A case study of extreme precipitation over the United States and the MJO

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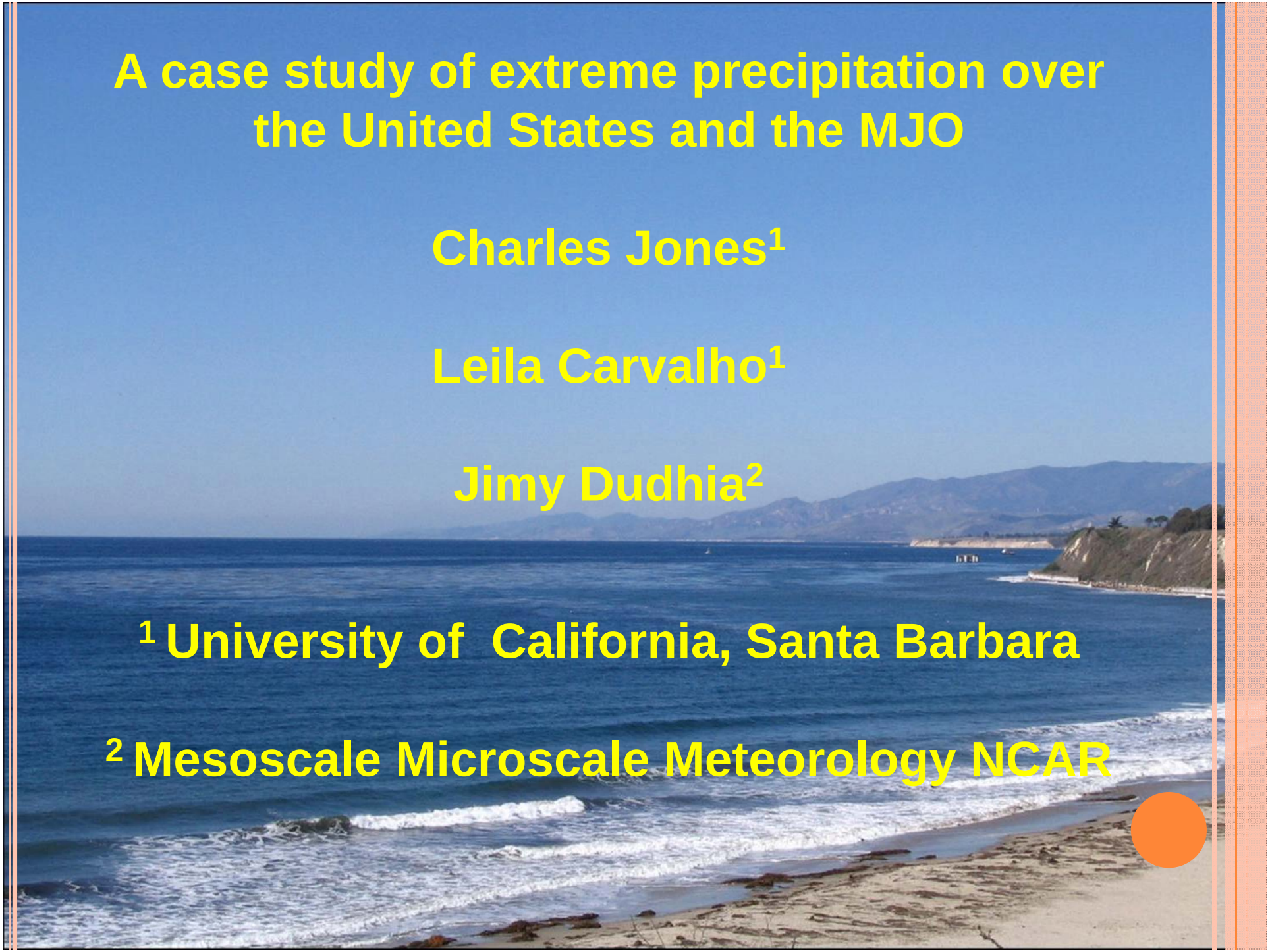


Motivation: previous studies show that teleconnections associated with the MJO influence precipitation variability in the extratropics including heavy events and forecast skill

Case study: 2004-05 winter season

Does the amplitude of the MJO have a significant role on the intensity of precipitation over the CONUS?

2004-05 winter season

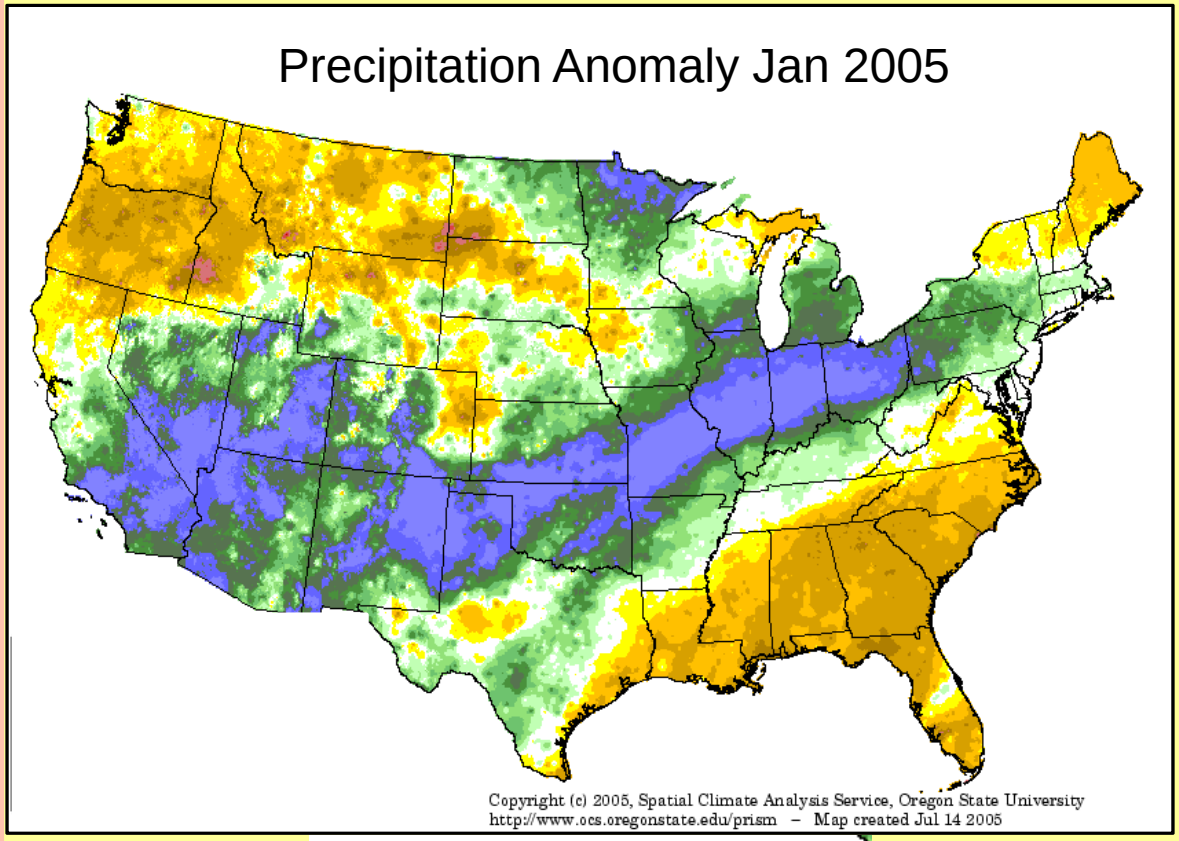
I. Major storms:18 December – 17 January 2004-05
   - 23 December: snow in Midwest
   - 28-29 December: precipitation in California
   - 2-5 January: heavy precipitation in Midwest
   - **7-11 January: heavy precipitation in California**
   - **11-13 January: heavy precipitation in Midwest**

