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On spline and polynomial interpolation of low earth orbiter data: GRACE example

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GRACE satellites, which are equipped with specific science instruments such as K/Ka band ranging system, have still orbited around the earth since 17 March 2002. In this study the kinematic and reduced-dynamic orbits of GRACE-A/B were determined to 10 seconds interval by using Bernese 5.2 GNSS software during May, 2010 and also daily orbit solutions were validated with GRACE science orbit, GNV1B. The RMS values of kinematic and reduced-dynamic orbit validations were about 2.5 and 1.5 cm, respectively.
Throughout the time period of interest, more or less data gaps were encountered in the kinematic orbits due to lack of GPS measurements and satellite manoeuvres. Thus, the least square polynomial and the cubic spline approaches (natural, not-a-knot and clamped) were tested to interpolate both small data gaps and 5 second interval on precise orbits. The latter is necessary for example in case of data densification in order to use the K / Ka band observations. The interpolated coordinates to 5 second intervals were also validated with GNV1B orbits. The validation results show that spline approaches have delivered approximately 1 cm RMS values and are better than those of least square polynomial interpolation. When data gaps occur on daily orbit, the spline validation results became worse depending on the size of the data gaps. Hence, the daily orbits were fragmented into small arcs including 30, 40 or 50 knots to evaluate effect of the least square polynomial interpolation on data gaps. From randomly selected daily arc sets, which are belonging to different times, 5, 10, 15 and 20 knots were removed, independently. While 30-knot arcs were evaluated with fifth-degree polynomial, sixth-degree polynomial was employed to interpolate artificial gaps over 40- and 50-knot arcs. The differences of interpolated and removed coordinates were tested with each other by considering GNV1B validation RMS result, 2.5 cm. With 95% confidence level, data gaps up to 5 and 10 knots can be gained within 2.5 cm for 30- and 40-knot arcs, respectively. The arc of more than 50 knot does not provide the accuracy of 2.5 cm at least.
As a result of the cubic spline approaches, especially not-a-knot, provide a enough precision to interpolate 5 second intervals, if there is in no data gap along with daily orbits. On the other hand, up to 10 continuous data gaps can be recovered by using the least square polynomial approaches.