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Relationship between Snow and Temperature over Some Iraqi Meteorological Stations

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ABSTRACT: ***Background:*** *Snow forms when tiny ice crystals in clouds stick together to become snowflakes. If enough crystals stick together, they become heavy enough to fall to the ground. Where background includes Precipitation falls as snow when the air temperature is below 2 °C (275.15 K). The falling snow does begin to melt as soon as the temperature rises above freezing, but as the melting process begins, the air around the snowflake is cold. It is a myth that it needs to be below 0 °C (273.15) K to snow.* ***Objective:*** *In Iraq, the heaviest snowfalls tend to occur when the air temperature is between (273.15-275.15) K (0-2) °C.* ***Methods:*** *The data for this study, which includes Temperature (T), Snow Albedo (SA), and Snow Density (SD) as monthly-daily mean, taken from the European Center for Medium-Range Weather Forecasts (ECMWF) for fifteen years from 2008 to 2022 for several selected stations over northern Iraq. The method was to take the monthly rates of snow density, snow albedo, and temperature for the stations of Erbil, Sulaymaniyah, Zakho, Dohuk, and Amadiyah, and the type of relationship and strength of the connection between them was also known.* ***Results:*** *The study found an inverse relationship between snow albedo and snow density across the selected stations, indicating that an increase in snow density leads to a decrease in snow albedo. Notably, Duhok City exhibited the strongest relationship between snow albedo and density, with a regression coefficient of 0.9699 compared to other regions.* ***Conclusions:*** *This study highlights the complex relationship between snow albedo and density in northern Iraq. The strong correlation observed in Duhok City suggests the importance of further research to understand the factors influencing snow properties in this region.*

KEYWORDS: *Temperature; Snow albedo; Snow density; ECMWF; Climate change*

INTRODUCTION

Snow is a type of precipitation in the form of fine ice crystals that occurs in the cold season, but it does not occur in all countries of the world. Snow abundance and intensity increase as move closer to the North and South poles [1], [2]. This phenomenon takes place at the convergence of moist and warm air currents with cold currents whose temperature is 12.5 °C (285.65K) below 0 °C (273.15K), and for the formation of snow, the condensation nuclei on snow are very small solid particles suspended in the upper atmosphere such as dust particles or ash, and when they exist, the three conditions that enable steam to be available water is to transform from the gaseous state to the solid state, forming ice [3].

This is done by the condensation of water molecules on the nucleus and because of their adhesion to each other, an ice crystal is usually built, at this stage, it is a thin plate with six sides. If enough crystals stick together, they will become heavy enough to fall to the ground. Snowflakes that slide through moist air that is slightly warmer than 0 °C (273.15K) will melt around the edges and stick together to produce large flakes [4]. The size and composition of a snowflake depend on how ice crystals

group together and this will be determined by air temperatures. Snowflakes that fall through dry, cool air will be small, powdery snowflakes that don't stick together. This 'dry' snow is ideal for snow sports but is more likely to drift in windy weather [5]. The previous study shows the relationship between snow reflection and snow density as the snow reflects effect is found to be active before, and especially during, the snowmelt periods, and regions of strong albedo-taken conjunction move northward during springs, with the degradation edges of the snowpack in the Northern Hemisphere [6]. Changes in surface reflection influence the measurement results of air temperatures and in the case of sensors above a snow cover surface, this effect is amplified due to the high amount of radiation reflected [7].

Types of Snow

There are two types of snow classified according to references [8], [9] to the following forms:

1 Dry Ice

Also called powder snow, skiers consider it the perfect snow. Dry snow generally falls when the weather is very cold, with temperatures below zero degrees Celsius (273.15 K), such as in the mountains. Since it does not contain any liquid water, this ice crystal is very light and does not stick together.

2 Wet Snow

This type of snow falls frequently on the plains when temperatures are slightly positive, and because it contains little liquid water, it sticks easily to anything it touches, often causing disruptions to air, rail, and road traffic. Since this wet snow is also heavy, it can cause serious damage when it piles up [10], [11].

