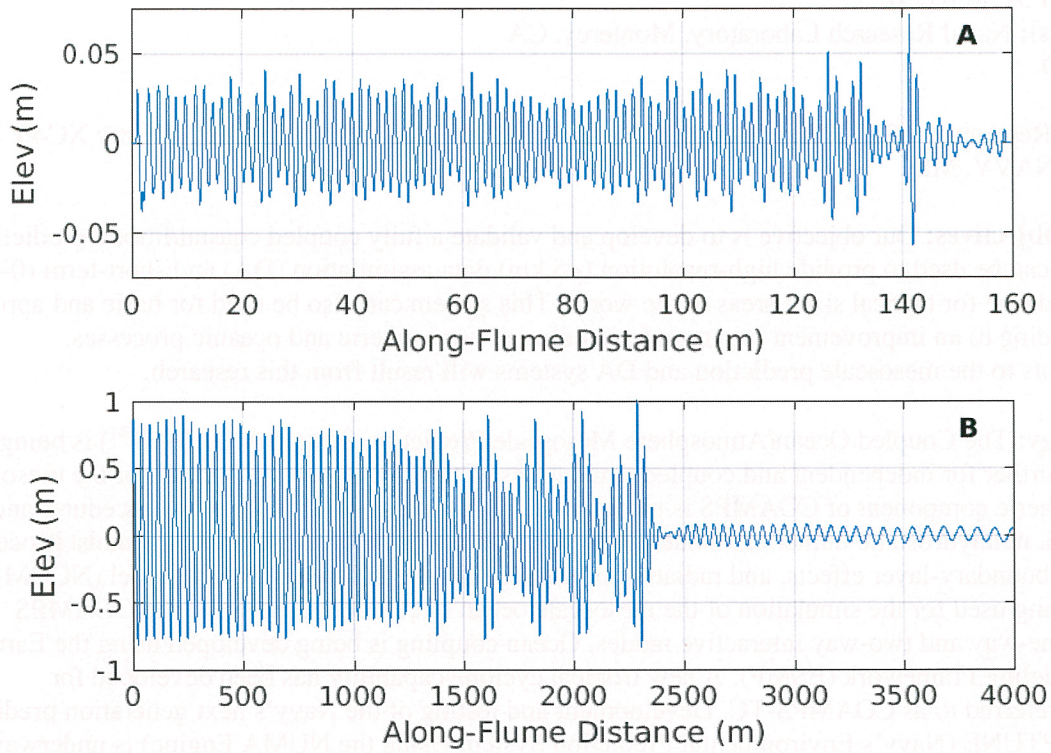

Figure 1. Surface elevation records of modeled rogue wave evolution in 2D wave flume from initial carrier wave and two lower amplitude sideband waves, caused by nonlinear modulation under two different sets of conditions. (**A**) Carrier wave period = 1.0s, amplitude = 2.5cm, depth = 2.1m. No current. Nonlinear modulation gradually develops over a longer time. (**B**) Carrier wave period = 5.0s, amplitude = 90cm, depth = 150-200m. Opposing current gradient, increasing from 0.28m/s at x=0m to 0.41m/s at x=4000m. The current causes relatively more rapid development of modulation and rogue waves.