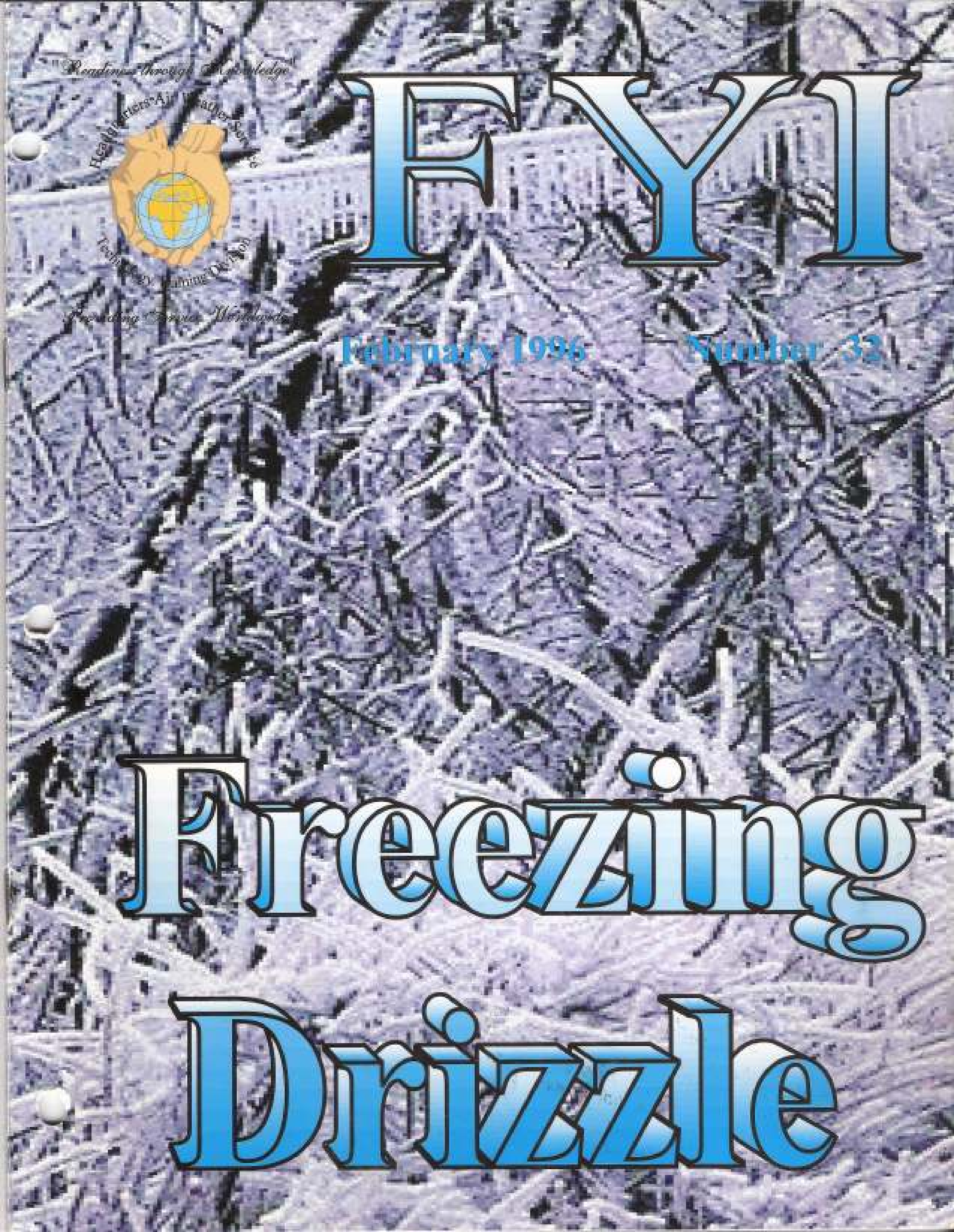

FYI

February 1996 Number 32

Freezing Drizzle

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A TECHNIQUE FOR FORECASTING FREEZING DRIZZLE

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Introduction

In winter, forecasters are often faced with the challenge of predicting the type of cold-weather precipitation. In many situations, all atmospheric variables suggest that snow will occur, yet freezing drizzle falls instead. These are the situations where the forecaster must *look beyond* numerical guidance, nomograms, thickness schemes, and various "rules of thumb" in order to accurately forecast the type of precipitation.

The purpose of this pamphlet is to present situations where you may receive freezing drizzle when snow would otherwise be forecast. We will discuss the importance of cloud properties and relate it to precipitation-type occurrence. A technique for forecasting freezing drizzle when the entire depth of the troposphere is below freezing will be introduced. To incorporate all aspects of forecasting freezing drizzle in this environment, a checklist has been developed for the operational forecaster.

". . . *look beyond* numerical guidance, nomograms, thickness schemes, and various "rules of thumb" in order to accurately forecast the type of precipitation."

Discussion

What types of atmospheric settings are conducive for freezing drizzle?

There are two distinctive types of atmospheric situations where freezing precipitation is known to occur. The first is when you have ice crystals fall through a sufficiently deep warm layer that is greater than 0° C and melt. The water droplets then hit a surface that is at or below freezing (0° C or less) and freeze on contact to form clear ice. This is the most common situation for freezing precipitation, whether it be freezing rain or freezing drizzle. In the second situation, the atmosphere is entirely below freezing, but water droplets remain supercooled and do not freeze until they hit the ground. This second situation, although not as common, is the one we will discuss to help you identify when it may occur.

If the entire depth of the troposphere is below 0° C, freezing drizzle can still occur under the right atmospheric conditions. The presence of supercooled water droplets versus ice crystals in clouds may be the determining factor between forecasting freezing precipitation or snow. When ice crystals and supercooled water droplets are both present in clouds, the ice crystals act as ice nuclei and will grow at the expense of the supercooled water droplets. This process is termed "heterogeneous nucleation." It is most efficient when temperatures are between -10° C and -15° C. If the process is occurring, you will most likely get snow and not freezing drizzle. When ice crystals are not present in clouds and they consist solely of supercooled water droplets, you will most likely experience freezing drizzle.

This process is something that occurs all over the world. Its influence on determining precipitation type has been studied in the upper midwest United States, but the same situations involving freezing rain and snow also occur in the European region and in the Pacific. This technique can be applied to these regions based on the same physical laws of the nucleation process.

How does the nucleation process influence the presence of supercooled water droplets?

In clouds where temperatures ar below 0° C, supercooled water droplets may or may not freeze depending upon whether ice nuclei are present. Experiments have shown that pure water droplets do not freeze until a temperature of -40° C is reached. When ice crystals are present, freezing

Definitions

Heterogeneous Nucleation: When ice crystals and supercooled water droplets are both present in clouds and the ice crystals grow at the expense of the supercooled water droplets.

Nucleation: Any process (condensation, sublimation, freezing) by which molecules of water or ice accumulate as a result of a phase change to a more condensed state.

Supercooled: The reduction of temperature of any liquid below its nominal freezing point.

Saturation Vapor Pressure: The maximum possible vapor pressure in a sample of air at a specific temperature.

Sublimation: Process by which water changes from a solid into a vapor without passing through the liquid phase.

occurs at -10° C to -17° C. Therefore, supercooling of water droplets down to -15° C or colder is not uncommon.

When ice crystals are present with a large number of supercooled water droplets, the cloud is unstable due to the different saturation vapor pressures of water and ice. If the cloud is continually resupplied with ice crystals and the number of supercooled liquid water droplets remain unchanged or decrease, then eventually all liquid water droplets will be removed from the cloud by diffusion onto the ice crystals. The resulting precipitation will ideally become snow, assuming steady state conditions and all layers of the atmosphere are below freezing. Similarly, if the ice crystal supply is cut off, all the ice crystals may precipitate out of the cloud and only supercooled water droplets will remain.

