Comparison of european network solutions

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Abstract:
In the last years European VLBI arrived at high efficiency. The number of stations increased and the frequency of campaigns was forced. The accuracy of station coordinates is about several millimeters and the formal errors of the horizontal motions are less than 1 mm per year. In Europe different groups analyse the observed data and provide results, which should in fact converge. In order to investigate this question an analysis was performed, which compares the analysis strategies and the results of the different groups in order to assess the consequences of the individual approaches.

1 Introduction

In Europe different groups work on the data analysis of VLBI–observations and all these groups use their own strategy and method of data analysis. Independent of these different procedures the result should remain the same. Thus one requires to comply with the

> **Principle:**
> *The determination of a parameter by different methods*
> *has to lead to the same result.*

Object of this presentation is to check, whether the different european network solutions fulfil this requirement. Surely contradictions are of special interest, because these need an exact explanation and therewith a detailed investigation.

2 Comparison

In order to make a comparison possible at all a common basis is needed. For this purpose the following odds were given. The NNR–NUVEL–1a should be used as drift model and the ITRF 1996 should serve as apriori station coordinates. The parameter estimation especially should provide and submit the station velocities of european stations with respect to NNR–NUVEL–1a in Up, East, North. The other aspects concerning the parameter estimation respectively solution were at disposal.
The following tables show the frame and general design of this comparison. In general the used software is CALC/SOLVE, but *Titov* used OCCAM. The session types as well as the time span are nearly the same, except for *Tomasi*, who used not only Europe–campaigns, but all experiments with at least three european stations from December 1987 to October 1998.
Table 2 shows, that the source coordinates are different, but this should have no significant influence on the parameter estimation, because the coordinates only slightly differ. On the contrary the different choice of the earth orientation series could cause a small rotation of the network.
The setup of the parameter estimation is nearly the same, but the modes of determination of the station velocity are different. Two methods were applied. The **direct method**, which determines the delay in the adjustment by immediate estimation and the **indirect method**, which is a two step

procedure. In a first step the station coordinates are estimated for each epoch and in a second step the station velocities are derived from this time series of station coordinates.
The differences of these two procedures as well as the advantages and disadvantages will become evident especially in the solution of *Tomasi*, who used the direct method, and *Nothnagel* & *Haas*, who used the indirect method.

	LANOTTE	TITOV	TOMASI	NOTHNAGEL & HAAS
USED SOFTWARE	F–SOLVE V98/08/09	OCCAM 3.4	F–SOLVE V98/11/25	CALC8.2/SOLVE
SESSION TYPES	EUROPE campaigns	EUROPE campaigns	all exp. with 3 european stations	EUROPE campaigns
TIME SPAN	Jan 1990 to Jun 1998	Jan 1990 to Jul 1998	Dec 1987 to Oct 1998	Jan 1990 to Oct 1998

Tab. 1: Software, sessions and time span

Before comparing the results a further note is necessary. The estimated station velocities of *Titov* have to be considered as preliminary ones, because it seems, that there is a mistake in his NUVEL–code, and this possible error sometimes causes great deviations from the other results.

	LANOTTE	TITOV	TOMASI	NOTHNAGEL & HAAS
STATION COORDINATES	ITRF 1996 **(required)**	ITRF 1996 **(required)**	ITRF 1996 **(required)**	ITRF 1996 **(required)**
SOURCE COORDINATES	ICRF 1995	ICRF 1996	GODDARD	ICRF 1995
EOP	IERS 97C04	IERS C04	GODDARD	GODDARD

Tab. 2: Aprioris

Object of the comparison are estimated station velocities and these motions are presented as velocity plots in *section 4*, so that the following considerations refer to this section. First the horizontal motion and then the height evolution is discussed.

The first that is remarkable in the velocity plot for **Ny Ålesund** is the great error ellipse of *Nothnagel* & *Haas* in relation to the error ellipse of *Tomasi*. Concerning this one has to take into account that different methods were used to determine the station velocity. When using the direct method the formal errors result from simultaneous adjustment in the batch solution. As a matter of principle in a batch solution a great number of observations is used, what means to deal with a great number of degrees of freedom. For this reason the formal errors and therewith the error ellipses will be small.

When applying the indirect method the number of degrees of freedom only depends on the number of coordinate triplets, which contribute to determine the station velocity. Thus in relation to the direct method the number of degrees of freedom will be smaller and therefore one obtains greater error ellipses. This "scaling effect" occurs in all plots.
The reference system for the velocities is the european plate with Wettzell fixed to NNR–NUVEL–1a motion. With that Ny Ålesund moves to west, but the great error ellipse points at a great scattering of the vector. For this reason the great error ellipse is a hint for a small number of observations or vice versa more observations have to be done in order to confirm this motion.

Onsala shows a clear motion to west with respect to Wettzell, too. Again to recognize the "scaling effect" of the error ellipse.

The results of **Effelsberg** contradict, in particular the vector of *Nothnagel* & *Haas* and the one of *Lanotte*. The comparison provides this statement and the error ellipse explains this phenomenon, because the size of the error ellipse directs attention to a non–significant motion. Thus the different solutions show arbitrary velocities.

The italian stations **Medicina** and **Matera** both show a clear and agreeing motion to east. **Noto** in South–Italy moves in northern direction, but it is not clear.

The last station in the network to be considered is **Madrid (DSS65)**. Remembering that the solution of *Titov* is preliminary, then a nearly zero velocity remains.

With regard to the height evolution of the stations the behaviour is similar to the horizontal motion and therewith the interpretations are similar. **Ny Ålesund** and **Onsala** both show an uplift, whereat the motion of Ny Ålesund is not significant due to the great error ellipse. As the horizontal motion the results of the height evolution of **Effelsberg** are inconsistent, i.e. there is no real vertical motion. **Medicina** shows a clear sinking motion. **Matera** and **Noto** do not really move in vertival direction due to great error ellipses. **Madrid** shows a clear uplift, which is in accordance with the lifting rate Antonius Rius presented at the last meeting in Oslo and which is about $2mm$ per year.

