Supplementary Material

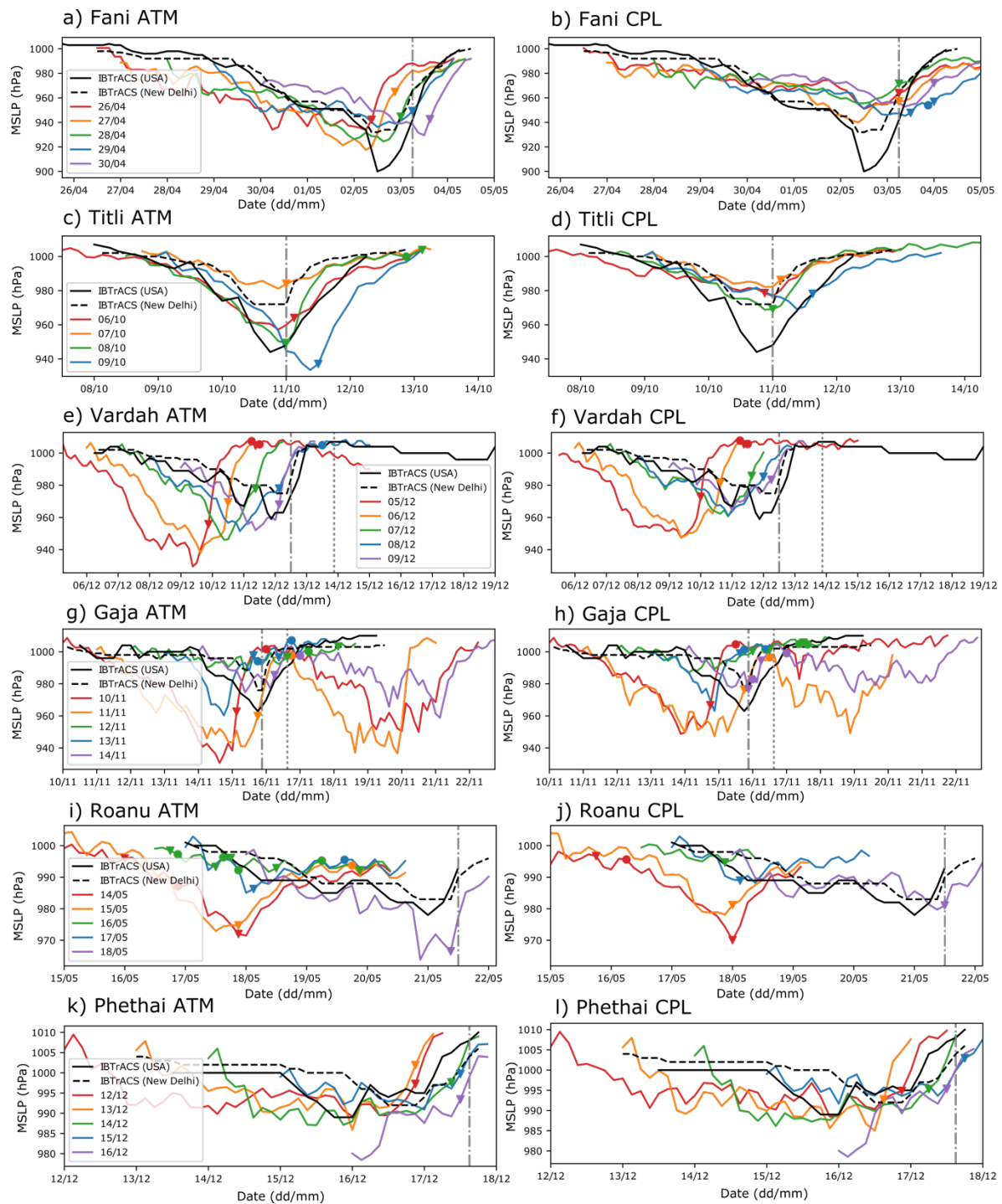
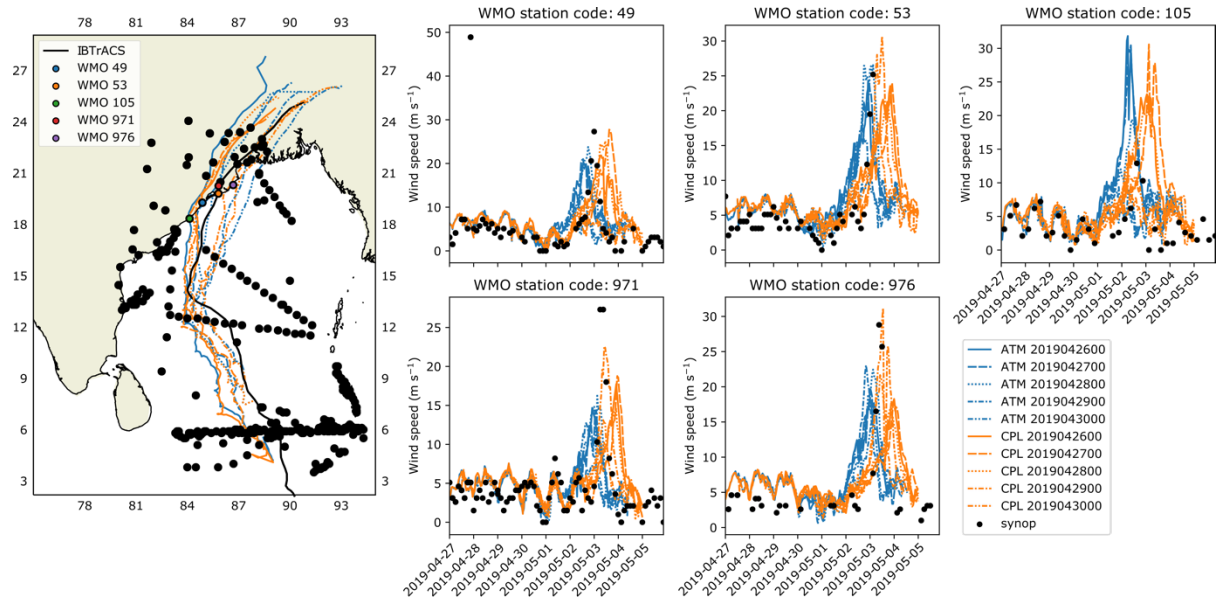



