Radar-Observed Characteristics of the Diurnal Cycle of Precipitation during NAME 2004

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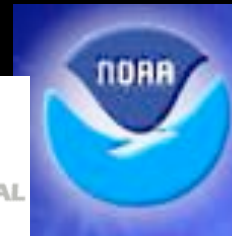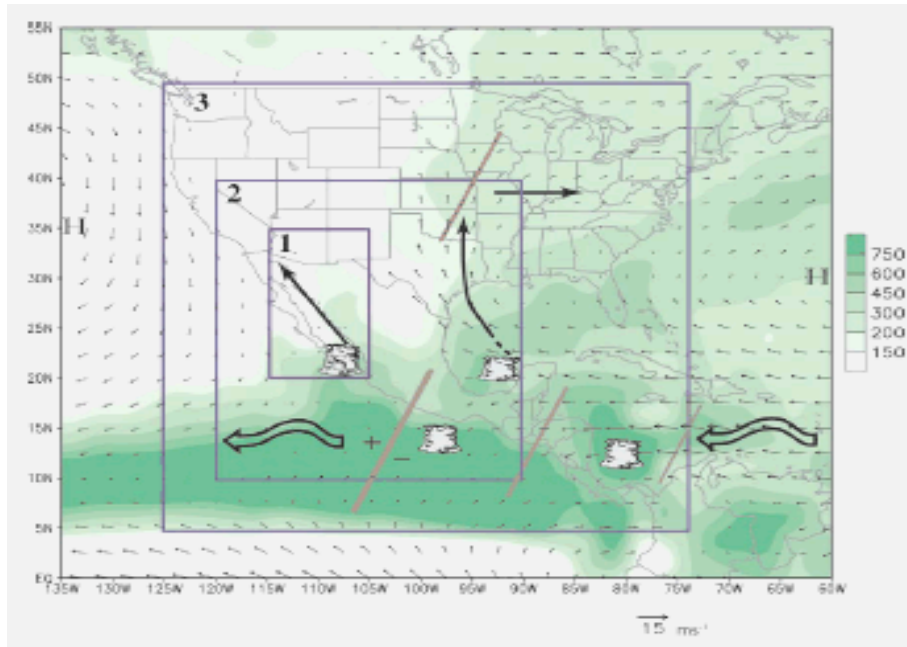National Center for Atmospheric Research

North American Monsoon Experiment (NAME)

Study aimed at determining the sources and limits of predictability of warm-season precipitation over North America

The scientific objectives of NAME are to promote a better understanding and more realistic simulation of warm-season convective processes in complex terrain, intraseasonal variability of the monsoon, and the response of the warm-season atmospheric circulation and precipitation patterns to slowly varying, potentially predictable surface boundary conditions. (*Higgins et al. 2006*)

**Key Goal** - Characterize and understand the diurnal cycle of precipitation in NW Mexico

Radar Data

•Three radars - Cabo & Guasave (SMN C-Band Doppler radars), and S-Pol (NSF S-Band Polarimetric Radar) within the core of the NAM region
•Operated inclusive of 7/10-8/21 during 2004 NAME EOP
•Low-level sweeps (0.5°-0.8°) updated every 15 minutes
•QC'd and composited into a 2-D regional grids of low-level radar reflectivity and rainfall rate (0.02° resolution)
•Domain subsetted and rotated 35° to reflect coastal orientation
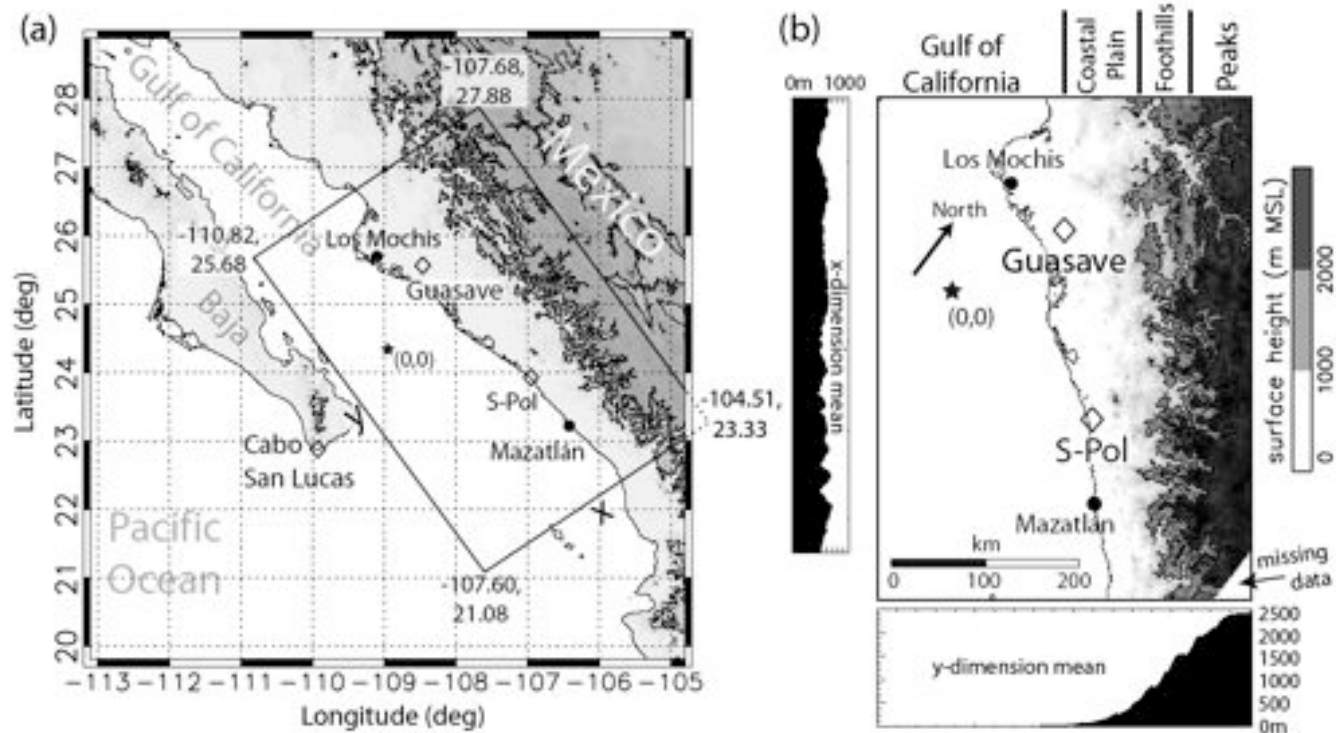
Diurnal cycle in reduced dimension analysis

