Air-Sea Coupling in an Eastern Boundary Current Region

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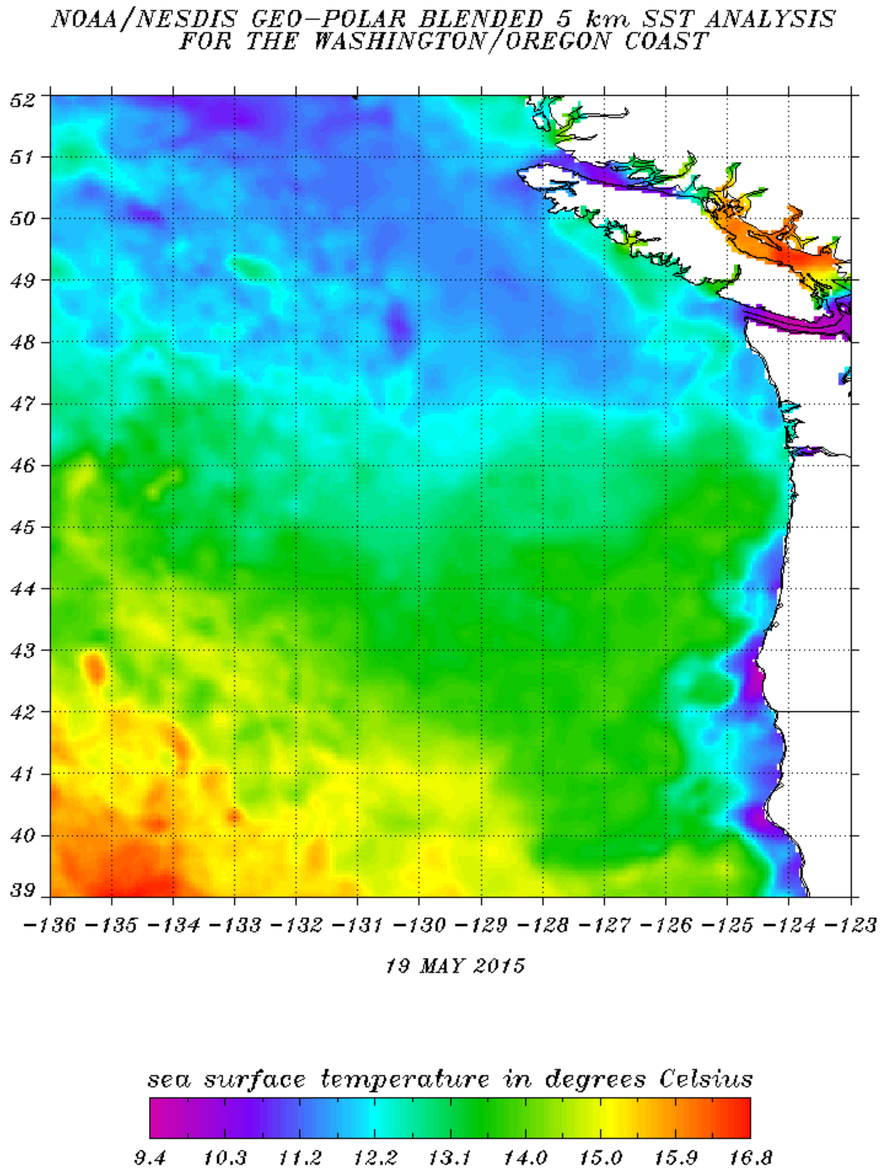
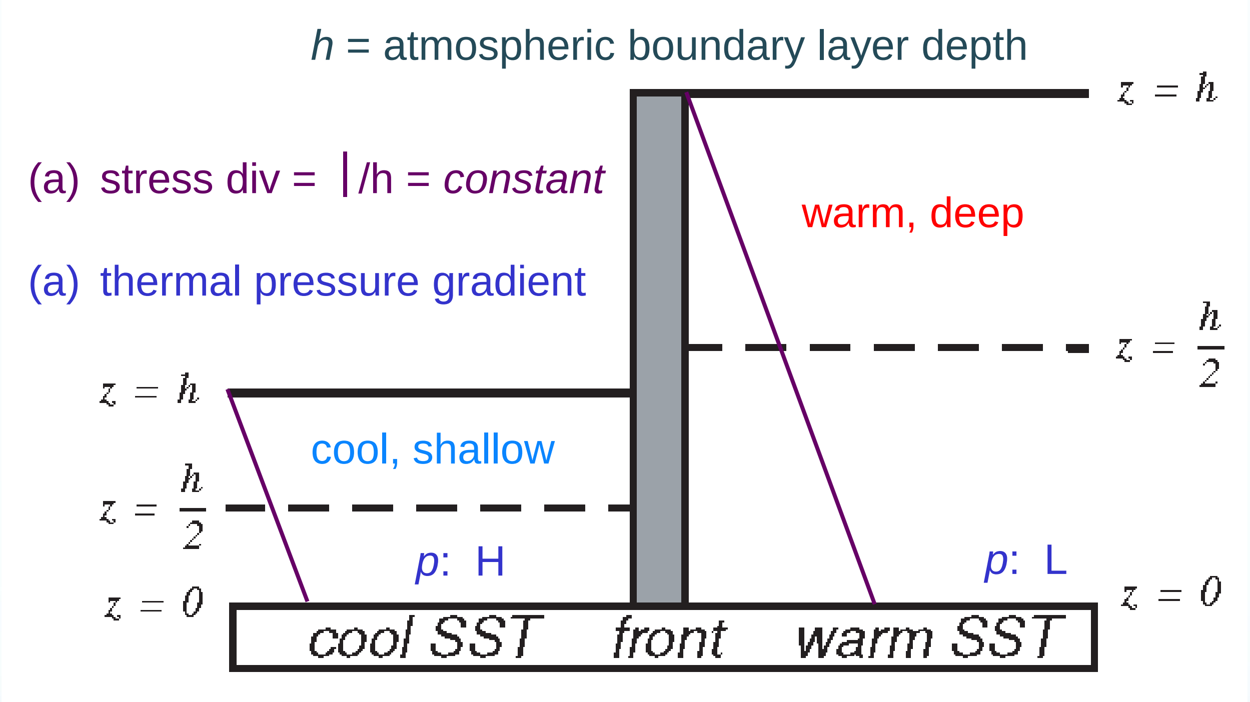
Tuesday SST From NOAA



- Upwelling generates mesoscale SST fronts confined to eastern boundaries that are not well-resolved in coarse resolution SST data or in climate scale OGCMs
- Wind speed/stress is correlated with SST, but upwelling is forced by winds -> 2 way coupling
- Equilibrium SST and wind stress conditions for coastal upwelling are unknown
- Here we examine how removing the effects of coastal upwelling changes coastal winds and how those altered winds modify the coastal ocean structure

SST-stress coupling mechanisms



Scaling:

h < 200 m => stress divergence effect dominates

h > 200 m => pressure gradient effect dominates

SST-stress coupling and California Current System (CCS)

Consider response of regional numerical ocean model (A. Kurapov, ROMS) to two different wind stress fields through one-way coupling

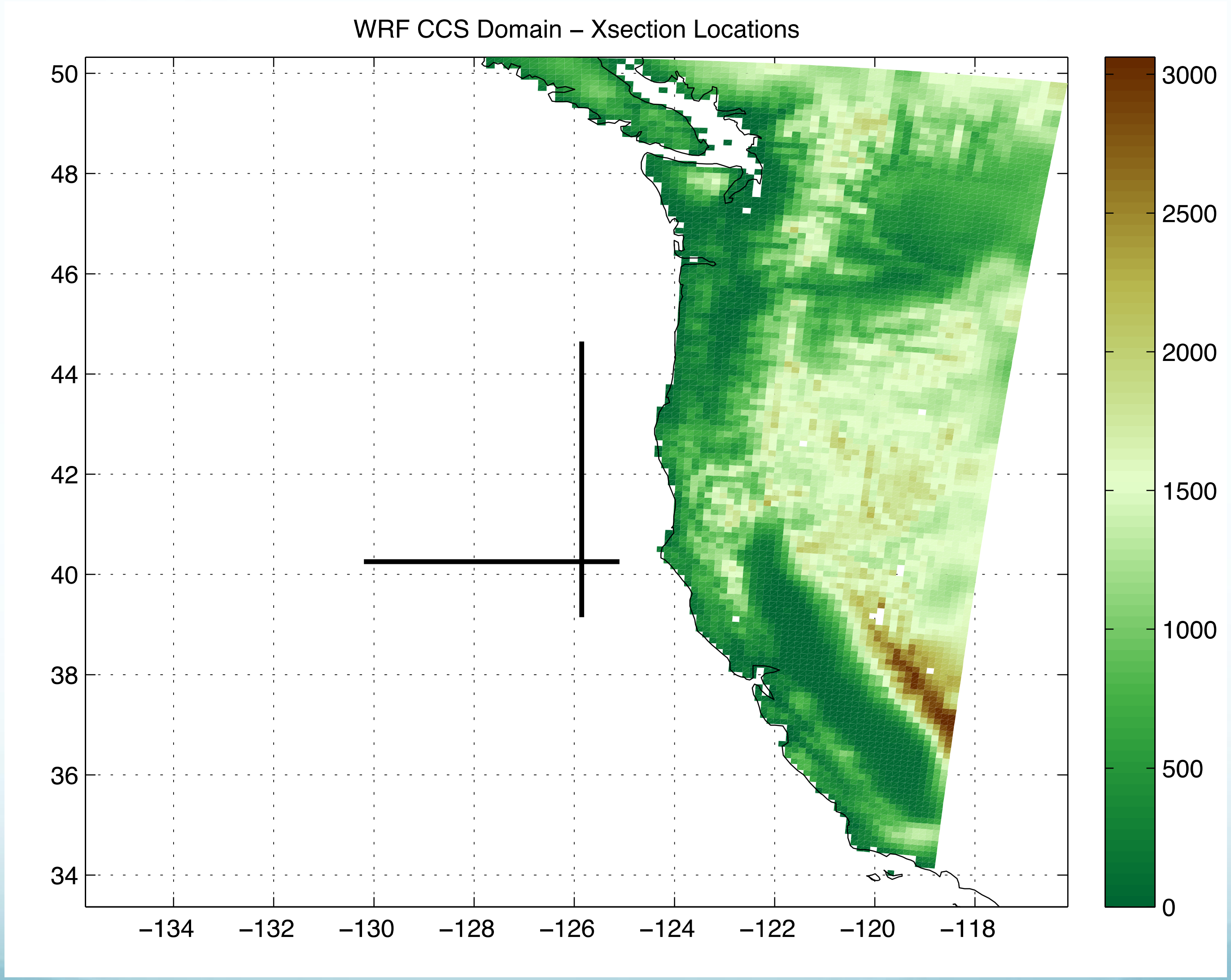
Base Case: Stress from atmospheric model with observed SST

