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An Inequality Constrained Least-Squares approach as an alternative estimation procedure for atmospheric parameters from VLBI observations

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On its way through the atmosphere, the signals of space-geodetic techniques, such as GNSS or VLBI, are delayed and affected by bending and attenuation effects relative to a theoretical path in vacuum. Changing atmospheric conditions contribute considerably to the error budget of the observations. At the same time, space-geodetic techniques play a crucial role in the understanding of the Earth's atmosphere, because atmospheric parameters can be linked to the water vapor content in the atmosphere.

In the VLBI data analysis, the tropospheric delay is usually taken into account by applying an adequate model for the hydrostatic component and by additionally estimating zenith wet delays for the highly variable wet component. Unfortunately, the standard Least-Squares approach sometimes leads to negative estimates, which would be equivalent to negative water vapor in the atmosphere and does of course not reflect the meteorological and physical conditions in a plausible way.

To cope with this phenomenon, we introduce an Inequality Constrained Least-Squares (ICLS) method from the field of convex optimization and use inequality constraints to force the tropospheric parameters to be non-negative allowing for a more realistic tropospheric parameter estimation in a meteorological sense. The impact of the ICLS approach will be validated with regard to station positions. Since deficiencies in the a priori hydrostatic modeling are almost fully compensated by the tropospheric estimates, the ICLS approach urgently requires suitable a priori hydrostatic delays. Thus, we present strategies to deal with missing or incorrect a priori model data.

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