Time Series Analysis using FODITS

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Introduction

Today many reprocessing efforts of GNSS data are initialized for global, regional, or even local networks. Even such homogeneously processed time series will contain outliers and discontinuities. Because of the big number of stations and the length of the series over many years an automated tool is necessary to detect such events.
Recently the Bernese GPS Software (BSW, Dach et al. 2007) has been extended by the program FODITS (Find Outliers and Discontinuities in Time Series, Ostini et al. 2009). Basically, the program tries to optimally represent a time series by a set of components (station coordinates and velocities, discontinuities, outliers, changes in the velocity, periodic functions) of a functional model. It provides the following functionality:

- ✓Predefined elements of the functional models (e.g., discontinuity at the epoch of an equipment change) are tested for their significance.
- ✓Epochs with other significant discontinuities, velocity changes, and outliers may be identified.
- ✓Significant periodic functions may be added to the functional model.
- ✓Combined processing of up to three components of a time series (e.g., three coordinate components).
- ✓The algorithm is fully generic allowing to process nearly all types of time series (e.g., mean orbital elements or even differential code biases).
- ✓The spatial variance information may be considered.

The program FODITS interacts with other components of the BSW mainly via a station information file, a key component for station handling in the BSW.

Algorithm and its Realization

The Nassi-Schneidemann diagram (norm DIN-66261) of the algorithm implemented in FODITS is given in Figure 1. The input and output files are in internal formats of the BSW for station coordinates (CRD), velocities (VEL), plotting time series (PLT), and station information (STA). A detailed description is given in Ostini et al. (2009).

