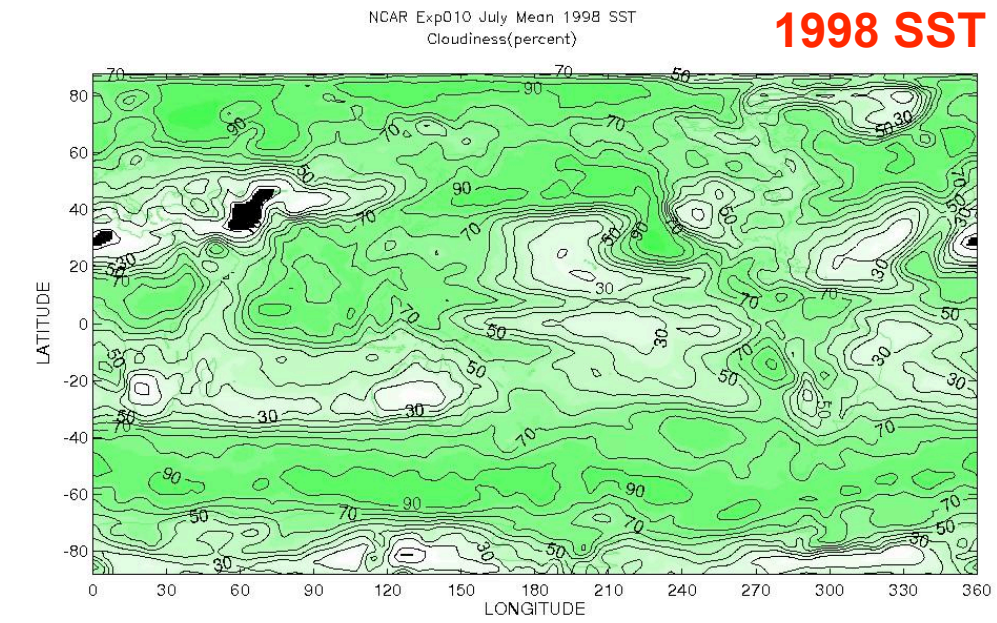
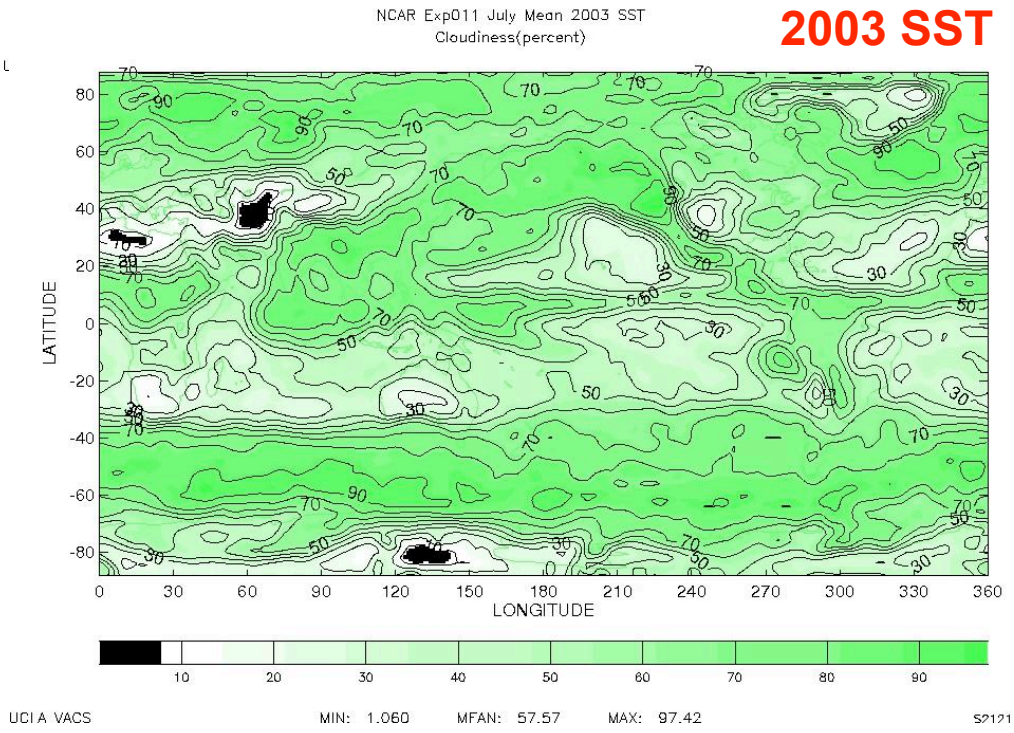


1998 SST

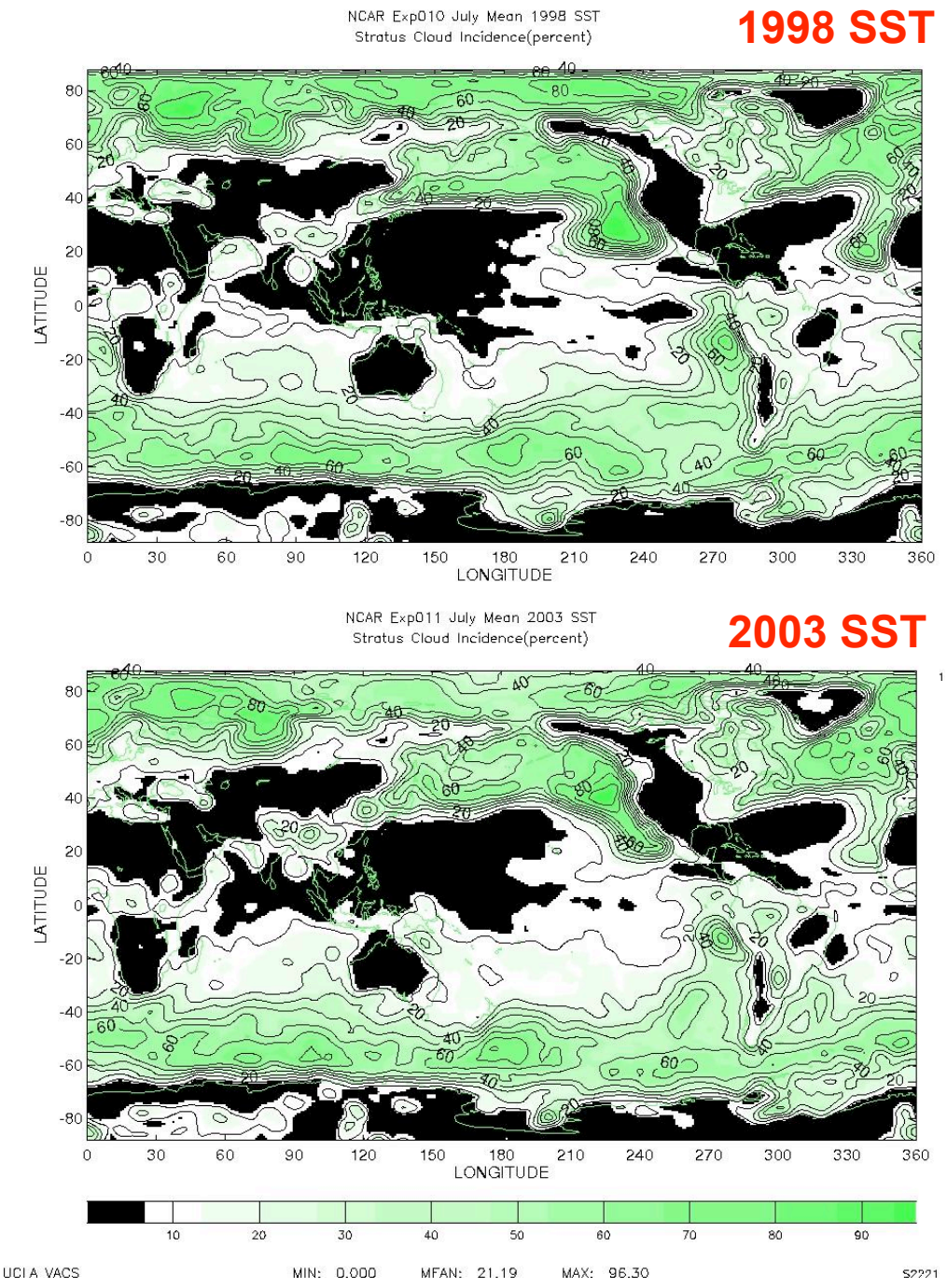


2003 SST

Cloudiness

July Mean

Simulations show more clouds in 1998.



