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

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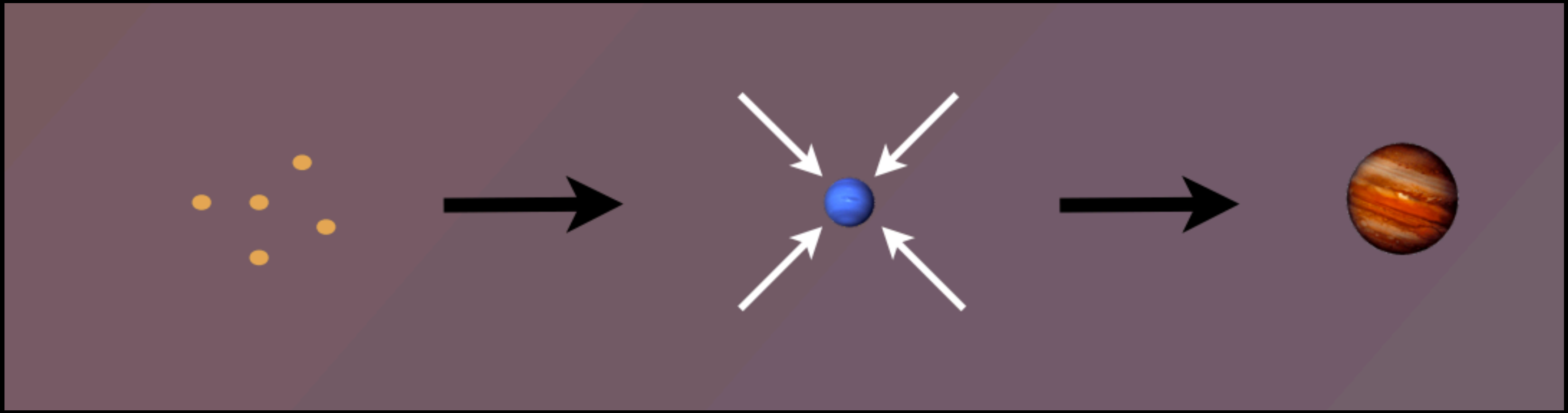
Core Accretion Model



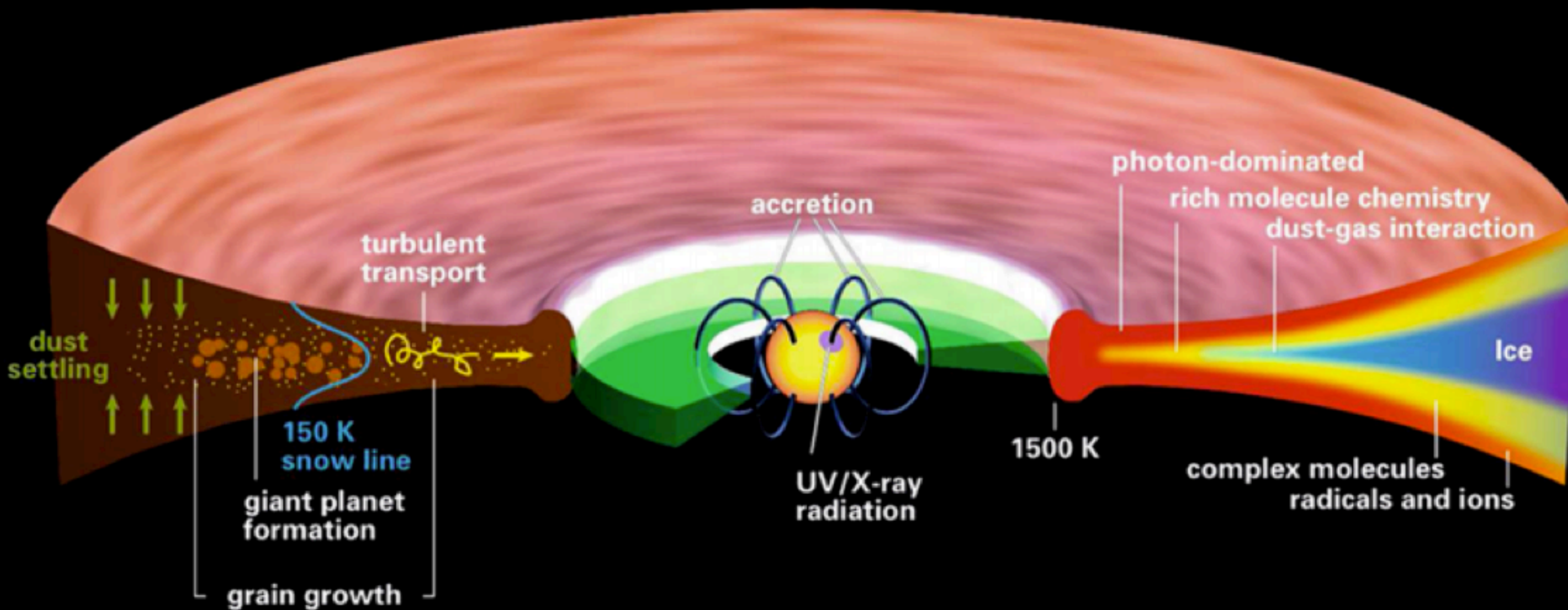
The composition of planets is determined by and tightly linked to the disk composition

