

Axial Seismic Network Fault Tolerance
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In this study I looked at the effect of “lost” seismic stations on capability to determine hypocenter with the remaining stations, using the USGS “hypoinverse” (aka “hyp2000”) software.

The attached figures show calculated hypocenters for a variety of actual hypocenter locations, both inside and outside of the caldera. For these Monte Carlo calculations, I assumed that clock synchronization jitter was within ± 10 milliseconds, which should be achievable using NTP. Small circles show computed hypocenter locations, color-coded by depth. The actual hypocenter is indicated by a diamond marked ‘A’. A single black circle on each map shows the “ERRH” (horizontal error) computed for a “representative” hypocenter on the map.

For each actual epicenter, I show four maps. The first map shows hypocenters using all five stations and p-arrivals only ($s\text{-wt}=0$), followed by a map showing hypocenters using p-arrivals and s-arrivals. The third map shows hypocenters using only three stations – Southeast, Hydrothermal, and Southwest stations, and using p-arrivals only. The fourth map shows hypocenters using three stations and s-arrivals as well as p-arrivals.

In these figures, “s-wt” is the s-arrival weighting factor, which determines the degree to which s-arrival times affect the hypocenter solution; $s\text{-wt}=0$ means that s-arrivals are not used at all, i.e. that hypocenter is based solely on p-arrivals. To account for s-arrivals, I somewhat arbitrarily chose $s\text{-wt}=1/2$ for all stations, but it is not clear to me if that is a “realistic” value. Perhaps someone with more experience with hypoinverse could comment on that.

We see from the figures that computed hypocenter accuracy is greatly improved when s-arrivals are included. Even with all five stations, significant location error can result when only p-arrivals are used, especially if the true epicenter is outside of the seismic array.

Moreover, it appears from these tests that very accurate hypocenters can be computed from only three stations, if s-arrivals are used for all of those stations. Thus it appears that the algorithm can tolerate loss of two stations – provided that reliable s-arrivals are available for the remaining three stations.

Finally, note from figure 6 that large location errors result when only two stations are used, whether or not s-arrivals are available. This finding contradicts my earlier assertion that reasonable results were possible with only two stations, but that assertion was based on faulty configuration of hypoinverse.