How do I determine if I have ice crystals or supercooled water droplets in my clouds?

Ice crystals usually appear in clouds when the temperature is colder than -15° C, therefore, cloud temperatures can be as low as -15° C and the precipitation may still fall as freezing drizzle.

Frequently, a sounding is examined for an above 0° C layer to determine if freezing rain/drizzle or rain/drizzle is possible. Check the sounding to see if the entire depth of the troposphere is at or below 0° C. Elevated deep dry layers appear to play an important role in precipitation type by cutting off or limiting crystal seeding into the lower moist layers. Look for substantial dry layers (more than 5000 ft) and temperature/dewpoint spreads greater than or equal to 10° C. Dry layer parameters necessary for complete ice crystal sublimation are unknown and will vary with different synoptic environments. These dry layers are important because they appear to limit the nucleation process in the lower moist layers. Remember, there is a possibility of mixed or freezing precipitation when soundings show that the entire depth of the troposphere is below 0° C.

Figures 1 and 2 are examples of atmospheric temperature profiles that produce freezing drizzle or a mixture of light snow and freezing drizzle.

The role of upward vertical motion may also be a factor for determining precipitation type when mid-level dry layers are present. If a low-level moist layer and a mid-level dry layer can be upwardly displaced together due to a lifting mechanism, convection can occur. The convection may erode the dry layer and reestablish/establish ice crystal seeding (ice nucleation) into the lower level moisture. If the entire troposphere is below freezing, then ideally the precipitation will change to all snow.

☑ Synoptic Settings

What are the synoptic-scale environments in which heterogeneous nucleation may determine whether I have freezing drizzle versus snow?

The most frequently observed synoptic scale environments in which heterogeneous nucleation appears to be the primary atmospheric process influencing precipitation type are: (a) the mature cyclone where aggressive "dry slotting" has developed to the west of the cold front, and (b) in arctic air masses where the cold air and moisture fields are shallow.

Mature Cyclone Case: The aggressive mid-level drying results in discontinuous vertical atmospheric saturation or vertical layers of dry air bounded by saturated layers. This dry air partially or completely separates the ice crystal source region (high moist layers) from the lower moist layer. As a result, the ice nucleation process may decrease or even stop in the lower moist layer. If this happens, a mixture of light snow and freezing drizzle (or just freezing drizzle) will result.

The following example (Figures 3-8) is of a mature cyclone case over the lower Great Lakes on

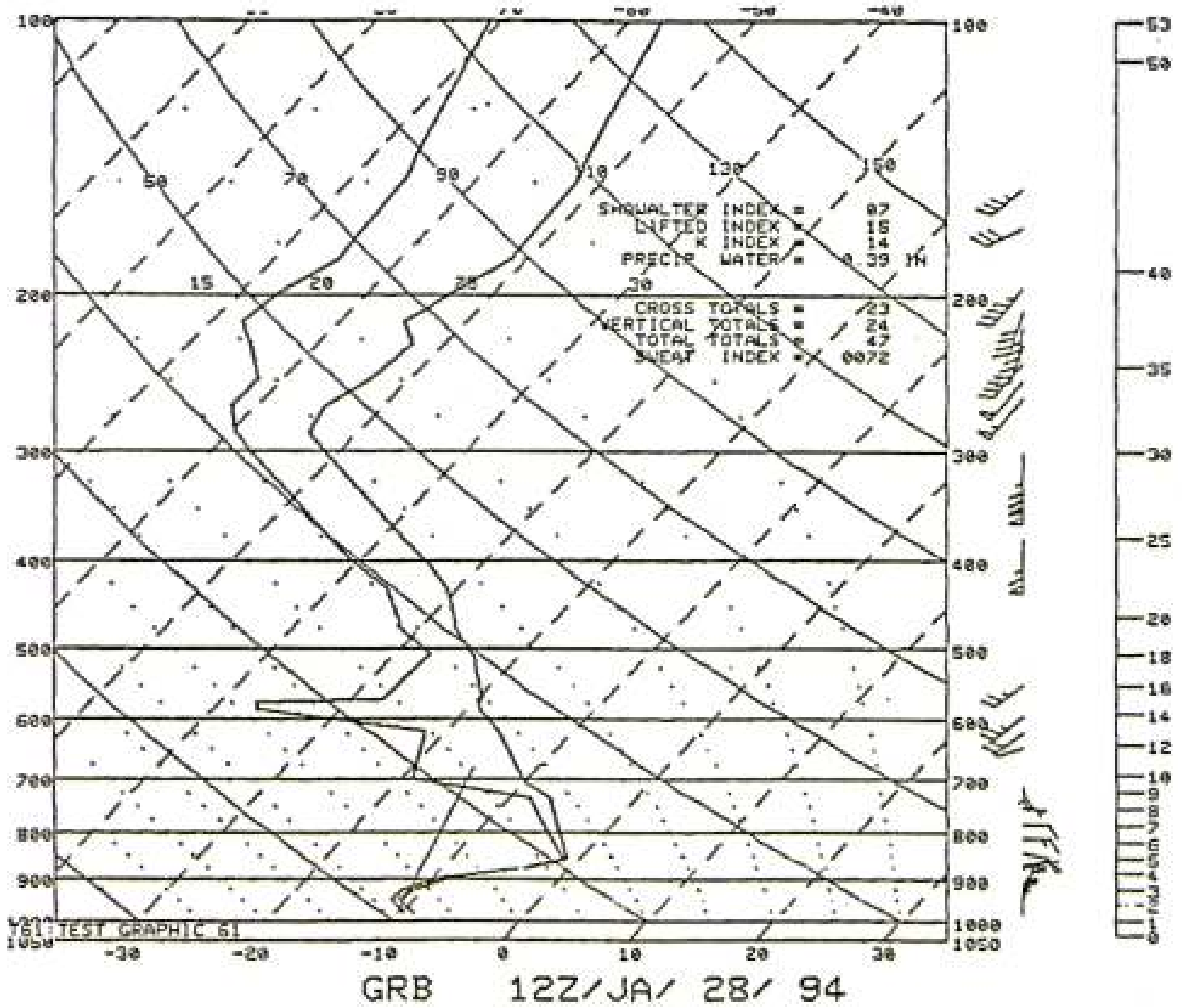

Figure 1. Green Bay sounding from 1200 UTC 28 Jan 94

28 Jan 94. The 1200 UTC Regional Analysis displayed thickness values at or below snow thresholds in the Milwaukee WI area on Figures 3, 6, and 7. Snow thresholds for 1000-500 mb is typically 5400 m, 1300 m for 1000-850 mb, and 1555 m for 850-700 mb. In each case on each chart, the predicted thickness value was below the threshold levels giving an indication that snow was likely to occur. The 700 mb relative humidity had decreased to 50 percent or less by 1200 UTC (not shown) over all of eastern Wisconsin, indicating mid-level drying. Milwaukee WI reported freezing drizzle and light snow until 1420 UTC, although thickness values were decreasing (see Figures 3 and 8). After 1420 UTC, Milwaukee WI reported just snow. It appeared as though mid-level moisture associated with a 500 mb cyclone moved into eastern Wisconsin after 1400 UTC. This reestablished continuous vertical saturation and began ice crystal seeding into the lower level moisture causing the ice crystal nucleation process to begin again at the lower levels. Due to the presence of moisture at the mid levels, the upper-level moisture containing ice crystals and the low-level moisture containing supercooled water droplets were able to mix. The freezing drizzle turned over to snow as ice crystal nucleation began and the supercooled water droplets slowly dissipated.

