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| WEATHER CLIMATE WATER | **World Meteorological Organization****COMMISSION FOR OBSERVATION, INFRASTRUCTURE AND INFORMATION SYSTEMS****Third Session**15 to 19 April 2024, Geneva | **INFCOM-3/Doc. 8.4(2)** |
| Submitted by:Chair of SC-ESMP5.III.2024**DRAFT 1** |

**AGENDA ITEM 8: TECHNICAL DECISIONS**

**AGENDA ITEM 8.4: WMO Integrated Processing and Prediction System**

# Update of the Guide to the WMO Integrated Processing and Prediction System (WMO-No. 305)

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| **Summary** |
| **Document presented by:** Chair of the Standing Committee on Data Processing for Applied Earth System Modelling and Prediction (SC-ESMP)**Strategic objective 2024–2027:** 2.3 Enable access to and use of numerical analysis and Earth system prediction products at all temporal and spatial scales from the WMO Integrated Processing and Prediction System**Financial and administrative implications:** within the parameters of the Strategic and Operating Plans 2024–2027.**Key implementers:** INFCOM and WIPPS Designated Centres**Time frame:** 2024–2027**Action expected:** review the proposed draft decision |

# DRAFT DECISION

## Draft Decision 8.4(2)/1 (INFCOM-3)

### Update of the Guide to the WMO Integrated Processing and Prediction System (WMO-No. 305)

**The Commission for Observation, Infrastructure and Information Systems decides:**

(1) To note that tropical cyclone low/cyclone vortex variables are introduced as mandatory and recommended products of WMO Integrated Processing and Prediction (WIPPS) Designated Centres conducting global deterministic and ensemble Numerical Weather Prediction (NWP);

(2) To introduce the guidelines for producing tropical low/cyclone vortex variable into the [Guide to WIPPS](https://library.wmo.int/records/item/28978-guide-to-the-wmo-integrated-processing-and-prediction-system) (WMO-No. 305), as per the [annex](#_Annex_to_draft_1) to this draft decision.

See the annex to the present decision.

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Decision justification:

[Resolution 1 (SERCOM-2)](https://library.wmo.int/viewer/39647/?offset=1#page=13&viewer=picture&o=bookmark&n=0&q=) – Updates to [the Manual on the Global Data-processing and Forecasting System](https://library.wmo.int/records/item/35703-manual-on-the-wmo-integrated-processing-and-prediction-system) (WMO-No. 485) proposed by the SERCOM standing committees, recommending INFCOM to update and classify the tropical cyclone tracks’ output of deterministic and ensemble of both global and limited-area NWP models as mandatory products,

Draft recommendation 8.4(1)/1 (INFCOM-3) - Amendments to the [*Manual on the WMO Integrated Processing and Prediction System*](https://library.wmo.int/records/item/35703-manual-on-the-wmo-integrated-processing-and-prediction-system?offset=2) (WMO-No. 485) for weather prediction, proposing the new list of tropical low/cyclone vortex variables into the Manual as mandatory and recommended products of the WIPPS Designated Centres for global deterministic and ensemble NWP.

## Annex to draft Decision 8.4(2)/1 (INFCOM-3)

## Guidelines for producing tropical low/cyclone vortex variables

2.3.1.1 Global deterministic numerical weather prediction

2.3.1.1.1 General summary of the Regional Specialized Meteorological Centre’s activity

Numerical weather prediction (NWP) skill has significantly improved since around the year 2000 and NWP data and products are essential for various activities. To maintain global deterministic NWP operational, considerable resources are necessary. Therefore, at the sixty-ninth session of the WMO Executive Council (EC-69) in 2017 (when the *Manual on the WIPPS* was thoroughly revised) global deterministic NWP was established as an activity conducted by RSMCs within the framework of the WIPPS, the purpose being to make quality-assured global deterministic NWP data and products available to all WMO Members.

Note: Prior to EC-69 (2017), some global NWP data and products were made available by the WMCs and a few RSMCs with geographical specialization, but without a consistent approach.

