Local and remote climate effects of eastern boundary upwelling

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Main Collaborators

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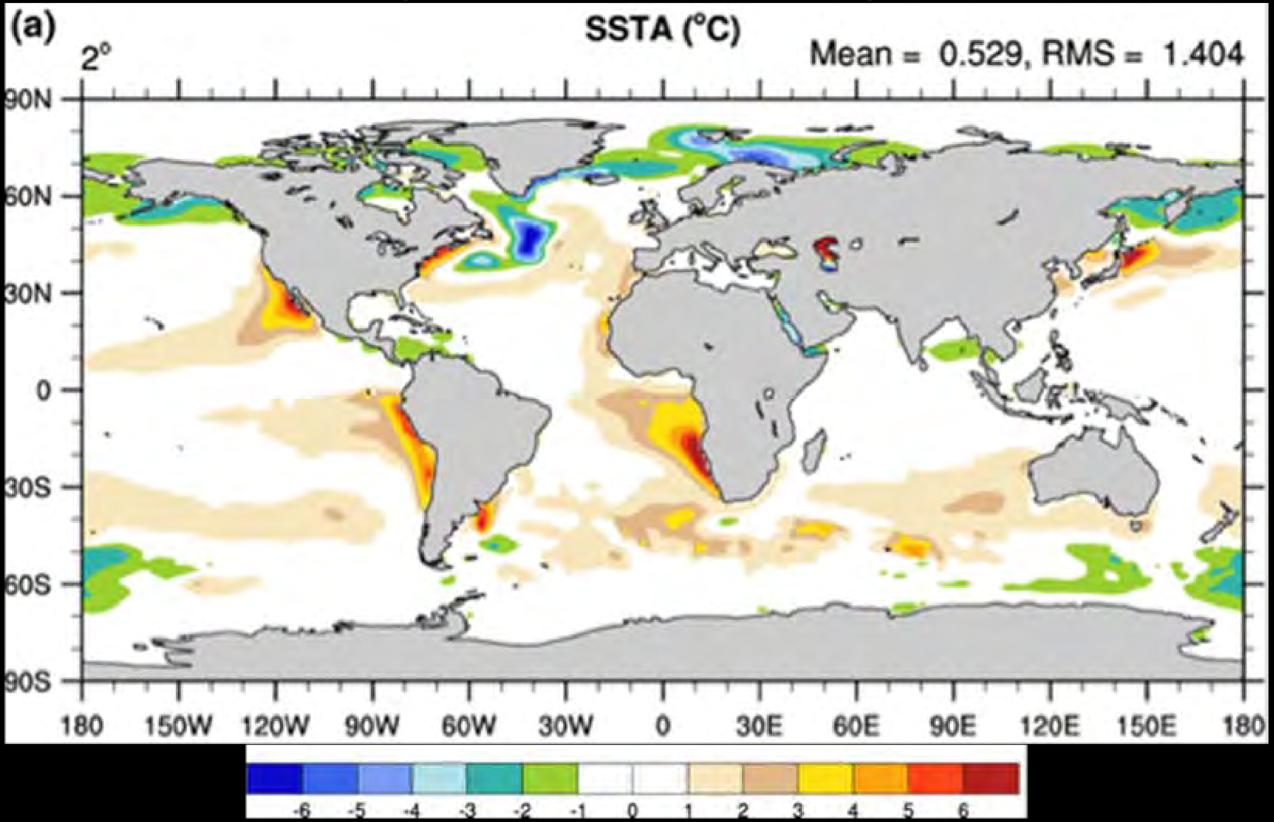
- Kate Hedstrom (ARSC/UAF)
- Brian Kaufman (NCAR)
- Bill Large (NCAR)
- Justin Small (NCAR)

Why do we want to “downscale”?

- Climate model biases
- Ecosystems
- Regional impacts

Climate model biases: Temperature

(CCSM 3.5 - WOA98)

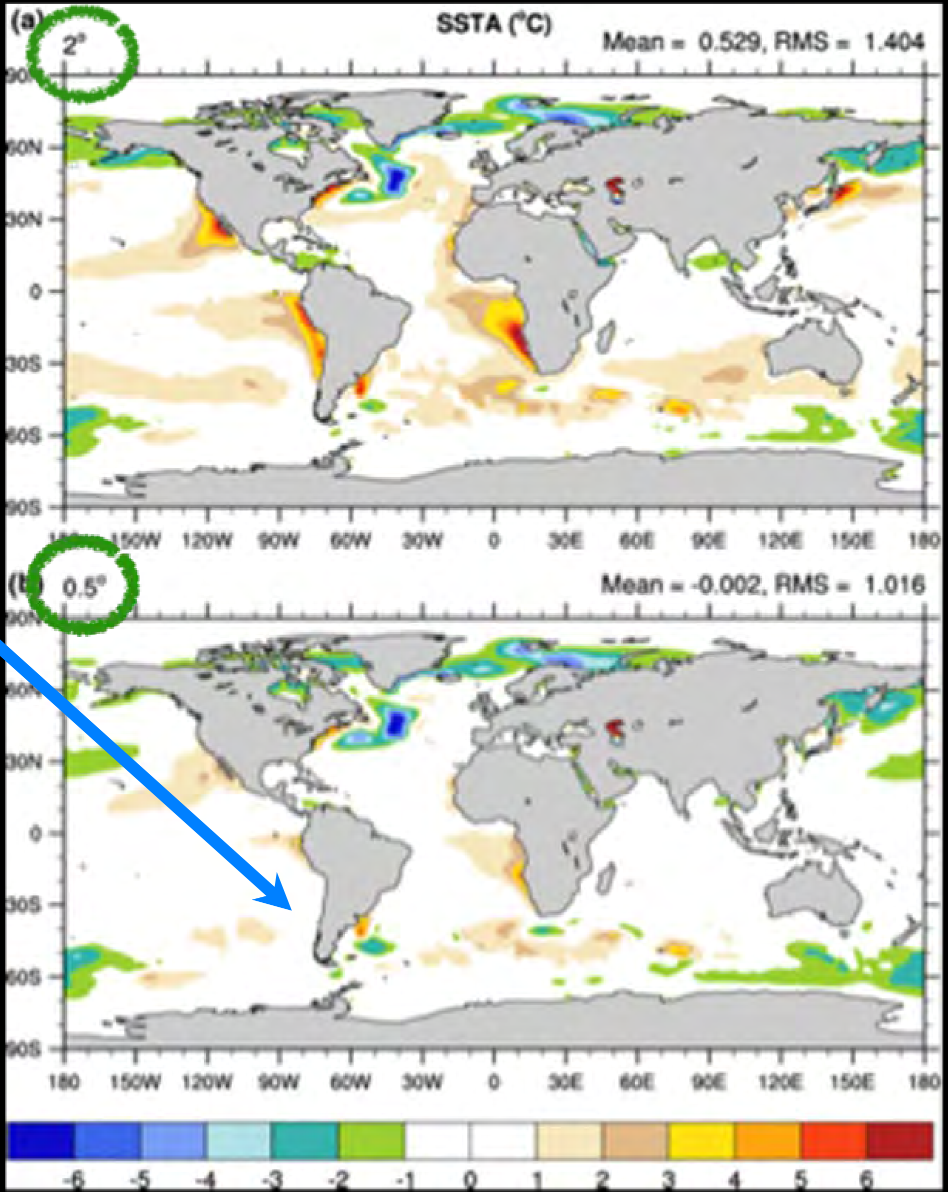


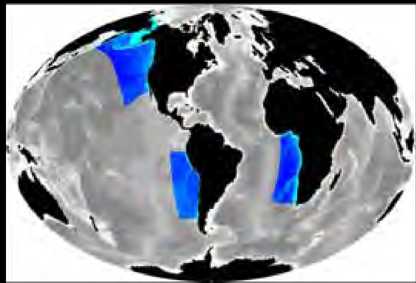
"Models still show significant errors ... The ultimate source of most is that many important small-scale processes are not represented explicitly in models ..."

Randal et al., 2007.

