1. Introduction

- 3-D models of the crust and upper-mantle are required to model the travel-times of the regional phases and better constrain event epicentre
- Late 1990s, an extensive, collaborative calibration effort was carried out to determine regional travel time models for:
  - Northern Eurasia,
  - Fennoscandia,
  - North America
- The resulting models are currently in use in provisional IDC operations for:
  - 44 of the 150 IMS stations [29%]
  - 16 of the 45 Primary stations [36%]
  - 61 of the 105 Auxiliary stations [27%]
- More recently, US has donated the RSTT model and software to provide a framework to extend regional models globally (Figure 1)
- The IDC has studied replacing its current regional models with the RSTT model (e.g., Given, 2014)

2. RSTT model development

- Numerical RSTT versions / 3.0 models:
  - 2.8.2 / nov 2010 – released January 2012
  - 2.8.4 / rev 3 – released February 2012, included minor modifications to the code
  - 3.0.0 / rev 3.3 – released June 2013, included GeoTess
  - 3.0.2 / rev 3.3.2 – released October 2013, fixed bugs in code
  - 3.0.4 / rev 3.3.4 – released October 2014
- Compared to previous RSTT versions 3.0.4 includes:
  - New 2.0 starting model and global tomographic data set of Pn, Pg, Sd, and Sg phase observations
  - Improved computational performance of the natural neighbour interpolation algorithm in GeoTess
  - Velocities have been modified, particularly (Fig. 2):
    - Southern hemisphere
    - Mantle velocity and gradient
- Travel times are significantly altered in places (e.g., PETK), while in other places it is similar (e.g., KBZ) (Fig. 3)

3. REB Pn time residuals: comparing SSSC and RSTT corrections

- What is the effect of using RSTT instead of SSSC in provisional operations?
  - Typically SSSC and RSTT correction surfaces are similar (Fig. 3 & 4)
  - Assess residuals of analyst time-defining Pn in the Reviewed Event Bulletin (REB)
  - Event Selection:
    - 10 years of REB data from Jan. 2004 – Dec. 2013 select events with:
      - Number of stations NSTA ≥ 10
      - Source depth h ≤ 40 km
      - Distance D ≤ 15° to a station with a SSSC
- Pn time is defined
  - Resulting in 13,645 events (Fig. 5)

- Calculate SSSC and RSTT (3.0.4 & 2.8.4) corrections for each event (setting h = 10 km as proposed for integration by IDC)
- Compare:
  - Pn residual from SSSC (SSSC_s)
  - Pn residual from RSTT (RSTT_s)
- Overall results (Fig. 6):
  - Centered on 0 s
  - Range ± 2.5 s (analytical guidelines)
  - ± SSSC_s correlation ± RSTT_s correlation

- Individual station results:
  - We calculated:
    - Mean and 95% confidence interval for each station (Fig. 7)
    - Median and 25th / 75th percentiles for each station (Fig. 7)
  - RSTT is less scattered compared with (Ref?/I91 results
  - Outliers include:
    - PDAR (Primary IMS station, USA)
    - QBN (Auxiliary IMS station, Russian Federation)
  - Extrapolation (e.g., Given, 2014)
  - Path-dependent residuals (e.g. Begnaud et al., 2015)

4. Travel time uncertainty and Pn picks at D ≥ 15°

- Travel time uncertainty variation:
  - Uncertainty for model rev 3.2.3 included a “correction” for “pick error” – error likely
  - Uncertainty for model 3.0.4 includes the pick error
  - Problems with interpolation (Fig. 10)
  - How do we combine RSTT model uncertainty with the IDC uncertainty calculation?
    - IDC uncertainty model variance + signal-to-noise dependent variance
  - What about Pn picks at D ≥ 15°?
    - RSTT model extends to 15°, yet analysts can pick Pn to 20° (Fig. 11)
  - What about P-wave triplication at ~18°?
  - Extrapolation (e.g., Given, 2014)
  - Path-dependent residuals (e.g., Begnaud et al., 2015)

5. Summary

- RSTT (3.0.4) is based on a global tomographic data set of Pn, Pg, Sd, and Sg phase observations
- In places travel times and velocities are significantly altered, while in other places they are similar
- Pn residuals from the simulated RSTT corrections compare well with the residuals from SSSC corrections applied in IDC provisional operations, and are less scattered than residuals due to the simulated I91 model
  - How to incorporate RSTT uncertainties in provisional IDC operations?
    - How does pick error affect the travel time model?
    - How to make RSTT model uncertainty consistent with the analyst guidelines?
  - A data set is now available on the IDC external database that used RSTT (3.0.4) to process data recorded by the
  - Possible methods to extend travel time uncertainty beyond 15°:
    - Extrapolation (e.g., Given, 2014)
    - Path-dependent residuals (e.g., Begnaud et al., 2015)

References

Given (2014), Status of Integrating RSTT into IDC processing, WEG42.
Begnaud et al. (2015), Developing path-dependent uncertainty estimates for use with the regional seismic travel time (RSTT) model, Science and Technology conference.

© British Crown Owned Copyright 2015/MOD