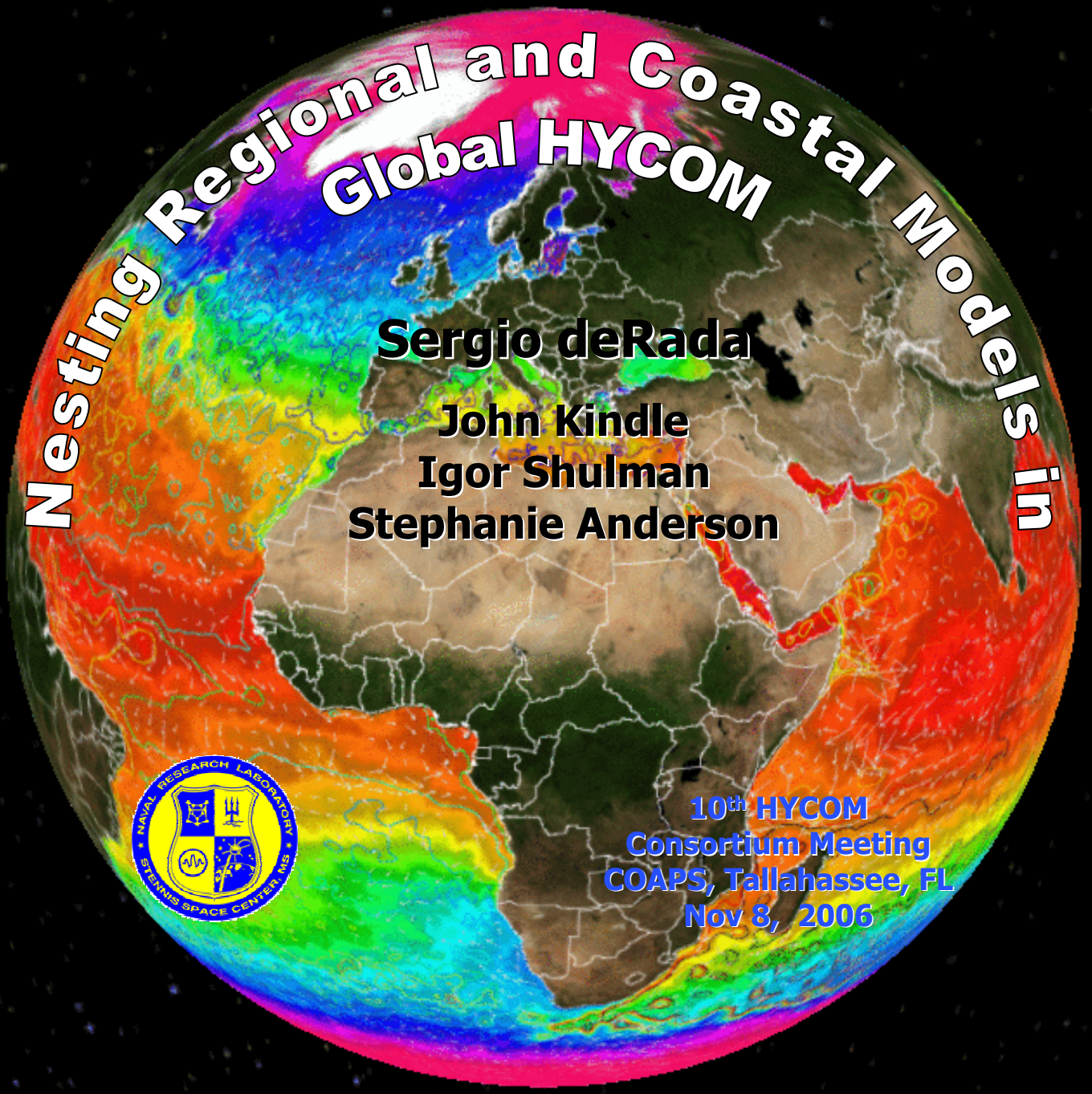
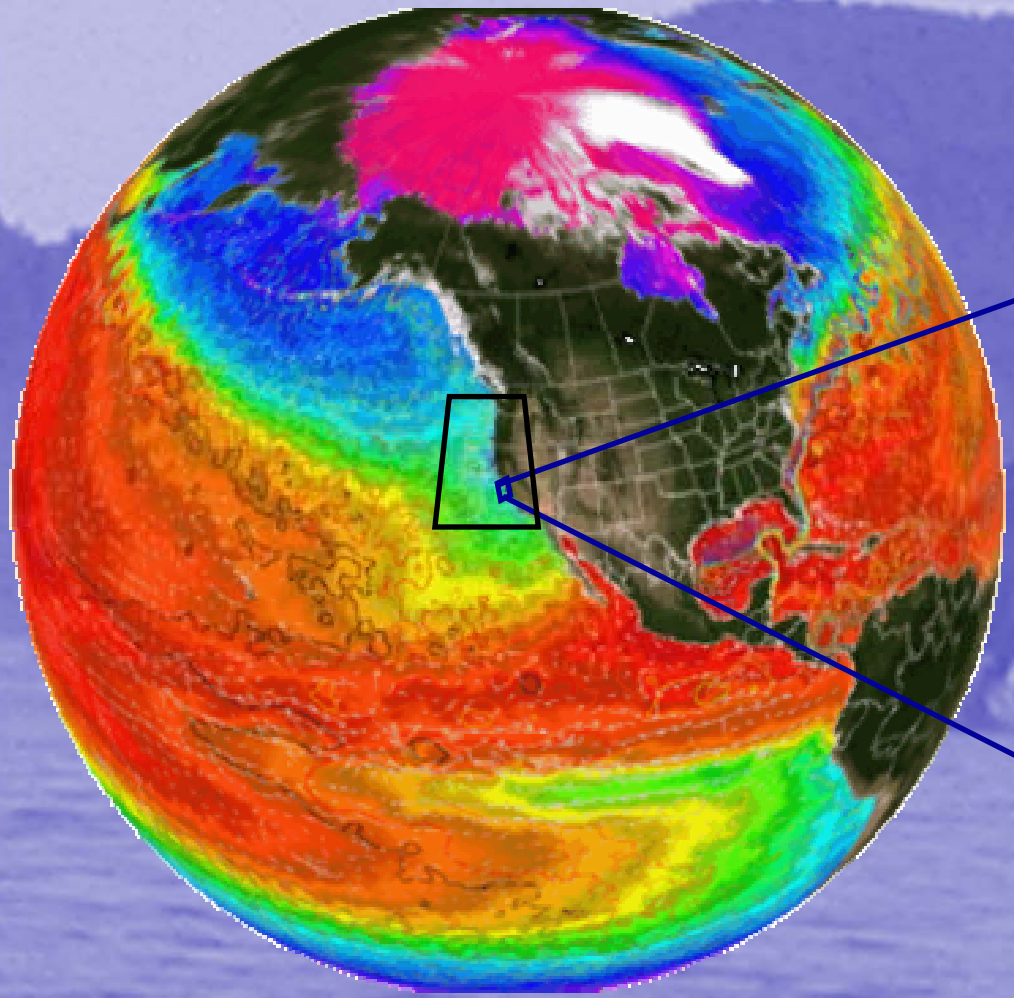

Nesting Regional and Coastal Models in Global HYCOM
Sergio deRada
John Kindle
Igor Shulman
Stephanie Anderson
NAVAL RESEARCH LABORATORY
STENNIS SPACE CENTER, MS
10th HYCOM
Consortium Meeting
COAPS, Tallahassee, FL
Nov 8, 2006

MODELS



Motivation: Global->Coastal

Global Models (NCOM)

California Current System (CCS)

1/12-degree GLOBAL HYCOM

- Mercator Grid (~7Km)
- 32 Layer p/σ/z (σ2)

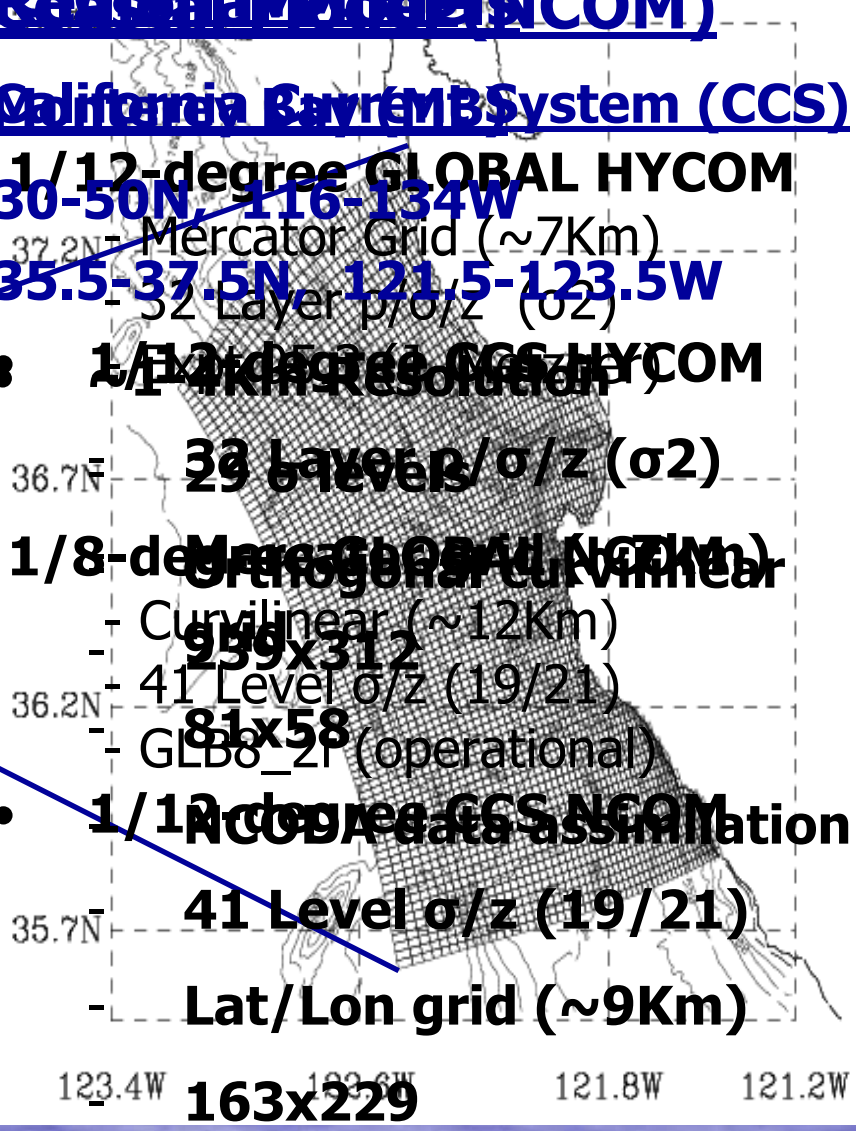
1/8-degree GLOBAL NCOM

- Curvilinear (~12Km)
- 41 Level σ/z (19/21)
- GLB8_2f (operational)

30-50N, 116-134W

35.5-37.5N, 121.5-123.5W

- **1/12-degree CCS HYCOM**
  - **~1-4Km Resolution**
  - **32 Layer p/σ/z (σ2)**
  - **Mercator Grid (~7Km)**
  - **Orthogonal Curvilinear**
  - **256x312**
  - **29 σ-levels**
- **1/3-degree CCS NCOM**
  - **NCODA data assimilation**
  - **41 Level σ/z (19/21)**
  - **Lat/Lon grid (~9Km)**
  - **81x58**
  - **163x229**



EXPERIMENTS

GLOBAL MODELS:

- **HYCOM: GLBa0.08 Expt 05.3 (Joe Metzger)**
  NCOM: GLB8_2f (Operational at NAVO)
- **3-hourly 1-degree NOGAPS Forcing, Bulk HF Formulation**
- **HYCOM: Atm. SST and Climatological SSS relaxation**
  NCOM: Full 3D Temperature and Salinity relaxation (MODAS)
- **HYCOM: GISS**
  NCOM: Mellor-Yamada

NESTING IMPLEMENTATION

- **Generalized Methodology for mapping vertical/horizontal grids**

On the HYCOM (source grid) side:

- **HYCOM tools**

  -layer to z

…to generate and intermediate Z grid.

(Suggested to match NCOM Z-structure)

***NCODA coupling on Z-Grid**

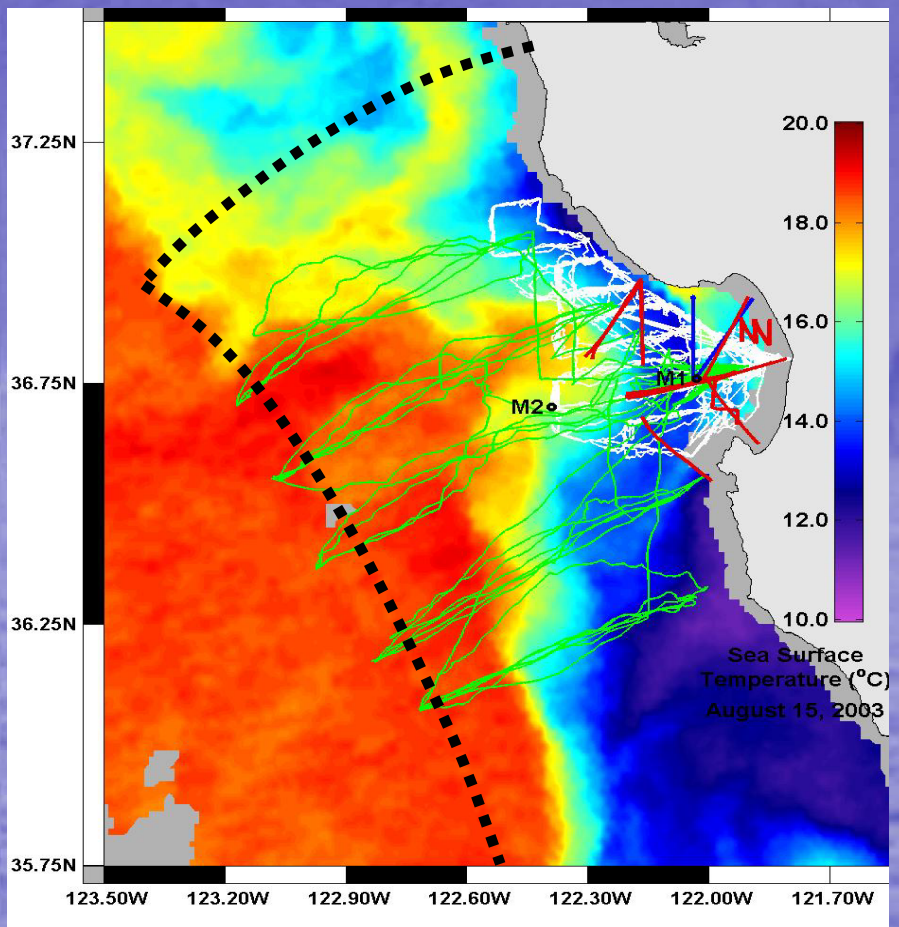
On the NCOM (target grid) side:

- **Use REGRID_GEN to interpolate:**
  - to final σ or σ/z grid
  - horizontally (optional)
- **NCOM "SETUP" tools to create final:**
  - **OINIT and OPNBC**

COMPARISONS (Coastal Models)

Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003



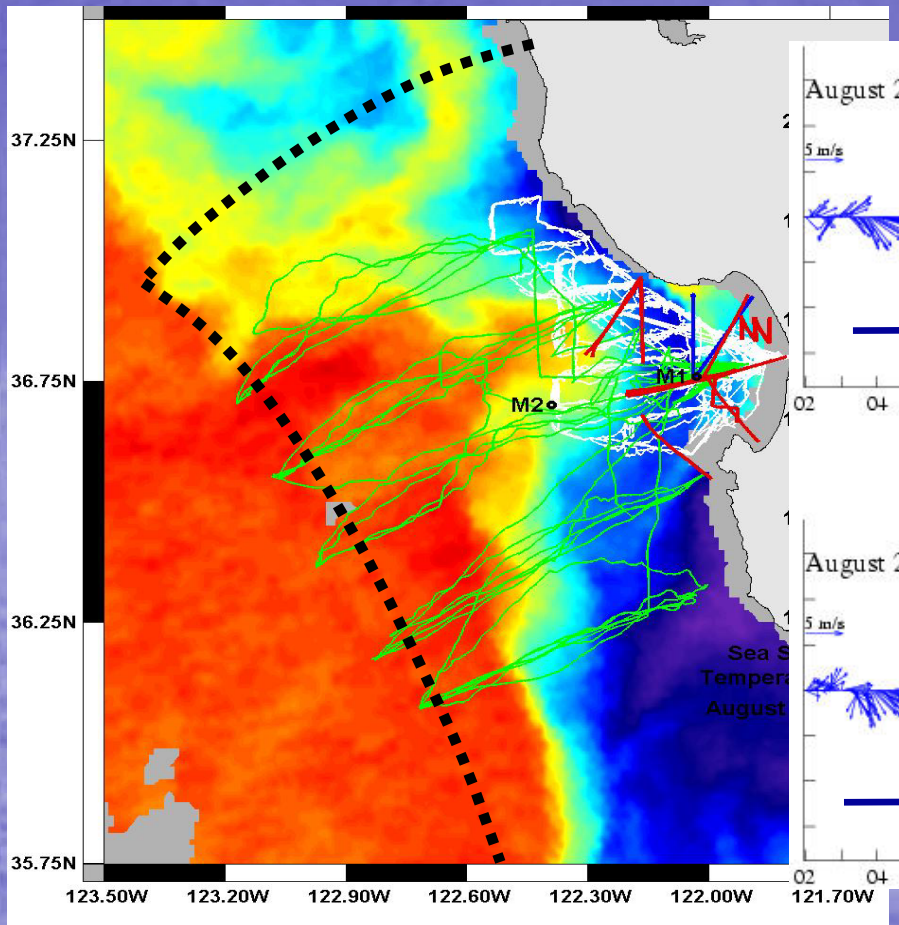
COMPARISONS

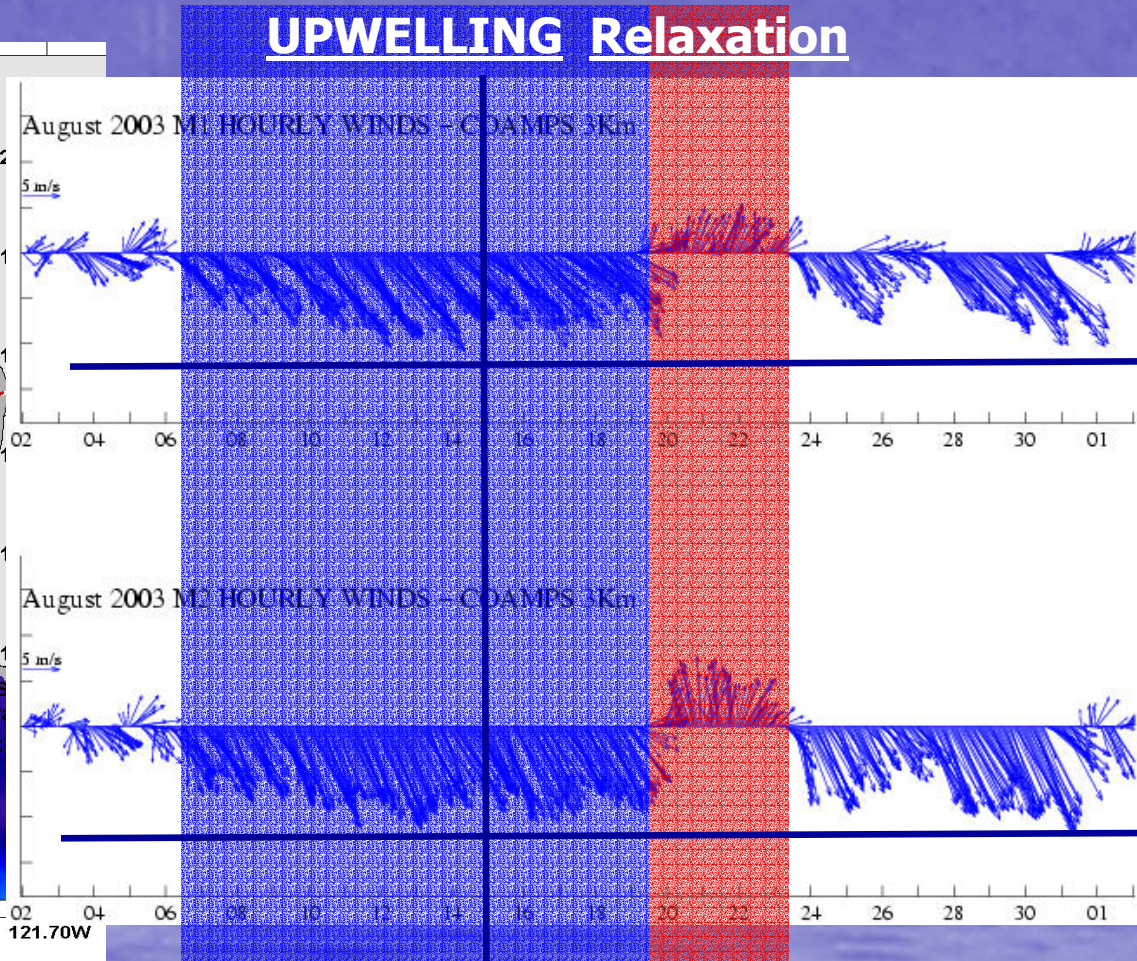
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003

10m winds at M1 and M2

COAMPS 3KM (hourly)

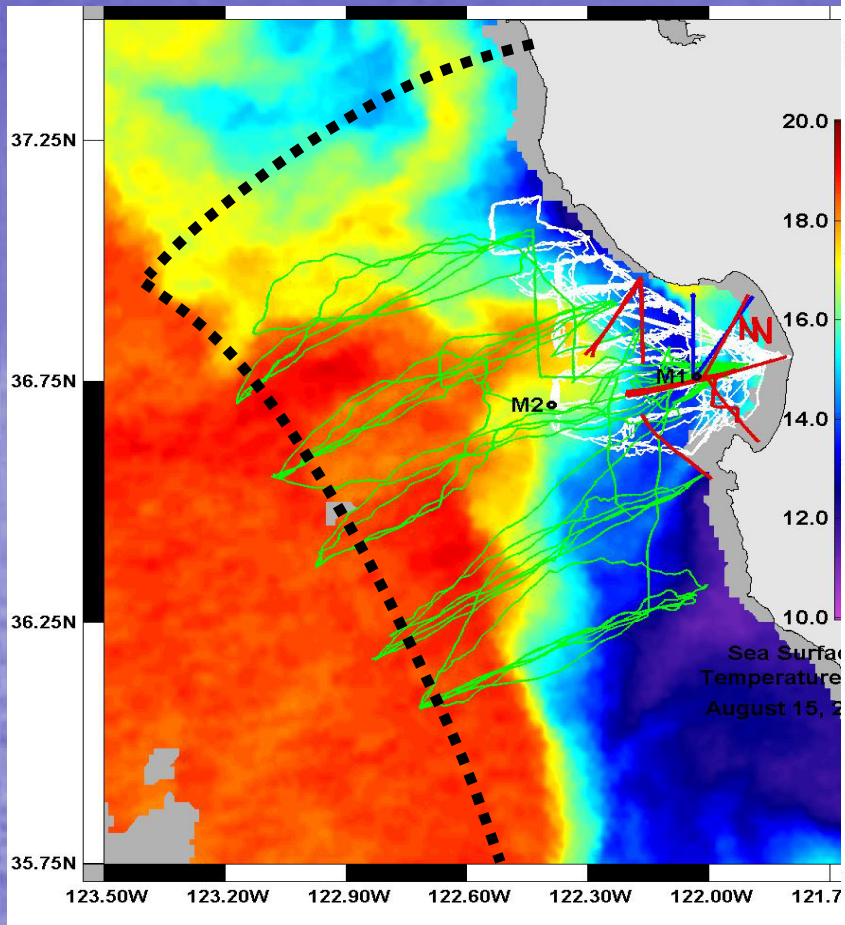




COMPARISONS

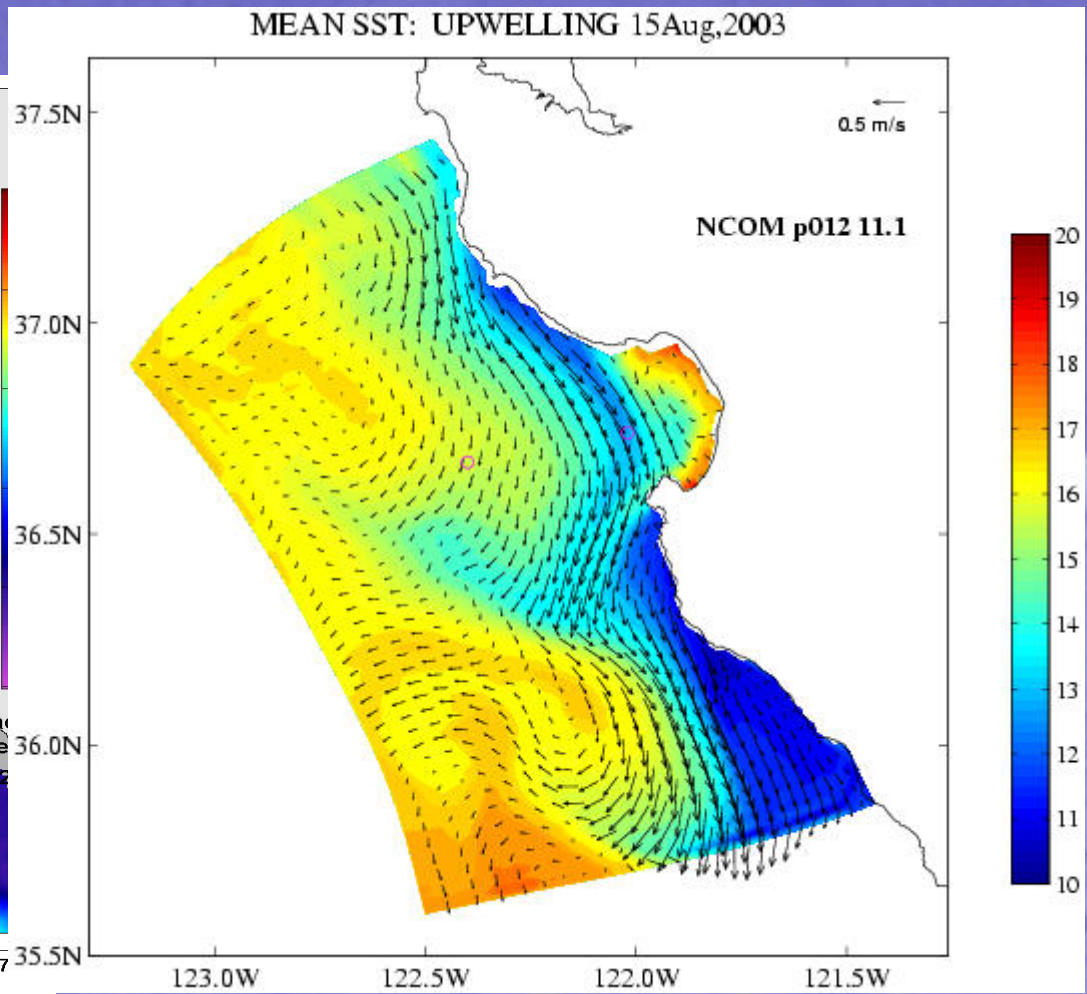
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003



