Bio-habitabilitiy and biotic abundance of Red Dwarf planets with future telescopes

51ESLAB, Noordwijk 7.12.2017

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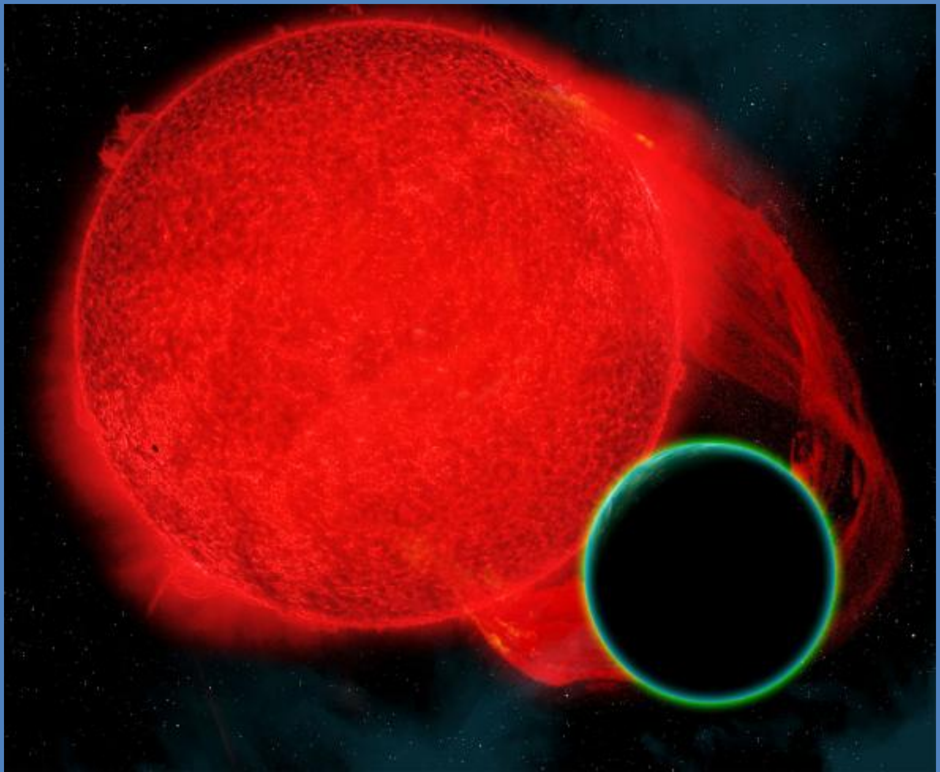
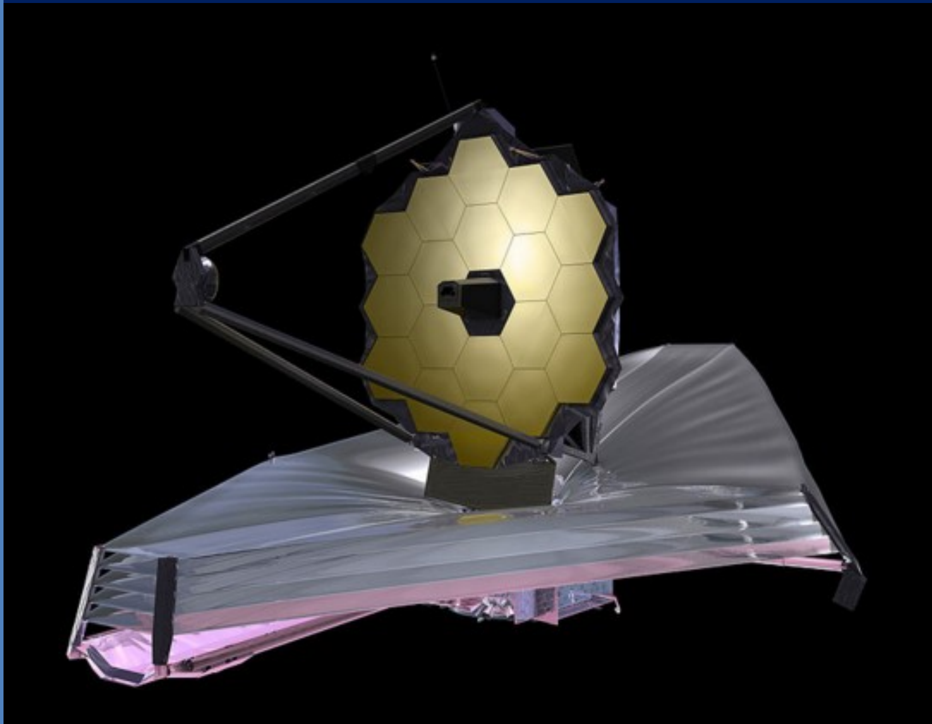
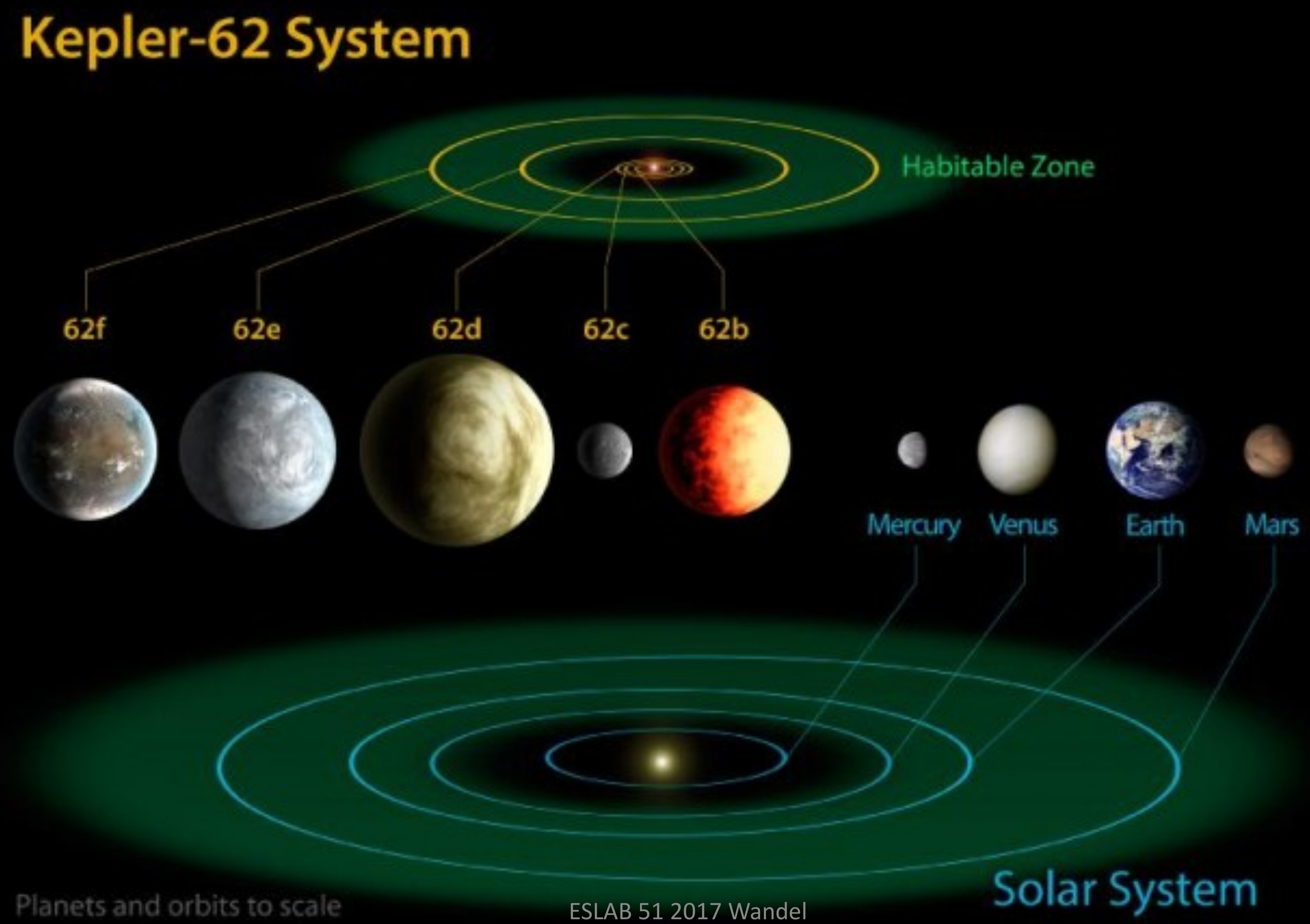
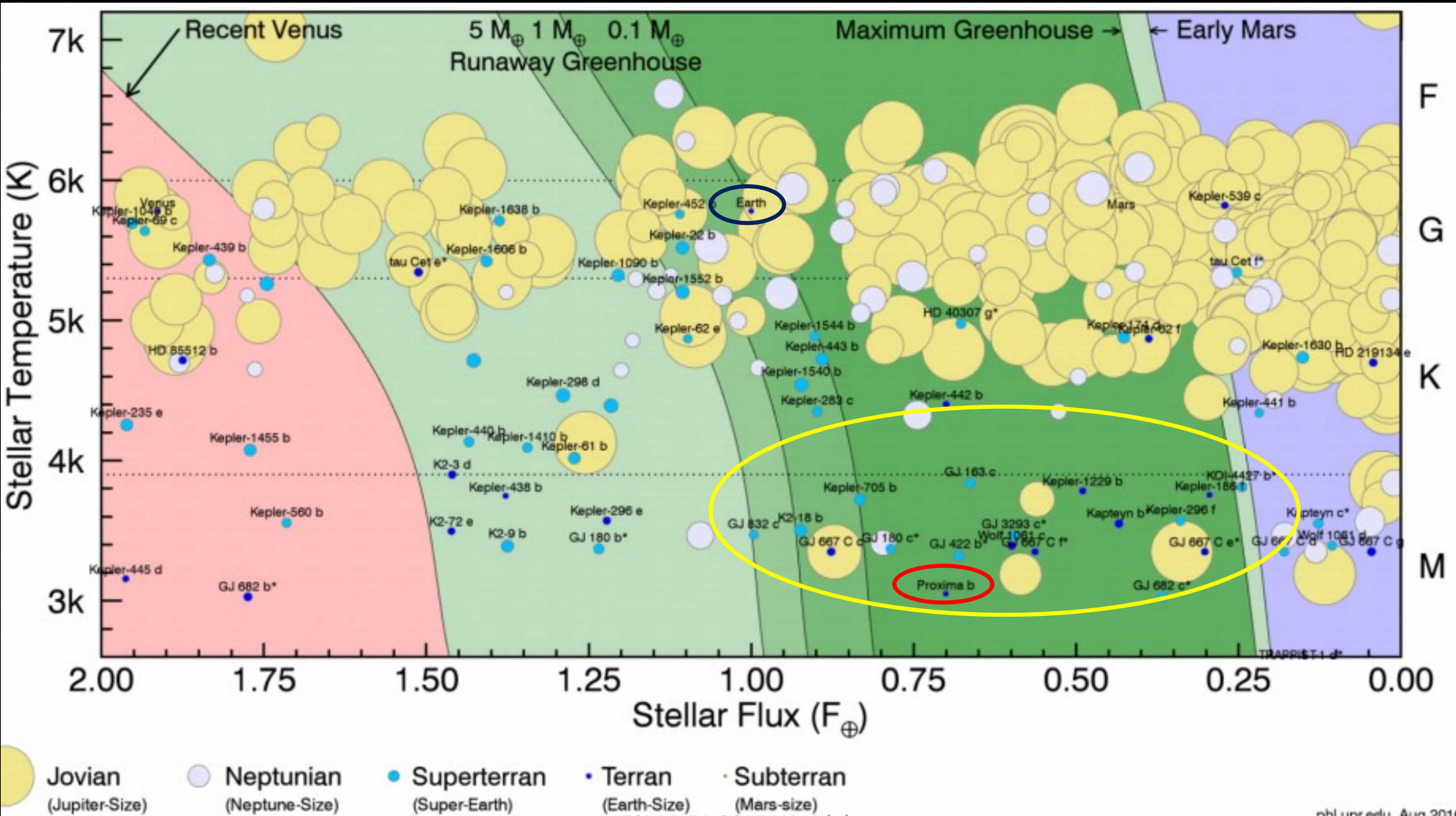