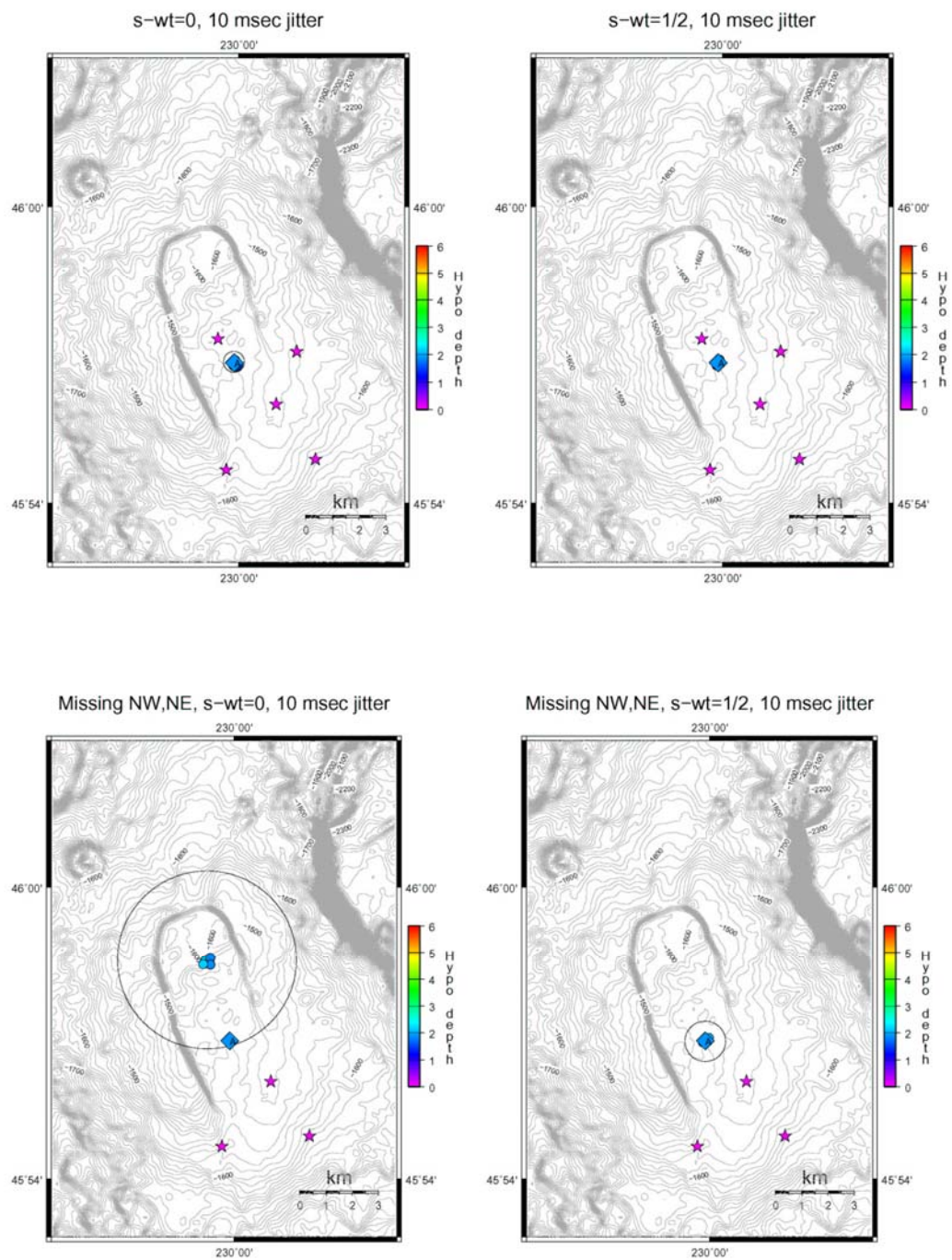


Figure 1: Central caldera event

