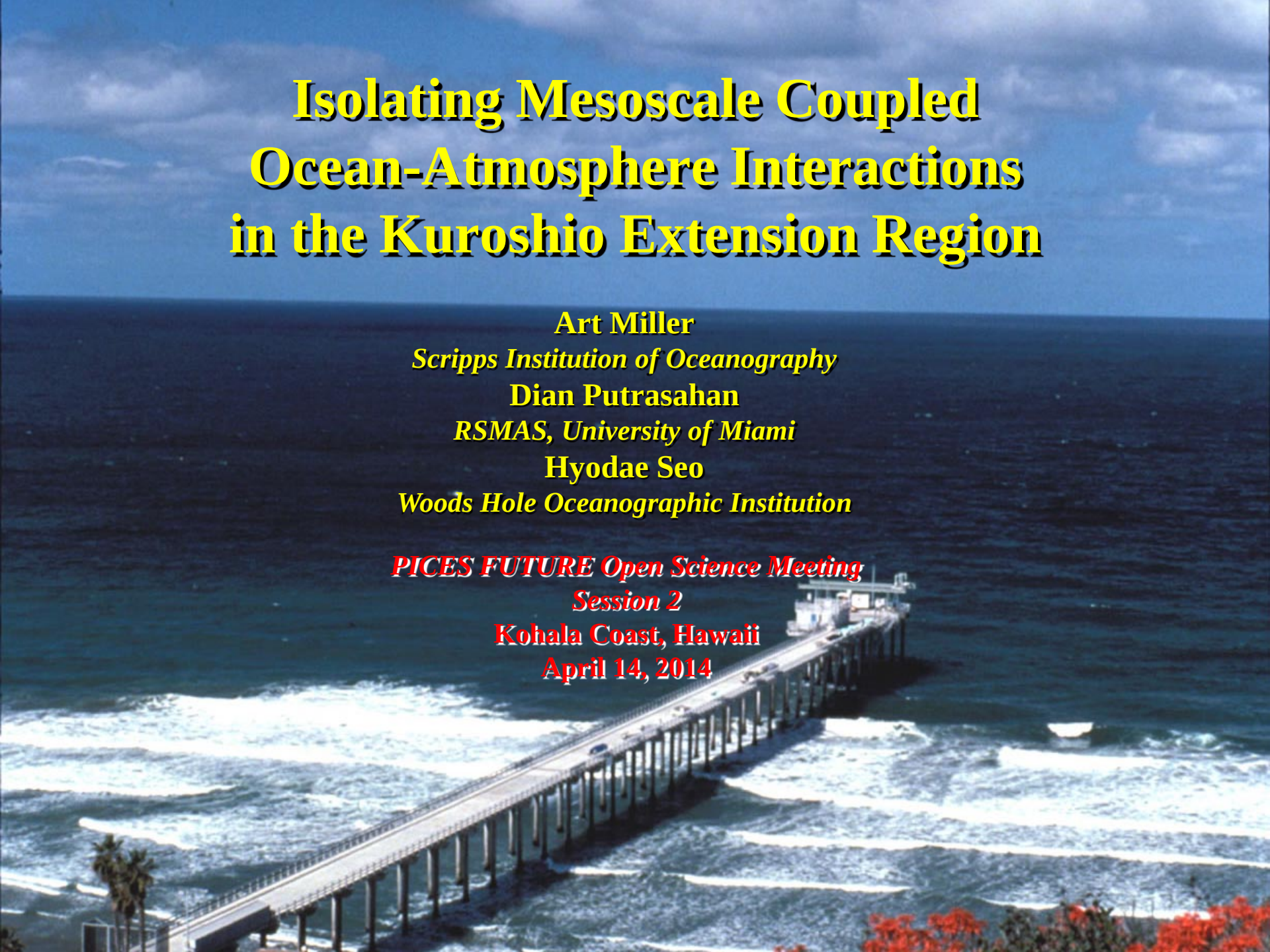

Isolating Mesoscale Coupled Ocean-Atmosphere Interactions in the Kuroshio Extension Region

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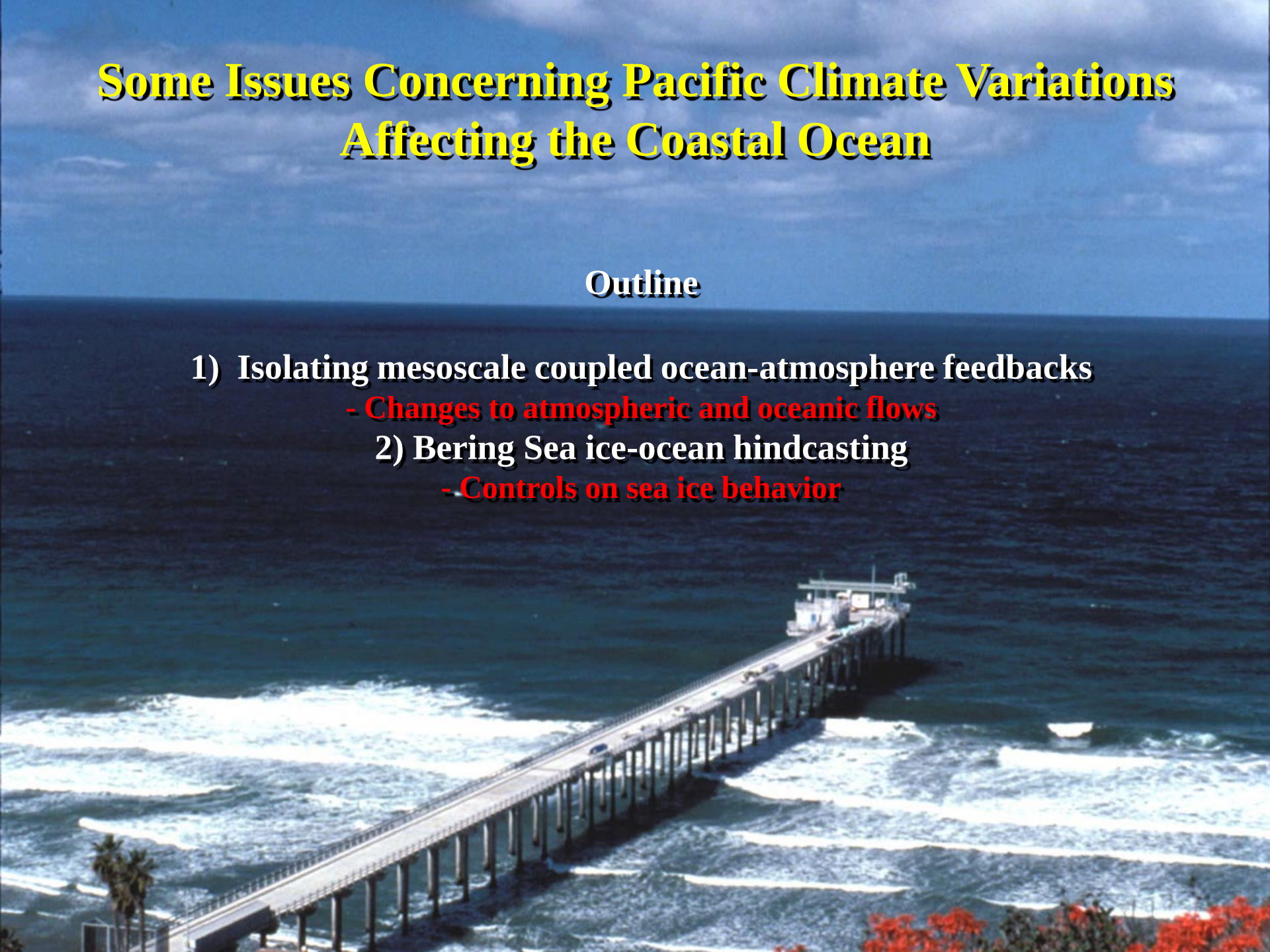
RSMAS, University of Miami
Hyodae Seo
Woods Hole Oceanographic Institution

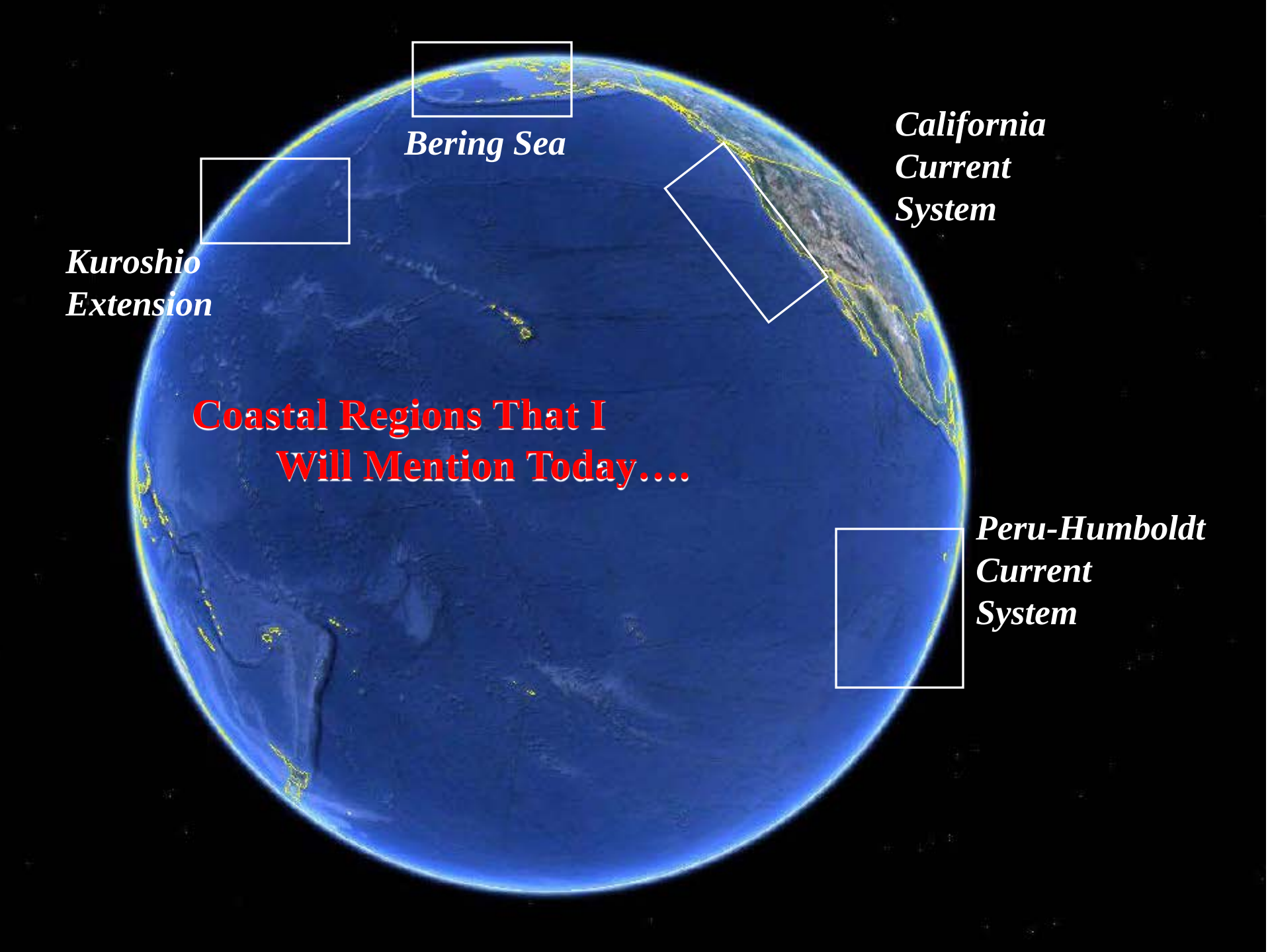
PICES FUTURE Open Science Meeting
Session 2
Kohala Coast, Hawaii
April 14, 2014

Some Issues Concerning Pacific Climate Variations Affecting the Coastal Ocean

Outline

1) Isolating mesoscale coupled ocean-atmosphere feedbacks
   - Changes to atmospheric and oceanic flows
2) Bering Sea ice-ocean hindcasting
   - Controls on sea ice behavior




Bering Sea
California Current System
Kuroshio Extension
Coastal Regions That I Will Mention Today….
Peru-Humboldt Current System

