

ASTERICS Meeting

Padua Sep 20th, 2018

ARTECS: the Trieste Exoclimates Archive

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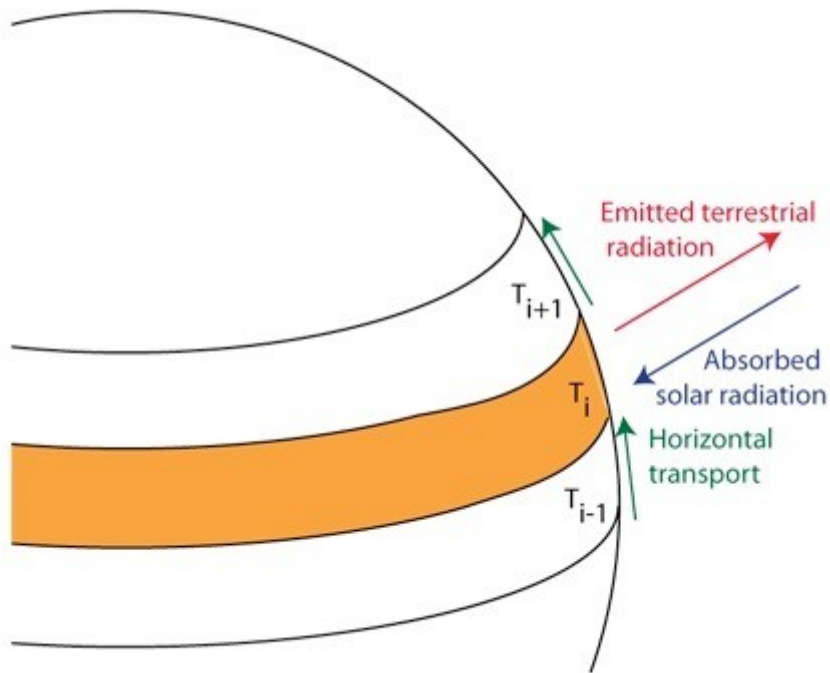
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<http://wwwuser.oats.inaf.it/exobio/climates>

Earth Like Surface Temperature Model (ESTM)

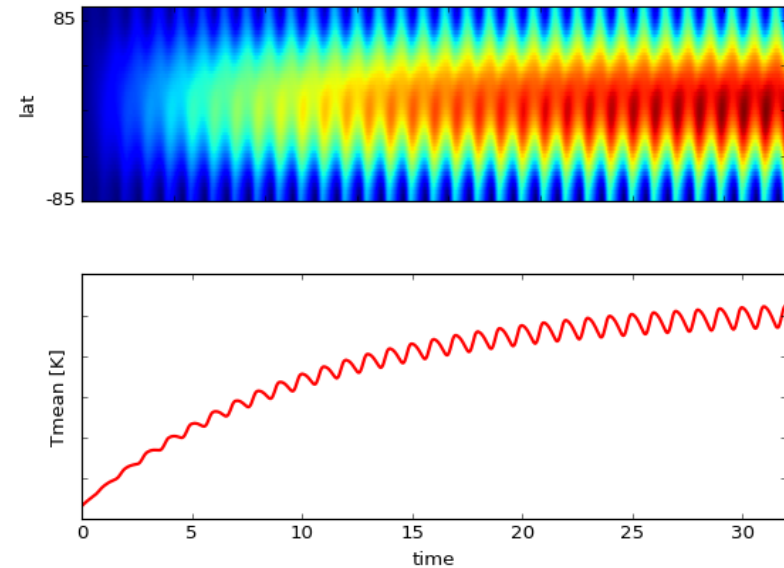
- ESTM (Vladilo et al. 2013, 2015):
 - EBM calibrated on 3D Global Circulation Models (GCM)
 - 1d model (lat) + time dependence (orbital motion)
 - Radiative equilibrium
 - Long v.z. short wave radiation transport
 - Meridional transport
 - Albedo accounts for: surface A_s , radiative transport in a column \Rightarrow top of atmosphere albedo
 - Accounts for distribution of “continents” (rock outside ocean) and ices



