

New Features of HYCOM

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HYCOM 2.2 (I)

- Maintain all features of HYCOM 2.1
 - Orthogonal curvilinear grids
 - Can emulate Z or Sigma or Sigma-Z models
 - ◇ It is “Arbitrary Lagrangian-Eulerian”, see:
Adcroft and Hallberg, O. Modelling 11 224-233.
 - Explicit support for 1-D and 2-D domains
 - KPP or Kraus-Turner or Mellor-Yamada 2.5 or Price-Weller-Pinkel
 - Rivers as bogused surface precipitation
 - Multiple tracers
 - Off-line one-way nesting
 - Scalability via OpenMP or MPI or both
 - ◇ Bit-for-bit multi-cpu reproducibility

HYCOM 2.2 (IIa)

- Alternative scalar advection techniques
 - Provided by Mohamed Iskandarani
 - Donor Cell, FCT (2nd and 4th order), MPDATA
 - FCT2 replaces MPDATA as standard scheme
- Vertical coordinate changes
 - Vertical remapping uses PLM for fixed coordinate layers
 - Thin deep iso-pycnal layers
 - Stability from locally referenced potential density
 - Spatially varying layer target densities
 - ◇ Different isopycnal layers in semi-enclosed seas

HYCOM 2.2 (Iib)

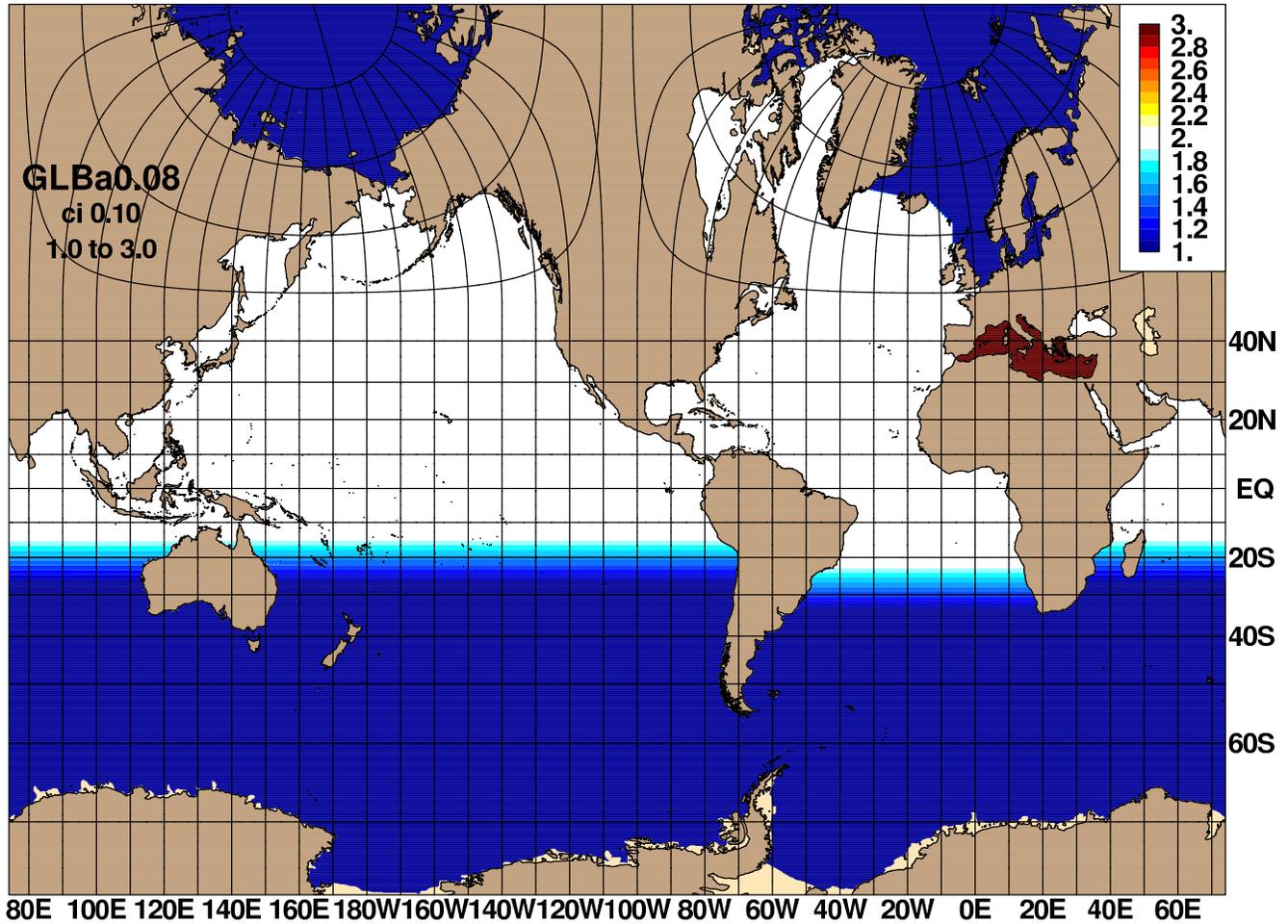
- Equation of state that is quadratic in salinity
 - HYCOM must “invert” the equation of state
 - ◇ $\text{tofsig}(r,s)$ and $\text{sofsig}(r,t)$
 - Traditional version is cubic in T and linear in S
 - ◇ Finding the root of a cubic is expensive, but exact
 - ◇ Linear in S is not accurate at low salinity
 - Optional version is cubic in T and quadratic in S
 - ◇ Coefficients provided by Shan Sun
 - ◇ More accurate at low salinity
 - Rivers, Black Sea, Caspian Sea
 - ◇ Not much more expensive

