

# *Non-habitability*

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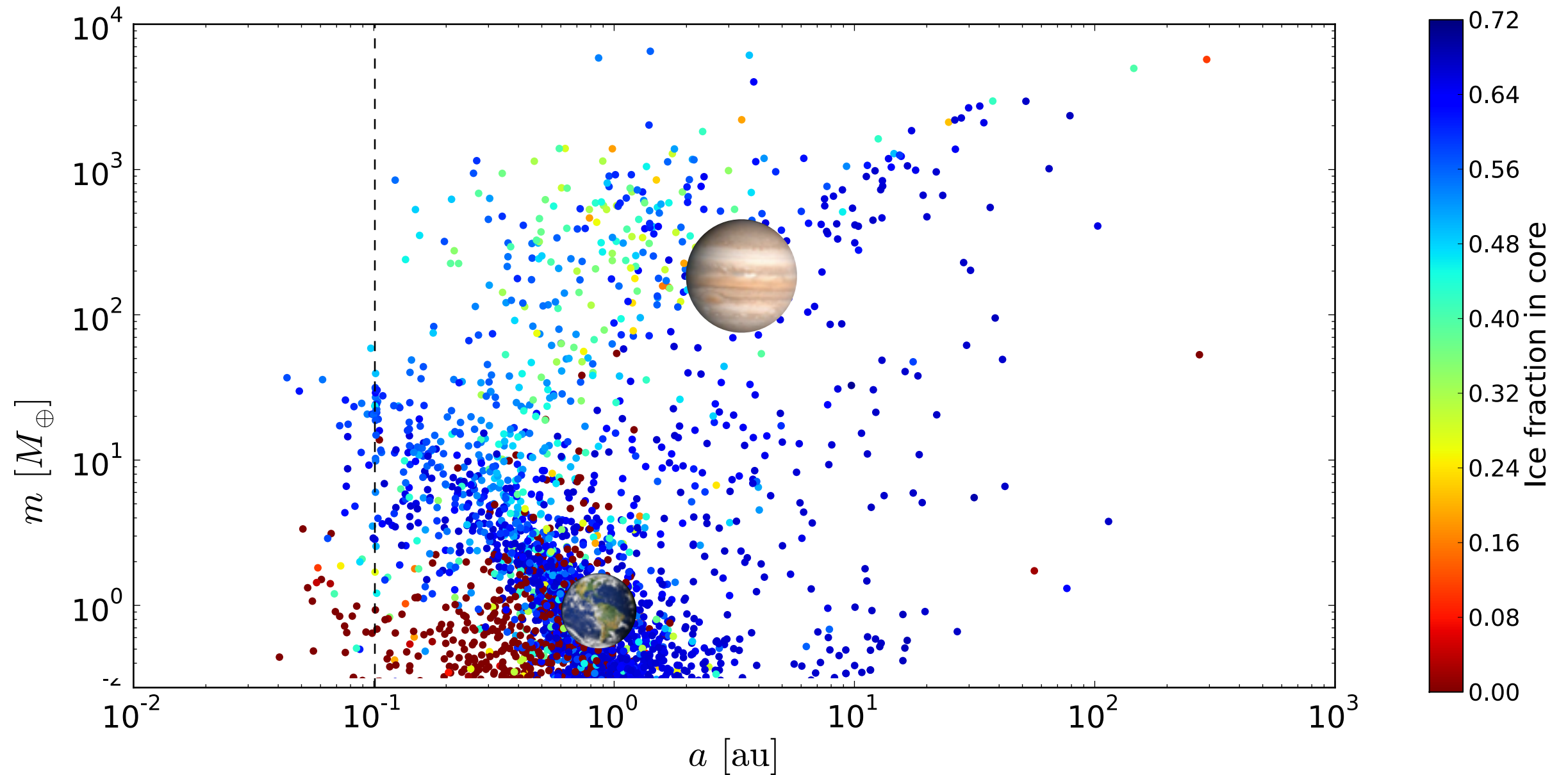


