Earth System Modeling: Are we ready?

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Tony Koslow (SIO/UCSD)

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Bern Megrey (NOAA-NMFS/AFSC)

Kenny Rose (LSU)

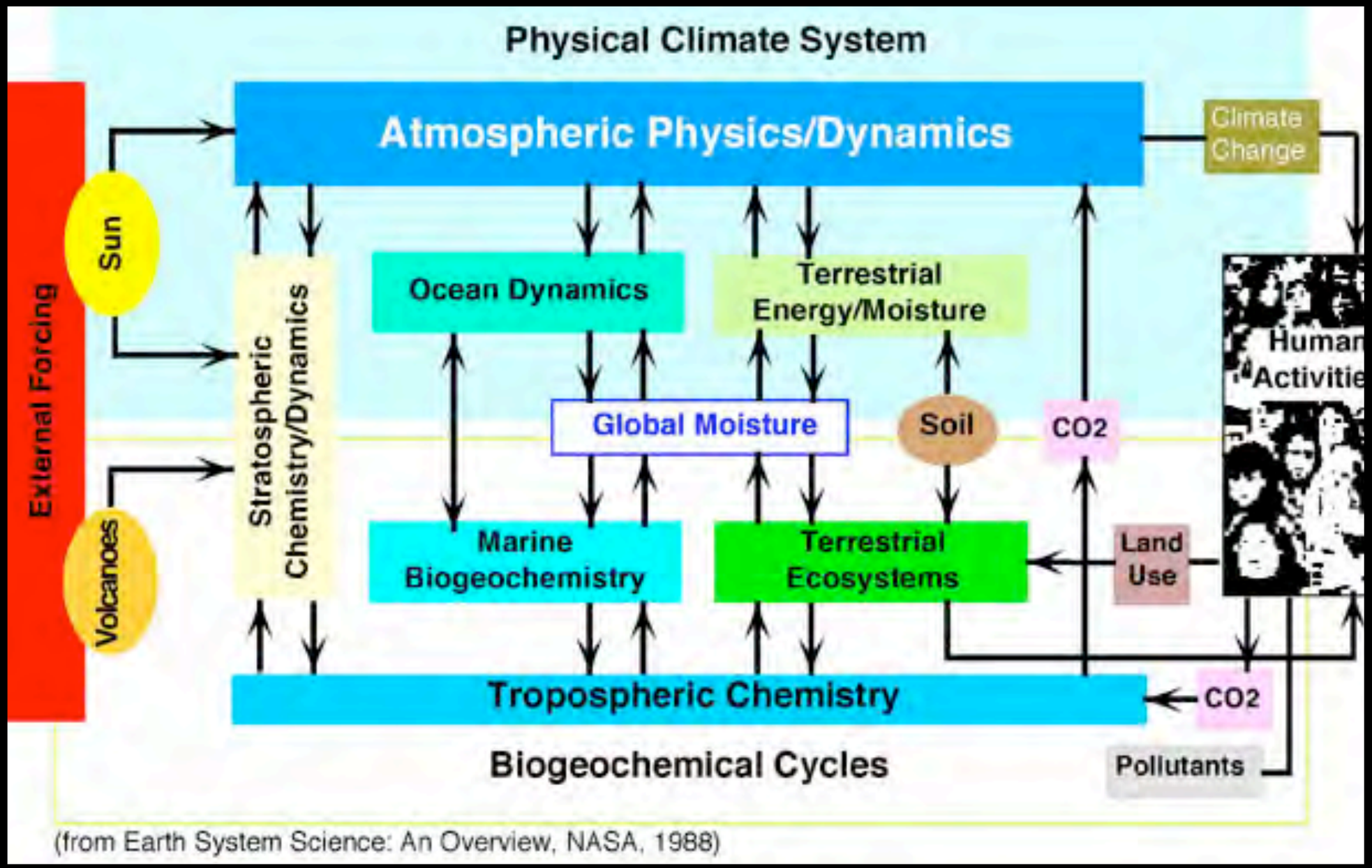
Justin Small (NCAR)

Cisco Werner (Rutgers U.)

Theme: "North Pacific ecosystems today, and challenges in understanding and forecasting change"

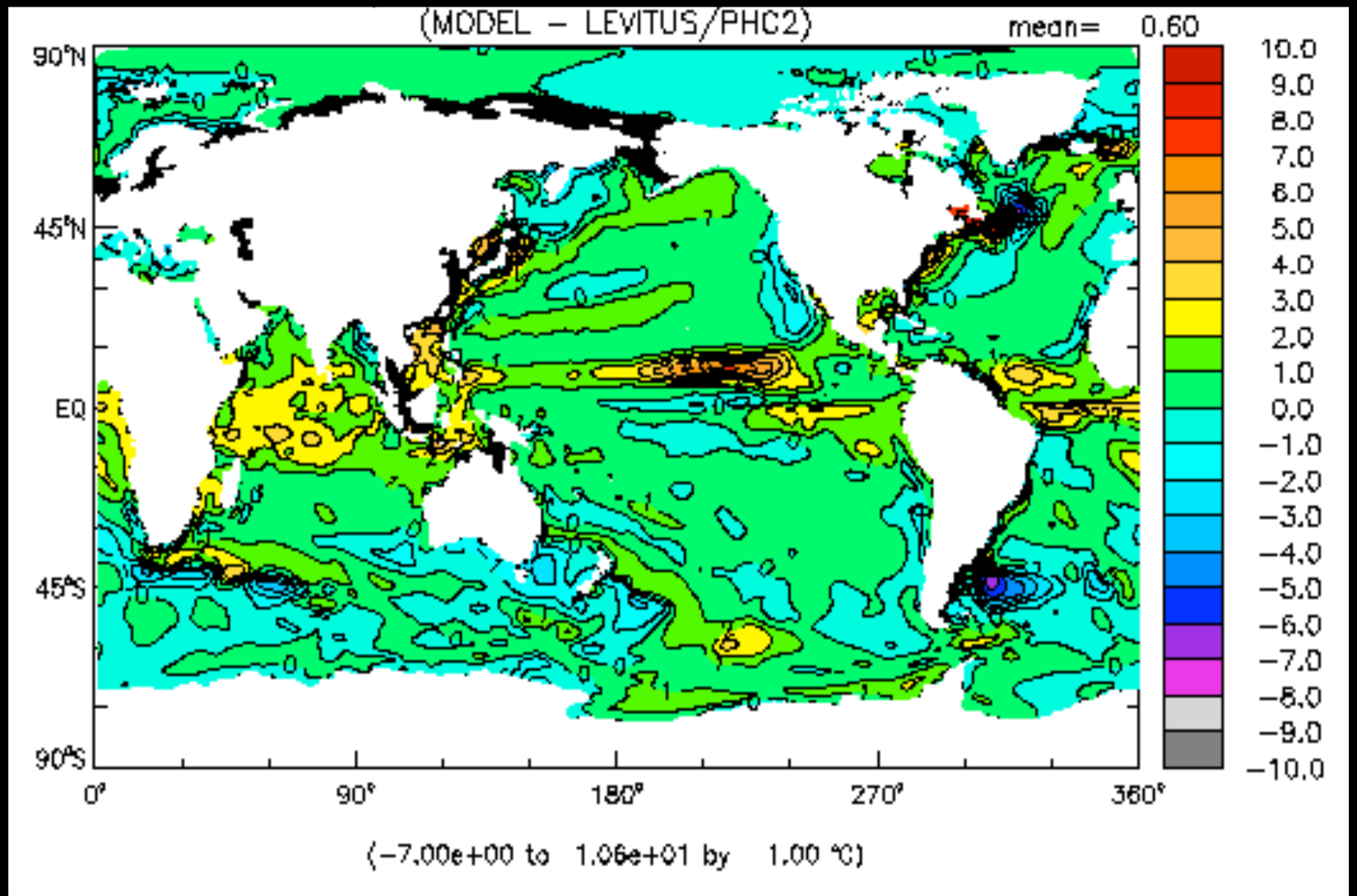
- **FUTURE advances:** Investigating the *mechanisms* underlying ecosystem response to natural and anthropogenic forcings.
- **FUTURE Science priorities:**
  - Improve forecasting capabilities
  - Study marine ecosystem responses on seasonal to decadal time scales
  - Assess direct and indirect effect of human activity
- **FUTURE strategy:** Data and models, process and retrospective studies.