HYCOM 2.2 (IIc)

- Special halo exchange for tripole global grid
 - Arctic dipole patch on standard Mercator globe
 - Logically rectangular domain
 - ◇ Two halves of top edge “fold” together
 - ◇ V-velocity changes sign across the fold
- Improved thermobaricity
 - No single reference state is appropriate for the global ocean
 - ◇ Hallberg, Ocean Modelling, 8, 279-300
 - Use a linear combination of pressure gradients from two out of three reference states
 - ◇ Atlantic (3°C, 35.0 psu)
 - ◇ Arctic/Antarctic (0°C, 34.5 psu)
 - ◇ Mediterranean (13°C, 38.5 psu)
 - Most locations use just one reference state
 - ◇ Linear combinations allow smooth transition between states
 - Do this in shallow water if possible
 - In deep water, constrain the T&S used for thermobaricity to be close to the reference state

1/12° GLOBAL THERMOBARIC REFERENCE STATE

TBARIC MAP (1=Arctic,2=Atlantic,3=Med.)

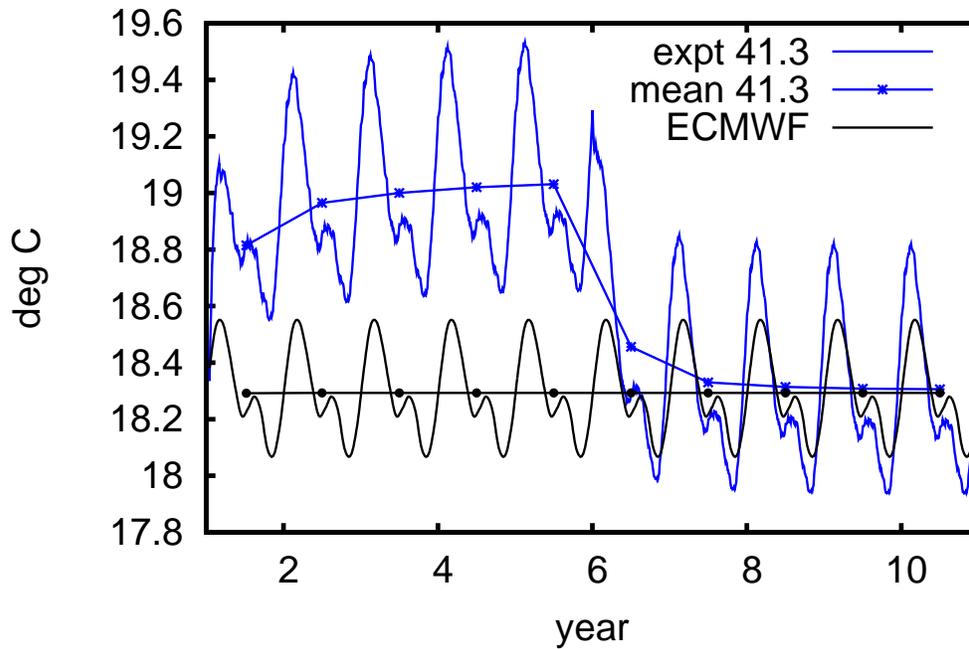


HYCOM 2.2 (IIIa)

