

Cloud Physics on Exoplanets: Insights from JWST Observations

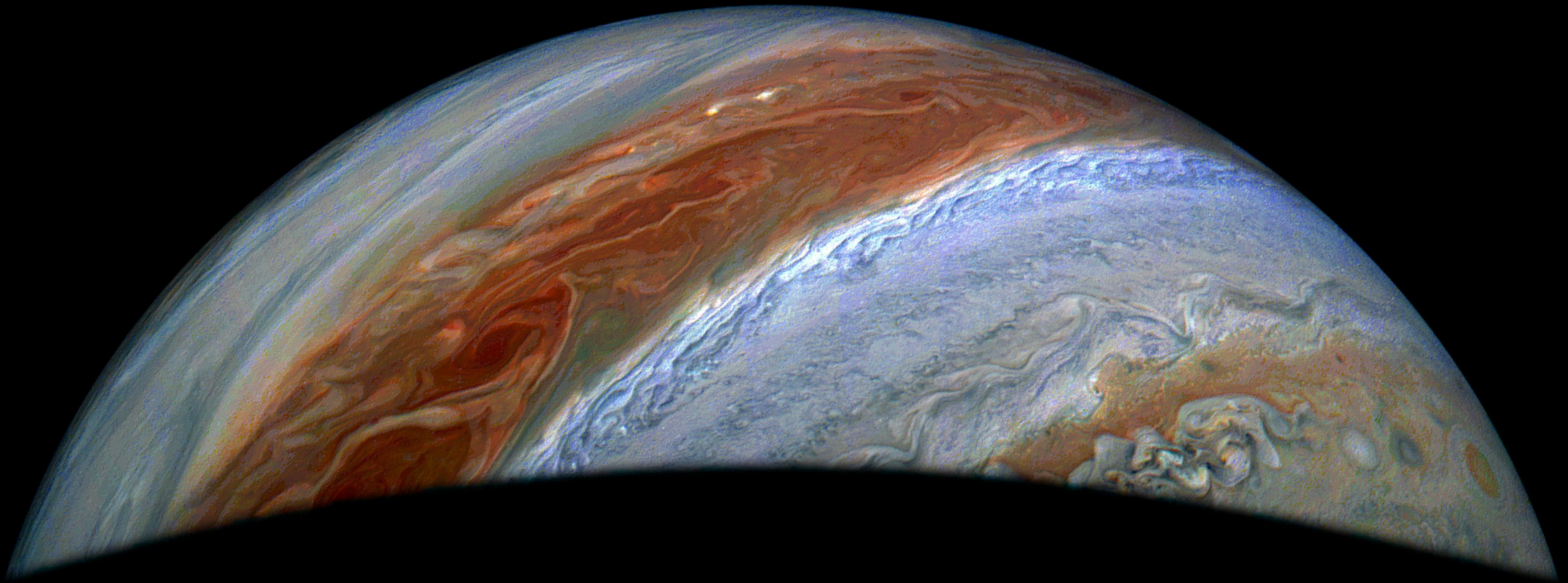
Sven Kiefer

Caroline Morley, Melanie Rowland

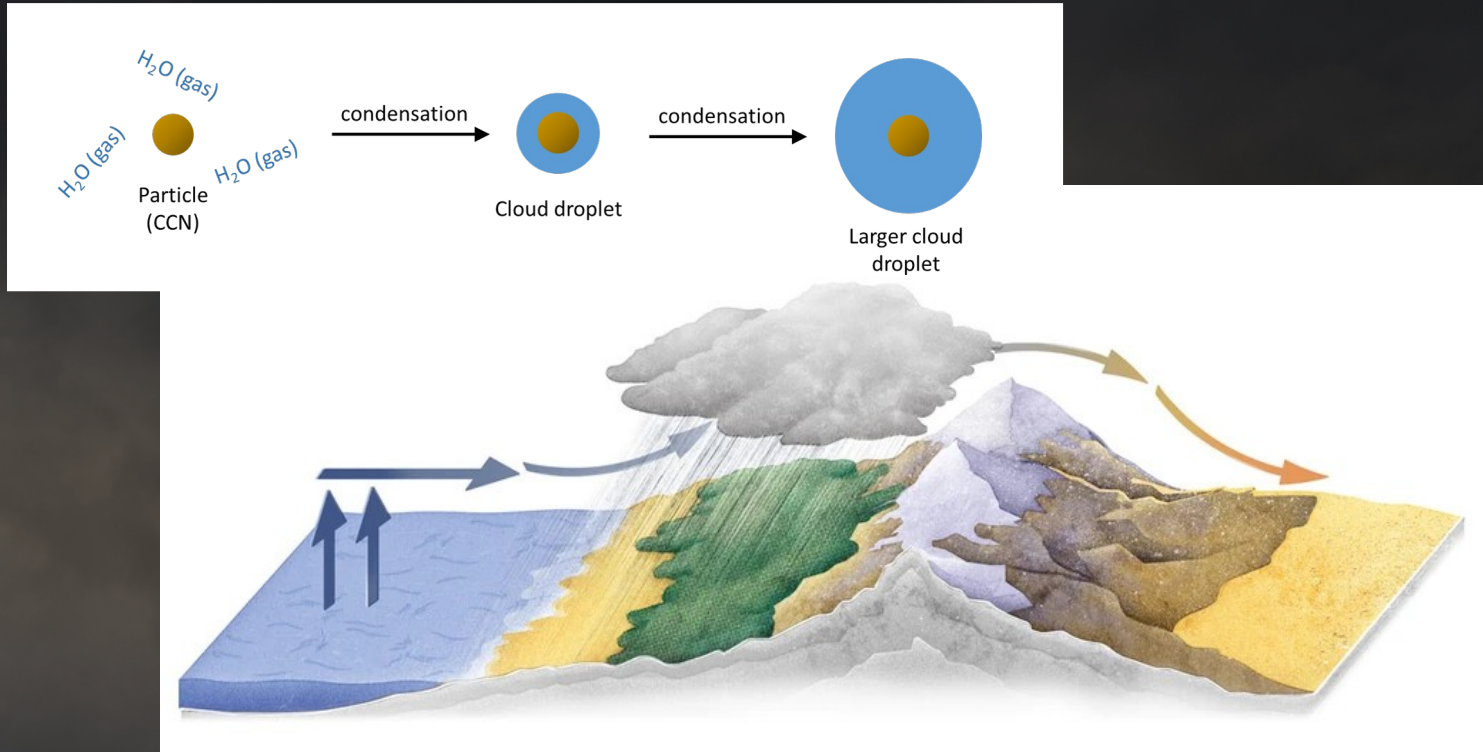


The University of Texas at Austin
Department of Astronomy

How Do Clouds Form on Planets?

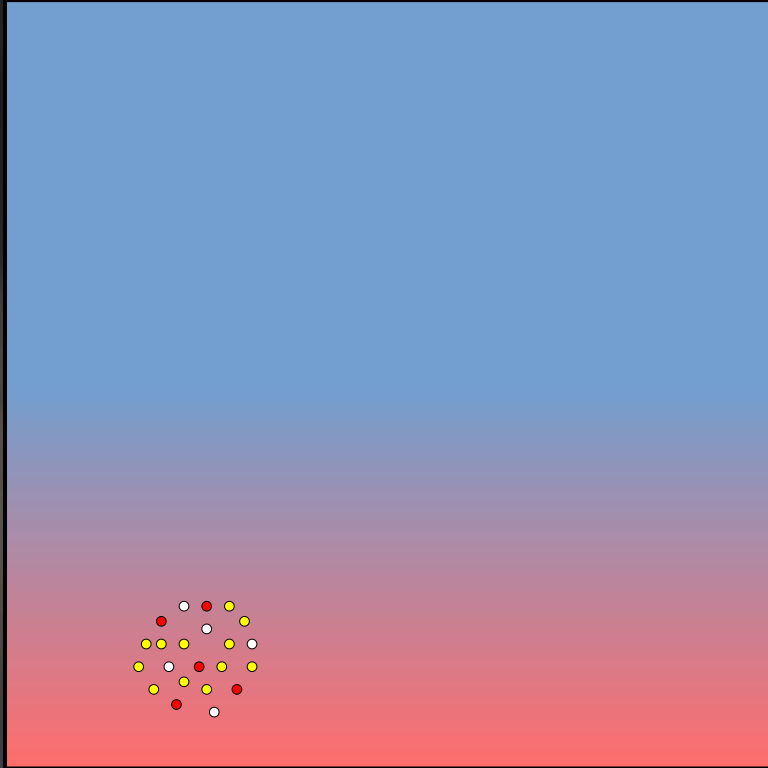


How do clouds form on terrestrial planets?



Top Image: Aerosols Department Of Physics And Astronomy Uppsala
Bottom Image: BBC science focus, Alexandra Franklin-Cheung

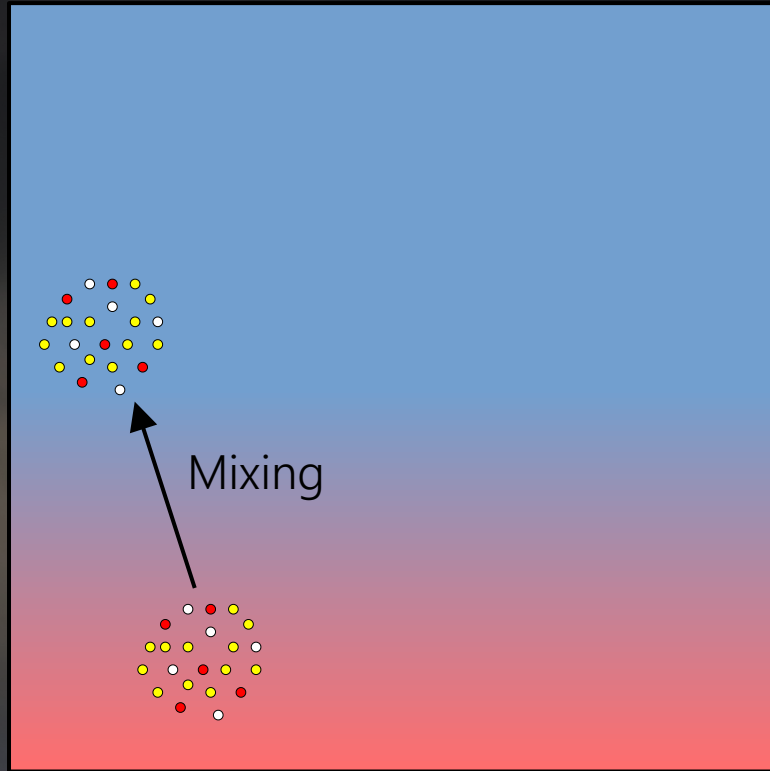
How do clouds form in gas giants?



Cloud formation cycle:

- Transport via mixing and settling
- CCNs have to form via nucleation
- Other materials grow onto CCNs

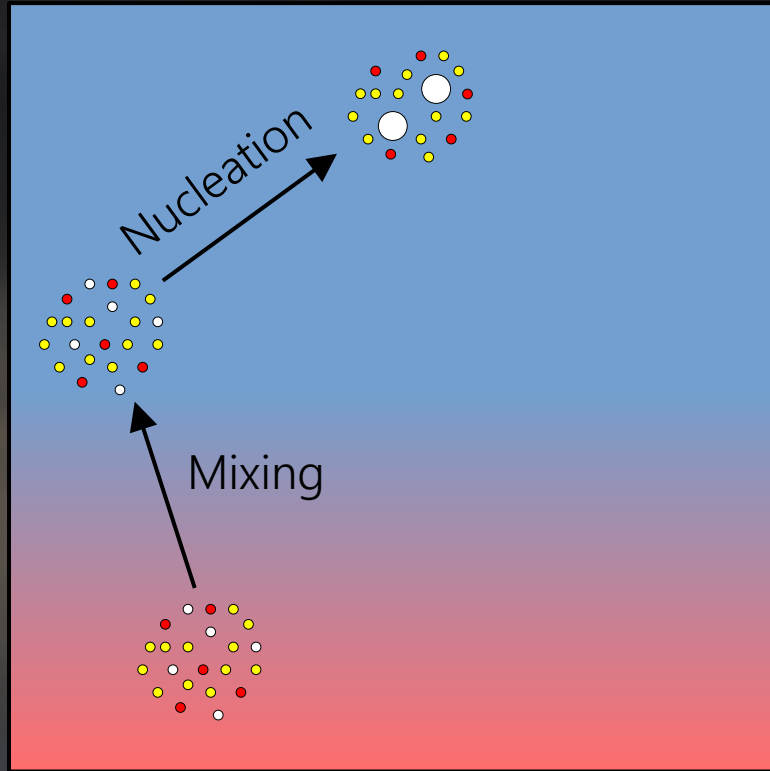
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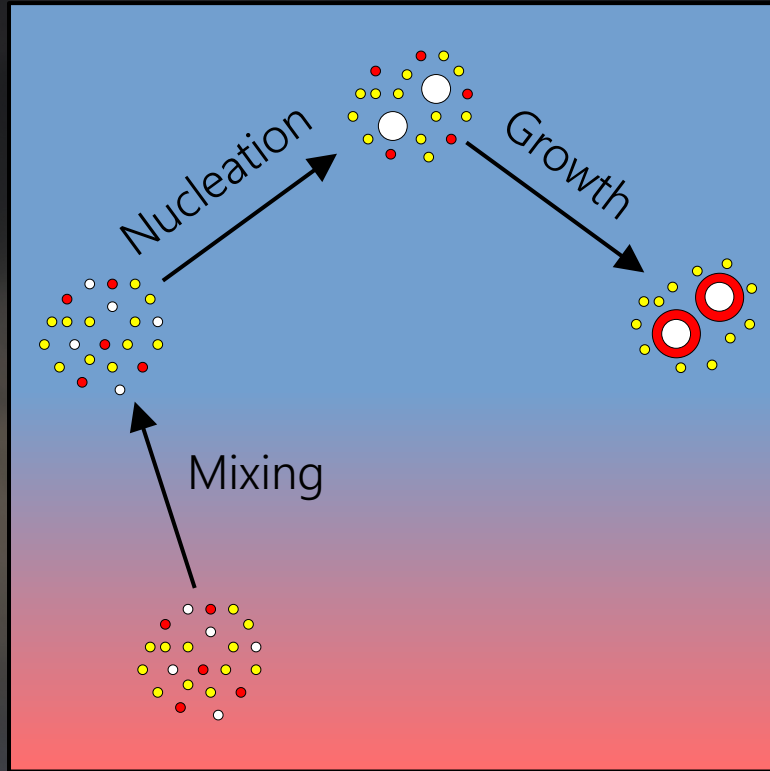
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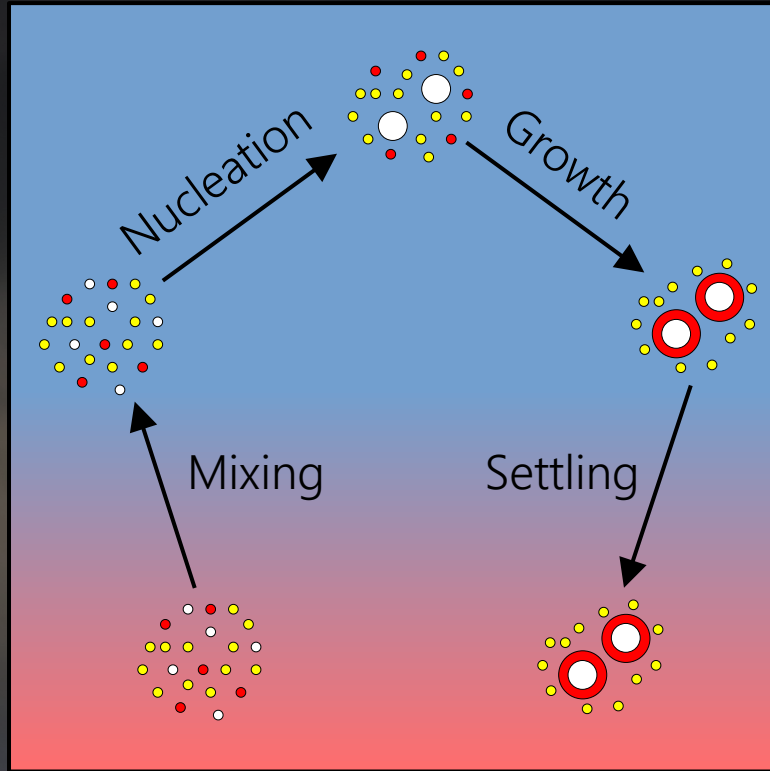
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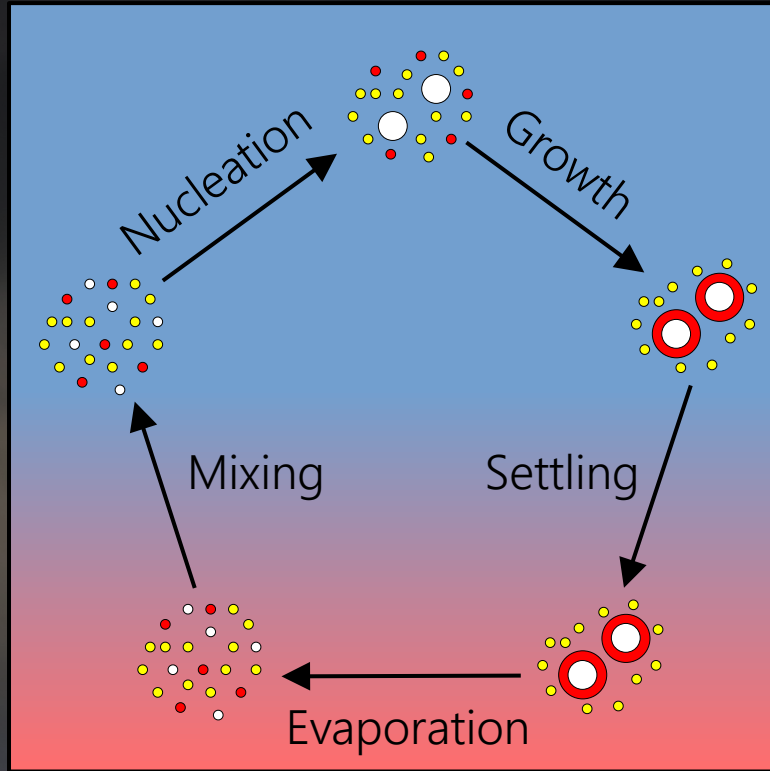
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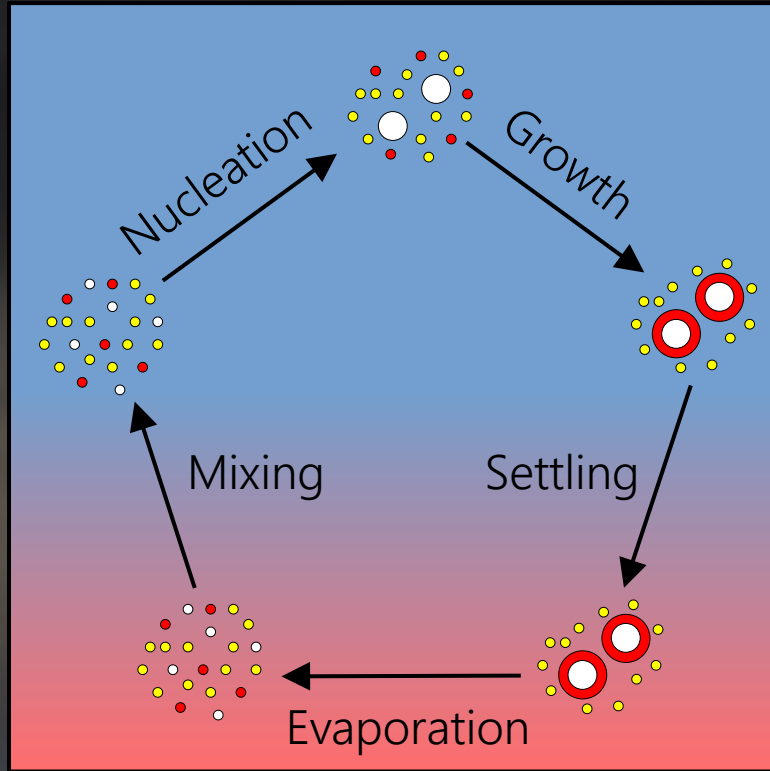
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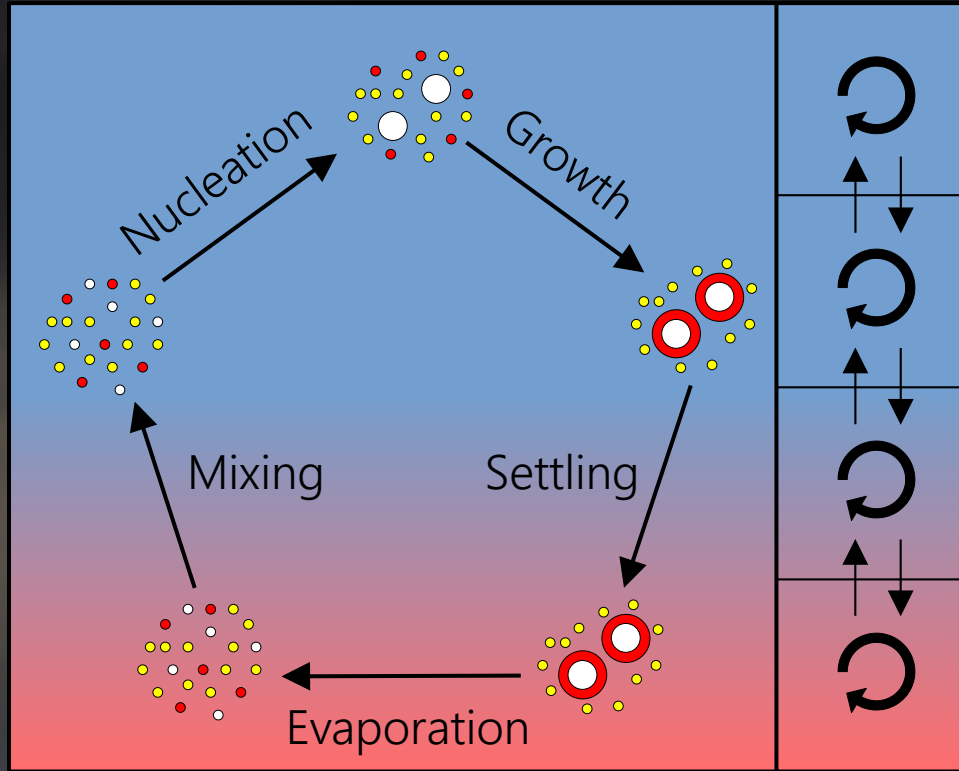
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Special for exoplanets:

- Cloud are made from rocks!
- SiO , SiO_2 , MgSiO_3 , Mg_2SiO_4

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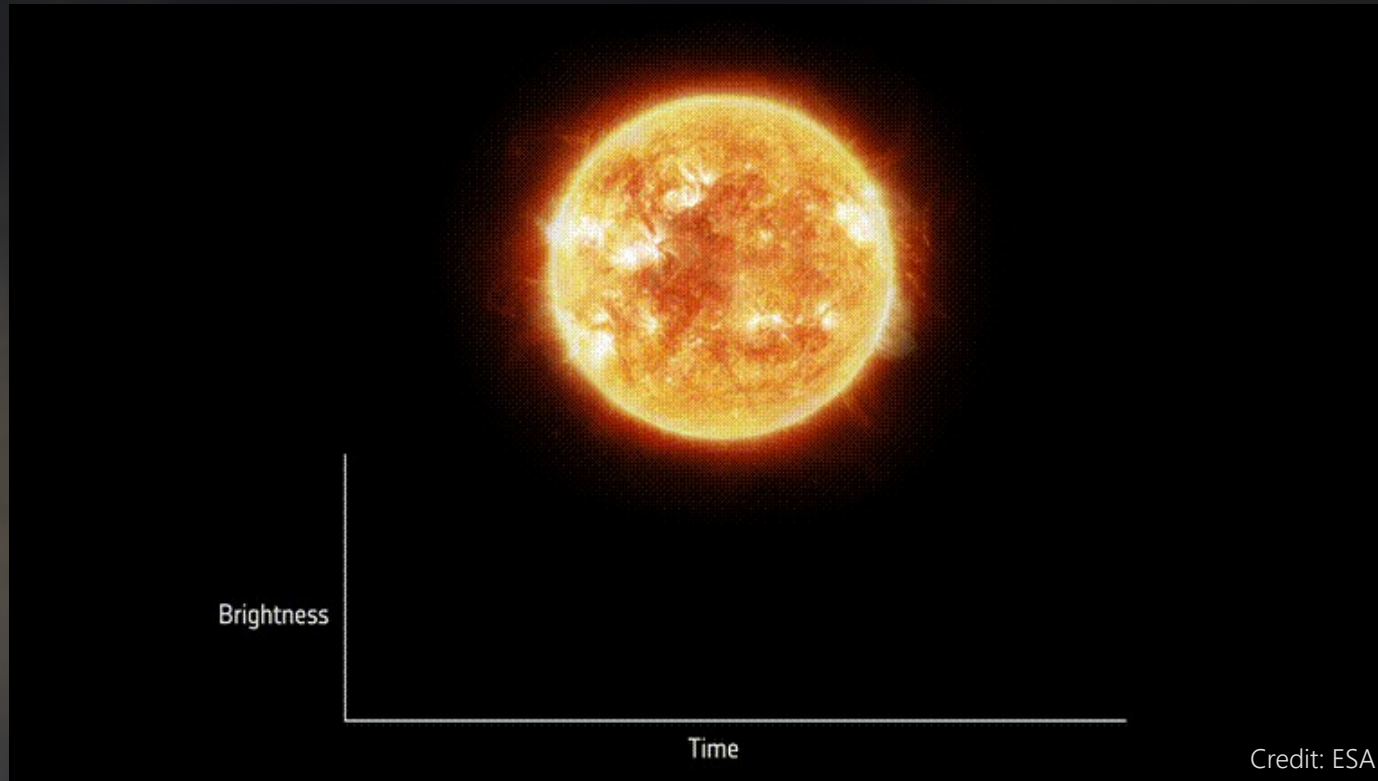
Cloud models:

- Balance of mass transport
- Nucleation and growth

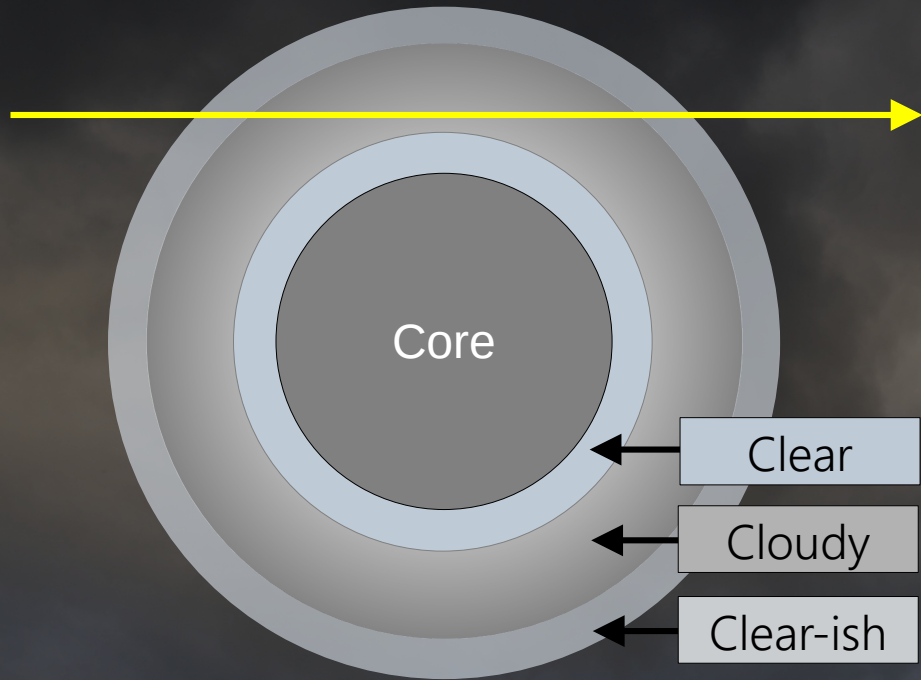


How Do We Probe Exoplanet Atmospheres?

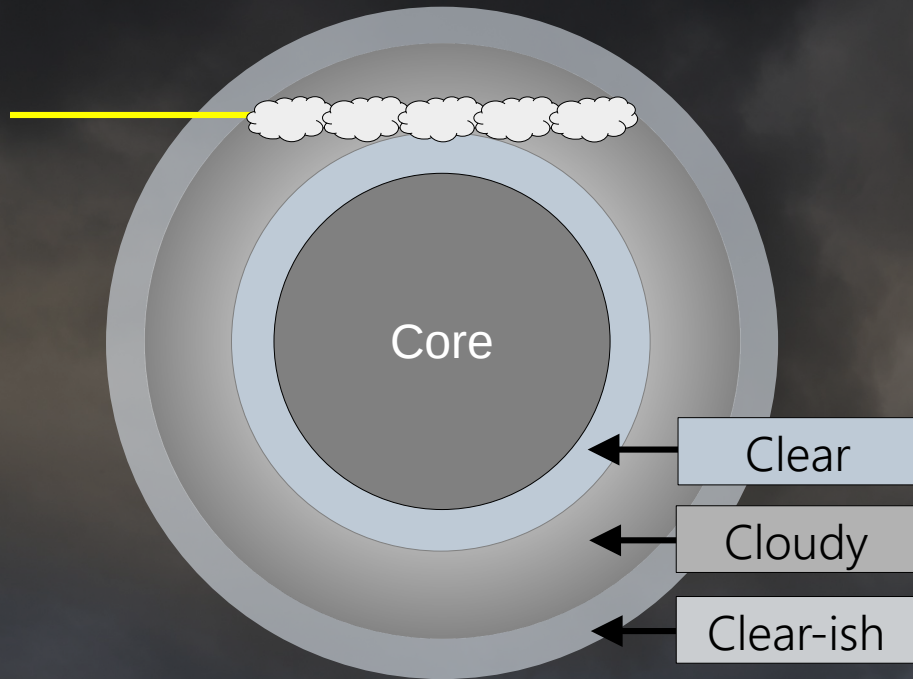
Cloud structures – Transmission spectra



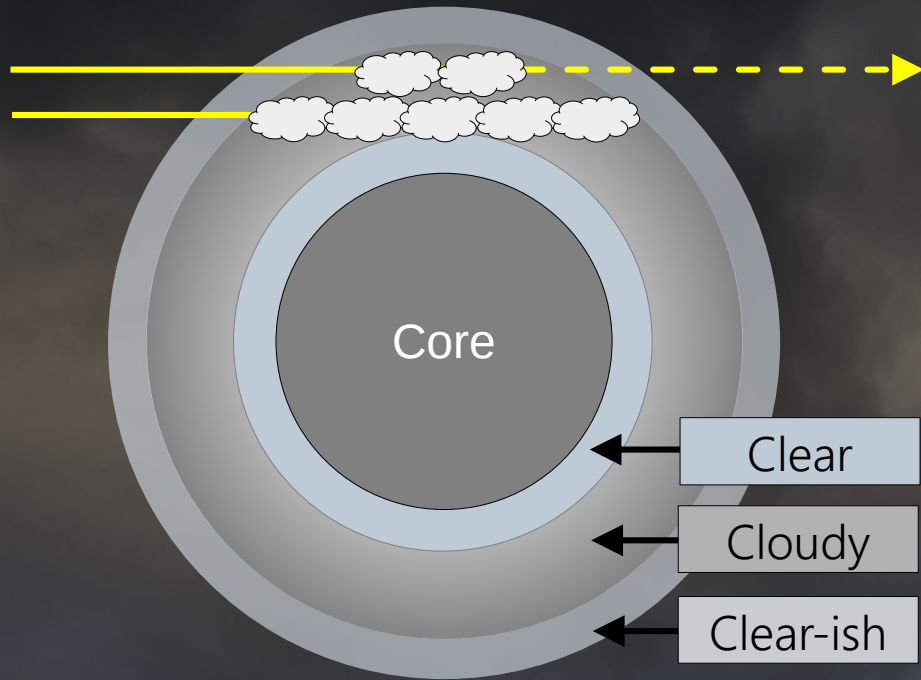
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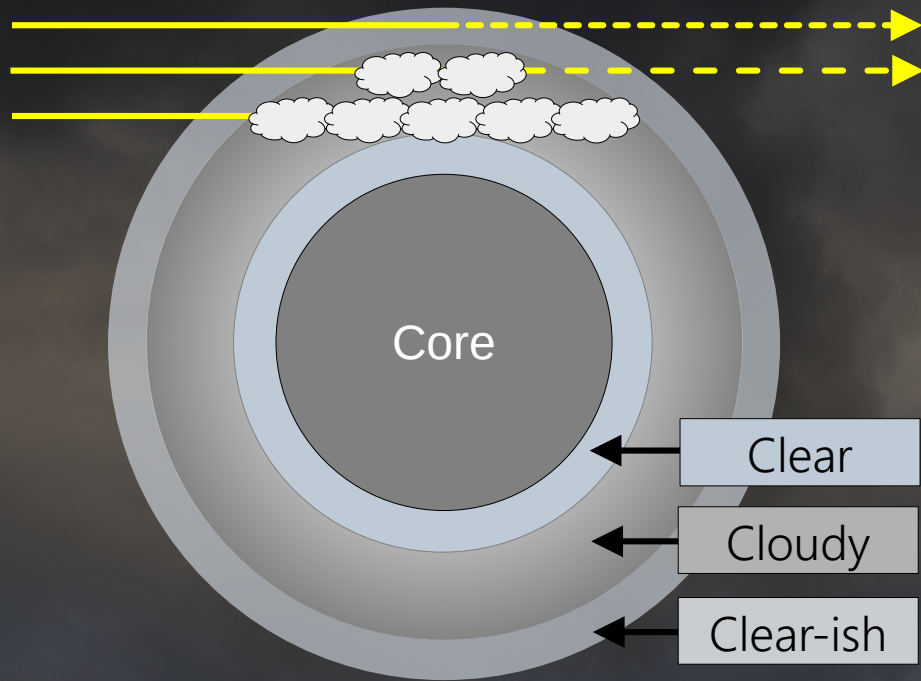
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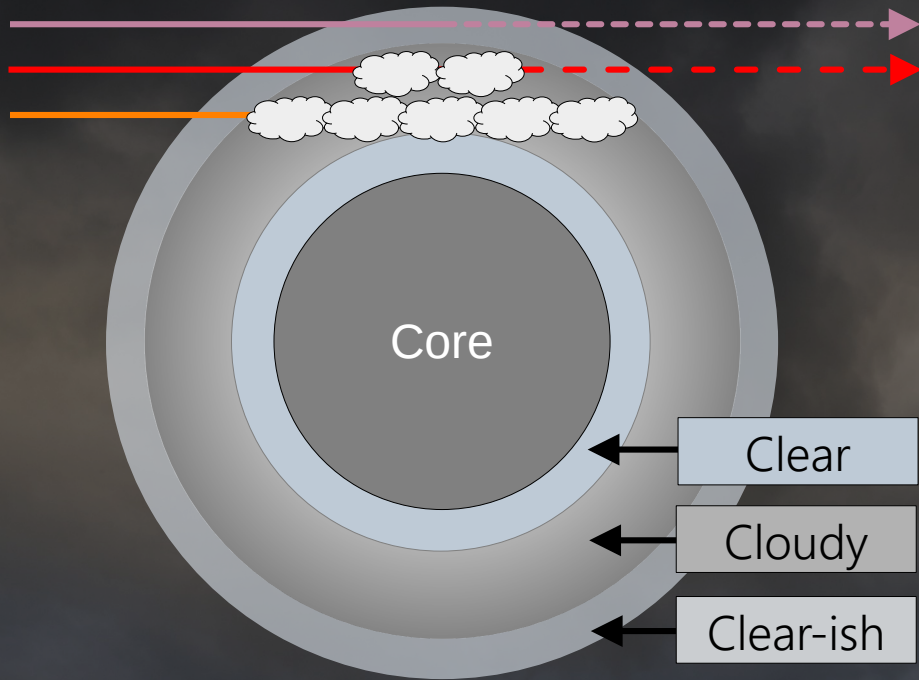
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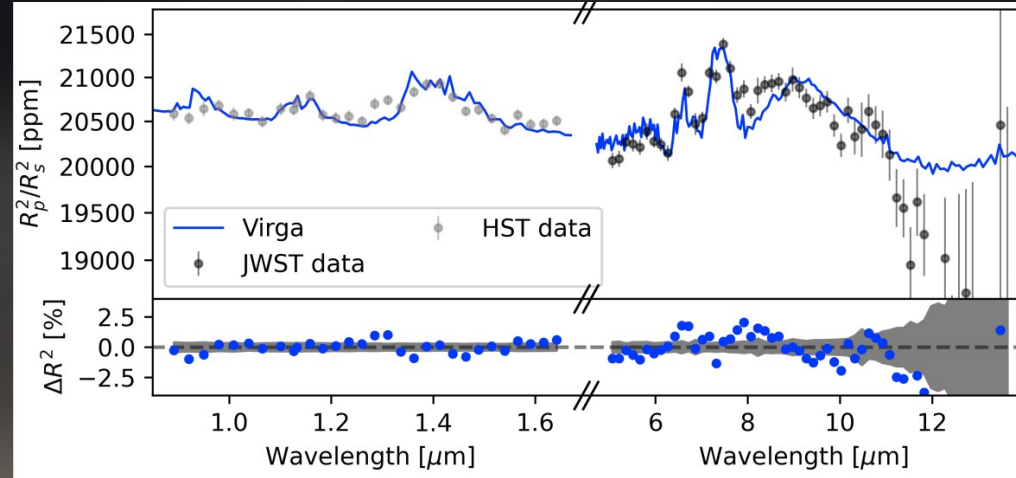
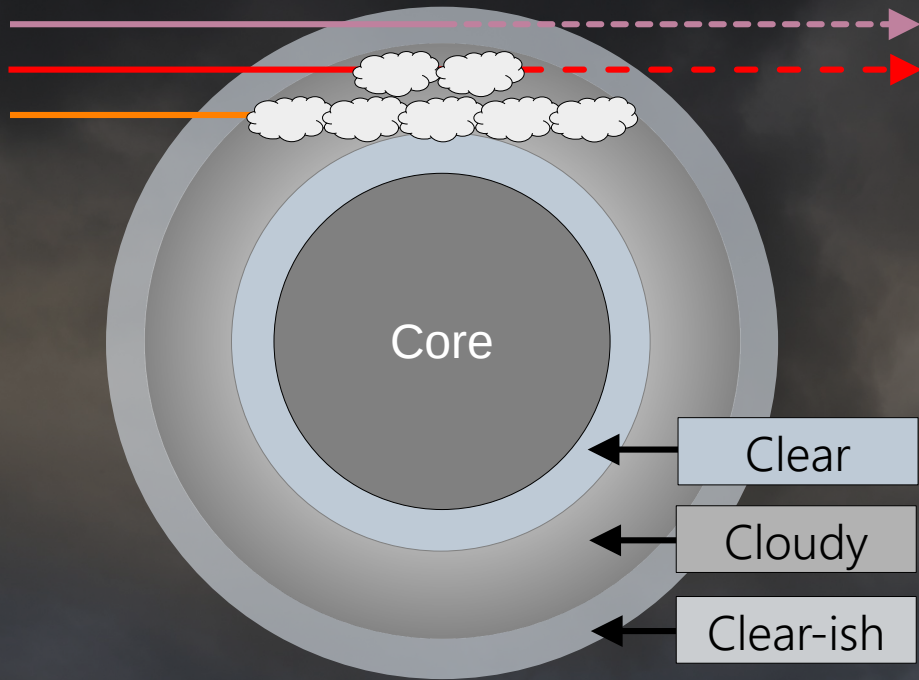


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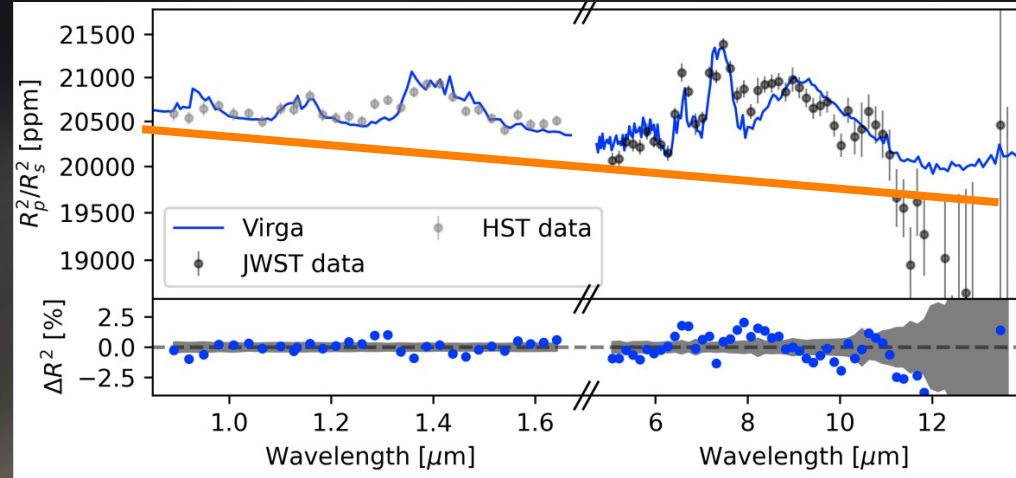
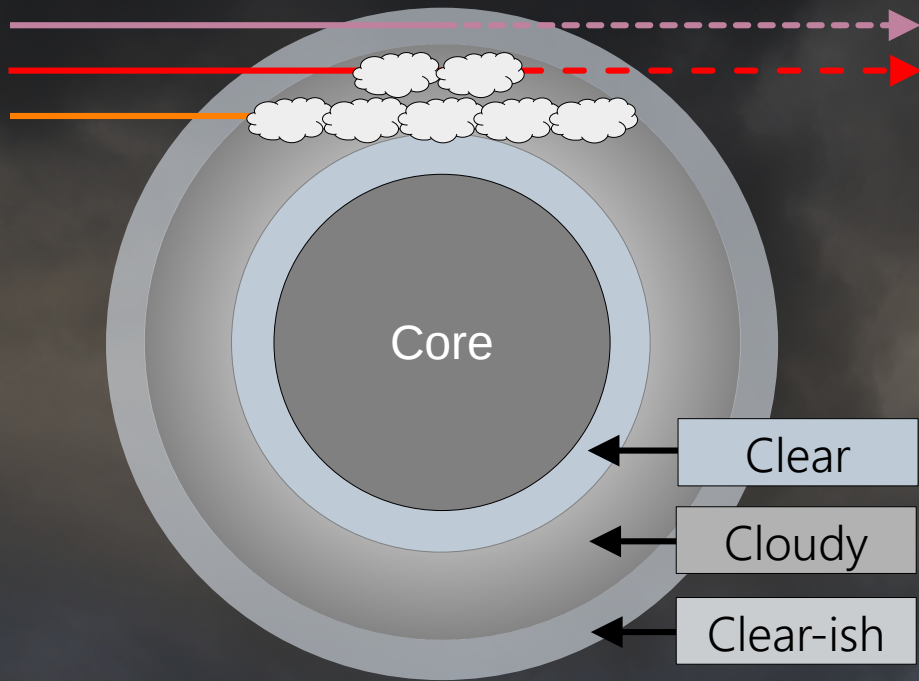
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Planet:
WASP 107 b