MATERIALS AND METHODS

Data Sources and Statistical Analysis

The work was carried out using daily data of temperatures, snow albedo, and snow density for fifteen years from 2008 to 2022 (00:00 AM) over northern Iraqi cities (Zakho, Amadiyah, Duhook, Erbil, and Sulaymaniyah) as shown in Table 1 and Figure 1 [12]. These data are driven by (ECMWF) where Iraq's climate is characterized by a desert and semi-desert nature, which is represented by high temperatures and evaporation in the summer in the southern region, rainfall and low temperatures, and a rise in relative humidity in winter in the northern region [13]. To calculate the monthly and annual behavior of snow albedo, snow density, and temperature testing the strength of the relationship between them using linear regression [14].

Table 1. Information on the Iraqi Meteorological stations

Station	Latitude	Longitude	Elevation in meters
Zakho	37 ° 08 37 N	42 ° 40 54 E	440
Amadiyah	37 ° 05 33 N	43 ° 29 14 E	1200
Duhook	36 ° 52 00 N	43 ° 00 00 E	565
Erbil	36 ° 19 11 N	44 ° 00 91 E	390
Sulaymaniyah	35 ° 33 26 N	45 ° 26 08 E	882

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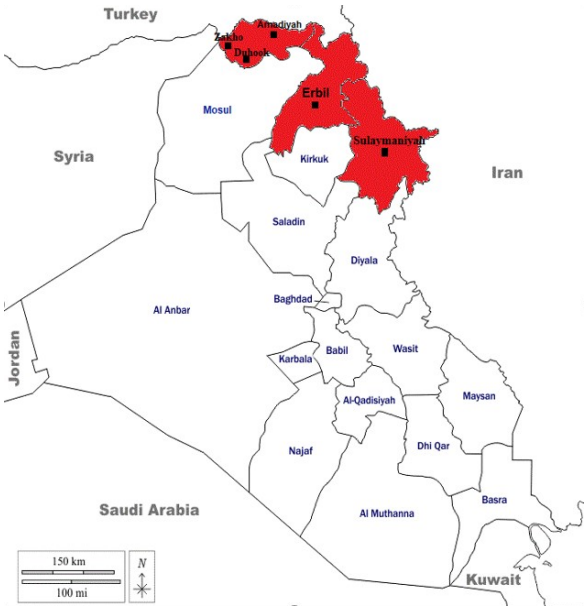

Figure 1. Iraq map with study sites

RESULTS AND DISCUSSION

Monthly Mean of the T, SA, and SD

Figures 2, 3 and 4 show the monthly means of T, SA, and SD in Zakho city for the period 2008-2022, SA observed high during November, and SD was high during January, while the temperature was high during July and August. In Amadiyah city, SA observed high during July, SD was high during January and March, and the temperature (T) was high during July and August. In Duhook city, SA observed a high during July, SD was high during January and February, and the temperature was high during July and August, In Erbil city, SA observed high during July, SD was high during January and November, and the temperature was high during July and August. In Sulaymaniyah City, SA was observed high during January and November, SD was high during January and February, and the temperature was high during July and August. This was due to stress devices, atmospheric cyclones, astronomical factors, and regional quality near Turkey's boundaries and Mountainous regions that help form snow clouds.