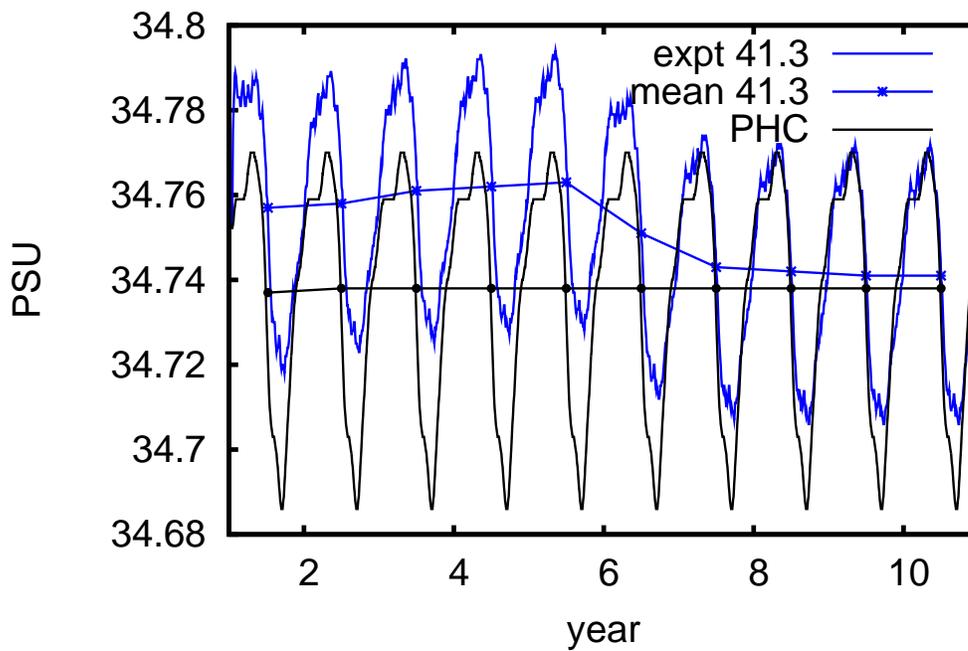
- Mixed layer changes
 - GISS mixed layer model
 - ◇ Provided by Armando Howard
 - KPP bottom boundary layer
 - ◇ Provided by George Halliwell
 - KPP tuning
- Atmospheric forcing changes
 - Option to input ustar fields
 - ◇ Best option for monthly forcing
 - ◇ Otherwise calculated from wind stress or speed
 - Can relax to observed SST fields
 - Improved COARE 3.0 bulk exchange coefficients
 - Black-body correction to longwave flux
 - Climatological heat flux offset, \overline{Q}_c
$$Q = (Q_{sw} - Q_{lw}) + (Q_l + Q_s) + \overline{Q}_c$$
 - ◇ \overline{Q}_c is constant in time
 - Typically based on the model's climatological SST error, times (say) $-45 \text{ W m}^{-2}/^{\circ}\text{C}$

