Simulation of Ice Thickness and Phenology on Small Northern Lakes using a Spatially Distributed Thermodynamic Lake Ice Model Coupled with Remote Sensing Observations

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Introduction

Lakes in the Northwest Territories are ice-covered roughly seven to eight months of the year and play a significant role in the climatic and hydrologic systems. Understanding climate factors and their influence on lake ice thickness is crucial to surrounding communities since winter roads are built on lakes to transport goods and services. However, monitoring ice thickness is challenging due to the limited spatial and temporal coverage of field observations. This research addresses this by developing a spatially distributed model (CLIMoGrid) coupled with satellite observations to simulate and analyze daily lake ice thickness.

Map of Study Lakes

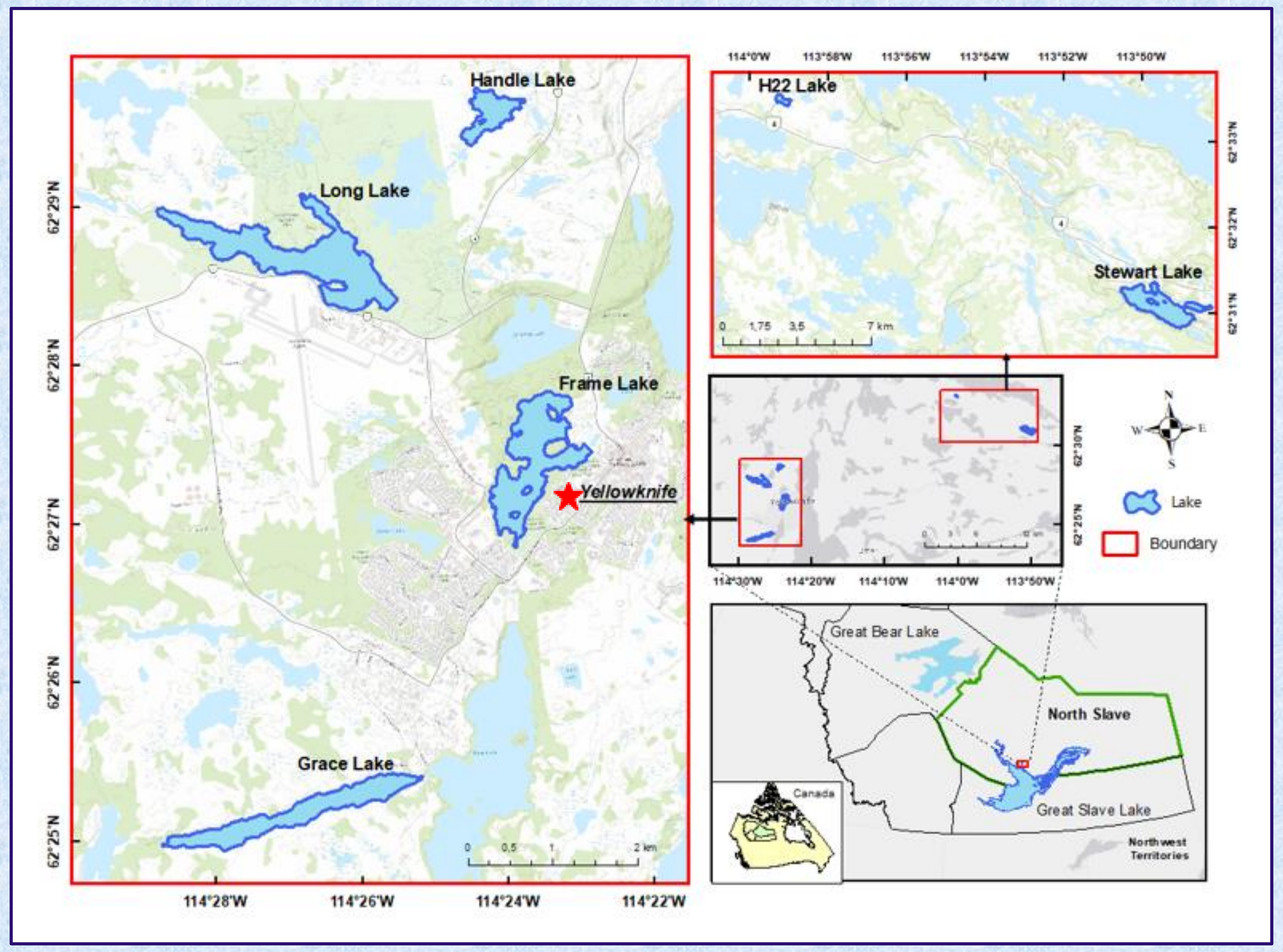

Fig 1: Lakes for study, near Yellowknife in the Northwest Territories.

Data Inputs

- **Model variables** – i) wind speed, ii) relative humidity, iii) snow depth, iv) cloud cover- are extracted from Reanalysis data (ERA5).
- ERA5 is re-gridded to 100m resolution.
- Model runs on each pixel of the data to estimate ice thickness.

