

HYCOM Caspian Sea Modeling.

Part I: An Overview of the Model and Coastal Upwelling

By

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MOTIVATION

- **Caspian Sea model set up**
 - **Resolution, vertical layers, atmospheric forcing, etc**
- **Upwelling along the eastern coast**
 - **ability of HYCOM in producing upwelling**
- **Hybrid** versus **sigma-z** simulations
 - **do they successfully generate the upwelling ?**

FINE RESOLUTION OGCMs

- The Caspian Sea is **NOT** included in majority of OGCMs

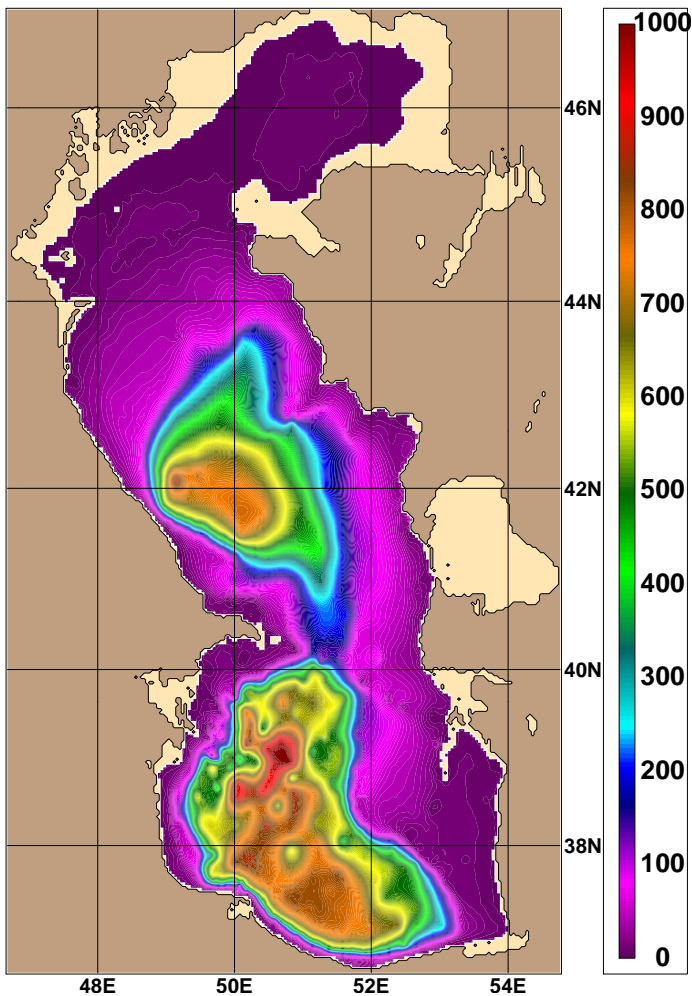
Resolution	OGCMs excluding the Caspian Sea
1/32°	NLOM (Wallcraft et al., 2003) NRL Layered Ocean Model
1/16°	MFSTEP (Pinardi et al., 2003) Mediterranean Forecasting System
1/12°	HYCOM (Chassignet et al., 2006) HYbrid Coordinate Ocean Model
1/12°	DMI (Buch and She, 2005) Danish Meteorological Institute
1/8°	NCOM (Barron et al., 2006) Navy Coastal Ocean Model
1/3°	MERCATOR (Ferry et al., 2005) Mercator Ocean