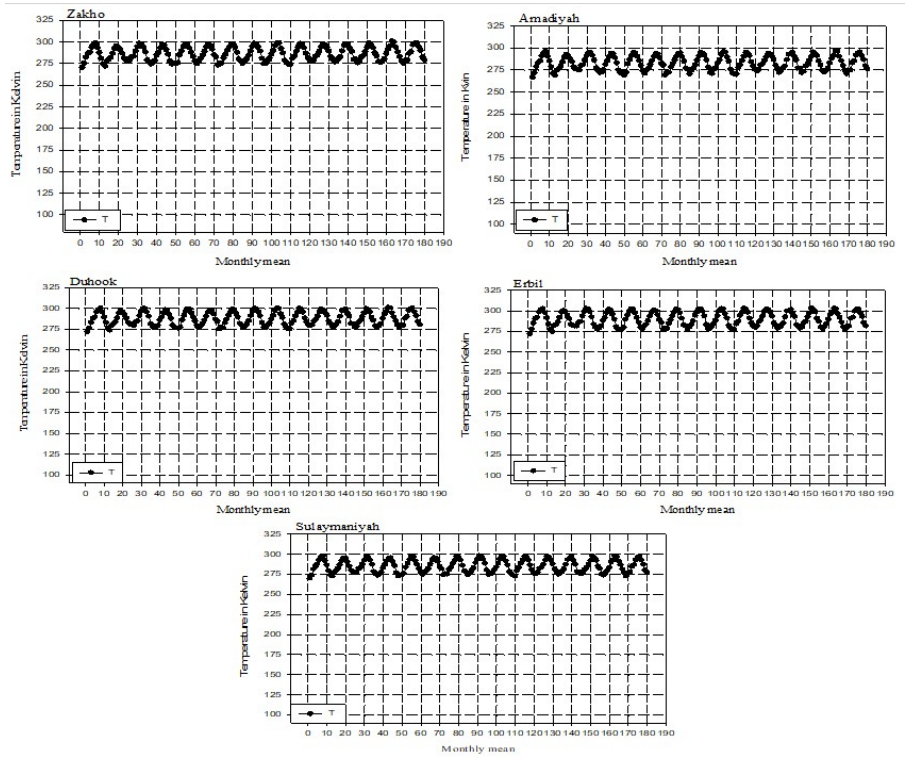

Figure 2. Monthly daily mean of the temperature in study stations for fifteen years

