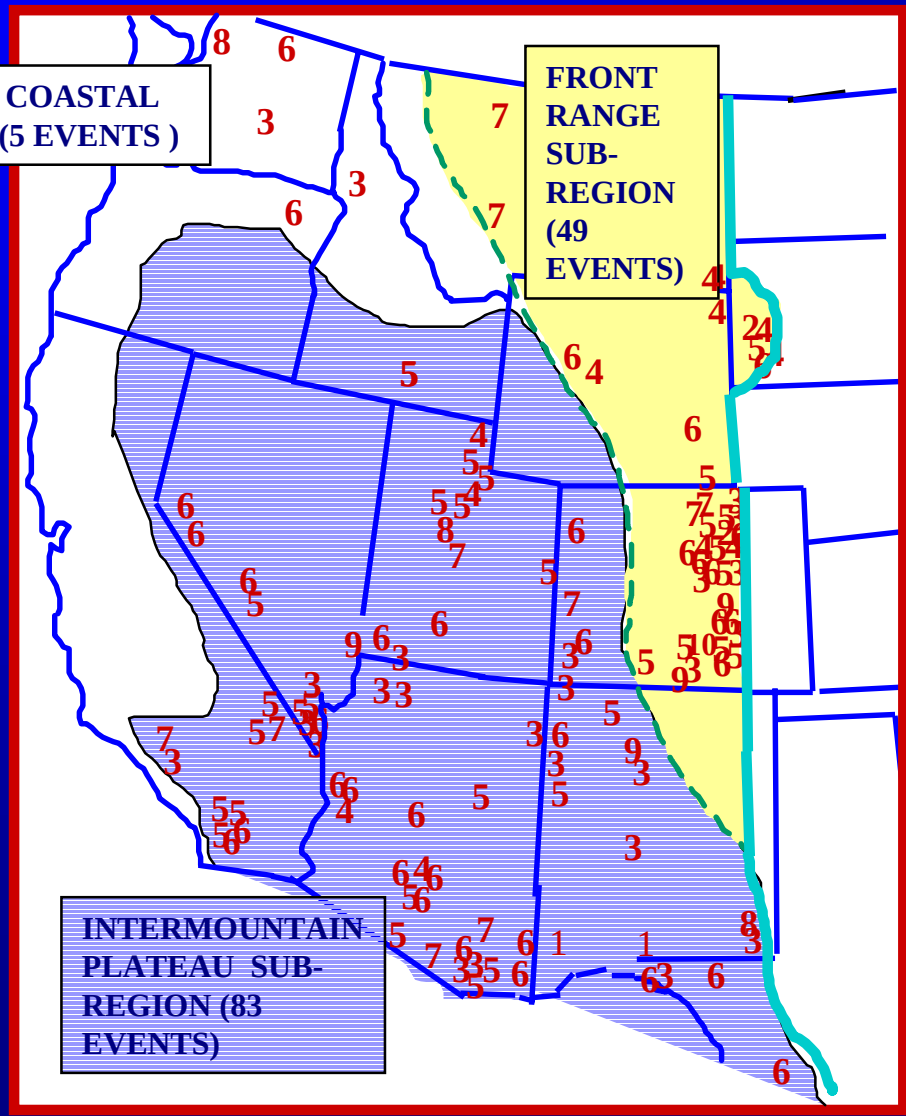
QPF IN WEST INCLUDING THE FRONT RANGE OF THE ROCKIES

- CHARACTERISTICS DIFFER BY SEASON
- IN SUMMER….SCALE OF THE EVENTS IS VERY SMALL.
- THE SCALE IS TIED TO THE MEAN RH AND FORCING
- LOOK FOR VORTS IN WATER VAPOR IMAGERY
- LOOK FOR MOISTURE SURGES ON SSMI AND GOES PW IMAGES
- IN WINTER, FORCING AND AREAS OF HEAVY RAIN ARE MUCH MORE DEPENDENT ON OROGRAPHY.

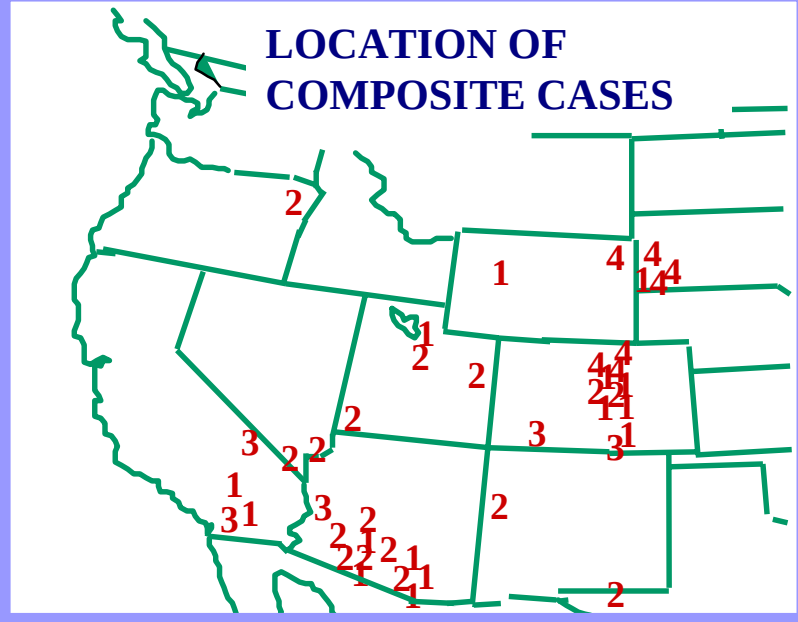
MAP OF LOCATION AND TYPE OF SYSTEM FOR 137 HEAVY CONVECTIVE RAINFALL EVENTS



#	TYPE	CASES
1	SYNOPTIC SCALE TROPICAL	2
2	SQUALL LINE	2
3	SINGLE CLUSTERED	28
4	MCS ALPHA	13
5	MCS-BETA CIRCULAR	32
6	MCS-BETA LINEAR	41
7	SYNOPTIC SCALE CYCLONIC CIRCULATION	10
8	LARGE SCALE OVERRUNNING	4
9	REGENERATIVE	4
10	COMBO OF TWO OR MORE SYSTEMS PASSING OVER THE SAME AREA WITHIN 24 HRS	1

FROM CHAPPELL COMET NOTES

LOCATIONS OF LARGEST 13 MCS AND MCC SYSTEMS USED TO PREPARE 4 TYPES OF ATMOSPHERIC COMPOSITES

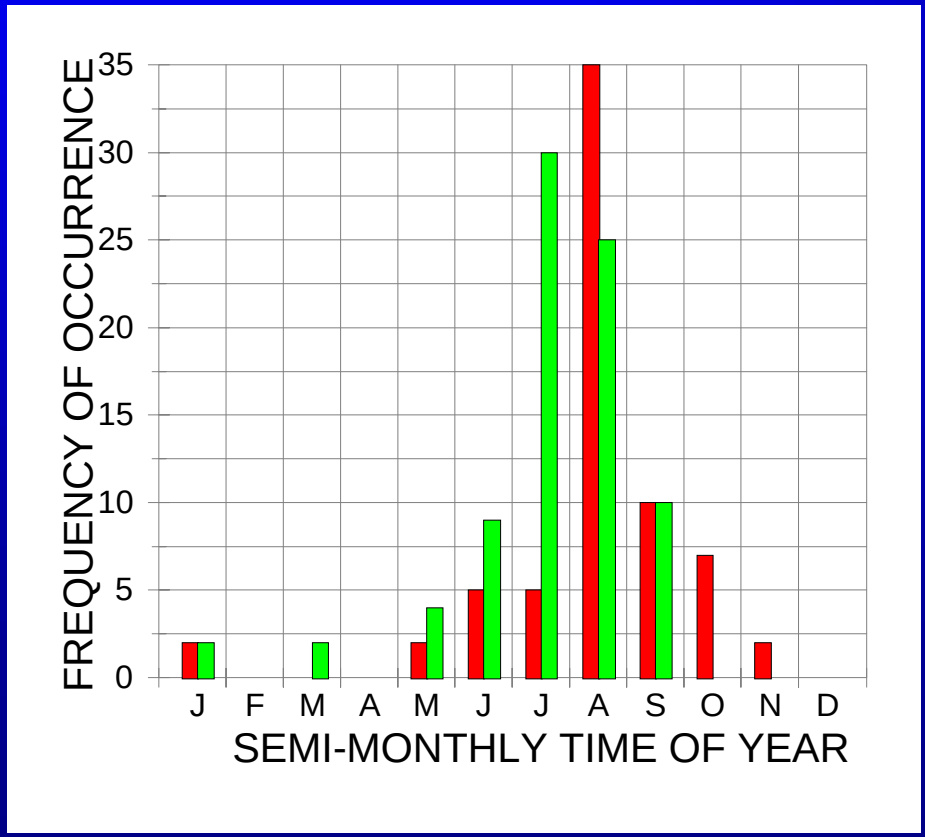


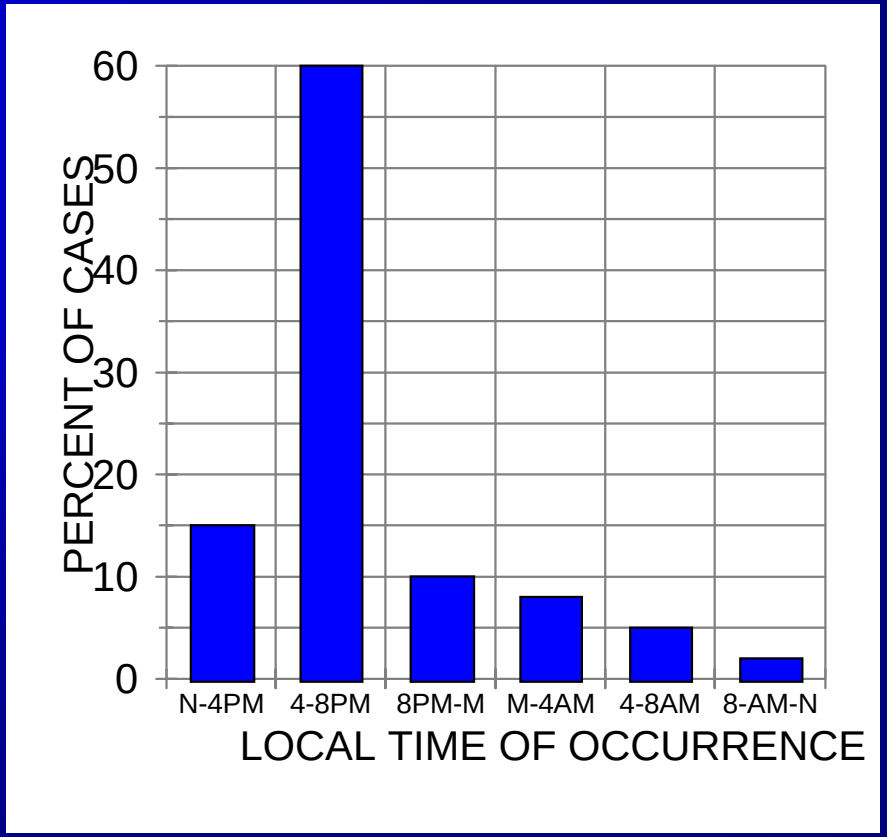
LEGEND	SYNOPTIC TYPE	#EVENTS (45)
1	BLOCKING ANTICYCLONE	15
2	DEFORMATION ZONE	17
3	SHORTWAVE TROUGH IN NORTHWEST FLOW	6
4	SHORTWAVE TROUGH IN ZONAL FLOW	7

FROM CHAPPELL
COMET NOTES

FREQUENCY OF FLASH FLOODING OR 2”/24HR RAINFALL FOR 137 EVENTS IN WEST

NOTE THE HIGH FREQUENCY IN LATE JULY AND AUGUST





FROM CHAPPELL COMET NOTES

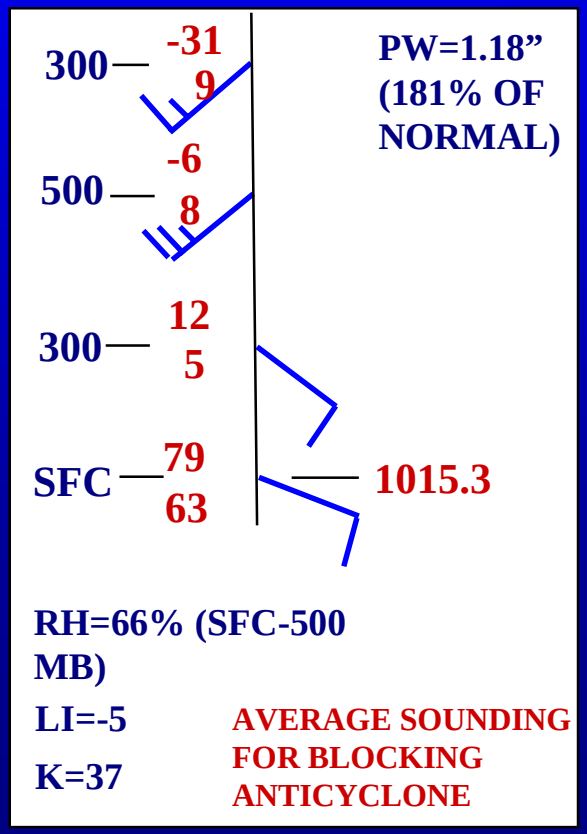
HEAVY RAIN EVENTS ALONG THE FRONT RANGE
BIG THOMPSON, FORT COLLINS, CHEYANNE, MADISON COUNTY (VA)

*******CAN ALSO BE CALLED BLOCKING ANTICYCLONE *******

- A LARGE AMPLITUDE NEGATIVE-TILTED UPPER RIDGE AXIS LIES JUST EAST AND NORTH OF THE THREAT AREA,
- WINDS ALOFT ARE LIGHT AND SOUTHEASTERLY
- A WEAK SHORTWAVE ROTATES NORTHWARD TOWARDS THE THREAT AREA RESULTING IN WEAK PVA
- A SLOW MOVING FRONT THAT HANGS UP JUST SOUTH OF THE AREA

