Improvements to a single-column ocean model

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Introduction:

The General Ocean Turbulence Model (GOTM) is a one-dimensional water column model for marine and limnological applications. In this study we make improvements to GOTM for the purpose of modelling diurnal sea surface temperature (SST). Ocean temperature is mainly affected by air-sea exchange, solar radiation, and ocean turbulence.

In this study we utilize observational data from an ocean mooring observing system. GOTM is initialized with observed ocean temperatures and forced using observed meteorological data (downward shortwave radiation, downward longwave radiation, wind speed, relative humidity, air pressure and air temperature).

The observations from the buoy site were taken every 7.5 minutes; however, we would ultimately like to use the new scheme to model SST. However, the new scheme requires the inverse of a large matrix and cannot be computed online, but must be calculated for the whole time series a priori.

The new linear interpolation scheme retains 6 hourly means and provides correct inputs for GOTM to model SST. However, the new scheme requires the inverse of a large matrix and cannot be computed online, but must be calculated for the whole time series a priori.

Albedo improvement:

Albedo is a reflection coefficient that is determined by the ratio of upward to downward irradiance.

$$\alpha(\lambda) = \frac{E_{up}(\lambda)}{E_{down}(\lambda)}$$

Although downward shortwave radiation is provided, GOTM requires an albedo in order to ascertain the net shortwave radiation that heats the upper ocean. Albedo varies significantly with solar elevation, wind speed, atmospheric transmittance (aerosols/clouds) and ocean optical properties. The current method in GOTM is based on atmospheric transmittance observations and does not consider the effect of ocean roughness and seasonal variability.

The new albedo calculation can treat the irradiance in specific wavelength or in broadband.

Discussion:

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Although downward shortwave radiation is provided, GOTM requires an albedo in order to ascertain the net shortwave radiation that heats the upper ocean. Albedo varies significantly with solar elevation, wind speed, atmospheric transmittance (aerosols/clouds) and ocean optical properties. The current method in GOTM is based on empirical measurements taken over a 4 month period by Payne in 1972 classified by atmospheric transmittance, location and solar angle. However, it ignores the effect of ocean roughness and seasonal variability.

The new albedo calculation can treat the irradiance in specific wavelength or in broadband.

Current and future work:

- Improving albedo by relating $f_{\text{dir}}$ and $f_{\text{dif}}$ with cloudiness.
- Examine albedo for specific wavelengths.
- Determine how radiation at different wavelengths travel through the upper ocean, and warms the ocean.

References:


Acknowledgements:

Huizhi Xu’s undergraduate research assistantship was supported by the M.J. Murdock Charitable Trust and Trinity Western University.

Figure 1: Observed and Modelled Diurnal SST at 0.4 metre depth at the TOGA-COARE buoy site (1°45'S, 156°E) with hourly output from Oct 21, 1992, to Mar 4, 1993.

Figure 2: Linear interpolation comparison between the original and improved method applied to the longwave radiation observations.

Figure 3: Broadband albedo calculated with different atmospheric transmittance and compared with the empirical measurement approach formerly used in GOTM.

$$\alpha(\lambda) = \frac{E_{up}(\lambda)}{E_{down}(\lambda)}$$

Where

- $\lambda$ = wavelength
- $\theta$ = incident angle (incident angle)
- $n$ = index of refraction (1.34 for ocean water)
- $w$ = wind speed
- $t(n,o)$ = flat surface Fresnel reflectance
- $m$ = mean slope distribution width of Gaussian function
- $\text{chl}$ = chlorophyll concentration
- $f_{\text{dir}}$ and $f_{\text{dif}}$ are based on atmospheric transmittance.

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where $A$ is a tridiagonal $N \times N$ matrix

$$T_0 = \text{the mean value after the linear interpolation}$$

$$T_1 = \text{the target mean value}$$