

Tuning and Validating HYCOM's KPP Mixed-Layer

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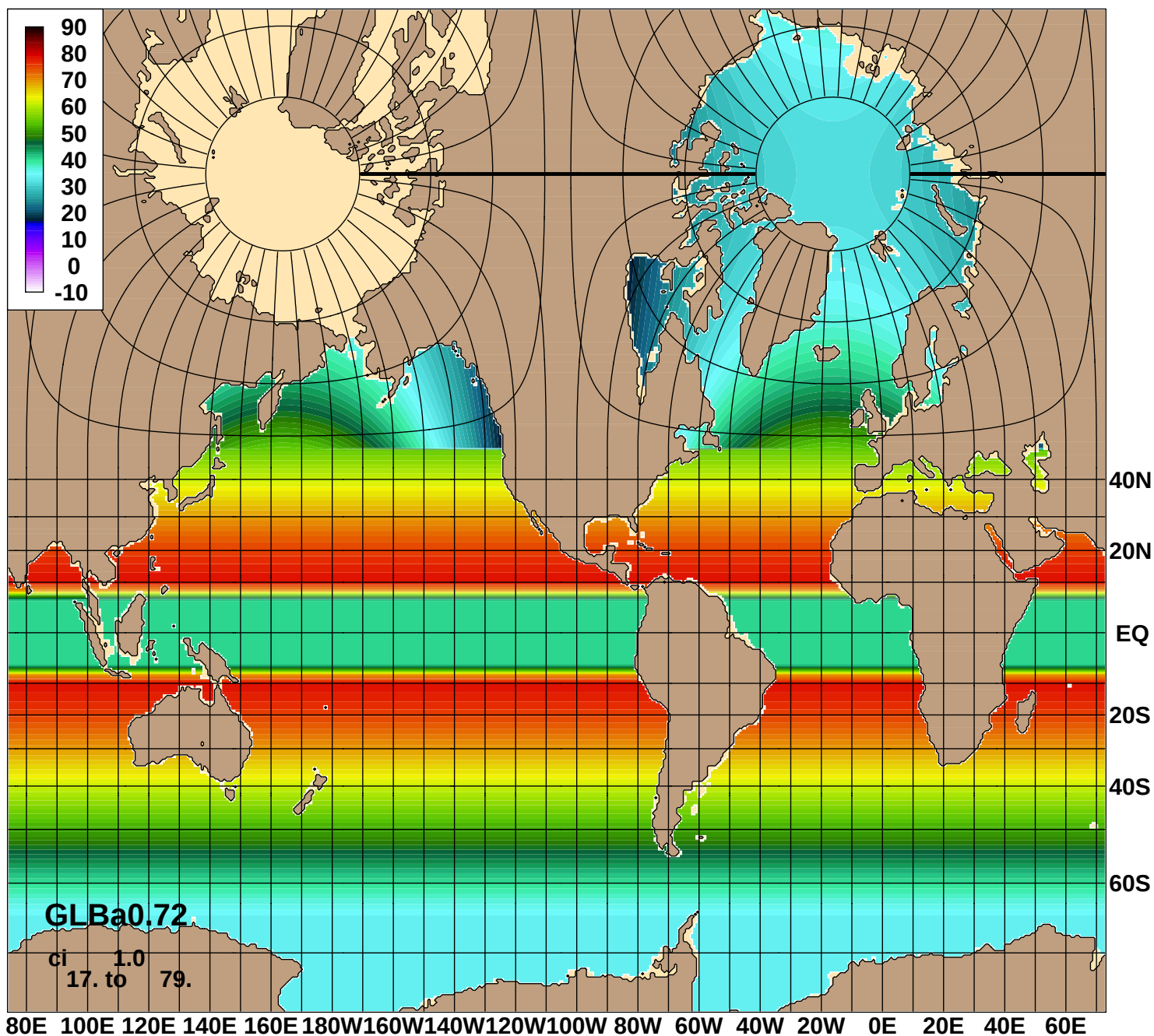
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- Long-term Global HYCOM Objective
 - To depict and predict the 3D global ocean state at fine resolution (0.08° on the equator, ~ 7 km at mid-latitudes)
- Strategy
 - Begin with 0.72° resolution global HYCOM and optimize the KPP mixed layer performance (the subject of this presentation)
 - Before the end of FY03, start running and development of 0.24° global HYCOM
 - Submitted DoD HPC Challenge proposal (FY04-06) to continue development at 0.24° and start 0.08° model development

