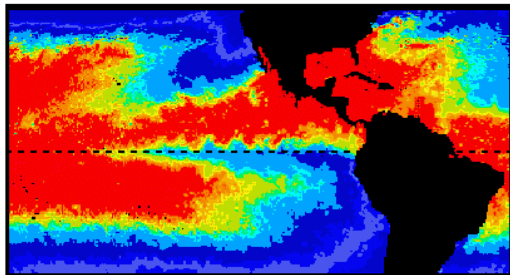
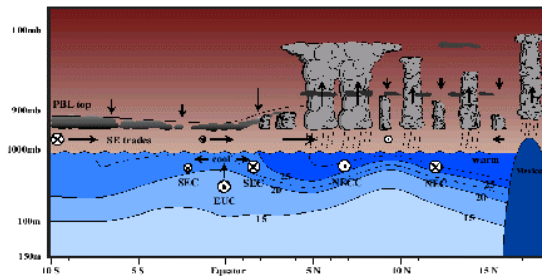


Eastern Pacific Investigation of Climate (EPIC)

A Science and Implementation Plan for EPIC:
An Eastern Pacific Investigation of Climate Processes
in the Coupled Ocean-Atmosphere System



Scientific Objectives:

(1) To observe and understand the ocean-atmosphere processes responsible for the structure and evolution of the large-scale atmospheric heating gradients in the equatorial and northeastern Pacific portions of the cold-tongue/ITCZ complex.

(2) To observe and understand the dynamical, radiative and microphysical properties of the extensive boundary layer cloud decks in the southeasterly tradewind and cross-equatorial flow regime and their interactions with the ocean below.

<http://www.atmos.washington.edu/gcg/EPIC/>

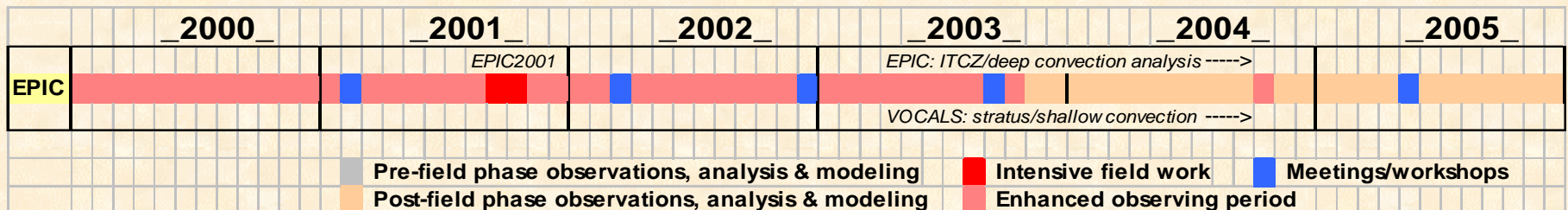
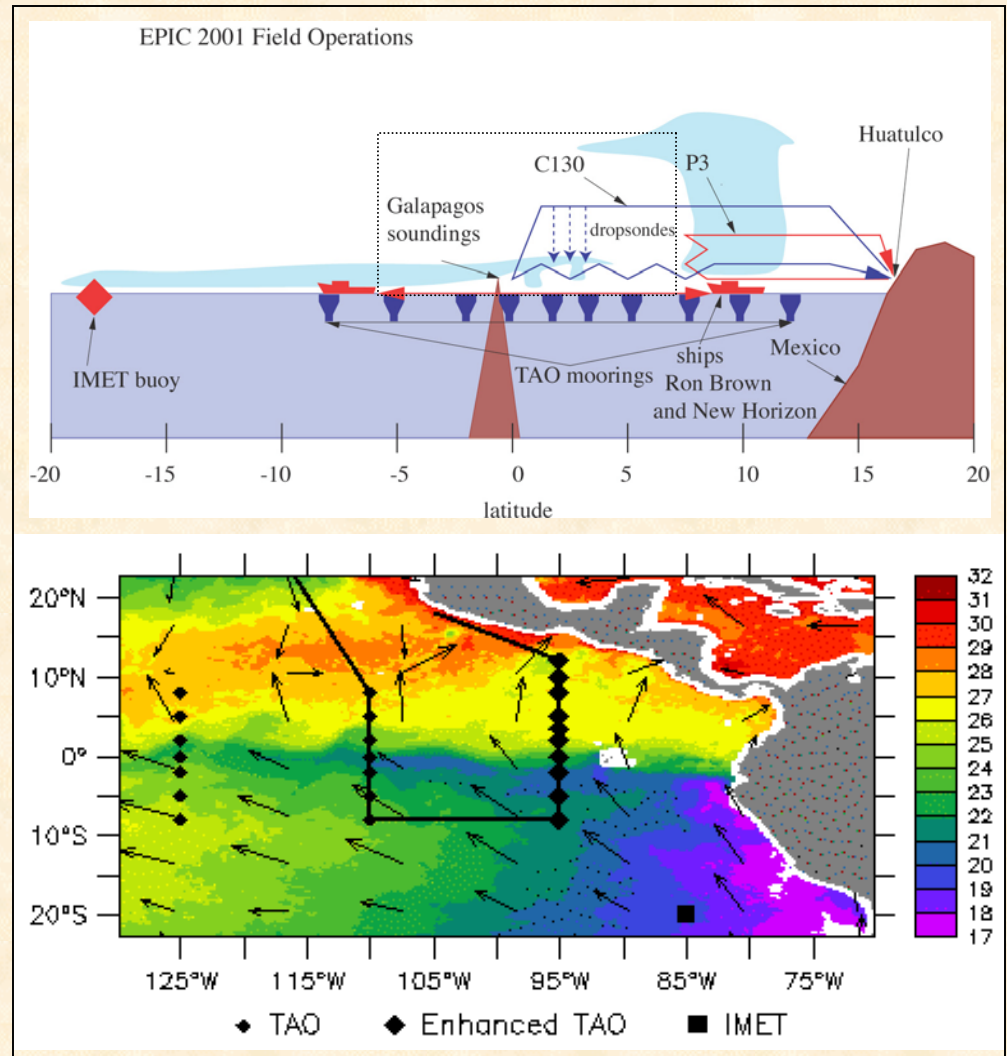
Also see:

<http://www.physics.ntm.edu/~raymond/epic2001/epic2001.html>

<http://www.joss.ucar.edu/epic/>

EPIC Field Program

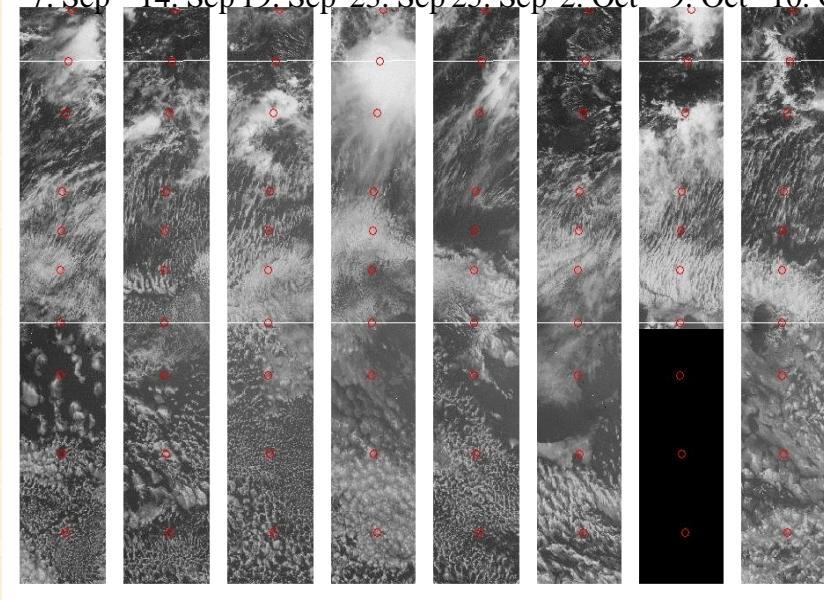
EPIC2001 was a 2-month intensive process study, embedded in 4-years of enhanced monitoring, built on the ENSO observing system.



EPIC is leading to improved understanding of the cold tongue / ITCZ complex

GOES channel 1 (VIS) images for EPIC 95W flights

RF03 RF06 RF08 RF10 RF11 RF14 RF18 RF19
 7. Sep 14. Sep 19. Sep 23. Sep 25. Sep 2. Oct 9. Oct 10. Oct

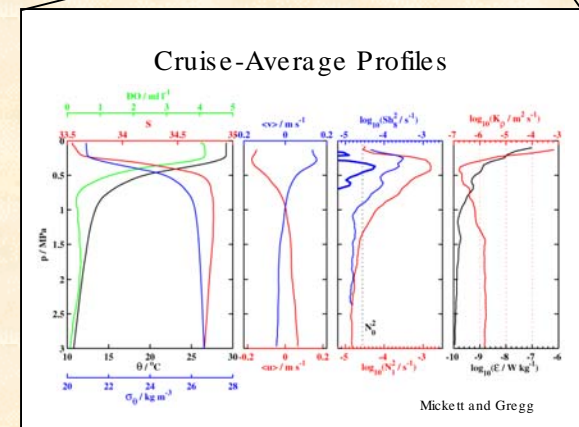
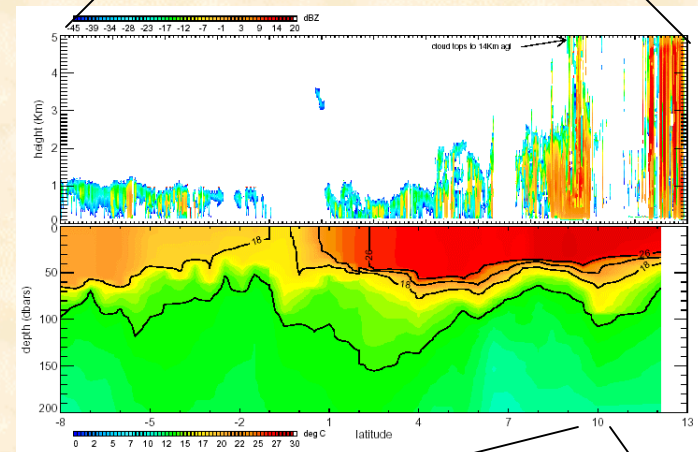
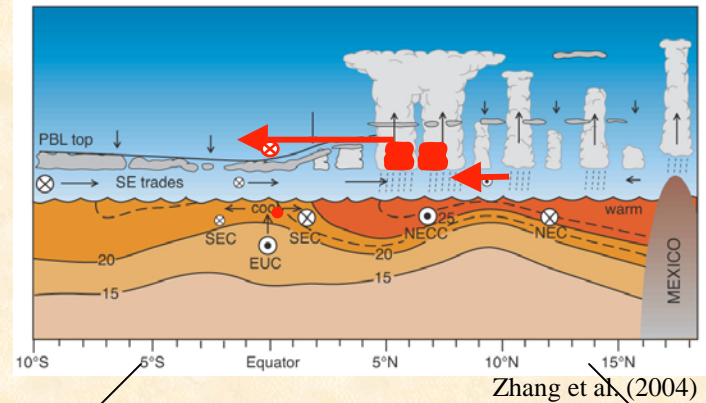


deSzoeko et al. (2004)

