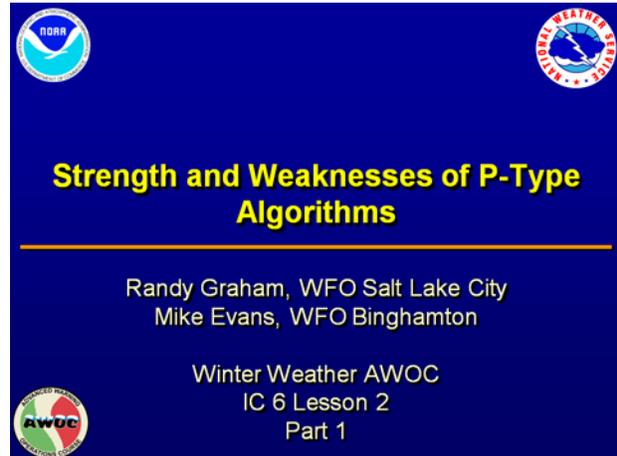

1. Strength and Weaknesses of P-Type Algorithms

Instructor Notes: Welcome to IC 6 lesson 2, Part 1. This lesson is approximately 30 slides long and will take approximately 20 minutes to complete.

Student Notes:



2. Assessing P-Type Algorithms

Instructor Notes: This is the 2nd lesson in IC6 and covers the strengths and weaknesses of several precipitation type algorithms. Part 1 will hit on the Baldwin technique and Ramer technique. This lesson will supply information on a variety of p-type algorithms that are widely utilized in the meteorological community at the present time and will present background material that will help you assess their output. The motivation for this lesson is to enable forecasters to intelligently assess algorithm output in an operational setting and to provide the tools needed to identify each algorithms strengths and weaknesses which should ultimately assist you in the determination of their skill in a given precipitation type forecast. The speaker notes for this lesson will contain additional detail above beyond that which on the slides and may serve as a good reference for review.

Student Notes:

AWOC Winter Weather Track

Assessing P-Type Algorithms

- Intelligently assess P-type algorithm output
- Identify strengths and weaknesses of algorithms
- Assist in p-type forecasting in an operational setting

3. Outline

Instructor Notes: This lesson is divided into five sections. The first section will provide a brief overview of the learning and performance objectives and the need for precipitation type (p-type) algorithms. The next two sections are dedicated to 4 different p-type algorithms beginning with the Baldwin technique and the Ramer technique.

Student Notes:

AWOC Winter Weather Track

Outline

- Section 1: Overview
 - Learning objectives
 - Performance objectives
 - Need for P-type algorithms
- Section 2: Baldwin Technique
- Section 3: Ramer Technique

4. Learning Objectives

Instructor Notes: The goal of this lesson to provide a basic understanding of the primary precipitation type algorithms in use in operational Numerical Weather Prediction and heavily utilized local applications. The learning objectives for this lesson are to simply identify the strengths and weaknesses of various p-type algorithms as well as assess the algorithms primary failure modes.

Student Notes:

AWOC Winter Weather Track

Learning Objectives

- At the end of this presentation you will be able to:
 1. Identify strengths and weaknesses of each p-type algorithm
 2. Assess algorithm failure modes

5. Performance Objectives

Instructor Notes: The ultimate success of the lesson driven by impacting performance in an operational setting. The performance objectives for this lesson are: To be able to assess the validity of algorithm output in different situations; To be able to assess potential algorithm failures in an operational setting; and To be able to compare algorithm output with an understanding of the algorithm structure as well as their strengths and weaknesses.

Student Notes:

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Performance Objectives

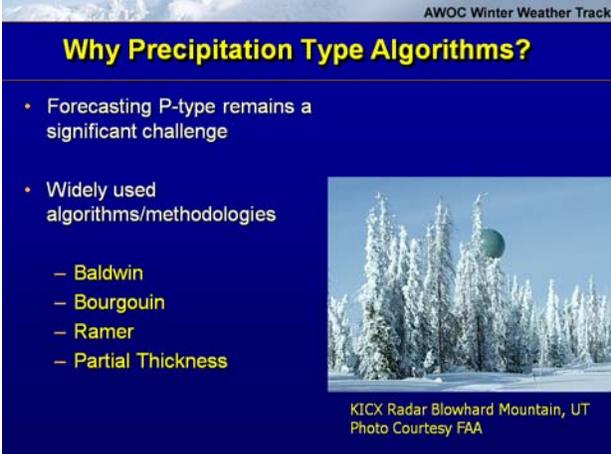
- From this instruction, you should be able to
 - Assess the validity of various algorithms in different forecast situations
 - Anticipate potential algorithm failures in an operational setting
 - Compare algorithm output with an understanding of each algorithms strengths and weaknesses

6. Why Precipitation Type Algorithms?

Instructor Notes: Forecasting precipitation type continues to present a significant challenge to forecasters across much of the United States during the cold season. Over the years a variety of precipitation type algorithms have been developed in an effort to address this forecast challenge. The methodologies encapsulated in these algorithms have different assumptions and can behave quite differently when given the same vertical profile. The observed precipitation type will depend a variety of atmospheric inputs including the vertical profiles of temperature and moisture, the distribution of vertical

motion, and the type of cloud and ice nuclei present. This lesson will provide basic information on the logic utilized in a variety of precipitation type algorithms. The lesson (broken into 2 parts) will focus on the Baldwin Technique, the Bourgoquin Method, the Ramer Technique, and the Partial Thickness approach. The lesson will identify the strengths and weaknesses of each precipitation type algorithm. Due to time constraints we will not cover every possible p-type determination for each method, but instead will discuss the philosophy of each method and cover some of the primary considerations that they utilize to assess p-type as well as things to watch for when utilizing these algorithms. One thing to consider as we go through the presentation is the idea of utilizing an ensemble approach by comparing the output of the different algorithms. Some have found this to be a successful approach in which the output from several algorithms can expose the bias of a single algorithm. As each algorithm or methodology has its own strengths and weaknesses an ensemble of the algorithms may yield the best answer in many cases.