Cross-coast   Along-coast
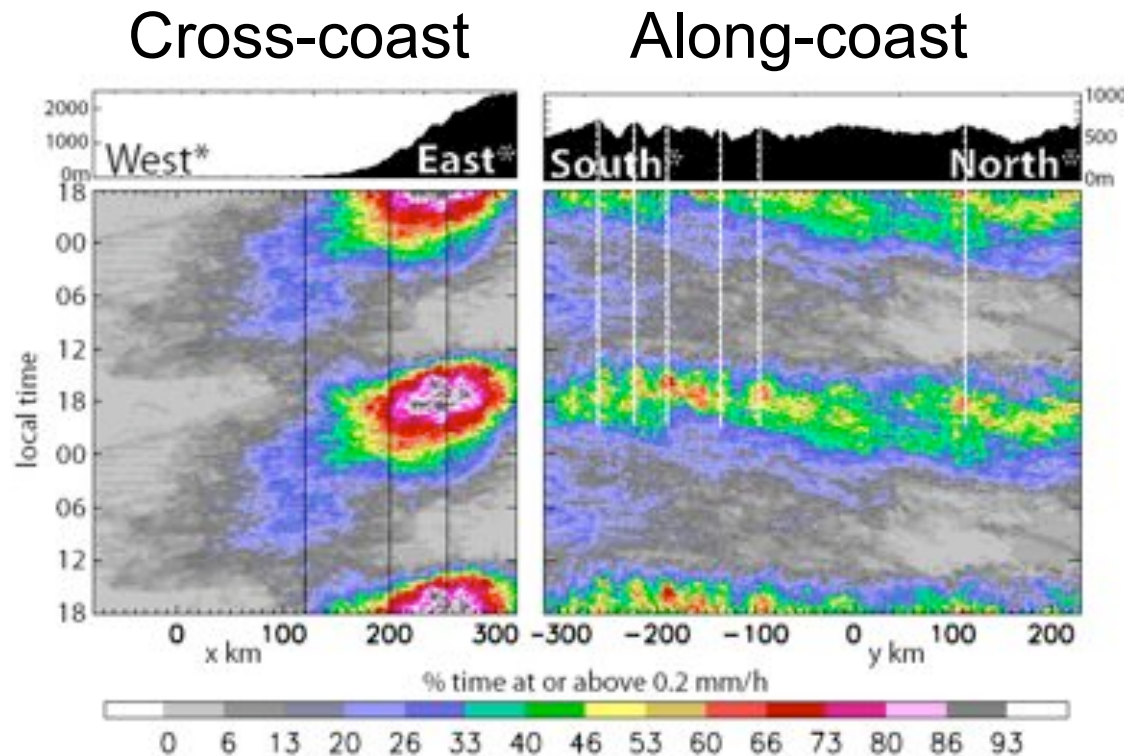
- Dataset analyzed via reduced dimension analysis (along-coast and cross-coast) à la *Carbone et al.* (2002)
- Formation over mountains in afternoon with gradual coastward movement
- Echoes tied to specific terrain features
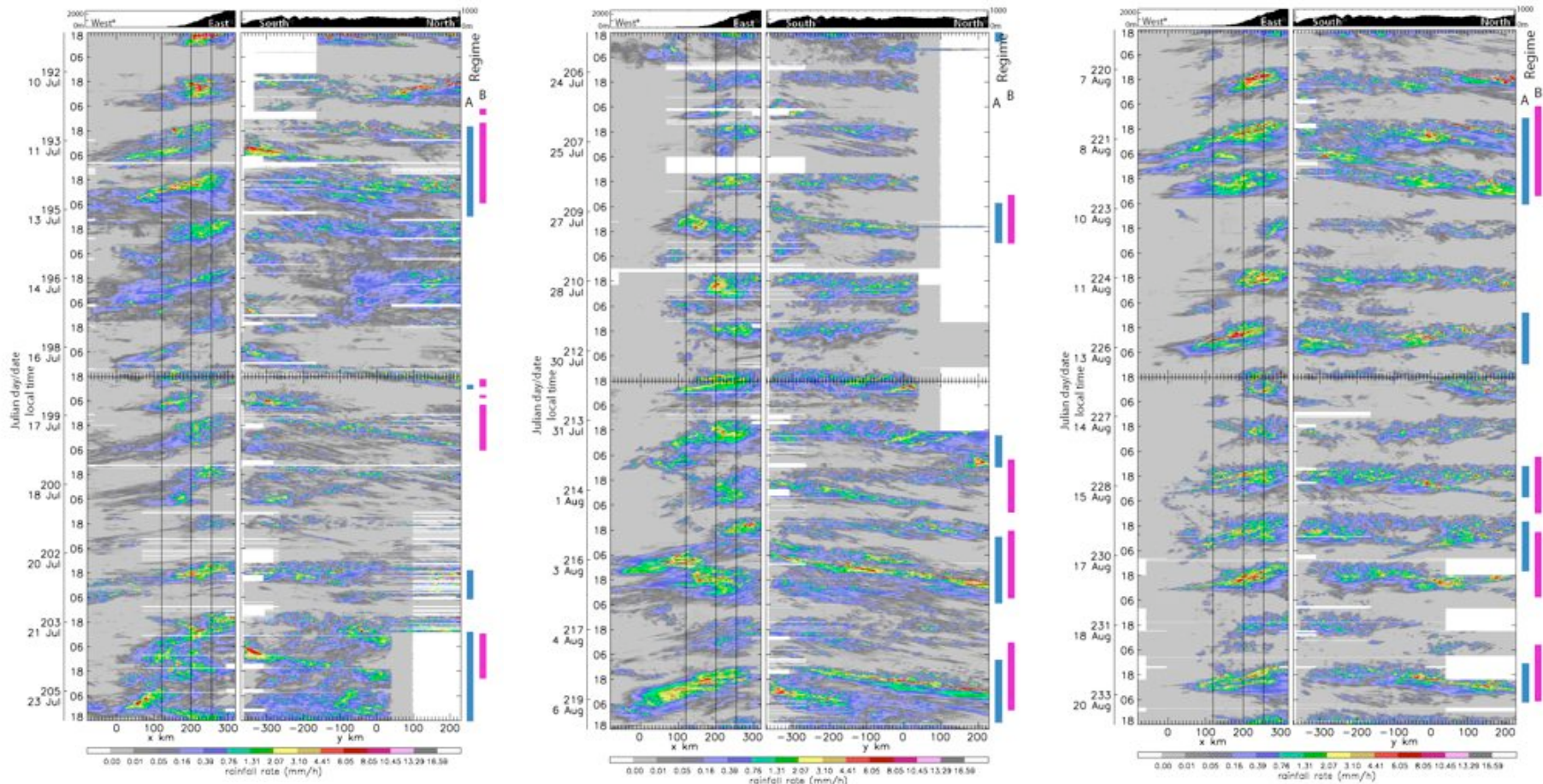
Two phenomenological regimes (not mutually exclusive)
**A** - Enhanced precipitation over the coast and Gulf
B - Significant along-coast northward propagation
(**AB** - When both regimes occur at same time)

