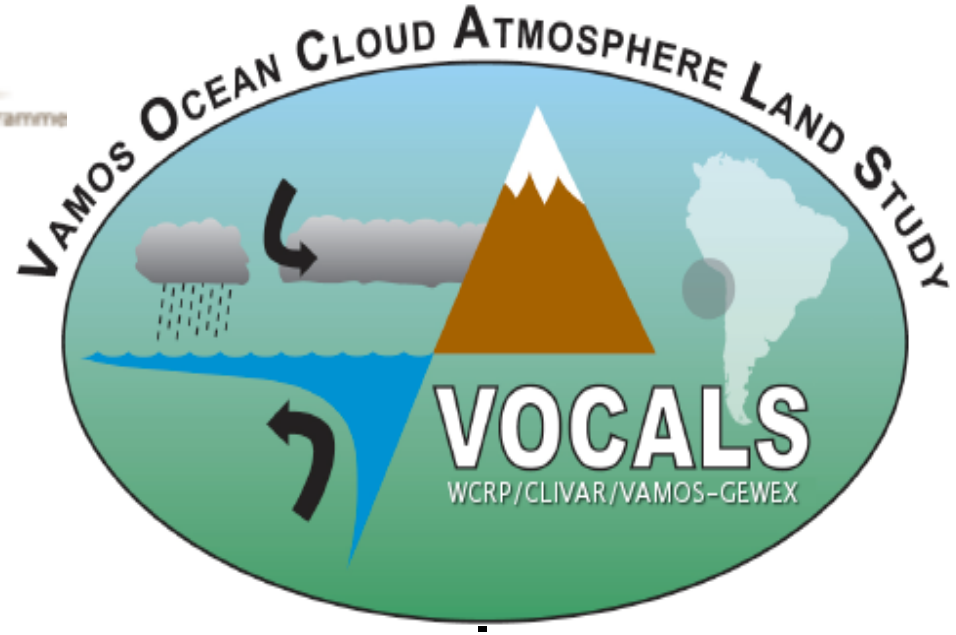
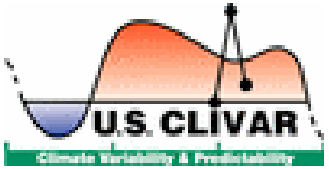
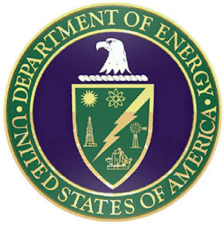


