

Spectrum of Atmospheric Radiation

EES 2110

Introduction to Climate Change

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Class #6: Monday, January 23 2023

Review Questions

Review Question

What is the “atmospheric window”?

1. Regions where there are few clouds to block radiation.
2. Desert regions with very little water vapor.
3. Tropical regions with low CO₂ concentrations.
4. A range of wavelengths where no greenhouse gases absorb much.

Review Question

What Is A Greenhouse Gas?

If someone gives a chemist a flask of an unknown gas, what would be the simplest way for the chemist to figure out whether that gas is a greenhouse gas?

- Test whether the gas transmits shortwave light.
 - Can you see through it?
- Test whether the gas absorbs longwave light.

MODTRAN Computer Model

What is MODTRAN?

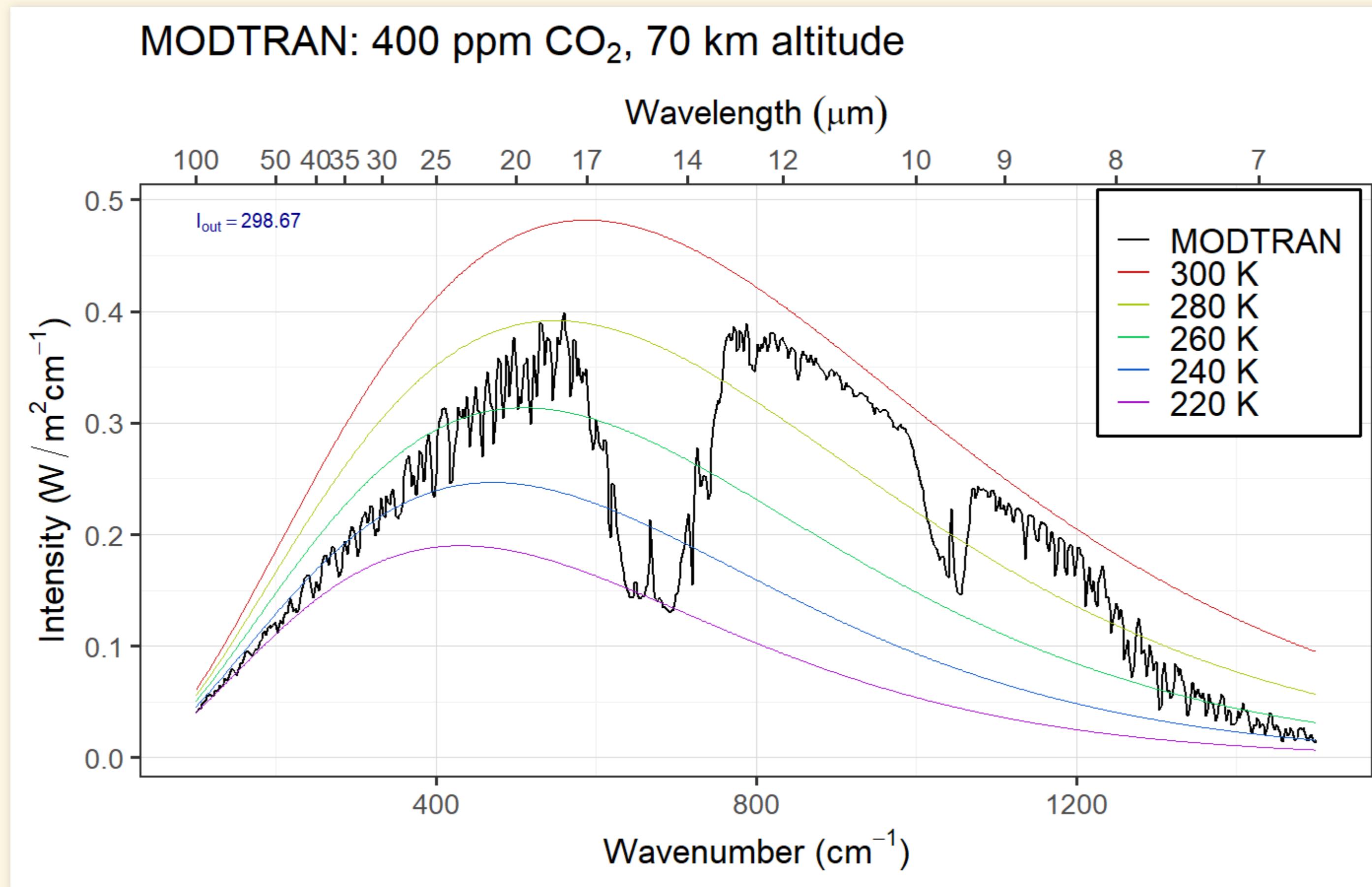
- Pure radiative calculation
 - Air does not move:
 - No wind or convection
- Only calculates infrared heat flux
 - Does not give equilibrium ground temperature
- Only calculates one spot
 - Does not give global averages
- You specify:
 - Ground temperature
 - Composition of atmosphere
- Modtran computes:
 - Longwave radiation at different altitudes
 - Total radiation to space

Running MODTRAN

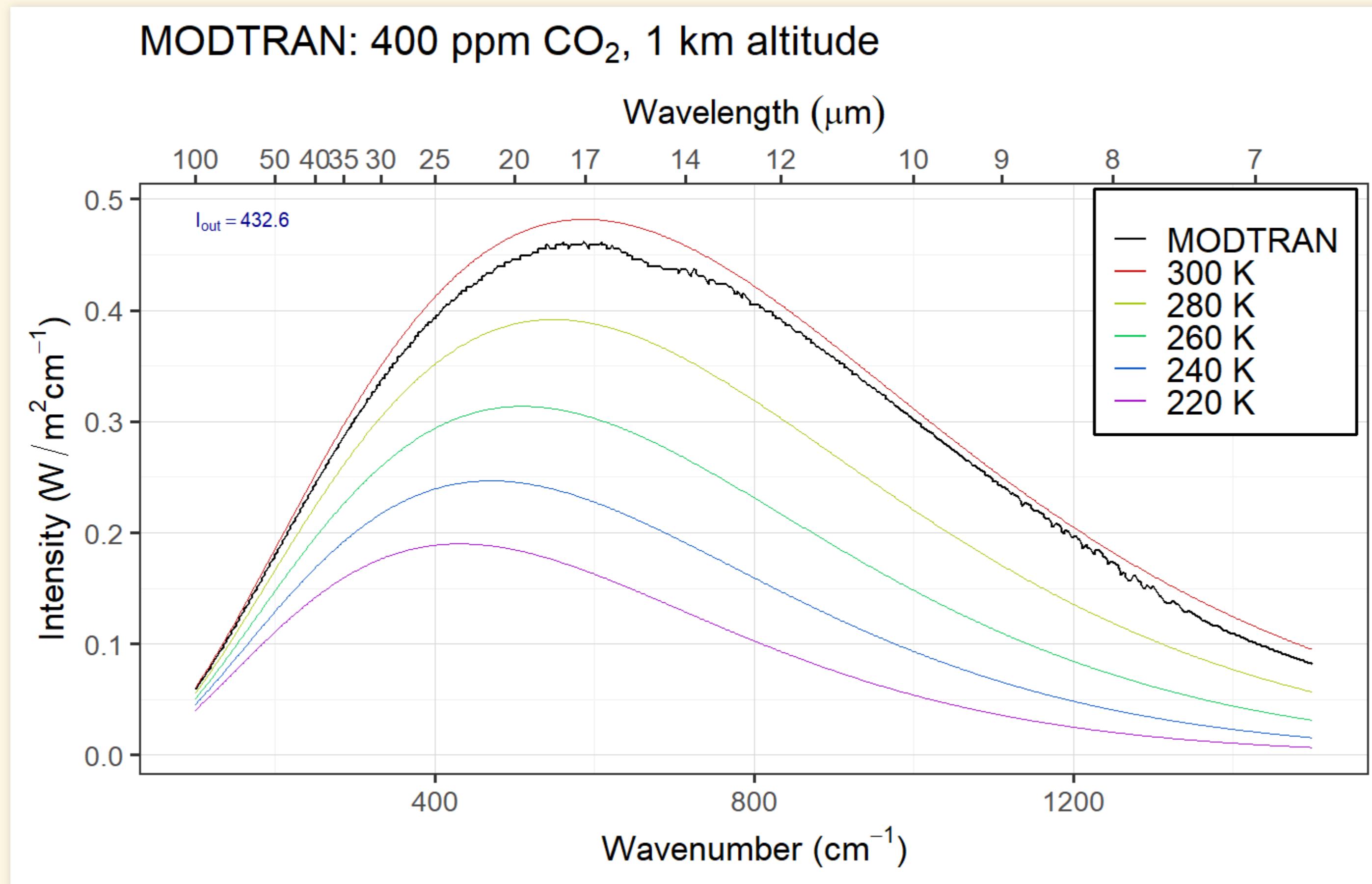
- Go to <http://climatemodels.uchicago.edu/modtran/>
- Next

