

WRF-ARW Simulation of Super Cyclone Gonu (2007): Track, Rainfall and Intensity Evaluation over the Arabian Sea

Nagalakshmi K.¹, Babji S.H.², Sabin T.P.¹, Roxy M.K.¹, Sridevi Ch³, Raju A.D.⁴, Satheesh Chandran P.R.¹, Fadnavis S.¹

¹Indian Institute of Tropical Meteorology (IITM), MoES, Pune · ²IIT Kharagpur · ³NCMRWF, Noida · ⁴IMD, Hyderabad | ✉ nagalakshmi.k@tropmet.res.in

1 INTRODUCTION

Super Cyclone Gonu is the most intense tropical cyclone ever recorded in the Arabian Sea — an extreme test case for regional models.

- Tropical cyclones over the North Indian Ocean are highly destructive, yet difficult to predict (rapid intensification, complex air-sea interactions)
- Global models (GFS) show large track errors over the NIO (70–359 km) and underestimate intensity (Sridevi et al. 2022)
- WRF-ARW improves mesoscale representation, but skill depends strongly on physics configuration (Deshpande et al. 2010; Osuri et al. 2012)
- This study:** evaluate WRF-ARW v4.5 for Gonu — a recurving track + broad rainfall spread = a challenging case for regional modelling

1 WHY GONU?

Feature	Details
Status	Strongest Arabian Sea cyclone on record (Cat 5)
Period	1–7 June 2007
Peak intensity	920 hPa, ~85 m/s (3 June)
Landfall	Ra's al Hadd, Oman — 6 June
Impact	Storm surge >5 m, >50 deaths, ~USD 4 billion
Challenge	Track recurvature + westward rainfall spread

2 OBJECTIVES

- Assess track accuracy vs. IMD best-track data with forecast lead time
- Evaluate simulation of wind intensity
- Validate rainfall against GPM IMERG observations

3 MODEL SETUP

Component	Configuration
Model	WRF-ARW v4.5
Domains	Two-way nesting: d01 = 75 km (52×52), d02 = 25 km (88×82), 45 levels
Domain centre	17.85°N, 62.23°E (Mercator)
IC/BC	NCEP-FNL (1° × 1°)
Simulation period	0000 UTC 1 June – 0000 UTC 8 June 2007
Microphysics	WSM6
Cumulus	Kain-Fritsch
PBL	YSU
Radiation	Dudhia (SW) + RRTM (LW)
Land surface	Noah LSM

