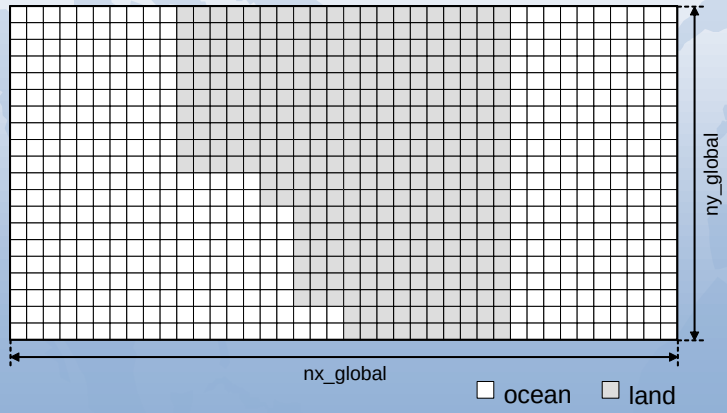
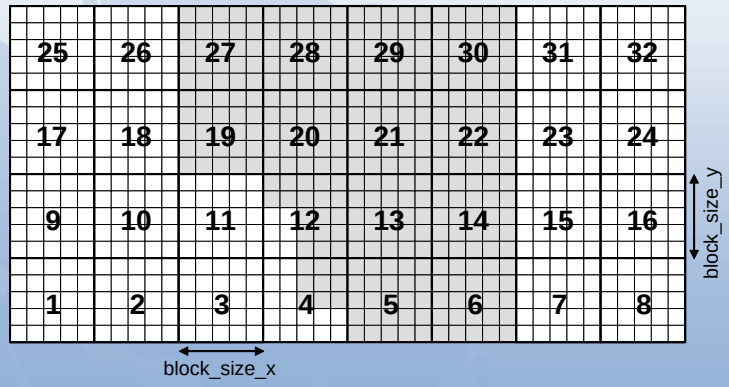
POP2, POP3, HYPOP

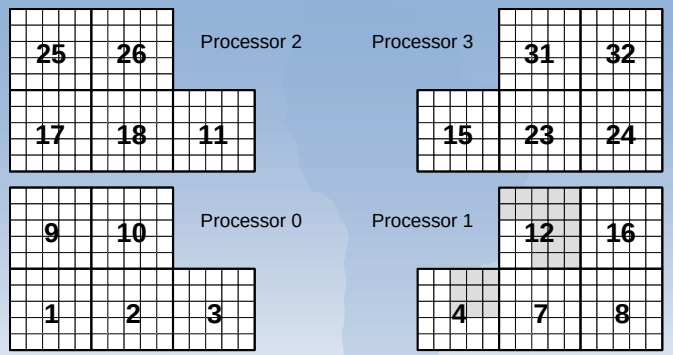
Phil Jones

Infrastructure Errors and Deficiencies (IEDs) and the Surge

POP Infrastructure



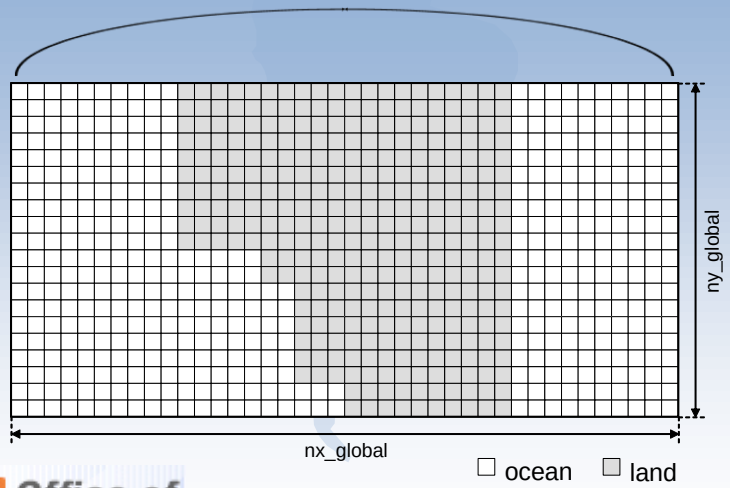




Load balancing
Land point elim.
Cache blocking
Hybrid parallel

- Problem with E-W, N-S optimization
- Do corners separately
- Bundle messages
- More friendly to unstructured grids

