$\Delta\lambda$(SAm 69 − WGS 84) = $-2.04''$ near $\Phi = -23°$, $\lambda = -68°$. Offset of PSAm 56 and WGS 84 longitudinal (Φ) and latitudinal (λ) coordinates are estimated to be $\Delta\Phi$(PSAm 56 − WGS 84) = $-13.0''$ and $\Delta\lambda$(PSAm 56 − WGS 84) = $-6.3''$ near $\Phi = -23°$, $\lambda = -68°$ [1].

Transformation of latitude and longitude into Universal Transversal Mercator (UTM) Zone 19 northing and easting, respectively, can be done based on the parameters of the reference ellipsoids such as the semi-major axis (a) and the flattening factor ($1/f$). The WGS 84 ellipsoid has $a = 6378137$ m, $1/f = 298.257223563$, whereas the International 1924 ellipsoid has $a = 6378388$ m, $1/f = 297$ and the South American 1969 ellipsoid has $a = 6378160$ m, $1/f = 298.25$ [5]. More convenient way may be to use a freeware such as Geographic Magnetic Calculator [6] for coordinate conversion of fewer points.

2.3 Positional Errors

GPS errors are combination of noise, bias, and blunders. According to introductory documents [7, 8], noise errors are the combined effect of Pseudo Random Noise (PRN) code noise of ~ 1 m in the Coarse Acquisition (C/A) code, and the receiver noise of ~ 1 m. At this moment, sources of bias errors include satellite and receiver clock errors of ~ 1 m, ephemeris errors of ~ 1 m, tropospheric delays of ~ 1 m, unmodeled ionosphere delays of ~ 10 m, and signal multipath of ~ 0.5 m. These noise and bias errors combine, resulting in typical positioning errors of ~ 20 m achieved with GPS 12 receiver after 2000 May 2.

These errors can be reduced by using larger number of satellites. In the cabins of 4WD trucks, handheld GPS receivers with built-in antenna (e.g., GPS 12) typically receive signals from 3–4 satellites at satisfactory level. Their gains significantly go up with external antennas, and the receivers can use 8–9 satellite signals to have significantly better positional accuracies. Typical positioning accuracy achieved with the GPS 12XL receiver equipped with the external antenna approaches to ~ 10 m after 2000 May 2.

Before 2000 May 2 UT 4:00, there were dominant bias errors result from Selective Availability (SA). SA is an intentional degradation of the SPS signals which was introduced by the US Department of Defense to limit accuracy for non-US military and government users. The SA bias on each satellite signal is different, and so the resulting position solution is a function of the combined SA bias from each satellite used in the navigation solution. Because SA is a changing bias with low frequency terms in excess of a few hours, position solutions or individual satellite pseudo-ranges cannot be effectively averaged over periods shorter than a few hours. The potential accuracy of the C/A code was only ~ 100 m when SA was on.

3 Data

3.1 Loci of Roads and Pipelines

Listed in Table 1 are files of the loci of roads and pipelines available from the ALMA-J site testing web page (`http://www.nro.nao.ac.jp/~lmsa/siteWG/siteWG.html`). The GPS receiver name and status of SA are shown in the table to indicate the data quality. In the case of multiple epoch measurements, the technical specification of the worst data is shown. Note that the coordinates are sometimes incomplete and will be occasionally updated. File names are also subject to change. The loci of the roads and pipelines are also overlaid on selected maps in Figure 3 (Atacama region), Figure 4 (Cerro Chascón science preserve area), and Figure 5 (San Pedro de Atacama).

3.2 Positions of Landmarks