A High-Resolution Global Convective Precipitation Probability Product from Geostationary Infrared Observations

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1) Background

- **Goal: Produce a high-resolution global convective-stratiform precipitation type product from global infrared (IR) brightness temperatures at 0.05° every half-hour from 1998.**
- **Novelty**: A global precipitation type monitoring product is **not presently available**.
- **Applications**: Classify storm types; identify extreme events; calculate latent heating profiles; evaluate numerical models.

2) Principles

- A global precipitation typology product can complement NASA's IMERG global precipitation rate product.
- To create a global precipitation type product, we synergize the extensive GEO-IR high-resolution cloud top height record with the precipitation type sensitivity of the Global Precipitation Measurement (GPM) Dual-frequency Precipitation Radar (DPR).

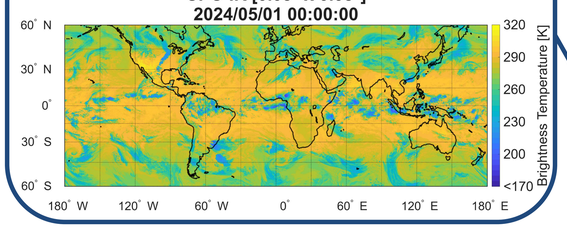
	IR	DPR	IMERG
Sampling	**60°N-S, 30-min.**	65°N-S, Instantaneous Overpasses	90°N-S, 30-min.
Period	**1998 - Present**	2014 - Present	**1998 - Present**
Observations/ Retrievals	Brightness Temperatures	**Precipitation Type** & Rates	**Precipitation Rates**

GROMIT: Generic Retrievals fOr MEaSUREs Infrared-based precipitation Typology

3) Retrieval Algorithm

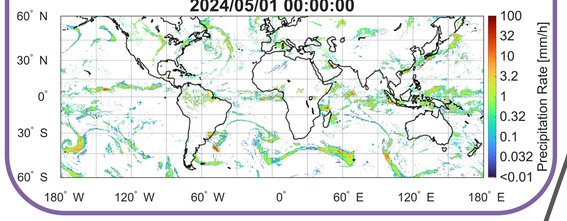
CORE PREDICTOR

CPC IR Brightness Temperature (Tb) [0.05° x 0.05°, 30-min.]



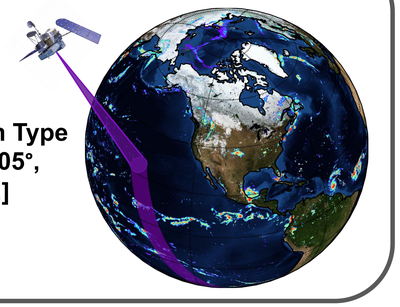
PRECIPITATION MASK

IMERG Precipitation Rate [0.05° x 0.05°, 30-min.]



TARGET

DPR Precipitation Type [0.05° x 0.05°, 30-min.]



- GROMIT convective precipitation probability outputs are retrieved using two models: V01) heuristic, and V02) machine learning (ML). This approach provides a benchmark for ML gains relative to heuristic methods.
- The GROMIT V01 lookup table computes the convective fraction as a function of the latitude, longitude, time and Tb measurement for each grid box with precipitation.

MODELS

Model Input: DPR-IMERG-IR matchups for 2022-2024

V01: Heuristic

Lookup Table

Dimensions [Resolution]: (Range)
1) Latitude [0.1°]: (60°N-S)
2) Longitude [0.1°]: (180°W-E)
3) Time of Day [30-min.]: (0-24 hr)
4) IR Tb [5 K]: (170-320 K)
5) DPR Precipitation Type: Convective or Stratiform