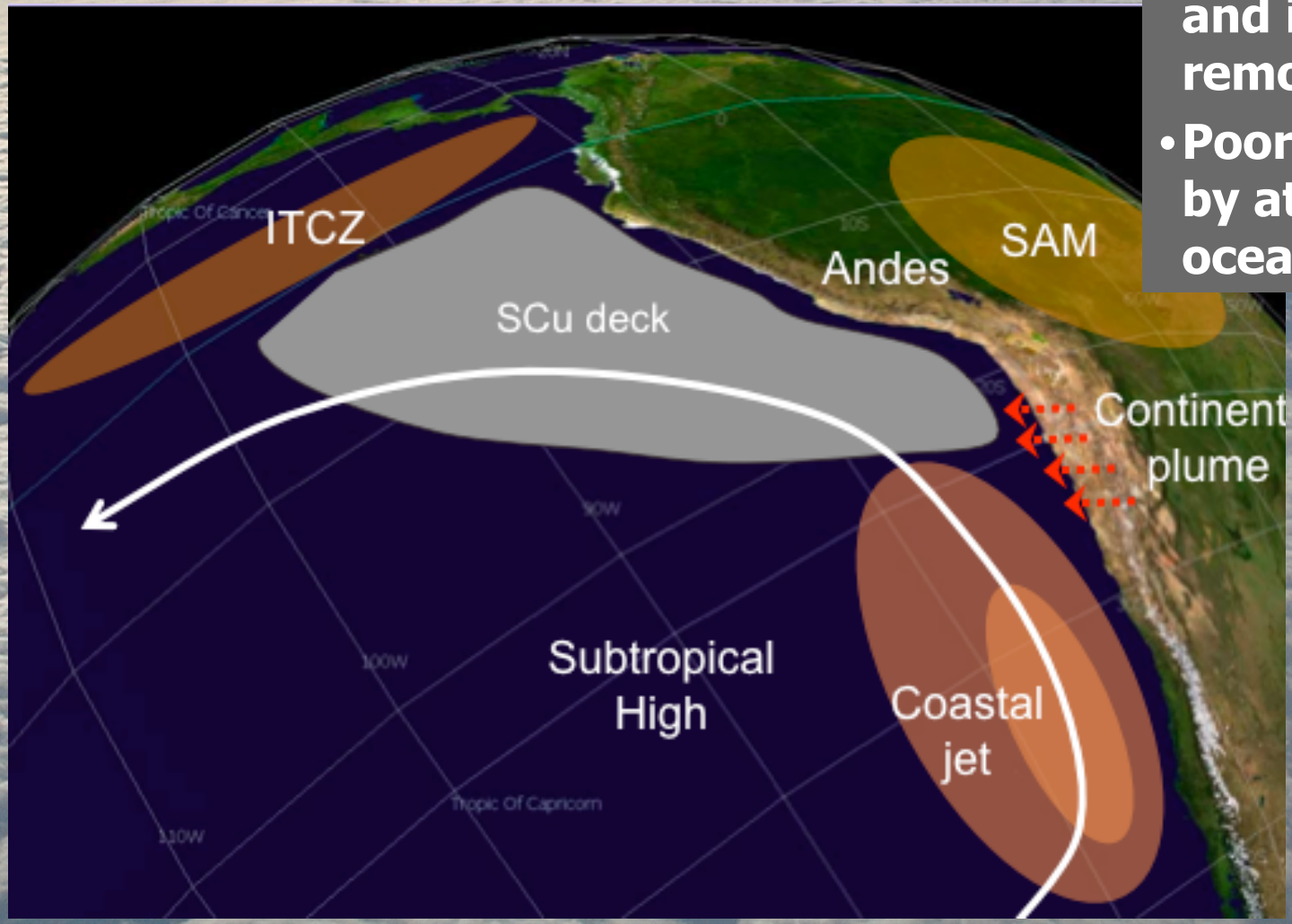


Atmosphere-Ocean-Land Interaction Theme

VOCALS Preparatory Workshop - NCAR, May 18-29, 2007



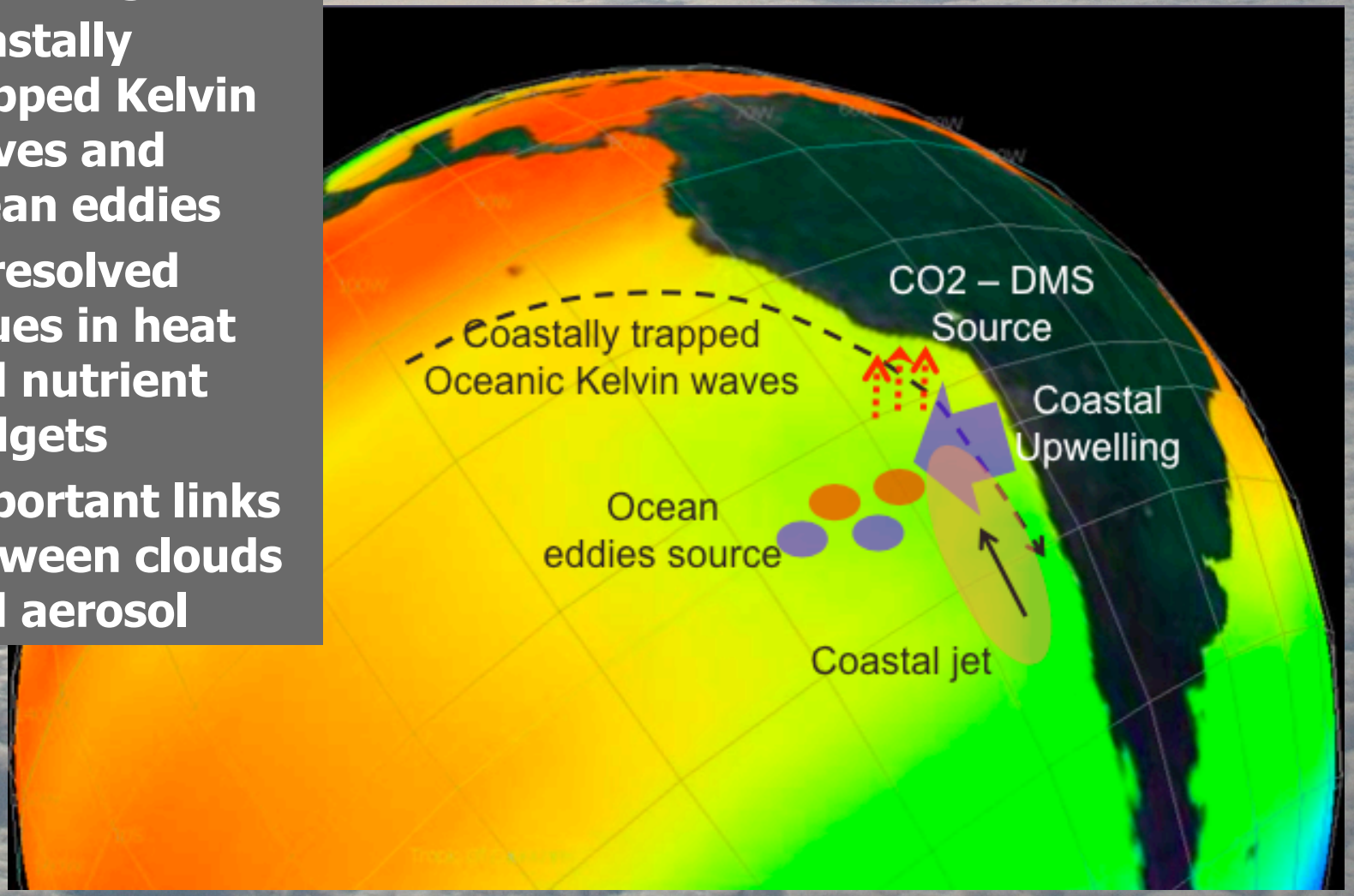
The Southeastern Pacific

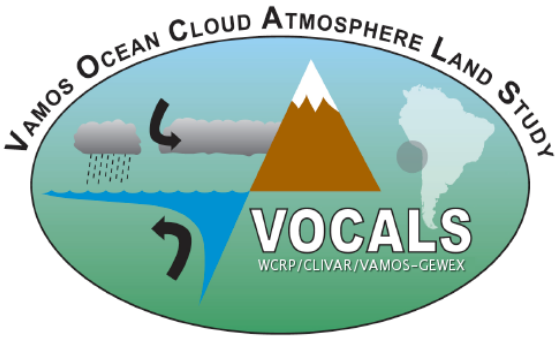


- Cloud-topped ABLs, with mesoscale structures
- Influenced by and influential on remote climates
- Poorly simulated by atmosphere-ocean GCMs

The Southeastern Pacific

- Cold SSTs, coastal upwelling
- Coastally trapped Kelvin waves and ocean eddies
- Unresolved issues in heat and nutrient budgets
- Important links between clouds and aerosol

