

Tropical cyclonic storms – Modeling studies in Indian Air Force

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सार – देश में भारतीय वायुसेना (आई. ए. एफ.) की सुरक्षित उड़ानों के लिए मौसम सेवाएँ उपलब्ध कराने का उत्तरदायित्व मौसम विज्ञान विभाग के निदेशालय का है। भारतीय वायुसेना के बेस पर स्थित मौसम (मेट) कार्यालय उष्णकटिबंधीय चक्रवातों के बनने, तीव्र होने और उनकी गति का सूक्ष्म रूप से मॉनीटरन करते हैं तथा वायुसेना की बहुमूल्य सम्पत्ति, मुख्य रूप से हवाई-जहाजों की सुरक्षा के लिए चेतावनी जारी करते हैं। चक्रवात के प्रकोप से प्रभावित किसी भी स्थान पर बचाव कार्यों में लगे हेलीकॉप्टरों/वायुयानों के लिए भी यह कार्यालय मौसम सेवाएँ उपलब्ध कराते हैं। मॉडल पर किए गए अध्ययनों के आधार पर वास्तविक समय पूर्वानुमान के लिए भारतीय वायुसेना द्वारा शोध कार्य किया जा रहा है। ग्रेल और कैन-फ्रिश 2 (सतही संवहन सहित) कपासी प्रचालीकरण योजना का उपयोग करके चक्रवात के मार्ग के पूर्वानुमान के लिए भारतीय वायुसेना के मौसम अनुभाग द्वारा उड़ीसा के महाचक्रवात के मेसोस्केल निदर्श एम. एम. 5 के आधार पर अध्ययन किया गया है। ग्रेल योजना से तूफान के वास्तविक मार्ग से लगभग निकट के मार्ग का पता चला है। कैन-फ्रिश 2 योजना से पता चले मार्ग से पश्चिम बंगाल और उसके आस-पास के क्षेत्रों में चक्रवात के प्रतिवर्तन का पता चला है।

ABSTRACT. The Directorate of Meteorology is responsible for the provisioning of weather services for safe conduct of Indian Air Force (IAF) flying operations in the country. The Meteorological (Met) Sections at IAF bases closely monitor a Tropical Cyclone formation, intensification and movement and issue storm warning to safeguard its valuable property that primarily includes Aircrafts. It also provides the weather services for all the helicopter/Aircraft Rescue Operations that are taken up after the fury of the cyclone experienced at a place. Generation of real time forecast from model studies is in the Research Stage in IAF. A meso-scale model (MM5) studies of super cyclone of Orissa were carried out by IAF Met to generate forecast tracks of the Cyclone using Grell and Kain-Fritsch 2 (with shallow convection) cumulus parameterization scheme. The Grell scheme indicated the track slightly close to the actual track of the storm. The KF2 scheme led to the generation of the track that indicated the re-curvedure of the system in to West Bengal and adjoining regions.

Key words – Air Force Met Section, Research tropical cyclone, MM5 model.

1. Introduction

The chief objective of a Met. Section (Met. Sec.) in IAF is to issue short-range weather forecast for aviation. IAF flying operations have unique requirement of very short and accurate weather forecasts because of endurance of the fighter aircraft. Tropical cyclones affect the operations of IAF at the bases, which are located along the coastal regions. The major concern of IAF Met. is the safety of aircraft that are generally placed in the open tarmac or inside the hangers. These aircraft in the open or inside the hangers can not sustain the fury of tropical storms. Therefore, the aircrafts are needed to be shifted to a safe place located away from the fury of a tropical storm. Also the safety of the supporting ground equipment and infrastructure needs attention in case of a tropical storm fury. IAF Met. issues storm warning in time to save the equipment and the personnel or inhabitants residing inside the base. Apart from this IAF Met. also caters for the operations that are taken up during the rescue work, after the landfall of the tropical storm at a place, by gearing up the IAF airfields. Met. briefings are given to the IAF authorities covering the tropical storm position,

future track and intensity. The tropical cyclone position and intensity is inferred from radar and weather bulletins that are issued by IMD and satellite imageries. For operational forecasting, IAF is in the process of implementing numerical weather techniques at all the Met. Sections. Presently, number of in-house training and workshops on NWP has been conducted. Few Met. officers have been sent to other national institutions for participating in the workshops and training activities.

