航空氣象現代化系統
The Advanced Operational Aviation Weather System (AOAWS)

氣象產品手冊
Meteorological Products Manual

交通部民用航空局

Civil Aeronautics Administration (CAA)

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Table of Contents

1 目的及其涵蓋之範圍 (Purpose and Scope)

航空氣象現代化系統 (AOAWS) 氣象產品手冊 (以下簡稱本手冊)之目的為介紹民用航空局「航空氣象現代化計畫」中各項顯示系統的氣象產品，AOAWS 主要的顯示系統為 JAVA 版多元化氣象產品顯示系統（JAVA based Multi-dimensional Display System，JMDS）。

The goal of the Advanced Operational Aviation Weather System (AOAWS) "Meteorological Products Manual" is to introduce each weather product presented for display in the AOAWS Project for the Civil Aeronautics Administration (CAA). The main display for the AOAWS system is the Java-based Multi-dimensional Display System (JMDS).

MDS/JMDS 顯示的氣象產品包括即時觀測資料與預報資料：

即時觀測資料包括衛星雲圖、中央氣象局雷達合成圖與來自桃園國際機場（TIA）都卜勒氣象雷達之資料、雲中亂流合成圖、機場地面觀測資料和空中報告資料等。

預報資料包括風場、温度場、結冰高度、相對濕度、亂流與積冰等。

The weather products presented by AOAW system include both real time and forecast data. The real time data includes satellite data, radar mosaics from the Central Weather Bureau and Doppler weather radar data from Tao-Yuan International Airport（TIA）, in-cloud turbulence mosaics, airport surface observational data, and aircraft reports. The forecast data includes winds, temperature, freezing level, relative humidity, turbulence and icing.

2 格點氣象產品 (Gridded Weather Products)

2.1 雷達合成圖及TITAN 系統之風暴追蹤圖 (Radar Mosaics and TITAN Storm Tracks)

2.1.1 三維雷達合成圖 (3-D Radar Mosaic)

中央氣象局以台灣各地不同的雷達回波場資料建立了一組雷達合成圖。雷達回波單位為 dBZ。dBZ 的值愈高表示天氣愈惡劣。

本項產品為三維產品，因此可利用暴風剖面圖得到其垂直結構及嚴重性。平面模式下，其顯示為回波強度。然而，本產品僅包含台灣本島及其周邊有限區域，因此其偵測遠距離暴風的能力有限。

一般來說，雷達回波大於 30dBZ 時，附近有對流亂流的風險便會提高。至於冰雹及強烈亂流會出現在回波大於 50dBZ 的區域。然而，亂流有時亦會出現在回波小於 30dBZ 的區域。AOAWS 系統的即時亂流偵測產品(NCAR Turbulence Detection Algorithm，NTDA)利用都卜勒氣象雷達的資料以量測雲中亂流。詳細資訊請參考 2.8.4、 2.8.5 及 2.8.6 節。

The CWB creates a mosaic from the reflectivity fields for the various radars operating around Taiwan. The units of reflectivity are dBZ. The higher the dBZ values, the more severe the associated weather is.

Since this is a 3D product, it is useful for performing cross sections through storms to reveal their vertical structure and severity. In plan view, the maximum reflectivity is shown. However, since the product only covers Taiwan and a limited area around the island, it is restricted in its ability to detect storms at long range.

In general, the risk of nearby convective turbulence increases as reflectivity grows above 30 dBZ or so, and hail and extreme turbulence may be present in regions with reflectivity above 50 dBZ. However, turbulence may sometimes occur in regions with reflectivity below 30 dBZ. AOAWS NTDA product uses Doppler weather radar data to quantify in-cloud turbulence. For details, see sections 2.8.4, 2.8.5 and 2.8.6.

2.1.2 由三維雷達合成資料製作的雷雨辨識、路徑追蹤及即時預報系統 (TITAN Storm Tracks from 3-D Radar Mosaic)

航空氣象現代化作業系統的雷雨辨識、路徑追蹤及即時預報系統（Thunderstorm Identification, Tracking and Nowcasting，TITAN）接收由中央氣象局傳來的三維雷達合成資料。TITAN 可辨識資料中的風暴，並以外延法來產生台灣地區的風暴短期追蹤預報。

在下列雷達圖中

- 以灰線圈起來的區域顯示目前的風暴區。
- 黃色箭頭表示一小時的風暴行蹤預報。
- 以黃線圈起來的區域是一小時後的風暴追蹤預報位置。
- 圖示中顯示的風暴移動速度單位為海浬(knots)。

The AOAWS TITAN system is customized to ingest the 3-D radar mosaic from the CWB. TITAN will identify storms in this mosaic and produce short term extrapolation forecasts for the Taiwan area.

- The gray polygons show the current storm areas.
- The yellow arrows show the 1-hour forecast movement for the storms.
- The yellow polygons show the 1-hour forecast position for the storms.
- The storm speed is printed in knots.

圖 2.1.2a 是由三維雷達合成資料製作的 TITAN 風暴追蹤預報範例。圖 2.1.2b 是三維雷達航路剖面圖。

Figure 2.1.2a shows an example of the 3-D radar mosaic along with the TITAN storms tracks. Figure 2.1.2b shows a 3-D radar route cross section.

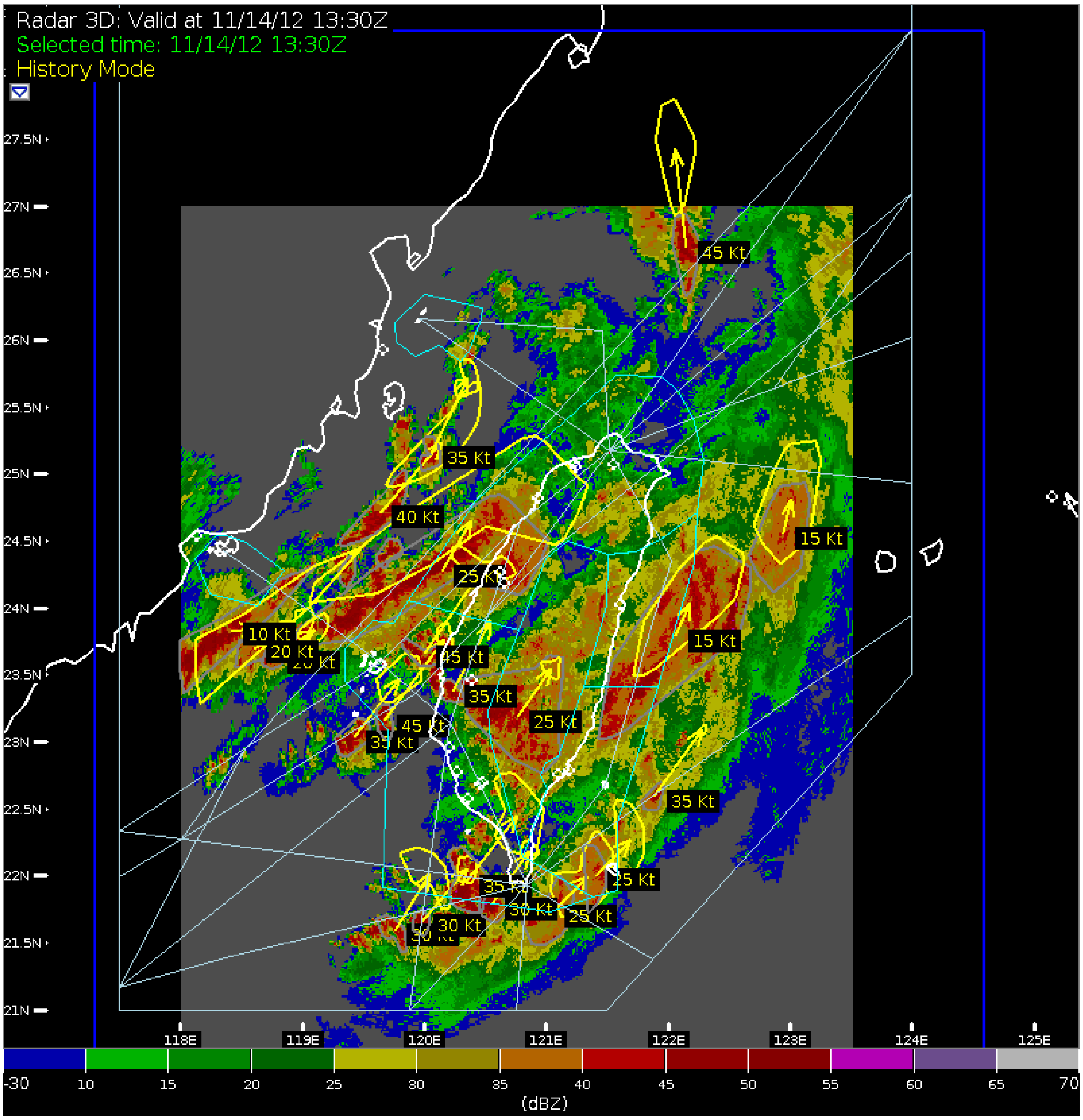


圖 **2.1.2a** 三維雷達合成及風暴追蹤圖

Fig. 2.1.2a 3-D Radar Mosaic with TITAN

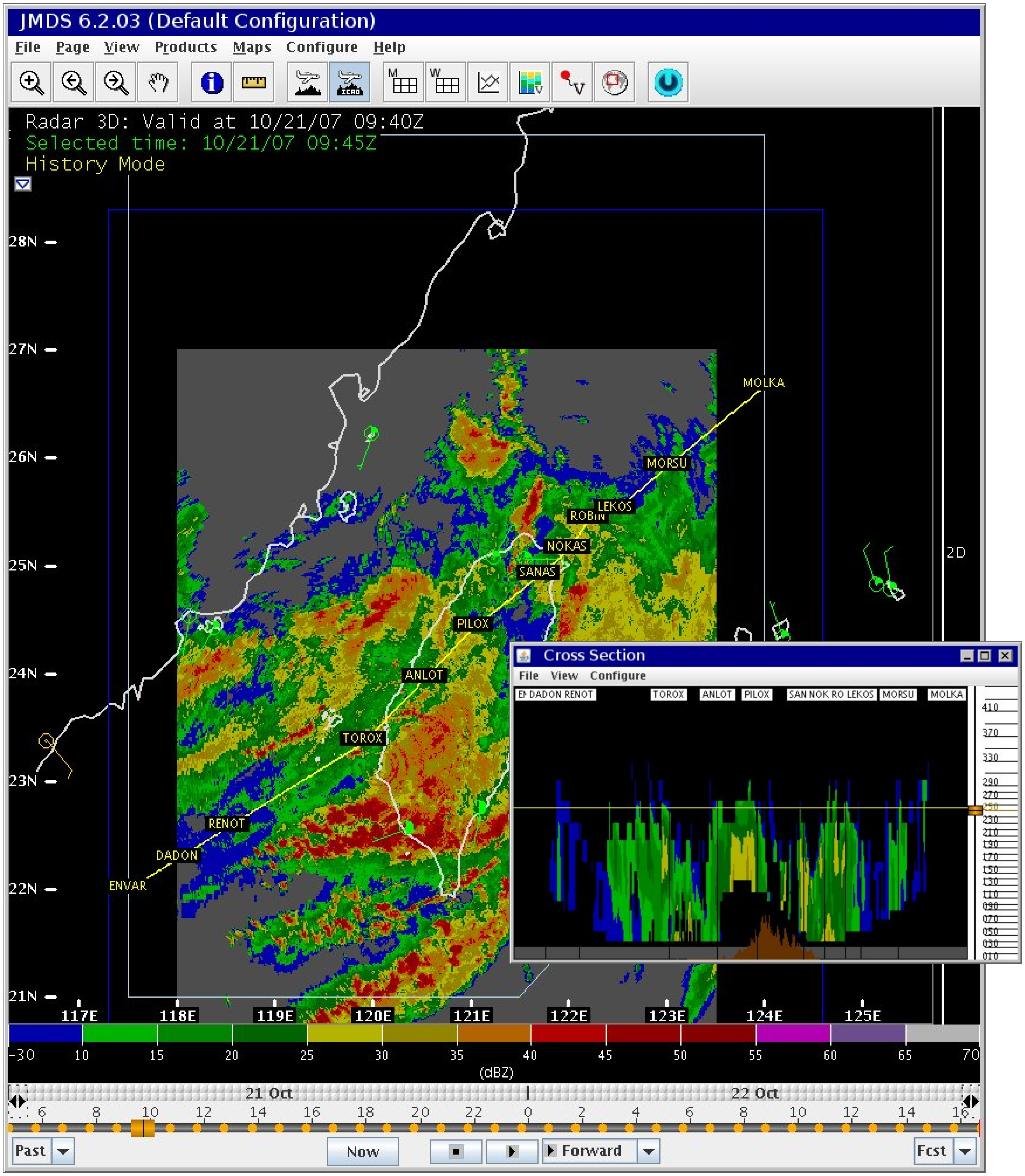


圖 2.1.2b 三維雷達航路剖面圖
Fig. 2.1.2b 3-D Radar Route Cross Section

TITAN 以雷達回波值 30dBZ 做為定義風暴的起點。過去的經驗顯示這個起點值可辨識顯著的強烈風暴以用來追蹤風暴，而不會因為顯示太多的輕度風暴圖示而使產品畫面顯得雜亂不堪。

TITAN uses a reflectivity threshold of 30 dBZ for defining the storms. Experience has shown that tracking storms using this threshold identifies the significantly strong storms, while not cluttering up the display with weak storms.

2.1.3 二維雷達合成圖 (2-D Radar Mosaic)

中央氣象局也提供二維雷達合成資料，它的優點是涵蓋的區域比三維雷達產品大，因此對偵測比較遠距離的風暴很有用，尤其對偵測颱風動態的效果更好，不過沒有顯示垂直結構的能力。

The CWB also produces a 2-D mosaic of radar data. It has the advantage of covering a larger region than the 3-D product, and is therefore useful for detecting storms at longer range. This is particularly useful for typhoon situations. However, no vertical structure is available.

圖 2.1.3a 顯示二維雷達合成圖。

Figure 2.1.3a shows an example of the 2-D radar mosaic.

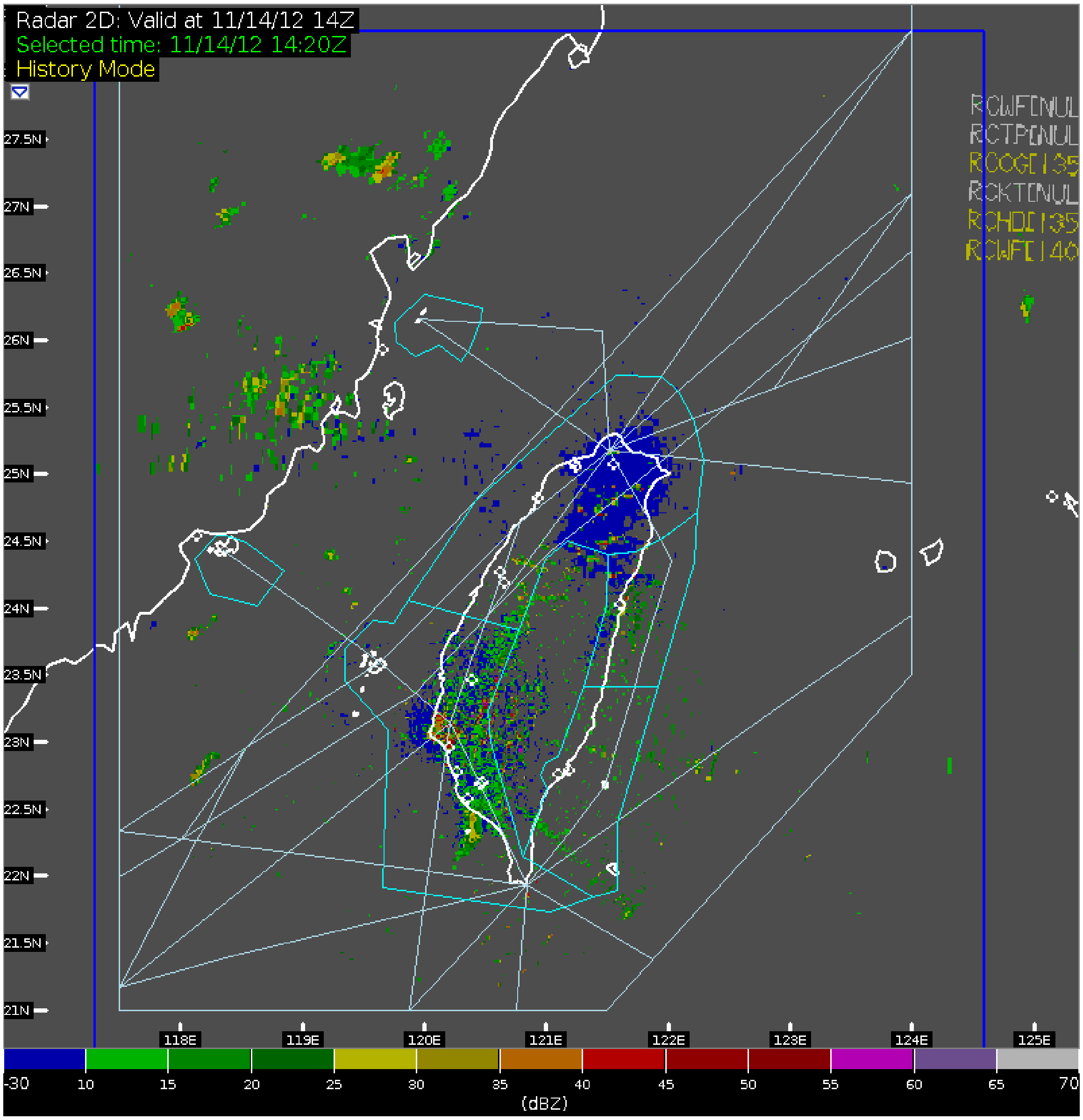


圖 2.1.3a 二維雷達合成圖

Figure 2.1.3a 2-D Radar Mosaic

2.1.4 由桃園國際機場都卜勒氣象雷達資料製作的雷雨辨識、路徑追蹤及即時預報系統 (TITAN Storm Tracks from TIA Radar)

航空氣象現代化作業系統的 TITAN 系統接收由桃園國際機場都卜勒氣象雷達傳來的三維雷達資料。TITAN 可辨識資料中的風暴，並以外延法來產生桃園國際機場周圍 150 公里範圍內的風暴短期追蹤預報。

TITAN 預報產品會被傳送並能顯示在 JMDS 上。這項預報產品是被預設為不顯示 (off) ，使用者必需選取才能顯示此產品。

在下列雷達圖中

- 以灰線圈起來的區域顯示目前的風暴區。
- 粉紅色箭頭表示一小時的風暴行蹤預報。
- 以粉紅線圈起來的區域是一小時後的風暴追蹤預報位置。
- 圖示中顯示的風暴移動速度單位為浬(knots)。

The AOAWS TITAN system is customized to ingest the 3-D radar data from the CAA Doppler weather radar at the TIA airport. TITAN will identify storms in this data and produce short term extrapolation forecasts for the area around the TIA airport, out to a maximum range of 150km.

The TIA TITAN forecast products are distributed to and displayed on the JMDS. This product is off by default, and must be selected by the user.

- The gray polygons show the current storm areas.
- The pink arrows show the 1-hour forecast movement for the storms.
- The pink polygons show the 1-hour forecast position for the storms.
- The storm speed is printed in knots.

圖 2.1.4a 顯示由桃園國際機場都卜勒氣象雷達資料及航路剖面圖範例，圖中也包含 TITAN 風暴追蹤預報訊息。

Figure 2.1.4a shows an example of the TIA Doppler weather radar and a route cross-section. This figure also includes the TITAN storms tracks.

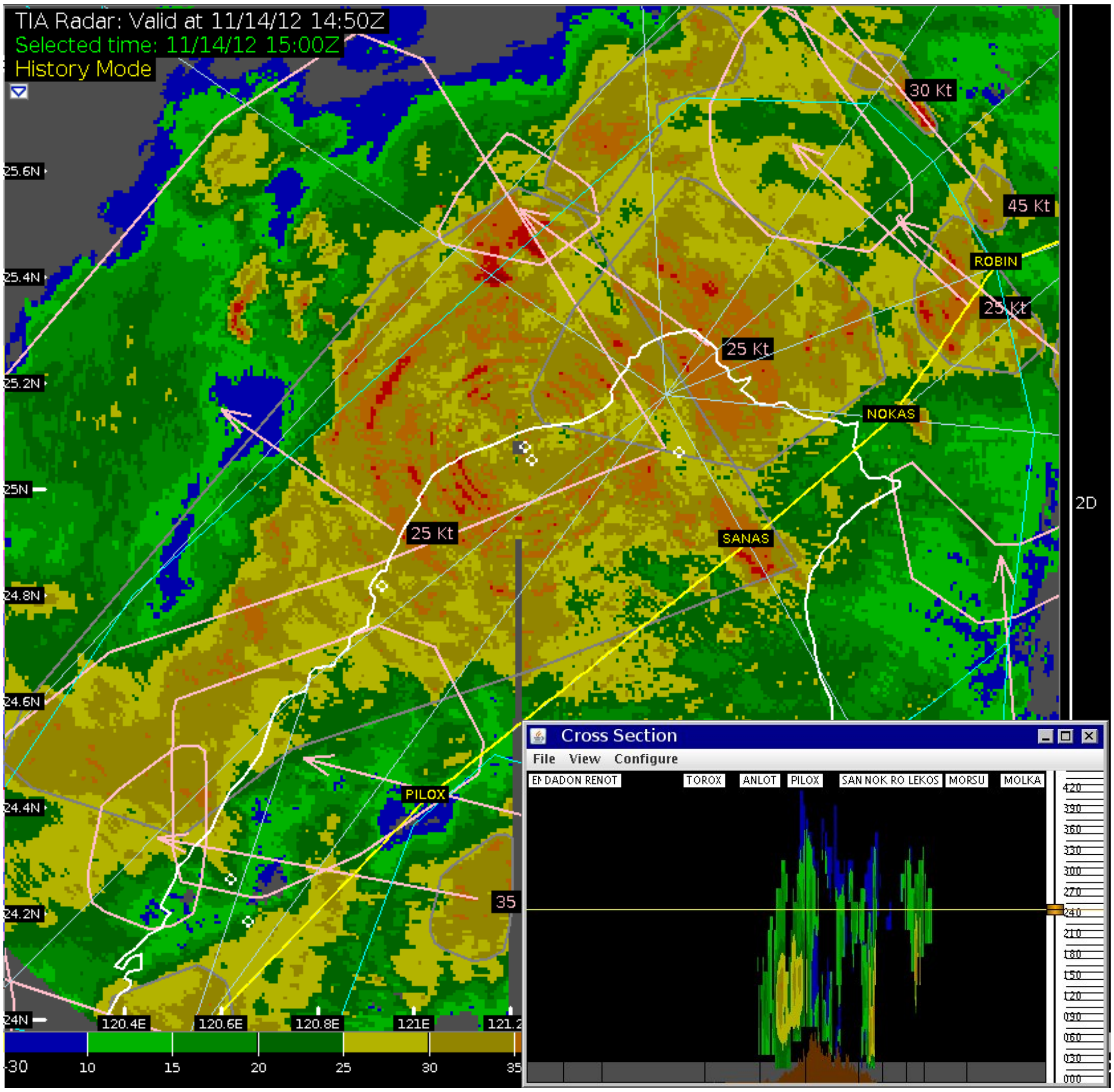


圖 2.1.4a 三維 TIA 雷達圖 (含 TITAN 風暴追蹤及剖面圖)

Figure 2.1.4a 3-D TIA Radar with TITAN Tracks and Cross Section

2.2 雲頂高度 (Cloud Top Height Image)

雲頂高度產品 (**圖 2.2a**) 是依據日本 MTSAT 衛星紅外線 IR1 頻道及 WRF 模式資料計算出的飛航空層雲頂高度。雲頂高度的計算方法如下:

- 首先找到網格點上的衛星紅外線亮度溫度 (brightness temperature)
- 然後利用 WRF 模式資料以此溫度為準來查出那一點的飛航空層

備註:

(a) 一般而言，厚實雲的雲頂高度將會被高估 - 估計出來的雲頂高度會比實際的雲頂高度高。
(b) 半透明雲的雲頂高度將會被低估 - 估計出來的雲頂高度會比實際的雲頂高度低。

Figure 2.2a shows an example of the estimated cloud top height, in Flight Level, computed from the Japanese MTSAT satellite IR1 channel and the WRF model data. The height is computed as follows:

- First find the IR brightness temperature for a grid point.
- Then, for that temperature, use the WRF model data to find the appropriate flight level.

Notes:

(a) Generally, for solid cloud decks, the cloud top height will be OVER-estimated, i.e. higher than the true height.
(b) For semi-transparent cloud decks, the cloud top height will be UNDER-estimated, i.e. lower than the true height.

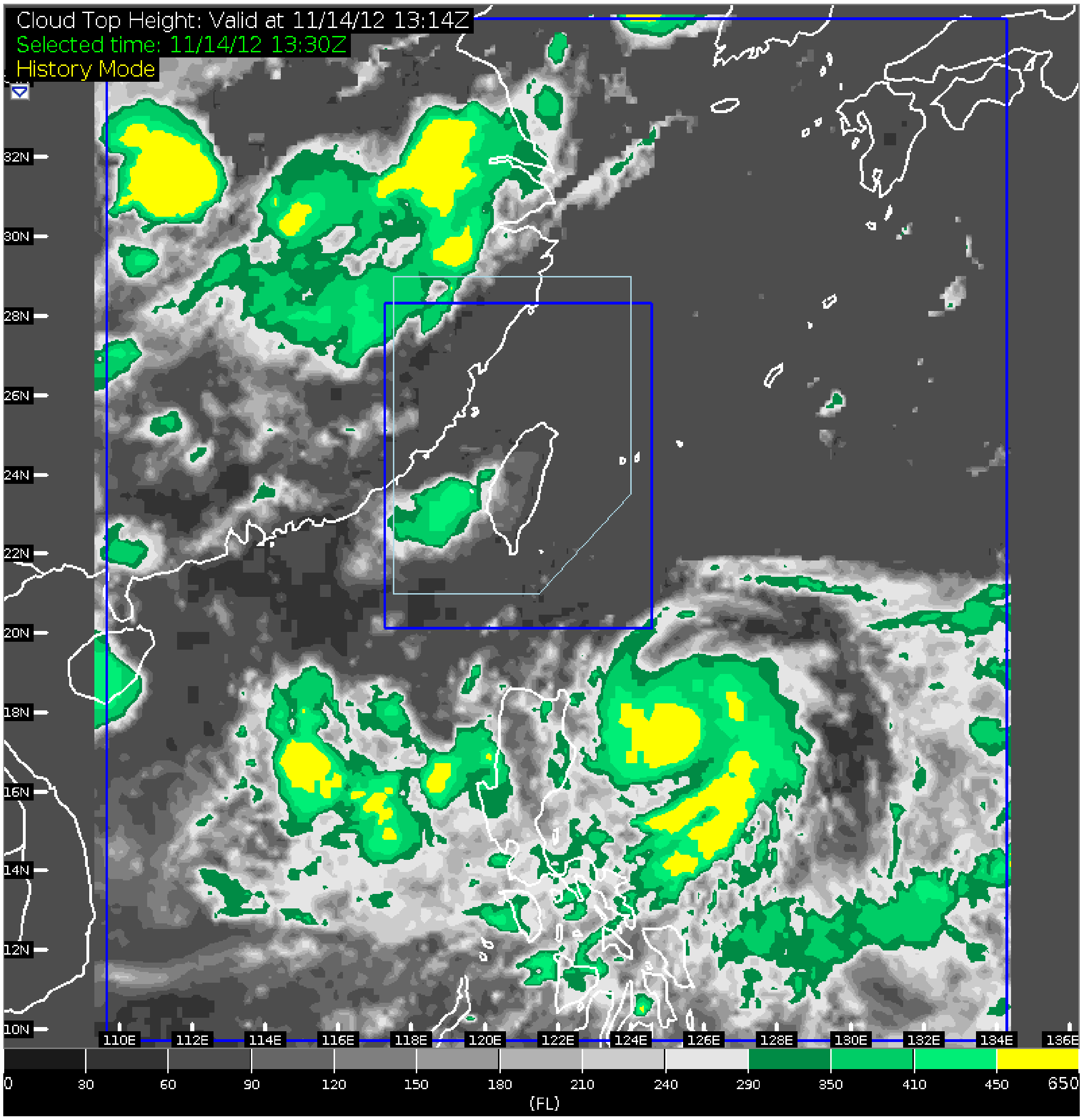


圖 2.2a 雲頂高度衛星雲圖

Fig.2.2a Cloud Top Height Image

2.3 衛星雲圖 (Satellite Images)

AOAWS 系統從下列五個地球同步衛星取得資料:MTSAT, Meteosat 0-degree, Meteosat 57-degree, GOES-East 及 GOES-West。系統同時接收紅外線影像全球衛星合成產品。

The AOAWS system takes in data from all 5 of the geostationary satellites: MTSAT, Meteosat 0-degree, Meteosat 57-degree, GOES-East and GOES-West. The system also receives a global satellite composite IR image product.

2.3.1 MTSAT Images

日本 MTSAT 衛星範圍涵蓋台灣區域，為 AOAWS 系統主要的衛星資料來源。系統接收該衛星的五個頻道資料：

- 可見光 (VIS): 0.55-0.80 □ μm
- 紅外線 (IR1): 10.3-11.3 □ μm
- 紅外線 (IR2): 11.5-12.5 □ μm
- 水汽頻道 (IR3): 6.5-7.0 □ μm
- 紅外線 (IR4): 3.5-4.0 □ μm

Because MTSAT covers the Taiwan area, it is the main satellite source for the AOAWS system. The system receives raw data for each of the 5 channels on the satellite:

- Visible (VIS): 0.55-0.80 □ μm
- Infrared (IR1): 10.3-11.3 □ μm
- Infrared (IR2): 11.5-12.5 □ μm
- Water Vapor (IR3): 6.5-7.0 □ μm
- Infrared (IR4): 3.5-4.0 □ μm

可見光衛星雲圖產品 (**圖 2.3.1a**) 為以灰階色調顯示日本 MTSAT 衛星可見光頻道資料。一般而言，白色區域是雲。愈亮的區域表示雲層厚度愈厚。

Figure 2.3.1a shows an example of a gray-scale image representing the visible channel from the Japanese MTSAT satellite. Generally speaking, white areas represent clouds. The brighter the color, the thicker the cloud layer is.

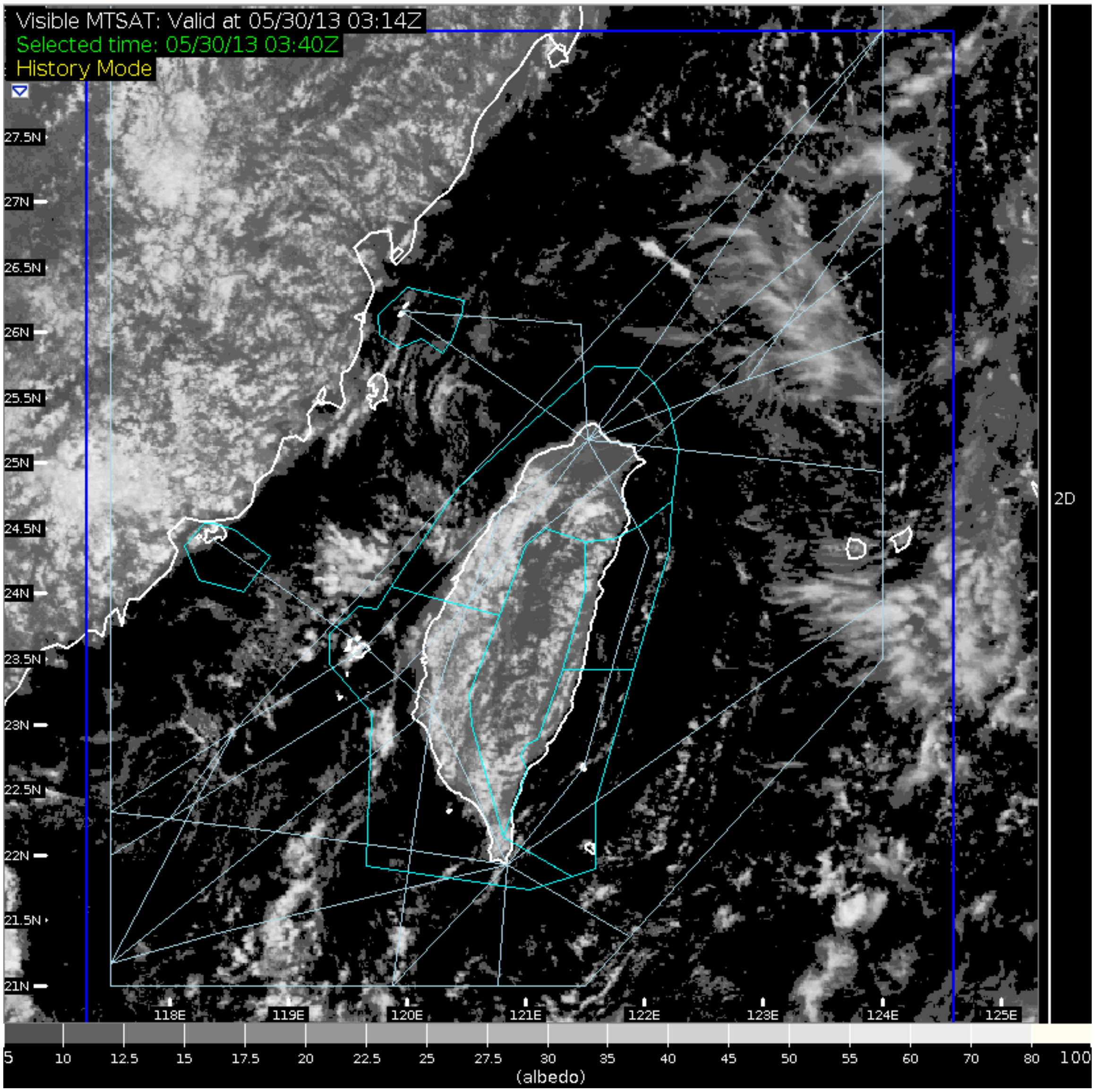


圖 2.3.1a 可見光衛星雲圖

Fig. 2.3.1a MTSAT Visible Satellite Image

JMDS 系統上紅外線衛星雲圖產品 (圖 2.3.1b, 2.3.1c 及 2.3.1d) 顯示日本 MTSAT 衛星紅外線 IR1 頻道資料。紅外線頻道的單位也稱為「亮度溫度 (brightness temperature)」，亦即假設一物體為黑體來量測其溫度。雲不是一個完全黑體，所以亮度溫度會比實際雲頂溫度低。

中央氣象局採用下列三種不同色階的紅外線影像。圖 2.3.1b 為 MB 色階影像，其顯示低層雲的效果很好。圖 2.3.1c 為 BD 色階影像，其在顯示惡劣天氣及高層雲的效果上也許會更好。圖 2.3.1d 為典型灰階影像。MTSAT 紅外線頻道包含上述所有色階影像。

Figures 2.3.1b, 2.3.1c and 2.3.1d show examples of images representing the IR1 channel from the Japanese MTSAT satellite as displayed on the JMDS. The units of the IR channel are the so-called "brightness temperature", which is a measure of the temperature of an object assuming that it radiates as a black body. Clouds are not perfect black bodies; therefore the brightness temperature tends to be lower than the actual cloud top temperature.

