Update on Acidification and Hypoxia Modeling of the California Current System

## Commission meeting
December 7, 2018

Ocean Models are Key Tools to Implement OA Action Plan Recommendations

- **Estimate the Impact of Local Pollution**

  - Experiment turning off sources

- **Support Marine Vulnerability Assessment**

  - You can't monitor all places, all the time

  - Model is needed to project future climate change scenarios

- **Assess Efficacy of Climate Change Mitigation Strategies**

  - Before investing on expensive sea grass or kelp restoration

The agenda today

- Model development is complete

- Broad scale validation at US west coast wide scale is complete
    - Focus validation ongoing

- We are in early stages of application for
    - Local pollution impact assessment
    - Marine vulnerability assessment
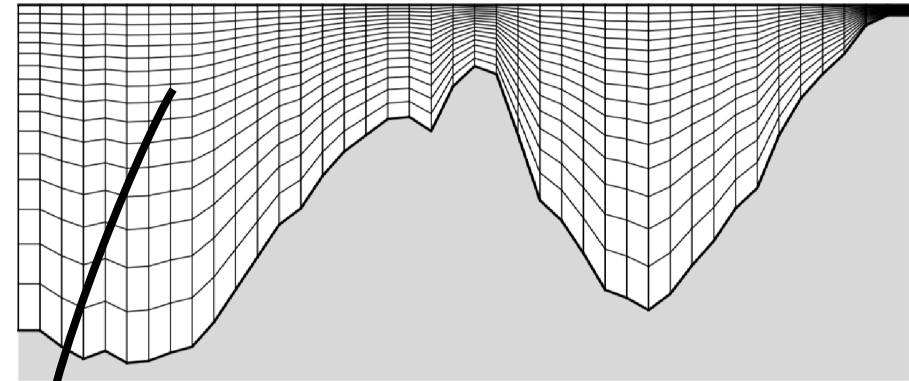
MODEL DEVELOPMENT, VALIDATION AND APPLICATION
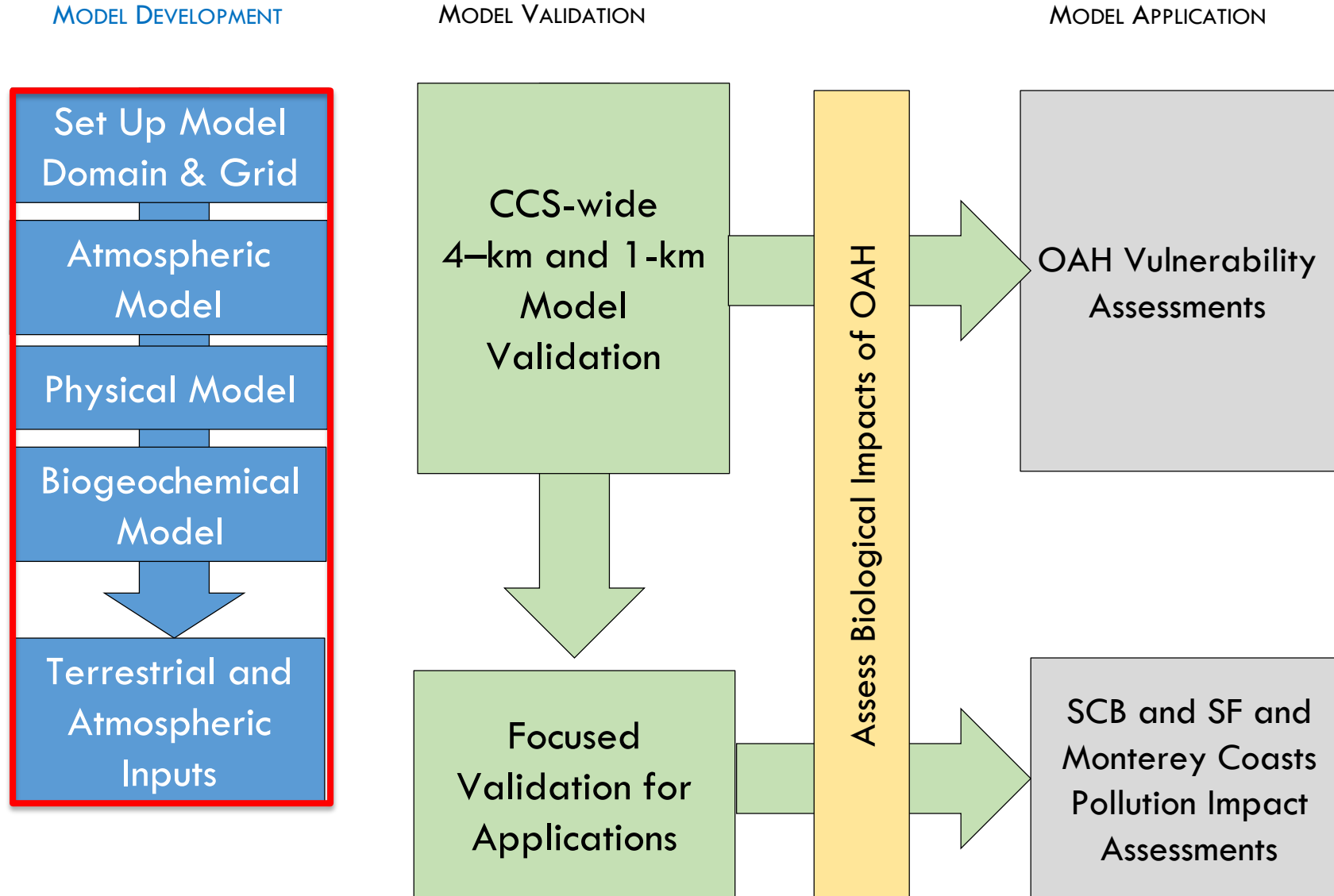
Set Up Model Domain and Grid

Model domain matches region of management interests of West Coast Governors Alliance
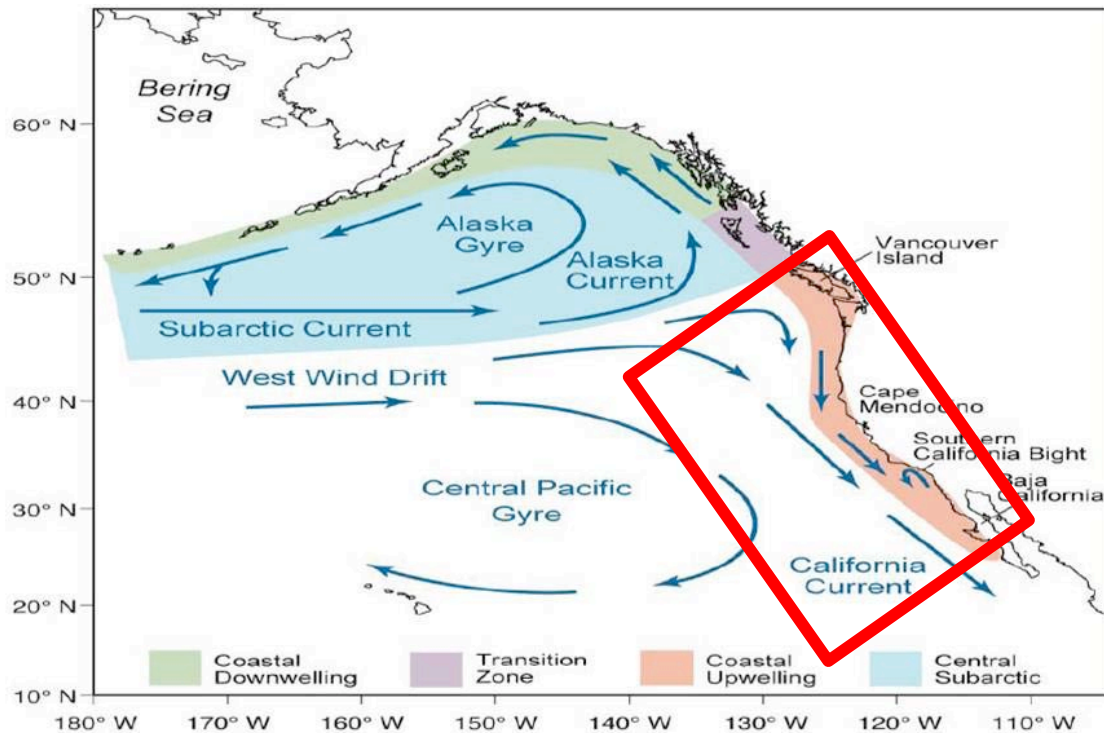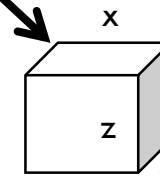
Grid

Models represent 3-D space in the ocean, with the horizontal size of each cell as the resolution