$\overline{Q_c}$ ADDED AFTER FIVE YEARS GLOBAL MEAN SST and SSS

GLBa0.72, Basin-Wide Mean SST

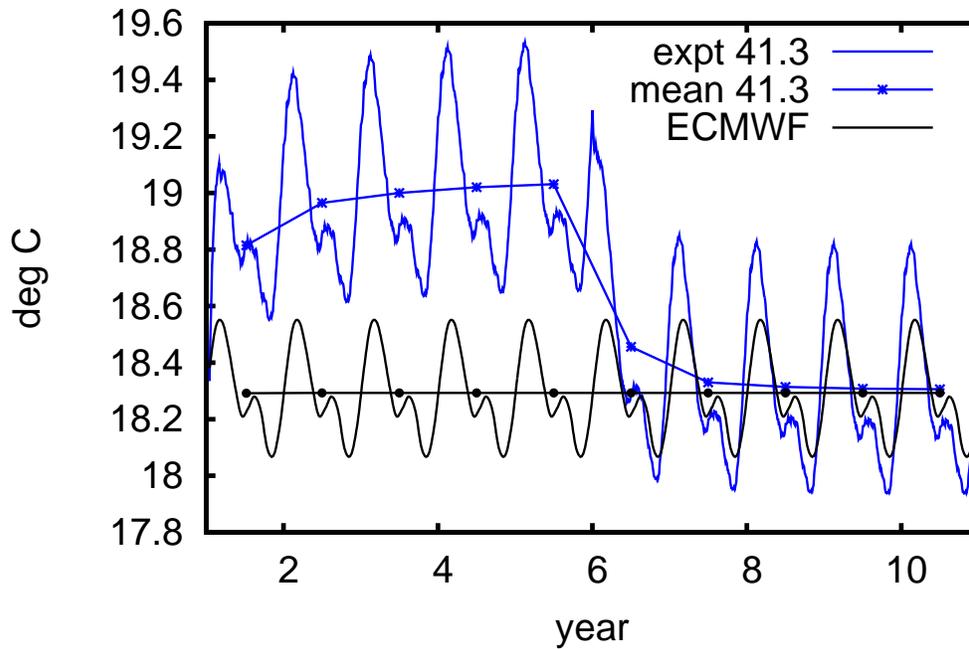


GLBa0.72, Basin-Wide Mean SSS

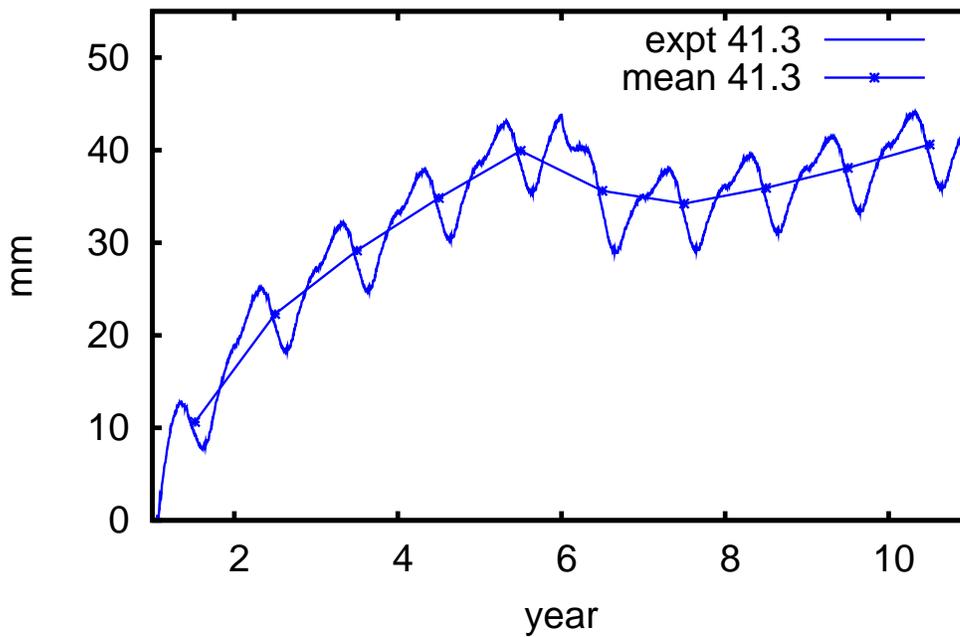


$\overline{Q_c}$ ADDED AFTER FIVE YEARS GLOBAL MEAN SST and SSH

GLBa0.72, Basin-Wide Mean SST



GLBa0.72, Basin-Wide Mean SSH



HYCOM 2.2 (IIIb)

- Improved support for rivers
 - Still bogused surface precipitation
 - High frequency inter-annual river flow allowed
 - ◇ Add it to atmospheric precip, off-line
 - ◇ Instead of monthly climatology, or in-addition to it (flow anomalies)
 - Better control of low salinity profiles
 - Option for mass (vs salinity) flux
 - Equation of state that is quadratic in salinity
- Tidal forcing
 - Provided by NCEP
 - Body forcing and open boundary forcing
 - Boundry forcing currently for “Flather” ports
 - ◇ Extend it to Browning-Kreiss ports and nesting

HYCOM 2.2 (IIIc)

- New diagnostics within HYCOM
 - Time-averaged fields (in archive files)
 - Synthetic instrumentation
 - ◇ Provided by George Halliwell
 - ◇ 3-D particle tracking
 - ◇ surface and constant depth drifters
 - ◇ isopycnic drifters
 - ◇ fixed instruments and moorings

HYCOM 2.2 (IIIId)

- Finer control over energy loan ice model
 - Melting point can be linear in salinity
 - Set ice minimum and maximum thickness
 - Set ice vertical temperature gradient
 - ◇ Or get ice surface temperature from T_a
 - Made compatible with coupled sea-ice approach
- Two-way coupling to LANL's CICE sea ice model
 - HYCOM exports:
 - ◇ SST, SSS, SSH
 - ◇ Surface Currents
 - ◇ Available Freeze/Melt Heat Flux
 - CICE exports:
 - ◇ Ice Concentration
 - ◇ Ice-Ocean Stress
 - ◇ Actual Freeze/Melt Heat/Salt/Mass Flux
 - ◇ Solar Radiation at Ice Base

