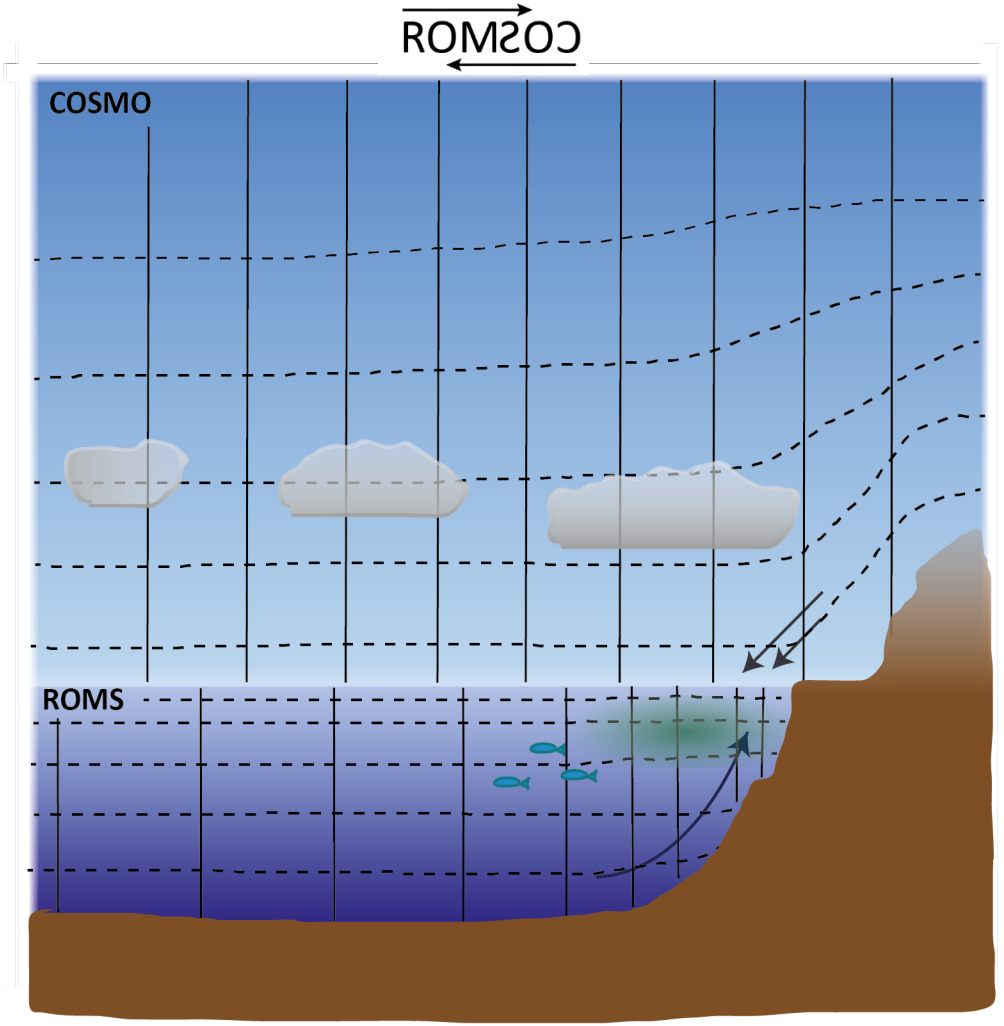
Coupled atmosphere-ocean dynamics in the California Current System off the U.S. West Coast

Gesa Eirund[1], Matthias Münnich[1], Matthieu Leclair[2] and Nicolas Gruber[1,2]

(1) Environmental Physics, Institute for Biogeochemistry and Pollutant Dynamics, ETH Zurich

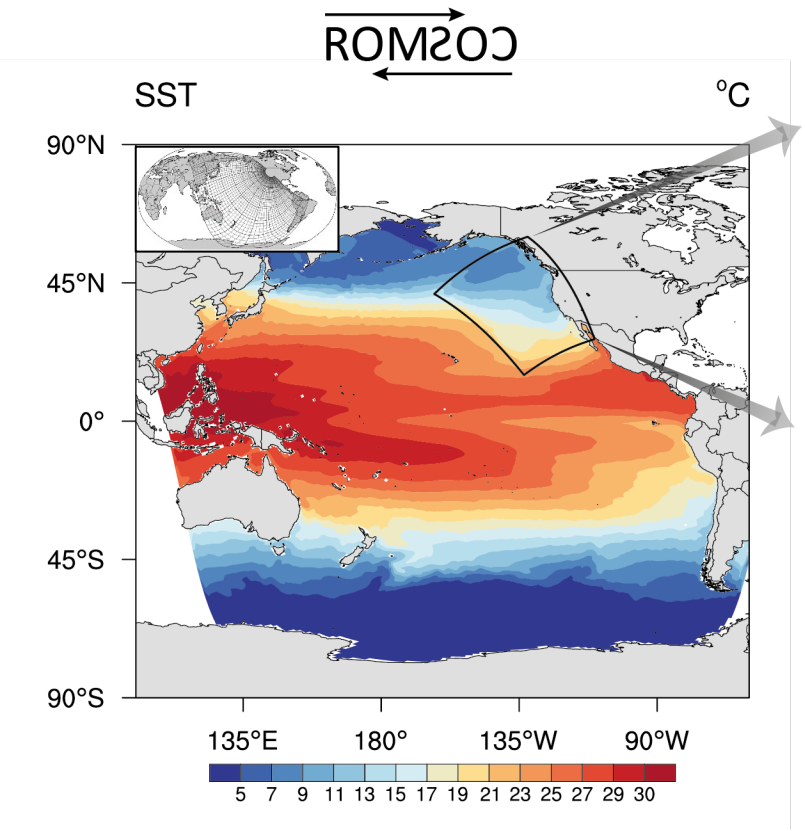
(2) Center for Climate Systems Modeling (C2SM), ETH Zurich