Student Notes:



AWOC Winter Weather Track

Why Precipitation Type Algorithms?

- Forecasting P-type remains a significant challenge
- Widely used algorithms/methodologies
 - Baldwin
 - Bourgoquin
 - Ramer
 - Partial Thickness

KICX Radar Blowhard Mountain, UT
Photo Courtesy FAA

7. Dominant P-type Ensemble

Instructor Notes: With the ensemble approach in mind I briefly wanted to mention the dominant p-type ensemble which I will reference several times in both part 1 and part 2 of this lesson. The dominant p-type ensemble looks at the output from a variety of p-type algorithms, most of which are covered in this lesson, to determine a dominant precipitation type. This approach is utilized for the WRF output available in both AWIPS and Bufrkit as well as the GFS output available in AWIPS. The WRF dominant p-type approach utilized 5 schemes including the Baldwin (sometimes referred to as the NCEP scheme), the revised Baldwin (sometimes referred to as the revised NCEP scheme), Bourgoquin, Ramer, and the Ferrier microphysics scheme utilized in the WRF. The GFS dominant p-type approach utilizes 4 schemes including the Baldwin, Revised Baldwin, Bourgoquin, and Ramer. The GFS does not utilize the Ferrier scheme in its microphysics package, therefore so it is not part of its dominant p-type ensemble. If there are ties in either the GFS or WRF dominant p-type ensemble the most dangerous precipitation type in the tie is selected with freezing rain given the highest priority followed by snow then ice pellets and finally rain.

Student Notes:

AWOC Winter Weather Track

Dominant P-type Ensemble

- Looks at output from a variety of algorithms to identify 'dominant' p-type
- Utilized for the WRF P-type in AWIPS and Bufrkit as well as the GFS for AWIPS
- WRF utilizes 5 schemes – Baldwin (NCEP), Revised Baldwin (Revised NCEP), Bourgouin, Ramer, Ferrier Microphysics
- GFS utilizes 4 schemes - Baldwin, Revised Baldwin, Bourgouin, Ramer
- Ties are broken by selecting the 'most dangerous' p-type in the tie
– ZR > SN > IP > RA



Snow in Washington County Utah – Spring 2007

8. What is the Baldwin Technique?

Instructor Notes: The technique was developed in the mid-1990s. The method was tuned by utilizing vertical profiles supplied from the ETA model with hourly precipitation reports at 259 sites across North America. The Baldwin method is applied during post-processing of model data. In other words, it is not direct model output, but rather, is a technique applied to a vertical profile produced by a numerical model. Output from the Baldwin technique is available on the EMC website shown here. On this EMC website the output is referred to as the 'NCEP algorithm'. Output from the Baldwin scheme is also utilized as part of a dominant p-type ensemble for both the WRF and GFS in AWIPS and the WRF BUFR data available in Bufrkit.

Student Notes:

AWOC Winter Weather Track

What is the Baldwin Technique?

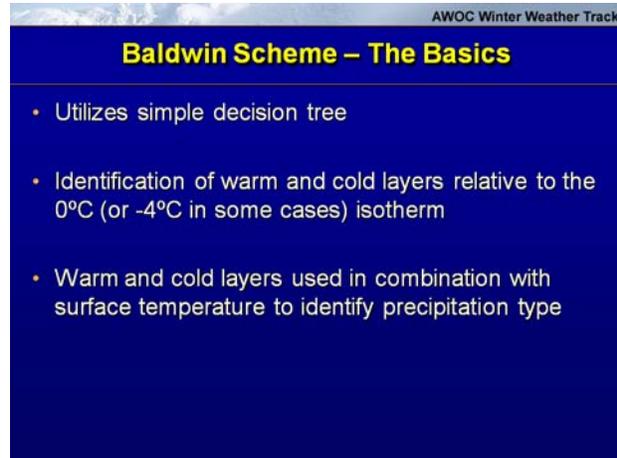
- Compared hourly p-type output from algorithm with hourly precipitation obs (Baldwin 1994)
- Applied during post-processing of the model.
- Not related to microphysics package in NAM.
- Available on the EMC website as 'NCEP' (www.emc.ncep.noaa.gov/mmb/precip_type/) and part of the dominant p-type ensemble for the WRF and GFS in AWIPS and the WRF in Bufrkit.

9. Baldwin Scheme – The Basics

Instructor Notes: The Baldwin scheme utilizes a simple decision tree in its determination of P-type. The method utilizes variables, such as ambient and wet-bulb temperatures at the surface and aloft, which play a significant role in hydrometeor initiation and melting and freezing. Warm and cold layers are identified by calculating areas bounded

by the 0 degree C or -4 degree C isotherm and the sounding wet-bulb temperature. We will go through some examples as to how these layers are calculated shortly. These warm and cold layers are calculated individually and then used in combination with the surface temperatures to identify the precipitation type.

