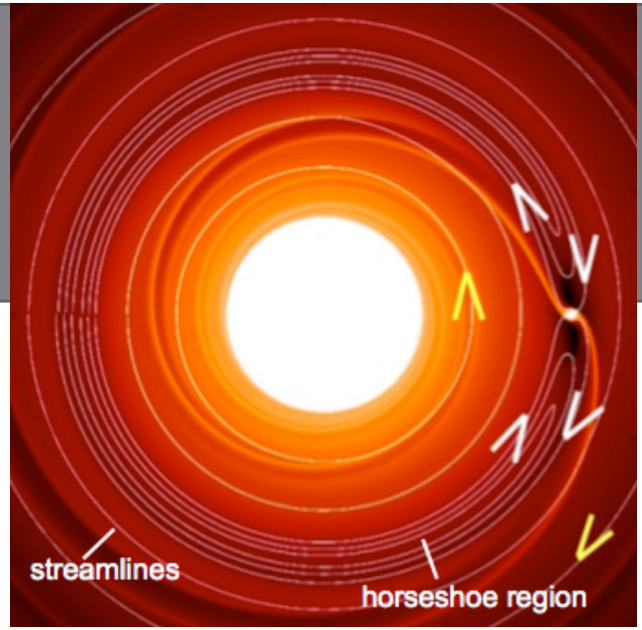
J. P. L.

Jovian Planet Migration

Type I migration $\dot{a}_p = 2\Gamma a_p \Omega \frac{a_p^2}{h^2} \Sigma_g \frac{M_p}{M_*^2}$

- Isothermal disk
- Adiabatic disk
- Lindblad torque and coratation torque



$\Gamma_1 = 1.364 + 0.541 p_g$ (Ida & Lin 2004) Mode 1

$\Gamma_{loc} = -0.85 + 0.9 p_T + p_g$ (Paardekooper et al. 2010) Mode 2

$\Gamma_{Lind} = \frac{1}{\gamma}(-0.25 + 1.7 p_T - 0.1 p_g)$

$\Gamma_{Corot} = \frac{1}{\gamma}(1.65 - 7.9 p_T/\gamma + (9 - 7.9/\gamma p_g)$ (Paardekooper et al. 2010) Mode 3

$\Gamma_{adia} = \Gamma_{Lind} + \Gamma_{Corot}$

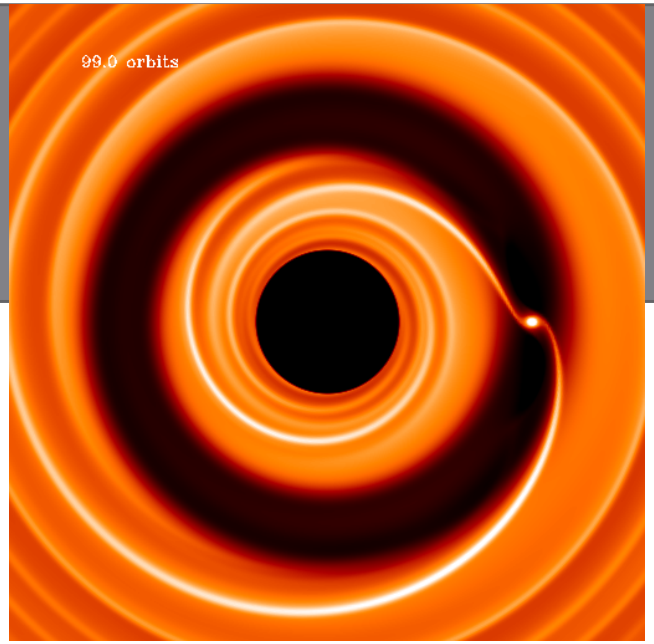
Type II migration

$$\dot{a}_p = 3\,\mathrm{sign}(a_p - R_m)\alpha \frac{\Sigma_{g,m} R_m^2}{M_p} \frac{\Omega_m}{\Omega} \left(\frac{H_m}{a_p}\right) \Omega_m$$

