A Coastal Atmosphere-Ocean Coupled System (CAOCS) for East Asian Marginal Sea (EAMS) Prediction

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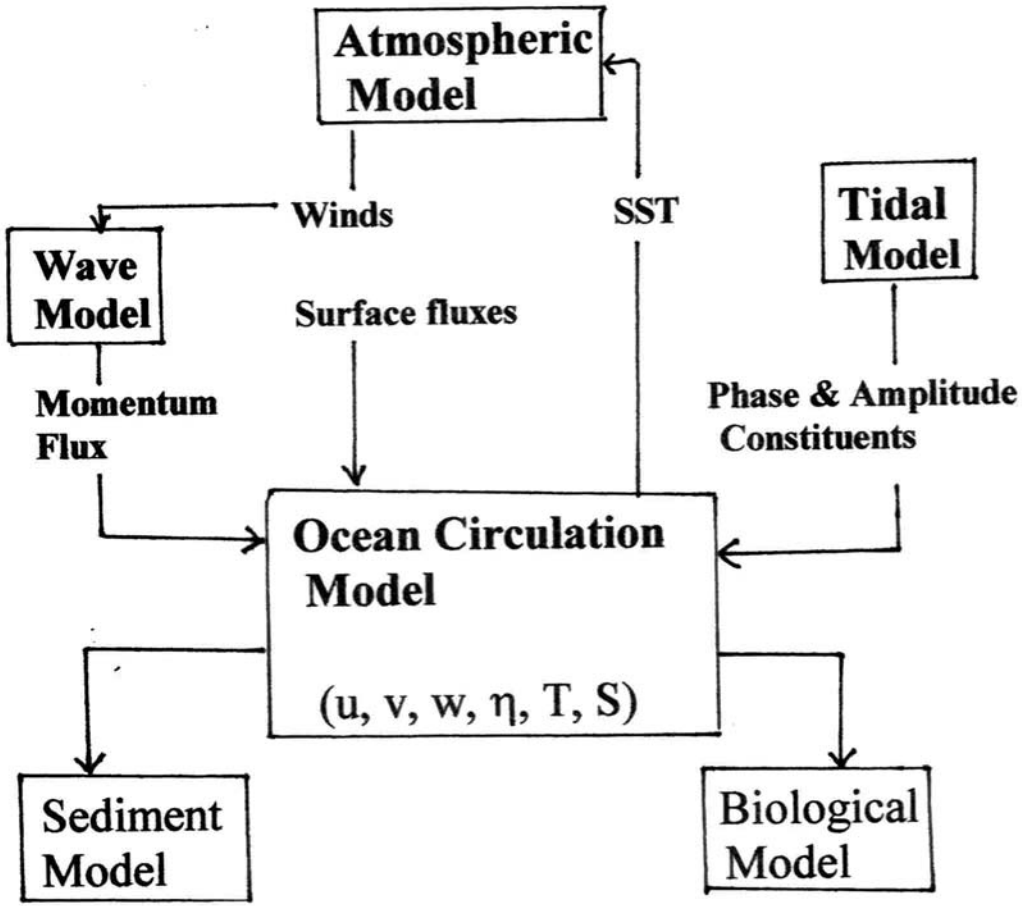
Coastal Model

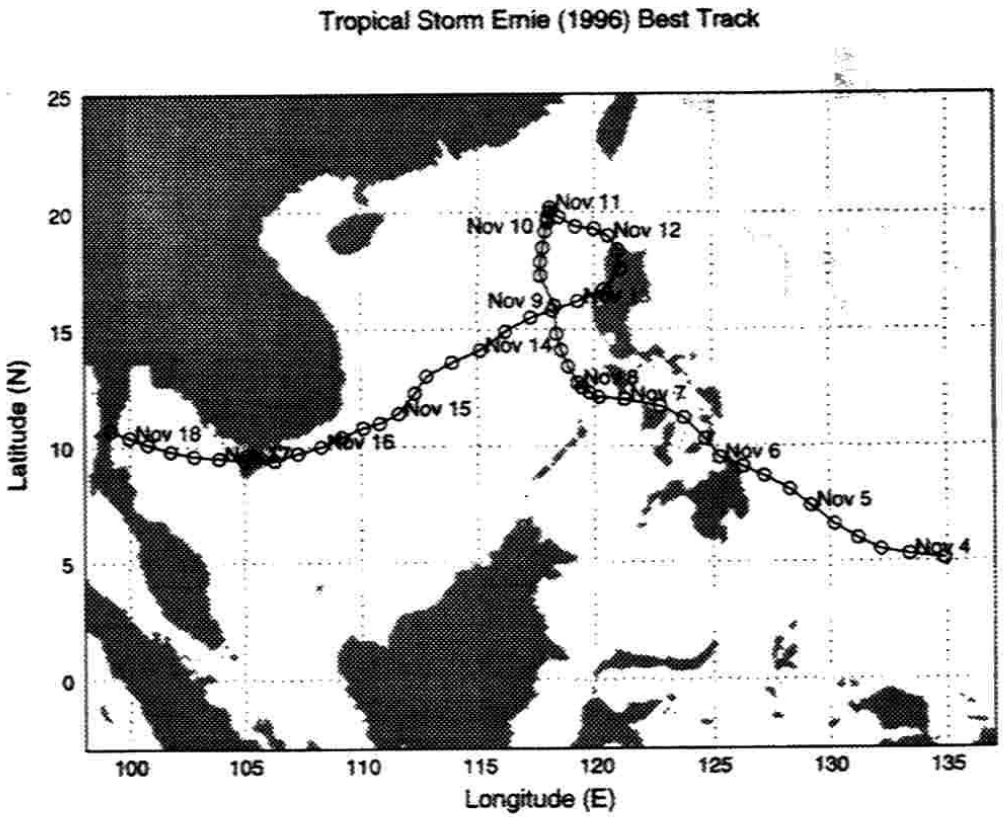


Necessity for Air-Ocean Coupling

- (1) Sparse Meteorological Observation over Ocean
- (2) Uncertain Surface Fluxes
- (3) Nowcast/Forecast

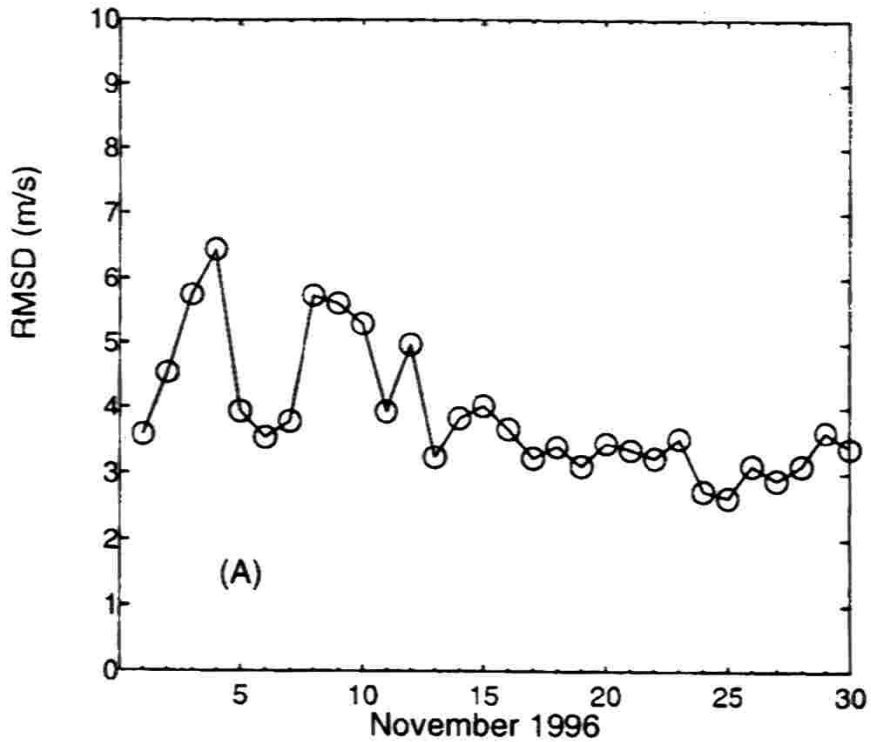
Uncertain Atmospheric Forcing

The track of the tropical cyclone Ernie 4-18 November, 1996 (from Chu et al., 1998).



RMS Difference Between NSCAT and NCEP Winds

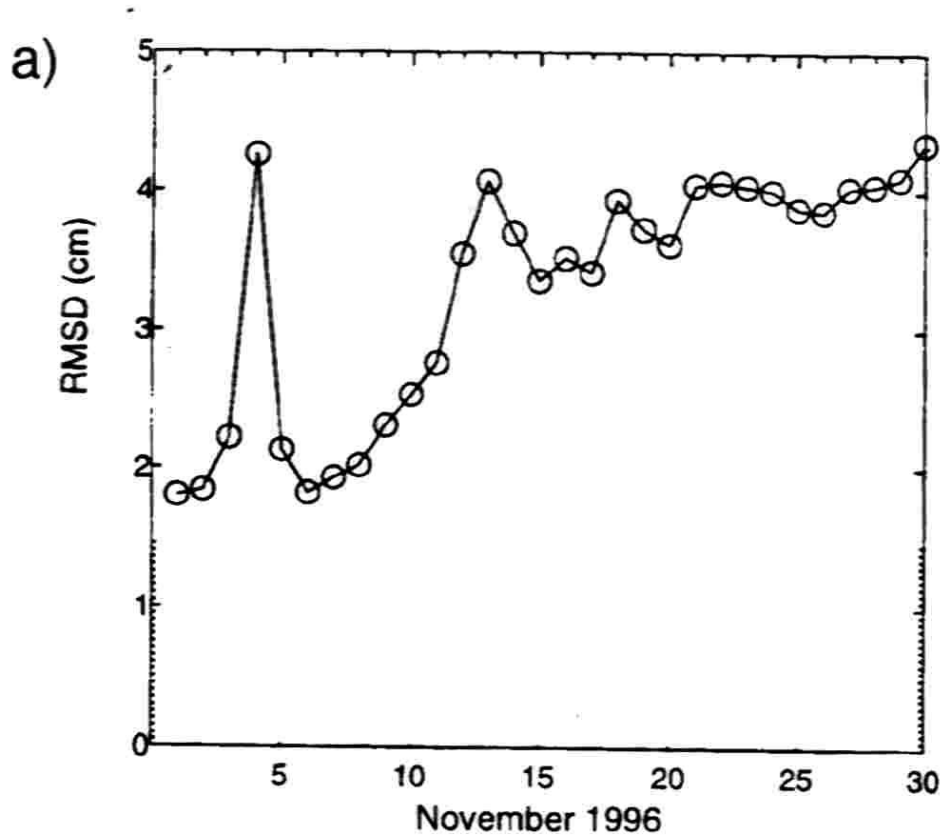
Temporally varying root-mean-square difference between daily mean NSCAT and NCEP winds over the whole South China Sea (from Chu et al., 1998).



