Blind-Window Forecasting: Real-Time Benchmarking and Multimodal Reconstruction for Tropical Cyclones

Zhaoran Feng[1,2] · Xuanhong Chen[3]* · Zeng-Bing Chen[1] · Shengjun Wu[1]* · Bin He[4]* · Kairui Feng[4,2]*

[1] Nanjing University [2] Shanghai Innovation Institute [3] USC-SJTU Institute of Cultural and Creative Industry, Shanghai Jiao Tong University

[4] Shanghai Research Institute for Intelligent Autonomous Systems & State Key Laboratory of Autonomous Intelligent Unmanned Systems, Tongji University

Feel free to contact me

Zhaoran Feng

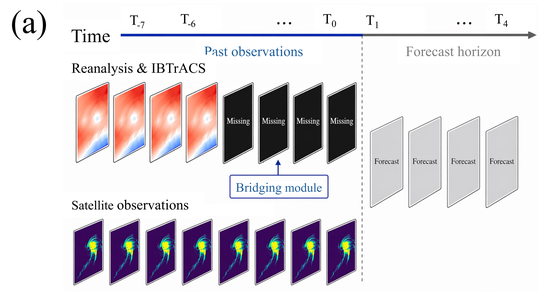
602025220012@smail.nju.edu.cn

* Corresponding authors

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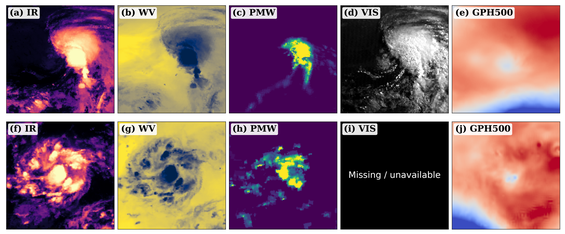
Motivation



A 24 h blind window raises global-model track ADE to 2.5–2.7 times its analysis-available value.

Can timely satellite observations bridge the missing environmental context?

Dataset & Protocol



1980–2023 multimodal benchmark

ERA5/GPH with IR, WV and VIS; PMW from 1998. Missing observations are masked.

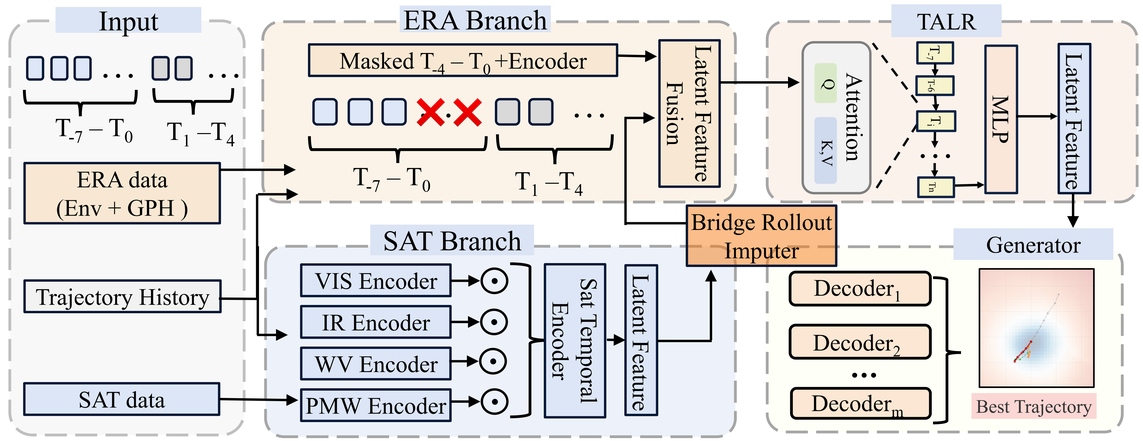
Issuance-time inputs

Eight 6-hourly frames. ERA/GPH ends at T_0 − 24 h. Satellite data are acquired by T_0.

Storm-disjoint split

Train/val 1980–2016. Test 2017–2023.

RECAST-TC Method



Availability-aware encoding

Delayed ERA and quality-weighted satellite memory.

Target-adaptive lag routing

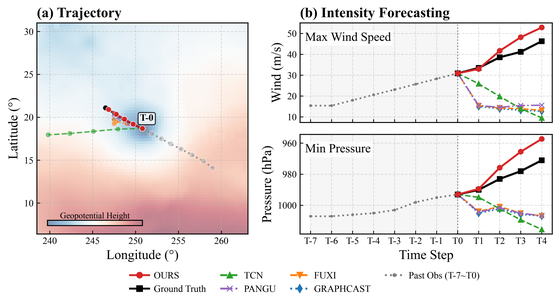
Target-specific temporal context for track and intensity.

Latent bridge rollout

Forecast-sufficient state recovery in the blind window.

Case Study & Controlled Results

East Pacific track and intensity



Capacity-matched comparison

Method	Track ADE (km)	Pressure MAE (hPa)	Wind MAE (m/s)
Late Fusion	114.88 ± 4.07	5.16 ± 0.13	3.53 ± 0.06
Cross-Attention	116.79 ± 4.25	5.35 ± 0.12	3.63 ± 0.12
Assimilation-Style	115.25 ± 4.08	5.21 ± 0.05	3.50 ± 0.06
RECAST-TC	**109.06 ± 4.28**	**5.08 ± 0.09**	**3.47 ± 0.08**

Mean ± SD over 20 seeds. Model sizes 5.13–5.25M parameters.

Controlled comparison. With matched inputs and training budgets, RECAST-TC achieves the lowest mean errors across track, pressure and wind.

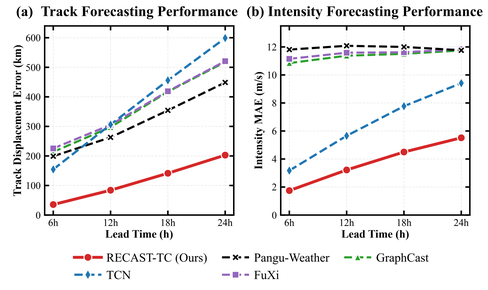
Quantitative Results

24 h blind window; forecast lead times 6–24 h

Model	Track ADE (km)	Pressure MAE (hPa)	Wind MAE (m/s)
GraphCast	361.55	11.63	11.37
FuXi	367.60	11.42	11.55
Pangu-Weather	316.24	13.37	11.91
TCN	378.83	10.87	6.50
HWRF/HWFI	140.11	—	5.12
RECAST-TC (Ours)	**109.06 ± 4.28**	**5.08 ± 0.09**	**3.47 ± 0.08**

RECAST-TC reports mean ± SD over 20 seeds.

71.2% lower track ADE than delayed-only TCN.



Contact

Zhaoran Feng

602025220012@smail.nju.edu.cn

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