FIM basics

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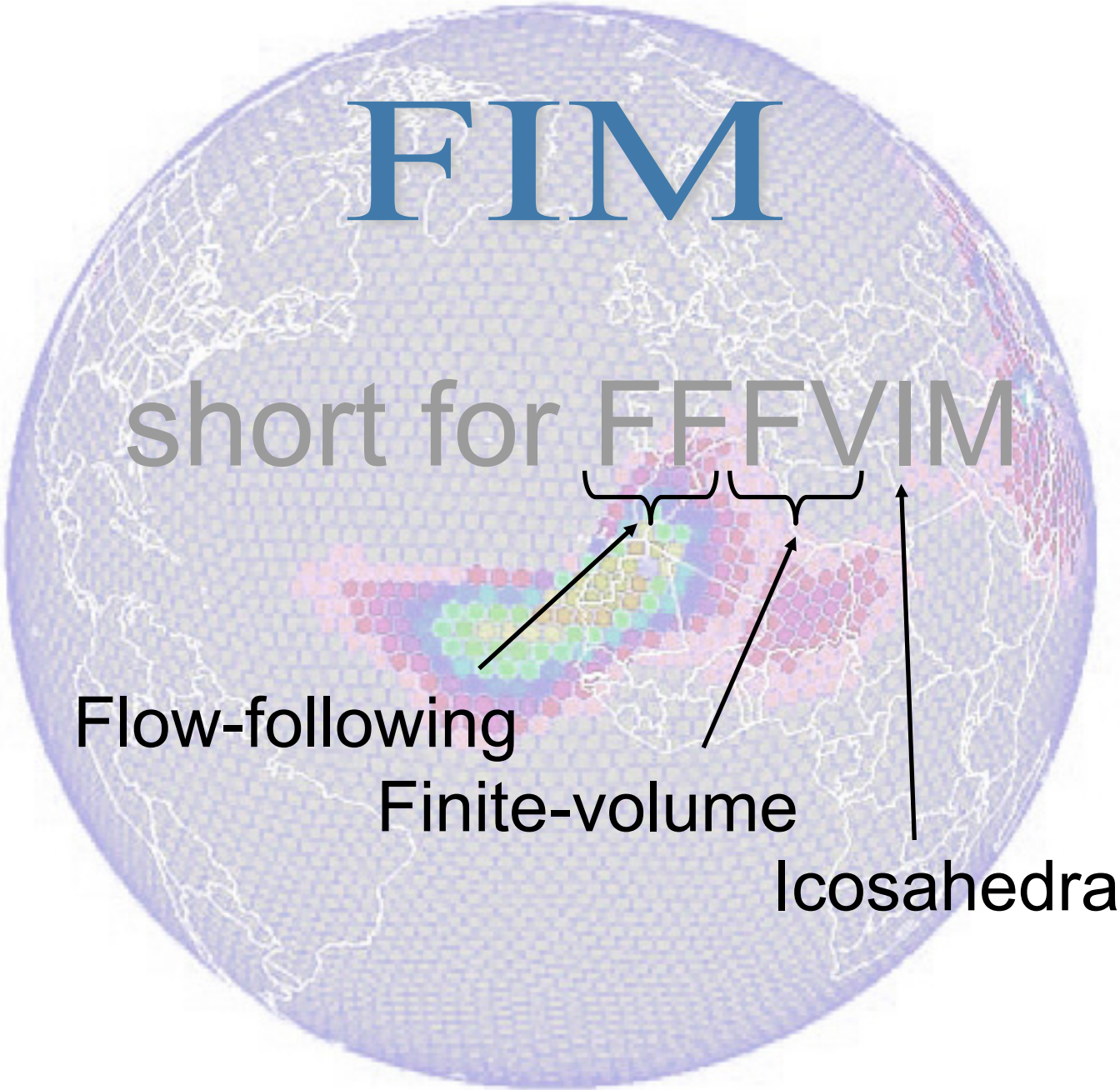
July 2012

