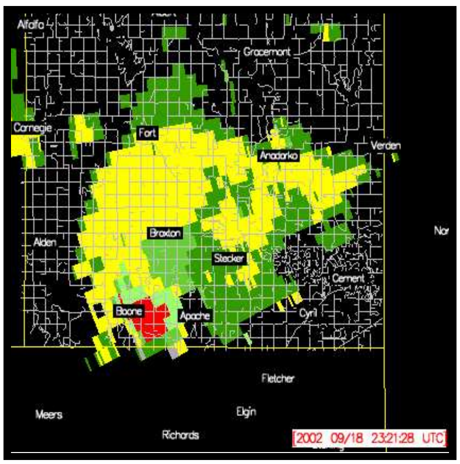
Joint Polarization Experiment

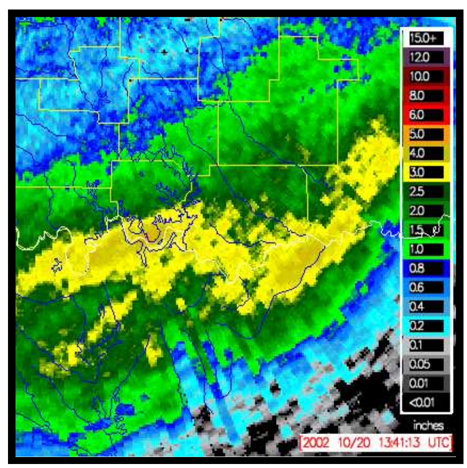
Spring 2003 Operational Demonstration

OPERATIONS PLAN



National Severe
Storms Laboratory

National Weather Service
Forecast Office
Norman, OK



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1 April 2003

I. PROJECT OVERVIEW

1. Introduction

The accurate estimation of precipitation type and accumulation has been a long-standing problem for operational meteorologists. When the estimates are obtained by weather radar, inaccuracies can result from radar miscalibration, attenuation of the signal in heavy precipitation, and the presence of non-meteorological scatterers such as ground returns, birds, and insects. Natural variations in the size, shape, and ice density of cloud and precipitation particles can also result in estimation uncertainties. Fortunately, many of these problems may be at least partially mitigated through the use of radar polarimetry.

As part of the future enhancement of the WSR-88D, NSSL recently upgraded the KOUN WSR-88D radar to include polarimetric capabilities. Unlike most research polarimetric radars, KOUN employs a simultaneous horizontal/vertical transmission scheme. While simultaneous transmission is expected to have practical advantages over the more common alternate horizontal/vertical transmission scheme, it remains largely untested. JPOLE will therefore provide opportunity to evaluate critical engineering and data quality issues.

The operational benefits will be examined by conducting an evaluation of the polarimetric rainfall rate and hydrometeor classification product performance. During the spring of 2003, algorithms estimating precipitation accumulation and hydrometeor type will be tested operationally during convective events. This document outlines the scope, goals, and requirements of the spring 2003 operational demonstration.

2. Scope

The JPOLE demonstration will be conducted at the National Weather Service Forecast Office (NWSFO) in Norman, Oklahoma from 1 April through 30 June 2003. During this period, an NSSL meteorologist will be “on call” to participate in any severe weather warning operations at the NWSFO.

While the entire NWSFO Norman county warning area (CWA) is within range of KOUN (Figure 1), this project is primarily concerned with polarimetric signatures and algorithm performance within about 200 km of the radar. It should be noted that this region includes portions of the NWSFO Tulsa CWA and NWSFO Fort Worth CWA.

During severe weather operations, the NSSL meteorologist will study polarimetric data provided by KOUN, and assist NWSFO staff in making probing phone calls to regions of suspected hail or flash flooding. The NSSL meteorologist will note radar data quality issues, document how the data are used in operations, and document the performance of the hydrometeor classification algorithm (HCA) and quantitative precipitation estimation algorithms (QPEAs). Finally the NSSL meteorologist will coordinate KOUN data collection efforts at NSSL. Specific documentation requirements are outlined below, while an overview of polarimetric products and algorithms is available in Appendix 1.

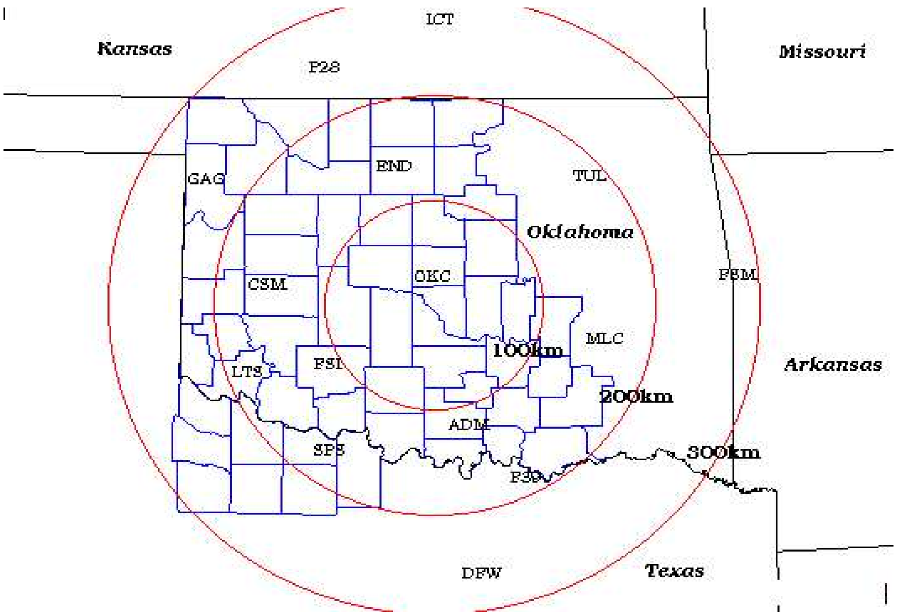


Figure 1. KOUN 100 km, 200 km, and 300 km range rings in red. NWSFO OUN CWA county outlines in blue.