(Ida & Lin 2004) mode 1

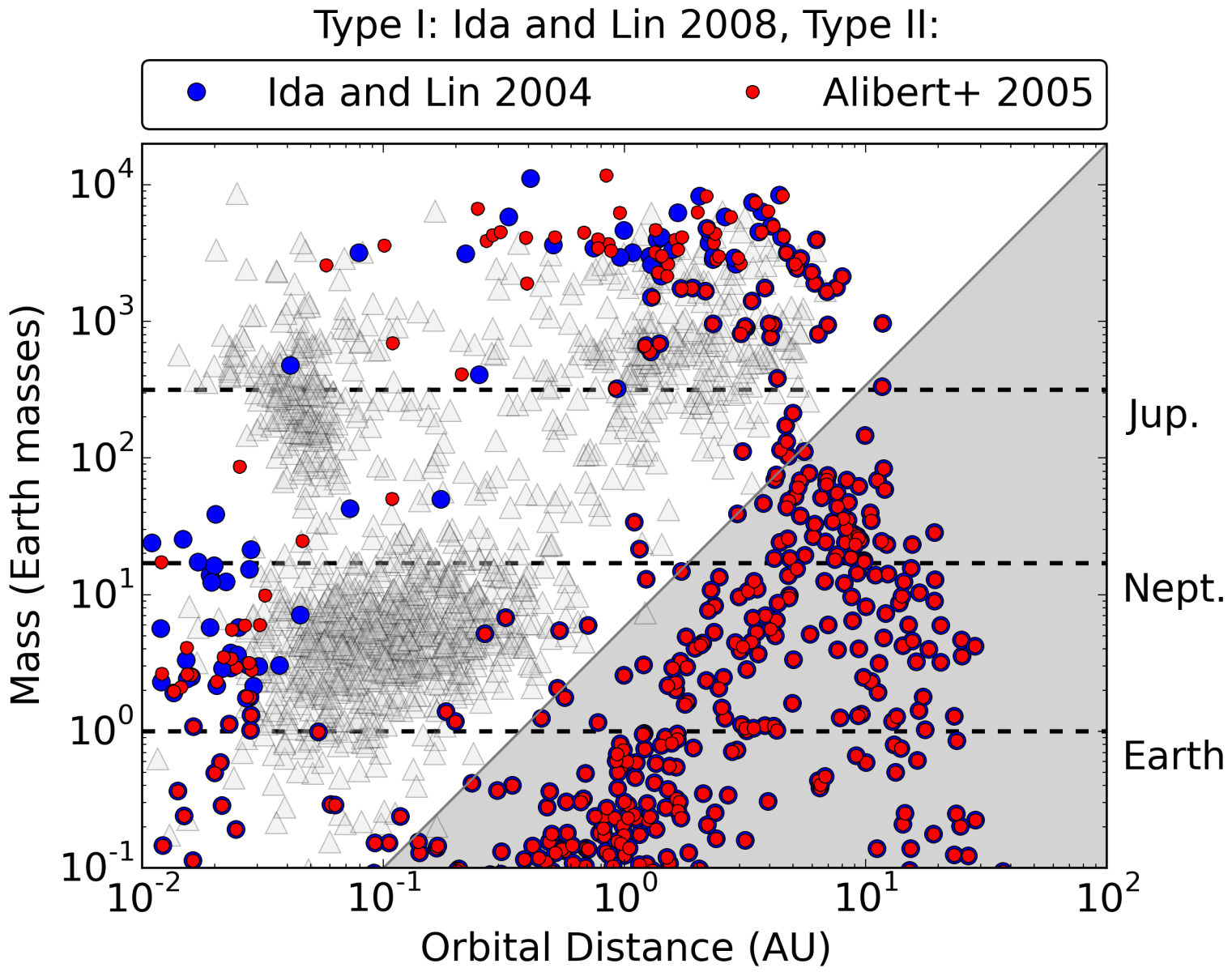
$$\dot{a}_p = \mathrm{sign}(a_p - R_m) u_r \min\left(1, \frac{2\Sigma_g a_p^2}{M_p}\right)$$