HYCOM SET UP FOR THE CASPIAN SEA

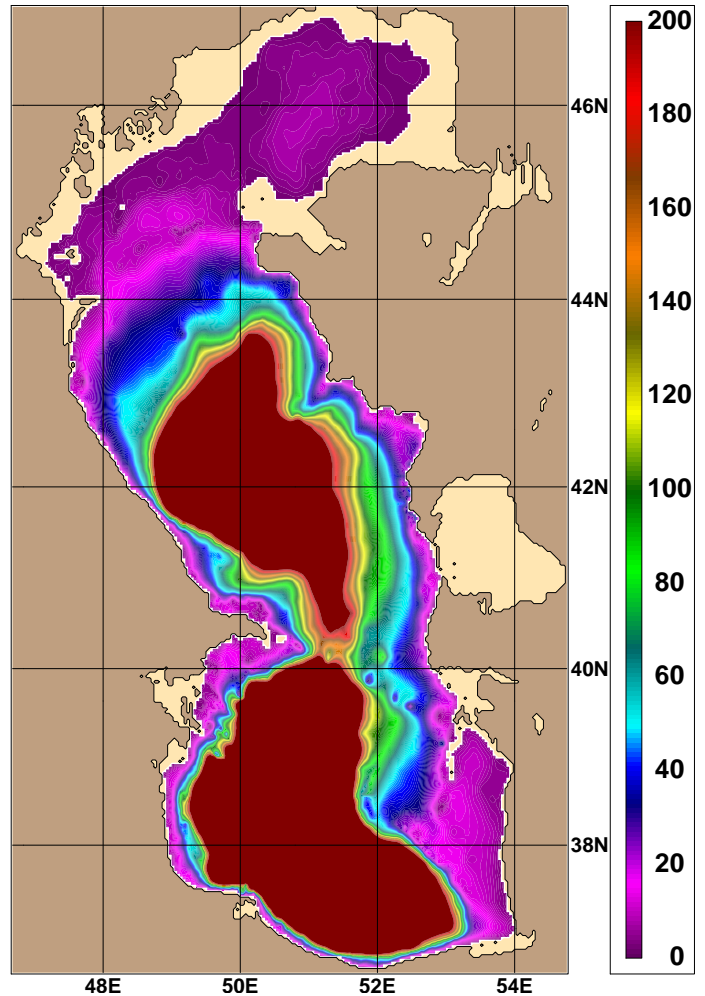
Grid resolution:	$[1/25^\circ \cos(\text{lat}) \times 1/25^\circ]$ $\approx 3.2 \text{ km}$
Vertical layers:	Two configurations 25 layer hybrid and 30 level sigma-z
Initialization:	Russian data-based T/S climatology
Mixed layer:	K-Profile Parameterization (KPP)
Bathymetry:	Modified DBDB-2 with the Russian data
Bottom layer:	Active bottom boundary layer
Atm. forcing:	ERA-40 climatology (1979-2002)
River forcing:	Three major rivers as runoff
Turbidity:	SeaWiFS ocean color data
Bulk formulas:	Sensible and latent heat fluxes
Relaxation:	Sea surface salinity only
Assimilation:	None

BOTTOM TOPOGRAPHY

(a) Full bathymetry (m)

