NOAA Agencies Partner with the Private Sector to Provide High Resolution Doppler Radar Data to San Francisco Bay Area Weather Forecast Office Based on Results from NOAA's Hydrometeorological Testbed (HMT) Pilot Study

In the early part of 2004, the Meteorologist in Charge of the San Francisco Bay Area Weather Forecast Office, Dave Reynolds, was contacted by the Chief Engineer, Mike Englehaupt, from the CBS television affiliate in San Francisco, call sign KPIX, to assist them in selecting a site for installation of a high-resolution, C-band Doppler radar for use by their on-air meteorologists. This would be the first TV station in the Bay Area to purchase and operate a radar. Input from the forecast office was that the North Bay, which includes the flood-prone Russian and Napa Rivers, had very poor radar coverage and had been a known area for very poor assessment of rainfall amounts (e.g., see Figure 1 from Reynolds, 1995). The reason for the poor NEXRAD radar coverage is that the KMUX radar, sited on 3500 ft. Mt. Umunhum in the Santa Cruz Mountains is too distant and too high to sample the low- level portions of the clouds over the North Bay (Figure 2). The KDAX radar located near Davis, Ca in the western sections of the Sacramento Valley, is blocked by the Vacaville Hills west of Davis (Figure 3). As Figure 3 shows, KPIX chose to site their radar at 2819 ft on what is called Mt. Vaca in western Solano County. This is the highest elevation in the County. Figure 4 shows a base map with the respective sites discussed above, color terrain information, along with county lines.

In requesting the permit for this site, both the MTR MIC and Dr. Marty Ralph of the Physical Sciences Division within NOAA's Earth Systems Research Laboratory (ESRL) wrote letters of support to the Solano County Board of Supervisors noting how valuable this data could be in critical life and property decisions by the NWS for the flood-prone North Bay. According to Mike Englehaupt, these letters were critical in KPIX's approval process. It was easy for Reynolds and Ralph to support this gap filling radar based on experience gained from a two-year field program in the Russian River Basin (the HMT Pilot study) that showed how radar positioned in the area would allow monitoring of shallow but potentially heavy rain producing clouds (Figure 5). In addition, a 2005 National Research Council report entitled "Flash Flood Forecasting over Complex Terrain," to which Dr. Ralph contributed, recommended that "the NWS should consider augmenting the NEXRAD network with additional short-range radars to improve observation of low-level meteorological phenomena." The challenge of using NEXRAD to detect heavy rain that can fall from shallow clouds in the region was also documented systematically using vertically pointing radar (Figure 6; White et al. 2003). The Hydrometeorological Testbed or HMT (hmt.noaa.gov) grew from an intensive field project called PACJET and from recommendations from the U.S. Weather Research Program (Ralph et al. 2005). HMT is a NOAA-led National effort with Regional Implementations lasting roughly 4 years, which is now running in the American River Basin of the Central Sierra. HMT is supported by the NOAA ESRL, the National Severe Storms Laboratory (NSSL), the NWS Office of Hydrologic Development, the California Nevada River Forecast Center, and the Monterey, Sacramento, and Reno forecast offices.

A key objective of HMT is to provide objective, science-based recommendations for implementing improvements to observational and other tools that will improve predictions, as shown in Fig. 7 (from Dabbert et al. 2005). These developments surrounding the KPIX radar constitute what can be considered the first research to operations success story for a major observational facility from the HMT, a fitting outcome from the HMT Pilot Study.

The KPIX radar was installed and became operational in the Fall of 2005. In February of 2006, NWS Monterey and KPIX began to discuss how the NWS could access the digital data directly from the radar, as is done with the NEXRAD data. To help facilitate this issue, Kevin Kelleher, Deputy Director of NSSL, was brought into the discussions. NSSL has had extensive experience in working on such projects as utilizing the FAA Terminal Doppler Weather Radar (TDWR) data and Canadian weather radar data, as well as doing the pioneering research in Project CRAFT (Collaborative Radar Acquisition Field Test) leading to the NWS's real time collection and distribution of the NEXRAD Level II data across the country. The main issue was accessing the data from the radar without interfering with the KPIX operational data feed. After a great deal of research by NSSL, under the leadership of Kelleher and NSSL Group Leader Kurt Hondl, and through the tremendous cooperation of Mike Englehaupt of KPIX, on Feb. 22, 2007 the first real-time digital image from the KPIX radar was captured at the NSSL facilities in Norman, OK(Figure 8).

