New Features of HYCOM

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2005 Layered Ocean Model Users' Workshop

January 28, 2005

HYCOM 2.2 (I)

- First public release of HYCOM 2.2
  - Scheduled for February, 2004
- Maintain all features of HYCOM 2.1
  - Orthogonal curvilinear grids
  - Can emulate Z or Sigma or Sigma-Z models
  - 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
- New diagnostics within HYCOM
  - Time-averaged fields (in archive files)
  - Drifters

HYCOM 2.2 (II)

- Alternative scalar advection techniques
  - Donor Cell, FCT (2nd and 4th order), MPDATA
- Vertical coordinate changes
  - Vertical remapping uses PLM for fixed coordinate layers
  - Thin deep iso-pycnal layers
  - Spatially varying iso-pycnal layer target densities
  - Stability from locally referenced potential density
- Atmospheric forcing changes
  - Option to input ustar fields
  - Option to relax to observed SST fields
  - Improved COARE 3.0 bulk exchange coefficients
  - Black-body correction to longwave flux
- Mixed layer changes
  - GISS mixed layer model
  - KPP bottom boundary layer
  - KPP tuning
  - Latitudinally dependent background diffusion

HYCOM 2.2 (III)

- Improved support for rivers
  - Still bogused surface precipitation
  - Better control of low salinity profiles
  - Option for mass (vs salinity) flux
- Nesting no longer requires co-located grids
  - General archive to archive horizontal interpolation
- Hybrid to fixed vertical grid remapper
  - Allows fixed-coordinate nests inside hybrid coordinate outer domains
    - HYCOM to (fixed-grid) HYCOM
    - HYCOM to NCOM
- Diagnostic fields to netCDF and other file formats
  - All x-y “hycomproc” fields
    - Layer space
    - Velocity interpolated to the p-grid
  - All 3-D archive fields interpolated to z-space
    - On p-grid, or
    - Sampled along arbitrary tracks
  - Forcing input fields

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
  - Can plot in "logical" (array) space
  - 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°
  - AOMIP grid is rotated uniform 1/2°

HYCOM PERFORMANCE

- Our 1/12° global domain is very large
  - Array size: 4500 x 3298 x 28
- Used in scalability study on 3,000 cpu IBM POWER4+
  - Large horizontal array extent scales well
  - Limiting factors are:
    - Halo exchanges
    - Global sums
    - I/O
- I/O performance most likely to improve
  - MPI-2 I/O limited by need to write data void values over land
    - MPI-2 I/O can have “holes”, but can’t fill them with data voids
  - Easier to improve read performance than write performance
    - writes are more important
  - Best approach may be asynchronous I/O (ESMF)

GLOBAL HYCOM BENCHMARK ON IBM P655

MPI Tasks	8-CPU NODES	WALL-TIME seconds	SPEEDUP
504	63	1515.1	(1.7 GHz)
1006	126	946.9	1.60x 504
2040	255	587.2	1.61x1006

