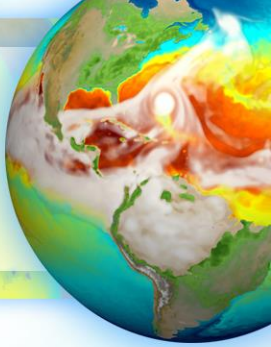
HEVI IMEX in the HOMME-NH dycore



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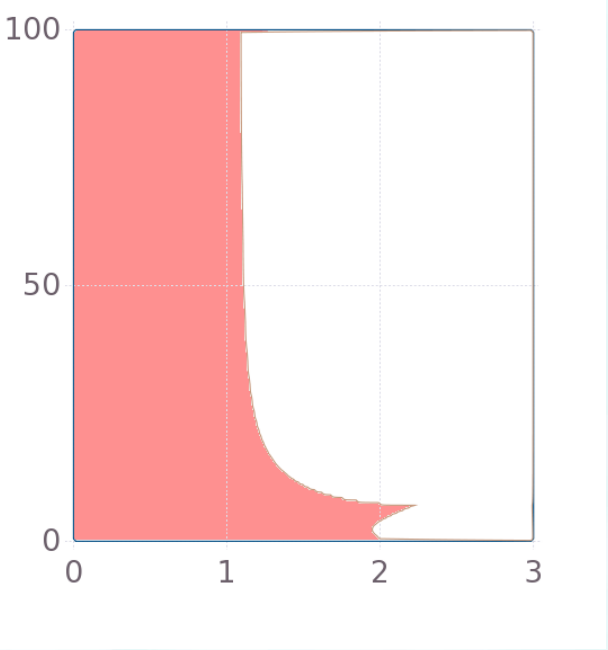
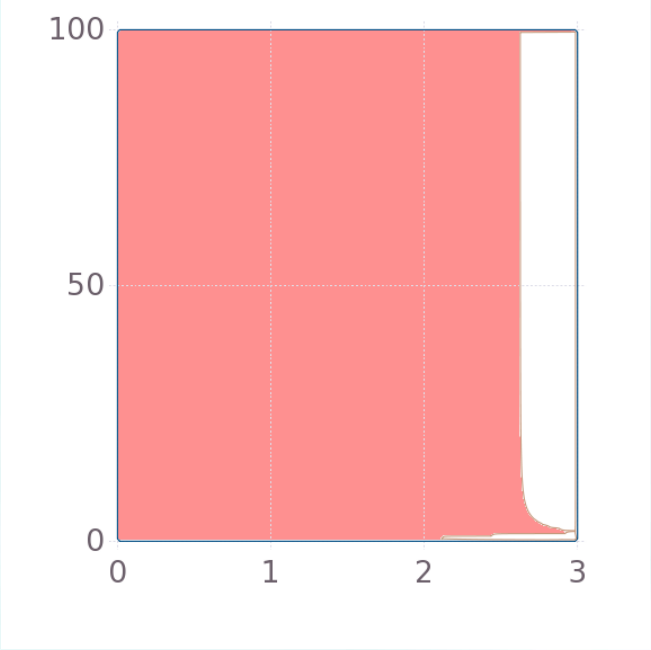
Special thanks to the SUNDIALS team at LLNL.

HEVI IMEX for HOMME-NH

- HEVI = horizontally explicit, vertically implicit.
- IMEX = implicit explicit – we use IMEX Runge-Kutta methods.
- Vertically propagating acoustic waves implicitly treated.
- Horizontal acoustic waves and advection explicitly treated.
- HEVI solvers are cheap (tridiag solves, parallel over the H grid).
- SCREAM wants to run at ~5km h and ~100m v res, aspect ratio 50.
- IMEX time-stepping boosts step-size by factor of 10 or so in this regime.
- Have developed various IMEX Runge-Kutta methods (IMKG methods).
- The big struggle is understanding IMEX stability for nonhydrostatics.
- “Efficient IMEX Runge-Kutta methods for nonhydrostatic dynamics” by A. Steyer, O. Guba, M. Taylor, and C. Vogl

HEVI stability theory for IMEX Runge-Kutta





Key to deriving methods efficient at SCREAM resolutions are methods that are stable at high AND low aspect ratios. Use the HEVI stability theory developed in Durran and Blossy (2012) and Lock et al (2014).

H-stability regions of IMKG232a (left) and IMKG232b (right), stable = shaded.

IMKG methods performance and scores

IMKG	232a	232b	242a	242b	243	252	253	254	343	353	354
dt x1	100	200	175	225	275	275	350	375	275	250	350
dt x100	1.75	1.75	2.25	2.5	2.5	3.5	3.75	3.75	2.25	2.5	2.75
score 1	20	40	29	37.5	39	39	44	42	39	31	39
score 100	.35	.35	.38	.42	.36	.50	.47	.42	.32	.31	.31

Maximum stable and weighted time-steps for various IMKG methods integrating the DCMIP2012 Test Case 4.1 (dry baroclinic instability) with 30 vertical levels, ne = 30 cubed sphere horizontal resolution at small planet x1 and small planet x100 (emulating high and low aspect ratios).