The Earth System Model



(from Earth System Science: An Overview, NASA, 1988)

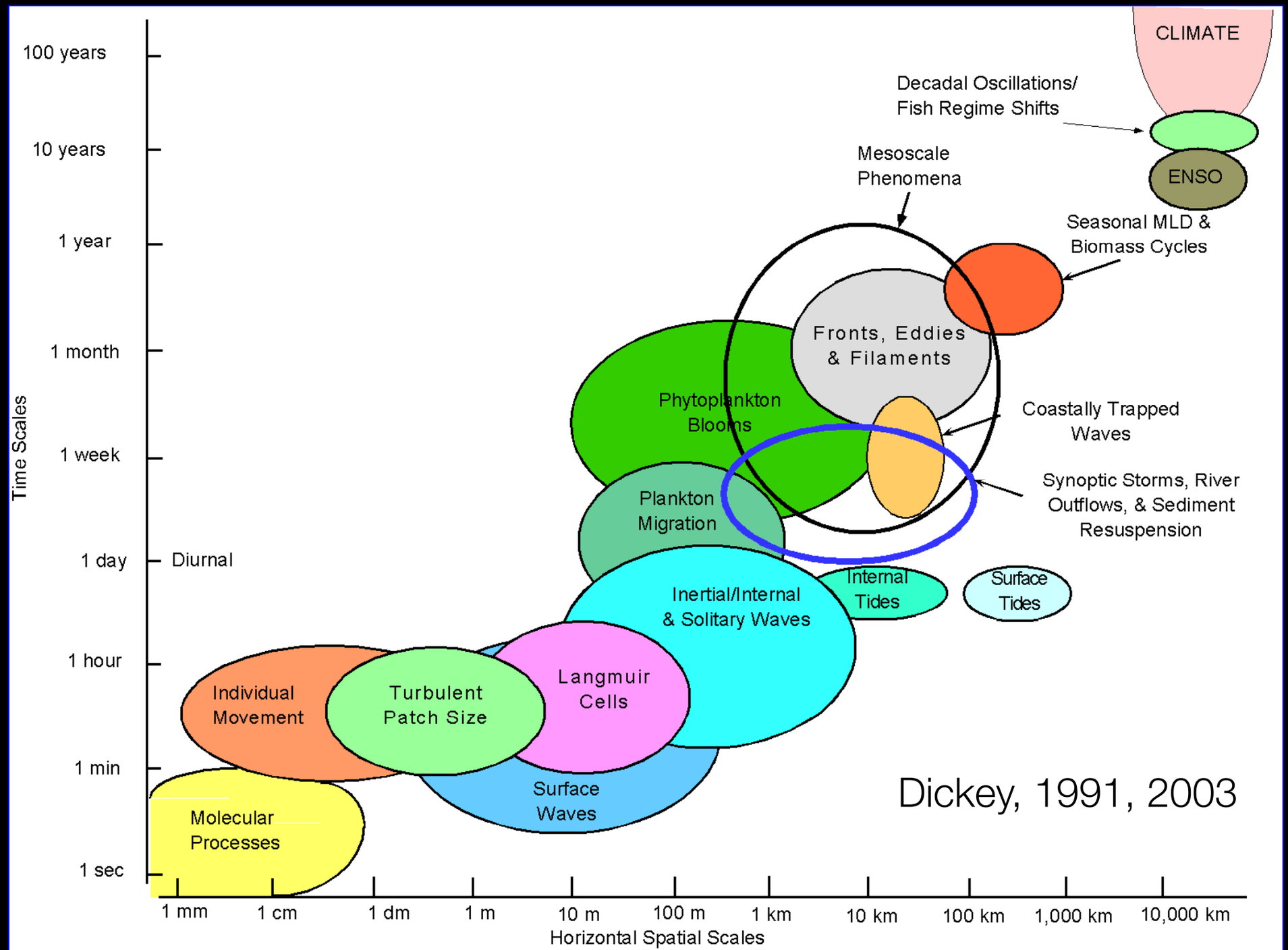
Challenges: Climate model biases



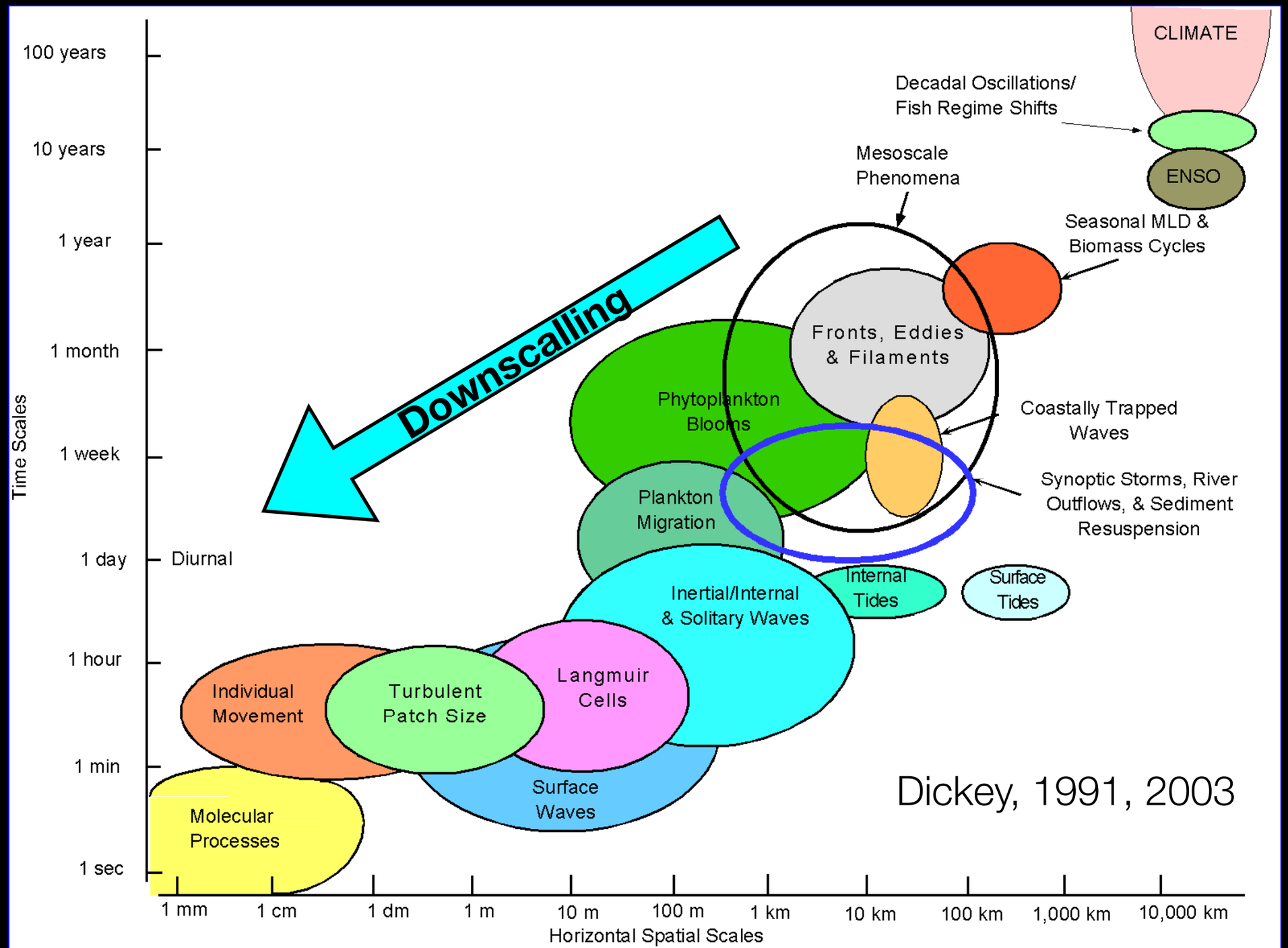
"Models still show significant errors ... The ultimate source of most is that many important small-scale processes are not represented explicitly in models ..."

Randal et al., 2007.

