



**WORKING PAPER**

**WORLD AREA FORECAST SYSTEM OPERATIONS GROUP (WAFSOPSG)**

**FOURTH MEETING**

**Cairo, Egypt, 26 to 28 February 2008**

**Agenda Item 6: Development of the WAFS**

**6.5: Visualization of WAFS forecasts in flight documentation**

**IMPROVING VISUALIZATION OF WAFS FORECASTS**

(Presented by China, Rapporteur of Ad Hoc Group)

**SUMMARY**

This paper presents the results of a study on how the visualization of WAFS forecasts could be improved to ensure that the most relevant WAFS forecasts would be presented in terms of space and time in the flight documentation, in particular for long-haul flights.

**1. INTRODUCTION**

1.1 At WAFSOPSG/3, the group considered a proposal to join several subsequent fixed time WAFS forecasts of the same product and level so that the information provided on one such concatenated chart would be relevant and consistent for the entire period of the flight concerned, especially for the increasing number of long-haul flights with duration more than fifteen hours. The group also noted that the formalized use of such concatenated WAFS charts, if endorsed by the users, would require modifications of the WAFS visualization workstation software for processing both BUFR- and GRIB-coded WAFS forecasts, as well as the development of the necessary Annex 3 provisions. In this connection, the group formulated Conclusion 3/19 calling for the WAFSOPSG Members from China (Rapporteur), France and Oman, in coordination with the WAFSOPSG Members from IATA, IFALPA and WMO, to study how the visualization of WAFS forecasts could be improved to ensure that the most relevant WAFS forecasts be presented in terms of space and time in the flight documentation; and report the results thereof to the WAFSOPSG/4 Meeting for final assessment. It was noted that the visualization of gridded products for icing, turbulence and convective clouds will be addressed in response to Conclusion 3/13 and does not need to be dealt with under this context.

1.2 This paper presents the results of the study by the ad hoc group.

## 2. DISCUSSIONS

2.1 In the proposal considered by WAFSOPSG/3, an example of joining three wind/temperature charts of the same level from the T+12 h, T+18 h and T+24 h forecasts based on the same model run/initial time and an example of joining three T+24 h SIGWX charts based on three different initial times separated by six hours (Appendix 1) were shown. The ad hoc group observes that, for the concatenated wind/temperature chart, some wind/temperature information could be missing at the grid points where two charts join, whereas for the concatenated SIGWX chart, discontinuities in the SIGWX features (e.g. jet streams, CB cloud and CAT areas) are observed. These discontinuities should be considered with care as users might not be able to get a clear understanding of the meteorological situation from the concatenated SIGWX chart, especially while crossing the seams of the joined chart. The green ellipses on the concatenated SIGWX chart example given in Appendix 1 show cases of significant data of one sub-chart being overlapped by an adjacent sub-chart. To try to partially resolve this problem, it would be necessary to modify workstation software so that the edges of each sub-chart would not cut across text boxes.

2.2 Despite these observations, Oman had coordinated with the Dubai Meteorological Office on the above subject and a trial was run with the Emirates Airline on the daily flight from Dubai to Sydney for a period of two months. The feedback received was generally very positive. The idea, format and layout of the charts with three validity time zones were generally accepted as a useful concept. No complaints from any pilot were received during the two-month trial.

2.3 In view of the above observations and user's feedback to the proof-of-concept trial on the use of concatenated charts, the ad hoc group supports that spatial and temporal linear interpolation could be used for generating a route-specific wind/temperature chart from data from consecutive forecast hours in a seamless manner (example and procedures given in Appendix 2). Even though such interpolation might smooth out some smaller scale features (which could be mitigated by increasing the temporal resolution of the WAFS gridded forecasts from 6 hours to 3 hours), the ad hoc group considers that the information provided by this space/time interpolated chart is equivalent to the overall picture that the pilots could derive manually by comparing the information from the individual wind/temperature charts. Using this spatial and temporal linear interpolation, time-lagged wind/headwind forecasts for the flight route (example and procedures given in Appendix 3) could also be generated to assist in flight planning by the pilots to cater for uncertainties in the flight time, e.g. due to air traffic or weather delays. Other more sophisticated interpolation schemes, e.g. 4-dimensional tension spline interpolation, may also be used for the space/time interpolation.