II. Active MJO:
   - 18 December (phase 1) – 20 January (phase 8)

III. Weak warm ENSO: June 2004 – February 2005

IV. Atmospheric rivers: early January 2005

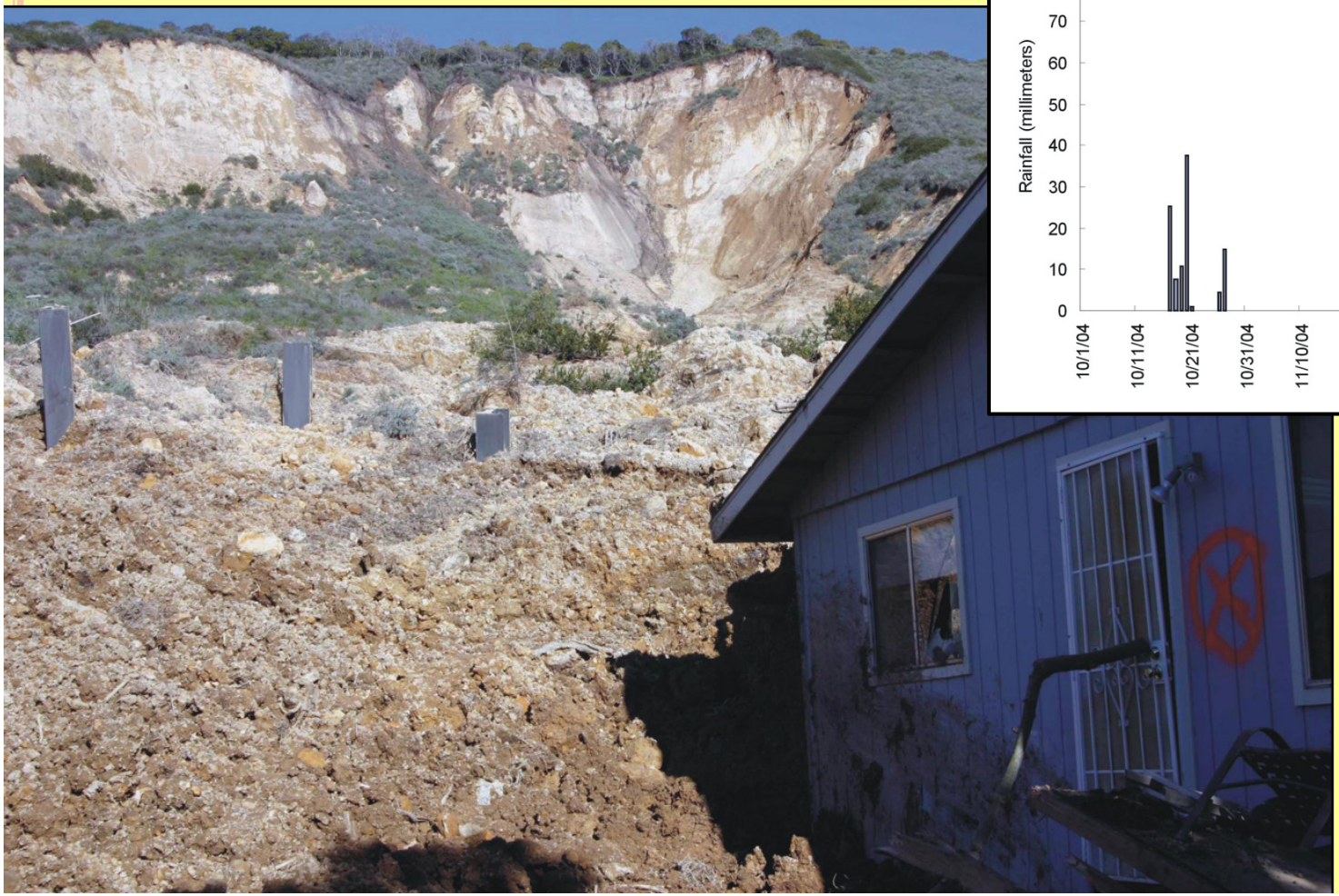
2004-05 winter season

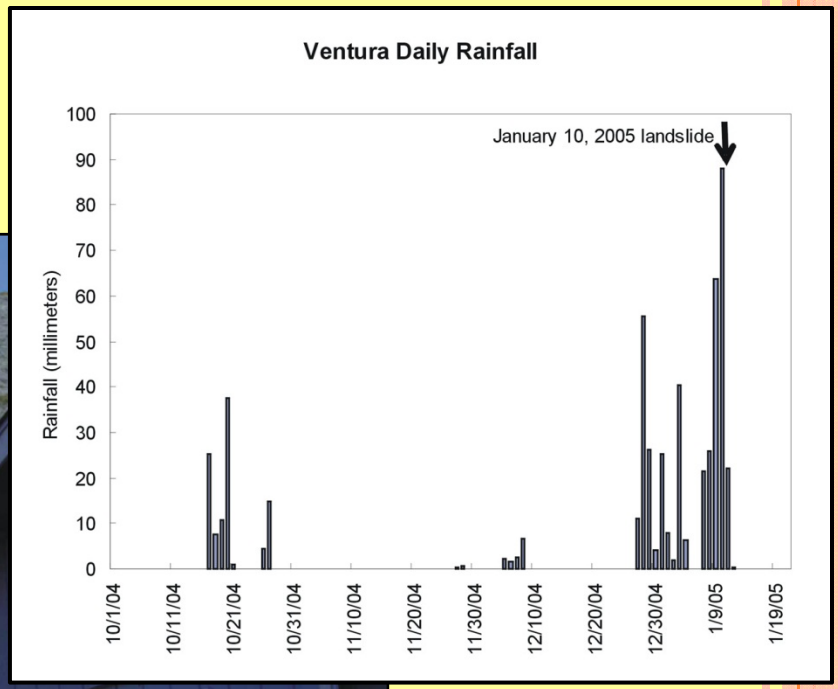


- 27 Dec-10 Jan: 16.97 inches in Los Angeles; wettest 15-day period on record
- 28 Dec-11 Jan: 13 feet snow at Sierra Lab
- 6-11 Jan: over 20 inches mountain stations in Santa Barbara
- 13 Jan: over 1 inch rain in 24h Mississippi & Ohio Valley
- More than 20 people killed, tens of millions dollars in damage