There are three IR images using different color scales, all used by the CWB. The MB color image, shown in figure 2.3.1b, is the usual one and shows low-level clouds well. The BD color scale, shown in figure 2.3.1c, is perhaps better for severe weather and high clouds. The Gray color scale, shown in figure 2.3.1d, is the classic grayscale image. All of the color scales are available for all of the MTSAT IR channels.

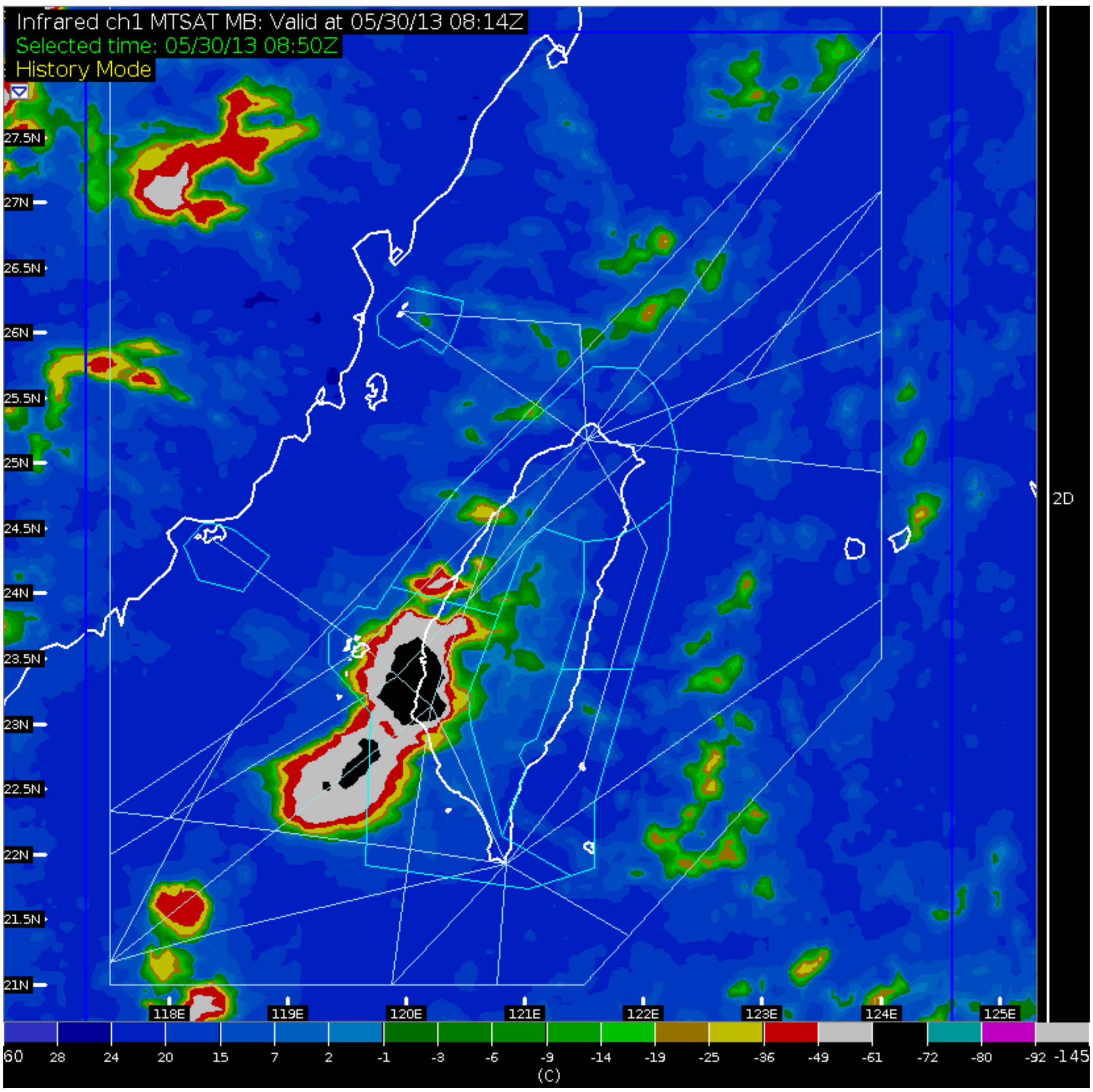


圖 **2.3.1b MTSAT IR1** 紅外線衛星雲圖**-**使用 **MB** 色階

Fig. 2.3.1b MTSAT Infrared Channel 1 Image Using MB Color Scale

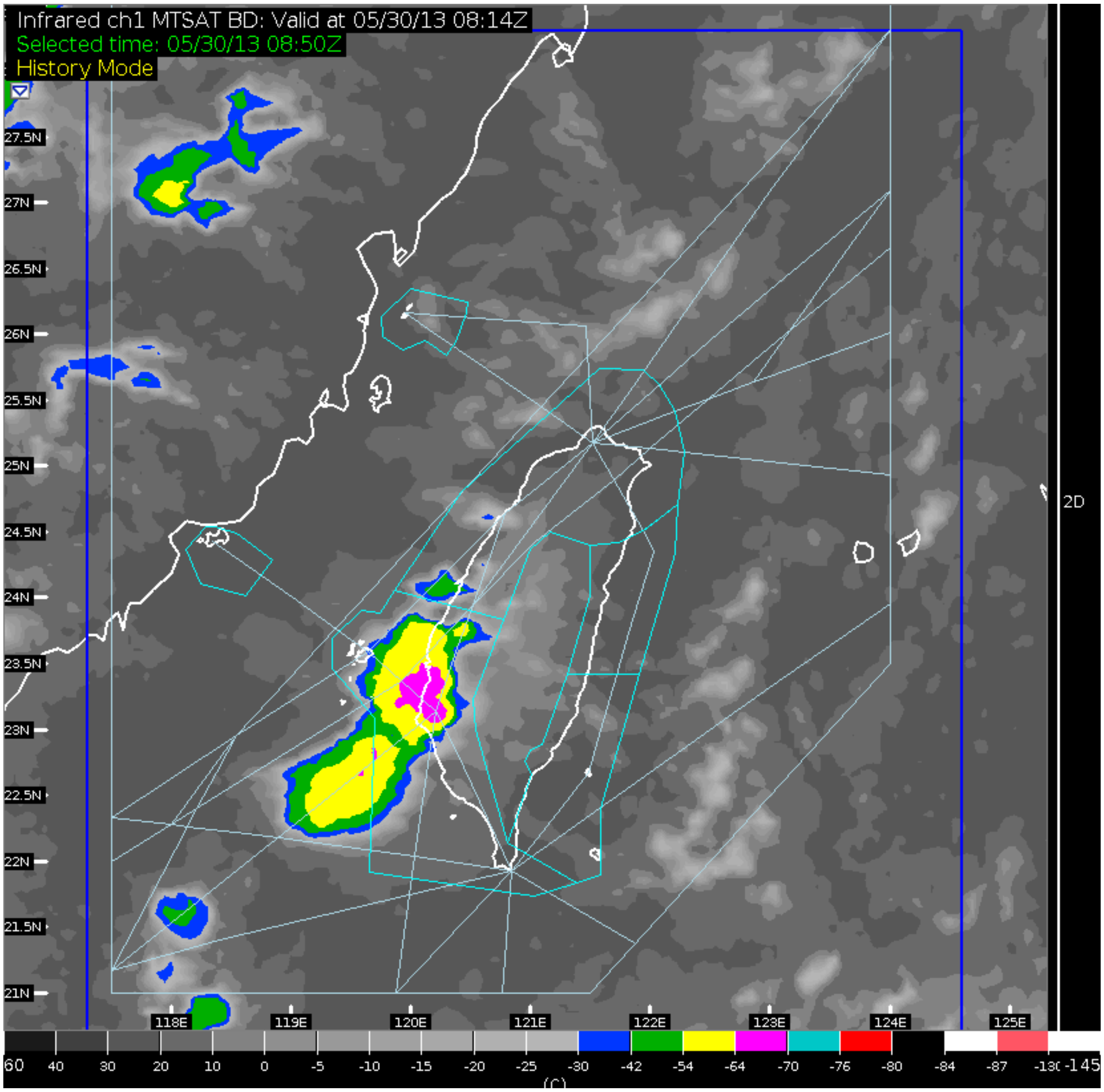


圖 2.3.1c MTSAT IR1 紅外線衛星雲圖-使用 BD 色階

Fig. 2.3.1c MTSAT Infrared Channel 1 Image Using BD Color Scale

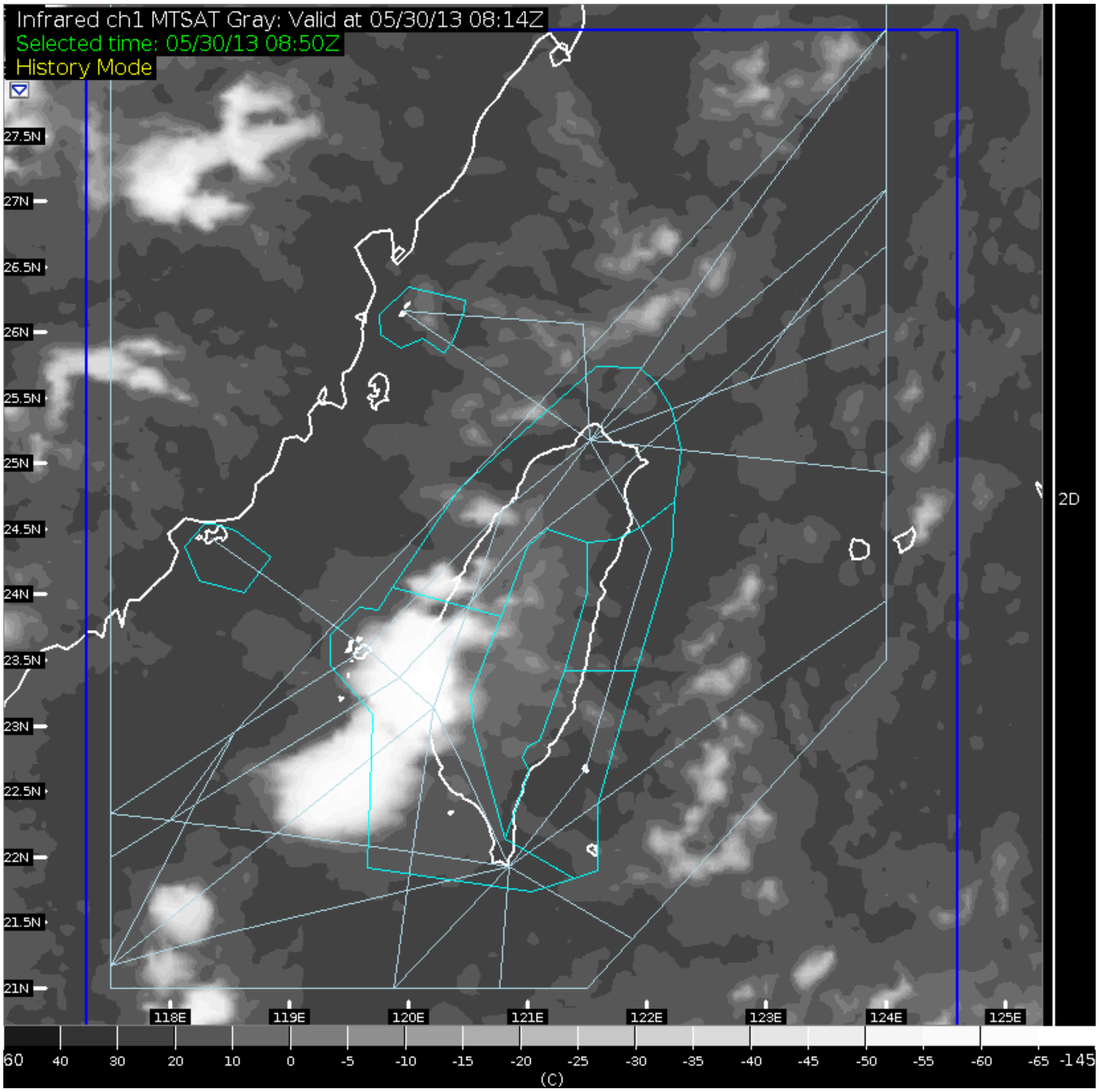


圖 2.3.1d MTSAT IR1 紅外線衛星雲圖-使用灰階

Fig. 2.3.1d MTSAT Infrared Channel 1 Image Using Gray Color Scale

圖 2.3.1e 及 2.3.1f 顯示 MTSAT 中其他兩種使用 MB 色階的紅外線頻道。

Figures 2.3.1e and 2.3.1f show the other two infrared channels available on MTSAT using the MB color scale.

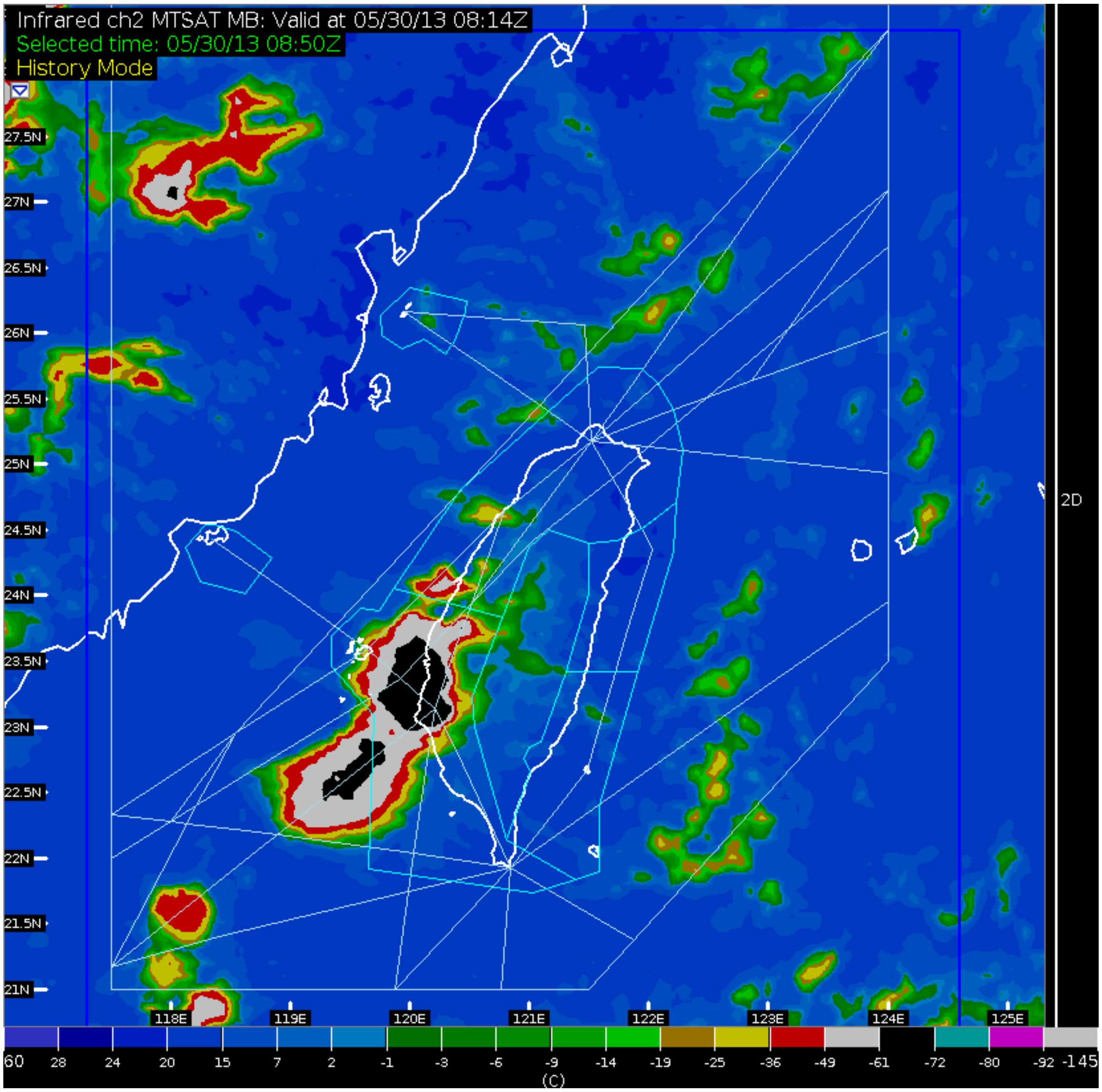


圖 2.3.1e MTSAT IR2 紅外線衛星雲圖-使用 MB 色階

Fig. 2.3.1e MTSAT Infrared Channel 2 Image Using MB Color Scale

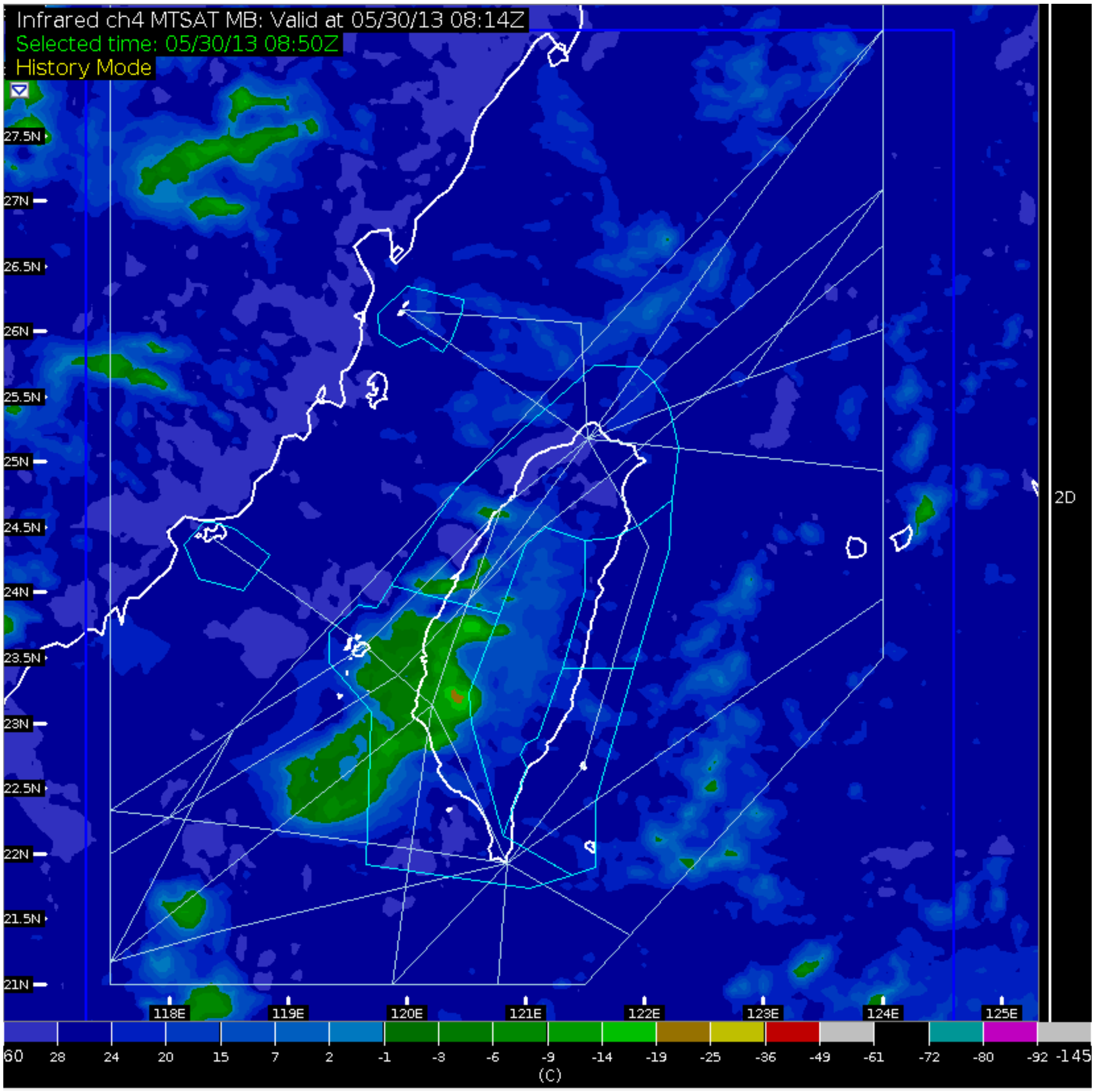


圖 2.3.1f MTSAT IR4 紅外線衛星雲圖-使用 MB 色階

Fig. 2.3.1f MTSAT Infrared Channel 4 Image Using MB Color Scale

圖 2.3.1g 顯示日本 MTSAT 衛星水汽頻道彩色影像產品。該資料是由波長 6 至 7 微米左右的輻射線導出。與其他的紅外線雲圖一樣，將放射出來的輻射轉換成亮度溫度來顯示。水汽頻道衛星雲圖顯示在 300 - 600 hPa 層的水汽含量。溫度愈高顯示在大氣高層的空氣愈乾燥。溫度愈低顯示在大氣高層的空氣愈潮濕。

Figure 2.3.1g shows an example of a color image representing the Water Vapor channel from the Japanese MTSAT satellite. The Water Vapor channel is derived from radiation at wavelengths around 6 to 7 microns. The emitted radiation is converted to brightness temperature for display purposes, as with other IR imagery. The data gives information about the moisture in the 300 - 600 hPa layer. Warmer temperatures indicate a dry upper atmosphere; colder temperatures indicate a moister upper atmosphere.

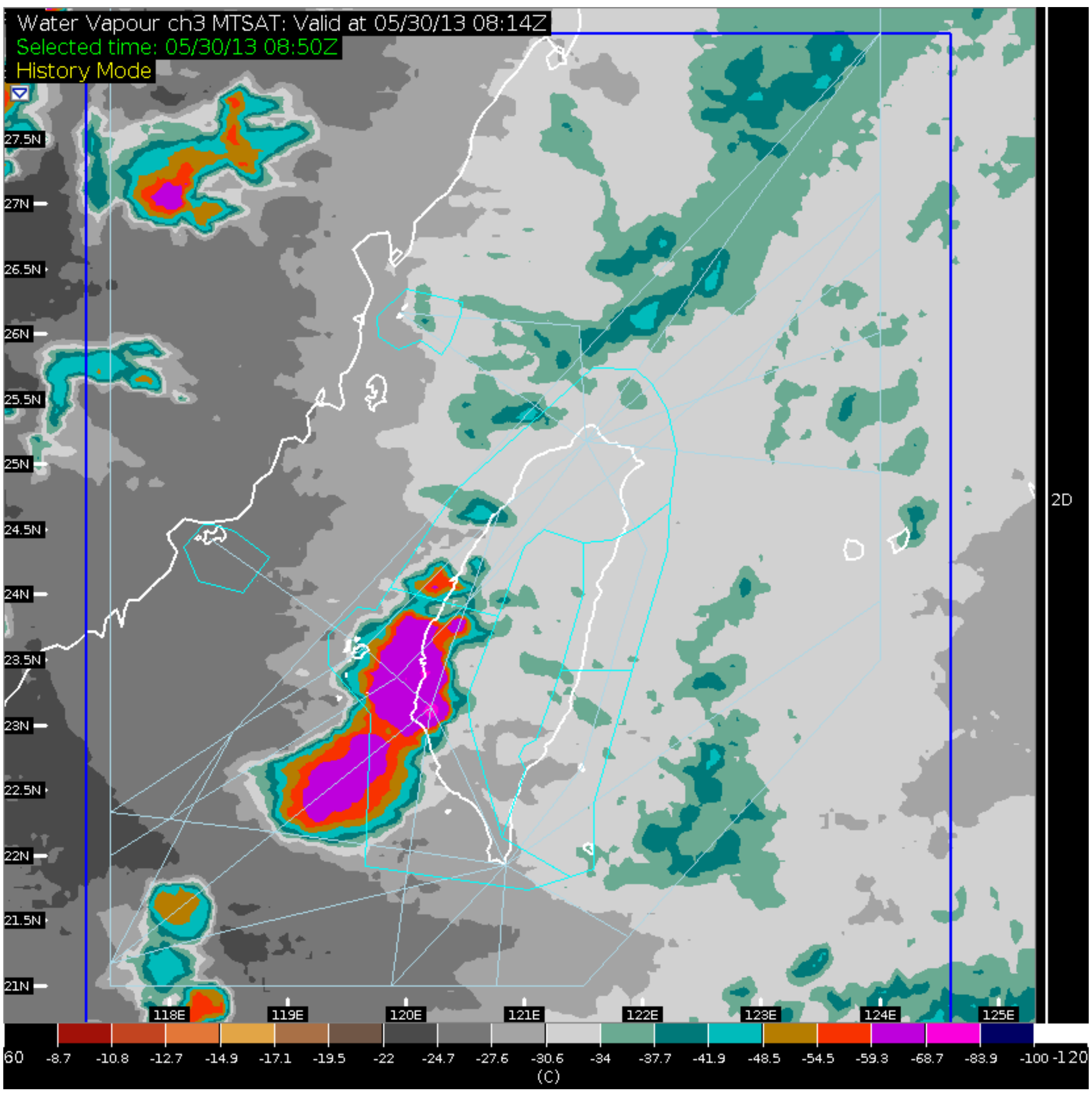


圖 2.3.1g MTSAT IR3 水汽頻道衛星雲圖

Fig. 2.3.1g MTSAT Water Vapor Channel 3 Image

除了個別頻道衛星產品，AOAWS 使用 MTSAT IR4 及 IR1 頻道資料計算差異場。圖 2.3.1h 為此產品的範例。IR4 頻道可同時觀測到高層雲及低層雲，因此，IR4 對低層雲的觀測能力很好；IR1 頻道則能觀測中、高層雲，對低層雲的解析度較差。將 IR4 及 IR1 頻道資料相減，可消除對流訊號，同時保留較低層雲的訊息。紅外線頻道差分圖最大的優點是可辨識出夜間低雲或霧。圖中比底色較白的均勻大範圍淺白色；深而濃的白色中夾雜有不規則黑色斑點訊號的部分，則為中高雲或發展較高的對流雲。

Along with the individual channels, the AOAWS also calculates a channel difference field using the MTSAT IR4 and IR1 channels. Figure 2.3.1h shows an example image of this product. The window of wavelengths the IR4 channel covers allows observation of both high- and low-level clouds. Thus, the IR4 channel is good for observing low-level clouds. The wavelength window of the IR1 channel observes middle- and higher-level clouds, but it does not resolve low-level clouds well. Taking a difference of the IR4 and IR1 channels produces a useful diagnostic by eliminating the convection signal, while retaining lower-level cloud information. The most advantageous uses of the channel difference diagnostic are to identify low-level clouds or fog at night. Large uniform light white areas in the image may be low-level clouds or fog. Deep and thick white areas interspersed with irregular and small black areas indicate high-level clouds or well-developed convective clouds.

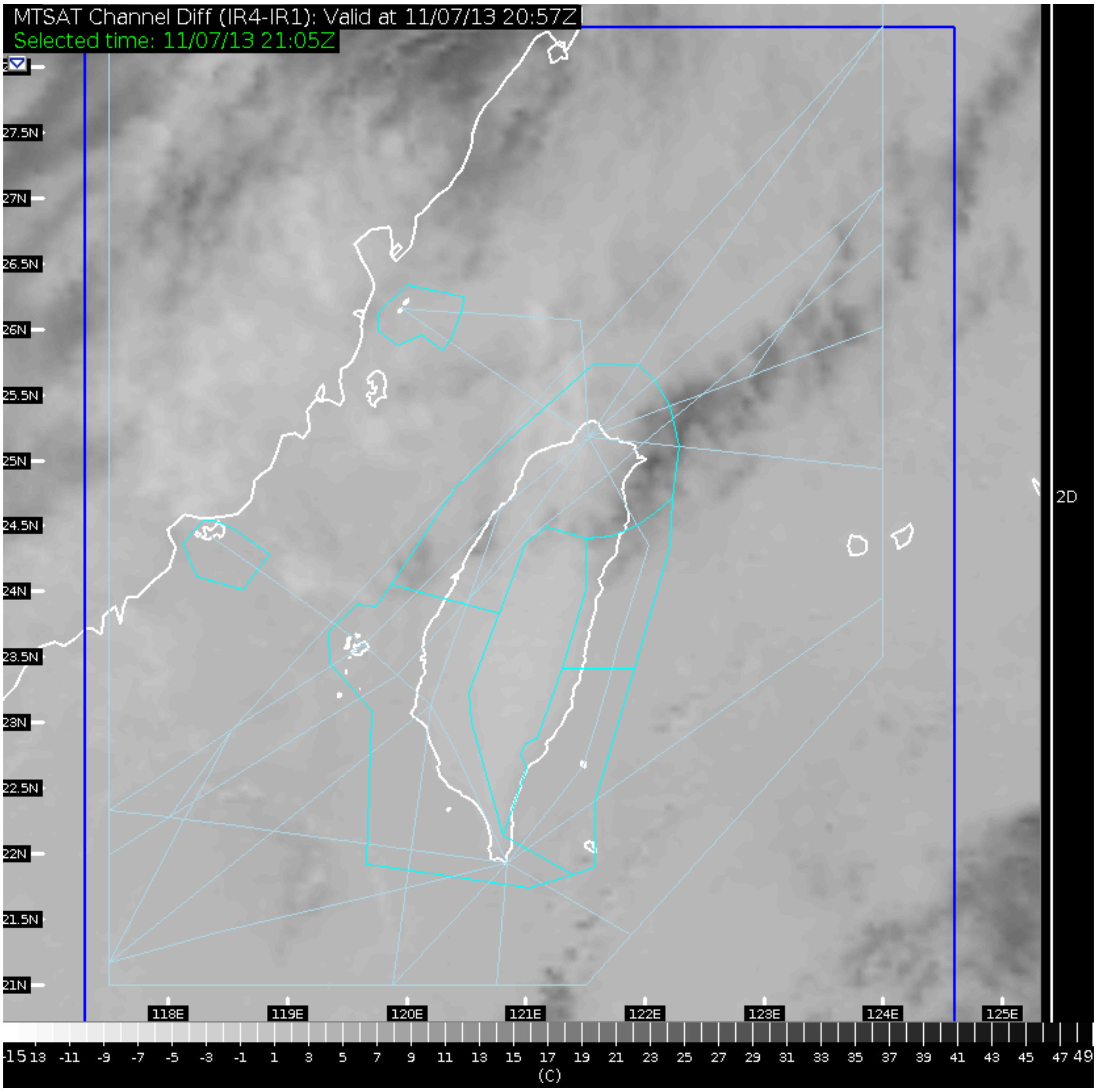


圖 2.3.1h MTSAT 紅外線頻道溫度差分圖 (IR4-IR1)

Fig. 2.3.1h MTSAT IR Channel Difference Field Image (IR4-IR1)

2.3.2 歐洲衛星影像 Meteosat Images

Meteosat 兩顆衛星分別位於 0 度經度線及 57 度經度線(東經)。AOAWS 系統接收這兩衛星之可見光及紅外線影像資料，並透過資料轉換應用於系統中。主要的涵蓋範圍為歐洲、非洲、印度洋及大西洋。

There are two Meteosat satellites: one located at the 0-degree meridian and the other at the 57-degree meridian. The AOAWS system receives visible and infrared brightness temperature data from both of these satellites as images. These images are converted back into data for use in the system. The images cover Europe, Africa, the Indian Ocean and the Atlantic Ocean.

