J.Natn.Sci.Foundation Sri Lanka 2022 50 (3): 675 - 684
DOI: http://dx.doi.org/10.4038/jnsfsr.v50i3.10761

RESEARCH ARTICLE

Meteorology

Forecasting the track and the intensity of the cyclone Burevi using WRF

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Submitted: 22 October 2021; Revised: 04 April 2022; Accepted: 04 May 2022

Abstract: The cyclone 'Burevi' was recorded in the North Indian Ocean in the month of December 2020. In this study a numerical weather forecasting model WRF-ARW was used to forecast the track, intensity, and landfall location and time of the cyclone. The forecasting was performed as 16 consecutive model runs. Each forecast was initiated with different model initializations with a 12 hour time interval. For such initializations, the lateral boundary condition was set by the global forecast system data with a horizontal resolution of 0.25° x 0.25° at 3 hour time intervals. The forecasts were conducted up to 120 hours and evaluated using the data obtained from an international best track archive. The forecasted track was evaluated using root mean square error, direct positional error, along-track error and cross-track error. The intensity of the cyclone was evaluated by comparing the minimum sea level pressure and maximum forecasted 10-m wind speed obtained from the positions of the forecasted cyclone track. The WRF-ARW model was successful in forecasting the track and the intensity of the cyclone up to a lead time of 48 hours having a mean direct positional error of less than 106 km. This cyclone recorded three landfalls in Sri Lanka. The accuracy of the forecasted first landfall position and time were within acceptable range, but the second and third require further investigation.

Keywords: North Indian Ocean, track forecast, tropical cyclone, WRF-ARW.

INTRODUCTION

Weather research and forecasting (WRF) is a numerical weather prediction system used for research and operational forecasting (Skamarock *et al.*, 2019). Advanced Research WRF (ARW) is a configuration of the WRF system having ARW as the dynamic solver. WRF has been used by a number of researchers in the past to track cyclones (Islam *et al.*, 2015; Kotal & Bhattacharya, 2020; Nadimpalli *et al.*, 2020; Mohanty *et al.*, 2021). Islam *et al.* (2015) used WRF to track the cyclone 'Haiyan' recorded over West Pacific Ocean. They managed to forecast the track of the cyclone prior to 40 hours with a track error less than 100 km. Although they were successful in forecasting the track of the cyclone, the intensity of the cyclone was underestimated. Nadimpalli *et al.* (2020) carried out an assessment of WRF and hurricane weather research and forecasting (HWRF) by forecasting tropical cyclones in the Bay of Bengal. They have shown that the results obtained using WRF and HWRF are comparable up to 36 hours. For longer forecasts beyond 36 hours HWRF has given better results. Hon (2020) has forecasted 13 North Indian Ocean (NIO) cyclones. Mean positional errors for those forecasts are 38 km, 69 km and 107 km for 0, 24 and 48 hour forecast lead times respectively.

The forecast error of rainfall depth due to a cyclone was subjected to experiment using ARW by Osuri *et al.* (2020). They reported higher rainfall error with the long-range (48 - 96 hour) forecast than the short-range (24 hour). The forecast of wind field displacement and speed of the cyclone 'Vardah' formed over the Bay of

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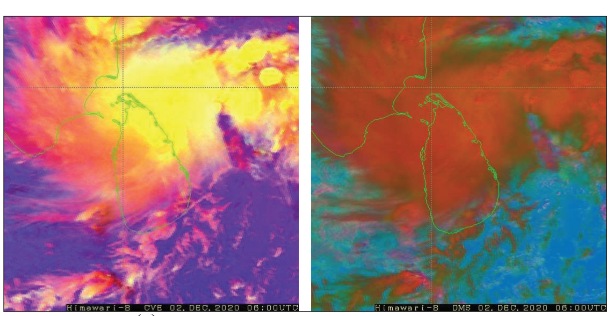
Bengal is improved by applying the following two methods. The two methods are relocation of the NCEP GFS forecast wind field and modification of the wind speed at each grid point over the cyclone influenced area (Kotal & Bhattacharya, 2020). Severe cyclonic storm 'Fani' over the Bay of Bengal was forecasted using WRF and HWRF by Mohanty *et al.* (2021). They concluded that the landfall time and position of the cyclone can be forecasted well with a 60 hour lead time. The tropical cyclone tracking and verification techniques used in weather prediction models by the UK Met Office is described elsewhere (Heming, 2017).