Not only is this a major milestone for the Monterey forecast office, but the manner in which NSSL engineered the data collection and data transfer can work for any private-sector radar using the SIGMET RVP8 system. There are many places in the country where private sector radars fill critical gaps in the existing NEXRAD coverage. Using the methodology developed on this project and with the cooperation of TV or other commercial ventures that operate these types of radars, the coverage of critical radar data, especially for quantitative precipitation estimation. This comes at a much reduced cost compared to NWS procuring, operating, and maintaining additional radar systems.

References

Dabberdt, W. F., T. W Schlatter. F. H. Carr, E. W. J. Friday, D. Jorgensen, S. Koch, M. Pirone, F. M. Ralph, J. Sun, P. Welsh, J. W. Wilson, and X. Zou, 2005: Multifunctional Mesoscale Observing Networks. *Bull. Amer. Meteor. Soc.*, **86**, 961-982.

National Research Council, 2005: Flash Flood Forecasting over Complex Terrain/, The National Academy of Science, Washington D.C., National Academies Press, 191 pp.

Ralph, F. M., R. M. Rauber, B. F. Jewett, D. E. Kingsmill, P. Pisano, P. Pugner, R. M. Rassmussen, D. W. Reynolds, T. W. Schlatter, R. E. Stewart and J. S. Waldstreicher, 2005: Improving short-term (0-48 hour) Cool-season quantitative precipitation forecasting: Recommendations from a USWRP Workshop. *Bull. Amer. Meteor. Soc.*, **86**, 1619-1632.

Reynolds, D.W., 1995: Warm rain process and WSR-88D. Western Region Tech. Attachment 95/08, 7pp. [Available from NWS Western Region Headquarters, Federal Building, Salt Lake City, UT 84138.].

White, A. B., P. J. Neiman, F. M. Ralph, D. E. Kingsmill, and P. O. G. Persson, 2003: Coastal orographic rainfall processes observed by radar during the California Land-Falling Jets experiment. *J. Hydrometeor.* **4**, pp. 264-282.

