The Monsoon Systems of the Americas

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with
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Motivation

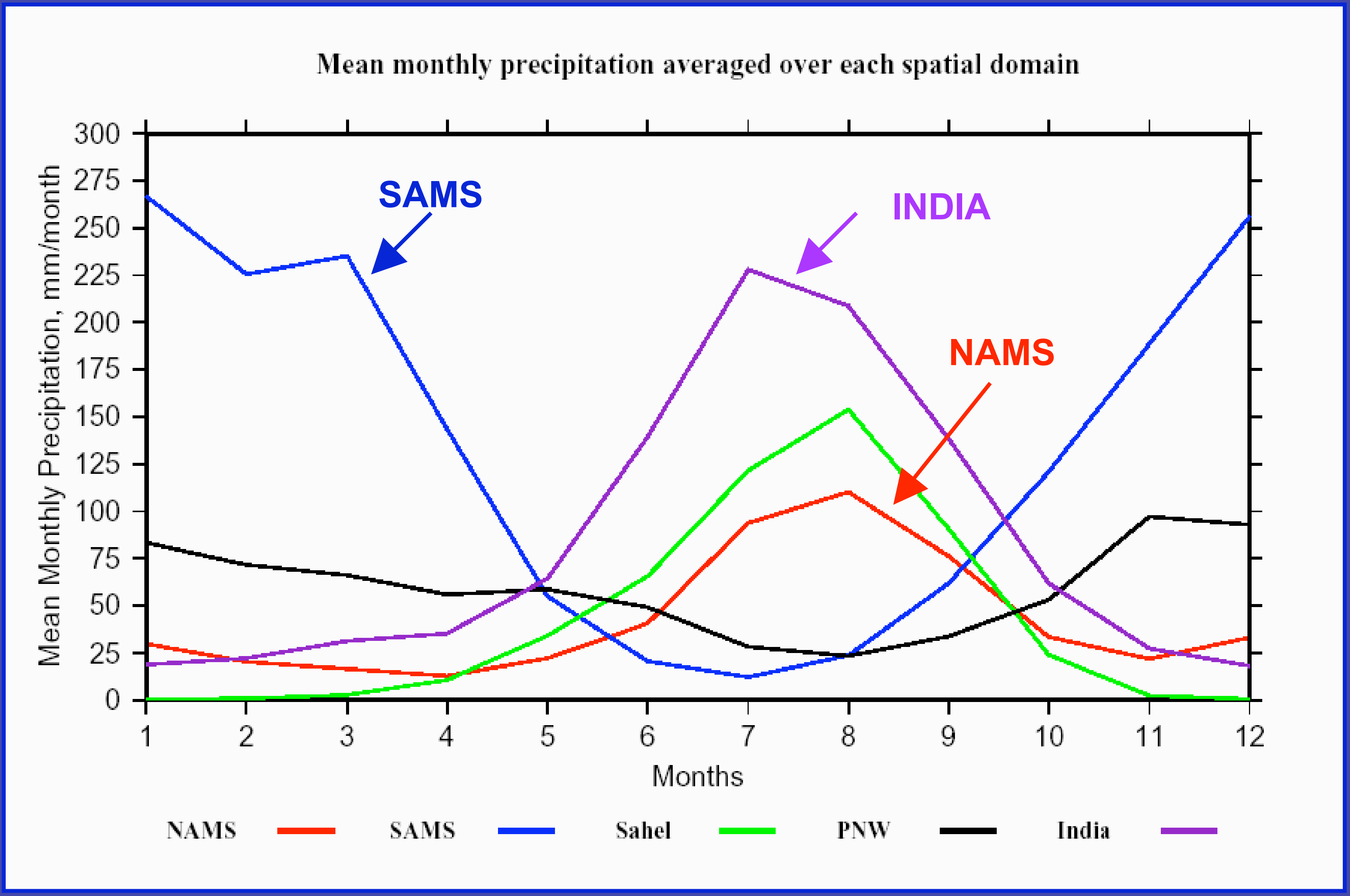
Objectives

1) to understand the key components of the American monsoon systems and their variability;
2) to determine the role of these systems in the global water cycle;
3) to improve observational data sets; and
4) to improve simulation and monthly-to-seasonal prediction of the monsoons and regional water resources.

Organization

- Basic Features
- Diurnal modulation and mesoscale variability
- Synoptic variability
- Intraseasonal variability
- Interannual variability
- Variability in decadal (and longer) timescales
- Land surface variations in the American Monsoon systems
- Monsoon Hydrology
- Future Challenges

Basic Features

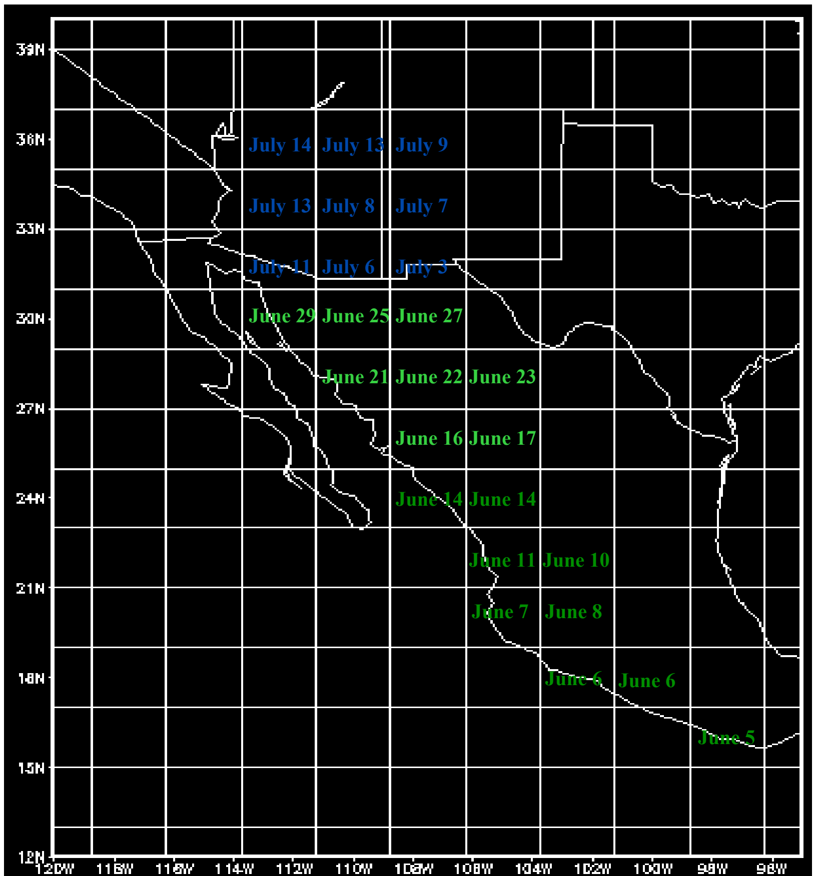


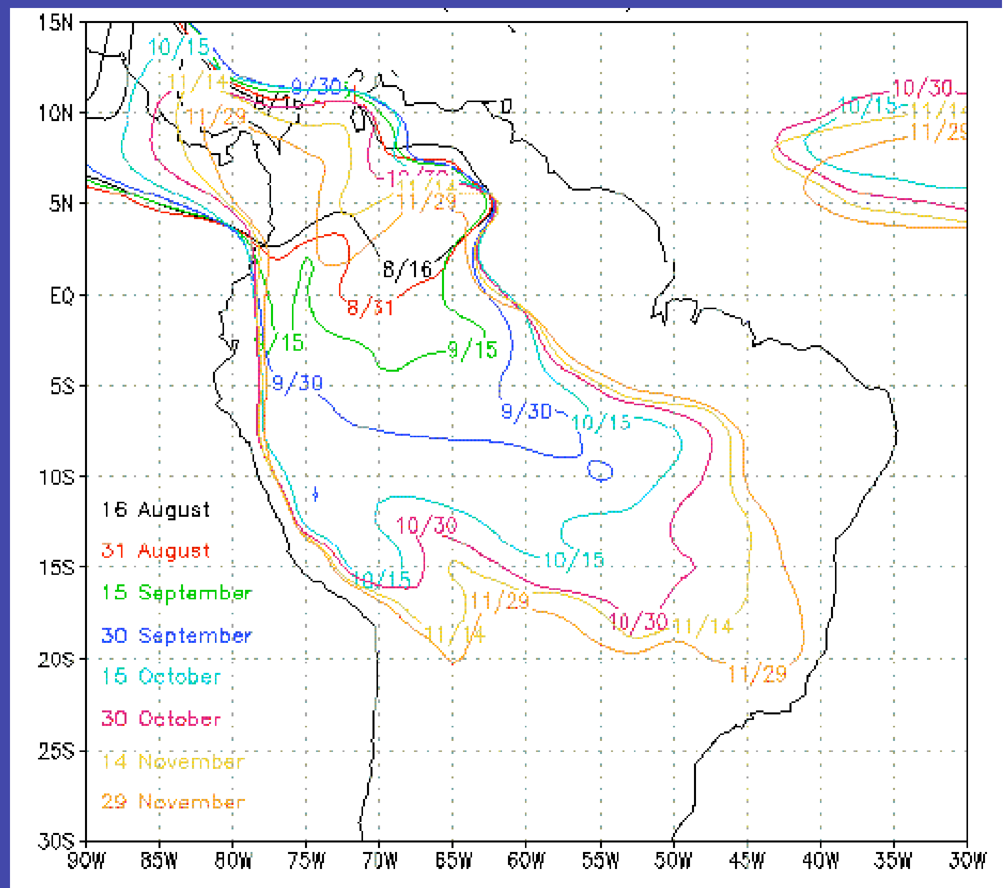
Monsoon Onset

North American Monsoon System (NAMS)

