

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
- 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

HYCOM 2.2 (IIa)

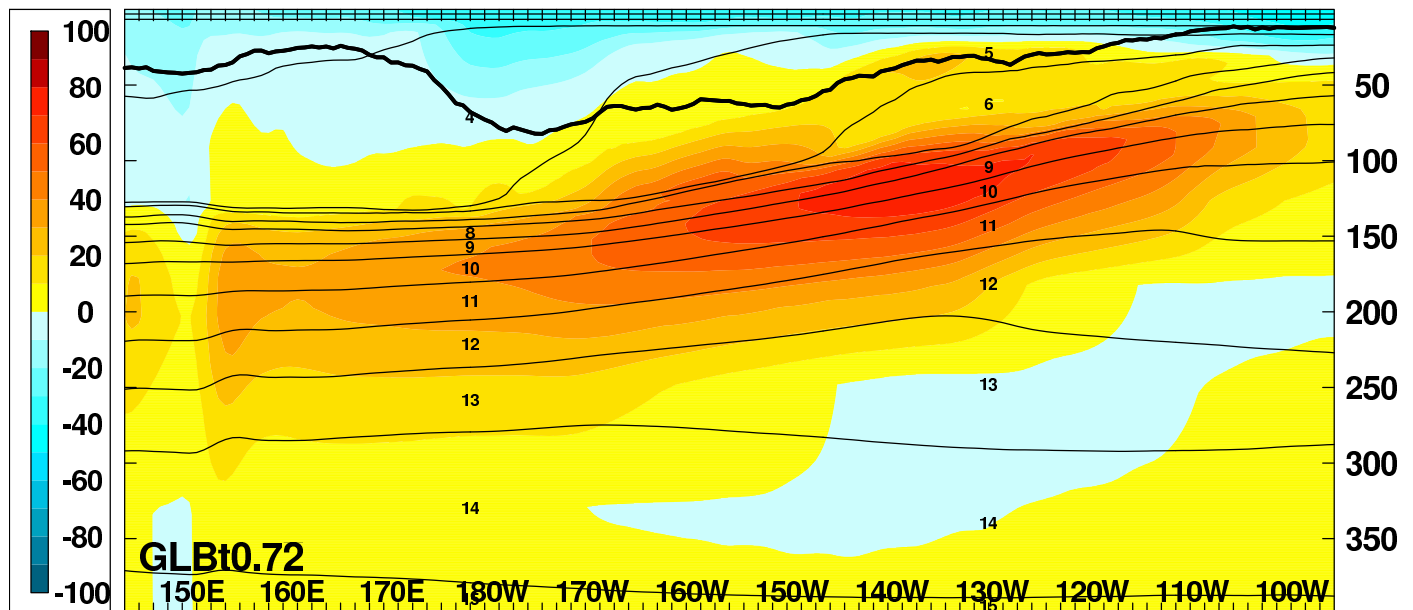
- Alternative LeapFrog barotropic time splitting
 - Provided by SHOM
 - Twice as expensive as standard scheme
 - ◇ Still a small fraction of total run time
 - Significantly more stable
 - May allow 2x longer baroclinic time step
- Alternative scalar advection techniques
 - Provided by Mohamed Iskandarani
 - Donor Cell, FCT (2nd and 4th order), MPDATA
 - FCT2 replaces MPDATA as standard scheme
- Mixed layer changes
 - GISS mixed layer model
 - ◇ Provided by Armando Howard
 - KPP bottom boundary layer
 - ◇ Provided by George Halliwell
 - KPP tuning

HYCOM 2.2 (Iib)