Understanding the Spectrum

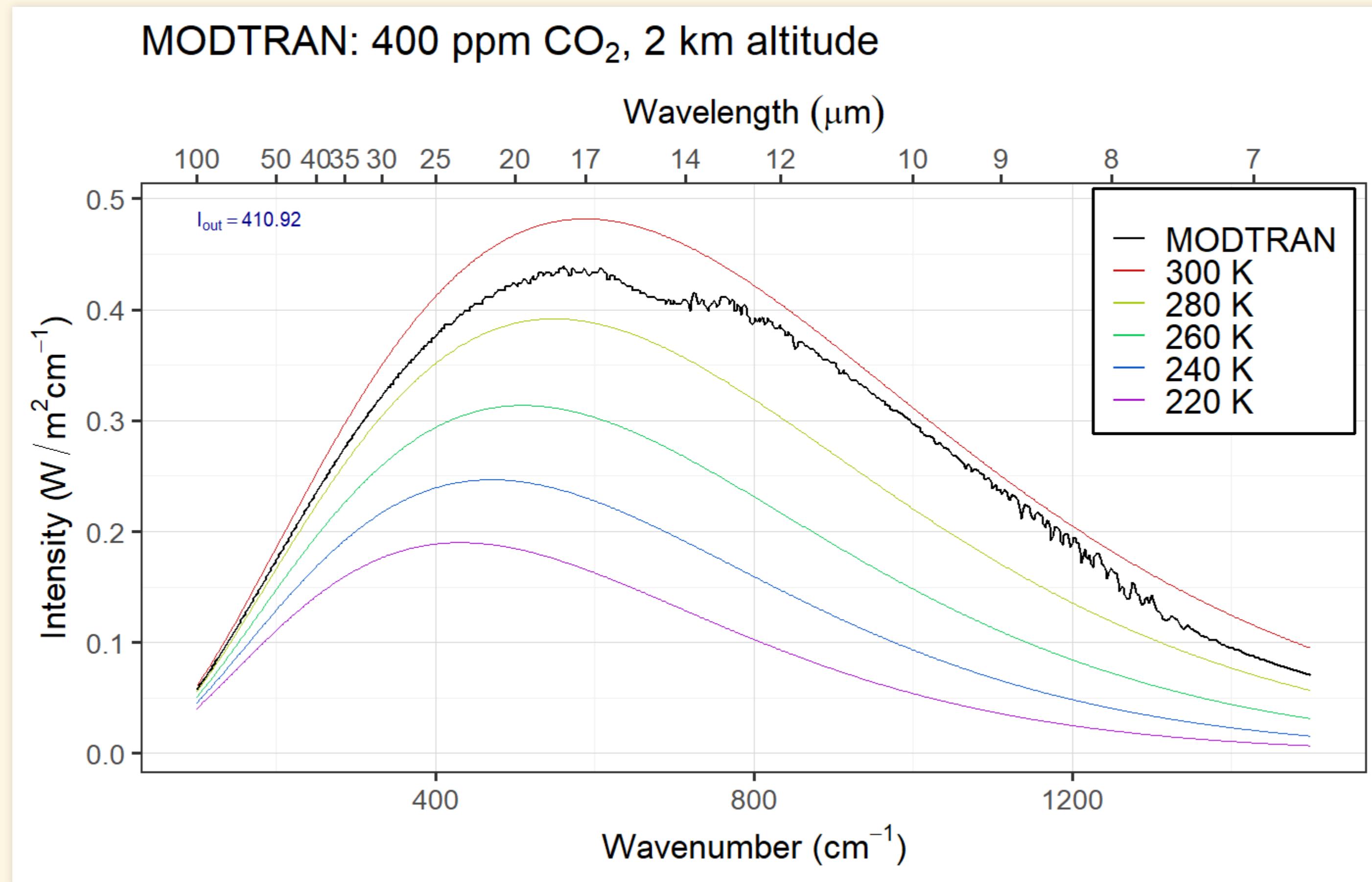
Earth's Tropics, Seen from Space



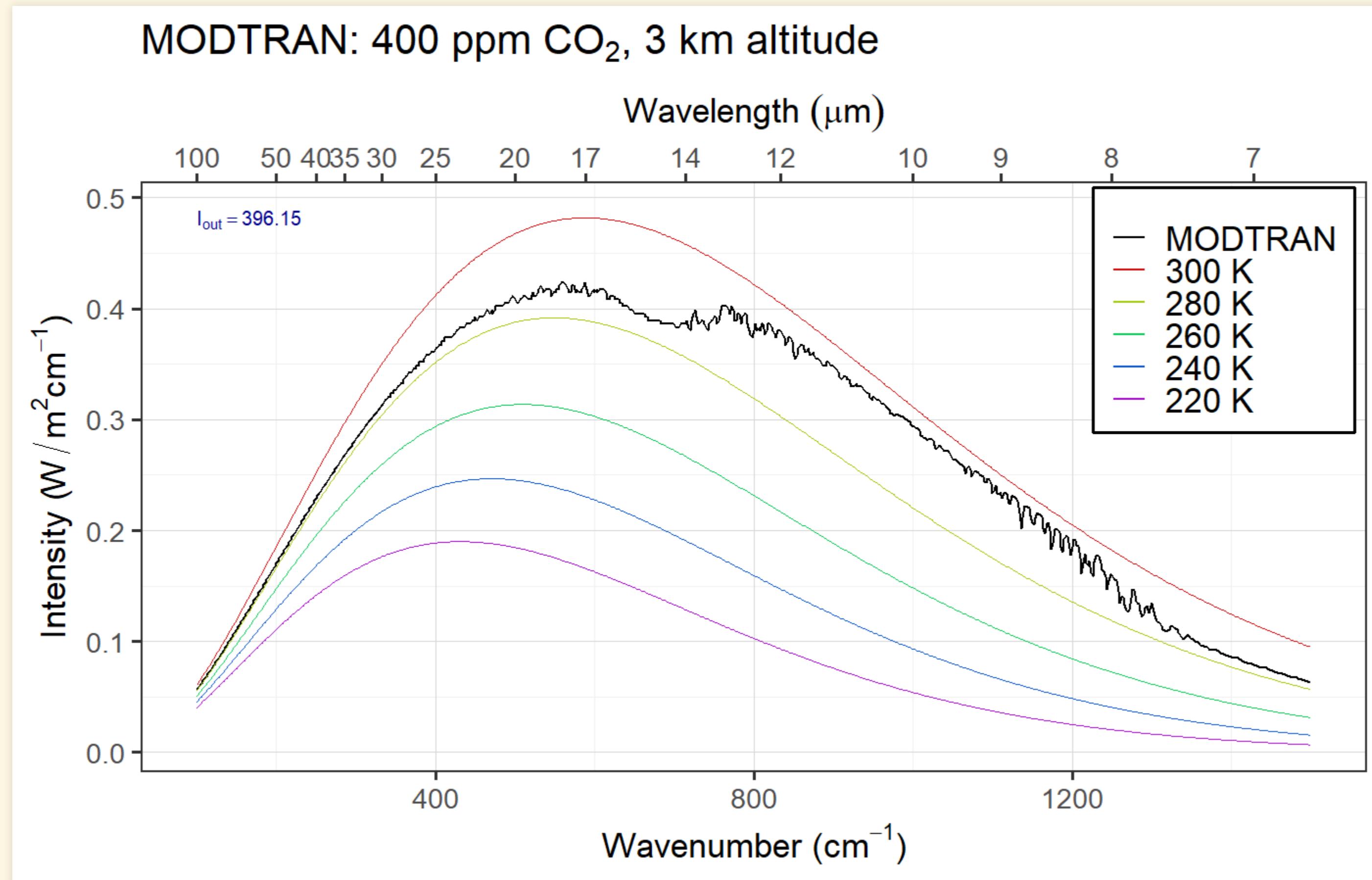
Seen from 1 km



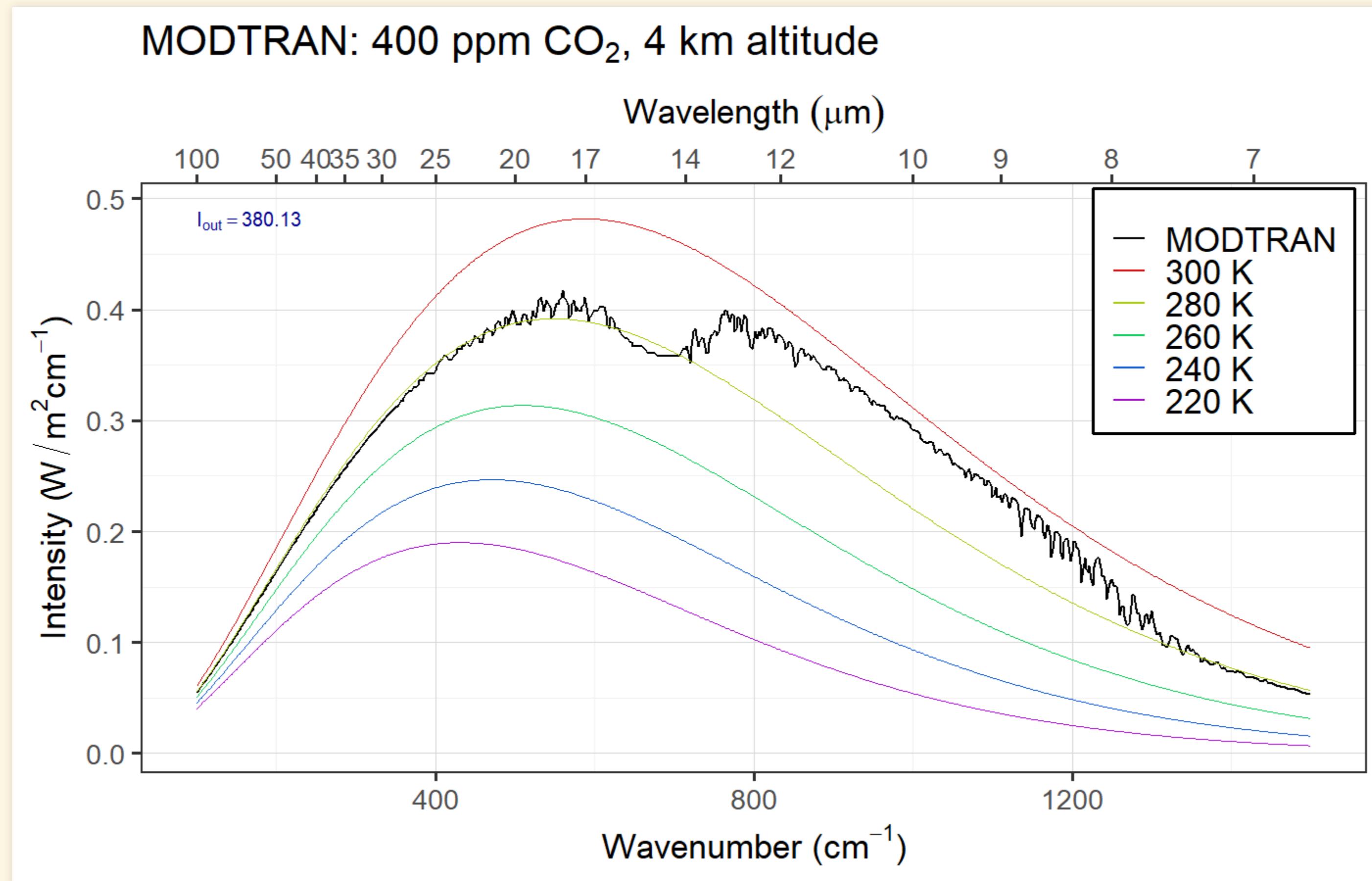
Seen from 2 km



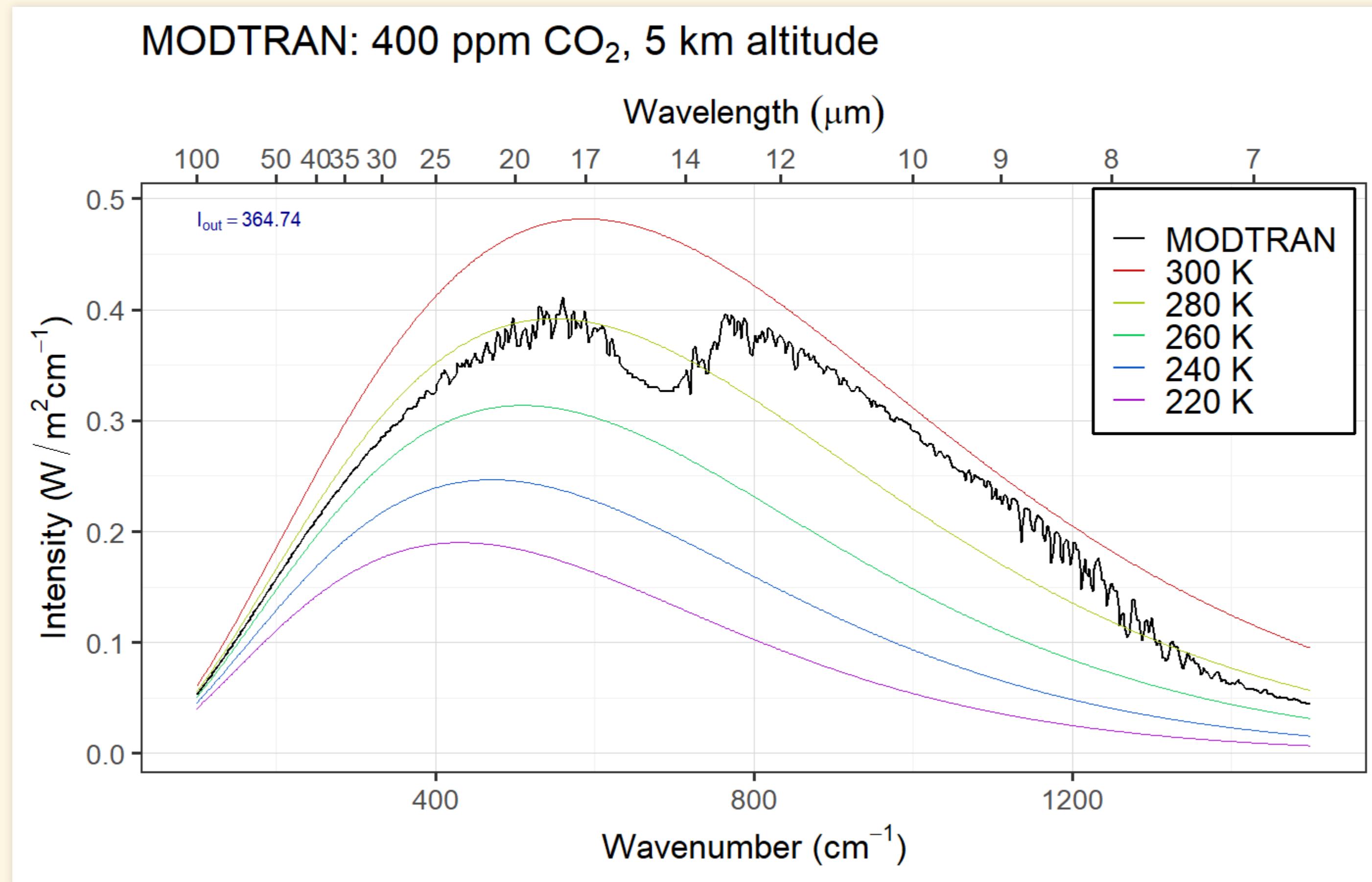
Seen from 3 km



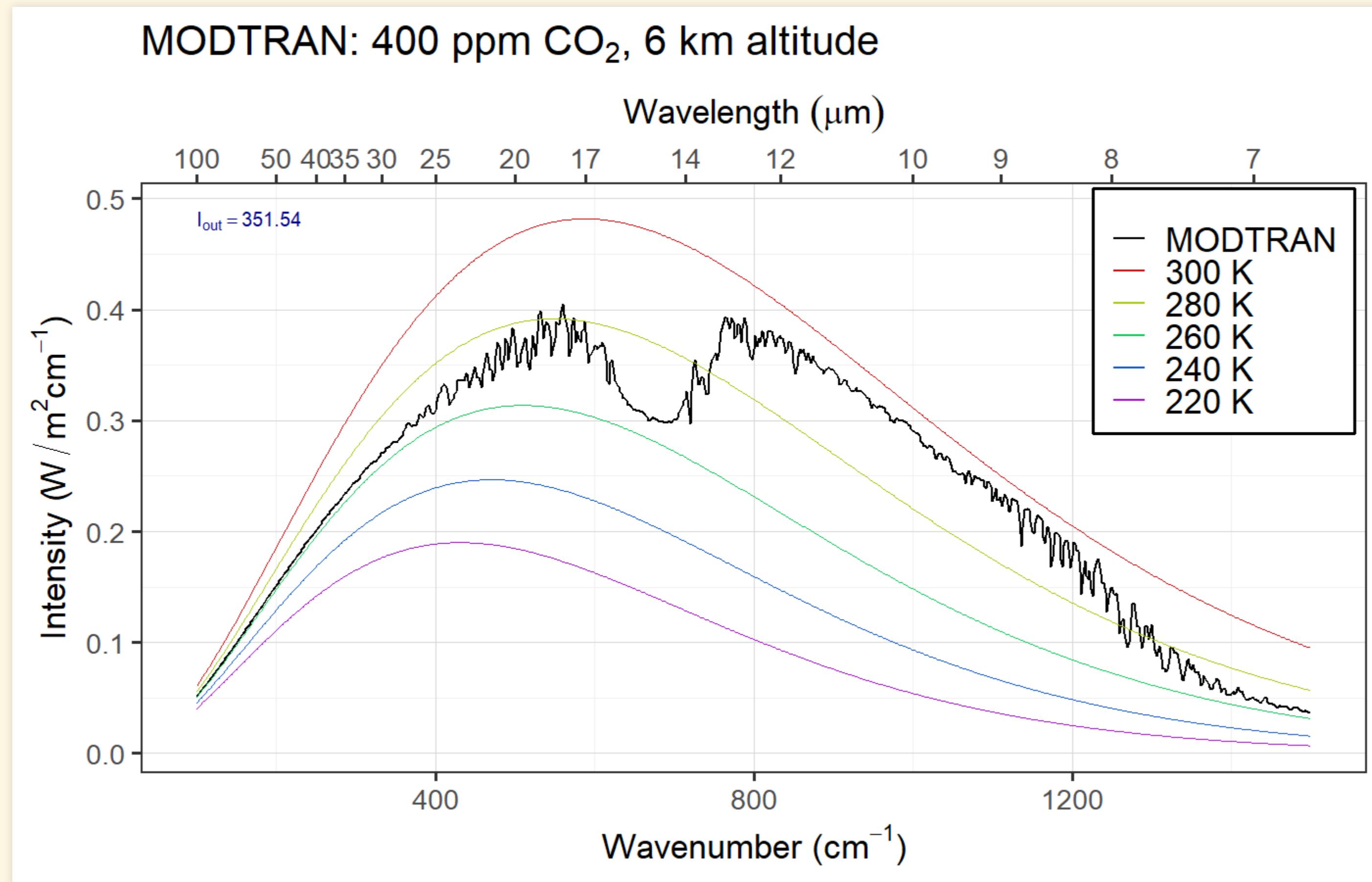
Seen from 4 km



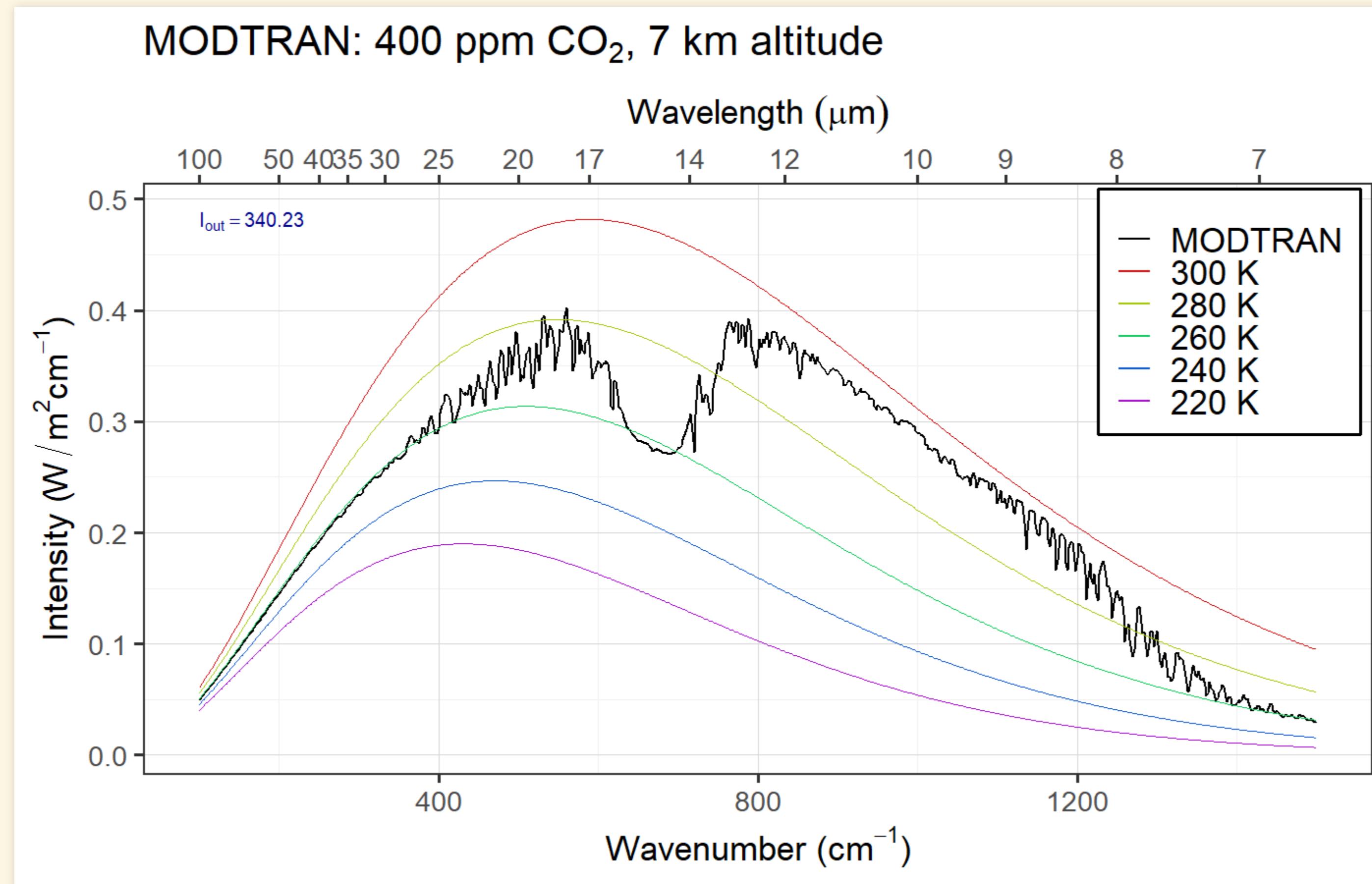
Seen from 5 km



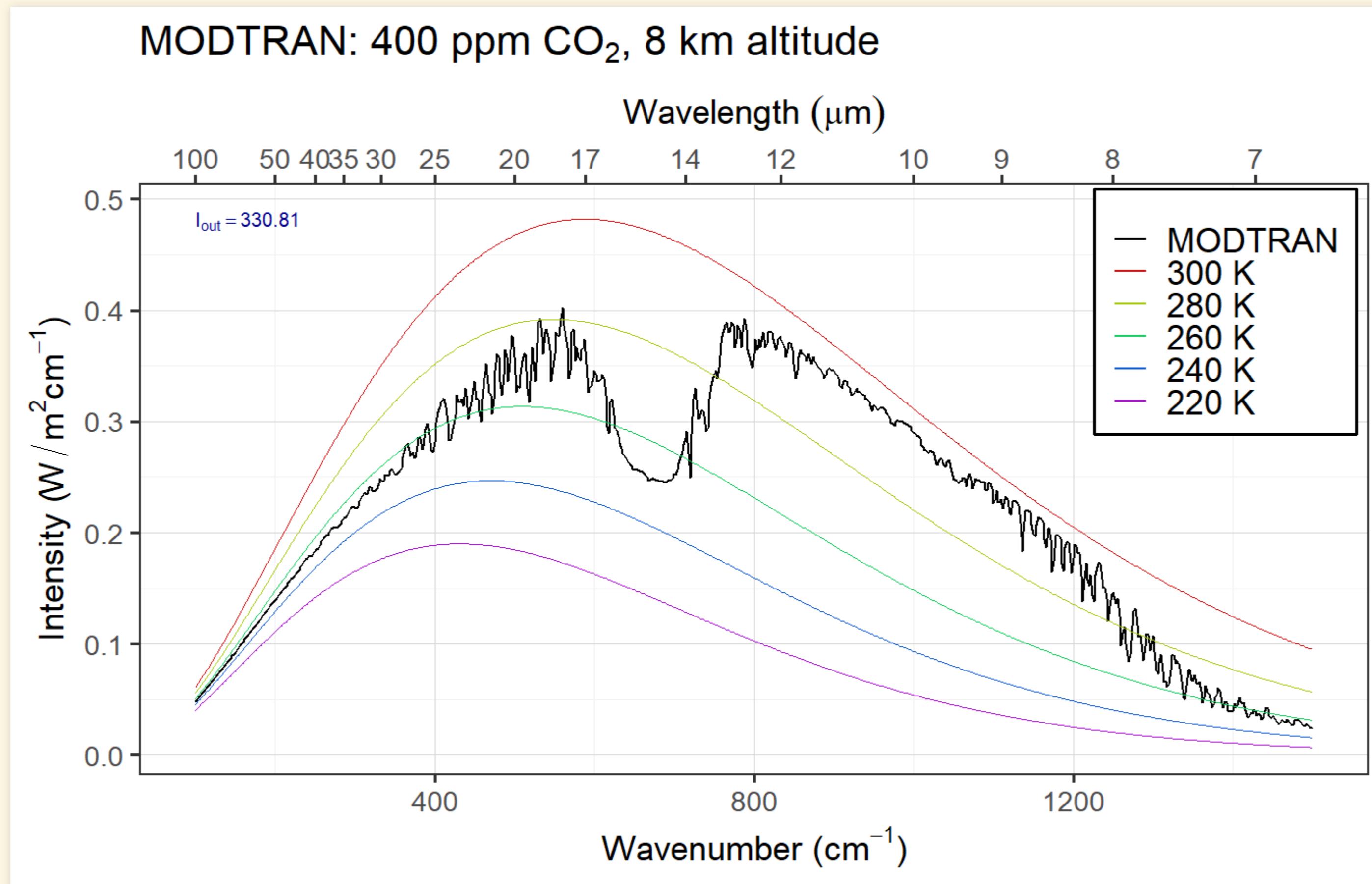
Seen from 6 km



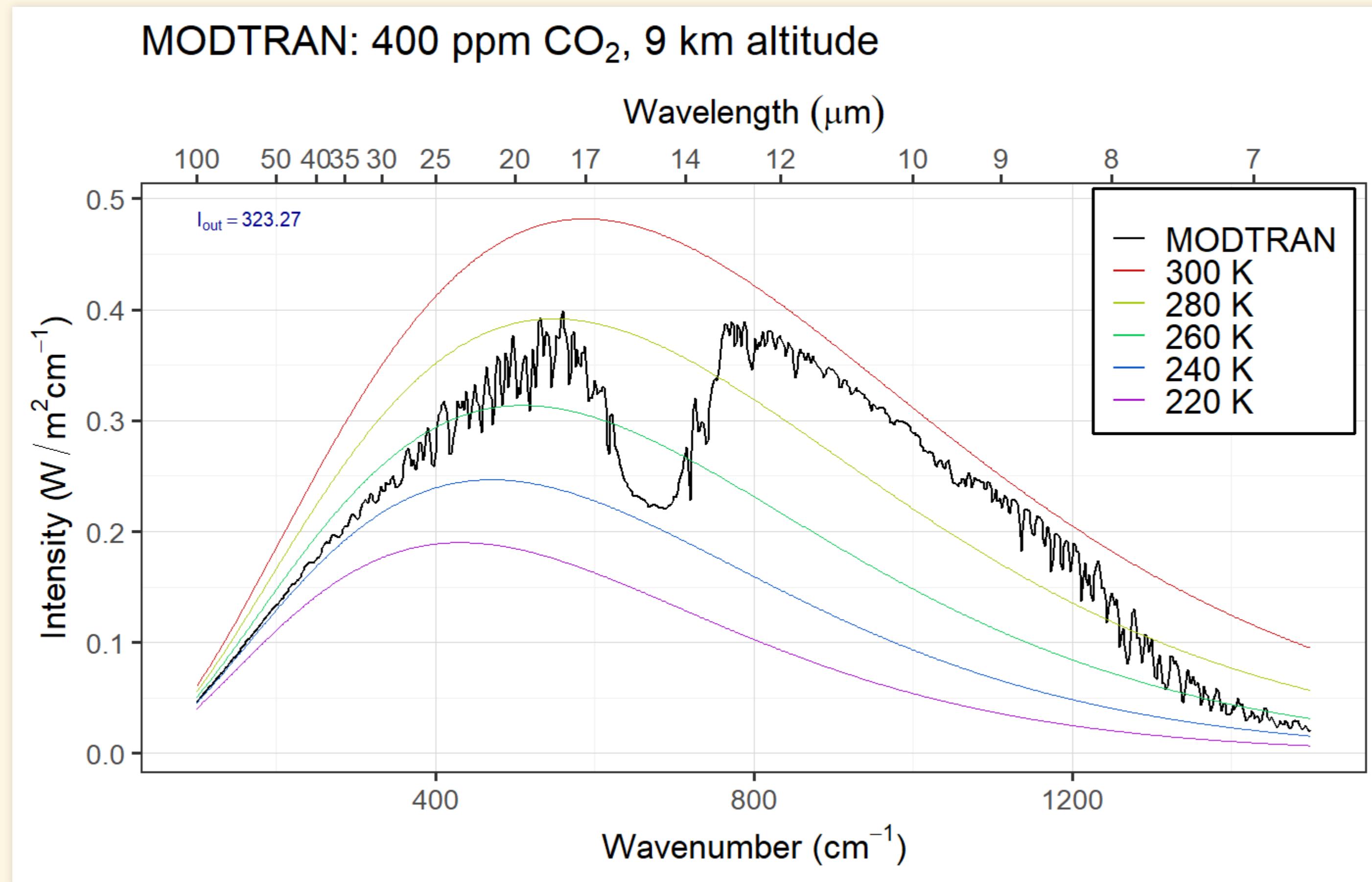
Seen from 7 km



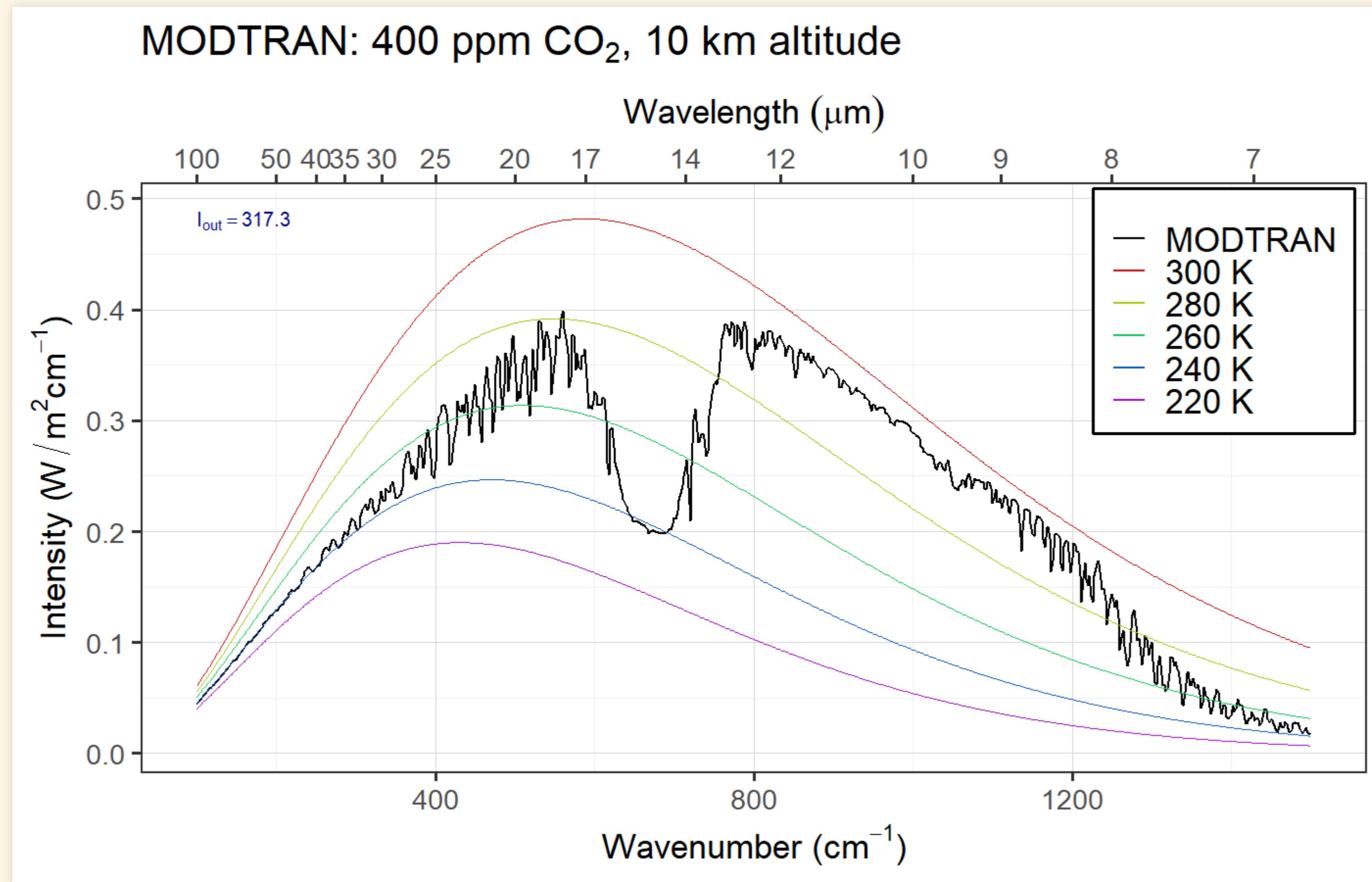