Diurnal cycle of precipitation very different between Regime and non-Regime days

During Regime A, precipitation survives moving off the mountains toward Gulf. Also, there is a secondary morning maximum near the location of the land breeze

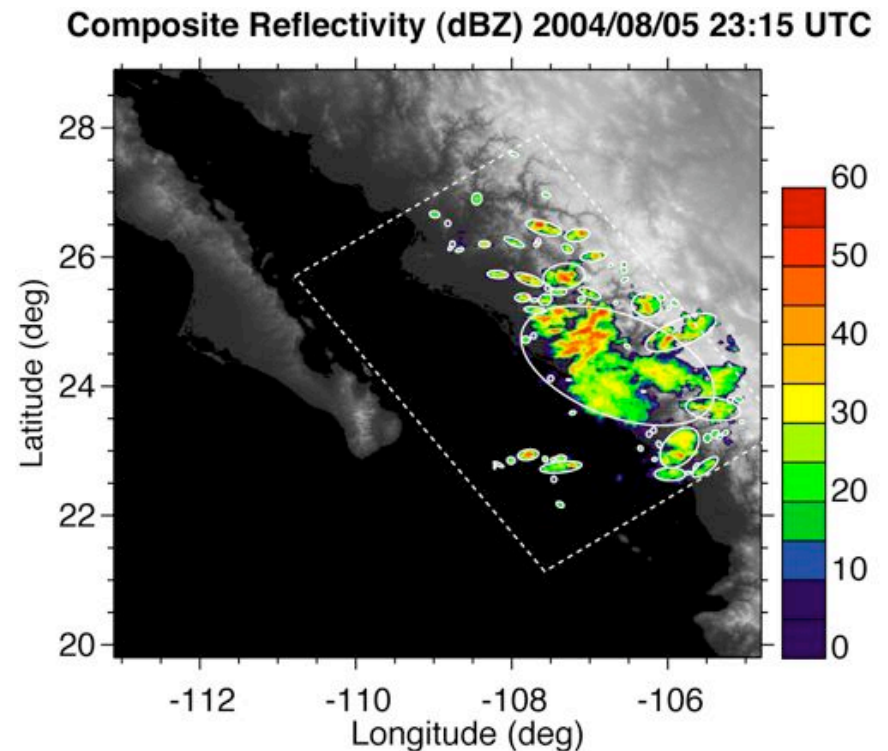During Regime B, there is coast-parallel movement toward the north
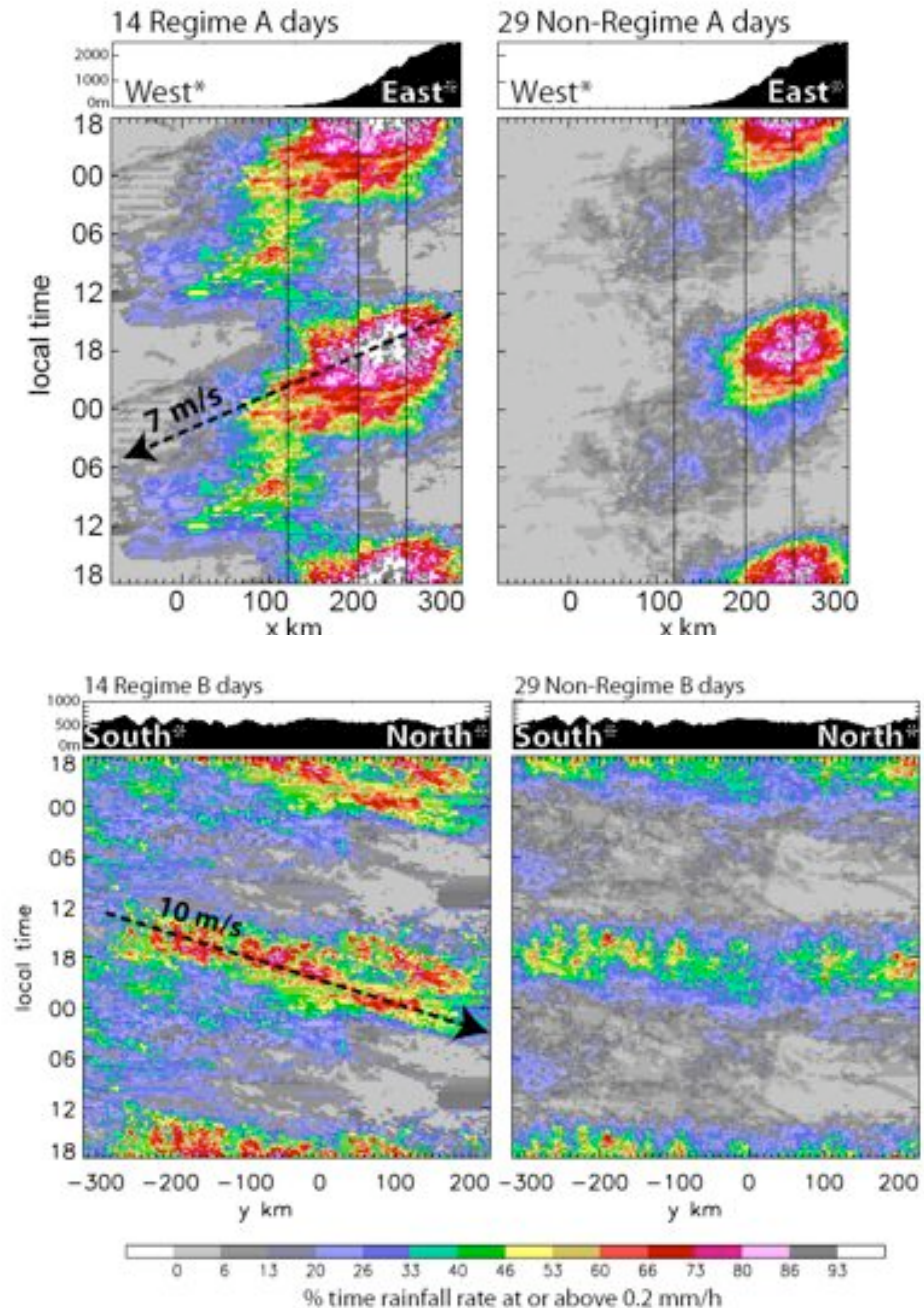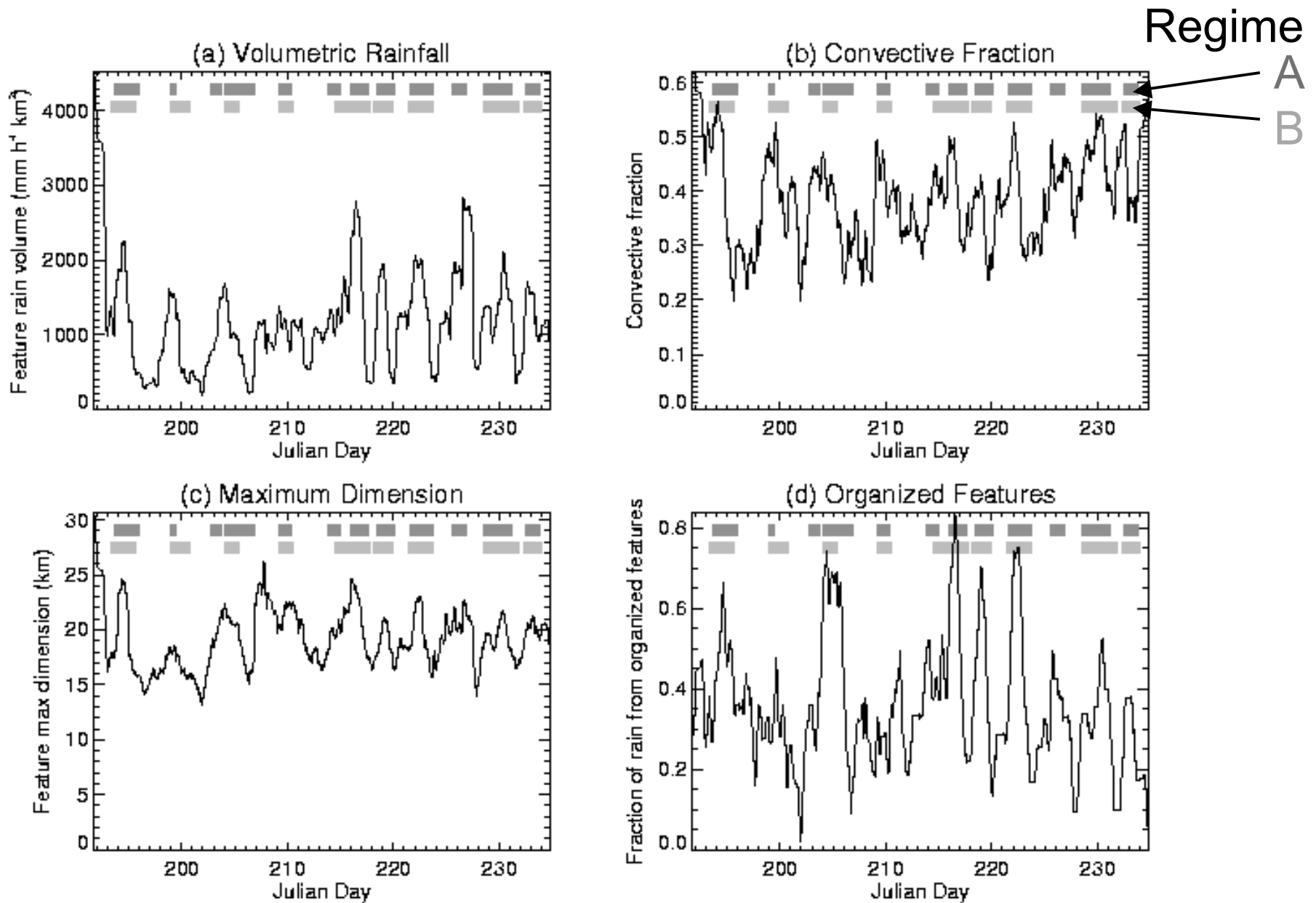
Precipitation Feature Analysis