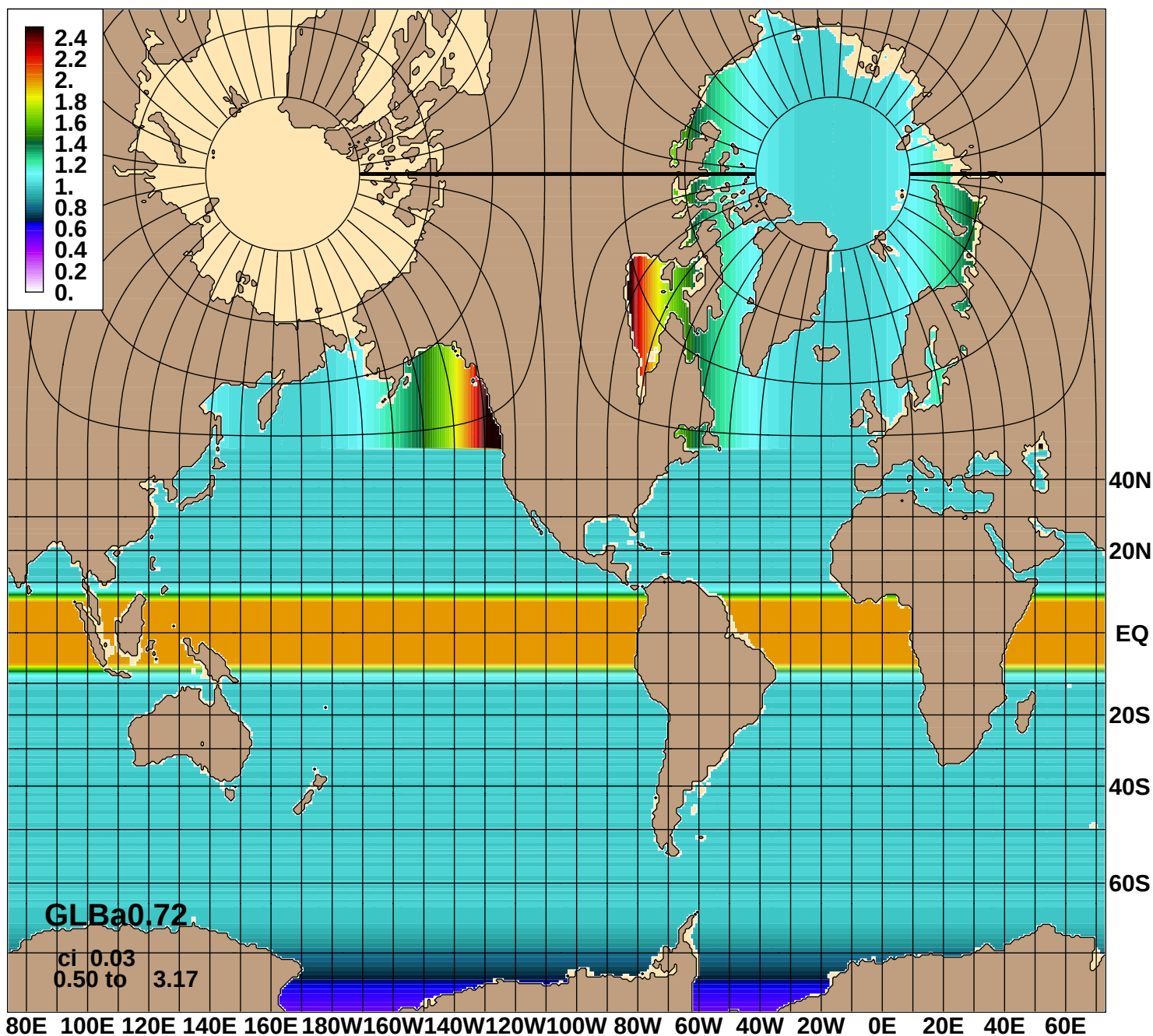
0.72 degree Global Domain

- Pan-Am Global Grid
 - 0.72 degree equatorial Mercator 78S-47N
 - Arctic bi-polar patch above 47N
 - * Low resolution global had patch at 59N
 - * Can't include Hudson Bay
 - Double latitudinal resolution near the equator
 - Halve latitudinal resolution in Antarctic
- Coastline at 50m isobath
 - Closed Bering Strait
 - No Sigma (terrain-following) vertical coordinate
- Same 26-layers as 0.08 degree Atlantic
- First Z-level 3 m, increases 1.125x up to 12 m

47N: SCPY (km)



47N: Grid Aspect Ratio (SCPX/SCPY)



0.72 degree Global Standard Configuration

- KPP mixed layer
- Energy-Loan ice model
- Sigma-theta (some Sigma-2 runs, not discussed here)
- Horizontal diffusion chosen to suppress eddies
- Initialize from Levitus
- ECMWF Reanalysis monthly mean forcing
 - Plus 6-hrly wind anomalies from sep94-sep95
- Annual mean of 10 largest rivers via precip bogus
- Strong relaxation to monthly Levitus SSS
 - Necessary to prevent SSS drift
- Weak relaxation to monthly Levitus SST
 - Parameterizes SST's effect on longwave radiation