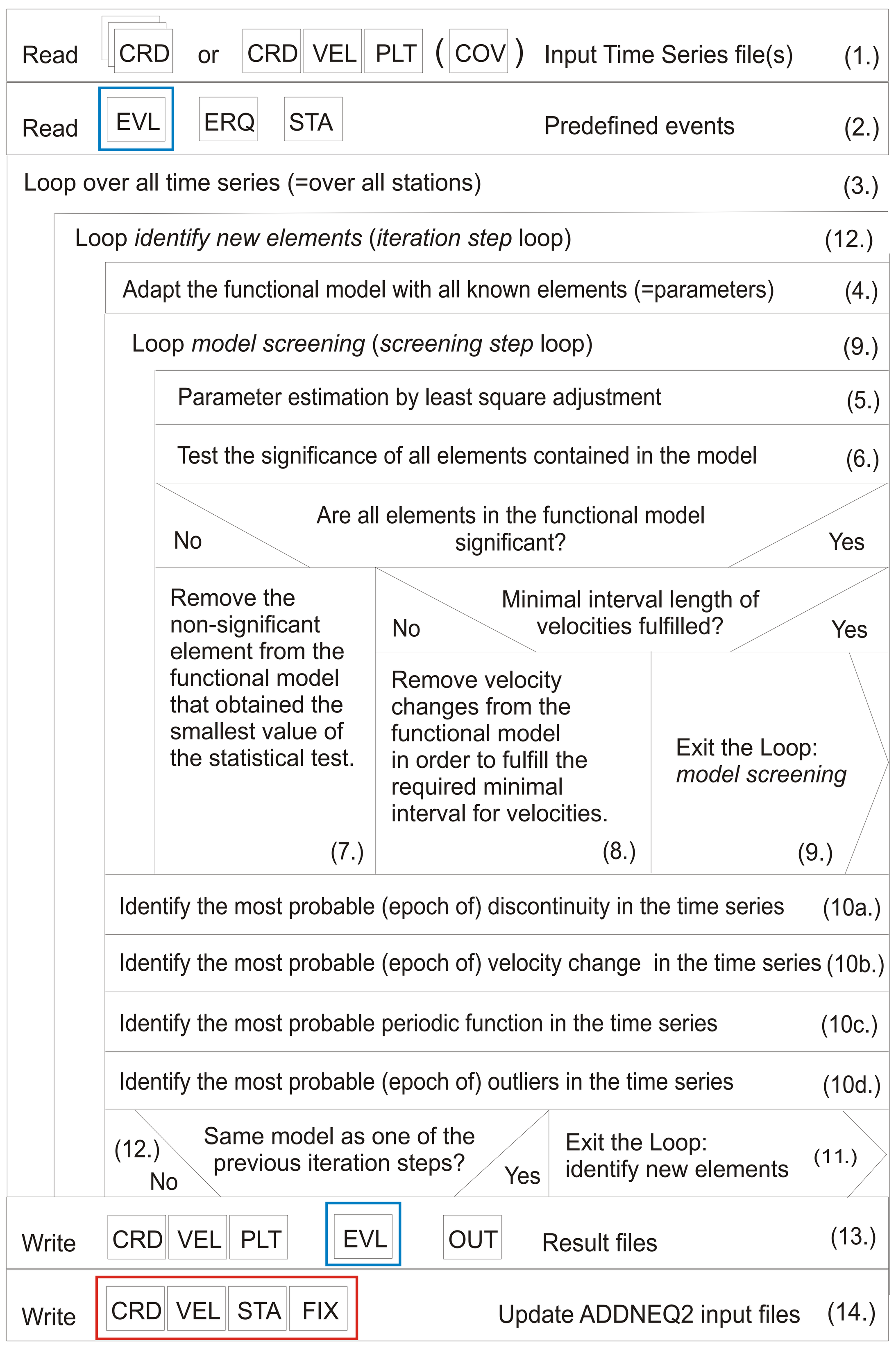
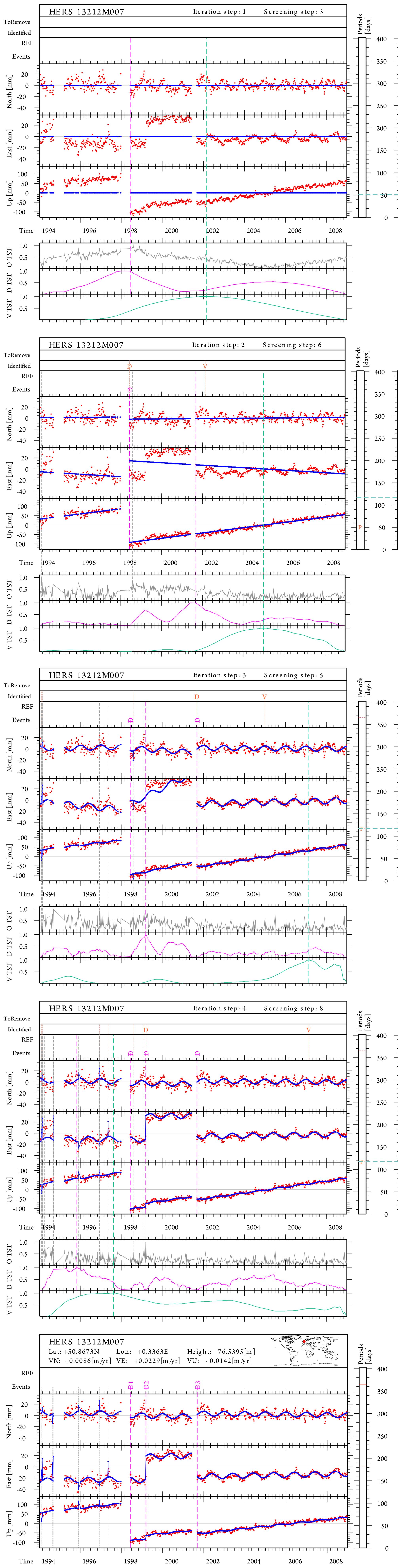


Figure 1: Nassi-Schneidemann diagram of the algorithm implemented in FODITS.