3 Final remarks

First of all it turned out, that a comparison is useful, because only by a comparison the results and statements become more certain, and only a comparison reveals contradictions, which then are an occasion for a detailed investigation. With regard to the results it is right to say, that at the present level of accuracy there is a general agreement.

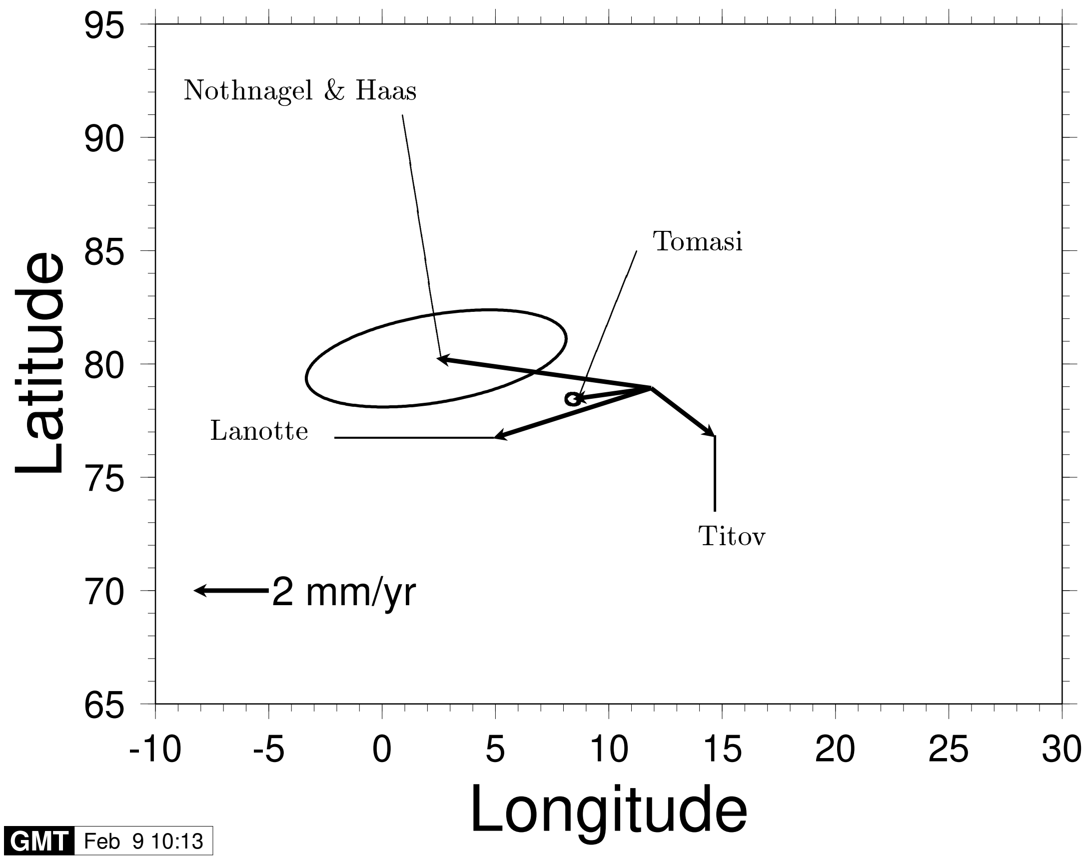
4 Acknowledgements

Thanks to *Rüdiger Haas, Roberto Lanotte, Axel Nothnagel, Oleg Titov* and *Paolo Tomasi* for submitting the solutions and thanks for a good cooperation.