FROM MADDOX ET AL., 1977

- A NARROW BAND OF MOIST UNCONDITIONALLY UNSTABLE AIR JUST BEHIND THE FRONT
- THE MOISTURE USUALLY EXTENDS TROUGH A DEEP LAYER (TO 300 MB)
- PWS 150-200% OR NORMAL
- OROGRAPHIC LIFT PROVIDES MECHANISM TO RELEASE INSTABILITY



Times when the surface dewpoints extend westward to the front range should be monitored very closely

especially when the low-level winds are easterly or southeasterly

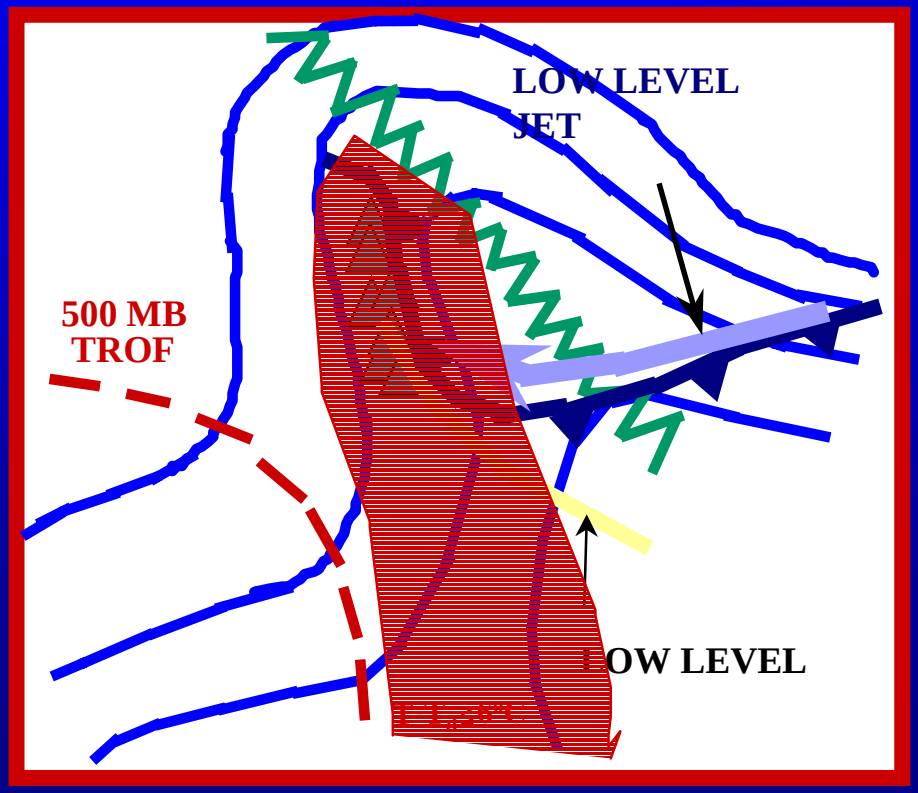
FROM CHAPPELL COMET NOTES

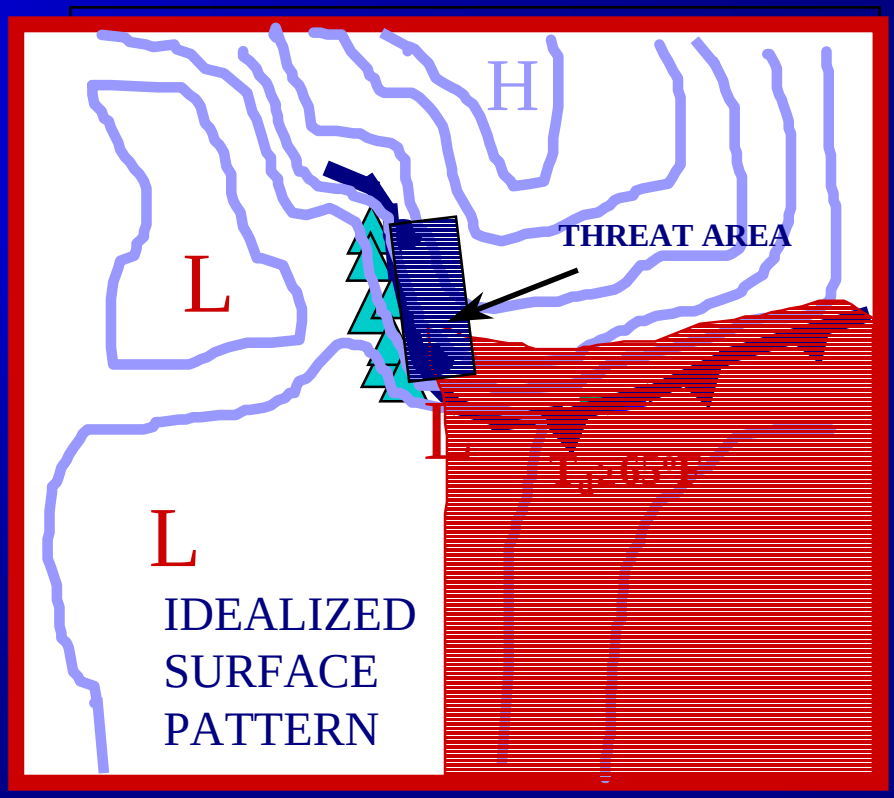
Cells develop east of highest terrain

+ Cells move slowly north and northwest

+ redevelopment on southeast or southern flank

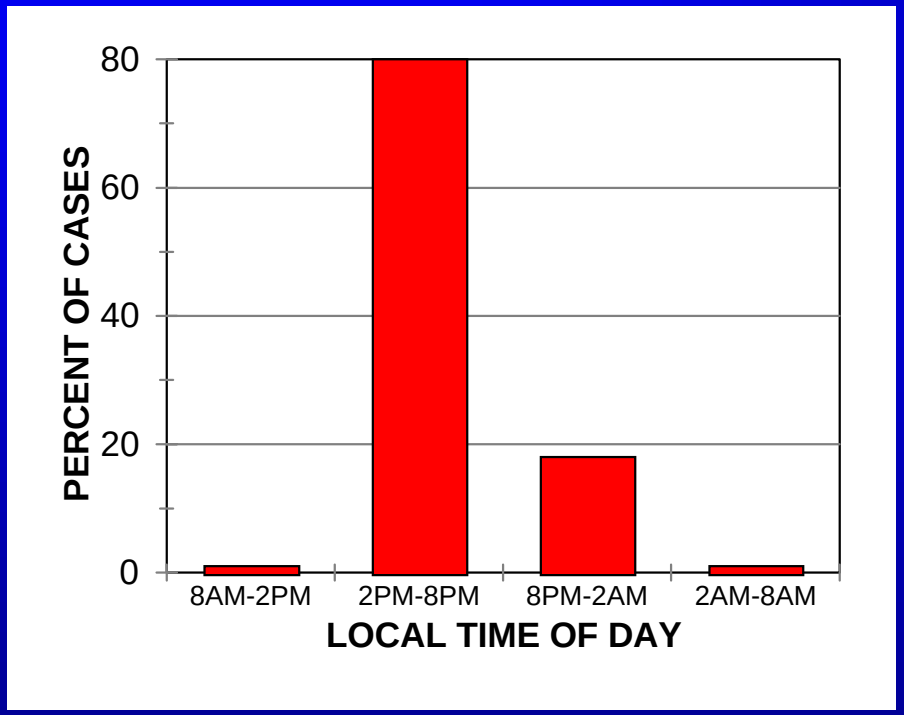
+heaviest rain falls over a very small area

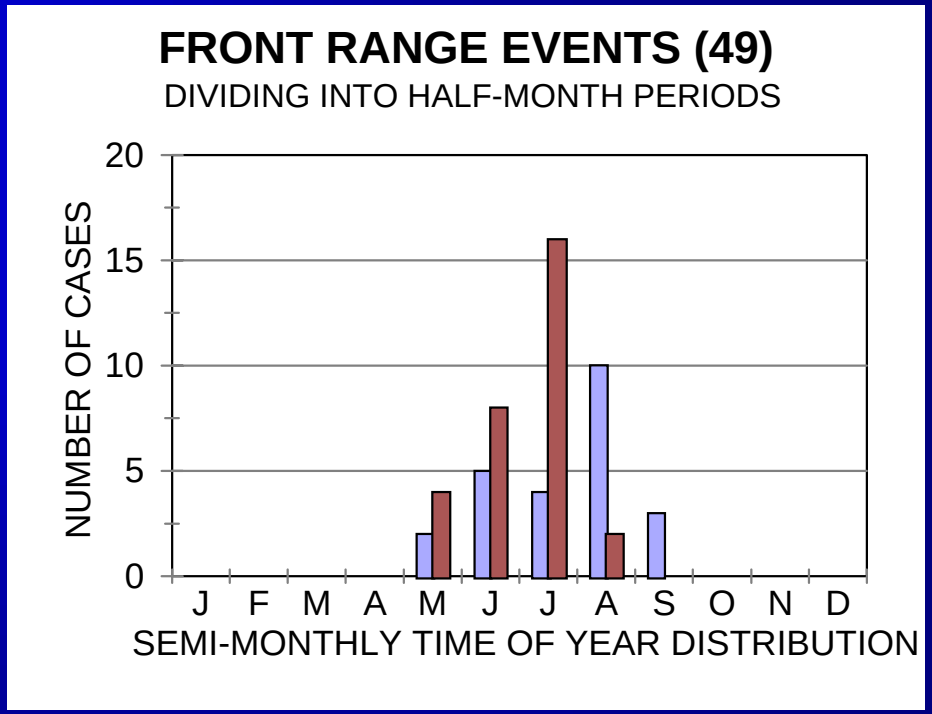




ADOPTED FROM MADDOX ET AL., 1977

The vast majority of front range events occur during the late July and early August,

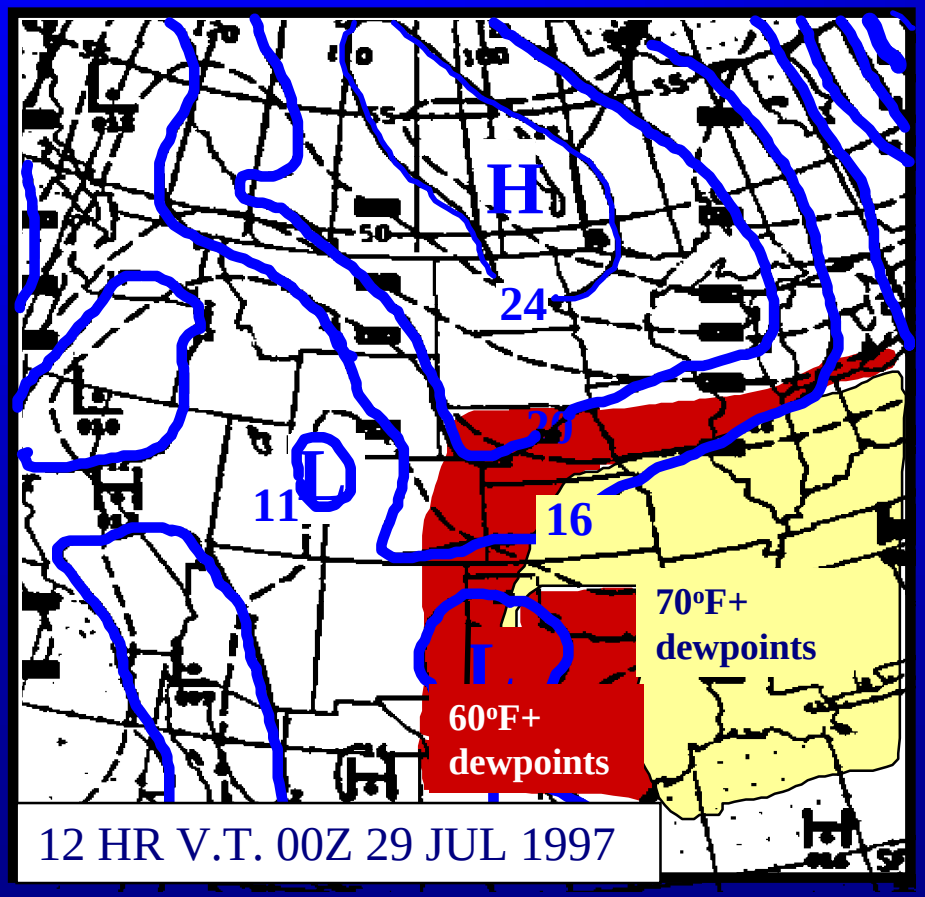


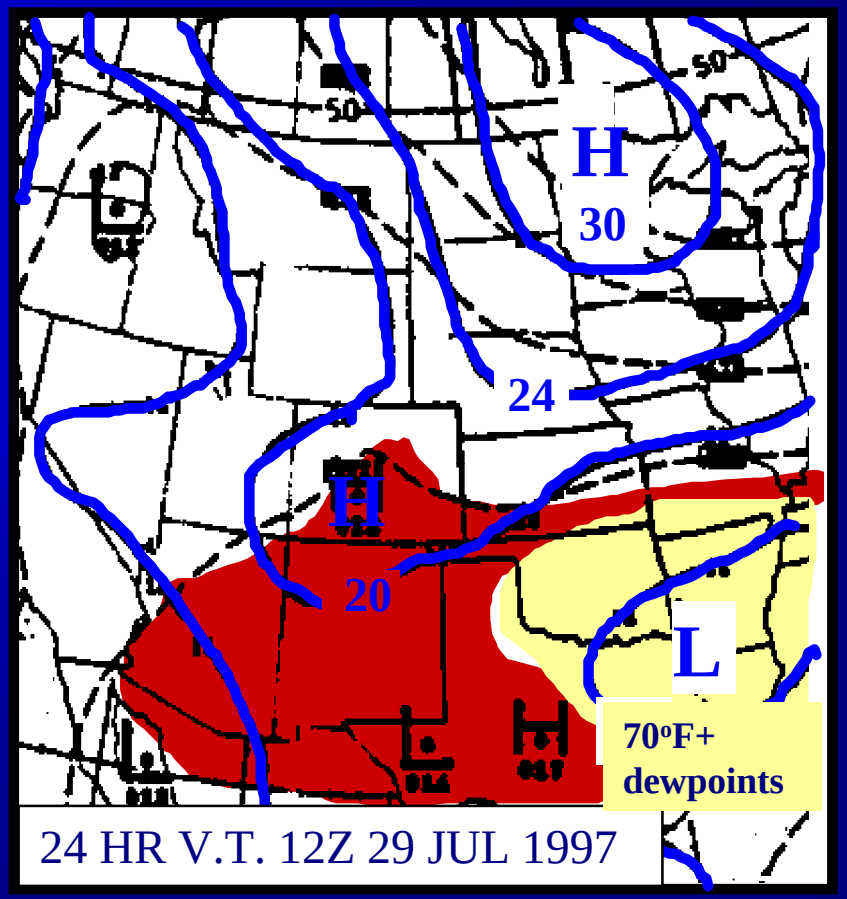


and take place during the late afternoon and early evening (2 PM-8 PM)