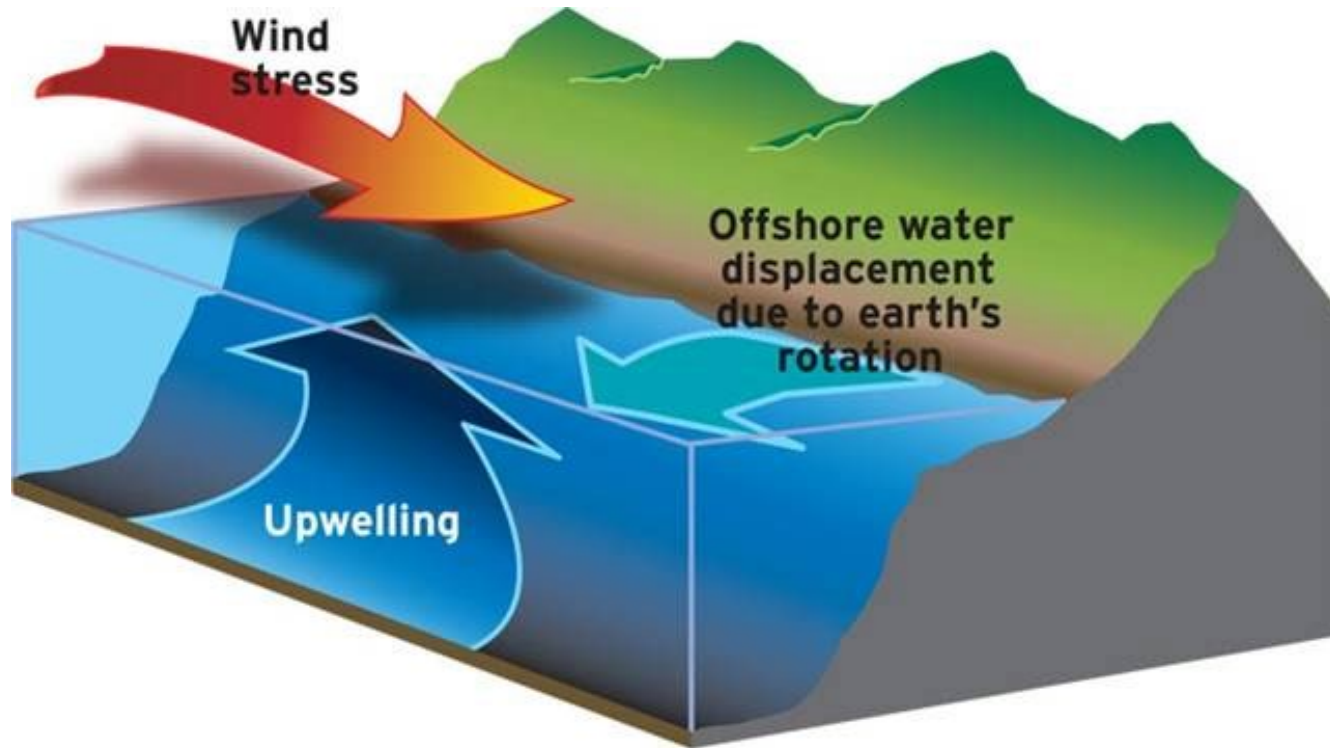60 variable vertical levels : Resolution is variable: 1m to 10s of meters
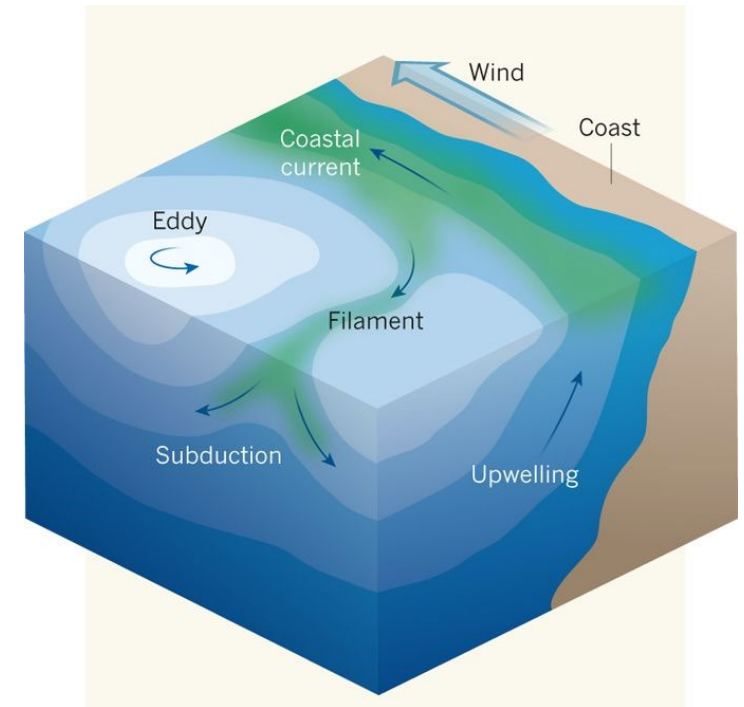
Horizontal 4km resolution

Model Development

Physical circulation model
Regional Ocean Modeling System (ROMS)

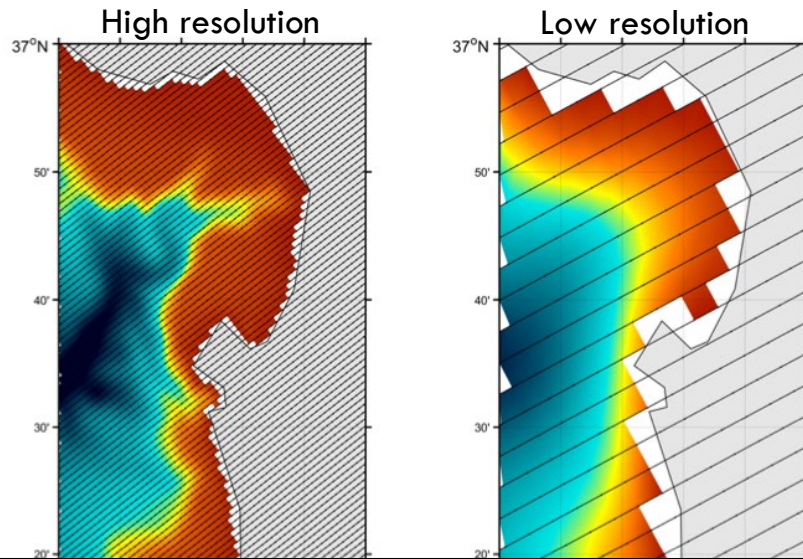Reproducing upwelling and coastal circulation
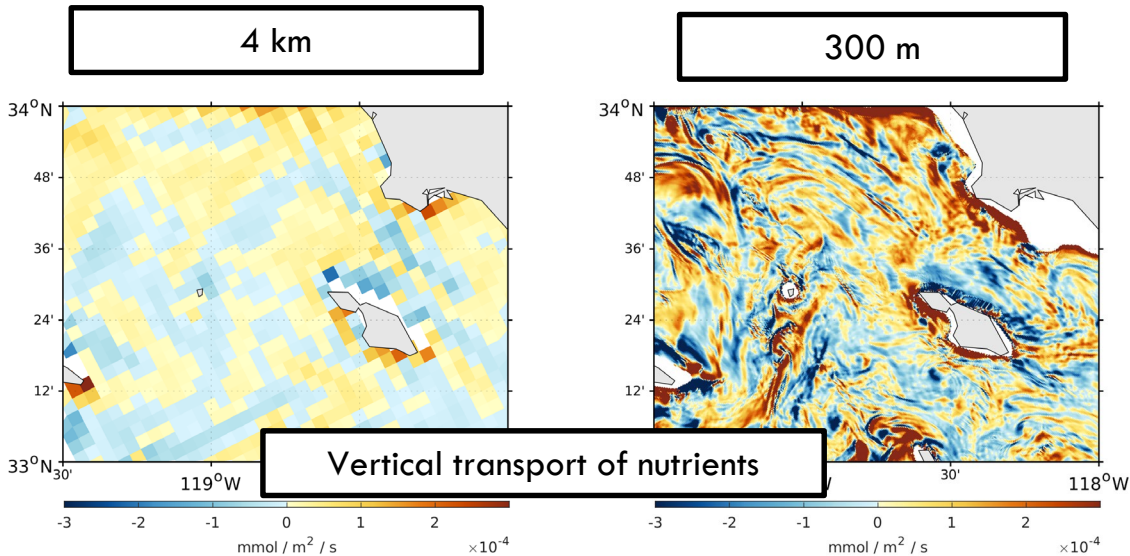
"Reproducing Eddies and filaments"

