1/12° Pacific HYCOM Results

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Pacific HYCOM Model Configuration

- Horizontal grid: 1/12° equatorial resolution (2294 x 1362 grid points, ~6.5 km spacing on average)
- 20°S to 65.8°N
- 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: ~3° band along southern and eastern boundary with relaxation to monthly climatological T and S
- Closed boundaries along 20°S, 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
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)

Forced with high frequency climatological **HR** winds and **ECMWF** thermal forcing
Comparison of the Basin-scale Circulation
MODAS climatology vs. 1/12° Pacific HYCOM

Mean dynamic height (dyn cm) wrt 1000 db

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

Mean Error

RMSE

ECMWF

HR

°C

°C
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)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
No ocean data assimilation in HYCOM
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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

Sb-ADCP data from Liang et al. (DSR Pt. II, in press)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
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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

Sb-ADCP data from Liang et al. (DSR Pt. II, in press)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
No ocean data assimilation in HYCOM

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
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
Velocity Cross-section at WOCE PCM-1
Current meter data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 1000 m

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
No ocean data assimilation in HYCOM
Velocity Cross-section at WOCE PCM-1
Current meter data (top) vs. 1/12° Pacific HYCOM (bottom) in the upper 1000 m

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 HR winds and ECMWF thermal forcing
No ocean data assimilation in HYCOM
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)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
No ocean data assimilation in HYCOM
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)
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 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

CTD/ADCP data from Johnson and McPhaden (2001, JPO)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
No ocean data assimilation in HYCOM
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

CTD/ADCP data from Johnson and McPhaden (2001, JPO)
6 year mean from HYCOM forced with high-frequency HR winds and ECMWF thermal forcing
No ocean data assimilation in HYCOM
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

CTD/ADCP data from Johnson and McPhaden (2001, JPO)
6 year mean from HYCOM forced with high-frequency ECMWF winds and thermal forcing
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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

CTD/ADCP data from Johnson and McPhaden (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 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
No ocean data assimilation in HYCOM
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)
6 year mean from HYCOM forced with high-frequency ECMWF winds and 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)
6 year mean from HYCOM forced with high-frequency HR winds and ECMWF thermal forcing
No ocean data assimilation in HYCOM
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)

North Hawaiian Ridge Current (NHRC)
Hawaiian Lee Counter Current (HLCC)

HYCOM mixed layer current field

HR wind forcing

ECMWF wind forcing

excessively strong HLCC extends all the way to the western boundary
unrealistic NHRC
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.)
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)

3-yr mean SSH (cm)

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
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Hawaiian Lee Counter Current (HLCC)

HYCOM mixed layer current field

ECMWF Hawaii modified wind forcing
more realistic HLCC
somewhat improved NHRC

ECMWF wind forcing
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


Cabo San Lucas  Mazatlán

30 September 2001  1 October 2001  2 October 2001

Puerto Peñasco

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

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.