Regional model simulations around Hawaii: Open BC and evaluation with local data

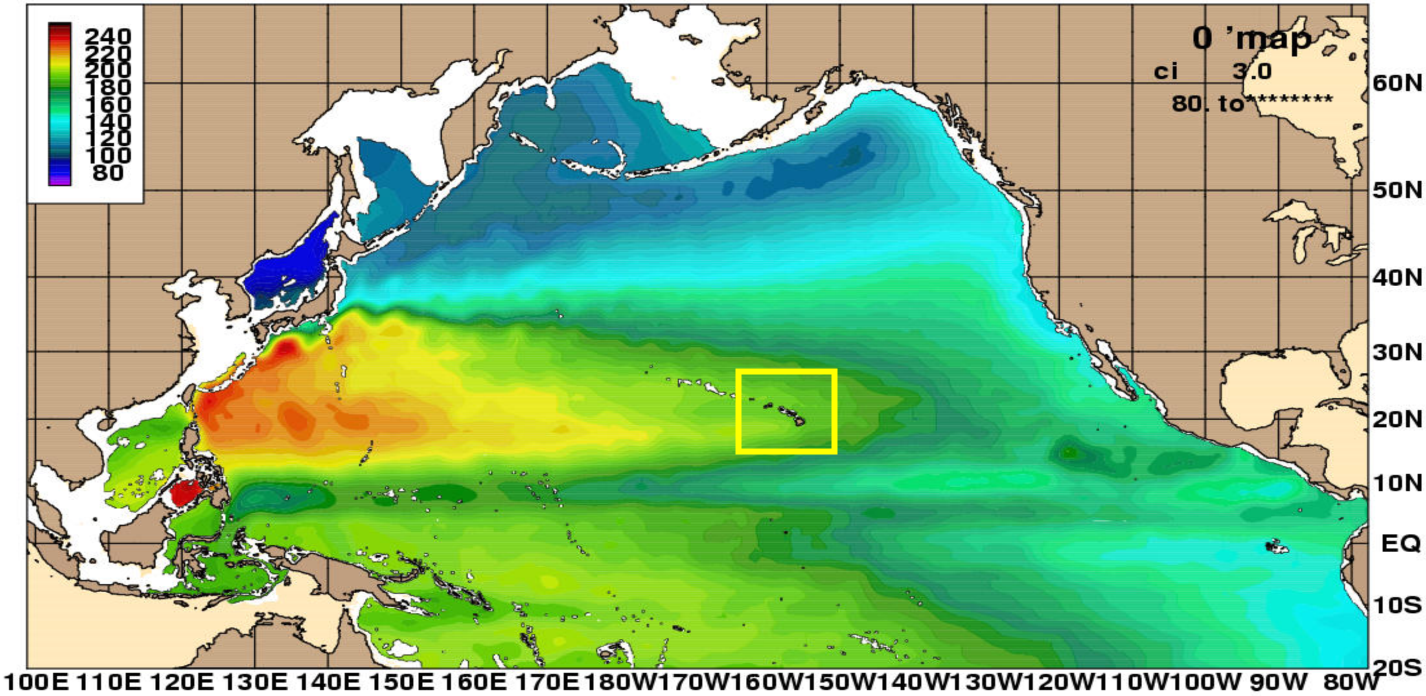
Max Yaremchuk,
Jim Potemra, Yanli Jia, Peter Hacker

International Pacific Research Center
University of Hawaii

Outline

1. STATUS REPORT
    a) 2001 simulations at 0.08^o and 0.04^o resolutions
    b) experiments with open BC
2. Evaluation with local data: HYCOM vs other GCMs
    a) tidal stations
    b) TOPEX/POSEIDON altimetry
    c) CTD/XBT
3. Conclusions
4. Vision for 05/06
5. Technical issues

Hawaiian Islands configuration



Pacific Basin experiment 1979-2003:

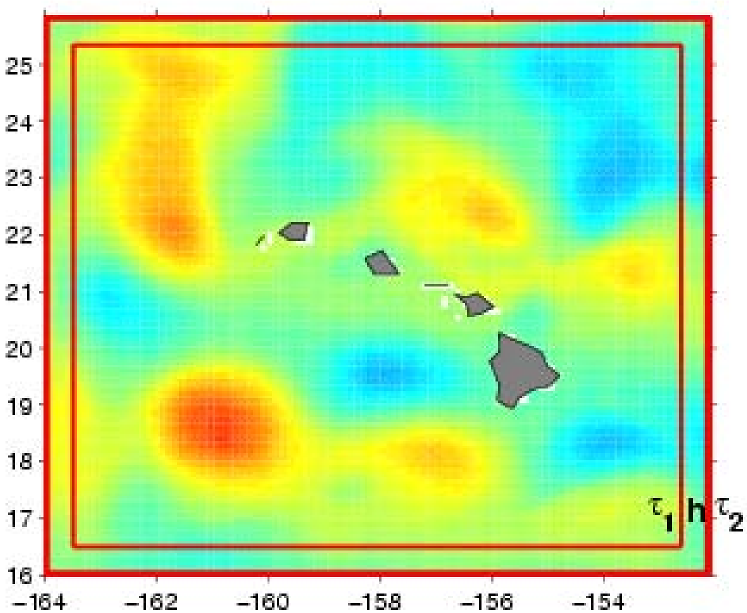
Resolution 0.08°
Forcing: ECMWF 6-hour winds modified near Hawaii ('00-'03); bulk heat flux, E-P + relaxation to climatological SSS
Indonesian throughflow, Bering Strait closed
3° sponge layers at the open boundaries with relaxation to monthly T/S

