Design of Atmosphere Models Based on the Nonhydrostatic Unified System of Equations in the Height and Sigma Vertical Coordinates

Ross Heikes, Celal Konor and David Randall, Colorado State University

- We present a brief description of the Unified Z-grid Icosahedral Model (UZIM). Results from various standard test cases are also presented.

- The unified system is a nonhydrostatic system applicable to the global cloud resolving models. It unifies the quasi-hydrostatic and anelastic systems.

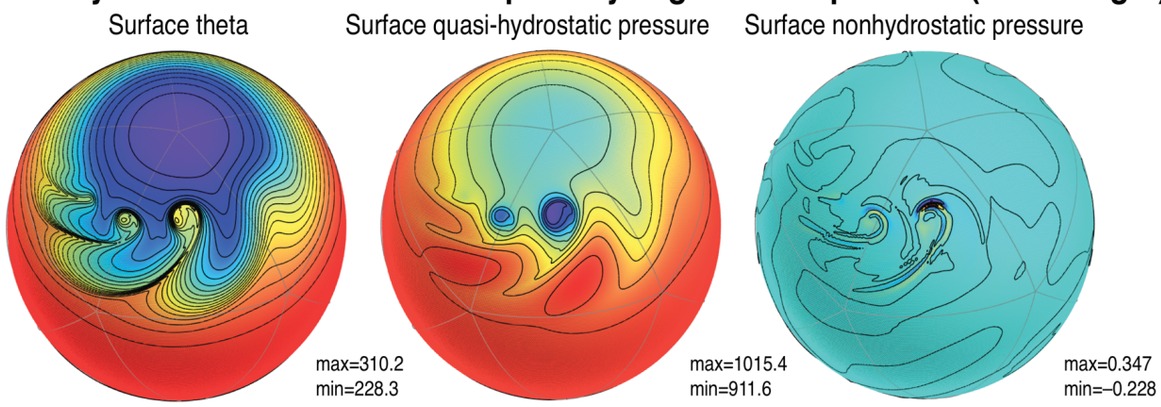
- The model uses an icosahedral grid with Z-grid staggering.

- The height vertical coordinate version of the model (UZIM-height) is nearing completion. This version uses a Lorenz vertical grid.

- The quasi-hydrostatic hybrid sigma-pressure vertical coordinate version of the model (UZIM-sigma) has been completed. Nonhydrostatic version is under development.

- Results from several test runs are presented in the poster

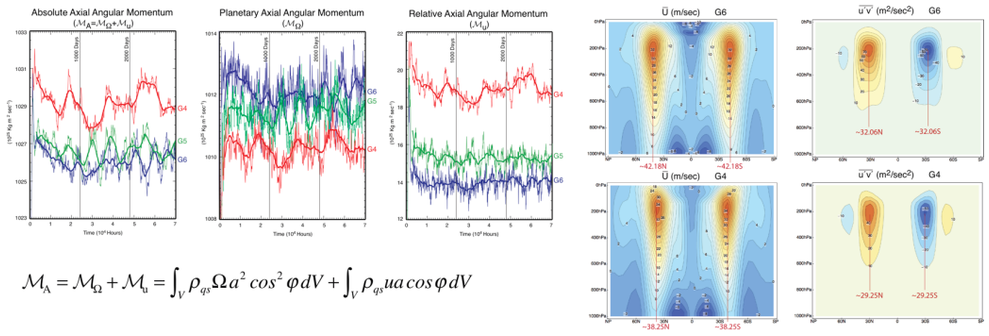
Nonhydrostatic Idealized Extratropical Cyclogenesis Experiment (UZIM-height)



G7 (grid distance=60 km) 32L (vertical grid distance=500 m)

Conservation of Axial Angular Momentum (Quasi-Hydrostatic UZIM-sigma)