3. *Warning Decision Support System – Integrated Information (WDSS-II)*

KOUN polarimetric radar data and algorithm output will be delivered to the NWSFO by the Warning Decision Support System – Integrated Information (WDSS-II) software package. An outline of WDSS-II features is available in Appendix 2. WDSS-II is a Linux-based prototype system designed to integrate data from multiple sensors and geographic information systems. In addition to other duties, the NSSL meteorologist during the operational demonstration will take note of WDSS-II performance and provide software developers a summary of bugs and potential improvements.

4. *Other Observing Platforms*

Other observing platforms will be used to evaluate polarimetric signatures and verify algorithm performance (Figure 2). Quantitative verification of the QPEAs is difficult in real time, due to the time lag associated with precipitation accumulation reports. In the post-event analysis, however, NSSL will use data collected by the Oklahoma Mesonet, the Agricultural Resource Service (ARS) micronet, NWS cooperative observer rain accumulation reports, rain gages along streams, and federal METAR rain accumulation reports. Real time qualitative evaluation of the QPEAs is important in the case of flash flood events. In those cases, communication with spotters, storm chasers, the media, and emergency managers should be attempted by the NSSL meteorologist at the NWSFO.

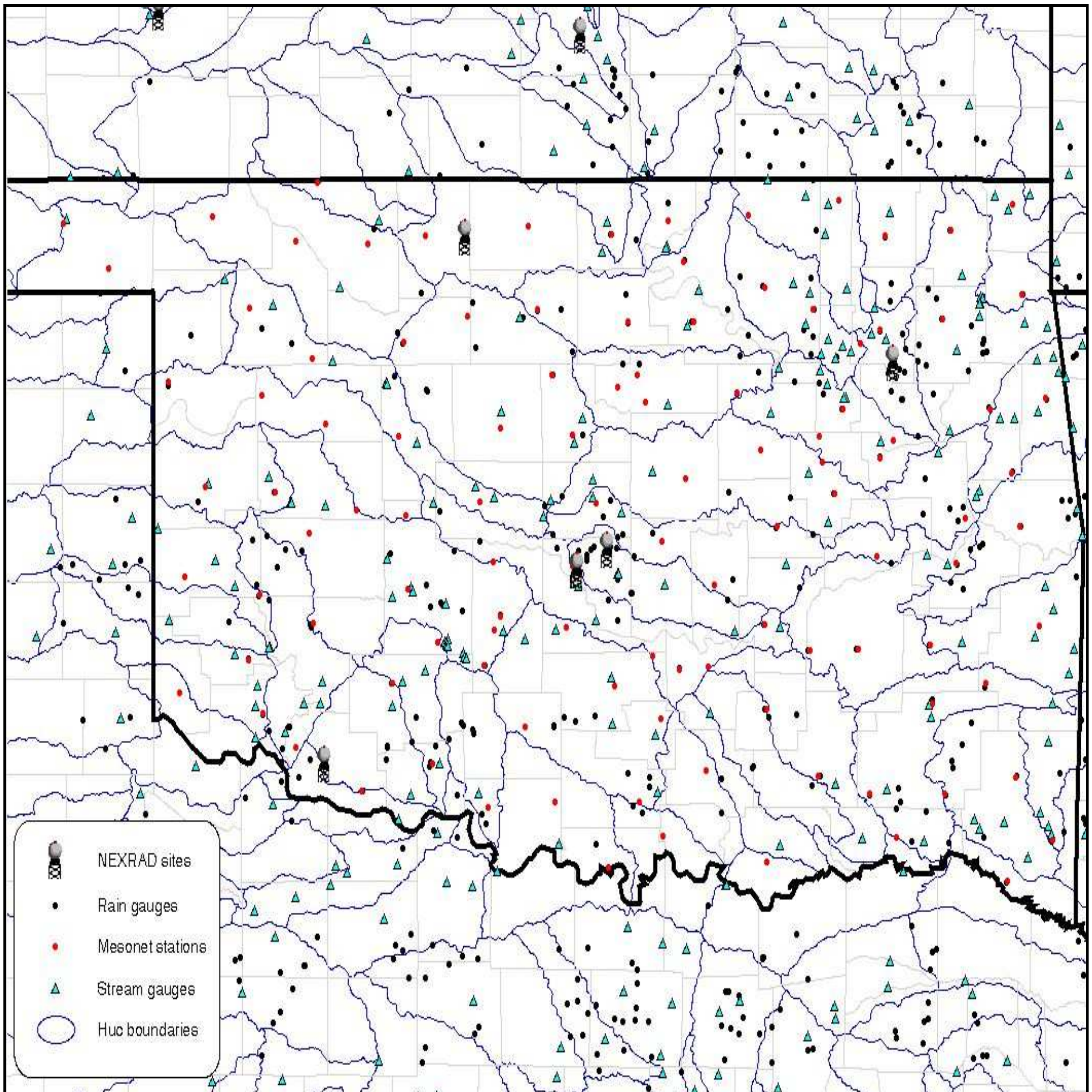


Figure 2. A summary of observing platforms within the JPOLE project domain.