圖 2.3.2a 及 2.3.2b 顯示 Meteosat 的可見光影像產品。圖 2.3.2a 顯示位於 0 度經度線衛星之影像產品，圖 2.3.2b 顯示位於 57 度經度線衛星之影像產品。

Figures 2.3.2a and 2.3.2b show examples of the visible images from the Meteosat satellites. Figure 2.3.2a shows an image from the satellite positioned at the 0-degree meridian while figure 2.3.2b shows one from the satellite positioned at the 57-degree meridian.

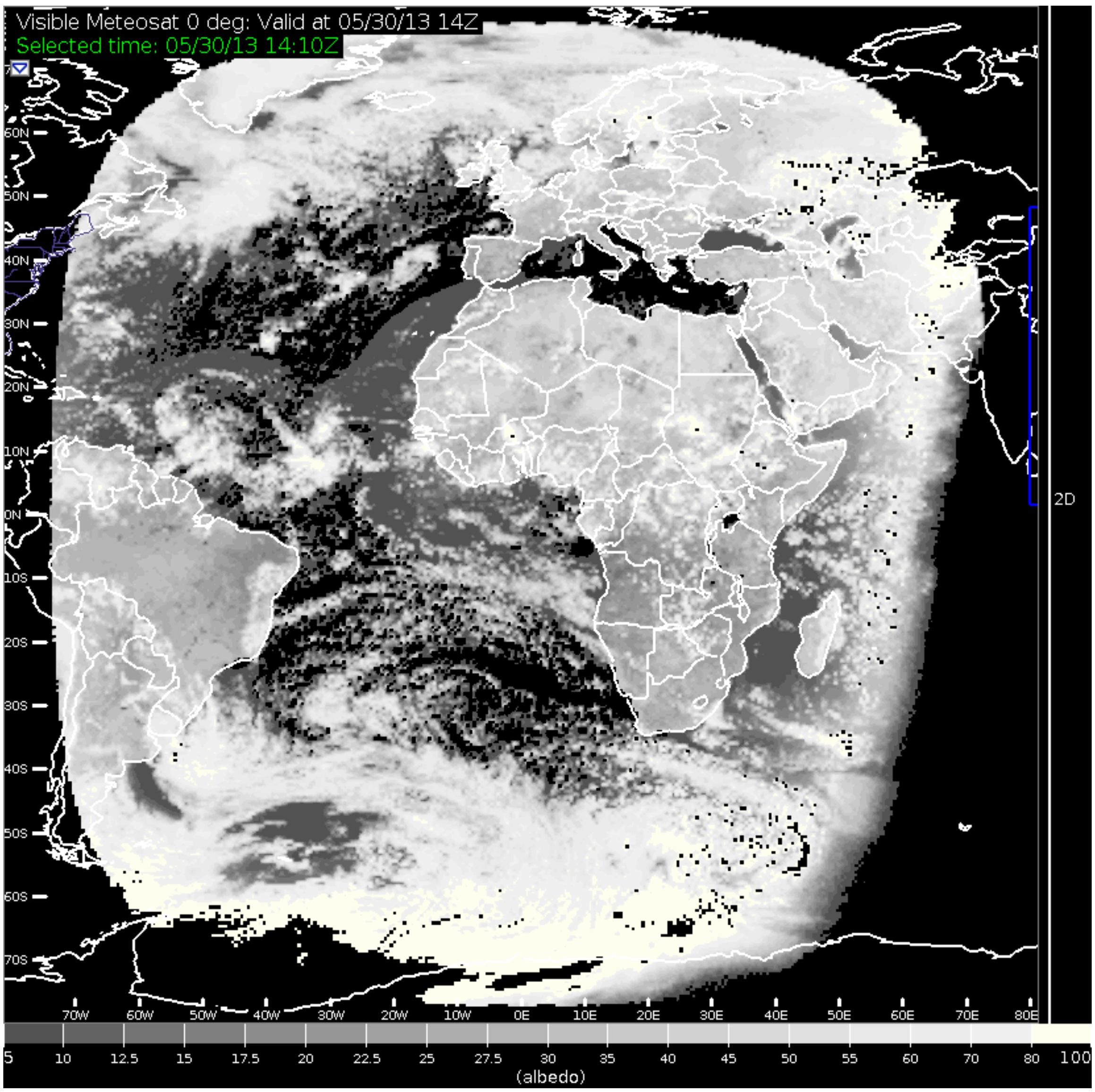


圖 2.3.2a 位於 0 度經度線之 Meteosat 衛星可見光衛星雲圖

Fig. 2.3.2a 0-degree Meteosat Visible Image

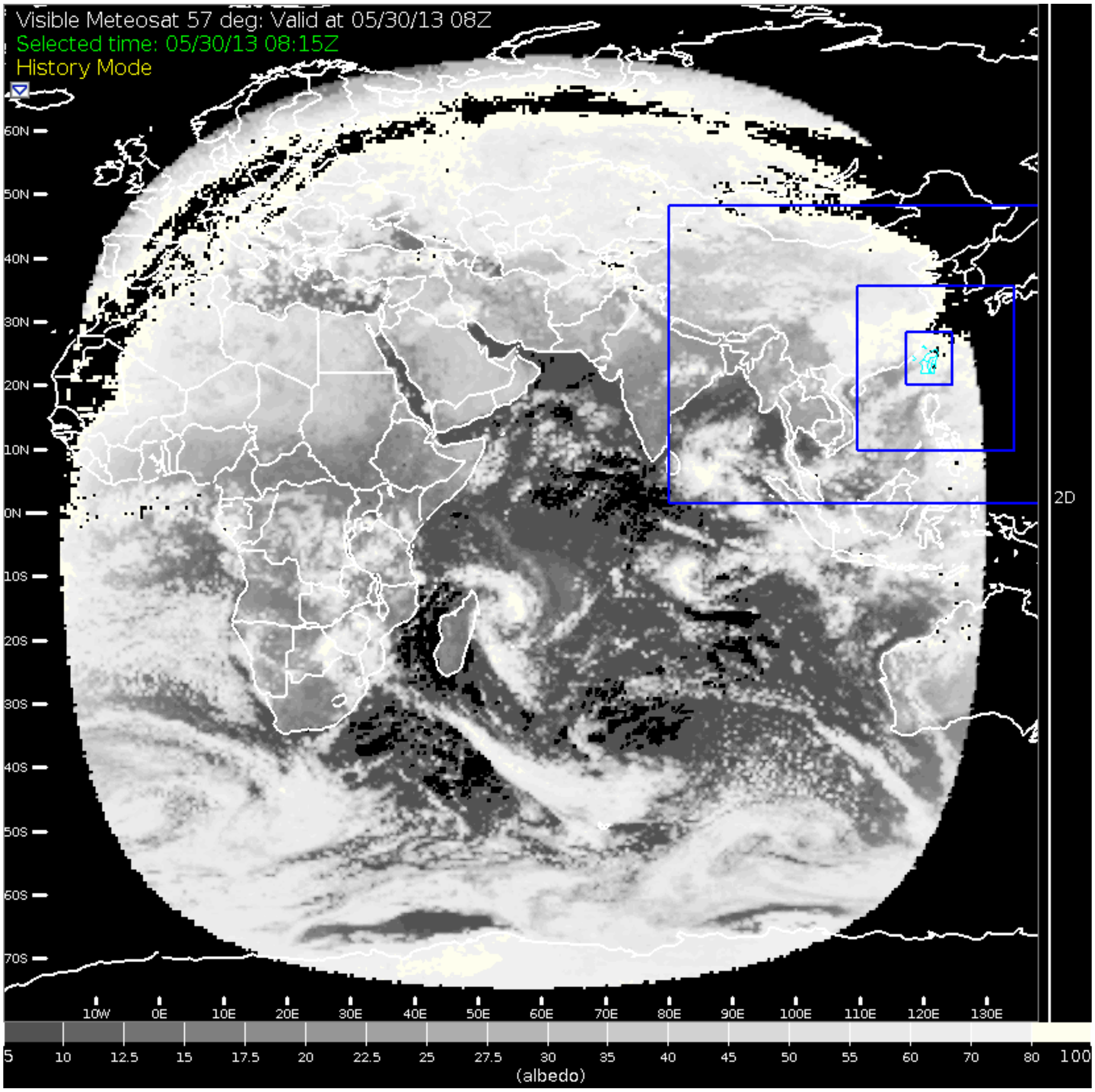


圖 2.3.2b 位於 57 度經度線之 Meteosat 衛星可見光衛星雲圖

Fig. 2.3.2b 57-degree Meteosat Visible Image

圖 2.3.2c 及 2.3.2d 顯示 Meteosat 的紅外線影像產品。圖 2.3.2c 顯示位於 0 度經度線衛星之影像產品，圖 2.3.2d 顯示位於 57 度經度線衛星之影像產品。

Figures 2.3.2c and 2.3.2d show examples of the infrared images from the Meteosat satellites. Figure 2.3.2c shows an image from the satellite positioned at the 0-degree meridian while figure 2.3.2d shows one from the satellite positioned at the 57-degree meridian.

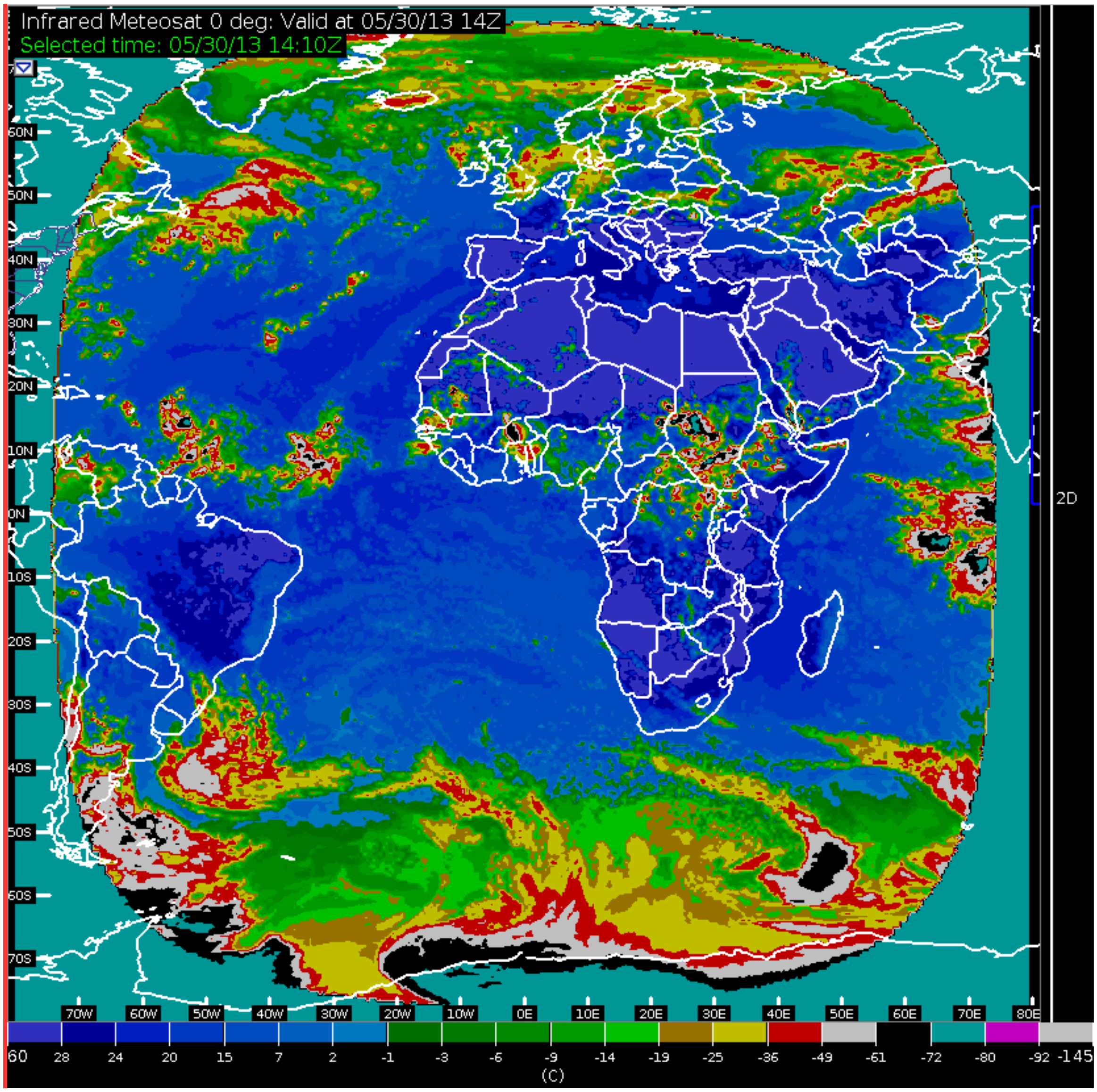


圖 **2.3.2c** 歐洲 **Meteosat** 衛星位於 **0** 度經度線之紅外線頻道雲圖

Fig. 2.3.2c 0-degree Meteosat Infrared Image

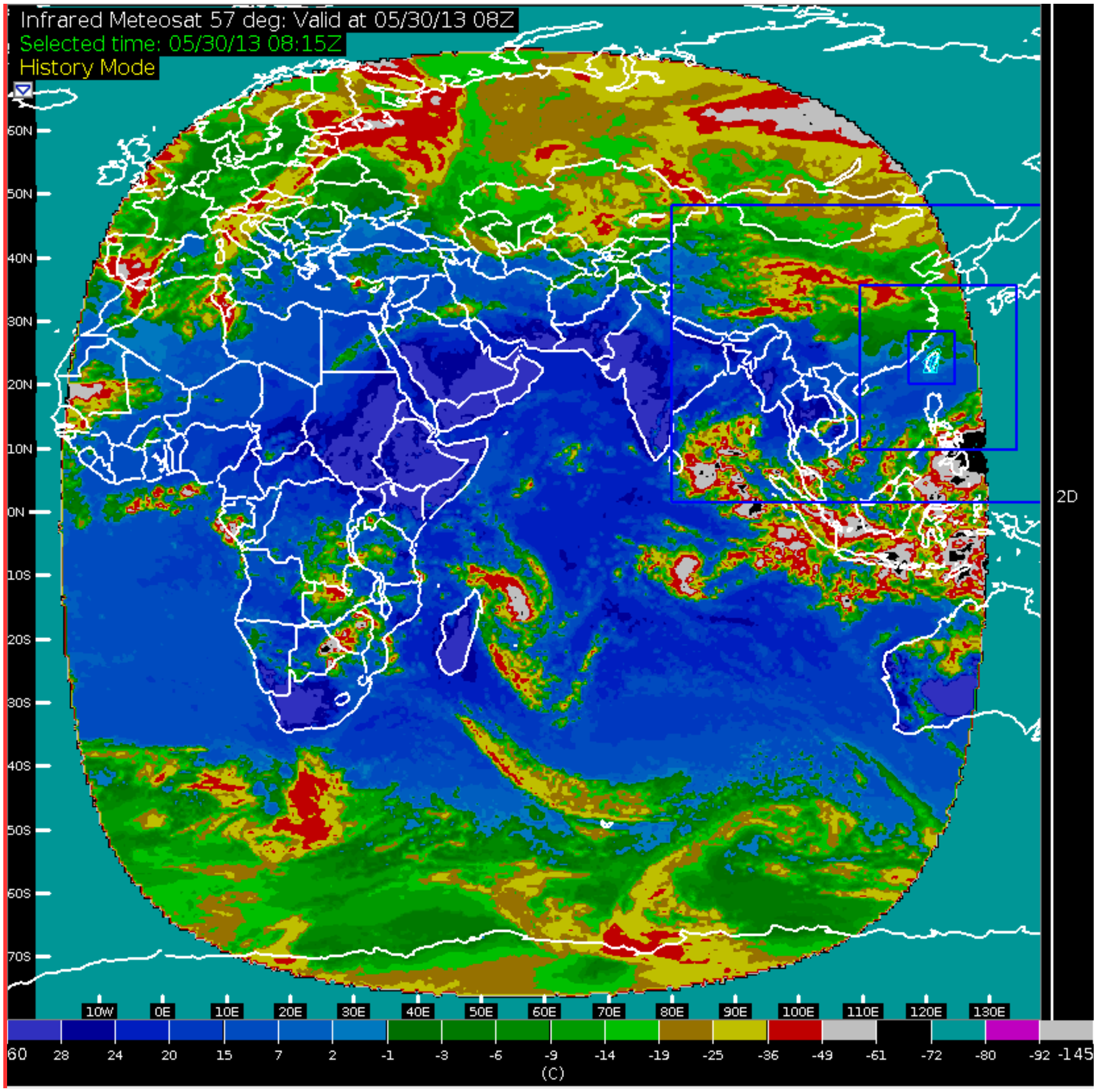


圖 2.3.2d 歐洲 Meteosat 衛星位於 57 度經度線之紅外線頻道雲圖

Fig. 2.3.2d 57-degree Meteosat Infrared Image

2.3.3 美洲衛星影像 GOES Images

美洲衛星影像來自 GOES East 及 GOES West 等兩顆衛星。AOAWS 系統接收這兩個衛星的可見光及紅外線影像資料，並透過資料轉換應用於系統中。主要的涵蓋範圍為南、北美洲及大西洋地區。

GOES images come from two GOES satellites: GOES East and GOES West. The AOAWS system receives visible and infrared data from both of these satellites as images. These images are converted back into data for use in the system. The images cover South and North America, and the Atlantic Ocean.

圖 2.3.3a 及 2.3.3b 顯示 GOES 衛星的可見光影像產品。

Figures 2.3.3a and 2.3.3b show examples of the visible images from the GOES satellites.

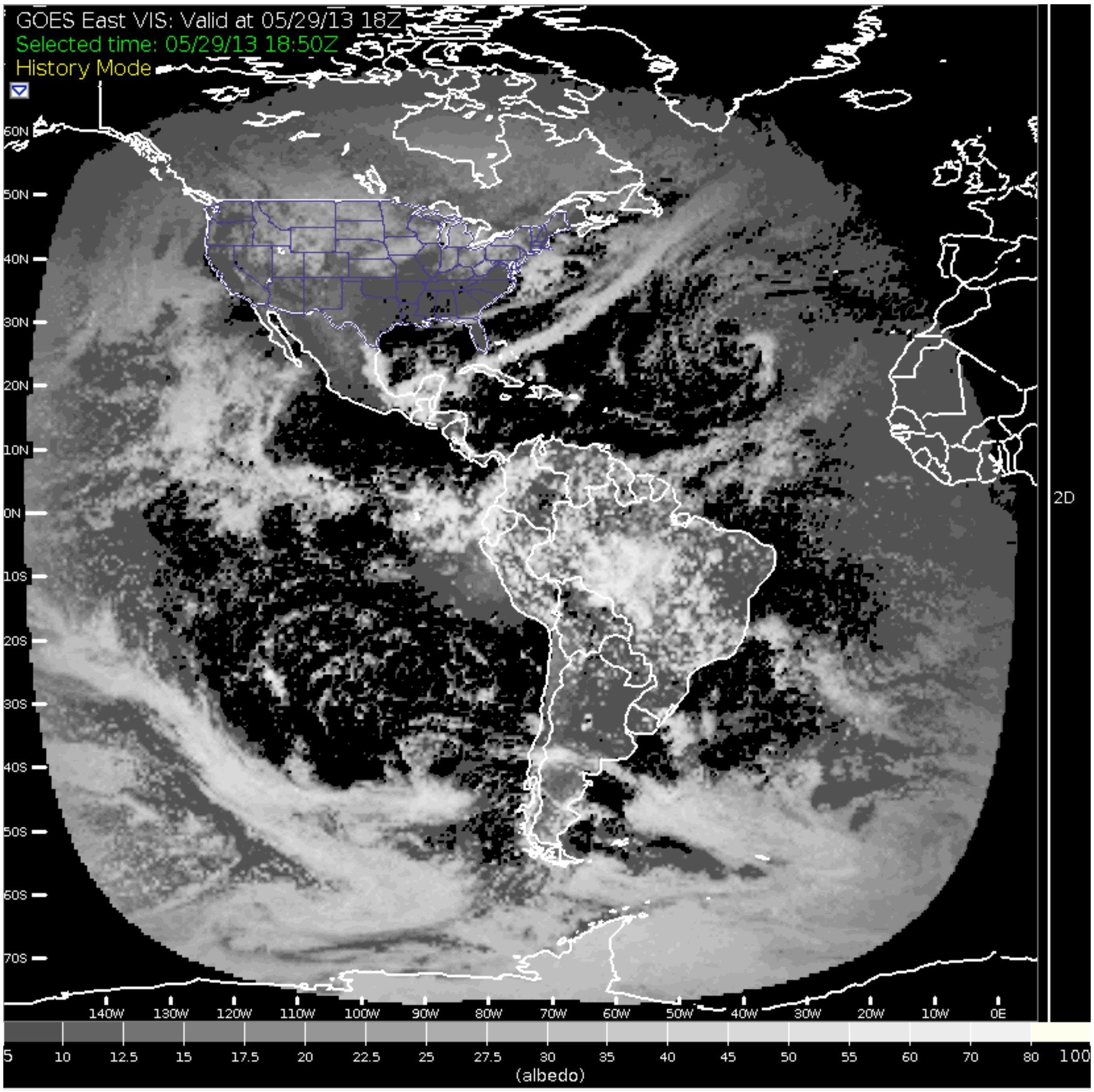


圖 2.3.3a GOES East 衛星可見光影像產品

Fig. 2.3.3a GOES East Visible Image

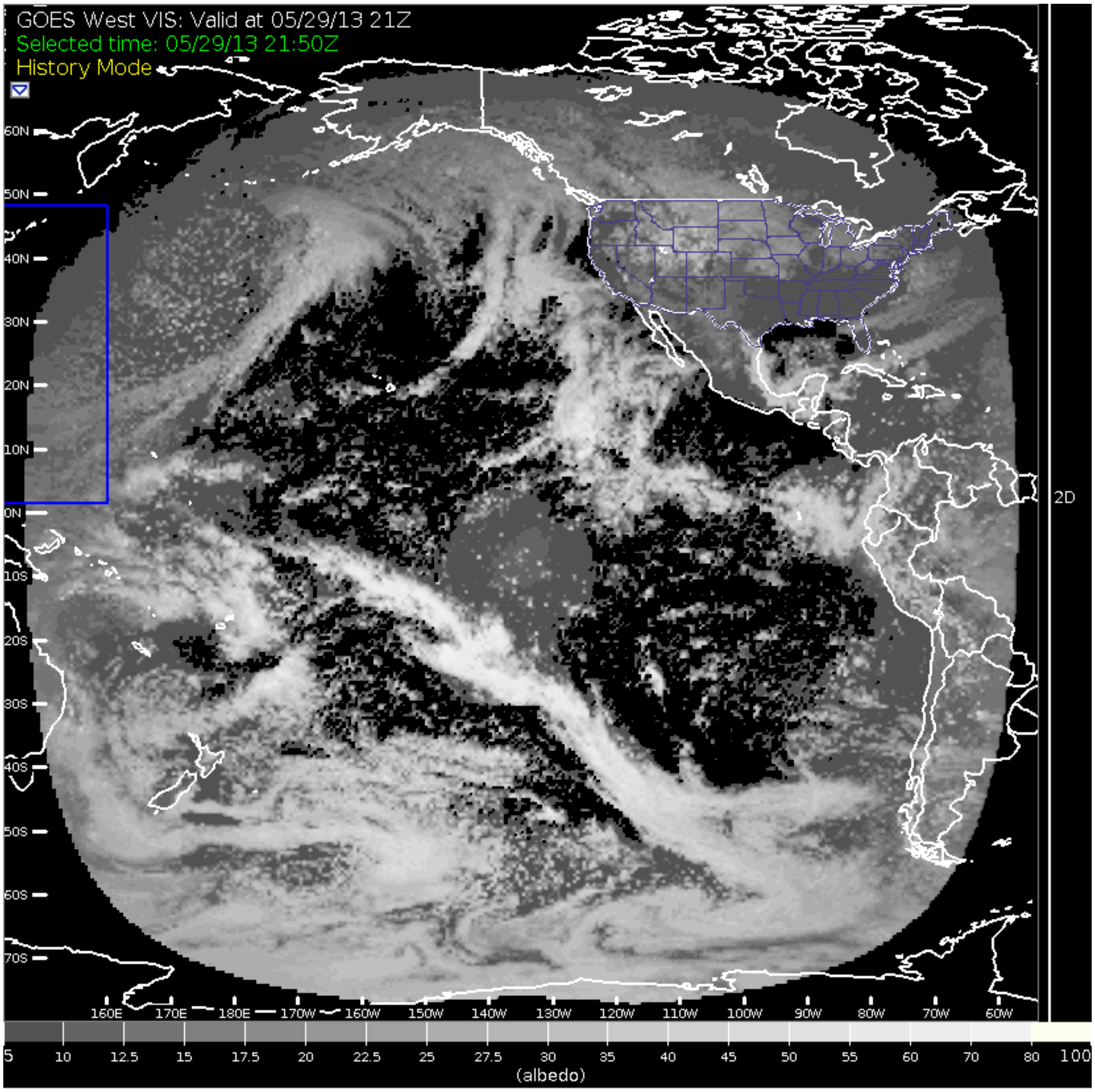


圖 2.3.3b GOES West 衛星可見光影像產品

Fig. 2.3.3b GOES West Visible Image

圖 2.3.3c 及 2.3.3d 顯示 GOES 衛星的紅外線影像產品。

Figures 2.3.3c and 2.3.3d show examples of the infrared images from the GOES satellites

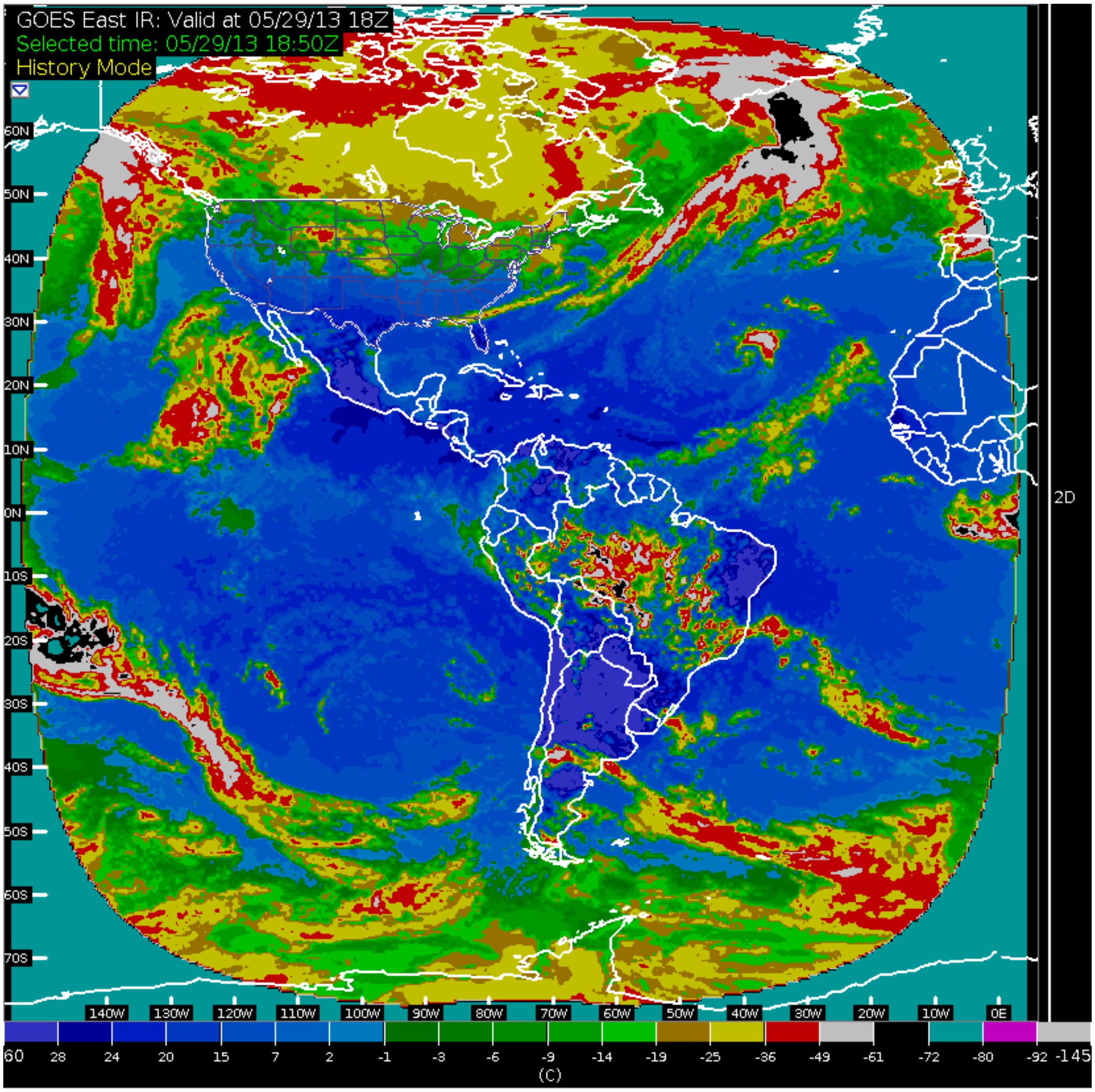


圖 2.3.3c GOES East 衛星紅外線圖

Fig. 2.3.3c GOES East Infrared Image

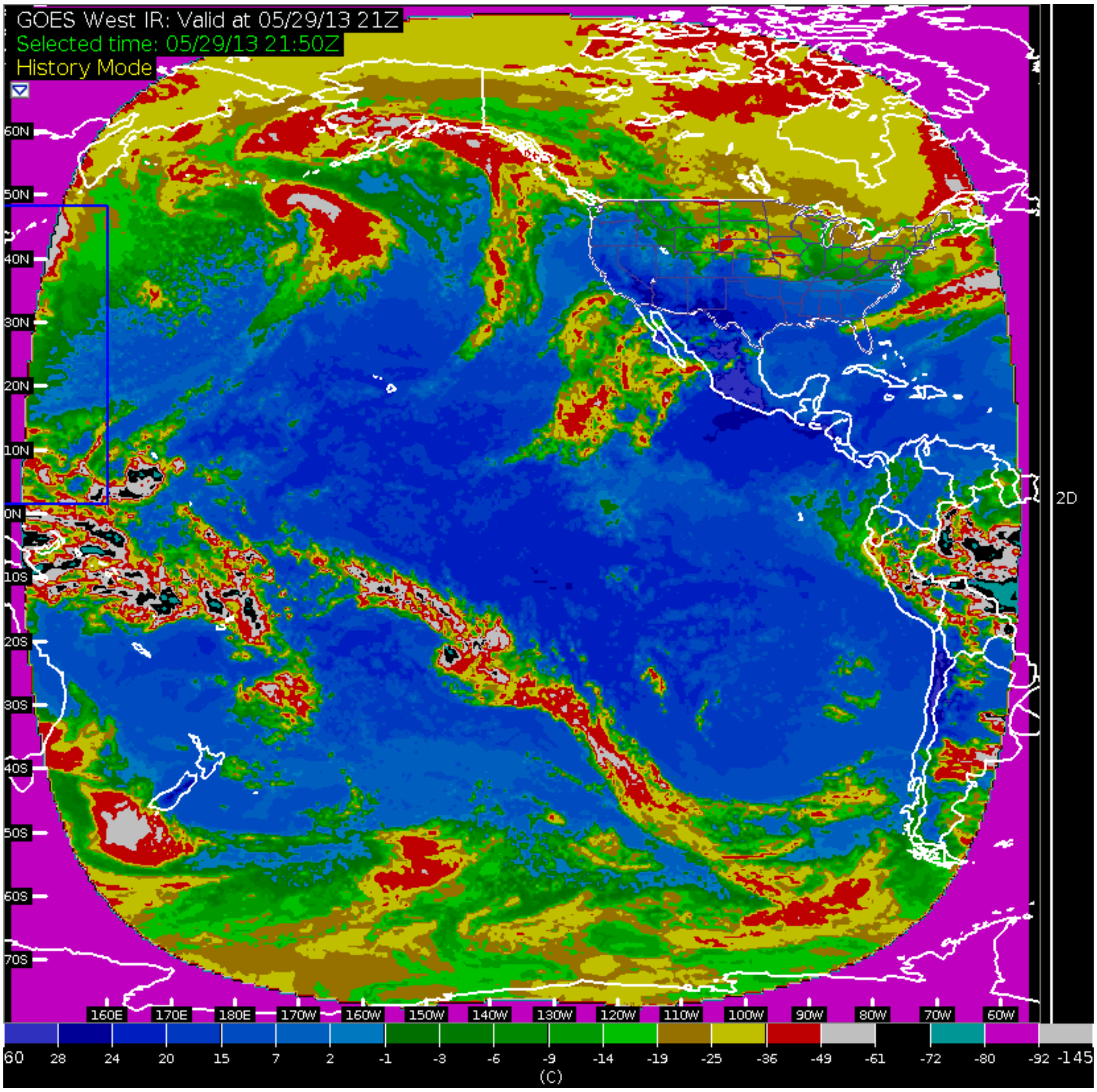


圖 2.3.3d GOES West 衛星紅外線圖

Fig. 2.3.3d GOES West Infrared Image

2.3.4 全球衛星影像 Global Satellite Images

AOAWS 系統同樣接收全球衛星合成影像產品，並透過資料轉換應用於系統中。圖 2.3.4a 顯示該產品範例。

The AOAWS system also receives a global satellite composite image. This image is also converted back into data for use in the system. Figure 2.3.4a shows an example of one of these images.

