ISSN 1946-7664. MCFNS 2025
Vol. 17, Issue 2, pp. 33–40
Mathematical and Computational Forestry & Natural-Resource Sciences

AVAILABLE ONLINE AT HTTP://MCFNS.COM

Submitted: Sep. 19, 2025
Accepted: Oct. 25, 2025
Published: Oct. 30, 2025
Last Correction: Oct. 31, 2025

SPATIOTEMPORAL PATTERNS OF TEMPERATURE, PRECIPITATION, WIND, AND SUNSHINE EXTREMES IN THE SEOMJIN AND YEONGSAN RIVER BASINS (2020–2023)

Hojung Kim , Kyo-Mun Shim*, Seung-Gil Hong

Division of Response for Climate Change, National Institute of Agricultural Science, Wanju, 55365, Republic of Korea
** Corresponding Author*

Abstract.Extreme weather poses increasing risks to agriculture in South Korea Seomjin and Yeongsan River basins. Using observations from the Korea Meteorological Administrations Automated Synoptic Observing System (ASOS) and Automatic Weather Stations (AWS), I investigated spatiotemporal extremes in temperature, precipitation, wind, and sunshine during 2020–2023. Station records were summarized by year and location, and spatial fields were generated with GIS-based interpolation at 30×30 m to 270×270 m resolution; precipitation fields included PRISM-style topographic adjustments. Both basins exhibited substantial fluctuations in minimum temperatures over the four years. Coastal areas tended to have higher minimum temperatures, consistent with maritime moderation. While extreme daily minimum temperatures differed between even- and odd-numbered years, extreme daily maximum temperatures were relatively stable; nevertheless, basin-average maximum temperatures increased from 34.1°C (2020) to 34.6°C (2021) and 35.3°C (2023). Precipitation extremes varied markedly, with station maxima up to 361.3 mm day^{-1} (Sunchang, 2020) and gridded maxima of approximately 280 mm day^{-1} in the Seomjin basin. In the Seomjin basin, northeastern sectors recorded higher daily maximum precipitation than southwestern sectors, likely reflecting topographic controls. Maximum instantaneous wind speeds reached 47.4 m s^{-1} at Heuksan Island, and daily sunshine duration peaked at 13.6 h at selected coastal stations. We discuss topographic influences and agricultural implications. Because the 4-year period is short, the results are descriptive rather than inferential; we recommend adopting standardized extreme-indices and cross-validated interpolation to improve comparability and uncertainty characterization in future work.
Keywords: Extreme weather; Seomjin River; Yeongsan River; ASOS; AWS; PRISM; GIS interpolation; agriculture.

1 Introduction

Weather and climate are central determinants of agricultural productivity, risk, and resilience. In regions dominated by rice, orchard, and mixed-field systems such as South Korea's Jeollanamdo Province the distribution and intensity of temperature, precipitation, wind, and sunshine directly affect planting windows, flowering and heading, pest and disease dynamics, and the probability of damaging events such as flooding, lodging, heat injury, and cold snaps. Over recent decades, the scientific literature has documented significant changes in the statistics of extremes at the global scale, including increases in the frequency and intensity of hot extremes and, in many regions, heavier short duration precipitation events. While attribution to anthropogenic forcing must be made with care, especially at local scales, the broader context underscores the practical need for location-specific analyses that can support adaptation planning in agricultural areas.

The Seomjin and Yeongsan river basins traverse the major agricultural plains of Jeollabukdo and Jeollanamdo, including the Naju, Songjeong, and Hakgyo plains. These basins encompass pronounced coastal-inland and lowland-mountain gradients, as well as complex orography (e.g., the Sobaek Mountains and the Jirisan range). Such physiographic contrasts can amplify spatial variability in minimum temperature (via cold air pooling and inversions), maximum temperature (via urban heat island and radiation differences), precipitation (via orographic lifting and rain shadow effects), and wind exposure. Capturing these fine-scale patterns

is therefore important for regional agricultural meteorology, early warning services, and crop risk management.

Despite the importance of basin scale characterization, comparatively few recent studies assemble a unified, station-to-grid view of extreme weather across the Seomjin and Yeongsan basins. Existing national assessments provide essential context on Korean climate extremes (e.g., national heat waves in 2018 and 2023 and the widespread floods of 2020), and sectoral reports describe agricultural impacts; however, decision makers in Jeollanamdo require information resolved to their basins and municipalities, synthesized across variables (temperature, precipitation, wind, sunshine), and presented in forms that can be cross referenced to station observations. This study responds to that need by compiling 2020-2023 data from KMAs Automated Synoptic Observing System (ASOS) and Automatic Weather Stations (AWS), deriving annual extremes at stations, and generating spatial interpolations to highlight intra-basin contrasts. To better reflect terrain effects on precipitation, we further apply a PRISM-style, topographic-informed approach.