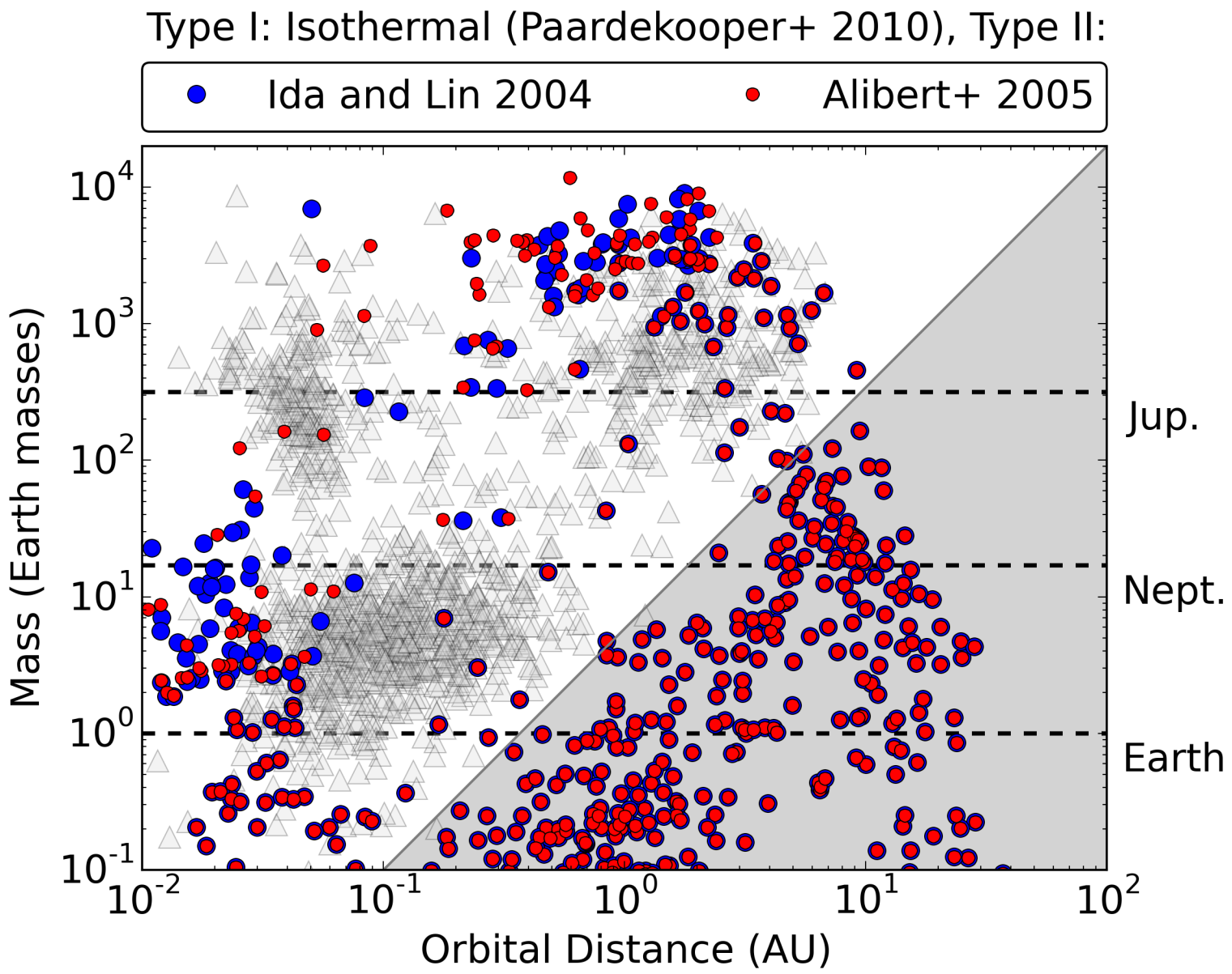
(Alibert et al. 2005) mode 2

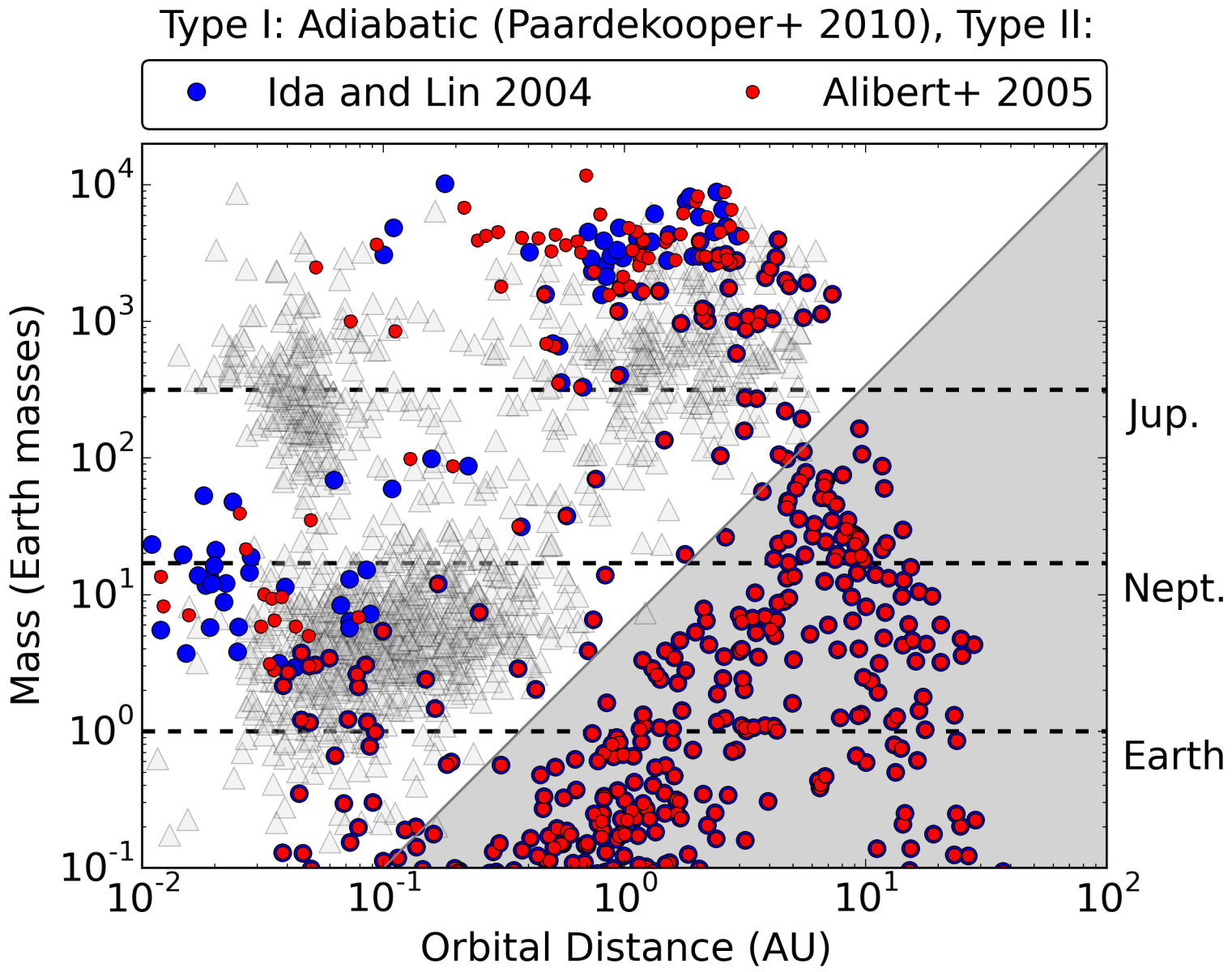