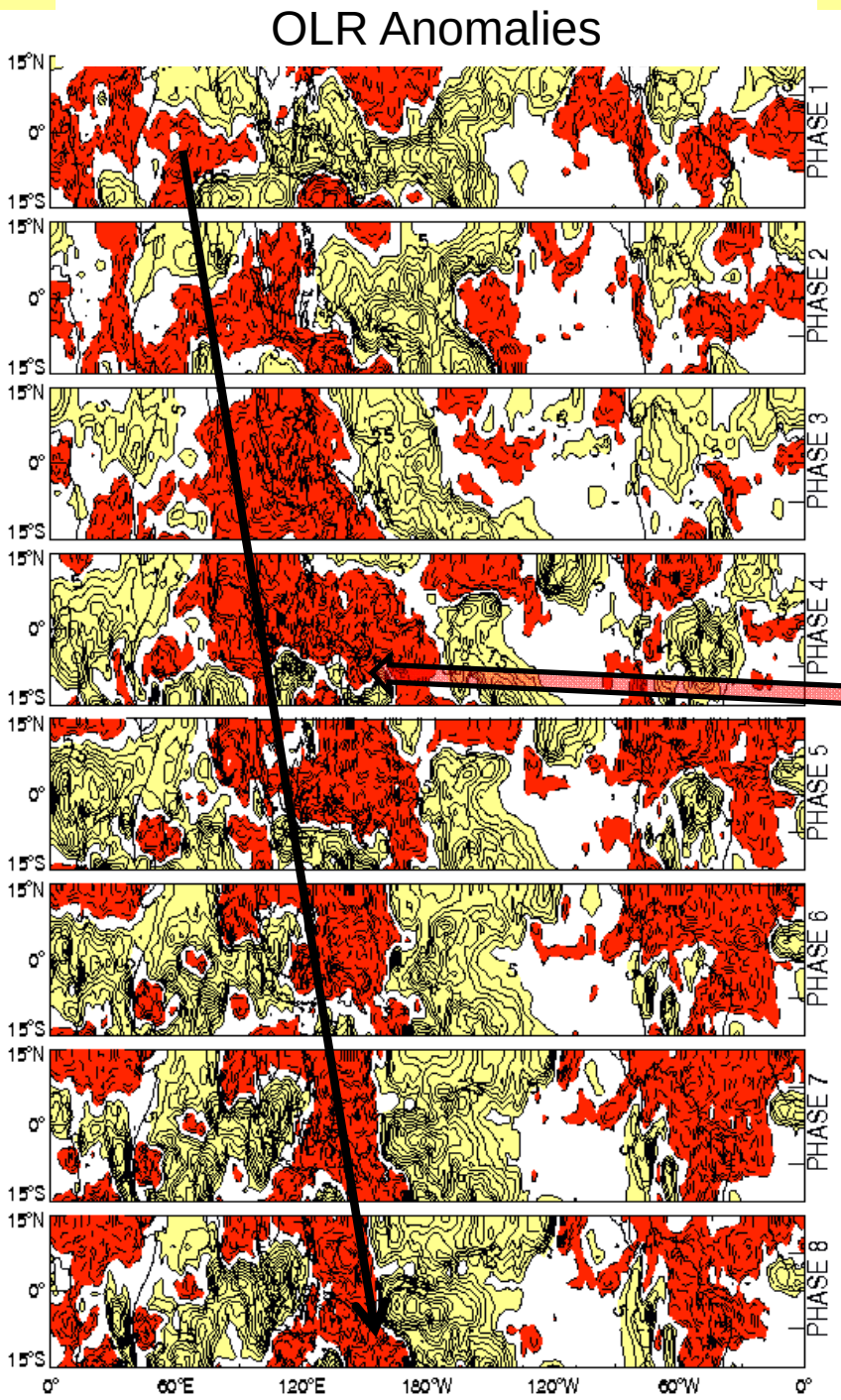
2004-05 winter season

La Conchita Landslide (between Santa Barbara and Ventura): 10 people killed





MJO: 2004-05 winter season



Phase 1
18 Dec

Phase 2
19-24 Dec

Phase 3
25 Dec-2 Jan

Phase 4
3-8 Jan

Phase 5
9-12 Jan

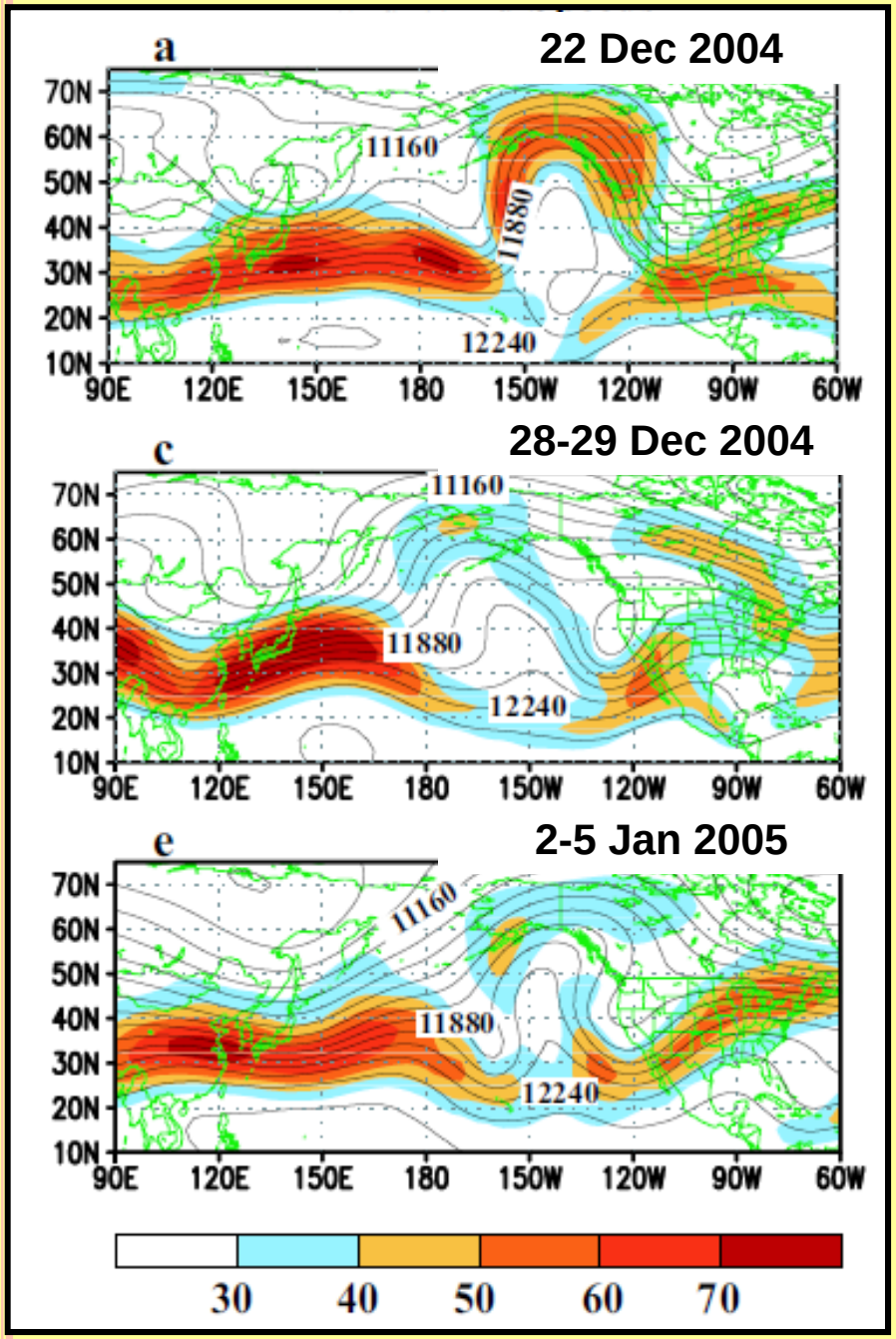
Phase 6
13-16 Jan

Phase 7
17-18 Jan

Phase 8
19-20 Jan

Enhanced Convection

Amplitude
$(PC1^2 + PC2^2)^{0.5}$



200-hPa Height Wind speeds

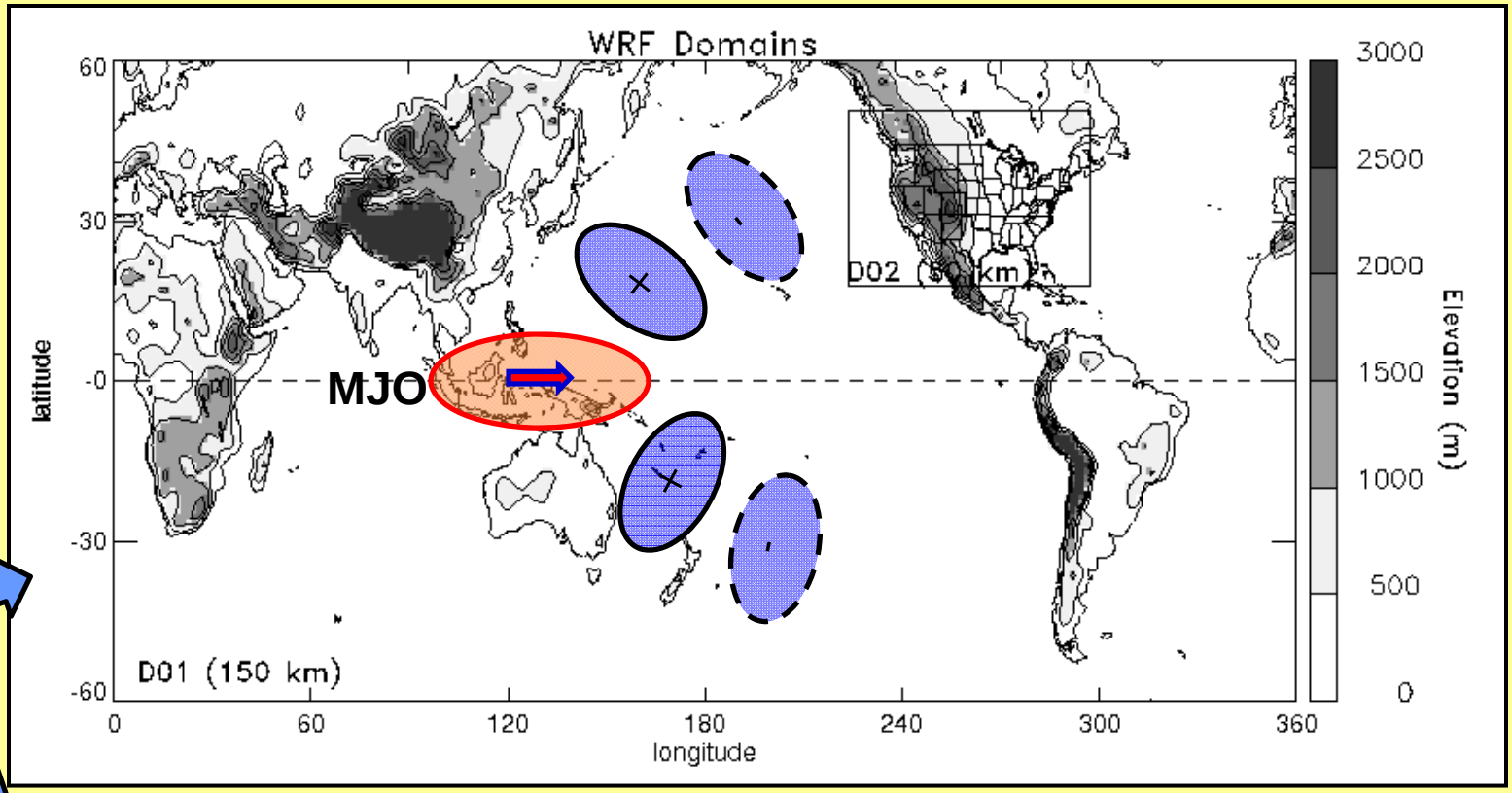
Highly anomalous temperatures and precipitation (23 December-14 January 2004-05) associated with exceptionally amplified circulation pattern at jet stream level: through over the southwestern and ridge over the eastern North America

