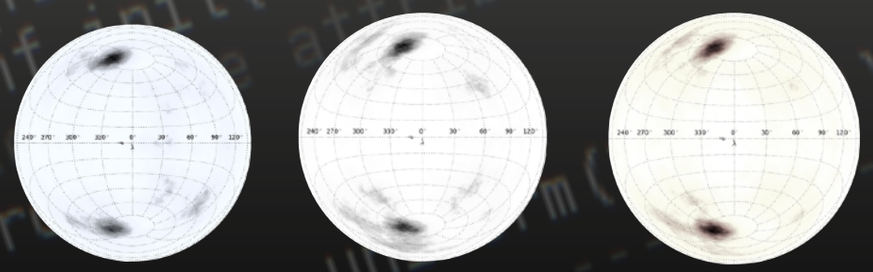
github.com/rosich/starsim-2

BRIEF USER'S MANUAL

STARSIM/2



STARSIM/2

AIM

STARSIM/2 is a fast code for simulating the effects of stellar activity in photometry and radial velocity due to rotating spots and faculae.

Coded in Python & Fortran 90

DEPENDENCIES

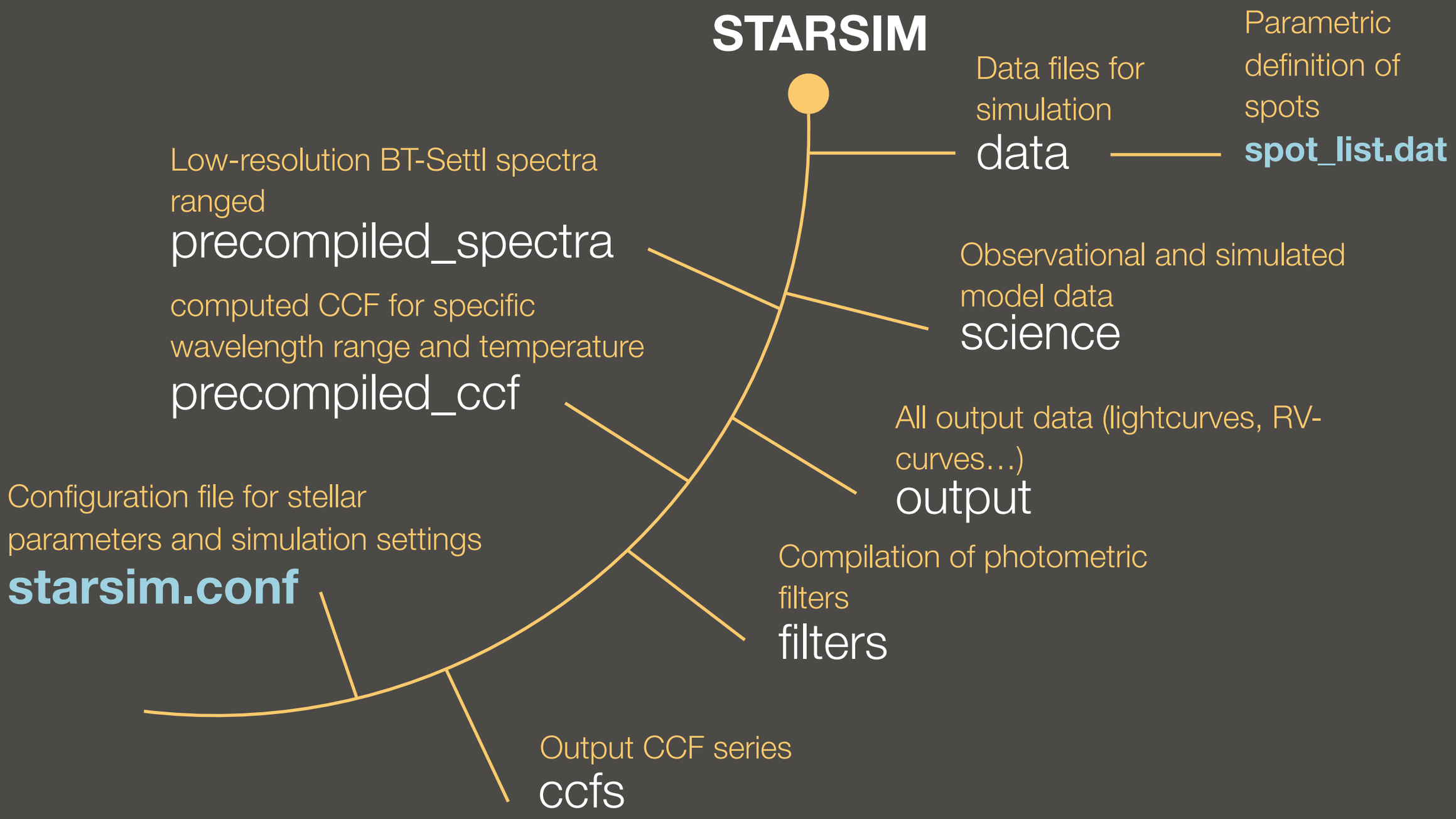
Python 2.7.3+
Numpy 1.7+
gfortran compiler
scipy 0.18.1+