Temporally Varying RMS Difference Between POM Model Results Under the Two Wind Forcing

(Chu et al. 1998, JGR)

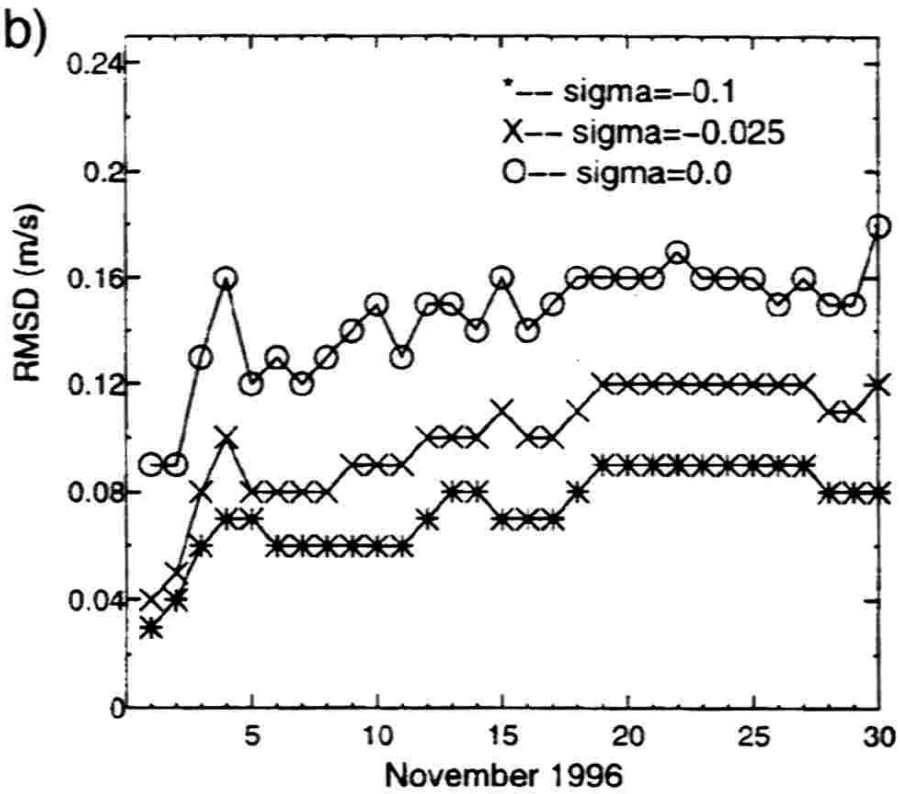
- Surface elevation



Temporally Varying RMS Difference Between POM Model Results Under the Two Wind Forcing

(Chu et al. 1998, JGR)

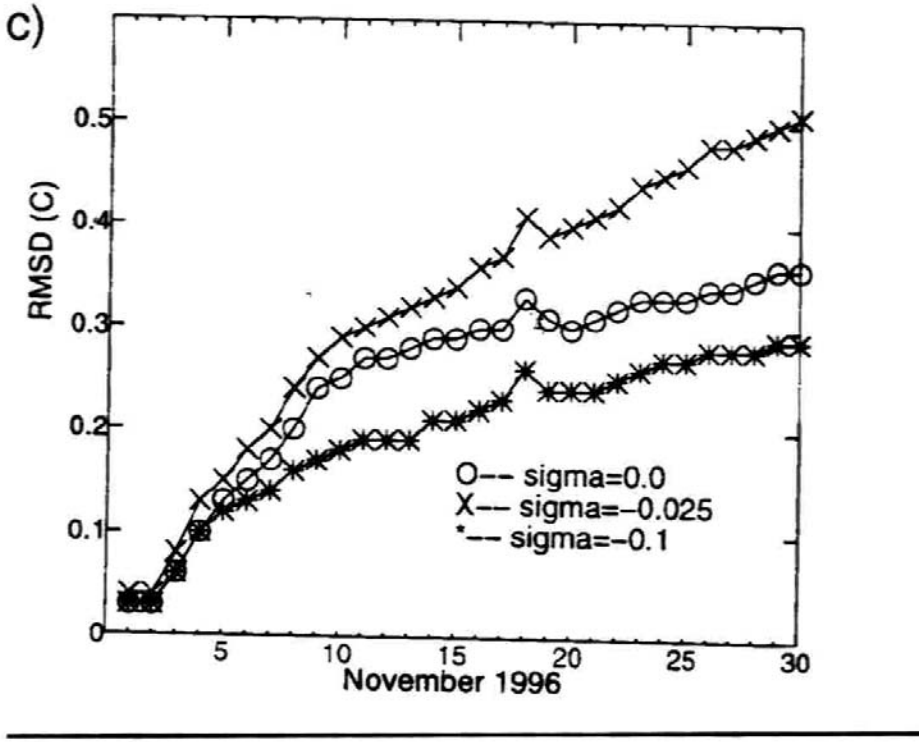
- Velocity



Temporally Varying RMS Difference Between POM Model Results Under the Two Wind Forcing

(Chu et al. 1998, JGR)