The objectives of this paper are fourfold: (i) to describe recent basin-scale extremes in daily minimum (TNn) and maximum (TXx) temperature, daily precipitation (Rx 1 day-like), maximum instantaneous wind speed, and daily sunshine duration using ASOS records; (ii) to produce spatially explicit fields of extremes using GIS-based interpolation from AWS/ASOS observations at 3030m to 270270m resolution; (iii) to interpret the resulting spatial patterns in the context of physiography and coastal influence; and (iv) to outline practical implications for agriculture, including temperature and rainfall hotspots that may require enhanced preparedness. Because the study period is limited to four years, we emphasize descriptive characterization rather than formal trend detection or attribution. Nevertheless, the compilation provides a recent baseline against which longer term analyses can be extended and supports ongoing development of agricultural meteorological services in the region.

The remainder of the manuscript is organized as follows. Section 2 describes the study area and summarizes the meteorological data and interpolation procedures used to produce station summaries and gridded fields. Section 3 presents the results for minimum and maximum temperature, precipitation, wind, and sunshine, integrating station-based and spatial perspectives. Section 4 (Discussion) reiterates the principal patterns and their value, articulates limitations of the short period and interpolation uncertainties, and outlines implications and priorities for future research. Section 5 concludes.

2 Materials and Methods

2.1 Study area

The Seomjin River originates near Mt. Palgong (1,151m) along the borders of Jangsu, Imsil, and Jinan (Jeollabukdo) and flows southwest to the Seomjin River Dam. The river length is 212.3 km with a drainage area of 4,896.5 km^2. The basin spans approximately 34°30′26” N–35°50′00” N and 127°53′05” E–126°51′50” E, covering parts of Jeollanamdo (47%), Jeollabuk-do (44%), and Gyeongsangnamdo (9%). Neighboring basins include the Nakdong (east), Yeongsan and Dongjin (west), and Geum and Mangyeong (north). Topography is largely mountainous; the Sobaek Mountains form the eastern boundary, and the Jirisan range (branching from Mt. Nogodan, 1,507m) trends southeast toward the estuary.

The Yeongsan River rises on Byeongpungsan (Damyanggun, Jeollanamdo) and flows NE-SW across the province before discharging to the West Sea. Major tributaries include the Hwangnyong, Geungnak, Jiseokcheon, and Gomakwoncheon. Although the main stem is relatively short (150km^2), the basin area (3,551km^2) accounts for about 29% of Jeollanamdo. Historically the lower main stem was tidal prior to the construction of the estuary barrage; the Seungcheon and Juksan weirs were added during the Four Major Rivers Restoration Project.

2.2 Data and procedures

We analyzed ASOS (Automated Synoptic Observing System) records for 2020-2023 to compute annual extremes at each observation point: minimum daily temperature, maximum daily temperature, maximum daily precipitation, maximum instantaneous wind speed, and maximum daily sunshine duration. Synoptic observations are standardized in time and method across stations, enabling comparison across basins. We also used AWS (Automatic Weather Stations) and radar echo information to generate spatially explicit fields of extremes using GIS-based interpolation at 3030m to 270270m resolution. For precipitation, a PRISM-style adjustment was applied to incorporate slope and elevation dependencies. Solar radiation fields were corrected for slope orientation before deriving sunshine-related summaries. Figures 1–5 summarize station based annual extremes. In Appendix, Figures 6–7 map the minimum temperatures, 8–9 map the maximum temperatures, 10–11 map precipitations, and 12–13 map maximum instantaneous wind speeds, as gridded fields for the two basins.