Hawaiian regional experiments 2001-2002:

164°W – 152°W; 16°N – 26°N
Resolutions: 0.08°, 0.04°, … , 0.01°?
Open boundaries:
width of the nudging zone: 10-20dx
Relaxation times: 0.1-50 d

Experiments with open BC

1. 12-18 months: (01.01.2001-30.06.2002)
2. Relaxation to reference T,S,p,U,V, linearily interpolated in time and space , $\tau_1 = 1...50$d; $\tau_2 = 0.1...5$d.



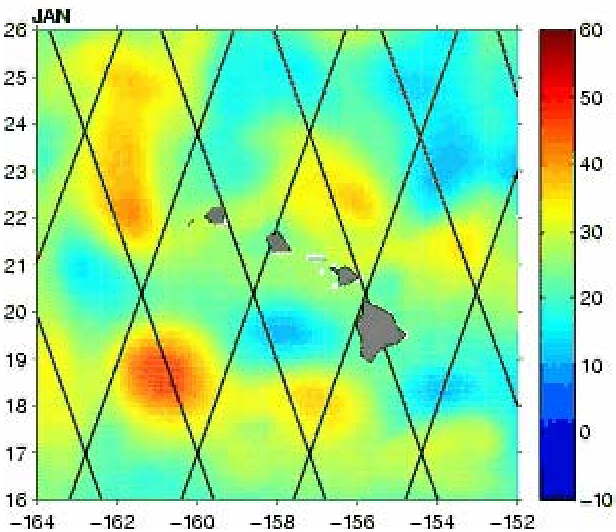
SGI/3000

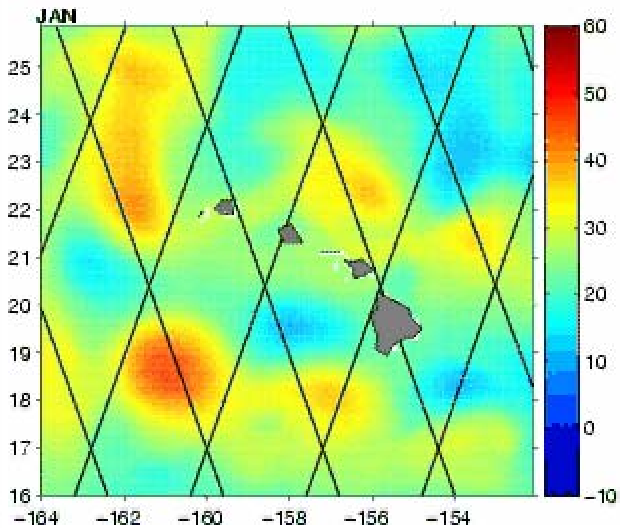
Resolution	walltime/month (16CPUs)	memory
0.08°	2 hours	0.5Gb
0.04°	15 hours	2.0Gb
0.02°	5 days	8.0Gb
0.01°-0.04°	10-15 days	10-12Gb

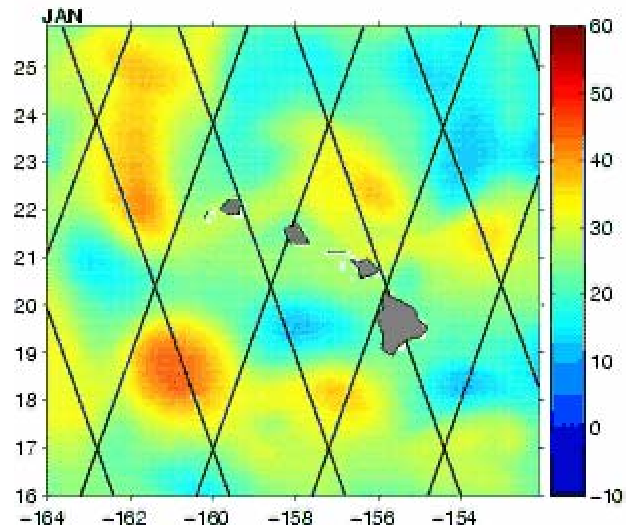
Altix? (:3); LINUX cluster? (:5)

τ_1 (days)	1	10	15	20	25	50
τ_2(days)	.1	1	1.5	2	2.5	5
dx	0.04°	0.04°	0.04°	0.04°	0.04°	0.04°
	0.08°	0.08				