Recently, an advanced course on tropical cyclones using MM5 model at the Andhra University was conducted. Using the data supplied by the Andhra University, MM5 studies on super cyclone of Orissa were carried out by IAF showed some interesting results. The subsequent paragraphs describe the studies.

2. Data

The data is 'fnldata' from NCEP with one degree resolution for the period 25 - 30 October 1999. This data was obtained from Andhra University.

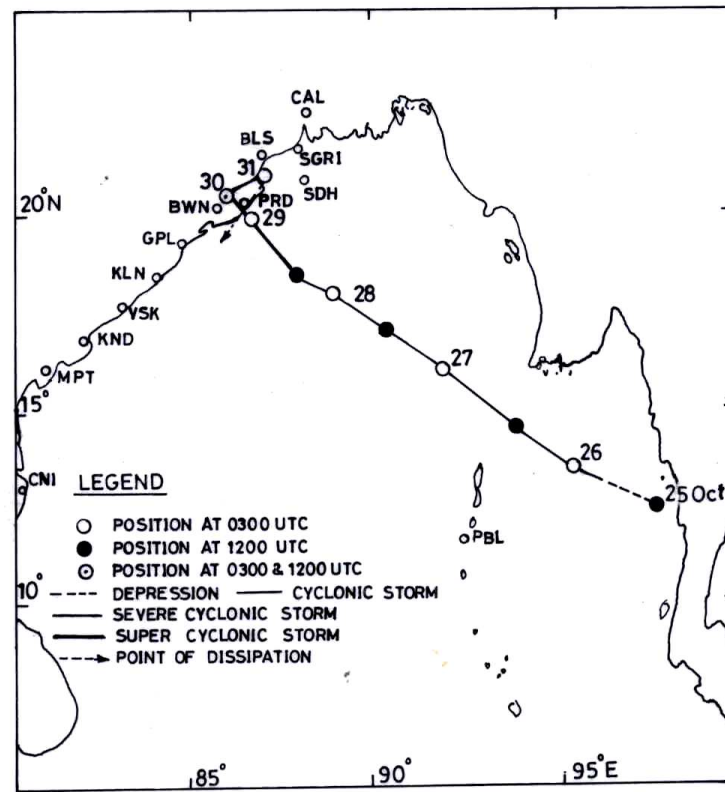
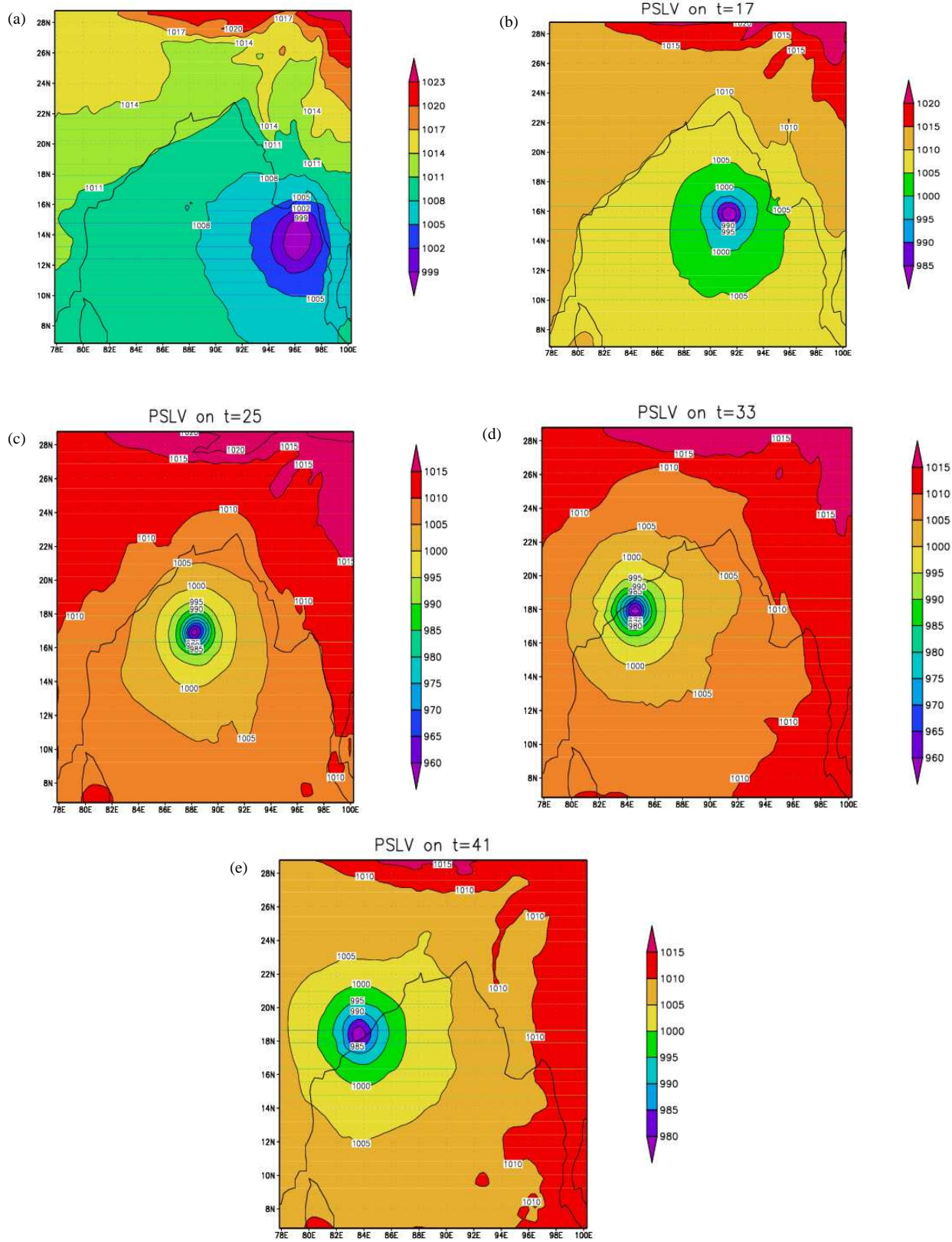


