Deformation modelling II: The New Zealand Experience

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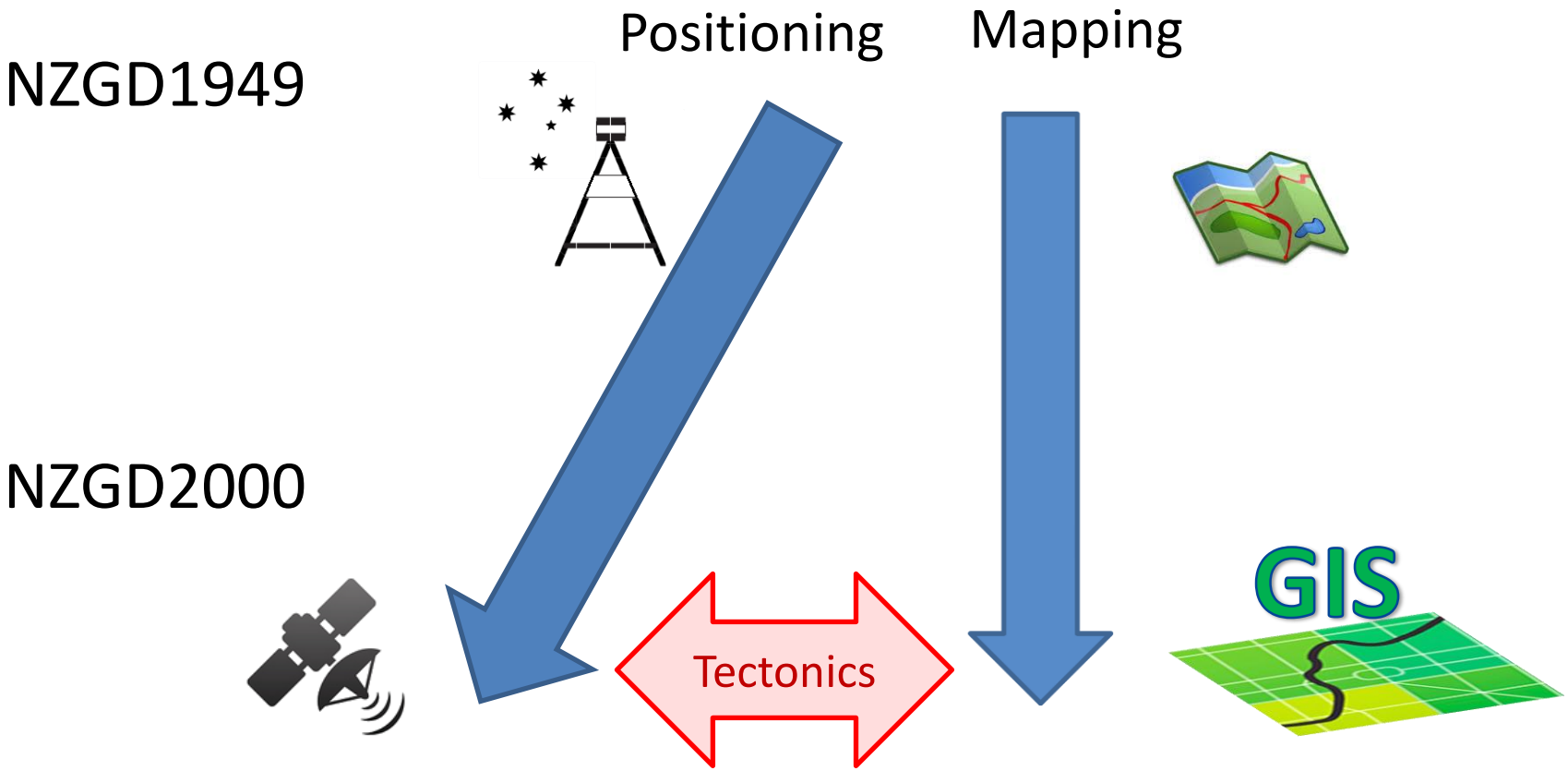
Land Information New Zealand

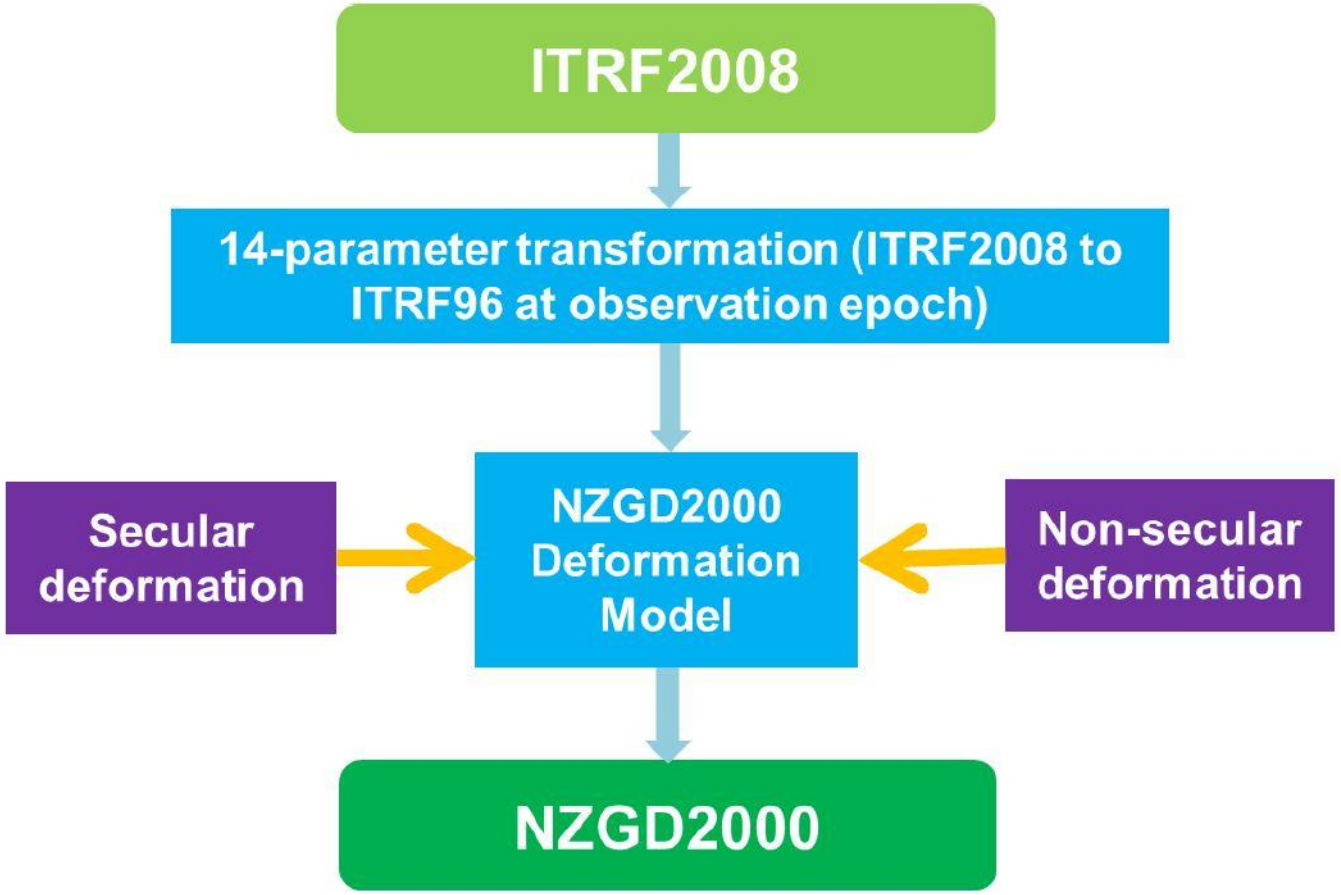
The role of a National Geodetic Datum



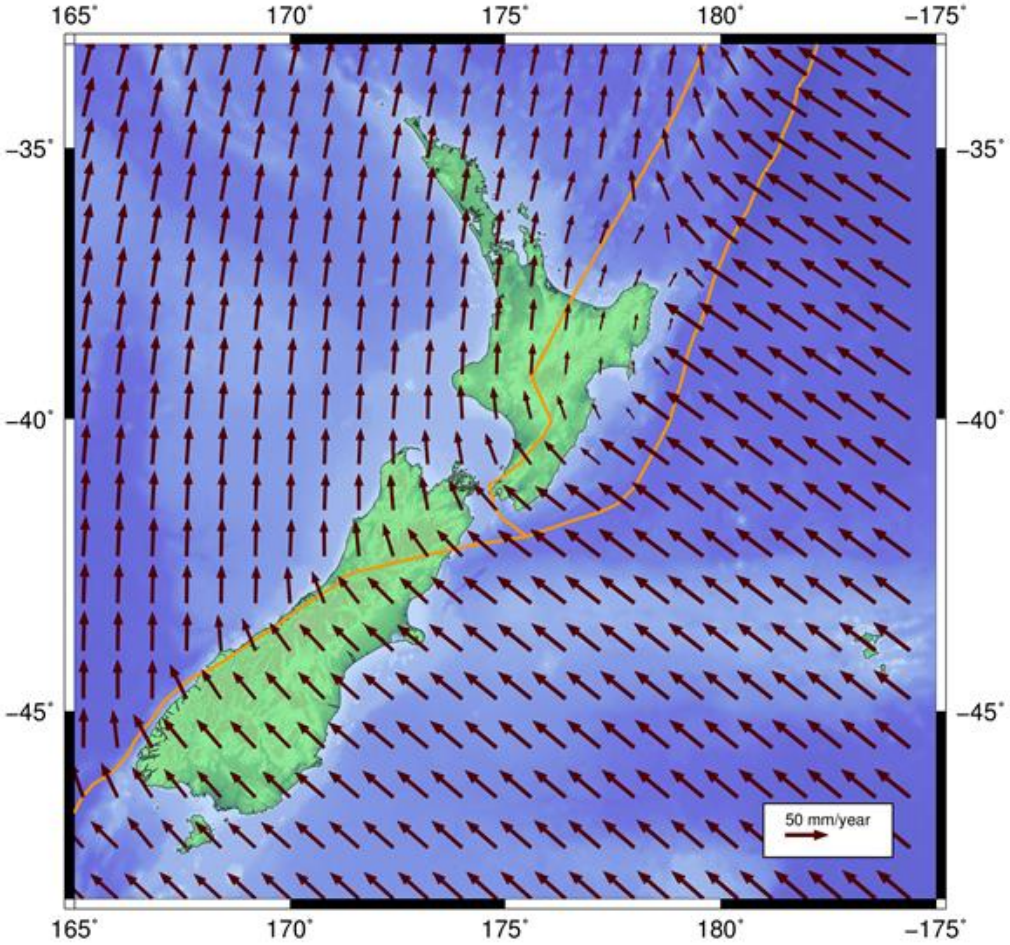
Discussion

- How accurate does the geospatial reference frame need to be?
- What applications will use local reference frame rather than global reference frame?
- For applications using global frame - how will they get reference data (eg road centrelines) in terms of the global frame?