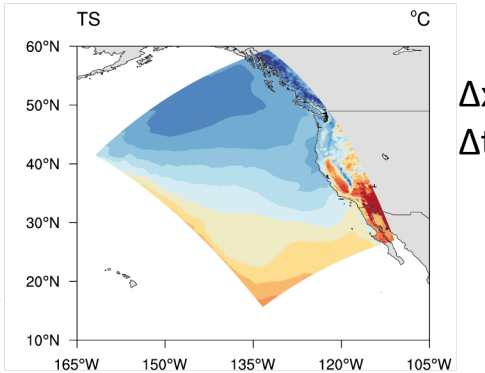
EGU 2022

Contact: gesa.eirund@env.ethz.ch

Our new model system: regional atmosphere-ocean coupled model ROMS⇄COSMO setup for the CalCS



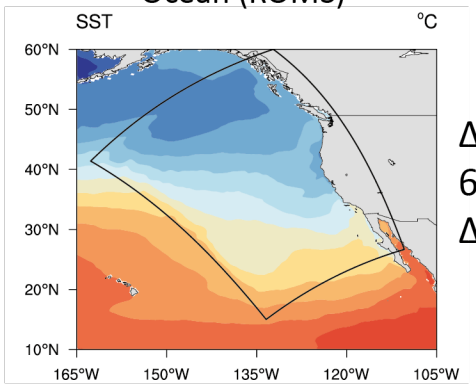
Atmosphere (COSMO)



Δx, Δy = 7 km
Δt = 40 s

Δt = 600 s

Ocean (ROMS)



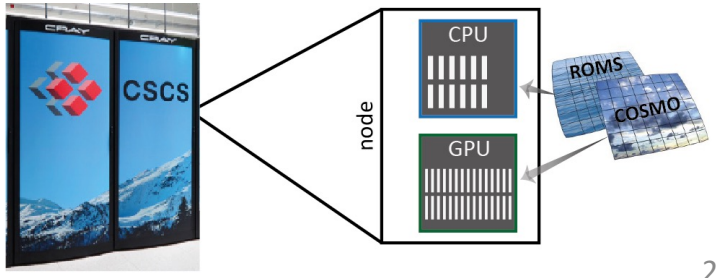
Δx, Δy = 4.1 - 63.8 km
Δt = 300 s

COSMO → ROMS

- Surface U and V momentum flux
- Surface net heat flux
- Direct shortwave downward radiation
- Total evaporation-precipitation rate

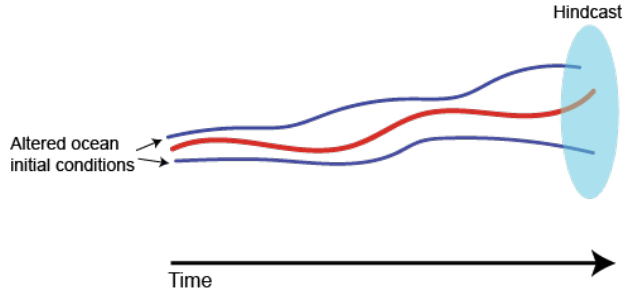
ROMS → COSMO

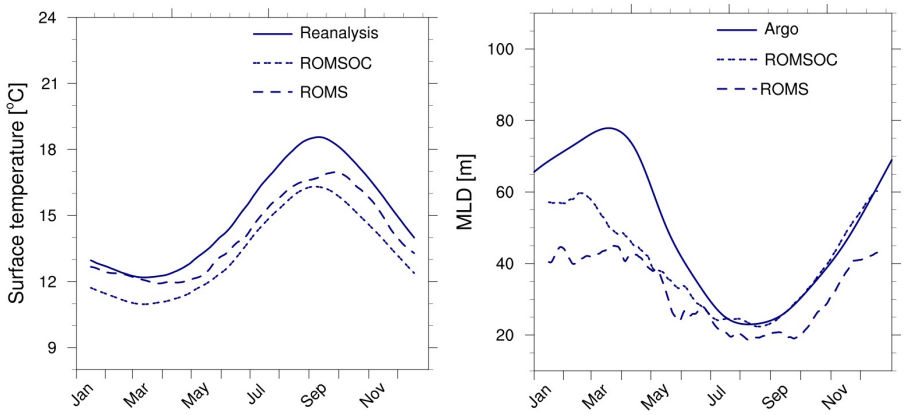
- Sea surface temperature
- Ocean current velocity (testing phase)