FROM CHAPPELL COMET NOTES

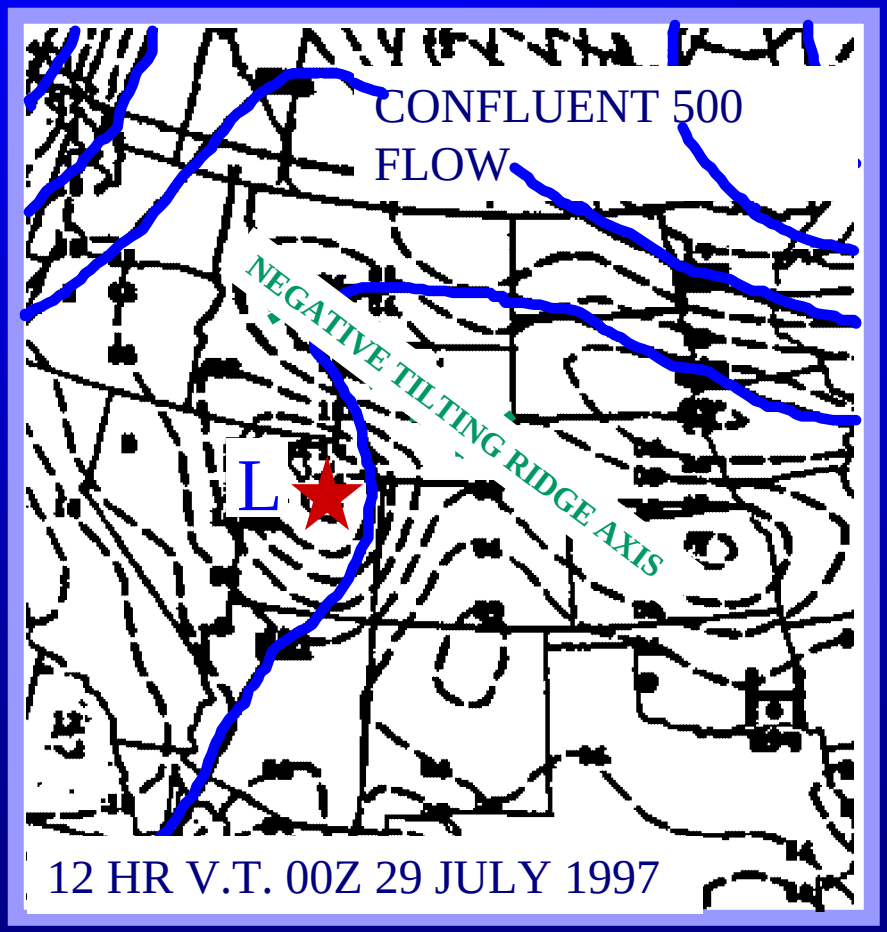
ETA MODEL FORECAST OF SFC AND 1000-500 MB THICKNESS. USING THESE FORECASTS AND THE THE MAPS TO FOLLOW, PREDICT WHERE THE HEAVIEST RAIN WILL FALL.

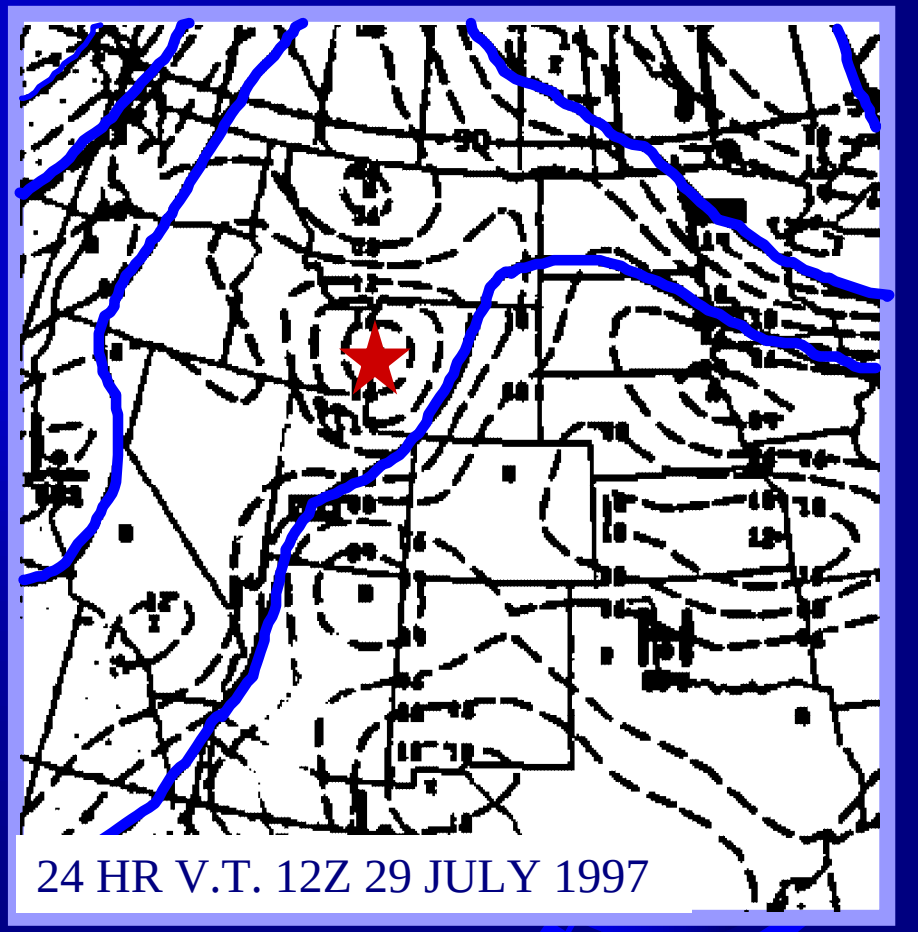




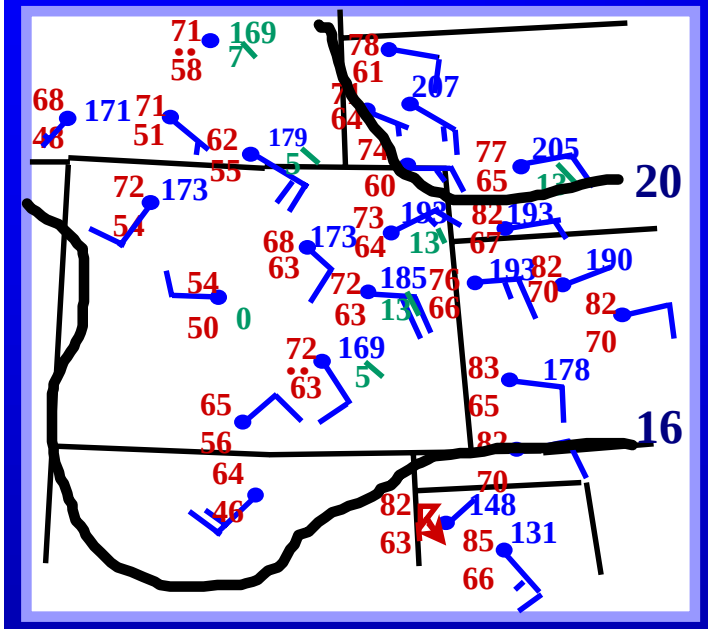
SURFACE DEWPOINTS ARE FORECAST TO BE IN THE 60S ACROSS EASTERN COLORADO. YOUR IN THE LAST WEEK OF JULY. ARE ANY BELLS GOING OFF?

ETA 500H AND VORTICITY FORECASTS NOTE THE TILT OF THE UPPER RIDGE AXIS.

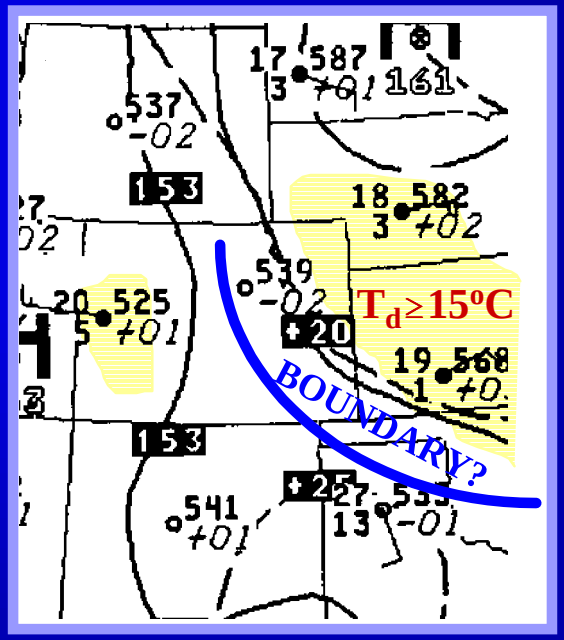




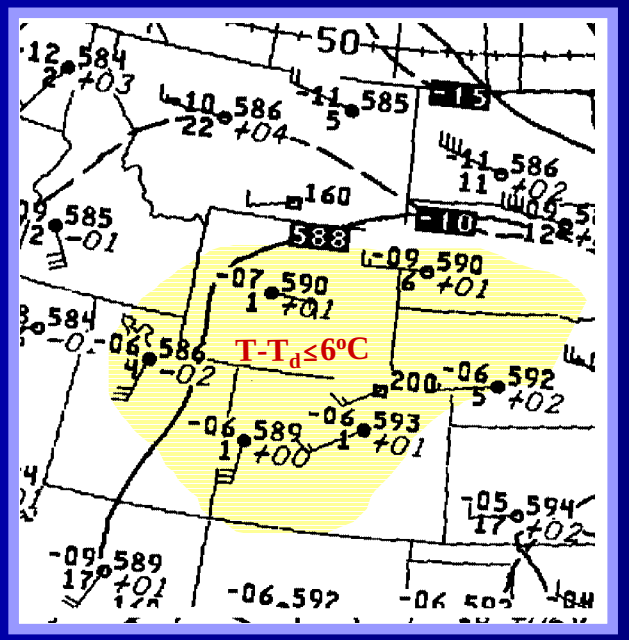
OBSERVED MAPS VALID 00Z JULY 29



SURFACE



850 MB

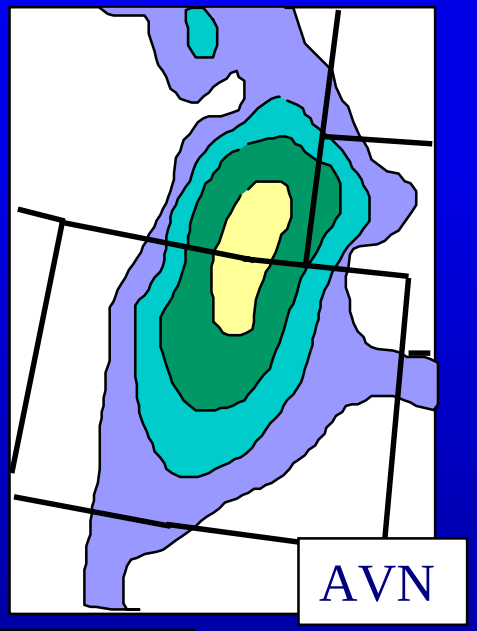


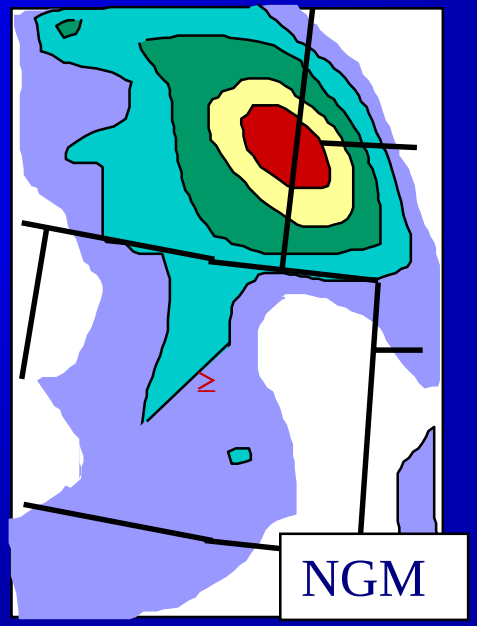
500 MB

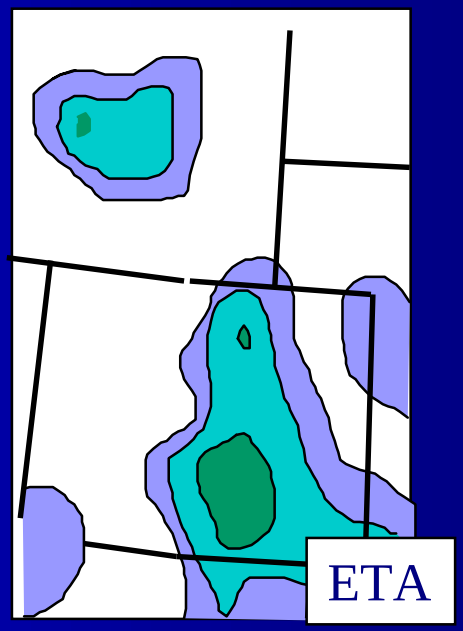
FROM THESE MAPS WHAT CAN BE INFERRED ABOUT THE PRECIPITATION EFFICIENCY OF ANY CELLS THAT FORM?