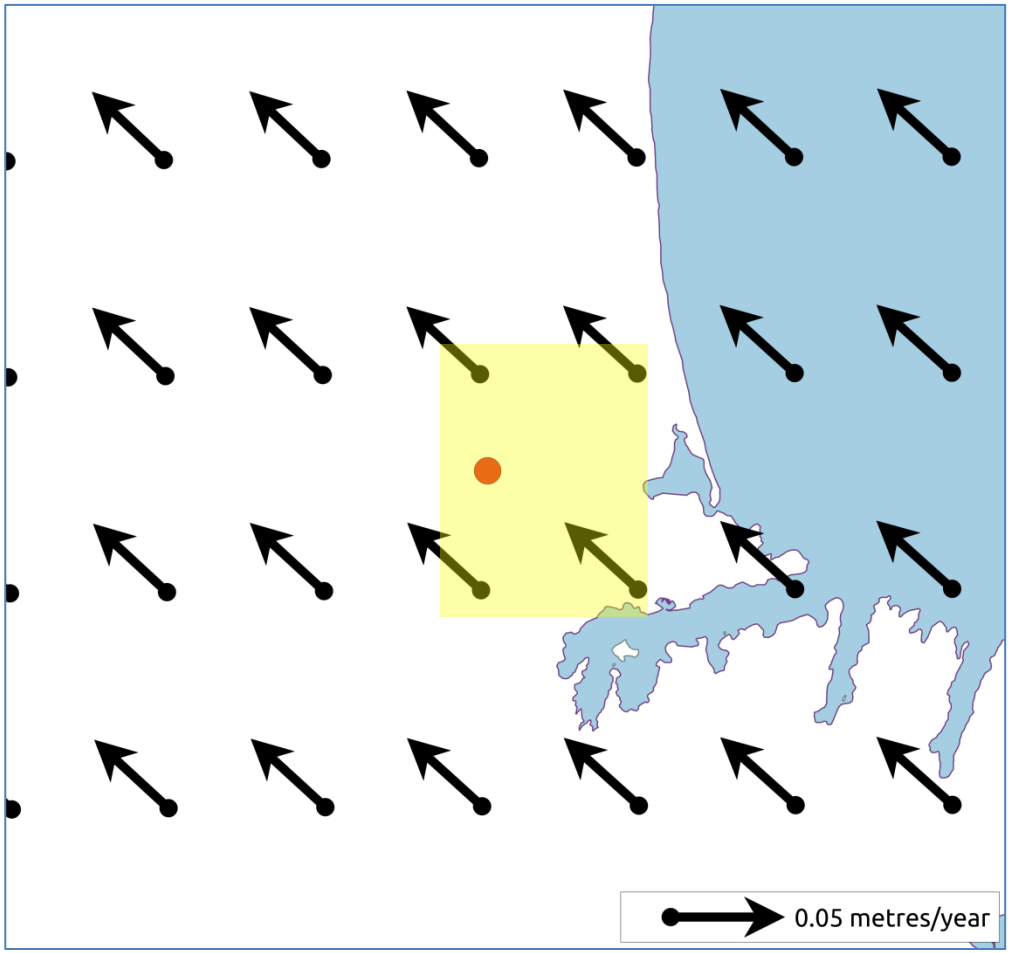
The NZGD2000 datum



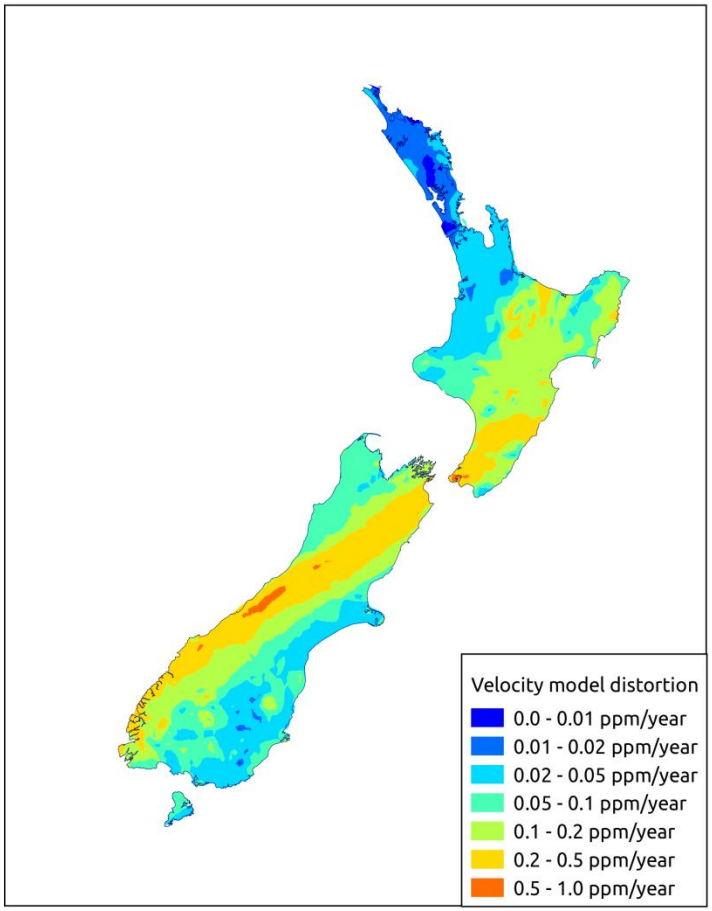
The national deformation model (ndm) component



Calculating the NDM component

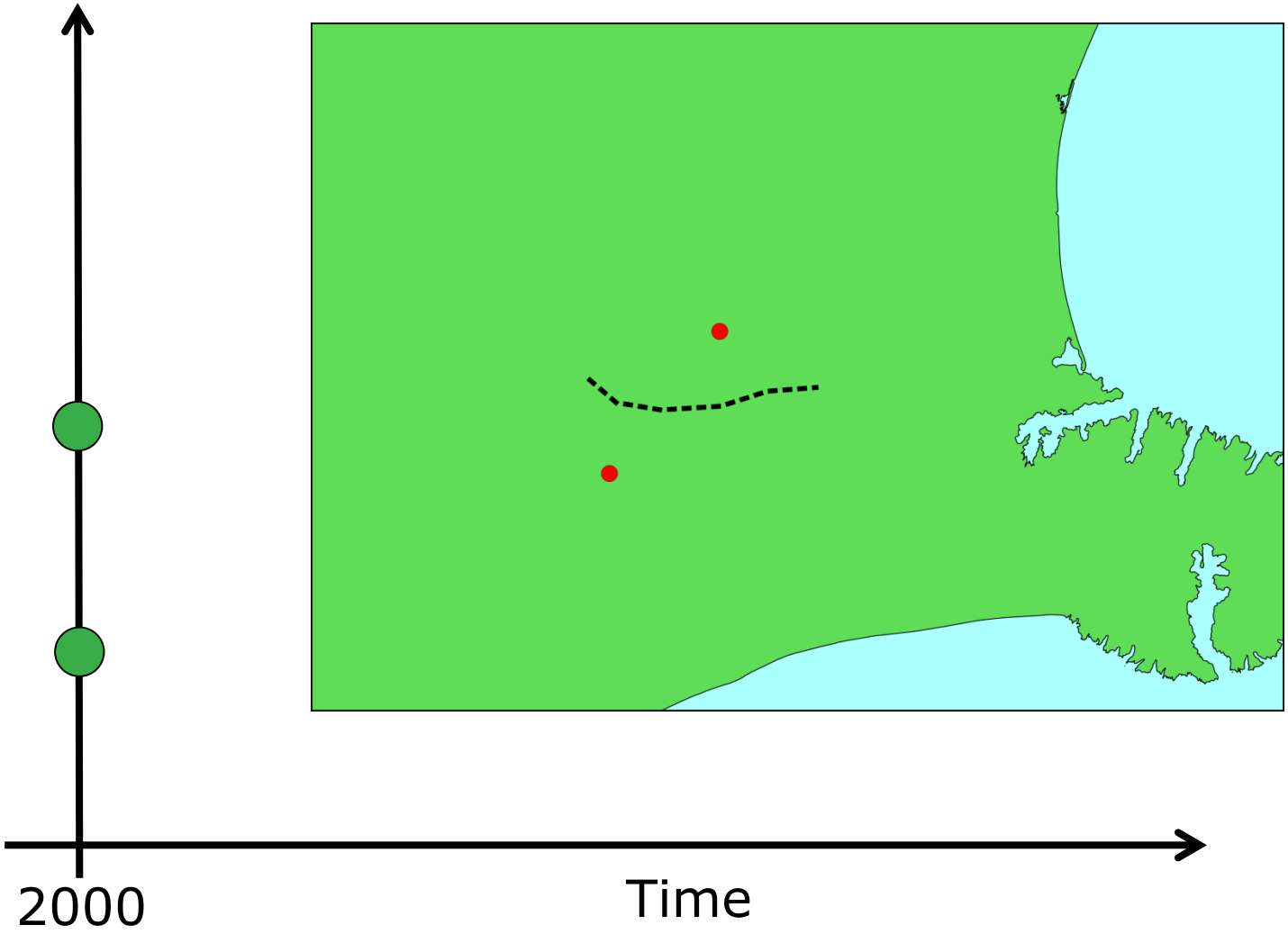


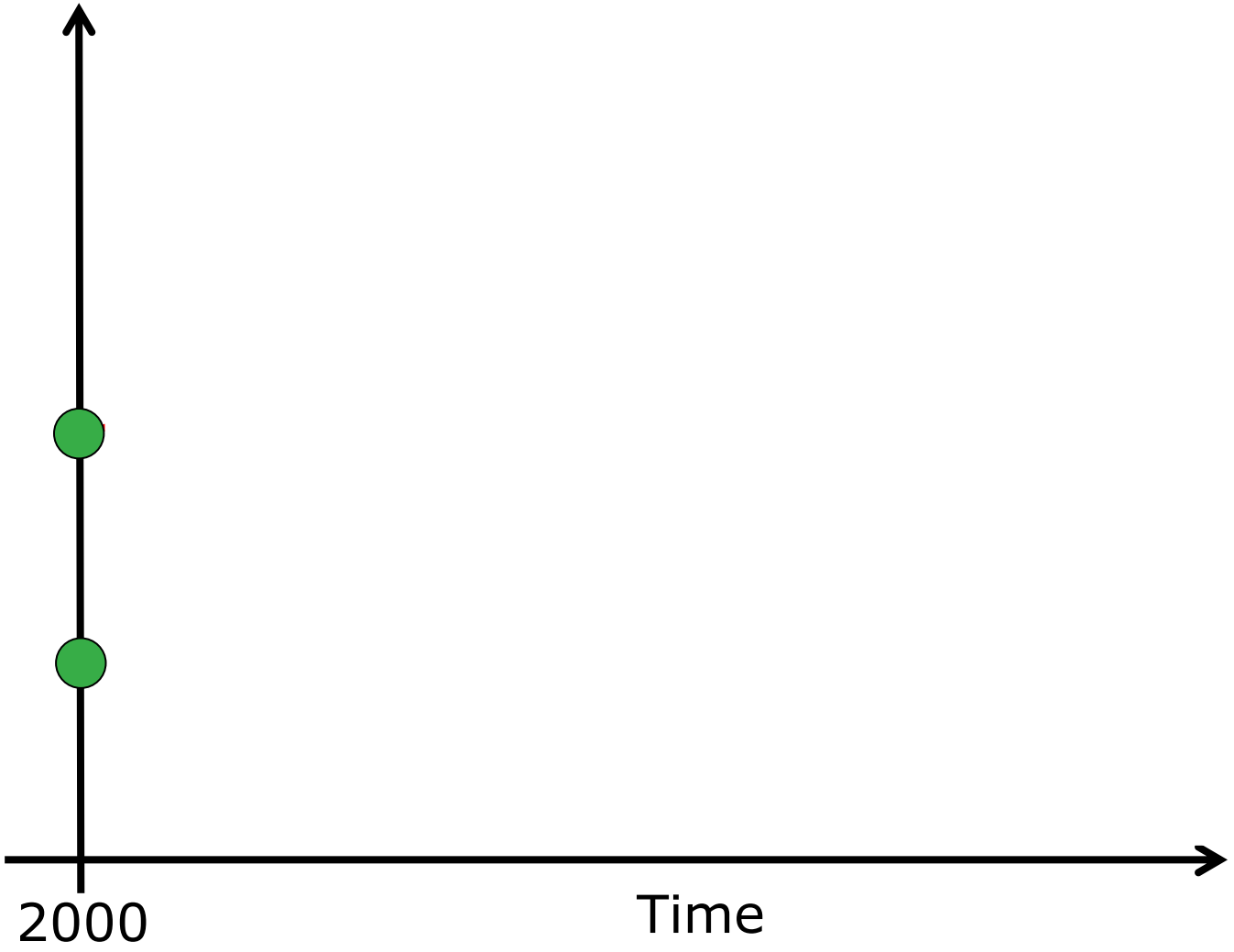
Distortion in the NZGD2000 coordinate system due to ndm