Stratus Incidence

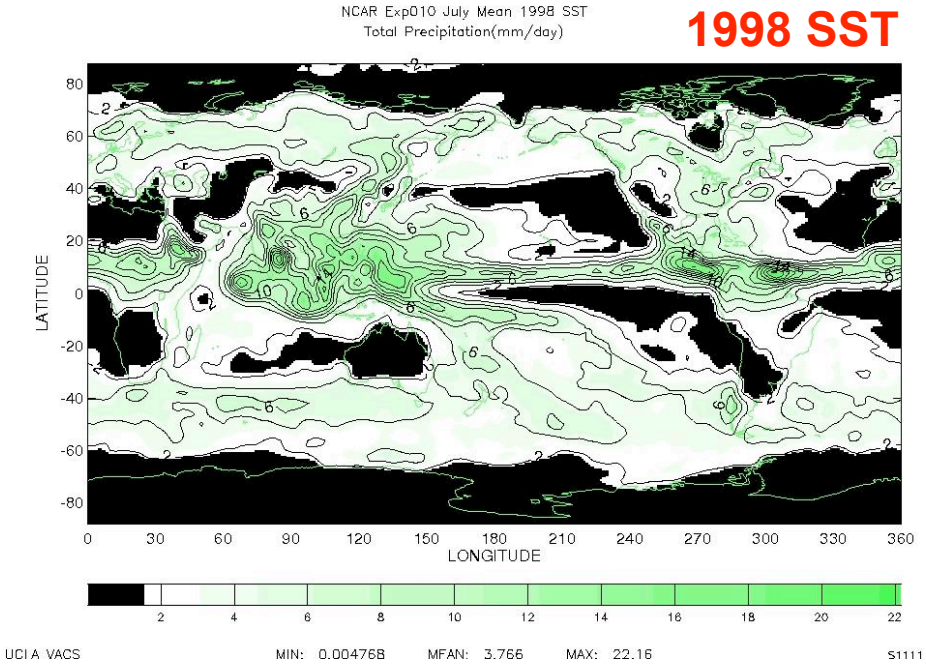
July mean

Simulations show more California and Peruvian stratus in 1998

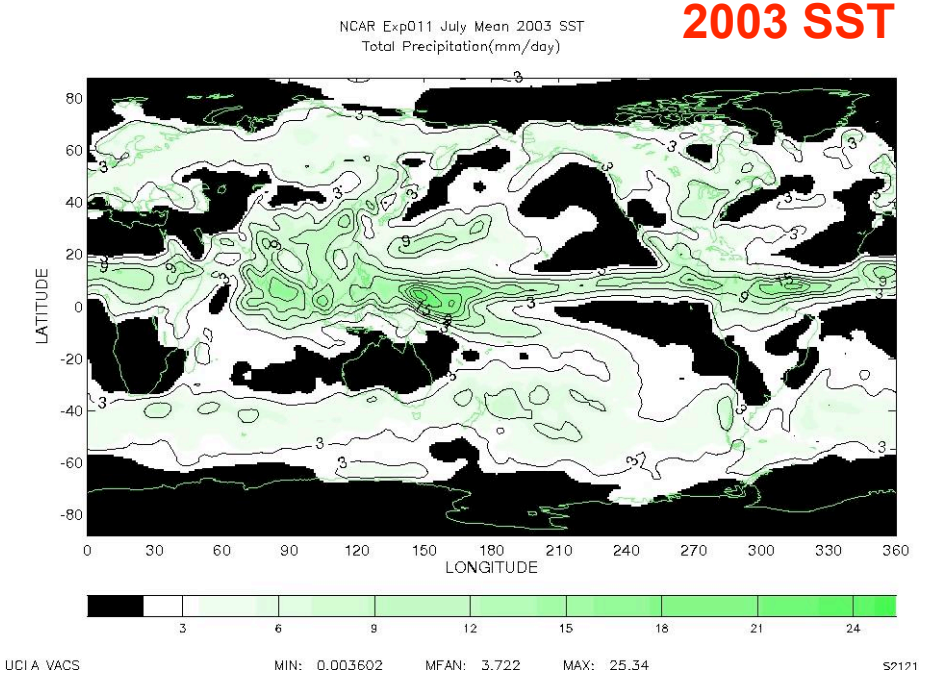
Precipitation

July Mean

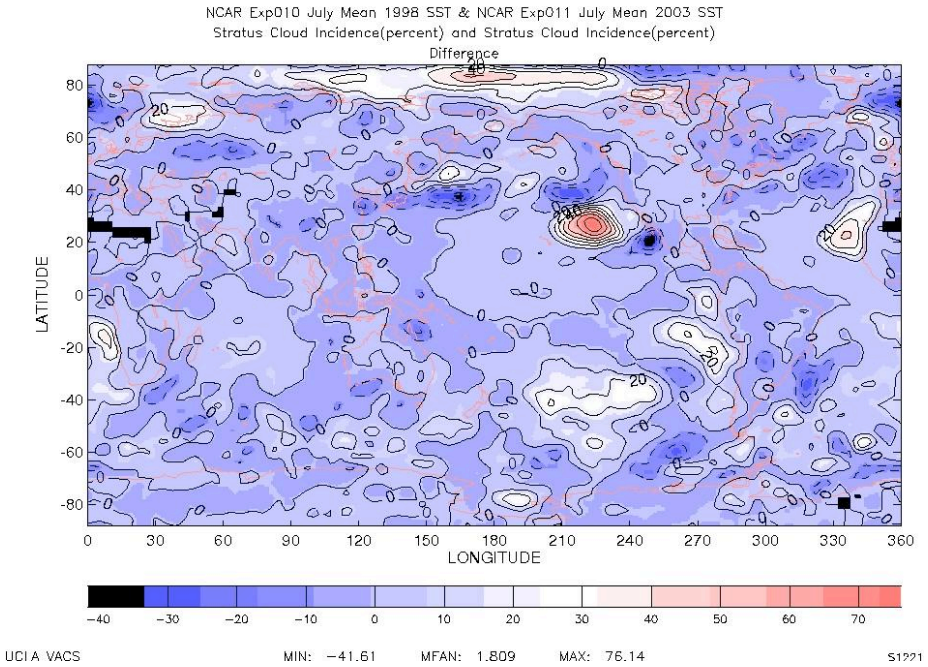
1998 SST

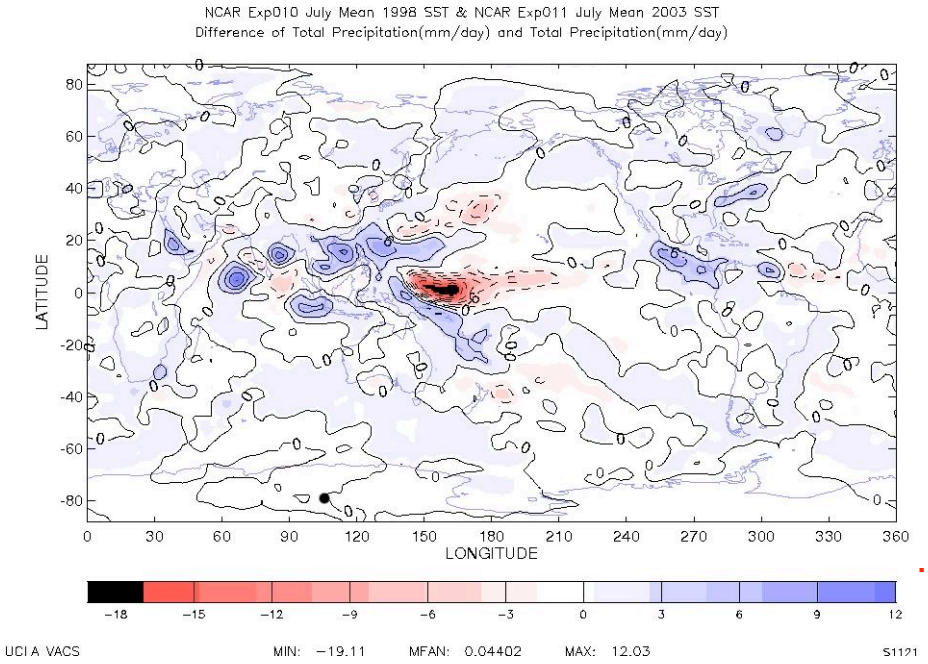


2003 SST



Simulations shows more precipitation in 1998





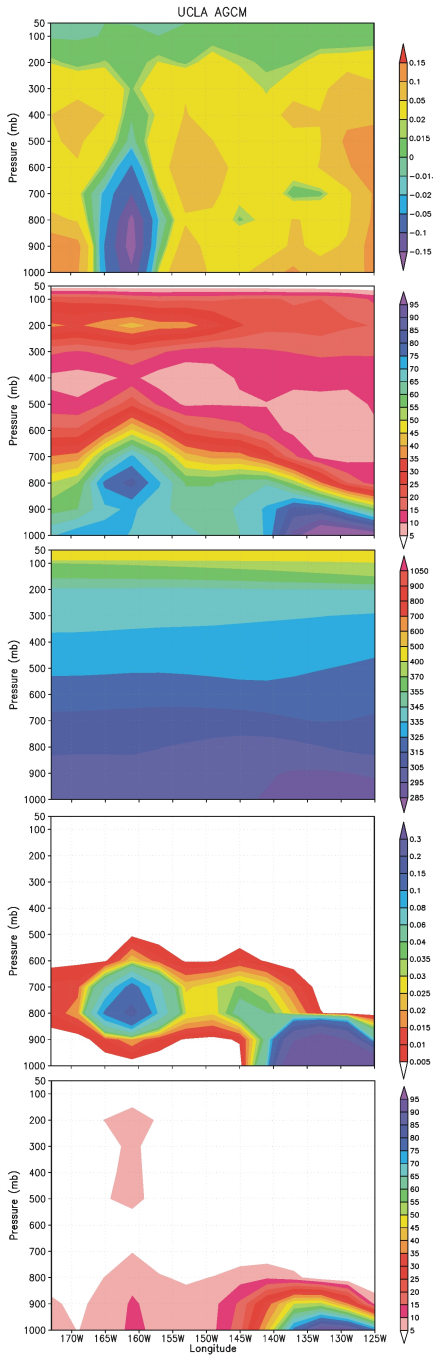
Difference between 1998 and 2003

Stratus Incidence

Precipitation

Cross Sections

1998 SST - July Means



Vertical velocity

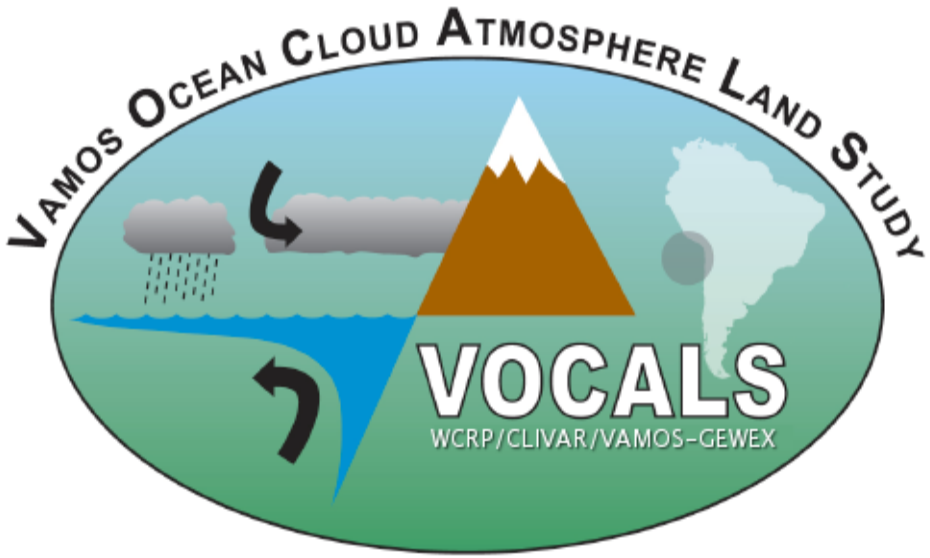
Relative humidity

Potential temperature

Liquid water

Cloud cover

Chile
Peru
USA



UCLA
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U. Hawaii
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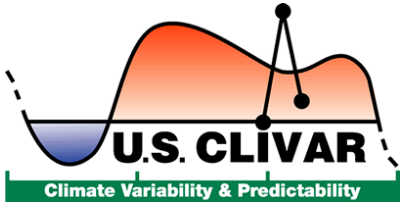
IMARPE-Peru
GFDL
NCAR NCEP
NOAA
WHOI