The cyclonic storm 'Burevi' was recorded in the Bay of Bengal in December 2020 (Farzan, 2020b). It is the fifth cyclone recorded in the North Indian (NI) basin during year 2020 (Knapp *et al.*, 2018). Three of those five are recorded in the Bay of Bengal subbasin. Those cyclones were named 'Amphan,' 'Nivar,' and 'Burevi' (Knapp *et al.*, 2018). It is worth noting that all those three cyclones have affected Sri Lanka, and cyclone 'Burevi' made a landfall in the east coast (Farzan, 2020a). Figures 1a and 1b are meteorological satellite observation images of cyclone 'Burevi' recorded at 0600 Coordinated Universal Time (UTC) on 02 December 2020. Those two images consist of Day Convective Storms RGB and Day Microphysics RGB, issued by the Japan Meteorological Agency (JMA) using their satellites. The yellow areas shown in Figure 1a are the cumulonimbus clouds with strong updrafts. Those clouds produce severe wind, tornadoes and heavy rainfall (Cotton *et al.*, 2011). In Figure 1b the red and brown colour area shows the thick clouds of cyclone 'Burevi' with deep precipitation.



(a) (b)

Figure 1: Satellite images captured at 0600 UTC on 02 December 2020

According to the report issued by the Disaster Management Center (DMC) of Sri Lanka there were three deaths due to cyclone 'Burevi' (Priyantha, 2020). The number of people affected in the Northern and Eastern provinces due to the cyclone are 102,098 and 30,830 respectively. In those two provinces, 103 houses were fully damaged and 3,598 were damaged partially. There were 1,054 small and medium scale enterprises were also damaged due to the cyclone (Priyantha, 2020). Prediction of the track and the intensity of the cyclone is important for the disaster management teams to take early mitigation measures to minimize the damage.

The main objective of this work is to forecast the track and the intensity of cyclone 'Burevi' that affected Sri Lanka, using WRF. Another objective is to identify the best possible forecast lead time in forecasting the track and the intensity of the cyclone. The final objective of this work is to identify the forecasted landfall position and time of the cyclone.

MATERIALS AND METHODS

In this study the track and the intensity of the cyclone "Burevi" is forecasted using WRF. WRF consist of two dynamical cores namely 'ARW' and 'NMM'. In this study the dynamical core 'ARW' was selected. The lateral boundary condition of the selected domain was set by the National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) data with a horizontal resolution of 0.25° x 0.25° at 3 h time intervals. The dataset was released four times a day in real-time and in this study 16 such datasets were used having 12 h time intervals, starting from 0000 UTC 27 November 2020 to 1200 UTC 04 December 2020. The domain was selected to cover the entire Bay of Bengal in the NI basin. It was centred over the point 12°N, 83°E having 240 x 180 grid points with 15 km grid spacing, covering a 3600 km x 2700 km area. The terrain height of the selected domain is shown in Figure 2. In the model configuration the number of vertical levels were set to 33. Based on the literature the pressure at the top of the model was set to 5000 Pa for all the forecasts (Baki *et al.*, 2022). However with the support of the dataset used to set the lateral boundary condition, it is possible to use a lower model top pressure (Hon, 2020). Adaptive time step was used to automatically set the time step to a maximum value while keeping the model numerically stable (Hutchinson, 2007; Skamarock *et al.*, 2019).

The physics options used in this study were WRF Single–moment 6–class Scheme (WSM6) for microphysics (Hong & Lim, 2006), New Tiedtke Scheme (Zhang & Wang, 2017) for the cumulus parameterization option, Dudhia shortwave Scheme (Dudhia, 1989) for the shortwave radiation, Rapid and Accurate Radiative

Transfer Model (RRTM) Longwave Scheme (Mlawer *et al.*, 1997) for the longwave radiation and University of Washington Boundary Layer Scheme (Bretherton & Park, 2009) for Planetary Boundary Layer (PBL). Added to those options MM5 Similarity Scheme (Beljaars, 1995) is used as the Surface Layer option and the Unified Noah Land Surface Model (Tewari *et al.*, 2004) is used as the Land Surface Option.

