

# Northeast Arizona Snow Study

NWS Flagstaff

# Introduction

- Better understand and forecast significant weather events across NE Arizona
- Study Significant Snow Storm Events
- Examine the potential of using data other than radar to determine heavy rain/snow

# Data

- xmACIS2 surface observations
- The NCEP/NCAR Upper Air Reanalysis (1948-present)
- Earth System Research Laboratory – Daily Mean Composite page
- <http://www.esrl.noaa.gov/psd/data/composites/day>
- <http://www.esrl.noaa.gov/psd/data/composites/day/datasets.html>

# Methodology

- Choose locations with a decent historical record (Canyon de Chelly, Ganado, Keams Canyon, Navajo N.M., Page, Teec Nos Pos, Window Rock)
- Select the top 20 daily snowfall events occurring during or after 1948
- Create mean charts for the top 10 then the next 10 events (500mb height, 700/500/250 mb wind, 700 mb RH, PW, Omega 500/250 mb Temp)
- Identify any significant features of all charts
- Identify differences between top 10/next 10 charts

# Results

- Mean 500 mb Heights
- Mean 700 mb Wind
- PW Anomalies
- 500/250 mb Wind Comparisons
- 500/250 mb Jet Max Speeds
- 500/250 mb Wind Speed Gradient
- 700 mb RH
- Upward Motion
- Comparison to previous study

# 700 mb Wind Anomaly 2-days before Storm

Top 10

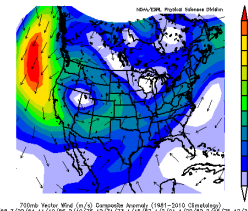
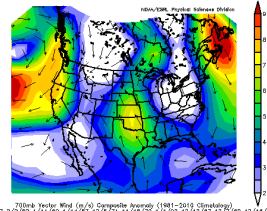
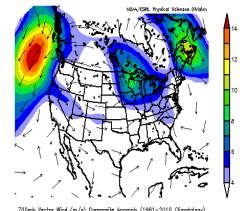
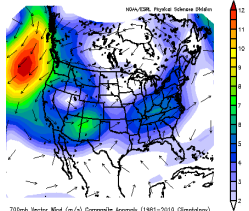
Next 10

Top 10

Next 10

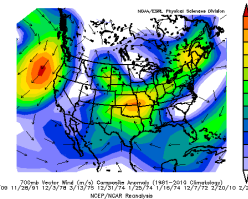
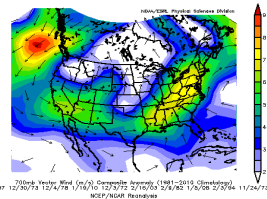
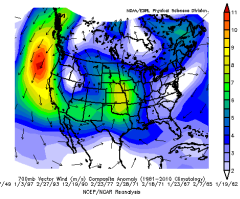
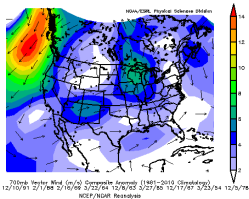
Canyon de Chelly

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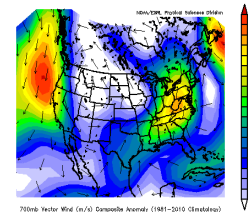
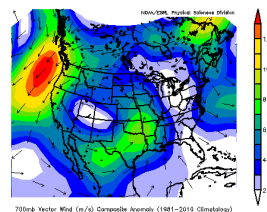
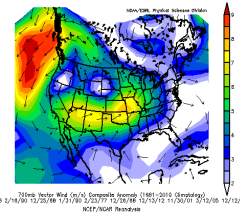
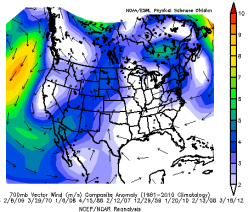
Ganado

Tec Nos Pos

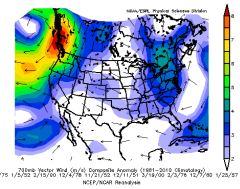
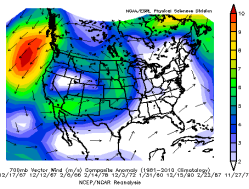


