Introduction to Earth Systems

Tutorial

Calculate the Temperature variation for varying solar constant in the model T^4 = S(1-a)/(4*sigma)

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In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

In [47]:
```
# Constants
a = 0.3   # albedo
sigma = 5.67 * 1e-8
S = 1360  # Solar Constant W/m^2
# Range of S values from (-30% to 30%)
S_range = np.array([952, 1088, 1244, 1360, 1496, 1632, 1768])
Temperature = (S_range * (1 - a) / (4 * sigma))**0.25
# Calculating the percentage change of Temperature for every S values
S_initial = 1360  # Solar Constant W/m^2
# Calculate corresponding T values for initial S
T_initial = (S_initial * (1 - a) / (4 * sigma))**0.25
# Calculate percentage change in T for each S
percentage_change_T = ((Temperature - T_initial) / T_initial) * 100

# Calculating for emission value
e = 0.61
S2 = 1362

# Range of S2 values from (-30% to 30%)
S2_range = np.array([953.4, 1089.6, 1225.8, 1362, 1498.2, 1634.4, 1770.6])

# Calculating Temperature for S = 1362
T2 = (S2_range * (1 - a) / (4 * e * sigma))**0.25  # for S2 = 1362

# Calculating the percentage change of Temperature for every S values
S2_initial = 1362  # Solar Constant W/m^2

# Calculate corresponding T values for initial S
T2_initial = (S2_initial * (1 - a) / (4 * e * sigma))**0.25

# Calculate percentage change in T for each S
percentage_change_T2 = ((T2 - T_initial) / T_initial) * 100

# Creating subplots
fig, axes = plt.subplots(2, 2, figsize=(12, 10))