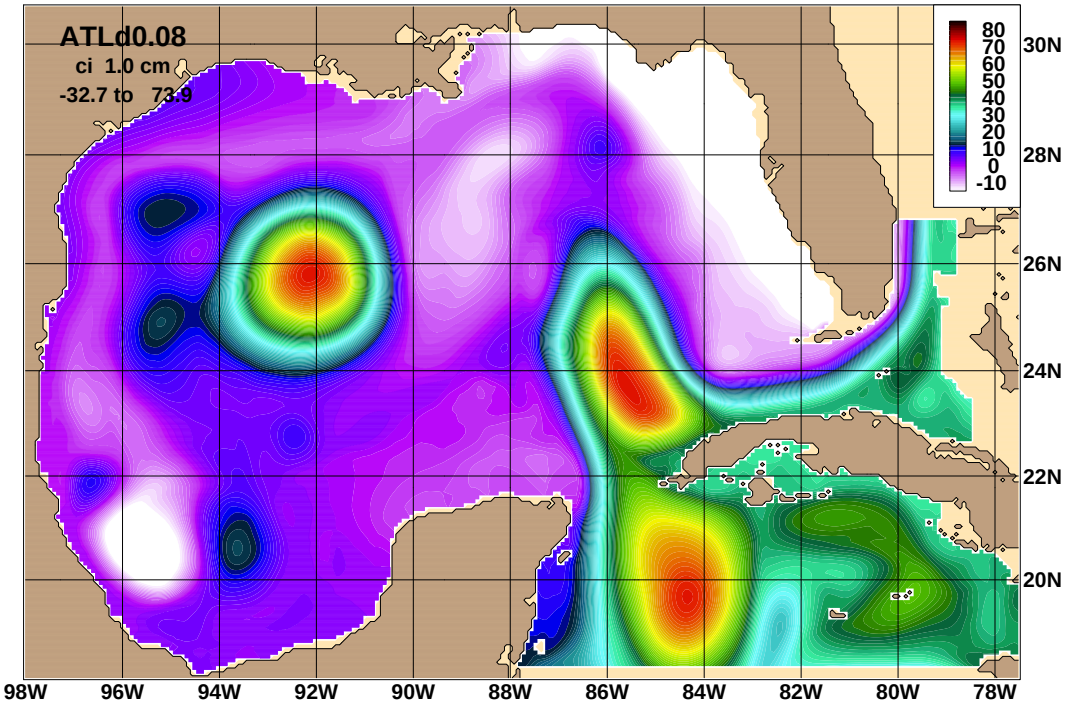
- I/O time is constant: 80 seconds
  - 5% to 15% of total time
- Global sum time increases: 15 to 30 seconds
- Halo exchange time decreases, 175 to 100 seconds

GoM NESTED TEST DOMAIN

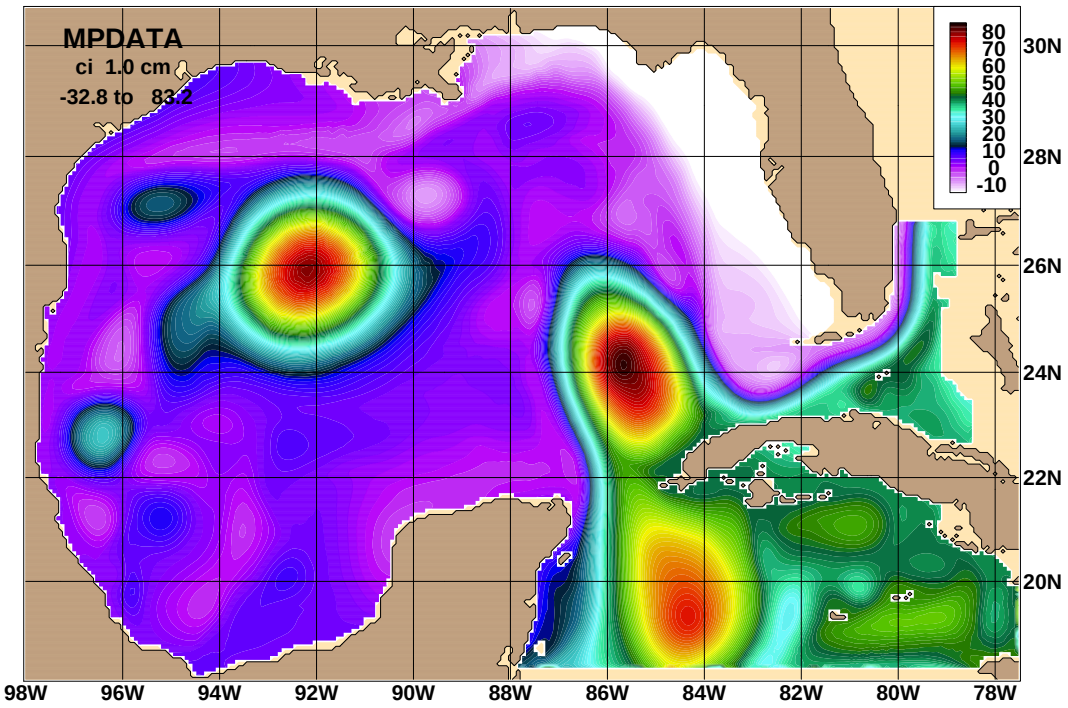
- Same resolution nesting unexpectedly useful
  - No need to rerun large domain
  - Change atmospheric forcing (e.g. use MM5)
  - Change vertical structure
  - Tracer studies (e.g. add biology)
- 1/12°: Gulf of Mexico inside Atlantic
  - Change from 20m to 5m coastline
  - Run for Aug 1999 to equilibrate
  - Run Sep-Nov as standard test case
- Used to test advection schemes
- All needed file are prebuilt
  - **ftp://hycom.rsmas.miami.edu/awall/hycom/GOMd0.08/**
  - Uses 2.1.20, and 2.1.27 is also available
  - Easiest way to get latest “unreleased” code
  - Includes a passive tracer