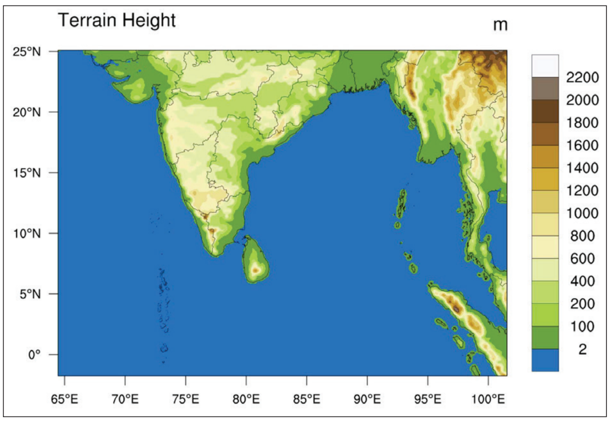


Figure 2: Terrain Height of the selected domain

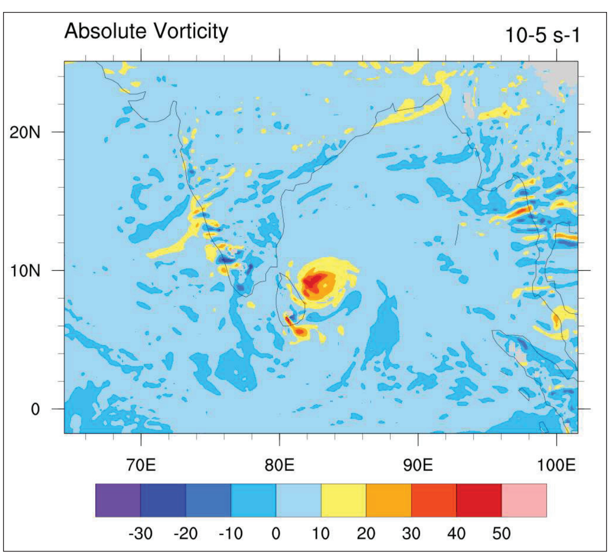


Figure 3: Absolute Vorticity at 0600 UTC 02 December 2020

The forecasting of the cyclone 'Burevi' is performed as 16 consecutive model runs. Each forecast is initiated a with different model initialization, from 0000 UTC 27 November 2020 to 1200 UTC 04 December 2020, with a 12 h time interval. The initialization times and the forecast durations are shown in Table 1. The forecast durations vary from 30 to 120 h. The forecast positions of the cyclone are identified in the literature using the forecasted minimum sea level pressure (MSLP) and relative vorticity (RV). The locations of maximum RV at 850 hPa and MSLP are close in a well developed cyclone over the open ocean (Heming, 2017). In this research the local MSLP locations are identified as possible positions of the cyclone. The absolute vorticity (AV) at 850 hPa is considered instead of RV for a search radius of 2° having local MSLP locations as the centres. The combination of local MSLP and the AV at 850 hPa is considered in selecting the forecasted position of the cyclone. The forecasted AV at 0600 UTC on 02 December 2020 is shown in Figure 3. All the forecasts conducted in this study are evaluated using the International Best Track Archive for Climate Stewardship (IBTrACS) (Knapp *et al.*, 2018). In that dataset the track records for the cyclone 'Burevi' are available from 1200 UTC 01 December 2020 to 1800 UTC 05 December 2020, and it is shown in Figure 4.

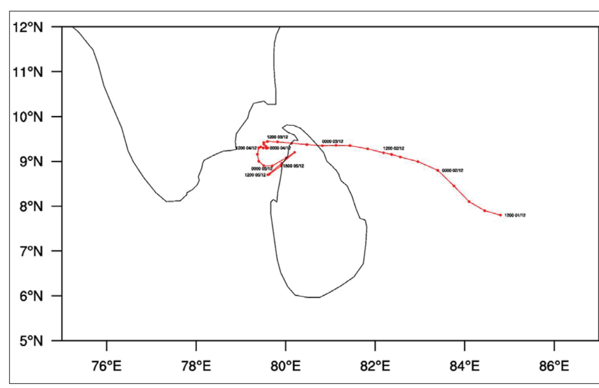


Figure 4: The track of cyclone "Burevi" (Knapp *et al.*, 2018)

The forecast leads vary from 0 to 120 h with a 3 h time interval. Since the track record of the cyclone 'Burevi' provided by IBTrACS is from 1200 UTC 01 December 2020 to 1800 UTC 05 December 2020 the number of verifiable forecasting positions for different forecast leads are different. The root mean square error (RMSE) is calculated to evaluate the track of the cyclone 'Burevi' using IBTrACS dataset as a reference. The calculation is done according to the Equation 1. In that equation '$simlat_n$' and '$simlon_n$' are simulated latitude and longitude coordinates of the cyclone. The values for '$btlat_n$' and '$btlon_n$' are the latitude and longitude of the cyclone track recorded in the IBTrACS dataset.

Table 1: RMSE of the selected forecasts with different initialization times

No	Initialization time	Forecast duration (h)	Verifiable positions	Track RMSE (km)
1	00 UTC 27 November 2020	120	5	340.1
2	12 UTC 27 November 2020	120	9	293.9
3	00 UTC 28 November 2020	120	13	127.0
4	12 UTC 28 November 2020	120	17	166.7
5	00 UTC 29 November 2020	120	21	59.0
6	12 UTC 29 November 2020	120	25	164.9
7	00 UTC 30 November 2020	120	29	215.7
8	12 UTC 30 November 2020	120	33	202.8
9	00 UTC 01 December 2020	114	35	146.4
10	12 UTC 01 December 2020	102	35	90.5
11	00 UTC 02 December 2020	90	31	245.1
12	12 UTC 02 December 2020	78	27	84.7
13	00 UTC 03 December 2020	66	23	195.7
14	12 UTC 03 December 2020	54	19	72.3
15	00 UTC 04 December 2020	42	15	87.9
16	12 UTC 04 December 2020	30	11	88.3

