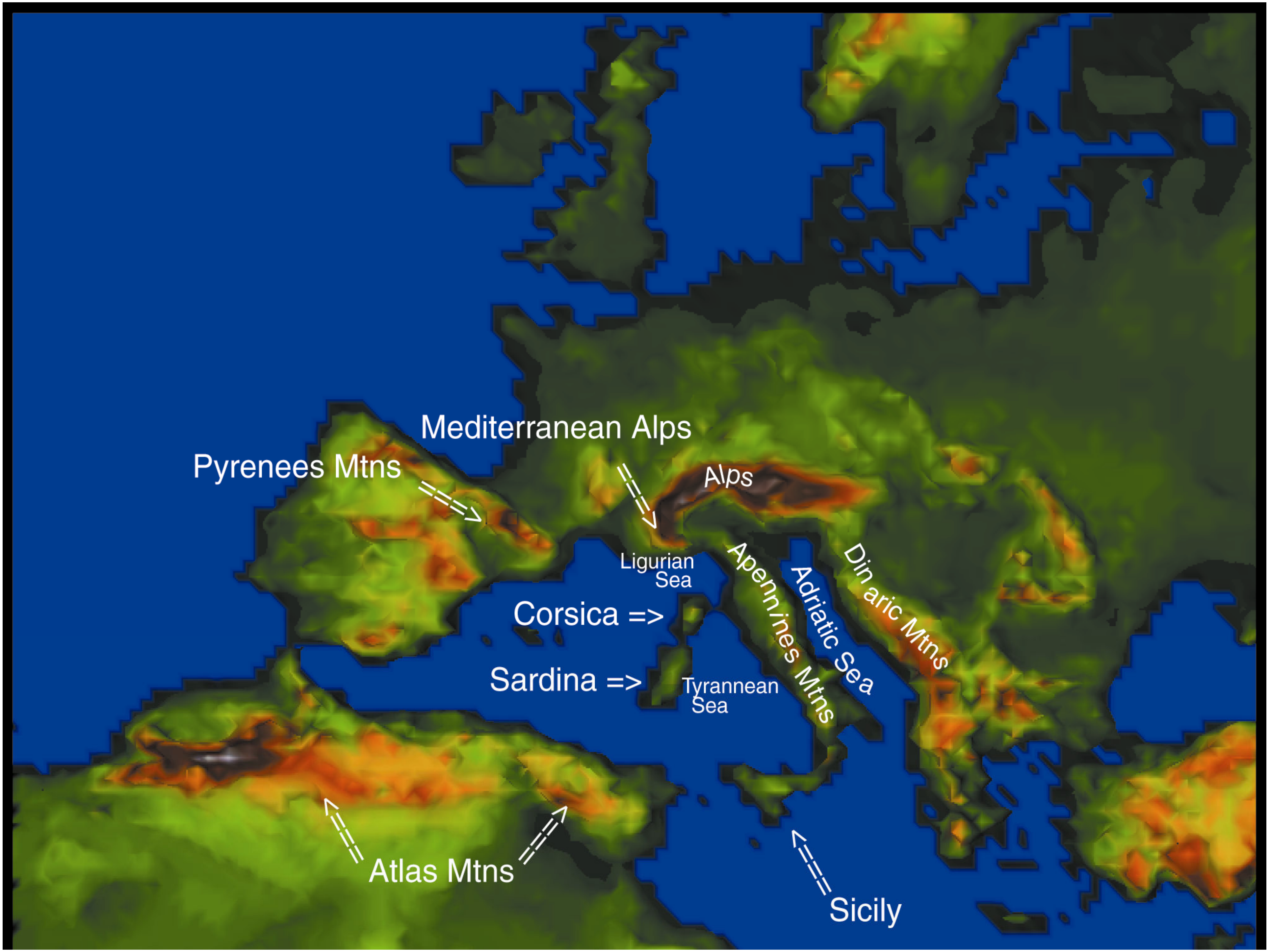
# Orographic Storms in the Southern Europe

- Heavy precipitating storms resulting from proximity to Mediterranean Sea
- Fall season particularly dangerous because of warm water
- Many ranges of mountains act to channel low-level flow into jets that focus lifting and lead to sustained precipitation that can result in flooding
- Two types of storms:
  - Simple orographic storms
  - Convective orographic storms


Mediterranean Alps
Pyrenees Mtns
Alps
Ligurian Sea
Corsica =>
Sardina =>
Tyrannean Sea
Apennines Mtns
Adriatic Sea
Din aric Mtns
Atlas Mtns
Sicily

# Piemonte Flood
# October 12-16, 2000

- Orographic heavy rain in piemonte region of northern Italy (along Swiss Border)
- Problem was duration of rain more than intensity.
- Moisture focused by low level channeling
- Upper level trough stalled by high pressure to east

# Alps

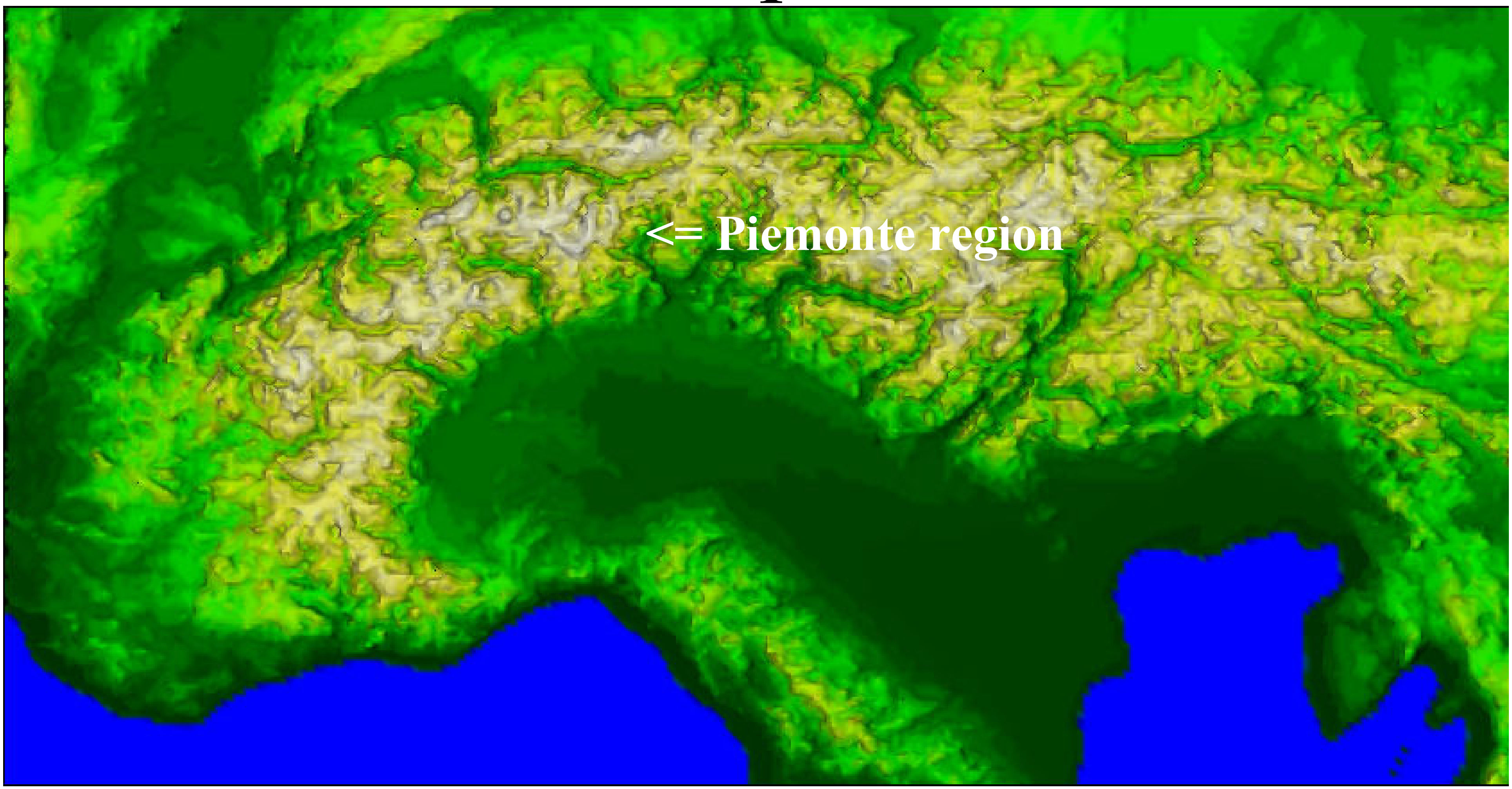


Foto22: *Comune di Alagna Valsesia. Strada Comunale per Dosso.*
*La piena del Torrente Olen asporta la carreggiata della strada, in sinistra.*

Foto 23: *Alveo modellato dalla piena del Torrente Stura di Valgrande.*

Foto 24: *Fiume Dora Baltea:ponte sulla ferrovia all'altezza di Tavagnasco dopo il passaggio della piena.*