European Research Council



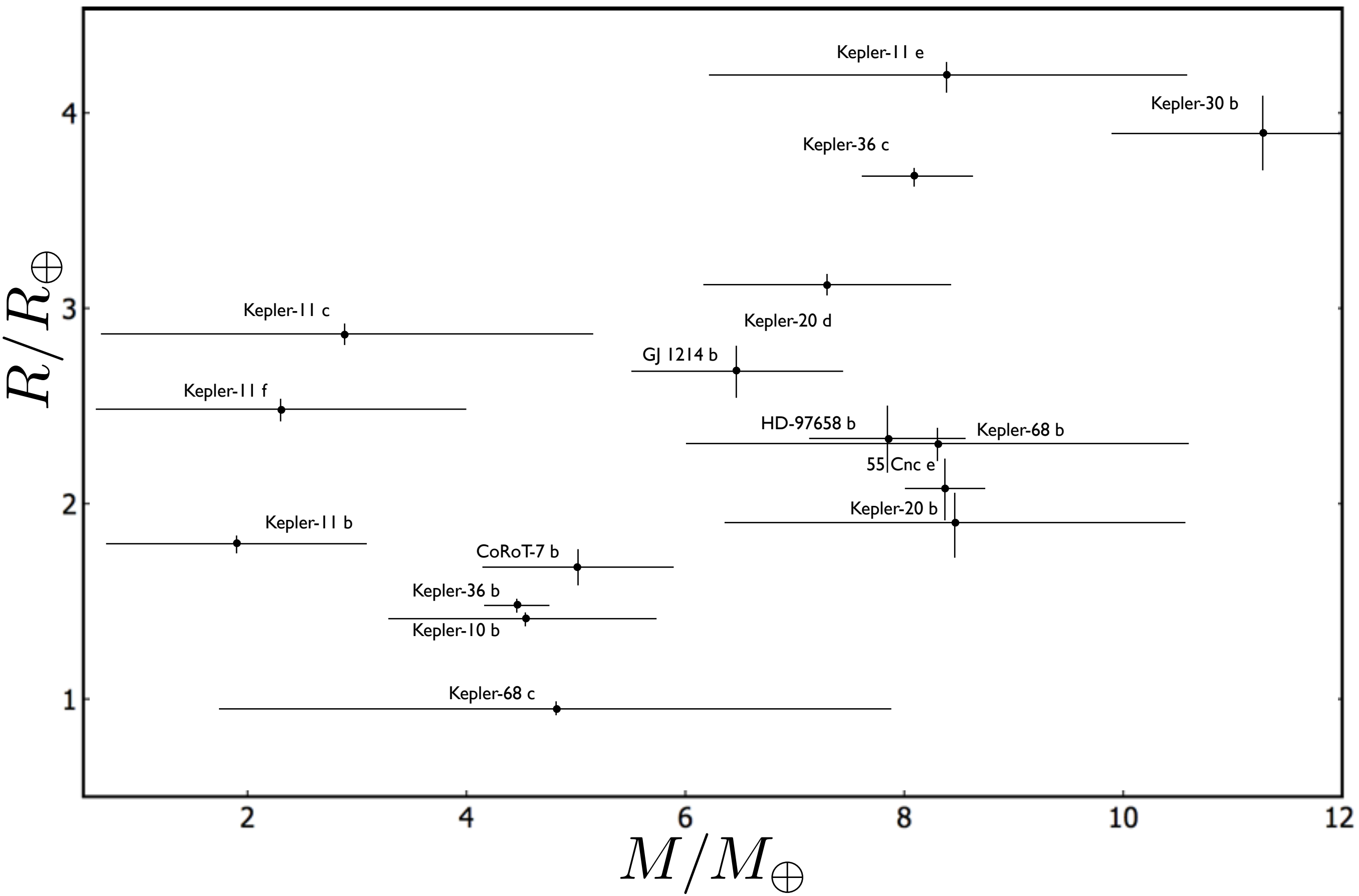
The National Centres of Competence in Research (NCCR)  
are a research instrument of the Swiss National Science Foundation