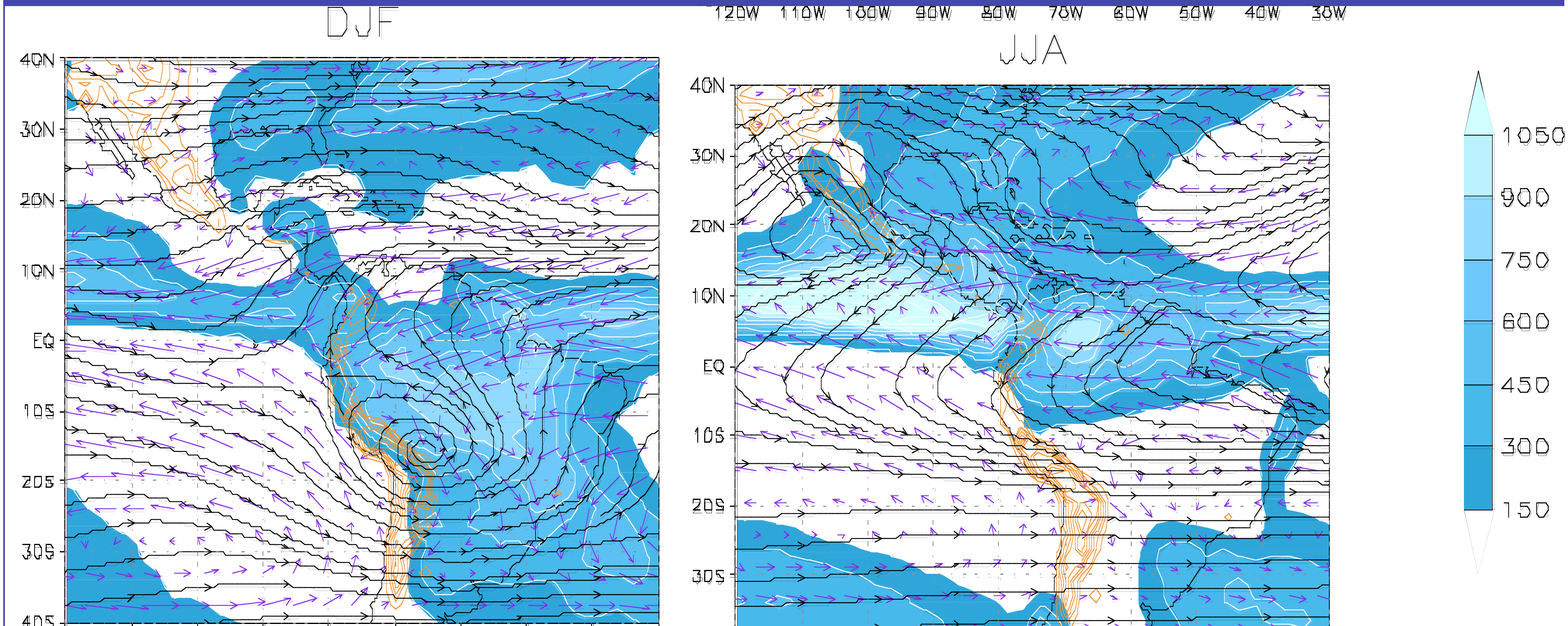
South American Monsoon System (SAMS)

(Courtesy V. Kousky)





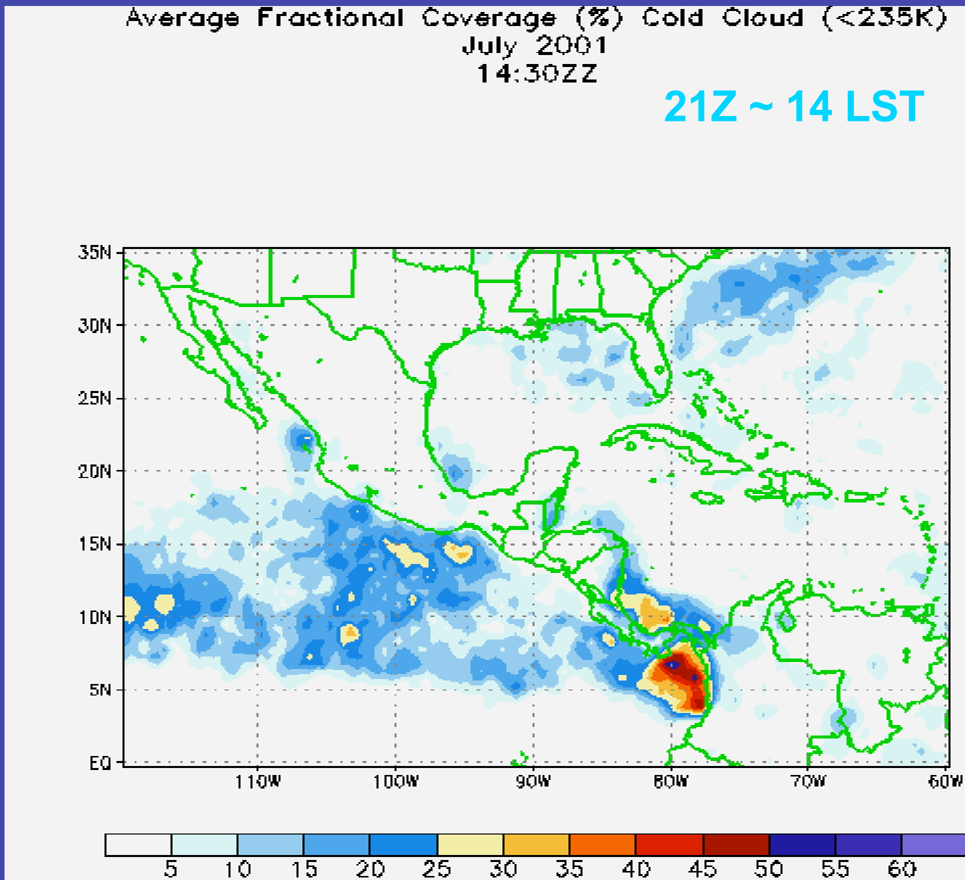
Monsoon mature phase



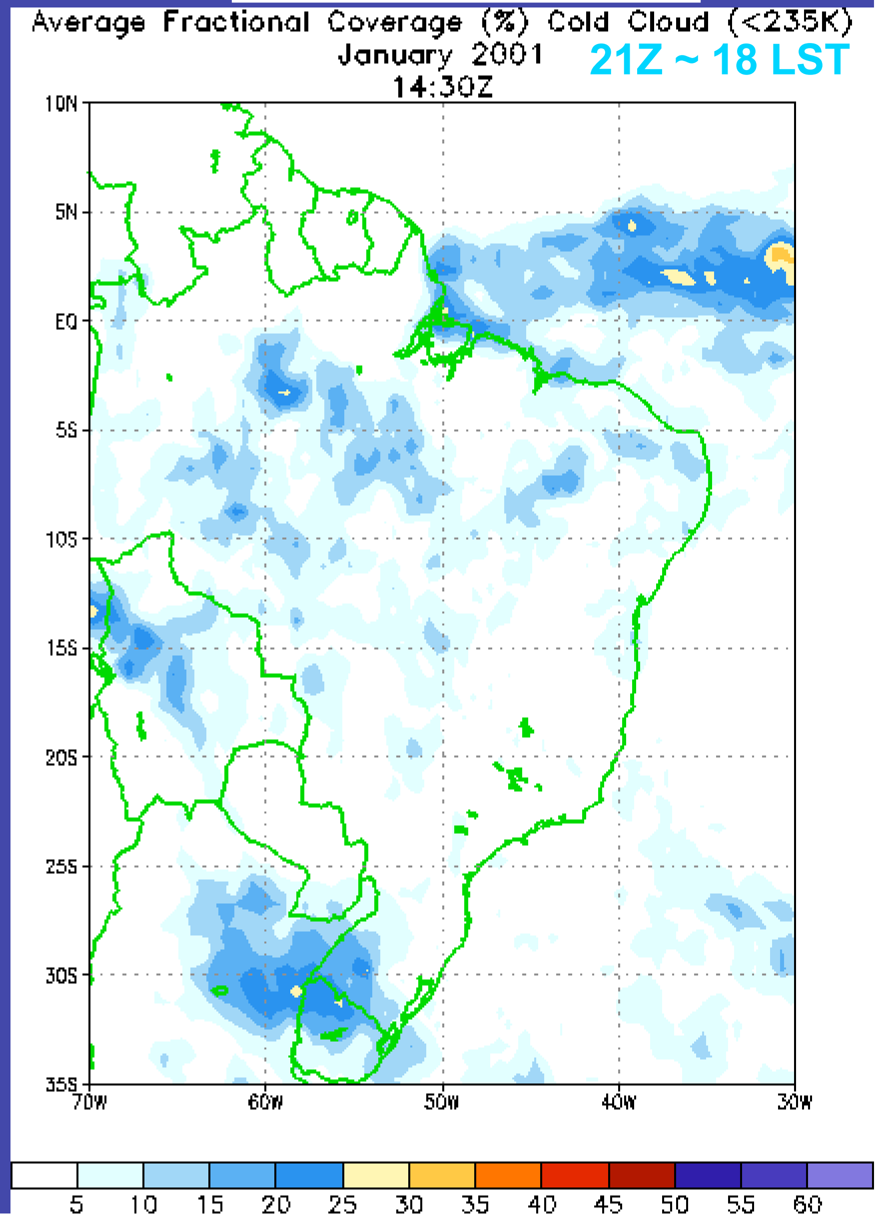
Climatological seasonal mean precipitation (shaded), 200-hPa streamlines (black contours) & vertically integrated moisture fluxes (arrows)