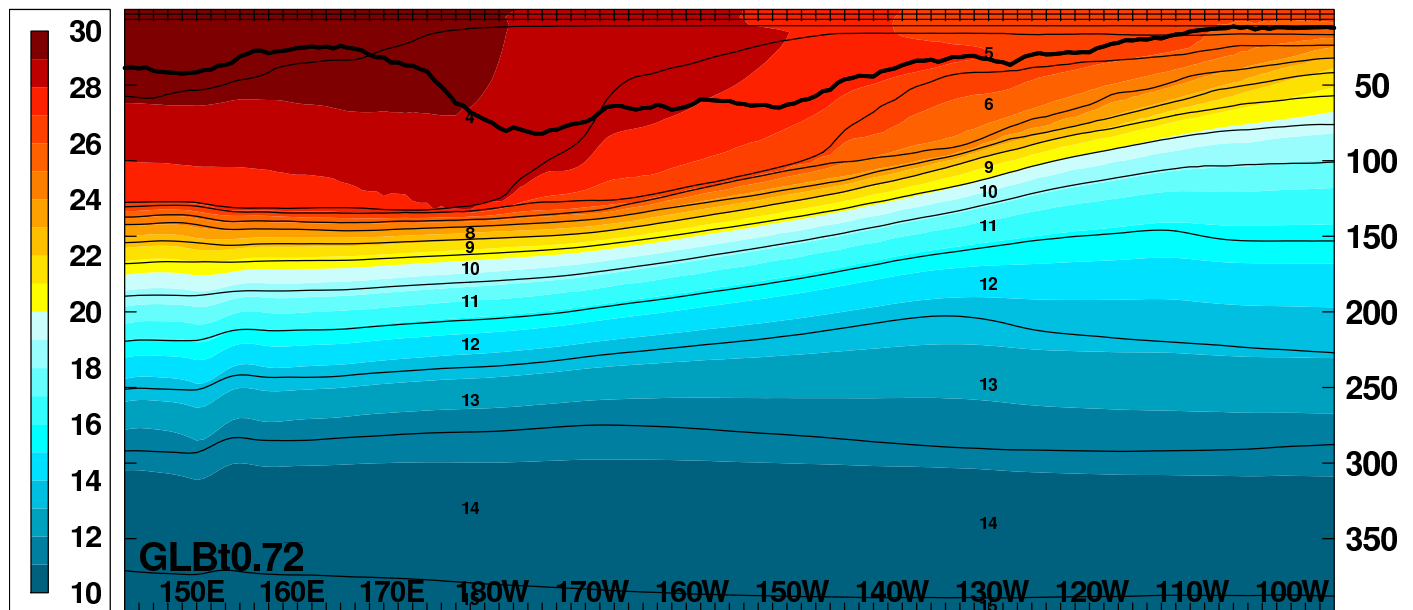
- Initial vertical coordinate changes
 - Must always use PCM for isopycnal layers
 - Vertical remapping used PLM for fixed coordinate layers
 - Thin deep iso-pycnal layers
 - Stability from locally referenced potential density
 - Spatially varying layer target densities
 - ◇ Different isopycnal layers in semi-enclosed seas
- Recent vertical coordinate changes
 - hybrlx only active below “fixed coordinate” surface layers
 - Major re-write of HYBGEN by George Halliwell and Alan Wallcraft
 - ◇ Must always use PCM for isopycnal layers
 - ◇ Vertical remapping uses PLM or PPM or WENO-like PPM (Laurent Debreu) for fixed and non-isopycnal coordinate layers
 - ◇ More layers are identified as non-isopycnal
 - ◇ Updated logic for two layers (one too dense, other too light)

ANNUAL MEAN EQUATORIAL PACIFIC GLBt0.72 HYCOM VERSION 2.2.03

u-velocity zonal sec. 0.00n mean: 4.004- 5.004 [06.0H]