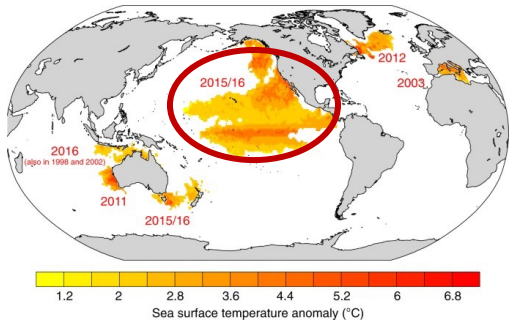
Main points

- Fully coupled simulations from 2010-2019 including ocean biogeochemical cycles (ROMS-BEC), currently three ensembles
  - Stronger wind forcing in ROMSOC as compared to ROMS-only
    → Enhanced coastal upwelling and cold SST bias
    → Deeper mixed-layer depth (MLD)
  - ROMSOC better resolves the seasonal cycles in SST and MLD





- **Outlook**: investigate potential AO-interactions during marine heatwaves, such as 'the Blob' in 2015-2016 off California



Froelicher and Laufkoetter, 2018

Thank you for your attention!

Questions? Ask gesa.eirund@env.ethz.ch

Additional material

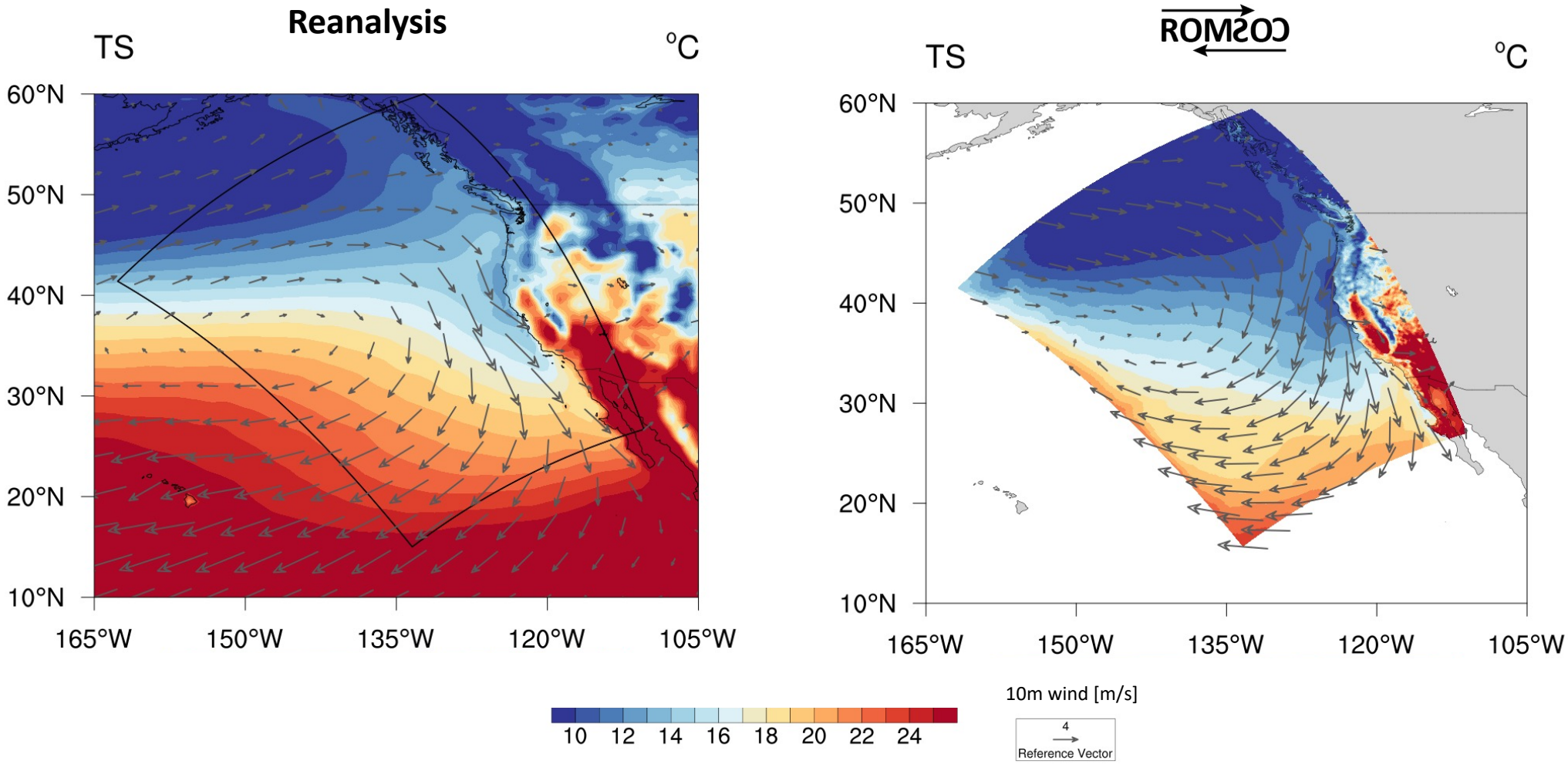
Please find attached a more in-depth evaluation of the model performance (only ensemble 1, all figures showing an average over the upwelling period April to August).

