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Wind stress

In physical oceanography and fluid dynamics, the **wind stress** is the shear stress exerted by the wind on the surface of large bodies of water – such as oceans, seas, estuaries and lakes. It is the force component parallel to the surface, per unit area, as applied by the wind on the water surface. The wind stress is affected by the wind speed, the shape of the wind waves and the atmospheric stratification. It is one of the components of the air–sea interaction, with others being the atmospheric pressure on the water surface, as well as the exchange of heat and mass between the water and the atmosphere.

Dynamics

The air blowing parallel to a water body imparts motion to the surface water by shear action. This is a downward transfer of momentum from the air to the water that ultimately generates a drift current underneath. The water surface also deforms under the action of wind and becomes wavy for increasing wind speeds, which modifies the grip that the wind has on the surface itself. The mechanics of the interaction between wind and water becomes thus increasingly complex. The Beaufort scale, for example, shows the correspondence between wind speed and sea states.

The magnitude of this shear force per unit contact area (τ, shear stress) is estimated through wind-shear or wind-drag formulas. These formulas parametrize the shear stress as a function of the wind speed at a certain height above the surface (U_h) in the form

$$\tau_{\text{wind}} = \rho_{\text{air}} C_D U_h^2,$$

where ρ_{air} is the density of the air; C_D is a dimensionless quantity wind-drag coefficient and is a repository function for all remaining dependencies. The height at which the wind speed is referred to in wind-drag formulas is usually 10 meters above the water surface.[1]

The expression of C_D contains, in first place, the correction to dependency on the second power of U_h for different ranges of U_h. The functional form of C_D is determined by an empirical formula that is determined from experiments in the laboratory and/or in the field. Different formulas have been established by various authors for different wind-speed ranges and taking into account the mechanics of the wind to varying degrees of detail.

References

1. Smith, Stuart D. "Coefficients for sea surface wind stress, heat flux, and wind profiles as a function of wind speed and temperature". *J. Geophys. Res*. **93** (C12): 15467. Bibcode:1988JGR....9315467S (https://ui.adsabs.harvard.edu/abs/1988JGR....9315467S). doi:10.1029/JC093iC12p15467 (https://doi.org/10.1029%2FJC093iC12p15467).

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