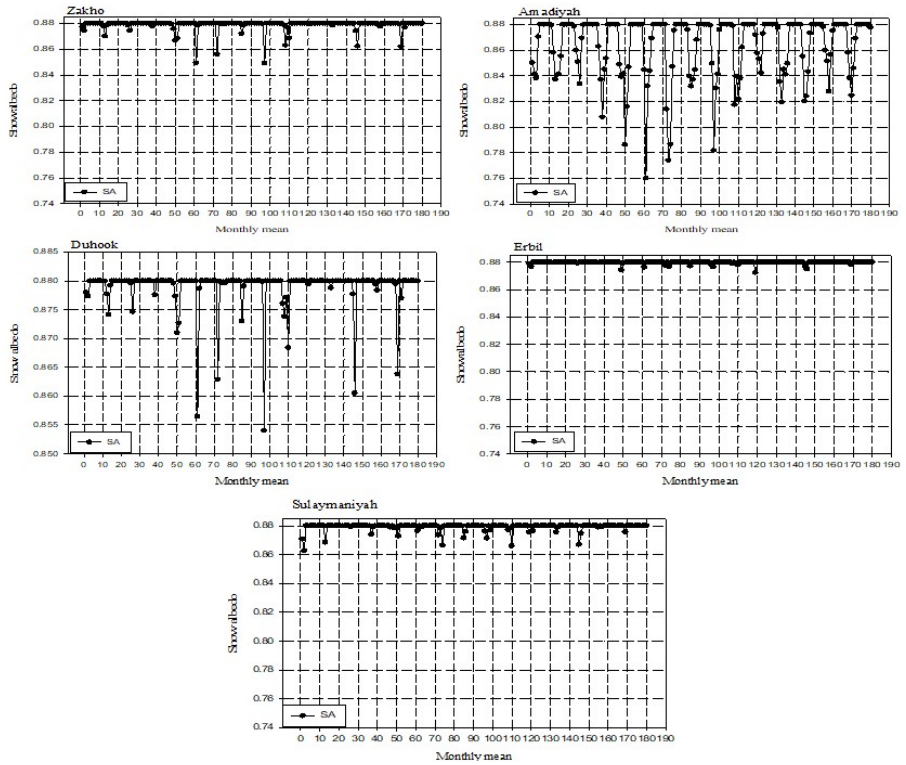

Figure 3. Monthly- daily mean of the SA in study stations for fifteen years

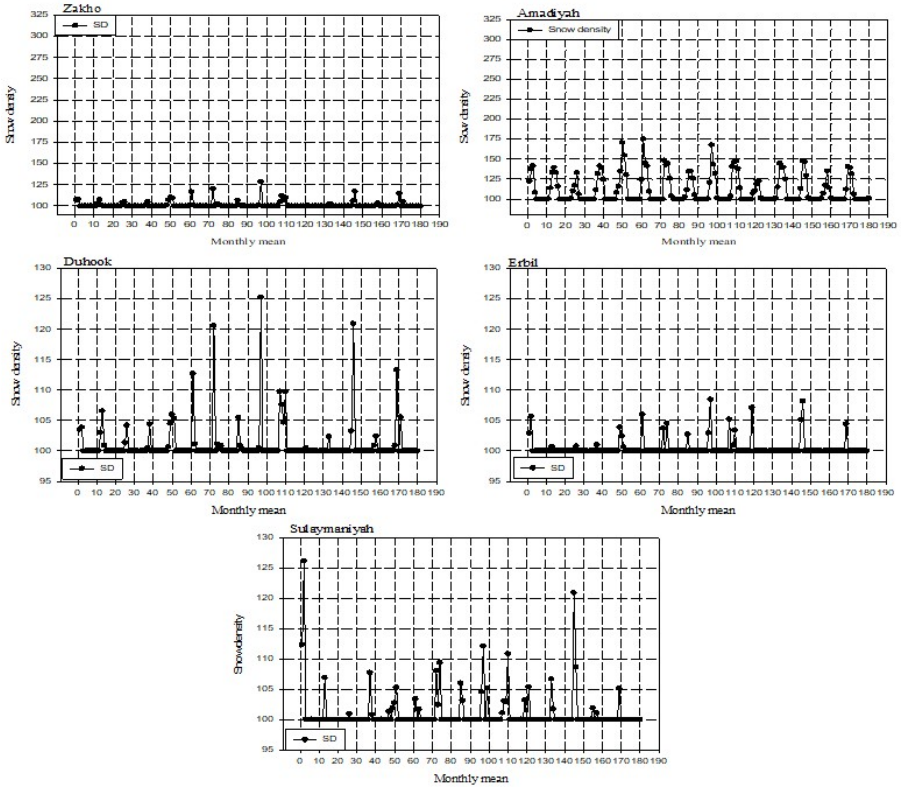

Figure 4. Monthly- daily mean of the SD in study stations for fifteen years

Relationship between the SA and SD

Figure 5 shows the type of relation and the intensity of the connection between snow albedo and snow density over study stations for the period 2008 to 2022. The results showed that the relationship was reversal because an increase in snow density leads to a decrease in snow albedo. The snow clouds depend on the altitude, density, and water content of the cloud temperature are low, and there is moisture in the atmosphere. That is why the relationship between clouds and meteorological effects, is very important.

