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Testing the Suitability of Snow Depth in Winter Recreation Areas in Cities in the Republican Period with InSAR Technique: Abalı Ski Center Example

Cumhuriyet Döneminde Kentlerde Kış Rekreasyon Alanlarında Kar Derinliği Uygunluğunun InSAR Tekniği ile Testi: Abalı Kayak Merkezi Örneği

Okan Yeler[1]

ÖZ

Cumhuriyet dönemi, Türkiye'nin modernleşme sürecine denk gelen bir dönemdir ve bu dönemde kentlerdeki yaşam tarzı da önemli ölçüde değişmiştir. Kış rekreasyon alanları, insanların soğuk aylarda eğlenmek, spor yapmak ve dinlenmek için tercih ettikleri alanlardır. Türkiye Cumhuriyeti turizm sektöründe büyük bir öneme sahiptir. Bununla birlikte alternatif turizm sektörü de hızla gelişmekte ve farklı yatırımlara öncü olmaktadır. İklimsel çeşitliliğin avantajı ile dört mevsim turizmin canlı kalabilmesi adına kış rekreasyon alanlarının ve tesisleşme yatırımlarının arttırılması alternatif turizm için ciddi önem taşımaktadır. Bu yatırımlar için uygun alanların belirlenmesinde eğim, bakı, yükseklik, ulaşım, güneşlenme süresi gibi farklı kriterler kullanılmaktadır. Ancak en önemli uygunluk kriteri ise kar faktörüdür. Tesislerin kurulabilmesi için karın kış sezonunda kalıcılığı ve belirli kalınlıkta olabilmesi gerekmektedir. Bu çalışmada, cumhuriyet döneminde kurulan Abalı Kayak Merkezi örneğinde kış sezonu (aralık-ocak-şubat) zamansal olarak (2020-21-22) incelenerek, alandaki ortalama kar derinliği değişimi InSAR (Interferometrik Yapay Açıklıklı Radar) tekniği ile tespit edilmiştir. Ayrıca çalışma alanında yapılan 2021-22 kış sezonu gerçek ölçümleri ile sonuçların doğruluğu test edilmiştir. Karşılaştırılan kar derinliği verileri sayesinde, Sentinel-1A C band RADAR görüntülerinin doğruluğunu değerlendirmek amacıyla yapılan analiz, 0,79 yüksek korelasyon değeri elde ederek güçlü ve tutarlı bir sonuç vermiştir. Bunun sonucunda alan kullanım uygunluklarının belirlenmesinde kar faktörünün hem bir uygunluk kriteri olarak hem de zamansal değişimde kar kalıcılığının uygunluğunun tesisleşme için önceden tespit edilmesinin önemi ortaya konulmuştur.

Anahtar Kelimeler: Cumhuriyet Dönemi, Kar Derinliği, Kış Rekreasyonu, Kayak Merkezi, RADAR, Interferometri

ABSTRACT

The Republican period is a period that coincides with the modernization process of Turkey, and the lifestyle in the cities has also changed significantly during this period. Winter recreation areas are the areas that people prefer to have fun, do sports and relax in the cold months. The Republic of Türkiye has a great importance in the tourism sector. In addition, the alternative tourism sector is developing rapidly and leading to different investments. Increasing winter recreation areas and facility investments in order to keep four seasons tourism alive with the advantage of climatic diversity is of great importance for alternative tourism. Different criteria such as slope, aspect, height, transportation, and sunshine duration are used to determine suitable areas for these investments. However, the most important suitability criterion is the snow factor. In order for the facilities to be established, the snow must be permanent and of a certain thickness in the winter season. In this study, the winter season (December-January-February) was examined temporally (2020-21-22), in the example of the Abalı Ski Center established in the republican period, and the average snow depth change in the area was determined by the InSAR (Interferometric Artificial Aperture Radar) technique. In addition, the accuracy of the results was tested with the real measurements of the 2021-22 winter season in the study area. The analysis conducted to assess the accuracy of Sentinel-1A C-band RADAR images by comparing snow depth data

[1] **Corresponding Author:** Department of Landscape Architecture, Faculty of Architecture and Design, Van Yuzuncu Yil University, Van, Türkiye, okanyeler@yyu.edu.tr, 0000-0002-0405-4829

has yielded a high correlation value of 0.79, indicating a strong and consistent result. As a result, the importance of determining the snow factor both as a suitability criterion in determining the suitability of land use and the suitability of snow permanence in temporal change for establishment has been revealed.

Keywords: Republican Period, Snow Depth, Winter Recreation, Ski Center, RADAR, Interferometry

INTRODUCTION:

Republican Turkey was a modern nation-state established after the collapse of the Ottoman Empire. During this period, the country experienced a number of social, cultural, economic and political changes. One of these changes was the urbanization process. Cities were at the center of modernization efforts and people's lifestyles changed greatly. People living in cities began to spend their free time in different ways (Atalay, 2008).

Winter recreation areas also emerged as a reflection of the lifestyle in cities during this period. The Republican administration cared about the physical and mental health of the people and therefore took steps to encourage sports and recreation. At the same time, efforts were made to develop tourism as an economic sector. In this context, spaces were created where people could both do sports and enjoy nature during the winter months (Akten et al., 2009).

The tourism sector, whose demand in our social life is increasing and which is constantly renewing itself in parallel with this, assumes the role of a leading locomotive that shows very different changes and developments both nationally and internationally. Looking at the world market, with this change, different tourist profiles have begun to emerge and efforts to create new destinations have begun. The collective travel preferences of individuals have been replaced by alternative tourism. This perspective has led the sector, which operates regionally, nationally and internationally, to create a universal center of attraction in all seasons. In other words, it is aimed to increase the added value by spreading the sector to all seasons (Elsasser & Burki, 2002; Yorulmaz, 2019).

Today, tourism constitutes 30% of the world service sector, which is one of the three service sectors from which countries can generate significant economic income (Gümüş, 2016). Strategy 2023 of Turkiye Tourism and 2013 year Action Plan aims to use our country's natural, cultural, historical and geographical values in a conservation-use balance and to increase Turkiye's share of tourism by developing tourism alternatives (Kaya, 2009; Kaya, 2018).