2.4 For SIGWX, on the other hand, it is apparent that insufficient data is available for interpolating the SIGWX features from the different forecasts. Using the SIGWX example in Appendix 1, it is not clear whether the jet stream at FL340 near 45° N 30° W on the chart valid at 1800, or the one further north at FL310, should connect with the jet stream at FL320 on the chart valid at 1200. Nevertheless, it appears that the above-mentioned interpolation procedures for generating concatenated route-specific wind/temperature chart from data from consecutive forecast hours could be similarly applicable to the gridded SIGWX forecasts of turbulence, icing and convective cloud, even though such SIGWX features might be associated with sub-grid scale physical processes. If this is indeed feasible, the concept of concatenated route-specific wind/temperature and gridded SIGWX forecast charts could also be extended to all available vertical levels so that route-specific vertical cross-sectional forecast chart could be generated. Indeed such charts are already being provided by some MET offices in support of flight planning operations of airlines (see example in Appendices 4 and 5).

2.5 Based on the above discussions and the positive users' feedback received from the proof-of-concept trial on the use of concatenated charts, the WAFSOPSG might wish to support formulating the following conclusion:

**Conclusion 4/.. — Use of concatenated WAFS forecasts in particular for long-haul flights**

That,

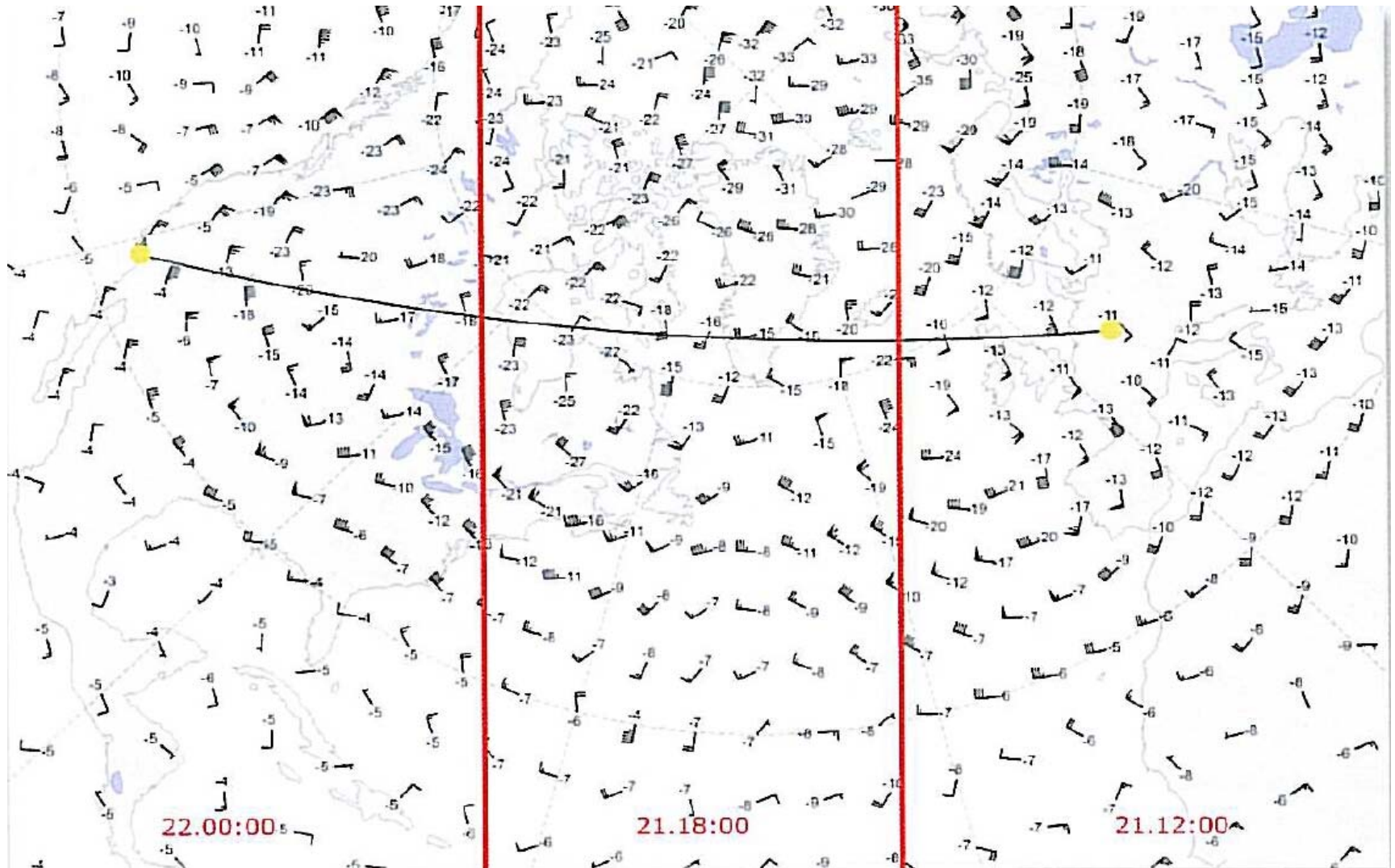
- a) the ICAO Secretariat, in coordination with WMO, be invited to develop Annex 3 provisions to enable the provision of concatenated route-specific wind/temperature forecasts generated preferably from interpolating data from consecutive forecast times, for review by the WAFSOPSG/6 Meeting; and
- b) the WAFC Provider States be invited to study if the interpolation could similarly be applied to the gridded SIGWX forecasts and report back to the WAFSOPSG/5 Meeting.