The great-circle distance between those two points was calculated using the 'haversine' formula (Sinnott, 1984). N is the number of verifiable forecasting positions for each forecast as shown in Table 1.

$$\mathrm{RMSE} = \sqrt{\frac{\sum_{n=1}^{N}\left(\mathrm{haversine}(\mathrm{simlat}_n, \mathrm{btlat}_n, \mathrm{simlon}_n, \mathrm{btlon}_n)\right)^2}{N}} \quad ...(1)$$

The verification of the tracks for different forecast leads is done using direct positional error (DPE), along-track error (ATE), and cross-track error (CTE) as mentioned by Heming (2017). The DPE is the great-circle distance between the observed and forecast positions considered at the same time instant in UTC. The DPE does not provide any information about speed and the direction of the forecast (Heming, 2017). The ATE was calculated by extrapolating the line joining observed position and the position observed 3 h earlier and drawing a perpendicular line from the forecasted point to it. The distance between the point of intersection of those two lines and the observed point is considered as the ATE. If the ATE is positive, the forecast is ahead of the observed position in the observed direction of motion having a faster movement, and if the ATE is negative, it is having a slower one. The CTE is the perpendicular distance from forecasted point to the extrapolated line joining observed position and the position observed 3 h earlier (Heming, 2017). Since the ATE and CTE require one observed position recorded 3 h prior to the observed position, it is not possible to calculate the ATE and CTE for the first observed position. In each of the DPE, ATE, and CTE calculations, the 'haversine' formula is used to calculate the great-circle distance.

The forecasted intensity of the cyclone was evaluated by comparing the sea level pressure and 10-m wind speed obtained in the positions of the forecasted track with the corresponding pressure and maximum sustained wind speed values recorded in IBTrACS dataset (Knapp *et al.*, 2018). The forecasted positions have the MSLP of the considered domain. The forecasted position of the cyclone 'Burevi' at 0600 UTC on 02 December 2020, having an MSLP of 1001.27 hPa, was rounded to 1001 hPa and marked in Figure 5. The absolute MSLP error was calculated by using such forecasted MSLP vales and using the pressure values recorded in the IBTrACS dataset as a reference.

The wind speed forecasted at 0600 UTC 02 December 2020 of the cyclone 'Burevi' is shown in Figure 6. A search radius of 2° is considered form the point of MSLP to obtain the maximum forecasted 10-m wind speed as used by Heming (2017). The absolute wind speed error of the forecasted maximum wind speed was calculated by using the maximum sustained wind speed of IBTrACS dataset (Knapp *et al.*, 2018) as a reference.

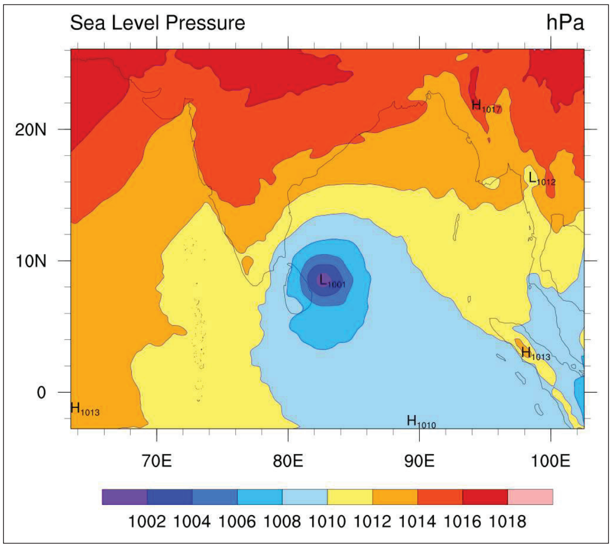


Figure 5: Forecasted sea level pressure at 0600 UTC on 02 December 2020.

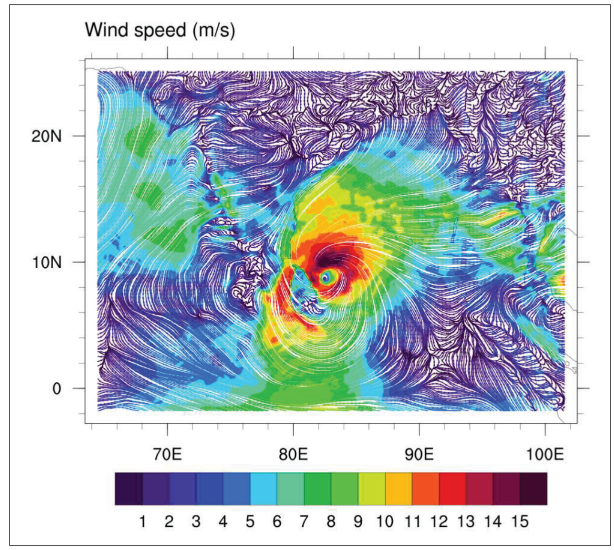


Figure 6: Forecasted 10-m wind speed at 0600 UTC on 02 December 2020.

