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MODIFYING ARIZONA VALLEY RAOBS FOR MOUNTAIN LOCATIONS

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Analysis of thermodynamic soundings are an integral part of the daily analysis routine for operational forecasters. During the warm season, thermodynamic diagrams are invaluable for determining convective cloud potential due to instability and moisture.

In the western U.S., most of the radiosonde launch sites are located in valleys. However, in weak flow situations where dynamic lifting is weak, convection most often initiates over high topographic features and may (or may not) propagate into valley locations. Therefore, forecasters must often ask themselves if values of trigger temperature, cloud condensation level, positive area, etc., calculated from valley radiosonde sites, are applicable over the mountains.

Atmospheric stability is especially sensitive to middle tropospheric distributions of temperature. Since valley radiosonde soundings are virtually the only source of this information, it may can be difficult to come up with valid modifications to the observed soundings. However, stability is also sensitive to the low-level temperature and moisture distribution. Surface observations in mountainous areas can give some idea of the local variations in the low-level moisture distribution. In some situations, this information can make a significant difference on calculated values of trigger temperature, cloud condensation level, etc.

The two raob sites in Arizona: Tucson (TUS) and Winslow (INW), are both valley locations (see Fig. 1). Winslow (elevation 4900 feet) is situated in the Little Colorado River Valley of northeast Arizona and is surrounded by higher terrain. Some of the highest terrain in Arizona (over 12000 feet) is located within 50 miles of Winslow. Tucson (2600 feet) sits on the western edge of the high Sonoran Desert where elevations typically are near 4000 to 5000 feet. A number of small 9000 foot mountain ranges also dot the southeastern Arizona area.

Figure 2 shows a Skew-T, Log P representation of a typical August morning sounding at Winslow (INW). The average mixing ratio in the lowest 100mb above Winslow is about 11 g/kg. However, if the sounding is assumed to also be valid for Flagstaff (station FLG, 50 miles west of Winslow at an elevation of 7000 feet) the average mixing ratio in the lowest 100mb above the surface would be about 9 g/kg. Note that even with this small difference in mixing ratio, the CCL for Flagstaff would be near 670mb (approximately 11000 feet), while at Winslow the CCL would be closer to 710mb (approximately 9500 feet). Adjusting this CCL level dry adiabatically down to the surface at Flagstaff yields a convective trigger temperature of about 19°C (67°F) while the Winslow trigger temperature is near 27°C (80°F). Since the CCL is higher at Flagstaff, the positive area in the sounding is also different. A saturated parcel from the Flagstaff CCL would intersect the temperature curve at 450mb (although just barely), while a parcel from the Winslow CCL would easily clear this cap and continue up to the tropopause near 200mb.

In the preceding analysis, the complete sounding for Winslow has been considered to be valid for Flagstaff. This assumption may be reasonable in this situation since the two sites are so close together. However, the surface observation at Flagstaff offers some additional information. The 12Z dew-point temperature of 52°F (11°C) is a little more moist than one would expect based on the sounding at Winslow, but it would not significantly change our earlier estimate of an average low-level mixing ratio of 9 g/kg.

Also note that some stability indices depend on temperatures of parcels lifted from the surface layer and can change due to consideration of mountain elevations. In the preceding example, the lifted index (500mb temperature - temperature of surface parcel lifted to 500mb) would be -1 at Flagstaff and -2 at Winslow. Note that low-level moisture gradients much stronger than shown here can exist and create more significant differences in calculated CCLs, trigger temperatures, and stability indices.

Figure 3 shows a similar situation for the sounding at Tucson, considered to be valid at Douglas, Arizona (station DUG, elevation 4400 feet - approximately 860mb). In this case, the 12Z dew-point observation at Douglas of 59°F (15°C) is almost exactly in line with what we could expect from the Tucson sounding. The average mixing ratio in the lowest 100mb above Douglas is estimated near 11 g/kg, while in the lowest 100mb above Tucson it is estimated near 13 g/kg. This produces a corresponding difference in the CCL from near 700mb at Douglas to 750mb at Tucson.

Any estimate of afternoon convective parameters based on morning soundings is subject to errors due to air mass changes during the day. Thus, techniques such as this should only be considered meaningful if the flow (and horizontal thermal gradients and moisture gradients) are weak enough that substantial changes to the thermodynamic profile are not expected during the day. Furthermore, it can be misleading to assume that temperature profiles above mountainous sites are the same as over valley raob sites, especially when the stations are widely separated or obvious horizontal temperature/moisture gradients exist.