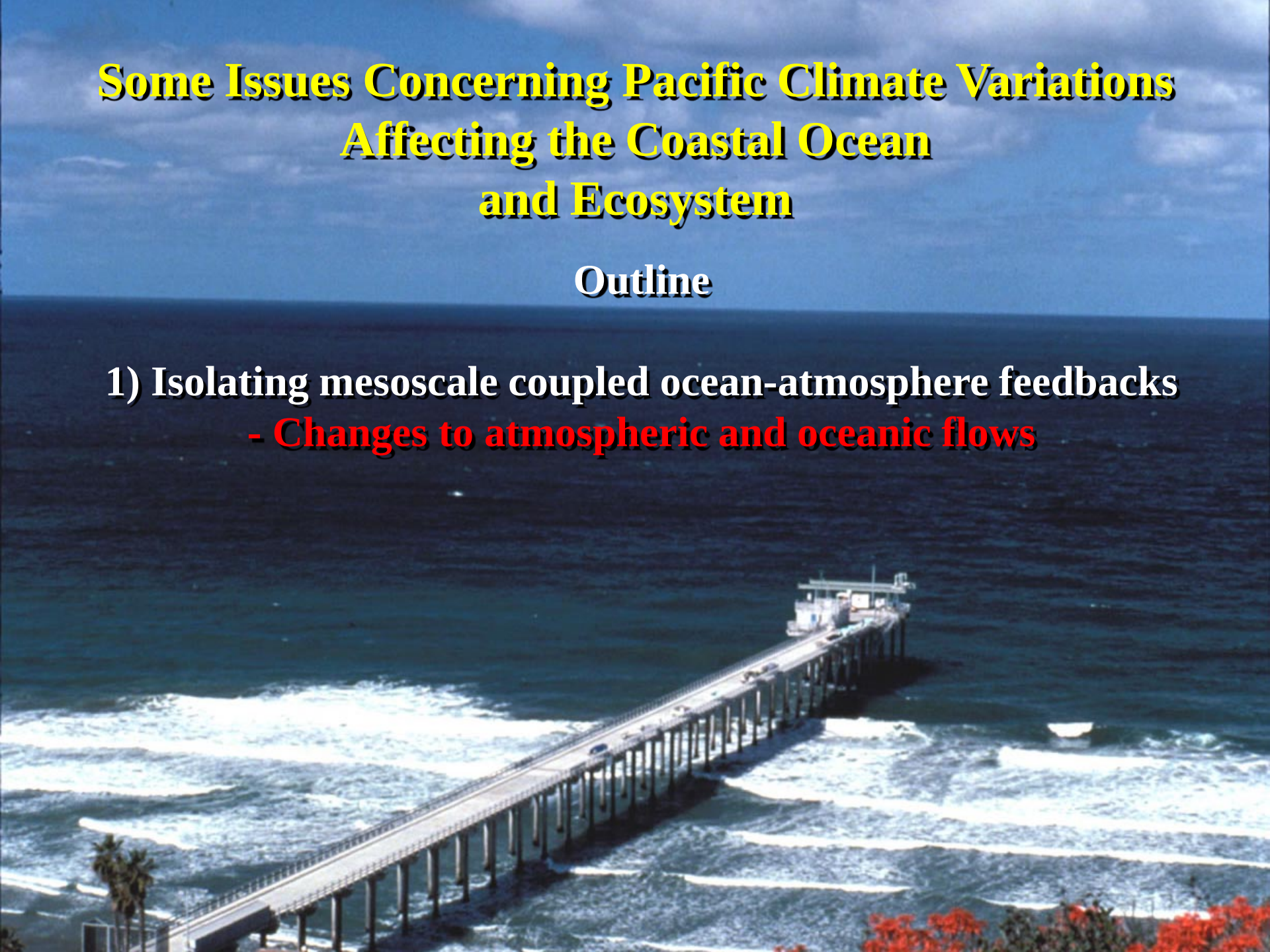
Driving Questions

- What impact do mesoscale-eddy generated surface flux anomalies have on the atmosphere and ocean? CCS, HCS, KE
- Why are uncoupled ice-ocean model hindcasts so good? BS

Some Issues Concerning Pacific Climate Variations Affecting the Coastal Ocean and Ecosystem

Outline

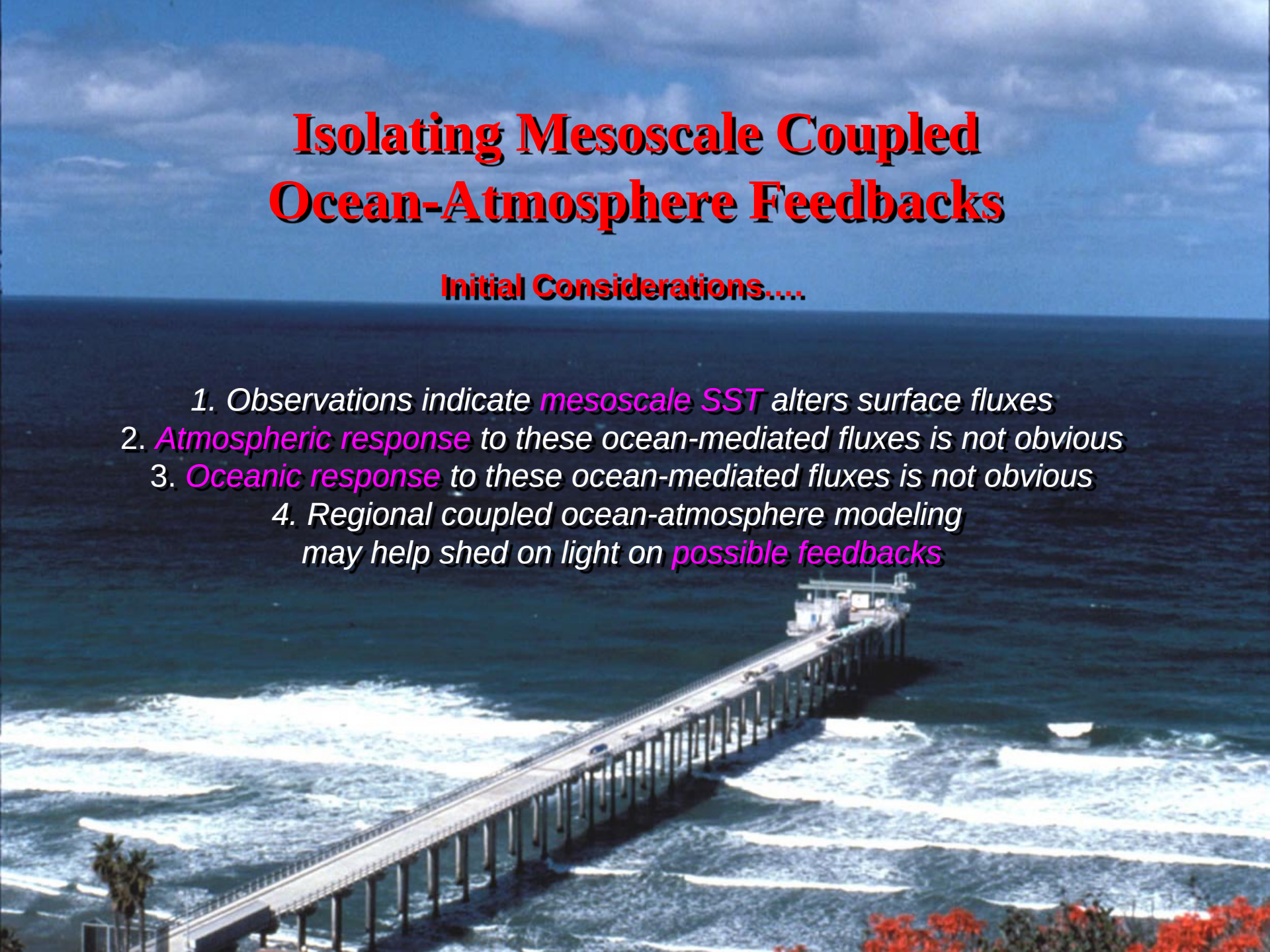
1) Isolating mesoscale coupled ocean-atmosphere feedbacks
- Changes to atmospheric and oceanic flows



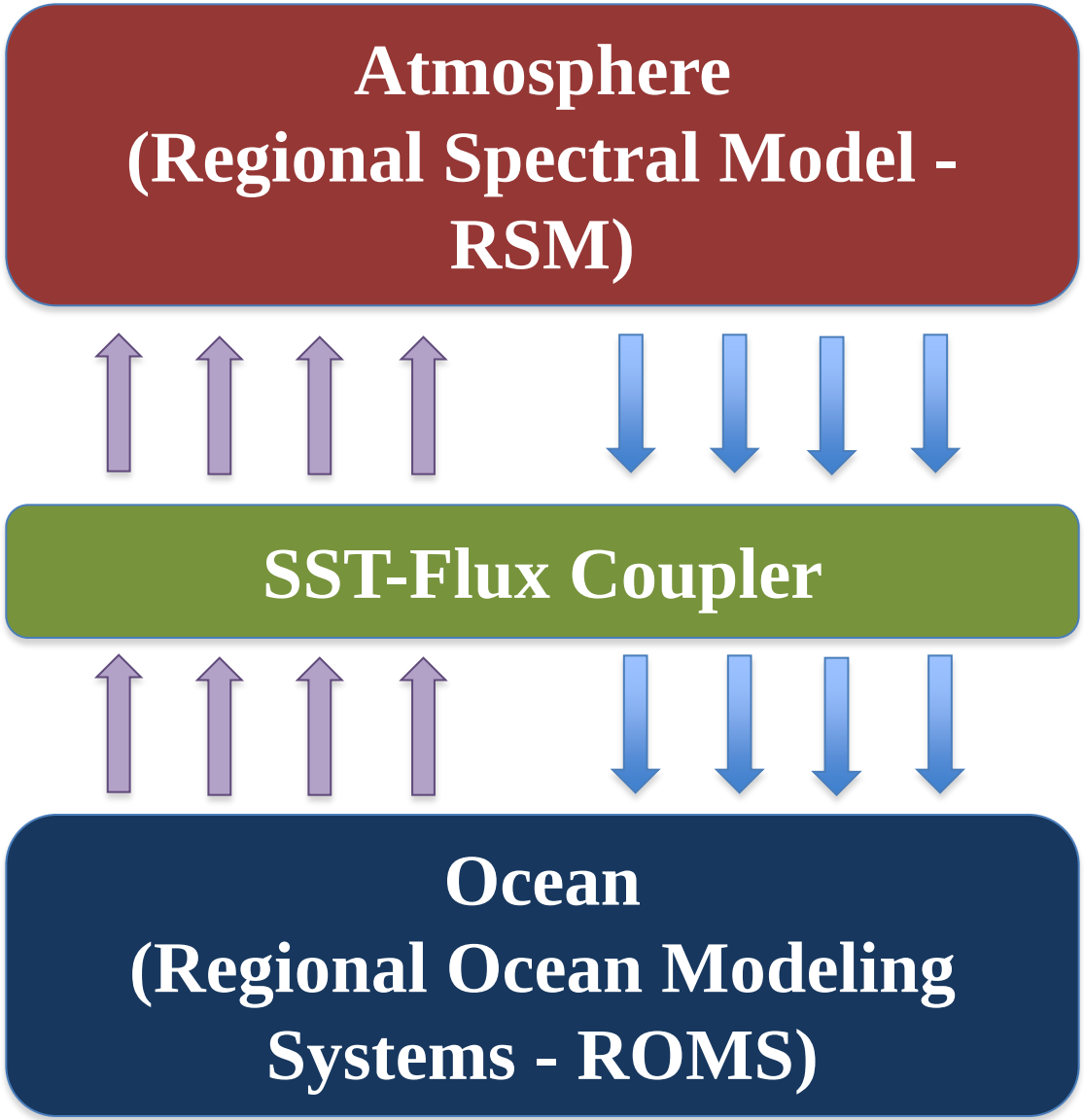
Isolating Mesoscale Coupled Ocean-Atmosphere Feedbacks

Initial Considerations….

1. Observations indicate mesoscale SST alters surface fluxes
2. Atmospheric response to these ocean-mediated fluxes is not obvious
3. Oceanic response to these ocean-mediated fluxes is not obvious
4. Regional coupled ocean-atmosphere modeling may help shed on light on possible feedbacks



Scripps Coupled Ocean-Atmosphere Regional (SCOAR) Model



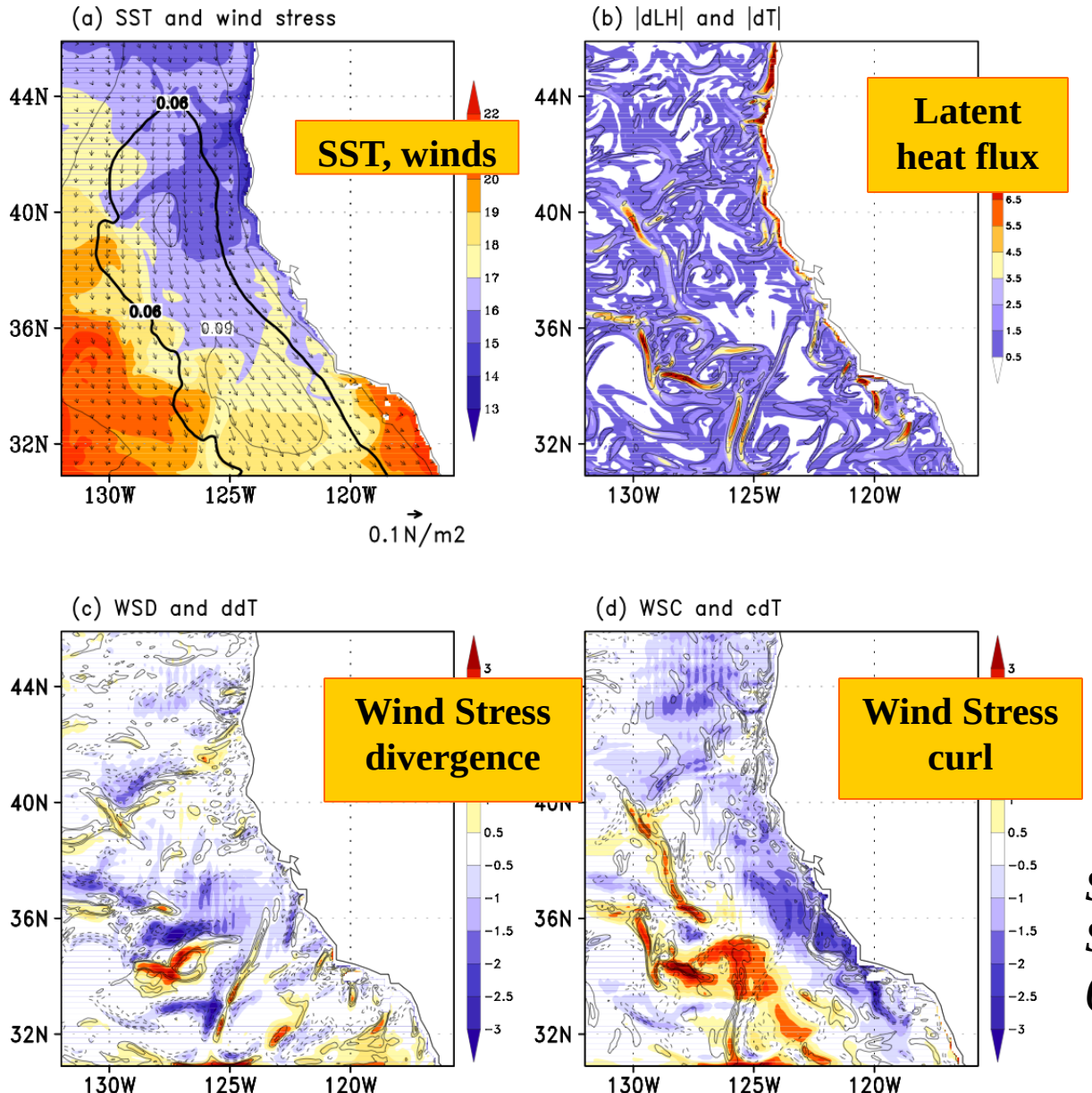
Mesoscale Air-sea Coupling Experiment	
Case 1: (Control SCOAR)	Control run composed of fully-coupled SCOAR run for 2000-2007
Case 2: (Smoothed SCOAR)	SCOAR run with daily, ~2.5 degrees spatial smoothing of SST at every coupling step *Putrasahan et al. 2013*