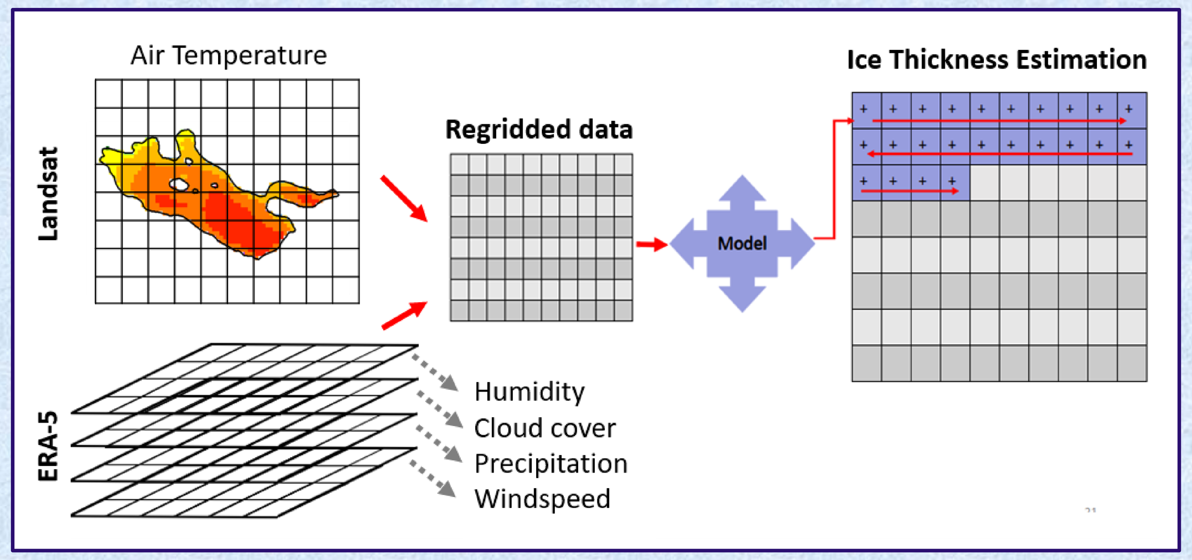

Fig 3: Data inputs, Process and Model Process

Air Temperature retrieval from Landsat

Landsat images are used as input for the model (resolution 30-100m). Air temperature values required for ice thickness simulation is extracted from Landsat using equations by Wang et al. (2012) and Avdan et al. (2016).

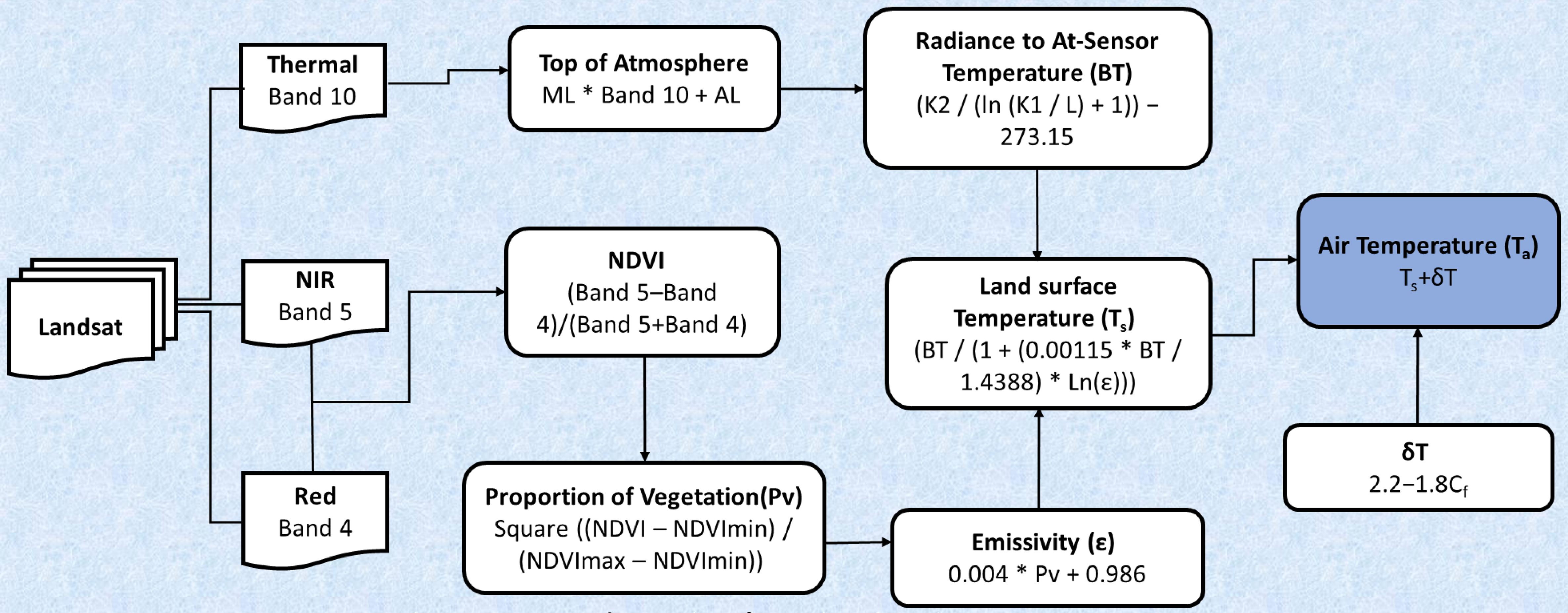

Fig 2: Process and equation for estimation air temperature

Distribution of Air Temperature and Ice Thickness

Preliminary results show simulated ice thickness for four of the lakes in the study area, on March 5, 2019.

