Seasonal Variations in Height demonstrated at the Radiotelescope Reference Point

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Abstract

Due to thermal expansion the height of a radiotelescope shows daily and seasonal variations. Since February 26, 1997 the height variations of the reference point are continuously monitored. The maximum of variation is up to 1 mm during a day and more than 3 mm a year, which is regarding the precision of VLBI not negligible.

The air temperature difference between summer and winter are in the domain of $+30°$C in summer and $-20°$C in winter. Due to the thermal expansion of steel and concrete the height of the telescope shows the temperature influence. With an expansion factor of approximately $11.0 * 10^{-6} \frac{m}{°C}$ for steel and concrete and $1.5 * 10^{-6} \frac{m}{°C}$ for invar one can expect more then 3 mm height variation of the reference point (12 m above the ground) over the year. This is regarding the precision of VLBI not negligible.

Therefore the height variations of the radiotelescope in Wettzell are continuously monitored. Figure 1 shows the set up of the invar measuring system. The reference point is the intersection between vertical and horizontal rotation axes. The invar wire (length 11.05 m, diameter 1.65 mm) is fixed below the reference point. There is a visibility from the reference point down to the ground through a steel pipe, which was useful for the purpose of surveying and was also suitable to hang up an invar wire. Because of the rotation of the reference point during observations, the ends of the invar wire are fixed with revolving swivels to prevent the wire from twisting, as they are used at a distometer. A weight of 1 kg at the lower end of the invar wire is fixed in this way that it can move up and down, but not rotate (figure 2). An anchor is fixed at the lower end of this weight and sticks into a inductive detector measuring the height variations precisely.

Figure 4 and 6 show the results of 2 measuring periods. The gap between these periods is due to an installation of a new servo and drive system inside the radiotelescope. The temperature (T) is measured in the middle of the central pipe in a small air chamber inside the steel construction. This temperature has the highest correlation with the measured height variations (L), compared to other temperatures measured at other places. The height variations are not corrected by the expansion of the invar wire due to temperature. This correction (C), which should be subtracted from (L), is shown separately.

Figure 4 and 6 show the results of a simple computation which was done to elucidate the grade of correlation between temperature and height variations. Starting with the values of figure 4 and 5, the average value of each day (T' and L') is taken. In this case the time lag of about 2 hours up to 4 hours between the two curves does not play a role. The difference curve (D) is derived from

$$D[mm] = L'[mm] - 0.126[\frac{mm}{°C}] * T'[°C]$$

The factor 0.126 is chosen in this way that the difference curve is as flat as possible. The value of this factor is slightly higher than expected. At October 26, 1997 the anchor was carefully readjusted and for this moment a jump in the difference curve (D) becomes visible. Little peaks occur persistently at each 24-hour-observation, maybe due to movements of the telescope during the observations and the waste heat of the motors. These temperature rise have little or no effect on the height.