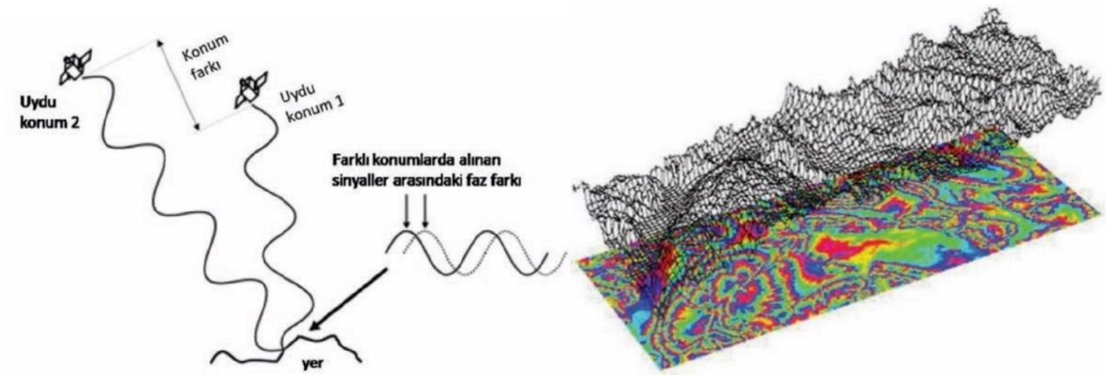
Although there are many alternative areas related to tourism, one of the areas that has attracted the attention of the tourism sector recently, winter recreation areas are preferred for winter tourism, where sportive activities and modern facilities take place, and which allow tourism to be actively promoted in the winter season (Katırcı & Oyman, 2011). In order to remove the negative effects of seasonal restrictions on tourism, to contribute to sustainable tourism and to use seasonal conditions with a positive effect, all factors affecting these investments and plans for the winter months should be evaluated in the planning of suitable areas. The development of winter recreation activities and the expansion of the sector can only be possible with the completion of sports facilities (Atasoy & Kurter, 2005). In this context, facilities with sports infrastructure in areas determined according to certain eligibility criteria are important in order to carry out sports activities appropriately (Campbell et al., 2002; Koşan, 2012; Kämpf & Kaspar, 2005). At the beginning of these eligibility criteria is the snow factor. One of the primary goals is to ensure that snow remains consistently in the chosen winter location and reaches a specific depth during the winter season.

The main purpose of the study carried out in this context is to examine whether the area to be used as a winter recreation area technically reaches the minimum depth of the snow in the temporal period and to test this with the ground truth data measured in the area. Thus, depth will be determined using remote sensing and radar data, and inferences will be made about the adequacy of the existing area and the permanence of the facilities.

1.1. The Concept of the InSAR (Interferometric Artificial Aperture Radar) Technique:

Interferometric SAR is a remote sensing technique that relies on both the amplitude and phase information of radar signals. The amplitude provides insights into the target's reflective properties, while the phase contains information about the target's distance. To extract altitude information, Interferometric SAR compares the phase difference between corresponding pixels in two SAR images. This phase difference is directly related to the target's elevation. It's important to note that the phase information alone lacks meaning; it gains significance when compared to another phase. This technique stands in contrast to conventional SAR methods, as it allows for the measurement of the third dimension (elevation) in addition to the target's reflectivity. Interferometric SAR is primarily used for mapping the Earth's topography and monitoring changes in terrain over time. These systems are often deployed on space platforms, such as satellites. To obtain phase information, two distinct images of the identical region are being juxtaposed. There are 2 roads to acquire these distinct images. The first method involves capturing images of the same region at different times using a space platform, known as the "repeat-pass interferometry" technique. This approach assumes minimal changes occur in the region between image acquisitions. The second method, known as the "single-pass interferometry" technique, involves capturing images simultaneously from different angles using two area stages at a specific interval from one another. These dual-perspectives approach enhances the accuracy of the phase information and provides valuable insights into the target's elevation. In summary, Interferometric SAR is a powerful technique that combines amplitude and phase information to measure elevation or topographic changes, commonly deployed on space platforms, and utilizes two distinct methods for acquiring phase information. (Irak, 2009) (Figure 1).

Figure 1. Interferometric SAR Technique Working Method and Obtaining Depth Information from Phase



Source: Irak, 2009.