# Results from planet formation models

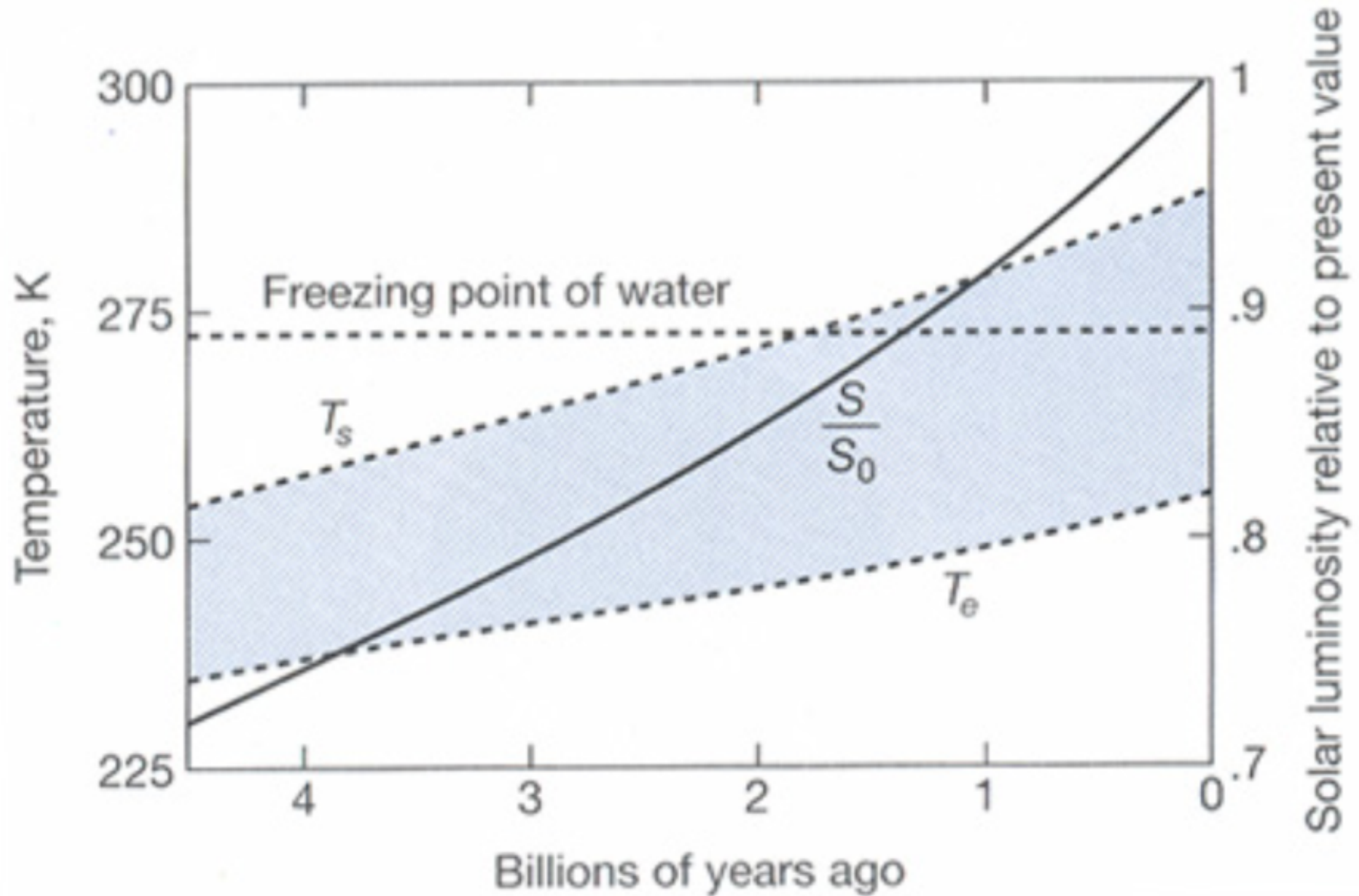


***Water-rich planets may be common - are they habitable?***

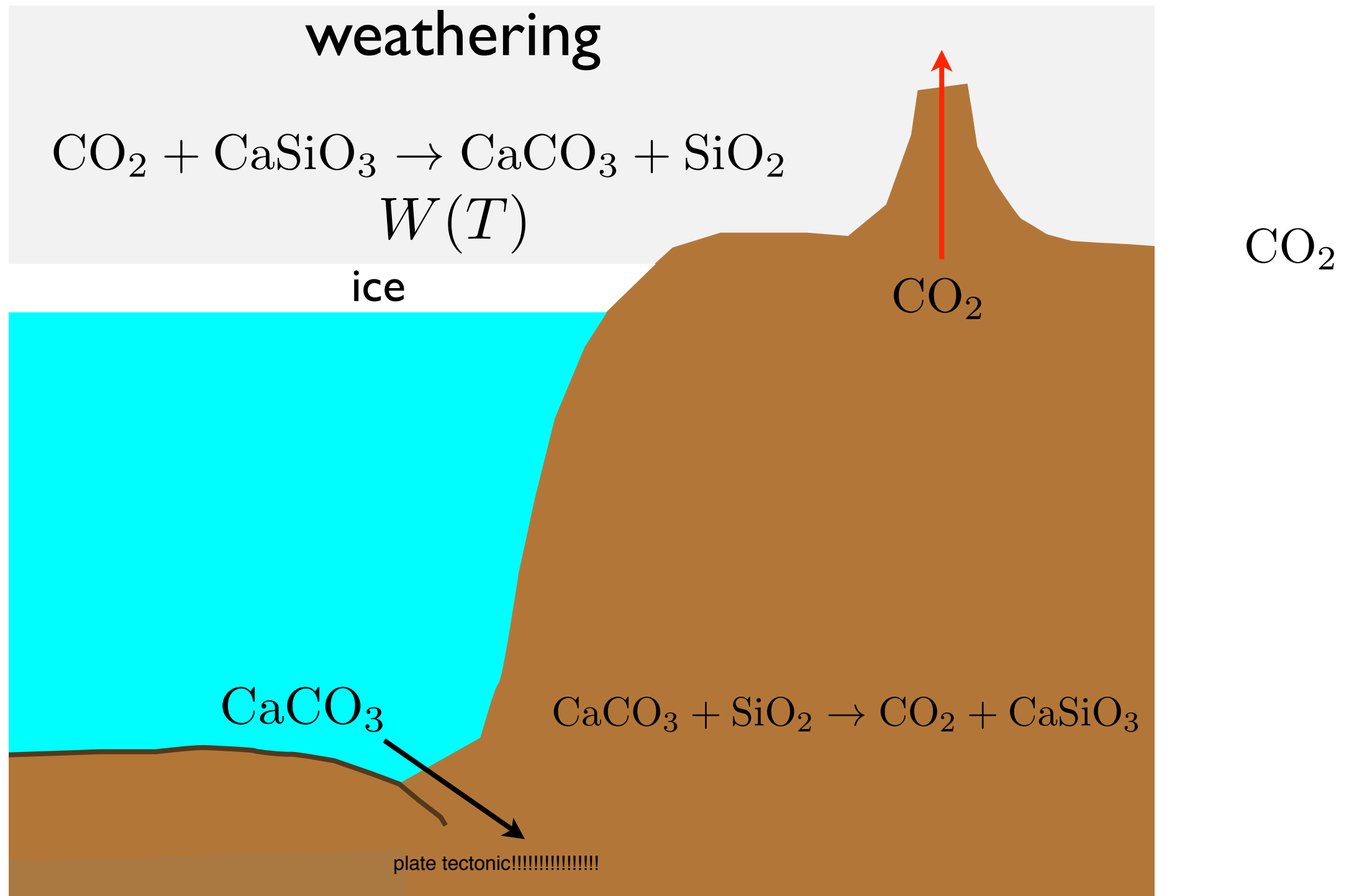