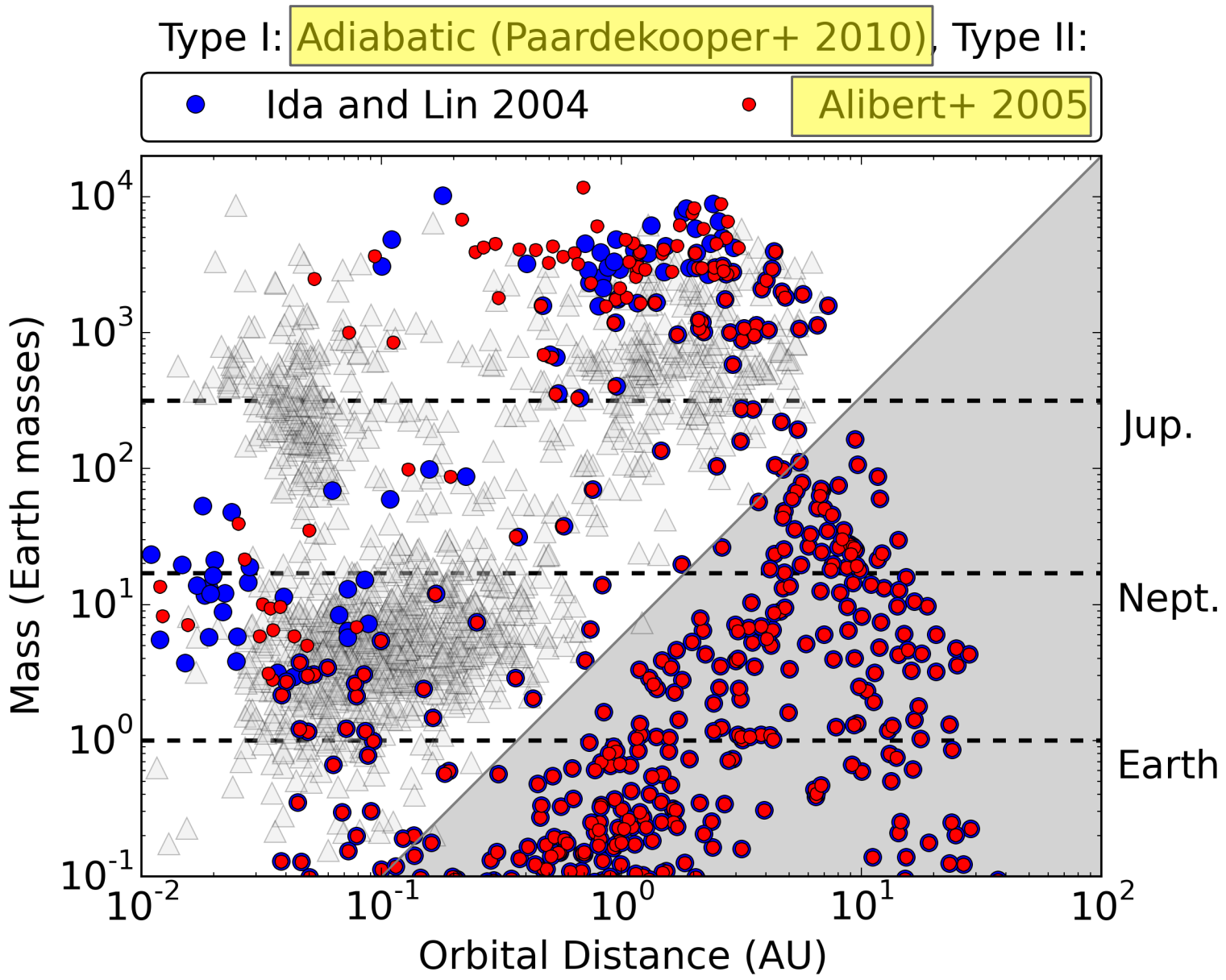
a)
Which models should we choose?



