Air Density Variation Equation: Application to Ottawa Temperatures

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April 30, 2024

1 Introduction

In this document, we will explore the air density variation equation and apply it to temperature changes in Ottawa, Canada.

2 Air Density Variation Equation

The air density variation with altitude (z) due to temperature changes can be described by the equation:

$$\frac{d\rho}{dz} = -\frac{\rho g}{RT}$$

Where:

$$\begin{aligned} \rho &: \text{Air density} \\ g &: \text{Acceleration due to gravity} \\ R &: \text{Specific gas constant} \\ T &: \text{Temperature} \end{aligned}$$

3 Scenario: Ottawa Temperature Variation

Let's consider the difference in air density between a winter day and a summer day in Ottawa.

3.1 Winter Day (January)

$$\begin{aligned} T_w &= -10°\text{C} \\ \Delta T &= T_w - T_s = (-10) - 25 = -35°\text{C} \end{aligned}$$

3.2 Summer Day (July)

$$T_s = 25°\text{C}$$

4 Calculating Air Density Change

Using the air density variation equation:

$$\Delta\rho = -\frac{\rho g}{RT}\Delta T$$

Substitute values:

$$\Delta\rho = -\frac{\rho g}{287 \times (T_w + 273.15)} \times \Delta T$$

Plugging in values:

$$\Delta\rho = -\frac{\rho g}{74,925.05} \times 35$$

$$\Delta\rho \approx -0.000015 \times \rho$$

5 Relevance

This calculation gives us the relative change in air density between the winter and summer conditions at a constant altitude. It shows that the colder winter air is denser compared to warmer summer air, which has lower density, due to their respective temperatures.

In practical terms, these density variations can influence various phenomena such as aircraft performance, atmospheric buoyancy, and signal propagation in communication systems, highlighting the importance of considering temperature effects on air density in real-world applications.

6 Conclusion

The colder winter air in Ottawa is denser compared to warmer summer air due to temperature differences, affecting air density and related phenomena.