UNIVERSITY of CALIFORNIA
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THERMAL EVOLUTION OF URANUS WITH CONDENSATION-INHIBITED CONVECTION

A thesis submitted in partial satisfaction of the requirements for the degree of

BACHELOR OF SCIENCE

in

ASTROPHYSICS

by

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Abstract

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This will be the last section written, once we have finished our analysis.

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To Who,

the owl

Acknowledgements

I'd like to thank my attorney, Bob Loblaw

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Introduction

Observations of Uranus show a planet that appears to be in thermal equilibrium with the Sun. Observation has also shown that Uranus is cooler than its more distant neighbor, Neptune. Meanwhile, thermal evolution models for Uranus have not matched observation, instead predicting a warmer effective temperature during the current epoch(Fortney et al., 2011), (M. Podolak, 1991), (W.B. Hubbard, 1995), (L. Scheibe, 2019) [There are other papers by Nettelmann 2013, Linder 2019 that I haven't looked at yet].

There have been various attempts to model the underluminous Uranus. [how much should i go into work done with different EOS's?] The formation of stable layers, trapping internal energy in the the interior of Uranus and Neptune was proposed by (M. Podolak, 1991). Work on the formation of stable condensation zones, inhibiting convection, have been investigated by (Friedson & Gonzales, 2017), (Leconte et al., 2017), and (Guillot, 1995).

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Methodology

Include equations of state for interior structure, alpha, grad rad, etc..

$$\alpha = 1 + \xi(q_s L / R_W T_0) \tag{2.1}$$

$$T(P) = T_{\rm top} + \int_{P_{\rm top}}^{P} \left(\frac{dT}{dP}\right)_{\rm rad} dP \tag{2.2}$$

$$\left(\frac{dT}{dP}\right)_{\rm rad} = \frac{T}{P}\nabla_{\rm rad} = \frac{T}{P} \times \frac{3}{16}\frac{\kappa_R P}{g}\frac{T_{\rm int}^4}{T^4} \tag{2.3}$$

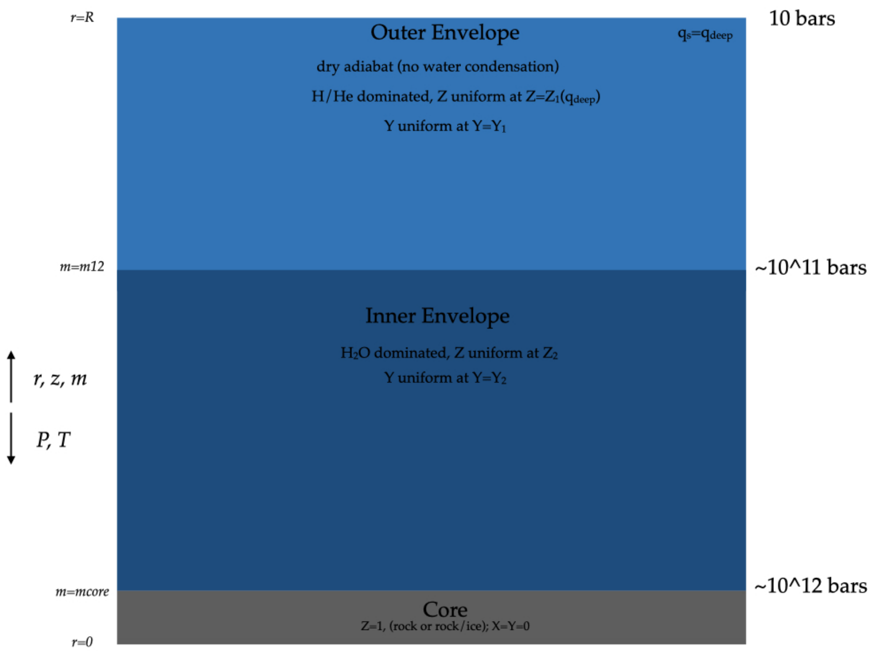
$$T_{\rm base} \equiv T(P + \Delta P) = T_{\rm top} + \left(\frac{dT}{dP}\right)_{\rm rad} \Delta P. \tag{2.4}$$

$$x_{\rm vap}(P,T) = x_{\rm vap}^{\rm sat}(P,T) = \frac{e_s(T)}{P}, \qquad P < P_{\rm base}. \tag{2.5}$$

