1/12° Pacific HYCOM Results

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Alan J. Wallcraft and Luis Zamudio

Pacific HYCOM Model Configuration

- Horizontal grid: 1/12º equatorial resolution (2294 x 1362 grid points, ~6.5 km spacing on average)
- 20ºS to 65.8ºN
- 20 vertical coordinates
- Bathymetry: Quality controlled ETOP05
- Surface forcing: (wind stress, wind speed, heat flux [using bulk formula], E-P + relaxation to climatological SSS)
- River runoff
- Buffer zone: ~3º band along southern and eastern boundary with relaxation to monthly climatological T and S
- Closed boundaries along 20ºS, in the Indonesian throughflow region and in the Bering Strait

1/12° Pacific HYCOM Modeling Progress

- Four 1/12° simulations

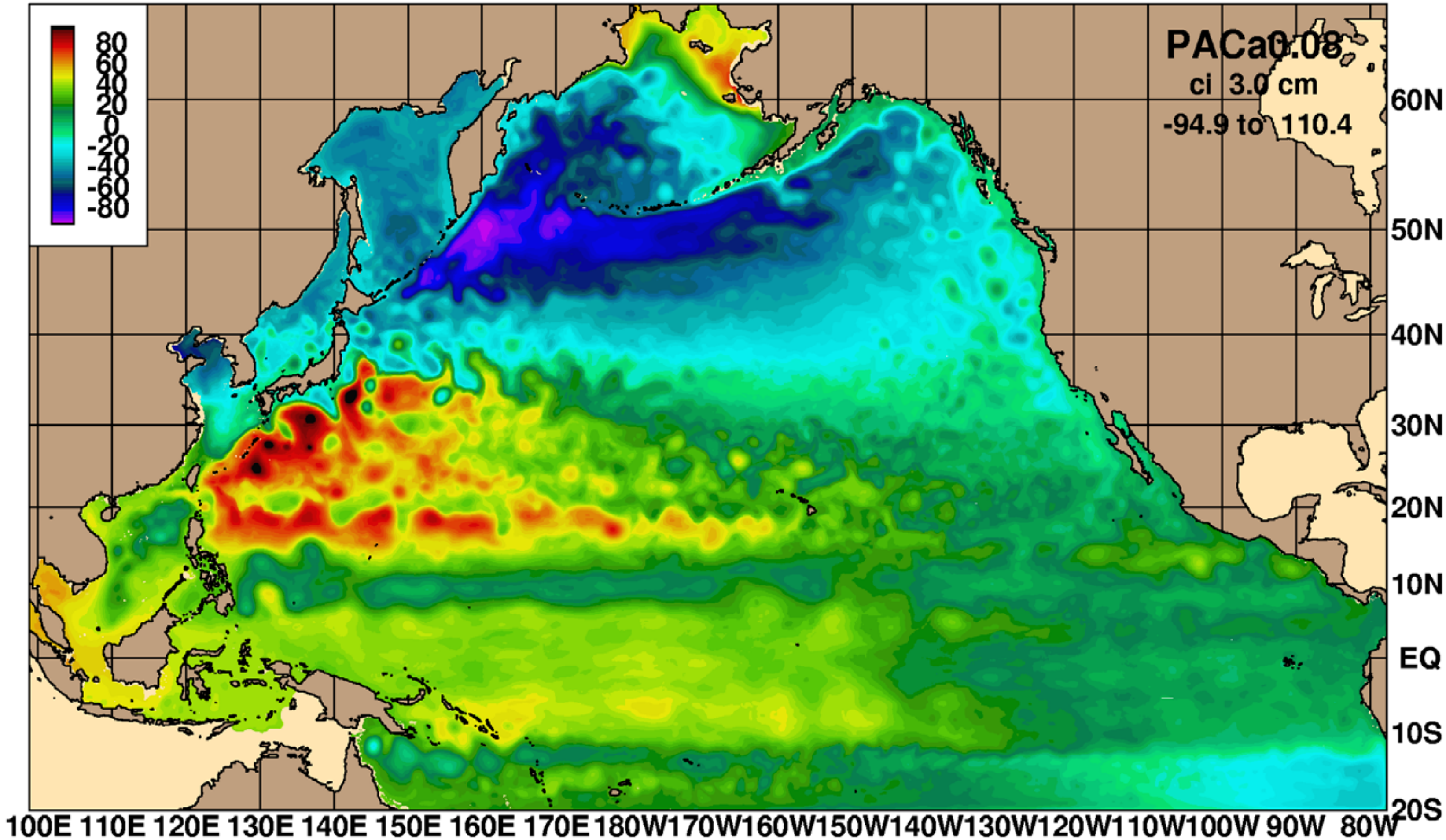
  - ❑ high frequency Hellerman and Rosenstein (1983, JPO) (HR) climatological forced simulation (9.5 years)

  - ❑ high frequency European Centre for Medium-range Weather Forecasts (ECMWF) climatological forced simulation (8.5 years)

  - ❑ high frequency ECMWF climatological forced simulation with modification to winds over Hawaii (4 years)

  - ❑ FNMOC NOGAPS/HR interannual simulation January 2001 – May 2002, a period that spanned the life cycle of Hurricane Juliette

1/12° Pacific HYCOM Basin-scale Circulation
SSH Snapshot – 1 January

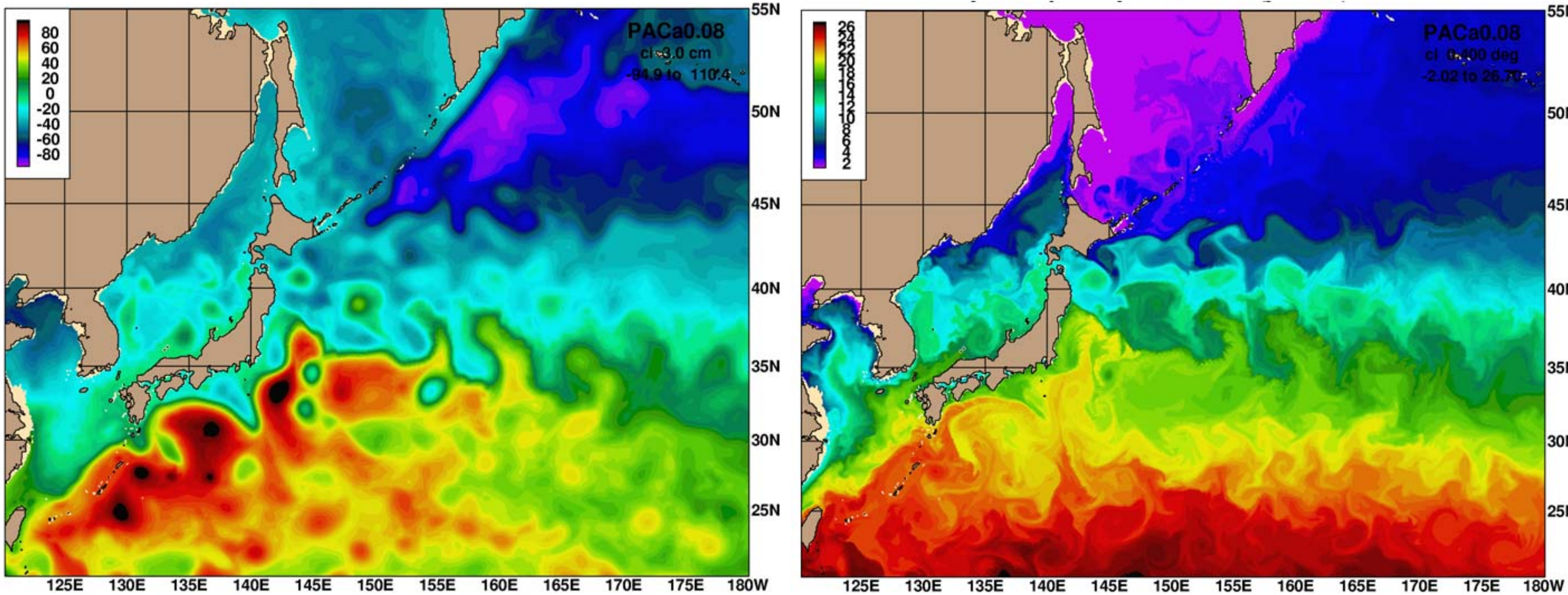


Forced with high frequency climatological ECMWF winds and thermal forcing

1/12° Pacific HYCOM

Zoom on the Kuroshio

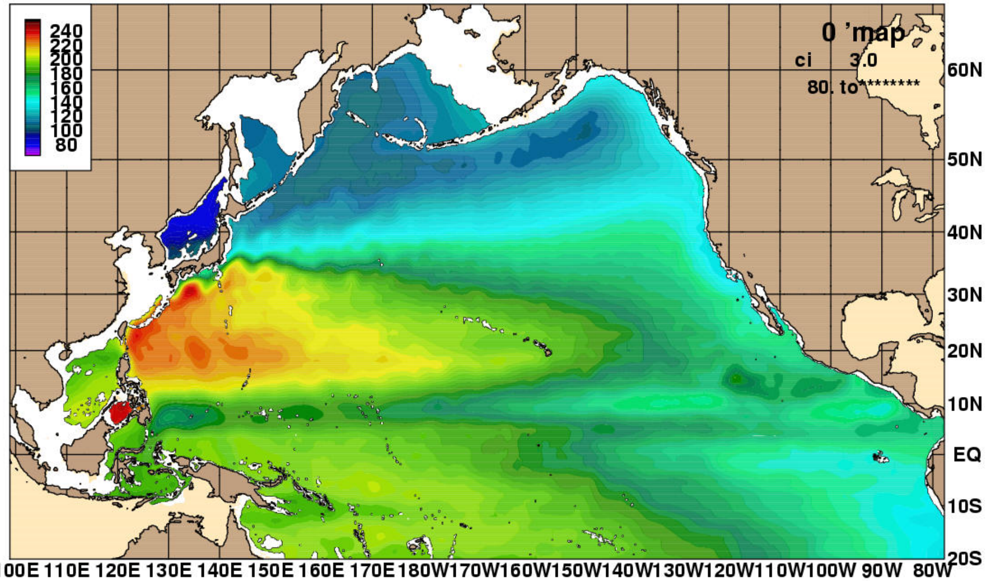
SSH and SST Snapshot – 1 January



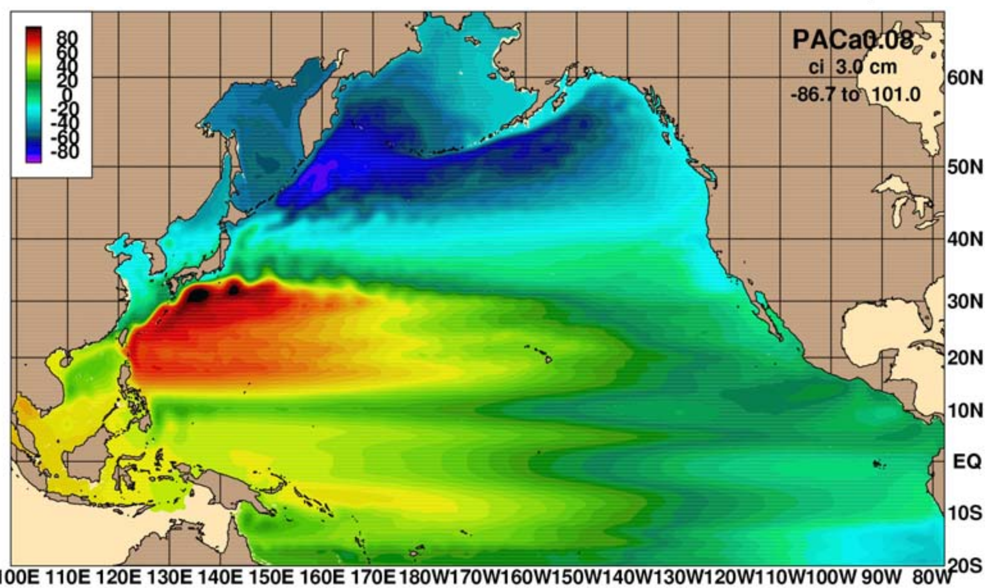
Forced with high frequency climatological ECMWF winds and thermal forcing

Comparison of the Basin-scale Circulation
MODAS climatology vs. 1/12° Pacific HYCOM

Mean dynamic height (dyn cm) wrt 1000 db



6-yr mean SSH (cm)



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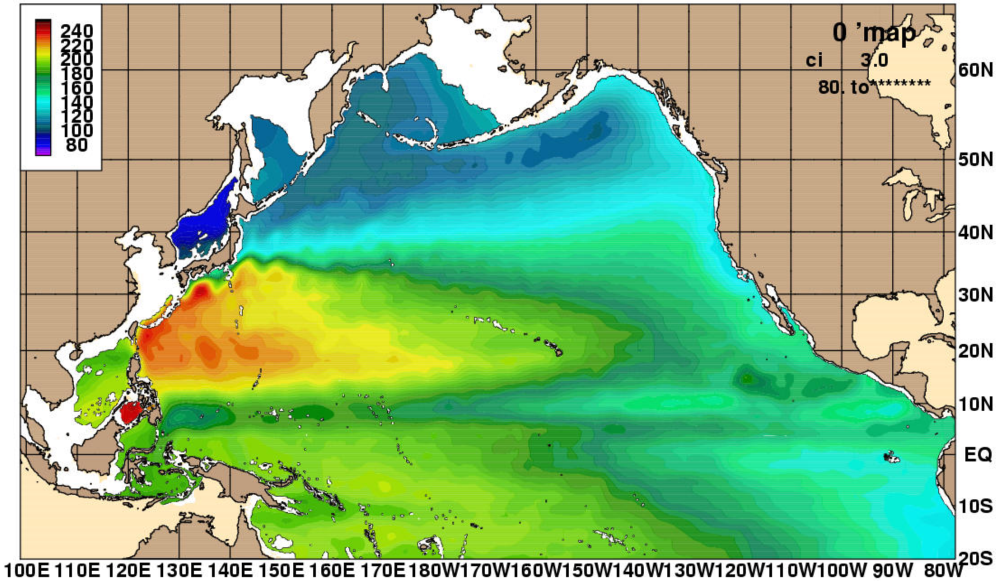

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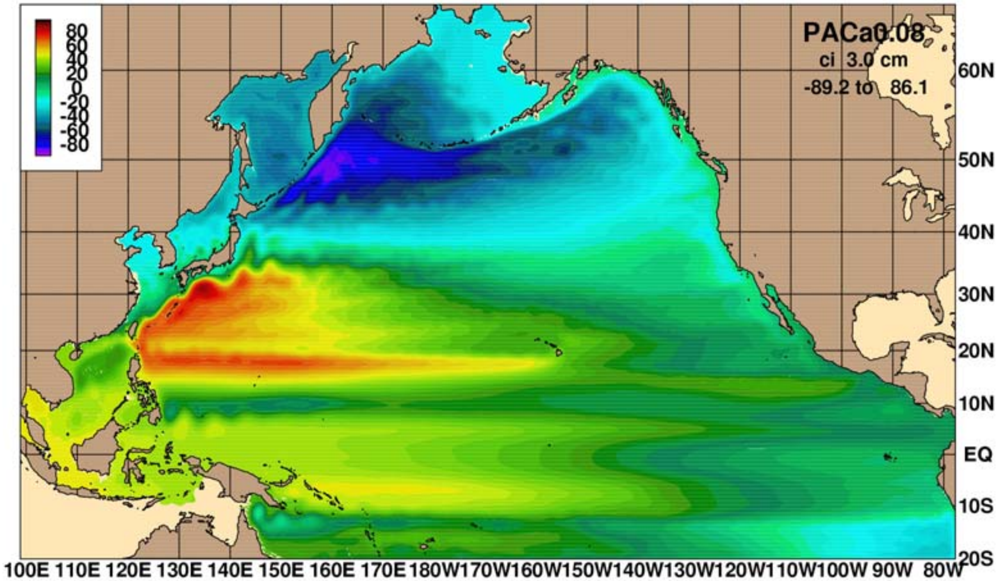
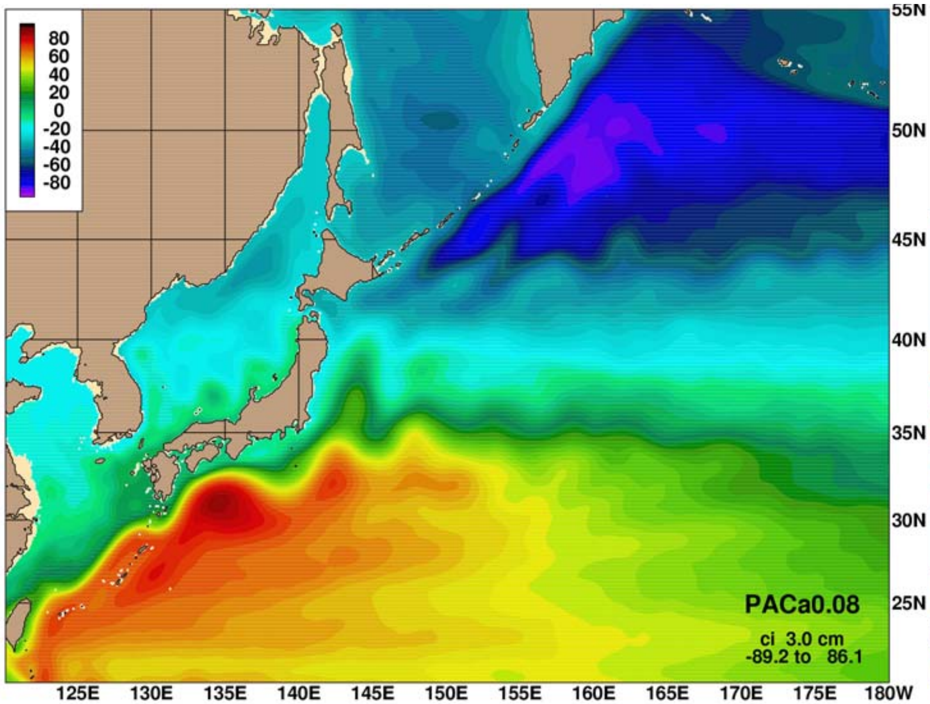
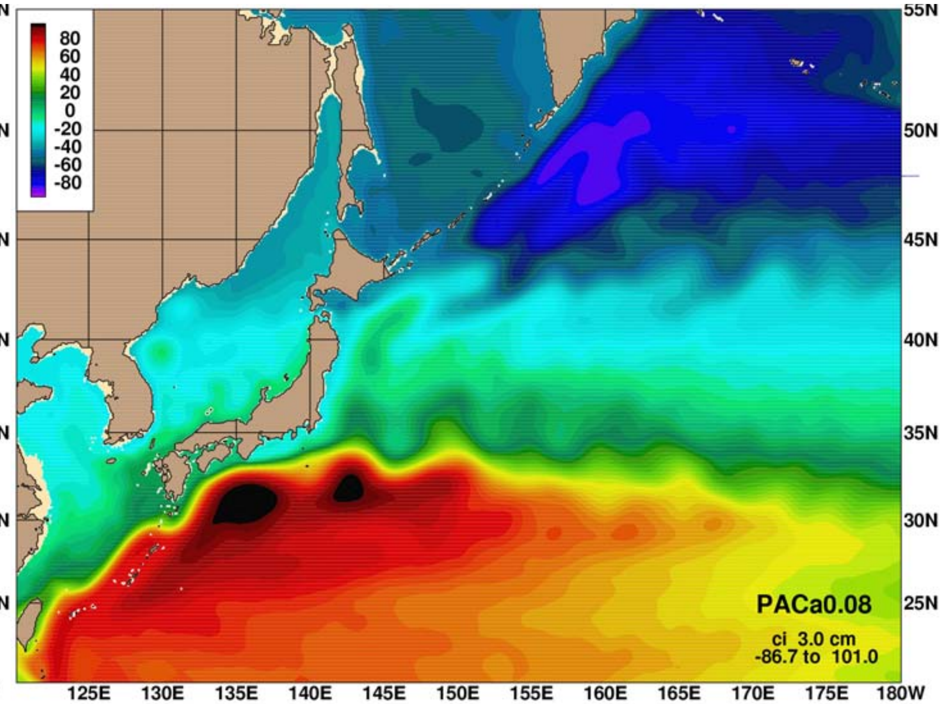


