VLB ARRAY MEMO No. 529

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Required Instruments for the VLBA Weather Stations

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Each VLBA station must have a weather station to monitor surface conditions. The requirements are as follows.

Windspeed monitor. May be used for approximate pointing corrections for windy conditions. For this reason it should have an accuracy of better than 10% and be mounted at a sufficient height and at a location suitable that it sample the wind blowing on the antenna reflector. The height should be at least 7m and it should be located at least 25 meters from the antenna or building, oposite the least occupied portion of the local wind rose.

Wind direction indicator. Five degree accuracy is sufficient.

Barometer. Required accuracy would appear to be set by the requirement that it give a reasonable estimate of dry air phase path to go with accurate water vapor phase paths derived from a water vapor radiometer or some similar device. An accuracy of 2mb would give a zenith phase path uncertainty of about 5mm, which seems sufficient and not out of line with uncertainties arising from, eg, fronts and geostrophic winds. This accuracy probably drives us to a strain-gauge type barometer rather than the diaphram-potentiometer type, at an additional cost of about $1000. If we forsake this type of sensor, we will still have adequate accuracy for pointing and rough phase path estimation, but the cost and effort of the better sensor would have to be counted as part of the upgrade to WVR or other path sensing equipment. A strain-gauge type barometer is probably more reliable as well, with no moving parts.

Thermometer. The only use for temperature seems to be in the calculation of surface refractivity for pointing. This does not seem to place very stringent conditions on the measurement - give or take 2 C would suffice for this purpose. However, for general interest, I should think a 0.5 C accuracy would be more appropriate and not very costly.

Dewpoint instrument(s). The accuracy required for measurement of dewpoint seems to be set by pointing; estimation of phase path is, for any sensible instrument, set by lack of knowledge of the vertical distribution of the water vapor. The accuracy needed depends on how hot and wet you wish to point at low elevations. There will be degradation at elevations below 6 degrees due to the uncertainty of the zenith phase path - 10 cm phase path uncertainty corresponds to 3" uncertainty in the cubic term contribution to refraction at 6 degrees elevation. (If the above sentence makes no sense at all to you, and if you care, see the chapter on refraction in Smart's Spherical Astronomy). A first class dew-point sensor has an accuracy of about 0.2 C in the dewpoint. At the hot/wet end of things (say 35 C temperature and 70% humidity), this error would correspond to a pointing offset of 3" at 6 degrees elevation. The second class of water-vapor sensors have an accuracy of about 0.5 C, and the 3" error point moves up to 10 degrees elevation. My own inclination is to say this is adequate - anybody trying to observe any lower at 6 mm in such conditions should have their head examined, and at 1.3 cm it would point well enough down to where the uncertain cubic term takes over. Unfortunately, there are other problems with the second class sensors - lithium chloride cells have problems with the hot-dry case (they will not indicate under 11% RH), relative humidity indicators (which come in three types - resistive, capacitive, and hair) tend to have unstable calibration, psychrometers freeze in cold weather, and all are sensitive to contamination. These defects make any one of the second rank of indicators inadequate. If we choose to excercise this option we would have to have two devices; a relative humidity indicator (probably an aluminum hydroxide capacitor type) would function adequately in the winter, and would work in the summer if calibrated by a lithium chloride cell or psychrometer (or the latter could be used by itself). The sum of the prices of the two second rank instruments would be significantly less than the price of a first rank instrument (an optical dewpoint detector, which has no calibration problems and excellent stability). A relative humidity indicator and a psychrometer might cost about $2000, whereas an optical detector would run slightly above $4000. However, making this substitution might have deleterious effects on maintenance and reliability.

I see no particular need for a rain gauge. It probably doesn't matter a great deal whether it is raining or if it is merely very wet (although some sort of dampness sensor on the feed covers might be informative).