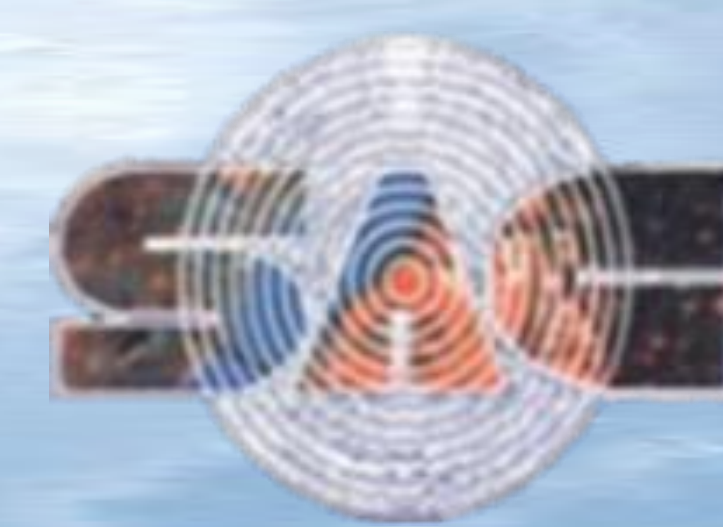


Retrieval of Atmospheric Motion Vectors from INSAT-3DS using Optical Flow for Enhanced Tropical Circulation Monitoring and Extreme Event Prediction

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Abstract

This work presents an initial study on the retrieval of dense Atmospheric Motion Vectors (AMVs) from INSAT-3DS Thermal Infrared (TIR-1) imagery using the Farneback Optical Flow Algorithm based on Polynomial Expansion (OFAPE). The derived AMVs are validated against GFS analysis and ERA5 reanalysis winds at three pressure-level ranges: high (100–400 hPa), mid (400–700 hPa), and low (700–1000 hPa). The OFAPE approach produces approximately 7 to 14 times more wind vectors than the operational INSAT-3DS AMV product while maintaining comparable accuracy.

Introduction and Objective

- AMVs are vital for NWP over the data-sparse tropics.
- Feature tracking gives sparse vectors; OFAPE tracks every pixel.
- Geostationary satellite INSAT-3DS provides continuous monitoring of atmospheric circulation and rapidly evolving weather systems.
- Objective:** Retrieval of dense AMVs from INSAT-3DS TIR-1 with OFAPE and Validation against GFS and ERA5 winds.

