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LINZ Technical Tour - Geodetic recovery from the Canterbury earthquakes

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This presentation covers key points of the live demonstration of geodetic tools carried out during the FIG Technical Tour of LINZ.

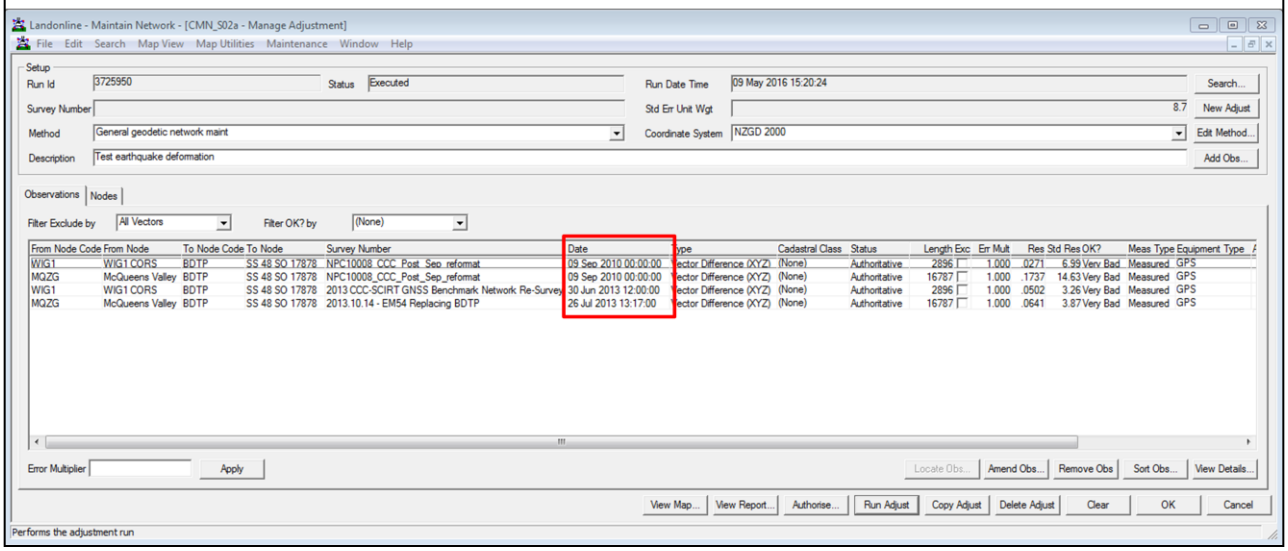
Introduction

- Two demonstrations: Landonline and PositioNZ-PP
- Show how geodetic coordinates can be generated after an earthquake by both surveyors and LINZ
- Show the deformation model in action

Two demonstrations are summarised in these slides. The first is a demonstration of the Landonline adjustment software, in particular how the deformation model is used to combined observations made at different times within an earthquake sequence. The second is a demonstration of the PositioNZ-PP service, an online GNSS processing service provided by LINZ. In particular, the demonstration shows how it can be used after an earthquake to calculate post-earthquake coordinates.

The first demonstration uses the Landonline system.