Figure S1. Minimum MSLP time series for ATM (left column), CPL (right column) and IBTrACS. Colours indicate initialisation date (dd/mm). Triangles indicate time of landfall; circles indicate re-emergence over the ocean. Dash-dot vertical line indicates time of landfall in IBTrACS; for Vardah and Gaja, the dotted line indicates time of re-emergence over the Arabian Sea in IBTrACS.

10   **Figure S2.** Location of SYNOP stations within 500 km of the track of TC Fani, used to evaluate forecasts in

this study; timeseries data for selected land SYNOP stations (close to the track at point of storm landfall).

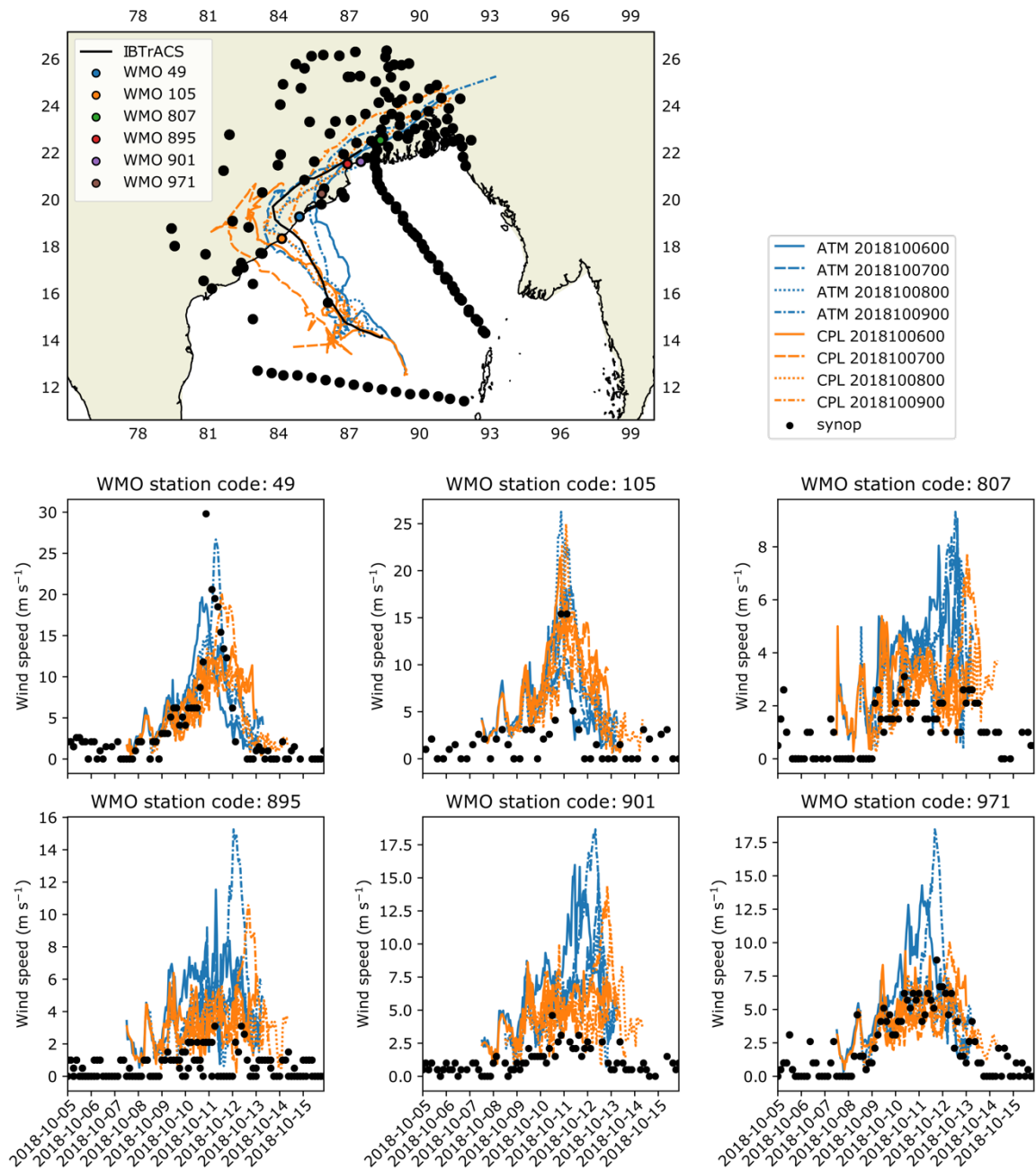



Figure S3. Location of SYNOP stations within 500 km of the track of Titli, used to evaluate forecasts in this study; timeseries data for selected land SYNOP stations (close to the track at point of storm landfall).