Challenges: The multi-scale problem



Challenges: The multi-scale problem



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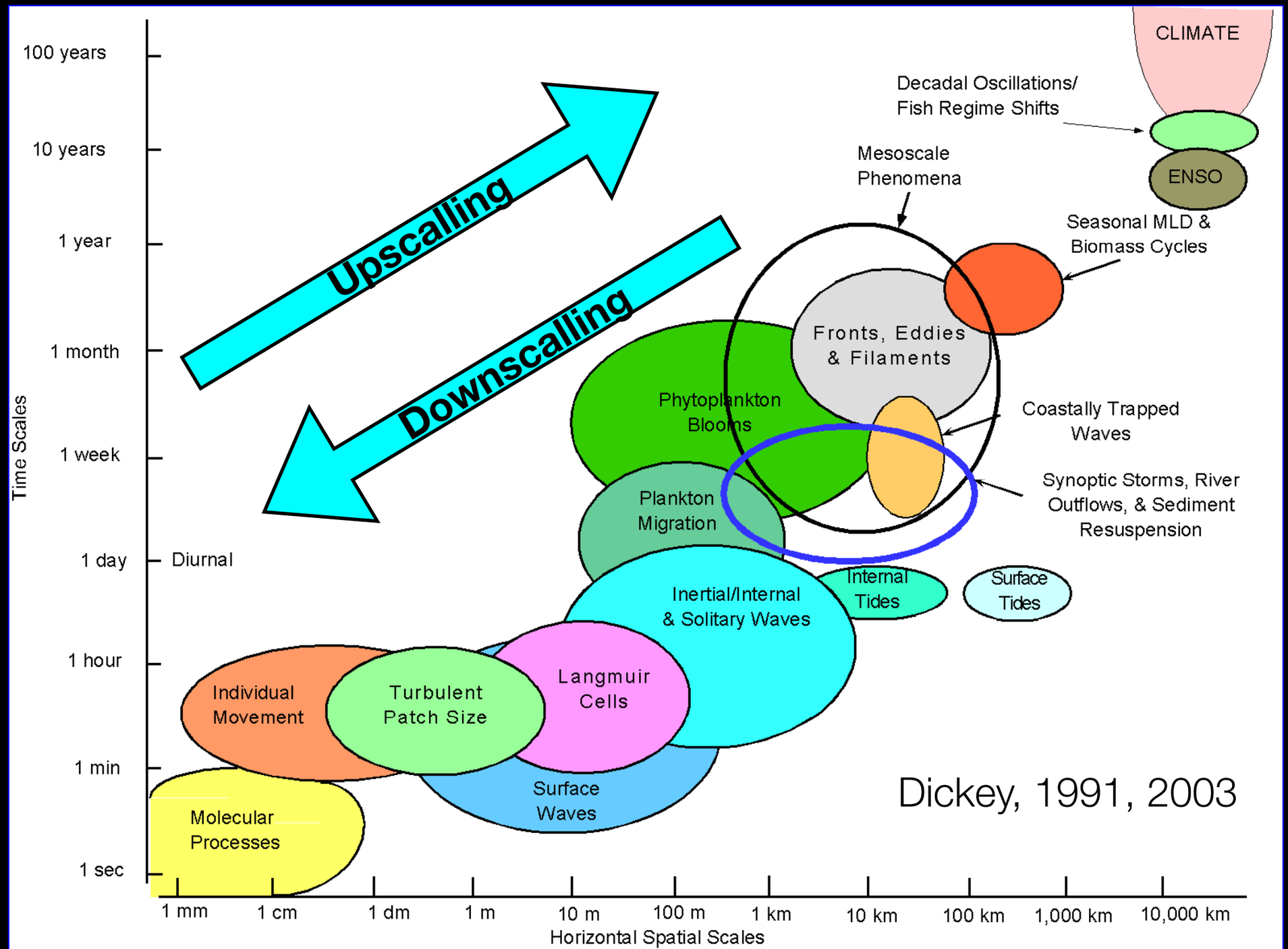
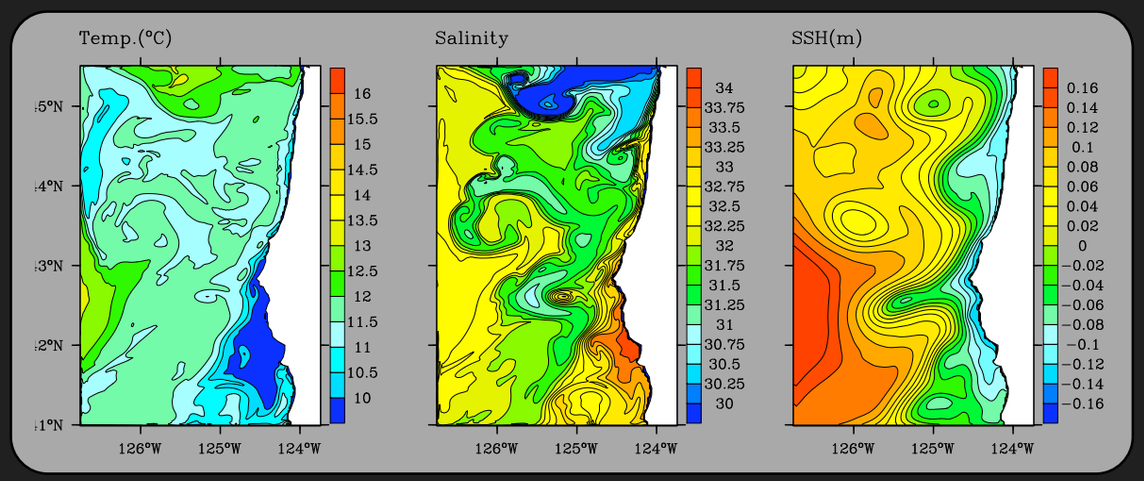