Keams Canyon

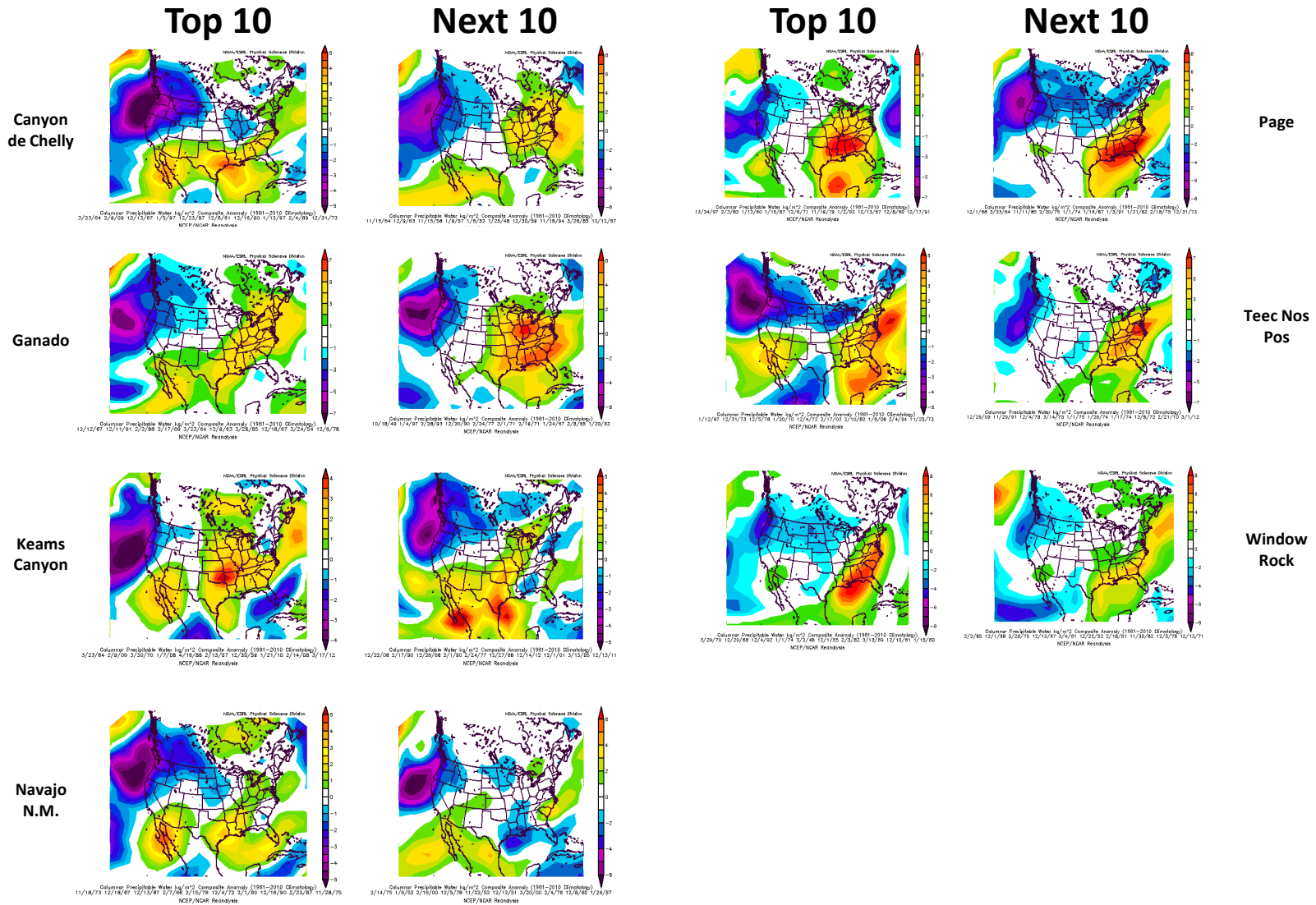
Window Rock