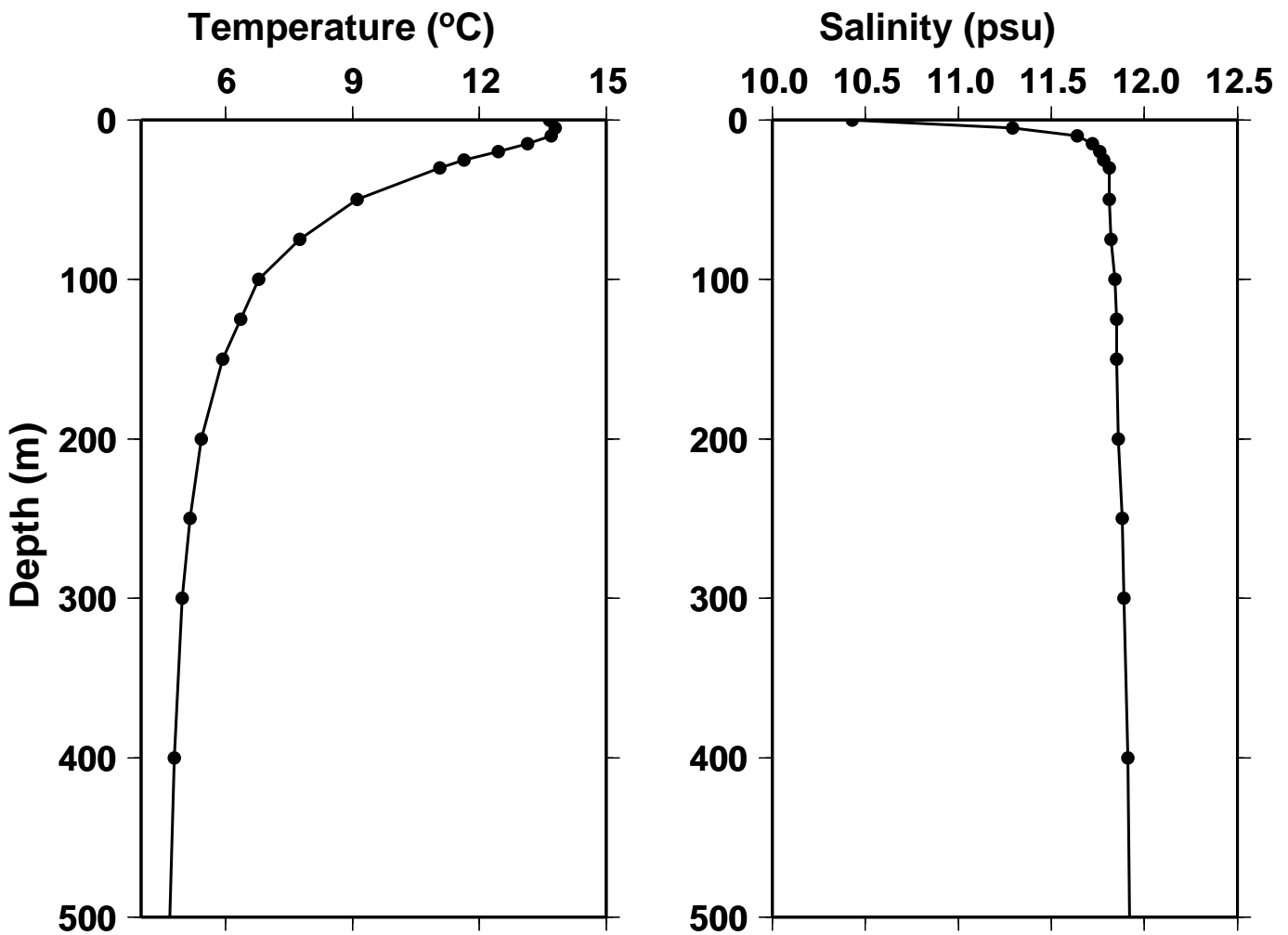


(b) Shallow regions (m)



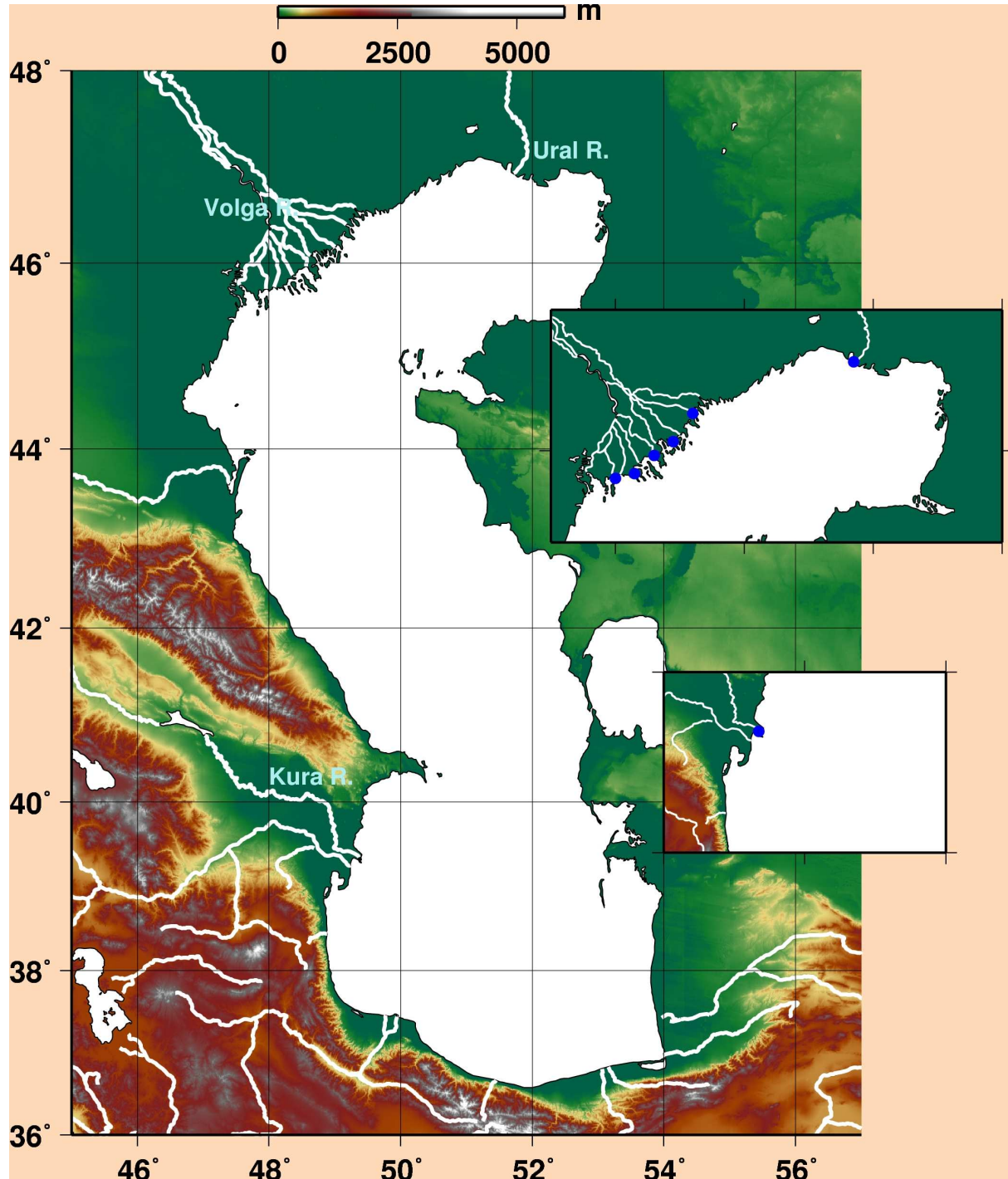
- **DBDB-2 in the Caspian Sea is not correct.**
- **The Russian data set was used to modify it.**
 - **HYCOM uses land-sea isobath of 2 m.**
 - **Maximum depth is ≈ 1015 m.**