Seen from 8 km



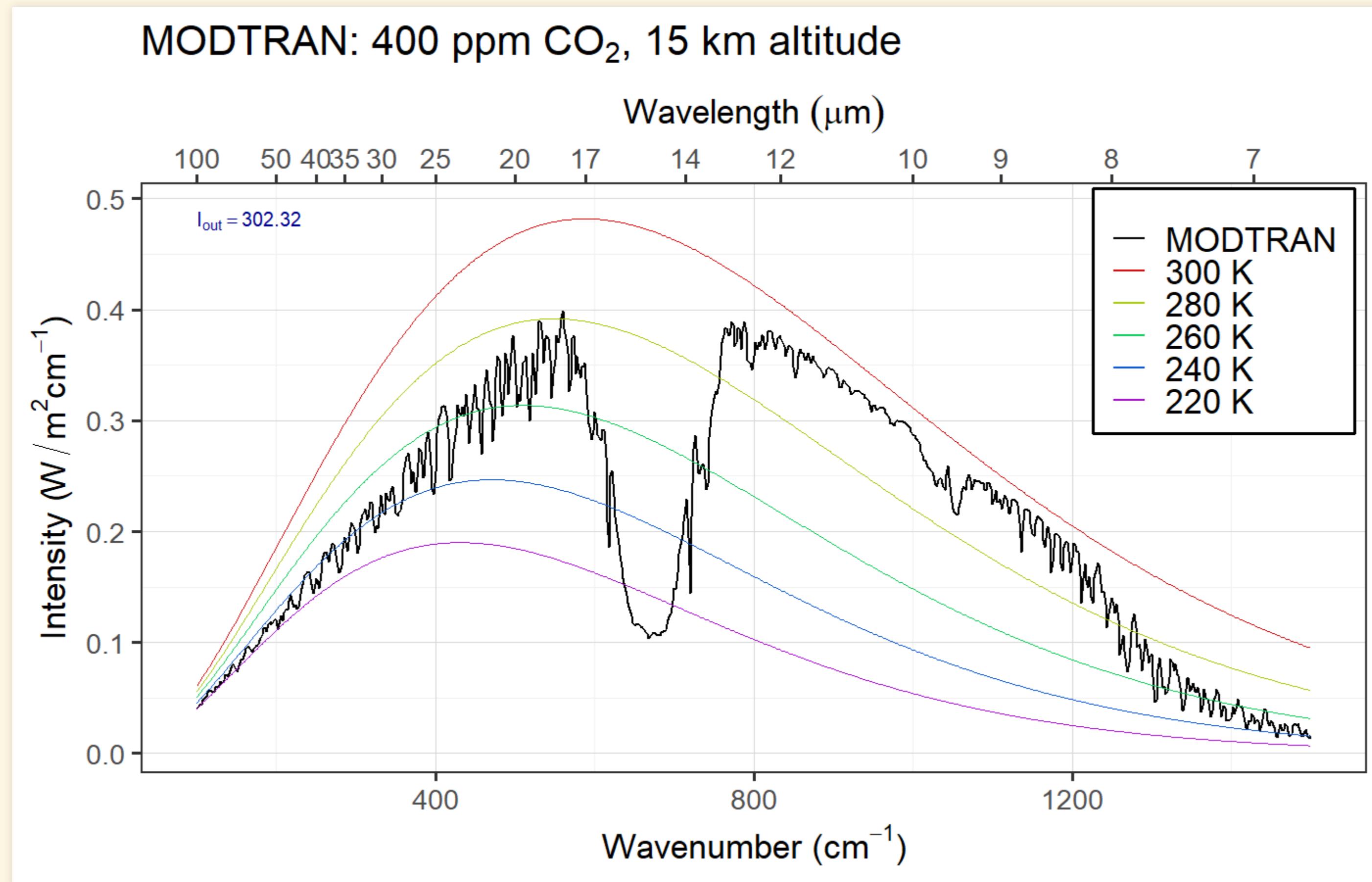
Seen from 9 km



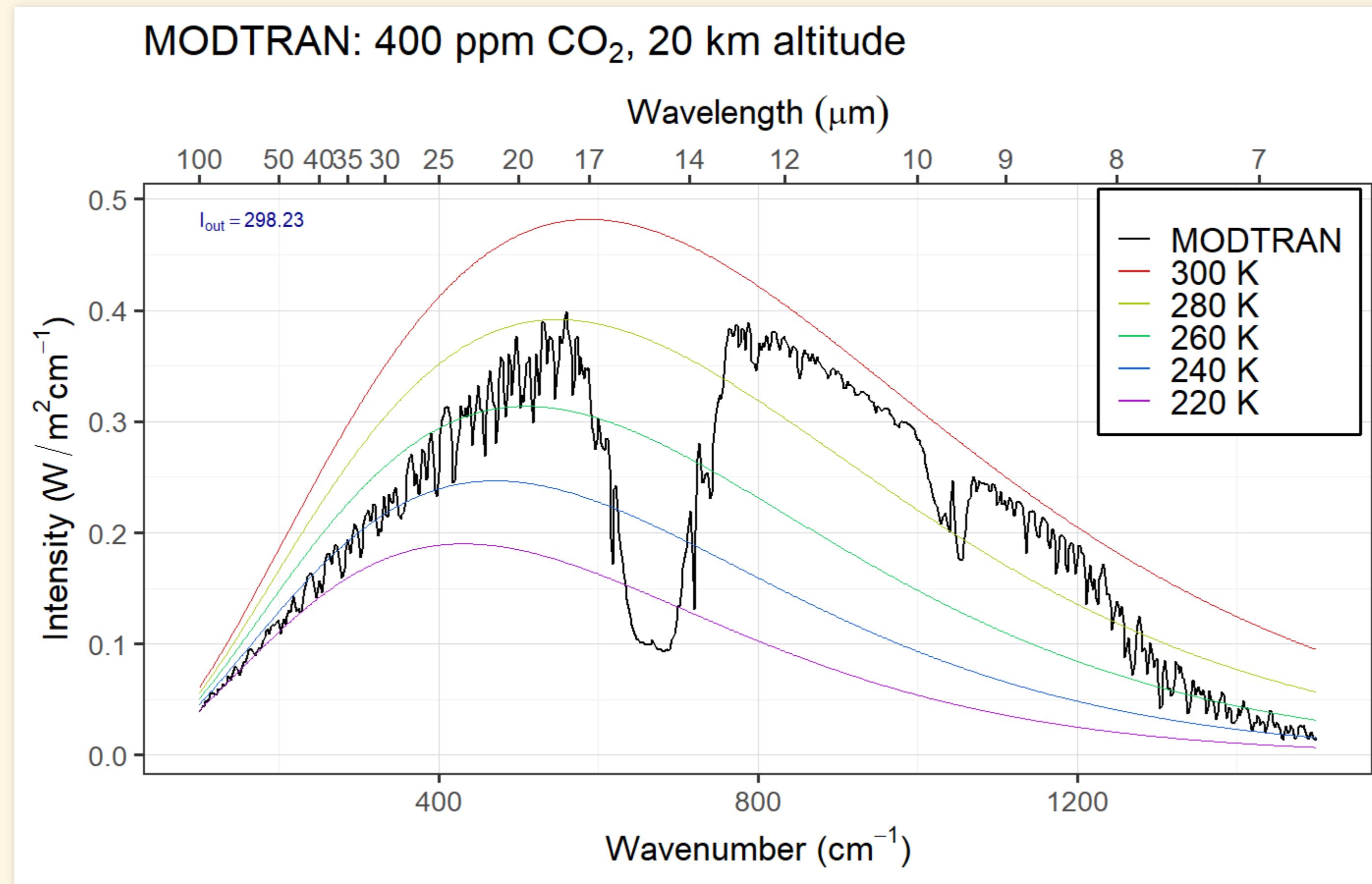
Seen from 10 km



Seen from 15 km



Seen from 20 km



Effect of Doubling CO₂

Double CO₂

- Set Locality to “Tropical Atmosphere”
- Click “Save This Run to Background”
- Note the Upward IR heat flux
- Double the amount of CO₂
- Adjust T offset until new heat flux = background flux
- What is the new ground temperature?

Exercise: Double CO₂

Different Gases

Different Gases

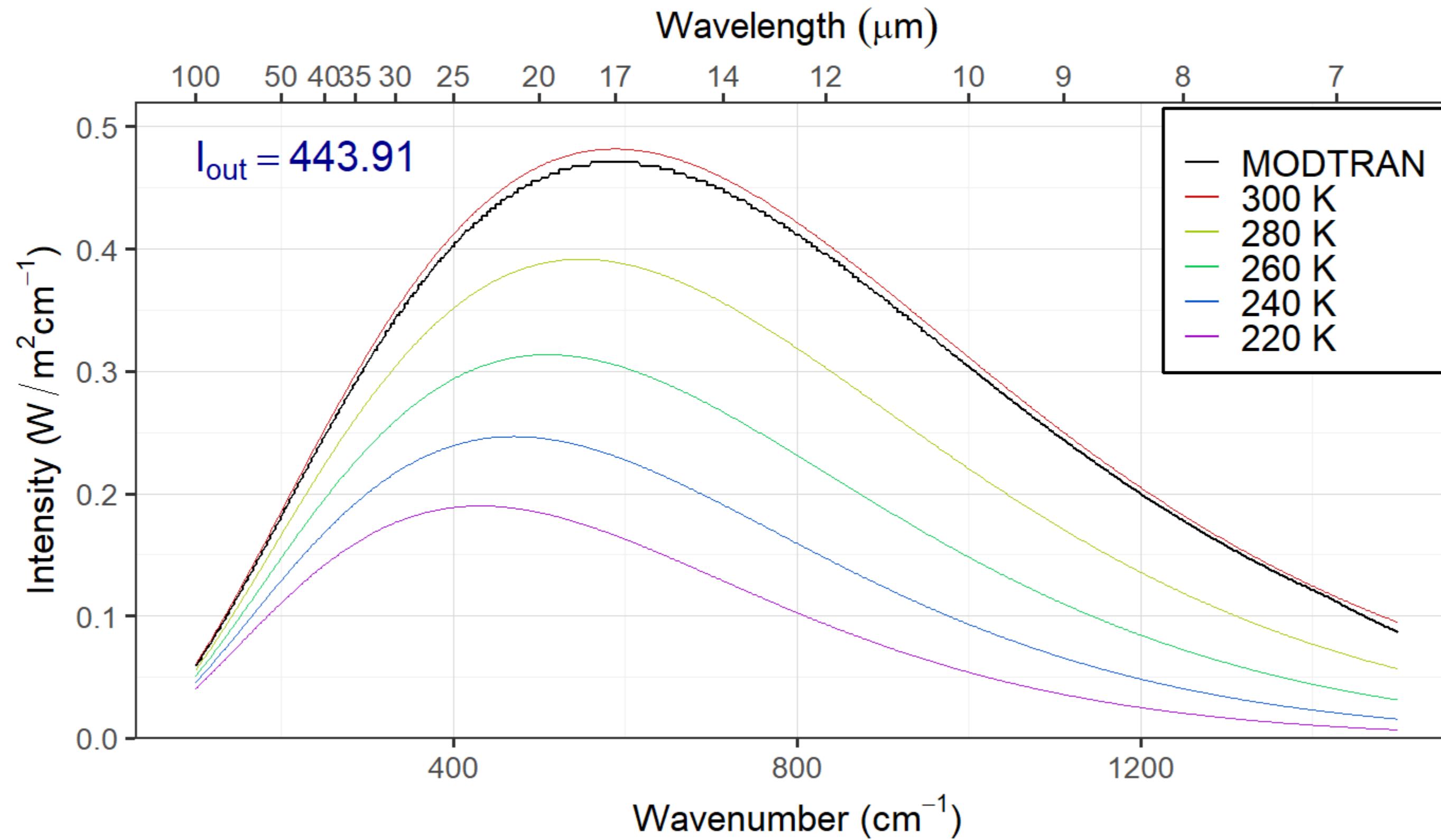
Measuring Greenhouse Effect:

Measuring Greenhouse Effect:

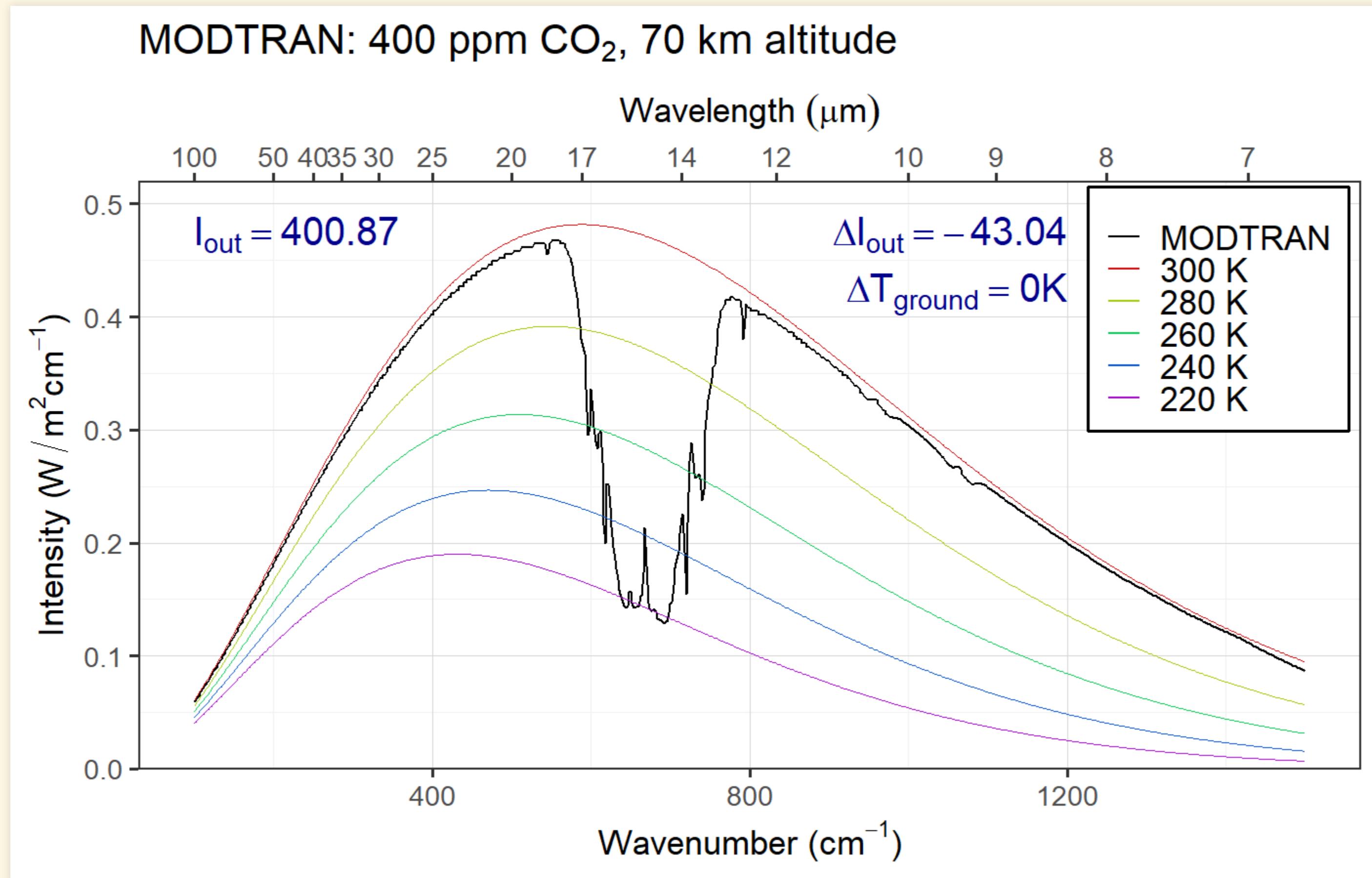
- Go to MODTRAN, set CO₂ to 0 ppm, and set all other gases to zero.
- Set altitude to 70 km and location to “Tropical Atmosphere”.
- Press “Save this run to background”
- Note I_{out}
- Set CO₂ to 400 ppm and note the change in I_{out}
- Adjust the temperature offset to make the difference in $I_{\text{out}}(\text{New} - \text{BG})$ equal zero.

No Greenhouse Gases

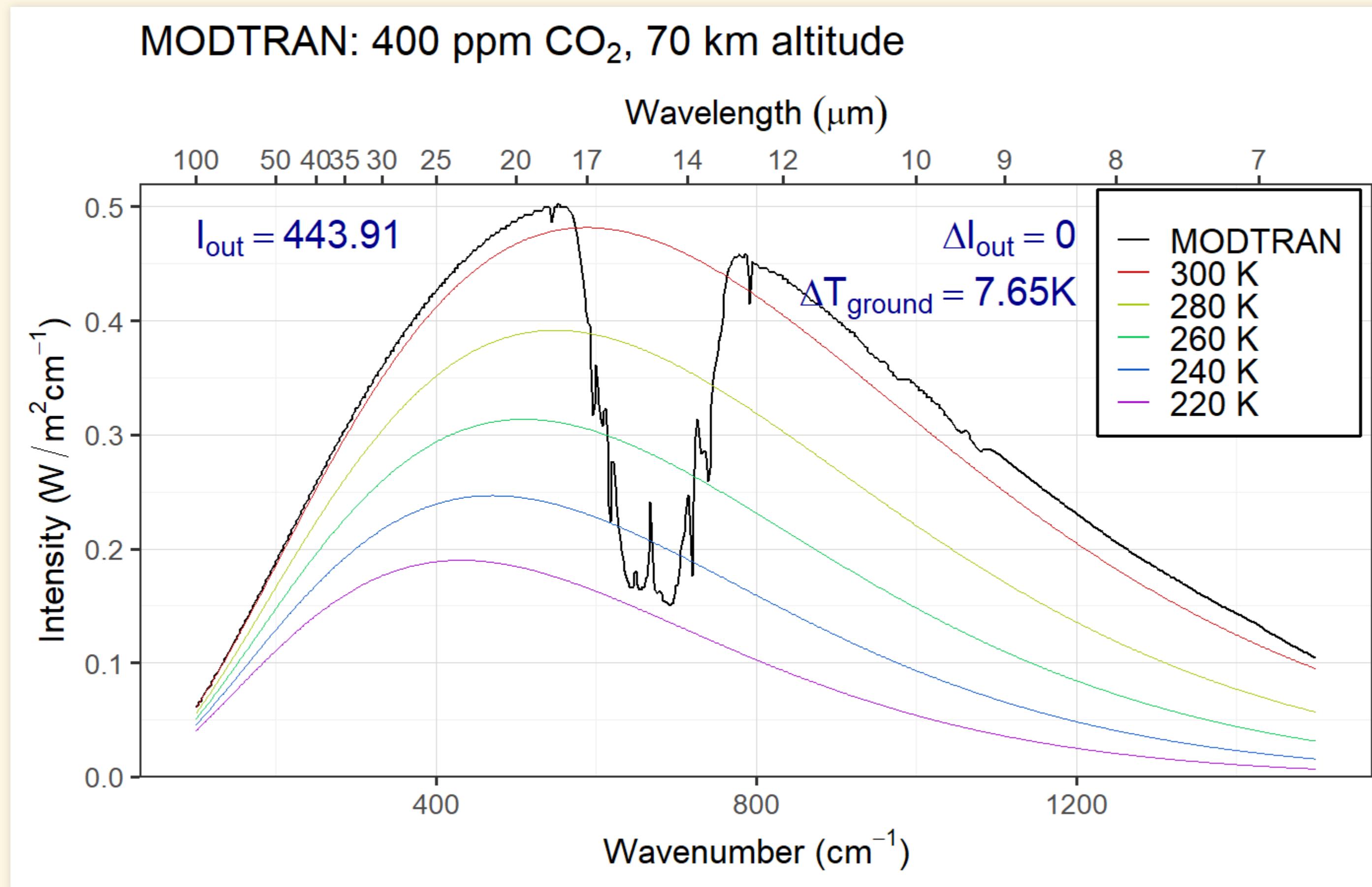
MODTRAN: 0 ppm CO₂, 70 km altitude



400 ppm



Adjust temperature



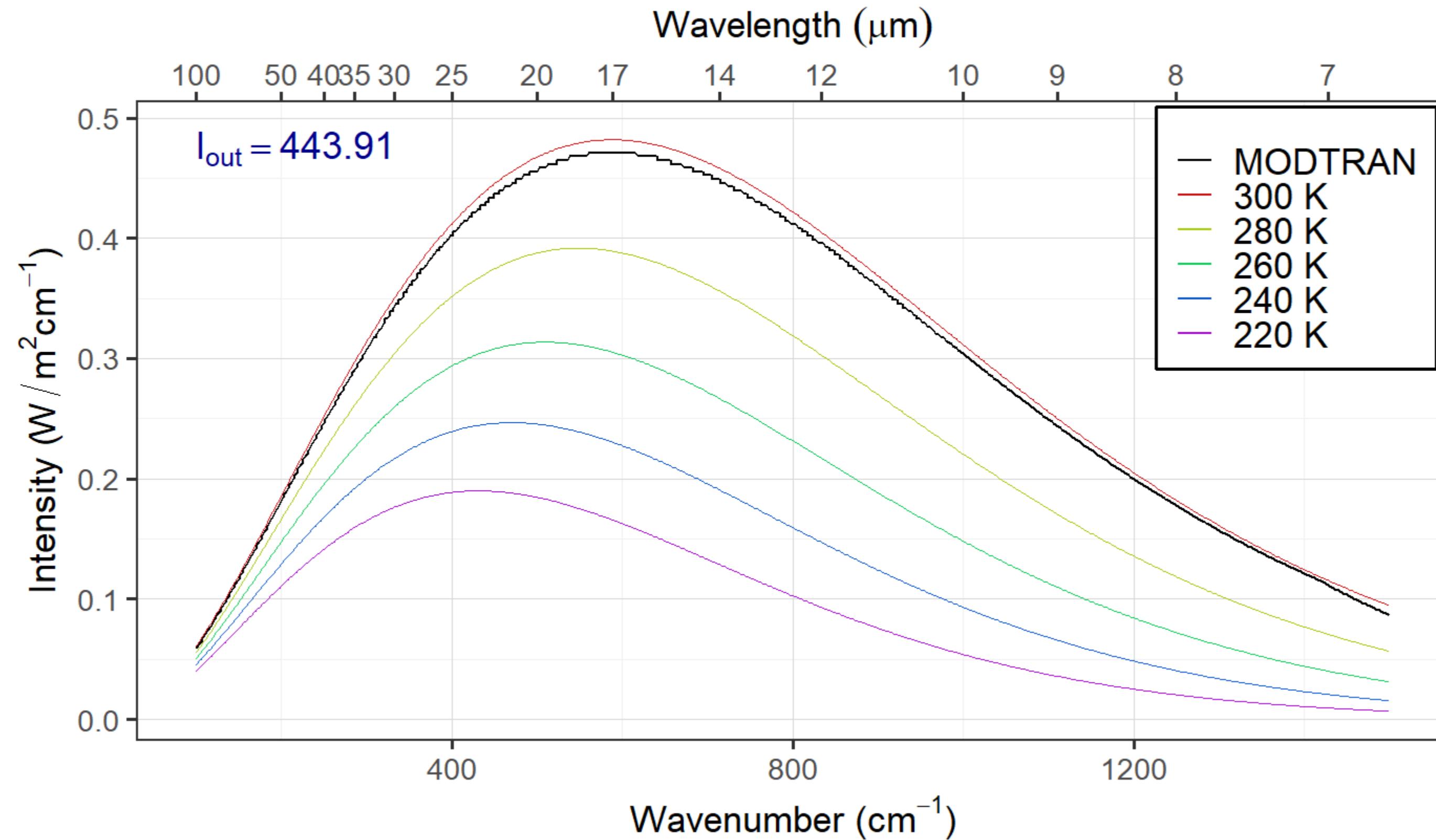
Band Saturation

Set up MODTRAN:

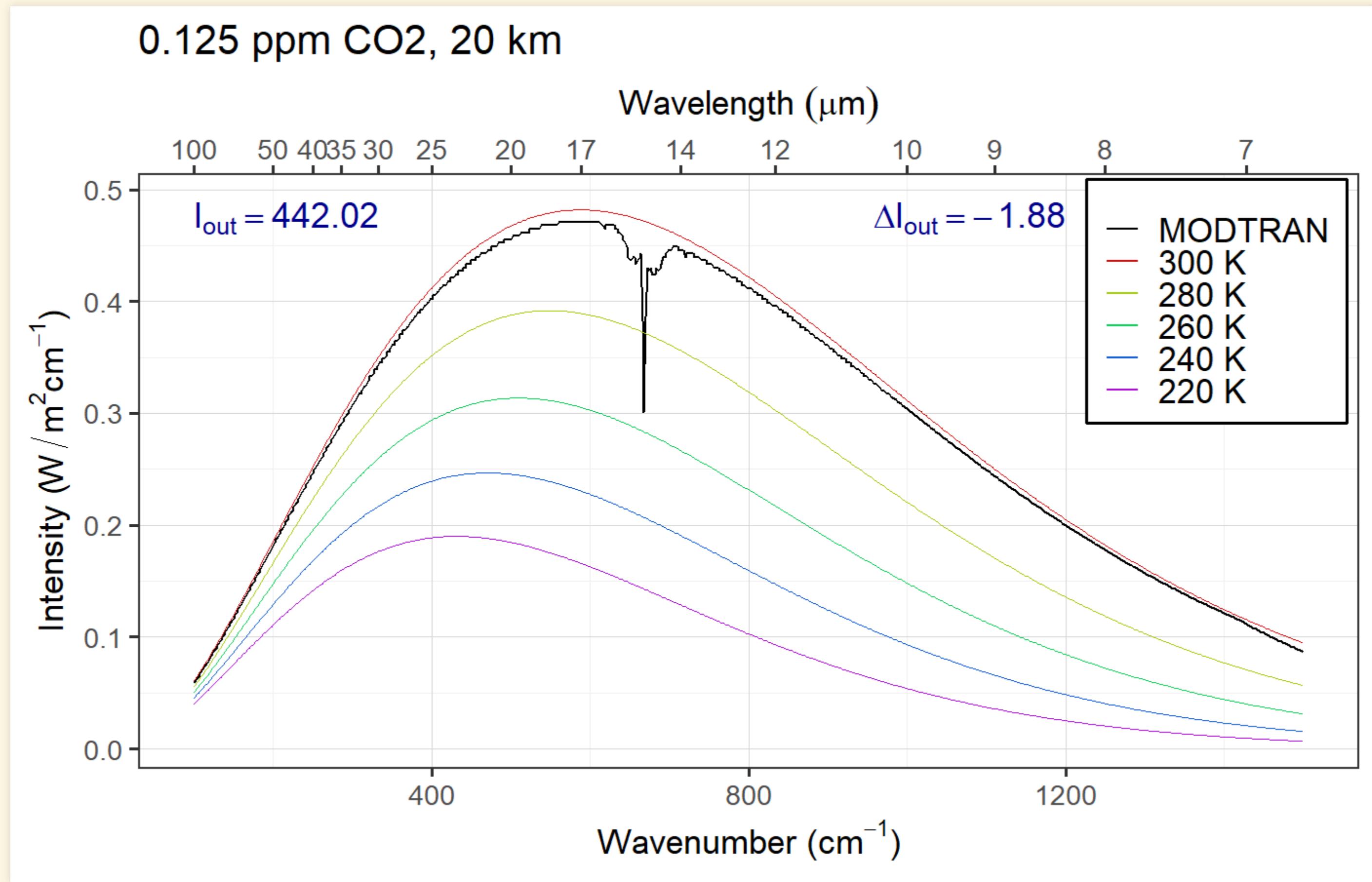
- Set “Location” to “Tropical Atmosphere”
- Set All greenhouse gases to zero
- Set altitude to 20 km