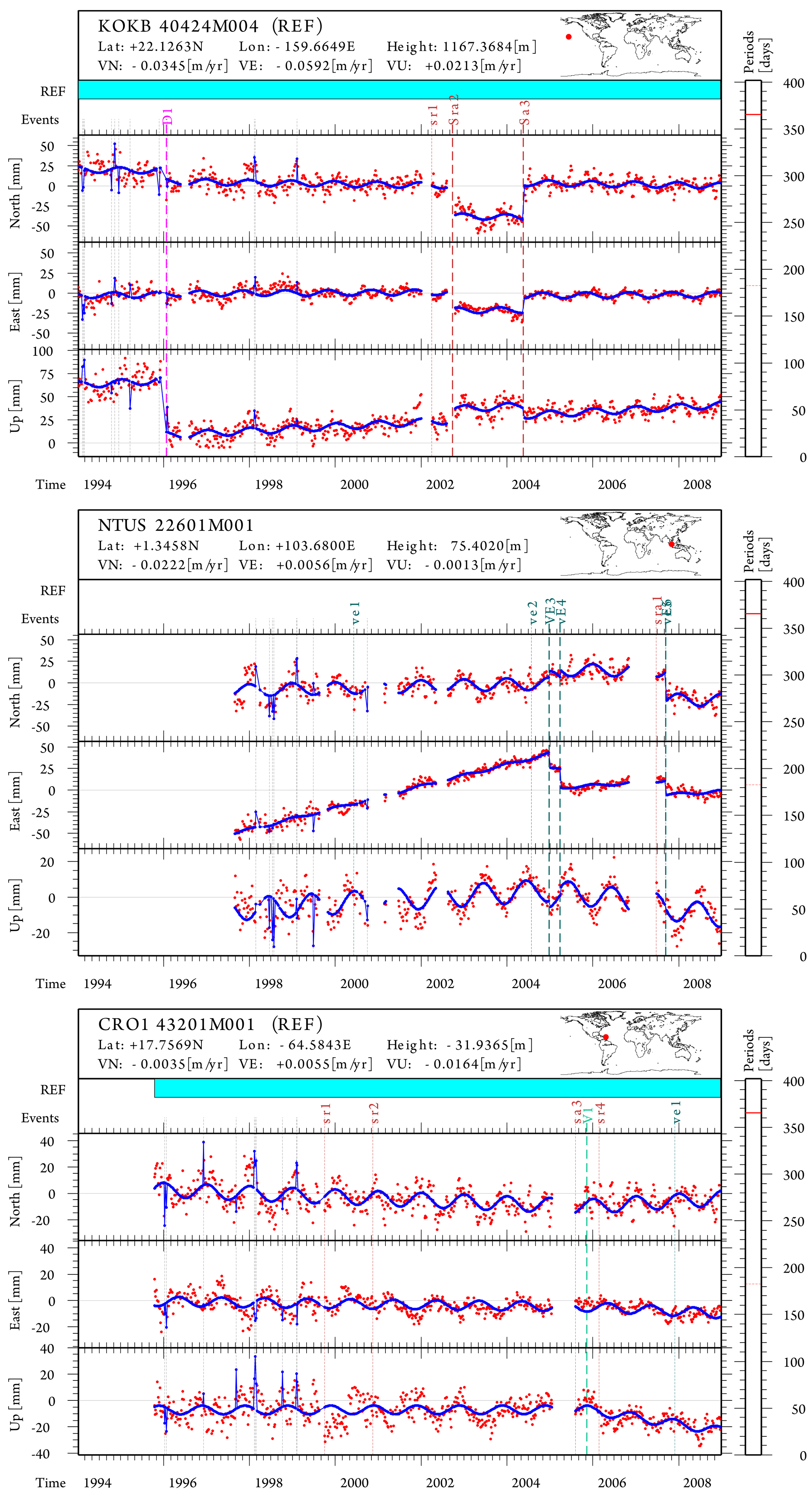
Starting from predefined elements for the functional model all non-significant elements are removed (screening steps). In the next step, a new component is added to the functional model that most likely helps to improve the representation of the time series. This might be a discontinuity, a velocity change, outlier, or a periodic function. If this new element provides a significant improvement of the representation of the original time series again all predefined elements are added and the algorithm starts its next iteration. This cycle is repeated until the lastly added component of the functional model does not improve the representation of the original time series anymore.

The next element to be added to the function model is defined by the analysis of test functions for outliers (O-TST), discontinuities (D-TST), velocity changes (V-TST), and periodic functions (P-TST). After four iterations the final functional model is achieved containing three discontinuities, eight outliers, and a yearly periodic function. The development of the functional model is provided in Figure 2 for the coordinate time series from the CODE contribution of the IGS repro1 effort (Steigenberger et al., 2009).



Figures 2: Development of the functional model to represent the coordinate time series for HERS using FODITS.