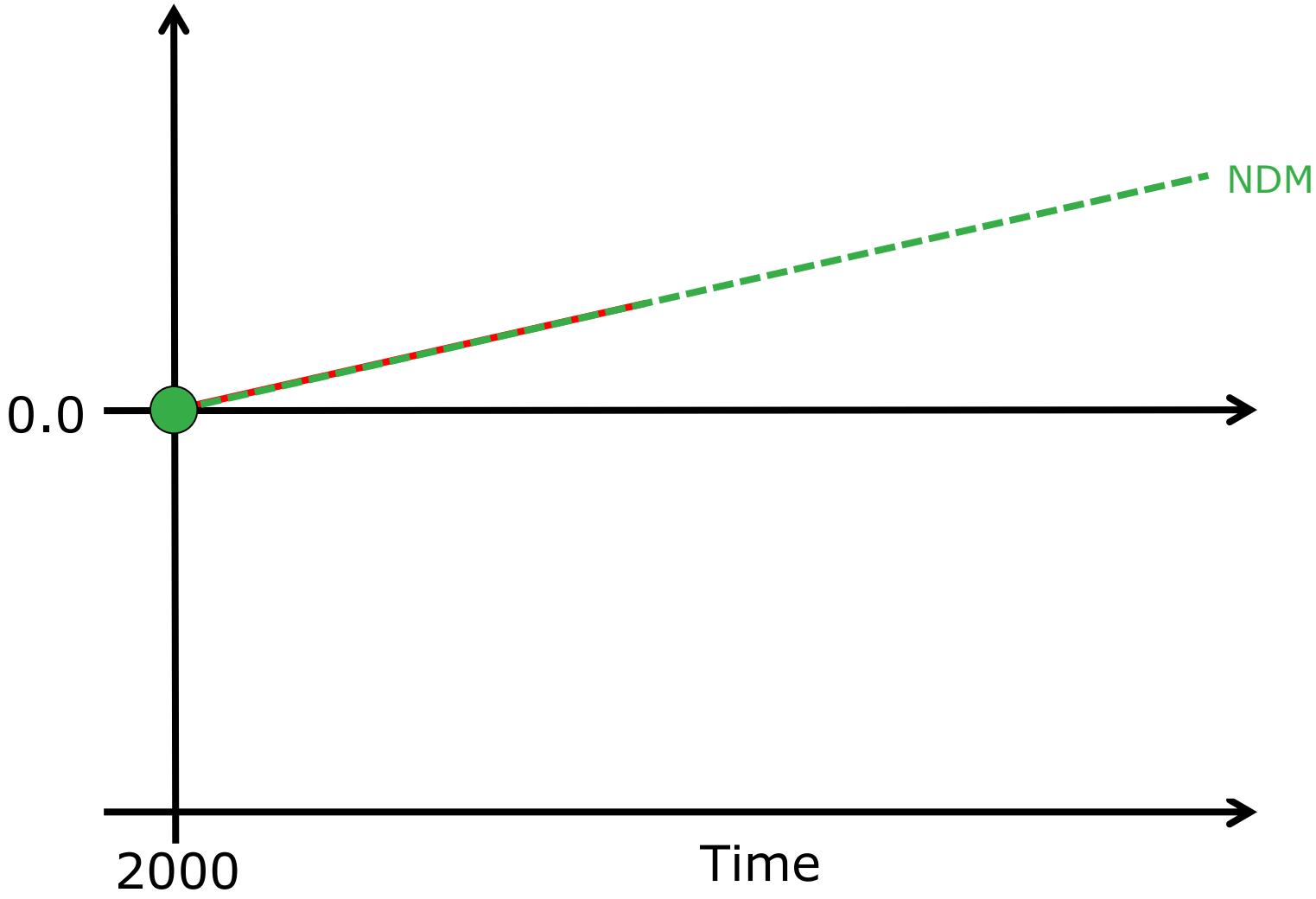


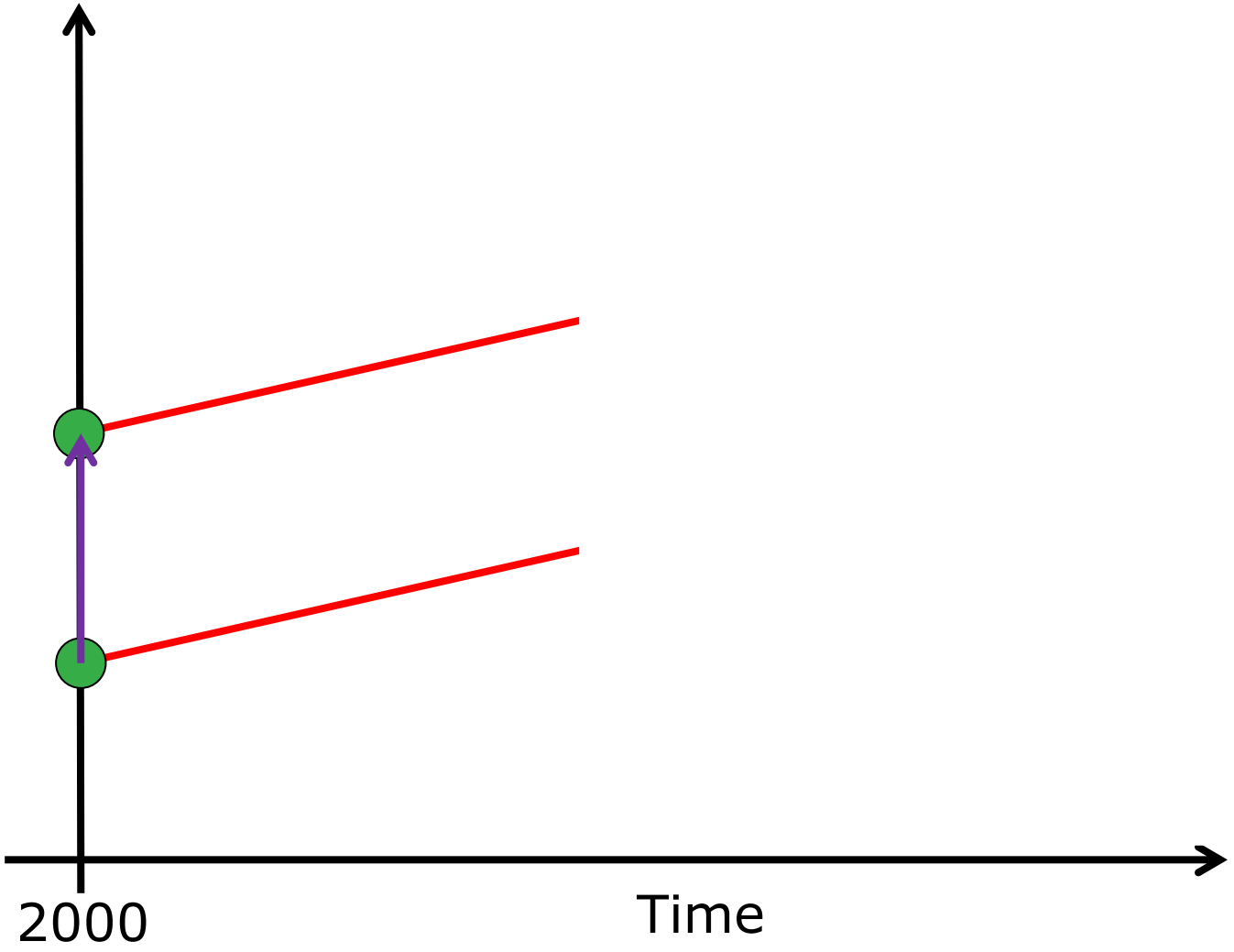
Questions on secular deformation model (ndm) component