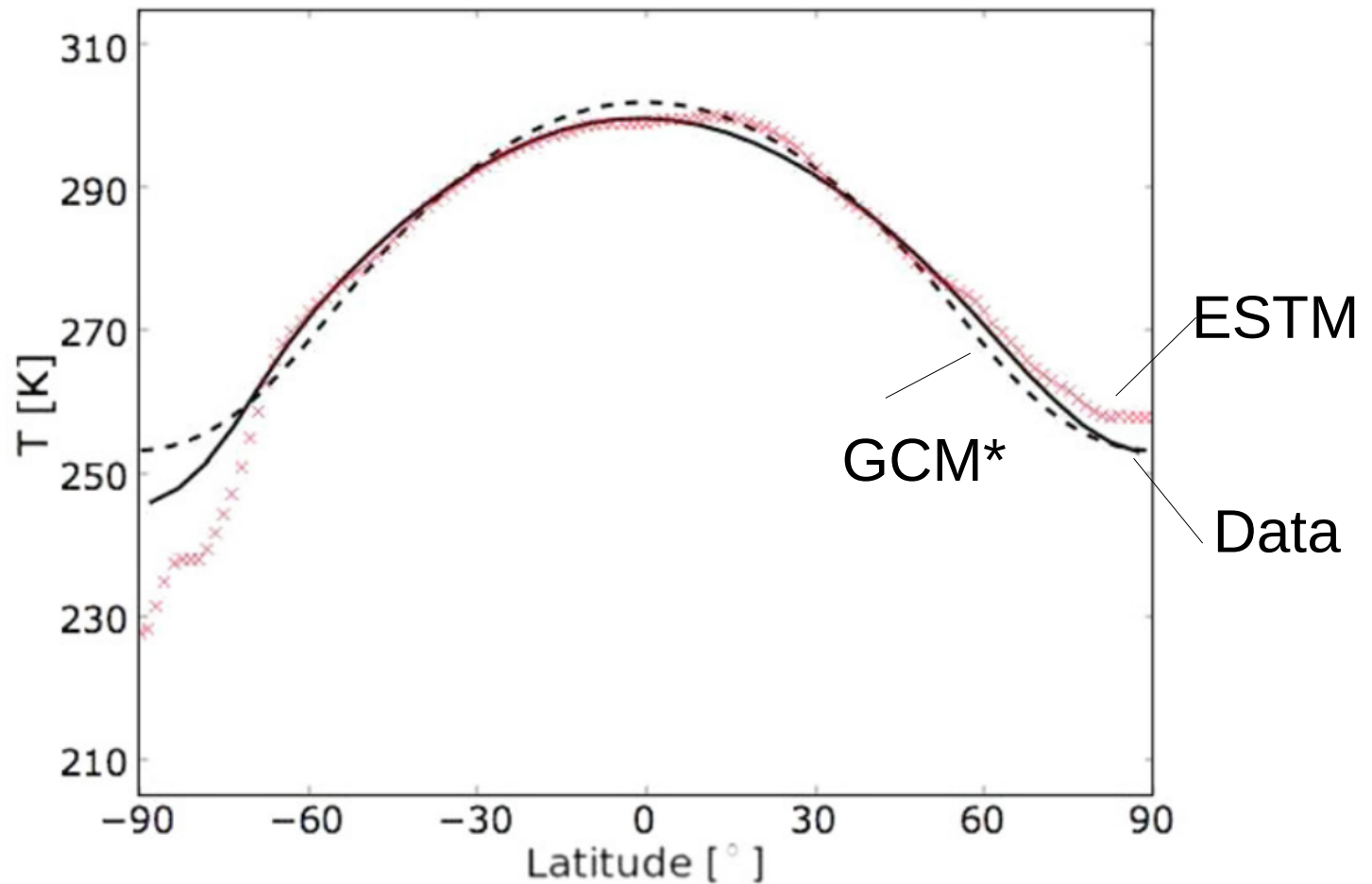
<http://wwwuser.oats.inaf.it/exobio/climates>

