Package ‘snvecR’

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Title Calculate Earth’s Obliquity and Precession in the Past

Version 3.7.7

Description Easily calculate precession and obliquity from an orbital solution (defaults to ZB18a from Zeebe and Lourens (2019) <doi:10.1126/science.aax0612>) and assumed or reconstructed values for tidal dissipation (Td) and dynamical ellipticity (Ed). This is a translation and adaptation of the C-code in the supplementary material to Zeebe and Lourens (2022) <doi:10.1029/2021PA004349>, with further details on the methodology described in Zeebe (2022) <doi:10.3847/1538-3881/ac80f8>. The name of the C-routine is snvec, which refers to the key units of computation: spin vector s and orbit normal vector n.

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Encoding UTF-8

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### get_solution

**Description**

Get an Orbital Solution

**Usage**

```r
get_solution(orbital_solution = "ZB18a", quiet = FALSE, force = FALSE)
```

**Arguments**

- `orbital_solution`: Character vector with the name of the orbital solution to use. One of "ZB18a" (default) from Zeebe and Lourens (2019), or "La11" (not yet implemented!).

- `quiet`: Be quiet?
  - If TRUE, hide info messages.
  - If FALSE (the default) print info messages and timing.

- `force`: Force re-downloading the results, even if the solution is saved to the cache.

**Value**

`get_solution()` returns a tibble with the orbital solution input and some preprocessed new columns.

**References**


**See Also**

`get_ZB18a()`

**Examples**

```r
get_solution()
```
**Description**
Calculates helper columns from an orbital solution input.

**Usage**
```r
data, quiet = FALSE
```

**Arguments**
- **data**: The output of `get_solution()`. It needs to contain columns:
  - `t` Time \( t \) (days).
  - `lph` Longitude of perihelion \( \varpi \) (degrees).
  - `lan` Longitude of the ascending node \( \Omega \) (degrees).
  - `inc` Inclination \( I \) (degrees).
- **quiet**: Be quiet?
  - If `TRUE`, hide info messages.
  - If `FALSE` (the default) print info messages and timing.

**Details**
New columns include:
- `lphu` Unwrapped longitude of perihelion \( \varpi \) (degrees without jumps).
- `lanu` Unwrapped longitude of the ascending node \( \Omega \) (degrees without jumps).
- `hh` Variable: \( e \sin(\varpi) \).
- `kk` Variable: \( e \cos(\varpi) \).
- `pp` Variable: \( 2 \sin(0.5I) \sin(\Omega) \).
- `qq` Variable: \( 2 \sin(0.5I) \cos(\Omega) \).
- `cc` Helper: \( \cos(I) \).
- `dd` Helper: \( \cos(I)/2 \).
- `nnx`, `nny`, `nnz` The \( x \), \( y \), and \( z \)-components of the Earth’s orbit unit normal vector \( \vec{n} \), normal to Earth’s instantaneous orbital plane.

**Value**
A tibble with the new columns added.

**See Also**
- `get_ZB18a()`
- `get_solution()`
snvec

Calculate Earth’s Obliquity and Precession in the Past

Description

snvec() computes climatic precession and obliquity (or tilt) from an orbital solution (OS) input and input values for dynamical ellipticity \( (E_d) \) and tidal dissipation \( (T_d) \). It solves a set of ordinary differential equations.

Usage

```r
snvec(
  tend = -1000,
  ed = 1,
  td = 0,
  orbital_solution = "ZB18a",
  tres = 0.4,
  atol = 1e-05,
  rtol = 0,
  solver = "vode",
  quiet = FALSE,
  output = "nice"
)
```

Arguments

- `tend`: Final timestep in thousands of years before present (ka). Defaults to -1000 ka.
- `ed`: Dynamical ellipticity \( E_d \), normalized to modern. Defaults to 1.0.
- `td`: Tidal dissipation \( T_d \), normalized to modern. Defaults to 0.0.
- `orbital_solution`: Character vector with the name of the orbital solution to use. One of “ZB18a” (default) from Zeebe and Lourens (2019), or “La11” (not yet implemented!).
- `tres`: Output timestep resolution in thousands of years (kyr). Defaults to 0.4.
- `atol`: Numerical absolute tolerance passed to `deSolve::ode()`’s `atol`. Defaults to 1e-5.
- `rtol`: Numerical relative tolerance passed to `deSolve::ode()`’s `rtol`. Defaults to 0.
- `solver`: Character vector specifying the method passed to `deSolve::ode()`’s method. Defaults to "vode" for stiff problems with a variable timestep.
- `quiet`: Be quiet?
  - If TRUE, hide info messages.
  - If FALSE (the default) print info messages and timing.
- `output`: Character vector with name of desired output. One of:
  - "nice" (the default) A tibble with the columns time, age, eei, epl, phi, cp.
  - "full" A tibble with all the computed and interpolated columns.
  - "ode" A matrix with the output of the ODE solver.
Details

This is a re-implementation of the C-code in the supplementary information of Zeebe & Lourens (2022). The terms are explained in detail in Zeebe (2022).