Model Response

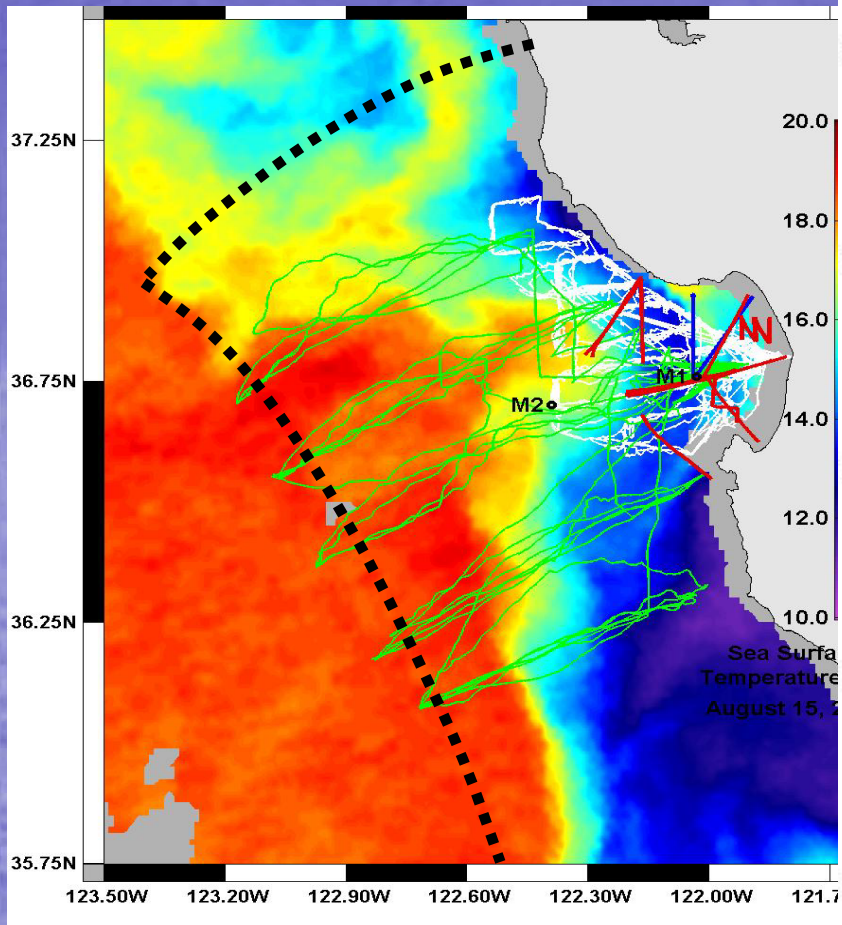
NCOMGLB->NCOMCCS->MB



COMPARISONS

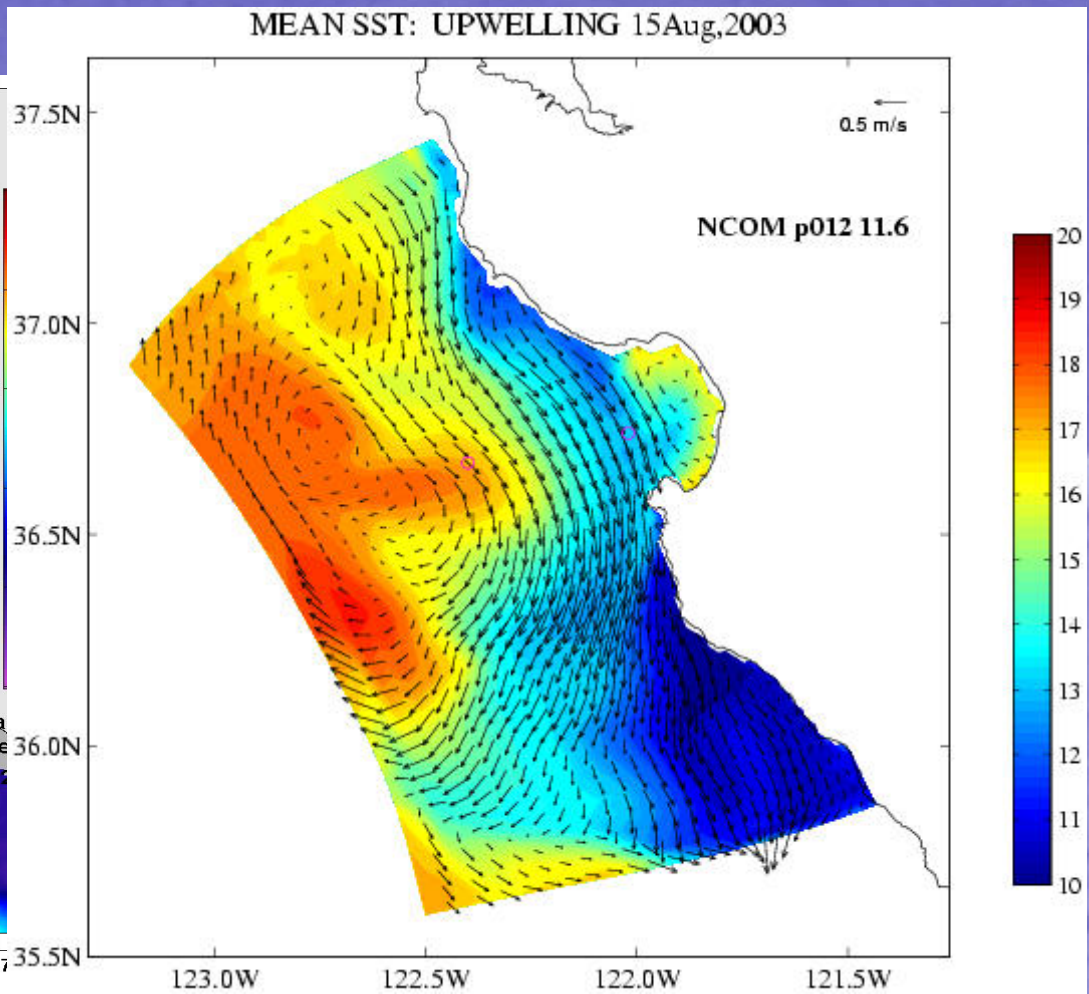
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003



Model Response

NCOMGLB->NCOMCCS->MBda



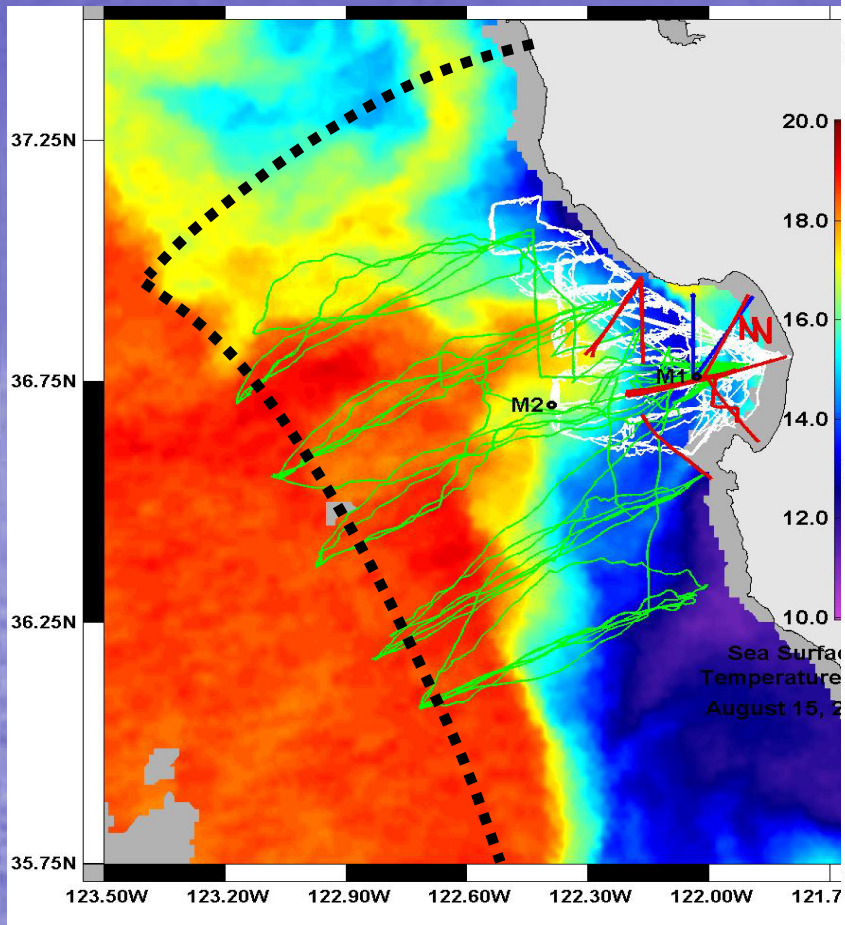
COMPARISONS

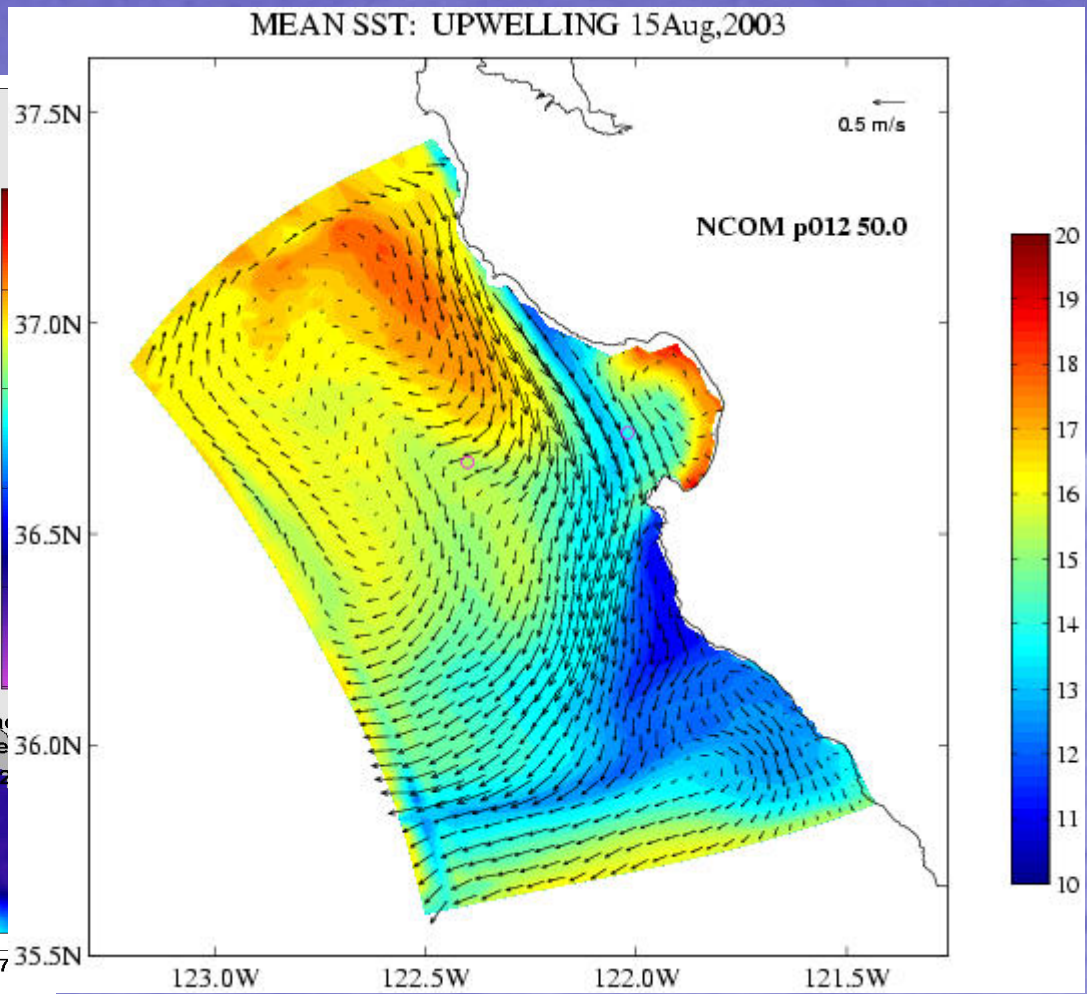
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003

Model Response

NCOMGLB->MB





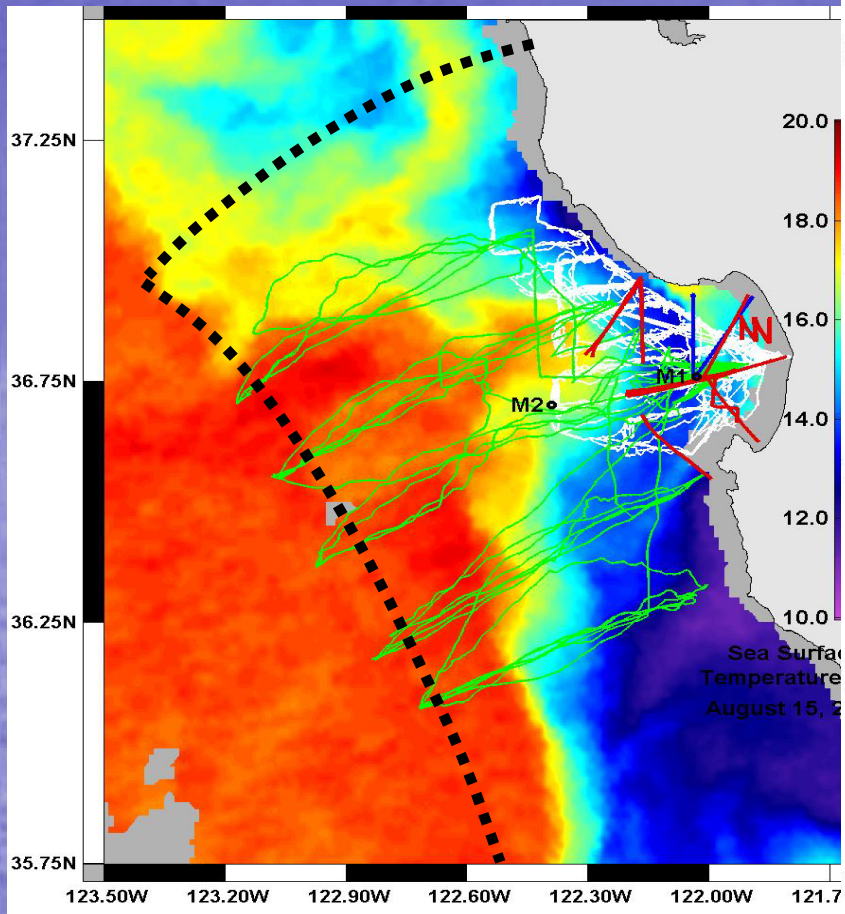
COMPARISONS

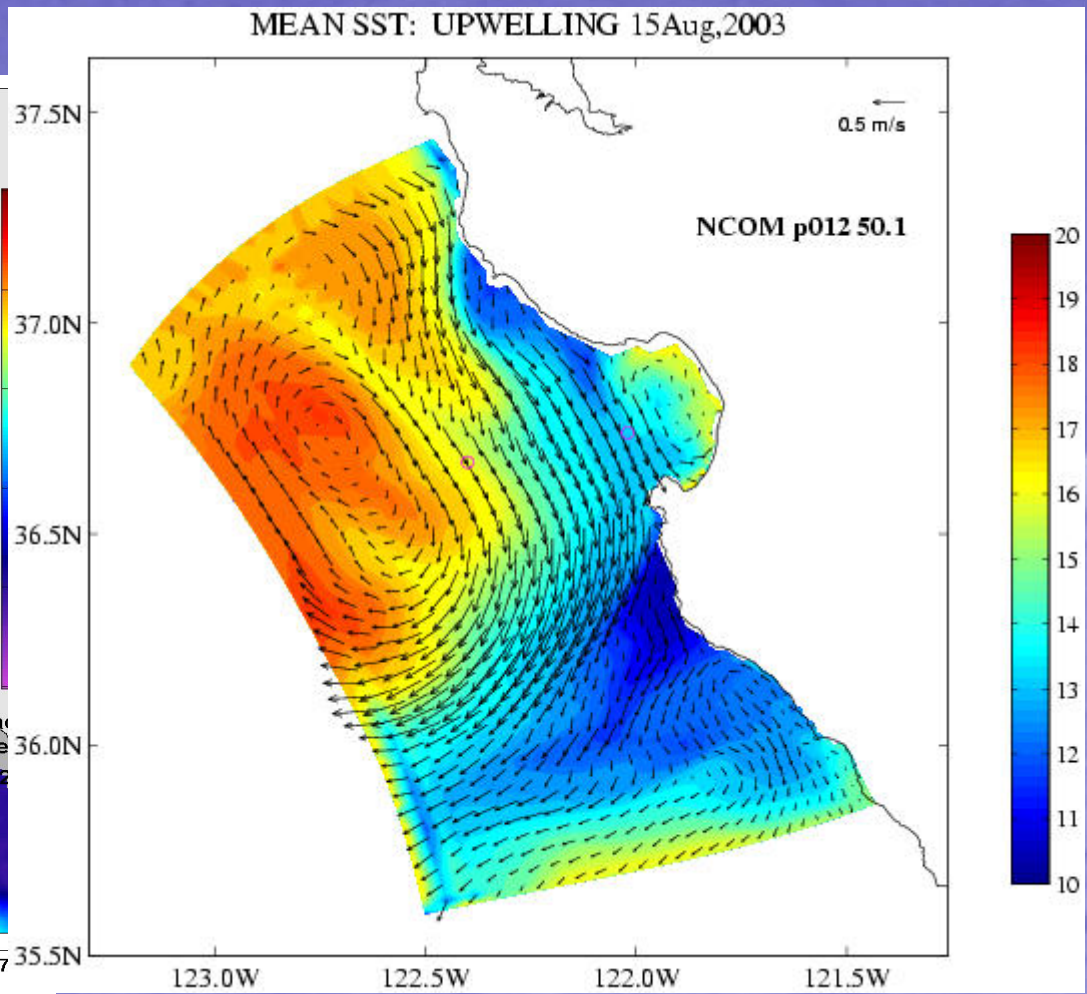
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003

Model Response

NCOMGLB->MBda

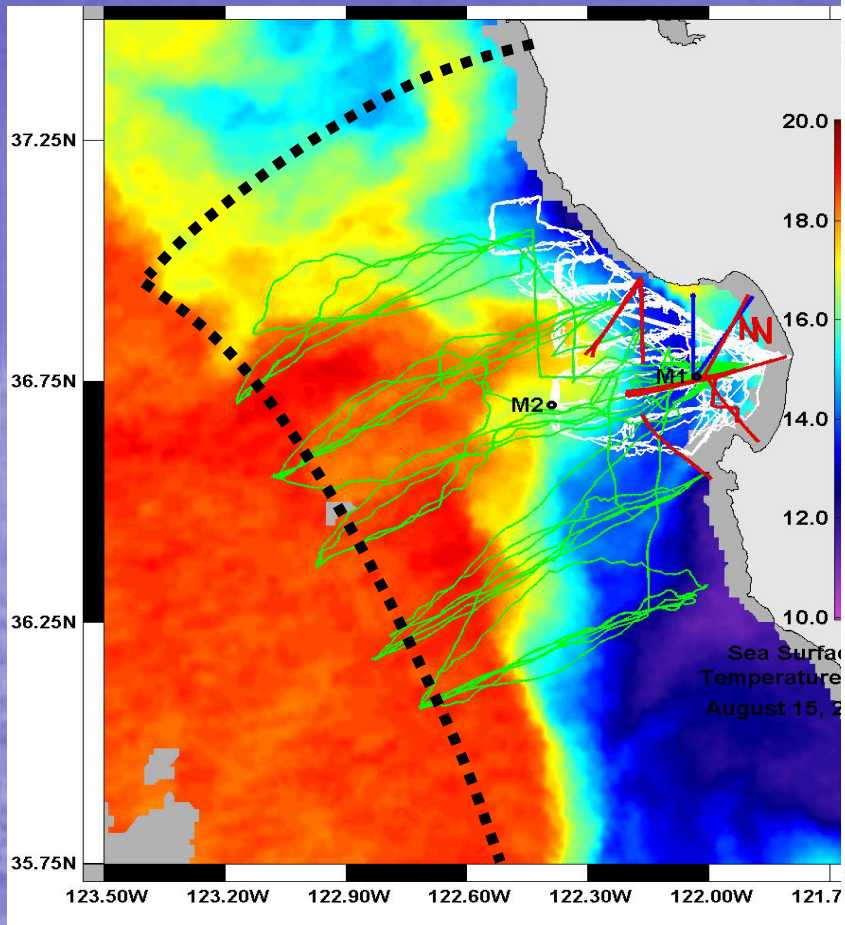




COMPARISONS

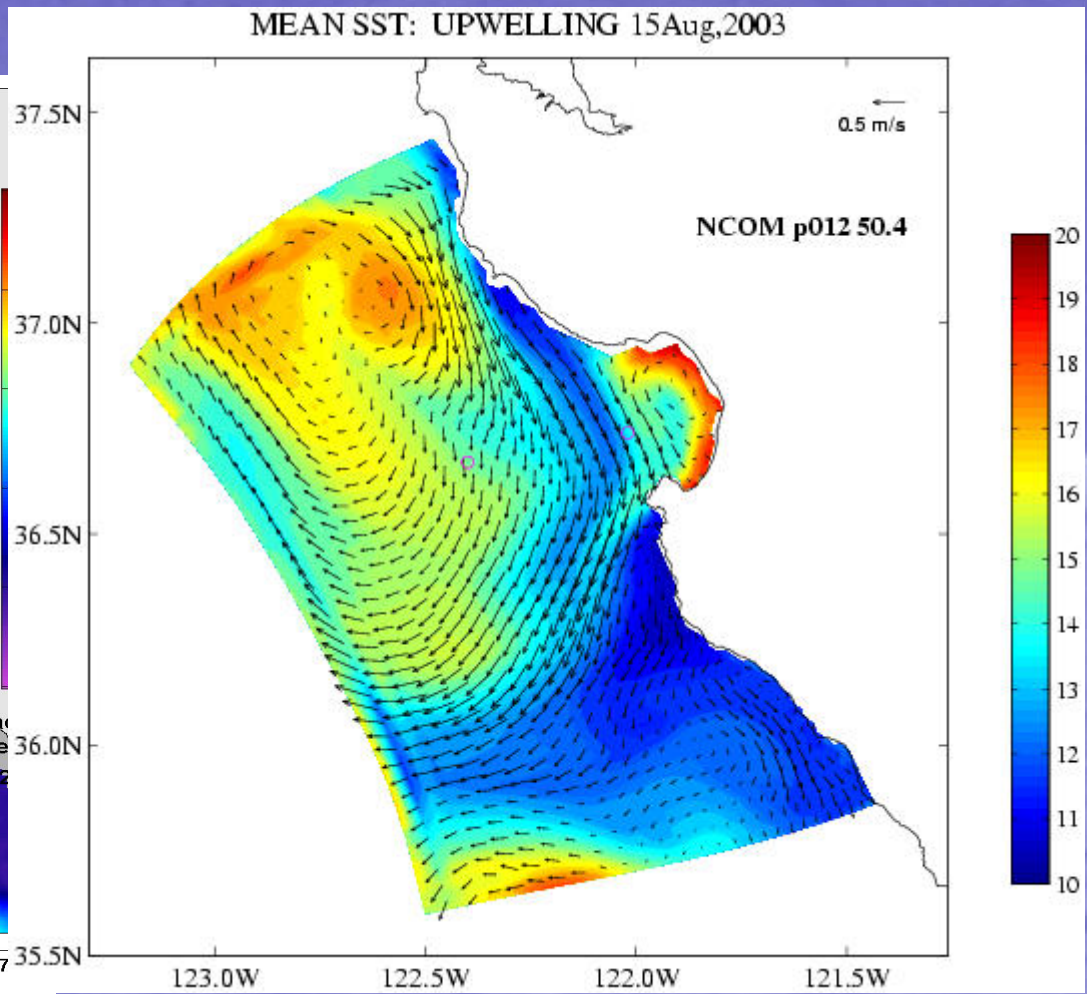
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003



