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Bühler, O.: Waves and mean Flows. Cambridge University Press, 2009. 370 pp., 10 b/w illustr., HB £ 55.00, ISBN:978-0-521-86636-1. e-book US $ 79.00 ISBN:978-0-511-60195-8, www.cambridge.org

Many recent technical progresses - both in measurement systems and techniques and in the numerical simulation of fluid motions at all scales – have greatly advanced our capabilities to detect and reproduce most of the wave-like phenomena occurring in geophysical flows. Nevertheless a deeper theoretical insight into their nature and dynamics still require use of an adequate treatment, by means of appropriate methods provided by mathematical physics. In particular many of these flows, either in the atmosphere or in the ocean, can be best understood and described by recognizing that they develop on multiple inherent space and time scales, which allow us to treat them as the superposition of mean flows – such as shear flows or vortices – and wavelike motions.

These two components of the flow typically interact, as far as momentum and energy can be exchanged between them, and such interactions are generally on a two-way mode, i.e. mean flows affect the development of superposed wavelike motions and vice versa. Thus, in order to explain and predict the effects of such interactions, their dynamics have to be appropriately evaluated on the basis of suitable conceptual schemes.

Bühler's book accomplishes the task of providing such a theoretical framework on a wide spectrum of wavelike phenomena, ranging form surface and internal gravity waves, to waves modified by Coriolis forces, such as Rossby waves.

The book puts the focus on the fundamental fluid dynamics, and shows how most of the results can be derived from three very basic concepts in fluid dynamics, i.e. Kelvin circulation theorem, the material invariance of potential vorticity in ideal fluid flow, and the dynamics of the wave pseudomomentum vector field.

The book is organised in three parts. Part I reviews the classical backgrounds on fluid dynamics and waves, including mathematical techniques (such as WKB method). In particular the reader is introduced to the basic concepts of fluid mechanics, the linear theory of wave motions and the geometric theory of waves, with an emphasis on the phenomenon of dispersion, by looking at dispersive waves and techniques for ray tracing (viewed as a generalisation of geometric wave theory for the leading order asymptotic description of a slowly varying wavetrain that is subject to both dispersion and refraction).

Part II concentrates on the theory of interactions between waves and mean flow. The treatment assumes spatially periodic flows and zonal averages. It provides the classical wave-mean interaction theory, based on a combination of three main simplifying assumption, i. e. small-amplitude waves, simple geometries and applicability of zonal averaging. An extensive description is provided of the internal gravity waves and their interactions with a zonally symmetric mean flow. Then the concept of pseudomomentum, both in the Lagrangian and in the Eulerian version, is introduced, as well as the dissipative pseudomomentum rule, relating the dissipation rate of pseudomomentum - due to viscous effects or wave breaking - to an effective mean force felt by the mean flow. Use of the above concepts is exemplified for the case of gravity waves in the lee of a mountain, and in the evaluation of the associated wave drag. The effect of shear in the mean flow, and in particular the possible occurrence of critical layers and the concomitant absorption of waves, is examined. The so-called generalized Lagrangian-mean theory allows extending the previous results to finite-amplitude waves. This theory turns out to be of great utility in order to make progress once the assumption of zonal symmetry is no more viable. An application to a planetary scale problem is provided with the analysis of Rossby waves and balanced dynamics in rotating flows.

Part III discusses wave-mean interactions beyond simple geometries. This makes the theory more complicated, but also better suited to cover small-scale waves propagating on a slowly varying, nonuniform mean flow (such as it often happens in the ocean, where zonally average can seldom represent planetary flows over a strongly inhomogeneous land-ocean distribution). Applications to the wave-driven vortex dynamics on beaches, and their interactions with shore currents and bottom landforms, as well as to wave refraction by vortices, make more clear the complications arising from more realistic situations on one hand, and on the other hand the power of theoretical insight offered by the appropriate mathematical tools. Indeed in these cases many of the previous simplifications can no more be assumed. Both velocity field and pseudomomentum have to be treated as full vector fields, i.e. it is no more viable the approach to single out a specific component of these fields for primary considerations. Moreover slowly-varying vortex flows, rather than steady shear flows, have to be more appropriately assumed as basic motions. Finally, and more important, mean pressure effects have to be disentangled from other interactions that depend intrinsically on the vorticity of the flow.

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