- Temperature



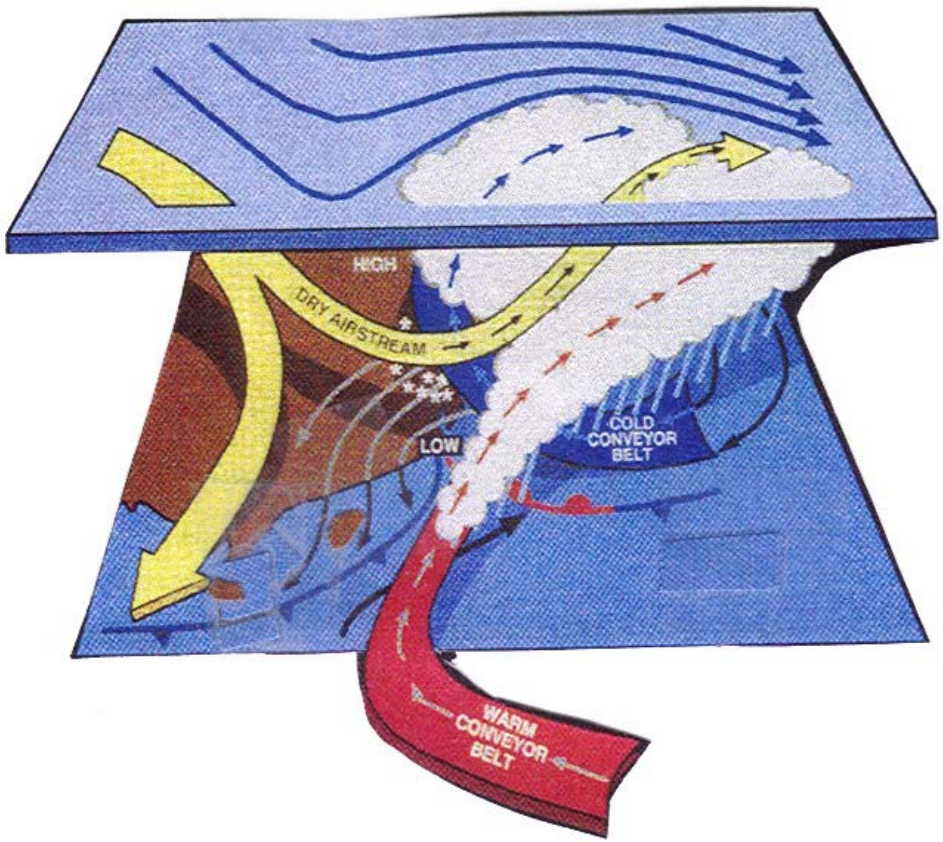
CAOCS Components

- Atmosphere: MM5-V3.4
- Ocean: POM
- Land Surface: BATS

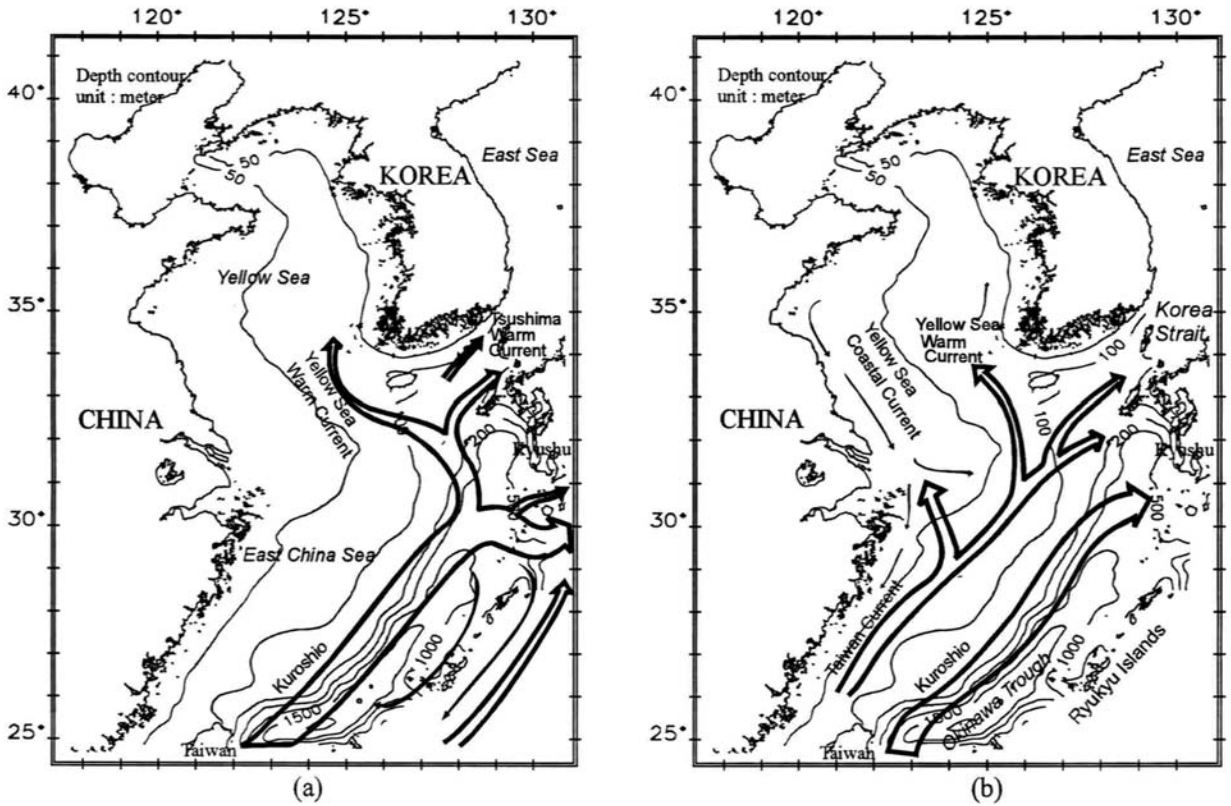
CAOCS for East Asian Marginal Sea Prediction

Chu et al. (1999, 2000)

Atmospheric Circulation in EAMS

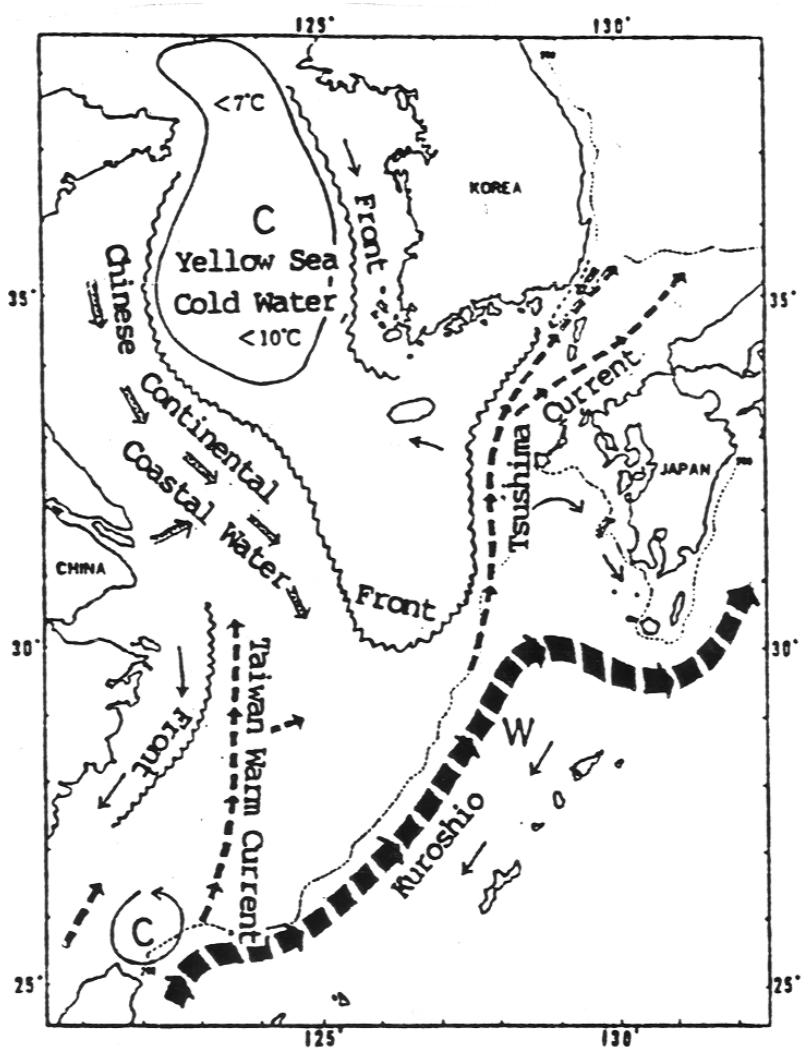


East Asian Circulation System

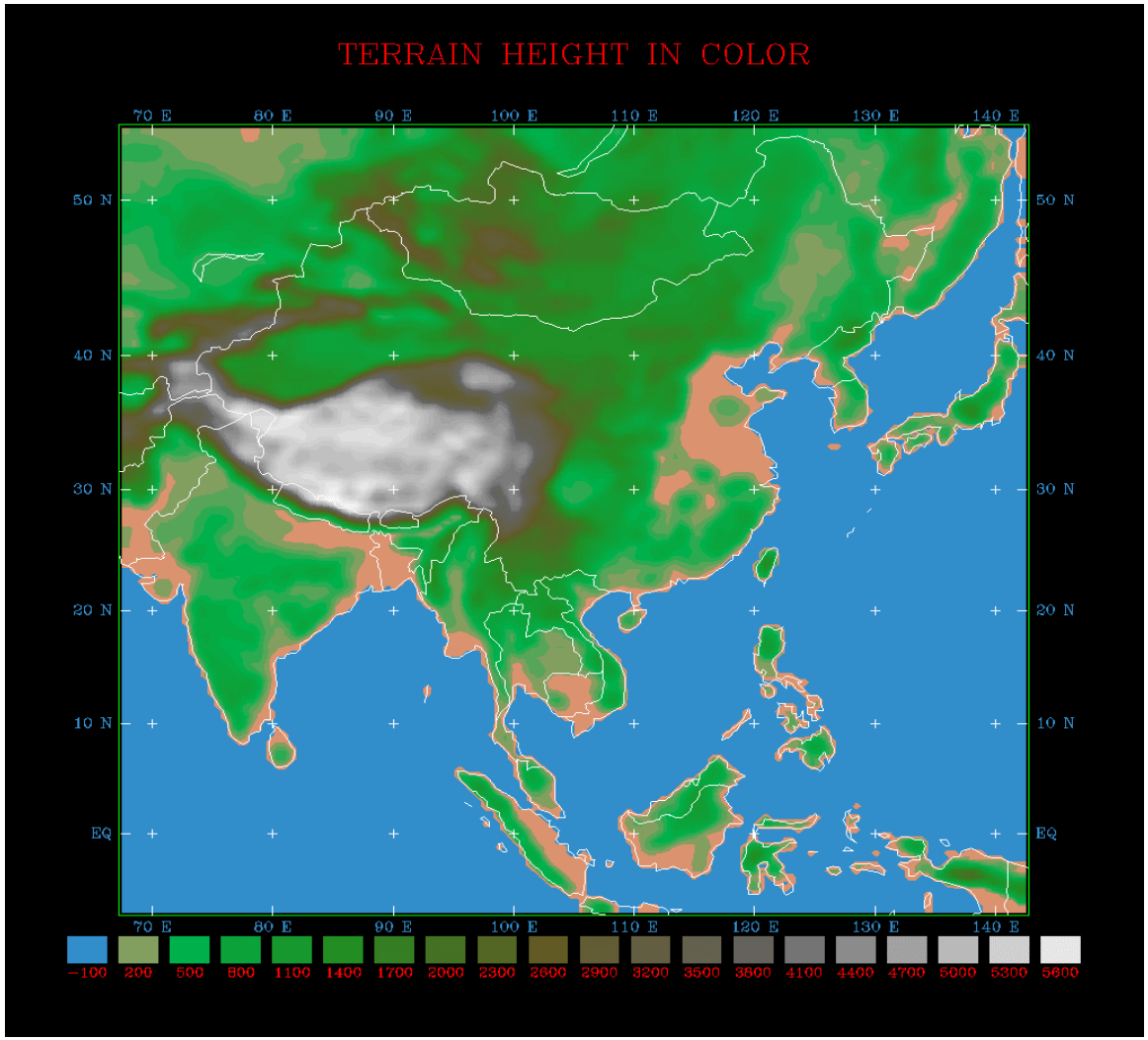


- Nitani (1972)
- Beardsley et al. (1983)

