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Numerical problems in evaluating high degree and order associated Legendre functions

O. Nesvadba

Czech Technical University, Prague, Thákurova 7, Prague 6, The Czech Republic (nesvadba@sky.cz)

The present extensive development of global Earth's gravity field models (EGMs) results into higher resolution, i.e. into high degrees and orders of spherical or ellipsoidal harmonics series not treated any time before. This development brings new challenges, so that the numerical approach in evaluating harmonic series has to be revised. The EGM08, as an example, shows that standard recurrence formulas cannot be used properly for numerical reasons. Therefore, a new approach for computing associated Legendre functions of the first as well as the second kind is introduced. Its high numerical efficiency, stability over latitudes and low decay of the accuracy are analyzed and improvements are demonstrated on examples. It is shown that using IEEE754 double precision floating-point numbers, we are still able to evaluate the spherical or ellipsoidal harmonic series with accuracy better than 1E-10 for degree and order 21600.