Habitable Zones of red dwarf stars



Discovered planets vs stellar flux & type

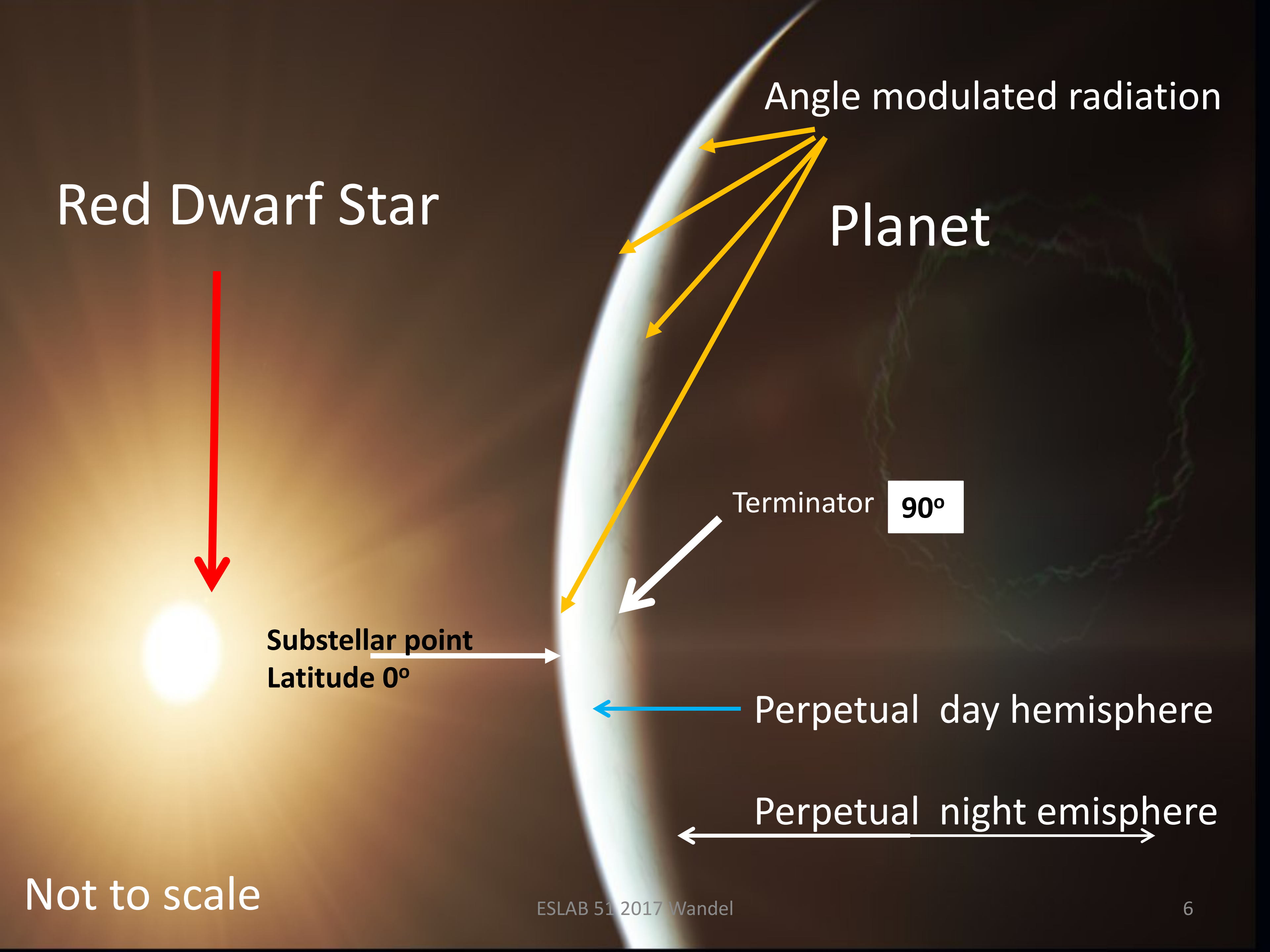


Why M-dwarfs?

- Abundant: 75% of all stars are M-dwarfs
- Easier bio-signatureare detection
- Faint hosts → smaller habitable zones (HZ),
- Planets in the HZ are nearer host star
- → Shorter periods – easier to detect (transit/RM)
- HZ planets are locked →
- wider surface temperature range (wandel 2017)
- a wider effective Habitable Zone

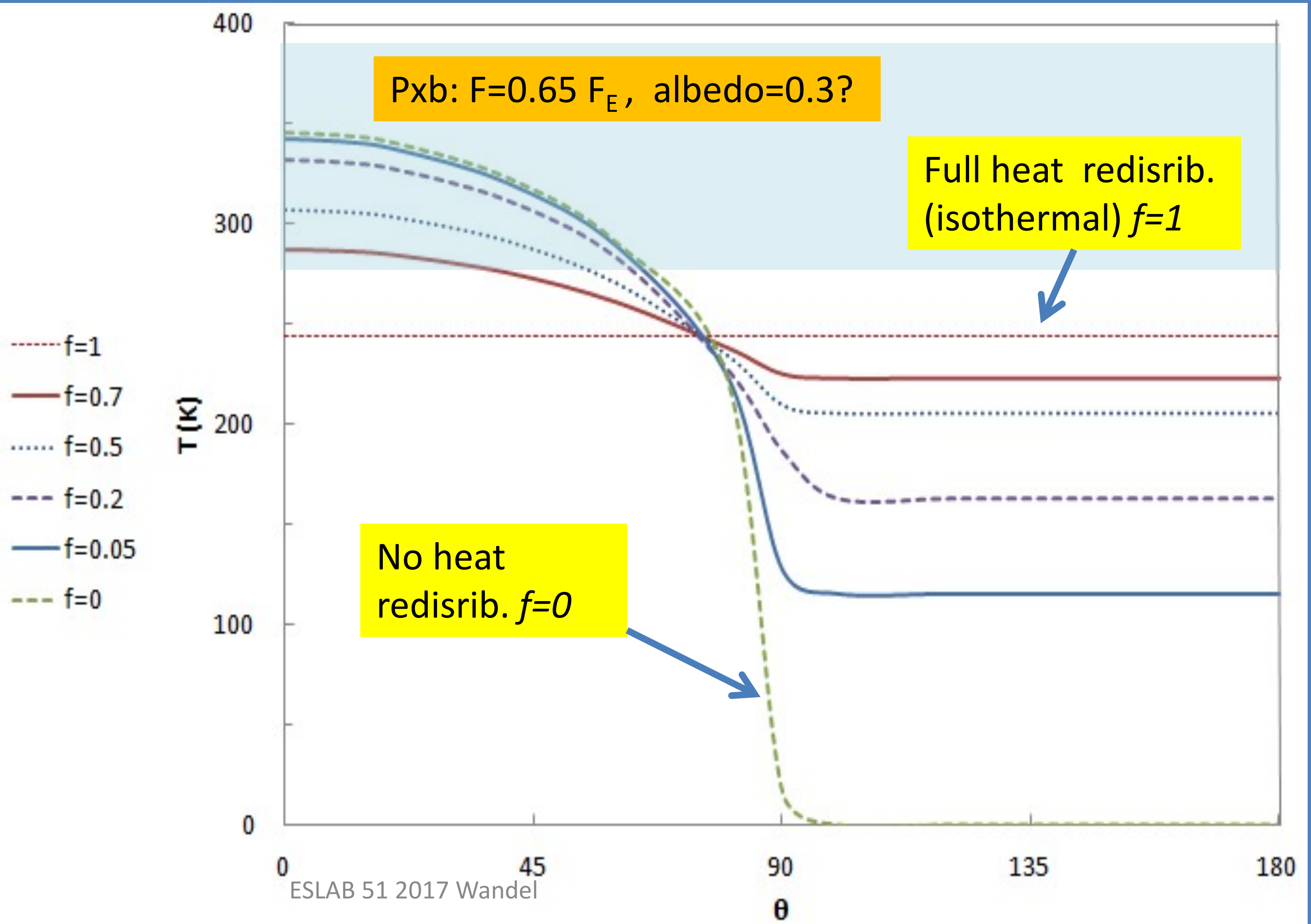
Why not M-dwarfs?

