

# 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 CO<sub>2</sub> 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?

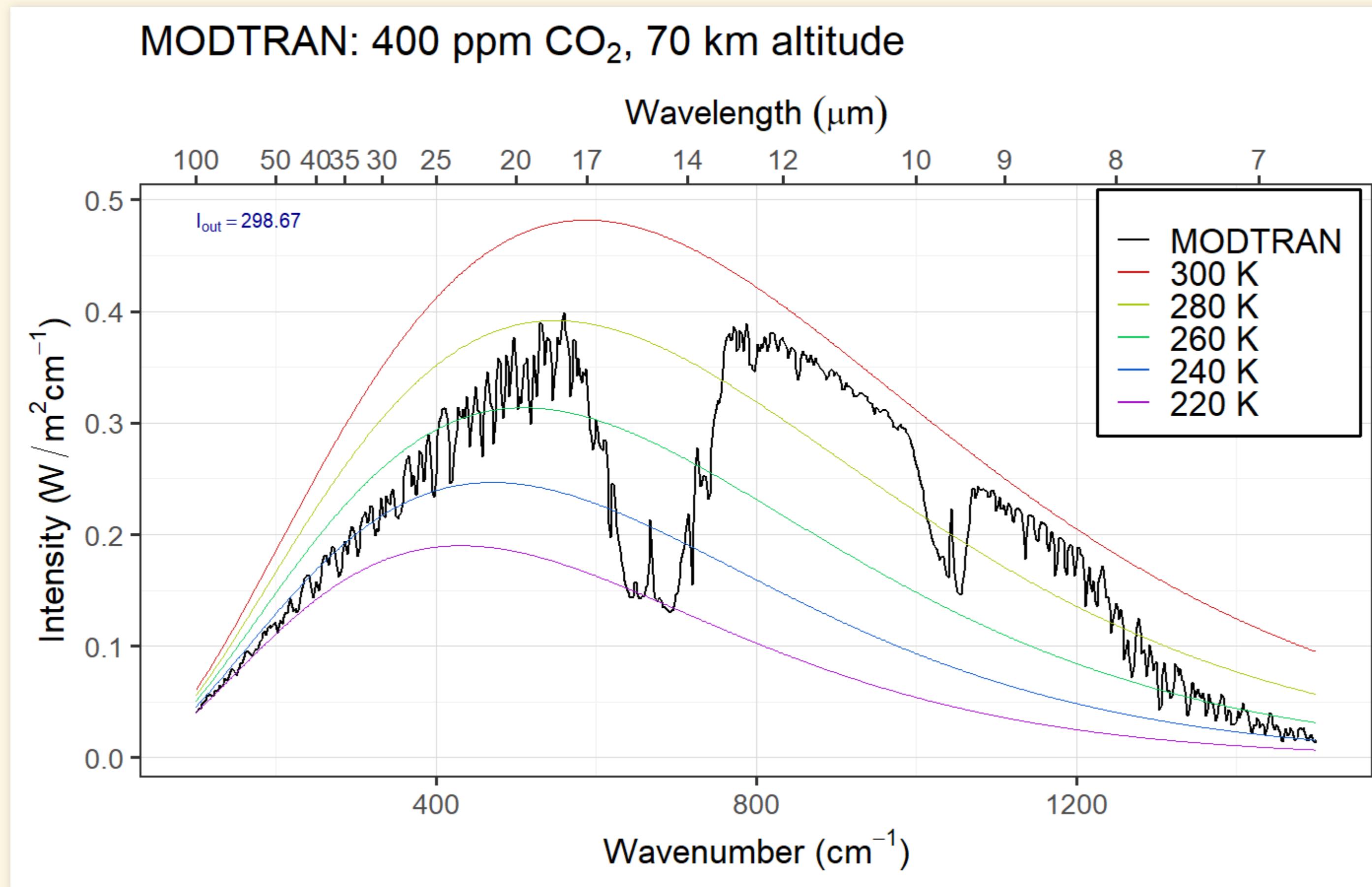
- Pure radiative calculation
  - Air does not move:
    - No wind or convection
- Only calculates infrared heat flux
  - Does not give equilibrium ground temperature
- Only calculates one spot
  - Does not give global averages
- You specify:
  - Ground temperature
  - Composition of atmosphere
- Modtran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

# Running MODTRAN

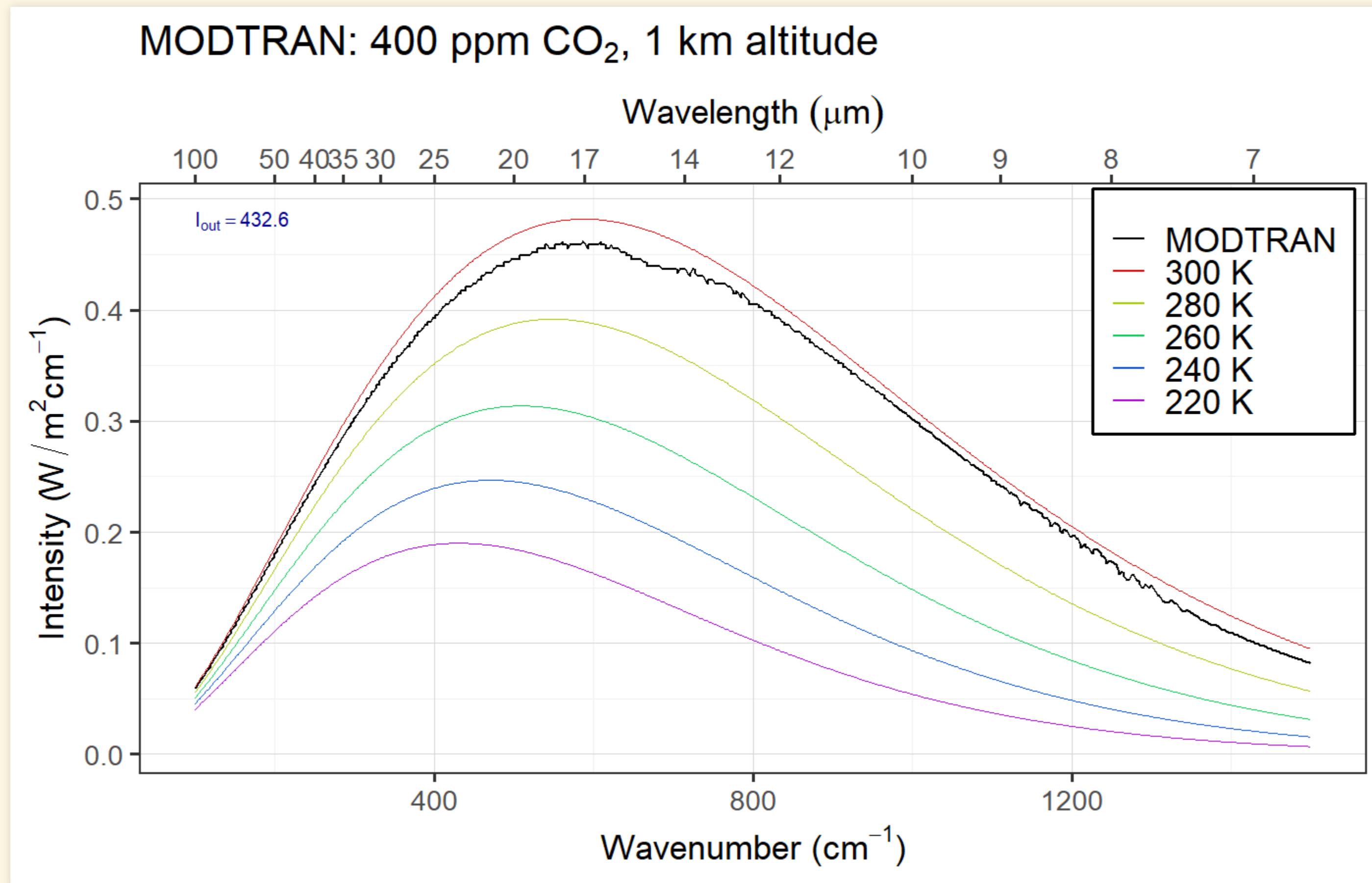
- Go to <http://climatemodels.uchicago.edu/modtran/>
- Next