Forced with high frequency climatological ECMWF winds and thermal forcing

1/12° Pacific HYCOM
6 Year Mean SSH – Kuroshio sub region

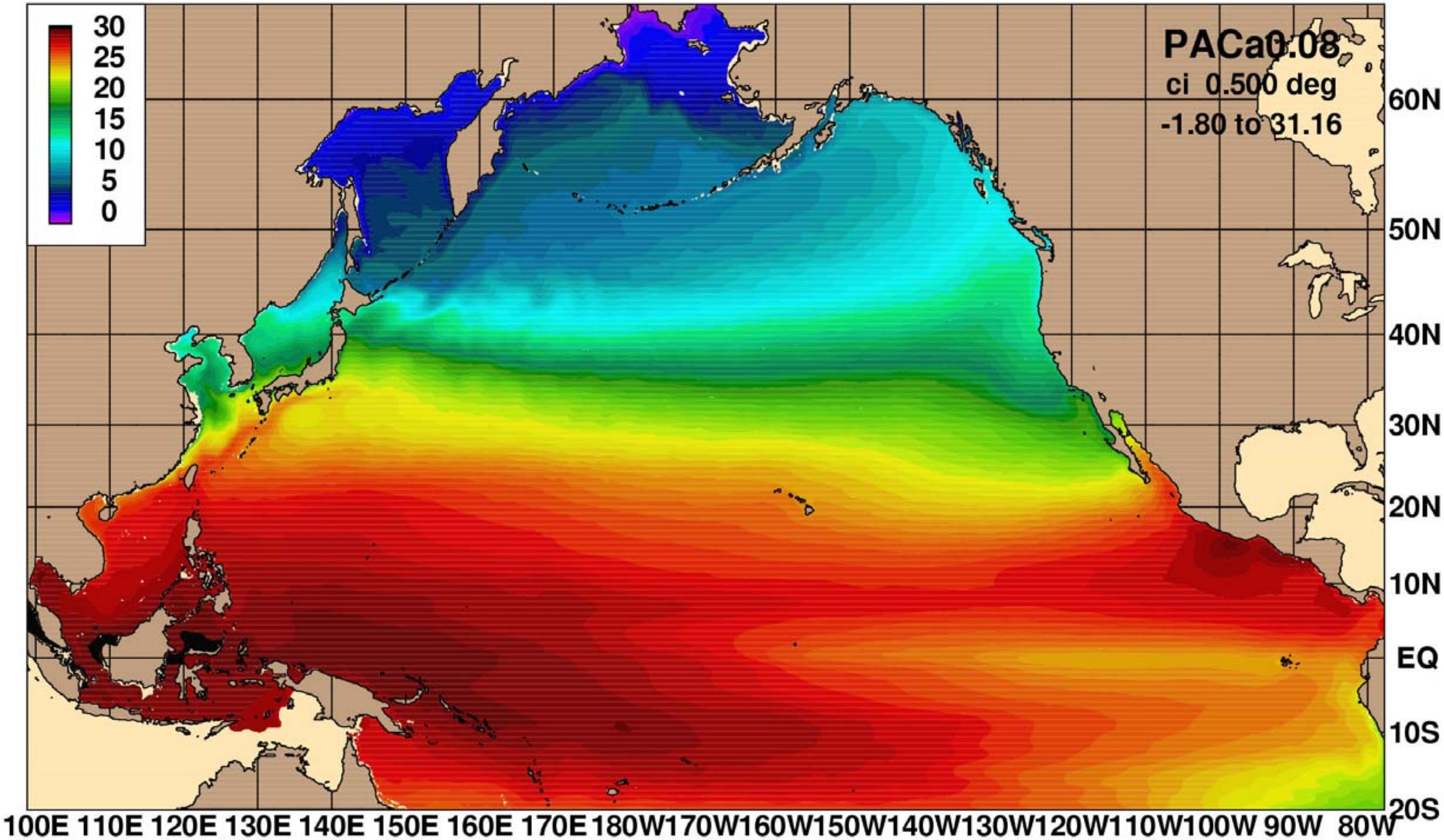


ECMWF forcing



HR forcing

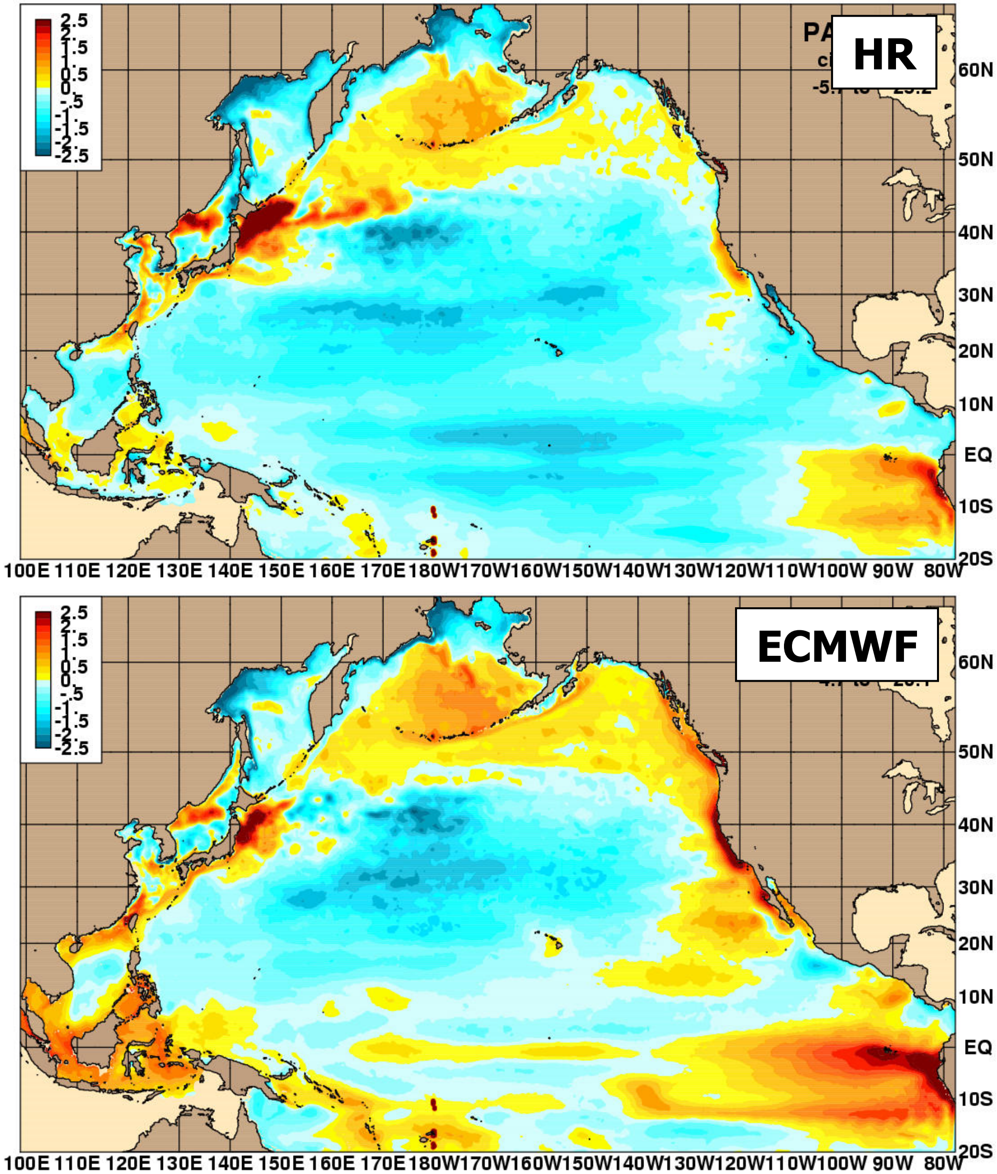
1/12° Pacific HYCOM Basin-scale SST
6 year mean



Forced with high frequency climatological HR winds and ECMWF thermal forcing

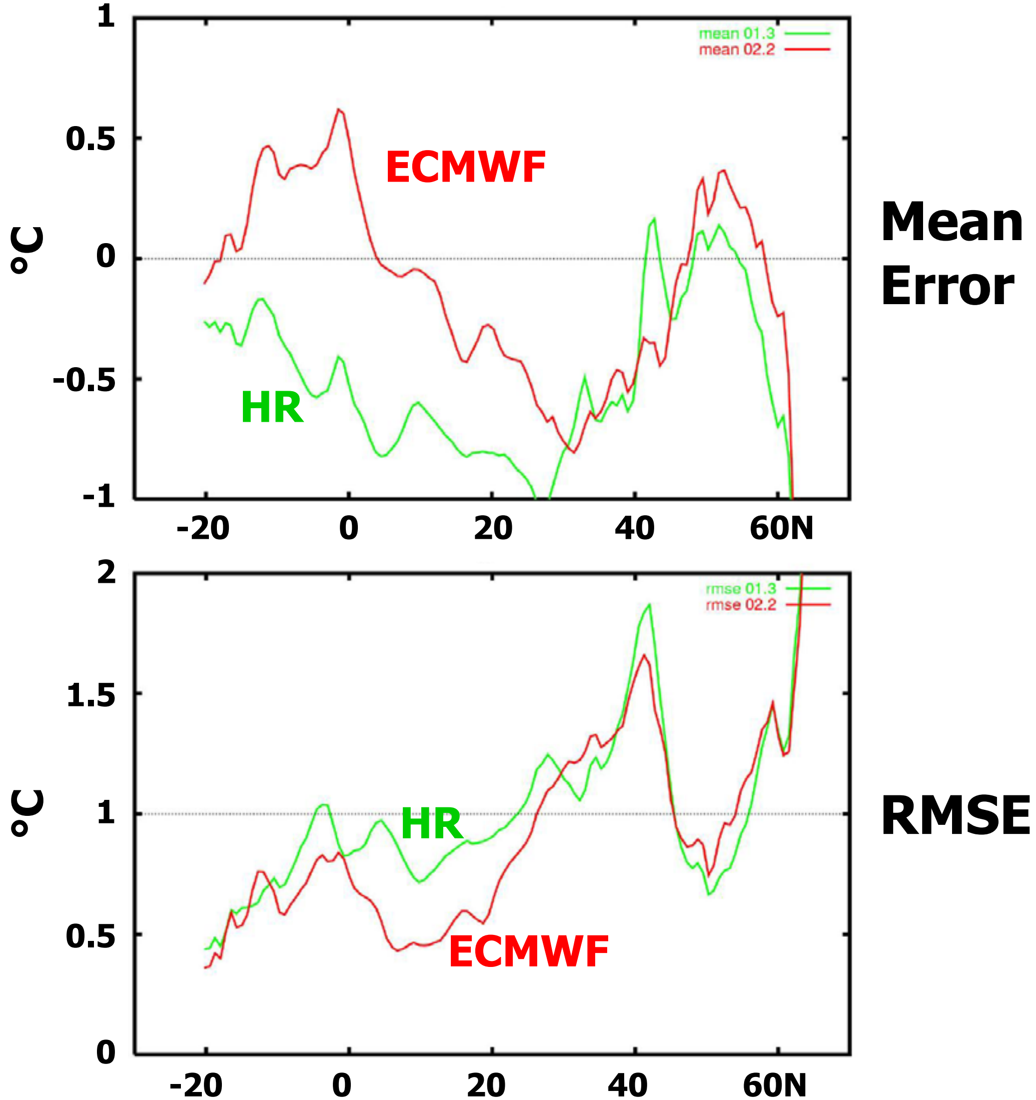
Comparison of the Basin-scale SST

Pathfinder vs. 1/12° Pacific HYCOM SST Mean Error



Comparison of the Zonal Average SST

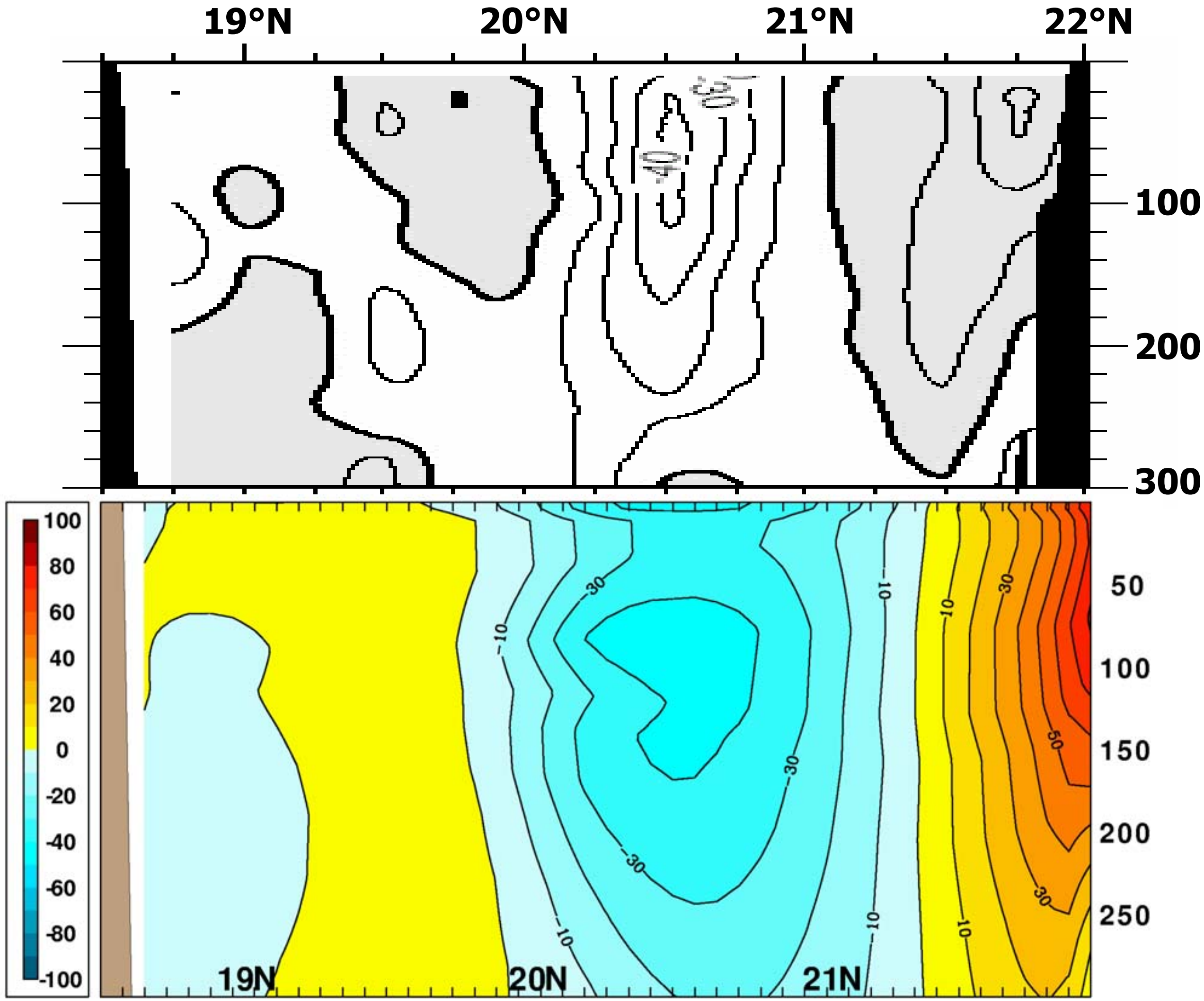
Pathfinder vs. 1/12° Pacific HYCOM



Velocity Cross-section Across Luzon Strait

Sb-ADCP data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 300 m

Section along 120.75°E between Taiwan and Luzon



Sb-ADCP data from Liang et al. (DSR Pt. II, in press)