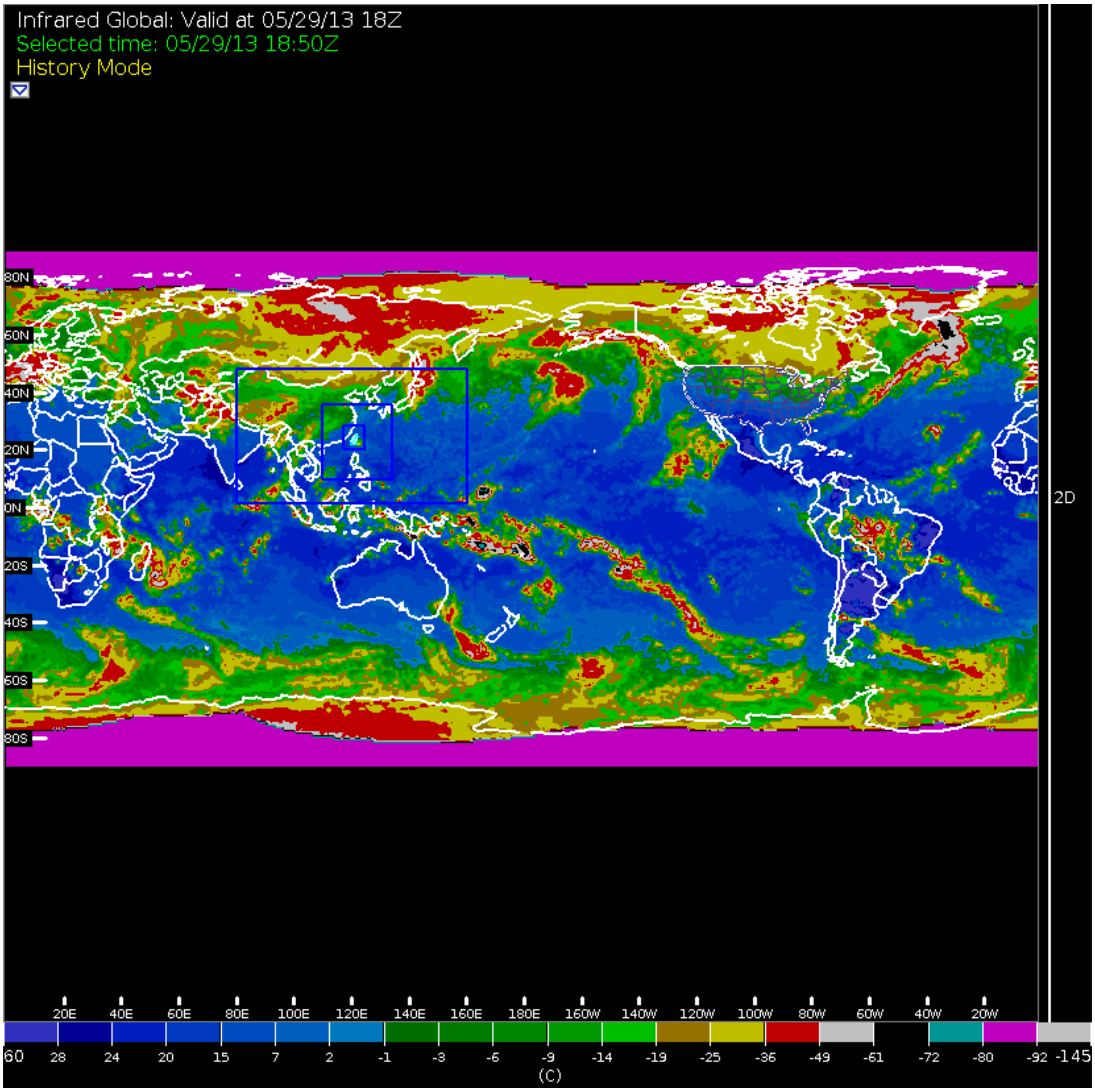


圖 2.3.4a GOES 全球紅外線衛星影像合成圖

Fig. 2.3.4a Global Composite Satellite Infrared Image

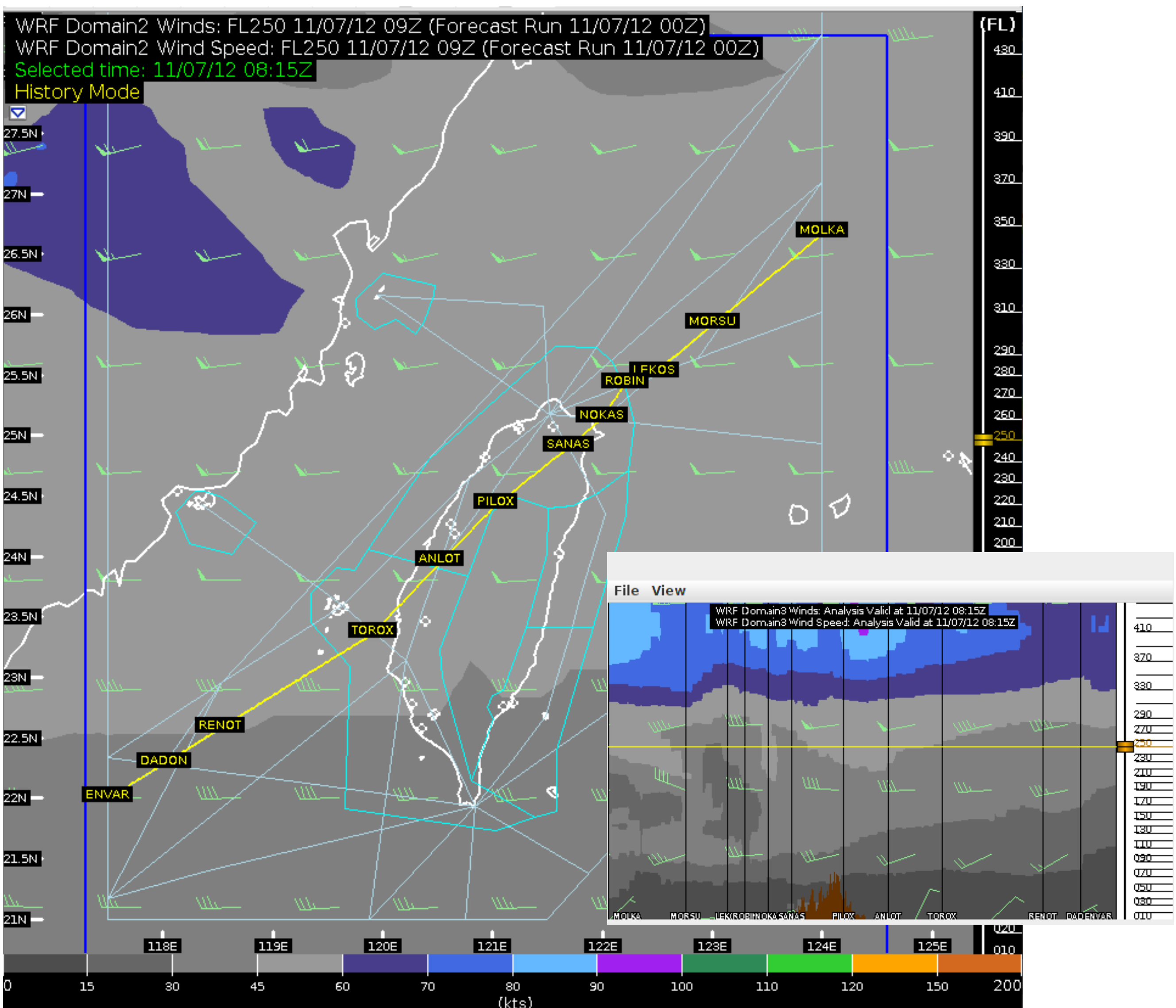
JMDS 之全球衛星影像合成產品，提供全球資料概況。換句話說，當放大全球影像時，若您選擇的範圍位於特定衛星範圍內，系統將切換至該衛星頻道，而不再顯示全球衛星影像。

The global composite satellite product is set up on the JMDS to provide progressive disclosure of the data. That is, when you zoom in on the global image, if your zoom is contained within a single satellite's domain then the data from that satellite will be displayed rather than the global composite image.

2.4 風場預報 (Wind Speed)

3D 風場預報產品顯示 WRF 模式預報的風場，風速單位為浬(knots)。一般而言，如果高空風速超過 60 浬表示這一區域有噴射氣流。圖 2.4a 顯示該產品的範例。

The 3-D wind speed field shows the wind speed grid as forecast by the WRF model. The units are knots. High altitude winds with speeds in excess of 60 knots generally indicate the location of the jet stream. An example of the 3-D wind speed field is shown in Figure 2.4a.



噴射氣流色階/Jet stream color scale

圖 2.4a 風場預報及剖面圖

Fig. 2.4a Wind Speed and Cross Section

2.5 溫度場預報 (Temperature Contours)

3D 溫度預報場產品) 顯示 WRF 模式預報的溫度場。溫度場以℃為單位。0℃等溫線 (結冰高度) 是以黃色顯示。其他的等溫線則是以紅色顯示。圖 2.5a 顯示該產品包含垂直剖面資料的範例。

The temperature contours field is a 3-D forecast of temperature values generated by the WRF model. The units are ℃. The 0 ℃ isotherm (freezing level) is shown in yellow. The rest of the contours are shown in red. Figure 2.5a shows an example of the temperature contours field including a vertical cross-section of the data.

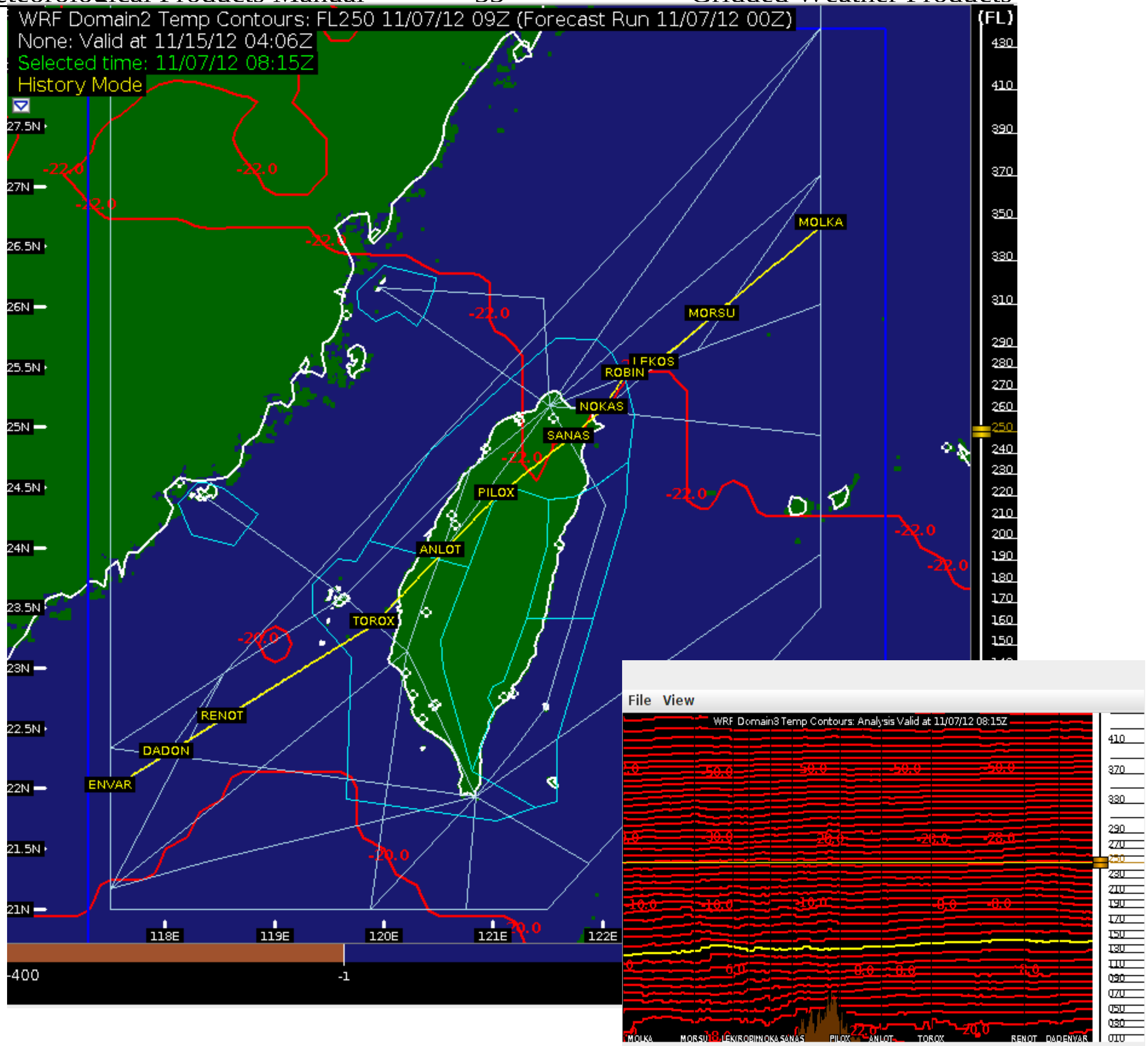


圖 2.5a 溫度場預報及剖面圖

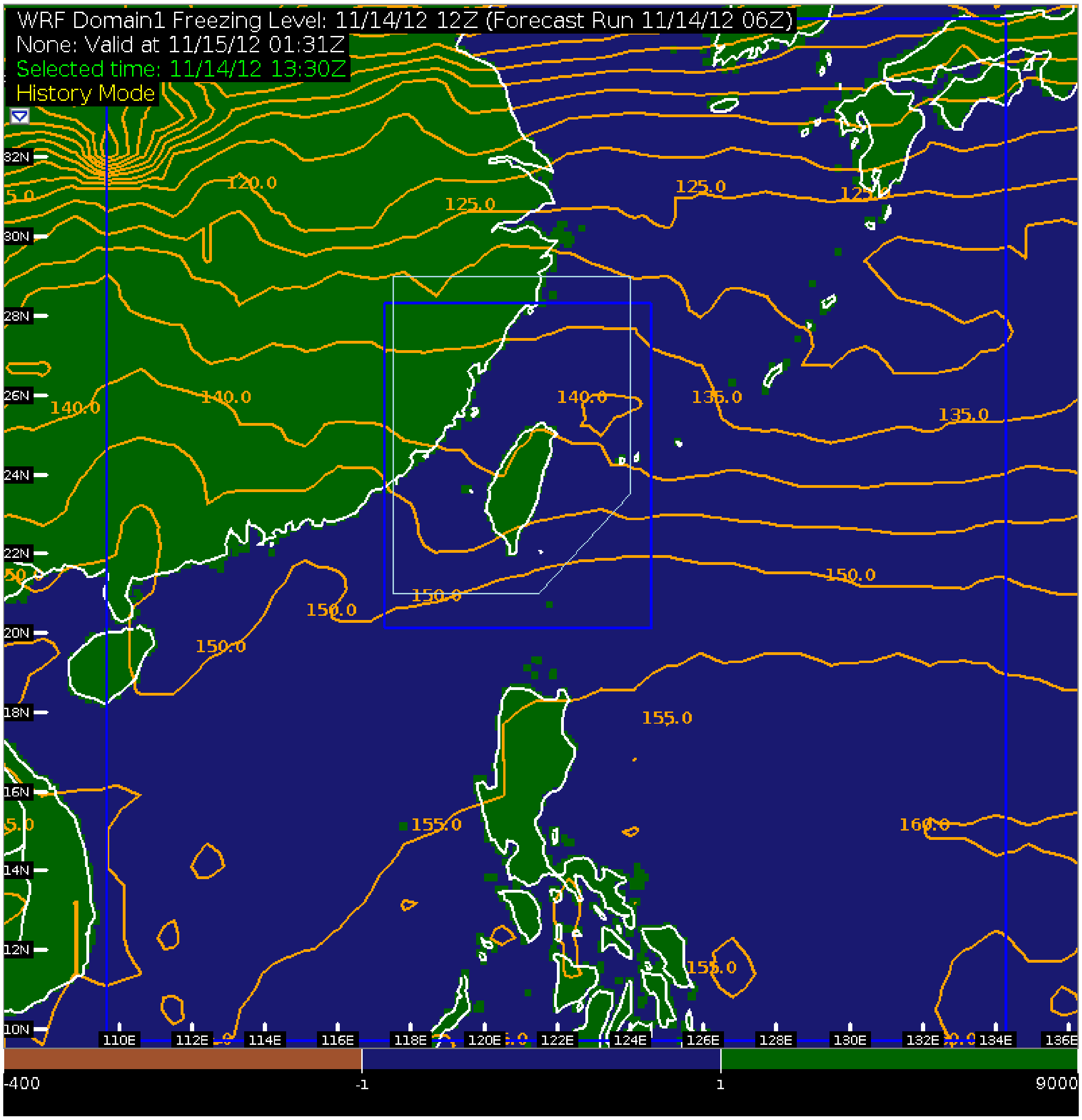
Fig. 2.5a Temperature Contours and Cross Section

2.6 結冰高度預報(Freezing Level)

結冰高度預報產品顯示由 WRF 模式預報的溫度場導出的結冰高度等值線。結冰高度以飛航空層 (FL) 為單位。結冰高度的計算是以氣溫 0℃為其最低結冰高度。有時 WRF 模式會預報逆溫而造成一個以上的結冰高度。此情況下這個區域的等高線就會顯得很擁擠。使用者若要獲得較詳細資料可以利用航路的垂直剖面圖來檢視該區域氣溫資料。圖 2.6a 顯示該產品範例。

The freezing level field is a 2-D contour of the freezing level heights as derived from the temperature field forecast by the WRF model. The units are Flight Level. The freezing level is computed as the lowest height at which the temperature is 0℃. Sometimes the

WRF model will predict temperature inversions, so that there may be more than one level at which the temperature is 0℃. In such regions the freezing level product will tend to have closely-spaced contours. You can get more detailed information about the 0℃ isotherm in such regions by displaying a flight route (vertical section) through the area and examining the temperature contours in the vertical section. An example of the



freezing level field is given in Figure 2.6a.

圖 2.6a 結冰高度預報

Fig. 2.6a Freezing Level

2.7 溼度預報(Humidity)

3D 溼度預報產品顯示 WRF 模式預報的溼度場，單位為百分比。圖 2.7a 顯示該產品範例。

The humidity field is a 3-D forecast of humidity generated by the WRF model. The units are percent. Figure 2.7a shows an example of the humidity field.

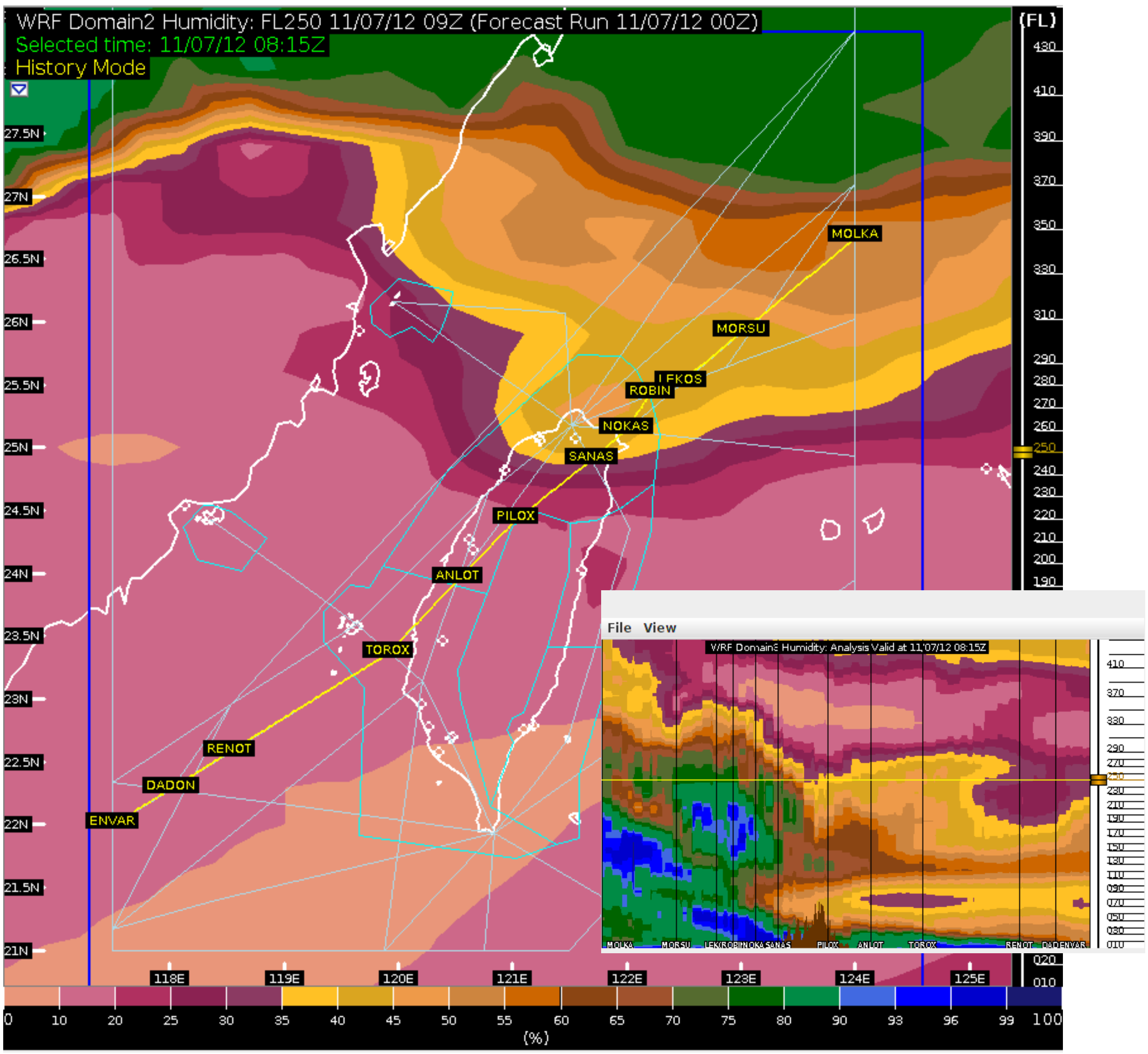


圖 2.7a 溼度預報及剖面圖

Fig. 2.7a Humidity and Cross Section

2.8 亂流預報(Turbulence)

2.8.1 亂流預報演算法 (ITFA Model-based Turbulence Algorithm)

AOAWS 所使用的 ITFA 亂流預報強度是使用 WRF 模式預報資料演算出來的。許多亂流科學研究者已經從模式 (如 WRF) 預報資料演算出針對預報亂流的各種指數。一般來說，在 4 公里與 20 公里解析度範圍的 ITFA 可能使用不同的指數，但此版本使用的是下列表格中的 6 種相同的指數，只是不同的解析度範圍 (domain)使用稍微不同的權重。

The AOAWS version of the NCAR Integrated Turbulence Forecasting Algorithm (ITFA) computes the severity of turbulence, using data from the WRF model. Various researchers have derived indices aimed at predicting the presence of turbulence from numerical weather prediction model data, such as WRF. In general, the set of indices used for 4-km domains and 20-km domains may be different; however, in this version they share the following same set of 6 indices with weights slightly different for the two domains:

Index	20-km	4-km
401 Brown2	0.668	0.668
425 DEF^2/Ri	0.686	0.664
434 $\|DIV\|/Ri$	0.677	0.651
451 C_T^2/Ri	0.690	0.671
454 EDR/Ri	0.683	0.664
458 F2D/Ri	0.700	0.667

AOAWS ITFA 將這些指數加權後求得總和，這個單一數值可解釋為預期可能發生亂流的強度。

The AOAWS ITFA then combines these indices as a weighted sum to produce the **single number** which may be interpreted as the expected turbulence intensity.

在任一指定網格點上組合亂流指數的演算法如下：

The combination of indices at any given point is calculated as follows:

1. 每一個指數的權重值 (W_i)是比對美國 (U. S.) 飛機報告及當時所測渦流消散係數(EDR)資料推導所得到之相對效能決定的。

1. A weight W_i is assigned to each index i based on its relative performance deduced from comparisons to PIREPs and in situ EDR data over the U. S.

2. 每一個指數 D_i 皆是由 WRF 模式預報資料演算出來的。

2. Each index D_i is computed from the WRF output.

3. 每一個指數被常態化成 介於 0 與 1 之指數值, D^*_i.

3. Each index is normalized to 0-1, D^*_i.

4. ITFA 的指數權重總值是用下列方程式演算出來的

4. The ITFA weighted sum of indices is computed as

$$ITFA = \Sigma W_i D^*_I / \Sigma W_i$$

目前使用於 4 公里與 20 公里範圍的指數權重值 W_i weight)設定如上表

The current weights W_i for the 4-km domain and the 20-km domain are given in the table above.

本亂流產品使用下列特定的 ITFA 門檻值 (threshold)來定義不同強度的亂流:

- 平穩 (none): ITFA < 0.25
- 輕度 (light): 0.25 ≤ ITFA < 0.370
- 中度 (moderate): 0.370 ≤ ITFA < 0.675
- 強烈 (severe): ITFA ≥ 0.675

The specific ITFA threshold value for each intensity category is:

- None: ITFA < 0.25
- Light: 0.25 ≤ ITFA < 0.370
- Moderate: 0.370 ≤ ITFA < 0.675
- Severe: ITFA ≥ 0.675

ITFA 演算法已經調成適用於大至重型飛行器 (B757 型飛行器大約是在大至重型之間) 。重型飛行器包含 B757、 B767、 B777、 B747、A300、A310、A330、及 A340， B 737 則屬於大或中型飛行器。飛行器型級之定義是以其產生的航跡旋渦為準。下列為 ICAO 之定義：

- 重型 >136,000 kg = 300,000 lbs
- 中或大型 7,000 kg 至 136,000 kg
- 輕型 ≤ 7,000 kg = 15,400 lbs

The ITFA algorithm is tuned for large to heavy aircraft, with a B757 being in about the center of the range. Heavy aircraft include B757, B767, B777, B747, A300, A310, A330, and A340. A B737 is in the large or medium category. Aircraft weight is defined by the wake vortex it generates. The ICAO categorizes aircraft as follows:

- Heavy: weight ≥ 136,000 kg (300,000 lbs)
- Medium or Large: 7,000 kg < weight < 136,000 kg
- Light: weight ≤ 7,000 kg (15,400 lbs)

2.8.2 3-D ITFA Model-based Turbulence Product

本項亂流預報產品是 ITFA (NCAR Integrated Turbulence Forecasting Algorithm) 預報結果，以介於 0 與 1 之指數值表示預期亂流程度的 3D 產品。不同的顏色表示不同的亂流強度(無、輕度、中度及強烈)。ITFA 採用 WRF 模式的 20 公里與 4 公里解析度範圍 (domain) 資料來計算亂流的強度。亂流產品的顯示則涵蓋 AOAWS 5 公里(範圍二- domain 2)及 15 公里(範圍三- domain 3)，以節省網路頻寬及電腦顯示資源。圖 2.8.2a 顯示該產品及其垂直剖面資料的範例。

The turbulence product is a 3-D forecast of expected turbulence levels on a 0-1 scale as predicted by ITFA. The colors indicate the turbulence level or intensity (none, light, moderate, and severe). ITFA is computed on both the 20-km and 4-km domains of the WRF model. For display purposes the Turbulence product is shown on the 5-km (domain 2) and 15-km (domain 3) domains. This is done to conserve network bandwidth and resources on display computers. Figure 2.8.2a shows an example of the turbulence field along with a vertical cross-section.

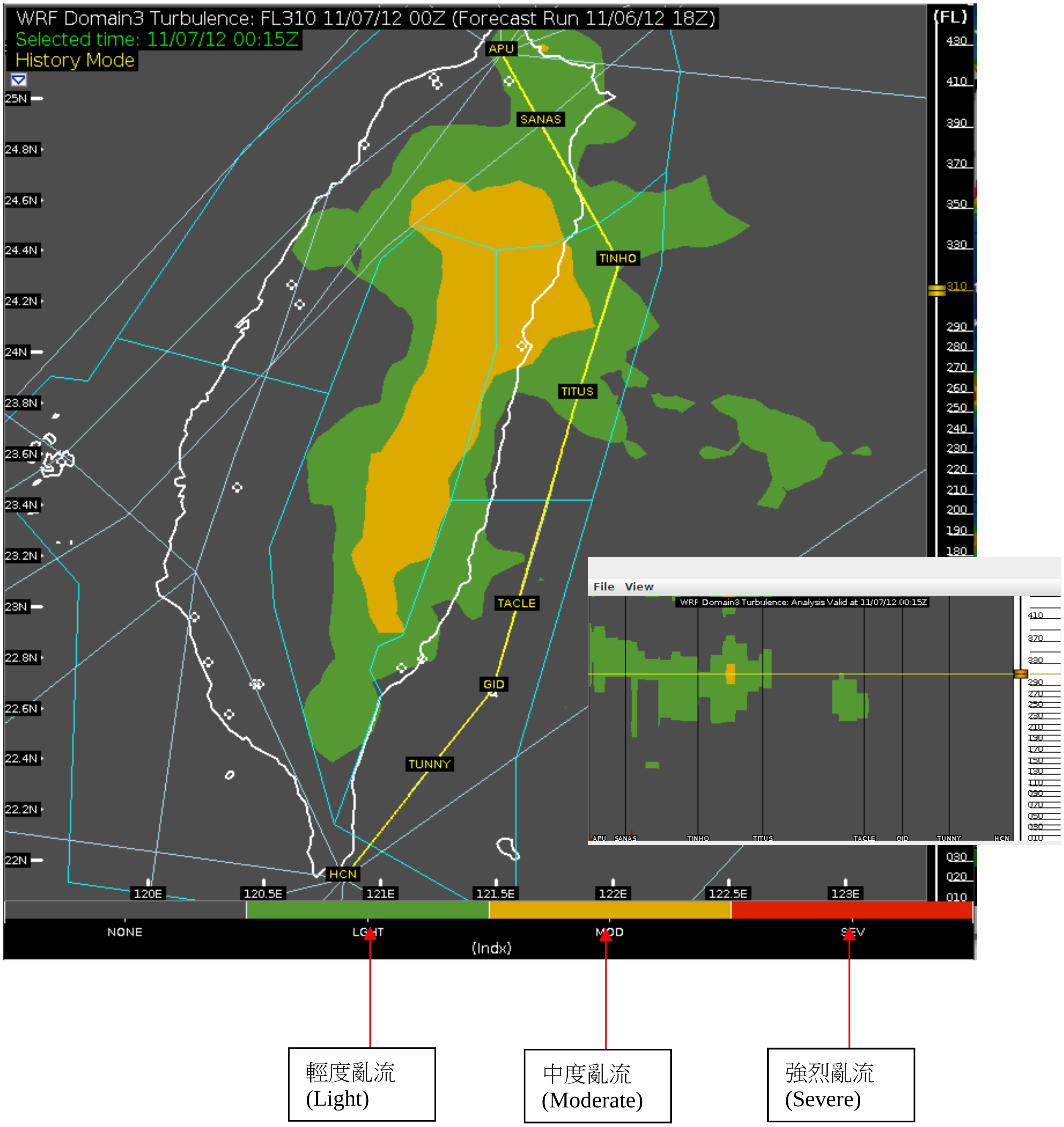


圖 2.8.2a ITFA 亂流預報產品及其剖面圖

Fig. 2.8.2a ITFA Turbulence and Cross Section

2.8.3 亂流預報疊加圖 (ITFA Model-based Turbulence All-levels)

亂流預報疊加圖是由三維亂流產品導出來的二維產品，它顯示在所有飛航空層 (FL200-FL450) 中的最大亂流強度。要得到比較詳細的亂流預報資訊的最好辦法是，在亂流預報疊加圖上選擇一條航路，觀看其剖面圖，然後切換到三維亂流的產品，如此可看出亂流預報的垂直發展狀況。圖 2.8.3a 顯示亂流預報疊加圖及包含垂直剖面資料的範例。

The turbulence all-levels field is a 2-D turbulence composite derived from the 3-D Turbulence field. It shows the maximum Turbulence intensity over all flight levels from FL200-FL450. The best way to get detailed information about the forecast Turbulence is to display this all-levels field, select a flight route through the indicated Turbulence, and then switch to the 3-D Turbulence product. That way you will see the vertical extent of the Turbulence forecast. Figure 2.8.3a shows an example of the 2-D turbulence field along with a vertical cross-section of the 3-D field.