No CO₂

0 ppm CO₂, 20 km

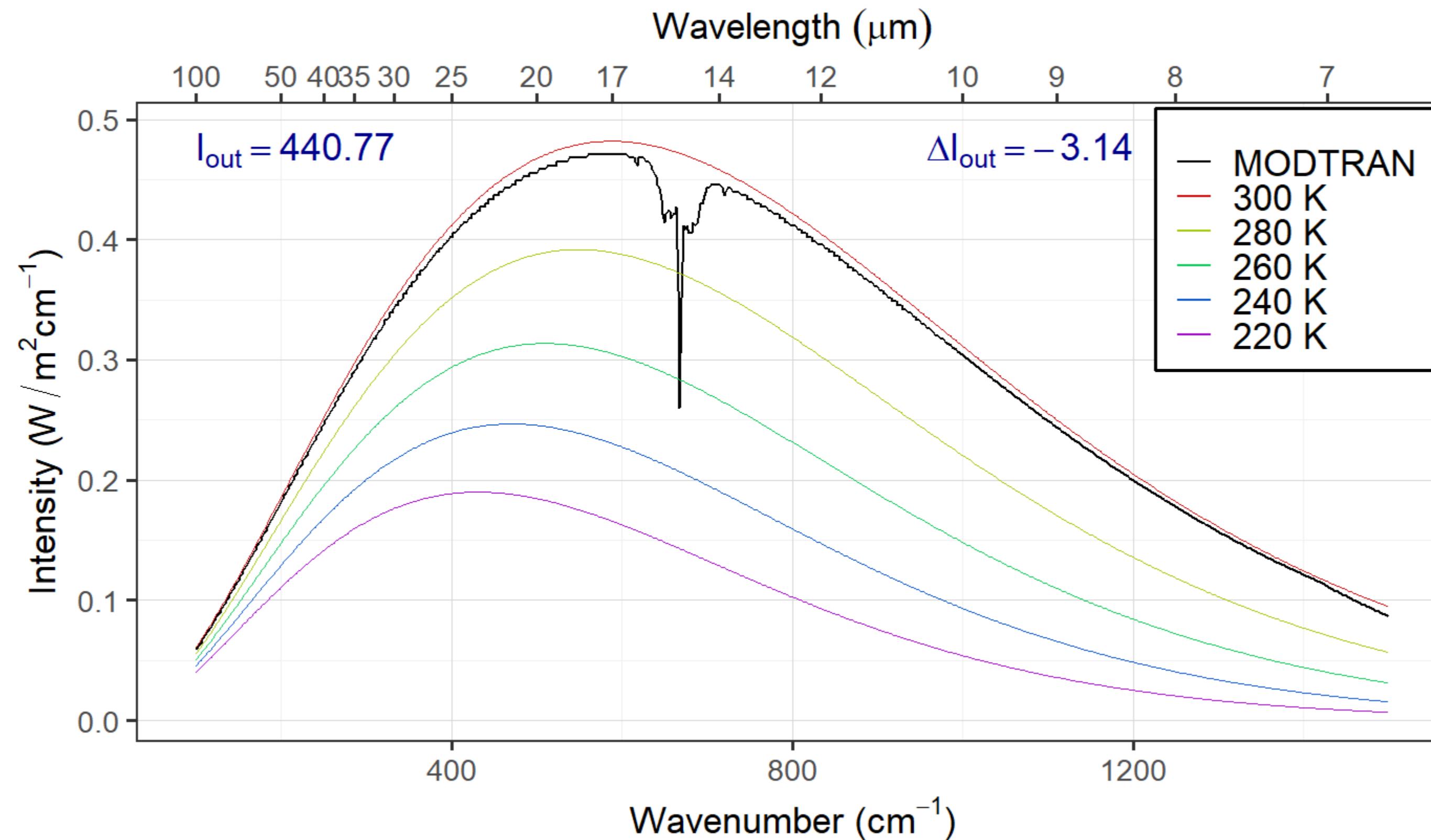


0.125 ppm CO₂

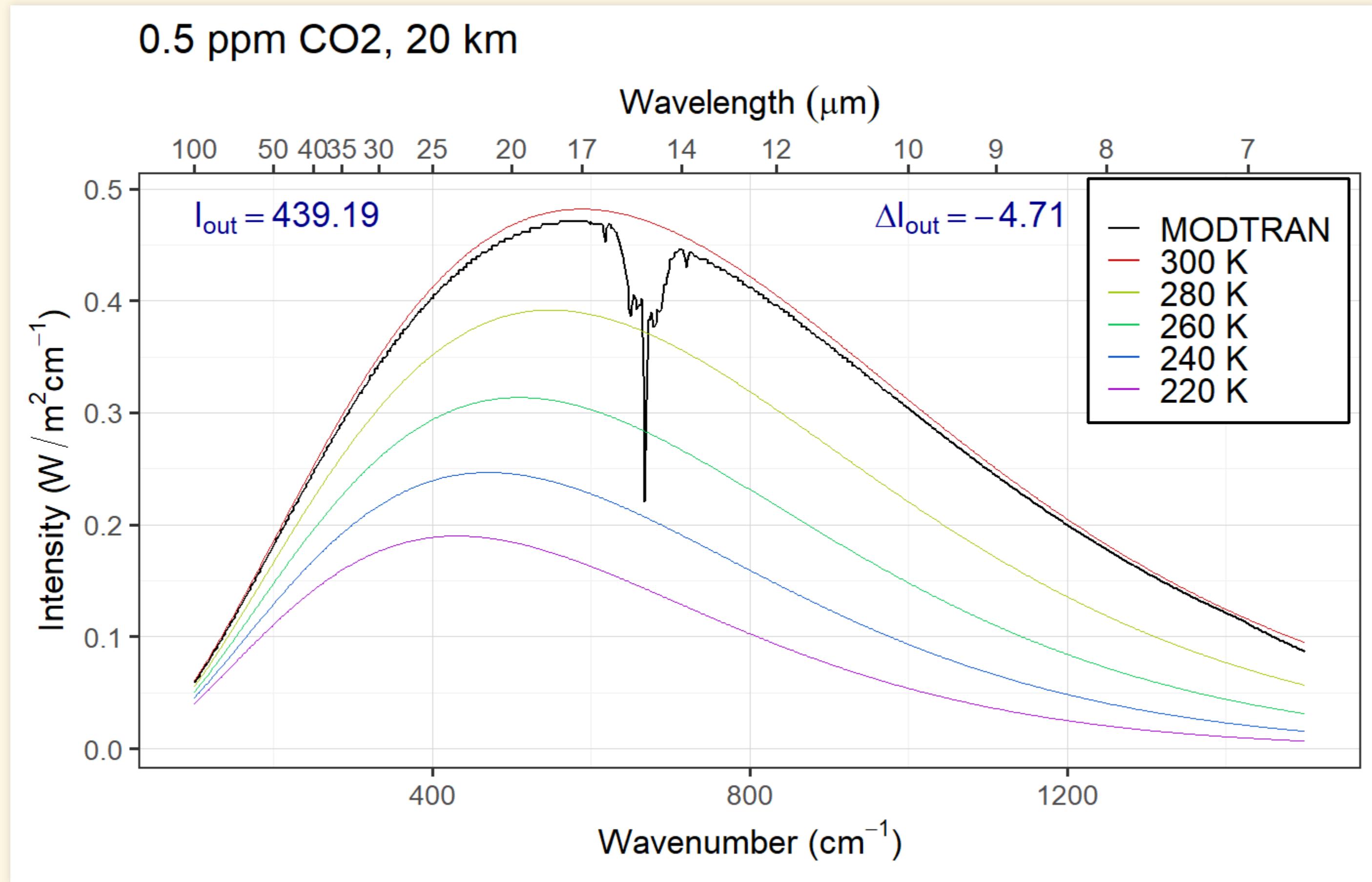


0.25 ppm CO₂

0.25 ppm CO₂, 20 km

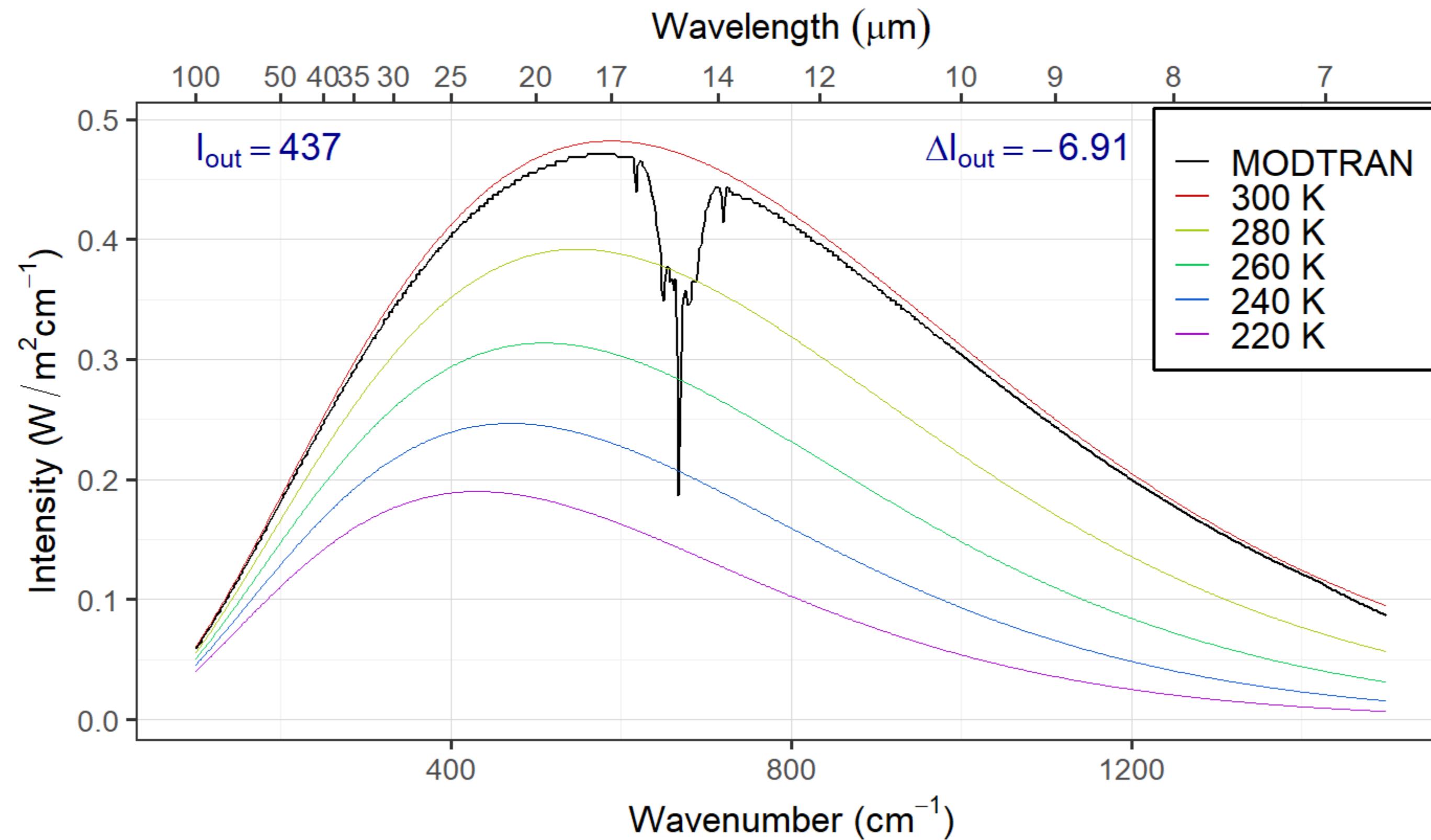


0.5 ppm CO₂

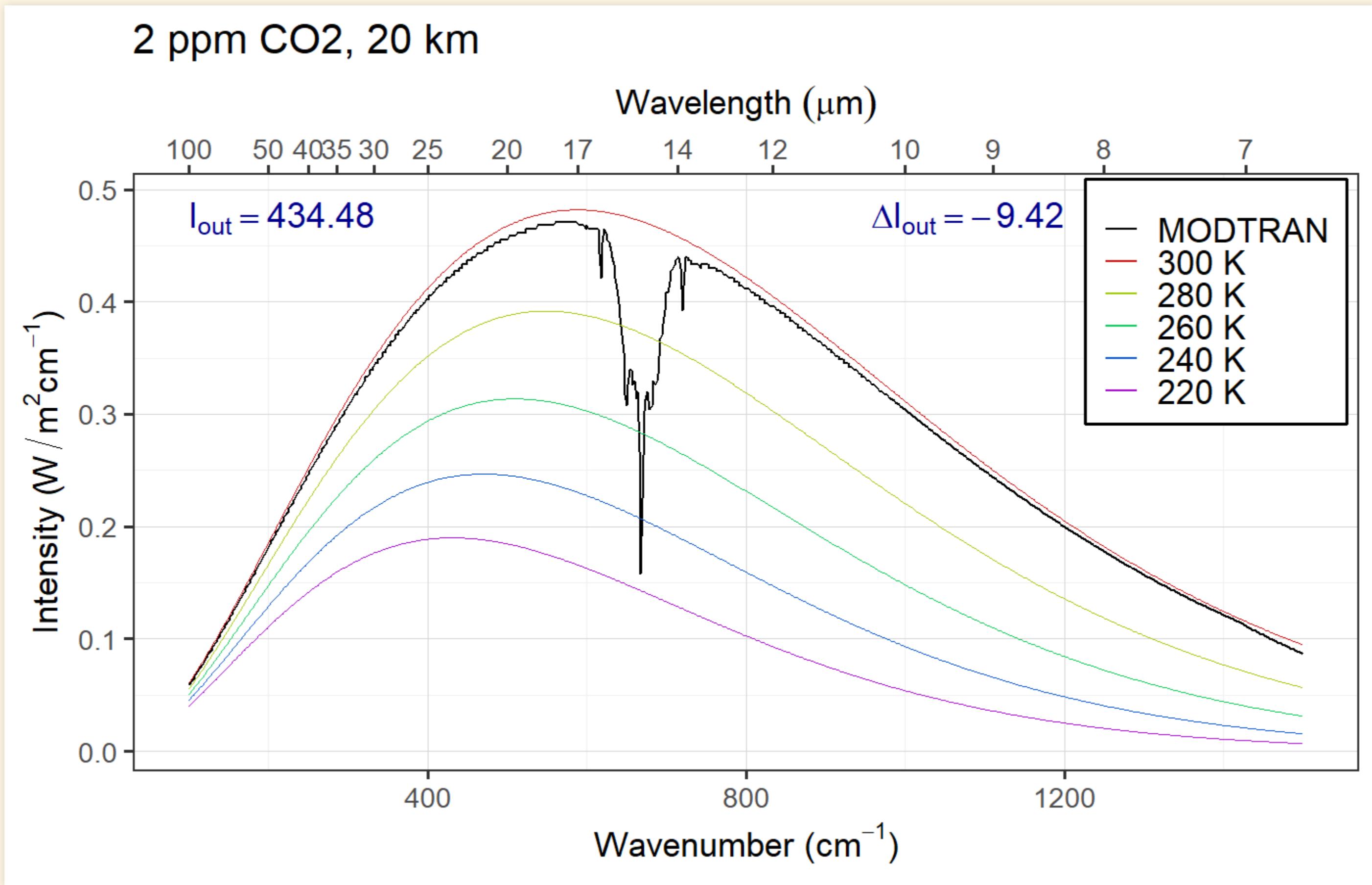


1 ppm CO₂

1 ppm CO₂, 20 km

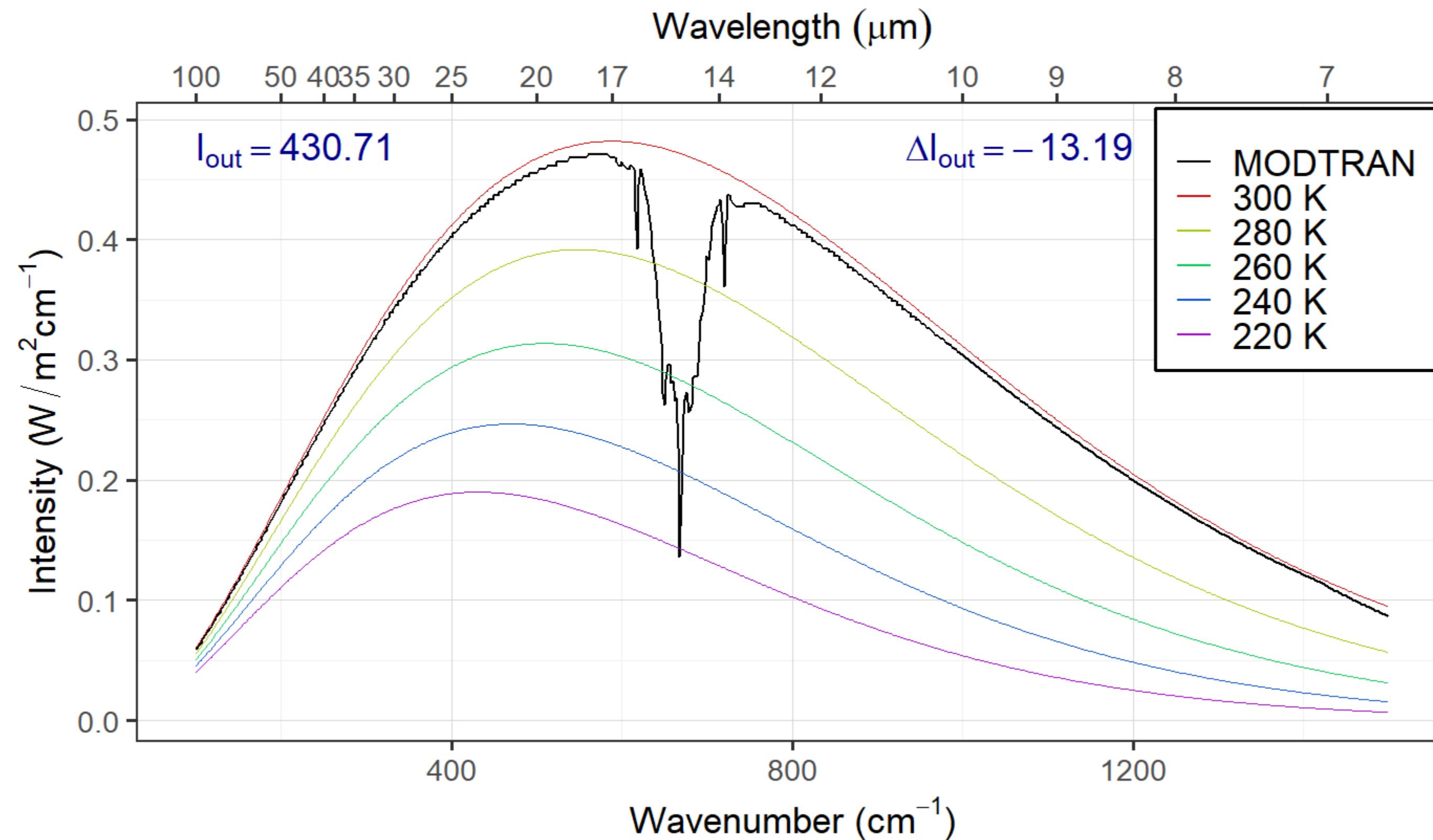


2 ppm CO₂



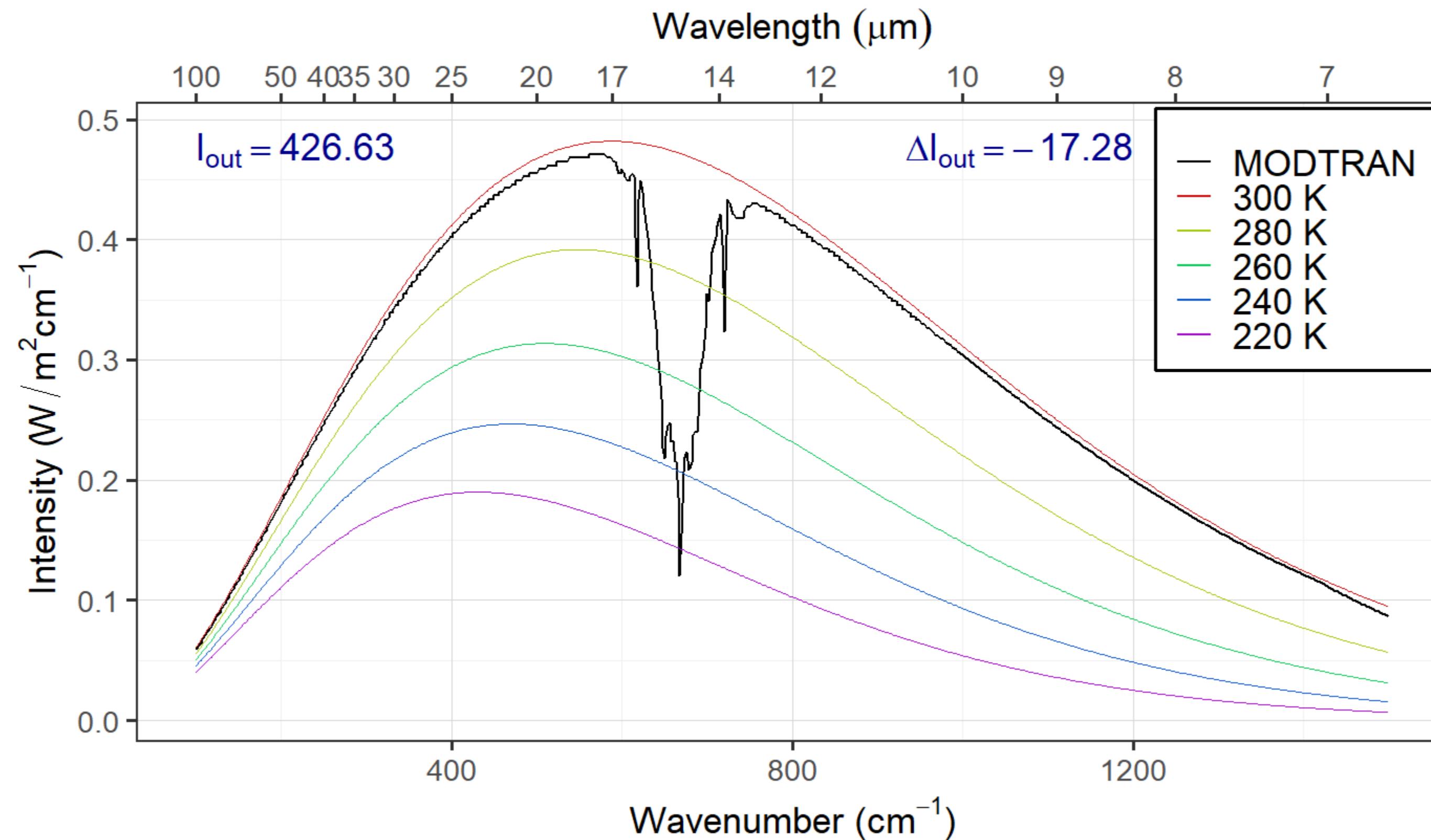
4 ppm CO₂

4 ppm CO₂, 20 km



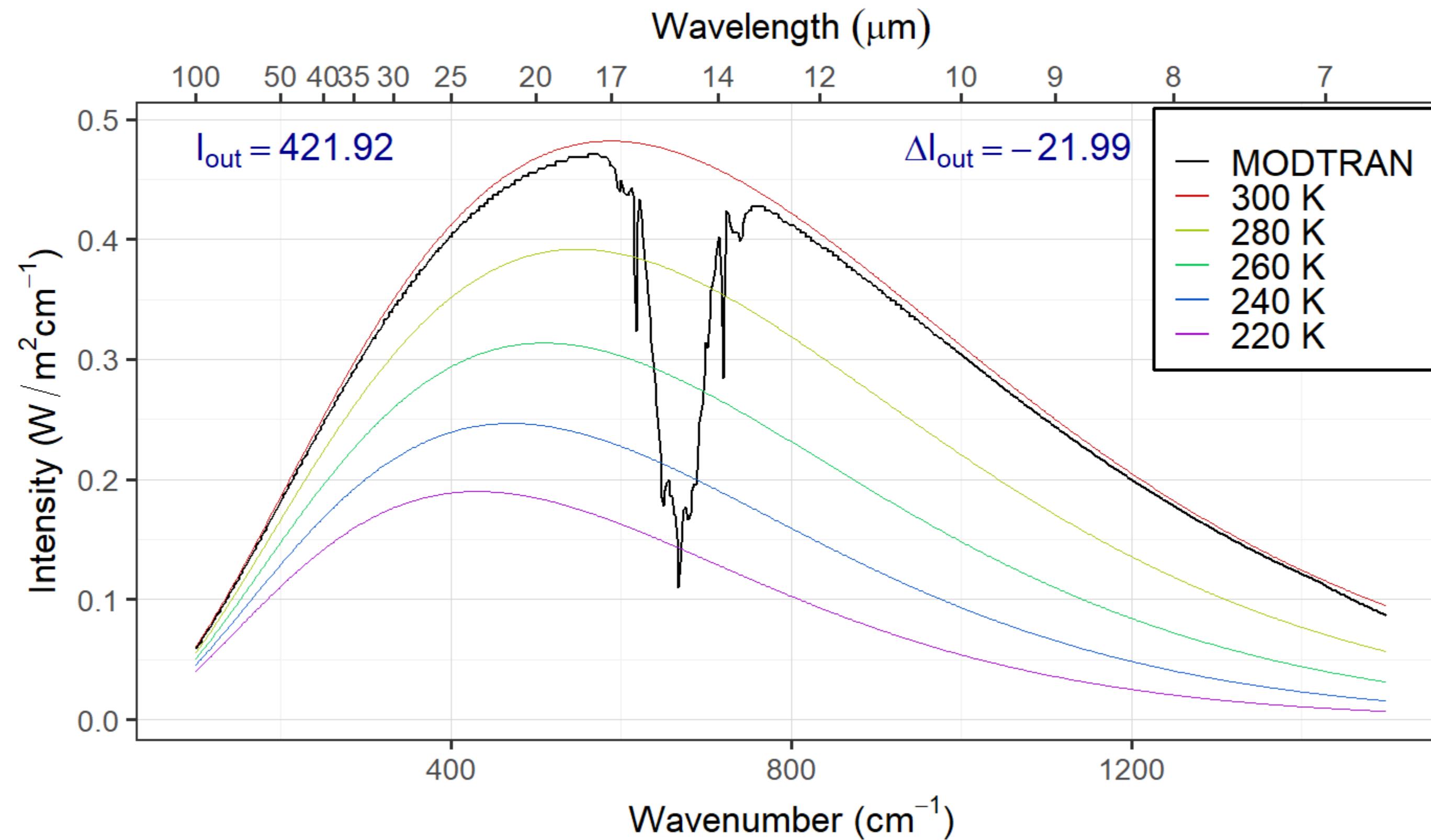
8 ppm CO₂

8 ppm CO₂, 20 km



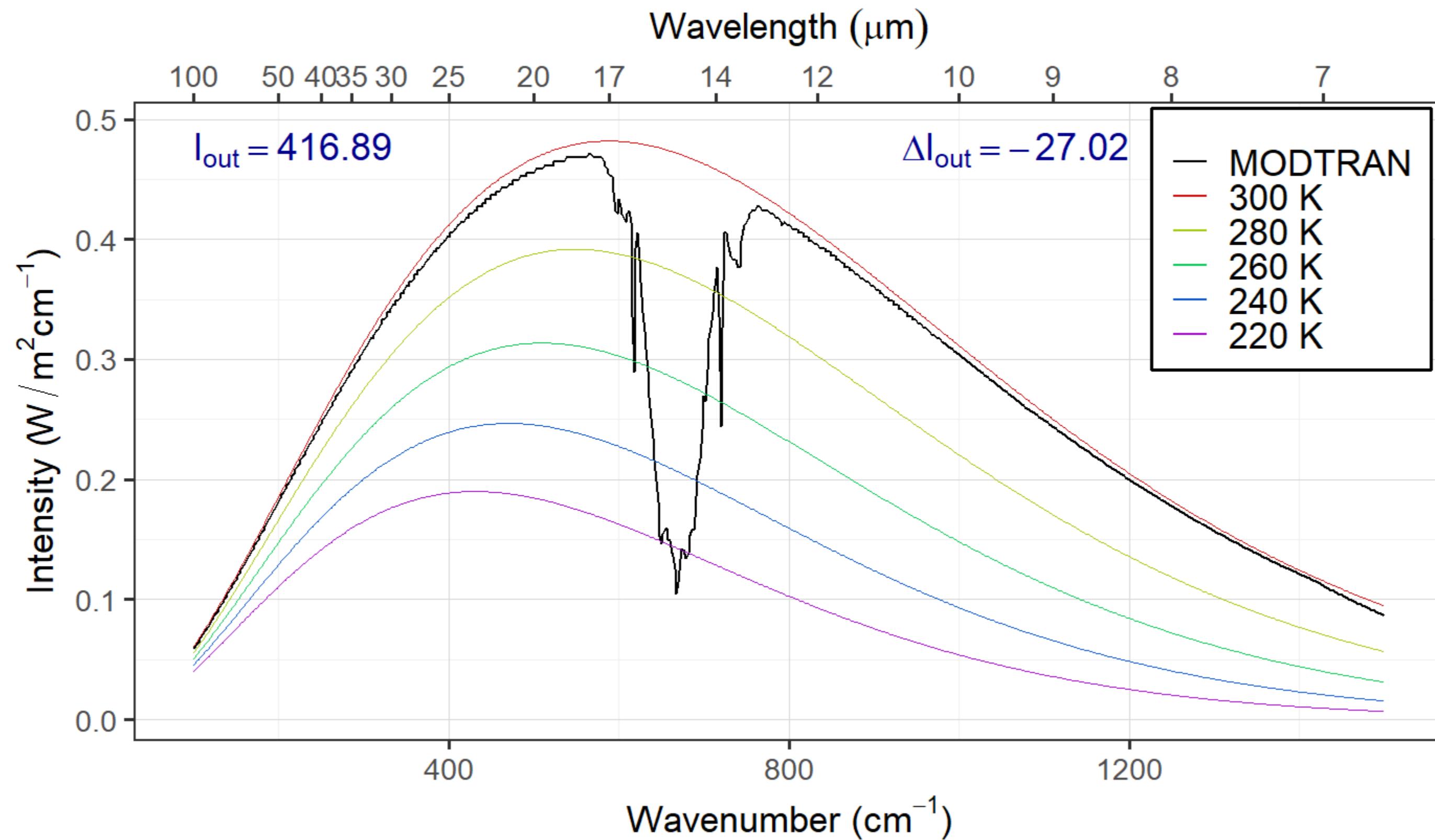
16 ppm CO₂

16 ppm CO₂, 20 km



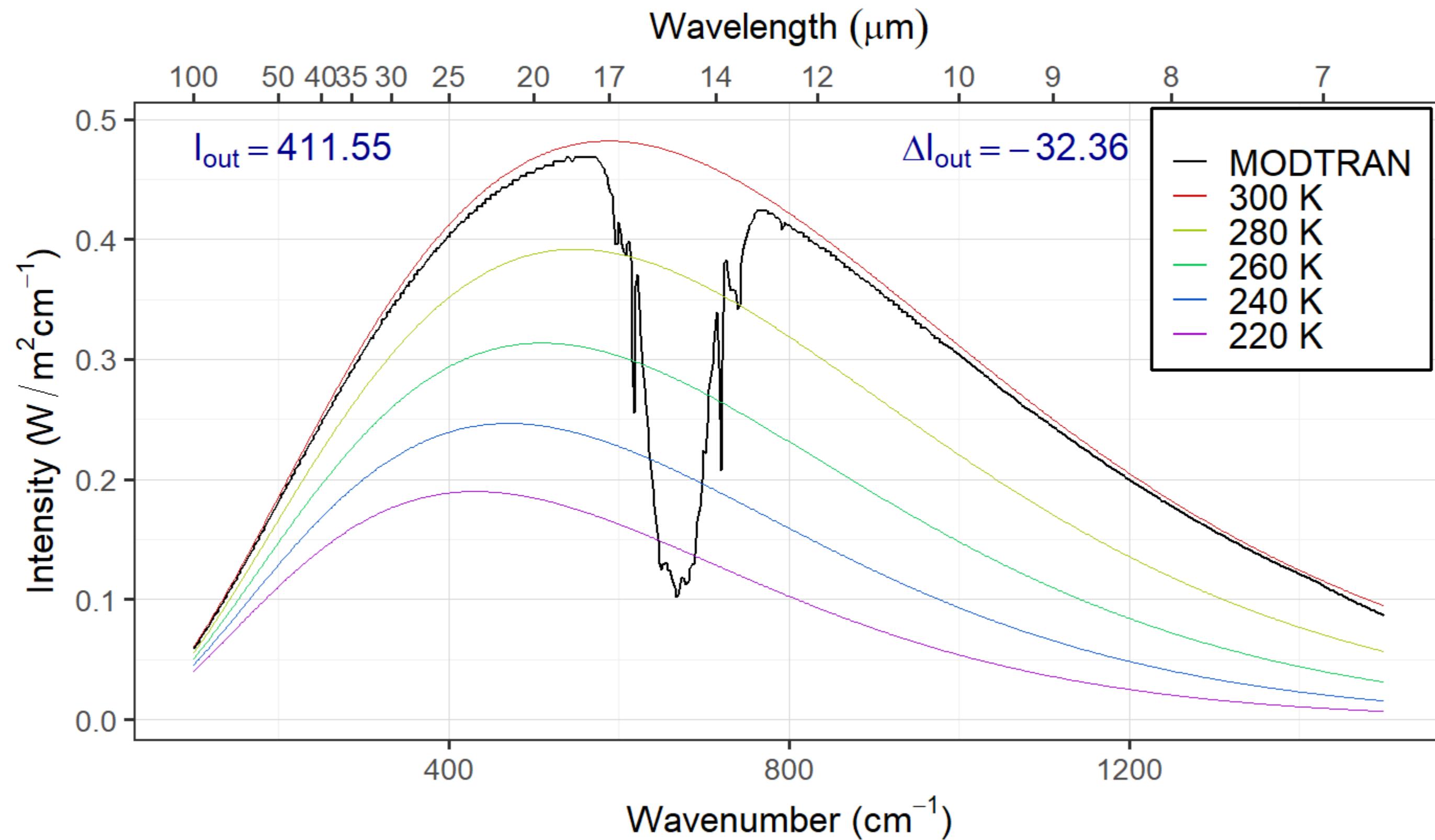