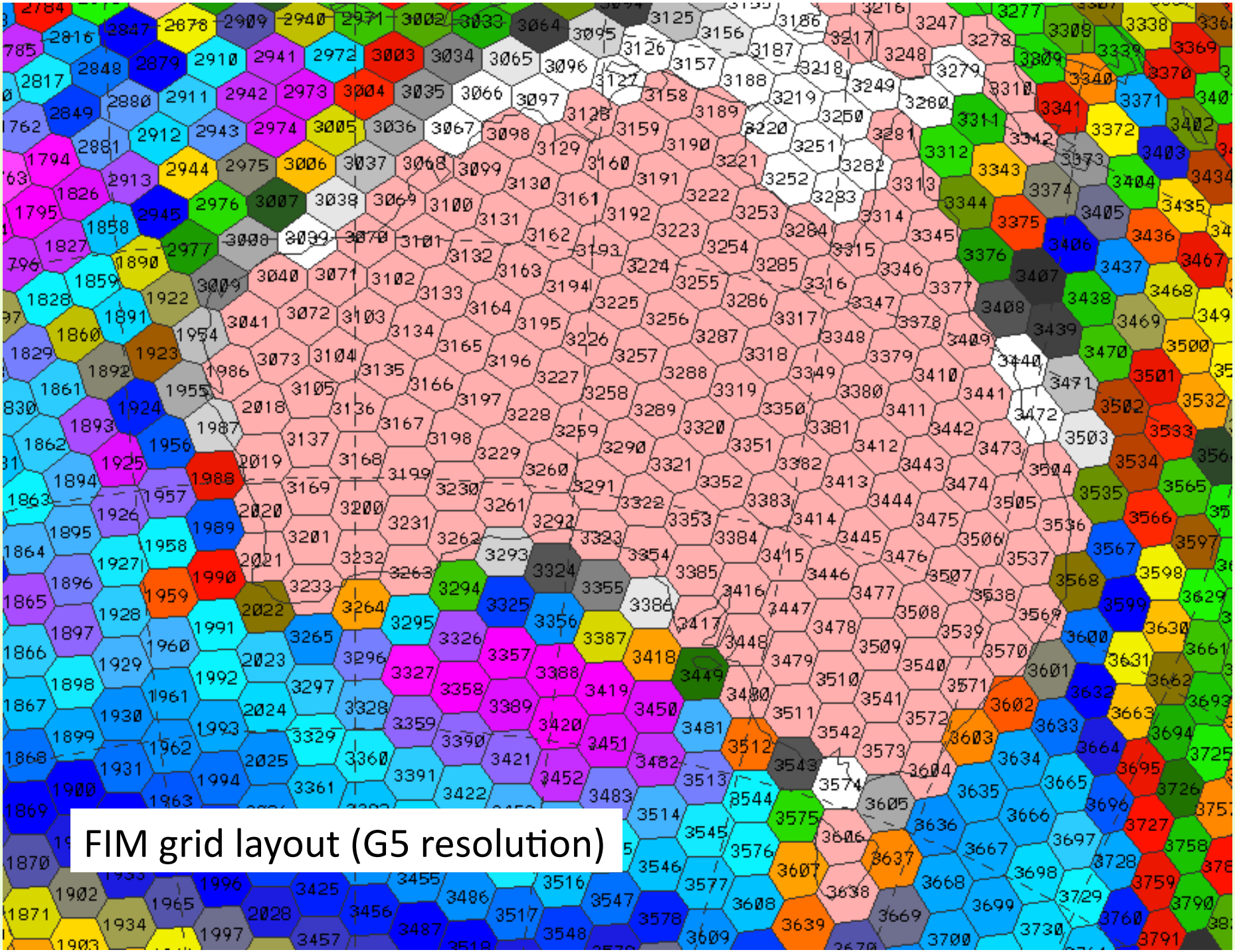
FIM

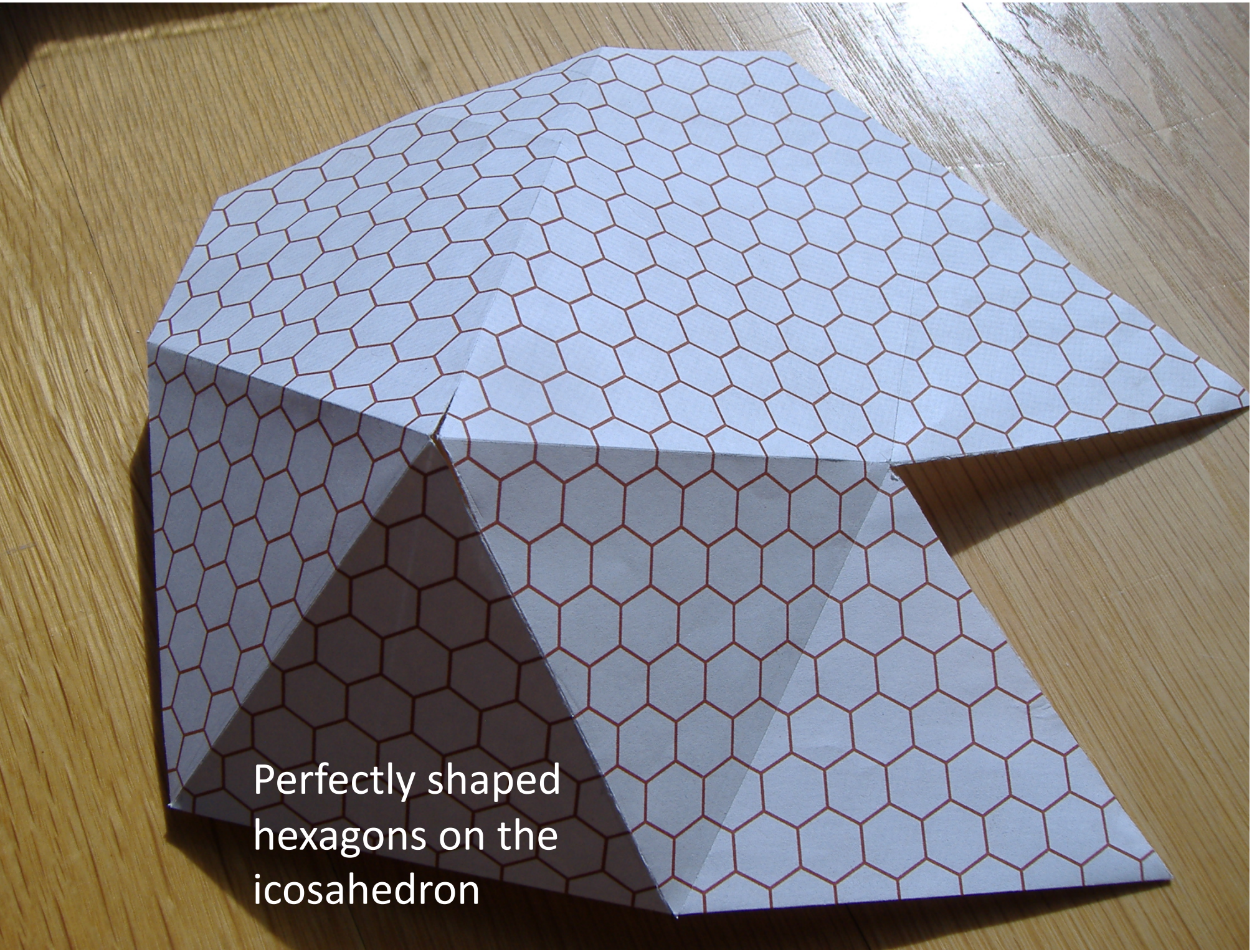
short for FFFVIM



Overriding goal: add genetic diversity to atmo and oceanic dycores