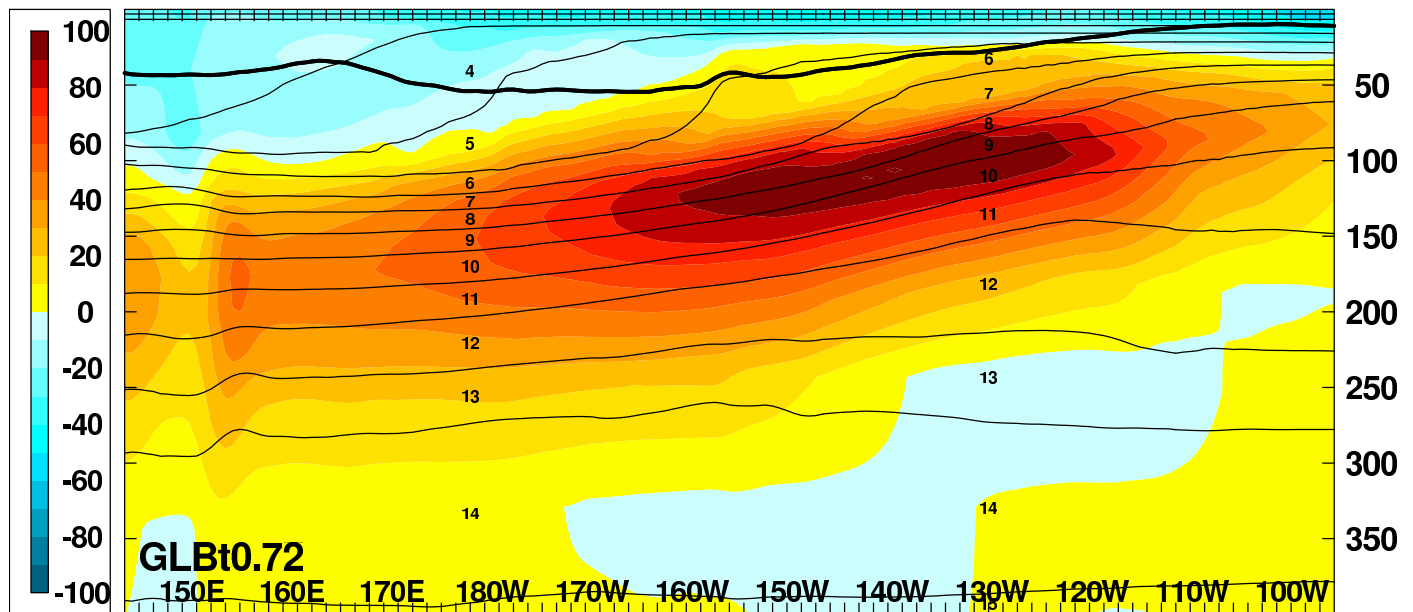


temperature zonal sec. 0.00n mean: 4.004- 5.004 [06.0H]