32 ppm CO₂

32 ppm CO₂, 20 km



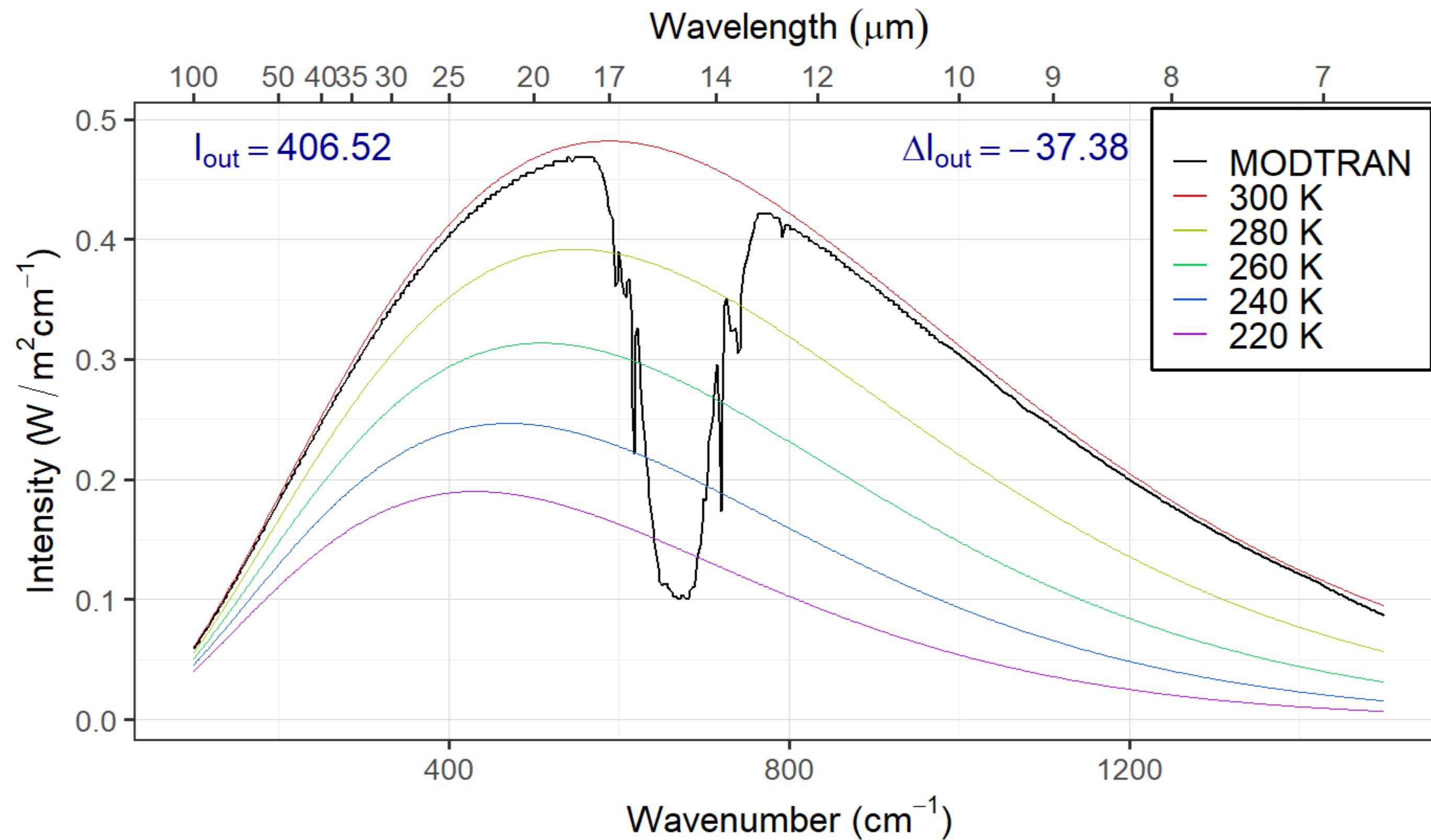
64 ppm CO₂

64 ppm CO₂, 20 km



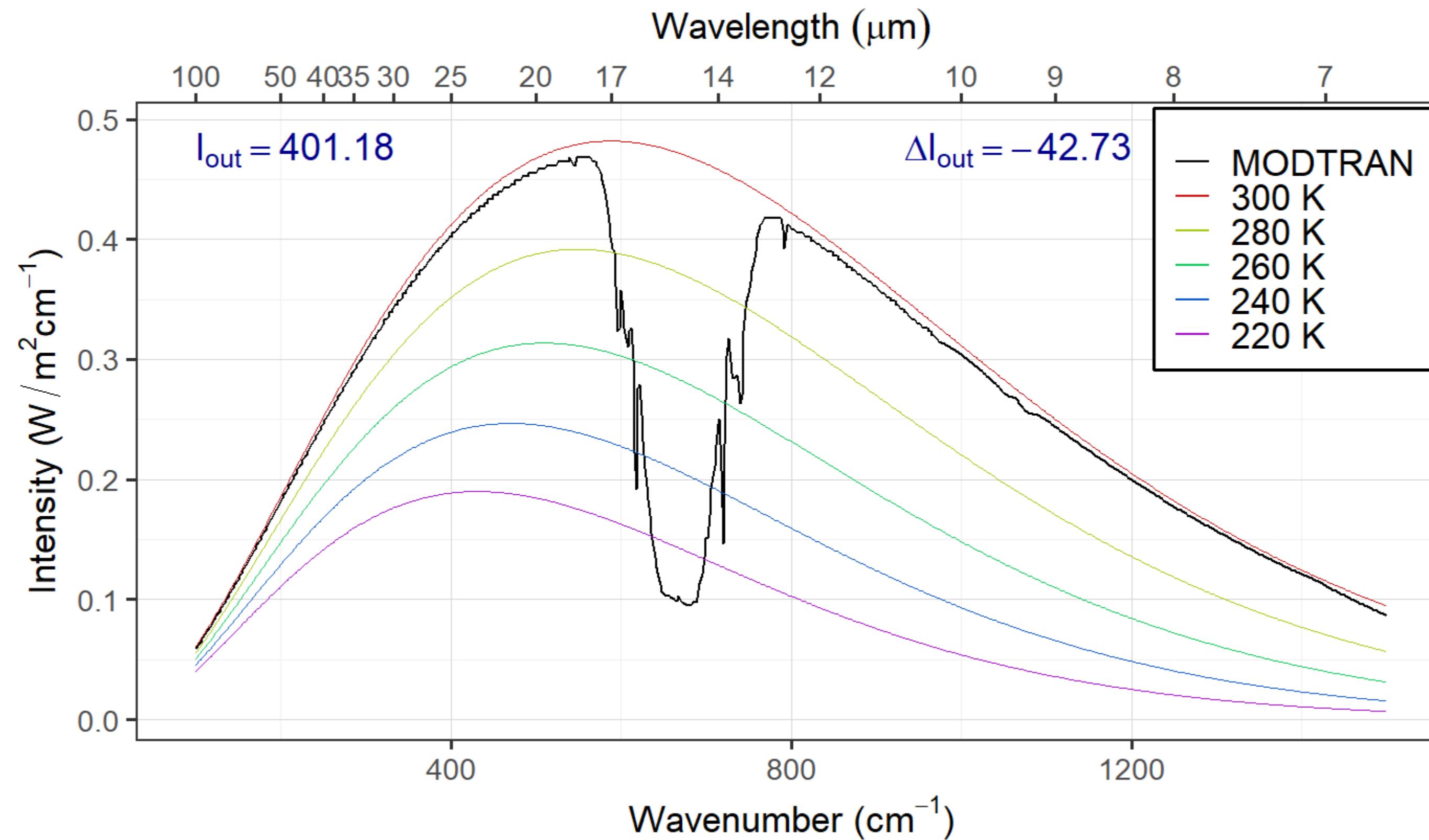
128 ppm CO₂

128 ppm CO₂, 20 km



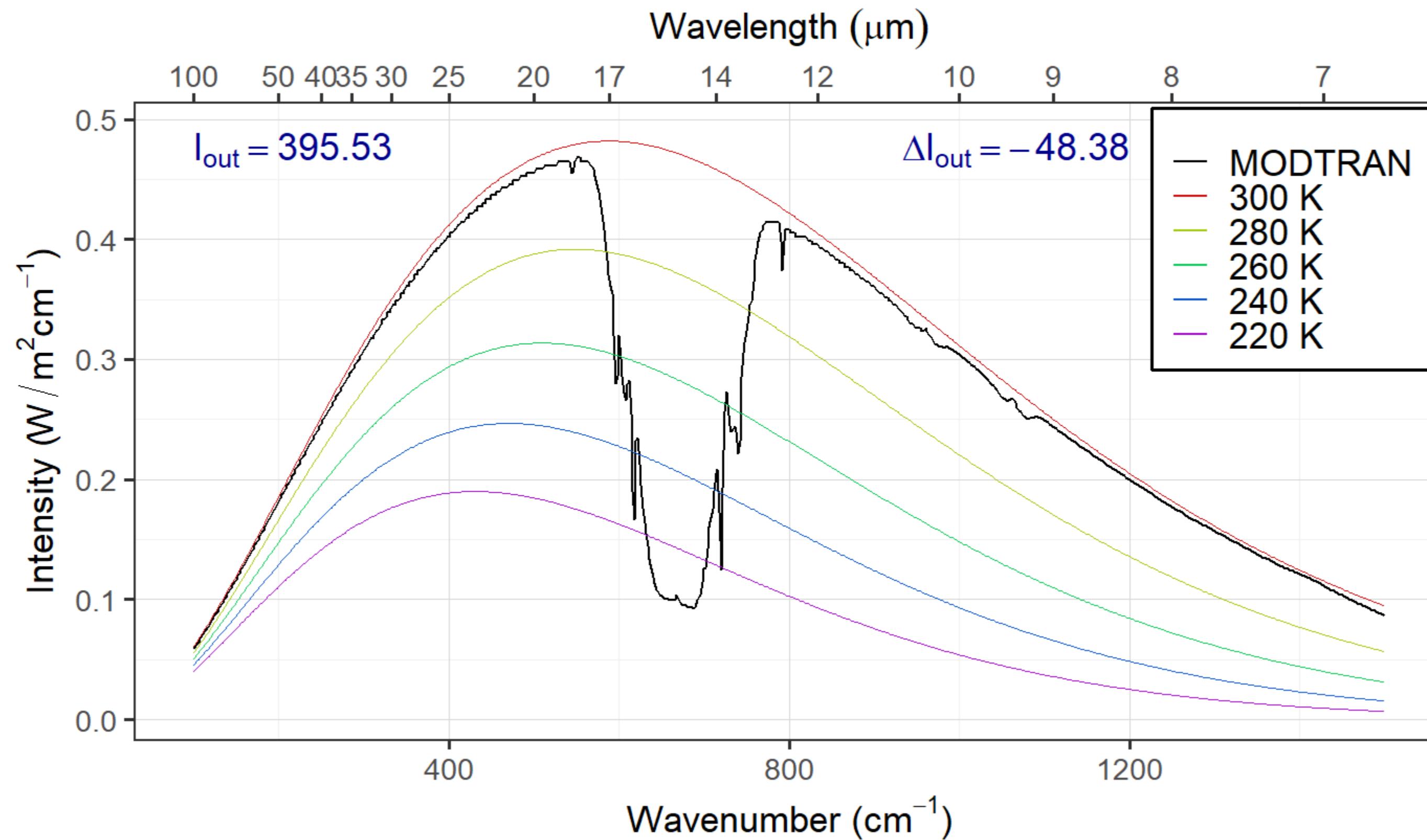
256 ppm CO₂

256 ppm CO₂, 20 km



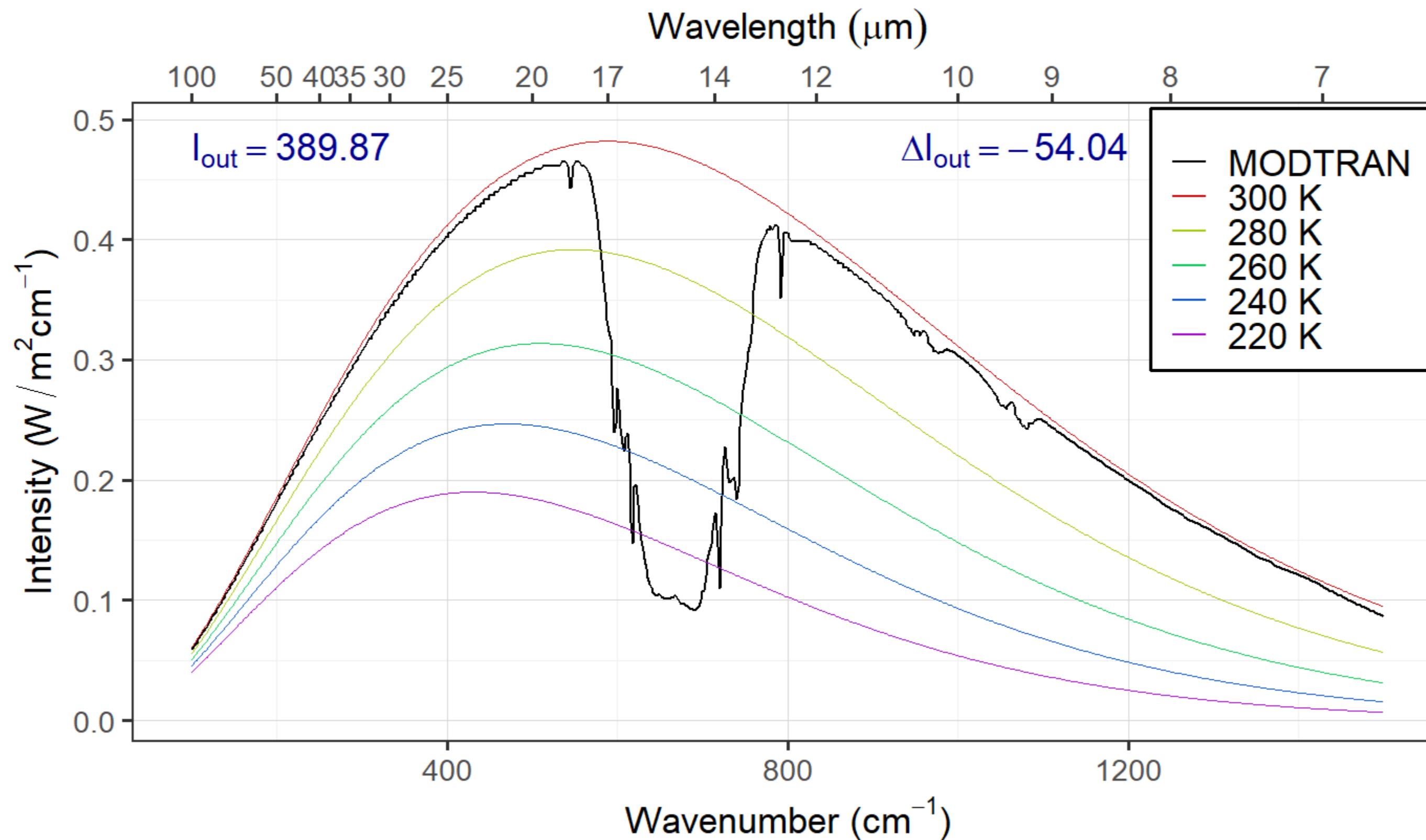
512 ppm CO₂

512 ppm CO₂, 20 km

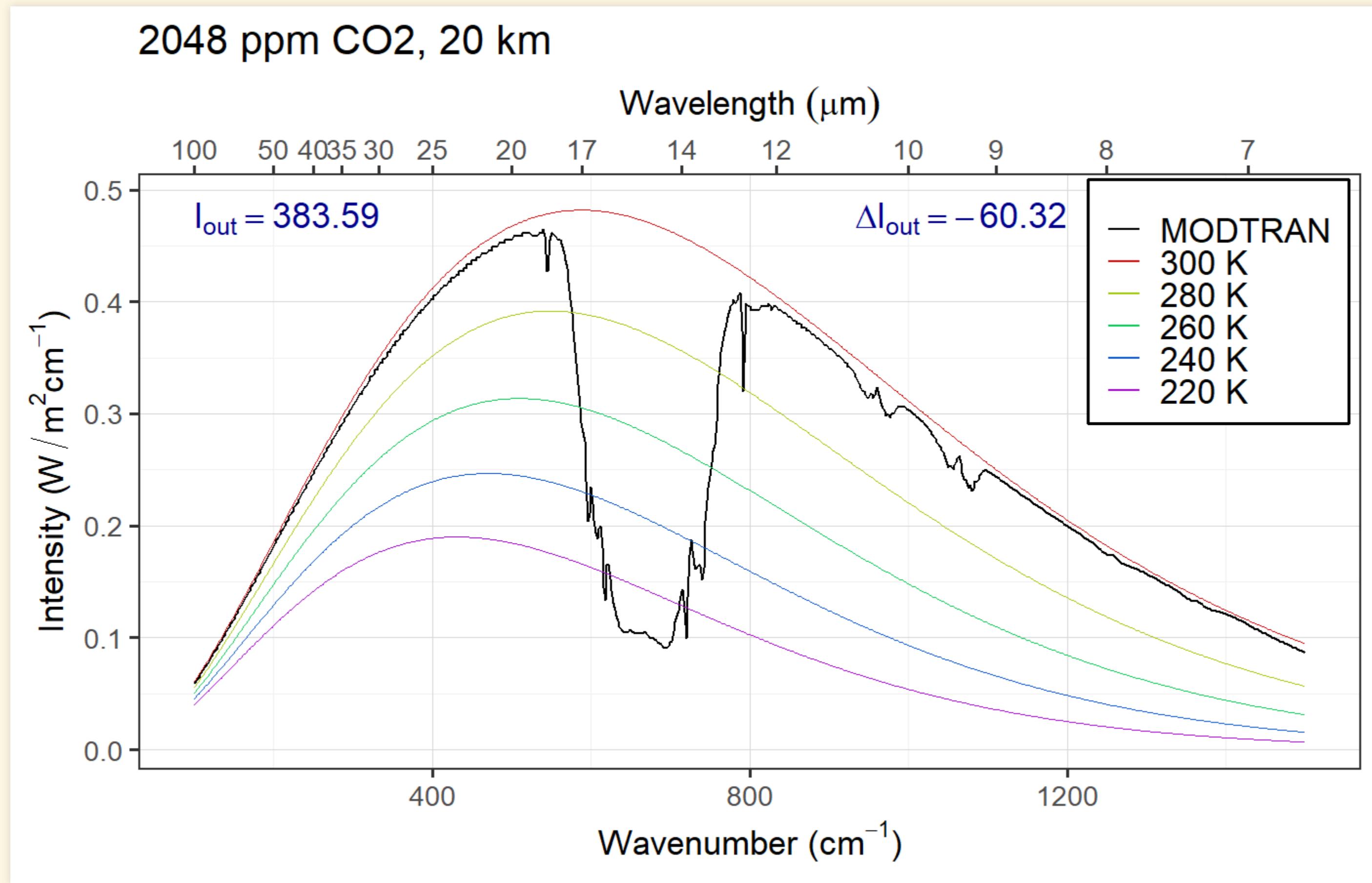


1024 ppm CO₂

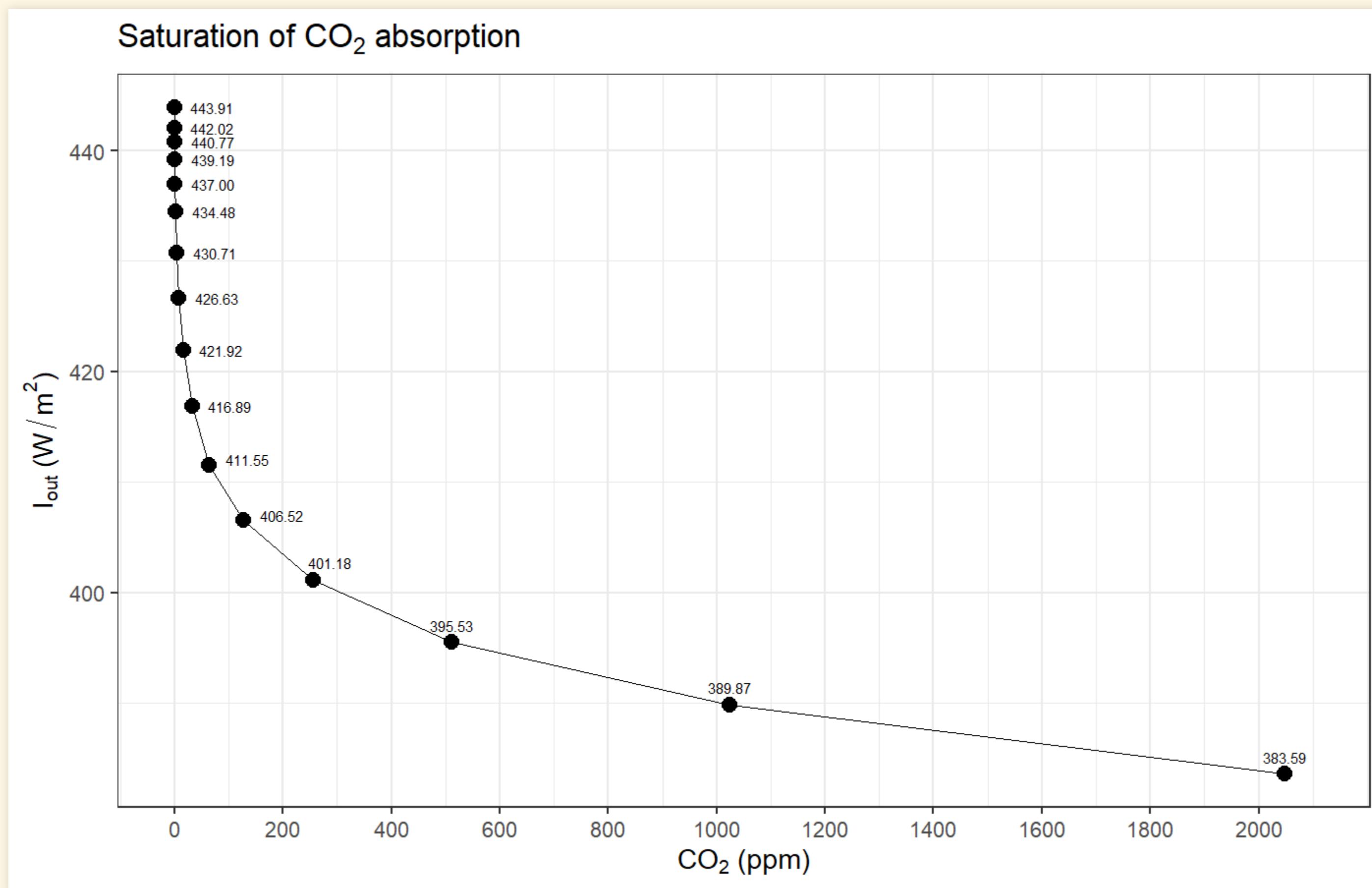
1024 ppm CO₂, 20 km



2048 ppm CO₂



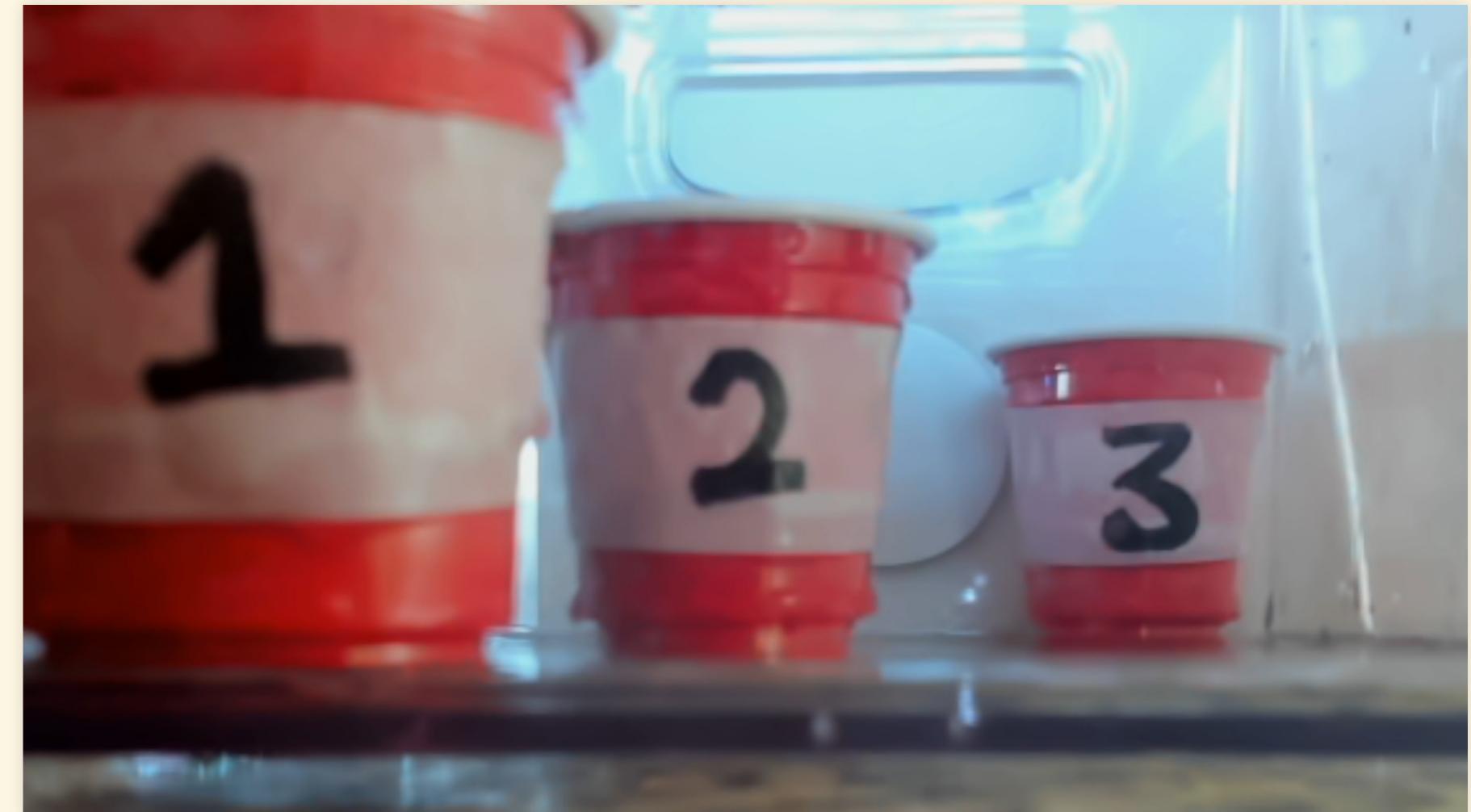
Band Saturation (I_{out})



Visible Radiation in Colored Water

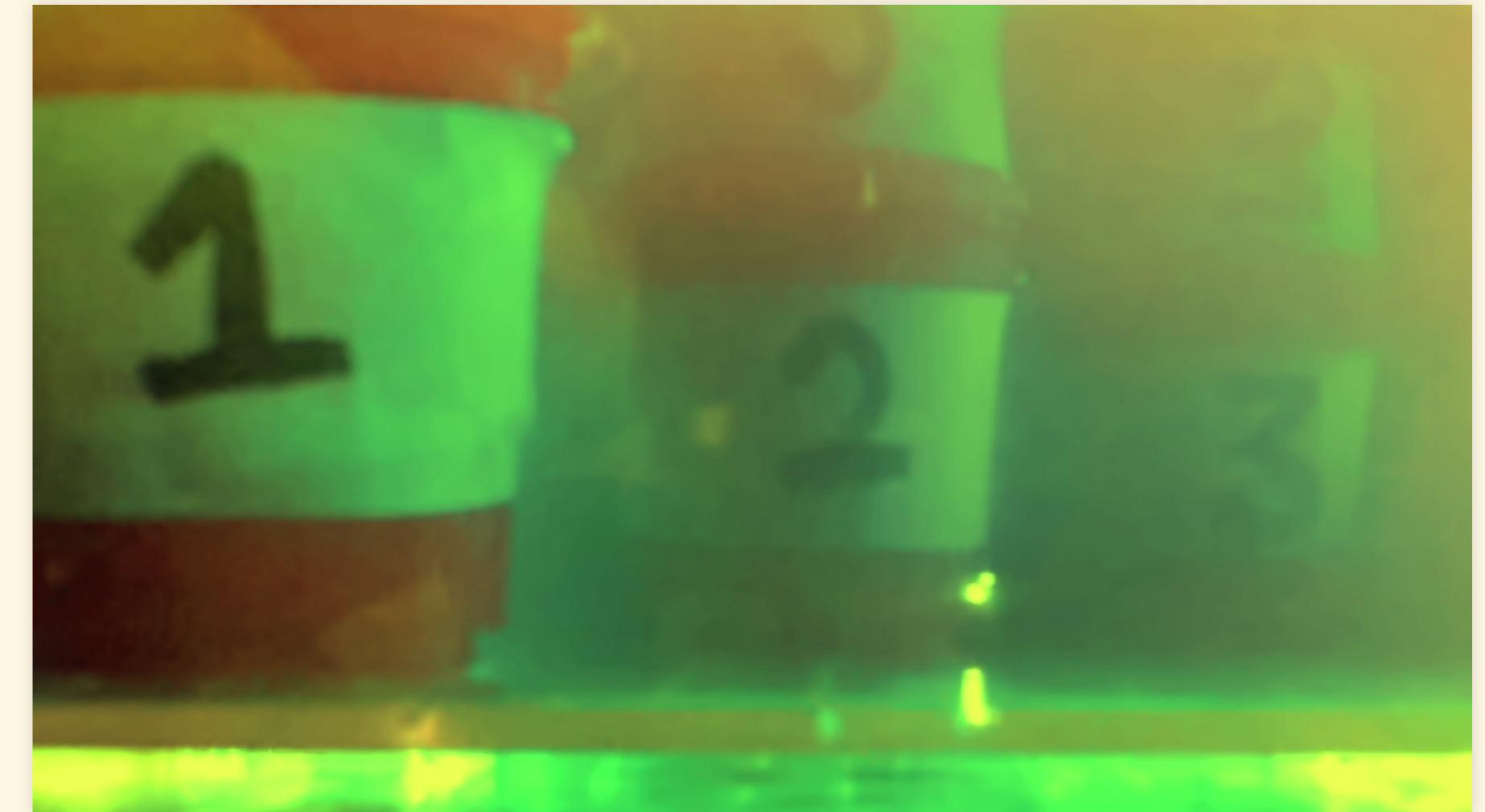