Student Notes:



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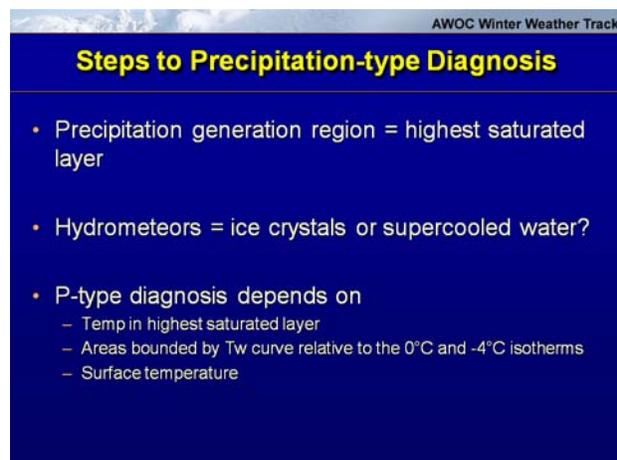
Baldwin Scheme – The Basics

- Utilizes simple decision tree
- Identification of warm and cold layers relative to the 0°C (or -4°C in some cases) isotherm
- Warm and cold layers used in combination with surface temperature to identify precipitation type

10. Steps to Precipitation-type Diagnosis

Instructor Notes: The Baldwin scheme first identifies the highest saturated layer, where saturation is defined as a dewpoint depression of 6 degree C or less. The scheme then considers this layer the 'precipitation generation layer'. Then the algorithm determines the initial state of these hydrometeors. If the temperature in this saturated layer is less than -4 degrees C it is assumed that the hydrometeors initiate as ice crystals. With temperatures warmer than -4 degrees C it is assumed that the precipitation initiates as supercooled water droplets. Ultimately, the precipitation diagnosis relies on the coldest temperature in a saturated layer, which determines if the hydrometeors initiate as ice or supercooled water, the magnitude of areas bounded by the sounding Tw curve relative to the 0 degree C and -4 degree C isotherms, and finally the surface temperature.

Student Notes:



AWOC Winter Weather Track

Steps to Precipitation-type Diagnosis

- Precipitation generation region = highest saturated layer
- Hydrometeors = ice crystals or supercooled water?
- P-type diagnosis depends on
 - Temp in highest saturated layer
 - Areas bounded by Tw curve relative to the 0°C and -4°C isotherms
 - Surface temperature

11. The Concept of Degree Meters

Instructor Notes: When assessing warm and cold layers in a sounding the Baldwin scheme utilizes the concept of degree meters to assess the strength of the layer being examined. This is an important concept with respect to understanding how the Baldwin method determines precipitation type. The degree meters for a given area are calculated by simply taking the depth of the layer and multiplying this by the average wet-bulb temperature within this layer. Note that it is not the highest or lowest wet-bulb temperature in the layer, but rather the average wet-bulb temperature. Also be aware that the reference wet bulb temperature is not always 0 degrees C, in some checks within the Baldwin scheme the warm and cold layers are calculated with respect to the -4 degree C isotherm. As an example of how the degree meters are calculated let's look at the diagram to the left. The vertical line is the reference wet-bulb temperature whether that be 0 degrees C or -4 degrees C. To calculate the warm nose to the right of the reference temperature we will take the depth, which in this case is 1500 m, and multiply it by the average wet-bulb temperature in the layer, which in this case is +2 degrees C, which ultimately yields 3000 degree meters.

Student Notes:

AWOC Winter Weather Track

The Concept of Degree Meters

Degree Meters Concept

Reference wet bulb temperature
(-4°C/39°F or 0°C)

- Utilizes degree meters (deg m)
- Layer depth * Ave. wet bulb temp
- Calculated by determining the depth of the layer in question (> 0°C or < 0°C...in some cases > -4°C or < -4°C)

12. Baldwin Scheme Logic

Instructor Notes: The decision tree to the left is the core of the Baldwin scheme. As we discussed previously the first check that it completes is to determine whether or not the coldest temperature in a saturated layer is warmer than -4 degrees C. If it is warmer than -4 degrees C the hydrometeors are assumed to initiate as supercooled water and if it is colder than -4 degrees C the hydrometeors are assumed to initiate as ice crystals. If the coldest temperature in a saturated layer is warmer than -4 degrees C it then checks to determine if the temperature in the lowest model layer is less than 0 degrees C in which case it forecasts freezing rain. Conversely, if the lowest layer temperature is greater than 0 degrees C then it outputs a p-type of rain.

Student Notes:

AWOC Winter Weather Track

Baldwin Scheme Logic

The flowchart starts with a decision box: 'Coldest T in a saturated layer > -4°C/268K?'. A 'YES' path leads to a 'Lowest layer T < 0°C' box, which then leads to 'Freezing Rain'. A 'NO' path leads to 'Area of Tw above -4°C/268K < 3000 deg m?'. From there, a 'YES' path leads to 'Snow' and a 'NO' path leads to 'Area of Tw warmer than -4°C < 3000 deg m?'. This final box has a 'YES' path leading to 'Freezing Rain' and a 'NO' path leading to 'Rain'.

- If coldest T in a saturated layer is warmer than -4°C, supercooled water
- If the lowest layer T is < 0°C, it produces freezing rain
- If the lowest layer T is > 0°C, it produces rain

13. Baldwin Scheme Logic

Instructor Notes: Now let's step through the decision tree for a case in which the coldest temperature in a saturated layer is less than -4 degrees C. Once it has assumed that ice crystals are present the algorithm calculates the degree meters relative to the -4 degrees C isotherm. If the area between the -4 degrees C isotherm and the wet-bulb temperature profile in the sounding is less than 3000 deg m the Baldwin scheme will indicate snow. If there are more than 3000 deg m of area between the -4 degrees C isotherm and the Tw profile in the sounding then the algorithm assumes melting of the ice crystals and it then steps down the flowchart to determine if the precipitation type will be ice pellets, freezing rain, or rain.