Running ESTM

- out of equilibrium
“initial conditions” for
atmosphere (ps, Ts)
are taken
- ESTM model is
evolved until
equilibrium conditions
(limiting cycle) are
reached
- < 150 Orbits, 10 - 15 min
- GCM 10^2 or 10^3 hours or more



Comparison with Earth



(*Kaspi, Y., & Showman, A. 2014, arXiv:1407.6349)

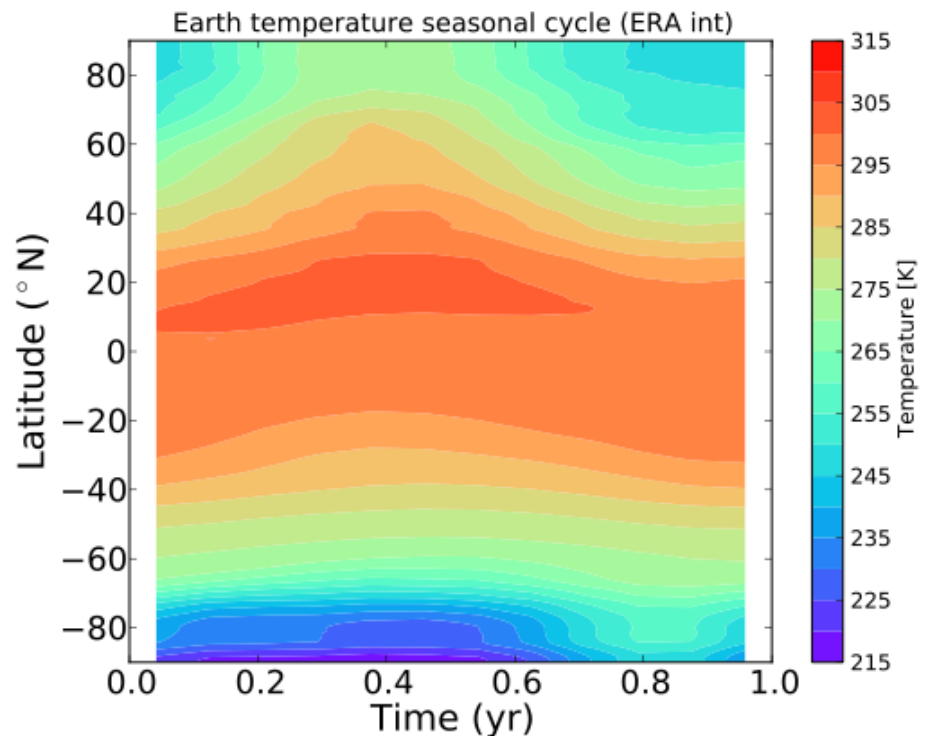
ESTM Limitations

- Limitations:
 - Earth like planets (no giants)
 - Thin atmosphere
 - Condensible: H₂O
 - Obliquity < 45 deg (meridional circulation)
 - Rotation period shorted or about one day, not tidally locked
 - No chemical evolution of atmosphere, but it is possible to play with Green House gasses, example: P_CO₂
 - Solar like stars

The Archive

<http://wwwuser.oats.inaf.it/exobio/climates>

- FITS files gzipped
 - ~10 K -> 50 K
 - 48 (Time) x 54 (lat)
 - HDU 0 – METADATA
 - HDU 1 – Binary Table
 - Latitude
 - Longitude
 - Surface Temperature
 - HDU ... future expansion



The Archive

<http://wwwuser.oats.inaf.it/exobio/climates>

- Hosted at INAF IA2 in Trieste
- Based on a systematic set of simulations produced with ESTM
- Selecting set of simulation according to combinations of search parameters
- Download metadata and model in form of FITS files

The screenshot shows the 'Exoclimates archive' search interface. It features several sections for filtering results:

- Stellar parameters:** Includes checkboxes for 'Stellar mass', 'Stellar radius', 'Stellar density', and 'Stellar age'. There are also input fields for 'Stellar mass' and 'Stellar radius' with units.
- Planet astrophysical parameters:** Includes checkboxes for 'Planet mass', 'Planet radius', 'Planet density', and 'Planet age'. There are also input fields for 'Planet mass' and 'Planet radius' with units.
- Planet geophysical parameters:** Includes checkboxes for 'Planet temperature', 'Planet surface pressure', 'Planet surface gravity', and 'Planet surface composition'. There are also input fields for 'Planet temperature' and 'Planet surface pressure'.