ATLANTIC vs GOM NEST (MPDATA)

sea surf. height Dec 01, 1999 00Z [02.6H]

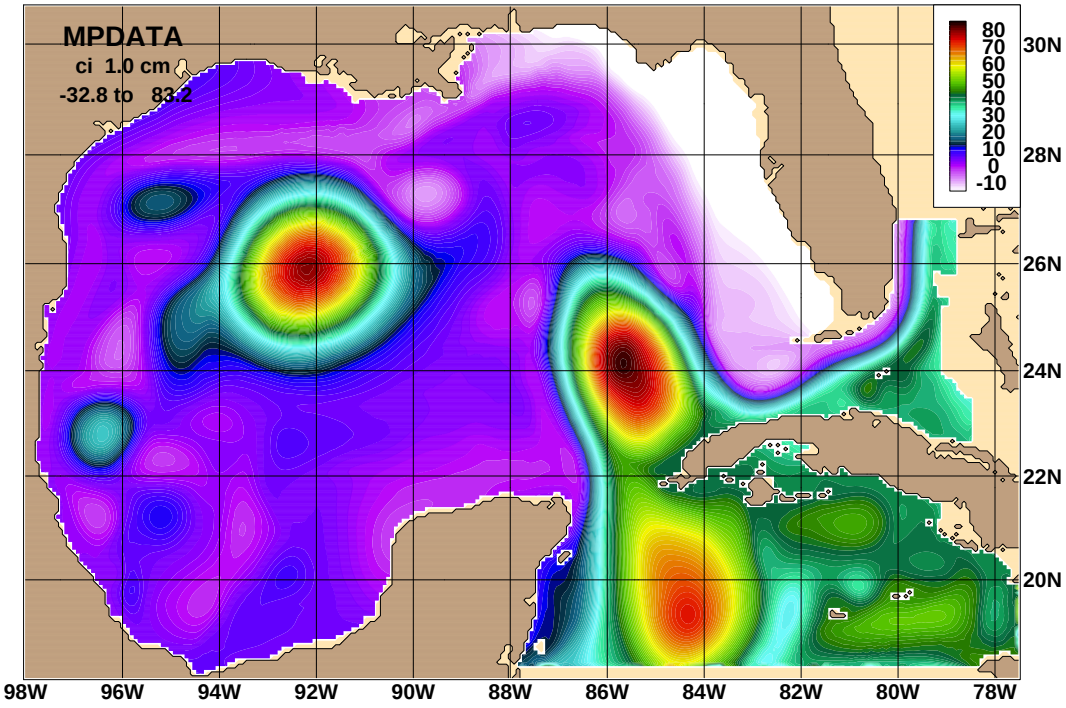


sea surf. height Dec 01, 1999 00Z [02.8H]



MPDATA VS LEAPFROG-FCT (SSH)

sea surf. height Dec 01, 1999 00Z [02.8H]