HYCOM AND ESMF

- Earth System Modeling Framework
<http://www.esmf.ucar.edu/>
 - Superstructure couples components
 - ◇ Air/Ocean/Ice/Land
 - ◇ Asynchronous I/O component
 - Run “concurrent” with model components
 - Infrastructure provides data structures and utilities for building scalable models
- Added a superstructure “cap” to HYCOM
 - Simplifies coupled systems
 - ◇ HYCOM coupled to LANL CICE sea-ice
 - ◇ Convert atmospheric field processing and the energy-lean ice model into ESMF components
 - Use ESMF for (user-level asynchronous) I/O
 - Interoperate with other ESMF compliant ocean models (e.g. Poseidon, MITgcm, MOM4)
- This initial ESMF support is optional
 - TYPE=esmf instead of TYPE=mpi
- ESMF will eventually required to run HYCOM
 - HYCOM version 3.0

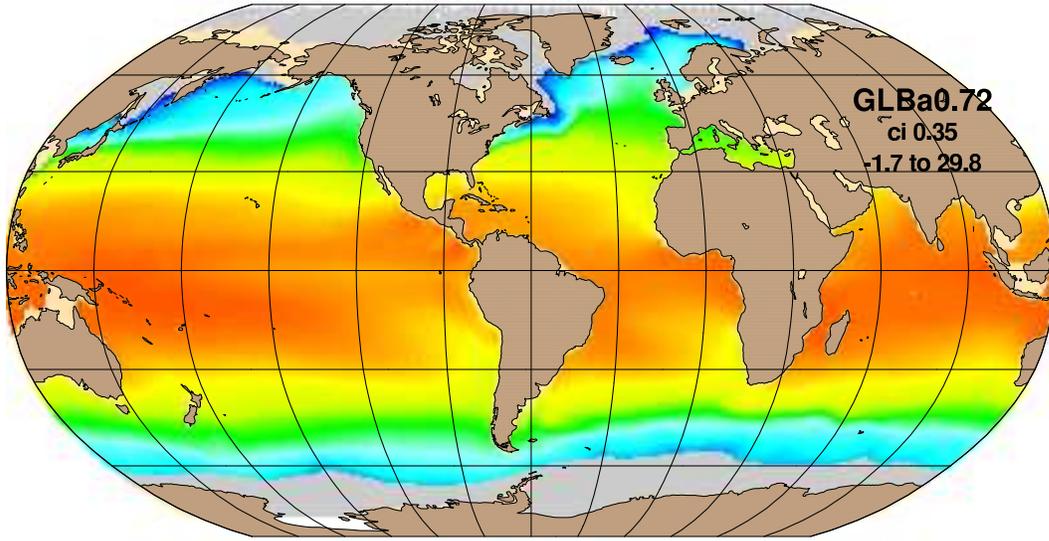
HYCOM 2.2 (IV)

- Climatological nesting now allowed
 - Start from monthly mean outer model archive files
 - Allows nested runs longer than the outer run
 - ◇ But with less accurate boundary state
 - Probably only suitable for regional nests
- Nesting no longer requires co-located grids
 - General archive to archive horizontal interpolation (curvilinear)
- Hybrid to fixed vertical grid remapper
 - Allows fixed-coordinate nests inside hybrid coordinate outer domains
 - ◇ HYCOM to (fixed-grid) HYCOM
 - ◇ HYCOM to NCOM

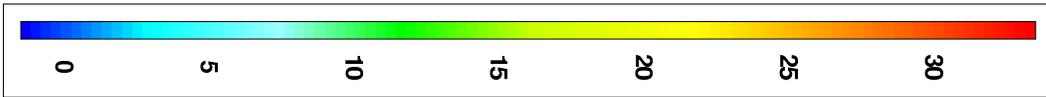
HYCOM 2.2 (V)

- Enhanced hycomproc and fieldproc
 - NCAR-graphics based
 - Many more color palette options
 - ◇ Can read in an arbitrary palette
 - Mark locations, and draw tracks, on plot
 - Plot diffusion coefficients and tracers (hycomproc)
 - Overlay vector and line-contours (fieldproc)
- Added fieldcell
 - Like fieldproc, but for cell-array (vs contouring)
 - ◇ Mark locations and draw tracks
 - ◇ Overlay line-contours
 - Uses NCAR's map projections
 - Typically much faster than fieldproc, but can leave unfilled cells
 - Option to increase resolution of input (bi-linear interpolation)

