

Climate patterns of habitable exoplanets in eccentric orbits around M dwarf

Yuwei Wang (Peking University)

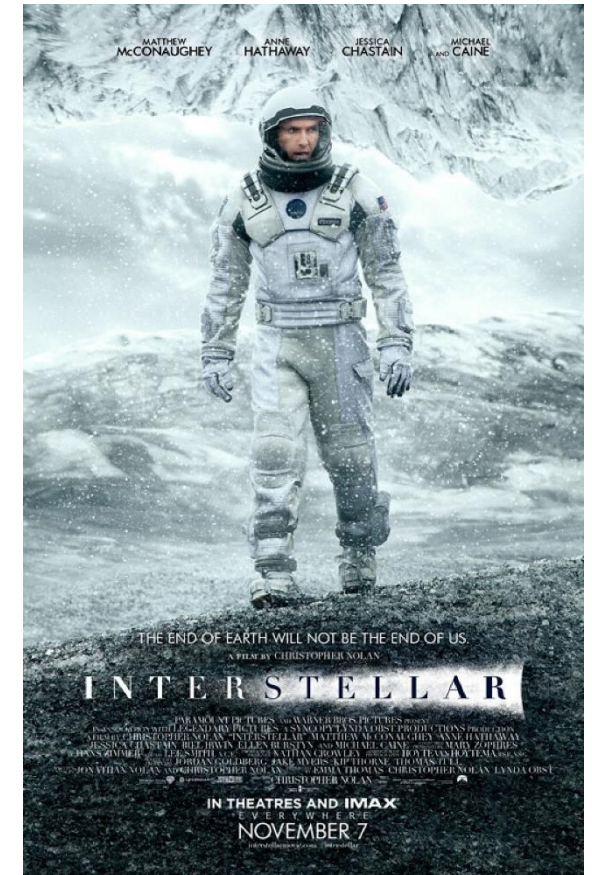
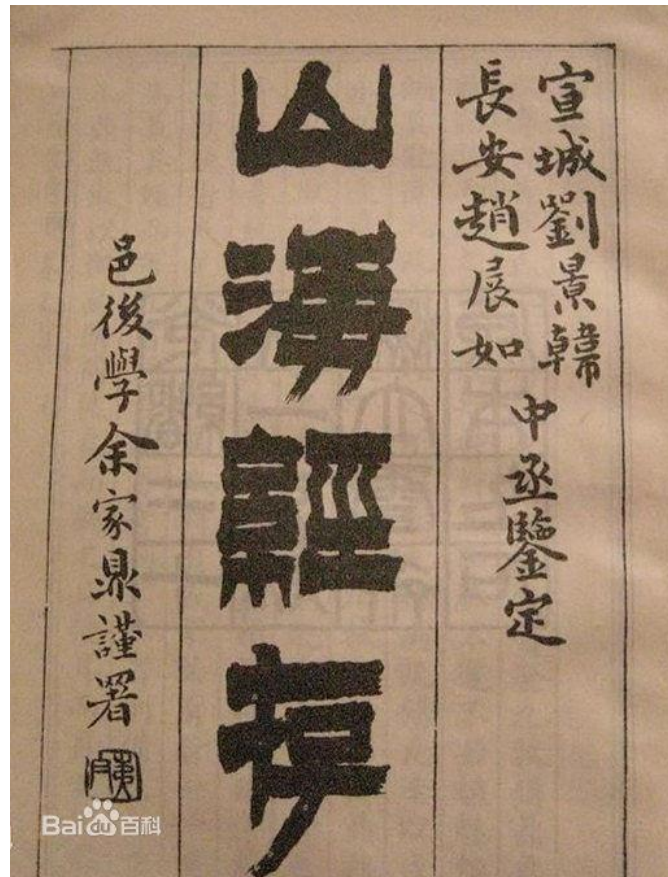


Feng Tian (Tsinghua University)
Yongyun Hu (Peking University)

The habitable world outside

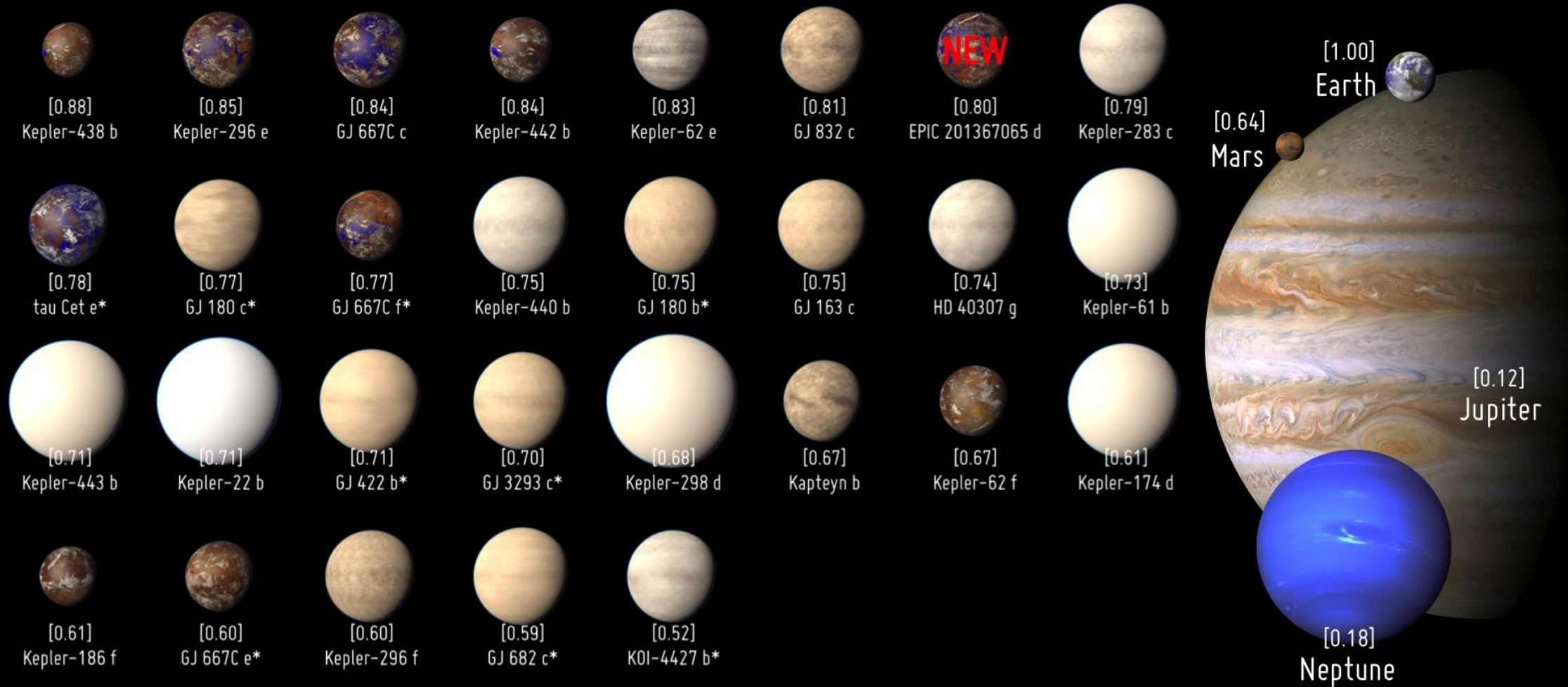
2000 years ago

Today



Potentially Habitable Exoplanets

Ranked by the Earth Similarity Index (ESI)