The HCA may be evaluated by ground level reports differentiating between rain, hail, and a mixture thereof. These reports may be gathered in real time from the NWSFO or after the event from spotters, chasers, the media, and emergency managers. In all cases, communication with spotters, chasers, the media, and emergency managers should be coordinated with the NWSFO staff to avoid redundant calls to the same source.

5. Required Observations

The NSSL observer should take special care to note the following observations (when applicable) during operations at the NWSFO:

- Performance of the HCA, including vertical continuity
- Performance of QPEAs

- Polarimetric signatures in regions of thunderstorm updrafts and downdrafts
- Polarimetric signatures in regions of hail
- Polarimetric signatures in and near the hook echo region of tornadic supercells, particularly at the 0.0 degree elevation angle
- Polarimetric signatures of non-meteorological scatterers
- KOUN data quality (alone and in comparison with KTLX WSR-88D)
- WDSS-II bug reports and comments
- How KOUN data were infused into the warning decision-making process

6. Post Event Questionnaire

The primary means of evaluating operational use of polarimetric radar data will be the questionnaire provided to forecasters at the end of this operations plan. This questionnaire should be distributed to NWSFO staff involved in the operational use of KOUN data after every day of operations. Please take a moment to review this questionnaire before every operations shift.

II. NWS OPERATIONS

1. Prior to the event

The NSSL meteorologist on duty will keep watch on the weather and coordinate with Terry Schuur the start of KOUN operations. If operations are expected, the NSSL meteorologist will carry the JPOLE cell phone. The JPOLE web page (http://weather.ou.edu/~kscharf/jpole) will also be kept updated by Kevin Scharfenberg with the current status of KOUN (up/ready/down).

2. Start of operations

When the Forecaster in Charge (FIC) or Severe Weather Coordinator (SWC) believes severe weather operations at the NWSFO are about to commence, they should check the JPOLE status web page at the following URL: http://weather.ou.edu/~kscharf/jpole. If the KOUN status is listed as "DOWN", the radar is not available for JPOLE operations.

If the radar status is "READY" or "UP", we are ready to begin operations. It is important we collect as many severe weather data sets as possible, so an NSSL meteorologist will be on call at all hours, and on weekends. If not already on site, he/she may be paged at the following URL: http://weather.ou.edu/~kscharf/protect/page.html, using username: --- and password: ---. Please send the page at least 30 minutes before the expected start of operations during business hours, and at least one hour early on weekends and after hours. The NSSL meteorologist will call back, briefly discuss the situation with the FIC/SWC and coordinate the start time of operations. The NSSL meteorologist will also contact the data collection person to say that NWS operations are ready to begin. The NSSL meteorologist should complete the pre-operations checklist before operations begin.

3. Operations

Once on site, the NSSL meteorologist will check in with the SWC/FIC and use the WDSS-II workstation along the west windows in the operations area. In addition to making the required observations listed in section I, the NSSL meteorologist will monitor the KOUN data feed and pass along any observations to the SWC/FIC. The meteorologist should use his/her best judgment in only passing along information that will be beneficial to the issuance of severe weather warnings and statements. All activity should be logged by the NSSL meteorologist.

In the event radar or display difficulties arise during operations, the NSSL meteorologist should consult the troubleshooting checklist.

4. End of operations

The NSSL meteorologist and SWC/FIC will make a joint decision when to conclude operations. In many cases, KOUN will be left running to collect data after operations have concluded. In any event, the NSSL meteorologist should complete the post-event checklist. This includes the distribution of a questionnaire to the SWC/FIC or any NWSFO forecaster who used KOUN data in decision-making.

Acknowledgments. Portions of this document were contributed by Terry Schuur, Travis Smith, and Greg Stumpf.

APPENDIX 1: POLARIMETRIC RADAR

<u>Differential reflectivity (Z_{DR})</u>: A measure of the reflectivity-weighted mean axis ratio of the hydrometeors in a radar volume.

$$Z_{DR} \sim 10 \log (P_h / P_v) \quad [\text{dB}],$$

where:

P_h is the returned horizontally-polarized backscattered power received from the horizontally-polarized transmitted pulse,

and:

P_v is the returned vertically-polarized backscattered power received from the vertically-polarized transmitted pulse.

- Z_{DR} values for meteorological echoes typically range between -2 dB and 6 dB.
- Values of Z_{DR} well above zero indicate the hydrometeors in the volume are horizontally oriented -- meaning their horizontal axis is longer than their vertical axis ($P_h > P_v$).
- Values of Z_{DR} well below zero indicate the hydrometeors in the volume are vertically oriented -- meaning their vertical axis is longer than their horizontal axis ($P_h < P_v$).
- Values of Z_{DR} near zero indicate the hydrometeors in the volume have a nearly spherical shape, in the mean ($P_h \sim P_v$).

For example, consider a field of large, falling raindrops. The drops tend to fall with an oblate orientation -- similar to a hamburger bun. The field of drops, as a whole, will have a larger cross-section of water in the horizontal compared to the vertical. A horizontally-polarized radar pulse will, therefore, be backscattered more in this field of drops than a vertically-polarized pulse, resulting in more radar return for the horizontal pulse than the vertical pulse. In this case, $P_h > P_v$, so $Z_{DR} > 0$. Differential reflectivity values above 2 dB are commonly observed in rain.