Fig. 1. Actual track of the Orissa super cyclone 1999

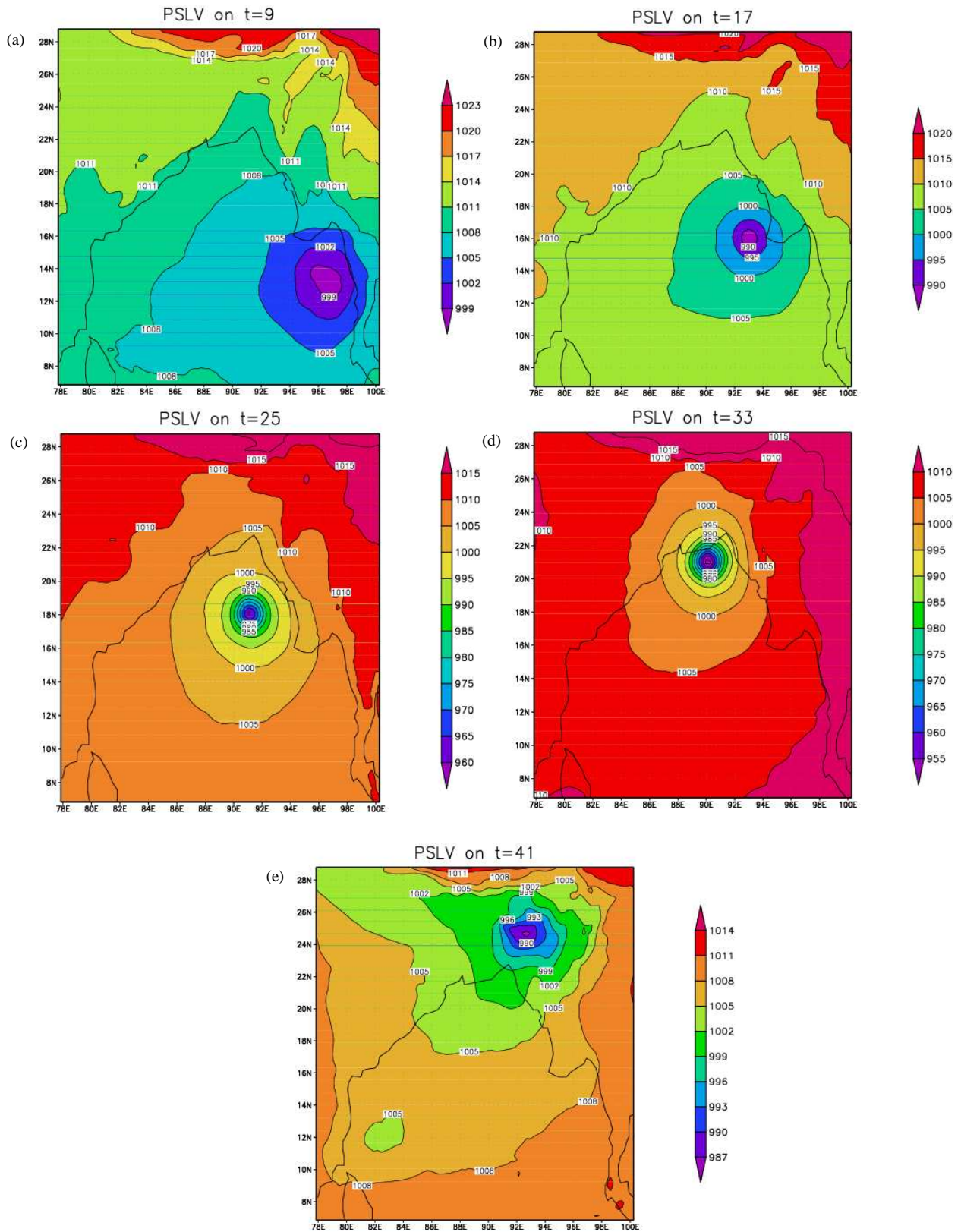
TABLE 1

The comparison of the positions of the center and the lowest values of central pressure of the cyclone

| Date | Time | Grell scheme | | | | | KF2 scheme | | | | | Actual position IMD | | |
|-----------|----------|-------------------|------------------|---------------------|---------------|-------------------------------------|-------------------|------------------|---------------------|---------------|------------------------------|---------------------|---------------------|---------------|
| | | Forecast position | Central pressure | Movement | | | Forecast position | Central pressure | Movement | | | Position | Movement | |
| | | | | Direction (Towards) | Distance (km) | Vector error (km) in Grell forecast | | | Direction (Towards) | Distance (km) | Vector error in KF2 forecast | | Direction (Towards) | Distance (km) |