Case 2: Stress from atmospheric model with modified SST

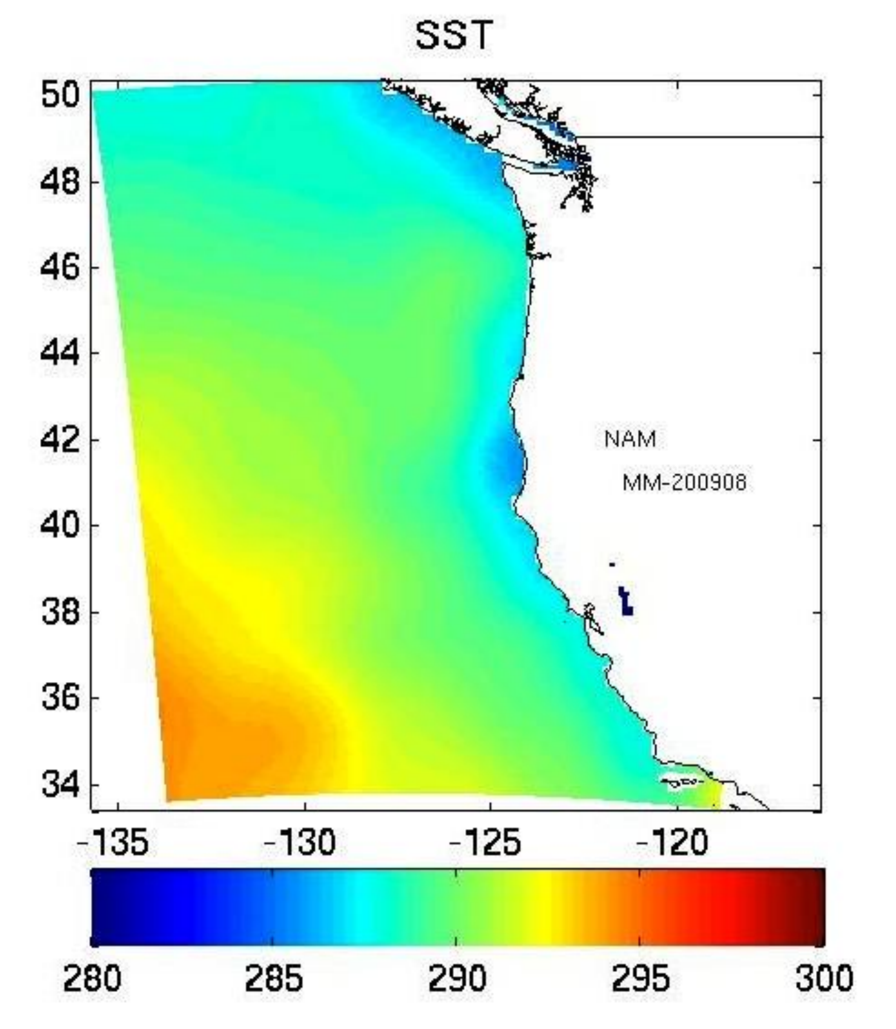
Simulation Parameters

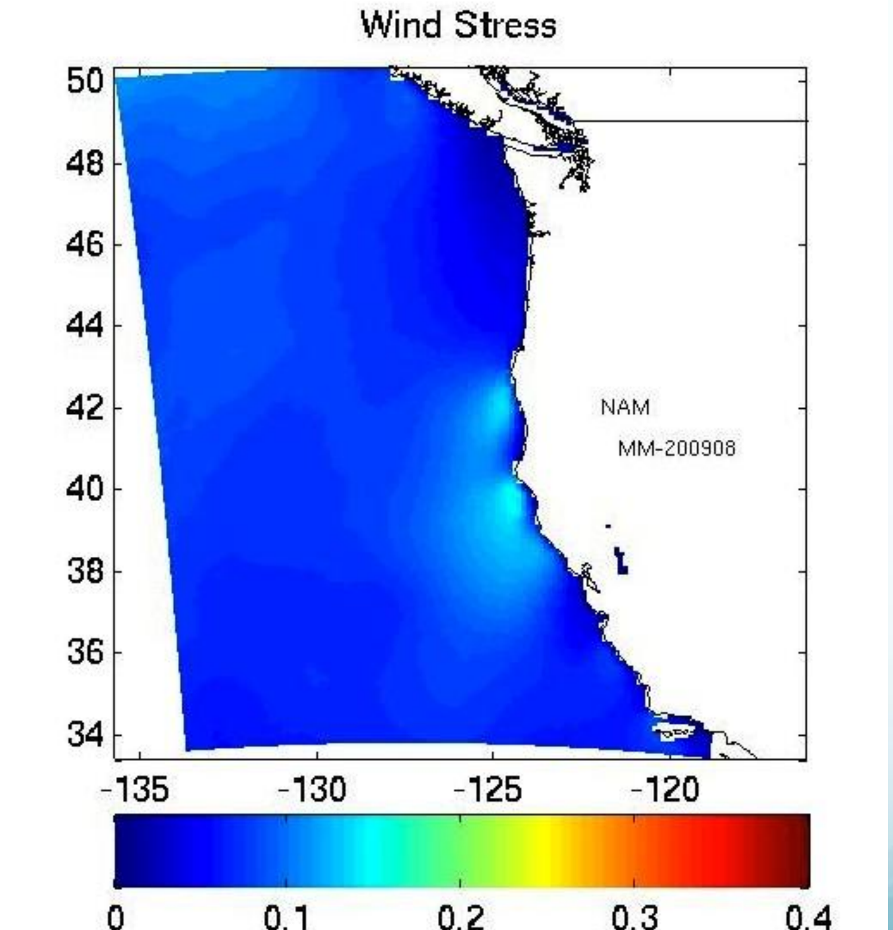
- Use NCAR WRF Model for atmosphere model and Regional Ocean Model (ROMS)
- Summer 2009 simulations averaged over June, July, and August. Reinitialized beginning of each month.
- SST updated from NOAA NAM model every 6 hours for WRF base case
- Outer domain resolution 36 km, inner domain 12 km (ocean and atmosphere)