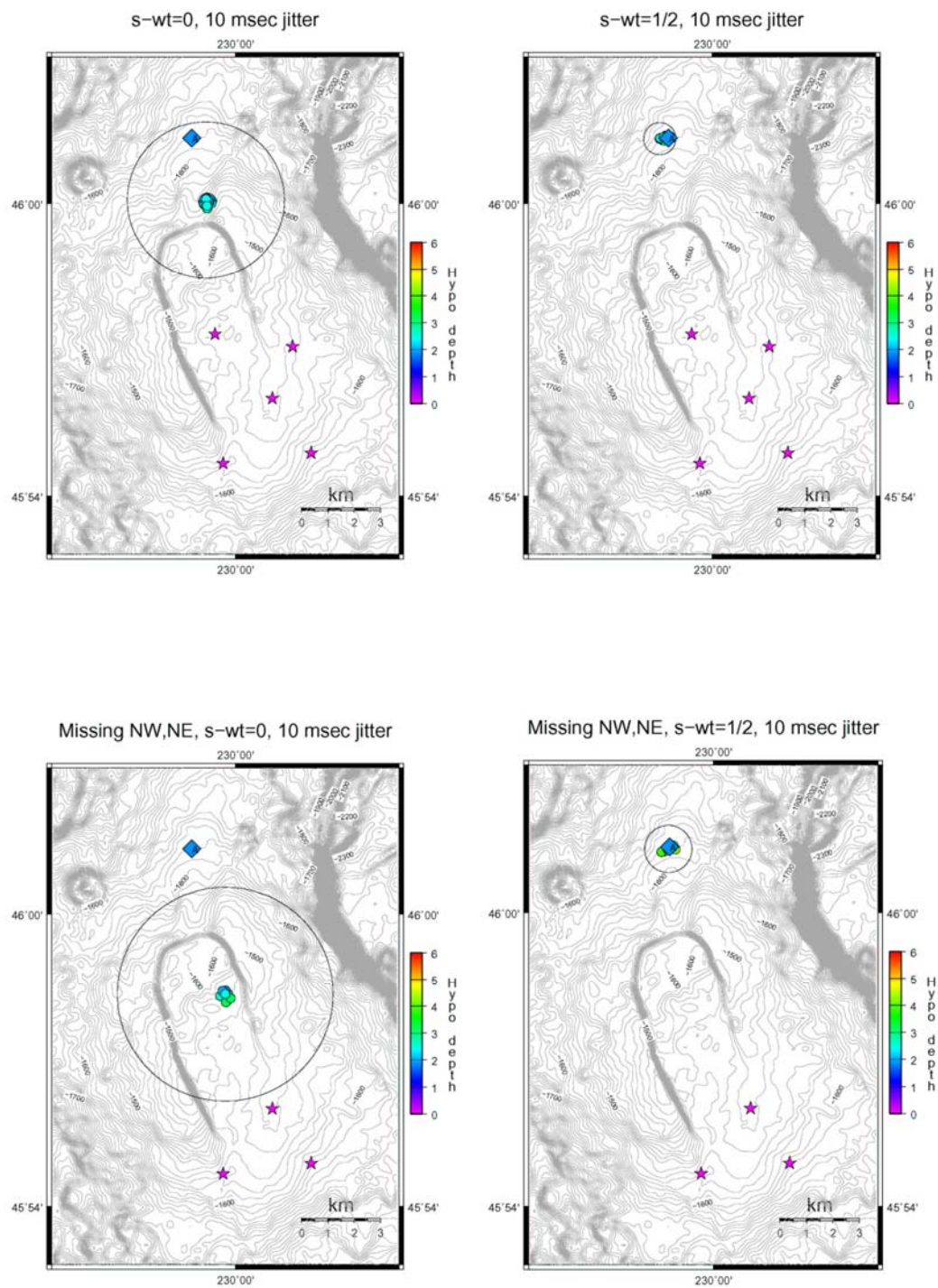


Figure 2: North rift event

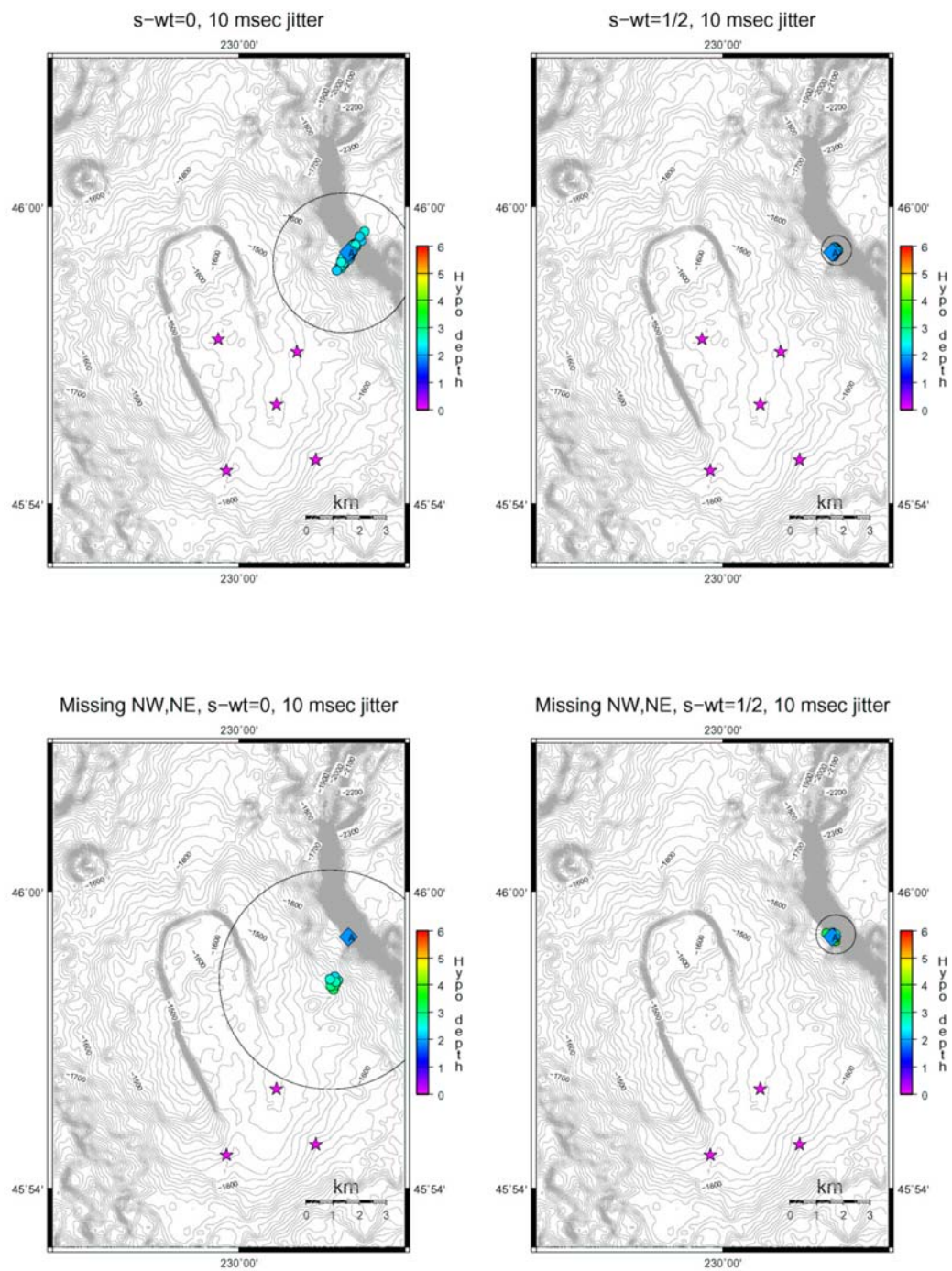