2001 simulations







dx=0.08° h=10dx
$\tau_1 = .1$**d** $\tau_2 = 1$**d**

Corr=+0.28

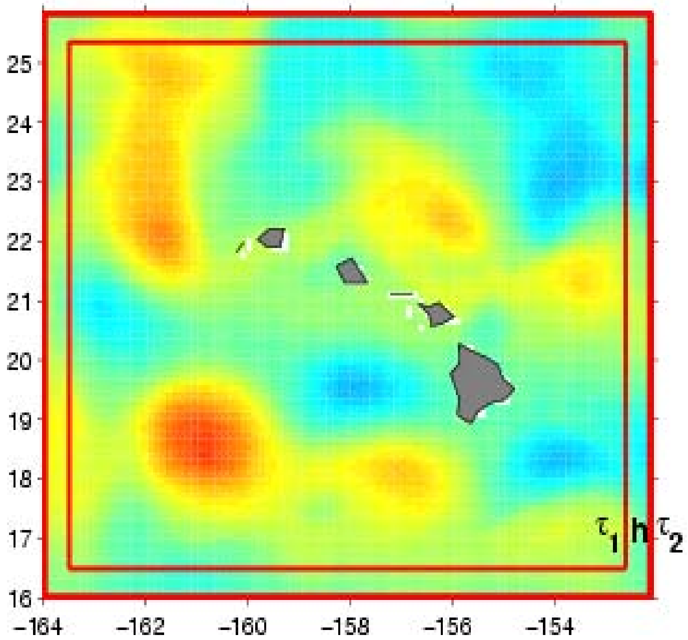
dx=0.04° h=10dx
$\tau_1 = .1$**d** $\tau_2 = 1$**d**