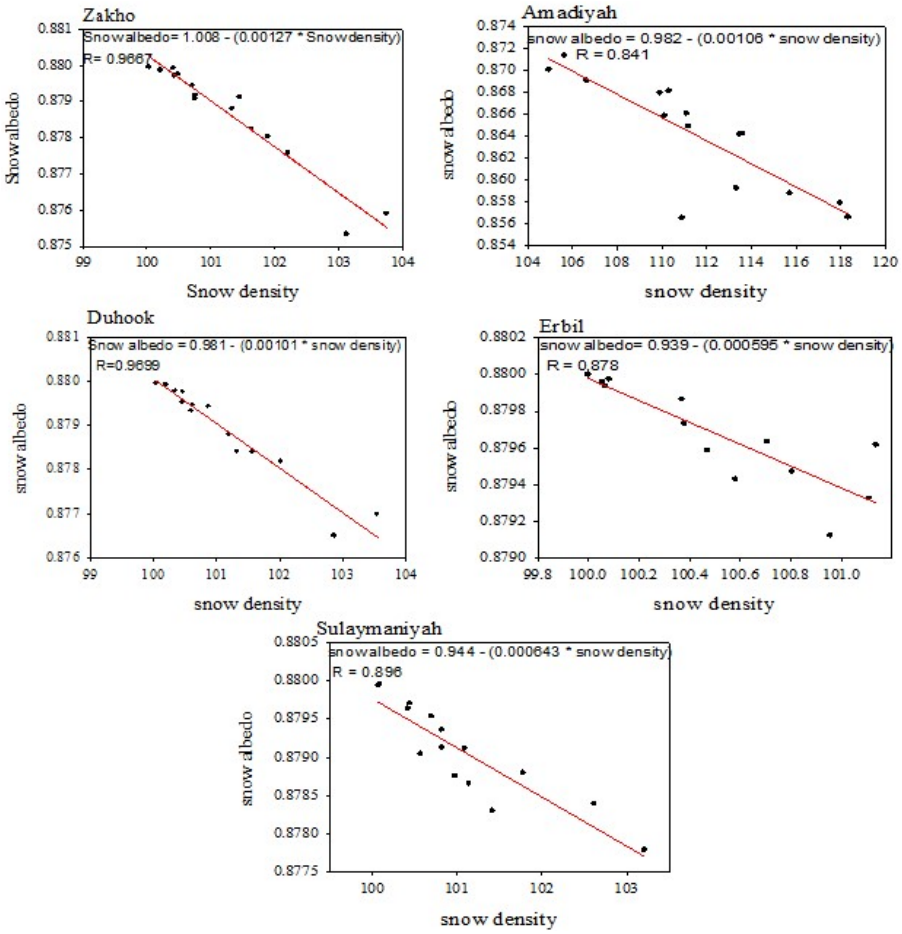

Figure 5. The relationship between the SA and SD over study stations for the period 2008 -2022

Annual mean Behavior of the T, SA, and SD

Figures 6, 7 and 8 show the largest value of snow albedo, snow density, and temperature that occurred for Zakho station where the years (2016, 2018, and 2021). The largest value of snow albedo, snow density, and temperature occurred for Amadiyah station where the years (2010, 2013, and 2021). The largest value of snow albedo, snow density, and temperature occurred for Duhook station where was (2016, 2018, and 2022). The largest value of snow albedo, snow density, and temperature occurred for Erbil station where the years (2011, 2016, and 2018). The largest value of snow albedo, snow density, and temperature occurred for Sulaymaniyah station where the years (2008, 2010, and 2018). According to atmospheric and astronomical factors, climatic changes, and the nature of the surface also or near or far from water regions Pressure systems, and wind blow systems. The albedo of snow varies with the age of the snow but is considerably higher than the albedo of most natural surfaces. Therefore, because of the seasonal changes in the extent of snow cover, the albedo of the surface of the Earth varies from season to season. Snow strongly reflects visible and near-infrared light that is it has a high albedo.