TEMPERATURE and SALINITY INITIALIZATION



- Basin-averaged T/S from the Russian data
- Temperature gradually drops with depth.
- Salinity is constant ≈ 11.8 psu below 50 m.
- Temperature has more effect on density.

RIVER DISCHARGE IN THE CASPIAN SEA



- HYCOM reads in monthly mean river discharges.
- Runoff addition to the surface precipitation field.

HYCOM SIMULATIONS

- Use KPP mixed layer model
- Perform climatologically–forced simulations
- Run 5 years until statistical equilibrium
- Run another 4 years and form monthly means

- As mentioned before, there is
 - **no** data assimilation, and
 - **no** relaxation except for sea surface salinity.

SENSITIVITY SIMULATIONS

What is the importance of heat and salinity fluxes in simulating upper ocean quantities in the Caspian Sea?

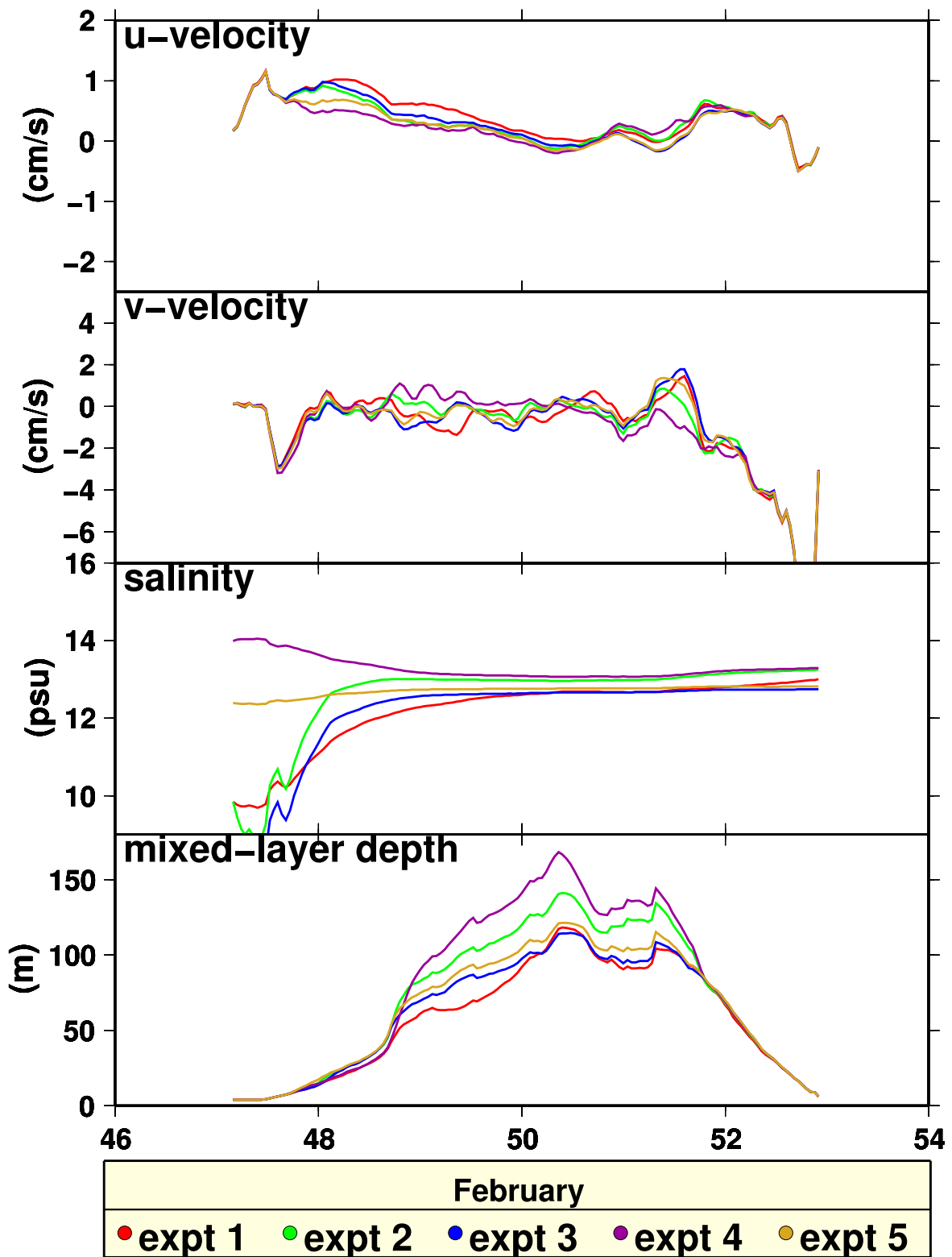
Note: Net buoyancy flux is the sum of

- o buoyancy due to heat flux and
- o buoyancy due to salinity (i.e., E–P) flux.

- **Four sensitivity simulations:**

- o expt 1: standard simulation (30 level sigma-z)
- o expt 2: twin of expt 1 but **no** salinity relaxation
- o expt 3: twin of expt 1 but **no** E–P
- o expt 4: twin of expt 1 but **no** rivers
- o expt 5: twin of expt 1 but **no** E–P and **no** rivers