Entire dataset grouped into precipitation features similar to *Nesbitt et al.* (2000; 2006)

Ellipses fit to each feature

Statistics compiled on reflectivity, rainfall, feature size, convective/stratiform partitioning (Yuter et al. 1998), and other feature characteristics

Organized features were defined as those with a maximum dimension of at least 100 km and 16 km^2 of convective area

Composite Reflectivity (dBZ) 2004/08/05 23:15 UTC

(a) Volumetric Rainfall

(b) Convective Fraction

Regime
A
B

(c) Maximum Dimension

(d) Organized Features

During "regimes": Larger features, lower convective fraction, more rainfall per feature, more rain from organized features

| Statistic	Mean (A/~A)	Mean (B/~B)	Mean (AB/~AB)
Volumetric Rainfall per Feature (mm h^{-1} km^2)	1494/868	1517/913	1693/858
Convective Rainfall Fraction (%)	52.8/55.0	53.3/54.2	52.9/54.8
Feature Maximum Dimension (km)	20.3/18.0	20.3/18.2	20.9/17.9
Fraction of Rain from Organized Features (%)	75.5/60.7	74.9/63.3	76.7/60.0
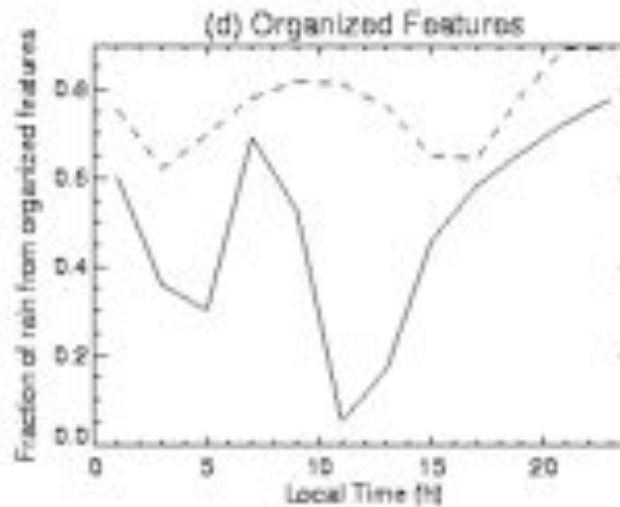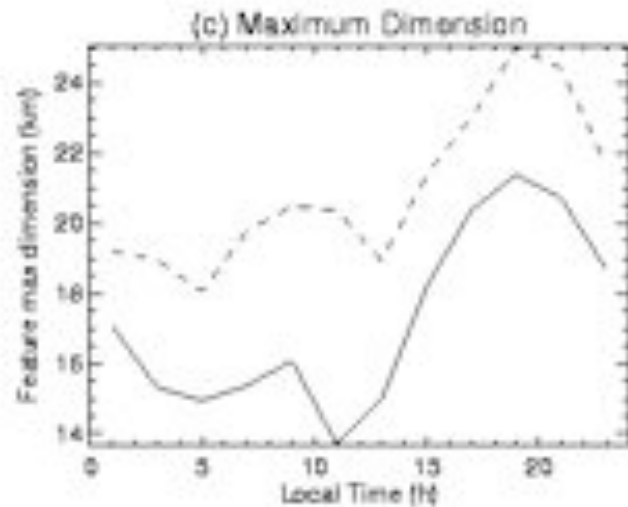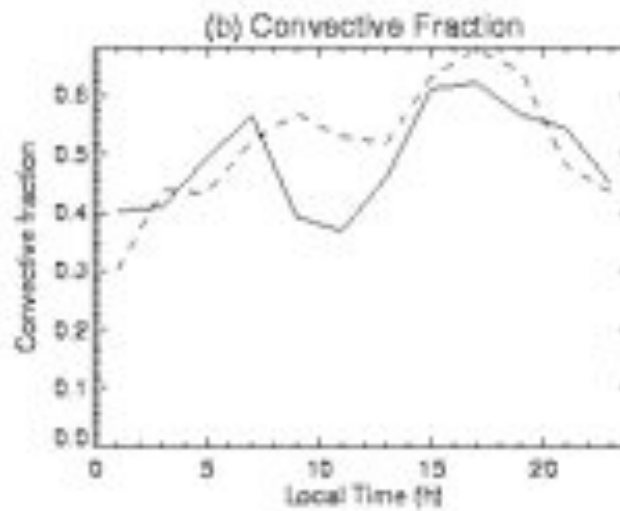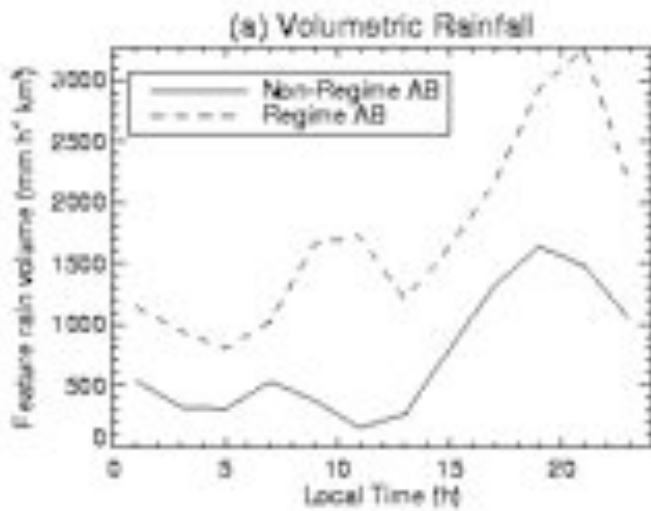
Feature
Diurnal
Cycle
by Regime