Although hailstones are not necessarily spherical, studies have shown that they fall with a tumbling motion -- meaning a field of falling hailstones within the radar resolution volume will "appear" to consist of nearly spherical hydrometeors. Therefore, the value of Z_{DR} for hail is usually close to zero. Some graupel and hail hydrometeors with a conical shape can fall with their major axes oriented in the vertical. In these cases, the Z_{DR} will be found to be negative.

Z_{DR} is <u>reflectivity-weighted</u>, meaning the shape of the more strongly reflective hydrometeors will contribute more to the Z_{DR} of a radar resolution volume than the more weakly reflective hydrometeors in the same volume.

For example, consider a resolution volume with a mixture of raindrops and hailstones. We know that, among other things, the reflectivity factor is a function of the average diameter of the hydrometeors in the volume to the 6th power, and the dielectric constant of the hydrometeors. Adding hailstones to a field of raindrops increases the average hydrometeor diameter, leading to a much higher reflectivity factor. Because hailstones are much more reflective than raindrops, the reflectivity for horizontally-polarized radar pulses should be about the same as that for vertically-polarized pulses. This means Z_{DR} should be near zero, in spite of the presence of rain.

Specific Differential Phase (K_{DP}): The difference between propagation constants for horizontally- and vertically- polarized radar pulses over a given range.

$$K_{DP} \equiv \frac{\phi_{DP}(r_2) - \phi_{DP}(r_1)}{2(r_2 - r_1)} \quad [\,^\circ\ km^{-1}\,]. \qquad \phi_{DP} \equiv \phi_h - \phi_v, \quad \phi_h \geq 0, \quad \phi_v \geq 0.$$

where:

ϕ_h is the phase of the horizontally-polarized pulse at a given point in the propagation path,

ϕ_v is the phase of the vertically-polarized pulse at the same point in the propagation path,

and:

r_1 and r_2 refer to measurements at range 1 and range 2 from the radar [km], where $r_1 < r_2$.

To understand the above equations, consider two consecutive radar pulses that travel the same propagation path. The first pulse is horizontally polarized, the second is vertically polarized. Along the propagation path is a uniform field of falling raindrops. As discussed earlier, falling raindrops are oblate, so the electric field will encounter more water content in the horizontal direction than in the vertical. The horizontally polarized pulse will, therefore, be affected by more water than the vertically polarized pulse. Since electromagnetic waves travel more slowly through water than through air, the horizontally polarized wave will travel more slowly through the field of raindrops than will the vertically polarized pulse. This is a two way process -- the backscattered radiation, horizontally polarized, will travel more slowly back to the radar than the vertically-polarized backscatter.

ϕ_{DP}, or *differential phase*, is simply the accumulated difference in phase between the horizontally- and vertically- polarized pulses at a given range along the propagation path. Naturally, differential phase will increase with range from the radar, so we can take the range derivative to determine where along the propagation path phase changes are occurring. This derivative is called the *specific differential phase*, or K_{DP}. Note the "2" in the denominator appears because there is a phase shift on both the outbound trip and the return trip.

For meteorological echoes, K_{DP} typically ranges from -1 $^\circ km^{-1}$ to 6 $^\circ km^{-1}$. Values of K_{DP} greater than zero indicate that ϕ_{DP} has increased over the range of interest (r_2-r_1). Since ϕ_h and ϕ_v are always > 0, that means the phase of the horizontally-polarized pulse has increased more rapidly than the phase of the vertically-polarized pulse. In other words, the horizontally-polarized pulse has slowed down more than the vertically-polarized pulse over the given range. This means there is more hydrometeor content in the horizontal plane, e.g., oblate hydrometeors. Likewise, values of K_{DP} below zero indicate vertically oriented hydrometeors are present in the range of interest. Values of K_{DP} near zero indicate nearly isotropic (spherical) hydrometeors are present. K_{DP} may also be negative in regions with shear gradients.

It is important to note that *K_{DP} is insensitive to isotropic (spherical) scatterers.* For example, when encountering tumbling hailstones, both the horizontally- and vertically- polarized radar pulses will slow down. Because these hydrometeors are nearly spherical, however, both pulses should change phase at approximately the same rate, so ϕ_{DP} and K_{DP} should not change. For this reason, K_{DP} is very helpful in rainfall accumulation estimation, because the amount of rain in a rain-hail mixture can be directly estimated. Another advantage of using K_{DP} for rainfall accumulation estimation is the fact that K_{DP} is immune to the reduction in reflectivity factor caused by partial beam blockage. The differential phase will shift at the same rate no matter the reflectivity factor, as long as some signal can make it to the scatterers and back.

Correlation Coefficient $|\rho_{hv}(0)|$: The Correlation Coefficient describes the similarities in the backscatter characteristics of the horizontally and vertically polarized echoes.

- For meteorological echoes, $|\rho_{hv}(0)|$ is typically greater than 0.7.
- Hail: Typically 0.90 to 0.95. Can be above 0.95 for a uniform field of small, dry, hail. Can fall significantly below 0.90 in large, wet hail (Mie regime).
- Rain: Typically above 0.95, except when drops are mixed with hail or partially frozen. Can be above 0.99.
- Drizzle/very light rain: Typically below 0.90, due to low signal-to-noise ratio.
- Ice pellets/graupel: Typically greater than 0.95, but significantly lower in mixed phase regions (as is often observed).
- Snow: Generally above 0.95, except potentially much lower in wet, melting snow.
- Bright band: Typically 0.90 to 0.95 due to mix of hydrometeor types.