Model Response

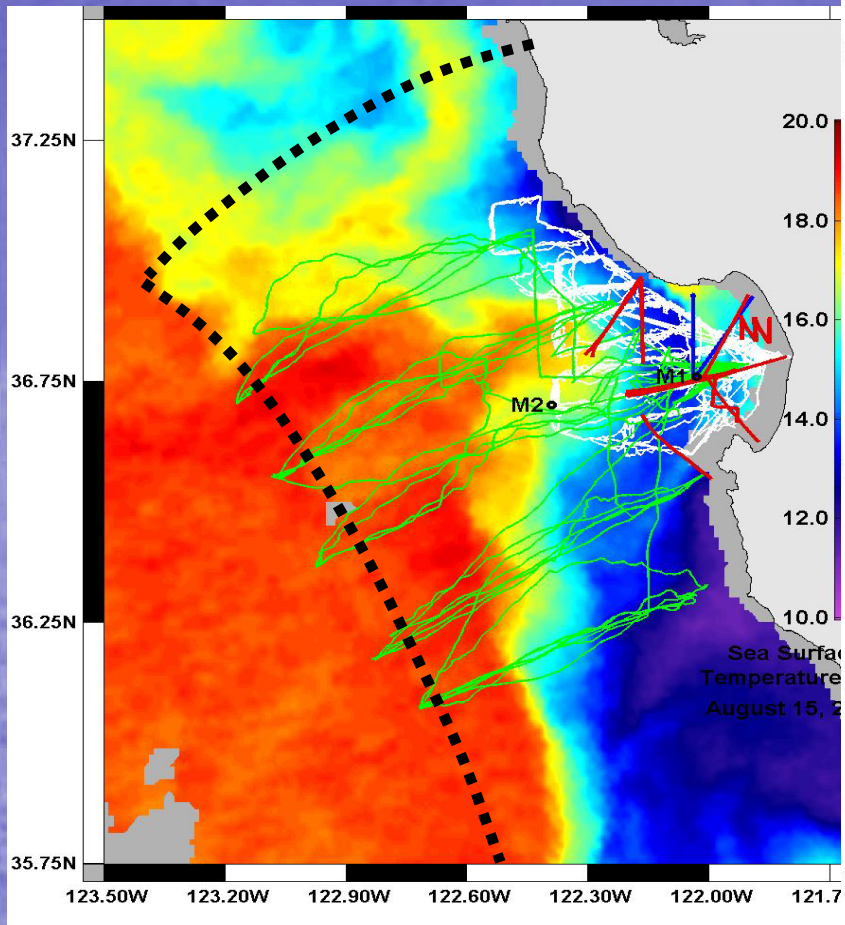
HYCOMGLB->HYCOMCCS->MB



COMPARISONS

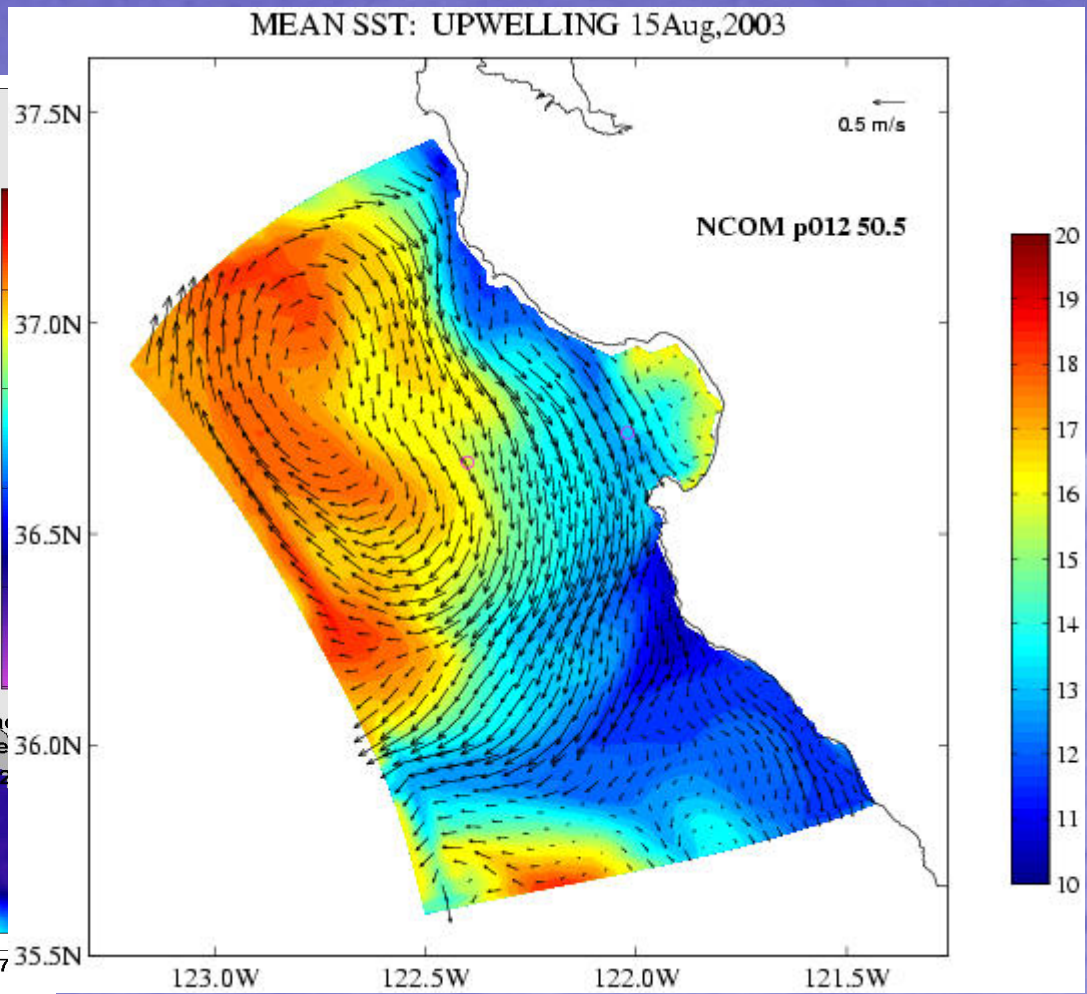
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003



Model Response

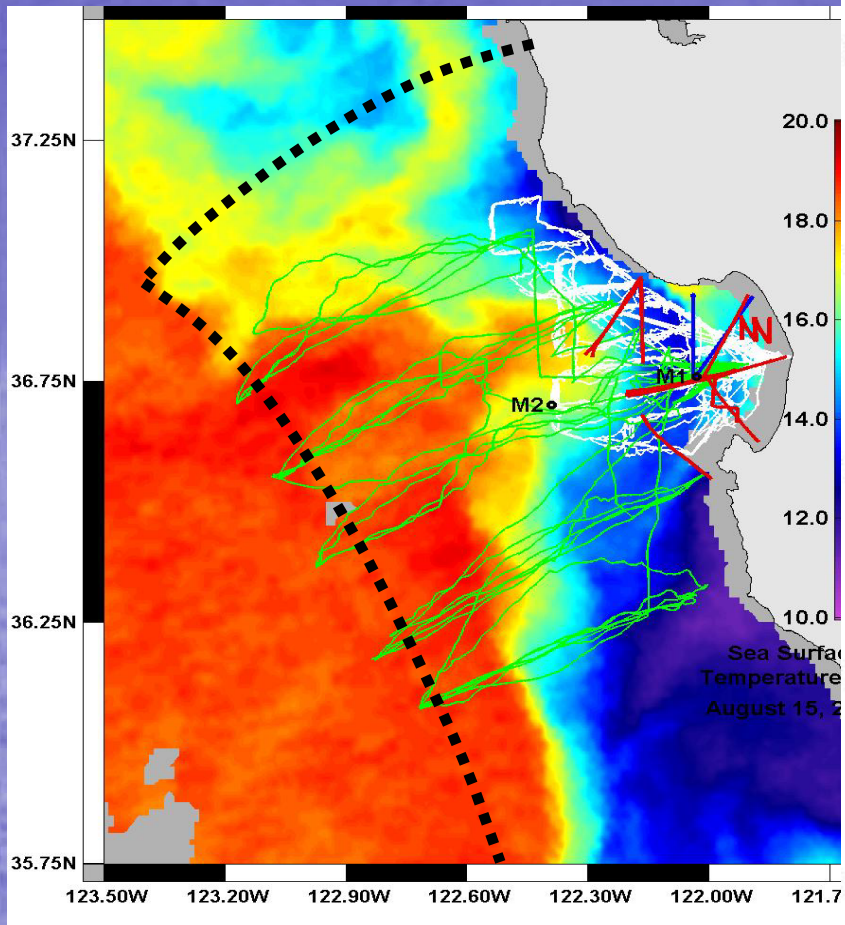
HYCOMGLB->HYCOMCCS->MBda



COMPARISONS

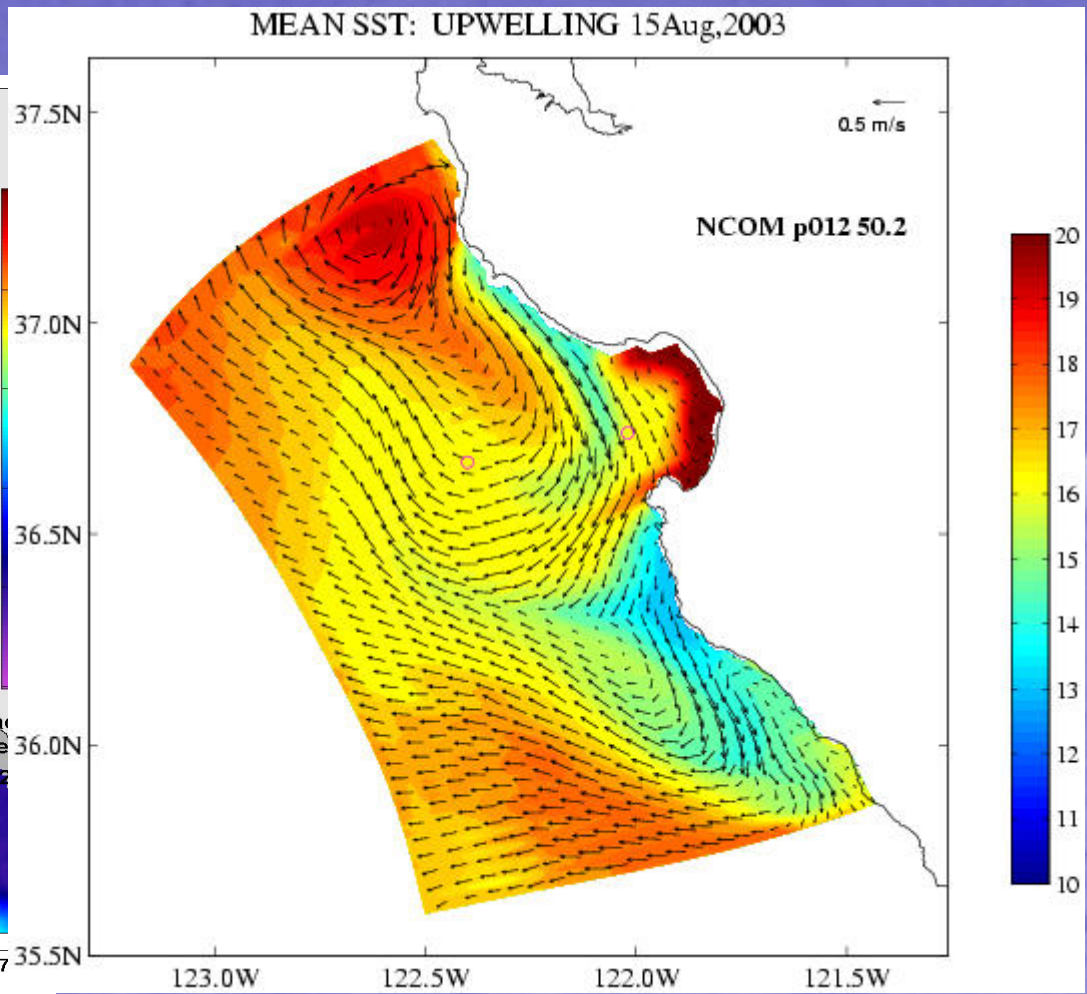
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003



Model Response

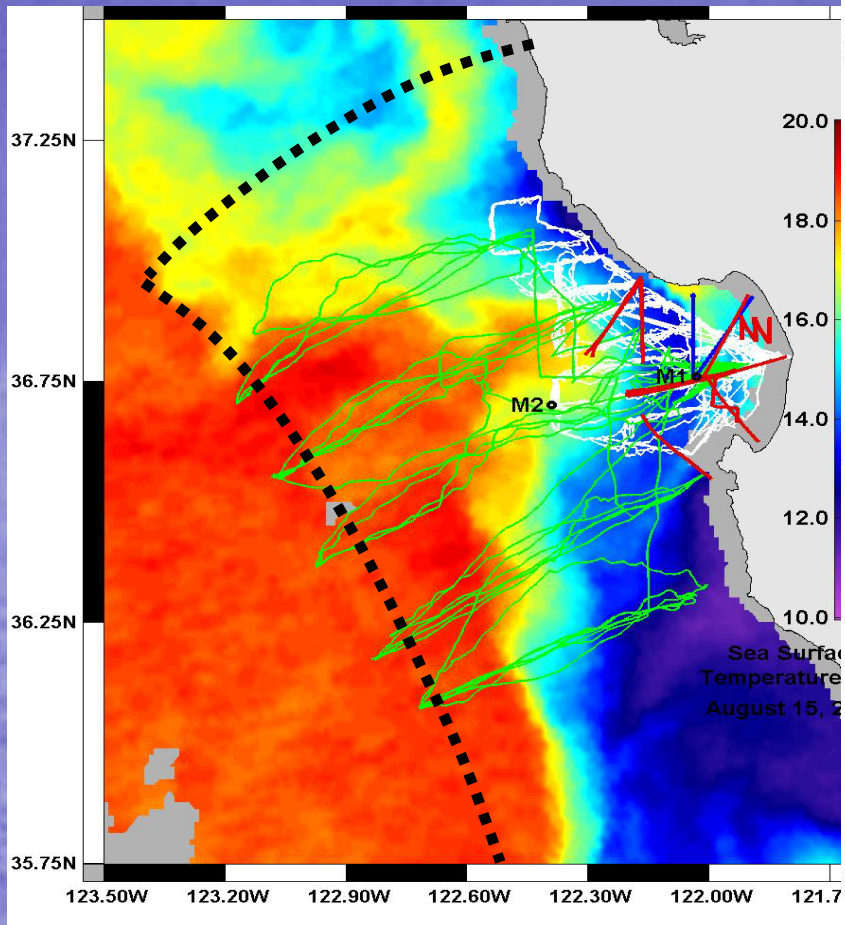
HYCOMGLB->MB



COMPARISONS

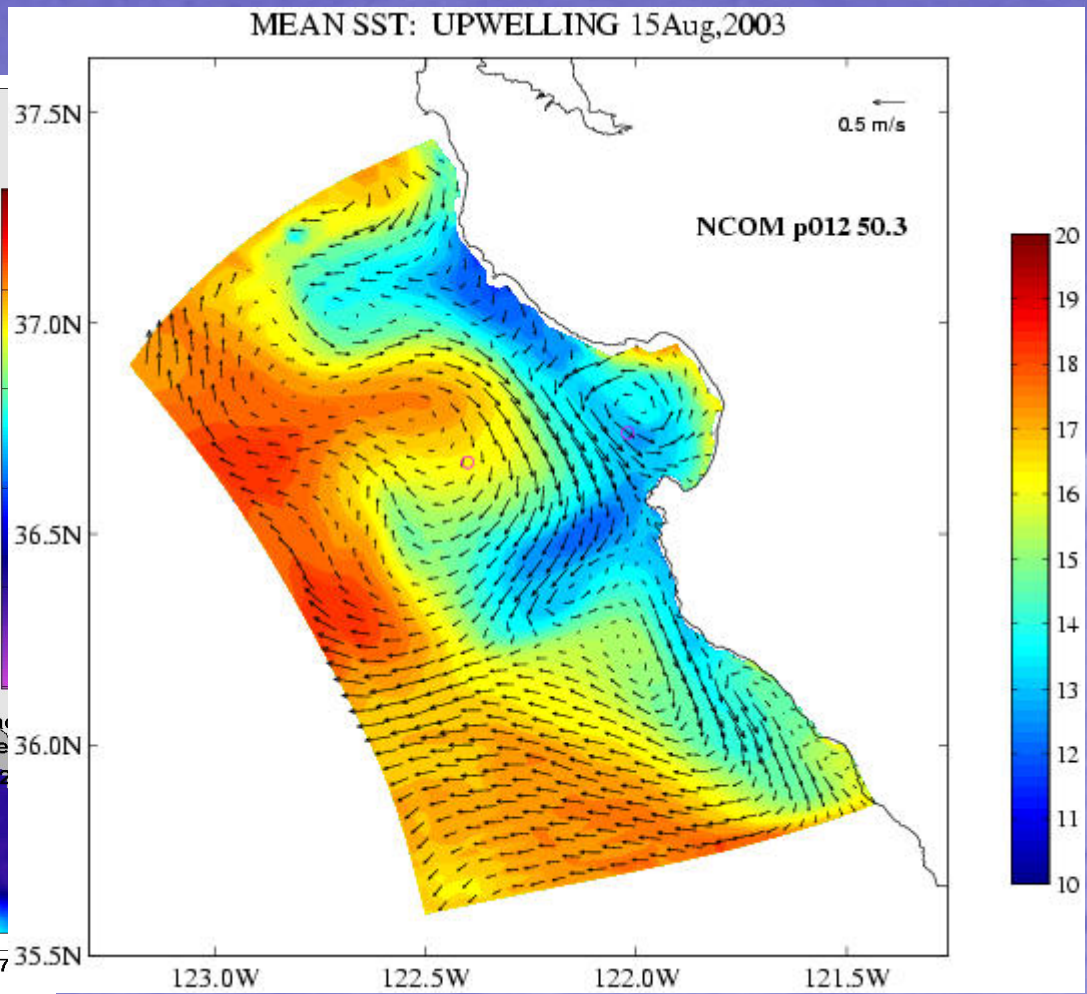
Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003



Model Response

HYCOMGLB->MBda

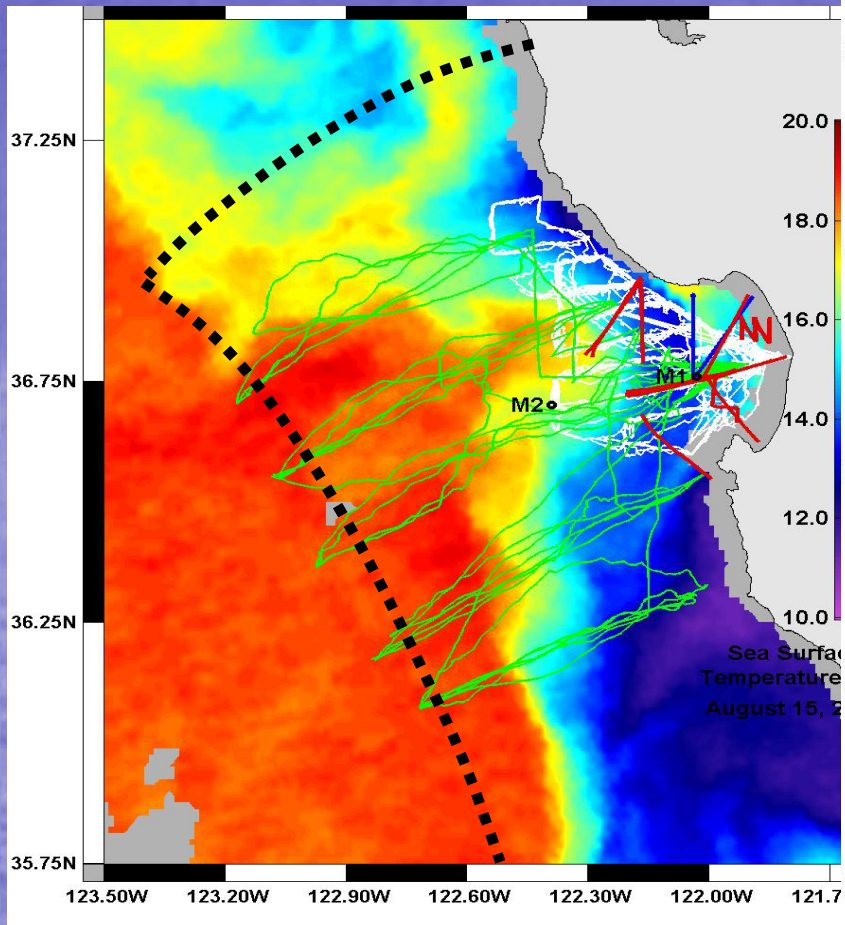


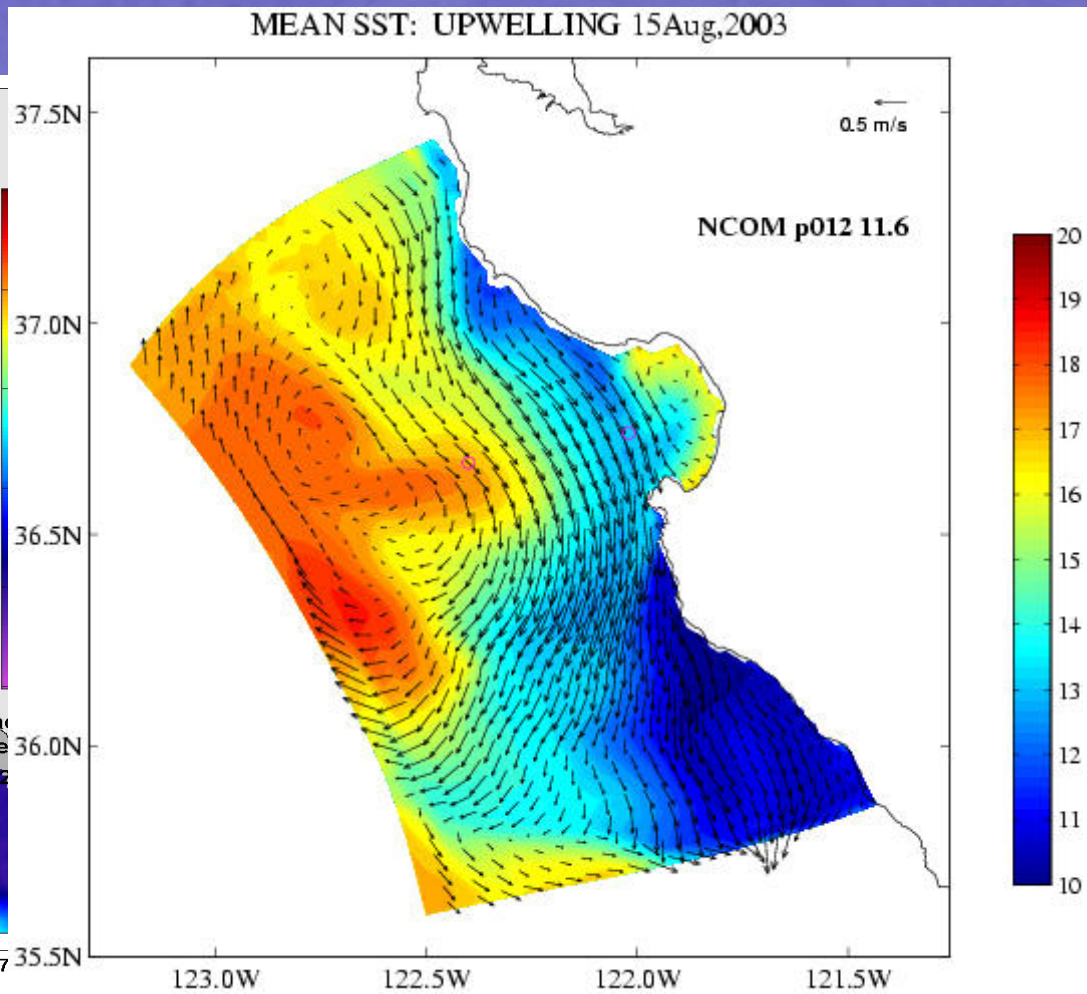
COMPARISONS

Concentration in the AOSN Period (August 2003)

AVHRR on August 15, 2003 Model Response

NCOMGLB->NCOMCCS->MBda (best comparison)