Current ongoing work is to evaluate the performance of the simulation including momentum coupling as well as an analysis of marine heatwaves in the coupled model.

For any questions and/or comments please do not hesitate to contact me at gesa.eirund@env.ethz.ch

Surface characteristics in ROMSOC

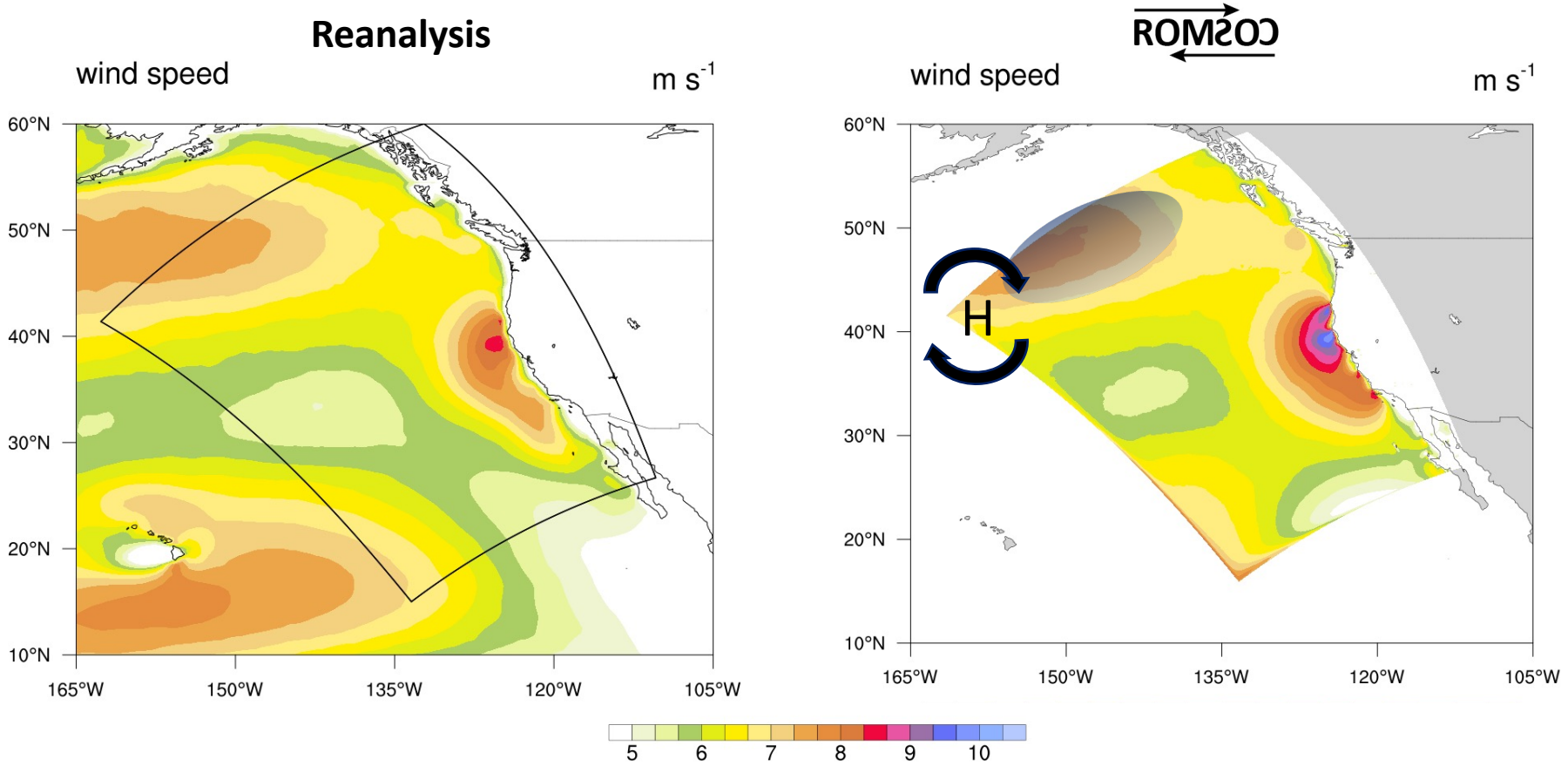
Upwelling season (Apr-Aug): surface temperature and wind pattern