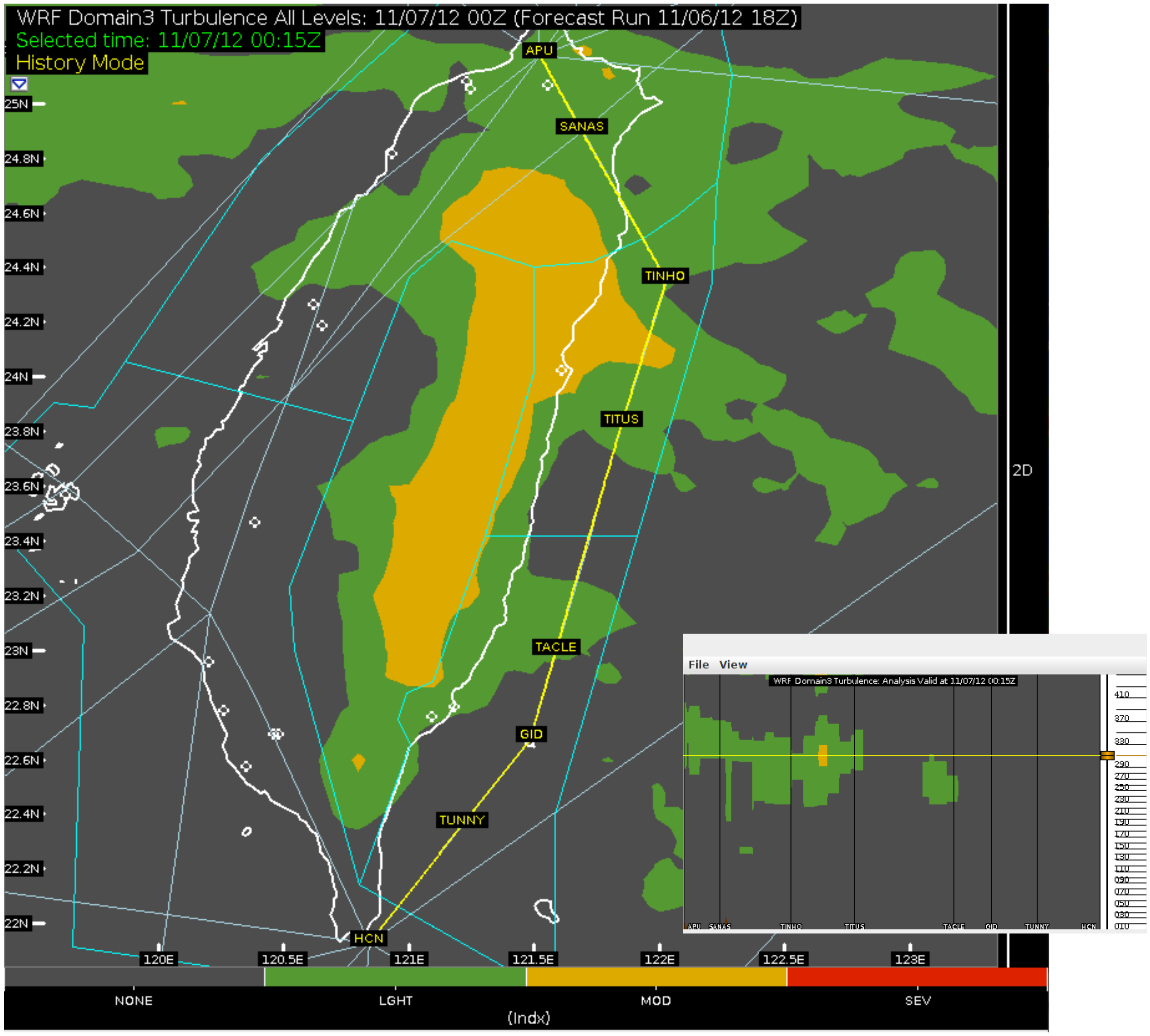


圖 2.8.3a 亂流預報疊加圖及其剖面圖

Fig. 2.8.3a ITFA Turbulence All-levels and Cross Section

2.8.4 NTDA 亂流偵測演算法 (NCAR Turbulence Detection Algorithm，NTDA)

NCAR 亂流偵測演算法(NTDA)提供以雷達資料為基礎，可辨識雲中亂流的 3D 產品。NTDA 以渦流消散係數(EDR)來量度大氣亂流之強度。EDR 之單位為 $m^{2/3}\ s^{-1}$，係 國際民航組織(ICAO)大氣亂流標準量。NTDA 與 ITFA 之不同在於 NTDA 使用都卜勒雷達資料來提供即時偵測雲中亂流之影像，包含對流亂流；而 ITFA 則使用 WRF 模式資料以提供亂流預報，特別是晴空亂流。因此，這兩項產品是具互補性的。

The NCAR Turbulence Detection Algorithm (NTDA) provides a 3-D radar-based product that identifies regions of *in-cloud* turbulence. NTDA provides a measurement of atmospheric turbulence intensity called eddy dissipation rate, EDR. EDR has units $m^{2/3} s^{-1}$.and is the ICAO standard quantity for atmospheric turbulence. NTDA differs from ITFA in that NTDA uses Doppler radar data to provide a current picture of detected in-cloud turbulence, including convective turbulence, whereas ITFA uses WRF model data to provide forecasts of turbulence, particularly clear air turbulence. The two products are complementary.

與 ITFA 類似，NTDA 強度分類已經調成適用於大至重型飛行器 (B757 型飛行器大約是在大至重型的中間)。重型飛行器包含 B757、B767、B777、B747、A300、A310、A330、及 A340， B 737 則屬於大或中型飛行器。下列為 ICAO 之定義：

Similar to ITFA, the NTDA intensity categories are tuned for large to heavy aircraft, with a B757 being in about the center of the range. Heavy aircraft include B757, B767, B777, B747, A300, A310, A330, and A340. A B737 is in the large or medium category. The ICAO categorizes aircraft as follows:

- 重型 >136,000 kg = 300,000 lbs
- 大或中型 7,000 kg 至 136,000 kg
- 輕型 ≤7,000 kg = 15,400 lbs

- Heavy: weight ≥ 136,000 kg (300,000 lbs)
- Medium or Large: 7,000 kg < weight < 136,000 kg
- Light: weight ≤ 7,000 kg (15,400 lbs)

2.8.5 三維 NCAR 亂流偵測產品 (3-D NTDA Radar-based Turbulence Product)

NTDA 亂流產品是以 3D 雷達資料為基礎之 EDR 偵測產品，該顏色表示亂流分級或強度(無，輕度，中度及強烈)。因其為 3D 產品，對風暴進行垂直剖面分析，可有效地顯示風暴的垂直結構及亂流強度。

NTDA 產品僅涵蓋台灣都卜勒雷達所涵蓋之範圍(訊號強且未受雜訊干擾)。NTDA 以黑色區域表示該處無法以雷達偵測亂流。缺乏 NTDA EDR 資料表示該區域無適當資料，而非無亂流。因此建議將 NTDA 偵測到之亂流產品應與 ITFA 晴空亂流產品合併檢視，以檢視未被 NTDA 偵測到之亂流。圖 2.8.5a 顯示 NCAR 亂流偵測產品及其垂直剖面資料的範例。

The NTDA turbulence product is a 3-D radar-based detection of EDR. The colors indicate the turbulence level or intensity (none, light, moderate and severe). Since this is a 3D product, it is useful for performing cross sections through storms to reveal the vertical structure and severity of turbulence within them.

The NTDA product covers only regions within range of the Taiwan Doppler radars in which strong and uncontaminated radar signals are returned. The NTDA display shows the black background color in regions where the radar signal does not permit turbulence detection. The absence of NTDA EDR data in these regions does *not* mean that there is no turbulence, but rather that no information is provided there. Thus, it is recommended that the NTDA product be viewed with ITFA Turbulence forecast contours overlaid to indicate regions of possible turbulence not detected by NTDA, including clear-air turbulence.

Figure 2.8.5a shows an example of the NTDA turbulence field along with a vertical cross-section.

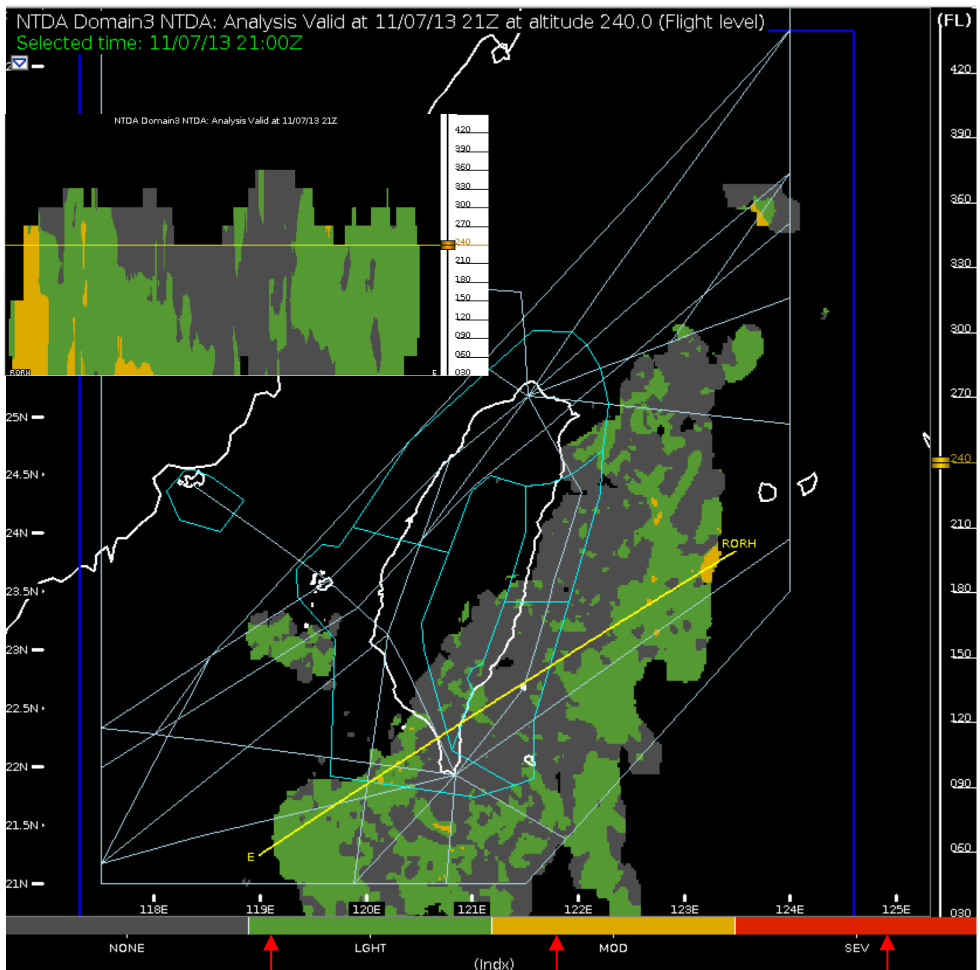


Fig. 2.8.5a NTDA Turbulence and Cross Section

輕度亂流 (Light)

中度亂流 (Moderate)

強烈亂流 (Severe)

2.8.6 NTDA 雷達亂流疊加產品 (NTDA Radar-based Turbulence Product All-levels)

NTDA 疊加圖是由三維 NTDA EDR 場疊合而成的二維產品，顯示在所有飛航空層 (FL200-FL450) 中最大的 NTDA EDR 強度。與 ITFA 相似，要得到比較詳細的亂流預報資訊的最好辦法是，在 NTDA 疊加圖上選擇一條航路，觀看其剖面圖，然後切換到三維 NTDA 的產品，如此可看出亂流的垂直發展狀況。圖 2.8.6a 顯示二維 NTDA 雷達亂流疊加產品的範例。

The NTDA all-levels field is a 2-D NTDA EDR composite derived from the 3-D NTDA EDR field. It depicts the maximum NTDA EDR over all flight levels from FL200-FL450. Similar to ITFA, the best way to get detailed information about the current NTDA EDR is to display this all-levels field, select a flight route through regions of concern, and then switch to the 3-D NTDA product. That way you will see the vertical extent of the turbulence. Figure 2.8.6a shows an example of the 2-D NTDA field.

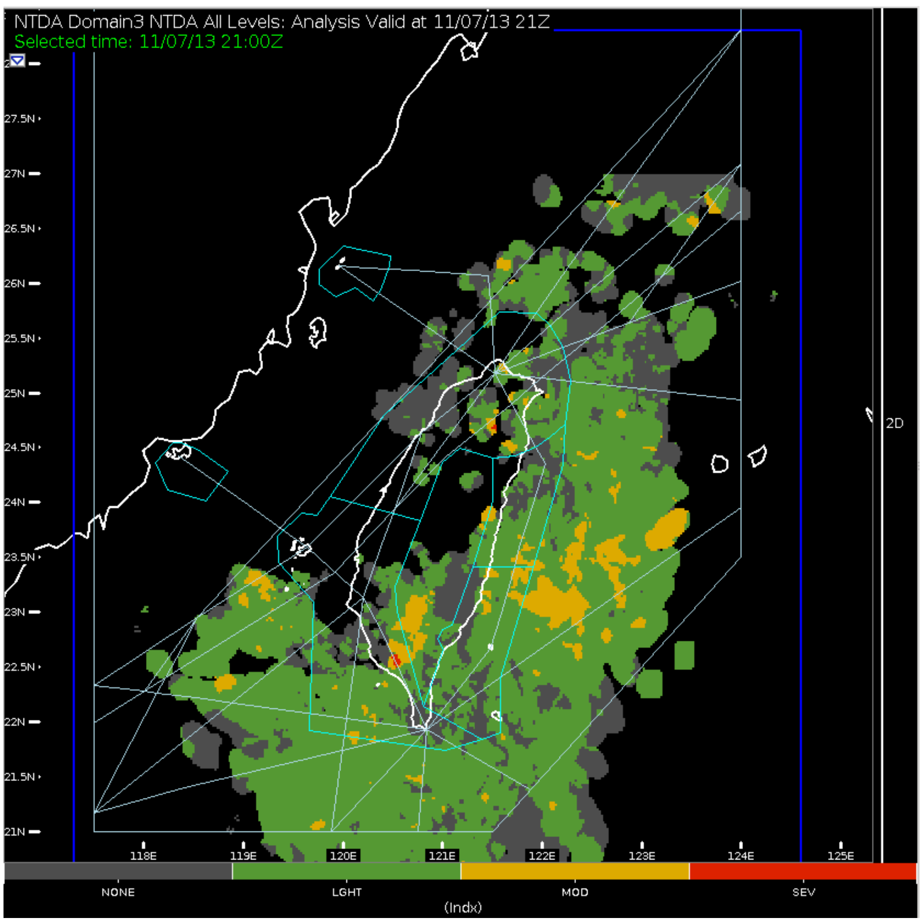


Fig. 2.8.6a NTDA Turbulence All-levels

2.9 積冰預報 (Icing)

2.9.1 積冰預報演算法 (**Icing** Algorithm)

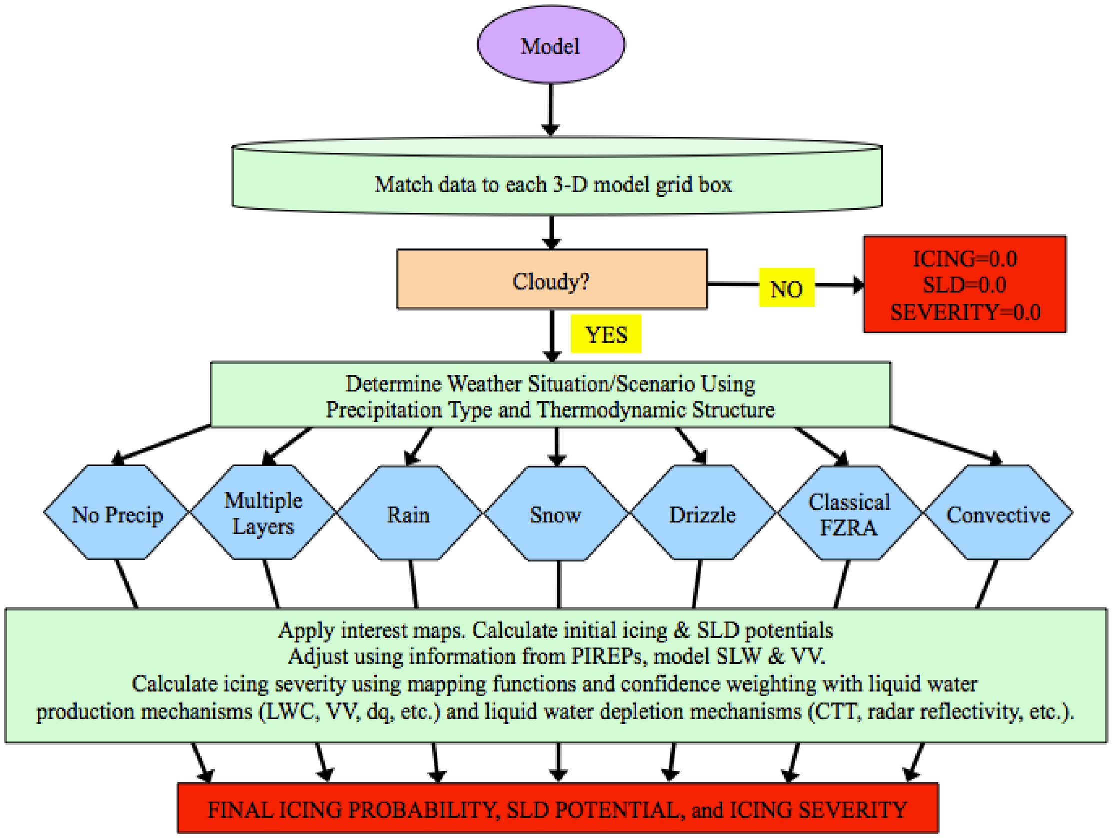
2.9.1.1 預報積冰產品(Forecast Icing Product，FIP)

FIP 是自動產生的積冰強度預報產品，其透過檢驗 WRF 數值預報模式的輸出資料，來決定航路上的飛行器可能遭遇的積冰位置和積冰強度。

The Forecast Icing Product (FIP) is an automatically-generated forecast of icing severity. FIP examines numerical weather prediction model output (from the WRF) and determines the likely locations and severity of in-flight aircraft icing conditions.

此演算法(**圖 2.9.1a**) 是採用最新雲物理原理及研究結果為基礎，由分析數值模式的輸出資料，來決定雲頂及雲底高度，檢驗嵌入式雲層，並辨識降水型態。一旦發現可能發生雲和降水的地點時，先決定積冰的物理性，然後用模糊邏輯(fuzzy logic)的方法來決定可能的積冰情況。模糊邏輯所使用的邏輯數(interest maps)是以數值模式的輸出資料為線索，以反應與積冰存在的相關性。許多模式輸出參數都被用來計算模式每個水平及垂直網格的積冰機率，過冷大水滴(super-cooled large drop，SLD) 潛勢和積冰強度。

The algorithm, shown in Fig. 2.9.1a, is based on the most up-to-date cloud physics research and principles. It analyzes the model output from a vertical column, determines the cloud top and base heights, checks for embedded cloud layers, and identifies a precipitation type. Once the likely locations of clouds and precipitation are found, the physical icing situation is determined and a fuzzy logic method is used to estimate the likely icing conditions. The fuzzy logic interest maps are based on clues from the model output, reflecting relevance to the presence of icing. Numerous fields from the model are used to determine the icing probability, super-cooled large drop (SLD) potential and the resulting icing severity at each model grid box both horizontally and vertically.


Model
Match data to each 3-D model grid box
Cloudy?
NO
ICING=0.0
SLD=0.0
SEVERITY=0.0
YES
Determine Weather Situation/Scenario Using
Precipitation Type and Thermodynamic Structure
No Precip
Multiple Layers
Rain
Snow
Drizzle
Classical FZRA
Convective
Apply interest maps. Calculate initial icing & SLD potentials
Adjust using information from PIREPs, model SLW & VV.
Calculate icing severity using mapping functions and confidence weighting with liquid water
production mechanisms (LWC, VV, dq, etc.) and liquid water depletion mechanisms (CTT, radar reflectivity, etc.).
FINAL ICING PROBABILITY, SLD POTENTIAL, and ICING SEVERITY

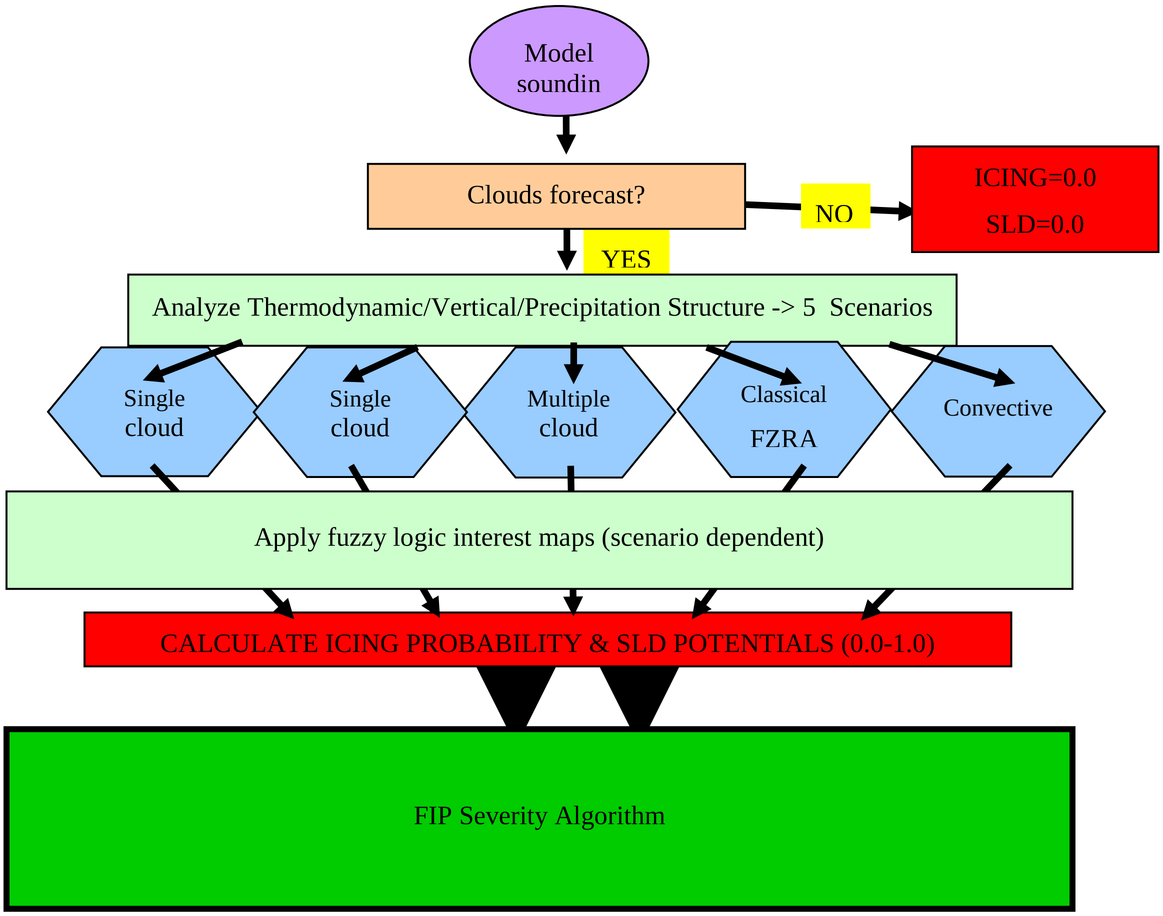


圖 2.9.1a FIP 演算法科學流程圖

Figure 2.9.1a FIP algorithm scientific flow chart

FIP 的積冰強度是 0.0 至 1.0 間的連續值，用此值用來進行積冰強度的分類，可分為無積冰、輕度積冰、中度積冰及重度積冰。

FIP 使用下列門檻值 (threshold) 來定義不同強度的積冰：

The icing severity output from FIP is a continuous value ranging from 0.0 to 1.0. This continuous value is mapped to categories, which are include none, light, moderate and severe icing.

The specific FIP severity threshold values for each level are:

- 無積冰(None)： Severity < 0.175
- 輕度積冰(Light)： 0.175 <= Severity < 0.425
- 中度積冰(Moderate)： 0.425 <= Severity < 0.75
- 重度積冰(Severe)： 0.75 <= Severity <= 1.0

2.9.1.2 即時積冰產品 (Current Icing Product，CIP)

CIP 的運作方式與 FIP 類似，但不同於 FIP 僅提供預報，CIP 則提供積冰診斷產品。因為 CIP 為一診斷工具，它能夠充分利用天氣觀測資料來產生積冰診斷產品。這些觀測資料提供了雲頂、雲底、降水的發生及降水形式等準確資訊。這些資訊與模式的輸出資料合併，以決定積冰機率、過冷大水滴(SLD)潛勢及積冰強度。圖 2.9.1b 為 CIP 的科學診斷流程圖，除了在模式資料之前，增加了衛星、測站及雷達(僅 domain 3)等觀測資料外，與圖 2.9.1a 相同。

The Current Icing Product (CIP) works similarly to the FIP, but provides an icing diagnosis rather than a forecast. Because it is a diagnostic tool it is able to take advantage of weather observations to create its products. These observations provide accurate information on the tops and bases of clouds along with precipitation occurrence and type. They are combined with model output to determine icing probability, SLD potential, and icing severity. A CIP scientific flow chart for Taiwan is shown in Fig. 2.9.1b. It is the same as in Fig. 2.9.1a except observations from satellite, surface stations, and radar (on Domain 3 only) are added to model fields in the first step.

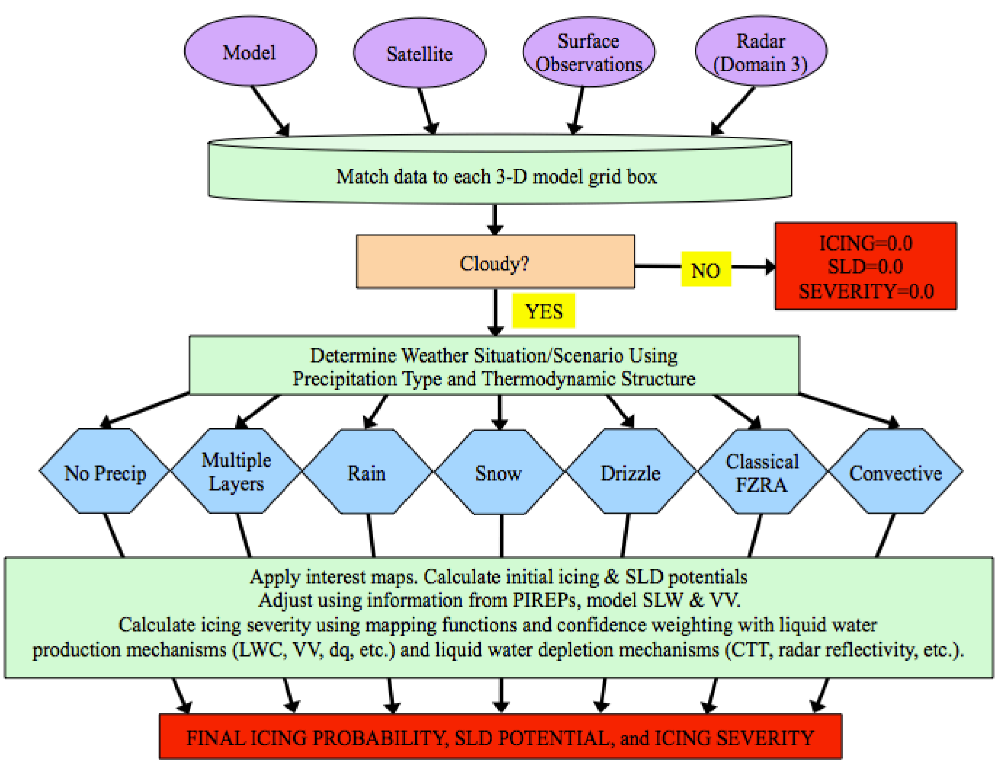


圖 2.9.1a CIP 診斷法科學流程圖

Figure 2.9.1b CIP algorithm scientific flow chart

CIP 使用與 FIP 相同的雲物理及模糊邏輯原則。然而，由於 CIP 利用針對雲層屬性、降水形態及降水覆蓋的觀測，以更好地反映特定空域的即時積冰狀態，以期待在特定的地點正確的捕捉積冰事件並進行空域警告。

All of the same cloud physics and fuzzy logic principles from the FIP are used in the CIP. (Politovich et al 2006) However, since the CIP is able to use direct observations of cloud properties, precipitation type, and precipitation coverage to better represent the current icing conditions expected at a particular point it generally quite well in terms of icing events correctly captured and volume of airspace warned (Fowler et al 2006).

如同 FIP 的積冰強度，CIP 的積冰強度是 0.0 至 1.0 的連續值，用此值用來做積冰強度的分類，此門檻值與 CIP 略有不同：

As in the FIP the icing severity output in the CIP is a continuous value ranging from 0.0 to 1.0, which is then mapped to categories. The thresholds differ somewhat for the CIP.

- 無積冰(None)： Severity < 0.175
- 輕度 Light)： 0.175 <= Severity < 0.375
- 中度 Moderate)： 0.375 <= Severity < 0.7
- 重度 Severe)： 0.7 <= Severity <= 1.0

2.9.1.3 產品應用資訊 (Product Application Information)

FIP 和 CIP 的產品更新頻率係依據使用於產製產品的上游資料。對於 FIP 而言，產品更新頻率和輸出時序係控制於中央氣象局 WRF 模式輸出資料抵達的時間，WRF 模式每天執行四次，從 00Z 開始每 6 小時執行一次。資料大約在模式時間開始後 5 小時更新，兩個模式範圍的預報長度分別為 48 小時和 72 小時。對 CIP 而言，產品更新的時間係依據日本 MTSAT 衛星資料的更新間隔，大約每 30~60 分鐘更新一次，產品有效時間為 1 小時。

The update frequency of FIP and CIP are driven by the upstream datasets used in creation of the products. For FIP, the frequency and output timing is controlled by the arrival of WRF model output from the CWB. The WRF Model executes four times a day at six hour intervals starting at 0Z. These results are not available to the AOAWS for up to results 5 hours after model initialization. The forecast lead intervals extend out are 48 and 72 hours for the inner and outer WRF domains. For CIP, the output frequency is driven by the update interval of MTSAT data, which updated approximately every 30 to 60 minutes. Results from CIP are considered valid for up to an hour.

2.9.1.4 參考文獻 References

Fowler, T. L., M. Chapman, A. Holmes, B. G. Brown, J. L. Mahoney, J. T. Braid, and P. Boylan, 2006: Current Icing Potential (CIP): Probability, Severity, and SLD. *Prepared for the Aviation Weather Technology Transfer Technical Review Panel.*

Politivich, M.K, C. Wolff, B. Bernstein, and F. McDonough, 2006: CIP severity scientific and technical document. *Prepared for the Aviation Weather Technology Transfer Technical Review Panel.* Report available from M. Politovich (marcia@ucar.edu).

Wolff, C.A, F. McDonough, M.K. Politovich, and B.C. Bernstein, 2006: FIP severity technical document. Prepared for the Aviation Weather Technology Transfer Technical Review Panel. Report available from Cory Wolff (cwolff@ucar.edu).

2.9.2 三維積冰產品 3-D Icing Product

此三維積冰預報產品 (圖 2.9.2a)是由 CIP(即時積冰產品)診斷或 FIP(預報積冰產品)預報的結果，表示航路上可能發生的積冰。不同的顏色表示在該區域內可能遭遇的積冰強度。積冰強度定義說明如下：

- 輕度積冰：
  輕度積冰狀況經常被描述為以下的狀況：”不必要改變飛行航道或高度”及”不會造成行機失速”。它也被嚴格地定義為每小時的外機翼積冰累積的速度在 0.25 英吋與 1 英吋 (0.6 to 2.5 cm) 之間。
- 中度積冰：
  中度積冰通常被描述為積冰累積的速度持續增加，但是除非是持久一段時間，否則不至於造成飛行危險，但空速可能會降低。其亦可被定義為每小時的外機翼積冰累積的速度在 1 英吋與 3 英吋 (2.5 to 7.5 cm) 之間。
- 重度積冰：
  重度積冰的描述狀況如下列：
  - 積冰或積冰累積的速度超過飛機的承受力；
  - 積冰持續累積並且開始嚴重地影響飛機的性能及可操作性；
  - 積冰速度快到飛機的除冰裝置無法去除積冰，並且會在不易積冰處結冰；
  - 為能全面操縱飛行器，即刻離開這個積冰區域是必要的。

積冰累積的速度和飛機的型號和飛機上的除冰設備種類有很大的關係。上述有關積冰的定義只能作為參考之用。

The icing field is a 3-D depiction of the existence of in-flight icing as diagnosed by the CIP or predicted by the FIP. The colors indicate the severity of the icing forecast for a given location. An example of the icing field is shown in Figure 2.9.2a.

Icing severity is defined as follows:

- Light - Light Icing is often described as conditions such that no change of course or altitude is necessary and no loss of airspeed occurs. It has been more rigorously defined by some as a rate of ice accretion on the outer wing between 0.25 inch and 1 inch (0.6 to 2.5 cm) per hour.
- Moderate - Moderate Icing has been typically described as ice accretion which continues to increase but not at a rate sufficient to affect the safety of the flight unless it continues for an extended period of time, but air speed may be lost. This can be defined as an ice accretion rate on the outer wing of 1 to 3 inches (2.5 to 7.5 cm) per hour.
- Severe - Severe Icing has been variously described as ice accretion:
    - in which either the icing rate or ice accumulation exceed the tolerance of the aircraft;
    - which continues to build and begins to seriously affect the performance and maneuverability of an aircraft;
    - at a rate such that ice protection systems fail to remove the accumulation of ice and ice accumulates in locations not normally prone to icing;
    - such that an immediate exit from the condition is necessary to retain full control of the aircraft.

The effect of icing on aircraft varies greatly with type of aircraft and type of deicing equipment. The above definitions should be used only as a guide.