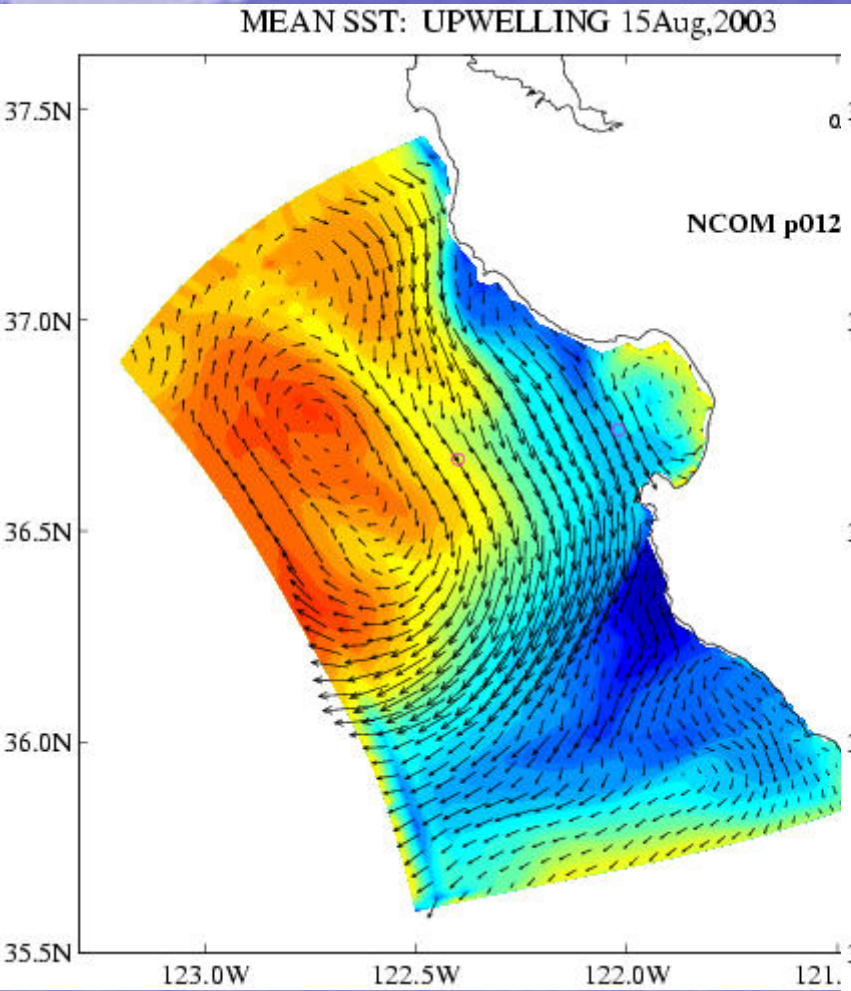


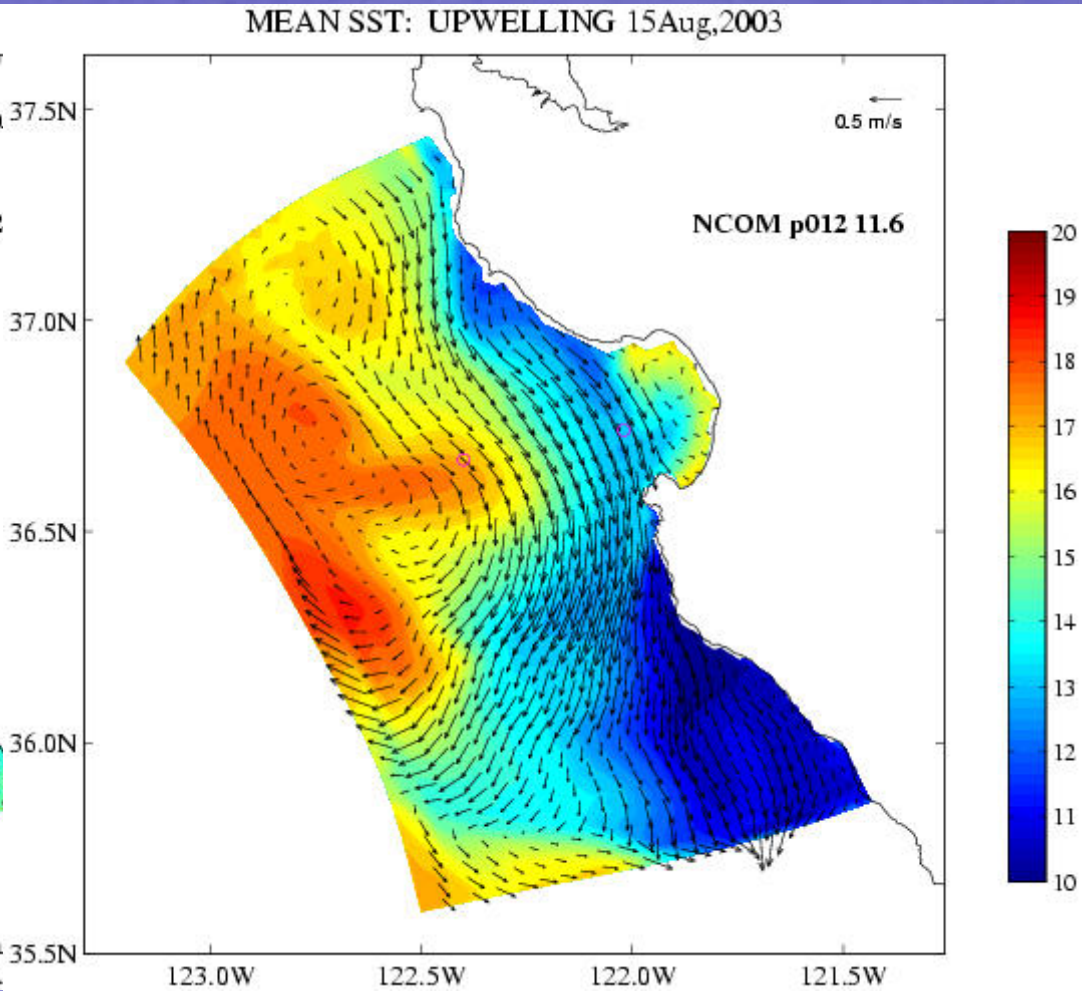


COMPARISONS

August 15, 2003

Nested in Global	Nested in Regional
NCOMGLB->MBda	NCOMGLB->NCOMCCS->MBda

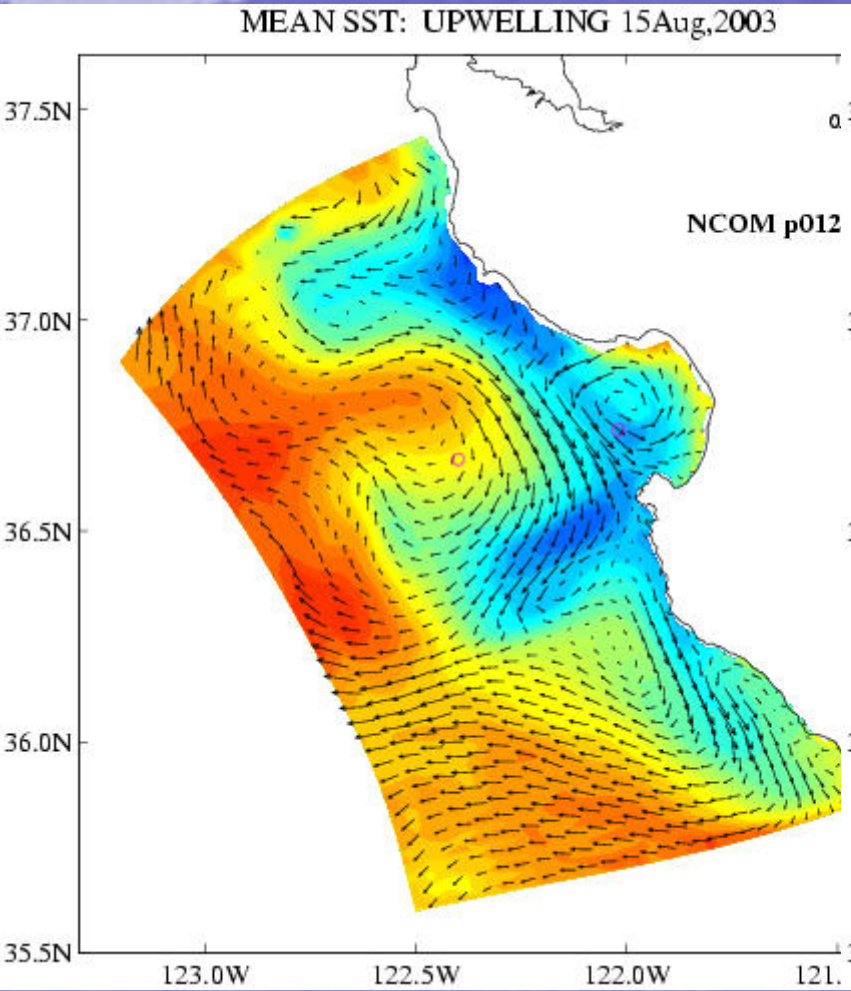


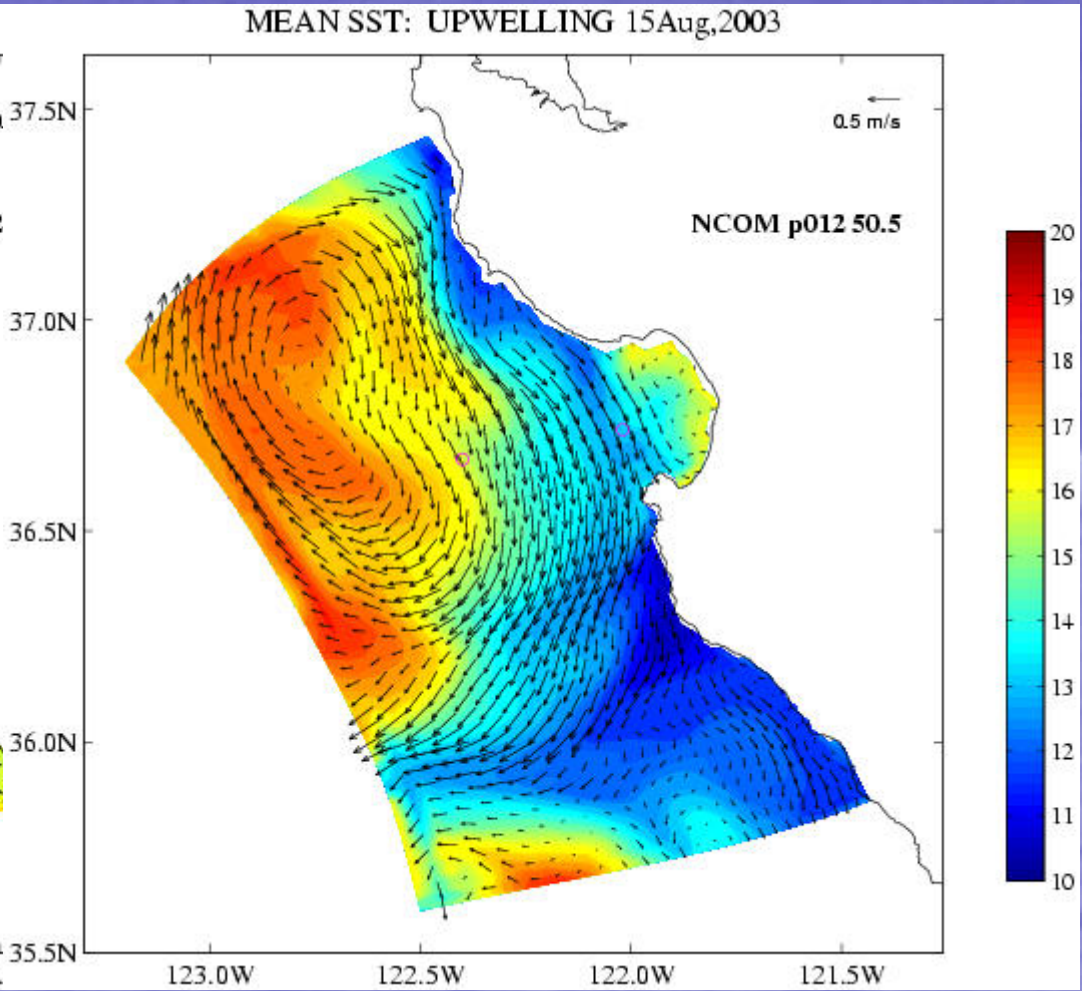


COMPARISONS

August 15, 2003

Nested in Global	Nested in Regional
HYCOMGLB->MBda	HYCOMGLB->HYCOMCCS->MBda

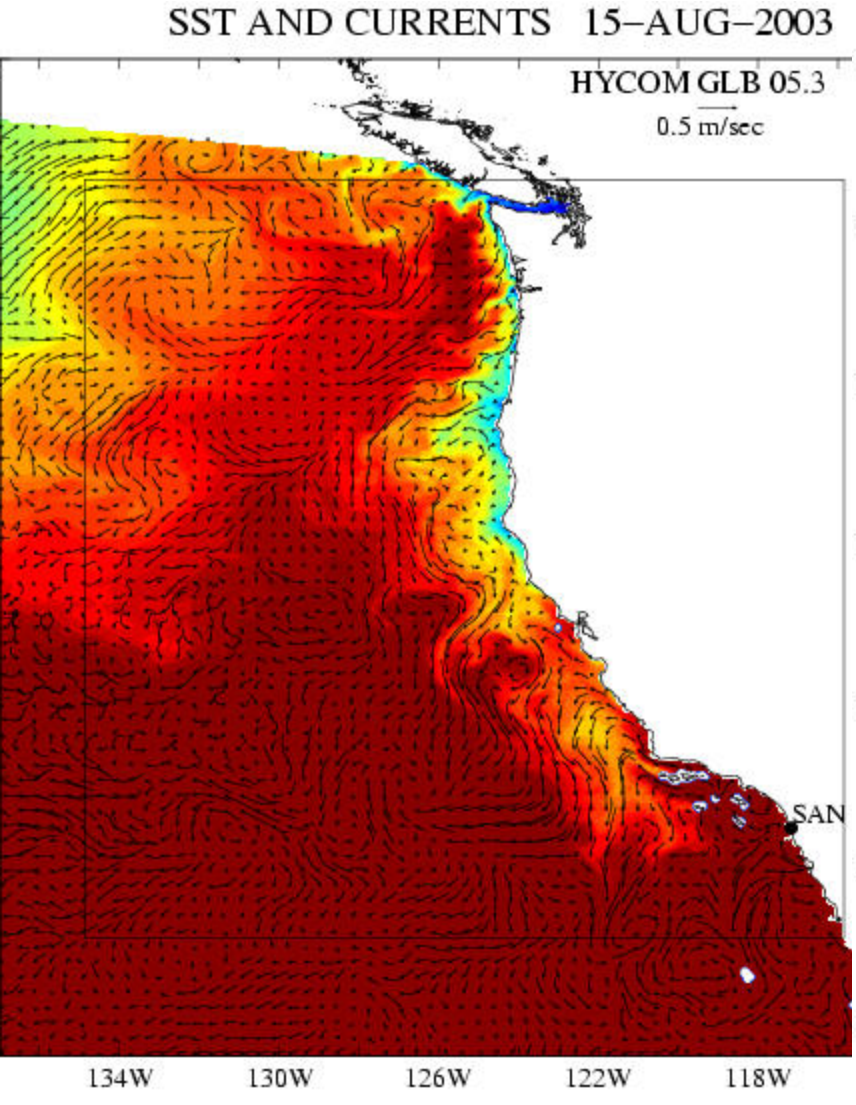




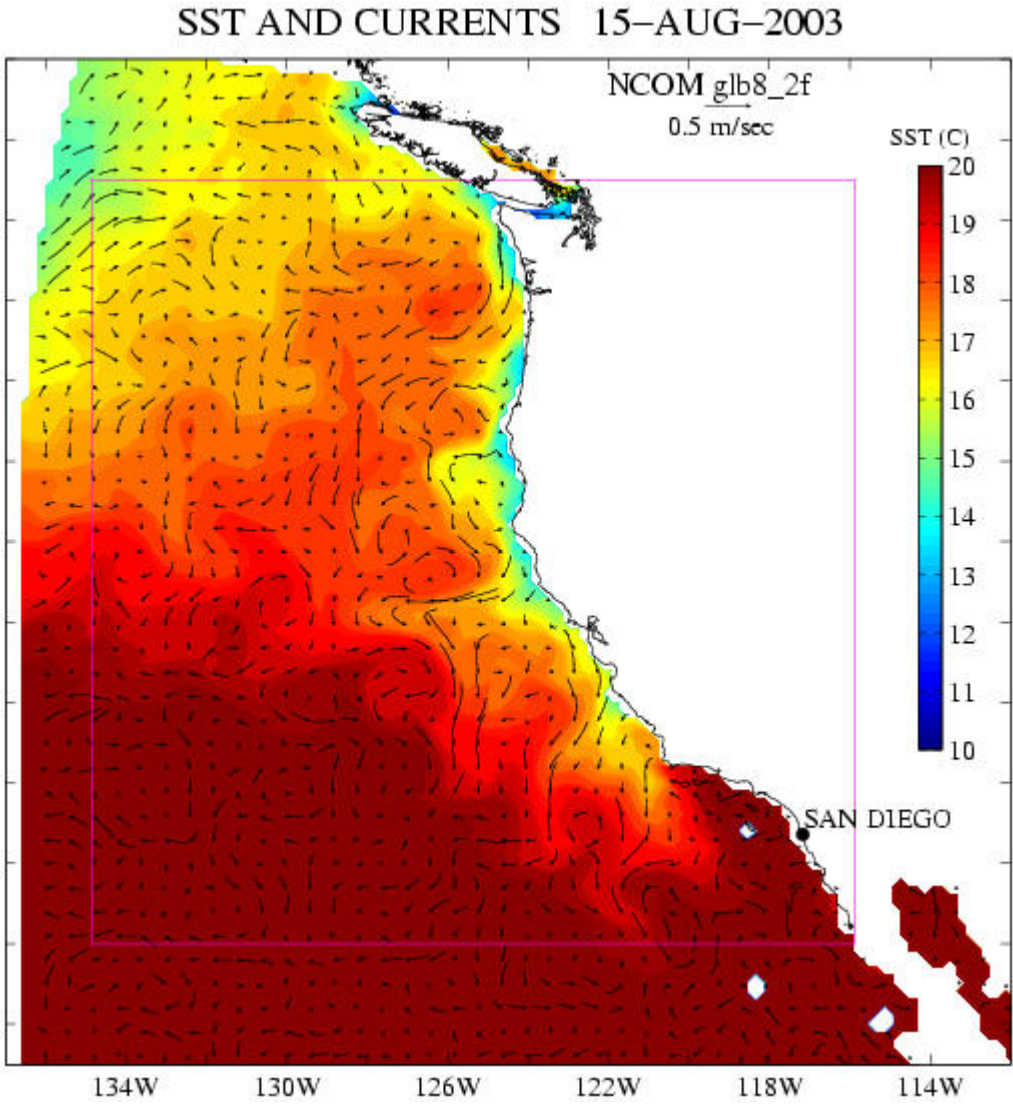
COMPARISONS (Global Models)

SST: August 15, 2003 (GLOBAL)

HYCOMGLB



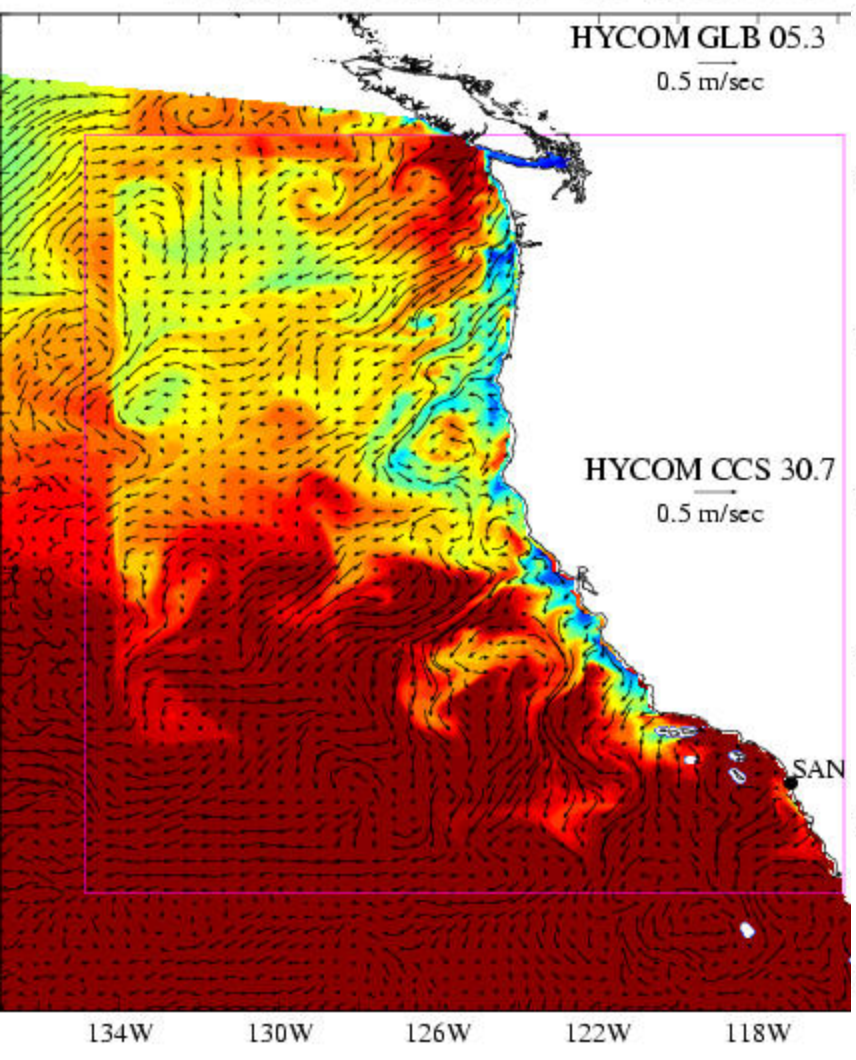
NCOMGLB



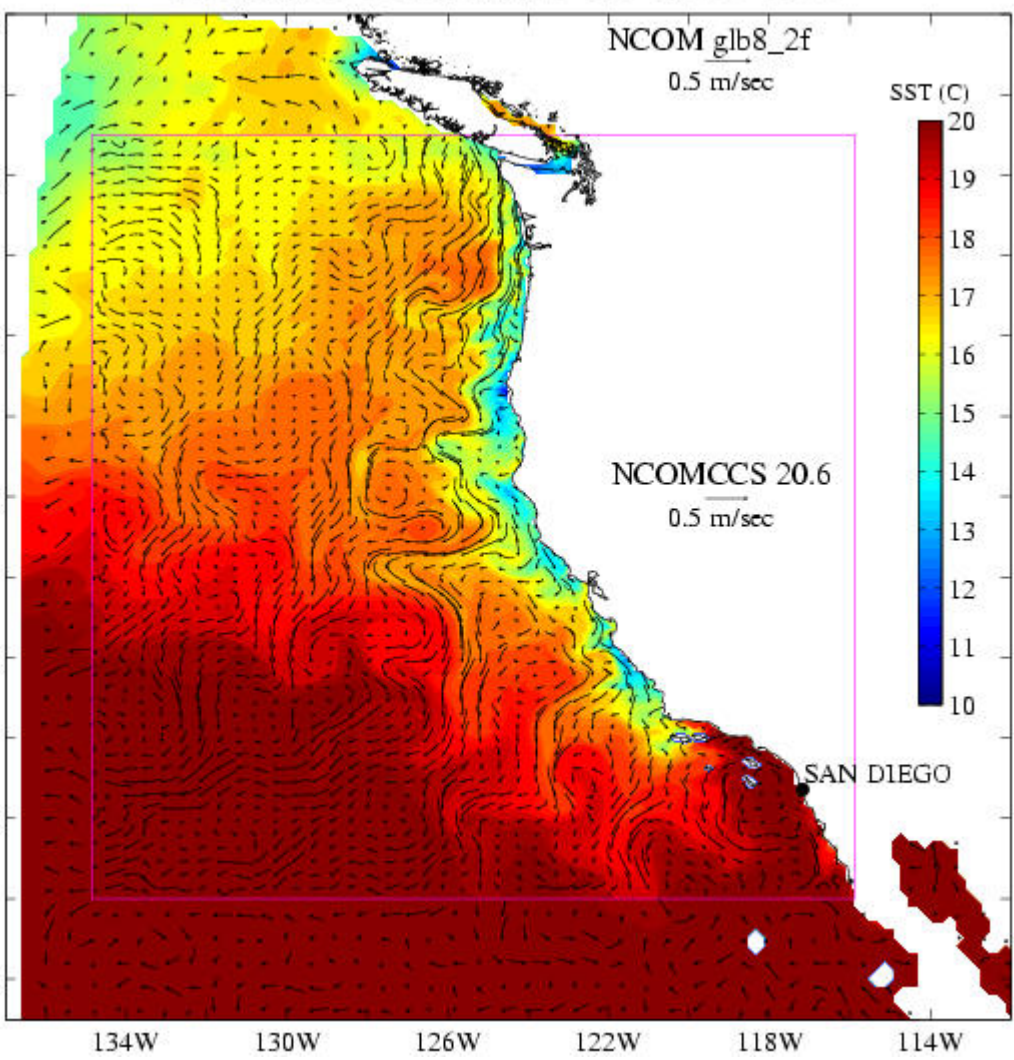
COMPARISONS (Regional Models)

SST: August 15, 2003 (GLOBAL->REGIONAL)