Model Domain



Base Case WRF: SST from NAM Model



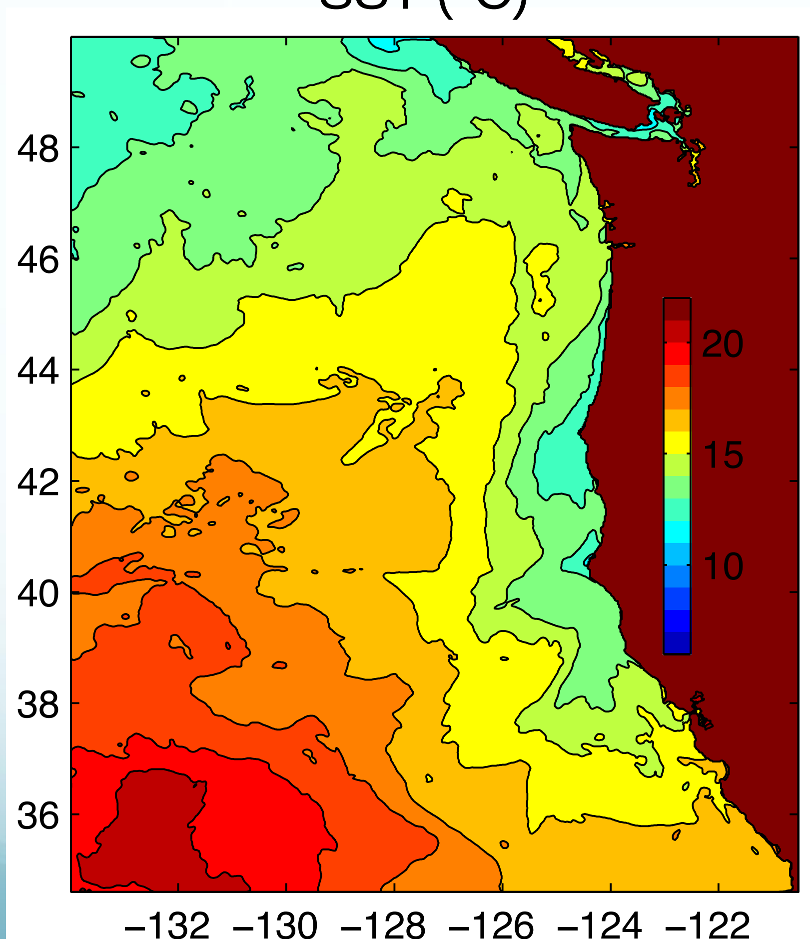


WRF Simulated Wind Stress

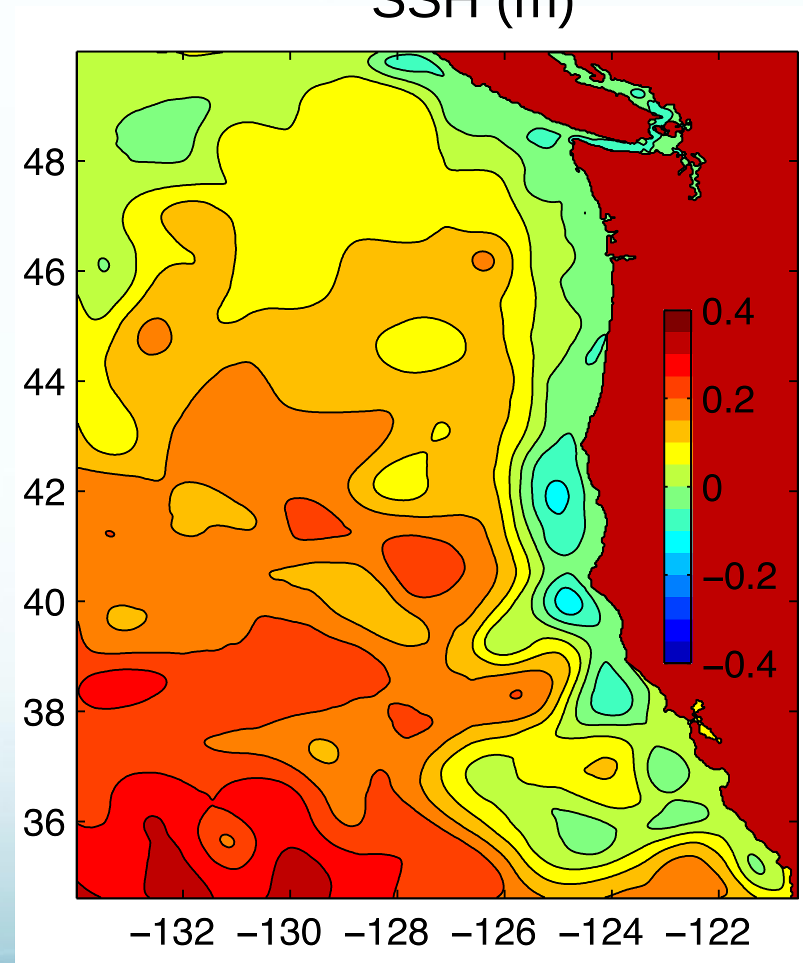
Basic Case: ROMS Ocean model Mean Jun-Aug 2009

Forcing from WRF case shown above

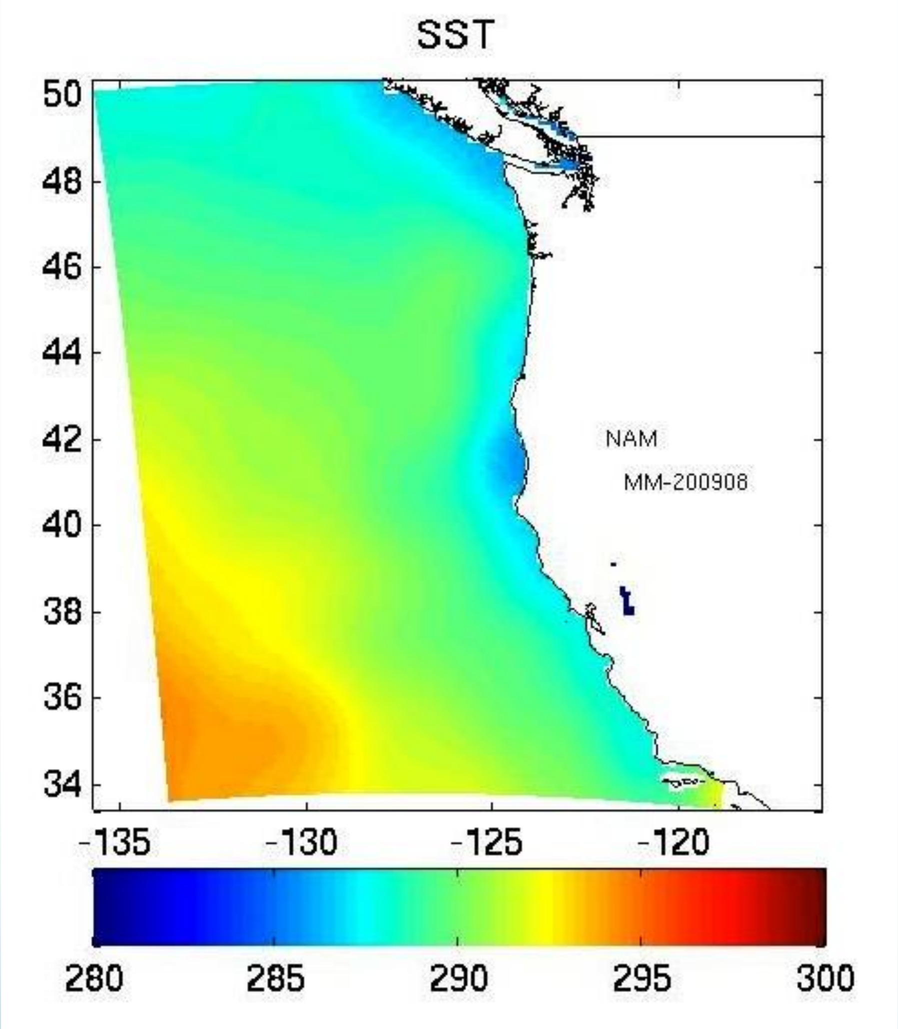
SST (^oC)



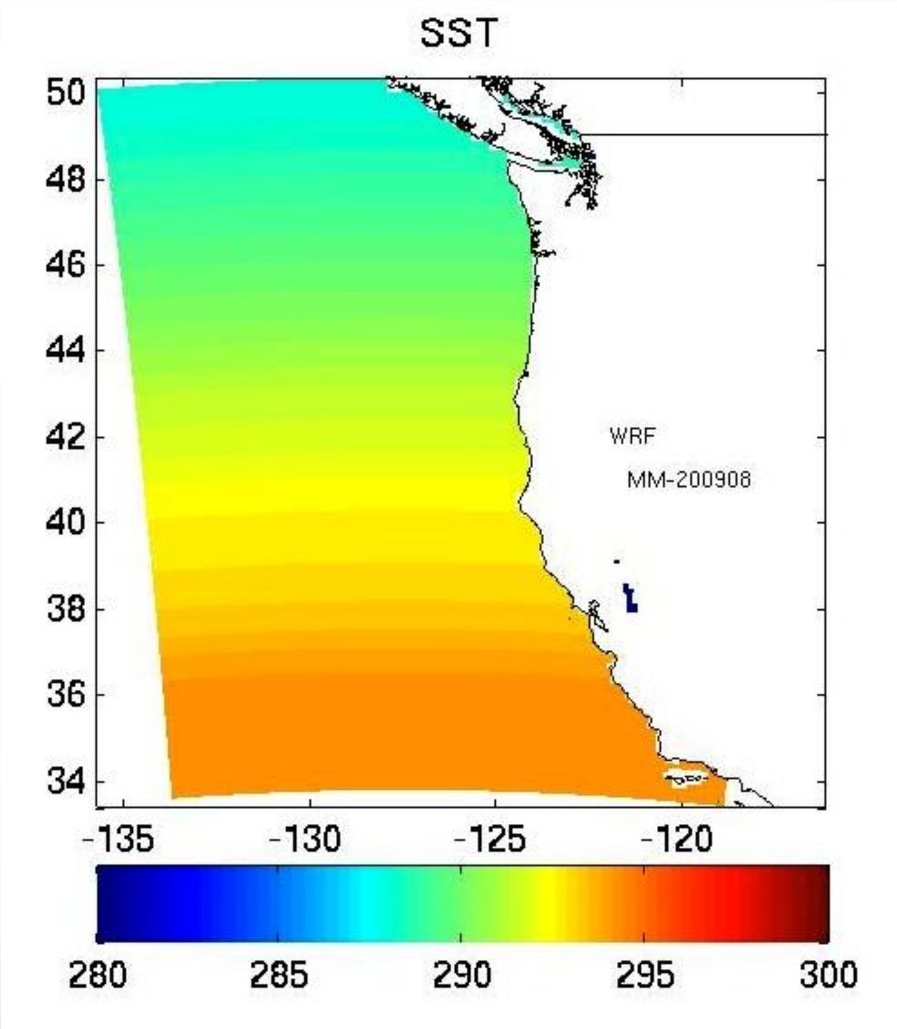
SSH (m)