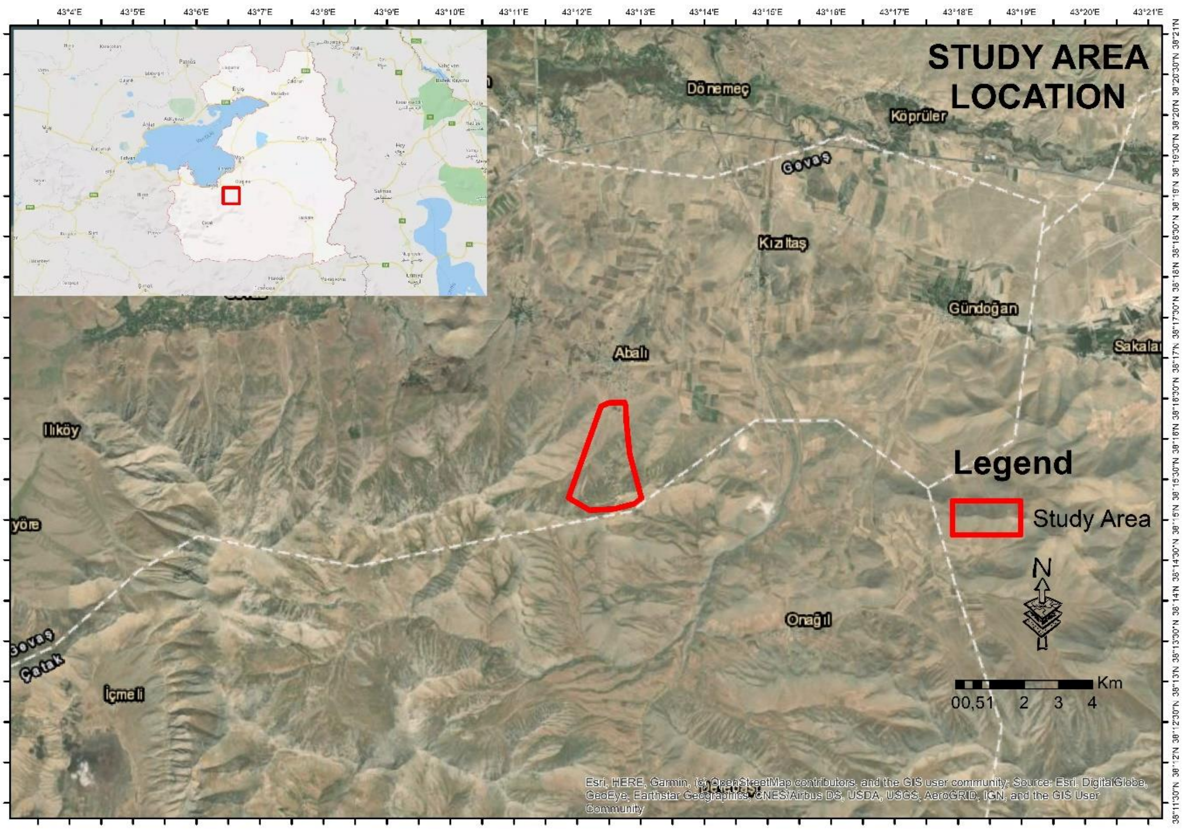
1.2. Material

1.2.1. Study Area and Selected Image Properties

Van is between 42 degrees 40 minutes and 44 degrees 30 minutes East longitudes and 37 degrees 43 minutes and 39 degrees 26 minutes North latitudes on Earth. On Turkey, it is in the closed basin of Lake Van in the Upper Murat-Van Section of the Eastern Anatolia Region. From the north, the province of Ağrı, Doğubayazıt, Diyadin and Hamur districts; from the west, Lake Van and Patnos district of Ağrı province, Adilcevaz Tatvan and Hizan districts of Bitlis; It is neighbor to Beytüşşebap and Yüksekova districts of Pervari Hakkâri province of Siirt from the south. The rake height of the province is about 1725 meters (Url-1, 2023).

The Abalı Ski Center Facility, which is determined as the study area, was established within the borders of Gevaş district, located in the south of Van province, in the range of approximately 1880 - 2400 meters. The Ski Center Facility, which was established in 2004 under the Van Youth and Sports Provincial Directorate, was put into service in 2005 (Figure 2).

Figure 2. Study area location



Abalı Ski Center is one of the important addresses of not only ski tourism but also professional skiing in Turkey. Abalı Ski Center is a candidate to be one of the few ski centers in the world with its slope, snow depth, snow quality and track length. With the huge investments made, Abalı Ski Center has been prepared for the standards that international organizations can be held (Figure 3) (Url-1, 2023).

Figure 3. Abalı Ski Center Images (January 2022)

1.2.2.Radar Data Set and Features Used in the Study

Radar data sets were created to cover Abalı Ski Center, which is our study area, during the winter seasons (December-January-February) between 2020-2022.

By making extensive analyzes on the data and programs planned in the use of radar satellite data, various studies have been revealed that the Radar data set, which is considered to be used in the study, is suitable data to be used in areas such as determining winter recreation areas and measuring snow depth (Badhwar, 1985; Avery & Berlin, 1992; Heady & Child, 1994; Clark & Swayze, 1995; Hall et al., 1998; Wynne, 1998; Dozier & Painter, 2004; Rignot, 2008; Joughin, 2010; Campbell et al., 2011).

The Radar backscatter signal from snow is affected by various factors, including the snow's dielectric properties, spatial distribution, age, surface roughness, internal structure, temperature, and snow cover. X-band and C-band radar systems have proven to be valuable tools for ice type and depth determination, especially in regions with mid to high latitudes. The European Space Agency's Sentinel-1A and 1B satellites, launched in 2014 and 2016, respectively, have played a pivotal role in this regard by providing C-band data with single or dual polarization. These satellites offer rapid data distribution, supporting a range of time-sensitive applications, including ship tracking, sea ice monitoring, oil spill detection, snow and ice assessment, flood monitoring, and responses to unforeseen natural disasters. The Sentinel-1A Synthetic Aperture Radar (SAR) satellites work in the C-band at 5.405 GHz and offer different imaging modes with varying resolutions and swath widths, including a 5-meter resolution mode and an 80 km long strip-map mode. Additionally, they have an extra-wide scan mode that delivers 40-meter resolution data over a 400 km swath. The satellites can also operate in a single-pass interferometric mode, allowing both Sentinel-1A and 1B to collect interferometric data with a 20-meter resolution over a 250 km swath. The temporal resolution of these satellites is approximately 6 days.

Table 1. Sentinel-1A Imaging Modes

Mode	**Scanning Width (km)**	**Resolution (Single Look Complex) (m)**	**Resolution (Ground Range Detected) (m)**	**Polarization Horizontal, H Vertical, V**
Strip Map	80	5 x 5	23 x 23	H H+H V, V H+V V, H H, V V
Wide Swath Interferometry	250	5 x 20	20 x 22	H H+H V, V H+V V, H H, V V
Extra-Wide Swath	400	20 x 40	50 x 50	H H+H V, V H+V V, H H, V V
Wave-Mode	20 x 20	5 x 5	-	H H, V V

Source: Yeler, 2021

Radar data sets to be used in the interferometry process to determine snow depth are taken at 12-day intervals between 2020-2022, covering December 2020, December, January and February 2021, January and February 2022; polarization, product type, sensor mode and track values are the same data sets (Table 2).