Our march towards an Earth System model

NCAR-CCSM Global Climate Model

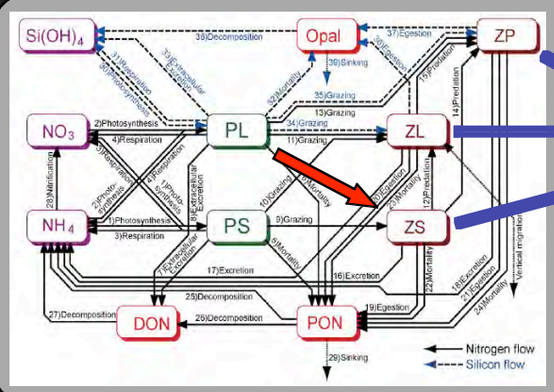
Dynamical two-way downscaling

ROMS regional ocean model



Tightly coupled to lower and upper trophic level models

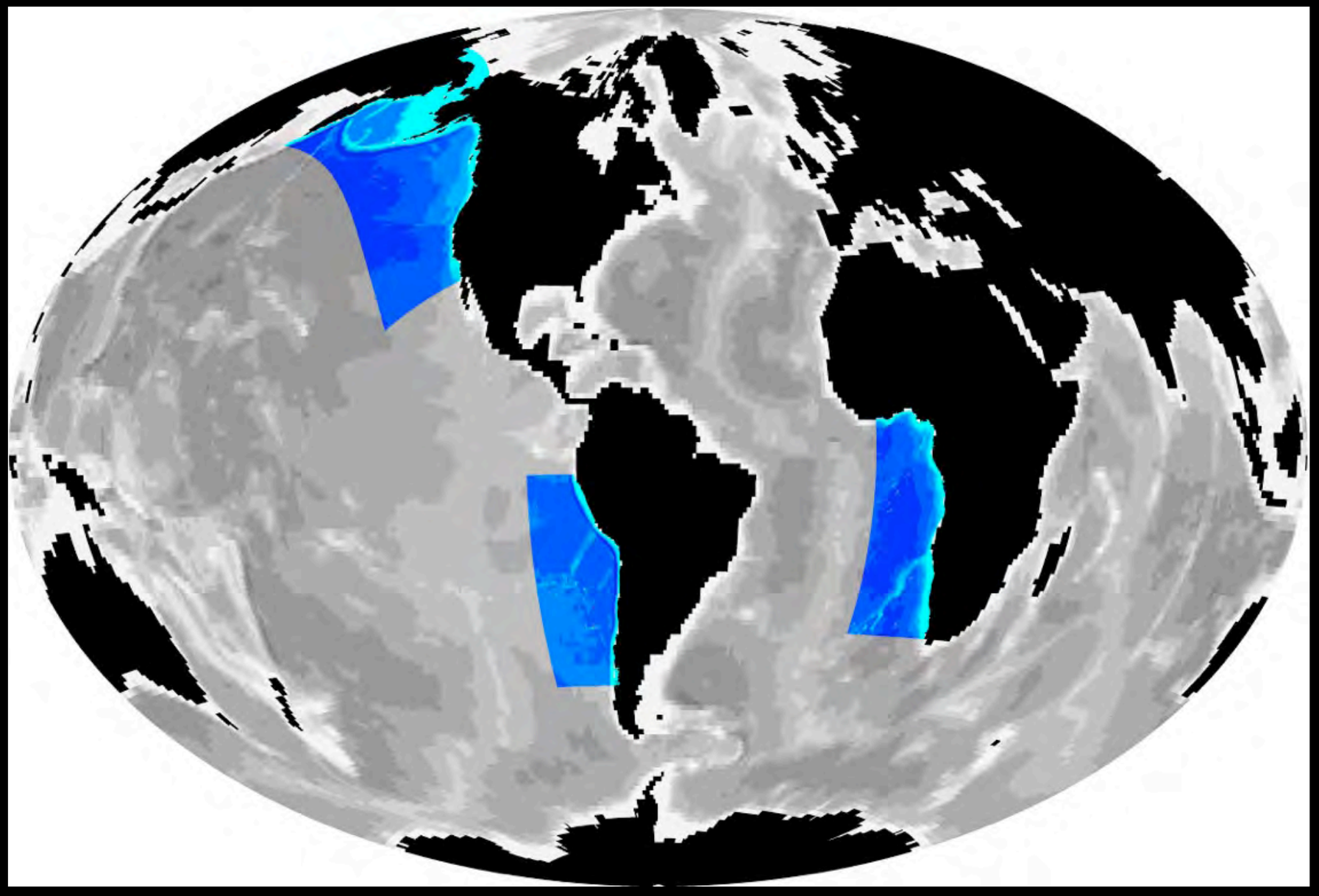
NEMURO NPZD and Individual Based Model



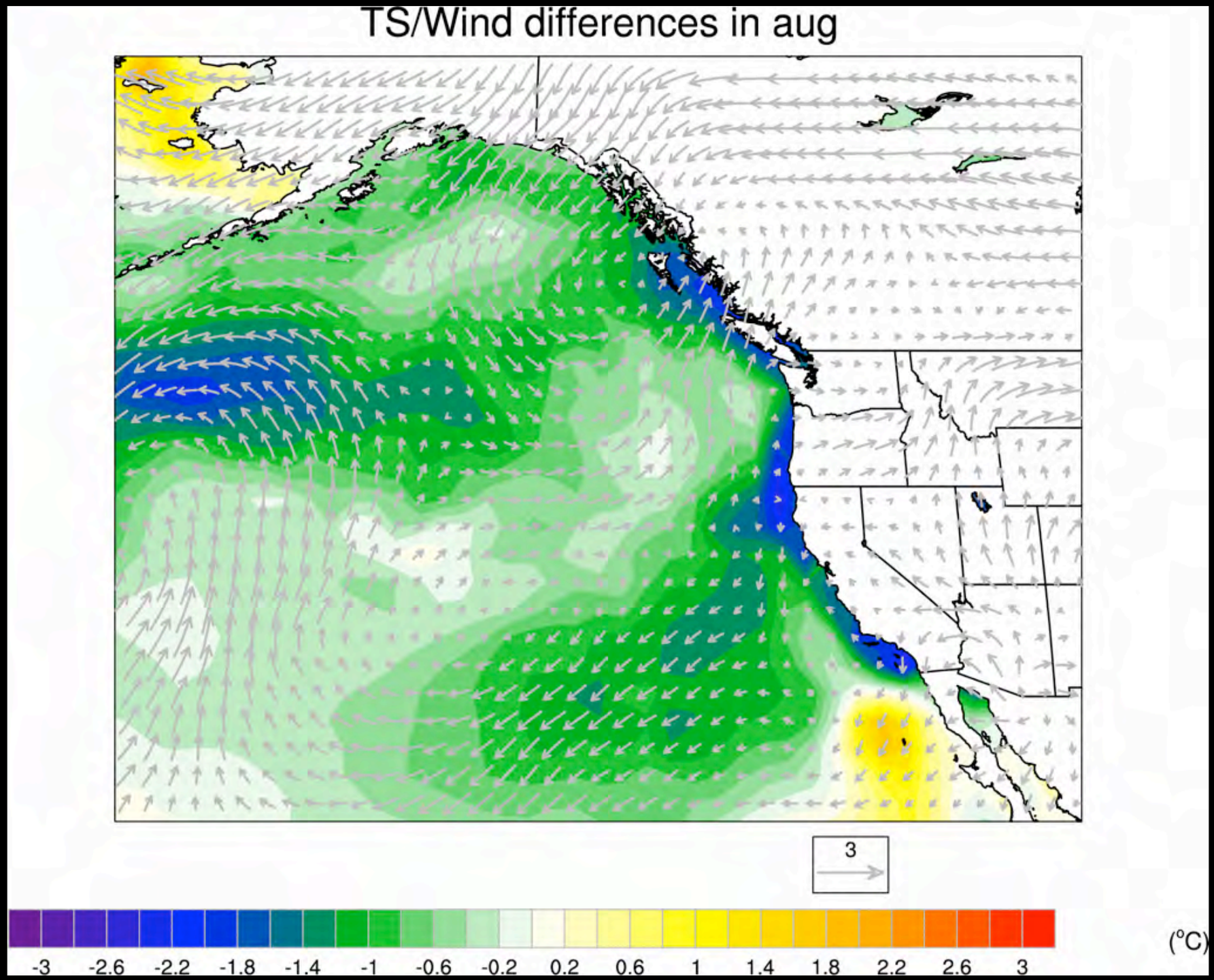
FISH IBM

Growth
Reproduction
Mortality
Movement

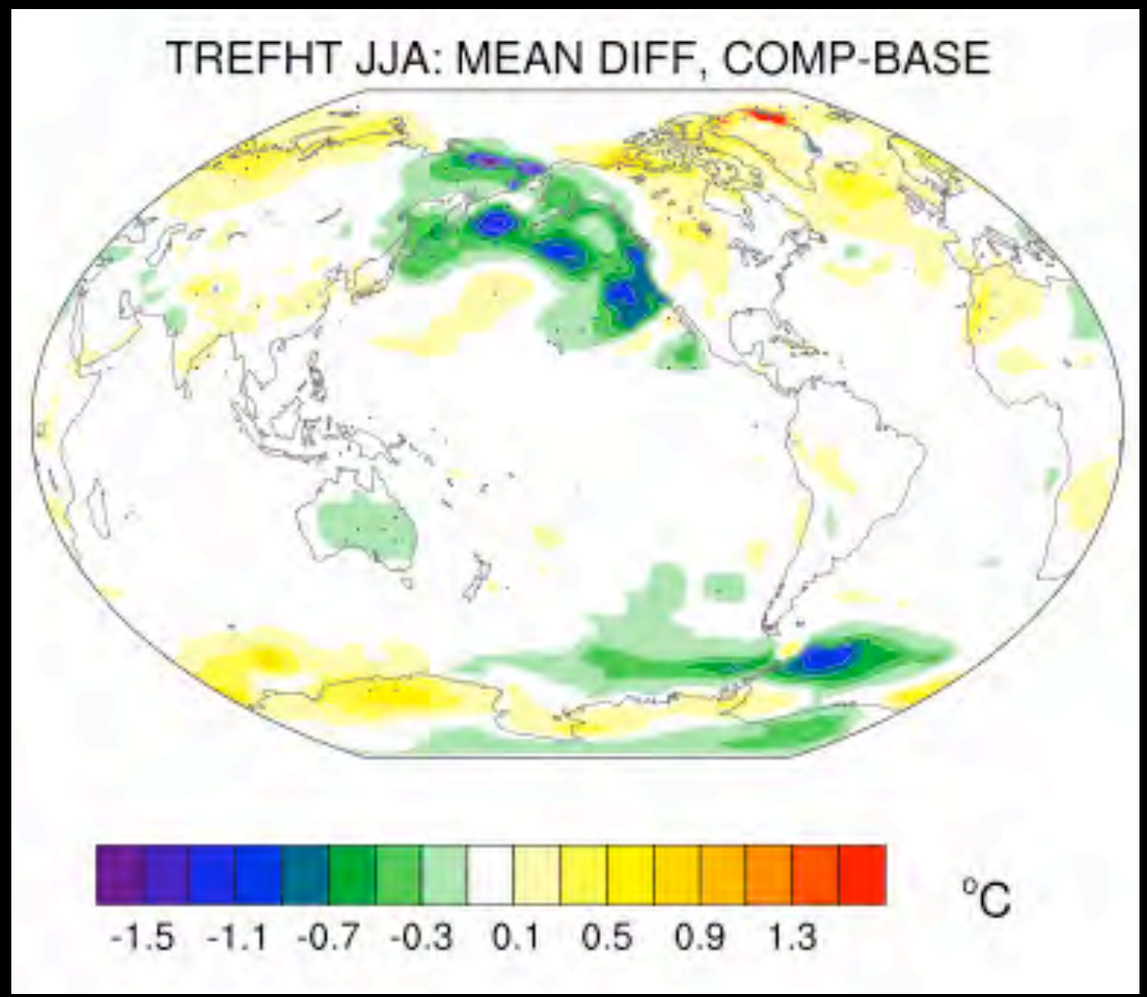
CCSM-ROMS coupling

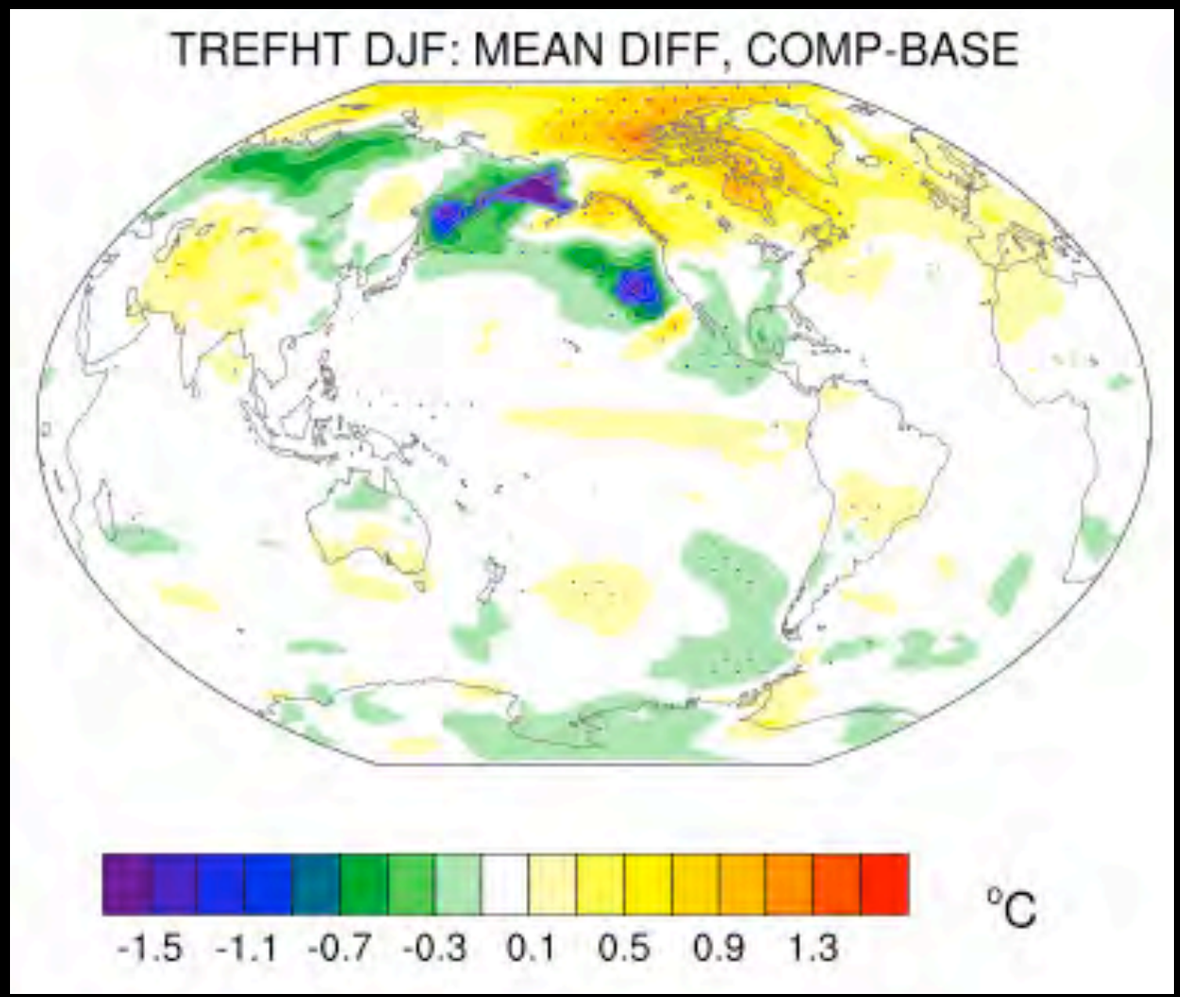


A close look at the down-scaled region (Sea surface temperature and wind anomalies)



