對航空器有積冰危險性的雲區

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摘要

積冰是影響航空器安全的顯著危害天氣之一。本文將介紹日本氣象廳，利用METSAT取得之各種衛星圖像，來掌握發生機體積冰，當時雲的型態和雲狀的特徵，進而利用在積冰的預報和實況監測方面，證實是非常有效的。

一、航空器積冰的概要

航空器發生積冰現象的主要成因，是水汽的昇華和過冷水滴撞上機體而引起的。當航空器發生積冰時，將會導致浮力降低、引擎停止、姿勢控制和著陸裝置動作的影響。

雖然發生積冰的雲層大都是伴隨於低壓、鋒面、雷雨、颱風等天氣系統的雨雲，但有可能發生積冰的區域則絕大部分都在氣溫0℃~-20℃之間的區域。從調查過去積冰發生的個案得知，過冷水滴佔有絕對的影響，因此當雲水量多時，特別注意0℃~-15℃之間的區域是必要的（航空預報作業指南）。另外，也有其他報告指出，當航空器外氣溫大約從-3℃到-10℃間，積冰的發生率是最頻繁的（ANA AVIATION WEATHER）。

圖1表示在日本附近航空器的積冰發生次數和氣溫的關係，而圖2則是表示氣壓型態和積冰的關係之模式圖。

圖1：在日本附近航空器的積冰發生次數和氣溫的關係

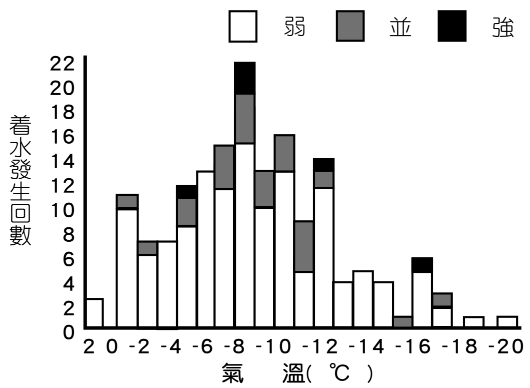
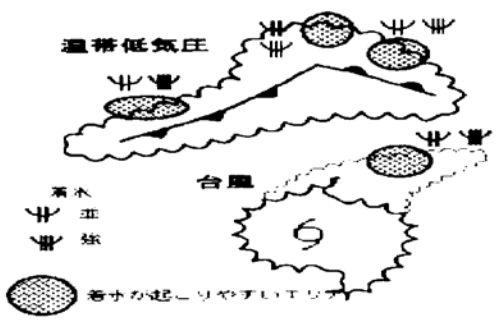


圖2：則是表示氣壓型態和積冰的關係之模式圖



二、積冰預測和實況監測的現況

在航空官方單位的空域情報方面，有關積冰的情報是諸多重要的情報之一。目前的預測技術尚未十分明確，因此現行狀況主要還是根據從航空器得到的情報來做處理。

針對不同的雲形與積冰發生之間的相關性調查，在過去施行多次。但是，即使是相同的雲形，由於其成因的差異，導致不同的顯示特性，因此僅用地面上所見到的雲形來做分類的統計值，其使用性並不理想。

表：積冰的強度

輕度	（Light Icing：LGT ICE） 利用除冰裝置可以處理的程度之積冰。
中度	（Moderate Icing：MOD ICE） 利用普通的除冰裝置只能呈現出抑制積冰成長效力程度的積冰。因此，雖然有除冰操作，但積冰還是會慢慢地成長。
強烈	（Severe Icing：SEV ICE） 即使執行除冰操作，還是會急速成長的積冰。在這個階段航空器會喪失大氣速度，高度也會下降。

由氣壓型態和積冰的關係之模式圖（圖2），強烈積冰發生在低壓和鋒面附近、積雨雲中的情形很多。活躍的暖鋒前方約500km內的雲中很容易發生中度-強烈的積冰，大體上，發展的低壓中心附近也被視為容易發生中度-強烈積冰的區域。

針對積冰發生的預測方法，能量圖（Emagram）的解析和「-8D法」（圖3）被視為是有效的，這是判別水汽有無過飽和狀態的方法。以實際的預報而言，潮濕層厚度的氣溫以0℃~-20℃為標準，在颱風的情況下則根據發展的程度來修正其上限（航空預報作業指南）。

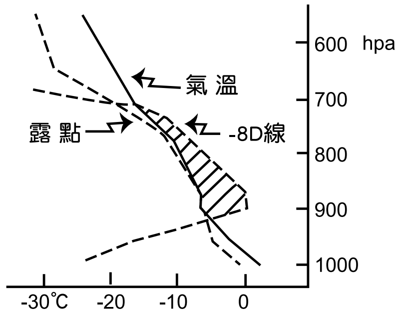


圖3：能量圖加入-8Ｄ線之例子

三、衛星圖像的利用

利用衛星圖像來掌握積冰發生時雲的型態和雲狀的特徵情況，對於積冰預報和實況監測是非常有效的。但是，在METSAT發射運轉以前由GMS所取得的圖像要用來掌握積冰發生時雲的型態和雲狀的特徵情況是非常困難的事，而且在夜間帶因為無法使用可見光圖像，所以幾乎無法執行調查。

目前，由於利用GOES-9就能取得新的3.9μm圖像(METSAT為3.7μm圖像)，加上利用紅外線圖像和3.9μm圖像來做成3.9μm差分圖像，雲的型態和雲狀的特徵可解析出來。利用這些圖像再結合從航空器得來的積冰報告，進行調查從衛星圖像是否可以解析出積冰危險區域的可能性。

運用夜間差分圖像和紅外線圖像的雲型判別圖來做說明，因為有判別出下層雲（包含地面上、海面上）是-10℃以上，而中層雲的下層部分為-10℃~-20℃，所以這表示中層雲也有積冰發生的可能性。

由層積雲（雲水量0.1gm-3）的雲厚度和發射率的關係，由於3.7μm（3.9μm）的放射率比紅外線小，如果雲厚度較厚的話，差值就會變大。

就 3.7μm差分圖像（3.9μm）而言，在水雲的情況下，如果是薄雲，因溫度差小表現較暗：如果是厚雲，因溫度差大（負的差值）顯現較白。

如果是水雲，因為也適合在中層，所以讓發生積冰的雲區變成表現為白色到灰色的雲區。以最有利於積冰發生之雲頂溫度(-15℃左右)的雲區為中心，利用夜間的3.9μm差分圖像來驗證這個案例。

以3.9μm差分圖像而言，根據觀測雲層的不同（水雲／冰雲），水雲為負值被表現得較明亮，而冰晶雲的情形時，則為正值被表現得較暗。針對這個情況利用紅外線圖像所測定的雲頂溫度的氣溫，來求得從0℃到-20℃有過冷卻雲粒的區域，去解析出適合積冰的區域。

然而，各層的高度現在是由氣象衛星中心輸出功率產品的各層高度，因為上層雲是400hPa以上，中層雲是400~600hPa，下層雲為600hPa以下，所以上／中／下層雲的判別是以這個為標準來區分的。

四、關東南方海上的低壓附近

在關東地區南方海上切變場的低壓附近，於2004年2月10日2318UTC時有 MOD ICE 的報告。位置是在羽田機場附近（圖6、圖7的積冰記號處）高度16000呎＊（約4800m）的上空，機型是上昇中的大型飛機。

圖4是2004年2月11日00UTC的地面天氣圖。在關東的南方海上有低壓正往東南東方前進。

圖4：2004年2月11日00UTC地面天氣圖

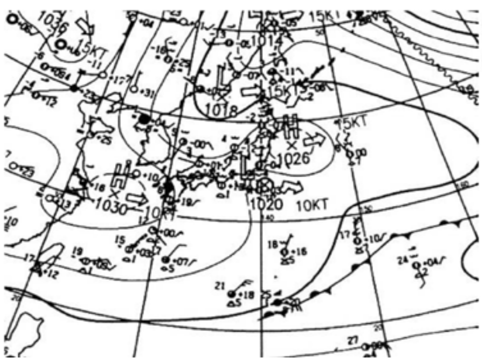


圖5：同時間之館野的高層實況

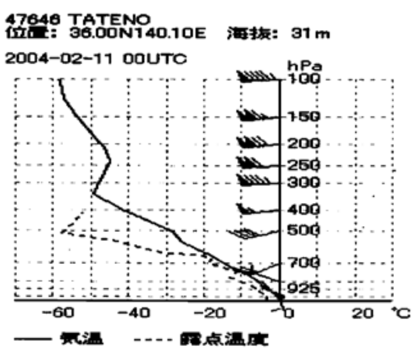


圖6：同時間之可見光圖像

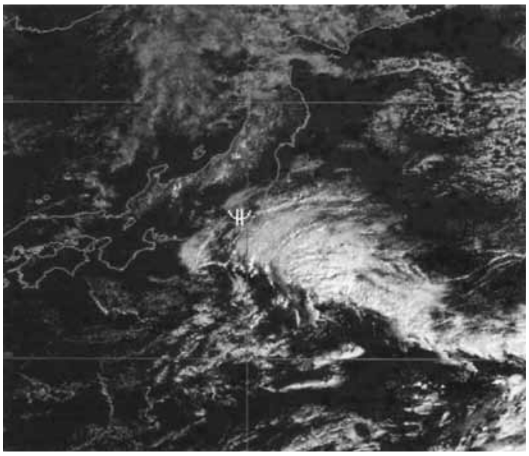
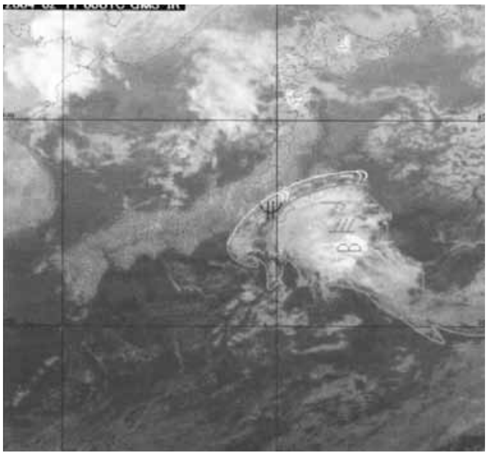


圖7：同時間之紅外線雲解析圖



接著在積冰報告大約40分鐘後的11日00UTC的可見光、紅外線圖像，對應在關東南方海上的低壓，可以見到稍稍發展的雲區。在東京附近也可以看見暗示著擾動的凸狀上層雲在擴展。

運用上節從埃瑪圖的氣溫基準，在這個案例上求得各層的高度

〇上層 -33℃以下(400hPa以上)

〇中層 -25～未滿-33℃(400~600hPa)

〇下層 為-25℃以上(600hPa以下)

如上所述，在有積冰報告的千葉縣，其上空所擴展的雲區，因為雲頂溫度在-13～-16℃，所以為下層雲。有積冰報告的高度因為約為4800m (做氣壓變換的話約在600hPa附近)，所以參考11日00UTC的館野高層資料之濕度(圖5)，可知正好在這個雲的雲頂附近(-18℃)。