# Rainfall AMounts

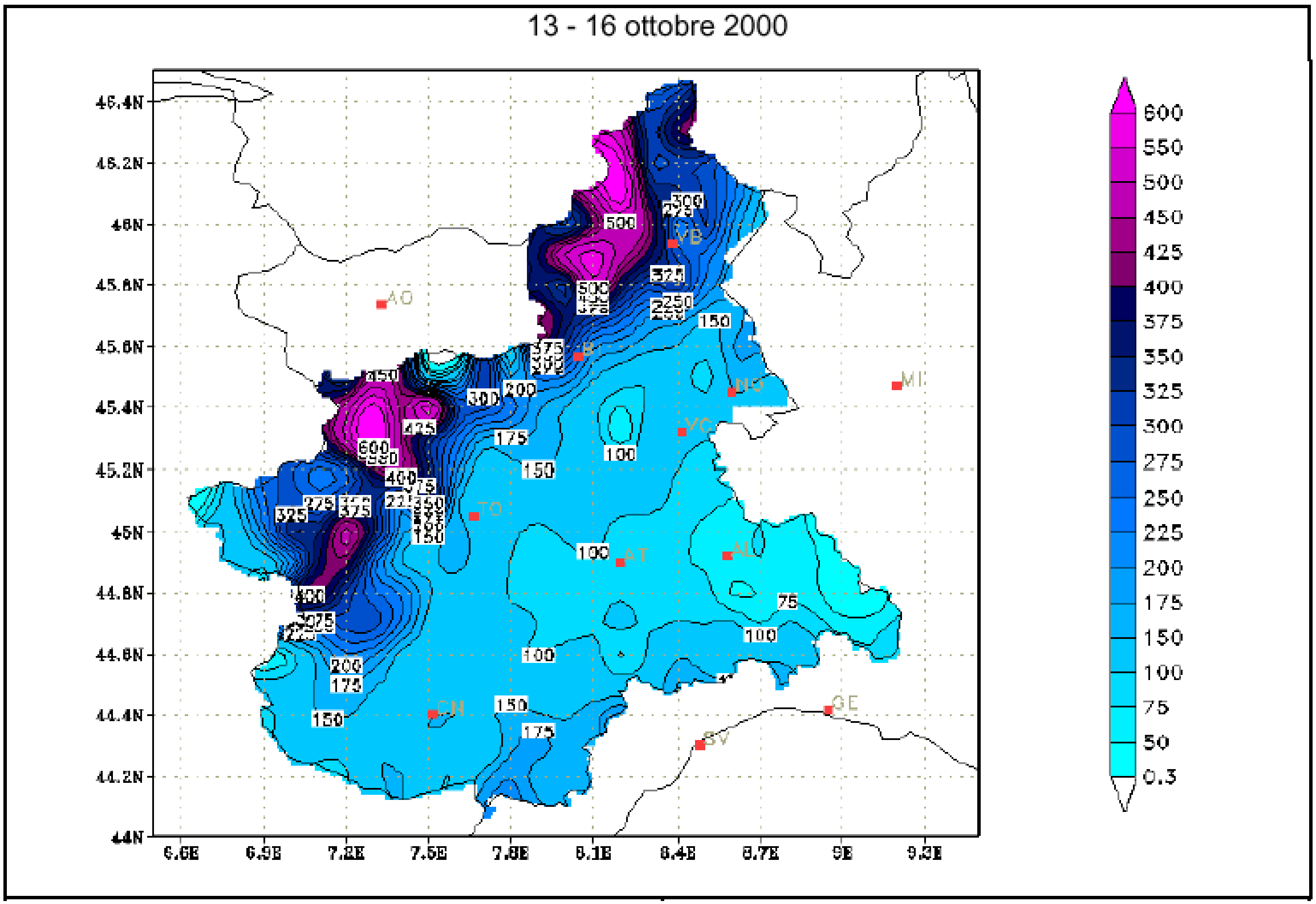


Figura 8 - Radiosondaggi nel corso dell'evento.

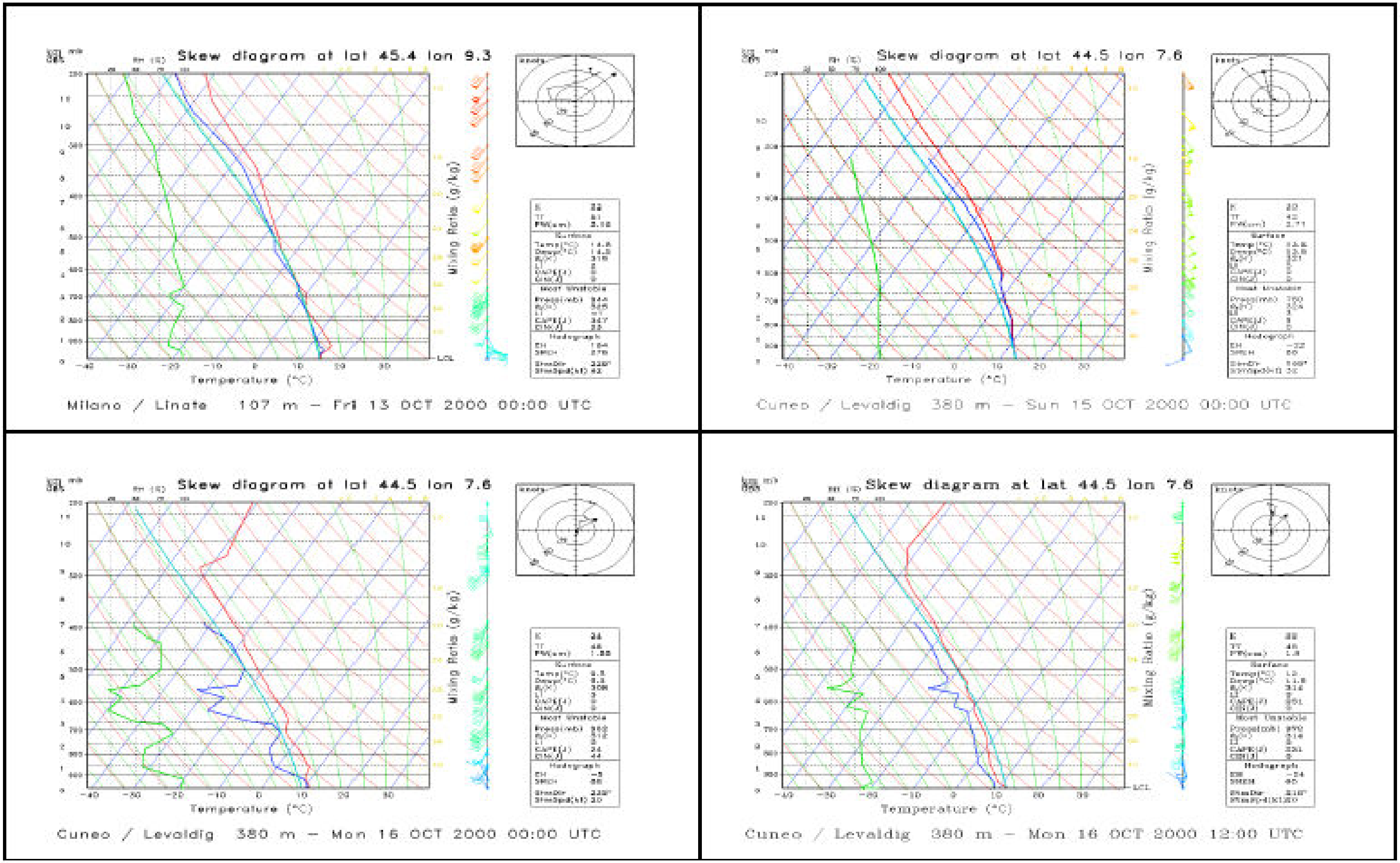
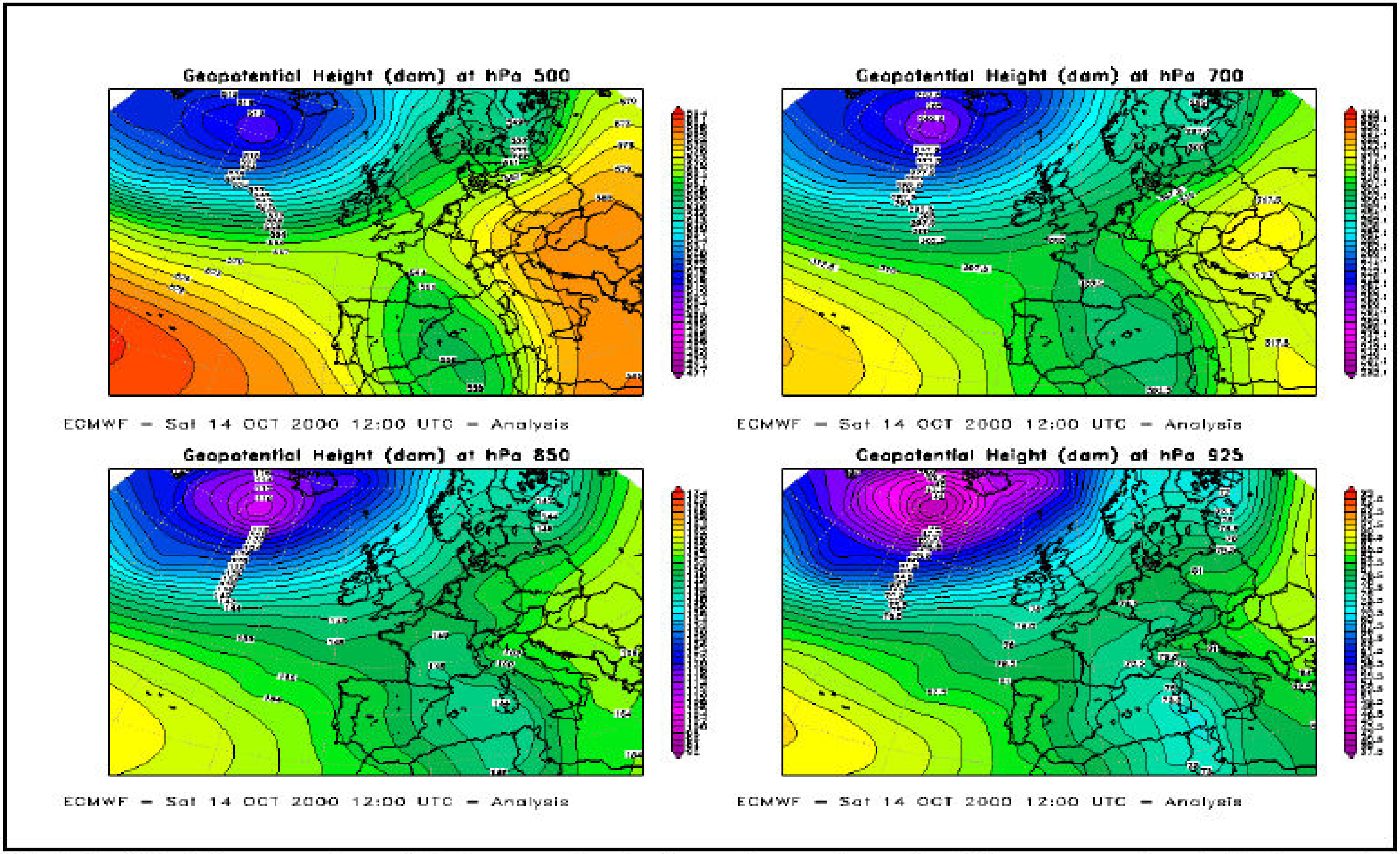
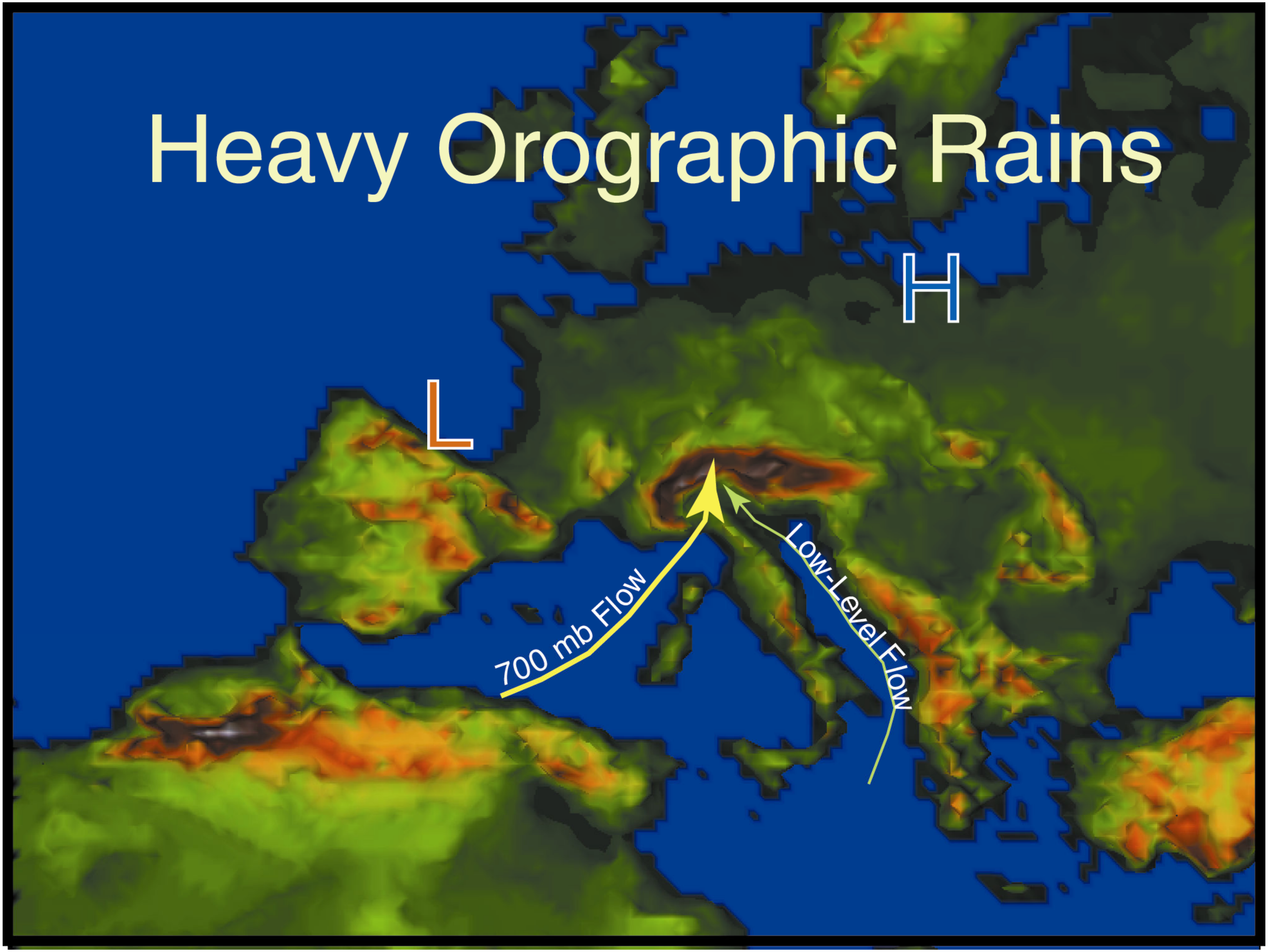