BASIC IDEA

Understand the disk well enough to:

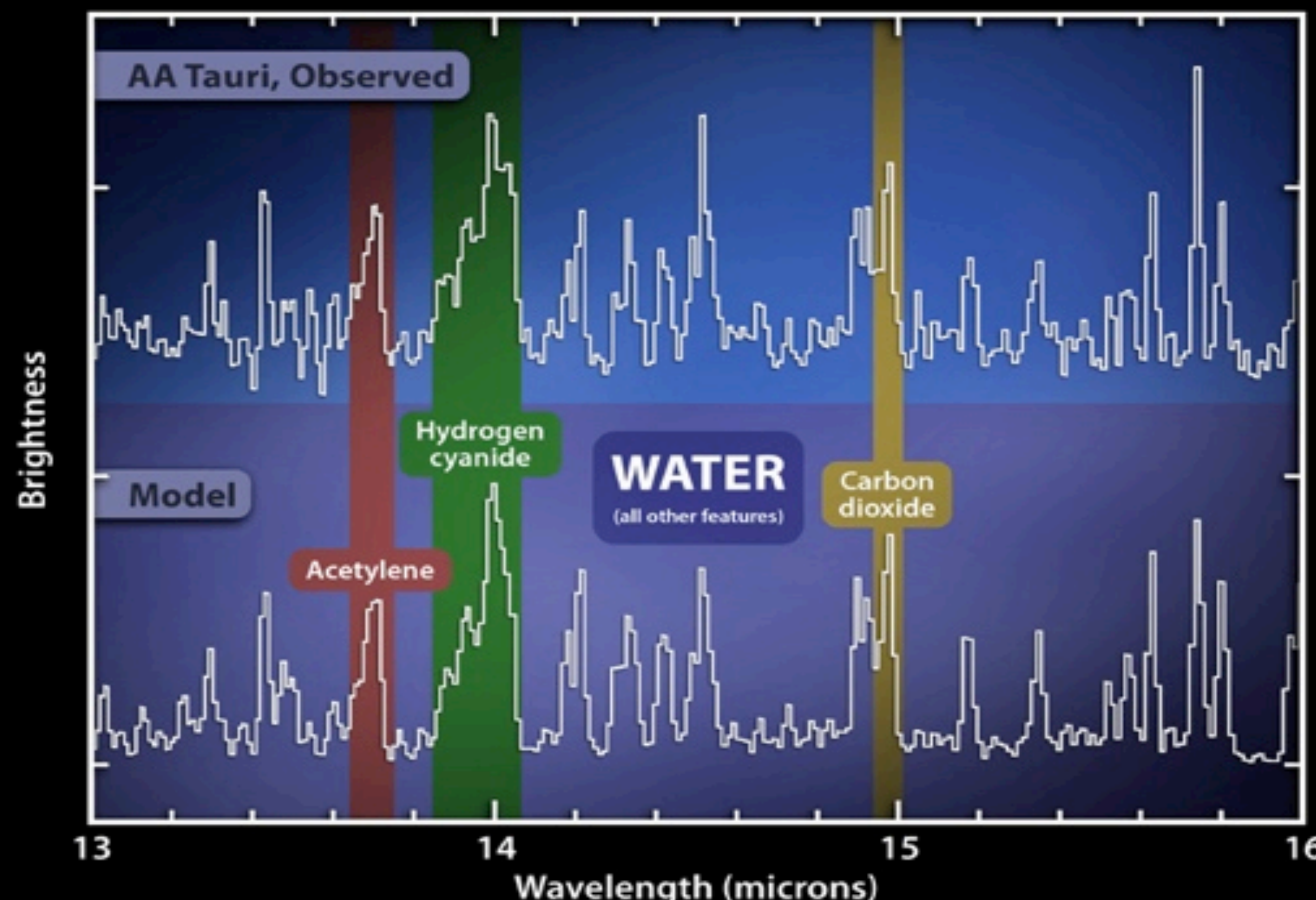
1. Predict what kind of planet compositions result from planet formation in different parts of the disk
2. Back-track the planet formation location based on the planet composition

Disk structure is complex!



