CLIMATIC AND SOLAR ACTIVITY INFLUENCES ON INTERANNUAL AND DECADAL VARIATIONS OF VLBI STATIONS

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ABSTRACT. The time series of the VLBI station coordinates and baselines contain significant interannual and decadal variations for the period 1983-2010. These variations are highly correlated with the climatic indices and solar activity cycles. The variations of the smoothed time series of several VLBI sites (Wettzell, Westford and Fortaleza in East, North and Up directions) and the baseline Wettzell - Westford are analyzed. The 11-year and 22-year oscillations of the VLBI station coordinates exactly match Wolf's numbers (W_n and W_{n22a}) variations with a time delay of 0.5 to 1.5 years. The interannual site displacements are in good agreement with the smoothed time series of the equatorial solar asymmetry (SA) and the geomagnetic index AA with a time delay of about 1.5 years. The interannual site oscillations are strongly affected by climatic variations, represented by the Palomar Drought Severity Index (PDSI) with irregular phase reverses in 5- to 8-year intervals.

1. VLBI STATION TIME SERIES

The individual solutions for VLBI station coordinates provide time series of site displacements with high accuracy for a time span of more than 25 years for some stations (Figure 1). These time series contain wide-spectrum signals from various local and global sources as well as some systematic errors and uncertainties of the used mathematical models. Böckmann et al. (2007) show that some colocated VLBI, GPS, or SLR station motions are highly correlated.

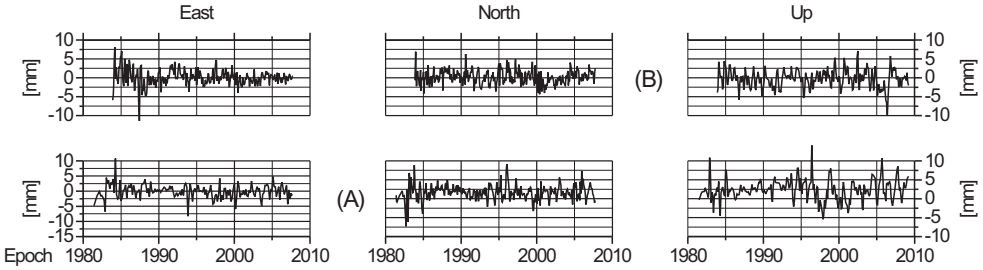

Figure 1: Time series of VLBI sites Wettzell (A) and Westford (B).

2. RESULTS

The smoothed variations of VLBI coordinates are determined in three steps - determination of 0.05-year normal points in the first step, interpolation to equidistant time intervals in the second step, and Fourier approximation with the Least Squares estimation, or Vondrak filtering in the last step. The 11- and 22-year oscillations of the VLBI coordinates are determined by the corresponding harmonics of the Fourier approximation, where the amplitudes are estimated with a level of accuracy of about 0.2 mm. A part of the interannual and decadal natural signals in Earth surface systems can be related to the decadal cycles of solar activity due to solar-terrestrial influences and the interconnection between climatic and

weather variations, atmosphere and ocean conditions, hydrological and underground water cycles and others. The comparison between the smoothed time series of VLBI coordinates variations and solar and climatic indices shows an almost exact match of the 11- and 22-year solar and VLBI cycles and good agreement between the interannual VLBI site motions and the solar and climatic indices (Figure 2).

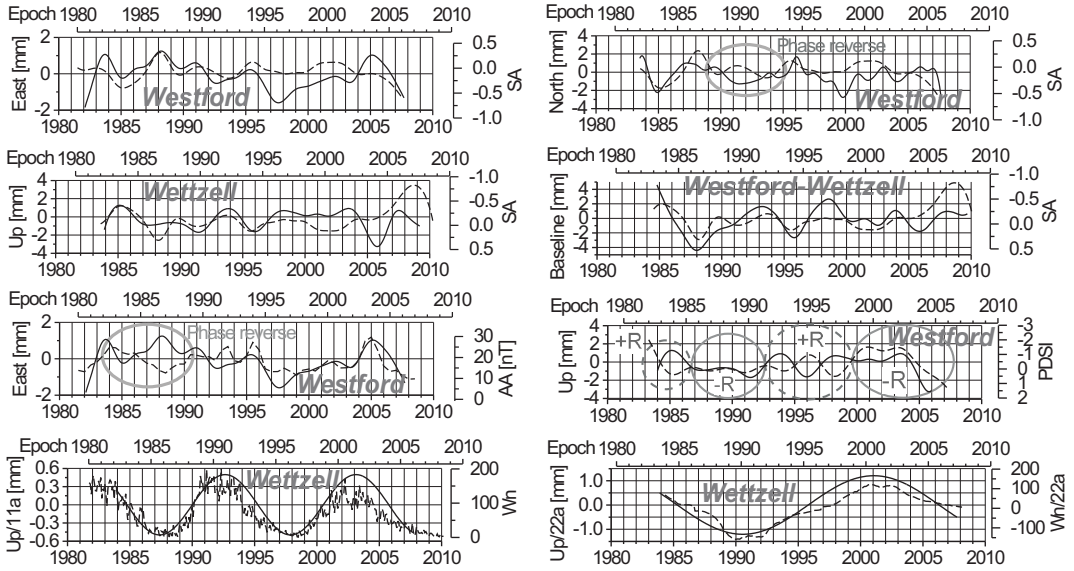

Figure 2: Comparison between the smoothed time series of VLBI sites Wettzell, Westford, the baseline Wettzell-Westford (solid lines) and SA, AA, W_n, W_{n22a}, and PDSI indices (dashed lines).

3. CONCLUSIONS

The decadal oscillations of the non-linear motions of the VLBI sites are correlated with the 11-year and 22-year solar cycles. The smoothed interannual variations of station coordinates and baselines are correlated with the smoothed variations of the equatorial solar asymmetry index SA and the geomagnetic index AA. The ground response to these cycles is not uniform for different sites, somewhere with opposite phases and somewhere without correlation. The climatic variations, expressed by the Palomar Drought Severity Index (PDSI), are connected with the interannual site motions. The smoothed PDSI variations strongly correlate with interanual site oscillations with phase reverse in 5- to 8-year intervals. The interannual and decadal variations of the equatorial solar asymmetry modulate the solar wind and corresponding geomagnetic field changes. The local ground changes are affected by the solar asymmetry and geomagnetic field variations, which is expressed by significant correlation and sudden phase change. The coordinates of individual stations seem to be more sensitive to the solar cycles than the baselines. All these results mean that the solar activity cycles affect crust deformations with dominating local effects and the solar-terrestrial influences show individual revealing for given Earth points.

The most probable interannual and decadal excitations of the local and global crustal deformations are climatic and atmosphere changes on the Earth surface, partially affected by the solar activity cycles, total solar irradiance, solar wind, interplanetary magnetic field and the corresponding response of the Earth's ionosphere. According to the results in Böckmann et al. (2007), the VLBI site motions are common for some colocated GPS and SLR stations, so it is possible to create models of local solar and climatic influences on VLBI, GPS, and SLR station variations.

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4. REFERENCES

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