圖8是在有積冰報告時約5小時之前的夜間帶10日18UTC的紅外線圖像。此圖像，在有積冰報告A附近的雲區，正好是低壓還在發展中的雲區頂端。A附近的雲區用3.9μm差分圖像來看的話，和其他的區域相比可以看見為白色且明亮的雲區。利用紅外線圖像試著測量亮度溫度，則A附近的雲區可以說是在-12℃～-14℃的下層雲區。

圖8：2004年2月10日18UTC紅外線圖像

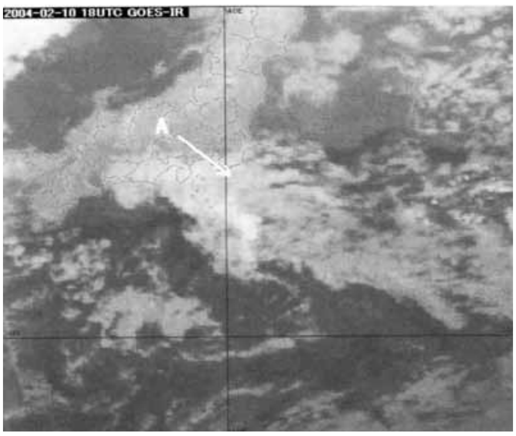


圖9：同時間3.9μm

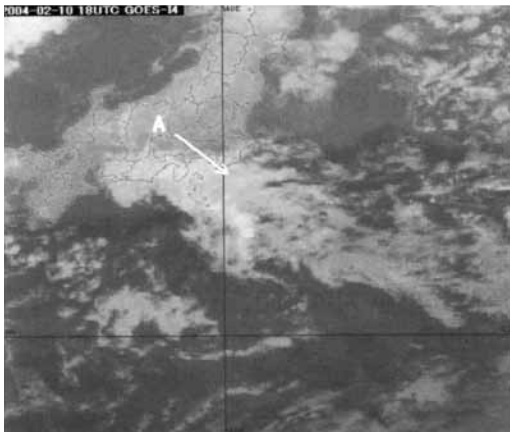


圖10：同時間3.9μm差分圖

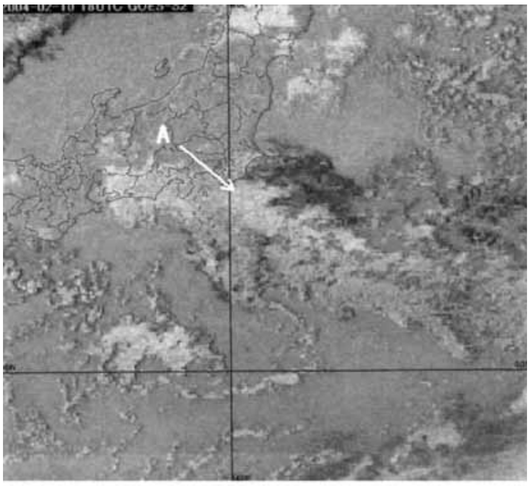


圖11：2004年2月10日21UTC紅外線圖像

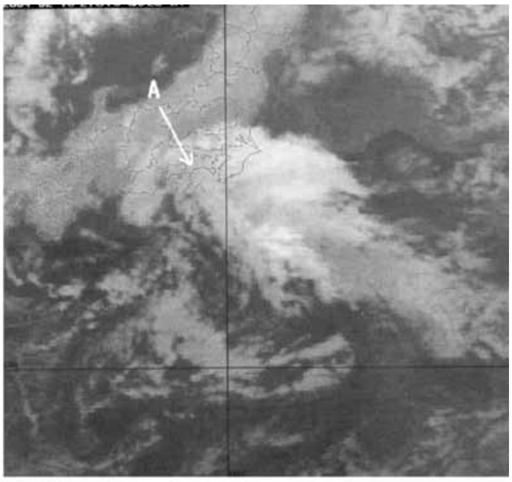


圖12：同時間3.9μm圖像

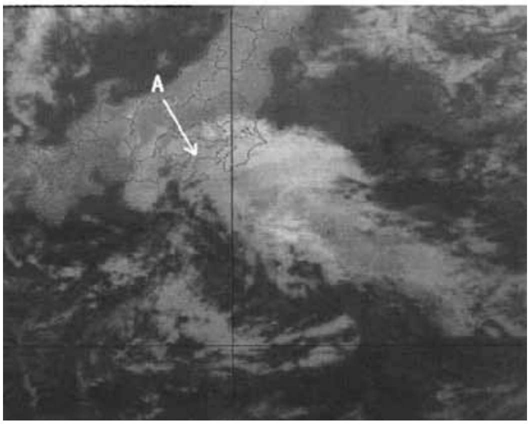


圖13：同時間3.9μm差分圖

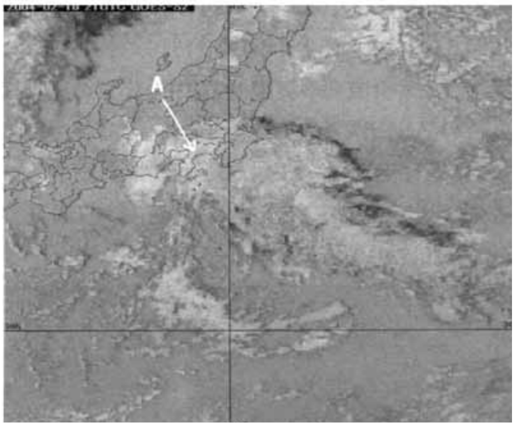


圖11~圖13是積冰報告3小時後的10日21UTC的紅外線、3.9μm圖像和3.9μm差分圖像。圖像的A區域仍在擴大中，從房總半島逐漸覆蓋到關東內陸地區。雲區A利用3.9μm差分圖像來看的話，所見到的白色區域正往西方擴展且白色增多。這正表示雲區內的對流活動被抑制，雲水量較多的層狀雲在形成。

比較普通的層積雲和出現對流活動被抑制的層積雲，後者的雲水量較多，積冰的危險度也變得較高，此次在雲區A內有積冰報告的情況，從圖像中也被證實。

圖14：2004年2月10日21UTC紅外線圖像(水色至白色為0℃～-20℃)

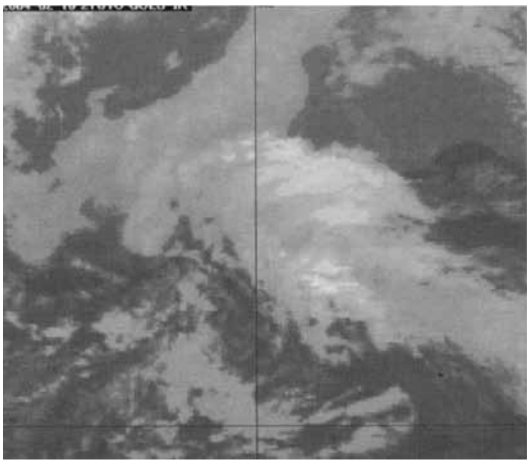


圖15：2004年2月26日09UTC雲解析圖

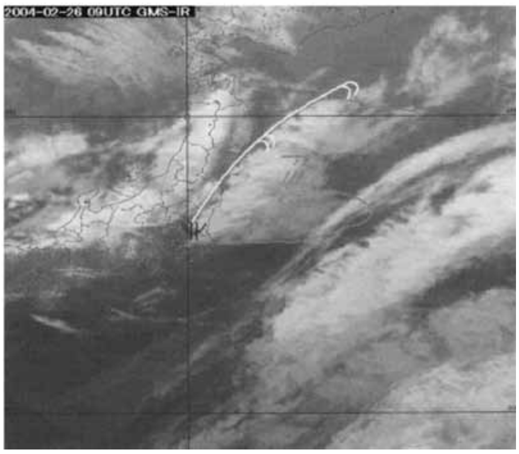


圖14是利用2月10日21UTC的紅外線圖像所測定的雲頂溫度，來求出氣溫從0℃到-20℃的過冷卻雲粒區域的情形。在圖像中，可以看見淺藍色和白色的部分正好是0℃到-20℃過冷卻雲粒區域。在3.9μm差分圖像上可以看見包含雲區A的白色區域(包含雲區A)正含有這個區域。

歸納：

①積冰發生的位置是正好在對應低壓雲區頂端的凸狀附近(圖7)。

②以3.9μm差分圖像而言，被表現為白色的雲區每每隨著時間而白色增加，因此可以推定為讓積冰發生的過冷卻雲區。

③以紅外線圖像而言，即使是相同的層積雲，利用3.9μm差分圖像分析，可從白色的增減值來判別是層狀性雲或強對流性雲。

五、發生在鋒面上的擾動附近之案例

2月26日，在冷鋒上新發生的擾動附近(圖15)的茨城縣南部上空，有2通 MOD ICE的報告。

第1通是在0825UTC時高度FL190(5700m)，內容為 MOD ICE，中型飛機，第2通是在0828UTC時高度FL130(約3900m)，內容為 MOD ICE，機型是中型飛機，兩者都是下降中的報告。兩者雖然有高度的差別，但發生的位置大致相同。在圖15是09UTC的紅外線圖像和表示積冰發生(積冰記號處)附近的雲解析圖。

圖16為2004年2月26日06UTC地面天氣圖，在北海道網走海上有發展中的低壓正往東北方向前進。從這個低壓到關東地區，冷鋒正在發展中。

來看相同時間的可見光、紅外線圖像(圖17、18)的話，對應冷鋒的雲區在北海道的東南方海上雖然可以解析出，但在三陸海上和關東的東方海上卻無法解析出對應鋒面的雲帶。在日本海上，有帶狀的對流雲，它的東面這端從北陸地區到達北關東、東北地區南部。還有，就是另外在茨城縣海上也可以解析出凸狀的上層雲。