Diurnal cycle

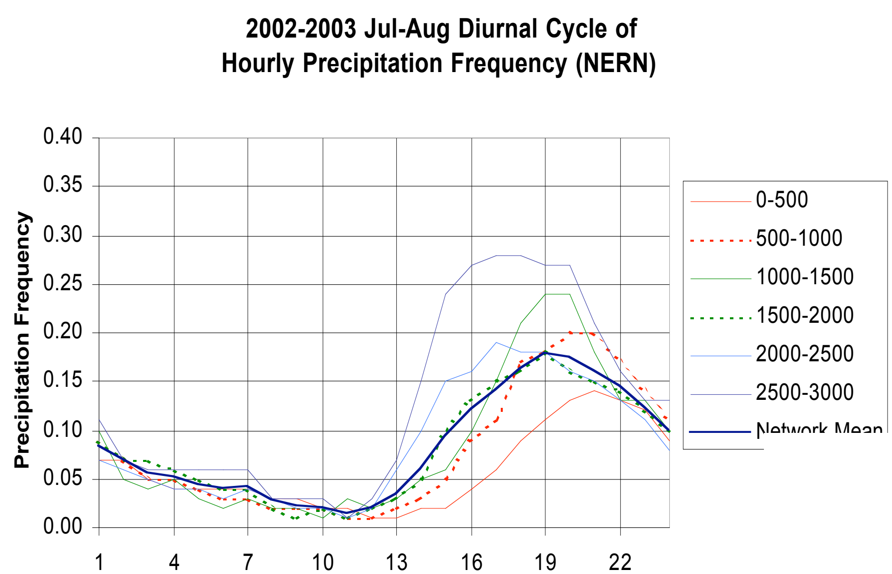
NAMS



SAMS



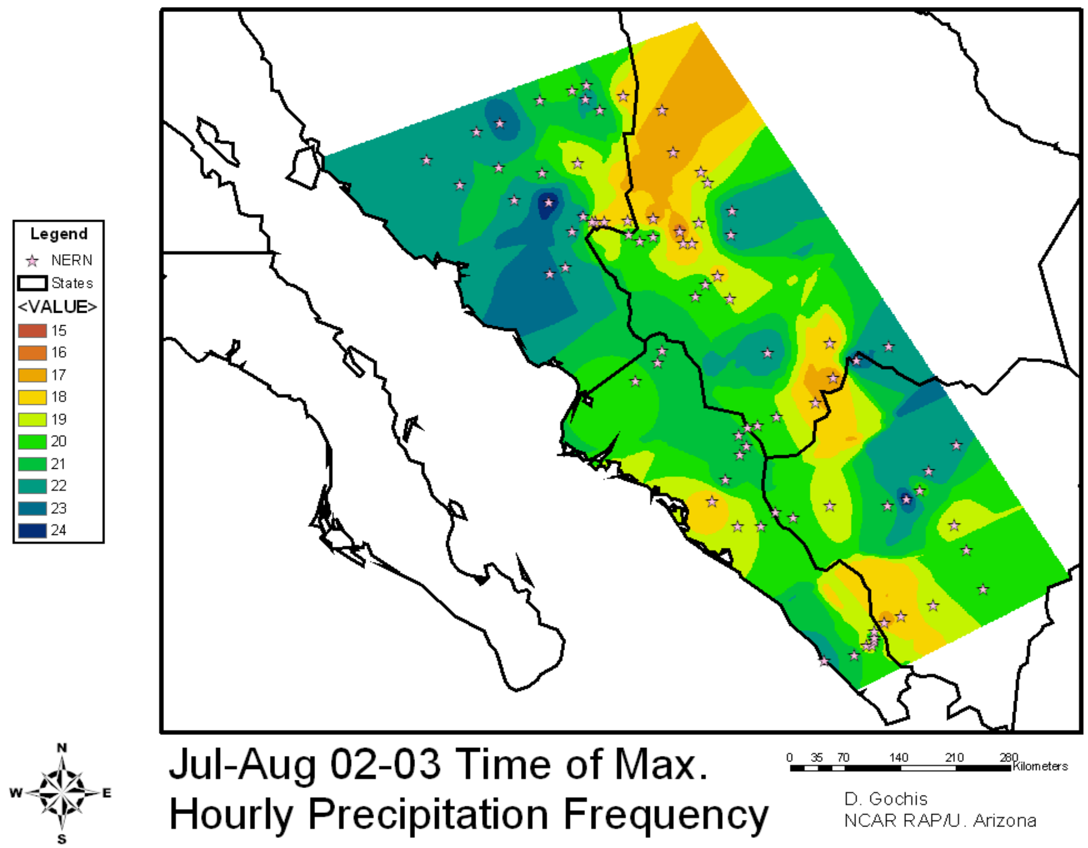
Diurnal cycle



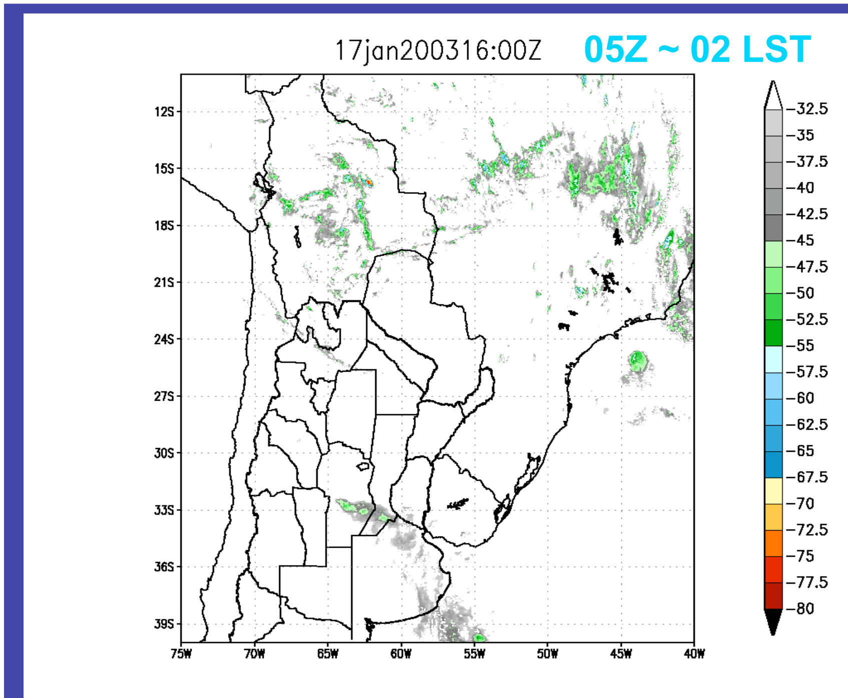
Wet-day hourly rain rates for various elevation bands in the SMO from the NAME Event Raingauge Network (NERN)

Time of Maximum hourly precipitation frequency from NERN

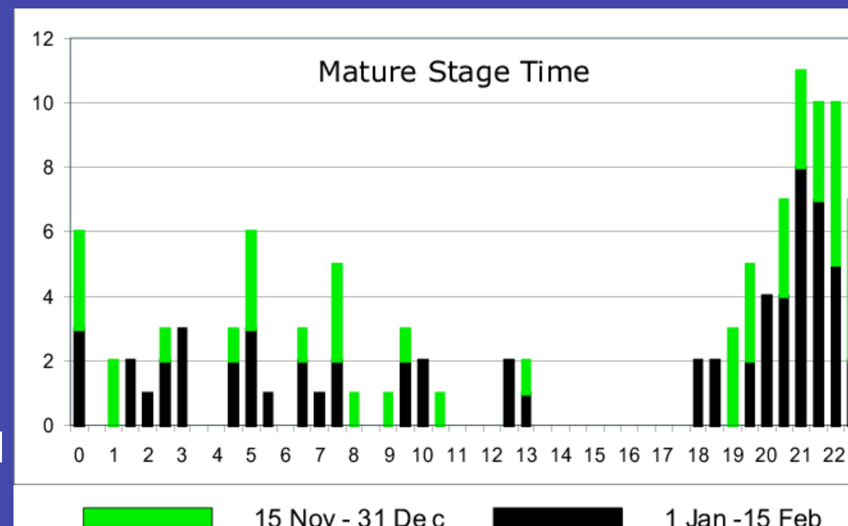
Gochis et al. 2003



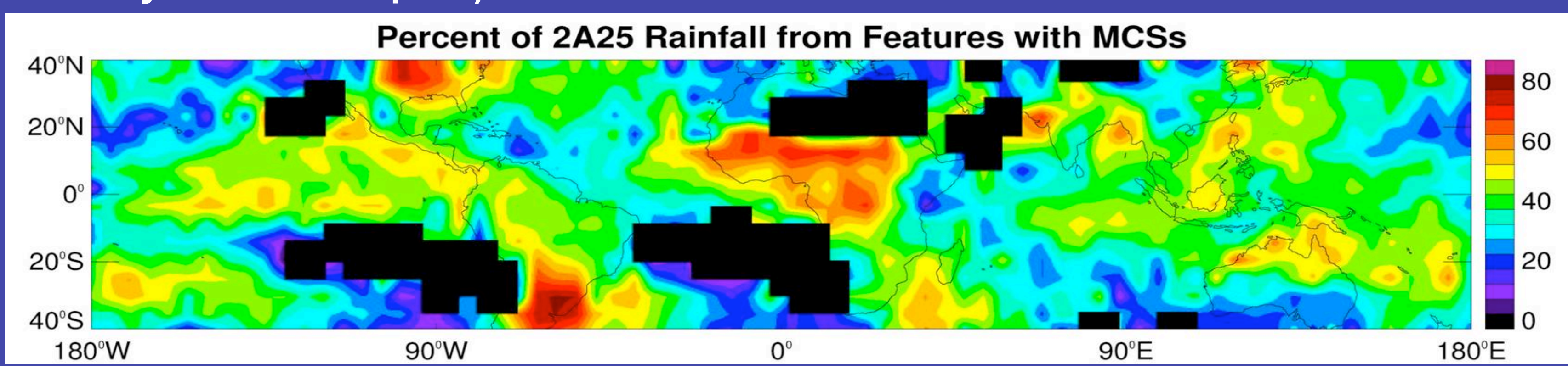
Mesoscale Variability



MCS mature stage time occurrence frequency during SALLJEX. Bars in green represent the period November 15 to December 31, in black January 1 to February 15 (Zipser et al. 2004)