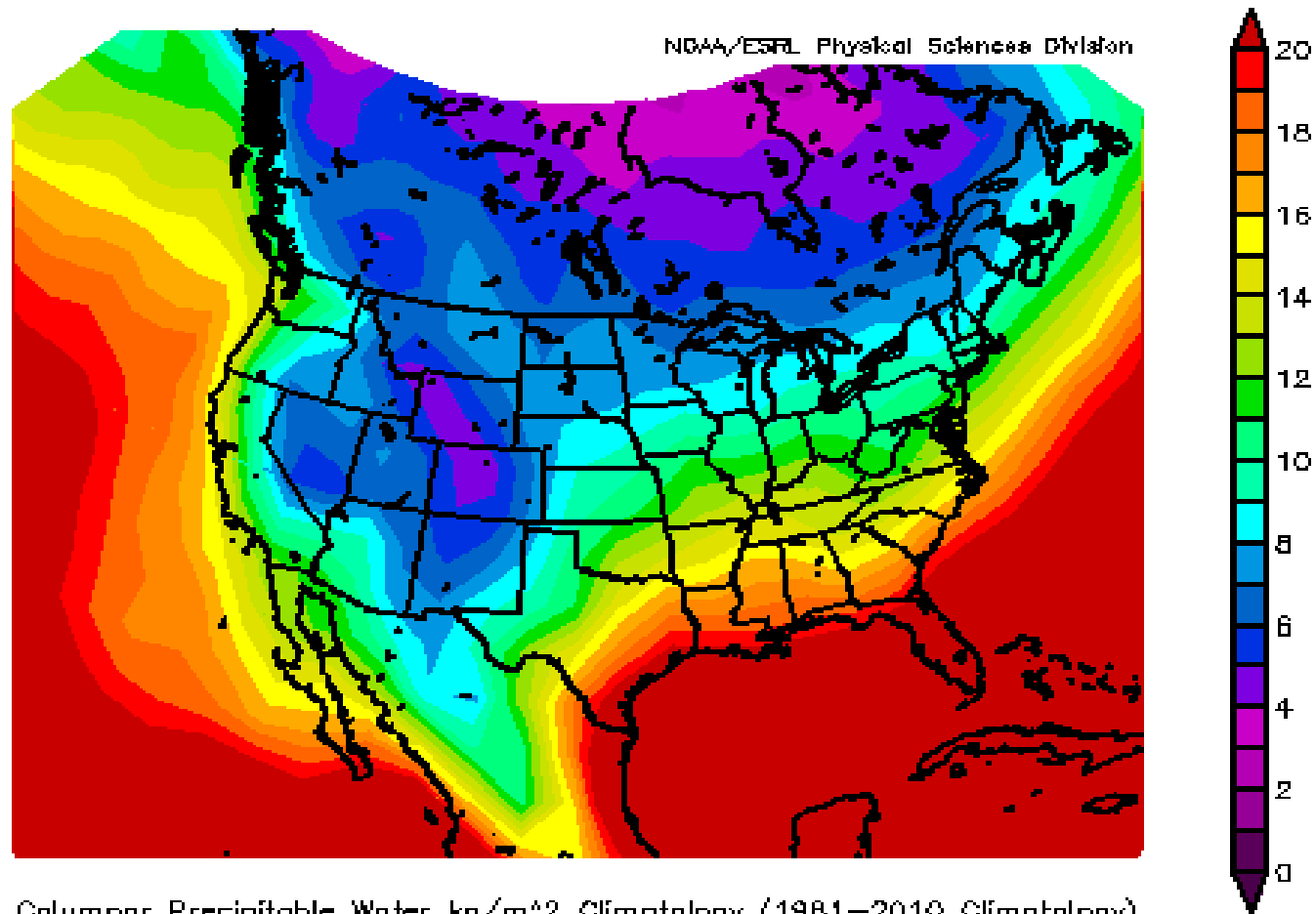
Navajo N.M.



