

# The Importance of Timing Metadata

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**Abstract.** We emphasize the crucial importance for authors and researchers to attach good and adequate metadata to their time-domain data. We provide pointers to existing and emerging standards, and provide guidance for labelling time in publications.

**Keywords.** Time

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## 1. When Time is of the Essence

When accurate timing really counts it is crucial to have good, complete and self-consistent metadata. Considering that often one cannot predict unambiguously how data will be used in the future, it is good practice and proper stewardship to attach good metadata to all data objects. To do so when the objects are created is really not a lot of trouble, and it makes life much easier later on. It will also make the data much more useful:

**if you want your data to be used 1, 2, 5, 10, 20, 50, 100 years from now,  
attach all the metadata you can, as accurately as you know them**

There are three metadata items that simply have to be there:

- **Time-Scale:** TCB, TCG, TDB, TT, TAI, GPS, UTC ...
- **Observation Location:** The precise location from where the observation was made
- **Time Reference Location:** Location to which the (arrival) time is referenced, such as Geocenter, Barycenter, Topocenter (i.e. the Observation Location)

There are three more items that may be required:

- **Time Zero Point**, in cases where time is recorded in the data as relative (or elapsed) time (such as a standard reference point for a mission, or the start of a time-series)
- **Time Reference Direction**, where the Time Reference Position is not the Observatory Location (Topocenter), in order to reconstruct path-length compensation
- **Solar System Ephemeris**, for cases in which the Time Reference Position, Observatory Location, and/or Time Scales are not tied to the earth (e.g., Barycenter)

Finally, there are two metadata items which may be implied by the Solar System Ephemeris or may need to be supplied separately:

- **State vectors** of Observatory Location and/or Time Reference Position
- **Gravitational potential** at Observatory Location and/or Time Reference Position

Concerning the Time-Scales, TT and TCG are earth-bound, while TDB and TCB are tied to the solar-system barycenter; TT and TDB are dynamical times, while TCG and TCB are co-ordinate times. TT, TAI, and GPS run synchronously at constant offsets from each other (TT-TAI = 32.184 sec; TAI-GPS = 19 sec), while UTC is offset by leap seconds (currently 34) from TAI to keep it within 0.9 sec of UT1. For further details on Time-Scales, see (for instance) Wallace (2011) or Rots (2010).

## 2. Standards for these Metadata

There are two standards that are, or will soon be, available to the astronomical community to guide data publishers in making proper metadata available:

### 2.1. IVOA

Time metadata standards for the Virtual Observatory are included in the standard for Space-Time Coordinate metadata (STC): <http://ivoa.net/Documents/latest/STC.html>

### 2.2. FITS

A FITS World Coordinate System paper (FITS WCS V) on Time is in preparation; the authors are Rots, Bunclark, Calabretta, Allen, Manchester & Thompson. A second draft was circulated in October 2011.

## 3. Proper Labelling of Time in Publications

It is vitally important to exercise care when referring to time in publications, especially in the labelling of axes in figures. There are three officially accepted ways to denote time: an ISO-8601 string (yyyy-mm-ddThh:mm:ss, where decimals may be added to the seconds field), Julian Date (JD), and Modified Julian Date (MJD, where  $MJD = JD - 2400000.5$ ). Note that none of these implies any particular Time-Scale or any particular Time Reference Position; that information needs to be provided separately. We strongly recommend labels such as

JD 2452300.487 (TT; Geocenter)  
MJD 53245.964 (TDB; Barycenter)  
2011-10-10T11:56:34 (UTC; Topocenter)

The above constitute an extension (by adding the Time Reference Position) of the IAU's recommended notation. What should be avoided at all cost are creative but utterly confusing labels like "BJD" or "BJD-240000". The former case appears to indicate a time, somehow related to the barycenter, but it is not clear whether it represents TDB, or just TT or UTC reduced to the barycenter. The latter case is even more confusing still since it leaves the reader wondering whether the author literally meant "2400000" or forgot to add the half day to it. Please use standard time designations; don't invent your own.

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### References

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