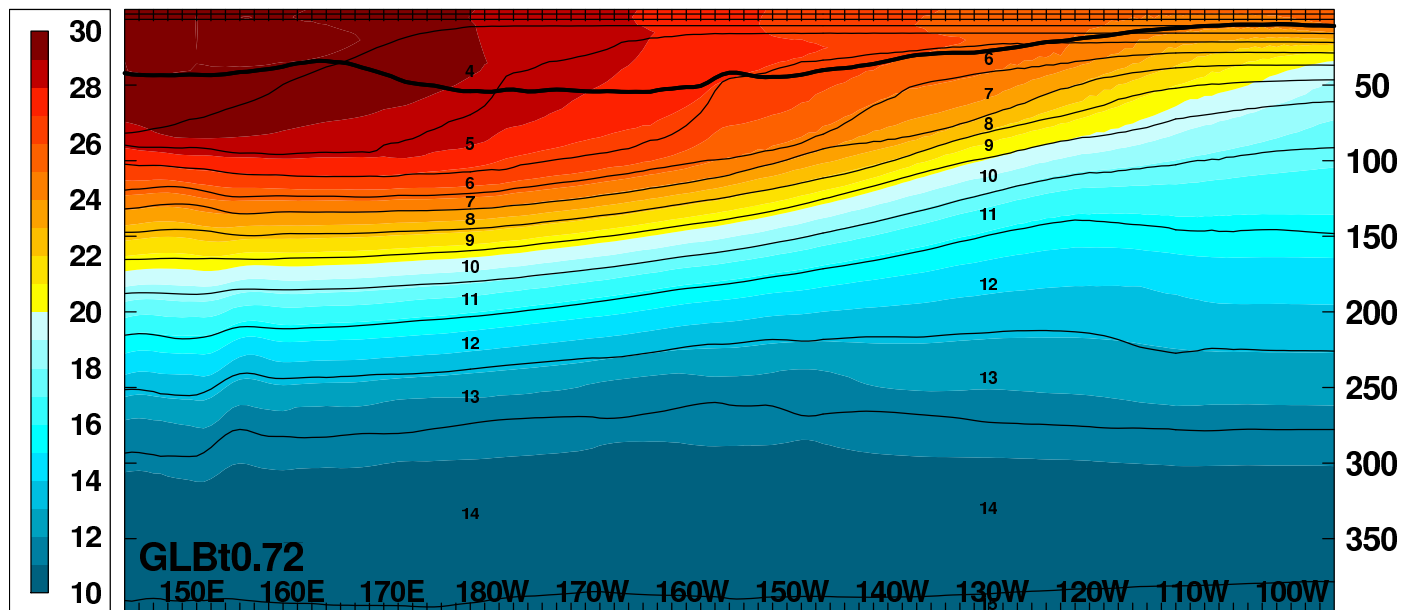


ANNUAL MEAN EQUATORIAL PACIFIC GLBt0.72 HYCOM VERSION 2.2.18

u-velocity zonal sec. 0.00n mean: 4.004- 5.004 [22.3H]



temperature zonal sec. 0.00n mean: 4.004- 5.004 [22.3H]



HYCOM 2.2 (IIc)

- Equation of state that is quadratic in salinity
 - HYCOM must “invert” the equation of state
 - ◇ tofsig(r,s) and 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
- Pade equation of state
 - Optional Pade version: P_{22}/Q_{11}
 - ◇ P_{22} is quadratic in T and S
 - ◇ Q_{11} is linear in T and S
 - Developed at NCEP
 - ◇ Only Sigma0 at present
 - More accurate at low salinity

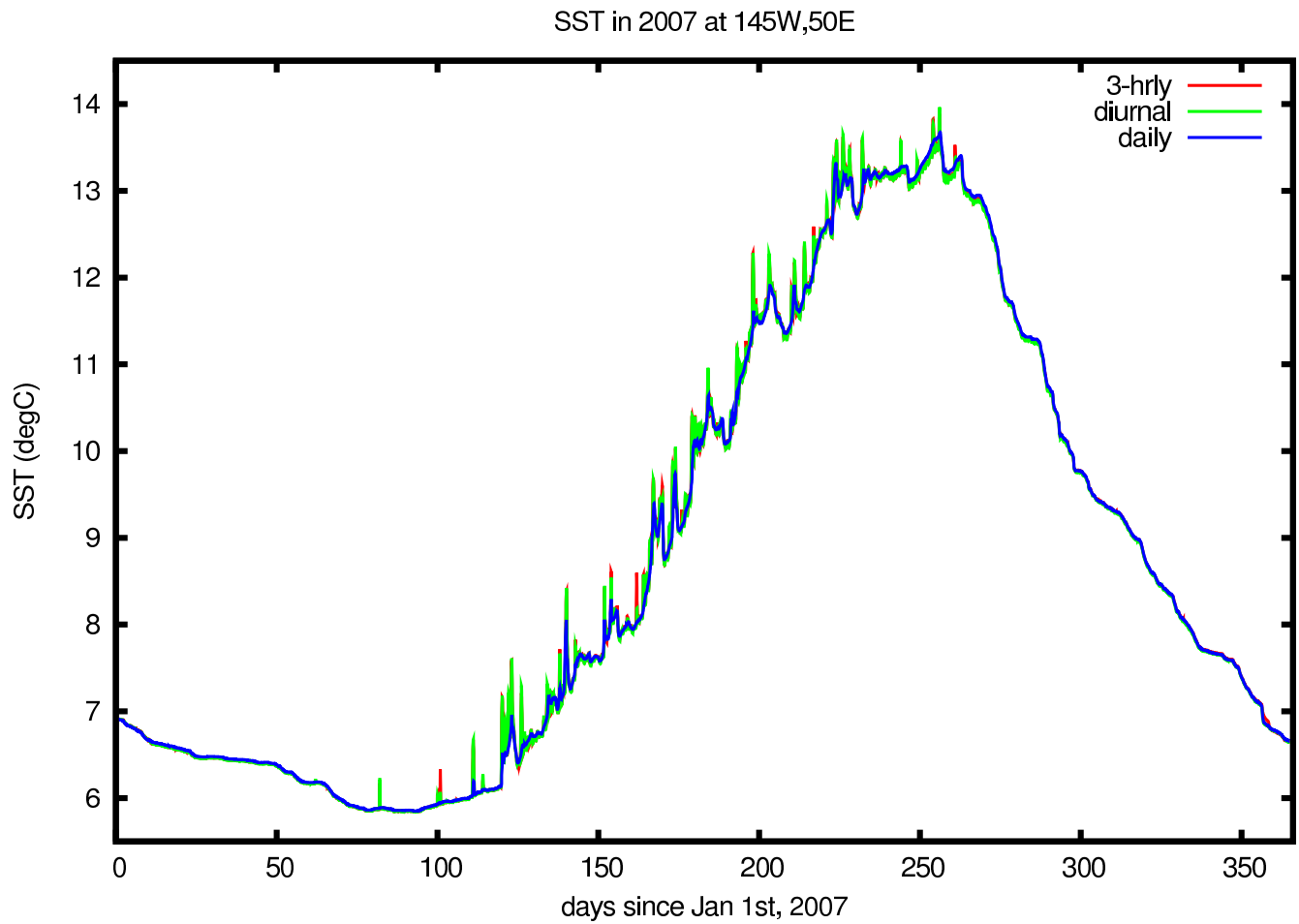
HYCOM 2.2 (IId)

