

IERS CONVENTIONS

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ABSTRACT. The International Earth rotation and Reference system Service (IERS) has implemented the IAU resolutions of the 24th General Assembly in its products. The IERS Conventions now provides an outline of the procedures to be used along with software consistent with those procedures. The Conventions Product Center is provided jointly by the U.S. Naval Observatory (USNO) and the Bureau International des Poids et Mesures (BIPM), who are working on the new edition of the IERS Conventions. The new edition of the conventions has been slightly re-organized with respect to previous issues, and numerous updates have been introduced. The work accomplished or in progress is described.

1. INTRODUCTION

The realization of the International Celestial Reference System (ICRS) requires a set of conventional models and procedures to be used in the analyses of the observational data. The International Earth Rotation Service (IERS) provides these in the IERS Conventions, which contain the recommended procedures not only to define the ICRS but also to derive and interpret the other products of the IERS, such as the International Terrestrial Reference Frame, and the Earth Orientation Parameters.

The IERS Conventions is a publication that is produced by the IERS Conventions Product Center provided jointly by the U.S. Naval Observatory (USNO) and the Bureau International des Poids et Mesures (BIPM). The Product Center provides a web site <http://maia.usno.navy.mil/conv2003.html> containing the IERS Conventions (2003). This site is to be updated as warranted at approximately annual intervals. In addition the Center produces the material for the IERS Technical Notes that document major changes, and it is expected that this document might be provided at approximately 5-year intervals.

The IERS Conventions (2003) is a continuation of the series of documents begun with the Project MERIT Standards (Melbourne *et al*, 1983) and continued with the IERS Standards (McCarthy, 1989; McCarthy, 1992) and IERS Conventions (McCarthy, 1996). The current issue of the IERS Conventions is called the IERS Conventions (2003). When referenced in

recommendations and articles published in past years, this document may have been referred to as the IERS Conventions (2000).

The celestial system described in the IERS Conventions (2003) is based on IAU (International Astronomical Union) Resolution A4 (1991). It was further refined by IAU Resolution B1 (2000). The definition of time coordinates and time transformations, the models for light propagation and the motion of massive bodies are based on IAU Resolution A4 (1991), further defined by IAU Resolution B1 (2000). In some cases, the procedures used by the IERS, and the resulting conventional frames produced by the IERS, do not completely follow these resolutions. These cases are identified in the document, and procedures to obtain results consistent with the resolutions are shown.

2. COMPONENTS

The IERS Conventions contain descriptions of units, models, software and procedures to be used in deriving and understanding the IERS products. These products assume the use of SI units (Le Système International d'Unités (SI), 1998) and are generally consistent with the use of Geocentric Coordinate Time TCG as the time coordinate for the geocentric system, and Barycentric Coordinate Time TCB for the barycentric system.

The Conventions describe the conventional concepts that underlie the definition of modern high-precision Celestial and Terrestrial Reference Systems. These have little relationship to the precision of the products but they are likely to affect the accuracy as well as the users interpretation.

Models are provided to describe various physical phenomena. These generally affect precision but might have only a minimal affect on the accuracy. Included also are constants, the numerical values of parameters of common interest. Perhaps the most important is the software that provides practical numerical implementation of the concepts and models.

Finally, the Conventions publication outlines procedures to implement all of the above. The IERS Conventions (2003) does not go so far as to describe standard procedures for data analyses, such as details regarding solution constraints and appropriate spans of data, but future versions may get to that point. These choices affect precision but have little effect on accuracy.

3. CONCEPTS

TBD

4. CONTENTS

The Contents of the document are outlined by the Table of Contents:

1. GENERAL DEFINITIONS AND NUMERICAL STANDARDS

Permanent Tide

Numerical Standards

2. CONVENTIONAL CELESTIAL REFERENCE SYSTEM AND FRAME

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Equator

Origin of Right Ascension

The ICRF

HIPPARCOS Catalogue

Availability of the Frame

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 - Concepts and Terminology
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 - TRF in Space Geodesy
 - Crust-based TRF
 - The International Terrestrial Reference System
 - Realizations of the ITRS
 - ITRF Products
 - The IERS Network
 - History of ITRF Products
 - ITRF2000, the Current Reference Realization of the ITRS
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 - Transformation Parameters Between ITRF Solutions
 - Access to the ITRS
5. TRANSFORMATION BETWEEN THE CELESTIAL AND TERRESTRIAL SYSTEMS
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 - Implementation of IAU 2000 Resolutions
 - Coordinate Transformation consistent with the IAU 2000 Resolutions
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 - The multipliers of the fundamental arguments of nutation theory
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 - Procedures and IERS Routines for Transformations from ITRS to GCRS
 - Notes on the new procedure to transform from ICRS to ITRS
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 - Solid Earth Pole Tide
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 - Conversion of tidal amplitudes defined according to different conventions
7. DISPLACEMENT OF REFERENCE POINTS
 - Displacement of Reference Markers on the Crust
 - Local Site Displacement due to Ocean Loading
 - Effects of the Solid Earth Tides
 - Rotational Deformation due to Polar Motion