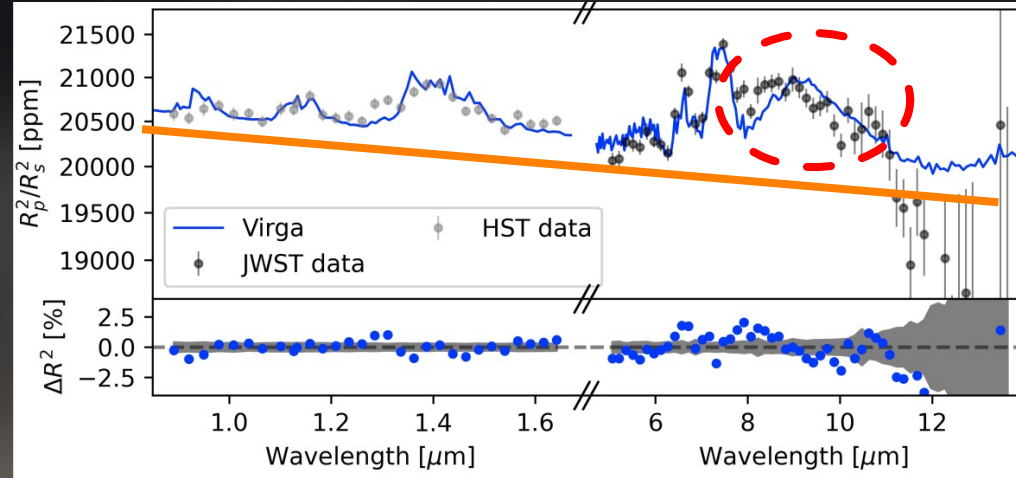
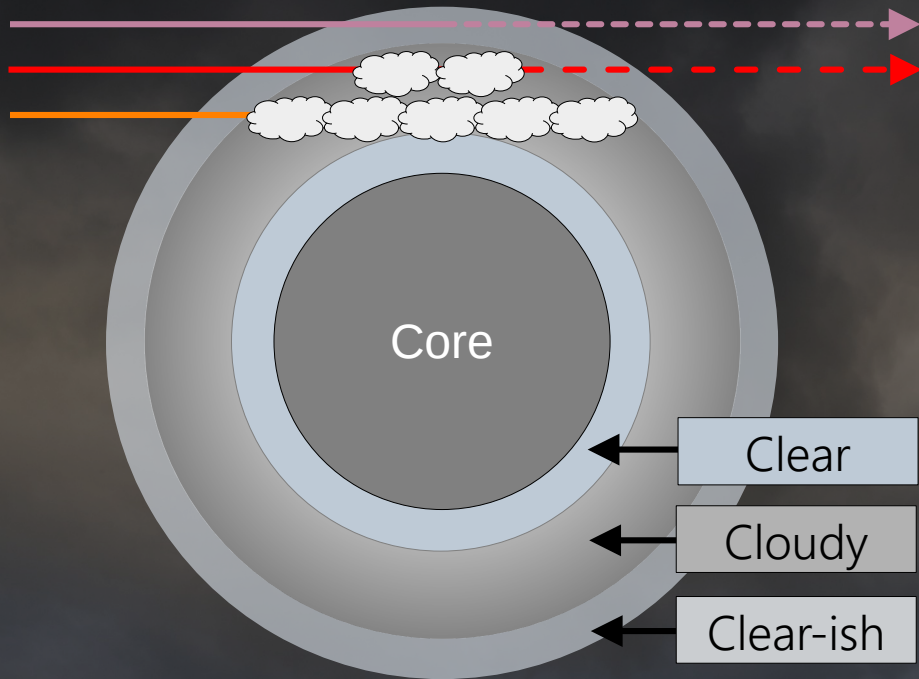
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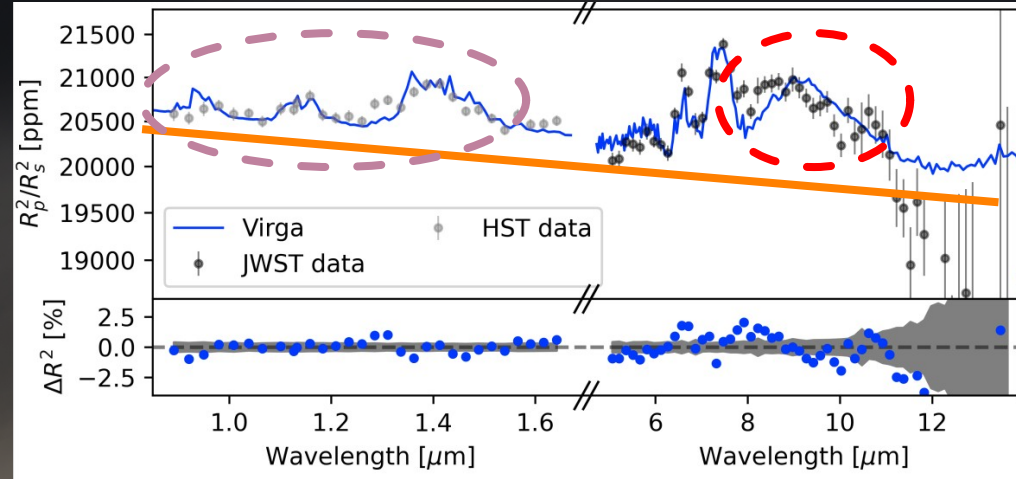
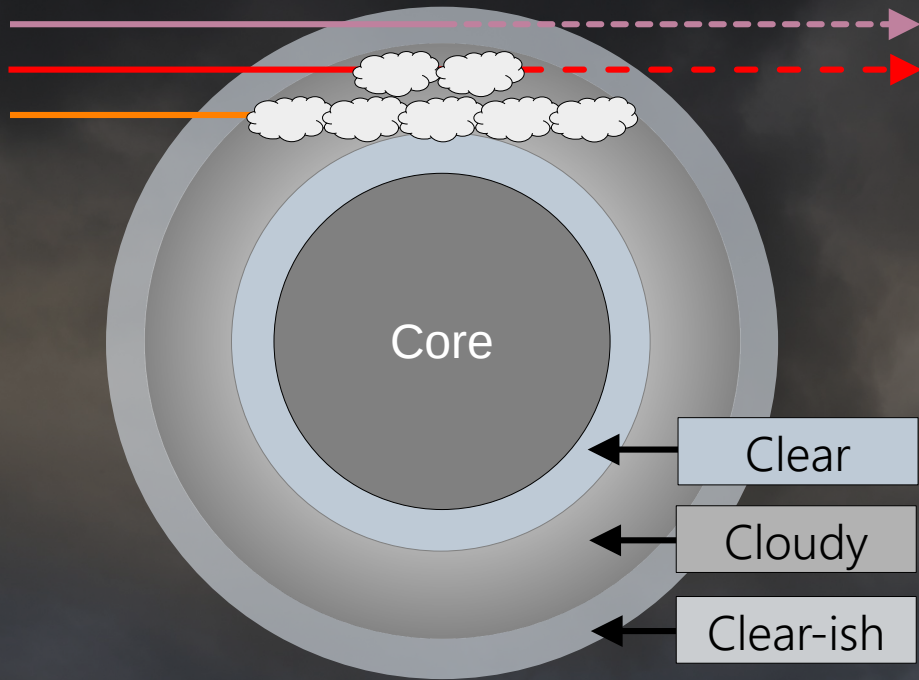
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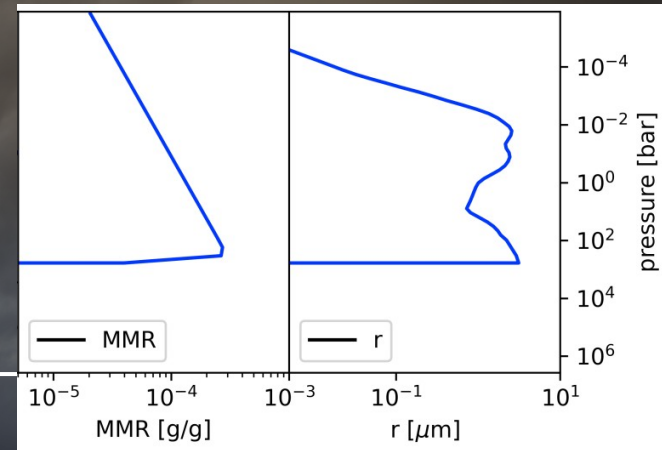
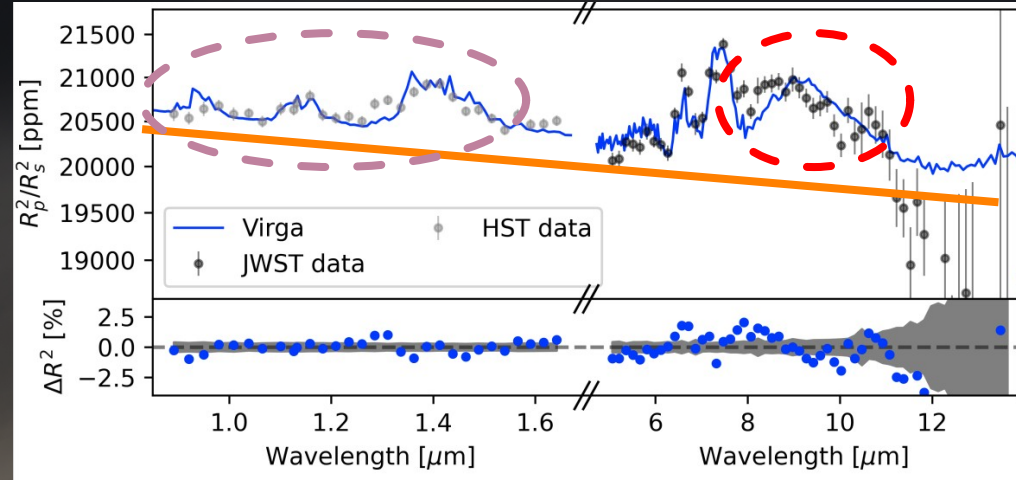
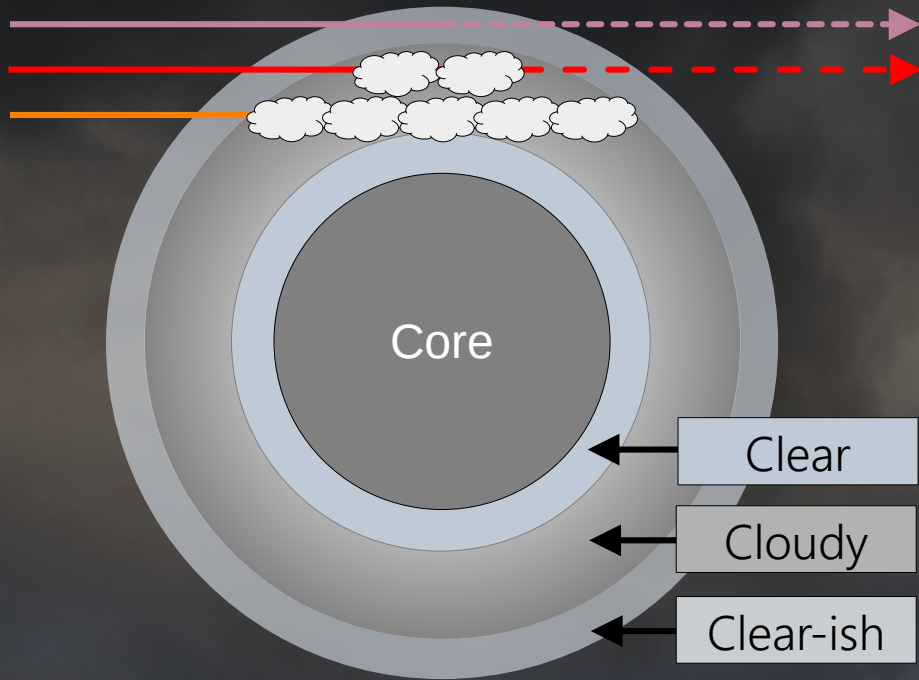
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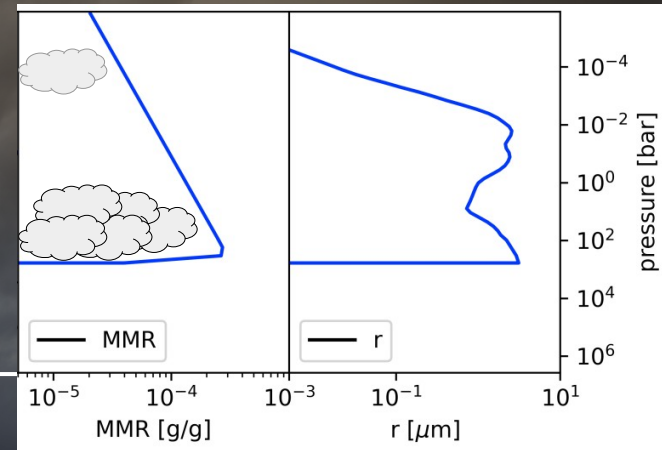
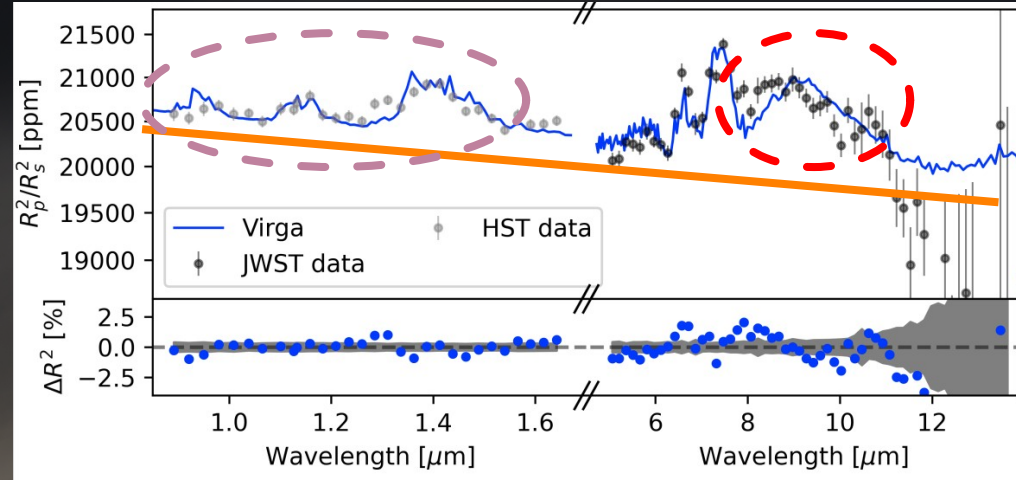
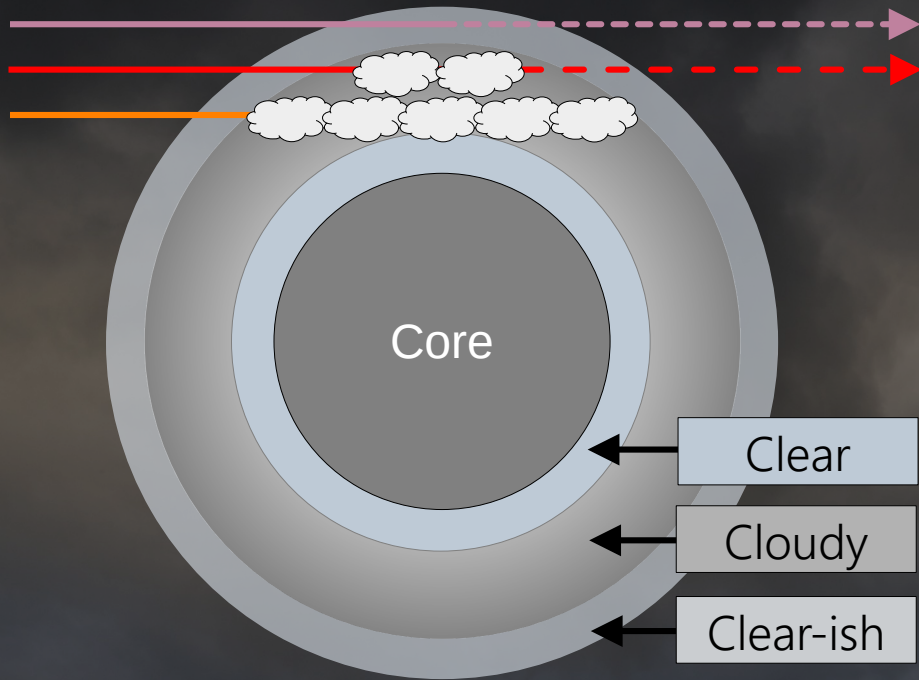
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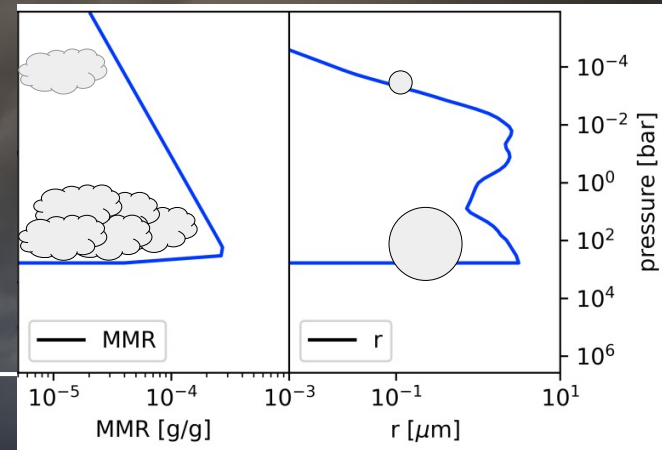
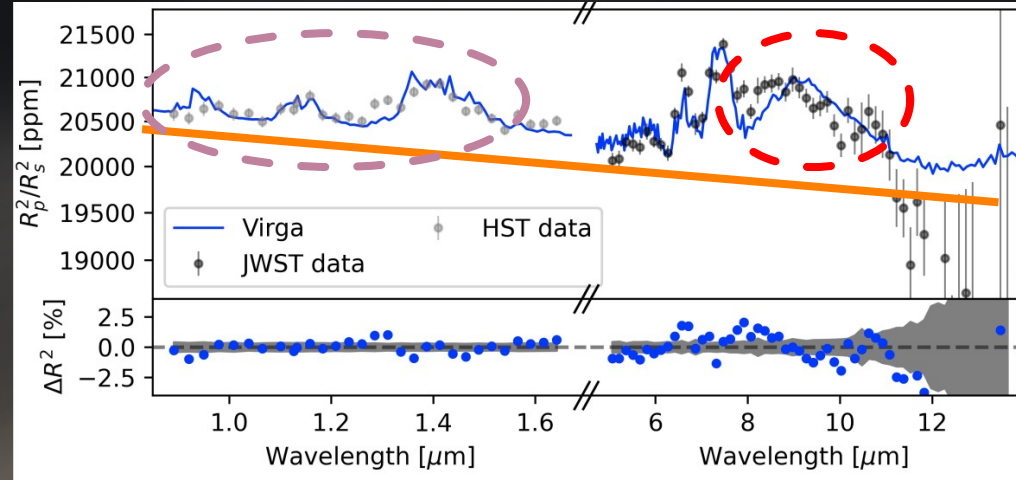
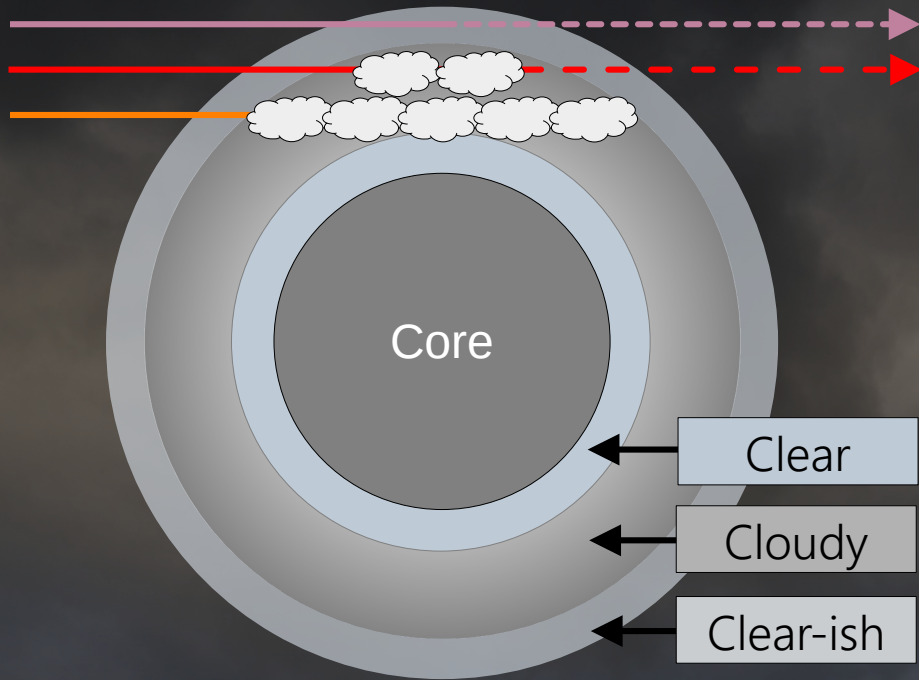
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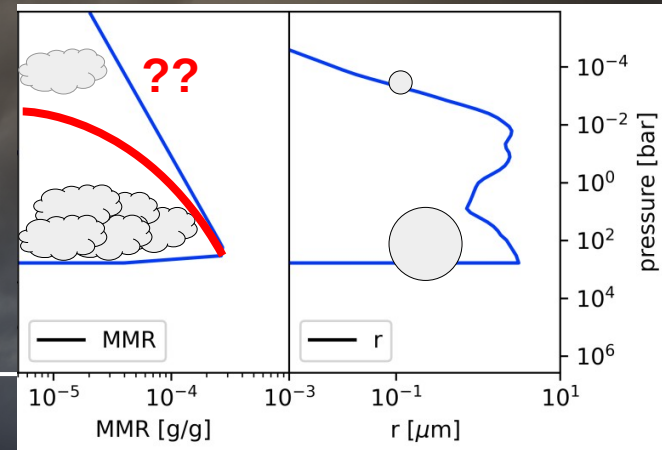
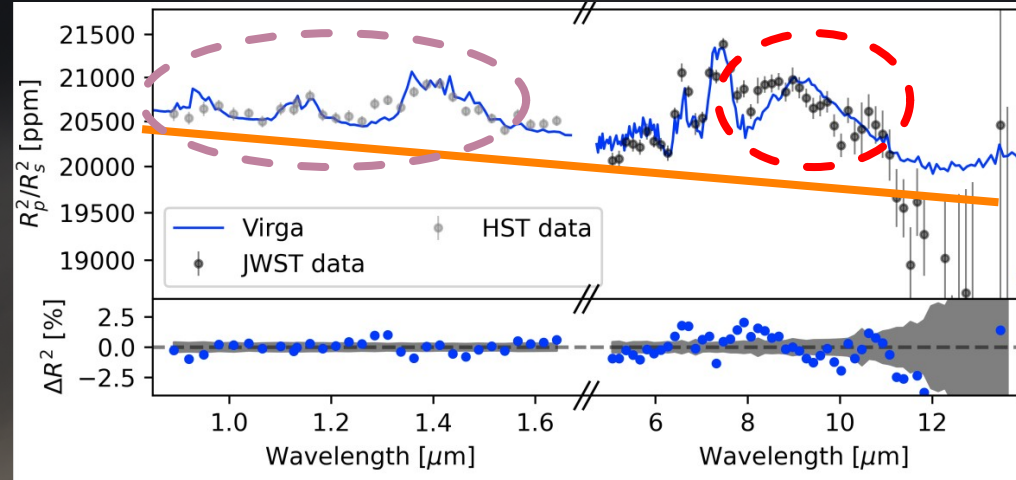
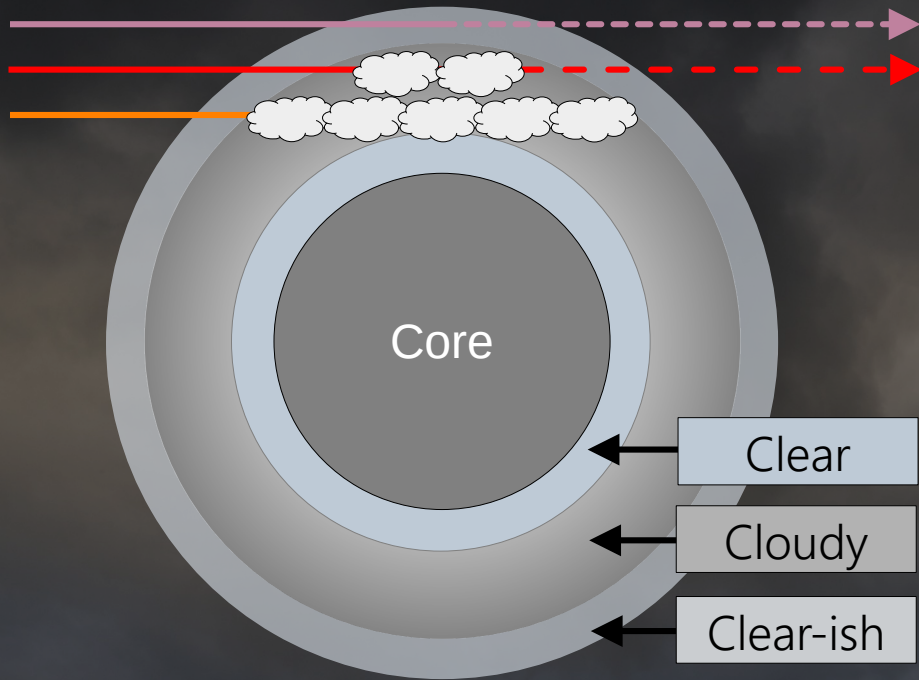
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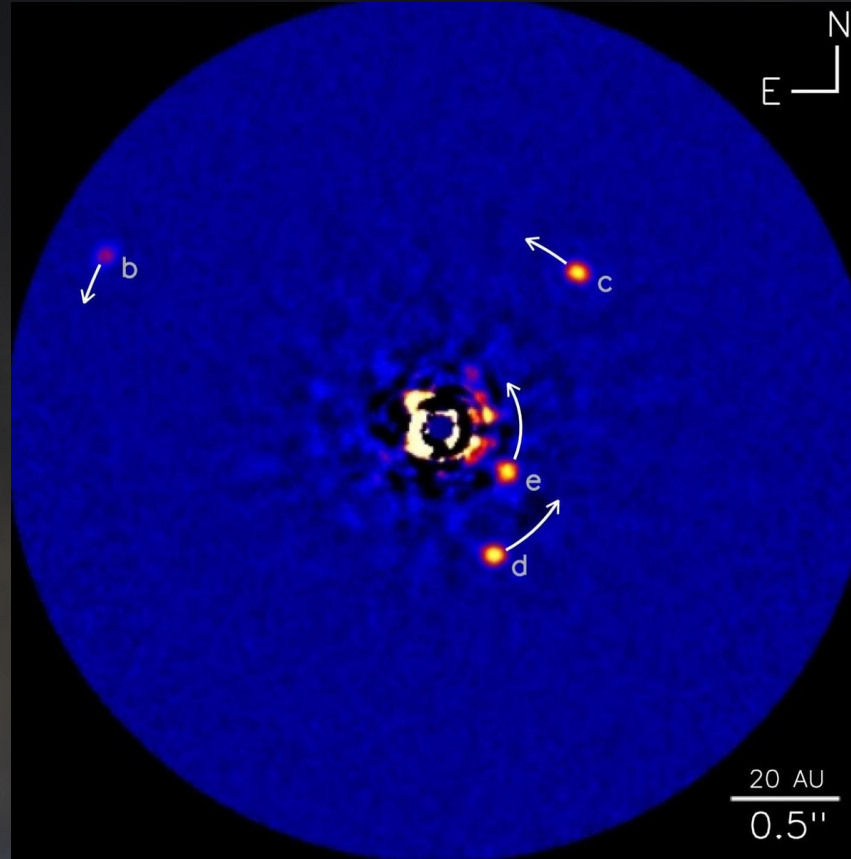