Note that the different ODE solver algorithm we use (Soetaert et al., 2010) means that the R routine returns an evenly-spaced time grid, whereas the C-routine has a variable time-step.

Value

\texttt{snvec()} returns different output depending on the \texttt{outputs} argument.

If \texttt{output = "nice"} (the default), returns a \texttt{tibble} with the following columns:

- \texttt{time} Time \( t \) (days).
- \texttt{age} Age in thousands of years ago (ka).
- \texttt{eei} Orbital solution’s eccentricity \( e \), interpolated to output timescale (\( \cdot \)).
- \texttt{epl} Calculated Obliquity \( \epsilon \) (radians).
- \texttt{phi} Calculated Precession \( \phi \) (radians) from ECLIPJ2000.
- \texttt{cp} Calculated Climatic precession (\( \cdot \)) as \( e \sin(\varpi) \).

where \( \varpi \) is the longitude of perihelion relative to the moving equinox.

If \texttt{output = "all"} (for developers), additional columns are included, typically interpolated to output timescale.

- \texttt{sx}, \texttt{sy}, \texttt{sz} The \( x \), \( y \), and \( z \)-components of Earth’s spin axis unit vector \( \vec{s} \) in the heliocentric inertial reference frame.

See the source code for descriptions of all the intermediate computational steps.

If \texttt{output = "ode"}, it will return the raw output of the ODE solver, which is an object of class \texttt{deSolve} and \texttt{matrix}, with columns \texttt{time}, \texttt{sx}, \texttt{sy}, and \texttt{sz} (see above). This can be useful for i.e. \texttt{deSolve::diagnostics()}.

References


See Also

- `deSolve::ode()` from Soetaert et al., (2010) for the ODE solver that we use.
- `get_ZB18a()` Documents the default orbital solution input.
- `get_solution()` A general function that in the future may be used to get other orbital solutions.

Examples

```r
# default call
snvec()

# remove the directory with the cached orbital solution to clean up
unlink(tools::R_user_dir("snvecR", which = "cache"), recursive = TRUE)
```

---

**ZB18a**

*Orbital Solution ZB18a*

Description

The HNBody output of Zeebe & Lourens (2019).

Usage

```r
get_ZB18a(quiet = FALSE, force = FALSE)
```

Arguments

- **quiet**  
  Be quiet?
  - If `TRUE`, hide info messages.
  - If `FALSE` (the default) print info messages and timing.
- **force**  
  Force re-downloading the results, even if the solution is saved to the cache.

Format

**ZB18a**:
A data frame with 250,001 rows and 20 columns:

- t  
  Time \( t \) (days).
- age  
  Age in thousands of years before present (ka).
- aa  
  Semimajor axis \( a \) in astronomical units (au).
- ee  
  Eccentricity \( e \) (unitless).
- inc  
  Inclination \( I \) (degrees).
- lph  
  Longitude of perihelion \( \varpi \) (degrees).
- lan  
  Longitude of the ascending node \( \Omega \) (degrees).
- arp  
  Argument of perihelion \( \omega \) (degrees).
**mna** Mean anomaly \( M \) (degrees).

The following columns were computed from the above input:

**lphu** Unwrapped longitude of perihelion \( \varpi \) (degrees without jumps).

**lanu** Unwrapped longitude of the ascending node \( \Omega \) (degrees without jumps).

**hh** Variable: \( e \sin(\varpi) \).

**kk** Variable: \( e \cos(\varpi) \).

**pp** Variable: \( 2 \sin(0.5I) \sin(\Omega) \).

**qq** Variable: \( 2 \sin(0.5I) \cos(\Omega) \).

**cc** Helper: \( \cos(I) \).

**dd** Helper: \( \cos(I)/2 \).

**nnx, nny, nnz** The \( x, y, \) and \( z \)-components of the Earth's orbit unit normal vector \( \vec{n} \), normal to Earth's instantaneous orbital plane.

### Details

The Wikipedia page on Orbital elements describes what the components relate to in order to uniquely specify an orbital plane. The function asks to download the files to the user's cache directory so that they can be accessed more quickly in the future.

### Value

`get_ZB18a()` returns a tibble with the orbital solution input and some preprocessed new columns.

### Source
- All orbital solutions by Zeebe can be found on [http://www.soest.hawaii.edu/oceanography/faculty/zeebe_files/Astro.html](http://www.soest.hawaii.edu/oceanography/faculty/zeebe_files/Astro.html).
- The specific one we use here is available at [http://www.soest.hawaii.edu/oceanography/faculty/zeebe_files/Astro/PrecTilt/OS/ZB18a/ems-plan3.dat](http://www.soest.hawaii.edu/oceanography/faculty/zeebe_files/Astro/PrecTilt/OS/ZB18a/ems-plan3.dat).

### References


### See Also

`prepare_solution()` Processes orbital solution input to include helper columns.

### Examples

```r
get_ZB18a()
```
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