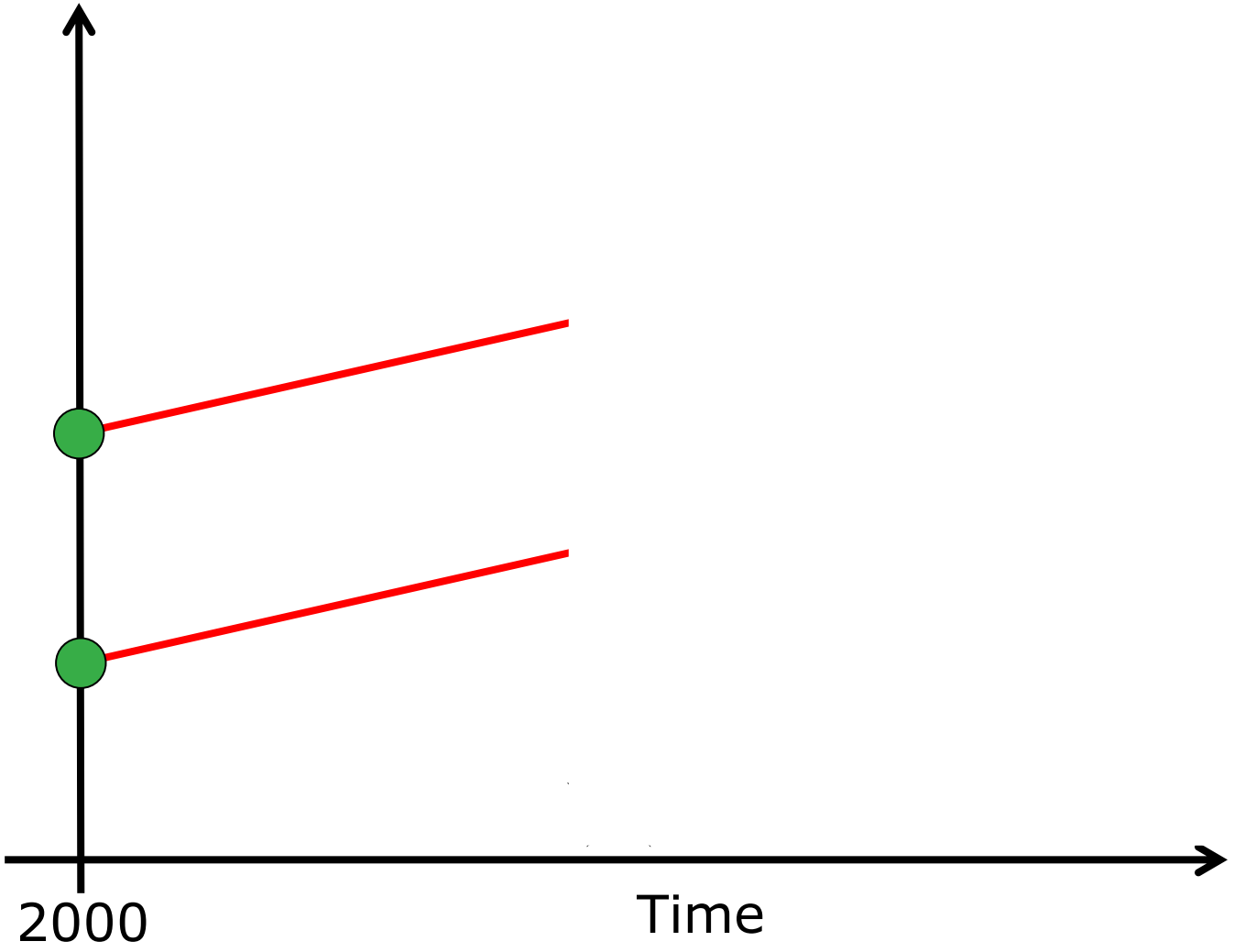
Patches to the deformation model

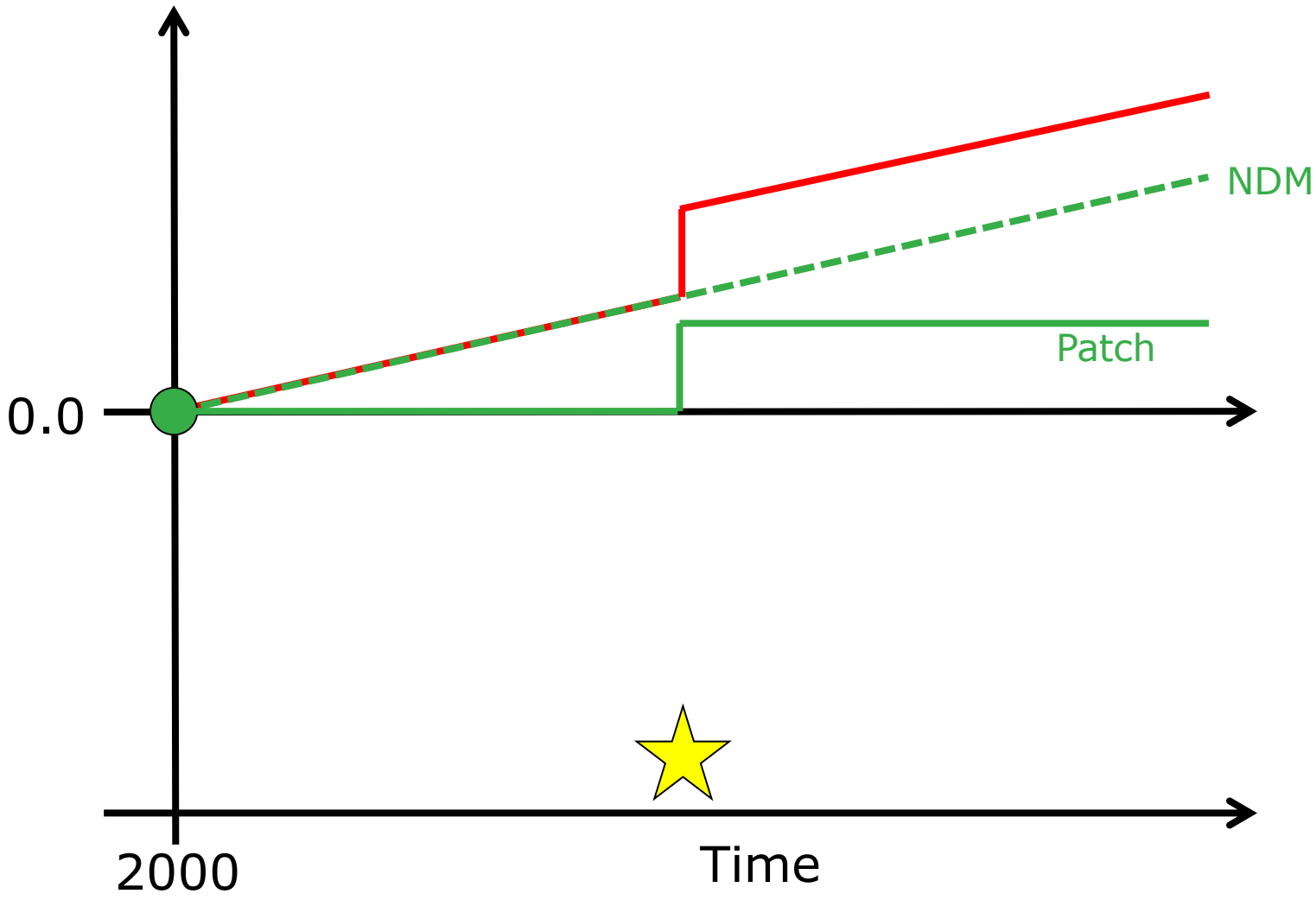

2000
Time

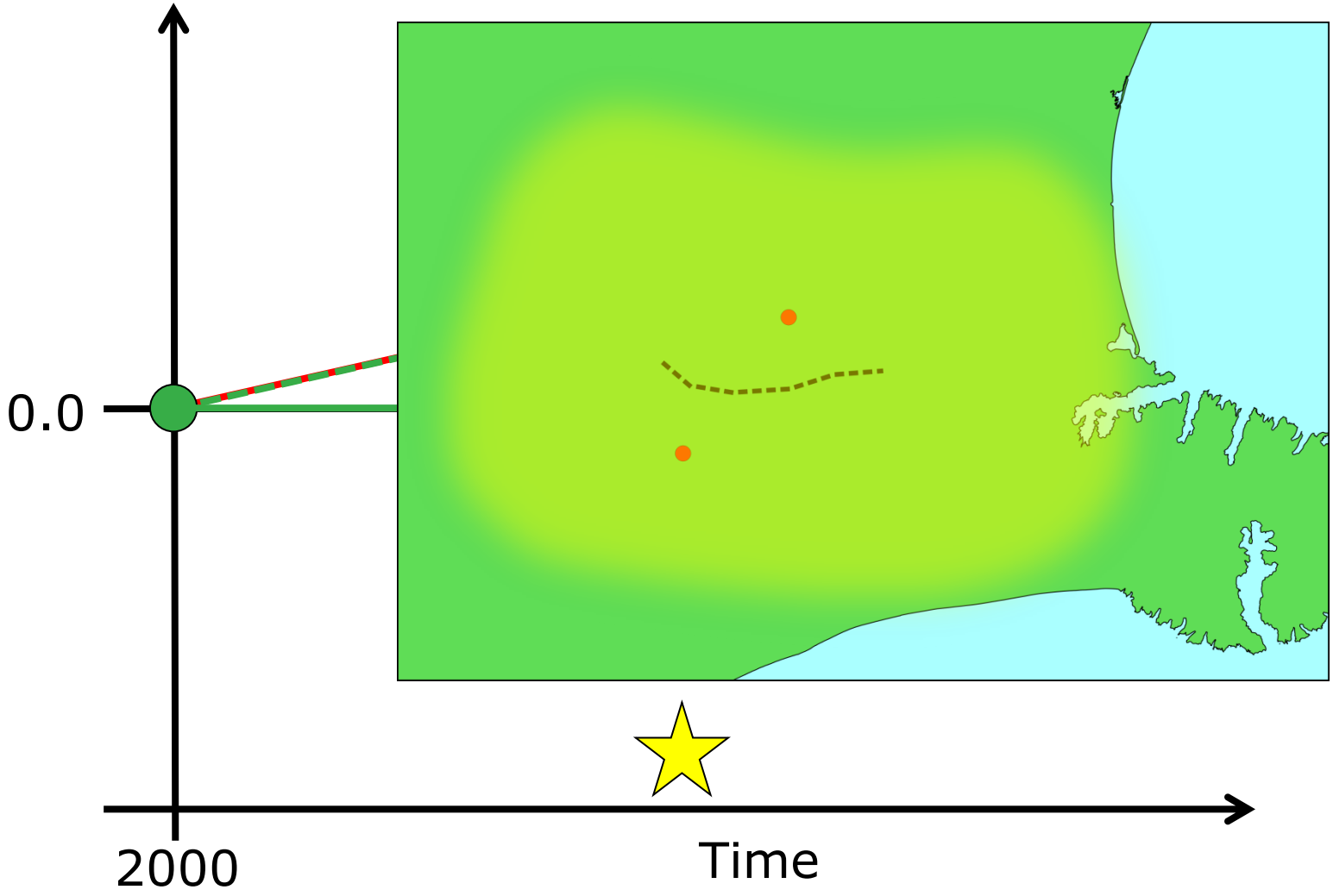

2000
Time

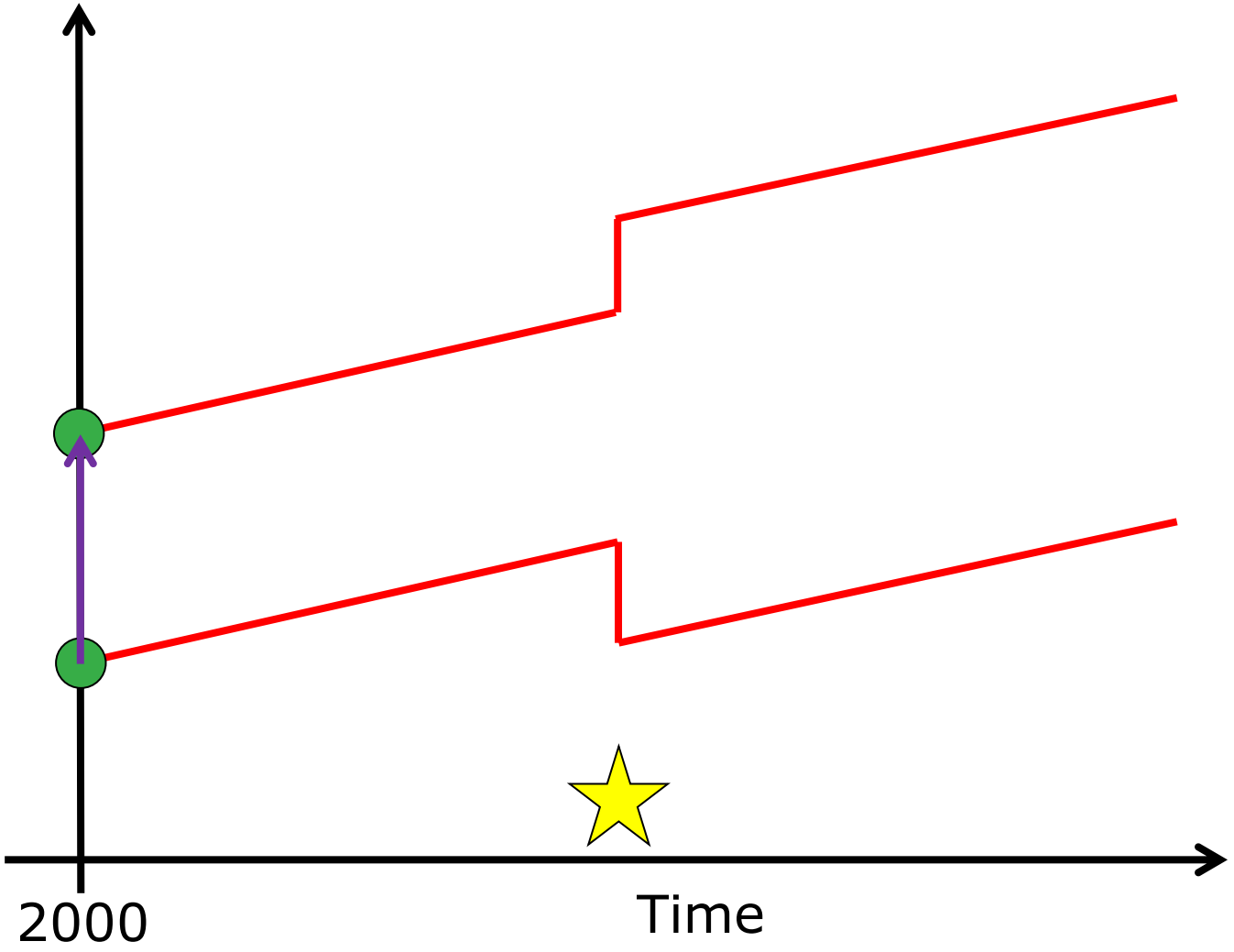

NDM
0.0
2000
Time

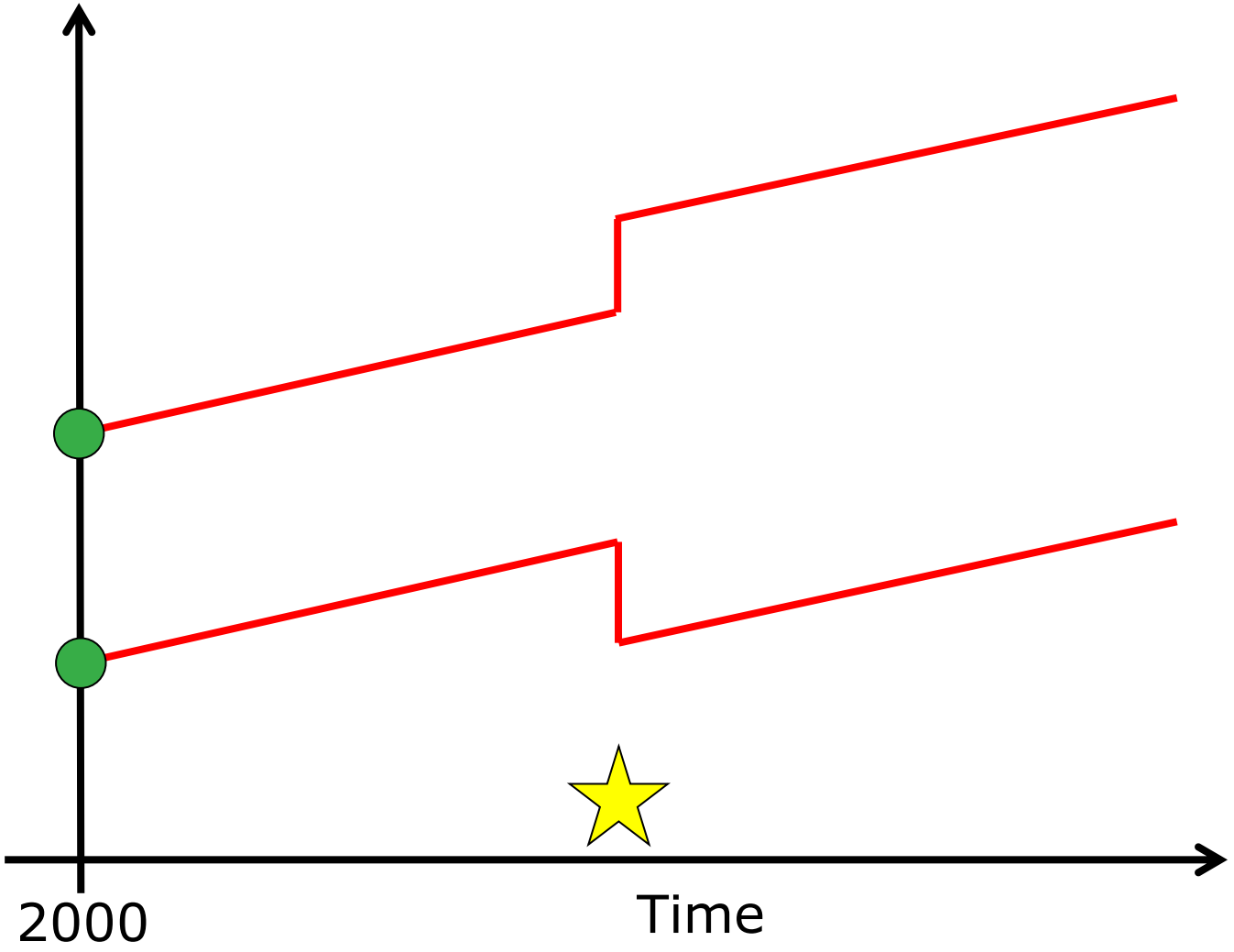

2000
Time

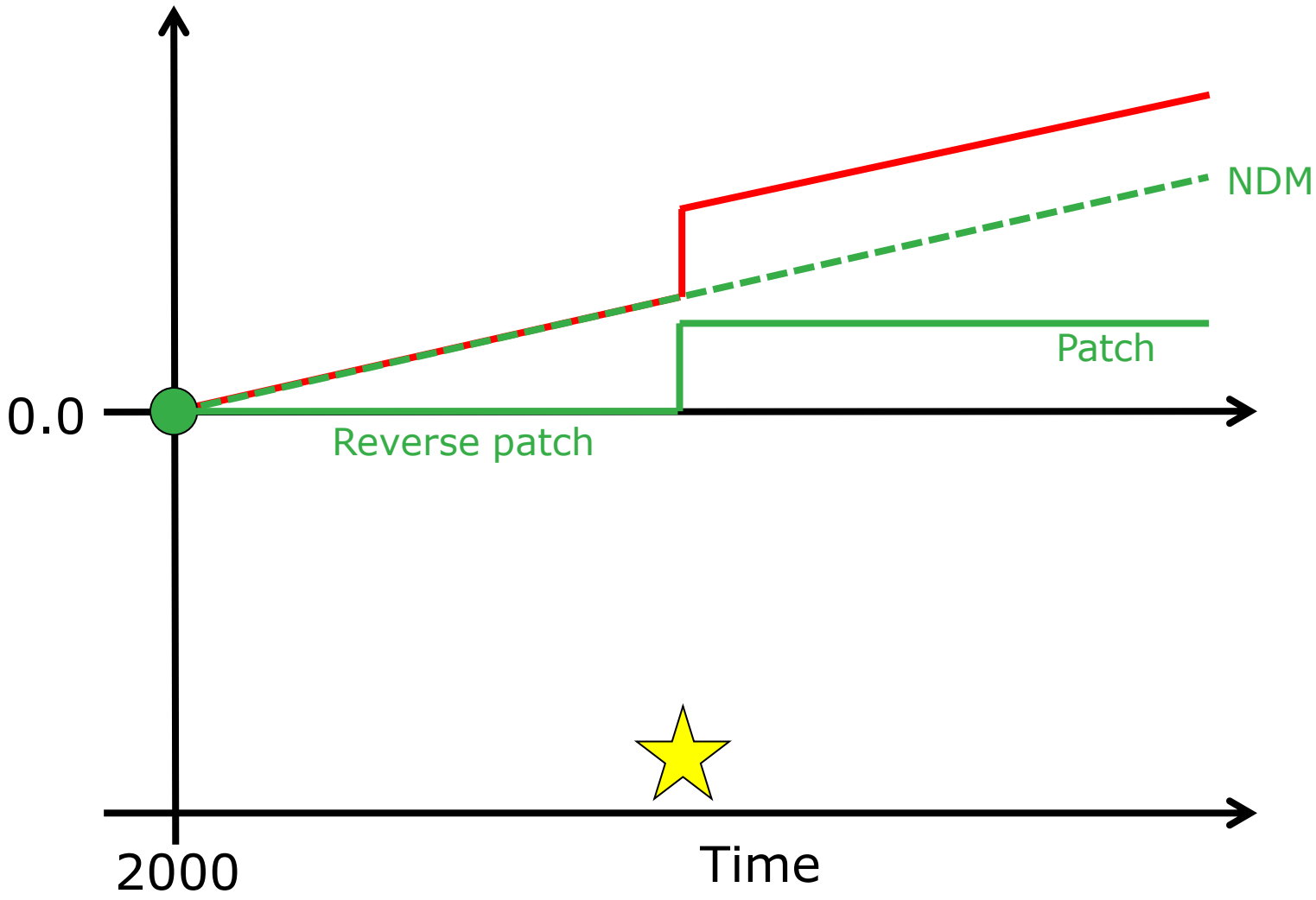

2000
Time


NDM
Patch
0.0
2000
Time


0.0
2000
Time


2000
Time


2000
Time


NDM
Patch
0.0
Reverse patch
2000
Time

Forward and reverse patches

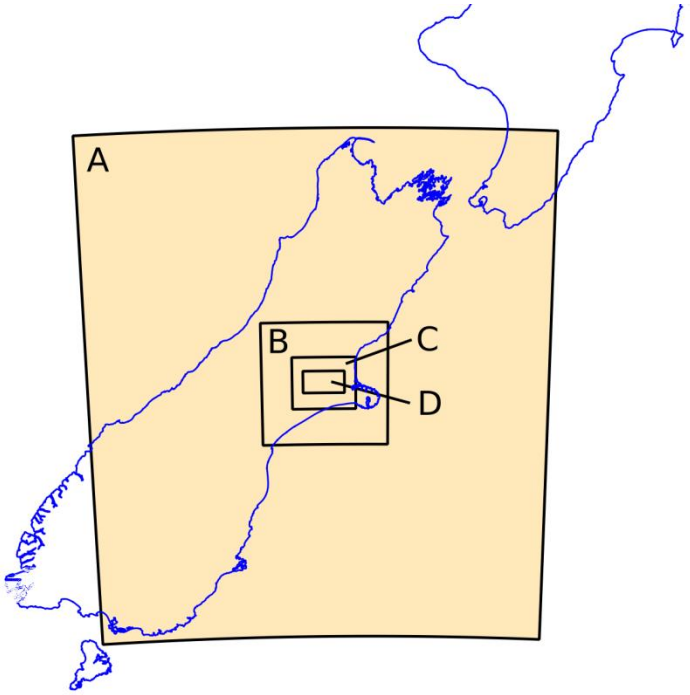
Forward patch	Reverse patch
NZGD2000 coordinates unchanged. Only deformation model updated 	NZGD2000 coordinates and deformation model updated – affects all databases of NZGD2000 coordinates 
NZGD2000 coordinates have poor **current** relative accuracy in affected area 	NZGD2000 coordinates have good **current** relative accuracy 
Patch used to convert coordinates after earthquake 	Patch only used to convert coordinates before earthquake 