- Atmospheric Loading
- Displacement of Reference Points of Instruments
- VLBI Antenna Thermal Deformation
- 8. TIDAL VARIATIONS IN THE EARTH'S ROTATION
- 9. TROPOSPHERIC MODEL
 - Optical Techniques
 - Radio Techniques
- 10. GENERAL RELATIVISTIC MODELS FOR SPACE-TIME COORDINATES AND EQUATIONS OF MOTION
 - Time Coordinates
- 11. GENERAL RELATIVISTIC MODELS FOR PROPAGATION
 - VLBI Time Delay
 - Background
 - The VLBI delay model
 - Laser Ranging
- Appendix — IAU Resolutions Adopted at the XXIVth General Assembly
- GLOSSARY

The actual contents of the IERS Conventions (2003) available at <http://maia.usno.navy.mil/conv2003.html> are presented below in outline form.

Introduction

Chapter 1 - Numerical Standards

Chapter 2 - Conventional Celestial Reference System and Frame

Chapter 3 - Conventional Dynamical Realization of the ICRS

Read me file for DE405 - Provides information concerning the retrieval and use of the DE405.

Chapter 4 - Conventional Terrestrial Reference System and Frame

ITRF2000 - Information on ITRF2000

GCONV subroutine - Transforms geocentric coordinates to geodetic coordinates. Provided by T. Fukushima

ABSMO Nuvel subroutine - Computes the new site position at time t from the old site position at time t_0 using the recommended plate motion model. Originally provided by J. B. Minster.

Chapter 5 - Transformation Between the Celestial and Terrestrial Systems

Chapter 5 Tables - Electronic versions of the tables for Chapter 5

Chapter 5 Subroutines - Electronic versions of the subroutines for Chapter 5

Chapter 6 - Geopotential

Chapter 7 - Site Displacement

Angular Argument subroutine - A FORTRAN subroutine to return the proper angular argument to be used with the Schwiderski phases

Mean Pole Positions - mean pole positions provided by the IERS Earth Orientation Centre (D. Gambis).

Atmospheric Regression Coefficients - site displacements due to atmospheric loading at specific sites; provided by T. vanDam.

Chapter 8 - Tidal Variations in the Earth's Rotation

ortho eop subroutine - Subdiurnal/Diurnal Subroutine

Chapter 9 - Tropospheric Model

Chapter 10 - General Relativistic Models for Time, Coordinates and Equations of Motion
Fairhead-Bretagnon Model - Computes the periodic terms of TT. Provided by A. Irwin.
Xhf2002.f routine - Computes TCB-TCG as a function of TT. Provided by W. Harada and T. Fukushima.
HF2002.dat - Parameter file read by Xhf2002.f. Provided by W. Harada and T. Fukushima.
xhf2002.out - Output file of the test driver. Provided by W. Harada and T. Fukushima.

Chapter 11 - General Relativistic Models for Propagation

Appendix - Resolutions from the 24th IAU General Assembly

Glossary - List of acronyms used in the Conventions

In comparison with previous versions the latest version has undergone significant changes. These are outlined below by chapter. The principal contributors are also listed for each chapter.

Chapter 1-General Definitions and Numerical Standards

The chapter has been updated for consistency of notation and concepts with other sections according to IAG (International Association of Geodesy) and IAU working groups. It provides general definitions for topics in other chapters and also the values of numerical standards that are used in the document. It incorporates the previous Chapter 4, which was updated to provide consistent notation and to comply with the recommendations of the most recent reports of the appropriate working groups of the International Association of Geodesy (IAG) and the IAU. It was prepared principally by D. McCarthy and G. Petit with major contributions from M. Burra, N. Capitaine, T. Fukushima, E. Groten, P. M. Mathews, P. K. Seidelmann, E. M. Standish, and P. Wolf.

Chapter 2-Conventional Celestial Reference System and Frame

The chapter, which appeared as Chapter 1 in previous editions has been updated to incorporate the effects of the IAU 2000 24th General Assembly by E. F. Arias with contributions from J. Kovalevsky, C. Ma, F. Mignard, and A. Steppe.