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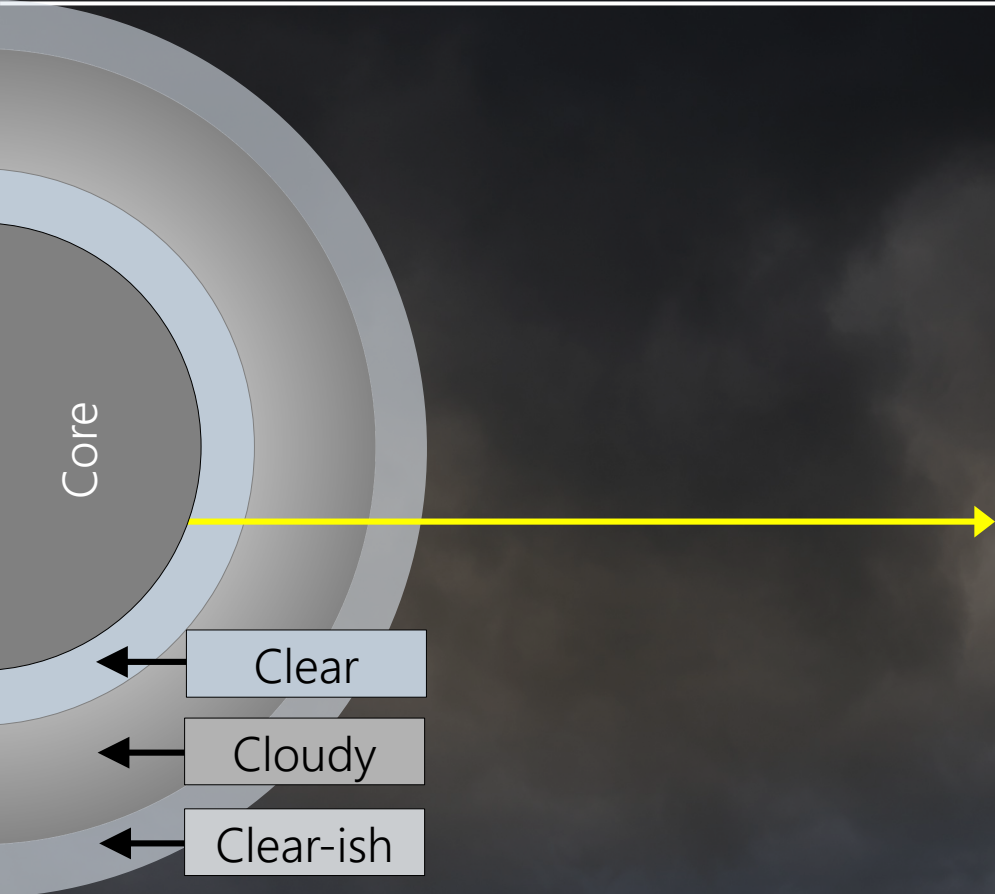


Cloud structures – Thermal emission spectra

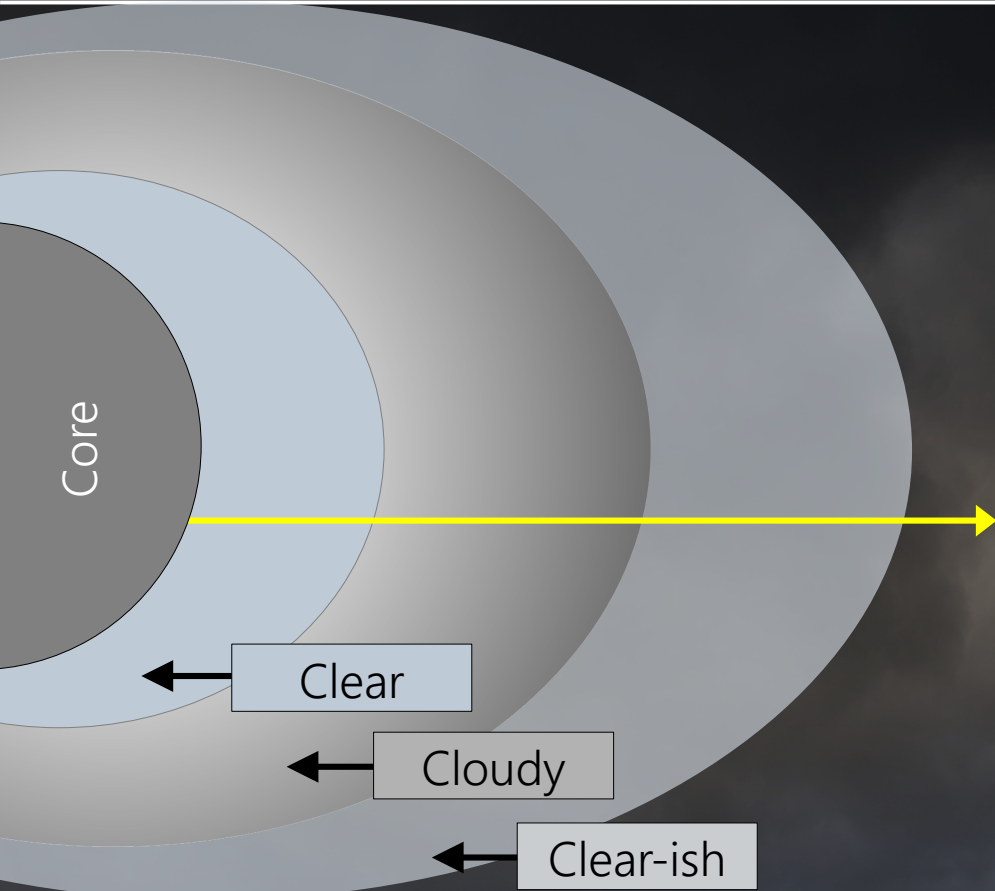


NRC-HIA, C. Marois, and Keck Observatory

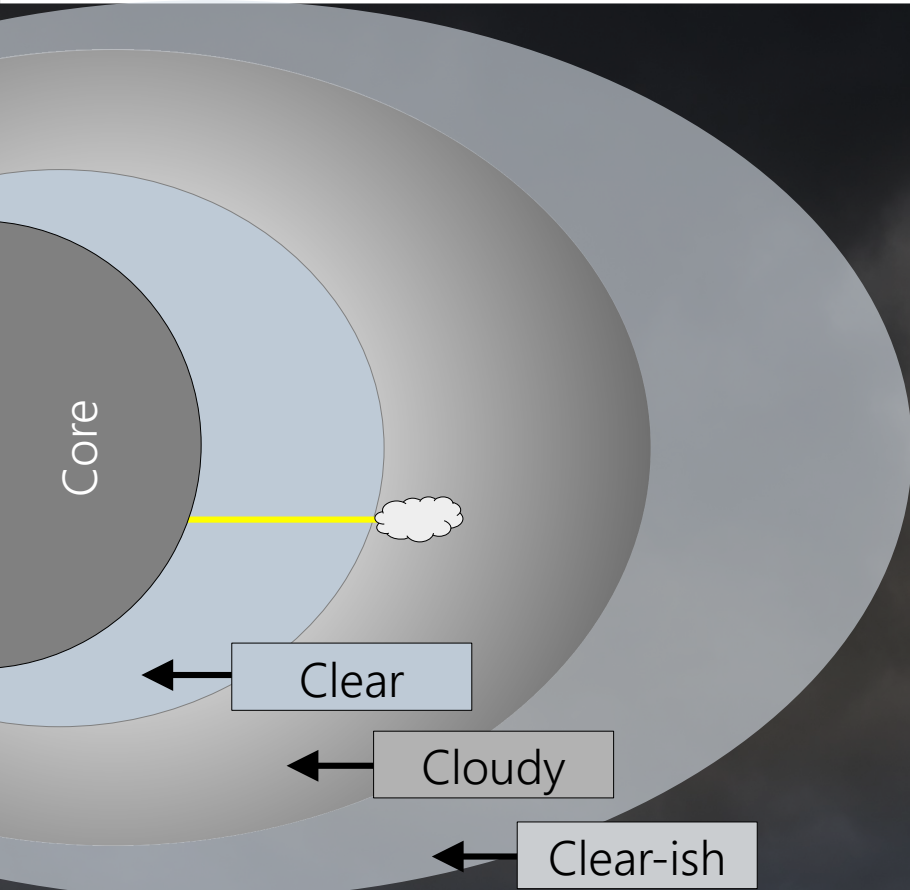
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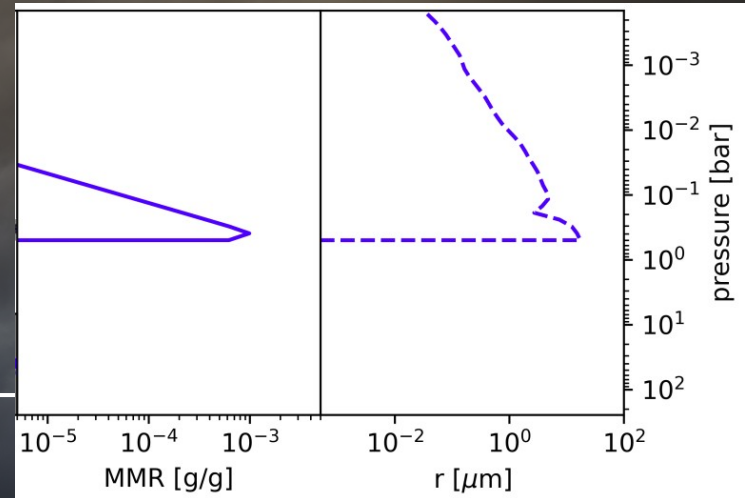
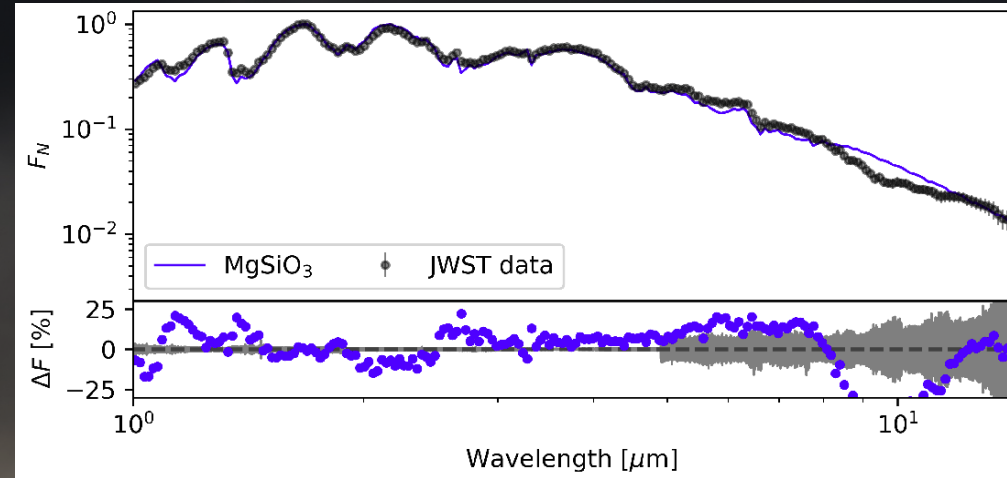
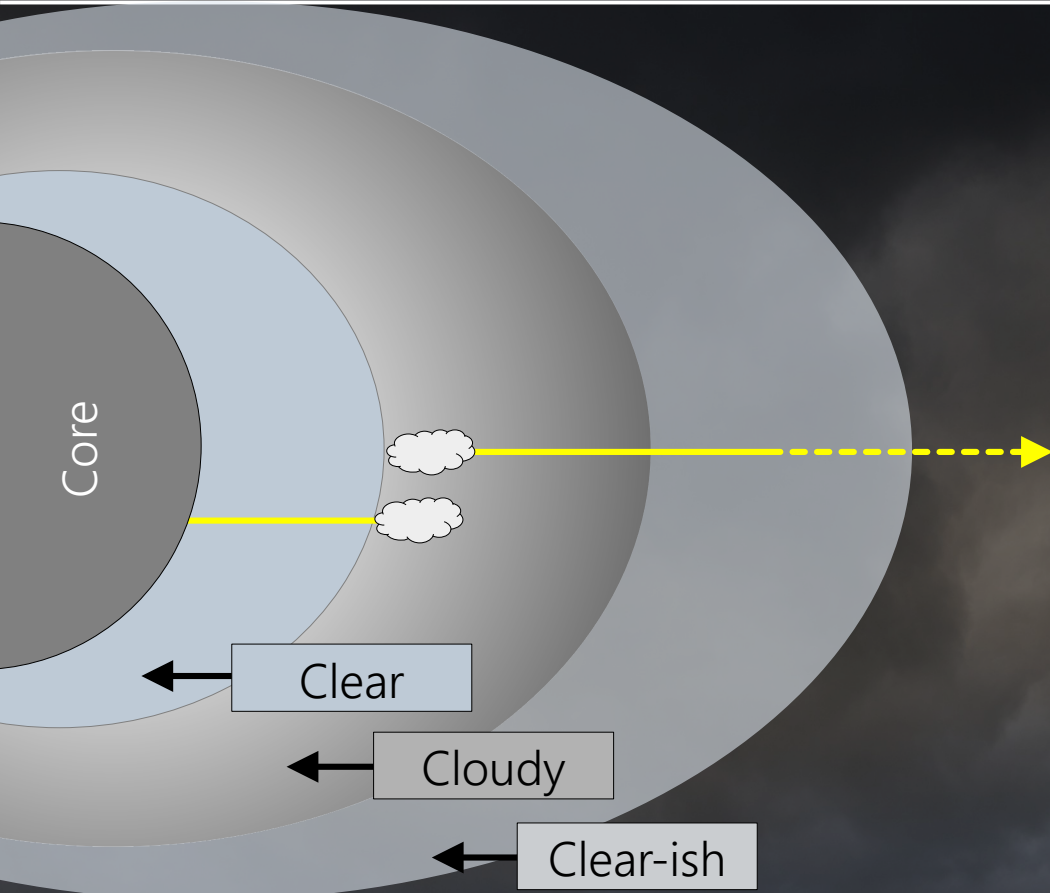