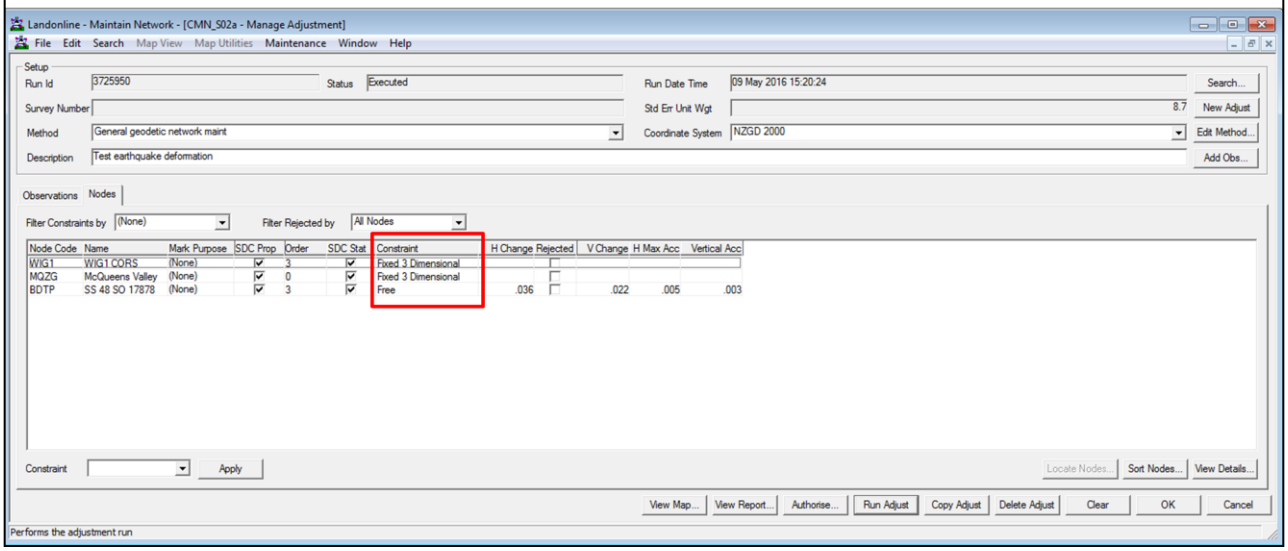
Landonline Adjustment Observations Grid



Landonline is the system that manages New Zealand's titles, cadastral and geodetic data. One of the modules within Landonline available to LINZ internal users, "Maintain Network", uses the least squares technique to calculate coordinates for survey marks (nodes). In this series of slides, we show how Landonline is able to combine observations that have been affected by different earthquakes to calculate a consistent set of coordinates. The "Manage Adjustment" function within the "Maintain Network" module has an "Observations" and a "Nodes" tab. We start with the Observations tab.

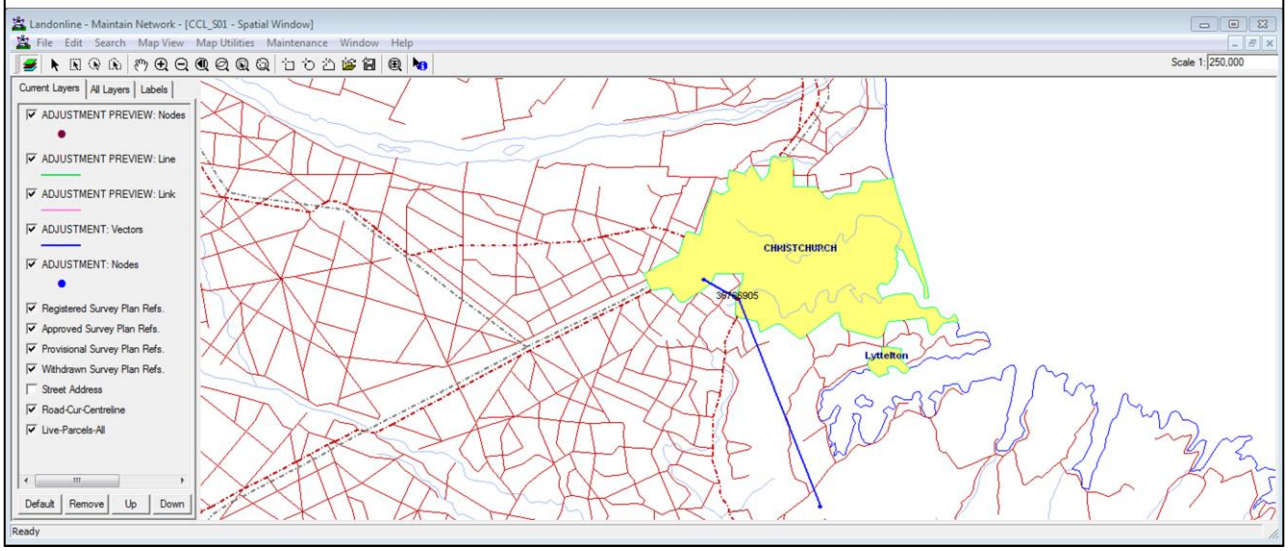
A very simple least squares adjustment has been set up, consisting of 4 GNSS vectors (dX,dY,dZ) and three marks. Two of the marks are Continuously Operating Reference Stations (CORS), the third is a passive control mark we are coordinating. This is real data collected by geodetic surveyors working under contract to LINZ and/or the Christchurch City Council. Take particular note of the date column (red box). Christchurch has been impacted by 5 significant earthquakes on the following dates: 4 September 2010, 22 February 2011, 13 June 2011, 23 December 2011 and 14 February 2016. So we have two vectors observed after the first earthquake and another two observed after the fourth earthquake. The survey mark would have been in a different position in 2013 than it was in 2010, so we might expect problems when combining these observations.