# Low mass transiting planets



# The Sun's luminosity



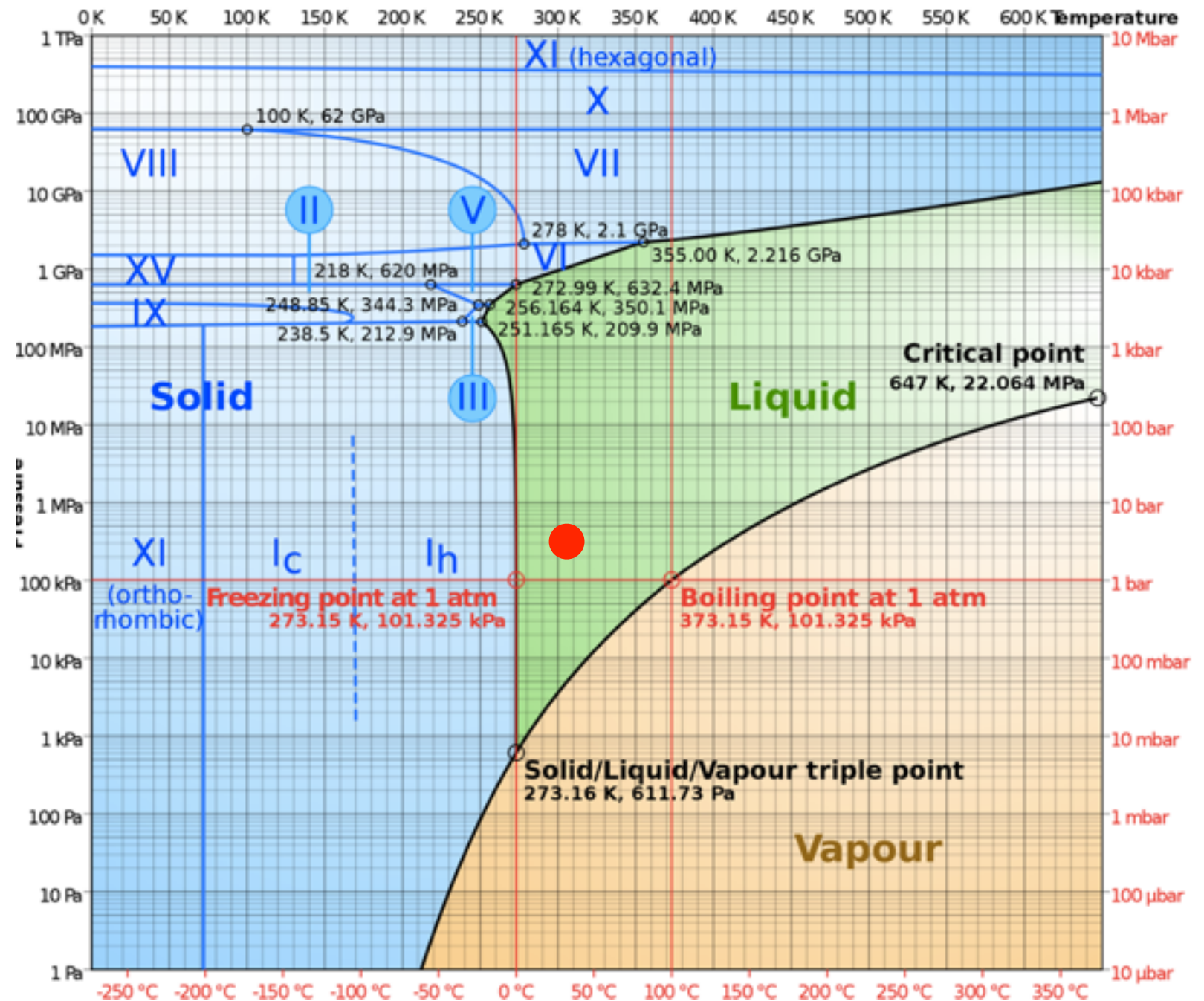
# The geological C cycle stabilizes the surface temperature



