

Commission 4: A new webpage for ephemerides comparison

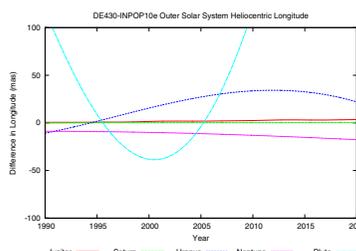
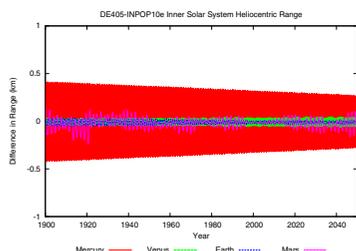
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Commission 4 Ephemerides is an IAU Division A Fundamental Astronomy commission. As part of its objectives work has been carried out to produce a new webpage that provides a tool for comparing three ephemerides, in particular EPM2011/m, DE430/LE430 and INPOP10e. These ephemerides are from expert groups around the world; Russia's Institute for Applied Astronomy, USA's Jet Propulsion Laboratory and France's IMCCE and Paris Observatory.

What are the aims of Commission 4?

- Maintain cooperation and collaboration between the national offices providing ephemerides, prediction of phenomena, astronomical reference data, and navigational almanacs.
- Encourage agreement on the bases (reference systems, time scales, models, and constants) of astronomical ephemerides and reference data. Promote improvements to the usability and accuracy of astronomical ephemerides, and provide information comparing computational methods, models, and results to ensure the accuracy of data provided.
- Maintain databases containing observations of all types on which the ephemerides are based.
- Encourage the development of software and web sites that provide astronomical ephemerides, prediction of phenomena and astronomical reference data to the scientific community and public.
- Promote the development of explanatory material that fosters better understanding of the use and bases of ephemerides and related data.

Example Plots



Information

Information has been requested from each of the ephemerides providers and a summary is shown on the webpage in an easy to compare format. The table includes, among other items, a comparison of which solar system objects are included, the type of coordinates and the reference system used, the dates covered and also details on the file structure of the ephemerides and how they may be read. There are various links to more detailed information and documentation located on the providers' websites, as well as download links.

Still to come

More information is still to be added to the website to aid ephemerides comparisons including details on initial assumptions used, how asteroids and TNOs are included and other parameters used.



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Comparison of Ephemerides

This page provides general information about three particular Ephemerides from three different institutes that are available for download. They are listed here in the order that they were created.

In particular we are studying EPM2011/m, created before the IAU 2012, which is EPM 2011 and EPM 2011m the extension with their time ephemeris, improved lunar ephemeris including librations from Russia. The French INPOP10e available since the end of 2012, and the US DE430/LE430, usually just referred to as DE430, available since 2013 April.

The tables and plots here make no claim as to which ephemerides is the best. They are all in good agreement. Just because differences appear large or small does not imply which is more correct. This comparison has been linked to comparing carrels with cabbages, apples with oranges, or perhaps more usefully as a comparison of varieties of apples. They all have their similarities, differences, strengths and weaknesses. It is the reader's responsibility to investigate and understand. Here we try to collect various pieces of information to help in that process.

EPHEMERIDES: EPM 2011/m INPOP 10e DE40-LE430

VISUAL COMPARISONS: Planetary Long. Lat. Planetary Distances

MOON: Moon B. Long. Lat. RA. Dec. Positional Angles

Visual Comparisons

This section of visual comparisons show the three ephemerides compared against each other and against the very much older JPL DE 405 created in the mid 1960s.

The inner (Mercury, Venus, Earth, Mars) and outer (Jupiter, Saturn, Uranus, Neptune and dwarf planet Pluto) solar system have been plotted separately, since the positions of the inner solar system are known more accurately. The ephemerides have been sampled every 10 days over two periods: 1.5 centuries from 1900, and 30 years from 1990 i.e. from the start of availability of accurate data for the inner planets. The plots have been split up into separate files for ease of downloading, but the plots are numbered consecutively for reference.

1.0 Plots of Differences: Heliocentric Longitude & Latitude, 1900–2020 & 1990–2020

These files contain plots that show **only** the differences in heliocentric coordinates.

DE 405 - EPM 2011 DE 430 - EPM 2011 INPOP 10e - EPM 2011

DE 405 - INPOP 10e DE 430 - INPOP 10e

2.0 Plots of Differences: Barycentric & Heliocentric Distance, 1900–2050 & 1990–2020

These files contain plots that show **only** the differences in barycentric and heliocentric distance.

Comment: The differences in barycentric distances between EPM and the other ephemerides are large because EPM includes the 21 largest TNOs (including Eris, Makemake, Haumea, and Sedna) in their integration process. The masses of these objects, at such large distances, affect the centre of gravity of the system and thus the position of its origin, the barycentre. However, the difference in the position of the barycentre does not affect the resulting heliocentric positions. This shows that just looking at one aspect, in this case plots, does not give the full picture.

DE 405 - EPM 2011 DE 430 - EPM 2011 INPOP 10e - EPM 2011

DE 405 - INPOP 10e DE 430 - INPOP 10e

3.0 Plots of Differences: Lunar Positional & Rotational Ephemerides 1900–2020 & 1990–2020

Lunar positions are usually considered in relation to the Earth and thus these plots show **only** differences in geocentric coordinates.