Finally, this technique can only be used to estimate stability parameters for the mountainous sites versus the valley raob stations. The lift needed to initiate convection and release any instability must also be carefully considered. Solar heating of mountainous areas produces an upper-level heat source and drives daytime, upslope mountain breezes that are usually sufficient to initiate convection when instability exists. However, even if valley locations seem to have less instability, lifting caused by, for example, subtle convergent wind fields left over from the previous day's convection can be enough to initiate valley convection before mountain convection.

Hand plotting of raobs to assess mountain instability requires some extra time and effort. However, the extra information can often prove to be useful.

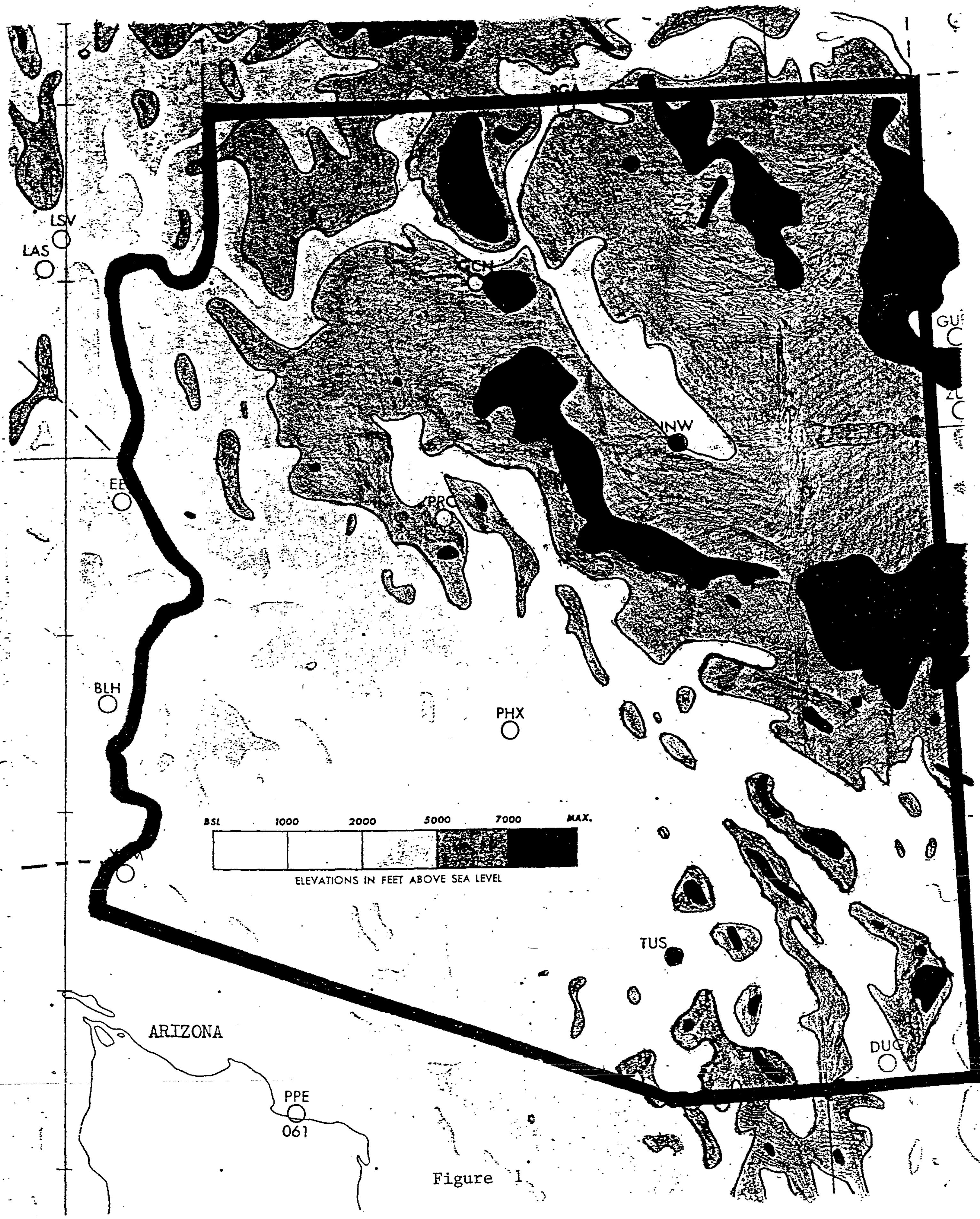
LSV
LAS
GCN
INW
PRC
EED
BLH
PHX
BSL
1000
2000
5000
7000
MAX.
ELEVATIONS IN FEET ABOVE SEA LEVEL
TUS
DUG
ARIZONA
PPE
061