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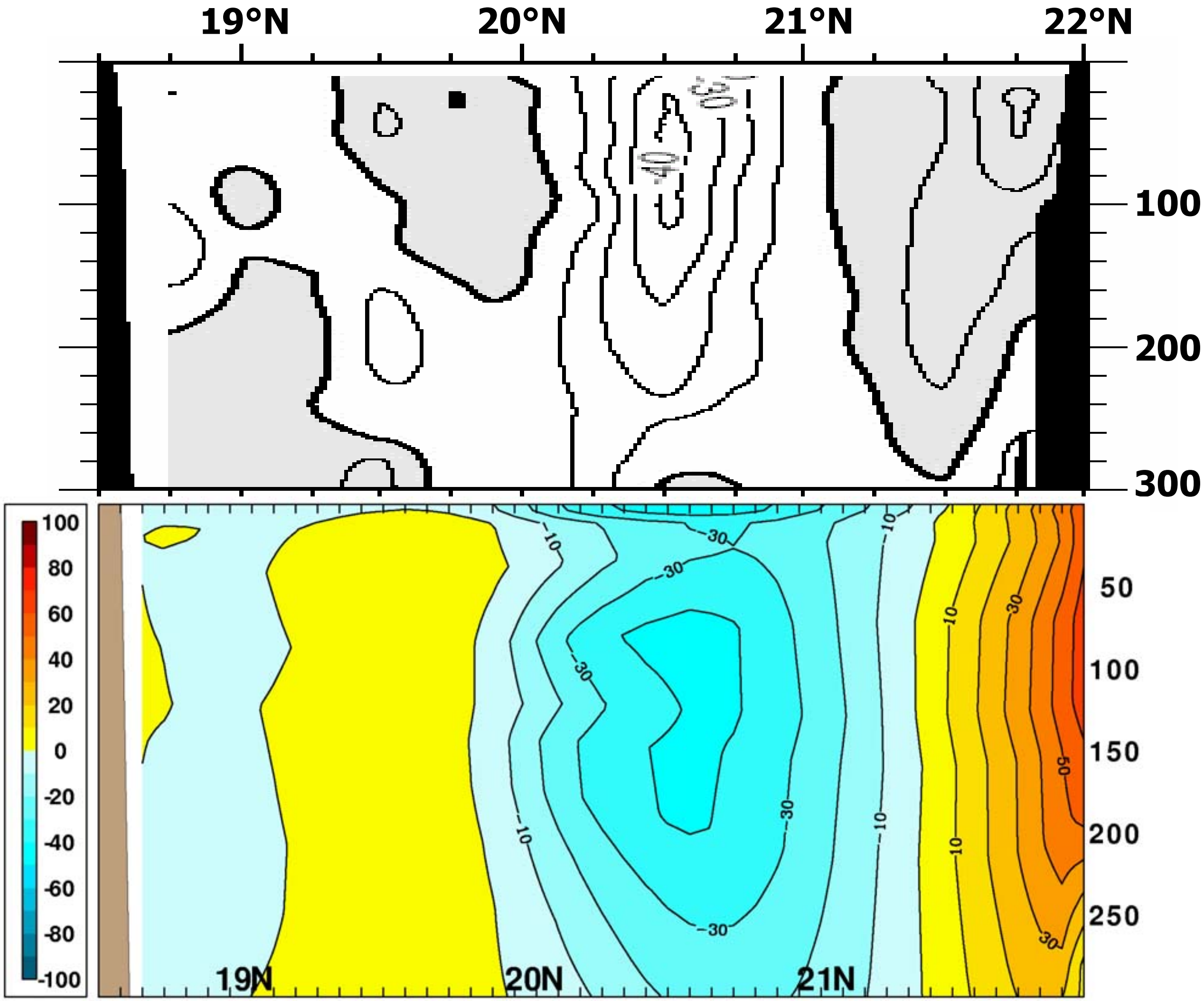

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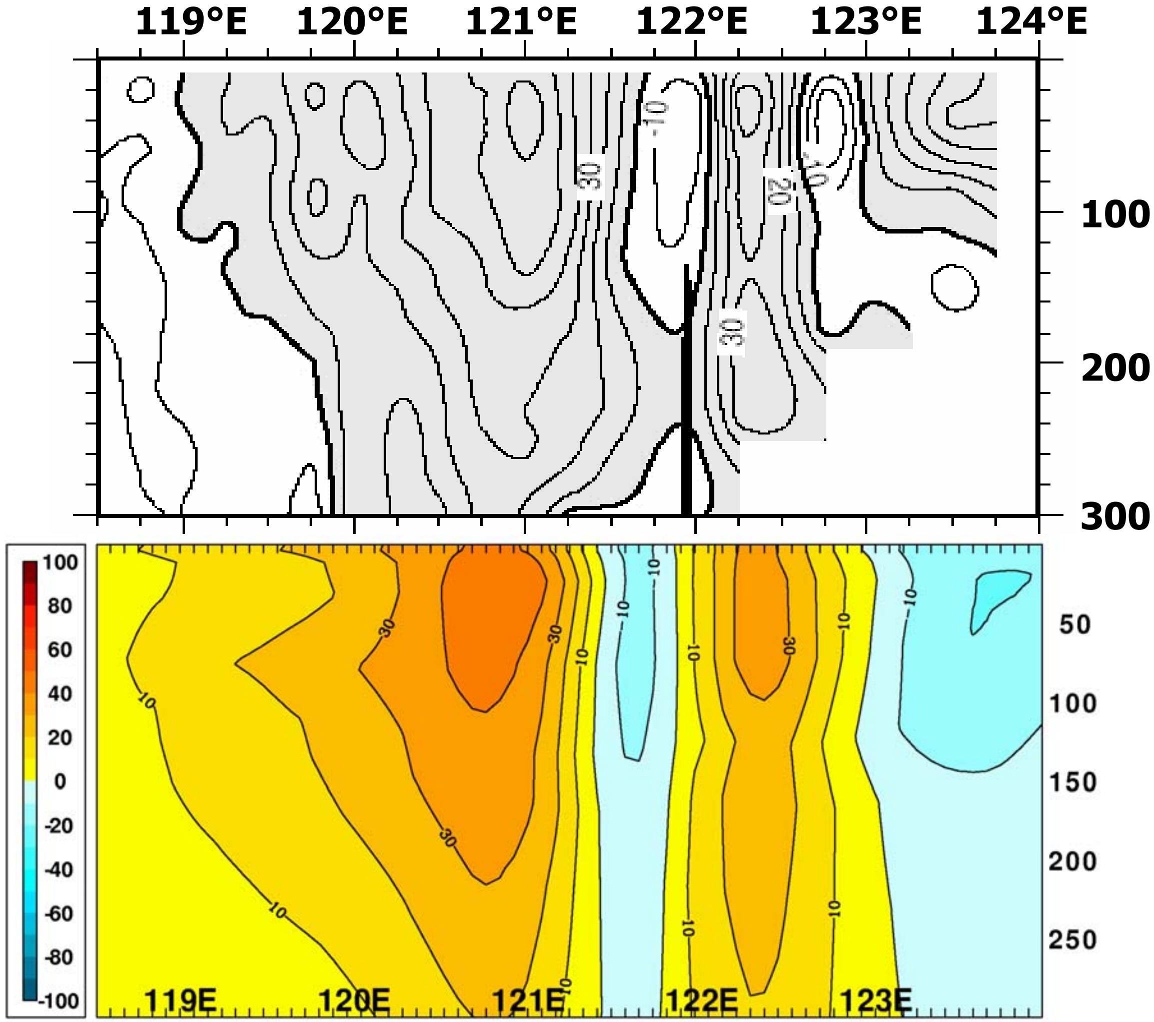
Velocity Cross-section Along Luzon Strait

Sb-ADCP data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 300 m

Section along 21°N between 118.5°E and 124.0°E



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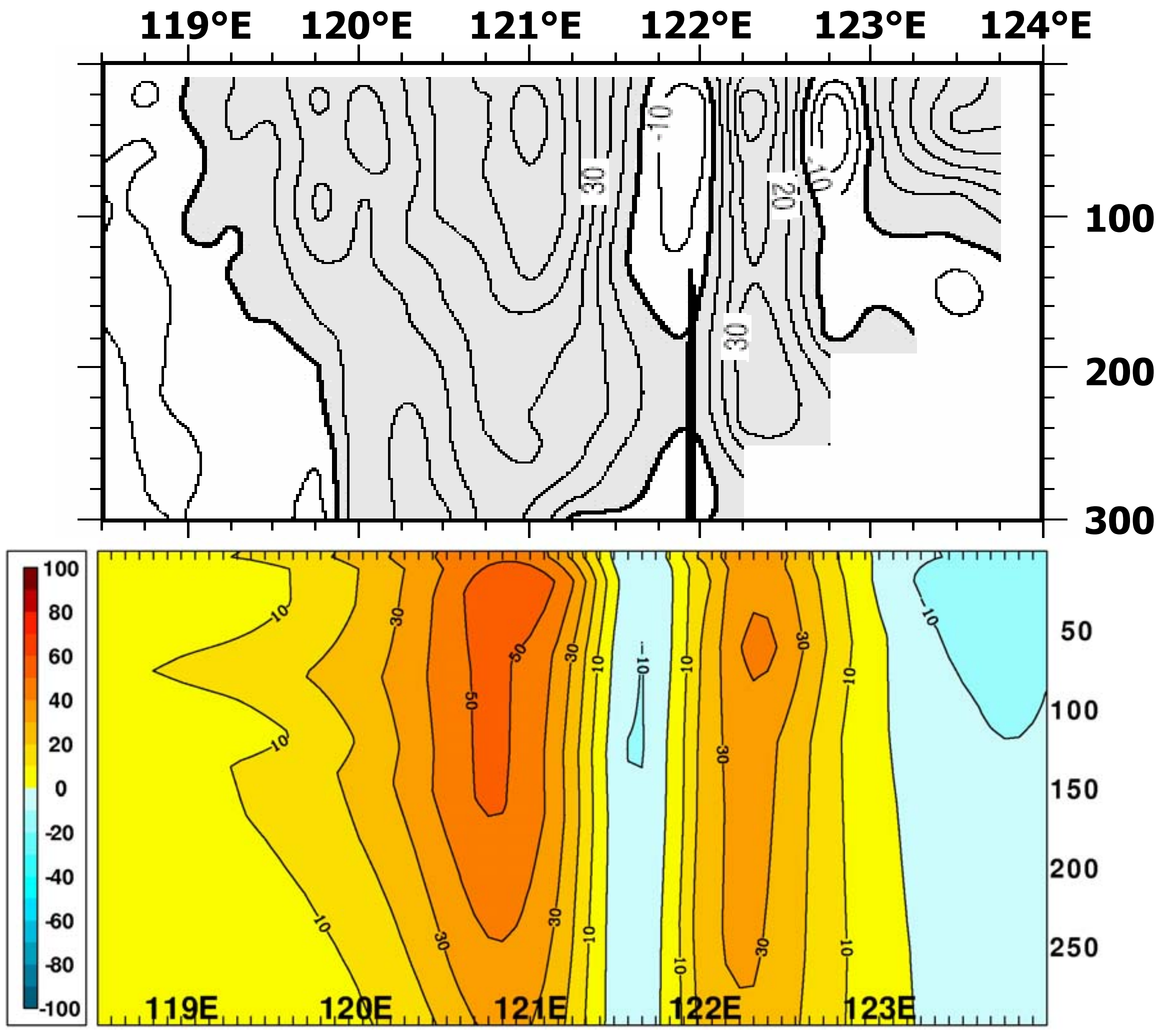

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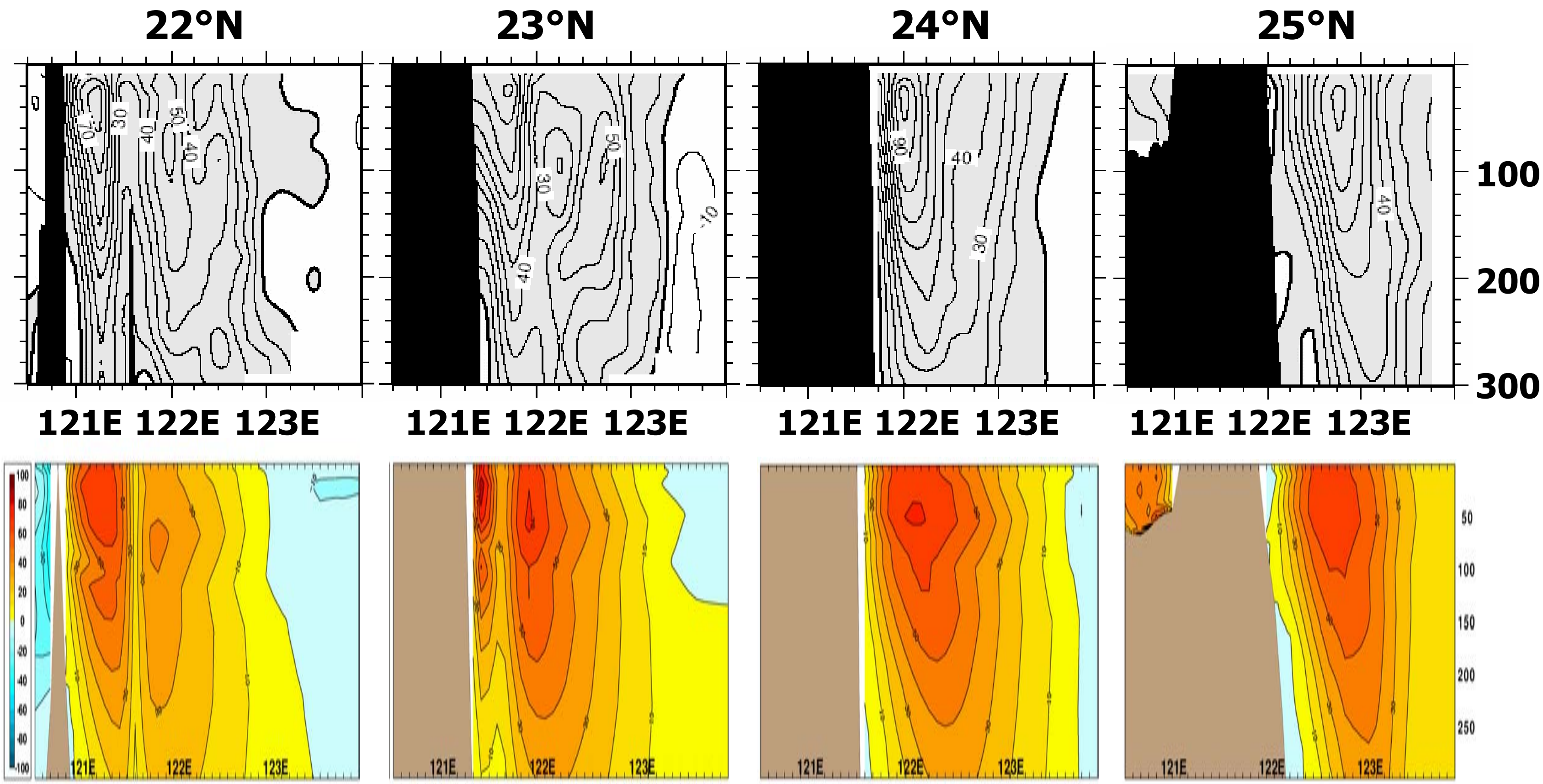
Velocity Cross-section East of Taiwan

Sb-ADCP data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 300 m

Sections at 22°N, 23°N, 24°N and 25°N



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Note how the two-core Kuroshio merges to a single jet in both the observations and HYCOM from the south to north along the Taiwan coast

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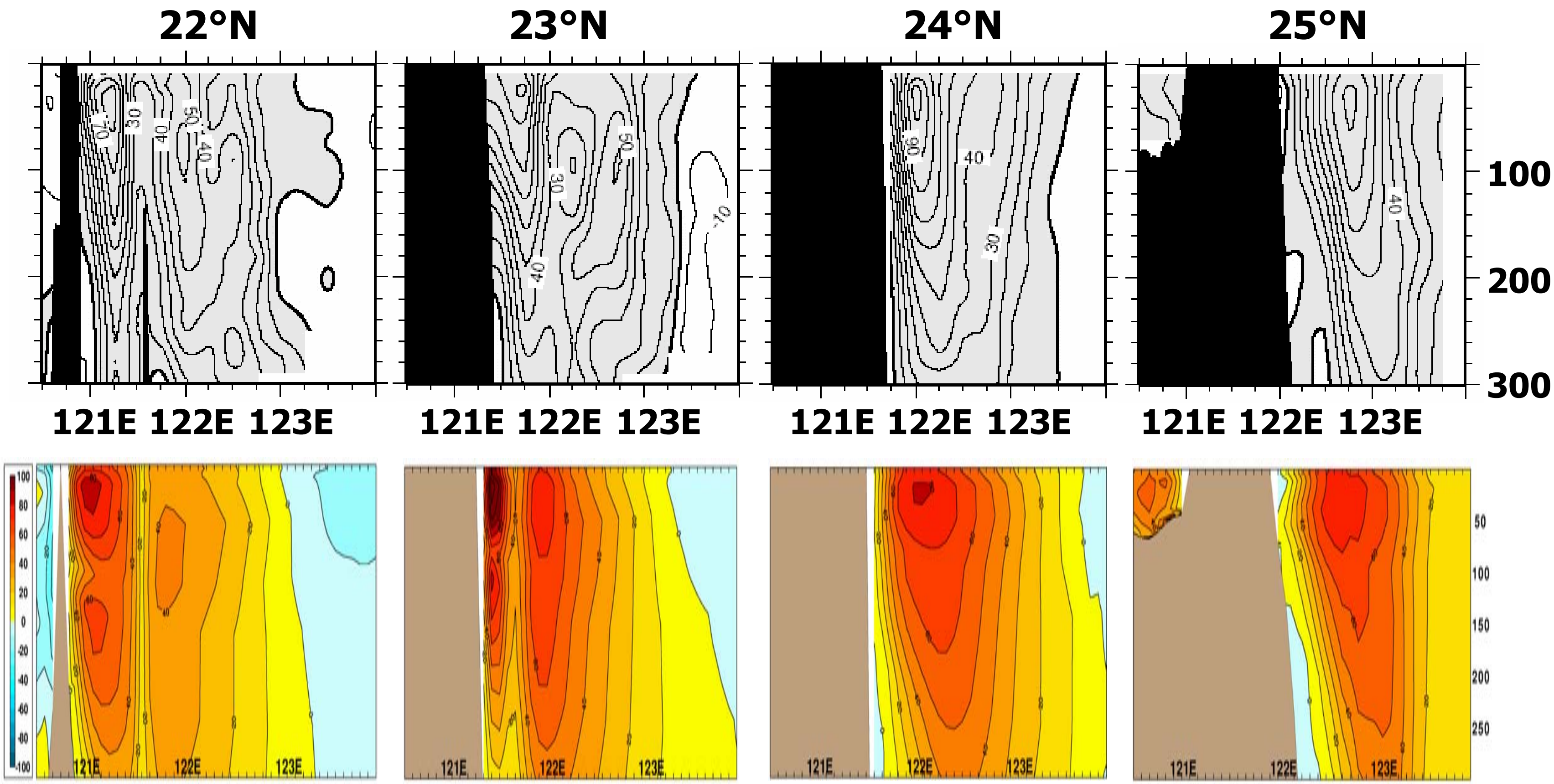