圖16：2004年2月26日06UTC地面天氣圖

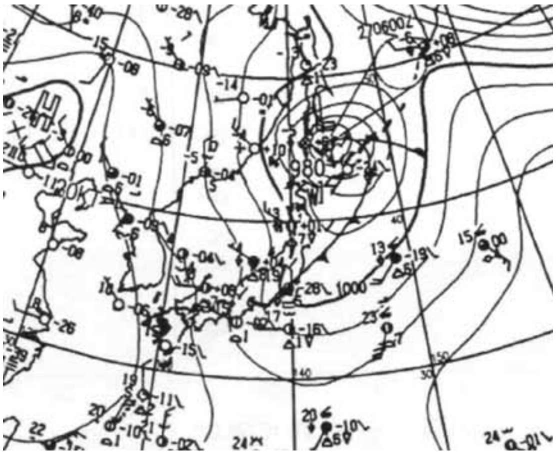


圖17：2004年2月26日06UTC可見光圖像

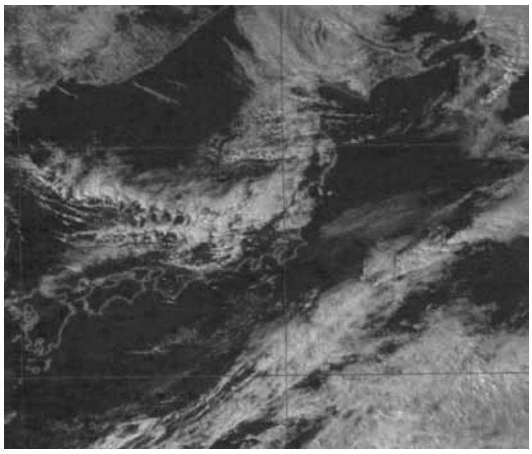


圖18：2004年2月26日06UTC紅外線圖像

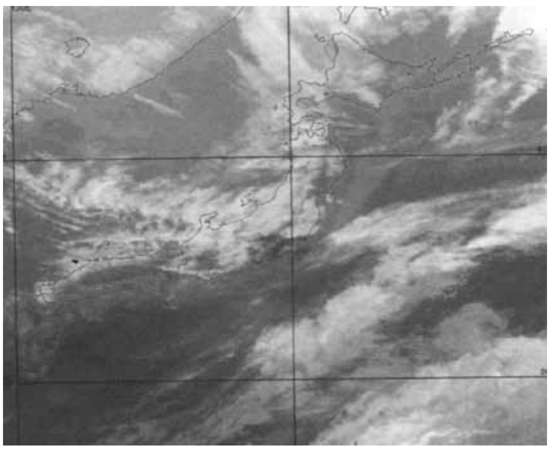


圖19：2004年2月26日09UTC紅外線圖像

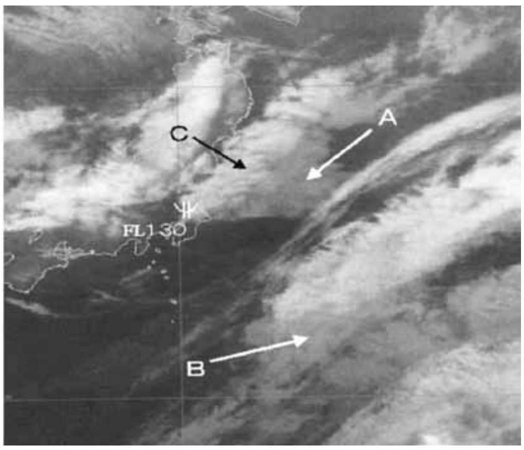


圖19、圖20是在09UTC的紅外線和3.9μm差分圖像上標示積冰記號(茨城縣南部附近)的情形。積冰正發生在呈現三角形狀雲區之西南端的鈎狀附近。由紅外線圖像來看，從北關東到東北地區南部的雲區(C)，其雲頂高度仍在升高同時雲區也在擴大，正在形成一個擾動的雲系統。在地面天氣圖上，這正好在冷鋒的西端。這個雲區，在3.9μm差分圖像上顯示為以灰色為主體的雲區，可知是多層構造的雲區。而且，在雲區的南端也可以解析出對流雲列。在雷達觀測上也被觀測出一般的回波(圖21)。

圖20：2004年2月26日09UTC3.9μm差分圖像

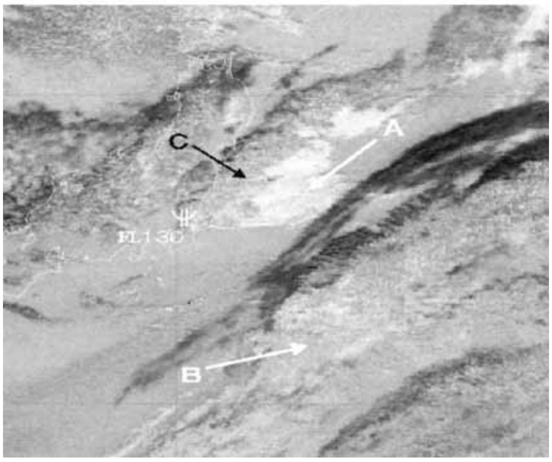
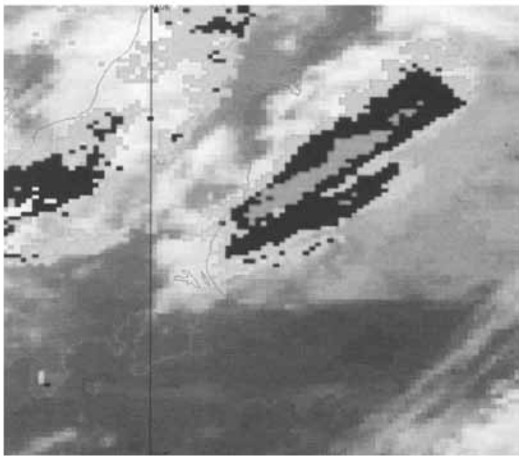


圖21：2004年2月26日09UTC雷達合成圖



由26日12UTC的館野高層資料(圖22)，約在500hPa處有清楚的穩定層，但也可以解析出速度切變。第1份亂流報告，發生高度約為5700m (500hPa附近)，所以被認為是比這個穩定層要稍微高一點的位置上所發生的。

和之前的案例相同，由埃瑪圖來定義各層的氣溫，以這個案例來說

〇上層 -33℃以下(400hPa以上)

〇中層 -24℃~未滿-33℃(400~600hPa)

〇下層 為-24℃以上(600hPa以下)

一求出這個雲(C)的亮度溫度，其溫度大約在-25℃左右，因為正好是中層雲，作為積冰的溫度場，比起到目前為止所說的氣溫要稍微低了一點。還有，第2份的發生高度大約在3900m(680hPa附近)，其氣溫為-16℃左右(正好在下層雲中)，是在穩定層的更下層處發生積冰。

從紅外線圖像來解析這個雲區，可以解析出是以下層雲為主體且混合了上層雲和中層雲的多層構造雲區。以3.9μm差分圖像而言，可以看見為稍帶點狀的雲區。

圖22：2004年2月26日12UTC館野的高層實況

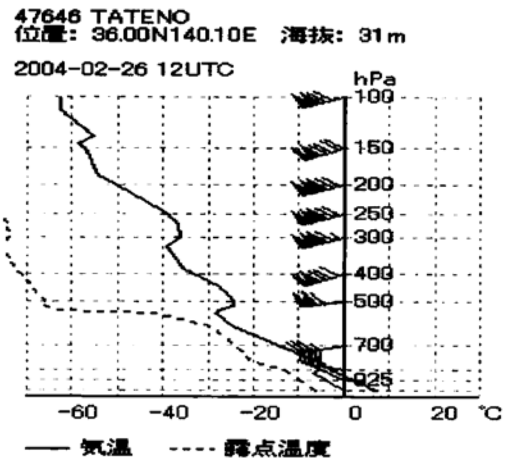


圖23：2004年2月26日09UTC紅外線圖像

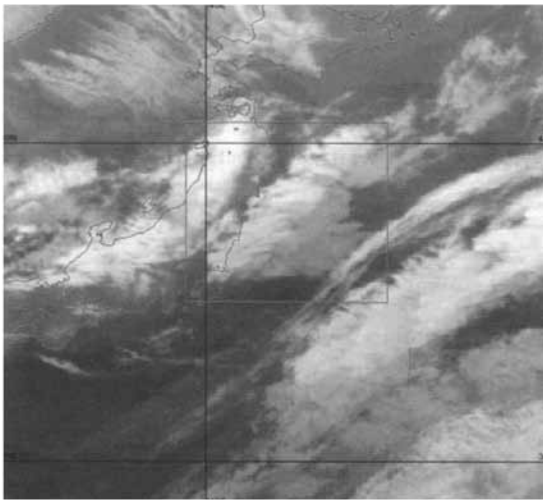


圖24：2004年2月26日09UTC亮度溫度圖

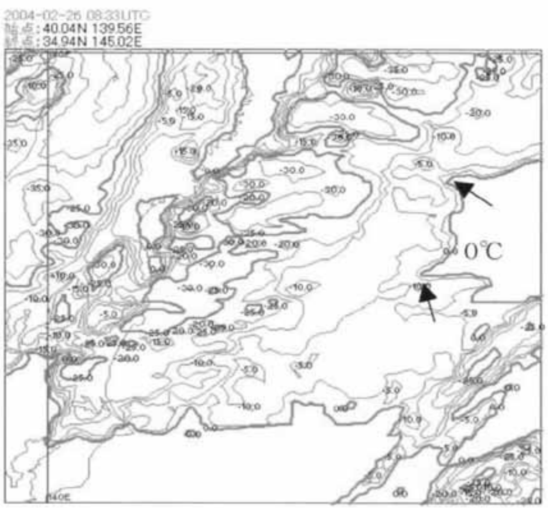


圖25：2004年2月26日12UTC紅外線圖像

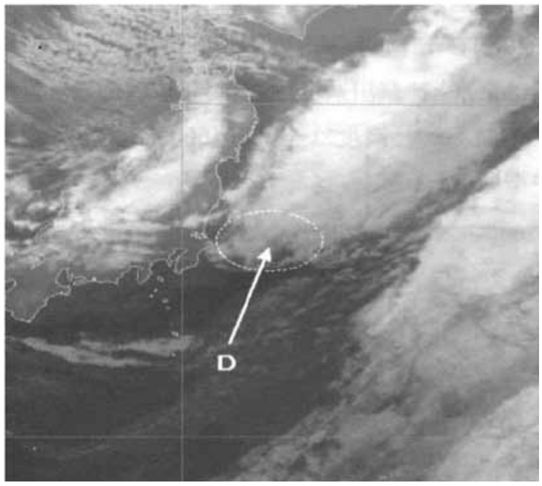


圖24是造成積冰的雲區(圖23的四角形區域)之亮度溫度分布圖。注意看用箭頭A所表示的雲區，這個雲區的雲頂溫度是-10℃～-16℃，可知是以下層雲為主體的雲區。即使是高層的資料，在比500hPa稍低的位置有清楚的穩定層，可知這個雲是往層狀來擴展的。

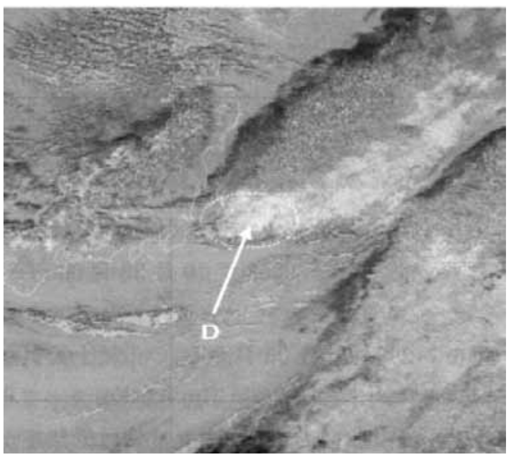
用3.9μm差分圖像來看，用D所表示的雲區是以白色為主體，可知是薄紗狀表面且平滑的層狀性水雲。

這個以層雲為主體的水雲，雖然有積冰的雲區和一連串的雲系統，但積冰的發生位置是在這個雲區的鉤狀附近且對流活動稍微活躍的部分。這個情形可說是對流雲的中層附近是過冷卻雲區。