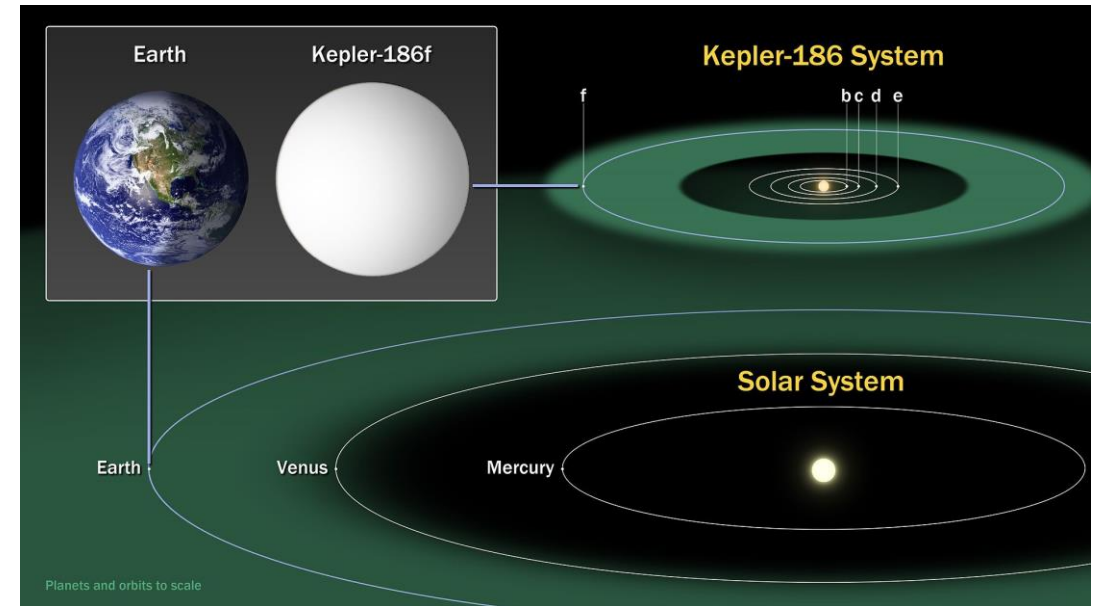
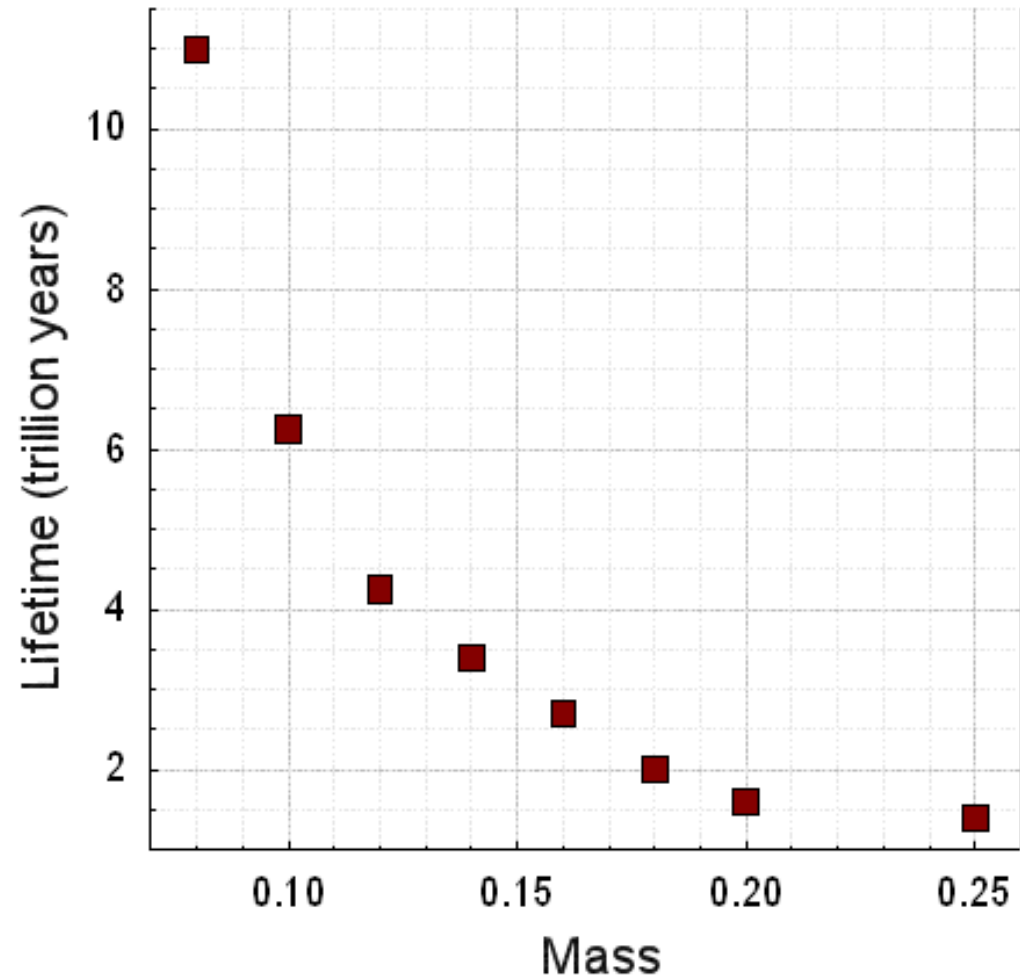
Artistic representations. Earth, Mars, Jupiter, and Neptune for scale. ESI value is between brackets. Planet candidates indicated with asterisks.

CREDIT: PHL @ UPR Arcibo (phl.upr.edu) January 16, 2015

From: phl.upr.edu

Find a habitable planet: start with M dwarf

large populations and long lifetime imperfect observation technology



(Adams et al., 2004)

(Quintana et al., 2014)