10N

EQ

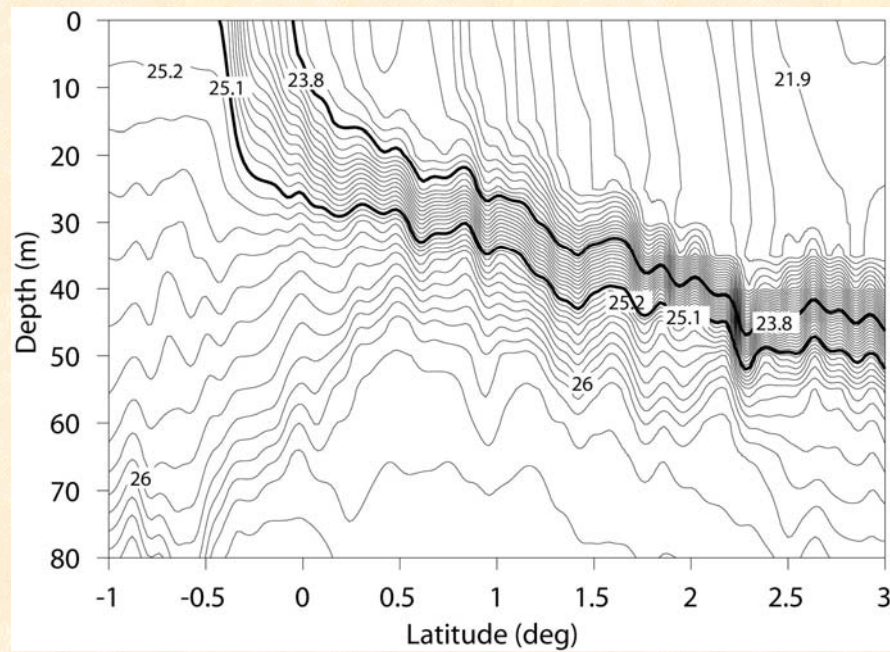
10S



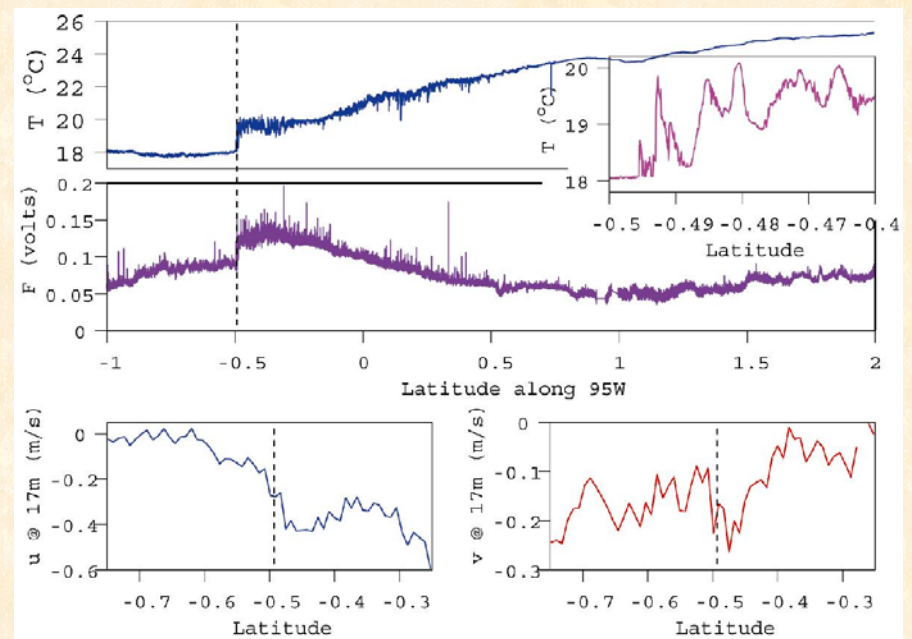
EPIC studies shown here include: shallow meridional wind circulation, cloud processes, frontal dynamics, and oceanic mixing beneath the ITCZ

High resolution EPIC2001 observations reveal an extraordinarily sharp cold tongue front, with SST and SSS changes of 1.7C & 0.2 psu over less than 1 km.

N → S Crossing along 95W: Density



S → N: T, Fluorescence, and velocity

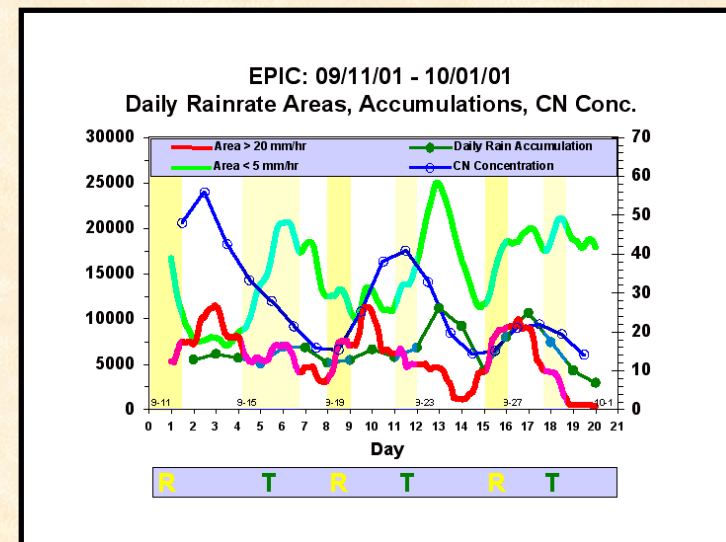
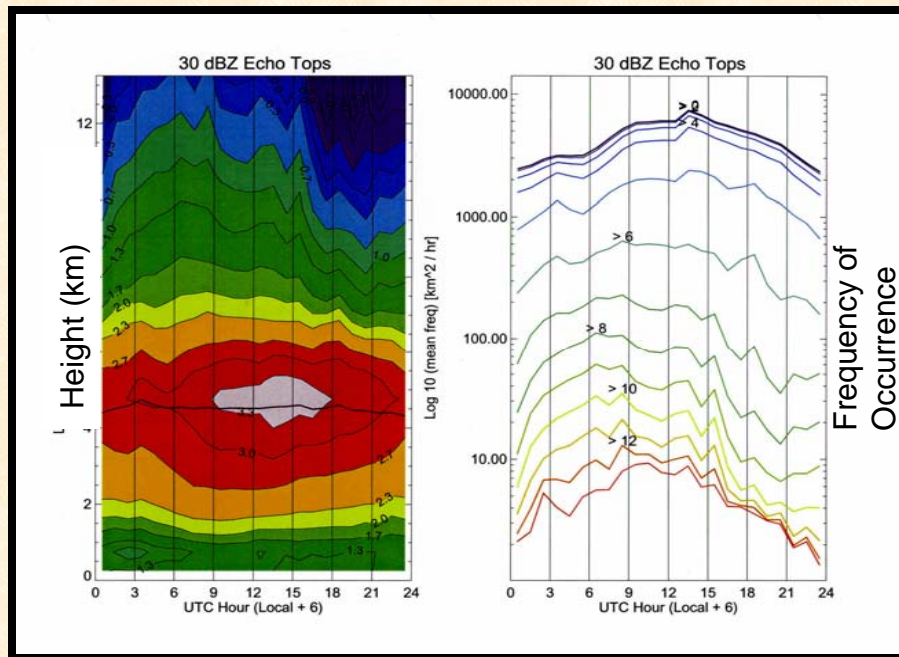


Rudnick et al. (2005)

Scanning radar studies have provided unprecedented observations of east Pacific ITCZ convection

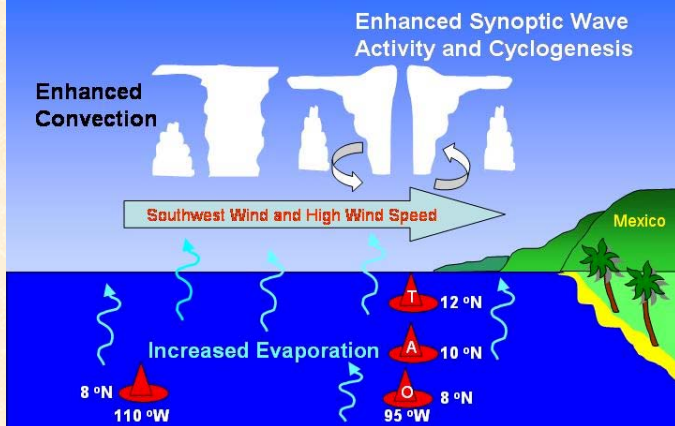
Diurnal cycle characteristics:
The most intense convection peaks in the early morning (~02L)