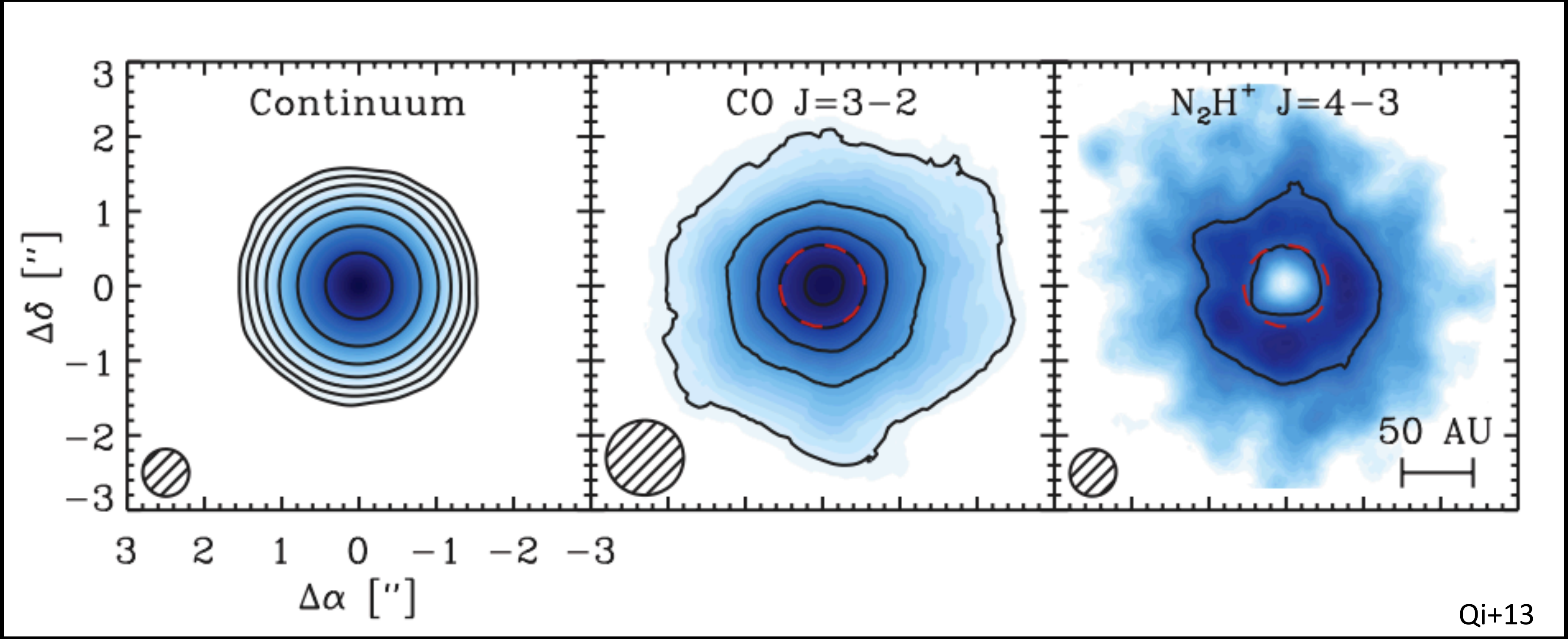
Henning&Semenov (2013)