- Relatively stronger XUV flux for longer epoch
- **Energetic early stellar evolutionary stages**
- May erode the atmosphere
- May lead to loss of surface water
- **But: hidrosphere may be re-aquired (e.g. comets)**
- **HZ planets are locked** →
- **water may trapped as snow on the night side** (Leconte)
- **Locked plantets hostile to life as we know it?** (but see Gale & Wandel 2017)


Angle modulated radiation
Red Dwarf Star
Planet
Terminator
90º
Substellar point
Latitude 0º
Perpetual day hemisphere
Perpetual night emisphere
Not to scale

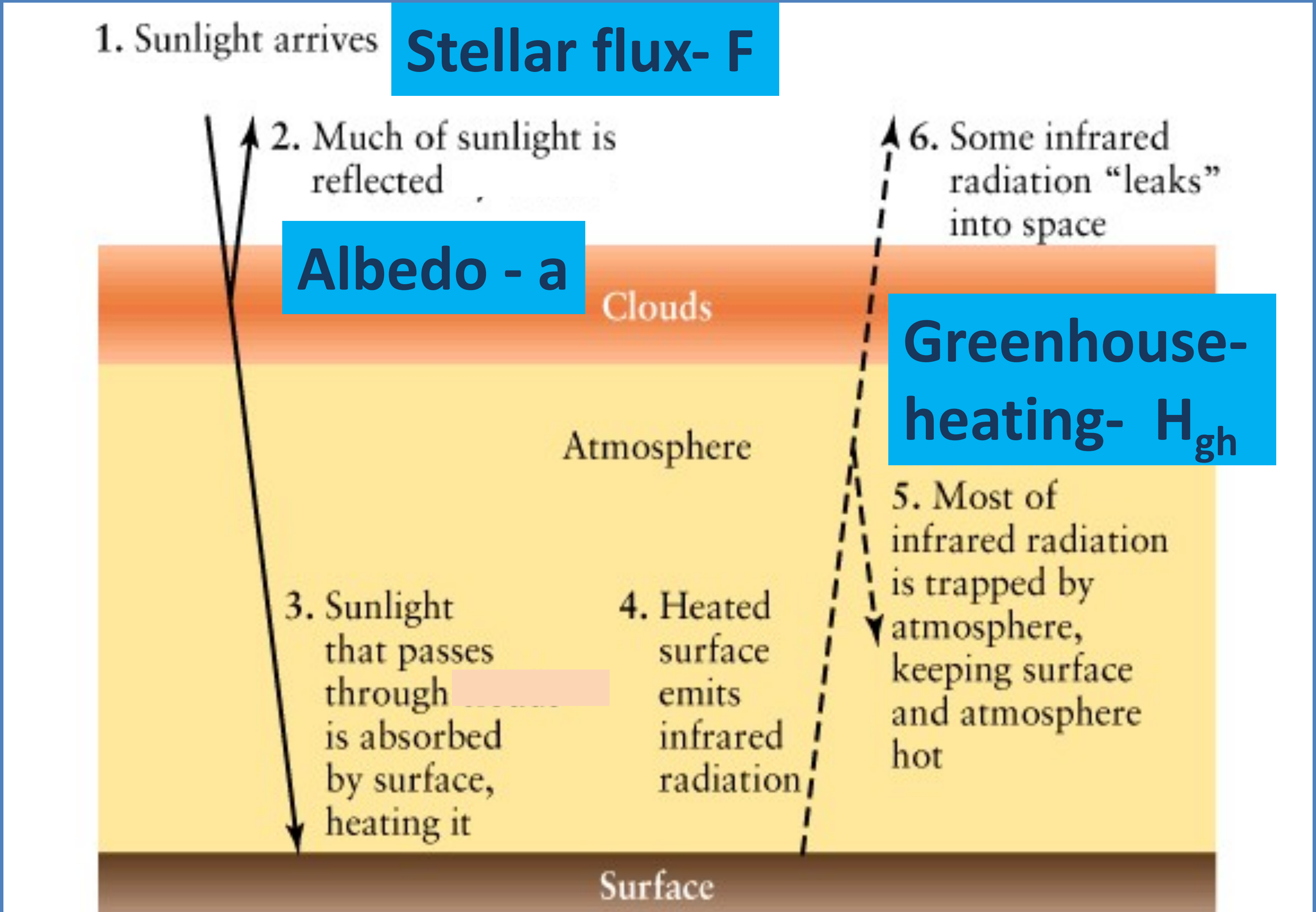
Surface T vs. lattitude model for Proxima b

f - heat redistribution factor (global advection)



Wandel 2017

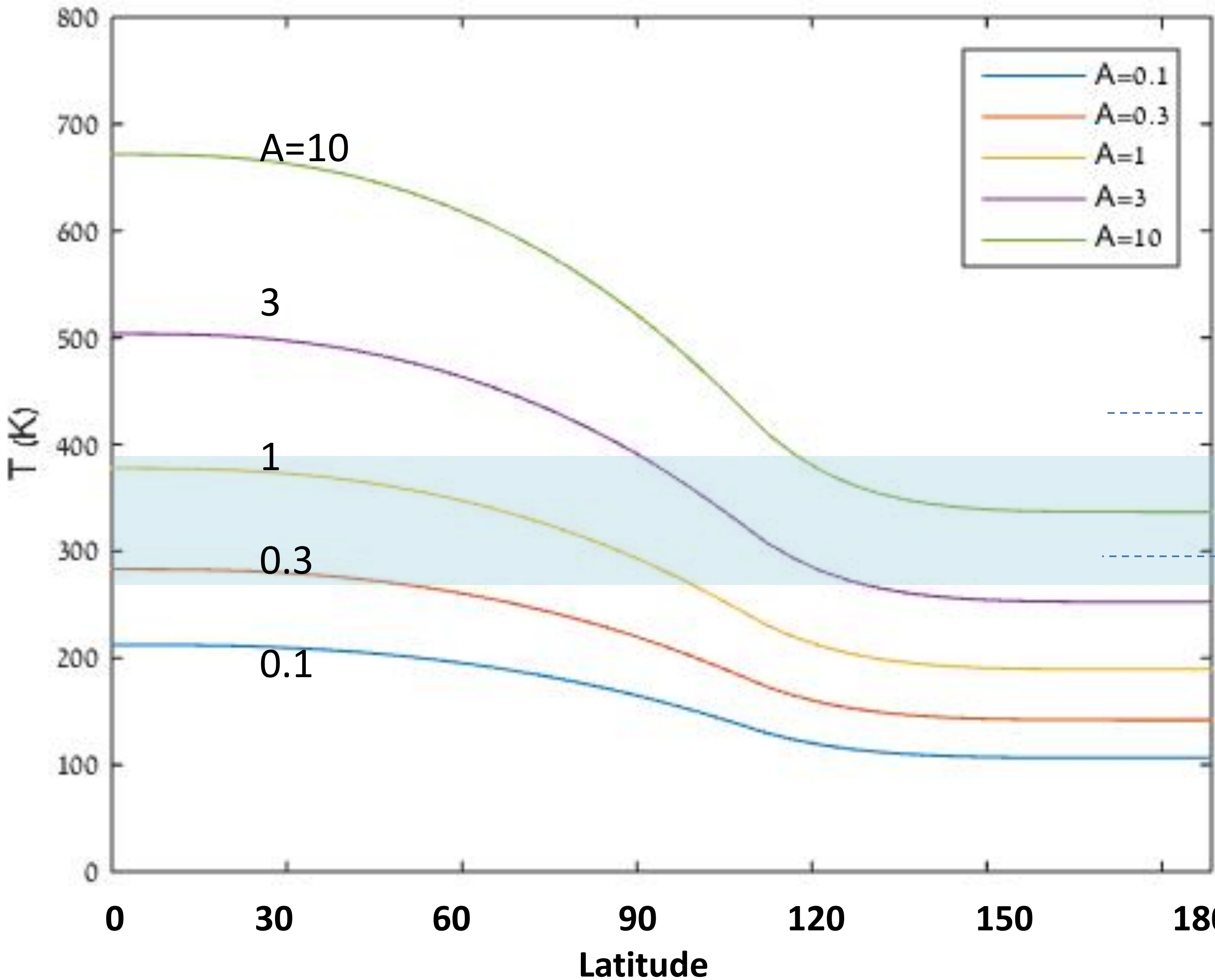
We define the combined heating factor *A*



