Historical Changes in Seasonal Freeze and Thaw Depths in Russia

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242 Russian Stations
Permafrost vs. Seasonally Frozen Ground

- Seasonally Frozen Ground Stations
- Permafrost Stations
Data

For 1930–1990:

- Soil temperature at 9 depths
- Measured freeze/thaw depth
- 0.5° x 0.5° globally gridded air temperature (CRU TS 1.0)
- Freezing and thawing index
- Snow depth from Historical Soviet Daily Snow Depth Data
Interpolation

**Active Layer**

\[ R = 1.0 \]

\textit{Interpolated} = +1.0 \textit{Measured} -0.059

**Freeze Depth**

\[ R = 1.0 \]

\textit{Interpolated} = +1.0 \textit{Measured} -0.060

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**Active Layer Trends**

1956–1990 net change: +0.20 m

1930–1990 net change: +0.23 m
**Freeze Depth Trends**

- **1956–1990 net change:** -0.34 m
- **1930–1990 net change:** -0.27 m
**Forcing Variables: Active Layer**

### Trends

- **Air Temperature (+0.47)**
- **Thawing Index (+0.34)**
- **Maximum Snow Depth (+0.43)**

### Correlations

- **R = 0.60**
- **R = 0.65**
- **R = 0.65**

### Multiple Regression

- \[ R = 0.85 \text{ (72\%)} \]

\[ Active \text{ Layer Depth} = +0.32 \ T_{air} +0.30 \ TI +0.52 \ SD \]
Forcing Variables: Freeze Depth

Trends

- Air Temperature (+0.42)
- Freezing Index
- Maximum Snow Depth (+0.59)

Correlations

- $R = -0.62$
- $R = 0.79$
- $R = -0.52$

Multiple Regression

$R = 0.90$ (80%)

Active Layer Depth =

$-0.28 \ T_{air} + 0.55 \ FI - 0.32 \ SD$
Conclusions

• By 1990, active layer depth had increased by at least \( \sim 20 \text{ cm} \)
• Freeze depth had decreased by over 30 cm by 1990
• Changes in active layer are due to snow cover and air temperature (mean annual and thawing index) forcing.
• Changes in freeze depth are due to air temperature (freezing index and mean annual) and snow cover
• Seasonally frozen ground region of Russia seems more susceptible to climate change than permafrost, although both are being significantly impacted.