Air temperature: Mean differences



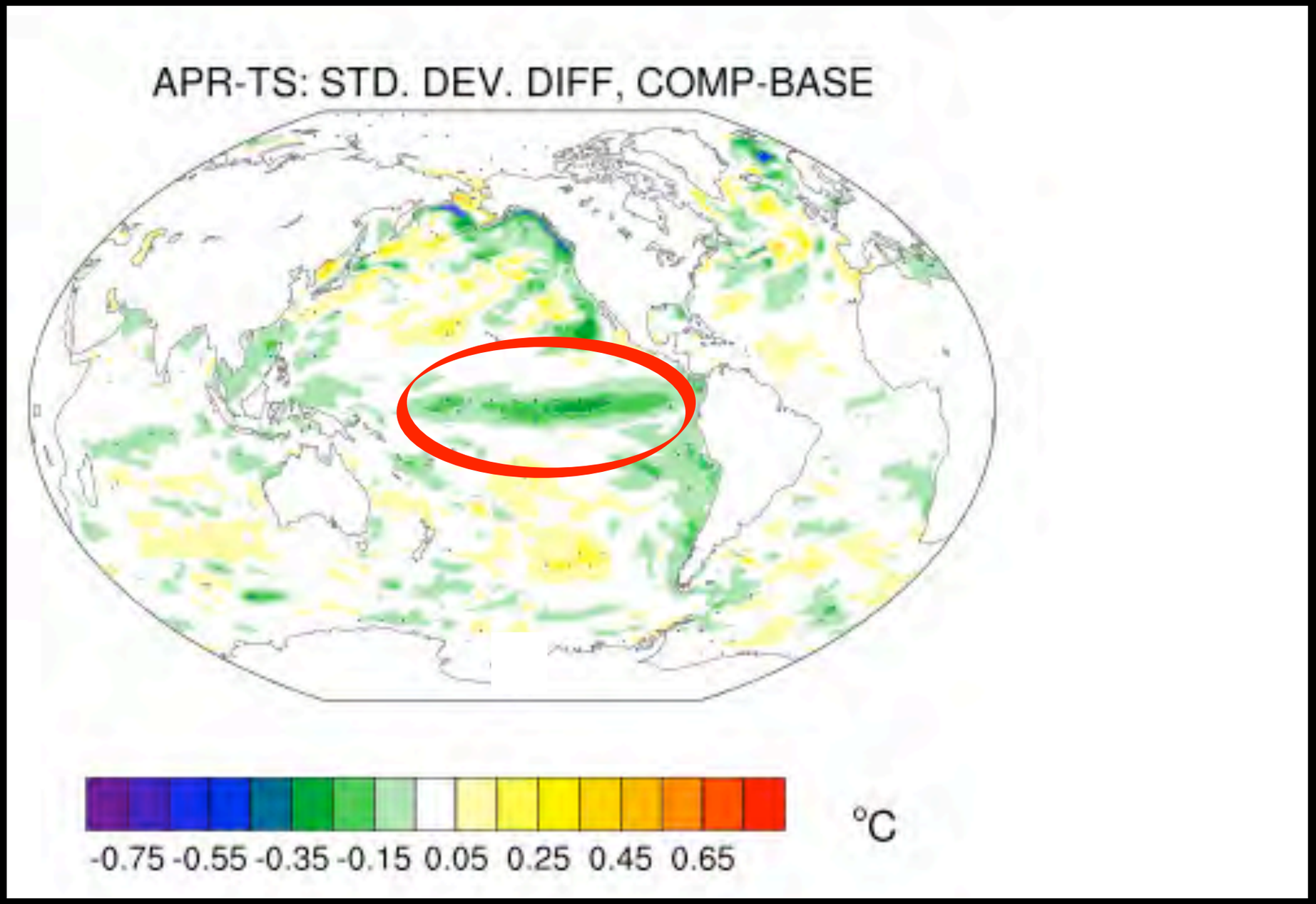


Summer

Winter

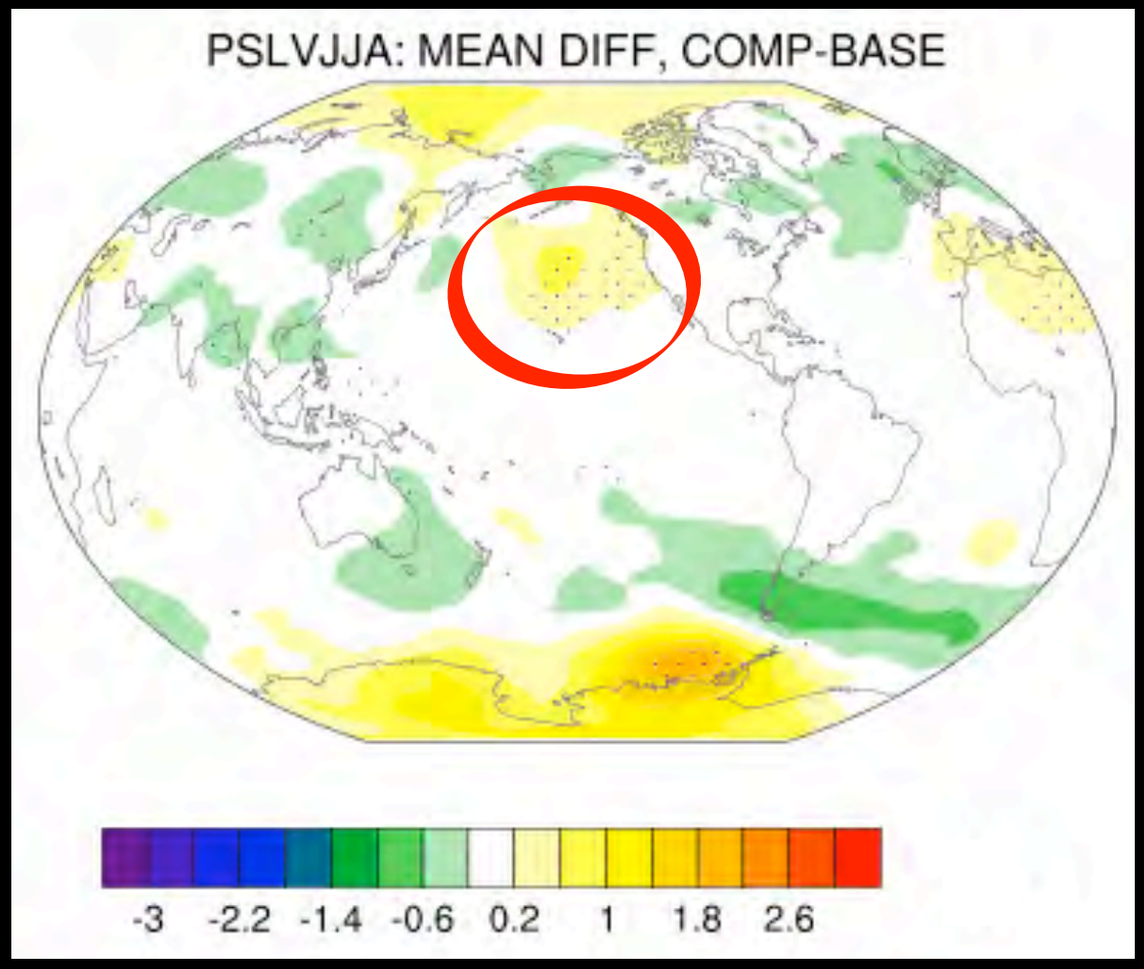
Method: T-test, 95% confidence

Air temperature: Variability



Method: F-test, 95% confidence

Sea level pressure



