

## The Red Sea Wind-Wave ATLAS

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### ABSTRACT

Due to the absence of wave measurements in the Red Sea basin, a third generation wind-wave model is used to hindcast the wave conditions in the Red Sea for about 16.5 years. The wave model was derived using the wind data obtained from the National Centers for Environmental Prediction (NCEP). The Model results are compared against satellite remotely sensed wave height data. The results were found to be in reasonable agreement with the satellite data. A wind-wave ATLAS is then established for the Red Sea.

KEY WORDS: Wave Atlas; Red Sea.

### INTRODUCTION

Knowledge of the wave conditions in both offshore and coastal regions is an essential prerequisite for the design of many near shore projects. Reliable data on the wind-wave characteristics can be derived from long-term extensive wave measurements, or extended wave hindcast using numerical wind-wave models. Long-term measurements of wind waves do not exist along the Red Sea, so it is necessary to utilize a reliable wave model to assess the wave climate for the Red Sea basin.

The main objectives of this study are: to implement a third generation wind wave model for the Red Sea; to develop detailed knowledge and understanding on wind waves affecting the Red Sea; and to construct a wave atlas for the Red Sea basin.

### THE WAVE MODEL

The wave model used in this study is the third-generation ocean wind-wave model WAVEWATCH-III (Tolman, 1991; Tolman and Chalikov, 1996) (hence-forth denoted as WWATCH III) developed at the Ocean Modeling Branch, National Centers for Environmental Prediction (NCEP), National Oceanic and Atmospheric Administration (NOAA, USA). The model is based on the discrete spectral action balance equation that is a generalization of the energy balance equation in the presence of currents. In the model

this balance is formulated for propagation over a spherical grid using longitude  $\lambda$  and latitude  $\phi$  coordinates as:

$$\frac{\partial N}{\partial t} + \frac{1}{\cos\phi} \frac{\partial}{\partial\phi} \dot{\phi} N \cos\theta + \frac{\partial}{\partial\lambda} \dot{\lambda} N + \frac{\partial}{\partial k} \dot{k} N + \frac{\partial}{\partial\theta} \dot{\theta}_g N = \frac{S}{\sigma} \quad (1)$$

$$\dot{\phi} = \frac{C_g \cos\theta + U_\phi}{R} \quad (2)$$

$$\dot{\lambda} = \frac{C_g \sin\theta + U_\lambda}{R \cos\phi} \quad (3)$$

$$\dot{\theta}_g = \dot{\theta} - \frac{C_g \tan\phi \cos\theta}{R} \quad (4)$$

$$c_g = \frac{\partial\sigma}{\partial k} \quad (5)$$

Where  $R$  is the radius of the earth,  $U_\phi$  and  $U_\lambda$  are the current components, with short-hand-notation  $N$  for  $N(k, \theta)$  which is the wave-number action density spectrum of the waves, defined as the energy density divided by the relative frequency  $\sigma$ . Where  $k$ , and  $\theta$  are the wave number, and the wave direction respectively.

The left-hand-side represents the advection term. The first term on the left-hand-side of the balance equation represents the local rate of change of wave action density. The second and the third terms represent propagation along great circles in geographic space. The fourth term represents shifting of wave number due to time variations in depth and currents. The fifth term represents refraction. The right-