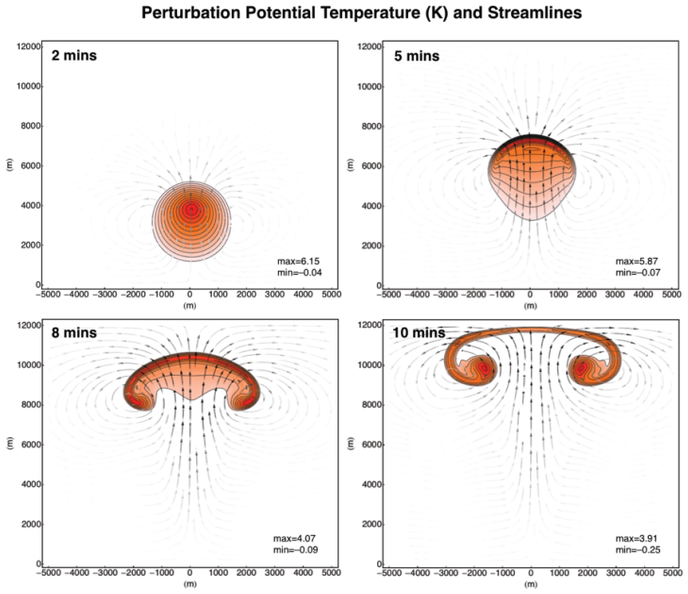
Held-Suarez idealized General Circulation runs with G4, G5 and G6 resolutions to examine conservation of the axial angular momentum.



$$\mathcal{M}_A = \mathcal{M}_\Omega + \mathcal{M}_u = \int_V \rho_{qs} \Omega a^2 \cos^2\varphi \, dV + \int_V \rho_{qs} u a \cos\varphi \, dV$$

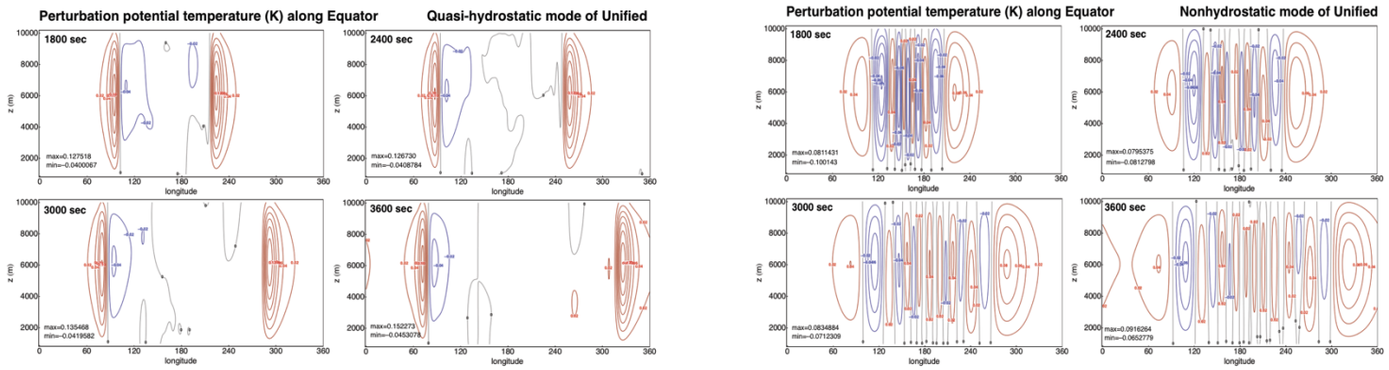
Warm Bubble Experiment (UZIM-height)

G6 (grid distance=115 m) 96L (vertical grid distance=125 m) a=6.37 km, ztop=12km



Quasi-hydrostatic and Nonhydrostatic Gravity Wave Propagation (UZIM-height)

G6 (grid distance=1000 m) 10L (vertical grid distance=1000 m) a=51 km, ztop=10km



See DCMIP website (https://www.earthsystemcog.org/projects/dcmip-2012/) for comparison to other models

