oceanweather inc.
Marine forecasts/hindcasts Research at the air-sea interface

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Oceanweather Field Variable Definitions:

SWAN Model Output, descriptions and equations copied from the SWAN User Manual:

Julian Date where 1 Jan, 1900 = 2; 2 Jan, 1900 = 3 etc.
Date in YYYYMM format
Date in DDHHMM format

WD Wind Direction (deg from):
From which the wind is blowing, clockwise from true north in degrees (meteorological convention).

WS Wind Speed (m/s):
Effective neutral wind at a height of 10 meters, consistent with a 10-minute wind, units in meters/second.

ETOT or M_0 Total Variance of Total Spectrum (m^2):
The sum of the variance components of the hindcast spectrum, over all of the spectral bins of the wave model, in meters squared. It is defined as:

$$ETOT = \iint E(\omega,\theta)d\omega d\theta = \iint E(\sigma,\theta)d\sigma d\theta$$

Where E(ω,θ) is the variance density spectrum and ω is the absolute radian frequency determined by the Doppler shifted dispersion relation. However, it is easier to compute using σ, which is the nominal frequency of each frequency bin.

TP Peak Spectral Period of Total Spectrum (s):
Peak period is the reciprocal of peak frequency, in seconds. Peak frequency is computed by taking the spectral density in each frequency bin, and fitting a parabola to the highest density and two neighboring bins on each side.

VMD or DIR Vector Mean Direction of Total Spectrum (deg to which):
To which waves are traveling, clockwise from north in degrees (oceanographic convention) as defined by Kuik et al., 1988.

$$\text{VMD} = \frac{180}{\pi} \text{arctan} \left(\frac{\int sin\theta\, E(\sigma,\theta)d\sigma d\theta}{\int cos\theta\, E(\sigma,\theta)d\sigma d\theta} \right)$$

PWD Peak Wave Direction of Total Spectrum (deg to which):
The discrete directional bin with maximum energy in degrees (oceanographic convention).

$$PWD = \int E(\sigma,\theta)d\sigma$$

HS or HSig Significant Wave Height (m):
4.000 times the square root of the total variance, in meters.

HSSw Significant Wave Height from the Swell Partition (m):
Significant wave height associated with the low frequency part of the spectrum, computed as:

$$\text{HSSw} = 4\sqrt{\int_0^{\omega_{swell}} \int_0^{2\pi} E(\omega, \theta) d\omega d\theta}$$

where $\omega_{swell} = 2\pi f_{swell}$ and f_{swell} = 0.1 Hz by default, unless changed by the “quantity” command.

T01 or TM Significant Period of Total Spectrum (s)
The significant or mean period (seconds) is the mean of the zero up-crossing periods associated with significant wave height. It is calculated using the total variance (M_0, see ETOT) and the first moment (M_1):

$$T_{01} = 2\pi \left(\frac{M_0}{M_1}\right)$$

T02 or TZ Mean Zero-Crossing Period of Total Spectrum (s):
The wave period theoretically equivalent with mean zero-downcrossing period Tz. It is calculated using the total variance (M_0, see ETOT) and the second moment (M_2):

$$T_{02} = 2\pi \sqrt{\left(\frac{M_0}{M_2}\right)}$$

PER Average Period (s)
By default, same as T01 above. T01 and PER are equivalent when the SWAN setting for “power” equals 1 which is set by the “quantity” command. If “power” equals 0, then PER is equivalent to TMM10.

TMM10 Mean Absolute Wave Period (s)
Also know as the energy wave period (seconds), TMM10 is calculated using the total variance (M_0) and the negative first moment (M_{-1}):

$$T_{MM10} = 2\pi \left(\frac{M_{-1}}{M_0}\right)$$

DirSpr Directional Spreading or Directional Standard Deviation (deg)
The one-sided directional width of the spectrum, DirSpr, is computed as conventionally for pitch-and-roll buoy data (Kuik et al, 1988):

$$DirSpr = \left(\frac{180}{\pi}\right)\sqrt{\int_0^{2\pi}\left(2\,sin\left(\frac{\theta-\overline{\theta}}{2}\right)\right)^2 D(\theta)d\theta}$$

SPECPK or QP Spectral Peakedness:
The peakedness of the wave spectrum represents the degree of randomness of the waves. A smaller value of SPECPK indicates a wider spectrum which means it has an increased degree of randomness (e.g. shorter wave groups). A larger value of SPECPK indicates a narrower spectrum which means a decreased degree of randomness and a wave field that is more organized (e.g. longer wave groups).

$$SPECPK = 2\frac{\iint \sigma E^2(\sigma,\theta)d\sigma d\theta}{(\iint E(\sigma,\theta)d\sigma d\theta)^2}$$

QB Fraction of Breaking Waves
Fraction of breakers in expression of Battjes and Janssen, 1978.

