Implementation and Comparison of different Computational Methods for Very-High Degree Spherical Harmonic Series

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In the course of the last decade, spherical harmonic series, used to represent the Earth’s gravitational field, are expanded to very-high degrees (~2190). In that range the Associated Legendre Functions cannot be computed at high precision level due to the occurrence of arithmetic underflow or overflow based on the Floating Point Arithmetic System that is used in modern computer programs. Therefore, in order to solve this numerical problem, new methods, based on Extended Range Arithmetic or even approximation techniques and computational approaches, have been proposed, making the computation of Legendre Functions to ultra-high degrees possible. In the present study we implement numerically these methods comparing their precision and time efficiency. In addition, we adopt new computational schemes which aim to overcome the existing limitations in the considered methods and make the computation of Legendre Functions even up to 1 million degree possible. Finally, we adapt the existing and new methods, so that they can be included in standard Spherical Harmonic Synthesis and Analysis computational algorithms, thereby assessing their time performance and efficiency.

**Keywords:** Spherical Harmonics, Legendre, Gravity Models, High Degree

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