Rainfall relative to Easterly Wave forcing: heaviest rain and deepest convection occurs ahead of the wave trough (T)

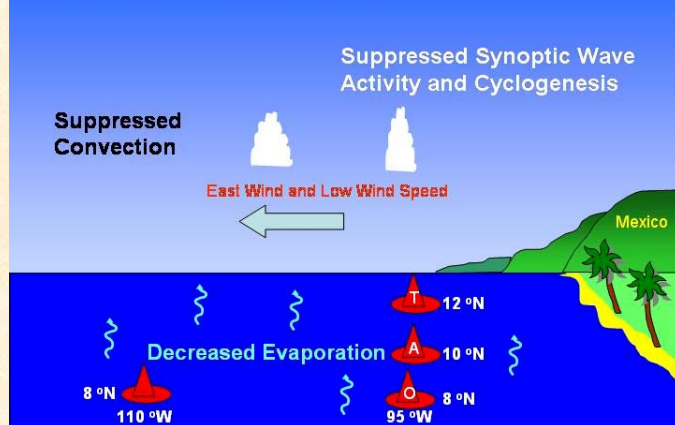


EPIC is helping us understand intraseasonal oscillations that modulate the North American monsoon and hurricanes

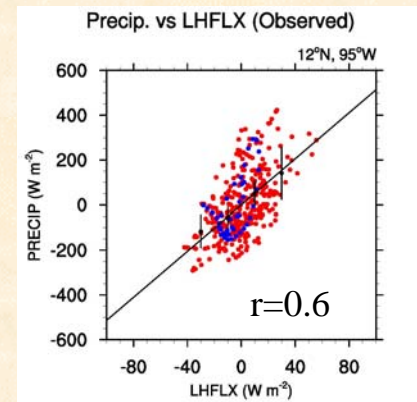
West Wind Phase of the Madden - Julian Oscillation



East Wind Phase of the Madden - Julian Oscillation

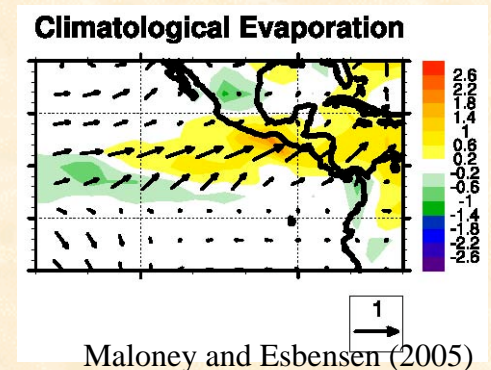
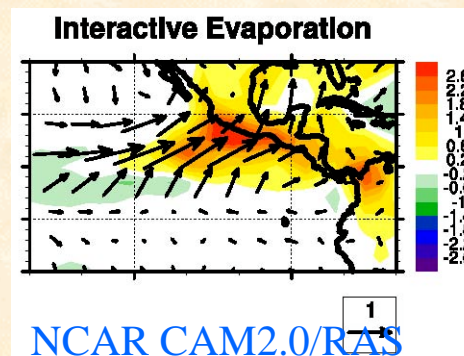


The enhanced TAO array shows a strong correlation between intraseasonal precipitation and surface evaporation anomalies

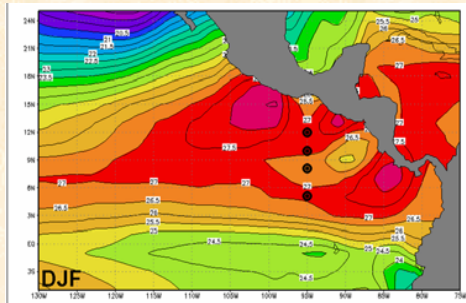


Two climate model simulations where wind-evaporation feedback 1) operates and 2) does not operate demonstrate that these evaporation anomalies support intraseasonal precipitation and surface winds anomalies.

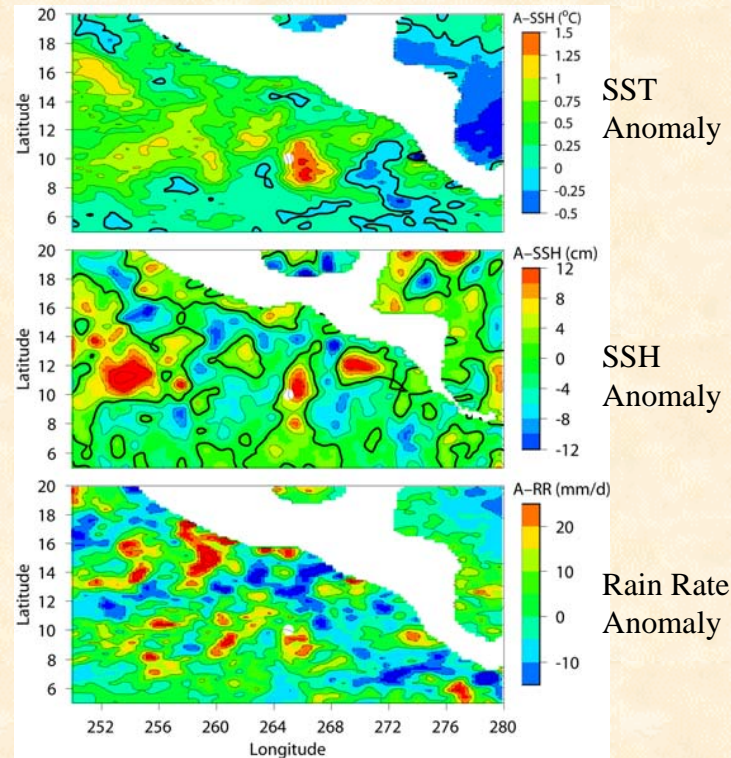
Composite Model MJO Event (Westerly Phase)



In situ and satellite observations show enhanced convection/rainfall over warm anticyclonic eddies