•Two diurnal rainfall peaks: a late afternoon peak and a morning peak
•The non-AB morning peak is a couple hours earlier
•The diurnal cycle of organized feature rainfall fraction shows that there is a relative maximum near midnight, and another morning peak
•Regime A- and B-only plots similar

(a) Volumetric Rainfall

(b) Convective Fraction

(c) Maximum Dimension

(d) Organized Features
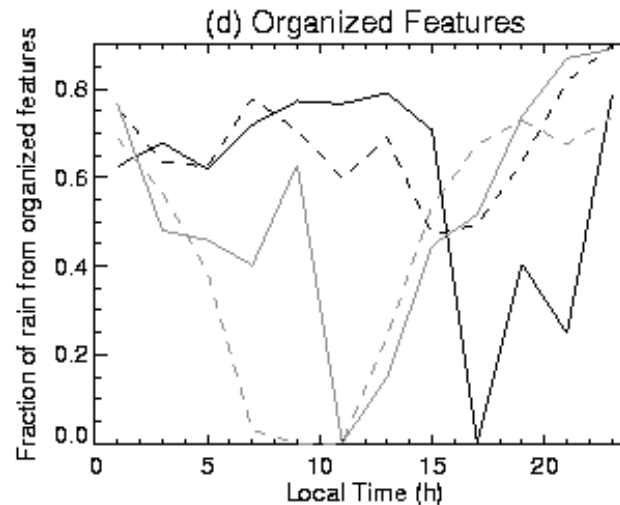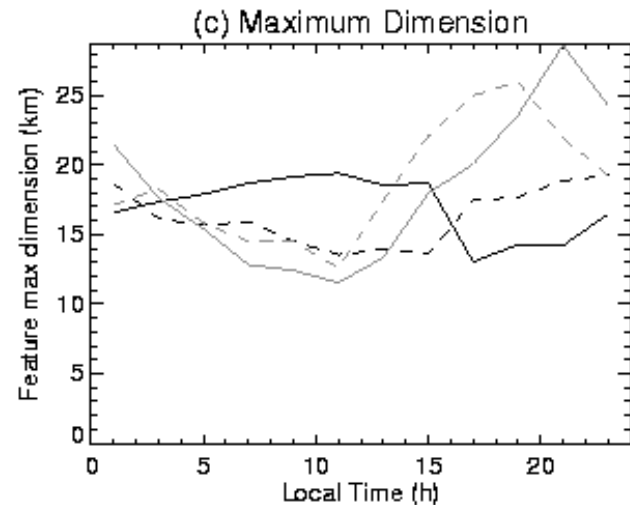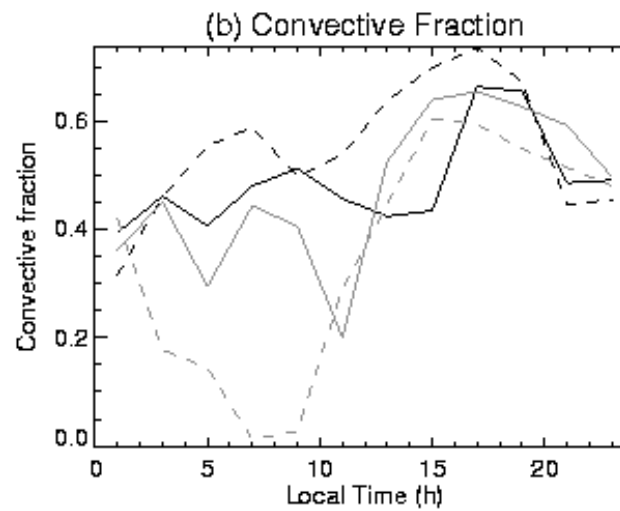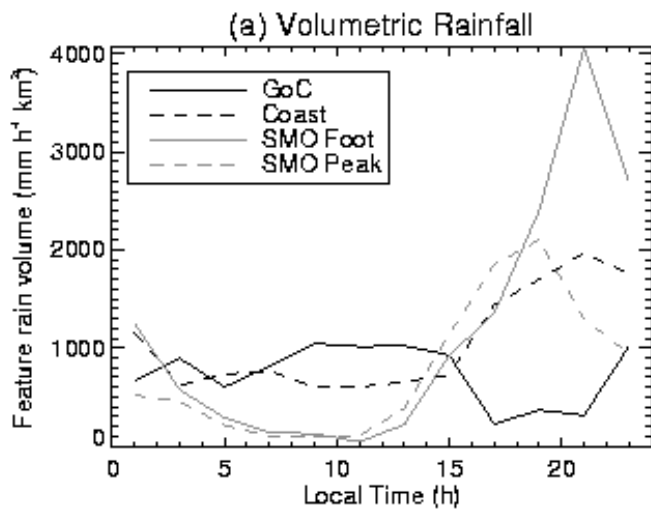
Feature Diurnal Cycle by Gulf-Normal Zone