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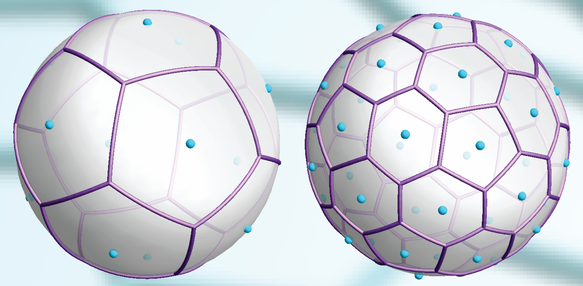
Unified Z-grid Icosahedral Model

Overview:

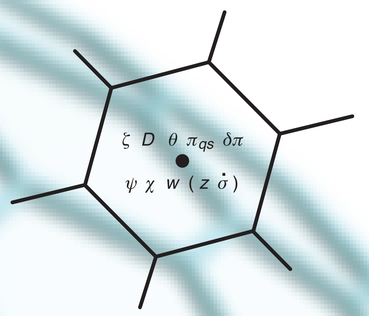
We present a global nonhydrostatic dynamical core based on the unified system of equations (Arakawa and Konor, MWR, 2009; and Konor, MWR, 2014). The dynamical core uses an icosahedral horizontal grid and Z-grid staggering (Randall, MWR, 1994). We call the model as the Unified Z-grid Icosahedral Model (UZIM). There are two versions of the UZIM: 1) the height vertical coordinate version which uses a Lorenz grid (UZIM-height), and 2) the hybrid sigma-pressure coordinate version which uses a Charney-Phillips grid (UZIM-sigma). The quasi-hydrostatic version of the UZIM-sigma has been completed. The nonhydrostatic version is under development.

Grid generation starting from an icosahedron

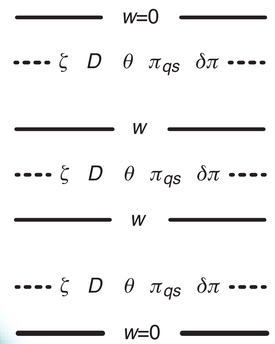


Grid generation, optimization and operator accuracy is discussed by Heikes et al. (MWR, 2013)

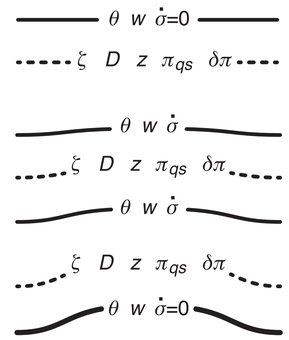
Distribution of variables on the Z-grid



Vertical L-grid of UZIM-height



Vertical CP-grid of UZIM-sigma



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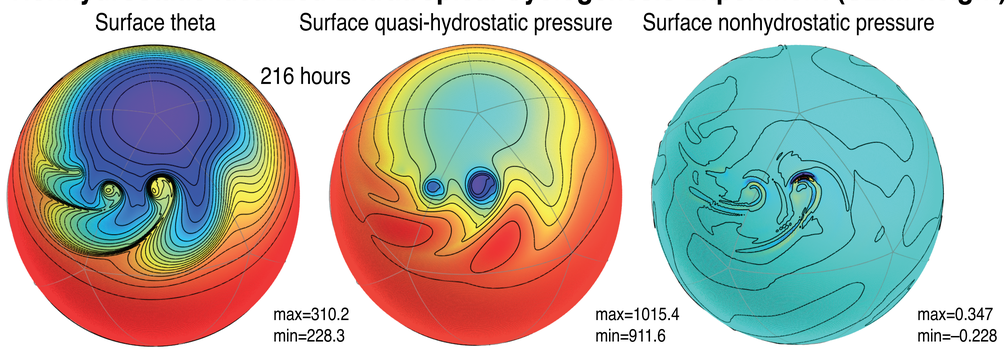


G7 (grid distance=60 km) 32L (vertical grid distance=500 m) Jablonowski and Williamson (QJRMS, 2006)