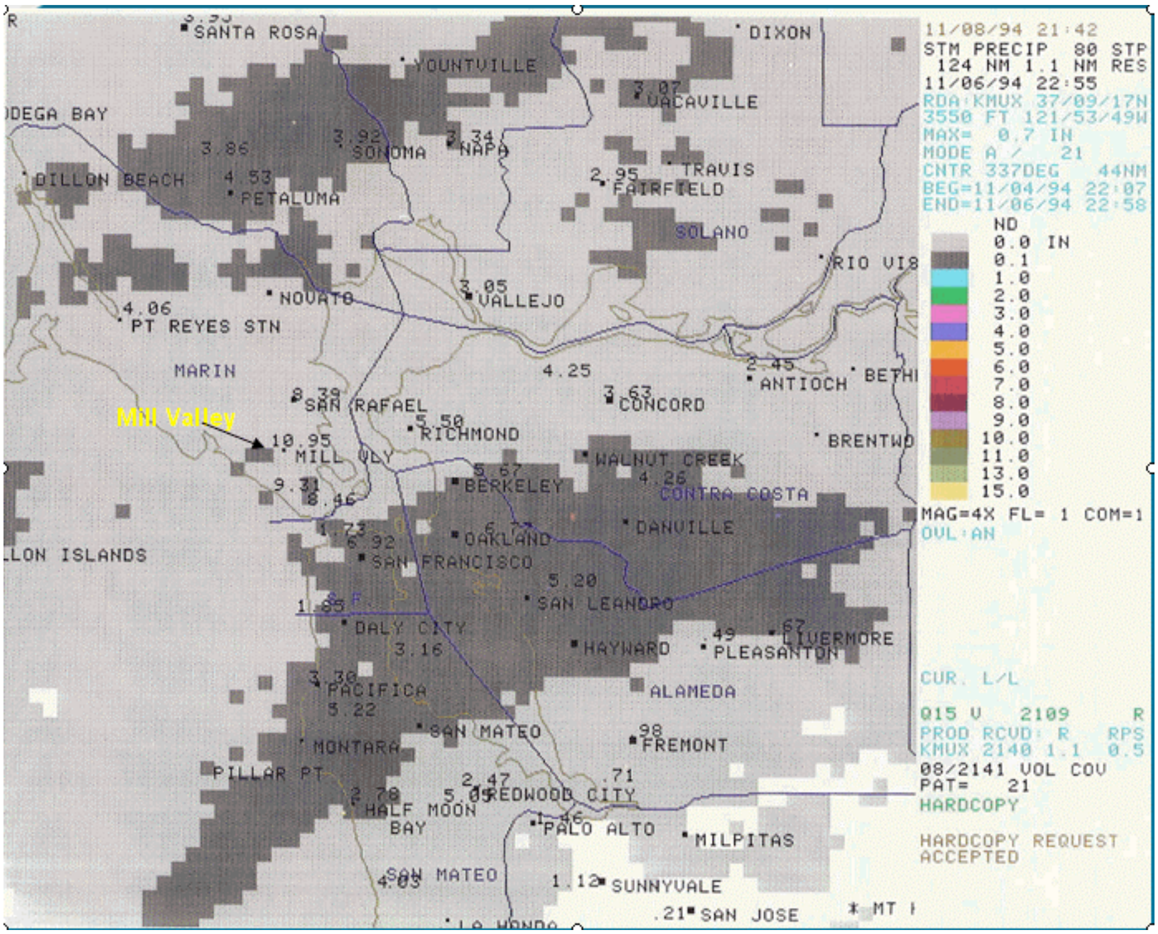

Figure 1 Observed versus estimated 48-hr rainfall for November 4-6, 1994. Note that Mill Valley, near the slopes of Mt. Tamalpias, observed nearly 11 inches of rain while the NEXRAD estimated only .10 inches. Cloud tops during this storm were only 10 to 13 k ft. County outlines are shown as per Figure 4.

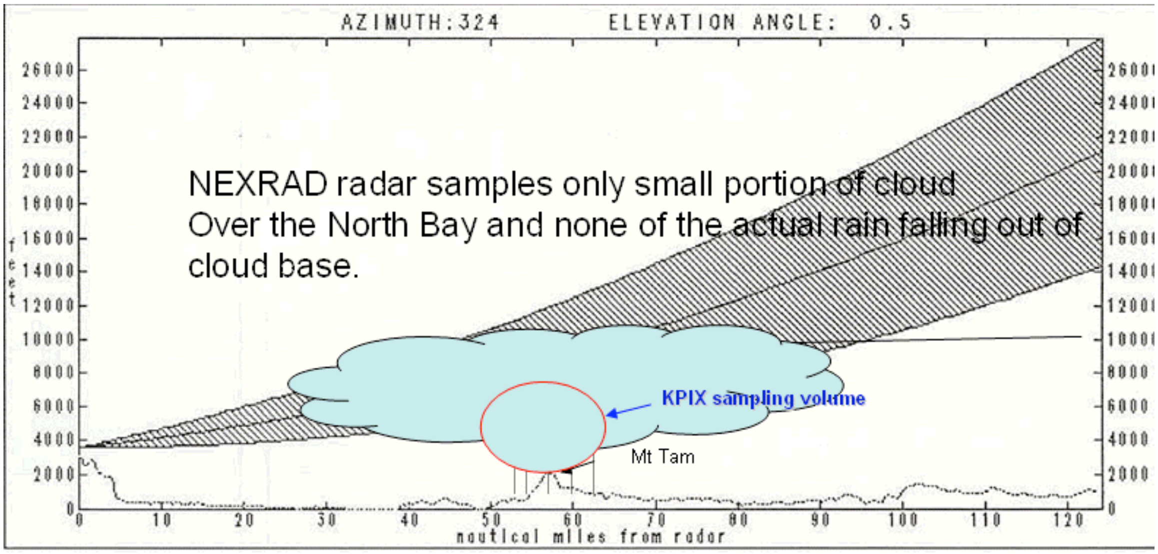

Figure 2 Schematic showing sampling volumes from KMUX and KPIX for a shallow precipitating cloud over the North Bay.

