*International Civil Aviation Organization*

**INFORMATION PAPER(IP/12)**

**ICAO ASIA AND PACIFIC (APAC)
THIRTIETH MEETING OF THE METEOROLOGY SUB-GROUP (MET SG/30)**

Bangkok, Thailand, 20 - 24 July 2026

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**Agenda Item 8: Research, Development and Other Initiatives**

# FINE-SCALE WIND FIELD FORECASTING TO ENHANCE AIRPORT OPERATIONAL EFFICIENCY

(Presented by China)

**SUMMARY**

This paper presents the development of an intelligent forecasting equation for mid-and low-level wind fields at coastal airports in East China, which is applied to airport wind field forecasting. It delivers high-resolution regional wind field forecast products and strong wind alerts for aviation stakeholders. Furthermore, it generates decision-support products for air traffic controllers regarding runway configuration changes and aircraft arrival/departure scheduling. For airport management authorities, it provides supporting products covering passenger boarding bridge management and ground vehicle movement control under high-wind conditions. The implementation of the above solutions improves flight safety and air traffic control efficiency, while reducing carbon emissions to a certain degree.

## 1. INTRODUCTION

1.1 Demand for accurate short-range nowcasting keeps increasing across industrial production and scientific research sectors; nevertheless, high-precision short-range forecasting remains a prominent technical challenge for the industry. The model utilized in this paper incorporates supplementary wind field observation data alongside conventional radar input datasets. Field verification tests indicate that the integration of wind field information delivers a notable improvement in the accuracy of radar extrapolation forecasts.

1.2 Integrating wind field models provides aviation users with refined regional wind field products, along with strong wind warnings that significantly affect aircraft parking, take-off and landing.

## 2. DISCUSSION

2.1 Using 2025 wind speed forecast data for East China, we downscale the forecast datasets from coarse grids to unified hourly fine grids, with horizontal resolutions of 0.125° for surface layers and 0.25° for upper-air layers. A comparative analysis of various interpolation algorithms is performed to select the optimal algorithm as the data processing scheme. Meanwhile, observational data from civil aviation airports and high-resolution terrain data for East China are introduced to correct the downscaling results via multiple linear regression. The corrected results are then incorporated into a multi-model ensemble forecasting algorithm, which fuses local observational data with forecast products to establish an intelligent forecasting equation for mid- to low-altitude wind fields over the

Shanghai airport area.

2.2 Low-level wind shear triggered by sea breeze fronts primarily manifests as headwind shear, tailwind shear or crosswind shear. To simplify the theoretical model, the impacts of sea breeze fronts on flight operations are analyzed under two separate scenarios: runway alignment parallel to sea breeze, and runway alignment perpendicular to sea breeze. In reality, an angular difference may exist between runway orientation and sea breeze direction, and the wind vector can be resolved into the above two components for analysis.

2.3 Based on the theoretical model of sea-breeze-front low-level wind shear, this study examines the angular relationship between sea breeze and runway alignment at Shanghai Hongqiao International Airport and Shanghai Pudong International Airport. Sea breezes are resolved into runway-parallel and runway-perpendicular wind components. The abrupt shift to onshore winds or the pronounced increase in onshore wind speed at the aerodrome surface is taken as the characteristic indicator marking the onset of sea breeze front influence on the aerodrome, to investigate the characteristics of sea-breeze-front-induced low-level wind shear.

2.4 In accordance with the diurnal variation characteristics of runway winds at Shanghai aerodromes, the correlation between runway changes and runway wind fields is statistically analyzed, thresholds for strong wind alerts at the aerodrome surface are proposed, and decision-support products for air traffic controllers to adjust runway operational directions are delivered.

2.5 In light of aircraft arrival/departure flight procedures and approach controller operational workflows, historical meteorological data are utilized to analyze the impacts of vertical distribution of low-level wind fields in different terminal airspace segments on approaching aircraft. Support products for scheduling during aircraft take-off and landing phases are researched and developed accordingly.

2.6 The operational procedures and regulations governing aerodrome surface movement are examined to establish windfield thresholds relevant to surface operations. Probabilistic analysis of forecast wind field data yields two indices: one for surface vehicle operations and one for passenger boarding bridge susceptibility to strong winds, which collectively underpin a high-wind warning product for surface movement. Furthermore, meteorological support products for boarding bridge allocation are developed, taking into account both the forecast evolution of aerodrome wind direction and ATC rules for runway direction changes. These products facilitate proactive planning of boarding bridges adjacent to the runway touchdown zone, thereby reducing aircraft ground-roll distance and fuel consumption.

2.7 A dedicated terminal airspace warning system shall be developed, whose core functions cover runway wind components, runway centreline, successive approach waypoints, horizontal wind field, vertical wind field and sea breeze circulation.

Display Functions for Air Traffic Control Users

2.8 Area Control Users: Turbulence is displayed on the interface using existing upper-air wind field products. When the jet-stream core at a given altitude intersects an air route, the corresponding altitude band is highlighted in red as an alert. Horizontal wind fields above 3,000 m are shown at vertical intervals of 300 m or 600 m. Jet-stream cores and strong wind zones are outlined in the same format as turbulence areas on Significant Weather Prognostic Charts.

2.9 Tower Control Users: A sliding control on the runway wind component interface enables controllers toview wind direction and speed forecasts across different time frames. This covers two scenarios within the next 6 to 24 hours: frequent wind shifts, and significant veering or backing events.

2.10 Approach Control Users: Dedicated display panels present wind direction and speed at various altitudes along the five-segment approach path to provide controllers with direct, intuitive visibility of detailed wind parameters for each approach segment.

Display Functions for Aerodrome Operators

2.11 The alert index for aerodrome surface vehicle operations and the index indicating passenger boarding bridge susceptibility to high winds for multiple forecast time horizons shall be displayed, with index values differentiated by distinct aerodrome zones. High wind warning products for aerodrome surface movement shall be presented with warning levels classified by aerodrome sub-areas; alerts are further categorized according to vehicle types for various working positions or boarding bridge types.Forecast runway operational directions over different time periods shall be shown, with recommended boarding bridge parking zones highlighted.

## 3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper

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