Temperature profiles for locked planet

A = combined heating factor, curves for *f=0.2 + local adv.*

Wandel 2017



$A=(1-a)\, H_{gh} F/F_E$

F/F_E stellar flux rel.ative to Earth

H_{gh}= Greenhouse heating factor

← Venus (A=30)

A=10

← Mercury (A=6)

← Earth (A=1.2)

← Mars (A=0.3)

A=0.1

Proxx b, H_{gh} 1-10

Wandel 2017 (in rev)

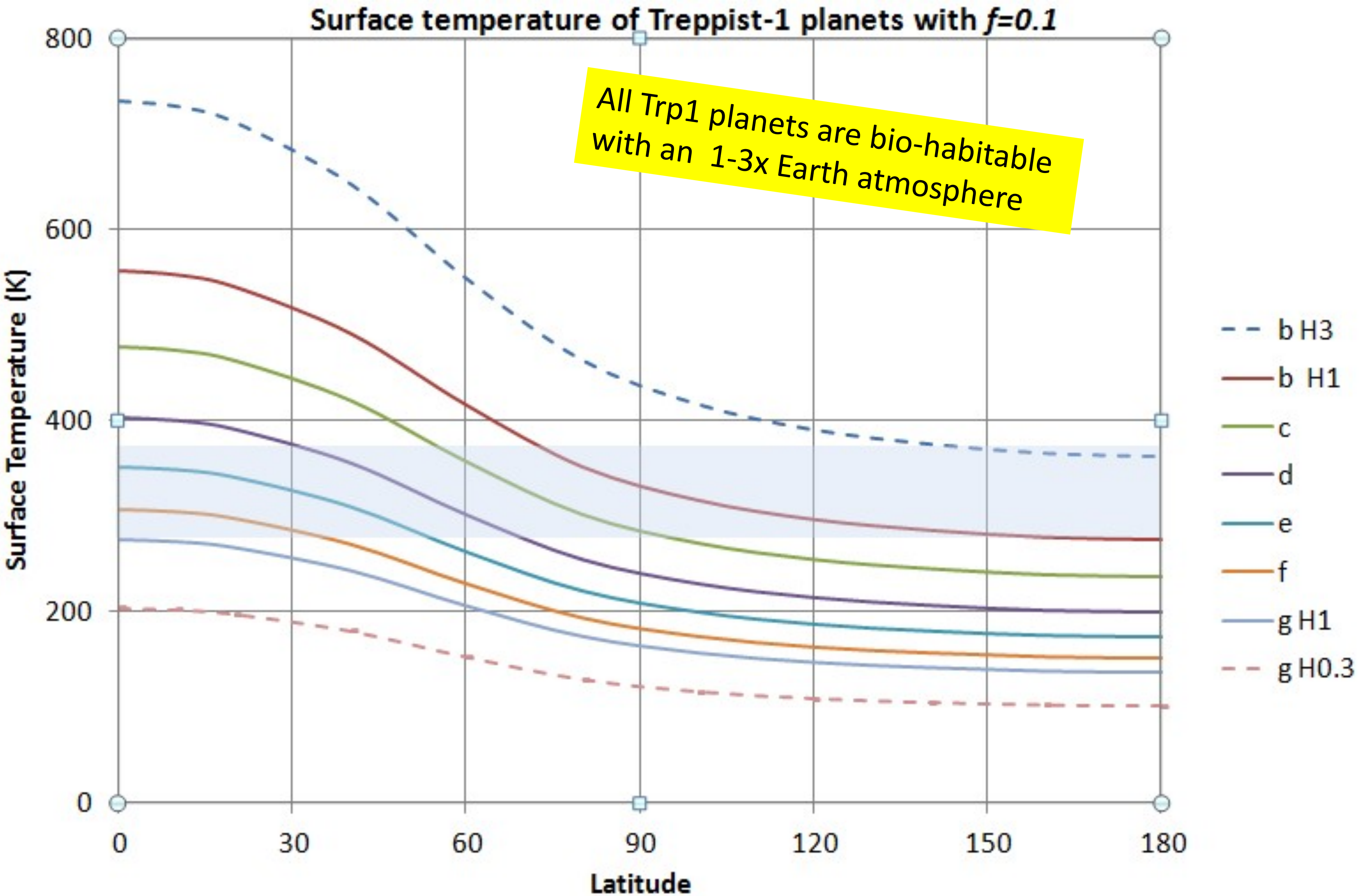
Bio-habitability

Definition of the classical Habitable Zone:

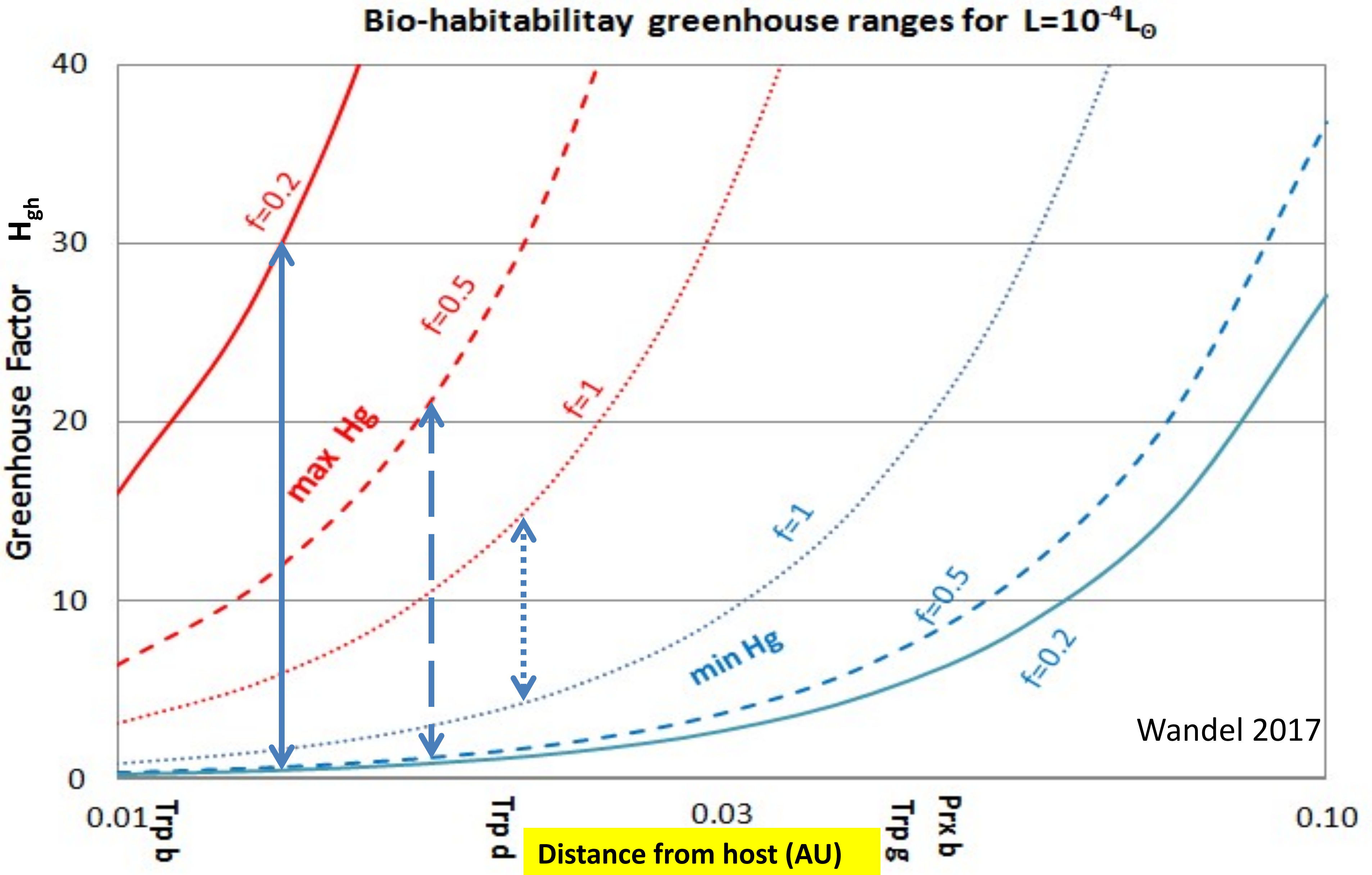
surface temperatures allowing Liquid water