SMO Peaks
SMO Foothills
Coastal Plain
Gulf of California

- Most rain per feature falls over the SMO Foothills during evening
- Diurnal cycle for the Coastal Plain probably reflects the combination of afternoon convection triggered along the coast line (e.g., sea-breeze front) and late evening convection moving off the SMO
- The GoC diurnal cycle is roughly 12 h out of phase with the SMO

(a) Volumetric Rainfall

(b) Convective Fraction

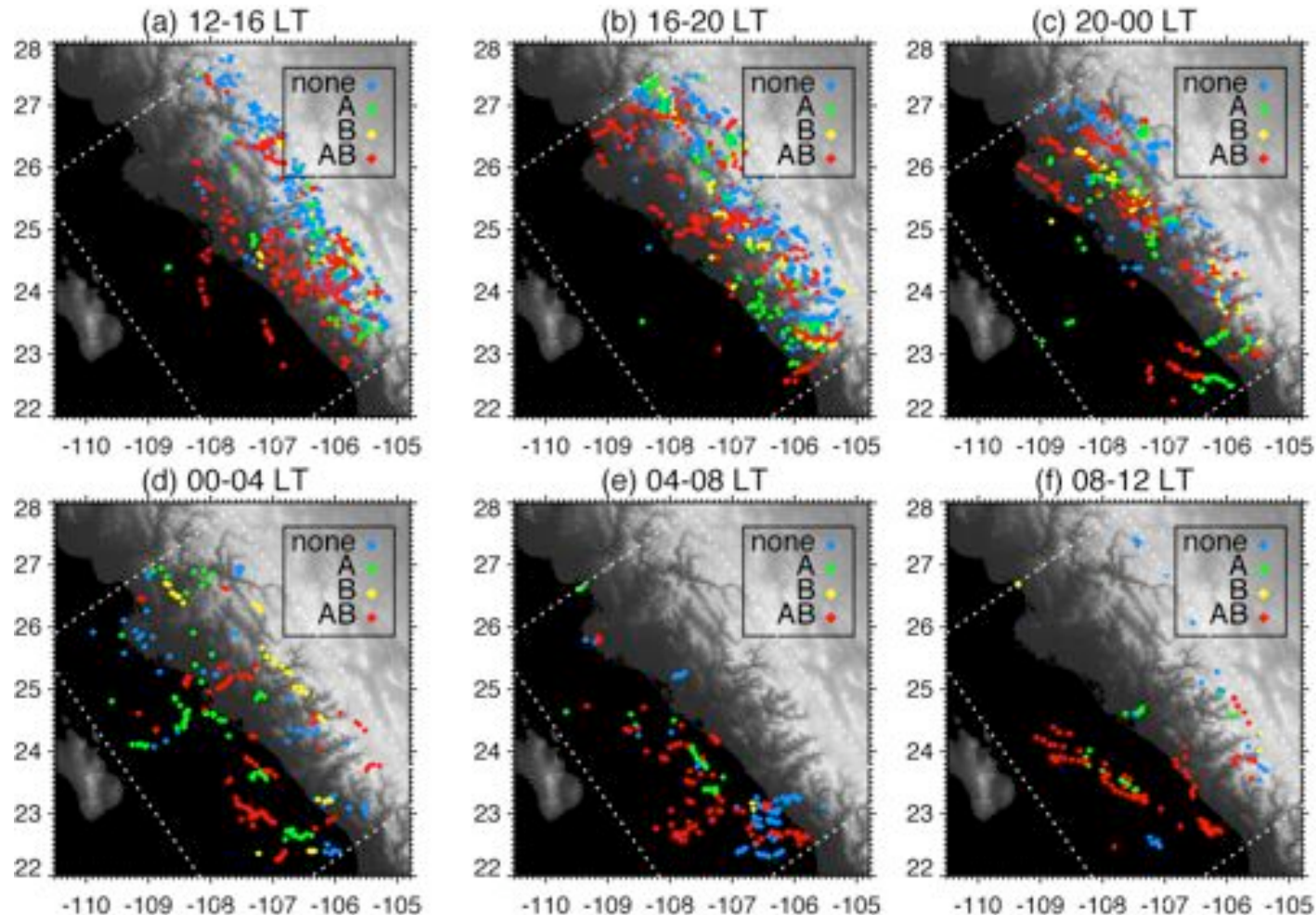(c) Maximum Dimension

(d) Organized Features
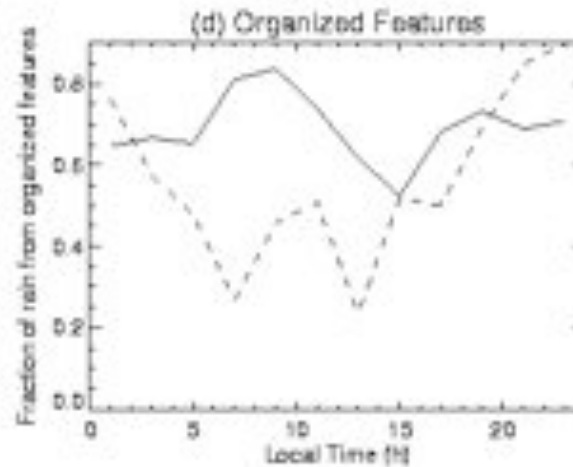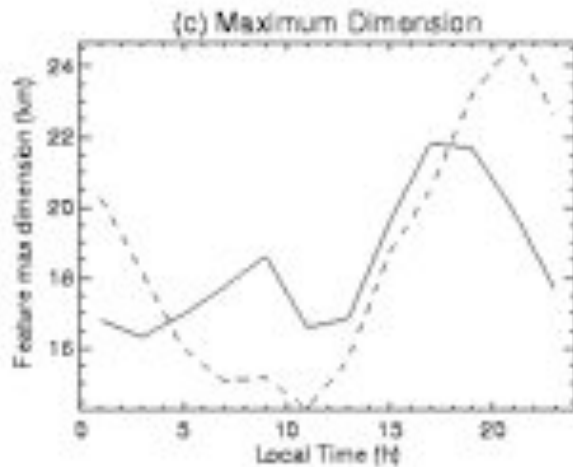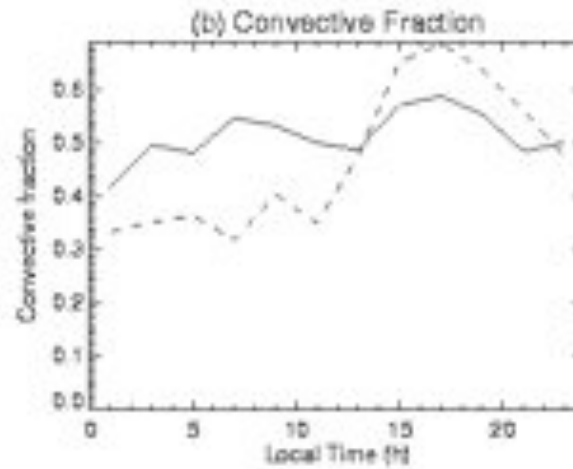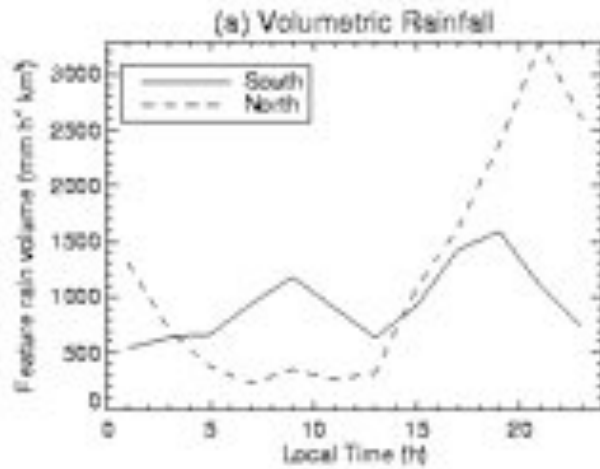
Feature Diurnal Cycle by Gulf-Parallel Zone

