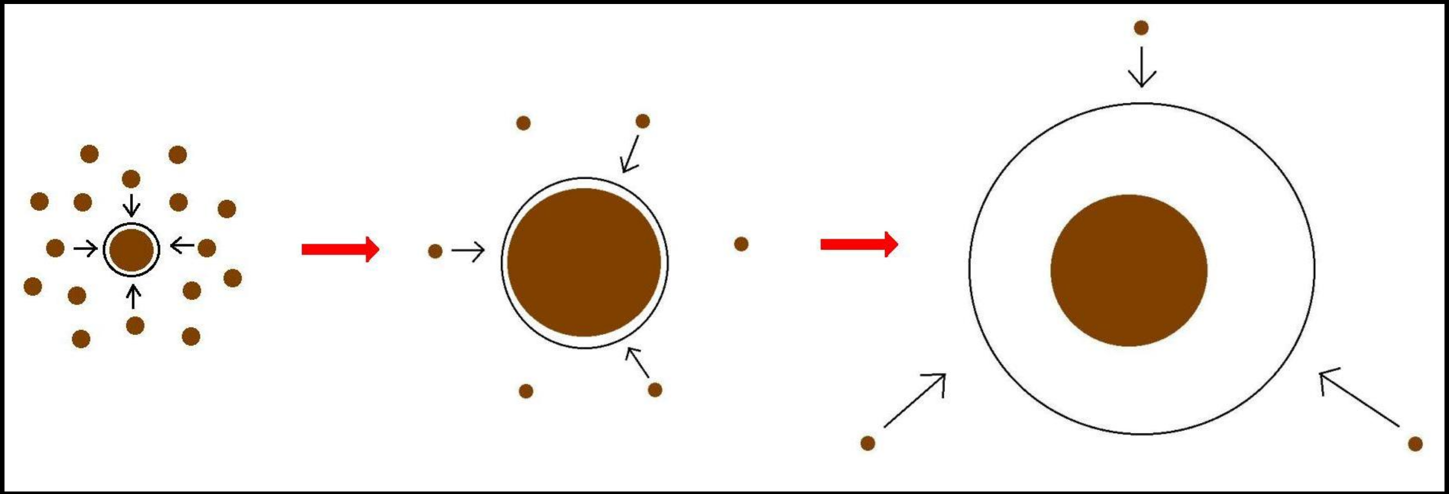
C/O and Snowline Locations in Protoplanetary Disks: The Effect of Radial Drift and Viscous Gas Accretion