Bell and Higgins, 2005: 18 December 2004- 17 January 2005: U.S. Storms and Flooding in the West and Midwest Exceptional Warmth in the Midwest and East. Available from www.cpc.ncep.noaa.gov

Does the amplitude of the MJO have a significant role on the intensity of precipitation over the CONUS?

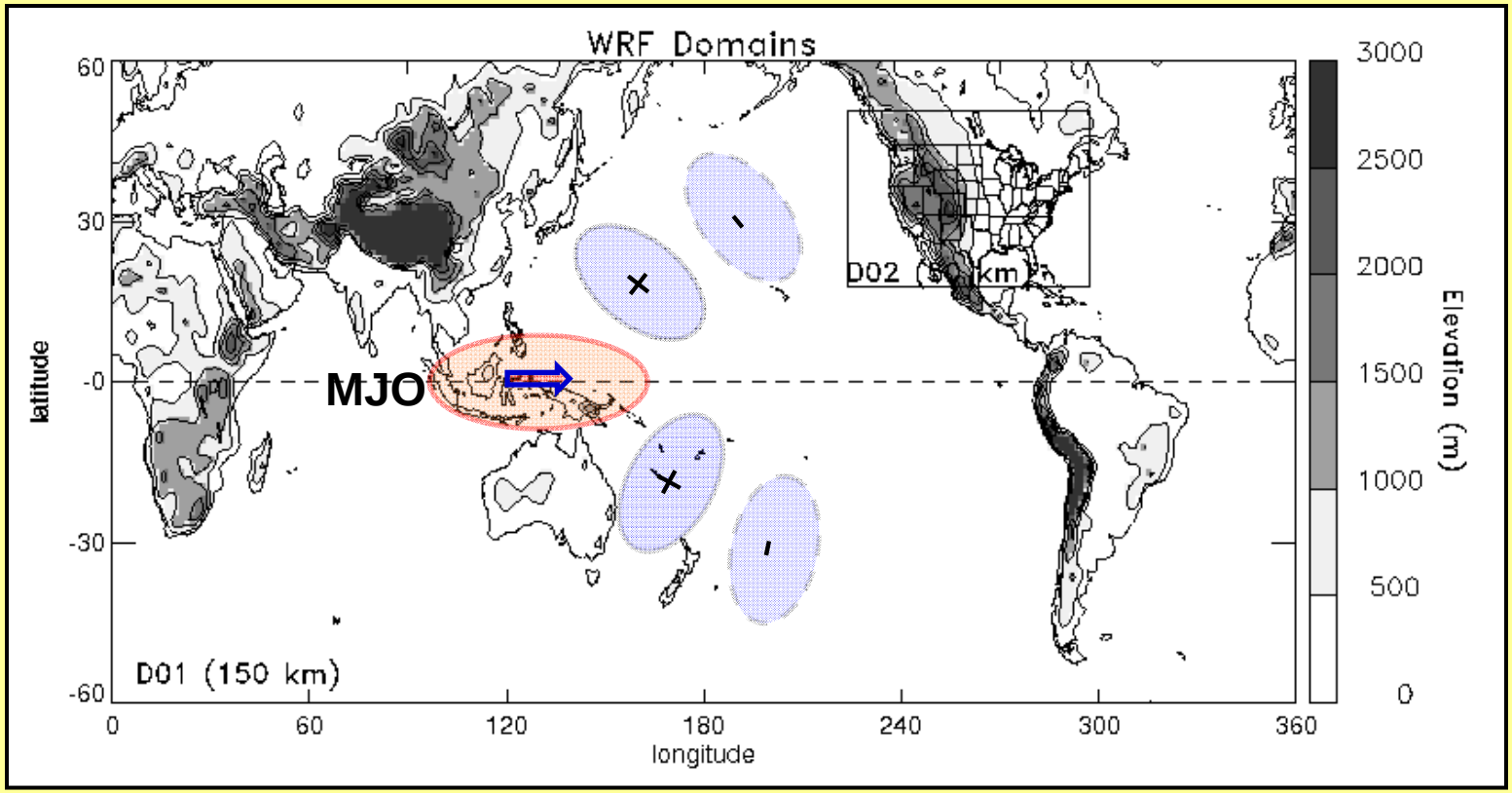
- Numerical experiment: WRF model
- Period: 5-15 January 2005
  - 7-11 Jan: heavy precipitation in California
  - 11-13 Jan: heavy precipitation in Midwest
- Two domains:
  - D01: 150 km grid spacing; 60S-60N,0-360W
  - D02: 50 km grid spacing over CONUS
- One way nesting, 35 levels, 9 min step
- Initial and boundary conditions: CFSR reanalysis, every 6hrs
- Parameterizations: WSM-5 microphysics, KF cumulus, M-O sfc layer physics, YSU pbl, unified Noah land-sfc physics
- Verification: CPC unified grid precipitation 0.5° lat/lon