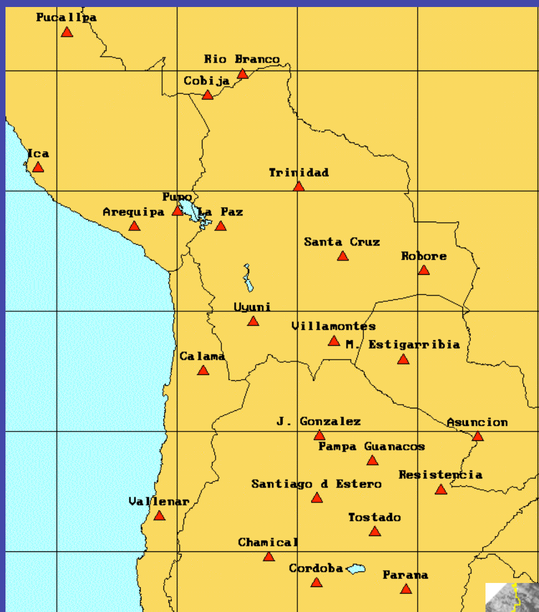
Subtropical South America has the largest fractional contribution of PFs with MCSs to rainfall of anywhere on earth between 36 N and 36 S (Courtesy Nesbitt & Zipser)



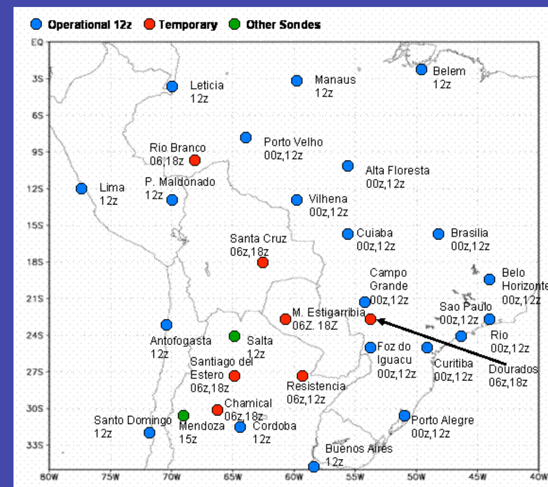
South American Low-Level Jet Experiment

SALLJEX
WCRP
CLIVAR / VAMOS-GEWEX
Field Campaign

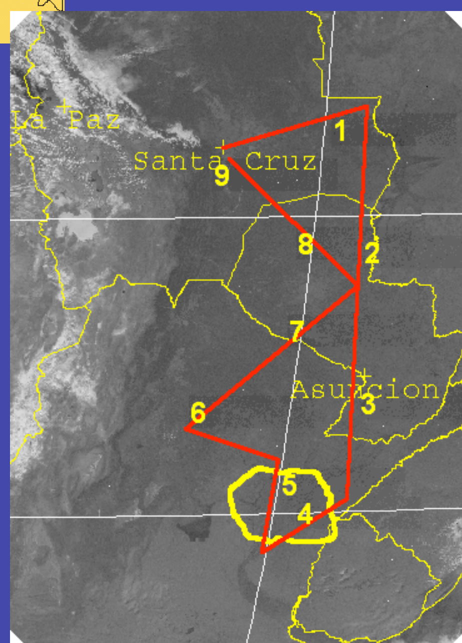
PIBALS



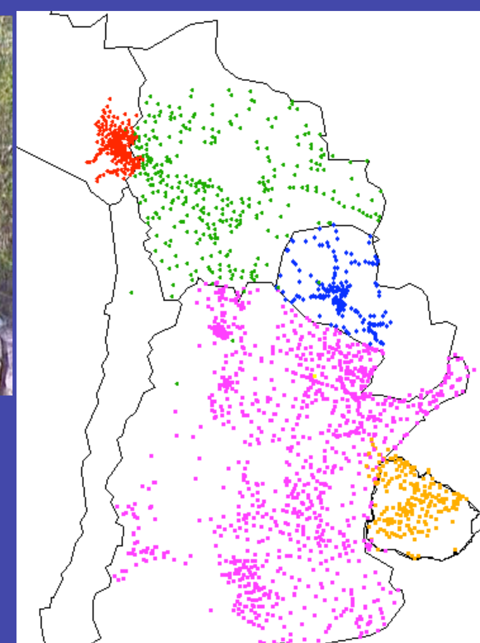
Radiosondes



NOAA/P-3 Missions

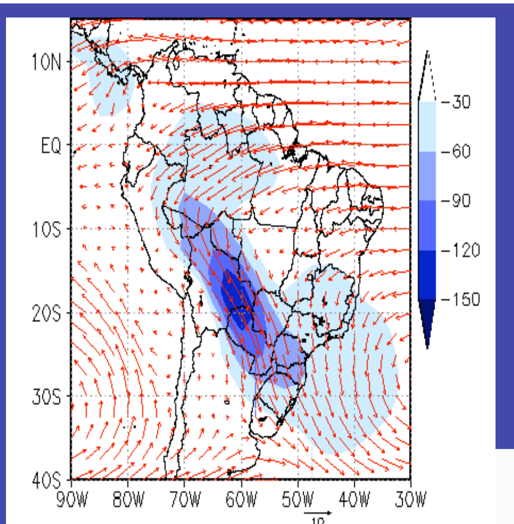


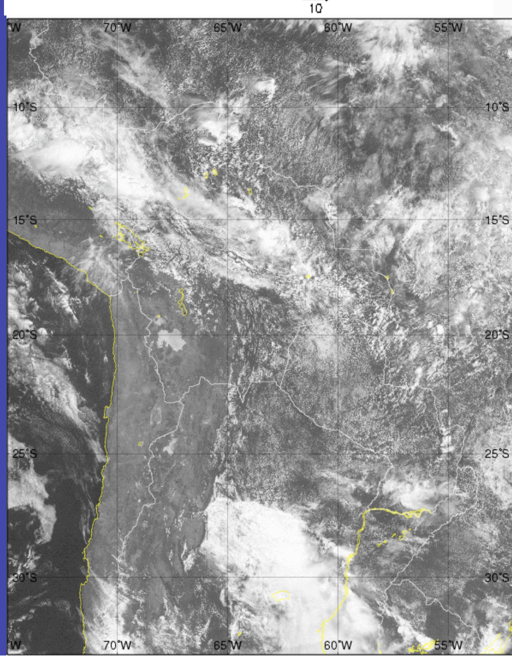
Enhanced precipitation gauge network

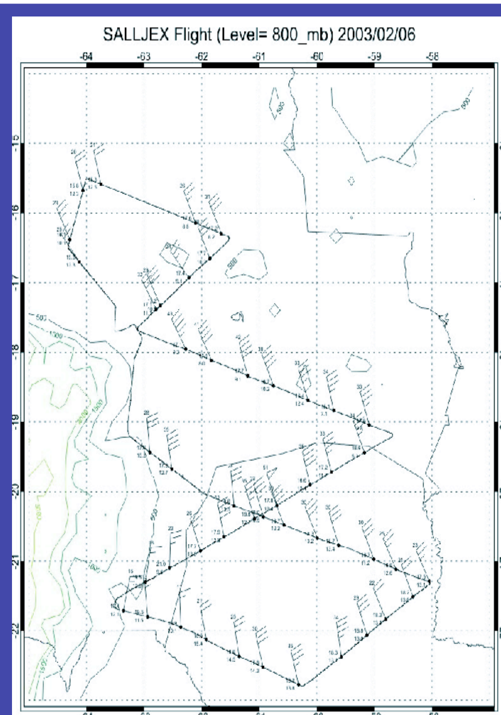


The South American Low-Level Jet

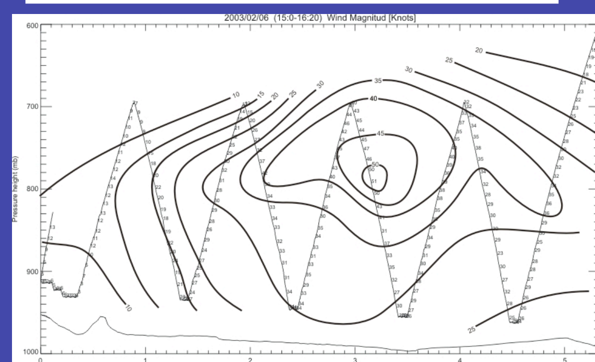
LLJ Composites NDJF, (Marengo et al. 2004)