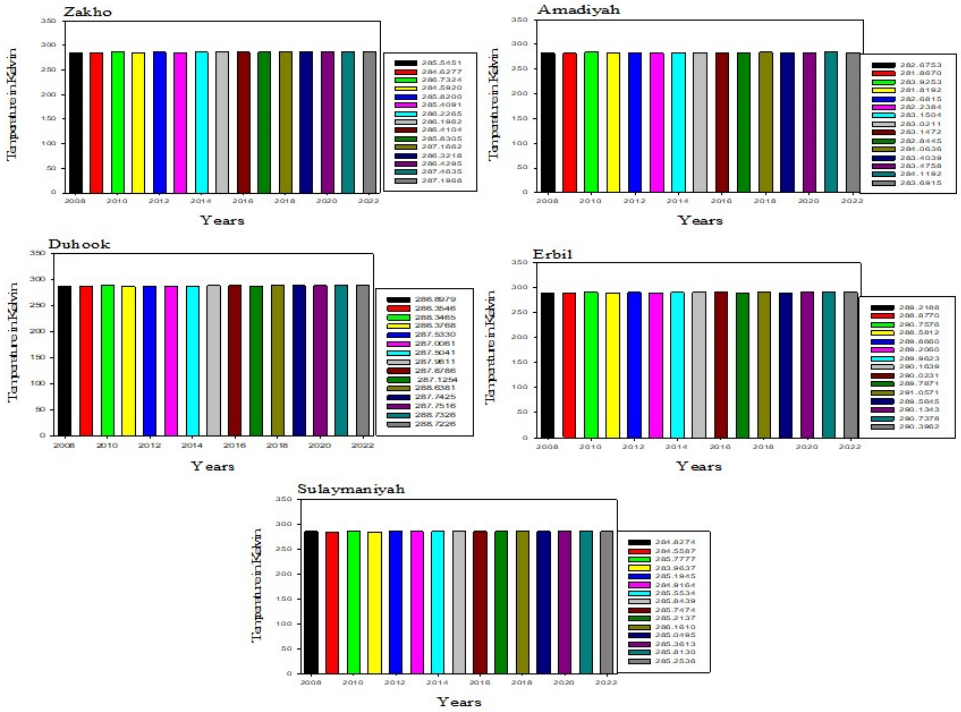

Figure 6. Annual mean temperature for study stations

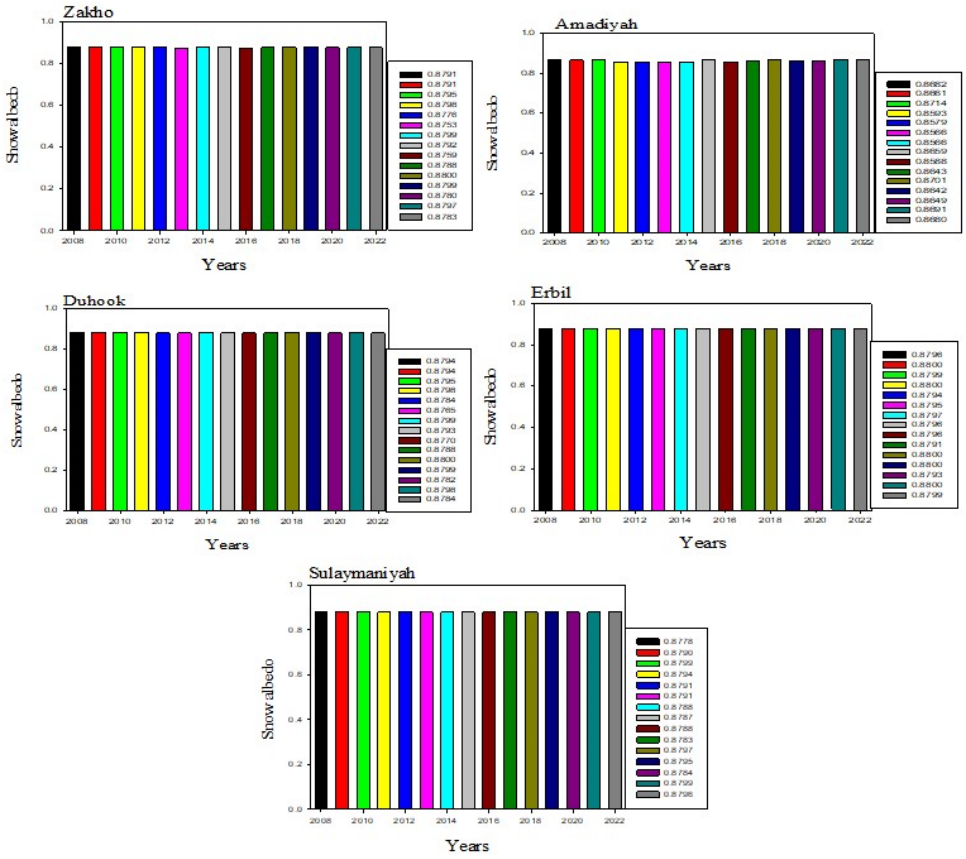

Figure 7. The annual mean of SA for study stations

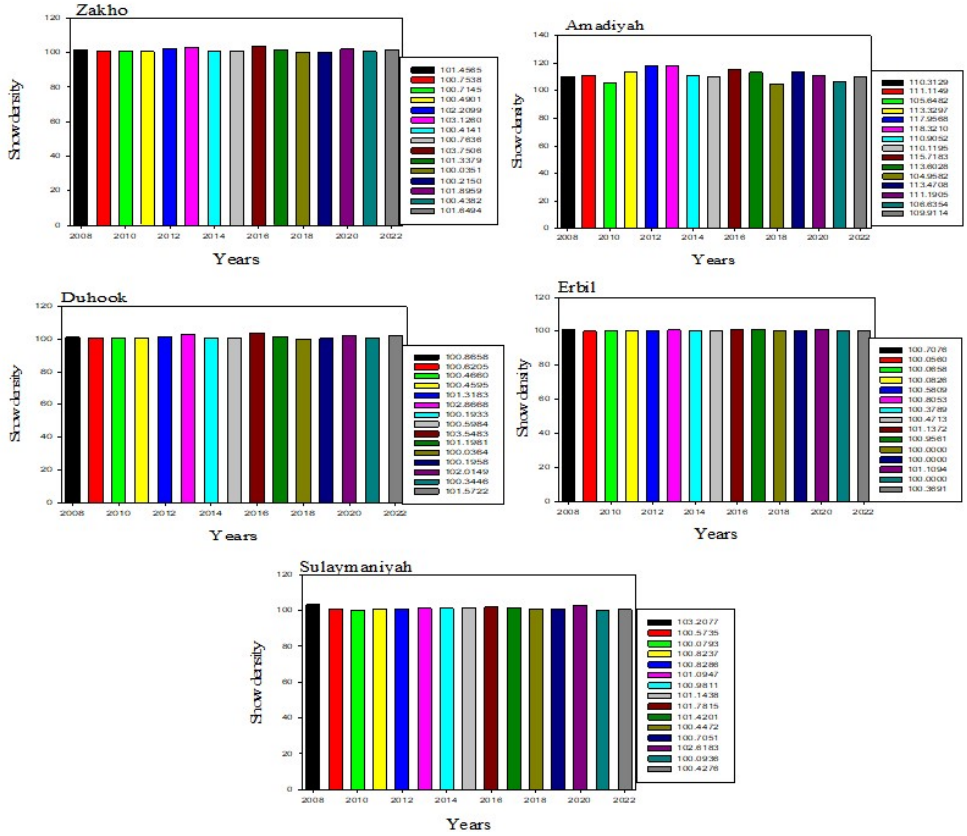

Figure 8. The annual mean of SD for study stations

CONCLUSION

The relationship between snow albedo and snow density is inverse. In Zakho station, the snow albedo was observed high during November, and snow density was high during January, while the temperature was high during July and August. In Amadiyah station, the snow albedo was observed high during July month, and snow density was high during January and March, while the temperature was high during July and August. In Duhook station, snow albedo was observed high during July, and snow density was high during January and February, while the temperature was high during July and August. In Erbil station, snow albedo was observed high during July, and snow density was high during January and November. In Sulaymaniyah station, snow albedo was observed high during January and November, and snow density was high during January and February, while the temperature was high during July and August.

SUPPLEMENTARY MATERIAL

None.

AUTHOR CONTRIBUTIONS

Osama T. Al-Taai supervised the study and wrote the final version of the paper; Zainab M. Abbood and Yasmin Q. Tawfeek prepared the first draft of the manuscript. Salwa S. Naif, Ahmed S. Hassan, Monim H. Al-Jiboori, and Zeinab Salah contributed to the interpretation of the results and approved the final version of the manuscript.

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None.