East Pacific Warm Pool SST



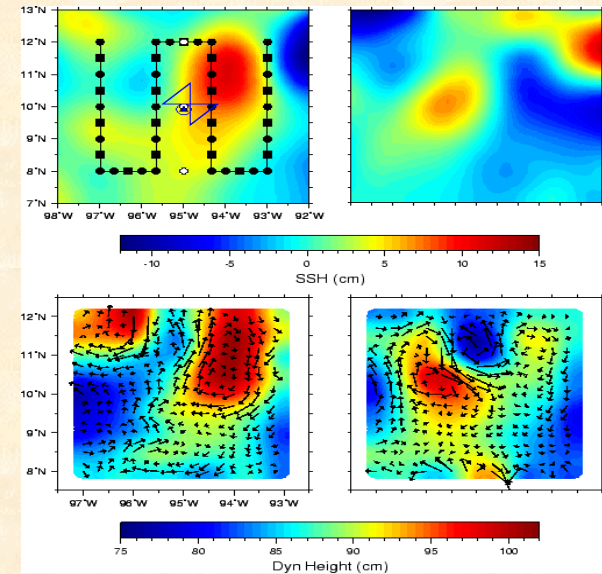
SST Anomaly

SSH Anomaly

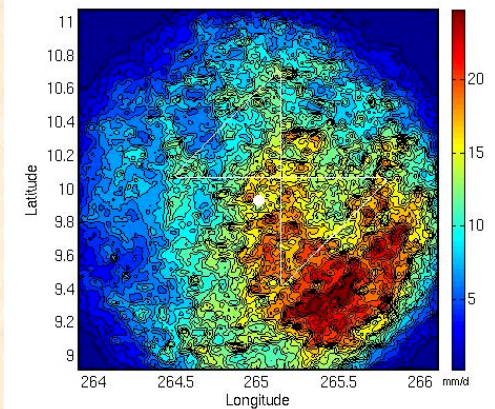
Rain Rate Anomaly

Rainfall from C-Band Radar strongly correlates with warm SST anomaly and positive SSH anomaly

Sep 2001 Oct 2001

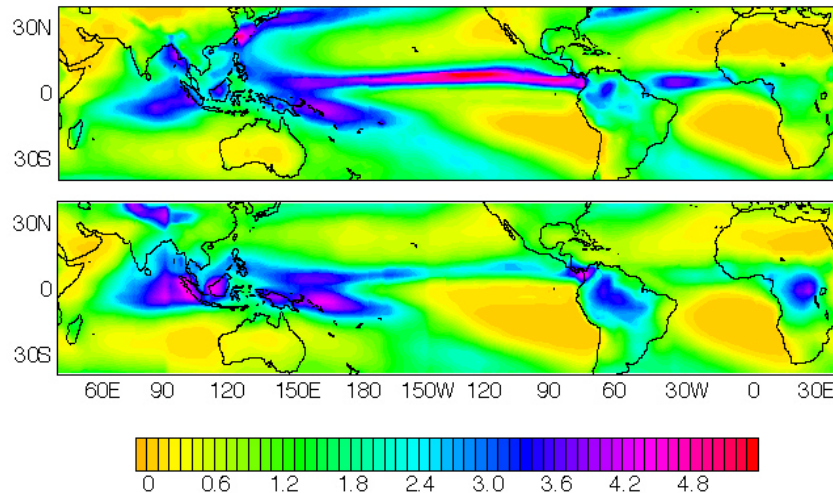


EPIC2001 surveys of eddy field will lead to better understanding of the oceanic processes that help organize convection.

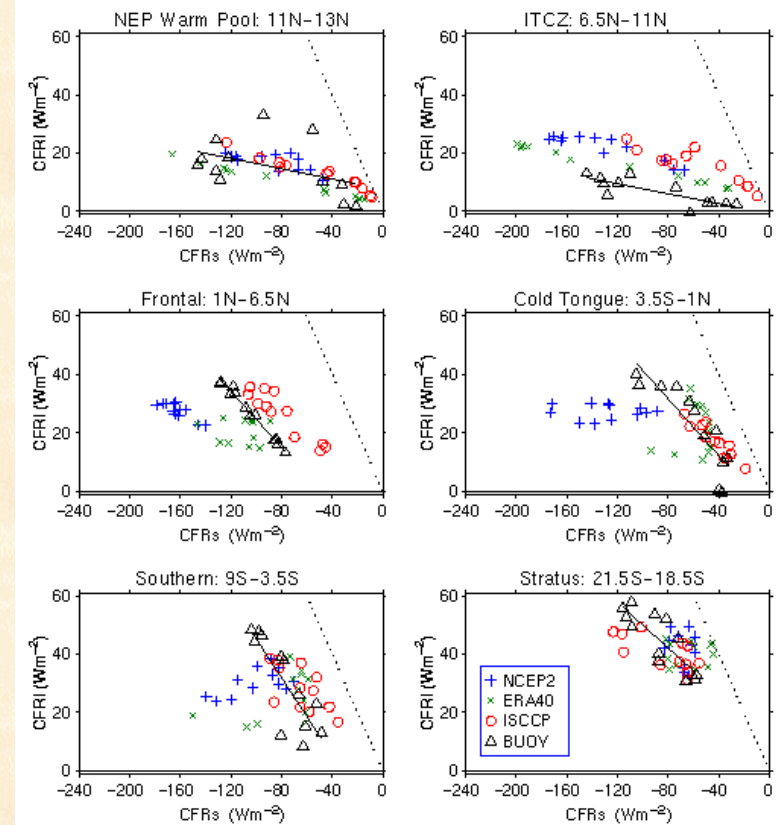


EPIC has provided benchmark data sets for evaluating model and numerical weather products and satellite fields

Satellite precipitation products evaluated with in-situ radar data, increased confidence in microwave retrievals (top panel) versus infrared measurements (bottom panel)