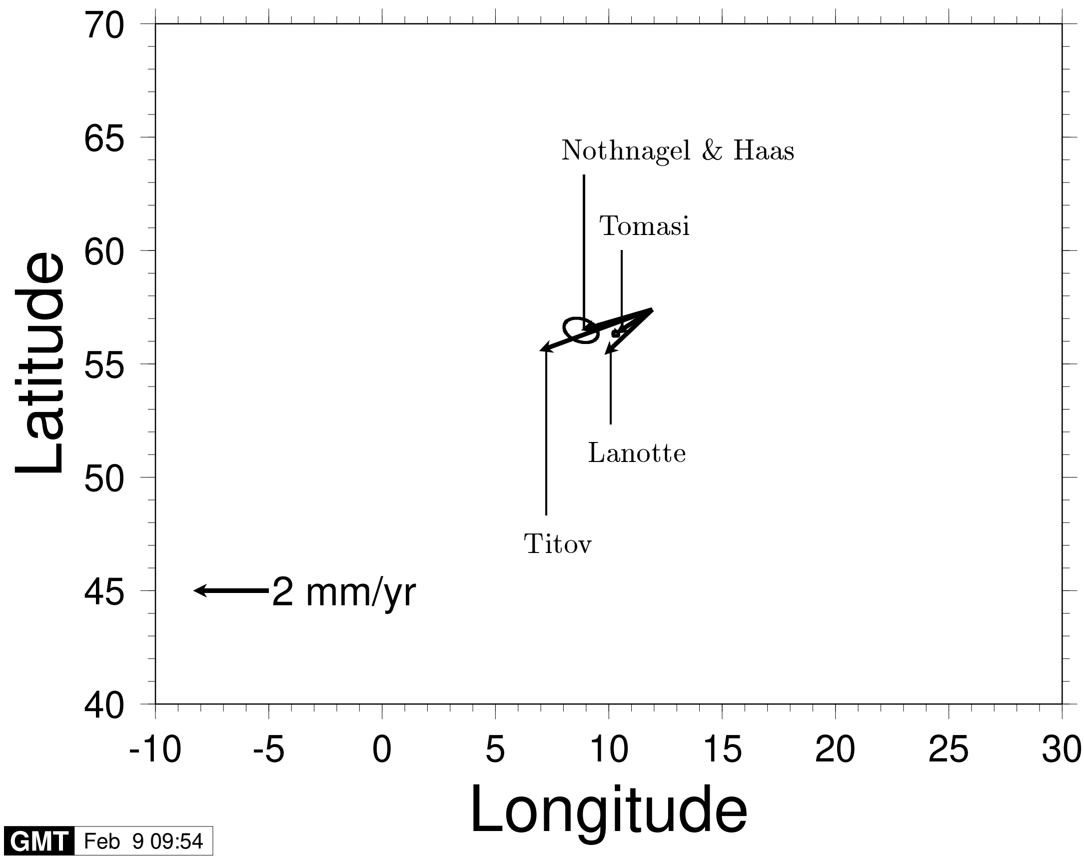
5 Plots

The following pages show the velocity plots for all mentioned stations.