DATA AVAILABILITY STATEMENT

All relevant data is included in the paper.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

[1] B. Zhou, Y. Li, and K. Zhu, "Improved length scales for turbulence kinetic energy–based planetary boundary layer scheme for the convective atmospheric boundary layer," *Journal of Atmospheric Sciences*, vol. 77, no. 7, pp. 2605–2626, 2020. doi: 10.1175/JAS-D-19-0334.1.

[2] H. M. Azeez, M. H. Khalafand, E. M. Degan, and S. M. Robaa, "Designing cloud chamber for simulate the microphysics processes in the formation of ice crystals," *Al-Mustansiriyah Journal of Science*, vol. 34, no. 2, p. 12, 2023. doi: 10.23851/mjs.v34i2.1231.

[3] M. Wahiduzzaman and A. Yeasmin, "A kernel density estimation approach of north indian ocean tropical cyclone formation and the association with convective available potential energy and equivalent potential temperature," *Meteorology and Atmospheric Physics*, vol. 132, no. 5, pp. 603–612, 2020. doi: 10.1007/s00703-019-00711-7.

[4] Y. Noh, "Improvement of the k-profile model for the planetary boundary layer based on large eddy simulation data," *Boundary-layer meteorology*, vol. 107, no. 2, pp. 401–427, 2003. doi: 10.1023/A:1022146015946.

[5] O. T. Al-Taai and Z. S. Muhammad, "Calculating the monthly frequency for cloud cover in baghdad station," *Al-Mustansiriyah Journal of Science*, vol. 29, no. 2, p. 12, 2018. doi: 10.23851/mjs.v29i2.130.

[6] P. Bogenschutz, "Unified parameterization of the planetary boundary layer and shallow convection with a higher-order turbulence closure in the community atmosphere model: Single-column experiments," *Geoscientific Model Development*, vol. 5, no. 6, pp. 1407–1423, 2012. doi: 10.5194/gmd-5-1407-2012.

[7] L. Xu and P. Dirmeyer, "Snow–atmosphere coupling strength part ii: Albedo effect versus hydrological effect," *Journal of Hydrometeorology*, vol. 14, no. 2, pp. 404–418, 2013. doi: 10.1175/JHM-D-11-0103.1.

[8] C. Musacchio, G. Coppa, and A. Merlone, "An experimental method for evaluation of the snow albedo effect on near-surface air temperature measurements," *Meteorological Applications*, vol. 26, no. 1, pp. 161–170, 2019. doi: 10.1002/met.1756.

[9] Z. M. Abbood and O. T. Al-Taai, "Data analysis for cloud cover and rainfall over baghdad city, iraq," *Plant Archives*, vol. 20, no. 1, pp. 822–82, 2020.

[10] P. Tremblin, "Advection of potential temperature in the atmosphere of irradiated exoplanets: A robust mechanism to explain radius inflation," *The Astrophysical Journal*, vol. 841, no. 1, p. 30, 2017. doi: 10.3847/1538-4357/aa6e57.

[11] Z. M. Abbood and O. T. Al-Taai, "Calculation of absorption and emission of thermal radiation by clouds cover," *ARPN Journal of Engineering and Applied Sciences*, vol. 13, no. 24, pp. 9446–9456, 2018.

[12] O. F. Khayoon and O. T. Al-Taai, "Severe meteorological factors affecting civil aviation flights at iraqi airports," *Al-Mustansiriyah Journal of Science*, vol. 33, no. 4, pp. 15–26, 2022. doi: 10.23851/mjs.v33i4.1179.

[13] O. T. Al-Taai, S. A. Hashim, W. G. Nassif, and Z. M. Abbood, "Interference between total solar radiation and cloud cover over baghdad city," *Journal of Physics: Conference Series*, vol. 2114, no. 1, p. 012 070, 2021. doi: 10.1088/1742-6596/2114/1/012070.

[14] O. T. Al-Taai, Z. M. Abbood, and J. H. Kadhum, "Determination stability potential energy of thunderstorms for some severe weather forecasting cases in baghdad city," *Journal of Green Engineering*, vol. 11, no. 1, pp. 779–794, 2021.