Seo, Miller and Roads
J. Climate, 2007

Regional Coupled Ocean-Atmosphere Feedbacks in the California Current Sector

RSM Atmos model: 16 km

ROMS Ocean model: 7 km

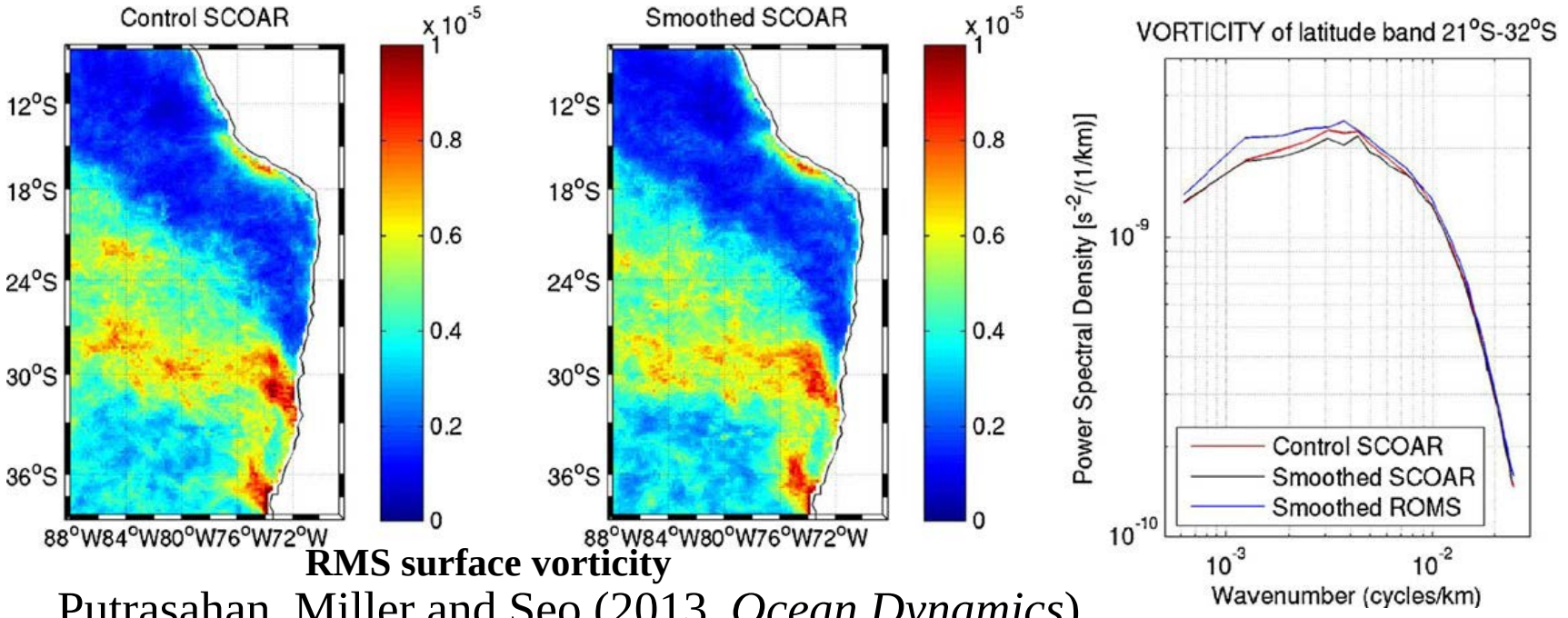


- Coupling of SST with Atmospheric Boundary Layer is observed and modeled in the CCS region over eddy scales

•How does this coupling affect statistics of ocean eddies, and the overlying atmospheric flows?

SCOAR simulation Seo, Miller and Roads (2007, J. Climate)

Peru-Humboldt Current System: Do coupled feedbacks of mesoscale surface fluxes (wind stress, heat) alter eddy statistics?



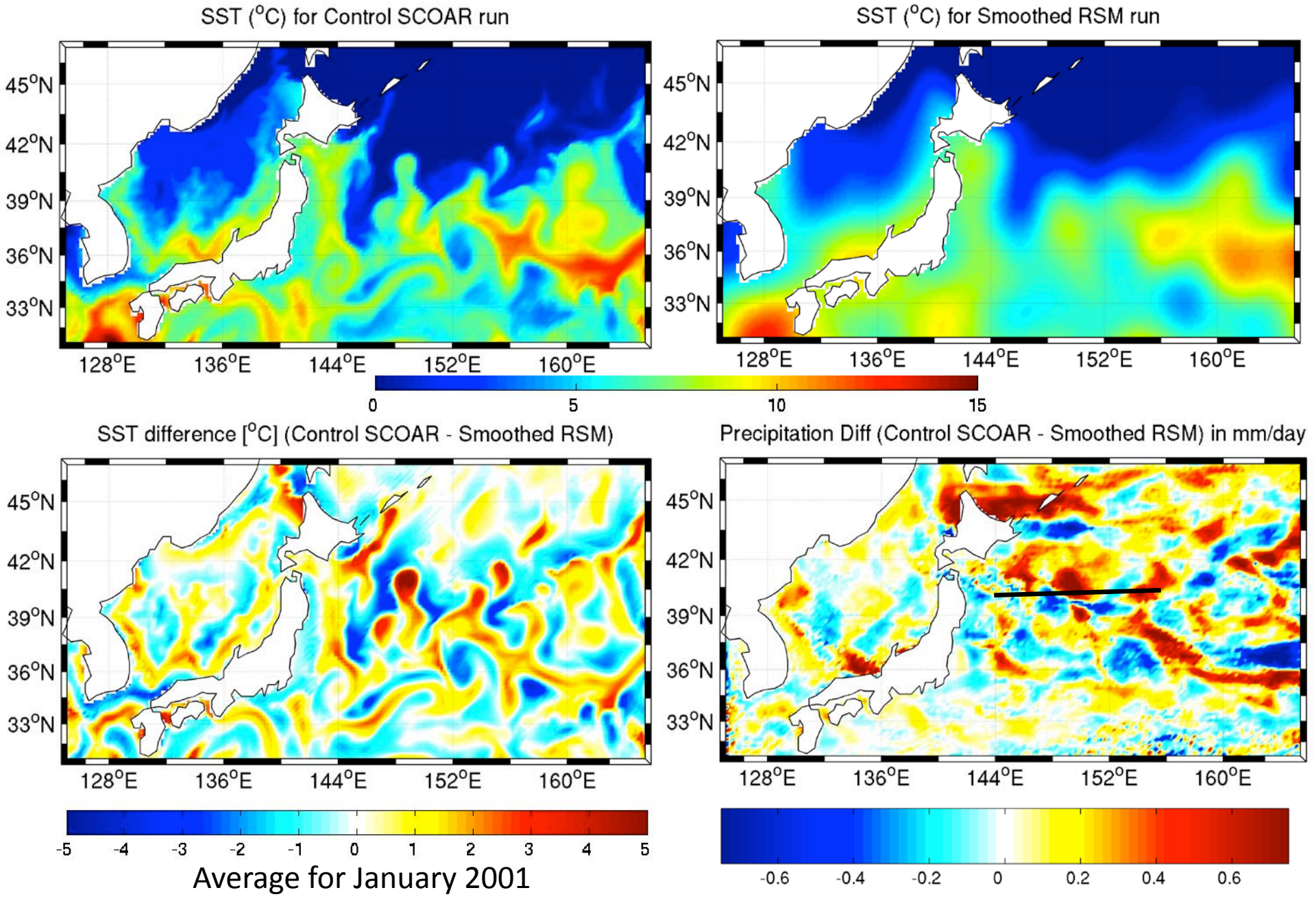
RMS surface vorticity

Putrasahan, Miller and Seo (2013, *Ocean Dynamics*)

Very small impacts – perhaps SST gradients are simply too weak

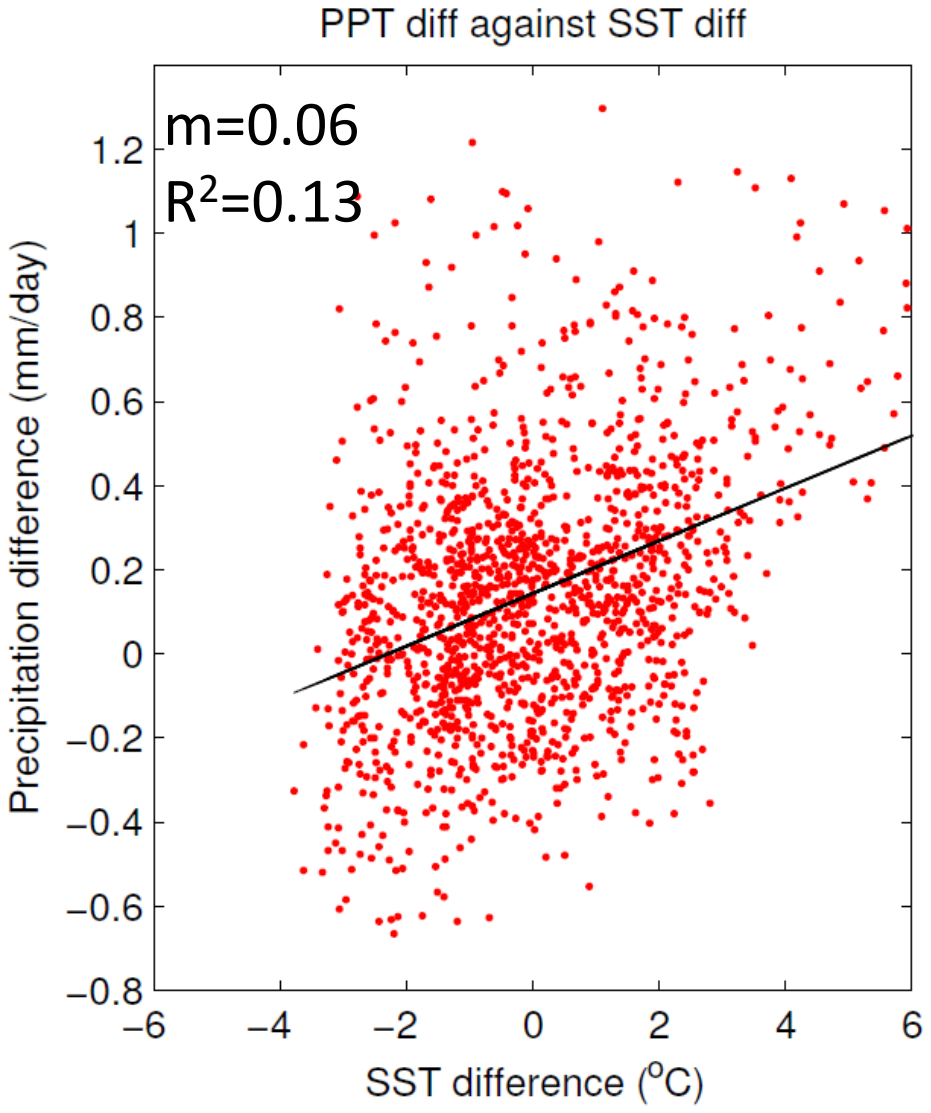
(Note: Chelton suggests wind-ocean velocity difference is vital in stress)

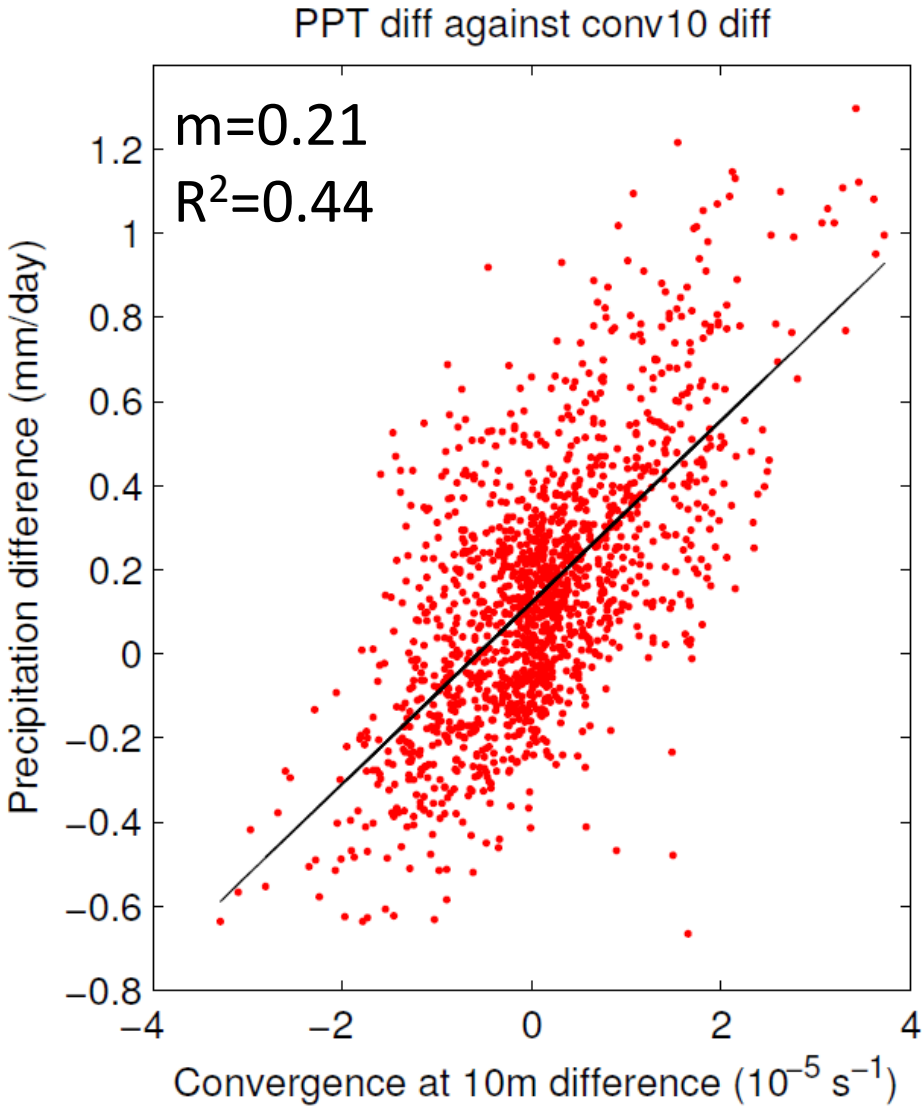
Kuroshio: Stronger Fronts….(Putrasahan, Miller, Seo, 2013, *DAO*)