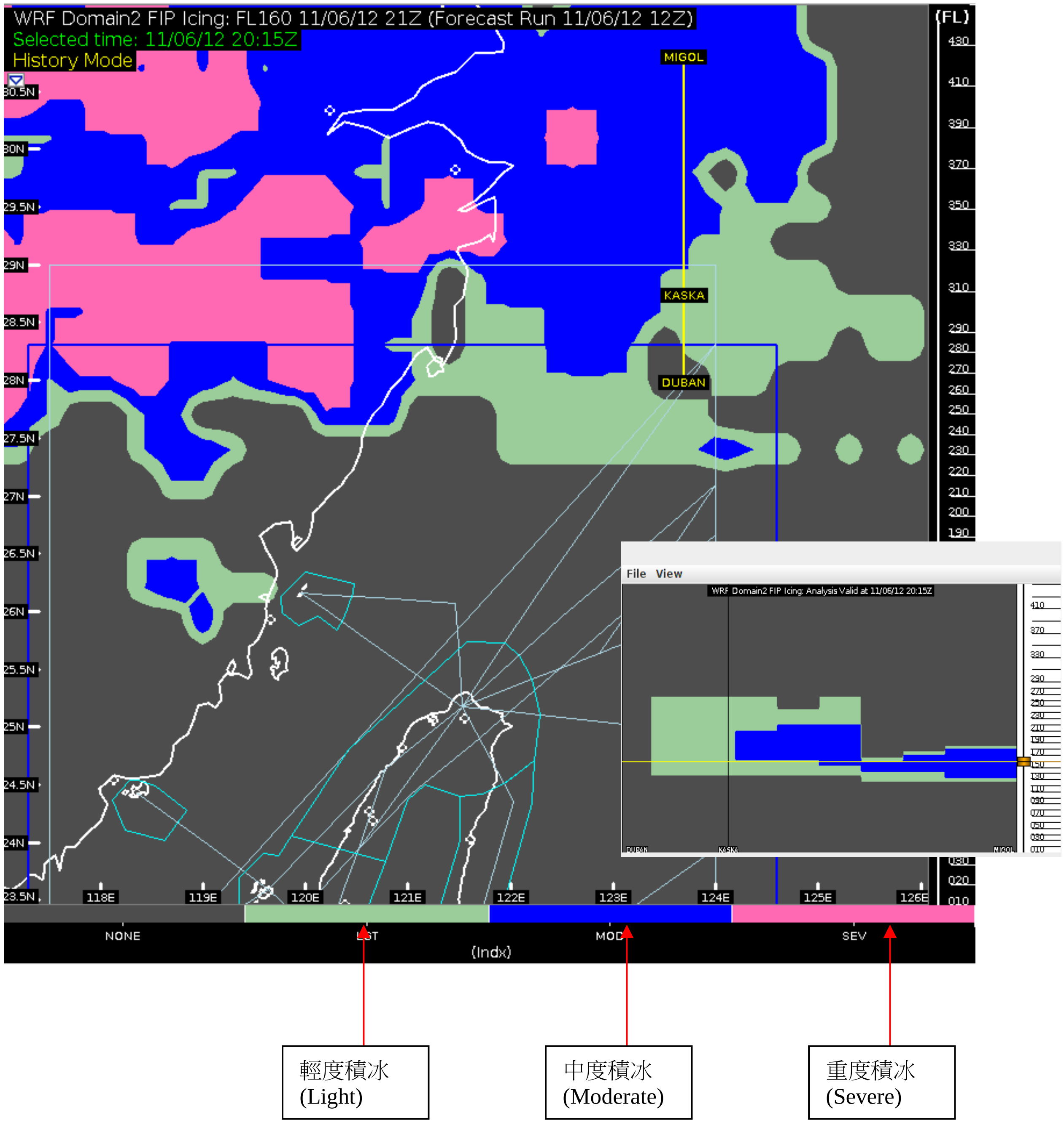


圖 2.9.2a 積冰預報產品及其剖面圖

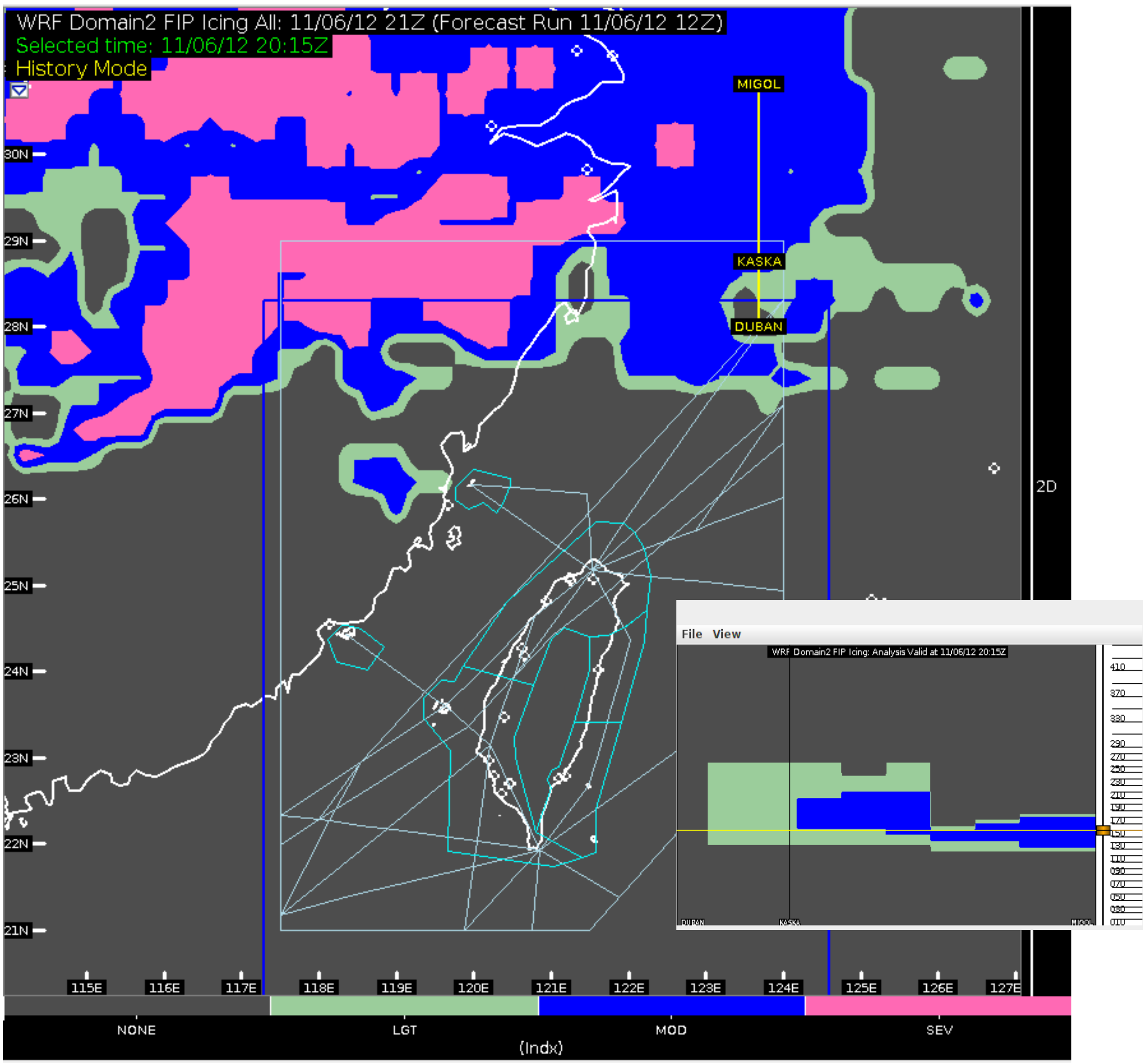
Fig. 2.9.2a Icing and Cross Section

2.9.3 積冰預報疊加圖 (Derived Icing Products)

積冰預報疊加產品(圖 2.9.3a)由三維積冰產品導出來的，其顯示所有飛航空層中的最大積冰強度。要得到比較詳細的積冰預報資訊最好辦法是在積冰預報區域的疊

加圖上選看飛行航路剖面圖，然後切換到三維積冰的產品顯示來看預報積冰的垂直發展狀況。

The icing all-levels field is derived from the 3-D Icing field. It shows the maximum icing severity at any flight level. The best way to get detailed information about the forecast for icing is to display this all-levels field, make a flight route through the indicated icing, and then switch to the 3-D icing product. That way you will see the vertical extent of the icing forecast. Figure 2.9.3a shows an example of this field along with a vertical cross-section



of the 3-D data.

圖 2.9.3a 積冰預報疊加及剖面圖

Fig. 2.9.3a Icing Severity All-levels and Cross Section

就如預報積冰產品(FIP)演算法所描述的，CIP 與 FIP 也可產製三維之積冰機率及過冷大水滴(SLD)場(均含疊加圖)。圖 2.9.3b 及圖 2.9.3c 顯示三維之積冰機率平面和疊加圖，而圖 2.9.3d 及圖 2.9.3e 則顯示三維之 SLD 平面和疊加圖。

As stated in the algorithm descriptions, the CIP and FIP also produce icing probability and SLD fields, both of which are 3-D fields that are also available as all-level fields. The icing probability 3-D field is shown in figure 2.9.3b, and the all-level field is shown in figure 2.9.3c. The SLD 3-D field is shown in figure 2.9.3d, and the all-level field is shown in figure 2.9.3e.

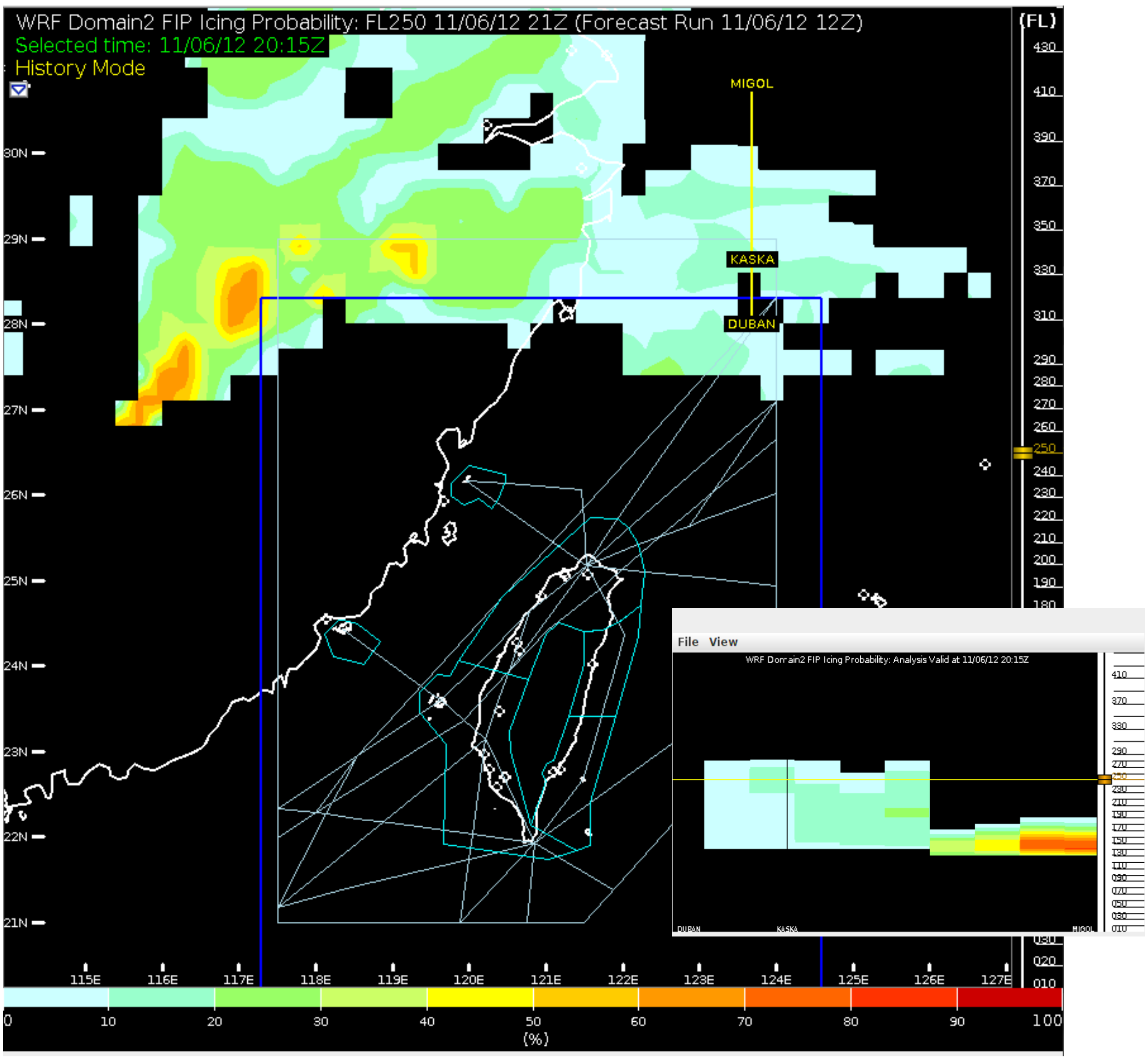


圖 2.9.3b 積冰機率及剖面圖

Fig. 2.9.3b Icing Probability and Cross Section

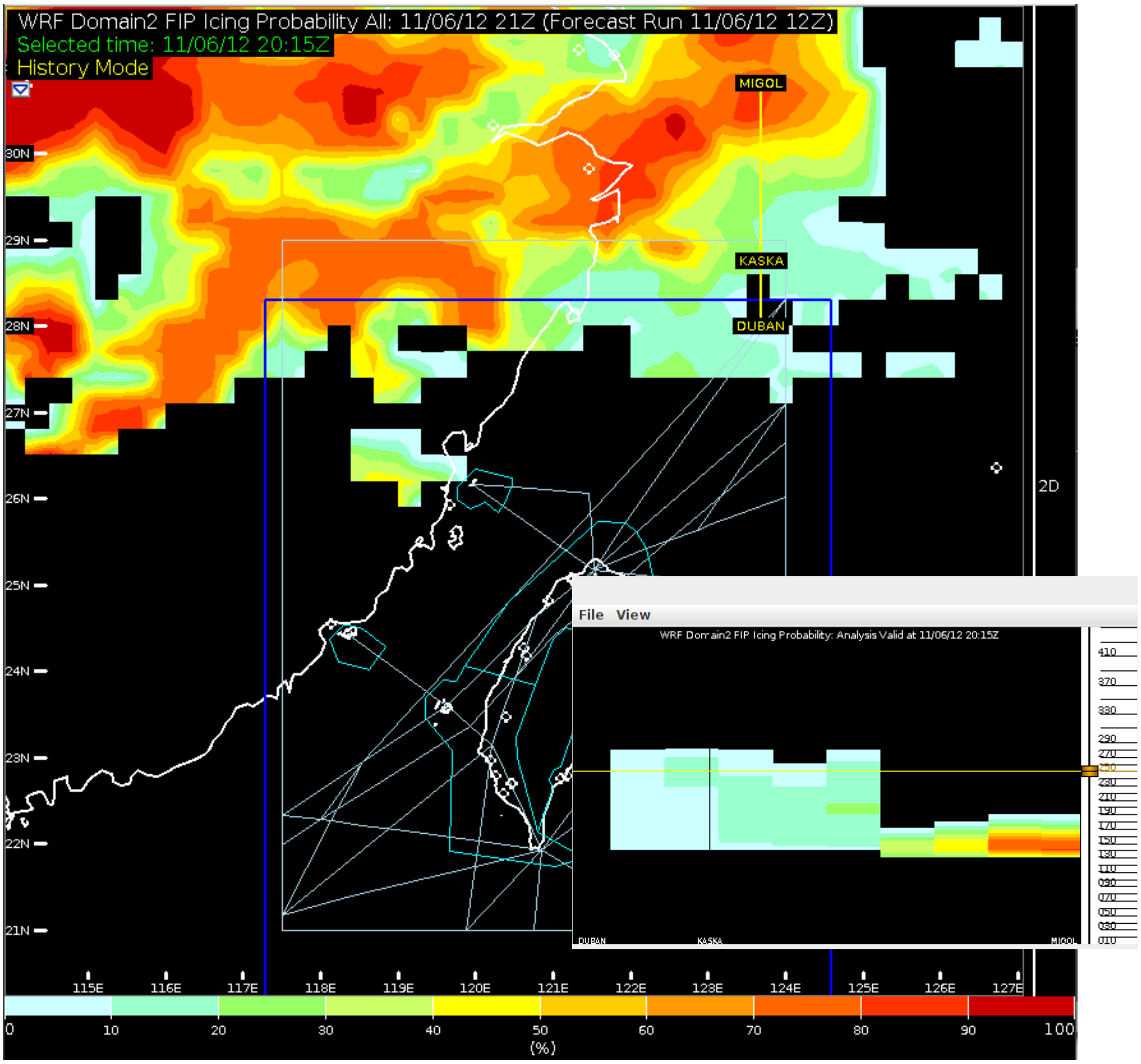


圖 2.9.3c 積冰機率疊加及剖面圖

Fig. 2.9.3c Icing Probability All-Levels and Cross Section

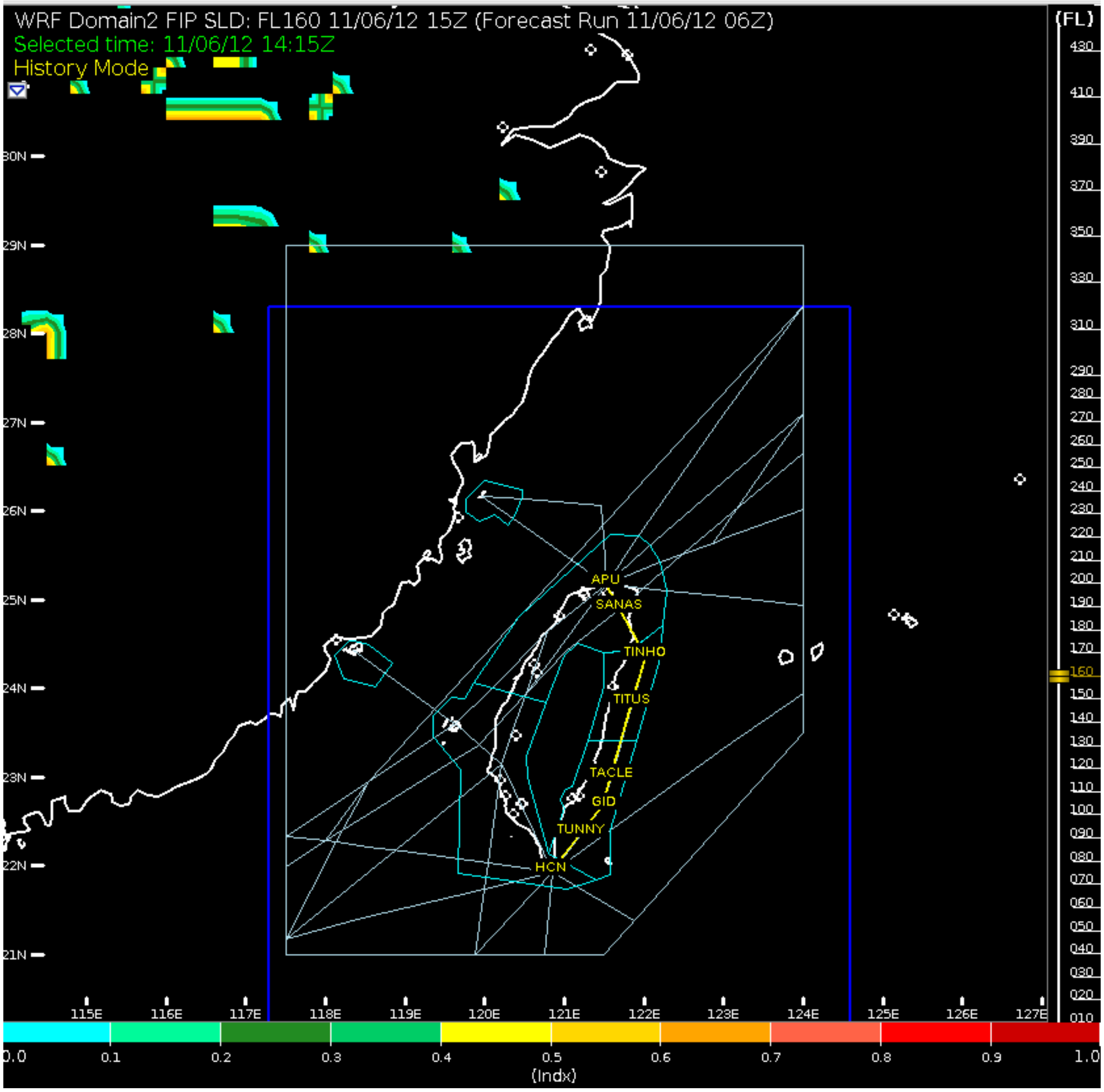


圖 2.9.3d 積冰 SLD 場

Fig. 2.9.3d Icing SLD

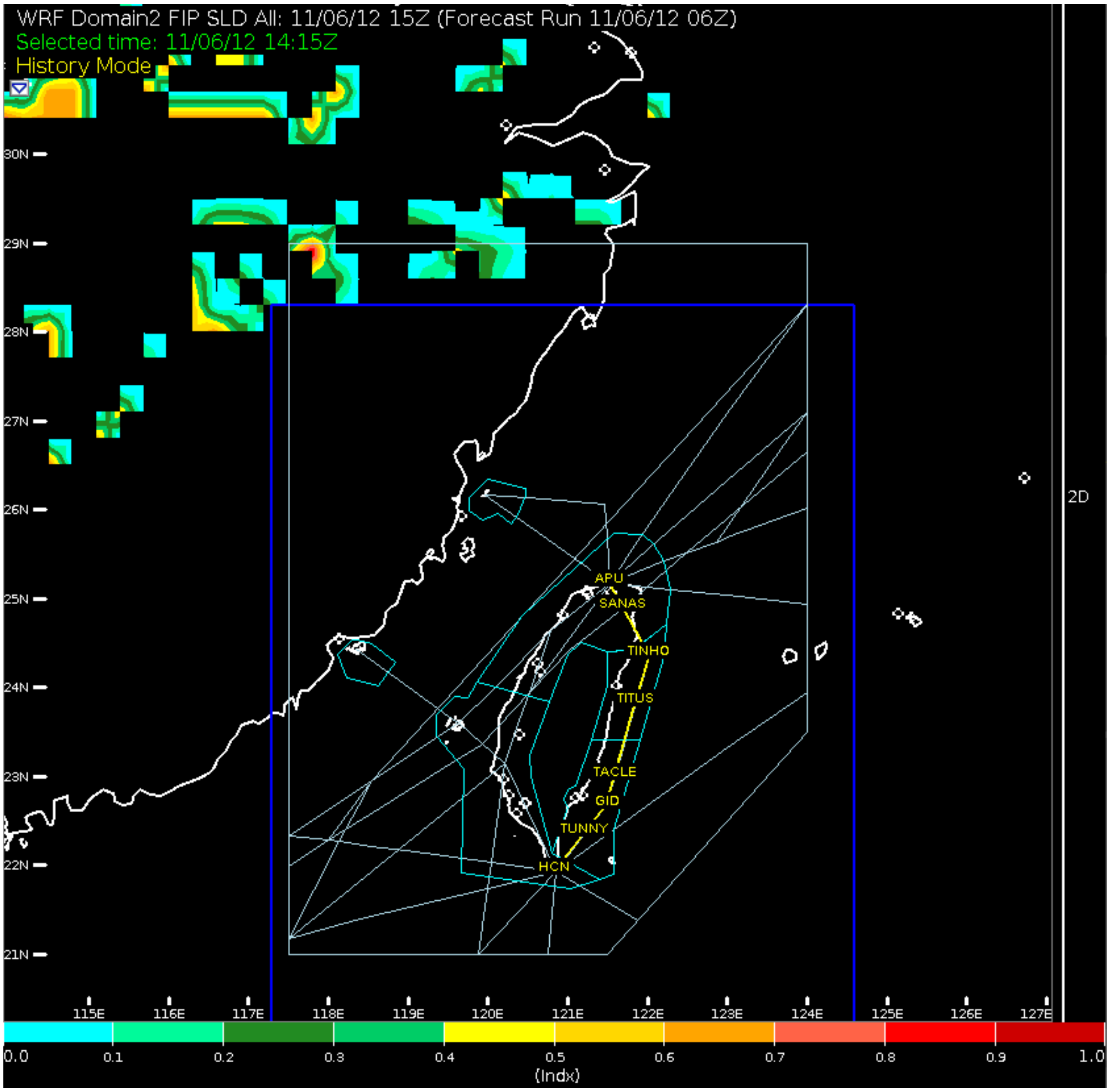


圖 **2.9.3e** 積冰 **SLD** 場疊加圖

Fig. 2.9.3e Icing SLD All-Levels

3 符號天氣產品 Symbolic Weather Products

符號天氣產品(Symbolic Weather Products)為點或區域產品。相對於覆蓋整個格點區域的格點產品，符號天氣產品僅在產品的位置上顯示影像或圖示。

Symbolic Weather Products are point or area products. An image or icon is displayed only at the location of the product, in contrast to gridded products which cover the entire grid.

3.1 等溫線 Temp Contours

等溫線顯示相同溫度區域的三維資料。大部分等溫線為紅色，結冰高度則以黃色表示。

Temperature Contours are 3D data that show regions of equal temperature. Most temperature contours are red, but the freezing level is identified by yellow.

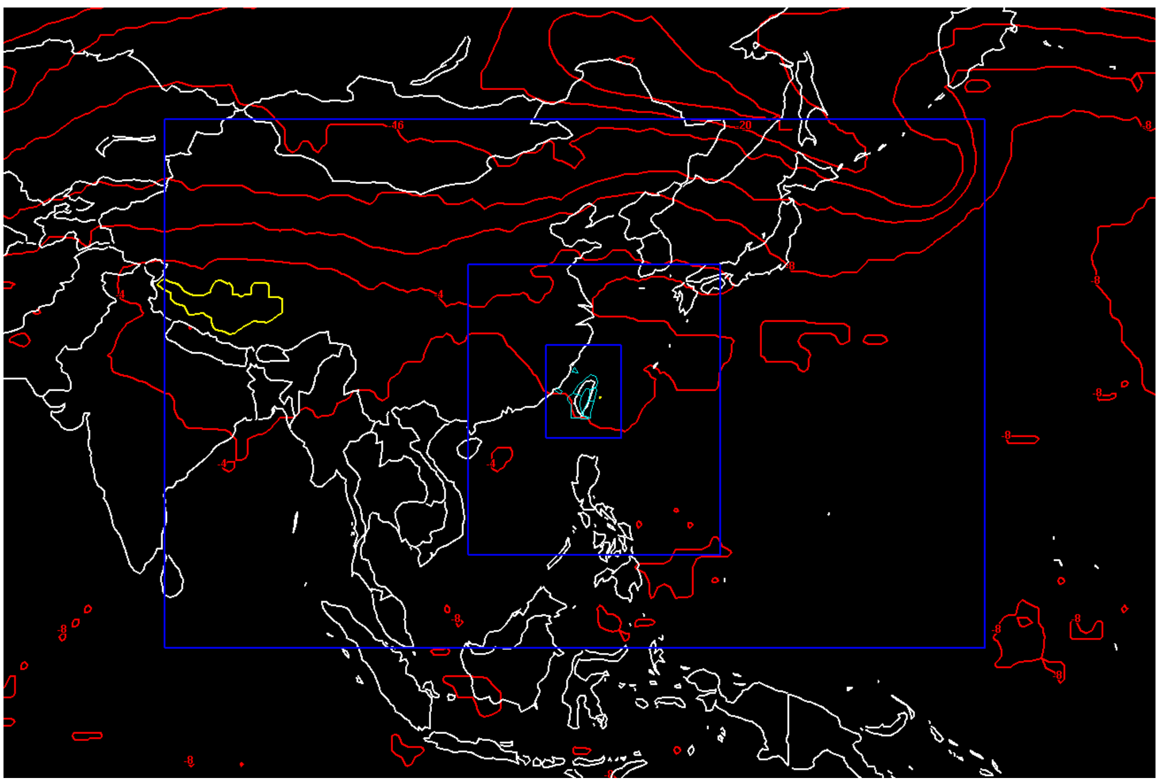


圖 3.1a JMDS 上的等溫線

Figure 3.1a shows Temperature Contours on the JMDS.

3.2 結冰高度 Freezing Level

結冰高度為結冰發生之飛航空層的二維資料。

Freezing Level is 2D data that shows the flight level where the freezing level occurs.

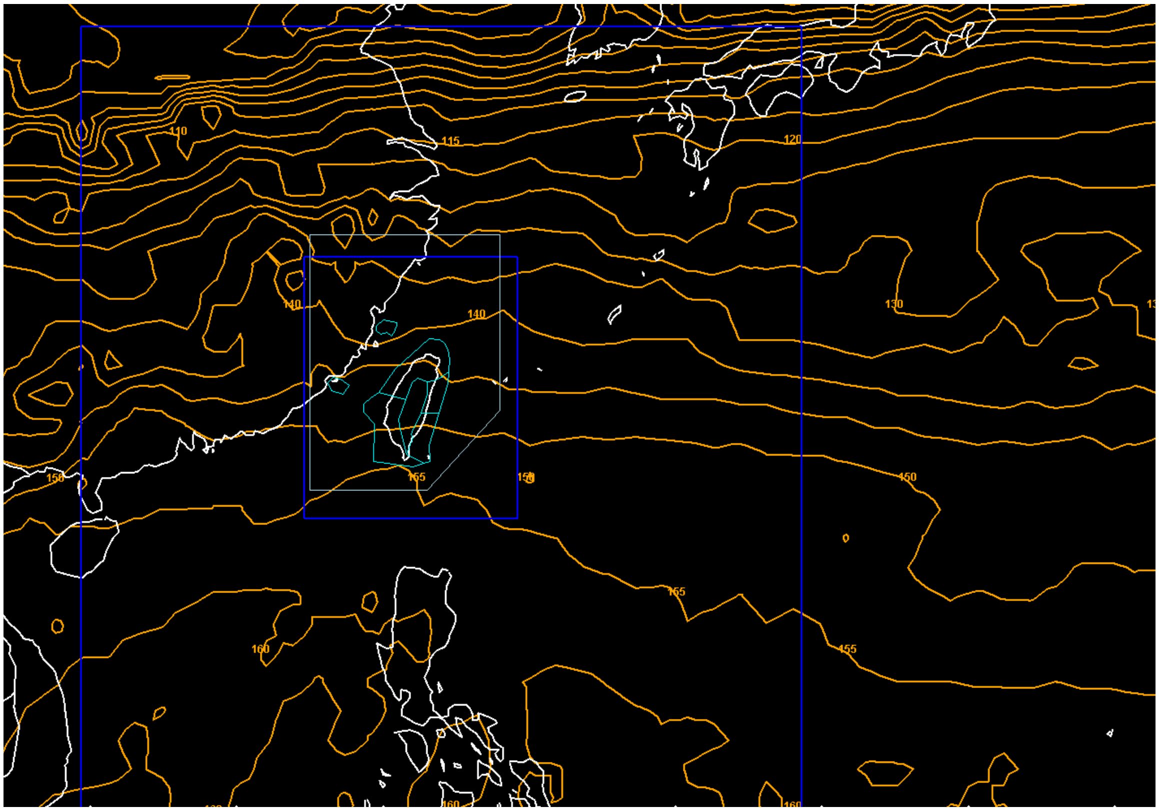


圖 3.2 JMDS 上的結冰高度圖

Figure 3.2a shows Freezing Level on the JMDS

3.3 風場 Winds

風場(Winds)為模式所導出之風速/風向資訊，其以風標表示。風標顯示在螢幕上的大小固定，因此放大時會提供較為詳細的風場資訊。滑鼠移至風標上，會跳出一視窗顯示風速及風向之數值。

The Winds are model derived wind speed/direction represented by wind barbs. Spacing of the wind barbs is constant on the display, so zooming in provides more detailed wind information. Mouse over a wind barb to produce a pop-up giving numerical values for speed and direction.