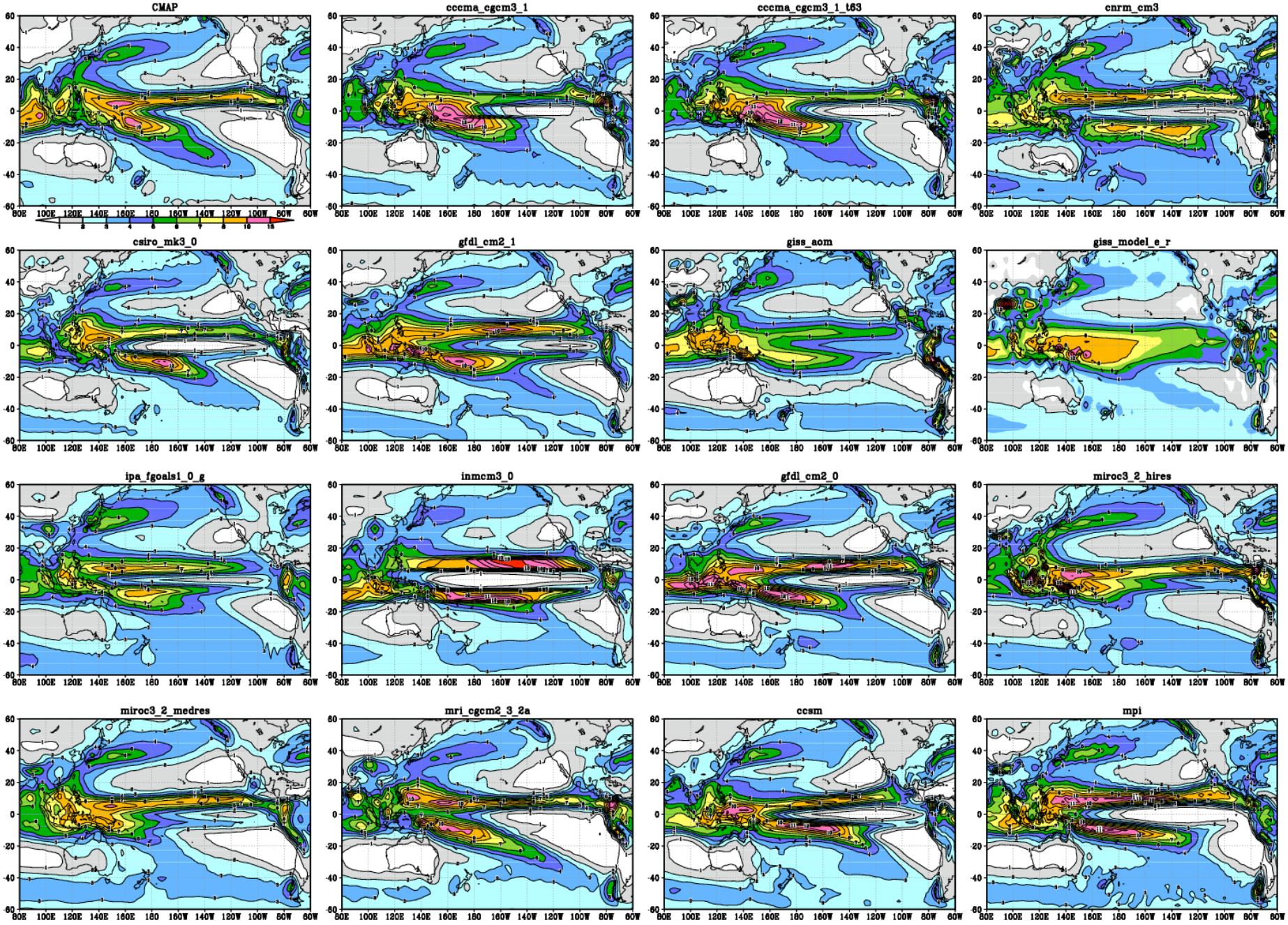
- *The climate of the Southeastern Tropical Pacific (SEP)*
- *Challenges to its Understanding, Modeling and Predicting*
- *Hypotheses*
- *VAMOS Ocean-Cloud-Atmosphere-Land Studies (VOCALS)*

www.atmos.ucla.edu/~mechoso/esm

VOCALS.CPPA.PI.8/06

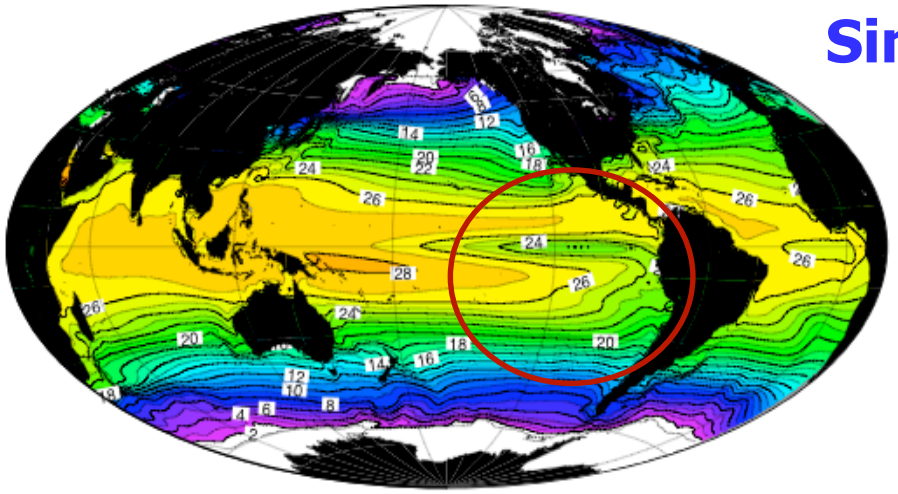


Annual Mean Precipitation - IPCC Models



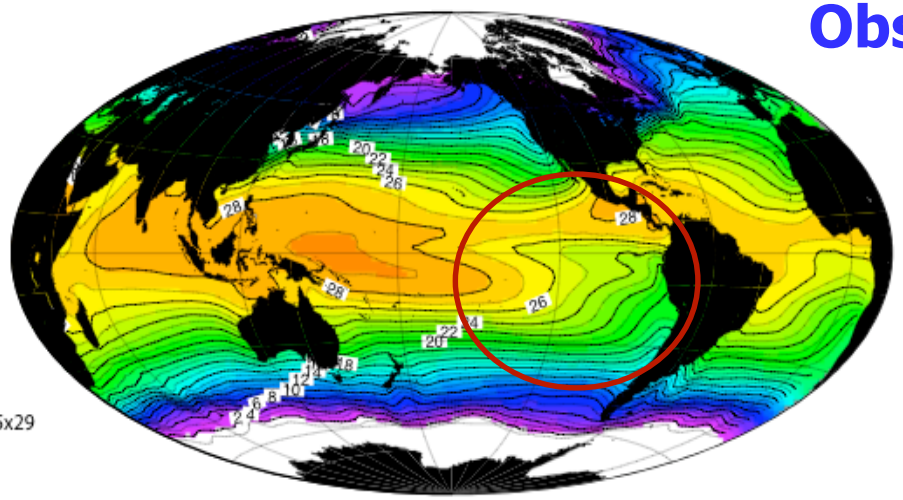
Excessive symmetry about the equator in simulated SST with a CGCM