Tripole Changes



- Communicated with all domains across top
  - Padding
  - Now only few nbr blocks
- $2N^2$ search on initialization
  - Now 2N
  - Save some nbr info
- Better Armor
  - Vetting the vetters
- Performance

Benchmarks for Withdrawal

- Surge for merge
- Incremental Remap advection
- New error handling
  - More component friendly
- New naming conventions
- Better encapsulation
  - Argument lists
  - Get/Put functions
- Better build
- Public subversion repo
- Trac for bug/feature tracking
- POP3

Hybridization of POP (HYPOP)

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U.S. DEPARTMENT OF ENERGY

Los Alamos
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Three Way Cross Hybrid

- Hybrid Momentum/Tracer
  - Eulerian momentum
  - Lagrangian Tracer
- Hybrid Tracer grid
  - ALE, Isopycnal/Eulerian target
- Bred from POP
- High performance
  - High torque for acceleration

Zeedonk

Hybrid Eulerian/Lagrangian

- Eulerian Z a "natural" momentum vertical coord
  - Pressure gradient
  - Boundary conditions simpler
  - Long evolutionary history: Re-use much of POP code, including barotropic splitting
- Lagrangian more "natural" for tracers and continuity
  - Eliminate undesirable mixing traits
  - Eliminates much complexity (e.g. G-M)
  - Advection easier to implement (2-d incremental remap) and must be monotone