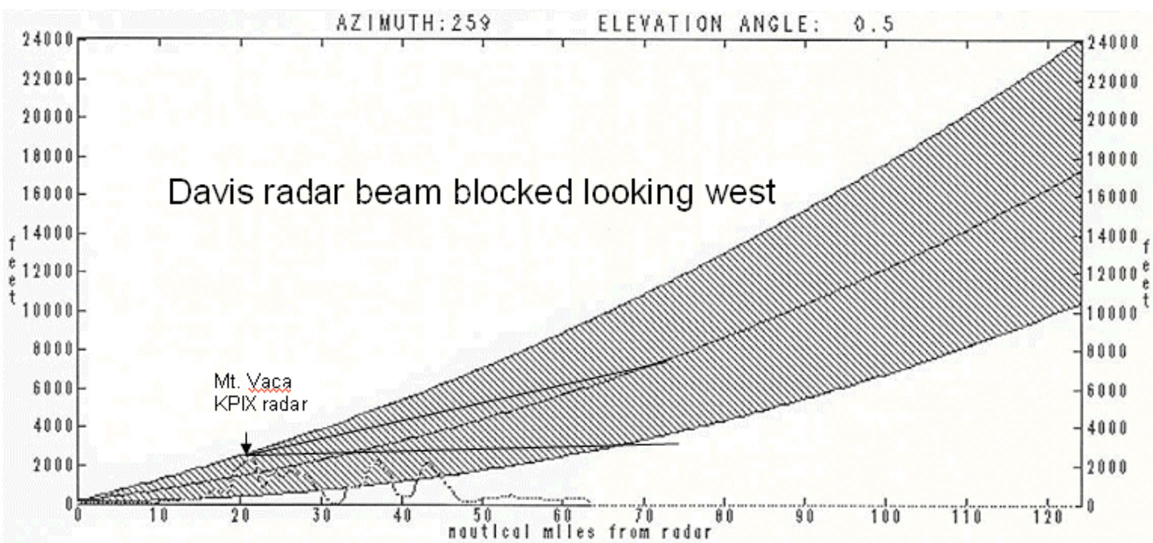

Figure 3 Note that the KDAX beam is completely blocked at the low levels by the same terrain where KPIX installed there radar.