# Plot of solor constant = 1360
axes[0, 0].plot(Temperature, S_range, marker='o', label='Temperature')
axes[0, 0].legend()
axes[0, 0].set_title('Temperature vs Solar constant (1360)')
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axes[0, 0].set_xlabel('Solar constant (W/m^2)')
axes[0, 0].set_ylabel('Temperature (K)')
axes[0, 0].grid(True)

#  Plot of solor constant = 1362
axes[0, 1].plot( T2, S2_range, marker='o', label='Temperature')
axes[0, 1].legend()
axes[0, 1].set_title('Temperature vs Solar constant (1362)')
axes[0, 1].set_xlabel('Solar constant (W/m^2)')
axes[0, 1].set_ylabel('Temperature (K)')
axes[0, 1].grid(True)

# Percentage Change in Temperature for S = 1360
axes[1, 0].plot( percentage_change_T, S_range, marker='o', label='Temperature change f
axes[1, 0].legend()
axes[1, 0].set_title('Percentage Change in Temperature vs Solar constant (1360)')
axes[1, 0].set_xlabel('Solar constant (W/m^2)')
axes[1, 0].set_ylabel('Percentage Change in Temperature (%)')
axes[1, 0].grid(True)

# Percentage Change in Temperature for S = 1362
axes[1, 1].plot(percentage_change_T2, S2_range,  marker='o', label='Temperature change
axes[1, 1].legend()
axes[1, 1].set_title('Percentage Change in Temperature vs Solar constant (1362)')
axes[1, 1].set_xlabel('Solar constant (W/m^2)')
axes[1, 1].set_ylabel('Percentage Change in Temperature (%)')
axes[1, 1].grid(True)

plt.tight_layout()
plt.show()
```
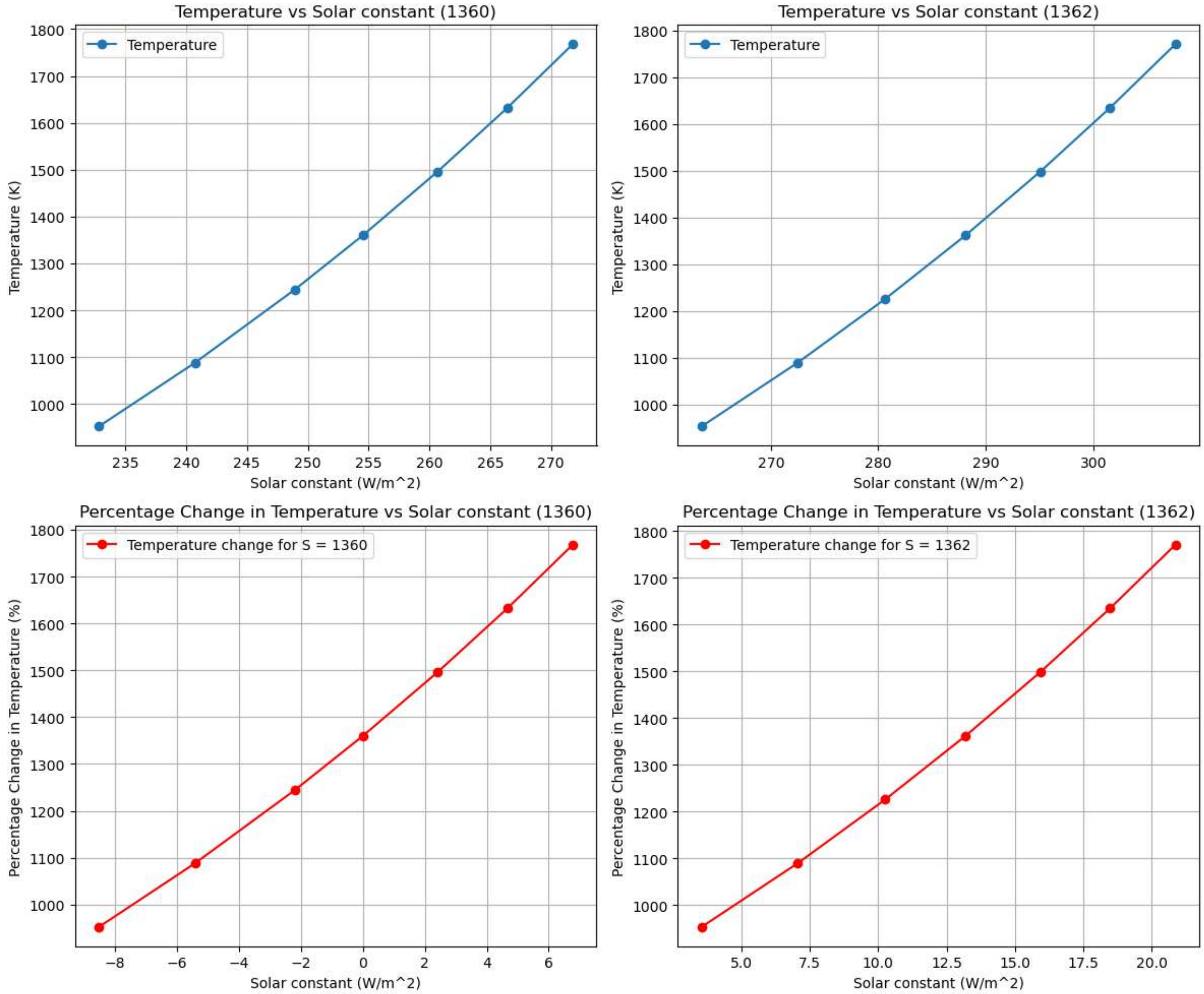
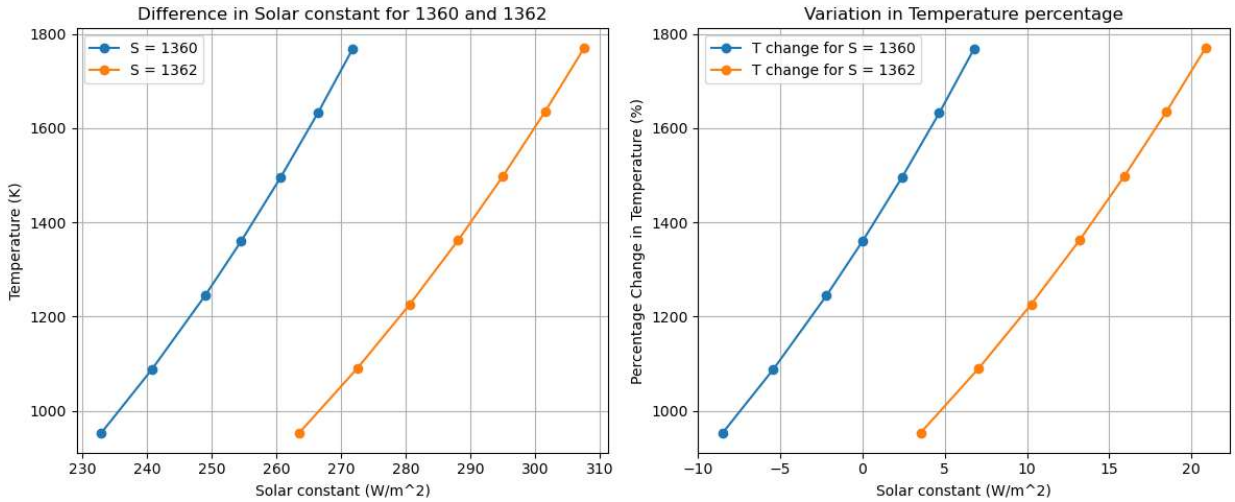