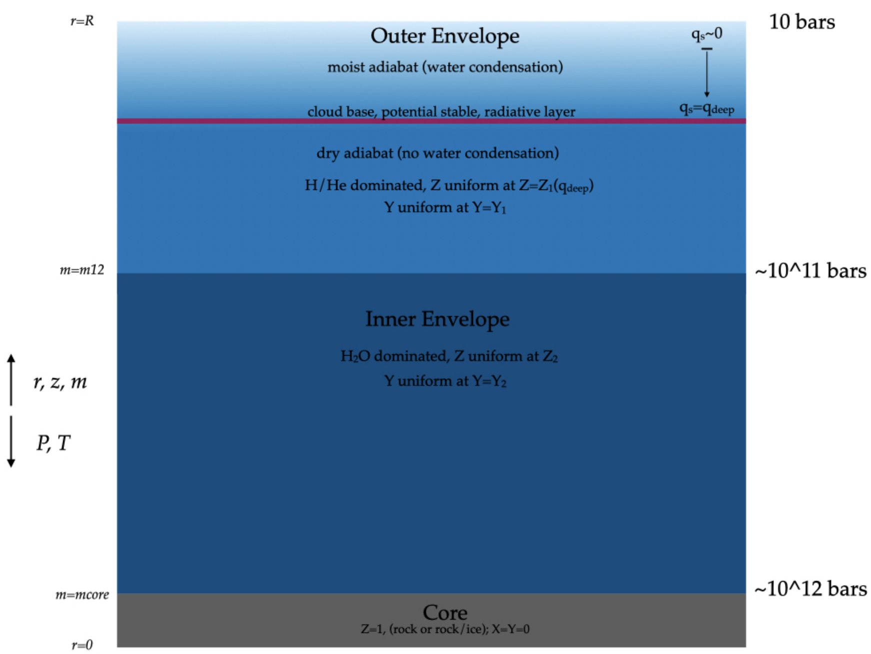
$$x_{\rm vap}^{\rm sat}(P_{\rm base}, T_{\rm base}) = \frac{e_s(T_{\rm base})}{P_{\rm base}} = x_{\rm vap}^{\rm deep} \Longrightarrow \Delta P \equiv P_{\rm base} - P_{\rm top} = \frac{e_s(T_{\rm base})}{x_{\rm vap}^{\rm deep}} - P_{\rm top} \tag{2.6}$$

$$T_{\text{base}} = T_{\text{top}} + \left(\frac{dT}{dP}\right)_{\text{rad}} \left(\frac{e_s(T_{\text{base}})}{x_{\text{vap}}^{\text{deep}}} - P_{\text{top}}\right) \tag{2.7}$$

$$T(P > P_{\text{base}}) = T_{\text{base}} + \int_{P_{\text{base}}}^{P} \left(\frac{dT}{dP}\right)_{\text{ad}} dP. \tag{2.8}$$



(a) The interiror structure for dry adiabat. This can also represent the situation in which the water condensation zone has eroded and the interior becomes fully convective.



(b) The interior structure when a condensation zone has formed, creating a potentially stable, radiative layer. This represents the cloud base. It's depth decreases with a decrease in T_{10}.

Figure 2.1: Interior structure model for Uranus

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Results

3.1 Condensation-inhibited Convection

Talk about Figure 3.1.

3.2 Formation of Radiative Layer

Talk about Figure 3.2.

3.3 Thermal Evolution

Talk about Figure 3.3.