UBOT RMS of the Maxima of the Orbital Motion near the Bottom (m/s)
Root-mean-square value in meters per second of the maxima of the orbital motion near the bottom defined as:

$$U_{bot} = \sqrt{2}\cdot U_{rms}$$

URMS RMS of the Orbital Motion near the Bottom (m/s)
Root-mean-square value in meters per second of the orbital motion near the bottom defined as:

$$U_{rms} = \sqrt{\int_0^{2\pi}\int_0^{\infty}\frac{\sigma^2}{sinh^2\,kd}\,E(\sigma,\theta)d\sigma d\theta}$$

ForceX X-Coordinate of Wave-Induced Force per unit Surface Area (N/m^2)
ForceX and ForceY are the gradient of radiation stresses of the wave model coordinate system. The Forces are defined as

$$F_x = -\frac{\partial S_{xx}}{\partial x} - \frac{\partial S_{xy}}{\partial y}$$

$$F_y = -\frac{\partial S_{yx}}{\partial x} - \frac{\partial S_{yy}}{\partial y}$$

Where S is the radiation stress tensor given by the following three equations and n is the group velocity over the phase velocity:

$$S_{xx} = pg \int \left(n\, cos^2\theta + n - \frac{1}{2}\right) Ed\sigma d\theta$$

$$S_{xy} = S_{yx} = pg \int (n\, sin\theta\, cos\theta)\, Ed\sigma d\theta$$

$$S_{yy} = pg \int \left(n\, sin^2\theta + n - \frac{1}{2}\right) Ed\sigma d\theta$$

ForceY Y-Coordinate of Wave-Induced Force per unit Surface Area (N/m^2)
See ForceX.

BFI Benjamin-Feir Index:
The Benjamin Feir Index is also known as Steepness-Over-Randomness Ratio and can be used to quantify the probability of freak waves. It is computed:

$$\text{BFI} = \sqrt{2\pi}\ (\text{Steep})(\text{SPECPK})$$

Steep Average Wave Steepness:
Ratio of wave height (HS) to wave length (WLEN):

$$\text{Steep} = \frac{HS}{WLEN}$$

Additional variables referenced above that are not typically archived:

MO1 or M01 or M_1 First Spectral Moment of Total Spectrum (m^2/s):
E(ω, θ) is the variance density spectrum and ω is the absolute radian frequency determined by the Doppler shifted dispersion relation. However, for ease of computation, M_1 can be determined as follows:

$$M_1 = \iint \omega E(\sigma, \theta) d\sigma d\theta$$

MO2 or M02 or M_2 Second Spectral Moment of Total Spectrum (m^2/s^2):
E(ω, θ) is the variance density spectrum and ω is the absolute radian frequency determined by the Doppler shifted dispersion relation. However, for ease of computation, M_2 can be determined as follows:

$$M_2 = \iint \omega^2 E(\sigma, \theta) d\sigma d\theta$$

M_{-1} Negative First Spectral Moment of Total Spectrum (m^2/s^{-1}):
E(ω, θ) is the variance density spectrum and ω is the absolute radian frequency determined by the Doppler shifted dispersion relation. However, for ease of computation, M_{-1} can be determined as follows:

$$M_{-1} = \iint \omega^{-1} E(\sigma,\theta) d\sigma d\theta$$

WLEN Wave length (m)
By default, the mean wave length is defined with p=1 using the following equation:

$$WLEN = 2\pi \left(\frac{\iint k^{p} E(\sigma,\theta) d\sigma d\theta}{\iint k^{p-1} E(\sigma,\theta) d\sigma d\theta} \right)^{-1}$$

References:

SWAN User Manual, https://swanmodel.sourceforge.io/download/zip/swanuse.pdf

Kuik, A.J., G. PH. Van Vledder, and L. H. Holthuijsen, 1988. A Method for the Routine Analysis of Pitch-and-Roll Buoy Wave Data, *J. of Phy. Ocean.*, 18:7, 1020-1034. https://doi.org/10.1175/1520-0485(1988)018<1020:AMFTRA>2.0.CO;2

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