Figure 3: East flank event

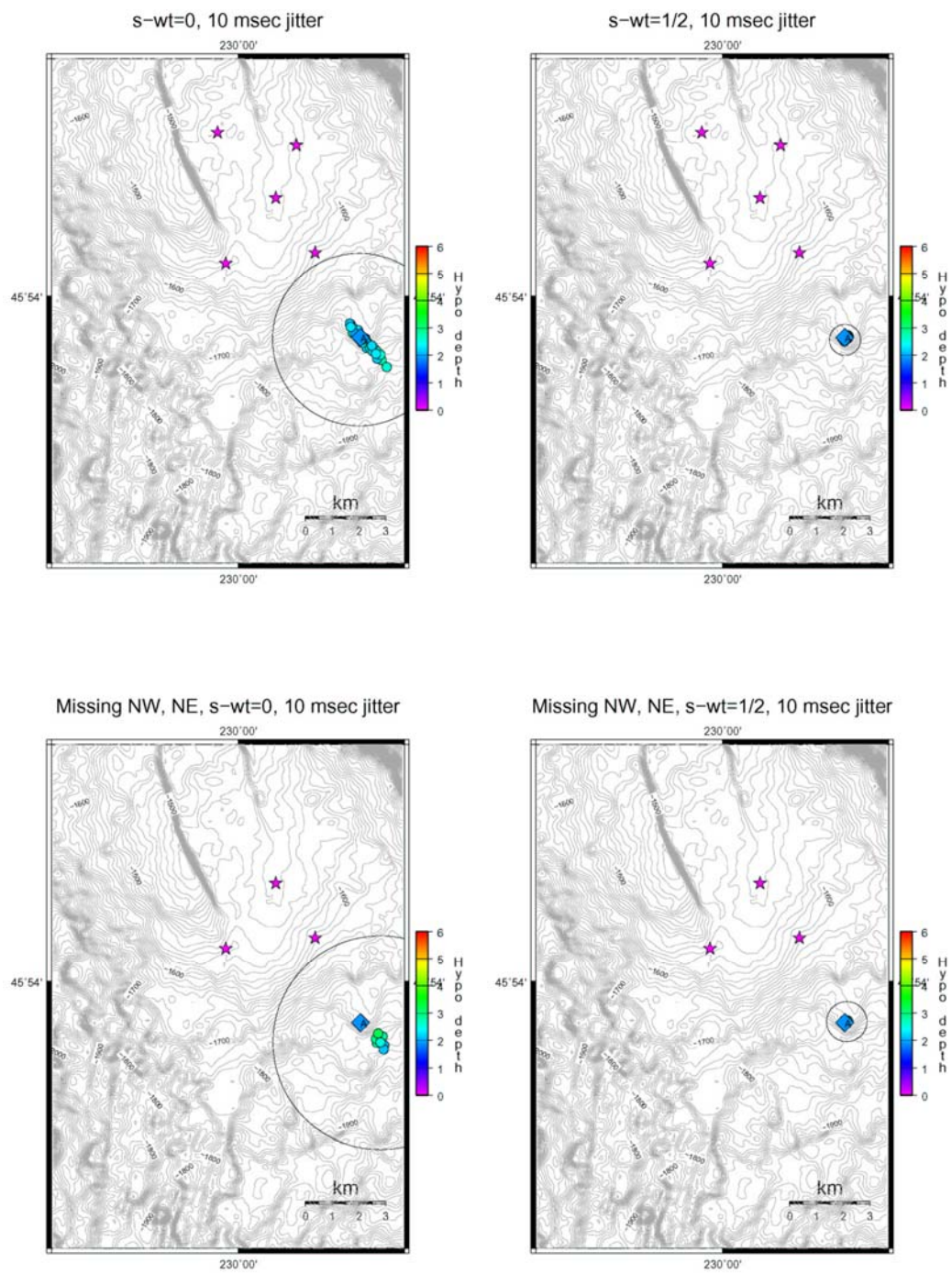


Figure 4: Magma