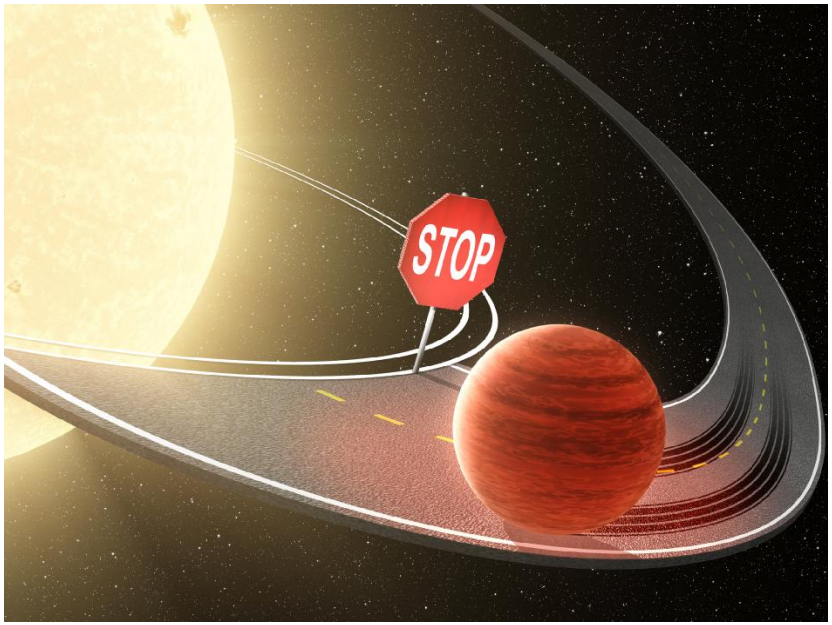

Type I: Ida and Lin 2008, Type II:
Ida and Lin 2004
Alibert+ 2005
Mass (Earth masses)
Orbital Distance (AU)
Jup.
Nept.
Earth
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


Type I: Isothermal (Paardekooper+ 2010), Type II:
Ida and Lin 2004
Alibert+ 2005
Mass (Earth masses)
Orbital Distance (AU)
Jup.
Nept.
Earth