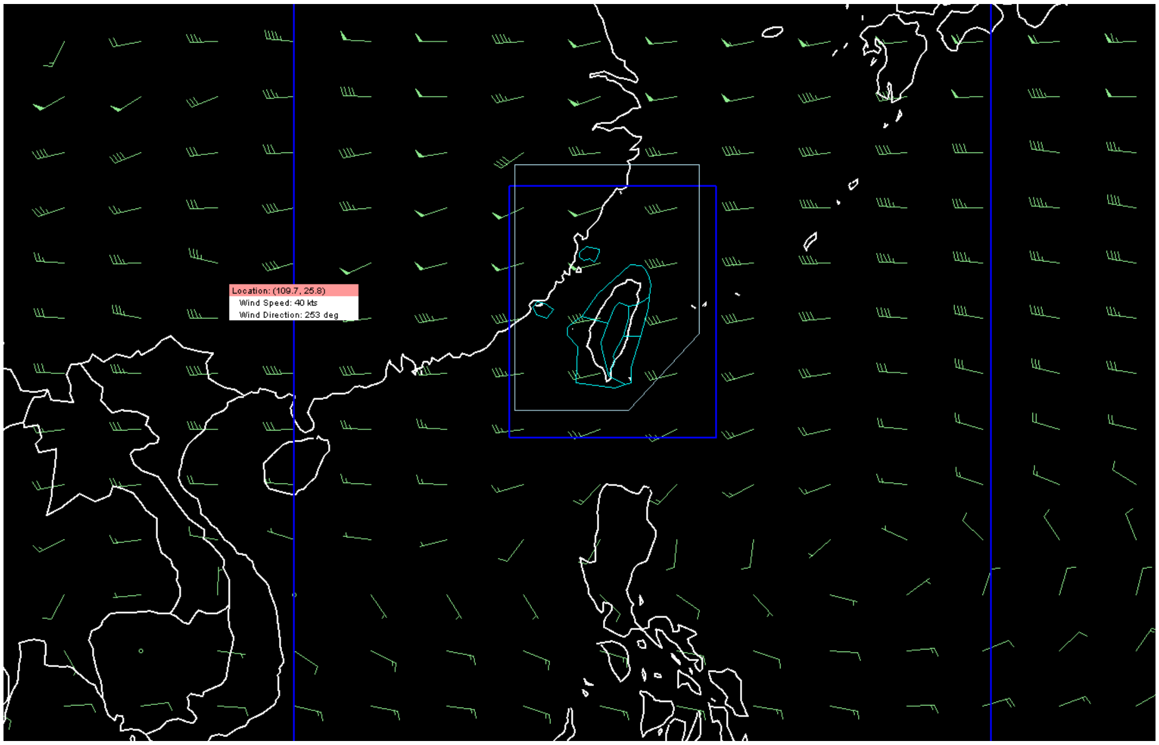


圖 3.3a JMDS 上的風場

Figure 3.3a shows Winds on the JMDS

3.4 地面觀測資料圖影像圖示說明 (METARs)

3.4.1 METARs – Plot

Plot METARs 以風標來表示風速/風向，以圓圈表示雲量。圖示顏色以 current metar filtering 控制，其定義於 Configure->Filter Metars menu (可參考 JMDS 手冊以得到詳細資訊)。滑鼠移至圖示上，將會跳出一視窗以顯示完整原始資訊。

Plot METARs have a wind barb to show wind speed/direction and a circle indicates obscuration values. Color is controlled by the current metar filtering, which is defined under the Configure->Filter Metars menu. (See the JMDS manual for more details). Plot METARs will produce a pop-up with the full raw metar on mouseover.

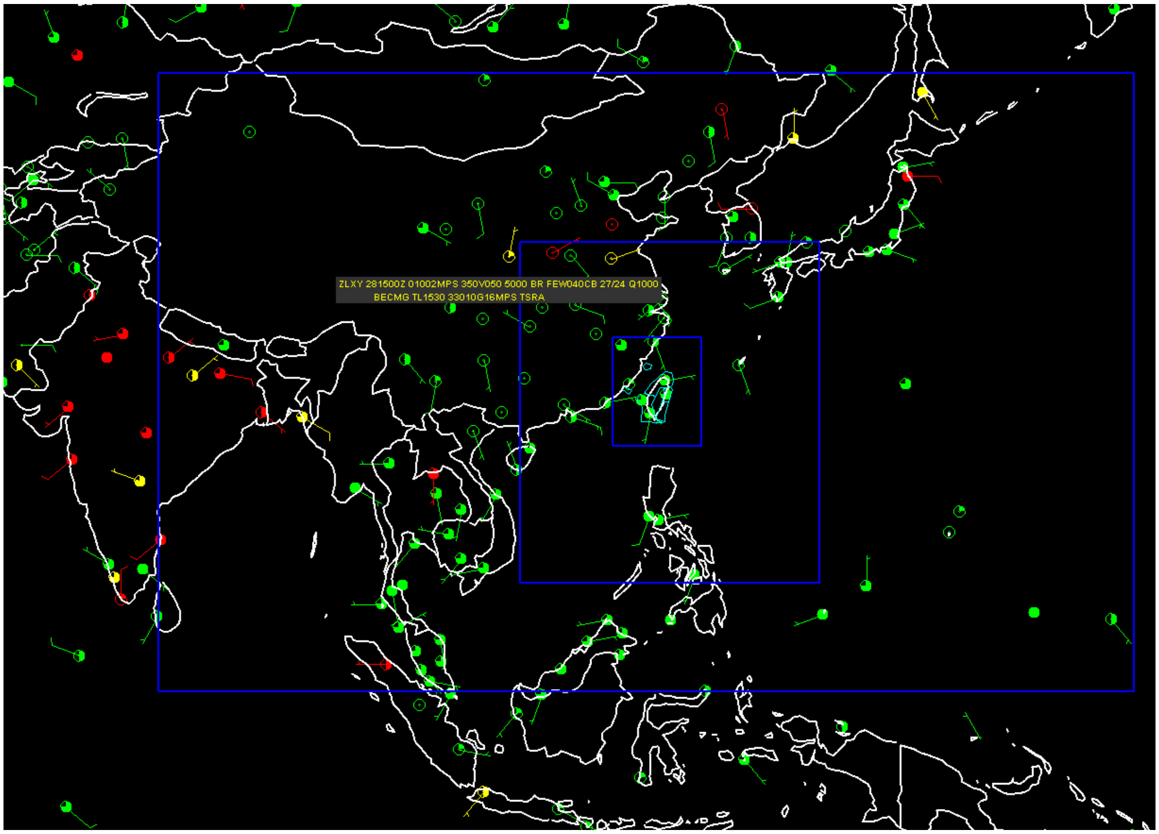


圖 3.4.1 JMDS 上的地面觀測資料圖

Figure 3.4.1a shows METARs - Plots on the JMDS

3.4.2 METARs – Labels

Label METARs 顯示細節(圖 3.4.2a 描述不同符號所代表的 METAR 資料)。Label METARs 如果彼此太靠近時將不被顯示，因此他們在大範圍檢視時不可見。

Label METARs show more details. (Figure 3.4.2a describes the meanings of the symbols used for representing METAR data.) Label METARs will not be displayed if they are too dense, so they will not be visible at wider zoom levels.

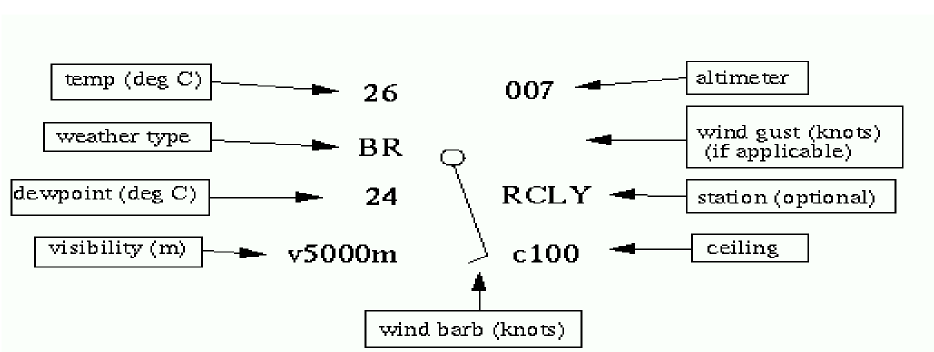


圖 3.4.2a 地面觀測資料符號

Fig. 3.4.2a 'Label' METAR Data Symbols

〝天氣類型 (weather type)〞是地面觀測中用來報告天氣狀況的縮寫 (e.g., rain, snow, fog).。

The "Weather type" field is used to report a weather phenomenon (e.g., rain, snow, fog).

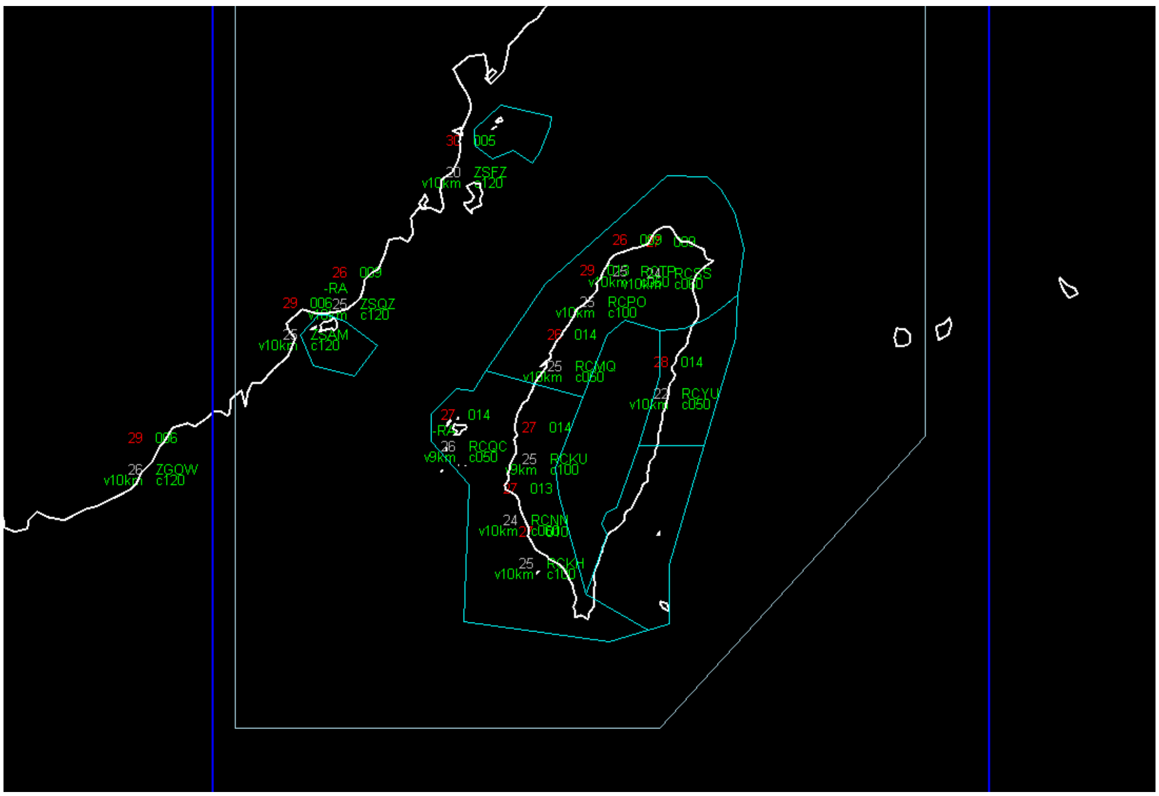


圖 3.4.2b JMDS 上的 METARs - Labels

Figure 3.4.2b shows METARs - Labels on the JMDS

3.5 風暴追蹤與TIA風暴追蹤 (Storm Tracks and TIA Tracks)

這些產品顯示即時與預報之風暴位置，兩者差異在於資料來源。風暴追蹤使用 CWB 雷達，TIA 風暴追蹤使用 TIA 雷達。細節請見章節 2.1。

These products show current and forecasted location of storms. The difference between them is the radar that is used as input. Storm Tracks uses the CWB Radar, TIA Tracks uses the TIA Radar. Storm Tracks and TIA Tracks are described in more detail in section 2.1 of this document..

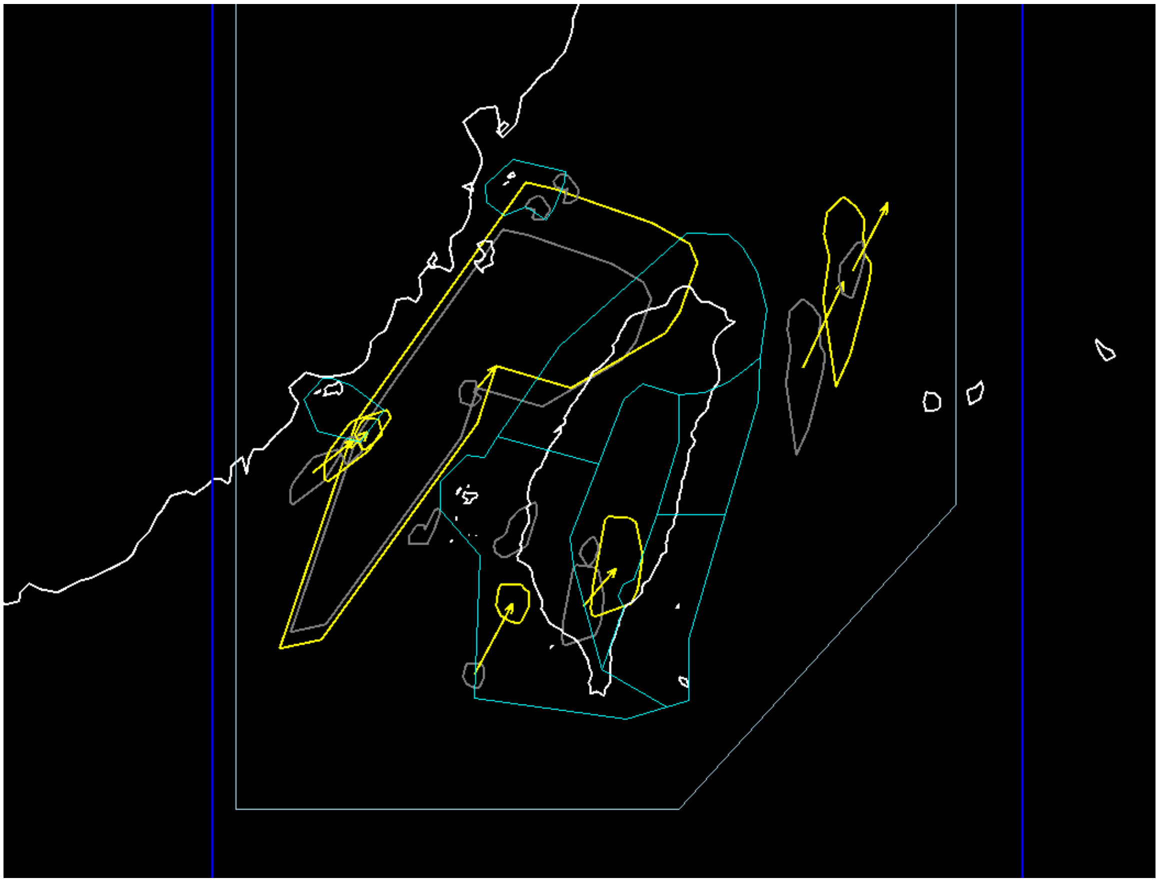


圖 **3.5a JMDS** 上的風暴追蹤資訊

Figure 3.5a shows Storm Tracks on the JMDS

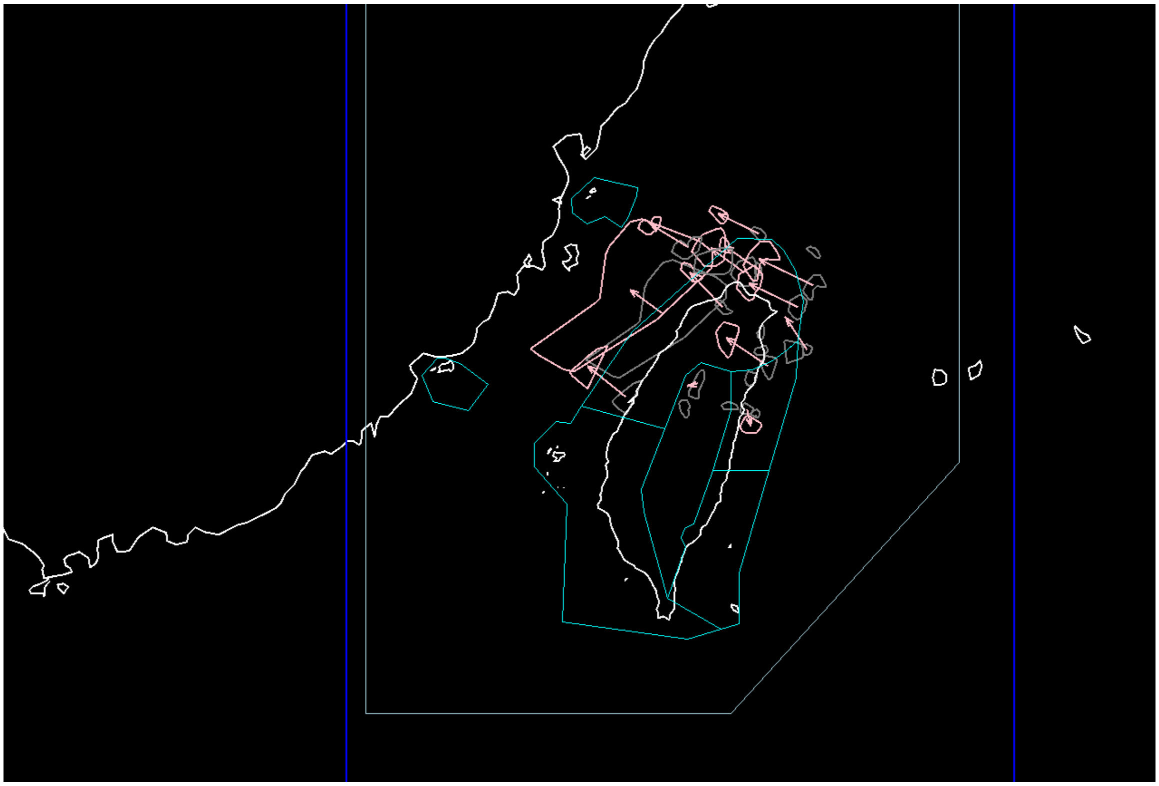


圖 3.5b JMDS 上的 TIA 風暴追蹤資訊

Figure 3.5b shows TIA Tracks on the JMDS

3.6 All WAFS (for printing)

All WAFS 為所有形式之 WAFS 資料之黑白輸出。細節請見章節 3.9。

All WAFS is a black and white render of all of the types of WAFS data. See section 3.9 below for more details.

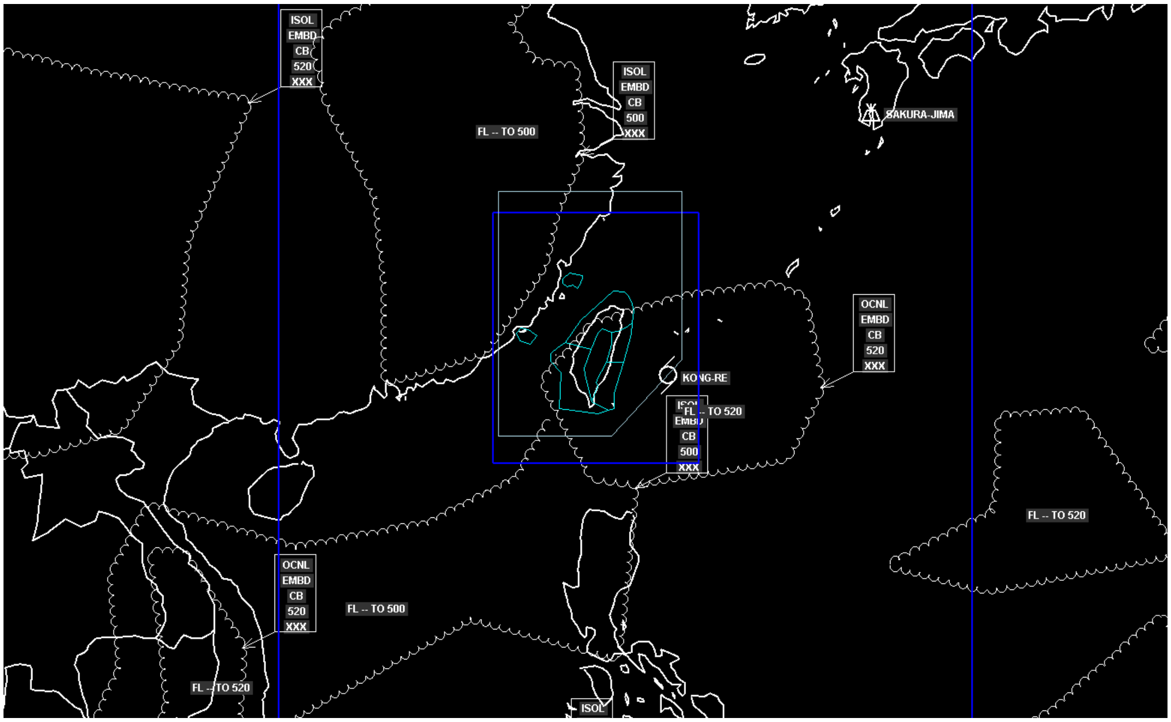


圖 3.6c JMDS 上的 All WAFS(for printing)產品

Figure 3.6c shows All WAFS (for printing) on the JMDS

3.7 低空/顯著危害天氣資訊(AIRMET/SIGMET)

和提供潛在的危害天氣資料給航空器。兩者之區別是 AIRMET 一個中等或以下的危險，一些飛機的低空氣象報告，而一個 SIGMET 是一個嚴重的危險的所有飛機的報告。主要目的是通知駕駛員有關在航路上可能發生的會影響到飛航安全的氣象資訊。顯著天氣類型如下：

低空危害天氣資訊(AIRMET)：

低空危害天氣資訊是正在發生或可能發生於航路上，可能會影響飛機安全的簡潔描述。 AIRMETs 對飛行高度在一萬呎以下之航機有效。包含中度亂流、山脈模糊不清、中度積冰和地面強風（> 30KT）等。AIRMET 有效時間通常為 4 小時。AIRMETs 是由臺北航空氣象中心針對未包括於為飛航情報區或其部分空域低空飛航所發布之預測。

AIRMET information: AIRmen's METeorological Information is a concise description of widespread weather phenomena that are occurring or may occur along an air route that may affect aircraft safety. AIRMETs are valid for flights operating below flight level 100. AIRMETs can cover moderate–turbulence, mountain obscuration, moderate icing, and strong surface winds (>30KT). AIRMETs generally cover six (4) hour periods. AIRMETs are issued by a meteorological watch office for weather phenomena not already included in the forecast issued for flights in the flight information region of concern or sub-area thereof.

顯著危害天氣資訊(SIGMET)：

顯著危害天氣資訊是包含與所有飛機飛航安全有關的氣象資訊。包含強烈亂流、強烈山岳波、強烈積冰、火山灰、熱帶氣旋及雷雨等。SIGMET 有效時間為不超過 4 小時，有關火山灰雲和熱帶氣旋的 SIGMET 則可以延長為 6 小時。

SIGMET information: SIGnificant METeorological Information is a weather advisory that contains meteorological information concerning the safety of all aircraft. SIGMETs can cover severe turbulence, severe mountain wave, severe icing, volcano ash, tropical cyclone and thunderstorm. The period of validity of a SIGMET message shall be not more than 4 hours, but SIGMET messages concerning volcanic ash cloud and tropical cyclones can be extended to six hours.

包含於 AIRMET 和 SIGMET 的天氣現象包含如下：

The types of weather phenomena covered by a AIRMET and SIGMET are listed below.

顯著危害天氣資訊 AIRMET

- 地面風速 Surface wind speed

- 地面能見度 Surface visibility
- 雷雨 Thunderstorm
- 冰雹 Hail
- 雲 Cloud
- 積雨雲 Cumulonimbus clouds
- 塔狀積雲 Towering cumulus clouds
- 中度亂流 Moderate turbulence
- 中度積冰 Moderate icing
- 山脈模糊不清 Mountain Obscuration
- 中度山岳波 Moderate mountain wave
- 天氣型態不明 Unknown weather type

顯著危害天氣資訊 SIGMET

- 熱帶氣旋 Tropical cyclone
- 雷雨 Thunderstorm
- 冰雹 Hail
- 颮線 Squall line
- 強烈亂流 Severe turbulence
- 強烈積冰 Severe icing
- 強烈山岳波 Severe Mountain wave
- 沙/塵暴 Sand/Dust storms
- 火山灰 Volcanic Ash
- 輻射雲 Radioactive cloud
- 天氣型態不明 Unknown weather type

圖 3.7a 顯示不同的 SIGMET 符號代表不同的顯著天氣現象意義。

Figure 3.7a shows the data symbols that representing different AIRMET/SIGMET criteria.

圖 3.7a 顯著天氣報文圖示

Fig. 3.7a SIGMET Data Symbols

圖 3.7b 至圖 3.7d 所顯示的是一些顯著天氣報文產品資料圖範例。

Figures 3.7b to 3.7d show examples of the SIGMET product for various view regions.

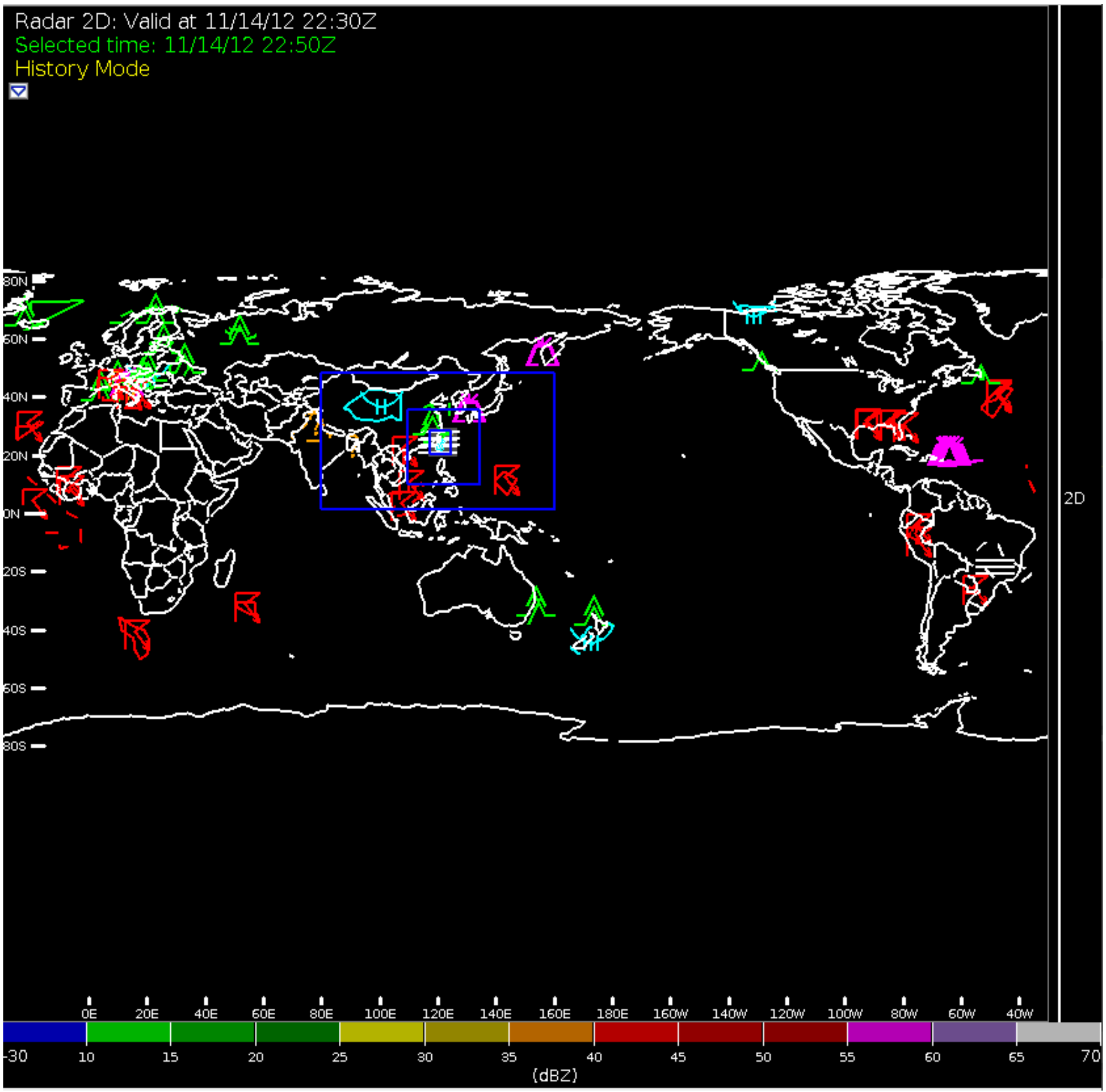


圖 3.7b 顯著天氣全球資料圖範例

Fig. 3.7b Sample SIGMETs - World view

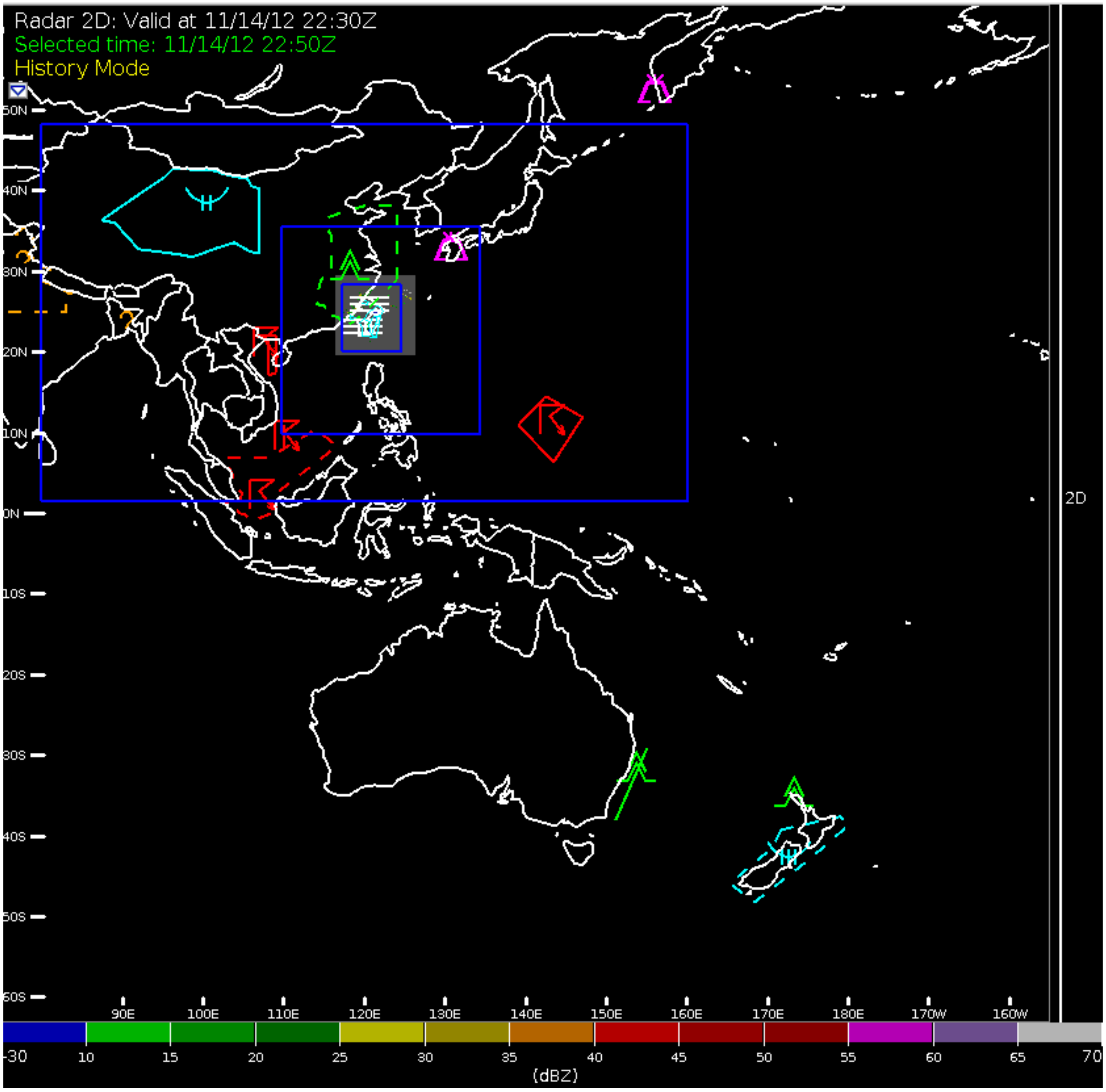


圖 **3.7c** 顯著天氣廣角區域資料圖範例

Fig. 3.7c Sample SIGMETs – Wide view

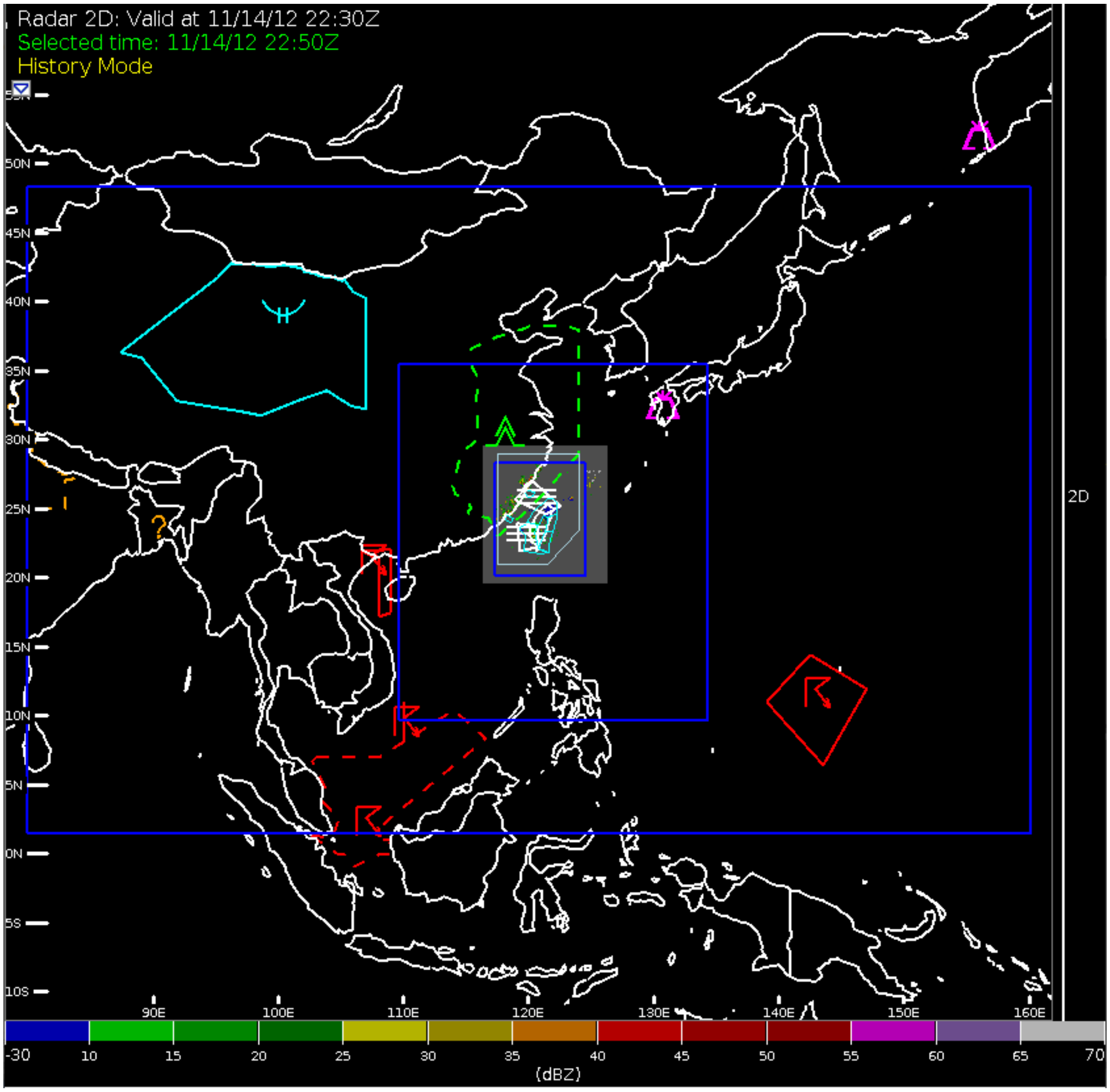


圖 3.7d 顯著天氣 AOAWS 範圍-1 資料圖範例

Fig. 3.7d Sample SIGMETs – AOAWS Domain 1 view

3.8 飛機報告(Aircraft Reports)

JMDS 目前有三種格式之飛機報告(ACARs,AIREPs 及 AMDARs)。ACARS (Aircraft Communication Addressing and Reporting System)為數據鏈，透過衛星或無線電於飛機與地面接收站間傳送較簡單之訊息。AIREPs 為飛機自動報告。AMDAR (Aircraft Meteorological Data Relay)為世界氣象組織(WMO)發起的計畫，利用商用飛機收集全球氣象資料。

滑鼠移至 ACARs 和 AMDARs 時將顯示解碼內容，滑鼠移至 AIREPs 時將顯示原始資料。

Three types of aircraft reports are available for display on JMDS. ACARs, AIREPs, and AMDARs. Aircraft Communications Addressing and Reporting System (ACARS) is a digital datalink system for transmission of short, relatively simple messages between aircraft and ground stations via radio or satellite. AIREPs are automatic reports from aircraft. Aircraft Meteorological Data Relay (AMDAR) is a program initiated by the World Meteorological Organization. AMDAR is used to collect meteorological data worldwide by using commercial aircraft. ACARs, and AMDARs will produce decoded details upon mouseover. AIREPs give the raw text of the AIREP on mouseover.