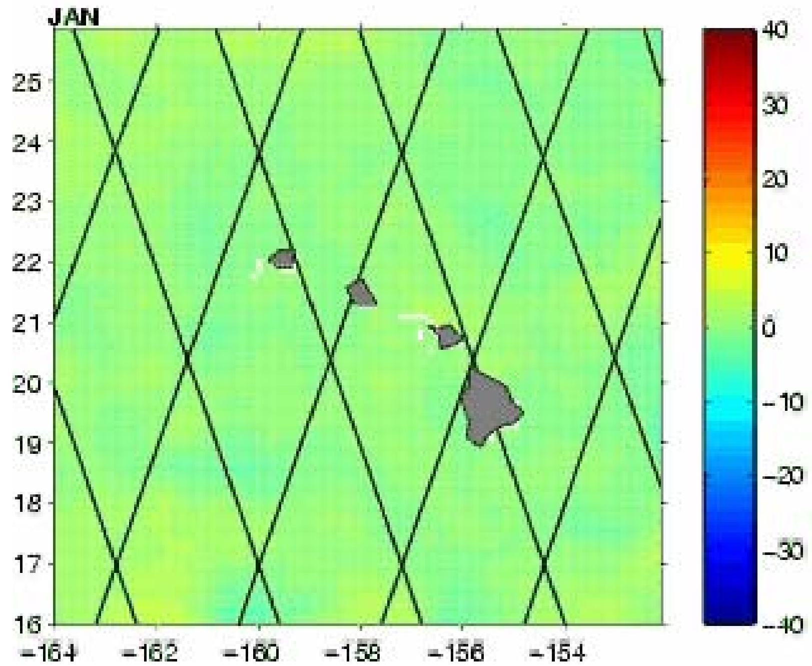
Corr=+0.26

dx=0.04° h=10dx
$\tau_1 = 1$**d** $\tau_2 = 10$**d**

Corr=+0.35

Difference between two open BC configurations





h=10dx

$\tau_1 = 1$**d** $\tau_2 = 10$**d**

WNSE boundaries

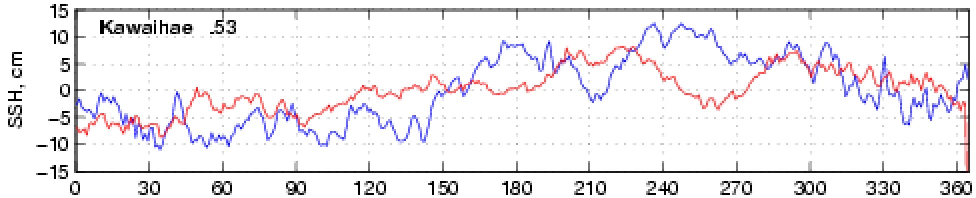
h=20dx

$\tau_1 = .75$**d** $\tau_2 = 15$**d** **E-boundary**

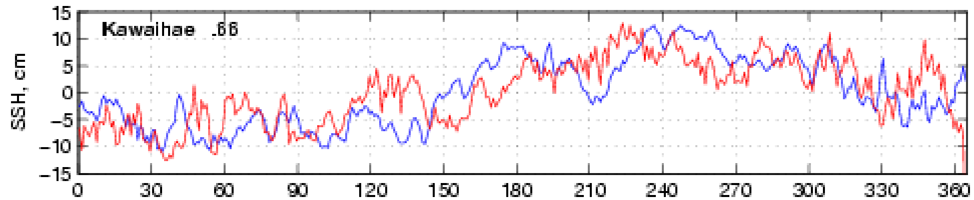
h=10dx

$\tau_1 = 1.5$**d** $\tau_2 = 15$**d** **WNS-boundaries**

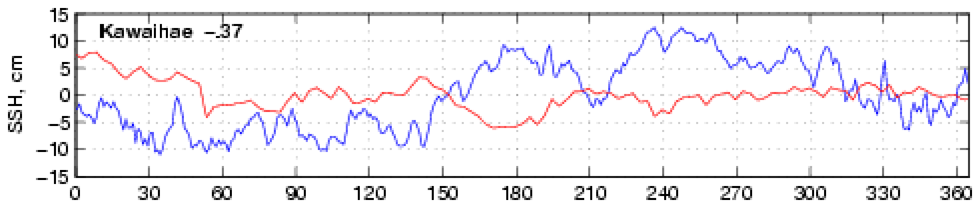
Comparison with tidal data



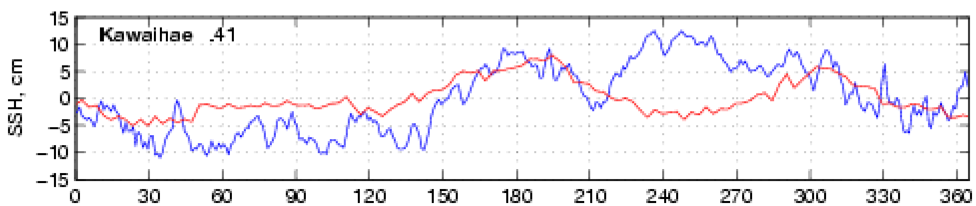