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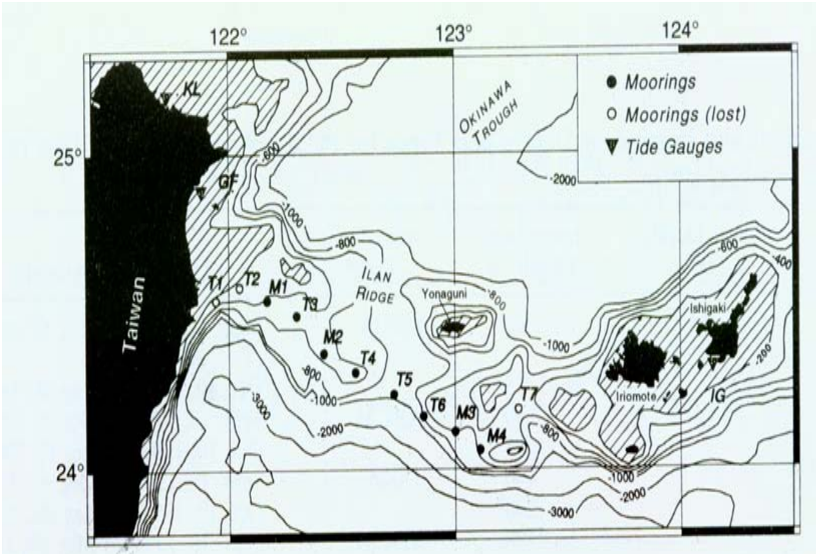
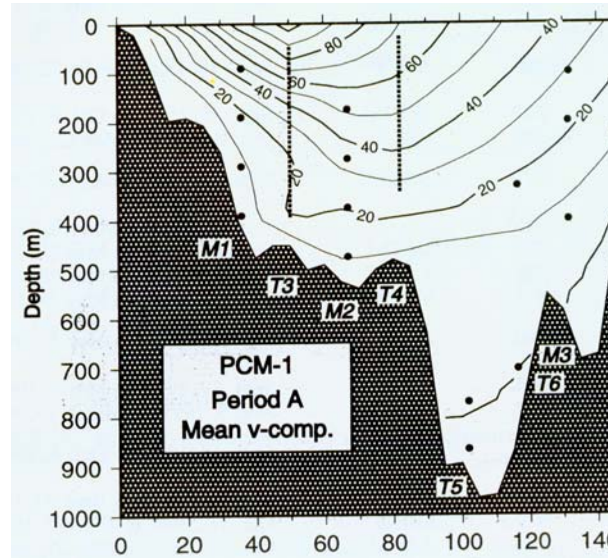
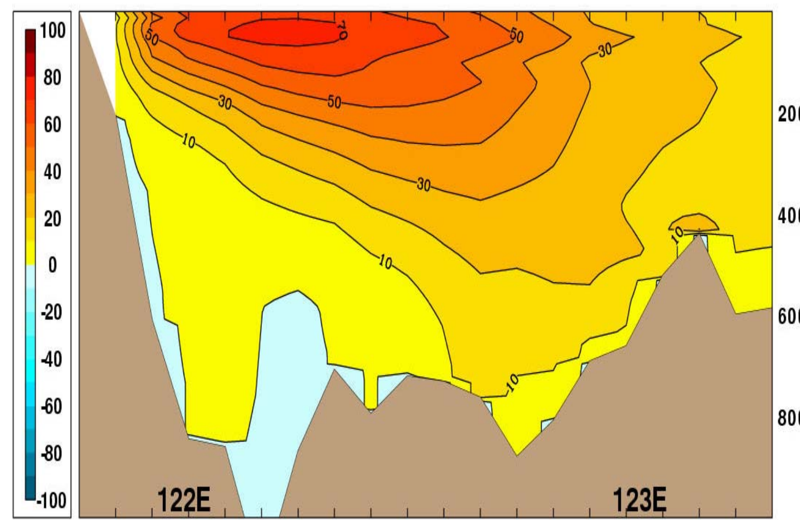
Velocity Cross-section at WOCE PCM-1

Current meter data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 1000 m





PCM-1 data from September 1995 to May 1996



Note the westward intensification of the Kuroshio in the channel between Taiwan and the Ryukyu Islands

Current meter data from Lee et al. (2001, JGR)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
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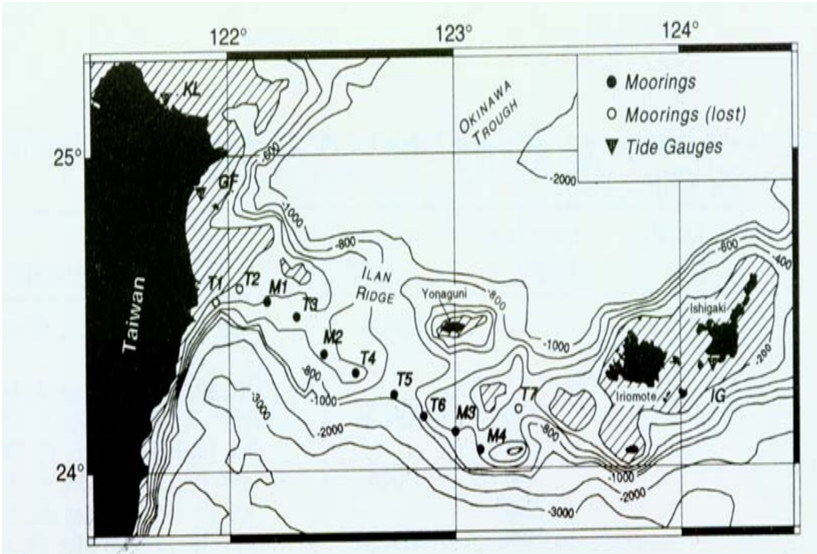

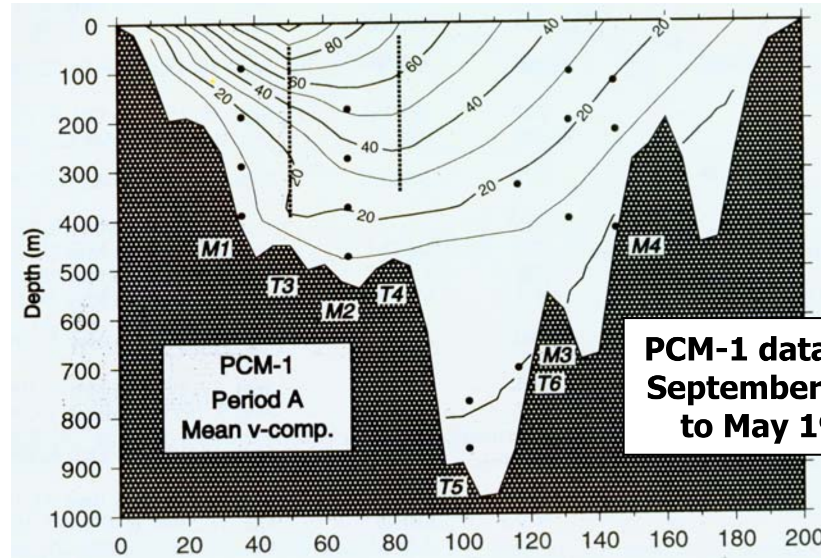

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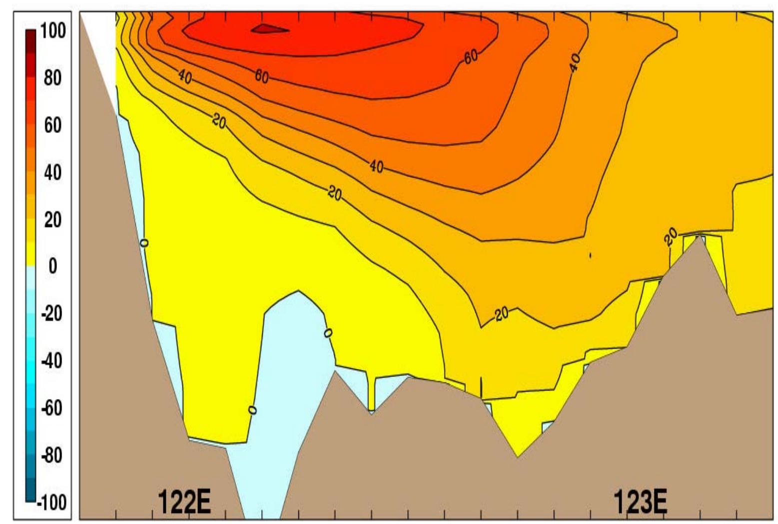

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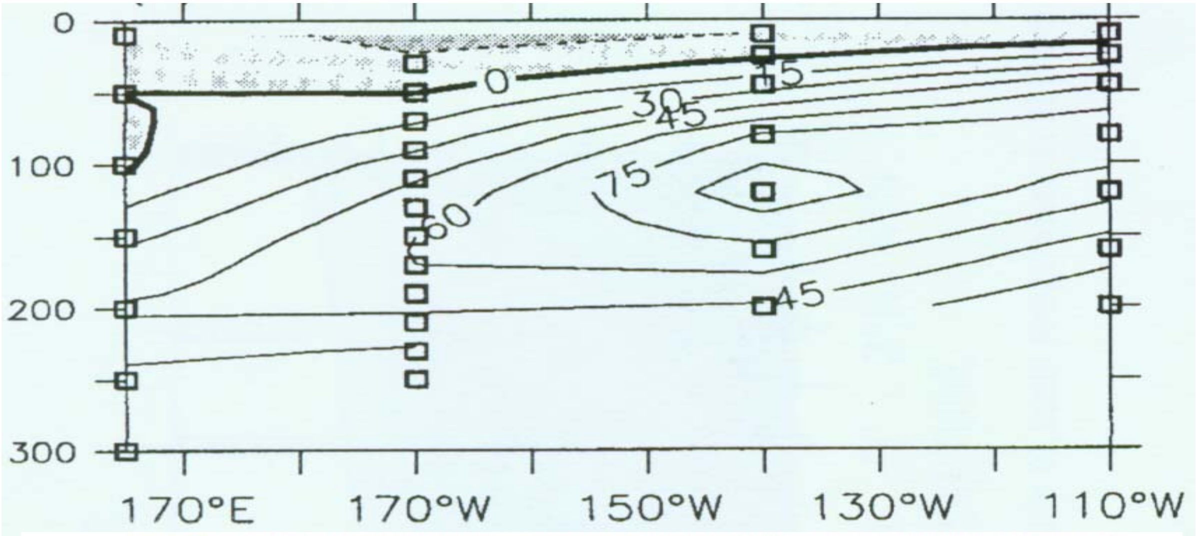
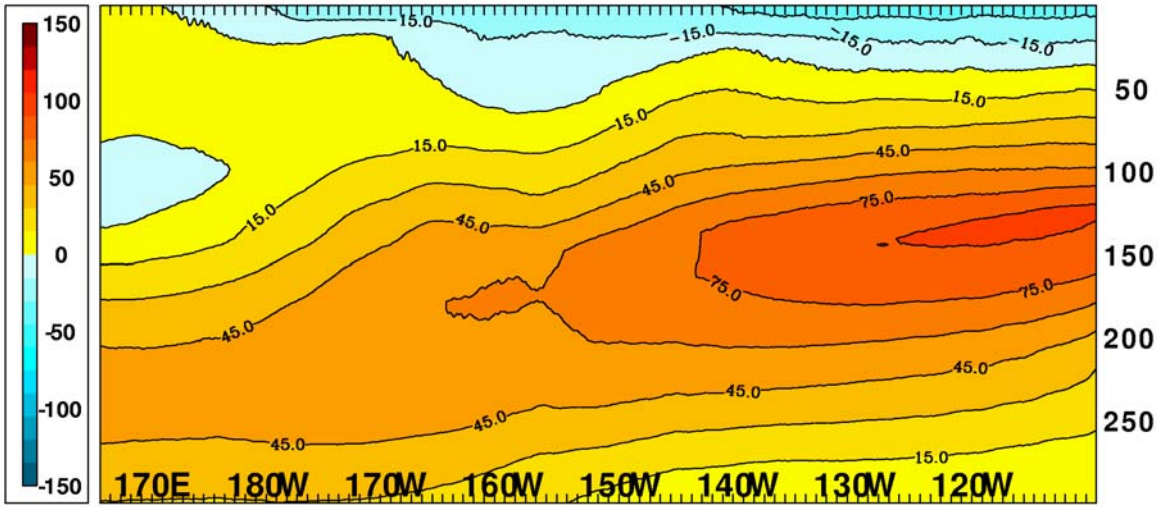
Velocity Cross-section Along the Equator

TOGA TAO data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 300 m

Section between 165°E and 110°W





TOGA TAO buoy data from Yu and McPhaden (1999, JPO)

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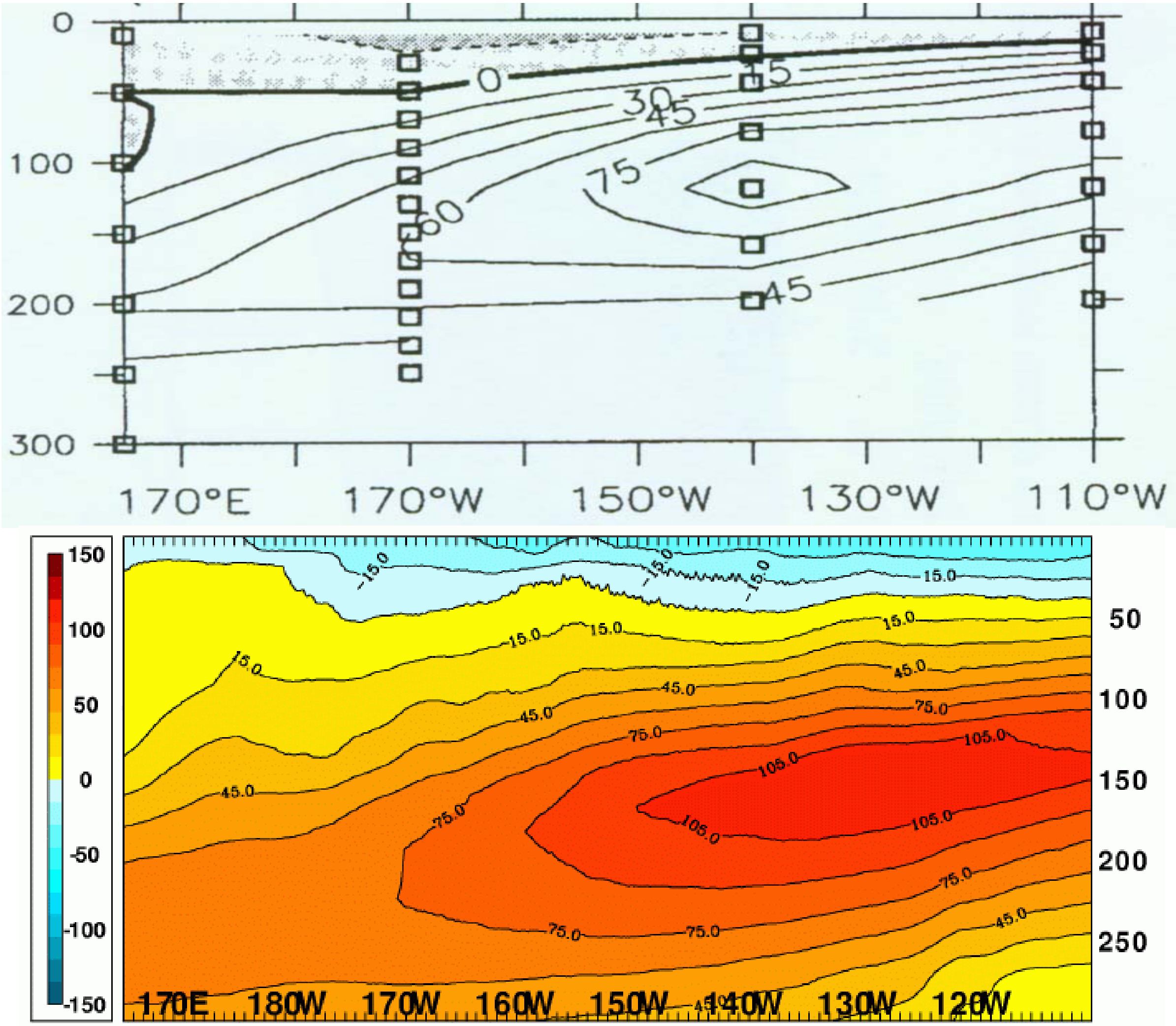

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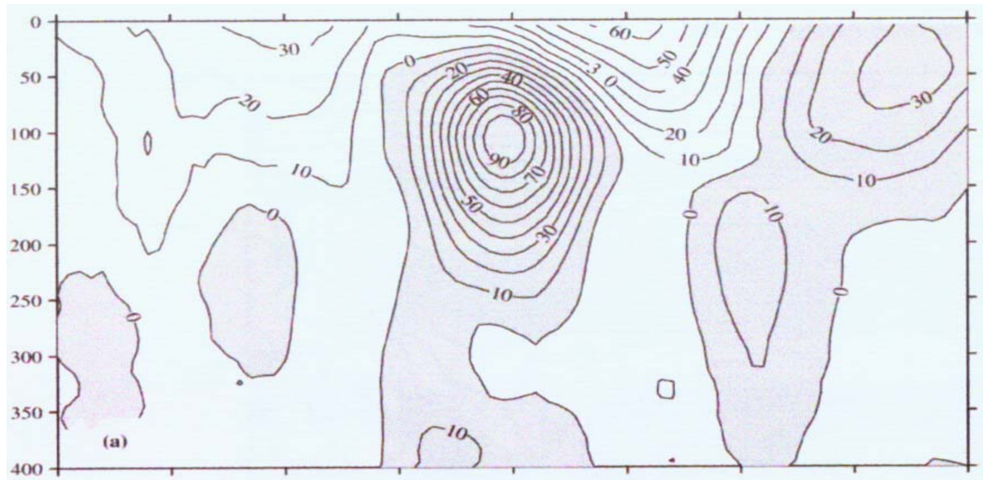
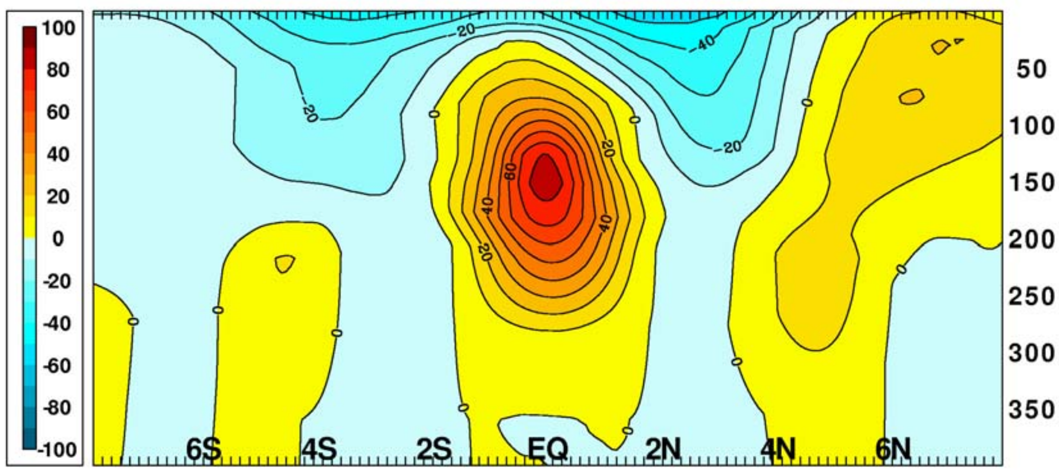
Velocity Cross-section Across the Equator at 135°W