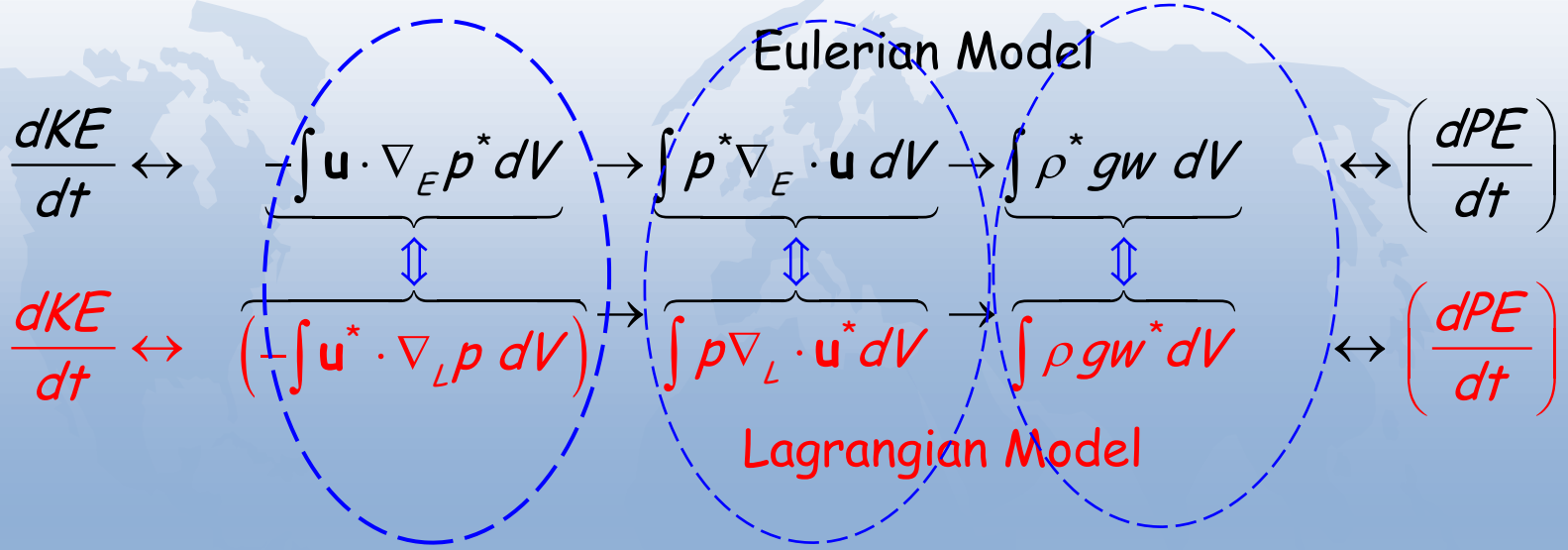
Hybrid operation

$$\frac{\partial h}{\partial \tilde{t}} + \tilde{\nabla} \cdot \left(h\mathbf{u}^* \right) = 0, \quad \frac{\partial h\Theta}{\partial \tilde{t}} + \tilde{\nabla} \cdot \left(h\mathbf{u}^* \right)\Theta = 0, \quad \frac{\partial hS}{\partial \tilde{t}} + \tilde{\nabla} \cdot \left(h\mathbf{u}^* \right)S = 0$$

$$\rho_0 \left(\frac{\partial \mathbf{u}}{\partial t} + \nabla_3 \cdot \mathbf{u}_3\mathbf{u} + f\mathbf{k} \times \mathbf{u} \right) = -\nabla p^* + \mathbf{F}_u$$

- Grafting p,u into pure lines
  - Momentum uses interpolated pressure from Lagrangian grid
  - Tracers use interpolated velocity from Eulerian grid

Energetic Consistency



Pressure Work due to Horizontal Velocities (KEX)

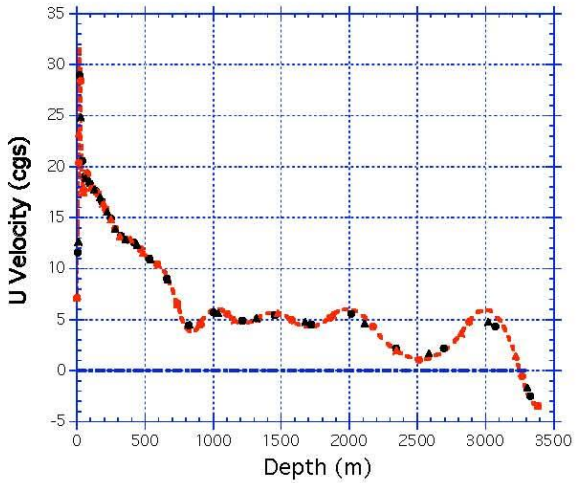
PdV Work due to Horizontal Velocities (PDV)

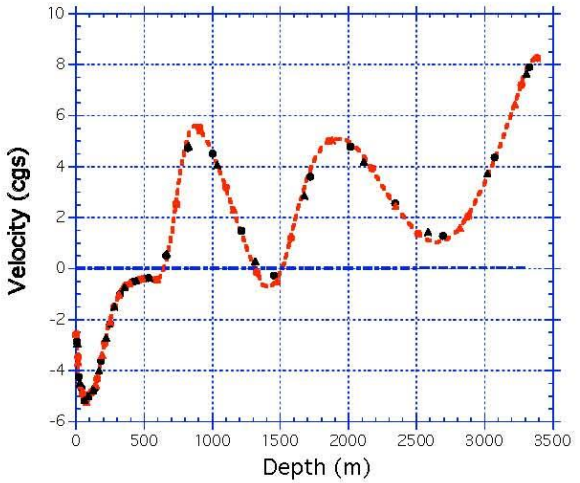
Rate of Energy Exchange (EX)