來看12UTC的紅外線圖像(圖25)，上層的槽通過，而且有積冰的雲區其對流活動正在減弱。用3.9μm差分圖像來看的話，點狀的狀態消失，可以看見以白色為主體的薄紗狀中・下層雲。這個情況和之前的案例相同，雲區內的對流活動被抑制，表示雲水量較多的層狀雲在形成。以普通的層積雲和出現對流活動被抑制的層積雲而言，後者的雲水量較多，積冰的危險度也變得較高。

由以上所述，讓09UTC發生積冰的雲區，被推測是過冷卻雲區。

圖26：2004年2月26日12UTC 3.9μm差分圖像



歸納：

①發生積冰的雲區，是在槽前的鉤狀區附近發生的(圖15)。

②發生積冰的雲區之中層而言，很清楚的有穩定層形成，而在雲區的東側，層狀的中／下層雲正在擴展。

③擴展到這個雲區東側的中／下層雲，在3.9μm差分圖像上顯現為白色，而積冰是發生在過冷卻雲區內。

六、颱風附近的案例

10月25日，在日本南方海上往東北方向前進中的颱風第0317號，其往東北方擴展之以中層雲為主體的雲區內，於0830UTC時有 MOD ICE的報告。這個位置正好在東京和神奈川縣邊界附近(圖29的積冰記號處)，高度為FL200(6000m)機型是上昇中的中型飛機。

圖28是10月25日06UTC的地面天氣圖。在日本的南方，有颱風第0317號正往東北方前進。而且，在日本海北部有低壓，然後冷鋒往日本海西部延伸。

圖27：2003年10月25日06UTC紅外線圖像雲解析圖

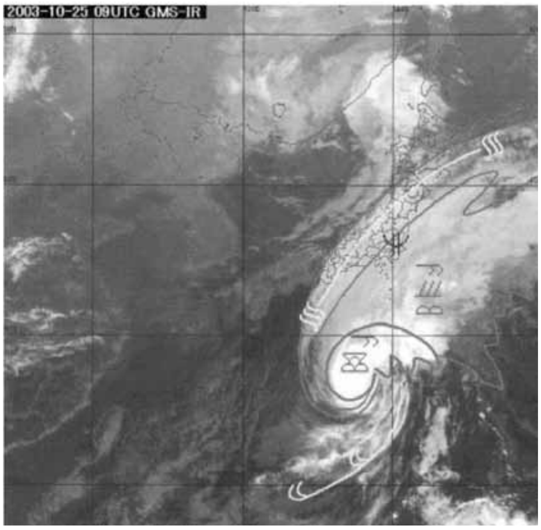


圖28：2003年10月25日06UTC地面天氣圖

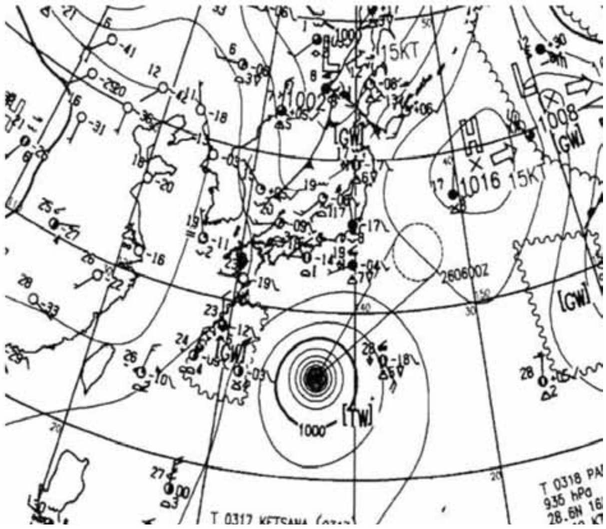


圖29~圖31是擴大09UTC的颱風周邊圖，有積冰的位置用積冰記號表示。有積冰報告之縣界附近的雲，由紅外線圖像的亮度可知是中層雲。從近畿地區到東北地區，正覆蓋著清楚的卷雲。而且，在颱風北面的日本東方海上，中層雲正在擴展中。

以3.9μm圖像而言，去除薄的上層雲，則中／下層的雲區變得更加清楚。

在3.9μm差分圖像上，在颱風中心附近可以看到表示活躍積雨雲的黑白混合點狀雲區。而且，颱風的南面和伴隨卷雲的薄上層雲區為黑色區域，從能登半島擴展到佐渡島附近、青森縣的東方海上。覆蓋在東北地區的灰白色雲區，是多層構造的厚雲區。

圖29：2003年10月25日09UTC紅外線圖像

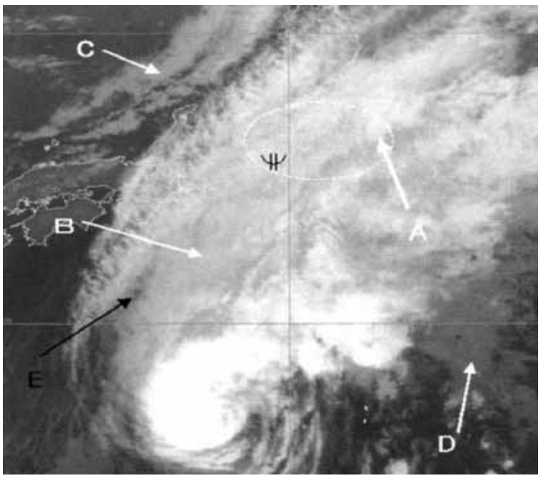


圖30：2003年10月25日09UTC3.9μm圖像

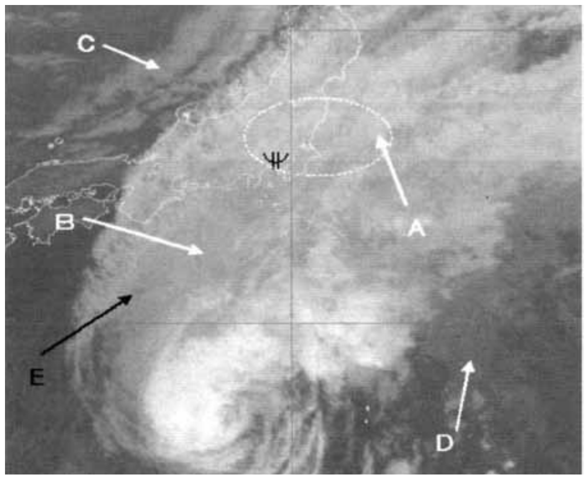


圖31：2003年10月25日09UTC3.9μm差分圖像

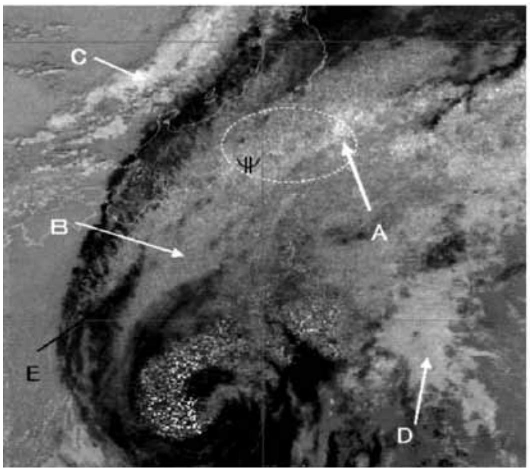
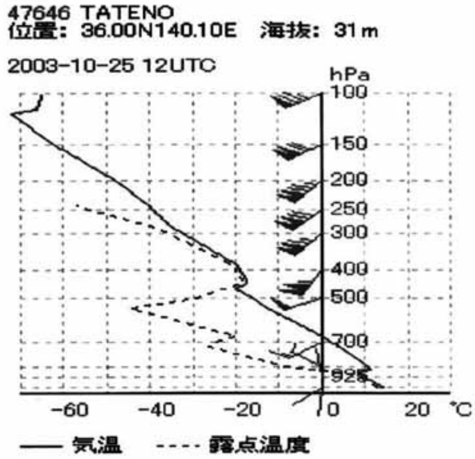


圖32：2003年10月25日12UTC館野的高層實況



有積冰的區域(點線處)，在3.9μm差分圖像上被表現成灰白色且為細點狀。亮度溫度是-22℃左右，這個附近的中層因為過冷卻的緣故，推測有積冰發生。

而且，用C所表示的雲區是下層雲，比起用B所表示的雲區，顯現為稍微薄的灰色。亮度溫度是5℃~8℃的下層雲區。

由25日12UTC的館野高層資料(圖32)，在500~400hPa之間有穩定層，而穩定層以上到300hPa附近，成為上層潮濕/下層乾燥。由這個情況，可知從日本東方海上到關東附近的雲區是以中／上層雲為主體的雲區。然而，發生積冰的高度FL200 (6000m附近：500hPa的高度場約為5700m)的氣溫，從館野高層的實際狀況可以推定為-15℃左右。

歸納：

以這個積冰案例而言，是發生在颱風前方以中／下層為主體的雲區內。在3.9μm差分圖像上被表現為灰色的層狀性雲區。

七、 全部案例的歸納

關於積冰的案例雖然歸納如下面的敘述，但是依然在調查的階段。還有，因為要考慮到即使出現那樣的雲卻沒有積冰產生的情形也很多，所以這裡以被報告有積冰的雲區作為參考，從衛星圖像來分析，說明有這樣特徵的雲區以做為主體的報告。

①在3.9μm差分圖像上，白色明亮的雲區附近發生積冰。

②在3.9μm差分圖像上，可以看見灰色的雲區是以中／下層雲為主體的雲區，要判斷這個雲區是水雲、或是冰雲呢?是用紅外線圖像求出亮度溫度，而且有必要由這個情報(-20℃做標準)來判斷雲層。

③從案例來看，積冰報告是積冰發生在層狀性的雲中。由此情況可以說是如在圖2所表示的是在擾動附近和鋒面附近，在以層狀性的雲為主體的雲區，有發生積冰的可能性。

④以3.9μm差分圖像而言，二層和三層的多構造雲區變得很冷(結構很高)，就能看見好像混合了點狀的雜訊雲區。但是，在這次各個案例的調查方面，在二層構造中其下層是層狀性雲的情況時，看不見這個雜訊，而當下層是對流性雲且有Cb和Cg時，考慮到可以看見是為混有少數雜訊的雲區，就需考量積冰的危險情形，並且必須注意混有這個雜訊的情況，去參考紅外線圖像的亮度溫度情報等，有必要解析是層狀性雲或是對流性雲。

然而，以在低壓附近和鋒面上發生擾動附近的案例而言，從混有少數雜訊的雲區(對流性雲)在變化成白色雲區(層狀性)的過程中發生了積冰。

在寒候期(每年10月至翌年3月)的海洋上所形成的層積雲(Sc)，由於上方的穩定層使對流雲出現被抑制的情形很多，所以形成雲時的空氣塊之垂直位移很大，且因為雲水量也比層狀的層積雲多，因此有注意的必要。

There danger cloud area to aircraft icing occurred

TUNG MAO -SHIANG

Abstract

Aircraft icing is one of the significantly hazards weather can affect aircraft safety. This article will introduce the Japan Meteorological Agency how to use a variety of METSAT satellite images to grasp the affect icing occurred and the characteristics of pattern clouds and cloud type at that time. Thus take advantage of the aircraft icing forecasts and live monitoring, proved to be highly effective.