3 Results

3.1 Minimum temperature

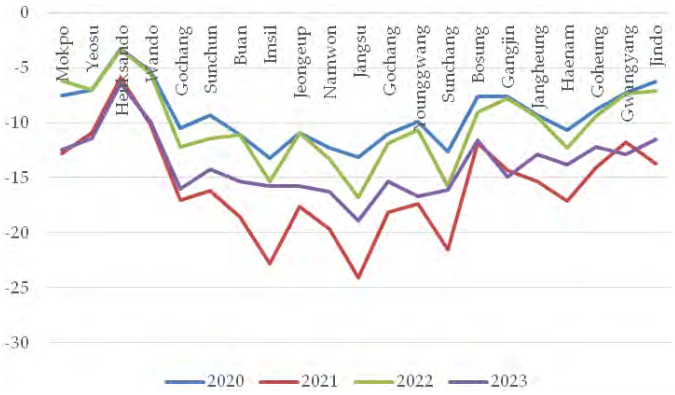

Figure 1: Annual distribution of daily minimum temperature at observation points within the Seomjin and Yeongsan River basins (2020-2023).

Annual daily minimum temperatures (2020-2023) based on ASOS data show marked variability across stations in both basins (Figure 1). Regionally, coastal and island stations (e.g., Heuksando, Wando, Mokpo, Yeosu) tended to have higher minimum temperatures than inland stations, consistent with maritime moderation. In contrast, some inland locations (e.g., Jangsu, Sunchang, Imsil) experienced lower extremes and greater inter-annual range. Over 2020-2023, the gridded extremes (lowest daily minimum per cell) ranged from 26.1 to 7.9°C in the Seomjin basin and from 23.9 to 6.1°C in the Yeongsan basin (see Figures in App. A). These spatial patterns reflect coastal-inland gradients and orographic influences.

3.2 Maximum temperature

Annual maximum daily temperatures (ASOS) varied modestly among years, with basin-average values of 34.1°C (2020), 34.6°C (2021), 34.1°C (2022), and 35.3°C (2023) (Figure 2). Among stations, Gwangyang recorded the highest average maximum (35.6°C), followed by Sunchang (35.5°C) and Gangjin (35.3°C), whereas coastal sites (Heuksando, Mokpo, Jindo, Yeosu) were comparatively lower. Gridded extremes (highest daily maximum per cell) ranged from 22.6 to 38.9°C in the Seomjin basin and from 27.5 to 41.8°C in the Yeongsan basin (see Figures in App. B).

3.3 Precipitation

Station-based maximum daily precipitation exhibited strong inter-annual variability (Figure 3). Basin-average station maxima were approximately 161mm in 2020 and

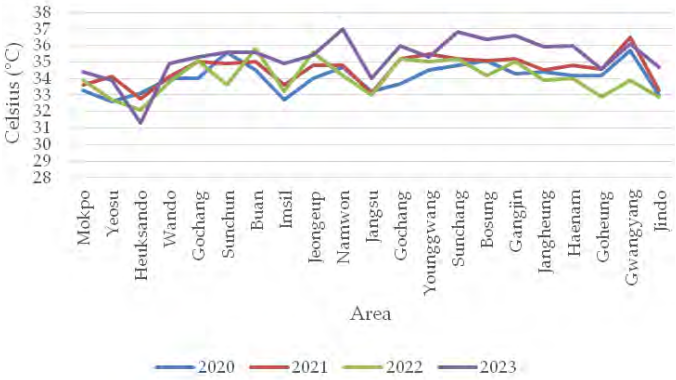

Figure 2: Annual distribution of daily maximum temperature at observation points within the Seomjin and Yeongsan River basins (2020-2023).

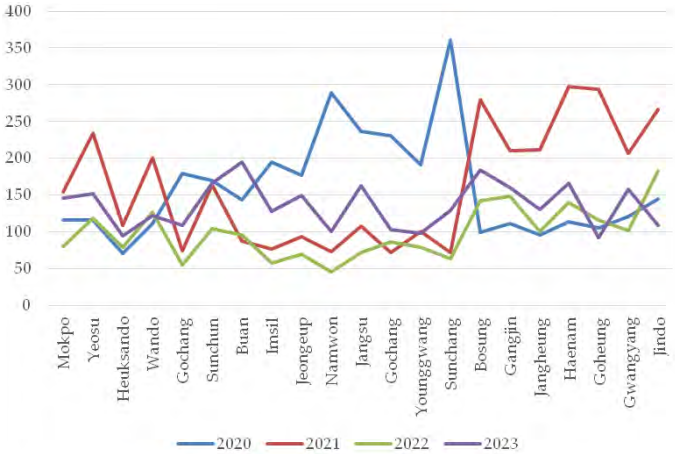

Figure 3: Annual distribution of maximum daily precipitation at observation points within the Seomjin and Yeongsan River basins (2020-2023).