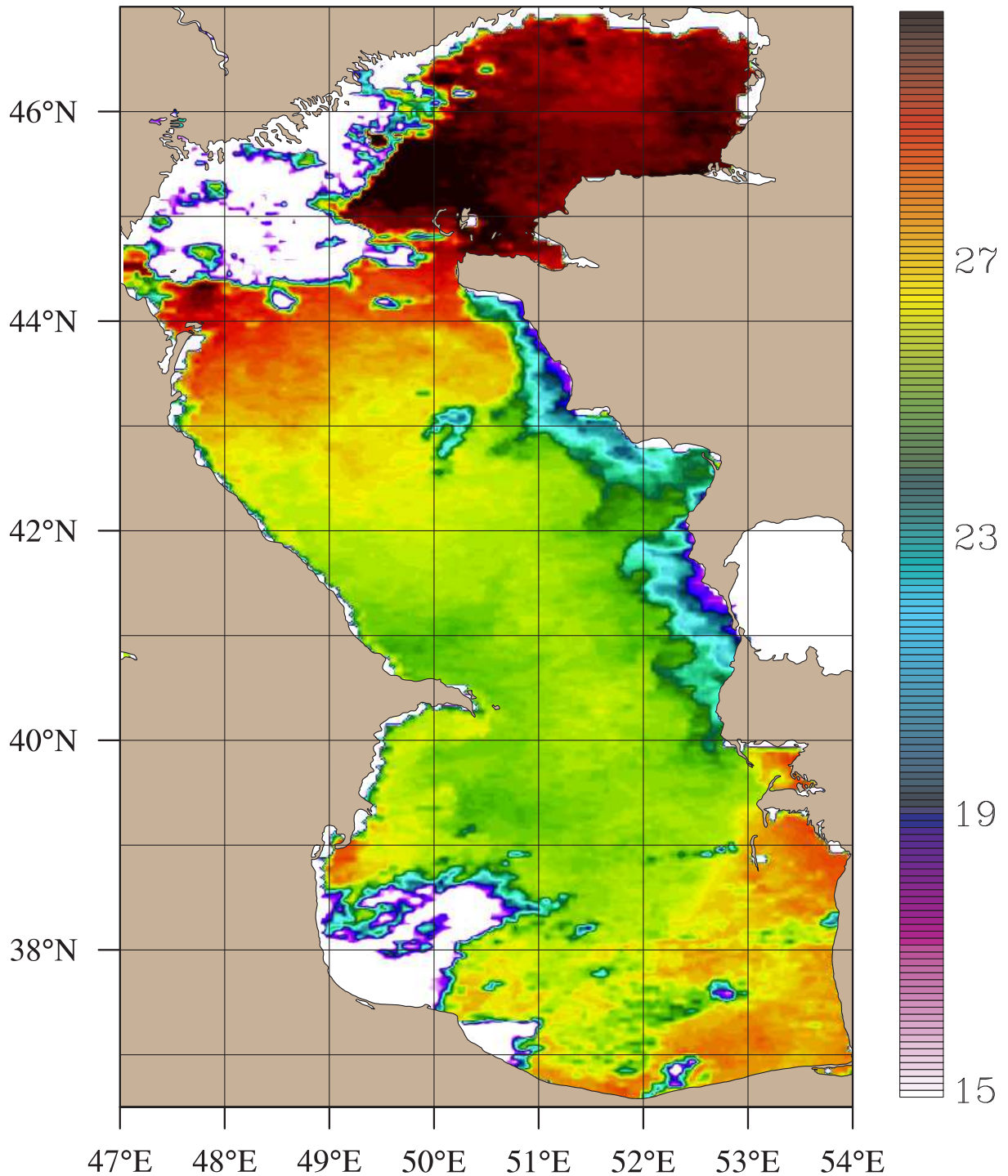
DEPTH-AVERAGED VARIABLES



- Meridional averages of variables from 40.5°N to 45.0°N

UPWELLING NEAR THE EASTERN COAST

- **Summer SST from AVHRR (16 June 2001)**



AVHRR: Advanced Very-High Resolution Radiometer

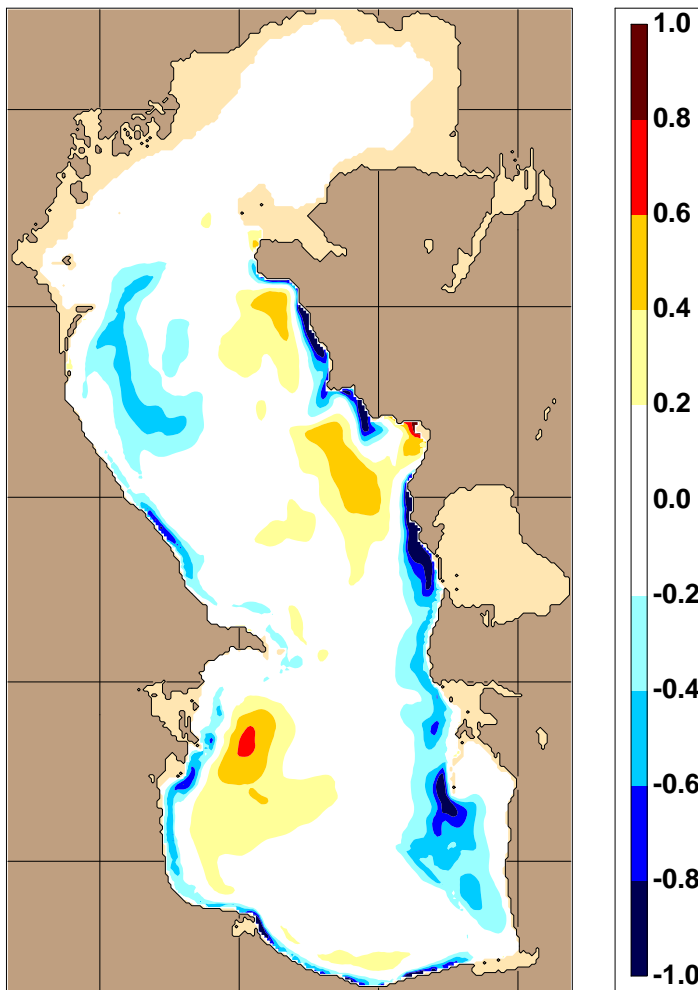
MOVIES OF SST

- **Snapshots of daily HYCOM SST from**
 - **25 layer hybrid**
 - **30 level sigma-z**
- **Existence of upwelling near the eastern coast**
- **We typically use daily MODAS SST as truth**
 - **because it is a satellite-based re-analysis product.**
- **However, it is not included in the movies**
 - **because MODAS has no SST in the Caspian Sea.**