Ana-Maria Piso

September 25th, 2015

Core Accretion Model



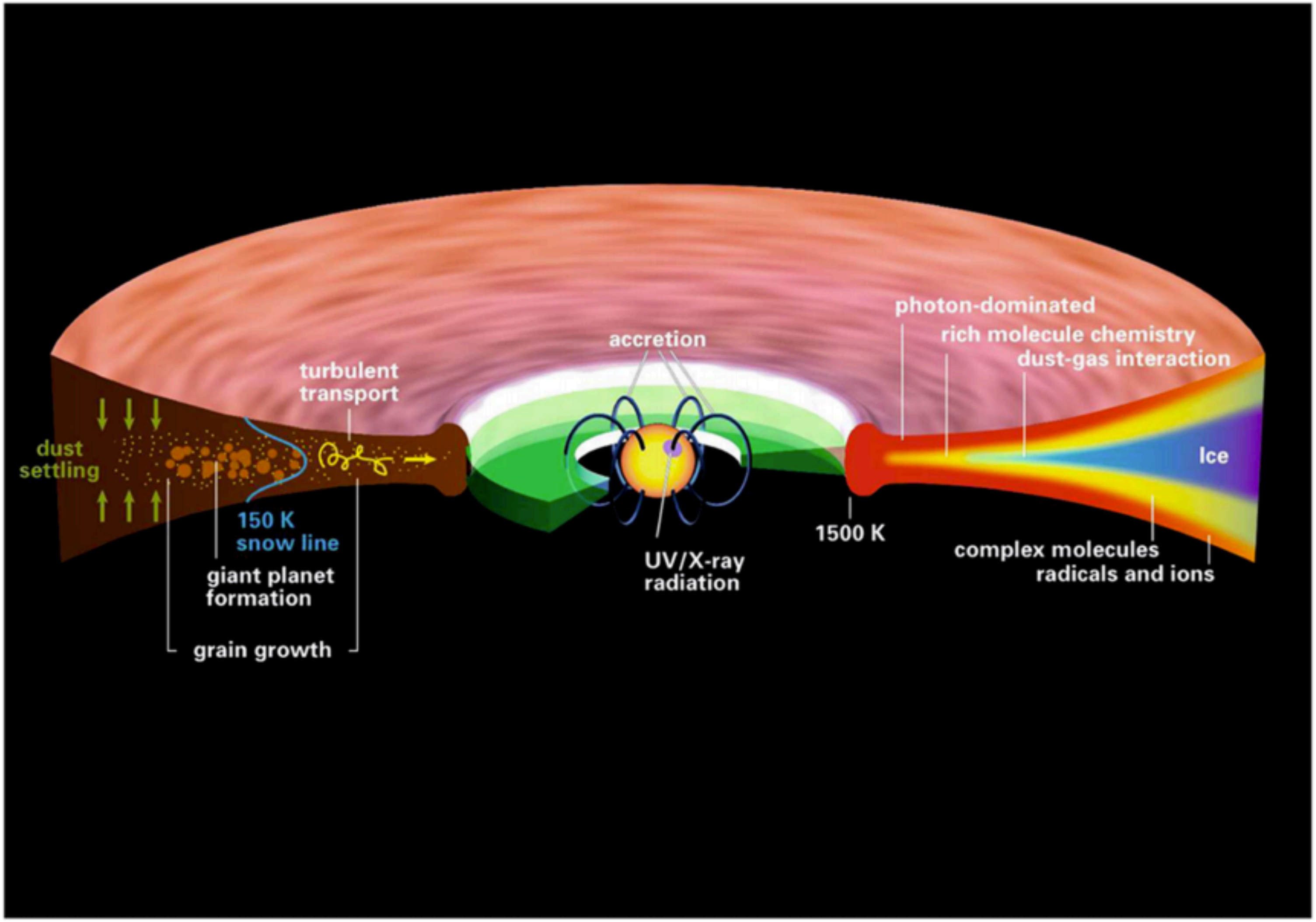
The composition of planets is determined by and tightly linked to the disk composition

BASIC IDEA

Understand the disk well enough to:

1. Predict what kind of planet compositions result from planet formation in different parts of the disk
2. Back-track the planet formation location based on the planet composition

Disk structure is complex!