2021, decreased to 98.4mm in 2022, and rebounded to 136.2mm in 2023. Spatial heterogeneity was pronounced: Haenam averaged 179.5mm for annual maxima, Boseong 176.4mm, whereas Heuksan Island averaged 88.5mm. The summer of 2020 produced notable extremes, including 361.3mm at Sunchang and 289.4mm at Namwon. Gridded daily maximum precipitation (270270m) peaked at 280.5mm (Seomjin) and 250.6mm (Yeongsan) in 2020 (see Figures in Appendix C). Northeastern Seomjin sectors and some upper basin areas showed higher maxima than southwestern sectors, likely reflecting topographic effects.

3.4 Wind

Based on ASOS synoptic observations, maximum instantaneous wind speeds (2020-2023) in the Yeongsan region ranged from 18.5 to 47.4ms, with the maximum

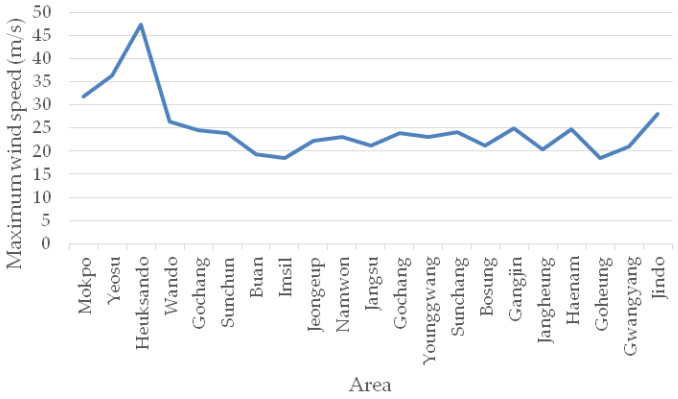

Figure 4: Maximum instantaneous wind speed (m s) in the Seomjin and Yeongsan River areas (2020-2023).

at Heuksan Island (Figure 4 and Figures in Appendix D). Gridded estimates from AWS-based interpolation indicated ranges of 6.8-81.2ms (Seomjin) and 7.7-77.0ms (Yeongsan) (Figures11-12).

3.5 Sunshine duration

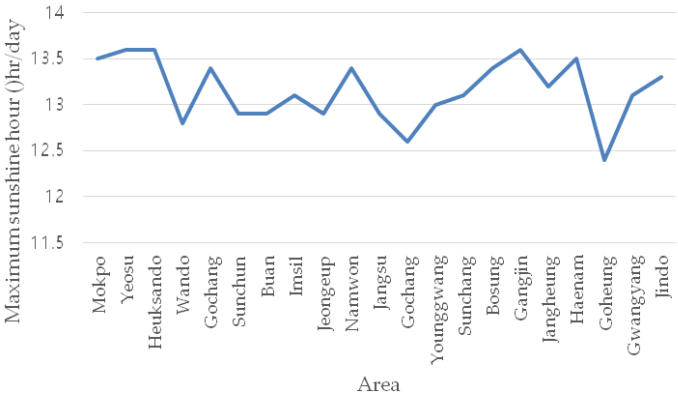

Figure 5: Observed daily maximum sunshine duration at monitoring stations in the Seomjin and Yeongsan River basins (2020-2023).

Maximum daily sunshine duration values (ASOS) reached 13.6h at Heuksando and Yeosu, while Goheung showed a relatively lower maximum of 12.4h (Figure 5).

4 Discussion and Conclusion

This study provides a consolidated, basin-scale view of recent (2020-2023) extremes across the Seomjin and Yeongsan river systems by linking station-based summaries to gridded fields. The results reiterate several practical points:

(i) Coastal moderation leads to higher winter minimum temperatures near the coast and islands, whereas inland basins exhibit lower TNn values and larger inter-annual variability; (ii) annual TXx values vary modestly from year to year but can be locally elevated in interior lowlands or urban-adjacent sites; (iii) Rx1day-like precipitation extremes are strongly year-dependent, with 2020 standing out basin-wide; and (iv) exposure to damaging gusts is substantial, particularly for coastal and island locations.