Annual Mean SST Simulation



Simulated annual mean SST

Annual Mean SST: Reynolds analysis

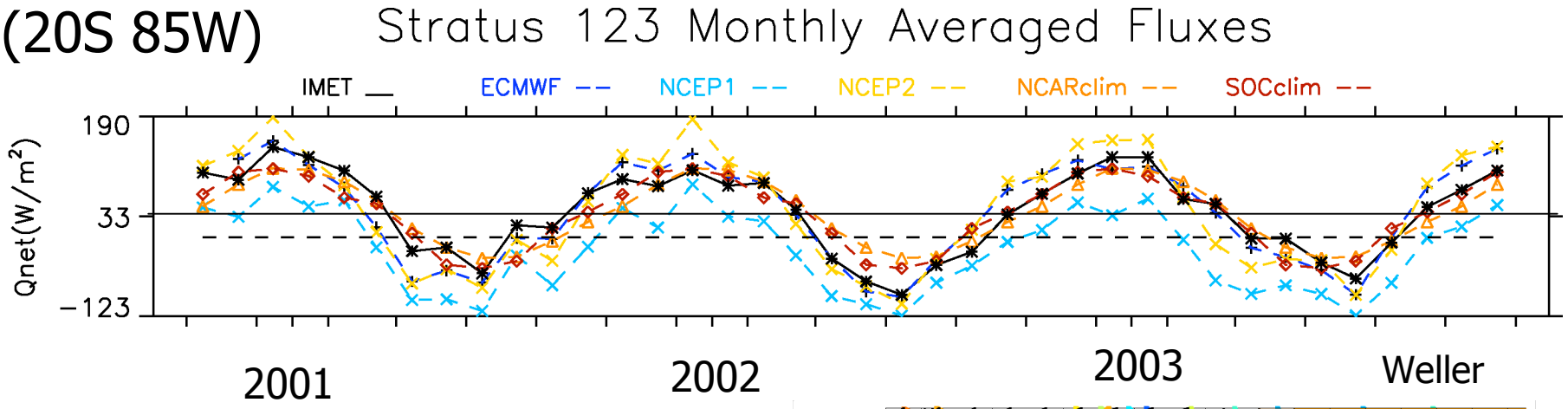


Observed annual mean SST

UCLA AGCM 8.0 2x2.5x29
MIT OGCM Global

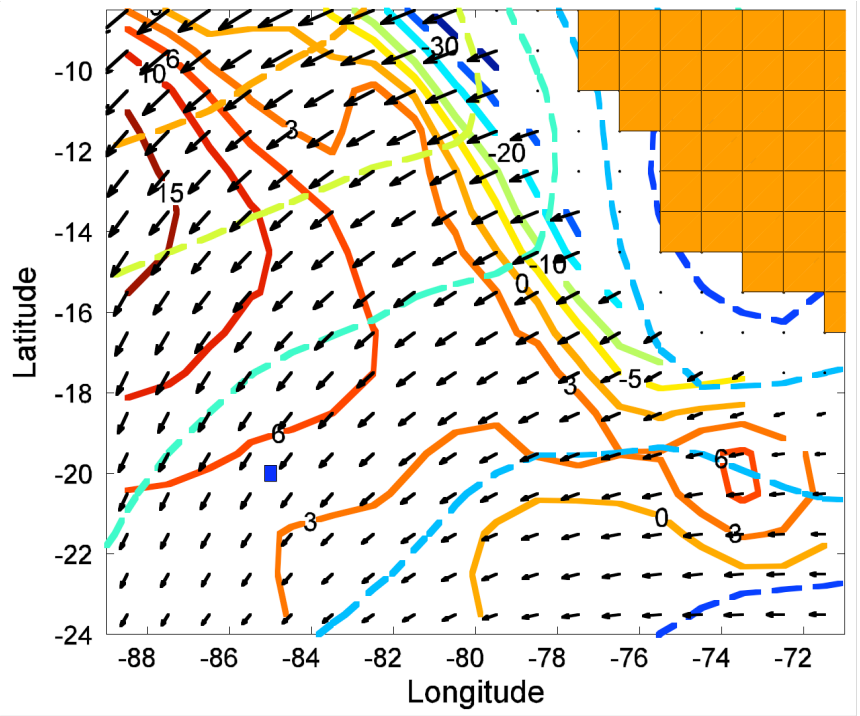
Heat Budget does not Close

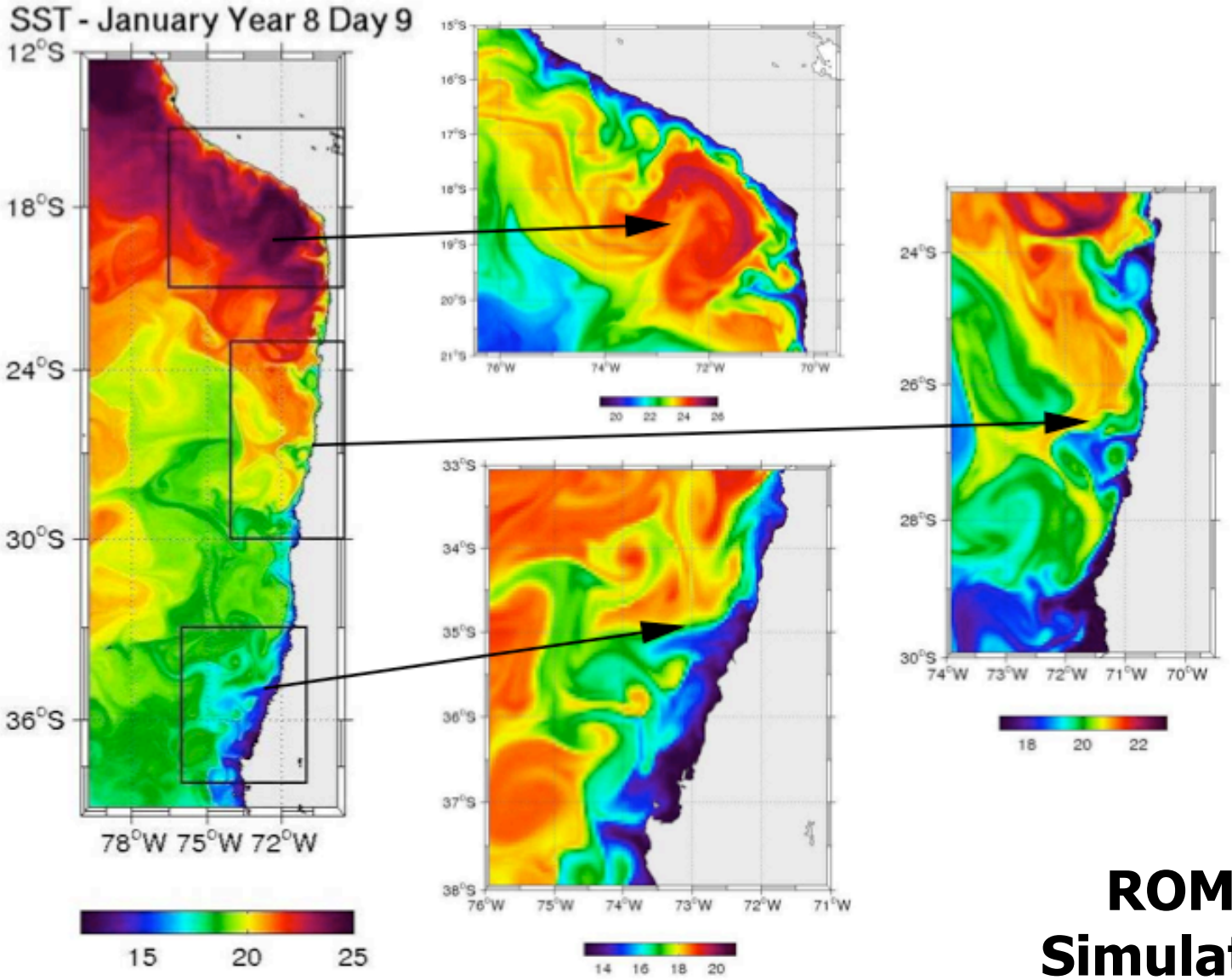
(20S 85W)



Annual-mean heat flux **into** ocean ~ 30 W m^{-2} at 1500 km offshore under persistent low cloud!

How is this net warming at the surface balanced by ocean heat transports?





ROMS Simulation

(From J. McWilliams)

Modeling issues in the SEP – 1

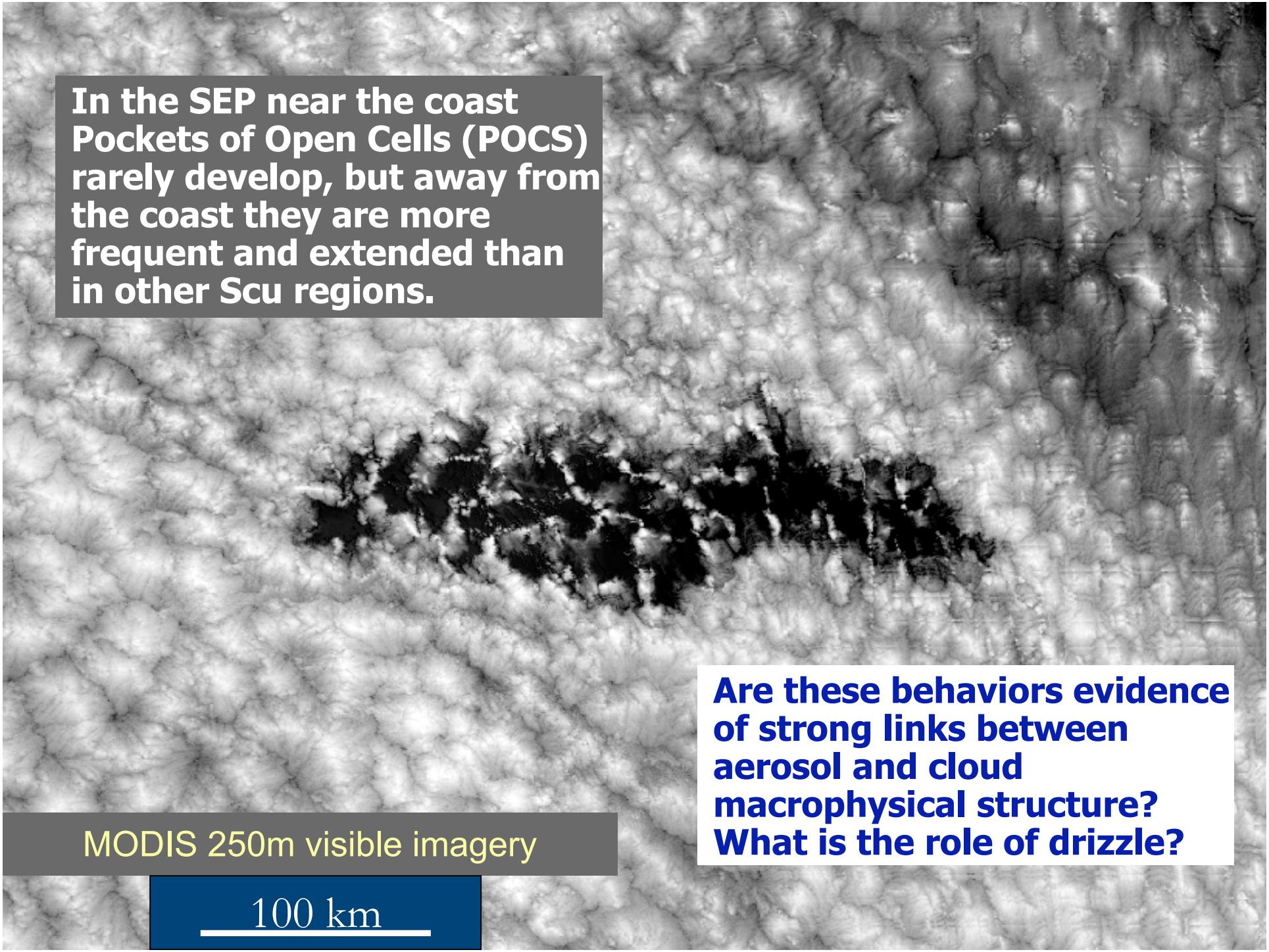
There is a consensus that the numerical simulations of the SEP climate faces major issues and challenges:

- In the SEP, as well as in the southeastern tropical Atlantic, coupled atmosphere-ocean models have difficulties in simulating stratocumulus clouds and produce large sea surface temperature (SST) and surface wind errors.