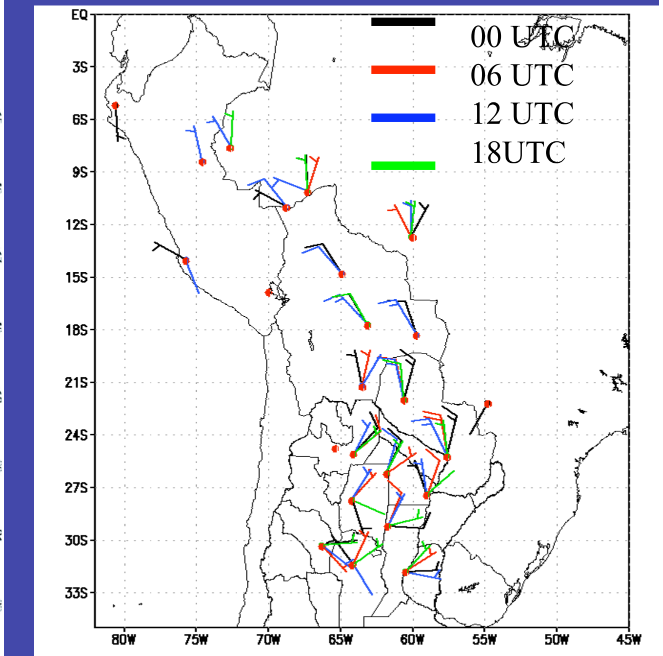




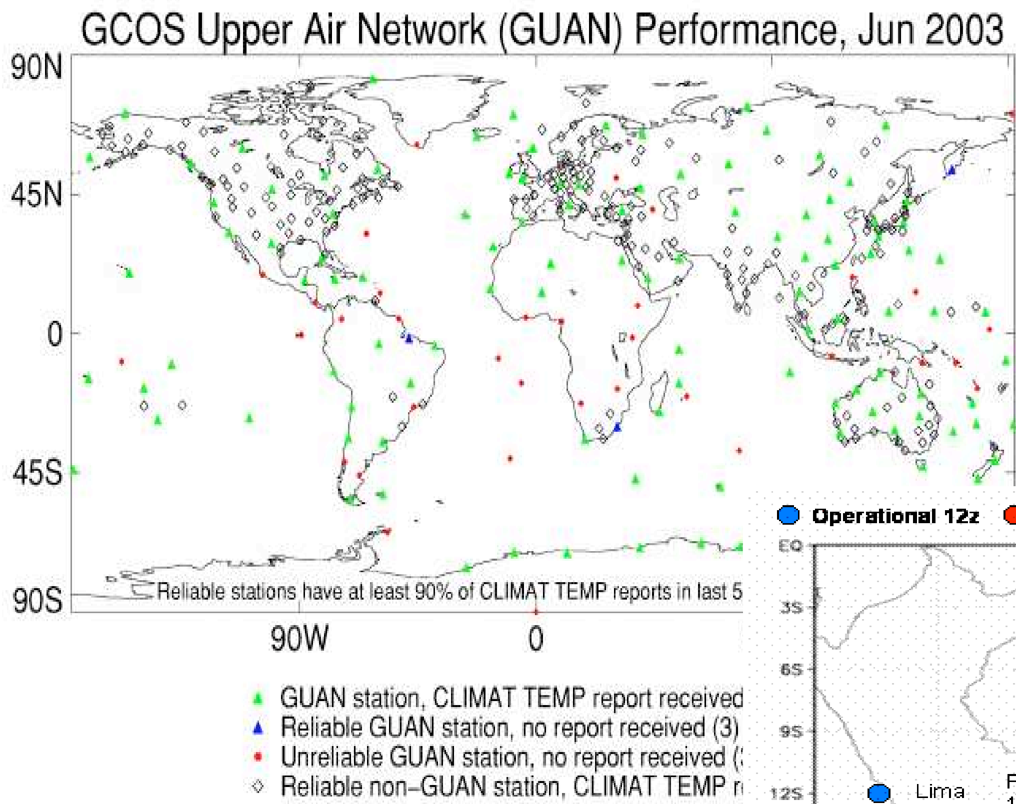


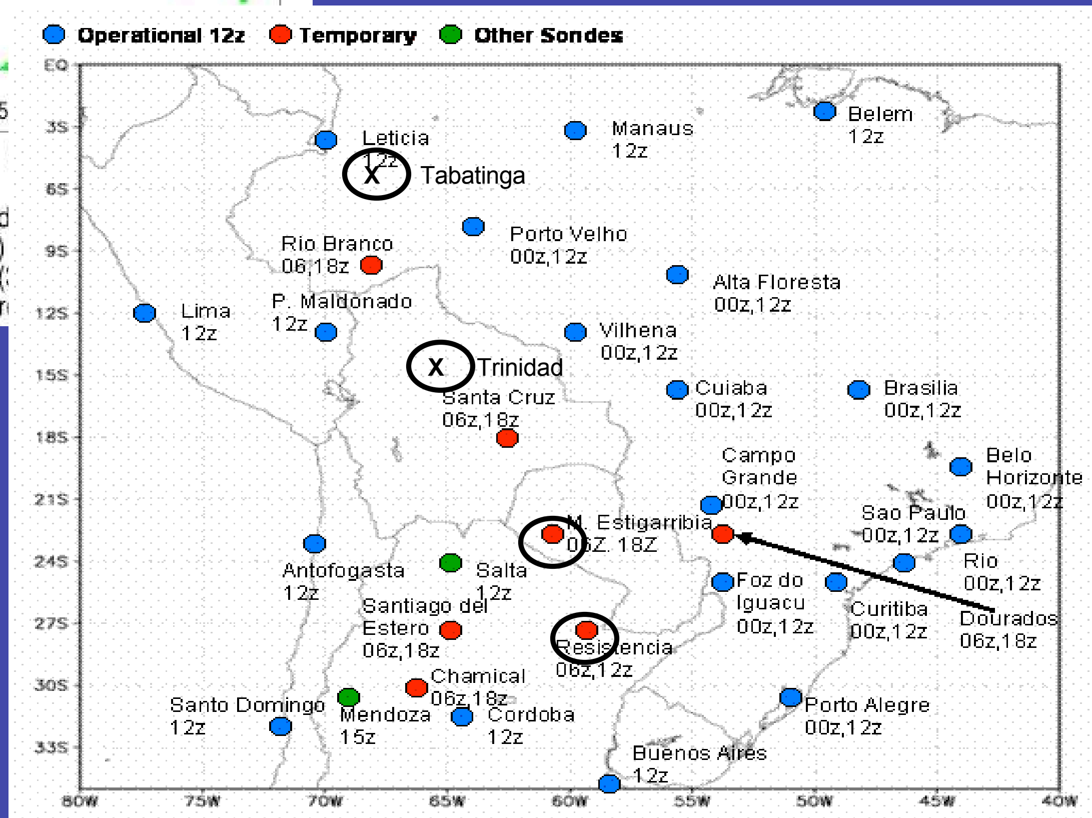
SALLJ spatial structure depicted by NOAA/P-3 missions in SALLJEX





SALLJ diurnal cycle at 700 asl depicted by SALLJEX observations (Nicolini et al. 2004)