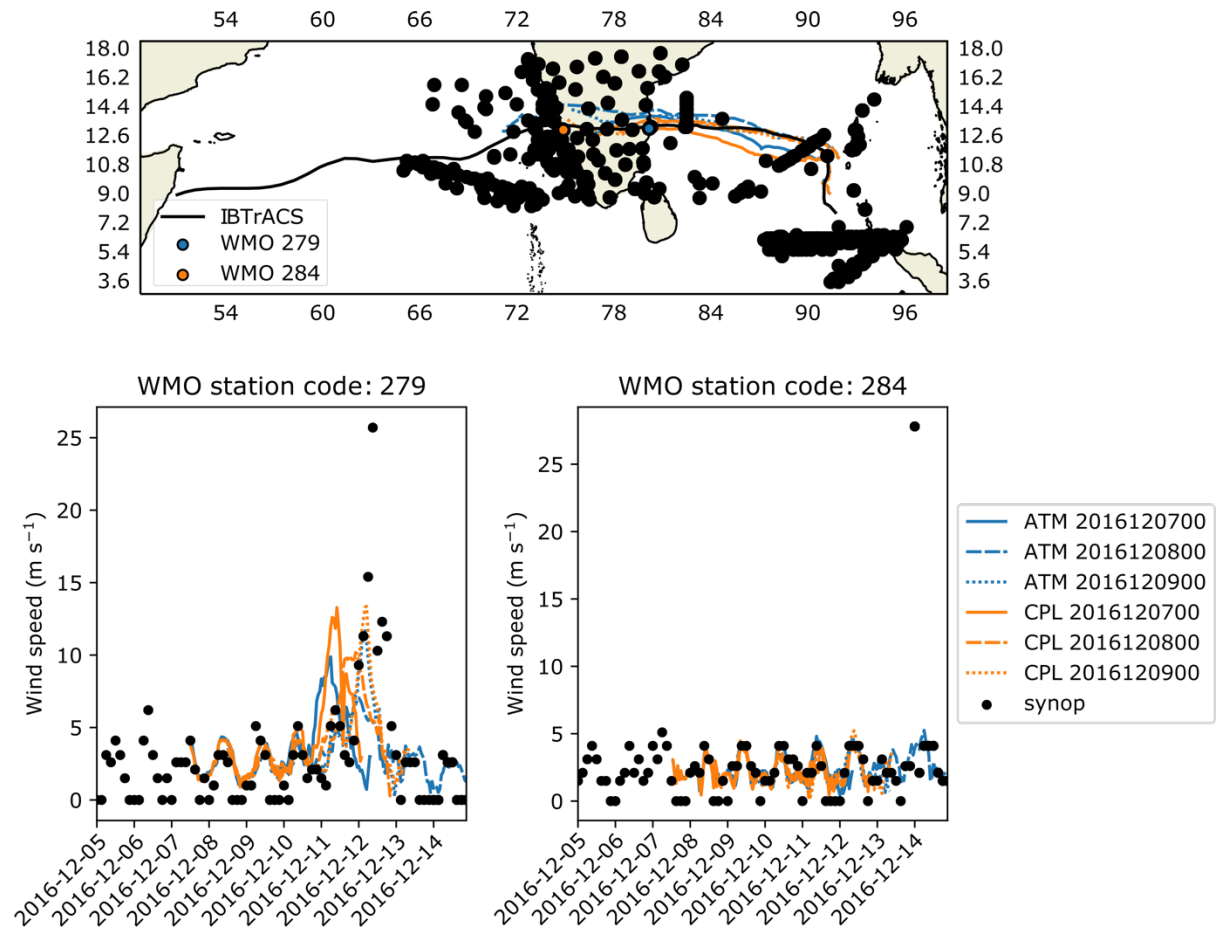



Figure S4. Location of SYNOP stations within 500 km of the track of Vardah, used to evaluate forecasts in this study; timeseries data for selected land SYNOP stations (close to the track at point of storm landfall).