# Understanding the Spectrum

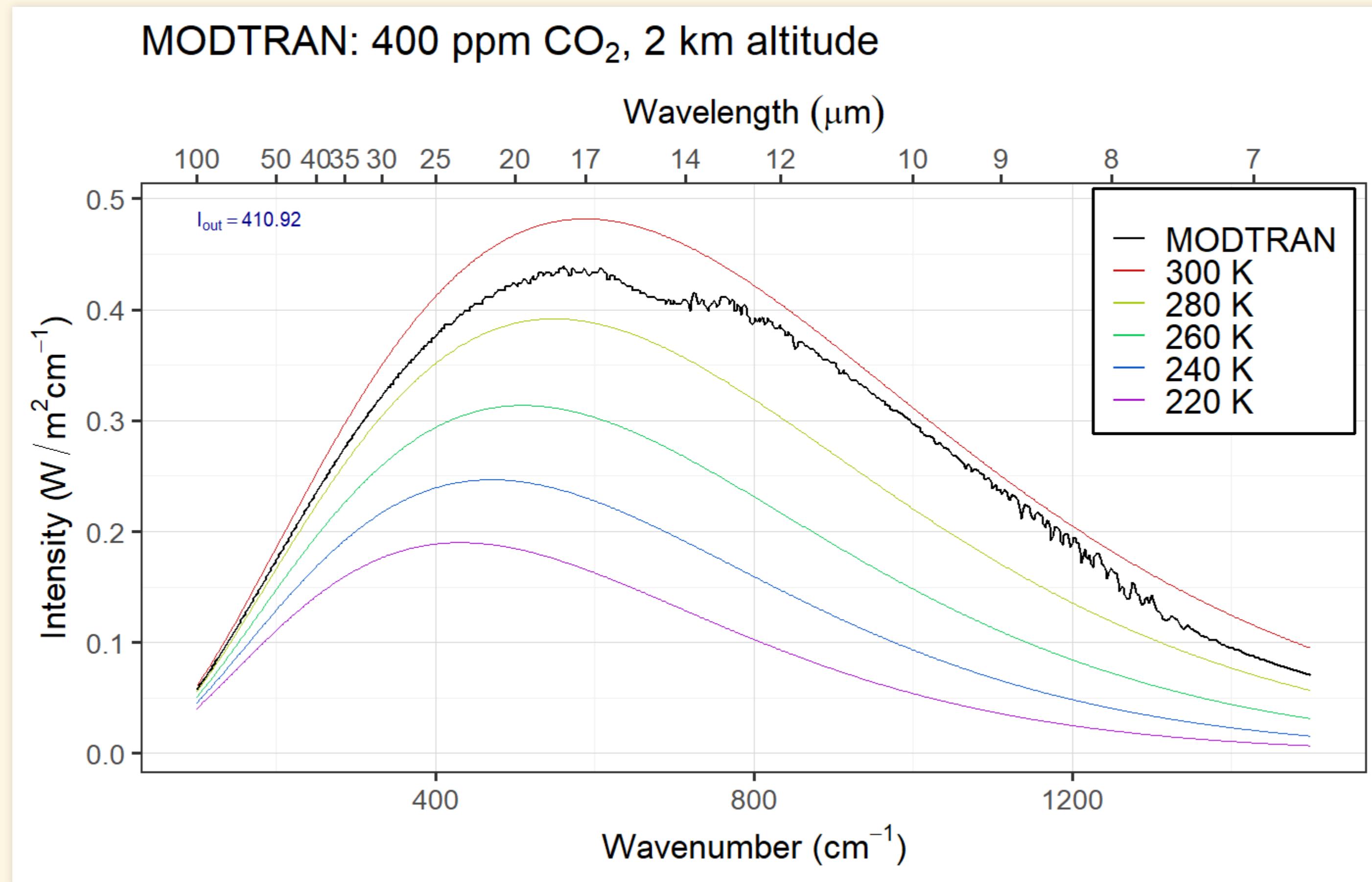
# Earth's Tropics, Seen from Space



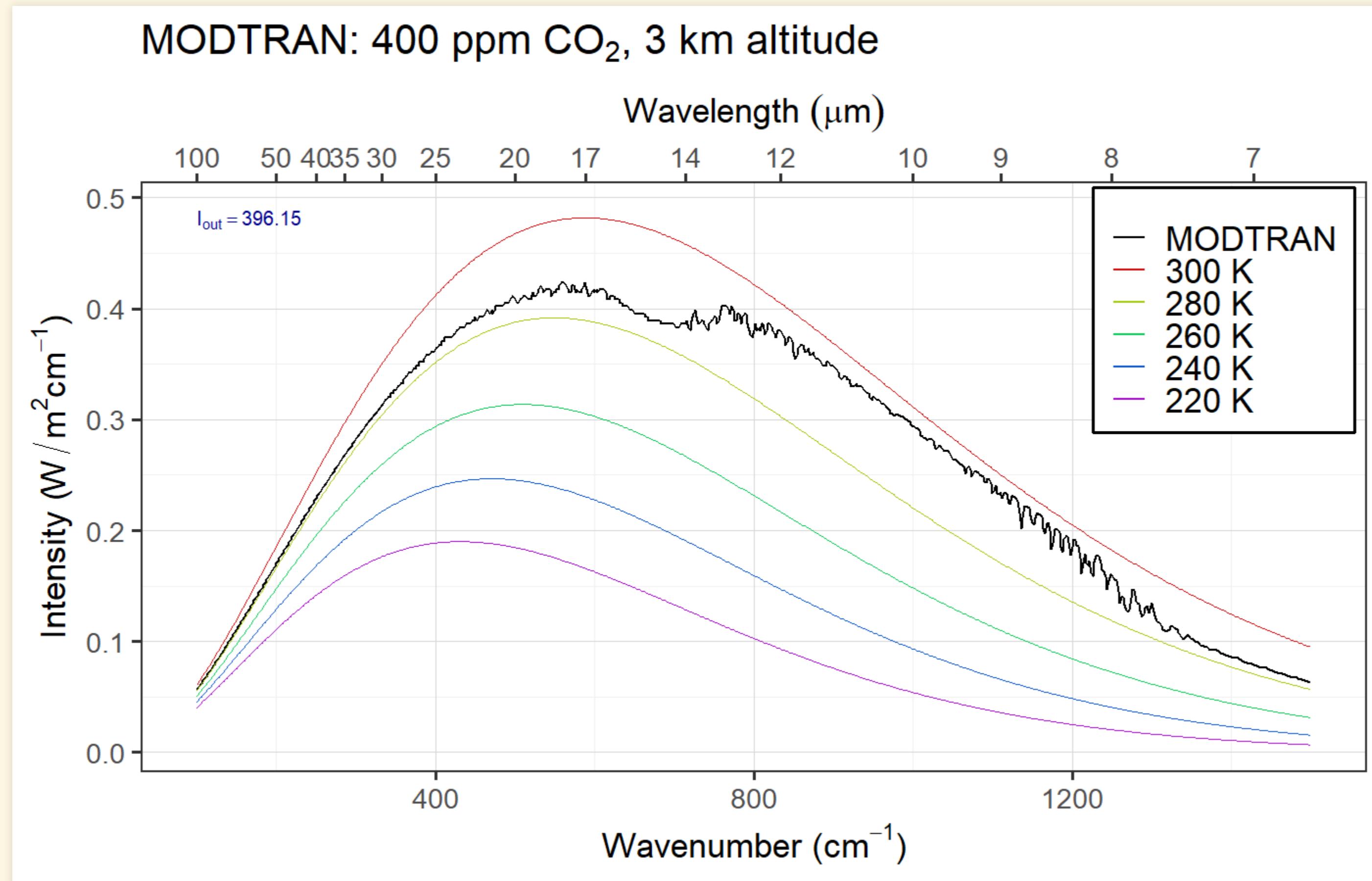
# Seen from 1 km



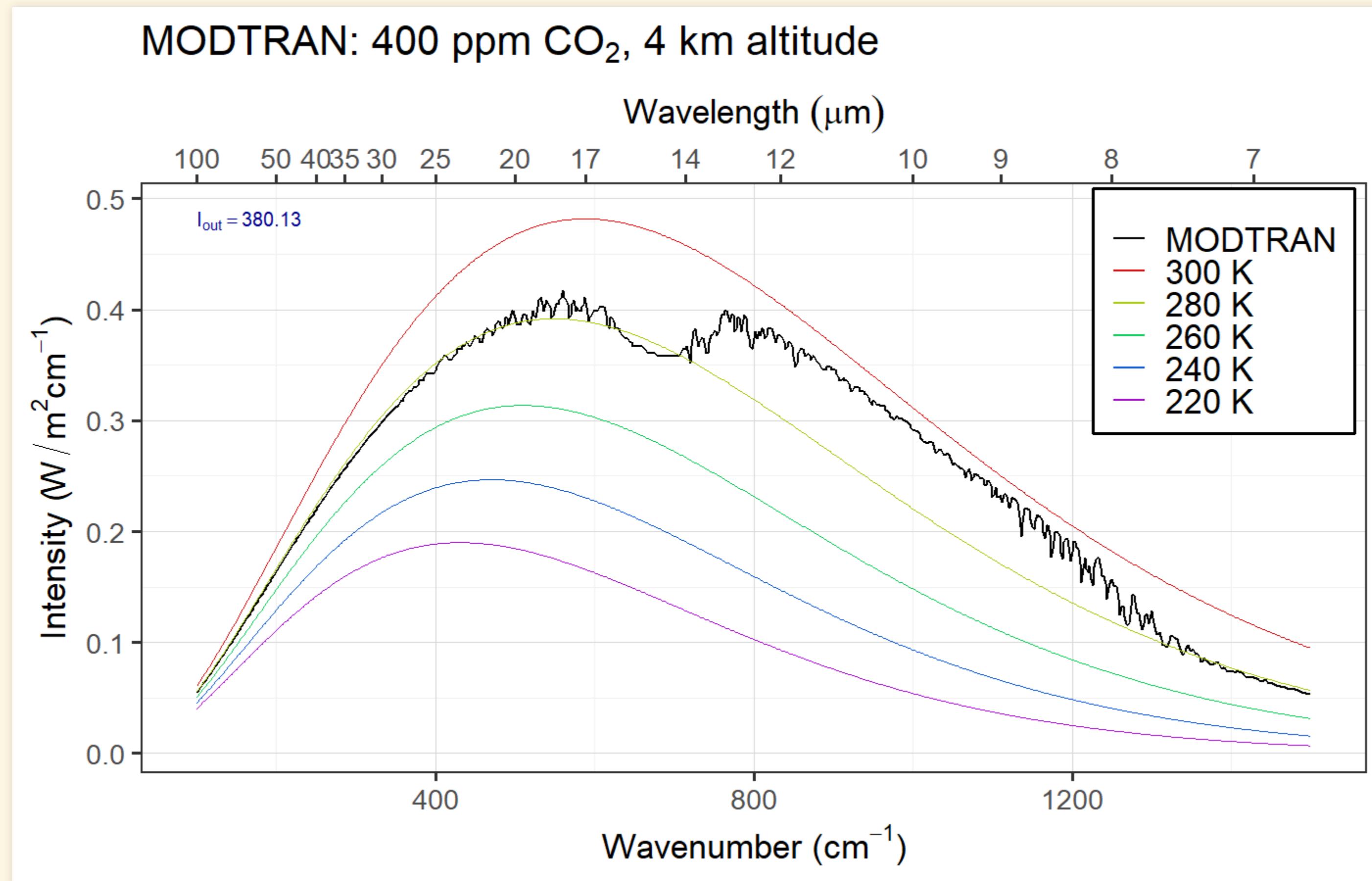
# Seen from 2 km



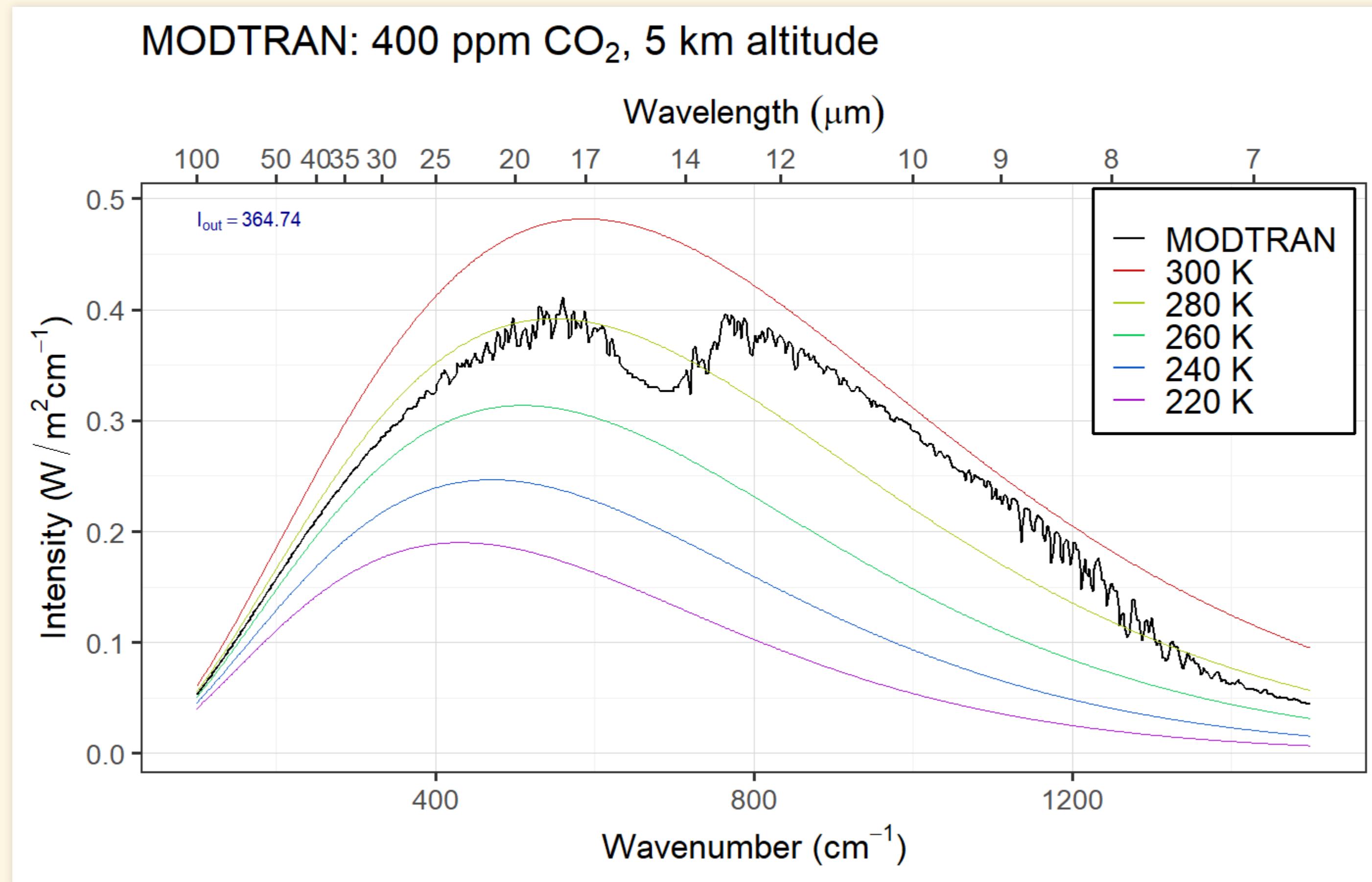
# Seen from 3 km



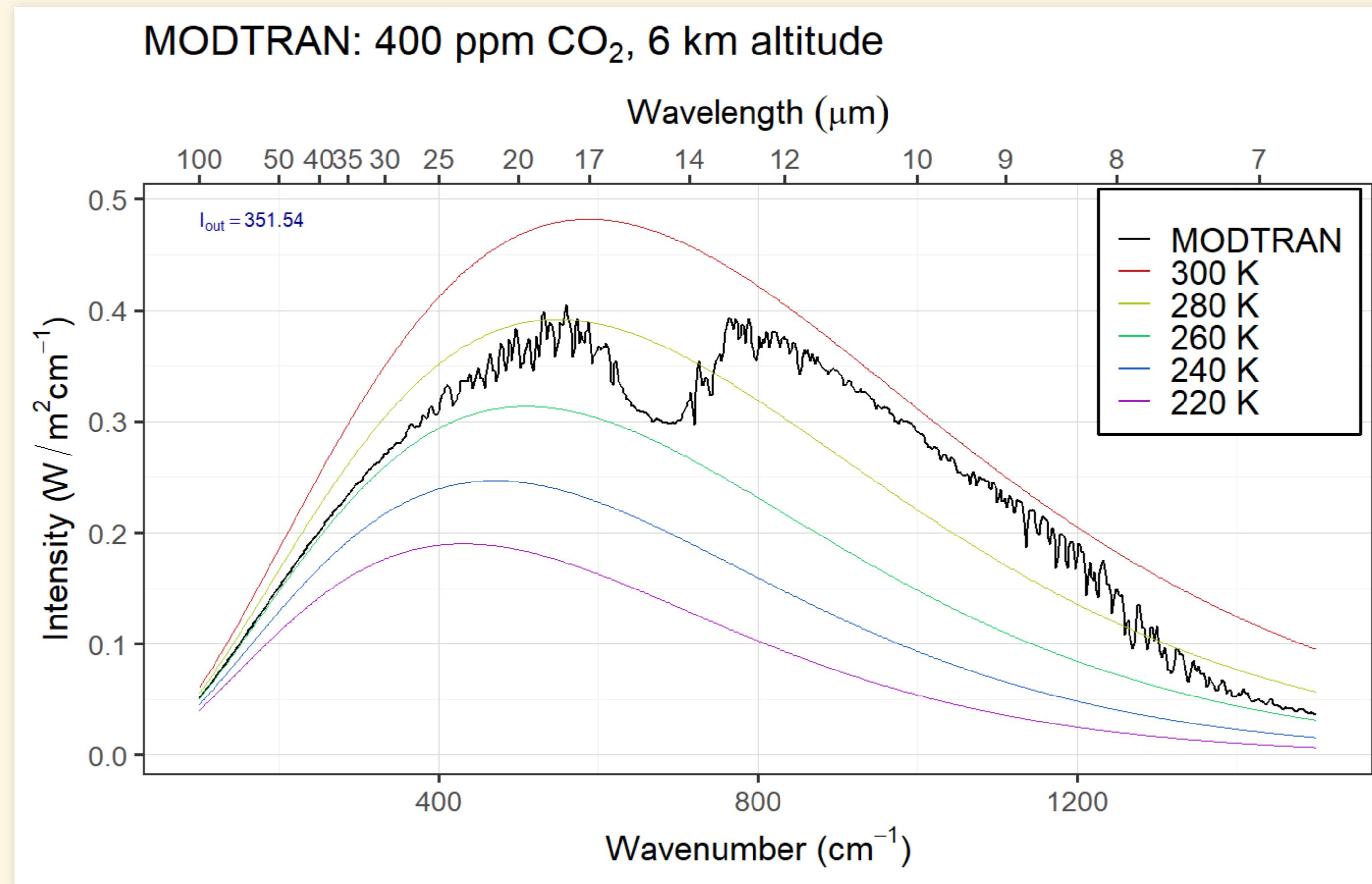
# Seen from 4 km



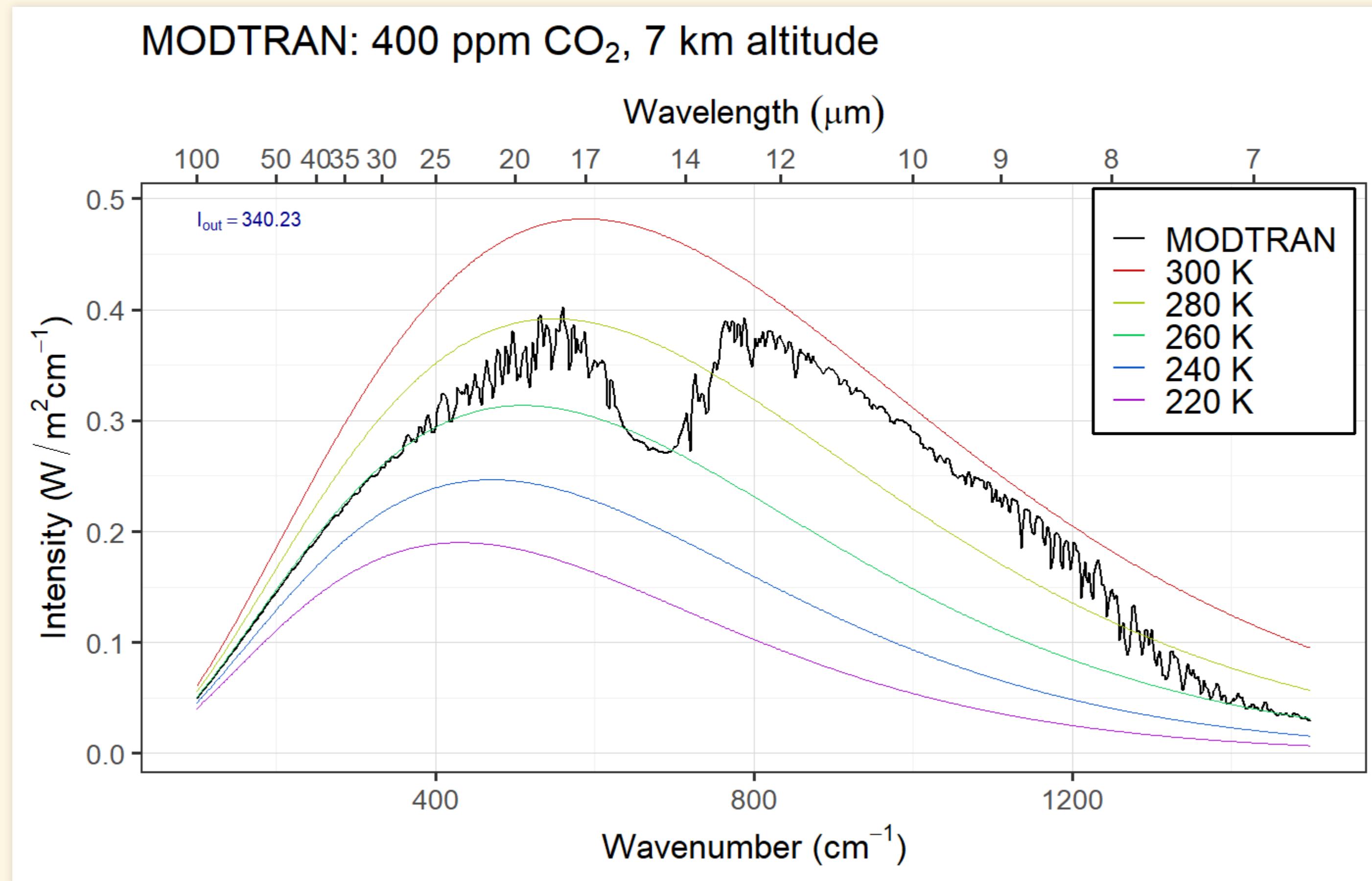
# Seen from 5 km



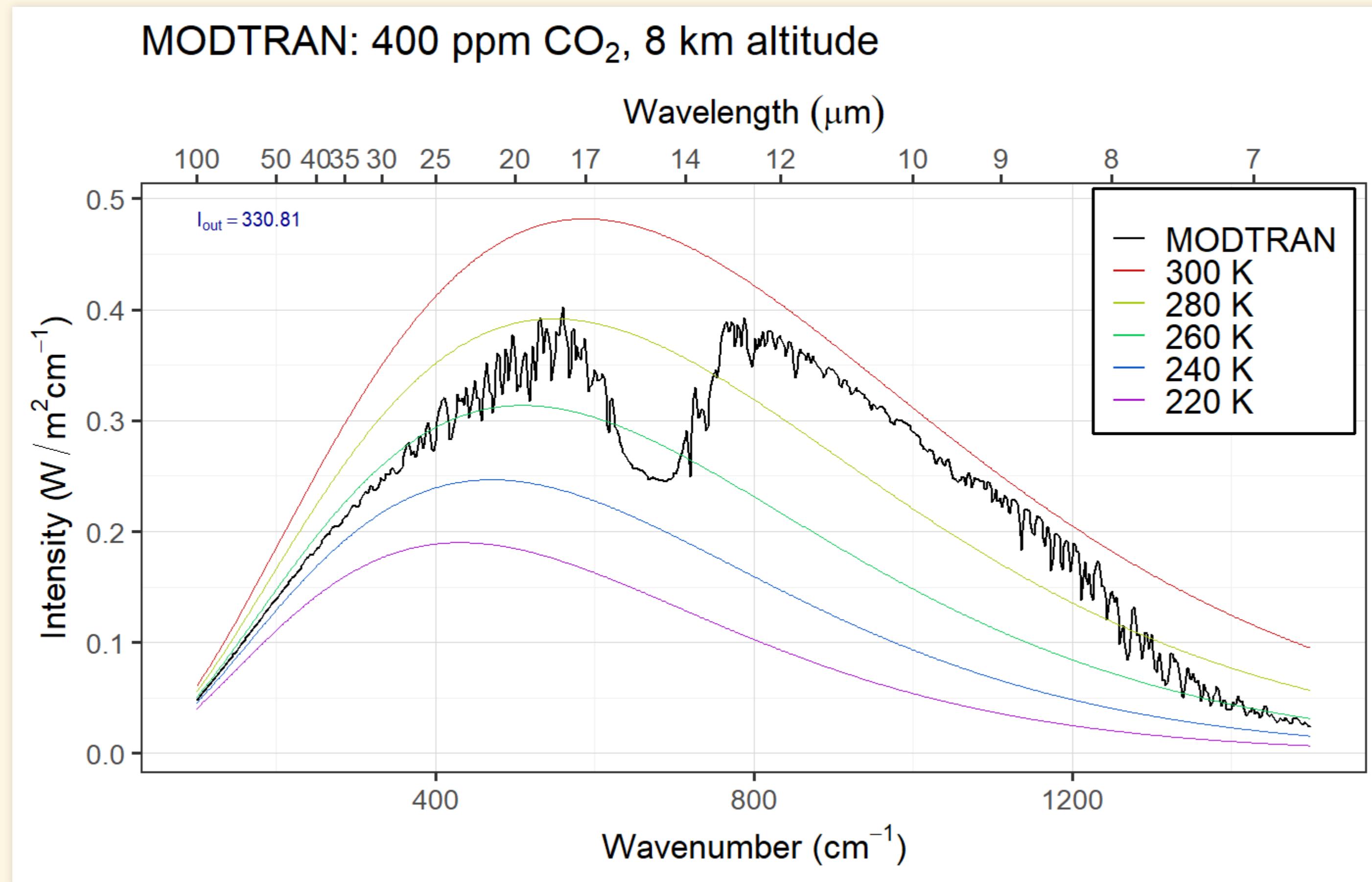
# Seen from 6 km



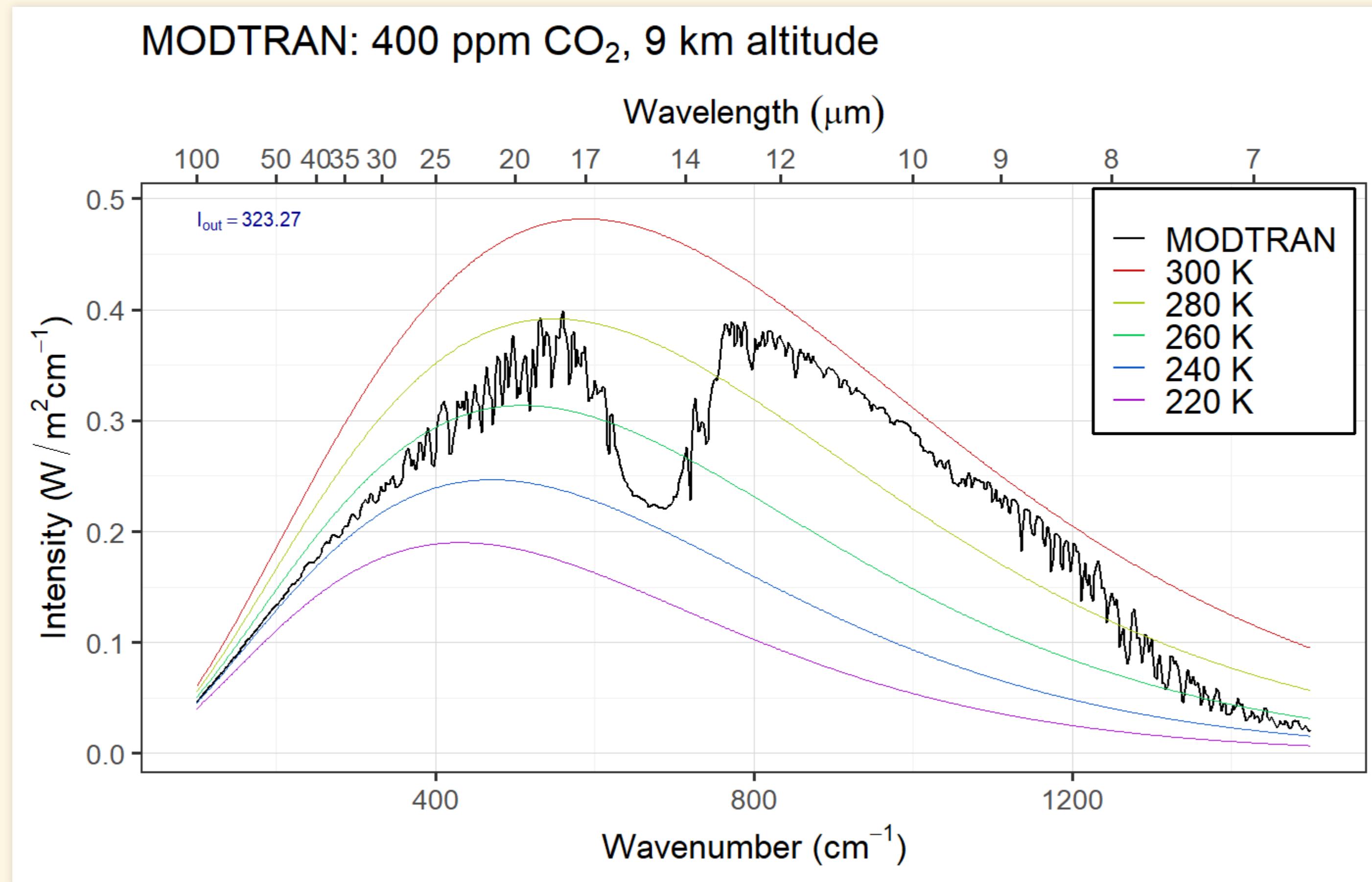