The cyclone 'Burevi' produced three landfall positions. Those positions were calculated based on the observed cyclone positions recorded in IBTrACS dataset (Knapp *et al.*, 2018). The latitude and longitude coordinates of such points before and after the landfall are used to find the equation of the straight line joining those two. Once the coefficients of the equation are obtained, it is possible to find all the latitude and longitude coordinates between the two points. The terrain elevation of all those points were obtained using the calculated latitude and longitude coordinates. The difference in terrain elevation between a location on sea and a location on land is used to identify the latitude and longitude coordinate of the observed landfall location. The same process described above was applied to the forecasted cyclone positions to obtain the forecasted landfall location. Landfall error was obtained by calculating the great-circle distance between the observed and forecasted landfall positions using the 'haversine' formula. Landfall time was calculated by assuming that the cyclone had moved at a constant speed between the two cyclone positions considered for a period of 3 h. It was calculated according to the distance ratio between the cyclone positions and the landfall location. Landfall time error was calculated by getting the time difference between the forecasted landfall time and the observed one.

RESULTS AND DISCUSSION

The track RMSE of the selected forecasts with 16 different model initializations are shown in Table 1. From the model initialization time 0000 UTC on 27 November 2020 to 0000 UTC on 29 November 2020, the track RMSE was reduced from 340.1 km to 59.0 km. For the model initialized at 1200 UTC on 01 December 2020, the track RMSE was 90.5 km.

In Figure 7 the forecasts of up to 72 hours are plotted in blue colour and the reference provided by IBTrACS dataset (Knapp *et al.*, 2018) is plotted in red colour. The cyclone started at 1200 UTC 01 December 2020 from the location 7.80°N, 84.80°E and moved towards Sri Lanka according to the IBTrACS dataset (Knapp *et al.*, 2018). It is worth noting that all those forecasts shown in Figure 7 are initiated before the starting time of the cyclone. The observed track of the entire cyclone is plotted in red from Figure 7a to Figure 7d as a reference. According to the observed track of the cyclone, it had got trapped between Sri Lanka and India and was weakened at the end (Knapp *et al.*, 2018). It had also made its second and third landfall on Sri Lanka during that final stage. That event is not forecasted and the cyclone points have moved away from Sri Lanka at the final stage as shown in Figure 7.

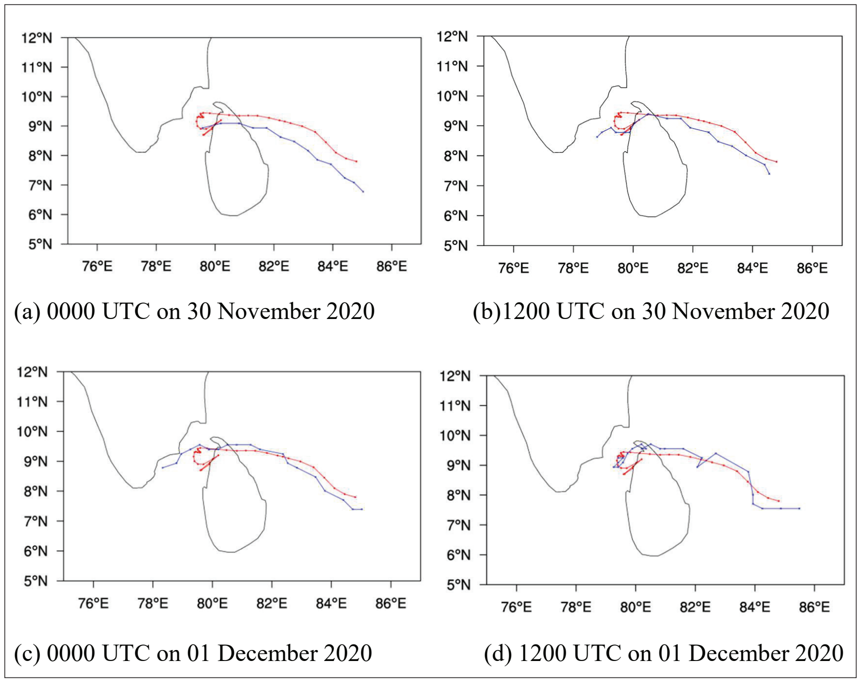


Figure 7: Forecast tracks up to 72 hour duration with different model initialization times. Observed and forecasted tracks are plotted in red and blue colours, respectively.