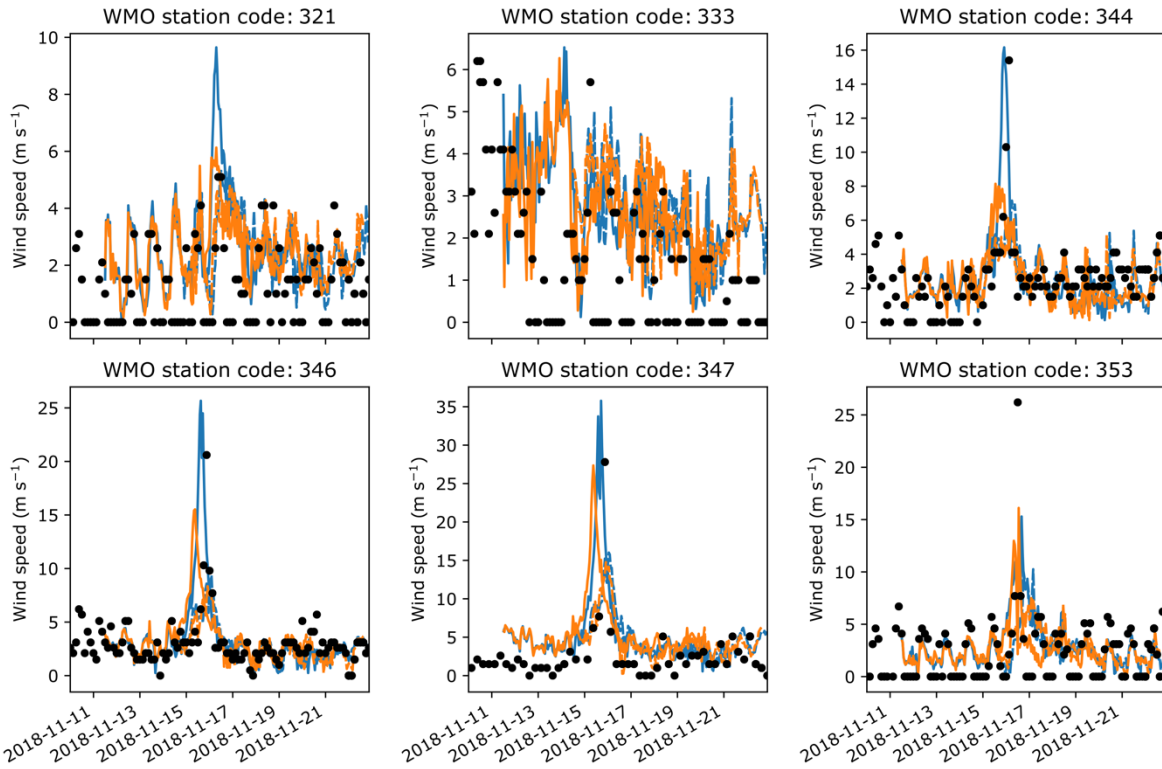
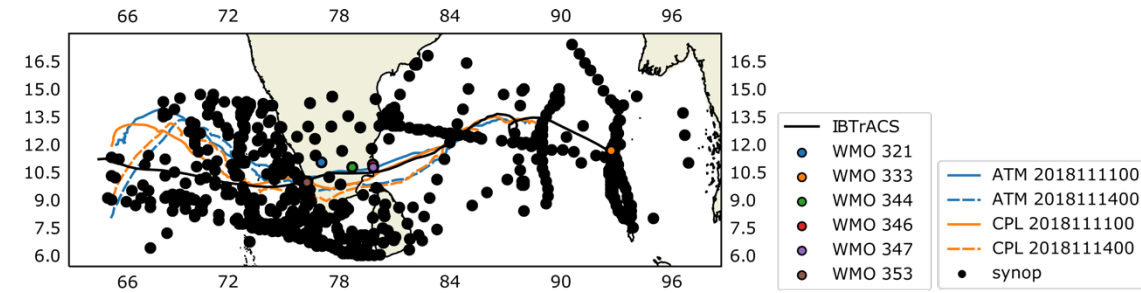



Figure S5. Location of SYNOP stations within 500 km of the track of TC Gaja, used to evaluate forecasts in this study; timeseries data for selected land SYNOP stations (close to the track at point of storm landfall).