# Seen from 7 km



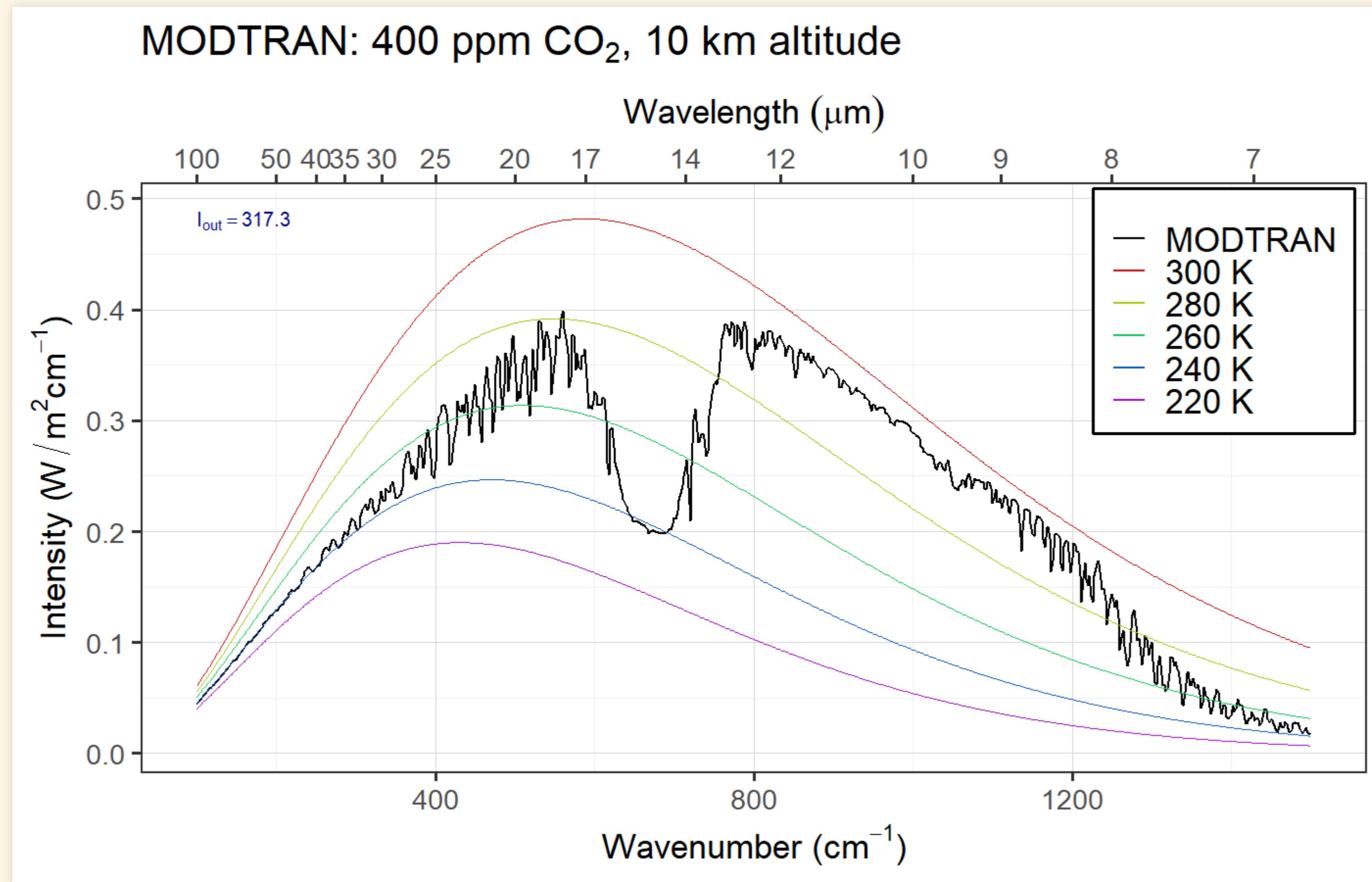
# Seen from 8 km



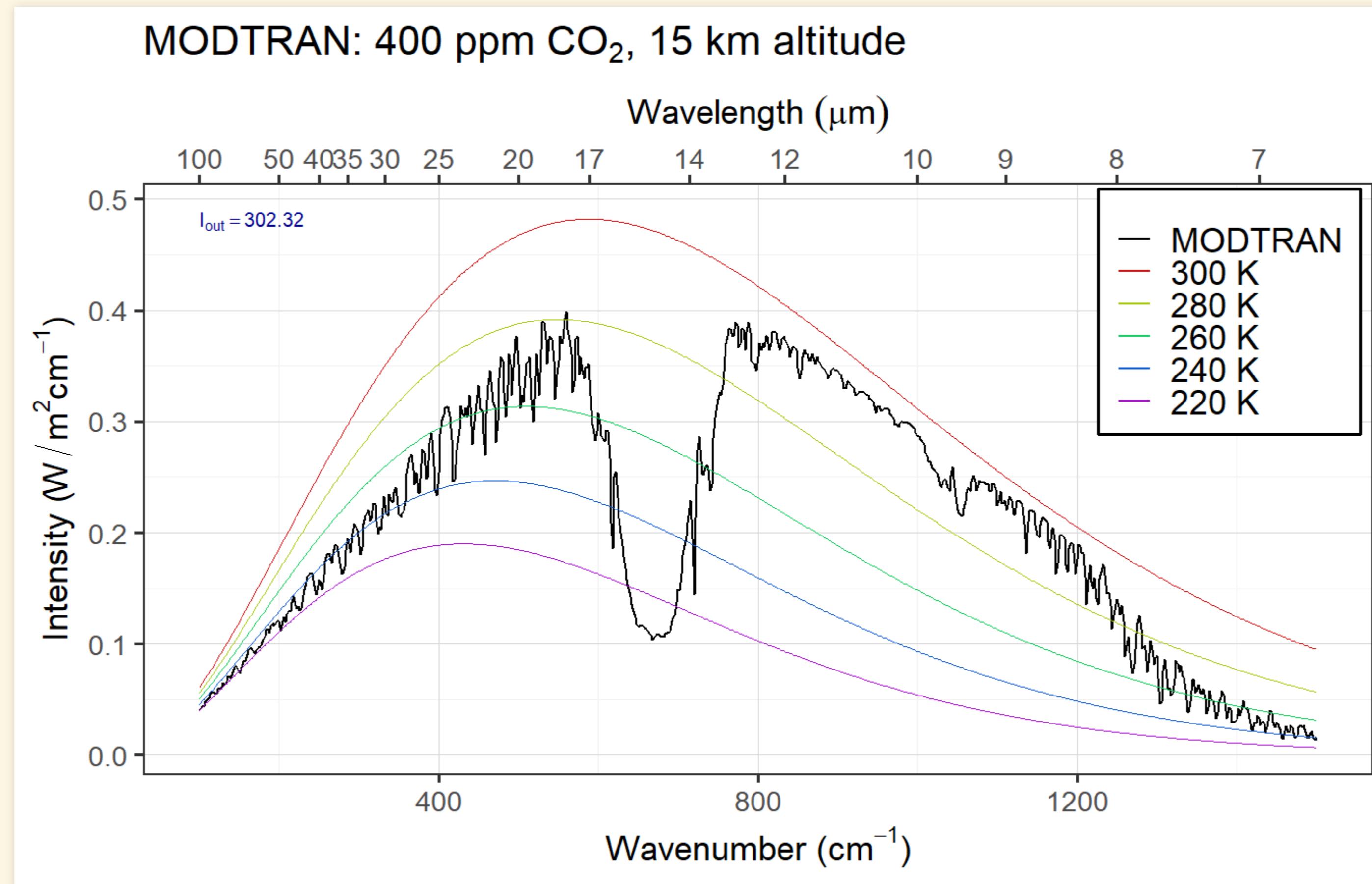
# Seen from 9 km



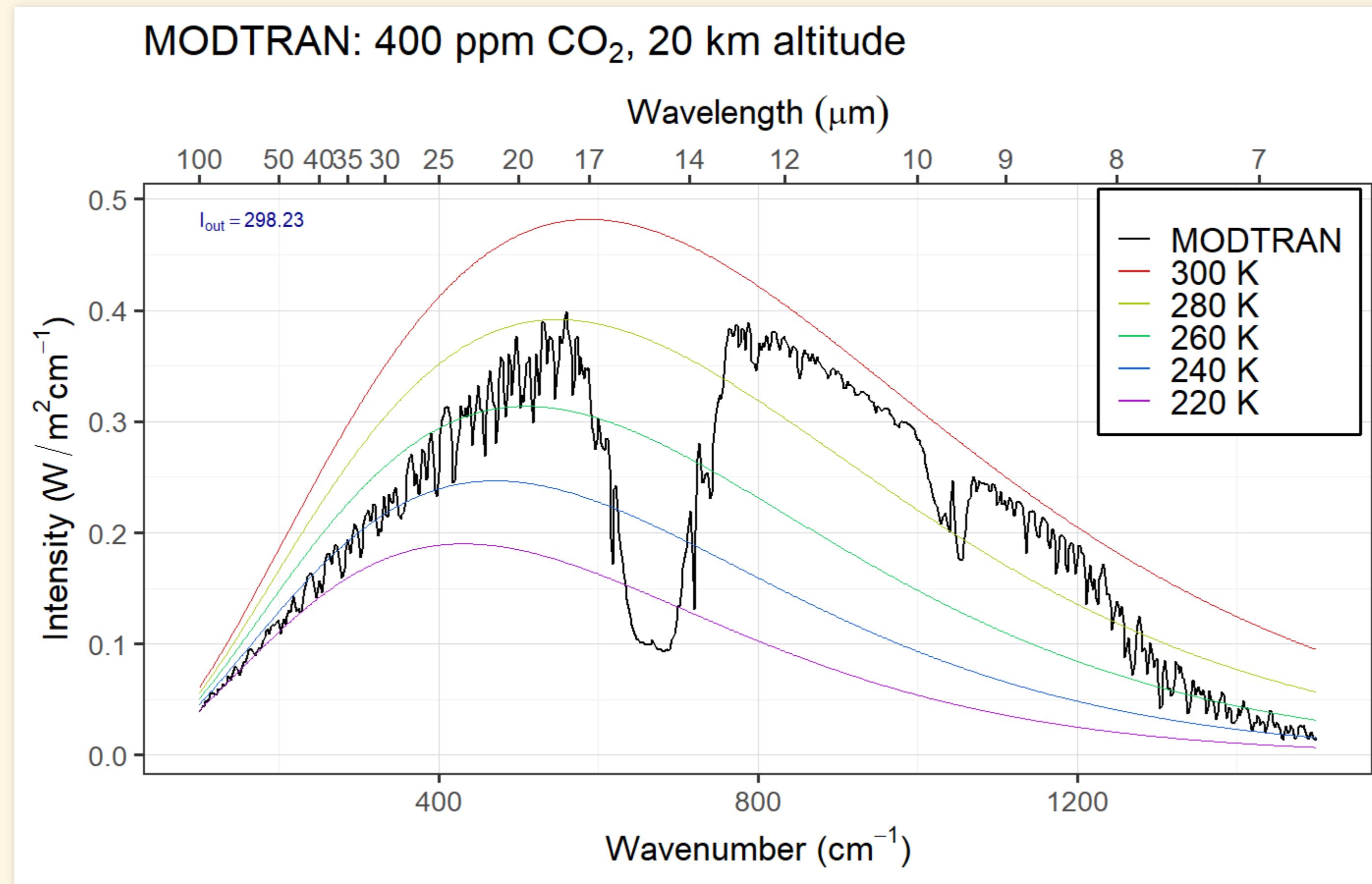
# Seen from 10 km



# Seen from 15 km



# Seen from 20 km



# Effect of Doubling CO<sub>2</sub>

# Double CO<sub>2</sub>

- Set Locality to “Tropical Atmosphere”
- Click “Save This Run to Background”
- Note the Upward IR heat flux
- Double the amount of CO<sub>2</sub>
- Adjust T offset until new heat flux = background flux
- What is the new ground temperature?