Figura 9 - Altezza di geopotenziale a 500, 700, 850 e 925 hPa alle 12 UTC del 14 Ottobre



# Heavy Orographic Rains



# Convective Orographic Storms

- Conditionally unstable flow approaching a barrier leads to the formation of deep convection along slopes of mountains
- Orographic lifting itself can destabilize the flow
- Mountains may act as a trigger to release instability built up elsewhere

# Flash Flooding

- Convective orographic rains are especially likely to lead to flash flooding
  - Topography focuses runoff
  - Topography can break a strong cap
  - Topography focuses convective release
  - Topography increases conditional instability

# Flash Flooding

- When large amounts of rain fall in a short time
- Most likely when
  - Cap is strong, focusing convection along slopes
  - Moisture is high leading to high energy release through latent heating and also high rainfall
  - Air is warm, and can hold a lot of moisture

# Flash Flooding in the Rockies

- Normally, there is not enough moisture
  - In the west, the ocean is relatively cool in the summer and so the on shore flow is not conditionally unstable
  - In the east, Gulf moisture rarely reaches the severe topographjy from the east
    - When it does, storms typically move away from their genesis region because of the upper level westerlies
- Normally, the upper level flow moves from the west, moving storms in the east off the slopes

# Two major Flash Floods: Both are listed as “Storms of the Century”

1. The 1972 Rapid City South Dakota Flood
2. The 1976 Big Thompson Canyon, Colorado Flash Flood

# Mouth of Big Thompson Canyon after Flood: Siphon pipe laying on hill.

ID. BIG THOMPSON CANYON FLOOD no. 34ct¦ Mouth of Big Thompson Canyon looking upstream into Narrows. Highway 34 at left, truncated by river. Preliminary calculated peak discharge at this point was 31,200 cubic feet per second. Larimer County, Colorado. August 1, 1976.

# House is still there!

ID. BIG THOMPSON CANYON FLOOD no. 17ct| House precariously undercut by lateral scour, Big Thompson River 1/4 mile below Glen Comfort, Glen Haven Quadrangle. Landslide to right in background caused by undercutting; a house was carried away at that point. River flows toward observer. Aug. 13. 1976.

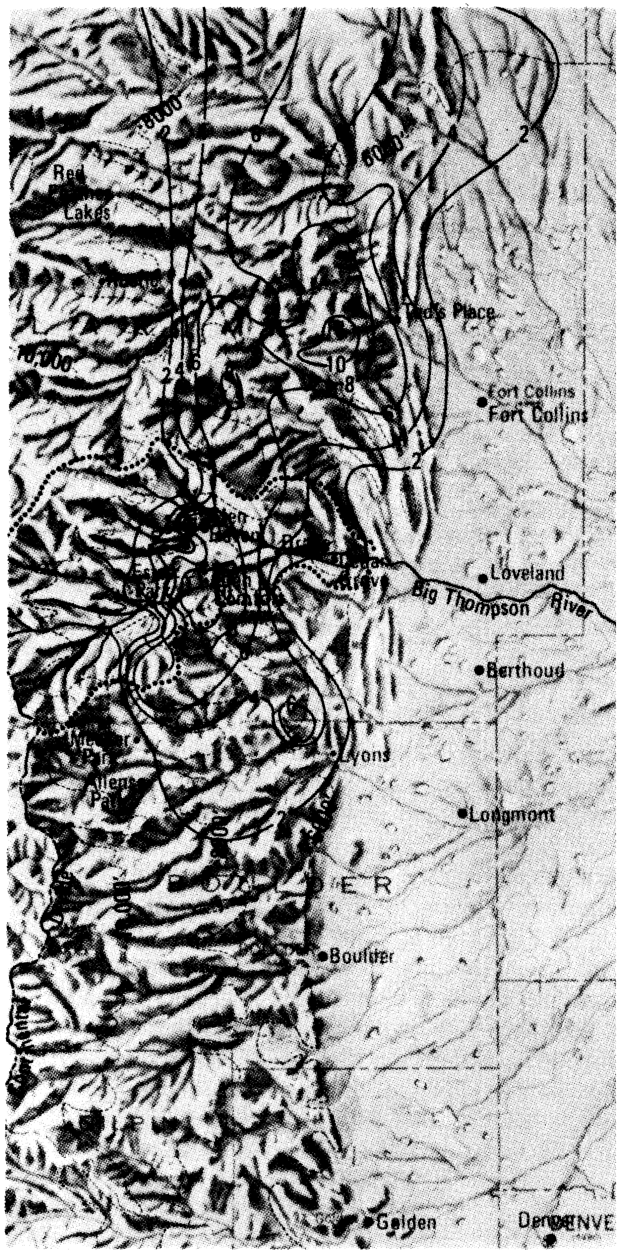



FIG. 2. Big Thompson and North Fork of the Big Thomps drainages (dotted line). Cumulative rainfall isohyets (black line are shown. Terrain contours (ft ASL) are dashed. The precipit tion summary and isohyetal map were prepared by the Nation Weather Service Central Region Headquarters in cooperation wi other Federal Agencies.