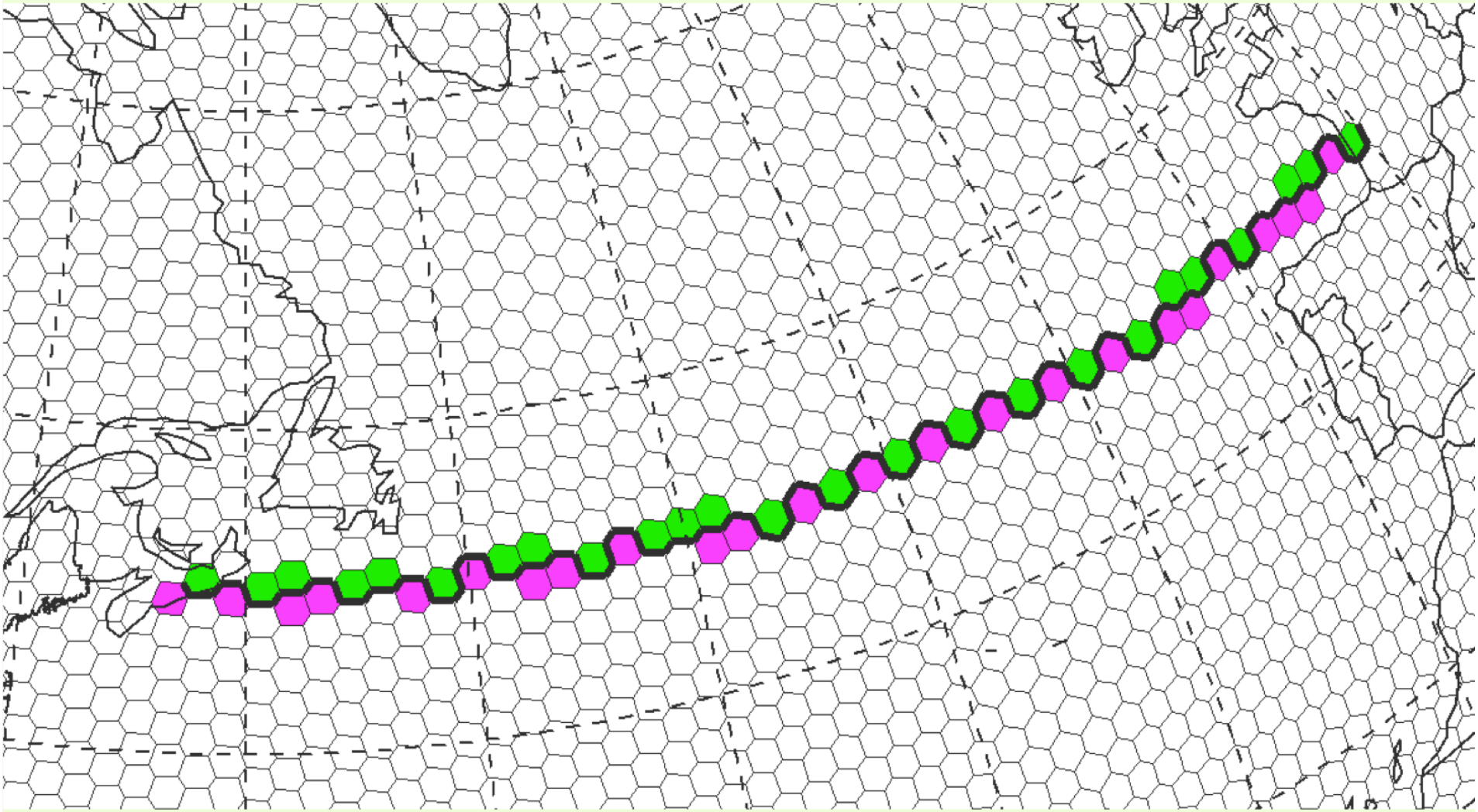
- Unique combination of two (not quite so unique) grid types:
  - Icosahedral horizontal grid
  - Adaptive (terrain-following/isentropic) vertical grid
- Tradeoffs:
  - Some drawbacks in traditional grids are avoided
  - must learn to cope with a few new problems


FIM grid layout (G5 resolution)