- Improved thermobaricity
 - Use exact formula for the thermobaricity
 - ◇ Eqn. 3 from Sun et al. 1999
 - 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

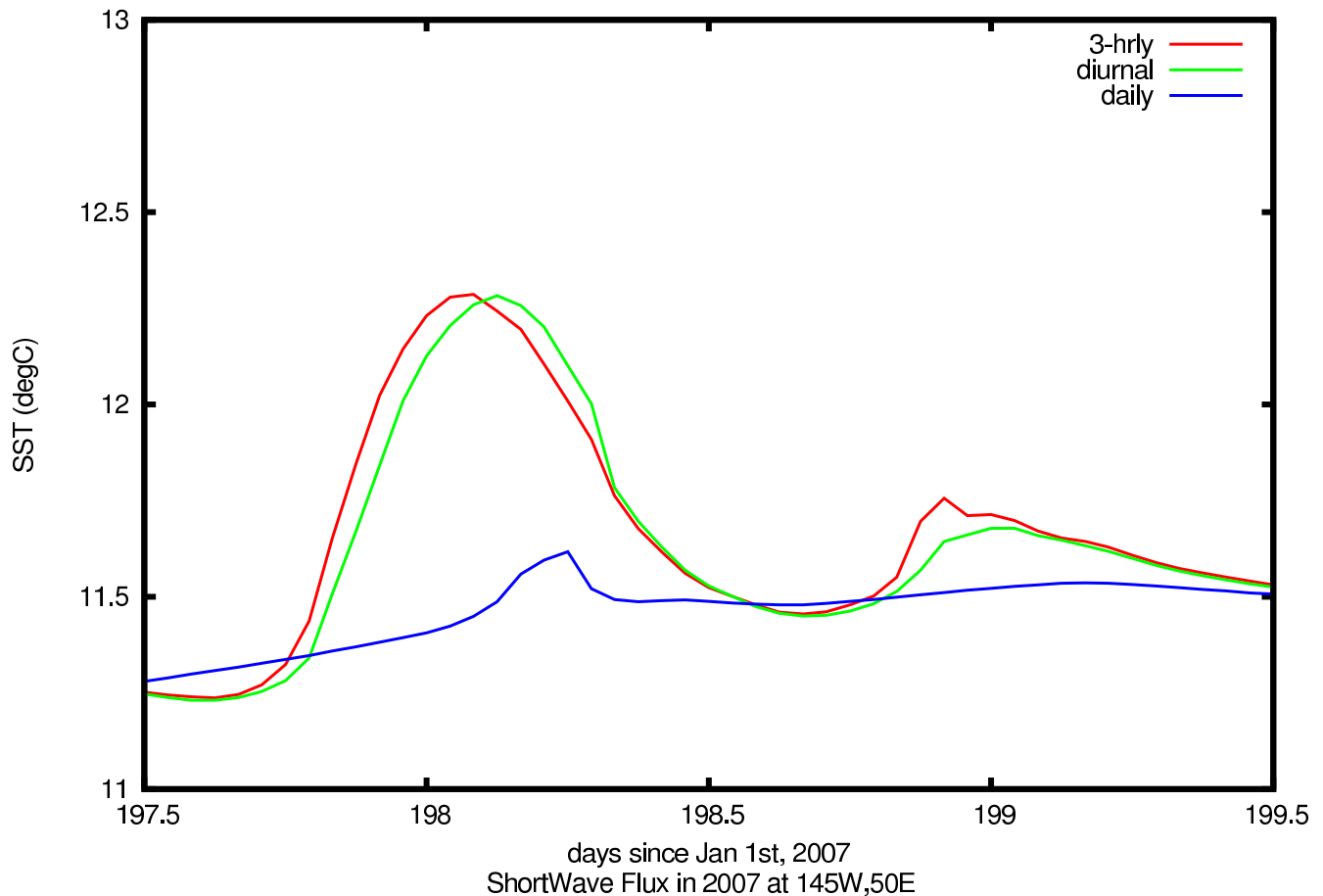
HYCOM 2.2 (IIIa)