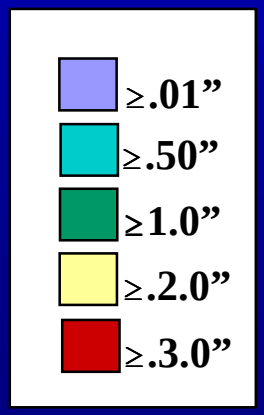
WHAT ABOUT THE LCL AND THE PROBABLE DEPTH OF THE WARM LAYER?

MODELS' 12-36 HR FORECAST OF ACCUMULATED PRECIPITATION







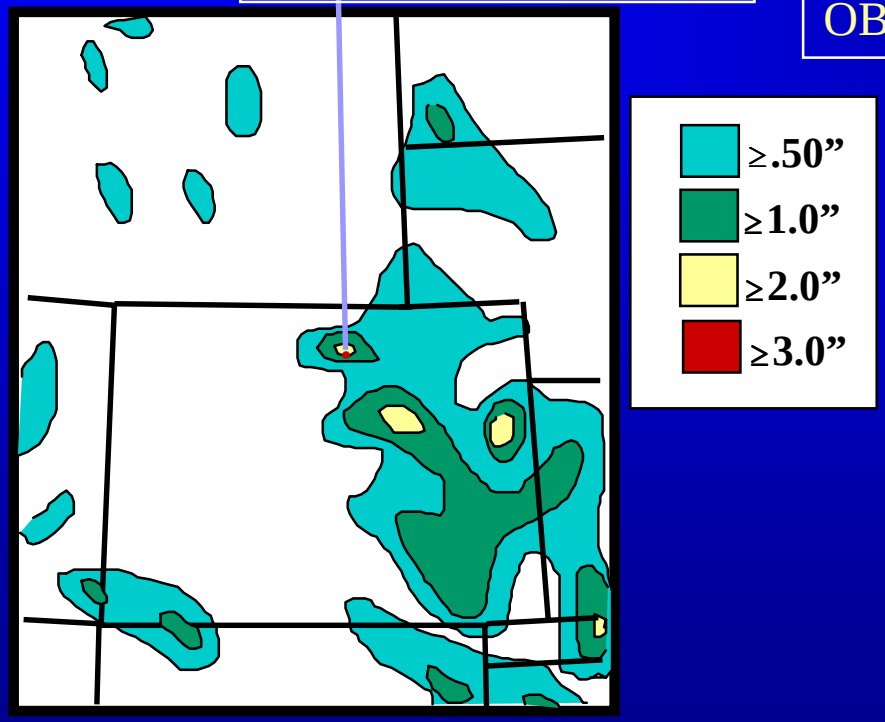


WHICH MODEL DO YOU THINK HAS THE BEST FORECAST OF THE SCALE OF THE 2.00" OR GREATER AMOUNTS? WHAT ABOUT THE LOCATION OF THE MAXIMUM RAINFALL?

HOW DID YOU DO?

8-10” OF RAIN ON FORT COLLINS & NEARBY FOOTHILLS

4 MILES AWAY ONLY .83” OBSERVED



295 HOUSES OR MOBILE HOMES DESTROYED, 4 KILLED

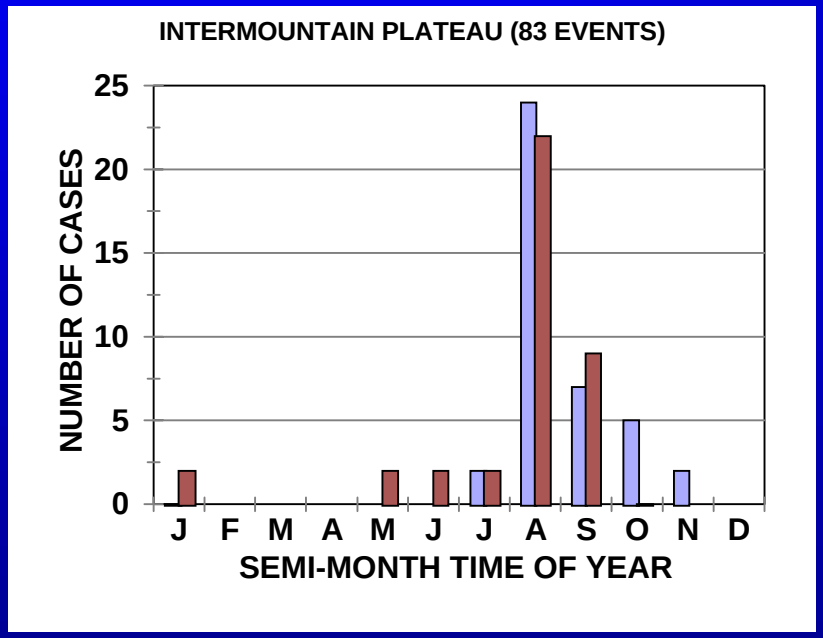
A LARGER MCS MOVED SOUTHEASTWARD AWAY FROM A SMALLER SCALE QUASI-STATIONARY CONVECTIVE STORM.

VERIFYING ANALYSIS
VALID 12Z JULY 29

SUMMERTIME QPF IN THE WEST AND ALONG THE FRONT RANGE INVOLVES

- DETERMINING WHETHER CONDITIONS WILL BE CONDUCIVE TO HEAVY RAINS
- IS STRONGLY RELATED TO THE MONSOON SEASON
- THE SCALE IS USUALLY TOO SMALL TO ALLOW A FORECAST TO REALISTICALLY PREDICT THE EXACT LOCATION WITH MUCH LEAD TIME.
- THE SCALE ARGUES FOR A PROBABILISTIC APPROACH TO THE PROBLEM

MORE ON SUMMERTIME WESTERN EVENTS

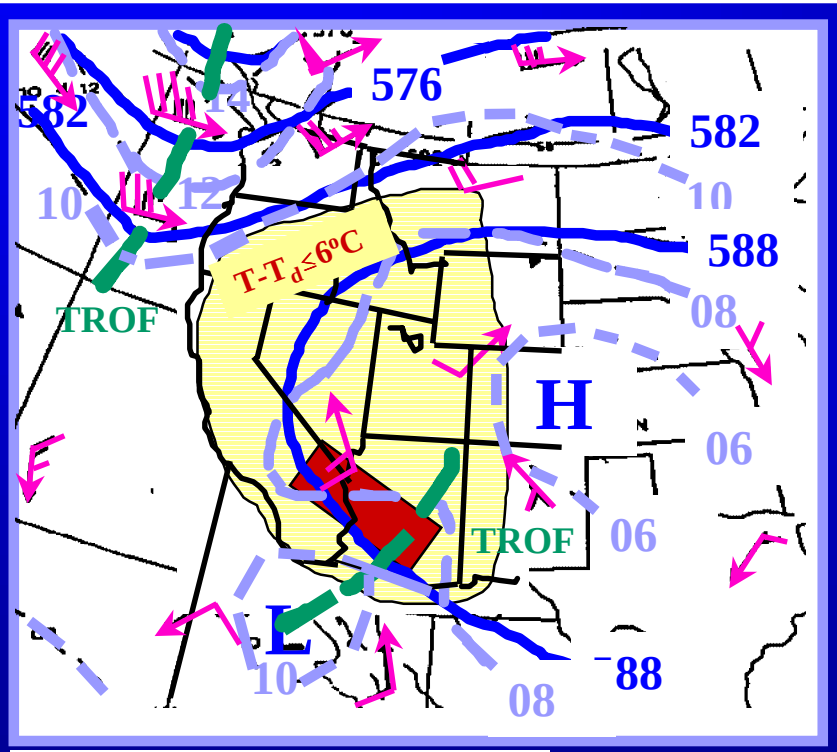


EVENTS IN INTERMOUNTAIN REGION ALSO HAVE A DISTINCT MAXIMUM DURING THE 6-HR PERIOD BETWEEN 2 PM AND 8 PM LOCAL DAYLIGHT TIME.

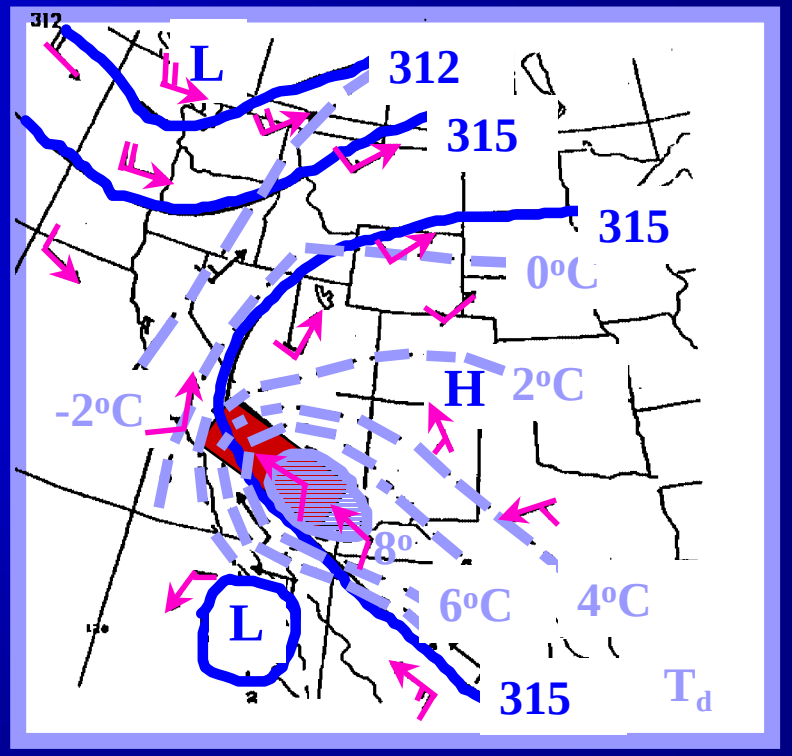
OCCUR MOSTLY IN AUGUST AND SEPTEMBER INTO EARLY OCTOBER.

Southwest, blocking high type heavy rainfall event.

Note that the high center shifts east of 4-corners. This allows moisture to be pulled northward from the Gulf of CA.



500 HEIGHTS AND VORTICITY

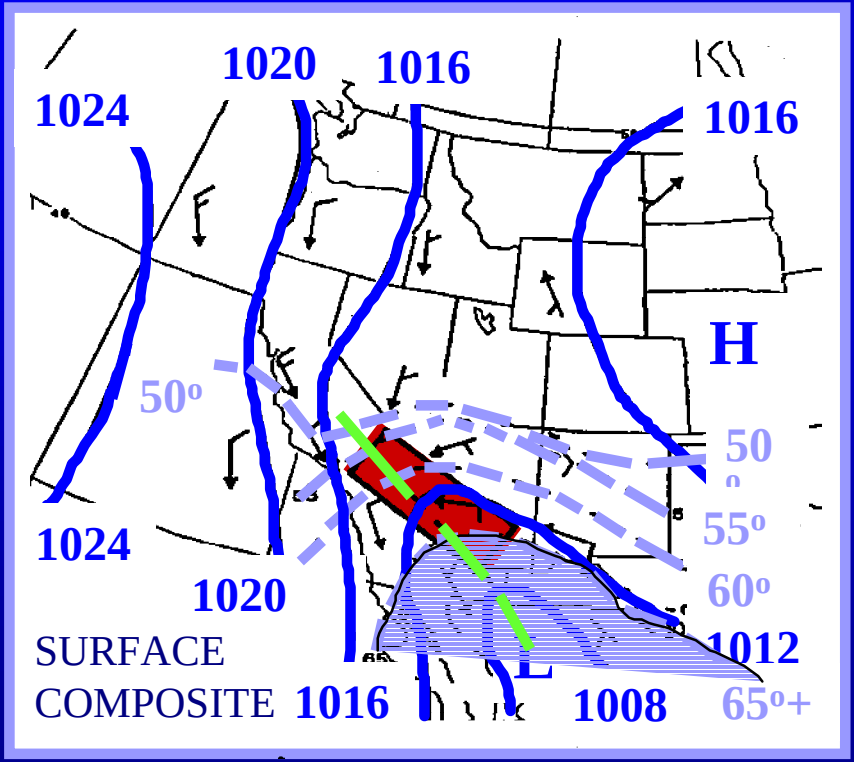


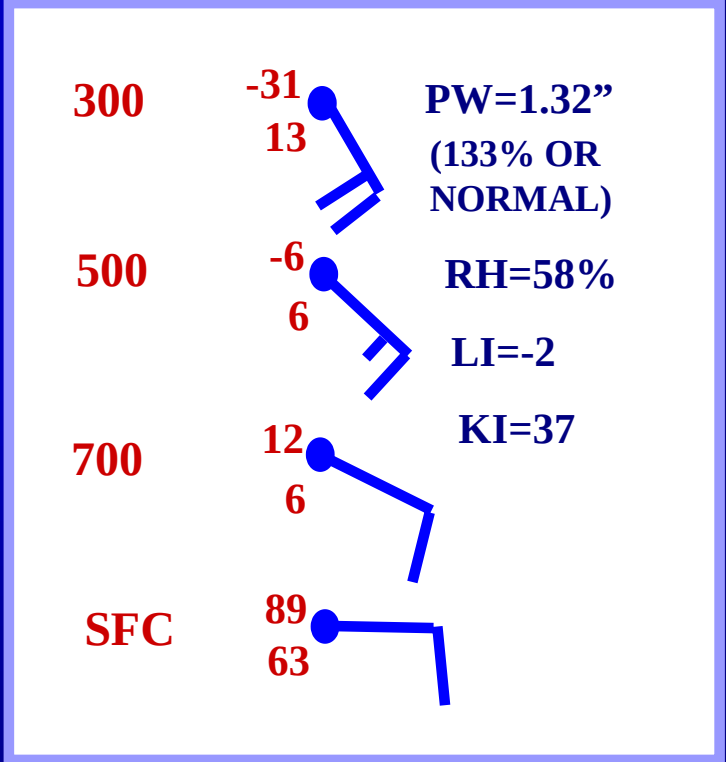
700 MB COMPOSITE

Note there is often a upper low to the southwest with a vort lobe extending towards the threat area. These features often show up best on water vapor imagery.