RSMCs conducting global deterministic numerical weather prediction are responsible for providing global analyses of the three-dimensional structure of the atmosphere and global forecast fields of basic and derived atmospheric parameters, generated from their own global deterministic numerical weather prediction systems, along with associated and standardized verification statistics.

1. Designated centres and work modality

The list of designated RSMCs conducting global deterministic numerical weather prediction is provided in the *Manual on the WIPPS*, Part III.

Each of these RSMCs provides data and products with global coverage. Guidelines for producing tropical cyclone low/cyclone vortex variables are provided in Appendix 2.3. No coordination among RSMCs is required. RSMCs are required to send verification statistics to the Lead Centre for deterministic numerical weather prediction verification (LC-DNV).

1. How National Meteorological Centres can benefit from and/or contribute to Regional Specialized Meteorological Centres

NMCs can access data and products made available by RSMCs conducting global deterministic numerical weather prediction through the WIS. The WIS metadata associated with each data and product file is accessible [here](https://wmo.maps.arcgis.com/apps/dashboards/7c3d45e5003a417988bad63e91ad8748) where users can select “Global deterministic numerical weather prediction” from the list of activities.

NMCs are encouraged to contribute to the activities of the RSMCs by, but not limited to: (a) performing objective verification of and providing feedback on the performance of the respective models used in their countries; (b) conducting case studies of specific events and sharing this information with the RSMCs; (c) collaborating with the RSMCs, based on the verification results, on specific model developments; and (iv) providing additional observational data for assimilation into the models.

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2.3.1.3 Global ensemble numerical weather prediction

2.3.1.3.1 General summary of the Regional Specialized Meteorological Centre’s activity

Ensemble NWP, in which the numerical model is run many times with slightly different initial conditions, provides a much more complete forecast picture than deterministic NWP, including estimates of uncertainty and probabilities of possible extremes or high-impact events. To maintain global ensemble NWP operational, considerable resources are necessary. Therefore, at the sixty-ninth session of the WMO Executive Council (EC-69) in 2017, global ensemble NWP was established as an activity conducted by RSMCs within the framework of the WIPPS, the purpose being to make quality-assured global ensemble NWP data and products available to all WMO Members.

RSMCs conducting global ensemble numerical weather prediction are responsible for providing global forecast fields of summary ensemble statistics for selected atmospheric parameters, generated from their own global ensemble NWP systems, along with associated and standardized verification statistics. Ensemble mean and spread products provide a summary of the predictable scales of synoptic evolution, while the ensemble spread indicates areas for greater confidence or significant uncertainty. Ensemble probabilities provide valuable alerts to risks of severe or potentially high-impact weather.

1. Designated centres and work modality

The list of designated RSMCs conducting global ensemble numerical weather prediction is provided in *the Manual on the WIPPS*, Part III.

Each of these RSMCs provides data and products with global coverage. Guidelines for producing tropical cyclone low/cyclone vortex variables are provided in Appendix 2.3. No coordination among RSMCs is required. RSMCs are required to send the verification results to the Lead Centre for ensemble prediction system verification.

1. How National Meteorological Centres can benefit from and/or contribute to Regional Specialized Meteorological Centres

NMCs can access data and products made available by RSMCs conducting global ensemble numerical weather prediction through the WIS. The WIS metadata associated with each data and product file is accessible through the [WIPPS Web Portal](https://community.wmo.int/en/wipps-web-portal), by selecting “Global ensemble numerical weather prediction” from the list of activities.

NMCs are encouraged to contribute to the activities of the RSMCs by, but not limited to: (a) performing objective verification of and providing feedback on the performance of the respective ensembles used in their countries; (b) conducting case studies of specific events and sharing this information with the RSMCs; (c) collaborating with the RSMCs, based on the verification results, on specific model developments; and (d) providing additional observational data for assimilation into the models.