This circulation impacts on O$_2$ and pH variability in the coastal ocean
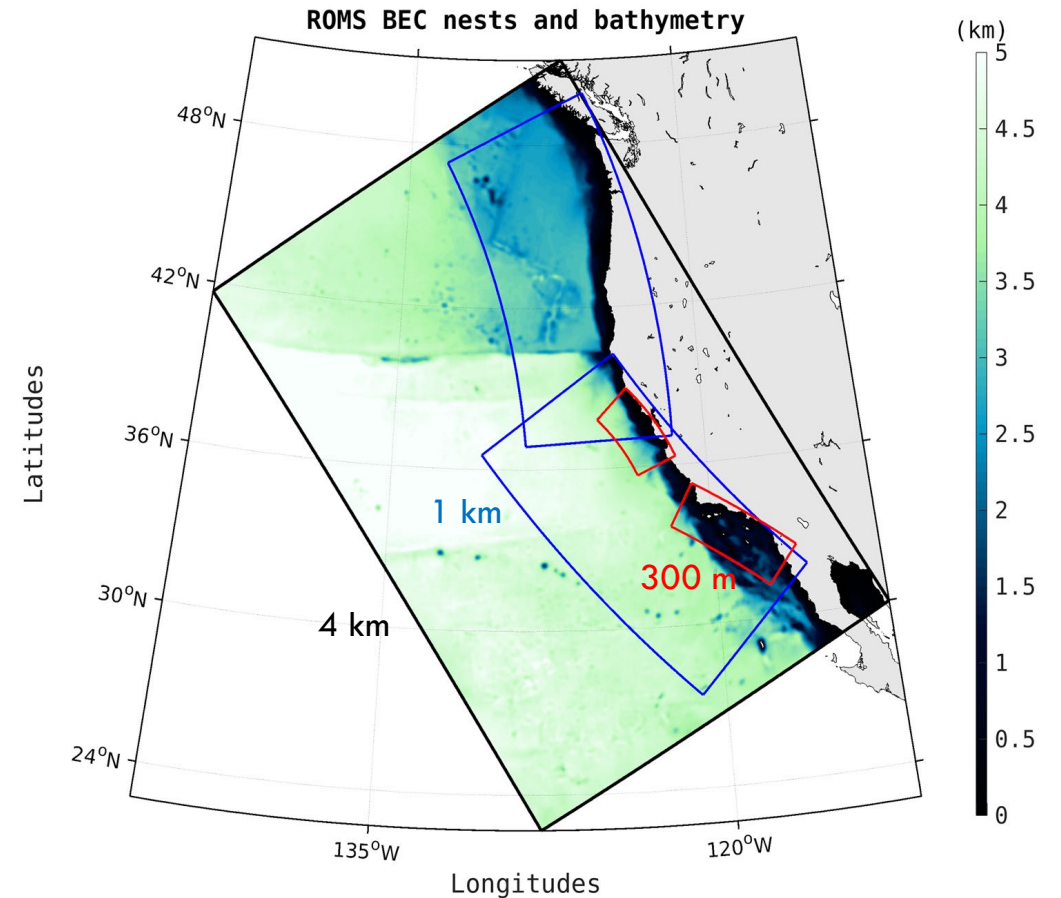
We need to reproduce the scale that matters

High resolution   Low resolution

→ Better Bathymetry
→ + other physical processes = better physical circulation

→ Physical processes: eddies/filaments

4 km   300 m

Vertical transport of nutrients

mmol / m^2 / s   mmol / m^2 / s

Increase resolution
Increase costs, time and storage

ROMS BEC nests and bathymetry
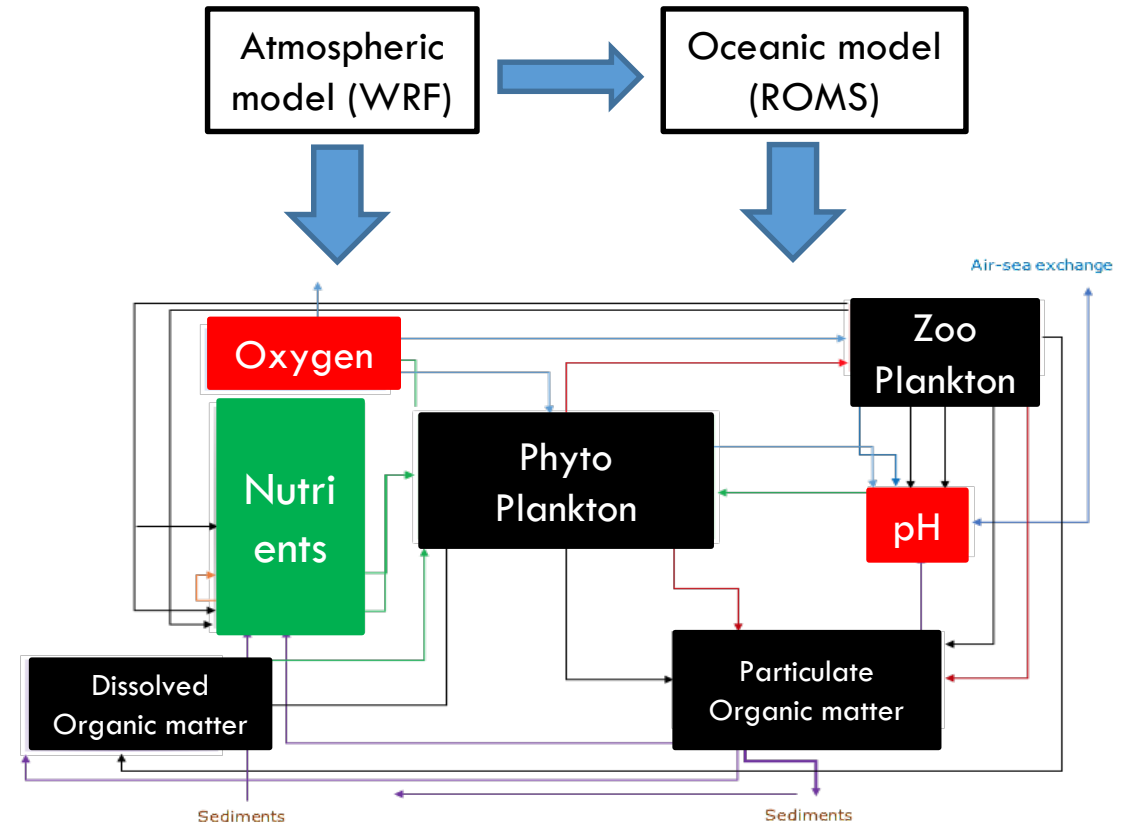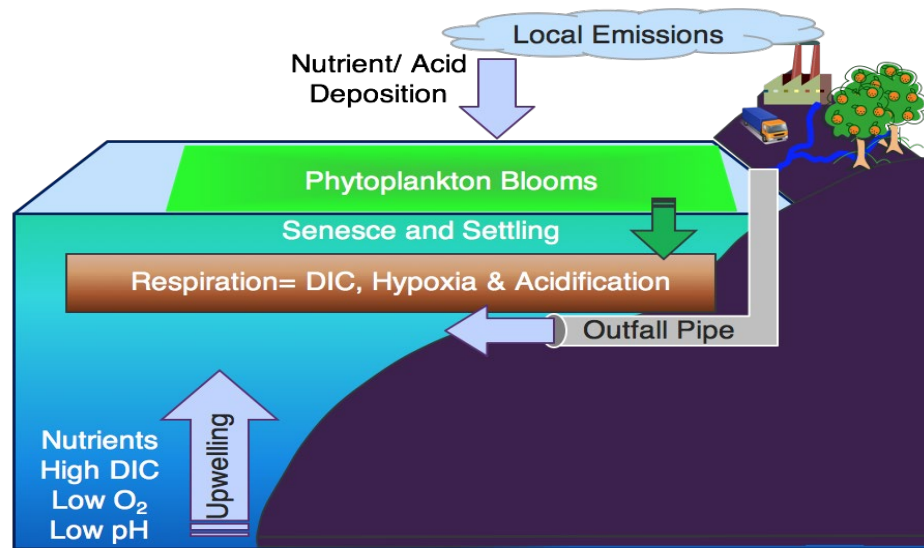
1 km

300 m

4 km

Full model domain is California Current wide at 4 km resolution, with higher resolution grids "nested" inside (1 km to 300 m)

Biogeochemical and Lower Ecosystem Model (BEC)

Biogeochemical and lower ecosystem (phytoplankton and zooplankton) model track fate of nutrients, organic and inorganic carbon

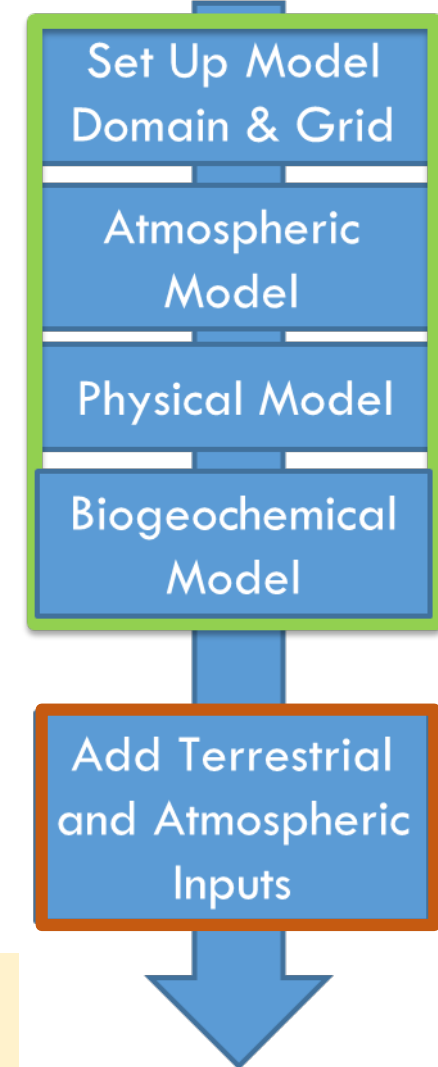- And ultimately, their impact on O2 and pH

Model is "coupled" with ROMS so that we can mechanistically predict impact of physics on chemistry and biology