Blocking anticyclone type

(also is known as Maddox Type 4)

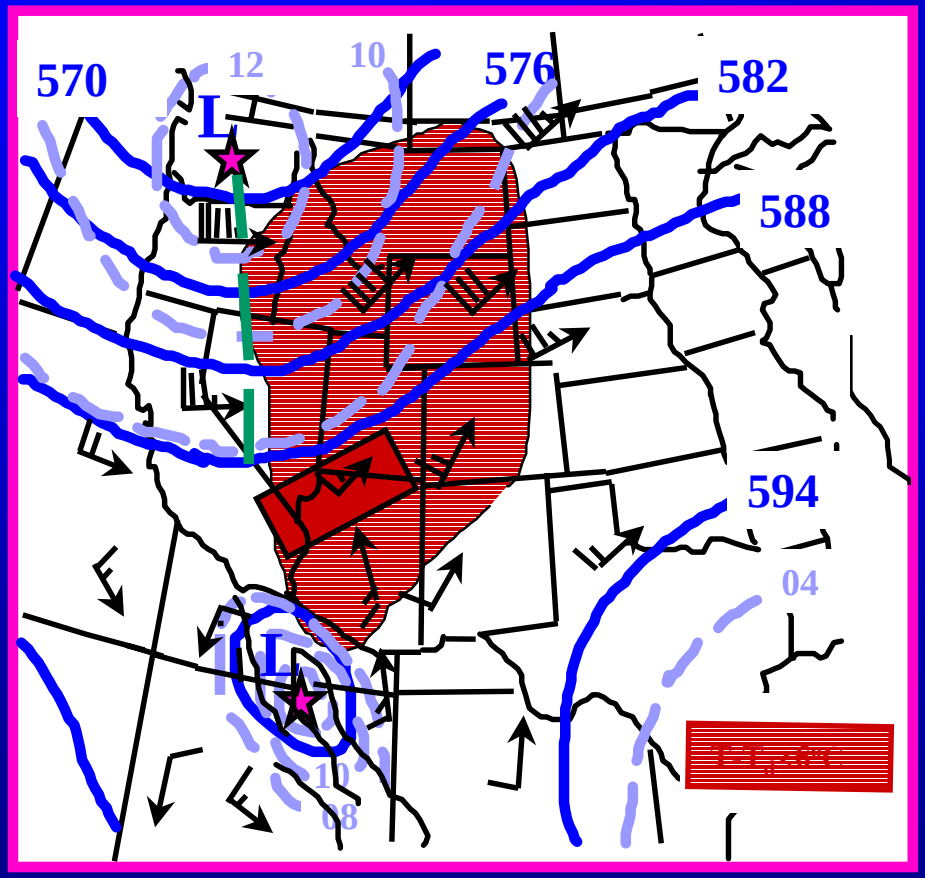




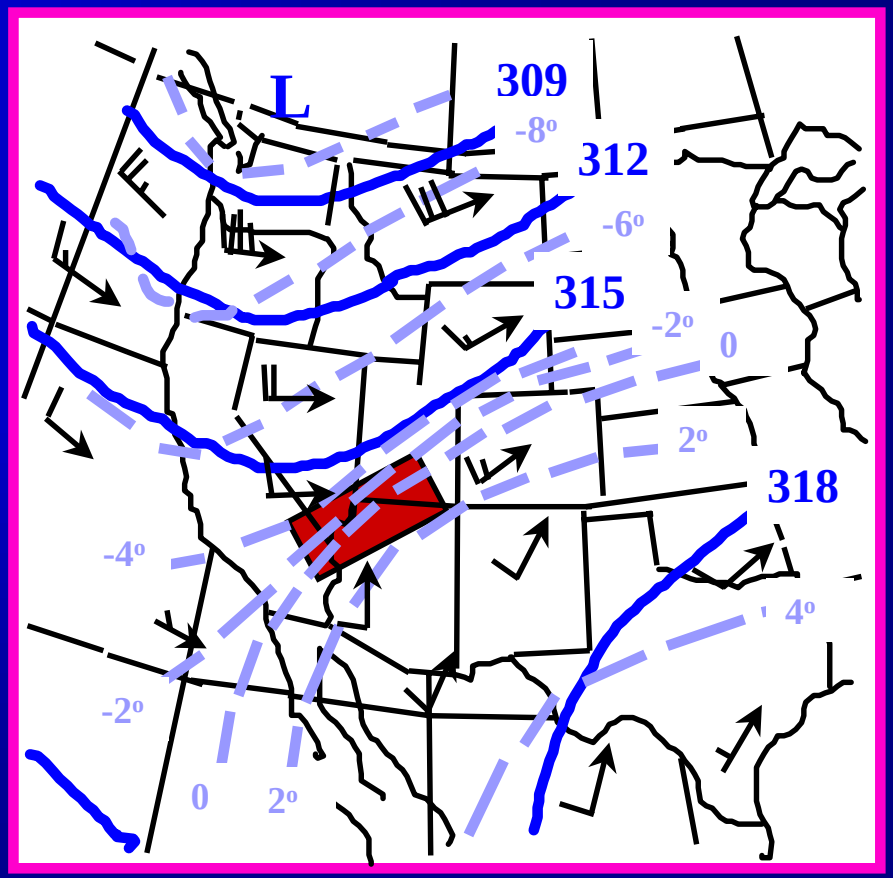
NOTE WEAK MEAN FLOW AND RELATIVELY DEEP MOISTURE. SCALE OF THE EVENT IS SMALL.

DEFORMATION TYPE HEAVY RAINFALL EVENT

STRONG UPPER LEVEL DIVERGENCE IS PRESENT, OFTEN ENHANCED BY ENTRANCE REGION OF UPPER LEVEL JET STREAK

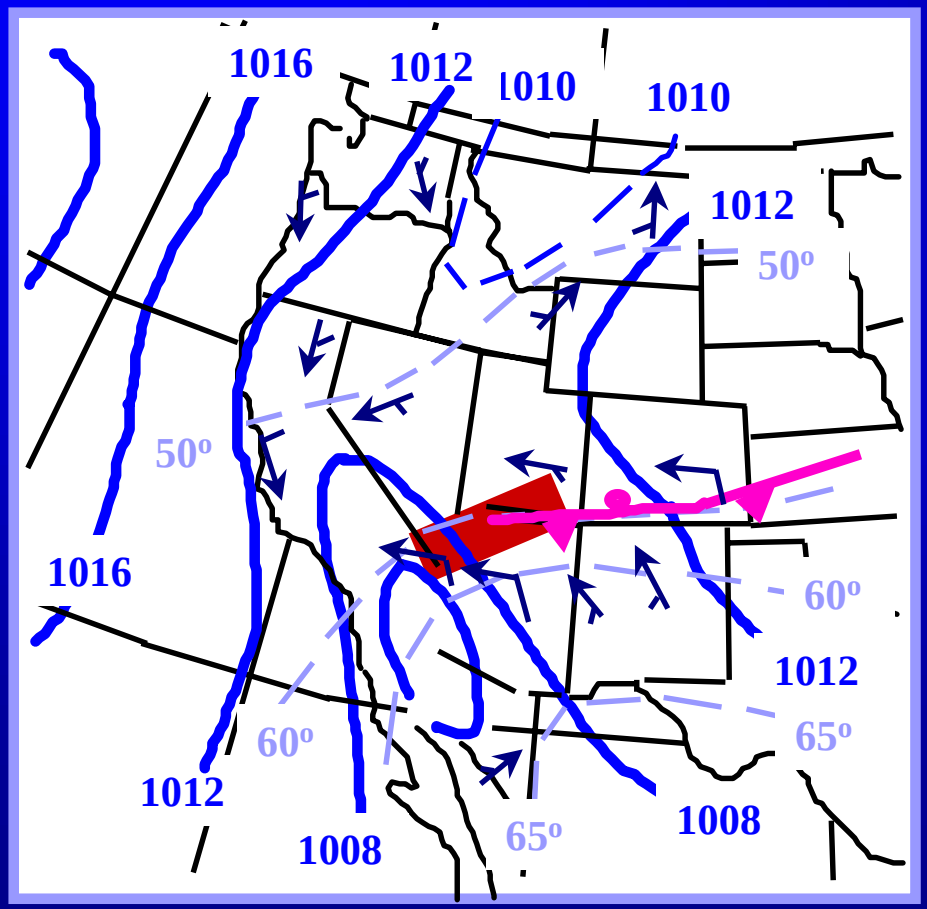


500 HEIGHTS AND VORTICITY



700 HEIGHTS AND DEWPOINTS

An old front or surface boundary and weak mean flow are usually present



300 -33 9

500 -8 5

700 10 8

SFC 81 59 1010.7

PW=1.15”

(160% OF NORMAL)

RH=66%

LI=-2

KI=35

QPF IN WEST DURING WINTER

- OVERALL SCALE IS LARGER THAN IN SUMMER
- SCALE AND POSITION OF HEAVIEST RAIN IS OFTEN CLOSELY TIED TO OROGRAPHY
- SATELLITE IMAGERY, SSMI AND GOES PW PRODUCTS ARE GREAT TOOLS
- TIMES WHEN AXIS OF DEEP MOISTURE IS QUASI-STATIONARY OFTEN PRODUCE 3 INCH OR GREATER AMOUNTS IN THE CASCADE AND SIERRA RANGES.

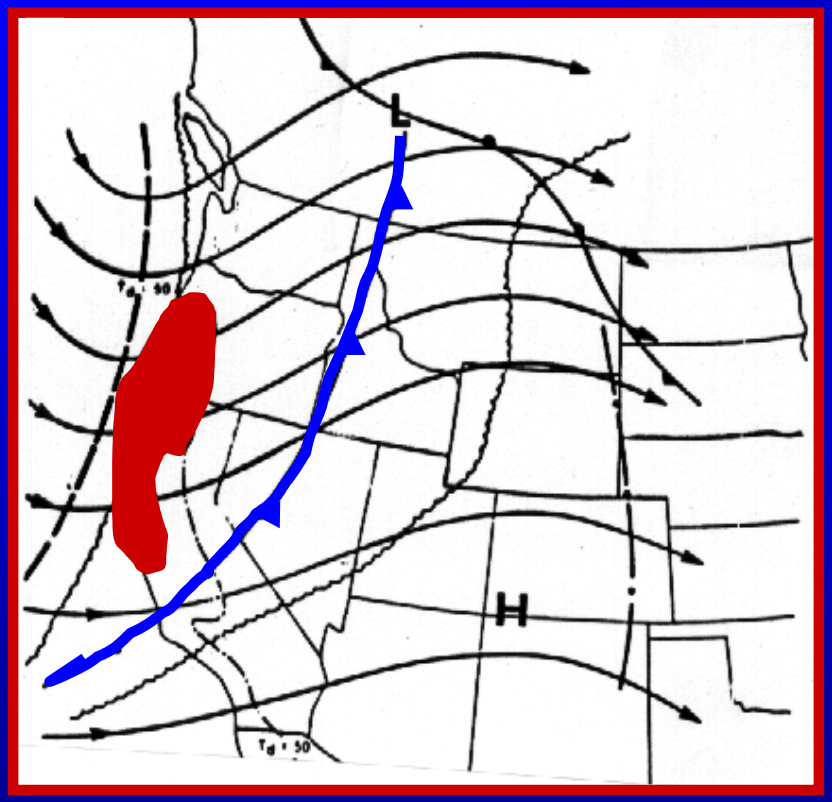
IN WEST IN WINTER CONT.