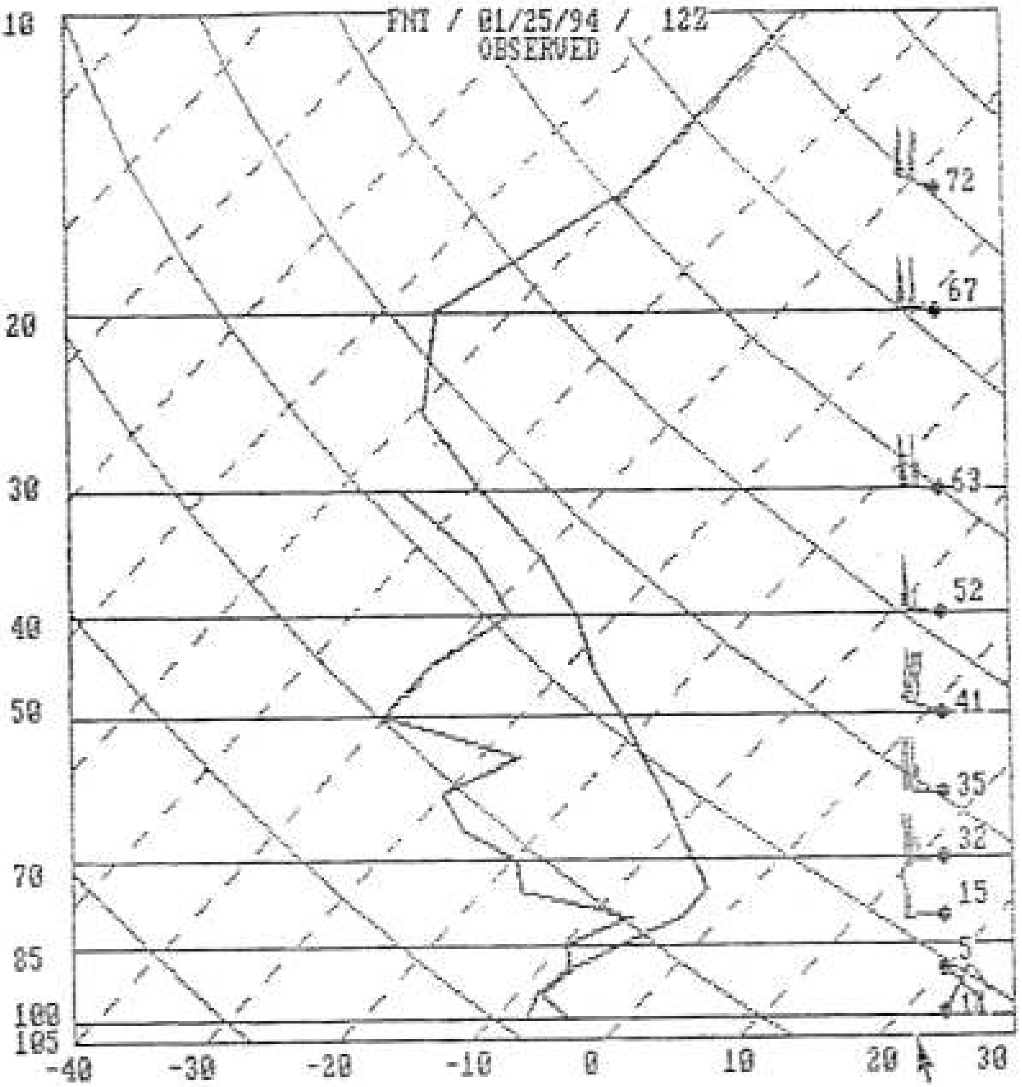

Figure 2. Flint, Michigan sounding for 1200 UTC 25 Jan 94

Arctic Air Mass: The depth of the cold air and moisture associated with arctic air masses appears to play an important role in precipitation type. When the low-level moisture (generally below 800 mb) is in an environment warmer than -15° C (but below 0° C) and bounded by a dry layer above, you should investigate this as a possible freezing precipitation case. Usually the precipitation is very light due to the discontinuous vertical atmosphere saturation. Mid-tropospheric moisture changes may enhance or disrupt ice crystal nucleation in the lower moist layers changing precipitation type.

The following scenario (Figures 9-14) is a shallow arctic air mass case over lower Michigan on 25 Jan 94. The leading edge of arctic air was over the northern Ohio valley and the front was 100 to 150 miles south of southeastern lower Michigan. Southeastern Michigan was well into the arctic air. The arctic air mass was relatively shallow as temperatures on the surface were as cold or colder than the 850 mb temperatures. The moisture was also shallow in the arctic air mass indicated by 20 and 40 percent 700 mb relative humidity over southern Michigan.

As the case before, the thicknesses were well below snow thresholds over all of southern Michigan at 1200 UTC, indicating that snow was likely. See Figures 9, 11, and 12. Several stations in

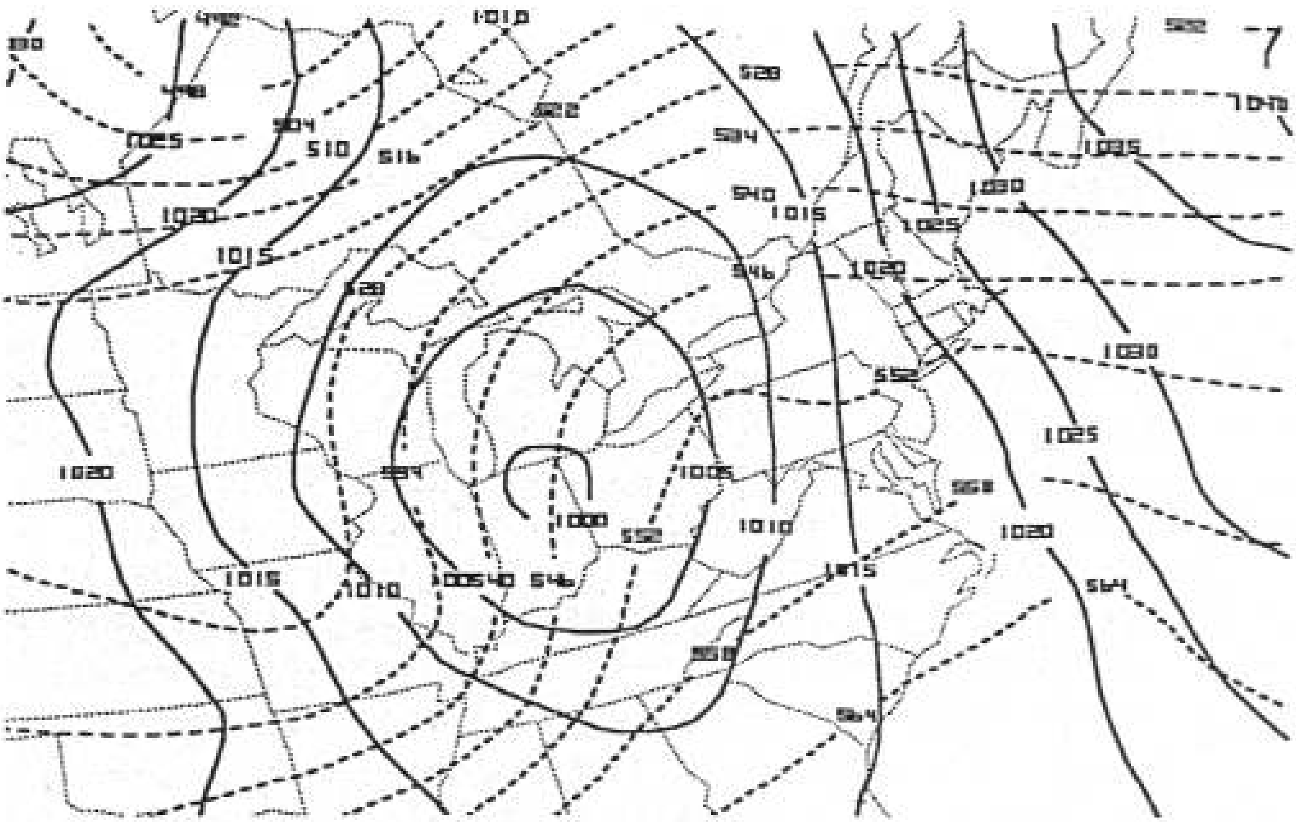

Figure 3. Mean sea-level pressure (mb) and 1000-500-mb thickness (dm) for 1200 UTC 28 Jan 1994 (RAFS 00 analysis)

