Groundwater Dynamics in the Swedish Sub-Arctic Region: Inferring from Standardized Index Based on Model and Observation Data

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1. Introduction

- The Arctic regions are experiencing faster warming than the global average, which reduces the impact of permafrost and seasonal ground frost on the hydrologic system.
- Meteorological factors could influence hydrological systems.
- Accompanied by changes in the ground surface, diminishing permafrost could increase hydrological connectivity and groundwater flow, which could influence the rate of thawing via impacts on soil thermal properties and advective transport of heat with groundwater.
- Basic understanding of the factors that drive groundwater dynamics in high-latitude landscapes remains limited.

2. Objective

Preliminary study to understand the status of groundwater in the Swedish sub-arctic region and how meteorological factors affect this dynamic.

3. Methods

Data: monthly groundwater observation from SGU[a], precipitation from SMHI[b], and groundwater level data from the LISFLOOD model (1991-2018)[c]. The investigated location is in Abisko, Northern Sweden.

Methods:

- Standardized Precipitation (SPI), Evapotranspiration (SPEI), and Groundwater (SGI) Index using gamma parameter distribution.
- Evapotranspiration was calculated using the Thornthwaite method.
- Correlation analysis was done by Pearson's correlation.

Table 1. Standardized Index Classification

SI Values	Classification
≥ 2.0	Extremely Wet
1.50 – 1.99	Very Wet
1.0 – 1.49	Pretty Wet
0.5 – 0.99	Wet
(-0.49) – 0.49	Near Normal
(-0.5) - (-0.99)	Mild Drought
(-1) - (-1.49)	Moderate Drought
(-1.5) - (-1.99)	Severe Drought
≤ -2.0	Extreme Drought

[a]https://www.sgu.se/grundvatten/grundvattennivaer/matstationer/

[b]https://www.smhi.se/data/hitta-data-for-en-plats/ladda-ner-vaderobservationer/precipitationMonthlySum

[c]https://data.4tu.nl/datasets/302cd0fd-59da-46e8-ac82-f98fad865751

4. Results

- Groundwater levels are strongly linked to precipitation in the preceding 6 months, as shown in the positive correlation between SGI-1 and SPI-6 (R=0.64).
- Evaporation (SPEI-3 and 6; R-values are 0.56 and 0.52) also had a strong impact on SGI-1.
- SGI-model has bias of 0.14 with MAE of 0.85 and R^2 of 0.15.

5. Discussion

- High SGI values during 2011-2017 indicate high wetness compared to normalized observed groundwater levels for the past 30 years.
- The fluctuation of groundwater levels in sub-arctic regions could be related to the thawing of permafrost and changes in seasonally frozen ground in the topsoil.
- Freeze-thaw cycles influence the fluctuation of groundwater levels and delay the effect of precipitation.
- The effect of precipitation is reduced by evapotranspiration, although not significantly.
- Hydrological complexity could affect the model performance.

6. Conclusion

- Meteorological factors have a lag effect before influencing groundwater level. It showed from SPI, SPEI, and SGI values.
- SGI from model output has low performance compared to the observation. But it captured the dry events during 2008-2011.
- The model doesn't capture wet events from 2011-2017.