| 25 Oct 99 | 0000 UTC | 11.5° N / 99.5° E | 1004 | --- | -- | 246 | 11.5° N / 99.5° E | 1004 | --- | -- | 246 | 12.5° N / 97.5° E | ---- | -- |
| 26 Oct 99 | 0000 UTC | 14.0° N / 96.0° E | 999 | 305 | 473 | 123 | 13.5° N / 96.0° E | 999 | 299/4 | 443 | 110 | 13.5° N / 95.0° E | 291/2 | 296 |
| 27 Oct 99 | 0000 UTC | 16.5° N / 93.5° E | 985 | 315/3 | 389 | 246 | 16.0° N / 93.0° E | 990 | 309/3 | 430 | 174 | 15.5° N / 91.5° E | 299/4 | 443 |
| 28 Oct 99 | 0000 UTC | 17.0° N / 88.0° E | 960 | 275/5 | 607 | 123 | 18.5° N / 91.0° E | 960 | 321/3 | 352 | 280 | 18.0° N / 88.5° E | 309/3 | 430 |
| 29 Oct 99 | 0000 UTC | 18.2° N / 84.5° E | 960 | 288/3 | 407 | 296 | 21.0° N / 90.0° E | 955 | 338/2 | 296 | 400 | 20.0° N / 86.5° E | 315/2 | 311 |
| 30 Oct 99 | 0000 UTC | 19.2° N / 83.0° E | 980 | 303/1 | 198 | 310 | 25.0° N / 93.0° E | 987 | 36/5 | 550 | 962 | 20.5° N / 85.5° E | 296/1 | 123 |