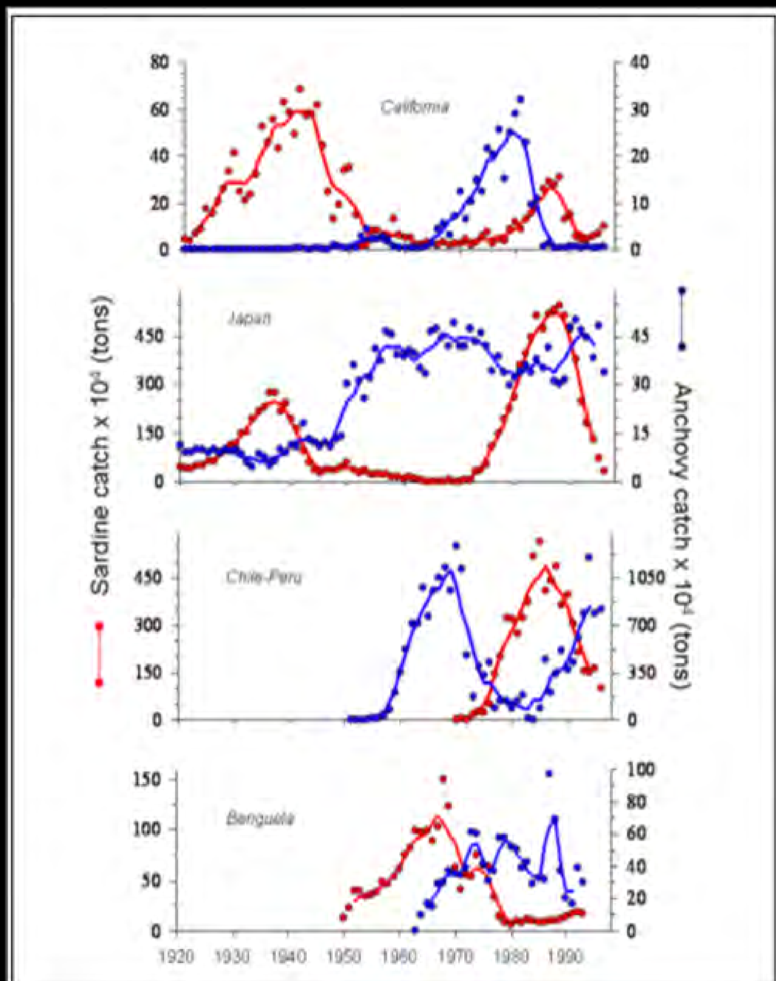
Approaches to address the problem

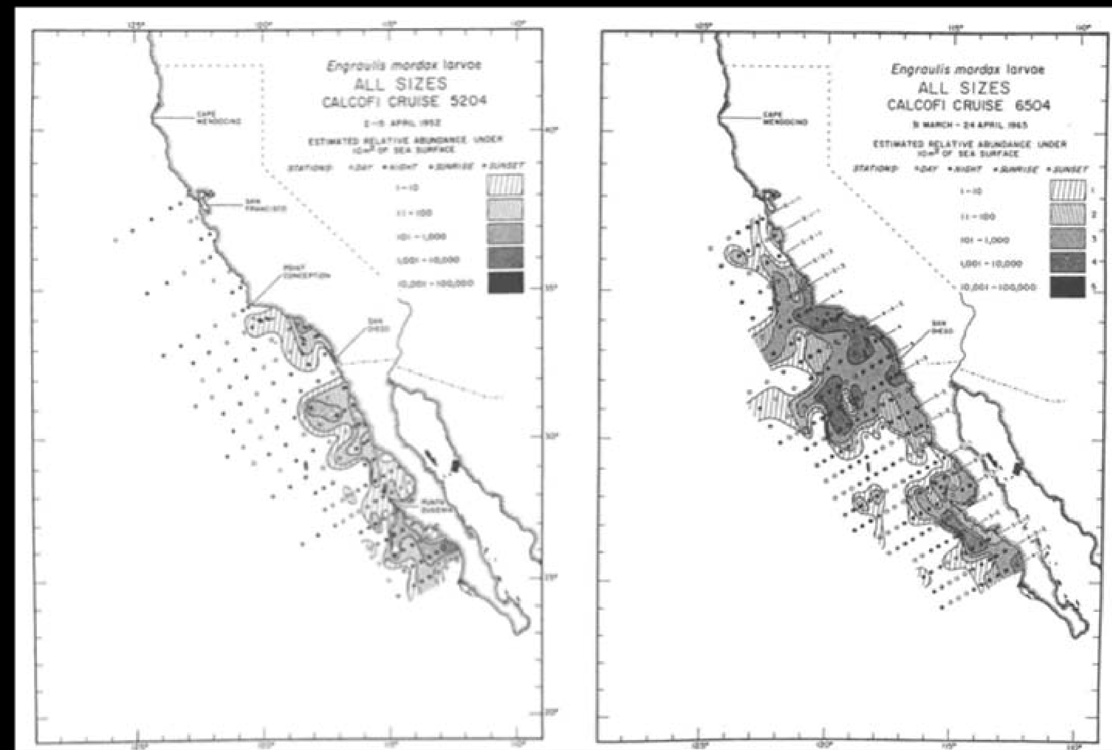
- Higher resolution in the atmosphere--better upwelling favorable winds (Gent et al., 2010)
- Improvements to boundary layer physics (Park and Bretherton, 2009)
- Improved resolution and physics in ocean--better upwelling





Ecosystems: Sardine and Anchovy Temporal and Spatial Variability

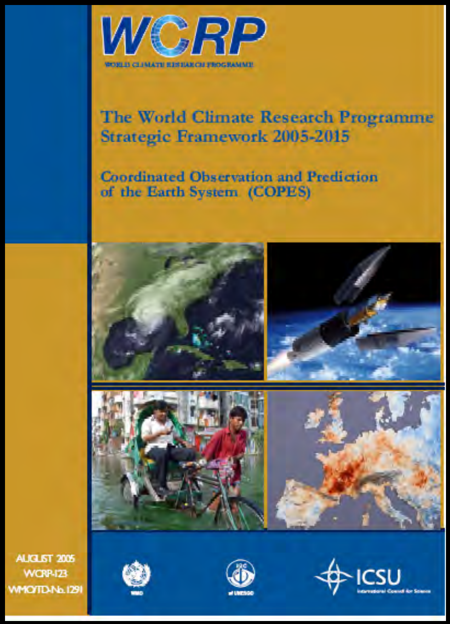




McCall, 1990

Time series of sardine (red) and anchovy (blue) landings since the 1920's. Data from Schwartzlose et al. (1999).

Regional impacts

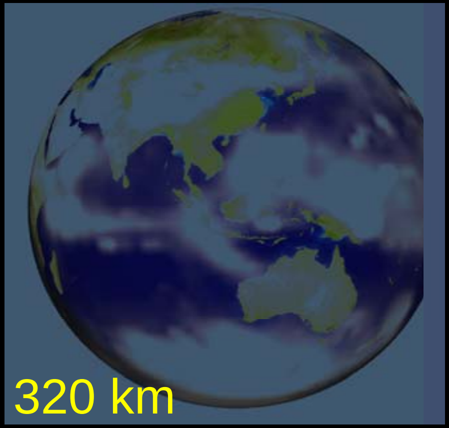


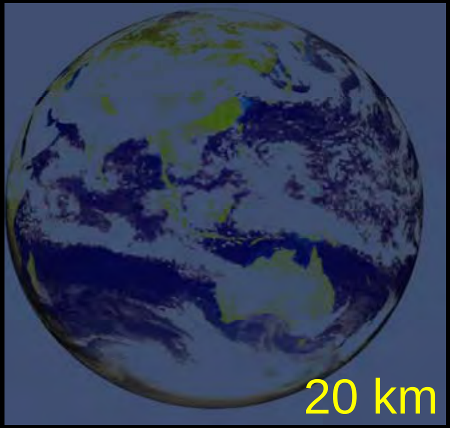
WCRP strategic framework

★Improved predictions of changes in statistics of regional climate, especially extreme events, are required to assess impacts and adaptation

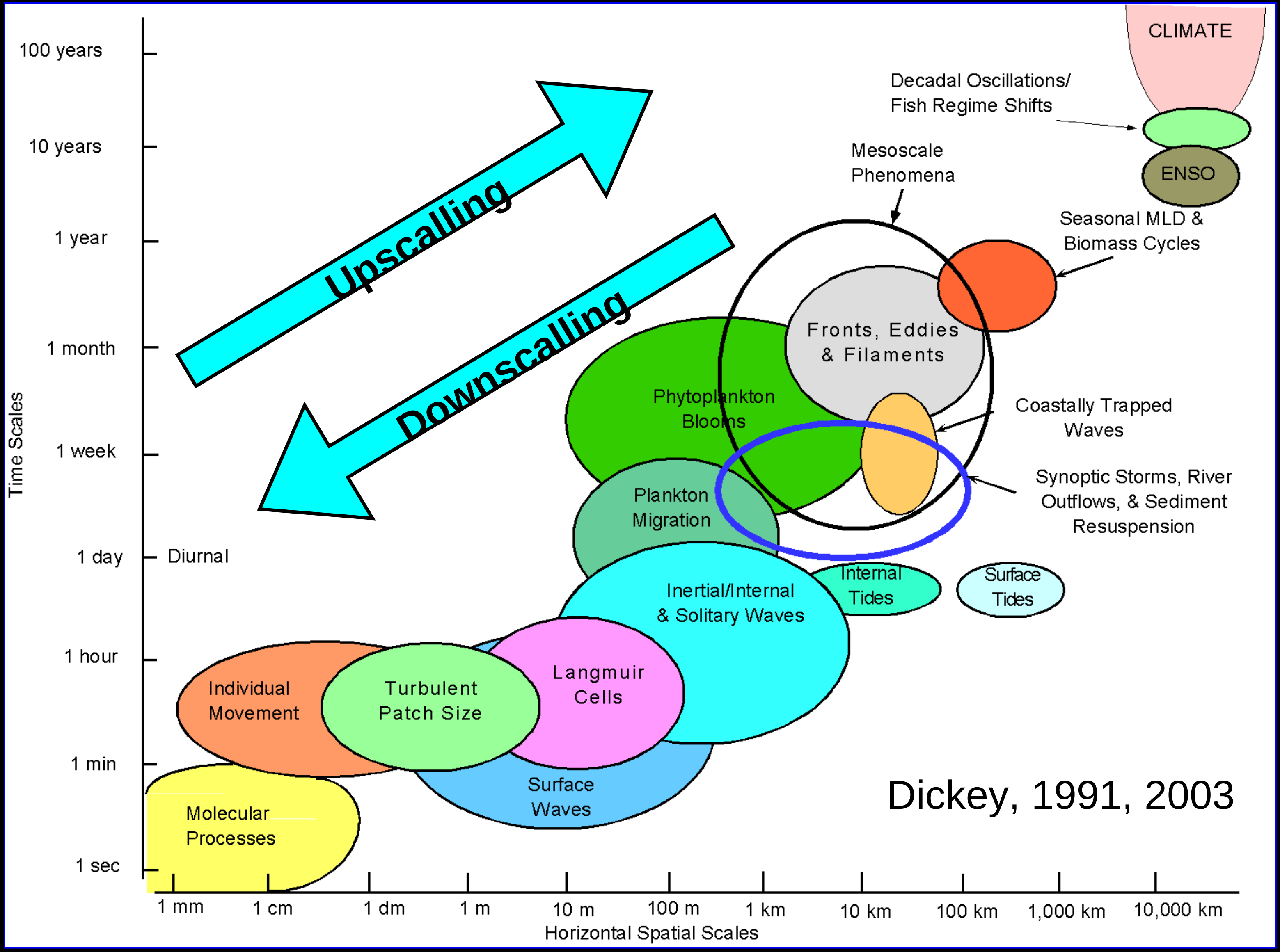
★Recognizes the need to improve representation of weather and climate link