North & South (domain evenly split)

- The morning secondary peak in the statistics is only significant in the south, not the north
- In addition, the relative amplitude of the afternoon/evening peak is smaller in the south

Diurnal Cycle of Organized Features

• Organized features mainly appear over land during early afternoon
• During "No Regime" periods, organized features confined to high terrain
• During disturbed periods, organized features appear over coast and Gulf later in the evening and early morning, mostly during regime AB

Why are systems able to survive the trip to
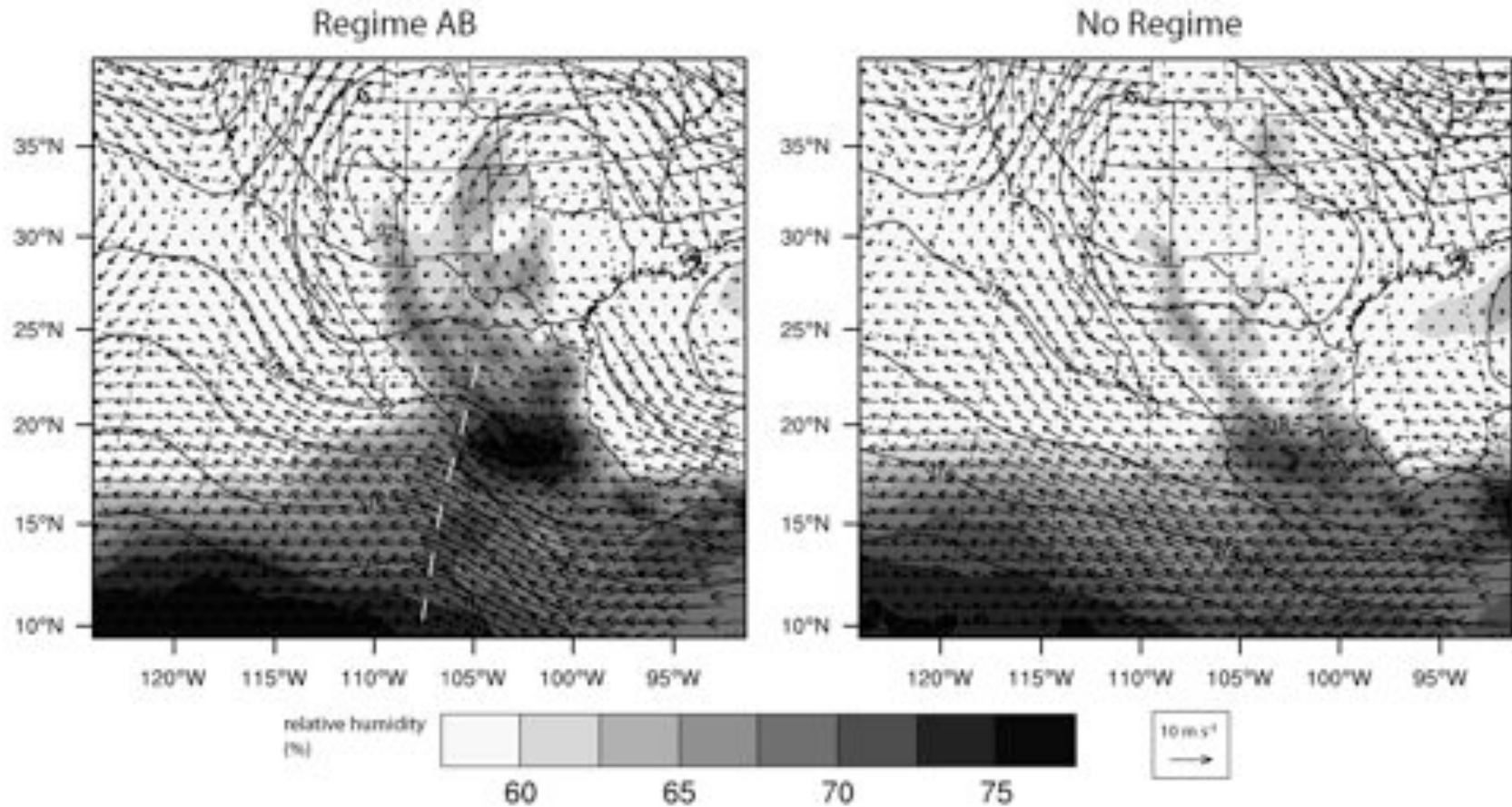the Gulf during disturbed periods?
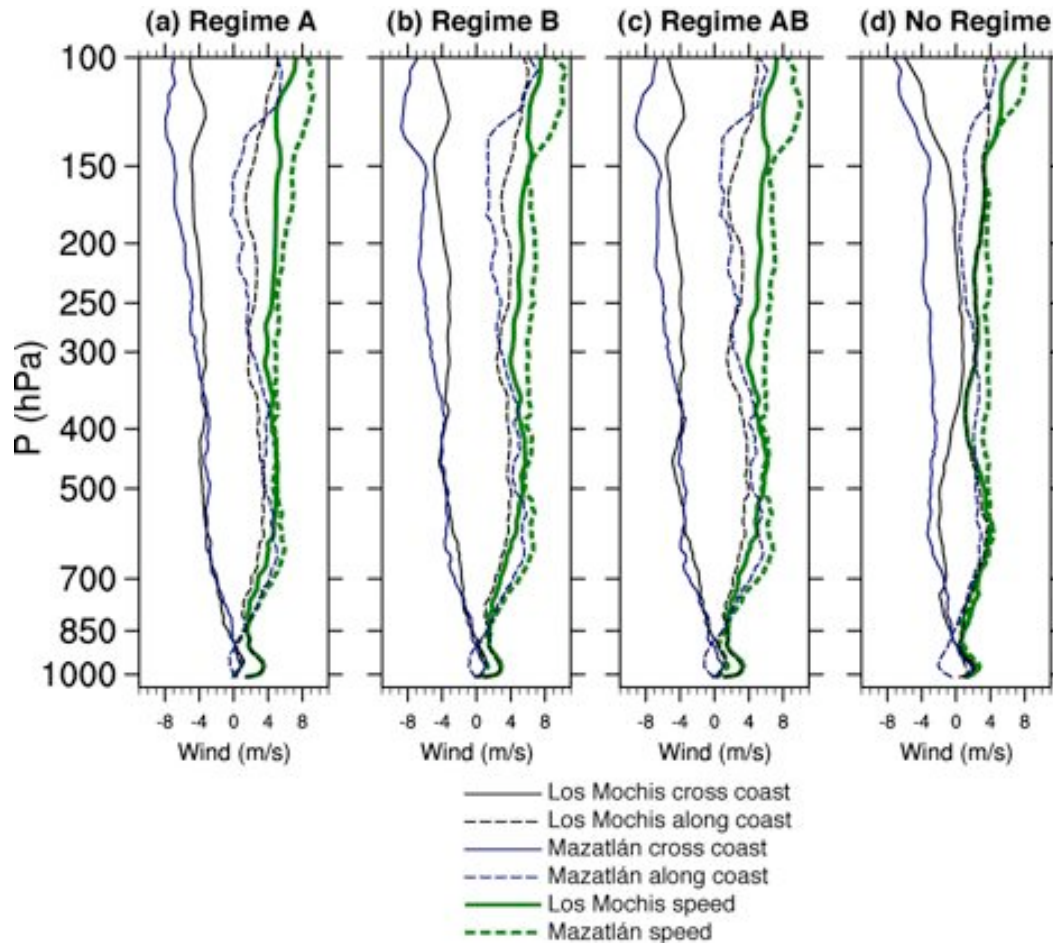
Mazatlan Sounding
0-4 km shear (m/s)