3 MODEL DOMAIN

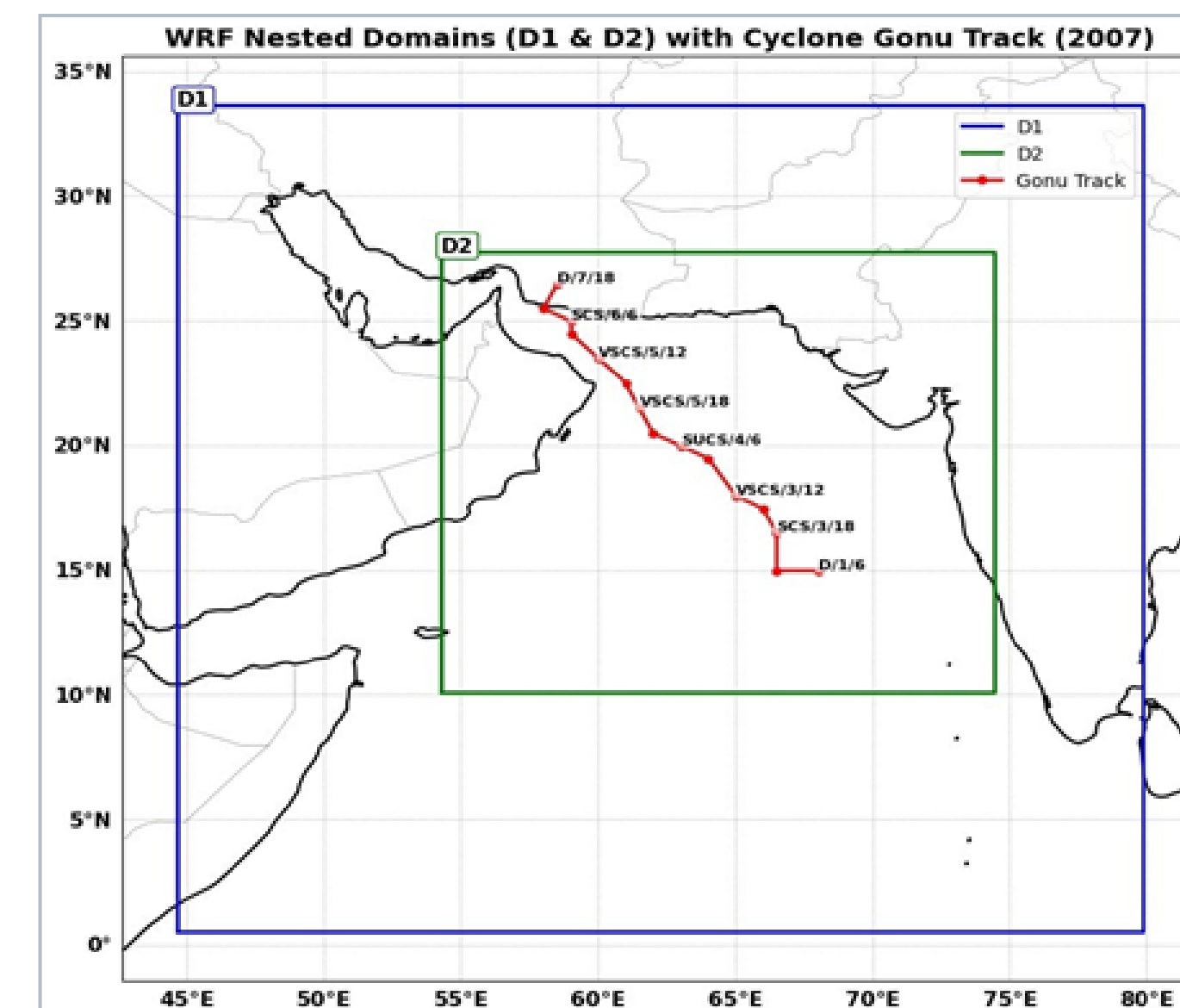


Fig. 1: WRF-ARW nested domains (D1, D2) with the Super Cyclone Gonu track (1–7 June 2007).

3 VALIDATION & METRICS

- IMD best-track** → cyclone position, wind, MSLP
- GPM IMERG (0.25°)** → observed rainfall
- Cyclone centre detection (objective algorithm): vorticity (850 hPa) $\geq 1.6 \times 10^{-4} \text{ s}^{-1}$, SLP < 1002 hPa, wind > 10 m/s
- Metrics:** DPE, MAE, RMSE, spatial correlation (CC)