The DPEs of the forecasted tracks for different forecast leads are verified using the IBTrACS data (Knapp *et al.*, 2018). The mean DPEs for different forecasting times up to 72 hours are shown in Table 2. The mean DPE is less than 61 km up to a 24 hour lead time. It is less than 106 km and 131 km for lead times up to 48 and 72 hours, respectively. These results are comparable with the results obtained by Hon (2020) for their forecasts of 13 cyclones in the NIO. The ATE is calculated for different forecast leads using IBTrACS data (Knapp *et al.*, 2018) as observed positions. The ATE gets positive and negative values depending on the forecast position. The absolute value of ATE is considered to calculate the mean ATE, and mean absolute ATE records up to 72 hours are shown in Table 2. The mean absolute ATE is less than 48 km up to a 24 hour forecast lead time. It is less than 84 km and 122 km for lead times up to 48 and 72 hours respectively.

The CTE is calculated for the forecast leads based on the observed positions recorded in IBTrACS data (Knapp *et al.*, 2018). The CTE is considered positive if the forecast position of the cyclone is recorded to the right (left) of the extrapolated line joining observed position and the position observed 3 hour earlier in the northern (southern) hemisphere. The absolute value of CTE is considered to calculate the mean CTE, and mean absolute CTE records up to 72 hours are shown in Table 2. Mean absolute CTE is less than 42 km up to a 24 hour forecast lead time. It is less than 47 km and 64 km for lead times up to 48 and 72 hours respectively. The mean DPE, mean absolute ATE, and mean absolute CTE are further illustrated in Figure 8. According to that figure the mean DPE, mean absolute ATE, and mean absolute CTE shows higher values for 0 and 3 hour forecast lead times compared to a 6 hour forecast lead time. The main reason is that, during that period, the model is in the spin-up phase to develop the waves and the clouds (Skamarock *et al.*, 2019). It is possible to provide a pre-forecast period to the model, which will provide the required time to adjust to the topography, and produce cloud fields (Skamarock *et al.*, 2019). Such a pre-forecast period is not configured in this model setup and will be considered in future work.

The use of AV with MSLP in selecting the forecasted positions of the cyclone has reduced DPE, ATE, and CTE compared to using only MSLP. When the forecasted MSLP is considered for the entire domain, there exist some MSLP points that do not belong to the cyclone. Those low pressure points may belong to another cyclone that is forecasted in the same simulation domain. If MSLP is the only parameter considered in selecting the cyclone position it would provide an erroneous point resulting in larger DPE, ATE, and CTE. Considering AV with local MSLP points avoids such erroneous points that do not belong to the forecasted track of the cyclone. It is possible to extend this method to forecast the tracks of multiple cyclones of the same simulation domain by using the MSLP and AV.

MSLP error is calculated based on the forecasted sea level pressure along the cyclone positions and the pressure values recorded in IBTrACS data (Knapp *et al.*, 2018). The mean absolute MSLP error up to a 72 hour lead time is shown in Table 2. The mean absolute MSLP error is less than 2.93 hPa up to a 72 hour forecast lead time. The forecasted MSLP is shown in Figure 9 for the corresponding observed MSLP values of cyclone 'Burevi' recorded in IBTrACS data (Knapp *et al.*, 2018). The correlation coefficient was calculated using linear regression based on the observed and forecasted MSLP. The MSLP forecast has a bias of 1.18, an RMSE of 3.07 hPa, and a correlation coefficient of +1.00 compared to the observations. In Figure 9 it is evident that the forecasted MSLP is increased based on the observed MSLP values, with a positive correlation coefficient of 1.00.

Table 2: Mean DPE, mean absolute ATE, mean absolute CTE, mean absolute MSLP error and mean absolute wind speed error for different forecasting lead times.

Forecast lead time (h)	Mean DPE (km)	Mean absolute ATE (km)	Mean absolute CTE (km)	Mean absolute MSLP error (hPa)	Mean absolute wind speed error (ms^{-1})
T + 0	58.2	45.4	23.8	1.15	2.71
T + 3	60.2	39.1	41.8	2.03	2.43
T + 6	46.4	27.9	36.1	2.14	1.73
T + 9	47.9	36.8	28.6	1.94	2.76
T + 12	50.4	38.7	25.6	2.85	3.02
T + 15	54.4	47.3	21.4	2.93	3.45
T + 18	54.9	39.6	27.8	2.25	3.27
T + 21	53.0	34.9	32.5	2.39	3.81
T + 24	50.2	38.6	24.5	2.54	3.85
T + 27	53.5	42.4	23.3	2.53	3.32
T + 30	68.0	53.5	33.2	2.11	3.09
T + 33	48.4	40.6	16.5	1.77	3.54
T + 36	62.1	44.0	24.7	1.85	3.92
T + 39	62.4	49.2	29.1	2.36	3.35
T + 42	83.3	60.8	36.8	2.00	3.57
T + 45	90.2	71.1	46.2	1.86	3.50
T + 48	105.7	83.1	42.9	2.20	4.13
T + 51	124.9	117.7	27.4	2.89	4.30
T + 54	130.9	121.7	33.4	2.17	3.65
T + 57	129.8	106.3	57.2	2.27	4.49
T + 60	104.1	92.4	49.6	2.58	4.51
T + 63	125.9	110.8	42.2	2.88	4.24
T + 66	124.2	92.9	63.1	1.89	3.79
T + 69	104.3	82.8	53.5	1.91	4.50
T + 72	128.8	112.9	53.2	2.24	4.55