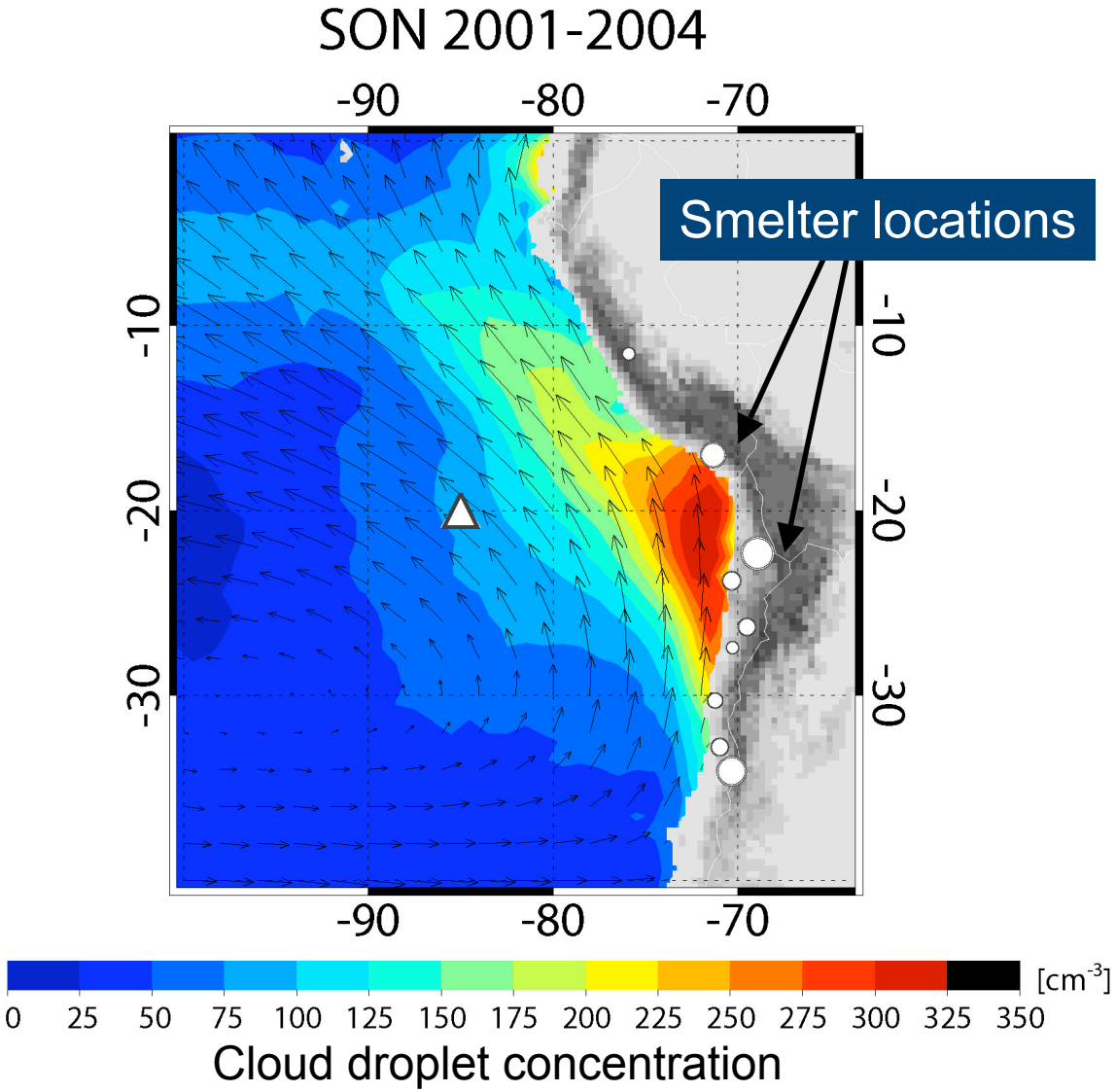
- A realistic simulation of the tropical stratocumulus by an AGCM (with prescribed SSTs) does not guarantee a single northern ITCZ in the coupled mode. Also, a CGCM can produce a weak double ITCZ and yet obtain a very symmetric SST distribution in the eastern Pacific. The OGCMs, therefore, provide their own contribution to a double ITCZ bias.

- The wind-driven oceanic circulation in the SEP develops a vigorous mesoscale and submesoscale eddy field that covers a much larger area than the coastal upwelling zone. The extent to which OGCMs capture this extension is unclear.

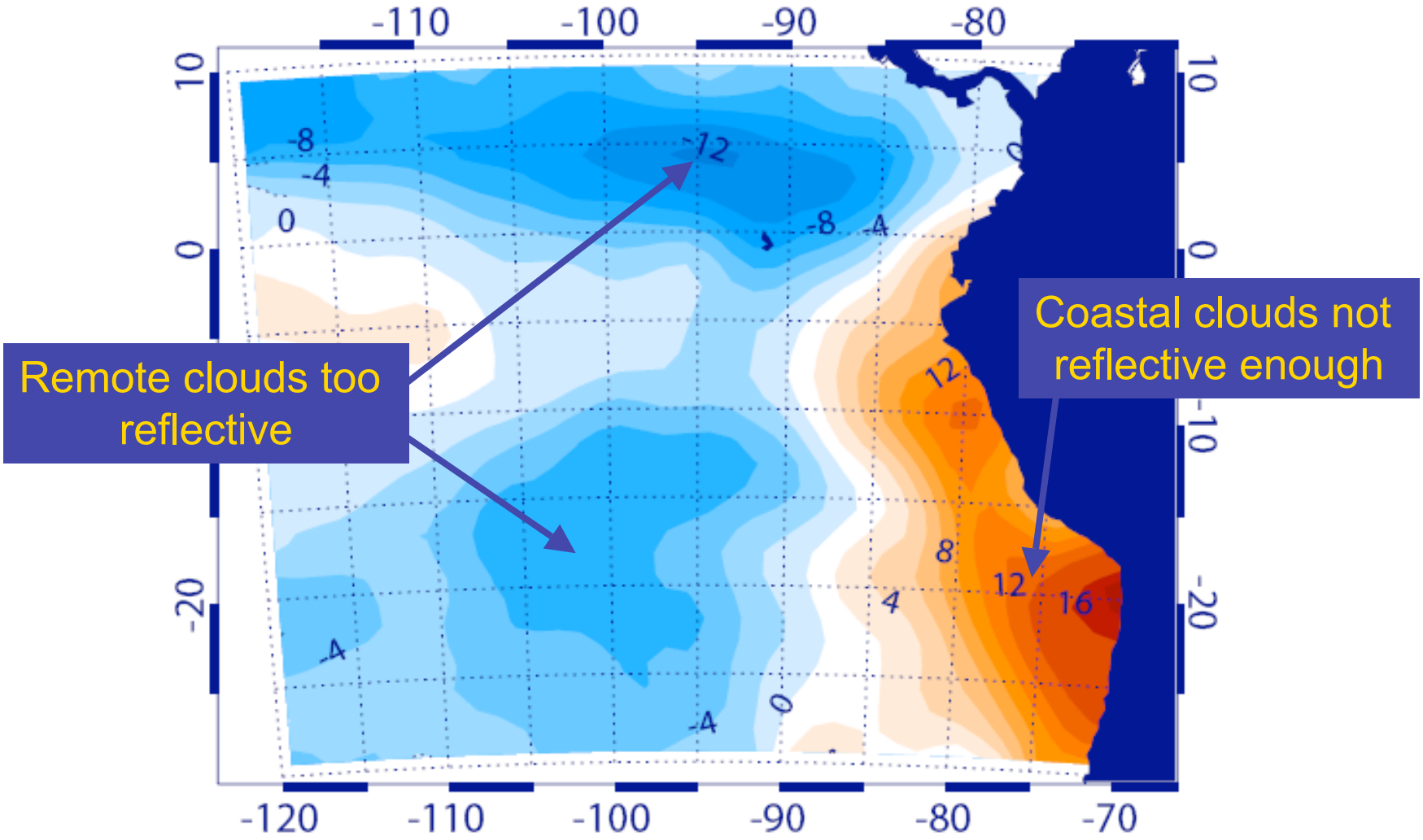
- Global OGCMs have difficulties with the simulation of eddy transports of heat, salinity, and nutrients in the SEP, most plausibly because they do not resolve well the regional upwelling currents and eddies.


In the SEP near the coast Pockets of Open Cells (POCS) rarely develop, but away from the coast they are more frequent and extended than in other Scu regions.
Are these behaviors evidence of strong links between aerosol and cloud macrophysical structure? What is the role of drizzle?
MODIS 250m visible imagery
100 km

Regional Sources of Aerosol



Difference between TOA assuming constant and satellite-estimated cloud droplet radius



Modeling issues in the SEP – 2

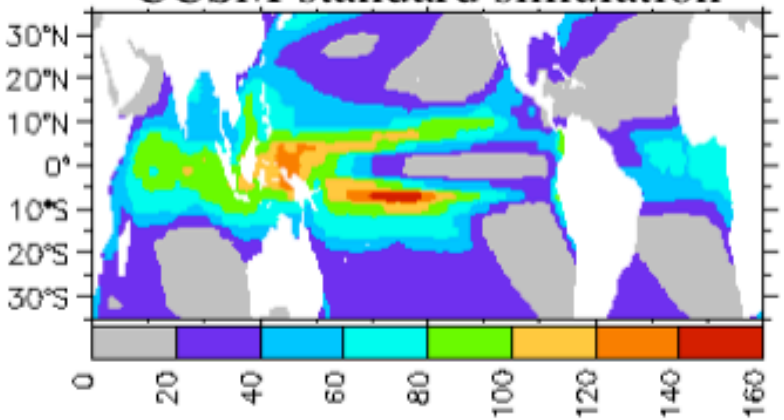
- Mesoscale atmospheric processes, such as those at work for pockets of open cells (POCS), influence cloud properties over the SEP. The PBL parameterization of AGCMs does not adequately consider those processes.

- Key elements of the PBL, including its height and cloud cover/albedo, are usually not well reproduced even in regional models with relatively high resolution in the vertical and horizontal. These problems are exacerbated in the near coastal strip. The large diurnal cycle of cloud cover and height, due in part to interactions with the Andes, adds to this challenge, but does seem to be qualitatively correctly simulated in some AGCMs/RAMs.