HYCOMGLB->HYCOMCCS



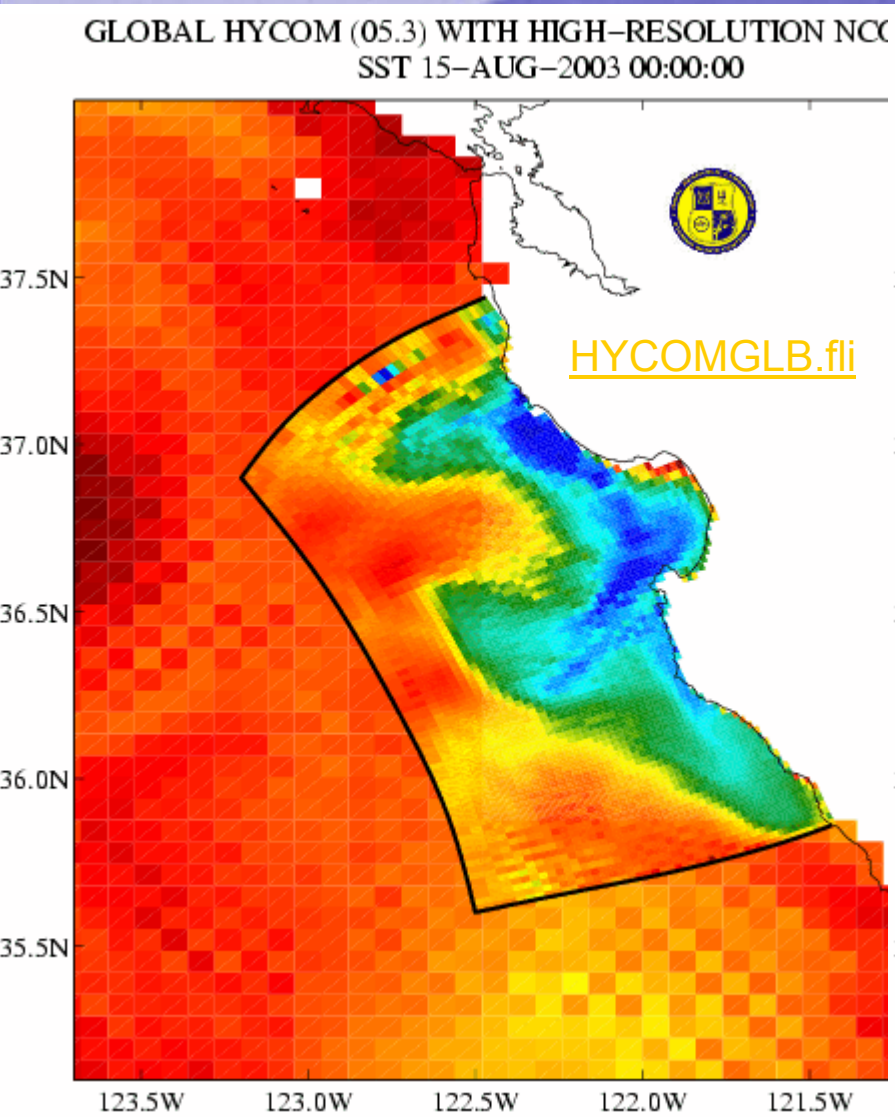
NCOMGLB->NCOMCCS



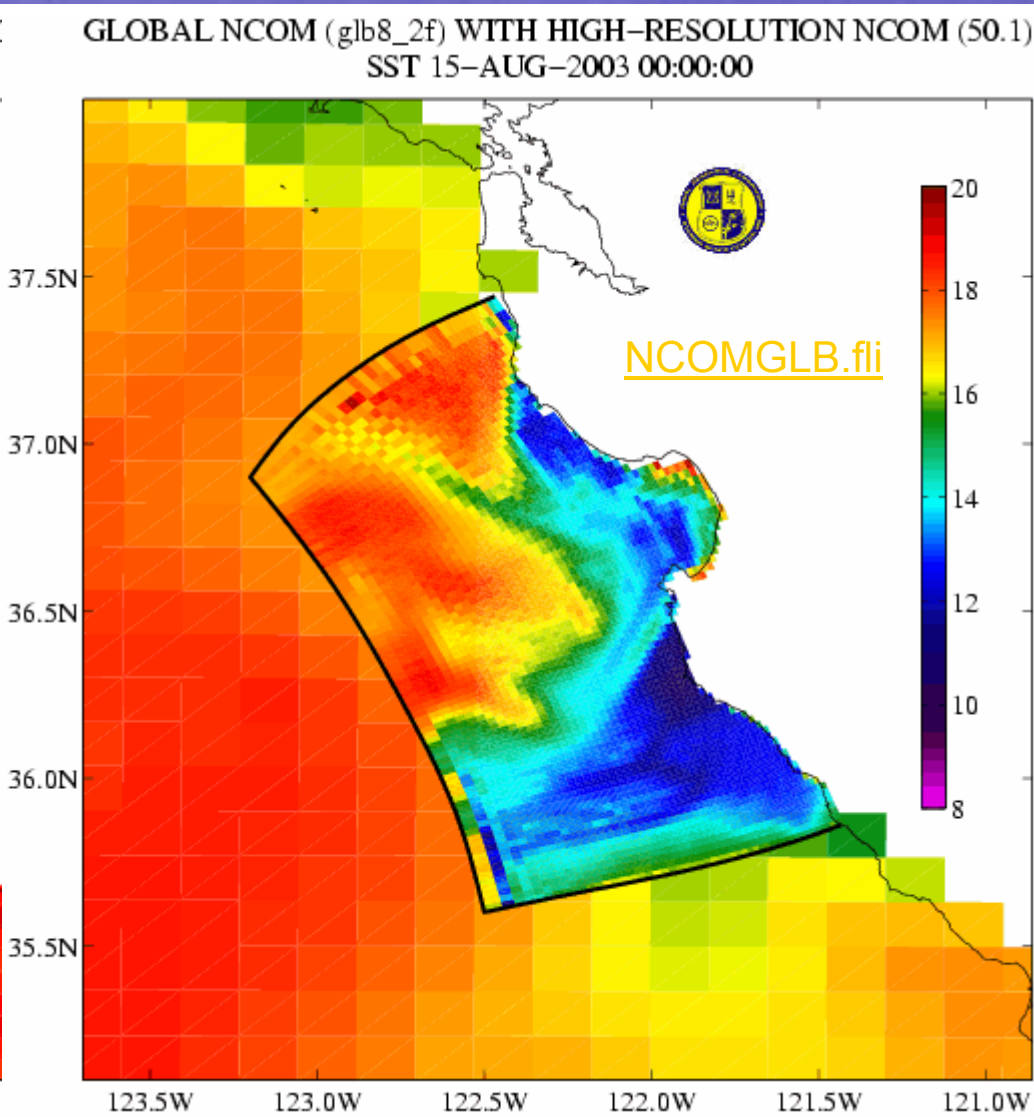
Coastal nested in Global

SST: August 02-24 (GLOBAL->COASTAL) @ native resolution

HYCOMGLB->NCOMMBda



NCOMGLB->NCOMMBda

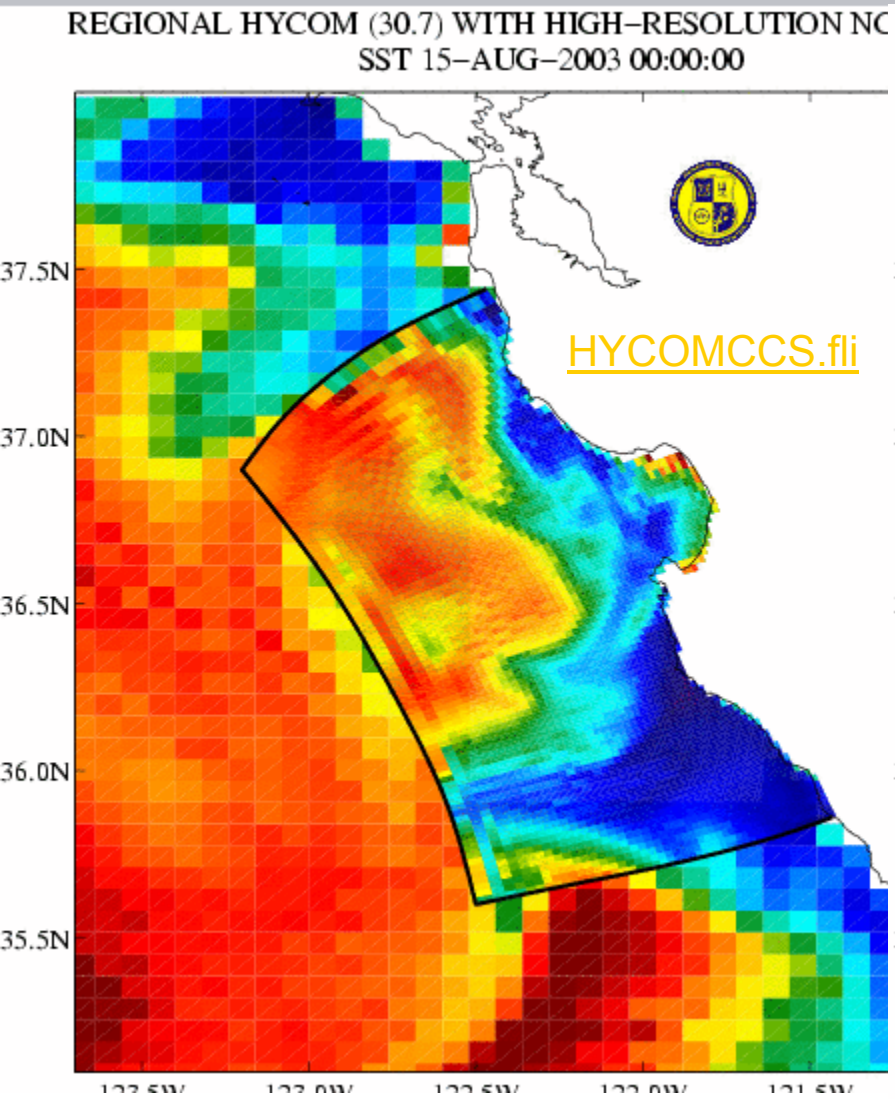


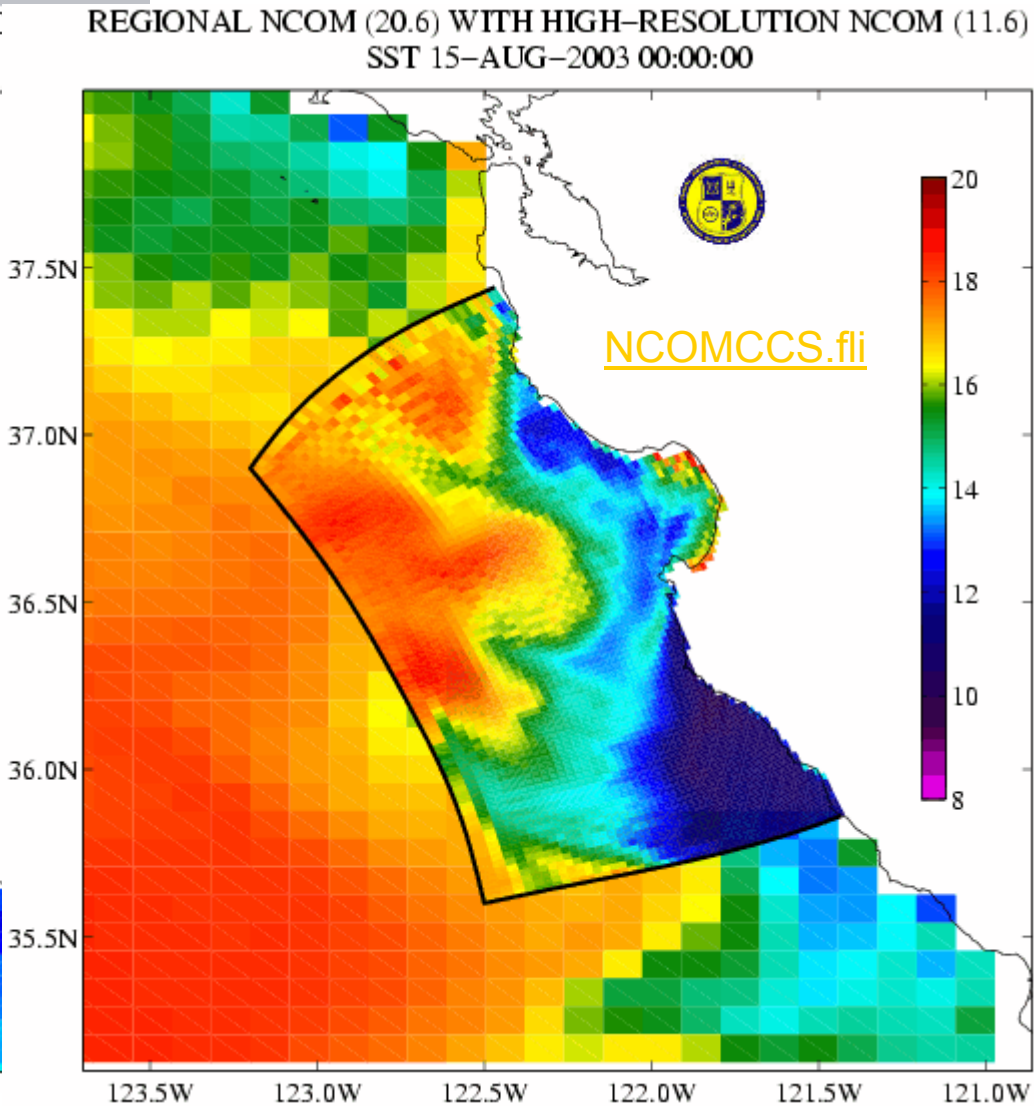
Coastal nested in Regional

SST: August 02-24 (REGIONAL->COASTAL) @ native resolution

HYCOMCCS->NCOMMBda

NCOMCCS->NCOMMBda





EVALUATION

SSH for qualitative measure of results: Tide-Gauges

- **@ San Diego (Global Boundary)**

  - Global->Regional assessment

- **@ Monterey (Within all domains)**

  - Influence of local forcing

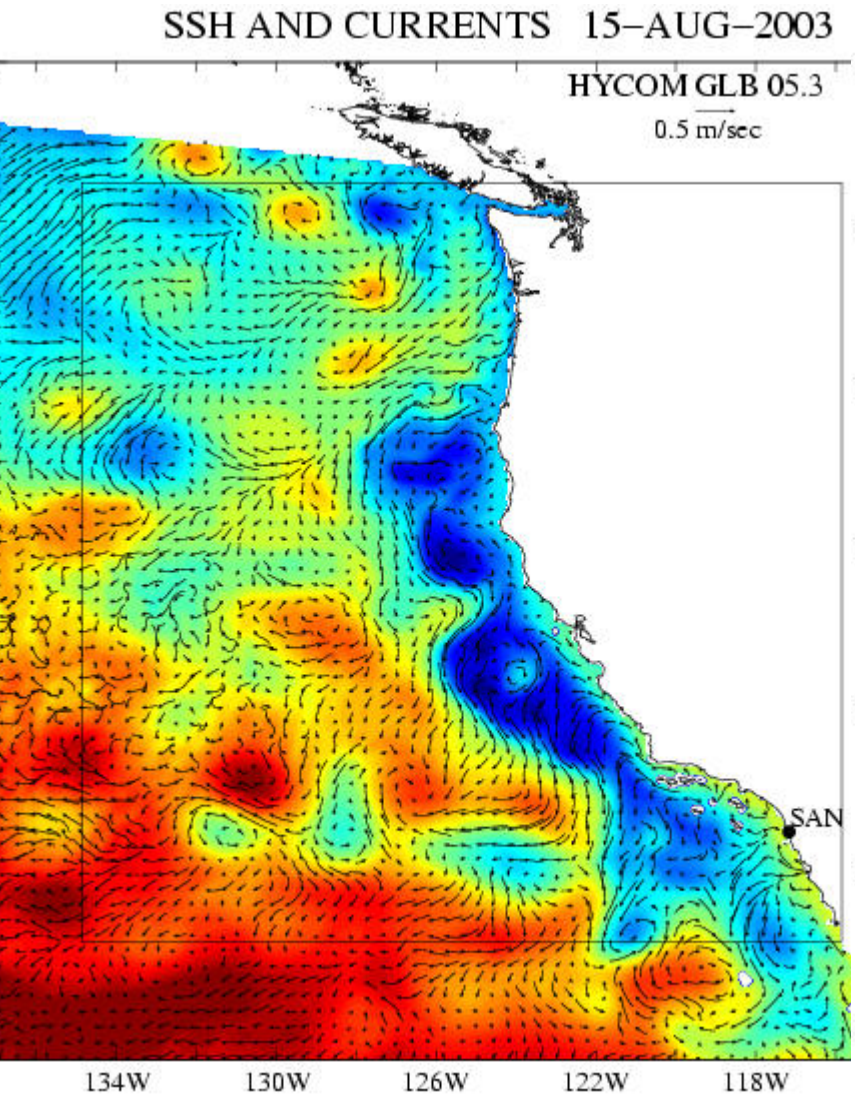
  - Global->Coastal, Regional->Coastal

  *** MB Coastal Model includes OSU Tidal forcing**

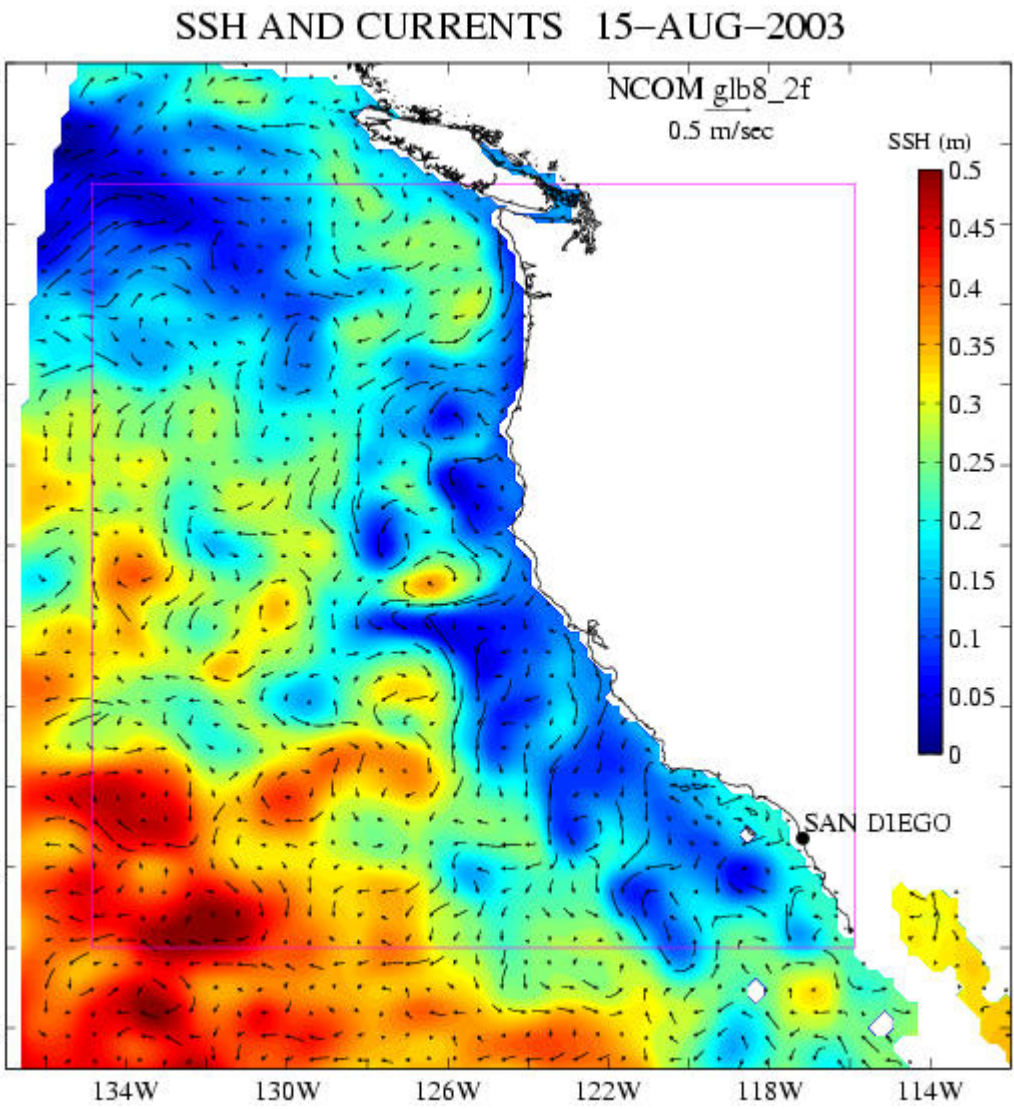
EVALUATION (Global Models)

SSH: August 15, 2003 (GLOBAL->REGIONAL)

HYCOMGLB



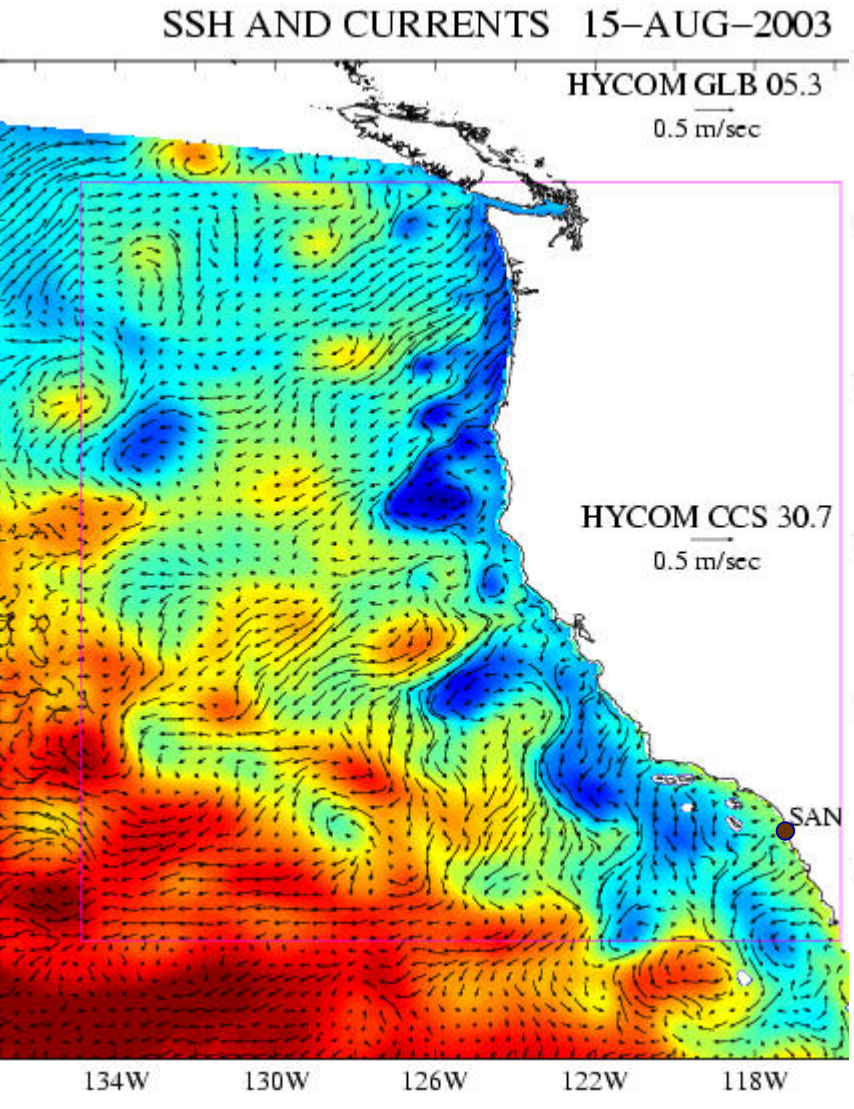
NCOMGLB



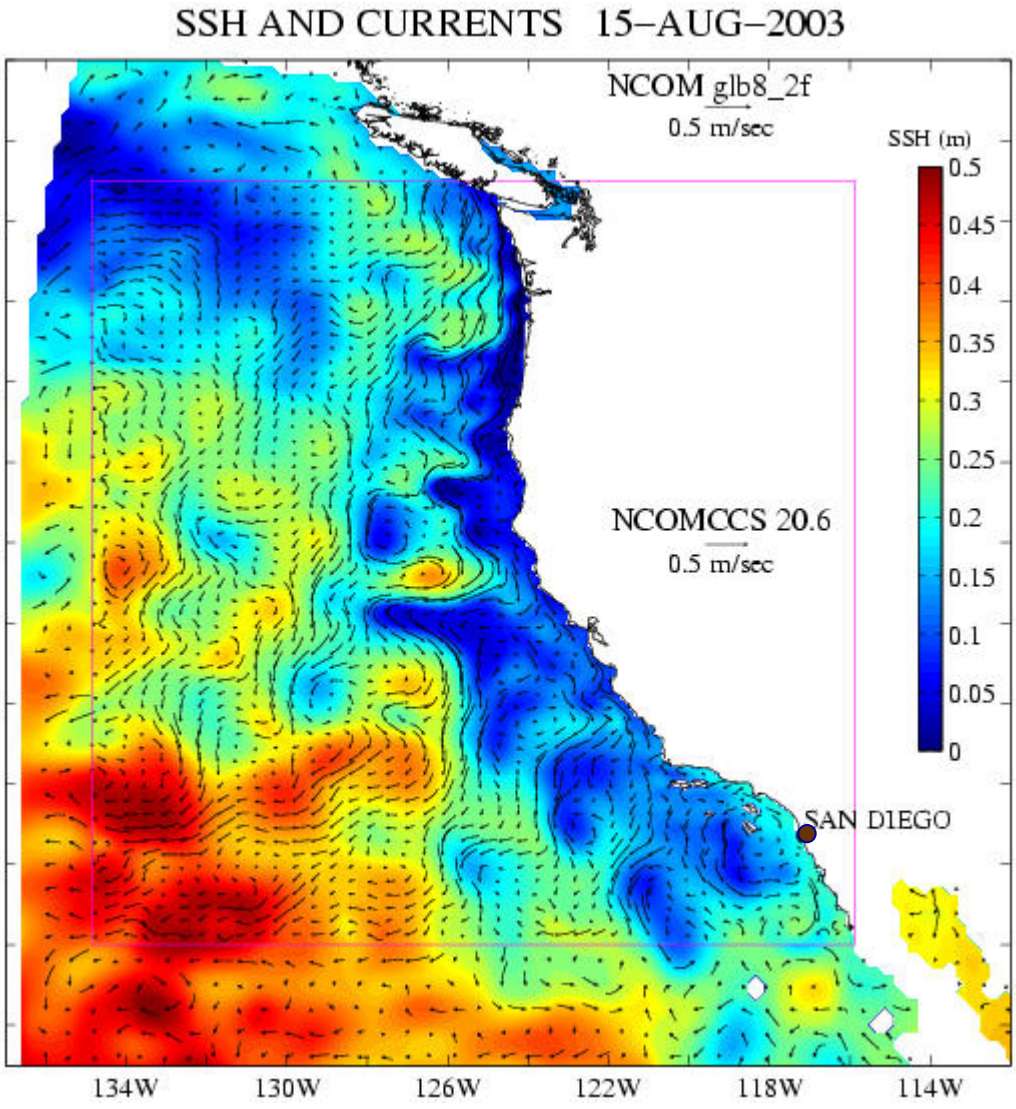
EVALUATION (Regional Models)

