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Diurnal Temperature Cycle Derivation from Geostationary Satellite Observations

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Introduction

The Diurnal Temperature Cycle (DTC) model represents the **daily temperature variations** of an area between daytime heating and nighttime cooling. It is influenced by factors such as land cover, bioregion, climate conditions, and atmospheric properties. The DTC model is crucial in several areas: it provides valuable insights into temperature patterns for climate studies, aids in environmental monitoring by detecting anomalies like heatwaves and urban heat islands, and is essential for fire detection, as it derives background temperatures that serve as a baseline to identify fire-related temperature anomalies.

Aim

Evaluate different DTC models derived from **physical-based** and **data-driven** methods to develop a robust method that performs well under high cloud coverage and various Australian land covers, bioregions, and climate conditions.

Methods

Data acquisition:

- **Satellite Data:** Himawari-8 Band 7 (3.9 µm) MIR data, collected every 10 minutes over a year (April 2019 - March 2020) for 1305 pixels in Australia.

Data-Driven Methods:

- **Basis:** Uses statistical approach using past observation data to derive the DTC model.
- **Proposed Method (NUR):** Combines elements from RW: Roberts and Wooster (2014); HAL: Hally et al. (2017); XIE: Xie et al. (2018). Uses 30 days of past data with cloud and fire masks. Applies Singular Value Decomposition (SVD) reconstruction.

Physical-Based Method

- **Basis:** Derives DTC using a formulaic approach from parameters derived based on physical principles.
- **Model**: GOT9 Developed by Göttsche and Olesen (2009) which includes 7 parameters (e.g. residual temperature overnight, temperature amplitude, time of maximum temperature, attenuation constant).