Base Case

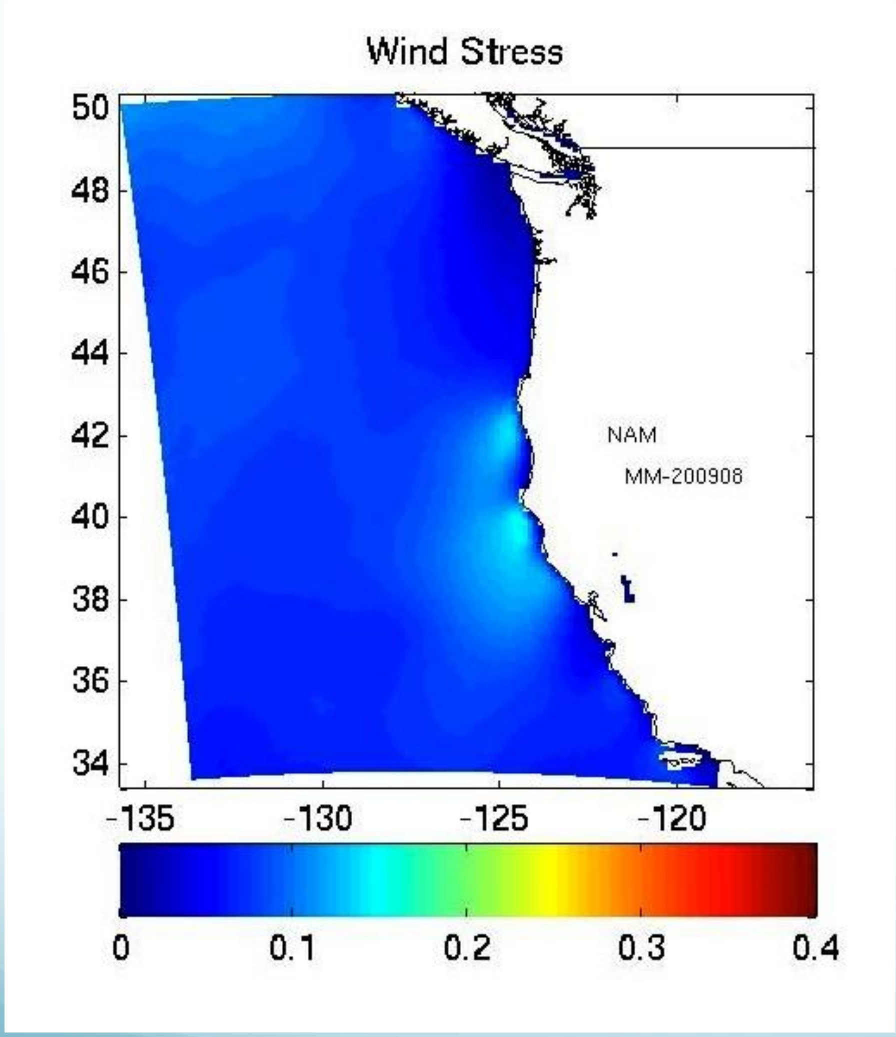


Case 2

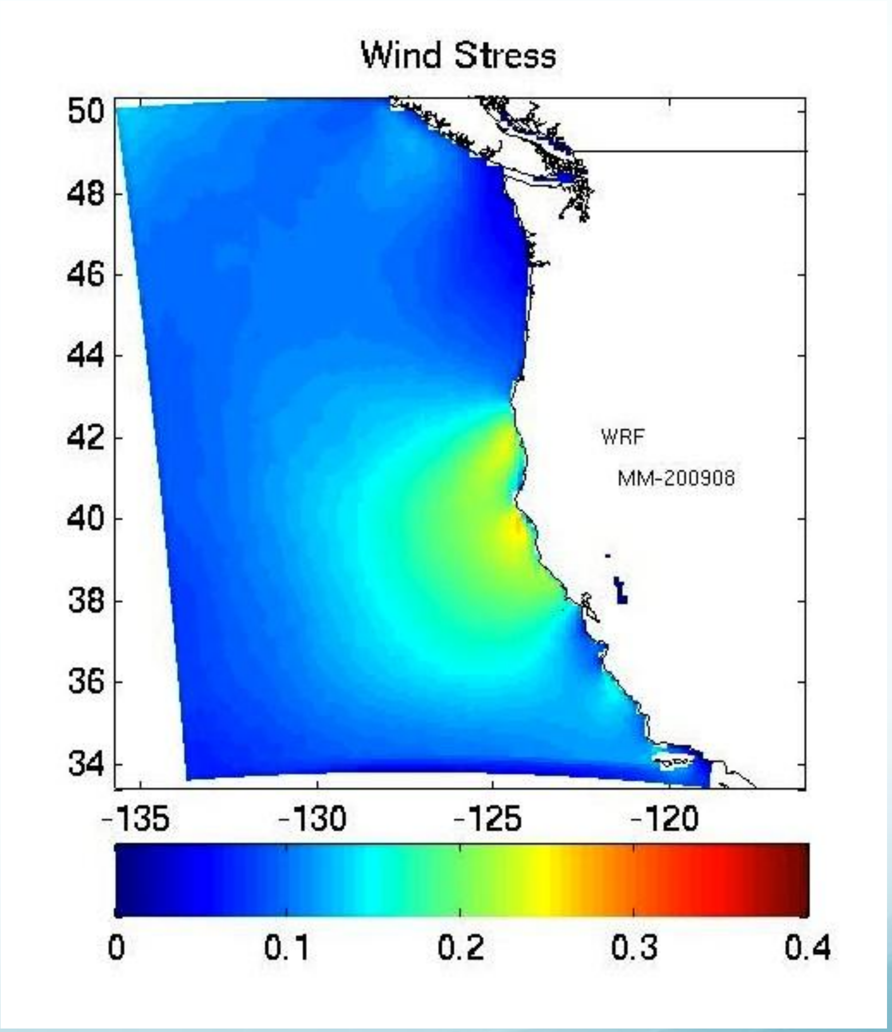


Case 2: Eliminate cold pool of upwelled water adjacent to coast by extending offshore temperatures zonally eastward to coast

Base Case

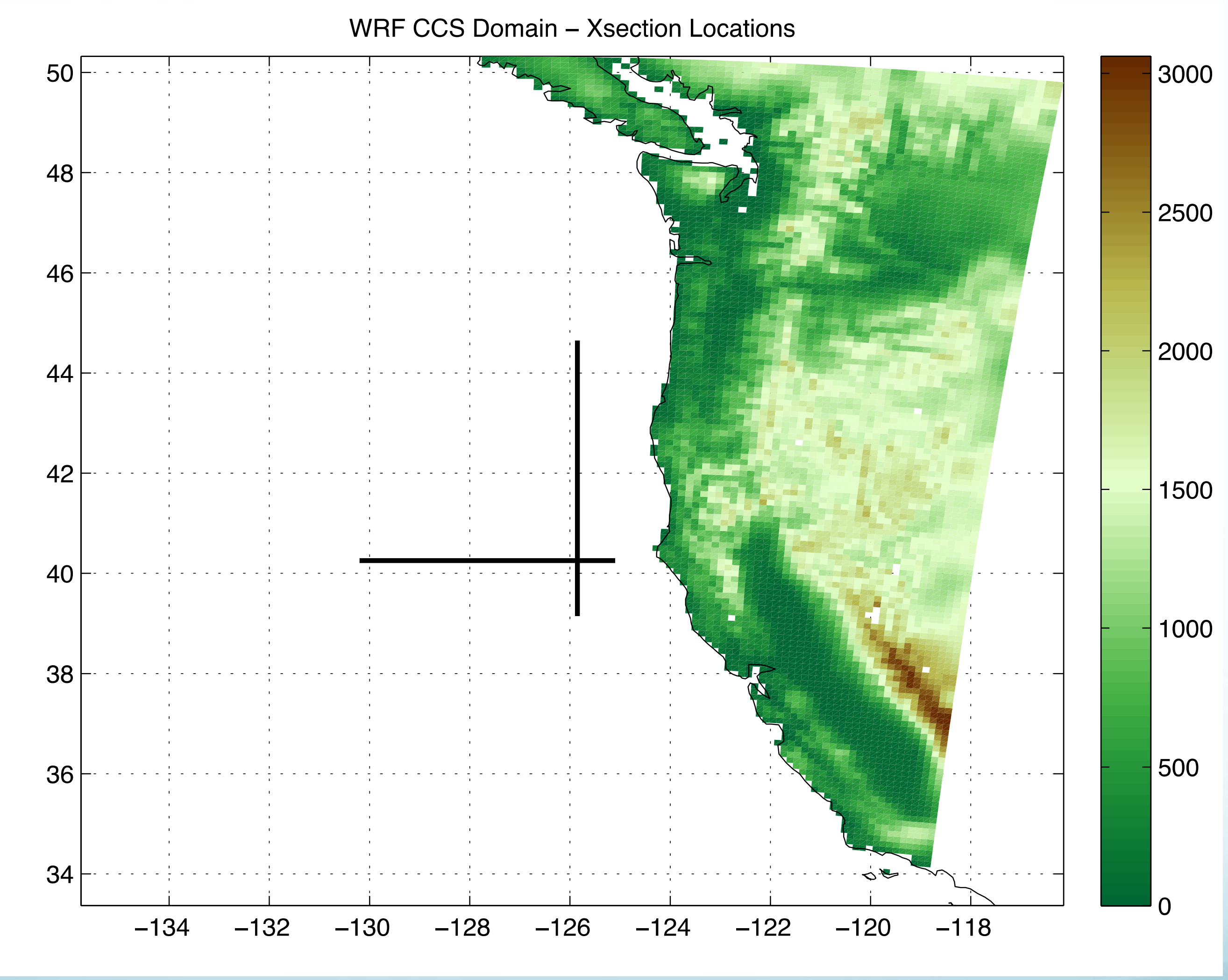


Case 2



Altered SST affects cape flow expansion fan: Pressure or MBL?