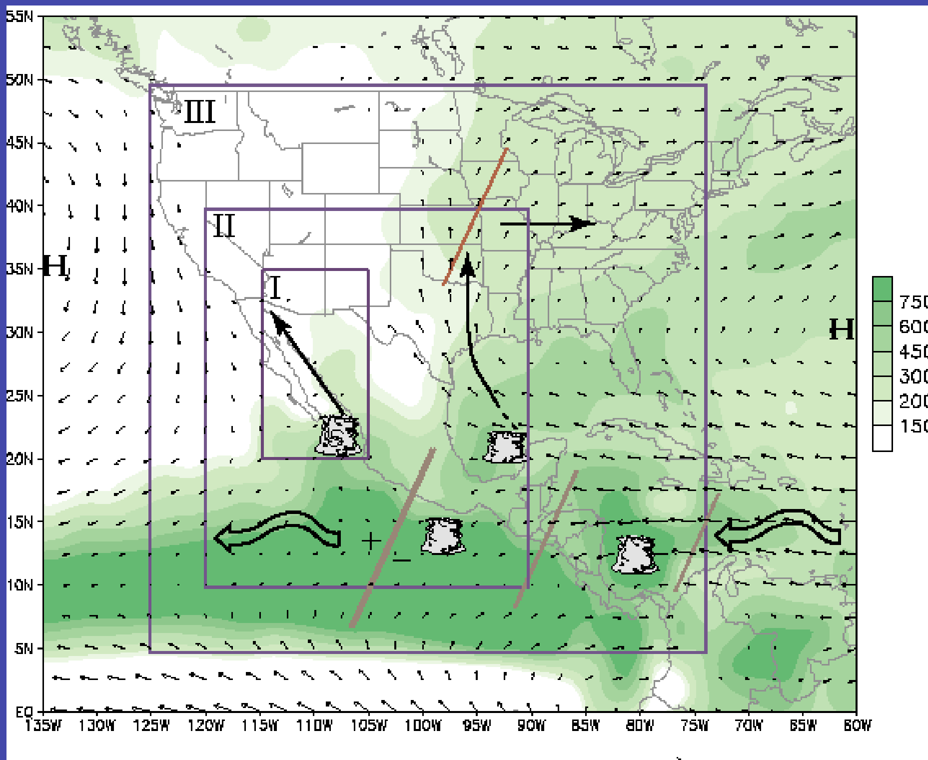




VAMOS Contribution to GCOS Action Plan for South America

Project Brief: Enhancement of the GUAN network in Central South America

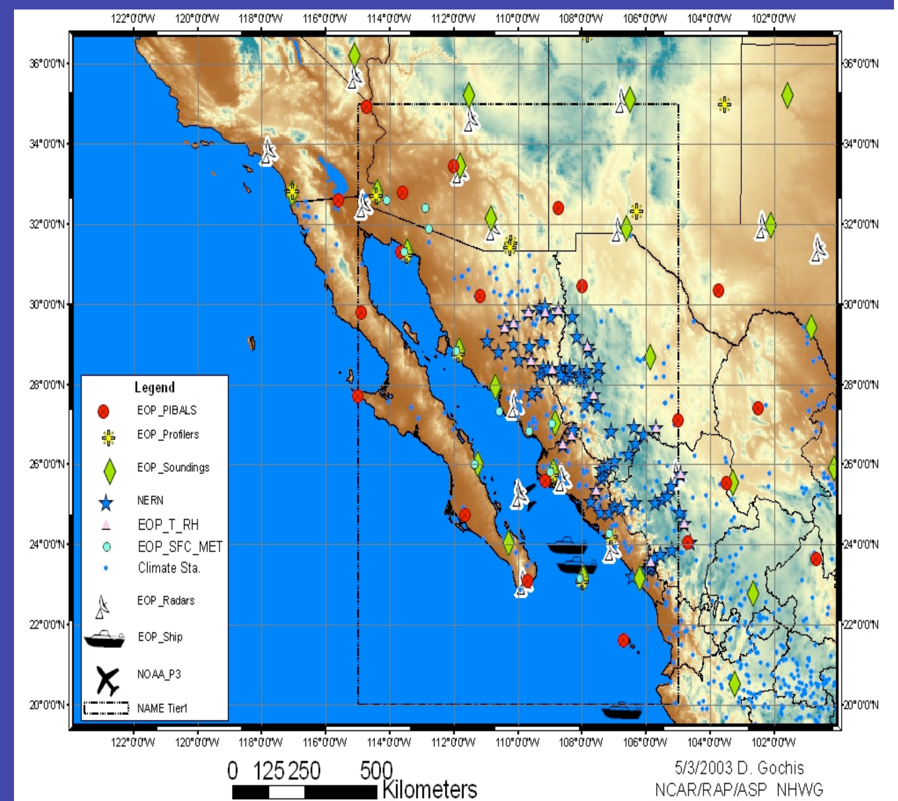
North American Monsoon Experiment (NAME)



NAME HYPOTHESIS:

The NAMS provides a physical basis for determining the degree of predictability of warm season precipitation over the region.

The NAME 2004 Field Campaign (on going) is an unprecedented opportunity to gather extensive atmospheric, oceanic, and land-surface observations in the core region of the North American Monsoon over NW Mexico, SW United States, and adjacent oceanic areas.



FUTURE CHALLENGES:
LOCAL SCALES

(1) What are the relationships between local low-level circulation features (e.g. the low-level jets; mountain-valley circulations; land and sea breezes) and the diurnal cycle of moisture and convection?

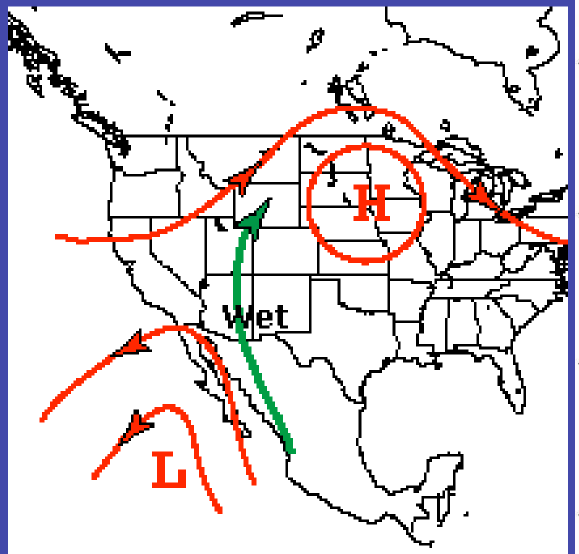
(2) What are the dominant sources of precipitable moisture for monsoon precipitation?

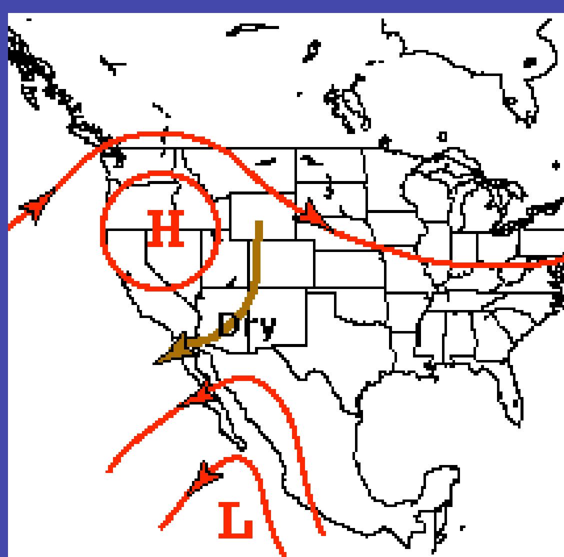
(3) What are the relative roles of local variations in sea surface temperature and land-surface parameters (topography, soil moisture and vegetation cover) in modulating precipitation?

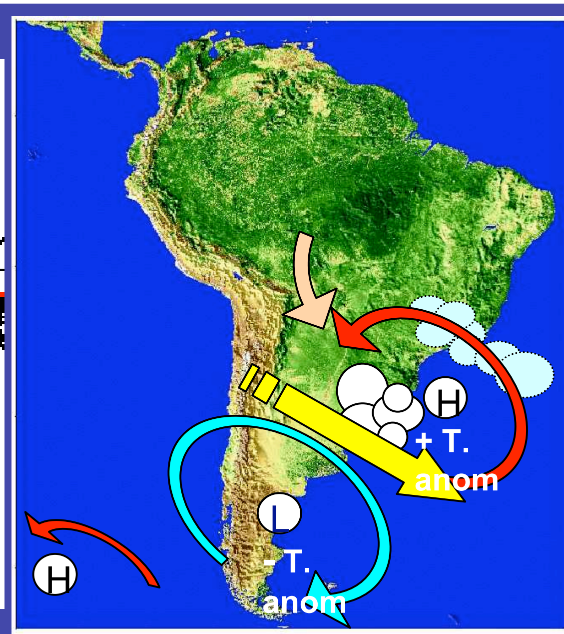
Intraseasonal Variability

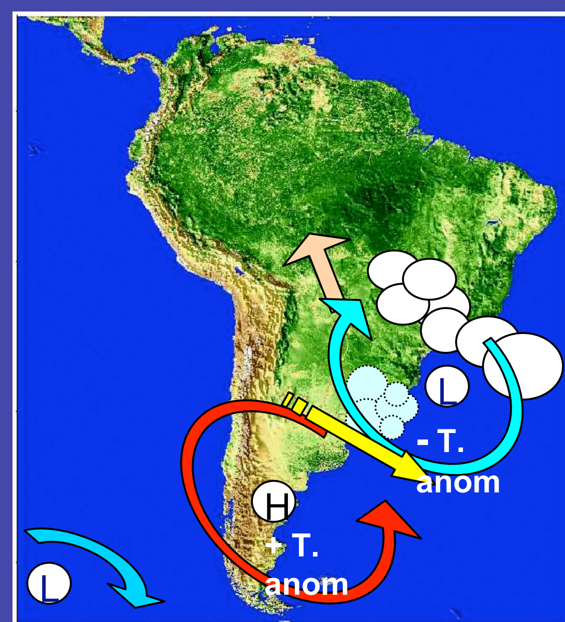
Typical circulation features of the NAMS accompany wet and dry surges keyed to Yuma, AZ.

(Higgins et al. 2004)





