Geophysical Research Abstracts, Vol. 8, 01978, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01978

Hyperbolic boundary value problems of Geophysical Fluid Dynamics

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Elliptic boundary value problems (BVPs) are common in Geophysical Fluid Dynamics. Prominent examples are surface gravity waves or Rossby waves in closed domains. Such problems are mathematically well-posed and they possess a discrete spectrum of smooth eigenmodes. In contrast, internal waves in bounded domains are governed by hyperbolic BVPs. In general, such BVPs neither possess a discrete spectrum nor smooth solutions. Typically, internal boundary layers exist for such problems, where the velocity field is singular. Due to the ill-posedness and the occurrence of non-regular solutions, hyperbolic BVPs cannot be solved by traditional analytical or numerical techniques.

Here we compare different recent methods to solve hyperbolic BVPs of Geophysical Fluid Dynamics. The first method maps characteristics onto special boundary segments (fundamental intervals). The second method can be seen as a boundary perturbation of a Cauchy problem, where data are given along a certain (non-characteristic) curve. The third method superposes eigenmodes of special *separable* hyperbolic BVPs such that boundary conditions of corresponding non-separable problems are fulfilled approximately. We compare the flexibility of the methods and we discuss the regularization of the solutions by diffusion and non-linearity.