COMPILATION OF NUMERICAL ROUTINES

```
$ bash compile_fmodule.sh
```

STARSIM/2 package

File tree and important files



./data/spot_list.dat

```
# init time :: lifetime  :: colatitude (deg) :: longitude (deg) :: radius (deg)
   -10.0          25.0          90.0              165.5              5.51
    2.5           31.5          76.3              315.0              3.58
   -5.6           28.0          81.6              225.0              7.80
~
~
~
~
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~
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```
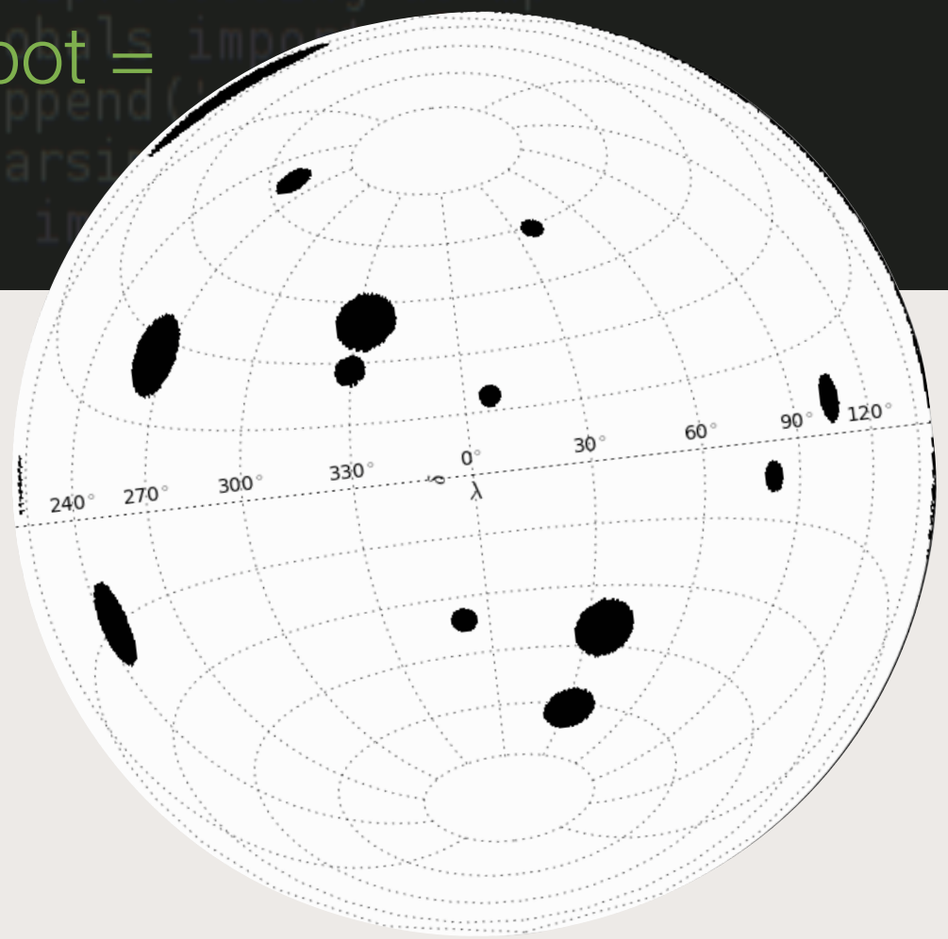

Appearance time and lifetime

Spots in spherical coordinates (equatiorial spot = 90º)

Radius (º)

List of all spot elements with 5 parameters



/stars.conf

Simulation parameters & star propierties

- Most important

```
ang_res : 0.5                       ; grid resolution (deg)
time_cadence: 60                    ; Time cadence (minutes)
min_spec_range_gen : 450.0          ; Min spec range to generate (nm)
max_spec_range_gen : 900.0          ; Max spec range to generate (nm)
init_time_sim : 0.0                 ; Initial time of simulation (days)
final_time_sim : 90.0               ; Final time of simulation (days)
spectra_resolution : low            ; Resolution of BT-Settl spectra (high/low)

[rv]

ccf_vel_range :  15.0               ; CCF velocity range (km/s)
spectral_mask :  G2                 ; G2/K5/M2 (HARPS) //  IR (wide VIS-NIR)