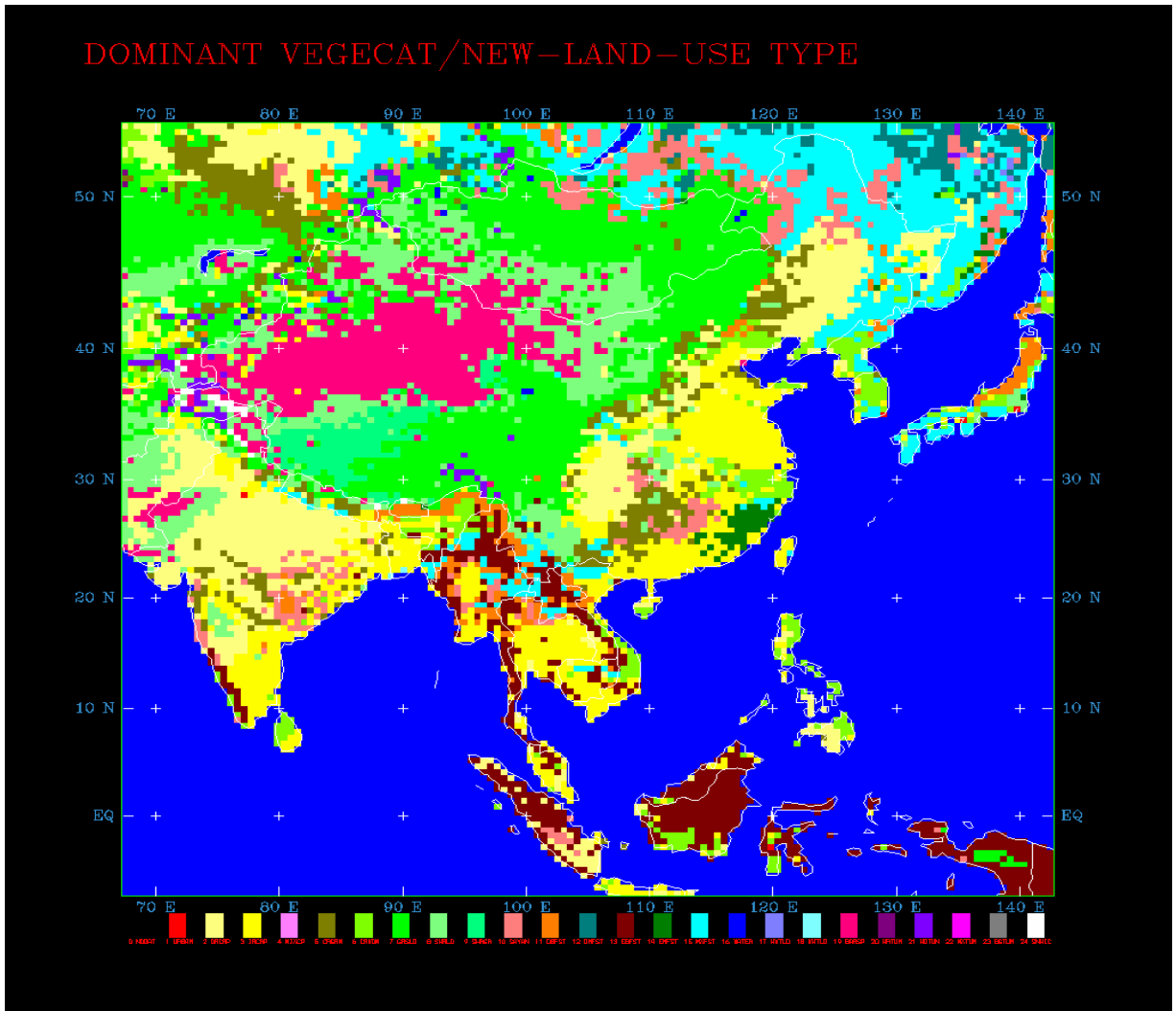
Water Mass Distribution of the Yellow Sea (Kondo 1985)



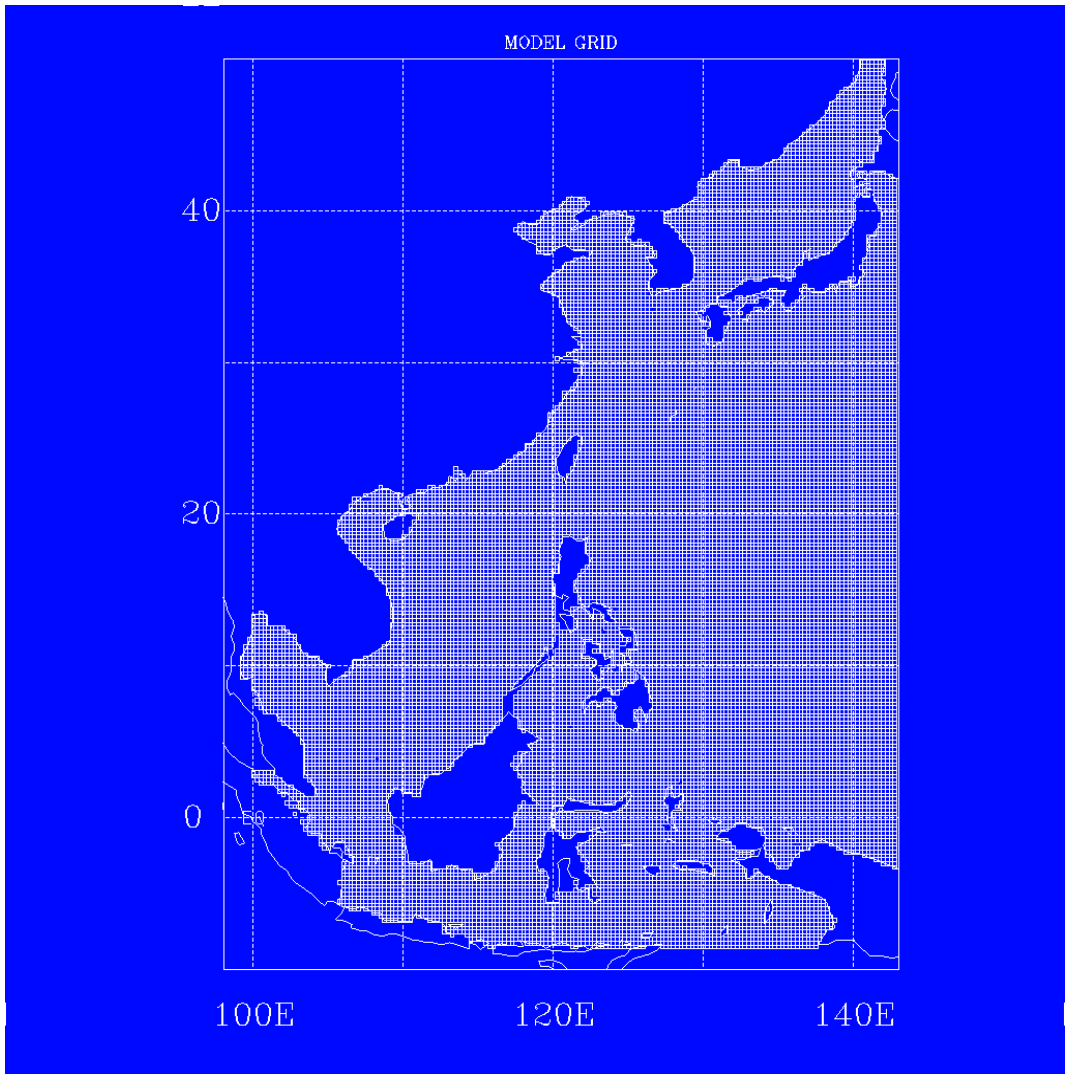
Area for Atmospheric Model



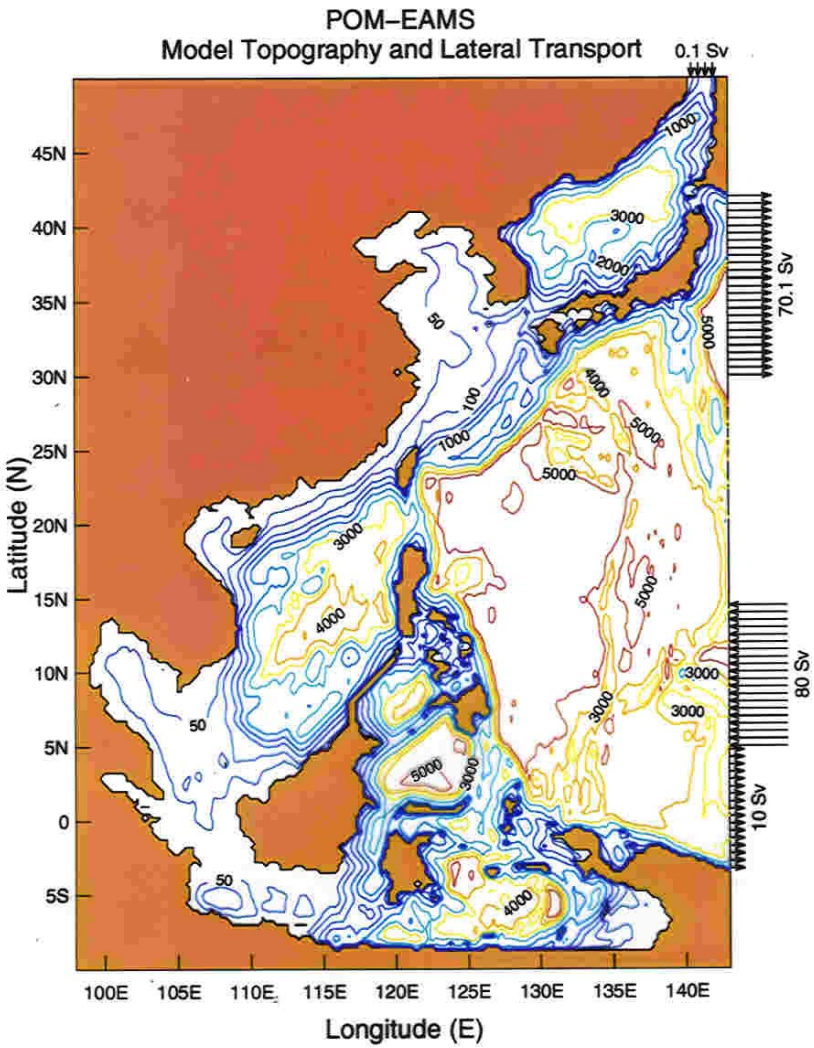
Distribution of Vegetation



Area for Ocean Model



Ocean Bottom



CAOCS Numerics

- MM5V3.4
  - Resolution
    - Horizontal: 30 km
    - Vertical: 16 Pressure Levels
  - Time step: 2 min
- POM
  - Resolution
    - Horizontal: $1/6^{o} \times 1/6^{o}$
    - Vertical: 23 σ levels
  - Time Steps: 25 s, 15 min

Ocean-Atmospheric Coupling

- Surface fluxes (excluding solar radiation) are of opposite signs and applied synchronously to MM5 and POM
- MM5 and POM Update fluxes every 15 min
- SST for MM5 is obtained from POM
- Ocean wave effects (ongoing)