Value and implications. The station-to-grid perspective helps agricultural stakeholders identify local hotspots—areas that combine low TNn with high TXx or intense Rx1day—so that crop choice, sowing dates, protected cultivation, drainage, and windbreak planning can be prioritized. For example, rice transplanting and vegetable planting in late summer may warrant contingency plans in locations that historically align with Rx1day peaks. Similarly, inland cold-air pools may require frost-protection strategies for sensitive crops. Specifically, subtropical fruits such as mangoes, star fruit, purple passion fruit, dragon fruit, lychee, longan, and avocados are sensitive to low minimum temperatures and may require protection in inland areas. Likewise, crops like wheat, rice, and flowering plants may need special care in regions with high maximum temperatures to mitigate heat stress. In precipitation hotspots, summer crops including kimchi cabbage, green onions, radish, and spinach should be cultivated with considerations for potential heavy rains and flooding.

Limitations. The four-year study window constrains inference: it is insufficient for trend detection or robust attribution of changes to external forcing. Furthermore, while high-resolution grids (30-270 m) are useful for visualization, their accuracy depends on station density and interpolation method. Uncertainties from interpolation parameters, station exposure differences, and complex terrain are not quantified here. Finally, combining ASOS and AWS records can introduce heterogeneity if sensor characteristics and QC differ.

Future work. Extending the time series (20 years), adopting standardized extreme indices (e.g., ETCCDI TNn, TXx, Rx1day, Rx5day), and reporting cross-validation metrics (RMSE, MAE, bias) for the interpolation would increase comparability and decision utility. Coupling extremes to crop-specific thresholds and phenology (e.g., heat degree-hours, lodging and flood thresholds) would sharpen agrometeorological guidance. Finally, uncertainty maps and sensitivity tests to grid resolution can help users interpret the gridded fields.

In conclusion, the Seomjin and Yeongsan river basins exhibit substantial spatial and inter-annual variability in recent extremes. Minimum temperatures are generally higher at coastal and island stations, while interior locations experience lower extremes. Annual maximum temperatures vary modestly but indicate higher basin-

average values in 2023 relative to 2020-2022. Precipitation extremes are highly variable, with 2020 producing the largest basin-wide maxima; gridded analyses highlight northeast Seomjin and selected upper basin sectors as precipitation hotspots. Maximum instantaneous wind speeds can be severe, particularly in coastal and island areas, and sunshine duration extremes cluster at coastal stations. Collectively, these findings provide a recent baseline for agricultural preparedness. Because the analysis spans only four years, the results should be treated as descriptive; longer records and formal uncertainty quantification are priorities for future studies.

5 Acknowledgement

This work was carried out with the support of "Cooperative Research Program for Agriculture Science & Technology Development (Project No. RS-2024–00336321)," Rural Development Administration, Republic of Korea.

References

Bita, C.E., and Gerats, T., 2013: Plant Tolerance to High Temperature in a Changing Environment: Scientific Fundamentals and Production of Heat Stress-Tolerant Crops. Frontiers in Plant Science 4, 273.

Ebi, K. L., Capon, A., Berry, P., Broderick, C., de Dear, R., Havenith, G., and Jay, O. 2021: Hot weather and heat extremes: health risks. The Lancet, 398(10301), 698–708.

Field, C.B., et al., 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Summary for Policymakers. IPCC SREX.

Intergovernmental Panel on Climate Change, 2021: Climate Change 2021: The Physical Science Basis. Cambridge University Press.

Intergovernmental Panel on Climate Change, 2022: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.

Kim, D. J., 2021: Past, present and future of geospatial scheme based on topo-climatic model and digital climate map. Korean Journal of Agricultural and Forest Meteorology, 23(4), 268–279.

Korea Meteorological Administration, 2025: Real-time Weather Data.

Korea Rural Economic Institute, 2017: Shifts in precipitation patterns and their impact on agricultural sustainability and rural economic recovery.

The Academy of Korean Studies, n.d.: Yeongsan River.

Korean Society of Agricultural and Forest Meteorology, 2023: Technical Guide for Early Warning Services on Agricultural Meteorological Disasters (Revised Edition).

Konno, S., and Sugiura, T., 2024: Experimental Study on Cold Tolerance Thresholds in Field Grown Subtropical Fruit Trees. Journal of Agricultural Meteorology 80(3), 90–97.

Lavell, A., Oppenheimer, M., Diop, C., Hess, J., Lempert, R., Li, J., and Myeong, S., 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. IPCC.

Lee, K.H., Ryu, Y.W., and Park, J.S., 2020: Investigation of Flood Damage and Cause Analysis in the Yeongsan and Seomjin River Basins in August 2020. Journal of Korean Society of Water Resources 53(11), 21–48.