- User expectation is that coordinates will change after earthquake
- If using deformation model forward and reverse patches are equivalent

Patches in NZGD2000(20150101)

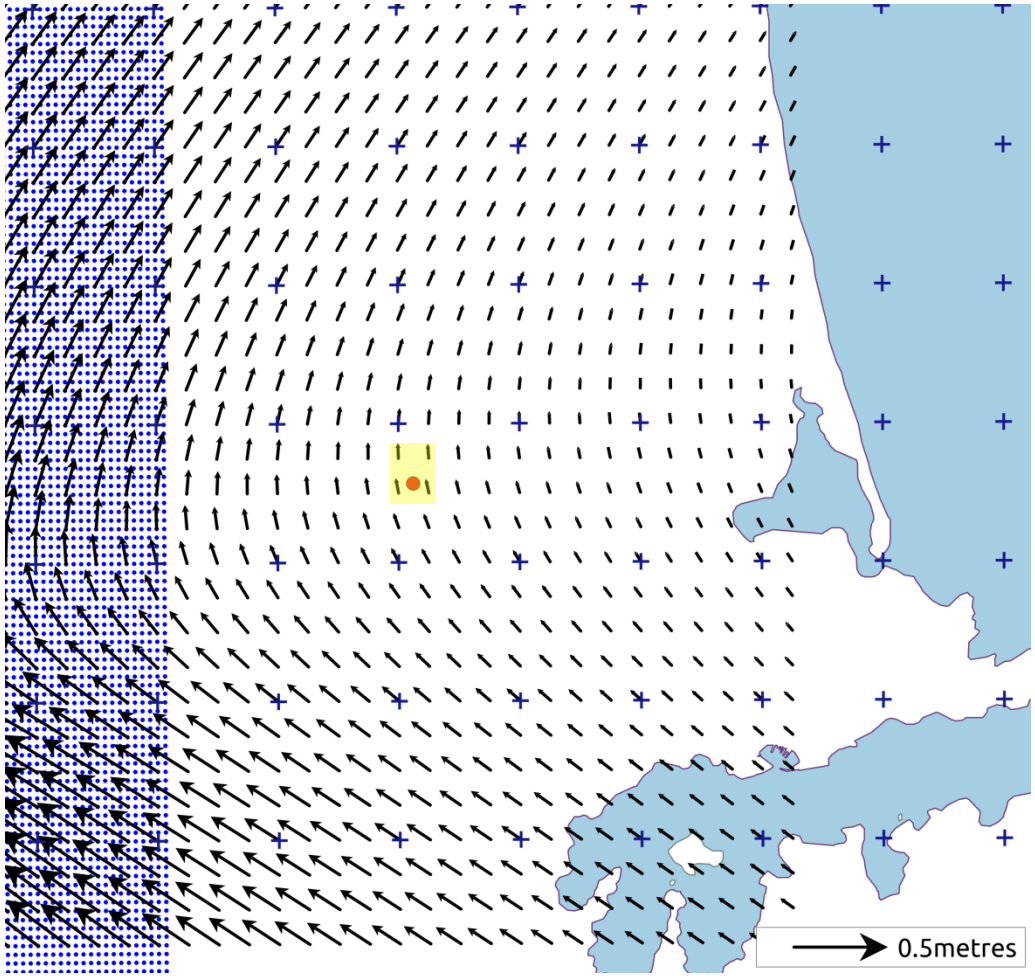
Name	Date	Magnitude	Max Hz (m)	Max Vt (m)
Secretary Island (Fiordland)	22 Aug 2003	7.2	0.27	0.72
Macquarie Island	24 Dec 2004	8.1	0.015	0.005
George Sound (Fiordland)	16 Oct 2007	6.7	0.13	0.27
Dusky Sound	15 Jul 2009	7.8	1.74	0.39
Darfield	4 Sep 2010	7.1	3.20	1.75
Christchurch	22 Feb 2011	6.3	0.31	0.48
Christchurch	13 Jun 2011	6.3	0.22	0.13
Christchurch	23 Dec 2011	6.0	0.25	0.36
Cook Strait	21 Jul 2013	6.0	0.082	0.024
Lake Grassmere	16 Aug 2013	6.6	0.34	0.26

Example of patch grids – 4 September 2010 Darfield

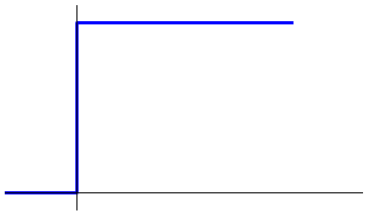


Grid	No Lon	No Lat	Size Lon (deg)	Size Lat (deg)
A	52	54	0.15	0.125
B	50	59	0.075	0.0625
C	84	118	0.0375	0.03125
D	141	306	0.01875	0.015625