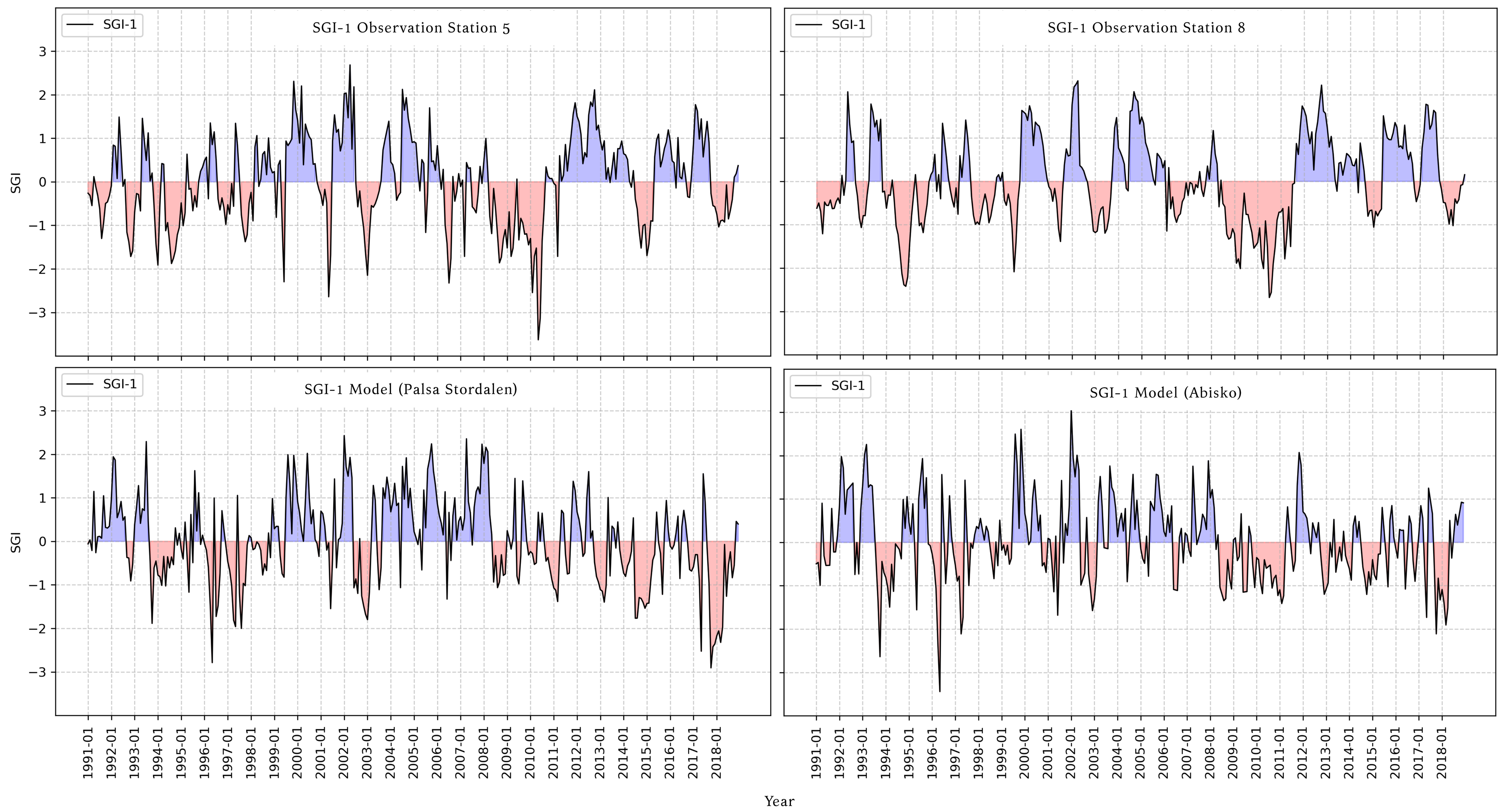

Figure 1. Standardized Groundwataer (SGI) Index based on observation and model.