$|\rho_{hv}(0)|$ significantly below 1 indicates regions where the horizontal and vertical backscattering fields are not proportional, where the particles are re-orienting or changing in number, or where there is a mixture of hydrometeor types, size, fall eccentricities, and/or shape. $|\rho_{hv}(0)|$ may drop to 0.5 or lower in regions of Resonant scattering (e.g., very large hail).

Hydrometeor Classification Algorithm (HCA)

Most HCAs use a "fuzzy logic" scheme to classify hydrometeor type. Fuzzy logic algorithms are used to quantify uncertainty, much like a system of probabilistic equations. In the case of hydrometeor classification, the exact boundaries between hydrometeor types using polarimetric variables are "fuzzy", so a zero to one probability must be assigned in the "fuzzy" region.

For example, consider the discrimination between rain and hail. Using differential reflectivity Z_{DR} alone is not helpful. Values of Z_{DR} near zero may suggest the presence of either hail or drizzle/cloud droplets, because both have nearly spherical shape. Combining reflectivity factor Z with Z_{DR} can help, because hail has a much larger Z than drizzle/cloud droplets. However, consider a case where Z= 53 dBZ and Z_{DR}= 1.5 dB. Studies have shown this combination of Z and Z_{DR} may result from heavy rain, small hail, or a mixture of both. In assigning hydrometeor type to this case , the fuzzy logic algorithm would assign a lower weight to Z vs. Z_{DR} than to potentially more useful combinations, such as Z vs. K_{DP}. Once all of the potential combinations of polarimetric variables are tested, weighting functions are applied to make the final classification, such that the highest confidence combination is weighted the most, and the lowest confidence is weighted least.

Different hydrometeor classification algorithms are constantly being developed and tested. Early results are encouraging, but there is still insufficient in-situ verification of the algorithm output to be certain the output is always accurate. Therefore, *forecaster feedback about the quality and usefulness of the tested HCA is very important!*

Quantitative Precipitation Estimation Algorithms (QPEAs)

Traditional Z Algorithms: Traditional reflectivity-based QPE algorithms, such as ones used by the WSR-88D network, relate radar reflectivity factor (Z) to rain rate (R). Unfortunately, the equation relating Z to R varies according to the drop sizes distribution (DSD) of the rain in the volume of interest, which can vary widely from one event to another. Currently, WSR-88D radars use a variety of assumed DSDs, ranging from those applicable to "tropical" air masses to those more suited for "continental" air masses. If the assumed DSD is not appropriate, the rain fall rate error may exceed 300%. In addition, this method does not correct for very high Z values found in hail, leading to the potential for gross over estimation of rain totals where hail is present. False returns, such as found in side lobe contamination, ground clutter and anomalous propagation, may also contaminate the rainfall estimates. Attenuation of the radar signal due to heavy rain or partial beam blockage often leads to an underestimate of rainfall accumulation. Finally, Z-based algorithms are sensitive to radar calibration. The standard (non-tropical) Z-R relation used by the WSR-88D is $Z = 300R^{1.4}$. In addition, Z values above 53 dBZ are assumed to be hail and are not considered. This assumption is not often valid and is another possible source of error.

Z-Z_{DR} Algorithms: In high reflectivity regions, differential reflectivity (Z_{DR}) can provide an estimate of the mean, mass-weighted drop diameter, reducing errors from calculations using Z alone by a factor of two. However, the estimate is not precise enough to yield an improvement for rates less than 20 mm h^{-1}. In addition, Z-Z_{DR} estimates can still suffer from errors due to hail, non-precipitating echoes, attenuation, radar calibration, etc.

K_{DP} Algorithms : Specific differential phase (K_{DP}) is much more directly related to the DSD and rain rate than either Z or Z_{DR}, particularly in heavy rain. Analysis of experimental data suggests significant improvement may be possible over Z-based algorithms, with errors as low as 10 to 15 percent for a well-calibrated radar.

K_{DP}-Z_{DR} Algorithms: K_{DP} and Z_{DR} can be used in unison for another rainfall estimate. A complete evaluation of this procedure and comparison with other procedures has not yet been made.

Case Studies

Specific case studies are available by visiting the following web URL: http://www.cimms.ou.edu/~kscharf/pol. This page will be updated throughout the spring as more cases become available.

To view archived KOUN cases in WDSS-II, click on the "WDSS-II – Case Studies" icon on the desktop of either WDSS-II machine. Choose the source and products for the desired case as described in Appendix 2.

APPENDIX 2: WARNING DECISION SUPPORT SYSTEM – INTEGRATED INFORMATION (WDSS-II)

NOTE: WDSS-II is a new multi-source display and application development environment that is still *under development*. As such, **your feedback is very important**, as it will help shape the look and feel of the display and will help guide the path of WDSS-II multi-sensor and multi-source algorithm development. You should expect some awkward display interface issues, some bugs, and some things that may not be very intuitive just yet. Please report these to the developers! It will help us to prioritize which things need to be implemented or improved. Please send feedback to wdssii_feedfack@nssl.noaa.gov each time you have trouble or a suggestion.

Starting the WDSS-II display (hereafter known as "w2"):

1) If not logged in already, you may log in at the WDSSII Display Machine in the NWSFO warning area as:
   Username: ------
   Password: -------
2) Click on one of the "WDSS-II Start" icons on the desktop.

Choosing a Source and Product:

Click on the "Products" button at the top of the w2 window (see Figure 2). This will bring up the product control window (Figure 1). Choose a data source by clicking on one of the product tabs. If the source you desire is not showing, try clicking the "<" or ">" buttons at right to see more sources. If your source is still not showing, call an NSSL staffer for help.