Student Notes:

AWOC Winter Weather Track

Baldwin Scheme Logic

The flowchart starts with a decision box: 'Coldest T in a saturated layer > -4°C/268K?'. A 'NO' path leads to 'Area of Tw above -4°C/268K < 3000 deg m?'. From there, a 'YES' path leads to 'Snow' and a 'NO' path leads to 'Area of Tw warmer than -4°C < 3000 deg m?'. This final box has a 'YES' path leading to 'Freezing Rain' and a 'NO' path leading to 'Rain'.

- Coldest T in a saturated layer < -4°C
- AND
- Area of Tw warmer than -4°C < 3000 deg m, then P-type = snow

14. Baldwin Method Failure Mode

Instructor Notes: One problem with this technique has to do with the check determining if the area between the -4 degree C isotherm and the sounding wet-bulb temperature curve is less than 3000 deg m. If there are more than 3000 deg m between the -4 degree C isotherm and the wet-bulb temperature profile the algorithm assumes that the ice crystals

tals have melted and it then moves on to check if the hydrometeors re-freeze into ice pellets or if they fall to the surface as rain or freezing rain. Thus the scheme can forecast freezing rain from a sounding that clearly supports heterogeneous nucleation and is entirely below freezing. Correspondingly, the algorithm may forecast liquid precipitation for a snow event in which the sounding clearly supports heterogeneous nucleation and has only a very shallow layer above freezing. The key is to watch for near surface deep isothermal layers between 0 degrees C and -4 degrees C. This is something to be cognizant of when assessing output from the Baldwin scheme. Failures such as this are quickly identified utilizing the top-down method. Let's go through an example which should better illustrate this issue.

Student Notes:

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Baldwin Method Failure Mode

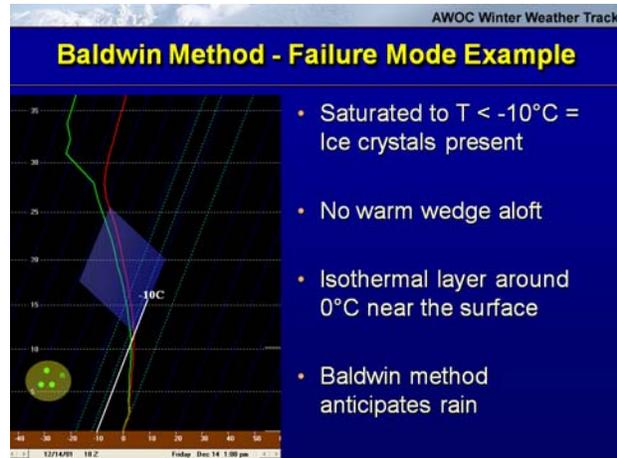
- Problem with logic of the $T_w > -4^\circ\text{C}$ area < 3000 deg m
- Can improperly diagnose liquid or freezing precipitation for snow events
- Watch for deep isothermal layers between 0°C and -4°C near the surface.
 - Apply top down methodology



15. Baldwin Method - Failure Mode Example

Instructor Notes: Let's take a look at a case where the Baldwin scheme's failure mode with respect to deep isothermal layers is exposed. Following a top-down methodology we can assume that there is ice in the cloud as it is clearly saturated at temperatures colder than -10 degrees C which is supportive of heterogeneous nucleation and the development of ice crystals. In other words, ice would clearly be present in this cloud layer. As we follow a crystal down from the saturated layer aloft we see that do not encounter a warm nose to melt the crystal. The last several thousand feet of the sounding exhibits a near isothermal layer around 0 degrees C. If this vertical temperature and moisture profile was accurate the ice crystal clearly would not melt as it descends. However, the Baldwin scheme outputs a P-type of rain in this case.

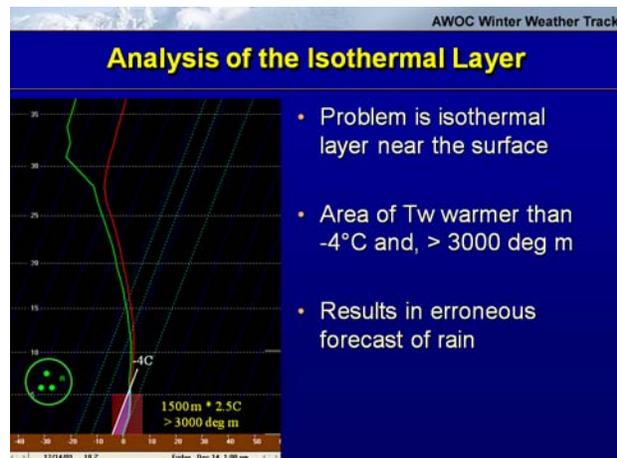
Student Notes:



16. Analysis of the Isothermal Layer

Instructor Notes: Taking a closer look at the logic utilized in the Baldwin algorithm we will see that the culprit in the failure is the deep isothermal layer near the surface. In blue I have outlined the wet-bulb temperature profile. When we overlay the -4 degree C isotherm we see that there is a pretty good size area swept out between these two lines. The area between these two lines is certainly greater than 3000 deg m . This deep isothermal results in the check on the degree meters between the wet-bulb temperature profile and the -4 degree C isotherm failing and as a result the algorithm incorrectly anticipates rain in this case. In this particular event forecasters were looking at the algorithm output leading up to the event and the output from the Baldwin scheme raised some questions about the resultant precipitation type anticipated by the algorithm. The forecasters working the event correctly anticipated that the precipitation would fall as snow in what turned out to be an advisory level event.