Lee, Y.H., Kim, J., and Park, K., 2022: Characteristics of Extreme High Temperature Events in South Korea. Climate Dynamics 55(1), 1685–1696.

Ministry of Environment, Yeongsan River Basin Environmental Office. Available online.

Ministry of Interior and Safety, 2021: Climate Change and Its Impact on Extreme Weather Events.

National Academies of Sciences, Engineering, and Medicine, 2016: Attribution of Extreme Weather Events in the Context of Climate Change. National Academies Press.

Parker, L.E., Mc Elrone, A.J., Ostoja, S.M., and Forrestel, E.J., 2020: Extreme Heat Effects on Perennial Crops and Strategies for Sustaining Future Production. Plant Science 295, 110397.

Stott, P., 2016: How Climate Change Affects Extreme Weather Events. Science 352, 1517–1518.

Yun, J. I., 2010: Agroclimatic maps augmented by a GIS technology. Korean Journal of Agricultural and Forest Meteorology 12(1), 63–73. (in Korean with English abstract).

Additional references added for methodological context:

Daly, C., Neilson, R.P., & Phillips, D.L. (1994). A Statistical-Topographic Model for Mapping Climatological Precipitation over Mountainous Terrain. Journal of Applied Meteorology, 33, 140–158.

Daly, C., Taylor, G.H., & Gibson, W.P. (1997). The PRISM Approach to Mapping Precipitation and Temperature. Proc. 10 th AMS Conf. on Applied Climatology, Reno, NV.

ETCCDI. Definitions of the 27 Core Climate Extremes Indices (TNn, TXx, Rx 1 day, Rx 5 day, etc.). (Accessed 2025).

A Minimum Temperatures

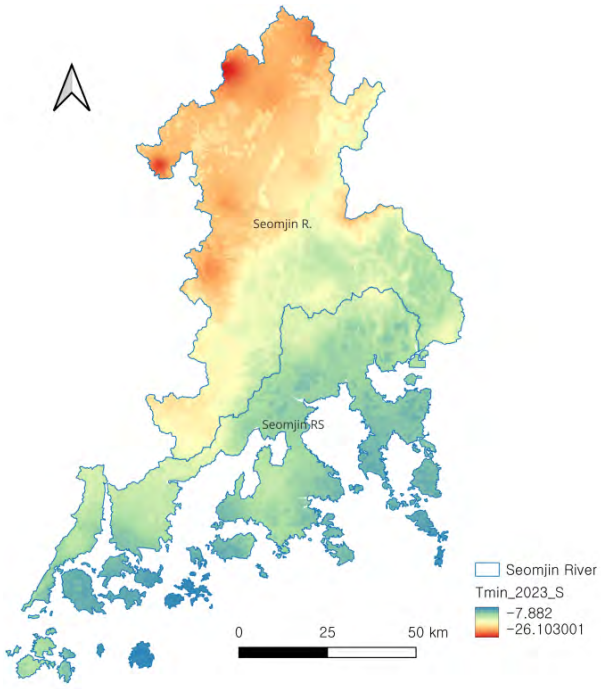

Figure 6: Gridded minimum temperature over the Seomjin River basin (2020-2023).

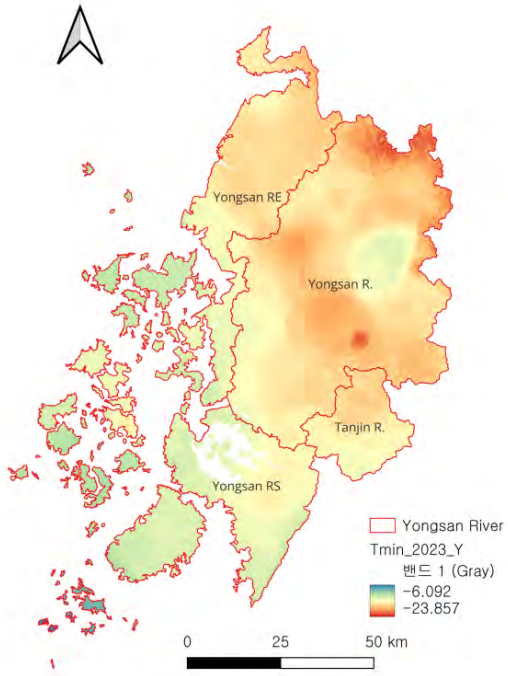

Figure 7: Gridded minimum temperature over the Yeongsan River basin (2020-2023).