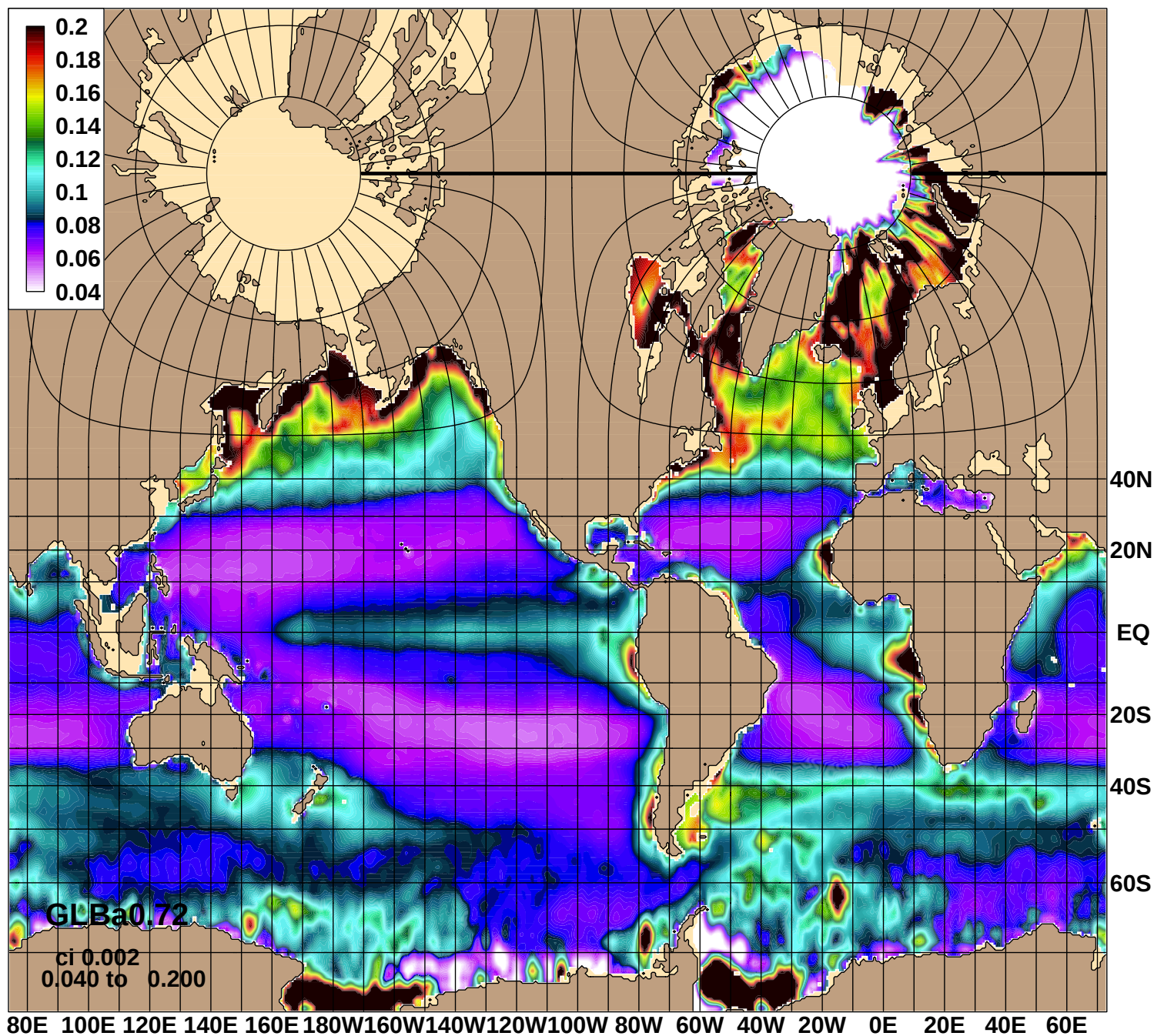
Longwave Radiation and SST

- Longwave Radiation is sum of:
 - Upward blackbody longwave radiation
 - * $Q_{bb} = -0.98 (5.67 \times 10^{-8}) (T_s + 273.16)^4$
 - Downward atmospheric longwave flux
 - * Highly dependent on cloudiness
 - * Unknown dependence on SST (assume independent)
- If longwave was calculated using a SST of T_{so} :
 - $Q_{lw}(T_s) = Q_{lw}(T_{so}) + Q_{bb}(T_s) - Q_{bb}(T_{so})$
 - $Q_{lw}(T_s) = Q_{lw}(T_{so}) + Q'_{bb}(T_s - T_{so})$
 - $Q'_{bb} = -0.98 (5.67 \times 10^{-8}) 4 (T_s + 273.16)^3$
- Or, approximately (in W/m^2):
 - $Q'_{bb} = -4.506 - 0.0554 T_s$
- So, $-5.3 W/m^2/degC$ is a good longwave correction
 - Equivalent to 3.5 m reference thickness and 30 day e-folding SST relaxation
 - 10x weaker than typically SSS relaxation
- Ocean Model Intercomparison Project includes $(Q_{bb}(T_s) - Q_{bb}(T_{so}))$ as a longwave correction

Variable Turbidity

- Penetrating solar (shortwave) radiation is important for accurate SST
- HYCOM parameterizes turbidity via a “two band” version of Jerlov water types
 - One of 5 classes, red and blue bands
 - Same everywhere in time and space
- NLOM used “single band” kPAR turbidity
 - Photosynthetically Available Radiation
 - kPAR from SeaWIFS k490
 - monthly climatological fields
- Single band approach only OK for bulk mixed layer
- Added two band Jerlov-like kPAR scheme
 - kPAR isn't a good fit to Jerlov
 - Much better than single class everywhere
- Need a better scheme:
 - 3-band based on chlorophyll (Morel & Antoine, 1994)?
 - Jerlov-like based on k490?

Annual SeaWiFS KPAR



SST Metrics I

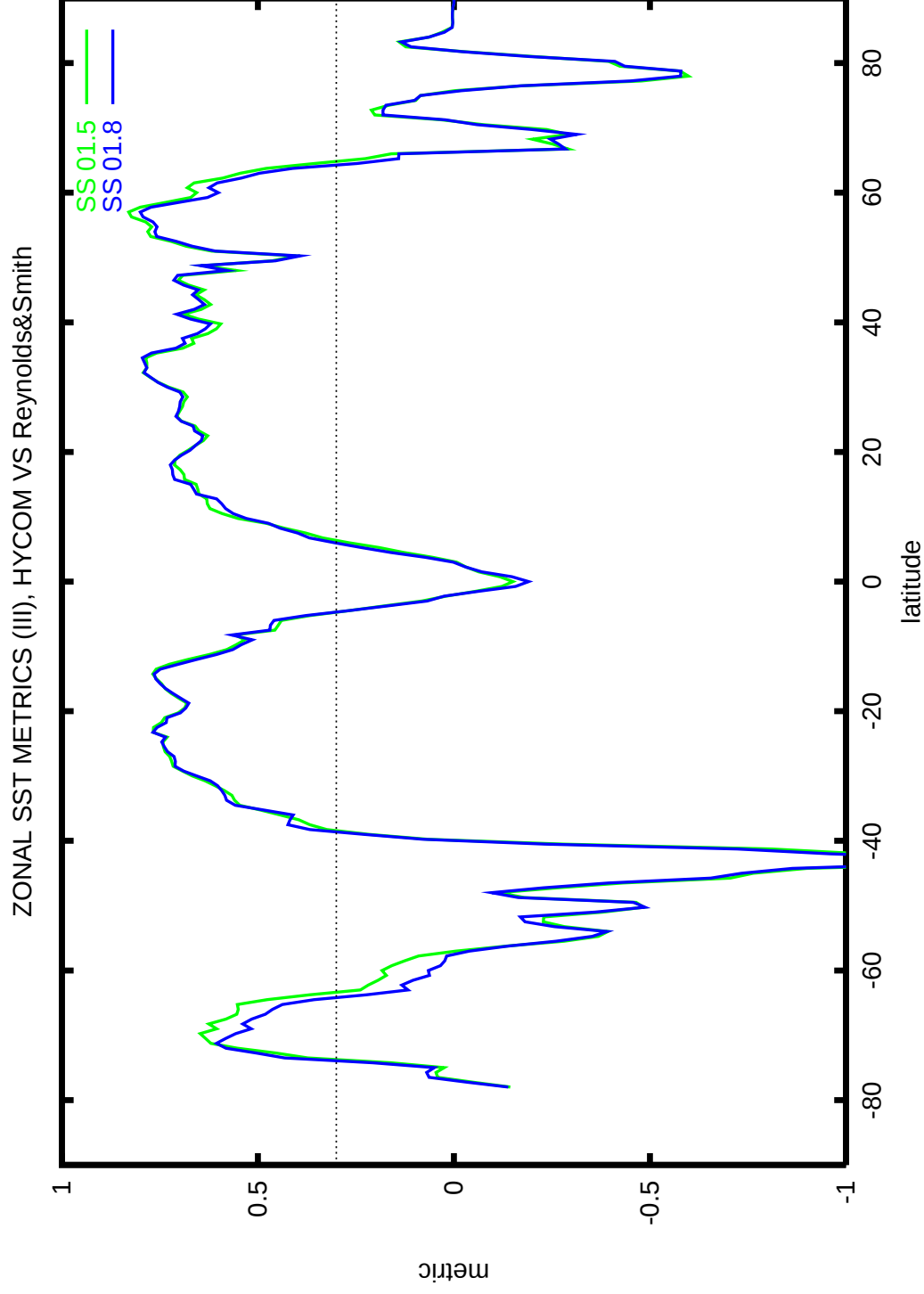
- Run for 5 years and form monthly means
 - May not be long enough
 - Length of run vs confidence in results
 - Takes two days on 64 IBM POWER4 cpus
- Compare monthly SST to Reynolds and Smith (R&S) climatology
 - Monthly anomalies
 - Annual mean difference
 - RMS difference
 - Correlation Coefficient
 - Skill Score
 - * Correlation squared - Unconditional Bias - Conditional Bias
 - * Maximum is 1, but minimum is -infinity
 - * Measure of error w.r.t. seasonal cycle (i.e. w.r.t. standard deviation)
 - * Use a minimum of 1 degC for standard deviation
 - Still get poor skill scores near equator