# Effect of Ocean mass



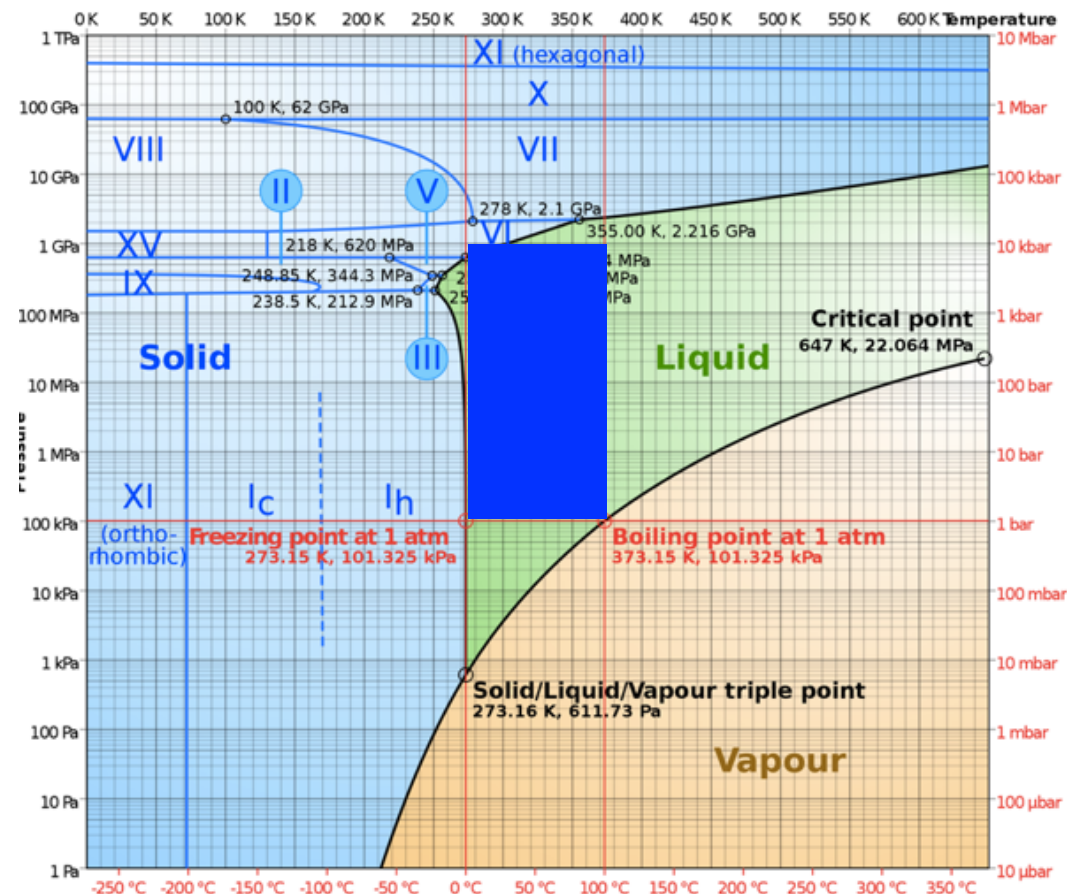
High pressure ice





# Necessary condition for habitable planet

1- the surface temperature and pressure are 'nice'



2- there is a CO<sub>2</sub> cycle

*the pressure at the bottom of the (global) ocean cannot be too high*

# A maximum radius for habitable planets

Large radius implies

large water fraction

*no CO<sub>2</sub> cycle*

large gas fraction

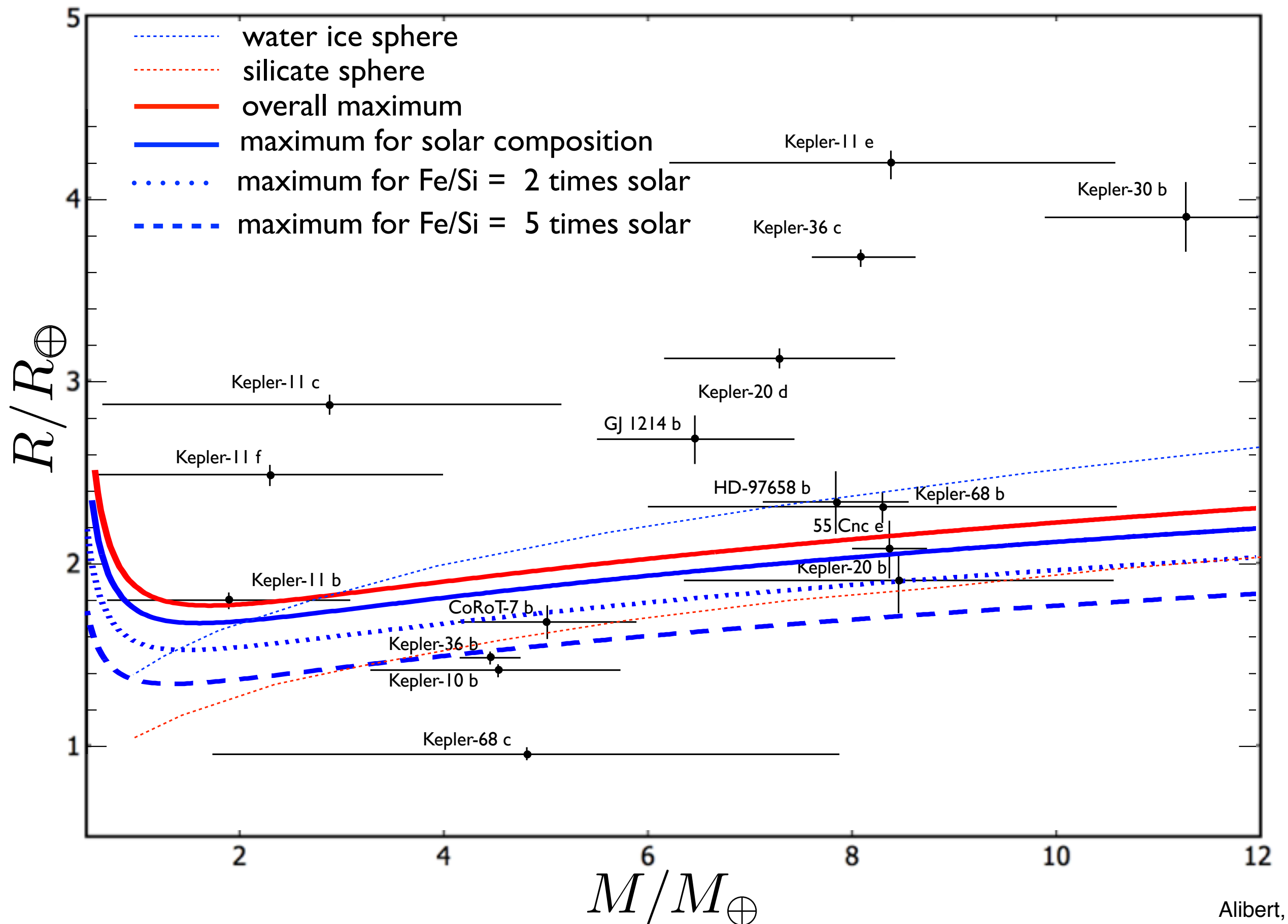
*surface T,P outside of the 'nice' zone*