HYCOM
dx=0.08°



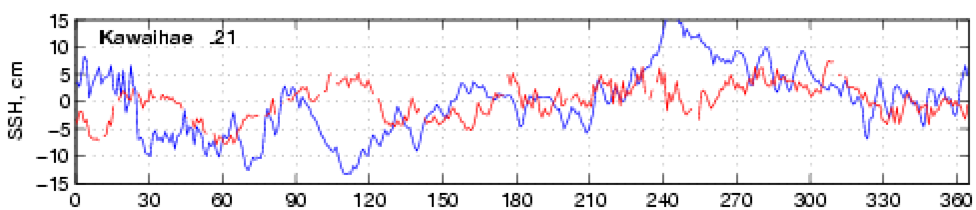
HYCOM
dx=0.04°



OfES (ECMWF)
dx=0.10°

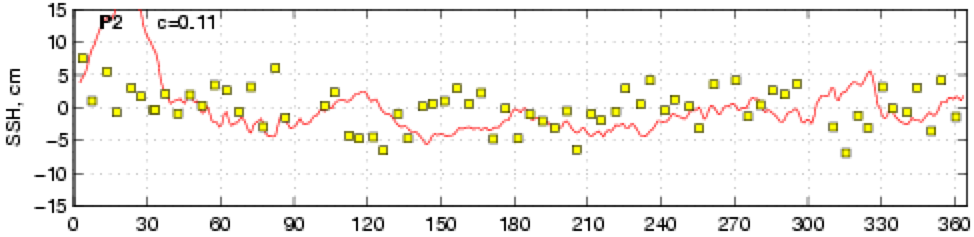


OfES (Qscat)
dx=0.10°

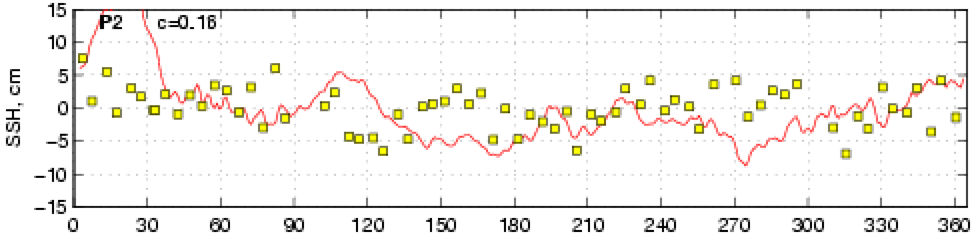


NLOM
dx=0.06°

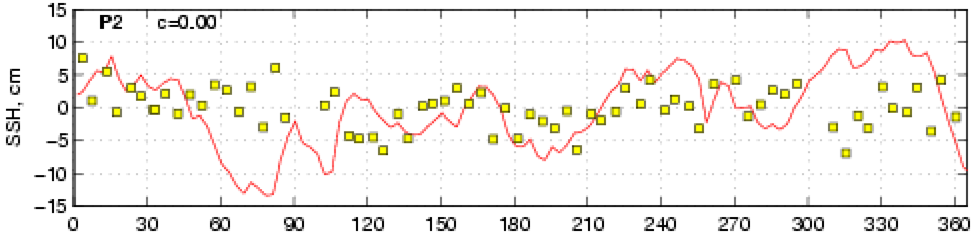
Comparison with T/P data



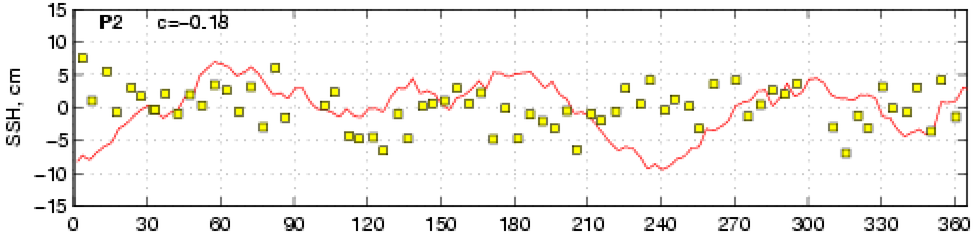
HYCOM dx=0.08°



HYCOM dx=0.04°

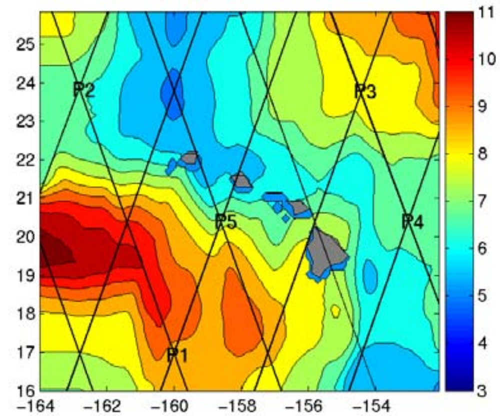


OfES (ECMWF) dx=0.10°

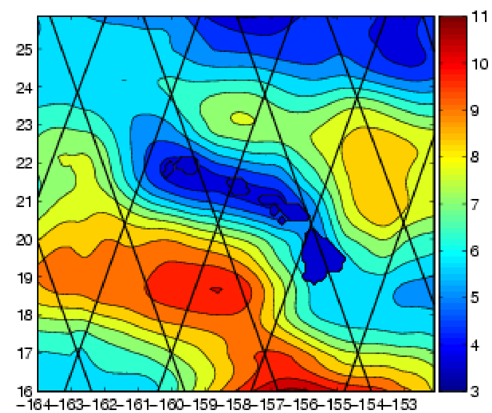


OfES (Qscat) dx=0.10°

rms SSH variance (2° horizontal smoothing)