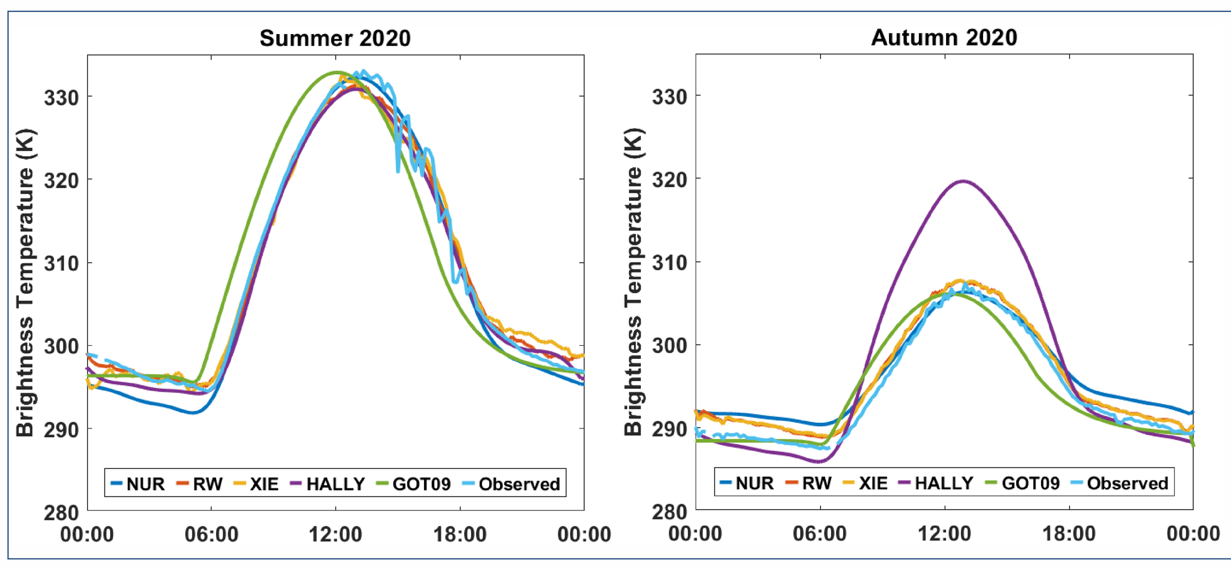
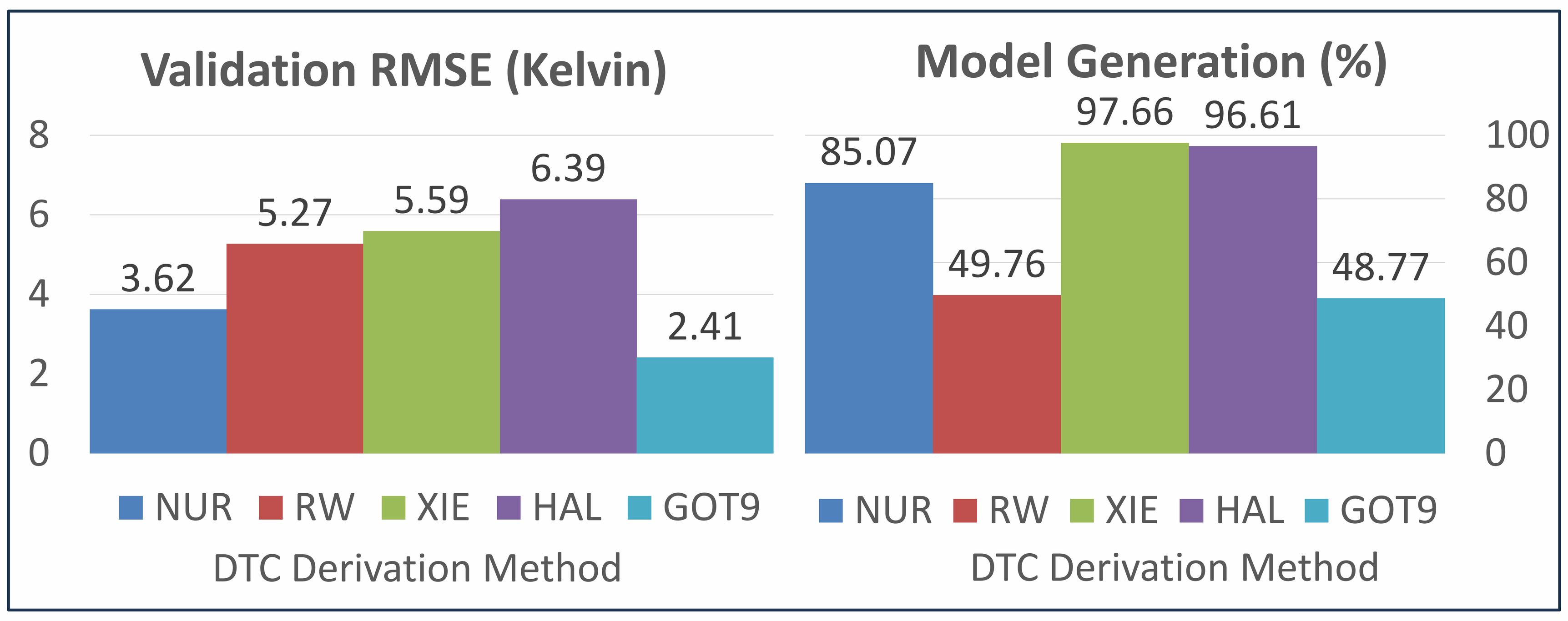


Figure 1. The brightness temperature captured by different DTC models (NUR, RW, XIE, HAL, GOT09) from a single himawari pixel (2x2 km) in South Victoria during two different seasons.