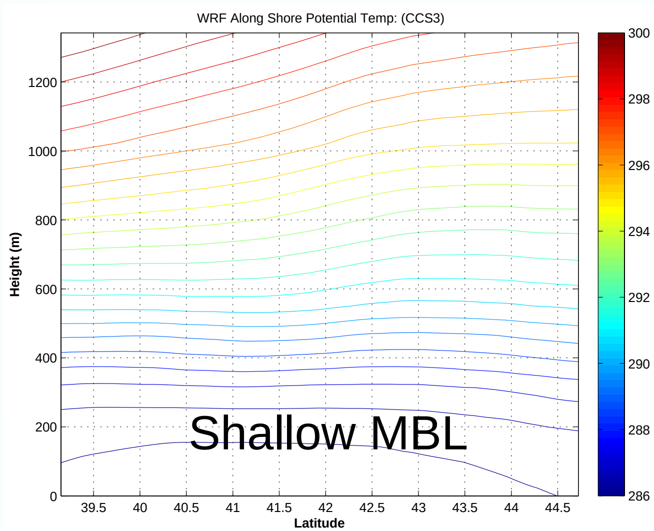
Cross Sections

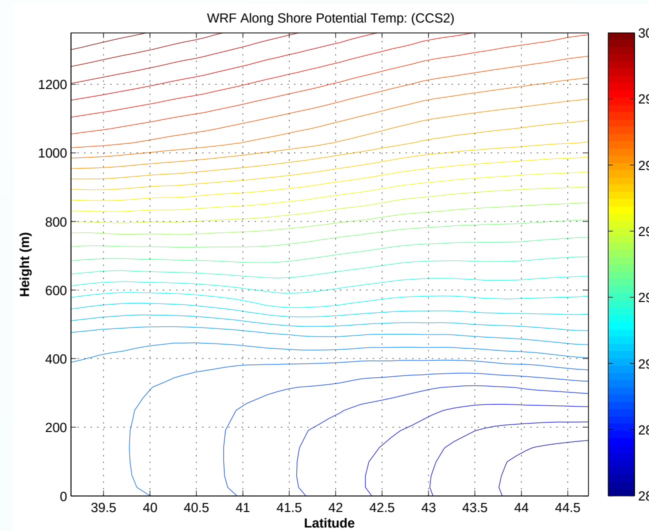


Potential Temperature

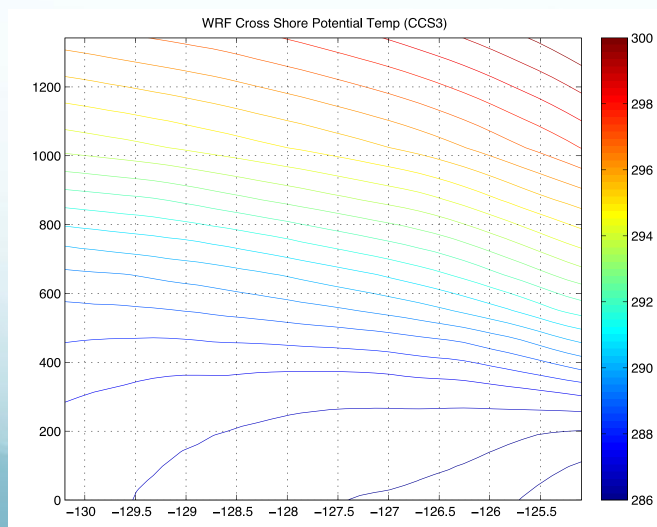
Base Case | Case 2

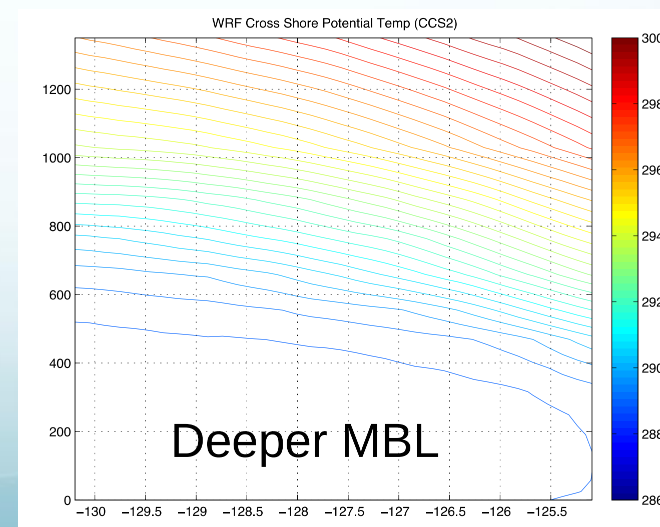
Alongshore





Cross-shore

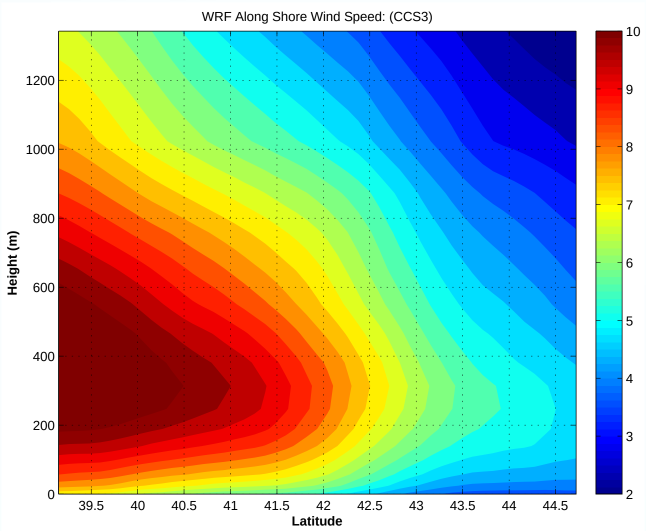


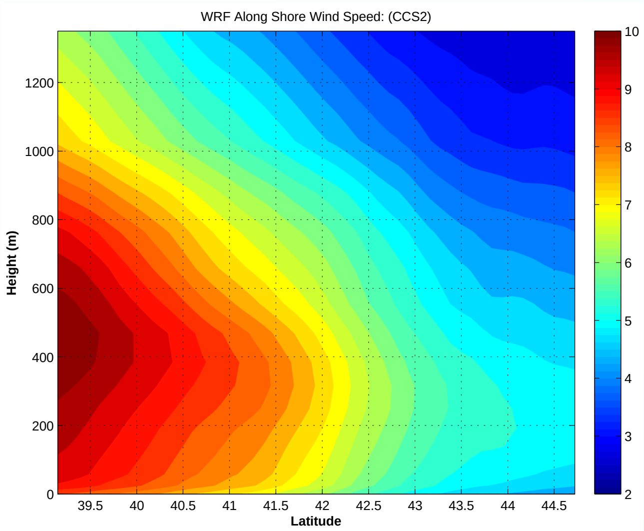


Wind Speed

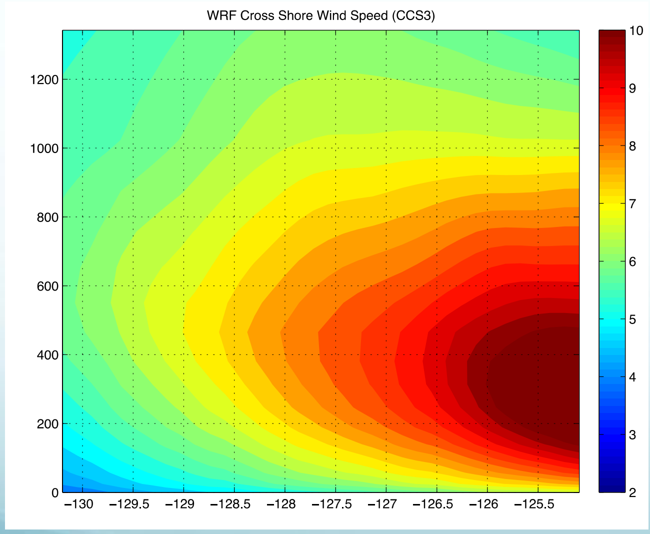
Base Case | Case 2

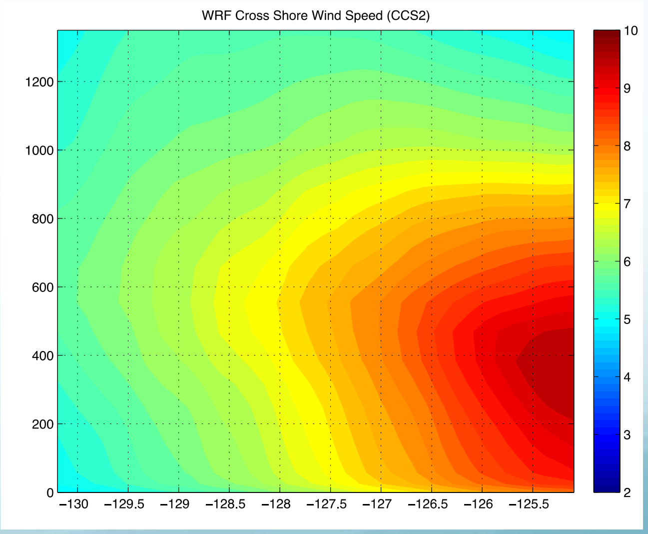
Alongshore





Cross-shore



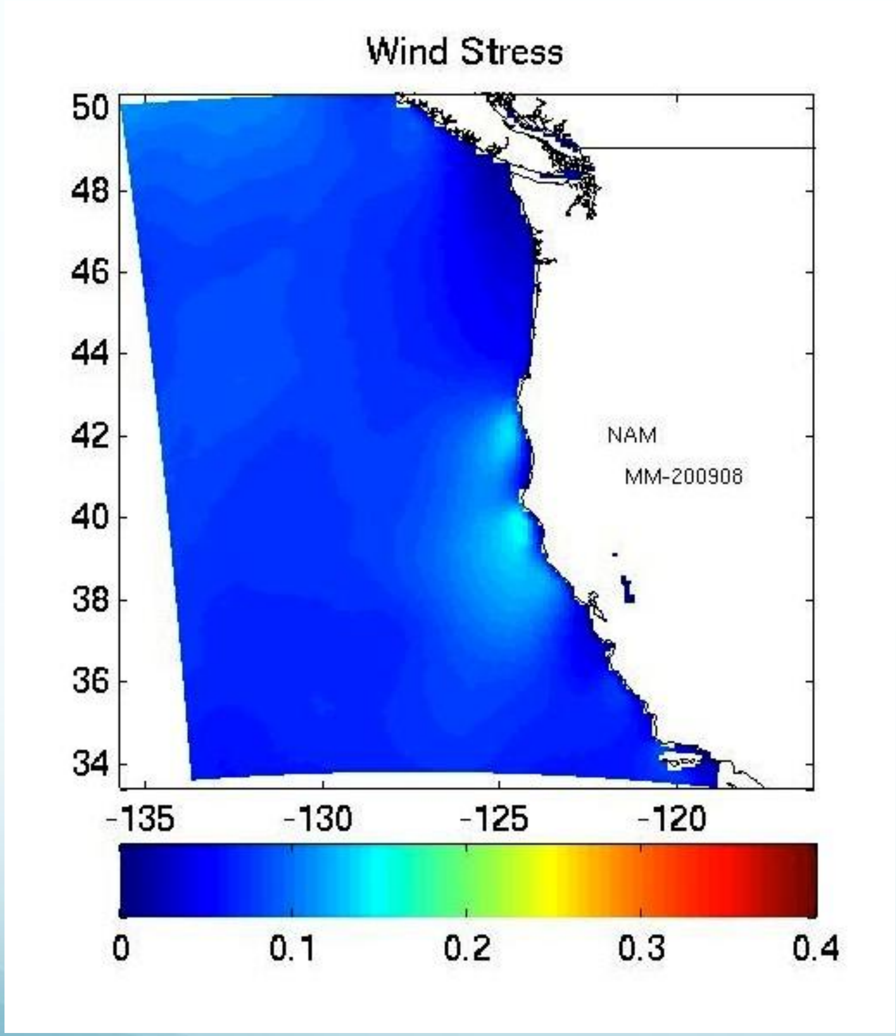


Acceleration mostly from MBL deepening from reduced cooling

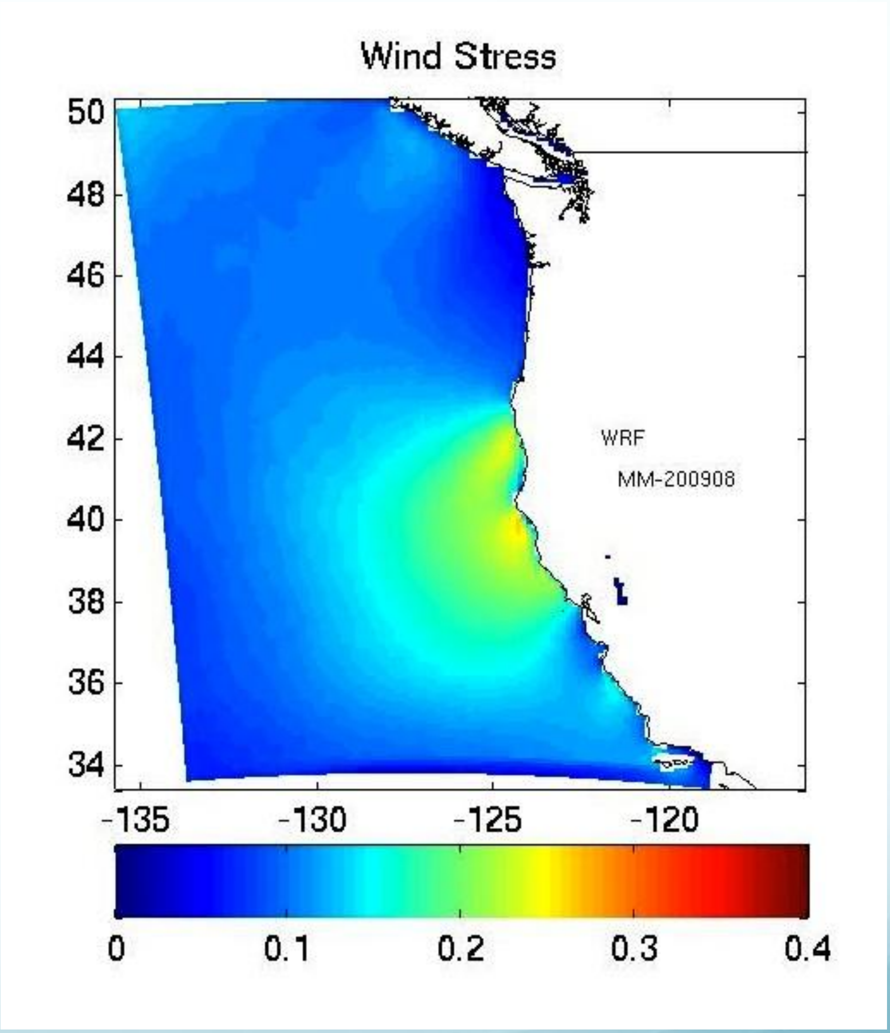
ROMS Simulation

- Use winds from Case 2 WRF simulation to force ROMS model
- Compare resulting SST and SSH to Basic Case

