Solar Cells in the Arctic

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Motivation

Limited access to fossil fuels in Arctic regions, combined with the global transition toward renewable energy, makes Arctic solar energy an important topic of study. Some questions to investigate are:

- How does a high albedo in the Arctic affect solar cells?
- How does the solar zenith angle in the Arctic affect solar cells?
- How does snow affect solar cell performance?

Surface albedo (α)

- α is defined as the ratio between reflected radiation and incident radiation from the surface [1].
- Snow and ice has a high α of around 0.5-0.9 compared to grass with an α between 0.15-0.25 [1] [3] [4].
- Some parts in the Arctic, like Greenland, have high α even in summertime (Fig. 3) [2].

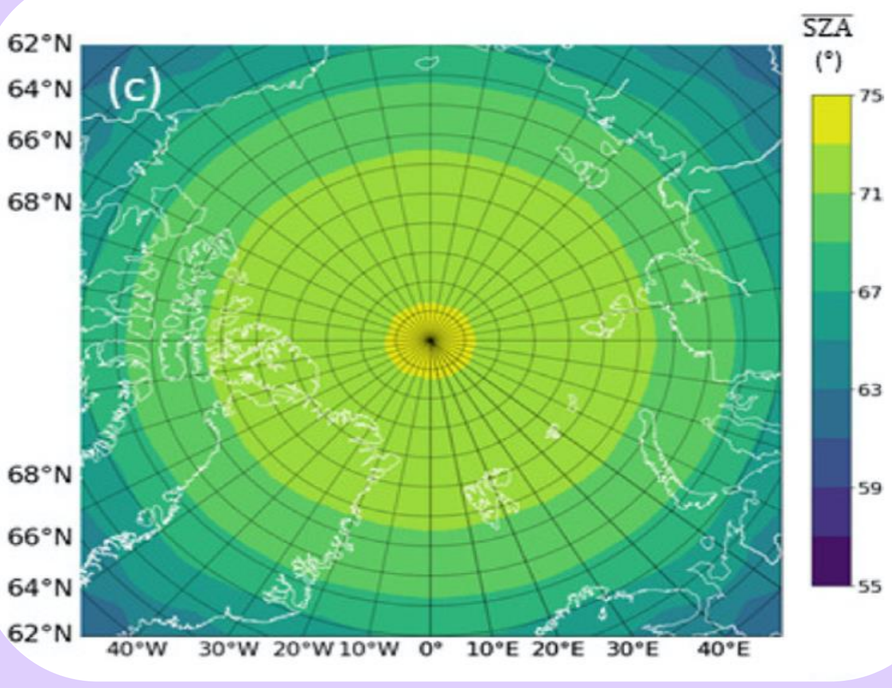

Figure 2: Map of mean value for Solar Zenith Angle (SZA) for April-September 2020 [2].

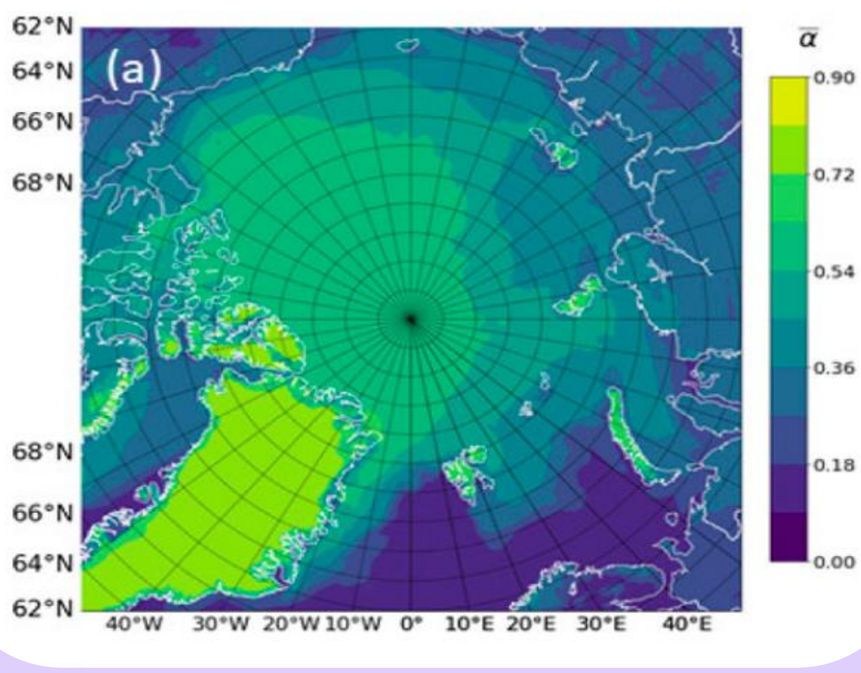

Figure 3: Map of mean value of surface albedo (α) for April-September 2020 [2].