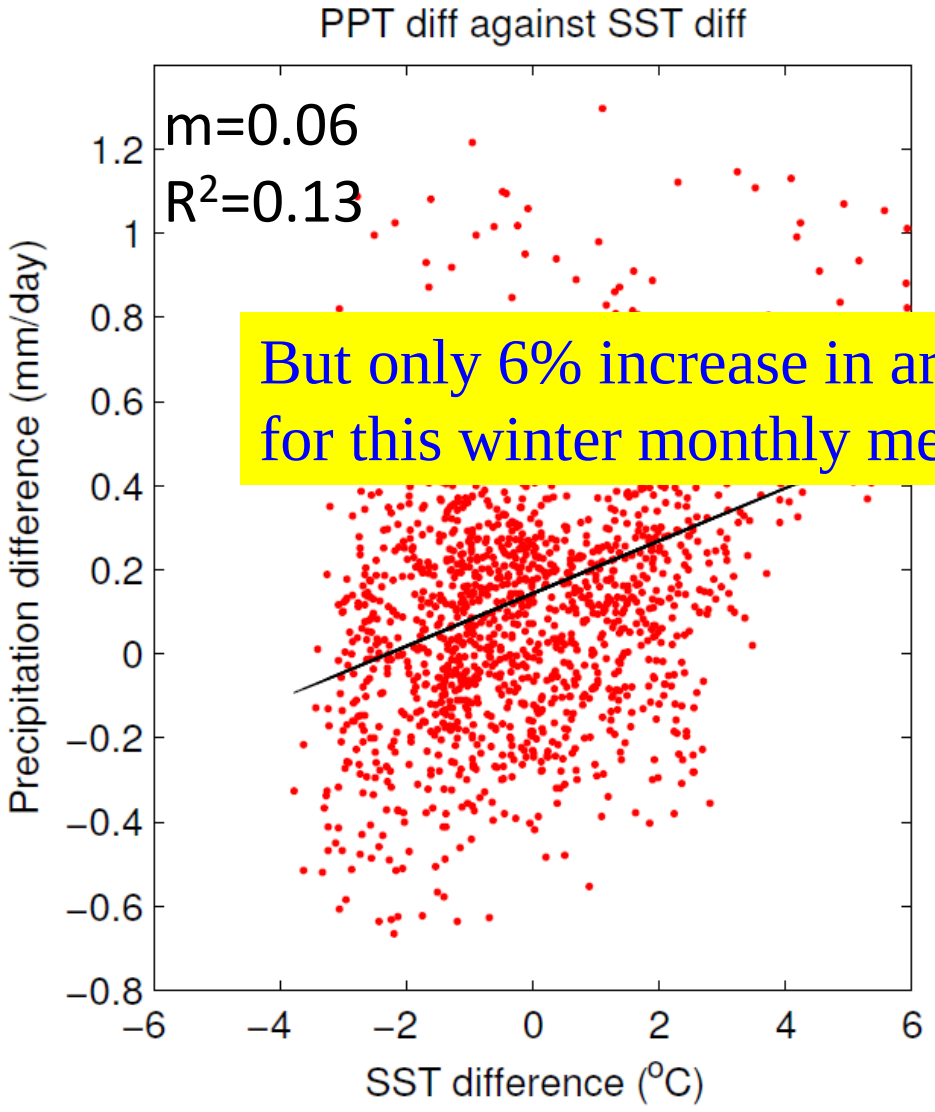
Average for January 2001

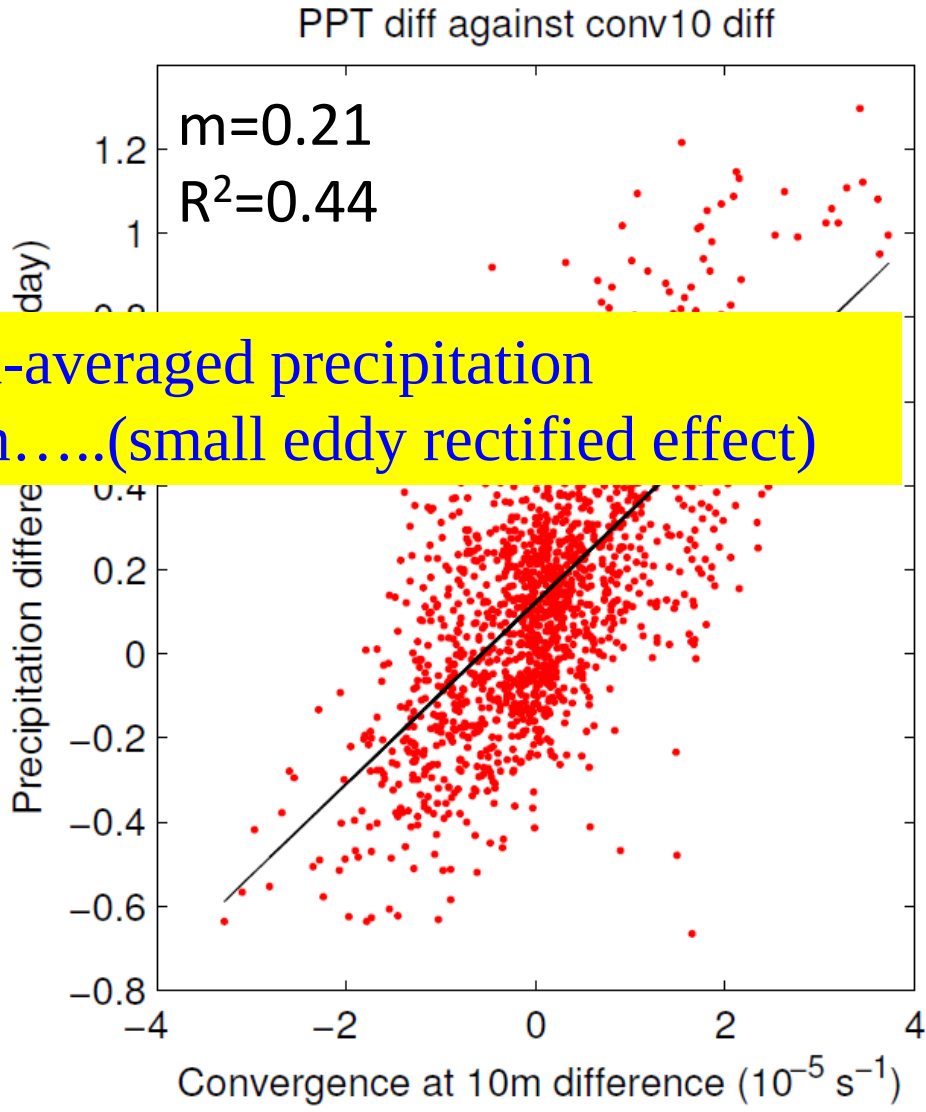
Kuroshio: Precipitation differences versus SST' and 10m wind convergence'





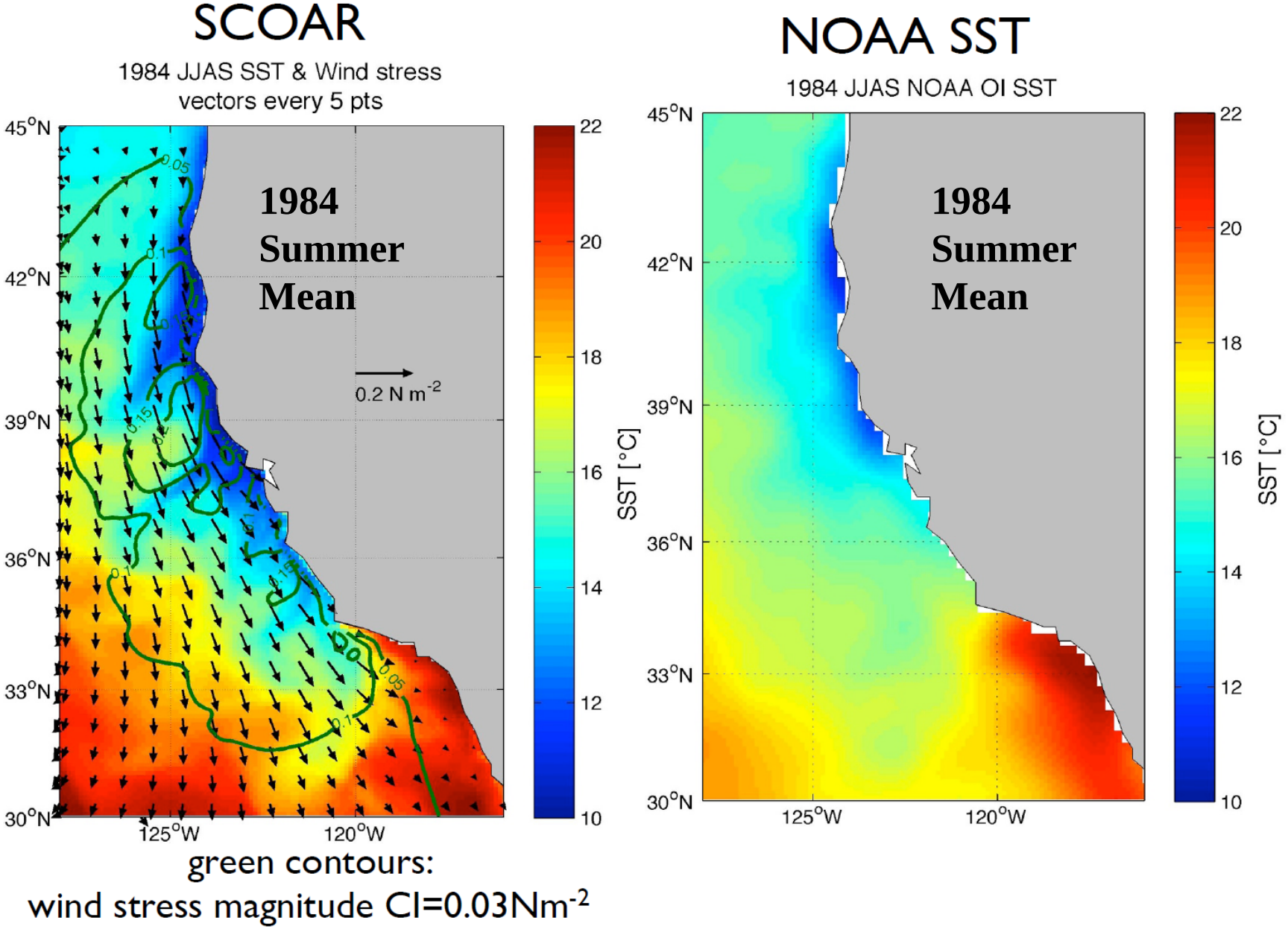
Kuroshio: Precipitation differences versus SST' and 10m wind convergence'





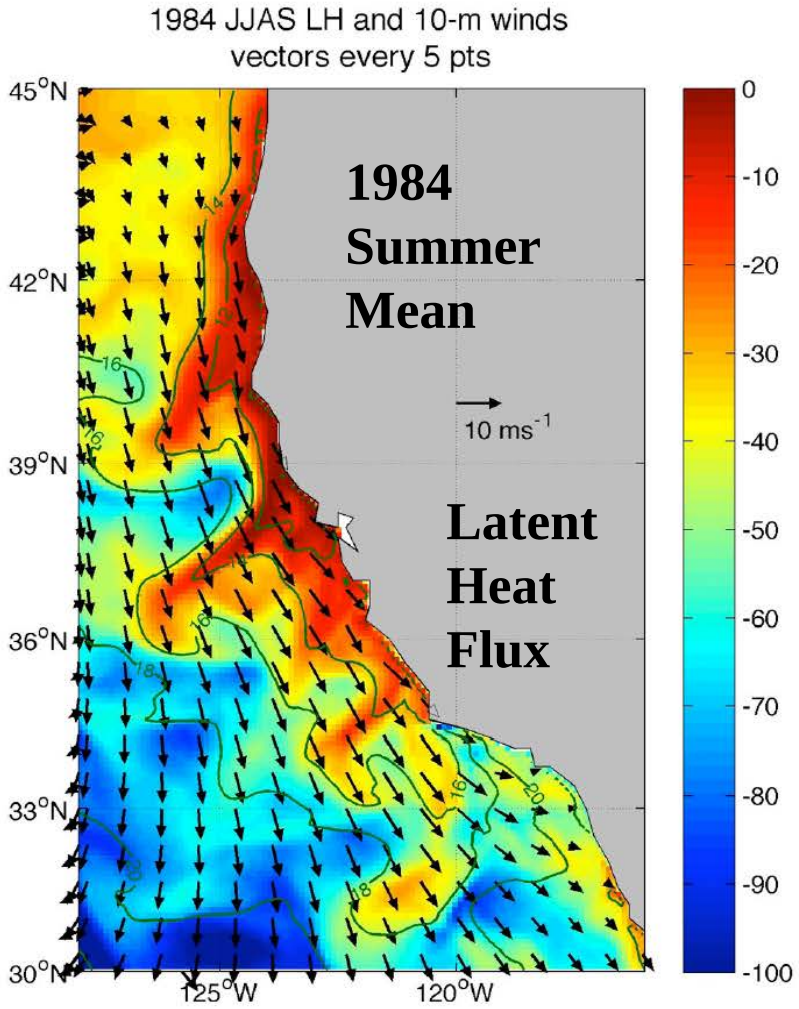
But only 6% increase in area-averaged precipitation for this winter monthly mean…..(small eddy rectified effect)