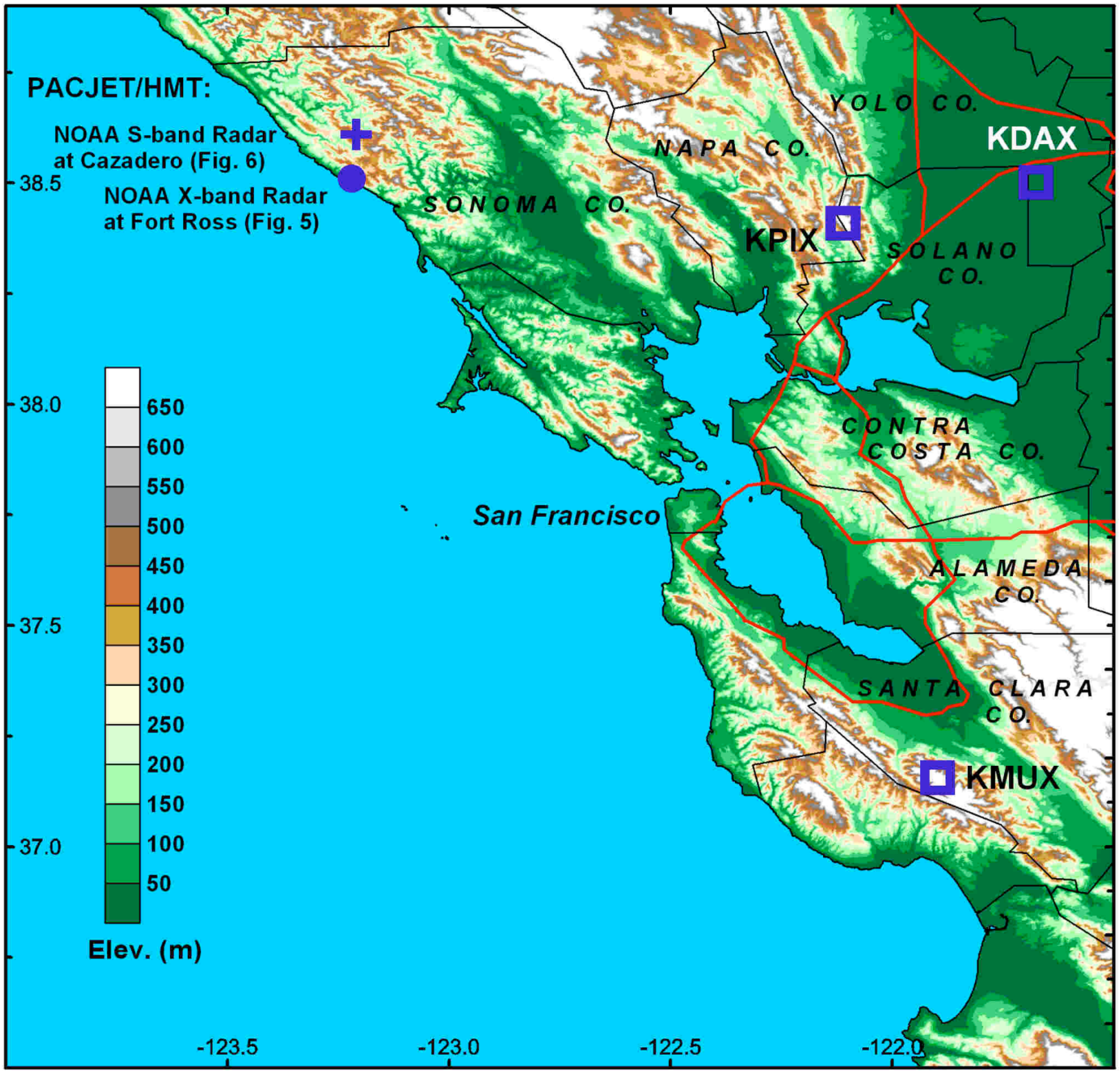

Figure 4 Greater San Francisco Bay Area terrain map with NEXRAD, KPIX, and NOAA PACJET/HMT locations annotated. Also shown are county outlines as appear in several of the accompanying figures.