Student Notes:



17. Baldwin Technique: Strengths and Weaknesses

Instructor Notes: The strengths of the Baldwin technique begin with easy application and widespread availability. The algorithm is easy to understand which makes interpretation more straightforward. The algorithm also employs a check for the initial phase of the hydrometeor. Another strength is that the algorithm utilizes the wet-bulb temperature in some of its checks to determine precipitation type. This is a more robust methodology than simply utilizing the temperature. The Baldwin method also has several weaknesses. The primary failure is that it will forecast liquid or freezing precipitation when the sounding contains a deep near surface isothermal layer in which the wet-bulb temperature is between 0 degrees C and -4 degrees C. It may forecast liquid or freezing precipitation even if ice is introduced into this layer and the temperature in the profile is never greater than 0 degrees C. Fortunately, once we are aware of this weakness it is easy to identify. A related weakness for the Baldwin scheme is that it tends to overforecast the occurrence of freezing rain and ice pellets. Another weakness in this approach is that it ignores dry layers. So, while it does utilize the wet-bulb temperature it does not account for the impact of a dry layer. For example, as hydrometeors fall through a warm dry layer the hydrometeors will initially be impacted by ambient air temperature in this layer and as the temperature cools to the wet-bulb temperature we may see a change in the precipitation-type and the algorithm does not account for this process.

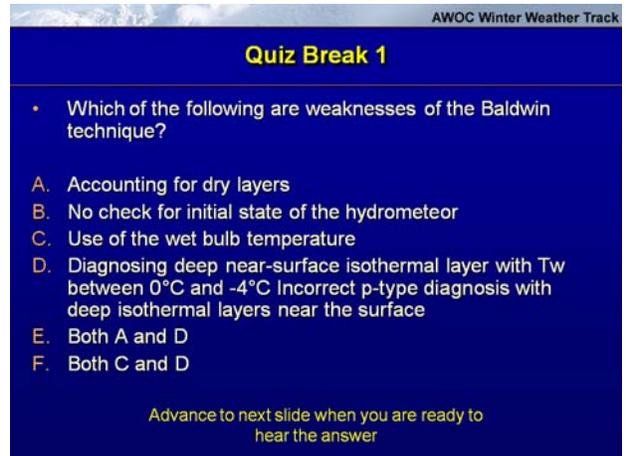
Student Notes:

AWOC Winter Weather Track	
Baldwin Technique: Strengths and Weaknesses	
<u>Strengths</u>	<u>Weaknesses</u>
<ul style="list-style-type: none"> • Easily applied and readily available • Initial check for ice versus liquid • Utilizes wet-bulb temperature 	<ul style="list-style-type: none"> • Liquid or freezing precipitation forecast with deep isothermal layer near the surface with T_w between 0°C and -4°C • Tends to over forecast occurrence of freezing rain • Ignores dry layers

18. Quiz Break 1

Instructor Notes: Given the material that we have covered which of the following are weaknesses of the Baldwin technique?

Student Notes:



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Quiz Break 1

- Which of the following are weaknesses of the Baldwin technique?

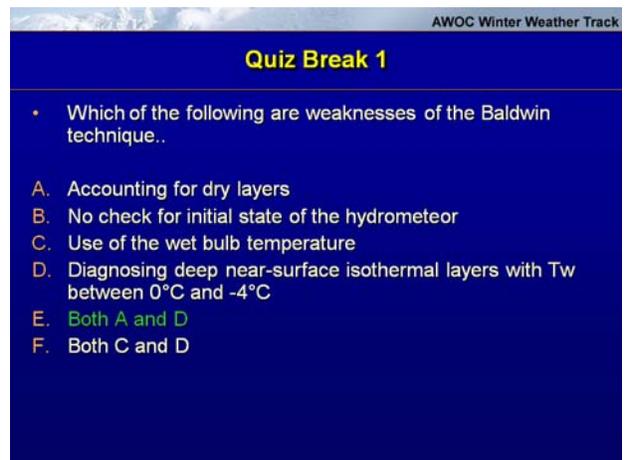
- A. Accounting for dry layers
- B. No check for initial state of the hydrometeor
- C. Use of the wet bulb temperature
- D. Diagnosing deep near-surface isothermal layer with Tw between 0°C and -4°C Incorrect p-type diagnosis with deep isothermal layers near the surface
- E. Both A and D
- F. Both C and D

Advance to next slide when you are ready to hear the answer

19. Quiz Break 1

Instructor Notes: The correct answer is E. The Baldwin technique has a weakness with respect to diagnosing deep near-surface isothermal layers with Tw between 0 degrees C and -4 degrees C. The technique will frequently generate an incorrect precipitation type in these scenarios. The technique also has a weakness in that it does not account for dry layers. So the correct answer is E.

Student Notes:



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Quiz Break 1

- Which of the following are weaknesses of the Baldwin technique..

