A Two-Frame Spatial Referencing System Accounting for Geodynamics

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Outline

The Changing Role of National Reference Frames

The Two-Frame System

Case Study: New Zealand
The Changing Role of National Reference Frames

The Two-Frame System

Case Study: New Zealand

Current Role of the National Reference Frame

Consistent spatial references to facilitate data integration
Near-Future of Positioning

Unmanned Aerial Vehicles
Intelligent Transportation Systems
Consumer “Smart” Devices

10cm positioning in terms of ITRF at current epoch

User Requirements of a National Reference Frame

Unchanging coordinates
Local frame
Relative accuracy
ITRF
Absolute accuracy
The Changing Role of National Reference Frames

The Two-Frame System

Case Study: New Zealand

Global vs Local Frame

<table>
<thead>
<tr>
<th>Global</th>
<th>Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driven by geodetic requirements</td>
<td>Flexibility to account for local user requirements</td>
</tr>
<tr>
<td>Time-varying coordinates</td>
<td>Time-invariant coordinates</td>
</tr>
<tr>
<td>Plate motion and/or deformation models to</td>
<td>Plate motion and/or deformation models to generate reference coordinates</td>
</tr>
<tr>
<td>propagate coordinates between epochs</td>
<td></td>
</tr>
<tr>
<td>Native system for modern positioning</td>
<td>Modern positioning techniques (GNSS) require</td>
</tr>
<tr>
<td>techniques (GNSS) and non-specialist users</td>
<td>transformation to the local frame</td>
</tr>
</tbody>
</table>

Global Commission 1 Symposium 2014: Reference Frames for Applications in Geosciences (REFAG2014)
13-17 October, Kirchberg, Luxembourg
Two-Frame Referencing System

IAG Commission 1 Symposium 2014: Reference Frames for Applications in Geosciences (REFAG2014)
13-17 October, Kirchberg, Luxembourg

Non-Deforming Region

IAG Commission 1 Symposium 2014: Reference Frames for Applications in Geosciences (REFAG2014)
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Deforming Region

ITRF

Secular deformation → Deformation Model → Non-secular deformation

Local frame

The Changing Role of National Reference Frames

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New Zealand

New Zealand Active Faults

Source: GNS Science
Deformation Model for ITRF Coordinate Propagation

Secular Deformation Distortion

Max distortion > 0.5 ppm/year
Max distortion 0.2-0.5 ppm/year
Secular Deformation

National Deformation Model
Secular Deformation

~10km Grid
Linear Velocity

Secular Deformation Distortion

0.10m difference in baseline over 20 years

Max distortion > 0.5 ppm/year
## Significant Earthquakes 2000-2013

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

- **Canterbury**
- **Fiordland**
- **Marlborough**
Canterbury Earthquakes Submodels

22 Feb 2011
Christchurch Earthquake
100 ppm max distortion
Summary

- The spatial/mapping community is not yet ready for kinematic coordinates, but positioning is increasingly ITRF-based
- A two-frame system formalises existing practice, provides a transition to ITRF and supports multiple communities
- Deformation models accounting for geodynamics are critical for both frames, but the use may be slightly different

Thank-you

- Acknowledgement: Deformation model for New Zealand developed from source models developed by John Beavan and Ian Hamling of GNS Science