An artist's impression of GJ667Cc

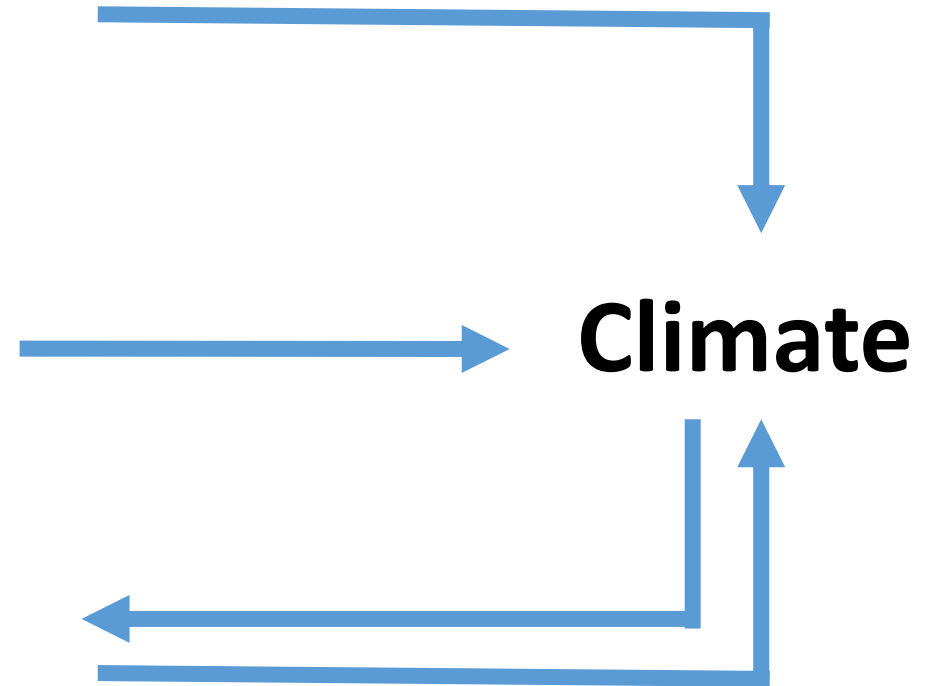


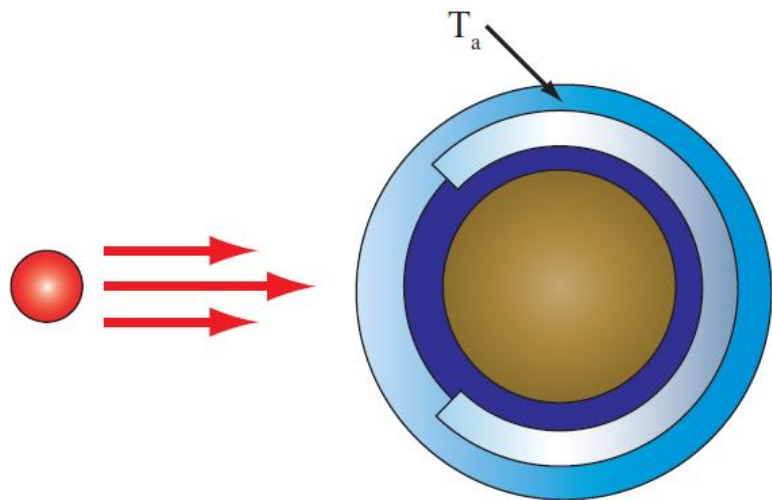
Key parameters controlling the climate of habitable planet:

Stellar insolation
(distance, *G* star or *M* star)

Orbital parameters
(eccentricity, obliquity et al.)

Atmospheric composition

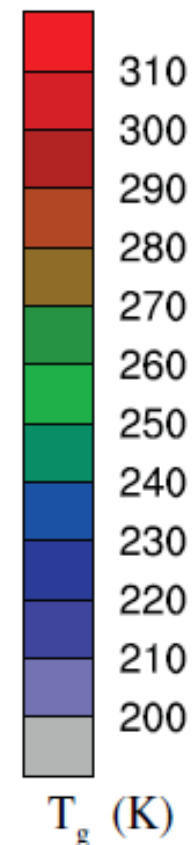
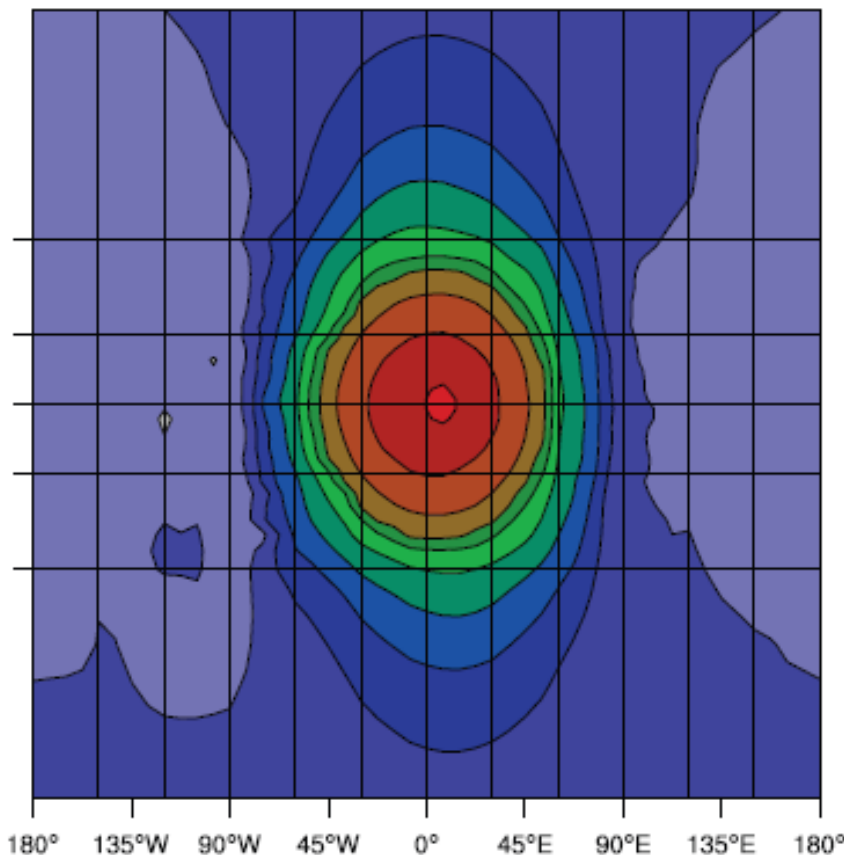
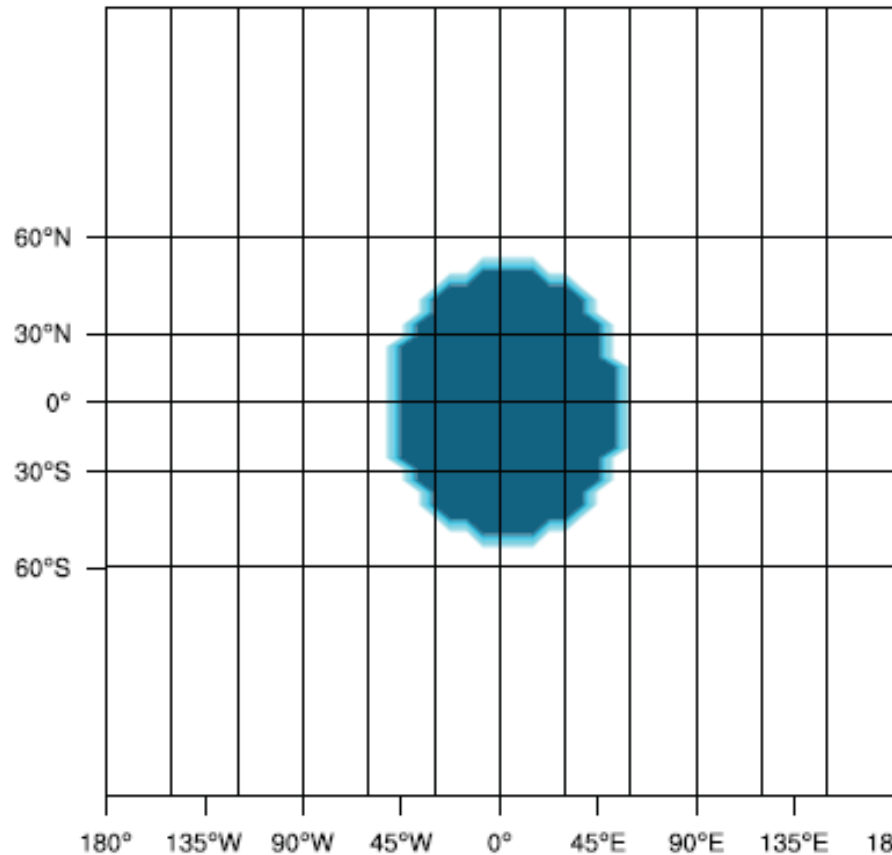