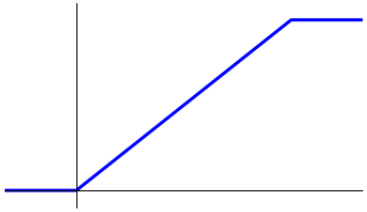
Calculating the patch deformation



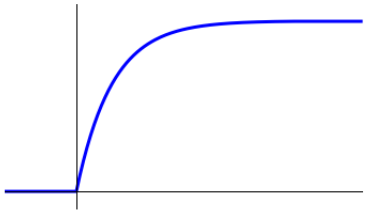
Patch time functions



Step function

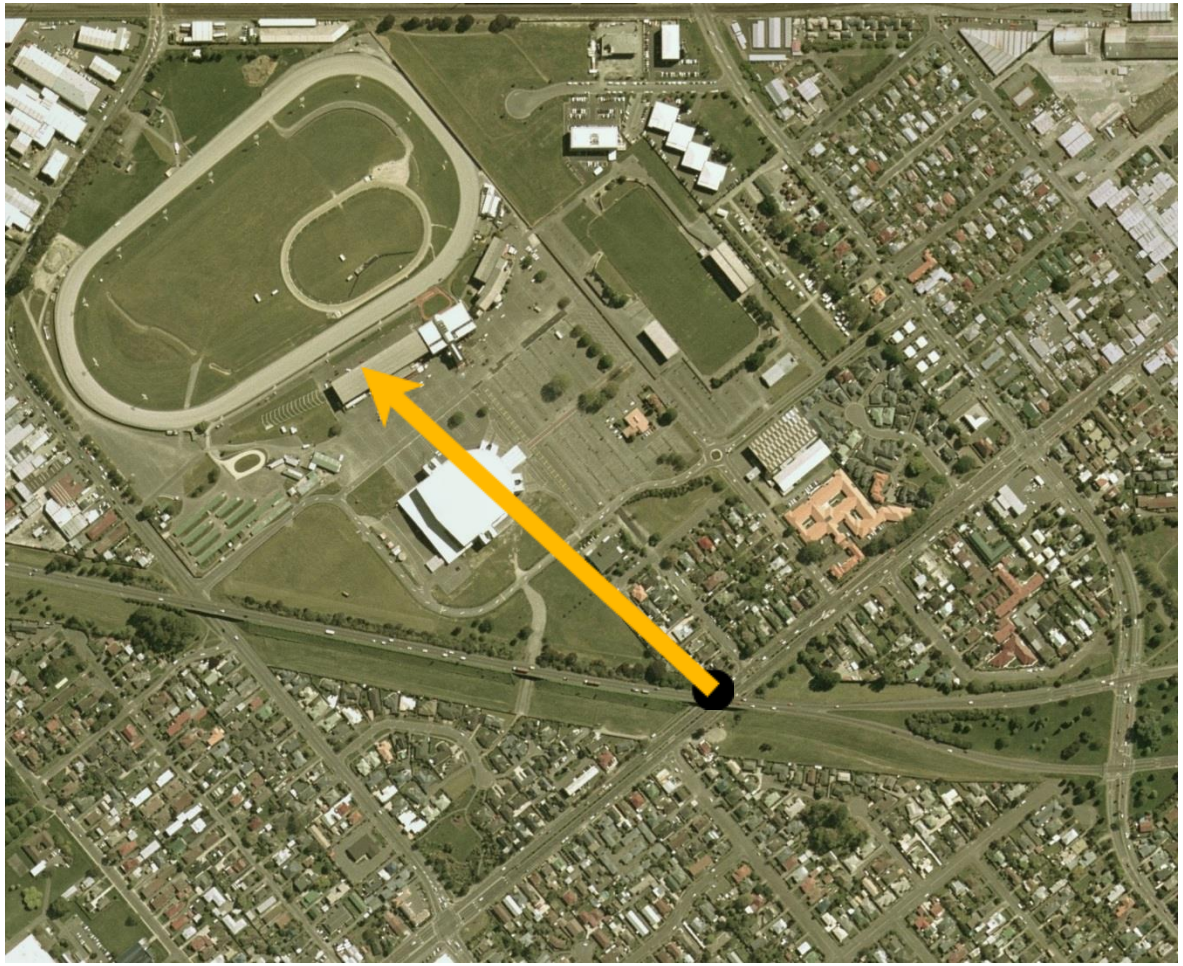


Ramp function



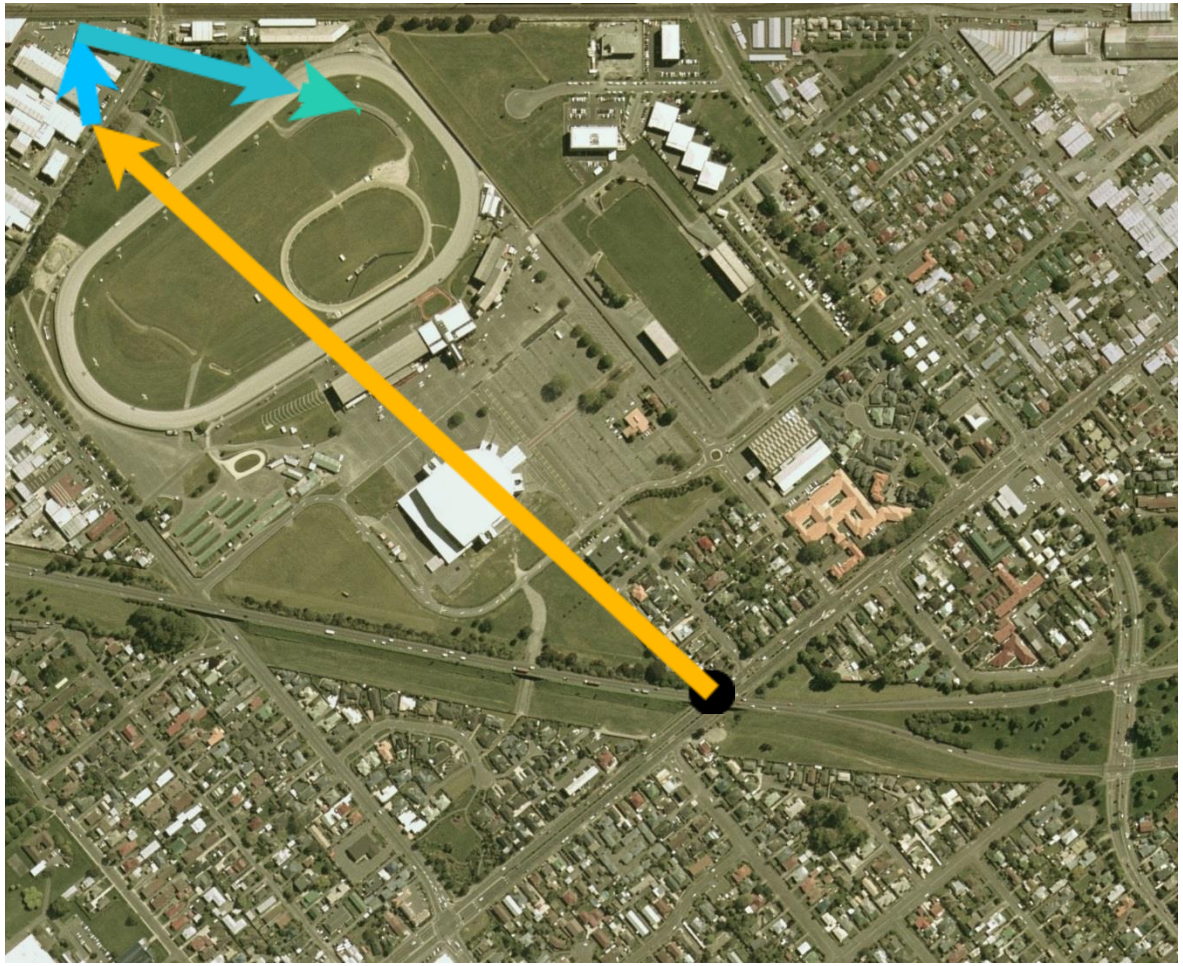
Exponential function

Forward patch deformation at 2010



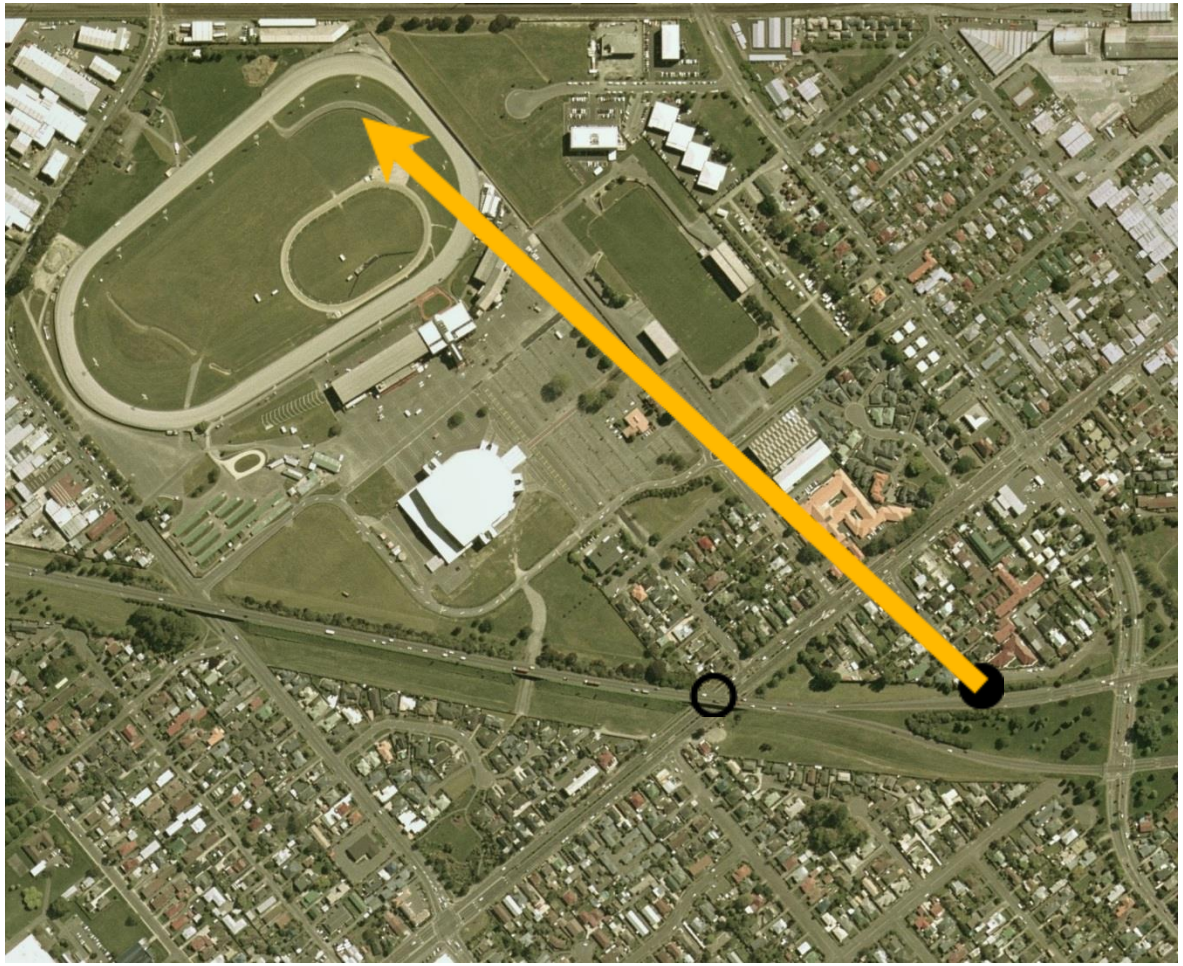
10cm

Forward patch deformation at 2016



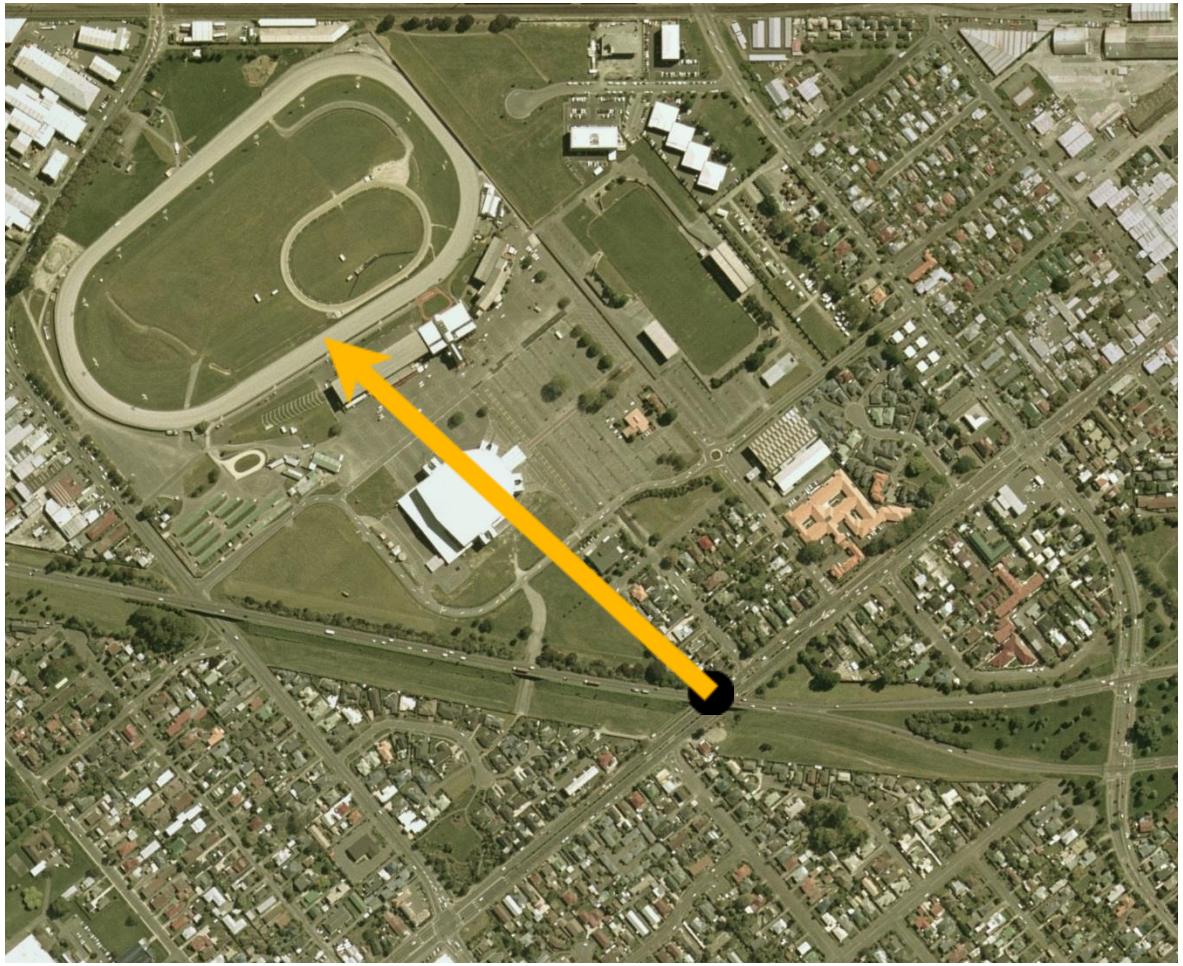
10cm

Reverse patch deformation at 2016



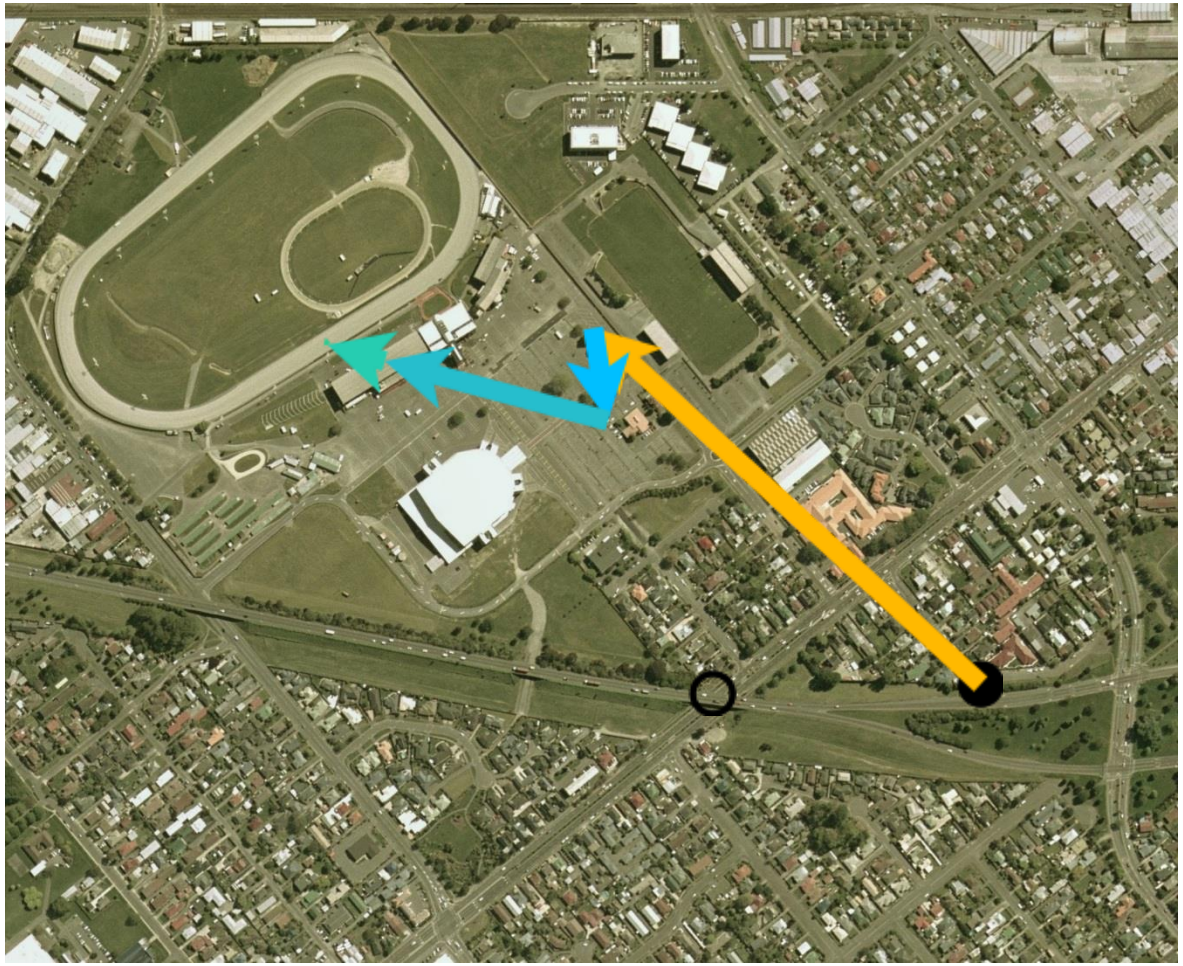
10cm

Forward patch deformation at 2010



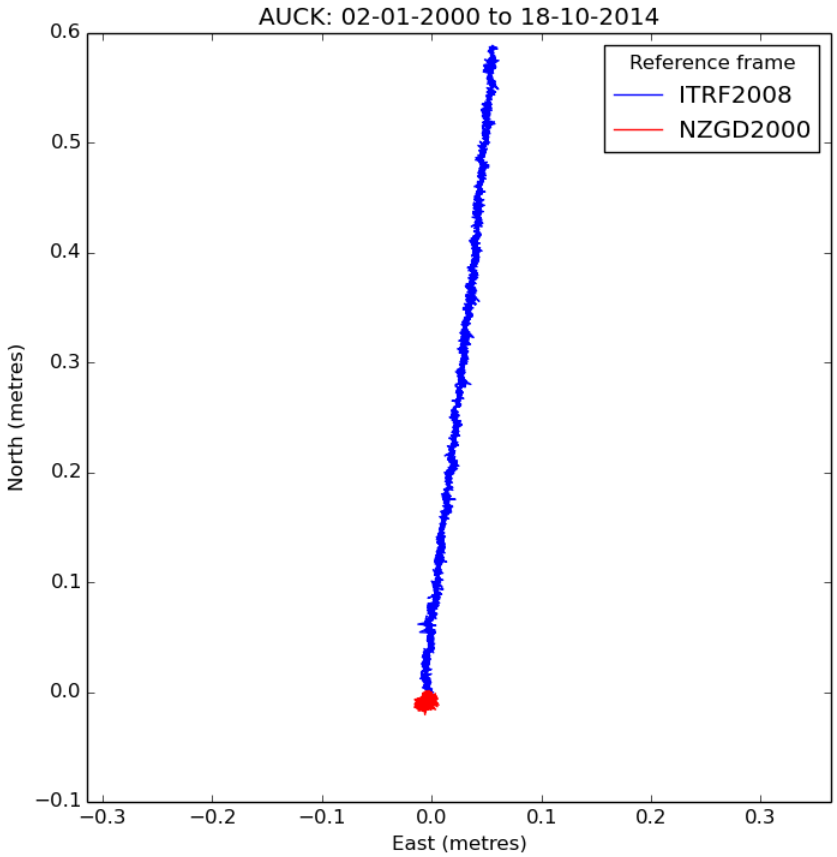
10cm

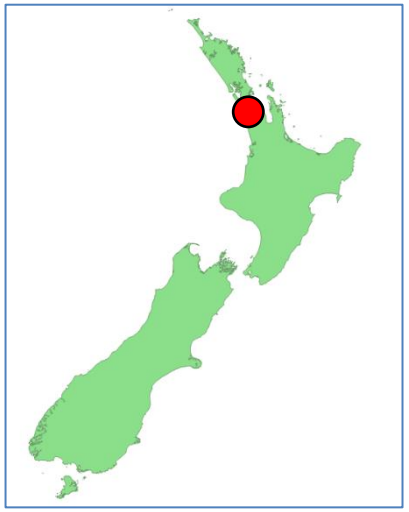
Reverse patch deformation at 2010



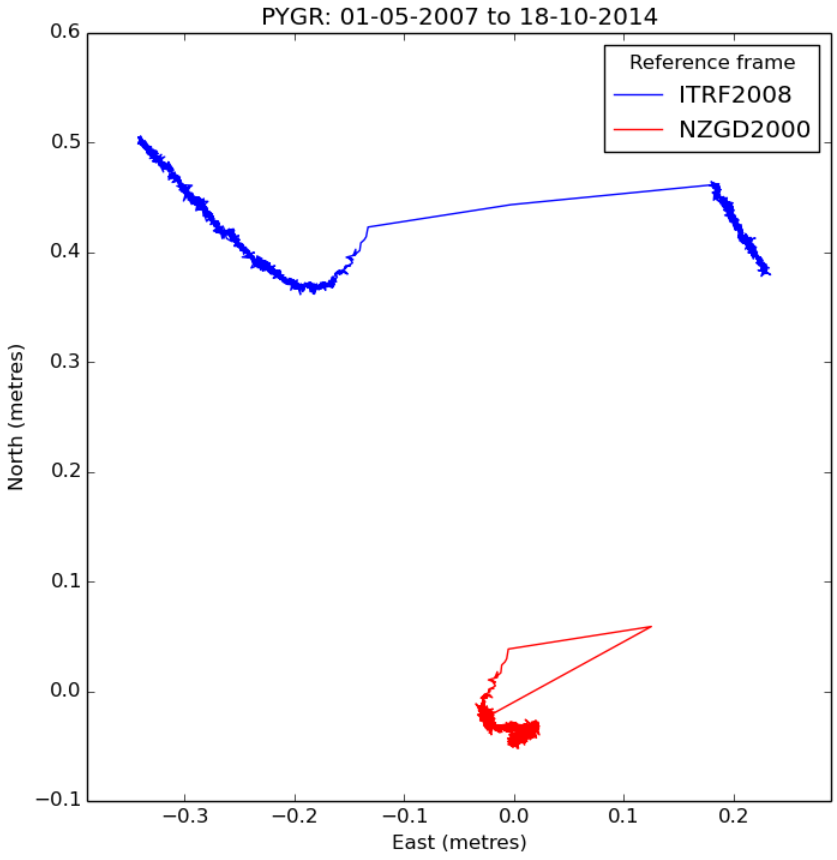
→ **10cm**

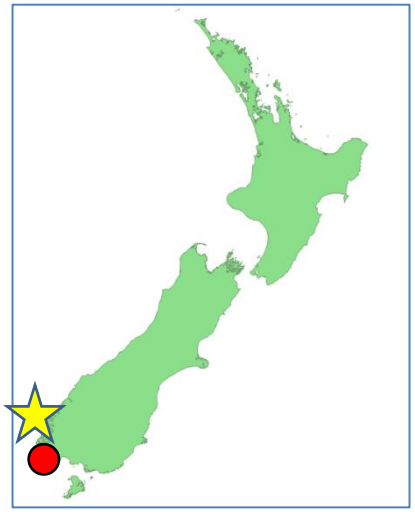
Auckland NZGD2000 time series



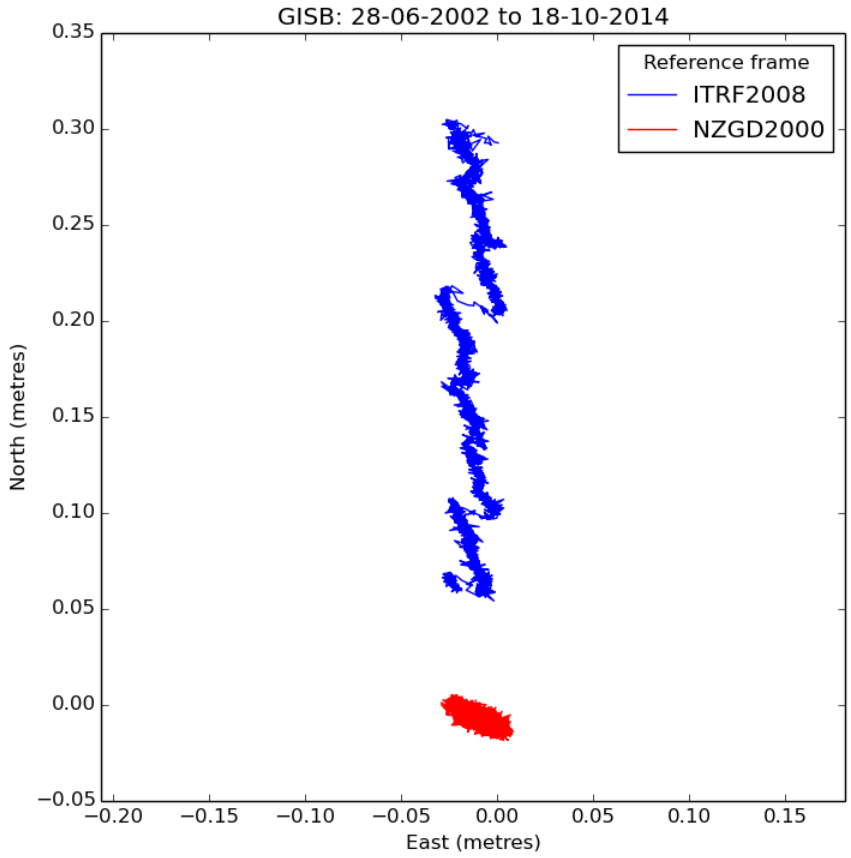


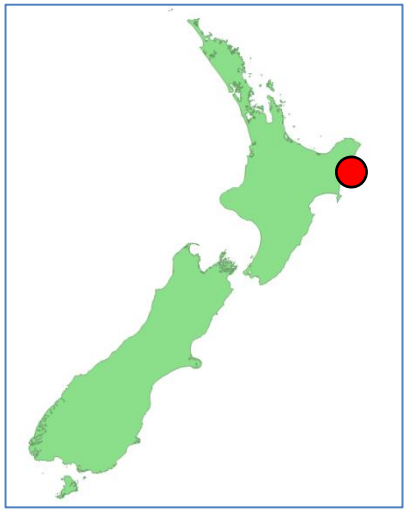
Puysegur NZGD2000 time series





Gisborne NZGD2000 time series

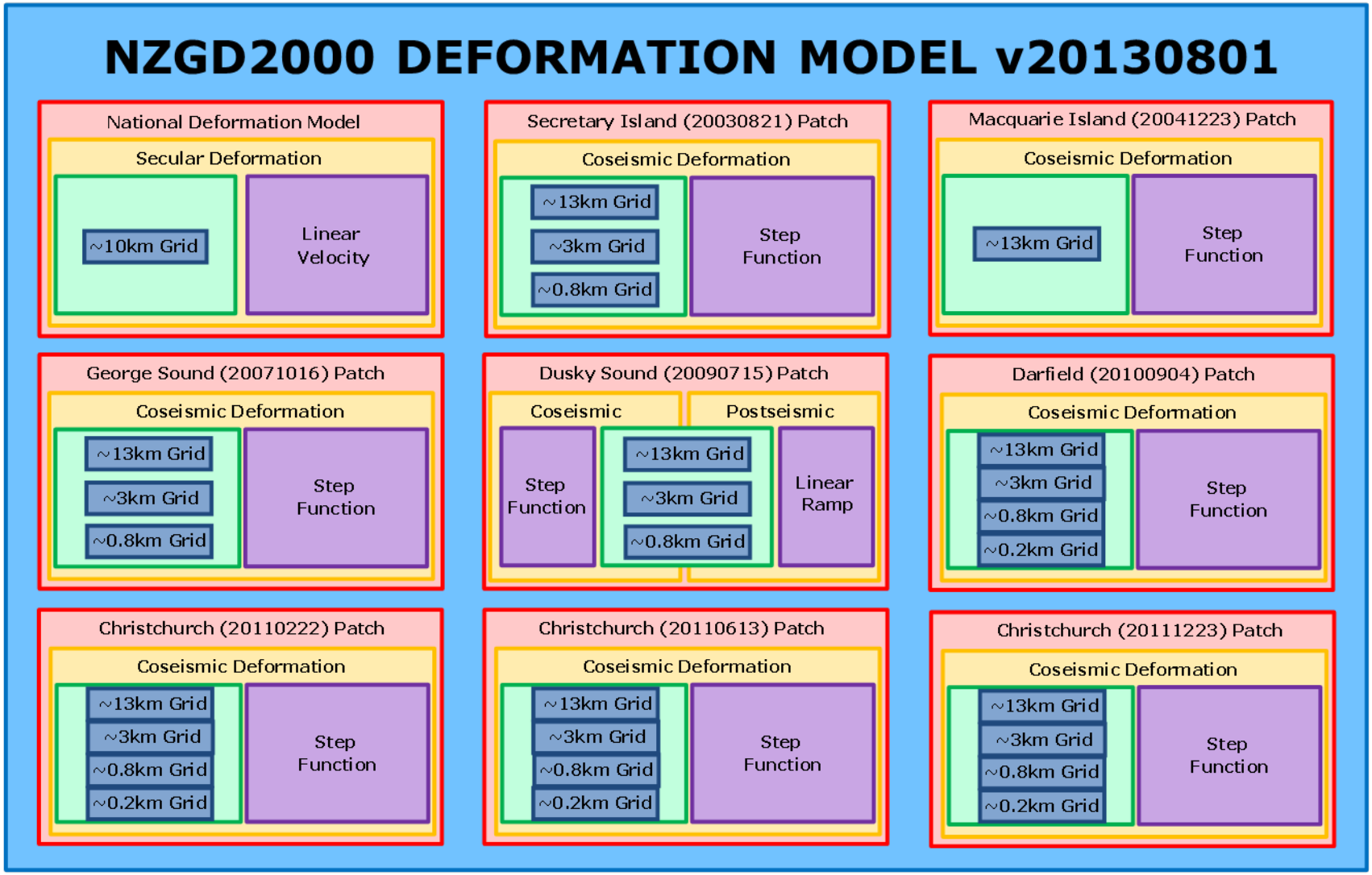




Questions on patching the deformation model

Publishing the deformation model

- Publication format for dissemination
- Based on simple CSV (comma separated value) files
- Model comprises CSV files for each grid, time function parameters, and metadata
- All CSV data compiled into a single.zip file for publication
- .zip file also includes documentation describing format, and example python language implementation of calculation


NZGD2000 DEFORMATION MODEL v20130801
National Deformation Model
Secular Deformation
~10km Grid
Linear Velocity
Secretary Island (20030821) Patch
Coseismic Deformation
~13km Grid
~3km Grid
~0.8km Grid
Step Function
Macquarie Island (20041223) Patch
Coseismic Deformation
~13km Grid
Step Function
George Sound (20071016) Patch
Coseismic Deformation
~13km Grid
~3km Grid
~0.8km Grid
Step Function
Dusky Sound (20090715) Patch
Coseismic
Step Function
Postseismic
~13km Grid
~3km Grid
~0.8km Grid
Linear Ramp
Darfield (20100904) Patch
Coseismic Deformation
~13km Grid
~3km Grid
~0.8km Grid
~0.2km Grid
Step Function
Christchurch (20110222) Patch