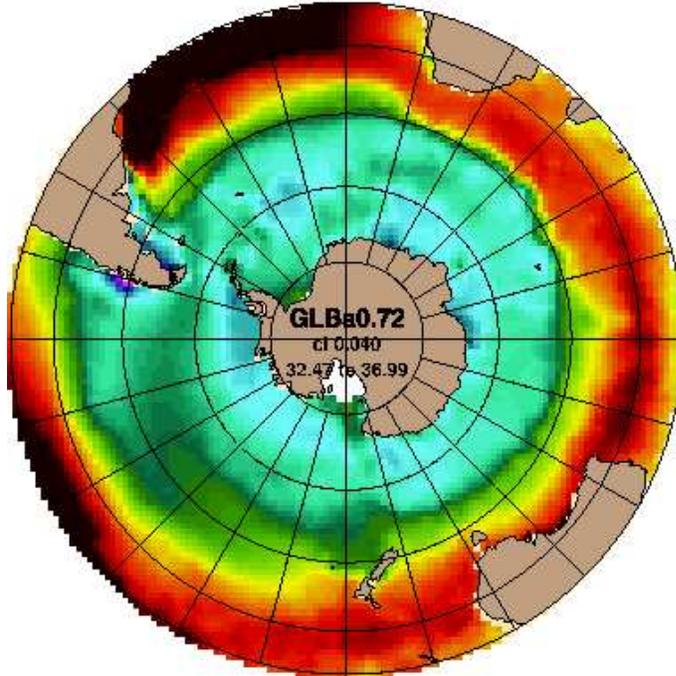
ERA-15 SST: Feb



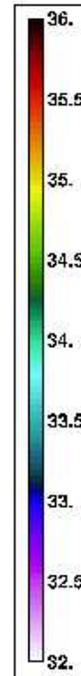
GLBa0.72
ci 0.35
-1.7 to 29.8



SSS (hour 0)



GLBa0.72
ci 0.040
32.47 to 36.99



HYCOM 2.2 (VI)

- Diagnostic fields to netCDF and other file formats
 - Archive fields in layer space
 - ◇ On p-grid (interpolated velocity)
 - 3-D archive fields interpolated to z-space
 - ◇ On p-grid, or
 - ◇ Sampled along arbitrary tracks
 - 3-D archive fields sampled on iso-therms
 - Meridional stream-function from (mean) 3-D archive
 - ◇ In logical array space (rectilinear grids)
 - ◇ Binned to latitude bands (curvilinear grids)
 - Atmospheric forcing input fields
 - ◇ Time axis depends on “.b” file format
 - ◇ Any “.a” file with the right “.b” file structure can be converted to netCDF
 - Fields binned into lon-lat cells

HYCOM CURVILINEAR GRIDS and NetCDF

- Most basin-scale cases use a Mercator grid
 - 1-D lat & lon axes (rectilinear)
 - Handled well by many netCDF packages
- Global HYCOM's Arctic patch grid is curvilinear
- HYCOM netCDF use the CF-1.0 conventions, which support curvilinear grids
 - If latitude and longitude are 2-D grids
 - ◇ 1-D axes are array indexes
 - ◇ Longitude and latitude arrays are also in the file and identified as alternative coordinates
- Most netCDF packages are not CF-1.0 aware
 - Bin into uniform lon-lat cells off-line
 - Interpolate to a 1-D latitude and longitude grid off-line
 - ◇ General archive to archive horizontal interpolation
- Archive to archive remapper can also be used for standard (non-native) grids
 - MERSEA grid is uniform $1/8^\circ$
 - AOMIP grid is rotated uniform $1/2^\circ$

CANDIDATE FEATURES FOR HYCOM 2.3

- Stable-code vs new features
 - Released code-base has to be tested and stable
 - New features can be a significant improvement
 - Will add interim releases to web page
 - ◇ Features may be removed in next released code
- Fully region-independent
 - Compile once, run on any region and any number of processors
 - ◇ Run-time memory allocation
 - ◇ Might reduce performance (fewer compiler optimizations available)
 - Needed for full ESMF compliance
- Wetting and Drying
- Diurnal heat flux cycle
- Wind drag coefficient based on model SST
- Support for HYCOM in CCSM
- Enhanced support for ESMF