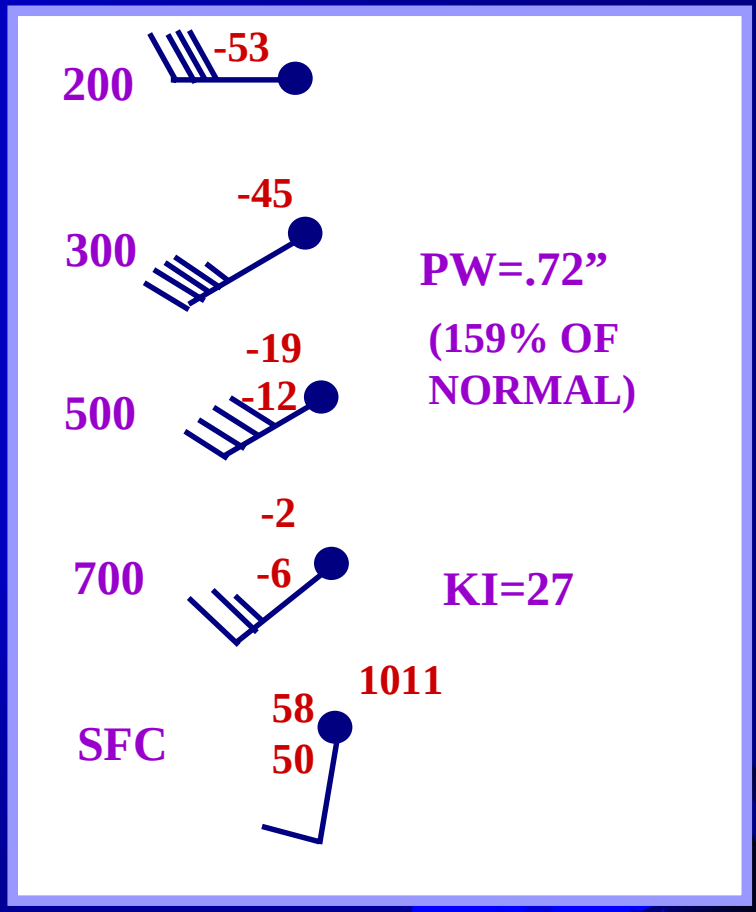
- USUALLY THERE IS A SIGNIFICANT RAIN SHADOW TO THE LEE OF THE MOUNTAINS.
- MOUNTAIN MAPPER AND THE RHEA OROGRAPHIC TECHNIQUE CAN COMBINE TO PROVIDE A VERY GOOD FIRST GUESS.
- WHEN MOISTURE IS UNUSUALLY DEEP RAIN, HEAVY RAIN WILL FALL ON THE LEEWARD SIDE OF THE SIERRA RANGE IN WESTERN NV AND EASTERN CA
- SIGNIFICANT SKILL IN 24 HOURS FORECASTS, SKILL IS CONSIDERABLY LOWER FOR 6 HOURLY FORECASTS

MADDOX ET AL., WINTER TYPE III

- MOST COMMON IN WINTER AND EARLY SPRING
- STRONG UPPER TROF SWEEPING INTO WEST COAST FROM PACIFIC
- HEAVY PRECIPITATION ENDS AS UPPER TROF AXIS NEARS COAST.
- THE STRONGER THE LOW LEVEL WINDS NORMAL TO THE MOUNTAINS, THE HEAVIER THE RAIN
- THERE IS USUALLY A BLOCK OVER ALASKA OR THE GULF OF ALASKA
- LOOK FOR TROPICAL CONNECTIONS

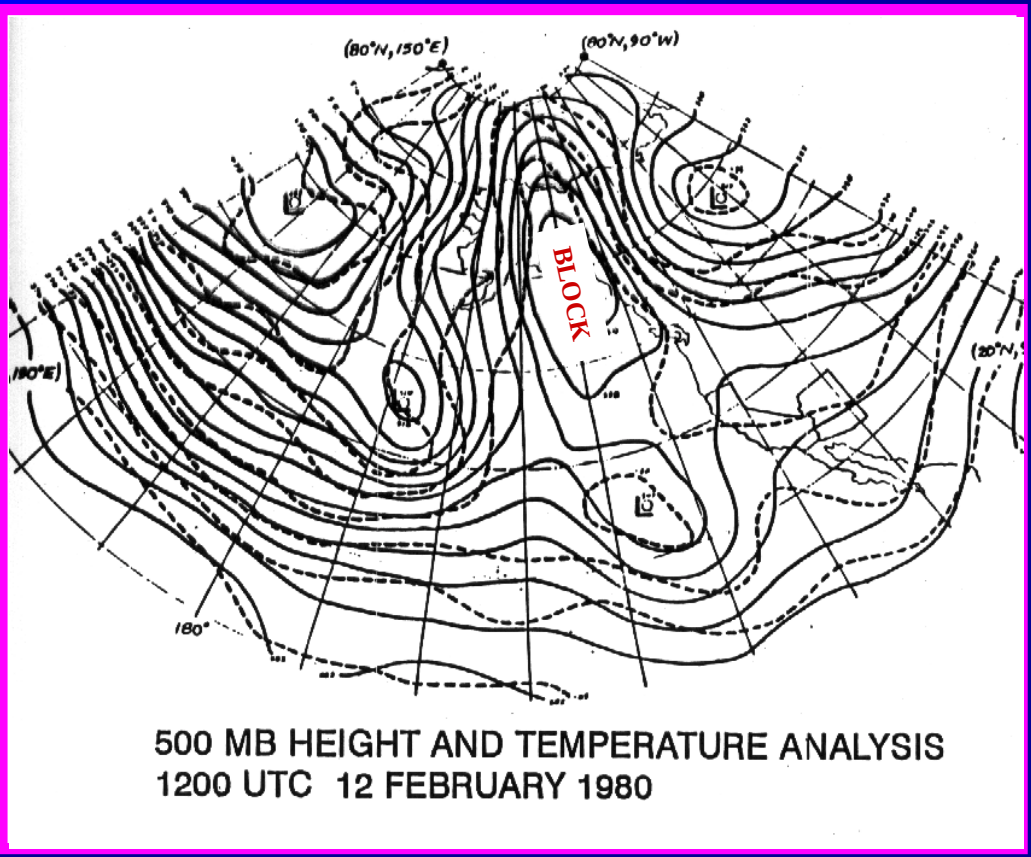
Maddox et al., Type III





At the end of the event, comprised about 20% of flash floods. In reality, risk area is bigger than shown.

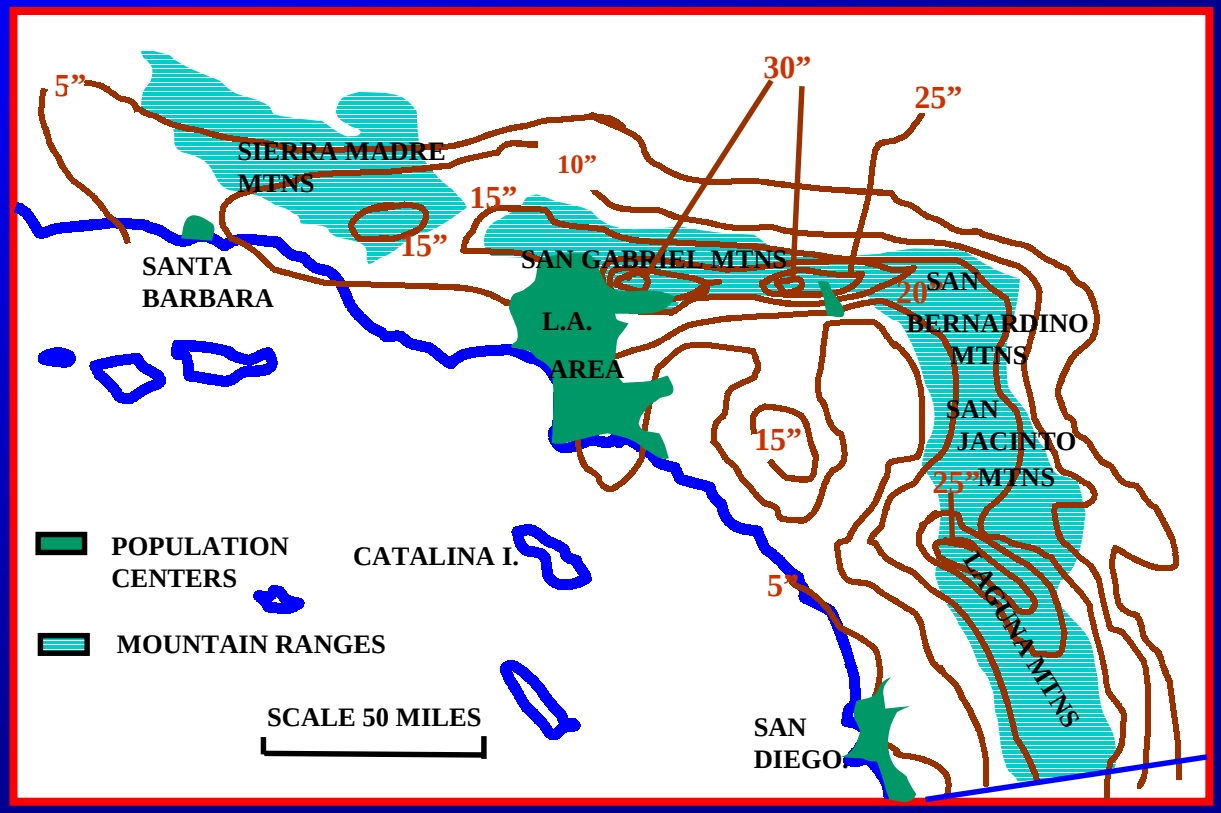
Type III events typically occur in southern California when a block forms over Alaska and the Gulf of Alaska and the westerlies break through to its south.



500 MB HEIGHT AND TEMPERATURE ANALYSIS
1200 UTC 12 FEBRUARY 1980

A number of shortwaves then affect the state and produce a prolonged period of heavy rains.

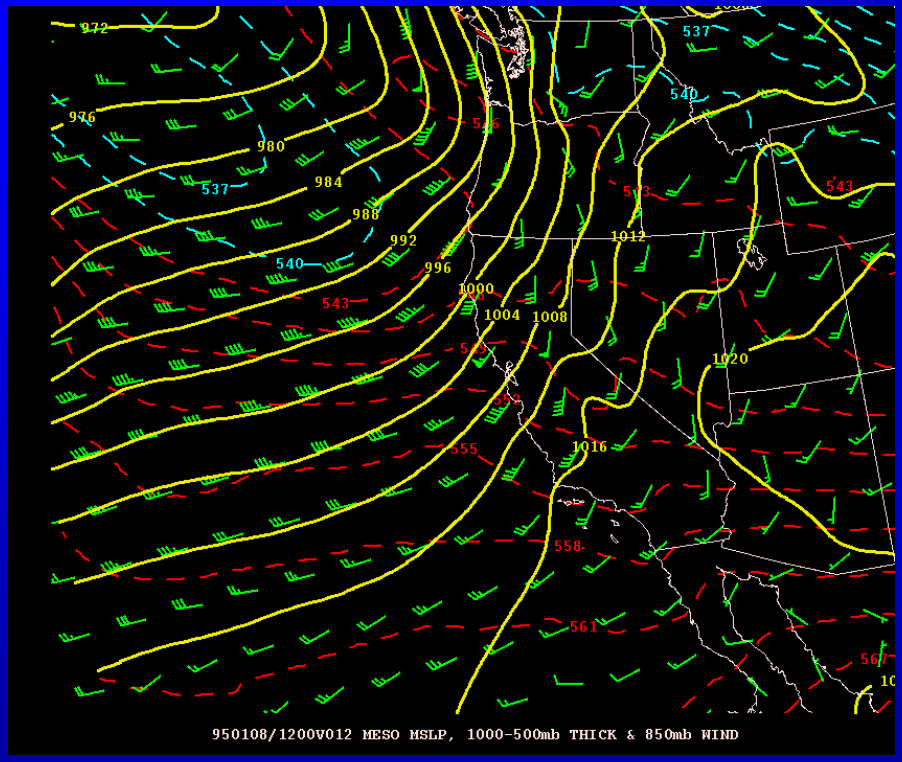
NEED TO KNOW TERRAIN AND WIND DIRECTION THAT FAVORS UPSLOPE



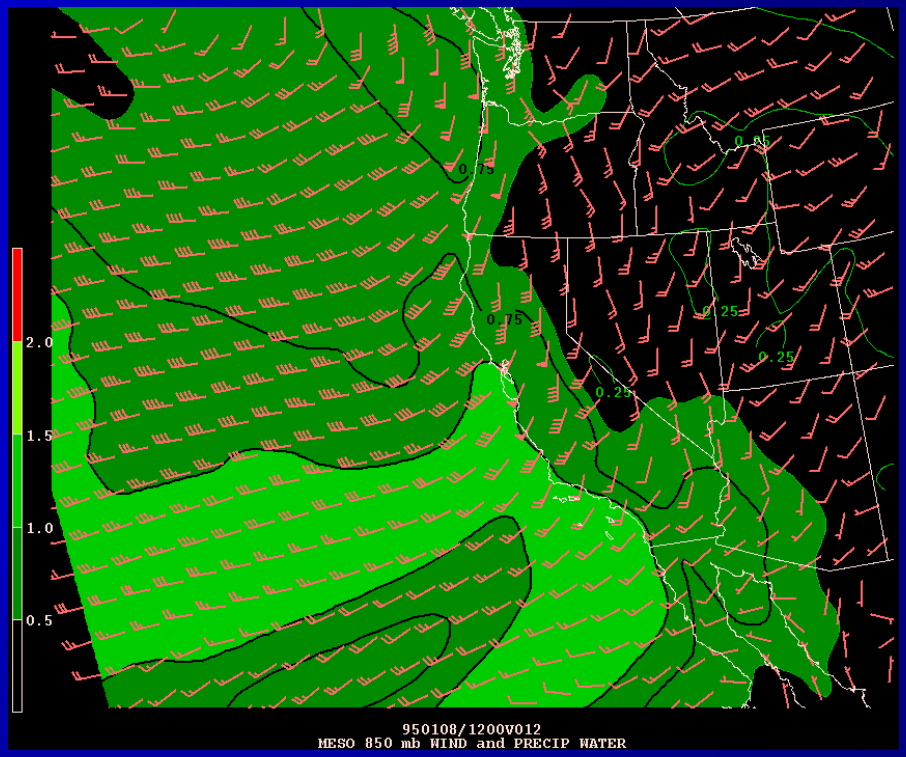
9-DAY TOTAL RAINFALL (6 SEPARATE STORMS) . HEAVY RAINFALL EVENTS IN WINTER ALONG THE WEST COAST OFTEN ARE ASSOCIATED WITH MULTIPLE STORMS.