Results

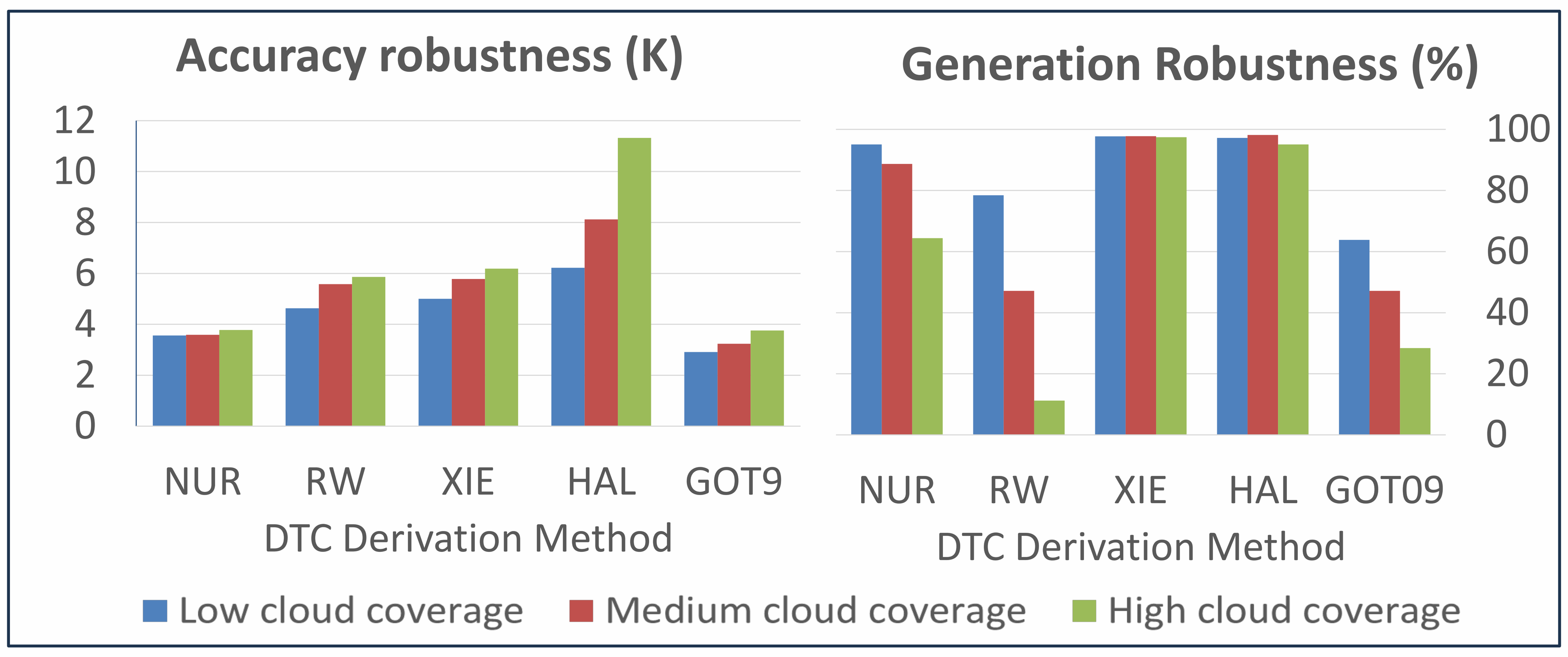
Five DTC derivation methods were implemented to 1305 stratified study cases across Australia for one year period (2019-2020).

Model Performance



Key Observations: Proposed Method (NUR) balances model accuracy (3.62 K RMSE) and model generation rate (85.07%). GOT09 has the highest accuracy (2.41 K RMSE) but lowest generation rate (48.77%).

Robustness to Outliers



Key Observations: Proposed Method (NUR) is robust with 3.78 K RMSE and 64.39% generation rate under high cloud coverage. GOT09 has RMSE of 3.76 K but only 28.44% generation rate in high cloud. XIE maintains high generation (97.44%) but RMSE increases to 6.19 K under high cloud.

Future Work: Enhance accuracy and robustness by combining physical-based and data-driven methods. Derive DTC models using multi-sensor data fusion from constellations of satellites.

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