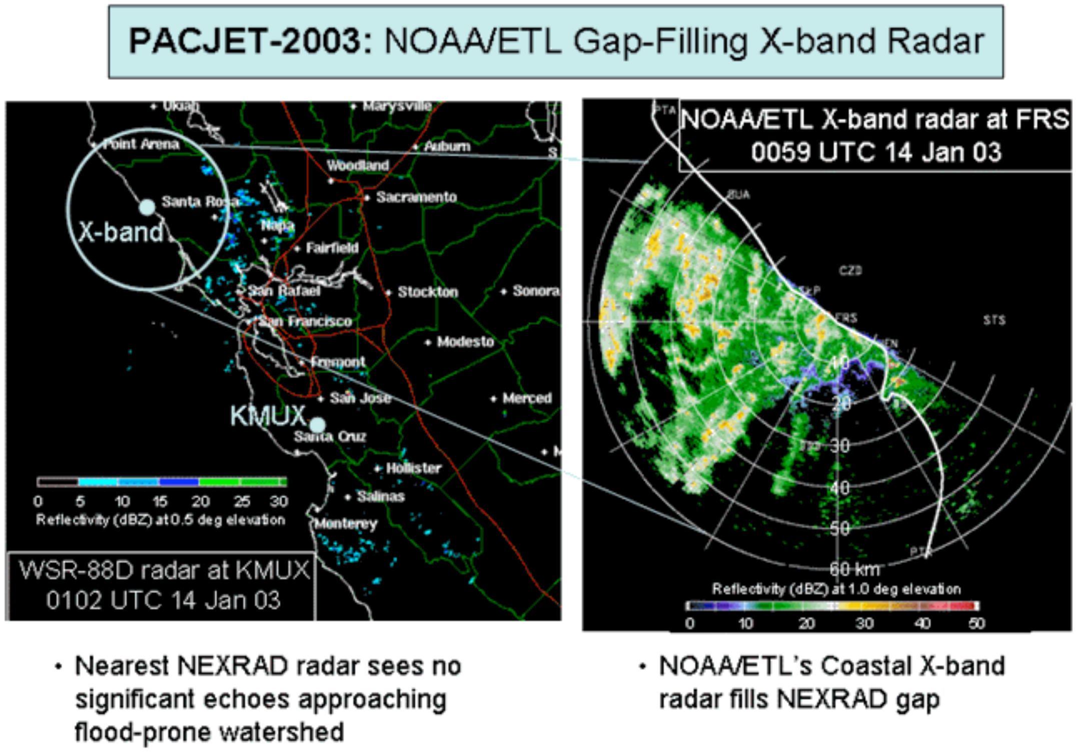

Figure 5 X band radar installed during the 2003 PACJET/HMT field exercise showing shallow but moderate rainfall approaching the Russian River drainage while the KMUX NEXRAD sees none of these echoes.