Control experiment



- Initialized 5 Jan 05 00 UTC run until 15 Jan 18 UTC
- Domain 01: grid nudging during 5-15 Jan ⇒ CFSR
  - MJO signal retained
- One way nesting: signals enter boundaries in D02

Perturbation experiments



- Initialized 5 Jan 05 00 UTC run until 15 Jan 18 UTC
- Domain 01: grid nudging 5-15 Jan ⇒ perturbed field
  - MJO signal modified: removed, weaker or stronger
- One way nesting: signals enter boundaries in D02

Perturbation experiments

- Domain 01: grid nudging 5-15 Jan ⇒ perturbed field

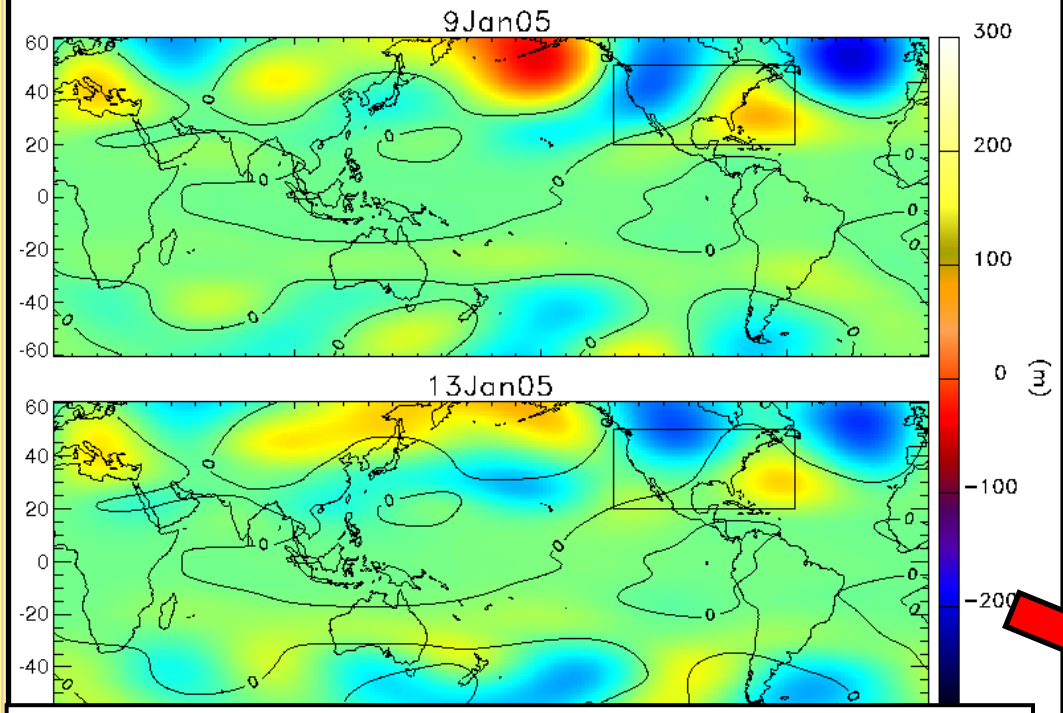
$$\Psi = \Phi + \{A \times N(\phi)\} \times Z$$

Where:

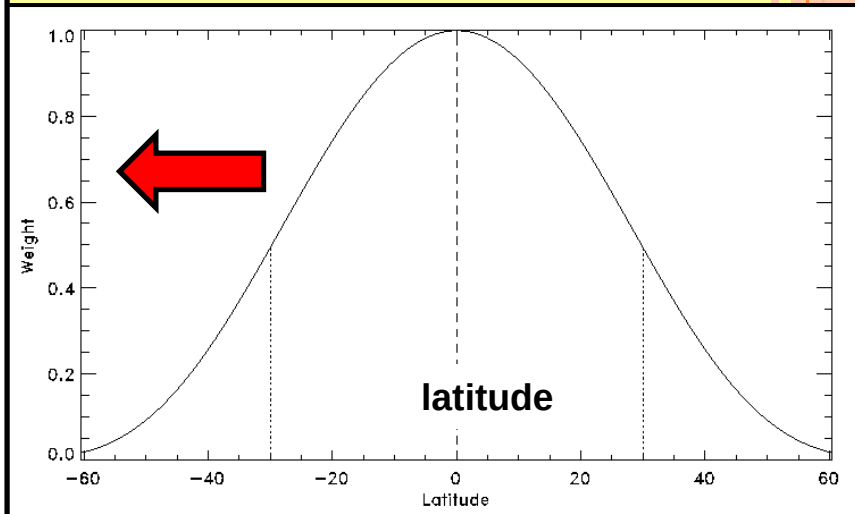
- Ψ is perturbed field
- Φ is CFSR reanalysis
- A is amplitude factor: -1.0, -.75, -0.5, +1.25, +1.50, +1.75
- $N(\phi)$ is Gaussian weight, ϕ is latitude
- Z is MJO signal: 20-100 days, wavenumbers 1-5
- Applied to H, U, V, T, RH, surface to 10-hPa (model top)

Perturbation experiments

H500 anomalies (20-100 days; 1-5 WVN)