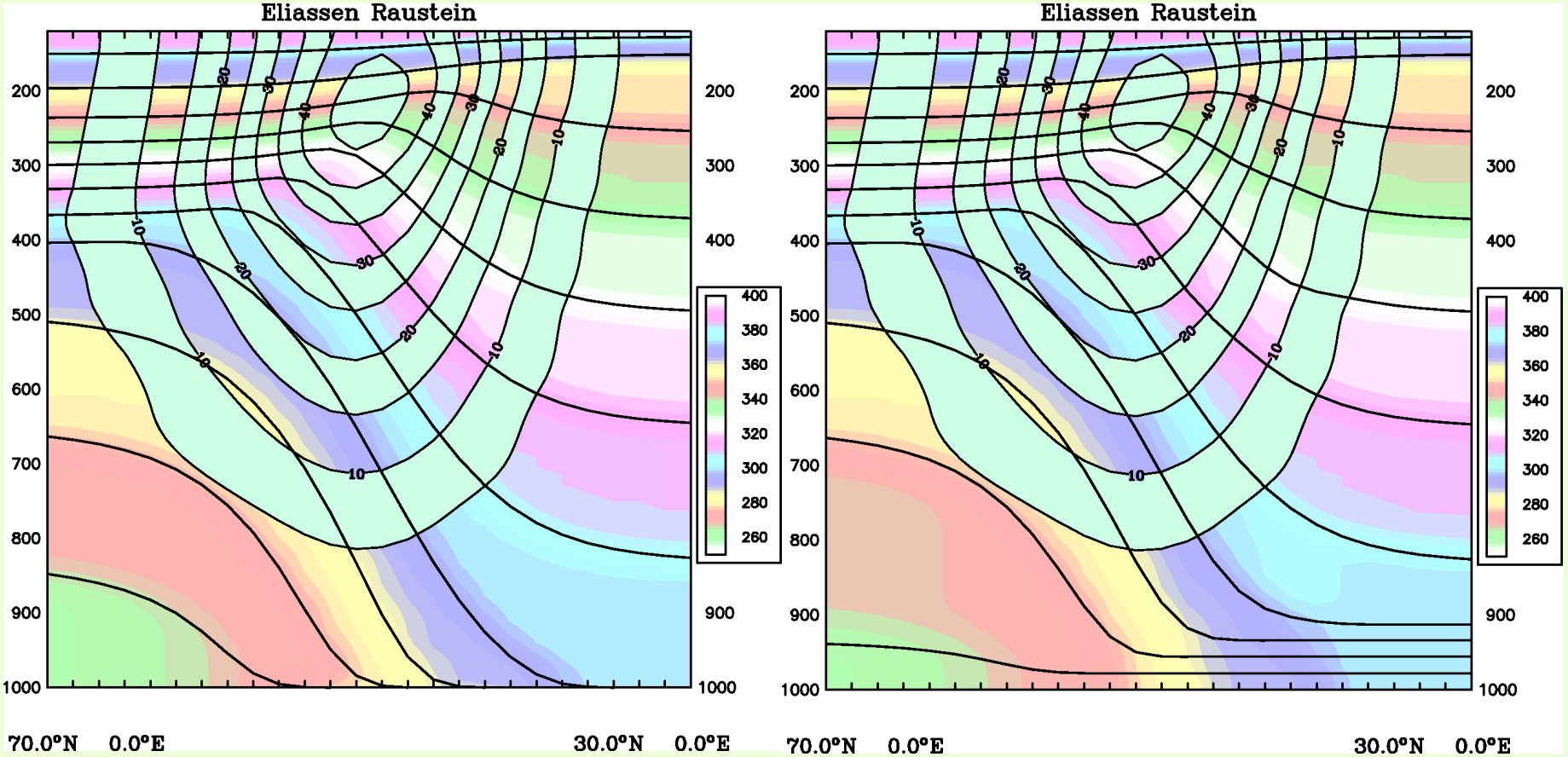

Perfectly shaped
hexagons on the
icosahedron

Horizontal grid: Pros and Cons

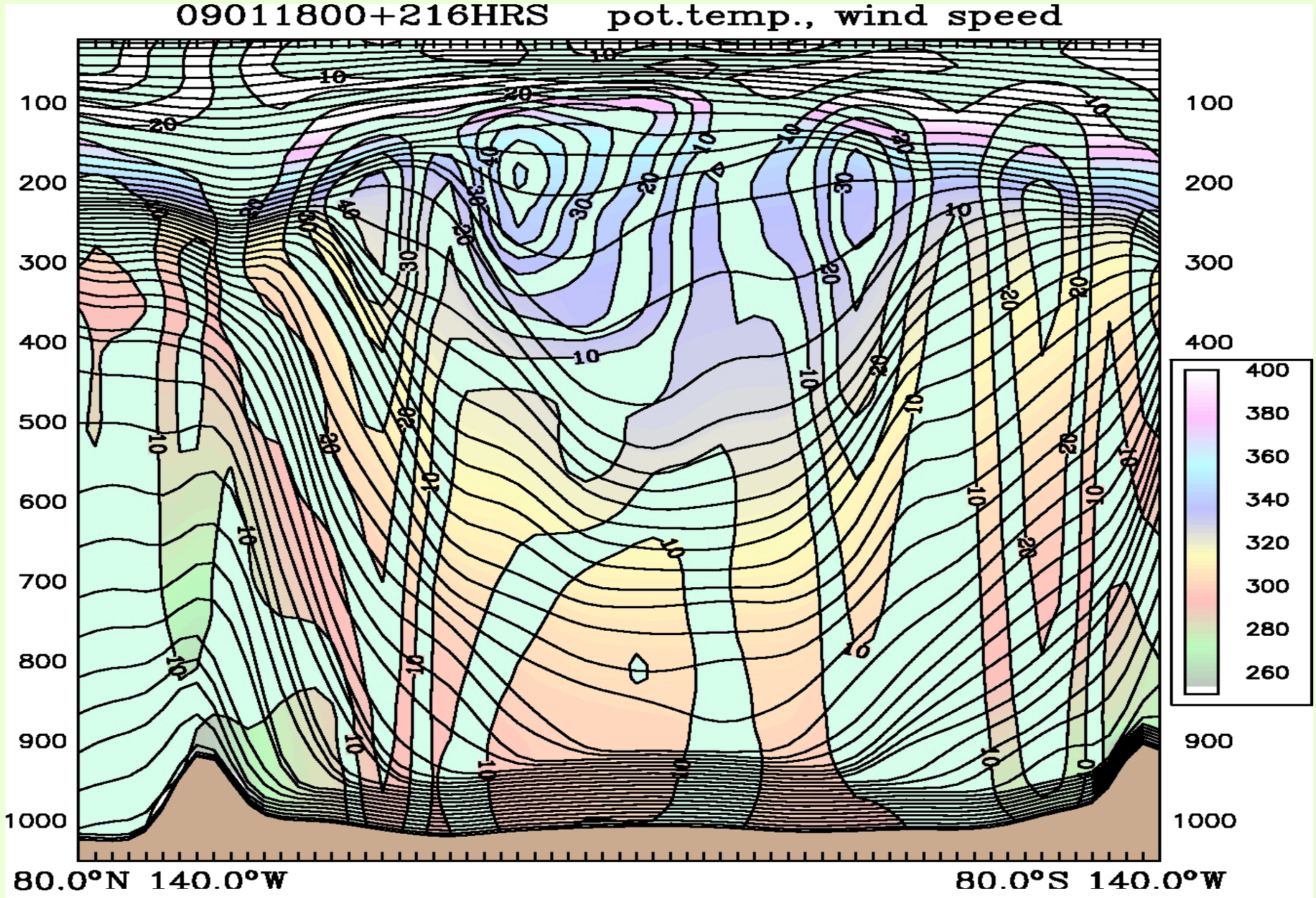
- Pros:
  - No pole problems
  - Fairly uniform mesh size & cell shape on sphere
- Cons:
  - Indirect addressing (an efficiency issue)
  - Wavenumber 5 zonal grid irregularity
  - Line-integral based discretizations hard to manipulate
- Minor annoyances:
  - Model diagnostics, graphics display more complex



Adaptive vertical grid
(primarily **isentropic**)



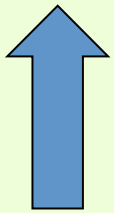
Coordinate surfaces and isotachs: solid. Pot.temperature: color



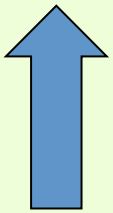
FIM hybrid-isentropic vertical coordinate

How we maintain the vertical grid: Continuity Equation in generalized ("s") coordinates

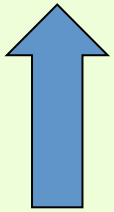
$$\left(\begin{array}{c}\text{vertical}\\ \text{motion}\\ \text{of}\\ s\text{ surface}\end{array}\right) + \left(\begin{array}{c}\text{vertical}\\ \text{motion}\\ \text{through}\\ s\text{ surface}\end{array}\right) = \left(\begin{array}{c}\text{vertically}\\ \text{integrated}\\ \text{horizontal}\\ \text{mass flux}\\ \text{divergence}\end{array}\right)$$



(zero in fixed grids)



(zero in material coord.)



(known)

Vertical grid: Pros and Cons

- Pros (in θ domain):
  - Numerical dispersion acts along isentropes
  - Optimal resolution of fronts and associated shear zones
- Cons (in θ domain):
  - Poor resolution in unstratified columns
- Positive side effect of hybrid design:
  - Weak stratification due to surface heating leads to deep sigma domain (=> more uniform grid spacing at low latitudes)

FIM

- Hydrostatic; primitive eqns (solved explicitly)
- Arakawa A-grid (i.e. no staggering)
- 3-level Adams-Bashforth time differencing
- Finite-volume discretization; no explicit mixing terms required to suppress grid-scale noise
- Variable vertical grid spacing requires transport eqns in flux form for conservation
  - Use FCT for pos-definiteness, monotonicity
- Divergence, vorticity, gradients expressed as line integrals along grid cell perimeter
- GFS column physics
- Horiz/vert. resolution specified at runtime
  - highest resolution regularly used: ~15km (2.6M cells)

See

http://fim.noaa.gov

for FIM documentation, skill scores, and twice-daily 10-day forecasts based on GFS initial conditions