T/P data

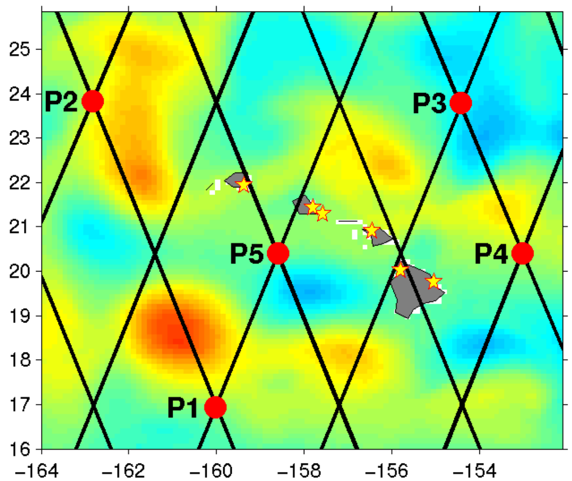


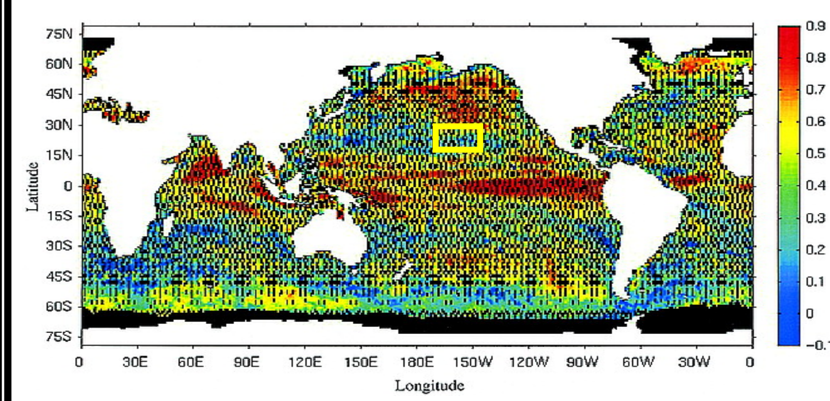
HYCOM.04

Cross-validation of the models using SSH

Model-data correlations

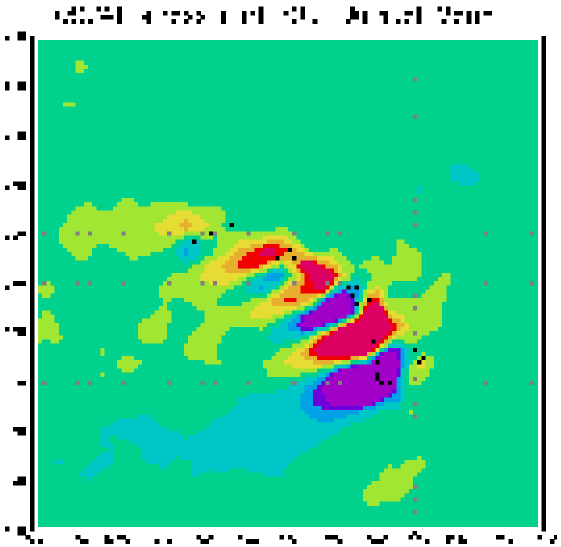
Station	HY.08	HY.04-0	HY.04-1	OfES(EC)	OfES(QS)	NLOM	SODA
Hilo	.33	.19	.15	-.17	.23	.06	-.07
Honolulu	.16	.32	.17	-.23	.18	.12	-.08
Kahului	.07	.27	.25	-.15	.13	.22	-.30
Kawaikae	.53	.66	.51	-.37	.41	.21	.14
Mokuoloe	.33	.29	.08	-.22	.19	.20	-.01
Nawiliwili	.26	.36	.43	.15	.36	.11	.15
mean	.28	.35	.26	-.16	.25	.16	-.03
P1	-.51	.01	-.43	.38	.24	.08	.15
P2	.48	.34	.46	.17	-.43	-.15	.53
P3	.37	-.02	.33	-.32	-.32	.54	.38
P4	-.00	-.52	-.08	.41	-.03	-.01	.51
P5	-.52	-.53	-.38	.19	.30	.00	.57
mean	-.03	-.14	-.02	.17	-.05	.09	.44

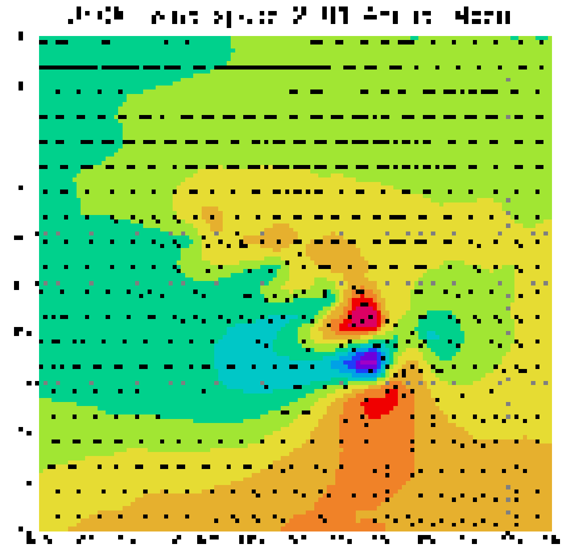


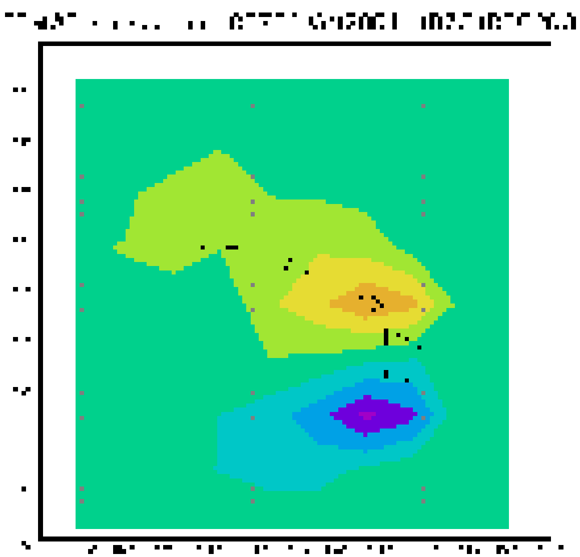


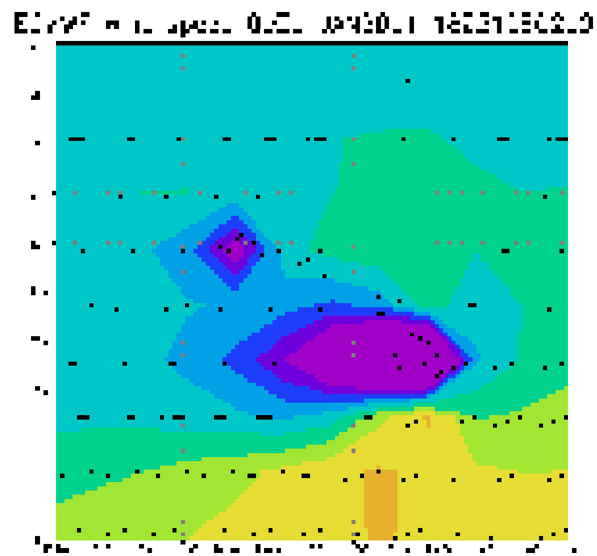
MIT GCM, '93-'97, [Lee et al., 2002]