*large-R planets are NOT habitable*

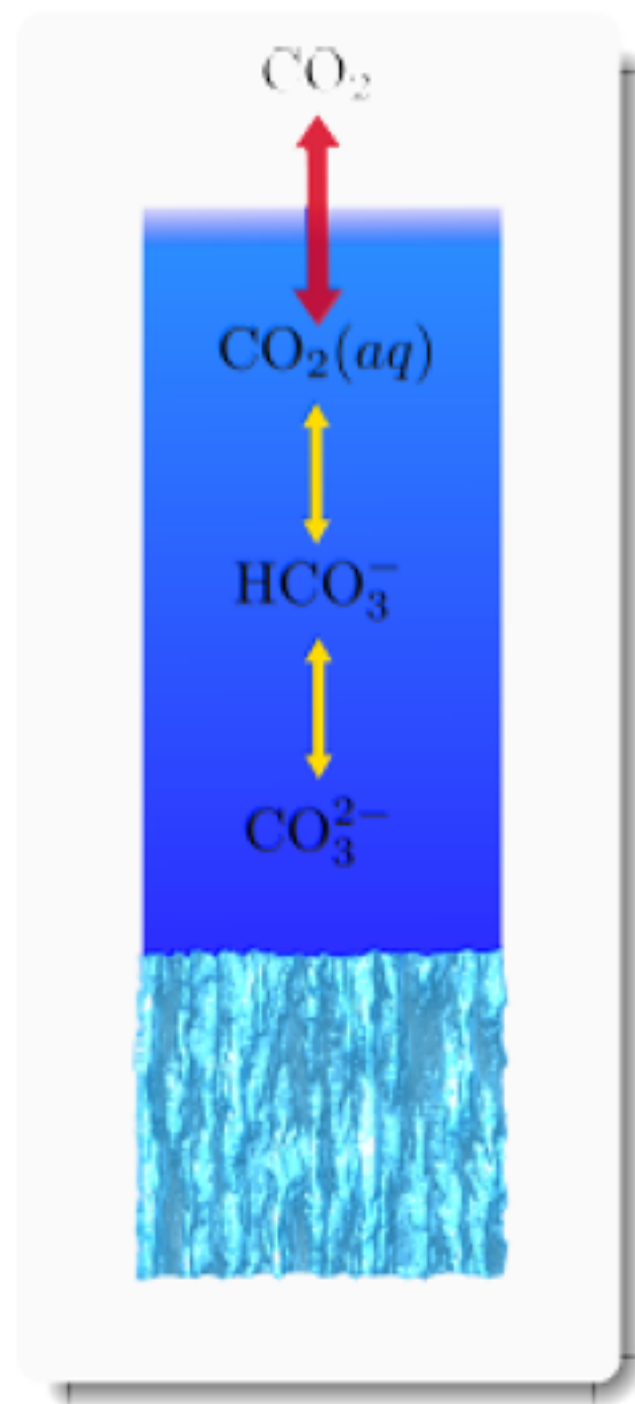
*small-R planets: we don't know*



# Maximum radius of habitable planets



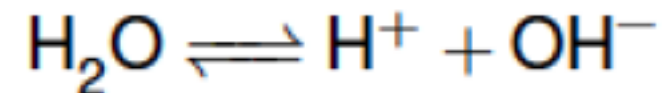
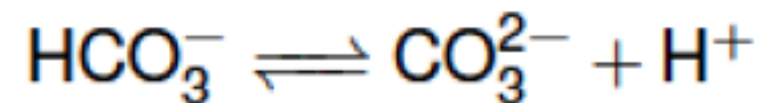
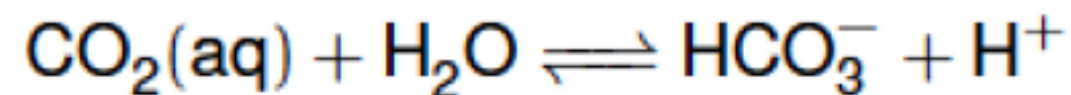
# CO<sub>2</sub> equilibrium on ocean planets