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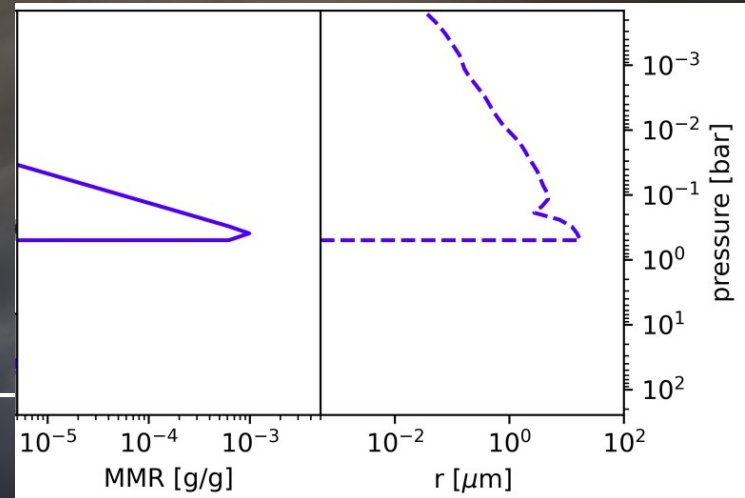
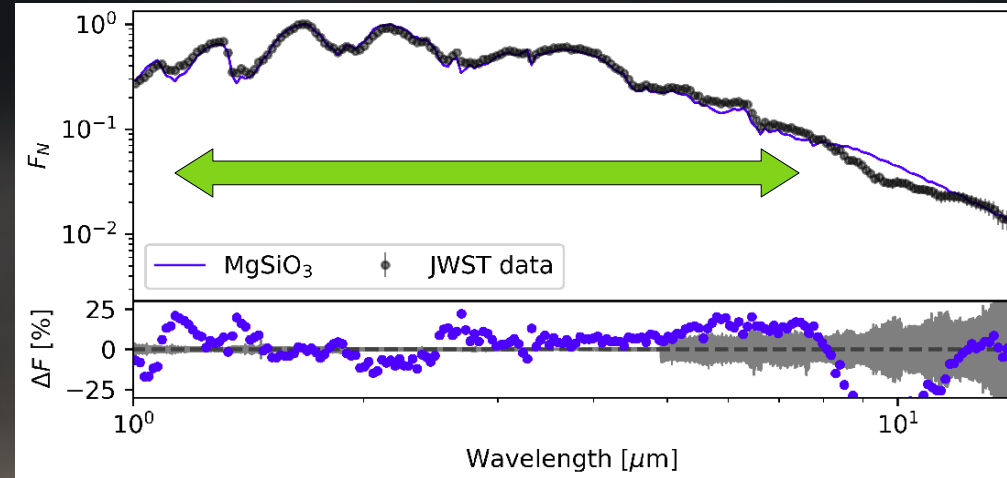
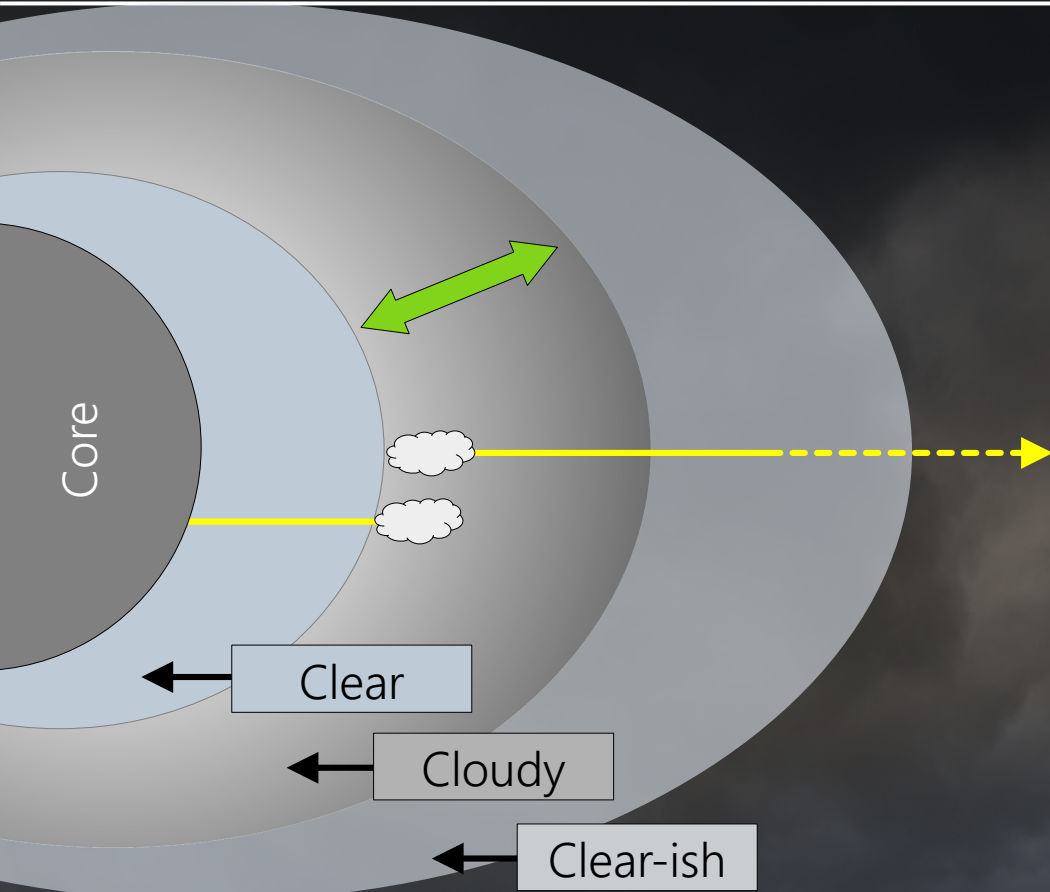
Cloud structures – Thermal emission spectra