SSH: August 15, 2003 (GLOBAL->REGIONAL)

HYCOMGLB->HYCOMCCS



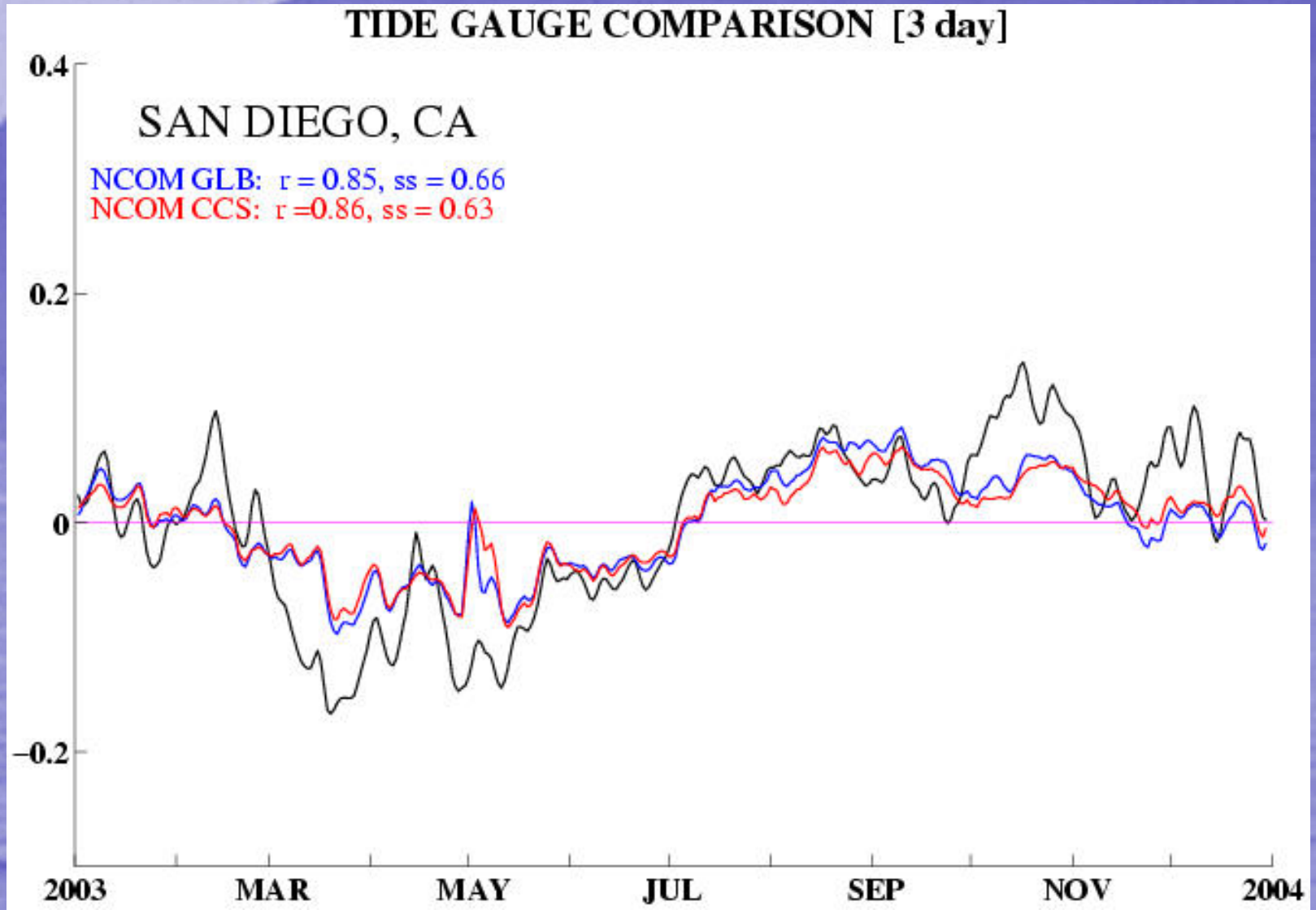
NCOMGLB->NCOMCCS



EVALUATION (NCOM)

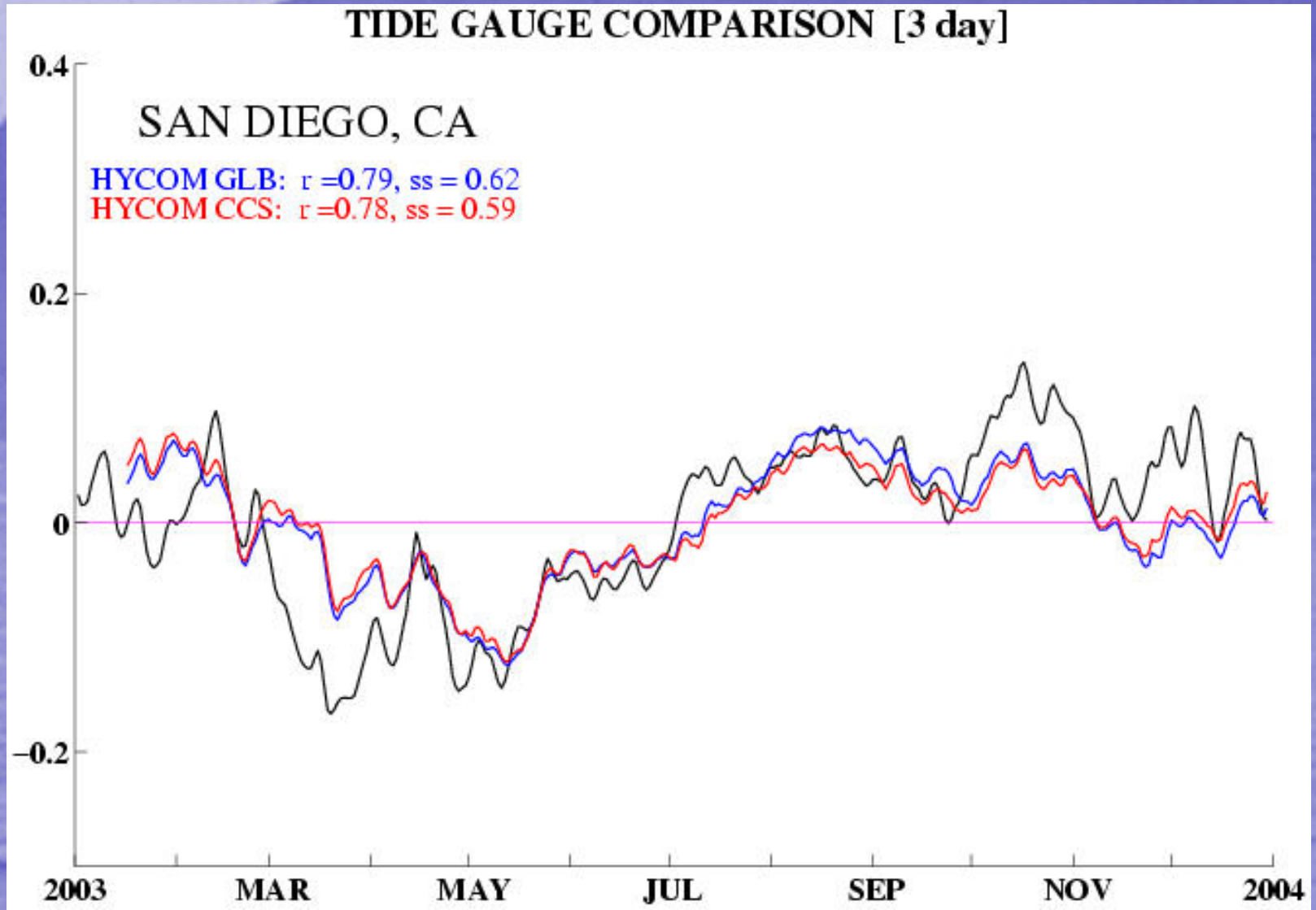
Tide Gauges for 2003 (NCOM: GLOBAL->REGIONAL)

- Data Assimilation*



EVALUATION (HYCOM)

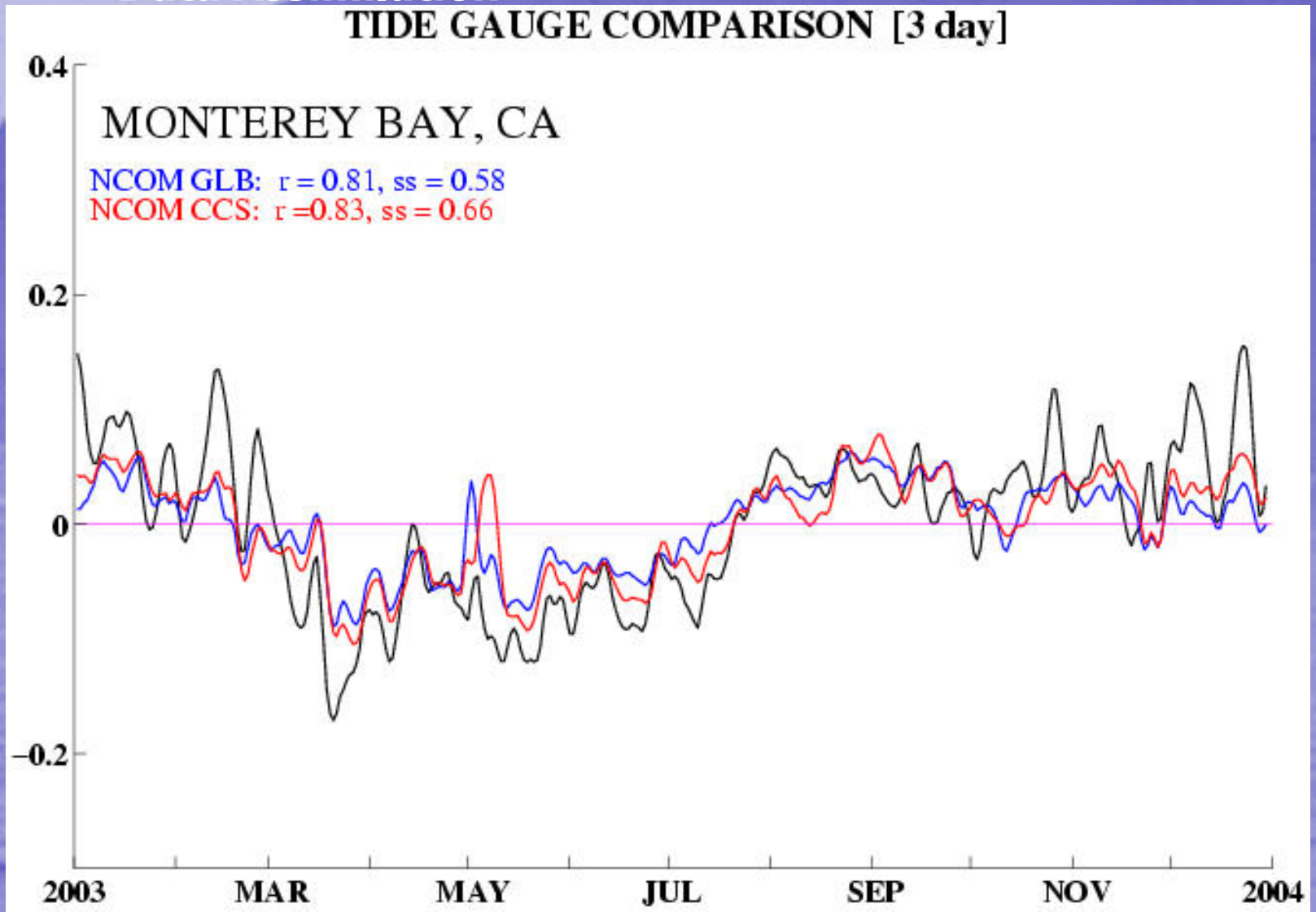
Tide Gauges for 2003 (HYCOM: GLOBAL->REGIONAL)



EVALUATION (NCOM)

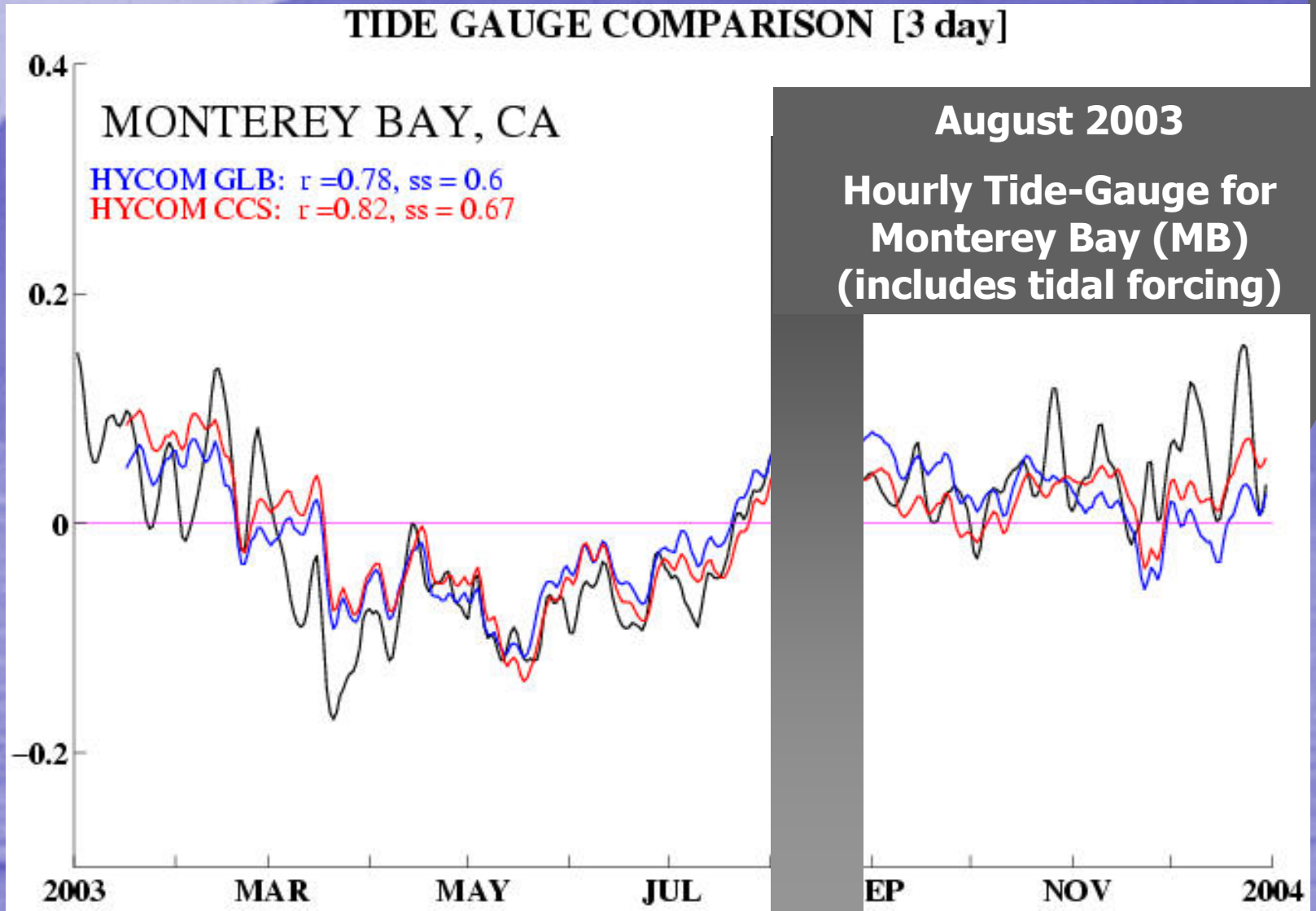
Tide Gauges for 2003 (NCOM: GLOBAL->REGIONAL)

- Data Assimilation*



EVALUATION (HYCOM)

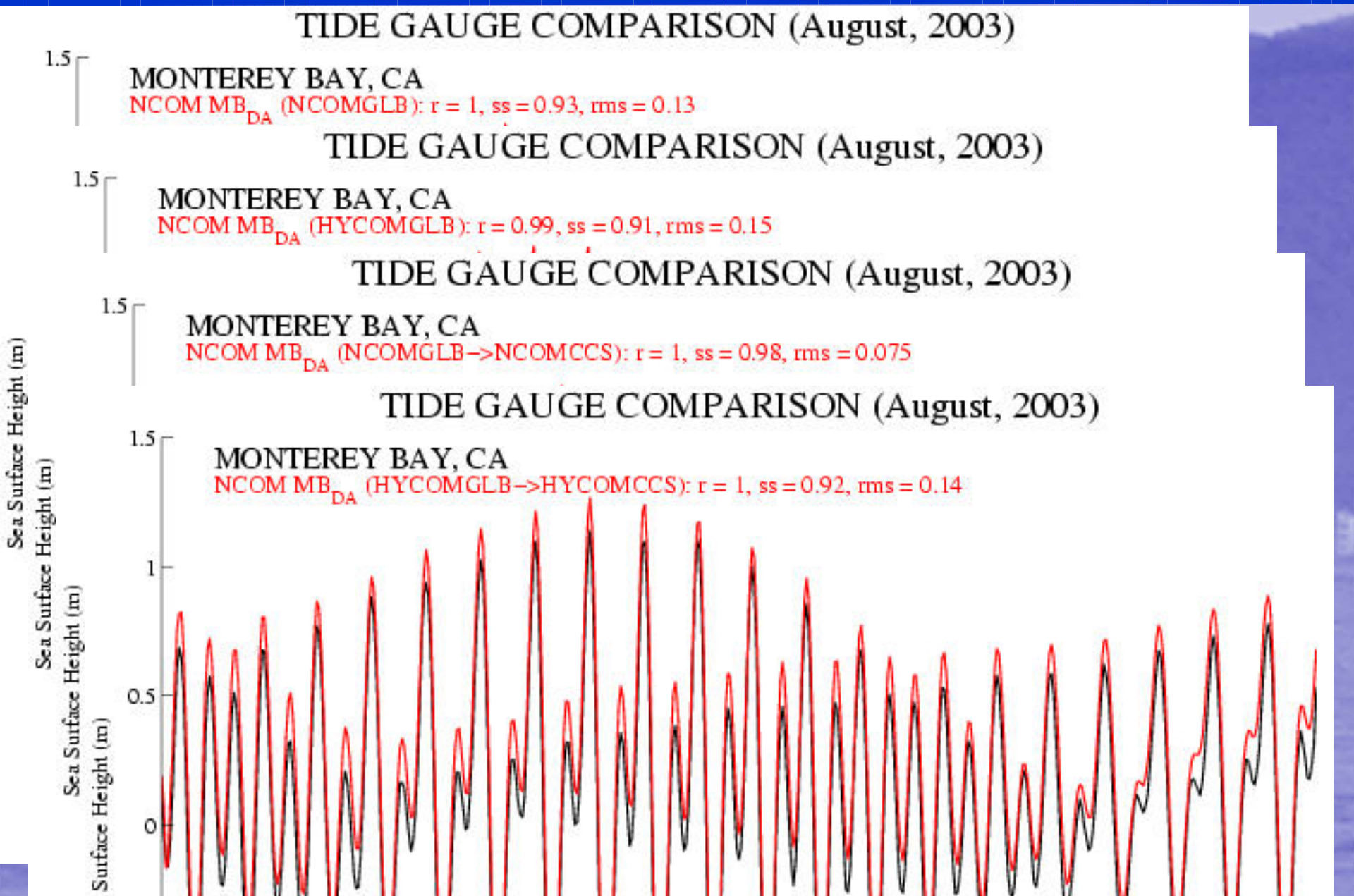
Tide Gauges for 2003 (HYCOM: GLOBAL->REGIONAL)



August 2003

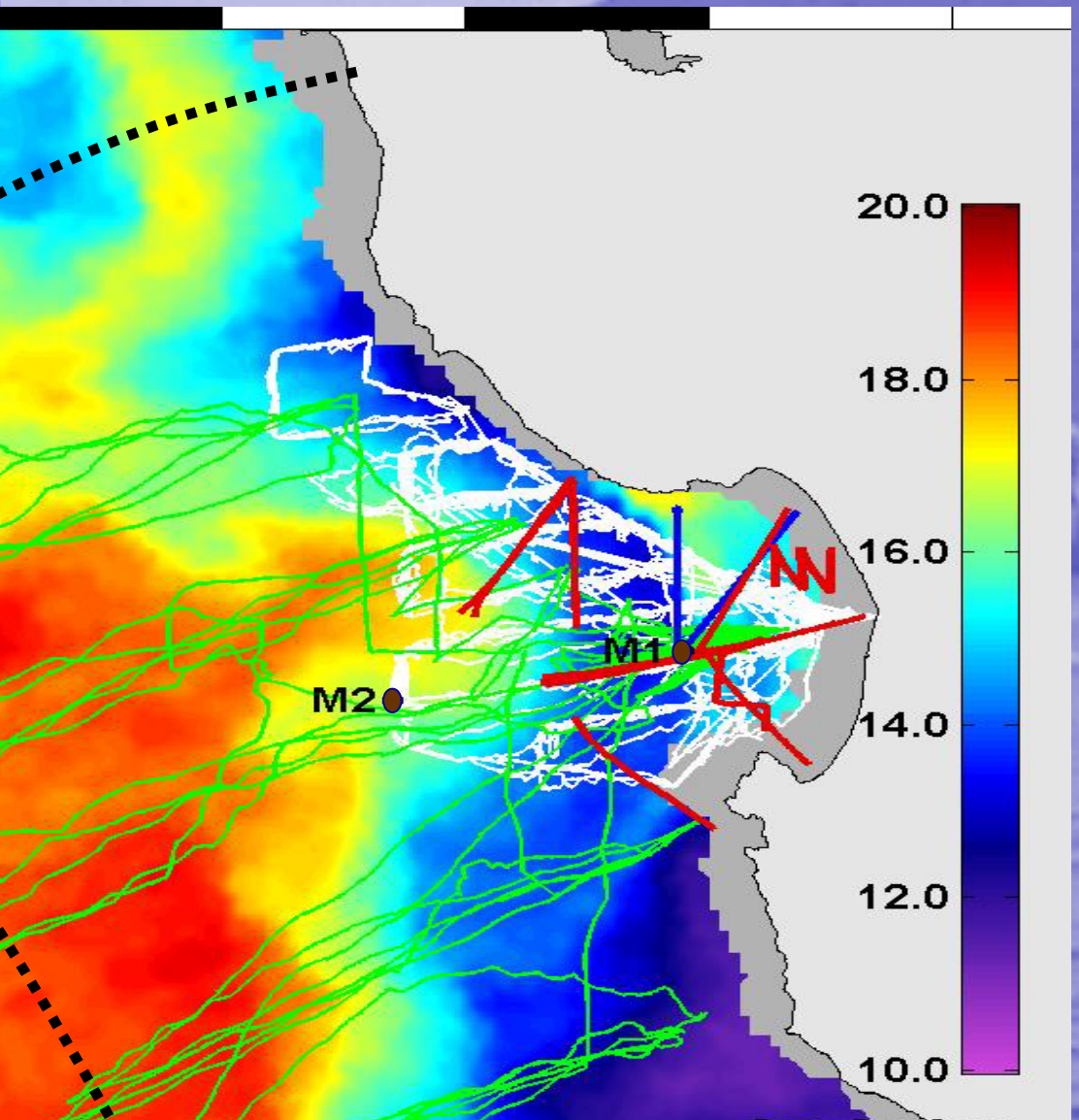
Hourly Tide-Gauge for Monterey Bay (MB) (includes tidal forcing)

EVALUATION (tides)