In [49]:

```
# Plotting the Variation in the in solar constant and Percentage Temperature
fig, axes = plt.subplots(1, 2, figsize=(12, 5))

# Plot of solar constant = 1360 and 1362
axes[0].plot(Temperature,S_range,  marker='o', label='S = 1360')
axes[0].plot( T2,S2_range, marker='o', label='S = 1362')
axes[0].legend()
axes[0].set_title('Difference in Solar constant for 1360 and 1362')
axes[0].set_xlabel('Solar constant (W/m^2)')
axes[0].set_ylabel('Temperature (K)')
axes[0].grid(True)

# Plot of variation in Temperature percentage
axes[1].plot(percentage_change_T,S_range, marker='o', label='T change for S = 1360')
axes[1].plot(percentage_change_T2, S2_range, marker='o', label='T change for S = 1362'
axes[1].legend()
axes[1].set_title('Variation in Temperature percentage')
axes[1].set_xlabel('Solar constant (W/m^2)')
axes[1].set_ylabel('Percentage Change in Temperature (%)')
axes[1].grid(True)

plt.tight_layout()
plt.show()
```



Interpretation of above plots

The simulation related to the temperature response of a planetary body to changes in incoming solar radiation (solar constant) and emission characteristics. This simulation allows us to understand how changes in solar radiation and emission characteristics affect the equilibrium temperature of the planetary body.It shows how the percentage responds to changes in incoming solar radiation, taking into account the surface's reflectivity and the atmosphere's emissivity.The percentage change in temperature provides insights into the sensitivity of the planetary body's temperature to variations in solar radiation.

Comparing different emission characteristics allow us to understand the role of greenhouse gases in regulating a planet's temperature. The calculated sensitivities for different percentage changes in the solar constant tell us how much the temperature would change for those specific percentage changes. For example, a 30% increase in the solar constant would lead to an increase in temperature of approximately 16.5 K. Similarly, a 30% decrease in the solar constant would lead to a decrease in temperature of approximately 21.5 K. The analysis suggests a direct relationship between the solar constant and temperature.

As the solar constant increases, the temperature tends to increase, and as the solar constant decreases, the temperature tends to decrease. This relationship is evident from the positive sensitivity calculated for both the 2 unit change and the percentage changes in the solar constant. The relationship between the solar constant and temperature appears to be non-linear

This analysis helps in understanding the relationship between variables and their impacts on each other. In this case, it helps in understanding how changes in solar radiation affect the temperature of a system, which is crucial for understanding climate dynamics and environmental changes.