Final Step in Model Setup

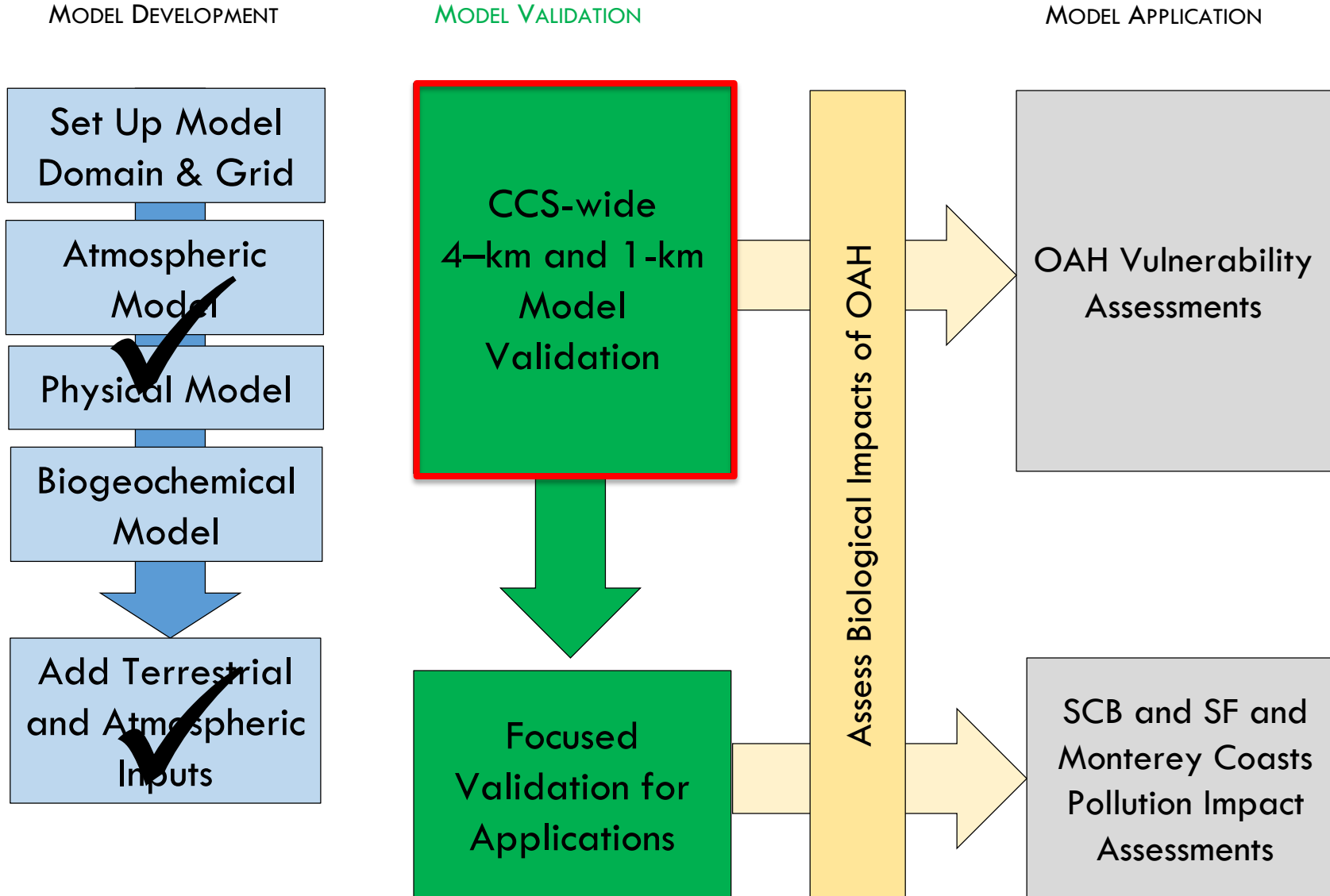Input land-based and atmospheric sources of nutrients and carbon

Riverine export

Ocean Outfalls

CO_2 Air-Sea Exchange

Atmospheric Deposition

Your comprehensive stormwater and POTW mass emissions data sets were key in simplifying this task for the Southern California Bight

MODEL DEVELOPMENT

Set Up Model Domain & Grid

Atmospheric Model

Physical Model

Biogeochemical Model

Add Terrestrial and Atmospheric Inputs

We've Spent 2 Years Validating the Models at a Broad Scale

Model Validation

West coastwide, we've demonstrated that model is reproducing seasonal cycle, vertical and horizontal gradients, climate events and long term trends for model predictions of

- Atmospheric circulation

- Ocean circulation

- Chemistry

- Plankton Ecosystem

The model reproduces realistic spatial distribution and seasonality of the atmospheric forcing