V02: Machine Learning

RUSBoosted Trees Model

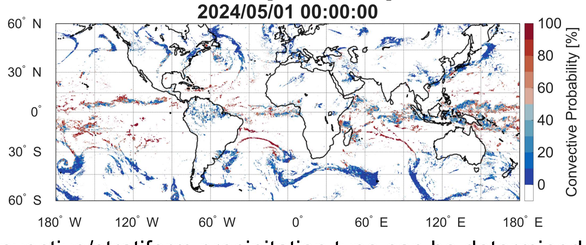
Training: Uniform random sample of 10^6 pixels from month days 4-12

Testing: Full sample of ~7×10^6 pixels from month days 20-28

Predictors:
1. IR Brightness Temperature [K]
2. Latitude [°N]

OUTPUT

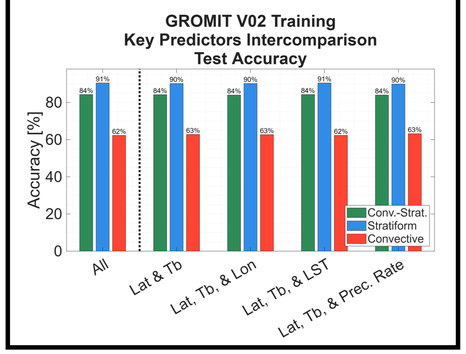
GROMIT Convective Precipitation Probability [0.05° x 0.05°, 30-min.]



Convective/stratiform precipitation type can be determined by applying a threshold to convective probability (e.g., 50%).

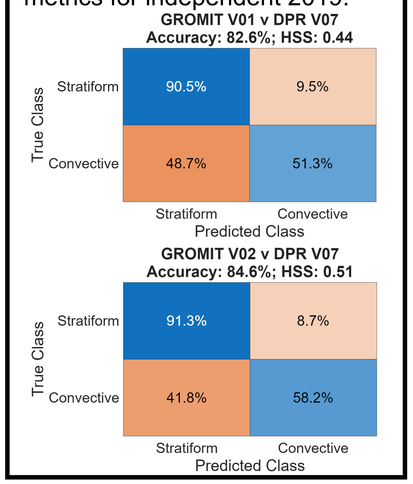
4) ML Predictor Selection

The latitude and Tb predictors optimized the RUSBoosted trees model accuracy. Adding longitude, time of day, IMERG prec. rate, elevation and surface water fraction did not improve performance.



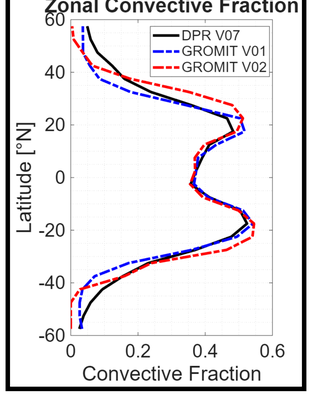
5) Detection Skill

V02 (ML) outperforms V01 in all metrics for independent 2019.



6) Zonal Skill

V01 better captures tropical convective fraction, but V02 is better in lower mid-latitudes.



7) Conclusions

- The GROMIT global precipitation type product, which uses a heuristic lookup table model (V01) and a ML ensemble model (V02) to estimate convective precipitation probability from IR brightness temperatures, can accurately estimate 82.6% and 84.6% of DPR precipitation types, respectively.
- ML techniques (V02) accurately estimates 91.3% and 58.2% of DPR-classified stratiform and convective events and improve upon heuristic methods by +0.8% and +6.9%, respectively, when evaluated for a year (2019; sample size 9.7×10^6) independent of the training period (2022-2024).
- Future work:
  - Expand the GROMIT lookup table to include IMERG precipitation rates with the purpose of increasing the accuracy of convective classifications in GROMIT V01.
  - Further evaluate GROMIT performance beyond bulk detection metrics – e.g., in capturing convective fraction relations with precipitation rate & Tb – and identify methods to improve skill.
  - A passive-microwave-based global precipitation type product is being produced concurrently by Veljko Petkovic and Marko Orescanic, and an alternative IR scheme by Jackson Tan. The team plans to merge the IR- and PMW-based retrievals like IMERG does for precipitation rates.

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