•Working hypothesis is that the internal dynamics of the system are more accurately represented at higher resolution

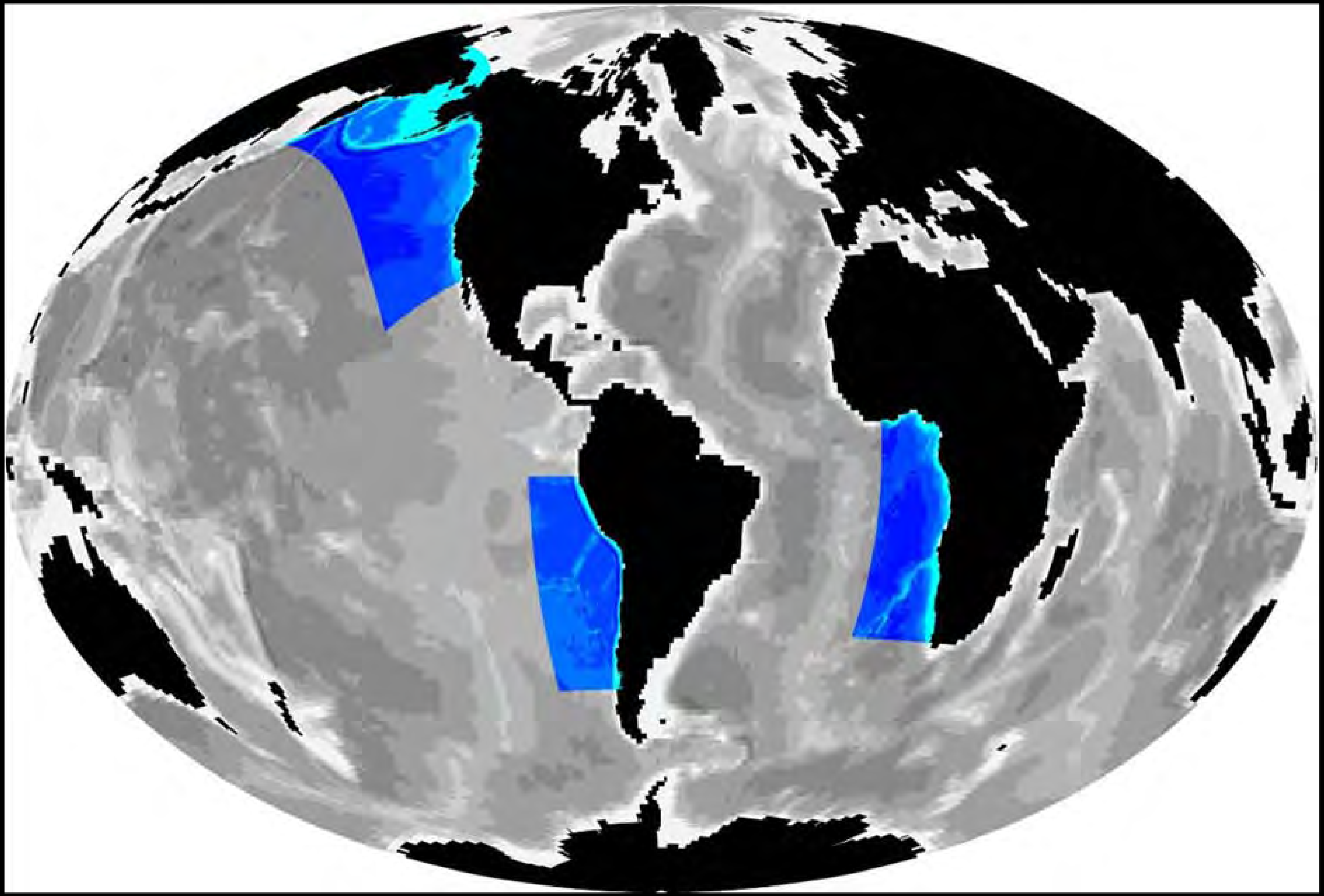




The multi-scale problem



CCSM-ROMS coupling

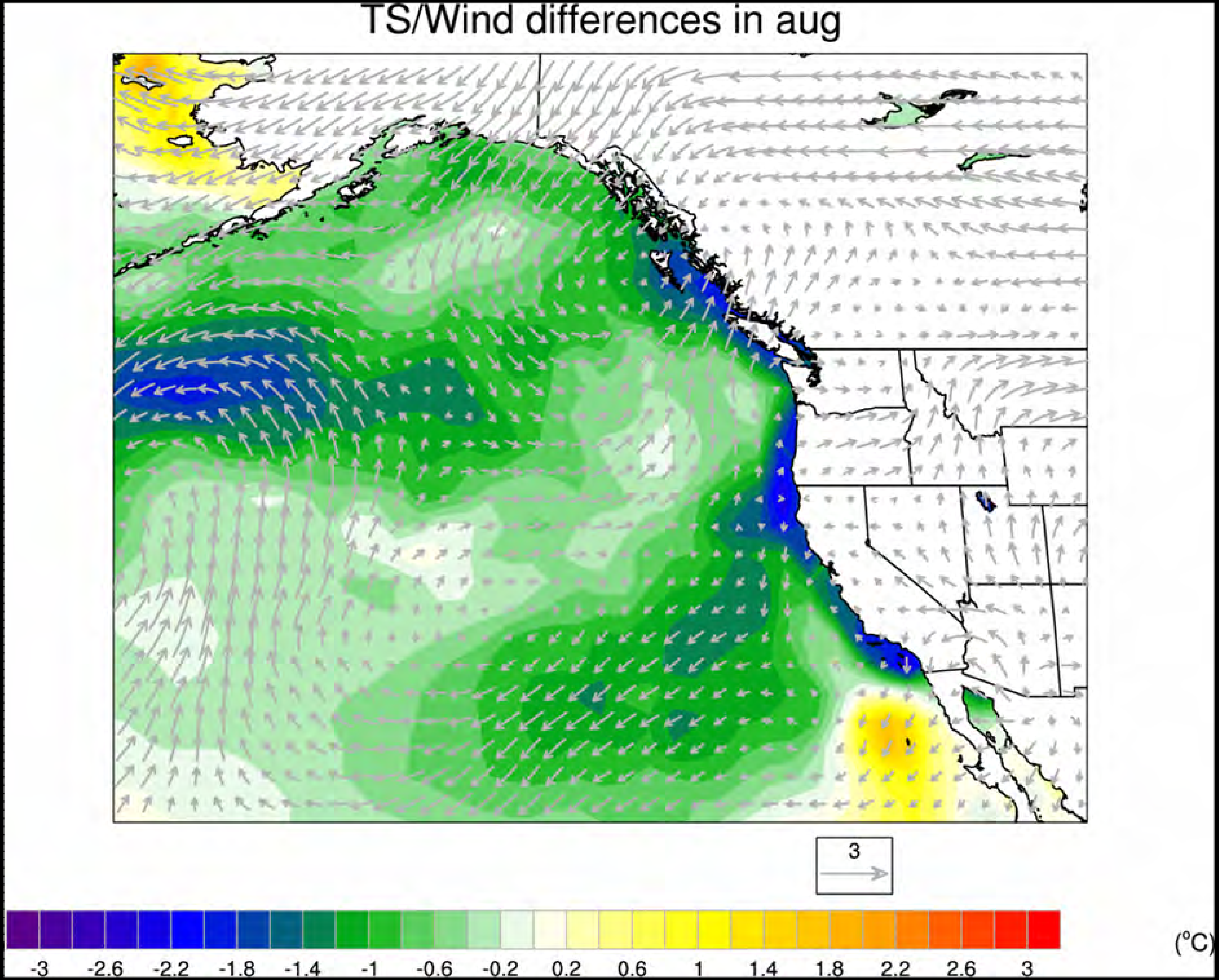


Numerical experiments

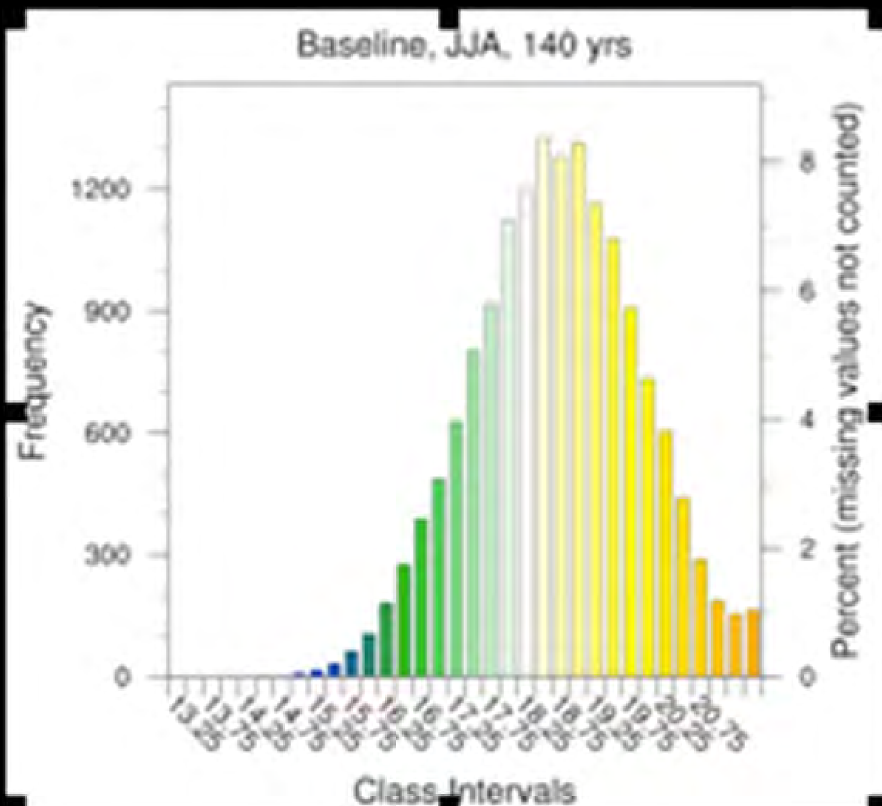
- **Baseline**: 150 year run of CCSM3.1, T85, g1v4, branched from 1870 control run.
- **Composite**: 150 year run of CCSM3.1-ROMS, same initial conditions.
- **Ocean:**
  - POP - ~1degree, 40 Z-levels
  - ROMS ~10km, 42 stretched sigma levels
- **Atmosphere:** CAM 3.3 – T85, 26 levels
- **Land:** CLM 3
- **Sea ice:** CSIM 5
- **Analysis:** 140 years of monthly means.
- **Statistics:** T-test for means, F-test for variability.