Zero eccentricity and zero obliquity

Planet parameter: Gl 581g

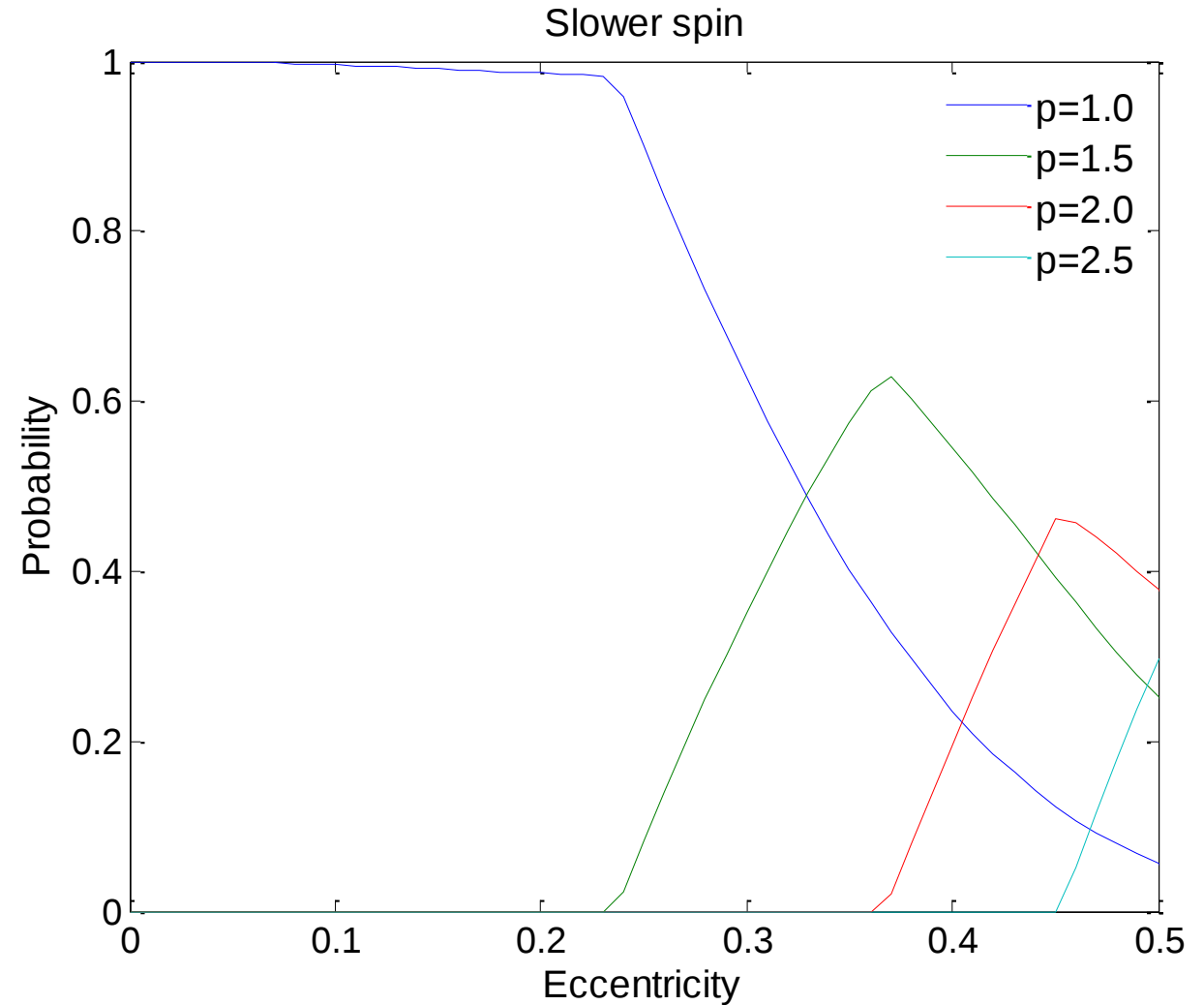
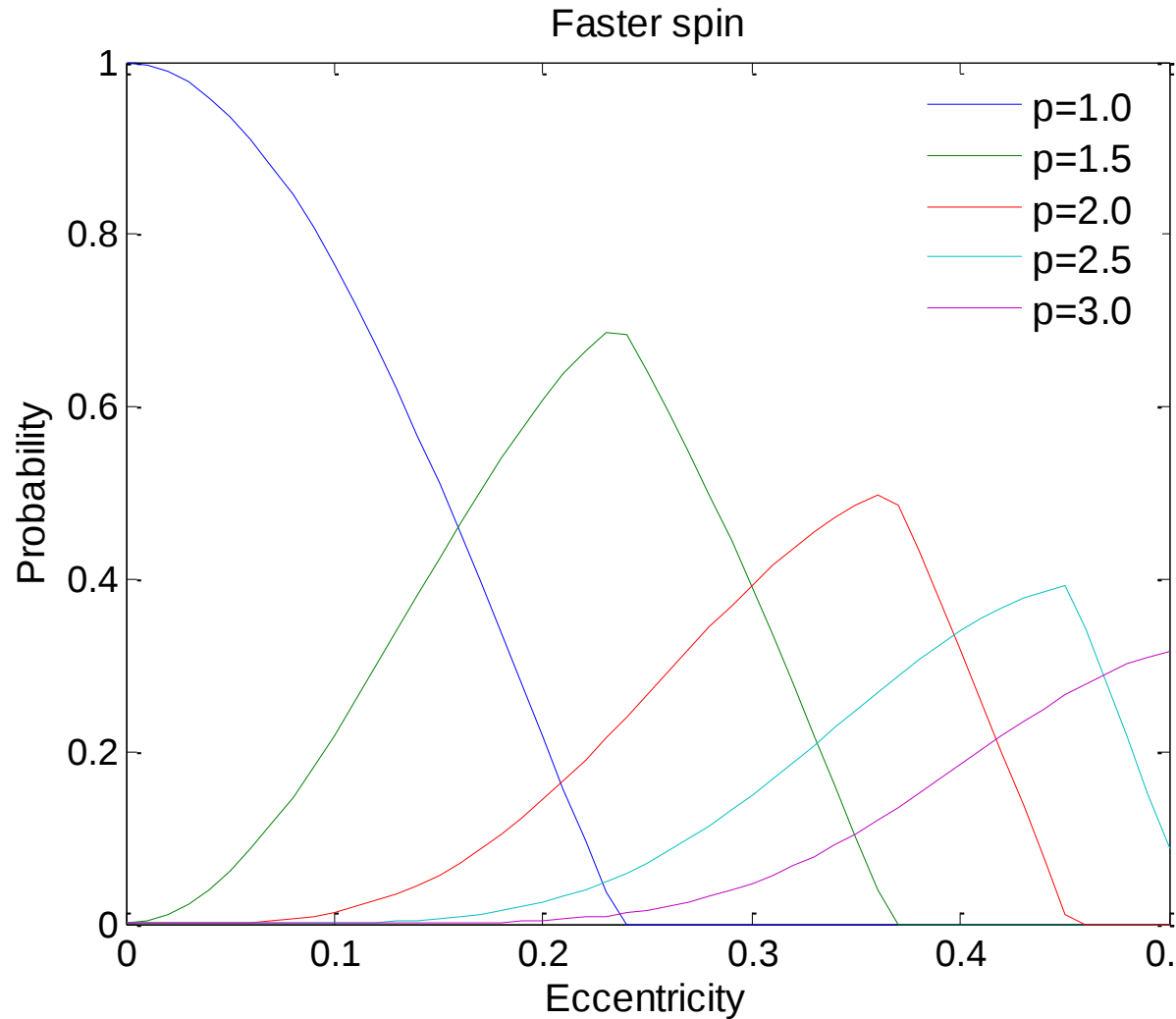
Note: Gl 581g is confirmed not existed now