Qscat vs ECMWF

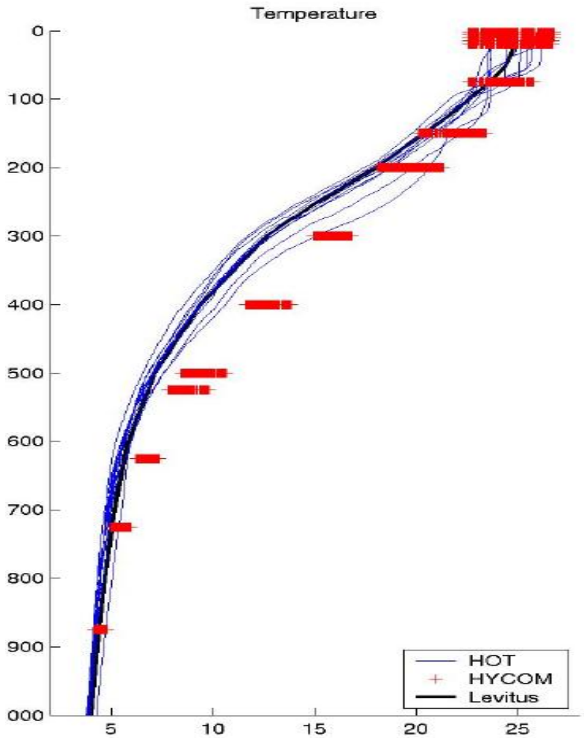


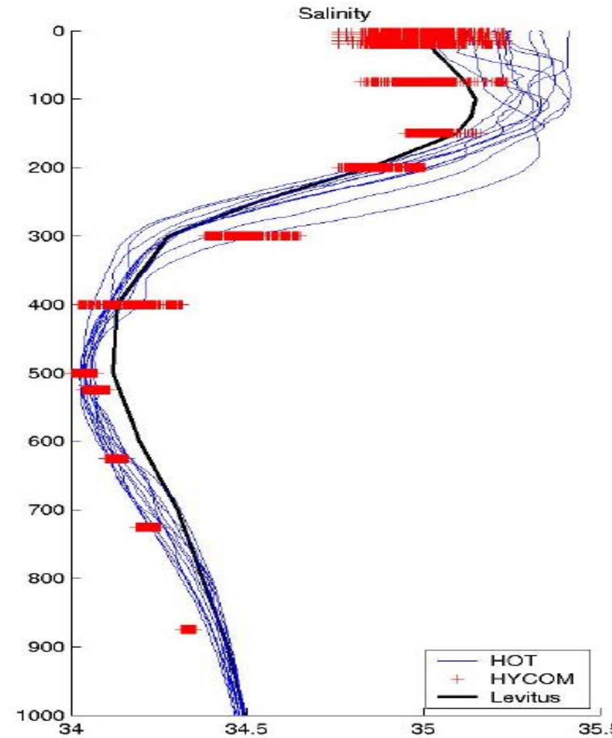




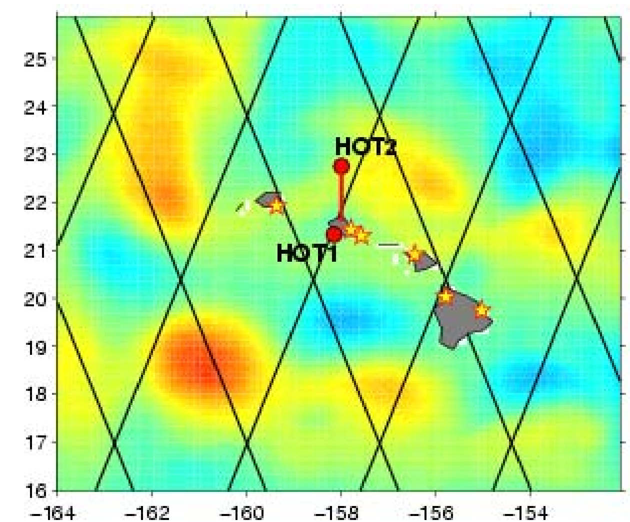


Comparison with CTD data (HOT2 station)