- Microphysical processes affect cloud properties in the SEP. The variability of those processes is strongly affected by aerosols, derived in varying degrees from natural (surface emissions) and anthropogenic (industrial emissions via the FT) sources. The aerosols impact clouds by enhancing cloud optical thickness and suppressing drizzle, while the clouds impact the aerosols through coalescence, loss by drizzle, and competition for precursor gases. CGCMs do not address the potentially important feedbacks associated with the effects of aerosol upon the SEP coupled ocean-atmosphere system.

UPSCALING EFFECTS FROM SUBTROPICAL EASTERN BOUNDARY OCEANS

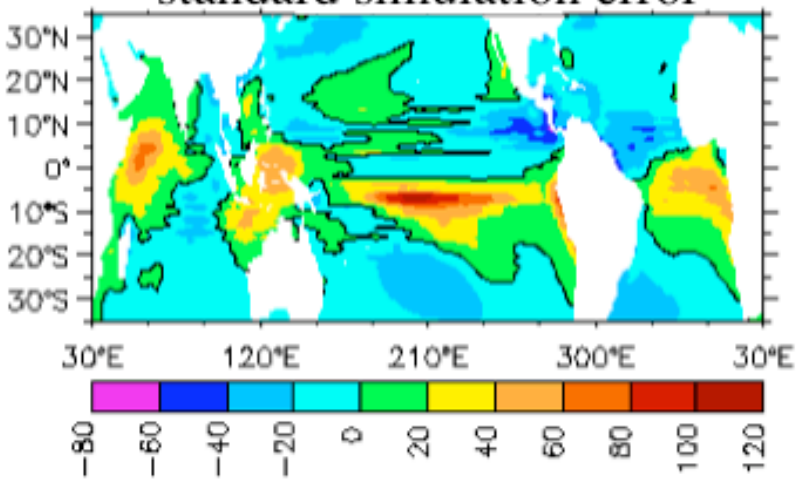
CCSM standard simulation



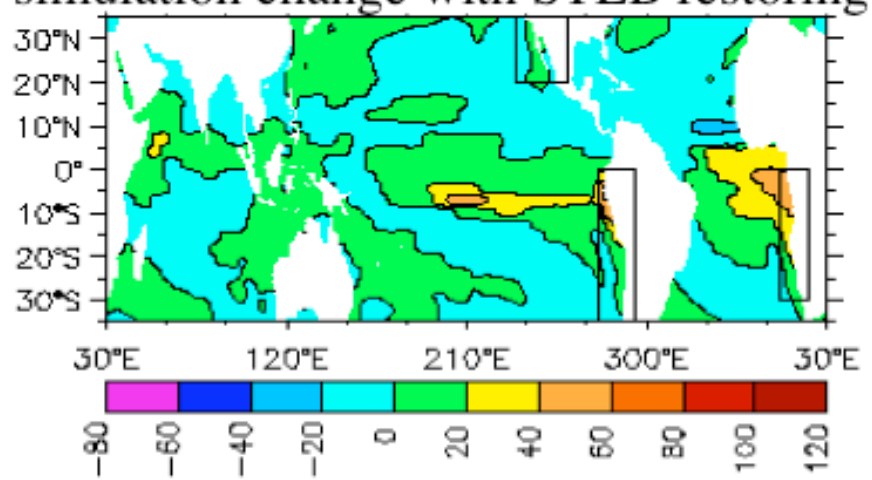
Mean precipitation [mg/m^2/s] in coupled model and its change with restoring of T & S in upper subtropical Eastern Boundary regions in N. & S. Pacific and S. Atlantic.

(Large & Danabasoglu, 2006)

standard simulation error



simulation change with STEB restoring



Remote Impacts

- There is also consensus that model difficulties in the SEP can imprint a signature in the simulation of large-scale fields via teleconnections:
- The CGCMs errors are consistent with a "double ITCZ bias" and the poor simulation of tropical variability (including ENSO). The interhemispheric asymmetry of the ITCZ is missed by practically all coupled atmosphere-ocean GCMs, which tend to produce either two ITCZs straddling the equator or a single one that migrates between the two hemispheres. Previous work has provided indications that it and other features of tropical precipitation patterns are strongly influenced by the SEP.
- Deficiencies in ENSO simulation and prediction can affect remote climates, particularly over the Americas.
- The pronounced annual cycle in the equatorial cold tongue is also considered to originate from the SEP.
- Atmospheric disturbances in the SEP with an asymmetric structure propagate westward in the form of Rossby waves, and oceanic disturbances similarly propagate westward as Rossby waves and eddies.

VOCALS

The overall goal of VOCALS is to develop and promote scientific activities leading to improved understanding, model simulations, and predictions of the southeastern Pacific (SEP) coupled ocean-atmosphere-land system, on diurnal to interannual timescales.

The focus of VOCALS in the SEP includes:

- **Interactions with remote climates.**
- **Systematic biases of atmosphere-ocean GCMs.**
- **Ocean budgets of heat, salinity, and nutrients.**
- **Aerosol-cloud-drizzle interactions in the marine PBL.**

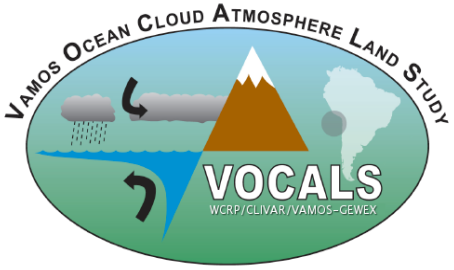
VOCALS Program

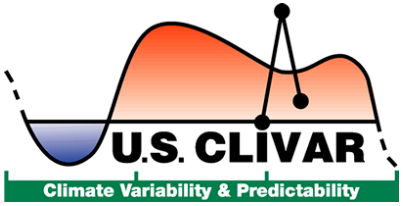
VOCALS-Rex

- Airborne Campaign: PBL clouds, aerosol
- Ship Campaign:PBL clouds, aerosol, ocean eddies

VOCALS Modeling

- Diagnosis and hypothesis/testing exps
- Simulation and/or prediction for the austral spring with CGCMs and ROAMs
- Assessment of the impact of enhanced observations by VOCALS-Rex
- Organized modeling activities



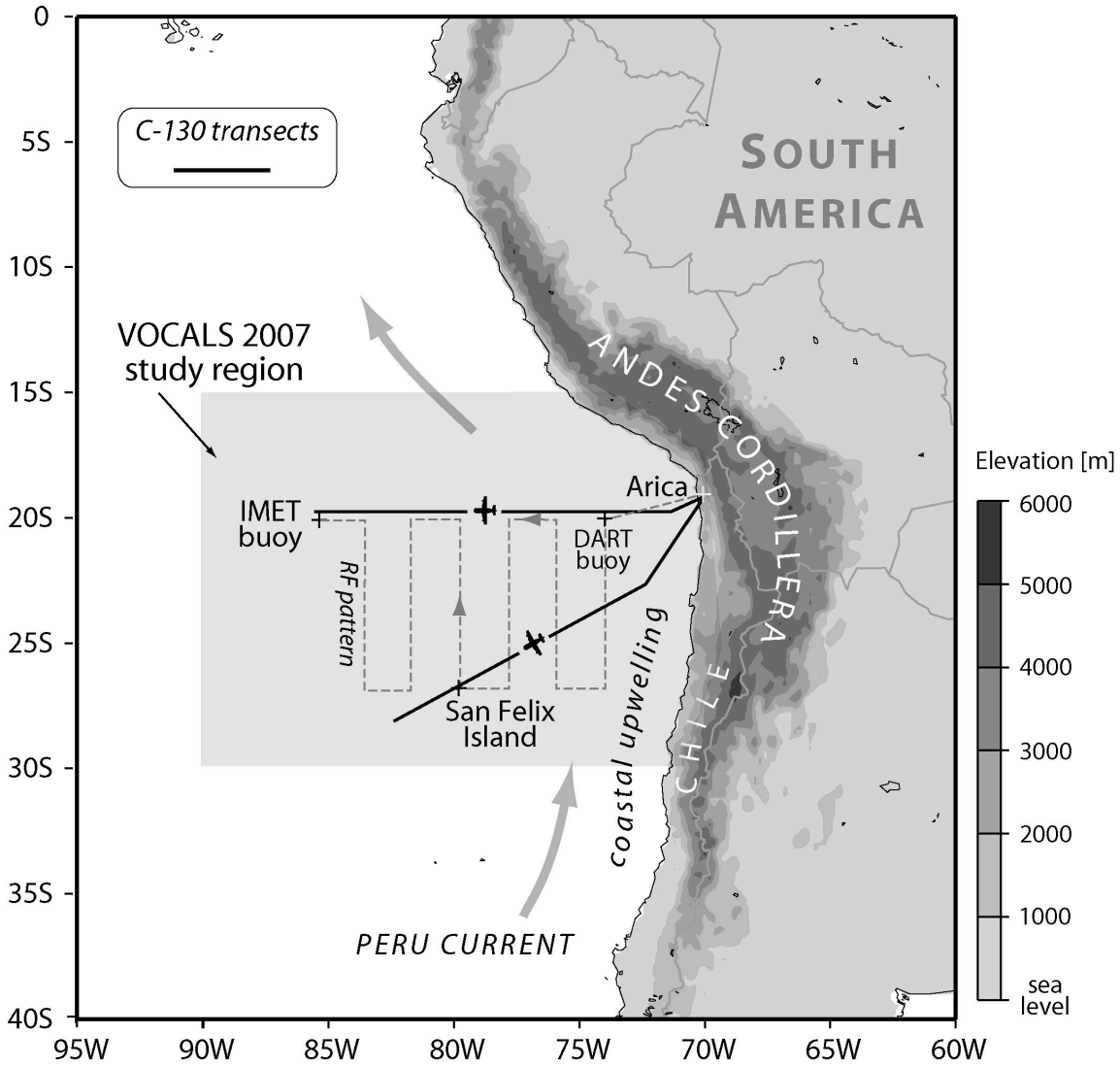


VOCALS-REX

Aircraft:
NCAR C130
NOAA P3

Ships:
1. **NOAA Ron Brown**
2. **Chilean**

October 2008



VOCALS models and modeling approach

- VOCALS will establish links among operational centers (NCEP), research laboratories (NCAR, GFDL) and universities (CSU, UCLA, UCSD, UH, UW, UCH,…).
- The collaborations established will assure the availability of the hierarchy of numerical models needed to address the broad range of space and time scales of processes in the VOCALS region. The numerical models in the hierarchy will include 1) Large-Eddy Simulation Models (LESs), 2) Regional Atmospheric Models (RAMs), 3) Regional Ocean Models (ROMs), 4) Coupled ROM-RAM Models (ROAMs), 5) Atmospheric General Circulation Models (AGCM), 5) Oceanic General Circulation Models (OGCMs, 6) Coupled Atmosphere-Ocean General Circulation Models (CGCM), and 7) Single Column Models (SCM) for clouds and aerosols.