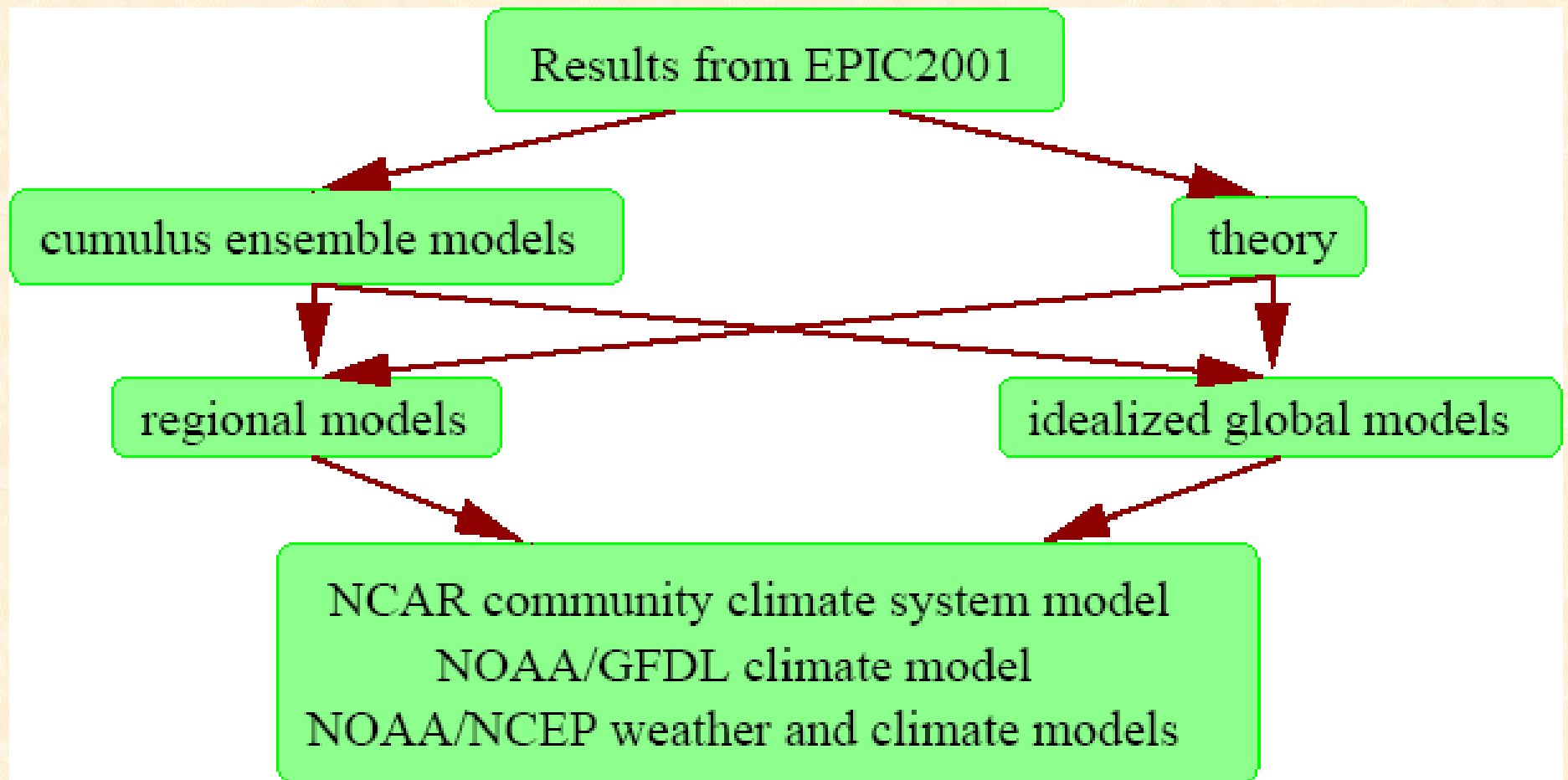
Yuter and Houze (2000)



Cronin et al. (2005)

Biases in cloud forcing products are consistent with a cold tongue which is too cold and a stratus region which is too warm

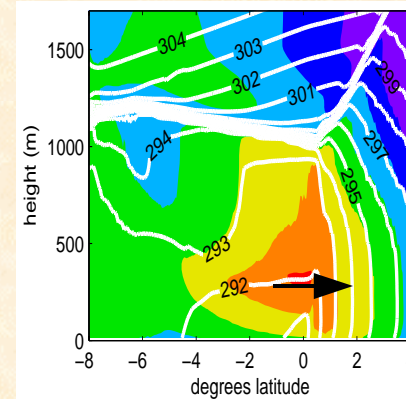
Improvement in weather and climate forecasts will proceed through a hierarchy of EPIC theoretical and modeling efforts



EPIC data are being used to assess a hierarchy of models

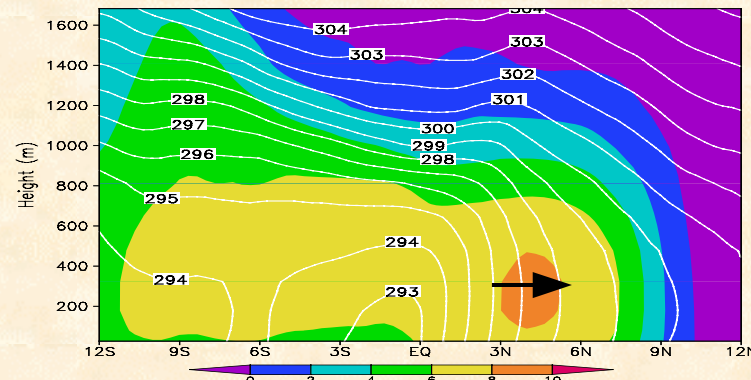
The Regional Climate Model (RCM) reproduces the location of the wind maximum better than the Large Eddy Simulation (LES) because the LES pressure gradient is specified coarsely by NCEP reanalysis. Boundary layer temperature advection is an important mechanism for generating realistic wind fields.

Potential temperature (K) and meridional wind (m s^{-1} , shaded) along 95°W



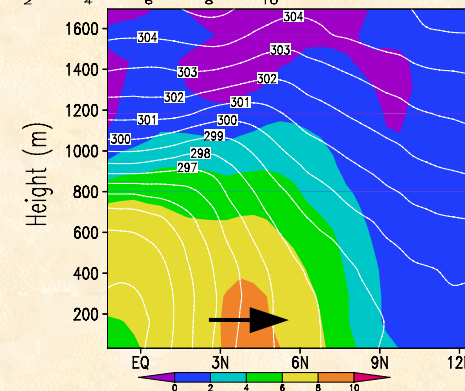
LES

(de Szoeke and Bretherton, 2004)



RCM

(Small et al., 2004)

