

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

Setup
Run Id: 0725950 Status: Executed Run Date Time: 09 May 2016 15:20:24
Survey Number: [] Std Err Unit Wgt: 8.7
Method: General geodetic network maint Coordinate System: NZGD 2000
Description: Test earthquake deformation

Observations | Nodes
Filter Exclude by: All Vectors Filter OK? by: (None)

From Node	Code From Node	To Node	Code To Node	Survey Number	Date	Type	Cadastral Class	Status	Length	Exc	Err Mult	Res	Std Res	OK?	Meas Type	Equipment	Type
W1G1	W1G1 CORS	BDTP	SS 48 SO 17878	NPC10008_CCC_Post_Sep_reformat	09 Sep 2010 00:00:00	ector Difference (XYZ)	(None)	Authoritative	2836	[]	1.000	0.271	6.59	Very Bad	Measured	GPS	
M2ZG	McQueens Valley	BDTP	SS 48 SO 17878	NPC10008_CCC_Post_Sep_reformat	09 Sep 2010 00:00:00	ector Difference (XYZ)	(None)	Authoritative	16787	[]	1.000	1.737	14.63	Very Bad	Measured	GPS	
W1G1	W1G1 CORS	BDTP	SS 48 SO 17878	2013 CCC-SCIRT GNSS Benchmark Network Re-Survey	30 Jun 2013 12:00:00	ector Difference (XYZ)	(None)	Authoritative	2896	[]	1.000	0.502	3.25	Very Bad	Measured	GPS	
M2ZG	McQueens Valley	BDTP	SS 48 SO 17878	2013.10.14 - EM54 Replacing BDTP	26 Jul 2013 13:17:00	ector Difference (XYZ)	(None)	Authoritative	16787	[]	1.000	0.641	3.87	Very Bad	Measured	GPS	

Error Multiplier: [] Apply Localize Obs Amend Obs Remove Obs Sort Obs View Details

View Map... View Report... Authorise... Run Adjust Copy Adjust Delete Adjust Clear OK Cancel

Performs the adjustment run

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

Setup
Run Id: 3725950 Status: Executed Run Date Time: 09 May 2016 15:20:24
Survey Number: Std Err Unit Wgt: 3.7
Method: General geodetic network maint Coordinate System: NZGD 2000
Description: Test earthquake deformation

Observations Nodes
Filter Constraints by: (None) Filter Rejected by: All Nodes

Node Code	Name	Mark Purpose	SDC Prop	Order	SDC Stat	Constraint	H Change Rejected	V Change	H Max Acc	Vertical Acc
WIG1	WIG1 CORS	(None)	<input checked="" type="checkbox"/>	3	<input checked="" type="checkbox"/>	Fixed 3 Dimensional				
MQZG	McQueens Valley	(None)	<input checked="" type="checkbox"/>	0	<input checked="" type="checkbox"/>	Fixed 3 Dimensional				
BDTP	SS 48 SO 17878	(None)	<input checked="" type="checkbox"/>	3	<input checked="" type="checkbox"/>	Free	.036		.022	.005

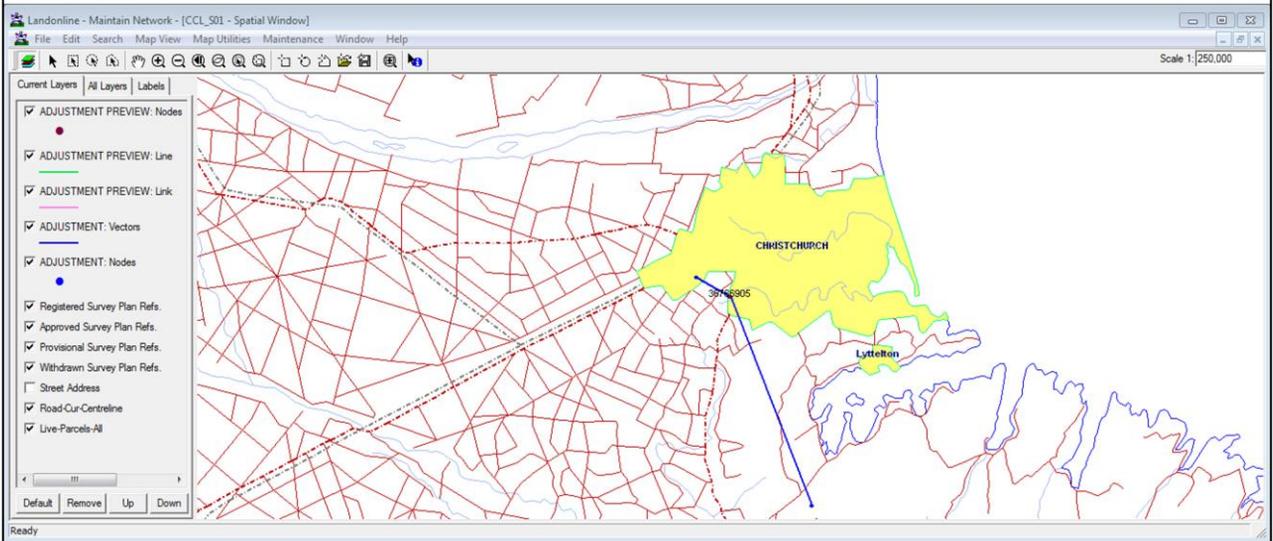
Constraint: [] Apply [] Locate Nodes... Sort Nodes... View Details...