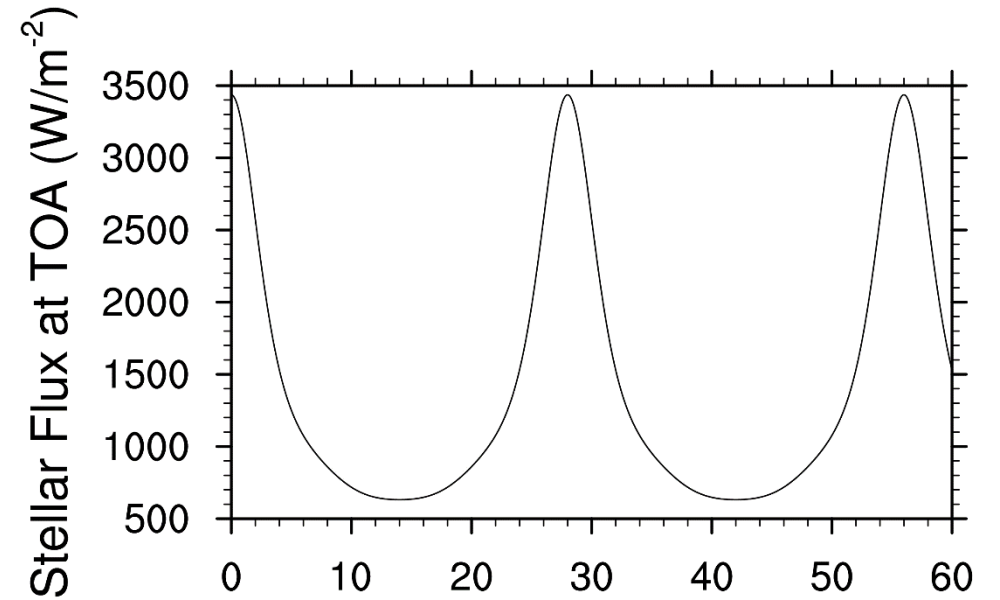
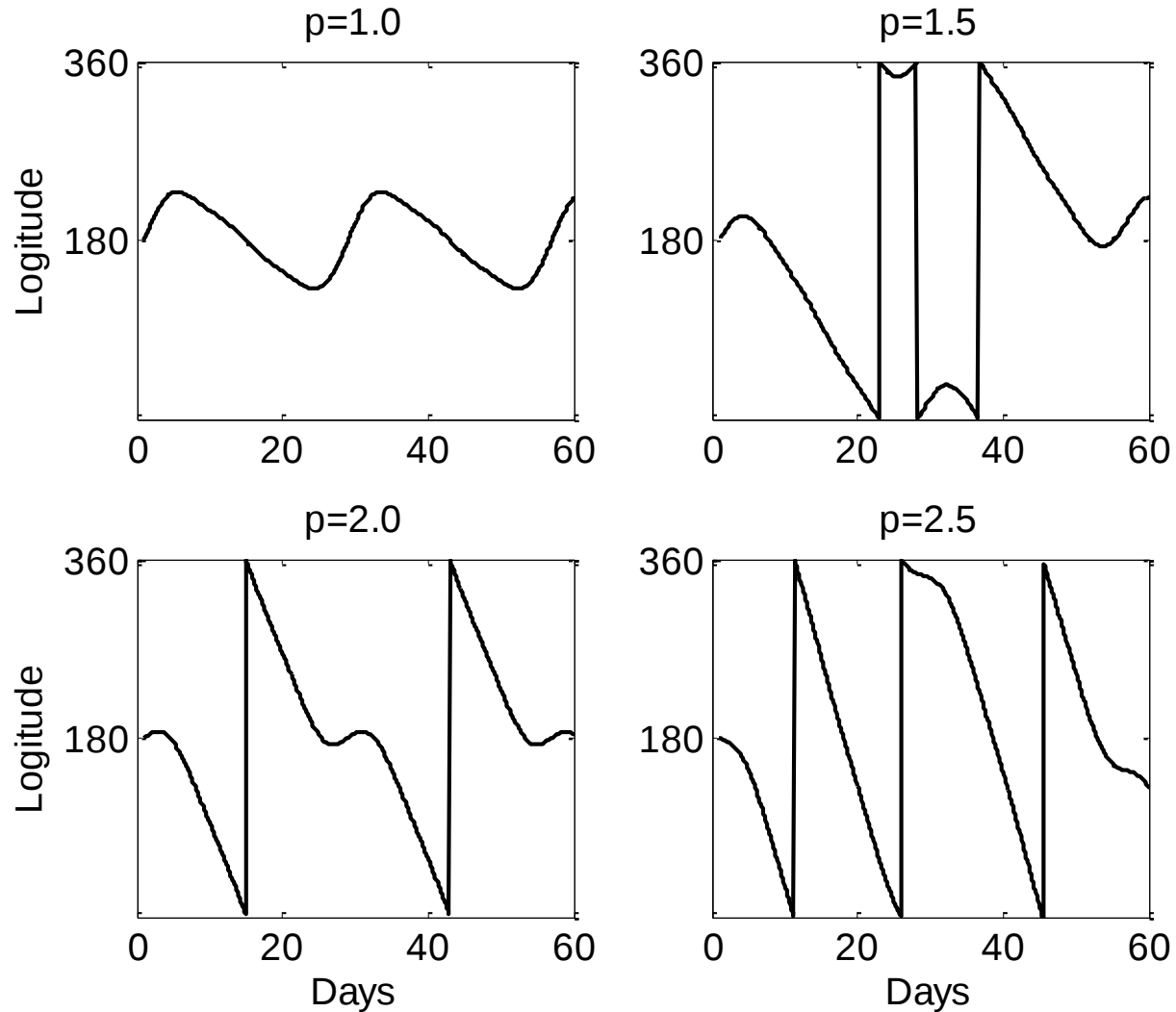
Eye-ball
pattern

(Pierrehumbert,
APJL, 2011)

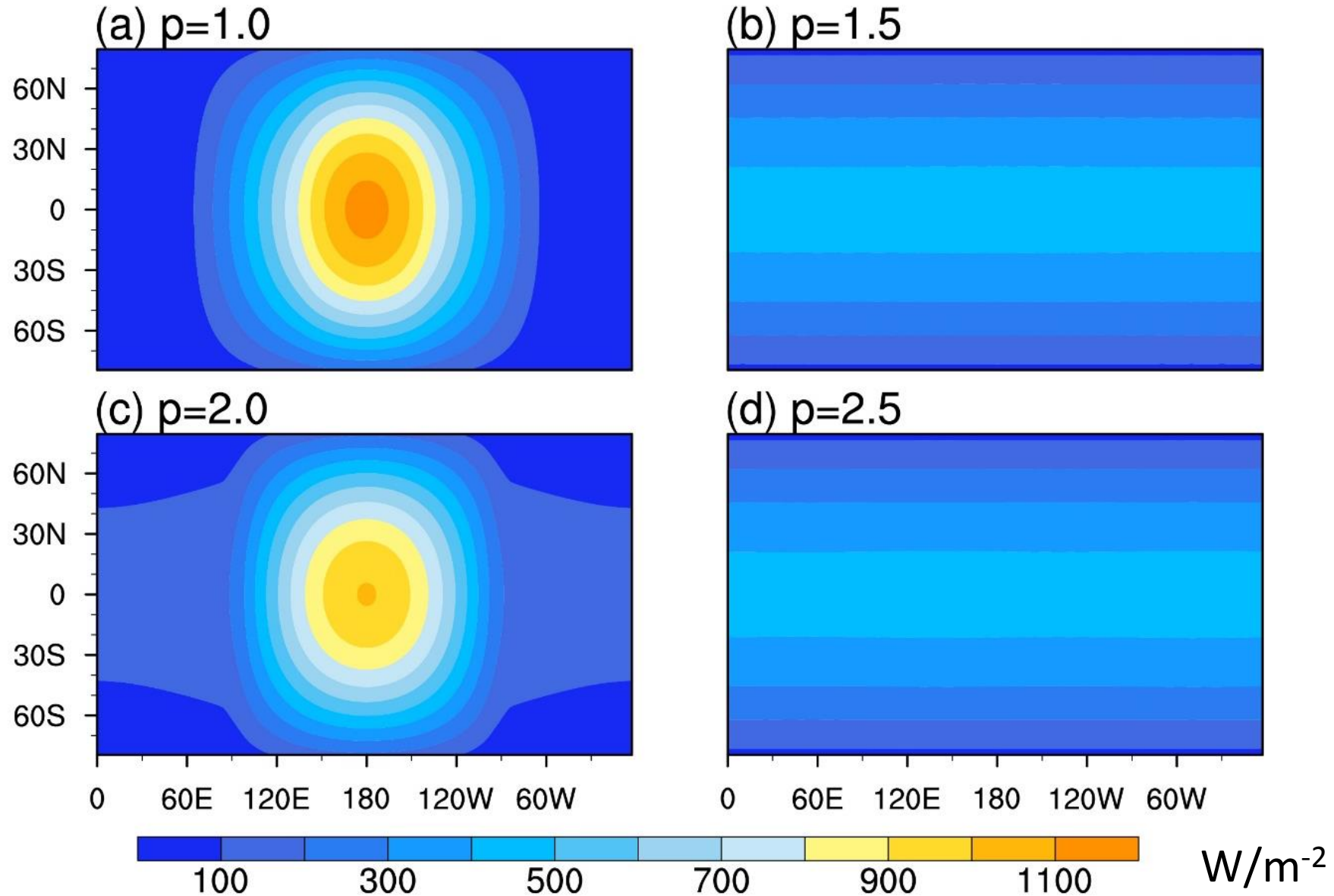
Spin-orbit resonance number: $p = \frac{\text{spin angular velocity}}{\text{orbital angular velocity}} = \frac{\text{orbital period}}{\text{spin period}}$