California Coast: SCOAR2 (WRF-ROMS)
12km joint resolution (Seo, Miller and Norris 2014, in progress)



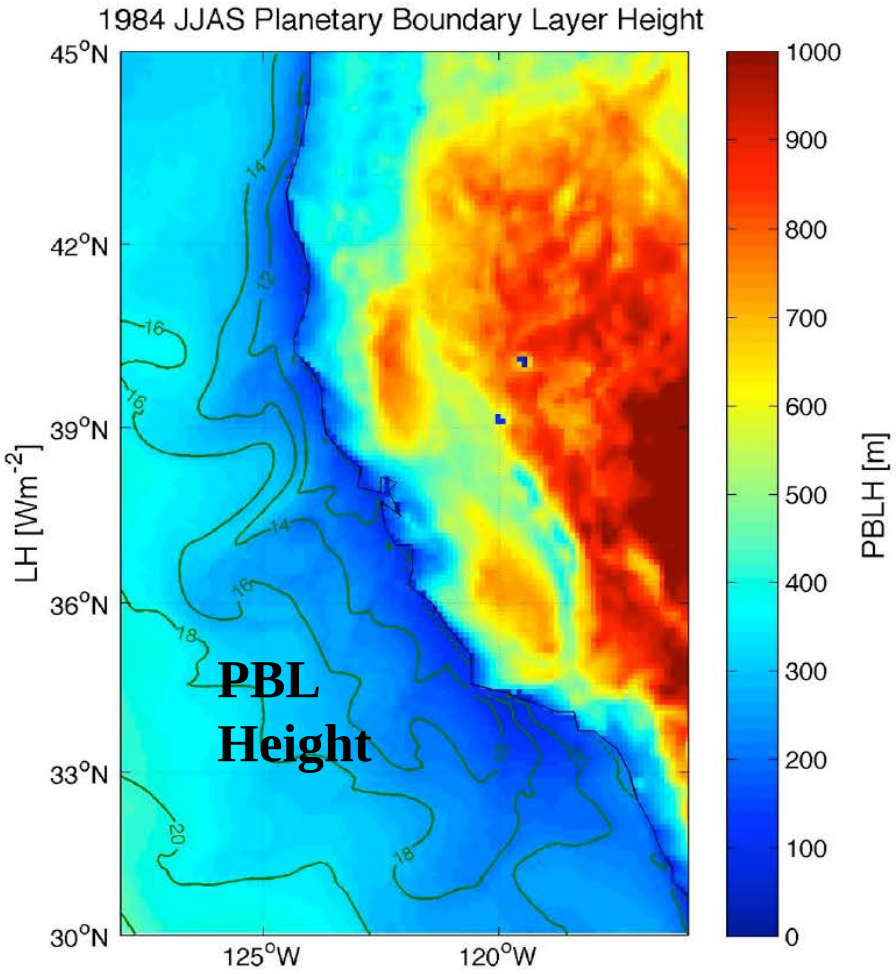
California Coast: SCOAR2 (WRF-ROMS)
12km joint resolution (Seo, Miller and Norris, 2014, in progress)

SCOAR



green contours:
SST, CI=2°C

SCOAR



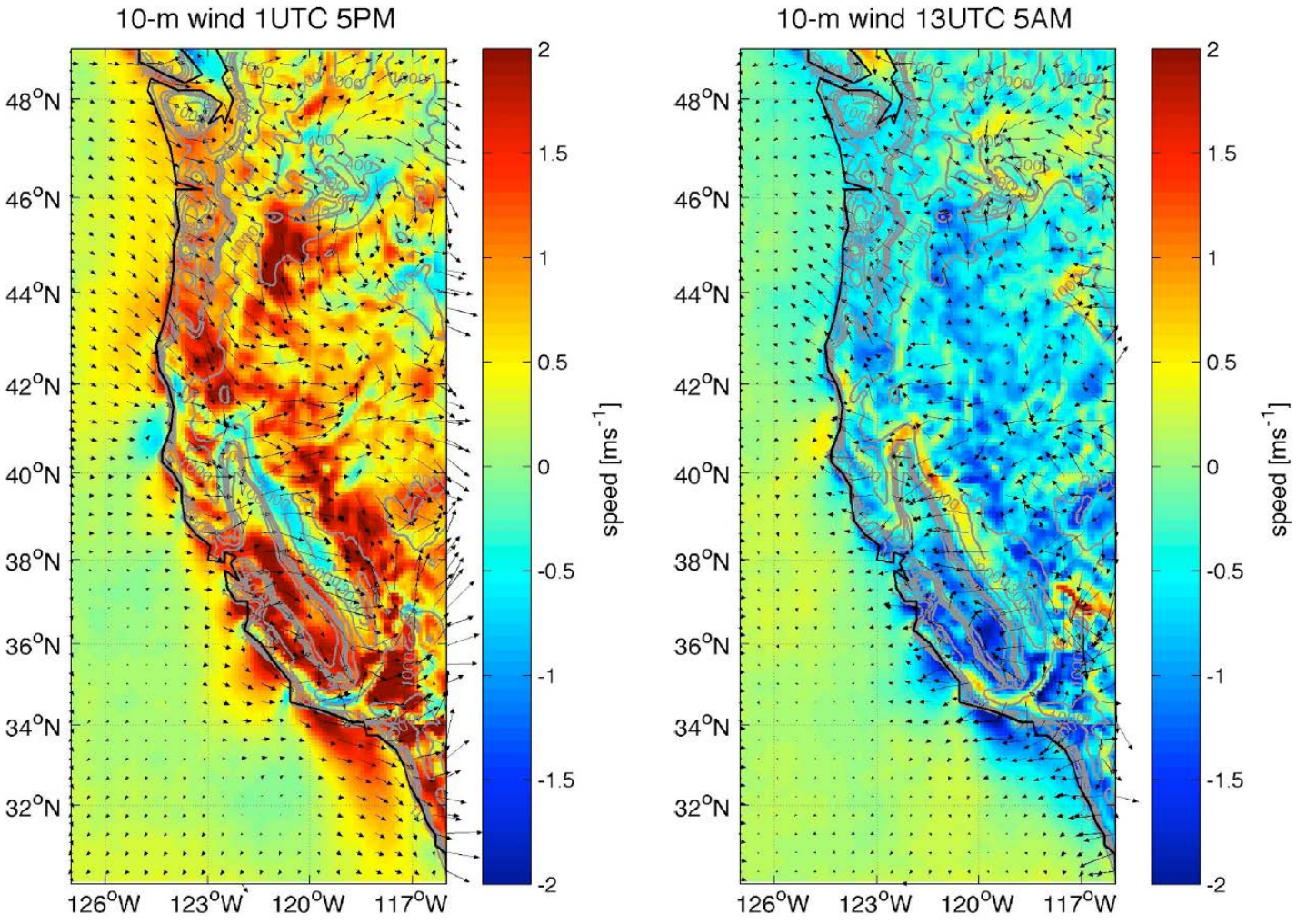
green contours:
SST, CI=2°C

California Coast: SCOAR2 (WRF-ROMS)

12 km joint resolution (Seo, Miller and Norris, 2014, in progress)

Do mesoscale coupled ocean-atmosphere feedbacks in the CCS affect the diurnal cycle Sea Breeze? (in an anomalous sense)

5PM and 5AM composite anomaly of JJAS 1988

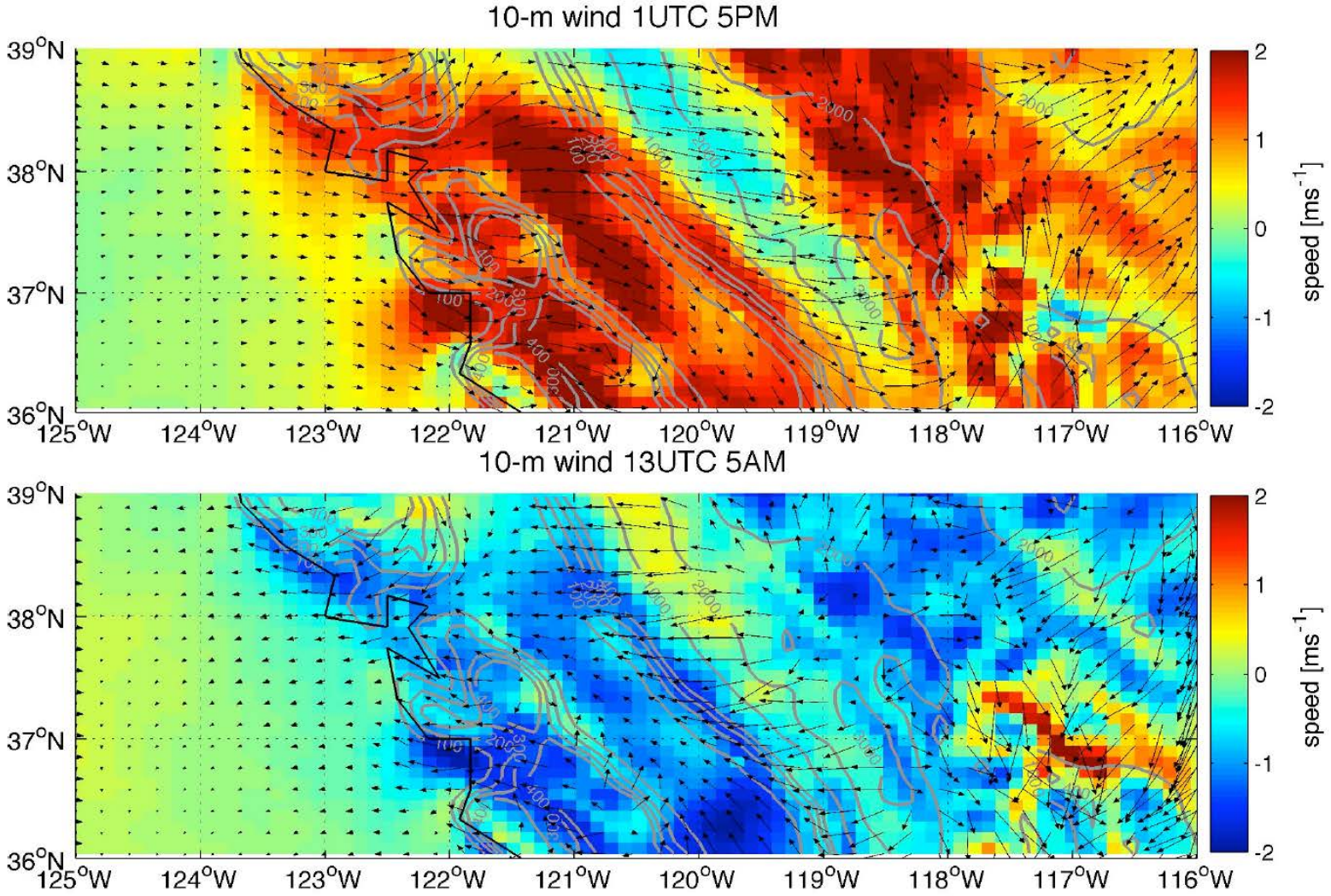


California Coast: SCOAR2 (WRF-ROMS)

12km joint resolution (Seo, Miller and Norris, 2014, in progress)

Do mesoscale coupled ocean-atmosphere feedbacks in the CCS affect the diurnal cycle Sea Breeze? (in an anomalous sense)

This is a zoom-up near the SF Bay area



What's next….?