- A. Accounting for dry layers
- B. No check for initial state of the hydrometeor
- C. Use of the wet bulb temperature
- D. Diagnosing deep near-surface isothermal layers with Tw between 0°C and -4°C
- E. Both A and D
- F. Both C and D

20. What About the Ramer Method?

Instructor Notes: The Ramer method was developed in the early 1990s. From a data set of over twelve thousand soundings the algorithm was tuned utilizing over 2000 cases in which the upper air sounding and a surface observation (located within 30 km of sounding site) were both detecting precipitation (Ramer 1993). The technique utilizes temperature, relative humidity, and the wet-bulb temperature at different pressure levels as input. These parameters are utilized to identify layers where precipitation is likely to be generated and also to control what is referred to as the 'ice fraction' which determines the resultant precipitation type. Essentially the technique follows an idealized precipita-

tion parcel down to the ground from a 'precipitation generating level' (which will be discussed shortly) anticipating the state of the hydrometeor as it descends based on the temperature, relative humidity, and wet-bulb temperature at various levels. The Ramer output is available for the GFS BUFR output in Bufkit and on the EMC website highlighted earlier in this presentation. The Ramer Method is also utilized as part of the NAM-WRF and GFS dominant precipitation type ensembles.

Student Notes:

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What About the Ramer Method?

- Designed utilizing over 2000 precipitation reports collocated with upper air soundings (Ramer 1993)
- Utilizes T, RH, and Tw at different pressure levels as input.
- Follows an idealized precipitation parcel down to the ground from a 'precipitation generating level'.
- Available on EMC website and GFS BUFR data in Bufkit. GFS and WRF dominant precipitation-type ensemble.



21. Preliminary P-Type Checks

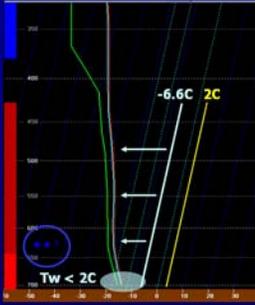
Instructor Notes: Before the Ramer method does a full calculation of the ice fraction two preliminary checks are complete. The first check is simply whether or not the wet-bulb temperature at the surface is > 2 degrees C. If this is the case then rain is diagnosed. This check was put in place in that none of the cases in their data set had a p-type other than rain when the surface Tw was > 2 degrees C. The second check determines if the surface temperature is less than 2 degrees C and the remainder of the vertical profile is < -6.6 degrees C then snow is diagnosed. If neither of these checks passes then a full calculation of the ice fraction of the precipitation particles is undertaken.

Student Notes:

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Preliminary P-Type Checks

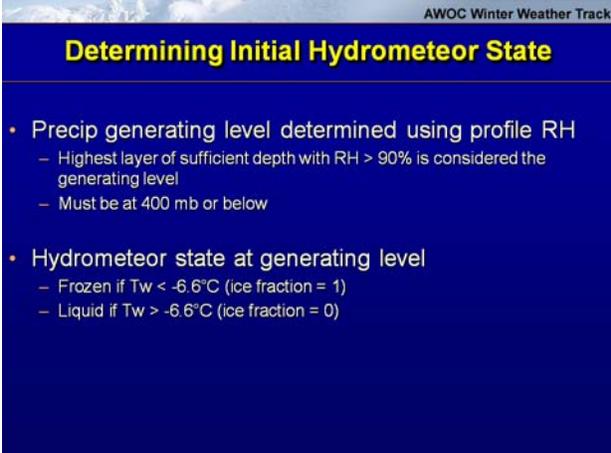
- Two preliminary checks are completed before the method performs a full calculation
 1. If surface Tw $> 2^{\circ}\text{C}$ then liquid precipitation is diagnosed
 2. If surface is Tw $\leq 2^{\circ}\text{C}$ and the Tw is $< -6.6^{\circ}\text{C}$ at all other levels then snow is diagnosed
- If these checks fail, a full calculation of the 'ice fraction' of the hydrometeor is computed.



22. Determining Initial Hydrometeor State

Instructor Notes: To begin the full calculation the Ramer method attempts to identify what is termed the 'precipitation generation level'. To do this it identifies the highest layer where the RH is > 90%. This level must be at or below 400 mb. This level is determined to be the precipitation generating level. Once this level is identified a determination is made as to the initial state of the hydrometeors. If the Tw at this level is < -6.6 degrees C the hydrometeors are considered to be completely frozen and given an ice fraction of 1. If the Tw is > -6.6 degrees C then the hydrometeors are considered to be entirely liquid and given an ice fraction of 0. The cutoff of -6.6 degrees C was utilized as this resulted in the most optimal performance of the algorithm during its development.

Student Notes:



AWOC Winter Weather Track

Determining Initial Hydrometeor State

- Precip generating level determined using profile RH
 - Highest layer of sufficient depth with RH > 90% is considered the generating level
 - Must be at 400 mb or below
- Hydrometeor state at generating level
 - Frozen if Tw < -6.6°C (ice fraction = 1)
 - Liquid if Tw > -6.6°C (ice fraction = 0)

23. How Does the Method Determine P-type?

Instructor Notes: Ultimately, what is called the 'ice fraction' determines the precipitation type. After the initial determination of the hydrometeor state the algorithm utilizes an empirically derived calculation to essentially follow the theoretical hydrometeor through the profile. The algorithm utilizes the wet-bulb temperature at different pressure levels as the hydrometeor descends to determine the final ice fraction. An ice fraction of 1 indicates that the hydrometeor is completely frozen while an ice fraction of 0 indicates that the hydrometeor is completely liquid. As the hydrometeor descends the algorithm determines the amount of freezing or melting, if any, that the hydrometeor will undergo. If a hydrometeor begins as liquid (ice fraction of 0) it will not begin to freeze until it hits a layer where the Tw < -6.6 degrees C. Conversely, if a hydrometeor initiates as ice (ice fraction of 1) it will not begin to melt until it encounters a layer where the Tw is > 0.

Student Notes:


How Does the Method Determine P-type?