Migration of sub-stellar point

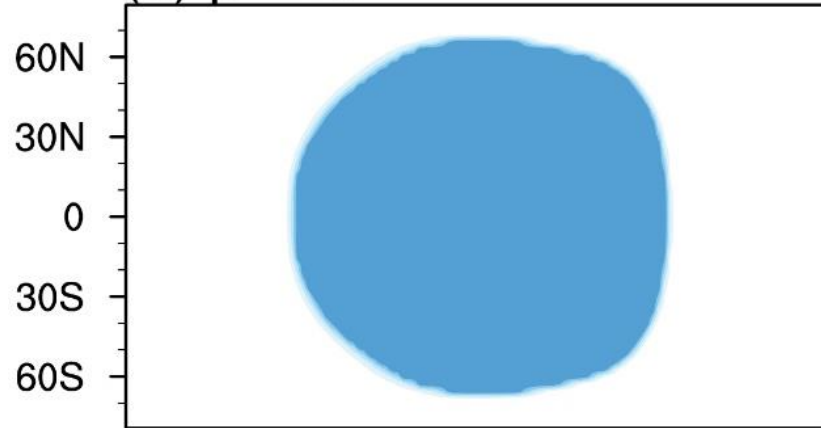


Annual mean insolation



Ice fraction

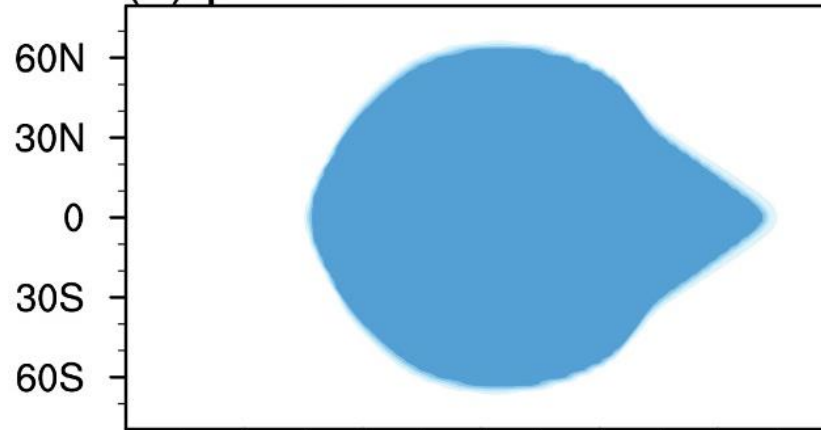
(a) $p=1.0$



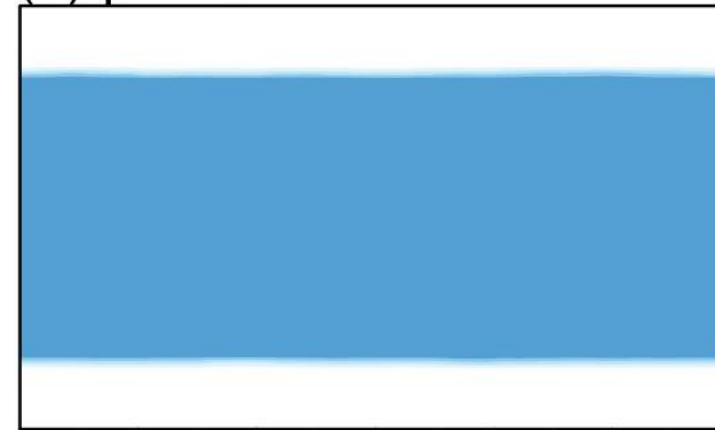
(b) $p=1.5$



(c) $p=2.0$



(d) $p=2.5$



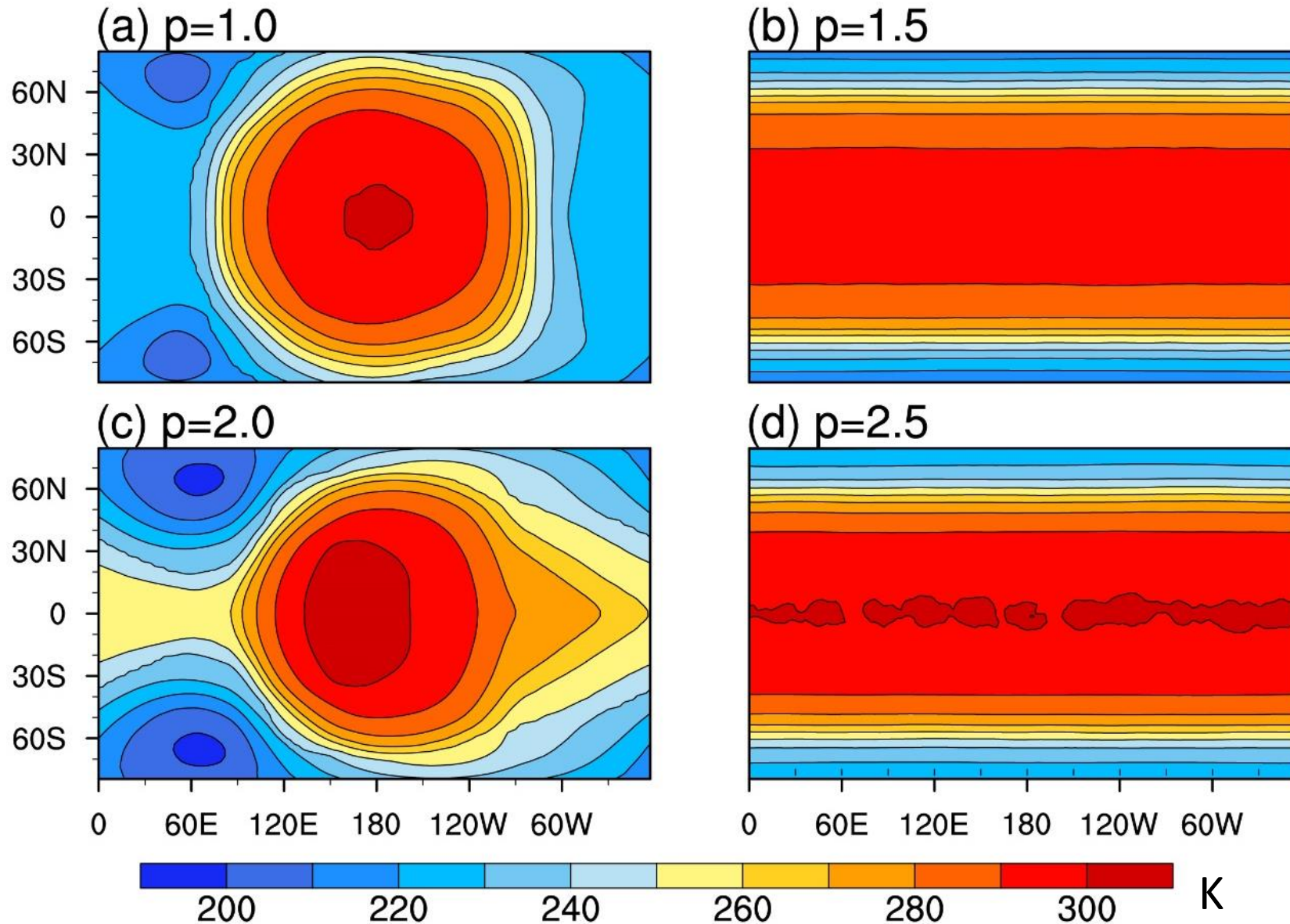