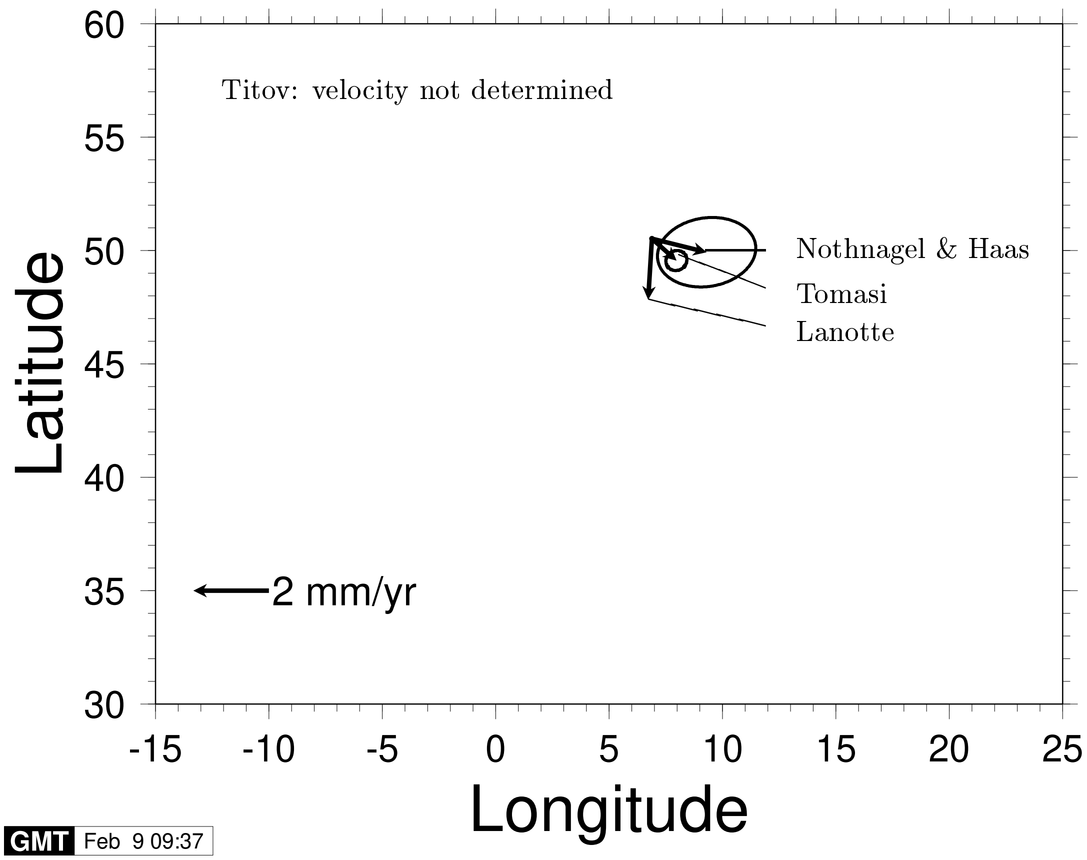
Velocity for NY ÅLESUND



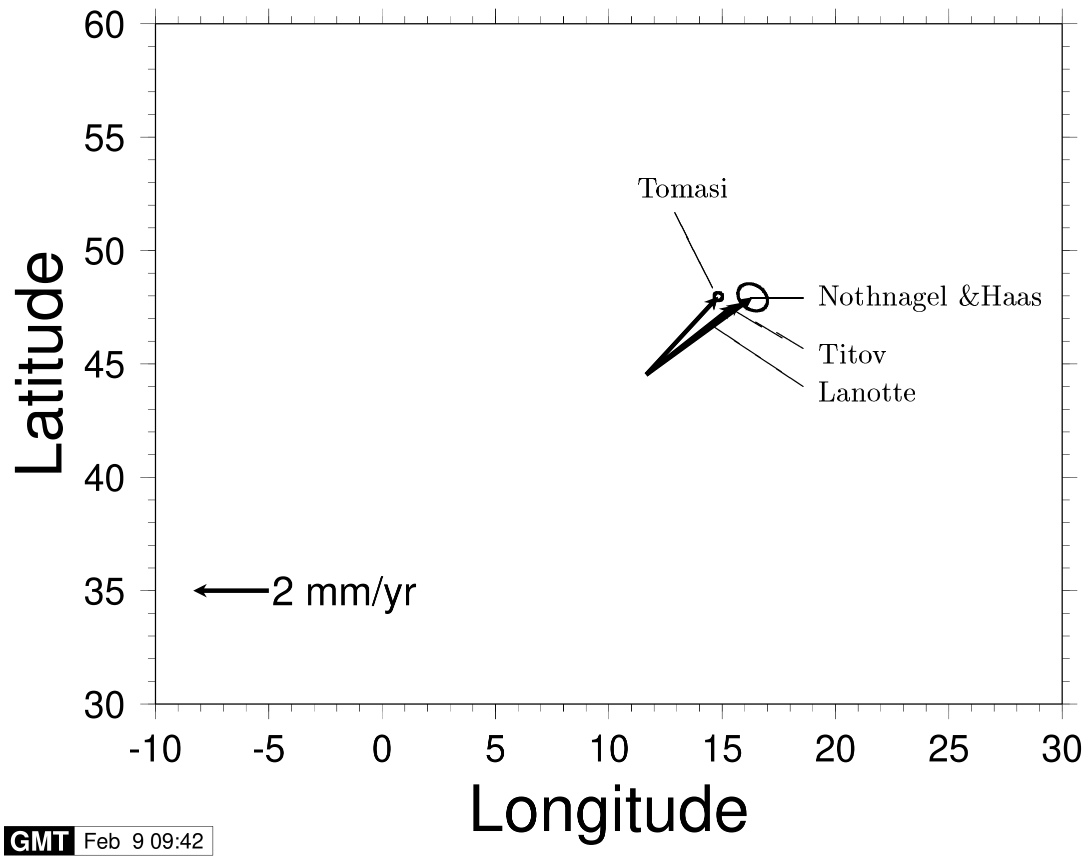
Velocity for ONSALA



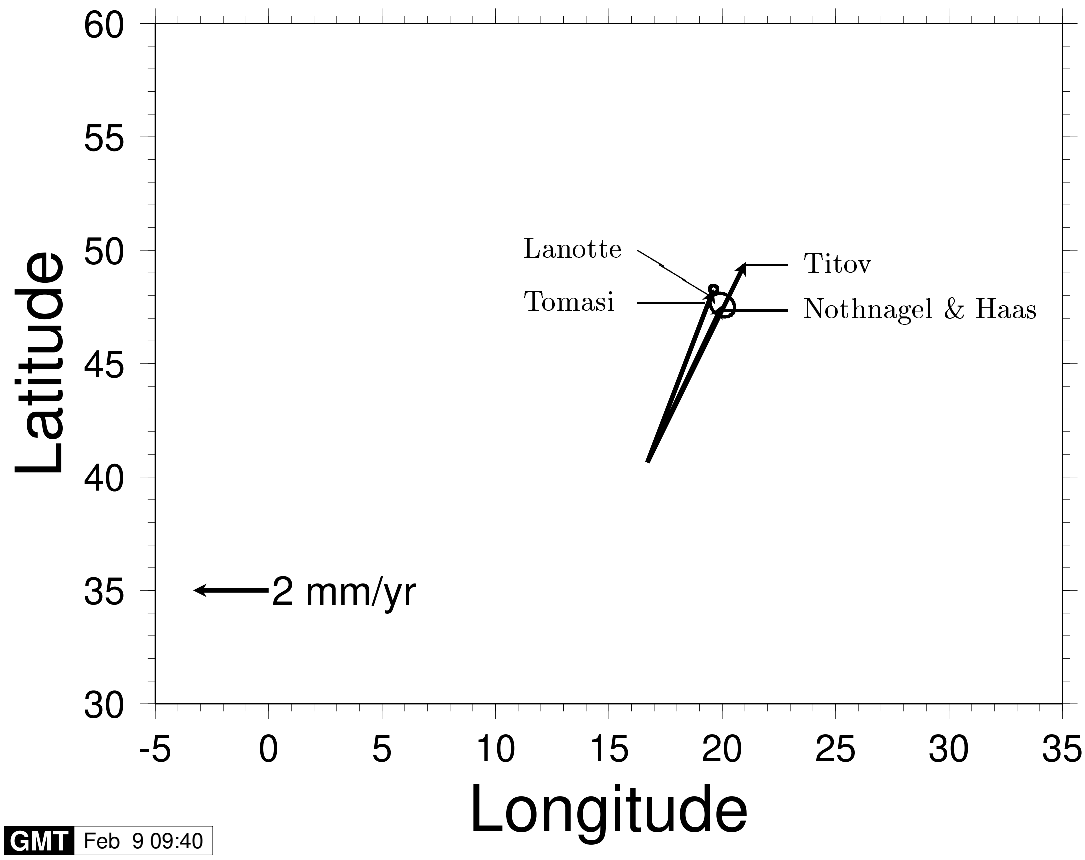