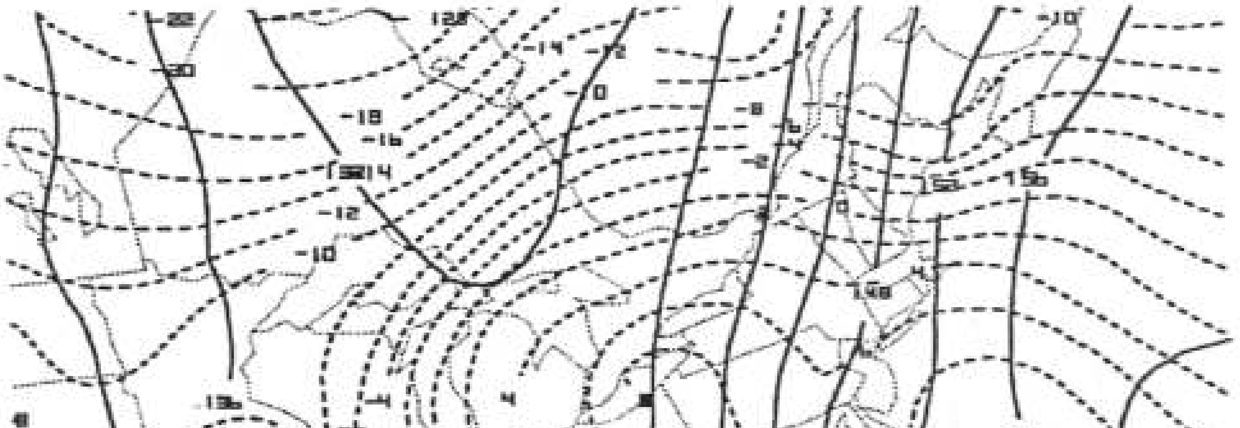

Figure 4. 850-mb heights (dm) and temperatures (C) for 1200 UTC 28 January 1994 (RAFS 00 hour analysis)

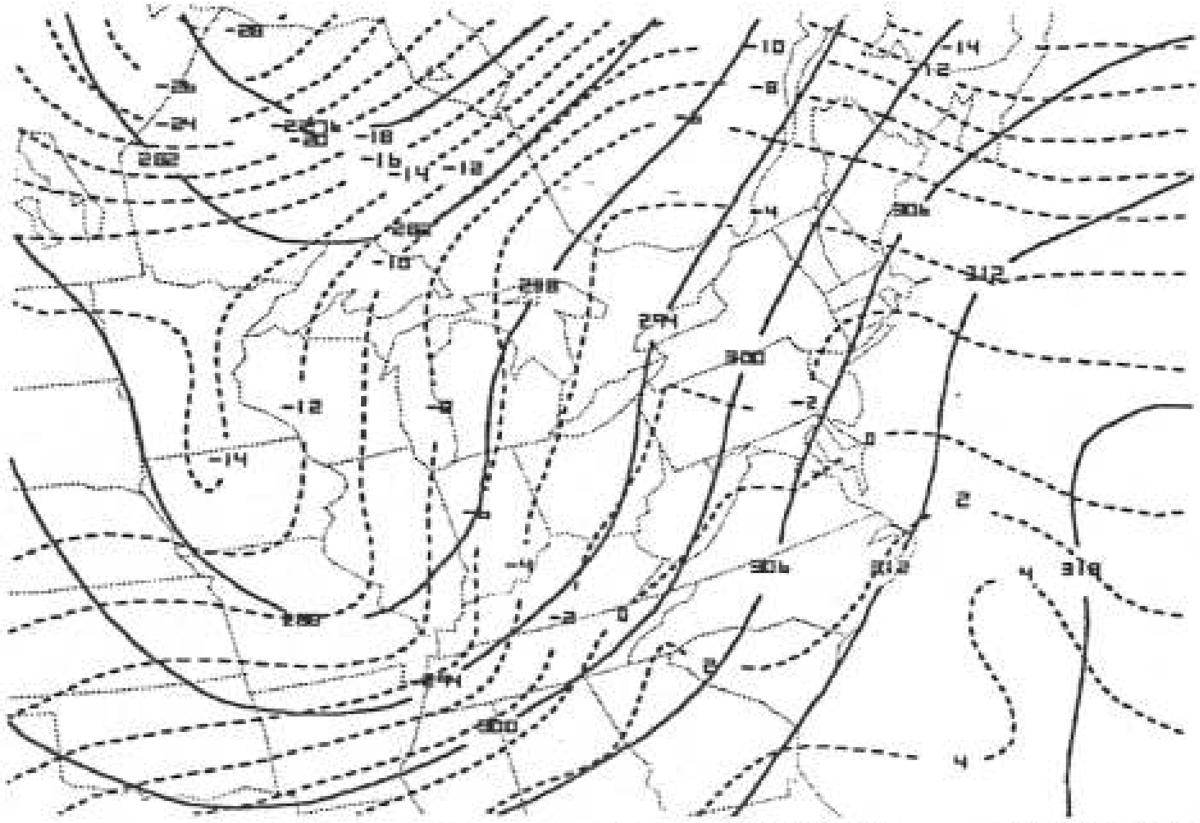

Figure 5. 700 mb heights (dm) and temperatures (c) for 1200 UTC 28 January 1994 (RAFS 00 hour analysis)

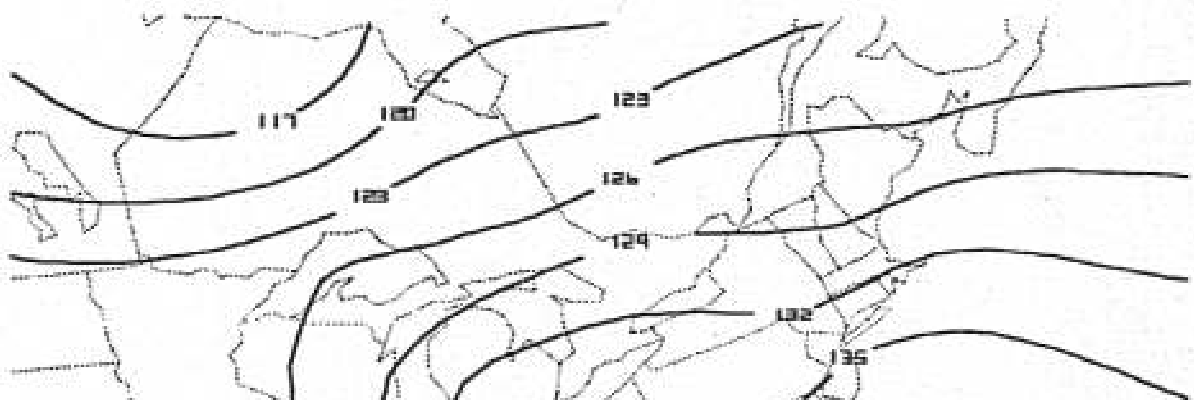

Figure 6. 1000-850-mb thickness (dm) for 1200 UTC 28 January 1994 (RAFS 00 hour analysis)