A TYPE III CASE STUDY

VALID AT BEGINNING OF PERIOD



MSL, THICKNESS AND 850 WINDS

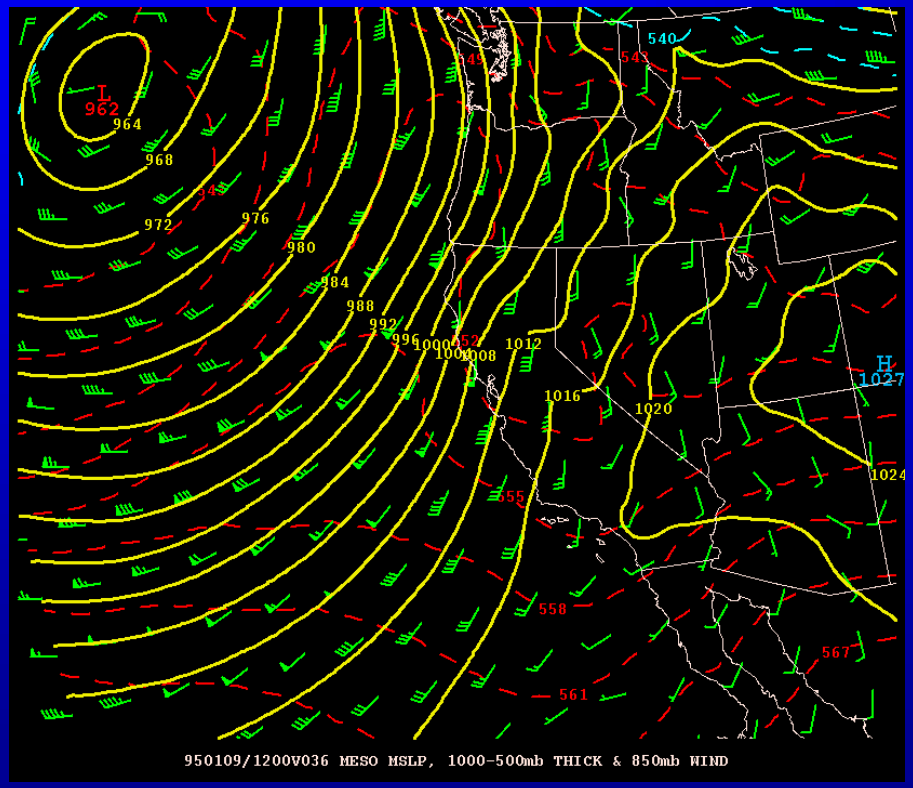


PRECIPITABLE WATER (INCHES) AND 850 MB WINDS

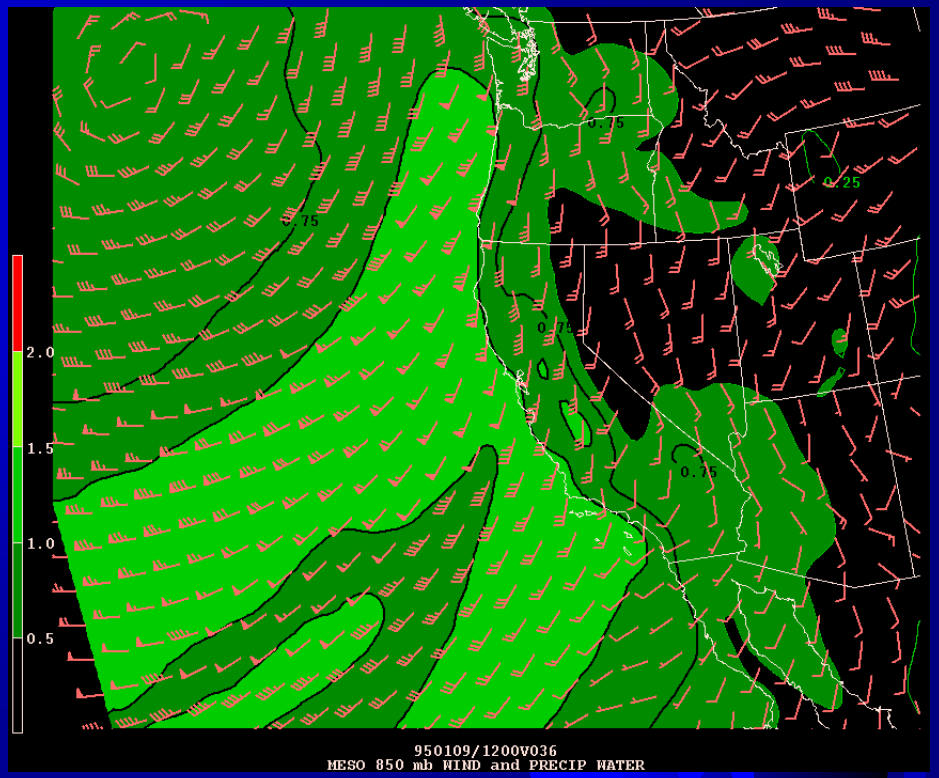
A COUPLE THINGS TO NOTE: 1) A LONG FETCH OF DEEP MOISTURE, 2) A BARRIER JET AND STRONG SOUTHERLY FLOW UP THE SACREMENTO VALLEY. THIS JET HELPS PRODUCE HEAVY RAINS NEAR SHASTA

DO THE FORECAST LOOK CONSISTENT WITH WHAT YOU SEE IN PACIFIC?

VALID AT THE END OF THE PERIOD

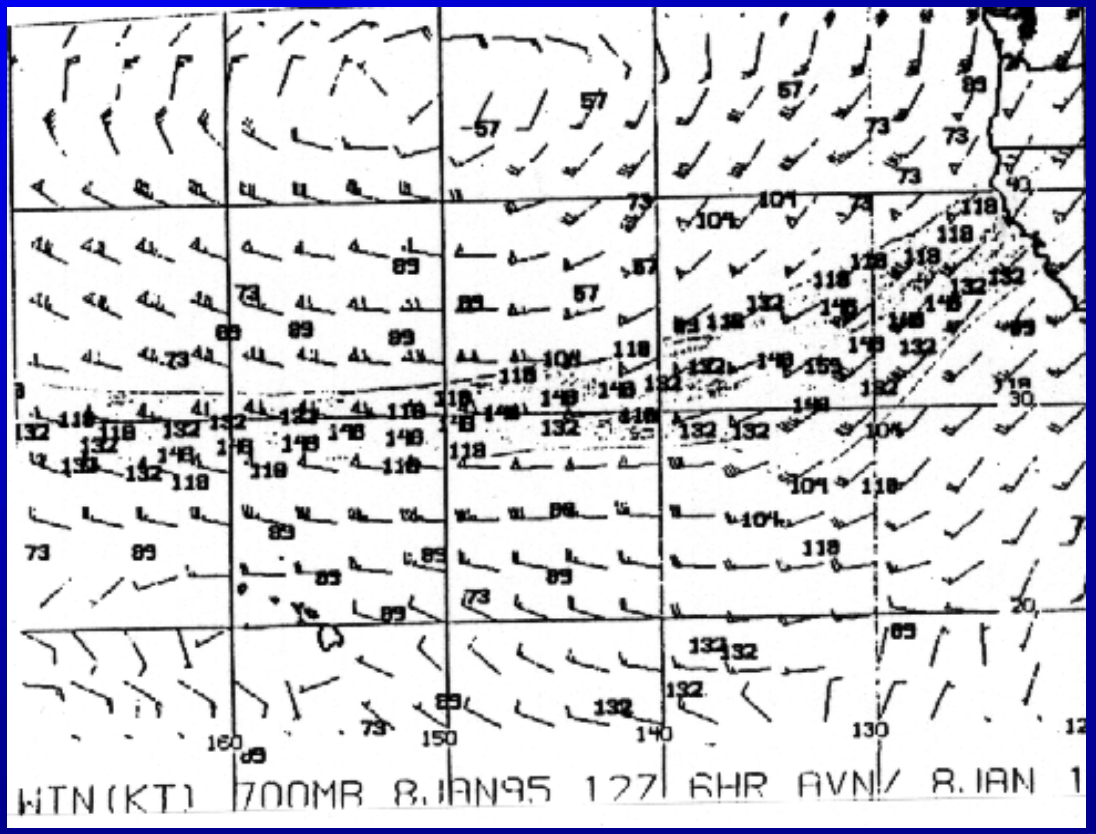


MSL, THICKNESS AND 850 WINDS



PRECIPITABLE WATER (INCHES) AND 850 MB WINDS

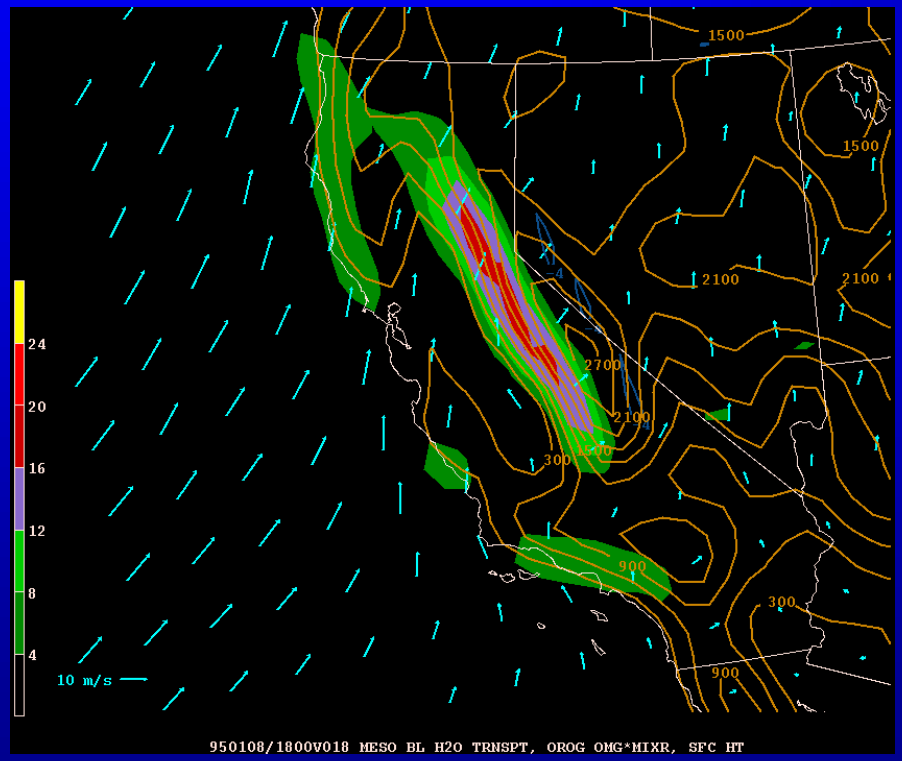
OVERLAYING MODEL OUTPUT WITH SSMI IMAGERY CAN GIVE YOU A GOOD IDEA OF THE MOISTURE THAT WILL BE FEEDING INTO THE WEST COAST. THE MODEL OUTPUT LOOKS REASONABLE

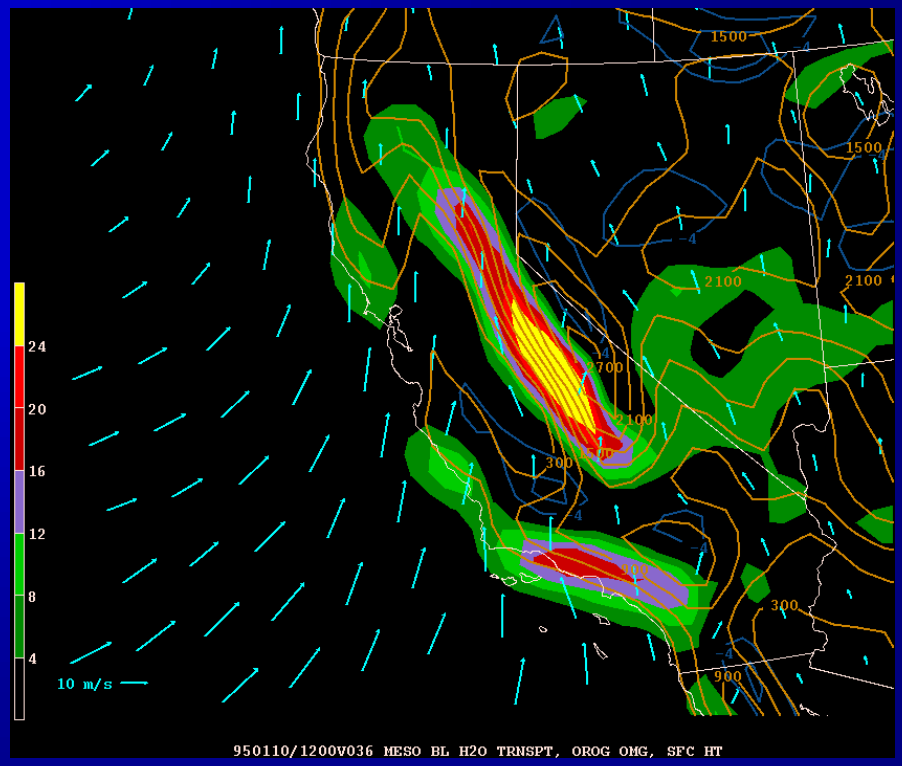


NOTE THE TROPICAL CONNECTION AND PLUME OF PWS ABOVE 1.00”