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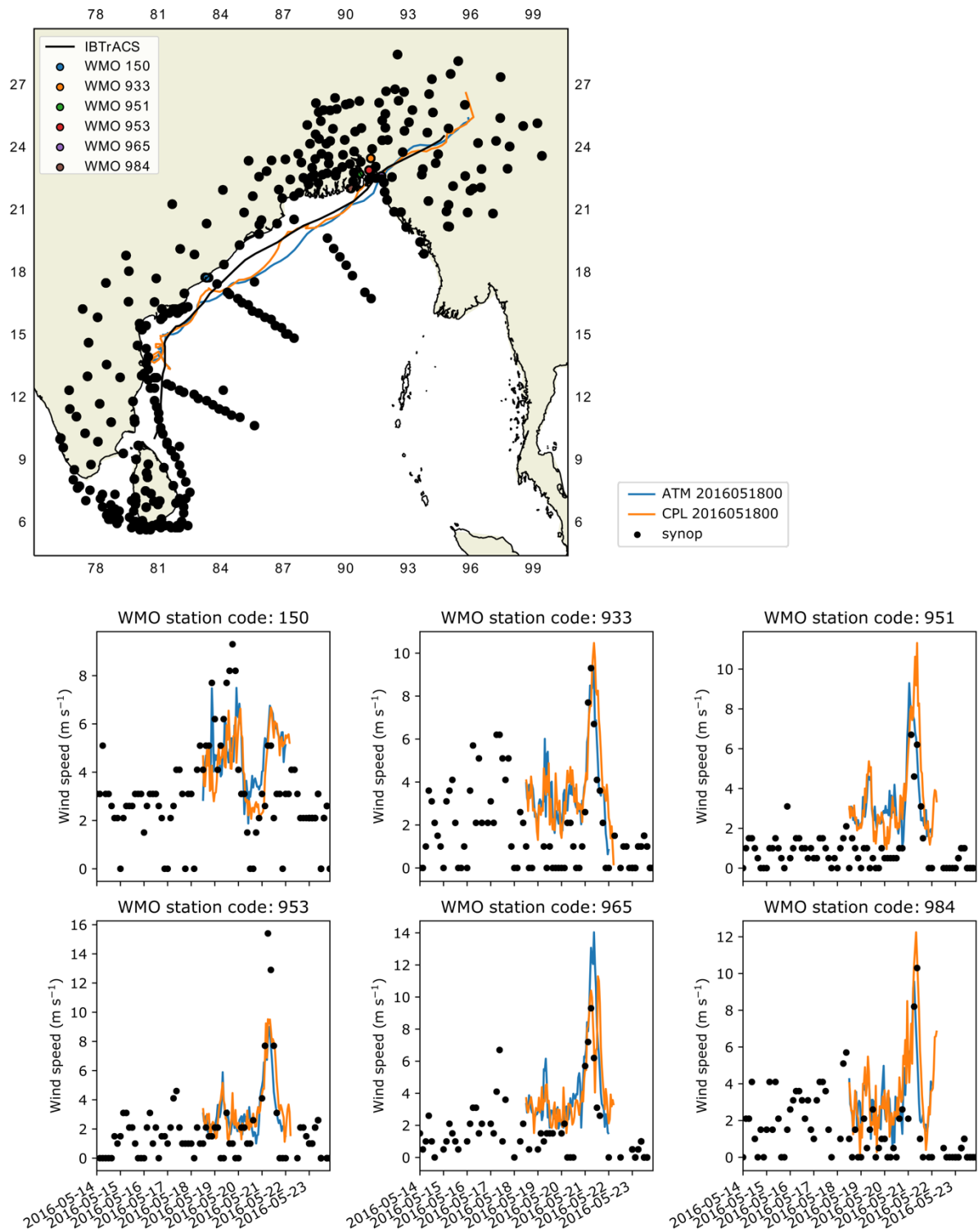
25 **Figure S6.** Location of SYNOP stations within 500 km of the track of tropical storm Roanu, used to evaluate forecasts in this study; timeseries data for selected land SYNOP stations (close to the track at point of storm landfall).
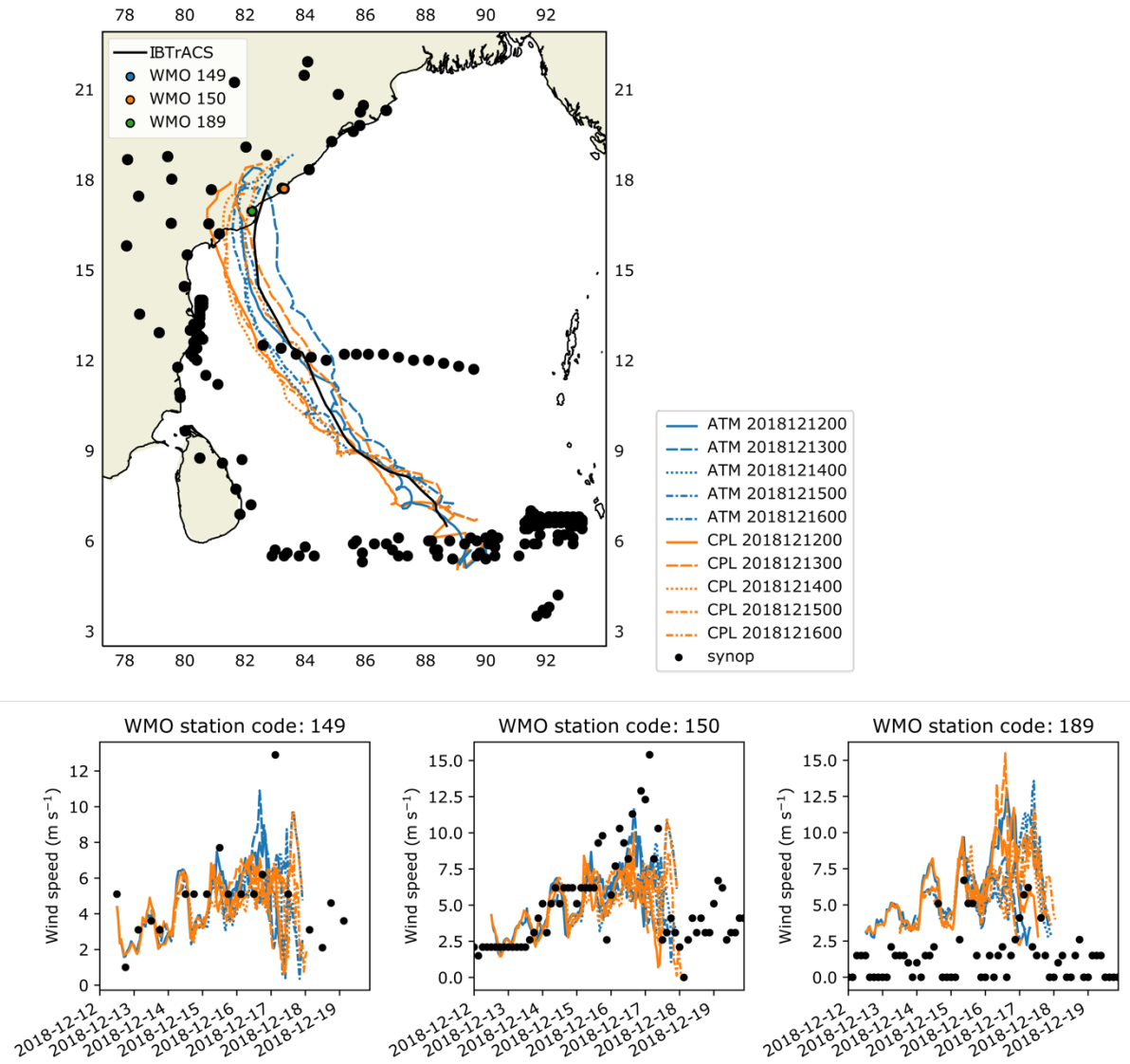
Figure S7. Location of SYNOP stations within 500 km of the track of tropical storm Phethai, used to evaluate forecasts in this study; timeseries data for selected land SYNOP stations (close to the track at point of storm landfall).
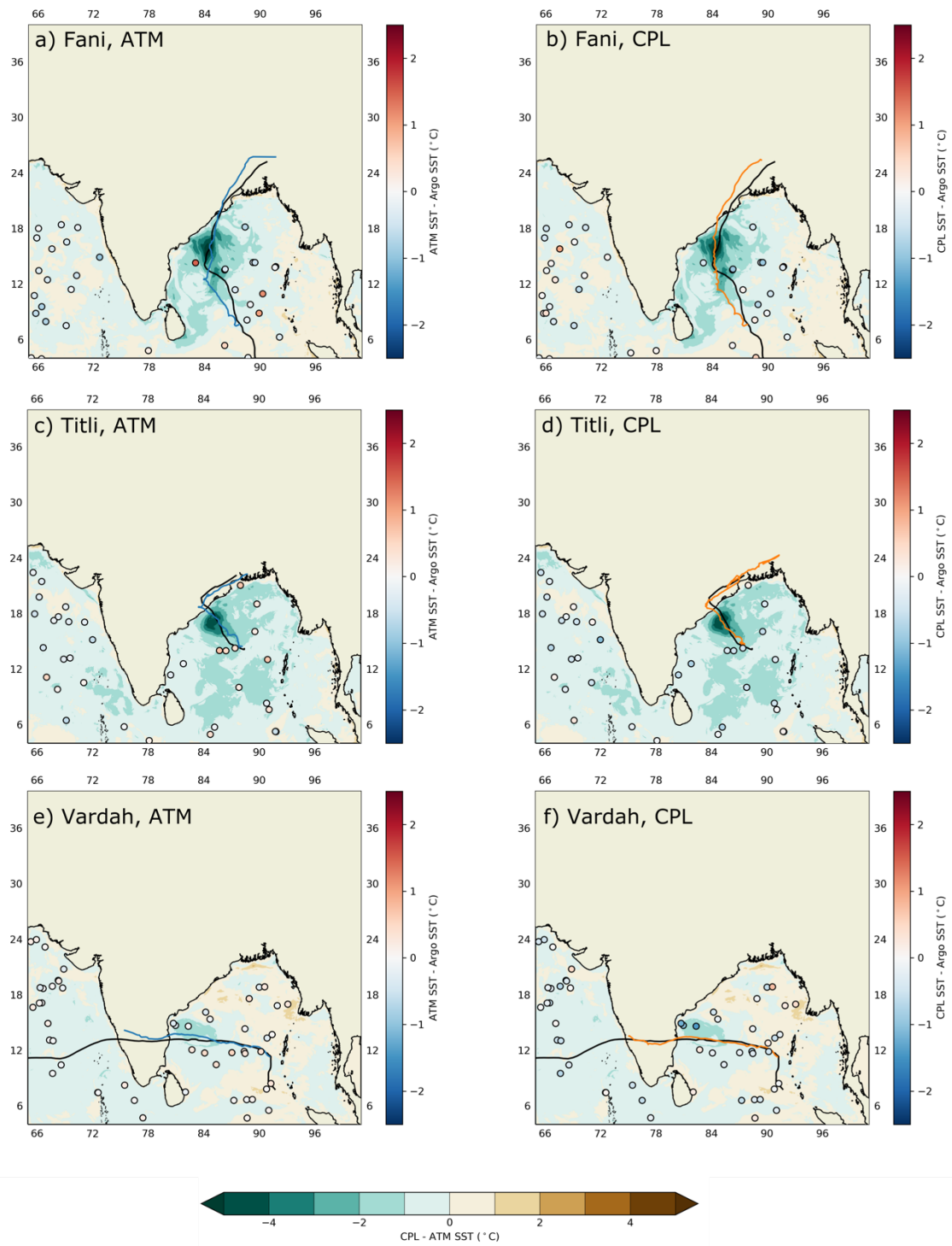
Figure S8. Difference in SST between CPL and ATM for forecasts with the best track in each lagged ensemble (Fani: 28/04/2019, Titli: 08/10/2018, Vardah: 09/12/2016); with locations of Argo floats used to assess these forecasts. Filled contours show CPL SST - ATM SST; circle colours show forecast SST – Argo float SST.