‘Cold blob’ simulated in ROMSOC in the North Pacific

Atmospheric characteristics in ROMS↔COS

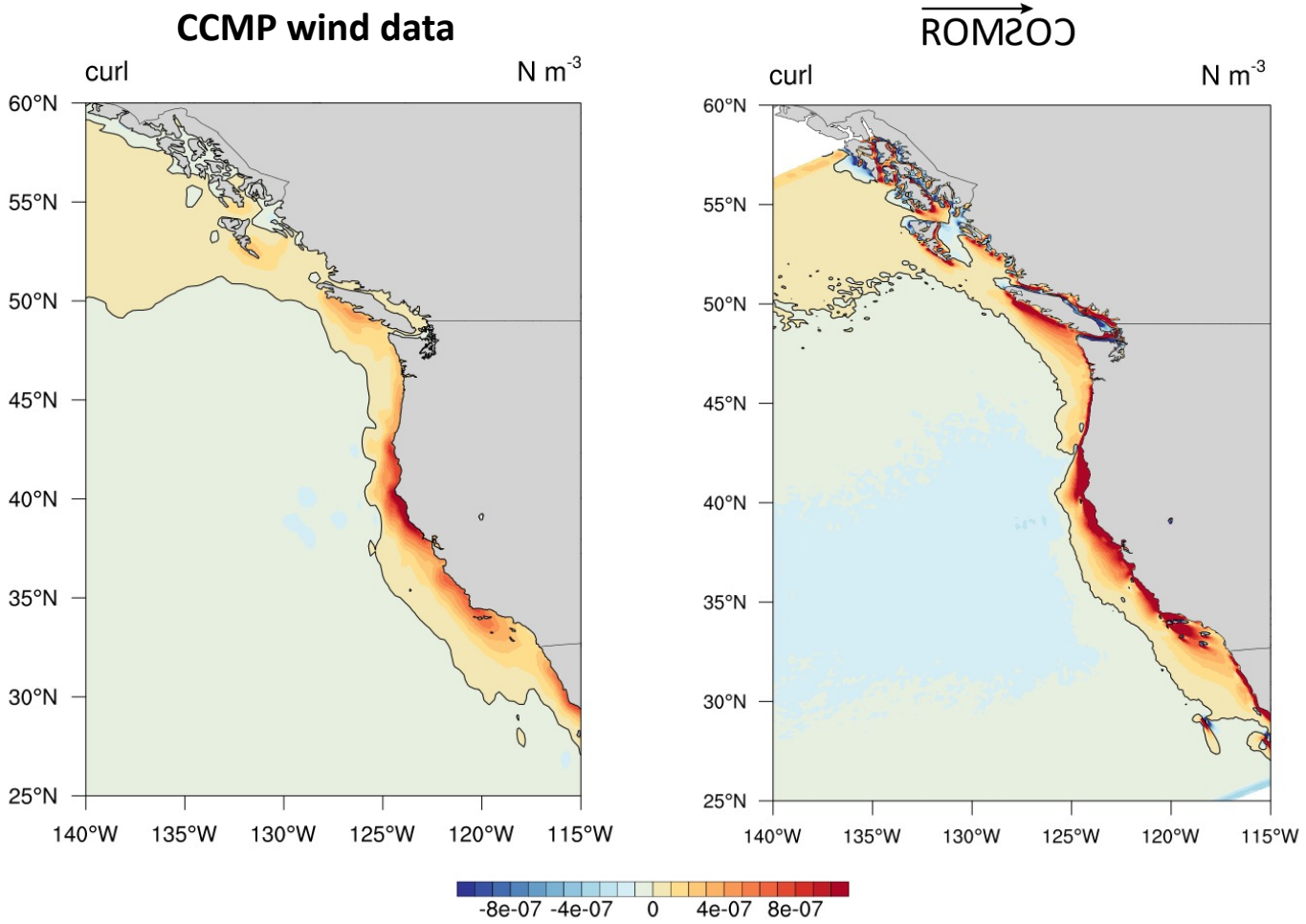
Upwelling season (Apr-Aug): 10m wind speed



Stronger simulated northerly winds associated with the high pressure system leading to stronger advection of colder SST and a shift of the North Pacific Gyre in the coupled model