Planet:
VHS 1256 b



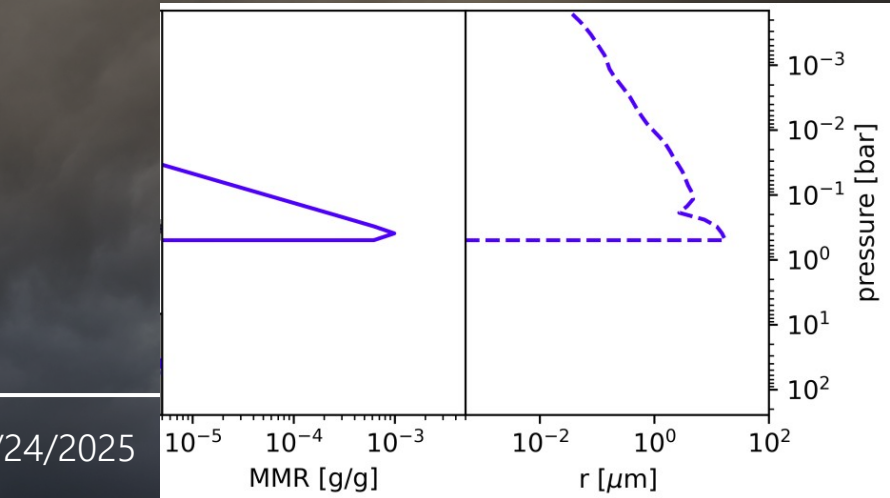
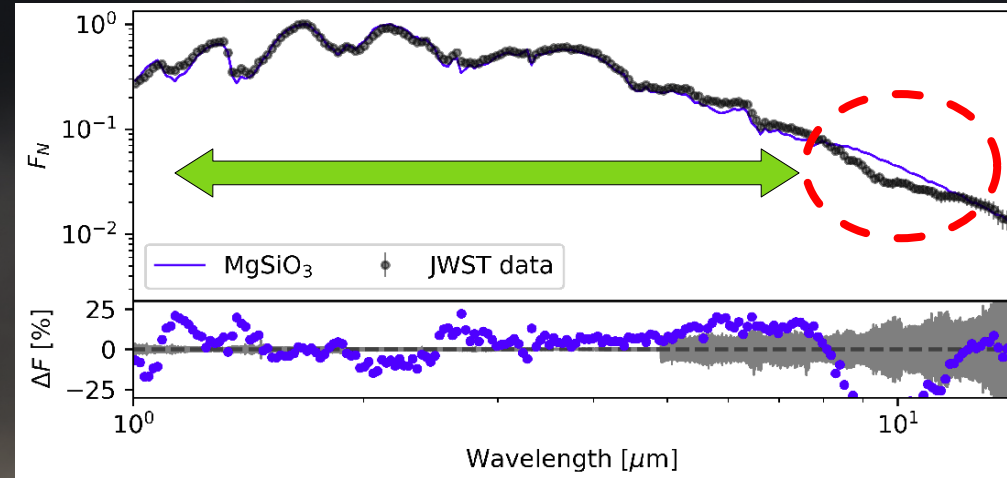
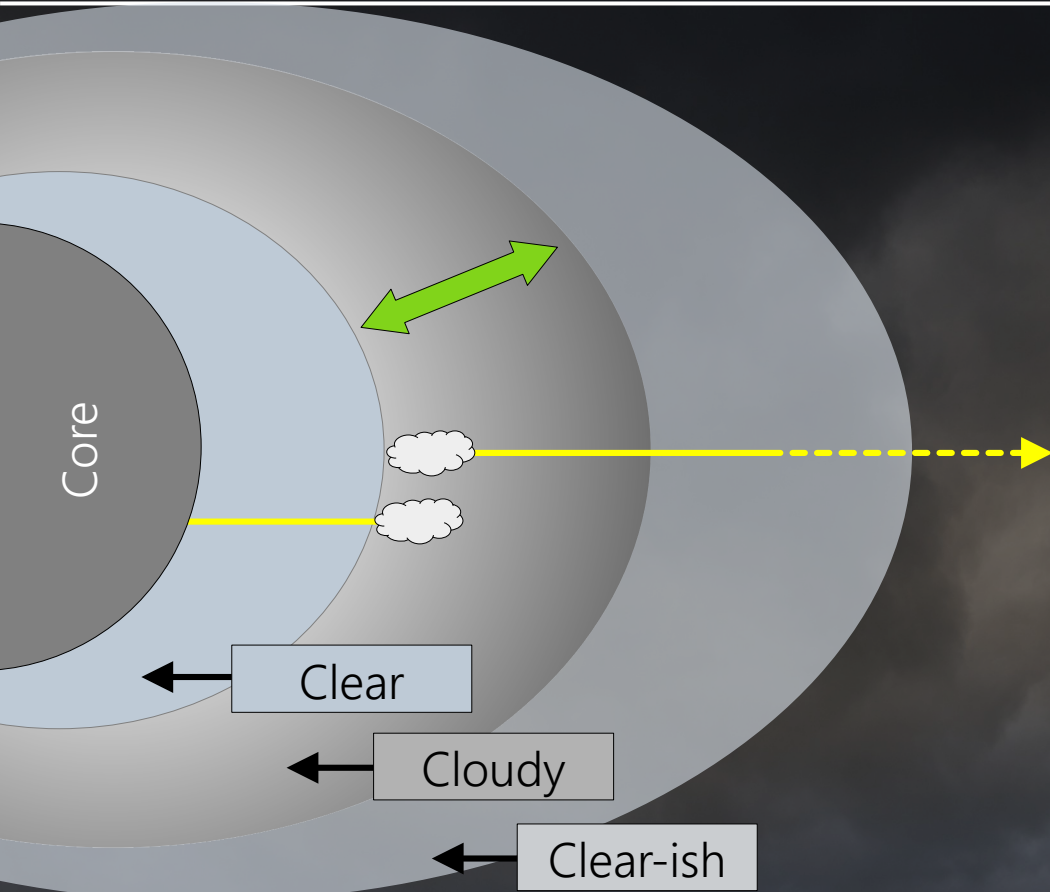
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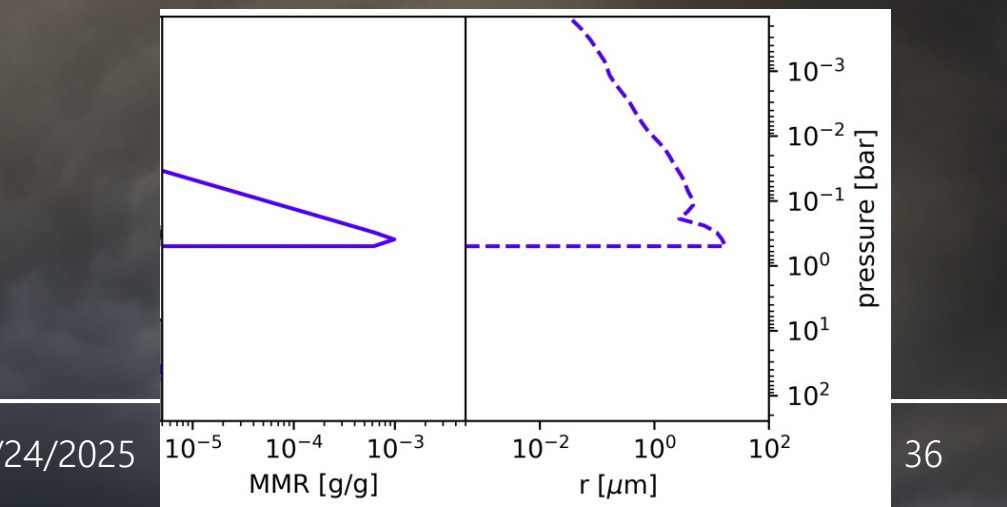
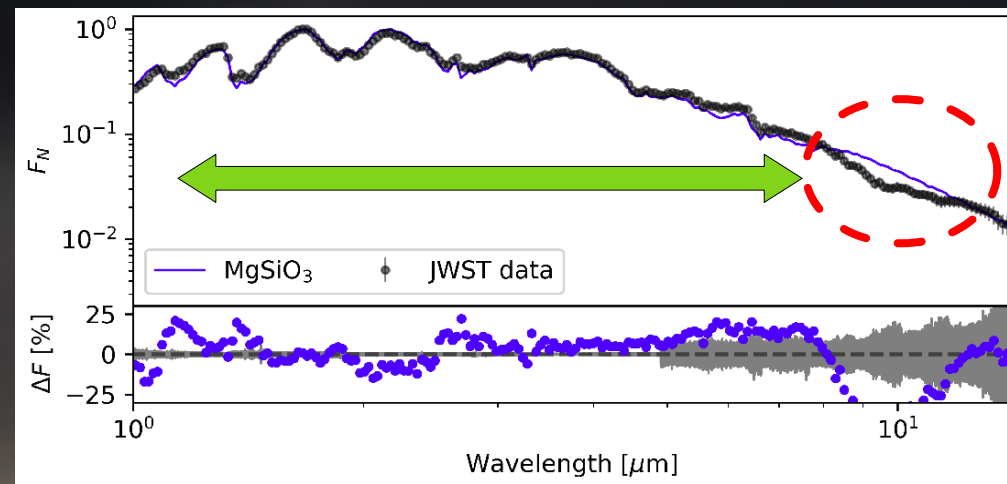
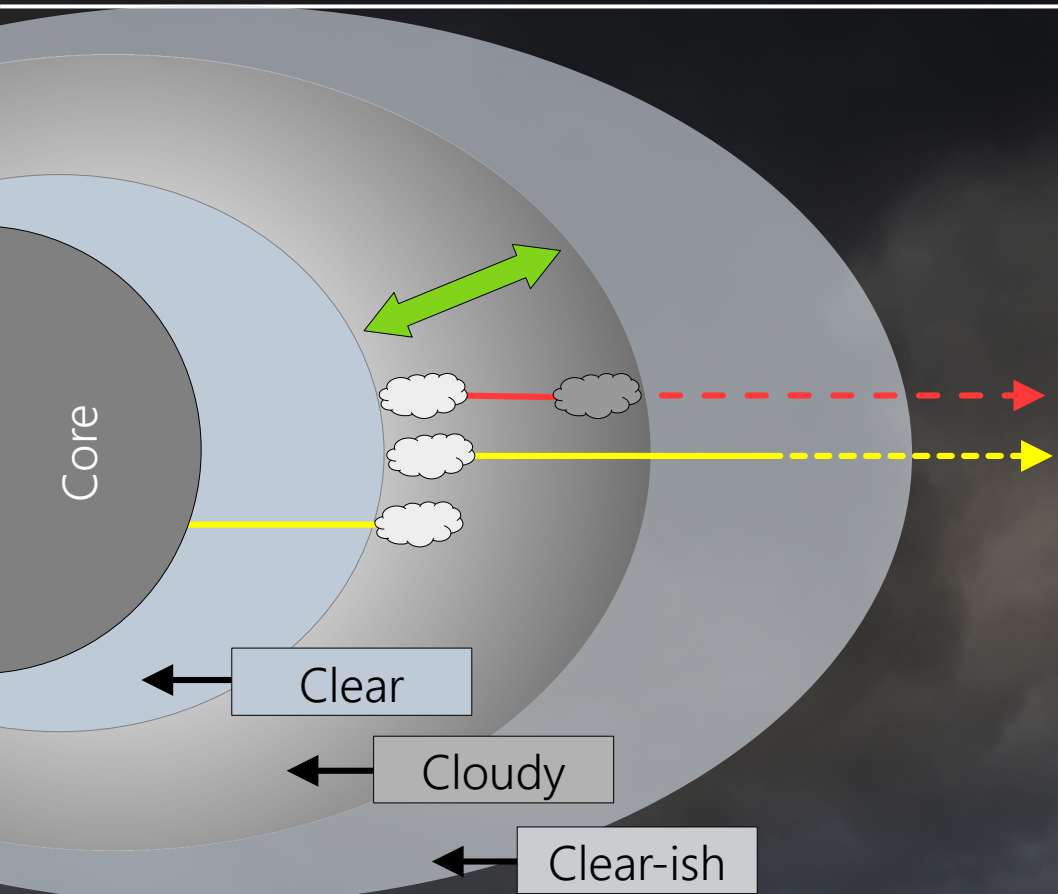
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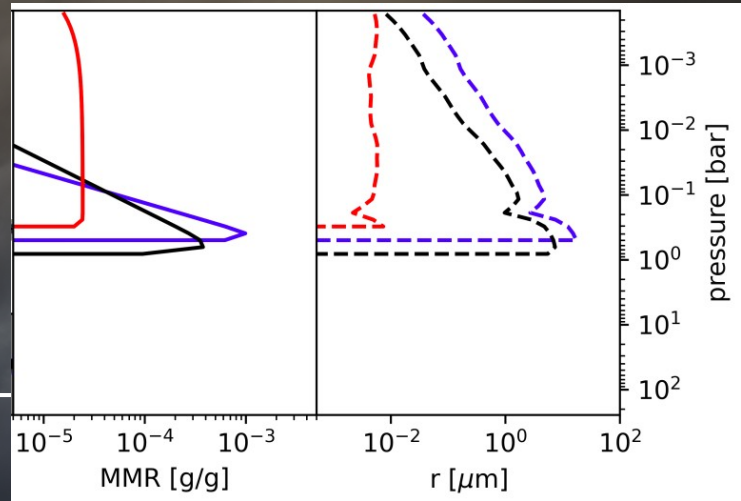
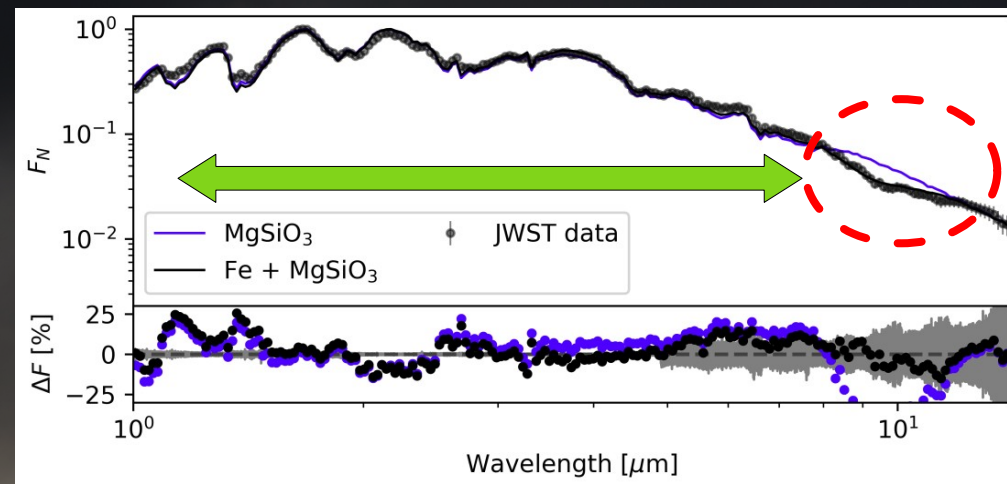
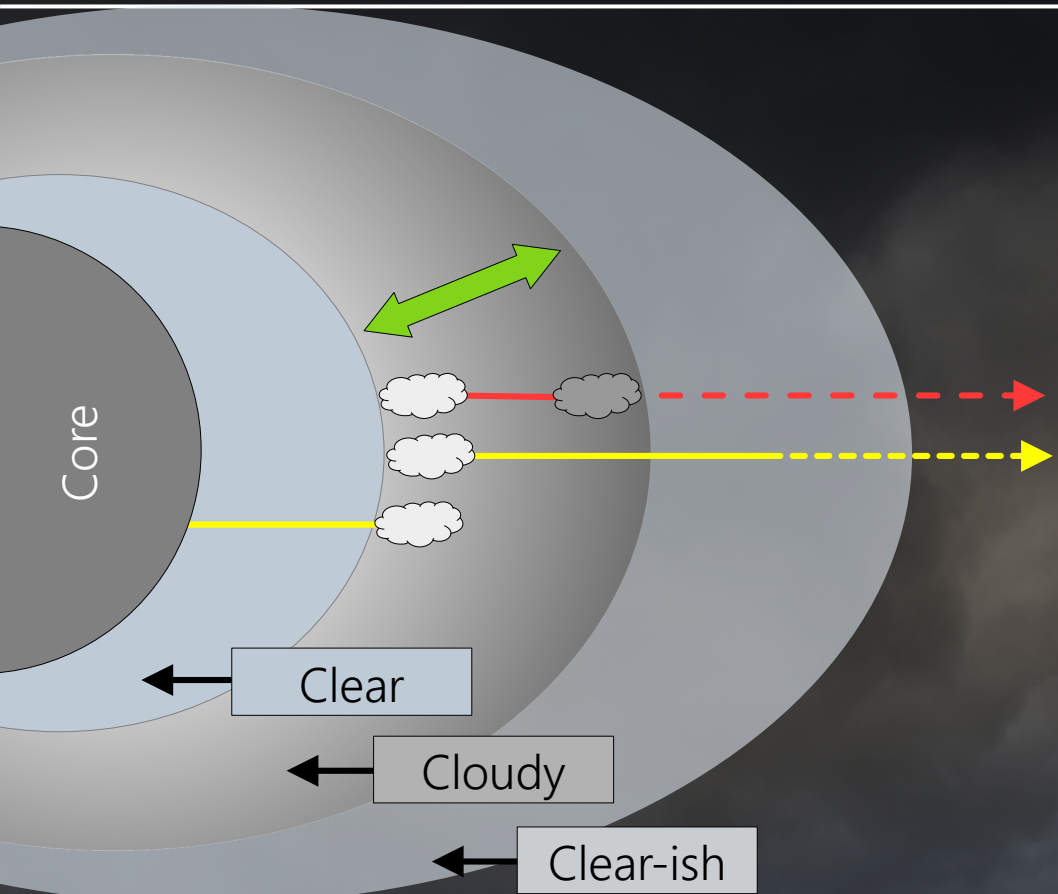
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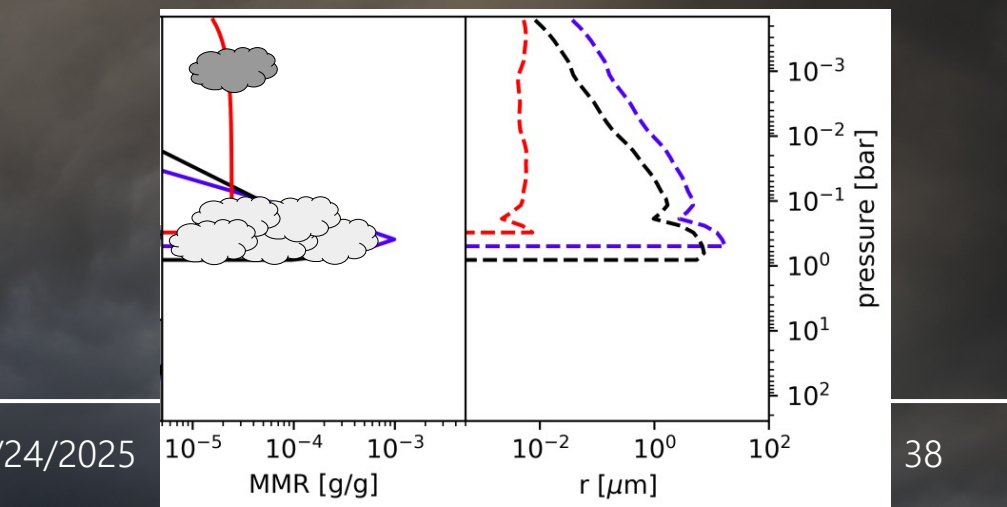
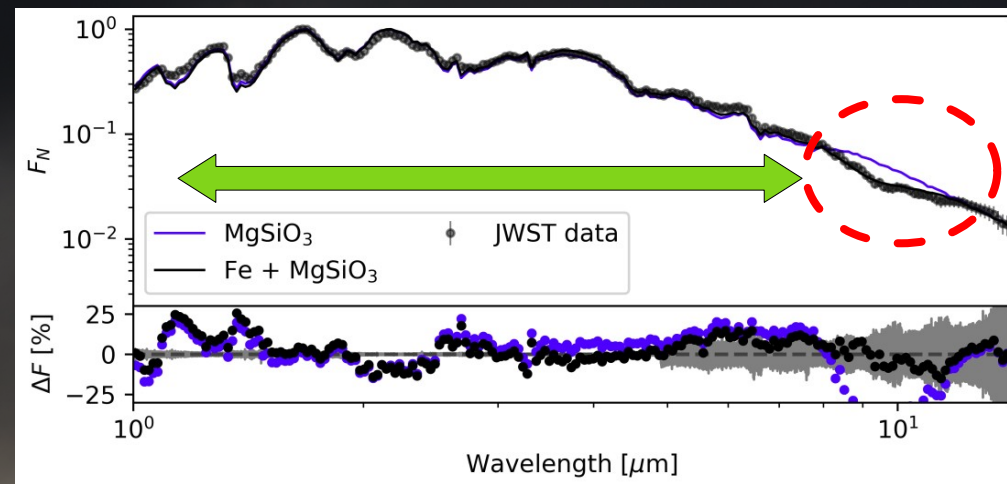
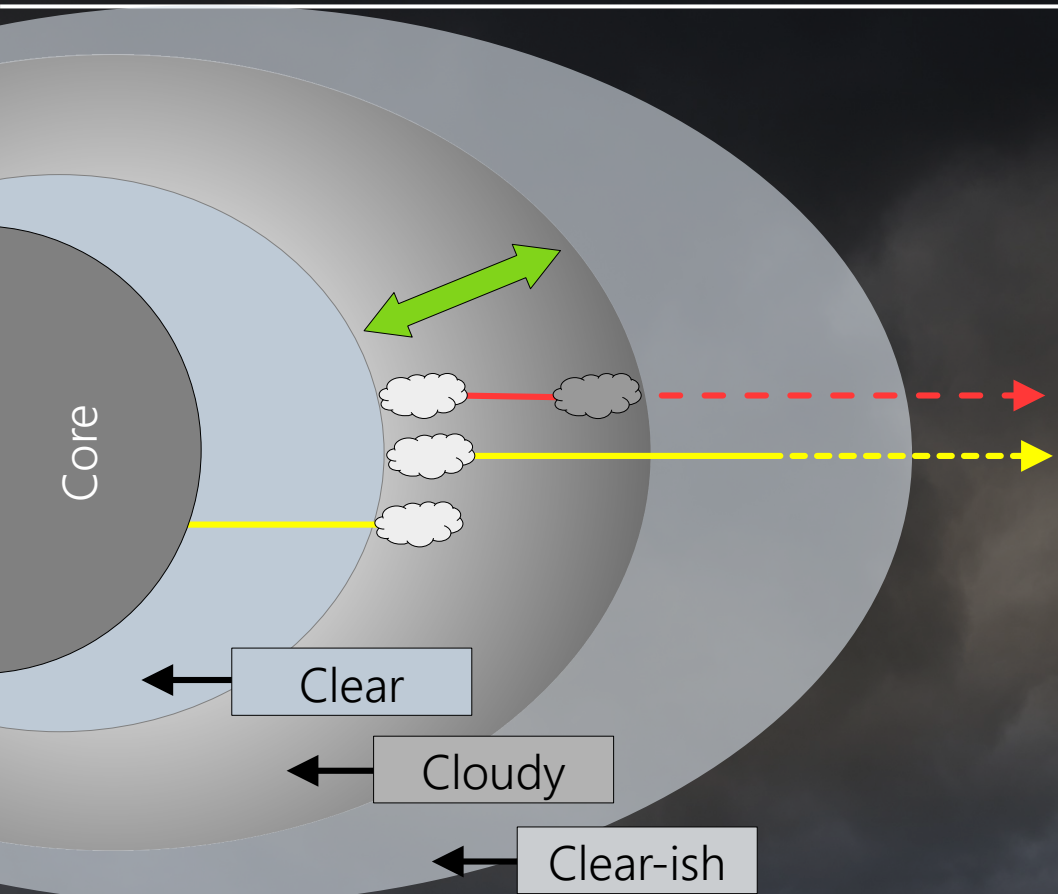
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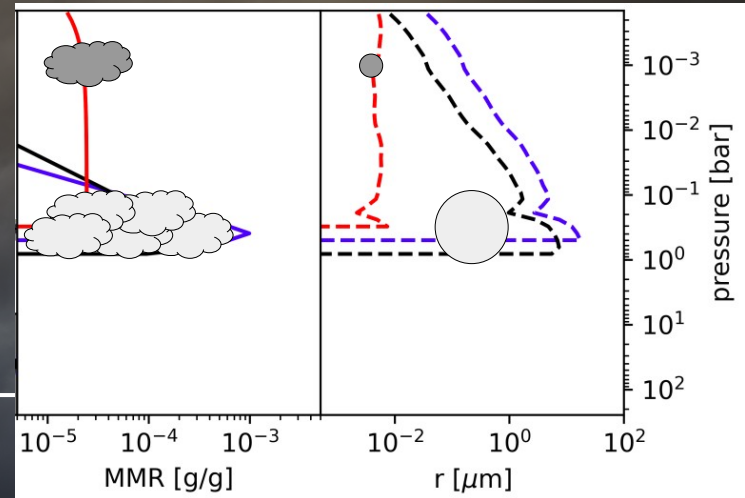
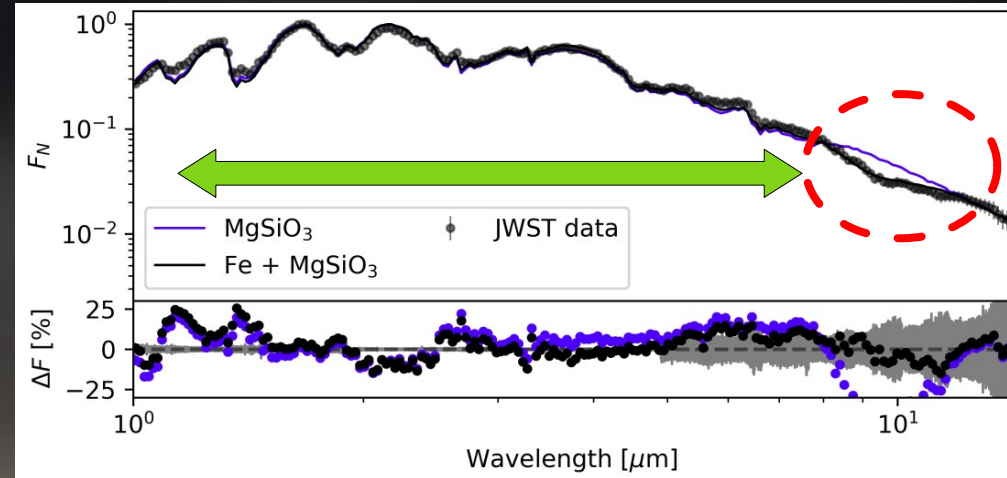
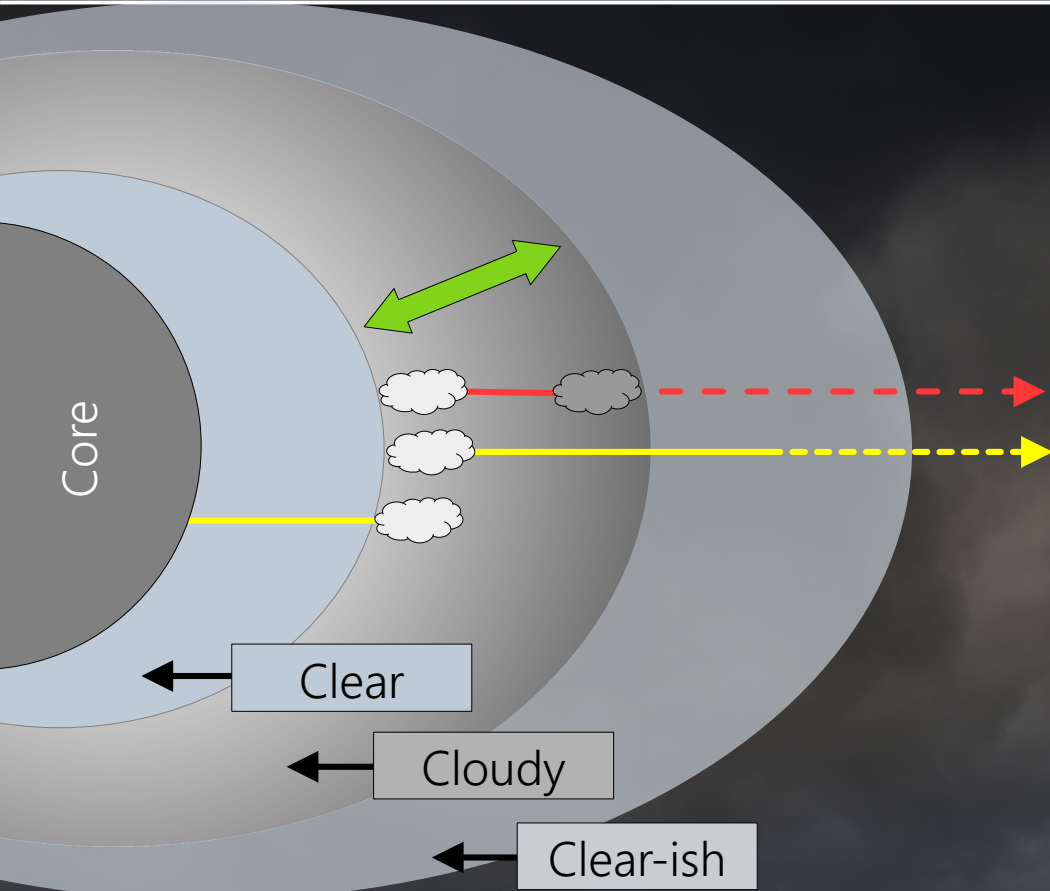
Cloud structures – Thermal emission spectra

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From Observations to Microphysics



Microphysics and observations

Sticking coefficients

Cloud particle sizes

Cloud particle materials

Microphysics and observations



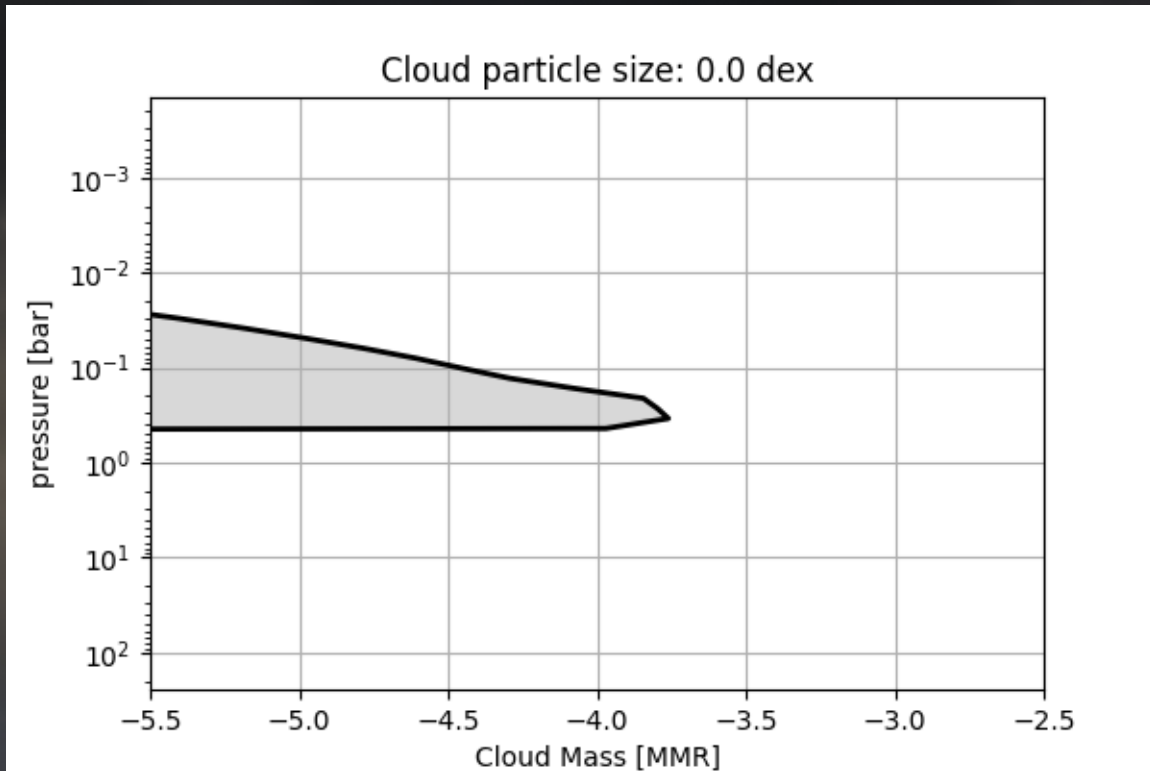
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Planet: VHS 1256 b Material: MgSiO_3