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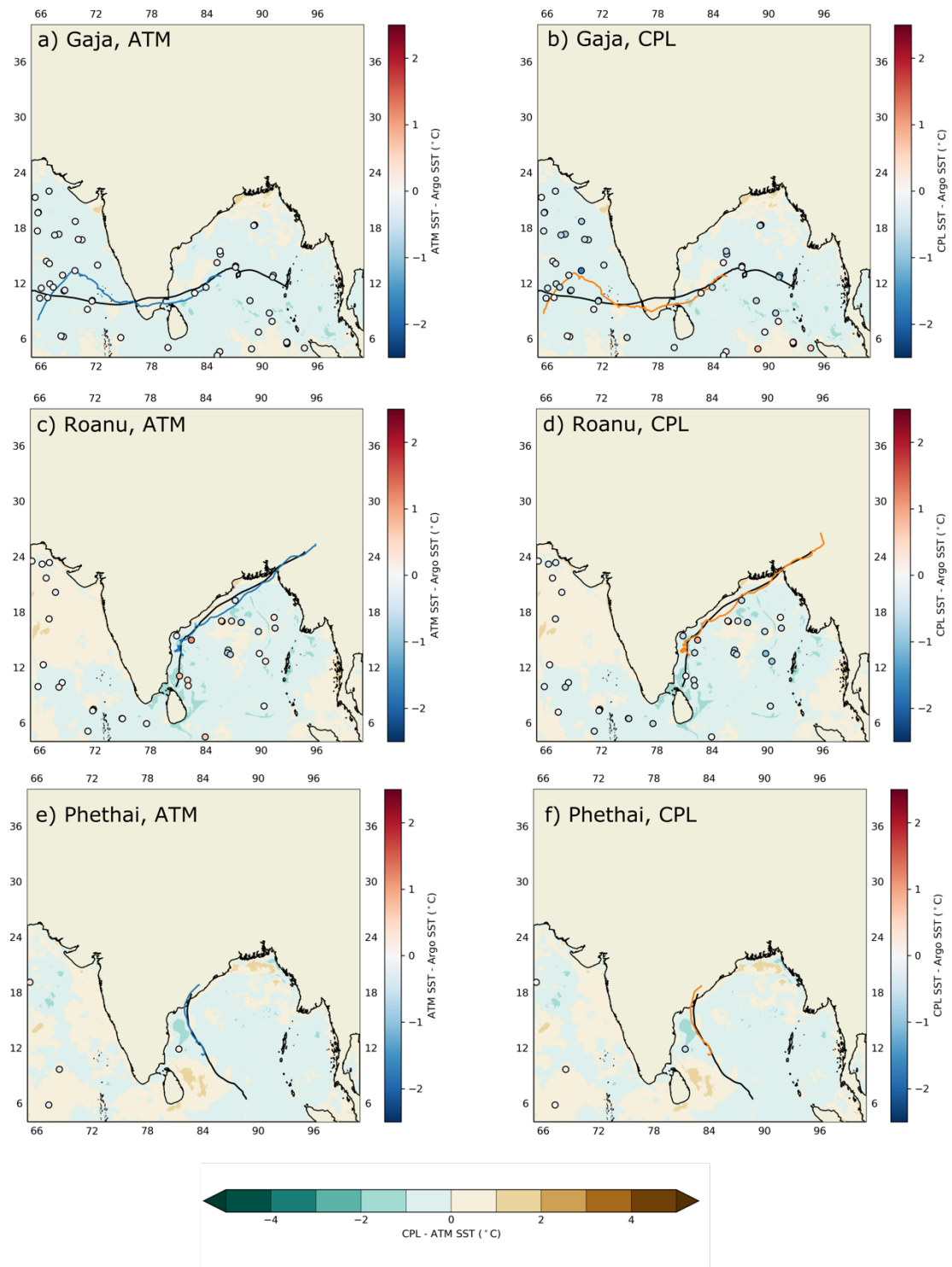
Figure S9. Difference in SST between CPL and ATM for forecasts with the best track in each lagged ensemble (Gaja: 14/11/2018, Roanu: 18/05/2016, Phethai: 16/12/2018); with locations of Argo floats used to assess these forecasts. Filled contours show CPL SST - ATM SST; circle colours show forecast SST – Argo float SST.