FODITS Analysis Results of Coordinate Time Series



Figures 3: FODITS analysis of CODE reprocessed weekly time series.

More examples for coordinate time series processed by FODITS are provided in Figure 3.

FODITS Analysis of Other GNSS TS

GNSS time series (up to 3 components) can be analyzed by FODITS. Figure 4 illustrates, e.g., the analysis of P1-P2 DCB correction time series for the station AMC2. The bottom time series of the figure shows the residuals with respect to the adapted functional model.

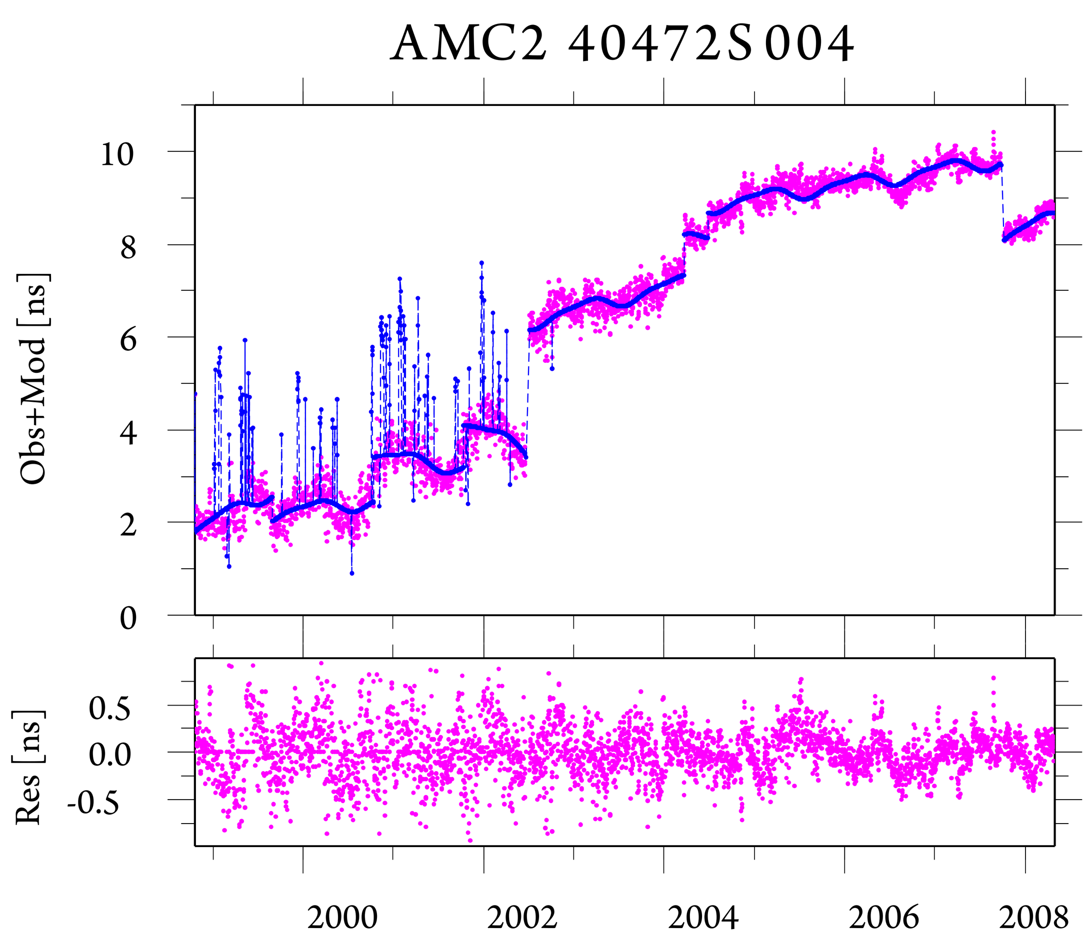


Figure 4: Differencial Code Bias (DCB) P1-P2 time series of **AMC2** analyzed be FODITS.

References
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Steigenberger, P., S. Schaer, S. Lutz, R. Dach, L. Ostini, U. Hugentobler, H. Bock, A. Jäggi, M. Meindl, D. Thaller: CODE Contribution to IGS Reprocessing: Status and Perspectives; European Geosciences Union General Assembly 2009, Wien, 21.04.2009.

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