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Appendix 2.3. GUIDELINES FOR PRODUCING TROPICAL LOW/CYCLONE VORTEX VARIABLES

To facilitate the provision of products of tropical low/cyclone vortex variables (hereafter, TC vortex products) generated using the same methods, the RSMCs for global deterministic and ensemble NWP are advised to adopt the following guidelines:

1. **Identifying Tropical Cyclones in NWP Grids**

Vortex parameter data is post processed from direct model output and is expected to include vortices of tropical cyclones that exist at analysis time or form in the forecast time range. In this context, tropical cyclone is a generic term for a non-frontal synoptic scale low pressure system which has a cyclonic wind circulation and does not refer to its intensity or strength. Regional examples of tropical cyclones include tropical low, tropical depression, tropical storm, tropical cyclone, cyclonic storm, typhoon, and hurricane. The presence and position of a tropical cyclone in the NWP gridded data is a fix. A time series of fixes is a track.

The method used to determine the presence of a tropical cyclone in NWP grids should try to filter out shallow heat/thermal lows and shallow weak circulations. The ECMWF tracker has proven to be effective in this, which is to include a check on 850hPa vorticity and the presence of a warm core.

If using 850hPa vorticity, one thing to consider is the grid resolution which has an impact on the calculated values. To avoid small-scale features being identified, vorticity calculations can be done using a coarse grid or by applying a spatial average.

1. **Tropical Cyclone Identifiers in BUFR Format**

In the BUFR file format for tropical cyclone vortex parameter data, different cyclone tracks are identified using the “stormIdentifier” and “longStormName” fields. The storm identifier is a 4-character string, with the first 3 characters being numbers and the last being a capital letter. The long storm name is a string.

These fields should be used with the following convention:

* If there is an analysis position from an RSMC together with a Tropical Cyclone Warning Centre (TCWC) with a WMO Storm Identifier, then the stormIdentifier should be this identifier (e.g. 02W becomes 002W) and the longStormName should be the name. The RSMC basins are W,E,C,L,A,B,S,P, F,U,O,T:
	+ W Northwest Pacific Ocean
	+ E Northeast Pacific Ocean to 140oW
	+ C Northeast Pacific Ocean 140oW - 180oW
	+ L North Atlantic Ocean, including the Caribbean and the Gulf of Mexico
	+ A North Arabian Sea
	+ B Bay of Bengal
	+ S South Indian Ocean
	+ P South Pacific Ocean
	+ F RSMC Nadi’s zone in the South Pacific
	+ U Australia
	+ O South China Sea
	+ T East China Sea
* If there is not an analysis position from an RSMC and there is an analysis position from a Joint Typhoon Warning Centre (JTWC) with an invest or storm identifier (e.g. 93P.INVEST or 09P.NINE) and the tracking agency chooses to include these analysis positions, then the stormIdentifier should be the number (e.g. 093P or 009P) and the longStormName should be name part of the identifier (e.g. INVEST or NINE). Invest numbers have the range of 90 to 99. The letter in the invest number indicates the basin. The JTWC basins are L, E, C, W, A, B, S, P:
	+ **L Atlantic**
	+ **E Eastern Pacific**
	+ **C Central Pacific**
	+ W **Western Pacific**
	+ **A Arabian Sea**
	+ **B Bay of Bengal**
	+ S **South Indian Ocean (20**o**E - 135**o**E)**
	+ **P South Pacific (135**o**E - 120**o**W)**
* If there is no analysis position from an RSMC or a JTWC, then the stormIdentifier should be a number in the range 100 to 999 and the letter should be the basin (e.g. 101A). The longStormName should be the same as the stormIdentifier or null. The basin should be based on the position of the first fix of the track. The basins are defined in the following table.