# Exercise: Double CO<sub>2</sub>

# Different Gases

# Different Gases

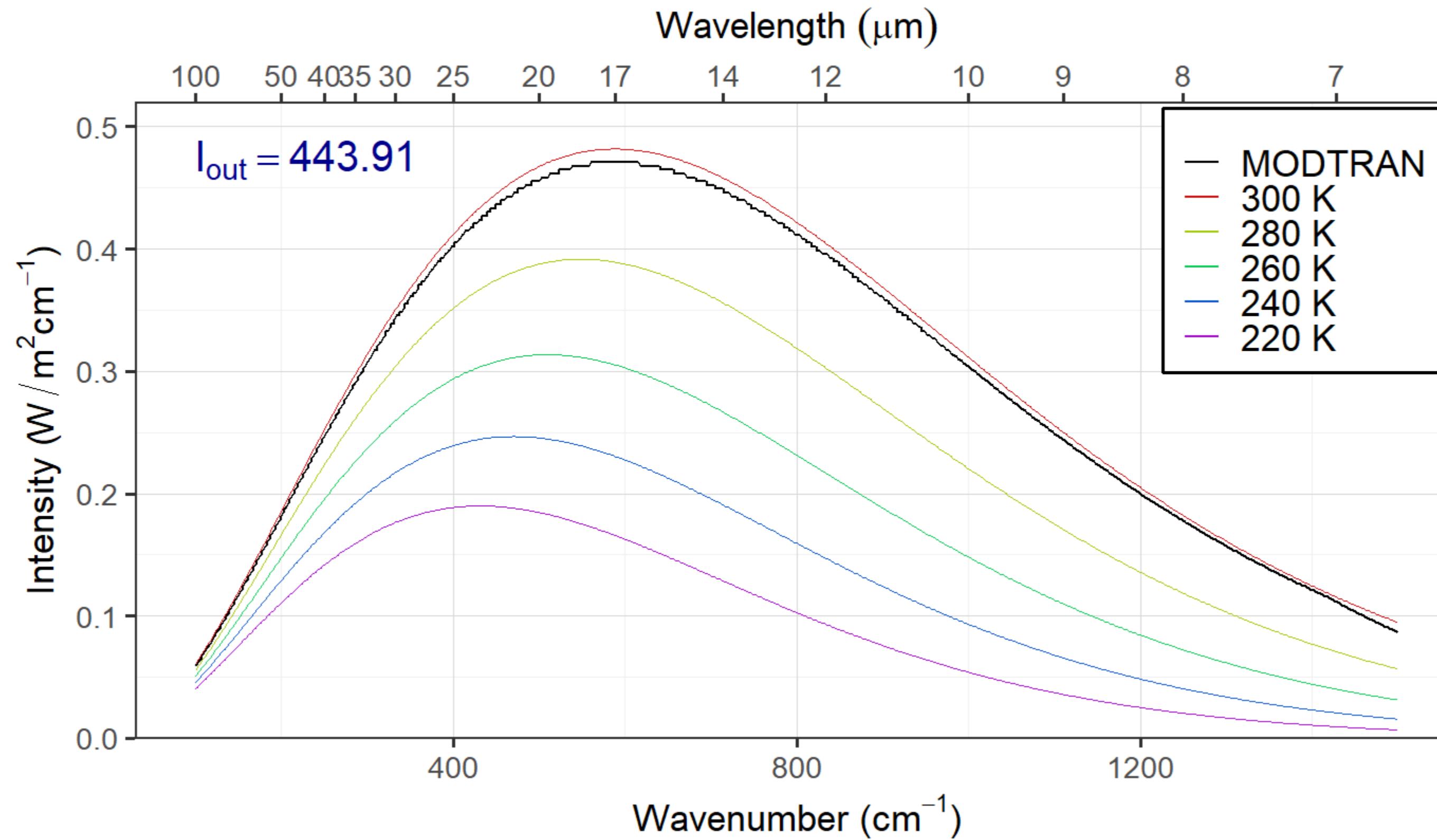
# Measuring Greenhouse Effect:

# Measuring Greenhouse Effect:

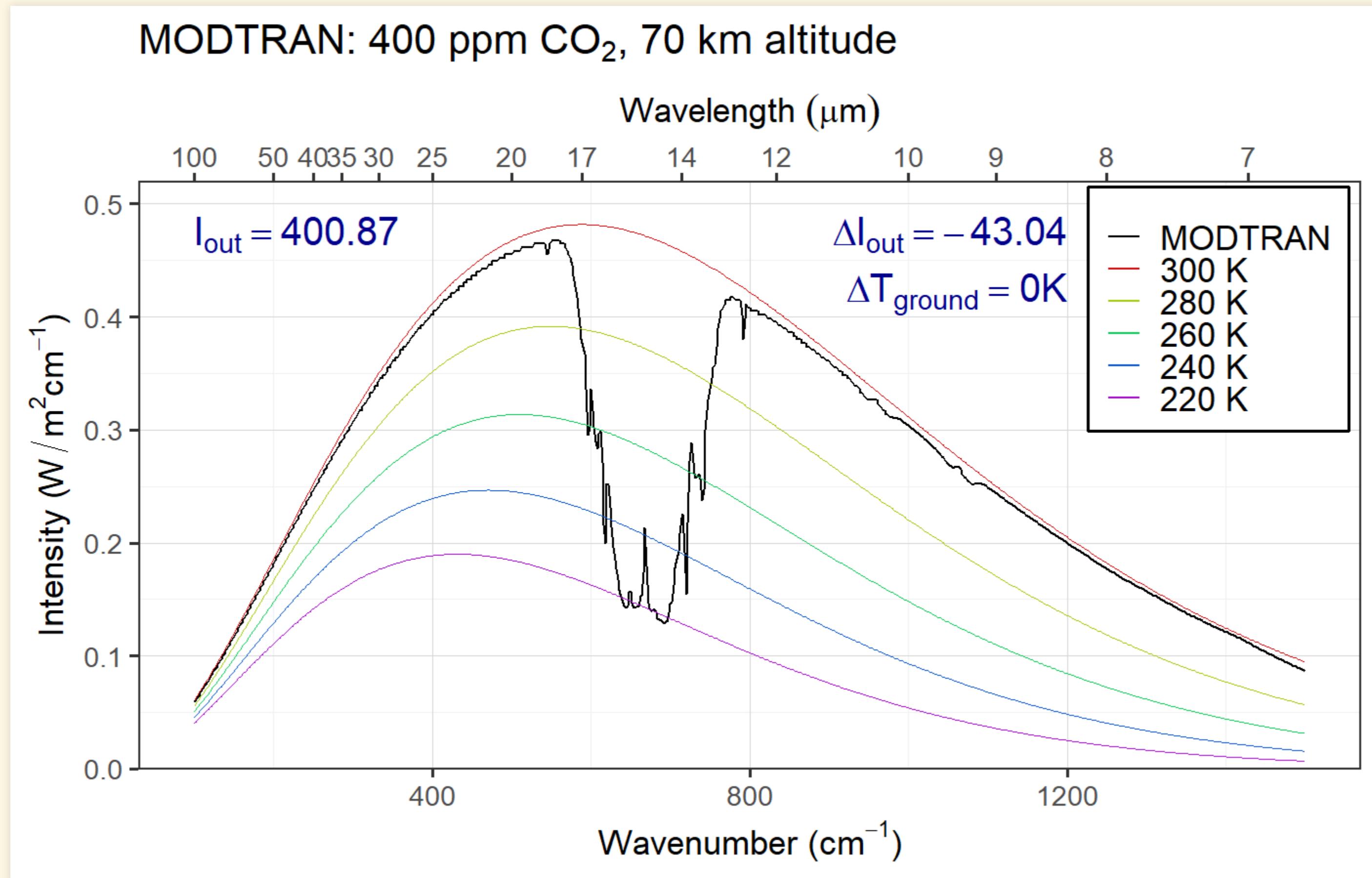
- Go to MODTRAN, set CO<sub>2</sub> to 0 ppm, and set all other gases to zero.
- Set altitude to 70 km and location to “Tropical Atmosphere”.
- Press “Save this run to background”
- Note  $I_{\text{out}}$
- Set CO<sub>2</sub> to 400 ppm and note the change in  $I_{\text{out}}$
- Adjust the temperature offset to make the difference in  $(I_{\text{out}}^{\text{New}} - I_{\text{out}}^{\text{BG}})$  equal zero.

# No Greenhouse Gases

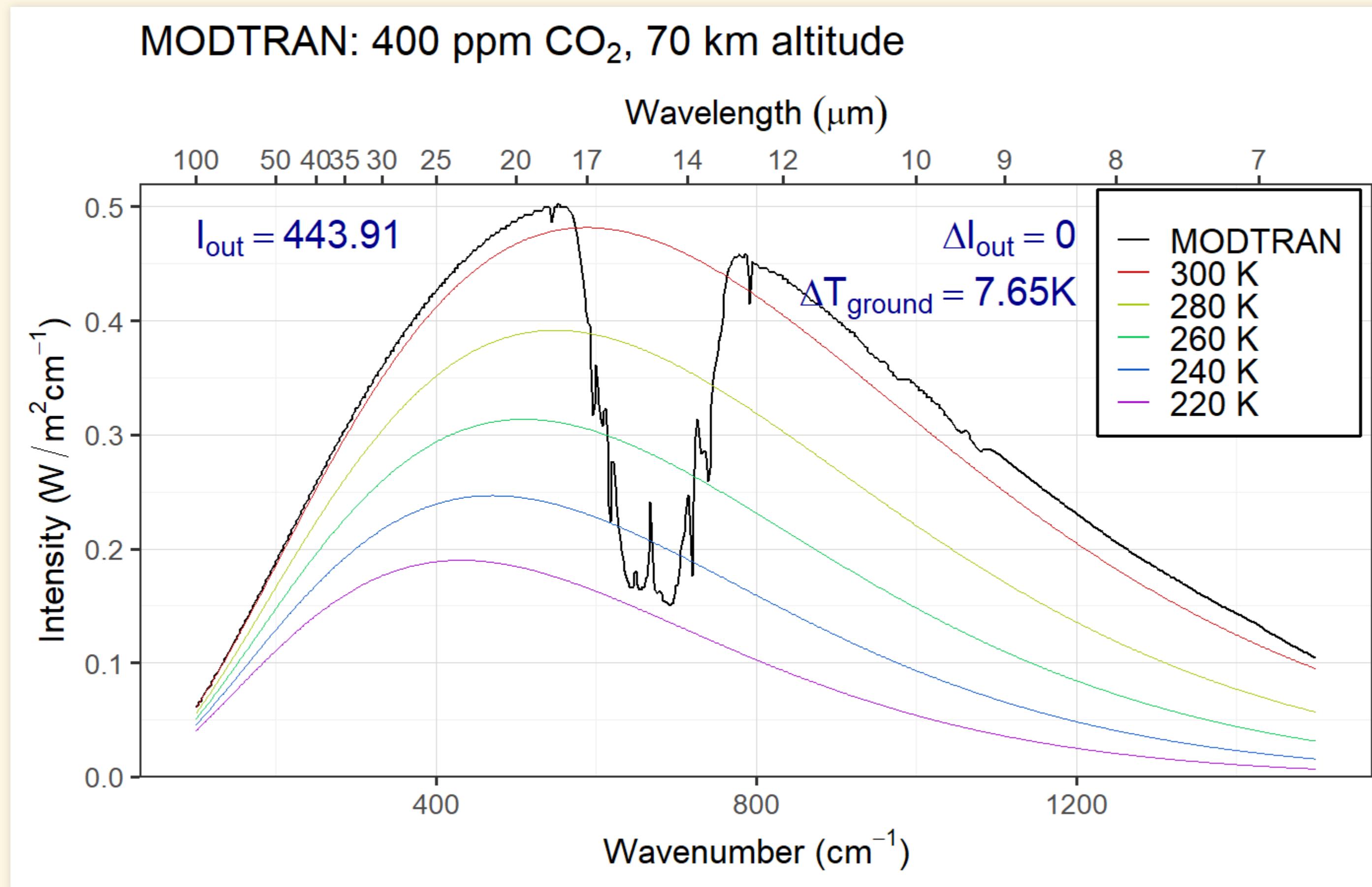
MODTRAN: 0 ppm CO<sub>2</sub>, 70 km altitude