No Regime: 2.6
Regime A: 5.7
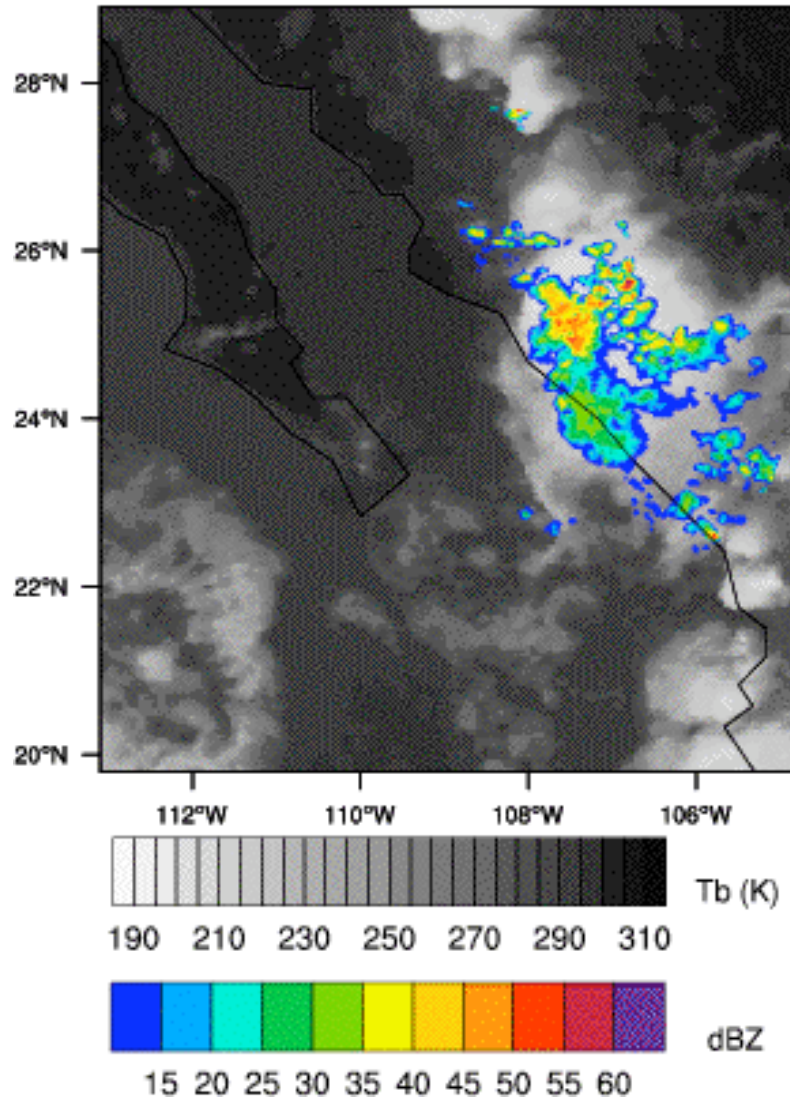Regime B: 6.5
Regime AB: 6.7

•Increased shear during disturbed periods
•Facilitates greater organization and longer lifetimes?

NARR Composite - 700 hPa winds, heights, and RH

Regime AB

No Regime

relative humidity (%)

60   65   70   75

10 m s⁻¹

Evidence for the passage of easterly waves enhancing convection in NAME domain

20040806_0029

Mesoscale Convective Vortex case

8/6/04

Conclusions

- Typical diurnal cycle - Precipitating systems form over specific terrain features in the SMO during afternoon, evolve/organize, and propagate toward Gulf during the evening

- During disturbed periods (e.g., AB), systems survive after sunset, possibly due to enhanced low-level shear, and actually reach the Gulf; Secondary early morning peak near position of land breeze

- Systems more organized during disturbed periods

- During Regime AB, there is weak propagation in excess of steering winds (+3-4 m/s coastward and +4-5 m/s northward along coast) - explainable by weak/shallow cold pools (0.5-1 km deep and 1-2°C depression)

- Easterly waves and possibly MCVs appear to play a role in causing the enhanced precipitation regimes, need further study