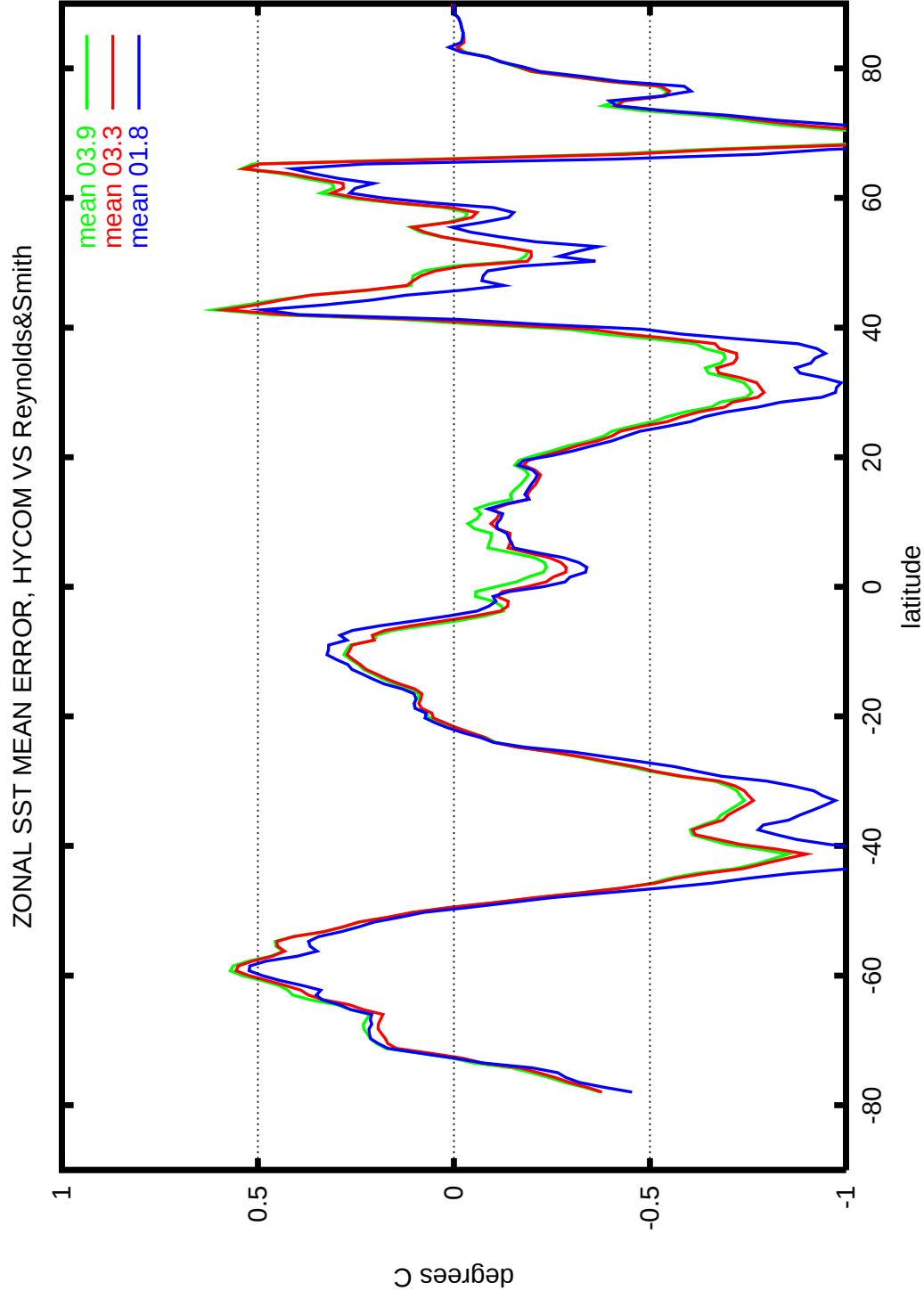
SST Metrics II

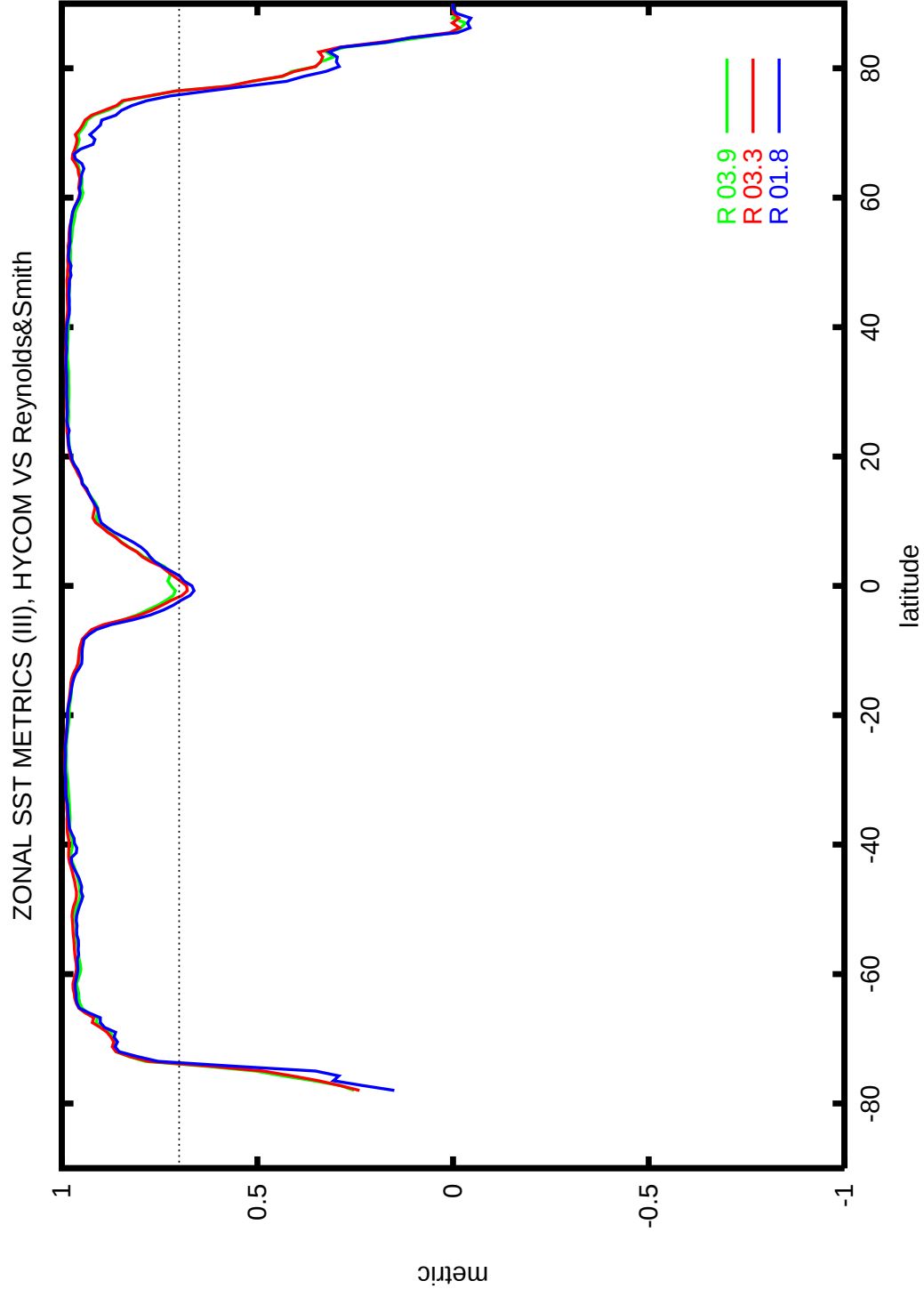
- Purpose of comparison is to find “good enough” configuration
 - Assume that “skill” on climatological forcing is maintained on interannual forcing
 - Is monthly thermal climatological forcing enough?
 - NLOM experience suggests that this is OK, but can’t be certain until we run interannually with HYCOM
- Targets:
 - Annual mean error < 0.5 degC
 - Correlation Coefficient > 0.6
 - Skill Score > 0.3
- Use zonal averages to reduce amount of data
 - Average not necessarily best statistic
 - * A few large negative skill scores can dominate the average
 - Same targets as for full field