View Map... View Report... Authorise... Run Adjust Copy Adjust Delete Adjust Clear OK Cancel

Performs the adjustment run

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

Setup
Run Id: 3725950 Status: Executed Run Date Time: 09 May 2016 15:20:24
Survey Number: Std Er Unit Wgt: 8.7
Method: General geodetic network maint Coordinate System: NZGD 2000
Description: Test earthquake deformation

Observations | Nodes
Filter Exclude by: All Vectors Filter OK? by: (None)

From Node Code	From Node	To Node Code	To Node	Survey Number	Date	Type	Cadastral Class	Status	Length	Exc	Err Mult	Res	Std Res OK?	Meas Type	Equipment Type
WIG1	WIG1 CORS	BDTP	SS 48 SO 17878	NPC10008_CCC_Post_Sep_reformat	09 Sep 2010 00:00:00	Vector Difference (XYZ)	(None)	Authoritative	2836		1.000	0.271	6.59 Very Bad	Measured	GPS
MQZG	McQueens Valley	BDTP	SS 48 SO 17878	NPC10008_CCC_Post_Sep_reformat	09 Sep 2010 00:00:00	Vector Difference (XYZ)	(None)	Authoritative	16787		1.000	1.737	14.63 Very Bad	Measured	GPS
WIG1	WIG1 CORS	BDTP	SS 48 SO 17878	2013 CCC-SCIRT GNSS Benchmark Network Re-Survey	30 Jun 2013 12:00:00	Vector Difference (XYZ)	(None)	Authoritative	2696		1.000	0.502	3.26 Very Bad	Measured	GPS
MQZG	McQueens Valley	BDTP	SS 48 SO 17878	2013.10.14 - EM54 Replacing BDTP	26 Jul 2013 13:17:00	Vector Difference (XYZ)	(None)	Authoritative	16787		1.000	0.641	3.87 Very Bad	Measured	GPS

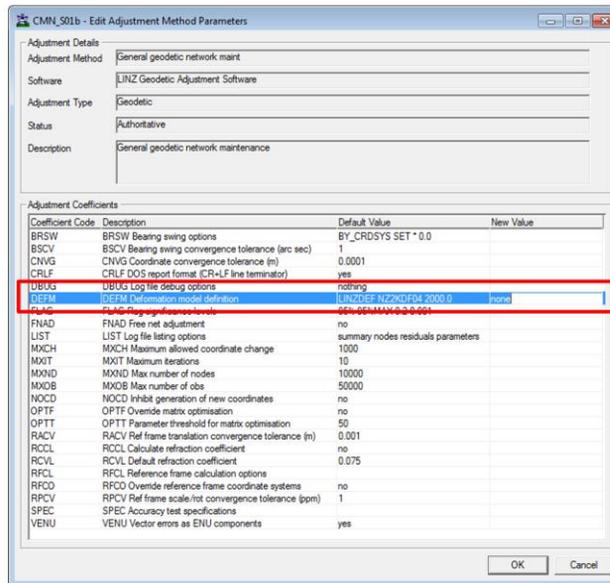
Error Multiplier: [] Apply
Locate Obs Amend Obs Remove Obs Sort Obs View Details

View Map View Report Authorise Run Adjust Copy Adjust Delete Adjust Clear OK Cancel

