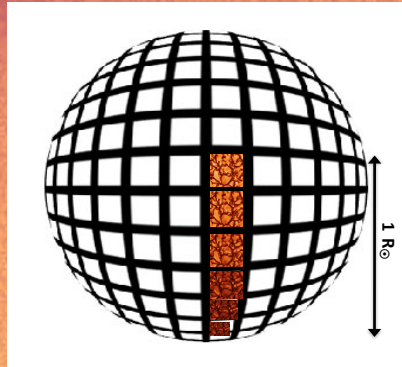
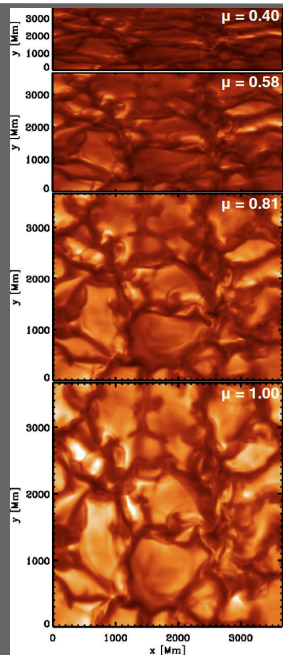
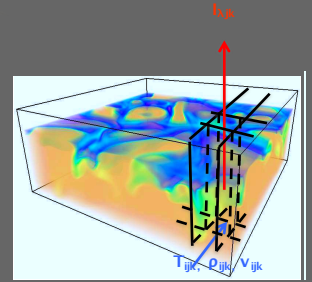




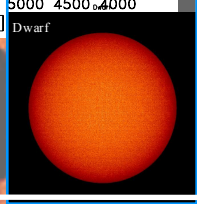
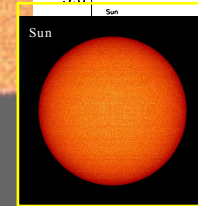
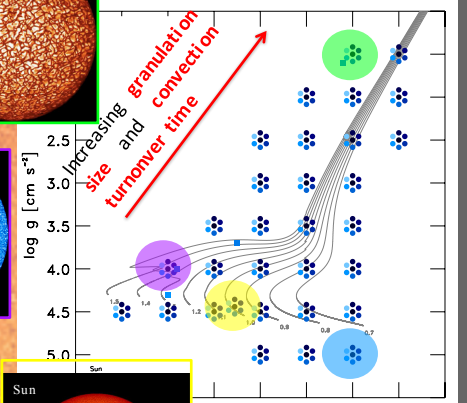
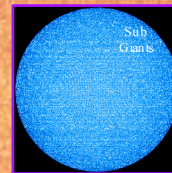
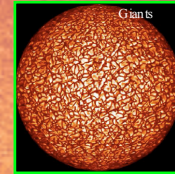
Stellar granulation is associated with heat transport and granules are **bright (hot)** areas surrounded by **dark (cooler) lanes** that tile the stellar surface. The **size/depth** of the granules **depend on the stellar parameters**.

Stellar granulation cause **bias** in stellar parameter, radial velocity, chemical abundances determinations, and **exoplanet transit**.

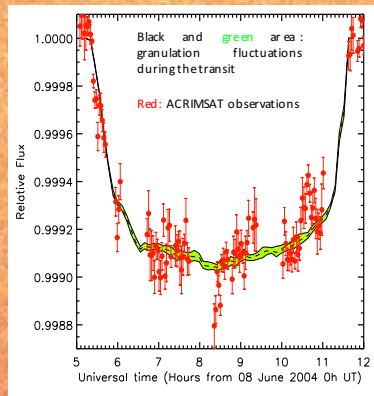
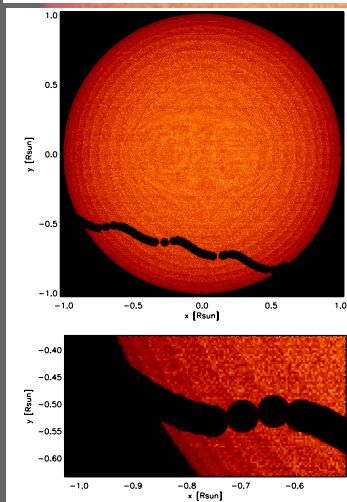
3D radiative-hydrodynamical stellar convection with Stagger Code (Nordlund et al. 2009, LRSP, 6, 2) cover a substantial part of the HR diagram (Magic et al. 2013, A&A, 557, A26). OPTIM3D is a 3D pure LTE radiative transfer code (Chiavassa et al. 2009, A&A, 506, 1351) used to compute **high resolution spectra and intensity maps** from 3D simulations including Doppler shifts caused by the convection and same extensive atomic and molecular data with billion of transitions included from optical to far infrared.



We computed center-to-limb granulation images (left) as a function of time and used them to map onto spherical surfaces (top) preserving randomness. We realized synthetic stellar surfaces in HR diagram (right) and several independent images of stellar photospheric granulation. The method is described and used in Chiavassa et al. 2010 (A&A, 524, A93), 2012 (A&A, 540, A5), 2014, (A&A, 567, A115), and 2015 (A&A, 576, A13)



Synthetic Venus Transit 8th June 2004

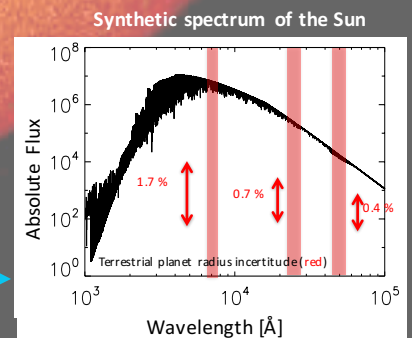
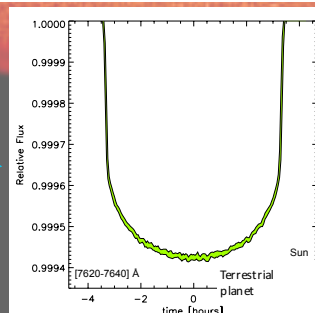
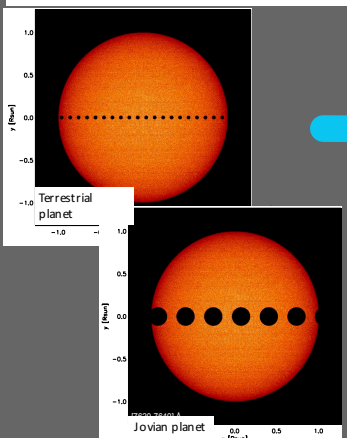


The overall agreement is very good either in term depth and Ingress/Egress slopes.

Granulation intrinsic noise that explain (better than LD models) part of the data.

Venus transit match is the first important benchmark test for 3D simulations (Chiavassa, Pere et al. 2015, A&A, 576, A13)

Measuring granulation noise impact on exo-planet radius



The **granulation pattern** signal **pollute** the detection of planets with impact on the **planet radius** (in particular for terrestrial planet).

3D simulations are important for quantifying the **bias** caused by the **granulation** (Chiavassa, Selsis, et al., submitted)

Example of the **granulation intrinsic noise** in the optical:

- Terrestrial planet 37 part per million
- Jovian planet 683 part per million