I. An overview of icing

The main cause for aircraft icing (abbreviated late, ricing) occurrence is the sublimation of water vapor and supercooled water droplets hit the aircraft body. When the icing occurs, it will result in reduced buoyancy, engine stop, postural control, and the impact of landing gear operation.

Although the clouds area of icing occurred are mostly accompanied in the low pressure system, cold fronts, thunderstorms, typhoons and other weather systems. But most of cloud areas at temperatures between 0℃ ~ -20℃ may induce the icing occur. From the investigation cases of icing occurred in the past, the supercooled water droplets have absolute influence. When the cloud contains a loud of water, special attention area at temperatures between 0℃ ~ -15℃ is necessary (aviation forecasts Operations Guide). In addition , there are other reports when the outside temperature of aircraft is from about from -3℃ to -10℃, the incidence of icing occurrence is the most frequent (ANA AVIATION WEATHER).

Fig 1 shows the relationship between the frequencies of icing occurs with temperature near Japan.

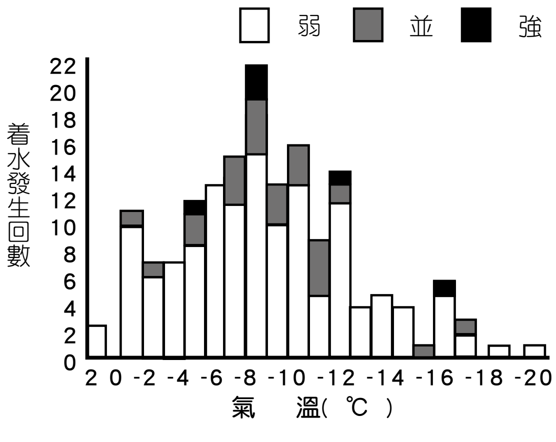
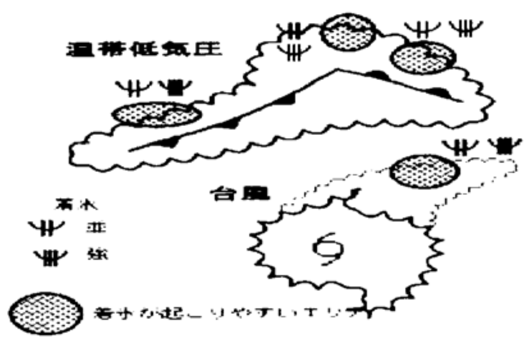


Fig 2 is the diagram of relationship between icing and pressure patterns.



2.Icing forecast and lives monitoring of the current status

The icing information is one of the important intelligence in FIR for aviation official. Current projections technology is not yet very clear, so in current conditions is primarily for processing according to the information received from the aircraft.

To investigate the correlations between the different cloud shapes and icing occurrence, had survived several execution in the past. However, even for the same cloud shape, because of its different genesis lead to different display characteristics. So, just only using the cloud shape observed on the ground for classification statistics, the result is not satisfactory.

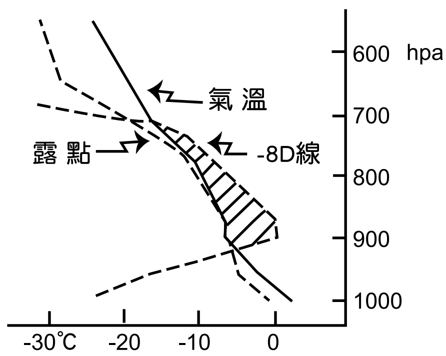
Table 1: The strength of icing

Light Icing：LGT ICE Deicer can be processed using the degree of icing.
Moderate Icing：MOD ICE Using common Deicer only showed growth inhibition effect of the icing. Thus, while the de-icing operation, but the icing will still grow slowly.
Severe Icing：SEV ICE Even if you execute deicing operations, icing will still rapidly grow. At this stage, the aircraft will lose air speed and altitude will fall.

Fig 2 is the models with relationship of air pressure patterns and icing, many strongly icing occurs in the vicinity of low pressure system and frontal, cumulonimbus. Ahead about 500km of the active warm front, the cloud in this area prone moderate to strong icing occurrence. In general, near the center of development low pressure system is also considered moderate to strongly prone to icing region.

For prediction icing occurrence method, energy diagram (Emagram) and " -8D method " (Fig. 3) is considered to be effective. It is a method for determine whether have supersaturated vapor or not. In actual forecasts, temperature 0 ℃ to -20 ℃ as the standard for the wet thickness layer. In case of typhoons based on the level of development to revise its limits (aviation forecasts Operations Guide).

Fig 3: Energy plans to join -8D examples of line



3. Utilization of satellite imagery

Using satellite imagery to get a grip on characteristics of cloud patterns and cloud type when icing occurs, it is very effective for the icing forecasts and live monitoring. However, in METSAT transmitter operation formerly made by the GMS image to be used to grasp the icing occurs. But it is very difficult to get the cloud patterns and cloud type feature situation, because cannot use a visible image in night. So, investigations are almost impossible to perform.

At present, due the GOES-9 can achieve new 3.9μm images (METSAT is 3.7μm image) , plus an image using infrared images and 3.9μm to 3.9μm made a difference image , cloud patterns and cloud type features can be parsed. Combined use of these images and icing reports, surveys from satellite imagery can parse out the possibility of icing danger zone.

Using the cloud pattern identification chart of differential image and infrared images at night do explain , because there are discriminated temperature of low layer cloud (including ground, sea) is -10 ℃ or more. While temperature in the lower part of middle layer cloud temperature is between -10℃ and - 20℃, it means the middle layer cloud in the likelihood of icing.

From the relationship between cloud thickness of the stratocumulus (water amount 0.1gm-3) and emissivity, as emissivity 3.7μm (3.9μm) is small than infrared radiation, then more thick cloud and the difference value becomes large.

As the 3.7μm (3.9μm) difference image, the case in water cloud, if it is thin cloud performance due to the small temperature difference is dark. If it is a thick cloud, temperature difference is large (negative difference) appear whiter.

If a cloud is water cloud, because also fit in the middle layer, so let happen icing cloud area becomes manifested as white to gray. The cloud top temperature at about -15 ℃ is most conducive to icing occurring and as the center of the cloud , using the 3.9μm difference image at nigh time to validate this scenario.

To 3.9μm differential image, according to observer different clouds (water cloud or ice clouds), the negative value is performed brighter for water cloud, while the case of ice clouds, the positive value is performed darker. For this situation by using infrared image to measure the temperature of cloud top to obtain from 0 ℃ to -20 ℃ cloud area had supercooled particles , to parse out the appropriate area of icing .

However, the height of the layers is output products by the Meteorological Satellite Center, because the upper layer cloud is 400hPa above , the middle layer cloud is 400 ~ 600hPa, 600hPa less is the low layer cloud , so the cloud of upper, middle and low layer are under discrimination is based on the cloud as a standard to distinguish.

4. Nearby the low pressure system at southern offshore of Kantou

In 2004, Feb. 10231800UTC nearby the low pressure system at southern offshore of Kantou had a MOD ICE reported. Location is in the vicinity of Haneda Airport (Figs 6 and 7 icing mark) and altitude is 16,000ft (about 4800m) and airplane type is a large aircraft .

Fig 4 is 1100UTC Feb., 2004 surface weather chart. In the southern offshore of Kanto, a low pressure system was moving toward advancing east-southeast.

Fig 4: 2004 on February 11 00UTCsurface weather map

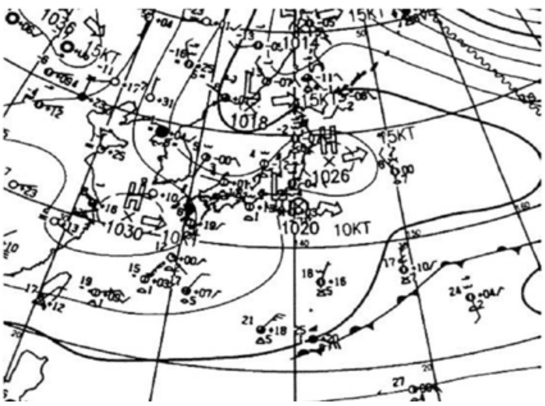


Fig 5: Tateno same time high-level fact sheet

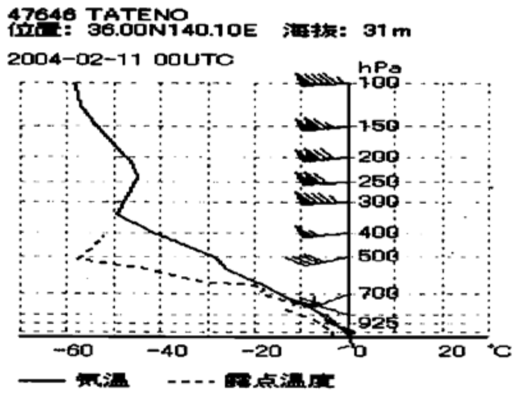


Fig6 : The same time visible image

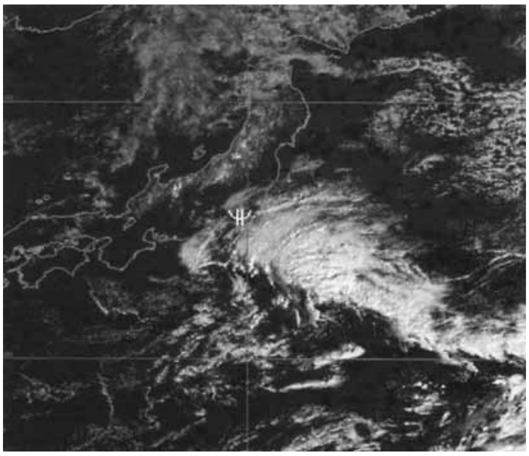
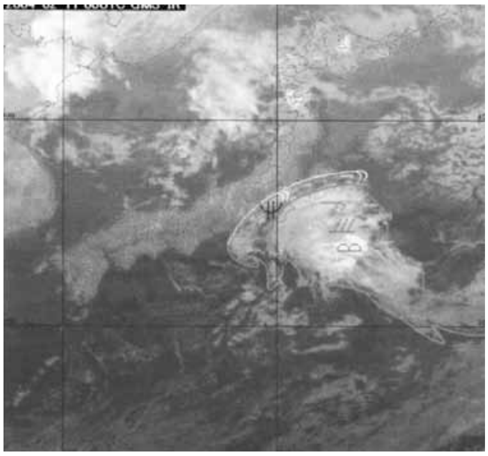


Fig7 :The same time IR cloud analysis diagram



About 40 minutes after an icing report, from 110000UTC visible and infrared images corresponding to the low pressure system at southern offshore of Kantou, you can see a little development cloud area. Can also be seen implies disturbances convex upper layer cloud is expensed in the vicinity of Tokyo.

Base from the Emagram temperatures found on the height of the layer in this case.

○ Upper layer -33 ℃ less (400hPa above)

○ middle layer -25 ~ less than -33 ℃ (400 ~ 600hPa)

○ lower layer for more than -25 ℃(600hPa less)

As mentioned above, there are reports of icing at Chiba. Upper the region a cloud area are extended, since the temperature of cloud top is -13 ~ -16 ℃, so it is a low layer clouds. Because the high of icing reports almost about 4800m (about 600hPa) , so refer to the 110000UTC of Tateno senior information humidity (Fig 5) , we can see just the top of the cloud in the vicinity (-18 ℃) .