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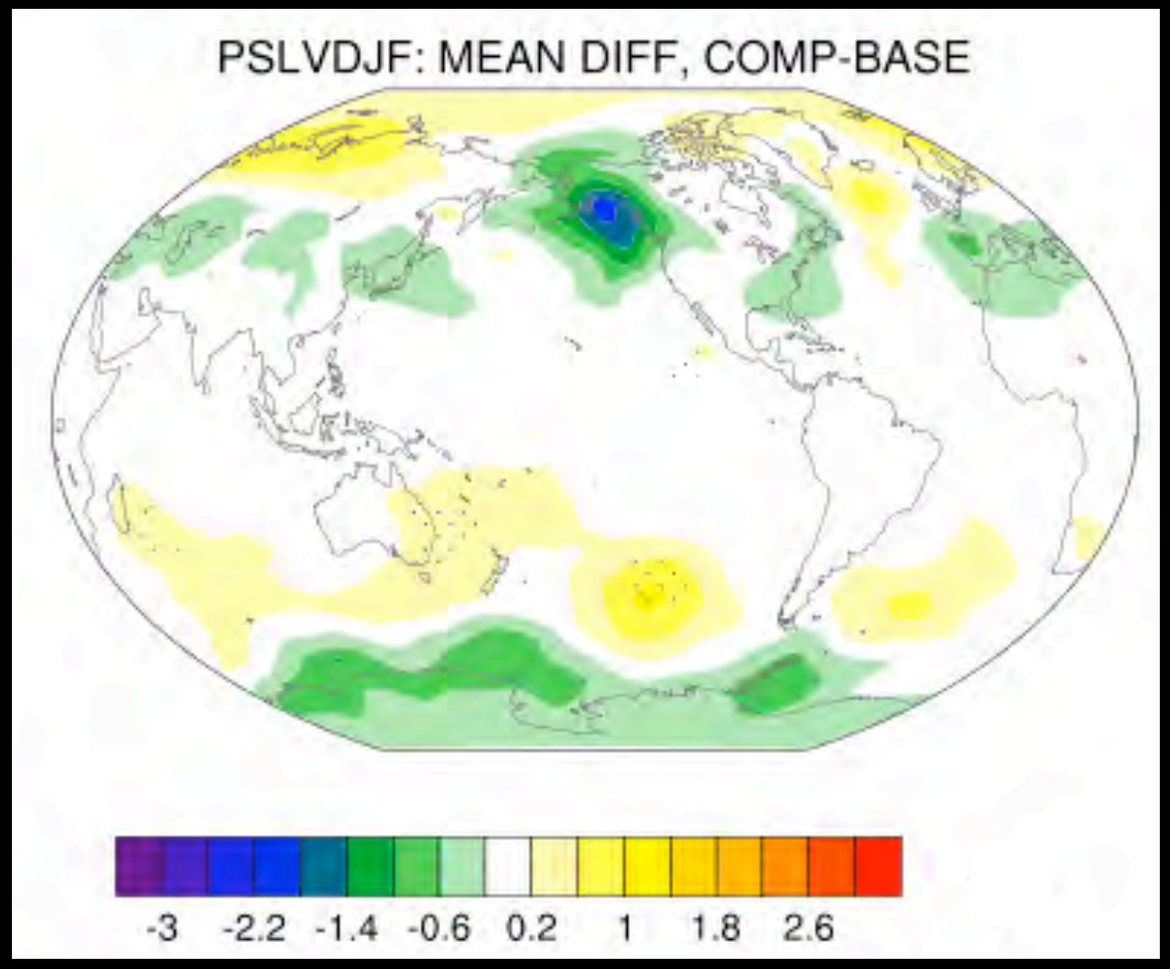
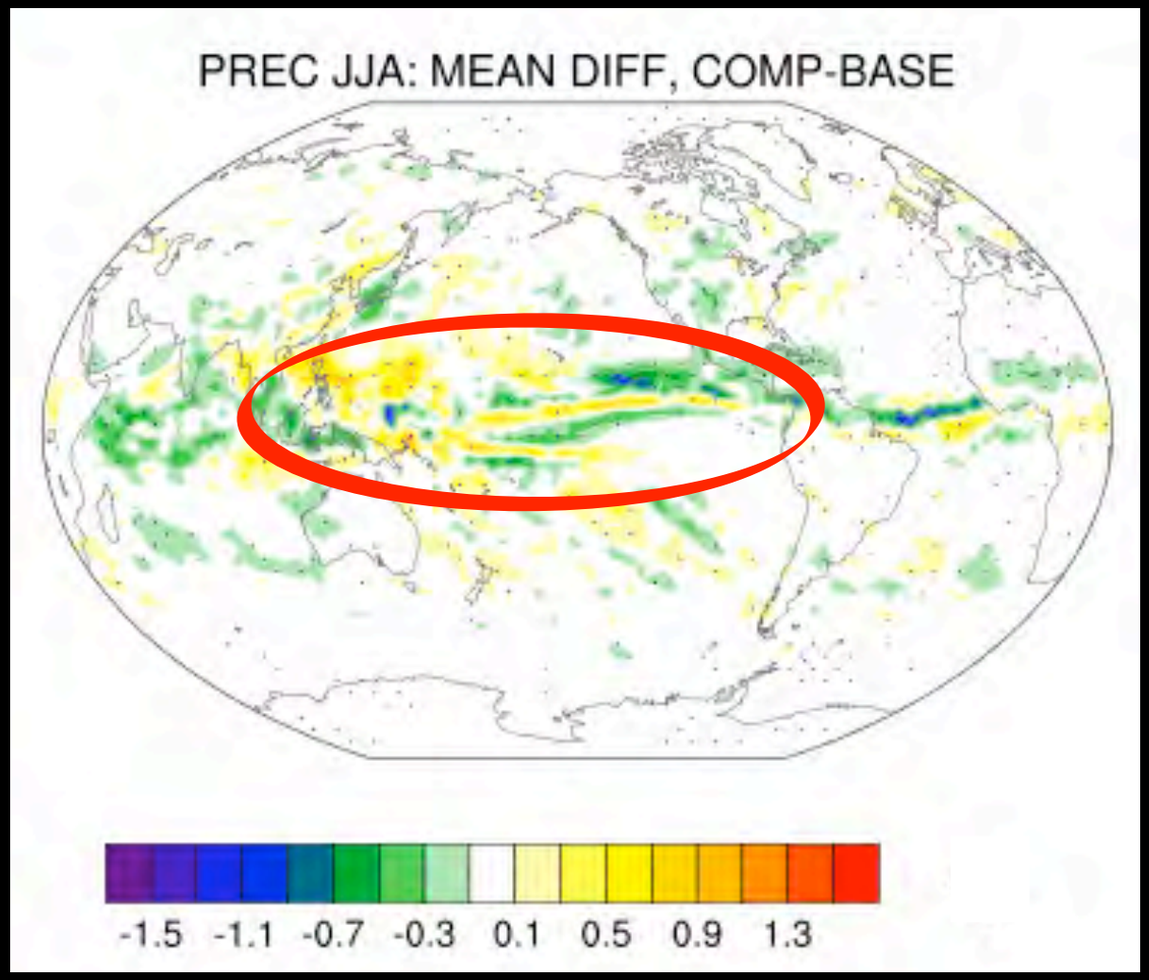


Winter

Precipitation



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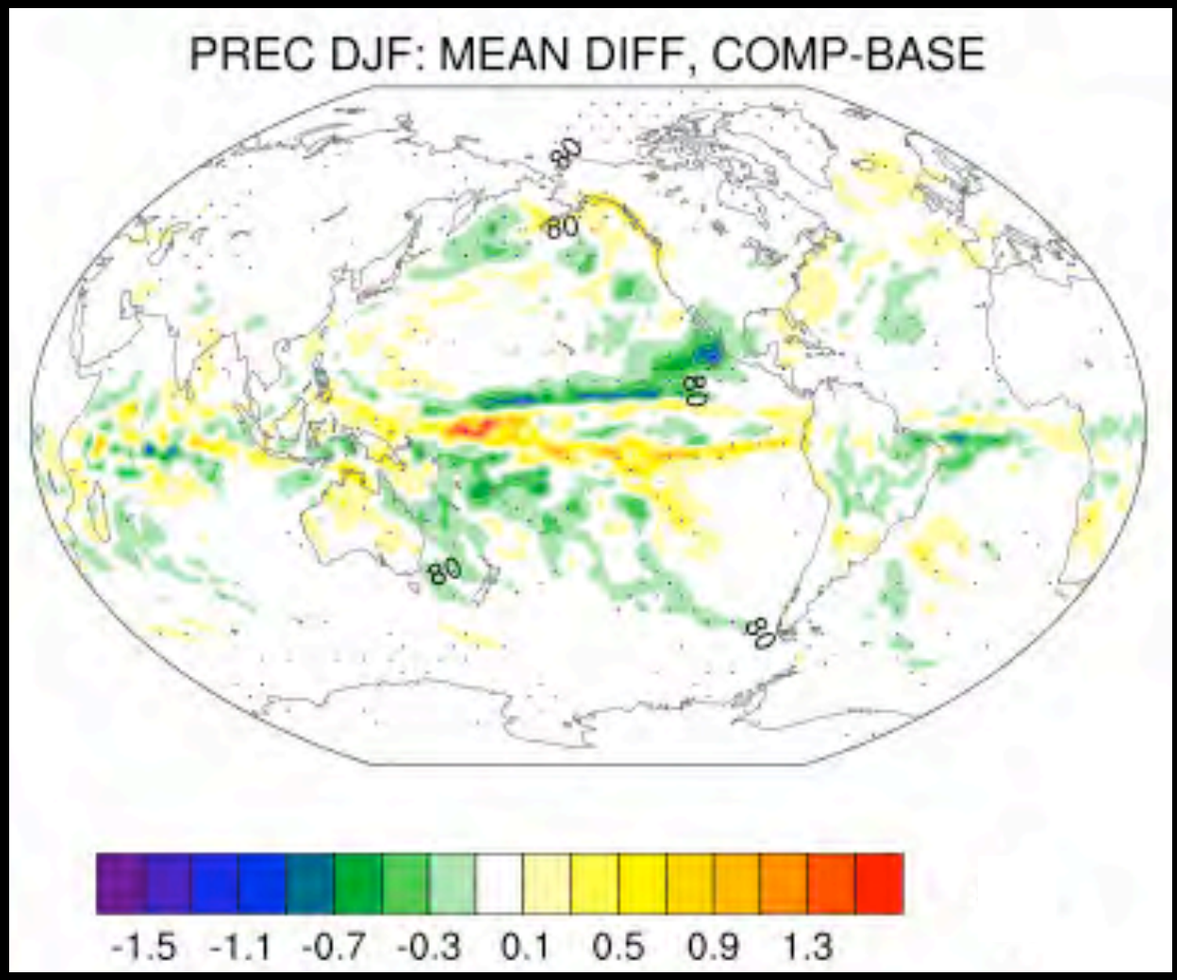