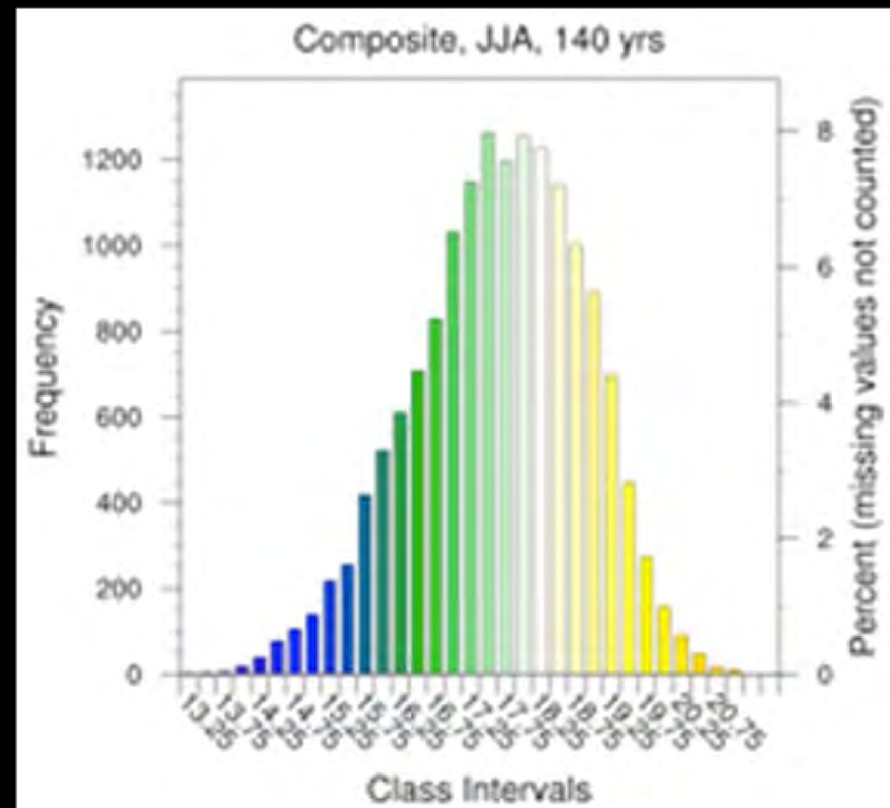
Local, regional and global responses

A look at the down-scaled region (Temperature and winds anomalies)

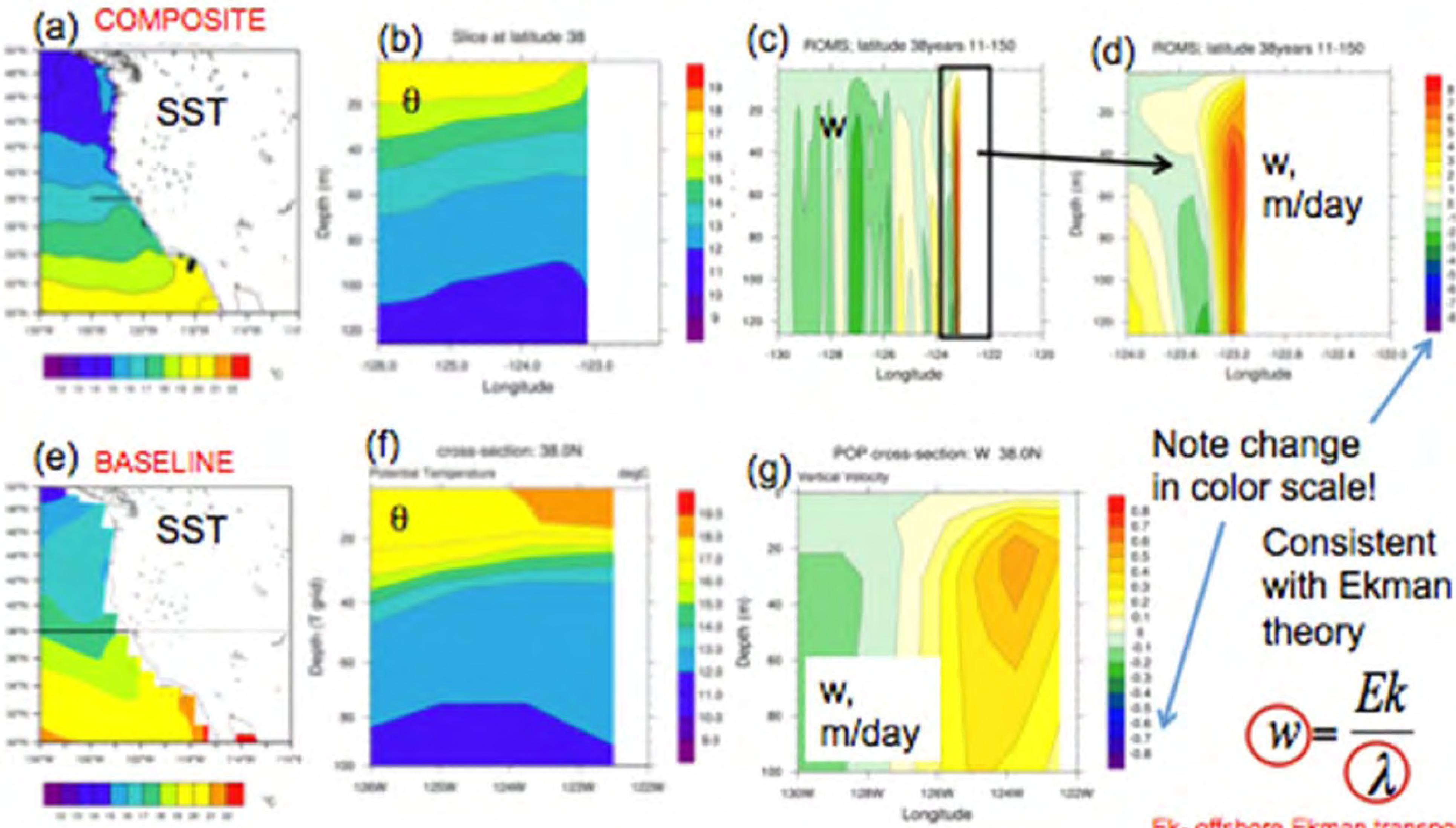


Temperature PDF’s





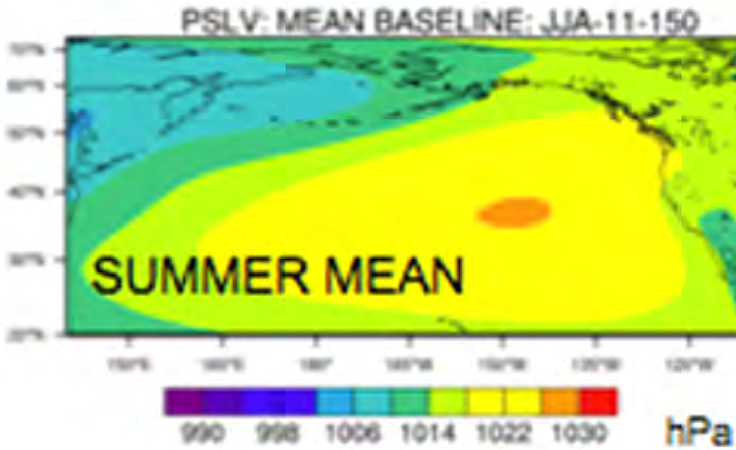
Upwelling

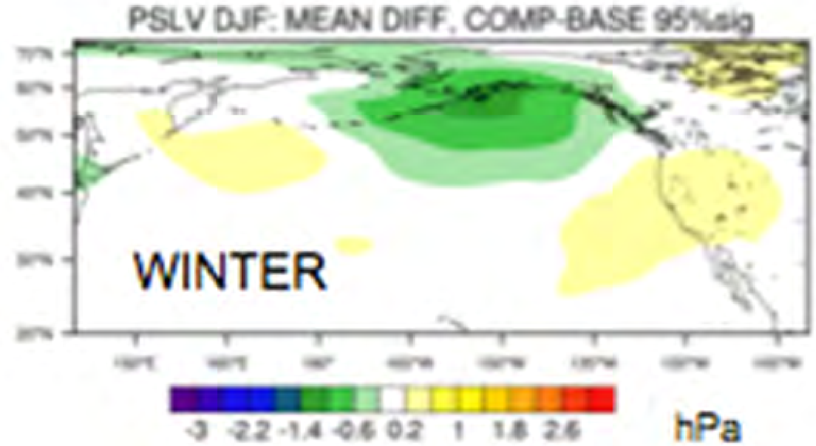


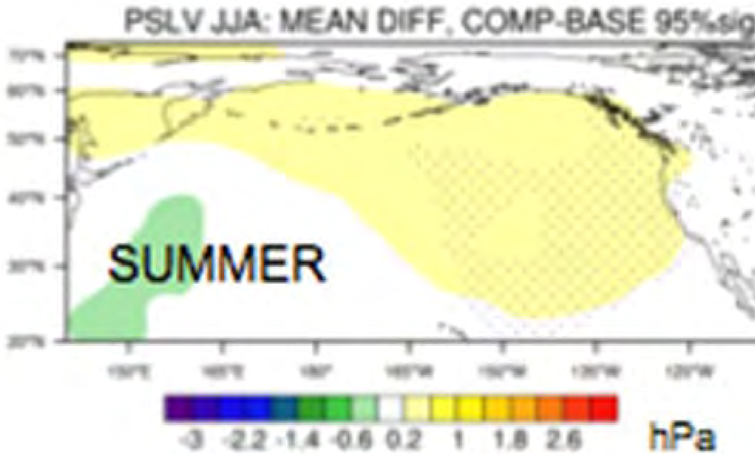
Ek- offshore Ekman transport
w – Ekman vertical velocity
λ- length scale