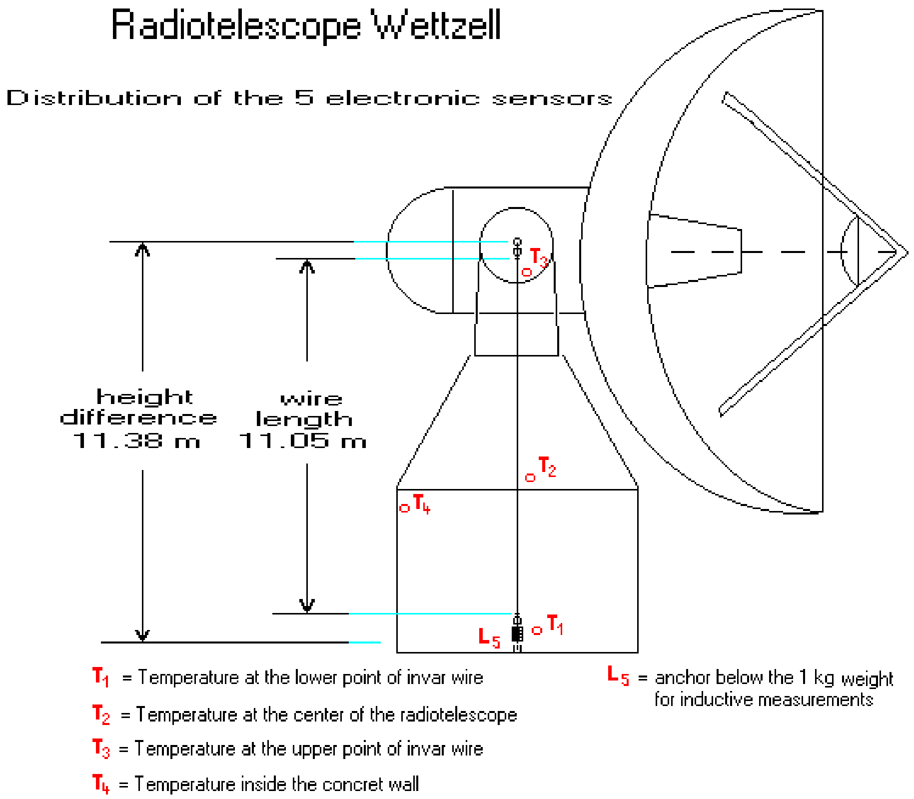

Fig. 1: Principle of Measurements.

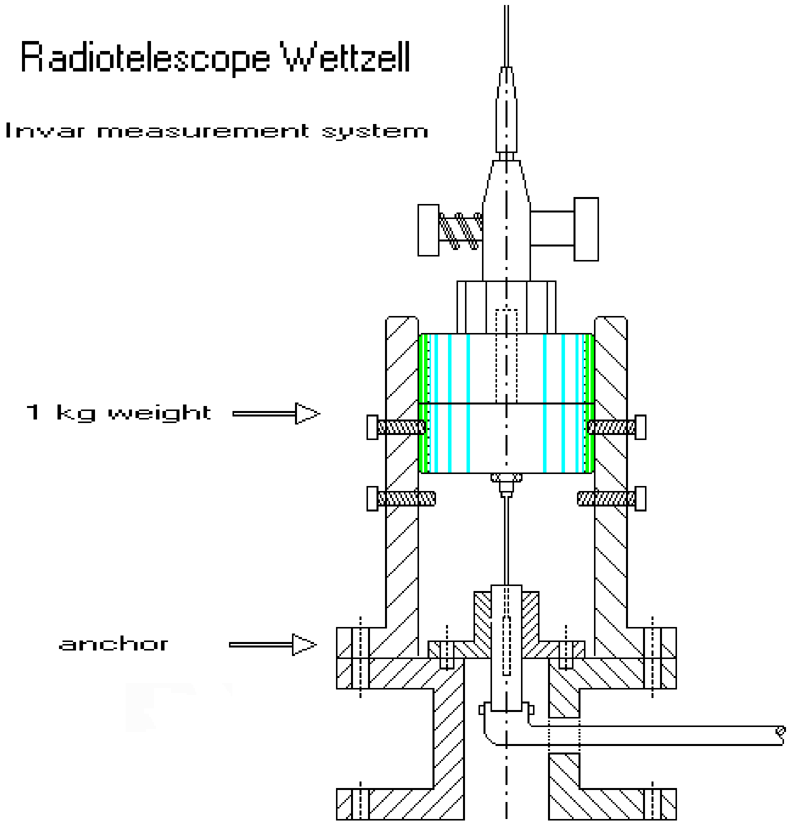

Fig. 2: Inductive Detector and the Principle.

