Geophysical Research Abstracts, Vol. 9, 01747, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-01747

Singular Value Decomposition and Cluster Analysis as regression diagnostics tools for geodetic adjustment problems

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So far, redundancy numbers are used for the detection of high-leverage observations and of redundant observations. It is well known that errors in high-leverage observations mainly affect the estimation of parameters. On the other hand, observations with large redundancy numbers can often be neglected. In this presentation a new, objective method for the detection of groups of important and less important (redundant) observations is shown. Furthermore the parameters which are mainly affected by these groups are identified.

Although in this presentation VLBI applications will be shown, this regression diagnostics tool can be applied to any geodetic adjustment problem. The method is well suited for the detection of (groups of) observations that significantly affect the estimated parameters or that are of neglectible impact (and are thus candidates for observations that can be omitted). For the case of VLBI, in this presentation an application example for the examination of the impact of each observation (group) on parameters such as station coordinates, polar motion or earth rotation will be presented. The new approach can thus be used for improving the sensitivity of VLBI and other geodetic observing techniques. In addition, the general impact of observations (or observation groups) onto any kind of geodetic and geophysical parameters can be assessed.

The new method is based on geometric aspects of adjustment theory and uses the singular value decomposition and cluster analysis methods for regression diagnostics. Therefore, the design matrix $\mathbf{A}$ of the adjustment problem is decomposed into $\mathbf{A} = \mathbf{USV}'$ of orthonormal matrices $\mathbf{U}$ and $\mathbf{V}$ and a diagonal matrix $\mathbf{S}$ with the so-called singular values on its main diagonal. Based on the left singular vectors in $\mathbf{U}$ a data resolution matrix $\mathbf{H}$ can be computed which contains 'impact factors' and 'impact co-factors'. The main-diagonal elements depict 'impact factors' which are closely related to redundancy numbers and which can be interpreted geometrically using projections onto the vector spaces of **A**. The entire matrix **H** is used for so-called 'data space investigations'. The off-diagonal elements of this matrix are called impact co-factors and can also be interpreted geometrically as angles between elements of vector spaces. Since these angles can be interpreted as similarity measures, cluster analysis algorithms can be applied for the determination of similarities in the information content of observations.