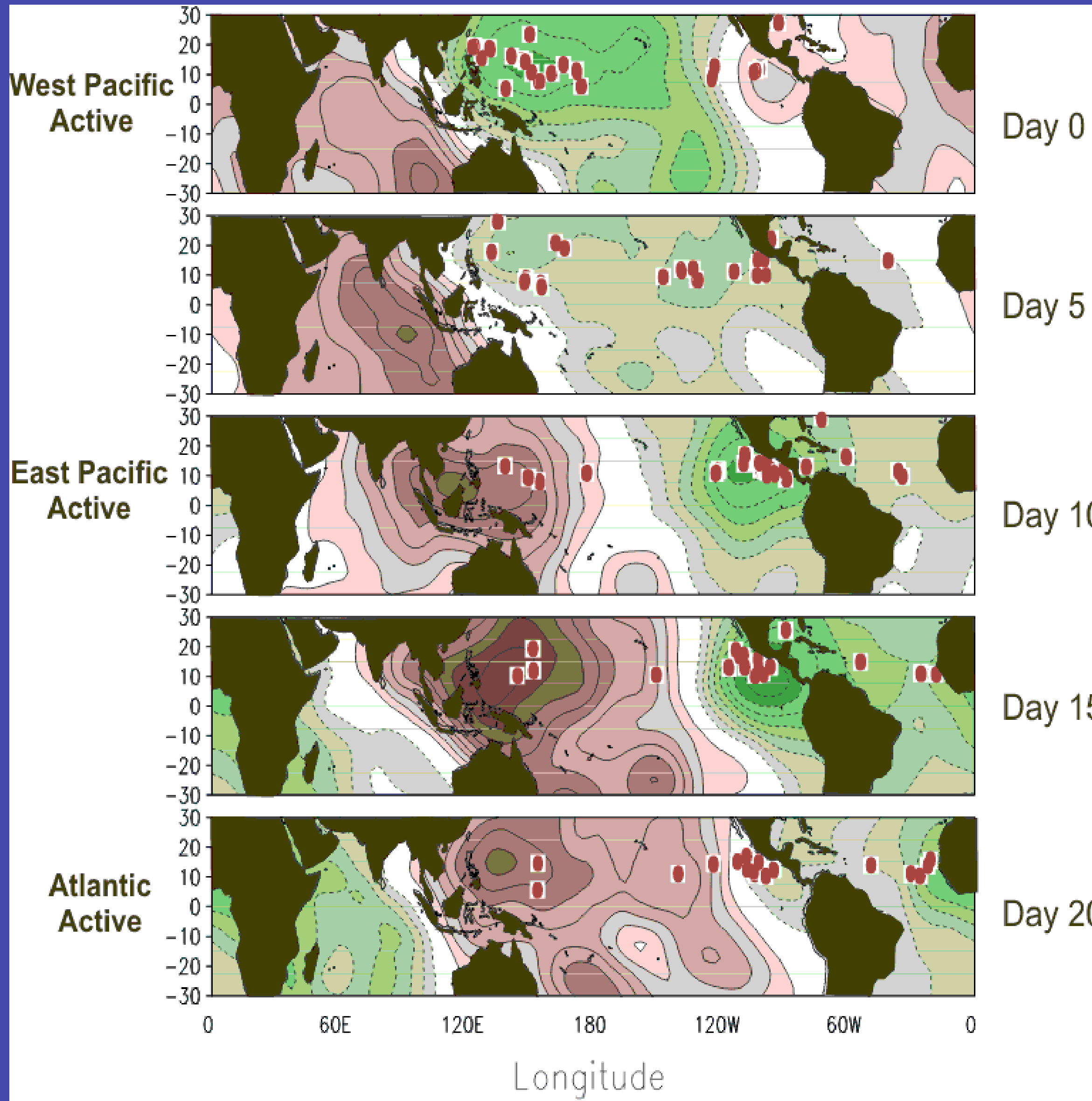




Typical circulation features of the SAMS accompany wet and dry conditions over Southeastern South America (e.g. Diaz and Aceituno 2003)

Intraseasonal Variability (MJO)

Composite evolution of 200-hPa velocity potential anomalies associated with MJO events and points of origin of tropical disturbances that developed into hurricanes or typhoons.



FUTURE CHALLENGES: REGIONAL SCALES

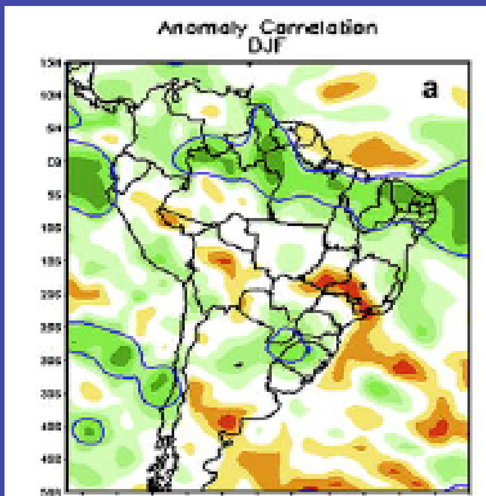
(1) What is the nature of the relationship between the MJO and monsoon precipitation?

(2) What are the relationships between the MJO and extreme weather events (such as droughts and floods) in the Americas?

(3) What are the relative influences of the MJO and ENSO on monsoon precipitation?

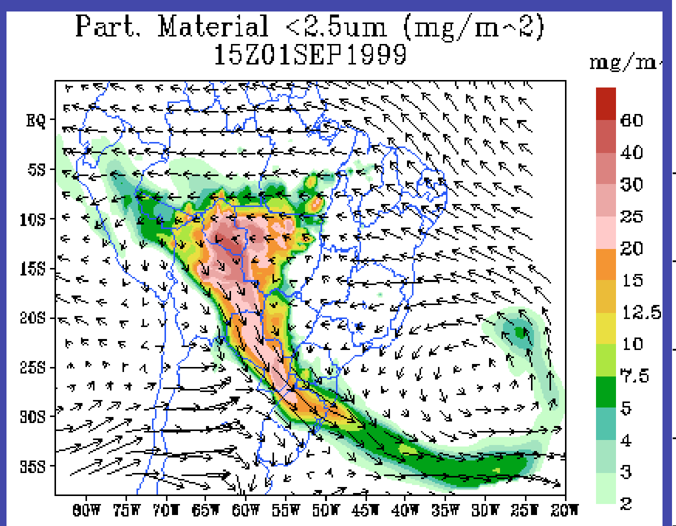
Interannual Variability

Role of land surface conditions



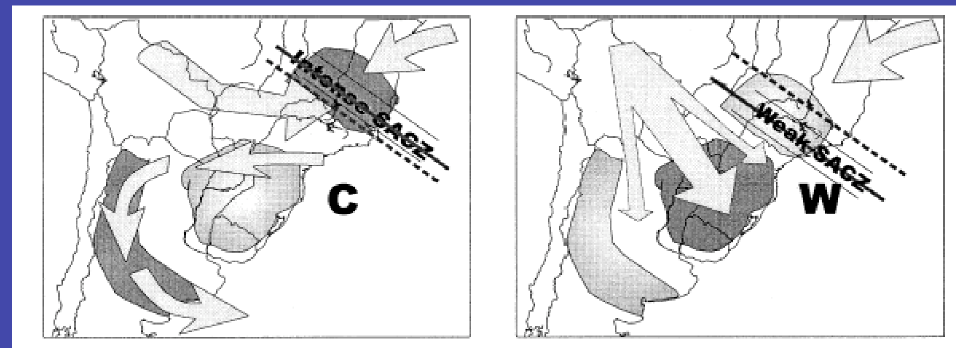
Correlation coefficients between CPTEC model anomalies and observed anomalies of rainfall (Marengo et al. 2003)

Aerosol plume produced by biomass burning at the end of the dry season and transported to the south (Freitas et al. 2004)



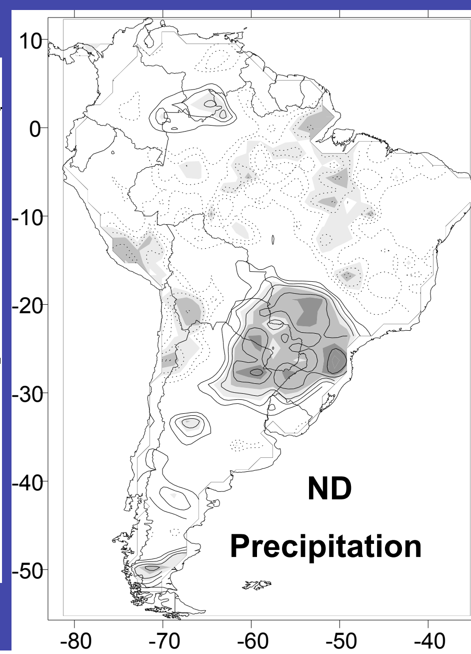
Role of SST anomalies

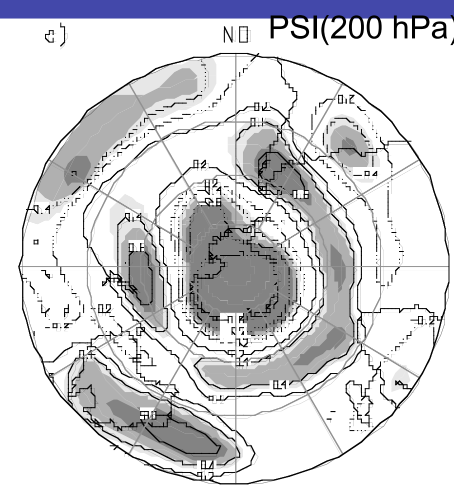
(Doyle & Barros 2002)



Role of Large-scale circulation

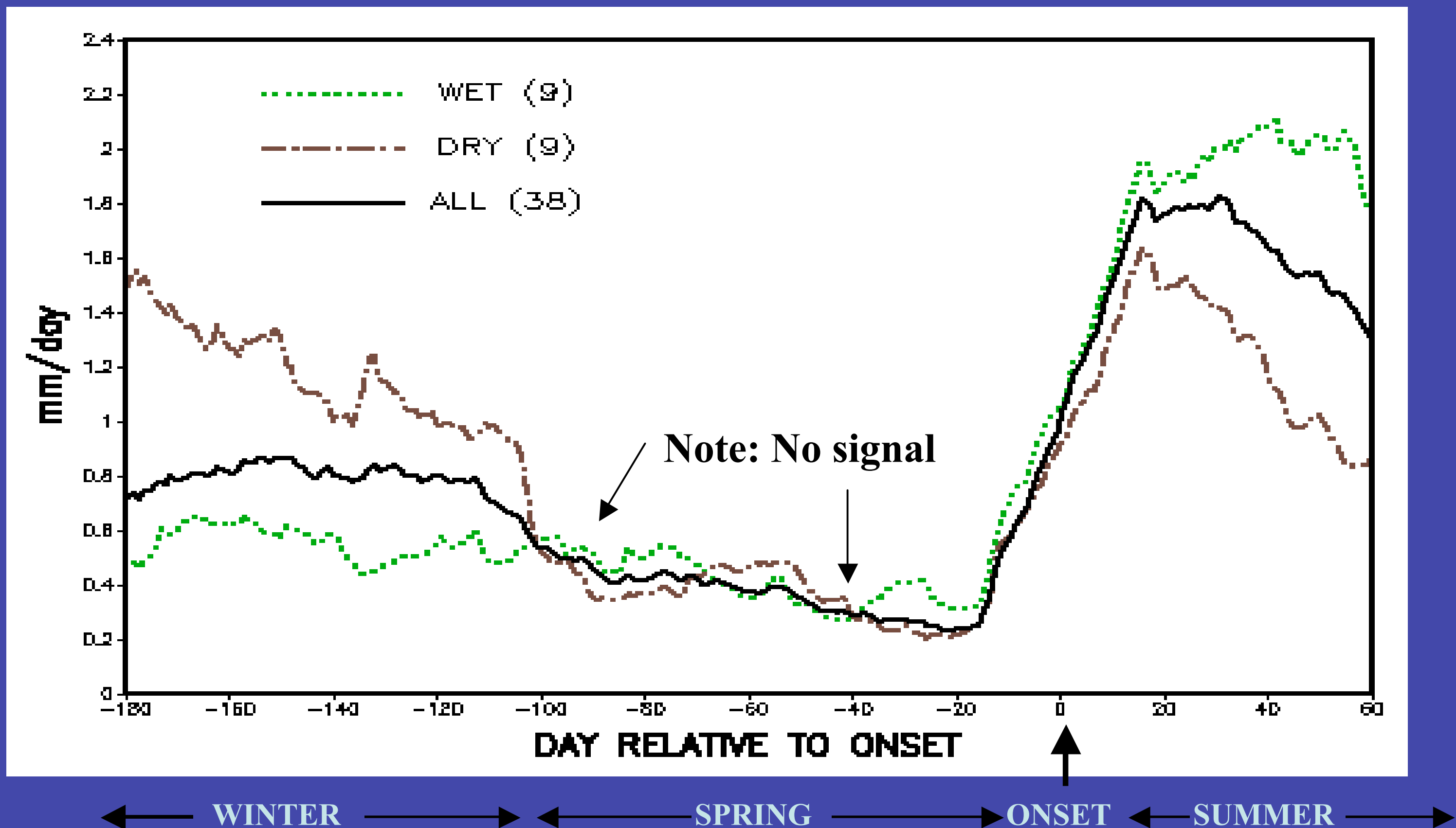
(Silvestri & Vera 2003)