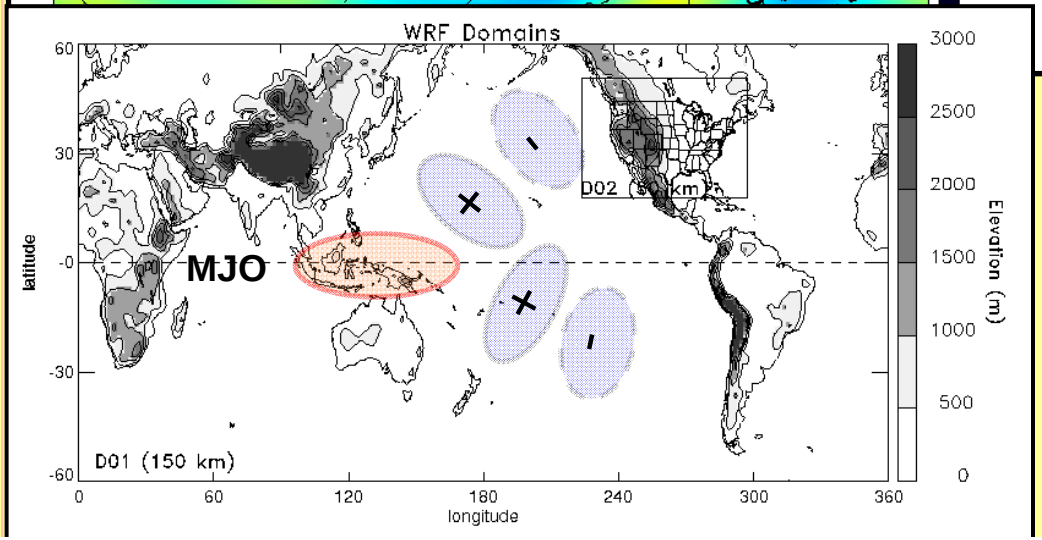


Gaussian weight $A \times N(\phi)$



$$\Psi = \Phi + \{A \times N(\phi)\} \times Z$$

CFSR



Nudging in D01

Sensitivity experiments

	MJO Amplitude						
07-11 Jan 05							
Mean	0	0.42	0.84	1.67	2.09	2.51	2.93
Percentile	N/A	9th	19th	Median	72nd	84th	95th
11-15 Jan 05							
Mean	0	0.27	0.54	1.08	1.35	1.62	1.89
Percentile	N/A	6th	12th	24th	46th	~Median	65th
Change in MJO Amplitude	**Removed**	**Decreased to 25%**	**Decreased to 50%**	**CTRL**	**Increased by 25%**	**Increased by 50%**	**Increased by 75%**