Chapter 3-Conventional Dynamical Reference Frame

Chapter 3 (previously Chapter 2), has been updated to be consistent with notation and concepts of other sections. The conventional solar system ephemeris has been changed to the Jet Propulsion Laboratory (JPL) DE405. It was prepared by E. M. Standish with contributions from F. Mignard and P. Willis.

Chapter 4-Conventional Terrestrial Reference System

Chapter 4 (previously Chapter 3) was rewritten by Z. Altamimi,, C. Boucher, and P. Sillard with contributions from J. Kouba, G. Petit, and J. Ray. It incorporates the new Terrestrial Reference Frame of the IERS (ITRF2000), which was introduced in 2001.

Chapter 5-Transformation Between the Celestial and Terrestrial Systems

The chapter was modified to be consistent with resolutions adopted at the 24th IAU General Assembly and the 2002 IERS Workshop. It was updated principally by N. Capitaine, with major contributions from P. M. Mathews and P. Wallace to comply with the recommendations of the IAU 2000 24th General Assembly. Significant contributions from P. Bretagnon, R. Gross, T. Herring, G. Kaplan, D. McCarthy, Burghard Richter and P. Simon were also incorporated.

Chapter 6-Geopotential

Chapter 6 was updated to include the EGM96 conventional geopotential model and the treatment of tides. V. Dehant, P. M. Mathews, and E. Pavlis were responsible for the revision. Major contributions were also made by P. Defraigne, S. Desai, F. Lemoine, R. Noomen, R. Ray, F. Roosbeek, and H. Schuh.

Chapter 7-Site Displacement

This chapter was updated to be consistent with the geopotential model recommended in Chapter 6. It was prepared principally by V. Dehant, P. M. Mathews, and H.-G. Scherneck. Major contributions were also made by Z. Altamimi, S. Desai, S. Dickman, R. Haas, R. Langley, R. Ray, M. Rothacher, H. Schuh, and T. VanDam. A model for post-glacial rebound is no longer recommended and a new ocean-loading model is suggested. The VLBI antenna deformation has been enhanced.

Chapter 8-Tidal Variations in the Earths Rotation

Changes were made to be consistent with the nutation model adopted at the 24th IAU General Assembly. The model of the diurnal/semidiurnal variations has been enhanced to include more tidal constituents. The principal authors of Chapter 8 were Ch. Bizouard, R. Eanes, and R. Ray. P. Brosche, P. Defraigne, S. Dickman, D. Gambis, and R. Gross also made significant contributions.

Chapter 9-Tropospheric Model

This chapter has been changed to recommend an updated model. It is based on the work of C. Ma, E. Pavlis, M. Rothacher, and O. Sovers, with contributions from C. Jacobs, R. Langley, V. Mendes, A. Niell, T. Otsubo, and A. Steppe.

Chapter 10-General Relativistic Models for Time, Coordinates and Equations of Motion

The chapter has been updated for consistency of notation and concepts with other sections. New software for the TCB-TCG transformation, developed by Harada and Fukushima, has been checked against existing programs and added to the list of such standards. Previously appearing as Chapter 11, it has been updated to be in compliance with the IAU resolutions and the notation they imply. It was prepared principally by T. Fukushima and G. Petit with major contributions from P. Bretagnon, A. Irwin, G. Kaplan, S. Klioner, T. Otsubo, J. Ries, M. Soffel, and P. Wolf.

Chapter 11-General Relativistic Models for Propagation

This chapter (previously Chapter 12), has been updated for consistency of notation and concepts with other sections. It was updated to comply with the IAU resolutions and the notation they imply. It is based on the work of T. M. Eubanks and J. Ries. Significant contributions from S. Kopeikin, G. Petit, L. Petrov, A. Steppe, O. Sovers, and P. Wolf were incorporated.

5. FUTURE

At the BIPM, in collaboration with the IERS Analysis Coordinator and different Product and Analysis centers.

Visiting scientist position + other collaborations possible.

Contributions to determine the most important directions to improve the consistency of IERS combined solutions and how to implement new conventional models/ procedures.

Important topics are, e.g., geocenter motion, impact of using "global" vs. "local" loading models, network effects in the solutions of different techniques...

6. CONCLUSION

The IERS Conventions are the product of the IERS Conventions Product Center. However, this work would not be possible without the contributions acknowledged above. In addition, we would also like to acknowledge the comments and contributions of S. Allen, Y. Bar-Sever, A. Brzeziński, M. S. Carter, P. Cook, H. Fliegel, M. Folgueira, J. Gipson, S. Howard, T. Johnson, M. King, S. Kudryavtsev, Z. Malkin, S. Pagiatakis, S. Pogorelc, J. Ray, S. Riepl, C. Ron, and T. Springer in the compilation of the work.

7. REFERENCES

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