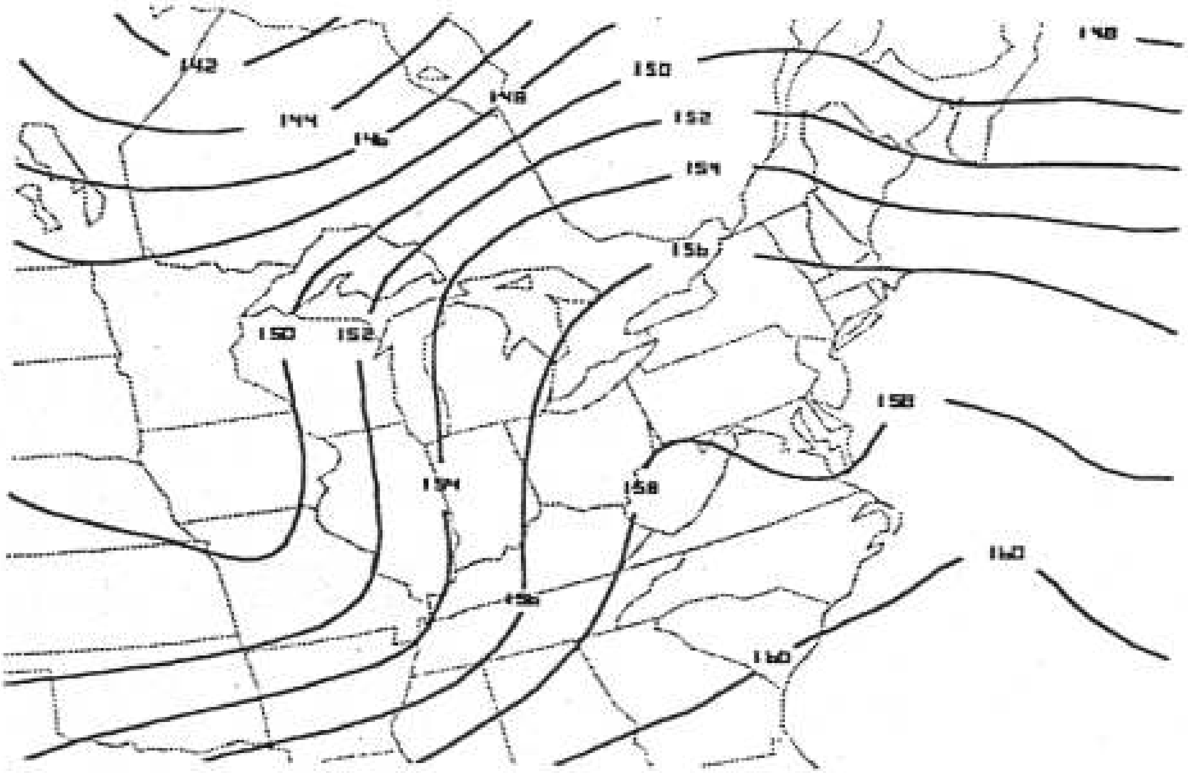

Figure 7. 850-700-mb thickness (dm) for 1200 UTC 28 January 1994 (RAFS 00 hour analysis)

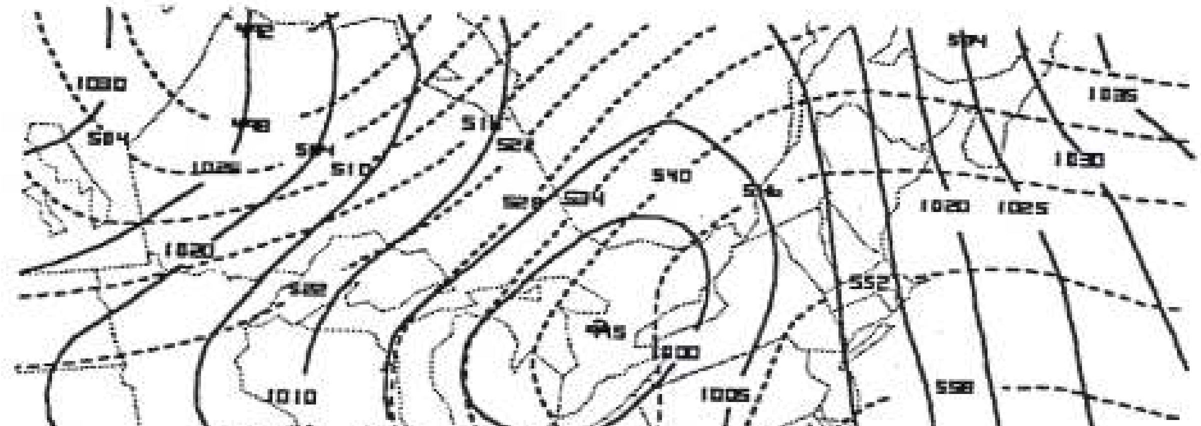

Figure 8. Mean sea-level pressure (mb) and 1000-500mb thickness (dm) for 1800 UTC 28 January 1994 (RAFS 6 hour analysis)

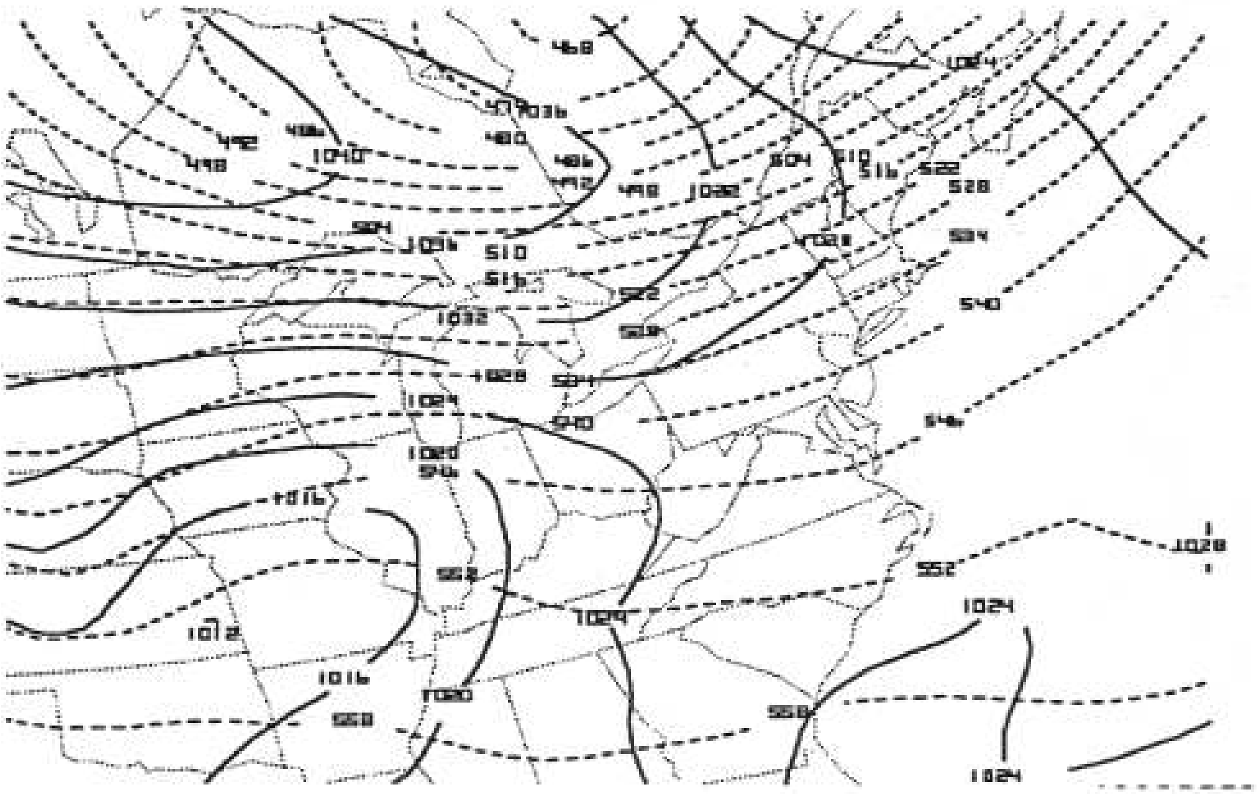

Figure 9. Mean sea-level pressure (mb) and 1000-500 mb thickness (dm) for 1200 UTC 25 January 1994 (RAFS 00 hour analysis)