Atmospheric characteristics in ROMSOC

Upwelling season (Apr-Aug): wind stress curl

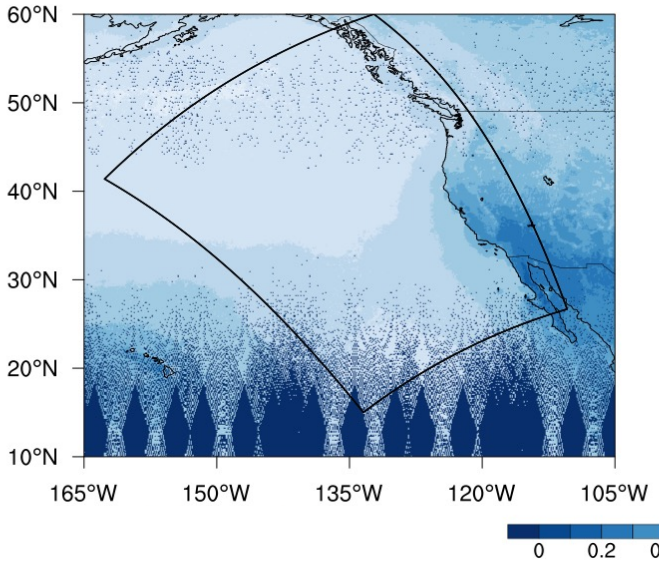


Contour: 0-wind stress curl contour

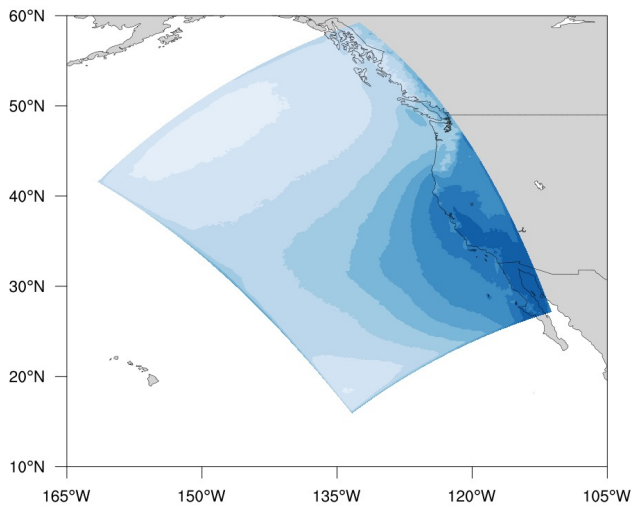
Stronger wind stress curl off the coast in ROMSOC enhances coastal upwelling

Atmospheric characteristics in ROMS↔COS
Upwelling season (Apr-Aug): cloud fraction and type

MODIS Terra



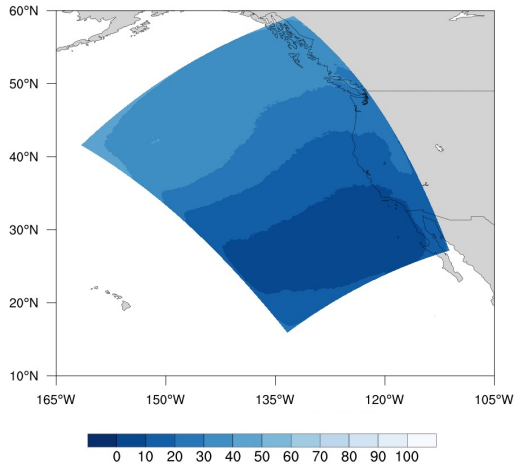
ROMS↔COS



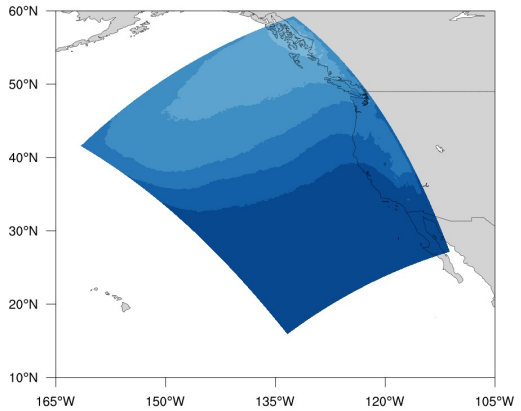
Large-scale cloud patterns well reproduced, but too few clouds along the coast