Velocity for EFFELSBERG



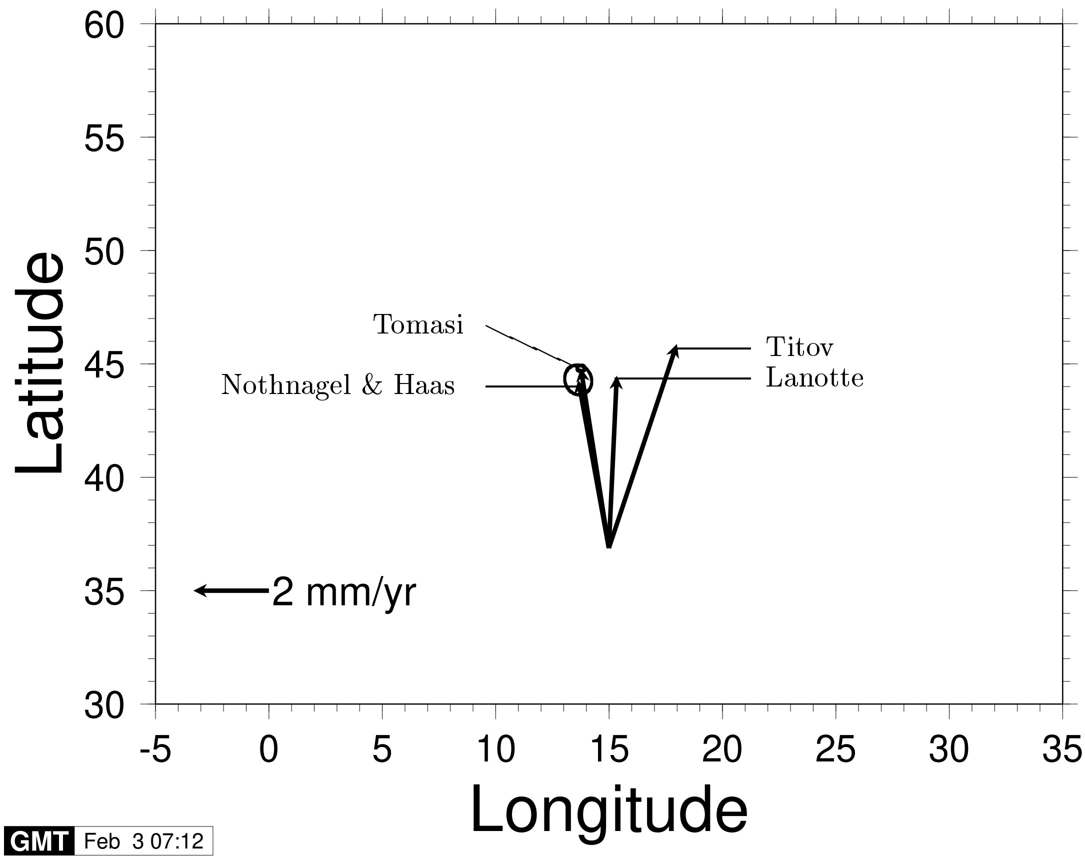
Velocity for MEDICINA



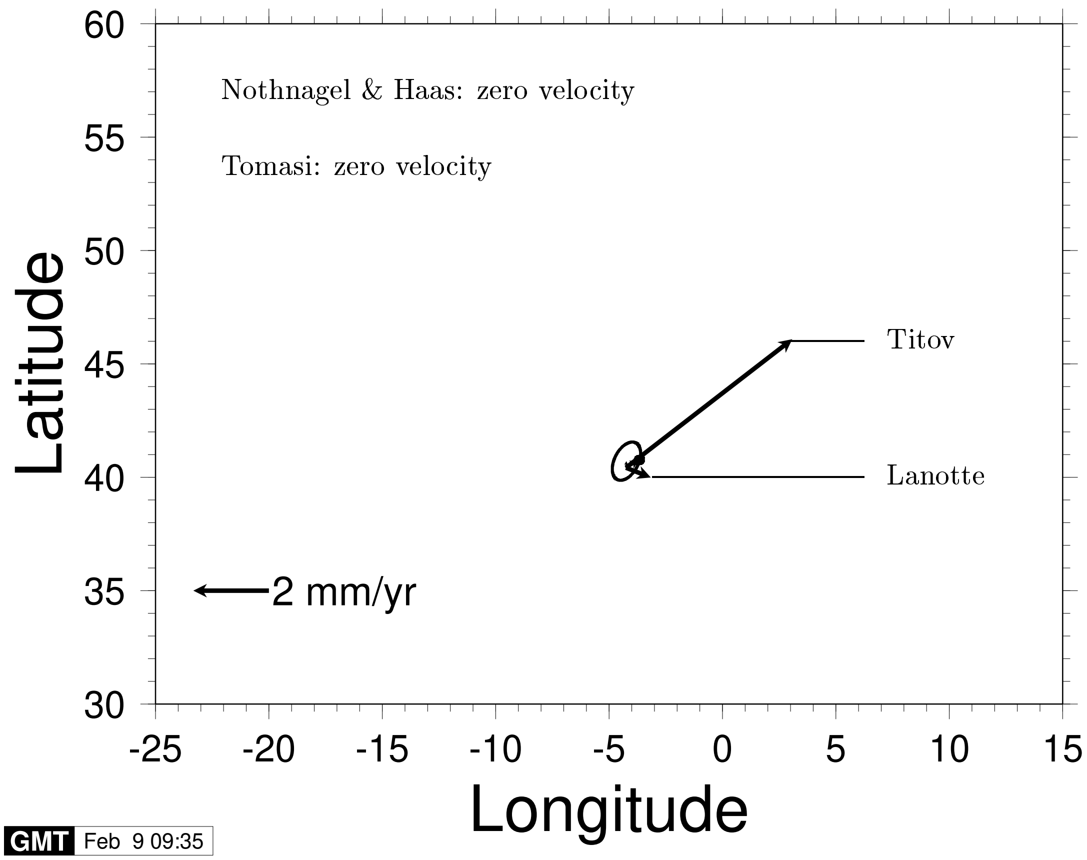
Velocity for MATERA



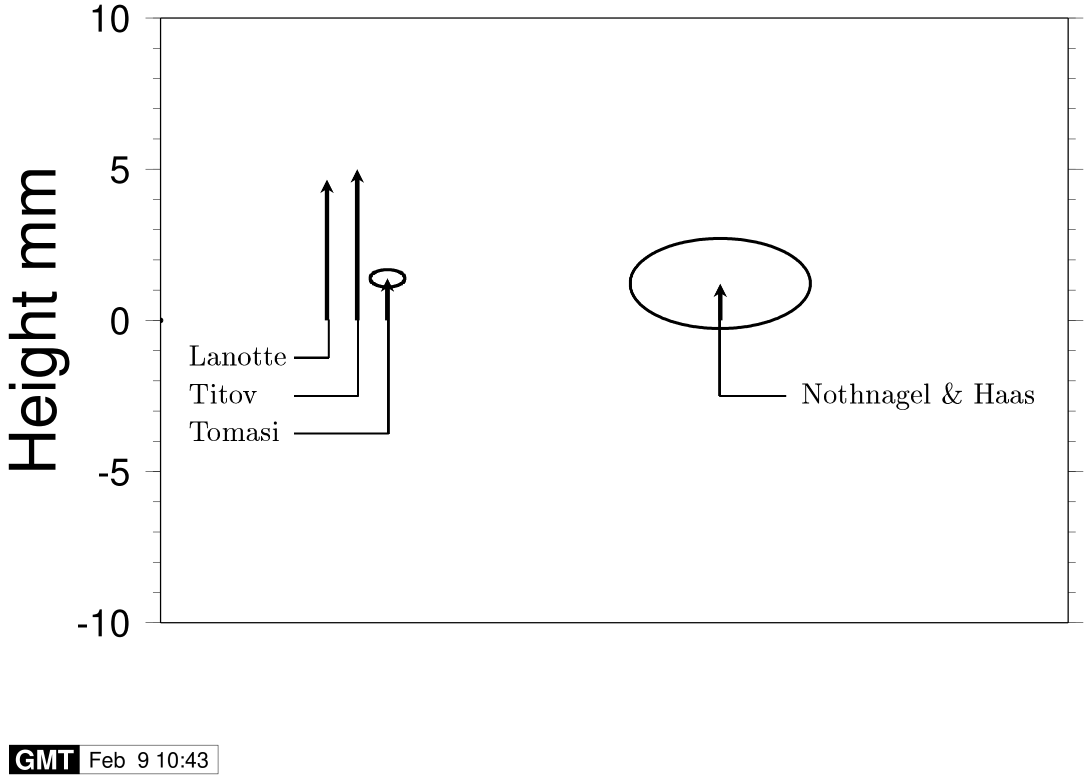