- 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) $-45 \text{ W m}^{-2} / ^\circ\text{C}$
 - Analytic diurnal heat flux cycle
 - ◇ Need hourly Q_{sw} for good cycle
 - Have 3 or 6 hourly (snapshots or averages)
 - ◇ Input daily-running average Q_{sw}
 - ◇ Apply multiplicative correction:
 - clear-sky_now / clear-sky_daily-average

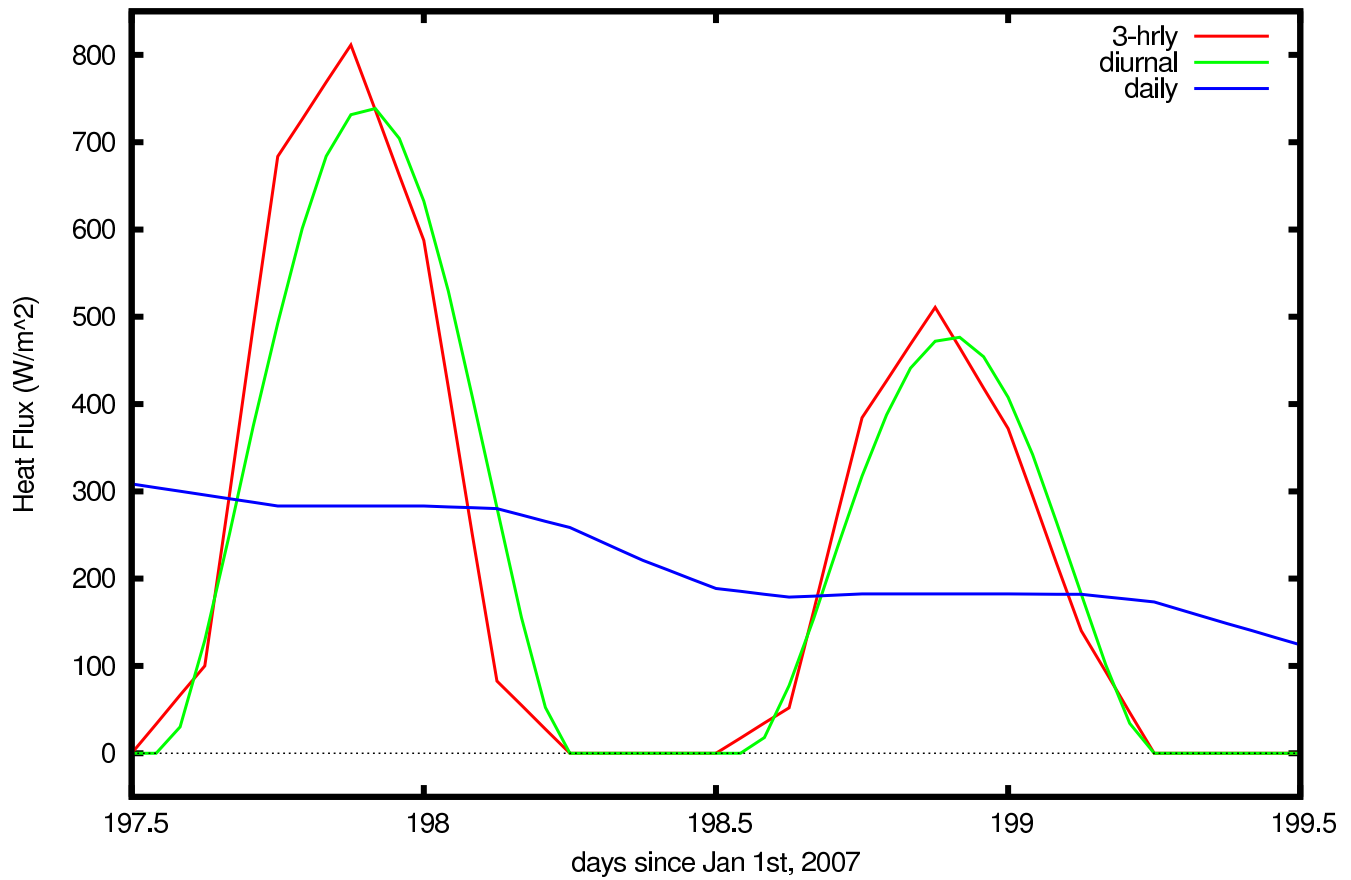
1-D HYCOM at OCEAN STATION PAPA NOGAPS FORCING