4 RESULTS — RAINFALL

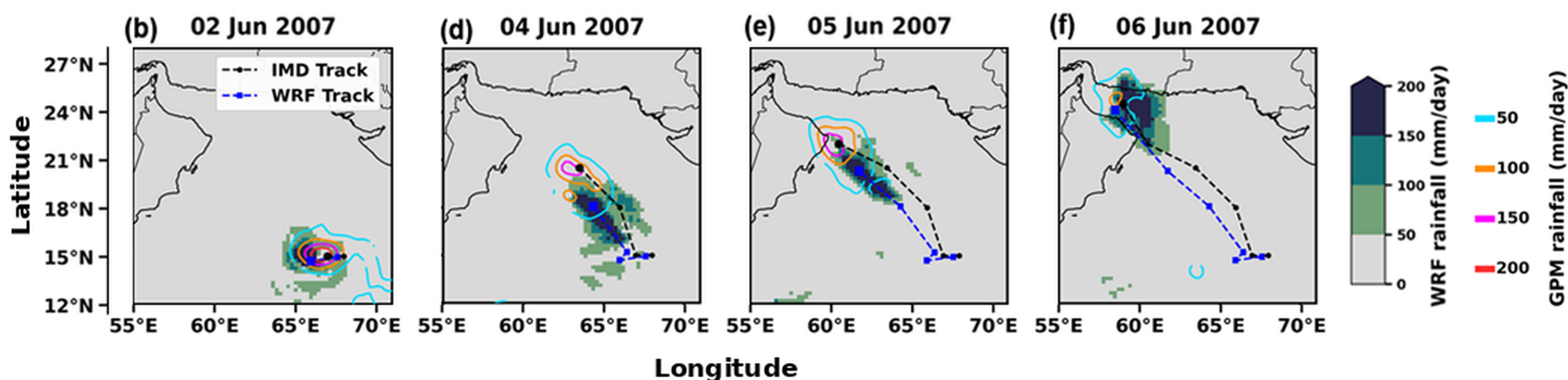


Fig. 2: Simulated (WRF, shaded) and observed (GPM IMERG, contours) daily rainfall with IMD and WRF cyclone tracks for 2, 4, 5 and 6 June 2007.

- Rainfall bands follow the storm's southeast→northwest track across the Arabian Sea
- Northward/westward shift of rainfall toward the Oman coast well captured
- Peak simulated rainfall: **615.95 mm/day** (4 June, 18.07°N, 64.34°E) — collocated with cyclone centre → convective core structure captured
- Spatial correlation with GPM IMERG: **CC = 0.68**
- Rainfall magnitude overestimated (**MAE = 92.99, RMSE = 117.27 mm/day**) → Kain-Fritsch cumulus scheme + 25 km grid
- Simulated cores more intense and concentrated vs. broader, diffuse GPM rainfall

4 RESULTS — TRACK

107.1 km Mean track error (MAE)	114.8 km Track RMSE	> 160 km Error at 72–96 h near landfall
---	-------------------------------	--

- Good agreement with IMD best-track during the oceanic phase
- Mean track error: **MAE = 107.1 km** (RMSE = 114.8 km) — comparable to operational models
- Errors grow with lead time: **> 160 km** during 72–96 h, near landfall
- Landfall-period errors linked to land-sea contrast, coastline geometry, and boundary-layer changes