3.1 Plots of Differences: Moon: Range, Longitude, Latitude, Right Ascension & Declination

DE 405 - EPM 2011/m DE 430 - EPM 2011/m INPOP 10e - EPM 2011/m

DE 405 - INPOP 10e DE 430 - INPOP 10e

3.2 Plots of Differences: Lunar Orientation & Rotation Angles

The lunar orientation and rotation angles (ψ , ϕ , ν) are defined relative to the ICRS Earth equator and equinox. They describe the orientation of the principal axes of inertia of the Moon, the PA system, sometimes called the axes of figure system. They are used to calculate lunar librations.

The LE403 rotational ephemeris has been used since use of LE405 rotational lunar ephemeris was discouraged.

DE 405 - EPM 2011/m DE 430 - EPM 2011/m INPOP 10e - EPM 2011/m

DE 405 - INPOP 10e DE 430 - INPOP 10e

Information

As time goes by more information will be added giving further insights into the things that are the same, the things that are different, and the things that matter. Questions concerning any of these issues may be directed to iaucom4@ukho.gov.uk and if possible Commission 4 will ascertain agreed upon answers.

Commission 4 does **not** recommend any particular ephemeris.

Ephemeris / Category	EPM 2011/m	INPOP 10e	DE 430/LE 430
Full Details	Not yet available	Not yet available	Not yet available
1.0 General Information			
Institute	IAA RAS, Russia	IMCCE, France	NASA JPL, USA
Web address for downloads	EPM 2011 (see top)	INPOP 10e (see below)	DE 430 (see top)
Published documentation	Radiative effects and dark matter in the Solar system from observations of planets and spacecraft. Pijav E.V., Pijav N.P., 2013, MNRAS 432.4, 3431-3437. DOI: 10.1093/mnras/stt055, p.3432	INPOP10e, INPOP10e new release INPOP10e	1011 not yet available.
Reading software name (language)	IRIS - C / Pascal / Java	CALCEPH Library / C or SPICE	SASA INPOP - SPICE tool kit Vintage Fortran
Planetary Objects	Sun, Mercury, Venus, Earth-Moon barycentre, Mars, Jupiter, Saturn, Uranus, Neptune, and dwarf planet Pluto.		
Moon:	Included	Included	Included
Other Objects	Ceres, Pallas, Vesta, Eris, Haumea, Makemake, Sedna	NA	NA
Lunar Resonances	Included	Included	Included
Time Ephemeris	Included	TT-TDB and TDS-TDB, in seconds depending on the time argument of the ephemeris.	Will be available
Reference system	Barycentric: Celestial Reference System (ICRS)		
Axes and origin	International Celestial Reference Frame (ICRF), origin the solar system barycentre (geocentric for the Moon)		
Time argument	TDB	TDB or TCB as chosen	TDB
Type of coordinates	Obliquity coefficients. The reading software handles evaluation and conversion to object-centric coordinates, e.g. heliocentric, geocentric, etc., as required. All planetary and lunar positions (km) and velocities (km/s) are rectangular equatorial cartesian coordinates, i.e. x, y, z, vx, vy, vz. (see relevant sections for other details)		
Date created	2011 - July 2012	2012 1205 - 2012 Dec 5	2013
Periods covered	JD 2350000.5 - JD 2350000.5 1978/09/10 - 22/4/1032	2000 +/-100 years 2000 +/-1000 years	1800 - 2300
Type of file	ASCII / Binary (PG / SPICE)	ASCII / Binary (both) / JPLEPH binary / SPICE	ASCII / SPICE
File structure	Each object in a separate file.	A binary file for all objects, separate ASCII files for position and velocity and object.	All objects in 1 file ASCII, 1 file binary.

Other Material

Some useful links that provide definitions, nomenclature and constants.
Glossary prepared by IAU WG on Nomenclature for Fundamental Astronomy
NSFA IAU Working Group on Astronomical Constants

Why do we need a comparison?

Ephemerides are used in a variety of ways by different users. As there is a choice of which ephemerides to use a comparison must be made to inform the user of the strengths, weaknesses, similarities and differences of the available options. This webpage hopes to provide such a comparison.

The webpage makes no claim as to which ephemerides should be used in any particular circumstance. Instead it just provides some tools to help the user make an informed decision on their choice of ephemerides.

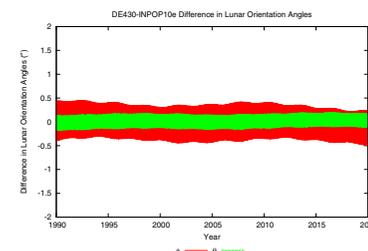
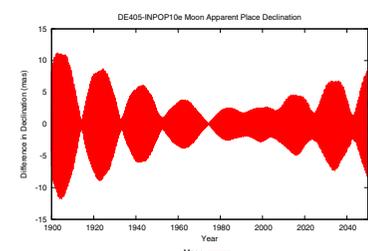
Visual Comparisons

Plots have been produced comparing the three ephemerides. The values compared are

- The heliocentric longitude and latitude of the planets.
- The barycentric and heliocentric distances of the planets.
- The geocentric range, longitude, latitude, right ascension and declination of the Moon.
- The lunar orientation and rotation angles.

The plots are produced over both long and short time periods.

Example Plots



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Questions and comments welcome.

Website

www.iaucom4.org



Acknowledgements

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