Ideally: $EX_E = -KEX_E = PDV_E = PDV_L = -KEX_L = EX_L$

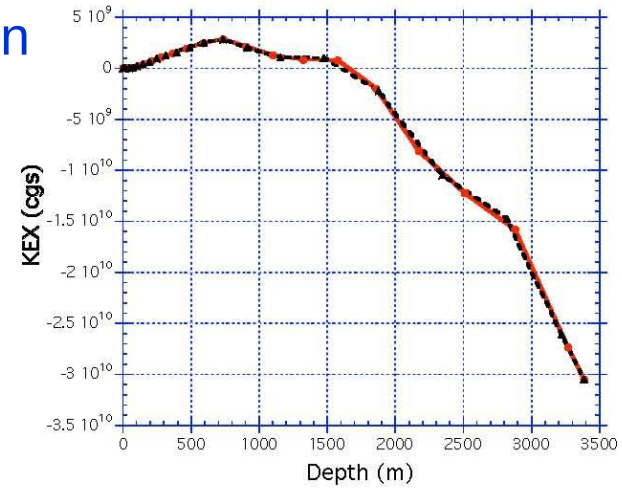
- Interpolate pressure and get velocity interpolation
  - Pressure from hydrostatic relation
  - Quad. Splines, max smoothness for interface u
  - Constrained least-squares for Lag. Mean u*

Results





Triangles are interpolated velocities on Lagrangian grid
Circles are Eulerian velocities

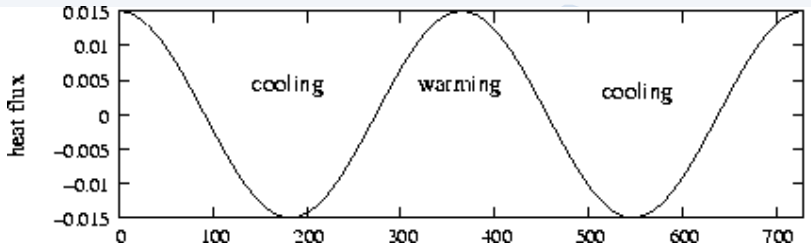


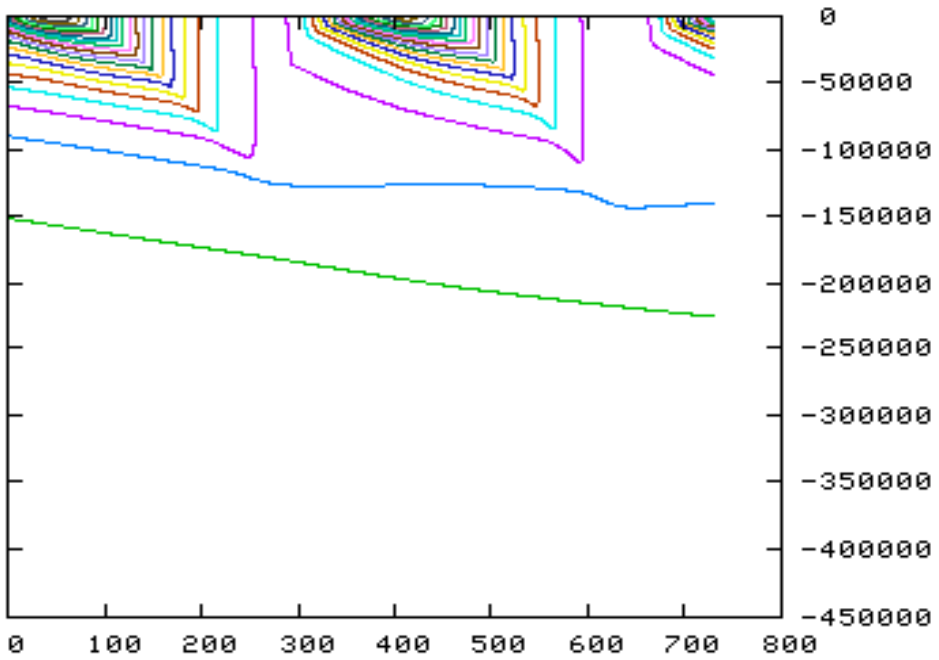
Column (6,20)