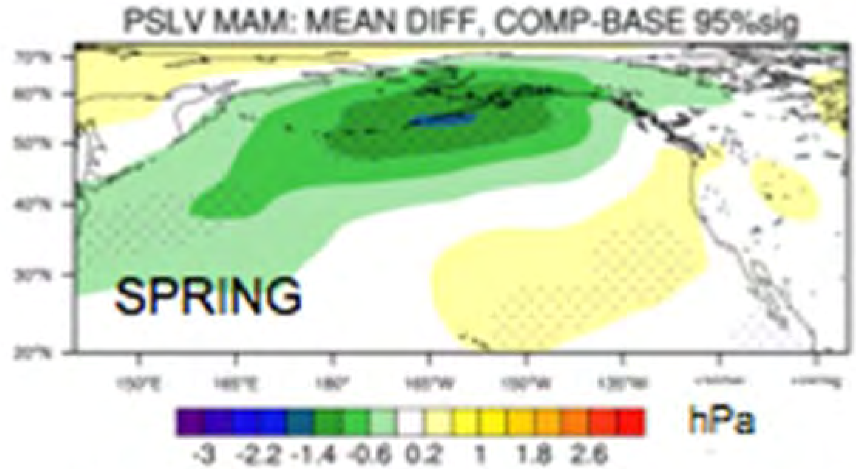
Temperature and vertical velocity sections from Top) ROMS component of composite model and Bottom) POP component of baseline run. a,e) Surface temperature map, mean JJA from 140 years; b, f) potential temperature vs depth along the line (38°N) ; c, d, g) vertical velocity (m/s) at 38 °N;

Sea level pressure and difference







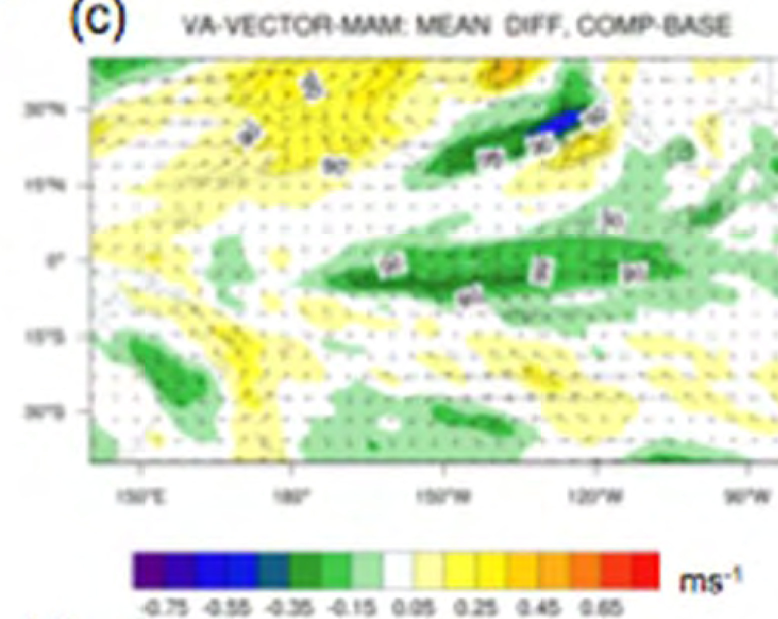


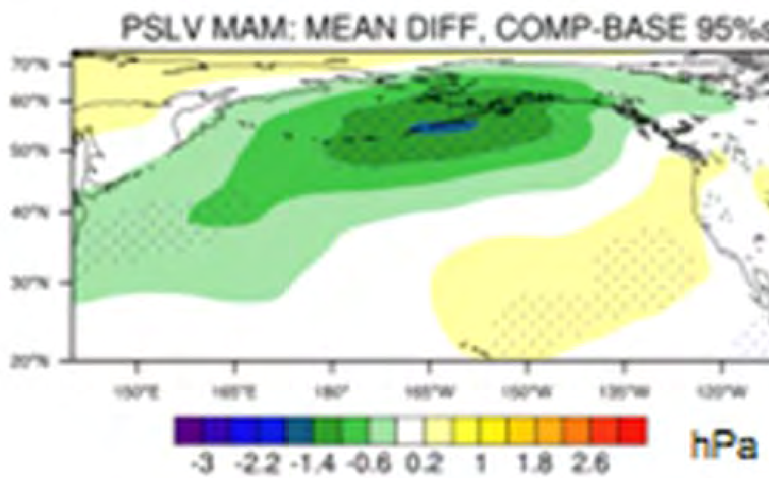
SUMMER –statistically significant enhancement of seasonal high

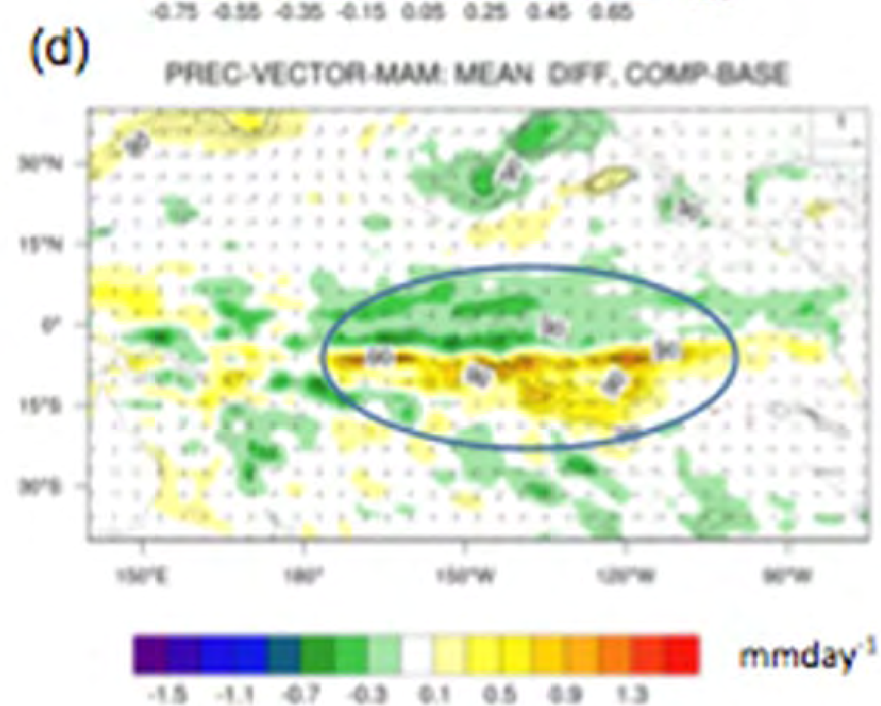
WINTER–low pressure enhanced in Gulf of Alaska, but not statistically significant **SPRING** – significant response