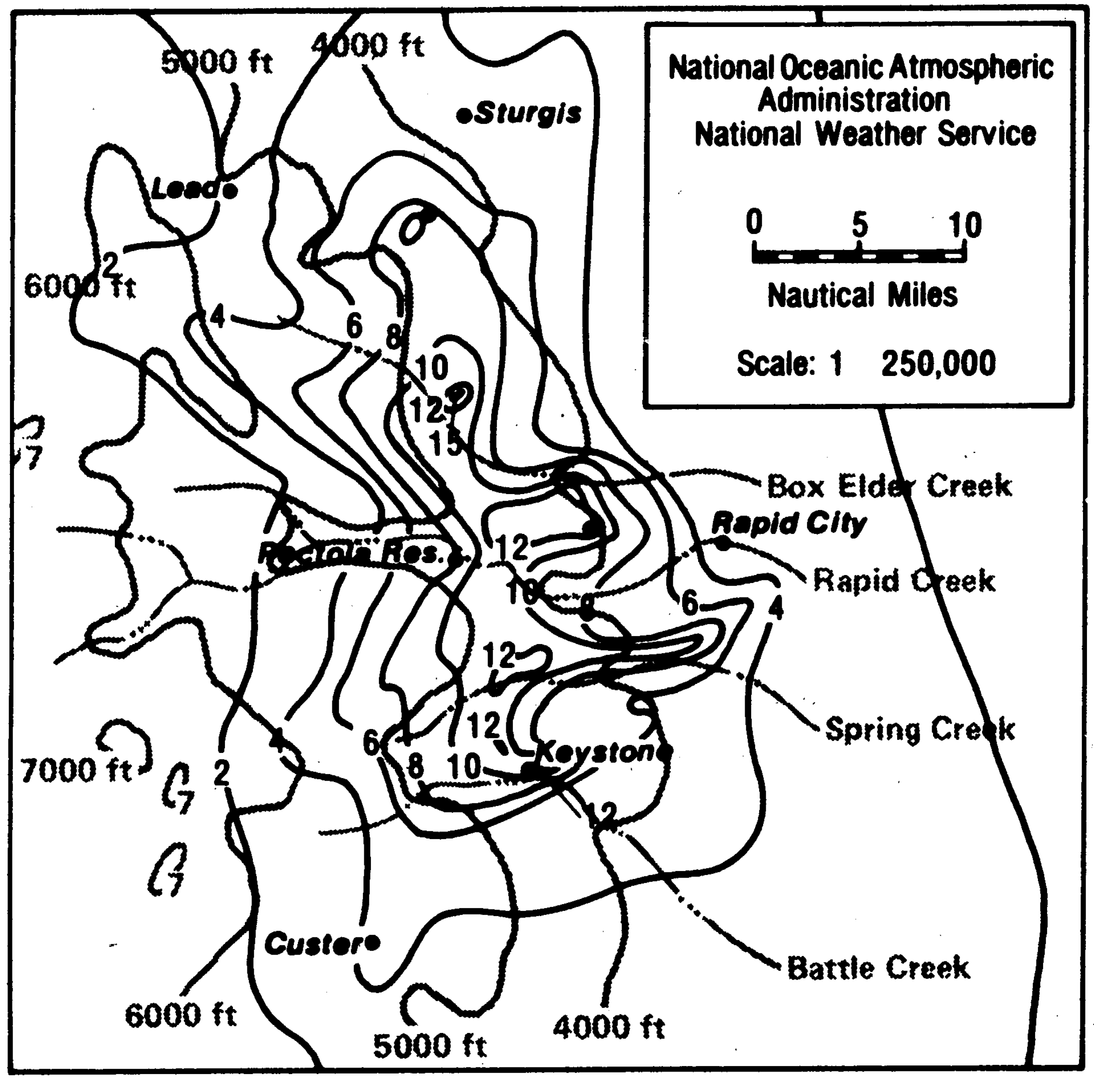



FIG. 3. Map of the Rapid City and Black Hills area affected by flooding. Cumulative rainfall isohyets (heavy lines) are shown. Terrain contours (1000's of feet AGL) are lighter. The precipitation summary and isohyetal map were prepared by the National Weather Service Central Region Headquarters in cooperation with other Federal Agencies.

# Big Thompson Situation

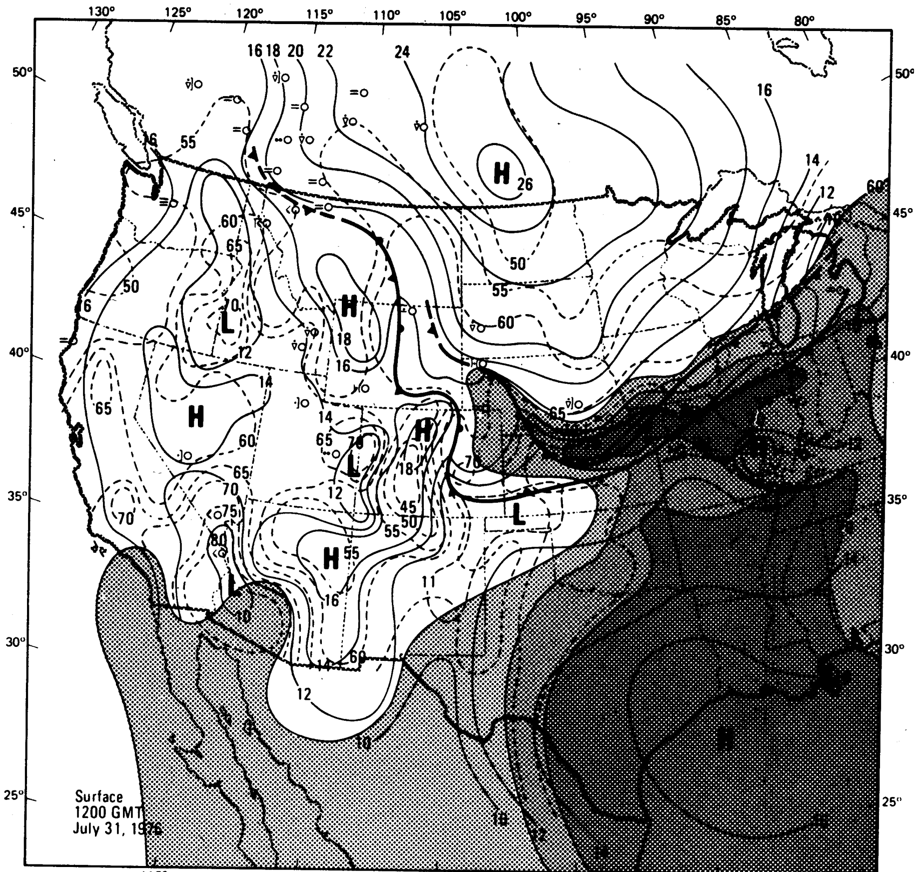



FIG. 4a. Surface analysis for 1200 GMT 31 July 1976. Frontal positions, pressure centers and isobars for 2 mb intervals (12=1012) are solid lines. Isotherms for 5°F intervals are dashed lines. Dew-points ⩾60°F are analyzed at 5°F intervals with the high dew-point region shaded.

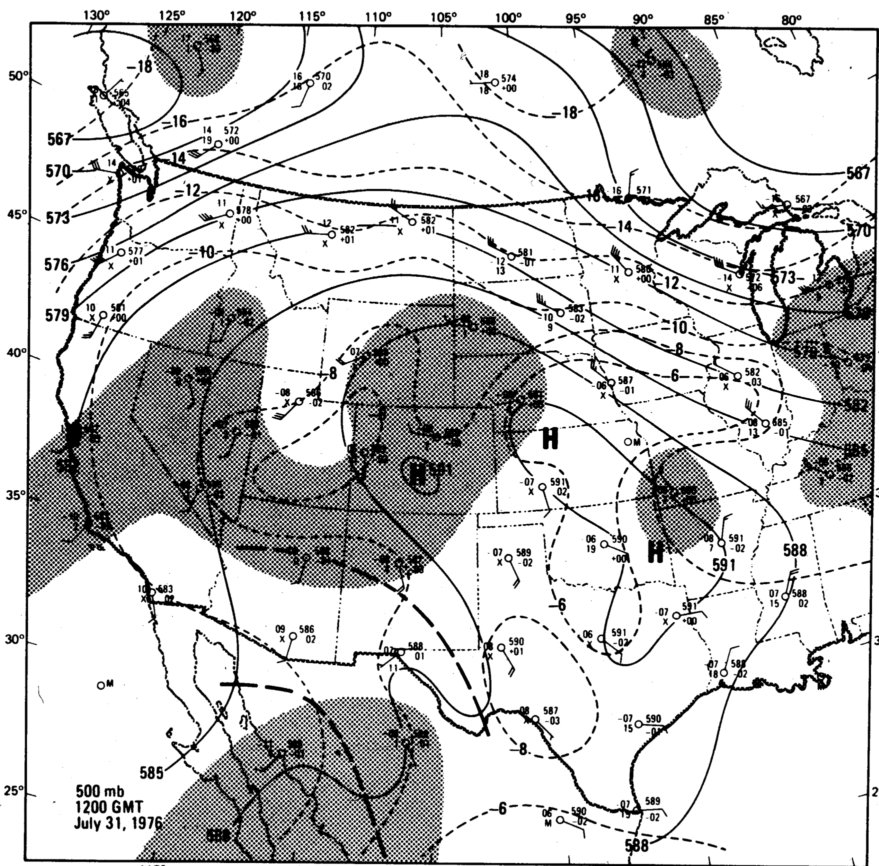



FIG. 4b. 500 mb analysis for 1200 GMT 31 July 1976. Height contours (drawn for every 30 m, 570=5700 m) and circulation centers are solid, short-wave troughs and isotherms for 2°C intervals are dashed. Regions where $T-T_d \leqslant 6$°C are shaded to indicate moist conditions.