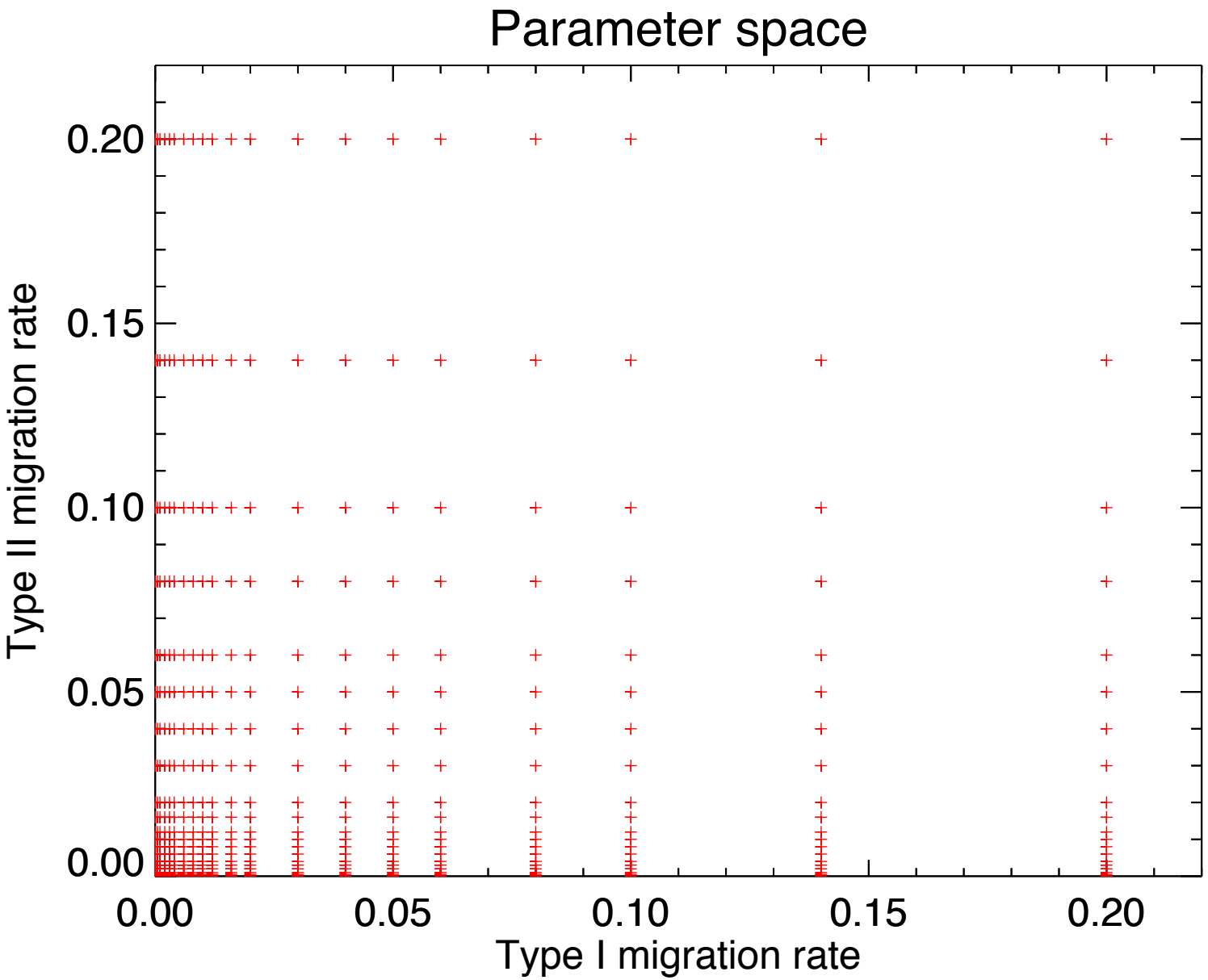

Type I: Adiabatic (Paardekooper+ 2010), Type II:
Ida and Lin 2004
Alibert+ 2005
Mass (Earth masses)
Orbital Distance (AU)
Jup.
Nept.
Earth