In the left column, a list of available products for that source will appear. You can double click on any radar product to immediately bring up image corresponding to the lowest tilt and latest time, or click once on a radar product to bring up a list of elevation angles in the middle column.

Double clicking on an elevation angle will bring up the image corresponding to the latest time at that elevation angle, or click once to see a list of product times in the right-hand column. Click on a product time to show that image.

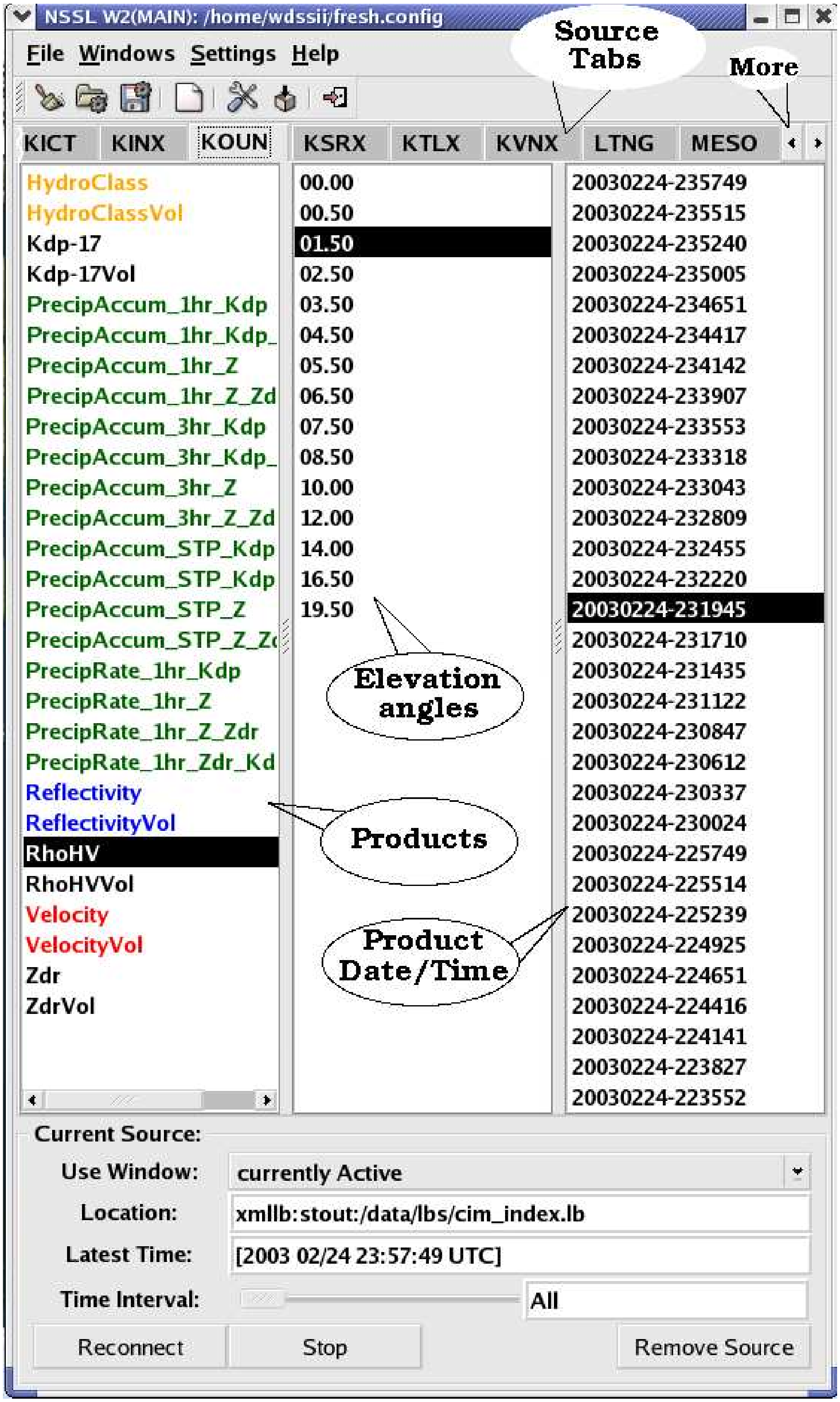


Figure 1. Source and product selection window

The WDSS-II Display Window:

Display window: top (Fig. 2)

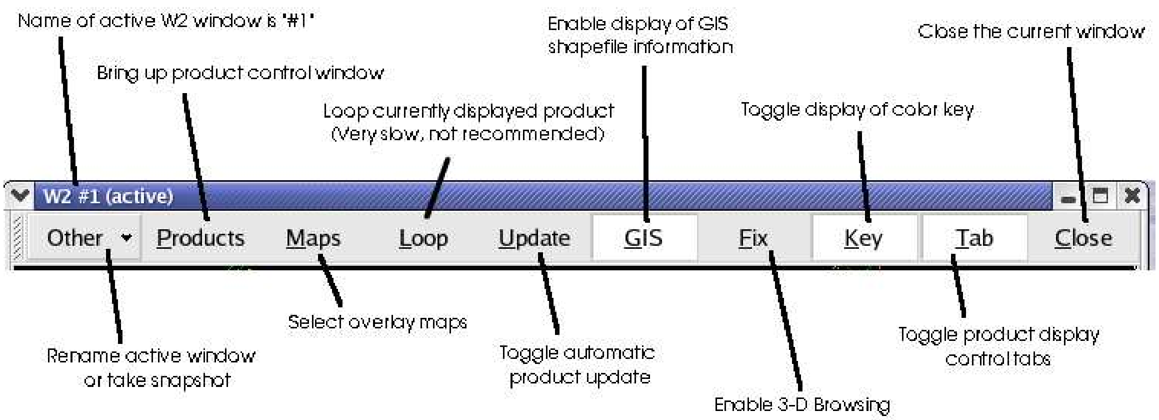


Figure 2. Button bar at top of display window

Other: Allow user to name the window (will show up in title bar) or take a screen snapshot.