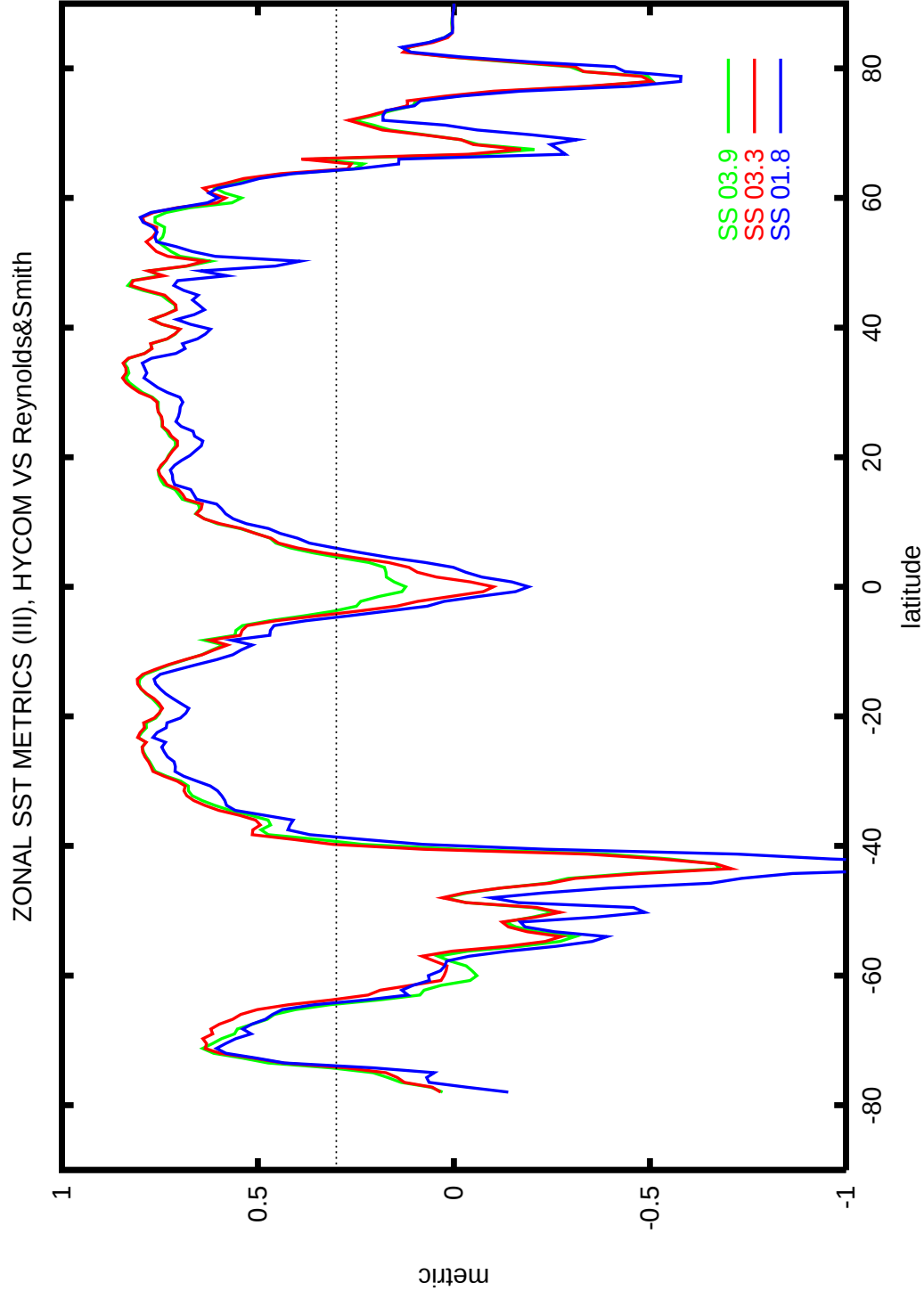
Simulation History

- Expt 1.5:
 - Standard KPP
 - Jerlov Ia everywhere
 - No rivers
 - No SST relaxation
- Expt 1.8:
 - Monthly kPAR turbidity
 - Annual rivers
- Expt 3.3:
 - “Longwave” SST relaxation
- Expt 3.9:
 - Modified KPP shear instability
- Expt 4.2:
 - Twin of 3.3 (same winds)
 - FNMOC thermal forcing (average 98-01)