CTD/ADCP data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 400 m

Section between 8°S and 8°N





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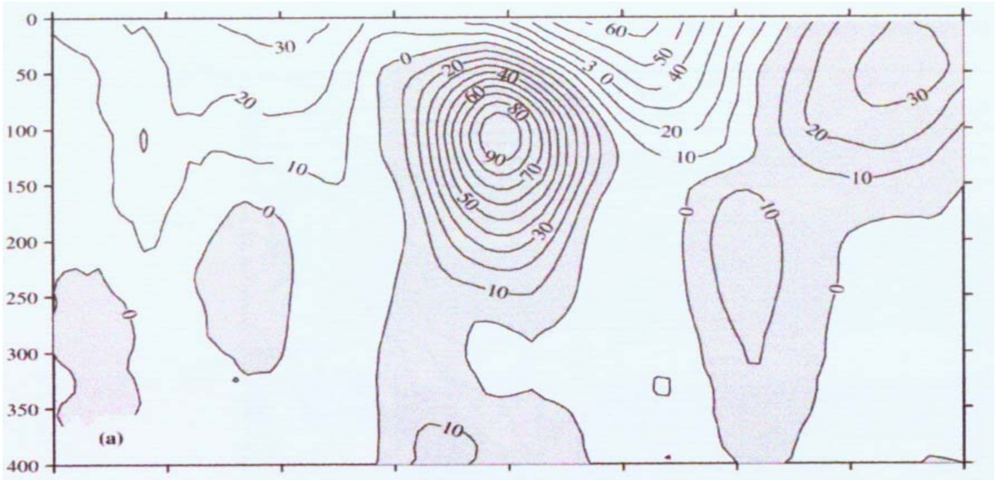

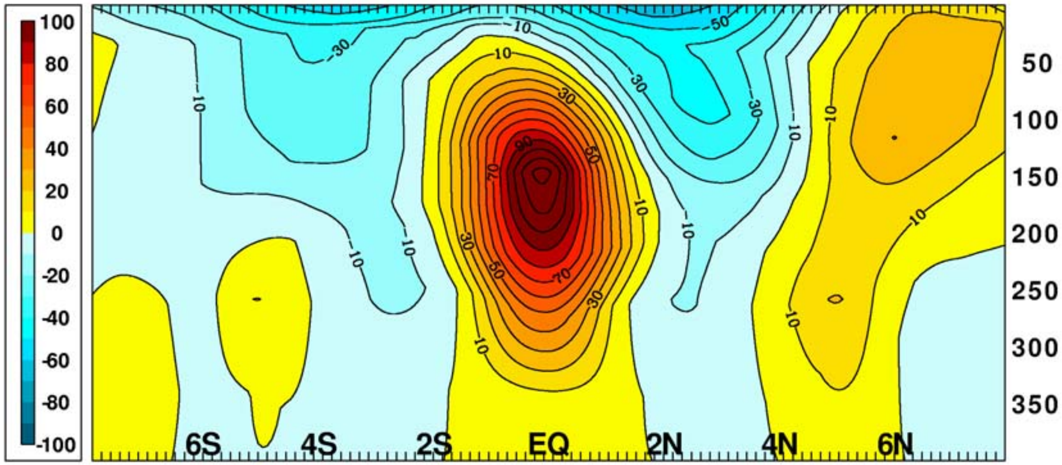

CTD/ADCP data from Johnson and McPhaden (2001, JPO)
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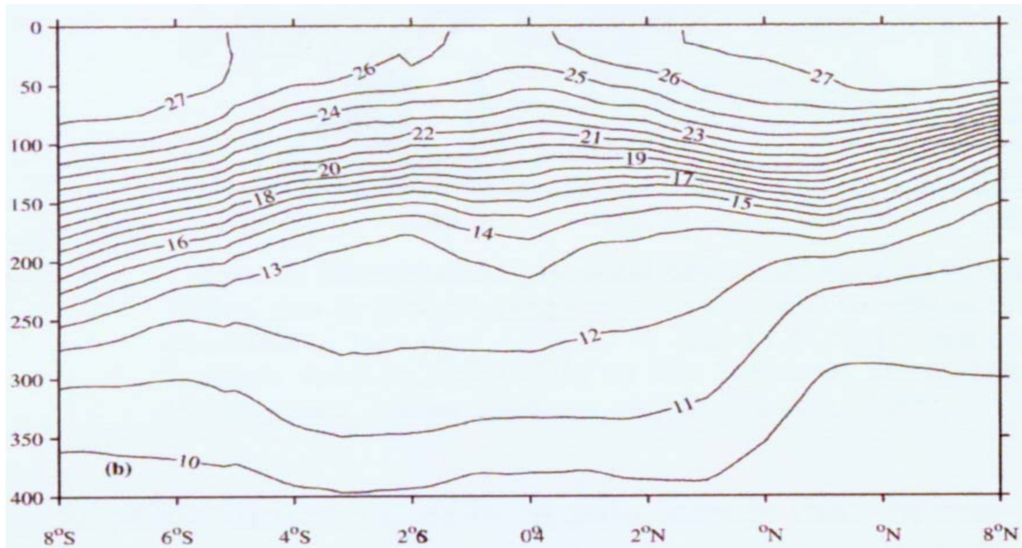
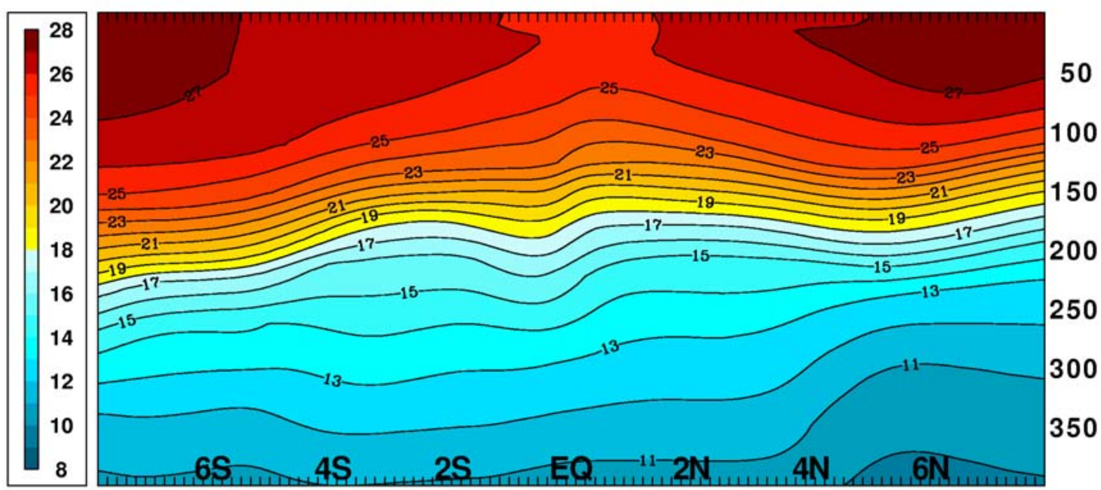
Temperature Cross-section Across the Equator at 135°W

CTD/ADCP data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 400 m

Section between 8°S and 8°N





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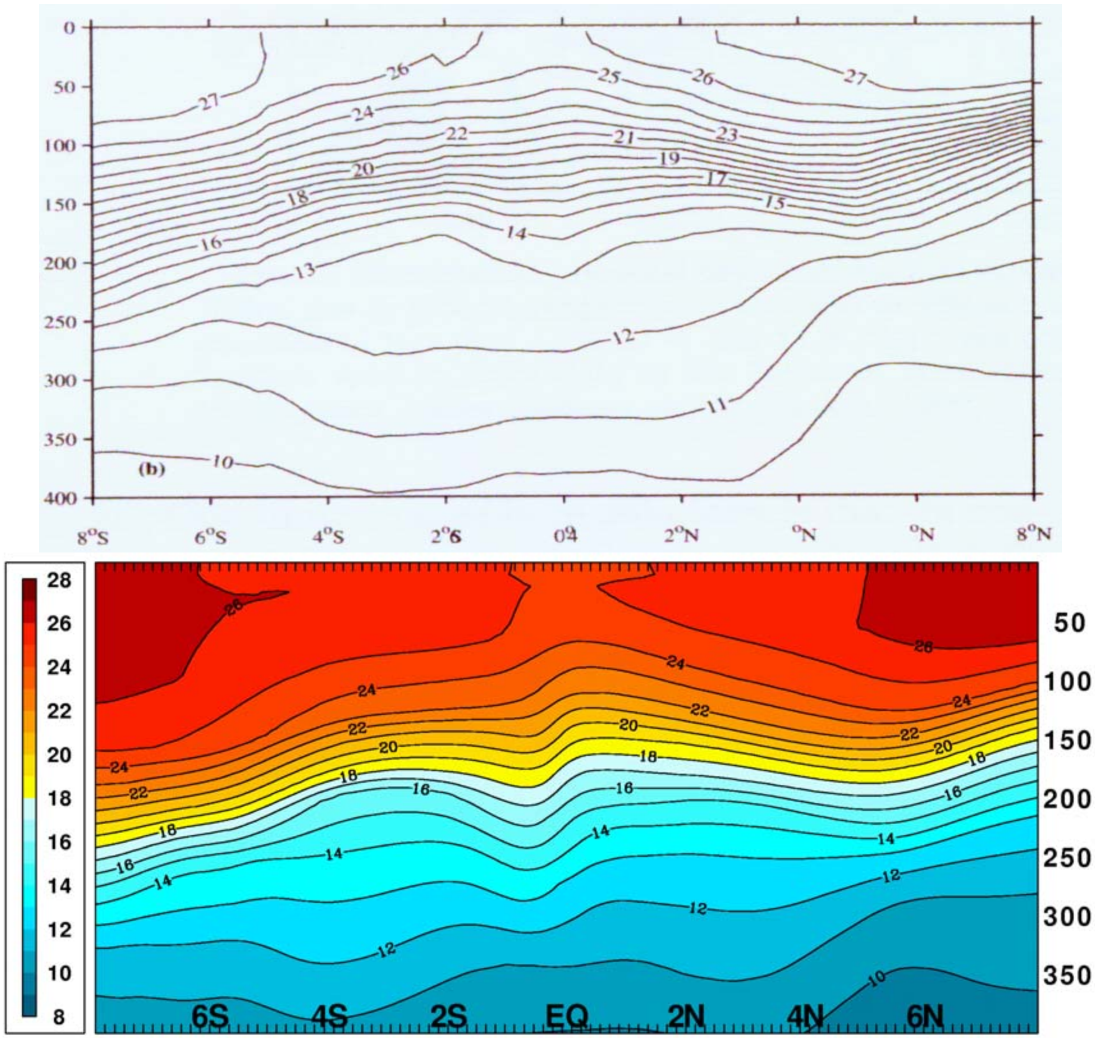

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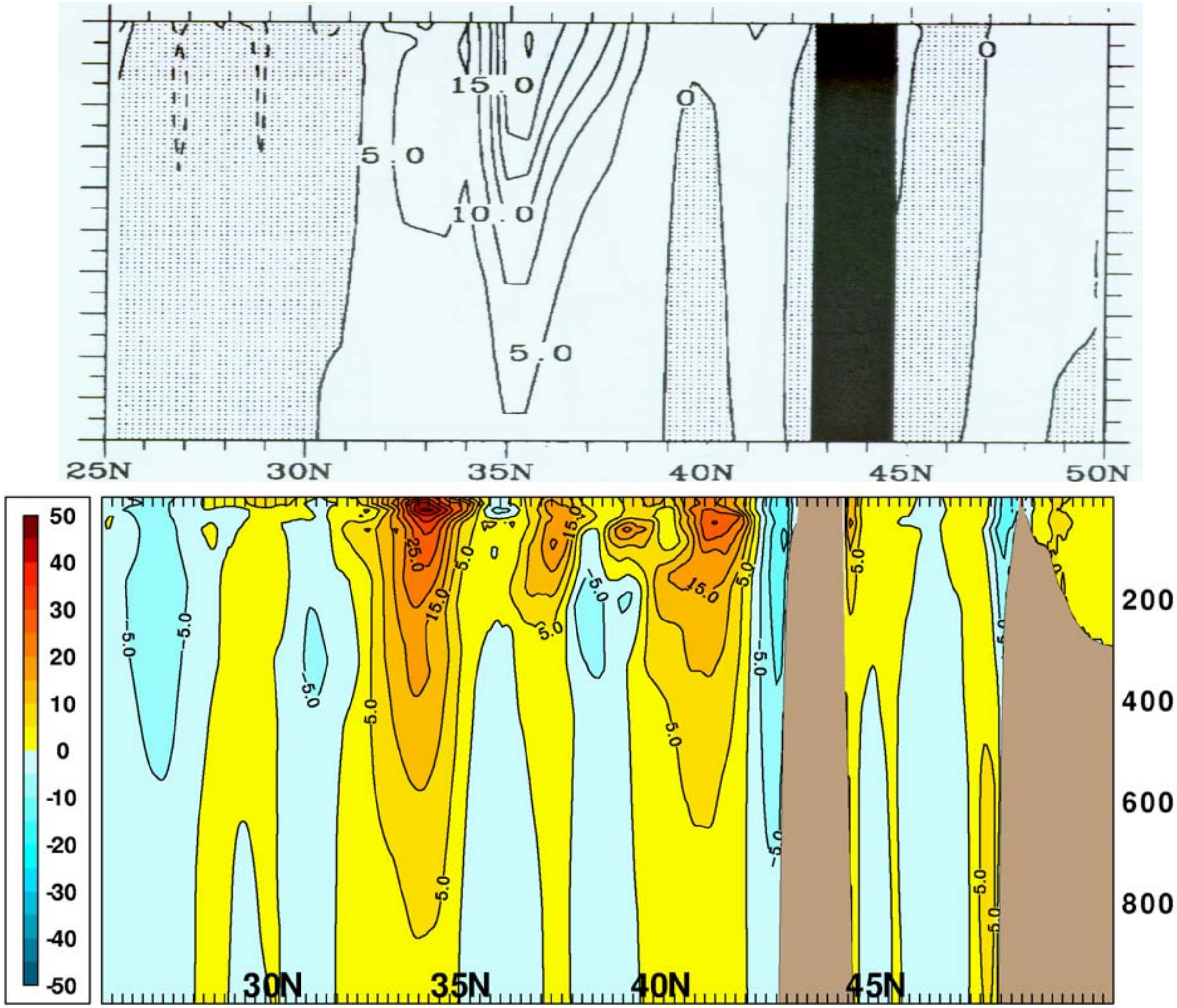
Velocity Cross-section Across the Kuroshio at 145°W

Hydrographic data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 1000 m

Section between 25°N and 50°N



Hydrographic data from Qu et al. (2001, JPO)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
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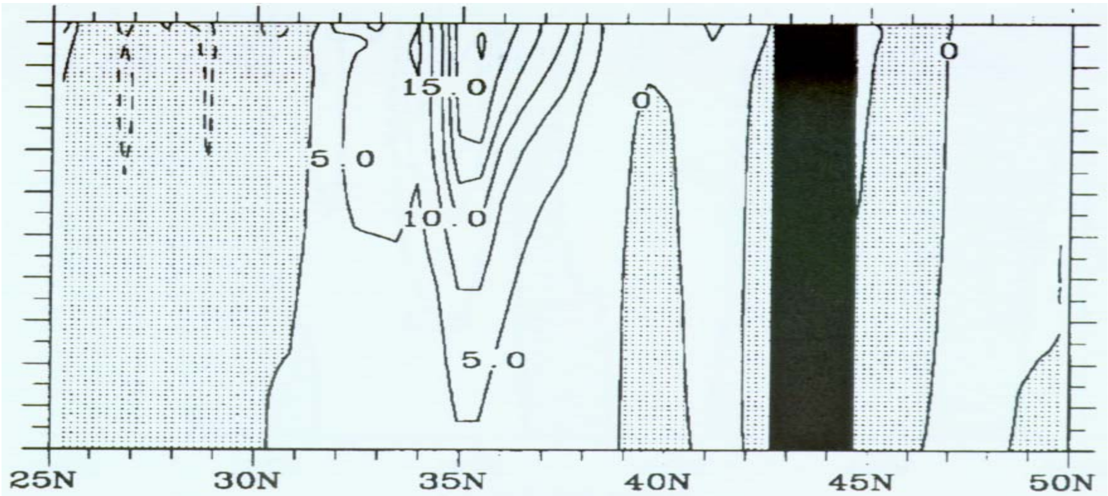
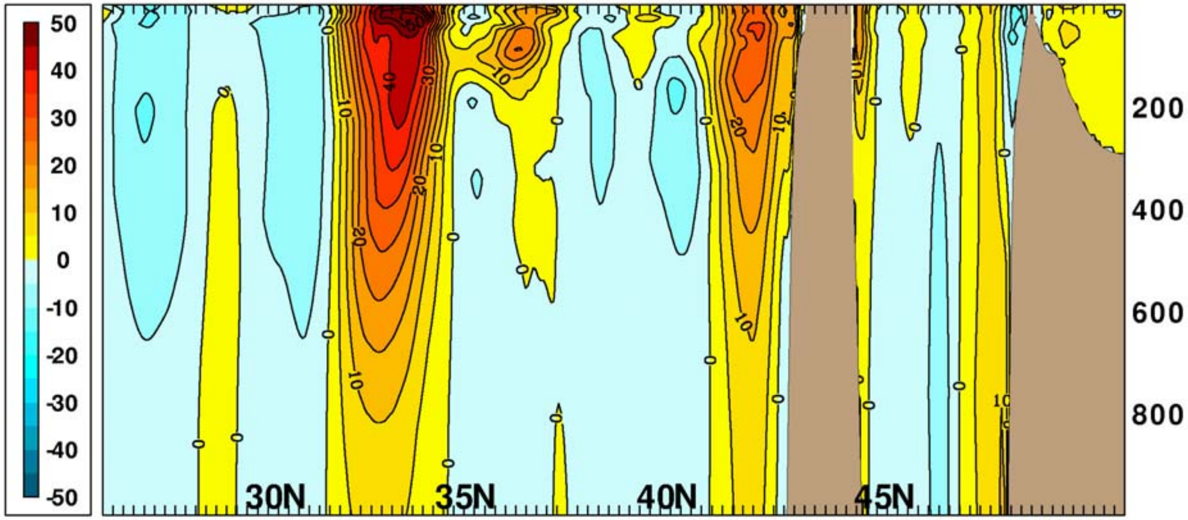
Velocity Cross-section Across the Kuroshio at 145°W