Figs. 2(a-e). Forecast position on successive days (26 to 30 October 1999) Grell scheme at 0000 UTC. (a) 24 hrs, (b) 48 hrs, (c) 72 hrs, (d) 96 hrs and (e) 120 hrs



Figs. 3(a-e). Forecast position on successive days (26 to 30 October 1999) Kain-Fritsch 2 cumulus parameterization scheme (a) 24 hrs, (b) 48 hrs, (c) 72 hrs, (d) 96 hrs and (e) 120 hrs

3. Methodology

The MM5 was run with two domains having resolutions 90 km for outer domain and 30 km for inner domain in the Bay of Bengal (area of cyclonic storm) respectively. The aim of the study is to understand the capabilities of the MM5 in generating forecast tracks of a tropical cyclone. For this the Grell and Kain-Fritsch 2 (with shallow convection) cumulus parameterization schemes were used separately to generate forecast tracks of the Orissa Super Cyclone 1999 between 0000 UTC, 25 October 1999 to 0000 UTC, 30 October 1999. Thus, one single initial condition was integrated for 120 hrs. Also lateral boundary conditions were also taken from the NCEP analysis interpolated to the boundaries of the domain of integration. The forecast tracks with an interval of 0300 hr were generated and studied. The various physics used in the study are as follows.

Explicit moisture scheme : Simple ice

Planetary boundary layer : MRF

Atmospheric radiation : Cloud

No shallow convection

4. Results and inferences

Using the above physics and methodology, it was found that when the cumulus parameterization schemes are changed, the track generated by the MM5 model is totally different. The actual track of the cyclone is shown in the Fig. 1. The some of the results of the MM5 study are shown in the Table 1. The positional difference of the centre of the cyclonic storm as per the NCEP analysis and actual position as per IMD was 246 km. In Grell scheme, the vector difference (distance) increased 310 km whereas in KF2 scheme, the difference increased to 962 km after 120 hrs. The Grell scheme indicated the forecast track slightly close to the actual track of the storm. The KF2 scheme led to the generation of the forecast track that indicated the re-curvature of the system in to West Bengal

and adjoining regions. The forecast track difference in both the schemes is mainly seen after 1200 UTC, 27 October 1999.

The forecast positions of the centre of the cyclone are depicted in the Fig. 2 and Fig. 3 for the Grell and Kain-Fritsch 2 cumulus parameterization scheme respectively. The forecast tracks generated by MM5 were almost same up to 0000 UTC / 27 October 1999 for both the schemes.

The Grell scheme generated track, indicated lowest pressure fall at the centre of the super cyclones 955 hPa on 0600 UTC / 28 October 1999. The landfall was indicated on 1200 UTC / 29 October 1999. The landfall is > 250 km south of the actual landfall track of the Orissa super cyclone.

The KF2 scheme also indicated the lowest pressure fall as 955 hPa 0600 UTC / 28 October 1999. The landfall was over West Bengal adjoining Bangladesh parts. The landfall track is totally different as per this scheme, when compared to actual track of the super cyclone.

5. Conclusion

The correct cumulus parameterization scheme is to be used for a reliable forecast through NWP. In the initial experiments by the IAF Met, it was found that the Grell cumulus parameterisation scheme could give the forecast track close to the actual track of a tropical cyclone. Out of two schemes used, both the cumulus parameterization schemes indicated maximum intensity of the super cyclone on 0600 UTC / 29 October 1999. However, more experiments are needed to establish a correct combination of the schemes to get accurate forecast tracks in case of a tropical cyclone.

References

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