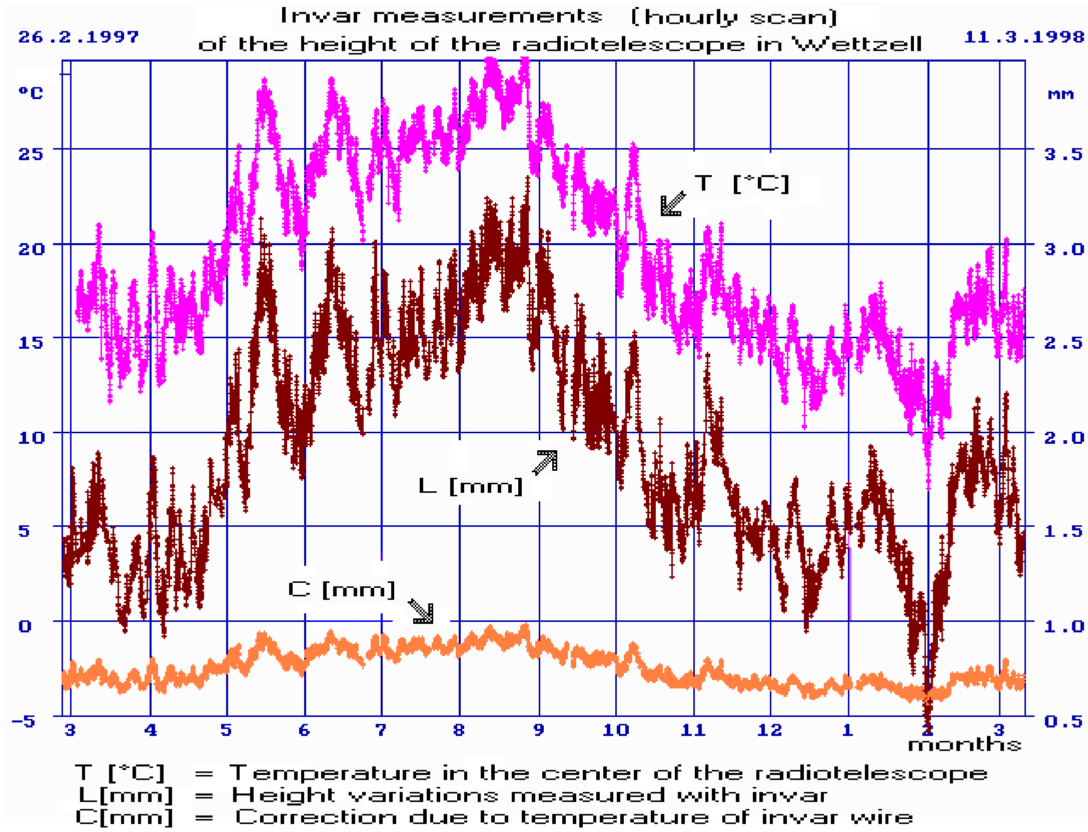

Fig. 3: Measurements of the First Period.