[star]

t_eff_ph : 2790.0                   ; Teff of the star photosphere (K)
spot_T_contrast : 0.0               ; Spot temperature contrast (K)
faculae_T_contrast : 150.0          ; Faculae temperature contrast (K)
p_rot : 7.55                        ; Rotation period (days)
logg : 4.5                          ; Stellar surface gravity
metal : 0.0                         ; Stellar metallicity
alpha_element  : 0.0                ; Alpha elements [alpha/Fe]
q_ratio : 0.0                       ; Facular to spotted area ratio Q
axis_i : 90.0                       ; Axis inclination (deg)
diff_rotation : 0.0                 ; Diff rotation (Sun=1); (3.1513 (deg/day)
B_rot : 2.39                        ; B rotation coefficient (deg/day)
C_rot : 1.78                        ; C rotation coefficient (deg/day)
spot_size_evo_rate : 0.5            ; Spot size evolution rate (deg/day)

[spots]

spots_lifetime : 50.0               ; Spots lifetime (days)
spots_lifetime_sigma : 25.0         ; Spots lifetime sigma (days)


[planet]

planet_impact_param : 0.313         ; Planet impact parameter b (no 0.0!)
spin_orbit_angle : 0.0              ; Spin-orbit angle (deg)
planet_radius : 0.1171              ; Planet radius (R*)
planet_eph_t0 : 0.09                ; Planet ephemeris T0 (days)
t_planet : 1.5804                   ; Planet period (days)
time_to_sim_mid : 0.07              ; Time to simulate since mid (days)
```

STARSIM forward problem

Given a spot map + spectra + star parameters → **OBSERVABLES**

lightcurves, radial velocity curves…