Sticking coefficients

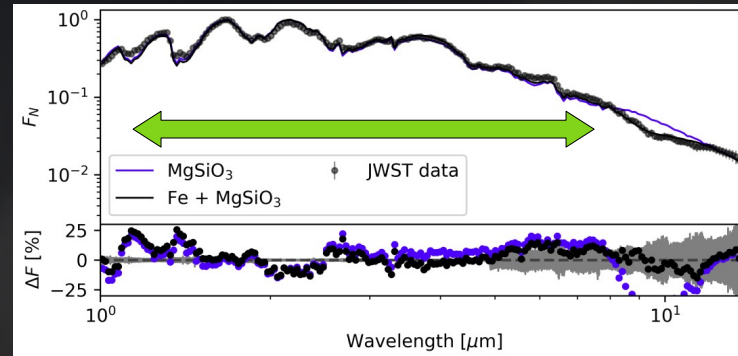
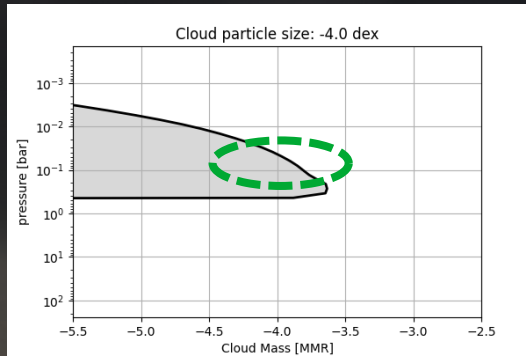
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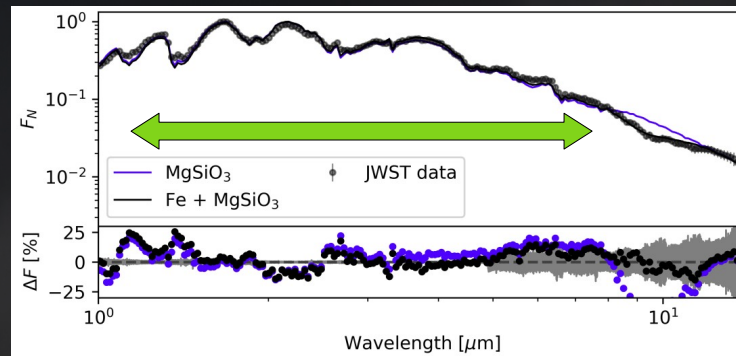
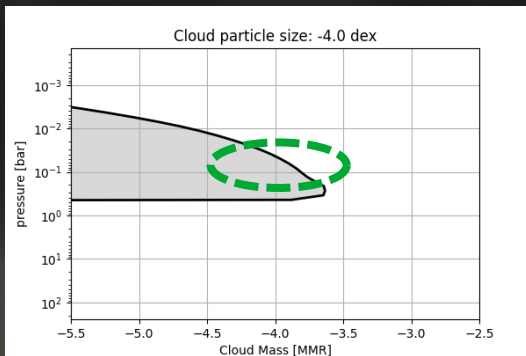
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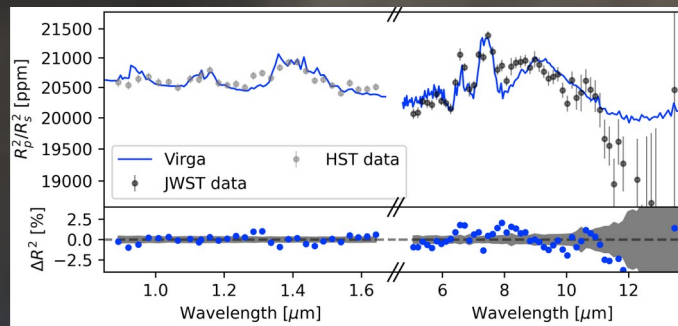
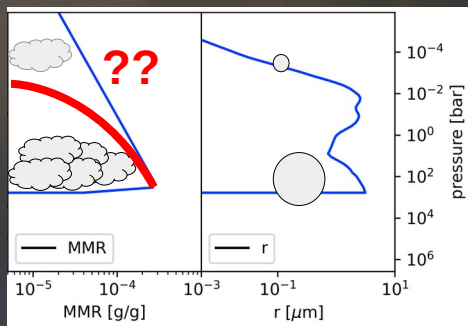


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Planet: WASP 107 b

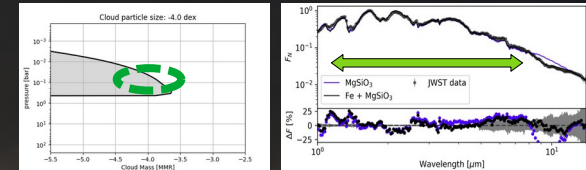
Material: SiO



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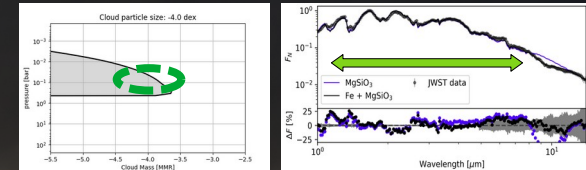


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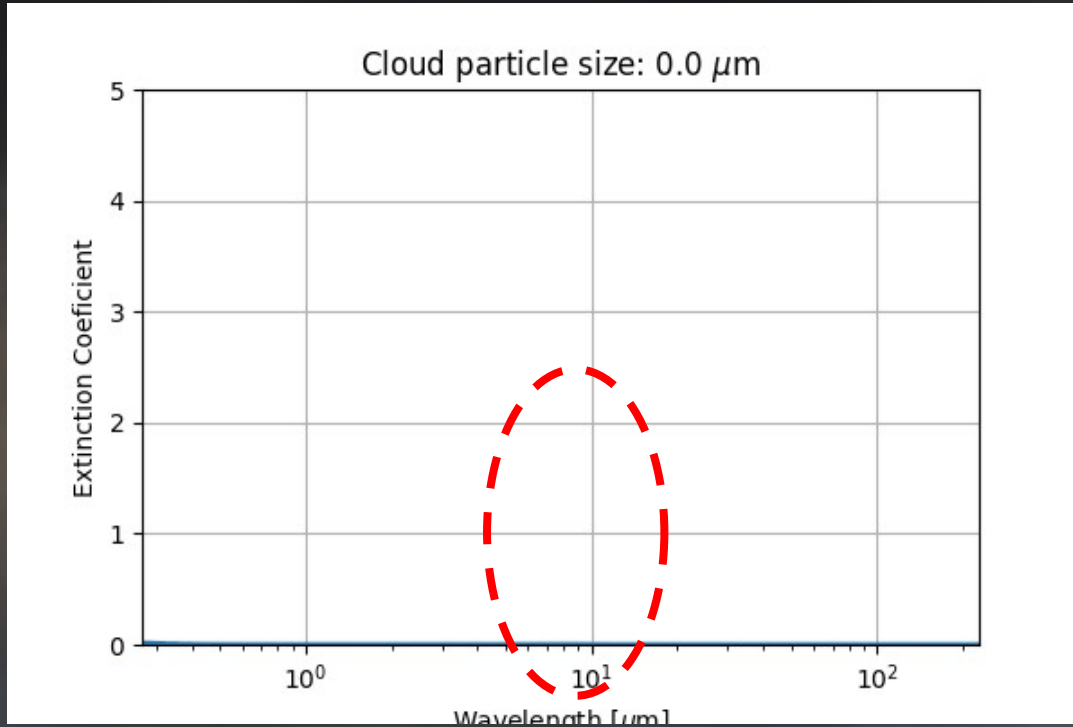


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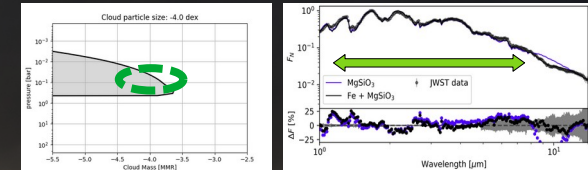
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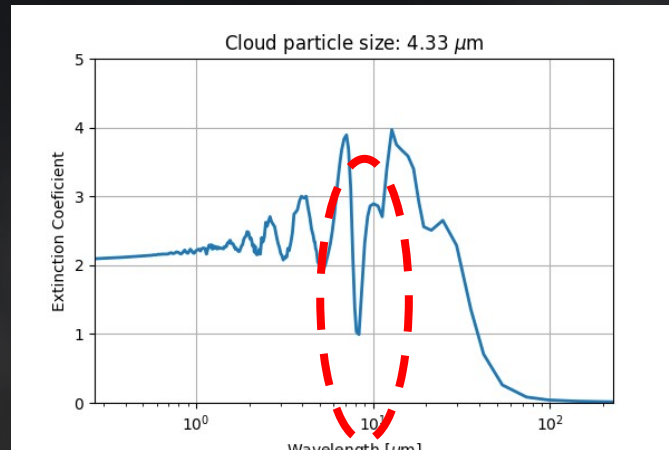
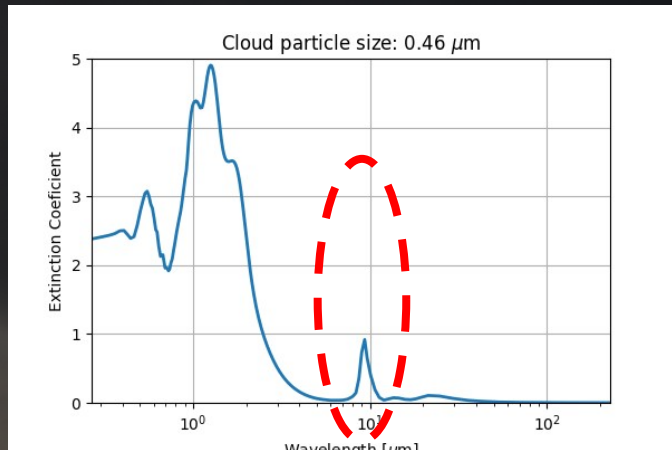
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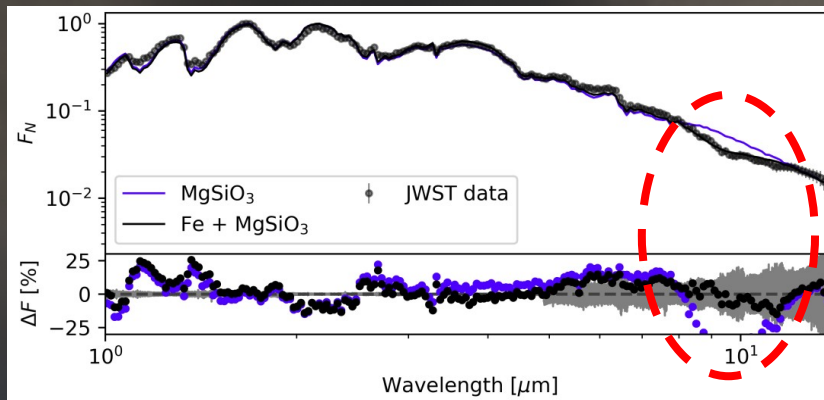
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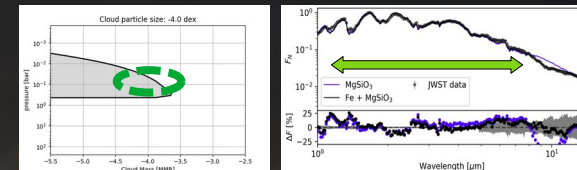
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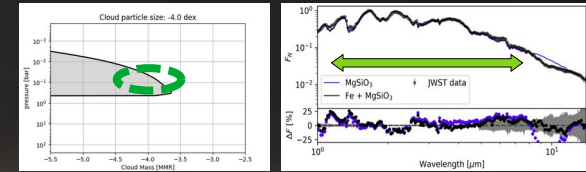


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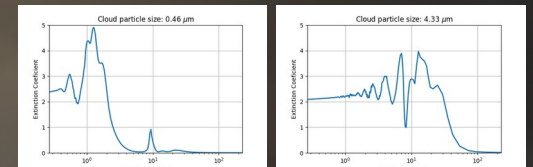
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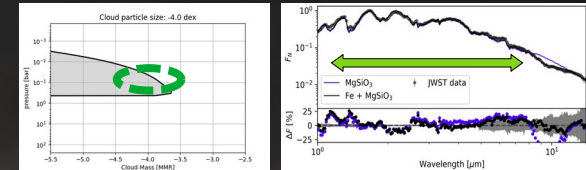
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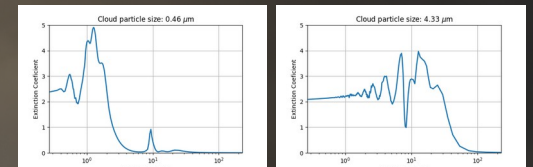
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Microphysics and observations

Sticking coefficients



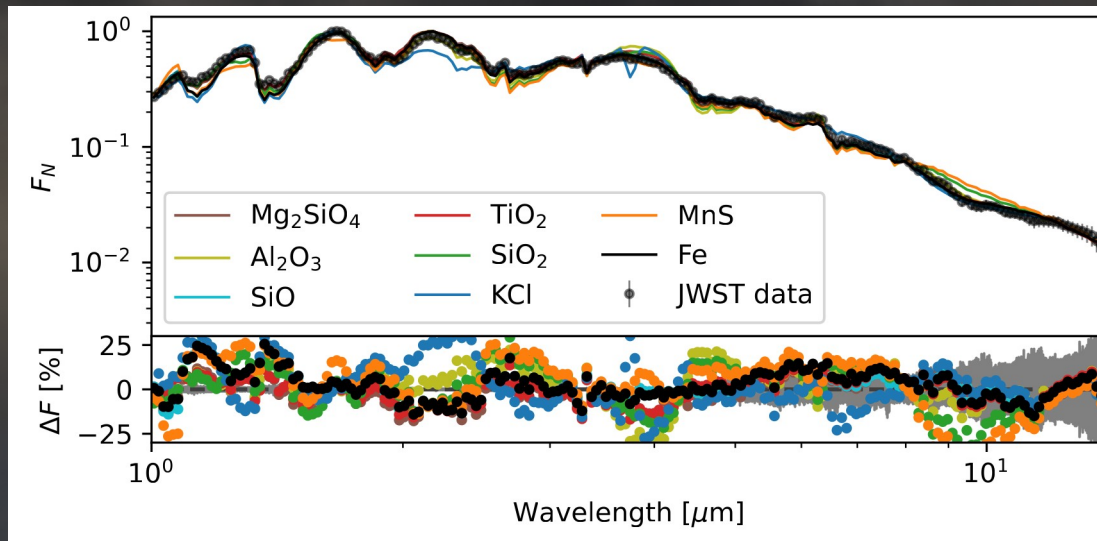
Cloud particle sizes



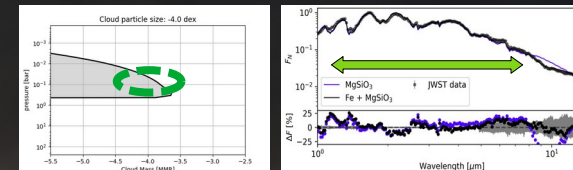
Cloud particle materials

Microphysics and observations

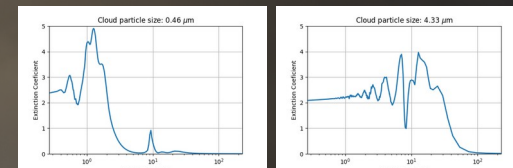
Planet: VHS 1256 b



Sticking coefficients



Cloud particle sizes

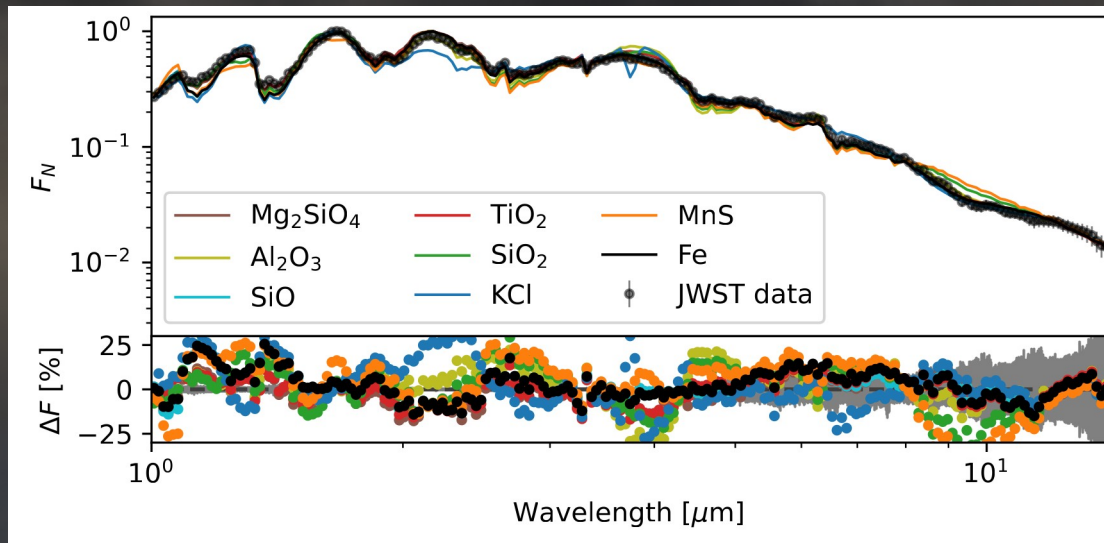


Cloud particle materials

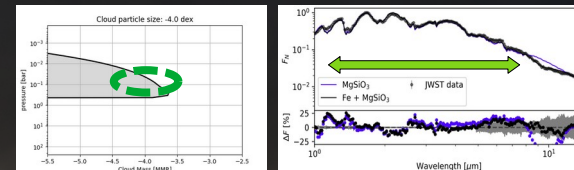
Microphysics and observations

Planet: VHS 1256 b

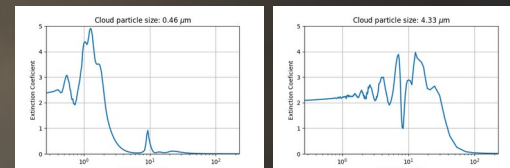
Cloud base:
 MgSiO_3 , Mg_2SiO_4 , SiO , or Fe