EVALUATION

- Surface and 3D Temperature at M1 and M2 buoys: Time Series

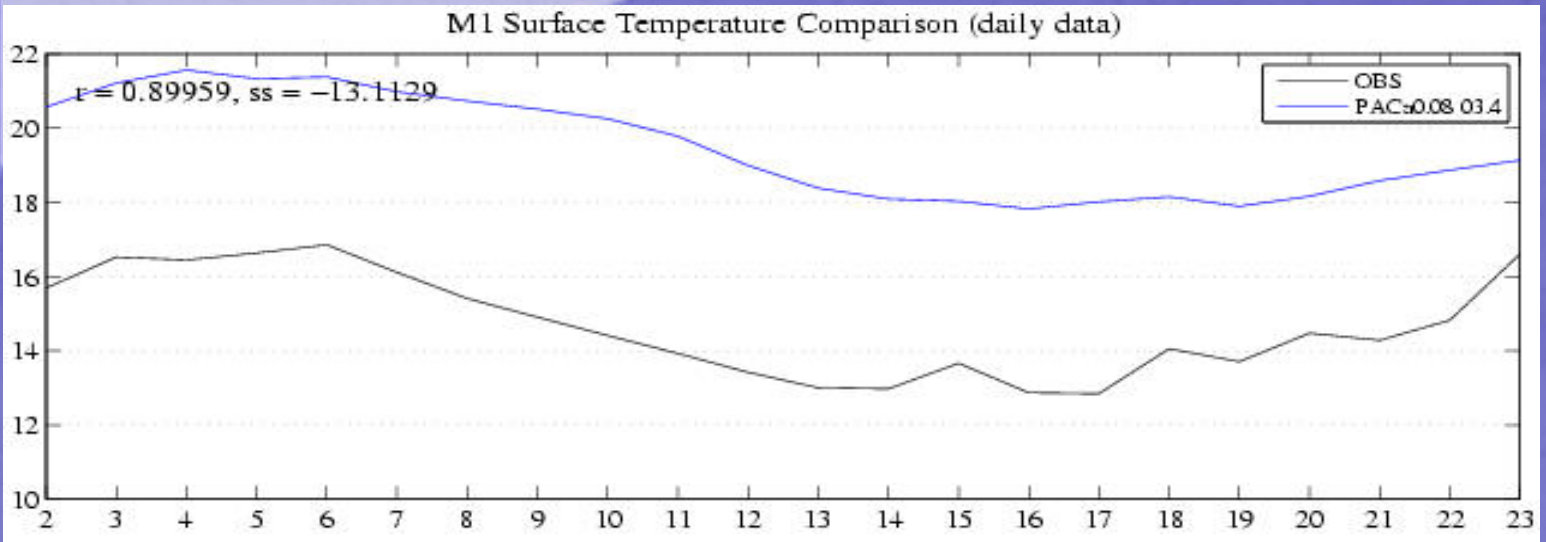


- baroclinic assessement *

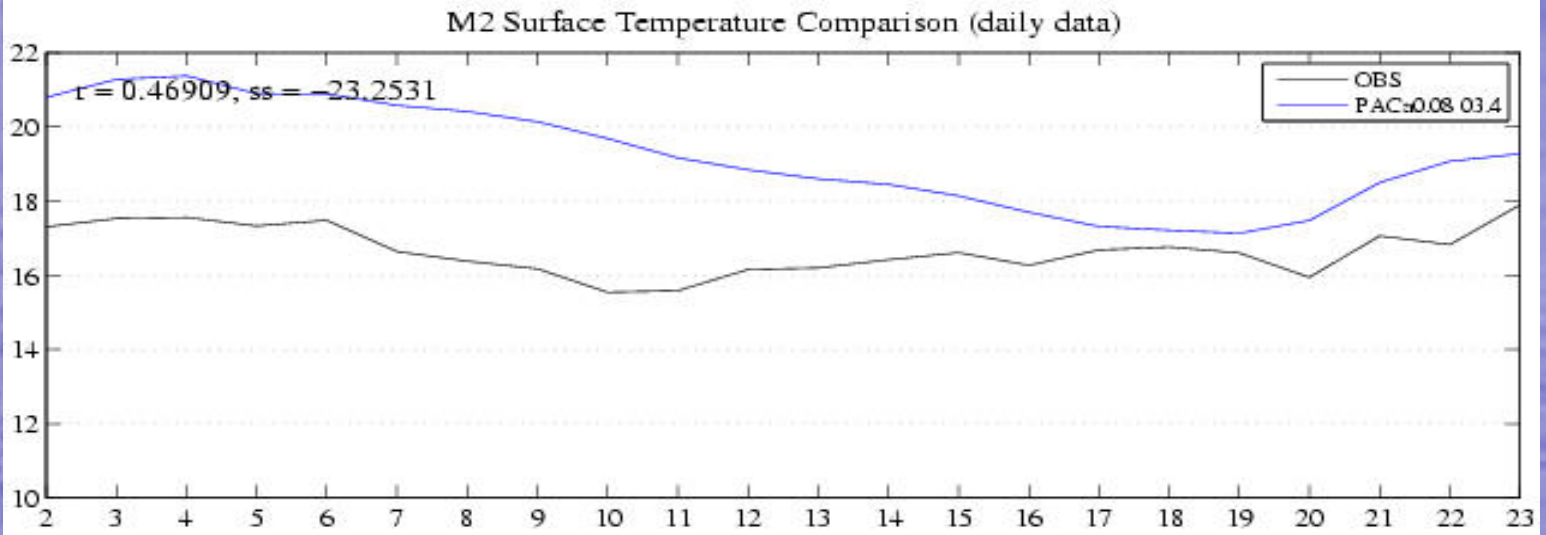
EVALUATION (HYCOM Pacific)

- SST Daily Time Series

HYCOMPAC (03.4)



M1

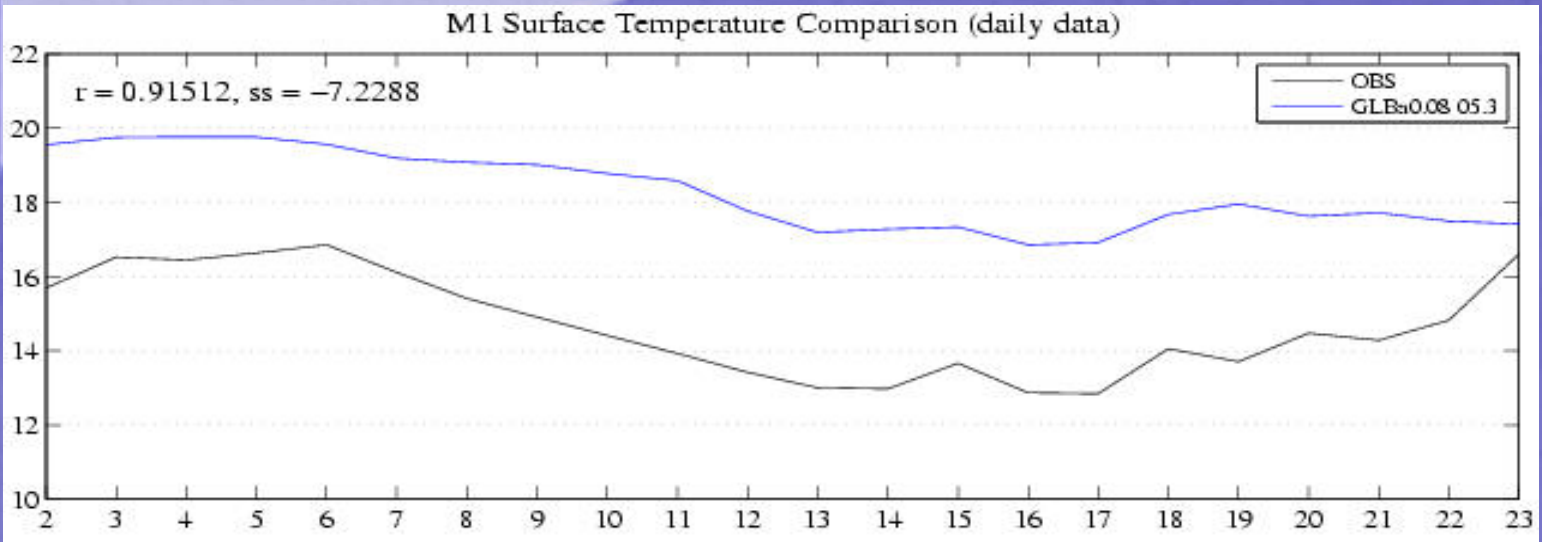


M2

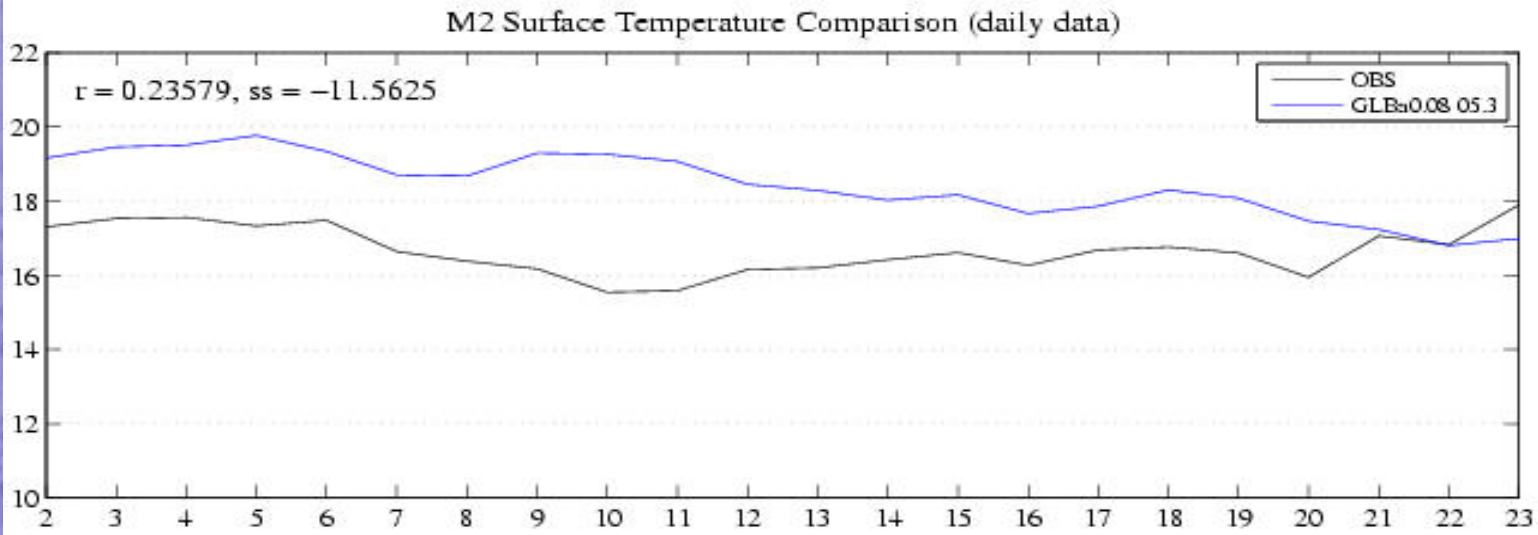
EVALUATION (HYCOM Global)

- SST Daily Time Series

HYCOMGLB (05.3)



M1

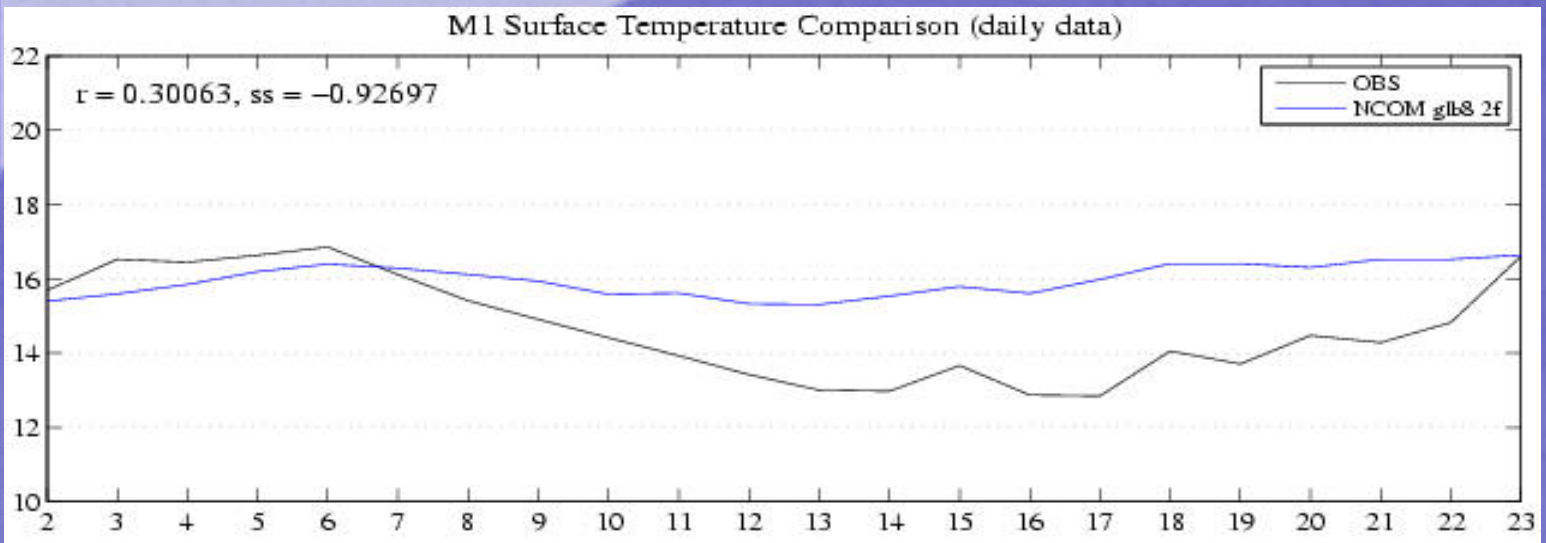


M2

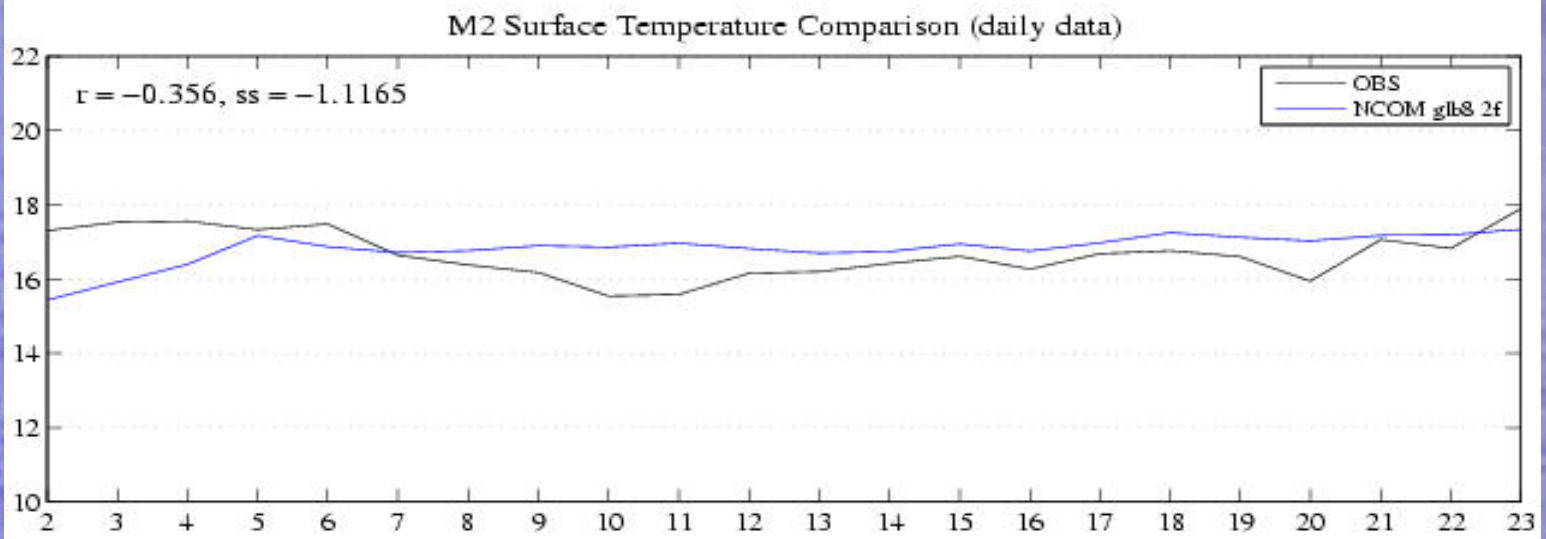
EVALUATION (NCOM Global)

- SST Daily Time Series

NCOMGLB

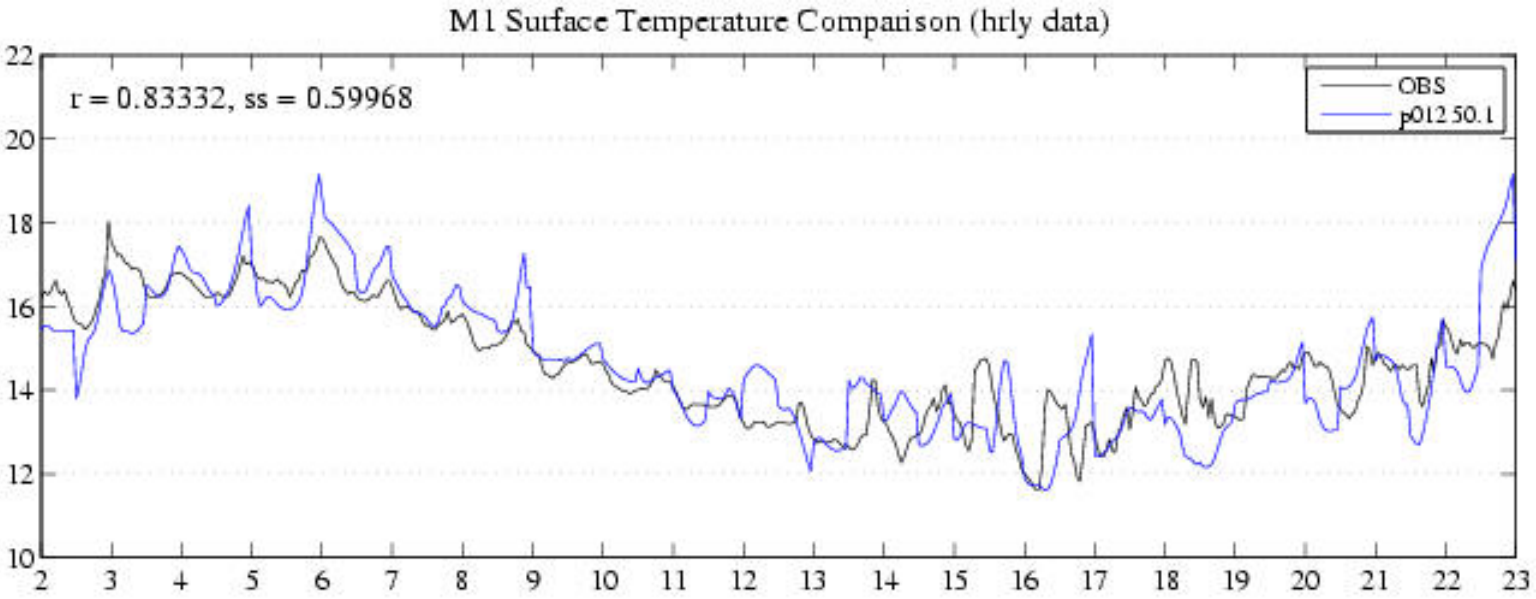


M1

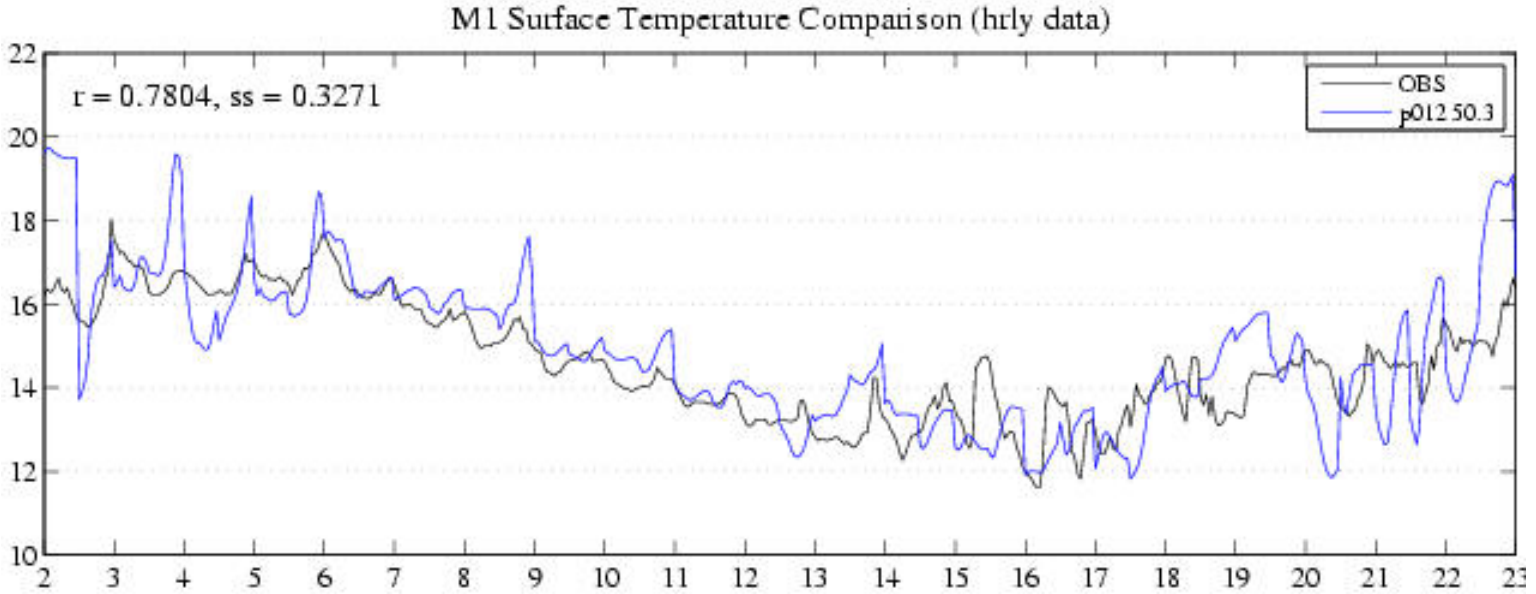


M2

EVALUATION (Global BC @ M1)

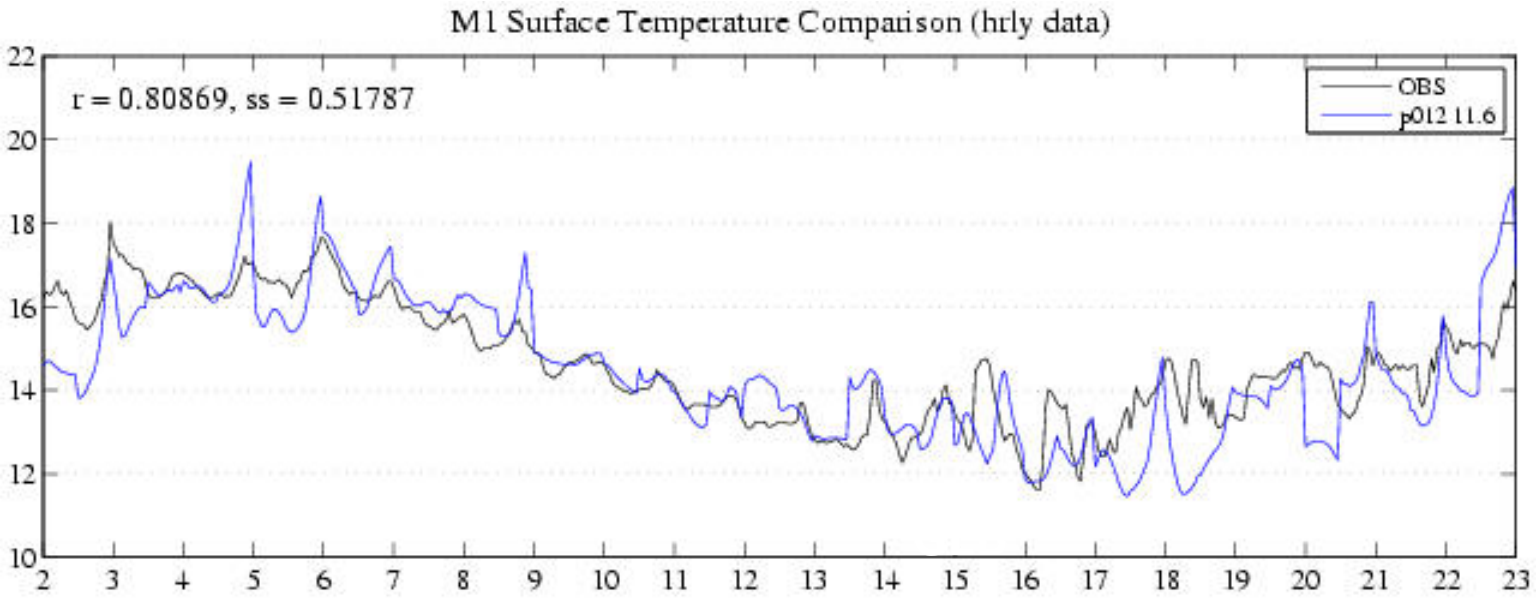


NCOMMBda @ M1 Coupled to GLBNCOM

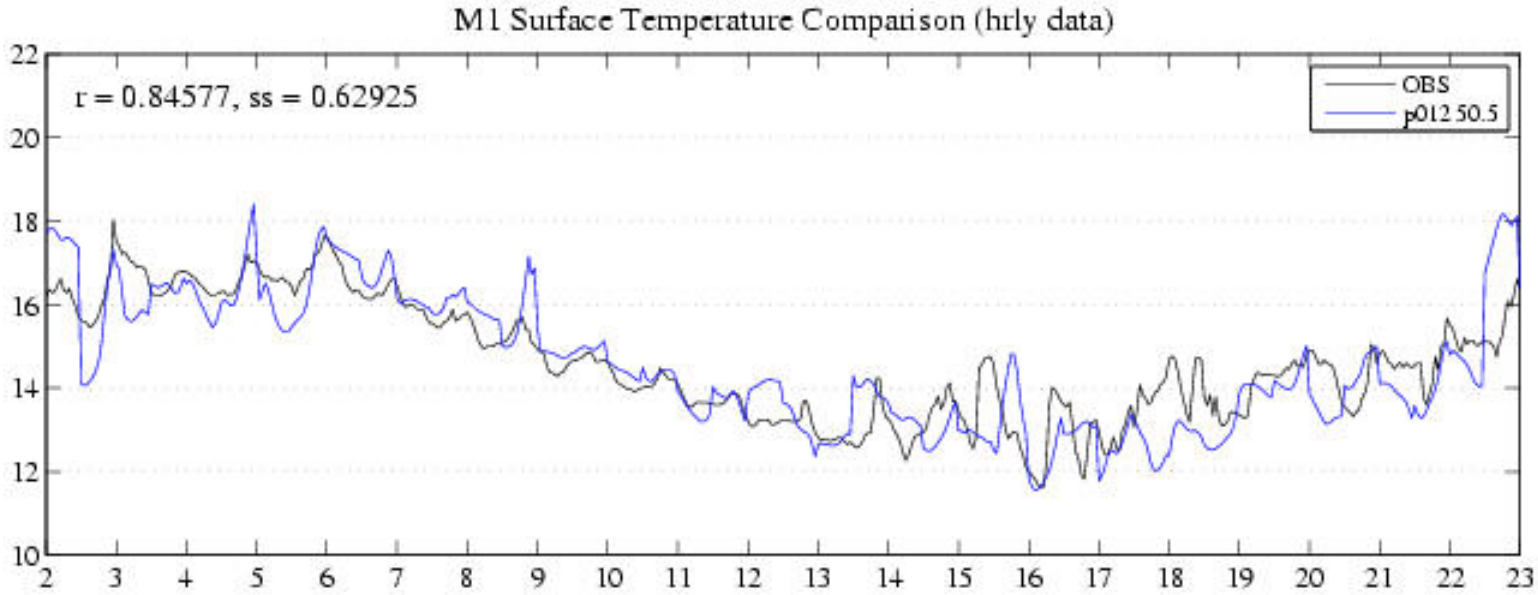


NCOMMBda @ M1 Coupled to GLBHYCOM

EVALUATION (CCS BC @ M1)



