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Opinion Article

Efflorescence: The Life-giving Force

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Abstract

Diffusive and advective processes form the essential framework for fluid dynamics. In this note, we consider how that in the interior of the fluid the down ward thrust of diffusion arising from thermodynamics is countered by the upward advection due to efflorescence. At the sea surface however, this balance is disturbed and the reduction in downward diffusion leads to the existence of an efflorescence in which the vertical velocity scale in the air is much greater than in the water, in a manner akin to the flowering of a plant in the ground.

Introduction

In [1] it was shown that an important upwelling process, which was called Flinders Upwelling, had been omitted in previous studies on the Southern Shelf of Australia. Flinders Upwelling, which is quite distinct from Ekman Upwelling, was found to be the dominant upwelling process on the Southern Shelf.

Efflorescence

In this note, we consider the effect of Flinders Upwelling, which we have called Efflorescence, throughout the water column. A steady state may be obtained in the interior of the water column by a balance in which there is a downward diffusive heat flux and an equal and opposite upward advective heat flux, which may be represented by the vertical heat flux equation,

$$Q(z) = \rho C_p [w_o T(z) - K_v d T(z) / d z] \quad (1)$$

in which Oz is sn upward vertical, and Q(z) is the specific upward heat flux, where T(z) is temperature, and ρ and C_p are respectively the density and specific heat at constant pressure of seawater, K_v is the vertical coefficient of heat diffusion, and w_o is the vertical velocity [2]. Eq. (1) is the basis for efflorescence

In a steady-state equilibrium water column,

$$Q(z) = 0 \quad (2)$$

and on assuming an exponential vertical diffusive temperature gradient.

(1) reduces to the identity,

$$w_o = KV / H \quad (3)$$

in which H is the depth scale of the thermal layer, as fully discussed for the ocean general circulation, in [2].

Eq. (3) is the fundamental relation for the universal process of efflorescence.

Efflorescence at the sea surface

At the sea surface, in the water, from (1),

$$Q_s = \rho C_p [w_o T_s - K_v d T / d z)_{zs}] \quad (4)$$

where wo is the vertical velocity at the sea surface (zs) and for an exponential vertical diffusive temperature profile,

$$T(z) = T_s \exp [(z - z_s)/ H_o], z \le z_s \quad (5)$$

in which Ho is the thermal depth in the water, (4) reduces to the relation,

$$Q_s = \rho CP [w_o - K_v/ H_o] T_s \quad (6)$$

Hence, in the steady-state ($Q_s = 0$) in the water, the upward vertical velocity,

$$w_o = K_v / H_o \quad (7a)$$

and similarly, in the steady-state in the air, the upward vertical velocity,

$$w_A = K_v / H_A \quad (7b)$$

in which we have assumed that the (dynamic) coefficient of vertical heat diffusion is the same in the two interacting fluids, however the thermal depth in the air (H_A).and in the water (H_o) may differ, and for $H_o > H_A$, from (7a) and 7b), it follows that, wo < w_A. This is the key property of efflorescence, namely that the vertical velocity scale in the air may be much greater than that in the water which is controlled by the stratification in the water column.

The life-giving Force

The upward efflorescent force at the sea-surface ($\rho C_p w_o T_s$) may be regarded as the life-giving force. In the interior of the fluid < however, the upward efflorescent force is suppressed by the downward diffusive force ($\rho C_p w_o K_v/H_o T_s$) as shown in (6). At the sea surface, the thermal energy from beyond the sea surface allows the hidden efflorescent force to flourish as shown by (7b). The inequality ($w_A > w_o$) suggests that this occurs in the manner of a blossoming flower. This is the life-giving force. The Great Red Spot of Jupiter is another fertile ground for the application of the efflorescent process [3].

Conclusion

This discussion of the air-sea interface opens up a new chapter in geophysical fluid dynamics GFD which is grounded in the concept of efflorescence, and is represented here through the twin relations (7a) and (7b). In previous studies, the importance of (7b) appears to have been ignored. This relation, however, shows that there is an inalienable export of terrestrial energy into space on the cosmic scale.

Note that the term 'force' has been used throughout in the sense of a general force rather than the Newtonian force (N).

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