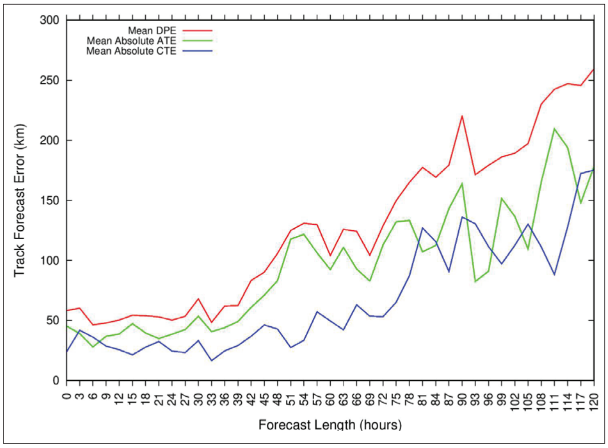


Figure 8: Mean DPE, mean absolute ATE and mean absolute CTE for different forecast lead times of the cyclone 'Burevi'.

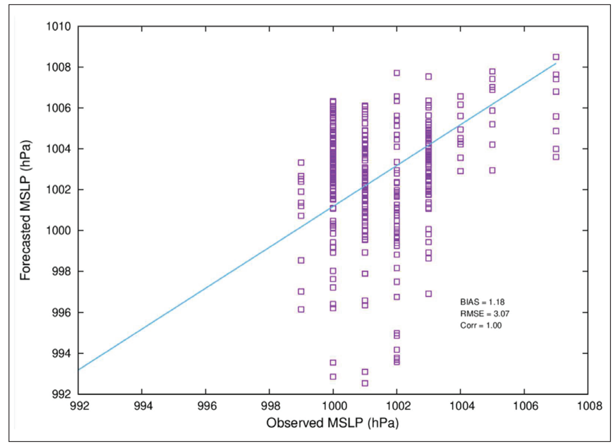


Figure 9: Scatter diagram of forecasted MSLP, line indicates the straight line fit to the data

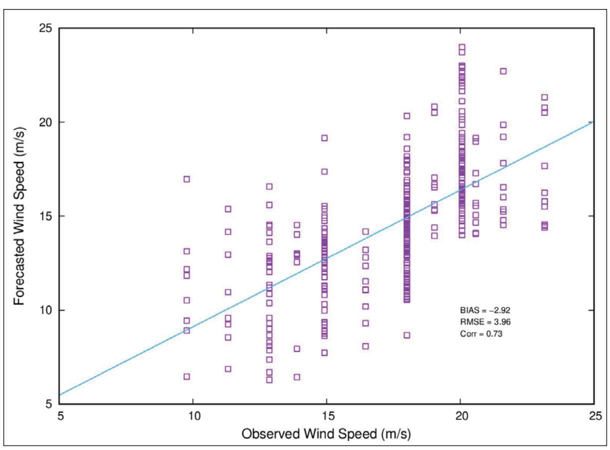


Figure 10: Scatter diagram of maximum forecasted 10-m wind speed, line indicates the straight line fit to the data

The forecast error of maximum wind is calculated based on the 10-m wind speed and the maximum sustained wind speed recorded in IBTrACS data (Knapp *et al.*, 2018). The mean absolute wind speed error up to a 72 hour lead time is shown in Table 2. The mean absolute wind speed error is less than 4.55 ms^{-1} for all the forecasts. The forecasted 10-m wind speed is shown in Figure 10 for the corresponding observed MSLP values of cyclone 'Burevi' recorded in IBTrACS data (Knapp *et al.*, 2018). The correlation coefficient was calculated using linear regression based on the observed and forecasted 10-m wind speed. The 10-m wind speed forecast has a bias of −2.92, an RMSE of 3.96 ms^{-1} and a correlation coefficient of +0.73 compared to the observations. In Figure 10 it is evident that the forecasted 10-m wind speed is increased based on the observed wind speed values with a positive correlation coefficient of 0.73.

