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Comparing Satellite and Weather Station Wind Speed Data: A Case Study of Telavi city (Kakheti, Georgia)

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ABSTRACT

In modern times, the use of satellite-derived information is becoming increasingly vital in both the operations of meteorological services and scientific research. This information plays a crucial role in evaluating air temperature, precipitation, drought monitoring, food security, and weather-related issues, as well as in making data-driven decisions. Studying ongoing processes via artificial satellites provides the opportunity to obtain unique data within a short timeframe.
This study assesses the potential risk of making incorrect decisions when utilizing satellite-derived meteorological data, using the case of Telavi (in particular, wind speed).

Key Words: *climate change, Kakheti, air temperature, wind speed, satellite data.*

Introduction

Satellite data plays a crucial role in assessing climate risks by providing accurate and timely information on environmental conditions. This data facilitates the monitoring of changes, forecasting of extreme weather events, and evaluation of climate change impacts across various regions. The primary advantage of using satellite data lies in its ability to cover vast territories, offer high-resolution satellite imagery to users, and provide near real-time updates, making it an essential tool for effective climate risk management. Since the early 1980s, polar-orbiting and geostationary satellites have been providing various types of data, including:

- Land surface temperature;
- Precipitation;
- Air temperature;
- Spatial distribution of drought intensity;
- Vegetation characteristics, their condition, etc. [1]

Study area, Materials and Methods

This paper compares the wind speed data of Telavi, one of Georgia's municipalities, with satellite-derived information spanning the years 2000-2016. TerraClimate data (derived from NASA's Terra satellite MODIS sensor) is utilized for this data comparison. Within the territory of Georgia, the combined application of satellite information and GIS methods allows for a more precise comparison and evaluation of the consistency between the country's meteorological stations and satellite data. Ultimately, this obtained satellite information can be utilized for forecasting purposes [https://www.climatologylab.org/terraclimate.html].

Modern meteorological stations integrate multiple sensors to provide a comprehensive view of environmental conditions. As for meteorological satellites, they are used to observe Earth's atmospheric

conditions from space, providing essential data for weather forecasting, climate change research, and environmental monitoring. Theoretically, satellites can monitor the environment at any point on Earth, at any time. Instead of directly measuring air temperature, they capture information across various wavelengths—such as infrared radiation from the Earth's surface—and then perform calculations to determine the temperature.

Terra is a NASA scientific research satellite. It investigates the connections between Earth's atmosphere, land, snow, ice, and ocean to better understand Earth's climate and climate change [https://terra.nasa.gov/]. MODIS stands for Moderate Resolution Imaging Spectroradiometer. It features numerous data products capable of measuring temperature, precipitation, land surface temperature, drought, phenology, and more.

Results

Wind speed data in Georgia is recorded by meteorological stations and observation posts across the country [2-13]. However, there are locations where meteorological stations are not installed due to various reasons. Consequently, satellite-derived information serves as an alternative option for measuring and verifying **wind speed**, capable of supplementing traditional methods. In Georgia, studying atmospheric processes using artificial satellites provides an opportunity to obtain unique data within a short timeframe; therefore, it is crucial to utilize all available information that enables more accurate and reliable forecasts of weather and natural disasters.

An integrated approach provides a large-scale, consistent, and continuous picture of the atmospheric processes occurring on the Earth's surface. Regular observations ensure a continuous flow of data. Furthermore, long-term satellite series allow for the comprehensive study of climate trends.

Table 1. Telavi Wind Speed Regression Statistics, Terraclimate and Telavi meteorological in 2000-2016 years

Parameter	Multiple R	R Square	Adjusted R Square	Standard Error	Number of observations
Value	0.445335	0.198323	0.194355	0.229063	204 month

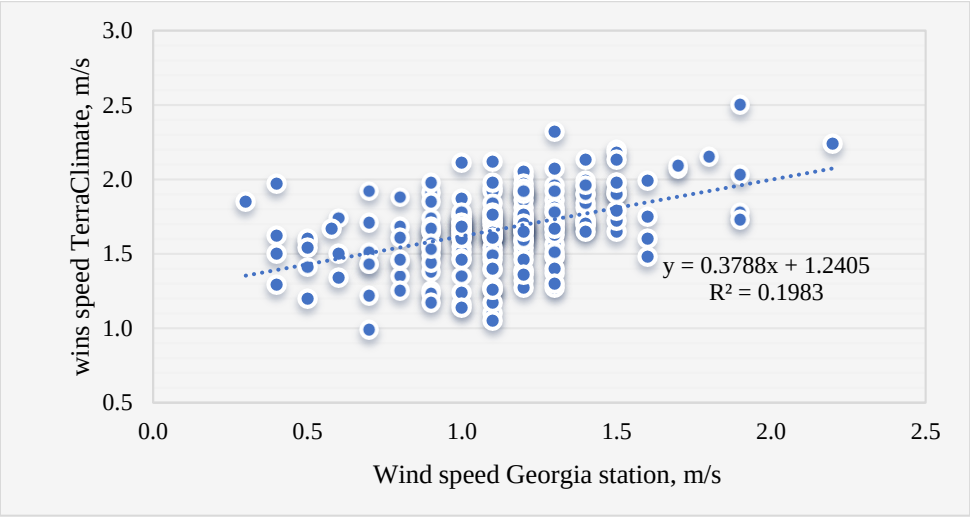

Fig. 1. Regression Statistics, Comparing Satellite and Weather Station Wind Speed Data: A Case Study of Telavi (2000-2016).

