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Interactive comment on "Quasi-hydrostatic equations for climate models and the study on linear instability" *by* Robert Nigmatulin and Xiulin Xu

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Dear Robert Nigmatulin and Xiulin Xu,

A very detailed review on connection between correctness of Cauchy problem and hyperbolicity in the problems of Weather Prediction was given in the books by V. Gordin: Mathematical Problems of the Hydrodynamic Weather Forecast. Numerical Aspects. Mathematical Problems of the Hydrodynamic Weather Forecast. Analytical Aspects. Hydrometeorological Center of USSR, 1987

Also you can find the book V.A.Gordin. Mathematical Problems and Methods in Hydro-

dynamical Weather Forecasting. Gordon & Breach, 2000, 842p.

With respect to hydrostatic approximation the general idea is the following.

For evolution equations in partial derivatives of the first order correctness of the Cauchy problem is equivalent to hyperbolicity.

The system of equations in hydrostatic approximation is not explicitly evolutional, since there are equations without time derivative.

But is can be made evolutional after appropriate vertical discretizations. And it was shown analytically, that the resulting system is not necessarily hyperbolic, for unstable stratifications it is not.

For certain restrains on stratifications and vertical discretizations the hydrostatic approximation can be considered as a system of shallow water equations with different sound velocities (velocities of propagations of small perturbations). $\sqrt{gH}$ ("sound speed" in shallow water) corresponds here to $\sqrt{\lambda_i}$ where i is the number of the layer. The system can lose hyperbolicity when λ_i becomes negative. Sometimes small scale mixing or convective adjustment can resolve this problem.

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