At the bottom, there are buttons for 'Search' and 'Reset'.

The screenshot shows the search results table. The table has the following columns:

- File name
- Stellar mass
- Eccentricity
- Obliquity of rotation axis
- Pressure

The table displays a list of simulation results, each with a unique file name and corresponding parameter values. The results are sorted by file name. At the bottom, there is a 'Total results: 2548' label.

http://

mates

- Hosted at
- Based on
ESTM
- Selecting
search pa
- Download

ced with

tions of

files

Exoclimates archive

[Explanation page](#)

Stellar parameters

<input type="checkbox"/> Solar masses	1.9891e30
<input type="checkbox"/> Luminosity	3.8247196e26
<input checked="" type="checkbox"/> Semi-major axis	From <input type="text"/> To <input type="text"/>
<input checked="" type="checkbox"/> Eccentricity	From <input type="text"/> To <input type="text"/>
<input type="checkbox"/> Argument of pericenter	-77.06300354

Planet astrophysical parameters

	Min	Max
<input type="checkbox"/> Planet radius	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Planet rotation period	<input type="text"/>	<input type="text"/>
<input checked="" type="checkbox"/> Tilt/obliquity of rotation axis	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Surface gravity	<input type="text"/>	<input type="text"/>

Planet geophysical parameters

	Min	Max
<input type="checkbox"/> Planet geography	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Const. fraction of oceans	<input type="text"/>	<input type="text"/>
<input checked="" type="checkbox"/> Pressure	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> CO2 Partial pressure		209460.0
<input type="checkbox"/> O3 Partial pressure		0.0
<input type="checkbox"/> H2 Partial pressure		780840.0
<input type="checkbox"/> CO partial pressure	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> CH4 partial pressure	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Relative humidity		0.6

Results of the simulation

<input type="checkbox"/> Mean temperature	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Mean albedo	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Mean cloud coverage	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Liquid-water habitability	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Complex-life habitability	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Continuous habitability	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Nr. of orbits before convergence	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Mean ice coverage	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Equator-pole temperature difference	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Mean OLR	<input type="text"/>	<input type="text"/>
<input type="checkbox"/> Mean ASR	<input type="text"/>	<input type="text"/>

Model parameters

<input type="checkbox"/> Nr. of latitude zones	54
<input type="checkbox"/> Nr. of outputs per orbit	48
<input type="checkbox"/> Object name	<input type="text"/>
<input type="checkbox"/> File name	<input type="text"/>

Download ▾

Rows displayed

20 ▾

<input checked="" type="checkbox"/>	Filename	Solar masses	Luminosity	Eccentricity	Obliquity of rotation axis	Pressure
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0002.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	10031.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0007.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	1003.1
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0003.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	50155.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0008.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	10031.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0009.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	50155.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0012.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	501550.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0013.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	1003.1
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0010.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	100310.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0016.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	100310.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0011.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	300930.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0014.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	10031.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0015.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	50155.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0018.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	501550.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0019.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	1003.1
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0021.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	50155.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0020.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	10031.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0017.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	300930.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0022.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	100310.0
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0025.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	1003.1
<input type="checkbox"/>	ESTM1.1.01-10.02.2017-0023.fits.gz	1.9891E30	3.8247196E26	0.0	0.0	300930.0