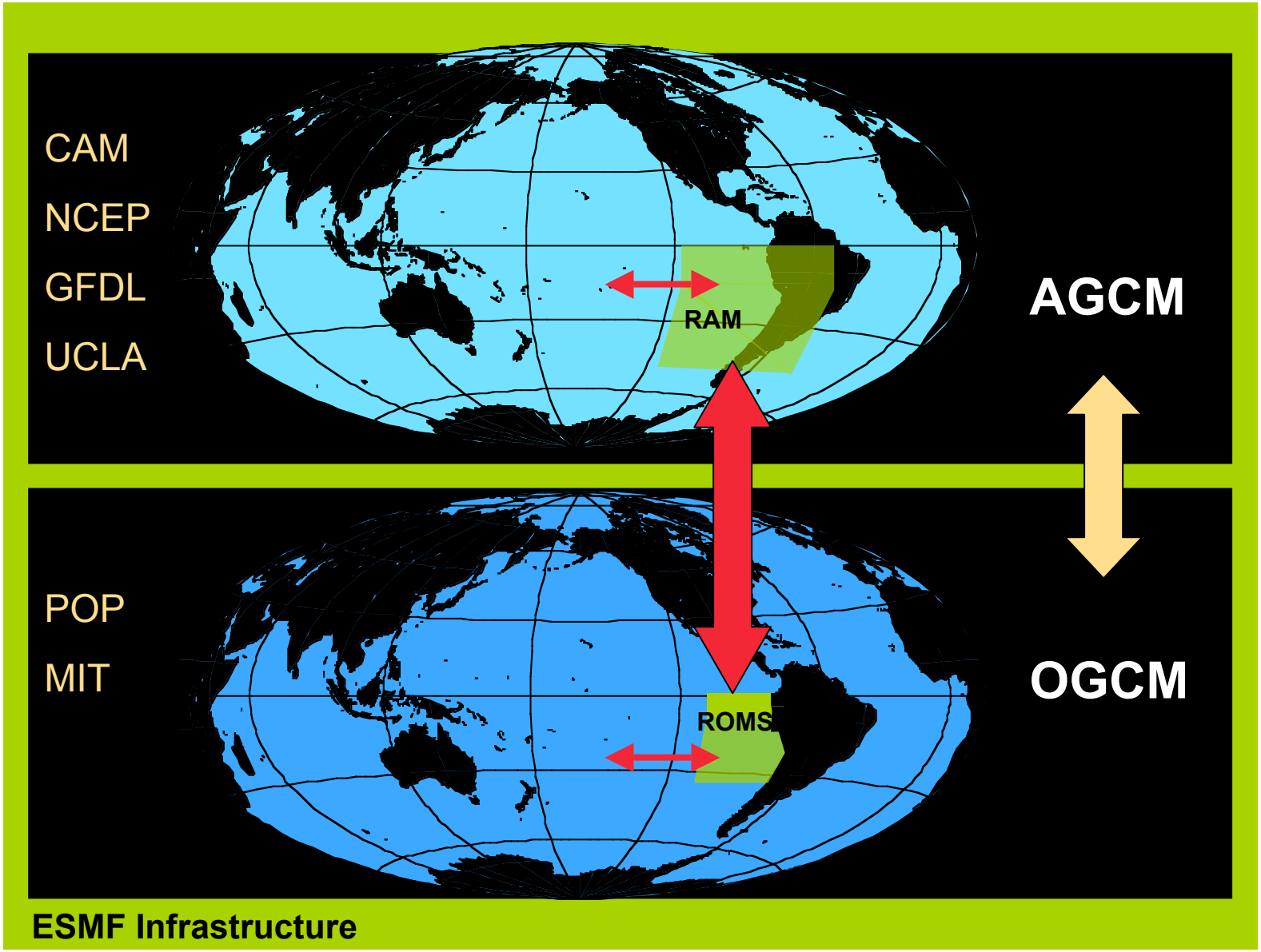
VOCALS modeling hypotheses

- The CGCMs difficulties in capturing the effects on the SEP of an upstream region with strong coastal upwelling and high Sc incidence are crucial contributors to the model errors in the region.
- In the atmosphere, southeast trades from the South American coast flow from a cool and dry PBL over strong SST gradients and regions where trade cumuli form moistening the lower troposphere. These processes are not well represented by AGCMs.
- In the ocean, mesoscale eddies not captured by OGCMs play a major role in the transport of heat and fresh water from coastally upwelled water to regions further offshore.
- An approach based on regional and high-resolution ROAM embedded within the seasonally and interannually varying global climate is the methodology with the highest potential to overcome climate model difficulties in the region within the VOCALS time frame.

VOCALS Multi-Scale System (MUSSIP) for prediction

AGCM: Atmosphere General Circulation Model

OGCM: Ocean General Circulation Model



VOCALS GOALS

- Improved simulation of the large-scale circulation in the atmosphere and ocean: elimination of CGCM errors.

- Improved representation of the aerosol indirect effects over the SEP by regional and/or global models.

- Detailed validation of techniques that provide satellite estimates of Scu microphysical properties (e.g. effective radius or cloud droplet number concentration from MODIS) and precipitation (from CloudSat or MODIS) under conditions that can be of broken cloudiness on the pixel scale.

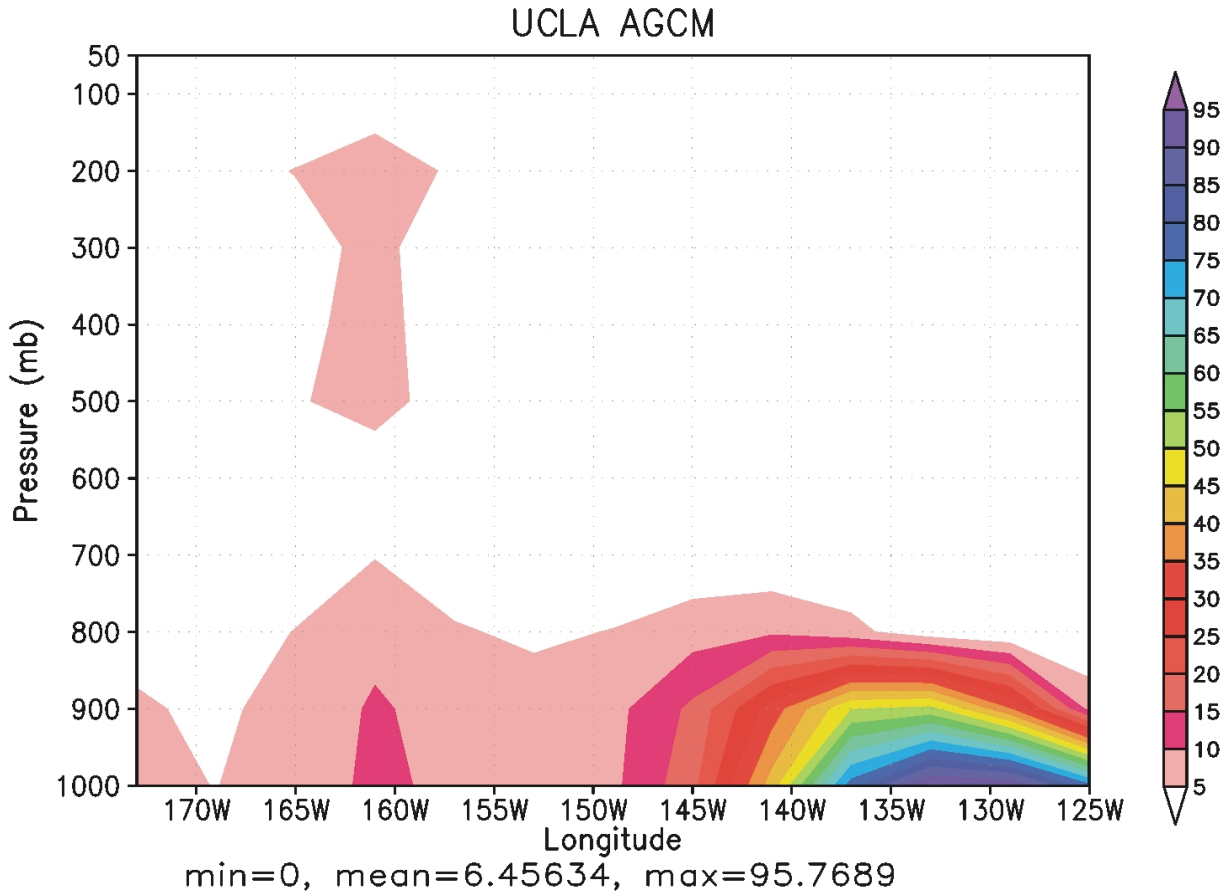
VOCALS Timeline

(from August 06)

- VOCALS submitted to NSF Science Plan and Experimental Design Overviews in early 2006. These documents got high marks from reviewers.
- NSF/NOAA have requested VOCALS to submit revised documents including summary budgets, by Sept 1, 2006.
- A decision on funding will be taken by January 1, 2007.
- VOCALS-Rex is scheduled for November 2008
- VOCALS sessions arranged at AGU F07, IUGG07