Coseismic Deformation
~13km Grid
~3km Grid
~0.8km Grid
~0.2km Grid
Step Function
Christchurch (20110613) Patch
Coseismic Deformation
~13km Grid
~3km Grid
~0.8km Grid
~0.2km Grid
Step Function
Christchurch (20111223) Patch
Coseismic Deformation
~13km Grid
~3km Grid
~0.8km Grid
~0.2km Grid
Step Function

Zip file contents - nzgd2000_deformation_20150101_full.zip

- BUILD
- README
- VERSION
- documentation/NZGD2000DeformationModelFormat.pdf
- documentation/ITRF_to_NZGD2000.pdf
- documentation/calcdeformation.pdf
- model/metadata.csv
- model/metadata.xml
- model/model.csv
- model/version.csv
- model/ndm/component.csv
- model/ndm/grid_igns1998b.csv
- model/ndm/grid_igns2011_nz.csv
- model/ndm/grid_nuvel1a_eez.csv
- model/patch_c1_20100904/component.csv
- model/patch_c1_20100904/grid_c1_L1.csv
- model/patch_c1_20100904/grid_c1_L2.csv
- model/patch_c1_20100904/grid_c1_L3.csv
- model/patch_c1_20100904/grid_c1_L4.csv
- model/patch_c2_20110222/component.csv
- model/patch_c2_20110222/grid_c2_L1.csv
- model/patch_c2_20110222/grid_c2_L2.csv
- model/patch_c2_20110222/grid_c2_L3.csv
- model/patch_c2_20110222/grid_c2_L4.csv
- ....
- tools/...

Contents of metadata.csv

item	value
model_name	NZGD2000 deformation model
description	New Zealand Deformation Model. Defines the secular model (National Deformation Model) and patches for significant deformation events since 2000.
version	20150101
datum_code	NZGD2000
datum_name	New Zealand Geodetic Datum 2000
datum_epoch	2000-01-01
datum_epsg_srid	4167
ellipsoid_a	6378137
ellipsoid_rf	298.2572
authority	Land Information New Zealand
authority_website	http://www.linz.govt.nz
authority_address	Level 7, Radio New Zealand House 155 The Terrace PO Box 5501 Wellington 6145
authority_email	customersupport@linz.govt.nz
source_url	http://www.linz.govt.nz/nzgd2000

Contents of the version.csv file

version	release_date	reverse_patch	reason
20000101	1/01/2000	N	National deformation model - initial version
20130801	1/08/2013	Y	Update of national deformation model. Reverse patches for the following events: Secretary Island, 2003 Macquarie Island, 2004 …..