# PW Anomalies 1-Day Before Storm



# Climatological PW for November 1<sup>st</sup> through March 31<sup>st</sup> 1981-2010



Columnar Precipitable Water  $\text{kg/m}^2$  Climatology (1981–2010 Climatology)  
11/1 to 3/31

NCEP/NCAR Reanalysis



# 700 mb RH 1-Day Before

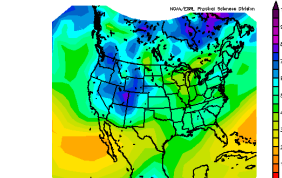
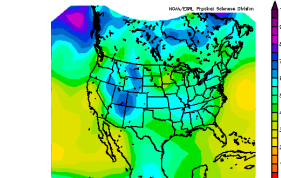
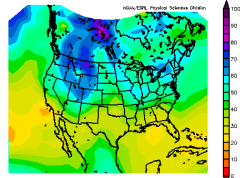
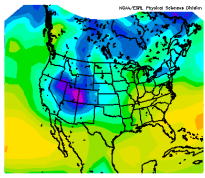
Top 10

Next 10

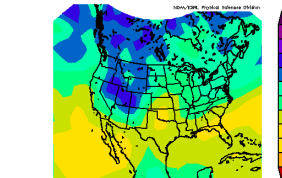
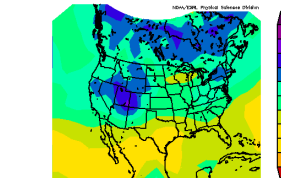
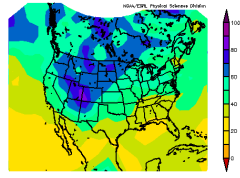
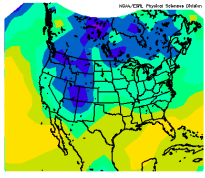
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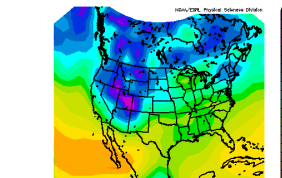
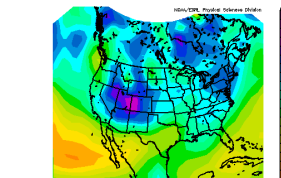
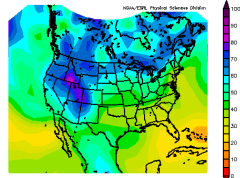
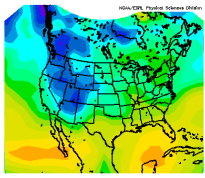
Canyon de Chelly



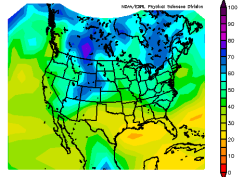
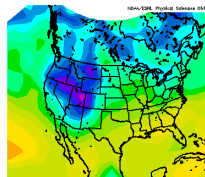
Ganado



Keams Canyon



Navajo N.M.



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Teec Nos Pos

Window Rock

# 500 mb Height Analysis Day of Storm

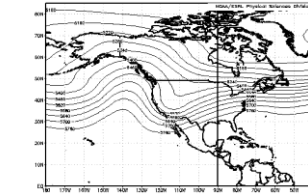
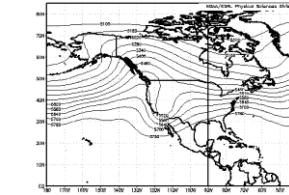
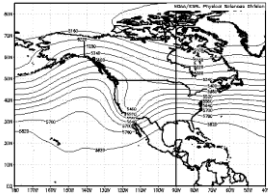
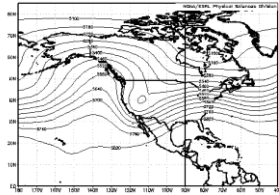
Top 10