**3. ACTION BY THE WAFSOPSG**

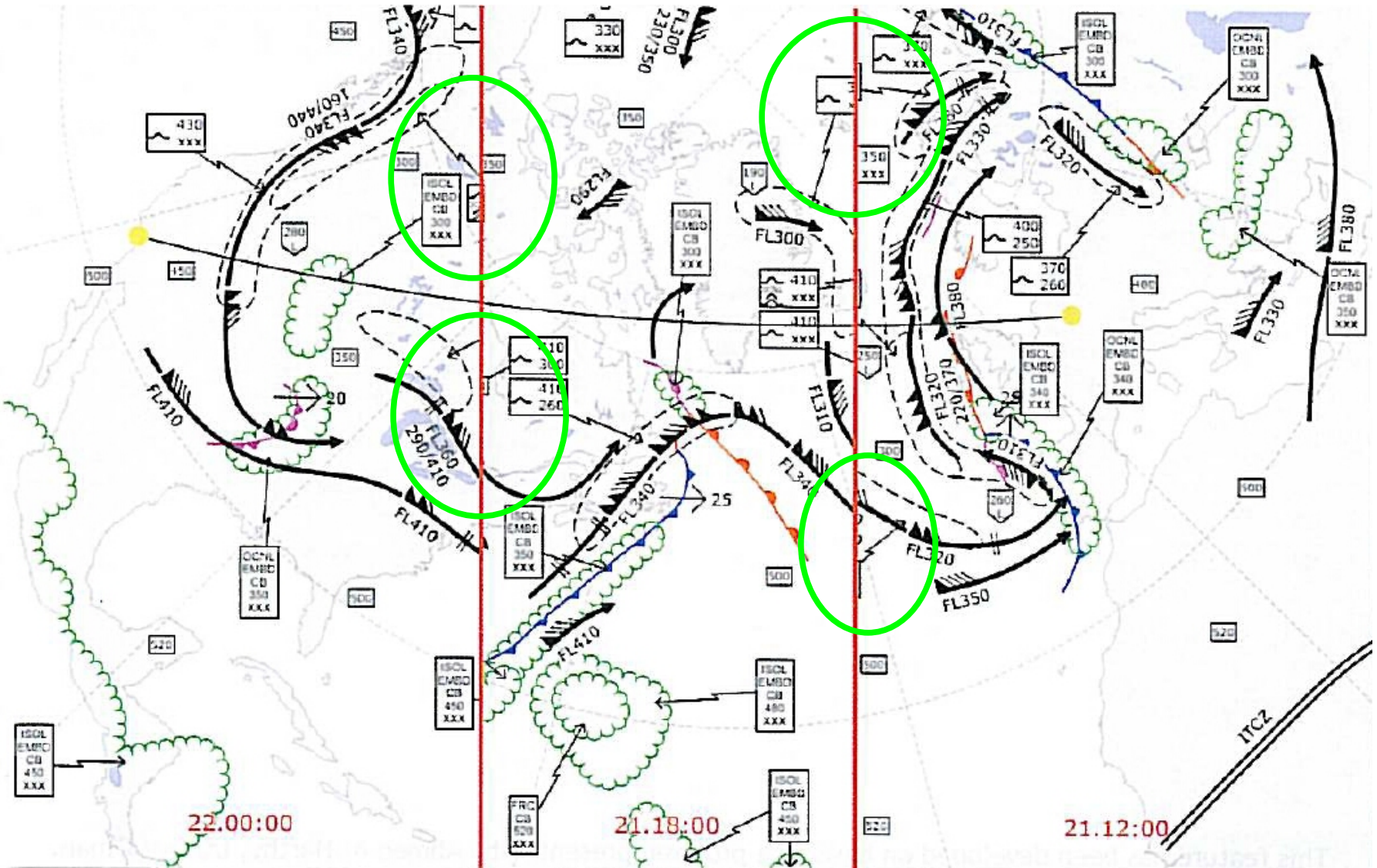
3.1 The WAFSOPSG is invited to:

- a) note the information in this paper; and
- b) decide on the draft conclusion proposed for the group's consideration.

-----

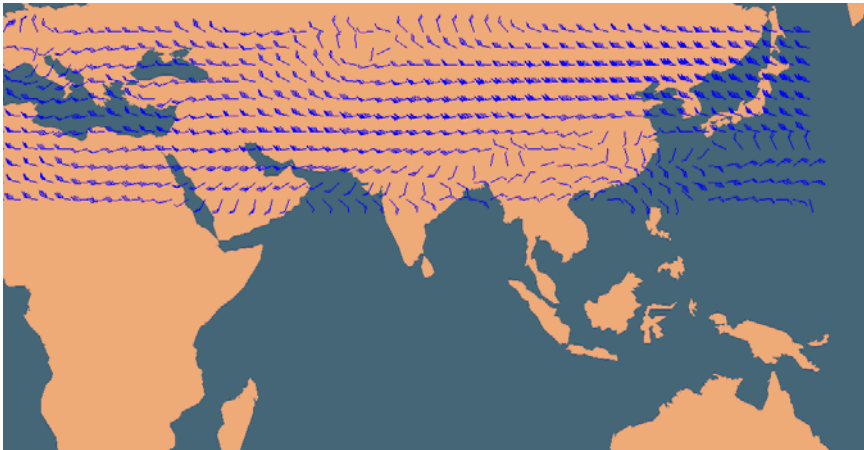


Example of joining WAFS wind/temperature forecasts

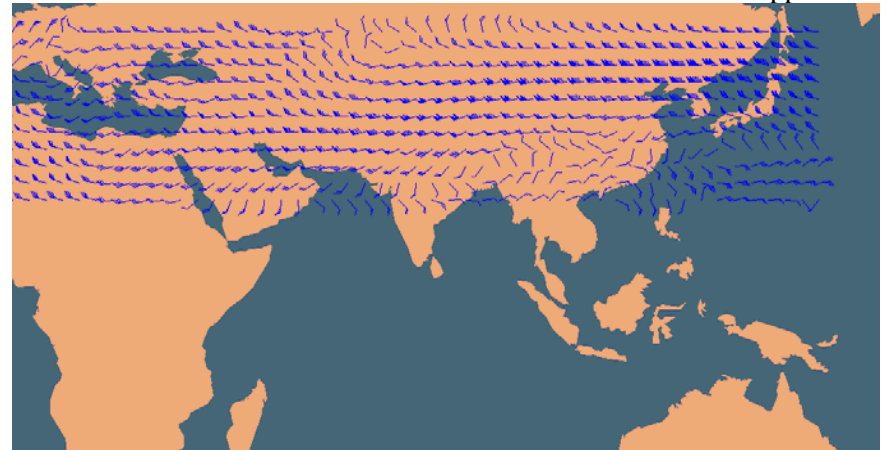


Example of joining WAFS SIGWX forecasts

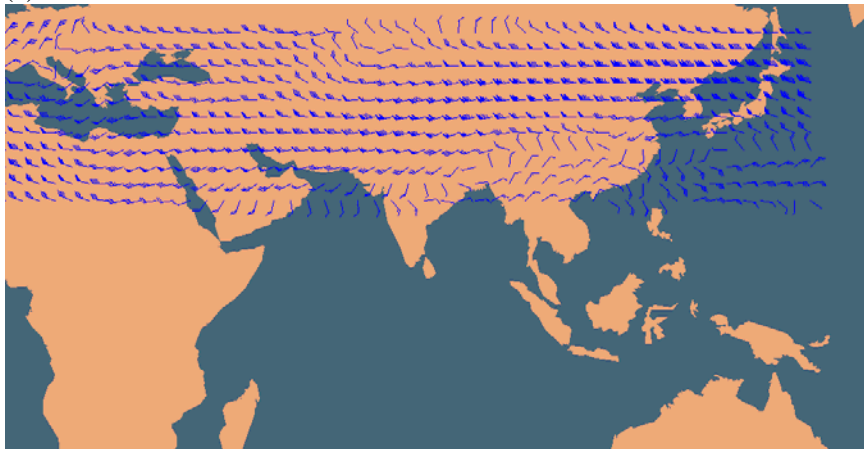




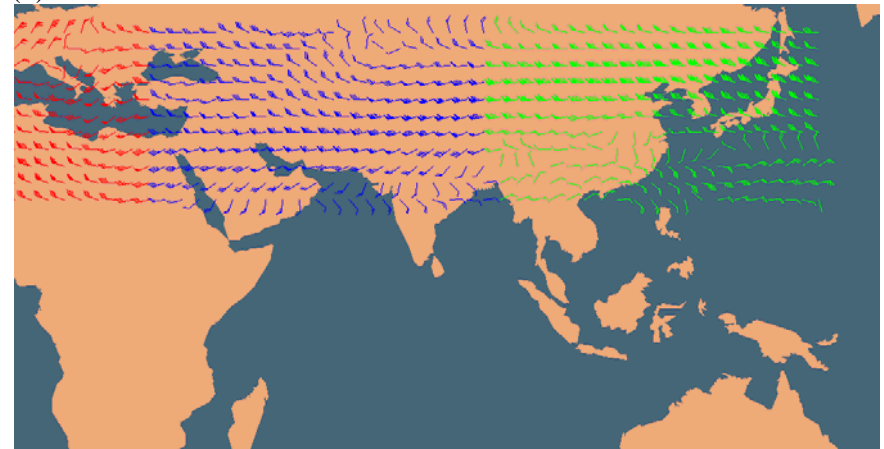
(a)



(b)



(c)



(d)

- (a) T+12 h WAFc London wind forecast for FL390 based on 20071010 00 UTC
- (b) T+18 h WAFc London wind forecast for FL390 based on 20071010 00 UTC
- (c) T+24 h WAFc London wind forecast for FL390 based on 20071010 00 UTC
- (d) Joining forecasts from (a), (b) and (c) based on the method in Appendix 1 for a hypothetical flight route from VHHH to LIRF