B Maximum Temperatures

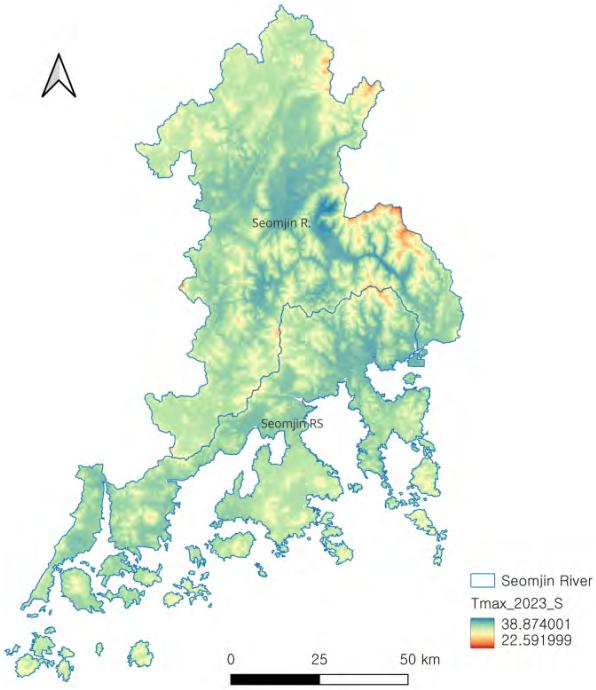

Figure 8: Gridded maximum temperature over the Seomjin River basin (2020-2023).

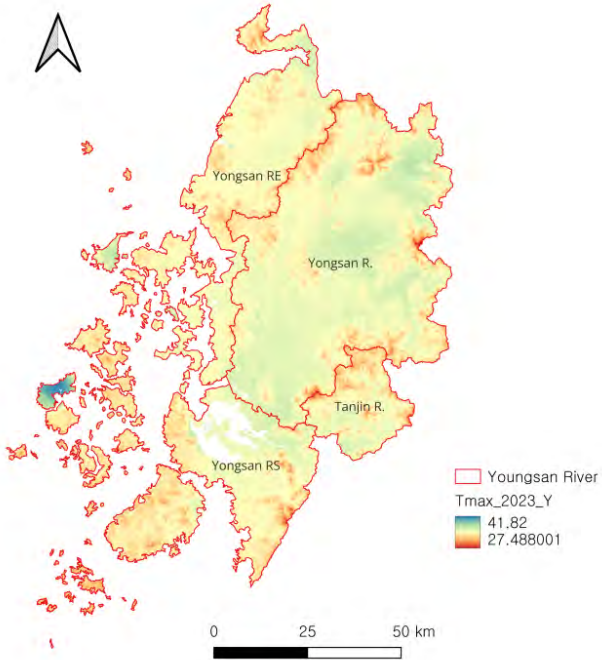

Figure 9: Gridded maximum temperature over the Yeongsan River basin (2020-2023).

C Precipitations

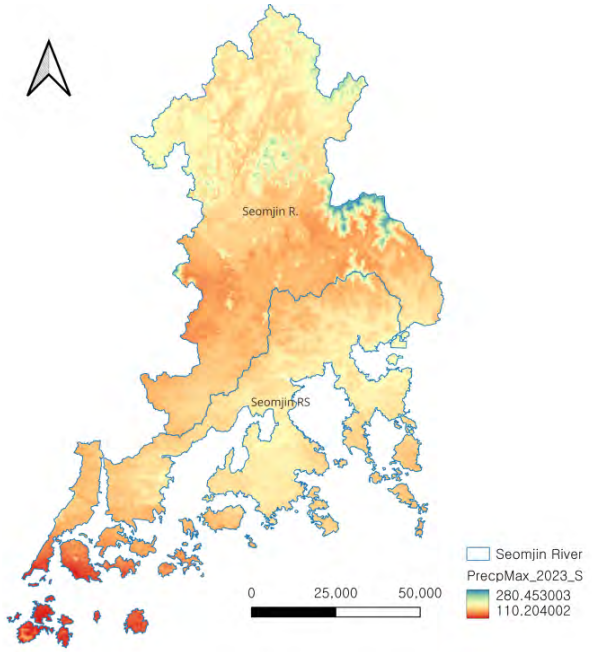

Figure 10: Gridded maximum precipitation over the Seomjin River basin (2020-2023).