CAN LOOK AT MODEL OUTPUT FOR LIFTING DUE TO TERRAIN

BOUNDARY LAYER MOISTURE TRANSPORT AND VERTICAL FLUX OF MOISTURE DUE TO OROGRAPHY



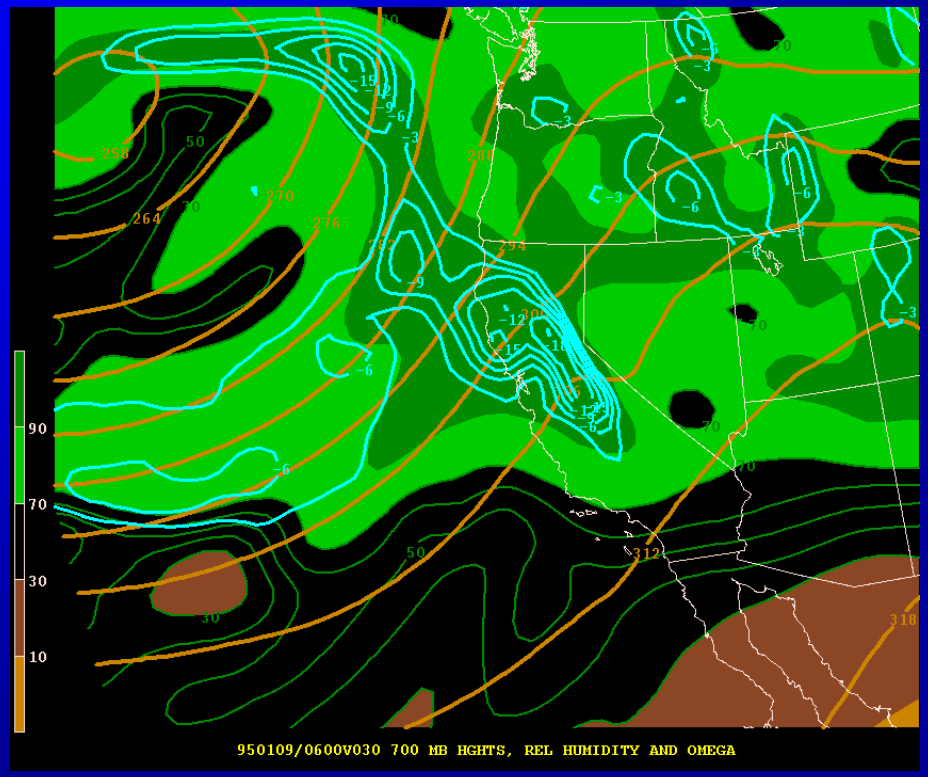


VALID 18Z 8 JAN. 1995

VALID 12Z 10 JAN. 1995

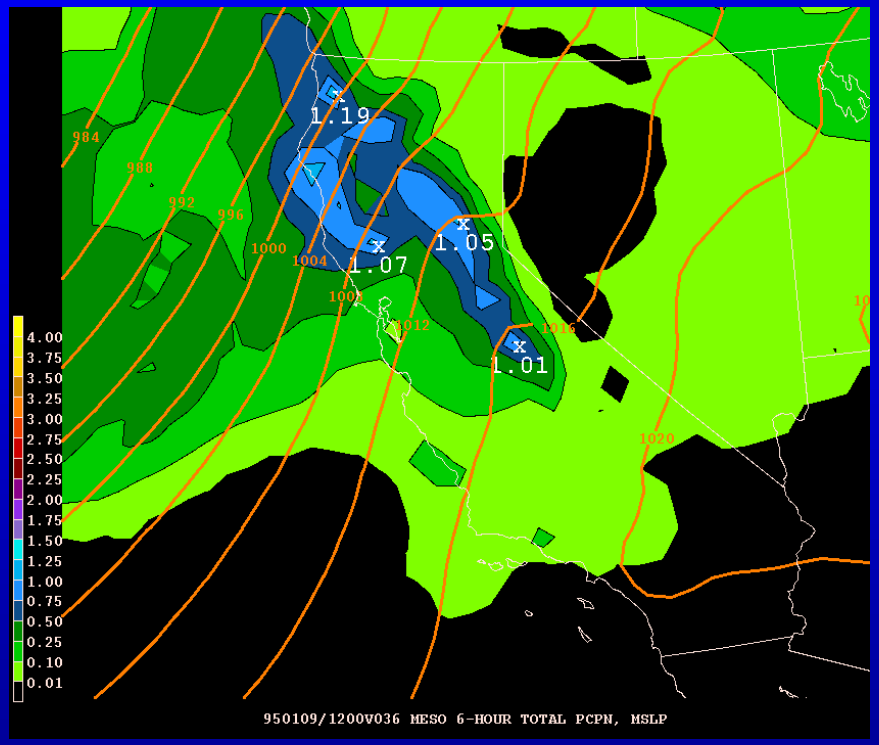
NOTICE HOW SLOWLY THE LIFTING SHIFTS SOUTH

THE MODEL'S TERRAIN IS AVERAGED OVER THE GRID BOX SO THE SLOPE OF THE TERRAIN IS USUALLY NOT STEEP ENOUGH



THIS CAUSES THE VERTICAL MOTION FIELD TO BE SHIFTED AWAY FROM THE MOUNTAINS

THINGS TO REMEMBER ABOUT MODEL QPFS IN COMPLEX TERRAIN DURING WINTER

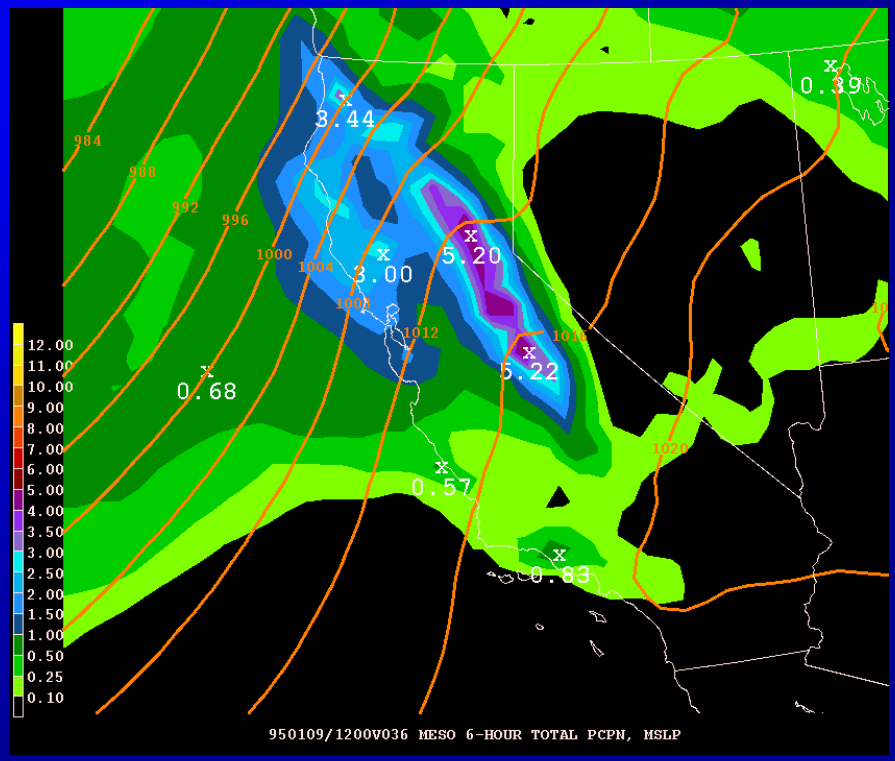


BECAUSE OF THE SIMPLIFIED MICROPYSICS AND INADEQUATE RESOLUTION OF MOUNTAINS. MODELS USUALLY:

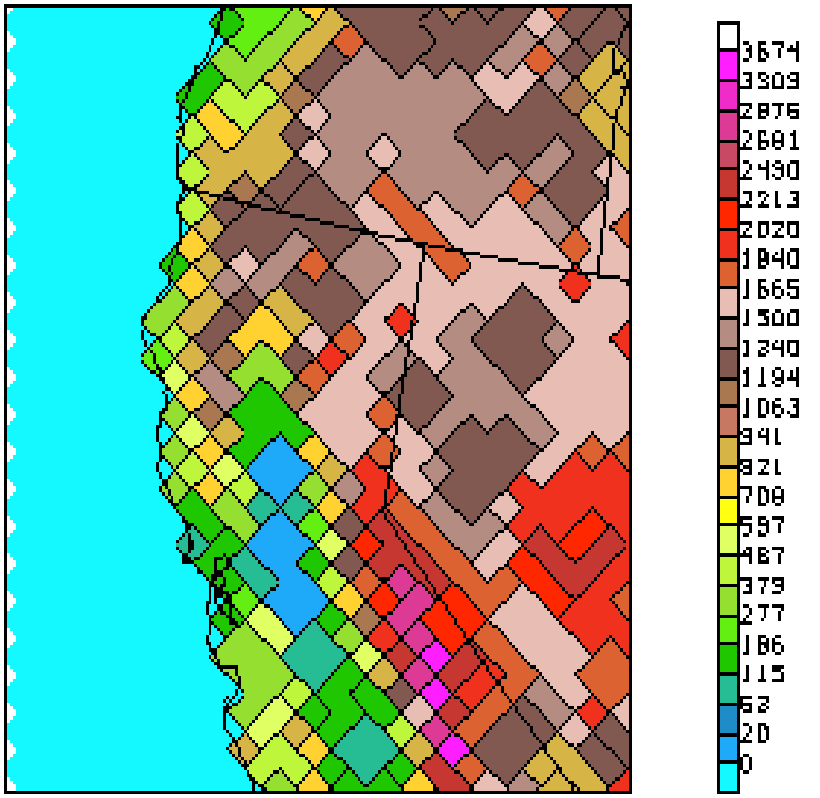
1) PREDICT PRECIPITATION TOO FAR WEST AWAY FROM MOUNTAIN PEAKS

2) DOE NOT ALLOW ENOUGH PRECIPITATION ON THE IMMEDIATE DOWNWIND SIDE OF MOUNTAIN RANGES

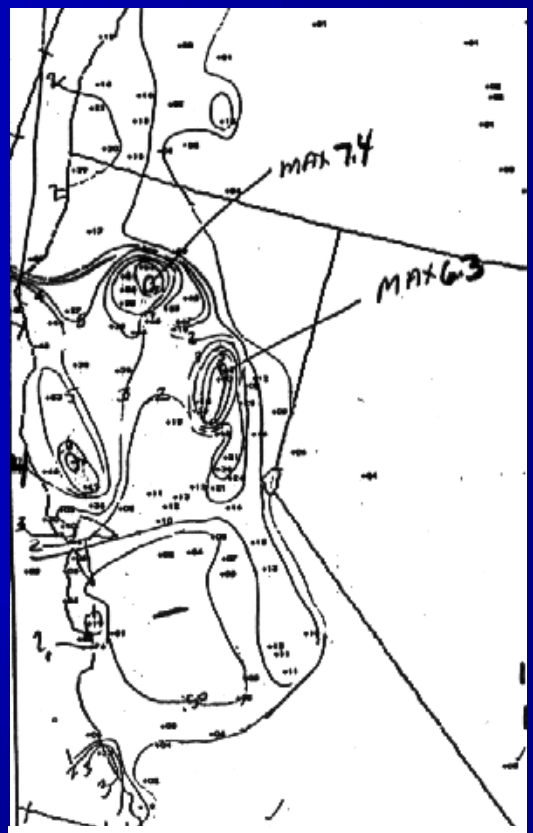
WHAT ADJUSTMENTS ARE NEEDED TO THIS 24 HR QPF



WITH STRONG VERY MOIST SOUTHWESTERLY FLOW AT 850 AND 700 MB NOTE HOW CLOSELY THE PRECIPITATION CONFORMS TO THE TERRAIN



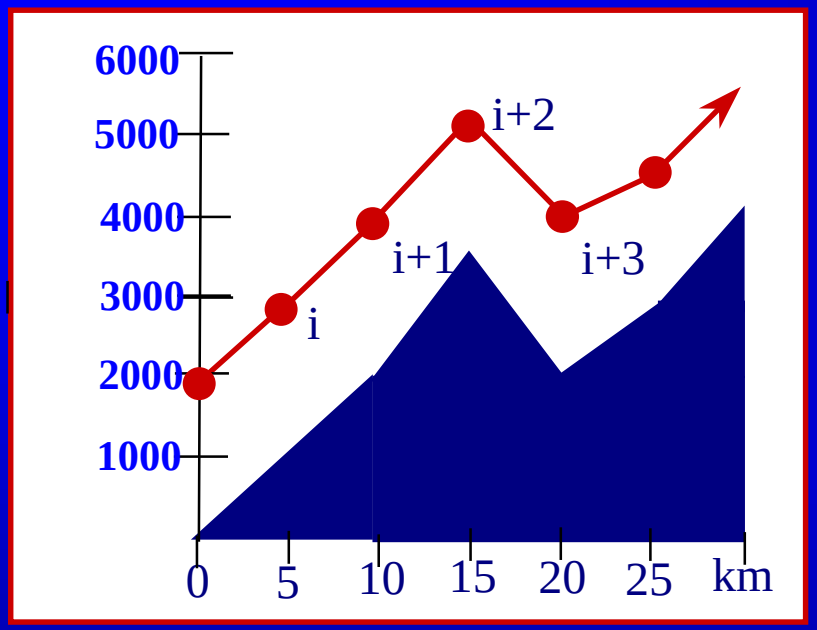
32 KM ETA TERRAIN



24 HOUR PRECIPITATION VALID JAN. 9, 1995

WHEN SOUTHWESTERLY FLOW IS PRESENT A BARRIER JET FORMS AND FUNNELS THE FLOW UP THE SACREMENTO VALLEY.

Rhea Orographic Model



- **For a layer forced up or down by terrain.**

  -keeps track of condensation or evaporation

  -part of condensate precipitates (based on empirical Precipitation Efficiency Factor)

  -the rest moves downstream with the parcel

- **At the next point**

  -Part of imported condensate precipitates along with additional condensate produced by additional orographic lift

  -the rest moves downstream with the parcel

- **For sinking motion**

  -Partial or total evaporation occurs

  -if the parcel becomes supersaturated, saturation deficit is computed

- **Layer interaction**

  -precipitation into a dry layer will partially or totally evaporate

Input Requirements for Rhea Orographic model

- Wind direction-dependent elevation grid
- observed or predicted soundings for period of forecast for the following fields
  - wind direction
  - wind speed
  - temperature
  - humidity

MOUNTAIN MAPPER

- USED IN WESTERN U.S.
- CAN BE USED WITH RHEA OBJECTIVE METHOD
- FILLS IS PRECIPITATION OVER COMPLEX TERRAIN BASED ON PRISM DATA
- COMBINATION OF MOUNTAIN MAPPER AND RHEA TECHNIQUE IS HARD TO BEAT ALONG SIERRA RANGE

IN SUMMARY

- DURING SUMMER OVER INTERMOUTAIN REGION AND MOST OF THE WEST, QPF IS ALMOST IMPOSSIBLE BECAUSE
  - THE MODELS DO A BAD JOB HANDLING THE MOISTURE
  - THE SCALE OF EVENTS IS USUALLY SMALL
- DURING WINTER, THE SKILL OF QPF IS HIGHER OVER NORTHERN CA, WESTERN OR AND WESTERN WA THAN ANYWHERE ELSE IN THE COUNTRY
  - BECAUSE THE FOCUS FOR MOST OF THE LIFTING IS STATIONARY (THE MOUNTAINS).
  - HOWEVER TIMING WHICH 6 HOUR PERIOD WILL RECEIVE THE HEAVIEST RAINFALL IS STILL DIFFICULT.