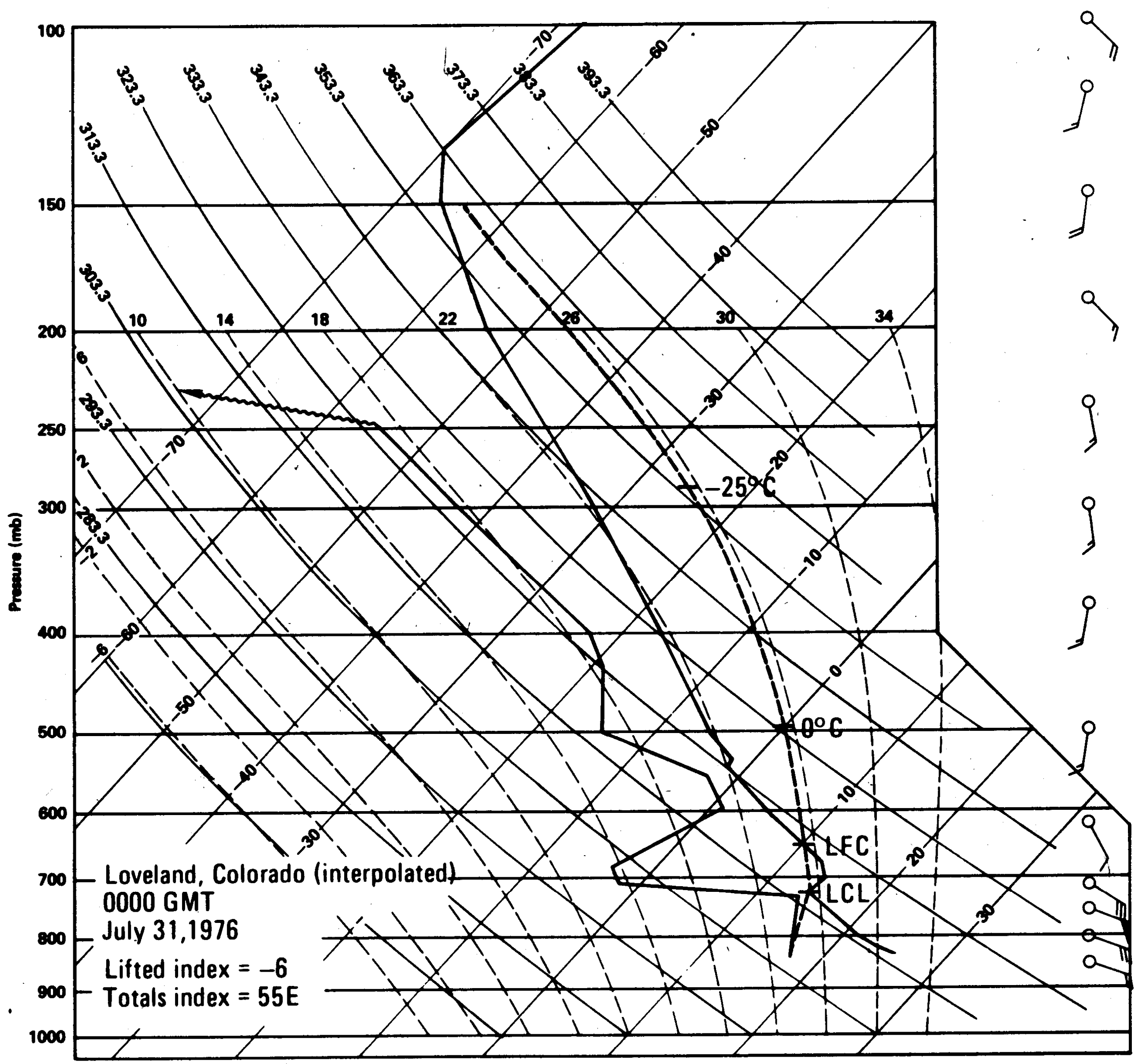



FIG. 16a. Skew $T/\log P$ plot of upper air sounding constructed for Loveland, Colo., at 0000 GMT 1 August 1976. LCL and LFC levels and the moist adiabat are shown for a lifted parcel with mean thermodynamic characteristics of lowest 100 mb layer.

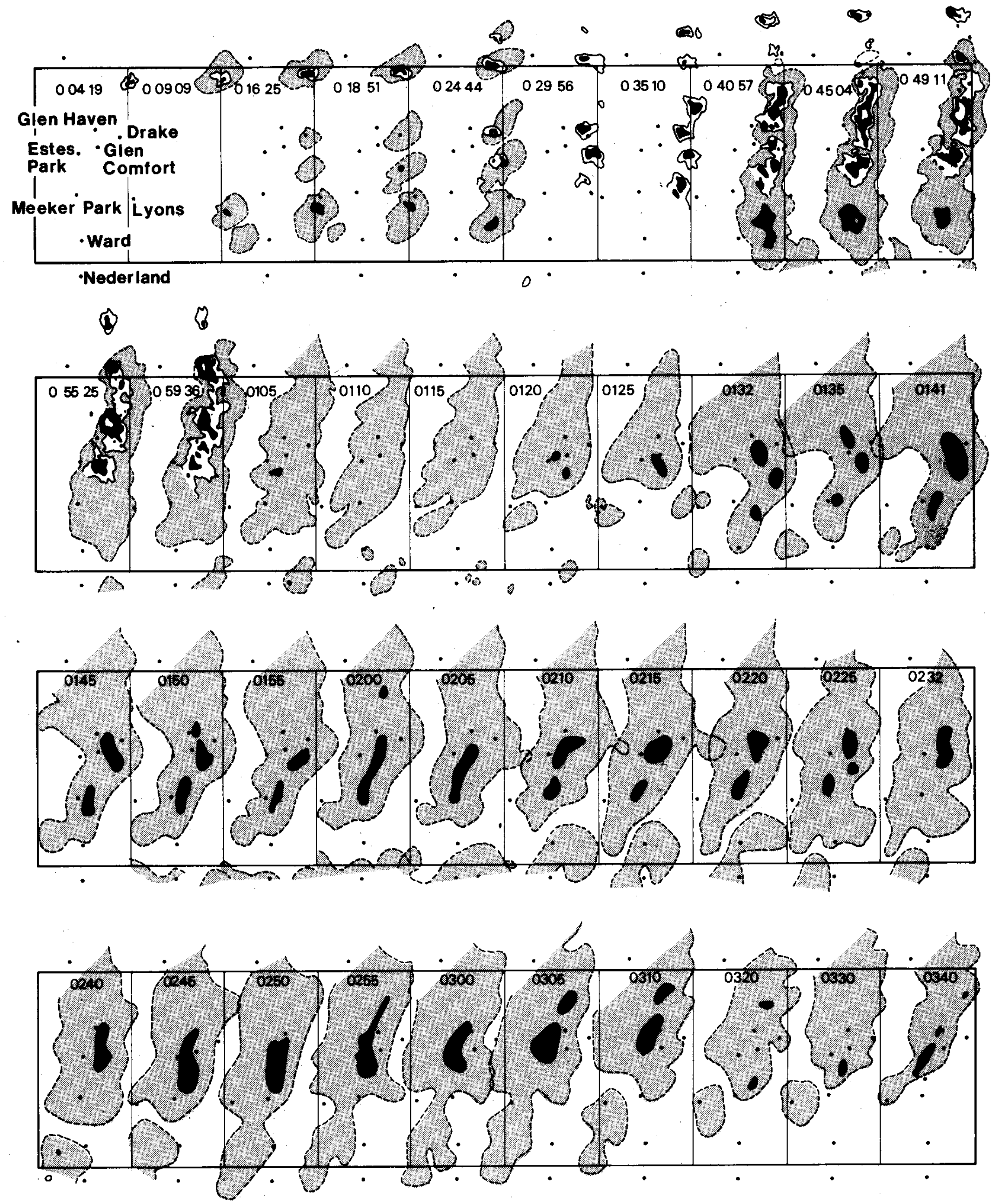
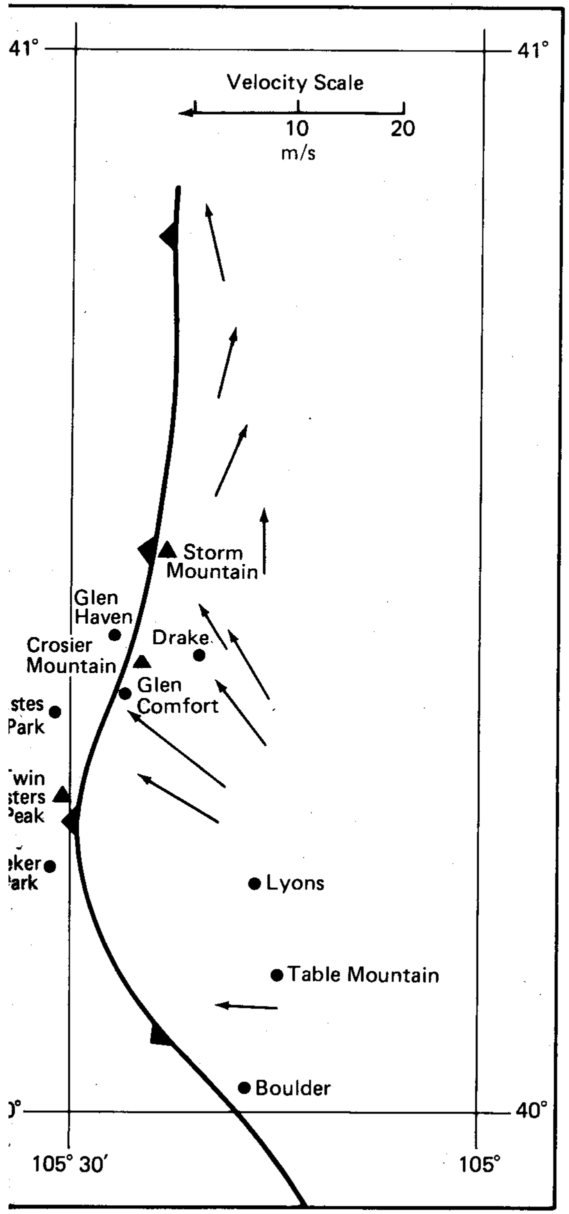