Landonline Adjustment Nodes Grid



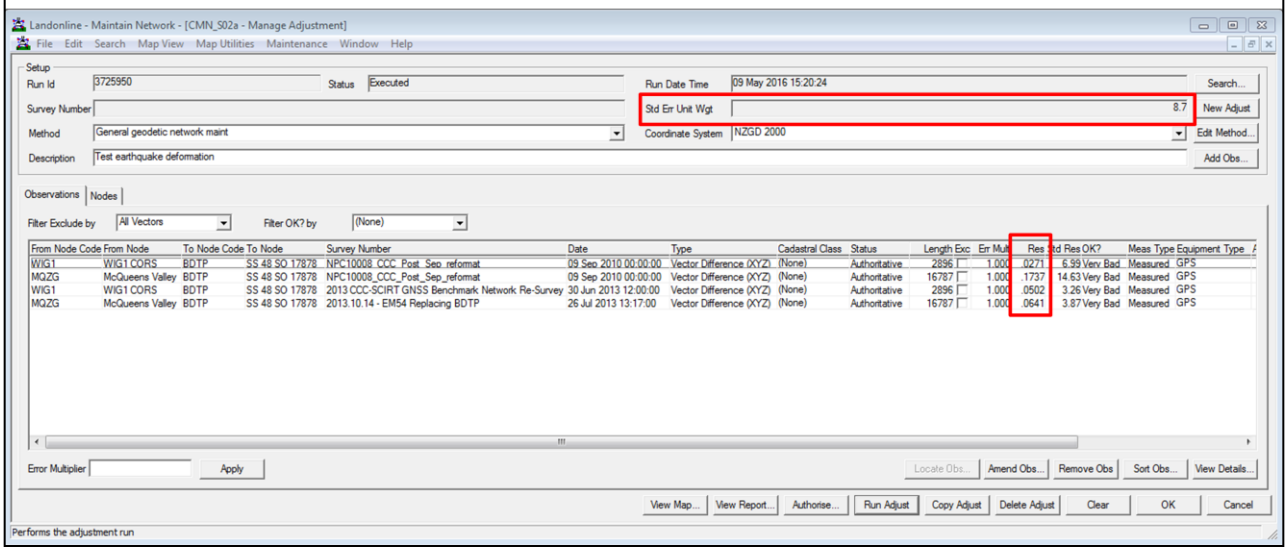
Moving to the Nodes tab, we see the three marks. There are two CORS (WIG1 and MQZG) and the mark we are coordinating (BDTP). We hold the two CORS fixed.

Landonline Adjustment Spatial Window



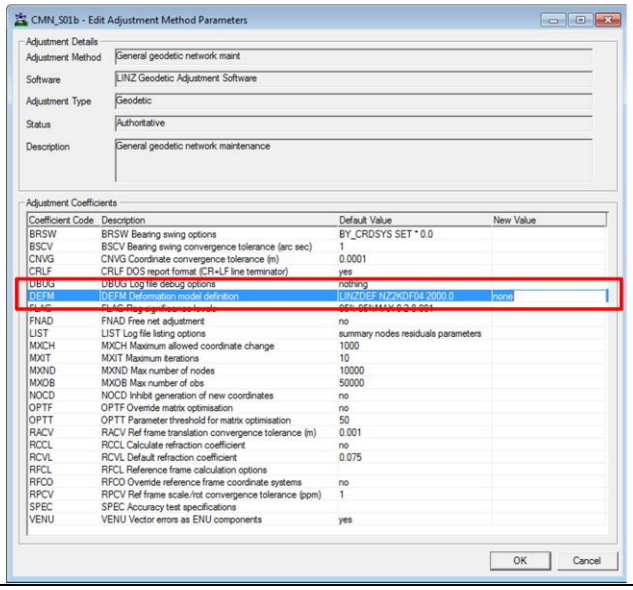
Looking at the adjustment spatially, we see the vectors (blue lines), fixed marks (small blue circles) and the mark to be coordinated (small brown circle with number over the top).

Landonline Adjustment Residuals without Deformation Model



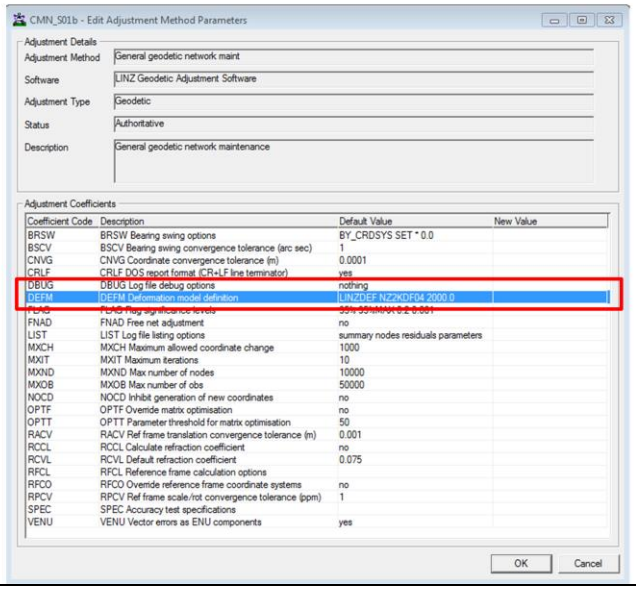
We run the adjustment and examine the results. In particular, we notice that the Standard Error of Unit Weight (SEUW) is 8.7. We normally expect this to be about 1. We also notice that the residuals ("Res" column) are quite large – up to 17cm. This is much larger than we would normally expect for geodetic GNSS data. Given that the data is in Christchurch, and was observed at different points in the earthquake sequence, we conclude that it is likely that the mark has moved between the 2010 and 2013 observations.