Base Case

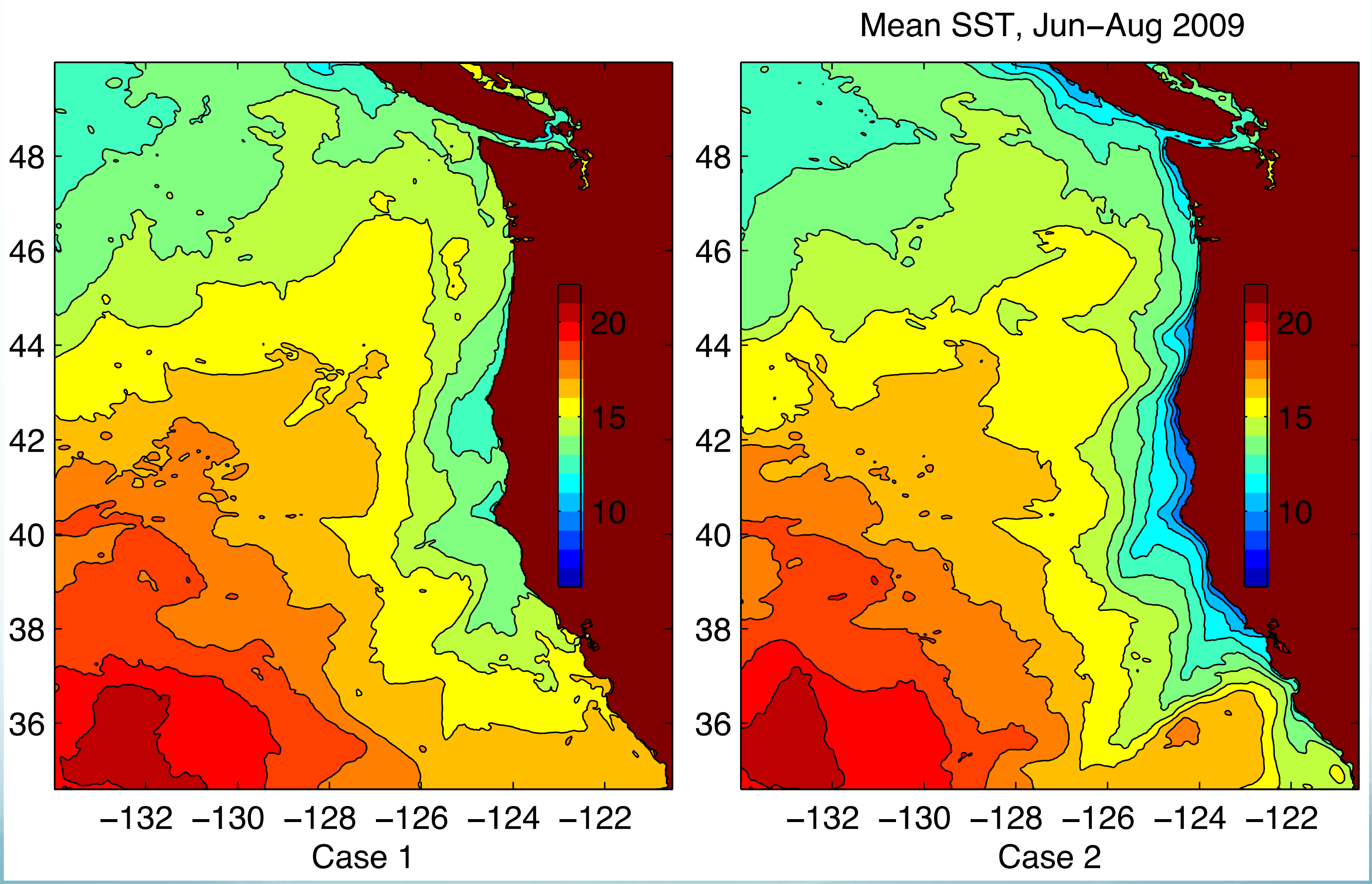


Case 2

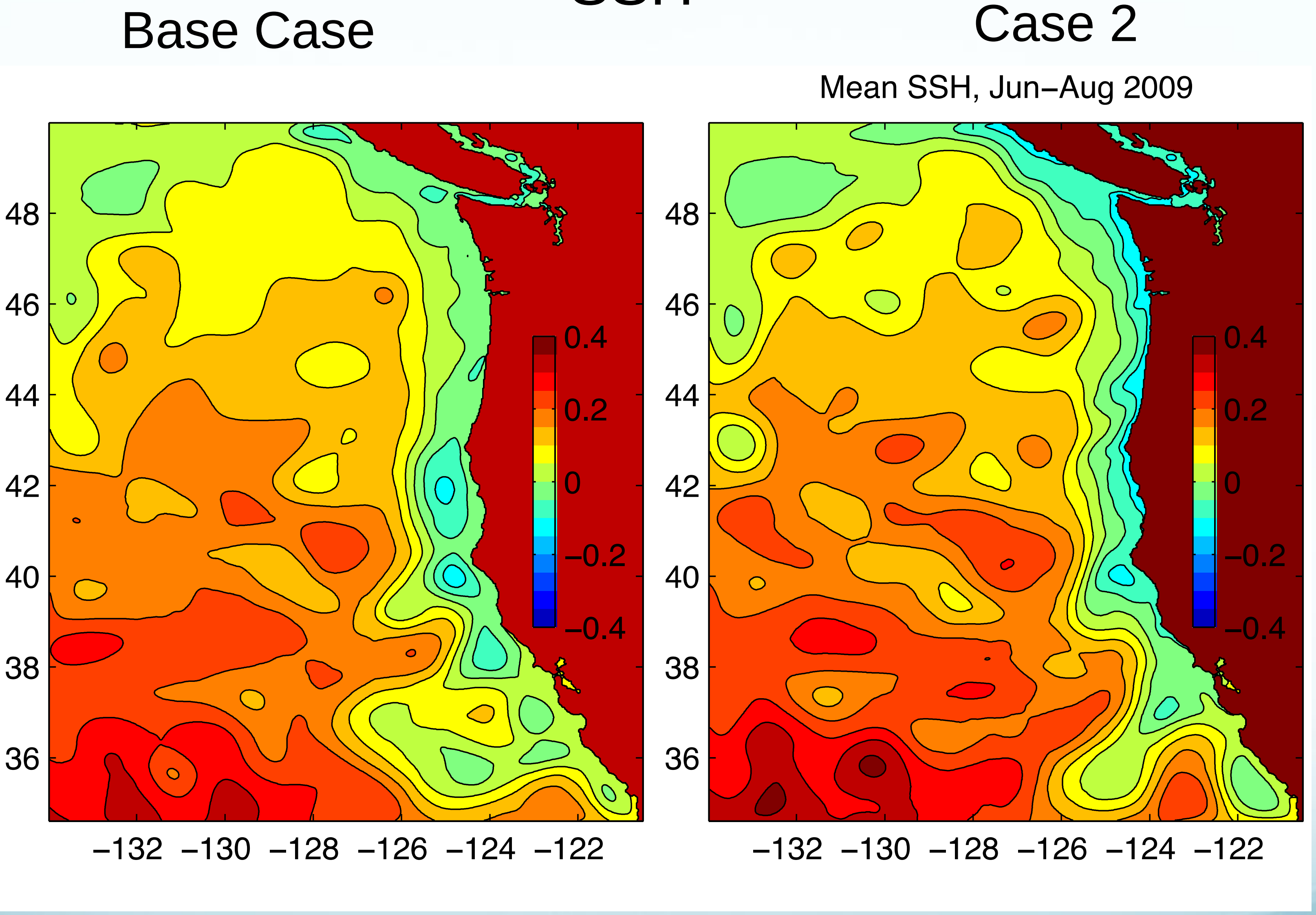


Base Case

Case 2

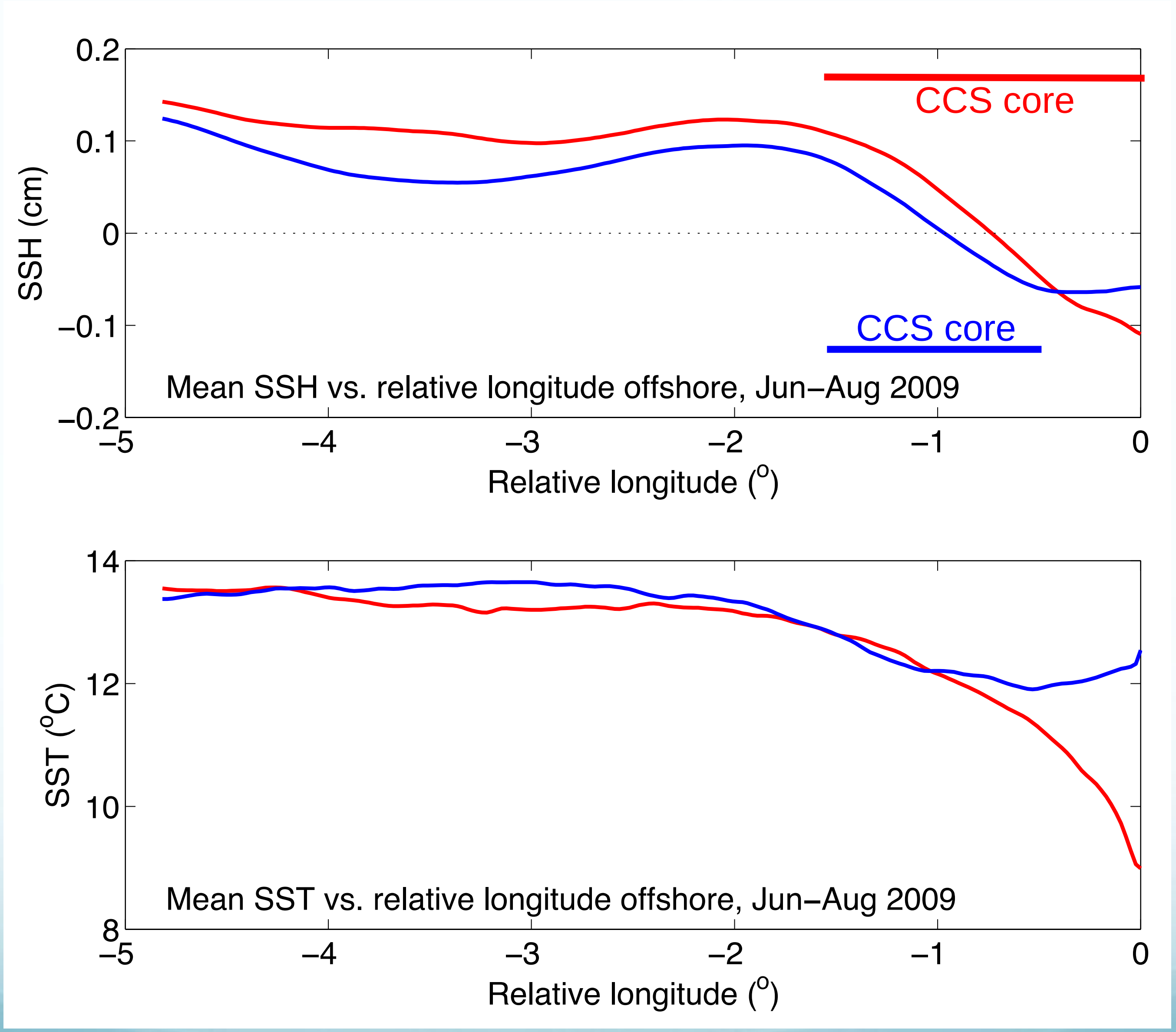


SSH



Note that SSH detaches from coast in Base Case

Ocean model response to stress with original (Basic Case; blue) and modified (Case 2; red) SST



Main Results