Velocity for NOTO



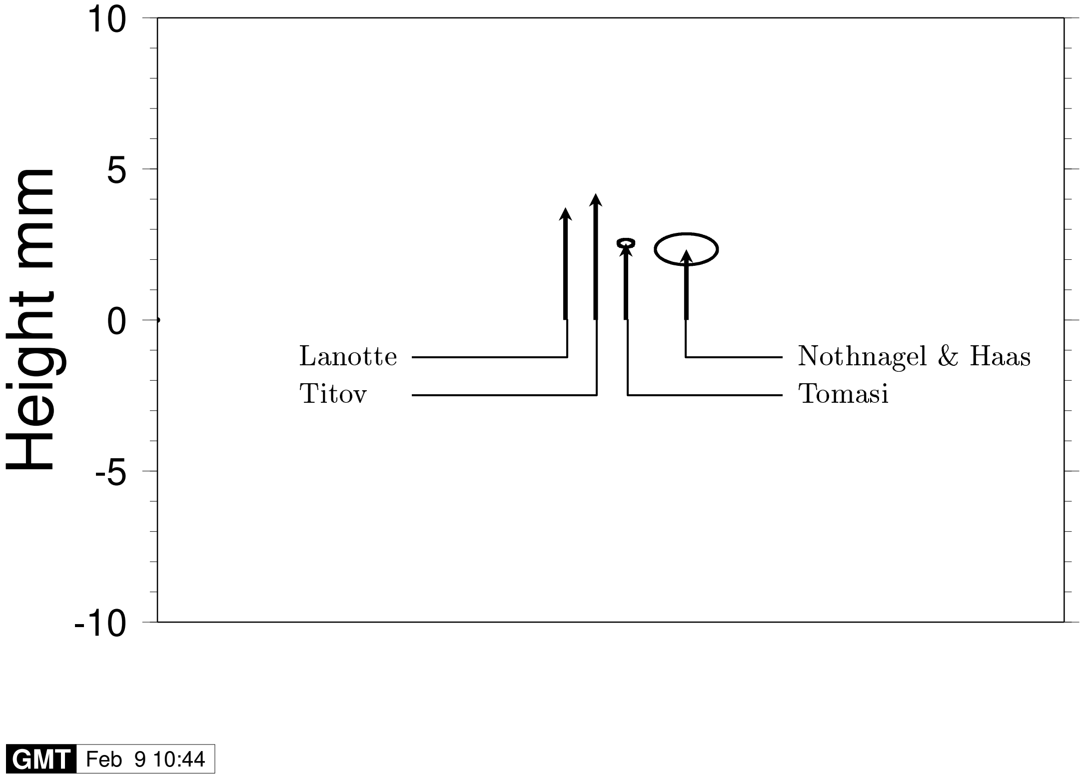
Velocity for DSS65



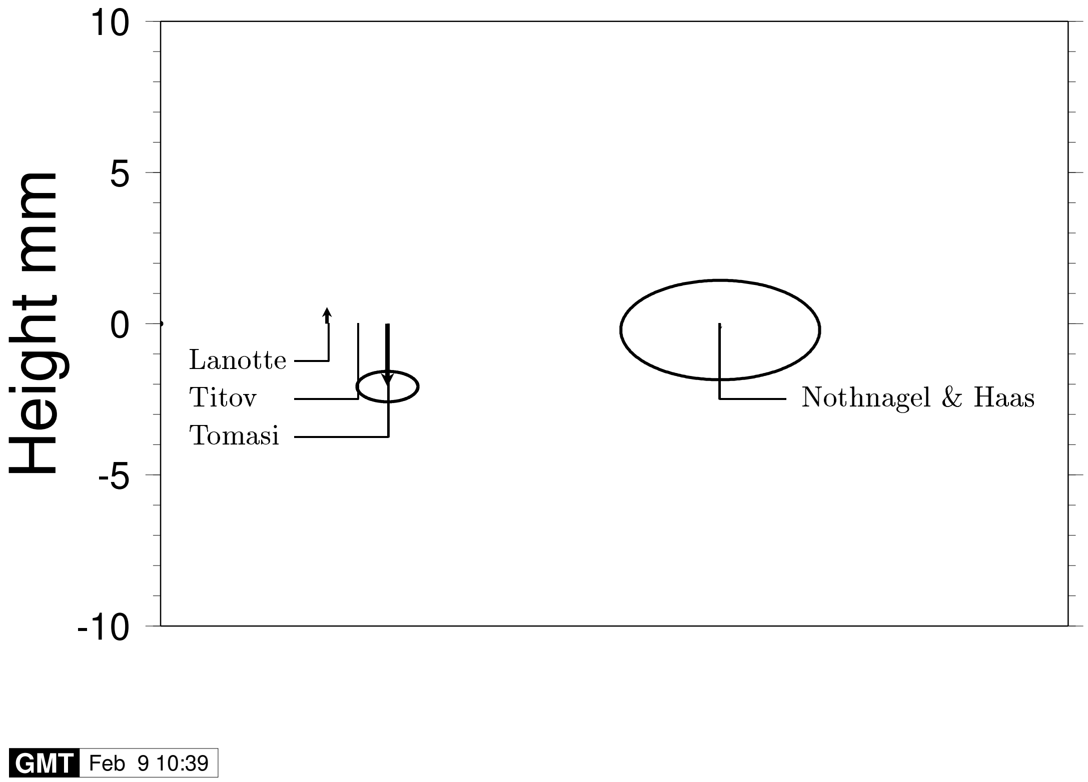
Height evolution for Ny ÅLESUND:



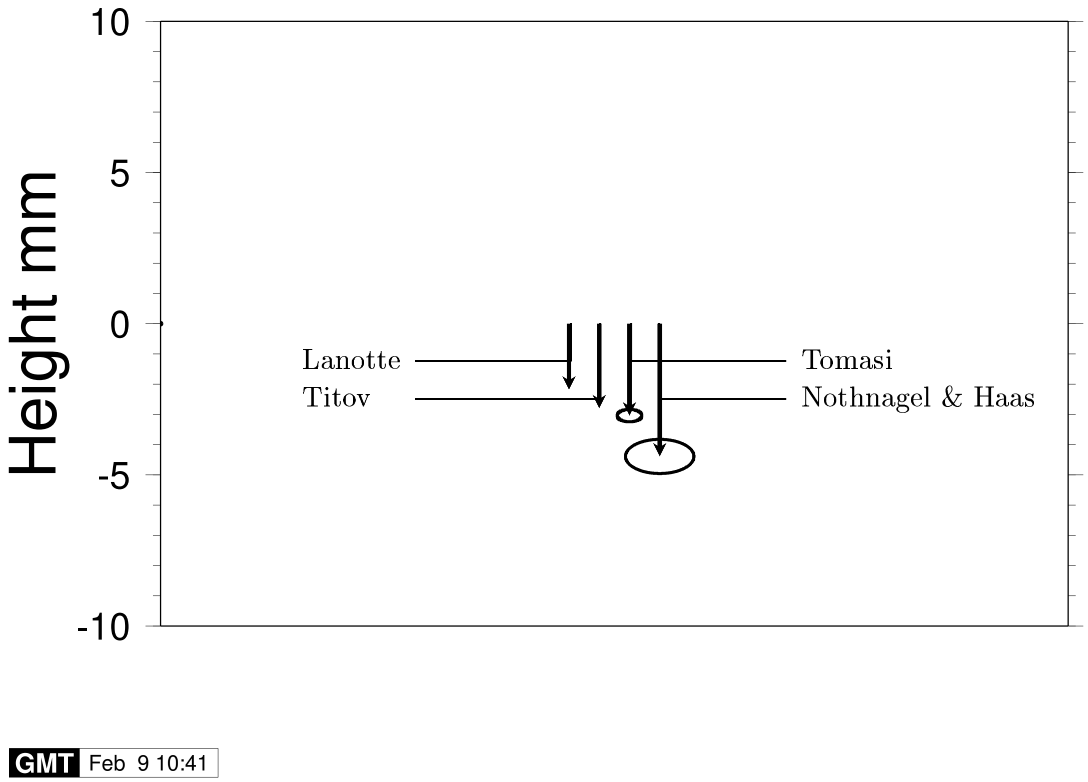
Height evolution for ONSALA:



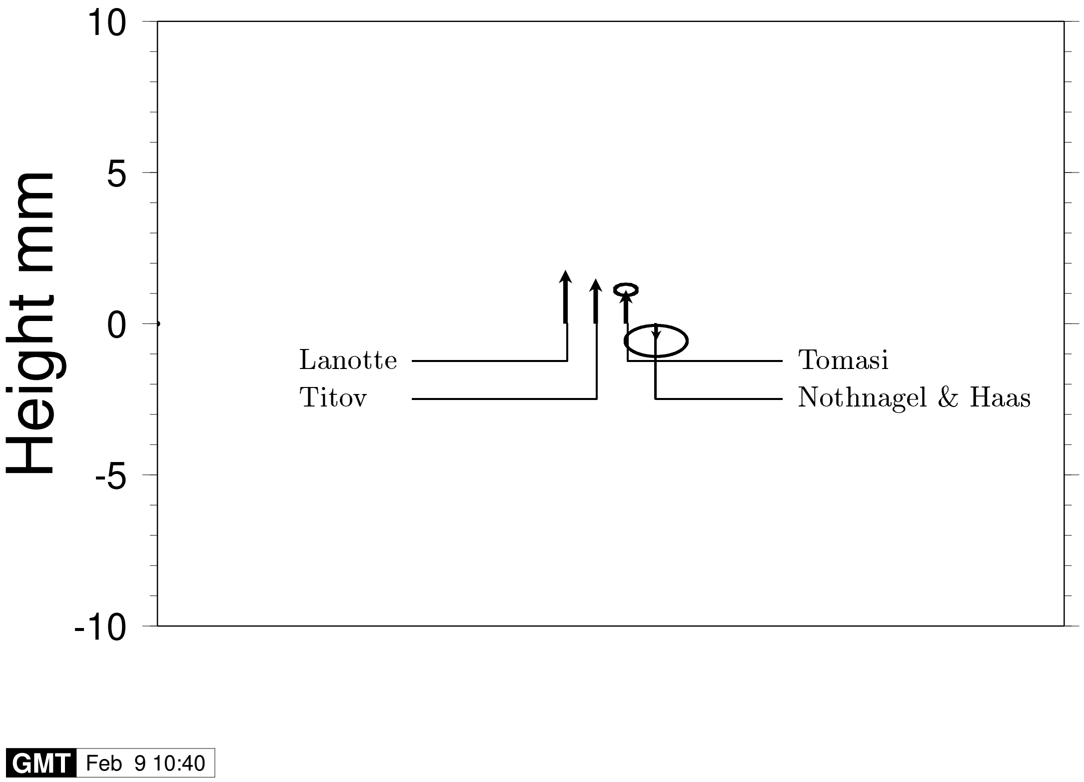
Height evolution for EFFELSBERG:



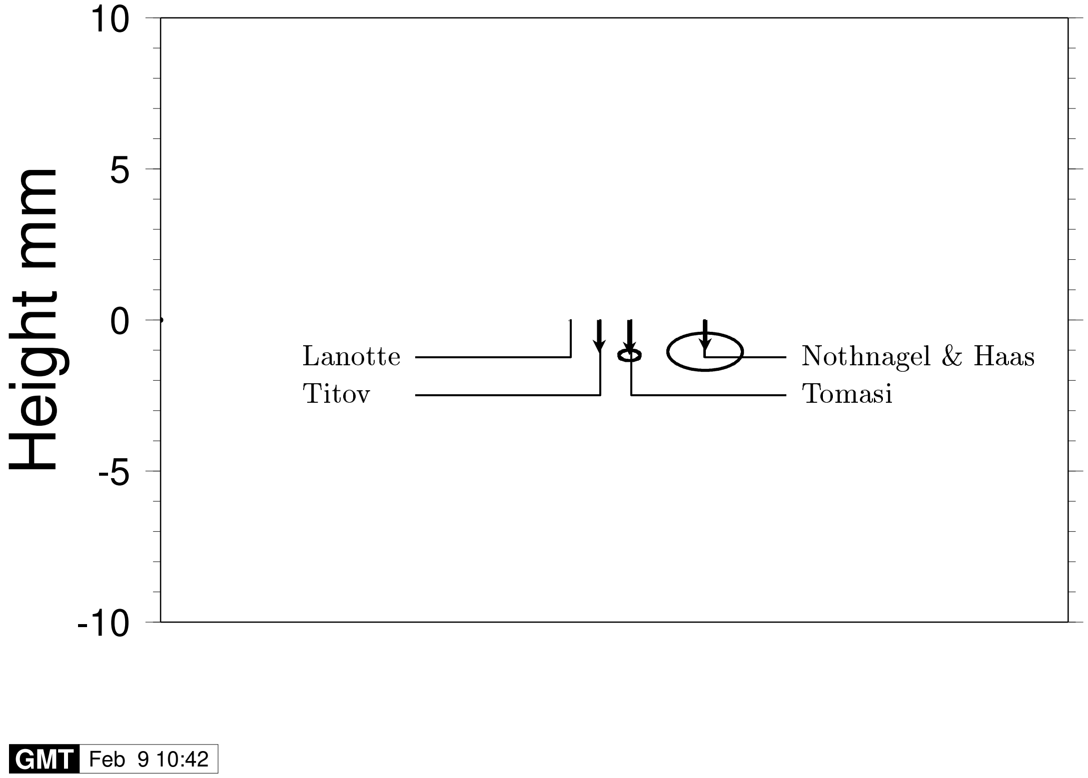
Height evolution for MEDICINA:



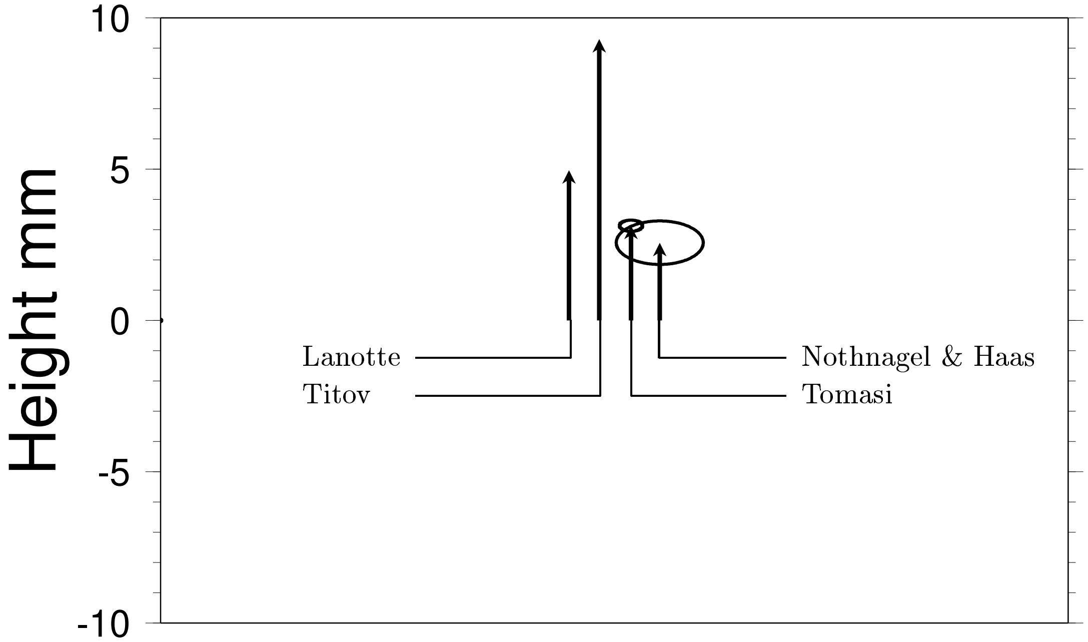
Height evolution for MATERA:



Height evolution for NOTO:



Height evolution for DSS65:



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