- 'Ice Fraction' determines resultant p-type
 - Empirically derived calculation
 - Utilizes Tw at different levels to track hydrometeor state as it descends
- Algorithm determines amount of freezing or melting from the Tw and RH profile (ice fraction)
 - If hydrometeors start out as liquid do not begin to freeze until they hit a layer where Tw is < -6.6°C
 - If hydrometeors begin as ice they do not begin to melt until they hit a layer where Tw is > 0°C

24. Ramer Method – Final Ice Fraction

Instructor Notes: As the hydrometeor descends through the profile the Ramer method simply identifies layers that are warmer than 0 degrees C and layers that are colder than -6.6 degrees C and melts or freezes hydrometeors based on the average wet-bulb temperature and the depth of these layers. The final ice fraction of the hydrometeor at the surface determines the p-type. If some melting has occurred and the ice fraction is greater than 85% then the algorithm will forecast Ice Pellets. If the ice fraction is < 4% and the Tw at the surface is < 0 degrees C then it will produce freezing rain. An ice fraction between 4 and 85% will result in mixed freezing and frozen precipitation. If the hydrometeor begins as ice and no melting occurs (Tw remains at or below 0 degrees C) then the ice fraction = 1 and snow is diagnosed. The Ramer Method is the most difficult of the precipitation type methods to visualize due to its empirical nature. This makes it more difficult to assess operationally than the Baldwin Method, for example.

Student Notes:

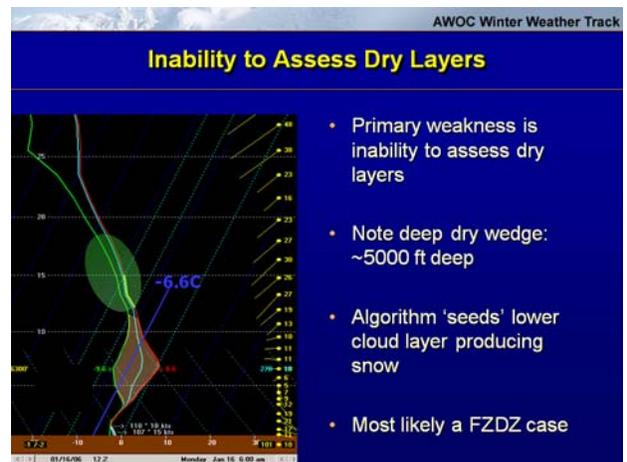

Ramer Method – Final Ice Fraction

- Final 'ice fraction' at the surface determines p-type
 - >85% and some melting has occurred = Ice Pellets
 - <4% and the Tw at the surface is <0°C = Freezing Rain
 - Between 4% and 85% = Mixed Precipitation
 - If the hydrometeor begins as ice and no melting occurs (Tw remains at or below 0°C) the ice fraction = 100% (i.e., 1) and snow is diagnosed

25. Inability to Assess Dry Layers

Instructor Notes: While the Ramer method is statistically a strong method, it too has weaknesses. One limitation of the Ramer method is that it has no knowledge of dry layers. While utilizing the wet-bulb temperature in a top-down approach is a robust methodology the inability to assess dry layers in the vertical profile can have a negative impact on the Ramer output. In this example we see a sounding which contains a deep dry wedge which is about 5000 feet deep. The Ramer method identifies the highest saturated layer below 400 mb and identifies this as precipitation generation level. It then determines the initial hydrometeor state as being ice crystals since the coldest temperature in this saturated layer is colder than -6.6 degrees C. The algorithm follows the hydrometeor as it descends utilizing the wet-bulb temperature to determine if any melting would occur. A problem with the Ramer method is exposed in this example as there is a considerable dry wedge over which sublimation could occur. The Ramer method does not account for this dry layer and essentially seeds the lower cloud deck producing snow. In reality, if we were to see precipitation out of this sounding it would likely be freezing drizzle if the low level cloud layer is of sufficient depth. Over time the dry wedge would likely be eroded as hydrometeors fall from the higher level cloud deck through the dry layer. Eventually snow would develop as this layer saturates and the ice crystals from the higher deck seed the low level clouds. However, the Ramer method would initially incorrectly diagnose this sounding by not accounting for the dry layer.

Student Notes:

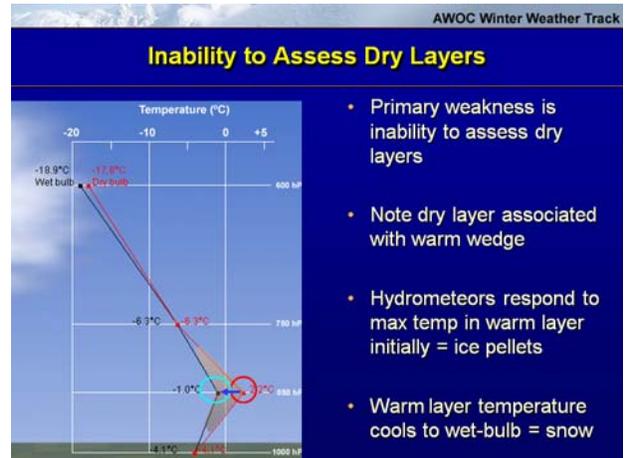


26. Inability to Assess Dry Layers

Instructor Notes: The impact of a dry layer would also be evident in a case such as this where the maximum temperature in the warm layer was say +2 or +3 degrees C while the wet-bulb temperature was below 0C. Again in this case we see that there is a decent dry layer in place. Initially the hydrometeors would undergo partial melting based on the strength of the warm layer. Given the cold temperatures in the near surface layer we would likely see ice pellets at the onset of precipitation in a case such as this. As the temperature in the warm wedge migrated towards the wet-bulb temperature the precipitation

type would change to snow. However, the Ramer method which would not account for the maximum temperature in the warm layer would simply forecast snow given the wet-bulb temperature profile. As a result it would incorrectly diagnose the precipitation type at the onset of precipitation. This inability to account for dry layers in the Ramer method is something to be cognizant of if you utilize its output.