0 60E 120E 180 120W 60W



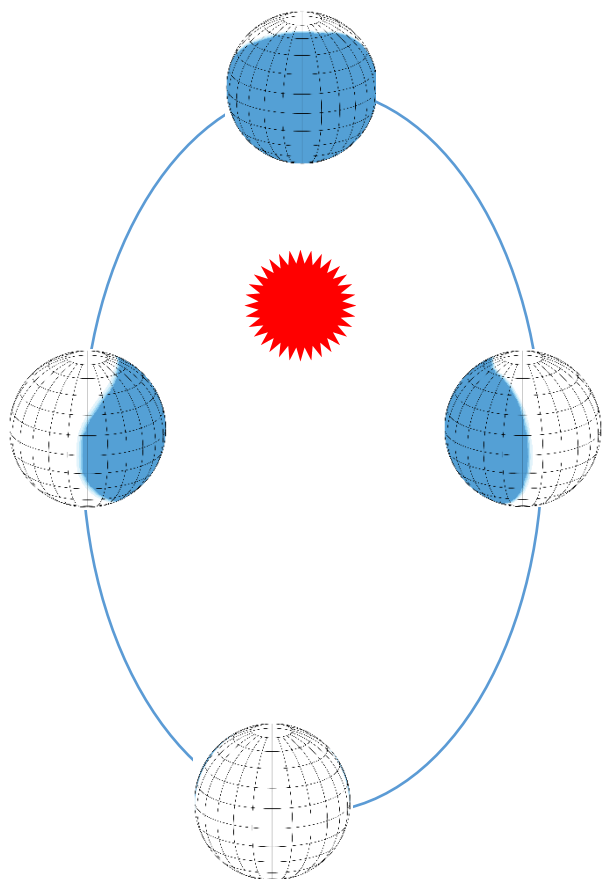
Eye-ball

Striped
-ball

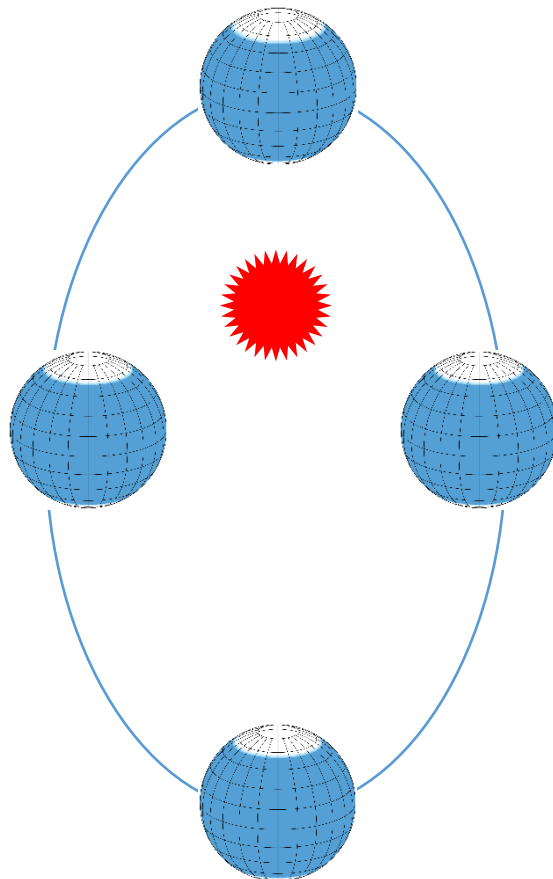
Annual mean surface temperature



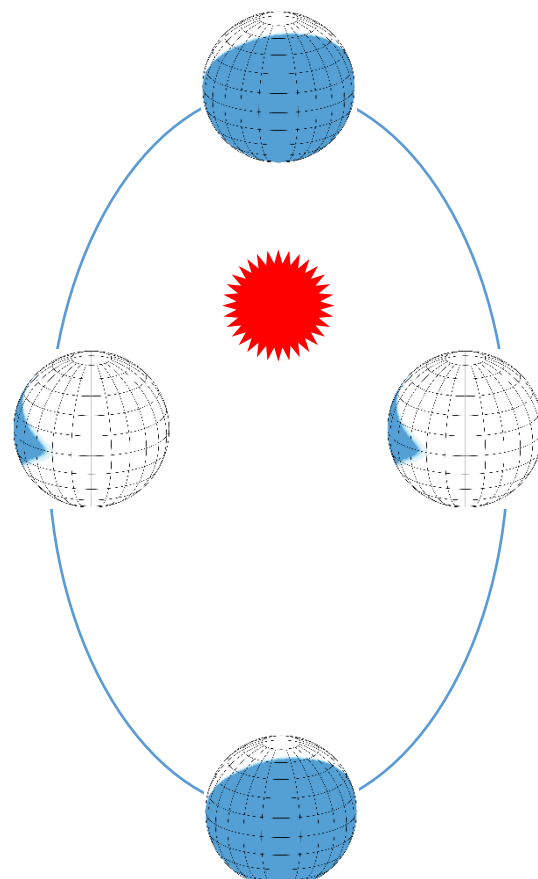
$P = 1.0$



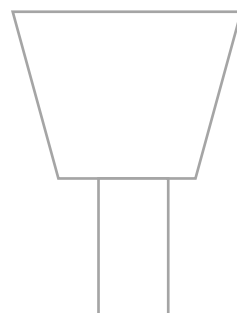
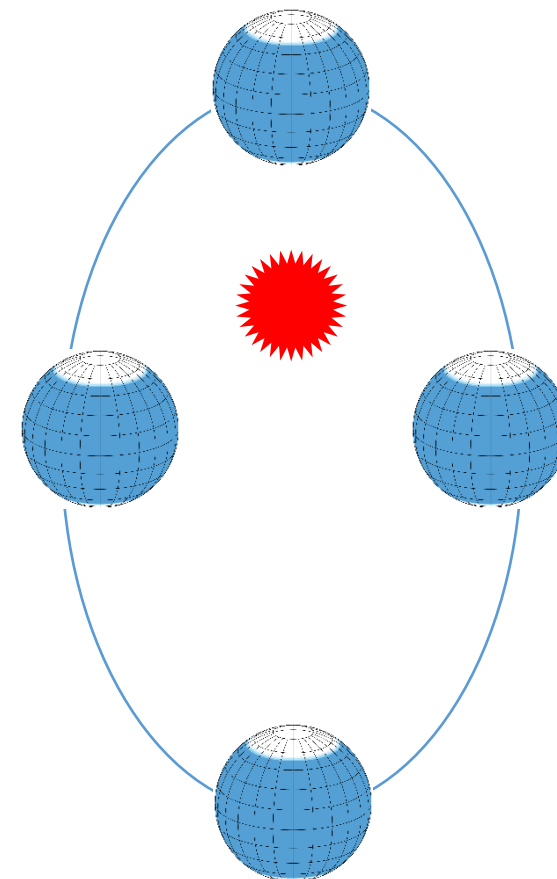
$P = 1.5$