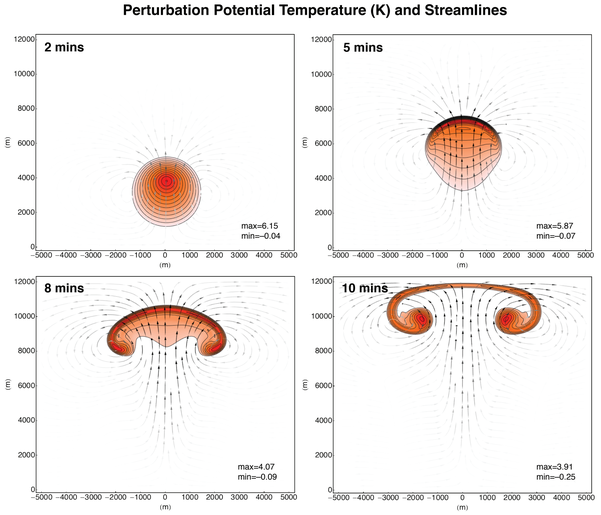
Warm Bubble Experiment (UZIM-height)

G6 (grid distance=115 m) 96L (vertical grid distance=125 m) a=6.37 km, ztop=12km

The initial bubble is 6.6K warmer than the environment.

Initial condition is the 3D version of Mendez-Nunez and Carroll (1994)

Perturbation Potential Temperature (K) and Streamlines



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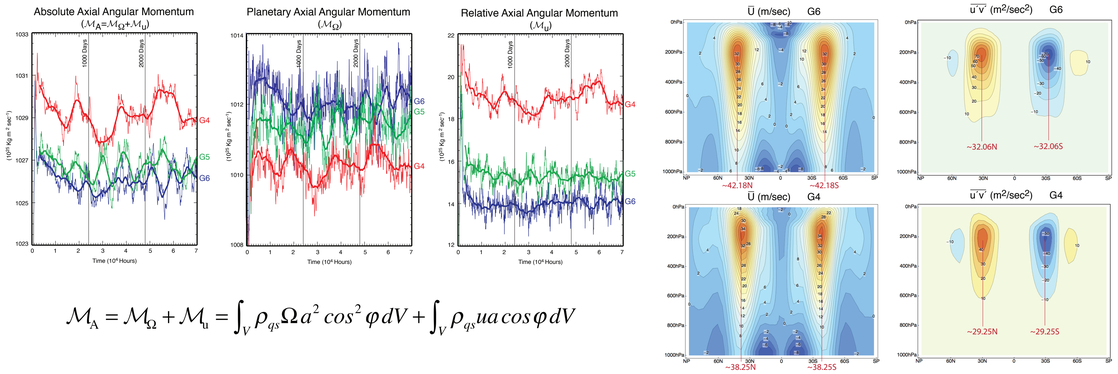

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See Lebonnois et al. (JGR, VOL. 117, 2012) for comparison to other models

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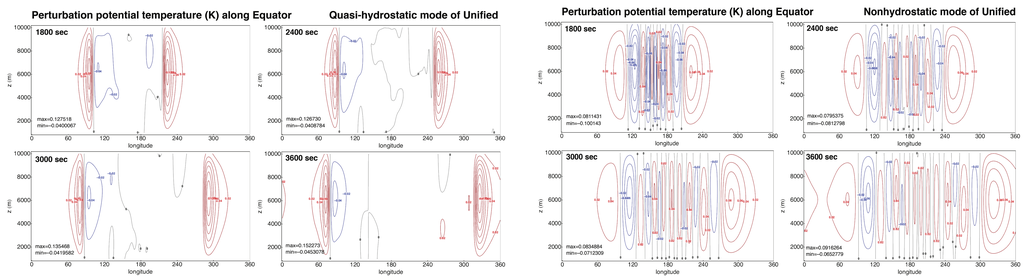

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