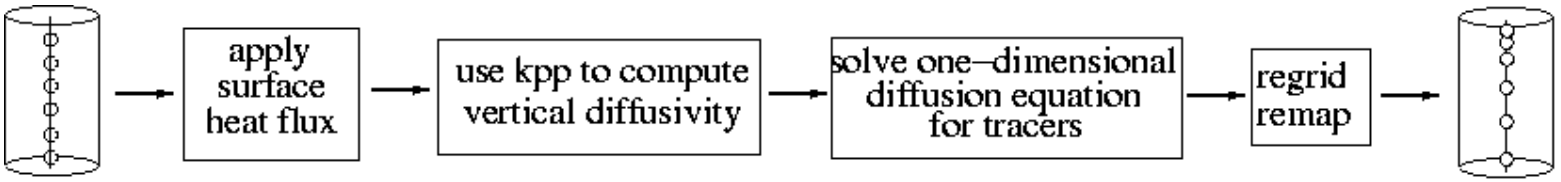
Hybrid Arbitrary Lagrangian-Eulerian (ALE)

- Solution advanced on Lagrangian grid
- Periodic regridding to desired target
- Goals for target
  - Resolve mixed layer (Eulerian)
  - Resolve, better represent mixing deep ocean (Lag)
- Factors
  - Number of levels/layers
  - Choice of targets
  - T,S profile
  - Minimize arbitrary regridding
  - Smooth grid spacings

Vertical coordinate unit test

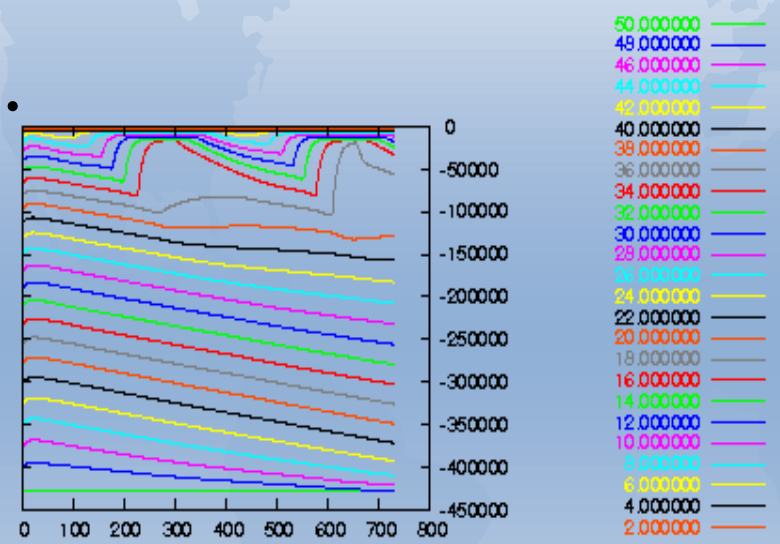




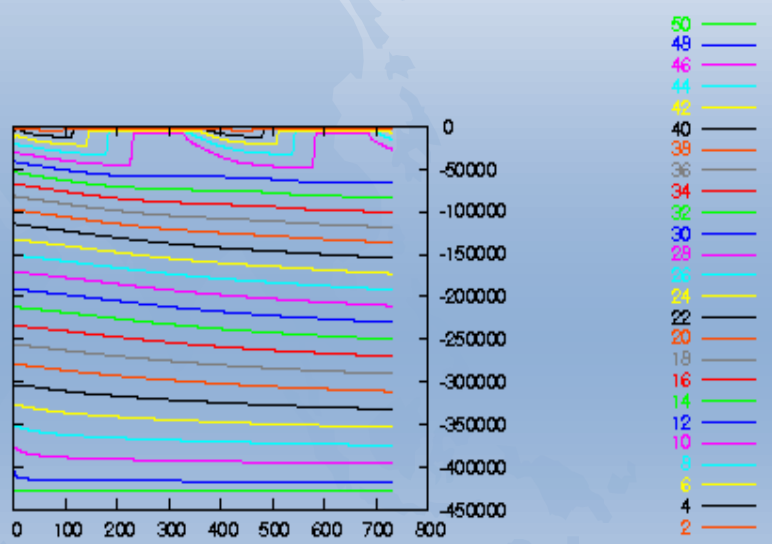


Minimum Layer Thickness

Figure 4 – sharp target distribution
Coordinate surfaces plotted in z coordinates