Products: Brings the Product Selection menu to the foreground.

Maps: Allows you to select which map overlays you want.

Loop: Animates the current set of products. <u>WARNING: Users should only animate a simple product from a single radar at this point. Looping still needs some development to get it running smoothly.</u> Looping parameters are set in the Preferences (see "Preferences" section).

Update: When turned on, it will automatically load in new products as they arrive. (Like "Auto-Update" in WDSS/RADS). In real-time operations, this defaults to ON and should remain set to ON most of the time.

GIS: If turned on, clicking on the main window will show some geographic information. See also the section on "Display Window: Maps"

Fix: "Fix" the view to the point on the Earth's surface that is currently in the middle of the screen. This allows you to rotate and zoom about this point (see "Mouse Controls" section)

Key: Turn on/off the colormap key on the right of the display

Tab: Turn on/off the product tabs at the bottom of the display

Close: Close the present window (one for each of multiple windows, if you are running more than one window). This does not completely shut down the display.

Display window: Mouse Controls

NOTE: WDSS-II uses a three-button mouse for control. Note that the middle mouse button is smaller and also a roll-wheel. The roll-wheel has no function in WDSS-II. Just depress the button (wheel) for the middle button features.

1) With "Fix" button off:

Hold left mouse:	Roam (pan) in the direction you move the mouse
Hold middle mouse:	Move "up" to zoom in, "down" to zoom out
Right mouse:	Nothing

2) With "Fix" button on:

Hold left mouse:	Rotate the view
Push up:	Rotate to view from above
Push down:	Rotate to view from the side
Push left:	Rotate counterclockwise
Push right:	Rotate clockwise
Hold middle mouse:	Move "up" to zoom in, "down" to zoom out
Hold left mouse:	If in 3D box mode, move forward and backward through the 3D box, and a dynamic cross-section, built perpendicular to your line of sight, will be displayed. When you release the button, the dynamic cross-section becomes static, and you can then fly around this new cross-section.

Display window: some general information

WDSS-II displays all data in time synchronized, three-dimensional earth-relative coordinates. This means that you can combine data from many different sources in the same window while maintaining the correct mapping of the data relative to each other in 3D space. Cross-sections of data will be mapped with no horizontal or vertical stretching.

Notes:

- It is possible to have multiple radars overlaying the same area on the earth. In fact, if you use the Fix button and rotate to view the elevation slices from the side, you can see how they relate to each other in space (e.g., if one is above the other)

- CAUTION!! Since you are looking down upon a 3D data field, there will be some parallax toward the edges of the screen (similar to a satellite image). Therefore, if you want to find the exact location of a feature you should move it to the middle of the screen (beneath the cross-hairs) to get the true location.

- WARNING!! As with any computer you **can** max out the memory if too many products are loaded at the same time (especially volume products). If you start seeing the display slow down when roaming or zooming, you may need to delete some of the products.

Display window: Gridded Image Products

The "tabs" at the bottom of the screen help control which data source is most prominent and displayed on the top-viewing layer (Fig. 3). The "current source" (e.g., KOUN) is highlighted in yellow, and the "current product" (e.g., Vel 01.50) is highlighted in yellow on a sub-tab. Under the tabs is the window with the **Products** and **Navigation** controls. When viewing a **Velocity** image, a third window on the right is included, the **Storm Motion** selection window (shown in the figure below for completeness).

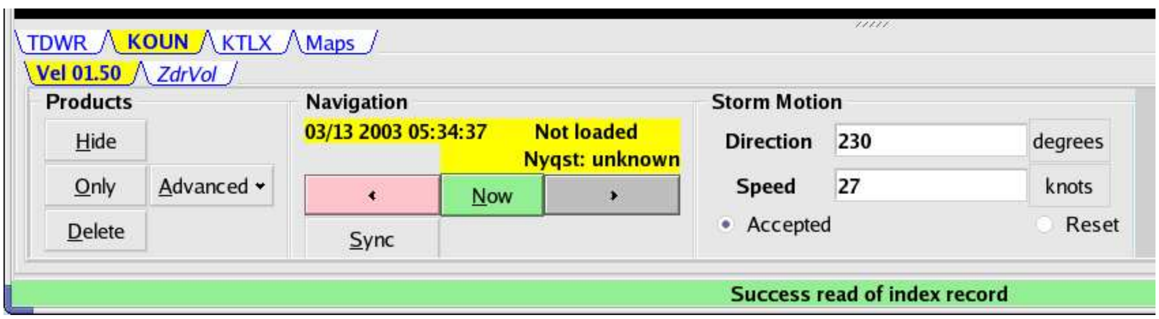


Figure 3. Gridded Image Product Controls.

On the far left of the window under the tabs are the **Products** controls. NOTE: Some of these buttons toggle two options. Only one is shown in the figure above:

- **Hide (Unhide)**: Hide/unhide this product from view

- **Only (Revert)**: Show only this product (when it is the "current product"). This is useful when you want to take a close look at a data field from a specific source and to blank out other data from cluttering your view.