Performs the adjustment run

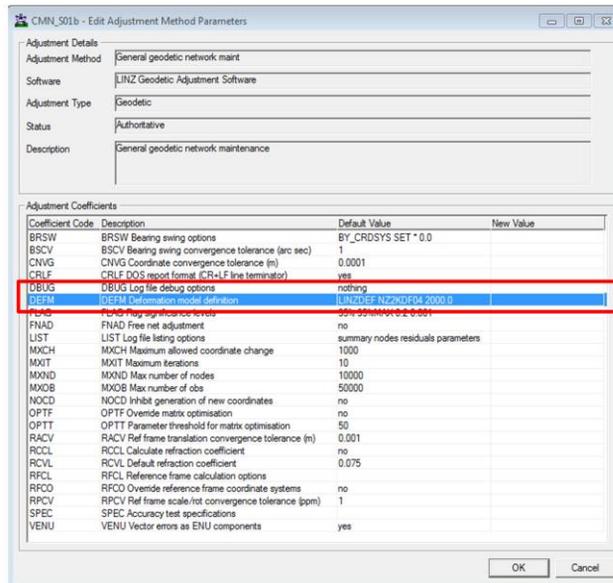
We run the adjustment and examine the results. In particular, we notice that the Standard Error of Unit Weight (SEUW) is 8.7. We normally expect this to be about 1. We also notice that the residuals (“Res” column) are quite large – up to 17cm. This is much larger than we would normally expect for geodetic 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

Setup

Run Id: 3725950 Status: Executed Run Date Time: 09 May 2016 15:42:22

Survey Number: [] Std Err Unit Wgt: 1.62

Method: General geodetic network maint Coordinate System: NZGD 2000

Description: Test earthquake deformation

Observations | Nodes

Filter Exclude by: All Vectors Filter OK? by: (None)

From Node	Code	From Node	To Node	Code	To Node	Survey Number	Date	Type	Cadastral Class	Status	Length	Exc	Err	Mult	Res	Std	Res OK?	Meas	Type	Equipment	Type
WIG1	WIG1	CORS	BDTP	SS 48 SO 17878	NPC10008_CCC_Post_Sep_reformat	09 Sep 2010 00:00:00	Vector Difference (XYZ)	(None)	Authoritative	2896		1.000	0.141	2.25	Bad	Measured	GPS				
MQZG	McQueens Valley	BDTP	SS 48 SO 17878	NPC10008_CCC_Post_Sep_reformat	09 Sep 2010 00:00:00	Vector Difference (XYZ)	(None)	Authoritative	16787		1.000	0.215	1.64	Bad	Measured	GPS					
WIG1	WIG1	CORS	BDTP	SS 48 SO 17878	2013 CCC-SCIRT GNSS Benchmark Network Re-Survey	30 Jun 2013 12:00:00	Vector Difference (XYZ)	(None)	Authoritative	2896		1.000	0.184	1.03	Good	Measured	GPS				
MQZG	McQueens Valley	BDTP	SS 48 SO 17878	2013.10.14 - EM54 Replacing BDTP	26 Jul 2013 13:17:00	Vector Difference (XYZ)	(None)	Authoritative	16787		1.000	0.378	1.73	Bad	Measured	GPS					

Error Multiplier: [] Apply

View Map... View Report... Authorise... Run Adjust Copy Adjust Delete Adjust Clear OK Cancel

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>

Home > PositionNZ-PP - GNSS Post-processing service

PositionNZ-PP - GNSS Post-processing service

Step 3/4: Edit RINEX file metadata

Check that the information extracted from the RINEX header (station name, antenna height) is correct. Note that PositionNZ-PP will only accept files that were unintentionally added.

Uploaded RINEX file: **gldb1790.14o (from gldb1790.14d.z) detected**

Remove file from job

Station Name:
GLDB
The value in the RINEX file is: GLDB

Antenna/radome type:
TRM55971.00
The RINEX file is: TRM55971.00 NONE

Antenna height (metres, max 4dp):
0.0550
The value in the RINEX file is: 0.0550

<< Back Next >> Cancel

Your mark

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

PositionNZ-PP - GNSS Post-processing service

Step 1/4: Setup job

Use this form to submit GPS RINEX data for processing by the LINZ PositionNZ online GPS processing service. For more information about this service see the [help](#).

Note: Land Information New Zealand (LINZ) does not provide a warranty of any kind with respect to the PositionNZ-PP service. In no event shall LINZ be liable for loss of any kind whatsoever with respect to the availability or use of this service, or the accuracy of any results obtained from it. Data submitted to PositionNZ-PP may be retained indefinitely by LINZ for testing the PositionNZ-PP service.

Please enter your email address. This will be used to send results to you.
The title of the processing job will be used to refer to the job in correspondence.