Lateral Boundary Conditions

- MM5: ECMWF T42
- POM: Lateral Transport at 142^{o}E

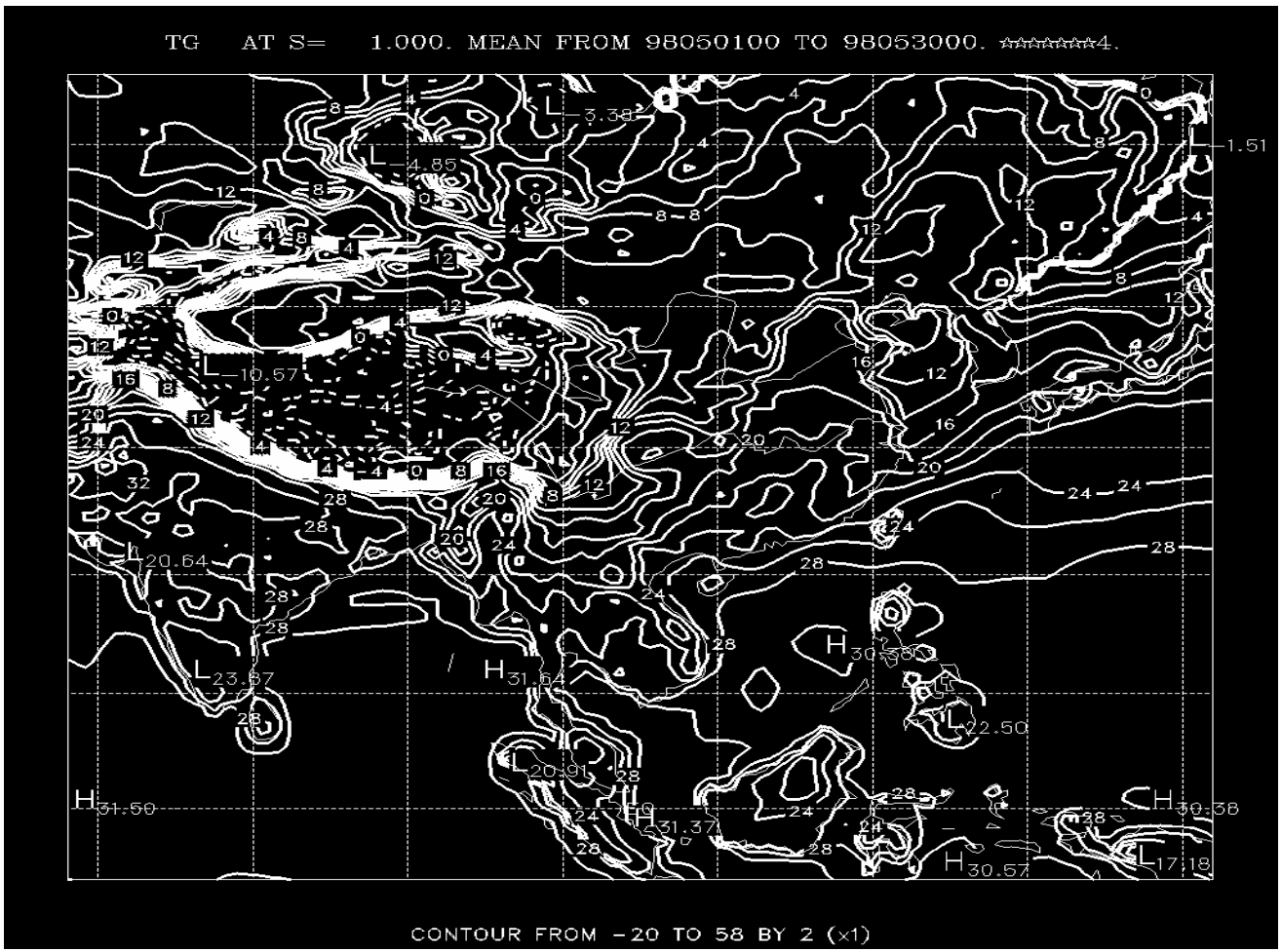
MM5 Initialization

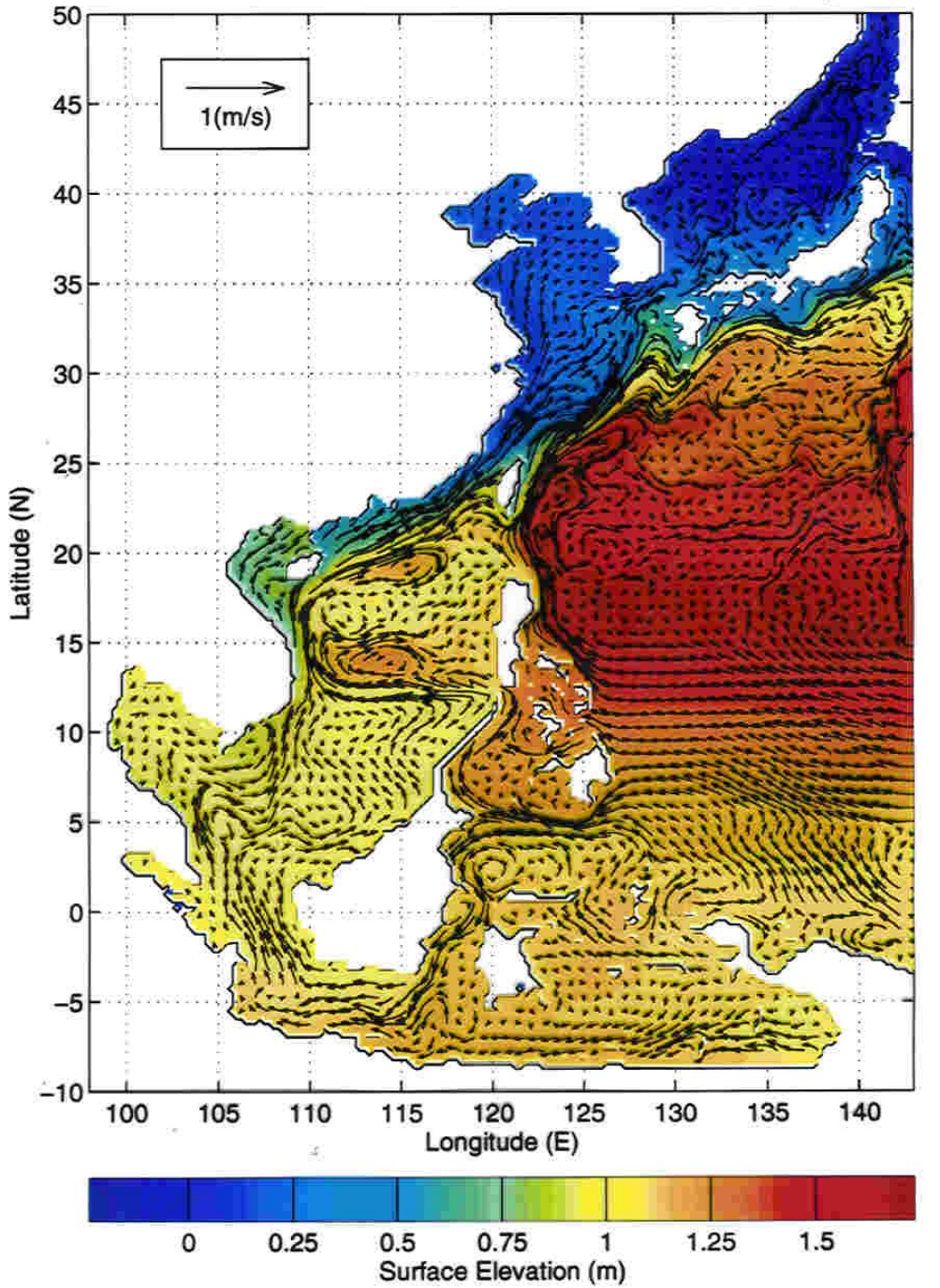
- Initialized from: 30 April 1998 (ECMWF T42)