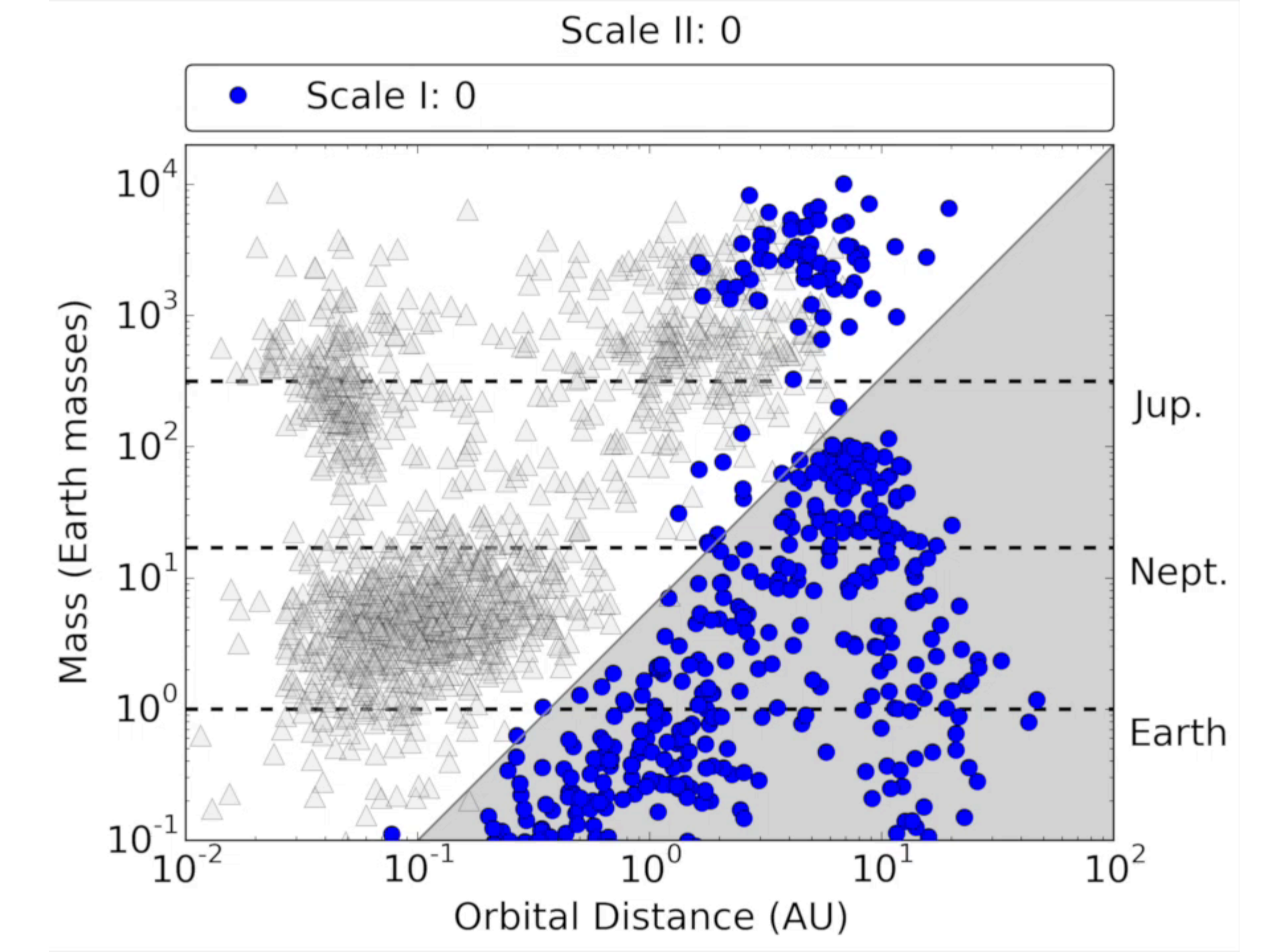

Type I: Adiabatic (Paardekooper+ 2010), Type II:
Ida and Lin 2004
Alibert+ 2005
Mass (Earth masses)
Orbital Distance (AU)
Jup.
Nept.
Earth

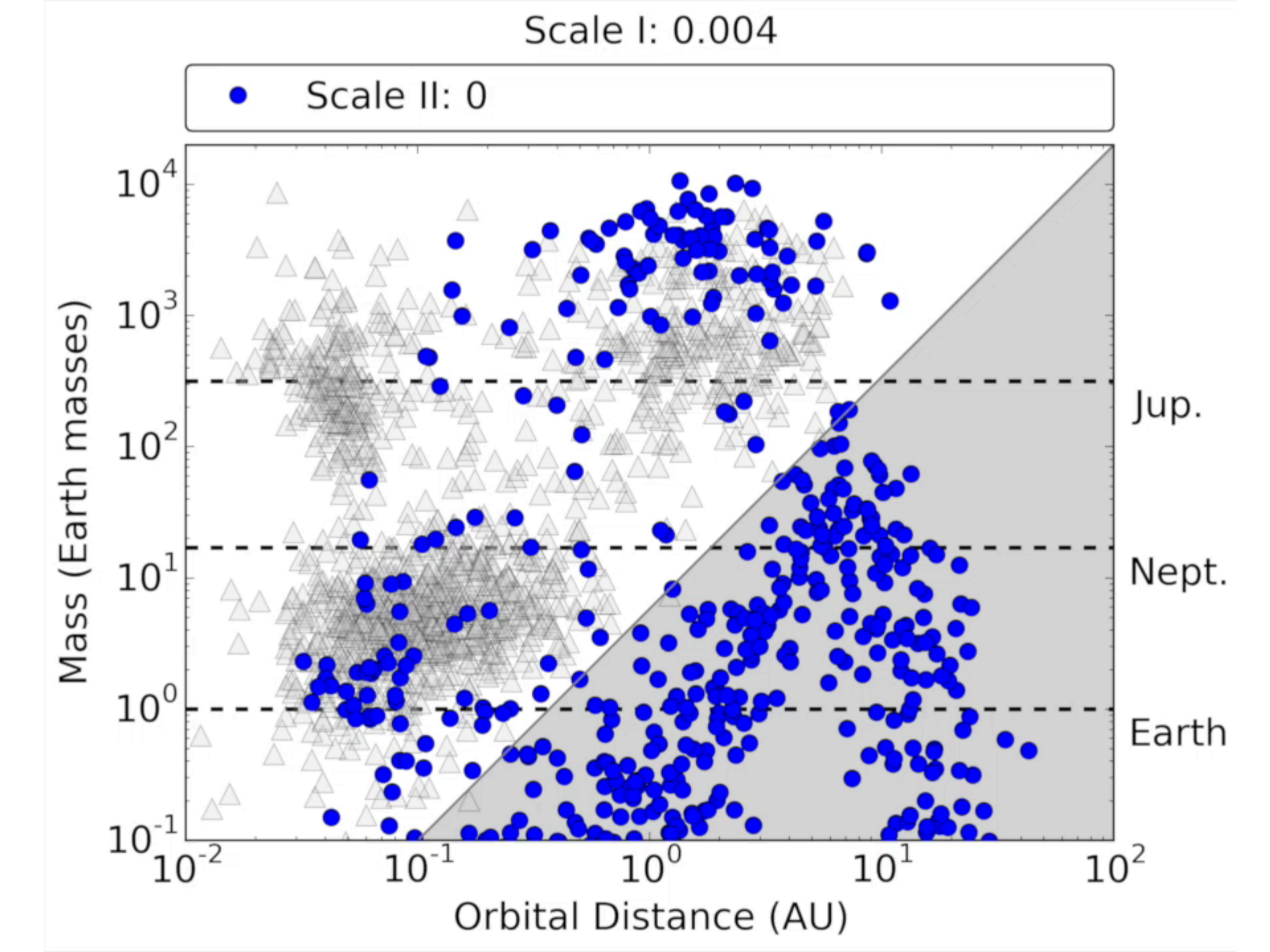
b)
How can we produce Hot Jupiters?