FIG. 8. Composite-echo time series formed from both Limon and Grover radar echoes showing the evolution of the storm from 0004 to 0340 GMT 1 August 1976. Light gray shading corresponds to Limon VIP level 2 (where available). 35 dBZ contours and higher (alternating white and black at 10 dBZ increments) from Grover radar over the period 0004–0059 replace Limon VIP levels 3 and higher. Where Grover data are available time is presented in the format hours (0), minutes and seconds.




G. 6. Velocities of identifiable radar echo cores in 3.3° PPI
tion scans made by Grover radar along the Front Range
g the period 0030–0100 GMT.

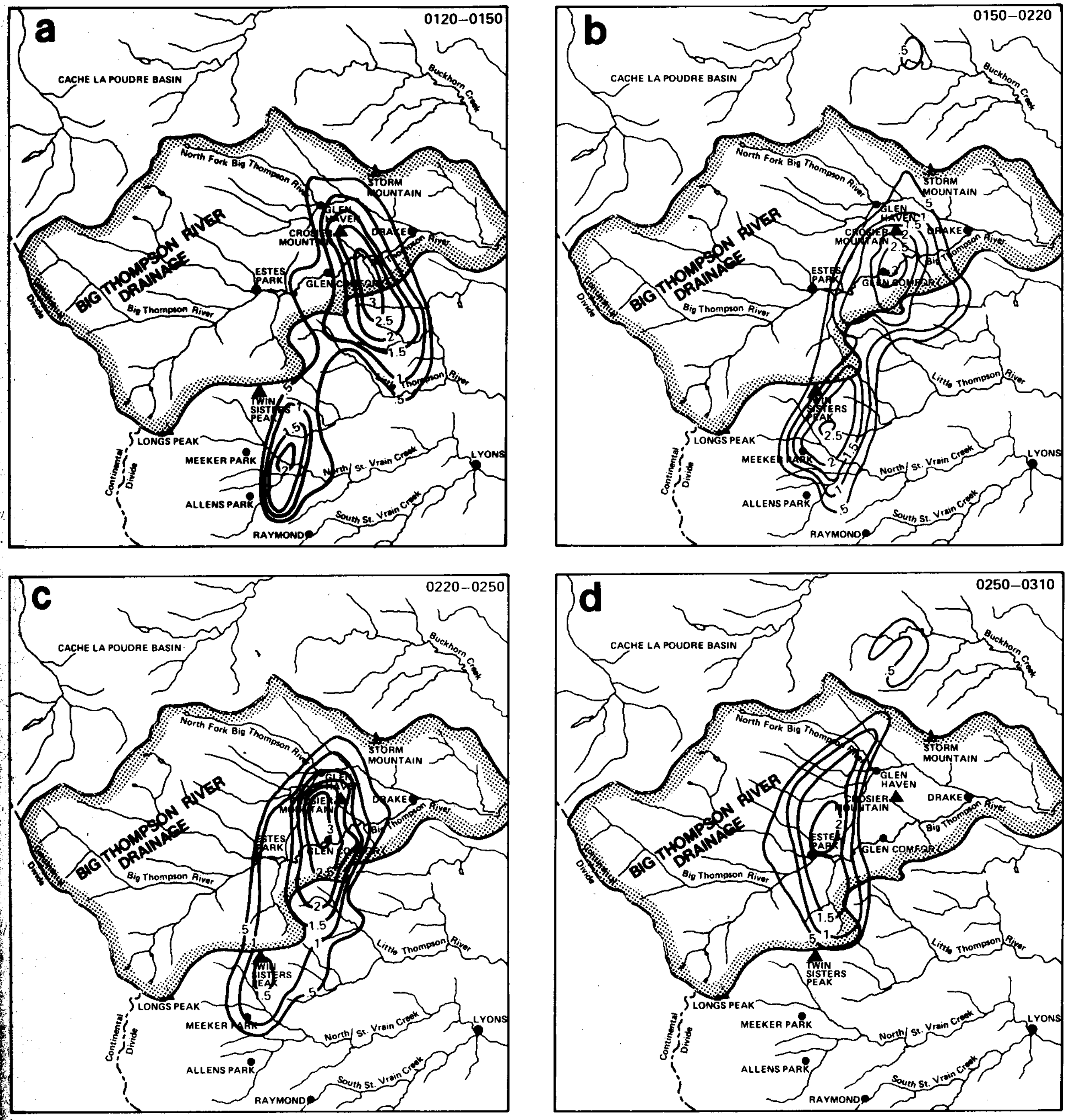



FIG. 10. Isoheyets of heavy rain component (accumulated VIP level 3 or higher) for 30 min intervals from 0120 to 0310 GMT 1 August 1976.

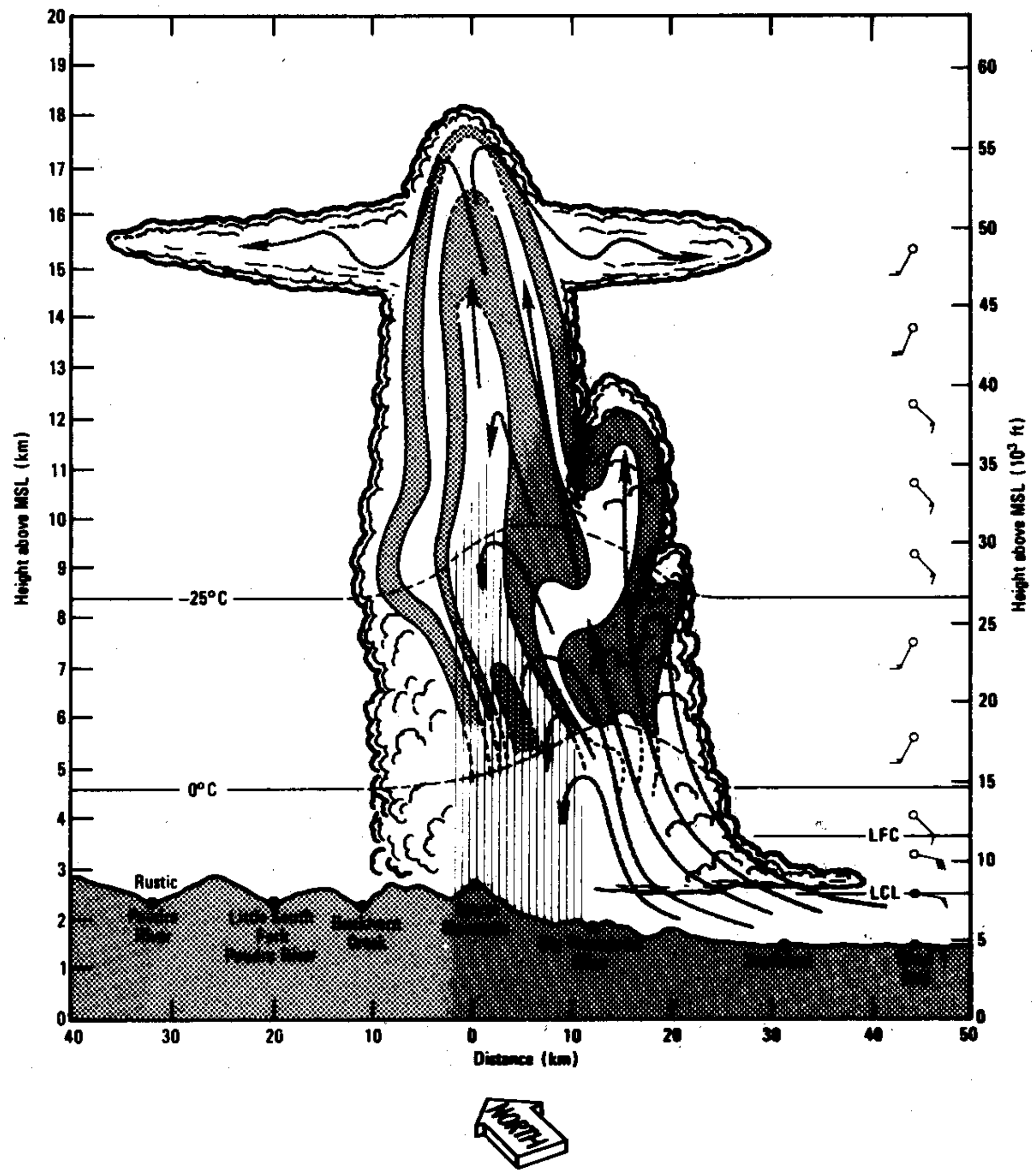



FIG. 15. Physical model of one of the initial cells of the Big Thompson storm complex. LCL, LFC, winds and levels of 0°C and −25°C isotherms are from interpolated Loveland, Colorado, sounding. Grover 0045 GMT radar reflectivities are shown with 10 dBZ contours beginning with 15 dBZ level.