Validation of the monthly wind speed data from 2000-2016 reveals a moderate to low positive linear correlation [14] (R=0.445, Table 1, Fig. 1) between satellite estimations and ground-based station

observations. The analysis yielded a Mean Bias Error (MBE) of +0.54 m/s and Root Mean Square Error (RMSE) of 0.615 m/s. The low correlation coefficient (R=0.445) can be primarily attributed to the spatial scale mismatch. While the satellite dataset represents a grid-averaged wind speed over a broad area, the ground station captures localized point, measurements heavily influenced by microtopography, surface roughness and local obstacles. Nevertheless, the low RMSE and small systematic positive Bias demonstrate that the overall magnitude of deviation remains within an acceptable range. Consequently, applying the linear regression correction allows for effective bias adjustment, making the satellite product a viable alternative for regional wind resource assessment where station data is absent.

Conclusion

Based on the provided regression analysis tables, we can conclude that there is a positive linear relationship between the TerraClimate data and the data from Georgian meteorological stations.

Wind is the most variable meteorological parameter. The spatial resolution of the TerraClimate is approximately 4 km. Although it can't provide accurate daily values, it can reflect seasonal trends or the general dynamics of windy periods. When ground-based observations are unavailable, satellite data serves as the sole source, despite its inherent errors. The average Bias for entire 17-year period (2000-2016) is 0.54. This indicates that the satellite overestimated wind speed by an average of 0.54 m/s compared to the measurements from Georgian stations.

Predicting global changes with high accuracy is essential for making prudent decisions related to environmental protection issues.

References

[1] Sivakumar M.V.K., Roy P.S., Harmsen K. Satellite Remote Sensing and GIS Applications in Agricultural Meteorology, Switzerald, 2004.

[2] Amiranashvili A.G., Chikhladze V.A., Gvasalia G.D., Loladze D.A. Statistical Characteristics of the Daily Max of Wind Speed in Kakheti in 2017-2019. Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 23(1), 2020, pp. 73-86. DOI: https://doi.org/10.48614/ggs2320202655

[3] Amiranashvili A., Chikhladze V., Gvasalia G., Loladze D. Statistical Characteristics of the Daily Max of Wind Speed in Kakheti in the Days with and without Hail Processes in 2017-2019. Int. Sc. Conf. „Modern Problems of Ecology", Proc., ISSN 1512-1976, v. 7, Tbilisi-Telavi, Georgia, 26-28 September, 2020, pp. 197-201. http://www.dspace.gela.org.ge/bitstream/123456789/8808/1/Eco_2020_3.32.pdf

[4]Beglarashvili N., Chikhladze V., Janelidze I., Pipia M., Tsintsadze T. Strong Wind on the Territory of Georgia in 2014-2018. International Scientific Conference „Natural Disasters in the 21st Century: Monitoring, Prevention, Mitigation". Proceedings, ISBN 978-9941-491-52-8, Tbilisi, Georgia, December 20-22, 2021. Publish House of Iv. Javakhishvili Tbilisi State University, Tbilisi, 2021, pp. 19 - 22.

[5] Amiranashvili A., Jamrishvili N., Janelidze I., Pipia M., Tavidashvili Kh. Statistical Analysis of the Daily Wind Speed in Tbilisi in 1971-2016. Int. Conf. of Young Scientists "Modern Problems of Earth Sciences". Proceedings, ISBN 978-9941-36-044-2, Publish House of Iv. Javakhishvili Tbilisi State University, Tbilisi, November 21-22, 2022, pp. 159-163. http://openlibrary.ge/handle/123456789/10250

[6] Beglarashvili N., Pipia M., Jamrishvili N., Janelidze I. Some Results of the Analysis of Number of Days with Strong Wind in Various Regions of Georgia in 2019-2022. Georgian Geographical Journal, E-ISSN: 2667-9701, Vol.3 (2), 2023, 5 p. DOI: https://doi.org/10.52340/ggj.2023.03.02.05

[7] Beglarashvili N., Jamrishvili N., Janelidze I., Pipia M., Tavidashvili Kh., Tsintsadze T. Some Results of Statistical Analysis of the Daily Wind Speed in Tbilisi in 1971-2020. Int. Sc. Conf. "Geophysical Processes in the Earth and its Envelopes". Proceedings, ISBN 978-9941-36-147-0, Publish House of Iv. Javakhishvili Tbilisi State University, November 16-17, 2023, pp. 151-155. http://www.openlibrary.ge/handle/123456789/10423

[8] Elizbarashvili E., Varazanashvili O., Lagidze L., Pipia M., Chikhladze V. About Strong Winds in Kakheti Region. Int. Sc. Conf. "Geophysical Processes in the Earth and its Envelopes". Proceedings, ISBN 978-