Applying the Deformation Model 1



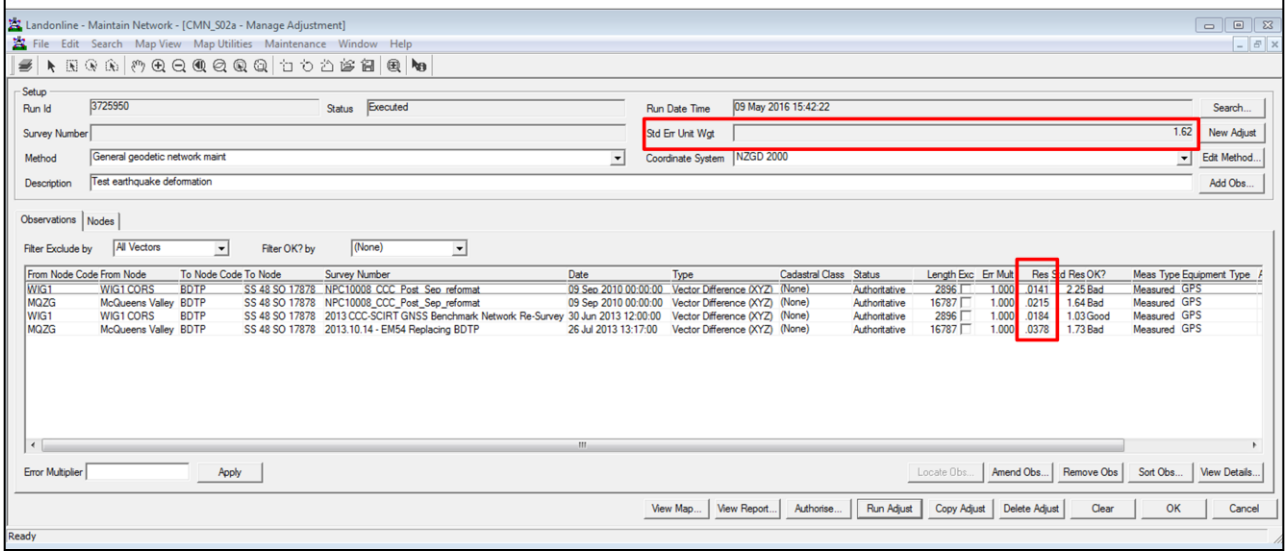
Landonline has the capability to incorporate a deformation model into an adjustment – which is in fact a requirement for adjustments being carried out to generate coordinates in terms of New Zealand Geodetic Datum 2000 (NZGD2000 is New Zealand's local reference frame). However, for the purposes of the demonstration, the deformation model had been turned off (set to "none").

Applying the Deformation Model 2



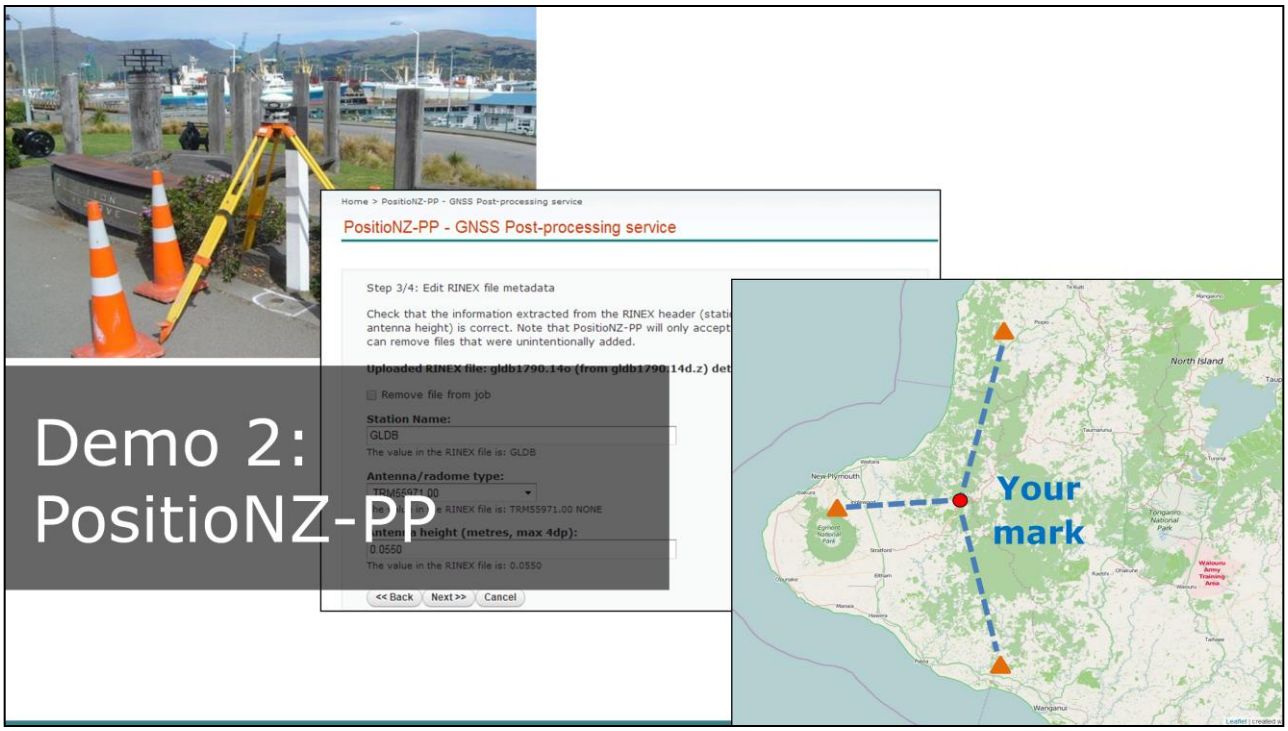
We now turn the deformation model on (by removing the value “none” so that the deformation model gets applied) and re-run the adjustment.