Weaker ← **MJO** → **Stronger**

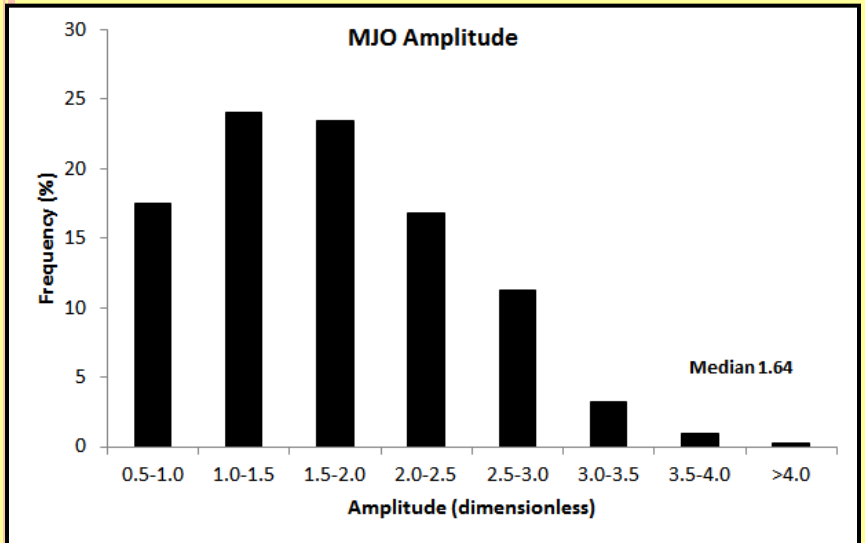
Storms in

California

MJO Phases: 4-5

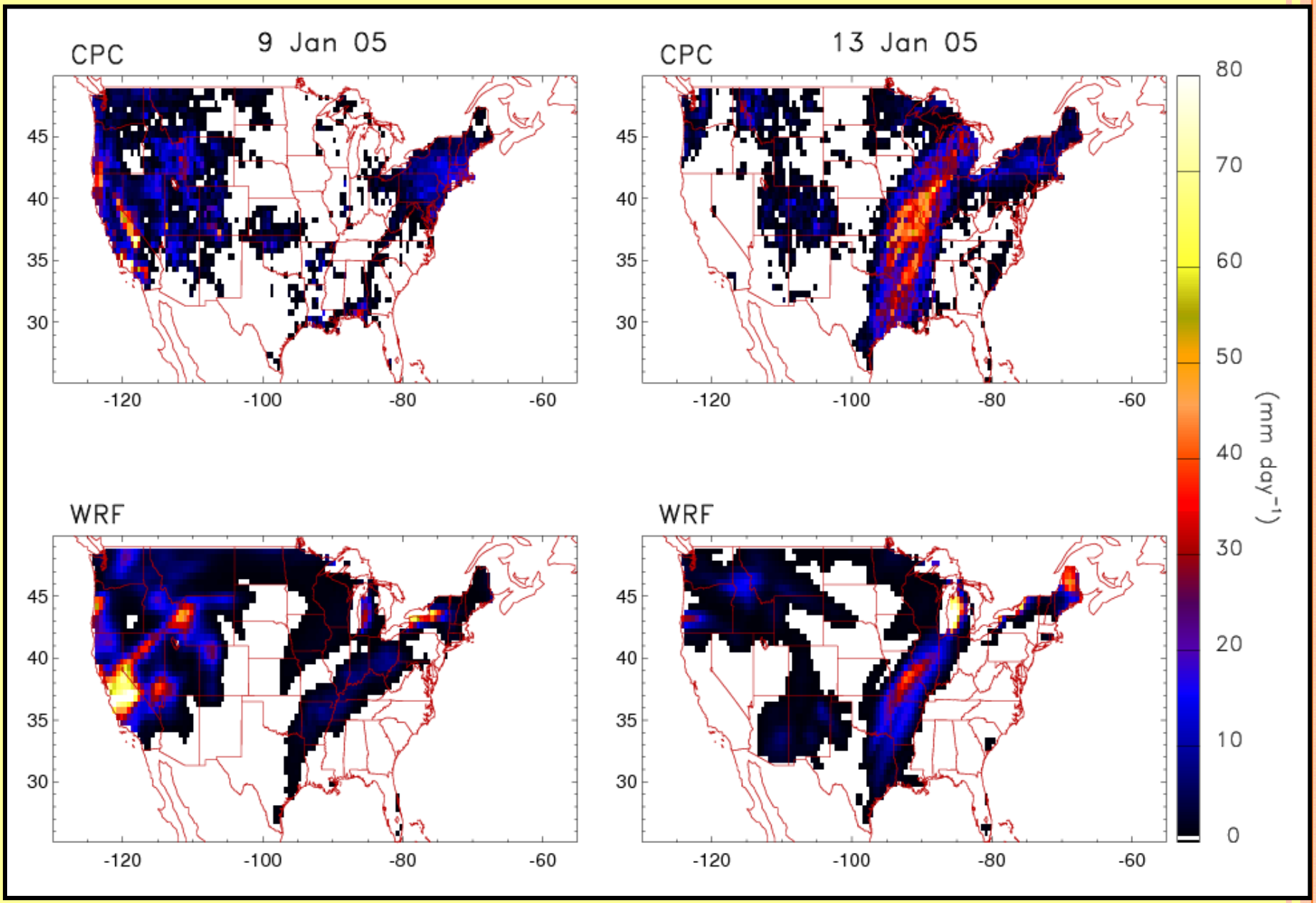
Midwest

MJO Phases: 5-6

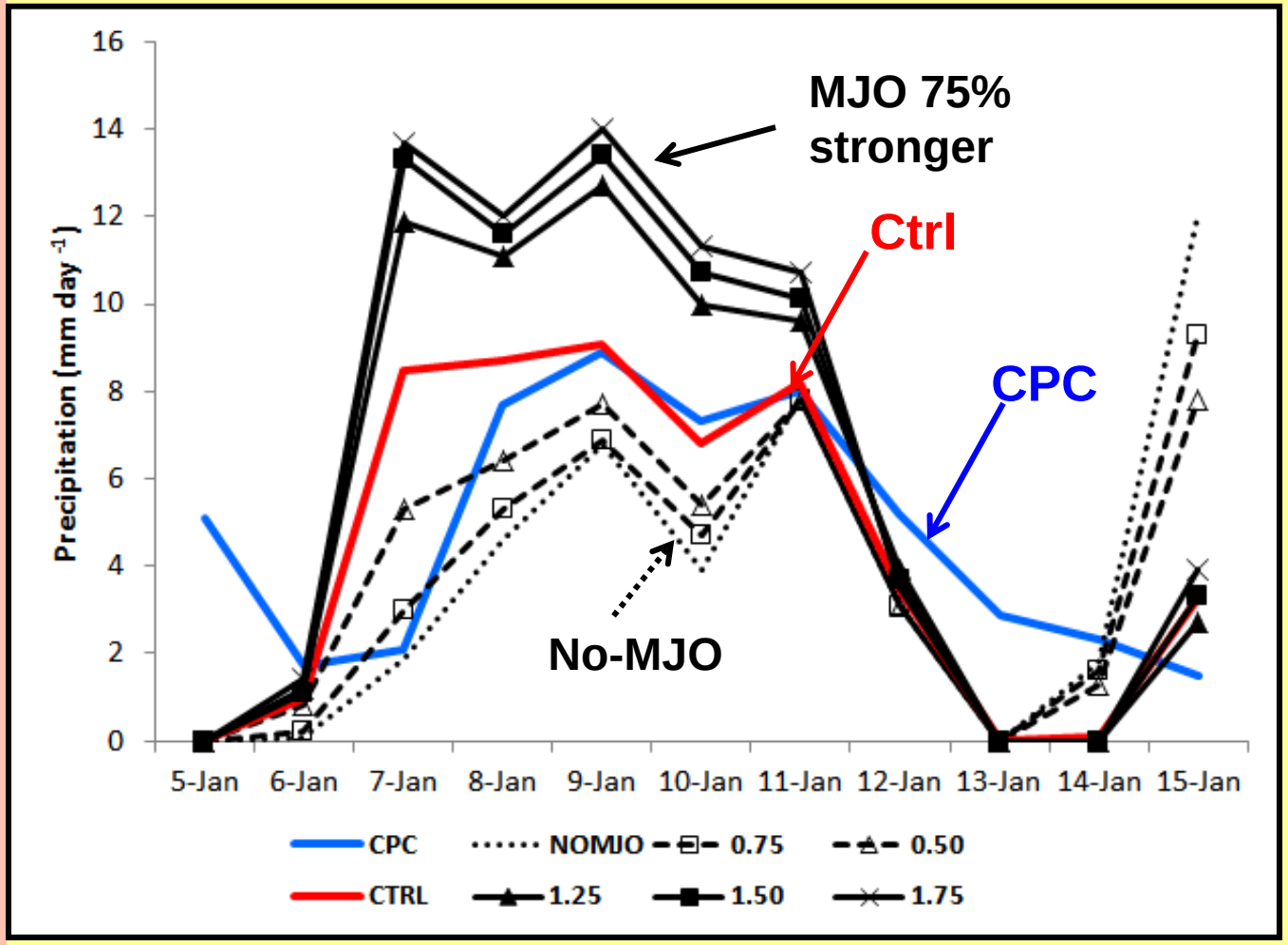


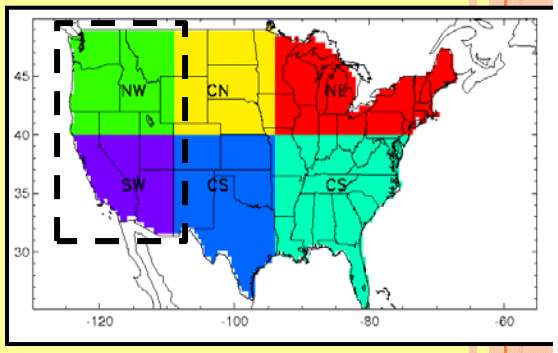
Distribution of MJO amplitudes (winter) 1979-2010

