# FOREWORD

Resolution No. 2 of the IUGG (1991) and the *IERS Conventions 1996* recommend that the origin of the terrestrial reference system be "the geocenter of the Earth's masses", including oceans and atmosphere. It is realized by observations of the dynamics of satellites moving in the Earth's gravitational field. However, analyses of satellite laser ranging (SLR) data have strongly indicated that the coordinate frame of tracking stations attached to the Earth's crust moves detectably relative to the Earth's center of mass. This translational motion, when viewed from a rigid crust-fixed frame, is known as "geocenter motion" and is caused by the mass movement of planetary fluids, primarily the atmosphere and oceans. The motions likely involve tidal, non-tidal, and secular components.

In view of this phenomenon, time-varying (albeit small) translational motions are inevitable between the Earth's center of mass and the origin of the International Terrestrial Reference Frame (ITRF), which has implicitly been realized as a time-averaged geocenter position. It is the responsibility of the IERS to be prepared to coordinate observations and distribute appropriate results to monitor geocenter motions when that is feasible. In this way users would be able to accurately account for the instantaneous vector offset of the geocenter from the ITRF origin, much like the Earth orientation parameter service already provided by the IERS.

Before embarking on such an ambitious expansion of IERS responsibilities, however, a better understanding is needed of the magnitude of geocenter motions and of the current ability of the observing techniques to measure the effects. To address this matter, the IERS, during its 1996 Workshop, asked the IERS Working Group on the ITRF Datum to conduct an investigative campaign. A call for participation was issued in January 1997 for the *IERS Analysis Campaign to Investigate Motions of the Geocenter.* At least 42 individual researchers from more than 25 groups responded with proposals to analyze satellite tracking data for both tidal and non-tidal signals, to analyze data for geophysical excitations (including oceanic, atmospheric, and other fluid motions), and to compare and synthesize the analysis results. The activities of the Campaign have been published and distributed at the Web site http://maia.usno.navy.mil/geoc.html and an e-mail exploder was created to promote interaction among the participants.

The Campaign culminated in a special session at the Fall 1997 AGU Meeting in San Francisco. The overall impression of the work presented there was that the net motion of the terrestrial reference frame relative to the Earth's center of mass is detectable but small, probably no more than ~1 cm in any component. The diurnal and semi-diurnal tidal variations appear to be well determined and in good agreement with modern ocean tidal models. There seems to be some general agreement of the techniques in detecting seasonal variations, although more work remains to be done in this area. Geophysical computations of the expected motions based on global fluid motions are only roughly consistent with the observations. It was agreed by the participants that their reports would be collected into this IERS Technical Note.

As a result of the Geocenter Campaign, the following set of recommendations, subsequently modified, was adopted and presented to the IERS Directing Board:

1) A tidal model for the diurnal and semi-diurnal geocenter motions should be adopted based on an ocean tide model such as CSR3.0 (M. Watkins & R. Eanes, *Geophys. Res. Lett.*, **24**(17), 2231-2234, 1997). This model should be included in the next edition of the *IERS Conventions*. Suggestions to include the geocenter effect into the standard ocean loading coefficients, as a convenience for some users, are *not* recommended as this could lead to confusion.

2) Because the satellite techniques do not yet seem reliable for measuring variations at other frequencies, a simple seasonal model should be investigated for the principal non-tidal motions. Such an empirical model could be based on a weighted combination of the analysis results, similar to the procedure described by H. Montag. However, results currently available do not yet justify recommending such models for general use. The IERS terrestrial reference frame section at the Institut Géographique National is asked to continue studies of this type to evaluate future improved observational data and analysis methods.

3) General geocenter monitoring can be continued in two ways: the new IERS coordinating center for Monitoring of Global Geodynamical Fluids (MGGF) will have a subcenter devoted to computing offsets of the ITRF origin from the geocenter due to large-scale fluid motions; and the ITRF section will soon begin to compute monthly realizations of the terrestrial frame which can be compared with the fluid motion effects. When detection of non-tidal geocenter motions appears feasible the situation can be reassessed.

The members of the IERS Working Group on the ITRF Datum, which has sponsored this Campaign, have been Geoff Blewitt, Claude Boucher, Richard Eanes, Martine Feissel, Mike Helfin, Tom Herring, Jan Kouba, Chopo Ma, Horst Montag, Jim Ray, and Pascal Willis. The following corresponding members have made valuable contributions to the Campaign and the efforts of the Working Group: Zuheir Altamimi, Marshall Eubanks, Gerard Petit, John Ries, Hans-Georg Scherneck, and Patrick Sillard.

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