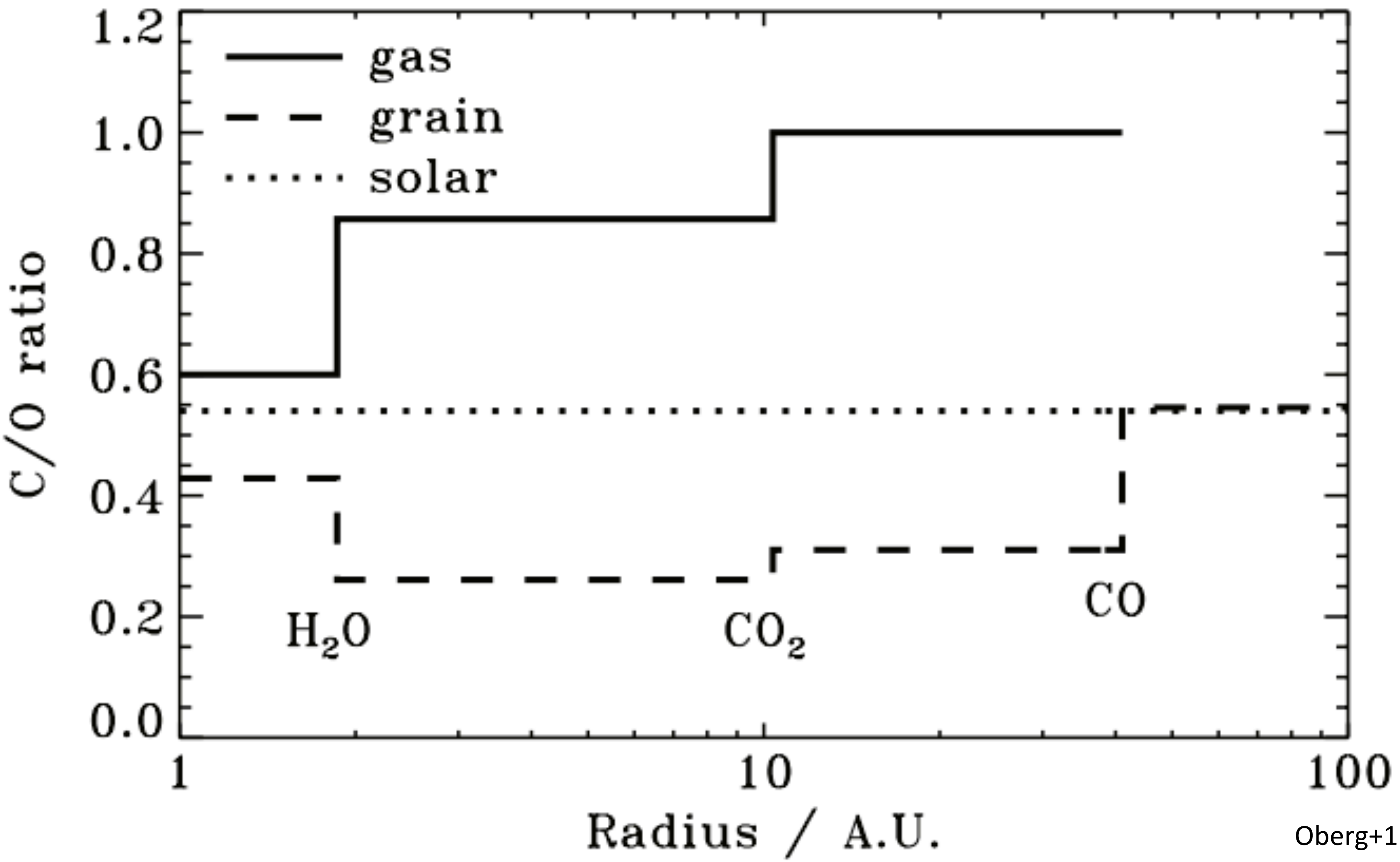


Henning&Semenov (2013)

MAIN GOAL

Explore and understand the dynamical and chemical processes occurring in disks, and their relative importance in shaping disk compositions throughout time

Primarily focus on understanding how all these processes affect the snowline location of volatile species


1.2
1.0
0.8
0.6
0.4
0.2
0.0
C/O ratio
gas
grain
solar
H2O
CO2
CO
1
10
100
Radius / A.U.
Oberg+11

“SUB”-GOAL

Understand how radial drift and gas accretion affect snowline locations, and thus the C/O ratio in gas and dust throughout the disk

Radial drift of solids

- Gas moves at sub-Keplerian velocity:

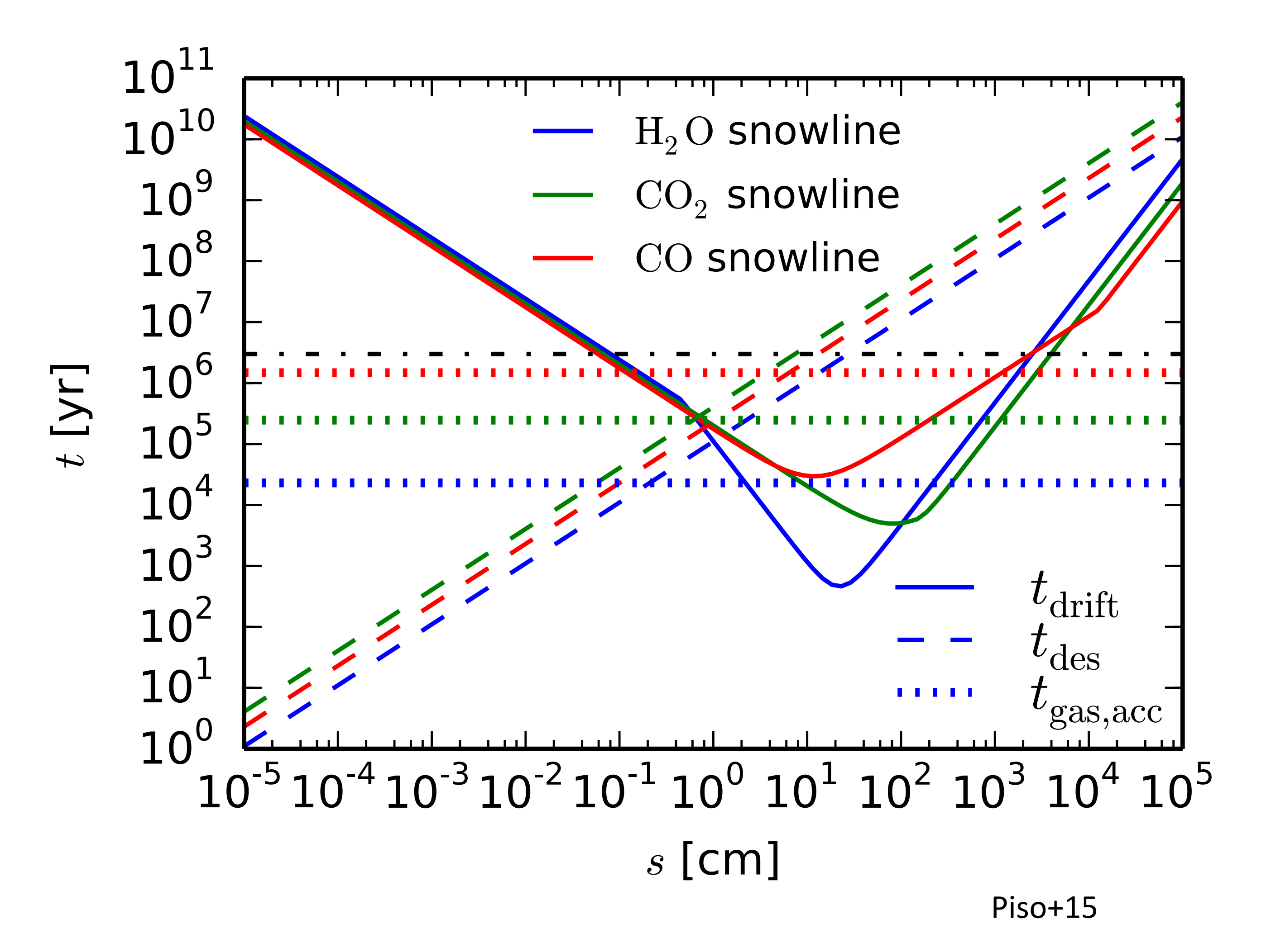
  $v_{gas} \sim v_K \, (1 - c_s^2 \, / \, v_k^2)$