Landonline Adjustment Residuals with Deformation Model

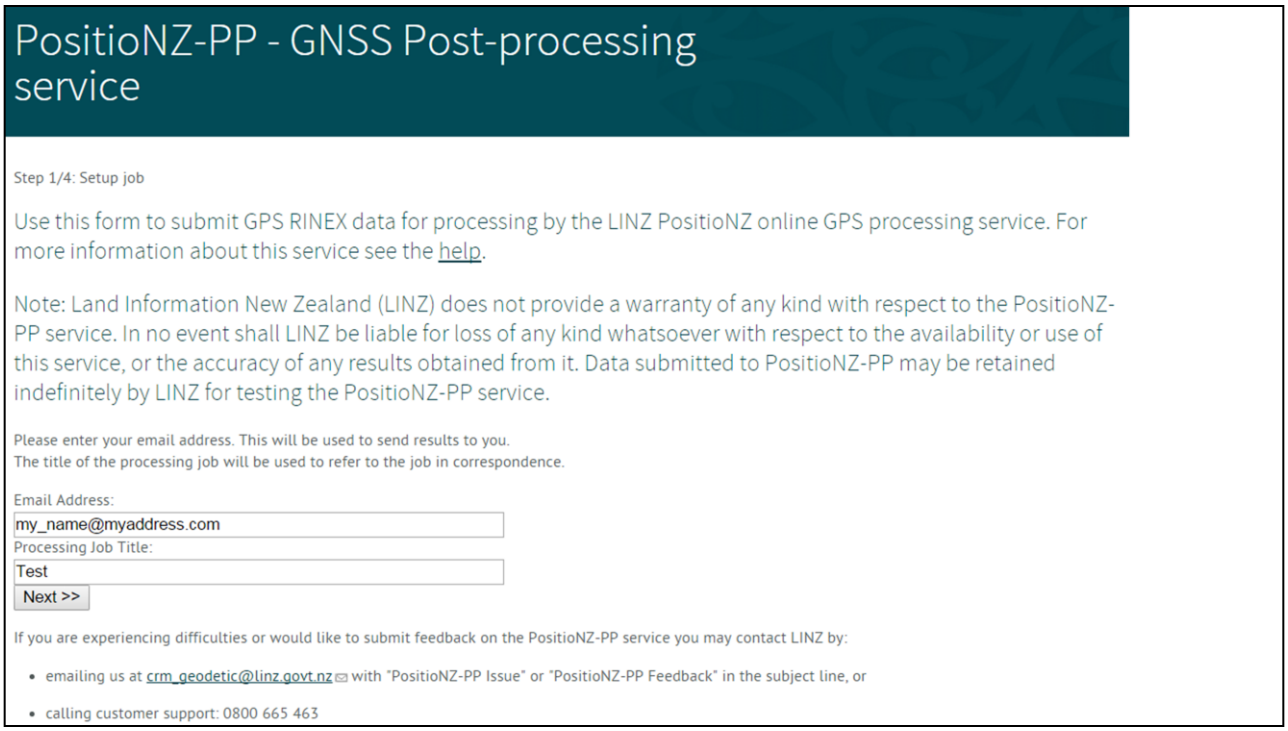


We notice a significant improvement in the adjustment results. The SEUW has reduced from 8.7 to 1.62 and the largest residual from 17cm to 4cm. The deformation model is not perfect so it is likely that at least part of the remaining residual is due to uncertainties in the deformation model. However, the level of accuracy now being achieved is adequate for many spatial applications.

This demonstration has shown that by using a deformation model, data collected at various times in the earthquake sequence (or before the earthquake sequence started) can be used to generate accurate NZGD2000 coordinates. While this demonstration has used Landonline, there is free software called SNAP that can be used by non-Landonline users http://www.linz.govt.nz/data/geodetic-services/download-geodetic-software/snap-concord-downloads



