DEVELOPMENT OF VERTICAL DIFFUSION MODELS FOR STABLE STRATIFICATION ON THE BASE OF A NEW SPECTRAL THEORY OF TURBULENCE*

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The spectral theory of turbulence employed in this presentation is based upon a process of successive elimination of small scale modes that leads to a model describing the largest scales of a flow (Sukoriansly and Galperin, 2004). Partial scale elimination can be used to derive viscosities and diffusivities suitable for subgrid-scale (SGS) parameterization in large eddy simulations (LES). The elimination of all scales leads to Reynolds-averaged Navier-Stokes equations-based models (RANS). The spectral model is derived from first principles and free of empirical coefficients. The model yields a dispersion relation for internal waves in presence of turbulence and offers a powerful tool to study wave-turbulence interaction. The model recognizes the horizontal-vertical anisotropy introduced by stable stratification and provides expression for the horizontal and vertical turbulent viscosities and diffusivities. The theory does not support an idea of a sharp cut-off critical Richardson number at which turbulence is fully inhibited. Instead, it predicts a transitional range of Ri in which vertical mixing is suppressed while the horizontal mixing is enhanced. The vertical turbulent viscosities and diffusivities obtained in the RANS mode (averaging over all scales) were used in 1-D HIRLAM *K-l* and K-ε models, *K* is the turbulent kinetic energy, ε is the dissipation and *l* is the mixing length. The new models has been tested in simulations of stable boundary layers over sea ice under the conditions of moderate and strong stable stratification. The predicted potential temperature and wind velocity, as well as the friction velocity, the Monin-Obukhov length scale and the boundary layer height are in good agreement with the corresponding values obtained in LES of Beafort Arctic Storms Experiment (BASE) (Kosovic and Curry, 2000) in the case of moderately stable stratification. In the case of strong stratification, the predicted potential temperature appears to slightly deviate from the LES results in the upper part of the SBL. The source of this discrepancy has been traced to the use of the SGS parameterization in the LES suitable for the neutrally stratified flows. The measure of deviation of the SGS viscosities and diffusivities from their values under neutral stratification is the ratio of grid resolution of the model and the Ozmidov wave numbers, respectively. When that ratio is $O(1)$, the effect of stable stratification on the SGS parameterization must be accounted for. Indeed, the part of the SBL where the LES and the present results differ coincides with the region where that ratio is $O(1)$. Additional observation data for such situation is necessary to fully resolve this complicated problem. Finally, the profiles of the potential temperature and wind speed predicted by the new *K-l* and K-ε models are in very good agreement with the observational data from Surface Heat Budget of the Arctic Ocean (SHEBA) experiment.

This presentation is only one of the first attempts to test and validate the new spectral clossure-based *K-l* and K-ε models; further comparisons with experimental and observational data as well as with LES results are clearly need. However, one can already see that the new technique appears promising for practical applications and can be beneficial if implemented in 3-D HIRLAM model.

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