Table 2. SAR Data Set Characteristics Used in the Study

Image Date	Satellite Platform	Product Type	Polarization	Sensor Mode
01/12/2020 13/12/2020 08/12/2021 20/12/2021 06/01/2021 18/01/2021 11/02/2021 23/02/2021 01/01/2022 13/01/2022 06/02/2022 18/02/2022	Sentinel-1A	Single Look Complex	Vertical Vertical, Vertical Horizontal	Interferometric Wide swath

1.2.3. Ground truth data:

In the context of the research, we documented the average snow depth measurements at three specific locations within the Ski Center during the winter season of 2021-2022 (December to February). Concurrently, we established ground truth data by directly measuring the distance between the soil surface and the snow cover on the field on the dates when interferometry was conducted, as illustrated in Figure 4 and detailed in Table 3. For the use of the Digital Elevation Model (DEM) of the area, the ASTER data set with a resolution of 30 meters was automatically drawn from the program (SNAP-Sentinel Applications Platform) and used within the scope of the analyses.

Figure 4. Station Measurement Points No. 1-2-3

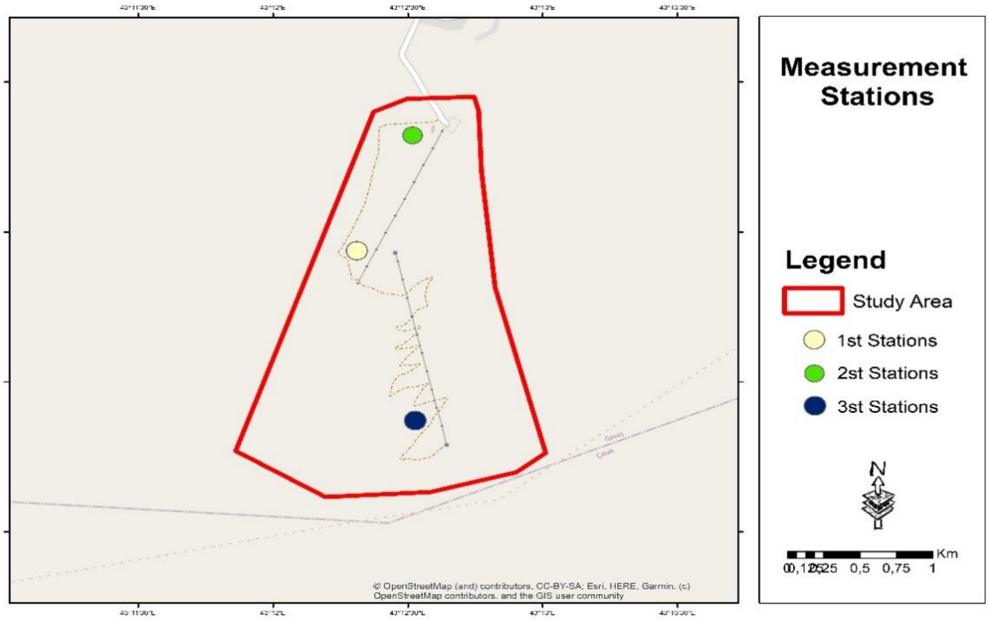
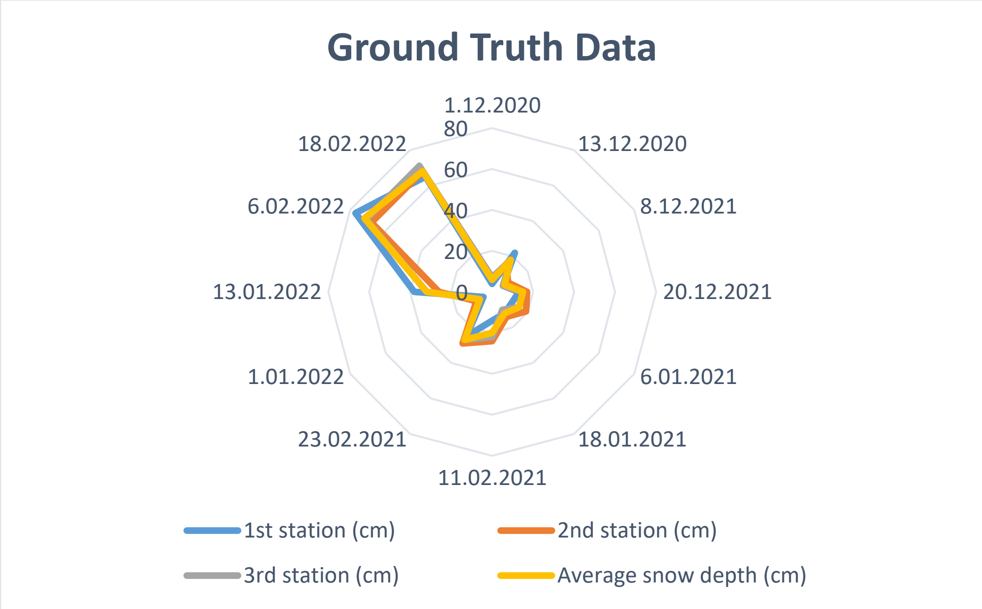


Table 3. Ground Truth Data Used in the Study



1.2.4. Snow Depth Data (Abalı Ski Center Station):

Daily average snow depth data for the 2020-2022 winter season (december, january, february) were obtained from the Abalı Ski Center Station number 19096, belonging to the General Directorate of Meteorology (Table 4). The presence of a meteorological station that makes ground measurements in the ski center paved the way for the study in terms of providing reliable data. In addition, the results could be interpreted with the support of these data.

Table 4. Abalı Ski Center Daily Average Snow Depth (Anonymous, 2023)

Image Date	**Average snow depth change (cm)**
01/12/2020	12,5
13/12/2020	
08/12/2021	9,5
20/12/2021	
06/01/2021	4
18/01/2021	
11/02/2021	7
23/02/2021	
01/01/2022	25,5
13/01/2022	
06/02/2022	9
18/02/2022	

1.3. Method

The objective is to utilize SAR RADAR datasets acquired simultaneously from various altitudes within the confines of the Abalı Ski Center. This approach employs interferometry techniques to as certain the snow depth variations within the specified area. Snow depth data determined in different time periods tests the persistence of snow in a regular density and volume in the study area. Thus, while producing the result data, it is desired to benefit more from the snow factor, which has a high degree of importance, in determining the appropriate areas by using this data set (Yeler, 2021).