Volatile compounds have been detected in protoplanetary disks

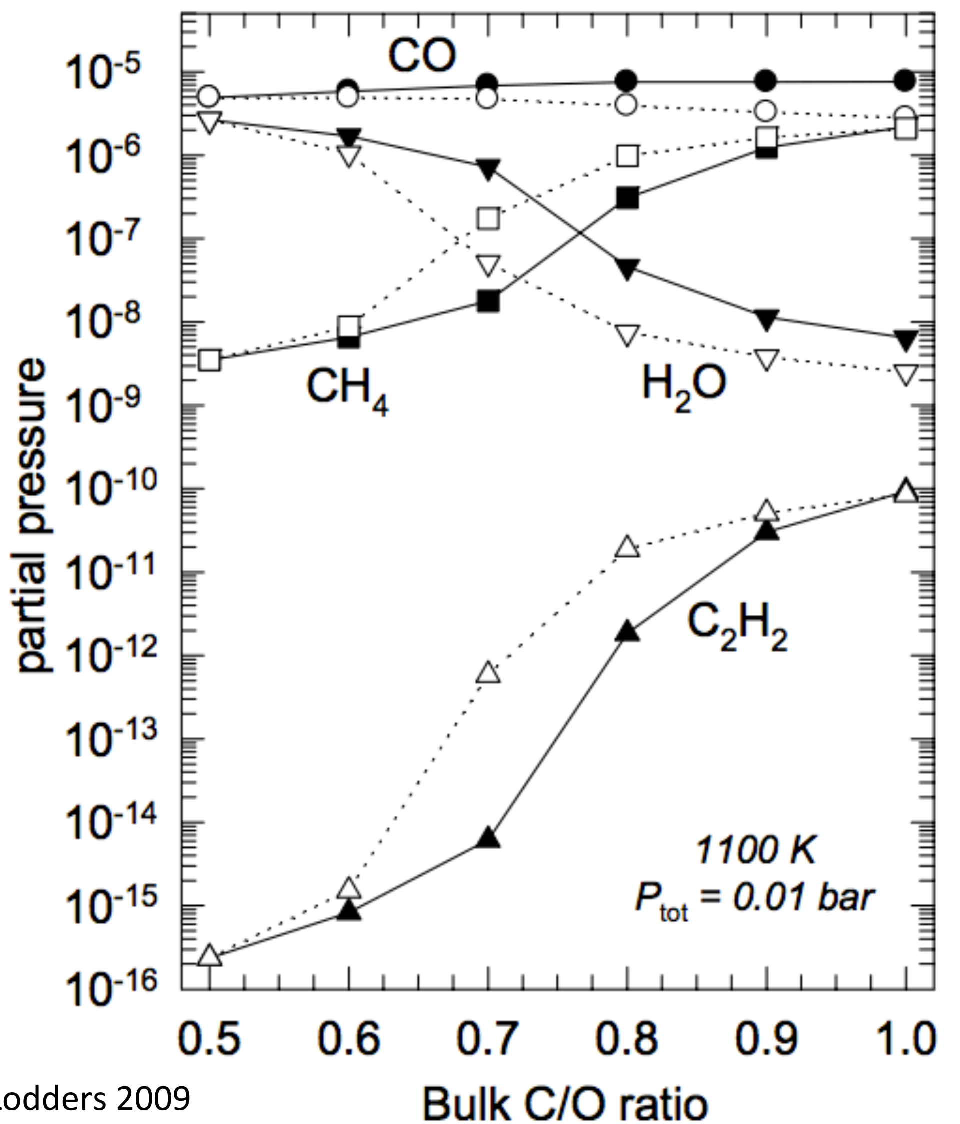


Organic Molecules and Water in a Protoplanetary Disk   Spitzer Space Telescope • IRS
NASA / JPL-Caltech / J. Carr (Naval Research Laboratory)   ssc2008-06a