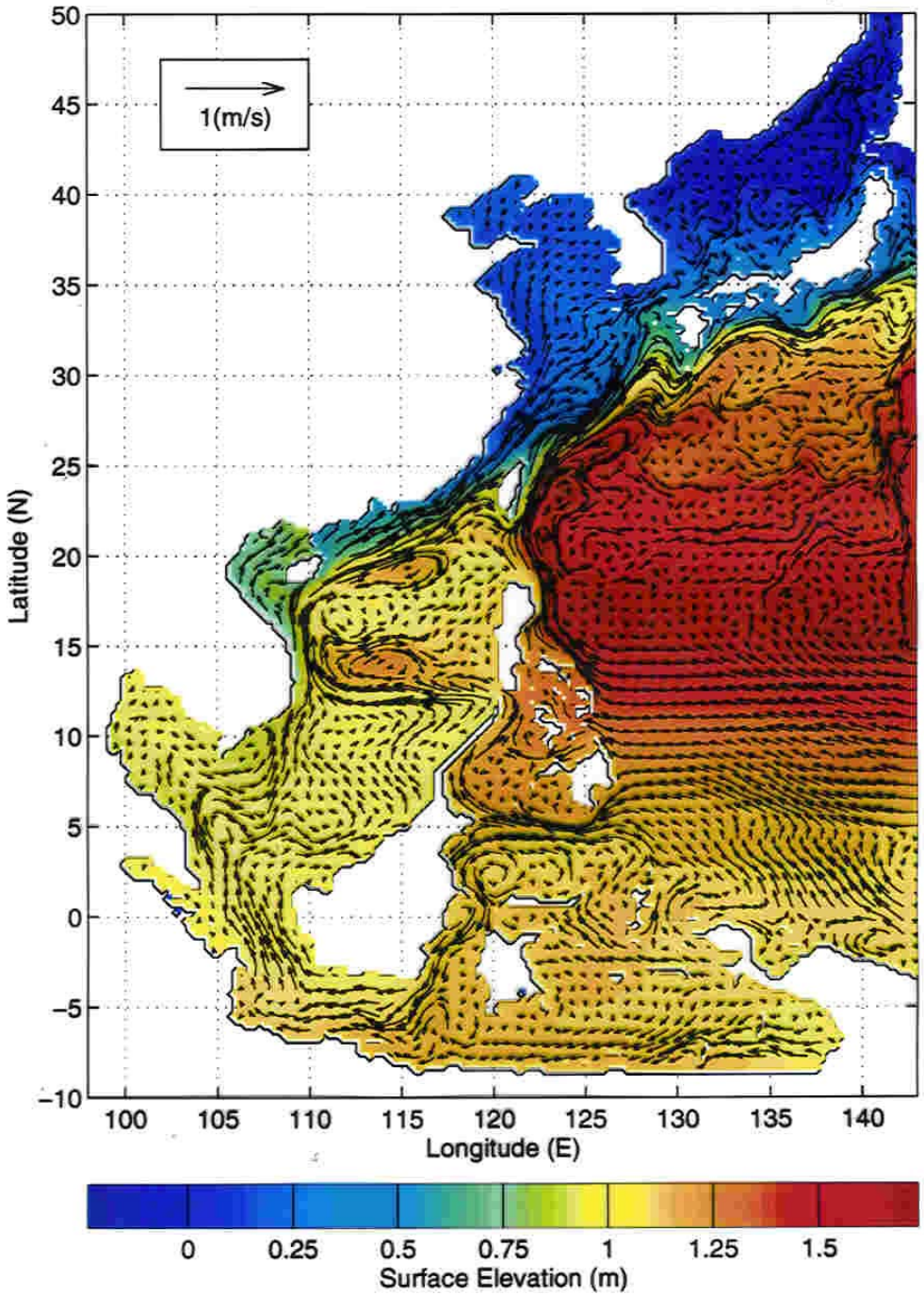
Three-Step Initialization of POM

- (1) Spin-up
  - Initial conditions: annual mean (T,S) + zero velocity
  - Climatological annual mean winds + Restoring type thermohaline flux (2 years)
- (2) Climatological Forcing
  - Monthly mean winds + thermohaline fluxes from COADS (3 years)
- (3) Synoptic Forcing
  - Winds and thermohaline fluxes from NCEP (1/1/96 – 4/30/98)
- (4) The final state of the previous step is the initial state of the following step

Simulated Surface Air Temperature, May 98




Simulated 1998 Jun Surface Elevation and Velocity Fields
1(m/s)
Latitude (N)
Longitude (E)
50
45
40
35
30
25
20
15
10
5
0
−5
−10
100
105
110
115
120
125
130
135
140
0
0.25
0.5
0.75
1
1.25
1.5
Surface Elevation (m)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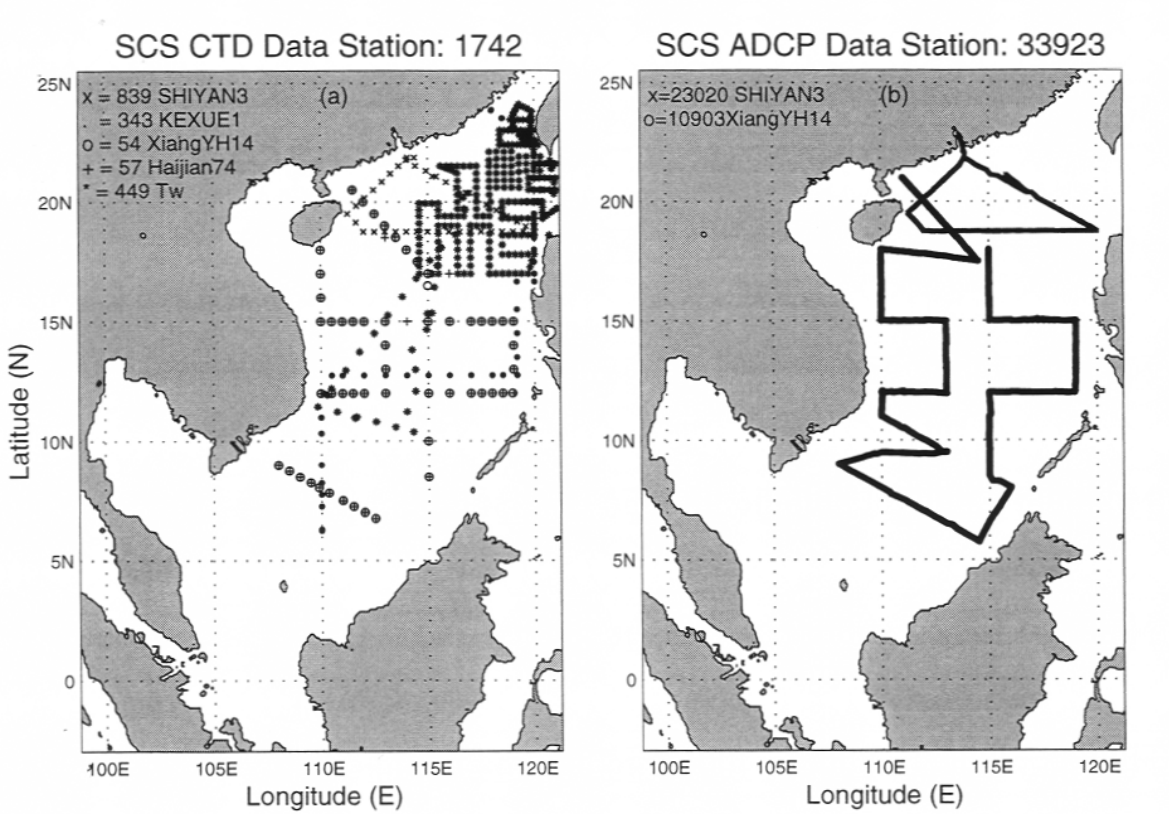
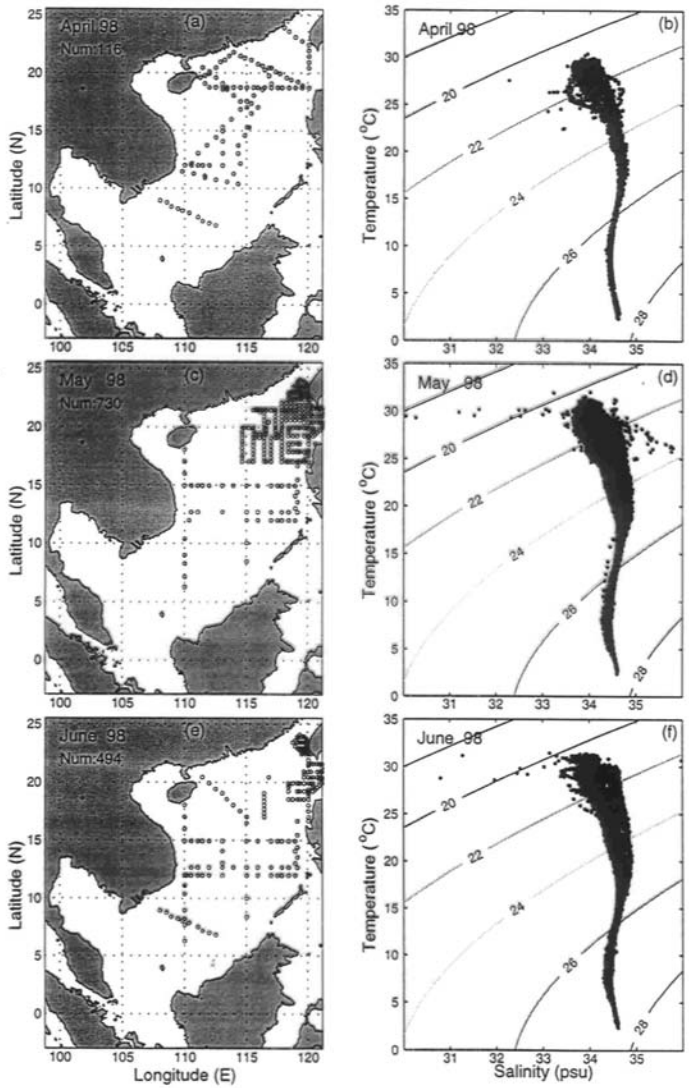
Latitude (N)
50
45
40
35
30
25
20
15
10
5
0
−5
−10
100
105
110
115
120
125
130
135
140
Longitude (E)
0
0.25
0.5
0.75
1
1.25
1.5
Surface Elevation (m)

Evaluation of CAOCS Using the South China Sea Monsoon Experiment (SCSMEX) Data

- IOP (April – June 1998)



T-S Diagram from SCSMEX Observations



Skill-Score

- Model-Data Difference
- $$\Delta\psi(x_i, y_j, z, t) = \psi_m(x_i, y_j, z, t) - \psi_o(x_i, y_j, z, t).$$
- Mean Square Error

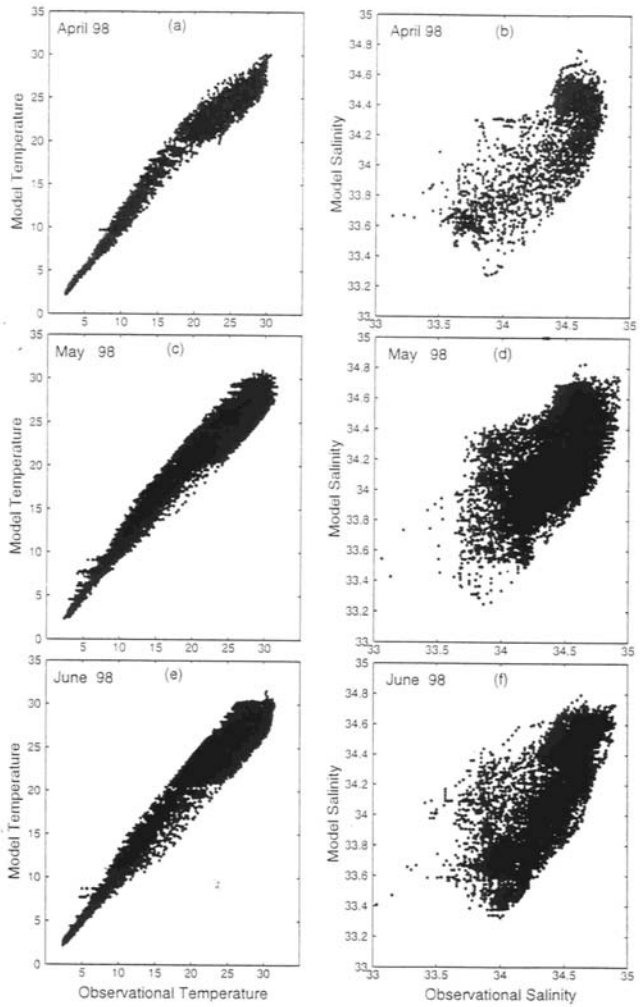
$$\mathrm{MSE}(z,t) = \sum_i \sum_j \frac{1}{N} \left[\Delta\psi(x_i, y_j, z, t)\right]^2$$

