Impacts of Crustal Deformations in North Borneo

Background
The island of Borneo is considered being part of the Sundaland block along its eastern margin. In North Borneo, the highest mountain on Sundaland is situated: Mount Kinabalu with a height of ~4100 meters. North Borneo seems to be also still deforming in a different way. The North Borneo region appears to be actively deforming therefore, not making up a rigid part of Sundaland. Deformation of western parts of North Borneo appears to be driven by gravity gliding due to frontal fold-and-thrust belts. However, the north-west of North Borneo is exhibiting different deformation patterns and the driving force behind it is part of an already long-lived scientific debate. Accurate estimates on ongoing vertical displacement are required to obtain better insight.

Global Navigation Satellite System (GNSS) is an excellent tool to study crustal motion and deformations in detail. Since 2007, the Department of Surveying and Mapping Malaysia (DSMM) has established additional continuous GNSS stations along the coastal area of North Borneo. The primary limits in previous researches were due to the lack of sufficient continuous GNSS (CGNSS) station coverage in the area.

Time Series

Acknowledgements
We would like to thank the Universiti Teknologi MARA (UiTM) and the Ministry of Education Malaysia for their PhD funding, the Department of Surveying and Mapping Malaysia (DSMM) for sharing the MyRTKnet CGNSS data, Universiti Teknologi Malaysia (UTM) for their scientific (GNSS,InSAR) joint analysis and the Sabah Parks for their cooperation in establishing and maintaining the CGNSS station at Mount Kinabalu.

Parameter | Technique/model
--- | ---
Data interval | 5 minutes
Cut-off angle | 7 degrees
Differential technique | Zero differences
Linear combination | Atmosphere free
Tropospheric mapping | VMF1
Ocean loading | FEJ2004
Ambiguity fixing | Ambizap3

Daily solutions were combined into multi-day averaged solutions as follows:
- Days : 7 day-average
- Outlier detection : Median Absolute Deviation
- Reference frame : ITRF2008
- Mapping : 12-20 well-defined IGS subnetwork / e-file
- Transformation : 7-parameter Helmert

Sundaland Pole Estimation

<table>
<thead>
<tr>
<th>Item</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNSS data range used</td>
<td>1999 - 2004</td>
</tr>
<tr>
<td>No. of Malaysia stations (available)</td>
<td>15 – 18 stations</td>
</tr>
<tr>
<td>No. of Indonesia stations (available)</td>
<td>3 – 7 stations</td>
</tr>
<tr>
<td>No. of Thailand stations (available)</td>
<td>3 – 6 stations</td>
</tr>
<tr>
<td>No. of IGS stations (mapping)</td>
<td>27 – 29 stations</td>
</tr>
<tr>
<td>No. of stations used (pole estimation)</td>
<td>12 stations</td>
</tr>
<tr>
<td>Latitude of pole</td>
<td>49.98°N</td>
</tr>
<tr>
<td>Longitude of pole</td>
<td>89.89°W</td>
</tr>
<tr>
<td>Rotation of pole</td>
<td>0.3382°/Myr</td>
</tr>
</tbody>
</table>

Establishment of Station MKNB (Mount Kinabalu)

North Borneo Motion

Progress and Objectives
Additional Malaysia GNSS data for 2012 and 2013 have been received last April and 80% of the processing is completed. This will provide better velocity estimations with a time span of up to 5-year available. A year data-span at station MKNB will provide significant insight in the going vertical movement there, relative to the 2009-2013 vertical velocities of ready CGNSS sites. The aim is to produce two journal papers in geodesy and geodynamics research field. The paper for geodesy field is in progress and estimated to be completed in July.