$P = 2.0$



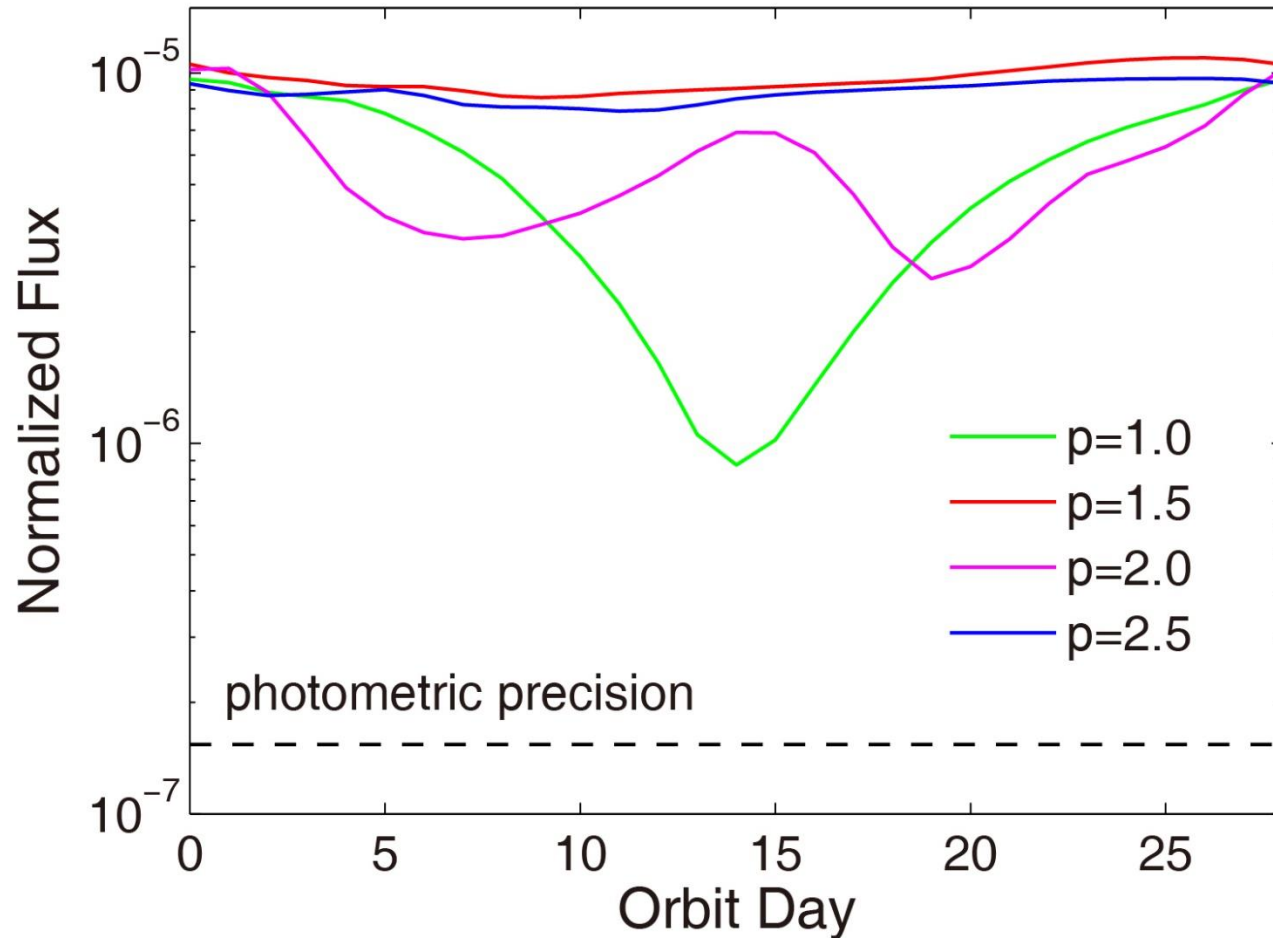
$P = 2.5$



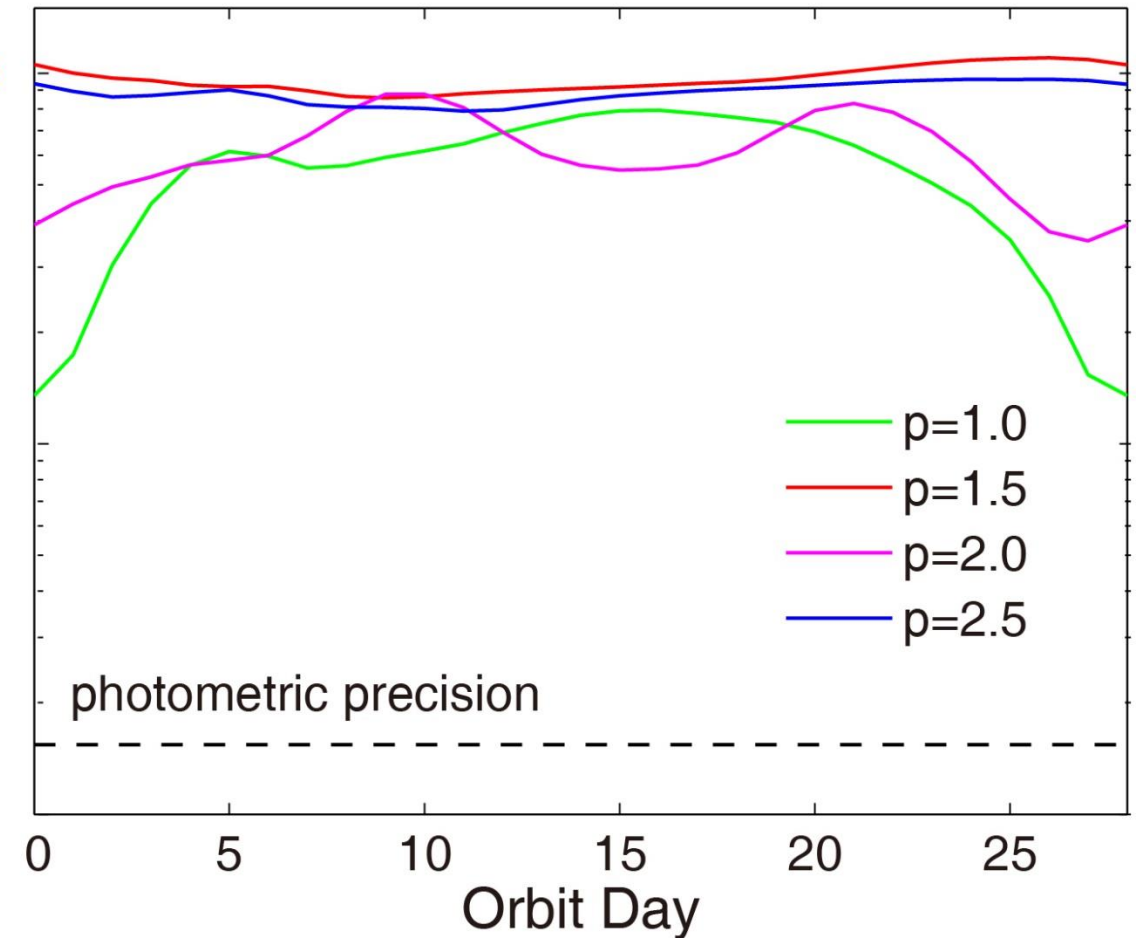
Telescope

Thermal Phase Curves

(a) View in the apoastron direction



(b) View in the periastron direction



Conclusions

- 1、 We demonstrate there are different climate patterns for habitable planets around M dwarf.
- 2、 Different climate patterns can be observed by thermal phase curves.