Next 10

Top 10

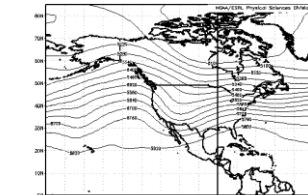
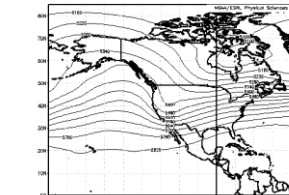
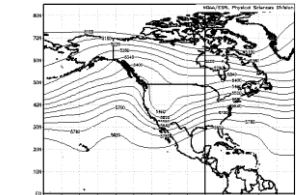
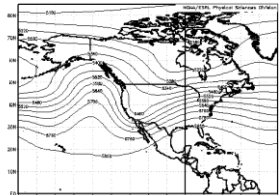
Next 10

Canyon de Chelly



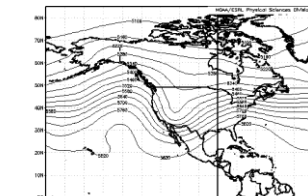
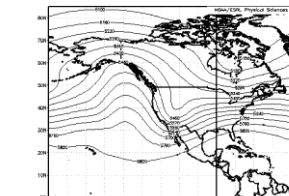
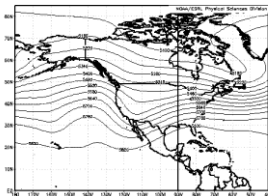
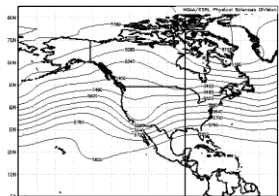
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Ganado



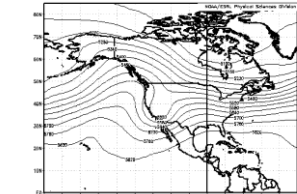
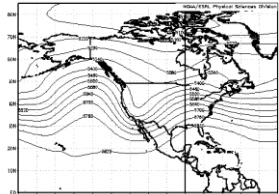
Teec Nos Pos

Keams Canyon



Window Rock

Navajo N.M.



# 500/250 mb Wind Comparison

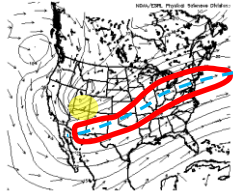
Top 10

Next 10

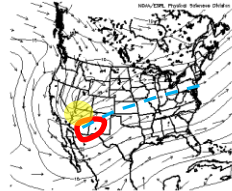
Top 10

Next 10

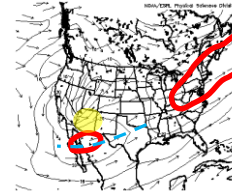
Canyon de Chelly



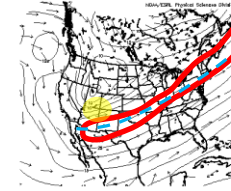
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3/24/84 2/10/89 12/14/87 1/29/84 12/28/87 12/8/81 12/17/90 1/14/87 2/26/88 1/1/74  
NCEP/NOAA Reanalysis



500mb Vector Wind (m/s) Composite Mean  
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NCEP/NOAA Reanalysis



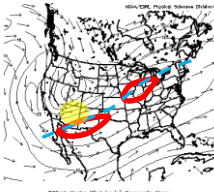
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NCEP/NOAA Reanalysis



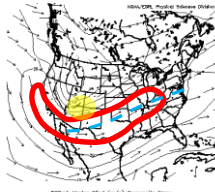
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NCEP/NOAA Reanalysis

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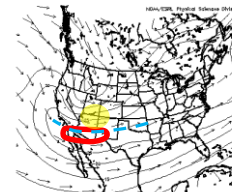
Ganado



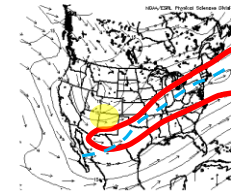
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NCEP/NOAA Reanalysis



500mb Vector Wind (m/s) Composite Mean  
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NCEP/NOAA Reanalysis



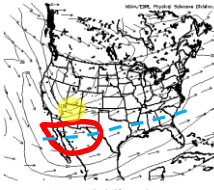
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NCEP/NOAA Reanalysis



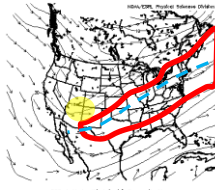
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NCEP/NOAA Reanalysis