Winter

Climate-to-fish-to-fishers

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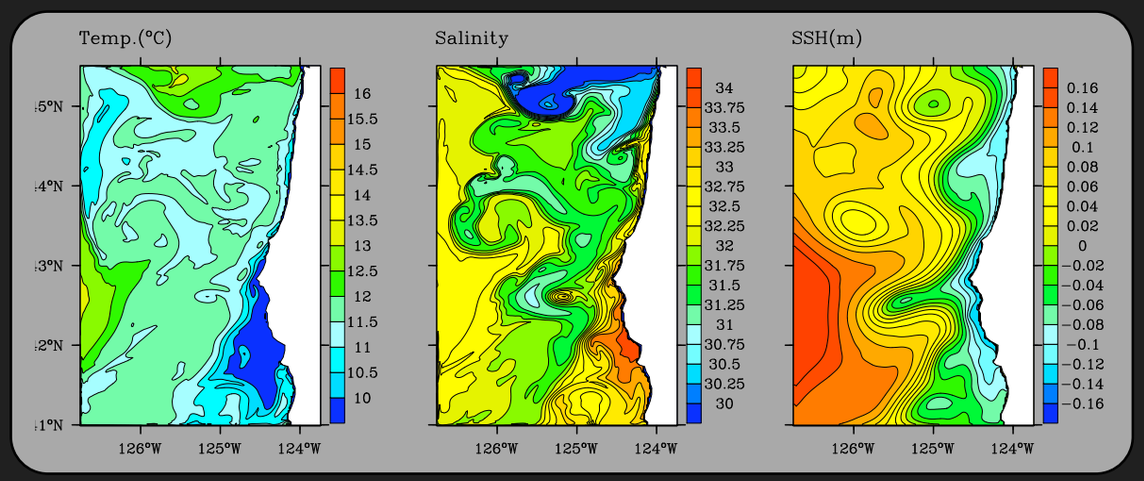

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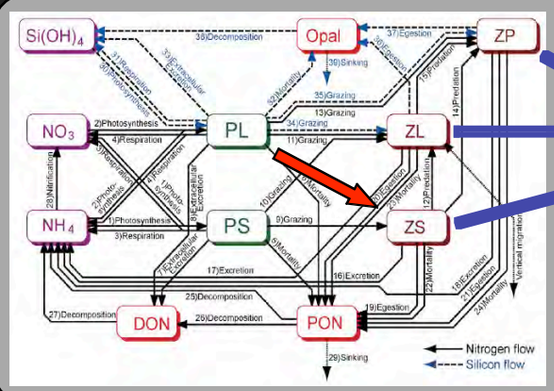

FISH IBM

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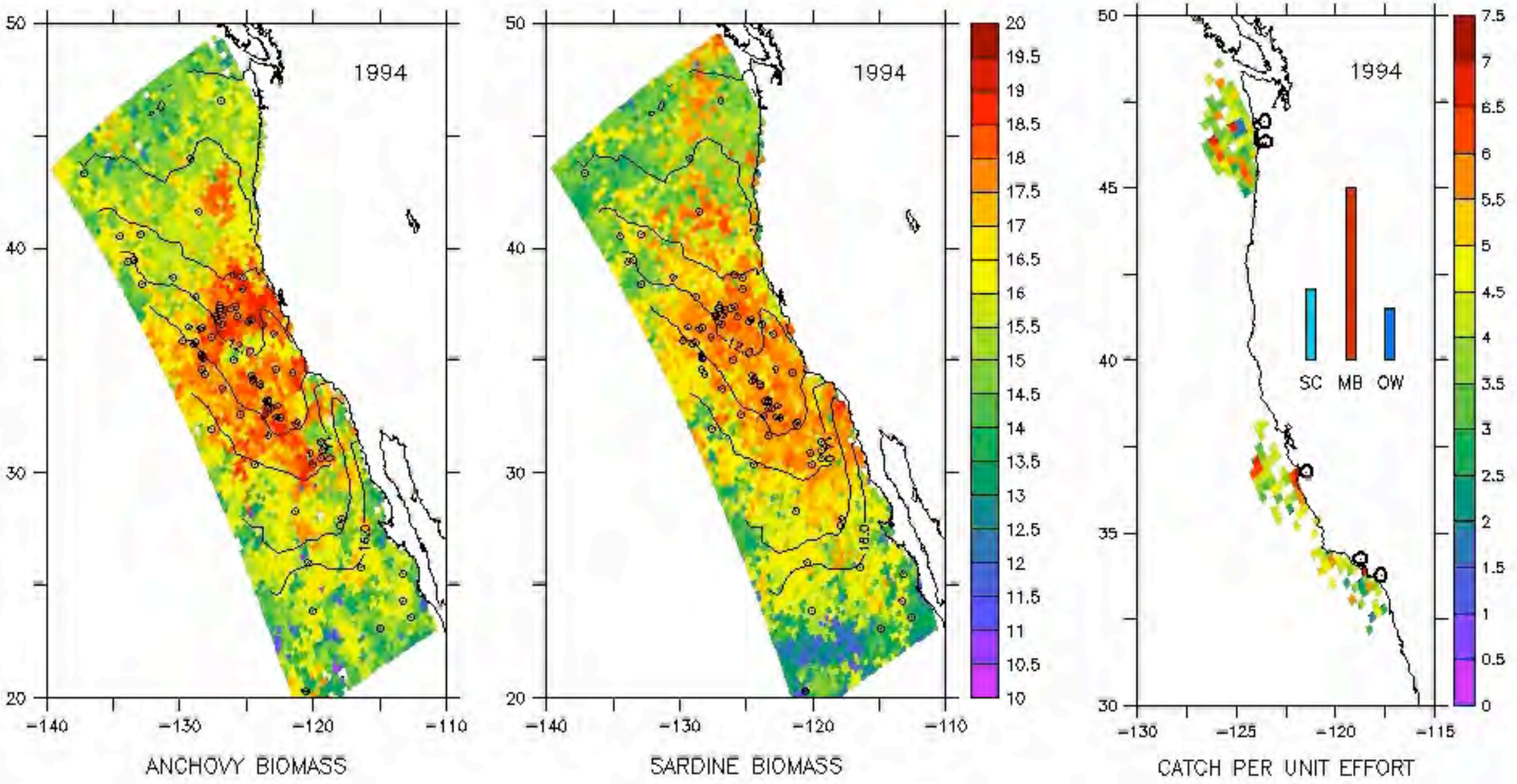
Multi-species fish model

- Simulate 5-6 species with an individual based approach.
- General food web: Species can compete for common prey and eat each other.
- One species can represent a fishing fleet as individuals.
- Explicitly model growth, mortality, reproduction and movement of target species.