SST in 2007 at 145W,50E



ShortWave Flux in 2007 at 145W,50E



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
 - Boundary forcing currently for “Flather” ports
 - ◇ v2.3: Extend it to Browning-Kreiss nesting
 - Body forcing for 8 largest components
 - SAL treated as a fraction of non-steric SSH
 - Tidal drag based on bottom roughness
 - ◇ Applied to near-bottom tidal velocity
 - Use a lagged 25-hour average as the non-tidal velocity

HYCOM 2.2 (IIIc)

- New diagnostics within HYCOM
 - Time-averaged fields (in archive files)
 - ◇ Identical to off-line mean archives
 - ◇ Daily 25-hour average for tides
 - ◇ No in-line capability to capture variability
 - ◇ Instantaneous archives still available
 - Sub-region archive files
 - ◇ Example: hourly 3-D from Global 1/12°
 - 3-4 small regions only
 - ◇ One file per involved MPI task (entire tile)
 - ◇ Reconstruct standard regional archive files off-line
 - ◇ Instantaneous archives still available
 - Synthetic instrumentation
 - ◇ Provided by George Halliwell
 - ◇ 3-D particle tracking
 - ◇ surface and constant depth drifters
 - ◇ isopycnic drifters
 - ◇ fixed instruments and moorings

HYCOM 2.2 (IIId)

- I/O optimizations
 - Typically, all I/O is from a single MPI task
 - I/O can be a bottleneck when running on many processors
 - ◇ MPI-2 I/O option
 - Do I/O from 1st MPI task in each row of tiles
 - ◇ Faster code for “endian” conversion
 - HYCOM files are always big-endian
 - Intel and AMD are little-endian
 - Do the conversion in parallel
 - Sub-region archive files
 - ◇ One file per involved MPI task
 - ◇ Can be much faster than writing a full archive
 - Remove density from restart and archive files
 - ◇ Less I/O, smaller files
 - ◇ Must track which equation of state is used

HYCOM 2.2 AND SEA ICE

- 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
 - Coupling via the Earth System Modeling Framework
 - ◇ Currently for non-global domains only
 - ◇ v2.3: ESMF version 4 and global domains

HYCOM 2.2 AND CCSM

- Community Climate System Model
<http://www.ccsm.ucar.edu/>
 - Fully-coupled, global climate model
 - Sea-Ice: CICE
 - Ocean: POP
- HYCOM can be used in place of POP in CCSM3
- Uses the standard HYCOM source code
- Subdirectory CCSM3 used to hold and build the CCSM3 version
 - Some source code files are specific to CCSM3
 - HYCOM ".f" files are renamed ".F" to simplify CCMS3 integration
 - Macro USE_CCSM3 for CCSM3-specific code

HYCOM 2.2 (IV)