- Small particles (~micron size) move with the gas

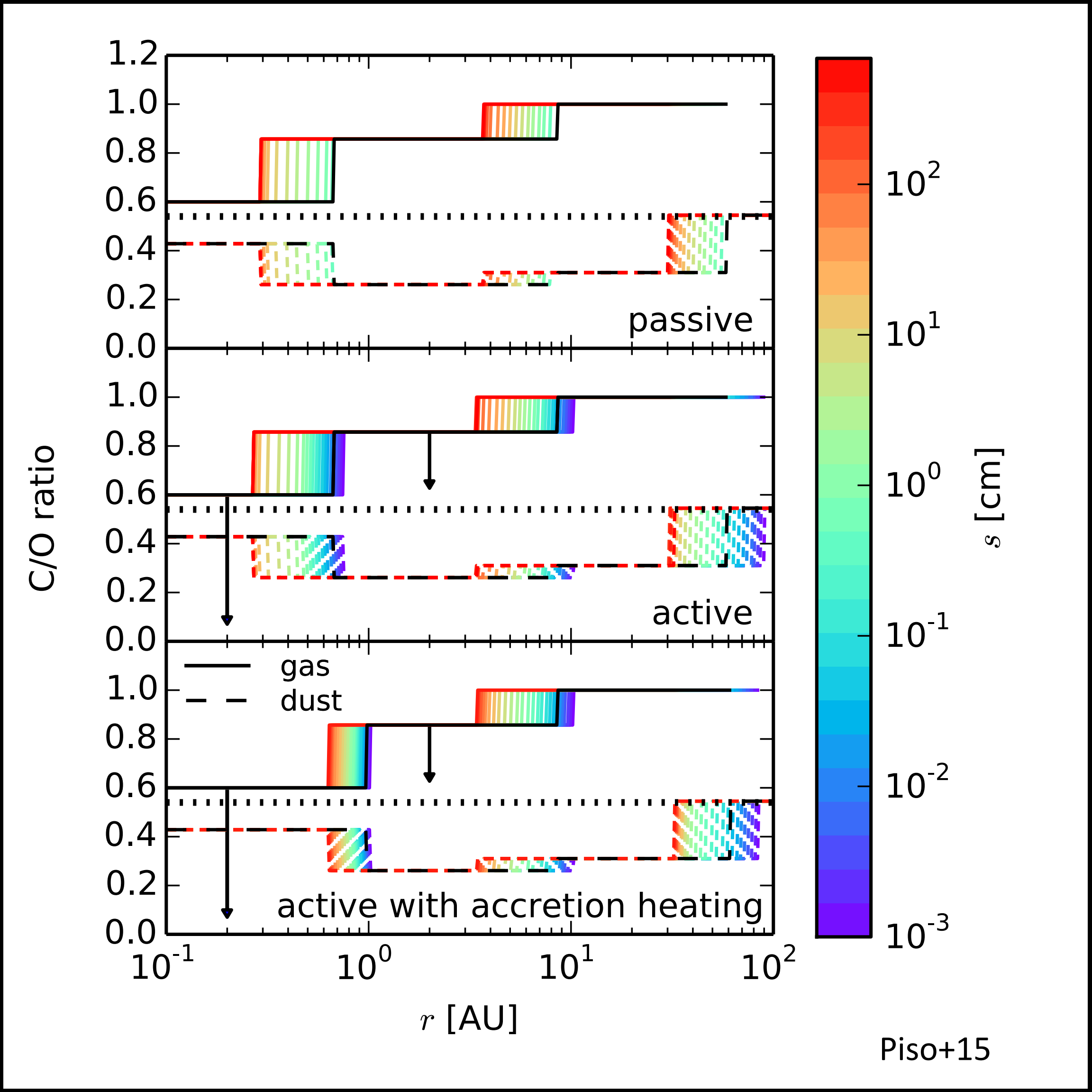
- Large particles (~km size) are unaffected by gas drag

- "Intermediate sized" particles (~cm-m size) experience a headwind and drift towards the star