Climate-to-fish-to-fishers

Movie director: *J. Fiechter*

Climate-to-fish-to-fishers



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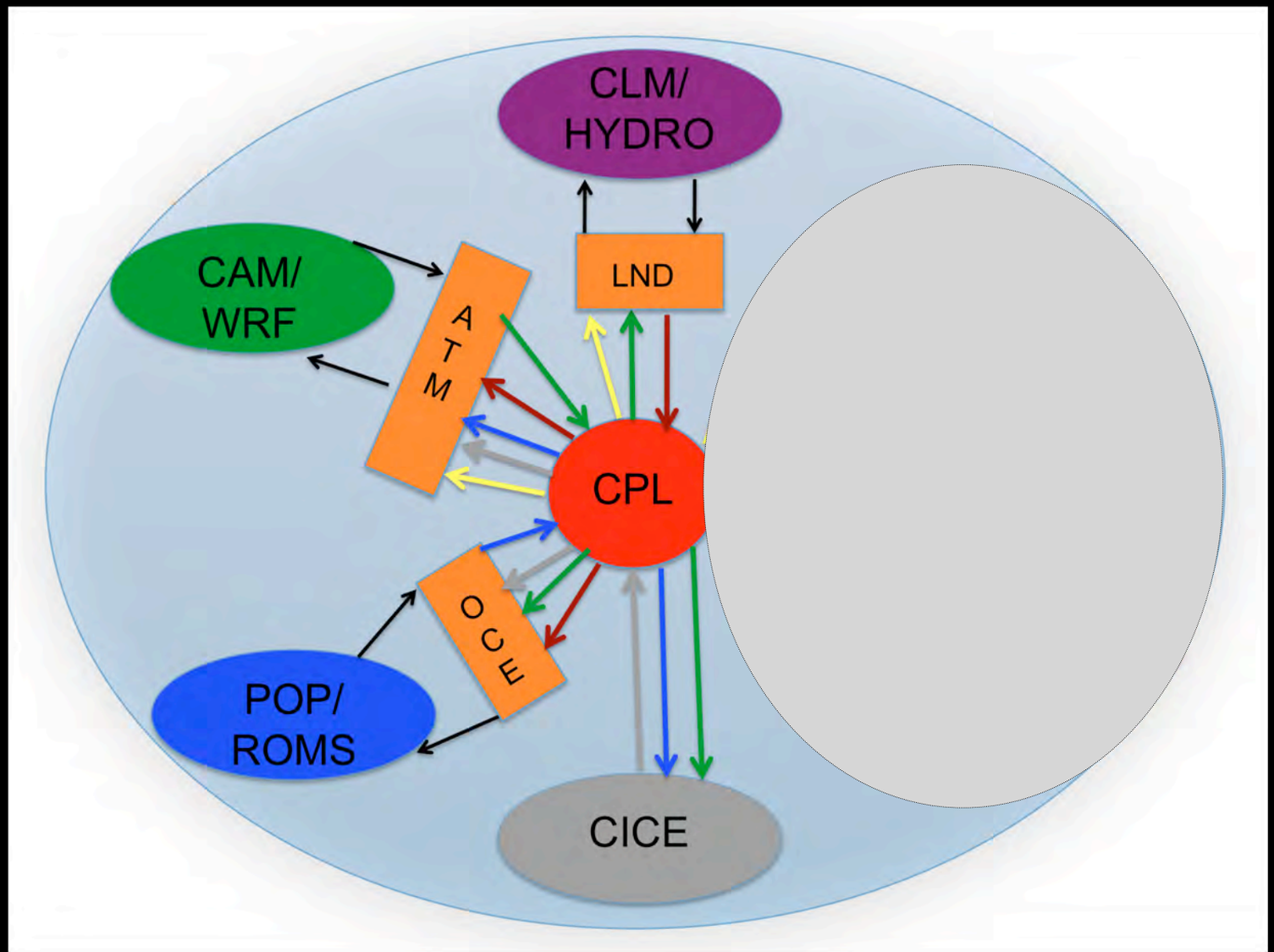
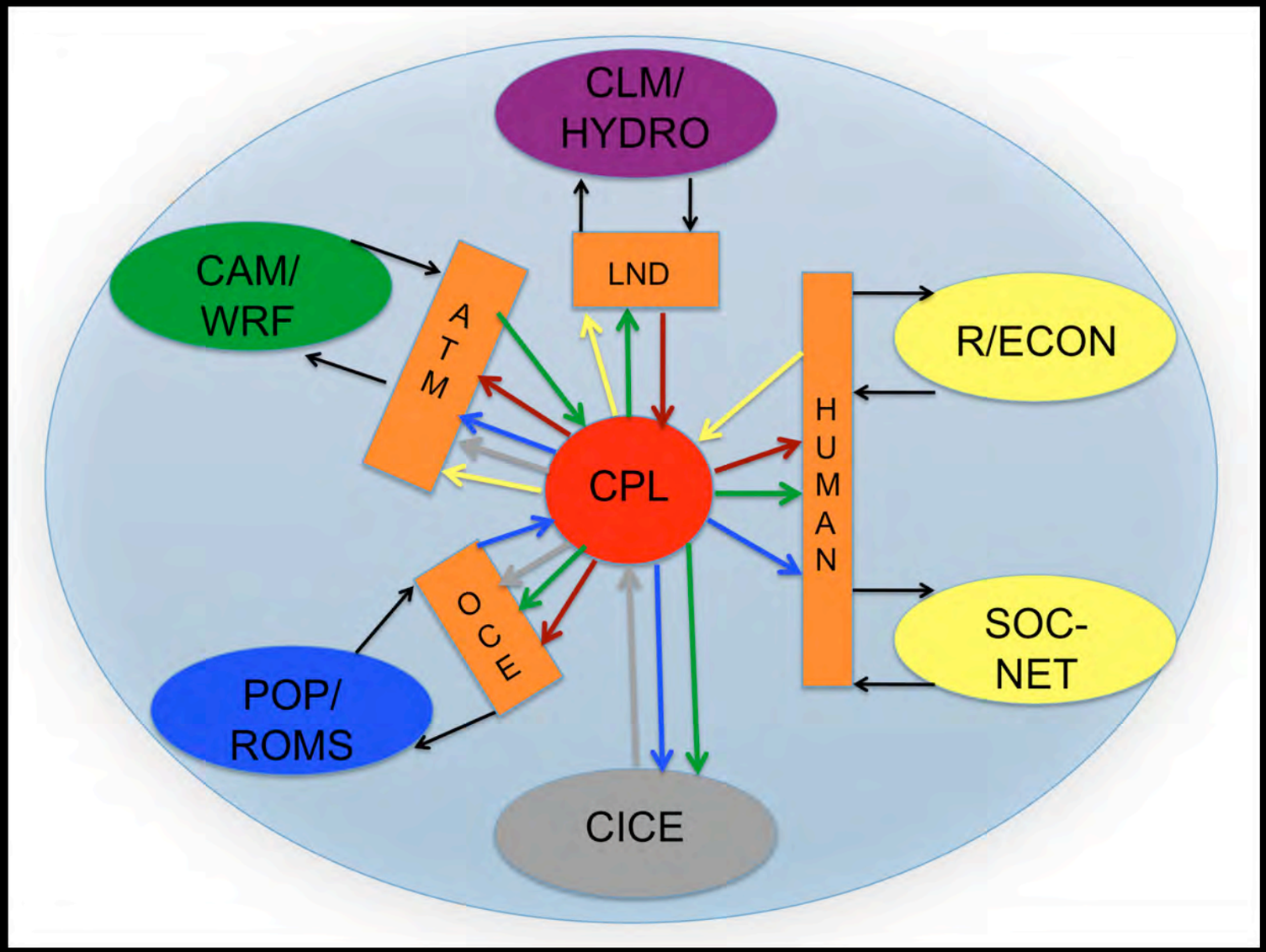
So, are we ready for Earth System Models?

We are getting there



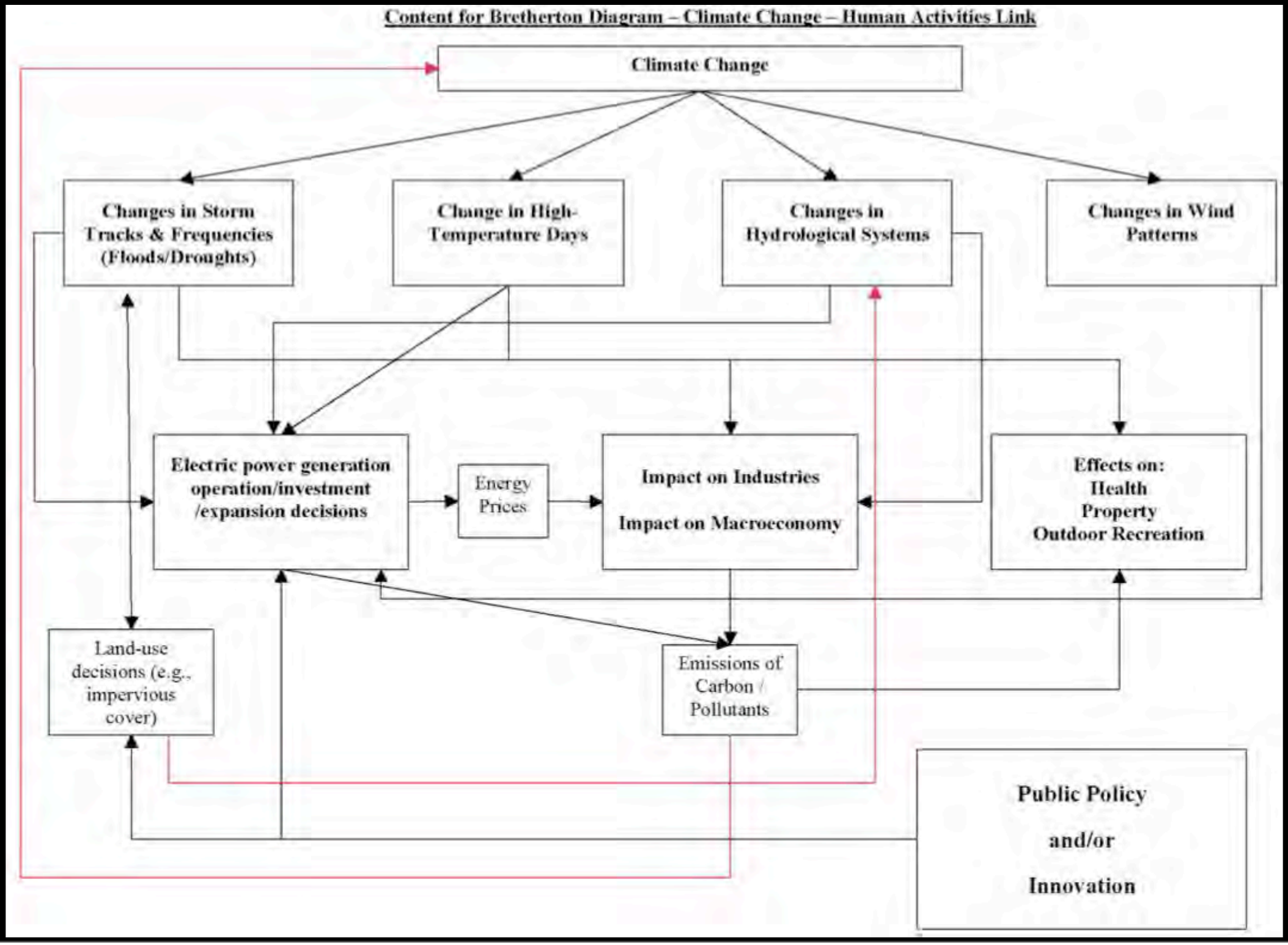
Schematic of NCAR-CCSM

We are getting there



Schematic of NCAR-CCSM

Linking climate and human activity



Discussion points

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- The coastal ocean responds to--and influences--the large-scale climate.
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  - Mid-latitude eastern boundary upwelling can influence tropical precipitation patterns, continental air temperatures, etc.
- End-to-end models are emerging for oceanographic applications.
- Can human activity be reduced to an emissions scenario?

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- Therefore....process, retrospective and comparative analyses need to remain significant activities.

- Links between the ecosystem and climate communities need to continue to expand.

Cheers, Bernie!