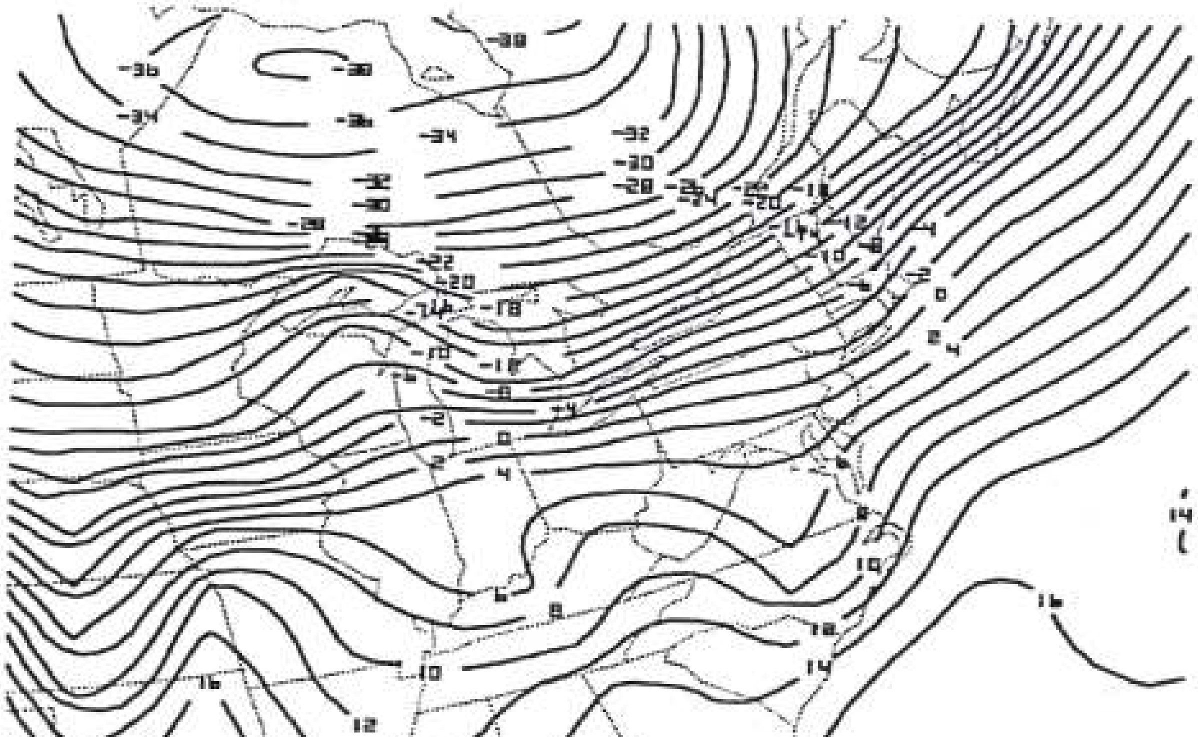

Figure 10. 1000-mb temperatures (c) for 1200 UTC 25 January 1994 (RAFS 00 hour analysis)

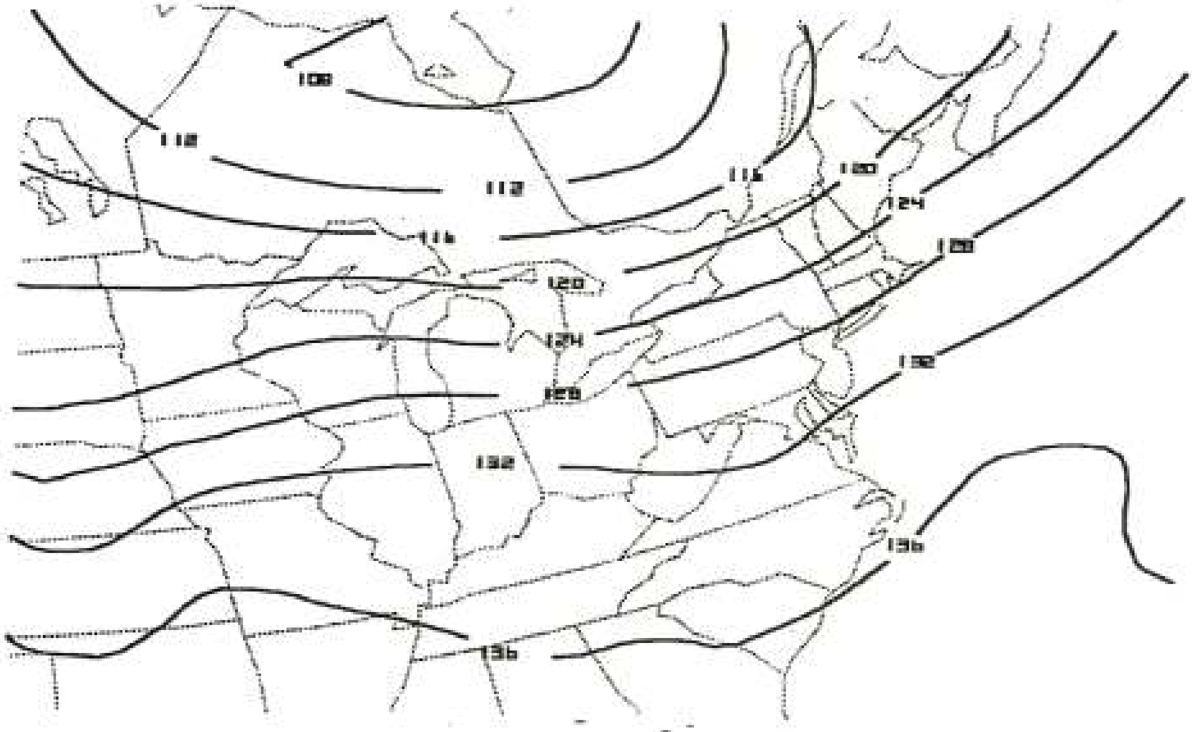

Figure 11. 1000-850-mb thickness (dm) for 1200 UTC 25 January 1994 (RAFS 00 hour analysis)