Snowlines of volatile molecules have been detected in disks

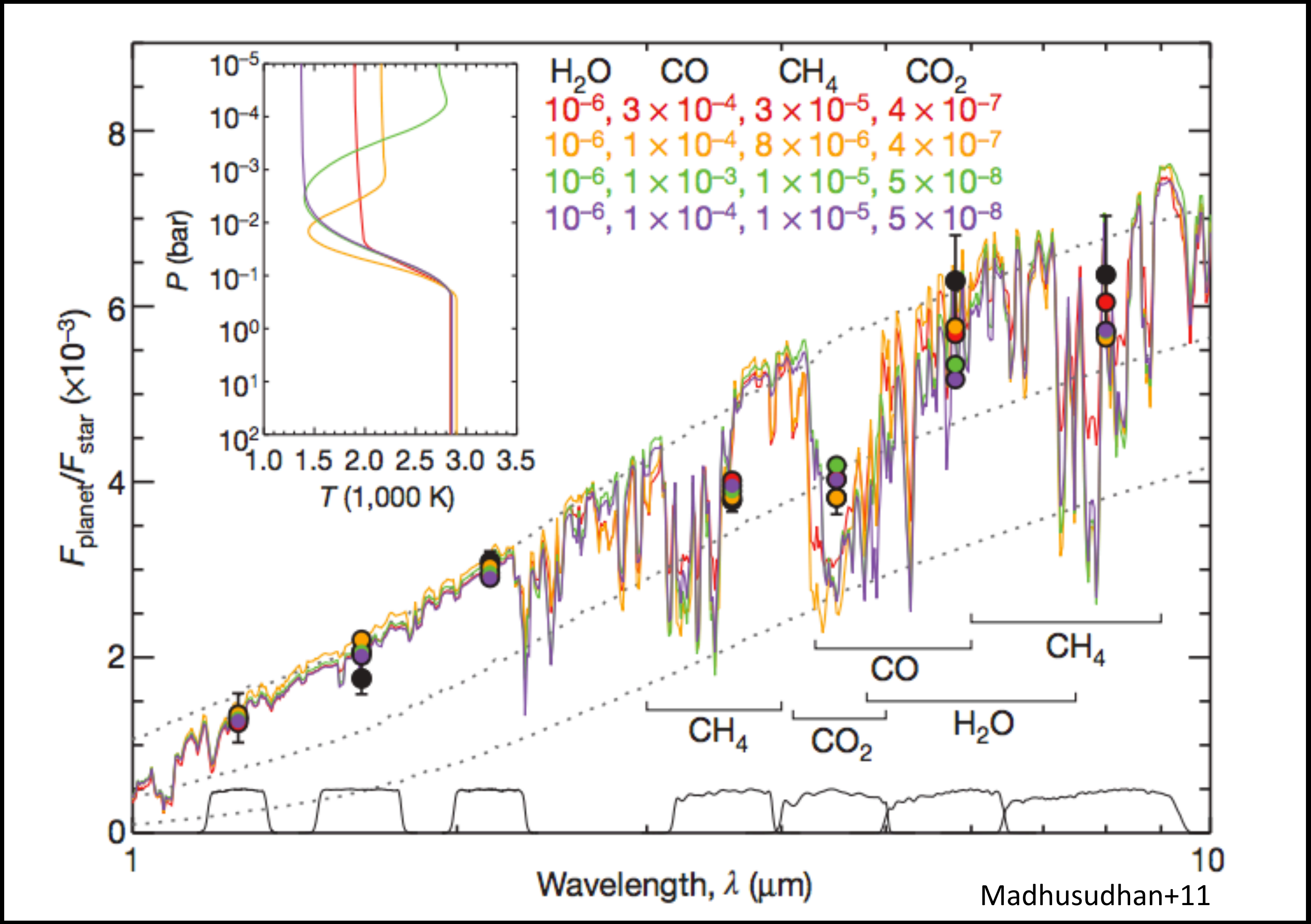


C/O ratio is an important signature of atmospheric chemistry



Lodders 2009

Some giant planets may have C/O ratios different from the stellar value of 0.54



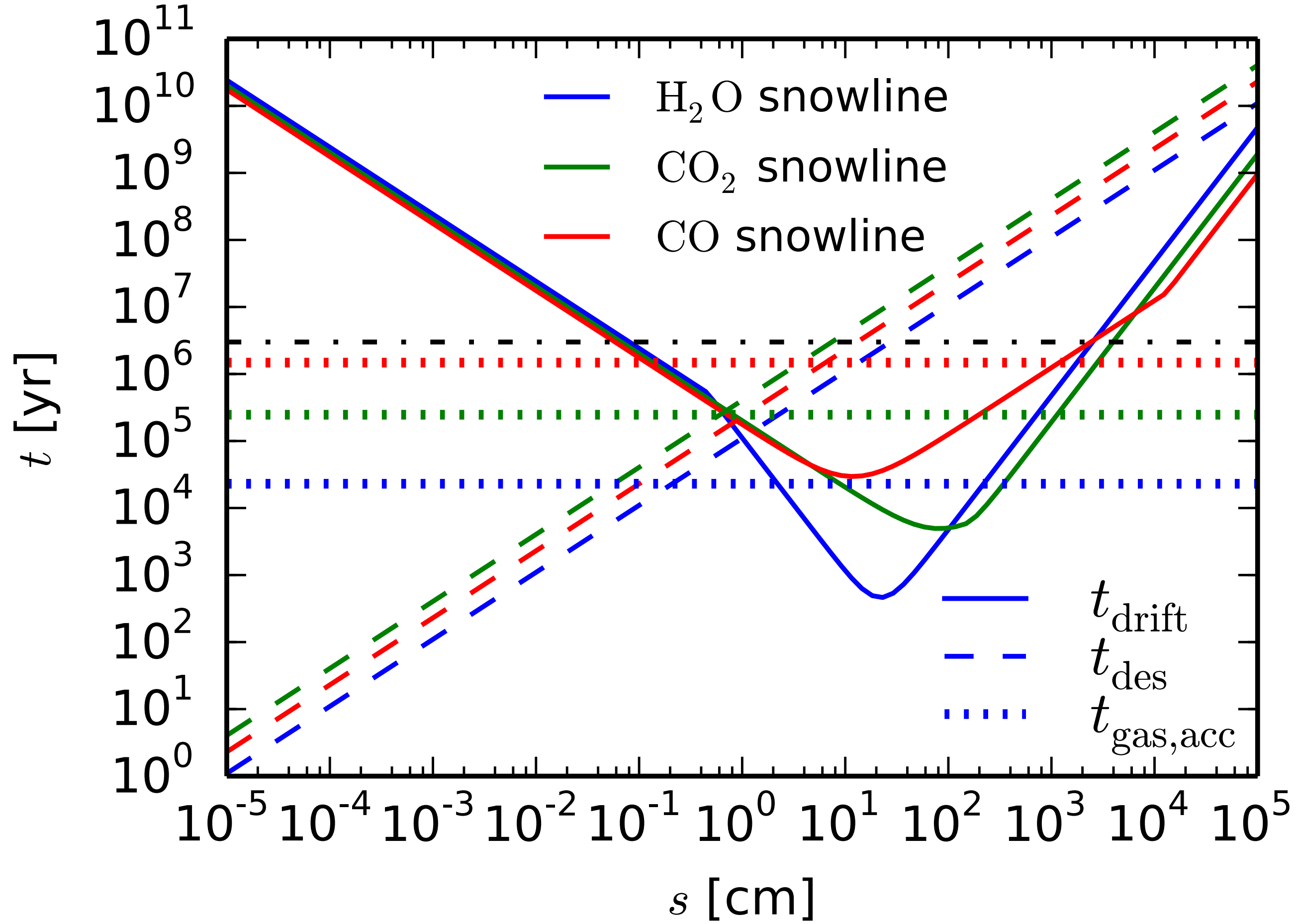
WHY?