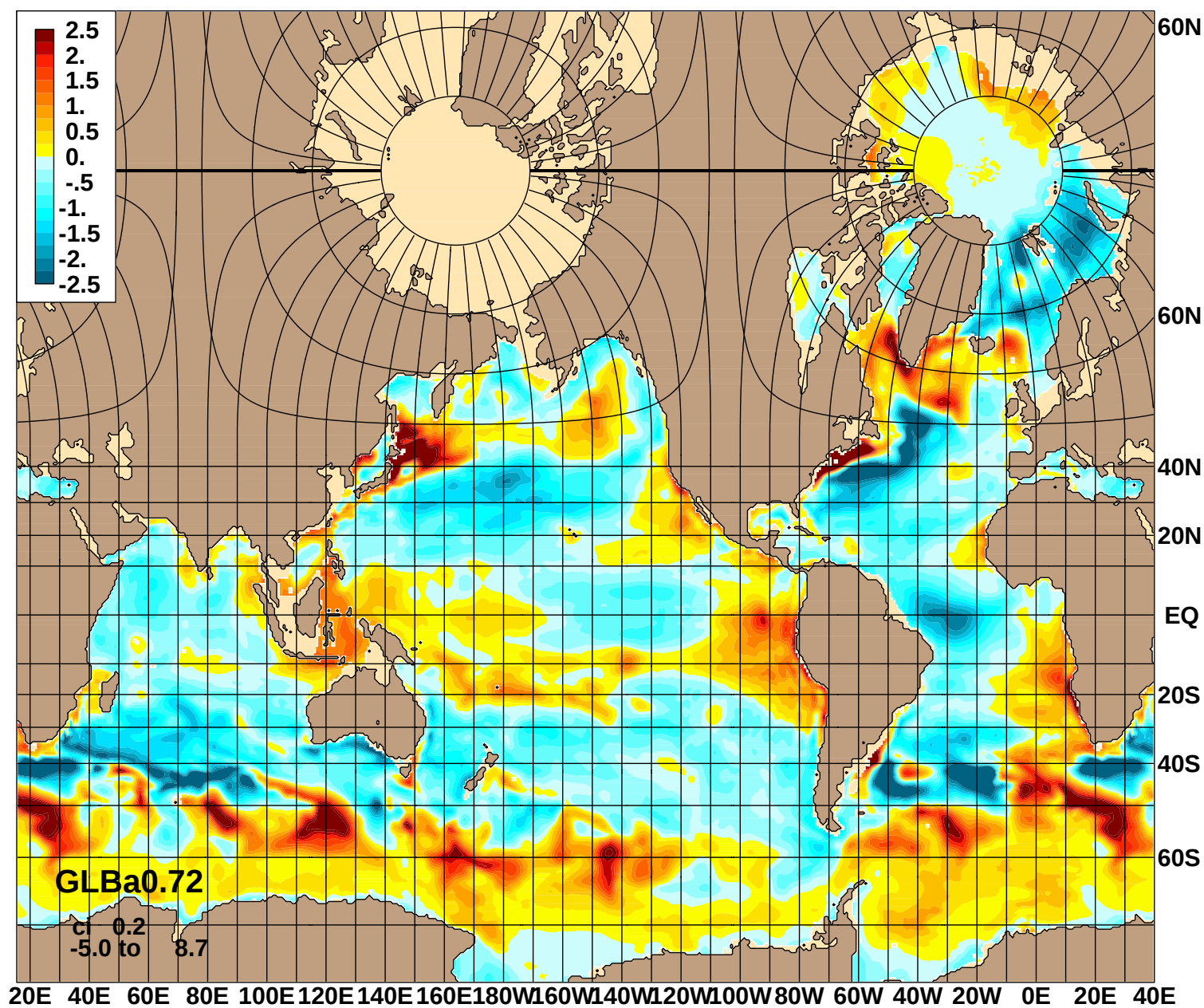




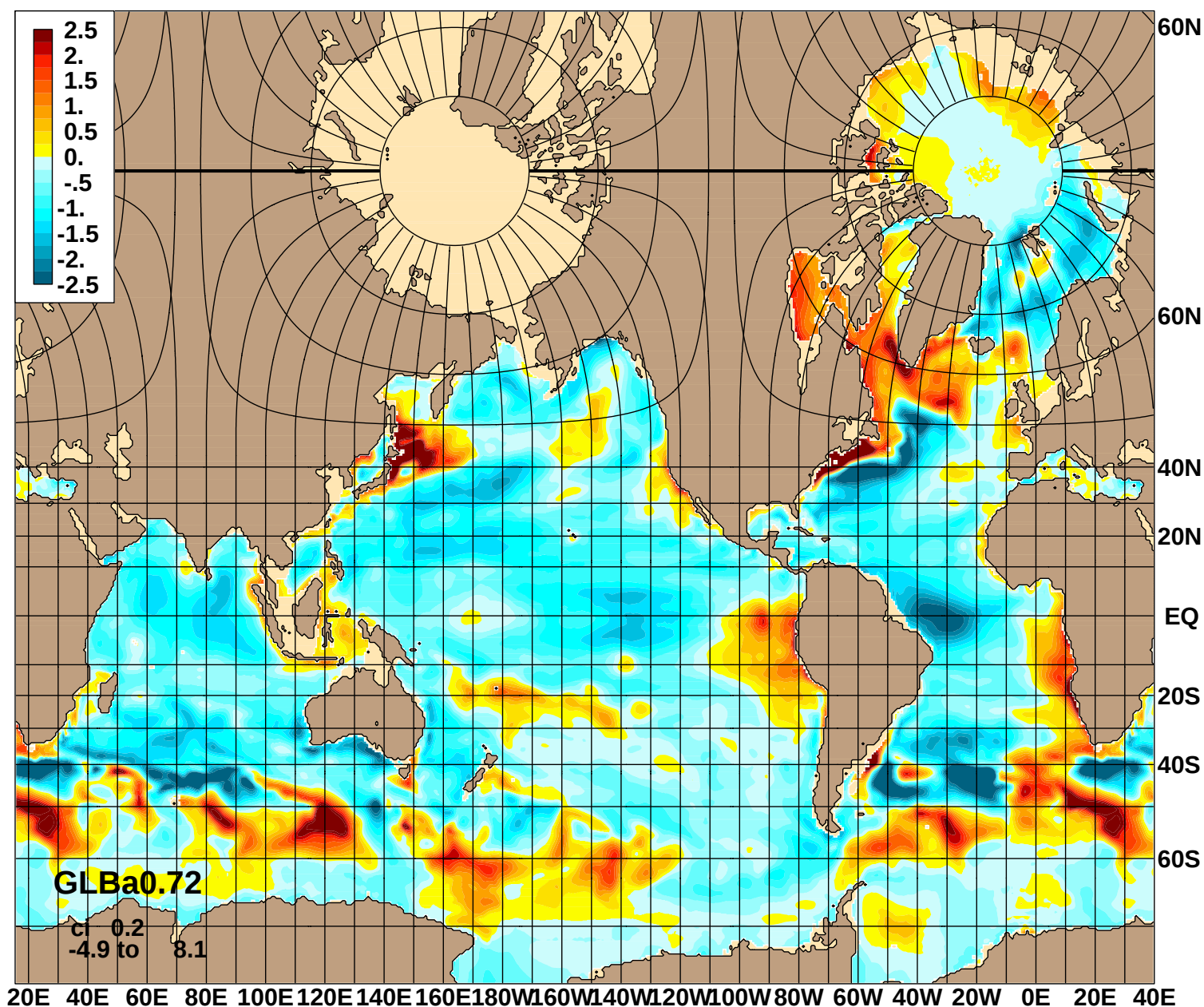




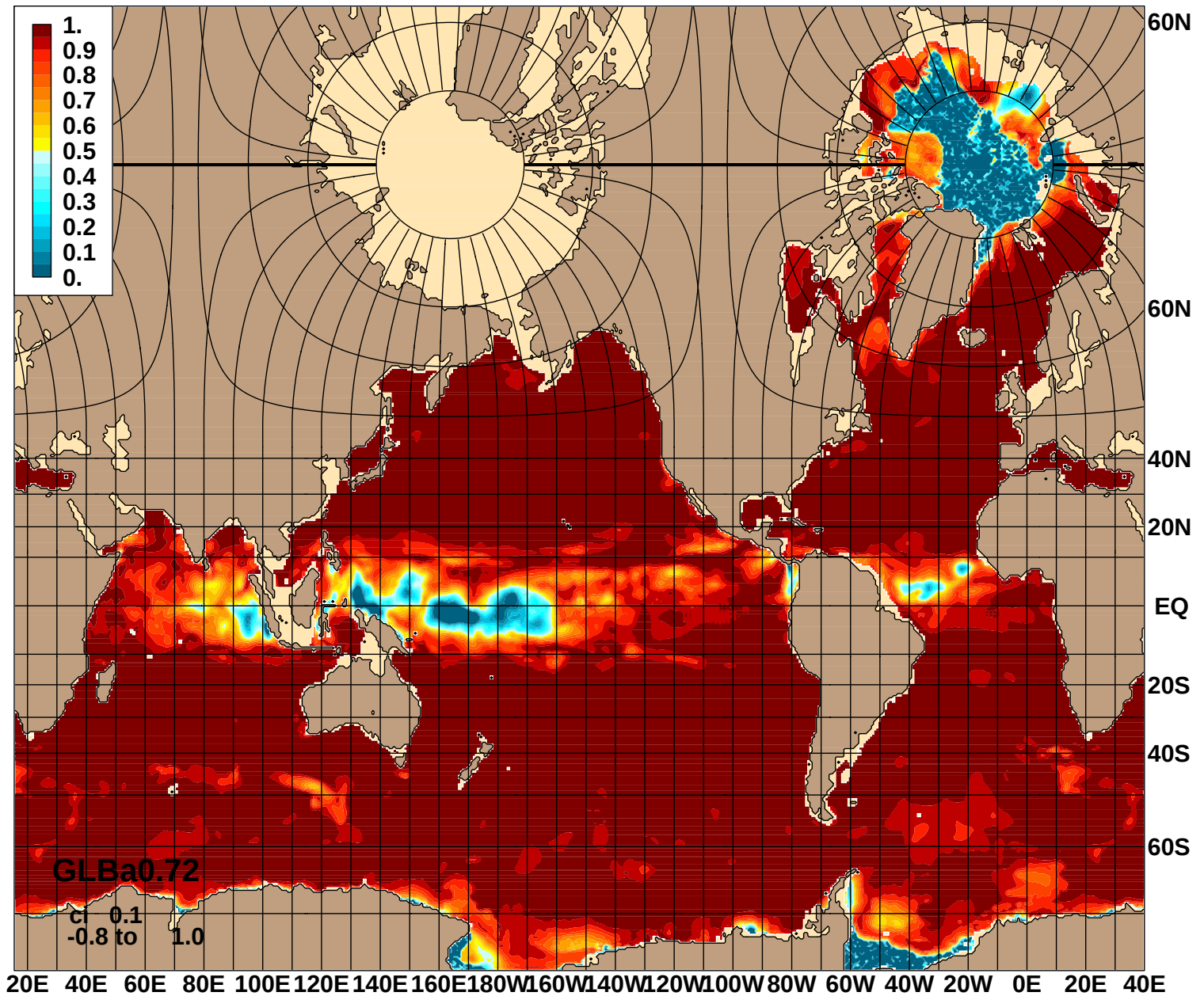
03.3 vs R&S SST: Mean Error



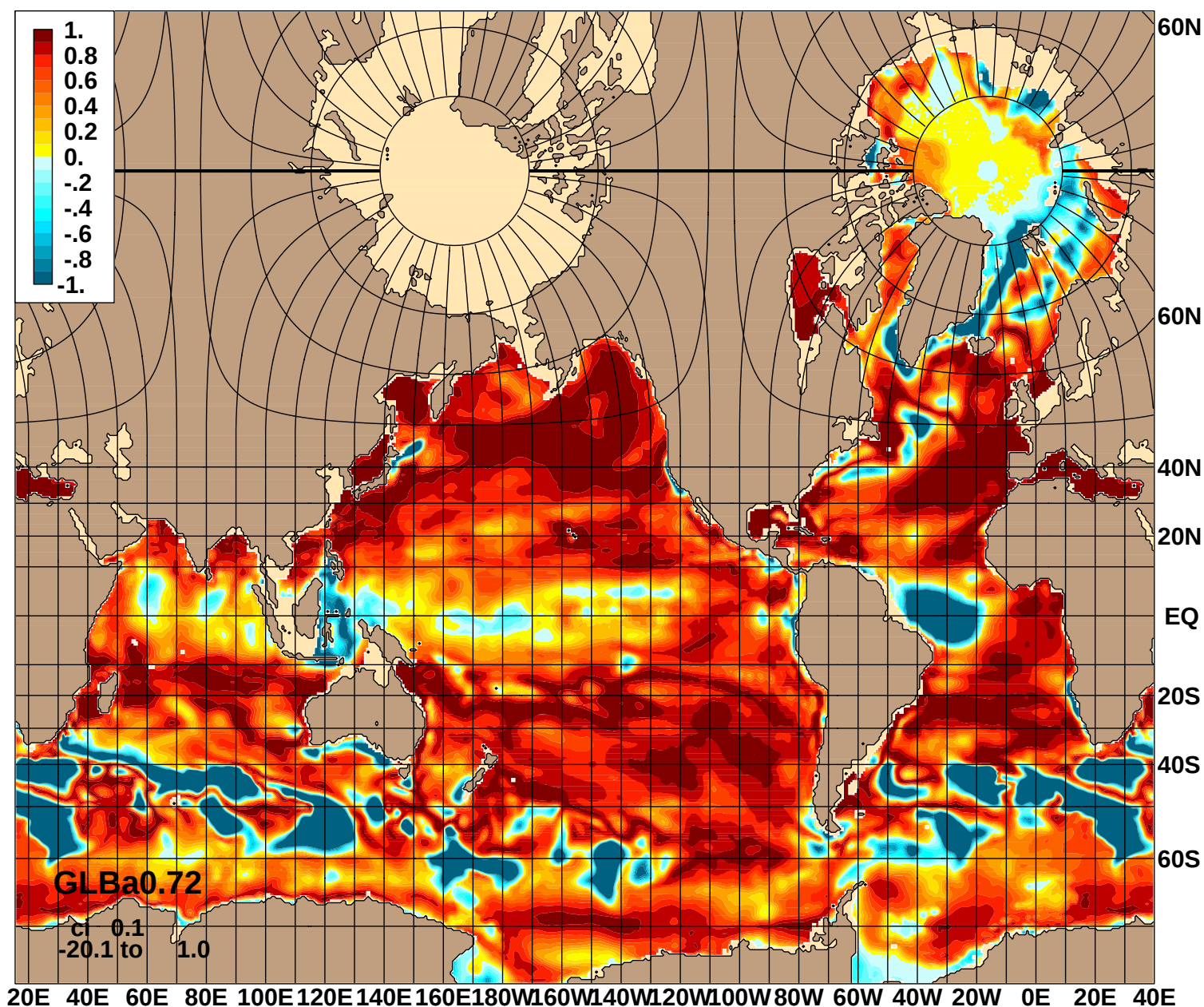
04.2 vs R&S SST: Mean Error