Boreal Spring

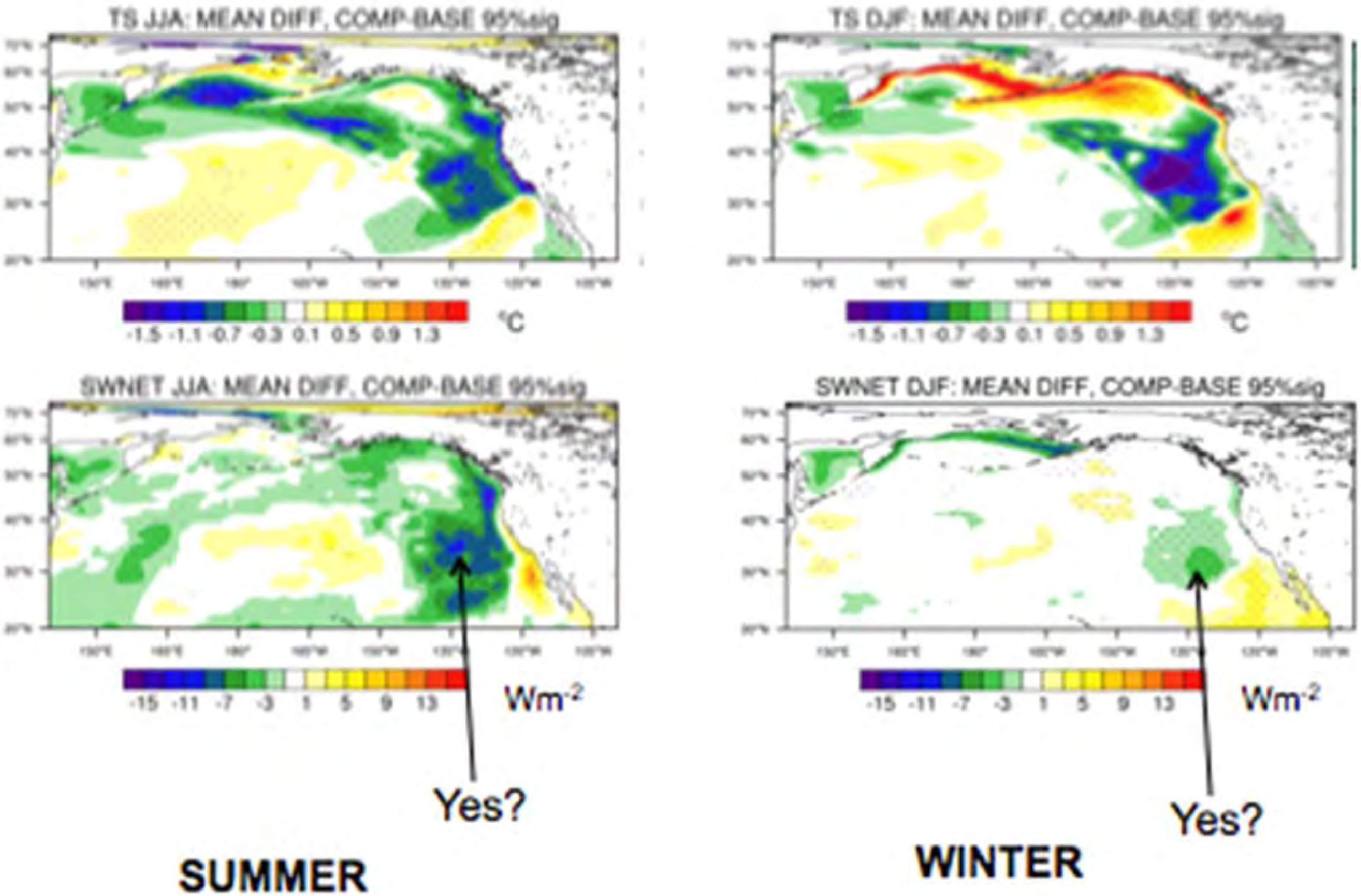
In Boreal Spring (MAM) there is a statistically significant North Pacific low response. Also, a southward shift of the ITCZ associated with anomalous southward winds away from high pressure regions.



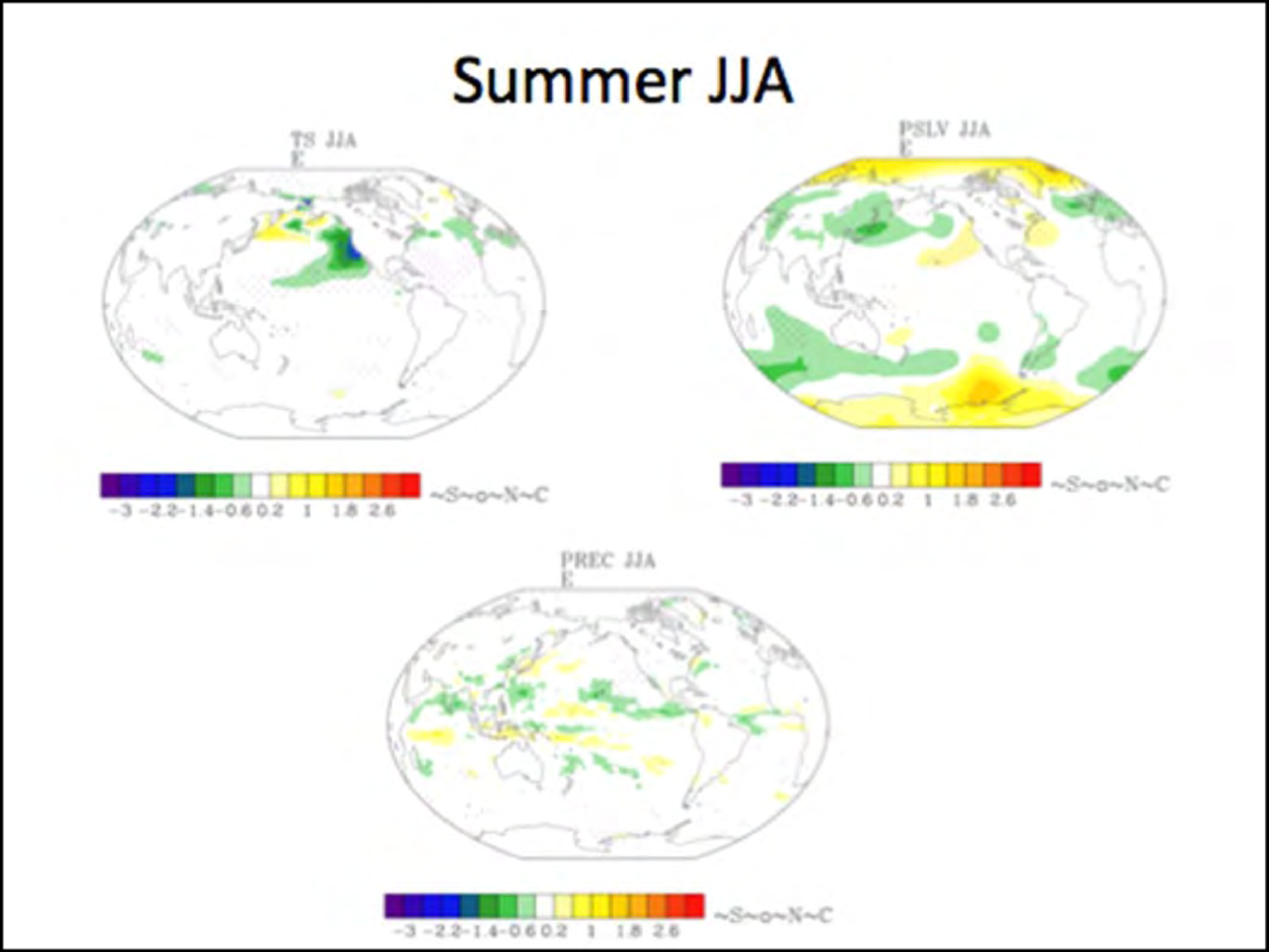




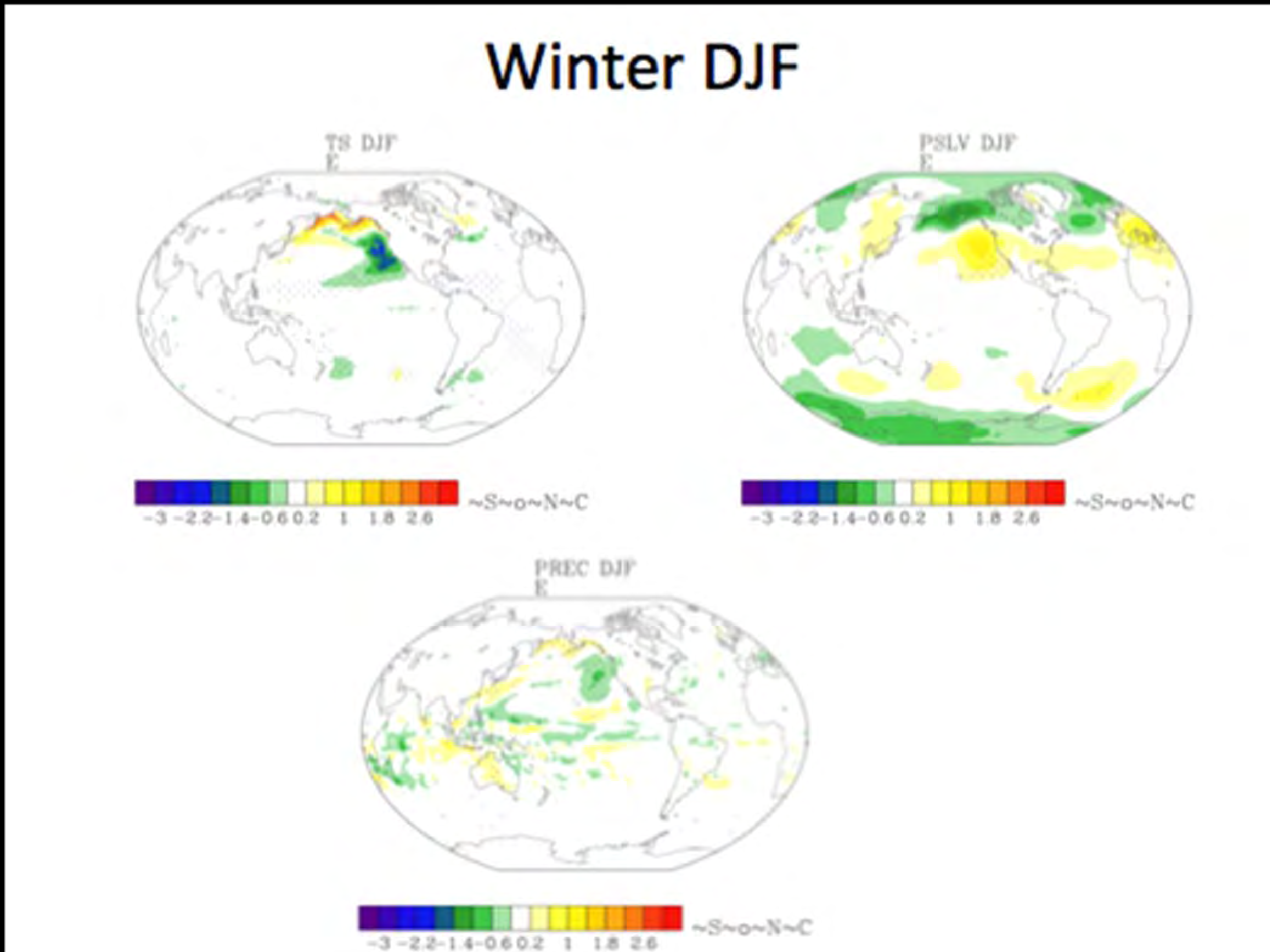
Net shortwave flux (any increase of stratus clouds when SST cools?)