Possible explanation: main carriers of C and O, i.e. H_2O, CO_2 and CO, have different condensation temperatures => variations in the abundances of C and O in solids and gas between the snow lines of these volatiles (Oberg+11)

GOAL

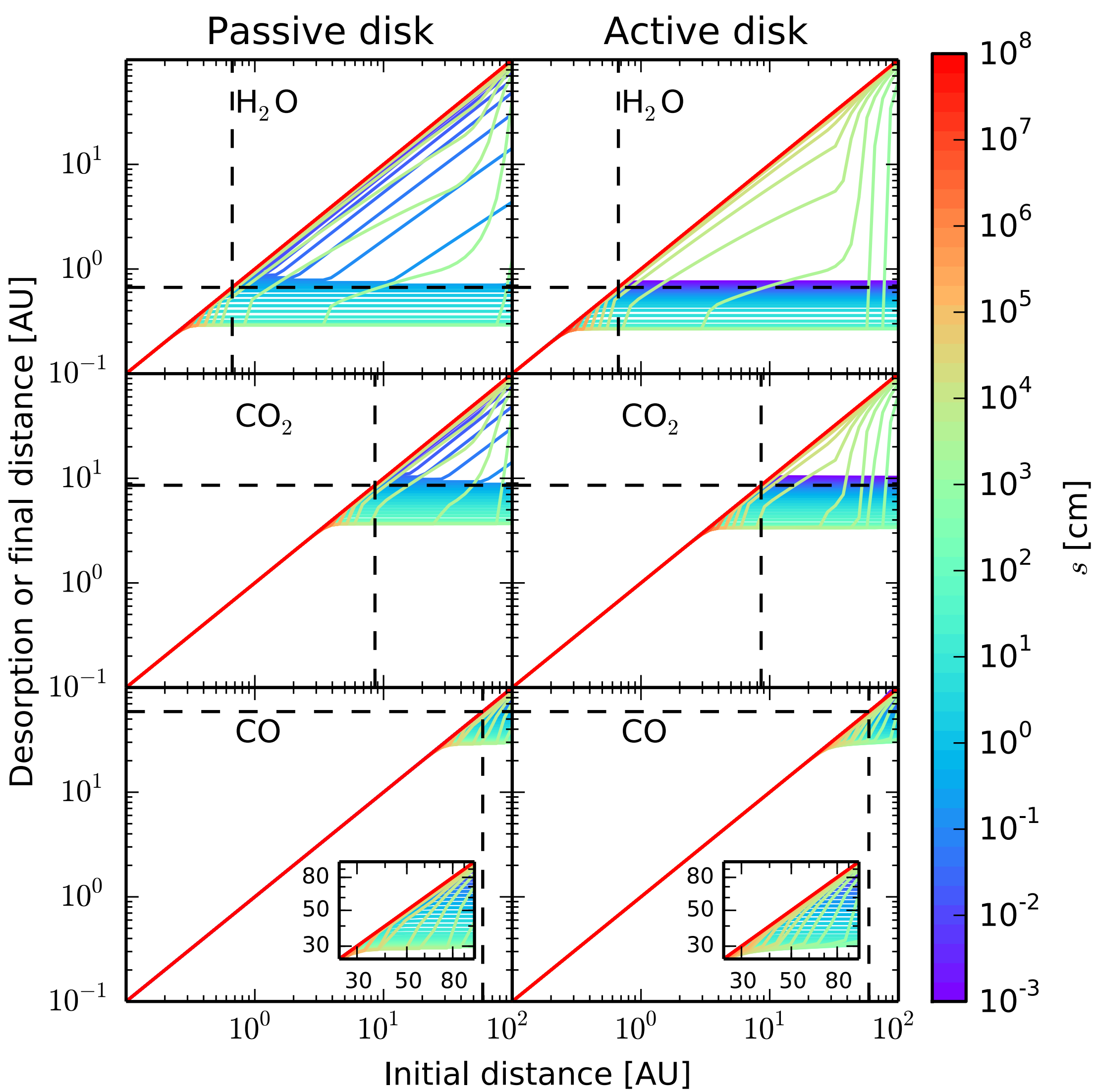
Understand how radial drift and gas accretion affect snowline locations, and thus the C/O ratio in gas and dust throughout the disk