# Rapid City June 9, 1972

# Rapid City Situation

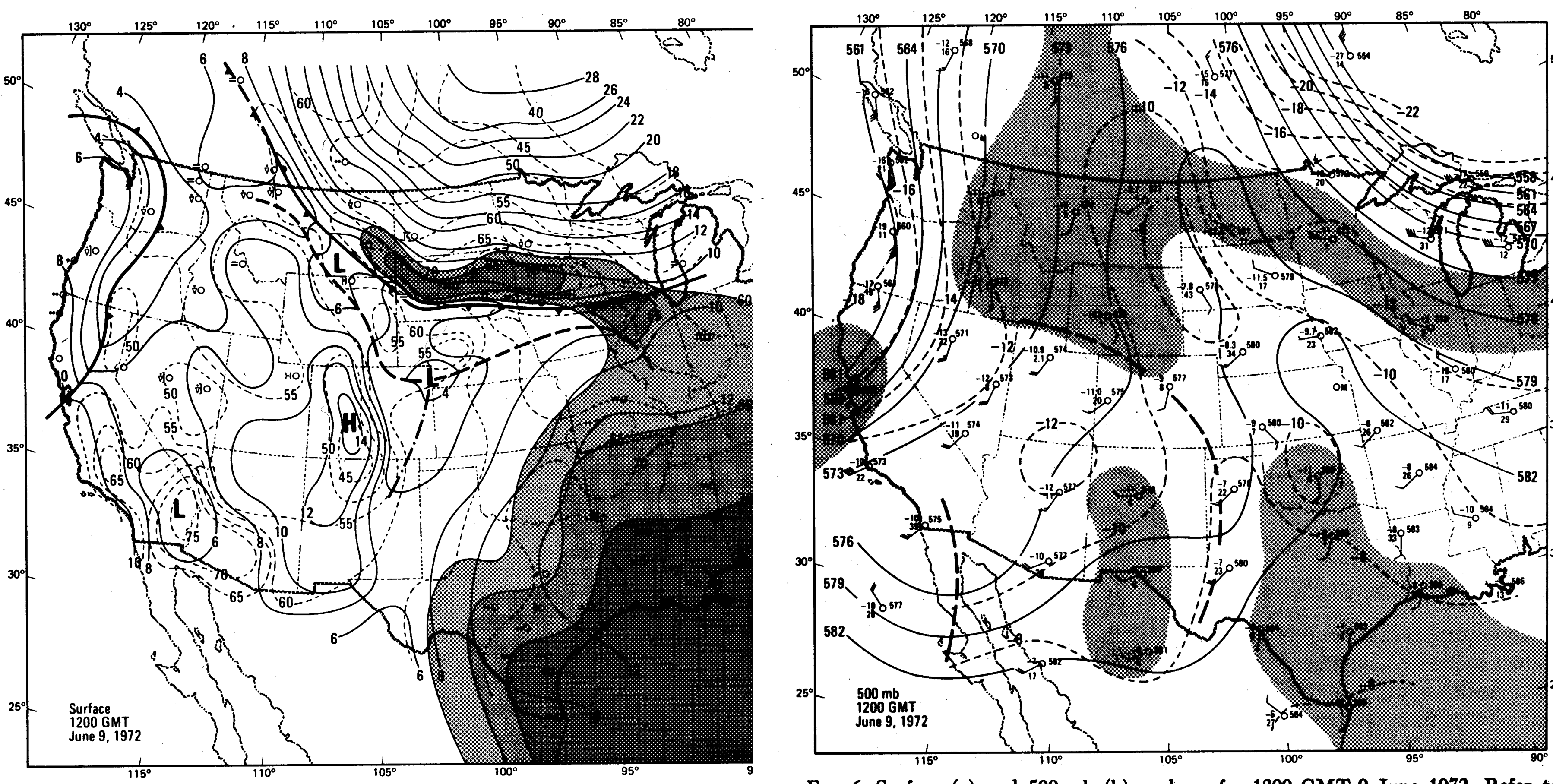



Fig. 6. Surface (a) and 500 mb (b) analyses for 1200 GMT 9 June 1972. Refer to legend of Fig. 4 for details.

for a lifted parcel with mean thermodynamic characteristics of lowest 100 mb lay-

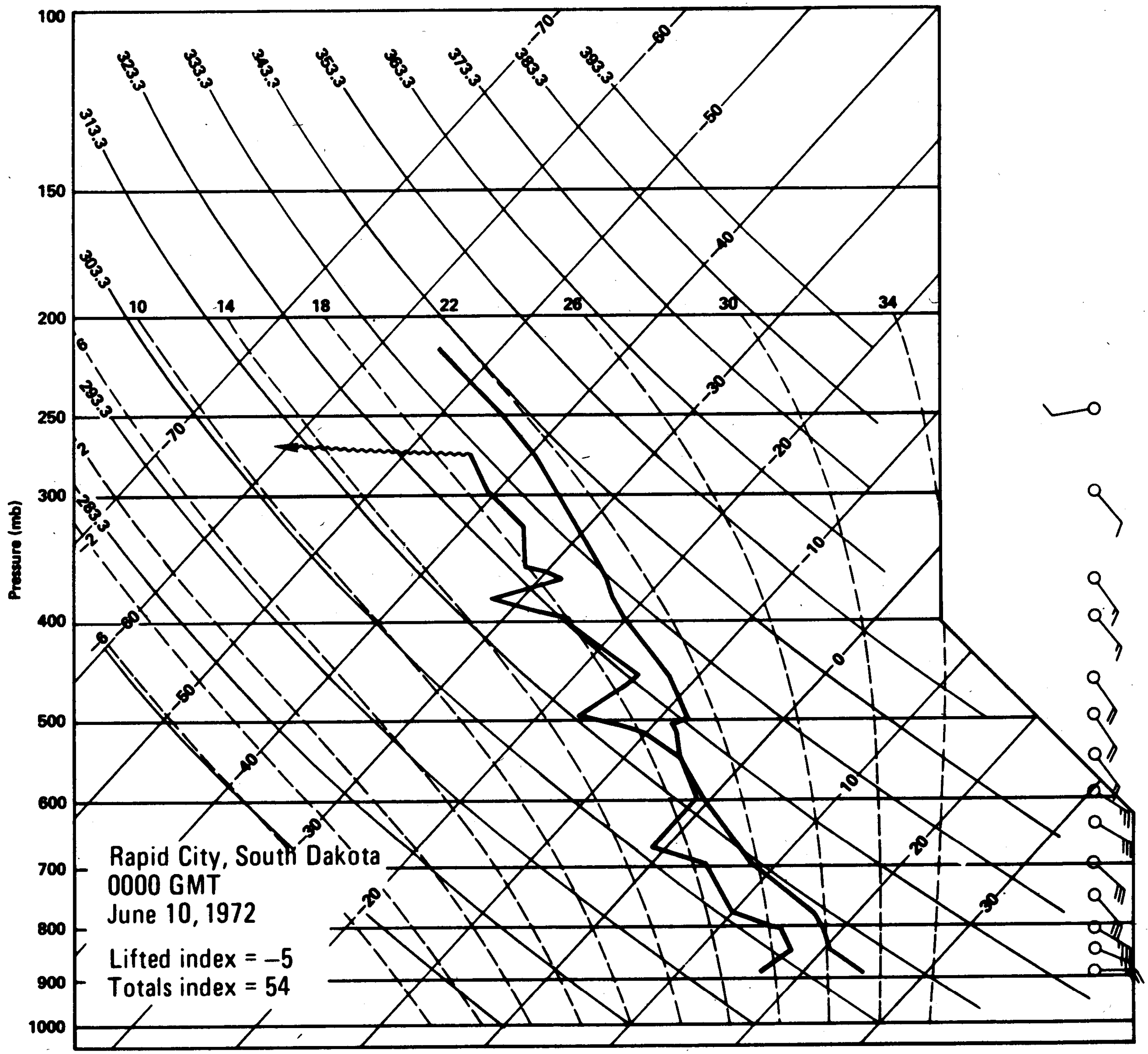



FIG. 16b. Skew $T/\log P$ plot of 0000 GMT 10 June 1972 Rapid City upper air sounding.