Teec Nos Pos

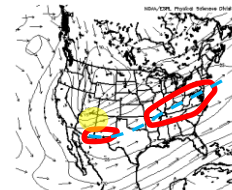
Keams Canyon



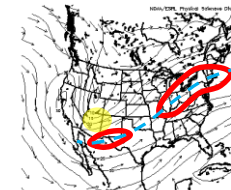
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NCEP/NOAA Reanalysis



500mb Vector Wind (m/s) Composite Mean  
12/23/88 02/18/85 12/27/88 02/03/88 02/03/88 11/23/72 12/02/74 03/14/83 12/14/  
NCEP/NOAA Reanalysis



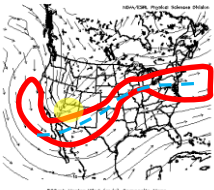
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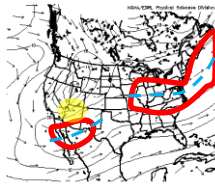
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NCEP/NOAA Reanalysis

Window Rock

Navajo N.M.



500mb Vector Wind (m/s) Composite Mean  
11/18/73 12/18/87 12/14/87 02/28/88 02/18/78 10/28/73 02/28/88 12/17/80 02/24/87 11/29/  
NCEP/NOAA Reanalysis



500mb Vector Wind (m/s) Composite Mean  
2/18/78 1/7/82 2/17/80 12/16/78 11/23/72 12/12/76 2/28/78 12/21/80 12/16/80 1/27/87  
NCEP/NOAA Reanalysis

# 500/250 mb Jet Max Speed

	Top 10	Next 10		Top 10	Next 10	
Canyon de Chelly	83 kt	72 kt	500 mb	62 kt	72 kt	Page
	120 kt	118 kt	250 mb	124 kt	123 kt	
Ganado	68 kt	74 kt	500 mb	66 kt	64 kt	Teec Nos Pos
	120 kt	122 kt	250 mb	123 kt	134 kt	
Keams Canyon	69 kt	67 kt	500 mb	67 kt	68 kt	Window Rock
	119 kt	114 kt	250 mb	127 kt	129 kt	
Navajo N.M.	72 kt	66 kt	500 mb			
	128 kt	125 kt	250 mb			

# 500/250 mb Speed Gradient



# 500/250 mb Speed Gradient

	Top 10	Next 10		Top 10	Next 10	
Canyon de Chelly	48 kt	54 kt	500 mb	48 kt	57 kt	Page
	88 kt	90 kt	250 mb	80 kt	82 kt	
Ganado	53 kt	54 kt	500 mb	42 kt	44 kt	Teec Nos Pos
	84 kt	94 kt	250 mb	79 kt	79 kt	
Keams Canyon	53 kt	50 kt	500 mb	50 kt	47 kt	Window Rock
	89 kt	83 kt	250 mb	80 kt	72 kt	
Navajo N.M.	57 kt	50 kt	500 mb			
	87 kt	73 kt	250 mb			

# Distance between centers of upward/downward motion couplets

	Top 10 (mi)	Next 10 (mi)
Canyon De Chelly	727	742
Ganado	689	790
Keams Canyon	722	708
Navajo N.M.	691	790
Page	640	752
Teec Nos Pos	707	731
Window Rock	770	809
Average Distance	707	760

# Summary

- Strong northerly wind anomaly at 700 m over the Pacific Ocean just off the west coast several days in advance.
- PW generally at or above the 30 year mean 1 to 2 days in advance of the storm. Essentially never below normal.
- 700 mb RH 65% to 75% percent 1 to 2 days in advance of storm.
- 500/250 jet max vertically stacked to the south to southeast of NE Arizona for >18 hours.
- 500/250 wind speed gradient centered over Arizona >18 hours
- Tend to be in the rear entrance region of a well established and quasi stationary 250 mb jet extending well downstream.
- 500/250 mb jet max rotates around bottom if existing trough
- Up/Down couplet center to center consistently about 700 miles.



# Future

- Look at common dates
- Look at analog days over a 10 year period to determine false alarm rate.