SST-stress coupling is sufficiently strong and persistent to affect the climatological mean structure of the California Current System.

These simulations suggest that the characteristic offshore displacement of the CCS core is a consequence of SST-stress coupling.

Future work – open questions

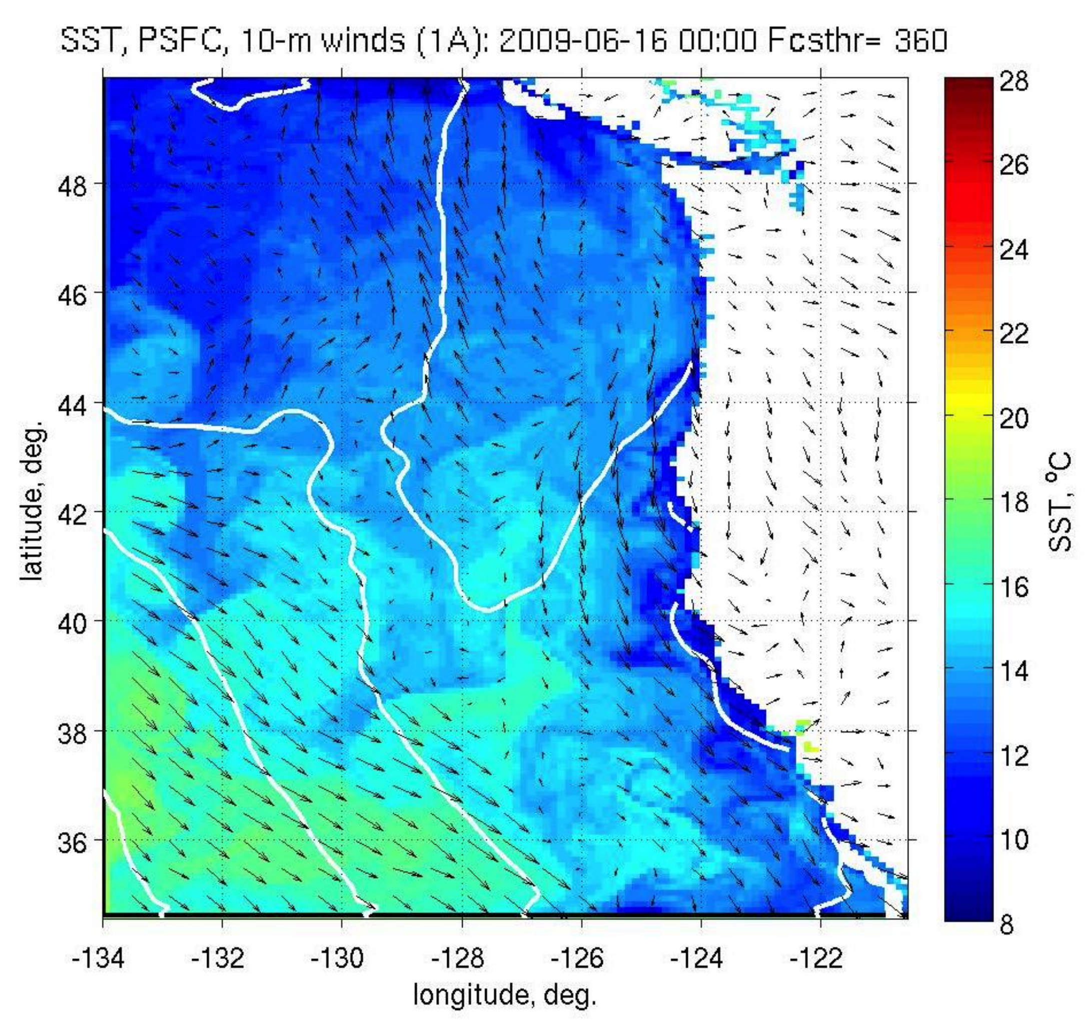
1. Does SST-stress coupling indeed control basic CCS structure?