# 400 ppm



# Adjust temperature



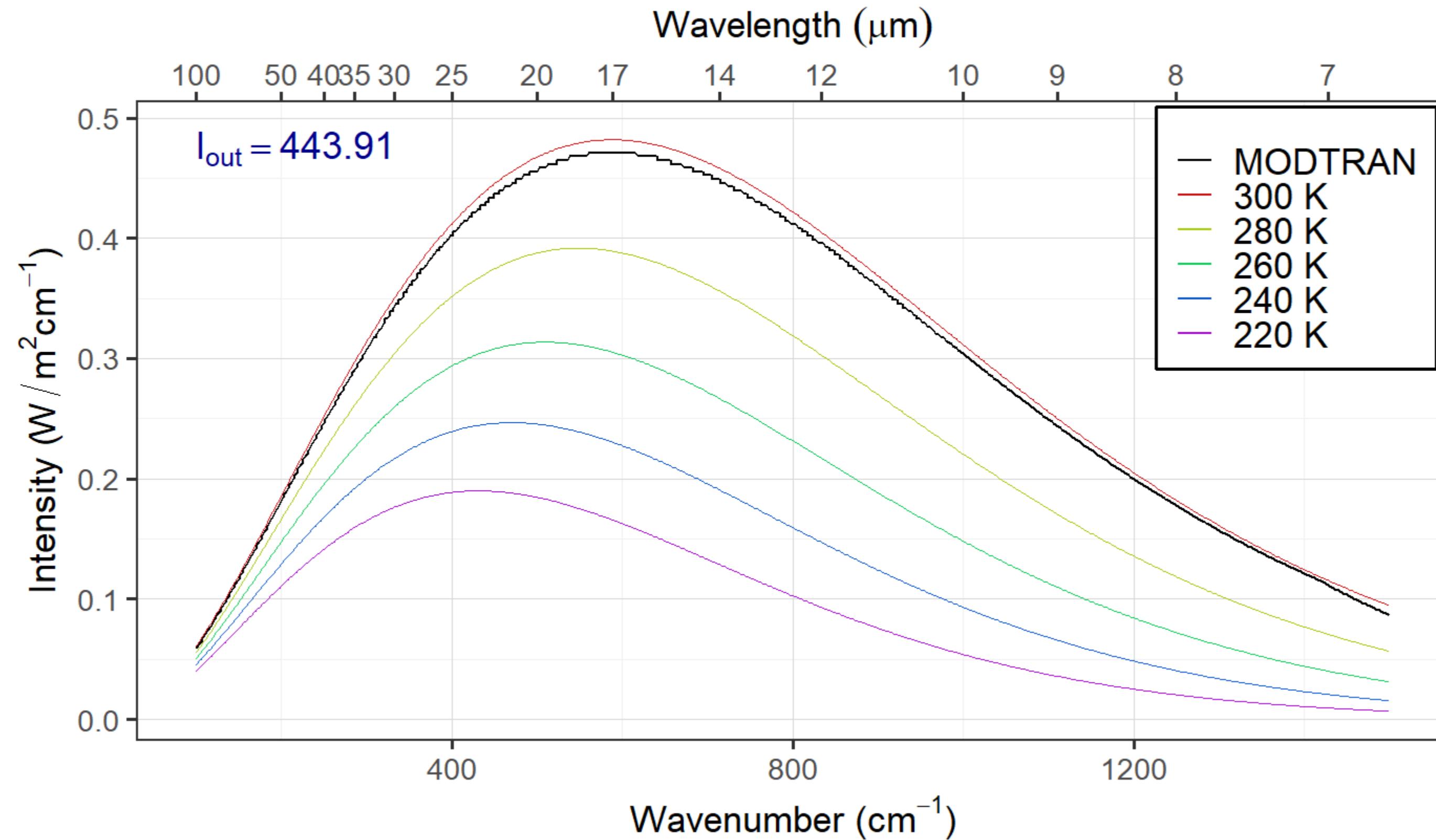
# Band Saturation

# Set up MODTRAN:

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

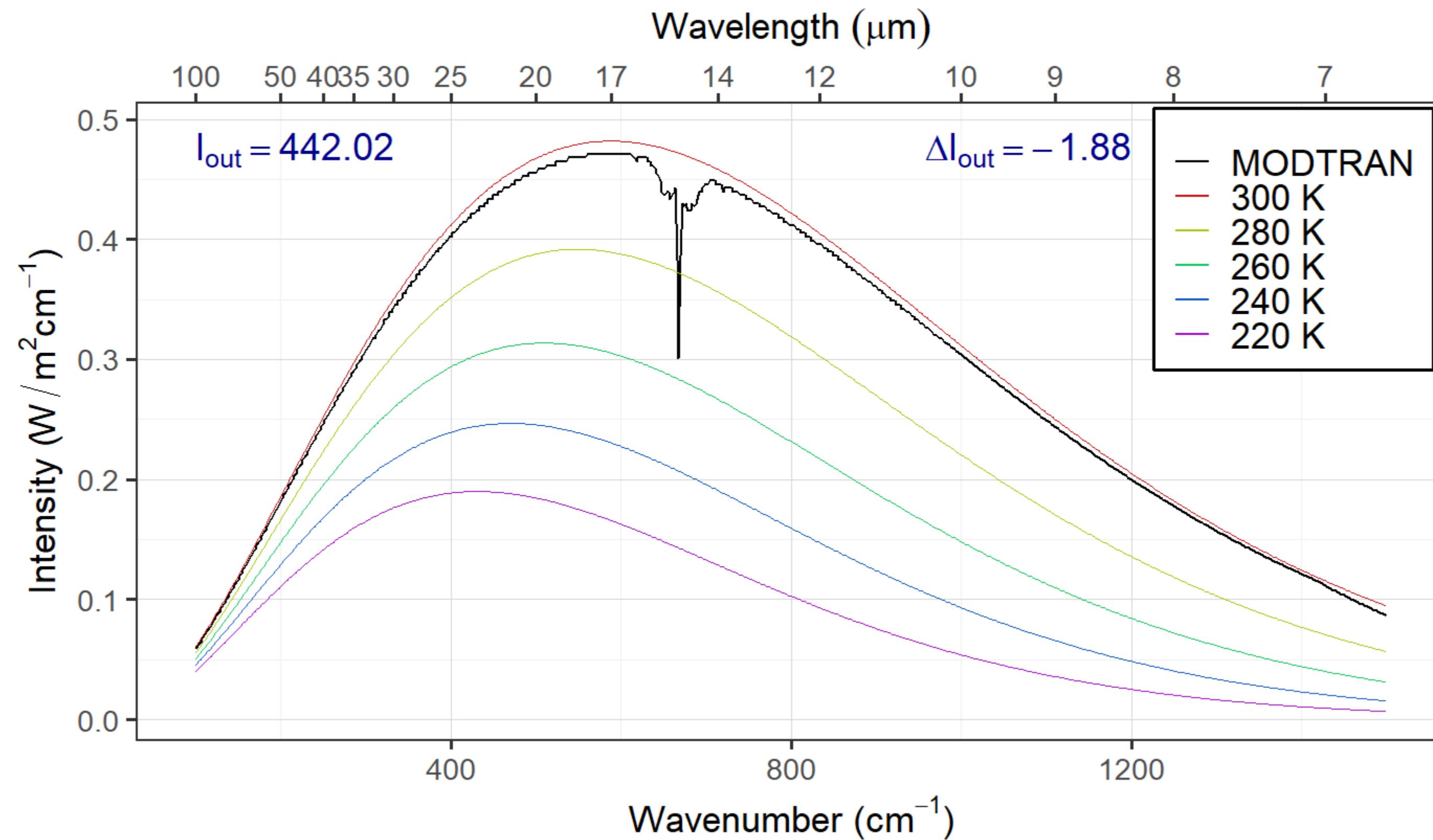
# No CO<sub>2</sub>

0 ppm CO<sub>2</sub>, 20 km



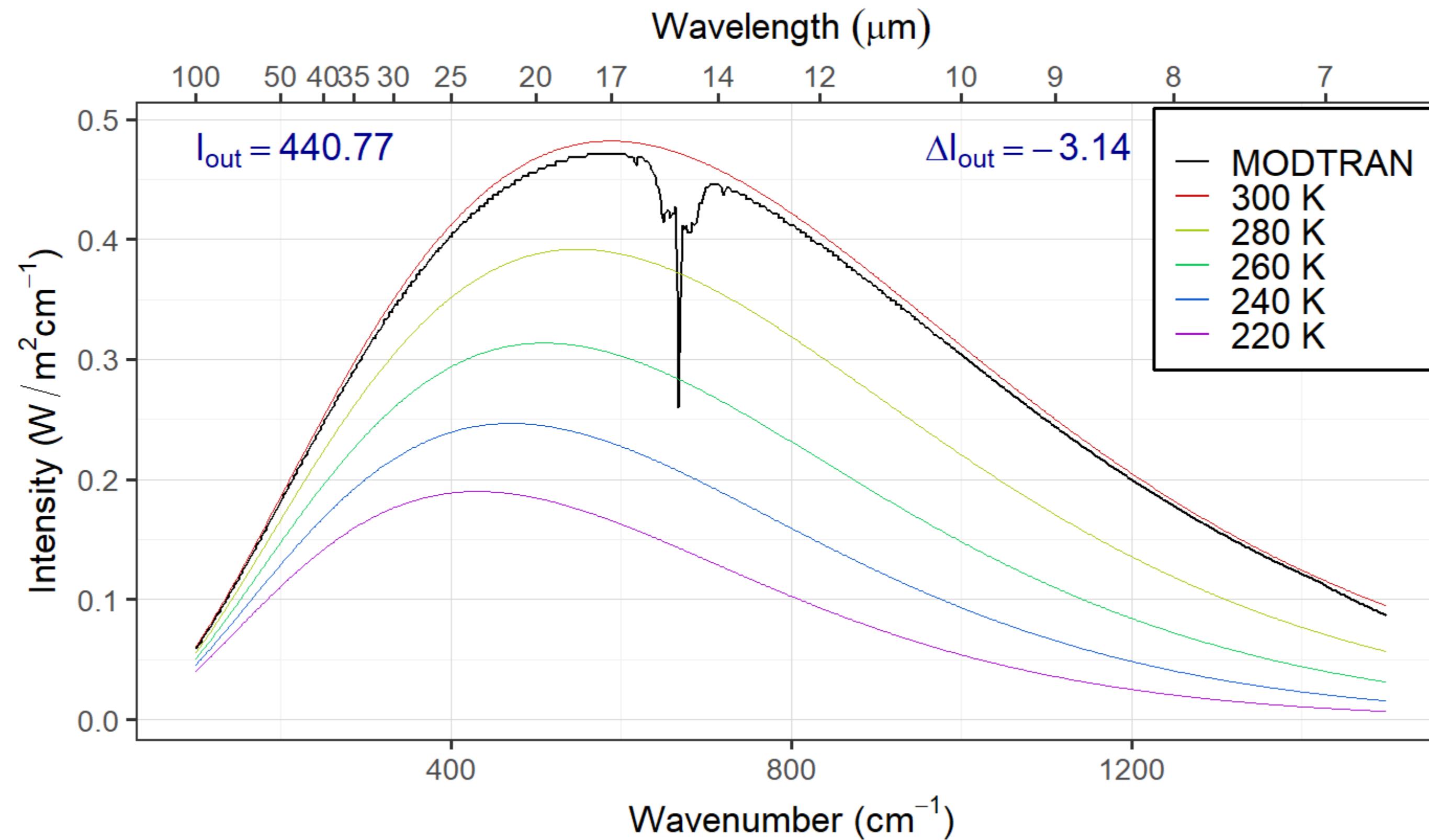
# 0.125 ppm CO<sub>2</sub>

0.125 ppm CO<sub>2</sub>, 20 km

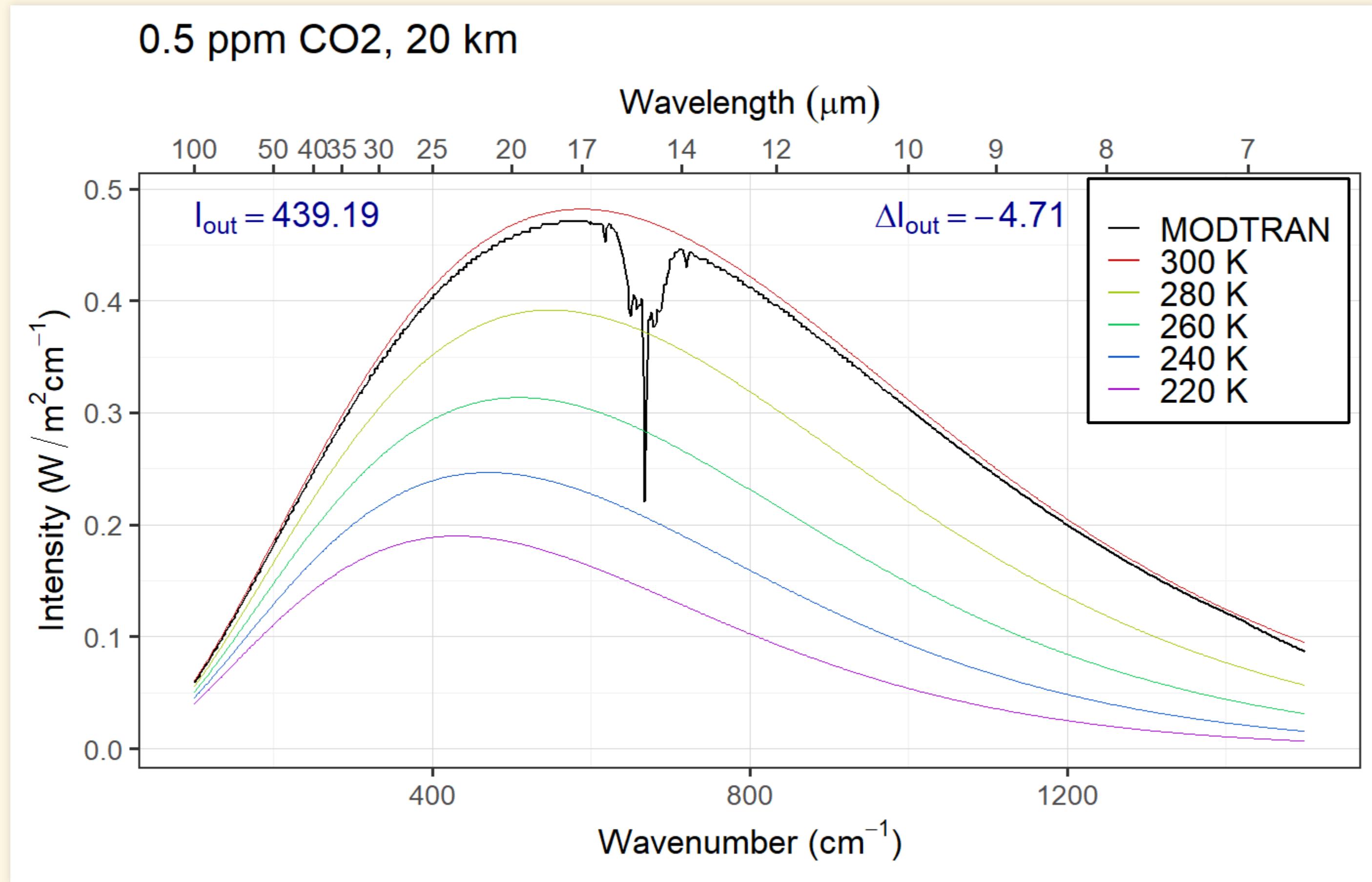


# 0.25 ppm CO<sub>2</sub>

0.25 ppm CO<sub>2</sub>, 20 km

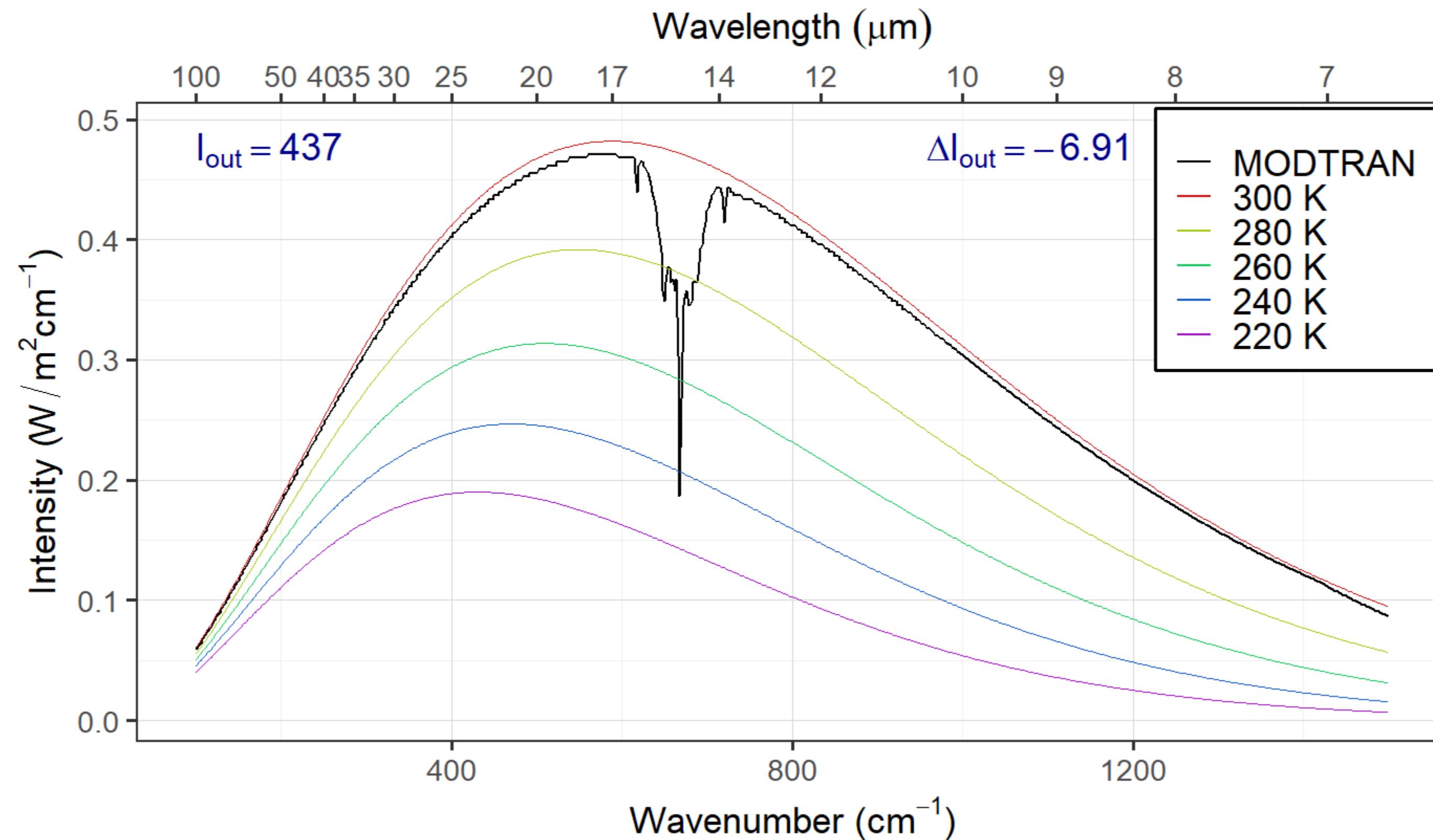


# 0.5 ppm CO<sub>2</sub>

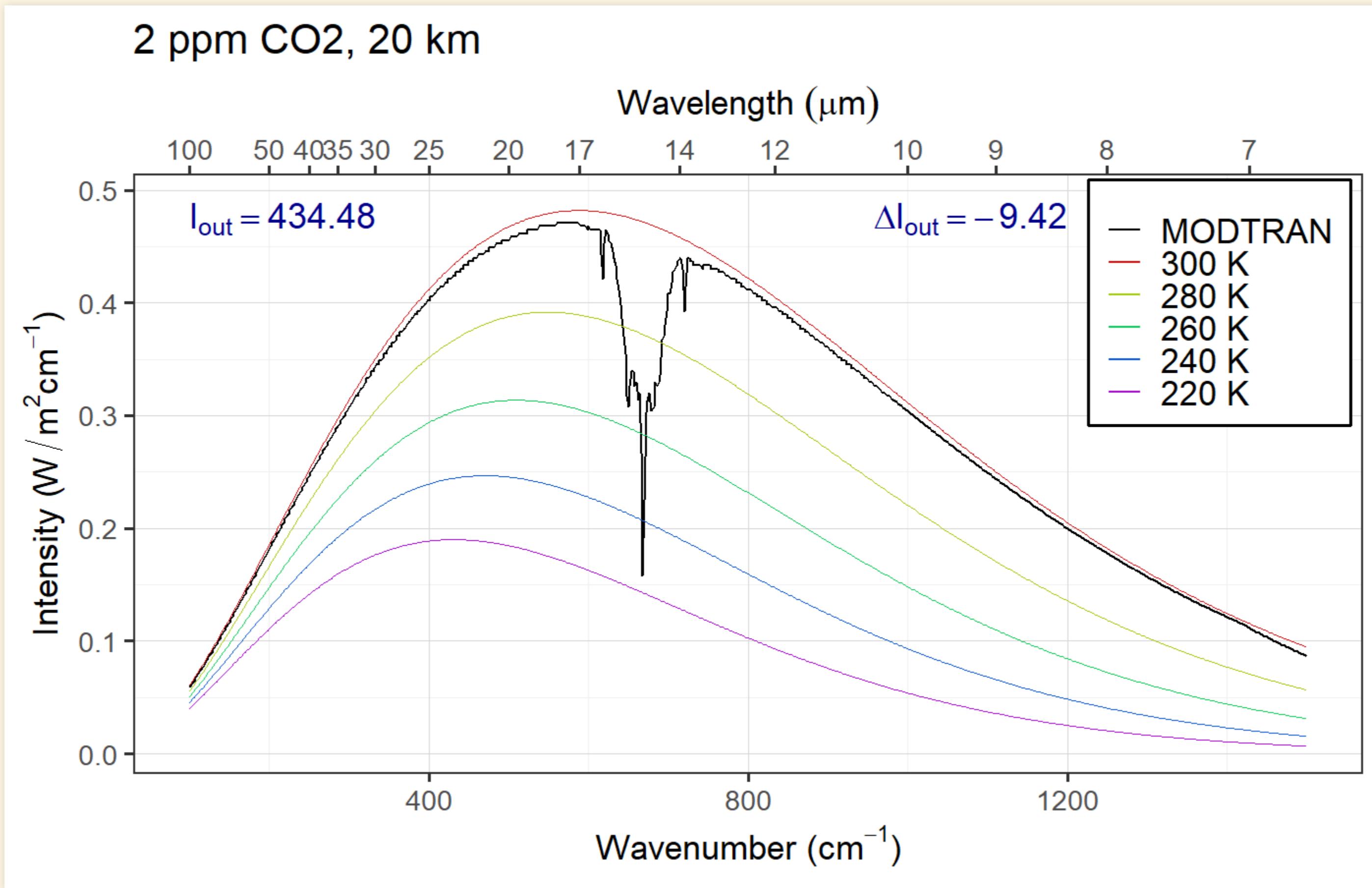