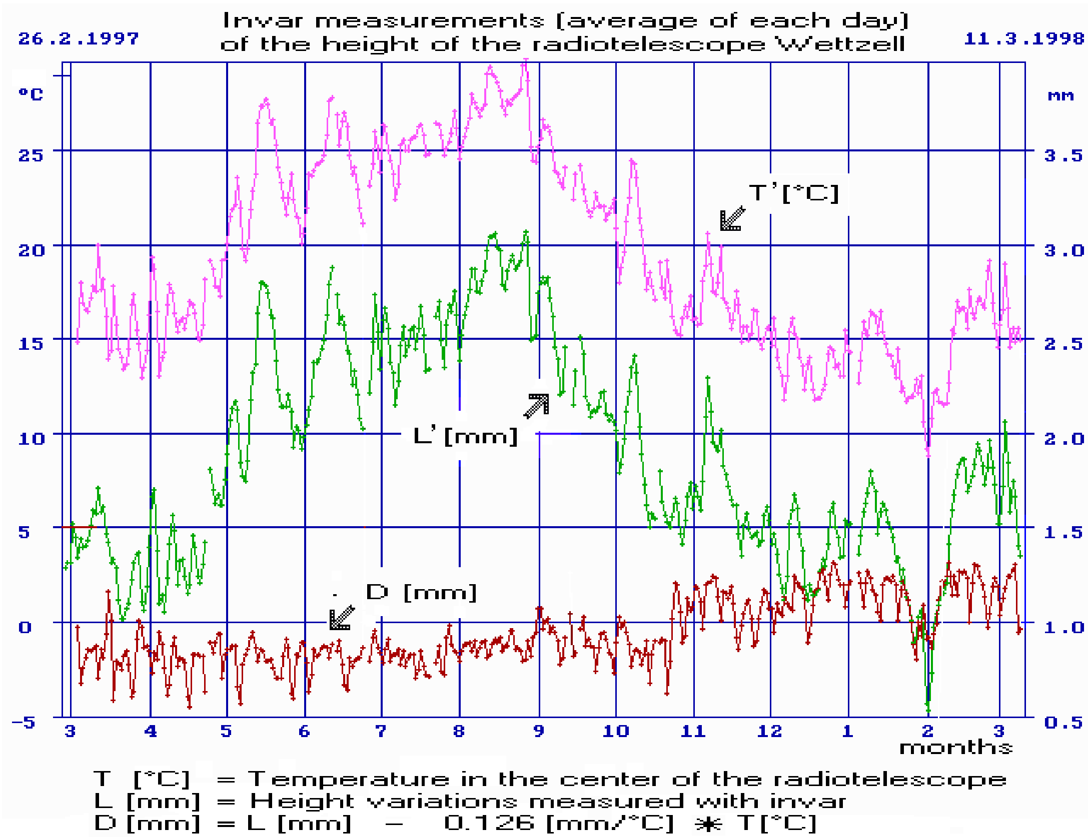

Fig. 4: Correlation between Temperature and Height of the First Measuring Period.