Ocean: low-level clouds
Land: medium/high level clouds

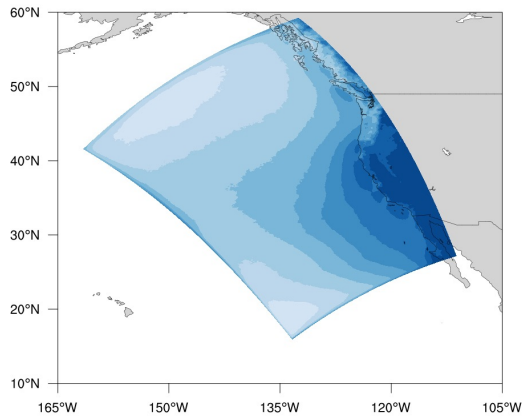
Fraction of high clouds



Fraction of medium clouds



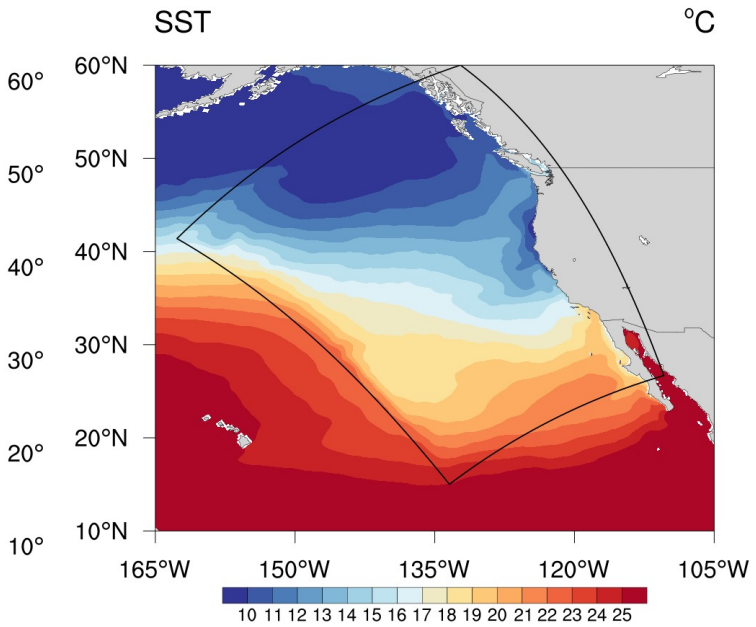
Fraction of low clouds



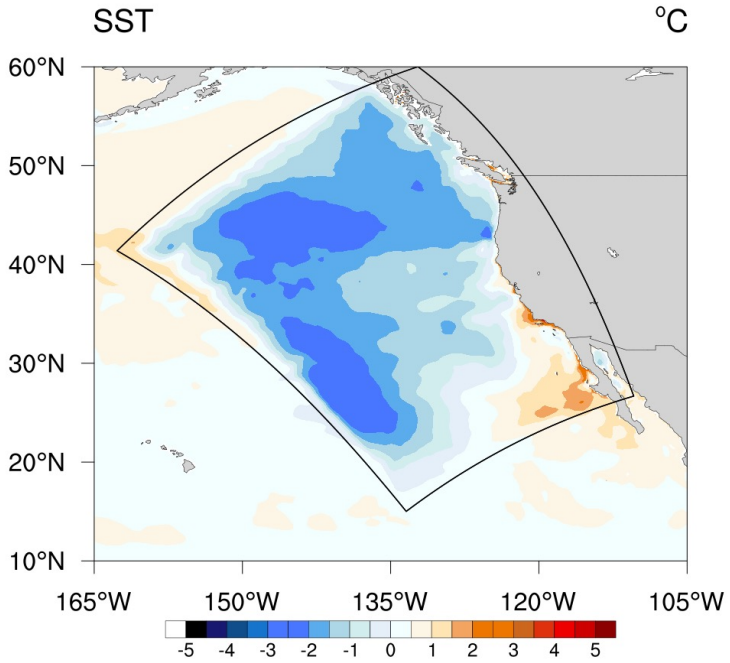
Ocean characteristics in ROMSOC

Sea surface temperature in the coupled and uncoupled model during the upwelling season

ROMSOC



ROMSOC - ROMS



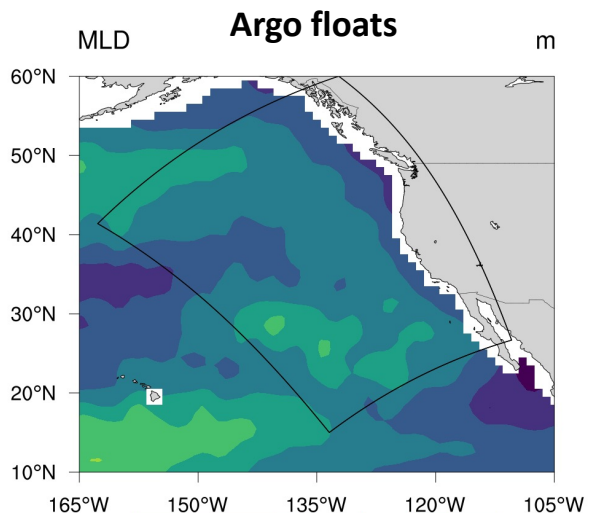
Colder SST in ROMSOC throughout the domain