# 1 ppm CO<sub>2</sub>

1 ppm CO<sub>2</sub>, 20 km

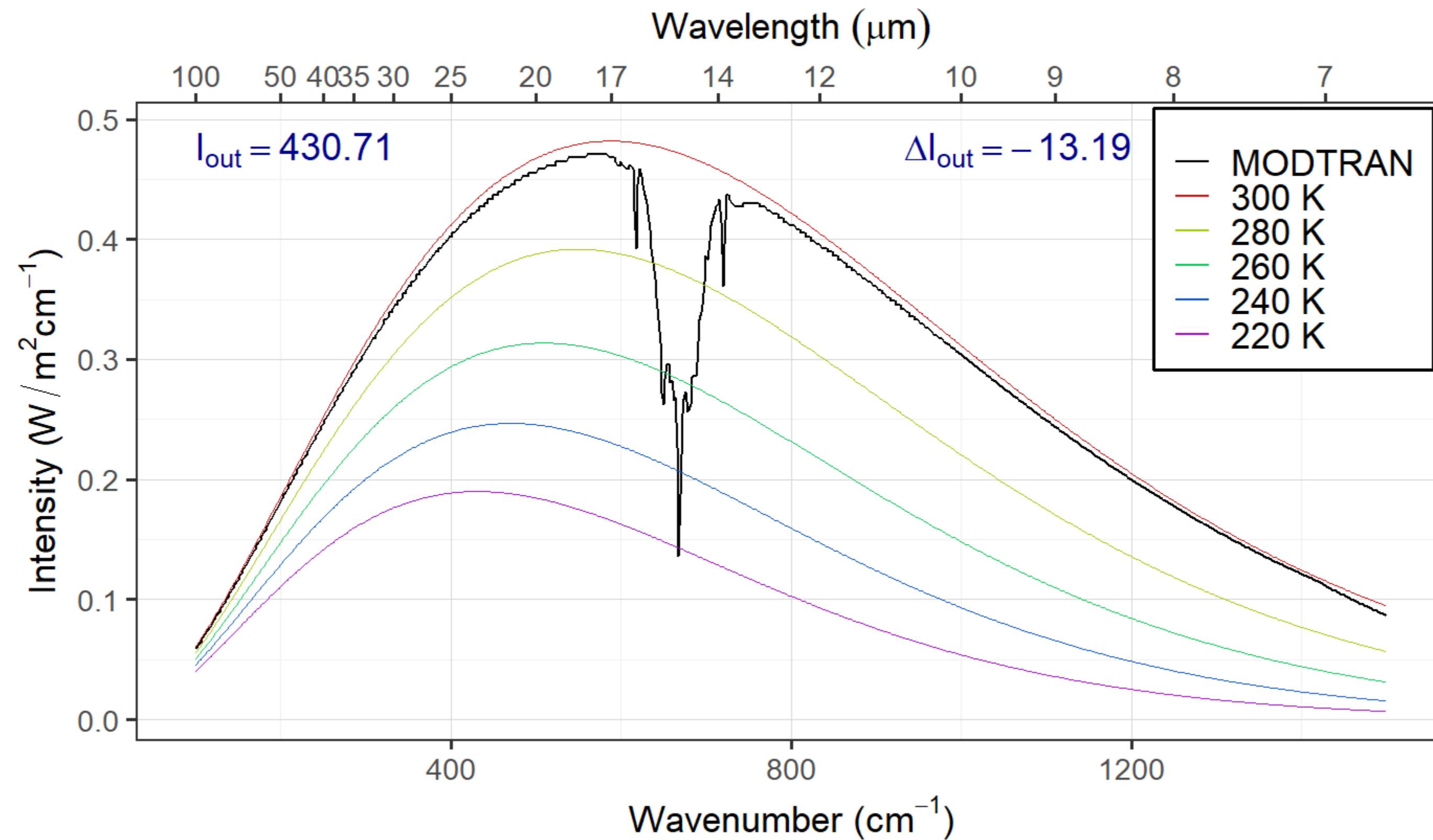


# 2 ppm CO<sub>2</sub>



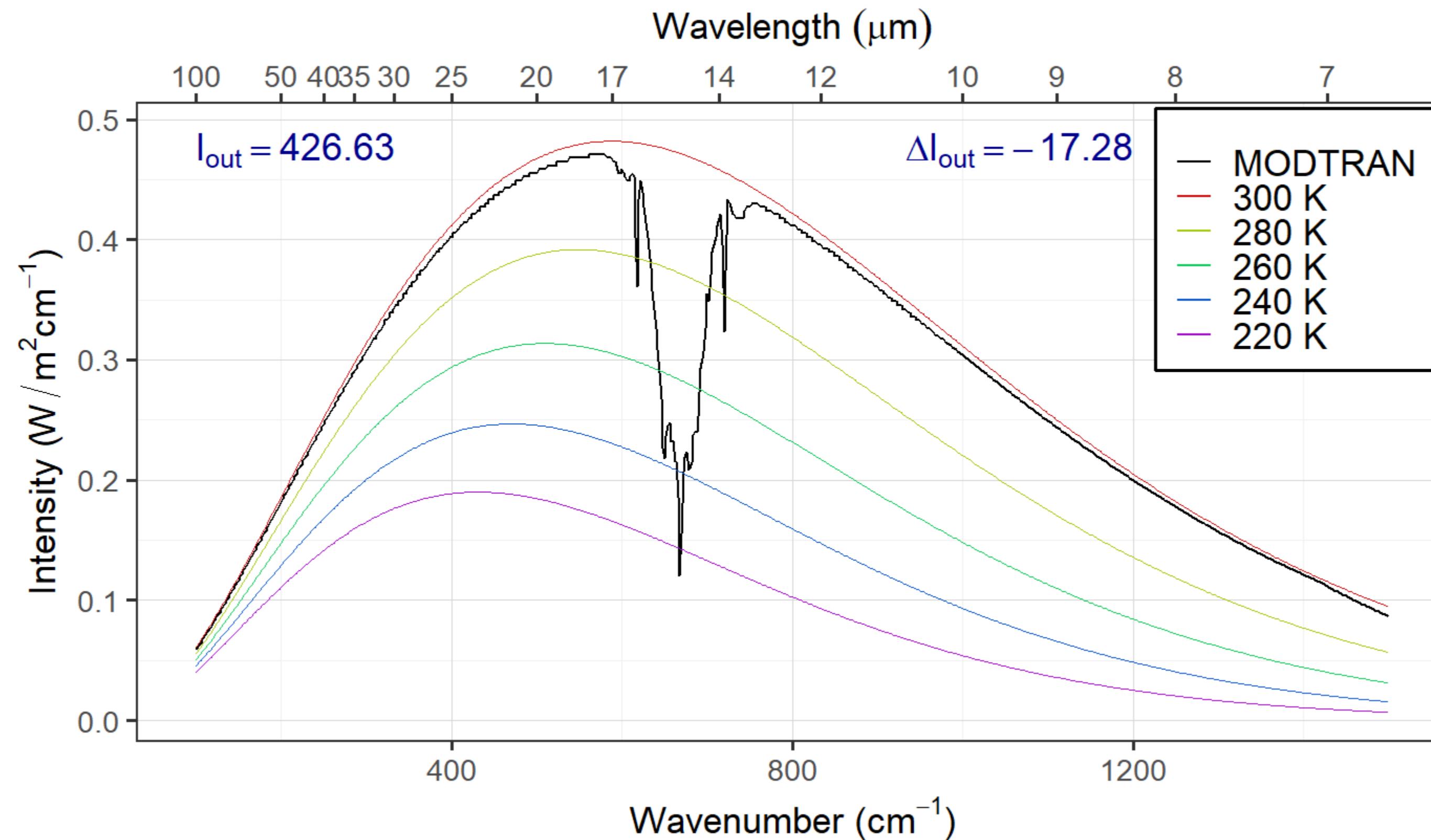
# 4 ppm CO<sub>2</sub>

4 ppm CO<sub>2</sub>, 20 km



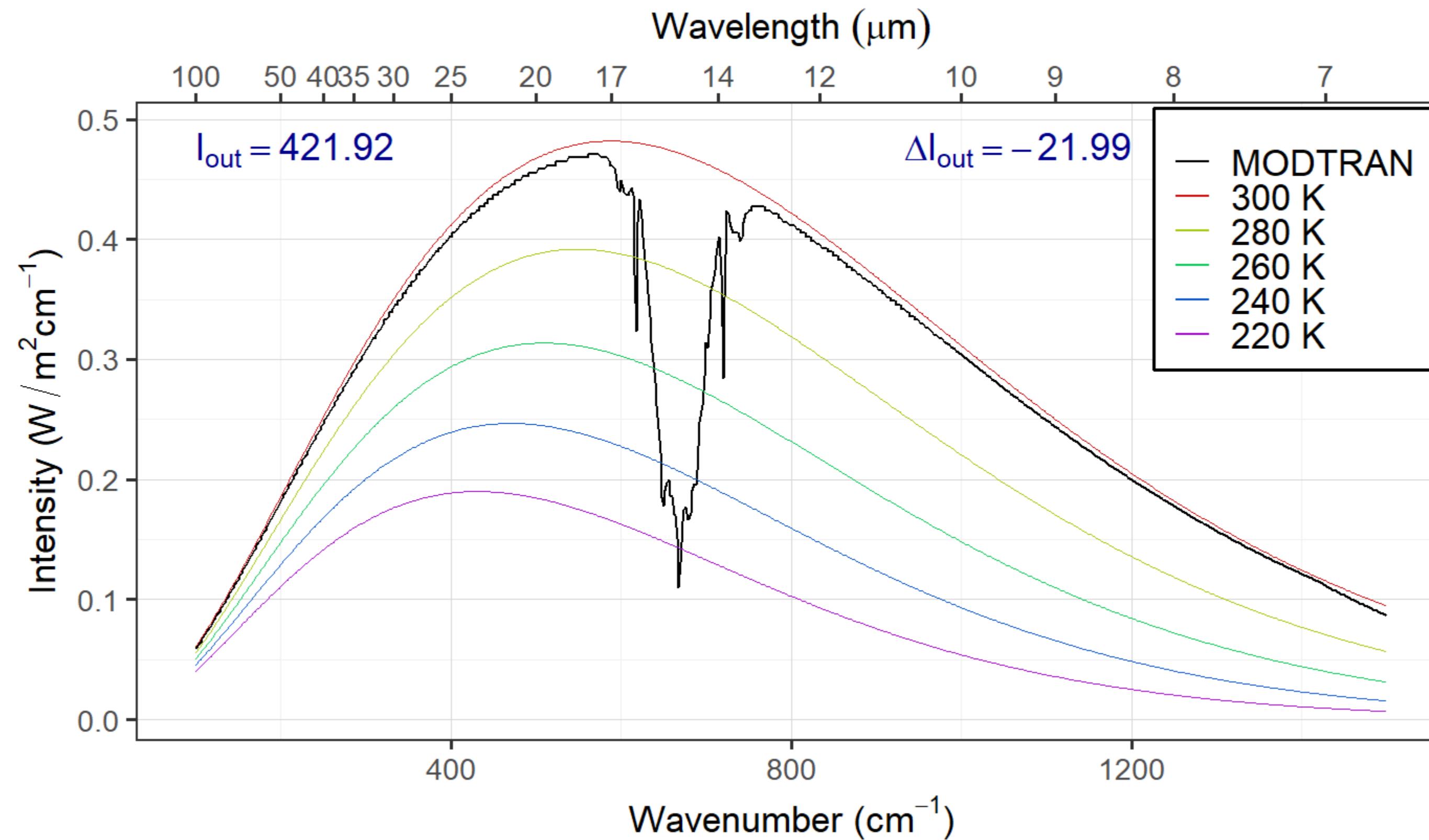
# 8 ppm CO<sub>2</sub>

8 ppm CO<sub>2</sub>, 20 km

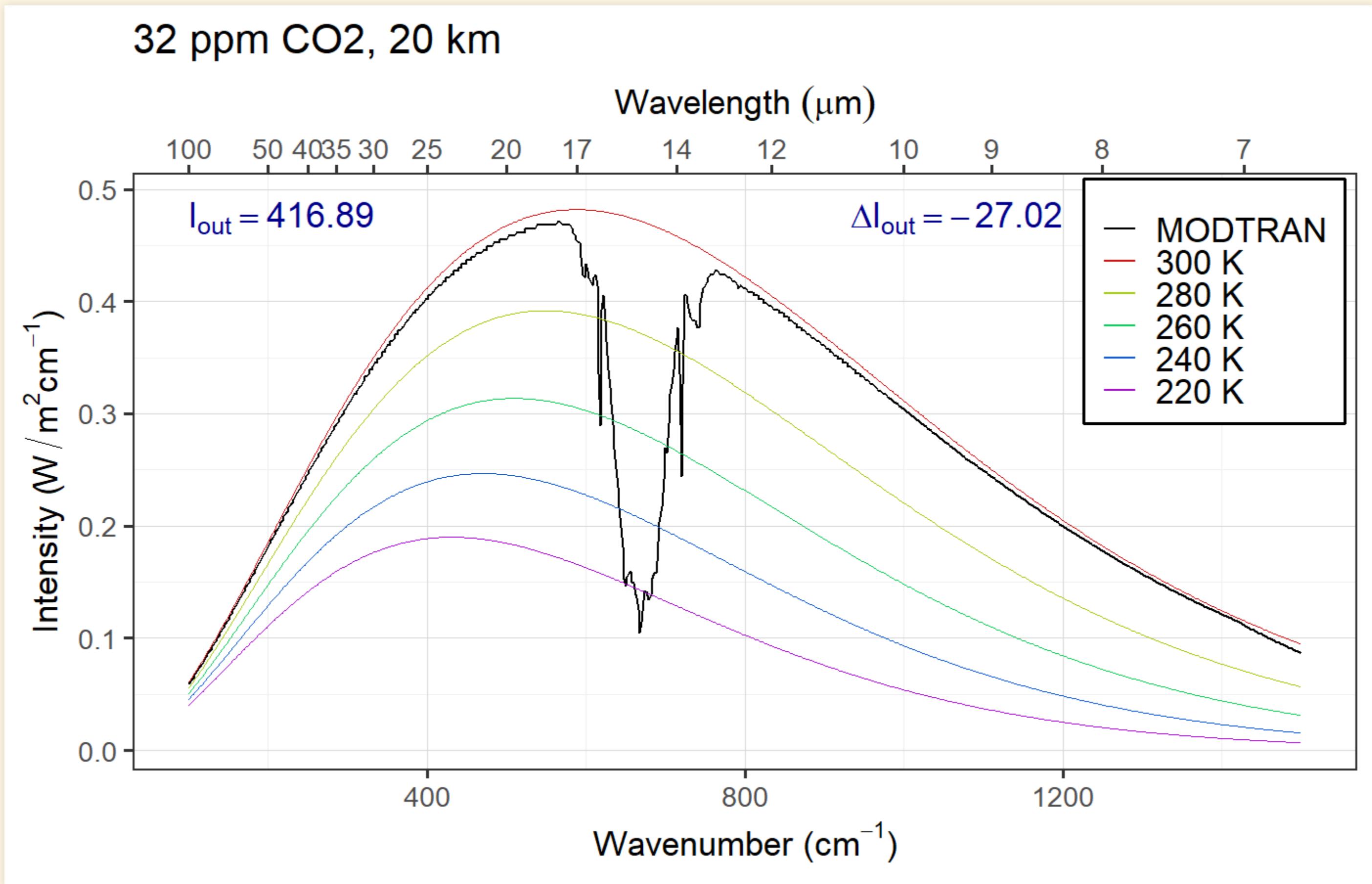


# 16 ppm CO<sub>2</sub>

16 ppm CO<sub>2</sub>, 20 km



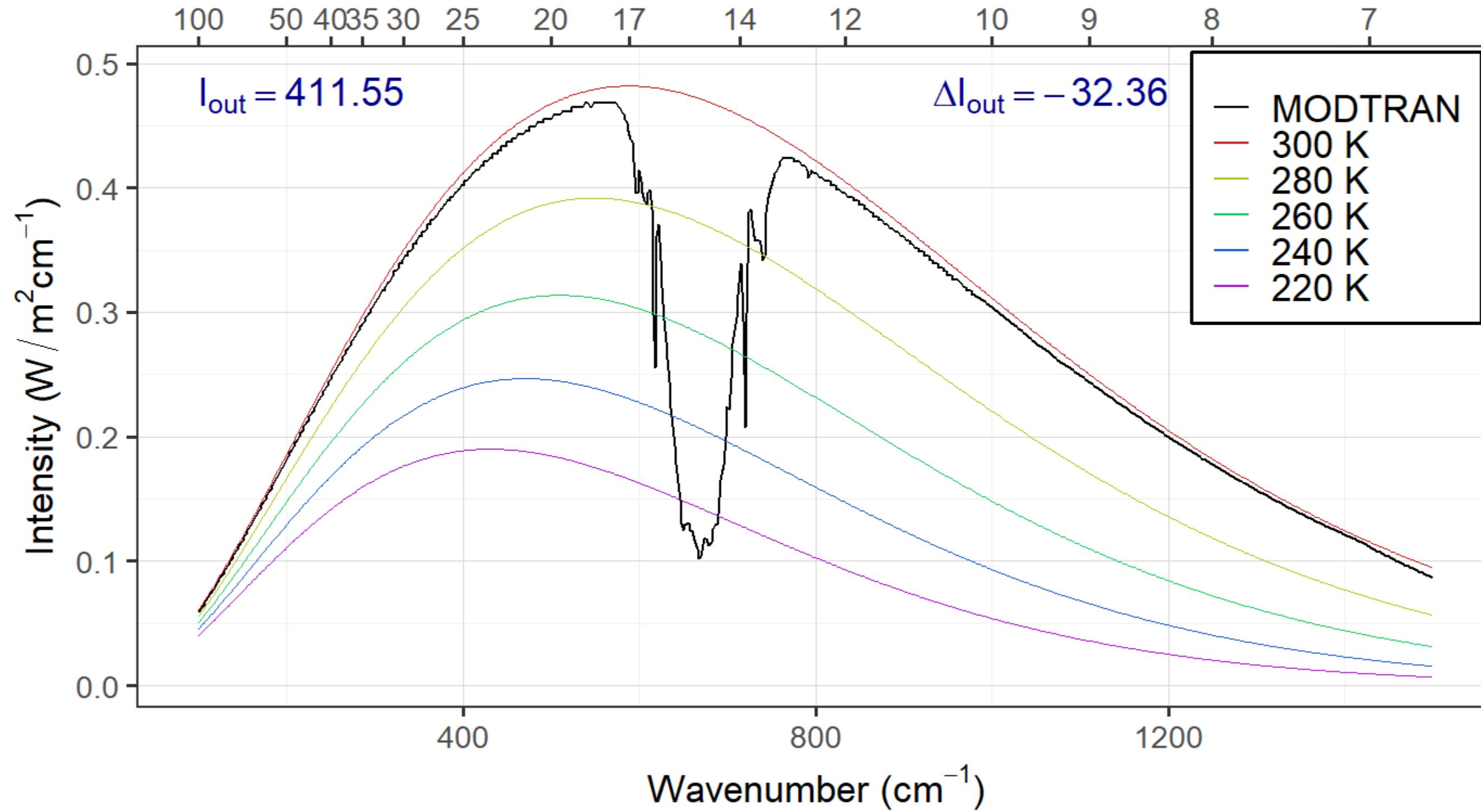
# 32 ppm CO<sub>2</sub>



# 64 ppm CO<sub>2</sub>

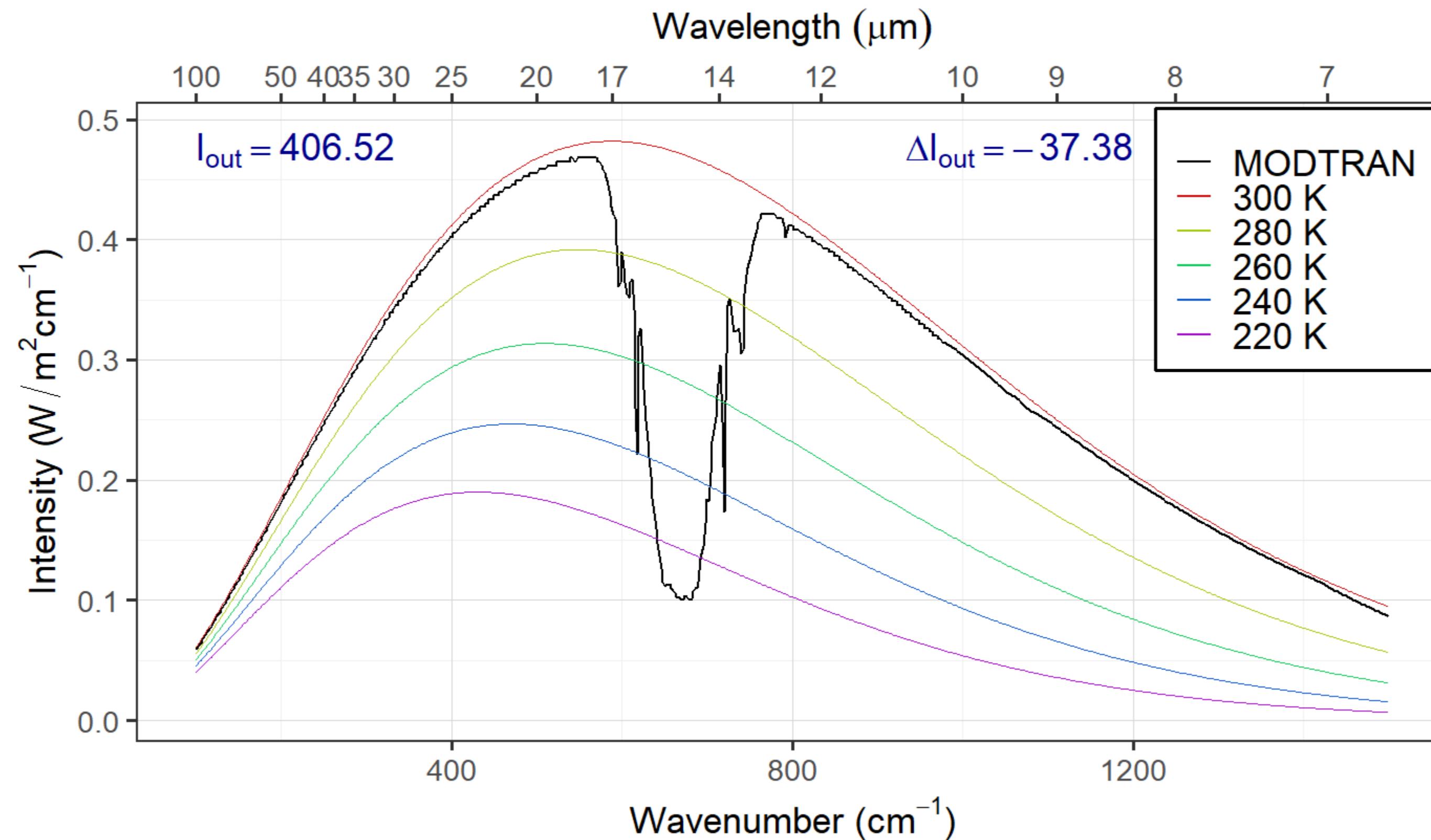
64 ppm CO<sub>2</sub>, 20 km

Wavelength ( $\mu\text{m}$ )