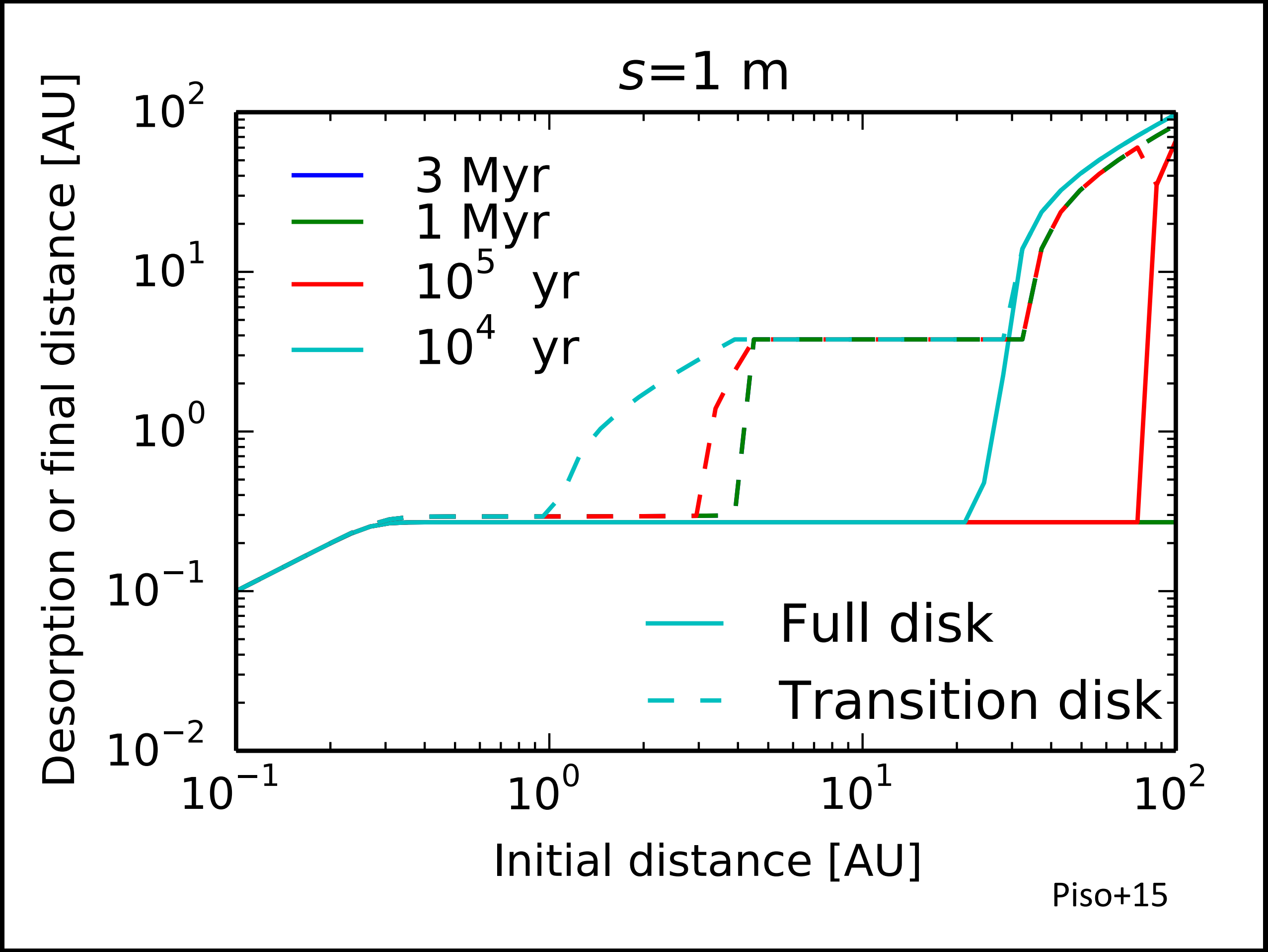
Timescales for desorption, radial drift and gas accretion ARE comparable



We determined upper limits for the C/O ratio across the disk



The desorption distance for transition disks agrees with observations



Summary

- Radial drift and gas accretion affect desorption and move the snowline locations compared to a static disk
- The H_2O, CO_2 and CO snowlines are created by the largest drifting particles in our model, i.e. $s \sim 7$ m
- Snowlines move inwards as the particle size increases
- Our results for a transition disk are consistent with observations