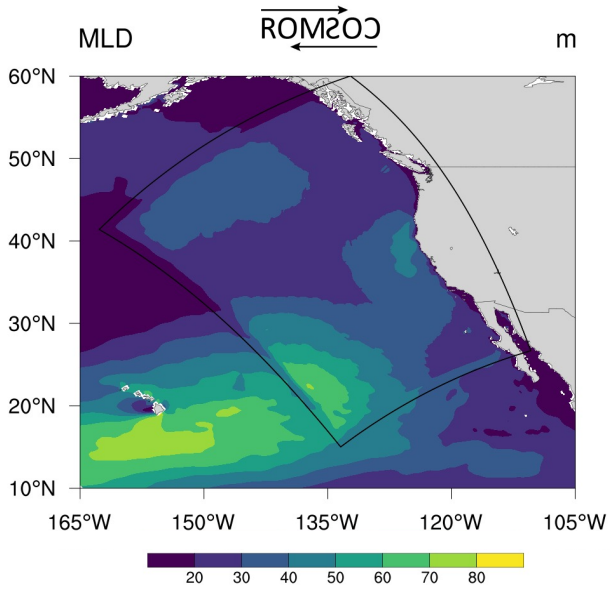
Colder coastal SST, indicating stronger upwelling and advection from the North

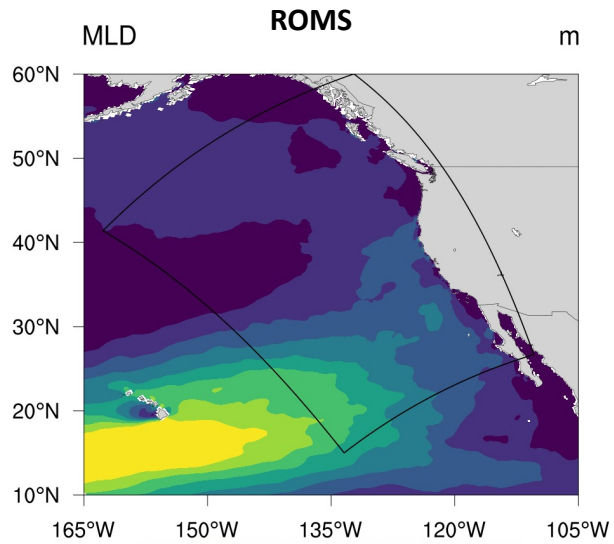
→ Associated with altered wind forcing

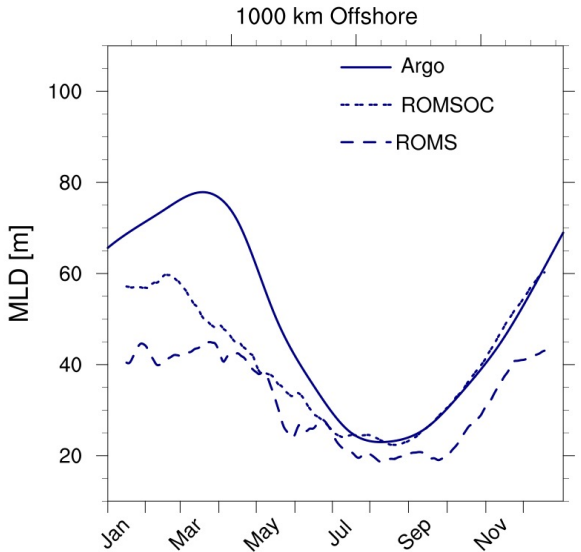
Ocean characteristics in ROMSOC

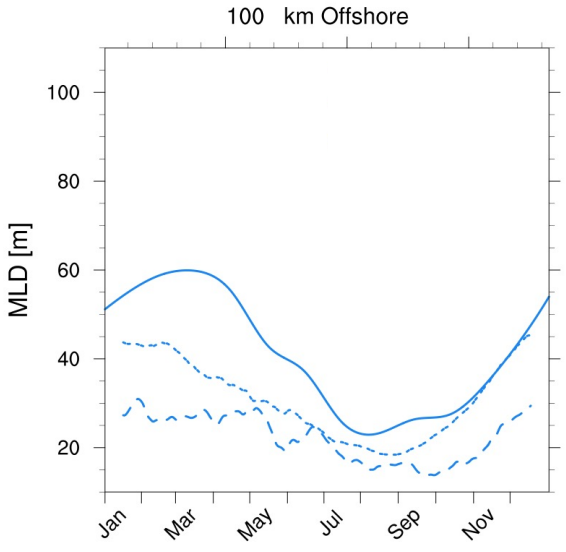
Mixed-layer depth during the upwelling season and in the annual cycle











Deeper mixed-layer in ROMSOC as compared to ROMS throughout the year → potential implications for biogeochemistry

ROMSOC shows better agreement with observations