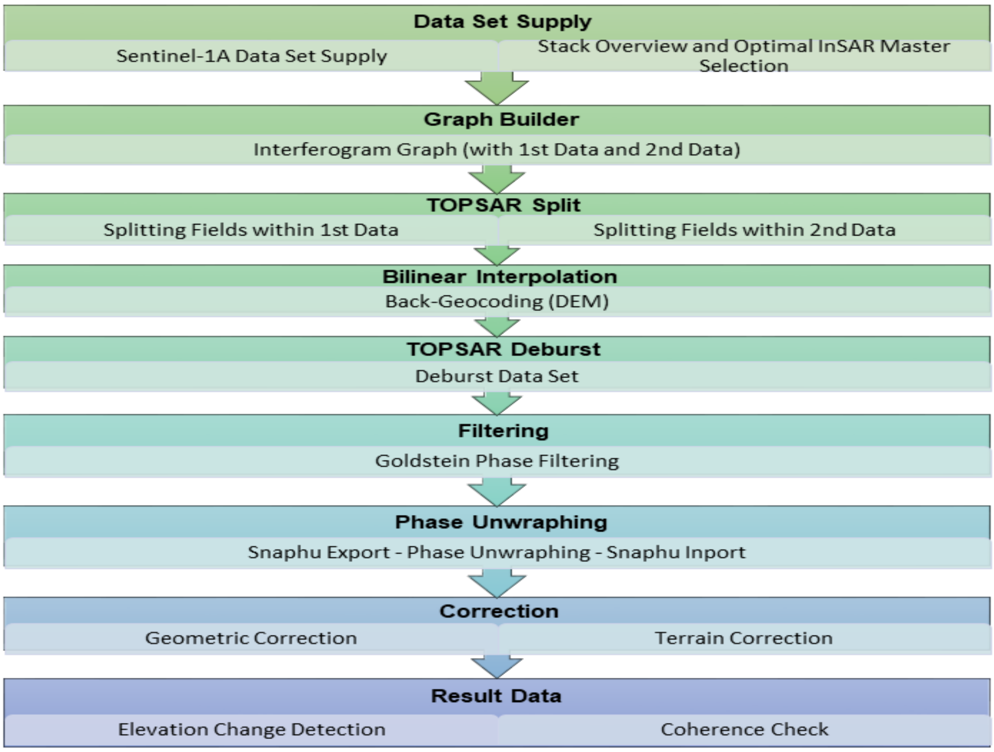
To initiate the interferometry procedure, the initial step requires acquiring the Sentinel-1A SAR dataset from the Copernicus platform. This dataset is chosen with specific features relevant to the analysis that will be conducted. Once the dataset is acquired, it needs to be prepared for analysis. Several data preparation operations are necessary to make the Sentinel-1A data ready for use. These data preparation operations are executed using a specialized software tool called SNAP, which stands for The Sentinel Application Platform, commonly known as SNAP, is specifically tailored for RADAR satellites such as Sentinel-1, and finds extensive utilization in a wide range of research projects that utilize Sentinel data. SNAP comes equipped with its own set of toolboxes tailored for RADAR satellite data processing. Researchers and analysts rely on these toolboxes to perform a range of operations on Sentinel data. Among the critical steps in the data analysis process is the phase unwrapping, which is essential for obtaining accurate results. This phase unwrapping operation is carried out using a specific section within SNAP known as SNAPHU. SNAPHU is a crucial tool within SNAP that specializes in phase unwrapping, ensuring that the data obtained from the analysis is properly corrected and suitable for further study or interpretation. Ultimately, after the necessary data processing and phase unwrapping have been performed using SNAP and SNAPHU, the resulting dataset is exported. This processed data becomes the basis for subsequent phases of interferometry analysis and can yield valuable insights for a variety of research studies.

1.3.1. Interferometry Stages:

Interferometry analysis consists of several stages. These stages are; data set supply and preparation, interferogram graph formation, area determination, background elevation model selection, conversion into single data, filtering, phase unwraphing, geometric correction, coherence control and obtaining the result data (Figure 5) (Yeler & Berberoğlu, 2023).

In the final stage of the study, as outlined in the processing steps, an image is chosen from a set of sub-images within the dataset known as "coherence." This selected image is then used to assess the consistency values of the data. When consistency values approach 1, they signify regions with a substantial degree of signal overlap, suggesting a high correlation success rate in those areas. They are essentially the locations where the difference in correlation is most pronounced. In the context of the study, when analyzing snow depth, special attention is given to areas with the highest consistency values. These areas are prioritized as they provide the clearest indication of variations in snow depth (Yeler, 2021).

Figure 5. Interferometry Method Flow Chart



Thus, as a result of these process steps, the working area will be tested with on-site snow depth measurements and the accuracy of the result data will be revealed.

RESULTS:

In the study, the change values were determined by analyzing the snow depth data with the RADAR data sets provided at 12-day intervals for the 2020-2022 winter season, covering the months of 2020, January, February, and December of 2021, and January and February of 2022.

When the snow change values of 01-13 December 2020 of Abalı Ski Center were analyzed by RADAR interferometry method, it was determined that the average snow depth change was 14 cm. The change of 08-20 December 2021 is 12 cm, the change of 06-18 January 2021 is 10 cm, the change of 11-23 February 2021 is 9 cm, the change of 01-13 January 2022 is 36 cm, and the change of 06-18 February 2022 is 6 cm has been detected (Table 5).

When the snow change values of 01-13 December 2020 were analyzed in spot measurements made on-site at Abalı Ski Center, it was determined that the average snow depth change was 12 cm. 08-20 December 2021 is 8 cm, 06-18 January 2021 is 3 cm, 11-23 February 2021 is 7 cm, 01-13 January 2022 is 25 cm, and 06-18 February 2022 average snow depth change is 4 cm was detected (Table 5).