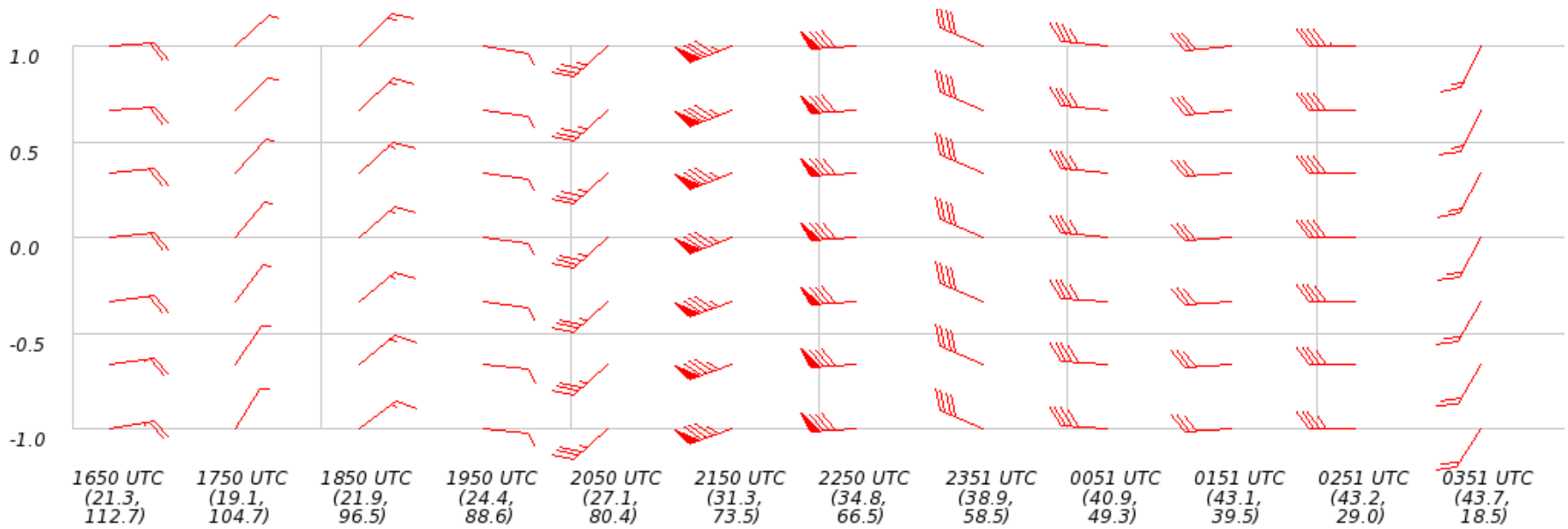


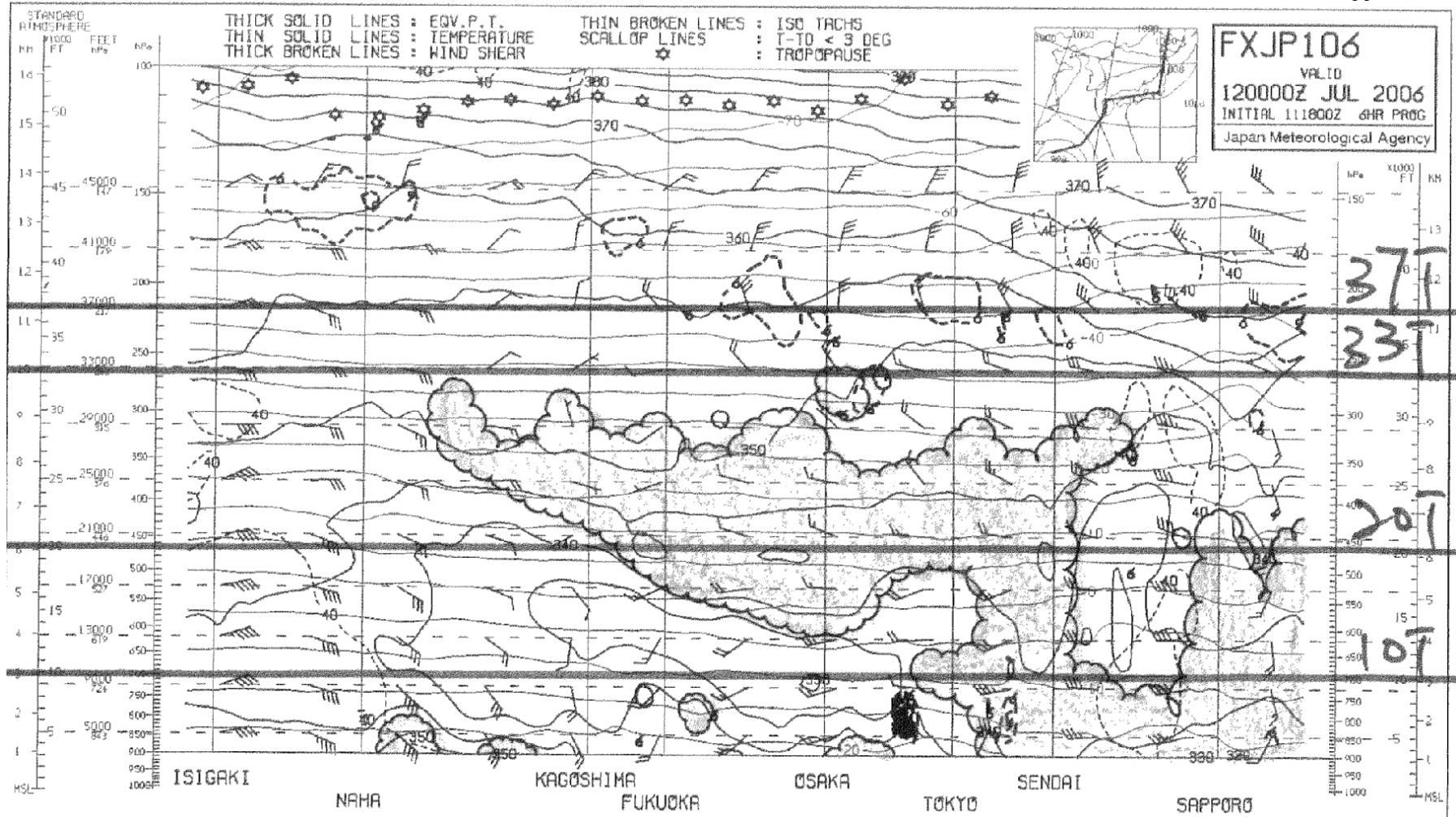
- (e) Route-specific concatenated WAFC London wind forecast chart at FL390 based on 20071010 00 UTC generated for the hypothetical flight route from VHHH to LIRF based on the following procedures:
- (i) the flight route is defined by a set of waypoints, where the aircraft is required to transit at specified hours during the flight. Given the departure time and for a typical ground speed, a sequence of fixed points with known times of transit, say at one hour interval, along the en-route portion of the route could be determined. These fixed points are referred to as the “skeleton points” below,
  - (ii) based on the skeleton points and taking account of possible deviations during the actual flight (e.g. to avoid SIGWX), a “route ribbon” could be constructed by tracing the 1-hour projected aircraft position in the forward 60 degree direction from each skeleton point

- (marked as white arcs in (e)),
- (iii) sampling points are selected evenly within the “route ribbon” and the WAFS grid-point data from the two forecast times nearest the transit time at each sampling point are then interpolated using linear interpolation scheme in both space and time to obtain the best estimate of the parameter at the time and location of the sampling point,
  - (iv) in case of overlapping of sampling points near sharp turns in the flight route, thinning would be needed to avoid cluttering.



Time-lagged WAFC London wind forecast chart at FL390 based on 20071010 00 UTC generated for the hypothetical flight route from VHHH to LIRF (vertical axis indicates the number of hours from the time of departure) by interpolating the WAFS grid-point data onto a set of time-shifted ( $\pm 1$  hour in this example) skeleton points.