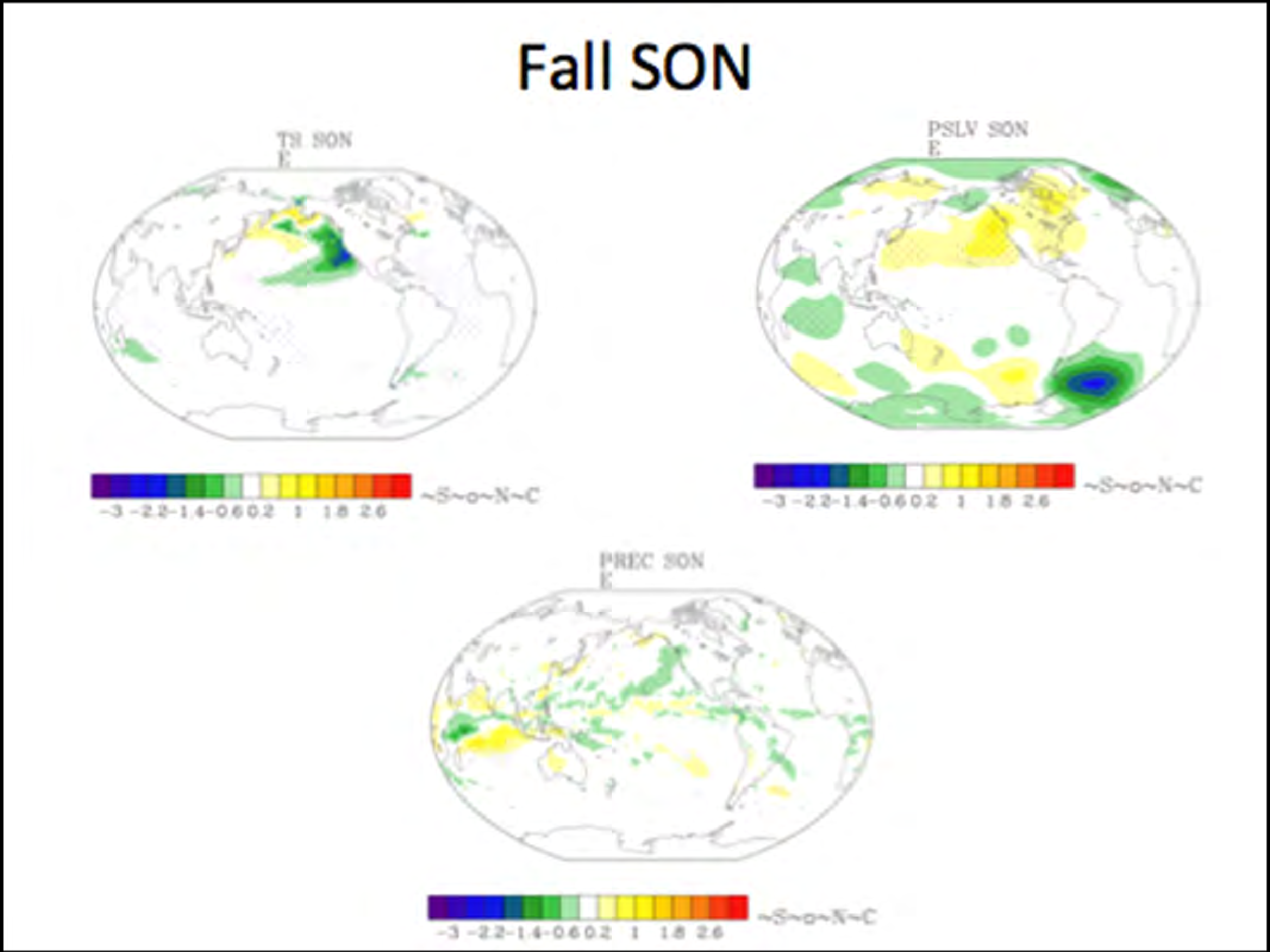
Summer (JJA): Temperature, Sea Level Pressure and Precipitation



Winter (DJF): Temperature, Sea Level Pressure and Precipitation



Fall (SON): Temperature, Sea Level Pressure and Precipitation



Summarizing

- We have developed a new approach to regional down/up-scaling of climate models that maintains the important feedbacks in the system.

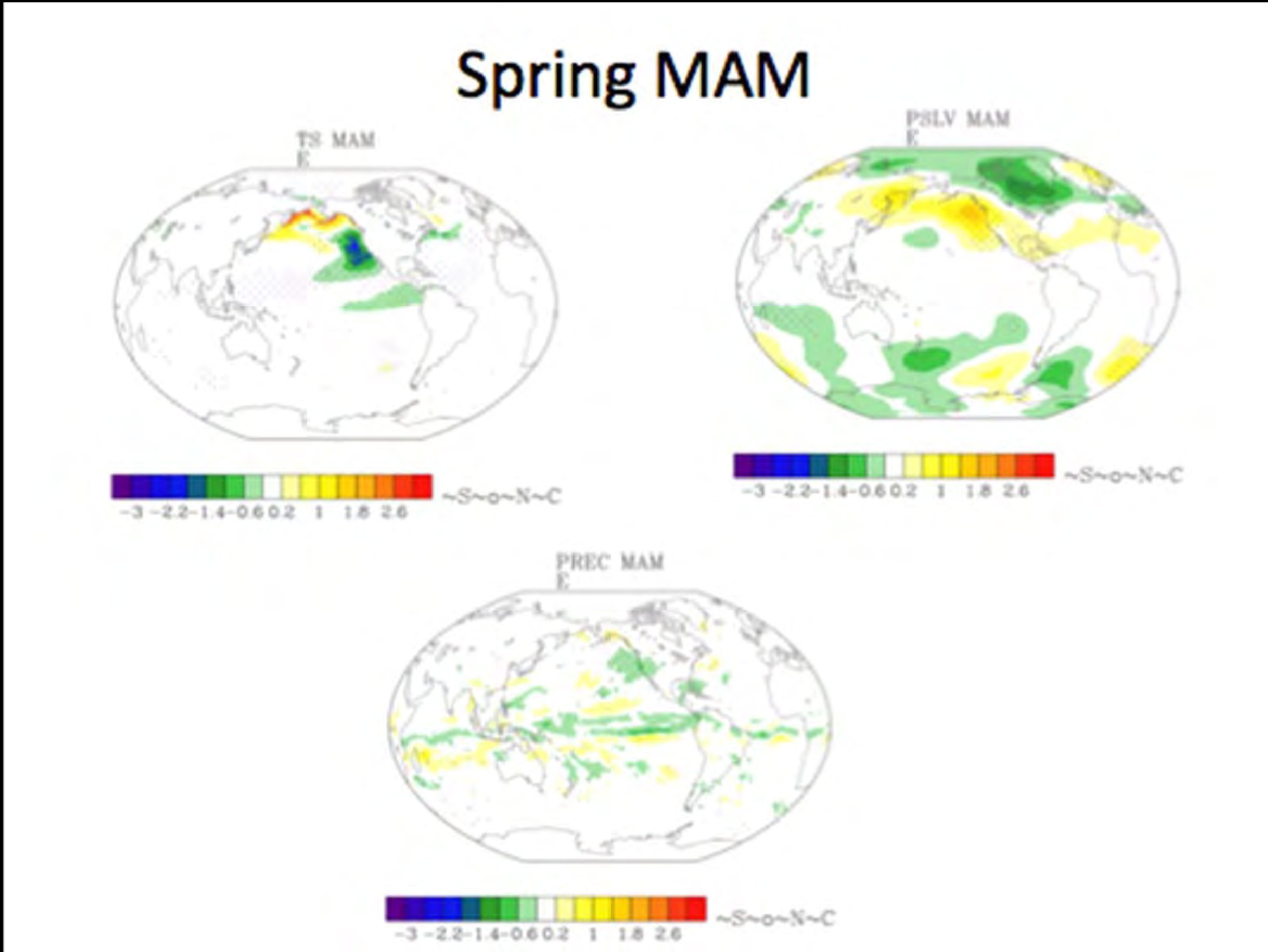
- Some regions of the ocean, e.g., the upwelling CCS, can have a significant global footprint.

- The new resolved physical scales are closer to what is needed for biology.