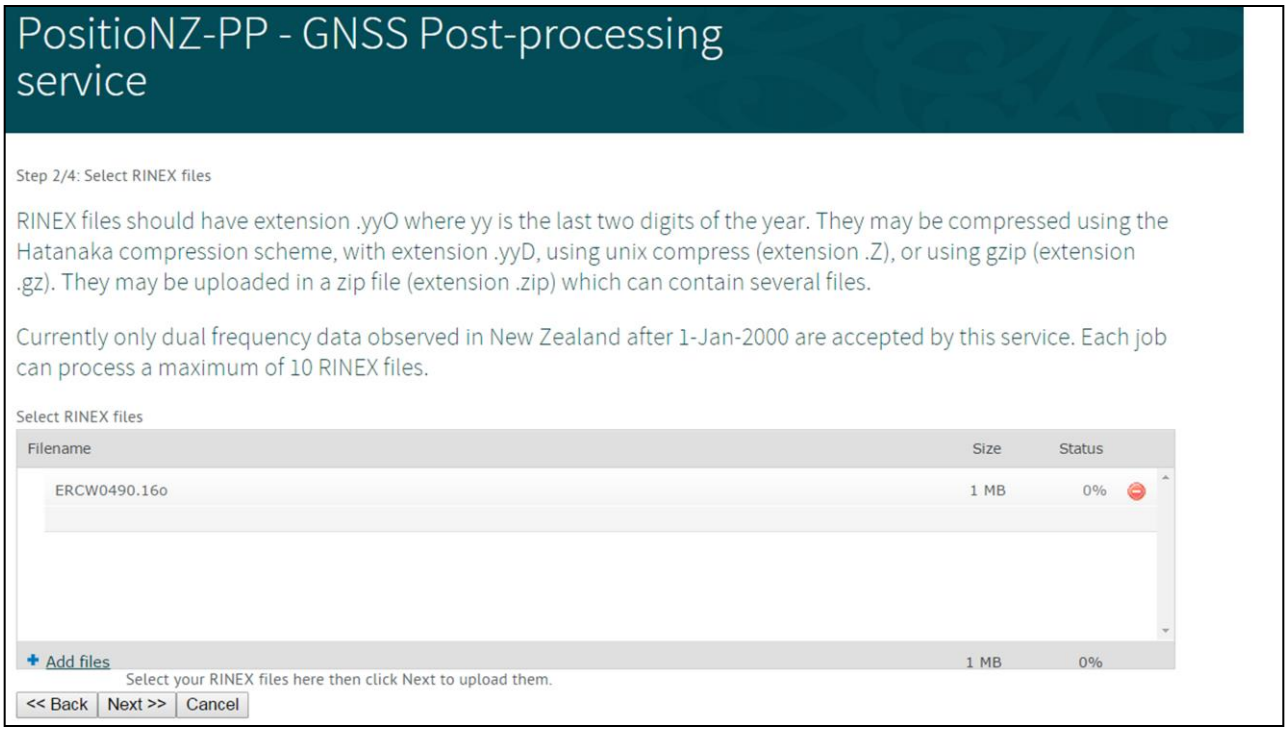
The second demonstration uses the PositioNZ-PP online GNSS processing system.



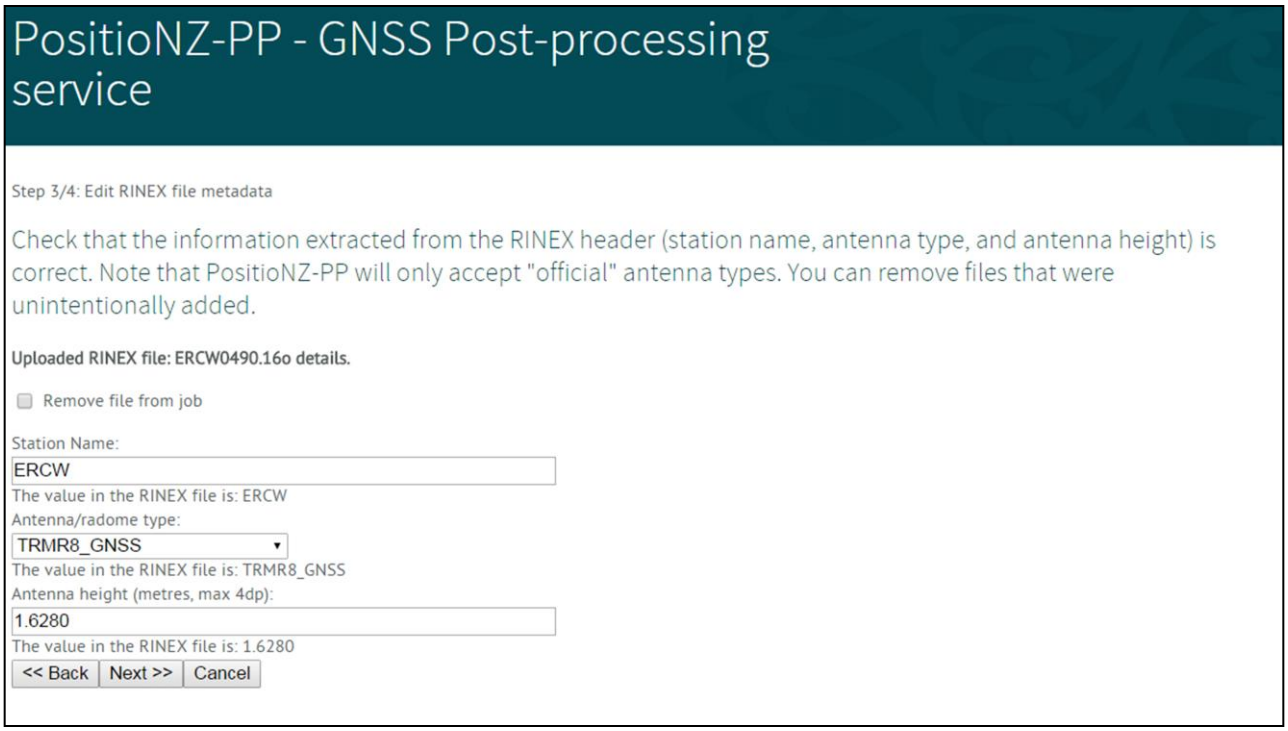
PositioNZ-PP is an online GNSS post-processing service operated by Land Information New Zealand. It's purpose is to provide global International Terrestrial Reference Frame (ITRF) and local NZGD2000 coordinates by processing a RINEX file submitted by the user with data from three nearby CORS. In the wake of an earthquake, the service can be used to calculate post-earthquake coordinates where and when the user requires them, rather than waiting for LINZ to provide updated control. In this series of slides, we show how PositioNZ-PP could be used to calculate coordinates after the 14 February 2016 earthquake in Christchurch. This earthquake did not significantly impact any of the CORS. If they had been impacted, the CORS coordinates would need to be updated by LINZ prior to the user generating their own control using PositioNZ-PP. Currently the PositioNZ-PP service only works using data collected in New Zealand.