The first landfall of the cyclone 'Burevi' was observed at the 9.35°N, 80.74°E latitude and longitude coordinate at 0041 UTC on 03 December 2020. The method used to calculate the observed landfall location and time is described in Section 2. The observed cyclone positions in the IBTrACS dataset (Knapp *et al.*, 2018) are used in that calculation. The same process is used to calculate the forecasted landfall location and time. The landfall location and time error for the first landfall were calculated and the results are shown in Table 3. The forecasted minimum landfall position error is recorded as 18.1 km with a lead time of 48 hours. The minimum forecasted landfall time error of the first landfall of the cyclone is 4 minutes with a lead time of 36 hours. Obtaining such information regarding the landfall location and time of the cyclone is an advantage when it comes to disaster management.

The intensity of the cyclone was reduced after the first landfall. This is clearly visible from the data recorded by Knapp *et al.* (2018), where the maximum sustained wind speed was 20 ms^{-1} at the first landfall, 14 ms^{-1} at the second landfall, and 10 ms^{-1} at the third landfall. The second landfall was observed at 9.08°N, 80.02°E at 0300 UTC on 05 December 2020. In all the forecasts conducted in this study the second landfall was only forecasted with a landfall error of 62 km in a forecast initialized at 0000 UTC on 03 December 2020. In that forecast, the landfall time error is minus 40 hours and 30 minutes. The third landfall was observed at 8.9°N, 79.9°E at 1800 UTC on 05 December 2020. This landfall is not recorded in any of the forecasts conducted in this study. The intensity of the cyclone was reduced when it reached its final stage. This is the reason for not forecasting the third landfall accurately.

Table 3: Landfall position and time error of the first landfall

Initialization time	Lead time (h)	Landfall position error (km)	Landfall time Error
00 UTC 29 November 2020	102	35.0	6 h 49 m
12 UTC 29 November 2020	96	21.0	11 h 49 m
00 UTC 30 November 2020	63	51.0	- 5 h 11 m
12 UTC 30 November 2020	48	18.1	- 11 h 33 m
00 UTC 01 December 2020	42	27.8	4 h 26 m
12 UTC 01 December 2020	36	48.8	4 m
00 UTC 02 December 2020	15	45.0	- 7 h 49 m
12 UTC 02 December 2020	0	58.8	- 9 h 56 m

CONCLUSIONS

The cyclone considered in this study has affected Sri Lanka by having its first landfall at 0041 UTC on 03 December 2020. Its track and intensity were forecasted with a maximum forecast duration of 120 hours using WRF. The track RMSE was reduced from 340.1 km to 59.0 km for model initializations from 0000 UTC on 27 November 2020 to 0000 UTC on 29 November 2020. This clearly shows the increase of accuracy of the forecasted track when the forecast lead time is reduced. For forecast lead times up to 24 hours the DPE, ATE, and CTE are less than 61 km, 48 km, and 42 km, respectively. When it comes to a forecast lead time up to 48 hours the DPE, ATE, and CTE are less than 106 km, 84 km, and 47 km, respectively. DPE, ATE, and CTE are higher for 0 and 3 hour forecast lead times compared to a 6 hour forecast lead time. The authors believe that this is due to the model spin-up phase. Providing the model with a pre-forecast period will be considered in future to minimize the effect of the spin-up phase. The forecasted mean absolute MSLP is less than 2.93 hPa up to a 72 hour forecast lead time. The forecasted MSLP has a positive correlation coefficient of 1.00 with its corresponding observations. The mean absolute wind speed error is less than 4.55 ms^{-1} for all the forecasts. The forecasted wind speed has a positive correlation coefficient of 0.73 with its corresponding observations. With all the above mentioned results, it is possible to conclude that WRF is capable of forecasting the track and the intensity of a cyclone that affects Sri Lanka with a forecast lead time up to 48 hours.

The first landfall of the cyclone 'Burevi' was forecasted with a minimum landfall position error of 18.1 km with a forecast lead time of 48 hours. The minimum forecasted landfall time error of the cyclone is 4 minutes with a forecast lead time of 36 hours. Obtaining such information is an advantage when it comes to disaster management. The intensity of the cyclone was reduced after the first landfall. The second landfall was forecasted by only one forecast. That had a landfall error of 62 km and a landfall time error of minus 40 hours and 30 minutes. The third landfall of the cyclone was not recorded in any of the forecasts conducted in this study. In conclusion, the first landfall position forecast of this cyclone is acceptable with the WRF configuration used in this study. The position and time forecasts for the second and third landfall require further investigation to improve their accuracy.

Acknowledgements

The authors would like to express their sincere gratitude to the National Center for Atmospheric Research (NCAR) and NCEP for providing the WRF model to the research community. The support given by the Faculty of Engineering, University of Ruhuna, Sri Lanka is highly appreciated.

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