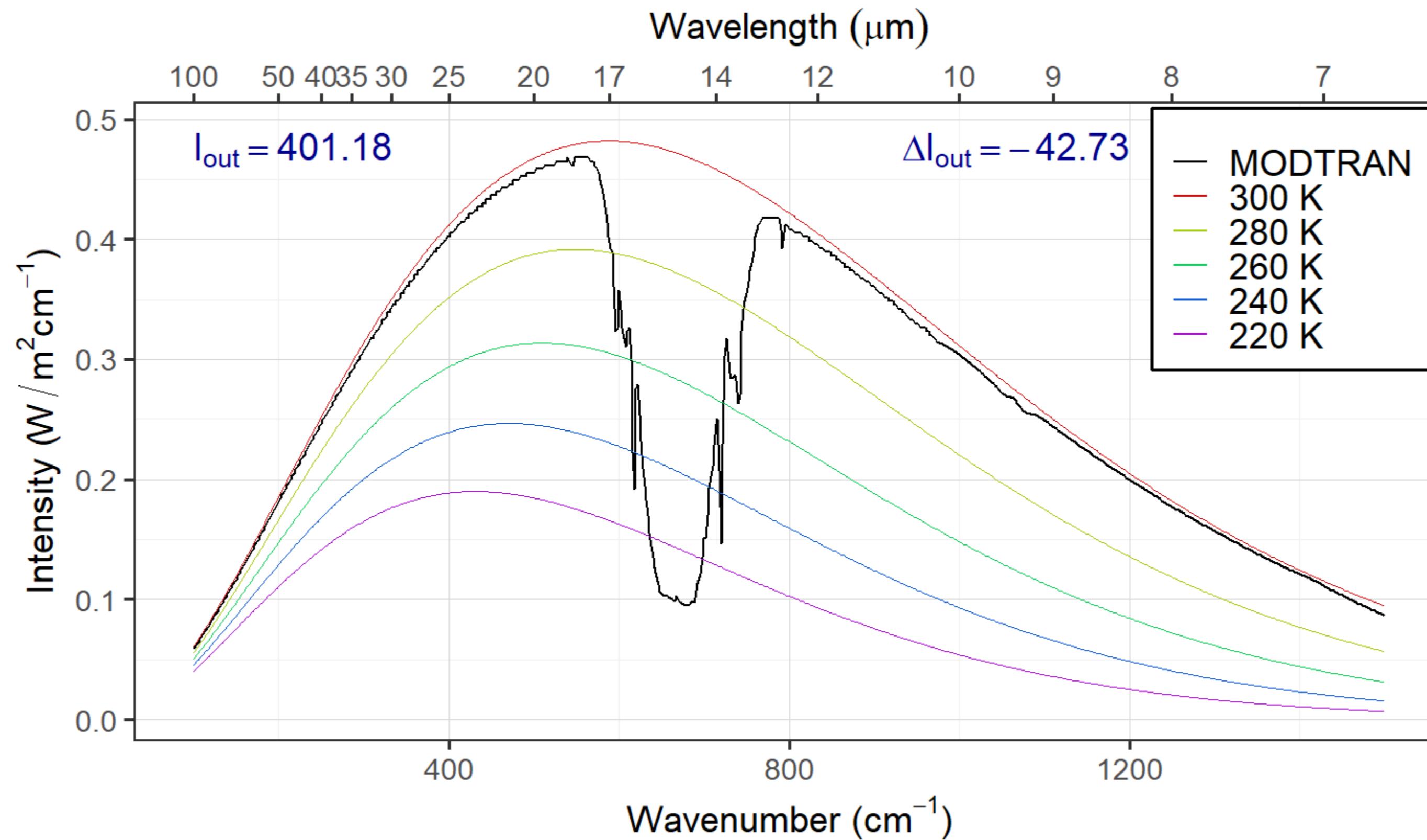
# 128 ppm CO<sub>2</sub>

128 ppm CO<sub>2</sub>, 20 km



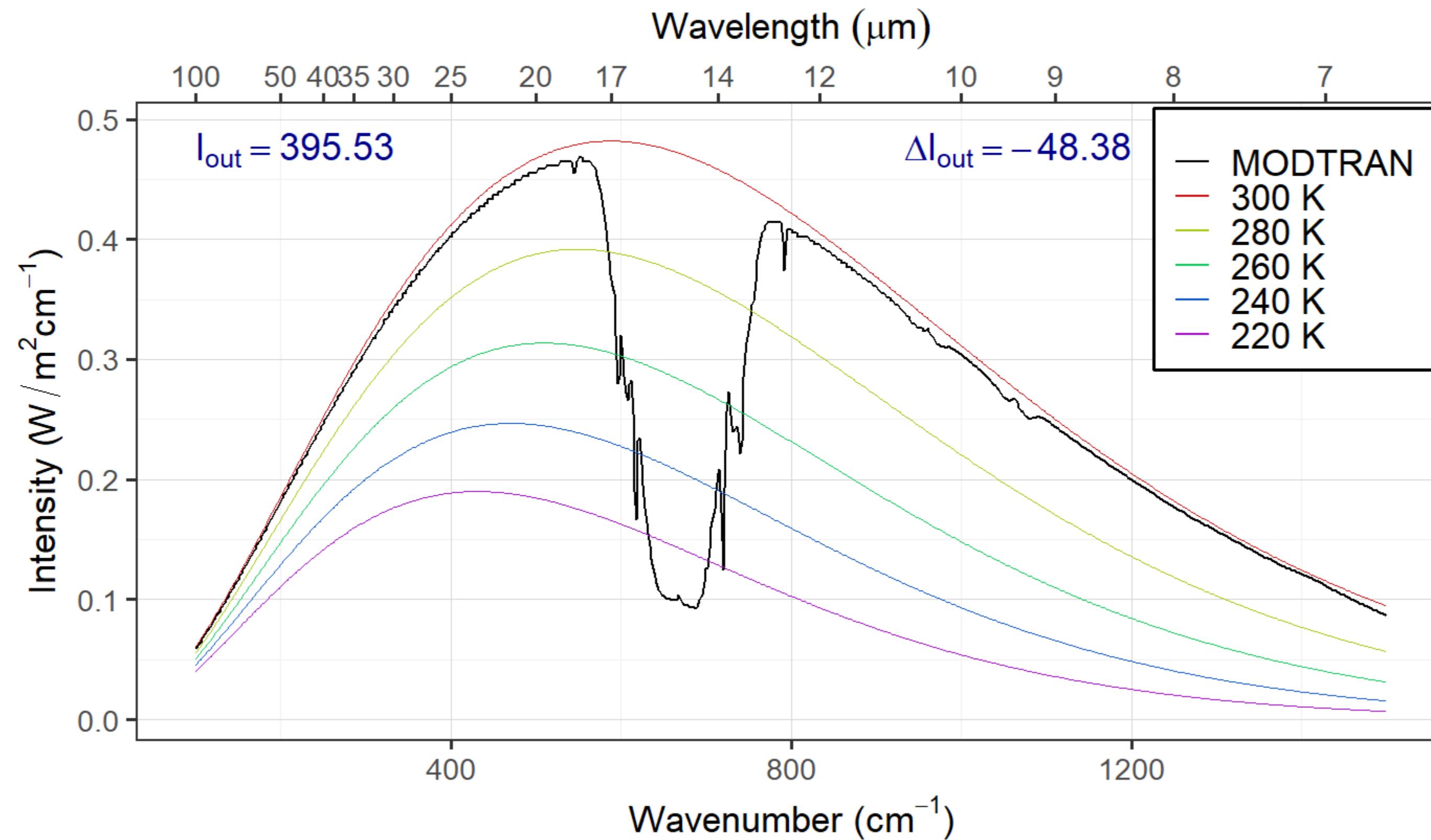
# 256 ppm CO<sub>2</sub>

256 ppm CO<sub>2</sub>, 20 km



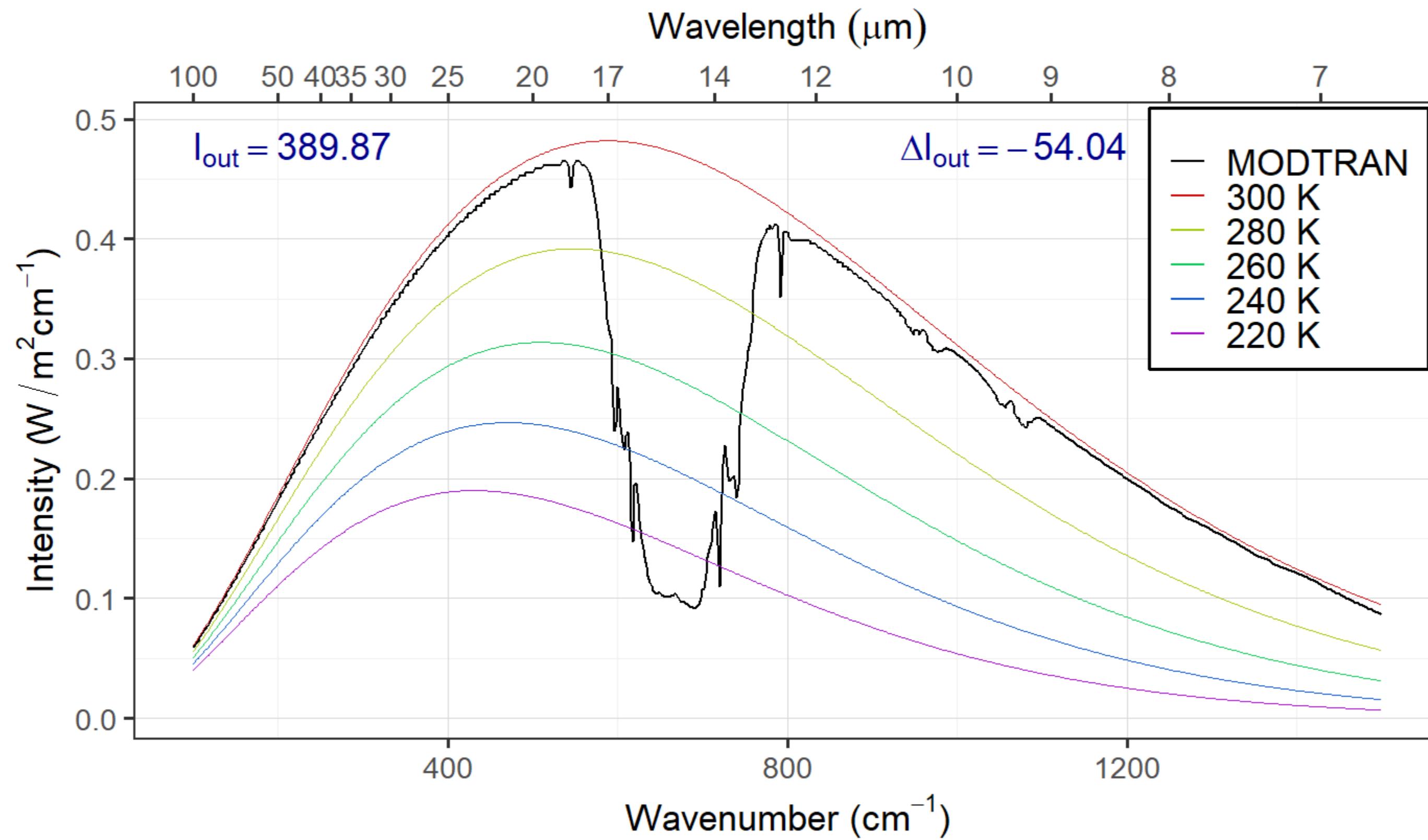
# 512 ppm CO<sub>2</sub>

512 ppm CO<sub>2</sub>, 20 km

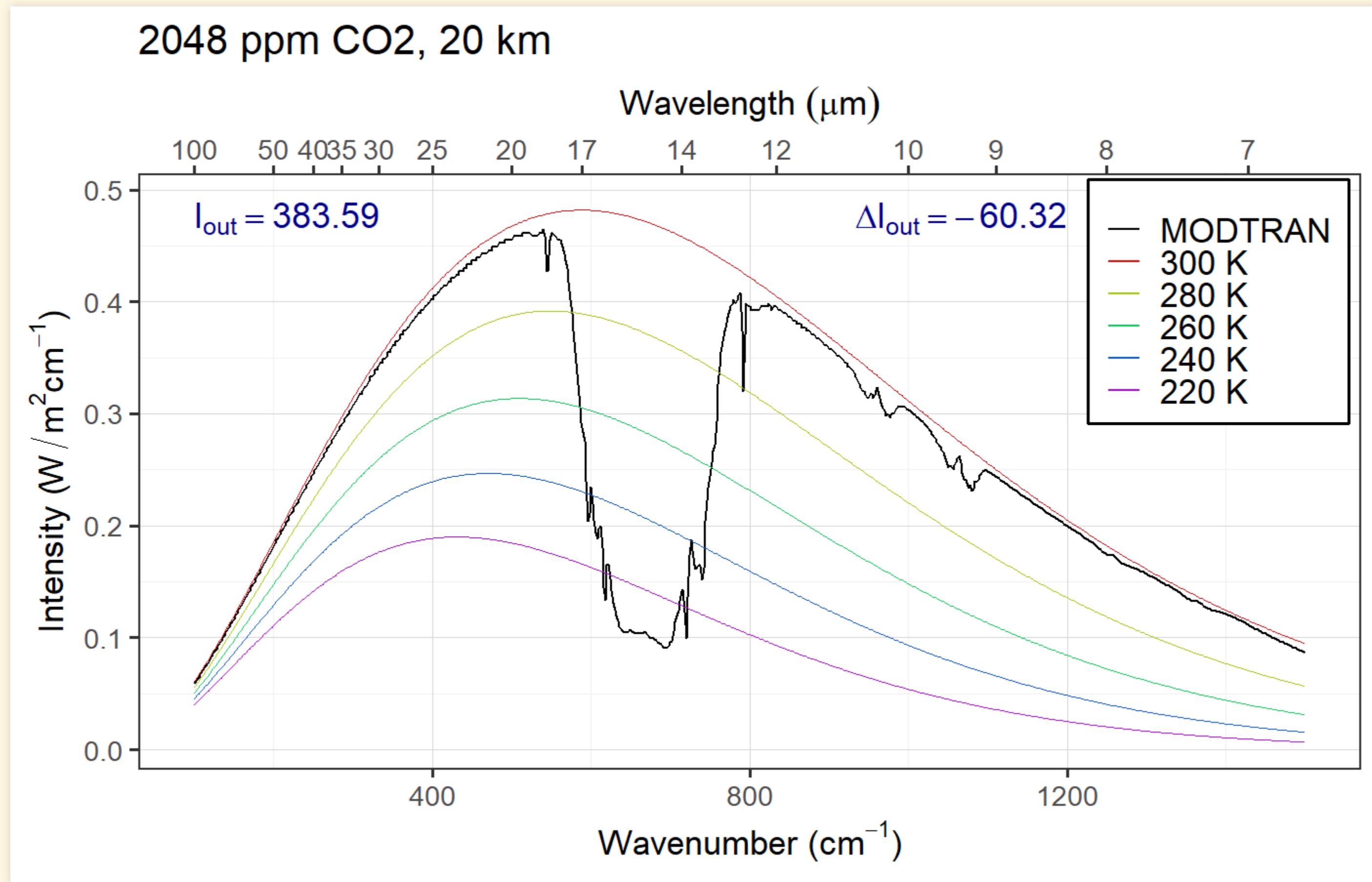


# 1024 ppm CO<sub>2</sub>

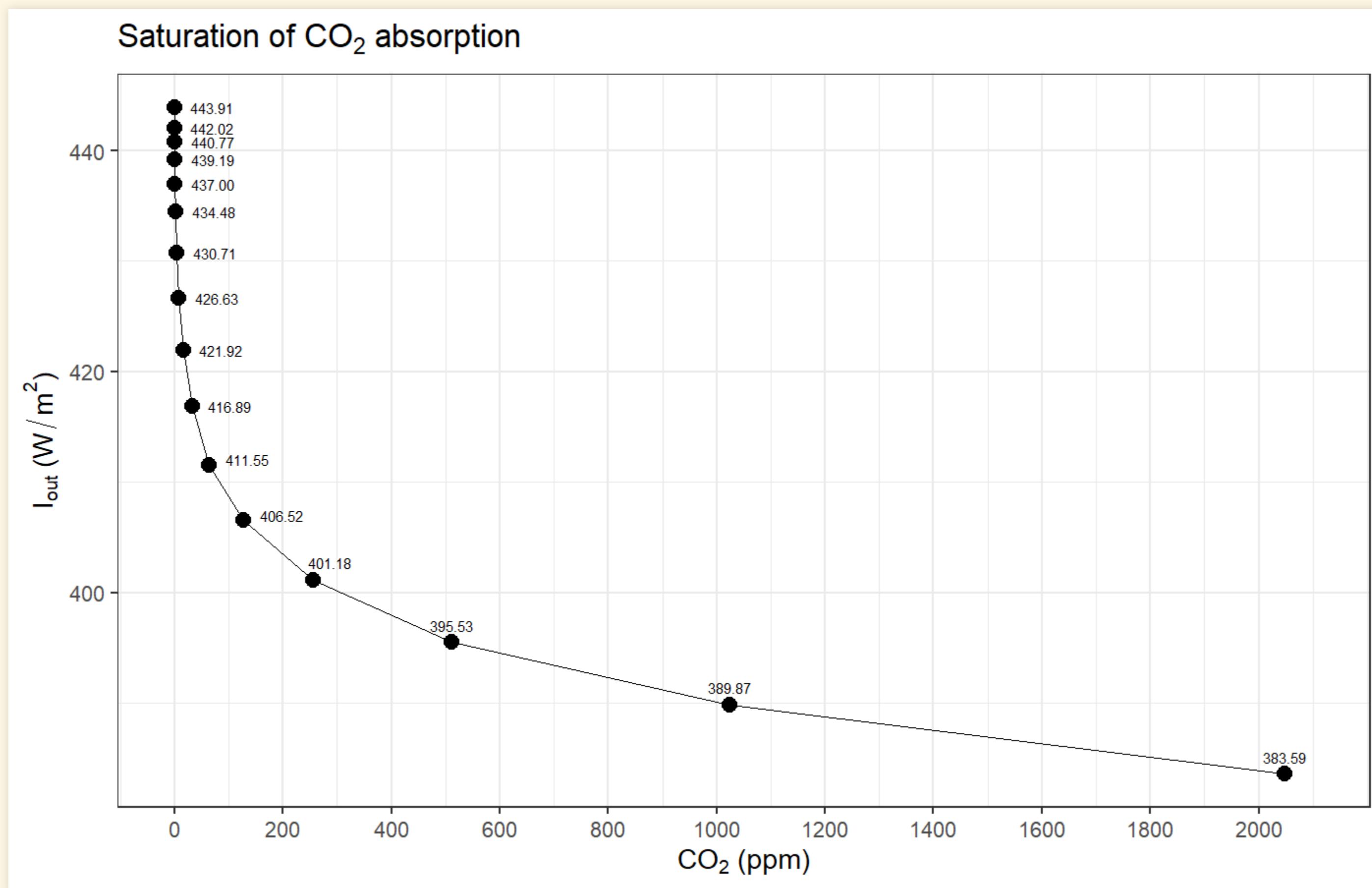
1024 ppm CO<sub>2</sub>, 20 km