20

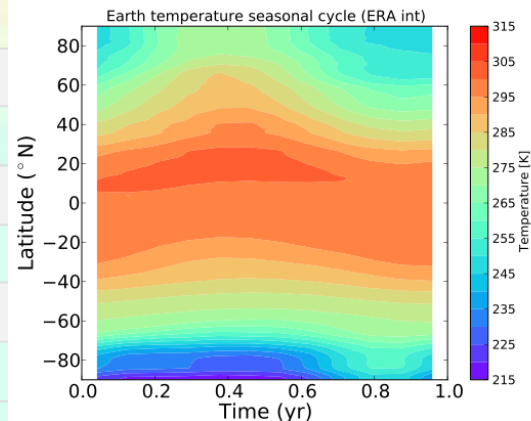
Your downloads 3 ▾

ESTM1.1.01-10.02.2017-0002.TTS.gz

Text file to be used with wget

```
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0062.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0067.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0063.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0064.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0069.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0012.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0013.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0014.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0016.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0011.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0015.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0015.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0018.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0019.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0020.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0021.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0022.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0023.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0024.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0026.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0027.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0028.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0029.fits.gz
http://archives.ia2.infn.it/FileServer/expro/file/ESTM1.1.0-10.02.2017-0030.fits.gz
```

SAMP Service
Download as XML



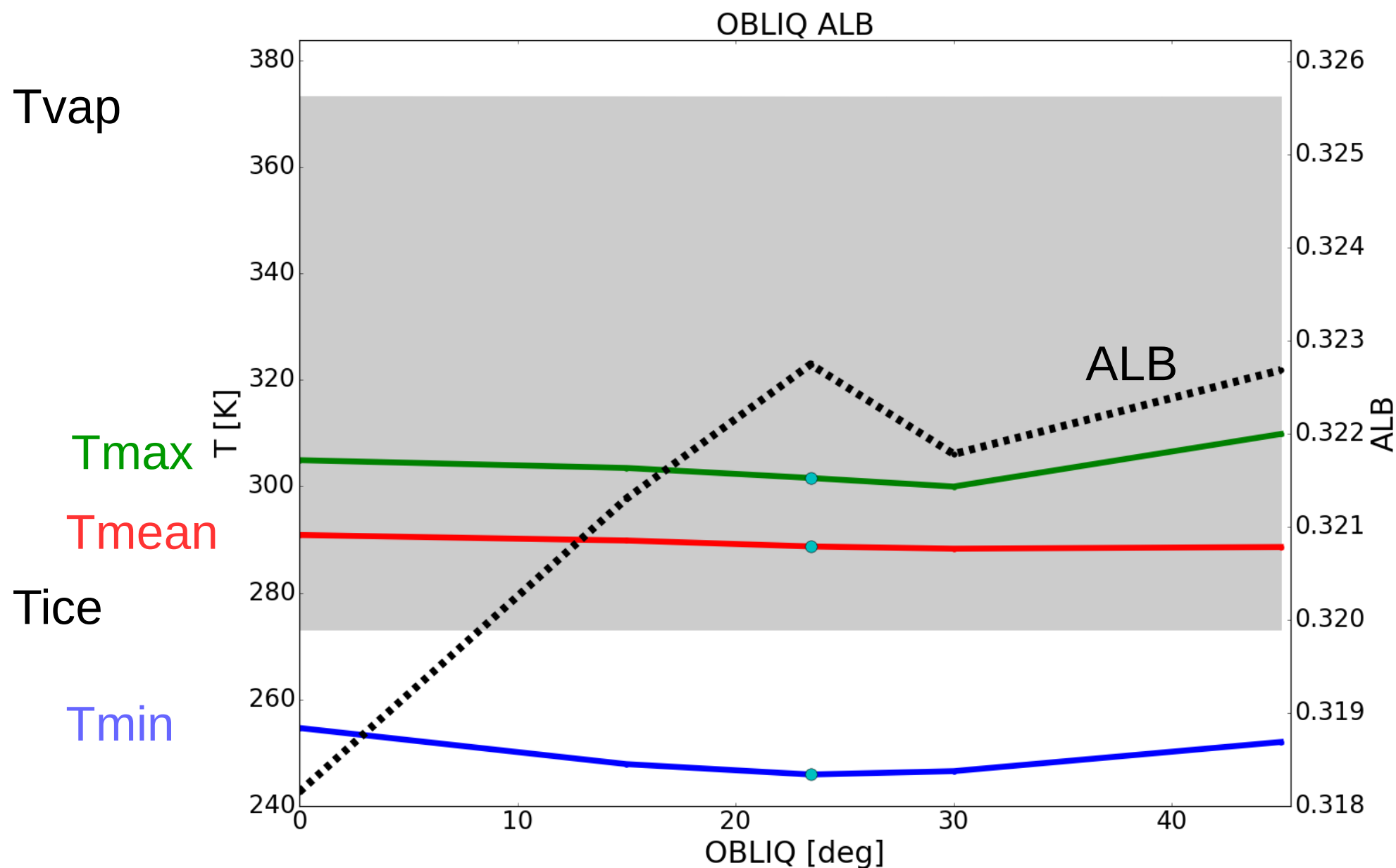
Total results: 2548

TAP Python Interface

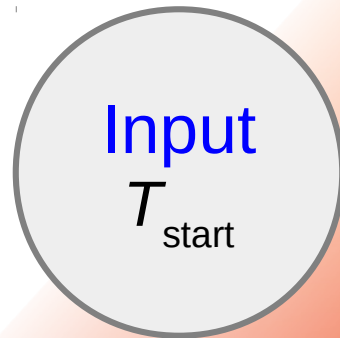
```
> import artecs  
  
> atap=artecs.exop_public_tap()  
  
> atap.EXPLAIN()  
  
> atap.keys()  
  
> tab=atap.search('(0.7 <= SMA) and (SMA <=3.)')  
  
> tab.FO_CONST.unique()  
  
> tab.to_csv('/tmp/pippo.csv',sep=' ')  
  
> MAP=atap.get_map(tab.URL[0])
```

Stimulated by a discussion with A. Zinzi, ESA - ASDC

Example: Earth Climate and OBLIQ

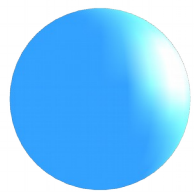
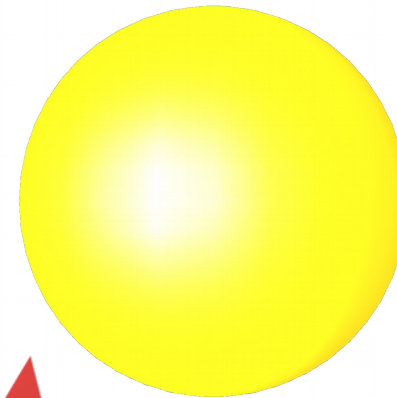


ESTM Parameters



Stellar
 M_* , R_* , L_* , Spectra

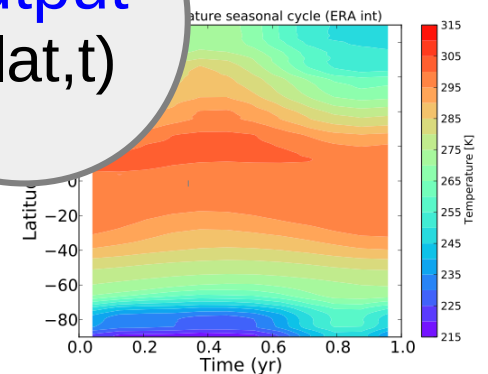
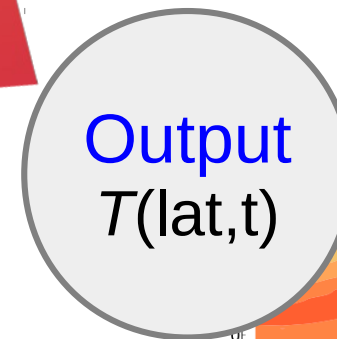
Astrodinamics
 a , e , obliq



Atmospheric
 $P_{\text{dry}}(X_{\text{N}_2}, X_{\text{O}_2}, X_{\text{CO}_2}, \dots)$,
 R_{H} , Condensible(H₂O)