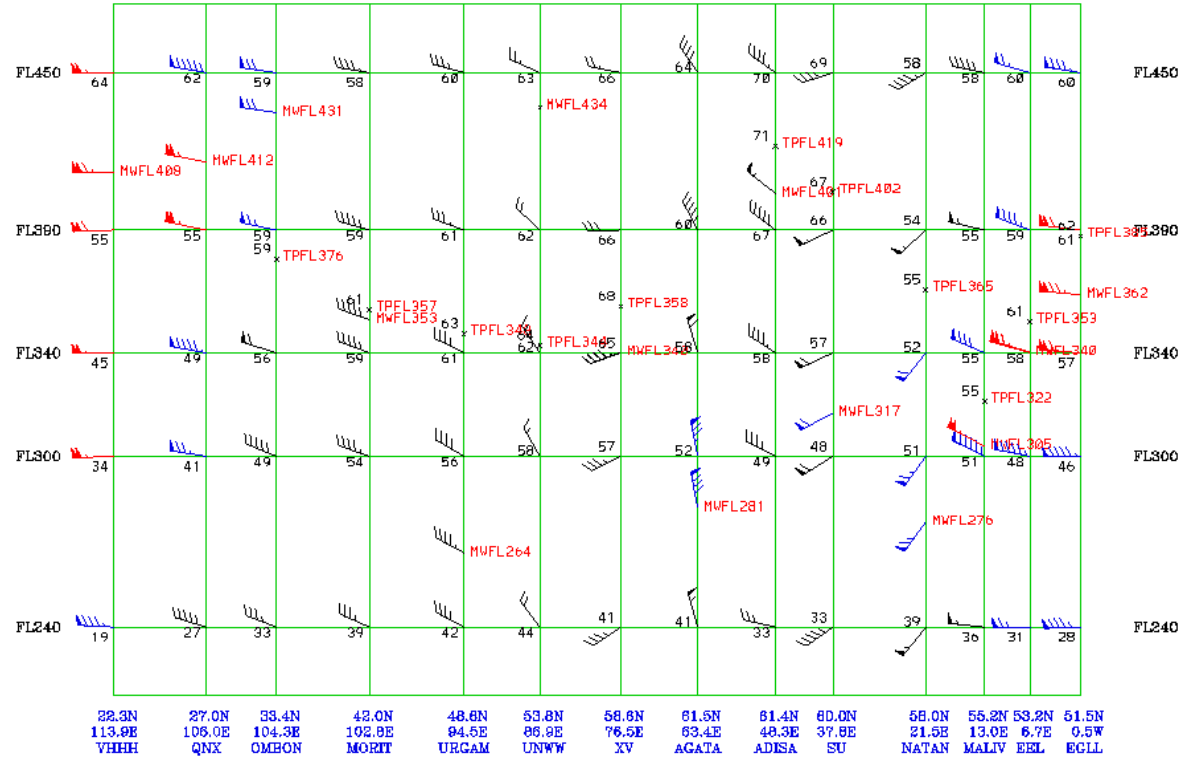




Route-specific vertical cross-section forecasts of wind, temperature and other meteorological parameters issued by JMA for airlines.

SPACE-CROSS SECTION  
ROUTE VHHH  
EGLL  
VALID 18 UTC 06 DEC 07

ISSUED BY HONG KONG OBSERVATORY  
BASED ON WORLD AREA FORECAST CENTRE LONDON  
DATA TIME 18 UTC 05 DEC 07  
Units wind speed in knots  
temperature in degree C negative  
unless prefixed by +  
altitudes in flight levels



Note:

a. Wind barbs will be shown in the following color according to the wind speed:

- black: 0 - 60kt;
- blue: 60 - 100kt;
- red: > 100kt

b. when wind information is not available, there will be a "x" label;  
c. height of maximum wind will be labeled by MWFLxxx; and  
d. height of tropopause level will be labeled by TPFLxxx.

Route-specific vertical cross-section forecasts of wind, temperature, maximum wind and tropopause flight levels issued by HKO for airlines.