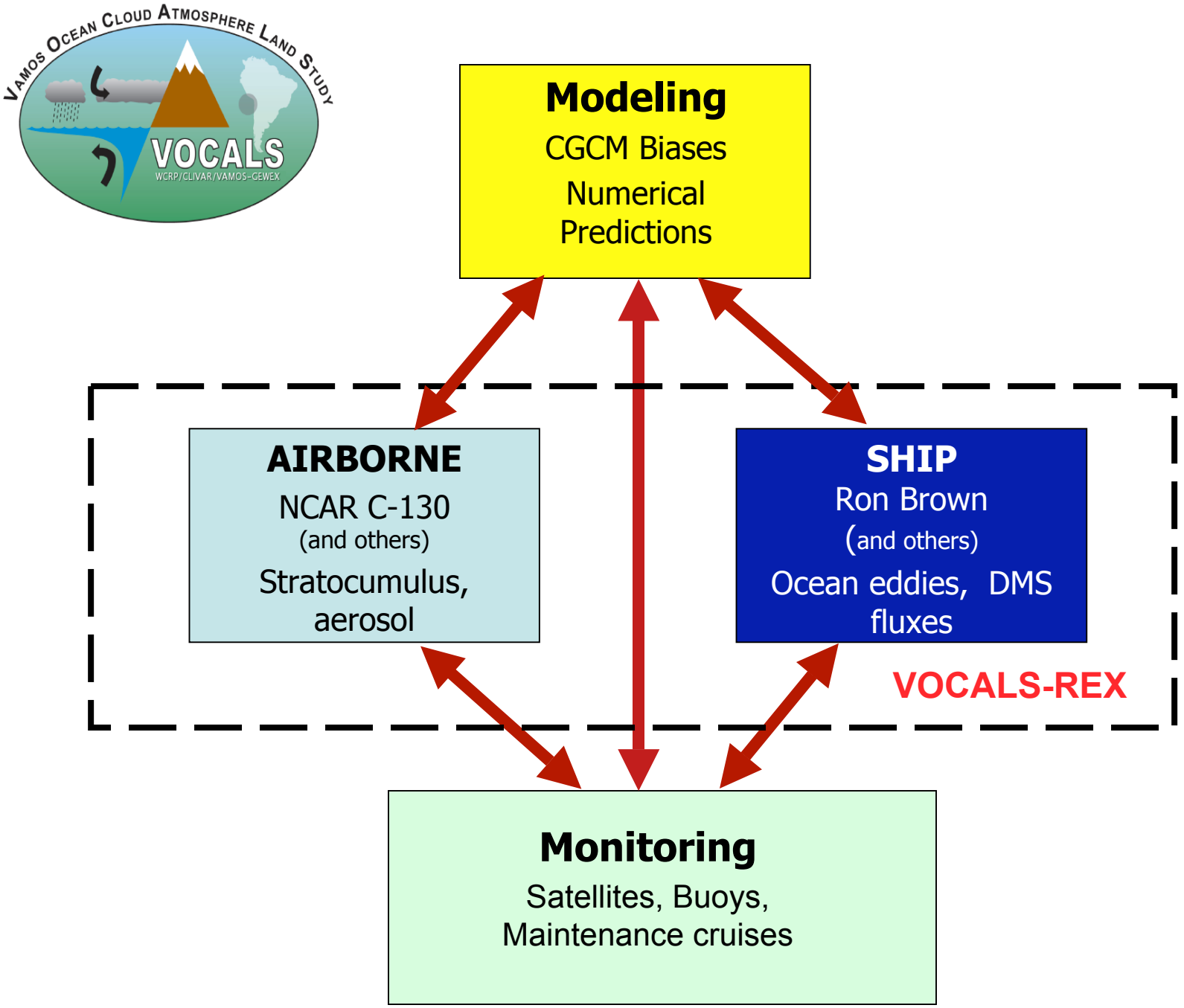




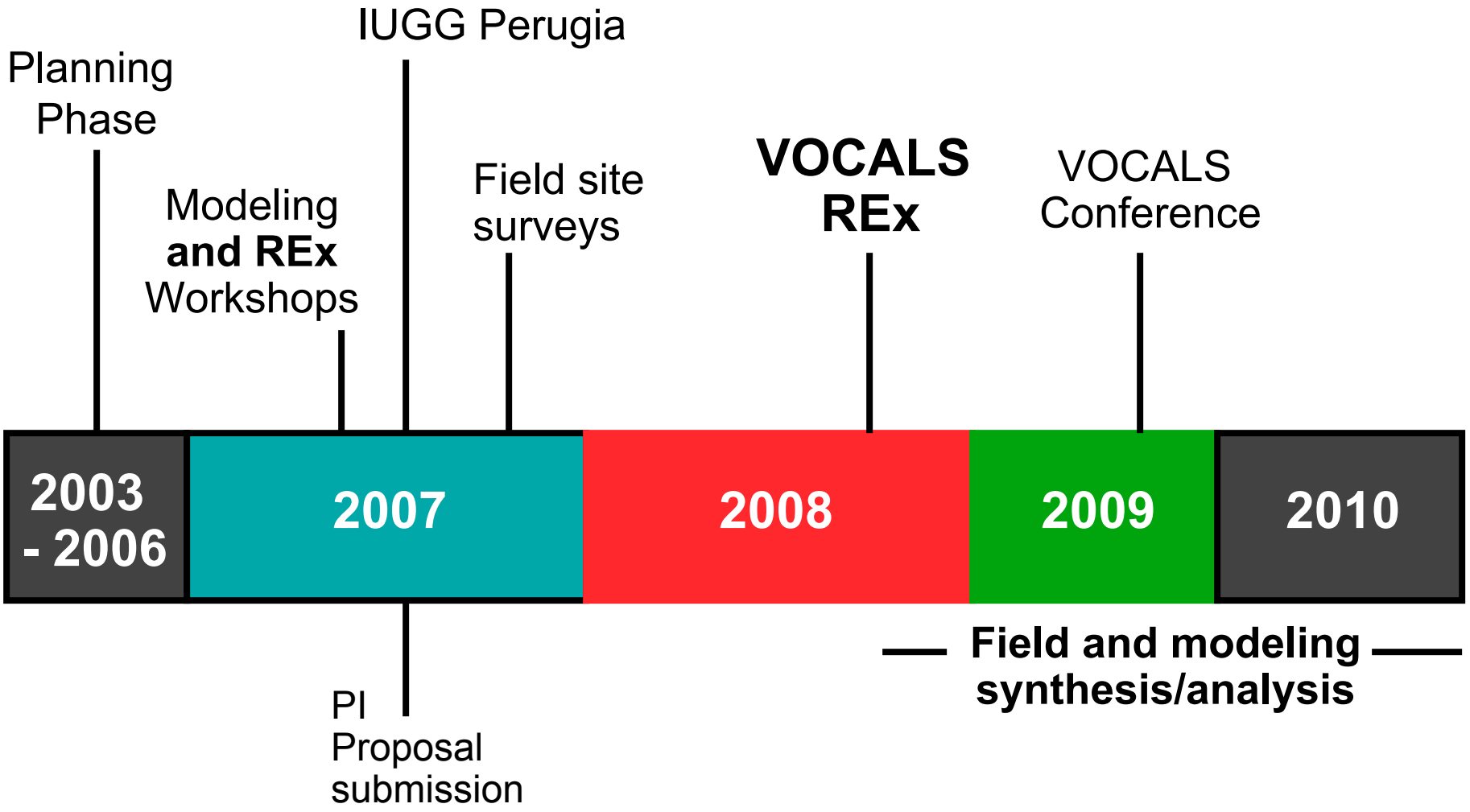
Principal Objectives

- **Elimination of CGCM systematic errors in the SEP, and improved model simulations of the coupled system in the region and global impacts of its variability.**
- **Improved understanding and regional/global model representation of aerosol indirect effects over the SEP.**

www.eol.ucar.edu/projects/vocals


VAMOS Ocean Cloud Atmosphere Land Study
VOCALS
WCRP/CLIVAR/VAMOS-GEWEX
Modeling
CGCM Biases
Numerical
Predictions
AIRBORNE
NCAR C-130
(and others)
Stratocumulus,
aerosol
SHIP
Ron Brown
(and others)
Ocean eddies, DMS
fluxes
VOCALS-REX
Monitoring
Satellites, Buoys,
Maintenance cruises

VOCALS Timeline



Coupled Ocean-Atmosphere-Land Theme in VOCALS

This theme aims to elucidate the roles that coupling between processes in the atmosphere (e.g., in PBL clouds), ocean (e.g., upwelling, mesoscale eddies) and land (e.g., exchange with the soil) play in determining the physical and chemical characteristics of the upper ocean across the SEP.