Visible Radiation in Colored Water

- To better understand the concept of how different parts of the atmosphere look to a satellite at different frequencies in the longwave spectrum,
 - Consider looking through colored water at different frequencies in the visible spectrum
- Here are three cups with black-on-white labels
 - The cups are in an empty tank



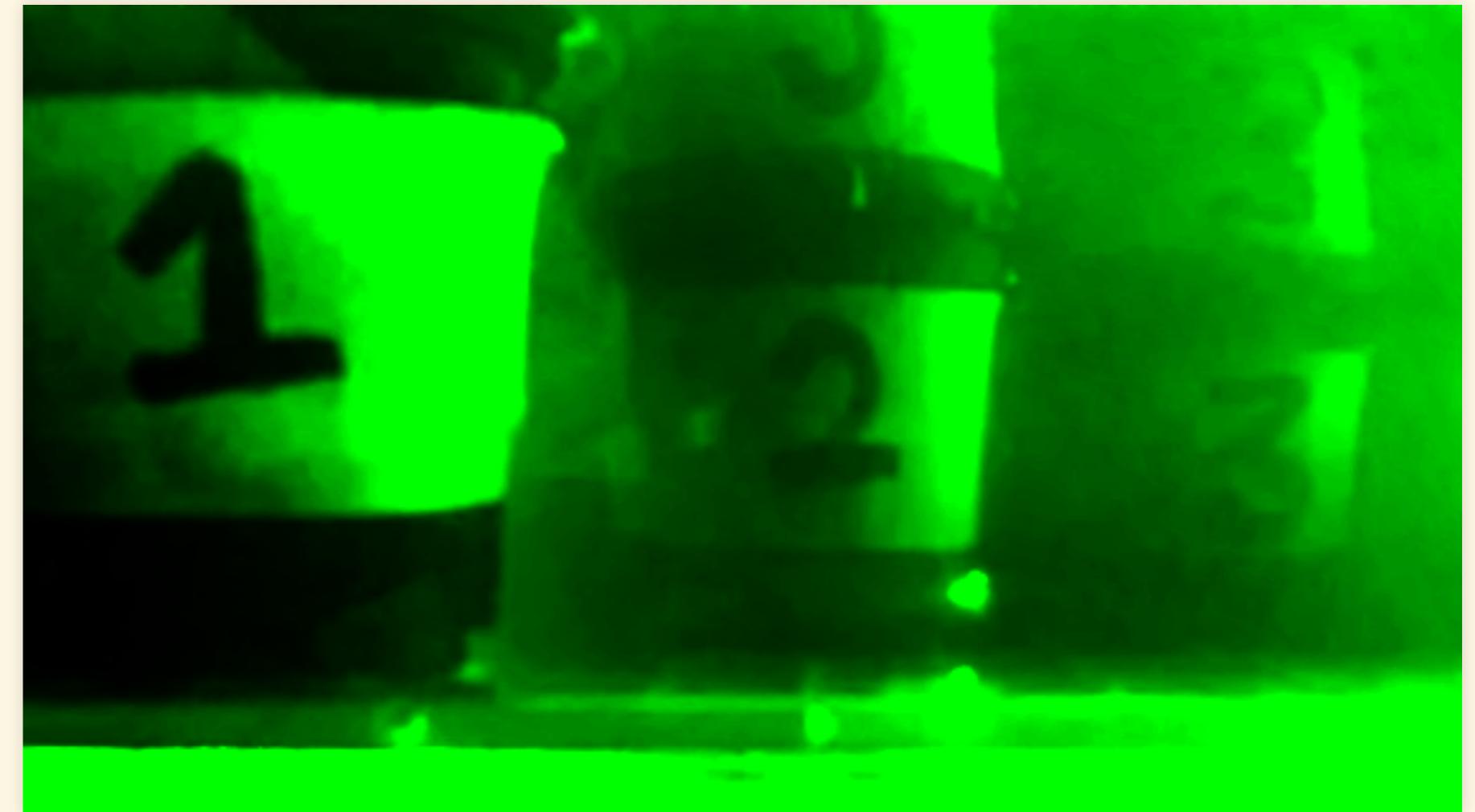
Visible Radiation in Colored Water

- Here are three cups with black-on-white labels
- The tank is filled with water, colored green with food-coloring
- Full visible spectrum



Visible Radiation in Colored Water