```
$ ./starsim 2.py —-mode=[option]
```

`—-mode=ph`	**Photometry**
`—-mode=rv`	**Radial velocity**
`—-mode=bis`	**CCF Bisector**
`—-mode=contrast`	**CCF Constrast**
`—-mode=fwhm`	**CCF FWHM**

TOY-MODEL EXAMPLE

0 `$ bash compile_fmodule.sh`

1

Set t_eff_ph = 5770 K

Set spot_t_contrast = 1500 K

Set p_rot = 9.5 days

Set axis_i = 90.0 deg

Set diff_rotation = 0.5 solar units

Set spot_size_evo_rate = 0.5 deg/day

[In ./starsim.conf]

2

Set min_spec_range_gen = 450.0

Set max_spec_range_gen = 900.0

(KEPLER RANGE)

3 ./starsim_2.py —— mode=ph

4

Set min_spec_range_gen = 380.0

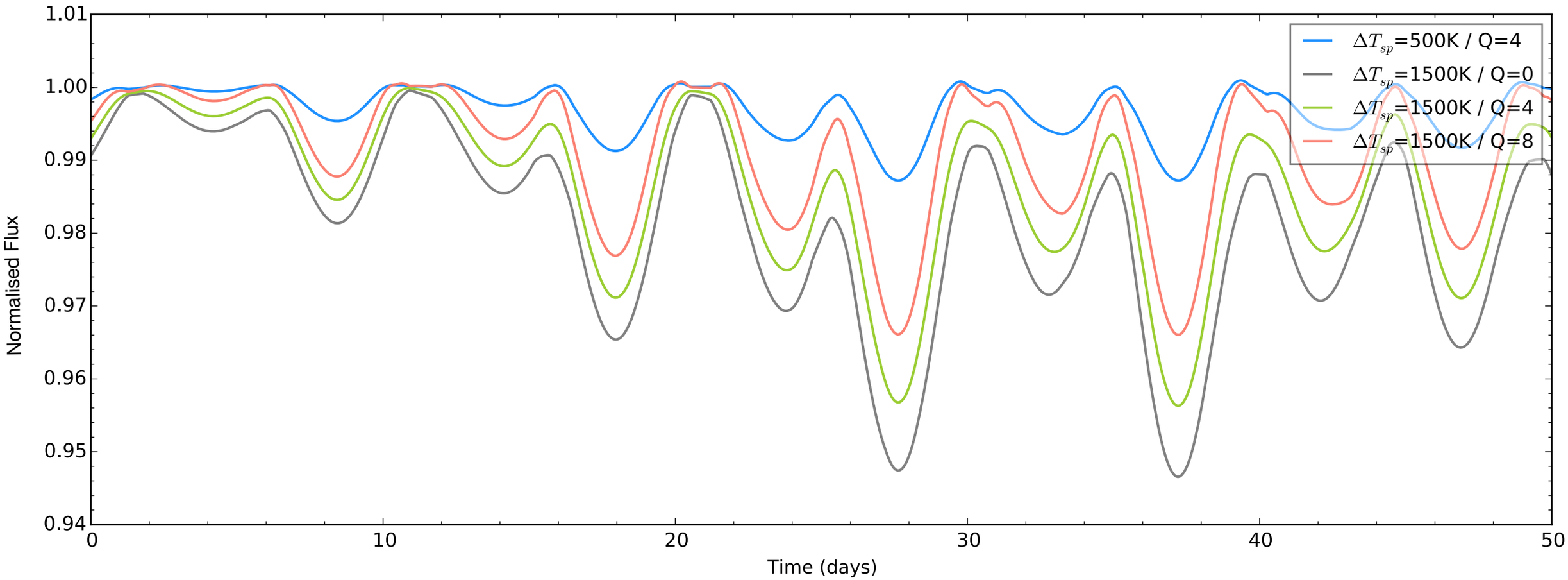
Set max_spec_range_gen = 690.0

(HARPS RANGE)

5 ./starsim_2.py —— mode=rv

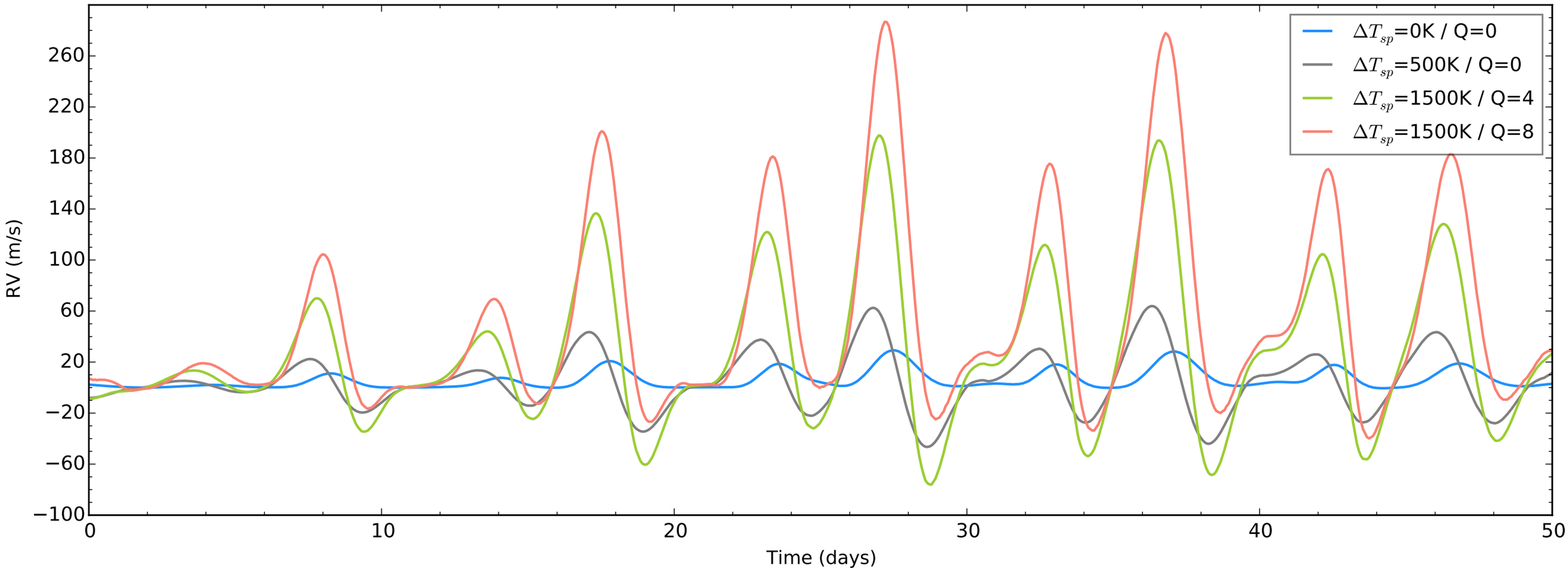
TOY-MODEL EXAMPLE ./output

Flux (Kepler filter)



TOY-MODEL EXAMPLE ./output

RV (HARPS)



SPECTRAL BANDPASS

- **STARSIM/2** is able to simulate acitivity patterns in a spectral range between 380–2400 nm
- Precomputed spectra and CCFs are available in folder ./precompiled_spectra ./precompiled_ccf in Kepler (450–900nm) and HARPS (380–690nm) bandpass.
- In case of modifying the spectral range in ./starsim.conf file, new CCFs will be computed and saved using HR Phoenix spectra (rather time-consuming).

RANDOM SPOT MAPS

- Generating a random spotmap of <int> spots

```
$ ./starsim_2.py —-spotmap=<int>
```

A random spot distribution will be saved in ./data/spot_list.dat using the the spot parameters in configuration file ./starsim.conf