Hydrographic data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 1000 m

Section between 25°N and 50°N



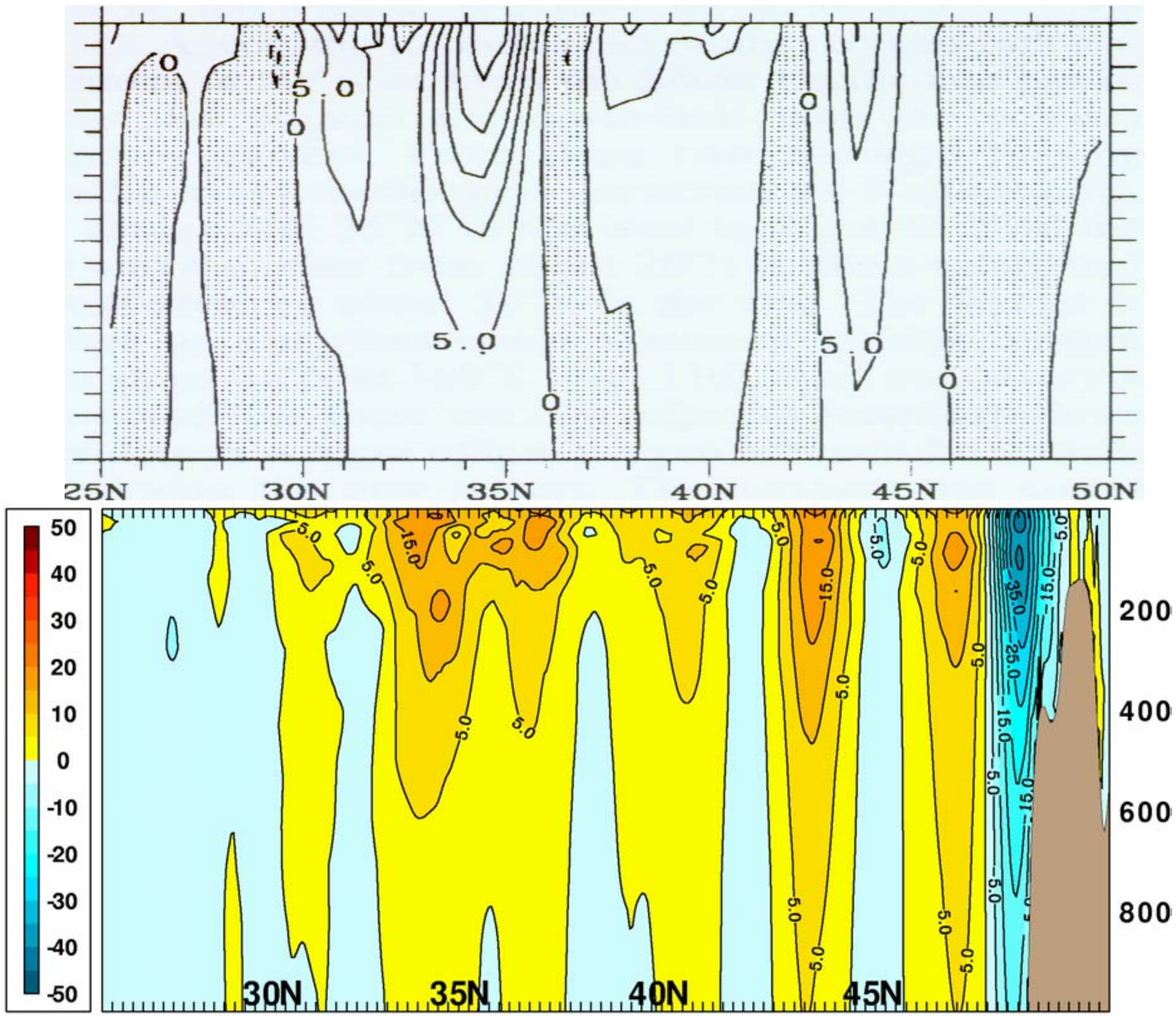


Hydrographic data from Qu et al. (2001, JPO)
6 year mean from HYCOM forced with high-frequency HR winds and ECMWF thermal forcing
No ocean data assimilation in HYCOM

Velocity Cross-section Across the Kuroshio at 155°W

Hydrographic data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 1000 m

Section between 25°N and 50°N



Hydrographic data from Qu et al. (2001, JPO)
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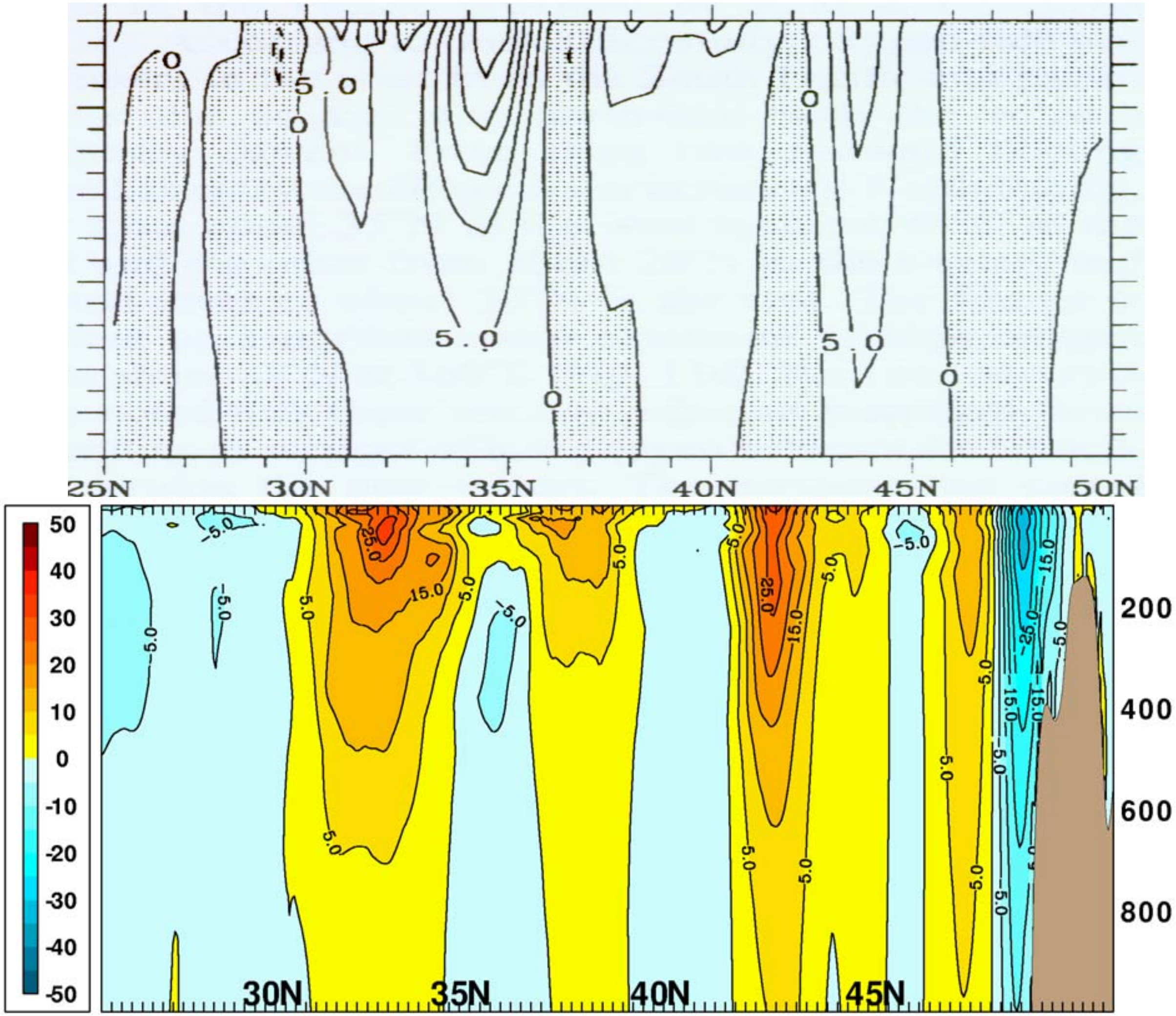
Velocity Cross-section Across the Kuroshio at 155°W

Hydrographic data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 1000 m

Section between 25°N and 50°N



Hydrographic data from Qu et al. (2001, JPO)
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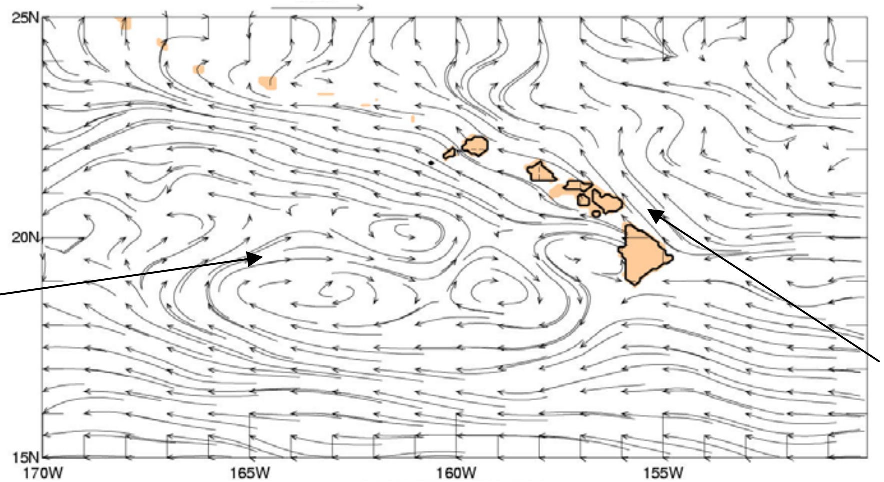
Comparison of Currents Around Hawaii
Composite drifter data vs. 1/12° Pacific HYCOM

Hawaiian Lee Counter Current (HLCC)

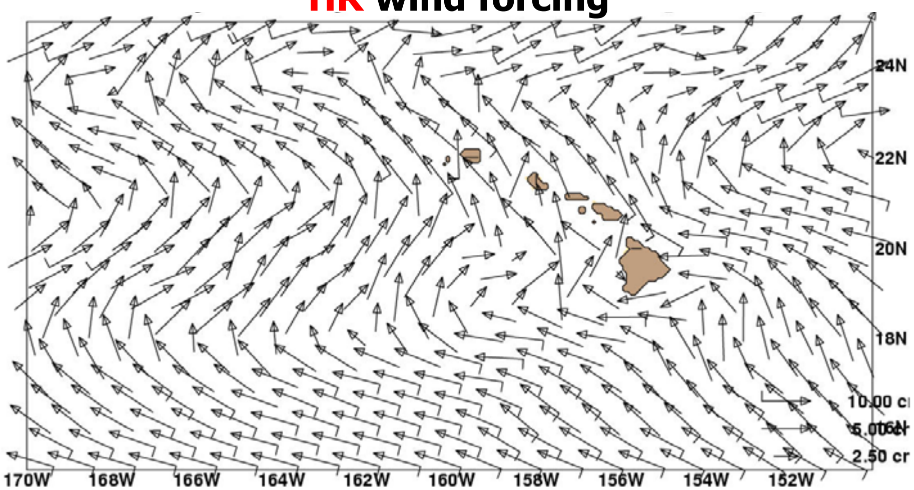


Mean flow field derived from 356 WOCE drifters, July 1987-March 1998; adapted from Flament et al. (1998) and Lumpkin (1998)

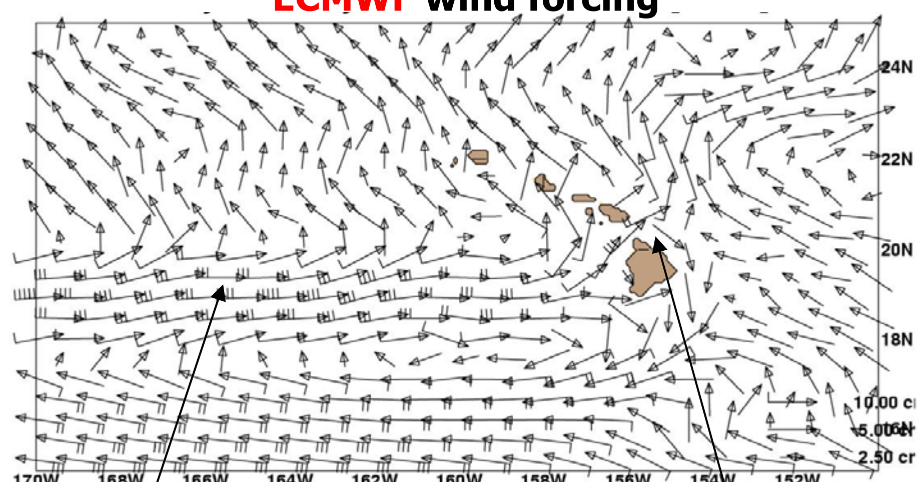
North Hawaiian Ridge Current (NHRC)

HYCOM mixed layer current field

HR wind forcing



ECMWF wind forcing

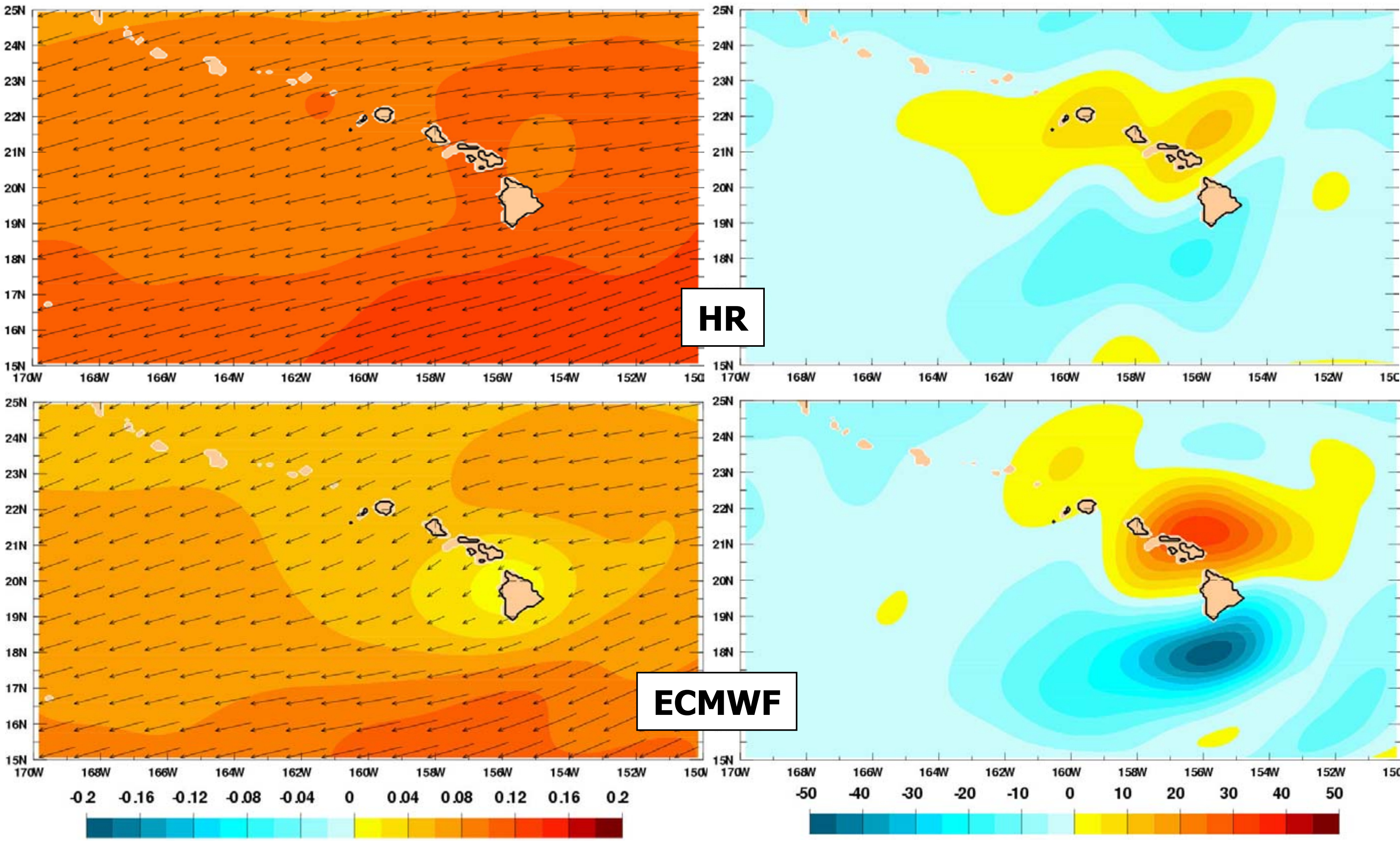


excessively strong HLCC extends all the way to the western boundary

unrealistic NHRC

Annual Winds Over Hawaii

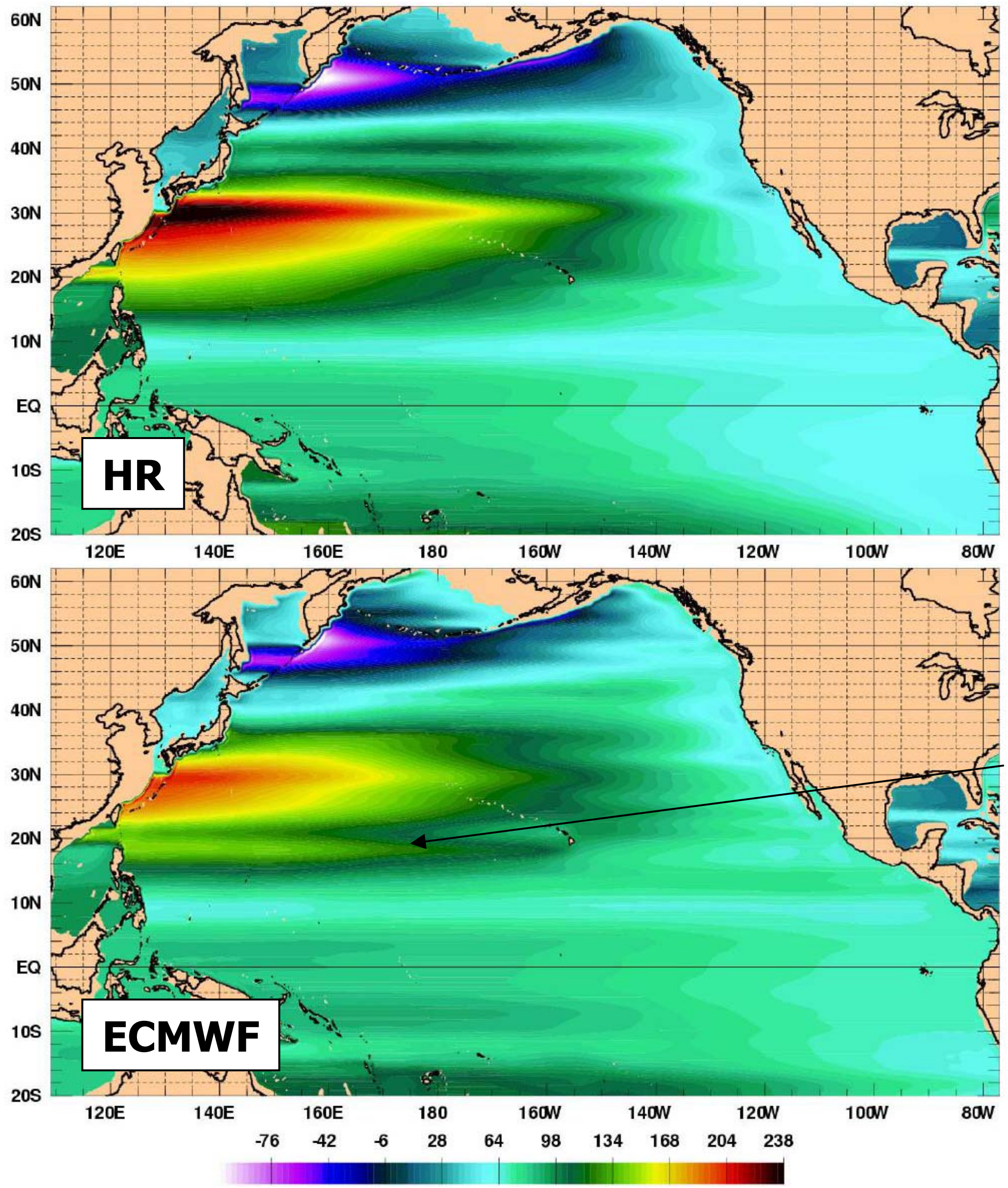
Wind stress | **Wind stress curl**



Unrealistic flow around the Hawaiian Islands appears to be related to the anomalously strong wind stress curl dipole in the ECMWF forcing; this is a feature of numerical weather models and not observational ocean wind climatologies