9941-36-147-0, Publish House of Iv. Javakhishvili Tbilisi State University, November 16-17, 2023, pp. 156-160, (in Georgian). http://www.openlibrary.ge/handle/123456789/10424
[9] Kartvelishvili L., Tatishvili M., Amiranashvili A., Megrelidze L., Kutaladze N. Weather, Climate and their Change Regularities for the Conditions of Georgia. Monograph, Publishing House "UNIVERSAL", ISBN: 978-9941-33-465-8, Tbilisi 2023, 406 p., https://doi.org/10.52340/mng.9789941334658
[10] Elizbarashvili E.Sh., Varazanashvili O.Sh., Amiranashvili A.G., Fuchs F., Basilashvili Ts.Z. Statistical Characteristics of Hurricane Winds over Georgia for the Period 1961–2022. European Geographical Studies, E-ISSN: 2413-7197, 10(1), 2023, pp. 8-18, DOI: 10.13187/egs.2023.1.8, https://egs.cherkasgu.press
[11] Amiranashvili A., Elizbarashvili E., Gaprindashvili G., Varazanashvili O., Fuchs S. Assessment of the Long-Term Risk of Dangerous Hurricanes on the Territory of Georgia Using Data from 1961 to 2022. "Reliability: Theory and Applications", ISSN 1932-2321, Special Issue № 6 (81), Part-2, Vol. 19, 2024, pp. 508 - 514. https://doi.org/10.24412/1932-2321-2024-681-508-514
[12] Aliyev V., Amiranashvili A., Pipia M., Varamashvili N. Wind Conditions at the Heydar Aliyev Baku and Shota Rustaveli Tbilisi International Airports in 2015–2024. Theory and Applications, ISSN 1932-2321, Volume 20, Special Issue No. 9 (87), November 2025, pp. 651-659. https://doi.org/10.24412/1932-2321-2025-987-651-659
[13] Elizbarashvili E.S., Varazanashvili O.S., Amiranashvili A.G., Pipia M.G. Long-term Trends in the Frequency and Intensity of Hurricane Winds over the Territory of Georgia in 1961–2022. Russ. Meteorol. Hydrol. 50, 2025, pp. 1061–1067. https://doi.org/10.3103/S1068373925120076
[14] Hinkle D. E., Wiersma W., Jurs S. G. Applied Statistics for the Behavioral Sciences. Boston, MA, Houghton Mifflin Company, ISBN: 0618124055; 9780618124053, 2003, 756 p.

ქარის სიჩქარის თანამგზავრული და მიწისზედა მეტეოროლოგიური მონაცემების შედარებითი ანალიზი ქ. თელავის მაგალითზე (კახეთი, საქართველო)

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რეზიუმე

თანამედროვე პირობებში, მეტეოროლოგიური სამსახურების საქმიანობაში და სამეცნიერო-კვლევით მუშაობაში, თანამგზავრებიდან მიღებული ინფორმაციის გამოყენებას სულ უფრო მეტი მნიშვნელობა ენიჭება. ეს ინფორმაცია მნიშვნელოვან როლს ასრულებს ჰაერის ტემპერატურის, ნალექებისა, გვალვის მონიტორინგის, სასურსათო უსაფრთხოების და ამინდთან დაკავშირებულ საკითხების შეფასებასა და მონაცემებზე დაფუძნებული გადაწყვეტილებების მიღებაში. მიმდინარე პროცესების ხელოვნური თანამგზავრების საშუალებით შესწავლა, მოკლე დროში უნიკალური ინფორმაციის მიღების შესაძლებლობას იძლევა.

მოცემული კვლევა ეხება თანამგზავრებიდან მიღებული მეტეოროლოგიური მონაცემების გამოყენებისას, არასწორი გადაწყვეტილებების პოტენციური რისკის შეფასებას თელავის მაგალითზე (კერძოდ, ქარის სიჩქარე).

საკვანძო სიტყვები: კლიმატის ცვლილება, კახეთი, ჰაერის ტემპერატურქარის, ქარის სიჩქარე, სატელიტური მონაცემები.

Сравнение спутниковых данных и данных метеостанции о скорости ветра: пример г. Телави (Кахети, Грузия)

М. Модрекелидзе, Л. Лагидзе, Г. Гамбашидзе

Резюме

В современную эпоху использование информации, полученной со спутников, приобретает все большее значение как в работе метеорологических служб, так и в научных исследованиях. Эта информация играет решающую роль в оценке температуры воздуха, осадков, мониторинге засухи, обеспечении продовольственной безопасности и решении погодных проблем, а также в принятии решений на основе данных. Изучение текущих процессов с помощью искусственных спутников предоставляет возможность получения уникальных данных в короткие сроки.

В данном исследовании на примере Телави оценивается потенциальный риск принятия неверных решений при использовании метеорологических данных, полученных со спутников (в частности, скорости ветра).

Ключевые слова: изменение климата, Кахетия, температура воздуха, скорость ветра, спутниковые данные.