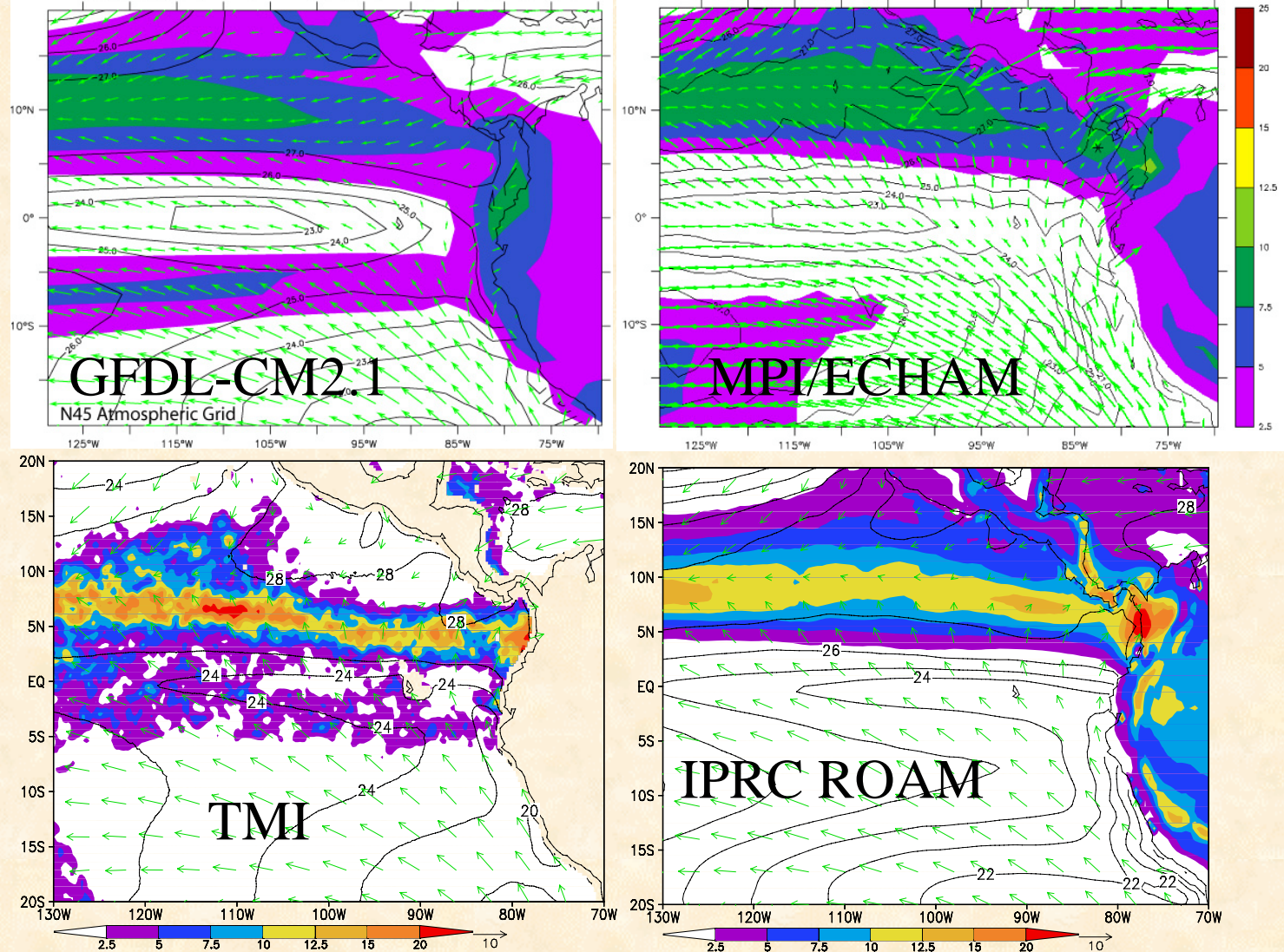


EPIC
2001

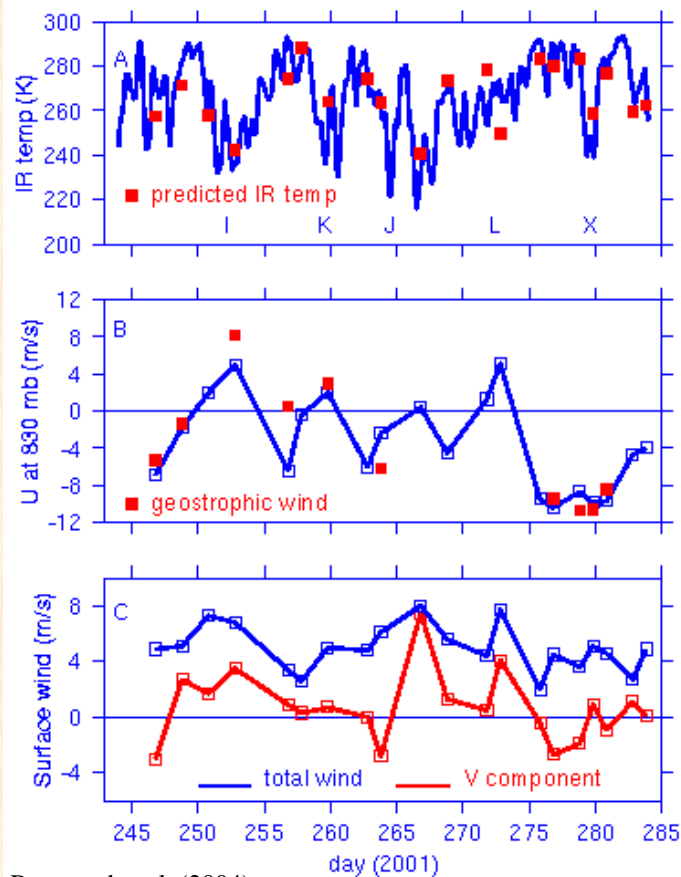
Regional climate models have been developed to explore biases seen in Global climate models

SST ($^{\circ}\text{C}$) contours, wind vectors, and precipitation (mm/day color)

COUPLED MODELING: State of the art global coupled models (top panels) exhibit biases in the mean state such as a double ITCZ and west-shifted cold tongue, when compared to TMI satellite observations (bottom left). One way to explore whether these biases arise from local or global processes is to construct a regional coupled model forced at the lateral boundaries with prescribed data. Preliminary investigations with a regional model (bottom right) show a significant reduction in bias.

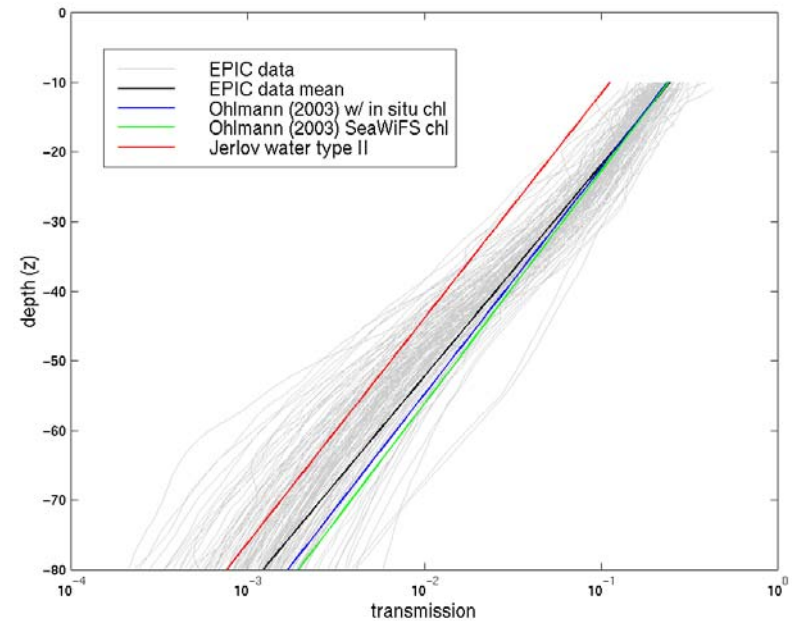


EPIC is leading to new parameterizations and improved general circulation models of the eastern tropical Pacific

