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VLB ARRAY MEMO No. 322

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NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

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MEMO TO: VLBA Site Group

FROM: K. I. Kellermann

SUBJECT: Hawaii Antenna

On February 7, 9, and 10, I attended the Mauna Kea Users' Committee meeting and together with Buck Peery made a preliminary inspection of sites on Mauna Kea and Haleakula.

Mauna Kea Users' Committee. Four major facilities are now in operation near the summit of Mauna Kea: UH88", CFHT, IRTF, and UKIRT. Two millimeter telescopes are being constructed by Caltech and UK/NL near the old NRAO 25m site. The California 10m Telescope (TMT), the N^2T^2, a Japanese ~4m, and the VLBA antenna are other prospective occupants of the mountain.

The UK/NL group report wind velocities near their site to be about 1/2 of that at the summit, although no quantitative data are available as they have no one to reduce their wind data. They are willing to make their data available to us when they are able to analyze them.

The N^2T^2 group is trying to compare seeing on Mauna Kea with that on Mt. Graham. They have not yet installed their "Seeing" instruments on MK because of concern over icing of the support towers.

The University of Hawaii plans to pave the road to the summit and to run a power line to the summit from the Saddle Road. This has now been approved by the state legislature. They were somewhat vague about the cost; 75K is in this year's budget for road planning, 600K is requested for the road design for next year. An overhead power line from the Saddle Road to the Midlevel facility is estimated to cost 1 million, and the underground line from the Midlevel facility to the summit about 4.5 million. From these numbers, I deduce an overall cost of the road and power well in excess of 10 million dollars which would be borne by the various users on the mountain. This is in addition to operating costs of actual power consumption, road and site maintenance, contributions to the support of a visitors center, etc.

Mauna Kea. The night before our visit to Mauna Kea it snowed at levels above about 11,000 ft. We found one unused tower lying on the ground near the summit which had about a 1-inch ice buildup on the downwind side. The domes had only a very thin cover of ice crystals covering less than 90° on the upwind side. The wind at the summit at the time of our visit appeared to be about 30 mph, but only about half this in the millimeter telescope area, in agreement with the UK/NL observations. However, we noted that the anemometer on top of the UK tower (~100') indicated a substantially higher wind velocity than one mounted about halfway up.

We also visited the Midlevel facility at Hale Pohaku. Considerable construction has taken place here in the last few years. The site now contains a 52-room dormitory, plus spacious dining, social, and recreational areas as well as laboratory, computer and library rooms. In addition, there are generator and other maintenance buildings. Although the total extent of current buildings greatly exceeds any potential VLBA construction, all present facilities have been designed to blend in with the local terrain and it may be difficult to do this with a 25m antenna. Nevertheless, I had the impression that the major impediment to locating our antenna in this area is simply the fact that it is not included in the Mauna Kea Master Plan, and it would be necessary to seek an amendment just after the Master Plan has been finally agreed to by all after years of discussion. The locals are said to be more favorably inclined toward astronomy than in previous years, and the University of Hawaii is prepared to aid and support our efforts if we wish to construct at the Midlevel facility. They are also prepared to put the VLBA antenna at the old 25m site, and since this is included in the Master Plan, no particular organizational problems exist, except that it would preclude the use of this site for a future mm or sub-mm telescope. In either case, however, we would need to justify our need for the site to the University before they would take our case to the state legislature. For our purposes, a site between Hale Pohaku and the summit would be ideal, but it is claimed that it would be even more difficult to obtain permission to construct there.

We located a potential site a few hundred meters east of the Midlevel complex at Hale Pohaku. From this point, a clear horizon exists above 5° for all azimuths between 30° and 220°, and above 10° for azimuths between 20° and 330°. Between roughly 300° and 15° to the north there is a ridge of elevation about 19° that provides some shielding from the north-east trade winds, but also blocks the northern horizon.

Haleakula. Haleakula is reached by a good hard surface road from Kalahui, which has very frequent plane service to the other islands, as well as several flights a day to the mainland. Driving time from Kalahui airport to the summit of Haleakula is only about 1½ hours. Haleakula is a "dormant" volcano. The crater near the summit is a National Park which is a major tourist attraction, and which probably accounts for the well maintained road. The summit area contains three separate transmitting separate forests, each of which appeared to have about 10 antennas of various types. ARPA has extensive facilities at the summit, which include a number of satellite laser tracking facilities. A solar telescope operated by UH is the only astronomical facility in the area.

UH people we talked to indicated a willingness to provide technical support for a VLBA antenna. They had no detailed meteorological records but indicated that wind velocities were in excess of 100 mph "several" times per year. 110 to 120 mph winds are "not unknown" and the anemometer broke once during the past 10 years when it went off scale at 130 mph.

They also reported that about 30 percent of solar observing time is lost to clouds. Since it generally clears off at night, I would estimate that clouds are present at the summit perhaps 15 to 20 percent of the time. Tourist literature describes how clouds commonly build up in the volcano crater, just below the summit.

Summary. In my opinion neither the Summit of Mauna Kea or Haleakula are satisfactory locations for a VLBA site. Construction costs at Mauna Kea might be 2½ million dollars greater than at a lower elevation site (more if a radome is needed), and probably more time would be lost due to wind (which when sufficiently high affects all wavelengths) than would be lost to clouds at Hale Pohaku. It should be noted that for a significant part of the time that the cloud layer is above Hale Pohaku, it also reaches the summit, so little observing time is lost by going to the lower elevation.

Cloud cover at Haleakula appears to be comparable to that at Hale Pohaku; but the high winds and unfavorable rf environment appear to make it a much inferior site.

In addition to Hale Pohaku, we should consider a lower elevation site near Waimea or the Kona (west) coast. The coastal region west of Waimea has only 10 inches of rain per year (mostly in winter). Near Waimea (elev. 3000') the rainfall is still only 15 inches per year. Higher elevations sites (up to 6500 ft) may be found on the south-western slopes of MK which are perhaps drier, but may be blocked to the south-east by the mountains and have greater rainfall.

The problem of locating the Hawaii element has led me to reconsider the general emphasis we have put on high elevation sites vs the traditional radio astronomy considerations of cloud cover, wind, and protection from rf interference. Mountain tops have the extreme range of conditions: at times very clear skies and very low water vapor, but at other times clouds and high winds. Optical, IR, mm, and submillimeter observatories pay the penalty of lost time due to winds and clouds in return for the periods of excellent seeing or extremely low water vapor content necessary for the best observations. VLBA requirements differ in several important respects. First, operation will be at wavelengths where extremely good atmospheric conditions may not be significantly better than moderately good conditions, but where high wind, rain, or heavy cloud cover will cause significant degradation. Second, it has not been demonstrated that pathlength fluctuations above a dry mountaintop, are necessarily less than above a somewhat wetter atmosphere above a lower flatter area. Finally, we require good conditions at ten widely separated sites, so ten moderately good sites may be preferable to ten sites which have extremes of both very good and very poor conditions. Consider the extreme case of ten sites each with half the time perfect and half the time unacceptable. Then assuming no correlation the full array is operating only 8 hours per year, and typically only 5 elements are operating.

The above arguments would argue for a Fort Davis site rather than the McDonald Observatory and possibly a site closer to Tucson, rather than the Kitt Peak Observatory.

In situ, water vapor measurements of the type done in Puerto Rico will be necessary both in Hawaii and at several continental sites to verify that water vapor fluctuations at potential clear sky sites are acceptable. In the absence of (or even with) our own measurements, clear sky statistics may be our best indicator of atmospheric quality.