2. Is surface-current coupling (through relative wind or vorticity effect on Ekman pumping) also important?

3. Does mesoscale air-sea coupling associated with time-dependent eddy and meander features affect the climatological mean CCS structure?

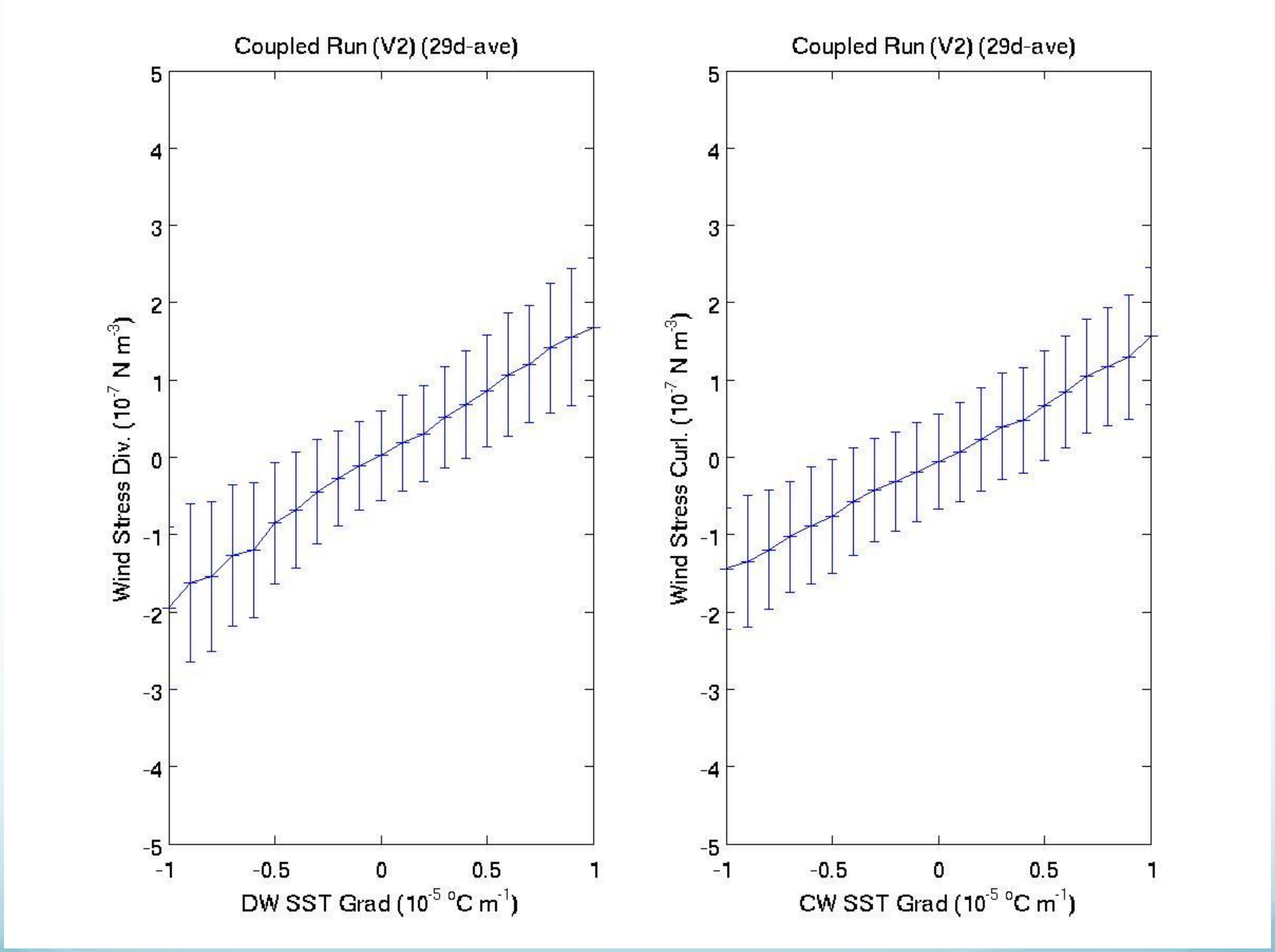
4. Does air-sea coupling stabilize CCS structure against changes in external forcing – and (how) does this affect the CCS response to global climate change?

Coupled COAMPS ROMS

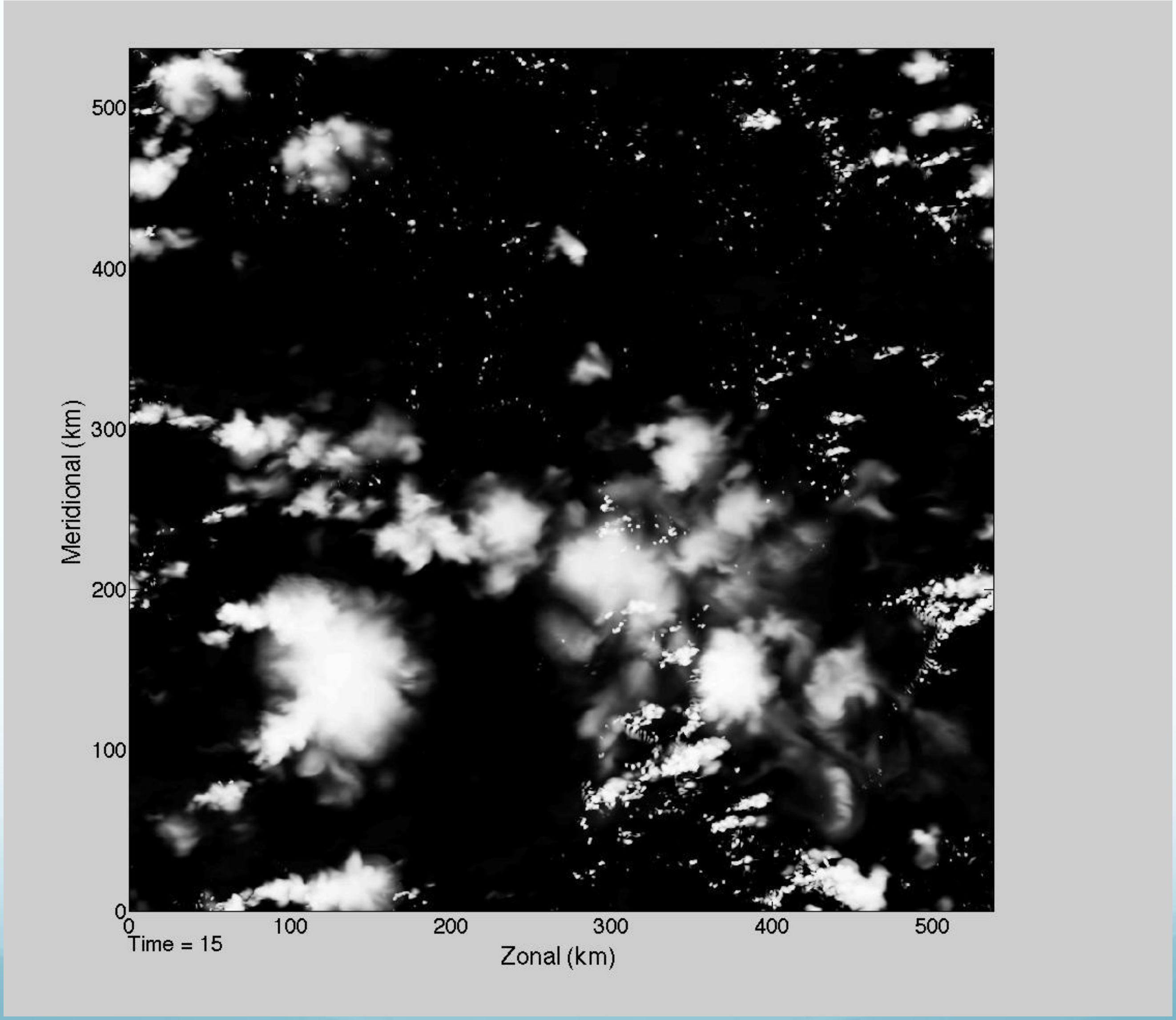


- COAMPS forced on boundaries by NCAR "final analysis"
- ROMS model boundaries set using NCOM Pacific simulation
- Models coupled over west coast domain
- Ocean structure generated by this approach should provide a more accurate test for curl and divergence (Chelton talk yesterday)

Divergence – Curl SST Correlations



Cloud Resolving Large-Eddy Simulation of Tropical Convection



Surface Specific Humidity (16-20 g kg^{-1})