Student Notes:



27. Ramer Method: Strengths and Weaknesses

Instructor Notes: The Ramer algorithm has several strengths. The algorithm does an initial check for the phase of the hydrometeor. It also utilizes the wet-bulb temperature to diagnose the state of hydrometeors as they descend. Another strength of the algorithm is that it was developed utilizing observed data as opposed to model soundings. Finally, the Ramer technique verifies very well. Statistically speaking it is the strongest of the precipitation type algorithms with respect to probability of detection for snow (94%) and freezing rain (60%). It also has the lowest false alarm rate for ice pellets, but has a correspondingly poor probability of detection for ice pellets. Overall, it is statistically the strongest method. As we have discussed the primary weakness of the algorithm is that it does not account for dry layers. Other aspects that could be considered as weaknesses are that it was empirically derived and that it does not account for precipitation rate. Of course, precipitation rate is not accounted for in any of the algorithms that we have or will examine.

Student Notes:

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Ramer Method: Strengths and Weaknesses

<u>Strengths</u>	<u>Weaknesses</u>
<ul style="list-style-type: none">• Does initial check for ice crystals versus liquid hydrometeors• Utilizes wet-bulb temperature• Developed utilizing observed data• Verifies well compared to other algorithms	<ul style="list-style-type: none">• Does not account for dry layers• Empirically derived• Does not account for precipitation rate

28. Quiz Break 2

Instructor Notes: Time for another short quiz break. If the surface wet-bulb temperature is greater the 2 degrees C the Ramer technique will forecast a precipitation type of rain regardless of the what the rest of the profile looks like.

Student Notes:

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Quiz Break 2

- If the surface wet-bulb temperature is greater the 2°C the Ramer technique will forecast a precipitation type of rain regardless of the what the rest of the profile looks like.

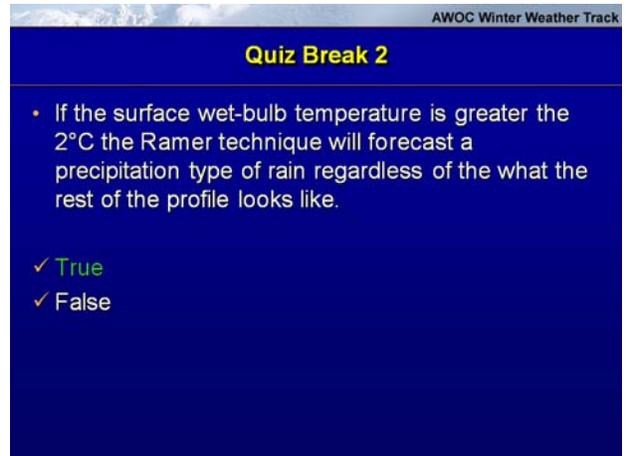
✓ True
✓ False

Advance to next slide when you are ready to hear the answer

29. Quiz Break 2

Instructor Notes: The correct answer is true. Two preliminary checks are completed before the Ramer method performs a full calculation. If surface $T_w > 2$ degrees C then liquid precipitation is diagnosed. Alternatively, if surface is $T_w \leq 2$ degrees C and the T_w is < -6.6 degrees C at all other levels, then snow is diagnosed.

Student Notes:



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Quiz Break 2

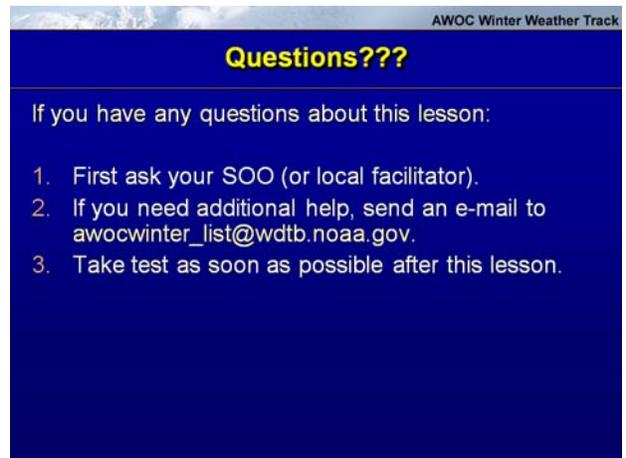
- If the surface wet-bulb temperature is greater the 2°C the Ramer technique will forecast a precipitation type of rain regardless of the what the rest of the profile looks like.

✓ True
✓ False

30. Questions???

Instructor Notes: After going through this lesson if you have any questions, first ask your SOO. Your SOO is your local facilitator and should be able to help answer many questions. If you need additional info from what your SOO provided, send an E-mail to the address on the slide. This address sends the message to all the instructors involved with this IC. Our answer will be CC'd to your SOO so that they can answer any similar questions that come up in the future. We may also consider the question and answer for our FAQ page. Thanks for your time and good luck on the exam!"

Student Notes:



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Questions???

If you have any questions about this lesson:

1. First ask your SOO (or local facilitator).
2. If you need additional help, send an e-mail to awocwinter_list@wdtb.noaa.gov.
3. Take test as soon as possible after this lesson.