NCOMMBda @ M1 Coupled to CCSNCOM



NCOMMBda @ M1 Coupled to CCSHYCOM

EVALUATION (M1)

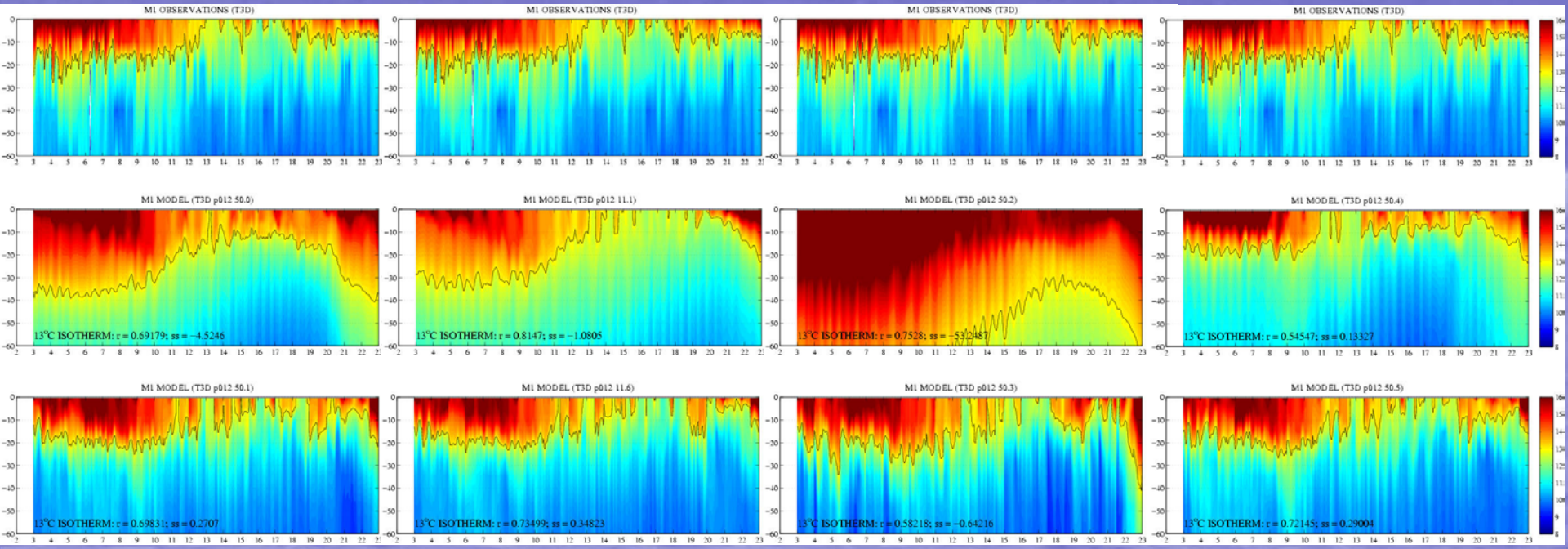
Temperature at M1 (0 to 60M with 13° *isotherm)*

MB without data assimilation

MB with data assimilation

Coupled to:

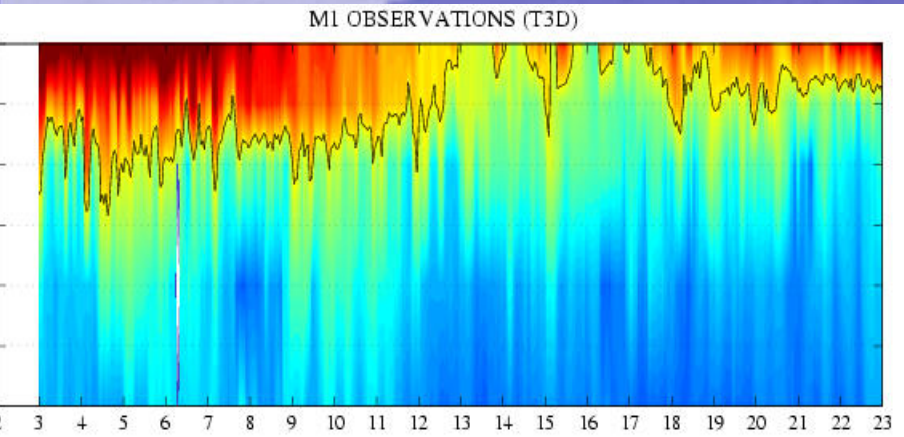
NCOMGLB ***CCSNCOM*** ***HYCOMGLB*** ***HYCOMCCS***

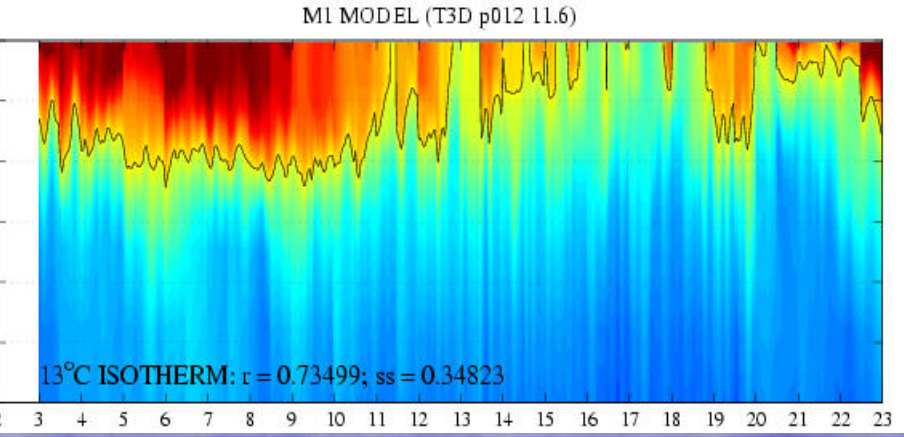


August 3-24 (data assimilation)

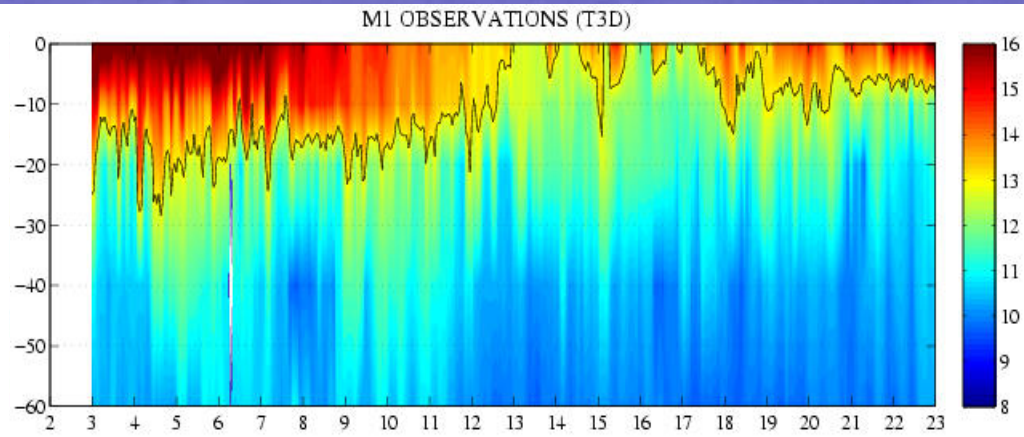
EVALUATION (best 2 @ M1)

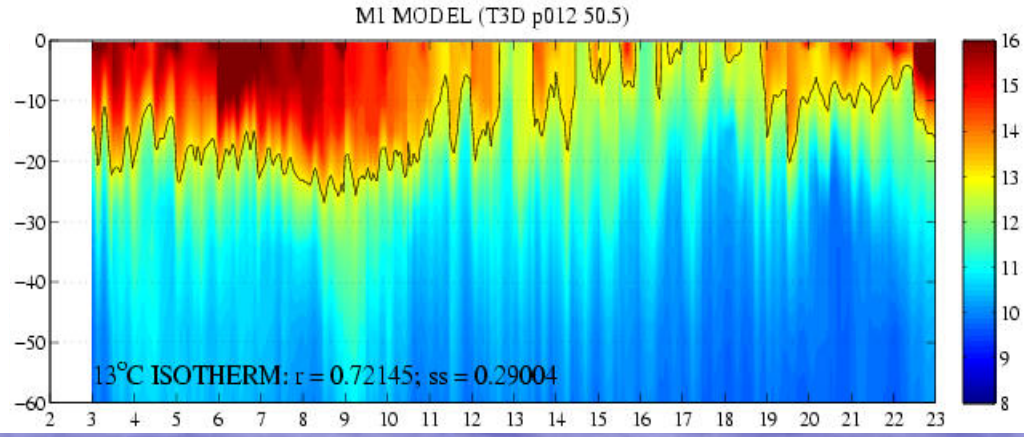
NCOMGLB->NCOMCCS->NCOMMBda





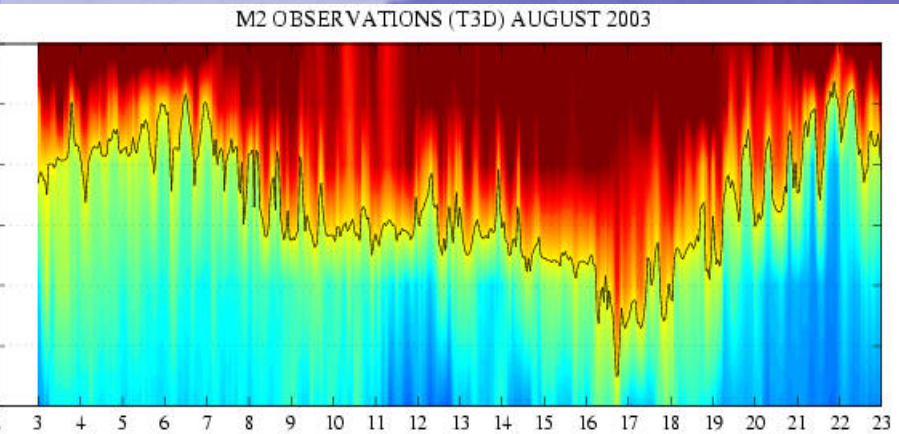
HYCOMGLB->HYCOMCCS-NCOMMBda

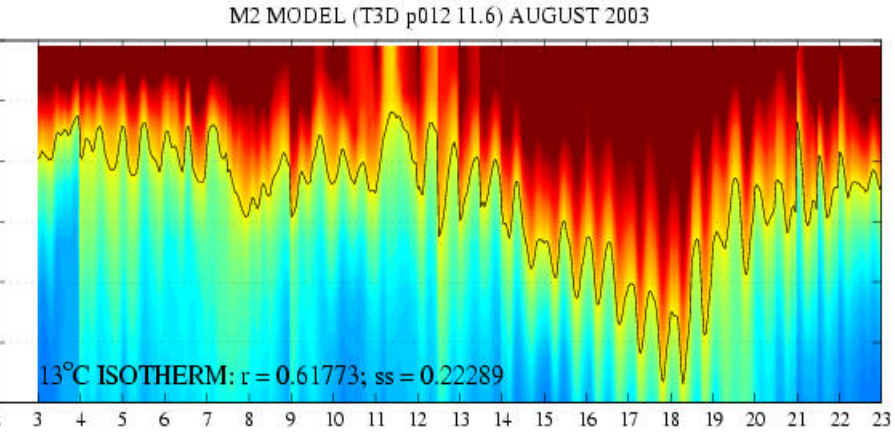




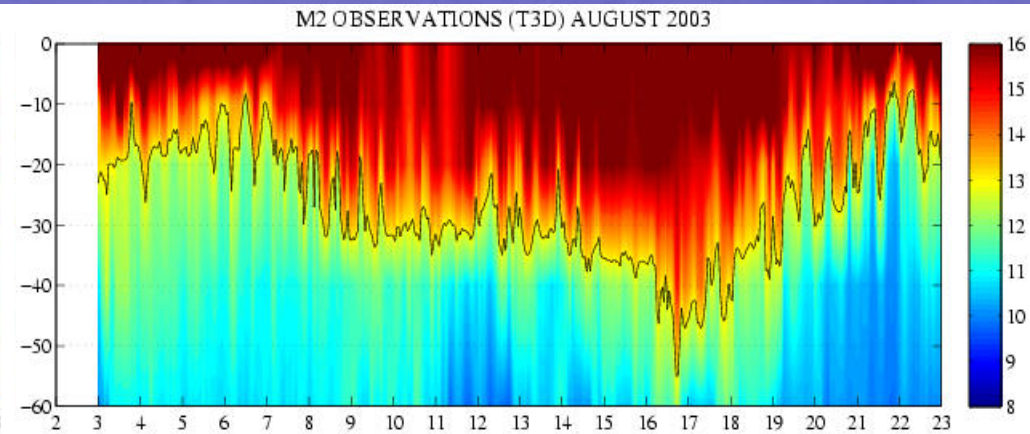
EVALUATION (best 2 @ M2)

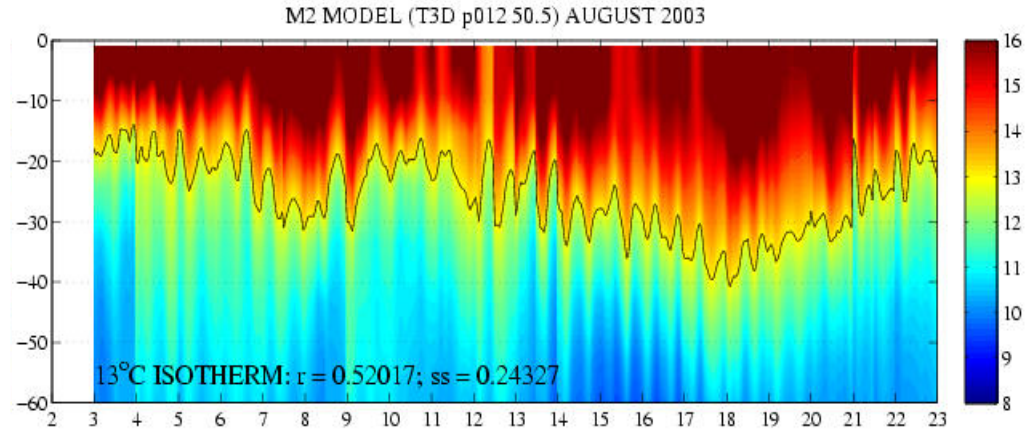
NCOMGLB->NCOMCCS->NCOMMBda





HYCOMGLB->HYCOMCCS-NCOMMBda





CONCLUSIONS

- Data Assimilation
  - In outer nest improves inner nest results
  - 7:1 nesting, warm bias between nests
- Regional Model Nesting
  - Significant value at the current resolutions
- Temperature still warmer in HYCOM
  - Global much better than Pacific
  - Possibly improved by NOGAPS 0.5
  - Will be improved by data assimilation
- SSH bias reduced (~.3 in Pacific)
  - Consistent with NCOM and observations (no da)
- Better than expected results seen with HYCOM OBC
  - Even without data assimilation
  - Possibly due to higher horizontal resolution

ACCOMPLISHMENTS

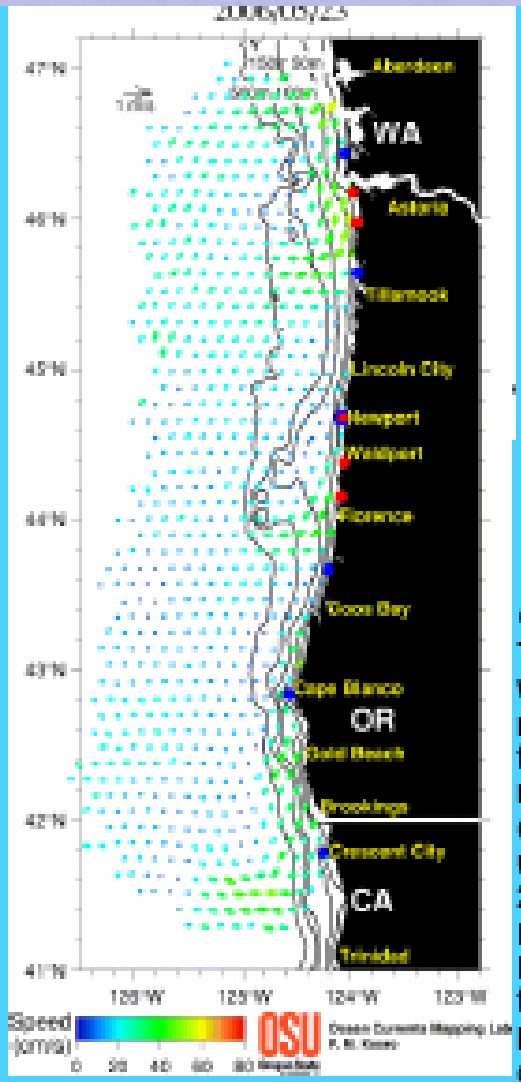
- Evaluation of HYCOM in the CCS Region
- Viability of HYCOM as IC/BC provider for Regional/Coastal Models

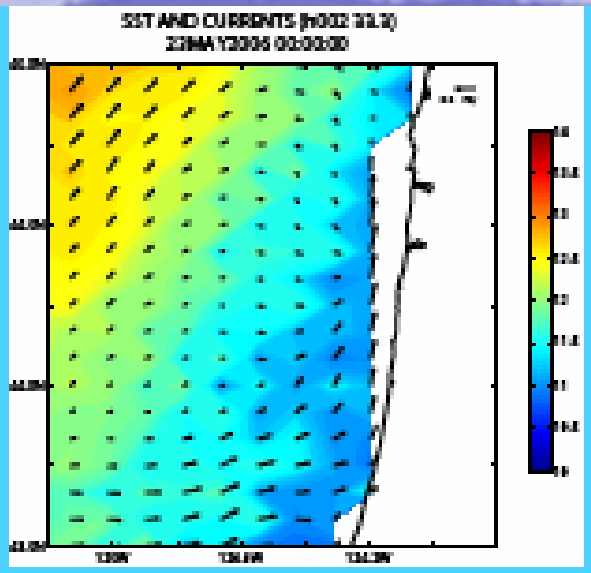
  -mapping to σ or σ/z grid
- Full coupling of Biological Model(s)
- Net-Heat Flux implementation; Bulk-Formulation with COAMPS
- Generalized methodology for vertical (and horizontal) grid mapping
  - CCS9Km, CCS4Km, MBOCG, OSU, Paul May, (Pat Hogan)
- Generalized Atmospheric Flux Coupler (*example*)
  - NRL, OSU
  - POM, NCOM, HYCOM, ROMS <- NOGAPS, COAMPS, NCEP, ECMWF
- TOPO-EDITOR (GENERATOR)

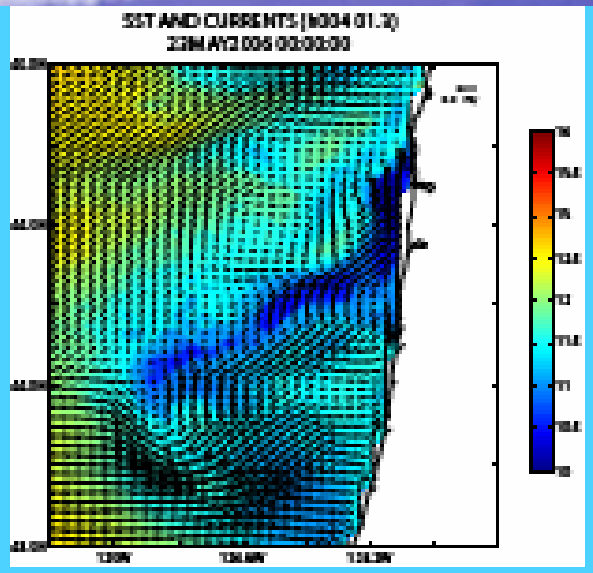
  -NCOM: ohgrd, ovgrd, odimens
  -HYCOM: regional.grid*, depth*, landmask*
- Visualization software compatible with HYCOM netcdf output (viz)

CURRENT WORK

1) Implementation of 1/25-degree HYCOMCCS (~4Km)







CENTRAL OREGON COAST REGION

The central Oregon coast exhibits wind-driven upwelling/downwelling responses which are mainly characterized by the prominent topographical features of the region where the uniform alongshore shelf breaks drastically by the Heceta Bank to the south. Recent papers [1, 2] discuss the reversal of ocean currents due to wind relaxation events and topography/flow interactions. For this initial evaluation, the OSU/COAS Radar-based Ocean Currents (http://bragg.coas.oregonstate.edu) are used as a comparison basis. It is sufficient to show 3 figures (May 21, May 22, May 23) to demonstrate that both models capture the reversal of the currents along the Heceta Bank, but this feature is much better represented by the 4Km model. Furthermore, the persistence of the coastal upwelling jet following the bank topography until it reaches its end and meanders anticyclonically in the lee of the bank, as described in the papers, is fully captured by the 4Km model, but completely missed by the 9Km.

1) J.A. Barth, S.D. Pierce, and R. M. Castelao. JGR. Vol 110. 2005. Time-dependent, wind-driven flow over a shallow midshelf submarine bank
2) J. Gan, J.S. Allen. JGR. Vol 110. 2005. Modeling upwelling circulation off the region coast

FUTURE PLANS

- 4Km and "Proxy" fully working
- Implementation of HYCOMMB (OCG) …and .5 nest
- Implementation of OSU Nest
  - Evaluations and comparisons with ROMS
- Further evaluation (nesting studies):
  -Conservation, Heat Budget analysis
  -Full baroclinic assessment
  -Sensitivity to atmospheric forcing resolution
  -Sensitivity to ob temporal resolution
  -Separation/Isolation of contributions:
  Atmospheric Forcing, vertical/horizontal resolution, temporal resolution (BC update)
  Climatology BC at a particular resolution with strong relaxation?
- Real-Time Model (quad-nested NCOM N/F System operational)

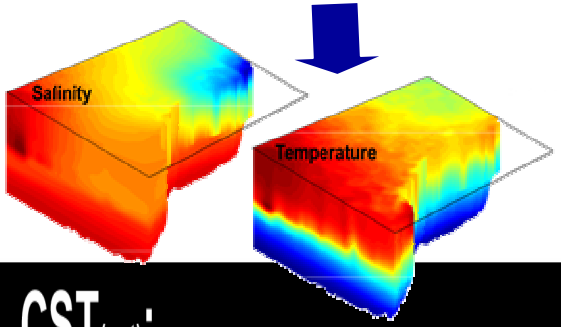
NCOMCCS RTM

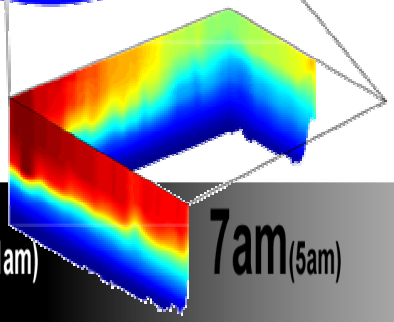
NOGAPS

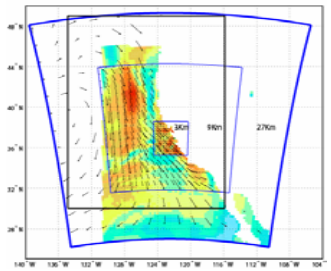
COAMPS

NLOM
MODAS

GNCOM







Kraken 64PEs.
HPQ under reservation

28-minutes

-2d hindcasts
NOWCAST
+2d forecasts
+7d LT forecasts

7GB RAM
350MB DATA

CST(pst):	3am(1am)	7am(5am)	9am(7am)	11am(9am)	1pm(11am)
EVENT:	NOGAPS simulation	COAMPS AOSN Simulation	RT-NCOMCCS Boundary Condition Generation from Global NCOM	Generation of Momentum and Heat Fluxes from COAMPS	RT-NCOMCCS execution	MODEL Output Generation

NLOM/MODAS Data Assimilation and generation of global synthetics

Global NCOM Simulation

Generation of NCOMCCS MODAS T & S Synthetics

File Dependency Heuristics

FUTURE PLANS

- 4Km and "Proxy" fully working
- Implementation of HYCOMMB (OCG) …and .5 nest
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  Atmospheric Forcing, vertical/horizontal resolution, temporal resolution (BC update)
  Climatology BC at a particular resolution with strong relaxation?
- Real-Time Model (quad-nested NCOM N/F System operational)

NEEDS:

- Data Assimilation
- Global Model(s) back to Jan 2003 (Currently Nov, 2003)
  -AOSN 2003 and ASAP 2006 periods
- Biological tracer/constituent nesting support