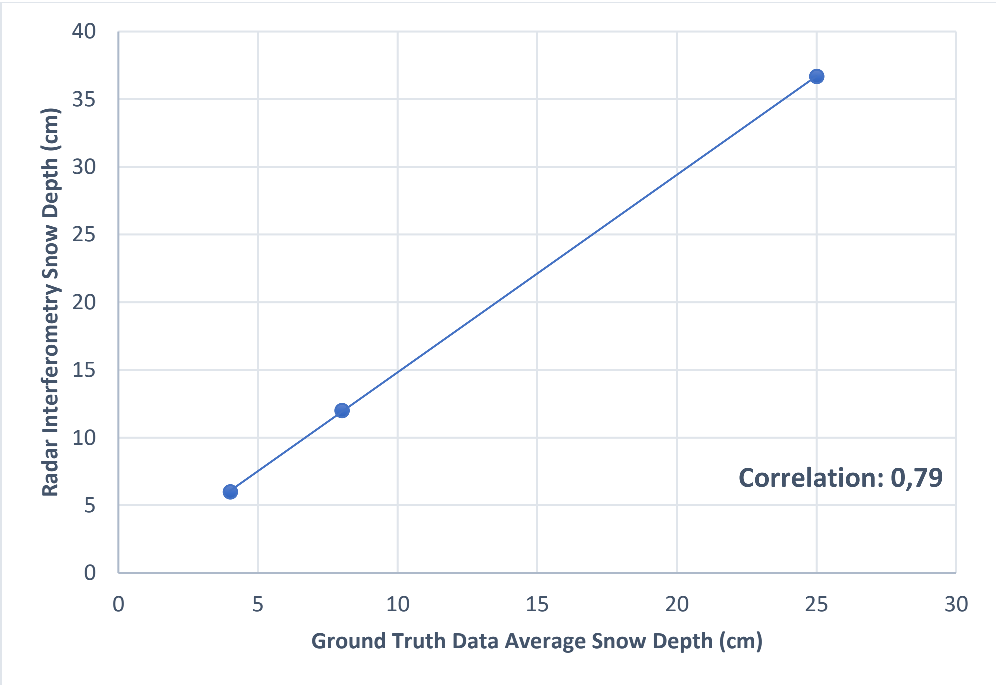
Table 5. RADAR Interferometry and Ground Truth Data average snow change values

Image Date	Average snow depth change (RADAR) (cm)	Average snow depth change (Ground Truth Data) (cm)
01/12/2020	14	12
13/12/2020		
08/12/2021	12	8

20/12/2021		
06/01/2021	10	3
18/01/2021		
11/02/2021	9	7
23/02/2021		
01/01/2022	36	25
13/01/2022		
06/02/2022	6	4
18/02/2022		

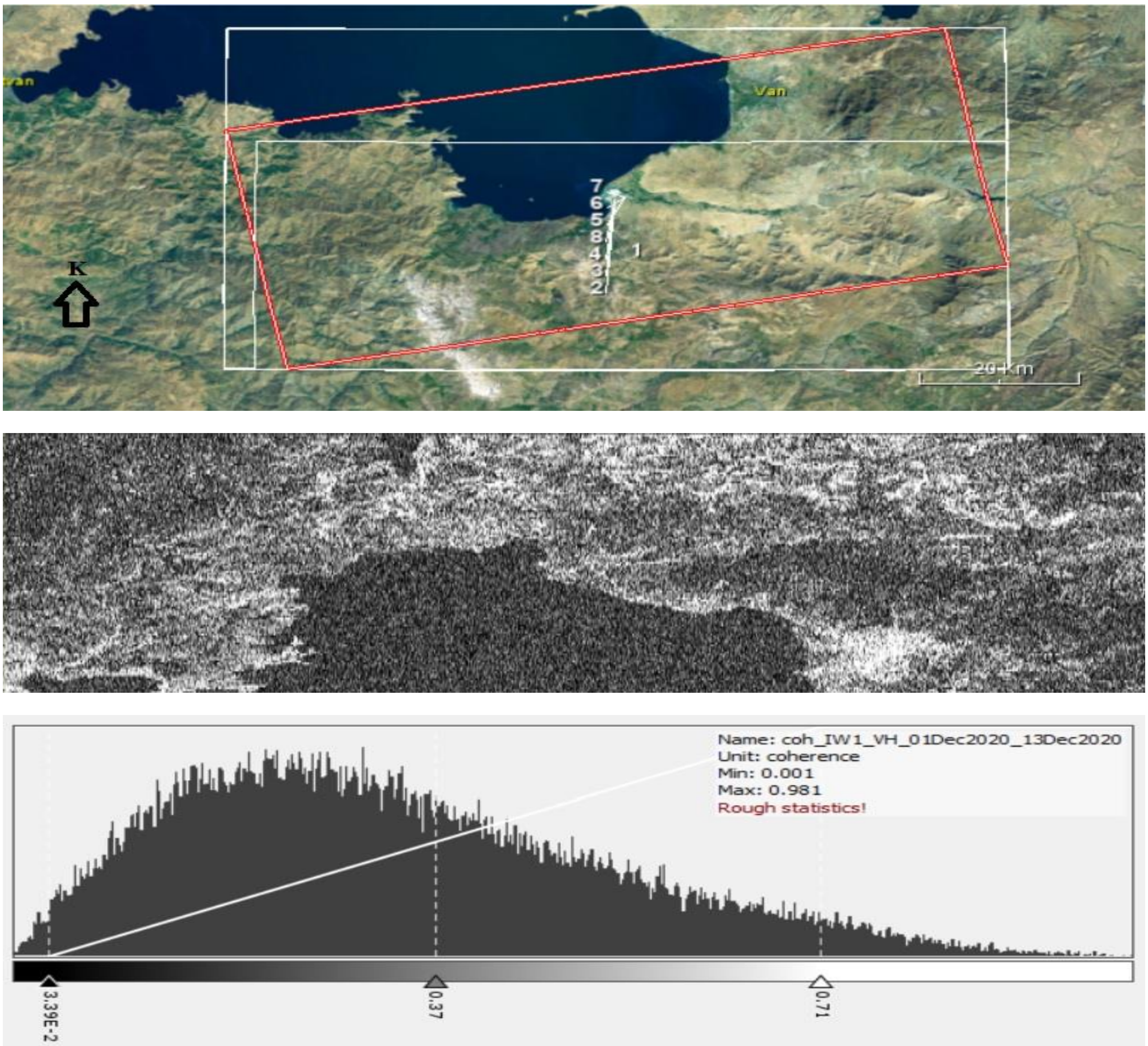
Upon reviewing the analysis results, it was observed that there exists a robust correlation between the datasets, indicated by a correlation coefficient of 0,79 (Figure 6).