Data Used and Study Domain

Domain: 50°S–50°N, 20–130°E **Period:** 1–9 Nov 2025

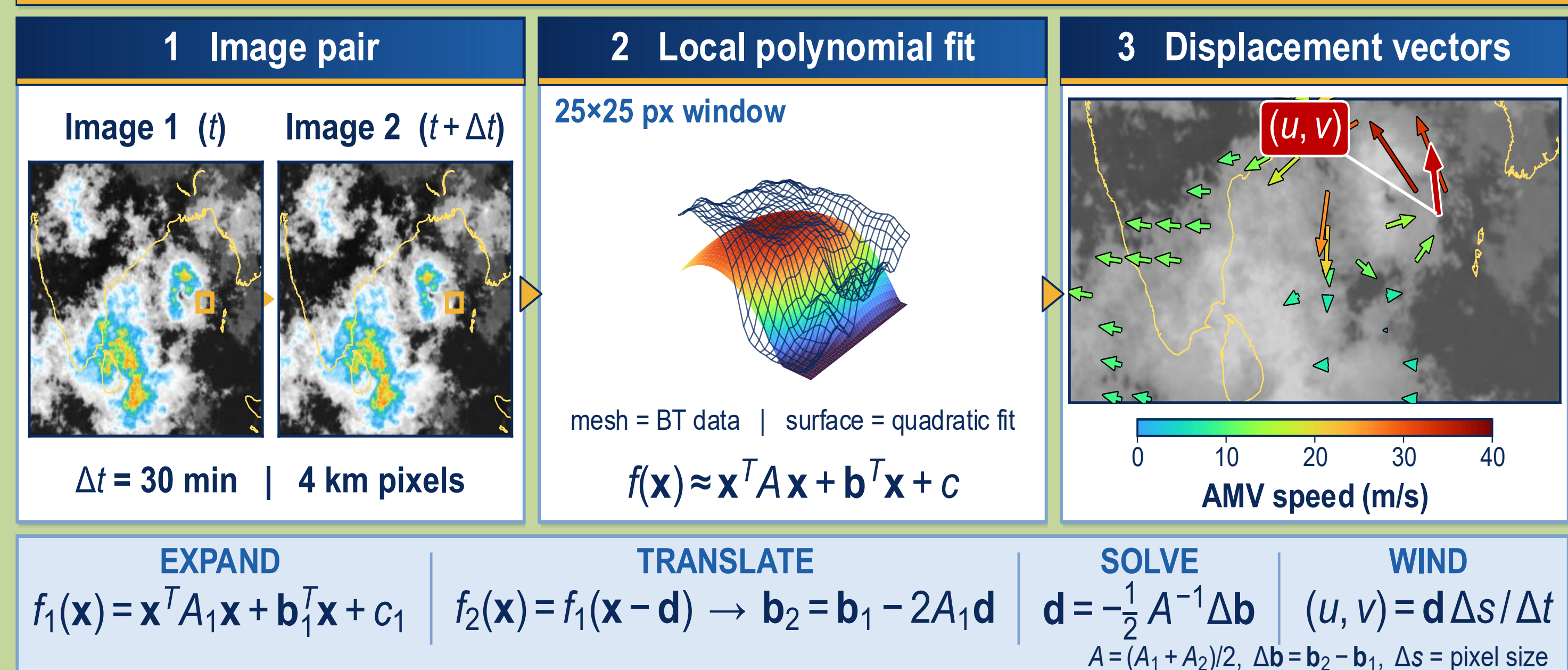
Dataset	Application	Resolution
INSAT-3DS TIR-1	Input	4 km, 30 min
NCEP GFS	Height, validation	0.5°, 6 h
ECMWF ERA5	Validation	0.25°, 1 h
Operational AMV	Comparison	30 min

Methodology

- Image pair:** Consecutive TIR-1 images 30 min apart
- Filter:** 5×5 median on brightness temp, For smooth edges
- OFAPE:** 3-level pyramid (16→8→4 km), 7 PEW, 35 LOW
- Height:** coldest 25% BT vs GFS Temperature-profile
- QC:** EUMETSAT-type QI; reject QI < 0.6
- Validation:** vs GFS and ERA5 (QI > 0.9)