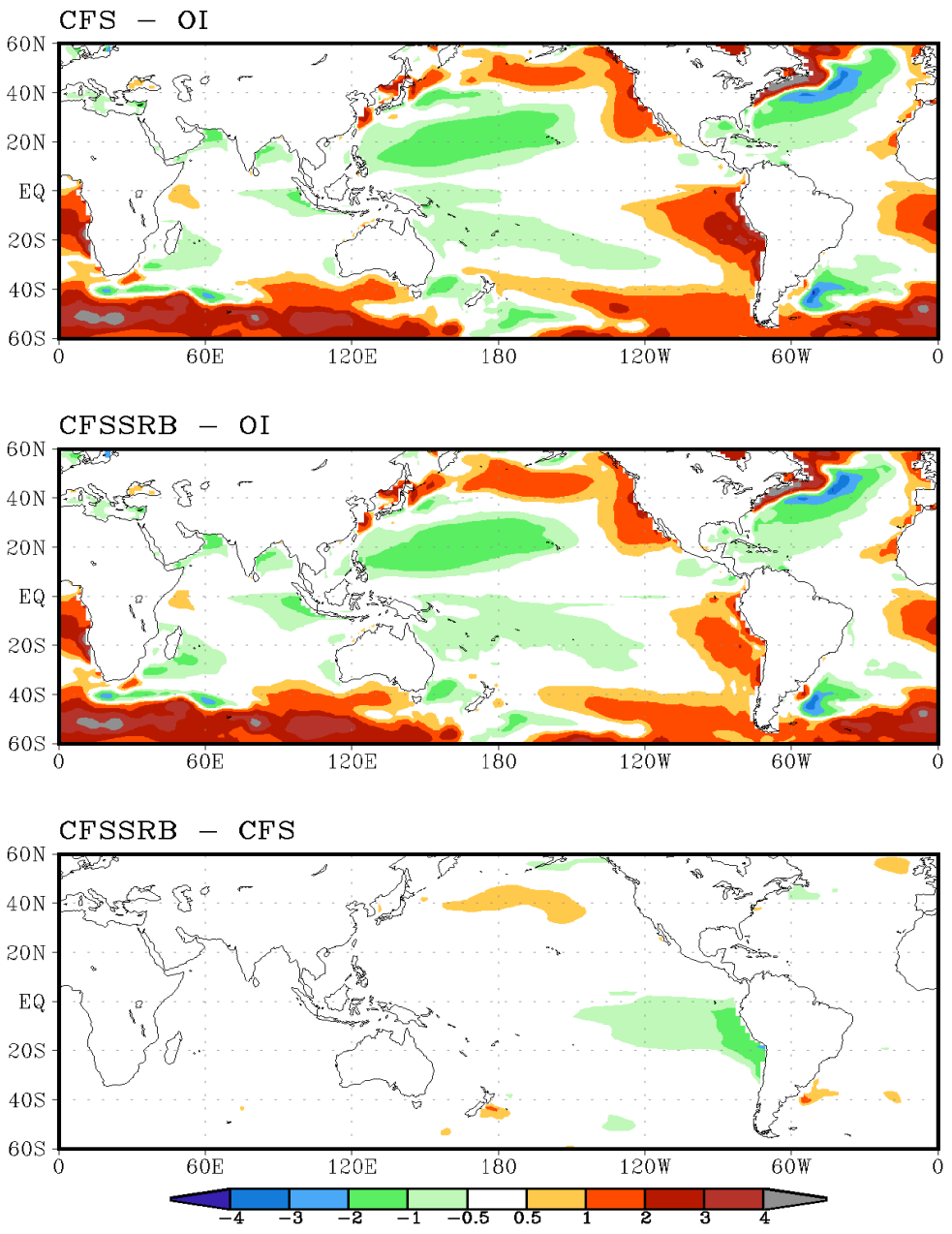
Systematic CGCM errors in the SEP

In the NCEP CFS model, for example, there is a strong warm SST bias over the SEP.

Also, interannual variability is very weak.

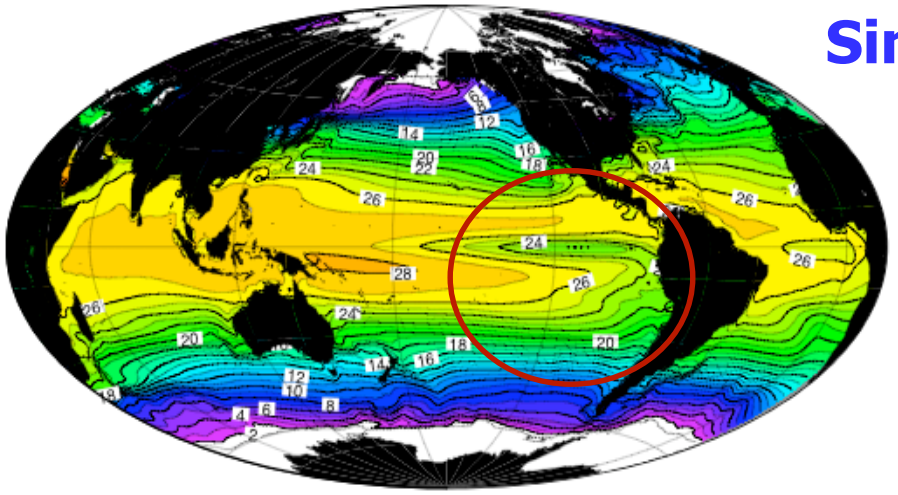
The SST bias isreduced by about half only if radiation at the ocean surface in the region is prescribed from a climatology.

Artificial GCM fixes do not work!



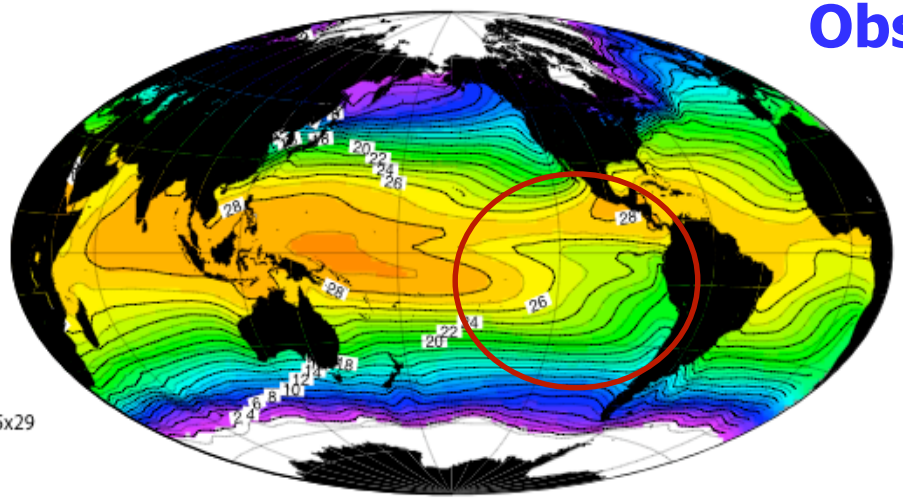
Excessive symmetry about the equator of SST simulated by most CGCMs