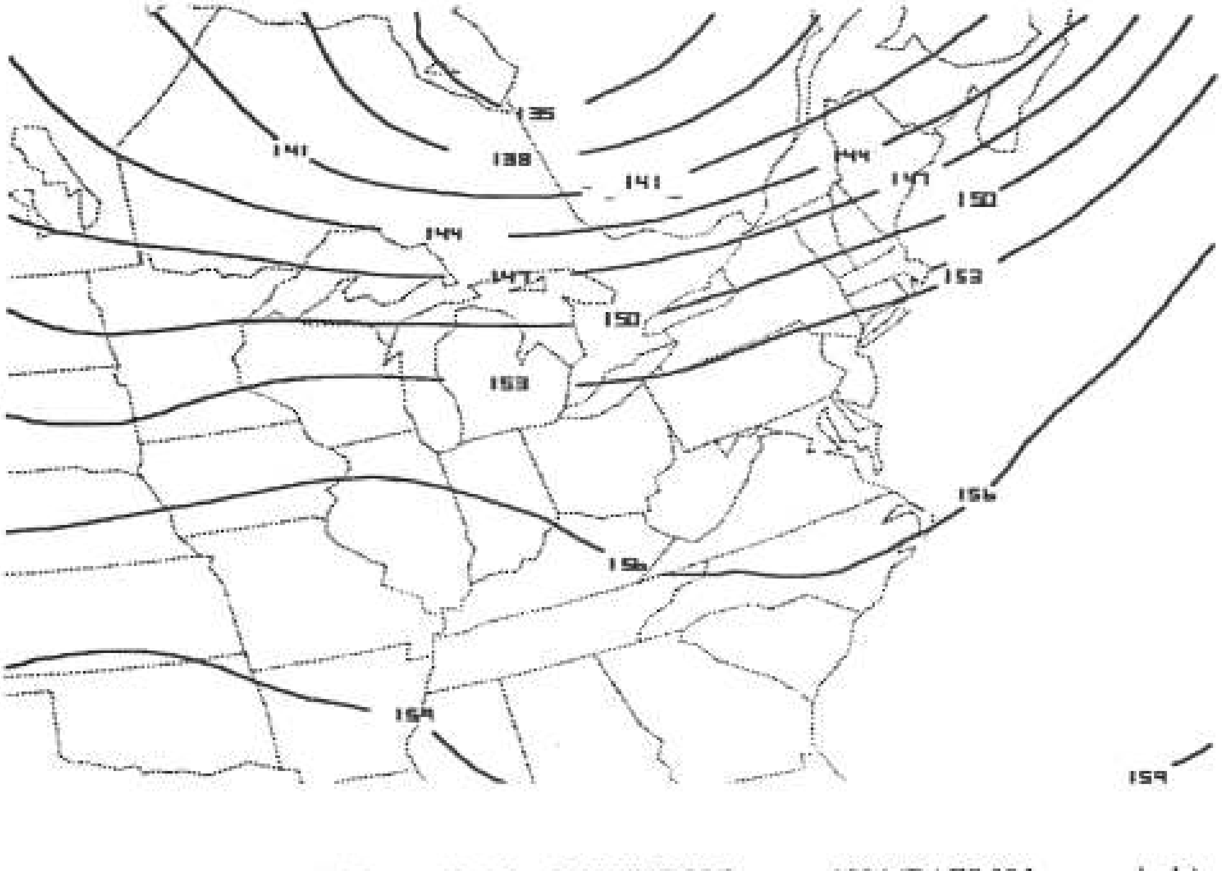

Figure 12. 850-700-mb thickness (dm) for 1200 UTC 25 January 1994 (RAFS 00 hour analysis)

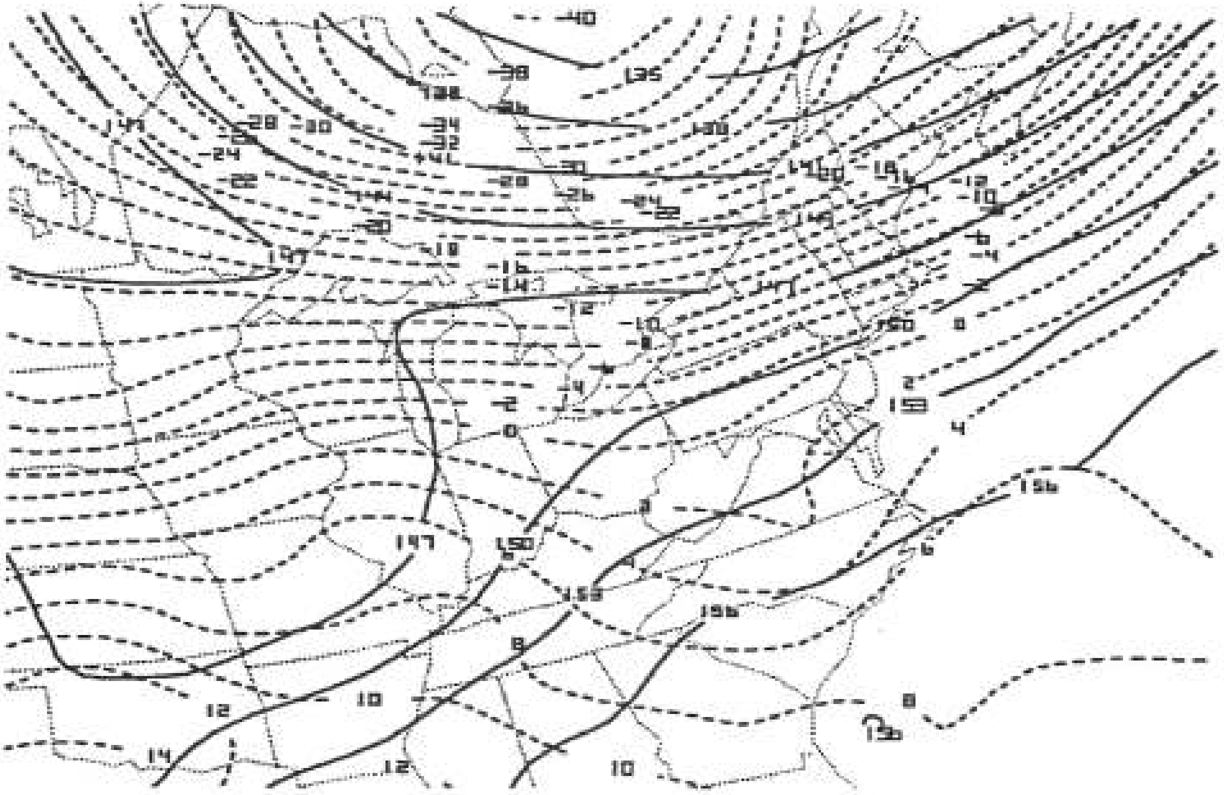

Figure 13. 850-mb heights (dm) and temperature (C) for 1200 UTC 25 January 1994 (RAFS 00 hour analysis)

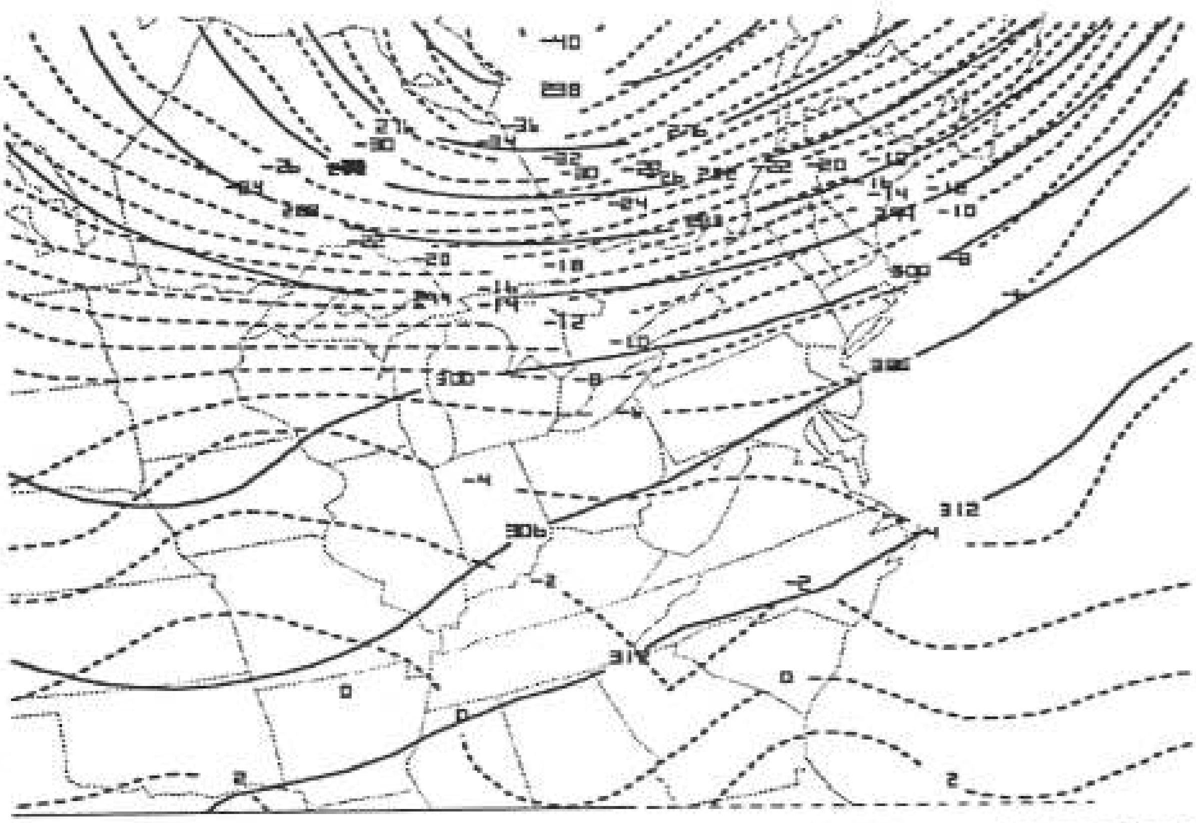

Figure 14. 700mb heights (dm) and temperatures (C) for 1200 UTC, 25 January 1994 (RAFS 00 hour analysis)