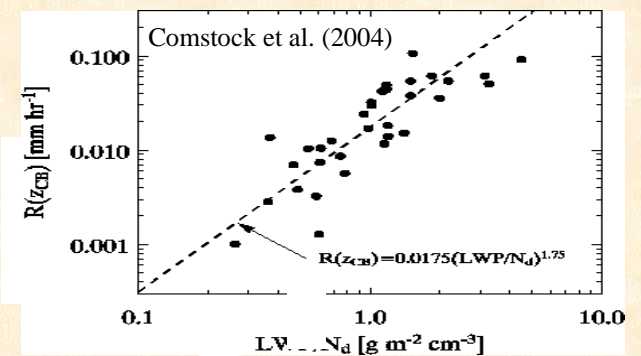


Raymond et al. (2004)

Infrared brightness temperature can be predicted based on surface wind speed and convective inhibition



Chlorophyll based parameterization of solar transmission has been implemented in NCAR CCM and is superior to Jerlov type.



Derived formula for cloud base drizzle rate useful for GCMs

EPIC2001 Stratocumulus Cruise exploration of SE Pacific stratus

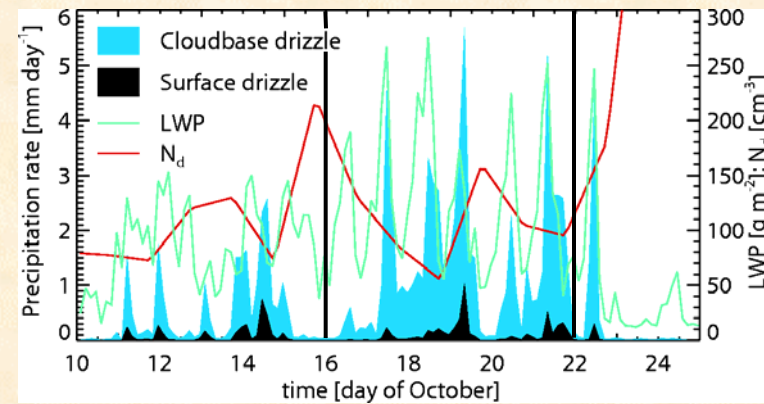
Surface mooring with 1-year turn-around
starting October 2000

Meteorology: Wind spd and dir, air temp, SST, RH, BP, incoming
SW and LW, precipitation. Two systems. Sampling: 1 minute

Ocean: Temperature, salinity, velocity in the upper 400 m, most
above 250m. Sampling: 7.5 to 60 minutes

Telemetry: Hourly surface met, not on GTS.

Weller et al.

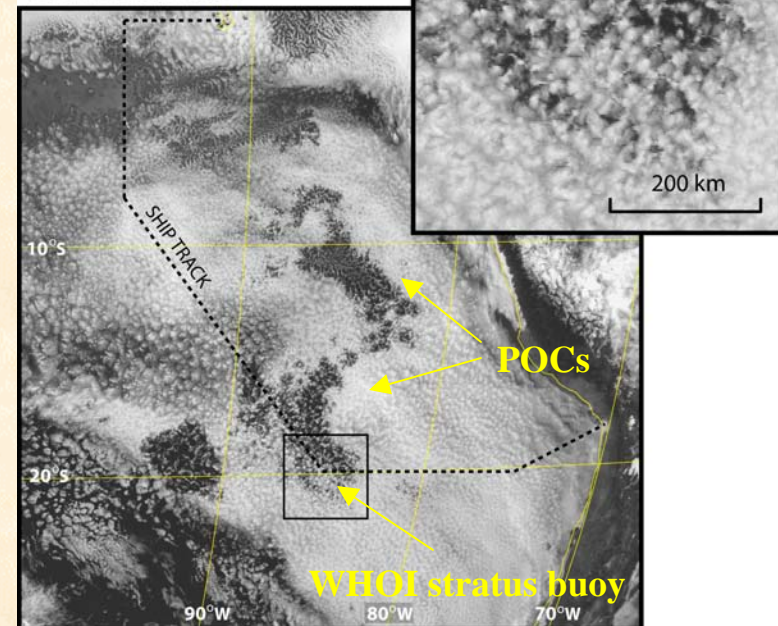


Issues: Control of cloud fraction, albedo

Findings:

- Extensive evaporating drizzle drives low-albedo patches of open cellular cloud (POCs) in aerosol-poor air masses.
- Strong diurnal cycle of cloud thickness amplified by Andes-induced subsidence wave

GOES-10 VISIBLE IMAGE AND DETAIL
October 17 2001, 15:00 UTC



EPIC Deliverables

- Integrated data sets:
 - 95W cross-section during EPIC2001 (Bretherton)
 - Seasonal cycle along 95W and 110W (Fairall/Cronin)
 - Warm Pool (Shay) / ITCZ (Bretherton)
 - Stratocumulus (Bretherton)
- Improvements to cumulus and cloud topped boundary layer parameterizations
- Tests and validations of NWP, GCMs and satellite products

EPIC Activities

- Describe and quantify physical processes controlling the coupled climate system of Eastern Pacific
 - Space-time variability of deep convection and coupling to underlying ocean-- diurnal cycle, easterly waves, MJO, seasonal cycle, North American monsoon, ENSO
 - Feedbacks between stratocumulus boundary layer, lateral eddy transports and upper ocean heat balance (VOCALS)
 - Warm Pool ocean eddies and relation to convection
 - Dynamics and thermodynamics of cold tongue front and feedbacks with PBL
 - Entrainment and fluxes across base of ocean mixed layer
- Test and improve parameterizations
 - Oceanic solar transmission profiles (Ohlmann, Ragu)
 - Stratocumulus drizzle and entrainment (VOCALS)
 - Deep convection and precipitation (Mapes, Bretherton, Raymond)
 - Ocean mixing (PUMP)
 - Air-sea fluxes
 - Sub-resolution frontal dynamics
- Verify and validate model and satellite products
 - Precipitation (Fairall, Serra, ...)
 - Vertical microphysical profiles of clouds
 - Surface energy budget components
 - Easterly wave structure
 - Coupled ocean atmosphere structure across stratus deck/cold tongue/ITCZ complex
 - East Pacific Warm Pool eddy field
- Improve skill of SI forecast

Roadmap for EPIC

- Support continued and new EPIC empirical and model analyses
- Foster connections between modelers and observationalist (joint workshops, CPTs, ...)
- Foster connections between NAME and EPIC ITCZ work
- Support continued research on stratus deck region through VOCALS
- Support research on cold tongue dynamics/thermodynamics through PUMP