Annual Mean SST Simulation



Simulated annual mean SST

Annual Mean SST: Reynolds analysis



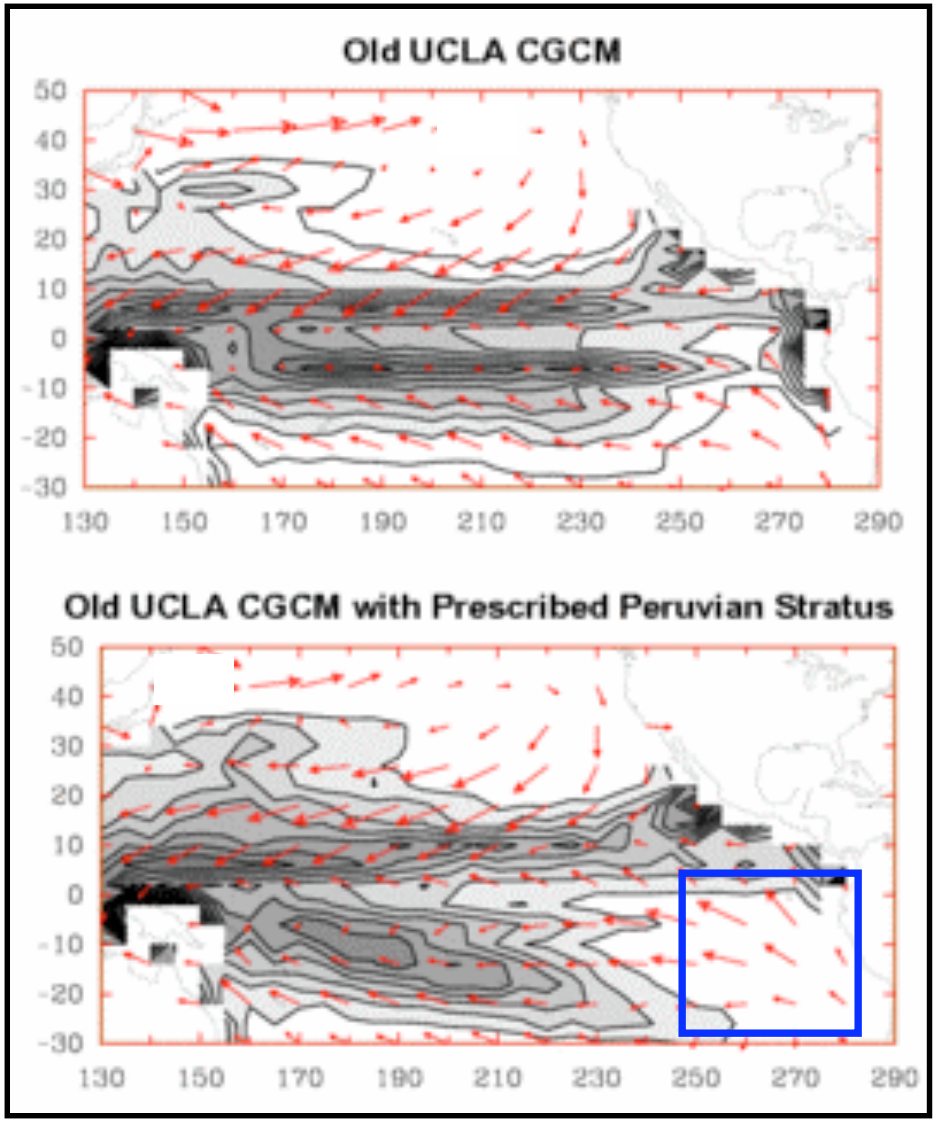
Observed annual mean SST

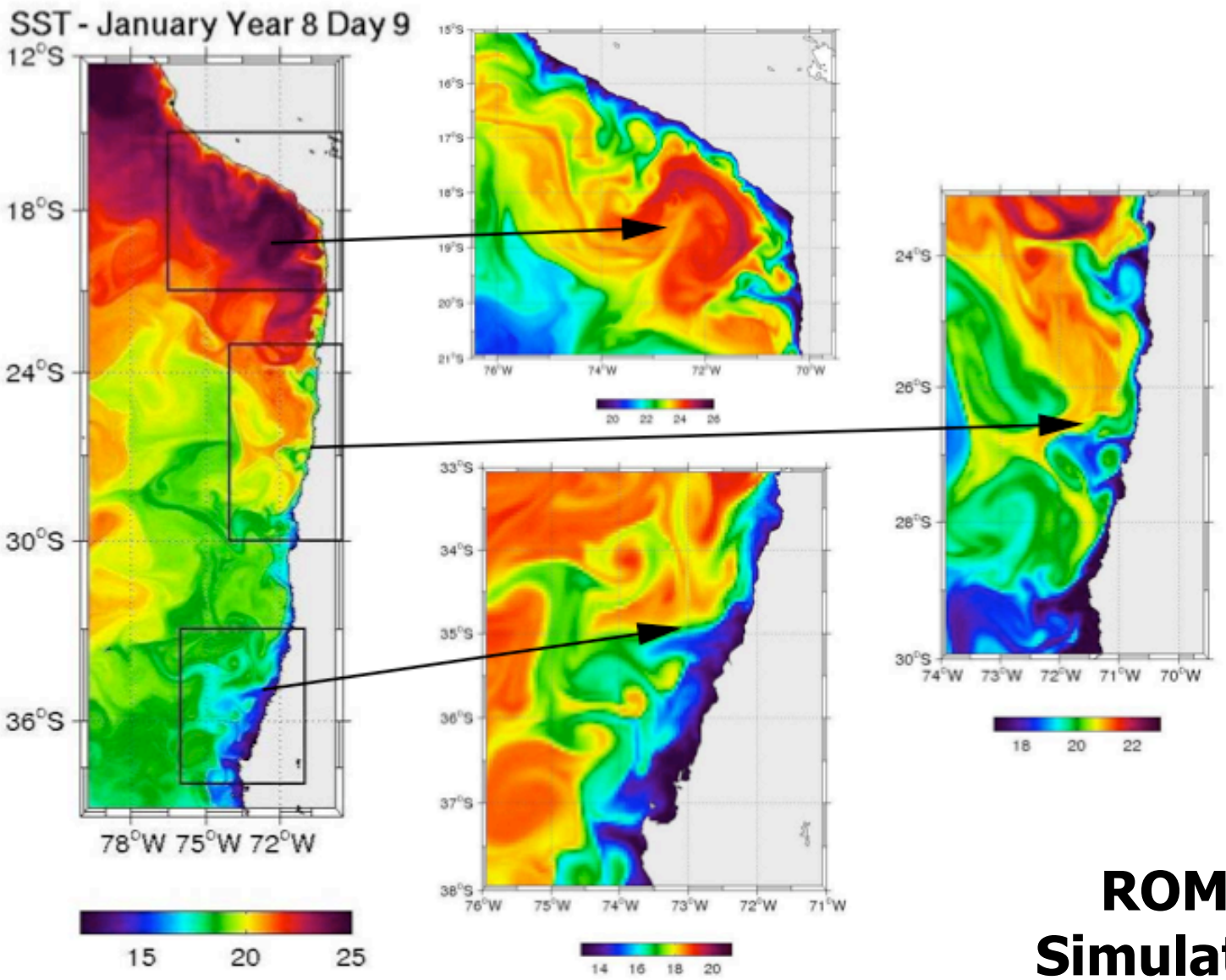
UCLA AGCM 8.0 2x2.5x29
MIT OGCM Global

A coupled problem

- Correct prediction of stratus properties is important for the correct prediction of the climate over the tropical warm pool
- Connections with ITCZ through both ocean and atmosphere