- Skill-Score (SS)

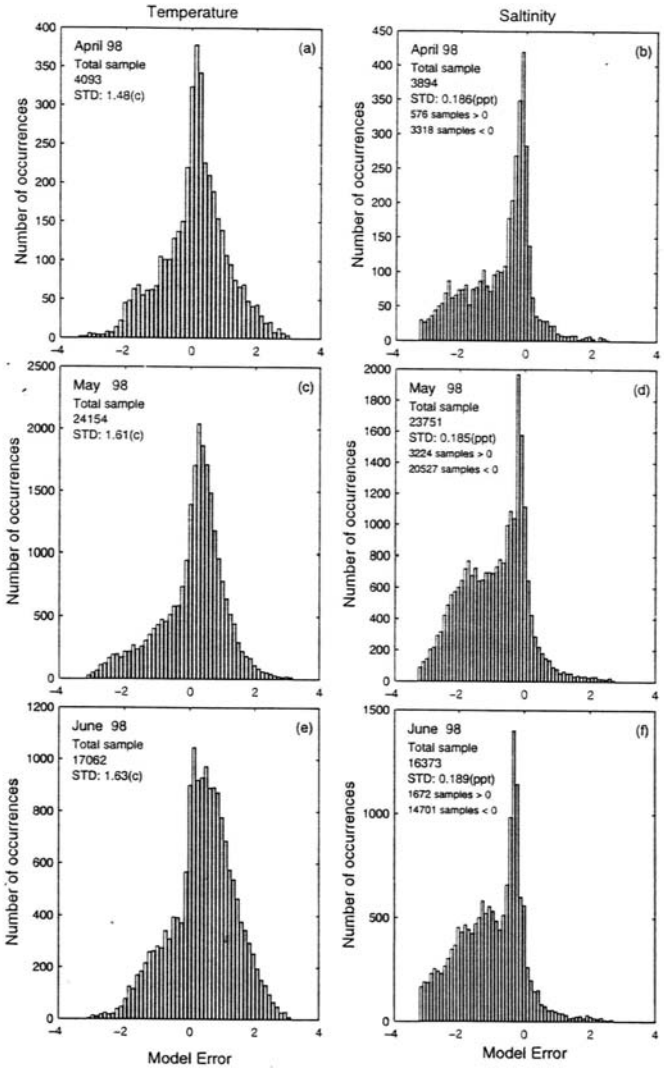
$$SS = 1 - \frac{\mathrm{MSE}(m,o)}{\mathrm{MSE}(c,o)},$$

- SS > 0, Model has capability

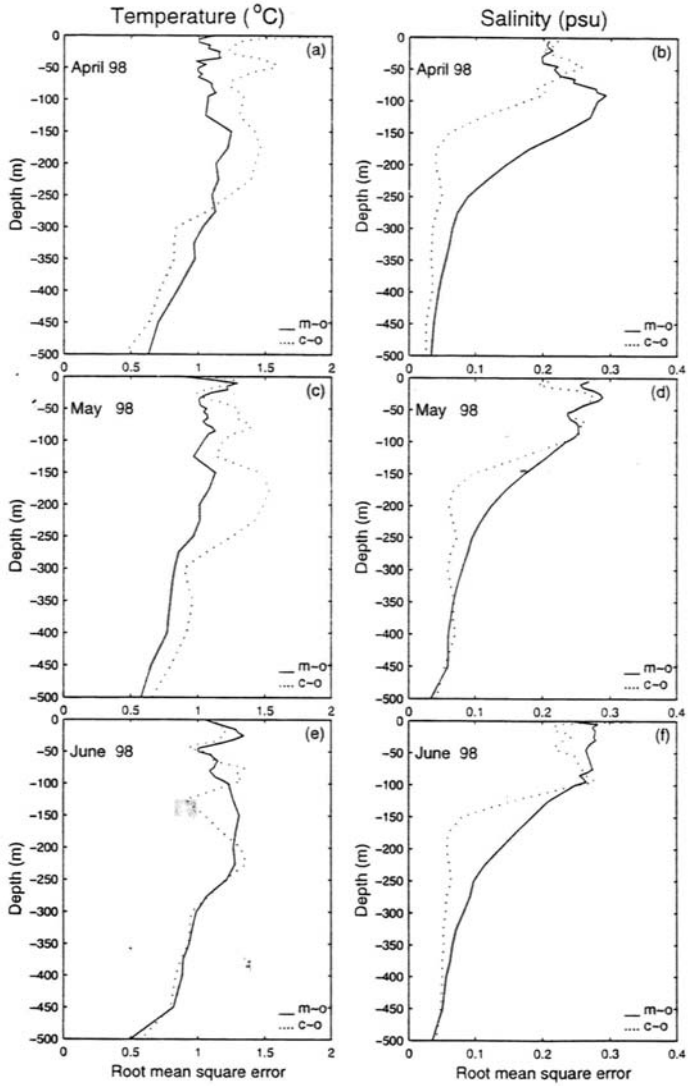
Scatter Diagrams Between Model and Observation