Also:
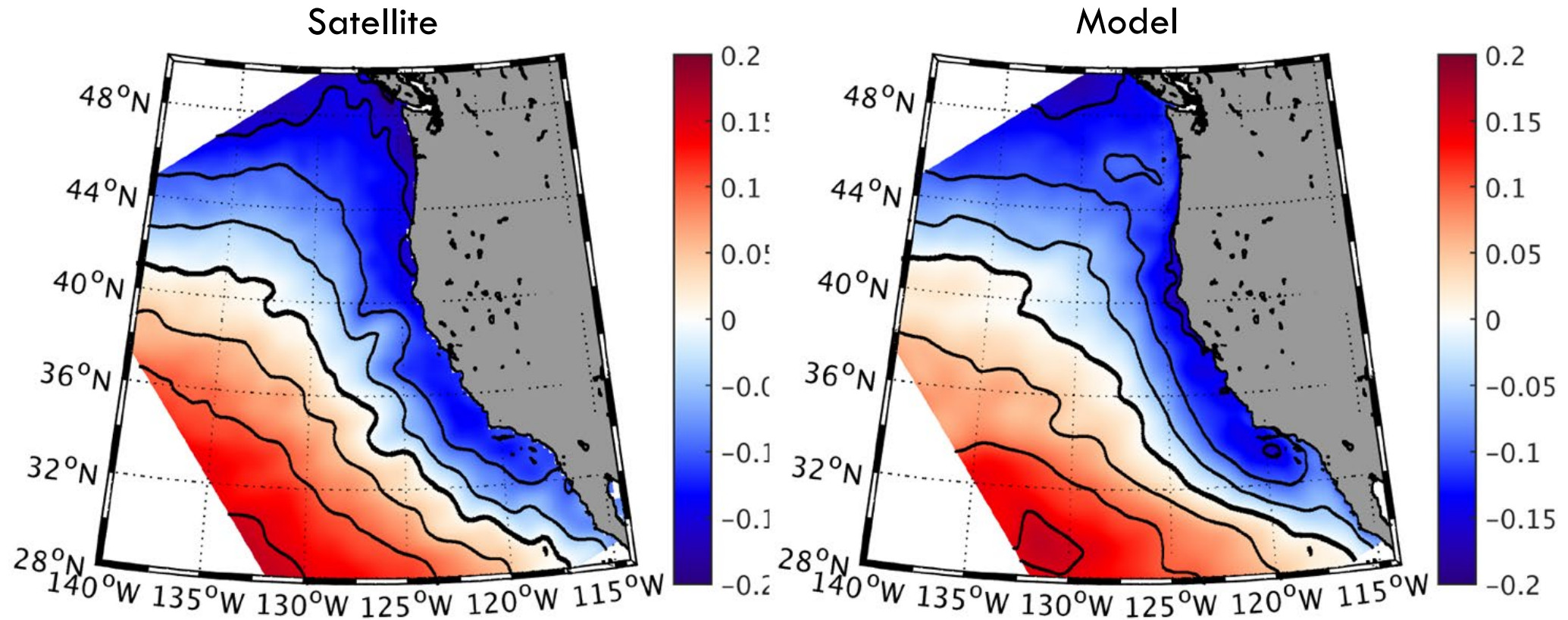Precipitation, wind speed, surface atmospheric temperature, humidity…
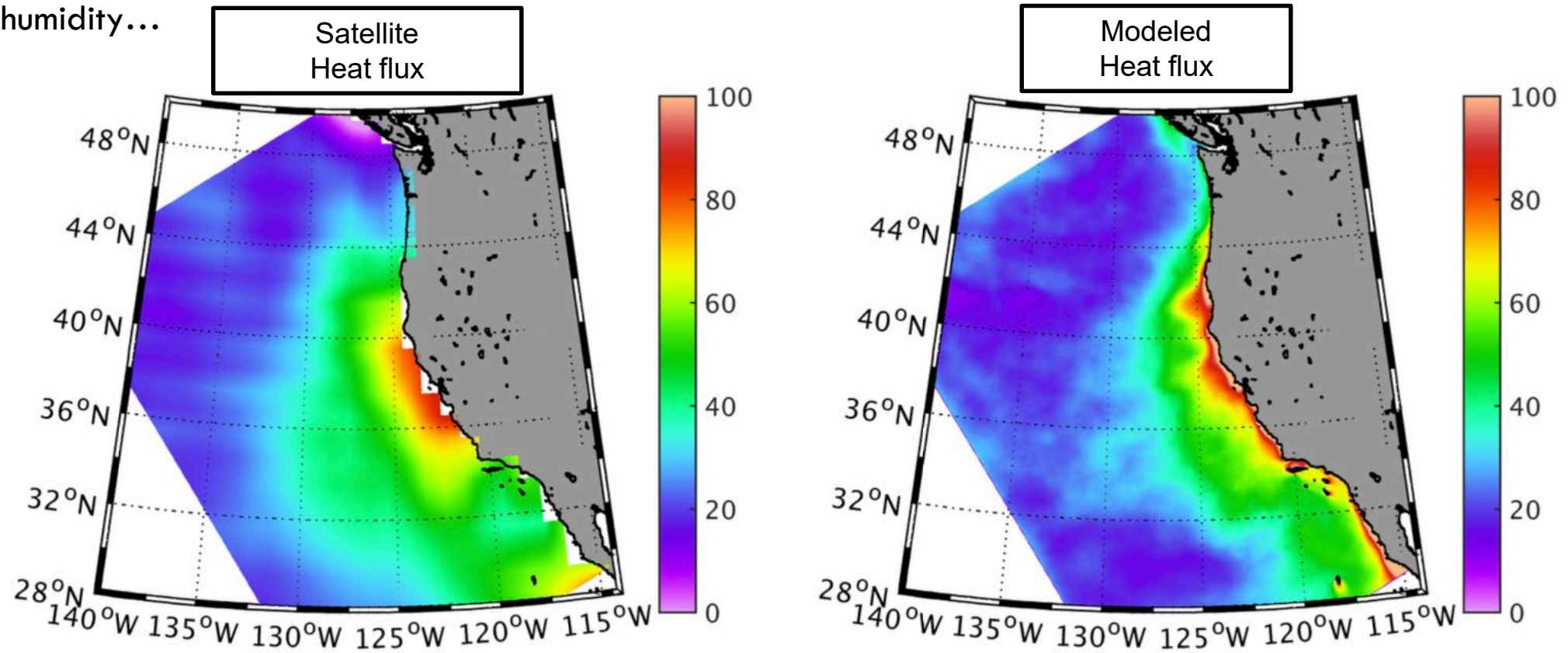
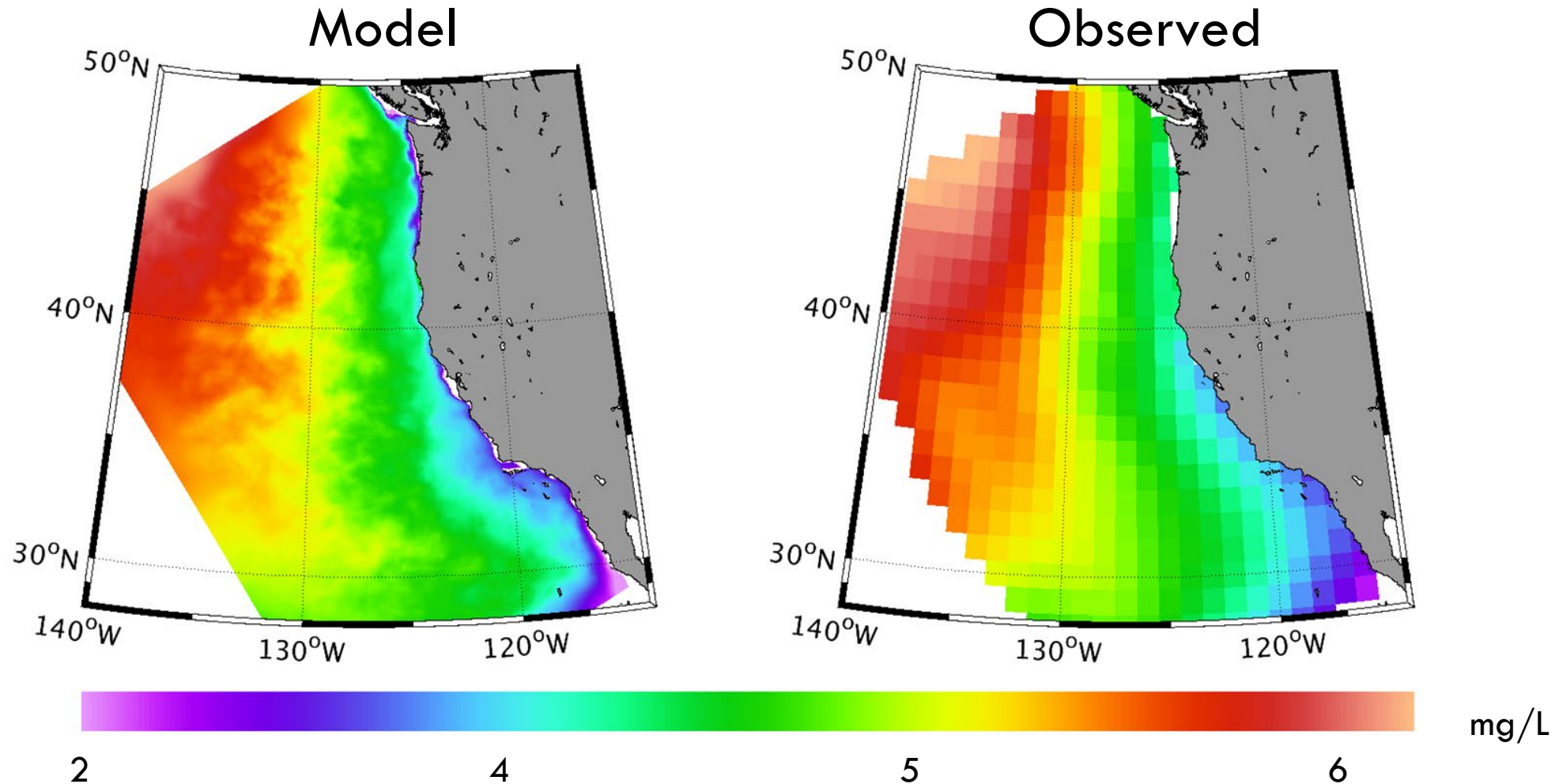# The model reproduces realistic oceanic circulation

Spatial distribution

Also:
Temperature, salinity, density, buoyancy of water masses, velocity, energy by eddies …

Surface elevation of the ocean

Satellite

Model

The model reproduces realistic spatial gradient, vertical gradient and seasonality of the chemistry