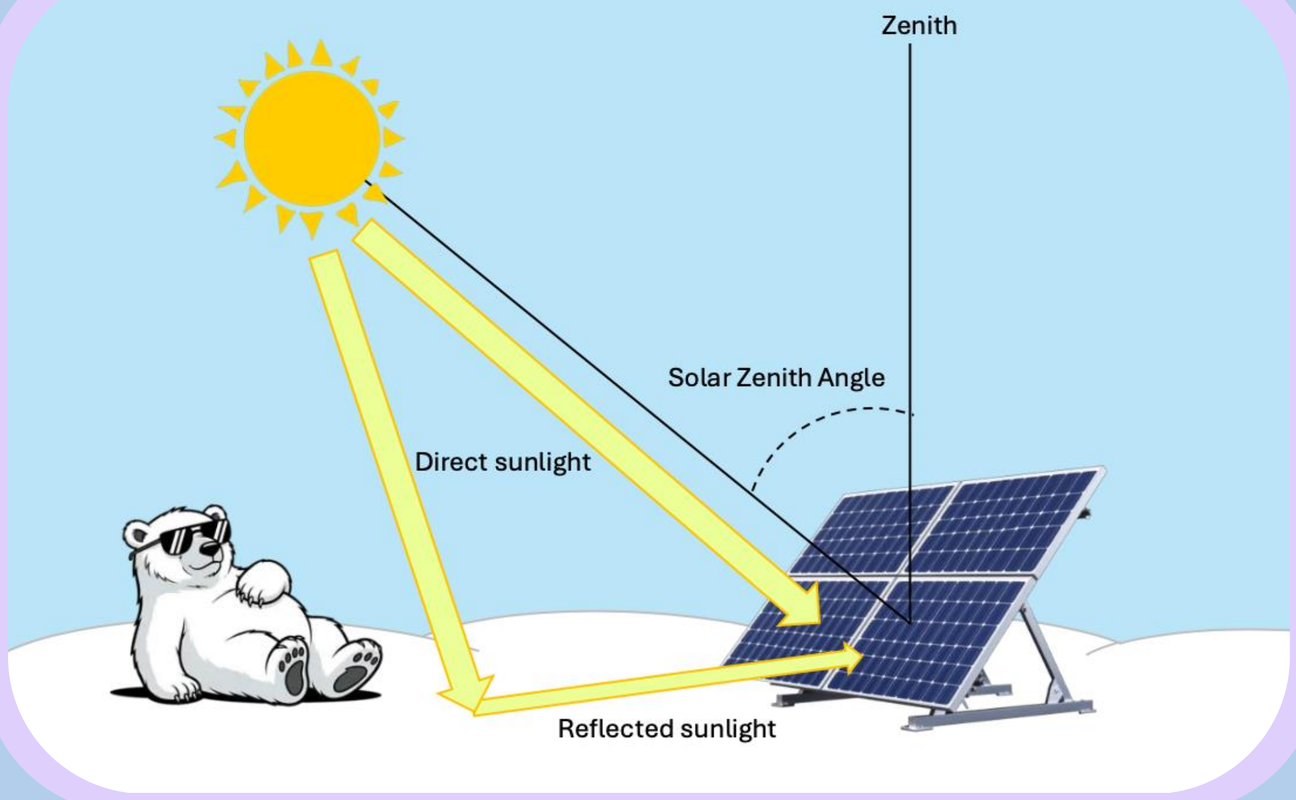

Figure 1: Illustration of a solar panel in a snowy environment. Solar radiation is shown as yellow arrows, with the reflected radiation as a thinner arrow. The Solar zenith angle is shown as the angle between the sun´s position and the vertical line above the panel.

Solar Zenith Angle (SZA)

- The SZA is the angle between the line pointing up from the observer's position and the line to the sun´s position (Fig. 1) [2].
- Small values of SZA mean that the sun is high in the sky, while large values indicate that the sun is low [2].

How albedo and SZA affect solar cells

The SZA is generally high in the Arctic (Fig. 2), which means that there is less incoming solar radiation. Because of this, even small changes in other factors, such as albedo, can have a big impact [2].

Higher albedo, like snow has, results in more of the incident radiation reflecting from the surface. This reflected radiation increases the total irradiance reaching the solar cells which enhances its performance [2][3].

How snow affect solar cells

Cold, snow-covered environments can improve solar cell efficiency because low temperatures reduce thermal losses [1]. However, snow accumulation on panels blocks incoming radiation and decreases power production.

Snow-related losses can be reduced using hydrophobic or ice-repellent coatings and by installing panels at steeper tilt angles to promote natural snow shedding [1].

Conclusion

- The albedo of the ground is important for the performance of solar cells
- Snow cover with high albedo can increase solar energy output by reflecting incident light onto panels
- The high SZA makes the albedo of snow and ice important for solar cell performance in the Arctic
- Snow have both positive and negative effects on the efficiency of solar cells

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References
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