- atmospheric pressure of CO<sub>2</sub> given by

$$p_{\text{CO}_2} = K_H(T) c_{\text{CO}_2(\text{aq})}$$

- further reactions within the ocean



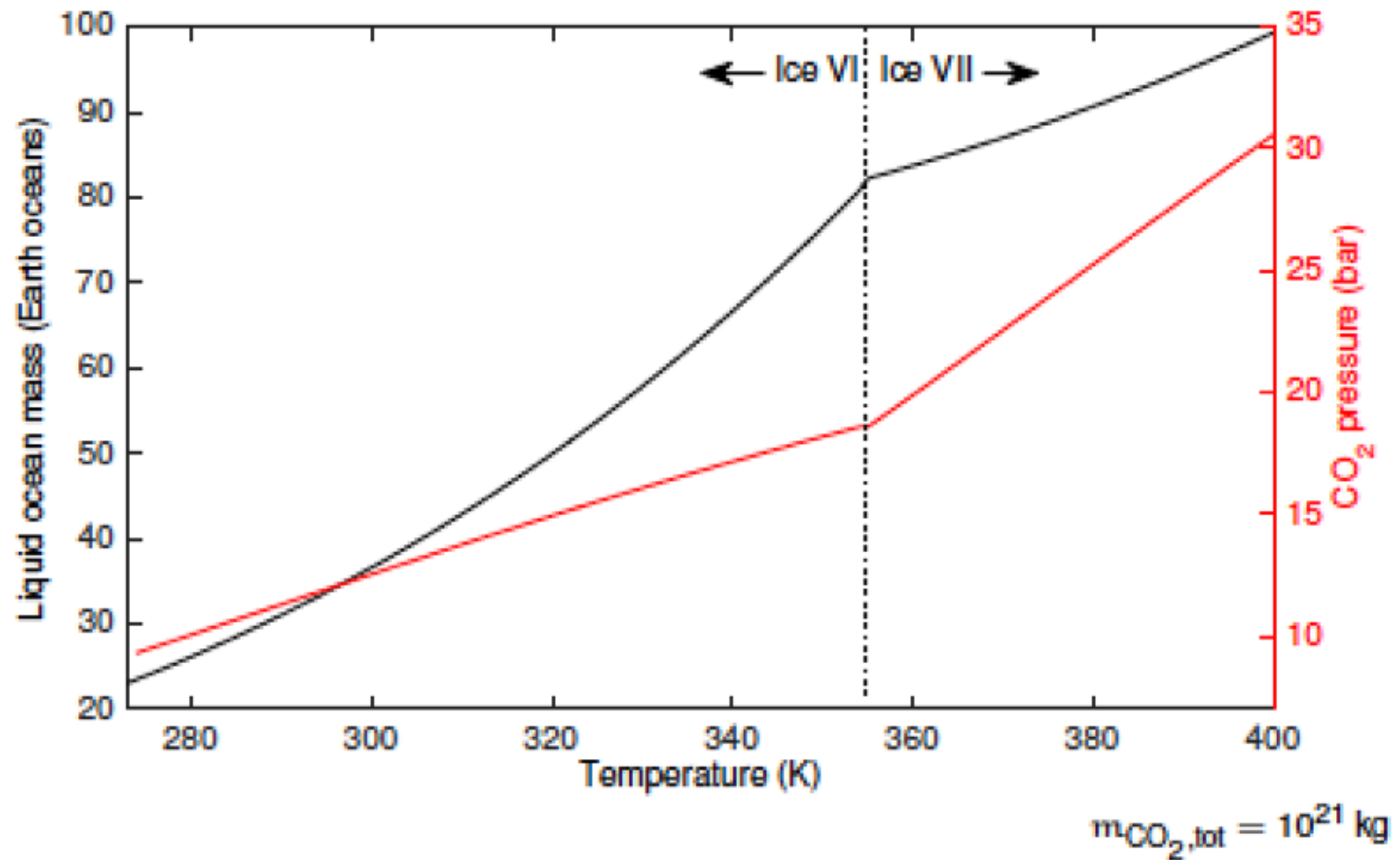
- additional constraint: charge balance

$$[\text{H}^+] = [\text{HCO}_3^-] + 2[\text{CO}_3^{2-}] + [\text{OH}^-]$$

⇒ strongly temperature-dependent

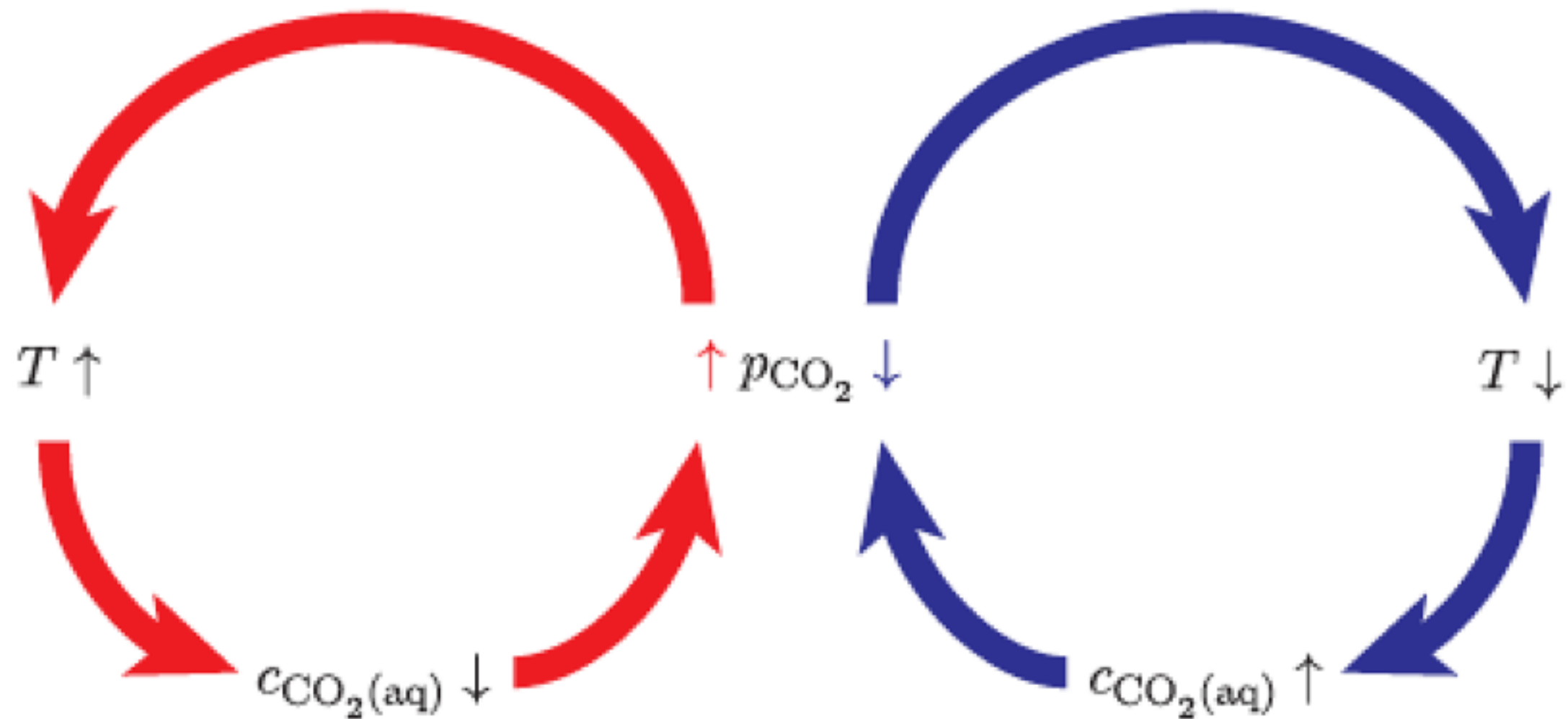
⇒ determined by available liquid water inventory