4 RESULTS — WIND

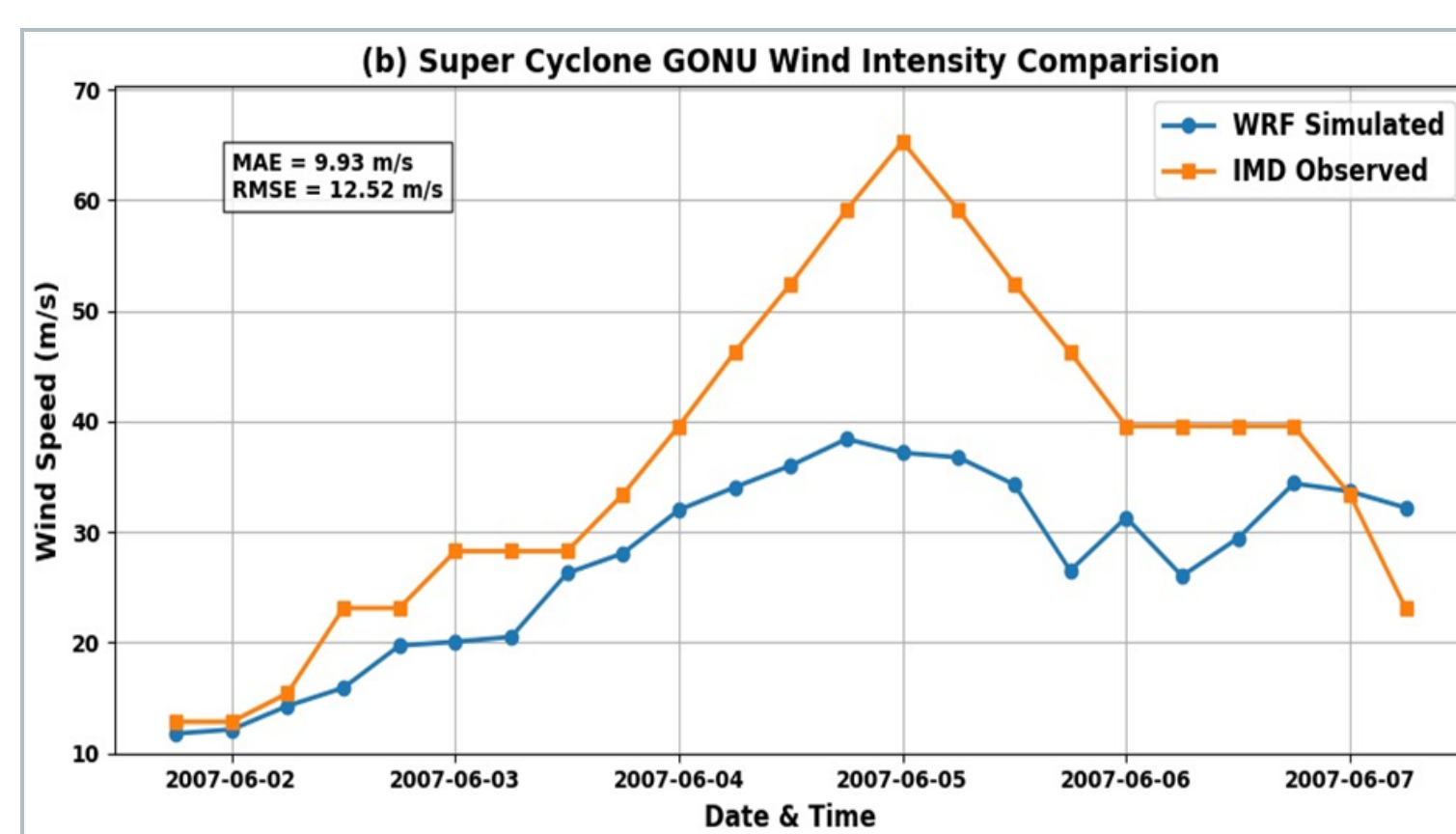


Fig. 3: Simulated (WRF) vs observed (IMD) wind speed for Super Cyclone Gonu.

- Overall intensification and decay evolution captured
- Peak wind speed underestimated — model does not reach observed Cat-5 intensity
- MAE = 9.93 m/s, RMSE = 12.52 m/s**
- Causes: 25 km resolution (unresolved inner-core convection) + no atmosphere-ocean coupling

5 CONCLUSIONS

WRF-ARW demonstrates useful skill in simulating the track, rainfall pattern, and intensity evolution of Super Cyclone Gonu — a benchmark case for Arabian Sea cyclone forecasting.

- Track MAE ~107 km — comparable to operational model performance
- Rainfall pattern well captured (CC = 0.68), but magnitude overestimated
- Peak winds underestimated (RMSE ~12.5 m/s)

★ ACKNOWLEDGEMENTS

Thank you to the organisers of the APARC General Assembly 2026 for the opportunity to present this work.

We thank the Indian Institute of Tropical Meteorology (IITM), supported by the Ministry of Earth Sciences (MoES), Government of India. We acknowledge NCEP (FNL), IMD (best-track) and NASA (GPM IMERG) for the datasets, and the WRF model developers at NCAR.

5 WAY FORWARD

- Higher resolution (<10 km, explicit convection)
- Coupled atmosphere-ocean model
- Data assimilation
- Ensemble simulations