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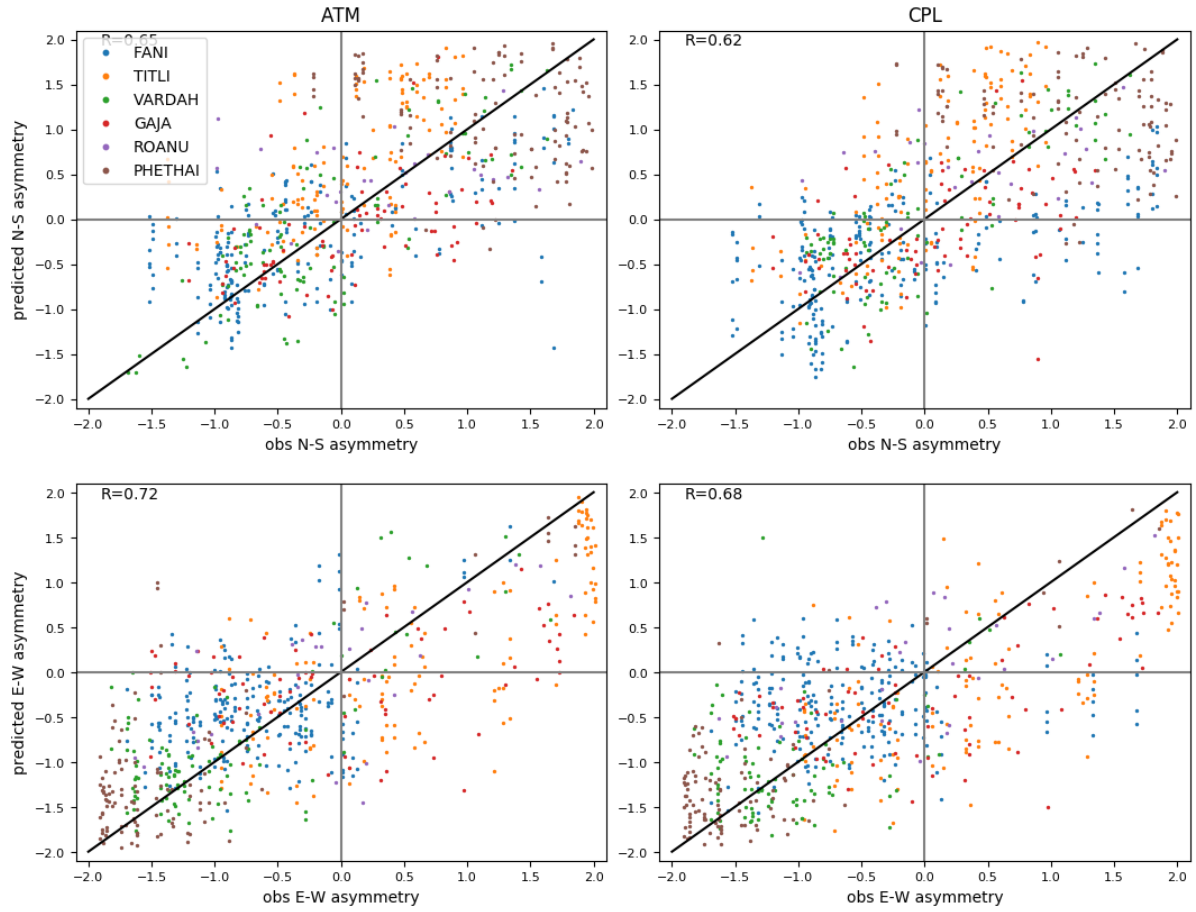
Figure S10. Predicted vs observed inner rain rate asymmetry for north minus south (top) and east minus west (bottom) and for ATM (left) and CPL (right). The black diagonal lines show the 1:1 relationship. Pearson correlation coefficients are given at the top of each panel. Forecasts with inaccurate tracks (marked with an asterisk in Table 2) are excluded.