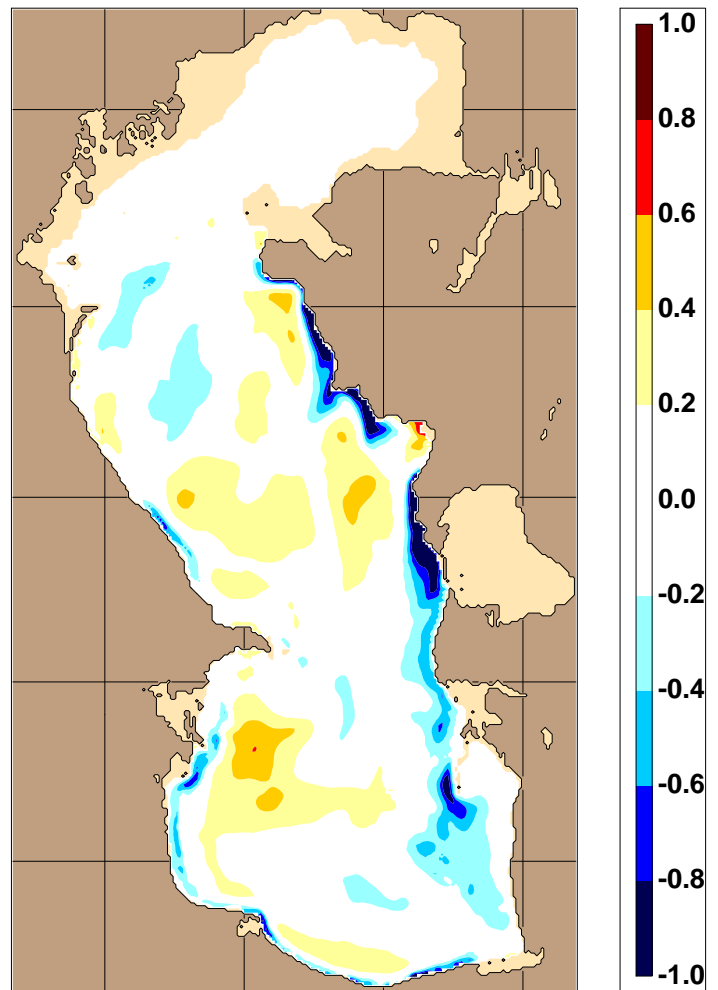
ANNUAL MEAN SST BIAS

- Bias ($^{\circ}\text{C}$) with respect to 4 km Pathfinder SST climatology

(a) 25 LAYER HYBRID



(b) 35 LEVEL SIGMA-Z



- Basin-averaged SST bias:

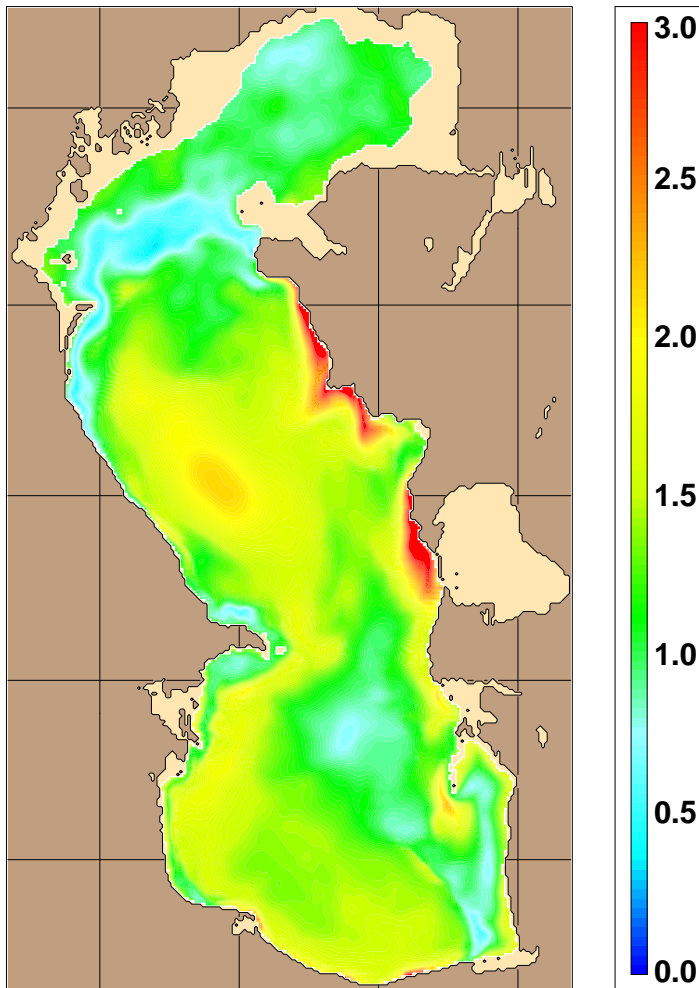
○ $\approx 0^{\circ}\text{C}$ for both simulations