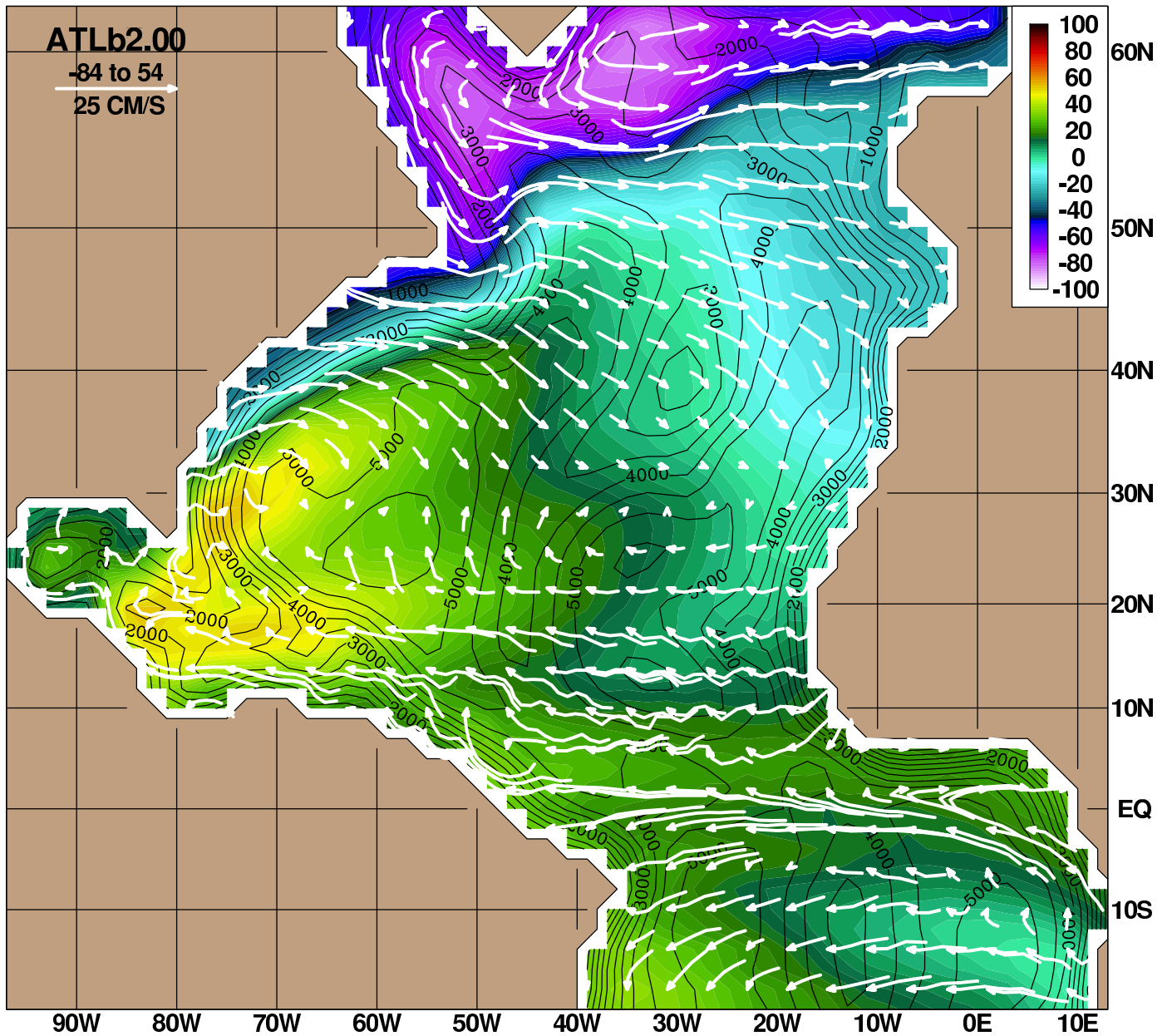
- Climatological nesting now allowed
 - Start from monthly mean outer model archive files
 - Allows nested runs longer than the outer run
 - ◇ But with less accurate boundary state
 - Probably only suitable for regional nests
- Nesting no longer requires co-located grids
 - General archive to archive 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)
 - ◇ Vectors can optionally follow streamlines
- 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)

EXAMPLE OF FIELDPROC SSH, SURFACE CURRENTS, AND BATHYMETRY

FSD (cm) and V.1 - Jan Year 20



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 at stations or 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

CANDIDATE FEATURES FOR HYCOM 2.3

- Wind drag coefficient based on model SST
- Regional tides and Browning-Kreiss nesting
- Wetting and Drying
- 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
- Enhanced support for ESMF
 - HYCOM+CICE on global tripole grid