southern lower Michigan reported freezing drizzle or a mixture of light snow and freezing drizzle during the morning. Flint MI reported a mixture of snow and freezing drizzle until 1440 UTC. Moisture in the mid-troposphere increased over southern lower Michigan shortly after 1200 UTC (not shown). This increase in mid-level moisture was enough to reinforce ice crystal nucleation in the lower moist layer, and as a result, the precipitation changed all to snow in the Flint MI area after 1440 UTC.

Forecaster Checklist For Freezing Drizzle Vs. Snow

* Note: This checklist is only applicable for below freezing temperatures through the entire depth of the atmosphere.

A. Is a low level moist layer (below 700 mb) between 0° C and -15° C? Yes No

If yes, then freezing drizzle is possible.

B. Is a mid-level dry layer (800-500 mb) present or forecast? Yes No

If yes, freezing drizzle or a mixture of snow and freezing drizzle is possible.

C. Is the mid-level dry layer deeper than 5000 ft and have a dewpoint depression of 10° C or greater? Yes No

If yes, the precipitation may completely change to freezing drizzle or a prolonged period of mixed snow and freezing drizzle is possible.

D. Is mid-level moisture increasing? Yes No

If yes, and freezing drizzle is occurring, the precipitation may change to all snow.

E. Is convection occurring or forecast? Yes No

If yes, the mid-level dry-layer may erode causing snow to fall instead of freezing drizzle.

The concepts in this FYI have been consolidated into a Forecaster Checklist for Freezing Drizzle vs. Snow (located on Page 12).

✓ Conclusion

Understanding the atmospheric environment will greatly enhance your forecast decisions. In an atmosphere where the temperature is entirely below freezing, there *is* a possibility of freezing drizzle. Heterogeneous nucleation is an important concept in understanding what type of precipitation to forecast. The process occurs when you have particles of the same substance that exist in different forms (liquid water, ice crystal). Ice crystal nucleation will act to increase ice crystal growth at the expense of the liquid water droplets. When the nucleation process is kept to a minimum and the clouds remain stable filled with supercooled water droplets, you will likely receive freezing drizzle.

Forecasters should be aware of the possibility for freezing precipitation when a lower tropospheric moist layer is confined to a layer warmer than approximately -15° C, but still below 0° C. Two synoptic environments can result in freezing drizzle due to the prevention or disruption of heterogeneous nucleation:

a. Aggressive "dry slotting" associated with mature cyclones; and,

b. Arctic air masses where cold air and moisture fields are shallow.

Use the forecaster checklist provided to help determine if freezing drizzle is possible when expecting precipitation in an atmosphere completely below freezing.

If you have any questions or comments on this or any other FYI, please feel free to contact your regional representative.

Also, if you have any questions, comments, or suggestions for HQ AWS/XOT in general, you can contact our 24-hour-a-day comment line (e-mail or voicemail) and leave a message.

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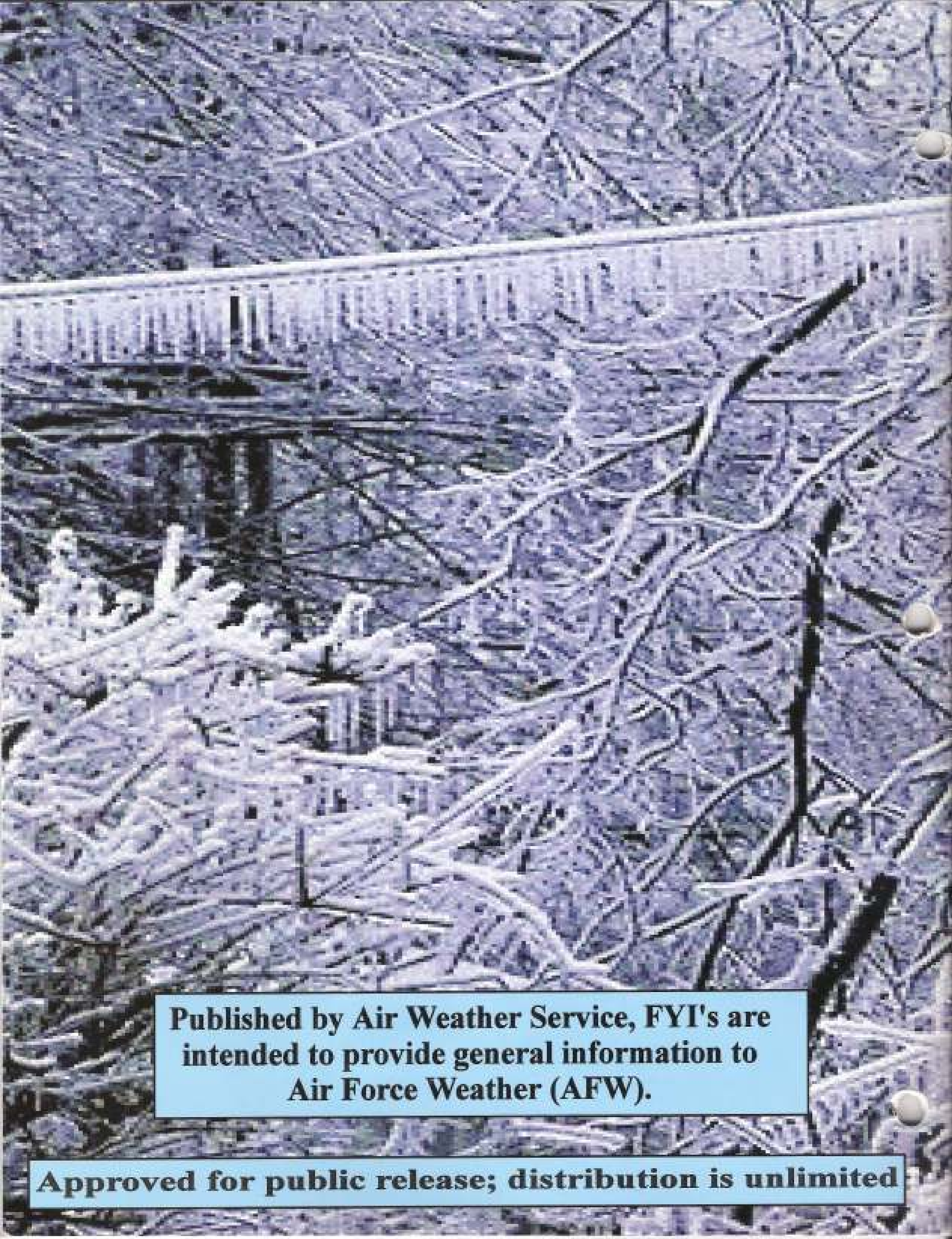

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