Fig 8 is an infrared image before icing report about 5 hours at the night time on 1018UTC. This image, there is cloud area nearby icing report dot A, just the cloud top in still developing low pressure system. On 3.9μm differential image, cloud area near A compared with other regions can be seen as white and bright. Try using infrared image brightness temperature measurements , the A nearby cloud area can be said to be a low layer cloud at -12 ℃ to -14 ℃.

Fig 8: 10. Feb.2004 1800UTC infrared image

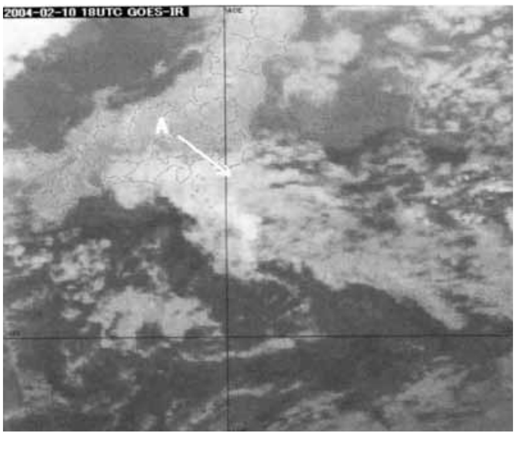


Fig 9: Same time 3.9μm image

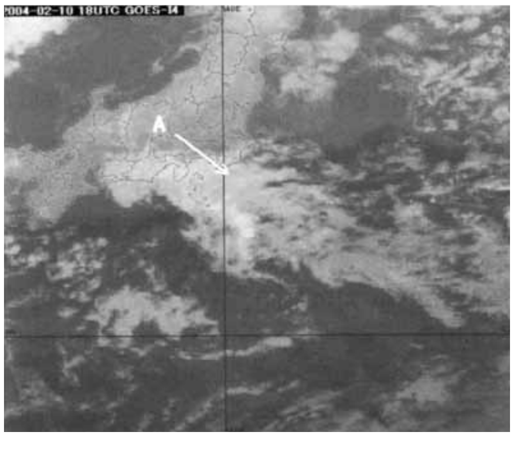


Fig 10: Differential same time 3.9 μm

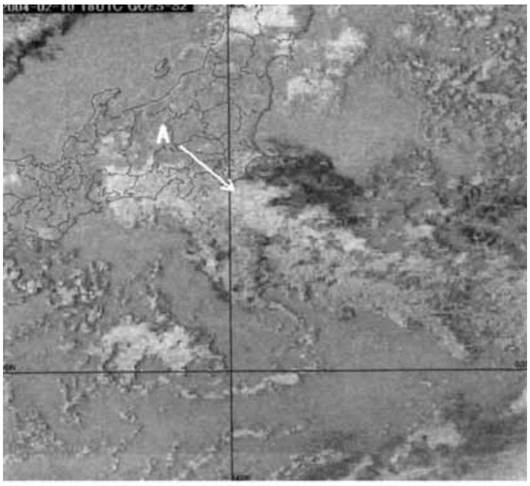


Fig 11: 10. Feb.2004 21UTC infrared image

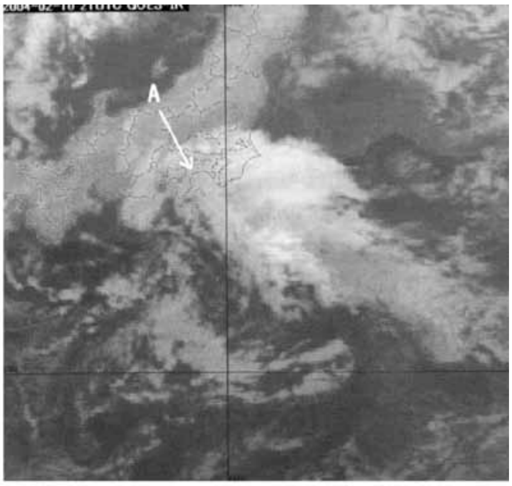


Fig 12: same time 3.9 μm images

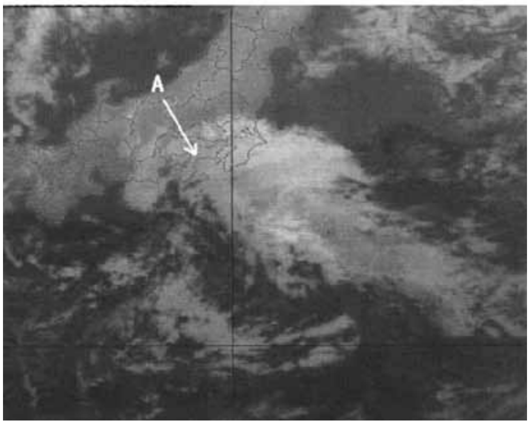


Fig 13: same time 3.9 μm differential image

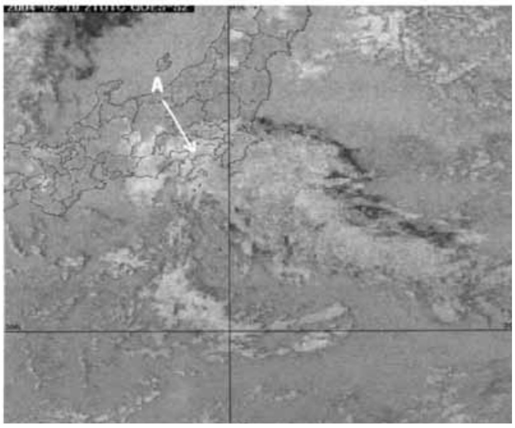


Fig 11 to Fig 13 is the 102100UTC infrared, 3.9μm and 3.9μm differential picture images after an icing report about 3 hours. Region A of the picture is still expanding from the Boso Peninsula gradually cover the Kantou inner area. On 3.9μm difference image, cloud region A have seen the white area is extended to the West and white increased. It is said that the convection active is suppressed and higher water stratus cloud in the formation.

Fig 14: 102100UTC Feb. 2004 Infrared images (color to white 0 ℃ ~ -20 ℃)

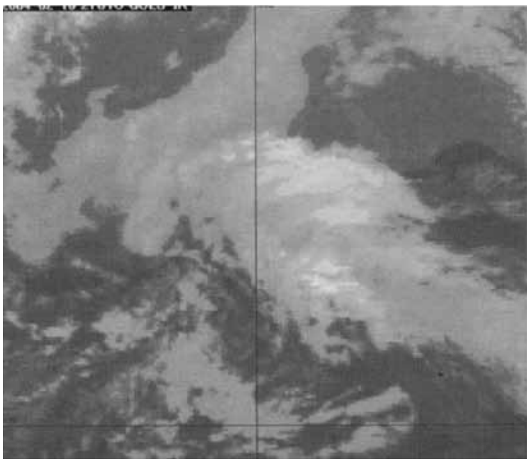
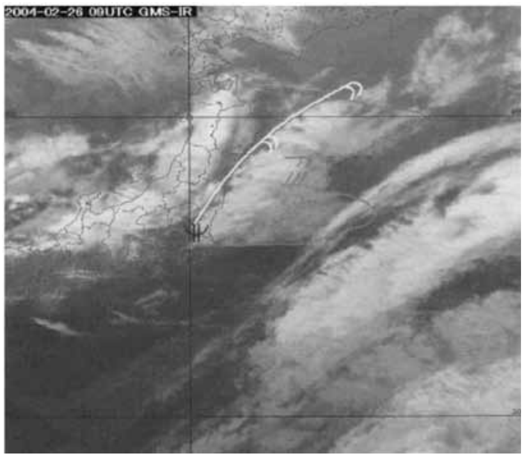


Fig 15: 260900UTC Feb. 2004 cloud analysis diagram



Compare the common stratocumulus between stratocumulus with convection is suppressed, the latter contains more water and more dangerous for icing. This time in the cloud icing within region A case report, also from the image been confirmed.

Fig 14 is the temperature of cloud top measured by infrared image and to determine the temperature from 0℃ to -20℃ for supercooled cloud particle region of circumstances on 21UTC Feb 10. In the image, you can see the blue and the white part is just 0℃ to -20℃ is a supercooled cloud particle region . In the 3.9μm differential image can be seen cloud region A includes the white area (area including cloud A) is contained in the region .

Summarized:

(1) Icing occurring at the corresponding position is just at the convex near the cloud top of low pressure system (Fig 7).

(2) The 3.9μm difference image is represented as a white cloud area and often increases over time , it can be presumed to occur icing of supercooled cloud area.

(3) Even if the same stratocumulus on infrared image , using 3.9μm differential image analysis, increase or decrease in value from white to distinguish is stratiform clouds or strong convective clouds.

5. The case of disturbances occurring nearby the front

Feb. 26, a new disturbance occurred near the cold front (Fig 15) over southern Ibaraki Prefecture, 2 MOD ICE was reported.

0825UTC first MOD ICE pass at FL190 (5700m) by medium-sized aircraft and 0828UTC the second MOD ICE pass at FL130 (approximately 3900m) the same size aircraft , both decline in the report . Although both occur at differential fly level, but the same position. In Fig 15 is 09UTC infrared image and the cloud analysis diagram nearby icing occurs (icing mark) area.

Fig 16 is 2606UTC, Feb. in 2004 surface weather chart, in Hokkaido Abashiri sea had a developing low pressure system which was moving to the northeast. From this low pressure system to the Kanto region, the cold front is under development.

Look at the same time visible and infrared images (Fig 17, 18) , then the corresponding cold front cloud district in Hokkaido southeastern maritime although you can parse out , but in the Sanriku sea and Kanto Eastern Sea could not parse the corresponding fronts cloud band . On Japan Sea have banded convective clouds, it is from this side of the east Hokuriku to North Kantou, then to the south part of Northeast region. There is another in Ibaraki Prefecture sea can also resolve the convex upper clouds.