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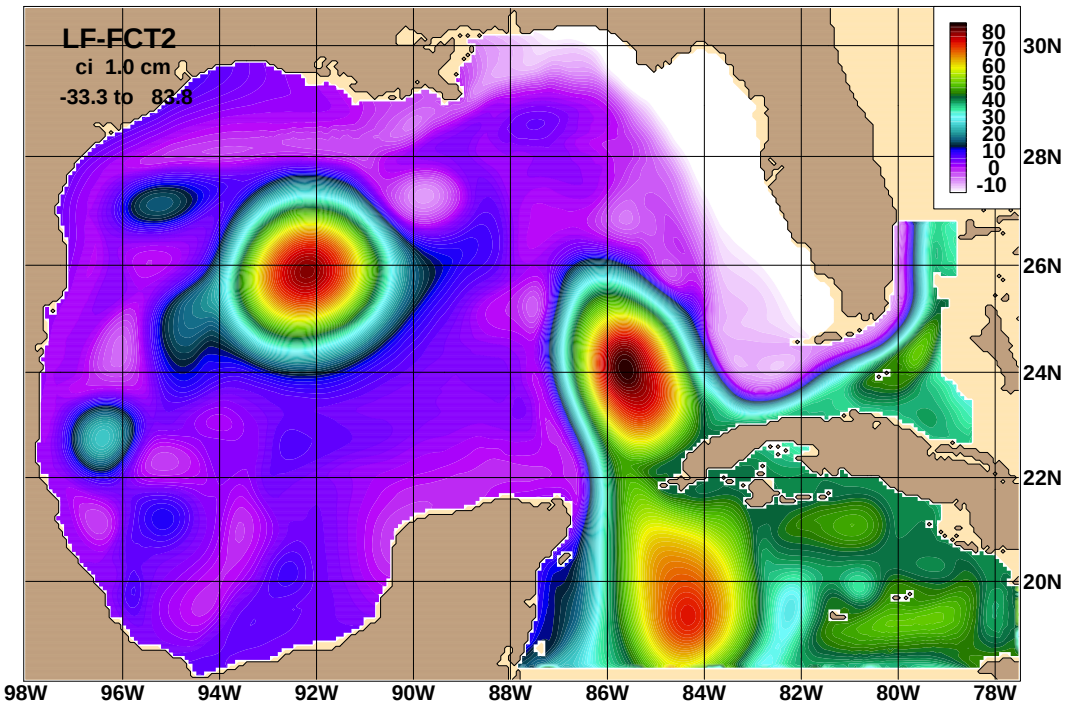
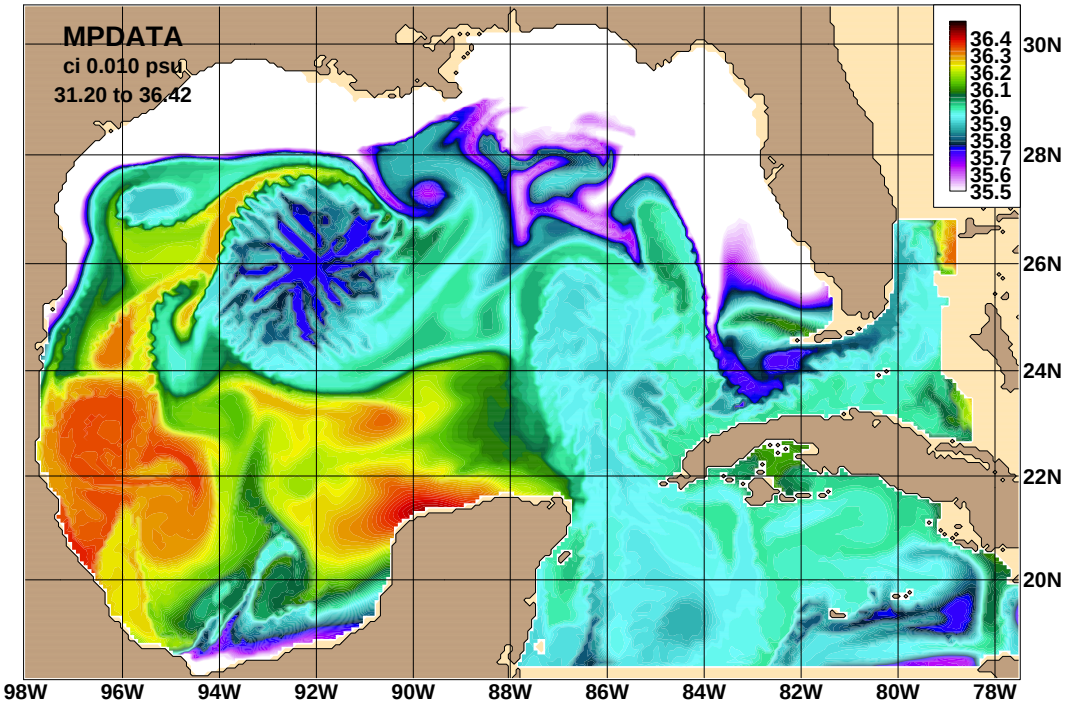
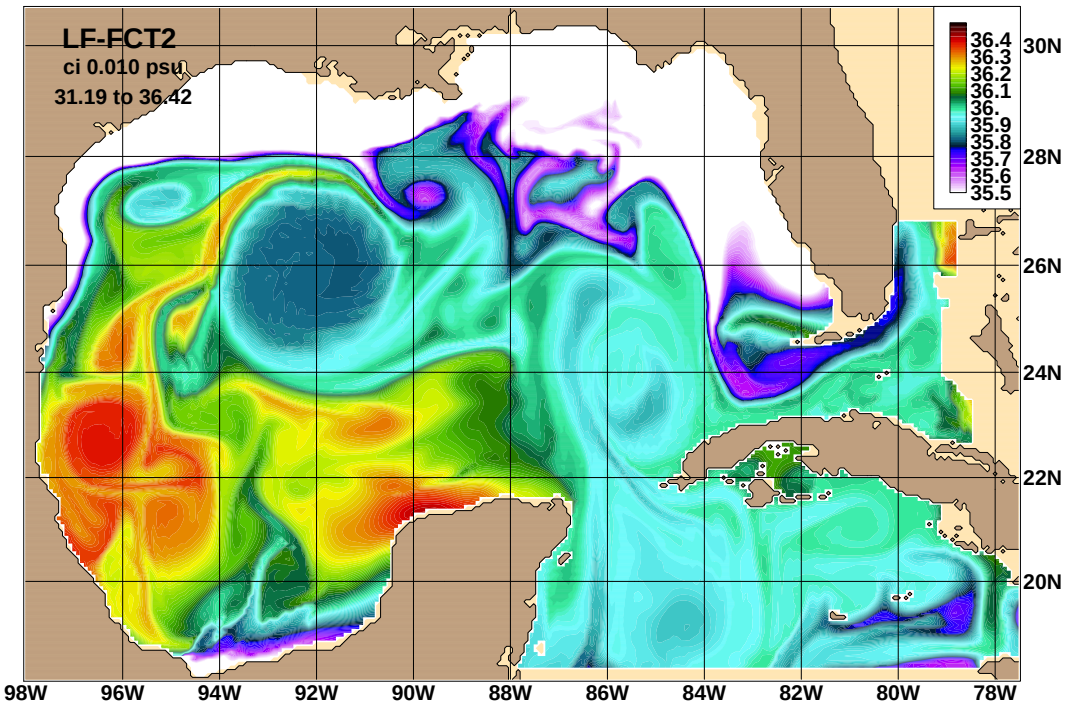


MPDATA VS LEAPFROG-FCT (SSS)

layer=01 salinity Dec 01, 1999 00Z [02.8H]



layer=01 salinity Dec 01, 1999 00Z [03.1H]



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
  - Needed for full ESMF compliance
- Improve split-explicit time scheme
- Tidal forcing
- Diurnal heat flux cycle
- Equation of state that is quadratic in salinity
- Even better support for rivers
- Wind drag coefficient based on model SST
- Initial support for ESMF

HYCOM AND ESMF

- Earth System Modeling Framework
  http://www.esmf.ucar.edu/
  - Superstructure couples components
    - Air/Ocean/Ice/Land
    - Asynchronous I/O component
      - Run “concurent” with model components
  - Infrastructure provides data structures and utilities for building scalable models
- Add a superstructure “cap” to HYCOM
  - Simplifies coupled systems
    - HYCOM coupled to LANL CICE sea-ice
    - Convert atmospheric field processing and the energy-loan ice model into ESMF components
  - Use ESMF for (user-level asynchronous) I/O
  - Interoperate with other ESMF compliant ocean models (e.g. HOME)
- This initial ESMF support will probably be optional
- ESMF may be required to run HYCOM at some point
  - Harder to get started with HYCOM
  - Will provide many new capabilities