Also:
Nutrients, carbon and carbonates…

Dissolved Oxygen in interior
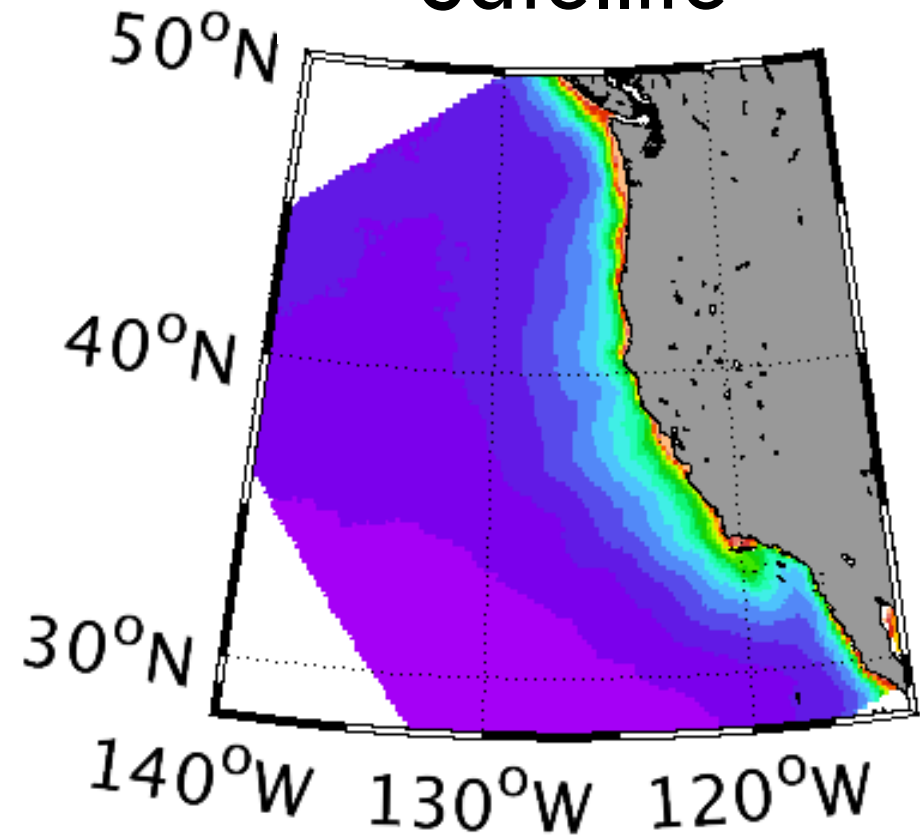

Model

Observed

mg/L

The model reproduces realistic spatial gradient, vertical gradient and seasonality of algal production
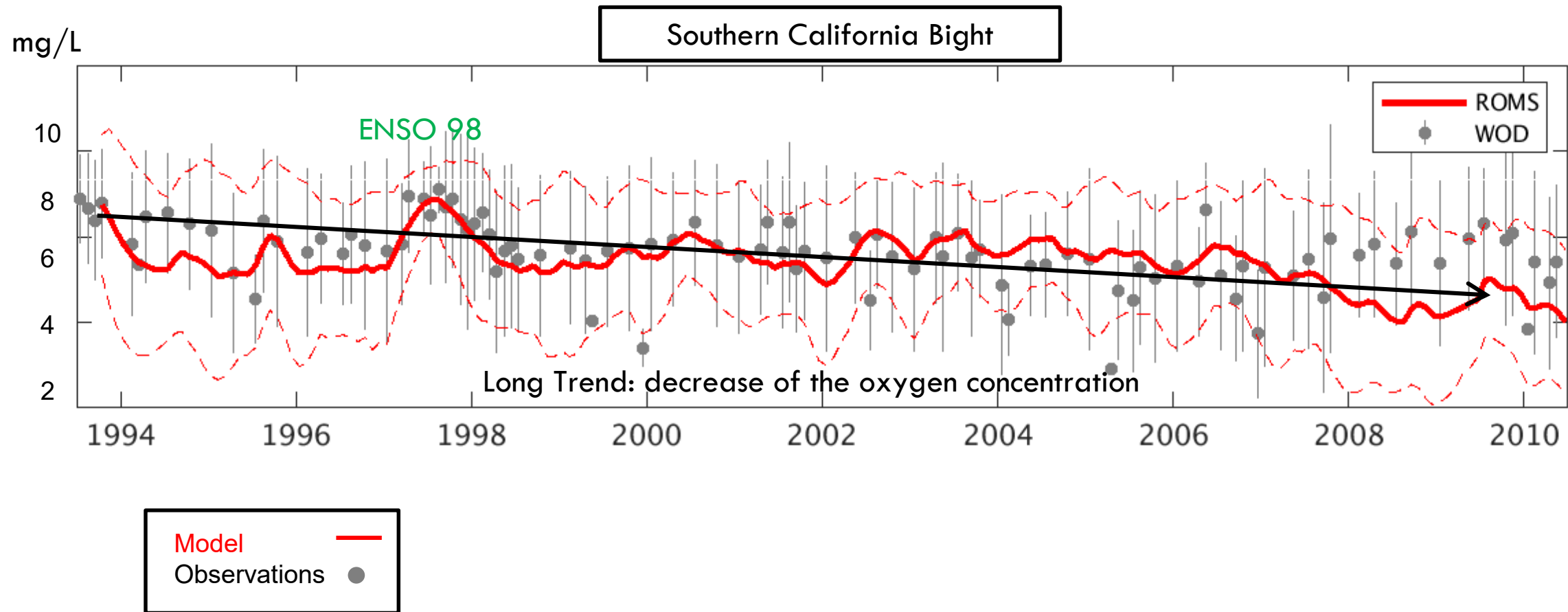
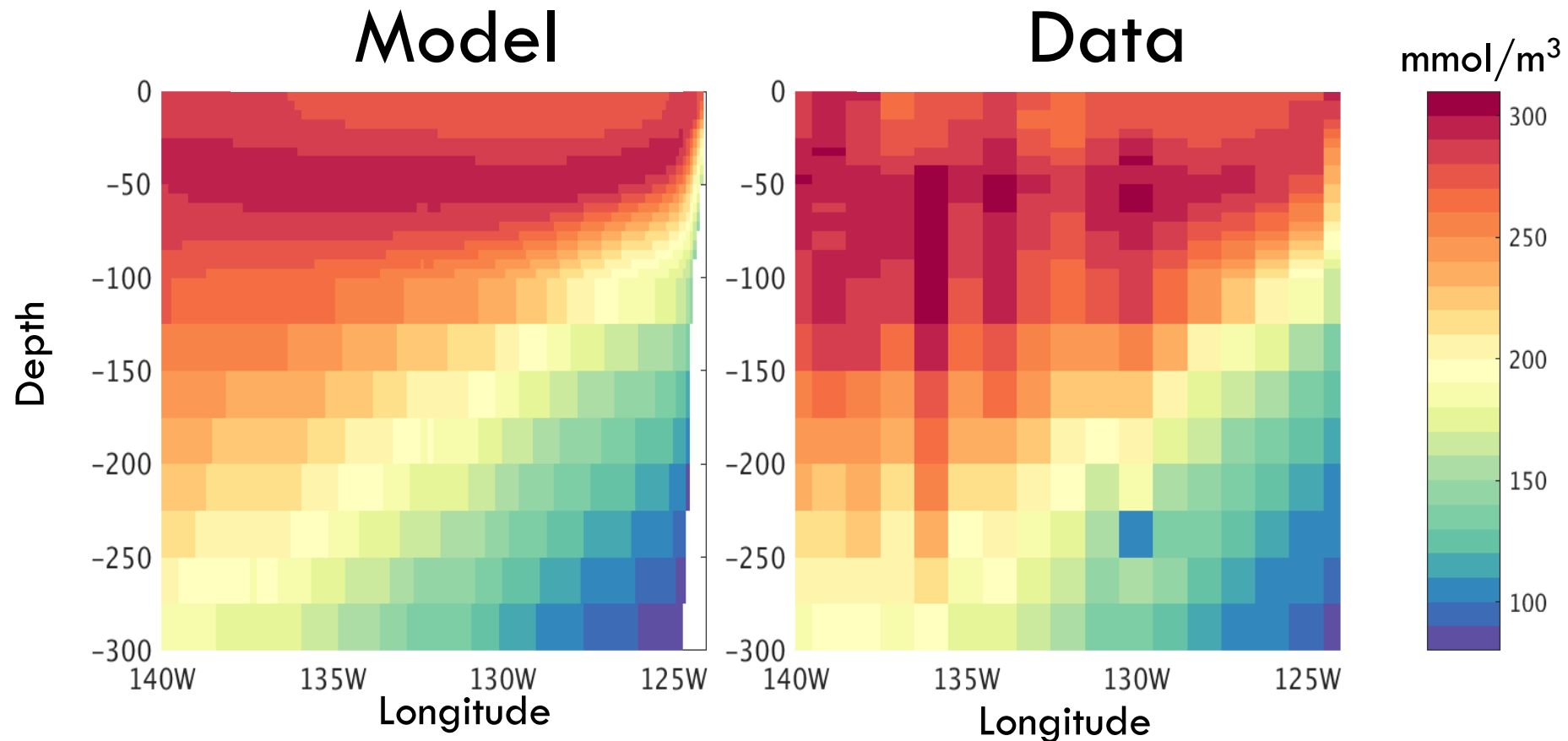Primary production