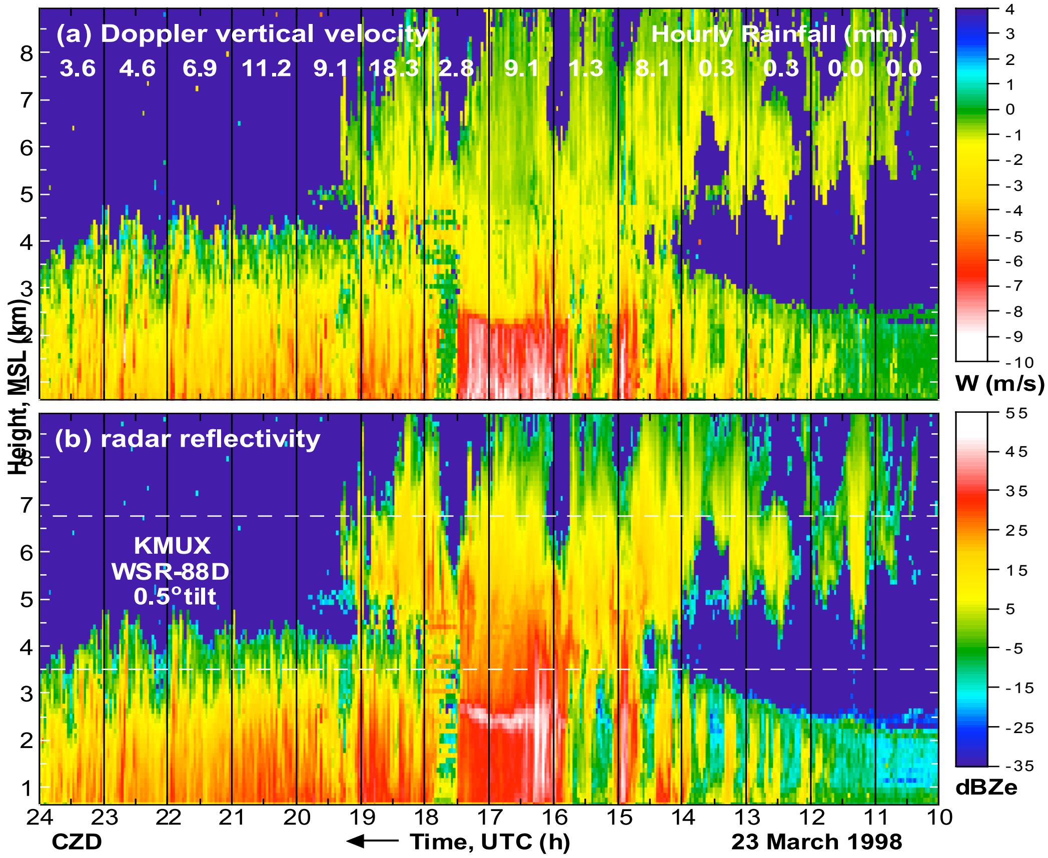

Figure 6 (from White et al. 2003). Observations from a vertically-pointing, S-band radar (same frequency as NEXRAD), combined with hourly rainfall data (top) and the position of the lowest-elevation angle radar beam from NEXRAD (bottom). This highlights how important periods of rainfall occur below the lowest altitude coverage from NEXRAD. It also shows how echoes aloft (and detected by NEXRAD) are not producing rainfall at the surface (i.e., virga).

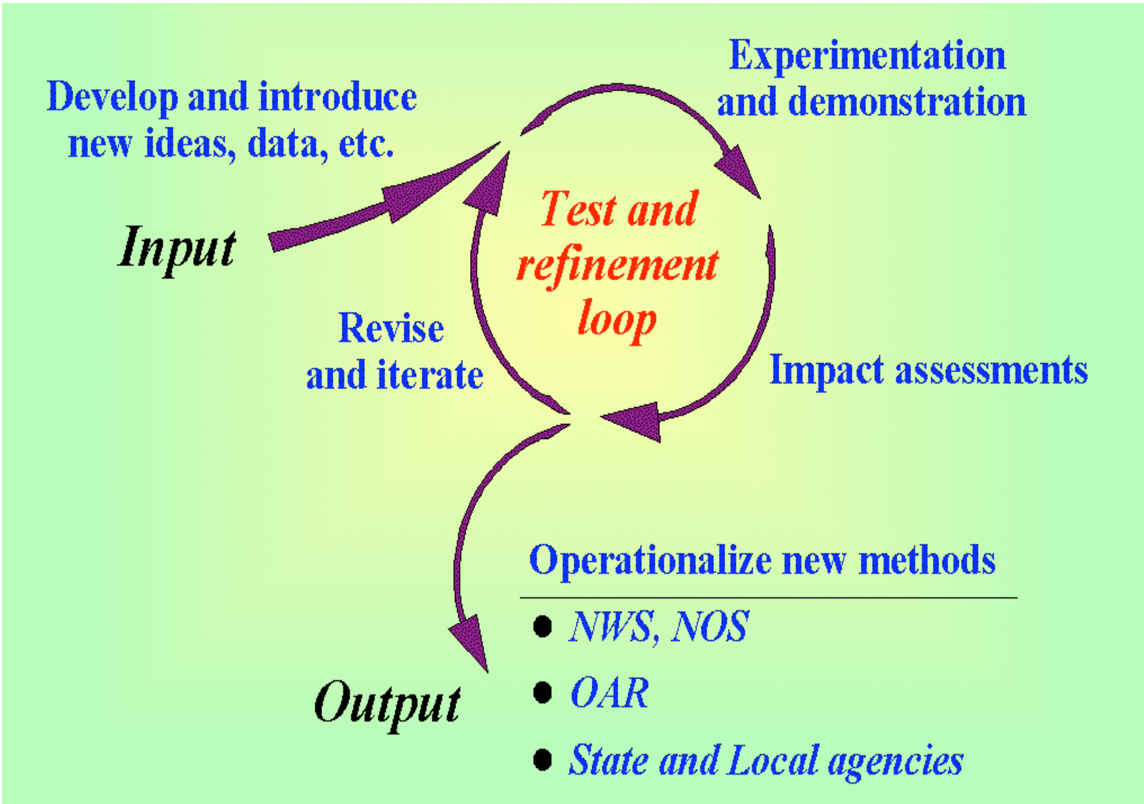

Figure 7. The testbed as a process. Ideas for improved products and services are demonstrated in a nearly operational setting. If the experimental products or tools stand up to rigorous tests of usefulness, accuracy, reliability, computational efficiency, cost effectiveness and repeated close scrutiny by users, they can make the transition to operations. Otherwise, user feedback leads to modifications of the products and another round of testing, or to elimination of the candidate tool or method.
(from: Dabbert et al. 2005, and
http://www.etl.noaa.gov/programs/2001/pacjet/pacjet_2001_update.pdf)