# Atmospheric CO<sub>2</sub> pressure depends on temperature



⇒ unstable, positive CO<sub>2</sub> feedback cycle

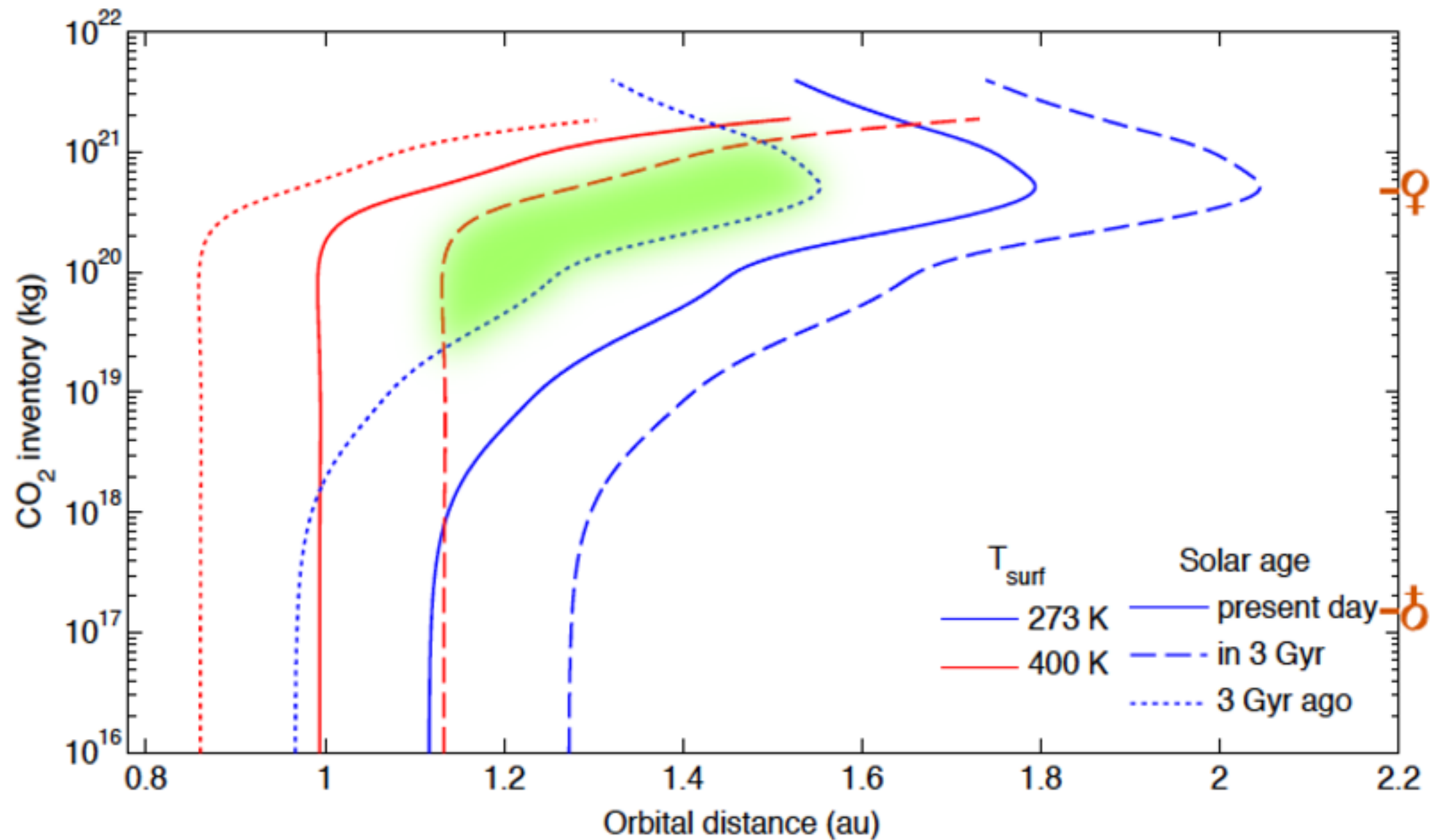
# The unstable CO<sub>2</sub> cycle



***-> the habitable zone of ocean planet is reduced***

# The 'habitable zone'

CO<sub>2</sub> cycle + atmospheric model = habitable zone



# Non-habitability vs habitability

Habitability is an ill-defined concept

Non-habitability can be used to select follow-up observations

*Large radius planets are not habitable*

Too much water is bad for life

*The habitable zone of water-rich planets is reduced by the unstable CO<sub>2</sub> cycle*