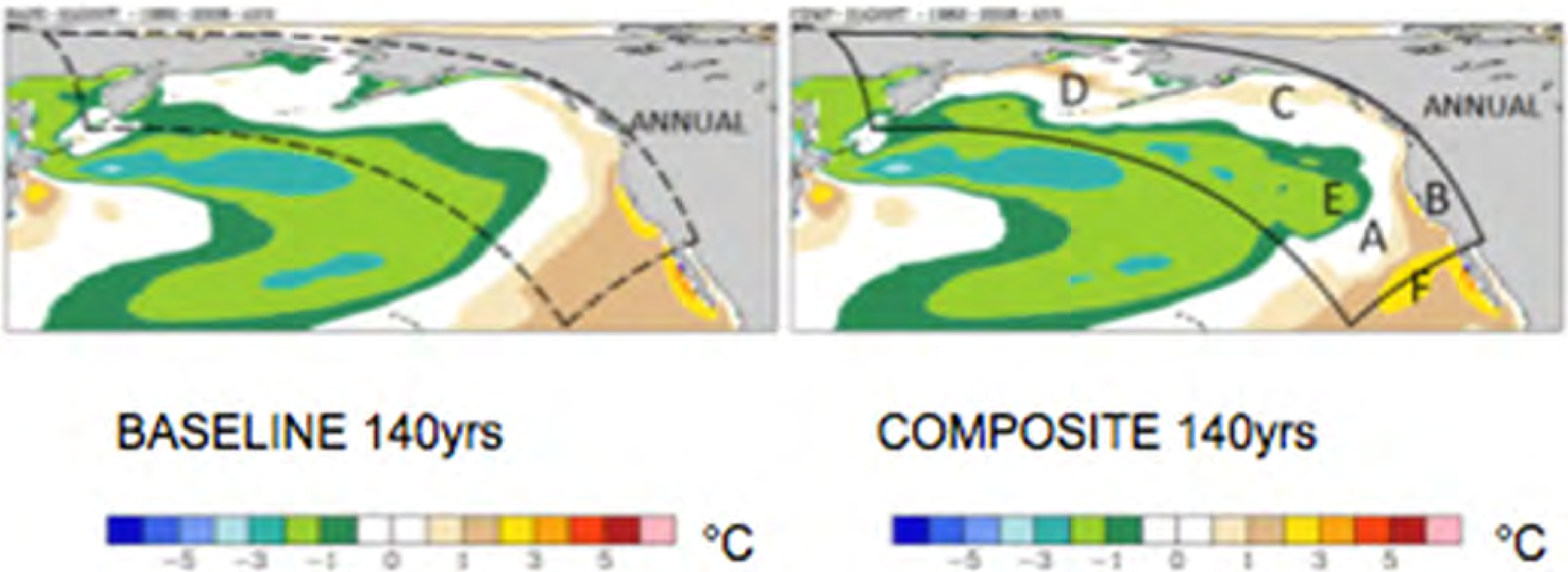
- The multi-scale problem exists in biology as well, and needs to be addressed.

Additional slides

Spring (MAM): Temperature, Sea Level Pressure and Precipitation

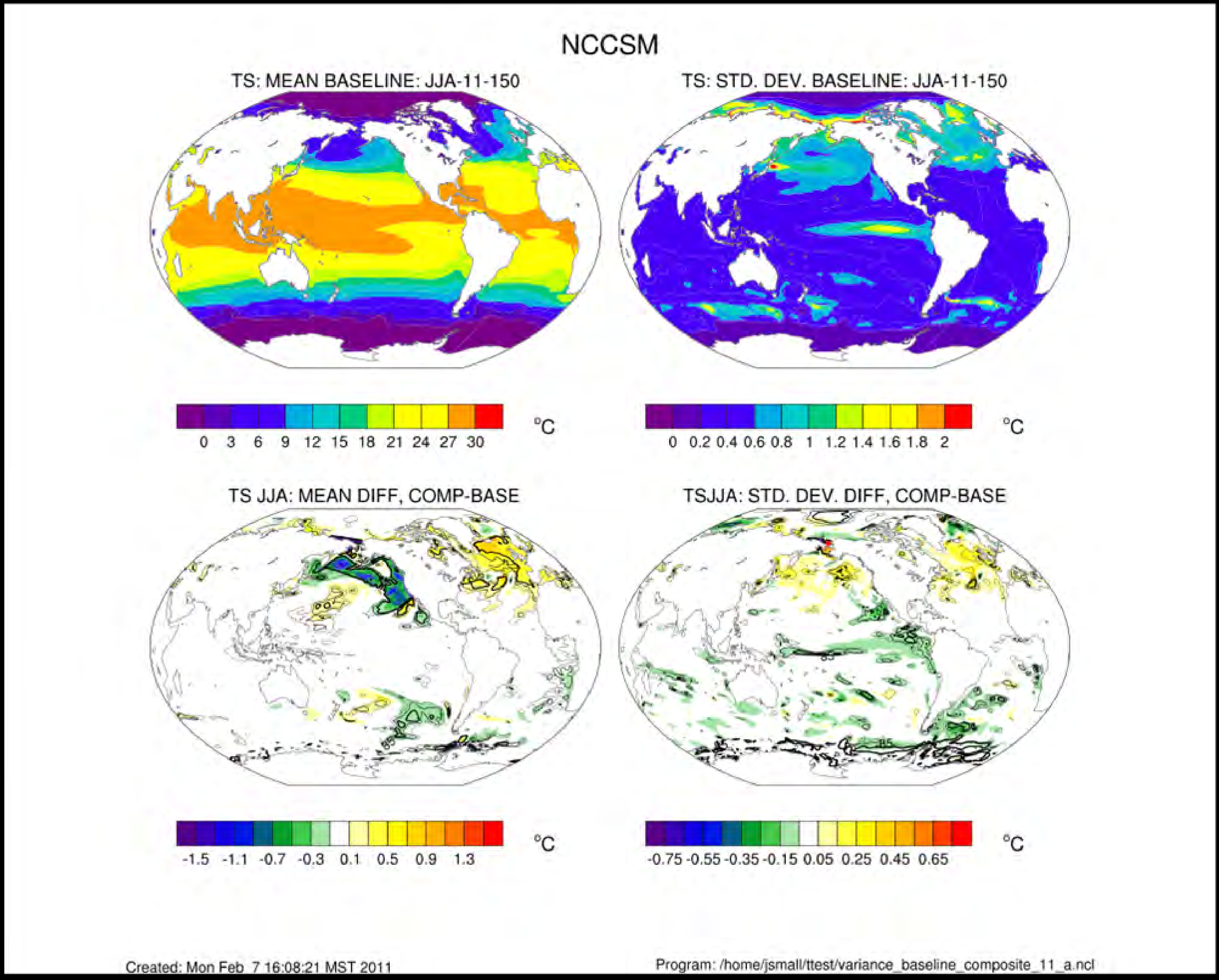


Annual Mean SST Bias
relative to HadSST 1982-2008

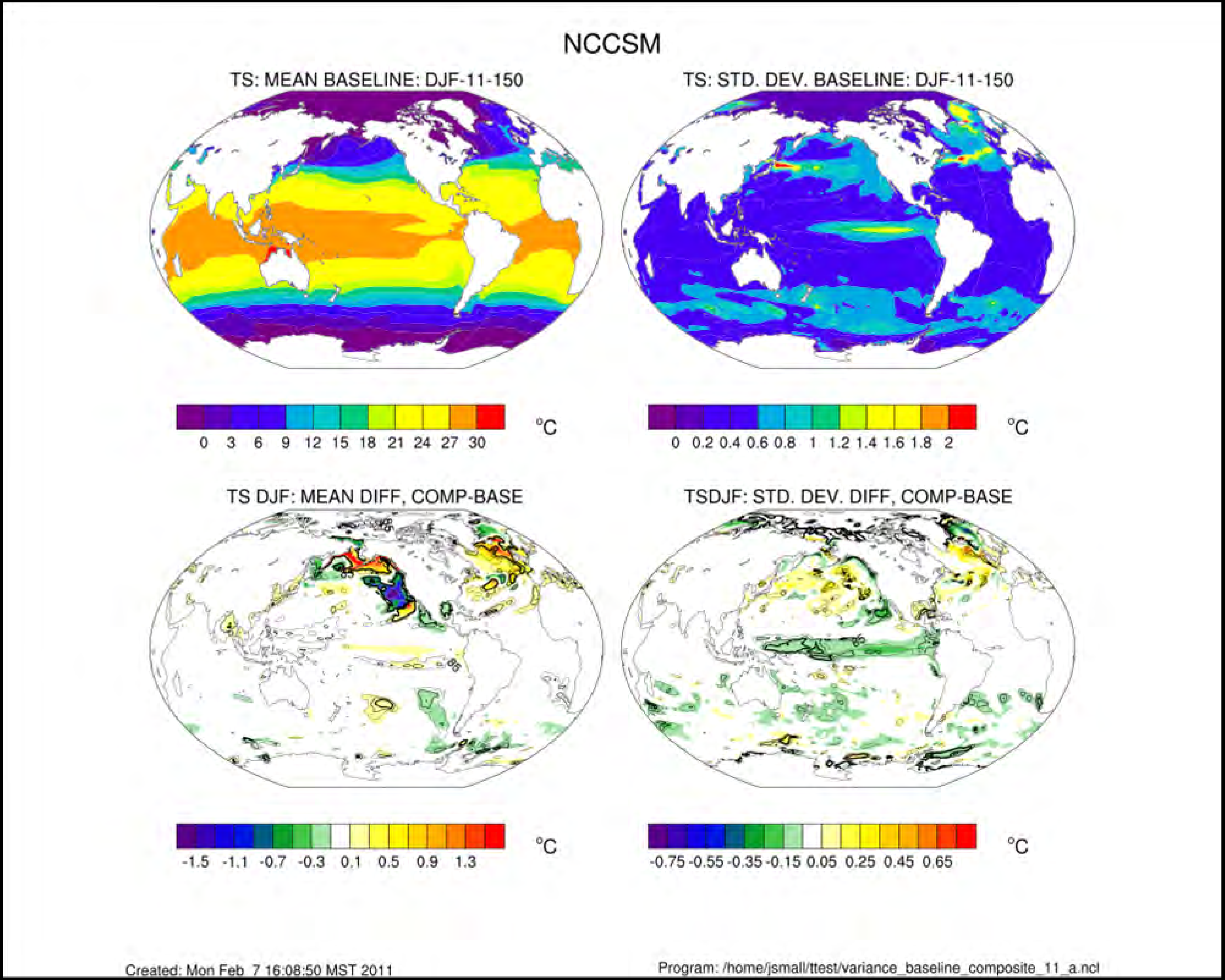


But Levitus & HadSST not ideal for coastal zone (resolution).

Sea surface temperature: JJA



Sea surface temperature: DJF



Surface air temperature: JJA