- Bio-HZ: surface temperatures allowing water *and* complex organic molecules (*T=0~130* C)
- On at least part of the planetary surface
- Biohabitable temp. range for locked planets:
- T (night side) <~130 C (bio habitability)
- T (substellar point) >0 C (liquid water)

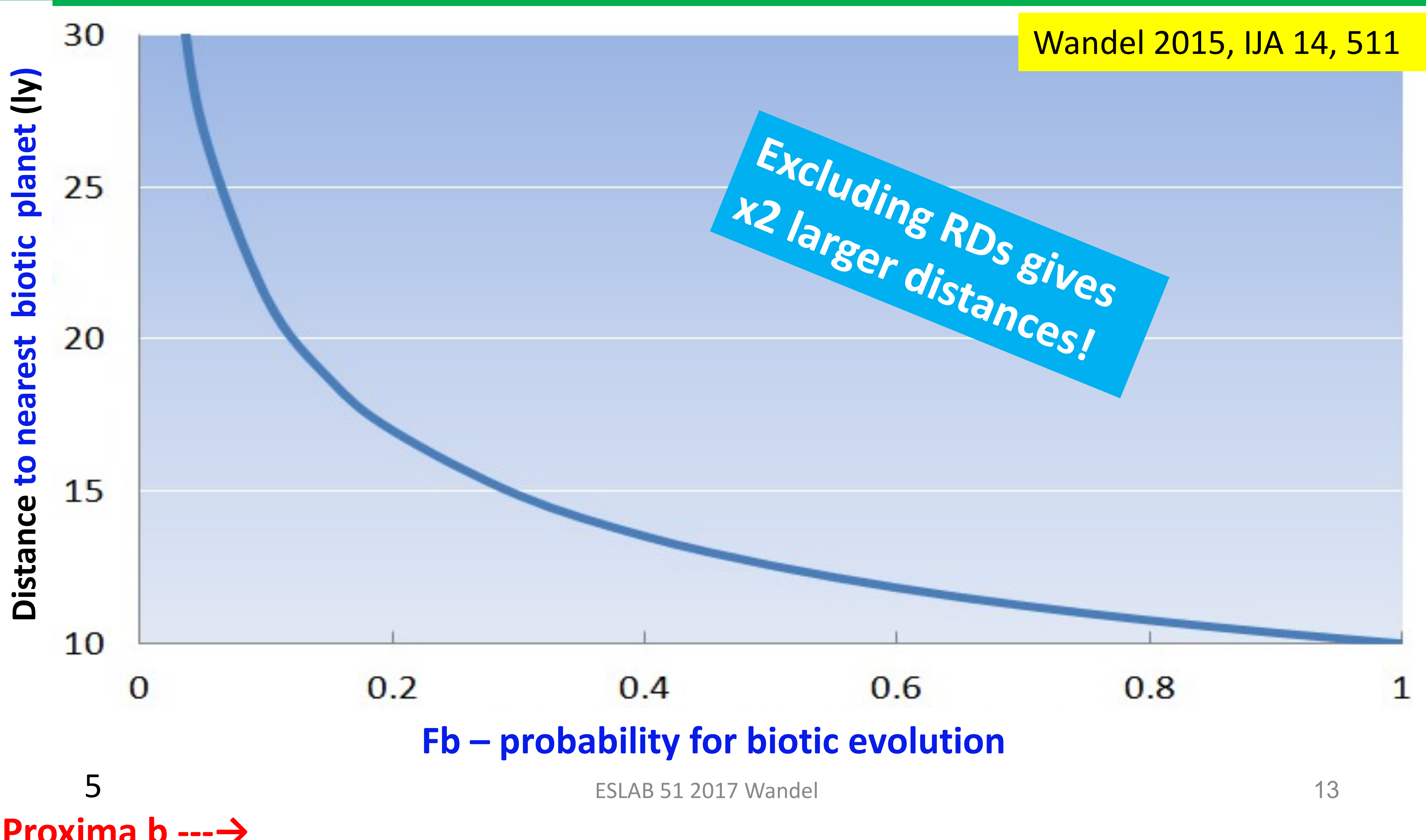
Trappist-1 *T(θ)* profiles (with *A=1*)



Bio-habitable GH-range vs. planet distance (ie. flux)