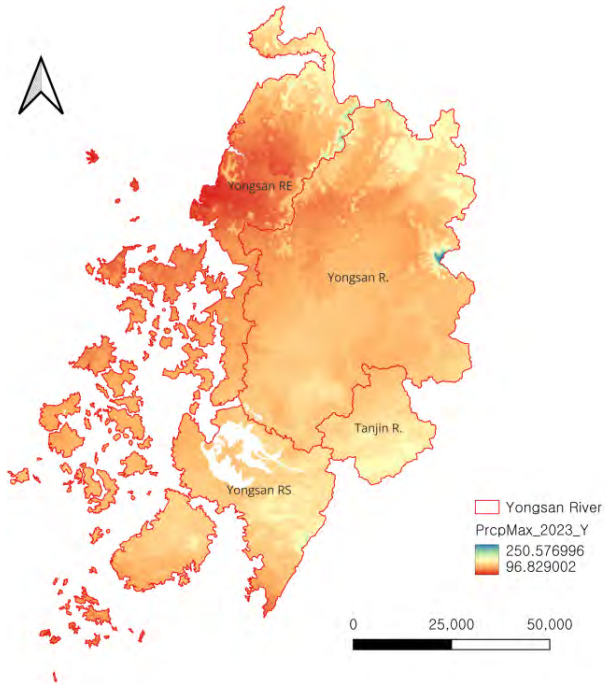

Figure 11: Gridded maximum precipitation over the Yeongsan River basin (2020-2023).

D Wind

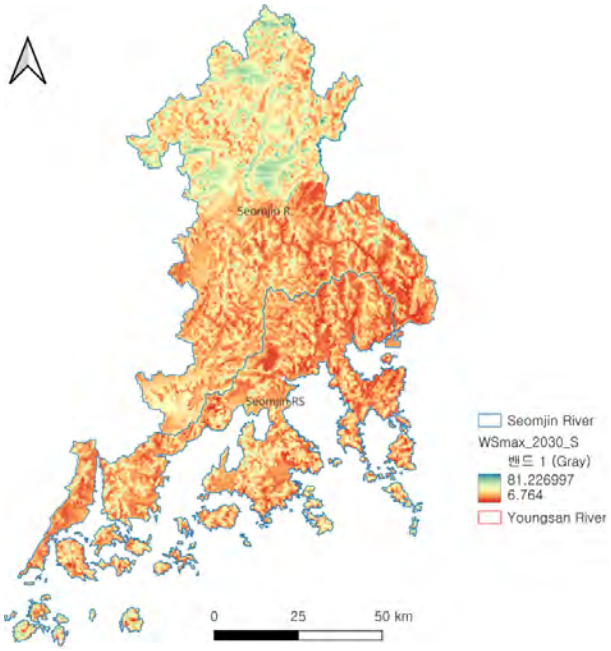

Figure 12: Gridded maximum instantaneous wind speed (m s) over the Seomjin River basin (2020-2023).

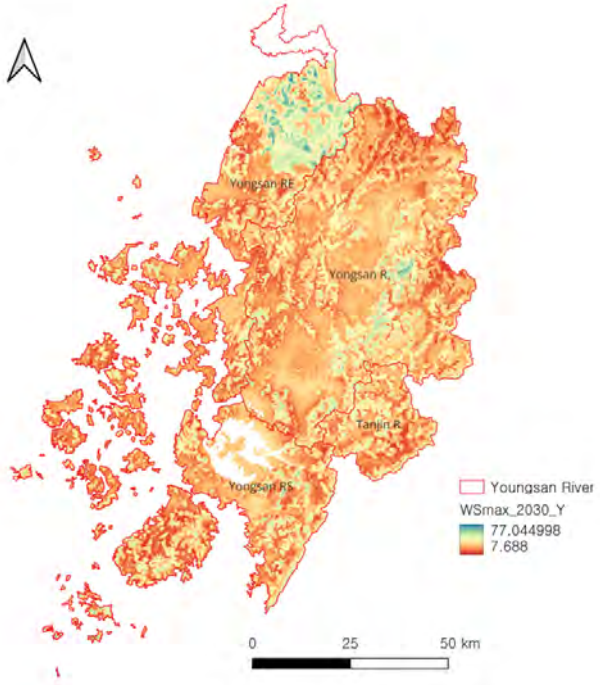

Figure 13: Gridded maximum instantaneous wind speed (m s) over the Yeongsan River basin (2020-2023).