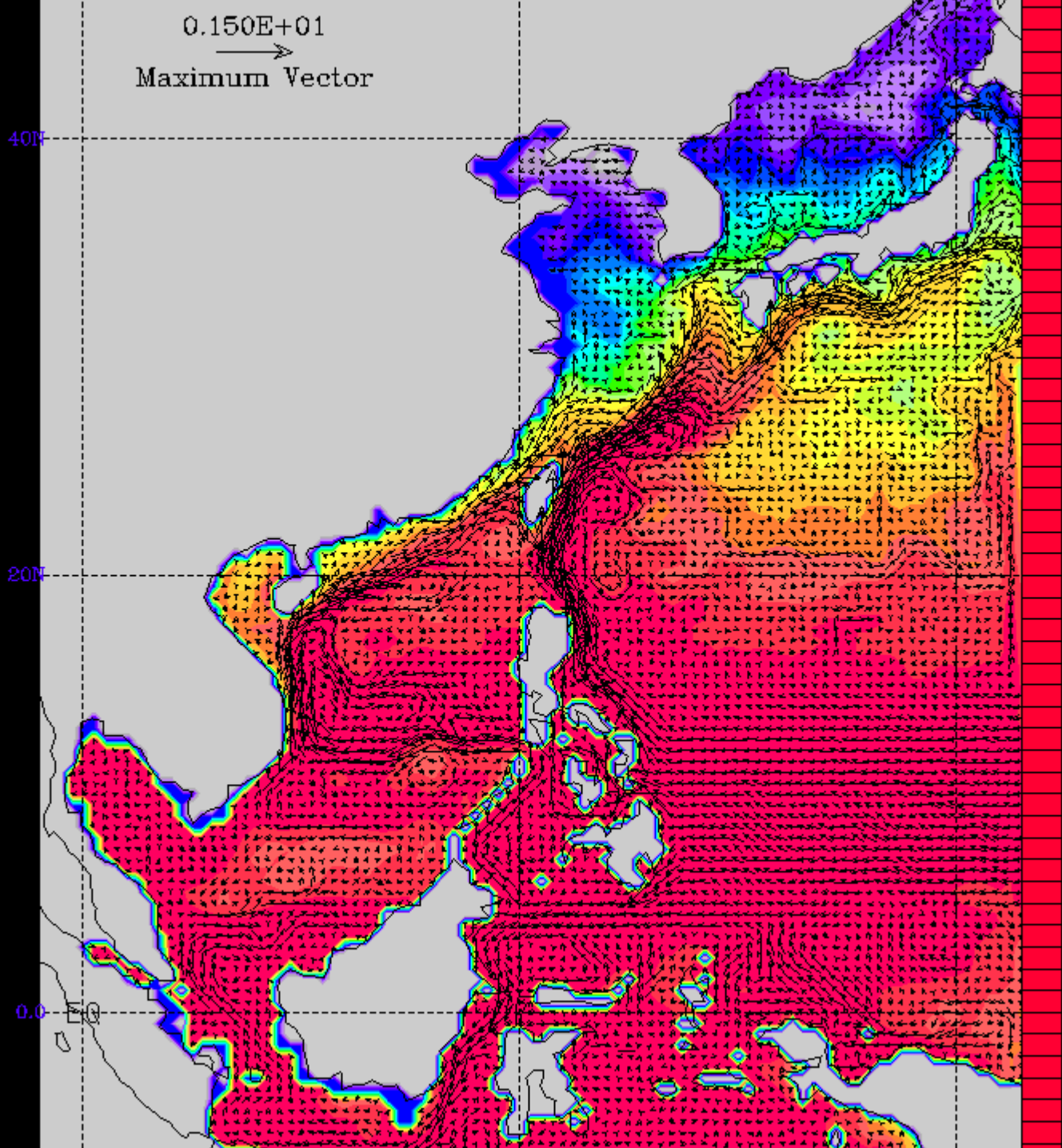


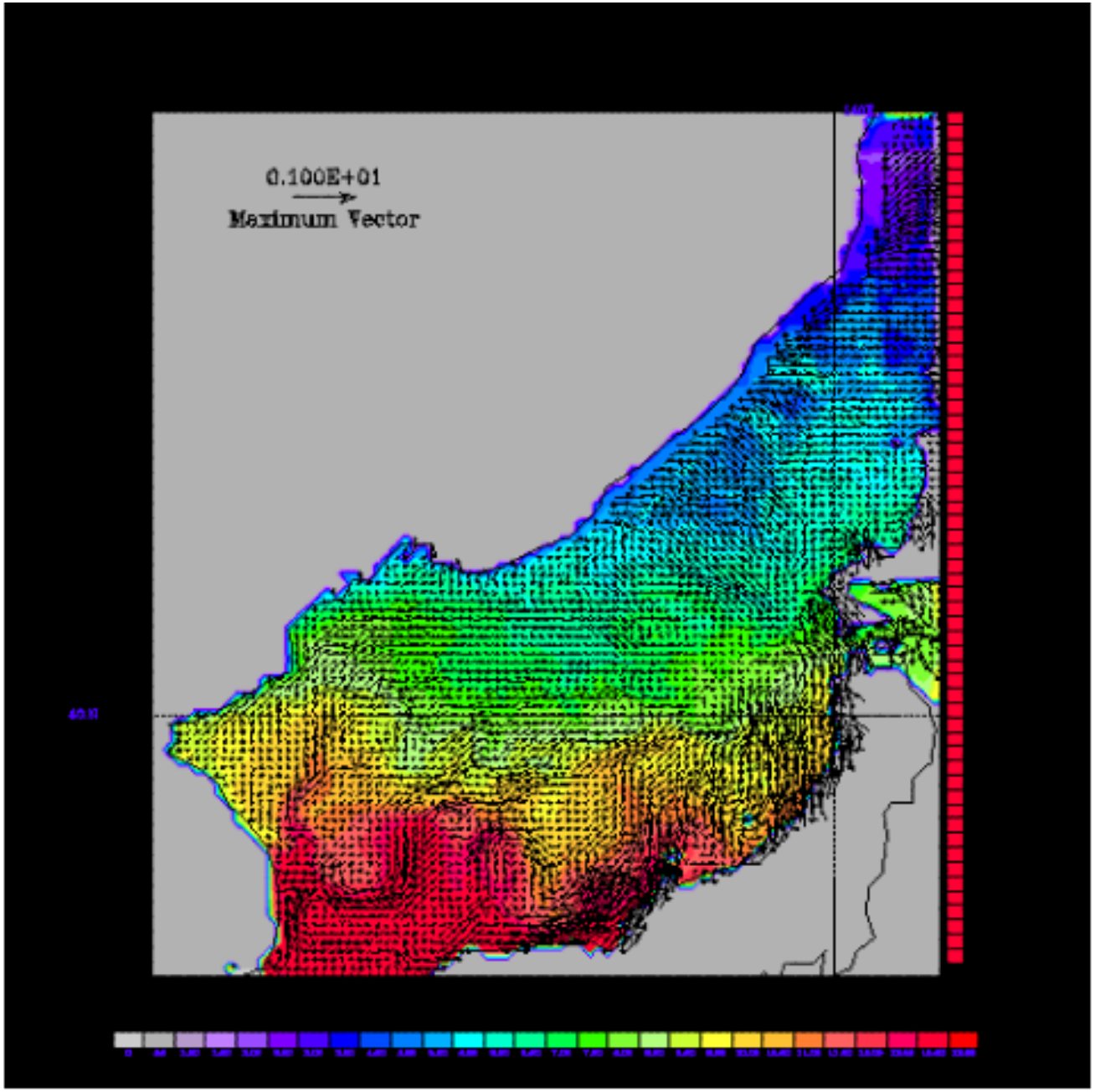
Histograms of (Model – Obs)

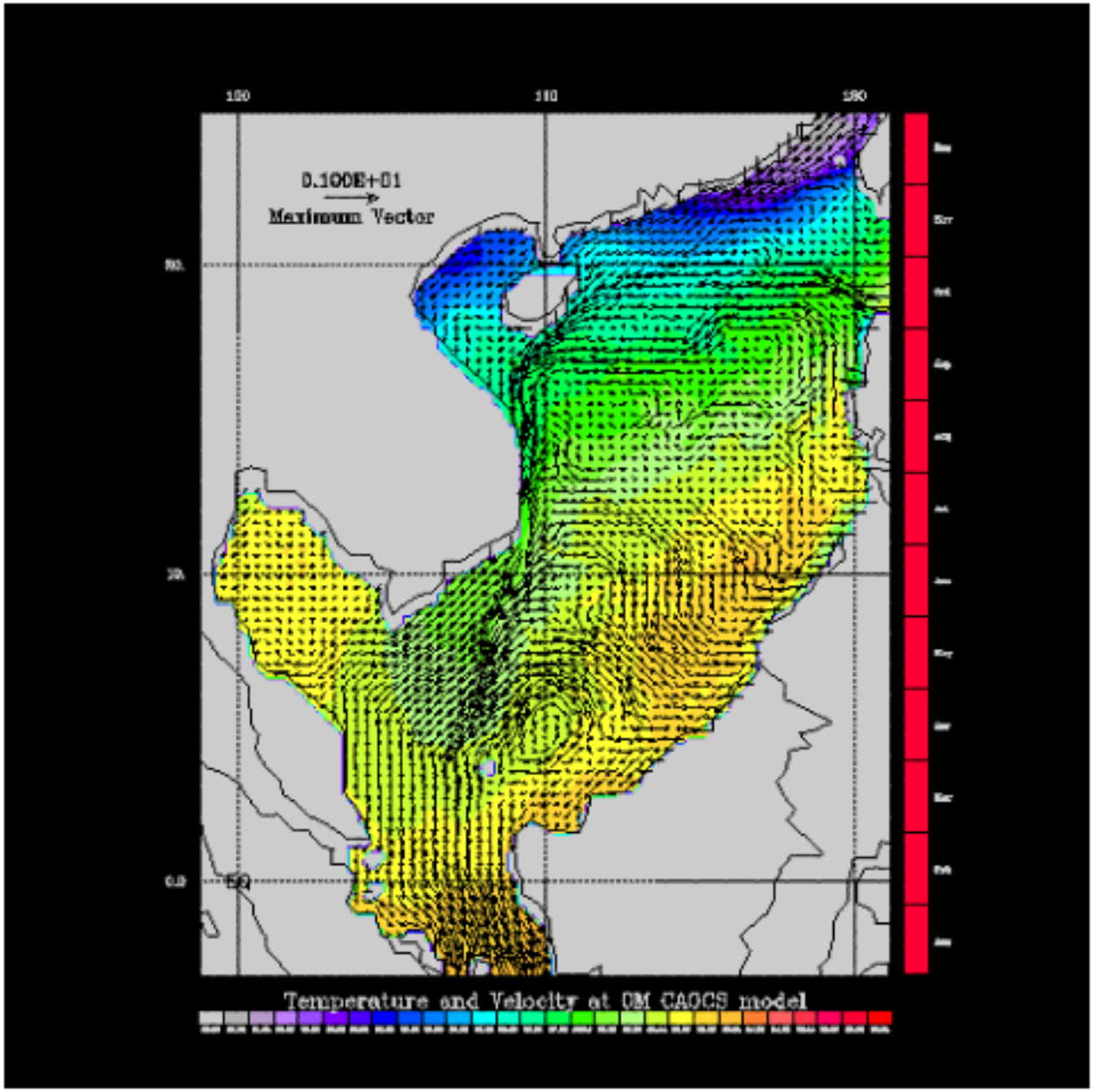


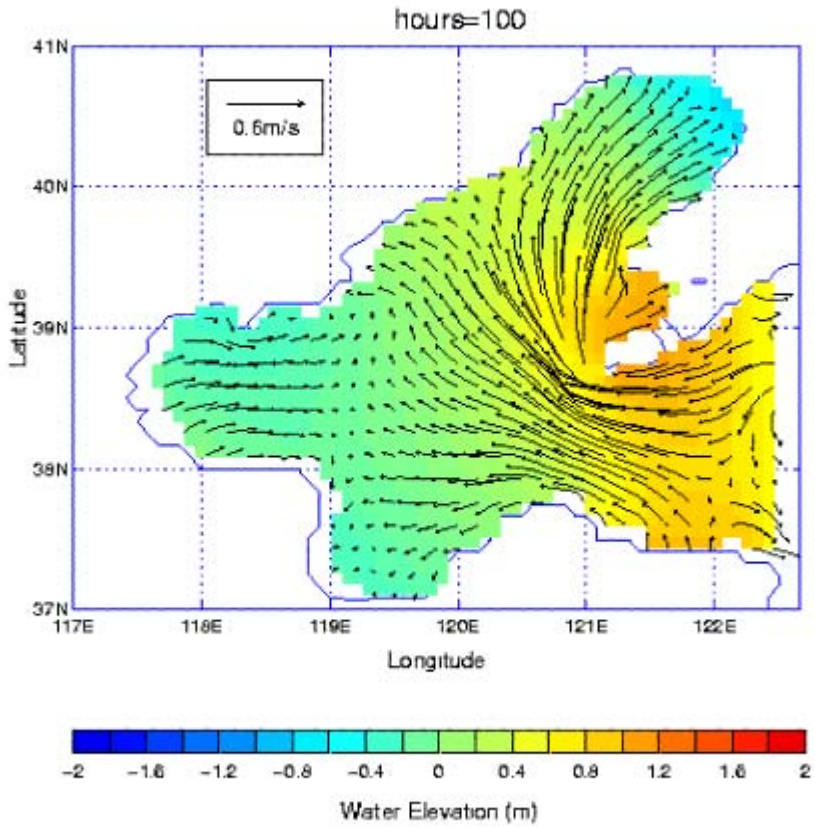
RMS Error


Temperature (°C)
Salinity (psu)
(a)
April 98
(b)
April 98
(c)
May 98
(d)
May 98
(e)
June 98
(f)
June 98
Depth (m)
m–o
c–o
Root mean square error
Root mean square error


0.150E+01
Maximum Vector
40N
20N
0.0
EQ


0.100E+01
Maximum Vector


100
110
120
0.100E+01
Maximum Vector
Temperature and Velocity at OM CAOCS model


hours=100
0.6m/s
41N
40N
39N
38N
37N
Latitude
117E
118E
119E
120E
121E
122E
Longitude
−2
−1.6
−1.2
−0.8
−0.4
0
0.4
0.8
1.2
1.6
2
Water Elevation (m)

Conclusions

- *CAOCS is a useful tool for studying coastal dynamics*
- *CAOCS has a capability to simulate and predict current system and thermohaline structure,*
- *CAOCS needs a reliable wave model (ongoing work)*