Yu and Mechoso 2001



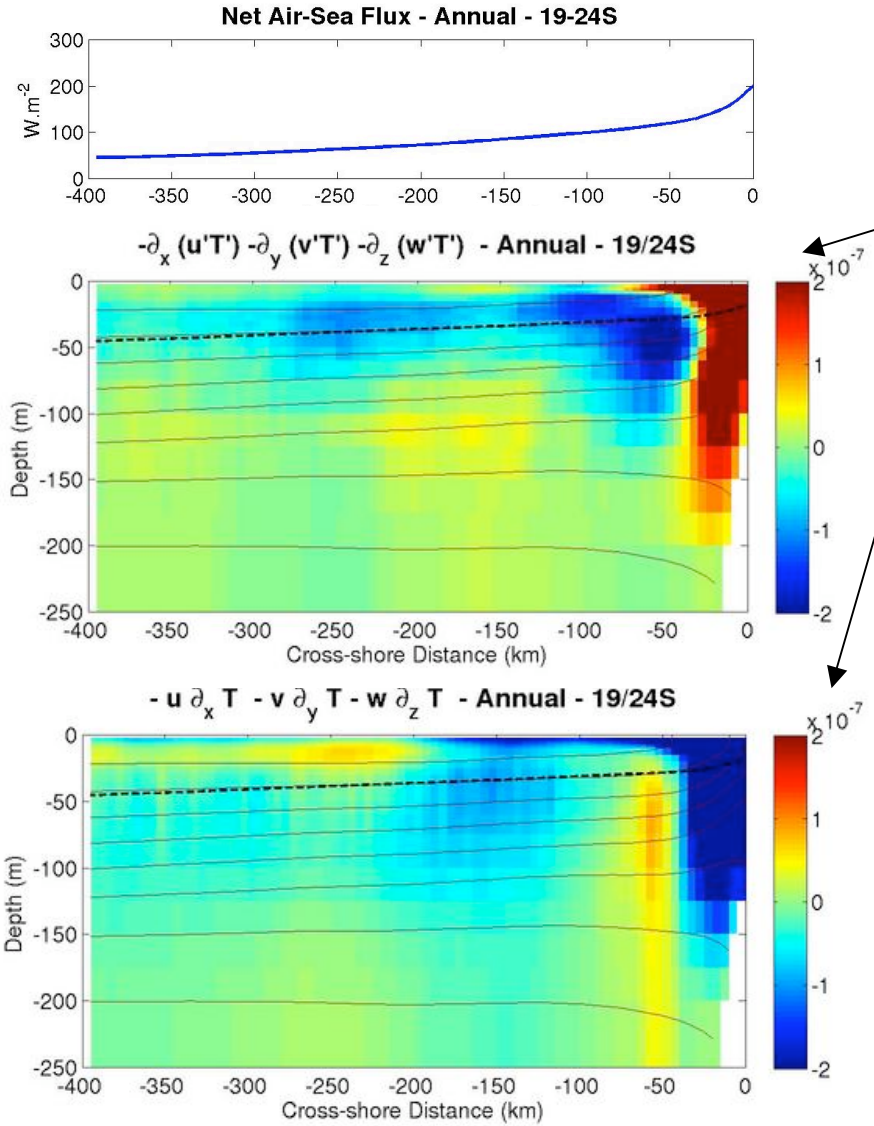


ROMS Simulation

(From J. McWilliams)

Oceanic Heat Balance in the SEP (19S-24S) by a high-resolution ocean model

ROMS, 5kmx5 km, 30 sig-levels, QUIKSCAT winds, COADS F & Q



Heat Budget:

$$-adv_{mean} - adv_{eddy} - diff_{vert} = airsea$$

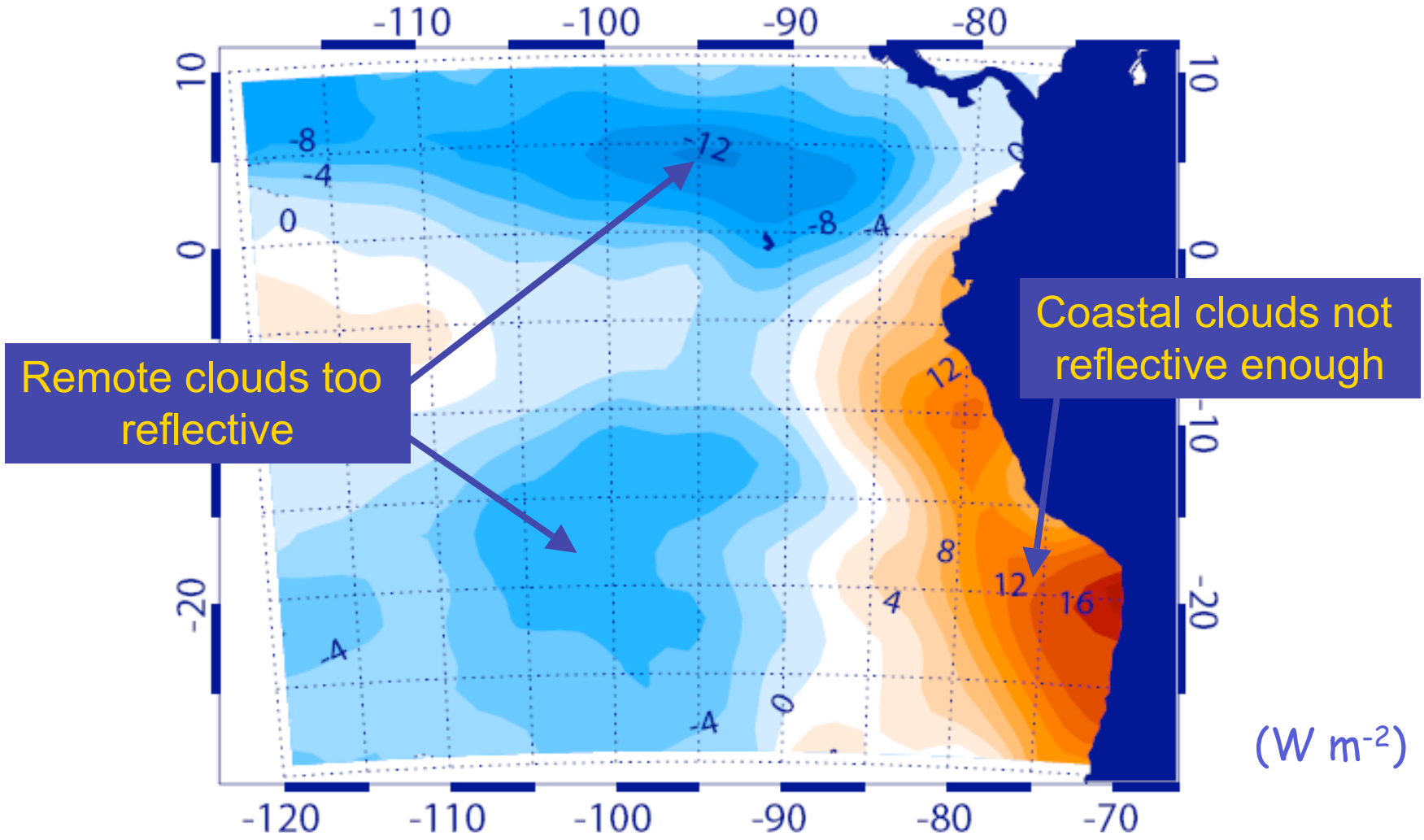
- Net heating by air-sea fluxes over the year
- Cooling needed to balance the airsea heating is provided by:

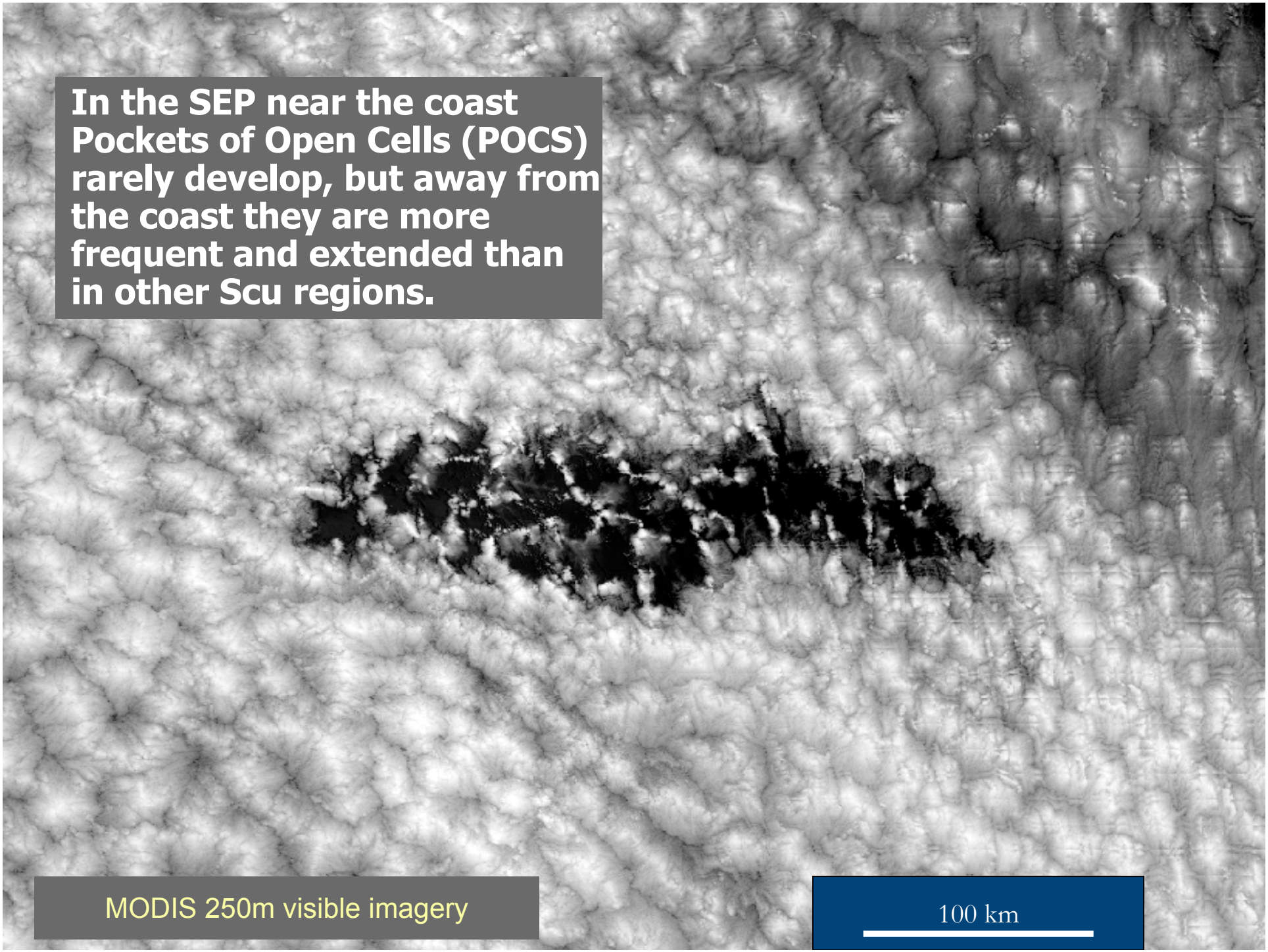
  Nearshore: Mean Advection (upwelling)

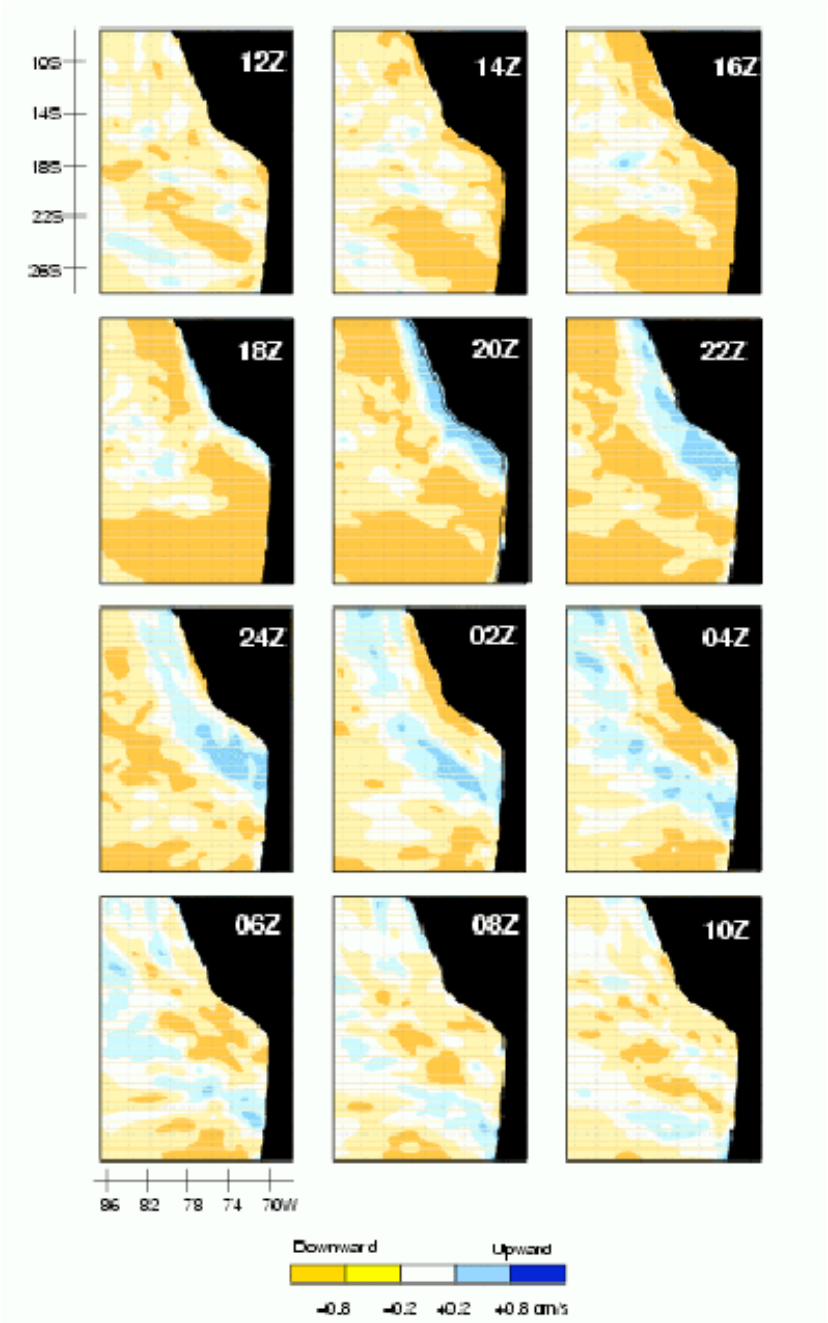
  Offshore : Eddy Advection
- Strong role played by eddies everywhere