Figure 6. Comparison of the months of December 2021, January and February of 2022



Consistency values within the range of 0.5 to 1 are considered acceptable in interferometry analysis. However, values that fall below this range and approach 0 are considered unsuitable, as illustrated in Figure 7. The resulting correlation value indicates a reliable and consistent relationship between RADAR interferometry and the ground truth data.

Figure 7. Interferometry coherence values (December 2020)



Within the scope of the study, the main purpose is to test the usability of the RADAR technique among Remote Sensing methods. The correlation values of the ground truth data and the RADAR interferometry method study are at a good level and support the highly consistent interferometry analysis results. However, the second issue that needs to be discussed and tested is the examination of the error rate of ground truth data and meteorological data values. The following Root Mean Square Error (RMSE) Formula was used to understand the error rate of the ground truth data obtained from the field and the data received from the meteorological station.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(X_{\text{ground truth},i} - X_{\text{meteorology},i})^2}$$

Here, n represents the number of data points, and X denotes the value of the respective set.

With this formula, the accuracy rate between the two data sets was also calculated. Thus, the margin of error in the station data compared to the one-to-one measurements made in the field was revealed. Error Rate(%) is determined as ≈20.02%. The error rate was observed to be serious, and it was determined that the error rate of the station data may be high or that the data entry should be made more accurately and should be discussed and tested. At the same time, there may be errors in the ground truth data, and a recommendation can be made to repeat the measurements in a more accurate way to correct this error. All these questions have been determined as important outcomes for large-scale studies.

CONCLUSION AND SUGGESTIONS:

As part of the research, the Interferometry method was applied to leverage SAR-based RADAR datasets, particularly for precise measurements. The accuracy and applicability of this method has been tested with ground truth data obtained with one-to-one point measurements. Temporal change values of snow depth between 2020 and 2022 for the months of December and January, when snow, which is the most important factor for winter recreation, stays in the area for the longest time, have been revealed. It has been determined that the consistency values of the result data obtained as a result of different processes are close to 1 and these results are applicable. With this interferometry analysis method, which was found to be suitable, correlation values between ground truth measurements and interferometry were revealed by looking at snow depth measurements in the same time period. Correlation agreement of the comparison results between 2020-2021 was found to be 0.79. With these results, it has been determined that RADAR precision measurements and ground truth data are compatible and this method can be used in different fields and studies. Moreover;

- It has been observed that there are difficulties in determining suitable areas due to the fact that snow stations do not make regular measurements in areas located in snowy regions and determined for facility investments. It has been determined that RADAR interferometry analyzes can contribute to appropriate area determination studies.

- The study has greatly advanced the way we map different aspects of snow in challenging, extensive areas with intricate terrain and has also assessed how precise the resulting data is.

- Within the scope of modeling, it was determined that it would be appropriate to calculate the components such as snow cover and snow depth by testing the input data.

- This study is based on the fact that winter recreation areas, especially established in cities after the Republican period, play an important role in many aspects such as health, entertainment, social interaction and economic development, increasing the general welfare of both individuals and society; It reveals its contribution to sustainable planning and investments in these areas.

Compliance with Ethical Standard

Conflict of Interests: *There is no conflict of interest between the authors or any third party individuals or institutions.*

Ethics Committee Approval: *Ethics committee approval is not required for this study.*

REFERENCES:

Akten, M., Yılmaz, O. & Gül., A. (2009). Alan Kullanım Planlamasında Rekreasyonel Alan Kullanım Ölçütlerinin Belirlenmesi: Isparta Ovası Örneği, Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi, A(2): 119-133.

Anonymous, (2023). Kar Kalınlıları, Meteoroloji Genel Müdürlüğü, Access Address (10.10.2023-17.11.2023): https://www.mgm.gov.tr/sondurum/kar-kalinliklari.aspx

Atalay, İ. (2008). Ekosistem Ekolojisi ve Coğrafyası, Cilt I-II, Çevre ve Orman Bakanlığı Yayınları, İzmir.

Atasoy, B. & Kurter, F. Ö. (2005). Küreselleşme ve spor. Uludağ Üniversitesi Eğitim Fakültesi Dergisi, 18(1), 11-22.

Avery, T.E. & Berlin, G.L. (1992). Fundamentals of Remote Sensing and Airphoto Interpretation, New York: Macmillan.

Badhwar, G.D. (1985). Classification of Corn and Soybeans Using Multitemporal Thematic Mapper Data, Remote Sensing of Environment, 16:175-181.

Campbell, N.A., Reece, J.B. & Mitchell, L.G. (2002). Biologi. Jilid 1. Edisi Kelima. Alih Bahasa: Wasmen. Jakarta: Penerbit Erlangga.

Campbell, J.B & Wynne, R.H. (2011). Introduction to Remote Sensing. Fifth edition, The Guilford Press, NY, USA.

Clark, R.N. & Swayze, G.A. (1995). Mapping Minerals, Amorphous Materials, Environmental Materials, Vegetation, Water, Ice and Snow, and Other Materials: The USGS Tricorder Algorithm, Summaries of The Fifth Annual JPL Airborne Earth Science Workshop, JPL Publication 95-1, Jet Propulsion Laboratory, Pasadena, CA, 95: 39-40.

Dozier, J. & Painter, T.,H. (2004). Multispectral and Hyperspectral Remote Sensing of Alpine Snow Properties, Annual Review of Earth and Planetary Science, 32: 465-494.