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| **Basin Name**  | **Letter**  | **Domain**  |
| North Indian Ocean | *A* | 20°E to 78°E, north of the Equator |
| North Indian Ocean | B | 78°E to 100°E, north of the Equator |
| North West Pacific | W | 100°E to 180°E, north of the Equator |
| North Central Pacific | C | 180°E to 220°E, north of the Equator |
| North Eastern Pacific | E | 220°E to north Pacific to north Atlantic cut over line, north of the Equator |
| North Atlantic | L | north Pacific to north Atlantic cut over line to 20°E, north of Equator |
| Southern Indian Ocean | S | 20°E to 90°E, south of the Equator |
| Australia | U | 90°E to 160°E, south of the Equator |
| South Pacific | F | 160°E to 240°E, south of the Equator |

The north Pacific to north Atlantic cut-over line is defined as (90.0N, 260.0E) to (20.0N, 260.0E) to (13.0N, 275.0E) to (9.0N, 277.0E) to (8.5N, 279.0E) to (9.0N, 281.5E) to (5.0N, 285E) to (0.0N, 285.0E).

1. **Parameter Calculation**
2. Location of the vortex centre

This should be the position of the minimum mean sea level pressure estimated from the grid at 0.1 degree precision.

1. Maximum sustained 10m wind speed

The method to determine this parameter for a time is to find the maximum wind speed in the grid for that time, within 500 km distance of the vortex centre.

The sustained wind speed is a direct model output and represents the value averaged over a period and over the grid box size. This means the wind averaging period may not be precisely 1 or 10 minutes. The maximum sustained value is not a gust value.

1. Location of maximum sustained 10m wind speed

This parameter is the latitude and longitude of the maximum sustained 10m wind speed found using the above method.

1. Minimum Mean Sea Level Pressure

Minimum mean sea level pressure of the grid cell (or nearest grid cell) from which the location of the vortex centre was determined. The value should be an actual grid value, not estimated using extrapolation.

1. Wind Radii

For each quadrant, the radius of the near maximum extent, but not including transient or isolated features, of wind speeds greater than or equal to the threshold that are part of the mean circulation. The quadrants are, in a clockwise direction, north to east, east to south, south to west, west to north.

The algorithms used in synthetic aperture radar (SAR) wind processing and the latest version of the Geophysical Fluid Dynamics Laboratory (GFDL) tracker use the 95th percentile to determine near maximum radius.

1. Average Steering Wind

The intent is to be able to calculate shear from these steering winds. The recommended method is for the zonal (u) and meridional (v) velocities at each pressure level to be the average value over grid cells within 500 km of the low-level centre after a vortex removal method has been applied.

Other methods may be used. The method should be described in the characteristics of the products (see Appendices 2.2.2 and 2.2.6 of the Manual on the WIPPS (WMO-No. 485)). Different distance values and vortex removal methods result in different steering wind values and therefore different shear values. If different guidance sources use different values or methods, then directly comparing values between the guidance sources may be mis-leading.

The method outlined below is based on the SHIPS vertical wind shear calculation method, which is a more up-to-date version than the one described in Knaff et al. (2009) cited in Kaplan et al. (2010).

1. Remove the symmetric vortex relative to the model vortex location.
2. Find the vortex position at 850hPa that maximizes the symmetric tangential wind, radially averaged from 0 to 500km. Start with a first guess of the surface vortex position.
3. Subtract the azimuthally averaged tangential and radial wind from the total wind field at the 850hPa, 500hPa and 200hPa levels, using the vortex position at 850hpa.
4. Subtract the averaged wind out to a radius where the azimuthally averaged tangential wind is at least 2 m/s. That radius is nearly always much larger at the low levels than upper levels and sometimes nothing is removed at the lower pressures.
5. Calculate the area average of the u and v components at the 850hPa, 500hPa and 200hPa levels from 0 to 500km centred on the surface vortex position.
6. **Reference**
* Kaplan, J., M. DeMaria, and J. A. Knaff, 2010: A Revised Tropical Cyclone Rapid Intensification Index for the Atlantic and Eastern North Pacific Basins. Wea. Forecasting, 25, 220–241, <https://doi.org/10.1175/2009WAF2222280.1>.
* Knaff, J. A., DeMaria M., and Kaplan J., cited. 2009: Improved statistical intensity forecast models. National Hurricane Center. [Available online as the final report (<https://www.nhc.noaa.gov/jht/05-07reports/final_Knaffetal_JHT07.pdf>) at <http://www.nhc.noaa.gov/jht/05-07_proj.shtml>].

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