Fig 16: 260600UTC Feb. 2004 Surface weather chart

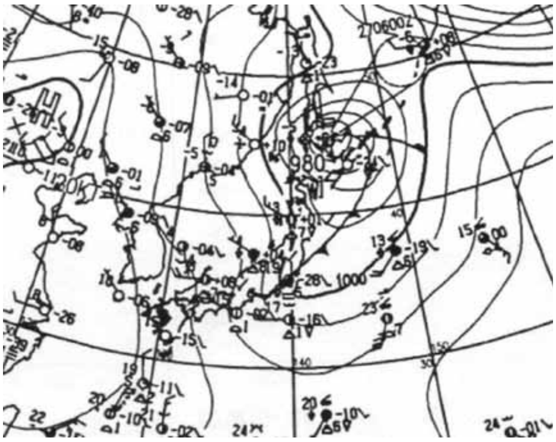


Fig 17: 260600UTC Feb. 2004 visible image

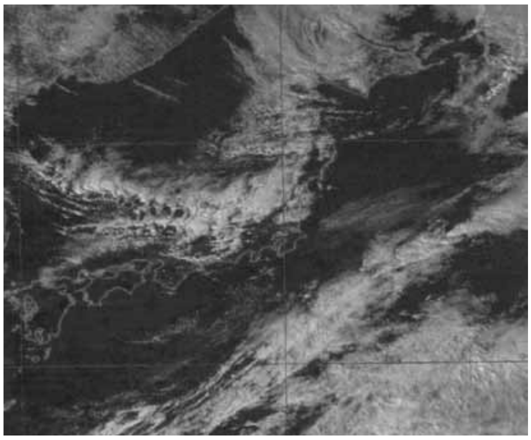


Fig 19 and Fig 20 are the marked an icing token (near south Ibaraki) on the 09UTC infrared image and 3.9μm differential image. Icing is happening near the hook of the southwestern part in the triangular shape cloud area. On infrared images a cloud region(C) from the north Kantou to southern part of northeast. Its height of cloud top still rise, while also expanding area is forming a perturbation of cloud systems. In surface weather chart, this is just the western end of the cold front. The cloud area in the 3.9μm difference image is displayed as gray as the main cloud area; we can see is a multilayer structure cloud area. Moreover, the southern region in the cloud can resolve the convective columns. Also the radar echo is observed a general (Fig 21) .

Fig 18: 260600UTC Feb. 2004Infrared image Infrared image

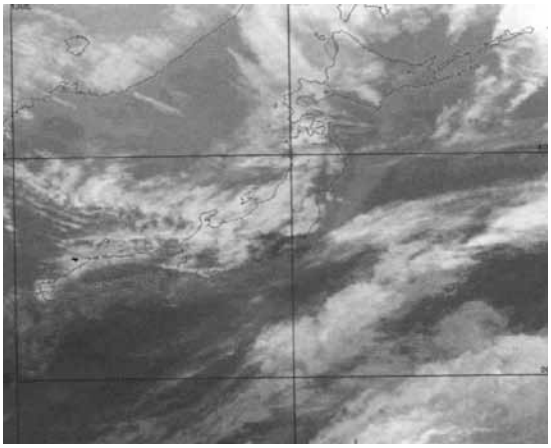


Fig 19: 260900UTC Feb. 2004Infrared image mage

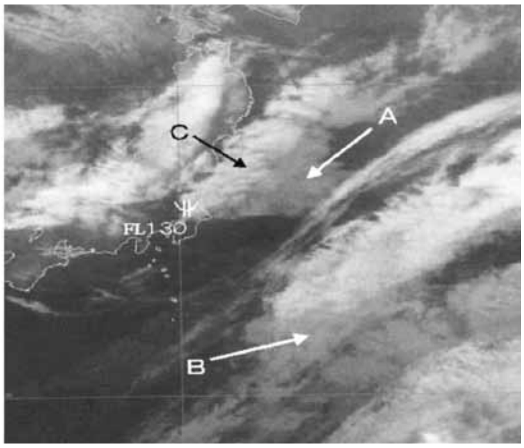


Fig 20: 260900UTC Feb. in2004 263.9μm differential image

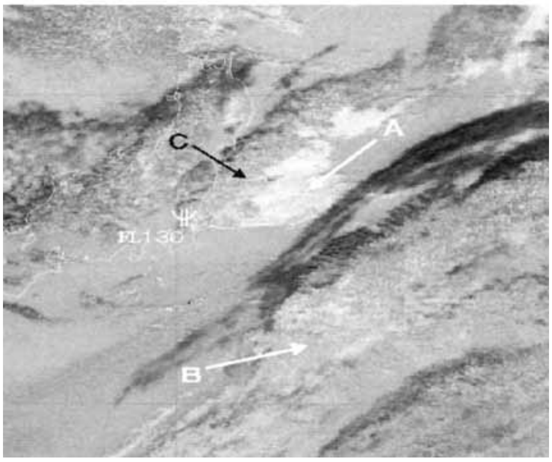
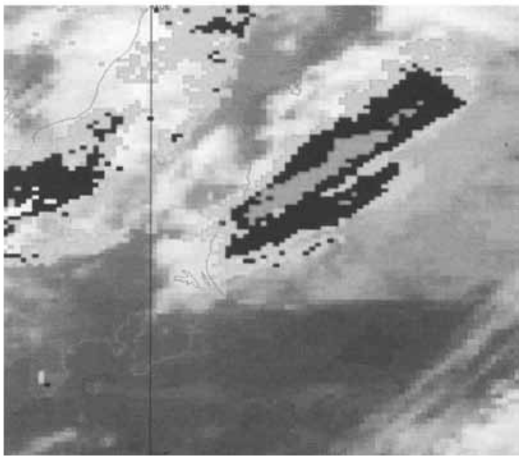


Fig 21: 260900UTC Feb. in2004 radar composite image



The 2612UTC high level data of Tateno (Fig 22), about 500hPa have a clearly stabilized layer, but can resolve the velocity shear. First turbulence report, the height of occurrence is about 5700m (500hPa), therefor the position of turbulence is considered to be slightly higher than the stable layer.

And the same as the previous case by Emma diagram to define the temperature layers to this case is

○ Upper layer -33 ℃ less (400hPa above)

○ middle layer under -24 ℃ to -33 ℃ (400 ~ 600hPa)

○ low layer more than -24 ℃ (600hPa less)

Fig 22: 261200UTC Feb.2004 Tateno live

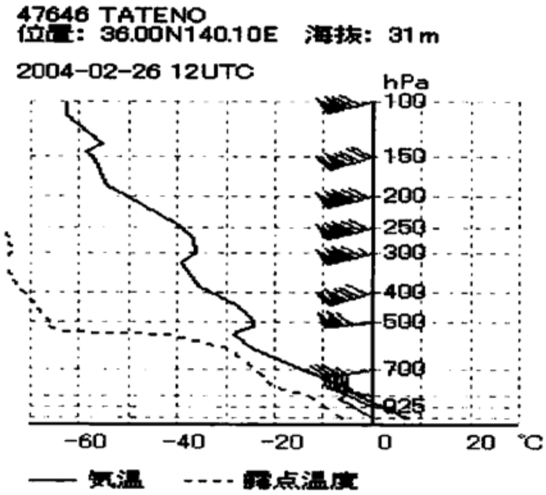


Fig 23:260900UTC Feb. 2004 infrared images

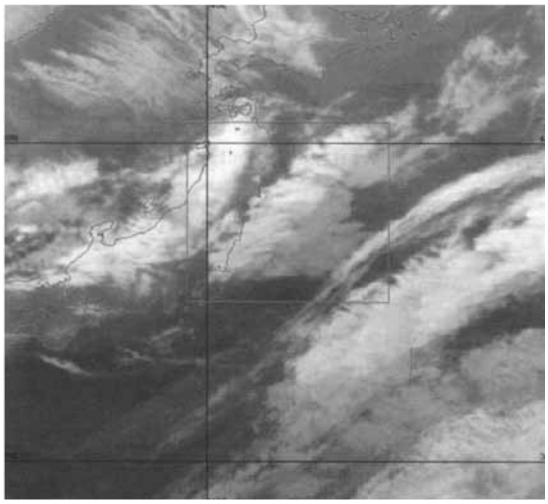


Fig 24: 260900UTC Feb. 2004 brightness temperature chart

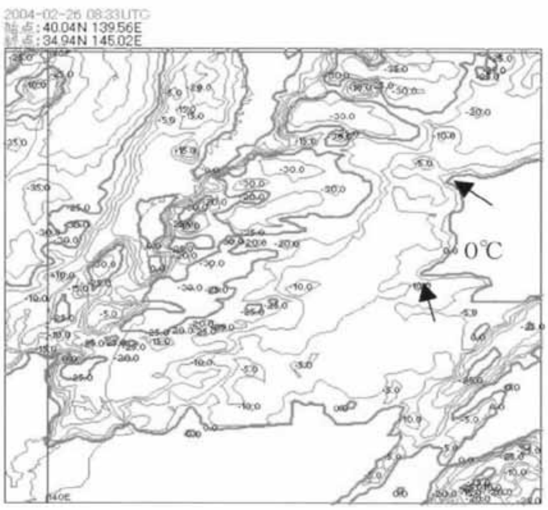
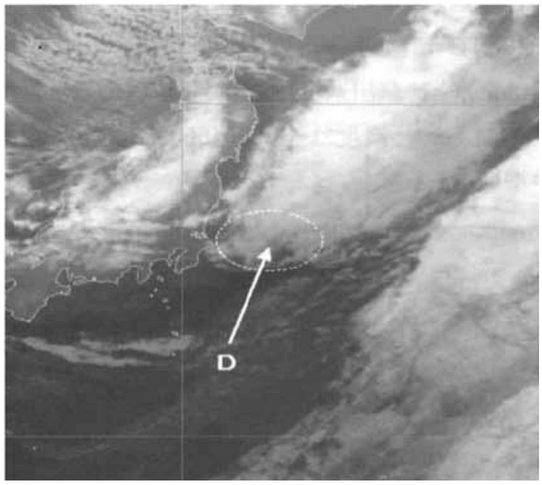


Fig 25: 261200UTC Feb. 2004 Infrared image



Calculate the brightness temperature of the cloud (C), the temperature about -25 ℃ just a middle layer cloud. As the temperature field of icing, compared to so far say to be slightly lower. Also, in second report the occurrence level is about 3900m (680hPa) and its temperature is about -16 ℃(just in low layer clouds) ,so icing occurs at a lower level than stable layer .

From the infrared images to resolve this cloud area, you can parse out the low layer cloud as the main body and mixed with middle and upper layer clouds. To 3.9μm differential image, can be seen as cloud area with slightly point.

Fig 24 is a brightness temperature chart for cloud area of icing (Fig 23 square -shaped region). Note cloud area represents by arrow A, its temperature of cloud top is -10° C to -16°C and you can parse out the low layer cloud as the main body. Even high level data, under 500hPa has a clearly stable layer and extended to stratiform cloud.

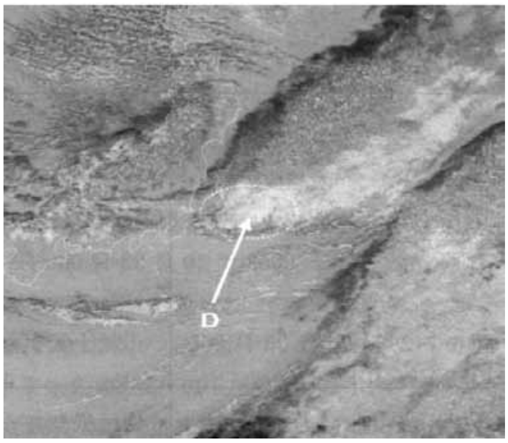
In 3.9μm differential image, the cloud area are represented by D with white color, we can see tulle -like surface and smooth stratiform water cloud.

This main body is a stratus water cloud, although contain the icing cloud area and a series of cloud systems, but location of icing occurrence area is in the vicinity of the hook and a part of convective activity. This situation can be said to be near the middle layer of convective cloud is a supercooled cloud area.