The service is located at http://www.linz.govt.nz/positionzpp

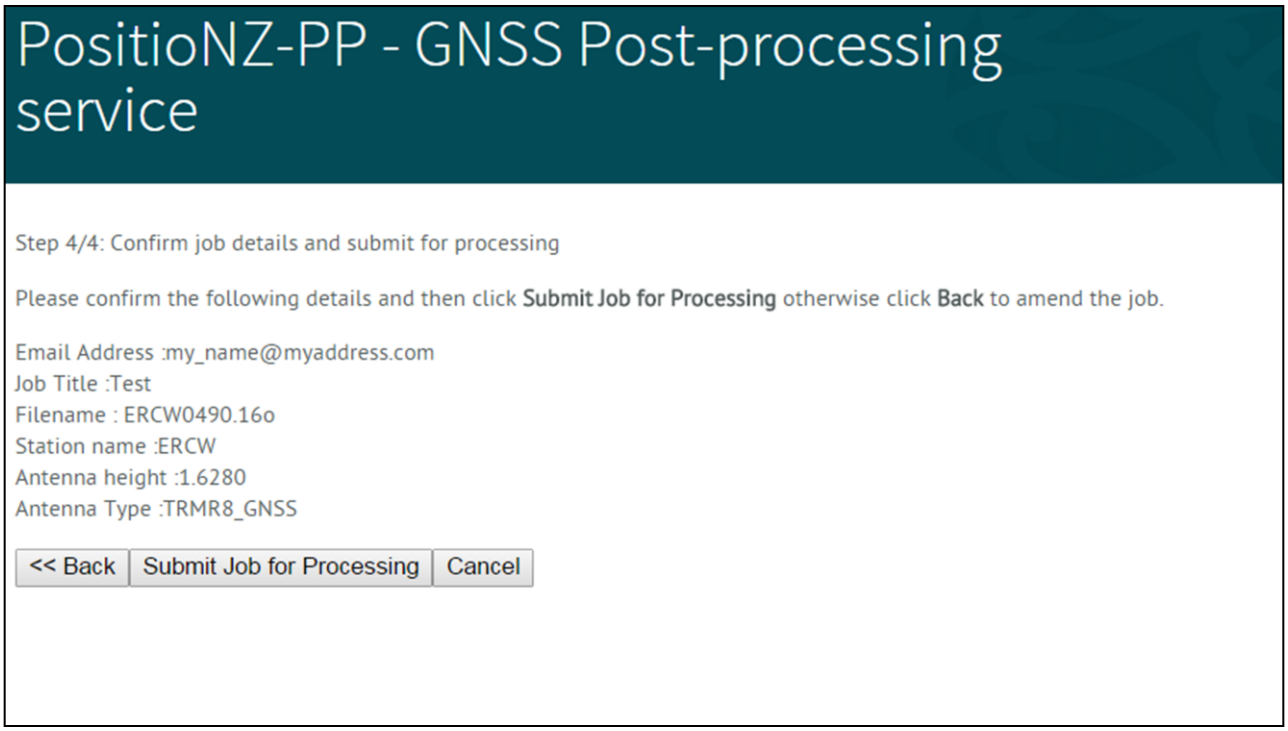
In Step 1, the user enters an email address and job name.