Linear Response To Wind

SSH from the linear 1/16°global NRL Layered Ocean Model



Note the unrealistic sub-gyre in the southern Subtropical Gyre that is a linear Sverdrup response to the wind forcing

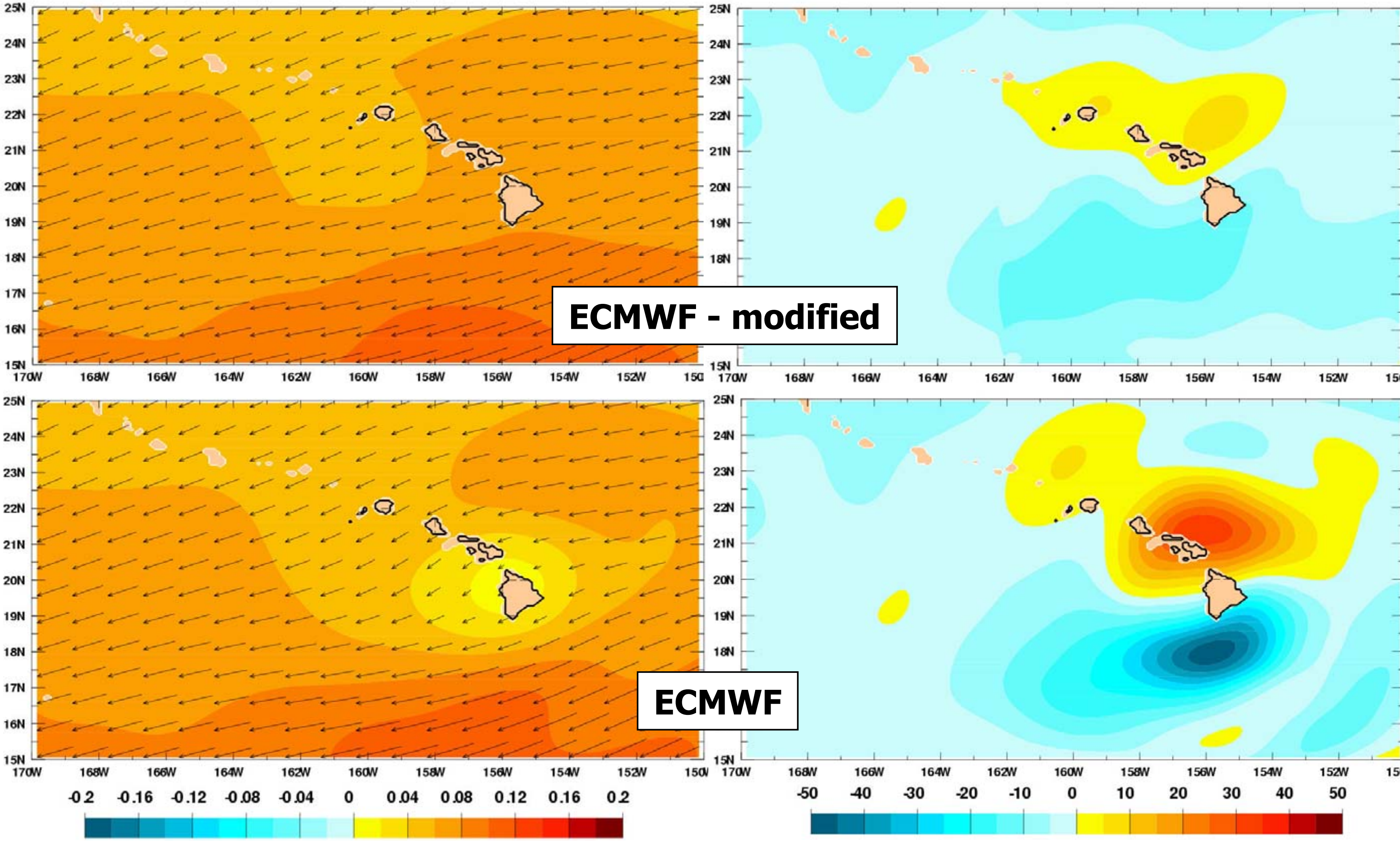
Methodology to Modify the ECMWF Wind Stress Curl Over the Hawaiian Islands

1. Define a rectangle in the ECMWF wind stress curl field circumscribing the bull's-eye near Hawaii.
2. Interpolate across the rectangle in both the ECMWF and HR wind stress fields.
3. Subtract the interpolated HR from the pure HR and add the residual to the interpolated ECMWF field.★
4. Calculate wind stress curl fields and make sure the blending does not create anomalous curl at the rectangle boundaries.
5. Calculate the linear solution using 1/16° global NLOM; if positive results run 1/12° Pacific HYCOM.

★(Over the Hawaii region the HR stresses are ~40% stronger than ECMWF, so the HR residual is reduced by this amount.)

Annual Winds Over Hawaii

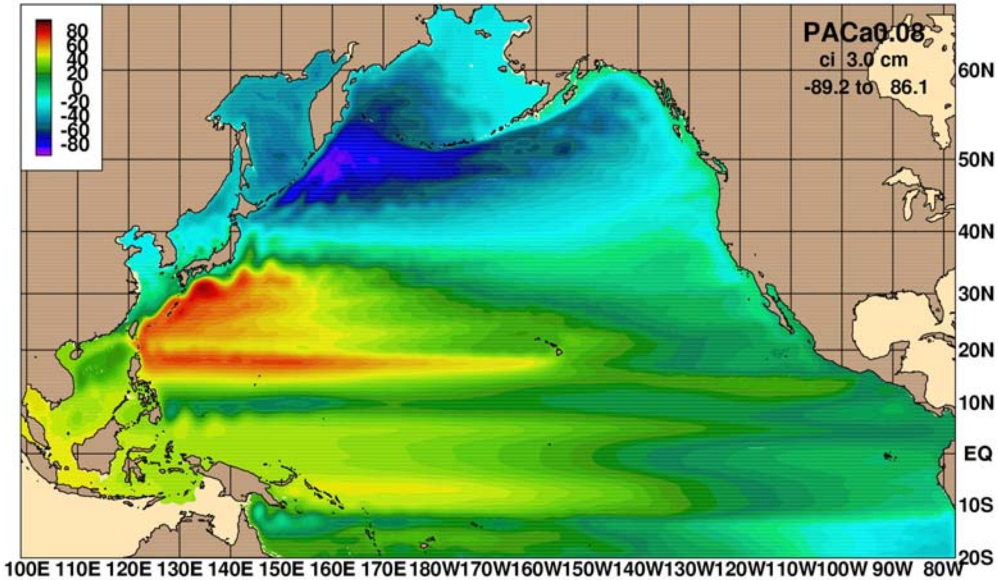
Wind stress | **Wind stress curl**



Successfully reduced magnitude of the wind stress curl dipole over the Hawaiian Islands without introducing anomalous curl at the boundaries

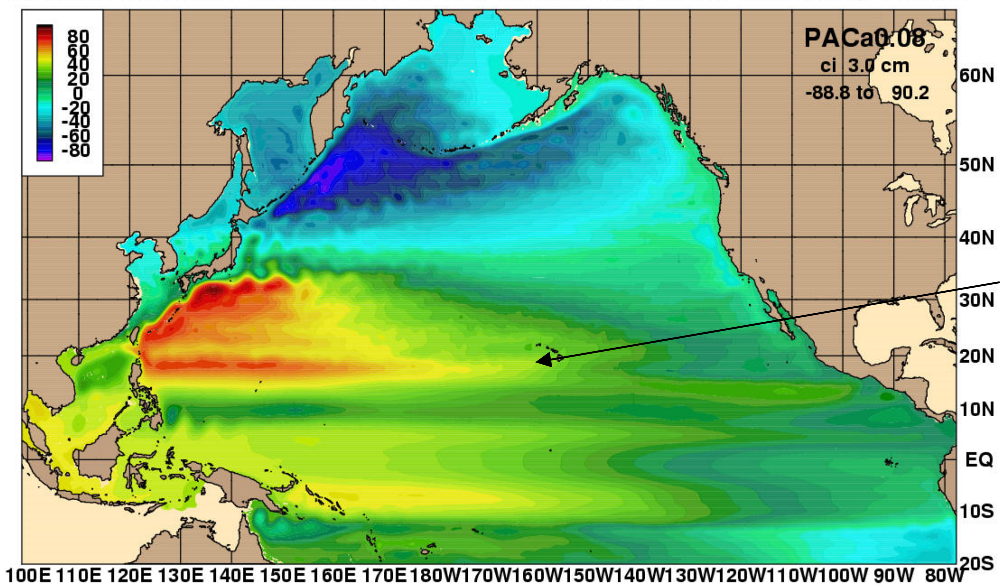
Comparison of the Basin-scale Circulation
1/12° Pacific HYCOM: ECMWF winds vs. ECMWF Hawaii modified winds

6-yr mean SSH (cm)



ECMWF winds

3-yr mean SSH (cm)



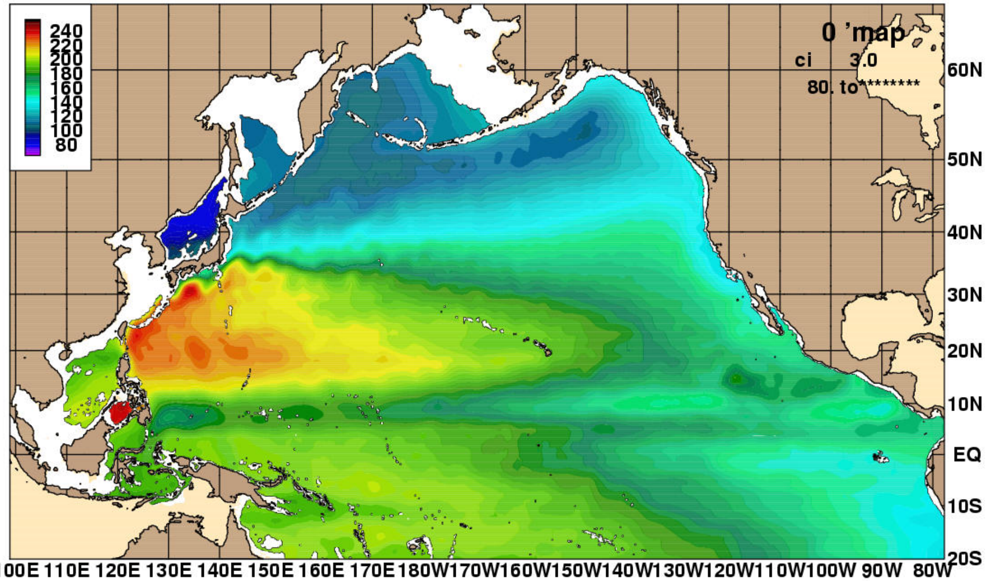
ECMWF Hawaii modified winds

Note the eastward extent of the sub-gyre has diminished

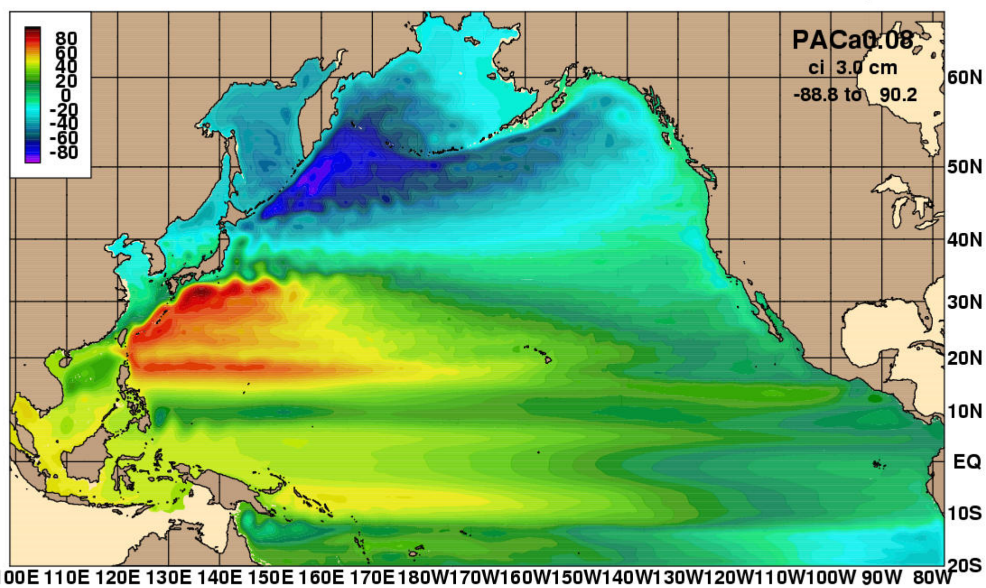
Comparison of the Basin-scale Circulation

MODAS climatology vs. 1/12° Pacific HYCOM

Mean dynamic height (dyn cm) wrt 1000 db

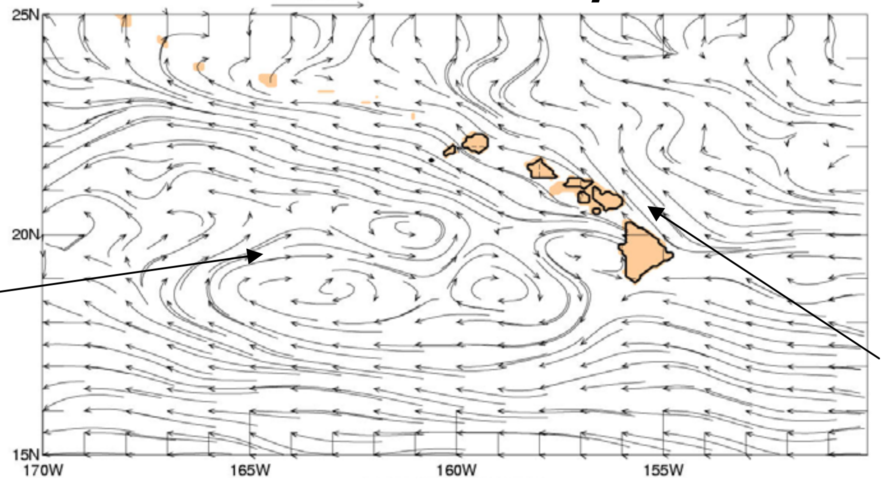


3-yr mean SSH (cm)



Forced with high freq. climatological ECMWF winds and a modification around the Hawaiian Islands

Comparison of Currents Around Hawaii
Composite drifter data vs. 1/12° Pacific HYCOM



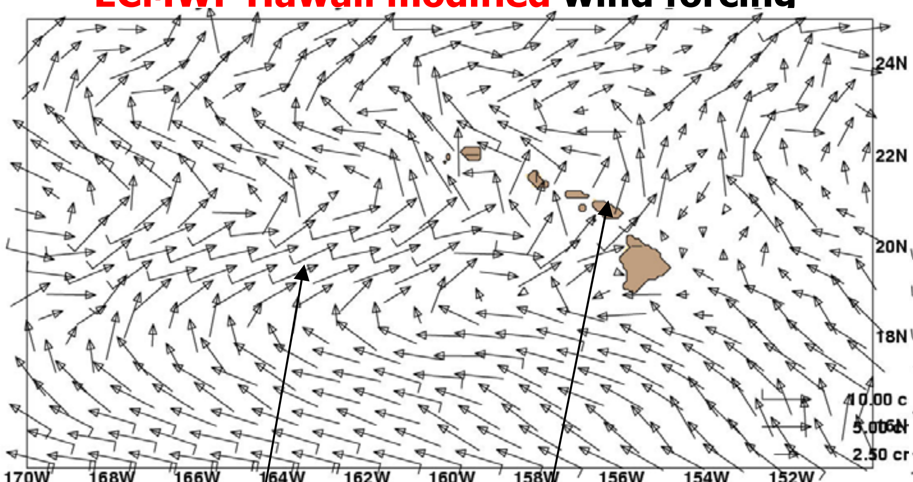
Mean flow field derived from 356 WOCE drifters, July 1987-March 1998; adapted from Flament et al. (1998) and Lumpkin (1998)

Hawaiian Lee Counter Current (HLCC)