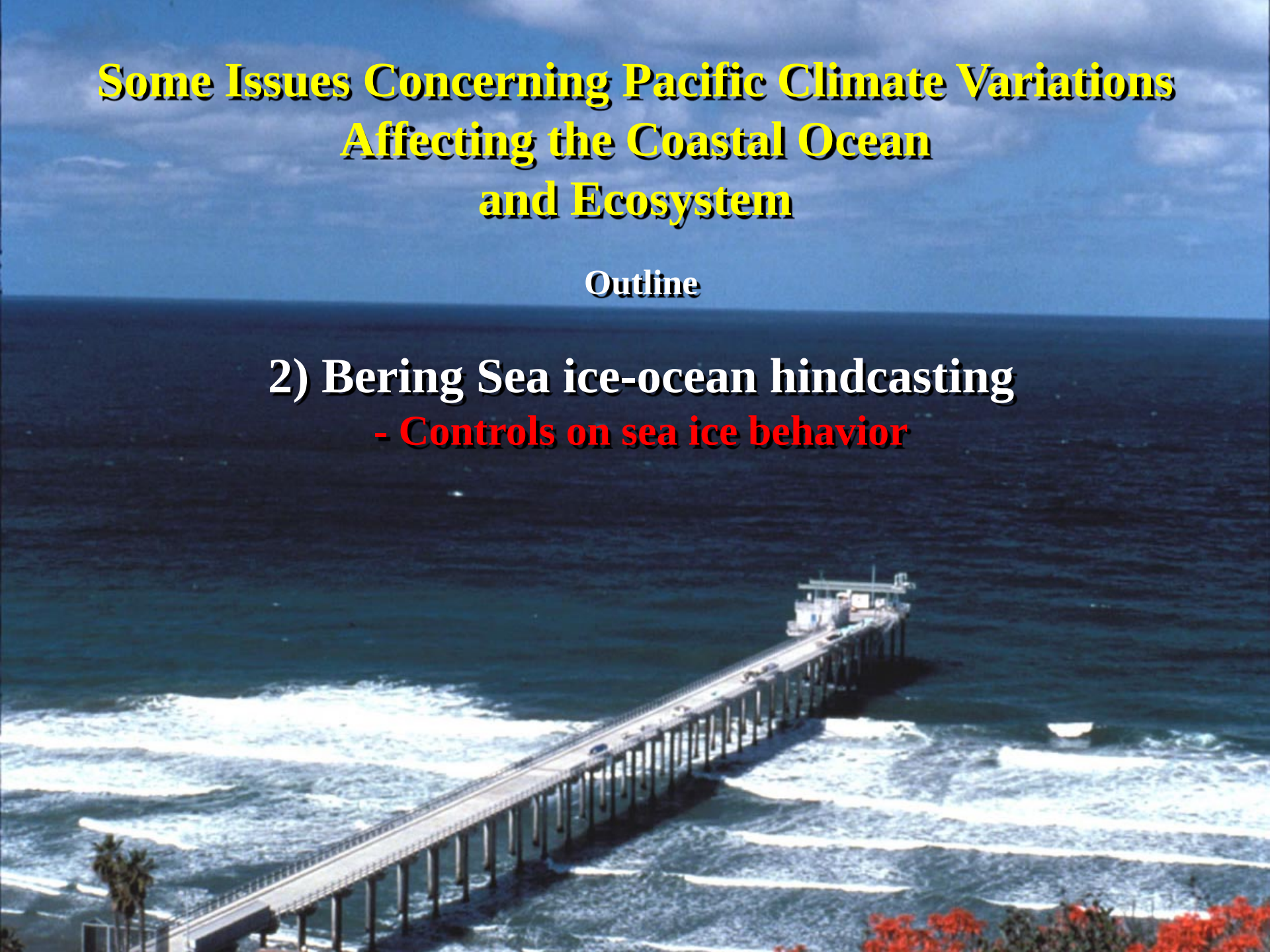
- Compare CCS coupled and uncoupled (still need to be done) runs to isolate SST anomaly effects on the diurnal sea breeze, eddy statistics, cloud statistics
- Compare KOE coupled versus smoothed-coupled model output for changes in ocean eddy statistics

Some Issues Concerning Pacific Climate Variations Affecting the Coastal Ocean and Ecosystem

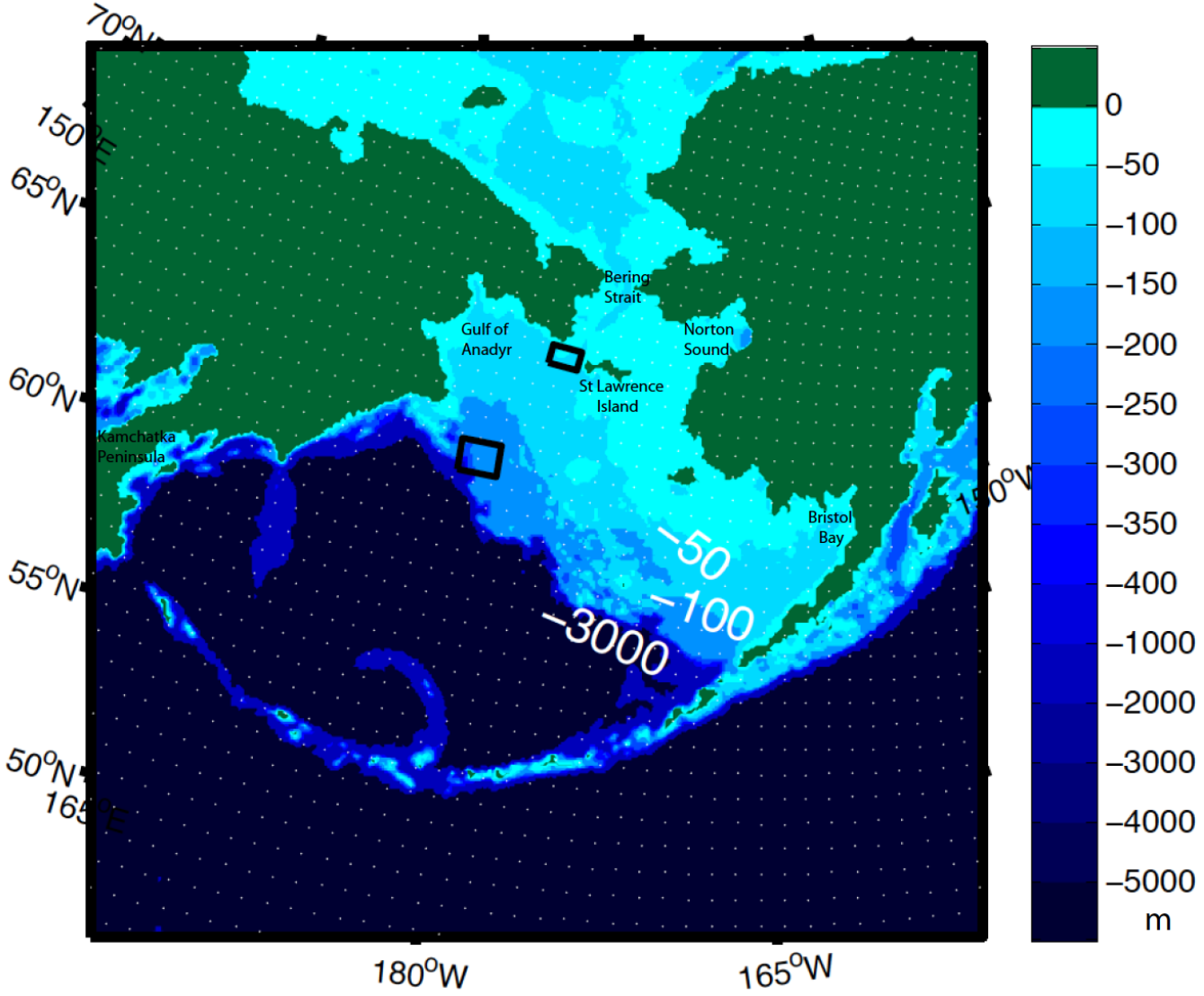
Outline

2) Bering Sea ice-ocean hindcasting

- Controls on sea ice behavior



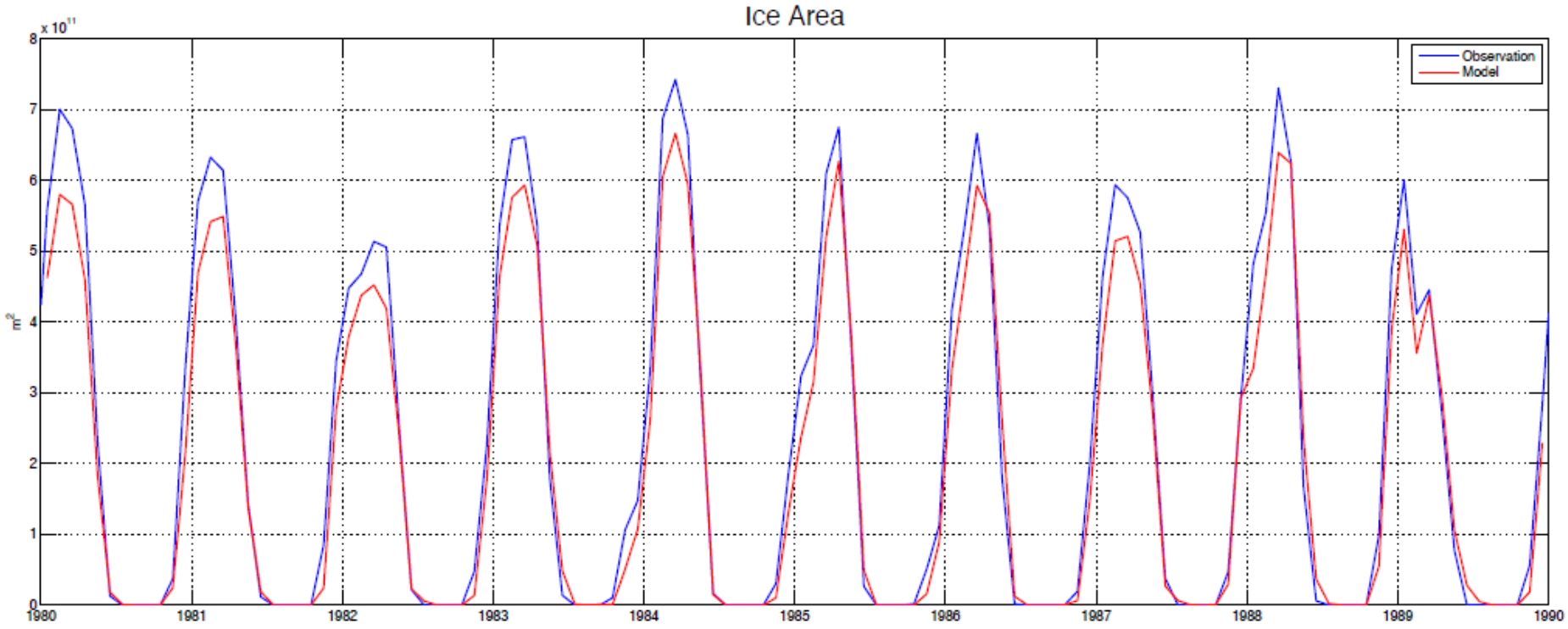
Controls on Bering Sea Ice Dynamics and Thermodynamics



Linghan Li, Ph.D. dissertation, 2013

Controls on Bering Sea Ice Dynamics and Thermodynamics

- Ice-ocean hindcasts of Bering Sea ice (here, 10km from 1980-89) using POP-CICE (and ROMS, too, over more recent times) exhibit ***strong correlations*** with satellite observed ice



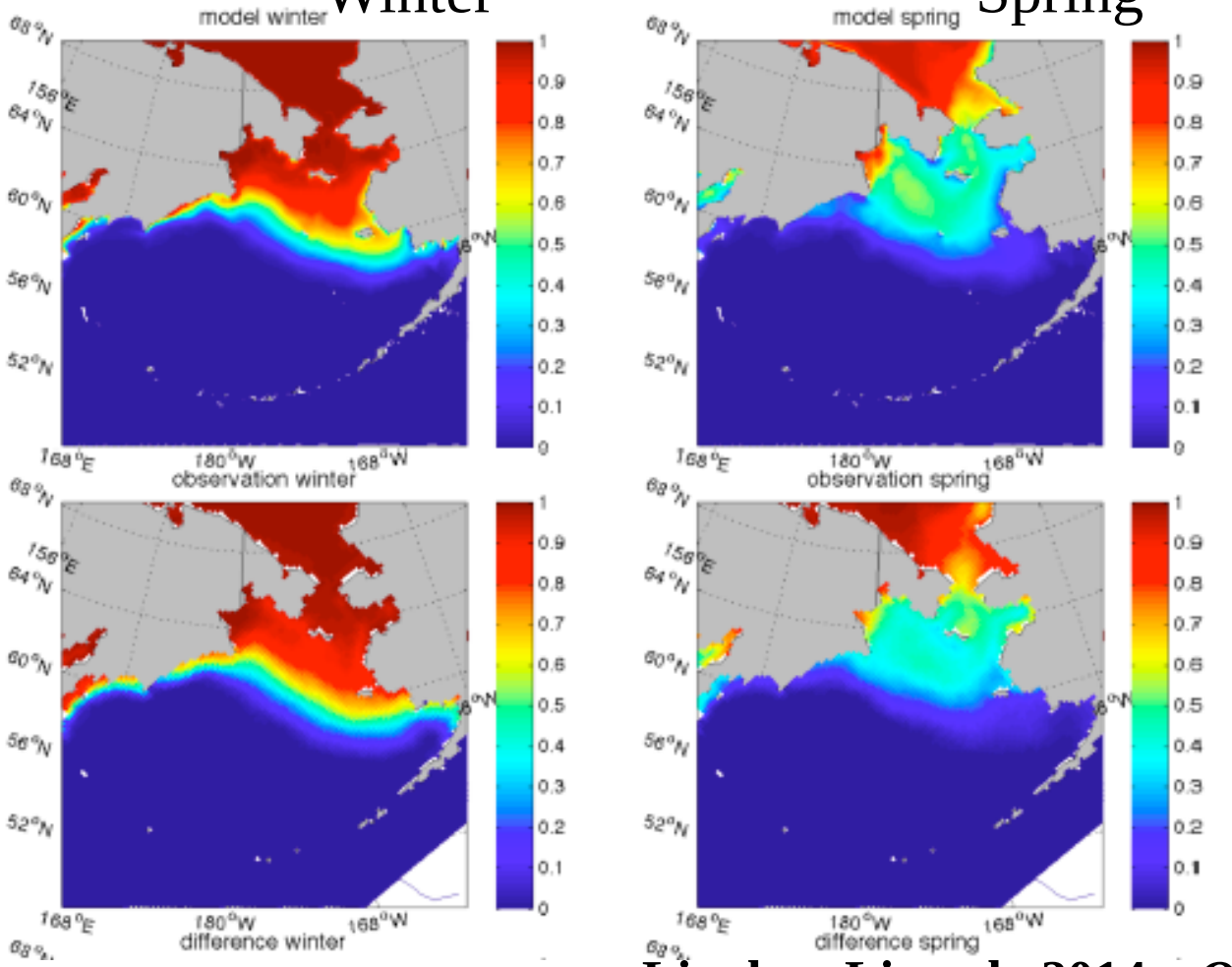
Linghan Li et al., 2014b, *Ocean Dynamics*

Controls on Bering Sea Ice Dynamics and Thermodynamics

- How can the model be so good?!

