A TERRESTRIAL REFERENCE SYSTEM CONSISTENT WITH WGRS

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ABSTRACT. The IAU and IUGG has jointly established in 1988 an International Earth Rotation Service (IERS) which is in charge of the realization of conventional celestial and terrestrial reference systems, together with the determination of earth orientation parameters which connect them.
The theoretical definition of the terrestrial reference system which is realized by IERS through a conventional terrestrial reference frame formed by SLR, LLR, VLBI and GPS stations is presented. In particular its origin, scale, orientation and evolution with time are reviewed, taking into account relativistic and deformation effects.

1. IERS Requirements for a Conventional Terrestrial Reference System (CTRS)

a) to permit realizations at millimeter level at the Earth's surface or 10^{-10},

b) consistent with IAU WGRS,

c) to take into account geodynamical effects at mm level,

d) to take into account relativistic effects at mm level.

2. Coordinate Systems

Four types of Coordinate Systems may be defined :

- Barycentric celestial CS (b) :

$$X^{\alpha} \qquad X^{0} = cT$$

- Quasi inertial geocentric CS (e) :

$$\tilde{x}^{\alpha} \qquad \tilde{x}^{0} = c\tilde{t}$$

where $\tilde{t}$ = TCG , Geocentric Coordinate Time

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- Terrestrial geocentric CS (t) :

$$x^{\alpha} \qquad x^{0} = ct$$

where $t = TT = TAI + 32.184s$

- Terrestrial CS (T)

$$\bar{X} = \bar{x} + \bar{T}_G(t)$$
$$= (1 - \ell)\, R(t)\, \tilde{x} + \bar{T}_G(t)$$

where R is a rigid spatial rotation, T_G a translation and ℓ a scale factor.

The transformation between these Coordinate Systems can be done as follows :

- from (e) to (t) :

$$x^i = (1 - \ell) R^i_j(\tilde{t}) \tilde{x}^j$$

$$t = (1 - \ell)(\tilde{t} - t_T) + t_T$$

with

$$\begin{cases} \ell = 6.97 \times 10^{-10} \sim \dfrac{W_0}{c^2} \\ t_T = 1977 \text{ January } 1 \end{cases}$$

- from (t) to (T)

$$X = x + T_G(t)$$

Applying Tisserand condition on the Earth's crust, the CTRS should have

- no global translation with regards to the Crust :

$$T_G(1988.0) = 0 \quad , \qquad \int_{Crust} \rho\, \dot{X}^k\, d^3X = 0$$

- no global rotation with regards to the Crust :

$$R(1988.0) = R_0 \quad , \quad \varepsilon_{ijk} \int_{Crust} \rho\, X^j\, \dot{X}^k\, d^3X = 0$$

where R_0 is a conventional orientation and ρ is the density of the Crust.

3. Realizations of CTRS

3.1. PURPOSE

Within IERS, analysis centers and the Terrestrial Reference Frame Section produce realizations of the CTRS or close systems, by set of station coordinates, or Terrestrial Reference Frames:

- the TRF Section combines data to obtain a realization of the CTRS, named IERS Terrestrial Reference Frame (ITRF), see (Boucher, Altamimi, 1989, 1990a and 1990b)

- individual analysis centers
  . either compute directly a realization of the CTRS,
  . or compute a specific frame, which is compared to ITRF and then converted as a realization of the CTRS.

3.2. SPECIFICATIONS FOR THE REALIZATIONS OF THE CTRS

+ List of coordinates of points at epochs in TT, with velocity, or time series of coordinates :

$$X(t)\ ,\ V(t) \qquad t \text{ in TT}$$

or

$$X(t_k) \qquad t_1, t_2 \ldots t_k \text{ in TT}$$

+ Corrected from periodic tidal deformation :

$$X(t)_{\text{instantaneous}} = X(t) + \Delta X_{\text{tid,periodic}}(t)$$

or in time average :

$$< X(t)_{\text{inst}} >_{\text{time}} = < X(t) >_{\text{time}}$$

+ Tisserand condition on residual velocities / CCVF (see below)

+ orientation from BIH/IERS

3.3. CONVENTIONAL CRUSTAL VLEOCITY FIELD MODEL (CCVF)

Tisserand condition (given in § 2) should be applied to a CCVF ensuring no net rotation/translation of the CTRS with regards to the Crust. CCVF will be established from plate (NUVEL 1 ?) and vertical (post glacial rebound ?) motion models. This leads to a velocity field $\bar{V}(P_k, t)$, for a network of stations P_k $(k = 1,n)$ and epoch t.

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3.4. USE FOR A DISCRETE NETWORK

In order to tie reference frames, one has to :

- define a residual velocity :

$$\bar{v}_k = \dot{\bar{X}}_{P_k}(t) - \bar{V}(P_k,t)$$

- apply a discrete Tisserand condition to the residual velocities :

$$\begin{cases} \sum_k \bar{v}_k = 0 \\ \sum_k \bar{X}_k \wedge \bar{v}_k = 0 \end{cases}$$

Note : For the ITRF89 results presented in this poster during the colloquium, see the IERS Technical Note n° 6 (Boucher, Altamimi, 1990b).

References

C. Boucher, Z. Altamimi, 1989, The initial IERS Terrestrial Reference Frame, IERS Technical Note n° 1.

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