Figure 1

INW 12Z

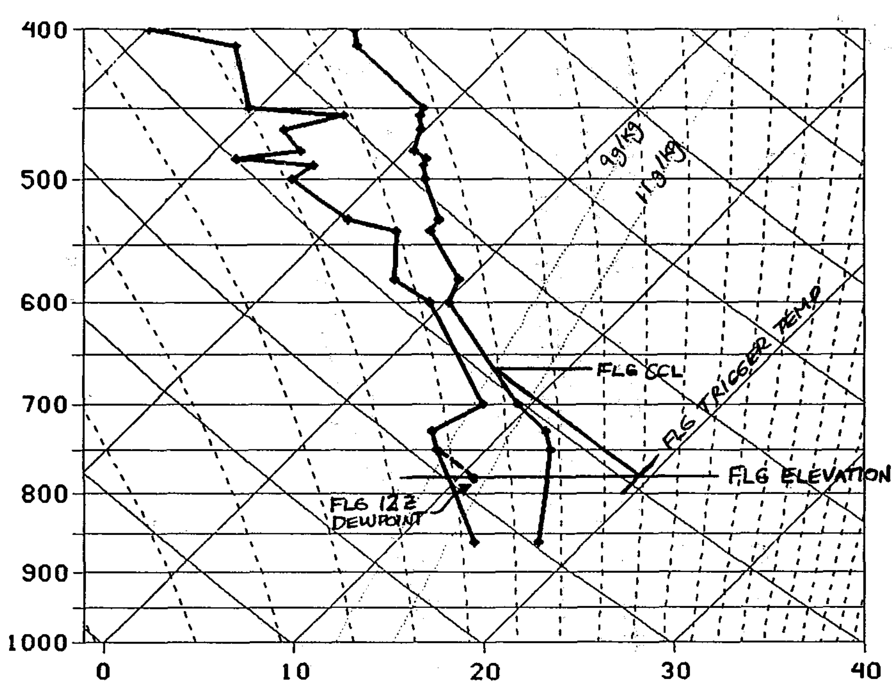

Figure 2

TUS 12Z

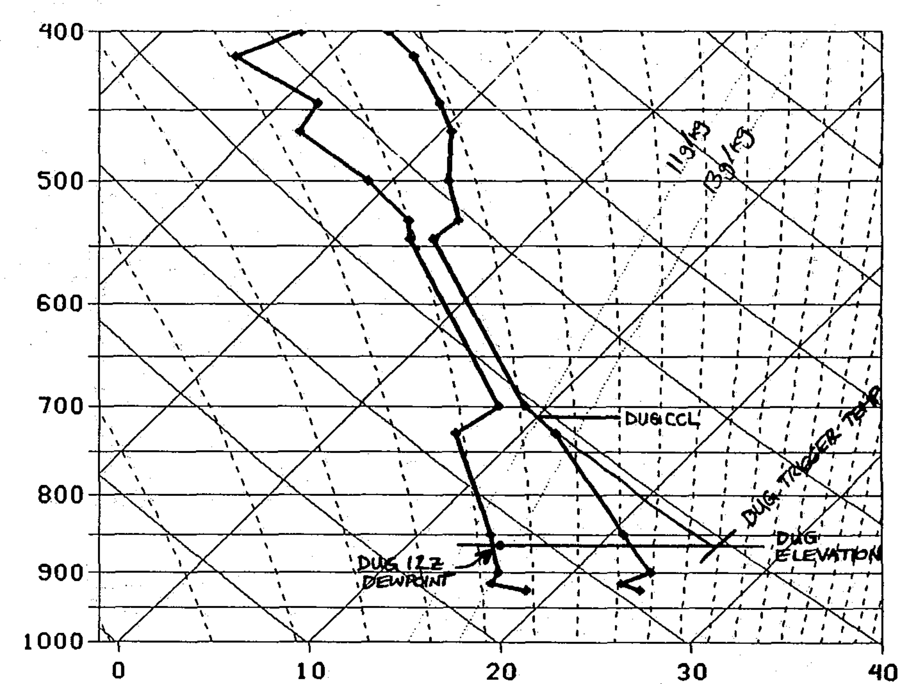

Figure 3