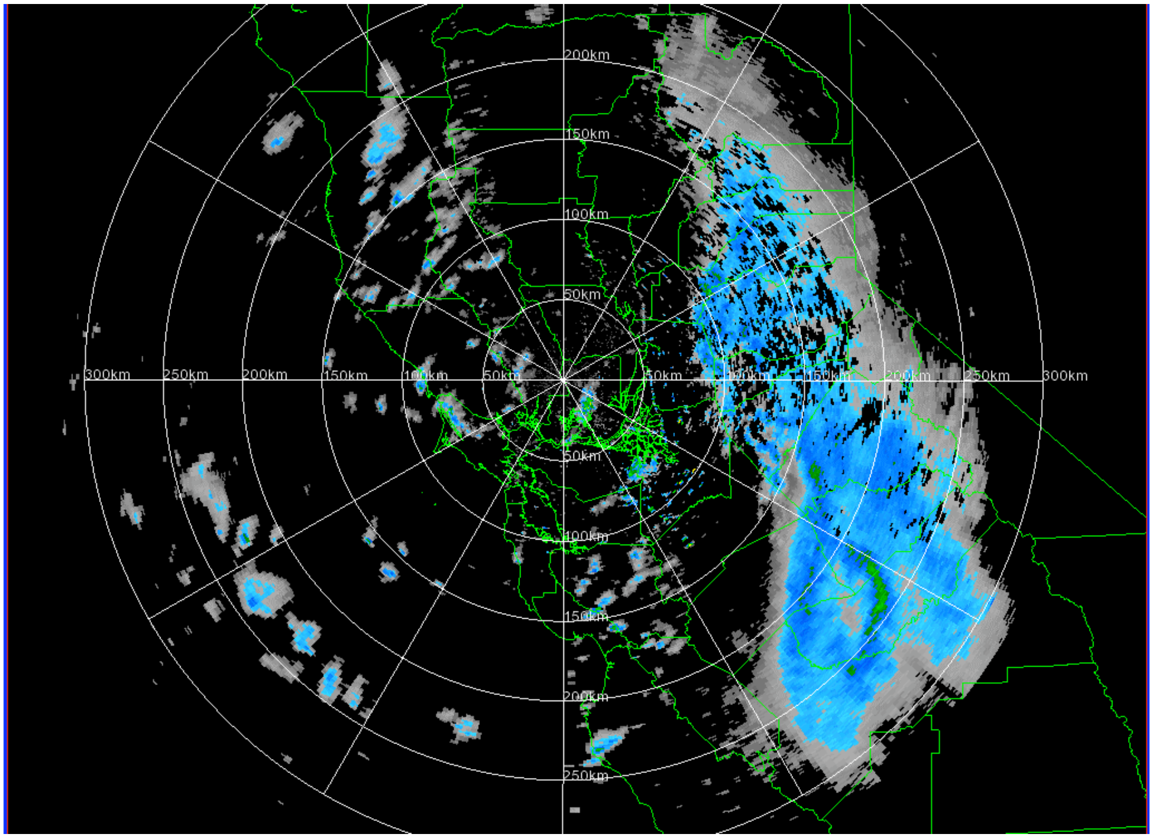

Figure 8. First 0-degree elevation reflectivity data from the KPIX radar on Feb. 22, 2007. It should be noted that the NEXRAD radars are restricted from scanning below 0.5 degrees elevation. KPIX radar can scan as low as -0.5 degrees which will be a great advantage in sampling the shallow orographic clouds noted in figures 4 and 5.