Winter

Spring

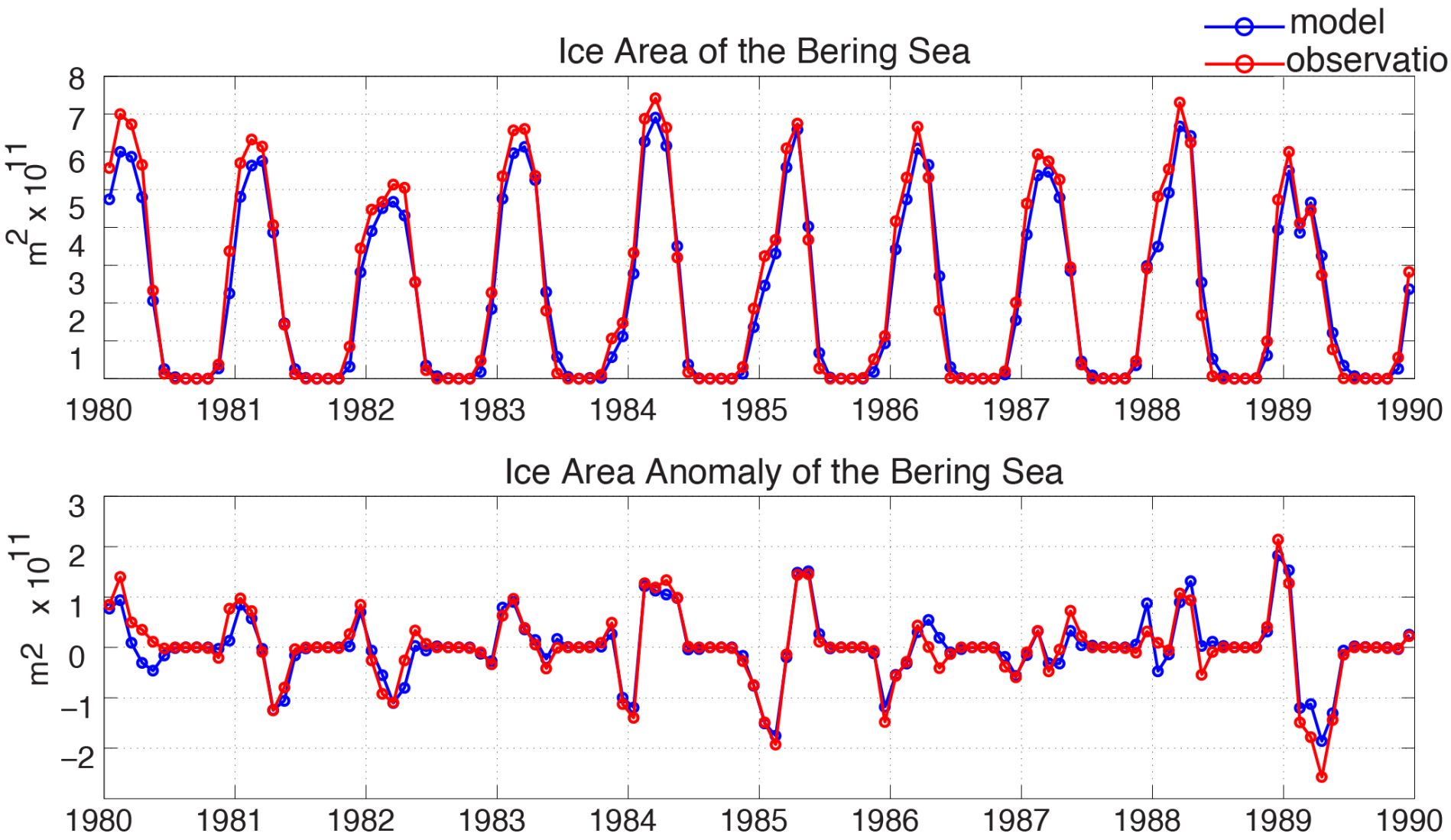


Model Climatology

Obs Climatology

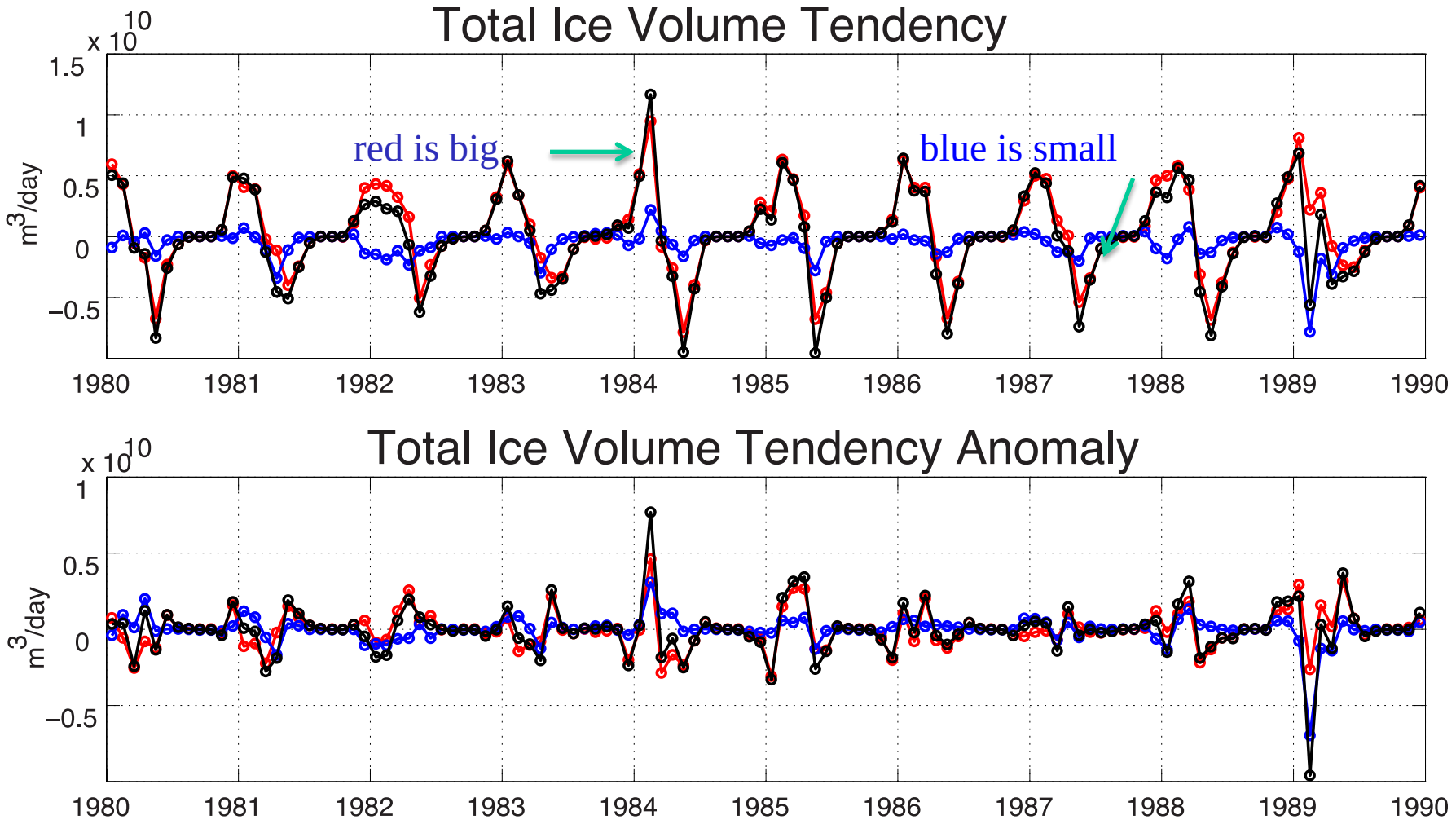
Linghan Li et al., 2014a, *Ocean Modelling*

Total Ice Area of Bering Sea



Linghan Li et al., 2014b, *Ocean Dynamics*

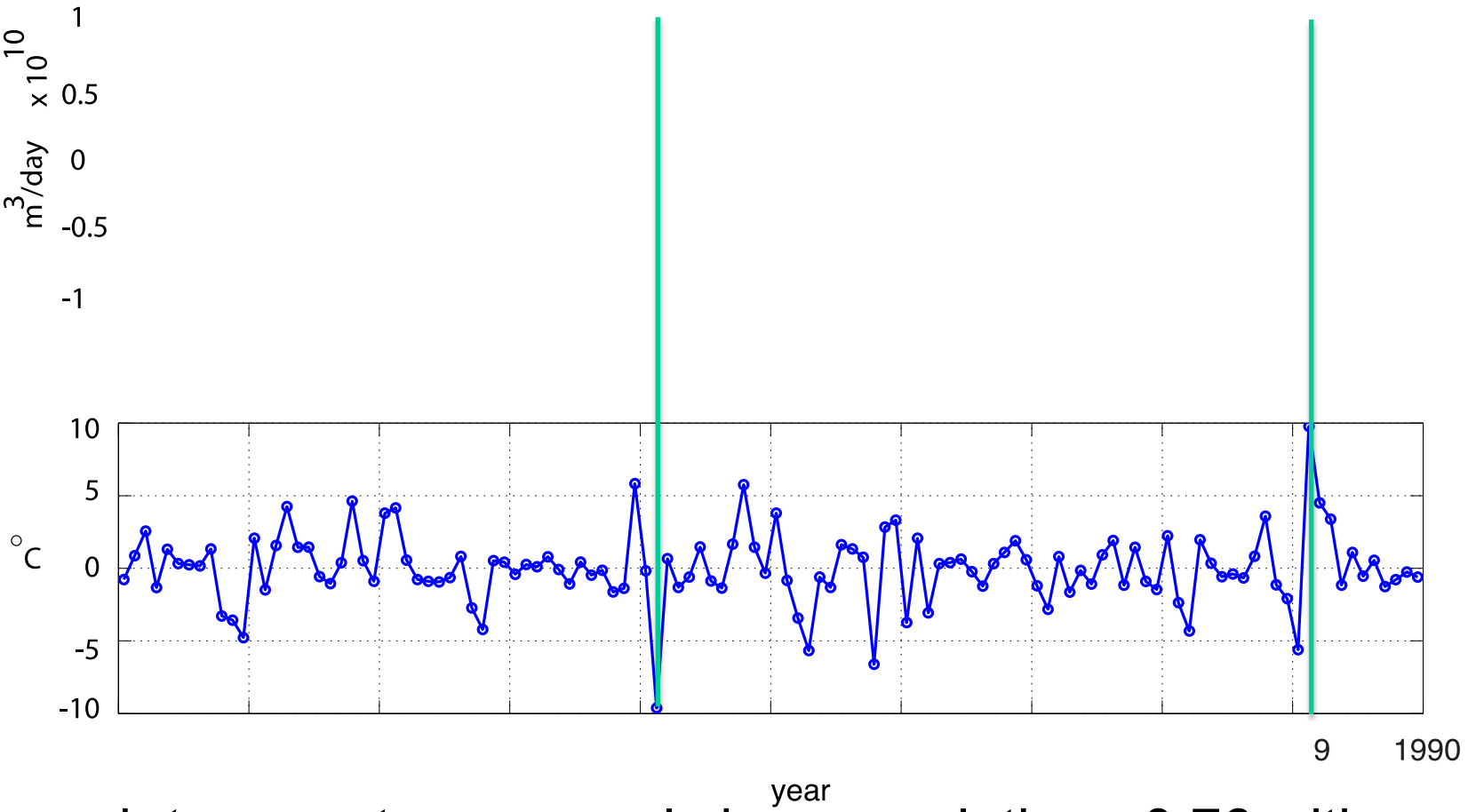
Thermodynamics dominate ice volume change on the large scale integrated over the Bering Sea



Linghan Li et al., 2014b, *Ocean Dynamics*

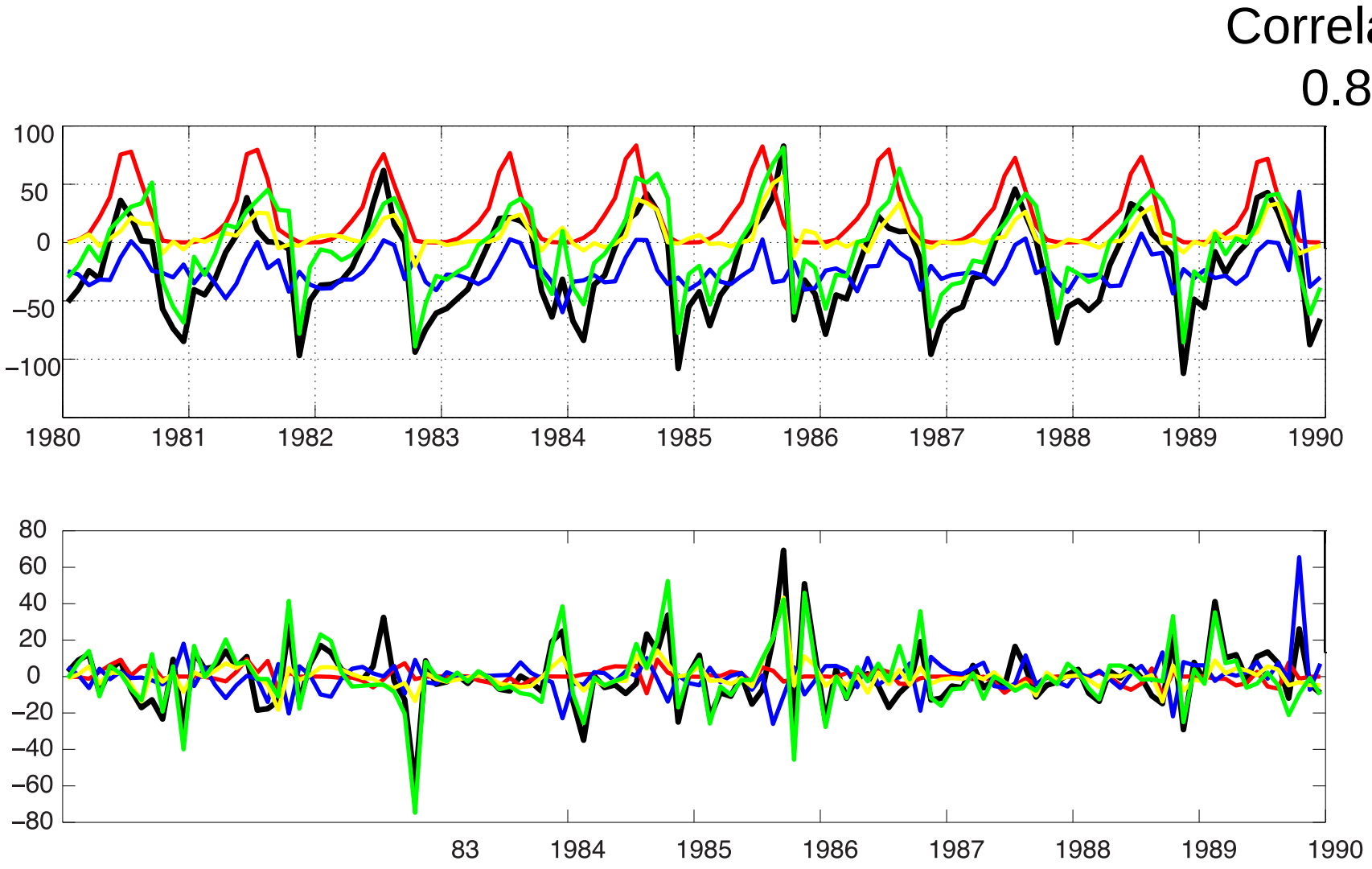
Air temperature is strongly correlated to the ice volume change on the large scale