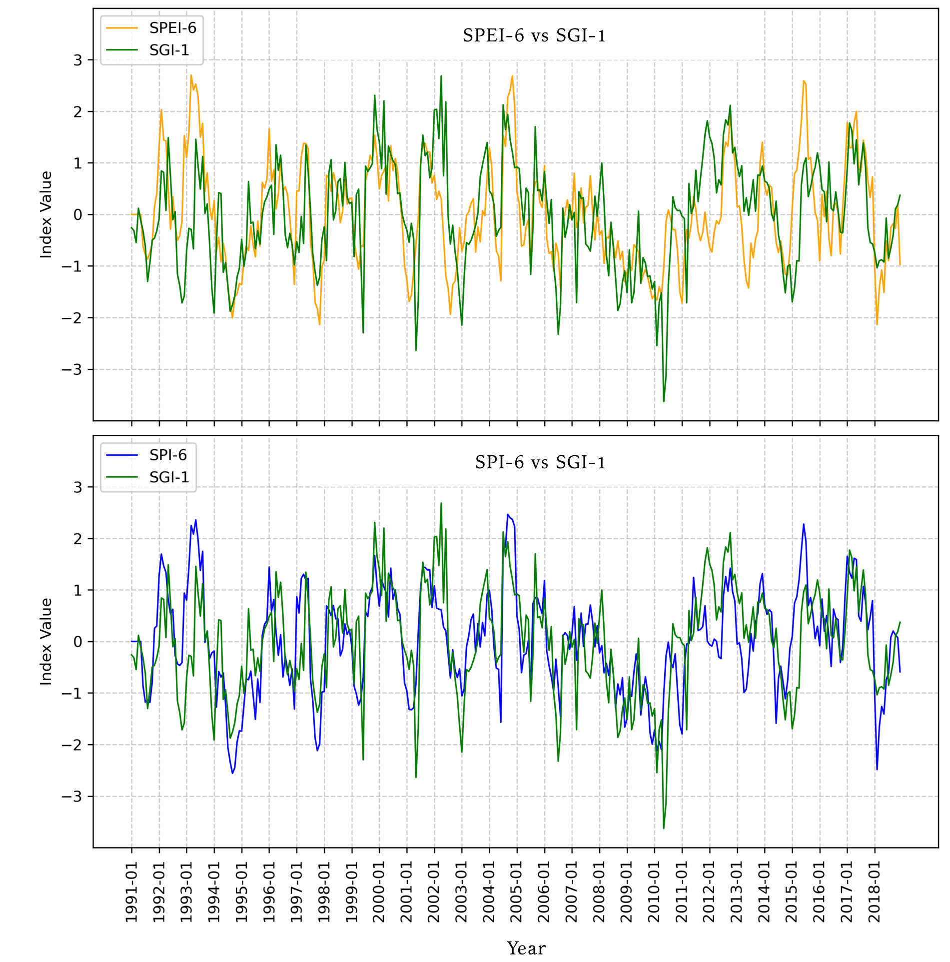

Figure 2. Comparison between SGI, SPEI, and SPI.

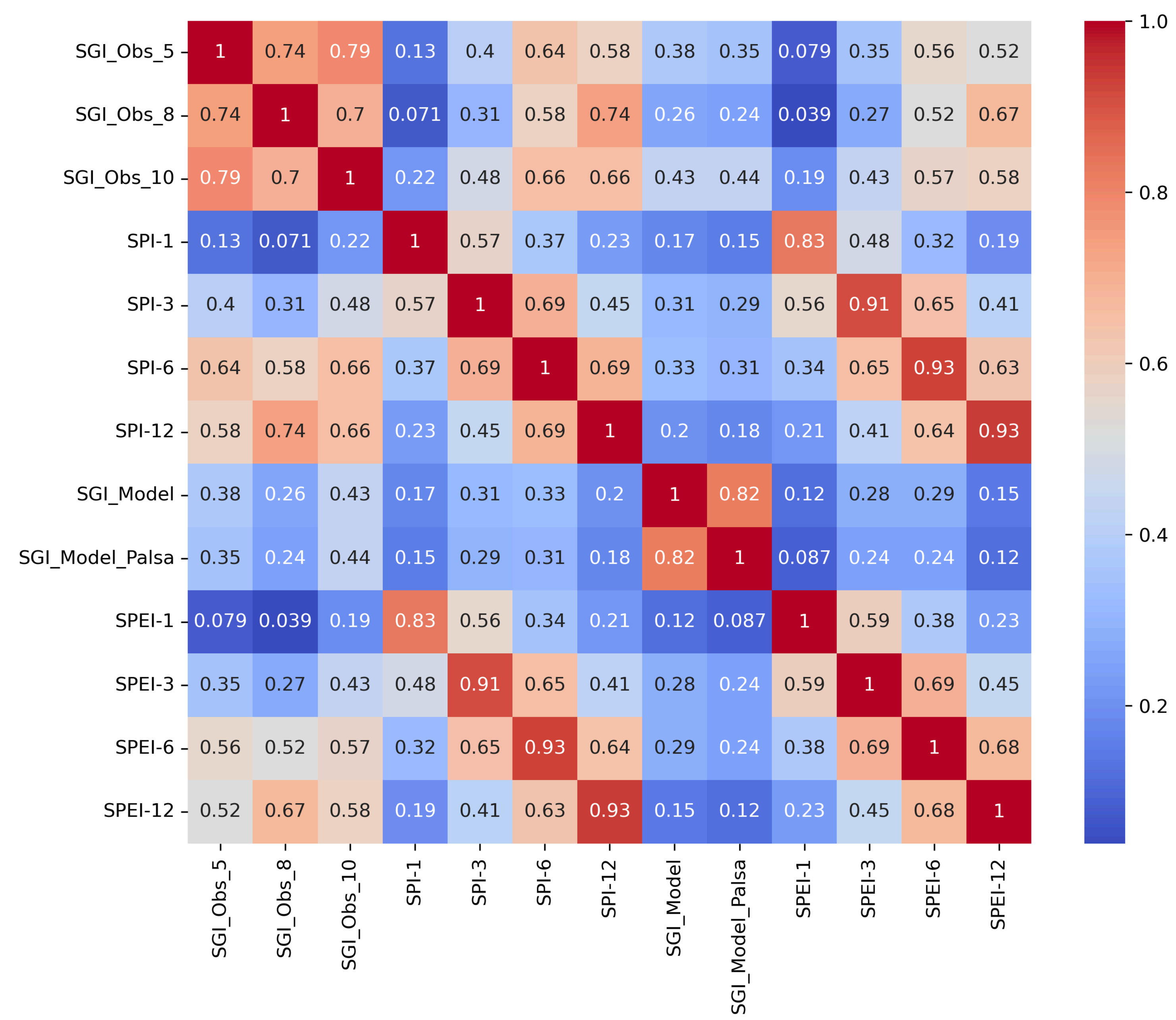

Figure 3. Correlation Matrix between SGI, SPEI, and SPI.

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