Example: Control Run



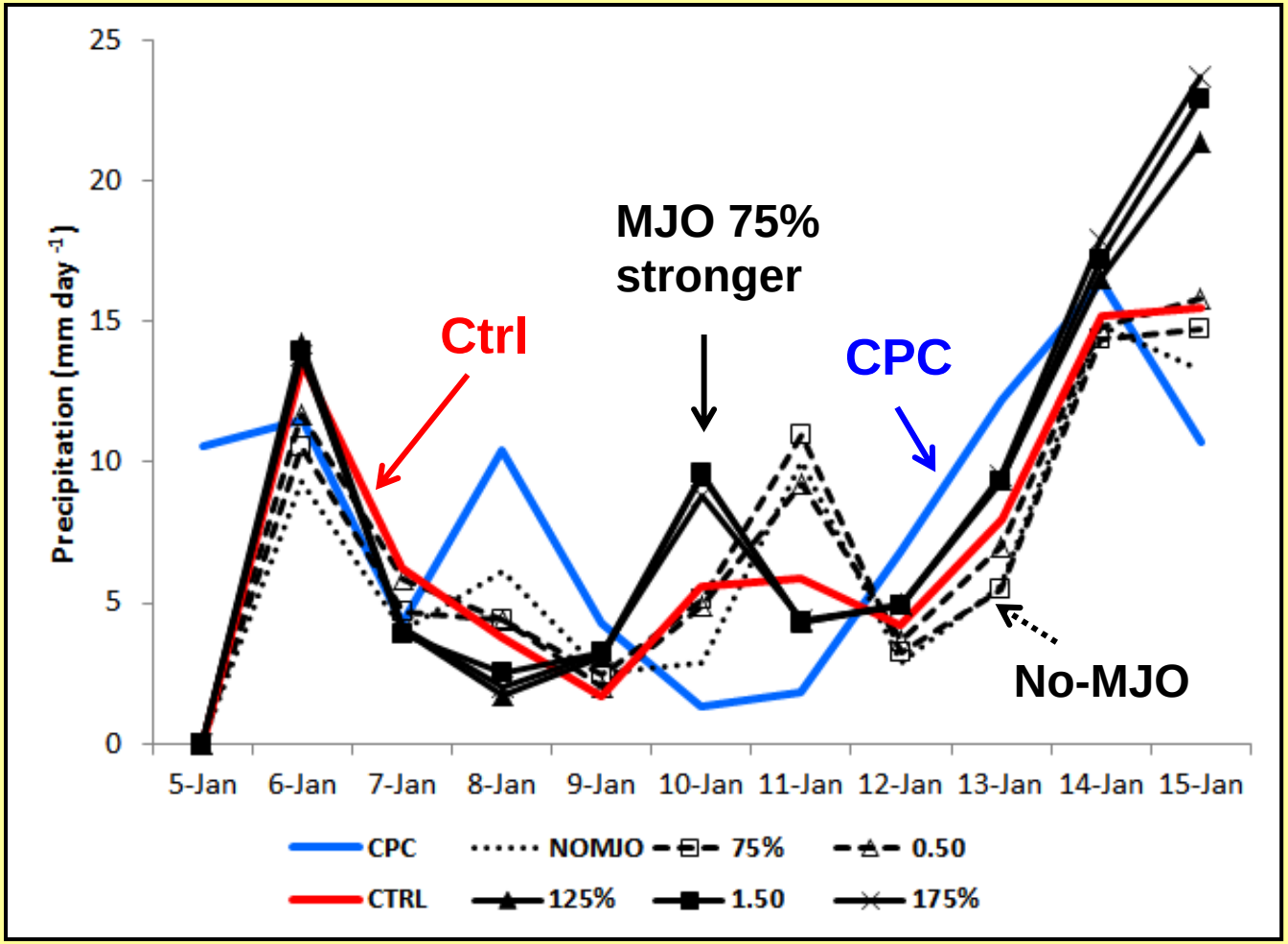
MJO and precipitation: western CONUS

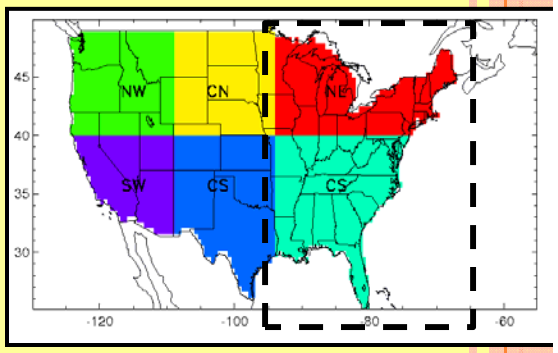




Mean precipitation over western CONUS (bias corrected)

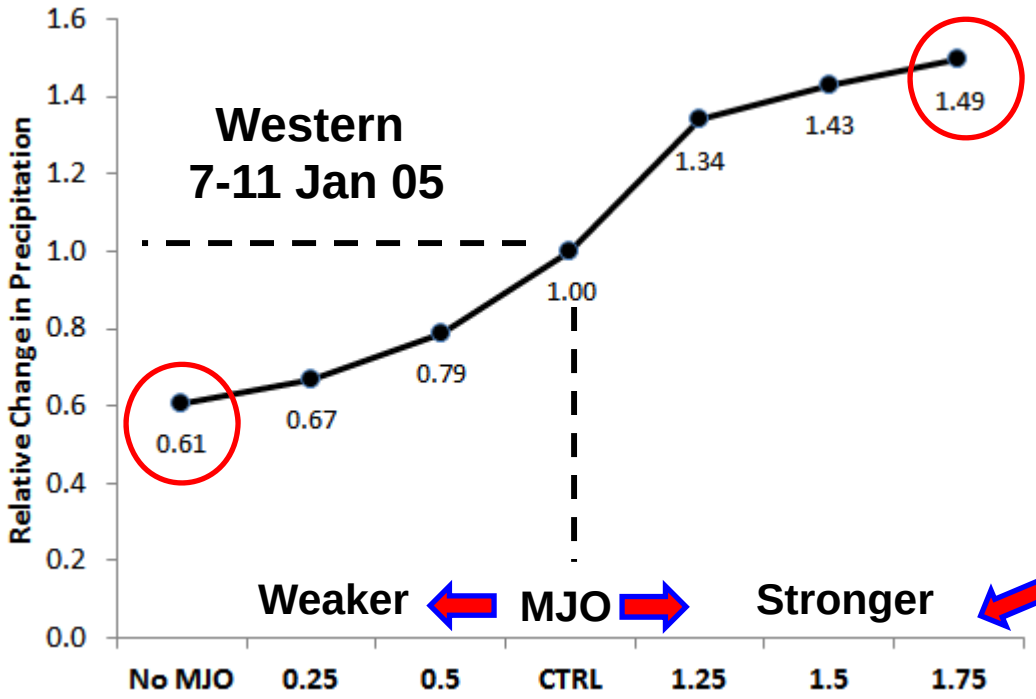
MJO and precipitation: eastern CONUS





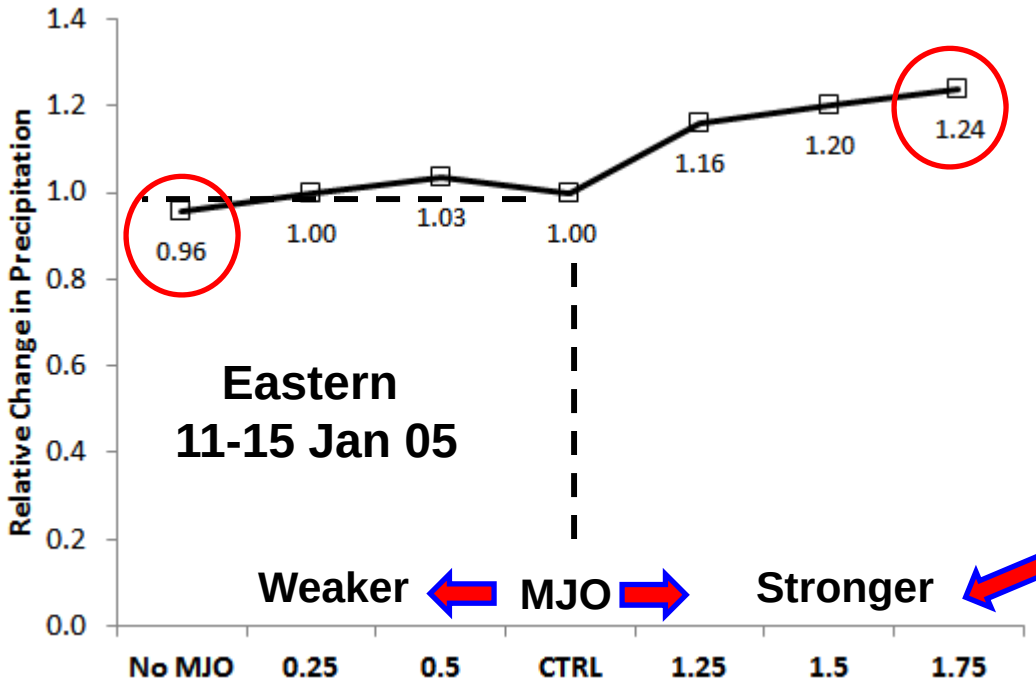
Mean precipitation over eastern CONUS (bias corrected)

Precipitation intensity and MJO amplitude



MJO Phases: 4-5

MJO Amplitude ~95th percentile



MJO Phases: 5-6

MJO amplitude ~65th percentile

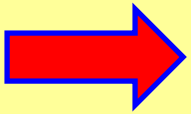
Conclusions

- 2004-05 winter season was characterized by extreme precipitation across southern states and parts of the Midwest

- Case study 5-15 January 2005: sensitivity experiments

  - **Western**: MJO amplitude important on the mean precipitation
    - No-MJO signal ⇒ precipitation decreases by ~40%
    - MJO amplitude 95th ⇒ precipitation increases by ~50%

  - **Eastern**: mean precipitation not very sensitive to MJO amplitude

  In progress:

  - Dynamical analysis of sensitivity experiments

  - Additional case studies