Bio-abundance: the distance to our nearest biotic neighbors



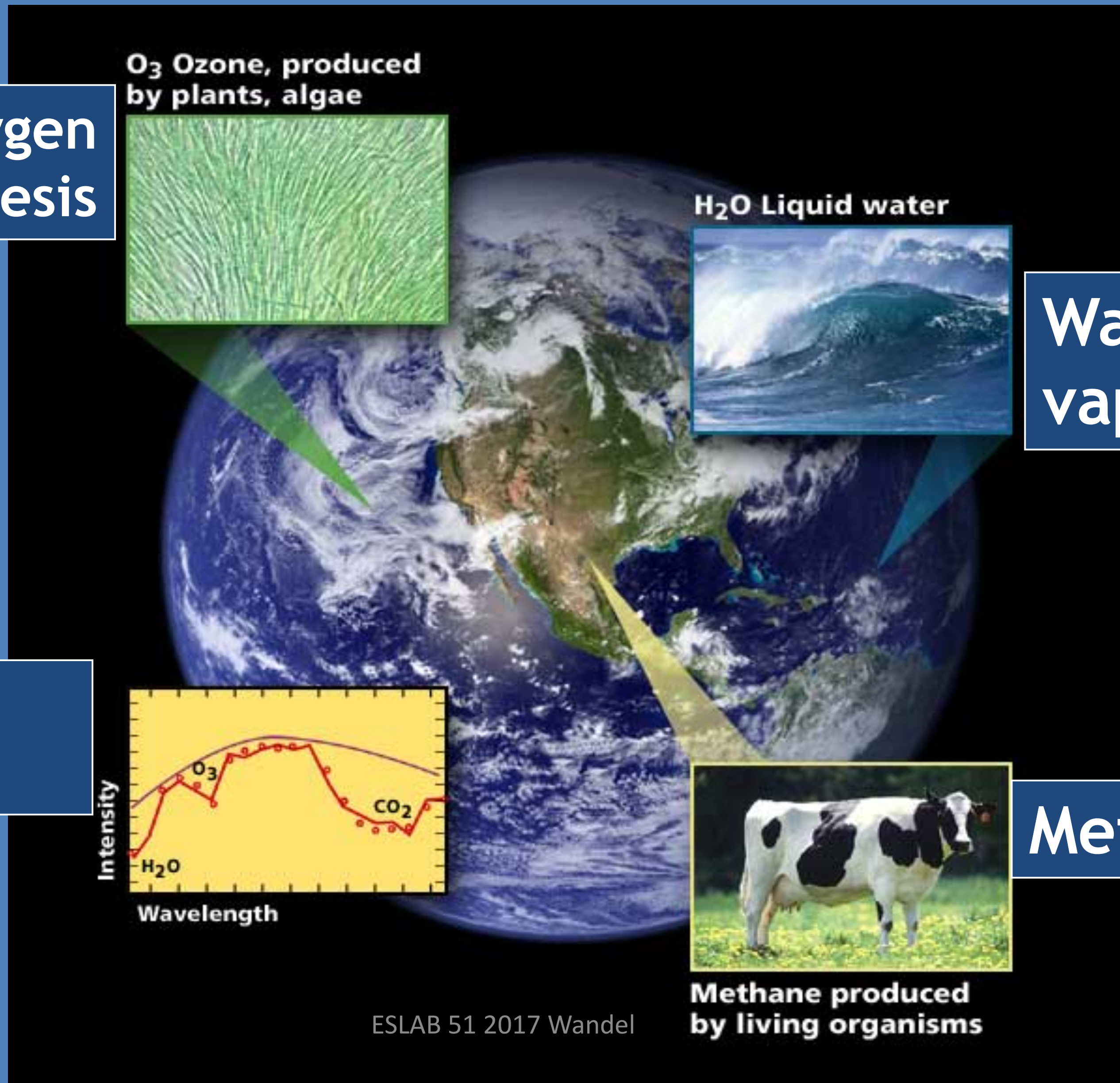
Bio-signatures

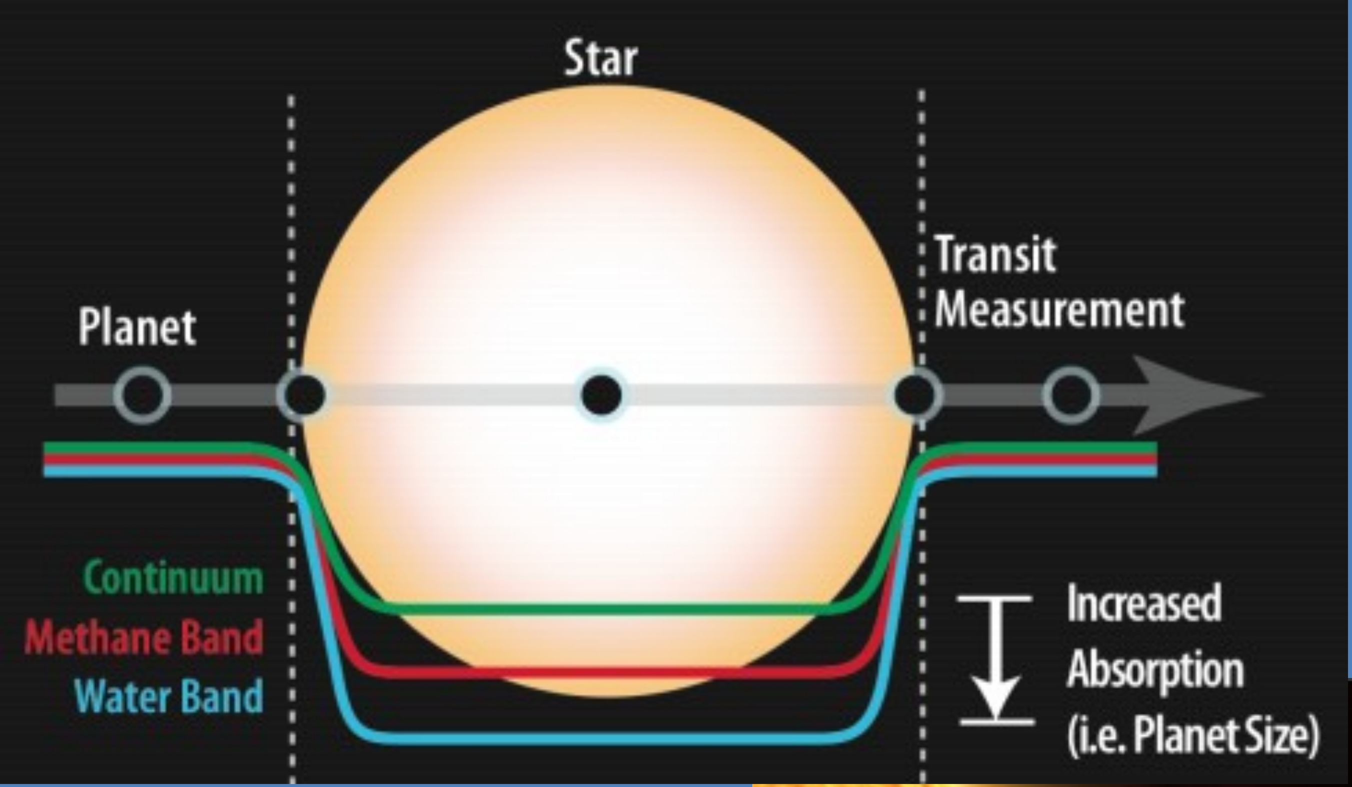
Oxygen photosynthesis

Water vapor

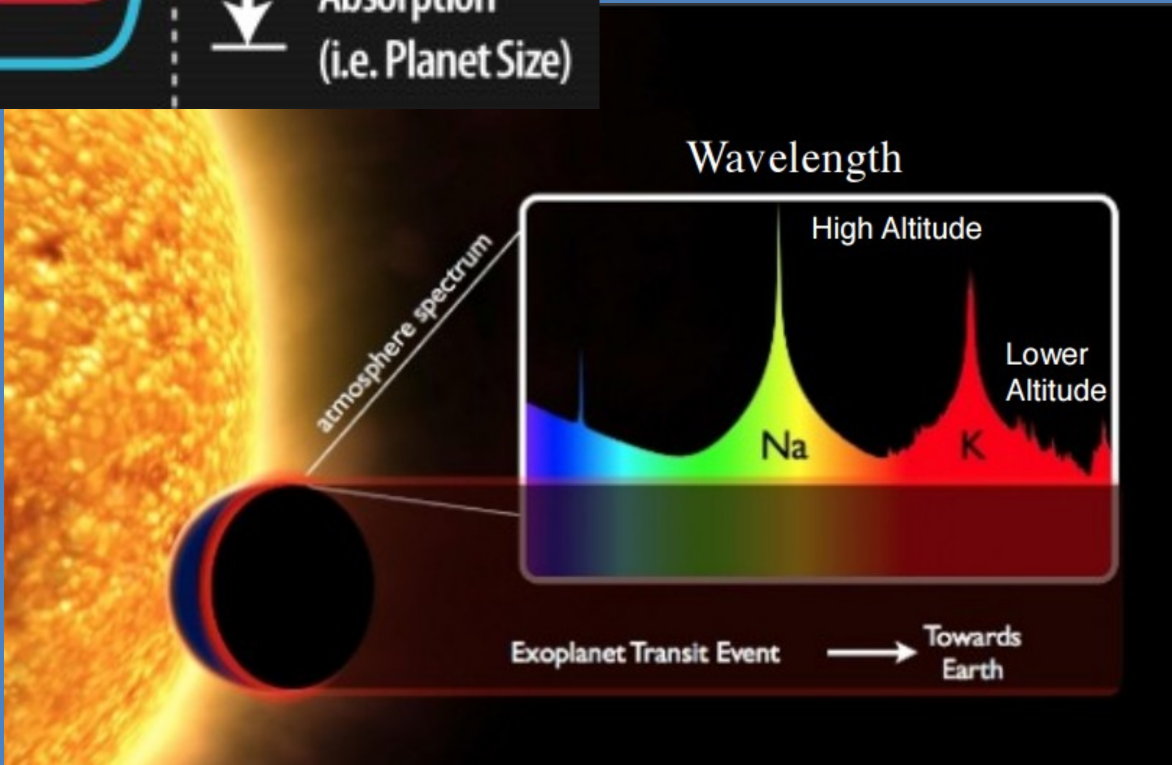
Spectral analyses

Methane





Bio-signatures for transiting planets



Expected number. of transiting planets in HZ vs. detection range and biotic probability

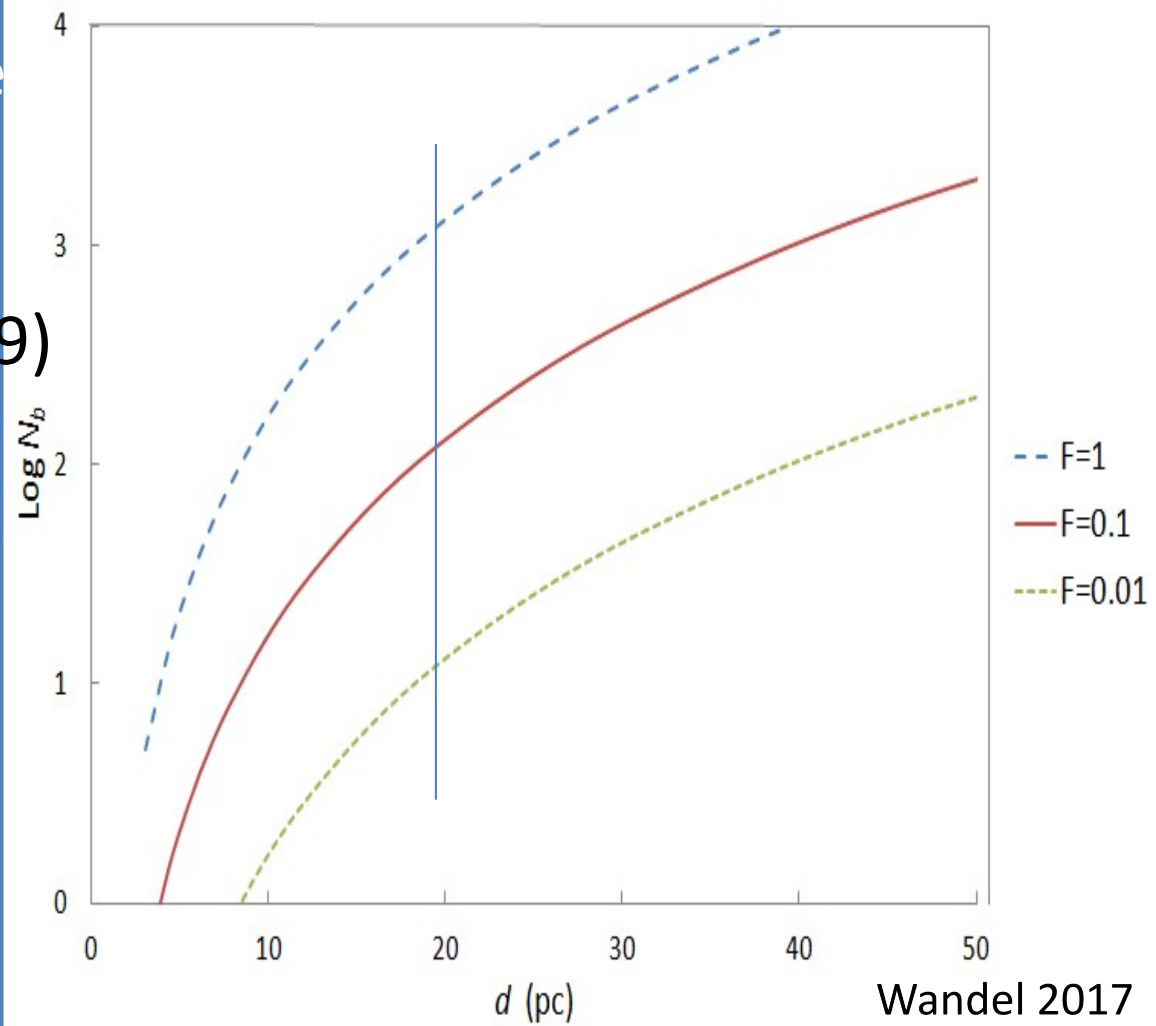
BioSig of transiting plane
of M-dwarfs

Spectroscopy: JWST(2019)

Sample: TESS (2018)

N depends on F_b-
the **biotic probability**

and vise versa: N→F_b



Wandel 2017

Conclusions

- Habitable Zone planets of red dwarf stars (RDP) may actually have conditions suitable to life
- Liquid water could exist on RDPs for a wide range of atmospheric properties (heating, redistribution)
- conditions on RDPs may be suitable for earthlike organic chemistry and life
- JWST may be able to detect bio-signatures for dozens of nearby transiting RDPs
- We may be able to find the abundance of biotic planets → estimate probability of life

The grass on Planets of Red Dwarfs may well be as green as on Earth