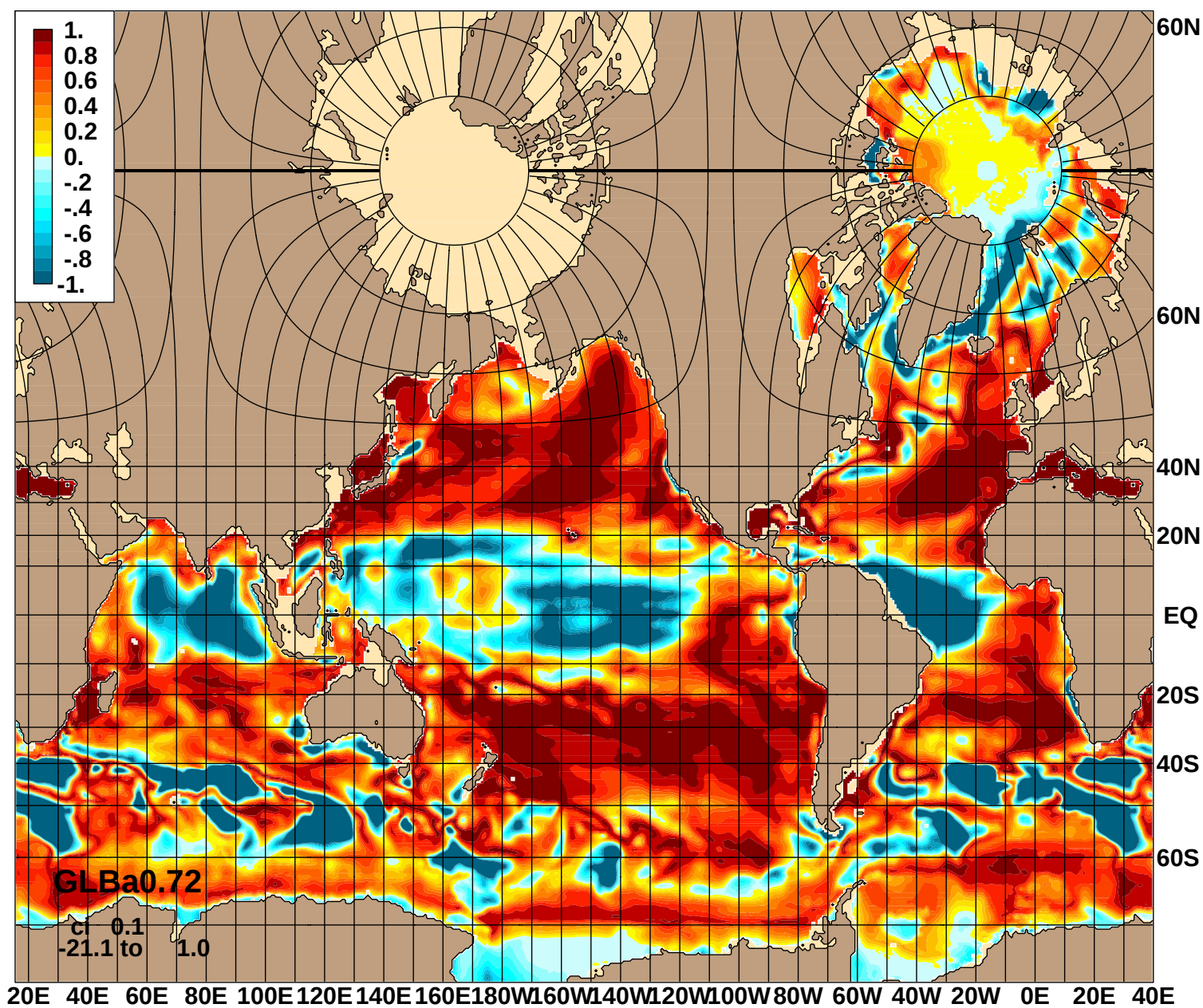
03.3 vs R&S SST: Correlation



03.3 vs R&S SST: Skill Score



04.2 vs R&S SST: Skill Score



Conclusions

- KPP is performing well in HYCOM
- Western Equatorial Atlantic a major trouble spot
 - Modifying KPP shear instability helps
 - More needs to be done
- In general, most of the SST error is in the annual mean
- Not yet clear how much is due to forcing and how much due to KPP