On infrared image (Fig 25), the upper trough had passed through, and convective activity of ice clouds area is weakening. From 3.9μm difference image, point-like condition is disappears and you can see white tulle as the main form of low layer clouds. This situation and the case before the same cloud convection zone are suppressed, which means the with more water stratiform clouds is forming. In ordinary stratocumulus and stratocumulus with convection is suppressed, the latter have more cloud water, the risk of icing becomes higher.

From the above, let 09UTC happen icing cloud area, was presumably supercooled cloud area.

Fig 26:2004 years February 26 12UTC 3.9μm difference image



Summarized:

(1)Occurred icing cloud area is near the hook region in front of the trough (Fig 15).

(2)The middle layer of icing cloud area appears a stable layer formed clearly.
While the eastern part in the cloud area, stratiform middle and low layer cloud are expanding.

(3)In eastern side of extended cloud area, the middle and low layer cloud at 3.9μm differential image show up as white, while the icing occurs in supercooled cloud area.

6. The Case near Typhoon

October 25 in Japan, on the southern sea of Japan had Typhoon No. 0317 moving to the northeast direction, its expansion to the north east of middle layer clouds as the main body, at 0830UTC when MOD ICE reported. This location just in Tokyo and Kanagawa Prefecture near the border (Fig 29 icing mark), height of FL200 (6000m) model is rising in the medium-sized aircraft .

Fig 28 is October 250600UTC surface weather chart. In Japan's south, a typhoon No. 0317 is moving to northeast. Moreover, a low pressure in the northern SEA OF JAPAN and a cold front extending to the west of SEA OF JAPAN.

Fig 27: 250600UTC Oct. 2003 Infrared image analysis diagram cloud

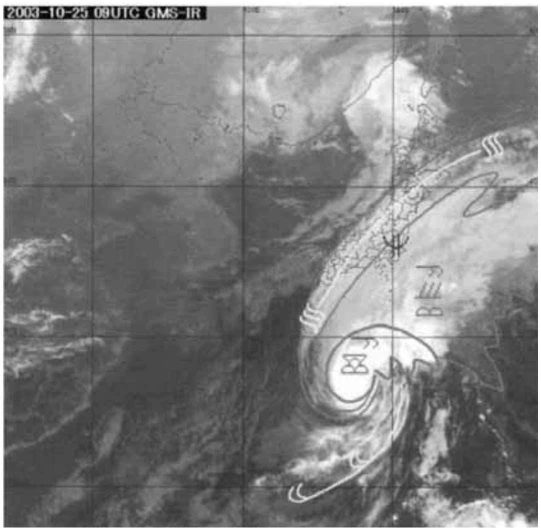


Fig 28: 250600UTC Oct. 2003 surface weather chart

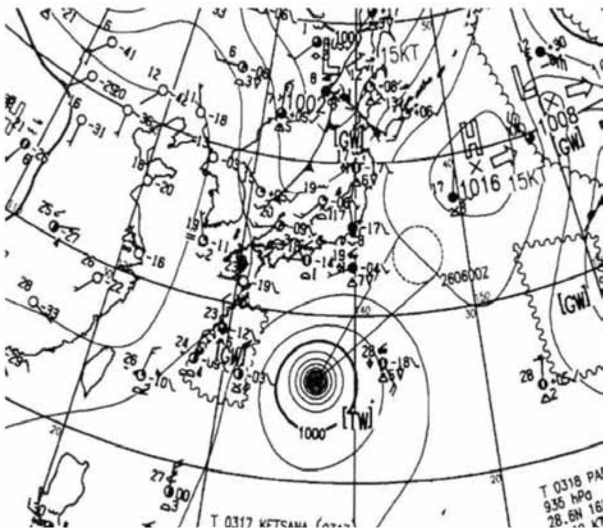


Fig 29 to Fig 31 is an enlarged graph of 0900UTC typhoon surrounding, the position with icing notation. There is cloud area of icing reported near county boundaries, known as middle layer clouds by the infrared brightness of the image. To the northeast region from the Kinki region, is covered with cirrus. Moreover, on the east sea of Japan in typhoon north, the middle clouds are expanding.

To 3.9μm image, the removal of a thin upper cloud, then the middle and lower layer cloud areas become clearer.

In 3.9μm differential image, you can see near the center of the typhoon represent active cumulonimbus clouds dotted black and white mixed zone. Moreover , typhoons in the south and the accompanying thin cirrus clouds upper zone is black areas , from the Noto Peninsula extends to near the island of Sado , Aomori Prefecture Oriental sea . Coverage in the Northeast region is the gray cloud, and thick clouds of a multi-layer structure area .

Fig 29: 250900UTC Oct. 2003 Infrared image

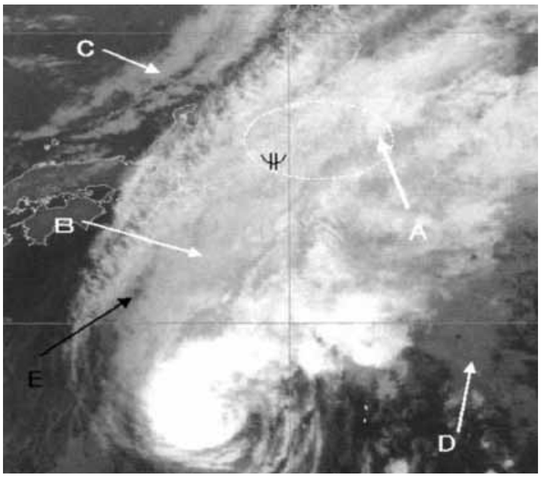


Fig 30: 2509UTC Oct. 2003 3.9μm image

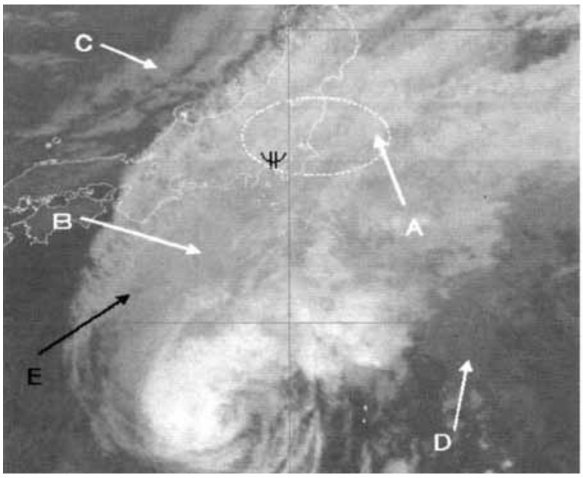


Fig 31: 250900UTC Oct. 2003 3.9μm differential image

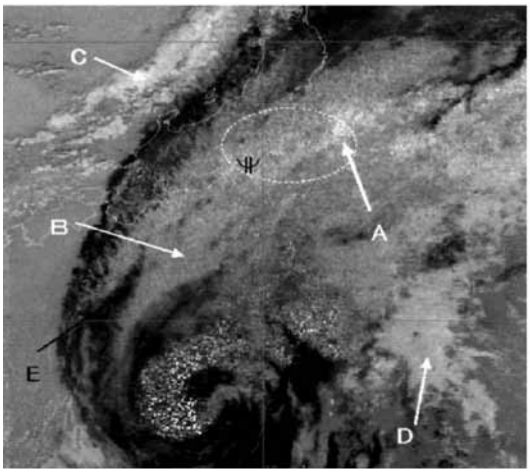
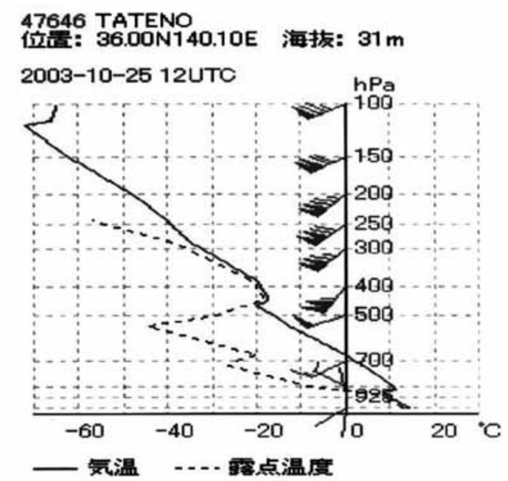


Fig 32: 251200UTC Oct. 2003 Tateno senior live



The icing area (dotted line) in 3.9μm differential image is represented as grey-white and fine dots . Brightness temperature of this area is about -22 ℃. Due to middle layer was supercooling, so presumably with icing occurs.

Moreover, C represents a lower layer cloud zone than a cloud area represented by B, appears as a thin gray slightly. Brightness temperature is 5 ℃ to 8 ℃,so it is a low layer cloud area.

2512UTC the high level data of Tateno information (Fig 32), between the 500 to 400hPa had a stable layer. From this stable layer up to 300hPa became wet. From this situation, the cloud region from the sea of east Japan to Kantou was the middle layer cloud and upper layer cloud as the main body. However , from Tateno upper layer condition can be presumed the temperatures of occurrence icing height FL200 (near 6000m : 500hPa height field about 5700m) to be about -15 ℃.

Summarized:

(1) In this icing case, icing is happening in front of the typhoon and the mid layer and low layer cloud as the main cloud zone. In difference 3.9μm image, stratiform cloud area is represented as a gray.

7. All cases are summarized

Concerning all the icing cases summarized as the following description, but still in the investigation stage. Also, because to take into account the situation at even if a suit condition cloud but not icing occur, so here is reported icing cloud area as a reference, from satellite imagery analysis shows there is such a cloud area characteristics to serve as the main body of the report.

(1)At 3.9μm differential image, nearby the bright white cloud area could occurred icing.

(2)At 3.9μm differential image , the gray clouds area is the middle layer and low layer clouds as the main cloud area. To determine the cloud area is water cloud or ice cloud, it necessary obtained the information of brightness temperature (the standard is-20 ℃) from infrared image.

(3)From the case point of view, the icing report is the icing occurs in stratiform clouds. This situation can be represented as in Fig 2, icing possible occurs in stratiform clouds as the main cloud near the disturbance and the front.

(4)To 3.9μm differential image , the cloud area have two or three layers structure in multi- zone (the structure is high)became very cold and cloud area look like a mix with point noise. However in this investigation of each case , in the two-layer structure which the low layer is the stratiform cloud the situation, see the noise. When the low layer cloud is a convective cloud (Cb and Cg), if clouds district is mixed noise, then need to consider the risk of icing conditions. At the same time must pay attention this situation and refer to the infrared image brightness temperature intelligence. It is necessary to resolve is stratiform cloud or convective cloud.

However, when disturbance is occurs in near the low pressure system or the front surface of the case. During the mixed noise cloud area (convective clouds) is changing color to white cloud area (stratiform), the icing will be occurred.

Stratocumulus (Sc) formed on the oceans in the cold period (October to March), due to the stable layer on the upper layer, so that convective clouds appear to be suppressed situation. Therefore, when the cloud is formation, the vertical displacement of the air block is very large and because the cloud water is also more than stratocumulus, it is necessary to pay attention to.

Memo

IASS 2013我方代表團於頒獎後與董事長在大廳合影

102年航空保安管理訓練班