hypop

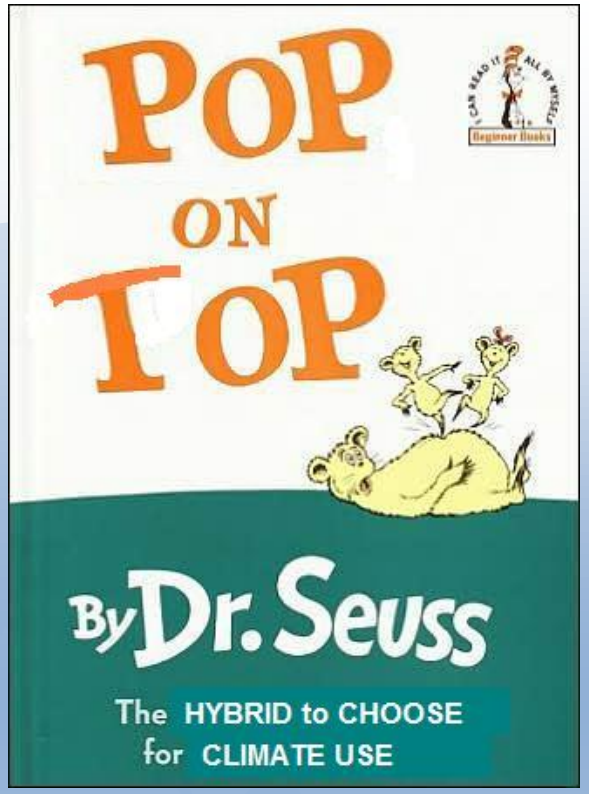


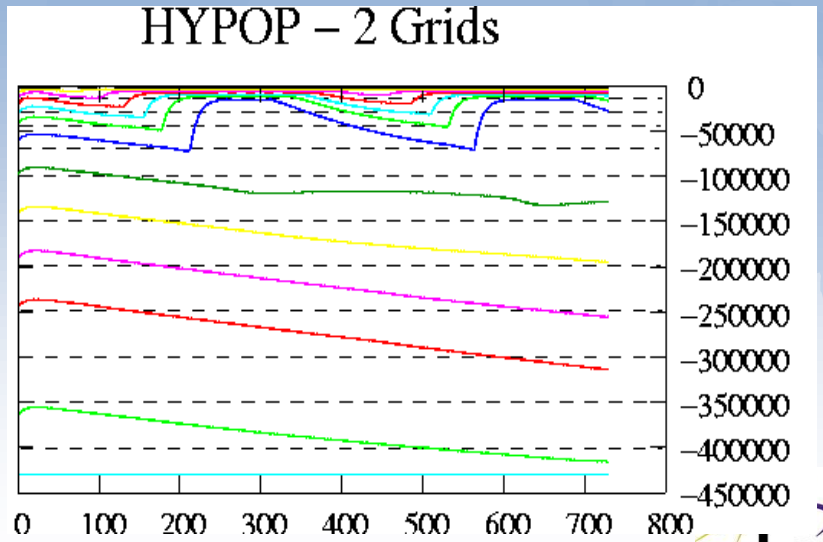
hybgen

Differences related to relaxation
Large variation in thickness causes problems w/ KPP
Less physical

POP on Top

- Use POP-like variable grid near sfc
  - Use momentum grid
- Stay Lagrangian deep
- Make transition at physical depth
  - MLD, thermocline, pycnocline
  - Better resolution at transition





Current Status

- HYPOP working in pure POP mode
  - 2 identical Eulerian grids
- HYPOP working with 2 different Eulerian grids
- Currently testing full ALE in POP mode (always remapping back to Eulerian)
- Experiment with other possible vertical grids
- Evaluating new 2 time level schemes to replace leap frog
- Evolutionary development
  - Eliminate sterile hybrids