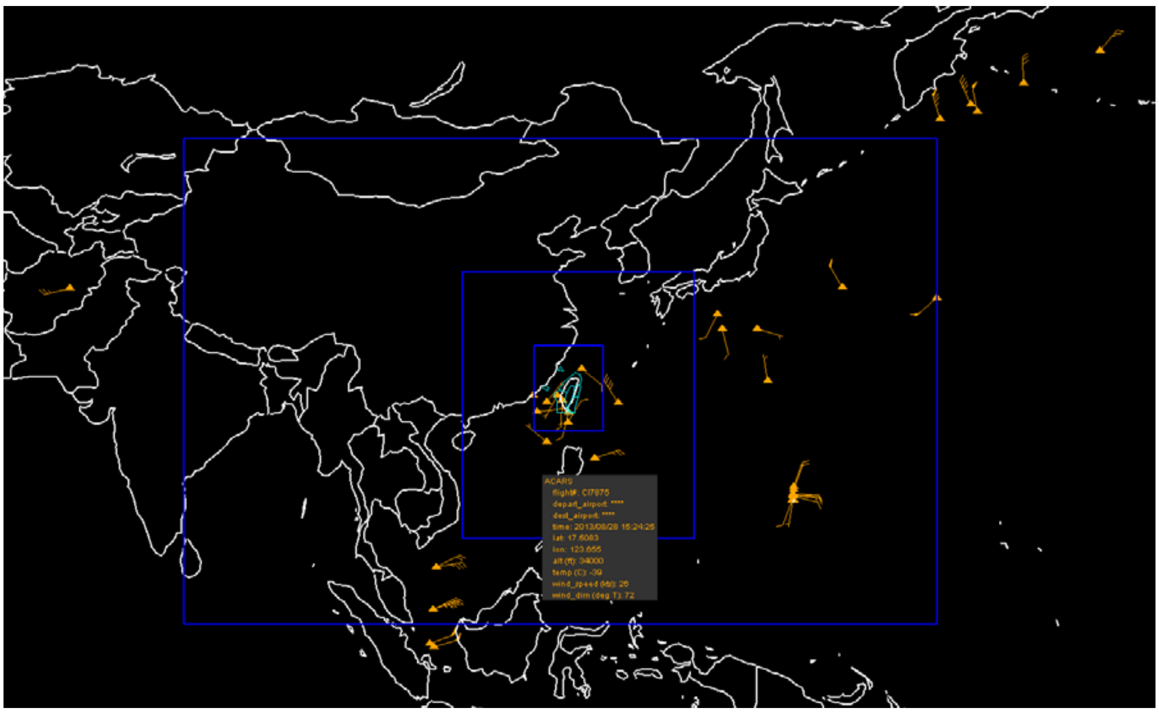


圖 3.8a JMDS 上的 ACARs 資訊

Figure 3.8a shows ACARs on the JMDS

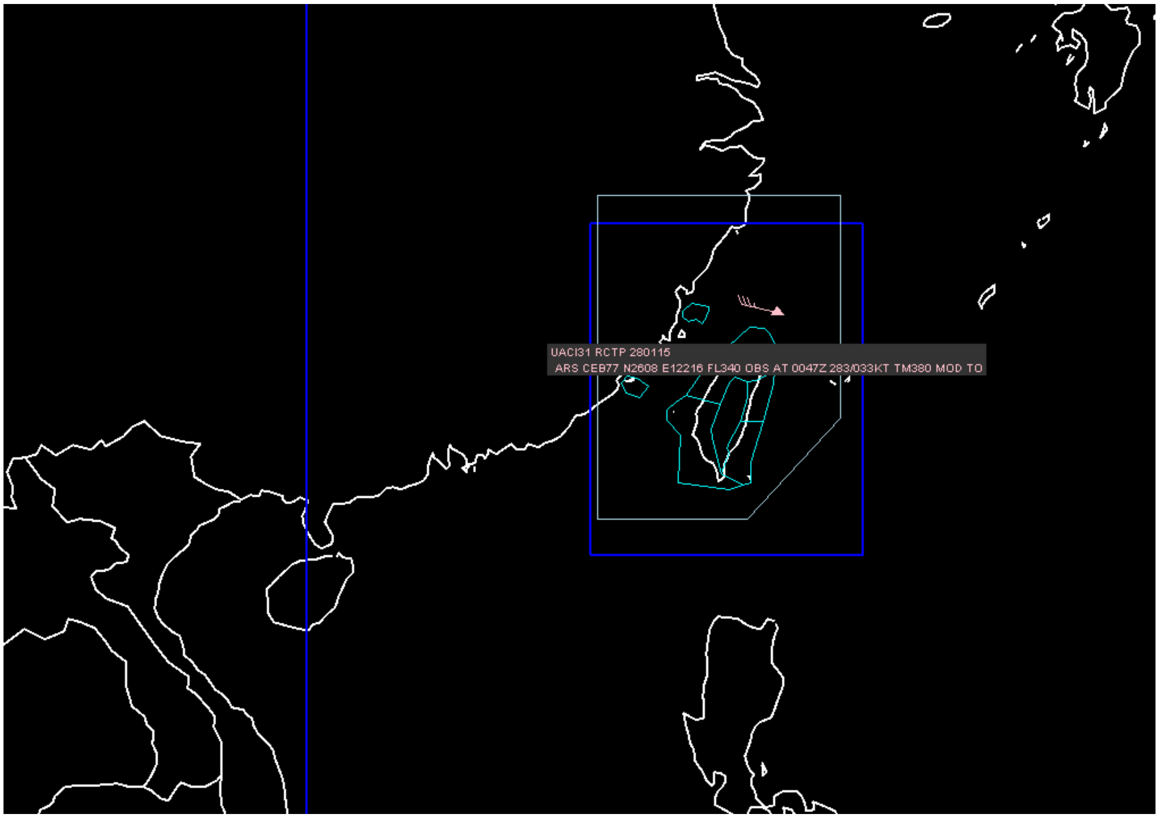


圖 3.8b JMDS 上的 AIREPs 資訊

Figure 3.8b shows AIREPs on the JMDS

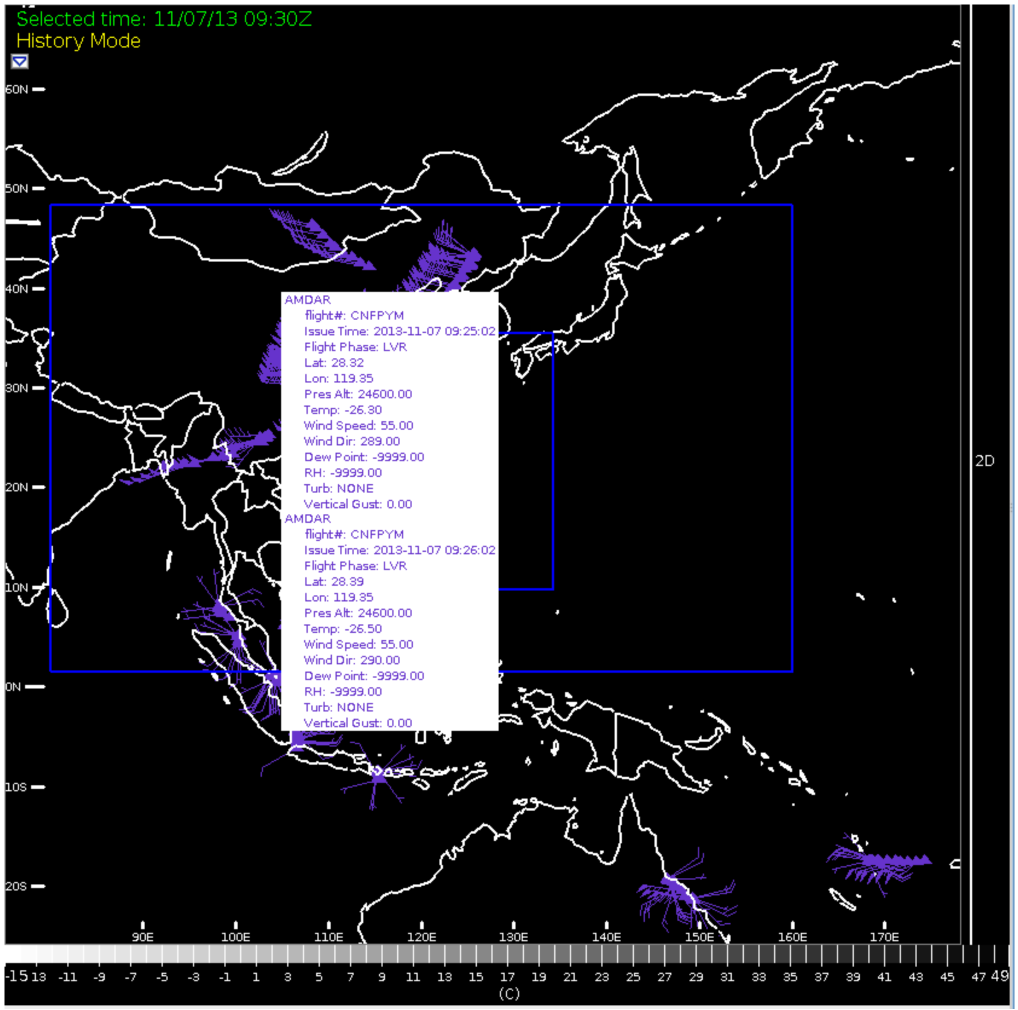


圖 3.8c JMDS 上的 AMDARs 資訊

Figure 3.8c shows AMDARs on the JMDS

3.9 終端機場預報資訊 (TAFs)

終端機場預報(Terminal Aerodrome Forecast，TAFS) 為機場中心至半徑 5 英里內之預報，天氣現象種類包含：“All(全部顯示)”、 “Clouds(雲)”、 “Tempo Clouds(預期的雲)” 、“Wx(天氣)”、 “Tempo Wx(預期的天氣)” 、 “Wind(風)”和“Gusts(陣風)”。操作方法請參考 JMDS 手冊

TAFs (Terminal Aerodrome Forecast) are forecasts that apply to a five statute mile radius from the center of an airport complex. The types of weather phenomena forecast are ‘Clouds’, ‘Tempo Clouds’, ‘Wx’, ‘Tempo Wx’, ‘Wind’, and ‘Gusts’. See the JMDS manual for instruction on how to display TAFs.

3.9.1 雲和預期的雲(Clouds & Tempo Clouds)

圖 3.10.1a 是 TAF 的雲資訊。每個圓形的填滿度依雲層覆蓋度可分為 0%，25%、50%、75%或 100%，顏色則取決於由雲幕高度與能見度所決定之飛航種類。

每個站點的飛航種類是使用下表所設定的雲幕高度(英尺)與能見度(公里)門檻計算而得。假如兩種數值皆超過門檻，飛航種類將會等同或高於這個飛航標準。

Figure 3.10.1a shows an example of cloud TAF. Each circle is filled in at 0%, 25%, 50%, 75% or 100%, depending on cloud cover. The color is determined by the flight category. The flight category at a station is computed using the ceiling and visibility thresholds specified in the table below. If both values exceed the threshold, the flight category will be equal to or greater that the specified category.

飛航種類 Flight Category	顏色 Color	雲幕高度門檻值 Ceiling Threshold (呎 ft)	能見度門檻值 Visibility Threshold (公里 km)
VFR	綠色 Seagreen	1500	5
MVFR	藍色 Blue	500	1.6
IFR	橘色 orange	0	0

圖 3.10.1a 雲之範例

Fig. 3.10.1a Sample view of Clouds

3.9.2 風(Wind)

黃色風標代表風速，單位是 KT。

Figure 3.10.2a shows an example of wind TAF. Wind is shown with a yellow wind barb representing wind speed in knots.

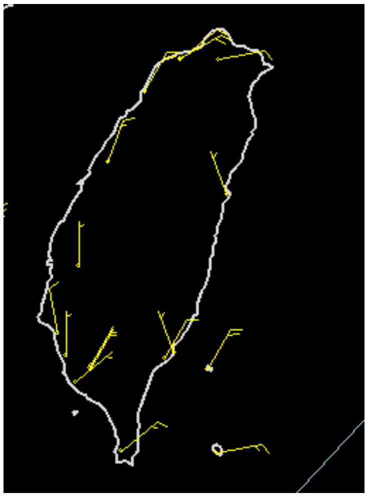


圖 3.10.2a 風之範例

Fig. 3.10.2a Sample view of Wind

3.9.3 陣風(Gusts)

紅色風標代表陣風，單位是 KT。

Figure 3.10.3a shows an example of wind gust TAF. Wind gusts are shown with a red wind barb representing wind speed in knots.

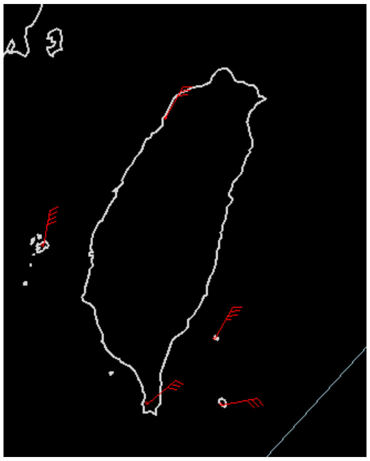


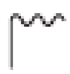
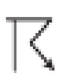
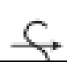
圖 3.10.3a 陣風之範例

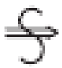
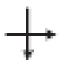
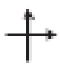
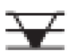
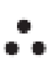
Fig. 3.10.3a Sample view of Gusts

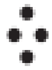
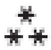
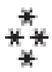
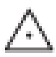
3.9.4 天氣和預期的天氣(Wx and Tempo Wx)

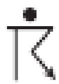
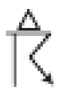
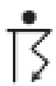
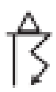
在 TAF 中符號所代表之天氣字串：

For the Wx and Tempo Wx TAF, symbols are drawn which represent the weather string found in the TAF. These symbols are defined in the following table:

Symbol	Wx String	Color
	FU	Red
	VA	Red
	HZ	White
	DU	White
	SA	White
	BLSA	White
	BLDU	White
	PO	White
	BR	Yellow
	MIFG	White
	TS	White
	SQ	White
	FC	White
	+FC	White
	SS	White

	DRSA	White
	DS	White
	DRDU	White
	+SS	White
	+DS	White
	BLSN	White
	DRSN	White
	BCFG	Yellow
	PRFG	White
	FG	Yellow
	FZFG	Yellow
	-DZ	Cyan
	DZ	Cyan
	+DZ	Cyan
	-FZDZ	White
	FZDZ	White
	+FZDZ	White
	-RA	Blue
	RA	Blue

	+RA	Blue
	-FZRA	White
	FZRA	White
	+FZRA	White
	-SN	White
	SN	White
	+SN	White
	SG	White
	IC	White
	PL	White
	-SHRA	White
	SHRA	White
	+SHRA	White
	-SHSN	White
	SHSN	White
	+SHSN	White
	-SHGS	White
	SHGS	White
	+SHGS	White

	-SHGR	White
	SHGR	White
	+SHGR	White
	TSSN	White
	TSGR	White
	TSGS	White
	+TSSN	White
	+TSGS	White
	+TSGR	White
□	UNKNOWN	White

3.9.5 全部顯示(All)

當選擇了“All”，上述風、陣風、天氣和雲的圖形皆會顯示出來。

When ‘All’ is selected in the TAF selector, the previously described graphics for Wind, Gusts, Wx, and Clouds are all shown. Examples of this are shown in figures 3.10.5a and 3.10.5b.

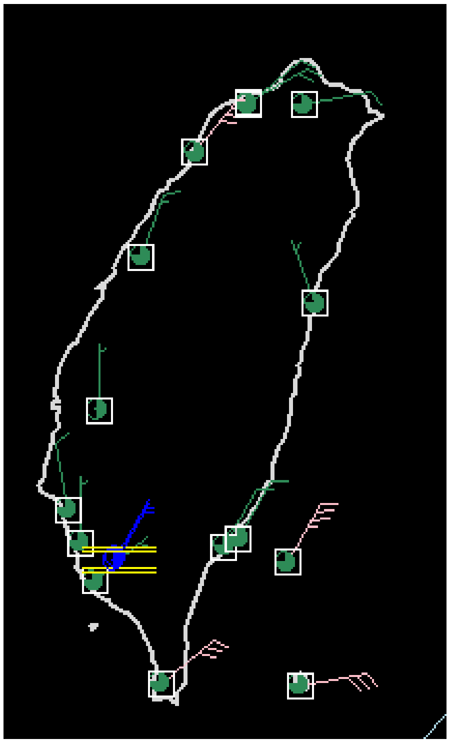


圖 **3.10.5a** 全部顯示之範例

Fig. 3.10.5a Sample view of All

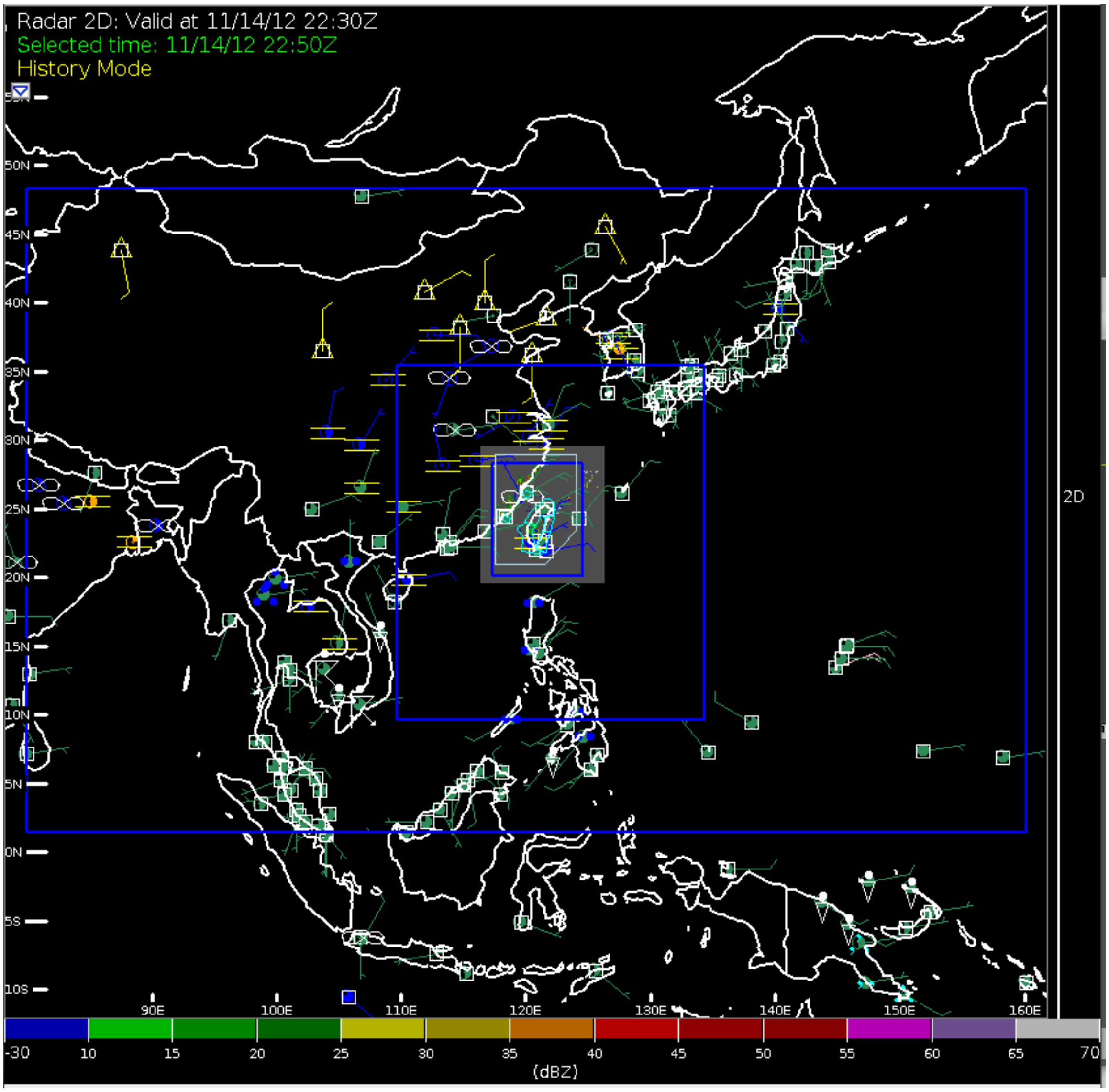


圖 3.10.5b JMDS 全部顯示之範例

Fig. 3.10.5b Sample JMDS view of All

3.10 WAFS 顯著天氣資訊 (WAFS SIGWX)

WAFS SIGWX 是來自於世界區域預報中心 (WAFCs) 的一套關於顯著天氣事件的氣象產品。這些包含：

The WAFS SIGWX is a set of weather products from the World Area Forecast Centres (WAFCs) that relate to significant weather events. These include:

- 噴流 (jet streams)
- 亂流 (turbulence)

- 雲 (clouds)
- 火山 (volcanoes)
- 熱帶氣旋 (tropical cyclones)
- 輻射 (radiation events)

火山、熱帶氣旋及輻射事件在 JMDS 系統中同分類”volcanoes”組。

The volcanoes, tropical cyclones and radiation events are grouped together as one category labeled ‘volcanoes’ on the JMDS.

以下這些圖顯示出代表不同 WAFS SIGWX 項目的資料符號

The images below show the data symbols that represent different WAFS SIGWX items.

噴流：標籤標示出飛行高度位置. 風標標示出噴流的速度. 每一個三角形代表 50 海哩, 每一個全線代表 10 海哩, 而半線代表 5 海哩.

Jet streams: the label indicates the flight level. The fleches (feathers) indicate the speed. Each triangle represents 50 knots, each full line represents 10 knots, and each half line represents 5 knots.

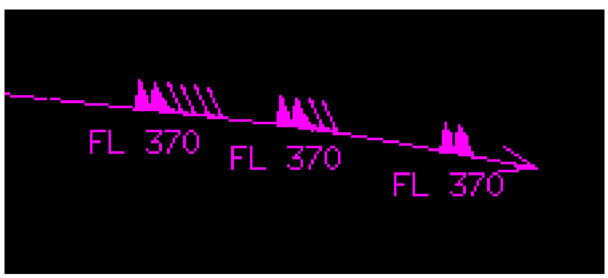


圖 3.9c 噴流圖範例

Fig. 3.9c Sample view of Jet streams

亂流：標籤標示出最大飛行高度值 (單位: 百英呎). 如果最小飛行高度存在則也會被顯示. 最後, 也會顯示所有的附加說明

Turbulence: the label indicates the maximum flight level in hundreds of feet. If the minimum flight level is available that is shown as well. Finally, any comments are shown.

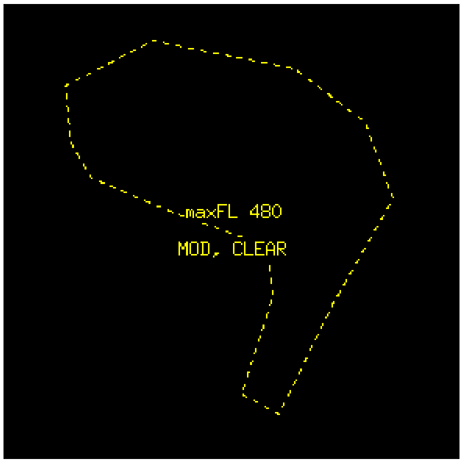


圖 3.9d 亂流圖範例

Fig. 3.9d Sample view of turbulence

雲：標籤標示出飛行高度的極大值與極小值 (單位: 百英呎) 與附加說明

Clouds: the labels indicate the maximum and minimum flight levels (in hundreds of feet), and any comments.

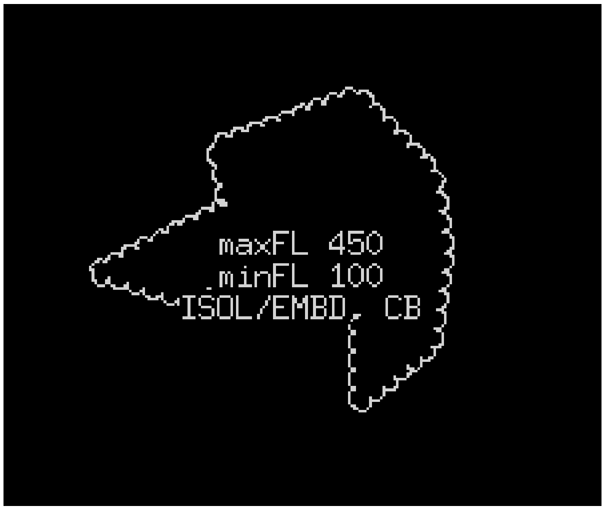


圖 3.9a 雲圖範例

Fig. 3.9a Sample view of clouds

熱帶氣旋：標籤標示出氣旋的名字

Tropical Cyclones: the label indicates the tropical cyclone name.

圖 3.9b 熱帶氣旋圖範例

Fig. 3.9b Sample view of tropical cyclone

火山：標籤標示出火山的名字

Volcanoes: the label indicates the volcano name.

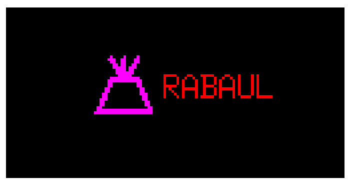


圖 3.9e 火山圖範例

Fig. 3.9e Sample view of volcano

輻射：如果有輻射就標示出事件的名稱

Radiation: the label, if any, indicates the incident name.

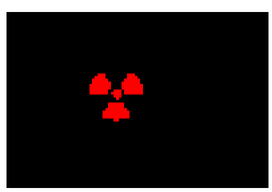


圖 3.9f 輻射圖範例

Fig. 3.9f Sample view of Radiation

圖 3.9g 顯示這些符號的典型圖案。

Figure 3.9g is an example of a display showing several of these symbols.

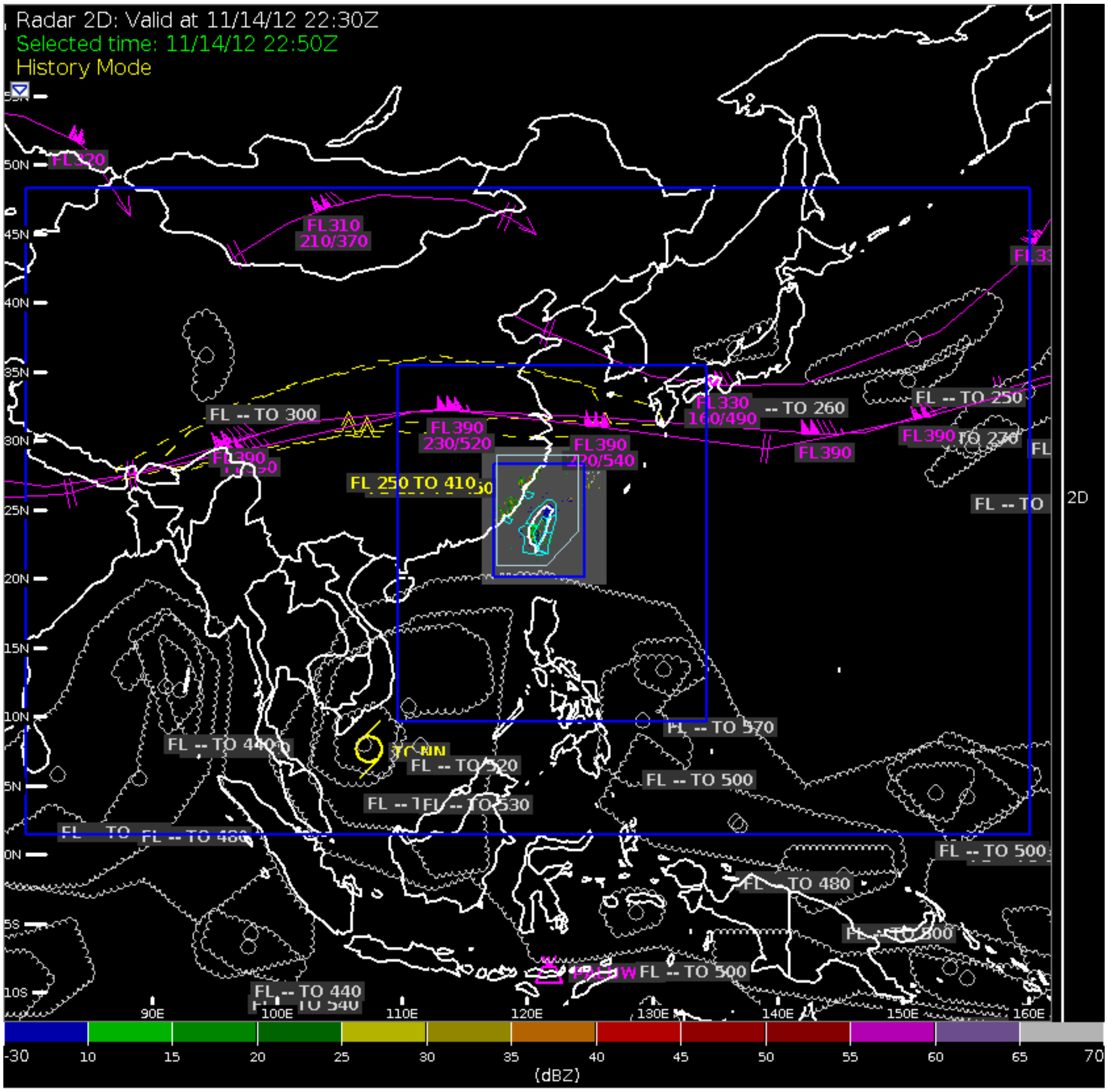


圖 3.9g 顯示 WAFS 顯著天氣資訊之圖形元件

Fig. 3.9g Image Showing Several WAFS SIGWX Objects