Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2017-234-AC2, 2018

Interactive comment on "Impacts of the Horizontal and Vertical Grids on the Numerical Solutions of the Dynamical Equations. Part I: Nonhydrostatic Inertia-Gravity Modes" *by* Celal S. Konor and David A. Randall

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Received and published: 15 March 2018

We thank Dr. Gassmann for very useful comments.

Answer to comment (1):

We can think of two major effects of (vertically) varying basic-state stability expressed by the Brunt-Vaisala frequency.

1- Abrupt change of stability

This is the case with the tropopause. The abrupt change of stability at the tropopause can act like a lid for the troposphere. As a result, the vertical extent of the waves is limited. From this point of view, we can estimate that the longest realizable vertical wavelength is limited to, say, n=9 for the domain used in our analyses. Recall that n=9 corresponds to roughly a 9-km half-wavelength that fits in to the troposphere. The discussion in section 7 of our manuscript indicates that nonhydrostatic effects are more important for the deep modes (see Fig. 15). The absence of very deep waves in realistic situations may be the reason that quasi-hydrostatic models, in practice, can give good solutions with horizontal grid spacing as small as 10 km

2-Gradual change of stability

Gradual changing static stability can cause internal refractions and reflections of waves, which also may limit their vertical extent.

Answer to comment (2):

Lindzen&Fox-Robinovitz (1989) suggest that the maximum vertical grid spacing used to resolve the quasi-geostrophic (and quasi-static) modes in the presence of critical layers should satisfy [see Fig.1 for this equation]. In practice, this means that the vertical grid spacing should not exceed about 1% of the horizontal grid spacing. For nonhydrostatic models with small horizontal grid spacings, using such a small vertical grid spacing can immensely increase the computational cost. However, the nonhydrostatic models may not have to satisfy Lindzen&Fox-Robinovitz rule, because the resolutions that are needed to simulate nonhydrostatic motions may automatically resolve the QG modes.

We prepared the following table [see Fig.2 for this table], showing the horizontal and vertical propagation speeds of the waves found in our analysis. The table can used in the selection of the horizontal and vertical grid spacings. In making the table, we assumed that the deepest and fastest wave has n=8.

Answer to comment (3):

At the end of the C-grid subsection, we added a short paragraph discussing the C-grid discretization on the hexagonal and triangular grids (page 12, line 17, of revised Part I).

Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-234, 2017.

$$(\delta z)_{max} = (f/N)\delta x$$

Fig. 1. Equation

$m = \pi n / z_T \quad z_T = 80$ km

Inertia-gravity waves

	n	$k^* = \sqrt{2}\,\pi/d$	$c_H \equiv \nu/k^*$	$c_z \equiv \nu/m$	c_z/c_H
$d = 2$ km	8	0.222144146908E-02	0.481901844357E+01	0.340756062011E+02	0.707106781187E+01
	9	0.222144146908E-02	0.480651989192E+01	0.302108694176E+02	0.628539361055E+01
	10	0.222144146908E-02	0.479266536687E+01	0.271114094470E+02	0.565685424949E+01
$d = 10$ km	8	0.444288293816E-03	0.198560405096E+02	0.280806817837E+02	0.141421356237E+01
	9	0.444288293816E-03	0.190326141538E+02	0.239254942789E+02	0.125707872211E+01
	10	0.444288293816E-03	0.182234775779E+02	0.206175113154E+02	0.113137084990E+01
$d = 25$ km	8	0.177715317526E-03	0.299096358343E+02	0.169194450570E+02	0.565685424949E+00
	9	0.177715317526E-03	0.272982045604E+02	0.137263968419E+02	0.502831488844E+00
	10	0.177715317526E-03	0.250598688090E+02	0.113408020291E+02	0.452548339959E+00
$d = 100$ km	8	0.444288293816E-04	0.340767827966E+02	0.481918483930E+01	0.141421356237E+00
	9	0.444288293816E-04	0.303836335749E+02	0.381946192673E+01	0.125707872211E+00
	10	0.444288293816E-04	0.274118268152E+02	0.310129418012E+01	0.113137084990E+00

Rossby waves

	n	$k^* = \sqrt{2}\,\pi/d$	$c_H \equiv \nu/k^*$	$c_z \equiv \nu/m$	c_z/c_H
$d = 2$ km	8	0.222144146908E-02	-0.232129064262E-05	-0.164140035450E-04	0.707106781187E+01
	9	0.222144146908E-02	-0.232128958774E-05	-0.145902187430E-04	0.628539361055E+01
	10	0.222144146908E-02	-0.232128840876E-05	-0.131311901994E-04	0.565685424949E+01
$d = 10$ km	8	0.444288293816E-03	-0.580298728932E-04	-0.820666332683E-04	0.141421356237E+01
	9	0.444288293816E-03	-0.580292136537E-04	-0.729472897449E-04	0.125707872211E+01
	10	0.444288293816E-03	-0.580284768744E-04	-0.656517271998E-04	0.113137084990E+01
$d = 25$ km	8	0.177715317526E-03	-0.362604929513E-03	-0.205120323640E-03	0.565685424949E+00
	9	0.177715317526E-03	-0.362579191118E-03	-0.182316234494E-03	0.502831488844E+00
	10	0.177715317526E-03	-0.362550429001E-03	-0.164071594796E-03	0.452548339959E+00
$d = 100$ km	8	0.444288293816E-04	-0.577841322363E-02	-0.817191034986E-03	0.141421356237E+00
	9	0.444288293816E-04	-0.577188385698E-02	-0.725571238310E-03	0.125707872211E+00
	10	0.444288293816E-04	-0.576460376944E-02	-0.652190466596E-03	0.113137084990E+00

Fig. 2. Table

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