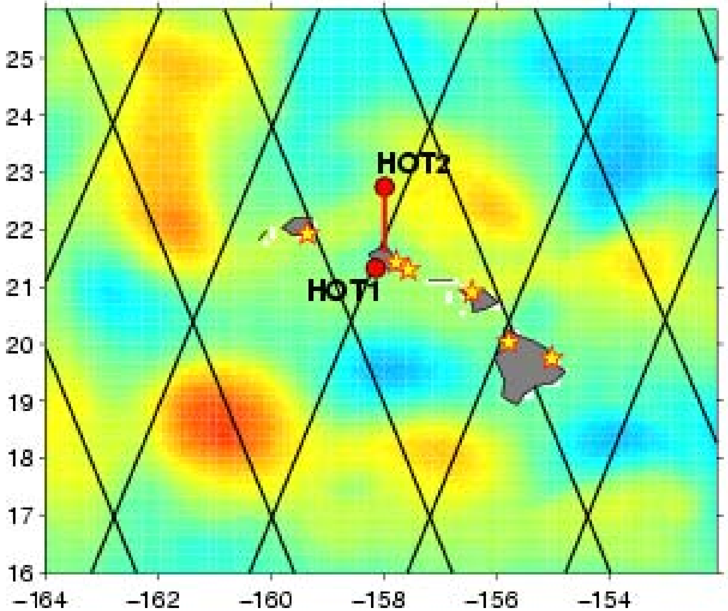


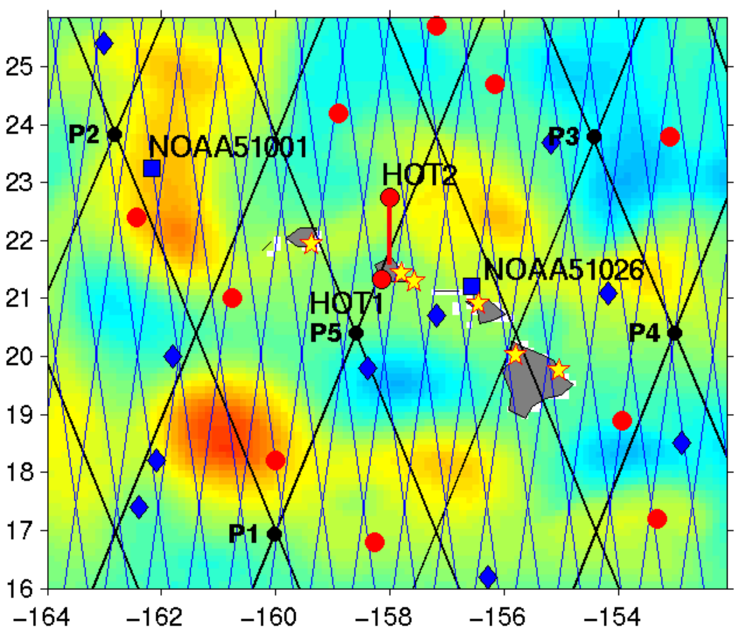


depth(m)	$\langle T_{OBS} \rangle$	$\langle T_{HYCOM} \rangle$	$\langle S_{OBS} \rangle$	$\langle S_{HYCOM} \rangle$
2.5	24.87±1.23	**24.99±1.15**	35.039±0.218	**34.980±0.093**
5	24.86±1.22	**24.98±1.15**	35.040±0.216	**34.980±0.093**
10	24.84±1.22	**24.97±1.15**	35.041±0.215	**34.980±0.094**
20	24.80±1.23	**24.95±1.15**	35.044±0.214	**34.981±0.095**
75	23.50±0.90	**24.42±0.83**	35.162±0.150	**35.007±0.090**
150	20.56±0.93	22.37±0.86	35.164±0.094	35.030±0.038
200	18.33±1.15	19.64±0.80	34.954±0.152	**34.878±0.065**
300	13.00±0.93	15.62±0.50	34.342±0.095	34.492±0.069
400	9.59±0.55	12.57±0.56	34.129±0.053	**34.184±0.065**
500	7.26±0.38	9.41±0.57	34.064±0.037	**34.047±0.018**
625	5.55±0.25	6.57±0.28	34.154±0.040	**34.125±0.018**
725	4.91±0.19	5.20±0.24	34.279±0.033	34.218±0.018
875	4.36±0.15	**4.30±0.16**	34.418±0.018	34.331±0.013



Data assimilation





Low-resolution data (2^o - $.25^o$ resolution)

Global:

1. **SSH altimetry (track, gridded (. 33^o), 7 days)**
2. **SST (gridded, 0.16^o , every 5-7 days)**
3. **SSS (gridded 0.16^o , every 5-7 days?)**

Local:

4. **Tidal stations (continuous)**
5. **In situ soundings, ADCP profiles**
   (HOT cruises, 0.1^o, every 2-4 weeks)
6. **Surface & ARGO drifters (1- 3^o, 1- 10 days)**

Hi-resolution data for nested configurations (0.04^o-0.01^o resolution, Local):

1. **Coastal HFR radars (0.01^o, 10-20 min)**
2. **Gliders (T/S, 0.01^o, 10-20 min)**

Method:

MVOI, PMOA, ROIF/ROAF, SEEK filter?…

Conclusions

0. Experiments with open BC seem to show better performance with the relaxation time scale of 1-10 days
1. Higher resolution seems to provide better agreement with tidal data (regHYCOM-0.08 vs regHYCOM –0.04)
2. Pacific HYCOM 0.04 is in better agreement with tidal data than global OfES (0.10), NLOM, and SODA/POP1.4
3. All GCMs considered (HYCOM, NLOM, OfES) are doing bad with regard to T/P data [without assimilation].
4. QuikScat winds definitely improve model performance in reproducing tidal station records (OfES-ECMWF vs OfES-QScat)
5. Data assimilation improves performance with regard to T/P data but has no effect on performance with regard to tidal station data (SODA/POP1.4)

Vision for 2005/2006

1. Comparison with local data, other models (global OfES, MIT Hawaian regional ROMS) - ongoing , and data assimilation products (MIT, SODA, Pacific/global HYCOM?)
2. Experiments with higher resolution wind forcing (Qscat, 0.25^o; local NOAA product, 0.02^o) and bottom topography (up to 0.01^o in area h < 2000m around Hawaii)
3. Nesting up to 0.01^o
4. Start implementing sequential data assimilation

Technical issues

1. HYCOM data assimilation products/software
2. Module for tracers (ongoing project with local fisheries)
3. Tidal module (important for higher-resolution nested configurations)
4. Configuring HYCOM for Altix3000, Linux cluster?