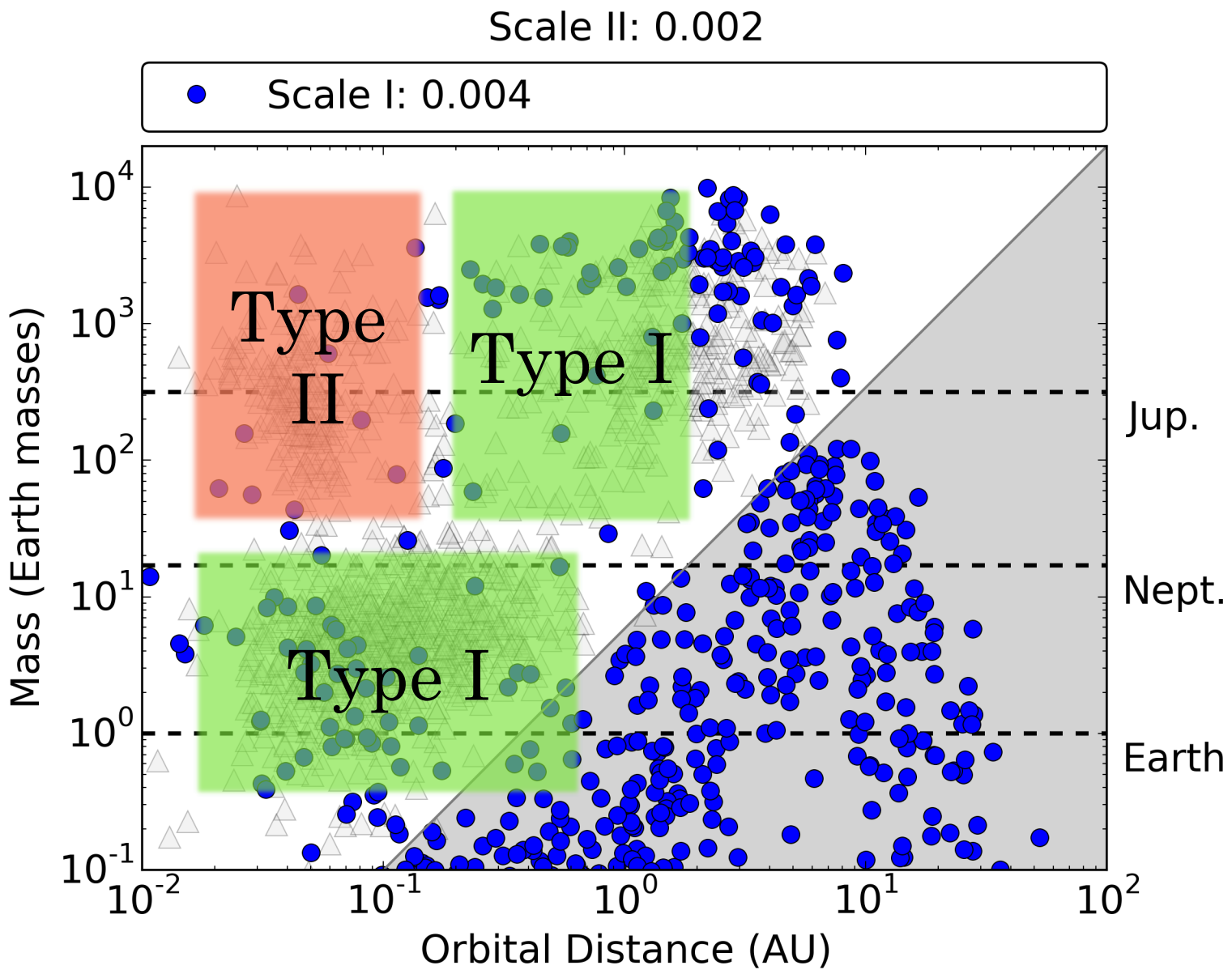


… without killing them


Parameter space
Type II migration rate
0.00
0.05
0.10
0.15
0.20
Type I migration rate
0.00
0.05
0.10
0.15
0.20


Scale II: 0
Scale I: 0
Mass (Earth masses)
Orbital Distance (AU)
Jup.
Nept.
Earth
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


Scale I: 0.004
Scale II: 0
Mass (Earth masses)
Orbital Distance (AU)
Jup.
Nept.
Earth
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


Scale II: 0.002
Scale I: 0.004
Type II
Type I
Type I
Jup.
Nept.
Earth
Mass (Earth masses)
Orbital Distance (AU)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

Summary

- Type II migration can explain Hot Jupiters

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- Type I and II migration rates alone are too strong
  → Hot Jupiters would get eaten
  → Need trends that preserve close-in planets
  → Tides?!

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  → Need trends that preserve close-in planets
  → Tides?!
  → Christoph needs to implement tides!!