- Here are three cups with black-on-white labels
- The tank is filled with water, colored green with food-coloring
- Only the green frequencies



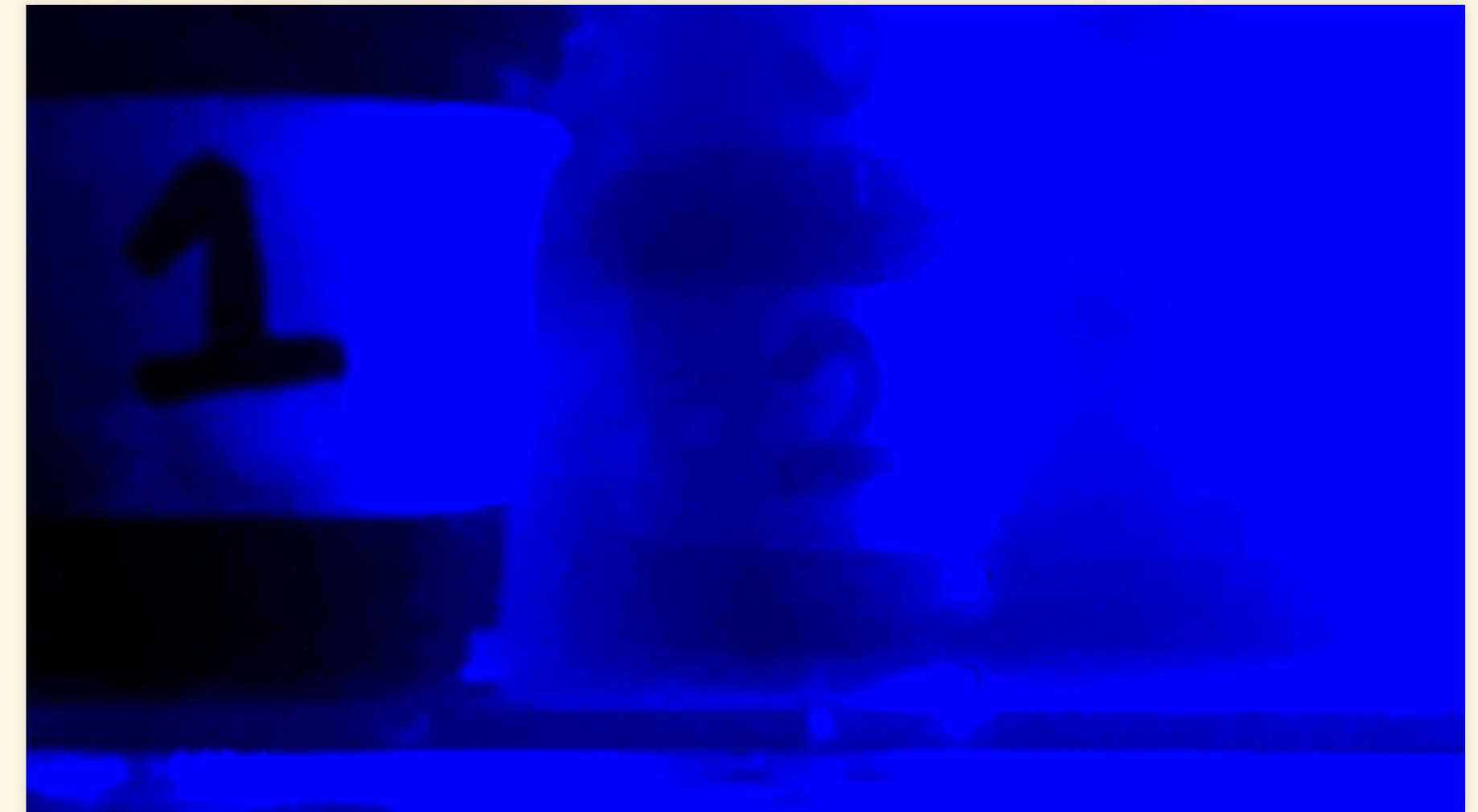
Visible Radiation in Colored Water

- Here are three cups with black-on-white labels
- The tank is filled with water, colored green with food-coloring
 - Only the red frequencies



Visible Radiation in Colored Water

- Here are three cups with black-on-white labels
- The tank is filled with water, colored green with food-coloring
- Only the blue frequencies



Compare to Longwave Radiation in Atmosphere