chamber event

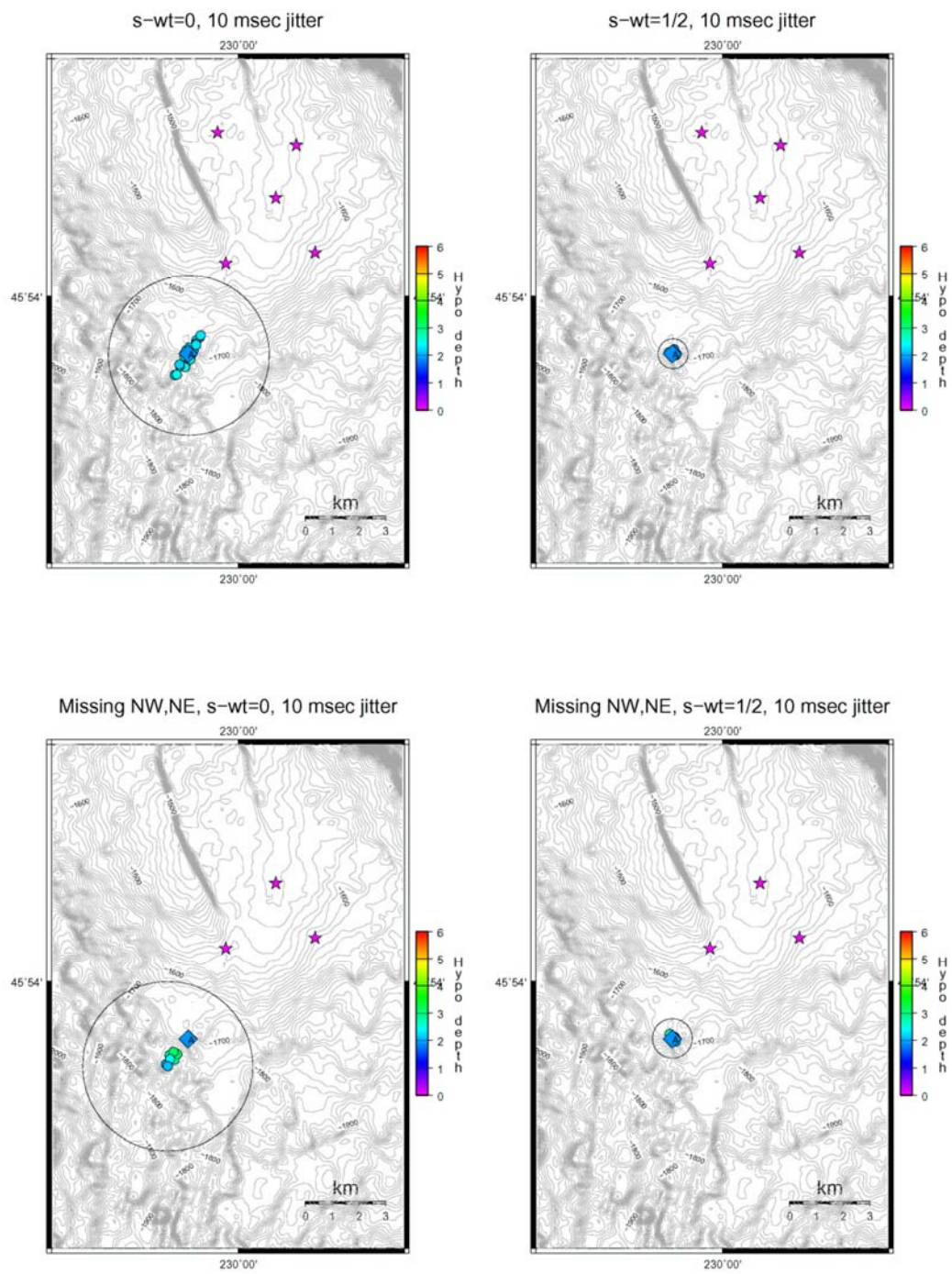


Figure 5: South rift event