(Colas, Capet & McWilliams, 2007)

Error in TOA net SW radiation caused by assumption of constant cloud droplet effective radius




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.
MODIS 250m visible imagery
100 km



Cloudiness and temperature off the coast of northern Chile and Southern Peru show a marked diurnal cycle.

Is this largely caused by a gravity wave generated by land effects (diurnal heating of the Andean slopes) on a very stratified troposphere?

GOALS of VOCALS Modeling

(1) Understanding and reducing the systematic in the eastern tropical Pacific present in most CGCMs.

(2) Using the SEP as a testbed for better simulation of boundary-layer cloud processes and aerosol-cloud interaction.

(3) Improving the understanding and simulation of oceanic budgets of heat, salinity, and nutrients in the SEP and their feedbacks on the regional climate.

(4) Elucidating interactions between the SEP and other parts of the earth's climate system.

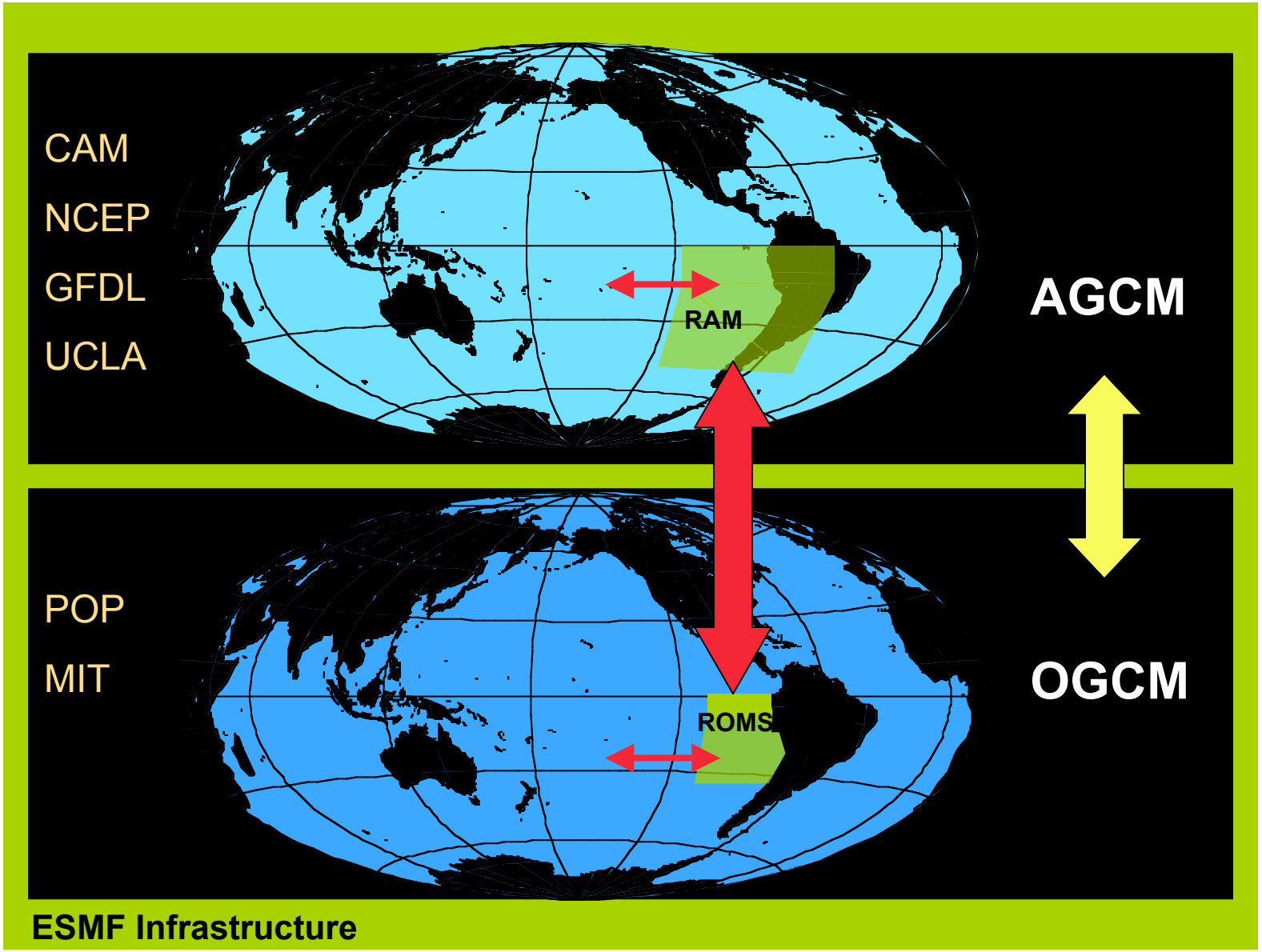
The VOCALS modeling vision is based on the concept of a multiscale hierarchy of models.

AGCM: Atmosphere General Circulation Model

RAM: Regional Atmospheric Model

OGCM: Ocean General Circulation Model

ROM: Regional Ocean Model



Synergy Modeling - REX

In the framework of the Coupled Ocean-Atmosphere-Land Theme of VOCALS, Modeling expects that Rex will provide observations on day-to-week timescales of:

- cloud and boundary-layer properties
- coupled patterns of SEP cloud-topped boundary-layer, wind and SST (upwelling and eddies)
- formation and maintenance of pockets of open cells (POCs)

The data gathered by REX will be used to validate several hypotheses.

Hypotheses

[H2a] Oceanic mesoscale eddies play a major role in the transport of heat and fresh water from coastally upwelled water to regions further offshore.

[H2b] Upwelling, by changing the physical and chemical properties of the upper ocean, has a systematic and noticeable effect on aerosol precursor gases and the aerosol size distribution in the MBL over the SEP.

[H2c] The diurnal subsidence wave ("upsidence wave") originating in northern Chile/southern Peru has an impact upon the diurnal cycle of clouds that is well-represented in numerical models.

[H2d] The entrainment of cool fresh intermediate water from below the surface layer during mixing associated with energetic near-inertial oscillations generated by transients in the magnitude of the trade winds is an important process to maintain heat and salt balance of the surface layer of the ocean in the SEP.