Timescales for desorption, radial drift and gas accretion ARE comparable



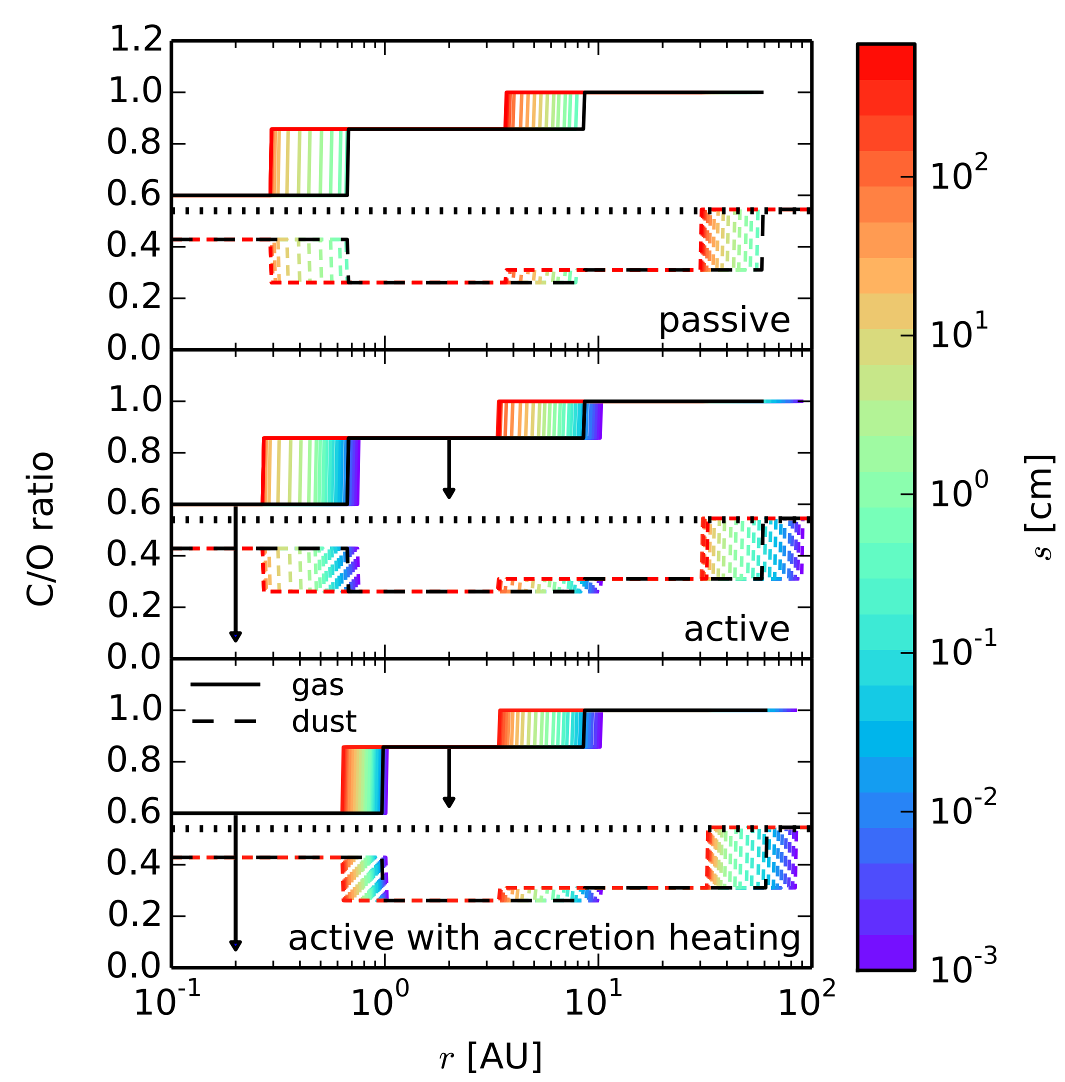
Piso, Oberg, Birnstiel, Murray-Clay (2015)