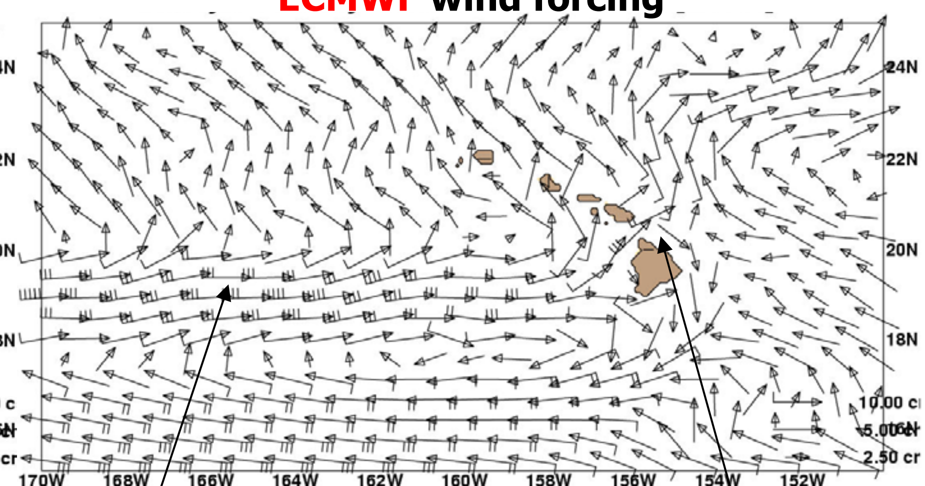
North Hawaiian Ridge Current (NHRC)

HYCOM mixed layer current field

ECMWF Hawaii modified wind forcing



ECMWF wind forcing



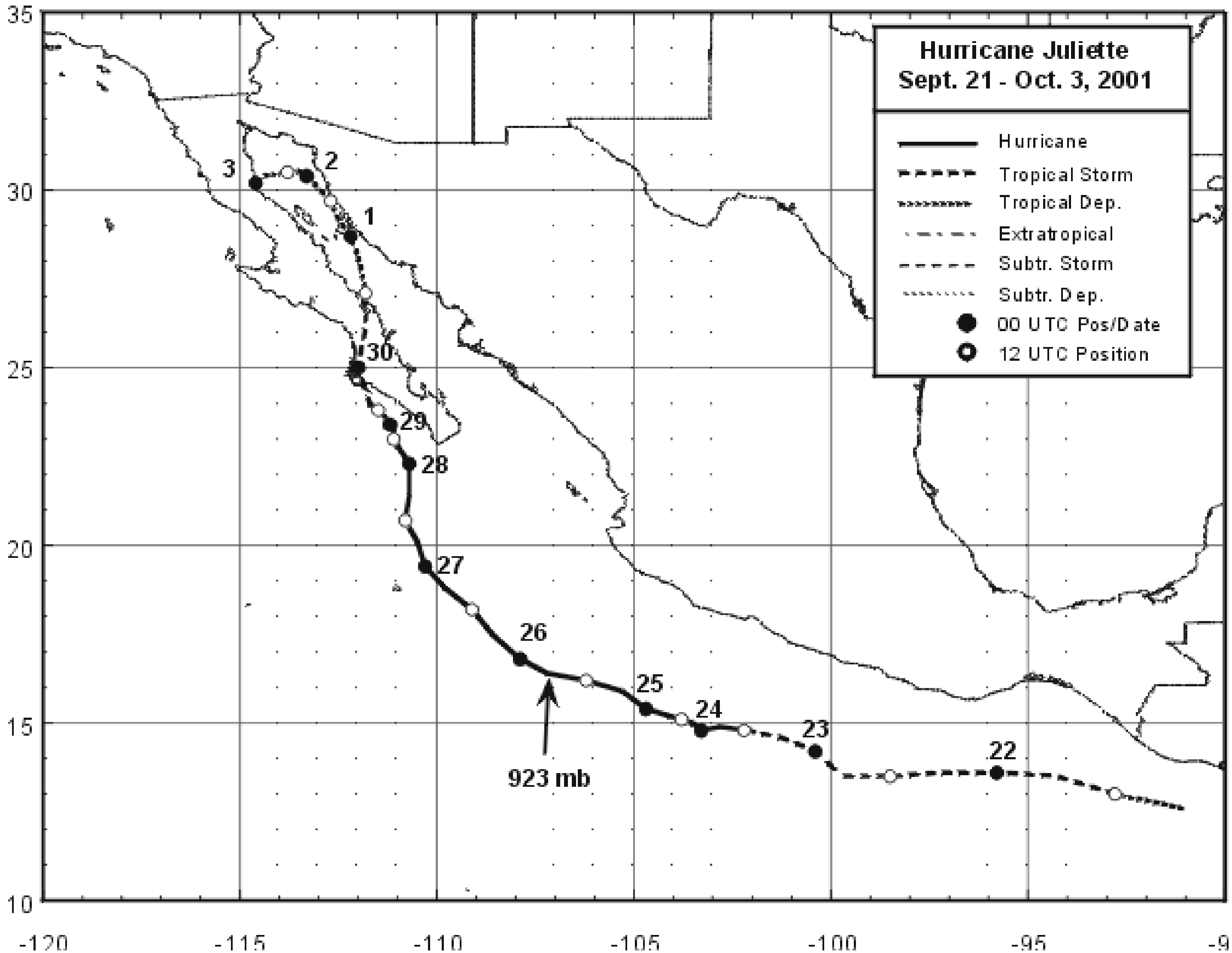
more realistic HLCC

somewhat improved NHRC

excessively strong HLCC extends all the way to the western boundary

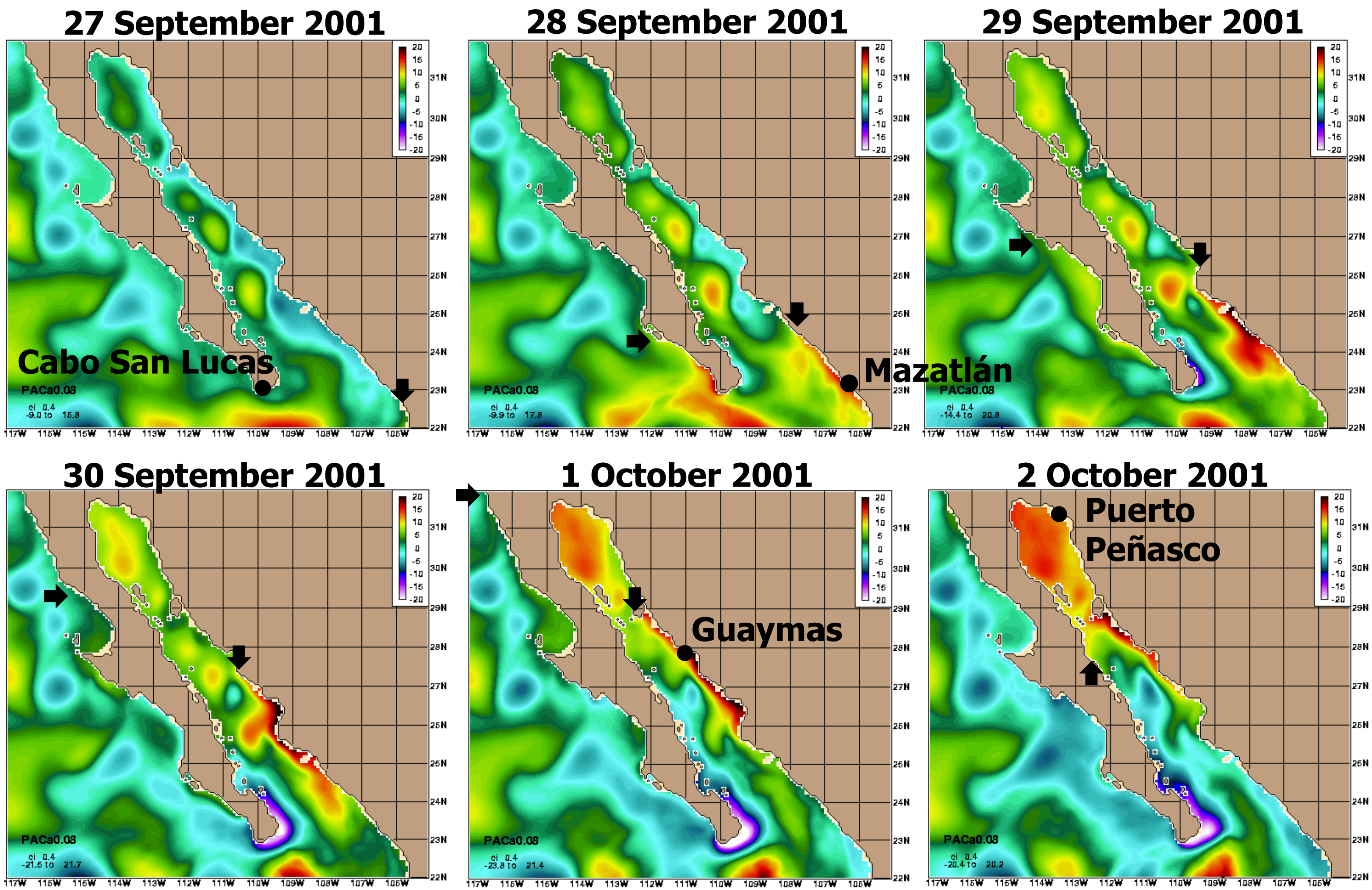
unrealistic NHRC

Track of Hurricane Juliette



Source: National Hurricane Center

Evolution of the Coastally Trapped Waves (CTW) Generated By Hurricane Juliette in 1/12° Pacific HYCOM



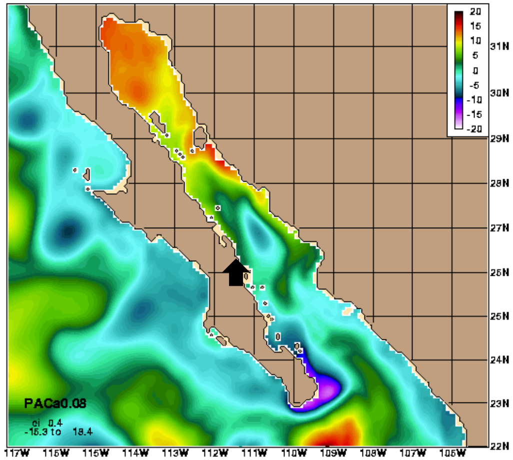
1/12° Pacific HYCOM forced with FNMOC NOGAPS/HR winds and FNMOC NOGAPS thermal forcing. No data have been assimilated into this model.

⬇ **Marks the leading edge of the first CTW**

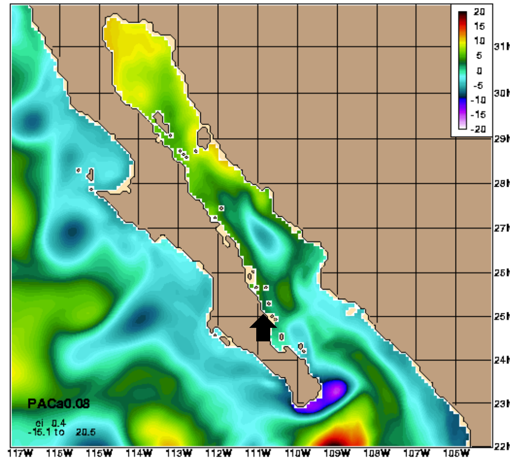
➡ **Marks the leading edge of the second CTW**

Evolution of the Coastally Trapped Waves (CTW) Generated By Hurricane Juliette in 1/12° Pacific HYCOM

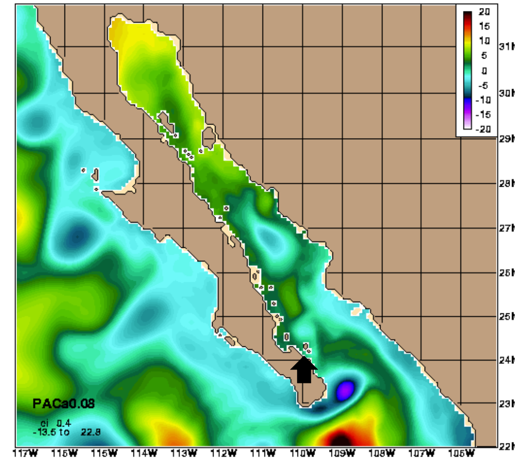
3 October 2001



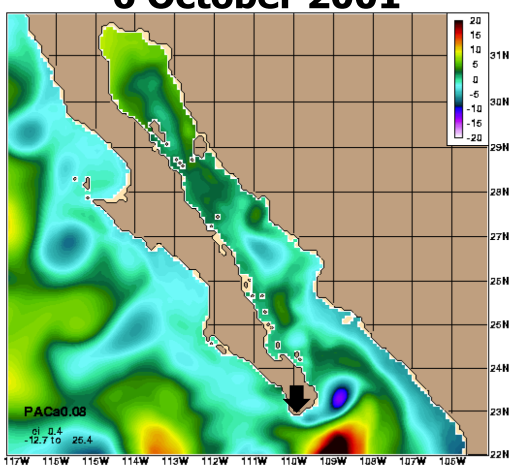
4 October 2001



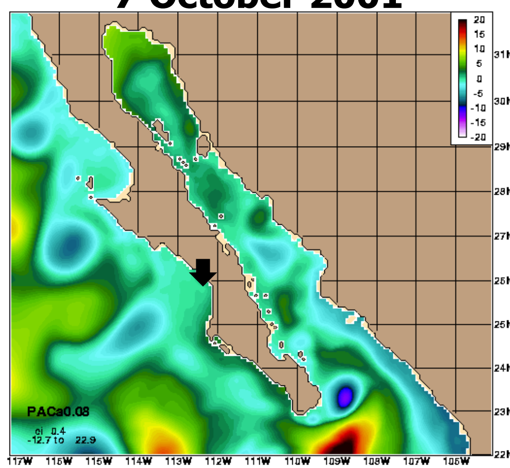
5 October 2001



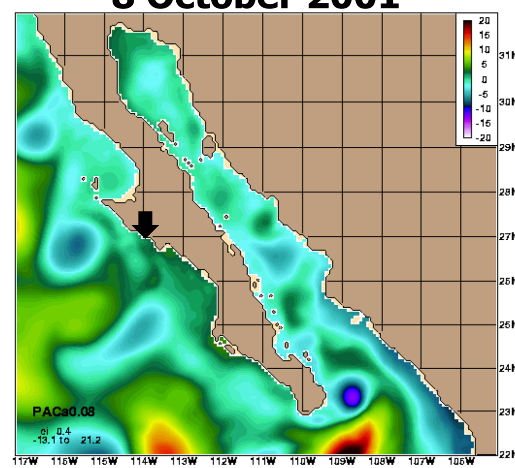
6 October 2001



7 October 2001



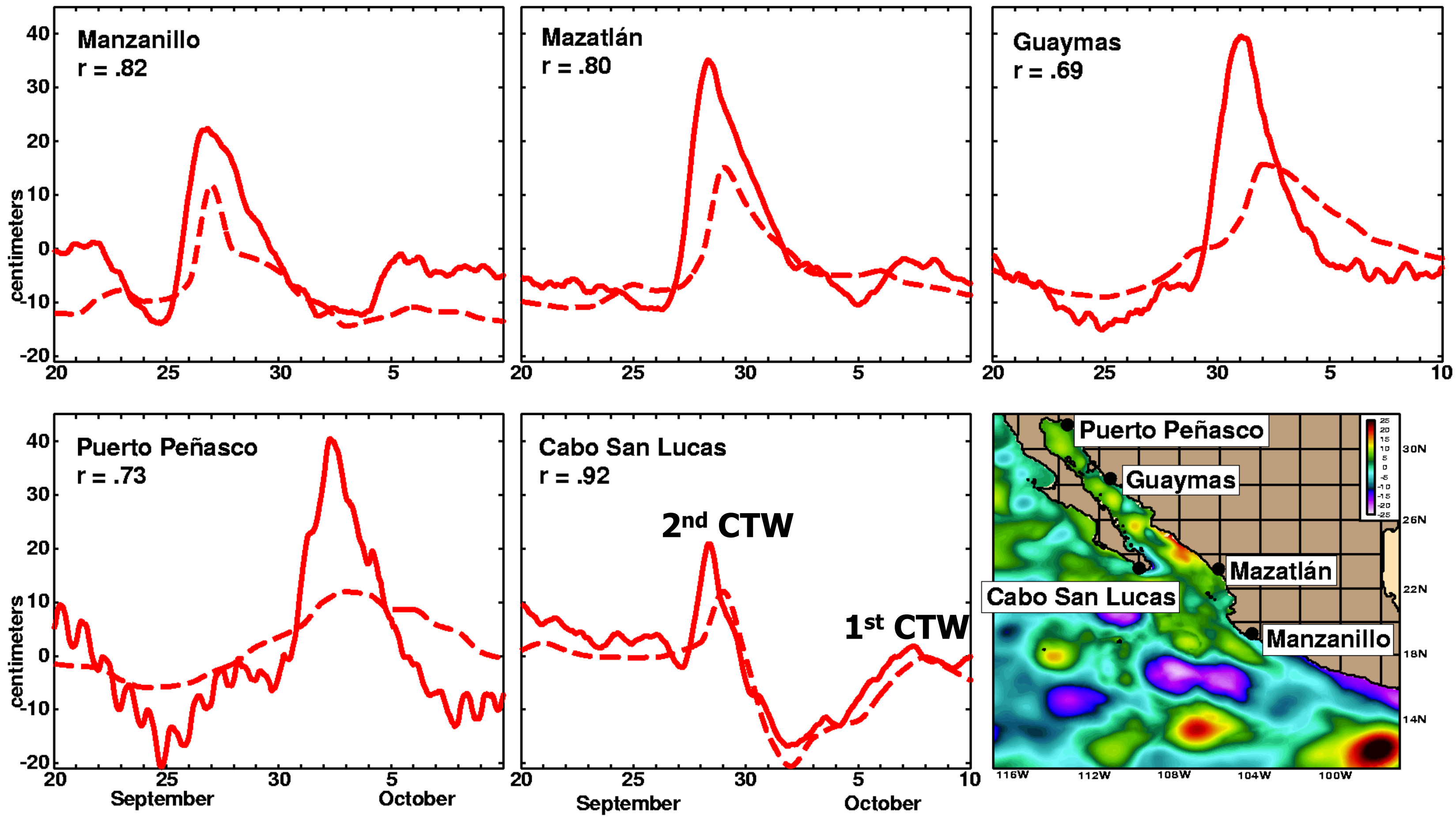
8 October 2001



1/12° Pacific HYCOM forced with FNMOC NOGAPS/HR winds and FNMOC NOGAPS thermal forcing. No data have been assimilated into this model.

⬇ **Marks the leading edge of the first CTW**

Observed (solid) vs. Modeled (dashed) Sea Level Along the Mexican Coast Associated With the Coastally Trapped Waves (CTW) Generated by Hurricane Juliette in 2001



1/12° Pacific HYCOM forced with FNMOC NOGAPS/HR winds and FNMOC NOGAPS thermal forcing. No data have been assimilated into this model. Sea level data provided by the University of Hawaii and the Secretaria de Marina de México.