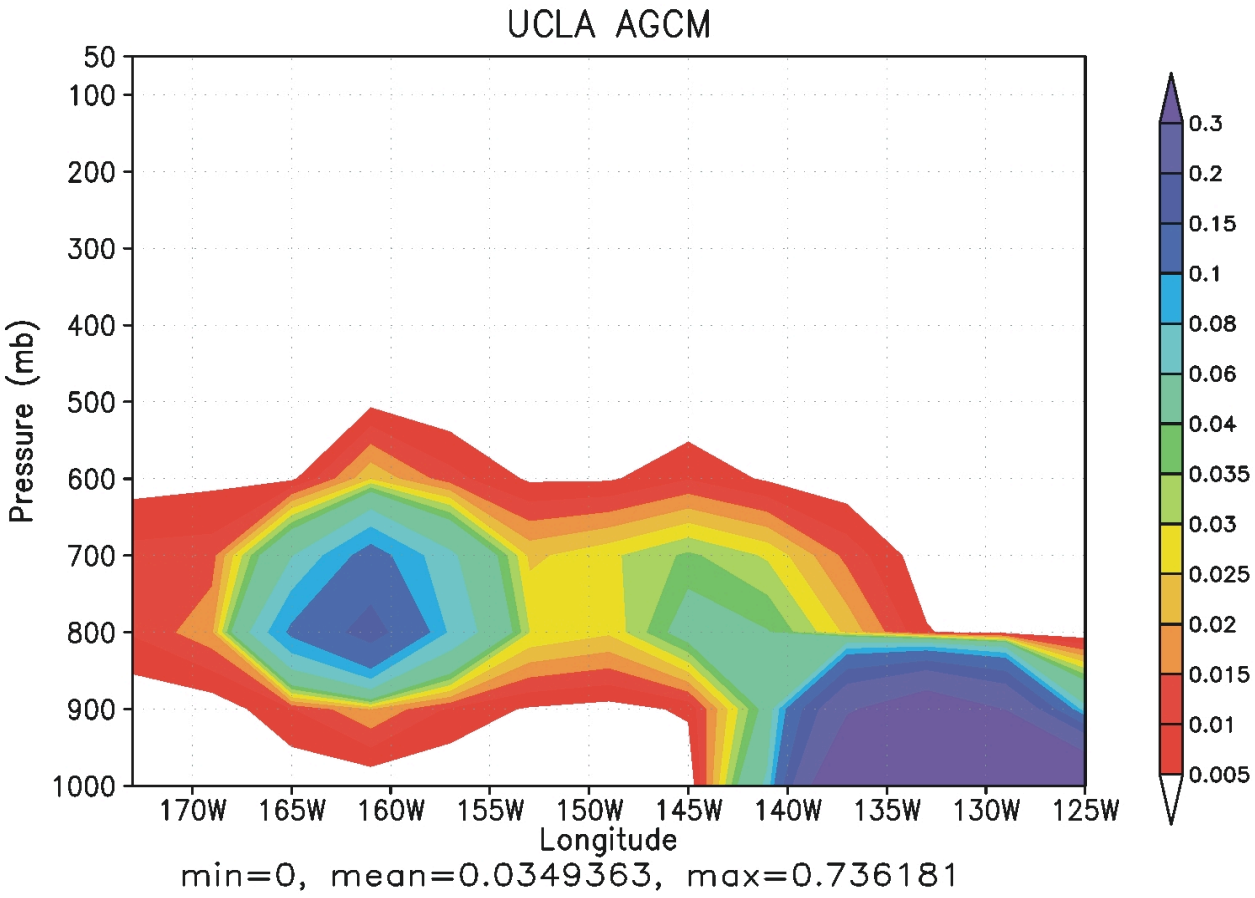
July mean cloud cover

1998 SST



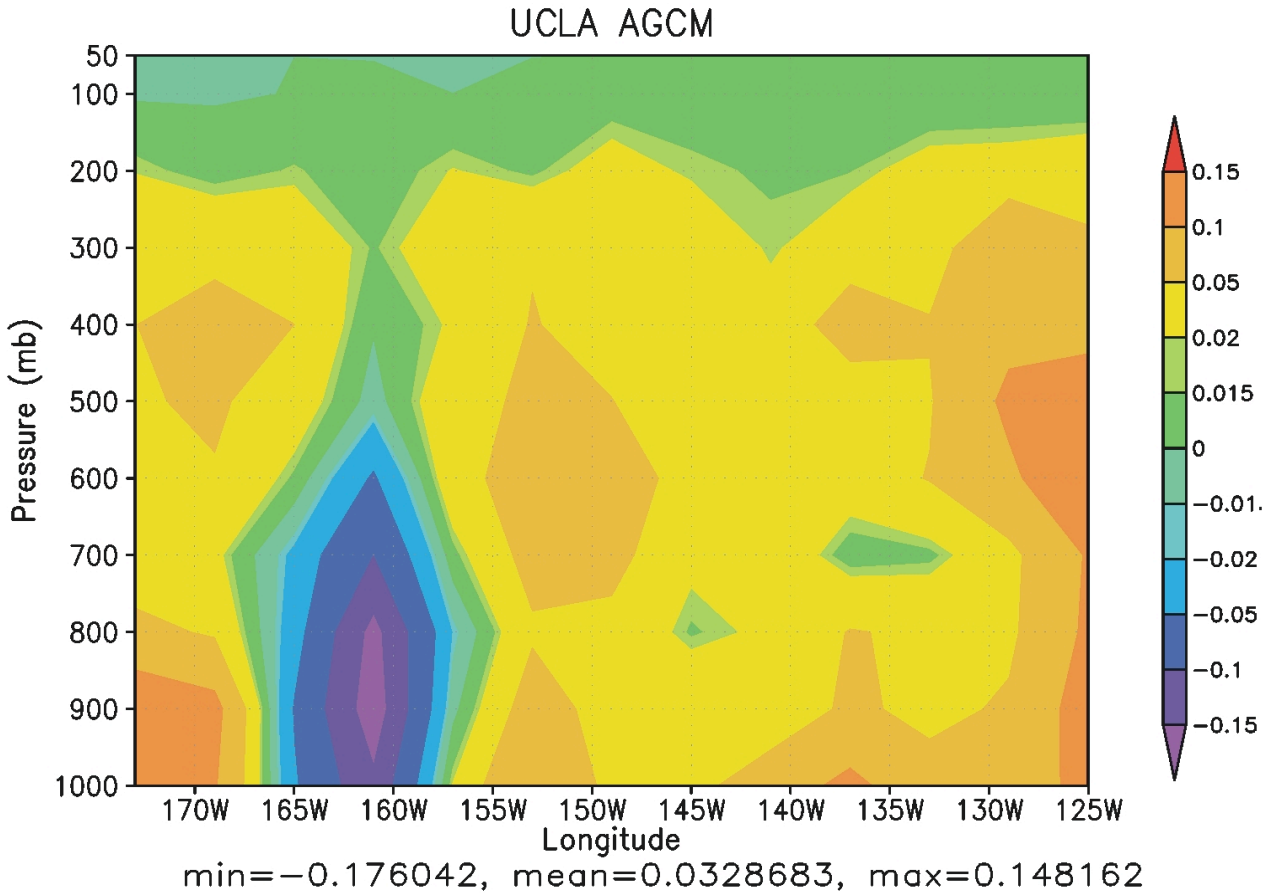
July mean cloud liquid water

1998 SST



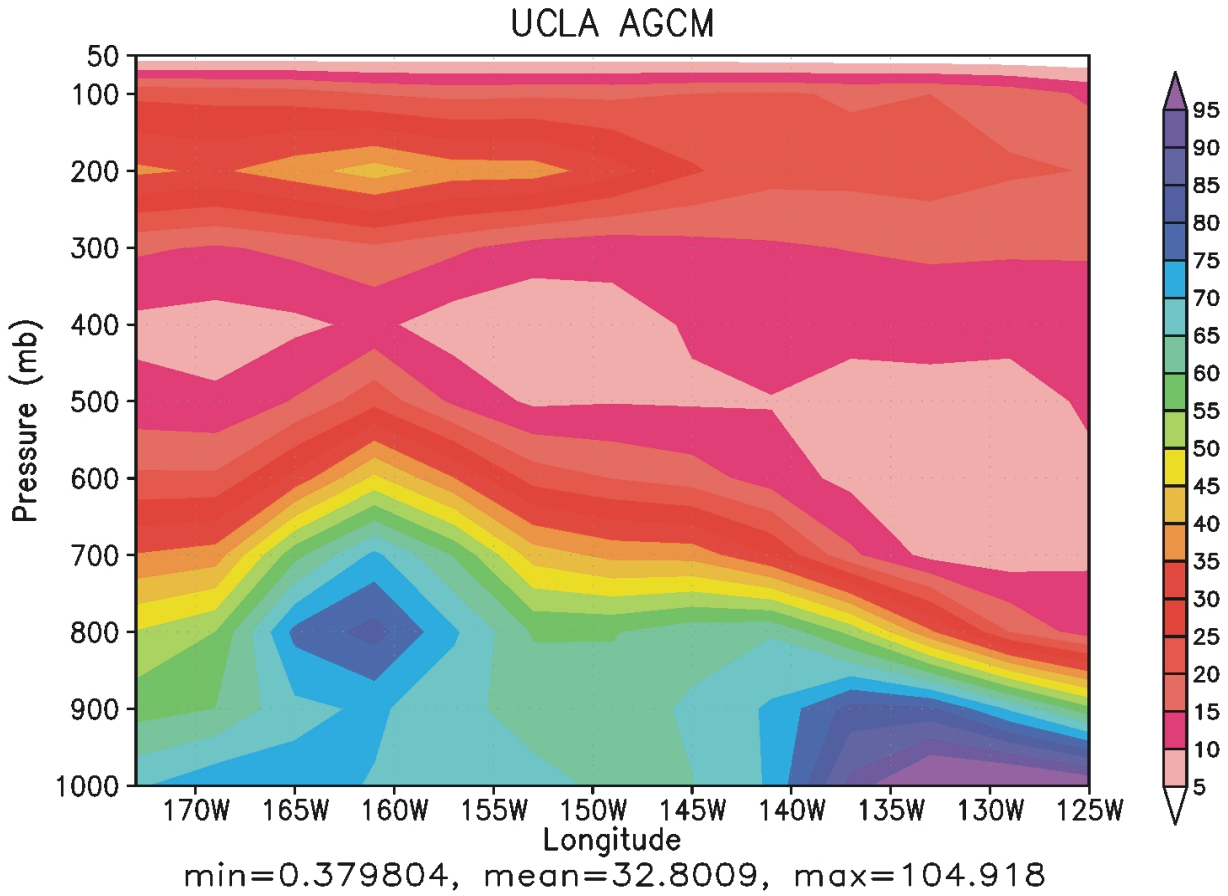
July mean vertical velocity

1998 SST



July mean relative humidity

1998 SST



July mean potential temperature

1998 SST