Radial drift affects snowline location



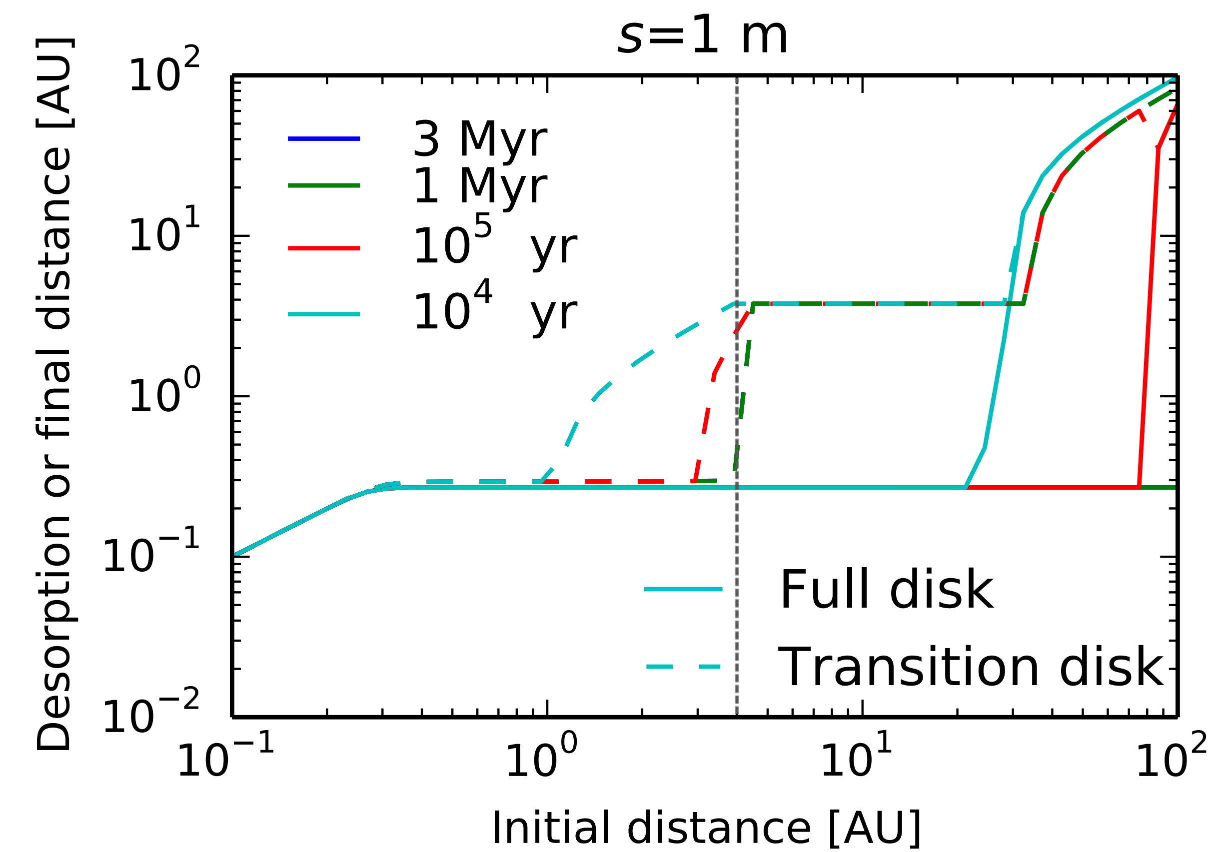
Piso, Oberg, Birnstiel, Murray-Clay (2015)

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



Piso, Oberg, Birnstiel, Murray-Clay (2015)

The desorption distance for transition disks agrees with observations



Piso, Oberg, Birnstiel, Murray-Clay (2015)

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* ~ 7 m
- Snowlines move inwards as the particle size increases
  - ~60% for H_2O
  - ~60% for CO_2
  - ~50% for CO
- Our results for a transition disk are consistent with observations

TAKEAWAY POINT

Radial drift and viscous gas accretion move the snowline locations inwards. This affects the C/O ratio in gas and dust throughout the disk, and thus has direct implications in shaping the compositions of nascent giant planets.