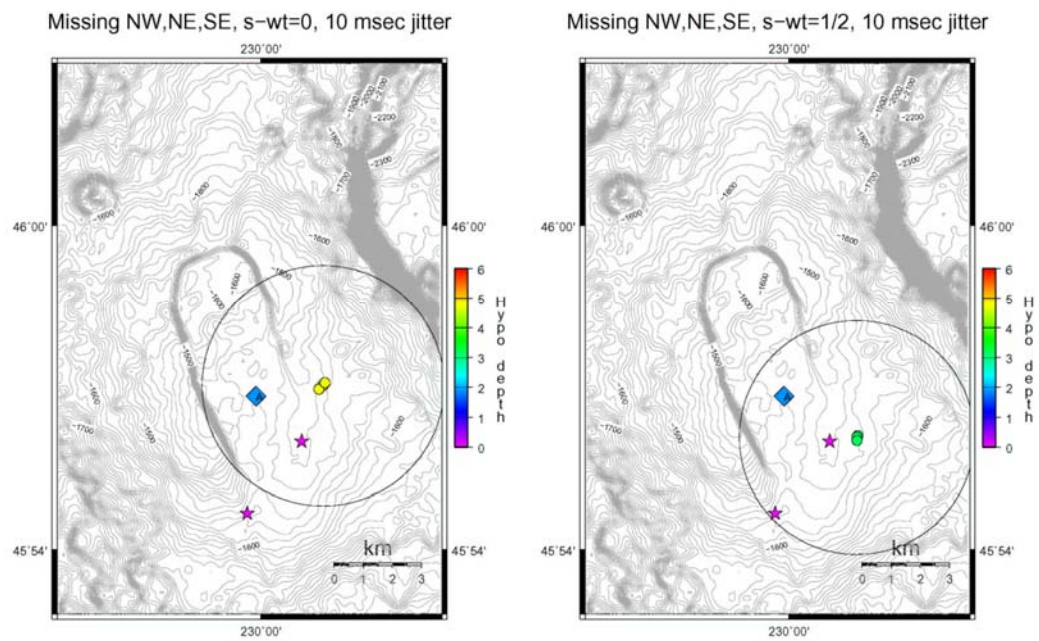


Figure 6: Central caldera event, missing three stations