# 2048 ppm CO<sub>2</sub>



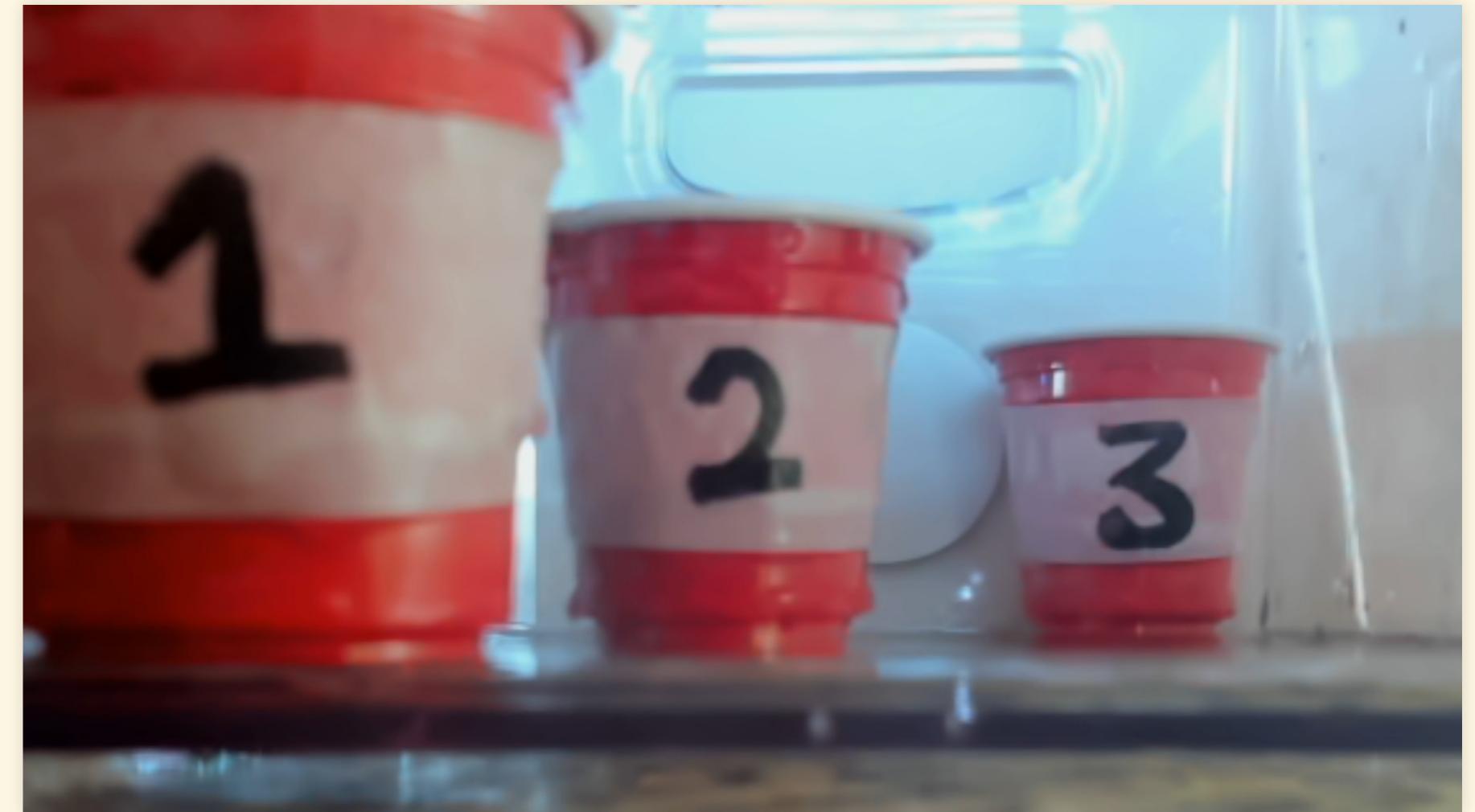
# Band Saturation ( $I_{out}$ )



# 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



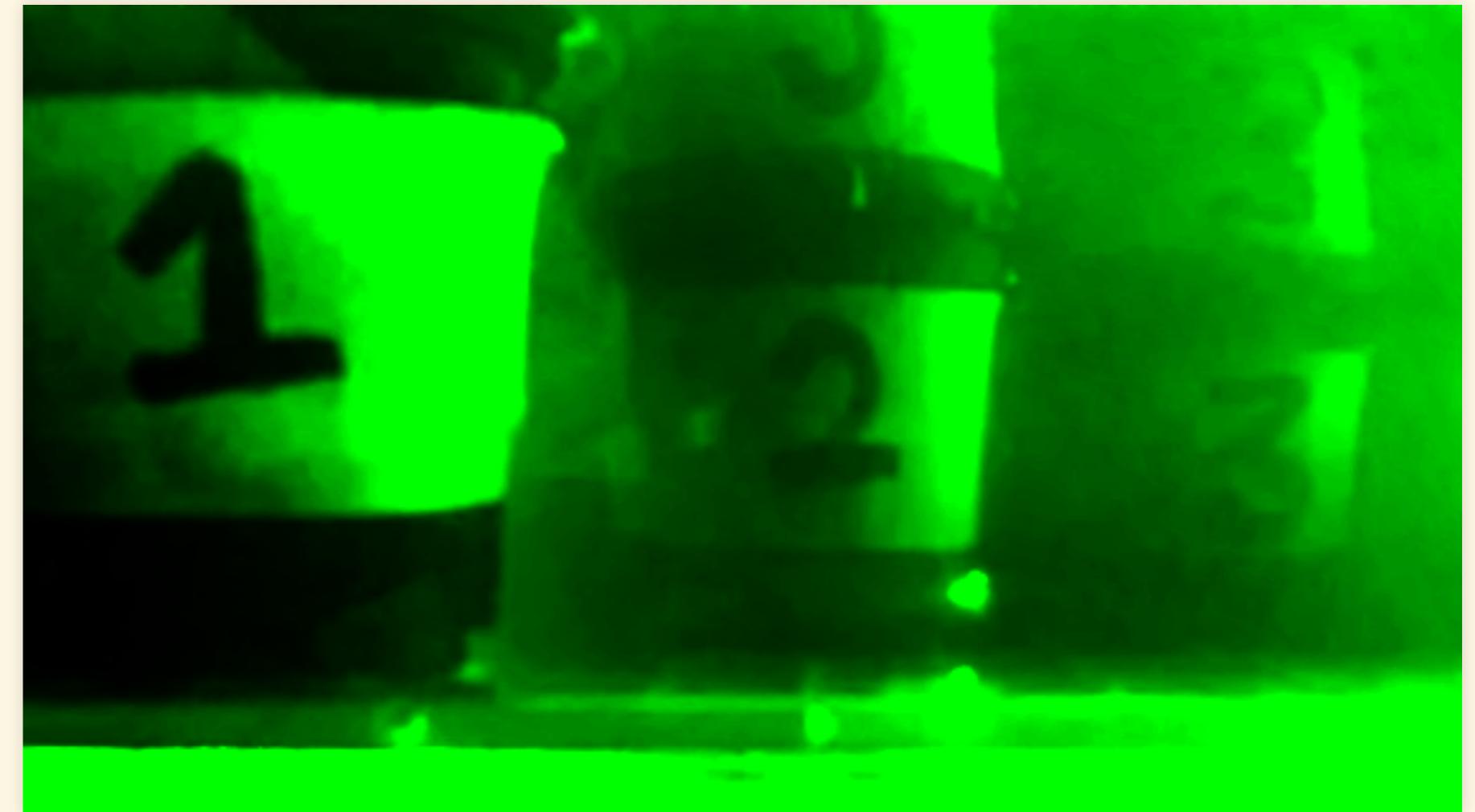
# Visible Radiation in Colored Water

- 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



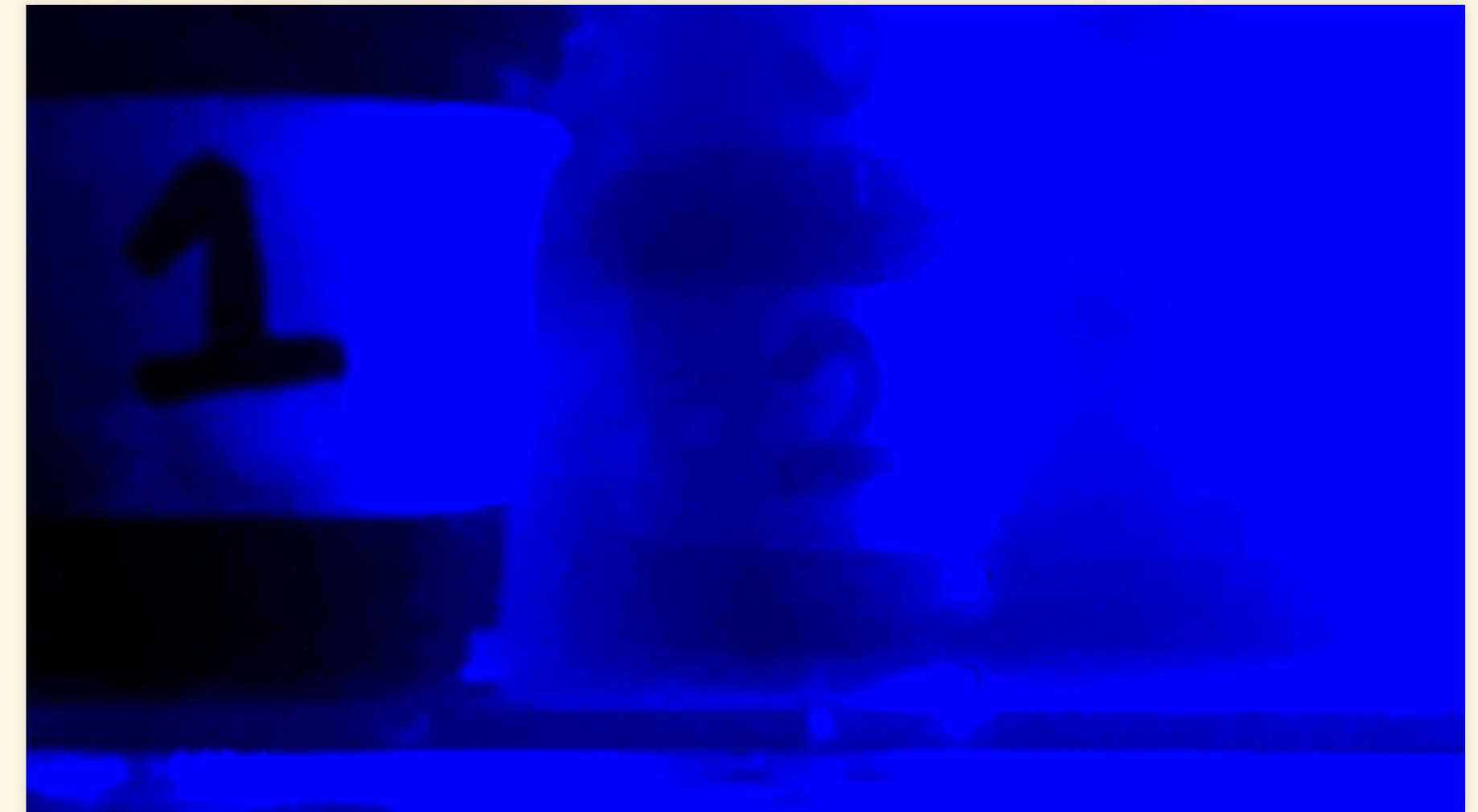
# Visible Radiation in Colored Water

- 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