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Table S1. Summary of track error statistics for tropical cyclone simulations for ATM and CPL. Values in bold are those which are significantly less than the other model at the 95% confidence interval using a paired T-test (i.e., p value ≤ 0.05). All simulations are included in this analysis.

Case study		Mean track error (km)	Landfall timing error (hr)	Landfall position error (km)	Mean MSLP absolute error (simulation-IBTrACS USA hPa)	Mean MSLP absolute error (simulation-IBTrACS New Delhi hPa)	Mean max wind absolute error (simulation-IBTrACS USA ms⁻¹)	Mean max wind absolute error (simulation-IBTrACS New Delhi ms⁻¹)
Fani	ATM	161.3	9.0	202.6	16.9	14.0	12.7	9.8
	CPL	**148.7**	4.8	216.8	17.5	13.0	13.4	10.1
Titli	ATM	129.8	3.8	118.5	**9.2**	9.9	**6.9**	5.6
	CPL	141.1	5.2	101.2	12.2	**5.0**	8.9	5.3
Vardah	ATM	**344.7**	31.2	117.5	19.0	21.2	12.8	13.5
	CPL	362.1	28.8	**42.8**	**15.8**	**17.4**	**11.3**	**12.2**
Gaja	ATM	**268.5**	10.8	105.1	19.0	17.0	11.5	11.1
	CPL	286.6	7.8	144.7	**16.9**	**13.6**	**10.7**	**9.5**
Roanu	ATM	**153.9**	83.4	1478.1	7.4	8.6	4.9	6.9
	CPL	191.4	78.0	1473.7	**6.4**	**6.5**	5.4	**5.6**
Phethai	ATM	**129.5**	9.6	**89.4**	5.0	**5.9**	6.1	7.1
	CPL	137.8	11.4	148.7	5.2	6.4	6.4	7.3
Cat3+ storms (Fani, Titli)	ATM	150.1	6.7	165.2	**14.4**	12.5	**10.8**	8.3
	CPL	146.0	5.0	165.4	15.8	**10.2**	11.9	8.4
N-ward storms (Fani, Titli, Phethai)	ATM	144.8	7.7	138.1	**12.0**	10.8	**9.6**	8.0
	CPL	143.9	7.3	159.4	13.0	**9.2**	10.5	8.1
W-ward storms (Vardah, Gaja)	ATM	**303.4**	21.0	111.3	19.0	18.9	12.1	12.2
	CPL	321.2	18.3	93.8	**16.3**	**15.2**	**11.0**	**10.7**
All storms except Roanu	ATM	**221.8**	13.2	126.9	15.5	14.7	10.8	10.0
	CPL	229.9	11.9	132.1	**14.7**	**12.1**	10.8	**9.3**
All storms	ATM	**215.3**	25.3	359.9	14.7	14.1	10.3	9.7
	CPL	226.2	23.3	363.4	**13.9**	**11.5**	10.2	**9.0**

Table S2. Summary of rain error statistics for tropical cyclone simulations for ATM and CPL. Values in bold are those which are significantly less than the other model at the 95% confidence interval using a paired T-test (i.e., p value ≤ 0.05). Simulations with inaccurate tracks (marked with an asterisk in Table 2) are excluded.

Case		Rainrate absolute error (mm/hr)	N-S asymmetry mean absolute error	E-W asymmetry mean absolute error
All storms	ATM	1.8	**0.58**	0.58
	CPL	**1.6**	0.60	0.61
All storms ocean	ATM	**1.6**	0.56	0.53
	CPL	1.7	0.56	0.54
All storms land	ATM	2.2	**0.72**	**0.68**
	CPL	**1.2**	0.85	0.77