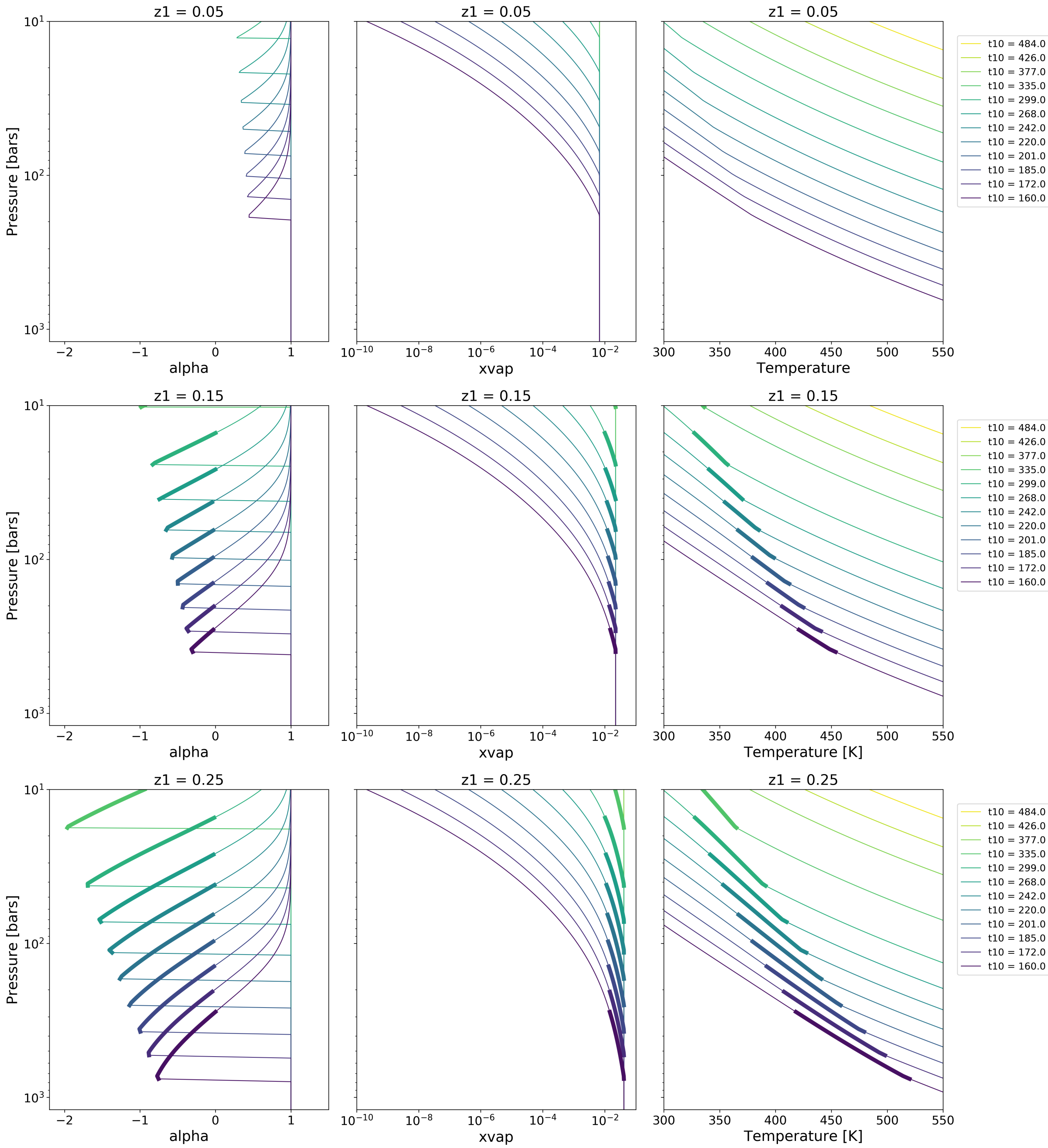

Figure 3.1: Need to add text here

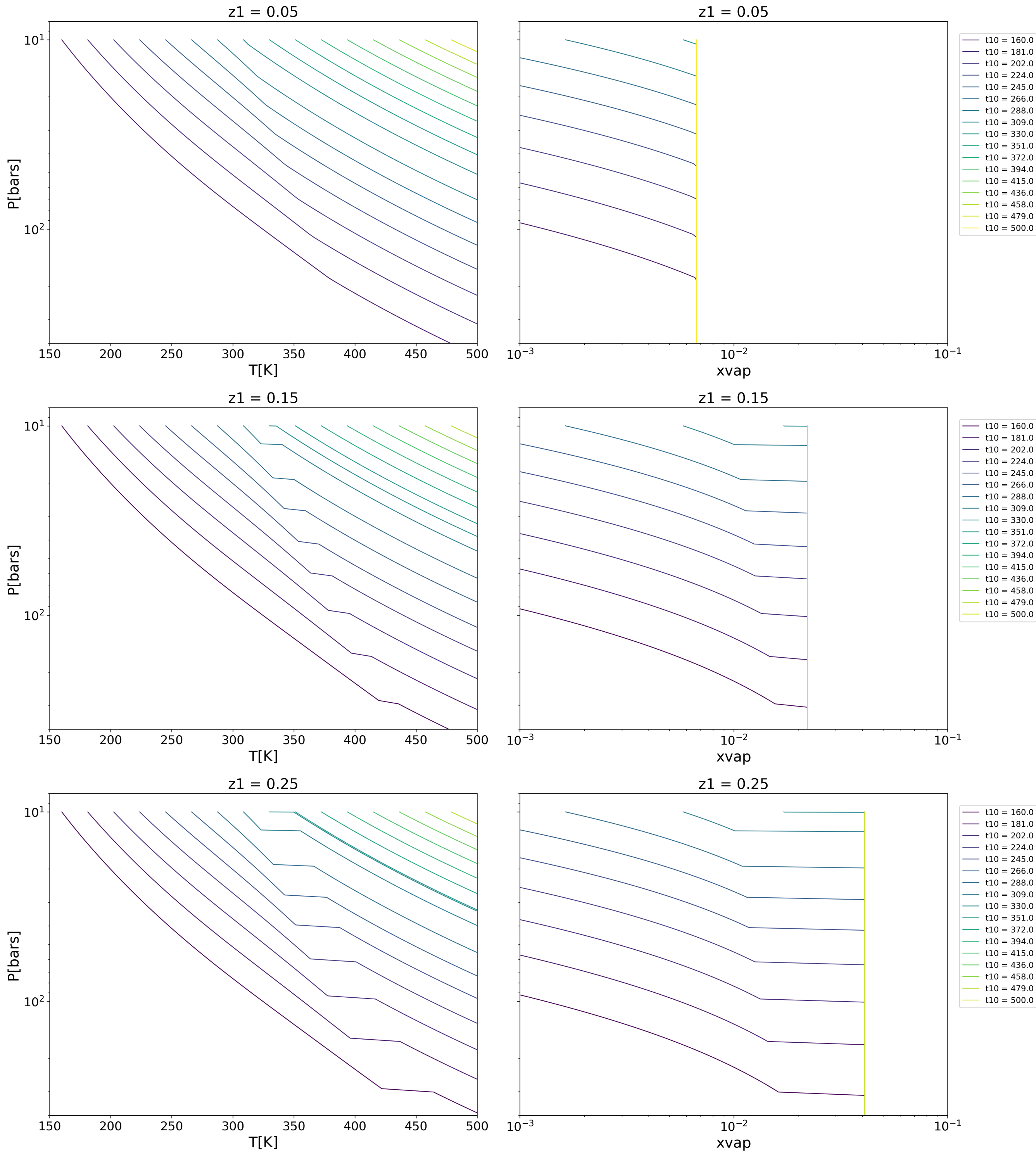

Figure 3.2: Need to add description here

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Discussion and Conclusions

Appendix A

Some Ancillary Stuff

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