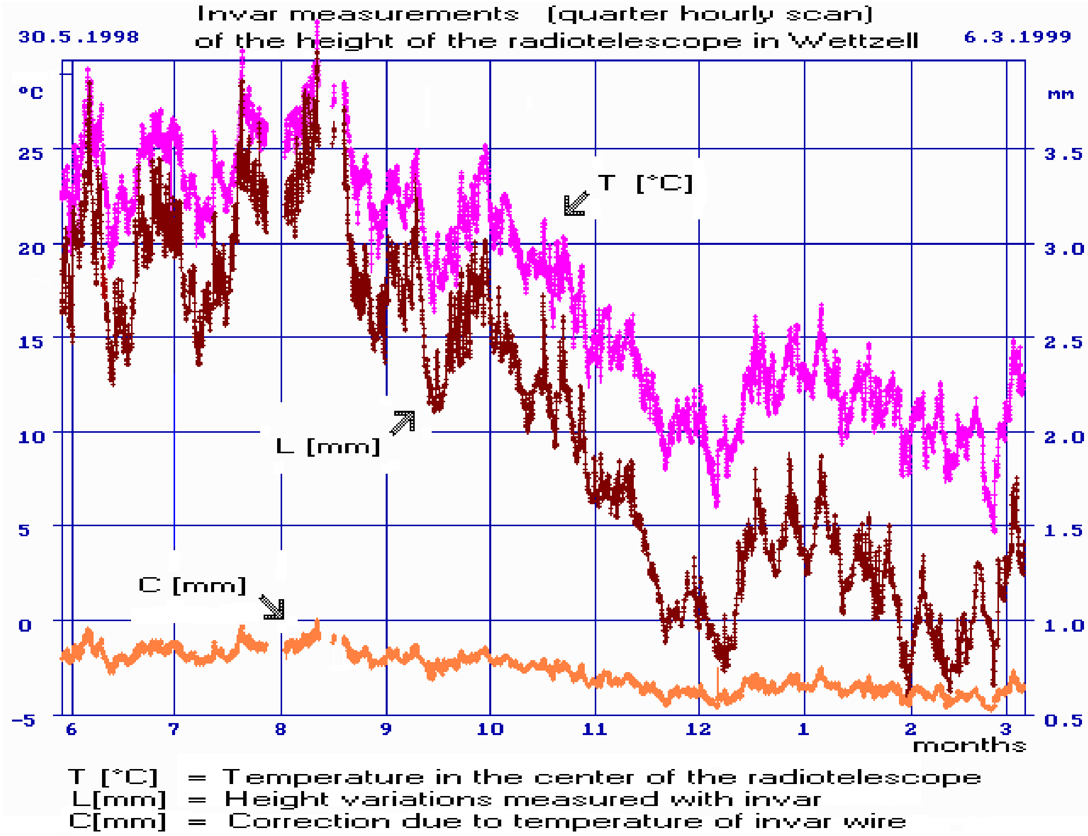

Fig. 5: Measurements of the Second Period.

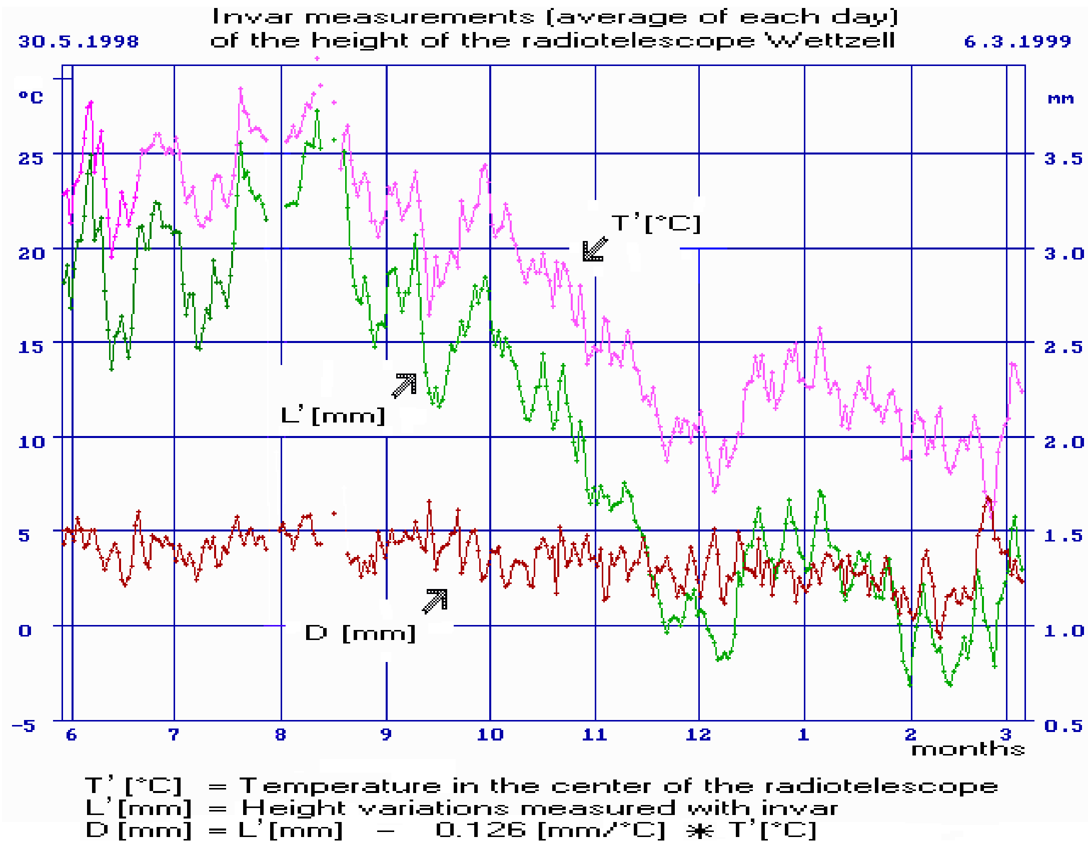

Fig. 6: Correlation between Temperature and Height of the Second Measuring Period.