- Large SST error near the eastern coast: Upwelling issues!!

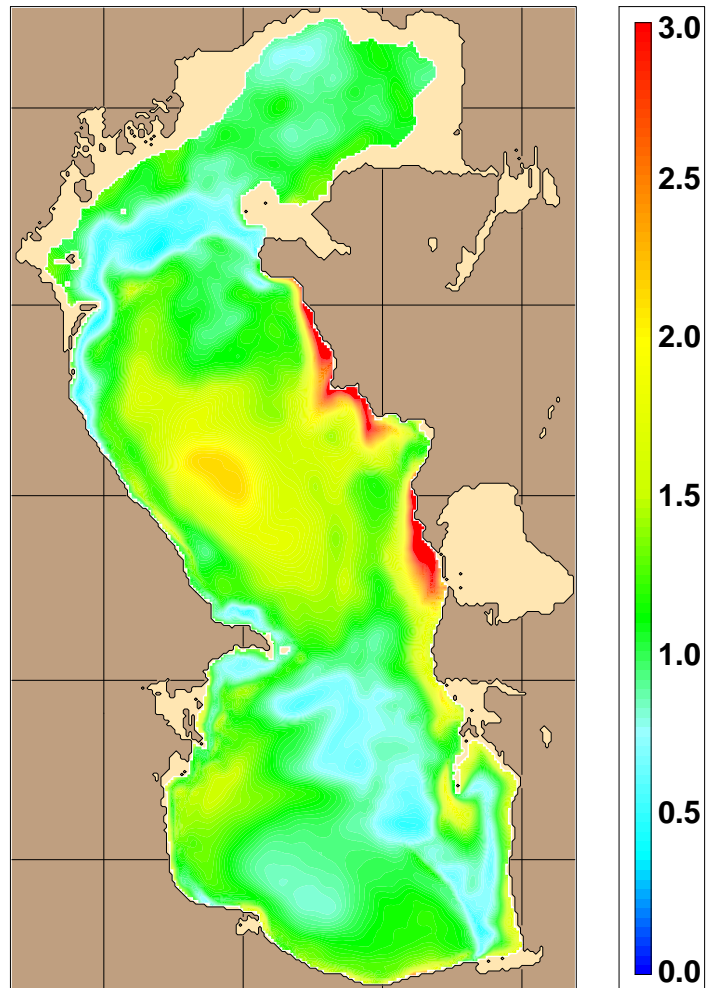
RMS SST OVER THE SEASONAL CYCLE

- RMS ($^{\circ}\text{C}$) with respect to 4 km Pathfinder SST climatology

(a) 25 LAYER HYBRID



(b) 35 LEVEL SIGMA-Z



- Basin-averaged RMS SST difference:

- o 1.4 $^{\circ}\text{C}$ (1.2 $^{\circ}\text{C}$) for HYBRID (SIGMA-Z) simulation

SUMMARY and CONCLUSIONS

- **A fine resolution (≈ 3.2 km) HYCOM Caspian Sea model:**
 - model set up for hybrid and sigma-z coordinates
 - climatologically-forced simulations (no assimilation)
 - used coarse resolution (1.125°) ERA-40 forcing
- **Initial evaluations for upper ocean quantities:**
 - evidence of upwelling consistent with observations
 - net heat flux generally dominates E-P flux
 - SST is well simulated, even with no assimilation
- **Ongoing studies and future plans:**
 - processes controlling upwelling near the eastern coast
 - finer resolution (0.25°) European ECMWF forcing
 - inter-annual model simulations (1990 through 2006)