Sticking coefficients



Cloud particle sizes



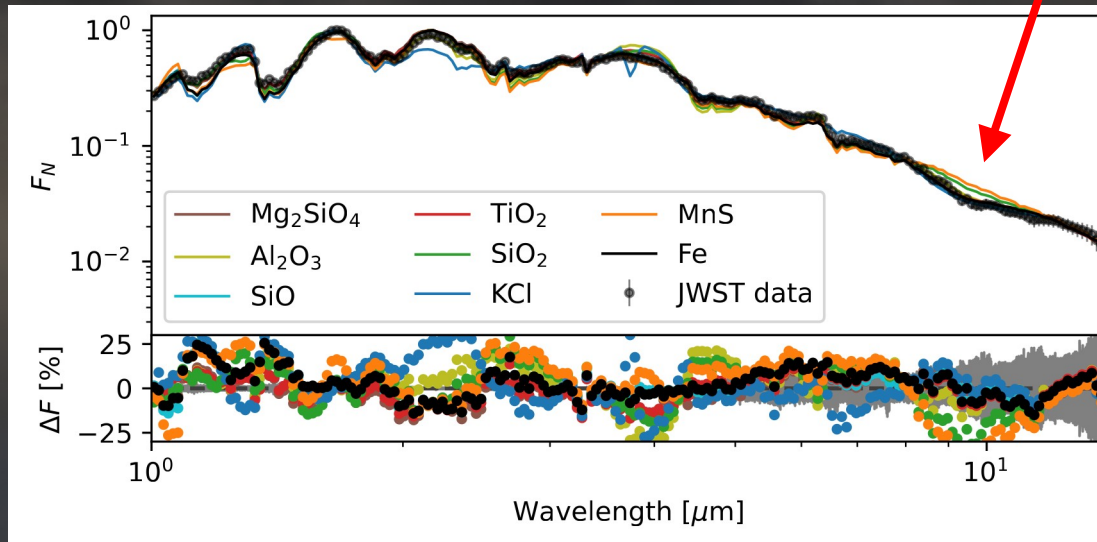
Cloud particle materials

Microphysics and observations

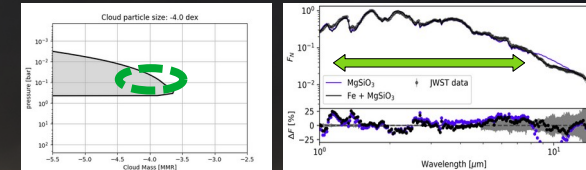
Planet: VHS 1256 b

Cloud base:
MgSiO₃, Mg₂SiO₄, SiO, or Fe

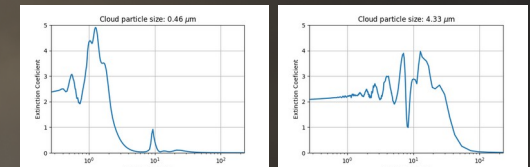
Si-O feature:
MgSiO₃, or Mg₂SiO₄



Sticking coefficients



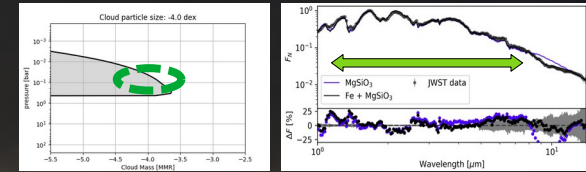
Cloud particle sizes



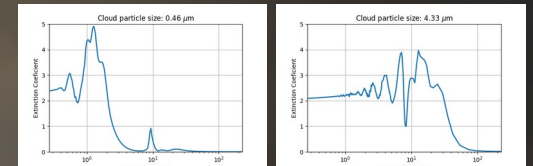
Cloud particle materials

Microphysics and observations

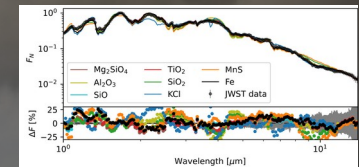
Sticking coefficients



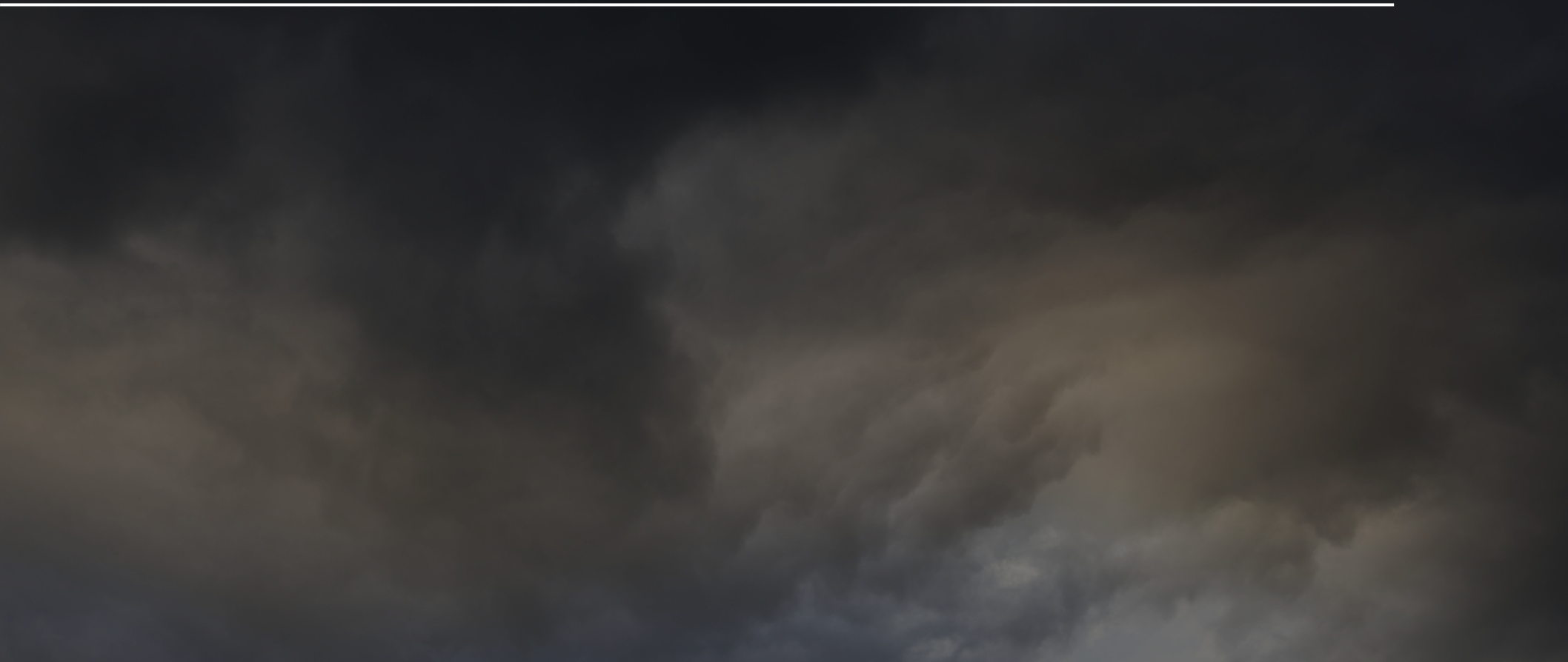
Cloud particle sizes



Cloud particle materials

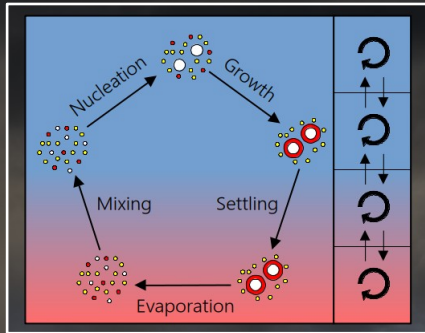


Cloud Physics on Exoplanets: Insights From JWST Observations



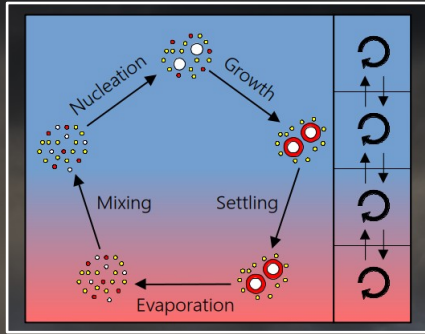
Cloud Physics on Exoplanets: Insights From JWST Observations

Cloud formation:
nucleation, growth,
mixing, settling

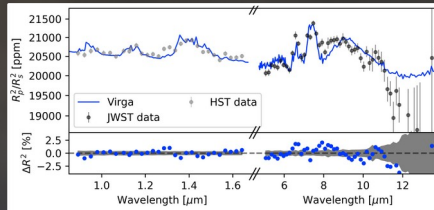
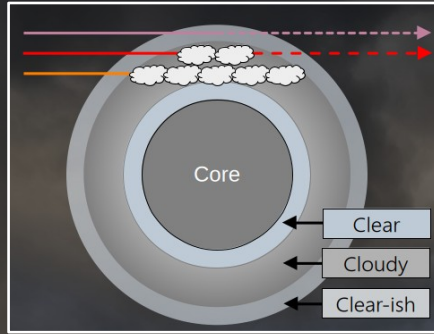


Cloud Physics on Exoplanets: Insights From JWST Observations

Cloud formation:
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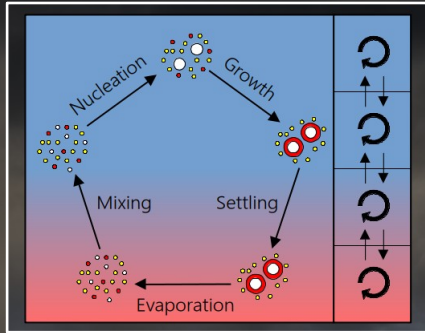


Transmission
spectra probe high
altitudes

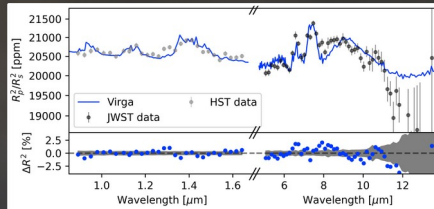
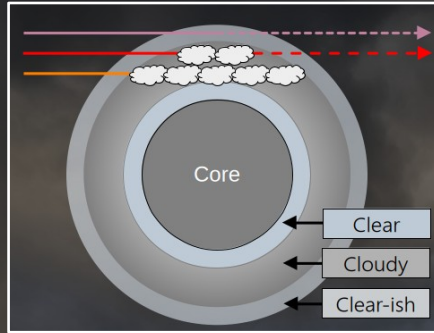


Cloud Physics on Exoplanets: Insights From JWST Observations

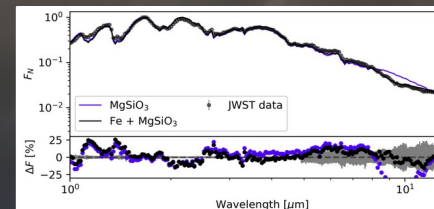
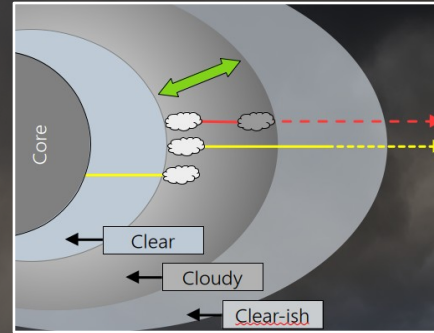
Cloud formation:
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Transmission
spectra probe high
altitudes

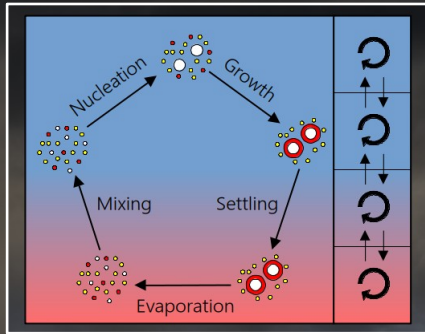


Thermal emission
spectra probe mid
altitudes

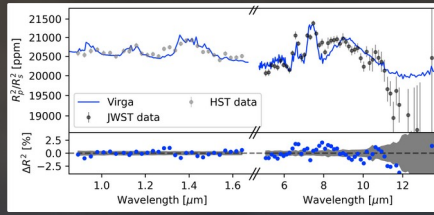
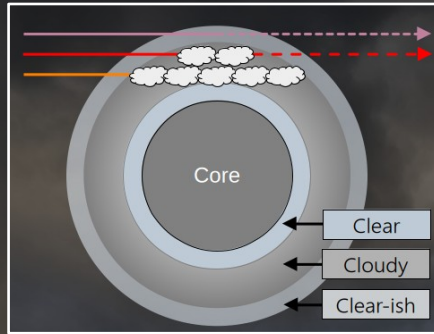


Cloud Physics on Exoplanets: Insights From JWST Observations

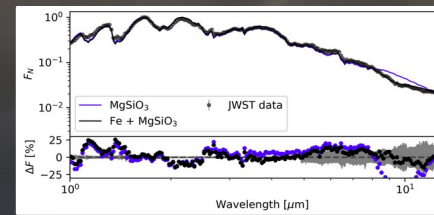
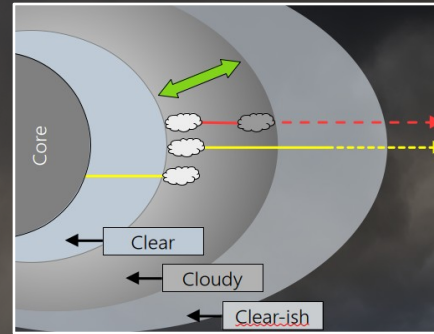
Cloud formation:
nucleation, growth,
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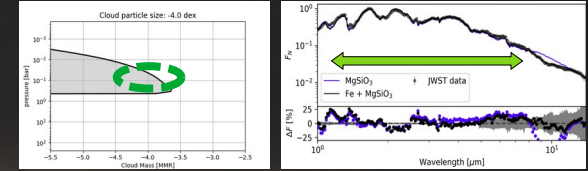
Transmission
spectra probe high
altitudes



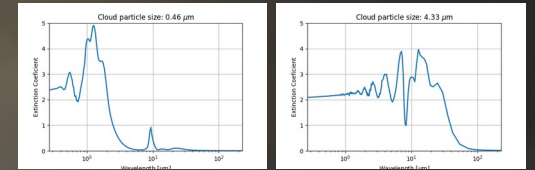
Thermal emission
spectra probe mid
altitudes



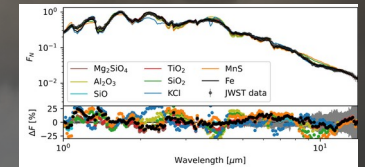
Sticking coefficients



Cloud particle sizes

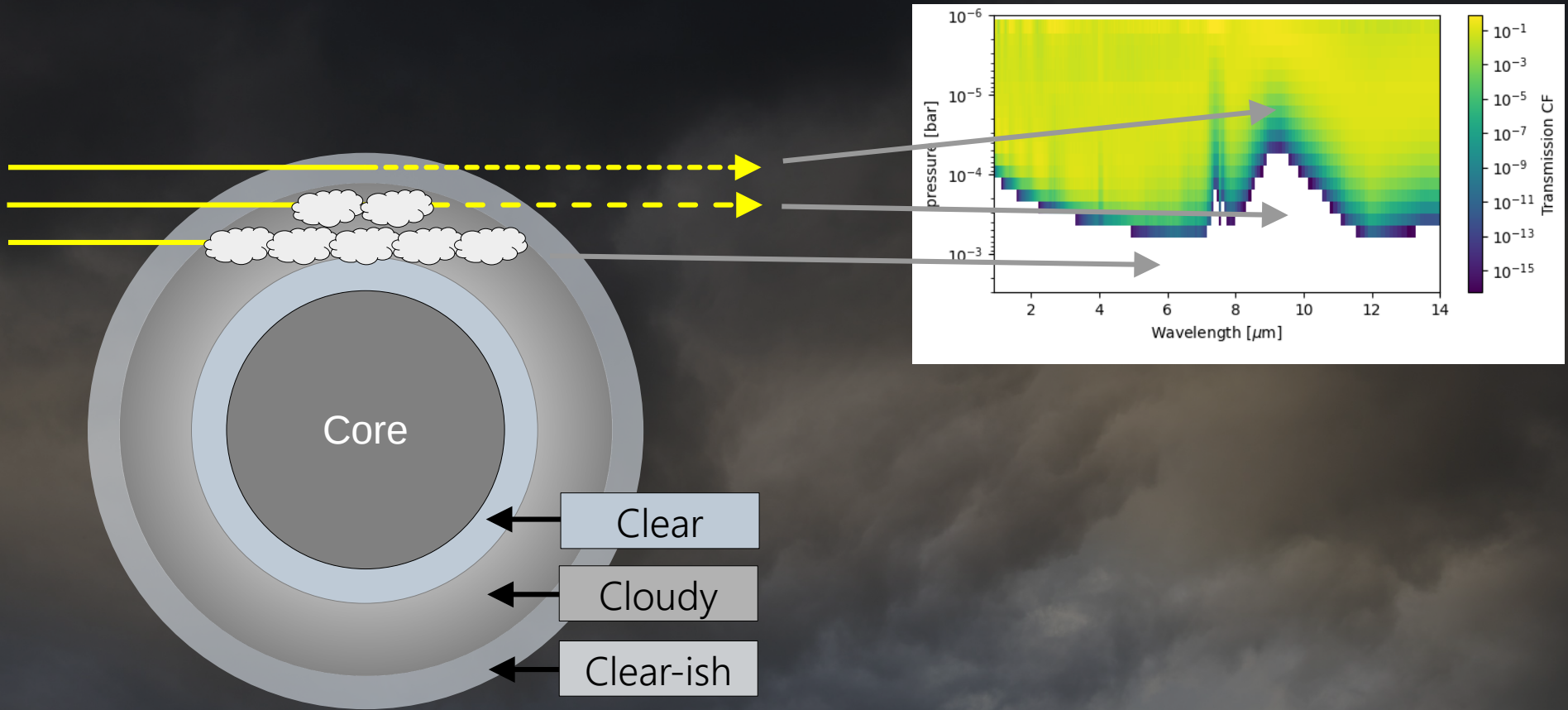


Cloud particle materials

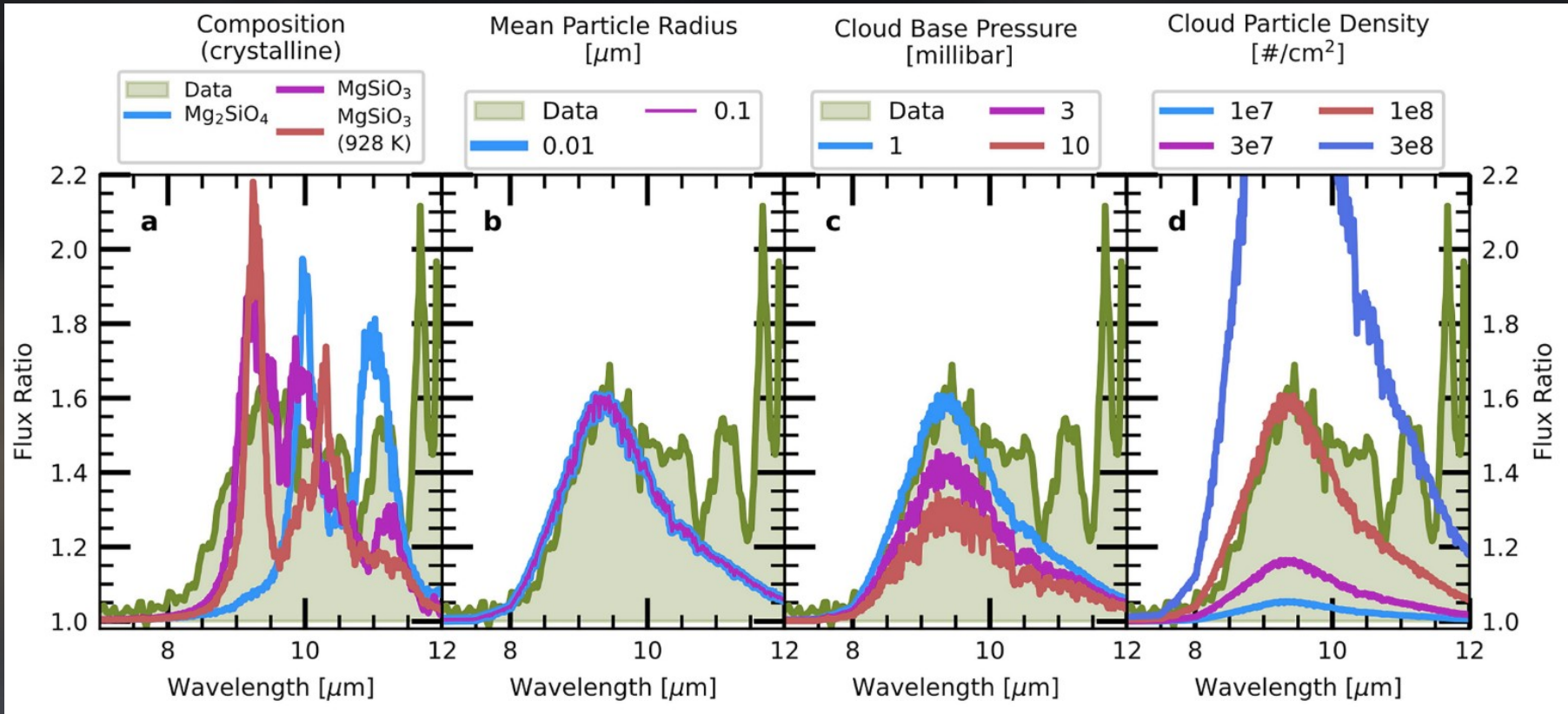


Additional slides

Cloud structures – Transmission spectra



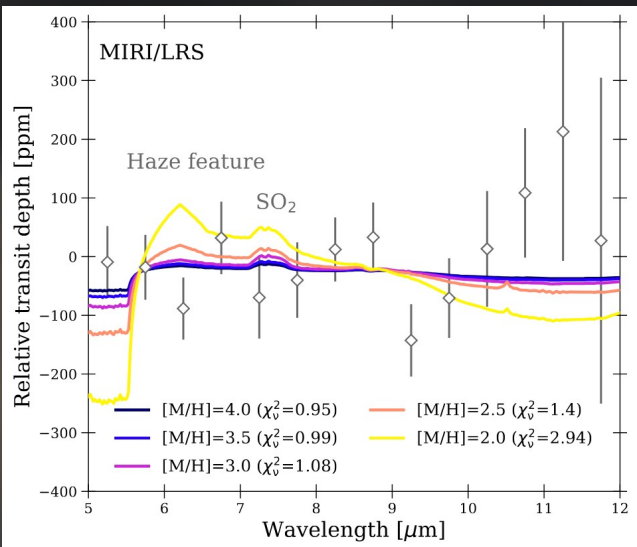
Particle properties from the SI-O feature



Hoch et al. 2025

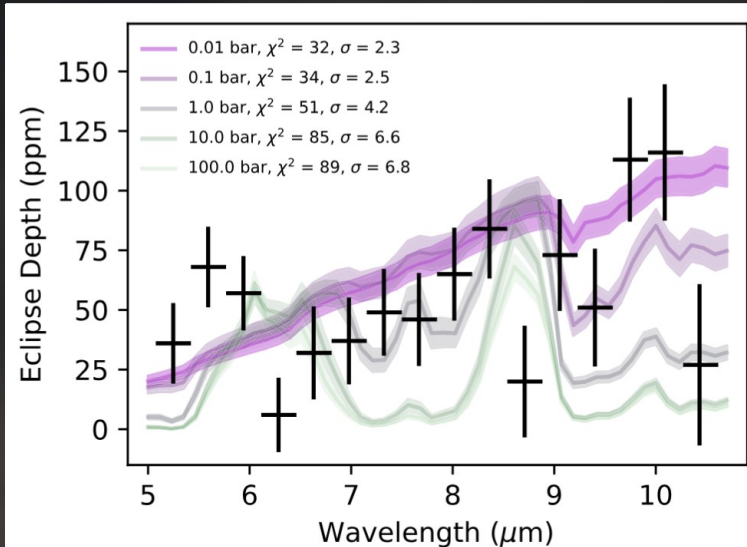
What about rocky planets?

Planet: GJ 1214 b



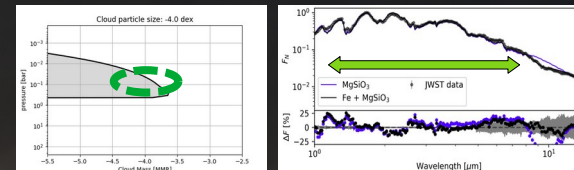
Ohno et al. 2025
Kempton et al. 2023

Planet: LTT 1445A b

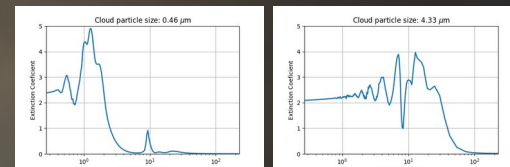


Wachiraphan et al. 2025

Sticking coefficients



Cloud Particle Sizes



Cloud particle materials