20140201	1/02/2014	N	Forward patches for events: Cook Strait, 17 July 2013 Lake Grassmere, 16 August 2013
20150101	1/01/2015	N	Extends existing models to cover the New Zealand Exclusive Economic Zone

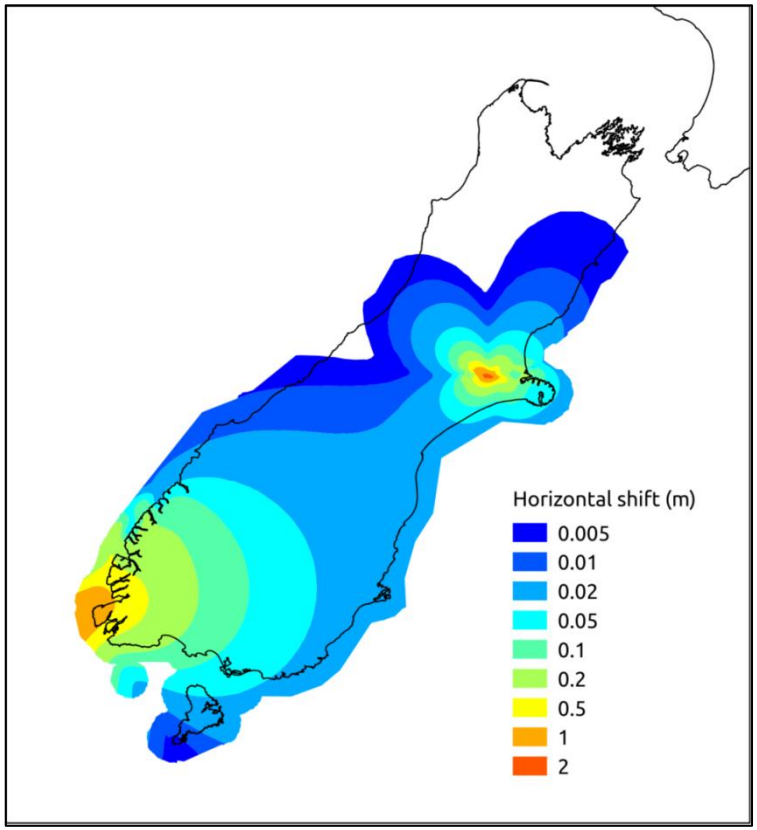
Contents of component.csv file

version_added	version_revoked	reverse_patch	component	priority	min_lon	max_lon	min_lat	max_lat	spatial_complete	min_date	max_date	time_complete
20000101	20130801	N	0	0	165	180	-48	-32	N	0	0	Y
20130801	0	N	1	0	158	194	-58	-25	N	0	0	Y
20130801	0	N	1	1	165.5	179.5	-48	-33	Y	0	0	Y

npoints1	npoints2	displacement_type	error_type	max_displacement	spatial_model
151	161	horizontal	none	0.056	llgrid
73	67	horizontal	none	0.062	llgrid
141	151	horizontal	none	0.062	llgrid

time_function	time0	factor0	time1	factor1	decay	file1	description
velocity	1/01/2000	0	1/01/2001	1	0	grid_igns1998b.csv	Secular deformation model …
velocity	1/01/2000	0	1/01/2001	1	0	grid_nuvel1a_eez.csv	Secular deformation model …
velocity	1/01/2000	0	1/01/2001	1	0	grid_igns2011_nz.csv	Secular deformation model …

Reverse patches: Applying the 20130801 reverse patch



Landonline updates

7,876,563 coordinates
2,215,410 nodes
2,745,690 lines
543,787 parcels
48,629 roads

Cadastral layers only updated where the change is greater than 5cm

Support for upgrading GIS data sets

- Coordinate shift model published (gridded model defining coordinate changes from reverse patch)
- Two formats: basic CSV format, and NTv2 grid format useable by many GIS software.
- Online educational material (eg how to apply coordinate update to GIS data)

The future for the NZGD2000 deformation model

Vertical deformation:

- Understanding vertical deformation very valuable
- Should it be incorporated in NZGD2000 deformation model

Improving the deformation model

- InSAR – improving the spatial and temporal resolution. Reducing latency

Improving usability

- Standards for distribution, binary format (HDF5?),
- Support in GIS software (eg PROJ coordinate conversion)
- Support in real time positioning products