Model
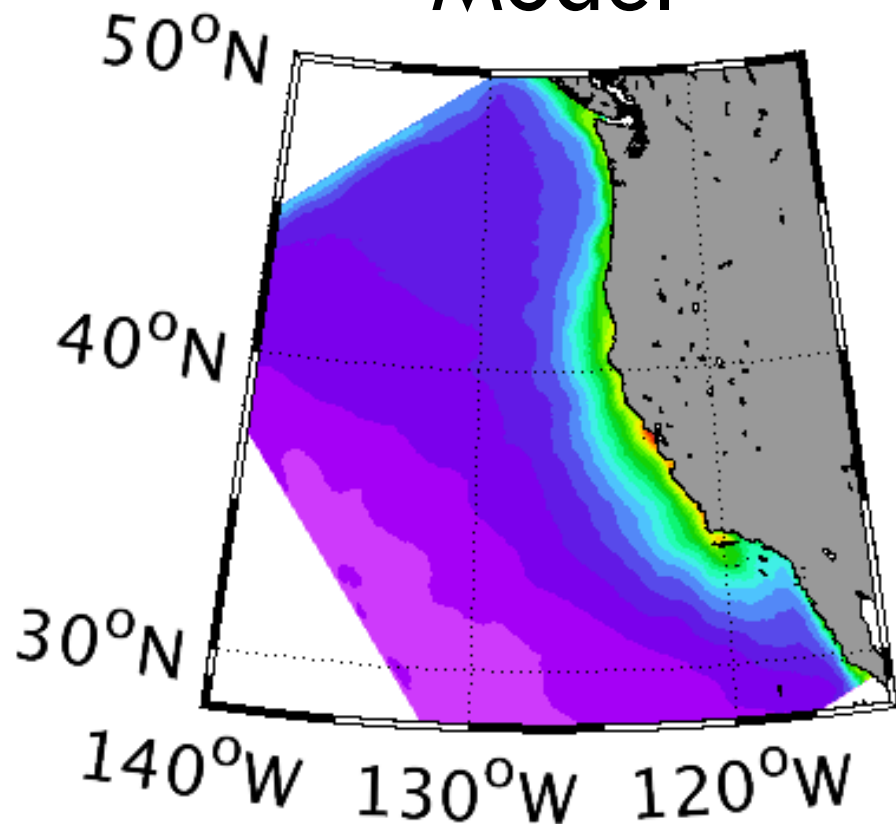
Satellite

The model reproduces realistic climate events and long trend
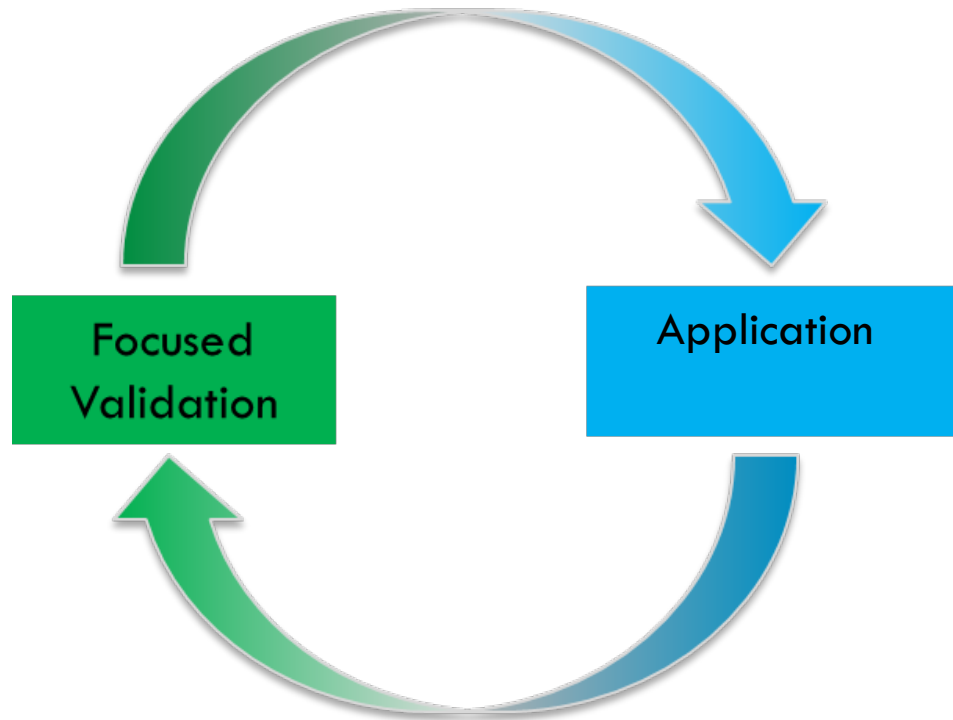## Example: Surface oxygen concentration

The model reproduces realistic vertical gradient

## Example: Vertical gradient of oxygen concentration

The validation process

- Focus validation is an ongoing process for application
→ Validate - adapt, revisit the scale - validate

Community approach:
- Science community
- Stakeholders

- We hold a special CTAG to agree on necessary validation steps

CTAG Helped Us Define Approach for Focused Validation of Model for Application to Pollution Impact Assessment
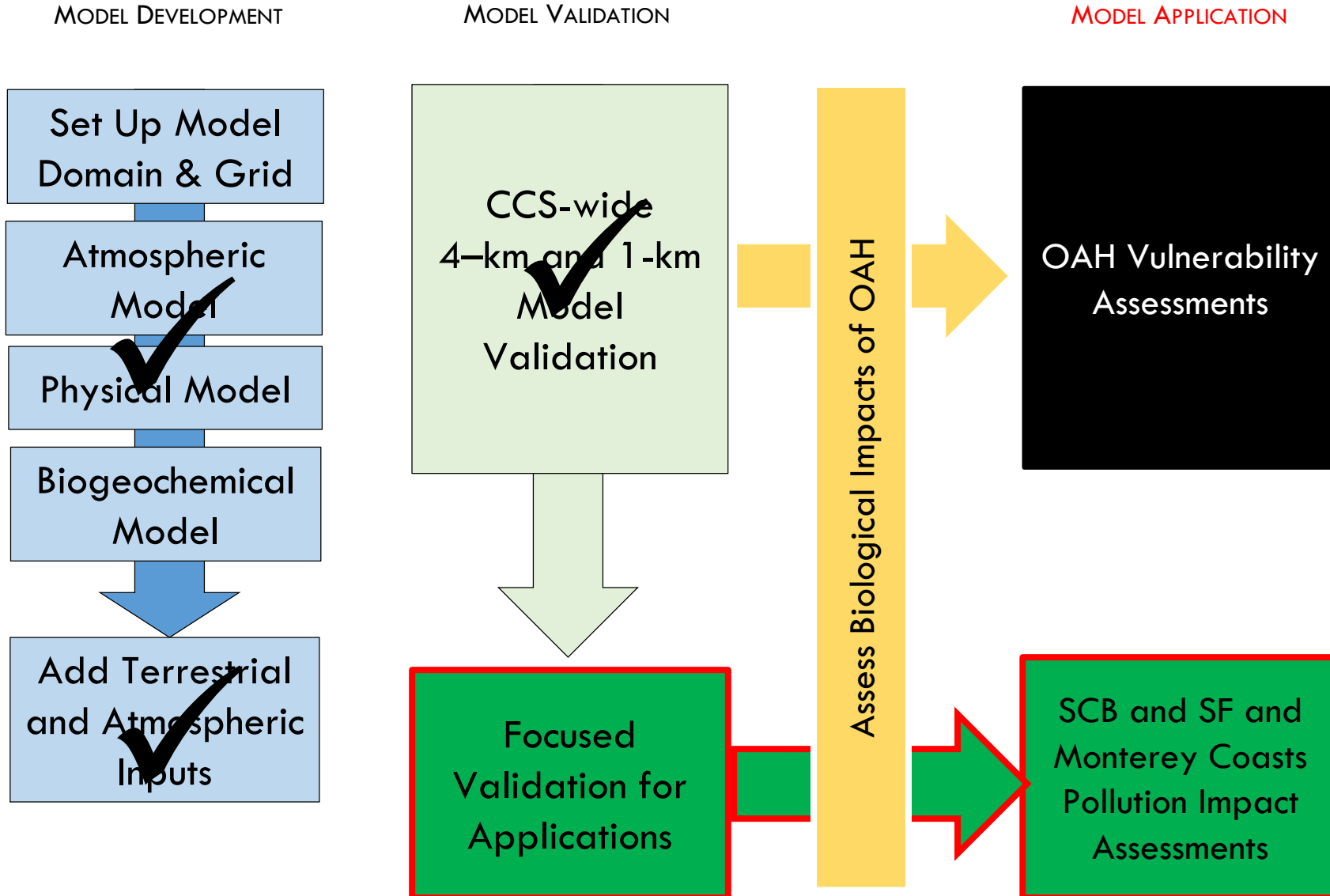
We Are Currently Running 3 Year Simulations With & Without Land-based and Atmospheric Nutrients at 300 m resolution

We will make a preliminary assessment of "impact" on OA & hypoxia and assess validation status

- We can assess changes on chemistry alone

- But will are working with biologists to assess implications of those changes for marine life
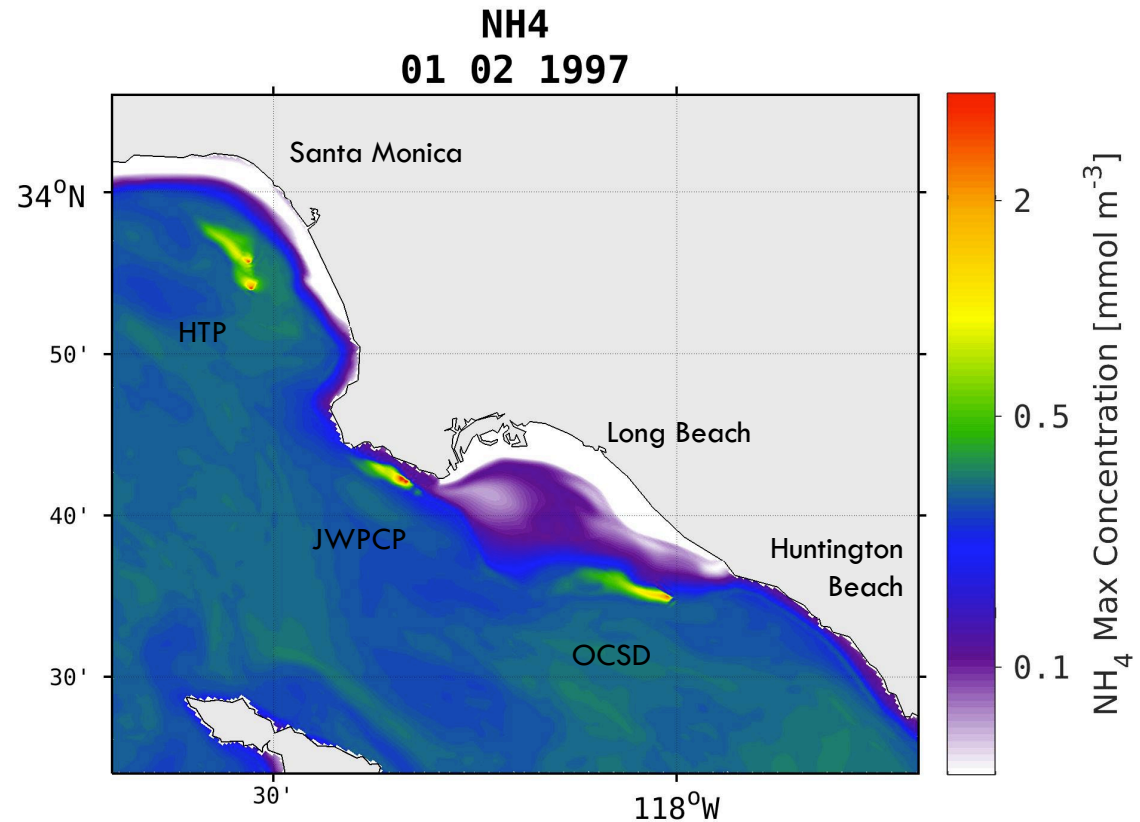
Example of model simulation of POTW outfall effluent impact on ammonia-N

Application: Local Pollution Impact Assessment

Anticipating **early spring 2019 meeting with SCB SAG and CTAG members**
to discuss preliminary findings of pollution impact assessment

OVER THE NEXT SEVERAL YEARS

→ **POTW plant management**
Source attribution
- Investigate what sources are having biggest impact?
- Individual source or combination of multiple sources?