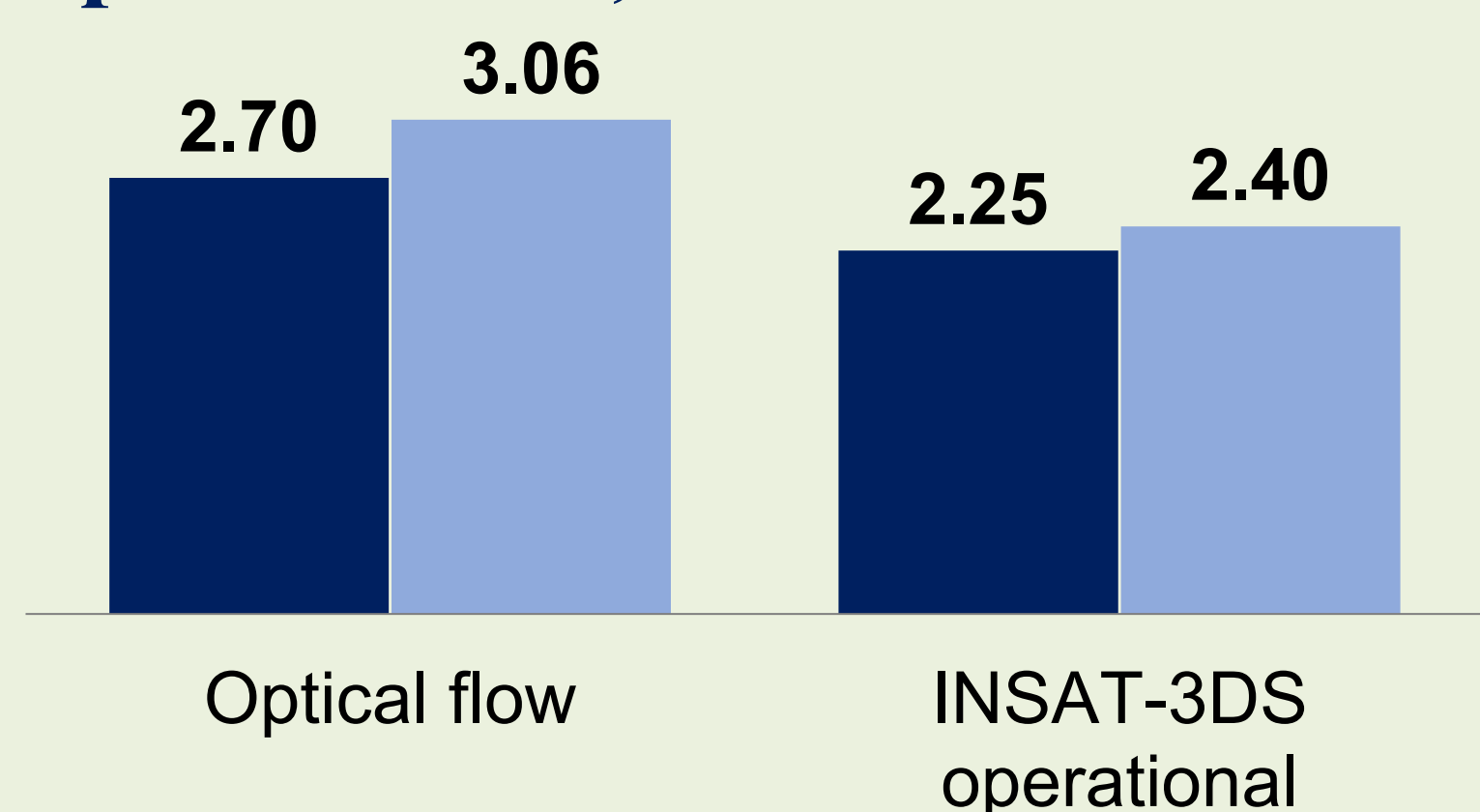
Farneback Optical Flow for Atmospheric Motion Vectors

INSAT-3DS TIR-1 | dense displacement field → wind vectors → validated vs GFS & ERA5