Planetary
 M_p , R_p , g_p , P_{rot}

Surface
 F_{ocean} , G_{eo}

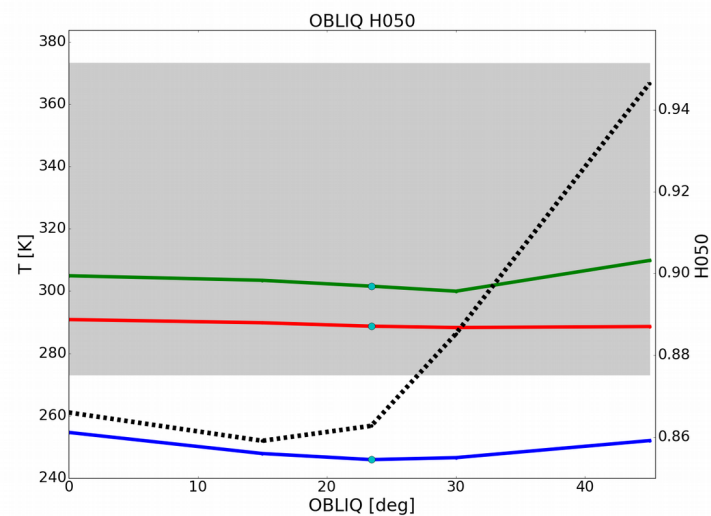
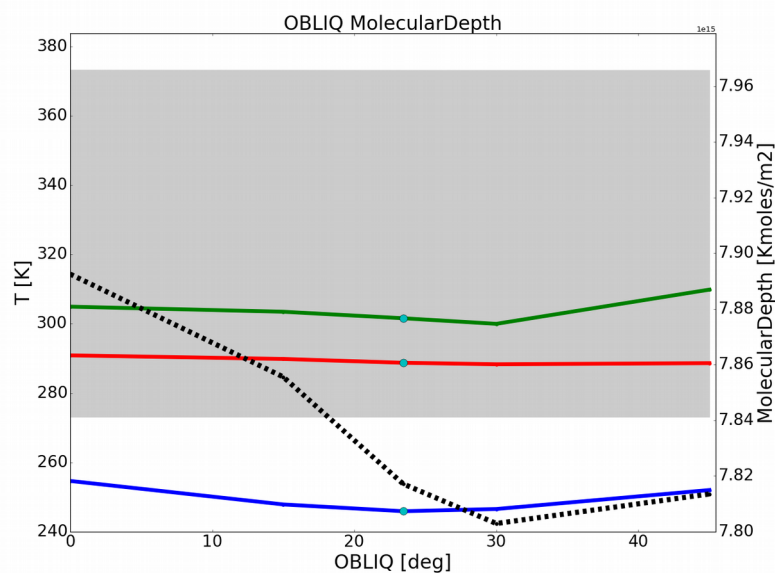
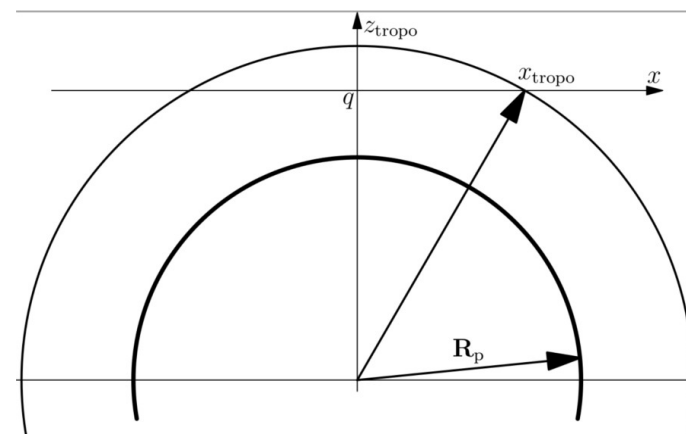
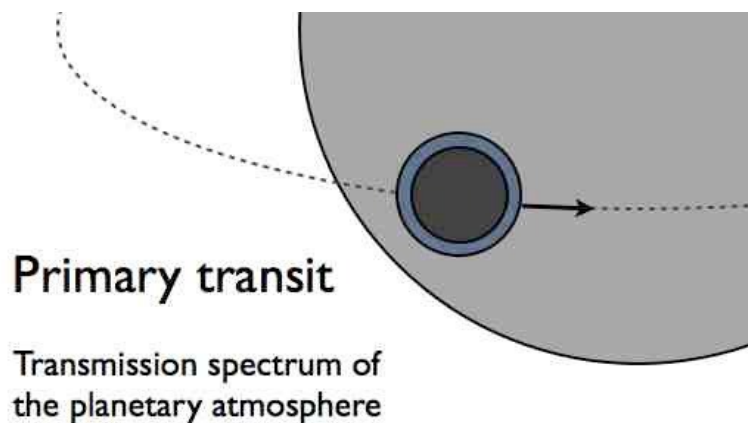