Elsasser, H. & Burki, R. (2002). Climate change as a threat to tourism in the Alps. Climate Research, 20, 253-257.

Gümüş, H. (2016). Rekreasyonel Alanların Kullanım Etkenlerinin İncelenmesi, Gazi Üniversitesi, Sağlık Bilimleri Enstitüsü, Beden Eğitimi ve Spor Anabilim Dalı, Doktora Tezi, Ankara.

Hall, D. K., Foster, J. L., Chang, A. T. C., Benson, C. S. & Chien, J. Y. L. (1998). Determination of Snow-Covered Area In Different Land Covers In Central Alaska From Aircraft Data, Nisan 1995, Ann. Glaciol. 26:149–155.

Heady, H.F. & Child, R.D. (1994). Introductory Geographic Information Systems, Boulder, CO: Westview Press.

Irak, H. (2009). SAR Sistem ve Teknolojileri, Elektrik Mühendisliği Odası Yayınları, 437: 86-90, Ankara.

Joughin, I. (2010). Greenland Flow Variability From Ice-Sheet-Wide Velocity Mapping, Journal of Glaciology, 56 (197): 415-430.

Kaya, G. (2009). Determination of Outdoor Recreation Potential: Case of The City of Bartın And Its Environs, Turkey, Fresenius Environmental Bulletin, 18 (8): 1513-1524.

Kaya, G. (2018). Kayseri'nin Kış Turizm Potansiyeli ve Tercih Edilmesindeki Sebepler: Erciyes Örneği, Seyahat İşletmeciliği ve Turist Rehberliği Anabilim Dalı, Yüksek Lisans Tezi, Konya.

Kämpf, R. & Kaspar, W. (2005). Erfolgsfaktoren im Alpinen Tourismus, BAK Basel Economics, seco Publikation Direktion für Standortförderung, IBC Report 2005, Basel.

Katırcı, H. & Oyman, M. (2011). Spor Merkezlerinde Tüketici Tatmini ve Sadakat, Niğde Üniversitesi, Beden Eğitimi ve Spor Dergisi, 5(2), 90-100.

Koşan, A. (2012). Kış Sporları Turizmi – Kayak Turistlerinin Kış Turizm Merkezlerini Algı ve Değerlendirmelerine Ait Bir Araştırma (Palandöken'de Bir Uygulama), Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi 2013 17 (2): 293-324.

Rignot, E. (2008). Recent Antarctic Ice Mass Loss From RADAR Interferometry and Regional Climate Modelling, Nature Geoscience, 1 (2): 106-110.

Url-1. (2023). Van İl Kültür ve Turizm Müdürlüğü. Retrieved August 12, 2023, from https://van.ktb.gov.tr/TR-52093/genel-bilgiler.html.

Wynne, R. H. (1998). Satellite Monitoring of Lake Ice Breakup On The Laurentian Shield (1980-1994), Photogrammetric Engineering and Remote Sensing, 64 (6): 607-617.

Yeler, O. (2021). Seyhan Havzası Örneğinde Kış Rekreasyon Alanı Belirlemede Uzaktan algılama ve CBS Tabanlı Model Geliştirme, Çukurova Üniversitesi Fen Bilimleri Enstitüsü, Peyzaj Mimarlığı Anabilim Dalı, Doktora Tezi, Adana.

Yeler, O. & Berberoğlu, S. (2023). Interferometric SAR Technique in Remote Sensing and GIS Based Planning Studies. Innovative Research In Architecture, Planning And Design, 149–171. https://doi.org/10.59287/irapd.490

Yorulmaz, E. (2019). Eskişehir'de Rekreasyonel Faaliyetlerin Dağılışı, İstanbul Üniversitesi, Sosyal Bilimleri Enstitüsü, Coğrafya Anabilim Dalı, Yüksek Lisans Tezi, İstanbul.

EXTENDED SUMMARY

Research Problem:

The main purpose of the study is to examine whether a region to be used as a winter recreation area technically reaches the minimum depth of snow in the temporal period and to test these data with on-site measurements. In this way, it is aimed to determine the snow depth using remote sensing and RADAR data and to make inferences about the adequacy of the existing area and the suitability of the facilities.

Research Questions:

Is it feasible to assess the long-term viability of snow depth in winter recreation sites created in cities from the republic period and to anticipate or assess how long the facilities in these areas can remain operational considering snow conditions?

Literature Review:

In the study, in addition to general information such as the modernization process, urbanization, the importance of the tourism sector in the republican period Turkiye, which is the period of the study, the development of alternative tourism, the importance of inter-seasonal tourism, the place of winter recreation areas in the tourism sector are also mentioned. In addition, the basic principles of the Interferometric Artificial Aperture RADAR (InSAR) technique are also explained based on the literature.

Methodology:

In this study, InSAR technique was used to monitor the change in snow depth in the winter season (December-January-February) in Abalı Ski Center. For this purpose, changes were detected using C band supported Sentinel-1A radar images. In addition, the accuracy of the results was tested with the data obtained from real measurements for the 2021-22 winter season and the reliability of the results obtained was evaluated. This methodology has been used to evaluate land use suitability and especially snow permanence in terms of suitable installation. Thanks to this study, it was understood how the snow conditions of the ski resort changed over time and how the facilities reacted to these changes.

Results and Conclusions:

In this study, the usability of SAR-based RADAR datasets for precise measurements with interferometry method was investigated. The accuracy of the method was tested by comparing it with point measurements and the consistency values of the obtained results were found to be high. Changes in snow depth in the months that are important for winter recreation of snow were examined and the results obtained by interferometry analysis were found to be compatible with real measurements. The results obtained by this method can be used in different fields. In addition, it has been seen that radar interferometry analyzes can provide solutions to the difficulties in determining the appropriate area. The study was considered an important step in mapping snow components in complex areas and testing the accuracy of the results. Modeling results show that factors such as snow cover and depth can be calculated. In addition, by emphasizing the effect of winter recreation areas on social welfare, the importance of this study for suitable planning and investments was emphasized.