# Common Large-Scale Features to Big Thompson and Rapid City

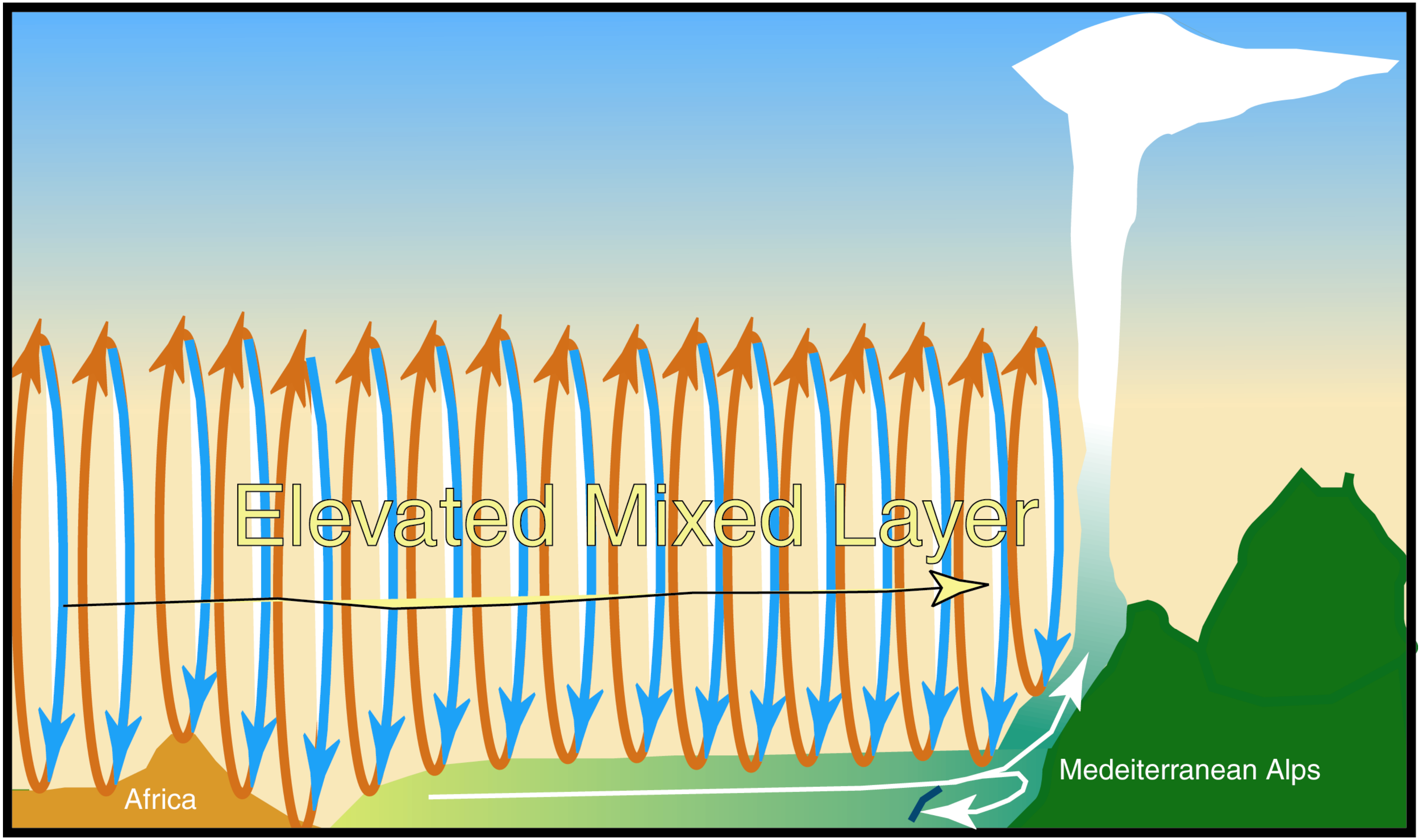
- Negatively tilted ridge just east of threat area, producing low inertial stability and low winds at storm outflow level
- A weak 500 mb short-wave trough rotates northwardin long wave trough as it approaches threat area, I.e. PVA
- Light southeast to south-southeast (5-20 kt) winds in upper troposphere over threat area
- Slow moving stationary polar front just to south of threat area
- High moisture content present through large depth of troposphere

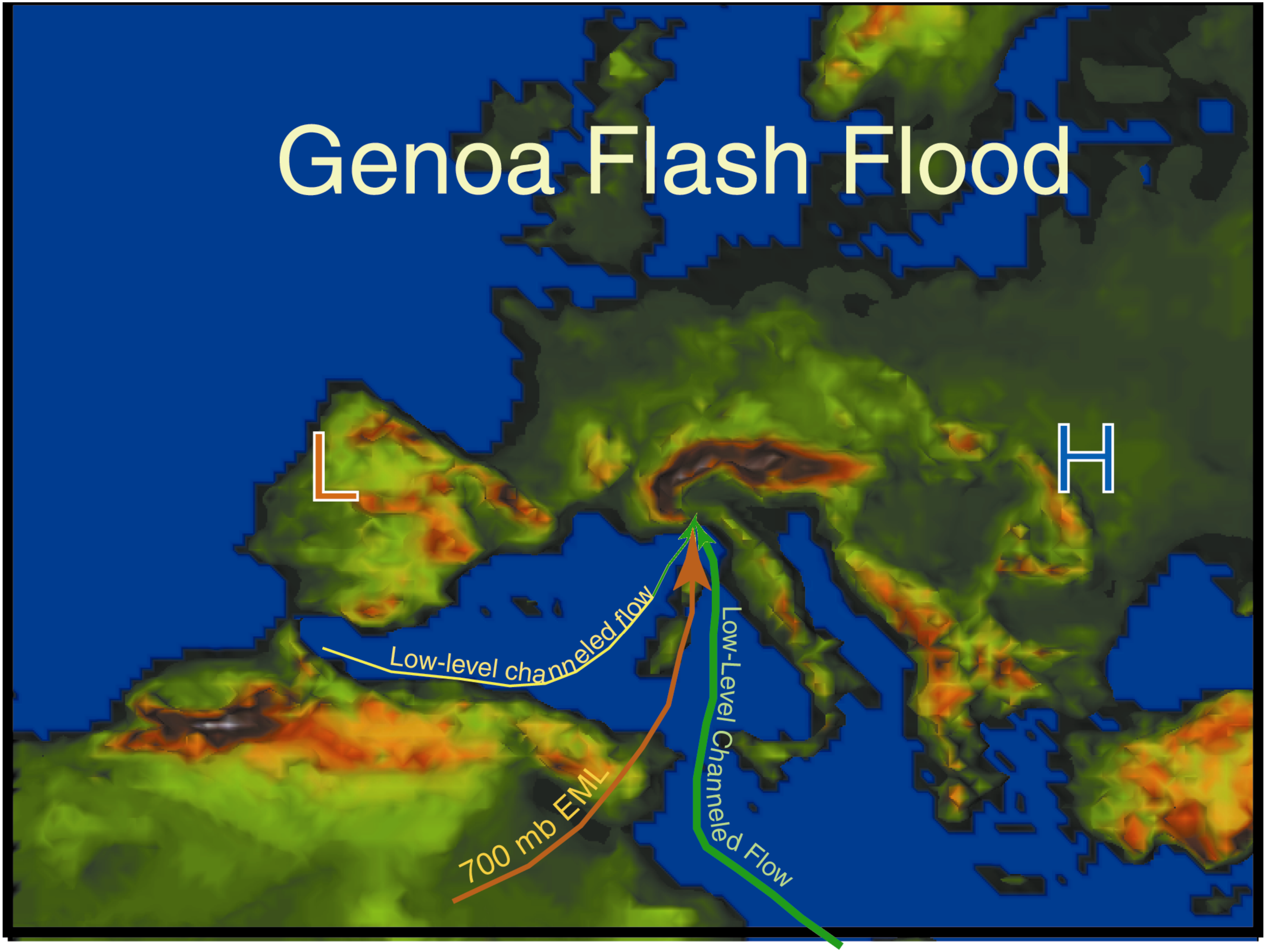
# Common Mesoscale Features to Big Thompson and Rapid City

- Afternoon heating to west of threat area and cold air advection to east combine to increase thickness and pressure gradients
- Narrow band of conditionally unstable and unusually moist air moves westward behind polar front
- Orographic lift provides mechanism to break cap and release instability
- Cells drift slowly north-northwestward and new cells regenerated on southern flank where cold front intersects mountains resulting in quasi-stationary system

# Flash Floods in Europe

- Fall season when first cold troughs move in and:
  - Mediterranean is still warm
  - Sahara is still hot and boundary layer is deep
  - Sawyer-Elliasen Circulation strong
- Elevated Mixed Layer off Sahara
- Channeling by topography


Elevated Mixed Layer
Africa
Medeiterranean Alps


Genoa Flash Flood
L
H
Low-level channeled flow
700 mb EML
Low-Level Channeled Flow

# Ingredients for Southern Europe Flash Flood

- Approaching long wave trough from west produces strong southerly flow surge
- Deep desert boundary layer drawn from Sahara northward over the Mediterranean marine boundary layer forming strong cap
- Air-sea interaction increasing moisture and theta_e below the cap
- Channeling by topography to focus flow into a jet against the continent
- Mountains breaking inversion to “pull the trigger”

# Summary of Orographic Flash floods

- Occur when orography acts to break a strong inversion and resulting storms remain focused along the slopes
- Ingredients include:
  - High conditional instability of air approaching mountains
  - Strong cap so that convection does not “jump the gun” and go off before the flow reaches the mountains
  - Upper level winds that will not allow convection to move back toward moisture and instability source region
  - Focusing of the flow along a particular mountain site:
    - Topography channeling
    - Local fronts