Effect of nutrient management scenarios
- POTW plant upgrades
- Environmental impact of water recycling?

(Investigate the effect of reduced volume of POTW)

} New project with OCSD to investigate impact of water recycling
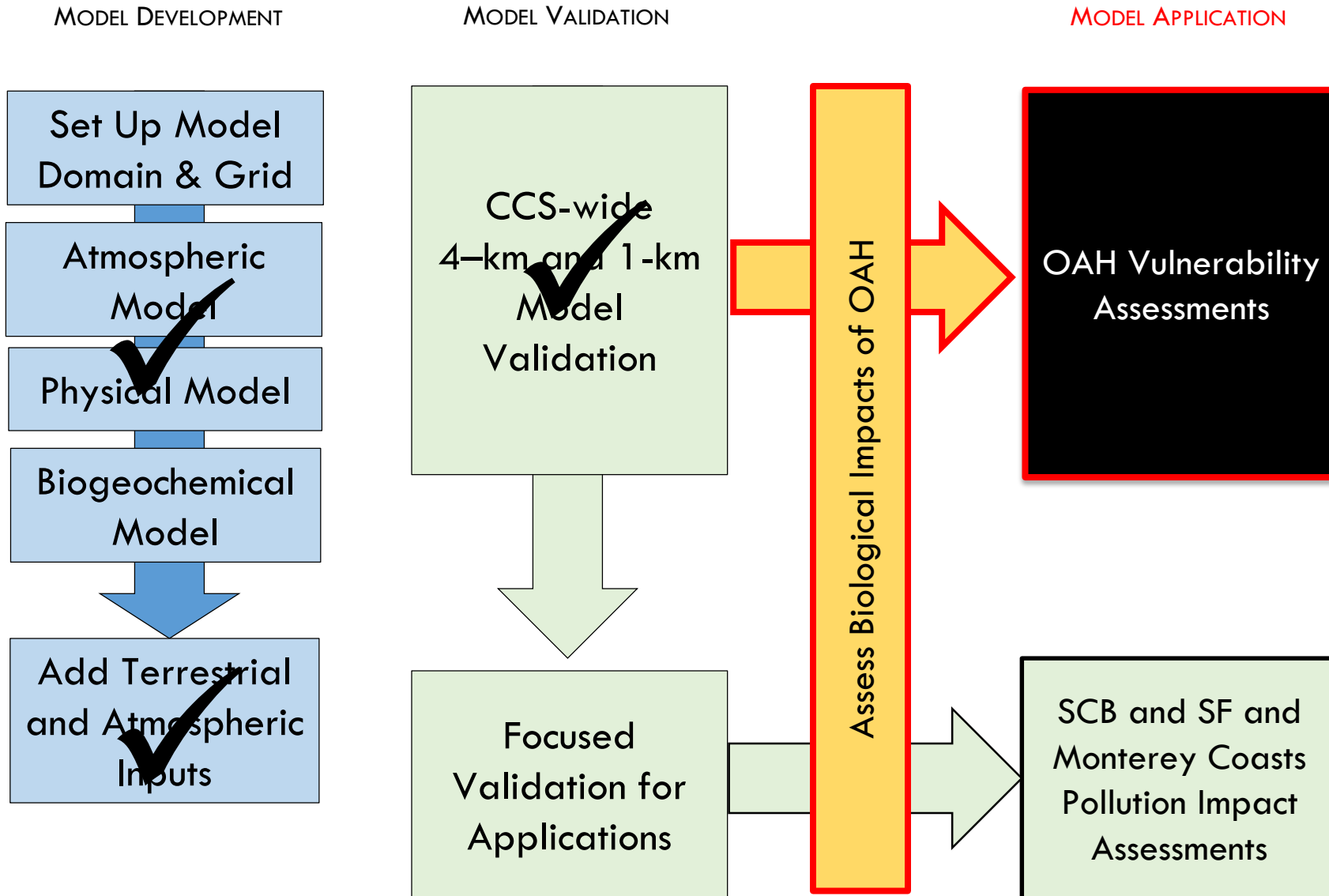
→ **Ecosystem phytoremediation**
Alternative approach (e.g. kelp restauration/aquaculture)

} Collaboration with UCI to develop & apply a kelp aquaculture model

We've Also Begun Applying Model for Marine Vulnerability Assessments

Application: Marine Vulnerability Assessment

Hind-cast in ROMS-BEC (1997-2007)
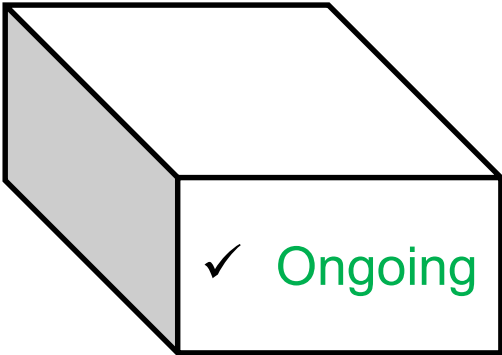
Chemical and physical regimes from the model

Assess Habitat Compression of Marine Organisms

✓ Ongoing

Temperature
Oxygen
pH

0 m

Low stress

San Francisco

Monterey Bay

Pt Conception

SCB

High stress

Biological tool

300 m

Low stress

High stress

Project future climate change scenarios

Pelagic fish (i.e. Calif. anchovy)

?
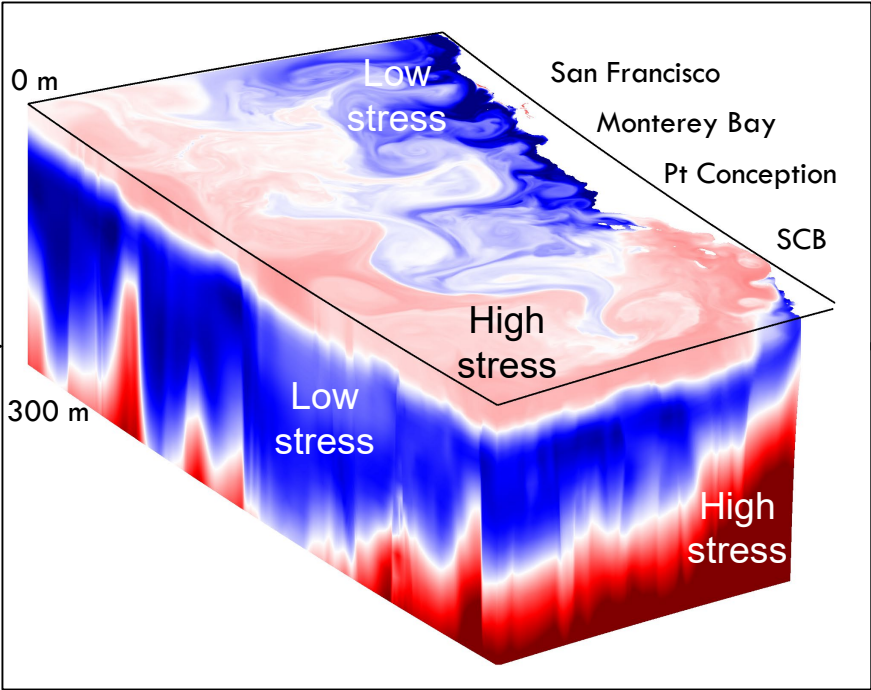
Application: Marine Vulnerability Assessment
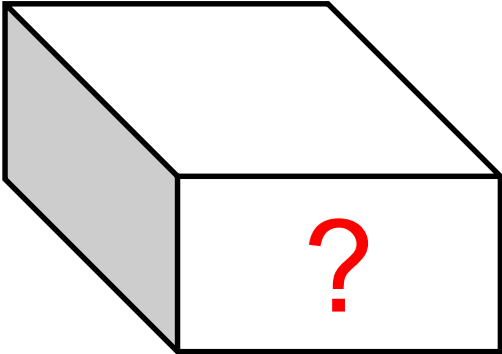
Modeled Chemical OAH Hotspots will be presented at **OPC Sponsored Modeling Forum on Marine Vulnerability Assessments** in Late Spring 2019

First of forums that will kick off discussion on how to use models to support OA action plan recommendations, e.g.:

California MPA management and marine spatial planning

Fisheries Risk Assessment and Resource Management

Reduce local stressors (pollution sources, fishing, navigation, ecotourism)

Evaluate mitigation strategies

Remember !

- Ocean model development is complete

- Broad scale validation over the entire US west coast is complete

- The ocean model is already being applied to help on Ocean Acidification Action Plan recommendations

EVENT 1	EVENT 2
"Modeling pollution impact assessment"	"Modeling OAH Hotspots"
SAG Meeting	OPC Meeting
Early Spring 2019	Late Spring 2019

Thank you!
Are there any questions, comments?

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