Linghan Li et al., 2014b, *Ocean Dynamics*



Surface air temperature anomaly has correlation −0.76 with ice volume tendency anomaly, −0.86 in winter

Sensible heat flux (Tair) dominates surface heat flux



Linghan Li et al., 2014b, *Ocean Dynamics*

Physical Controls on Ice Variability in the Bering Sea

Primary Results of Linghan Li's Dissertation (2013)

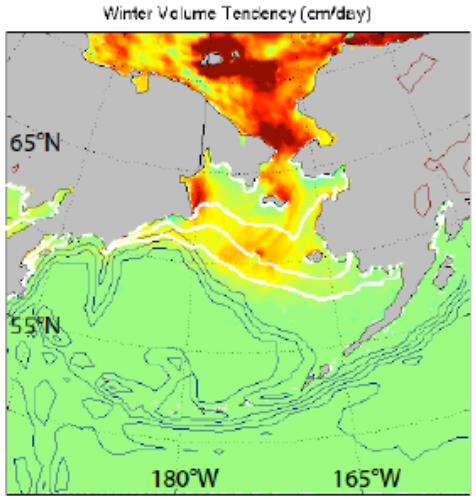
Climatic Variability

- **Specified air temperature** explains **high model skill** in simulating variability: Thermodynamic processes dominate on the large scale via air-ice sensible heat flux.
- **Dynamic processes** can be **important locally** near ice margins. Wind stress drives (and the ocean drags) ice motion in the meridional direction.

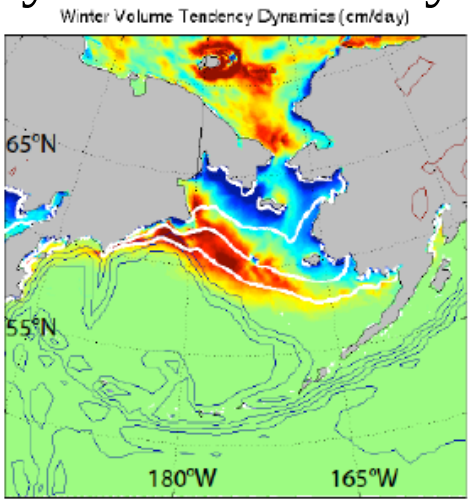
Controls on Bering Sea Ice Dynamics and Thermodynamics

- We also have diagnosed the seasonal cycle balances of ice volume thermodynamic and dynamic tendencies….

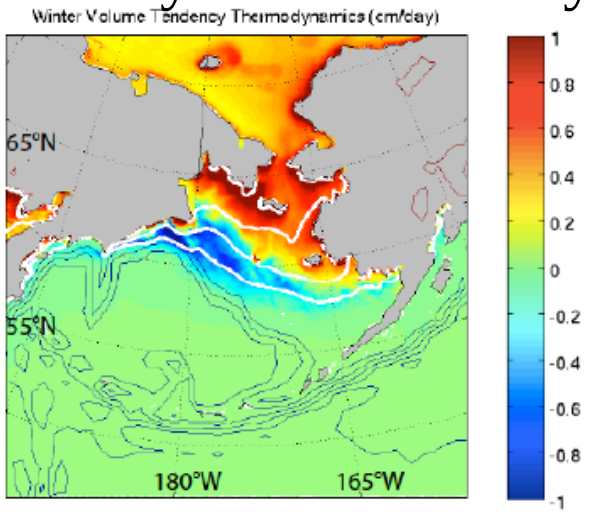
Winter mean model
Ice volume tendency



Winter mean model
dynamic tendency



Winter mean model
thermodynamic tendency

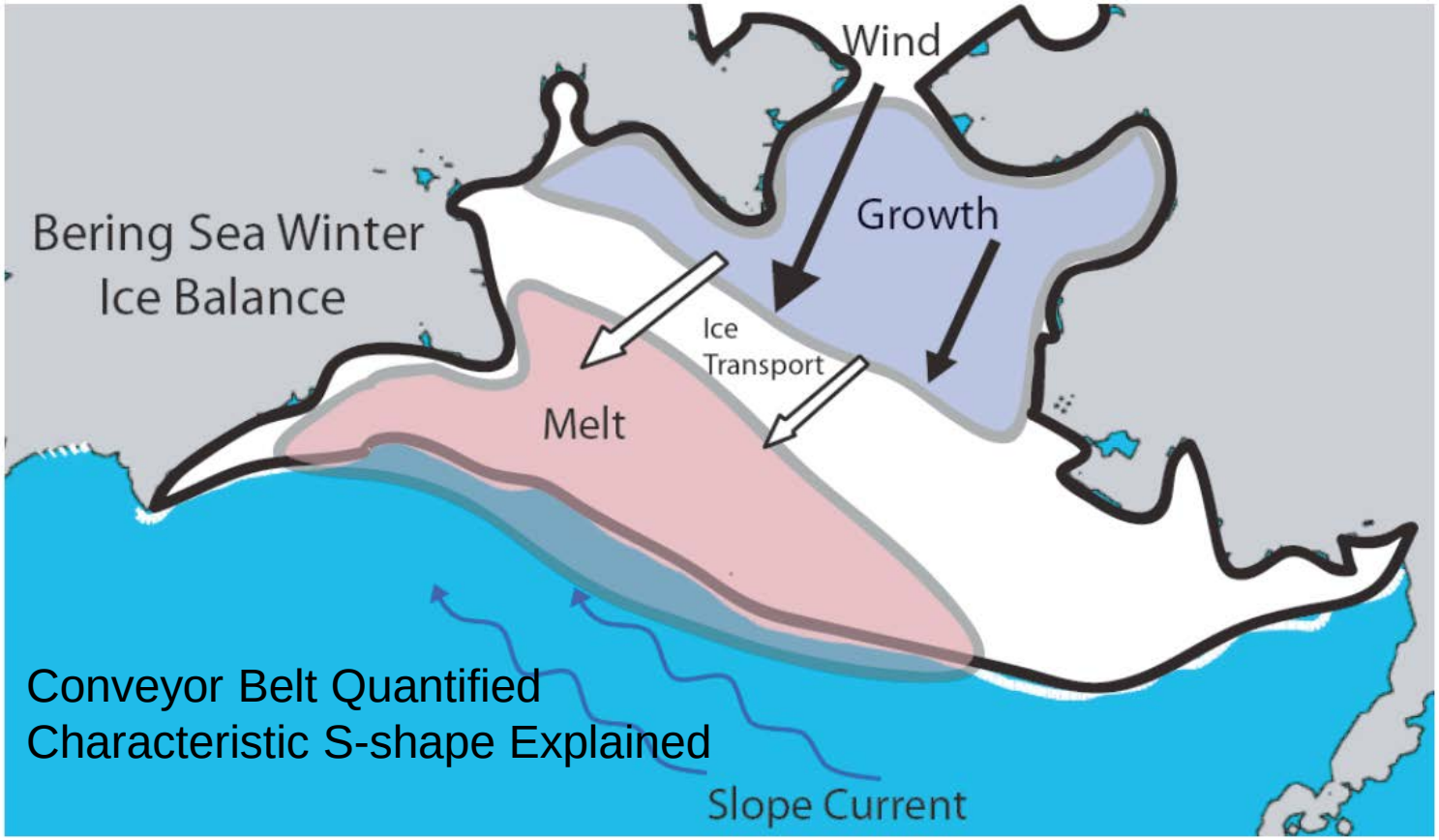


10 km res POP-CICE seasonal cycle

Linghan Li et al., 2014a, *Ocean Modelling*

Controls on Bering Sea Ice Dynamics and Thermodynamics

- ….to come up with a nice simple sketch of the basic processes in the seasonal cycle:



Linghan Li et al., 2014a, *Ocean Modelling*

Physical Controls on Ice Variability in the Bering Sea

Primary Results of Linghan Li's Dissertation (2013)

Seasonal Cycle

- **Conveyor belt hypothesis** (from observations) is confirmed and **quantified**: In winter, ice grows in north, drifts southwestward driven by wind, and is melted along the ice edge by warm waters carried by the Bering Slope Current.
- This leads to the **S-shaped asymmetric pattern** along the southern ice edge.

Climatic Variability

- **Specified air temperature** explains **high model skill** in simulating variability: Thermodynamic processes dominate on the large scale via air-ice sensible heat flux.
- **Dynamic processes** can be **important locally** near ice margins. Wind stress drives (and the ocean drags) ice motion in the meridional direction.

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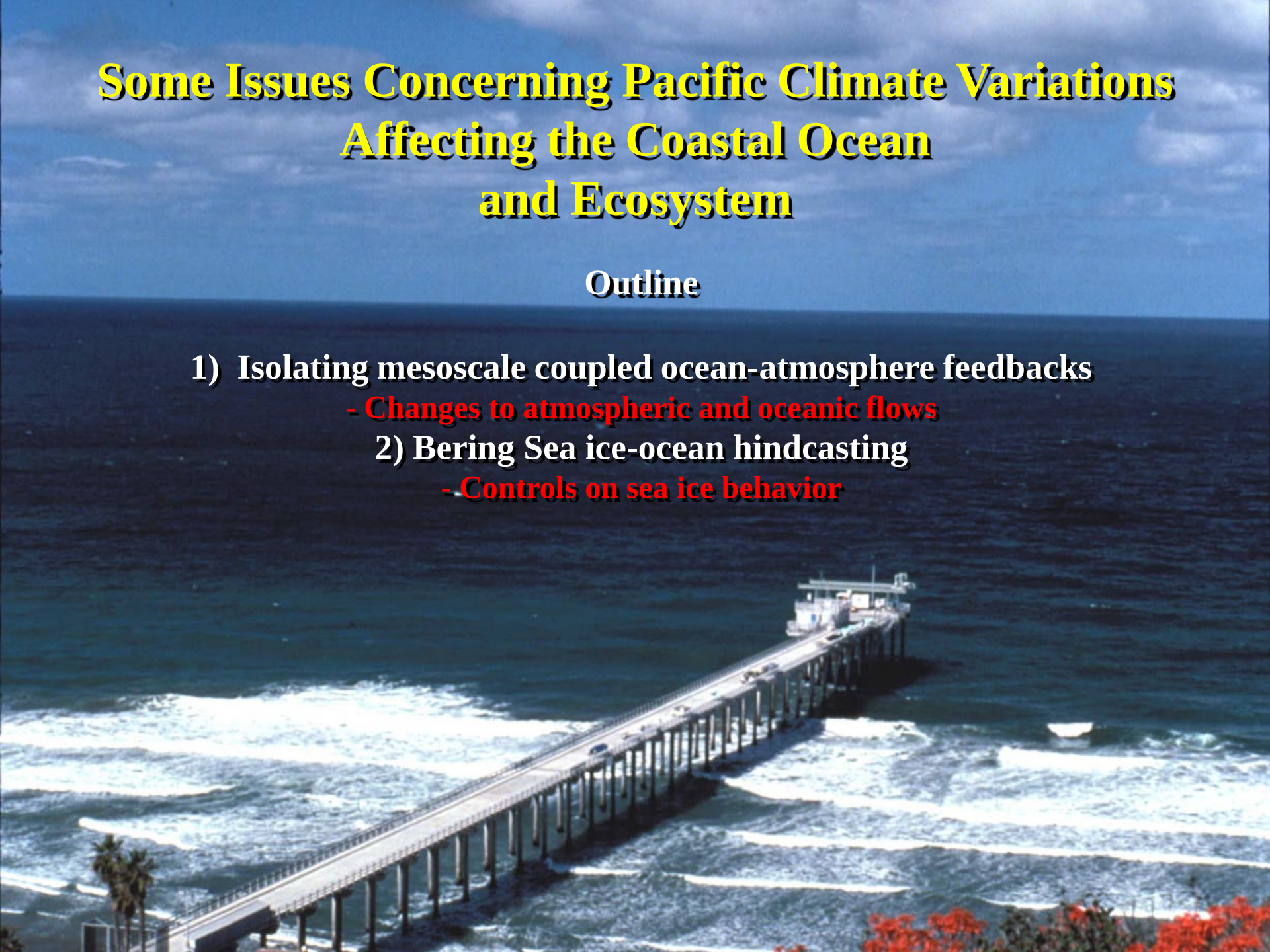

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PICES FUTURE Open Science Meeting
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April 16, 2014

Thanks!