Email Address:

Processing Job Title:

If you are experiencing difficulties or would like to submit feedback on the PositionNZ-PP service you may contact LINZ by:

- emailing us at crm_geodetic@linz.govt.nz with "PositionNZ-PP Issue" or "PositionNZ-PP Feedback" in the subject line, or
- calling customer support: 0800 665 463

PositionNZ-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 PositionNZ-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 PositionNZ-PP. Currently the PositionNZ-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.

PositionNZ-PP - GNSS Post-processing service

Step 2/4: Select RINEX files

RINEX files should have extension .yyO where yy is the last two digits of the year. They may be compressed using the Hatanaka compression scheme, with extension .yyD, using unix compress (extension .Z), or using gzip (extension .gz). They may be uploaded in a zip file (extension .zip) which can contain several files.

Currently only dual frequency data observed in New Zealand after 1-Jan-2000 are accepted by this service. Each job can process a maximum of 10 RINEX files.

Select RINEX files

Filename	Size	Status
ERCW0490.16o	1 MB	0% 
<hr/>		
+ Add files	1 MB	0%

Select your RINEX files here then click Next to upload them.

<< Back | Next >> | Cancel

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.

PositionZ-PP - GNSS Post-processing service

Step 3/4: Edit RINEX file metadata

Check that the information extracted from the RINEX header (station name, antenna type, and antenna height) is correct. Note that PositionZ-PP will only accept "official" antenna types. You can remove files that were unintentionally added.

Uploaded RINEX file: ERCW0490.16o details.

Remove file from job

Station Name:

ERCW

The value in the RINEX file is: ERCW

Antenna/radome type:

TRMR8_GNSS

The value in the RINEX file is: TRMR8_GNSS

Antenna height (metres, max 4dp):

1.6280

The value in the RINEX file is: 1.6280

<< Back Next >> Cancel

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).

PositionZ-PP - GNSS Post-processing service

Step 4/4: Confirm job details and submit for processing

Please confirm the following details and then click **Submit Job for Processing** otherwise click **Back** to amend the job.

Email Address :my_name@myaddress.com

Job Title :Test

Filename : ERCW0490.16o

Station name :ERCW

Antenna height :1.6280

Antenna Type :TRMR8_GNSS

<< Back

Submit Job for Processing

Cancel

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.

PositionNZ-PP Results and Geodetic Database



ERCW: Mark details

MARK IDENTIFICATION

Code:	ERCW	Country:	New Zealand
Name:	IT VII SO 11487 POSN 20111223	Land District:	
Alternatives:	P1M 6 DP 473065	Topo50 sheet:	BX24
	IT VII SO 11487	NZTM:	5180045.000 1575882.010

NZGD 2000 COORDINATES

Latitude:	43° 31' 55.73415" S	Order:	4
Longitude:	172° 42' 05.45543" E	Authorised:	9-Jul-2014
Ellipsoidal height (m):	17.786	Reference:	2014 Misc Control - BDVV Disturbed Positions

Circuit	Mount Pleasant Circuit 2000	Northing (m)	806488.939	Easting (m)	397944.475	Scale Factor	1.0000001	Convergence	-0° 01' 03"
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Input data

File : ERCW0490.16o
Mark : ERCW
Antenna : TRMR8_GNSS (changed to TRMR8_GNSS NONE)
Receiver : TRIMBLE NETRS
Antenna height: 1.628 m

Orbit type: Final

Final Coordinates

Epoch coordinates - defined at the observation epoch (decimal year 2016.13)

ITRF2008 XYZ (m) : -4593921.1492 588371.9411 -4370563.8455
ITRF96 XYZ (m) : -4593921.1427 588371.9155 -4370563.8734
ITRF2008 lon/lat/hgt : 172.701508453 -43.532144476 17.7288
ITRF96 lon/lat/hgt : 172.701508757 -43.532144719 17.7410

NZGD2000 coordinates - defined at nominal epoch 2000.0

Deformation model version:

NZGD2000 lon/lat/hgt (DMS): 172 42 05.45481 E 43 31 55.73645 S 17.7412
NZGD2000 lon/lat/hgt : 172.701515225 -43.532149013 17.7412
NZTM2000 east/north : 1575882.0006 5180044.9327
PLEATM2000 east/north : 397944.4608 806488.8676
NZVD2009 height : 5.5306

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 PositionNZ-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 PositionNZ-PP, which may be used by external users to generate accurate coordinates.

Useful websites

- 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>
- PositionNZ-PP:
<http://www.linz.govt.nz/positionzpp>

Questions?