Results: OF vs Operational AMVs

Speed RMSE, m/s ■ GFS ■ ERA5

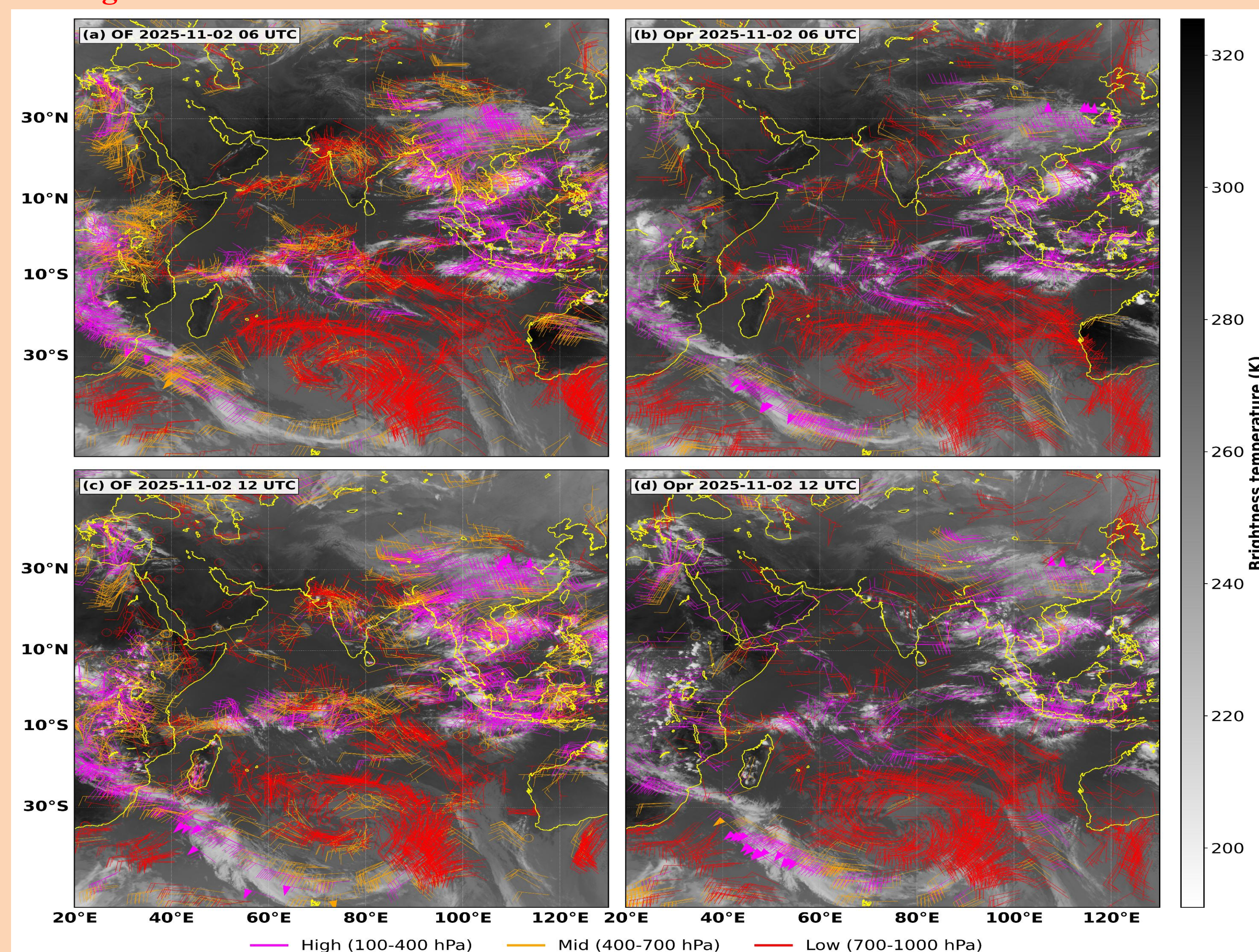


Product	Vectors	Bias
OF	480,291	-0.63
Operational	63,154	+0.72

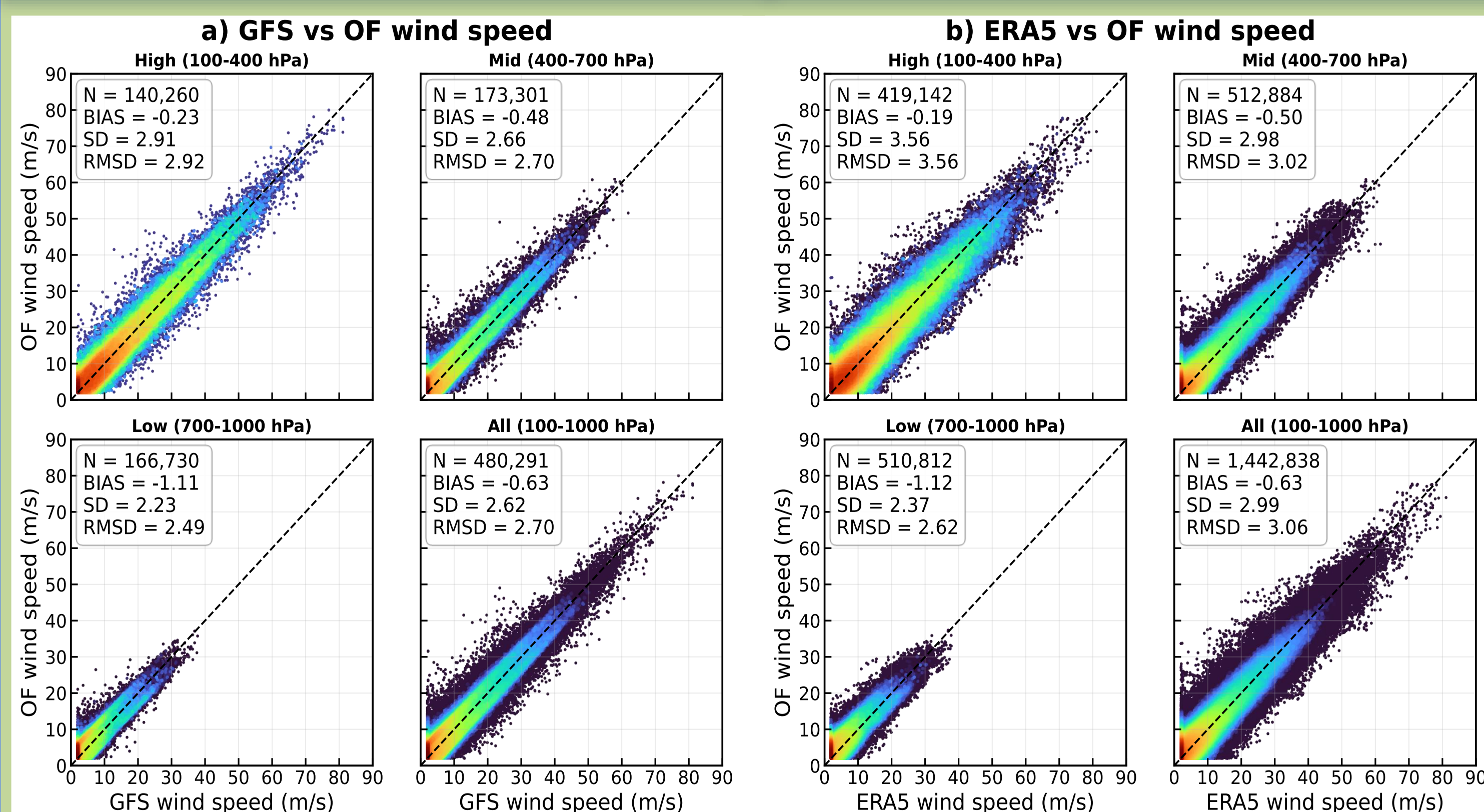
Bias vs GFS, m/s; QI > 0.9. ERA5 is independent of OF heights.

Results: Dense OFAPE vs Operational AMVs

- Denser coverage, even 144× thinned; Cyclonic flow agrees; Similar layer heights; Higher number of tracer identification.



Results: Wind-Speed Validation



Speed (m/s)	High	Mid	Low	All
Bias vs GFS	-0.23	-0.48	-1.11	-0.63
RMSE vs GFS	2.92	2.70	2.49	2.70
Bias vs ERA5	-0.19	-0.50	-1.12	-0.63
RMSE vs ERA5	3.56	3.02	2.62	3.06

Conclusions

- Optical flow-based AMV retrieval from INSAT-3DS has the potential to produce dense wind fields.
- Validation statistics are temporally stable across the study period.
- The future scope of the study includes improvement in height assignment and Optical Flow specific Quality Checks (QC).

Acknowledgements

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