Post Processing Metadata

- Derived quantities from the model or statistics drawn on the model
 - Habitability parameters (already present)
 - Atmospheric optical depth (next release)
 - Extinction spectra (planned)
- As a function of model starting parameters

Link Models to Observations

Atmospheric Optical Depth



Data Model

45 parameters

Astrodinamics
a, e, obliq

10 Classes

Atmospheric

$P_{\text{dry}}(X_{\text{N}_2}, X_{\text{O}_2}, X_{\text{CO}_2}, \dots),$
 $R_{\text{H}}, \text{Condensible}(\text{H}_2\text{O})$

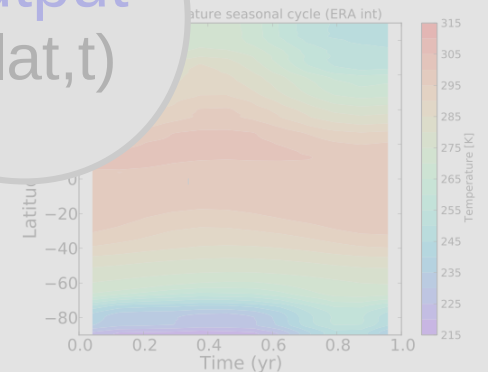
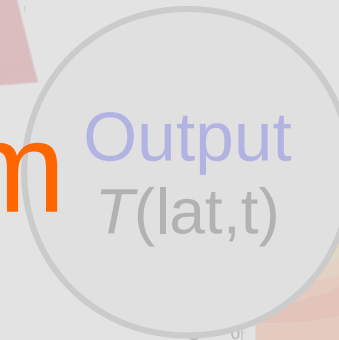
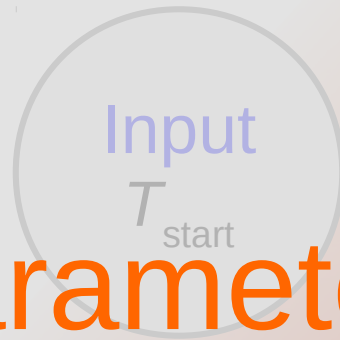
Planetary

$M_p, R_p, g_p, P_{\text{rot}}$

Minimum
params
description

Stellar

$M_*, R_*, L_*, \text{Spectra}$



Data Model

Parameters Description

Metafield	Description
name	The name of the parameter
IN/OUT	Data flow direction (if applicable)
Ordering	The class of the parameter
Nord	The numerical Class ID
Sub-order	The numerical parameter ID
Description	Description of the parameter
Ucd	
Unit	
notes	

Data Model

Sim	
<u>1 IN</u> 0. N 1. NS 2. PRJNAME 3. SIMTYPE 4. VERSION 5. DATE	<u>7 OUT</u> 1. NORBIT

Star	
<u>2 IN</u> 1. MSTAR 2. LUMSTAR 3. SpectType	<u>OUT</u>

Planet	
<u>4 IN</u> 1. NAME 2. RPLAN 3. MPLAN 4. GRAV	<u>4IN</u> 5. OBLIQ 6. PROT 7. GEO 8. FO_CONST

Orbit	
<u>3 IN</u> 1. SMA 2. ECC 3. OMEGAPER	<u>OUT</u>

Data Model

ATMO

5 IN

1. RH
2. PRESS
3. PN2
4. PO2

5 IN

5. P_CO2
6. P_CH4
7. P_O3

Climate

8 OUT

1. TMGLOB
2. Tmin
3. Tmax
4. DTEP
5. ALB

8 OUT

6. CLOUDS
7. ICE
8. MOLR
9. MASR
10. CLASS

Habit

9 OUT

1. HLW
2. H050
3. CONTHAB

9 OUT

Other

10

1. URL
2. POLICY

10

Extensions

xxx

1. References
2. Validation data

xxx

3. bistability
4. transitional