- Retrieved air temperature showed a spatial distribution from -14--20℃ while Yellowknife station recorded 15.6 ℃.
- Stewart is located further north compared to the other three lakes and has the maximum thickness which could be attributed to relatively colder water temperatures.
- Model result show a variation in thickness of about 10 cm.
- Frame Lake was the warmest and also the closest to Yellowknife.

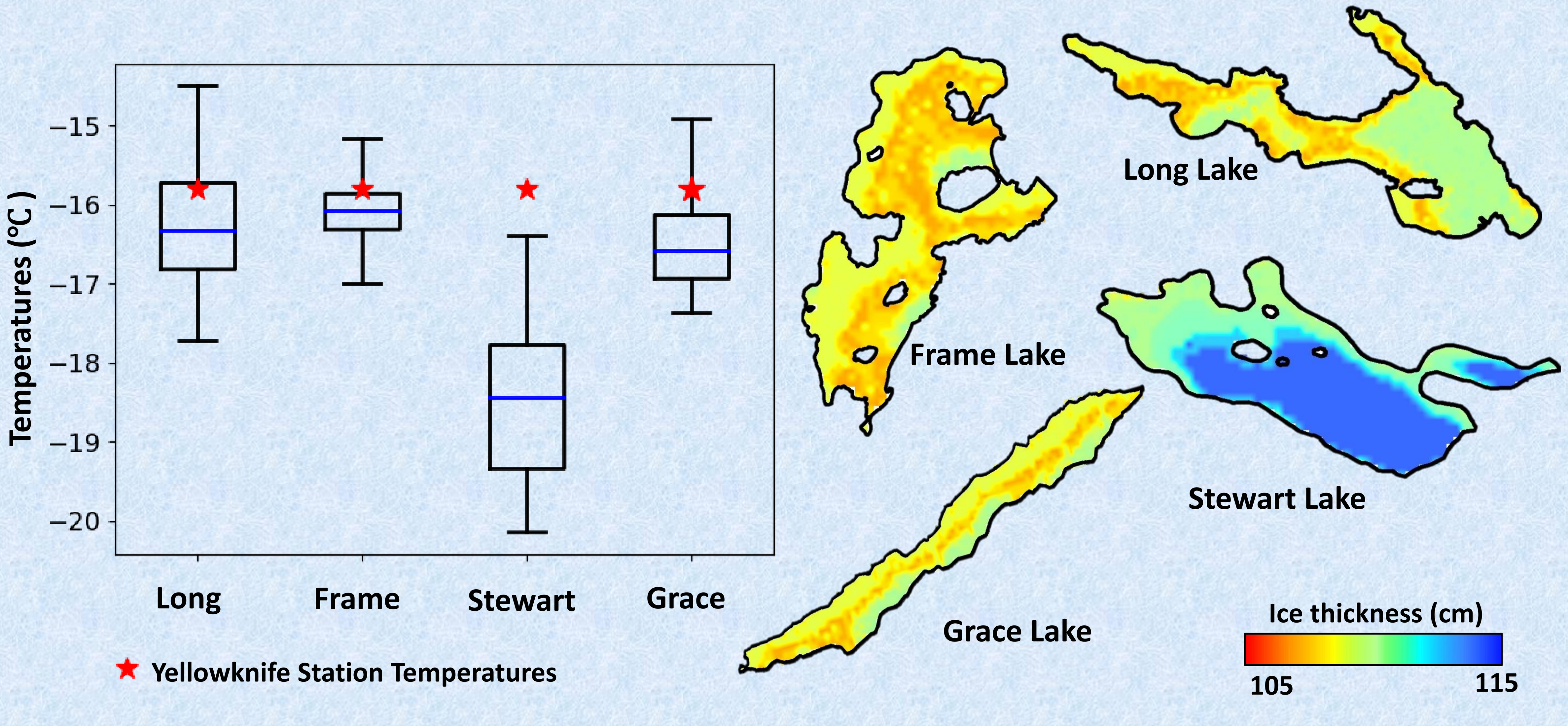

Fig 4: Comparison of derived Landsat versus station air temperature and ice thickness estimation for 5th March 2019

Conclusion

- Simulating the distribution of ice thickness and phenology allows for the monitoring of trends and process which affect changes in ice development.
- Remote sensing can provide extensive data for a number of variables at regional scale, which is integrated into the numerical models.
- Variables affecting ice development are heterogenous and hence important to capture in modelling.

Next Steps

- Restructure CLIMoGrid inputs and variables.
- Calibrate and validate model with in-situ data.
- Analyze impact of variables on lake ice.

Acknowledgement

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References

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