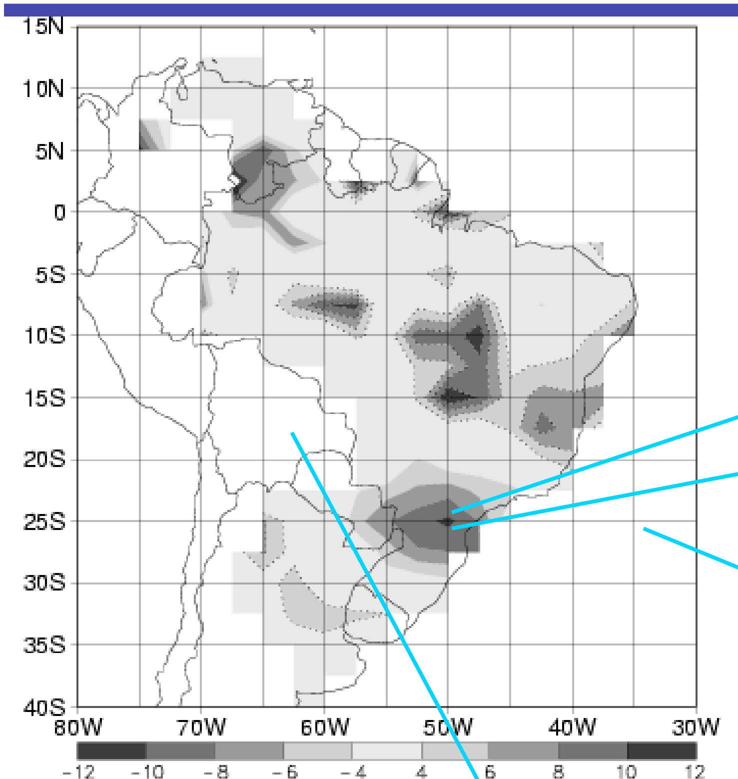
Interannual Variability

AREA MEAN PRECIPITATION OVER ARIZONA AND NEW MEXICO FOR WET, DRY AND ALL MONSOONS (1963-2000)

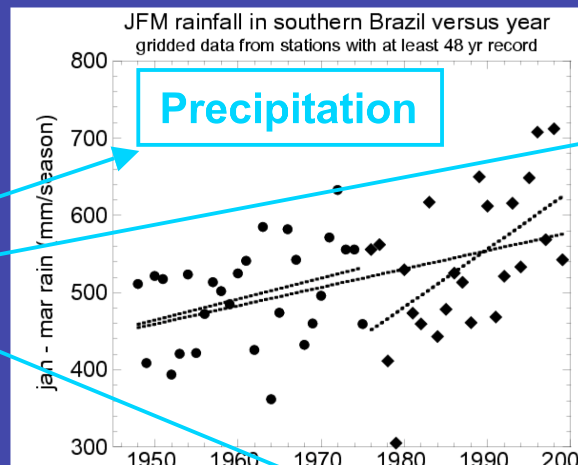


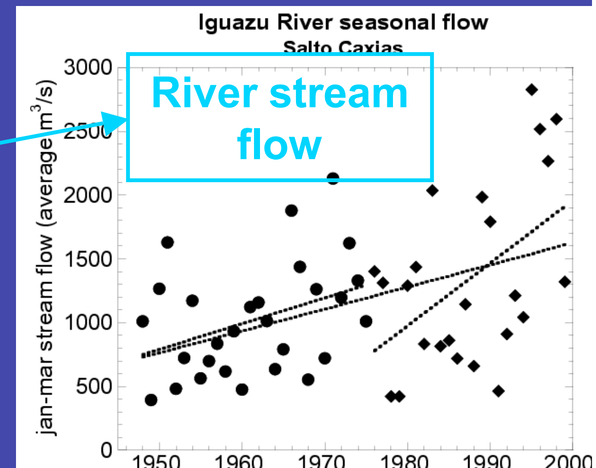
- The Winter preceding wet (dry) summer monsoons is on the dry (wet) side in this region.
- There is no signal in the spring suggesting that this “memory” is communicated via remote SST’s or through the land surface. Unfortunately, the correlation with ENSO is not significant in this region.

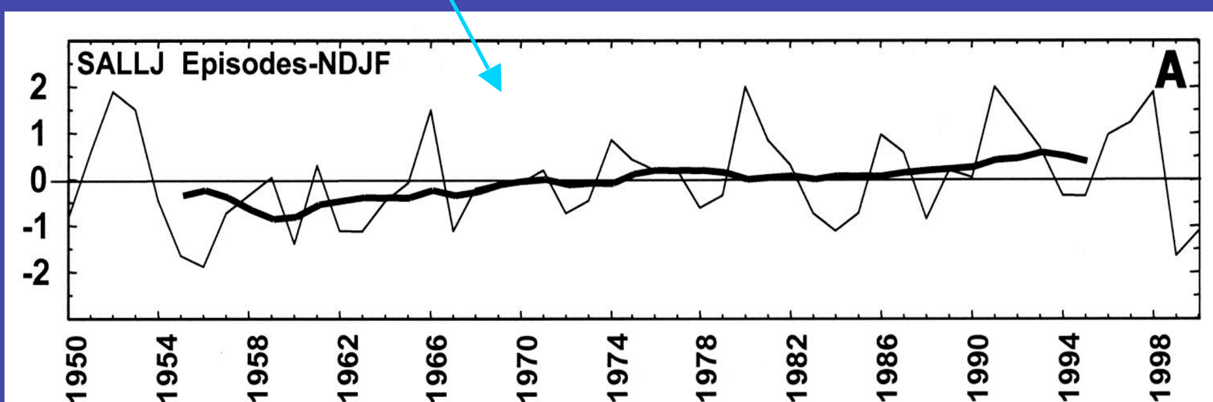
Variability on decadal (and longer) timescales

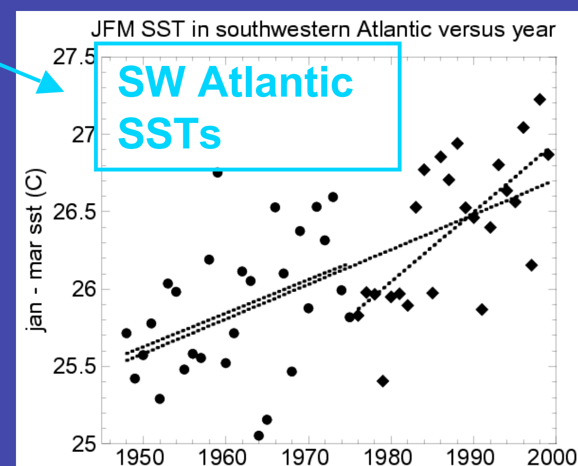


JFM precipitation trends
(Liebmann et al. 2004)









Normalized annual departures of SALLJ-event annual counts

FUTURE CHALLENGES: CONTINENTAL SCALES

(1) How is the evolution of monsoonal precipitation related to the seasonal evolution of the oceanic and continental boundary conditions?

(2) What are the relationships between interannual variations in the boundary conditions, the atmospheric circulation and the continental hydrologic regime?

(3) What is the correlation between the anomaly-sustaining atmospheric circulation and the land and ocean surface boundary conditions that characterize precipitation and temperature anomalies during the summer?

MESA and NAME

•Roadmaps with joint modeling and data assimilation activities are being planned. Emphasis is on modeling activities that include:

- Baseline seasonal simulations that correspond to major field campaigns (SALLJEX, NAME04, PLATIN)
- Multi-year simulations focused on key physical processes (e.g. the diurnal cycle of convection).

http:/www.clivar.org/organization/vamos

Thanks to the VAMOS community from the tremendous scientific contributions to our understanding of the American Monsoon Systems!

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