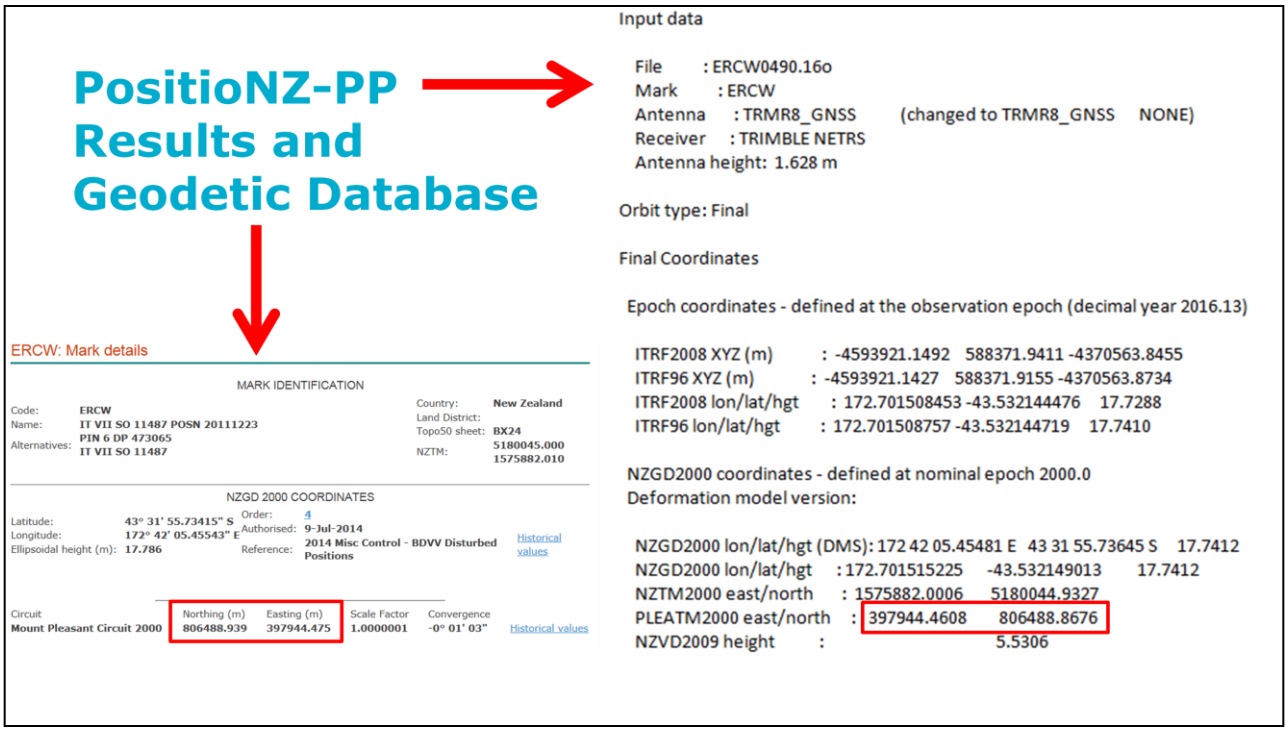
In Step 2, the user uploads their RINEX data. The minimum length of data is 1 hour, although 4 hours is recommended for more accurate results, given that some of the reference stations could be up to 100km away.



In Step 3, the service reports on the key metadata it has read from the RINEX file header. Any of this information can be changed at this stage. It is important that the antenna height and type are both correct, or there will be errors in the vertical coordinate. The antenna height is the height from the ground mark to the Antenna Reference Point (ARP).



In Step 4, there is an opportunity to check that the supplied information is correct, before the job is submitted. Once submitted, it will typically take 2-5 minutes for results to be returned, although the time can be longer if there are a large number of jobs already in the queue.



The results are sent via email, as shown on the right-hand side of the slide. Several different coordinates are provided, but the one we are interested in is the Mt Pleasant Meridional Circuit (PLEATM2000) coordinate. We can compare these with the existing coordinates in the Geodetic Database http://apps.linz.govt.nz/gdb/ (left-hand side of slide).

The coordinates differ by 2cm in the easting and 7cm in the northing, indicating that the mark has moved during the 14 February 2016 earthquake.

Key Points

- Data collected at different times in a deforming region can be combined using a deformation model to generate consistent coordinates
- Users can collect their own GNSS data and submit it using the PositioNZ-PP online processing service after an earthquake, to generate control where and when they need it

In summary, the presence of significant deformation (earthquake-related or otherwise) is a reality for many parts of New Zealand. Managing this deformation requires a deformation model to be incorporated into coordinate-generation tools. Examples of such tools are the Landonline system, used by LINZ to generate coordinates, and PositioNZ-PP, which may be used by external users to generate accurate coordinates.

Useful websites

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- Geodetic database: http://apps.linz.govt.nz/gdb/
- SNAP least squares adjustment software: http://www.linz.govt.nz/data/geodetic-services/download-geodetic-software/snap-concord-downloads
- PositioNZ-PP: http://www.linz.govt.nz/positionzpp

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Questions?