- **Delete**: Delete this product from the tabs and from memory. Use this to free up resources when you don't expect to revisit a product any time soon.

- **Advanced**: The things you need to worry about here are:

    - **Data Readout** - when checked, show the data values at the cursor, along with azimuth/range/height (heights are above the surface and in thousands of feet, and ranges are in nautical miles). You can change what is shown by looking at the "Preferences/Read out options" tab on the product selection window.

    - **Show Polar Grid** - for radars, you can turn a polar grid on/off. For the time being, these are hardwired to 25 nautical mile intervals.

On the right part (or center if viewing a Velocity image) of the window under the tabs are the **Navigation** controls, which control rapid browsing through the data:

<	Step back in time by one volume scan
>	Step forward in time by one volume scan (unless gray, in which case you are already at the latest time)
Now	If pink, this button will jump ahead to the most current data (info in status bar at bottom of display). If green, already at the latest time.

If viewing a Velocity image, the right part of the window under the tabs is the **Storm Motion** controls. Velocity images can be converted to Storm Relative Velocity by entering in a storm motion vector (**Direction** and **Speed**) and hitting **Accept**. NOTE: Only the current and subsequent velocity images will have the new motion vector applied. This motion vector will not apply to previous images. The **Reset** button will reset the motion vector to the default vector (currently zero).

Display window: "Virtual Volume" Gridded Image Products

These are the primary products for browsing base data (e.g., ReflectivityVol, ZdrVol). They update as each tilt arrives, so you will always have the latest data available for all elevation scans. These are called "virtual volume scans".

The "tabs" at the bottom of the screen help control which data source is most prominent and displayed on the top-viewing layer (Fig. 4). The "current source" (e.g., KOUN) is highlighted in yellow, and the "current product" (e.g., ZdrVol) is highlighted in yellow on a sub-tab. Under the tabs is the window with the **Products**, **Navigation**, and **X-Section** controls. The **Products** controls work exactly the same way as already described above.

Figure 4. Virtual Volume Gridded Image Product Controls

On the middle part of the window under the tabs are the **Navigation** controls, which control rapid browsing through the data. For the virtual volume products, these are a little more sophisticated.

< Step back in time by one volume scan

- > Step forward in time by one volume scan (unless gray, in which case you are already at the latest time)
- The middle row of buttons (0.00, 0.50, ... 19.50) controls the elevation angle. The middle button is the current elevation angle. Push the top button to select the next higher elevation (wraps back to the bottom if you are at the top, and the opposite for the bottom button to the top), and the bottom button to move down. There is no **Now** button for volume products.
- Green buttons show that the data are from the current volume scan, while red buttons indicate that the data are from the previous volume.
- **Base**: Select the lowest elevation angle
- **Sync**: Synchronize all data sources to the time of the data set you are currently browsing.

On the right part of the window under the tabs are the **X-Section** controls, which allow you to manipulate volume data in three-dimensions:

- **3-D box**: This product allows you to dynamically cut cross-sections through volumetric data perpendicular to the users field of view.

  1) Select 3D Box
  2) Use the left mouse to draw (hold-draw-release) a small box around the storm you are interested in. Best keep these to one or two storms. This automatically turns on the "Fix" button.
  3) Right-click in the display window to draw the box.
  4) Left-mouse to rotate to desired viewing angle and middle-mouse to zoom in and out.
  5) Hold right-mouse and move through the data to see cross-section dynamically change. Release the right mouse to freeze the cross-section plane.
  6) Left-mouse to rotate to desired cross-section plane viewing angle and middle mouse to zoom in and out.
  7) Click "Reset" to remove the box and turn off the Fix button.

- **X-plane**: This is more like the traditional cross section

  1) Select "X-plane"
  2) Use the left mouse to draw (hold-draw-release) a line across the storm you are interested in.
  3) Right-click in the display window to draw the plane. This automatically turns on the "Fix" button.
  4) Left-mouse to rotate to desired cross-section plane viewing angle and middle mouse to zoom in and out.
  5) Click "Reset" to remove the plane and turn off the Fix button.

To get a clear view of the plane, you may find it useful to click the "Only" button so that you are only viewing data from the single source.

- **Reset**: As described above this button will remove you 3D Box or X-Plane and turn off the Fix button so you can return to another 3D Box, X-Plane, or back to normal product browsing.

- **Elev Scan**: If the elevation tilt is also in your way, you can toggle it off and on using this button.

Display window: Maps

There is not a good interface for maps, yet. To select a map, push the "**Maps**" button at the top of the window and select the maps you desire (toggle on/off). If you want city or county names (this is where it gets ugly, and improvements are planned), then:

1. Click the "**Maps**" tab at the bottom
2. Click the map type tab (e.g., OUN Rivers)

Note that map overlays available include county/city streets, CWA counties, urban area boundaries, rivers, major highways, etc.

Under the tabs is the window with the **Text**, **Figure**, and **Filter** controls. Do not use the **Figure** and **Filter** controls for now. To use the **Text** controls:

1. Choose "Name" (for cities or counties) from the **Column** drop down menu.
2. Use the up/down arrows to choose a **Size** of "10"
3. Choose a **Color**.
4. Click "**Draw**"

To remove the names (they can sometimes get in the way of viewing the data), click the "GIS" button at the top of the display window.

If you have an ArcView shape file with a specific purpose (e.g. street-level maps for specific cities), then it can be added to WDSS-II. Just ask the NSSL staff to help.

Other settings:

From the Product Selection Window, you can do some other functions (Fig. 5):

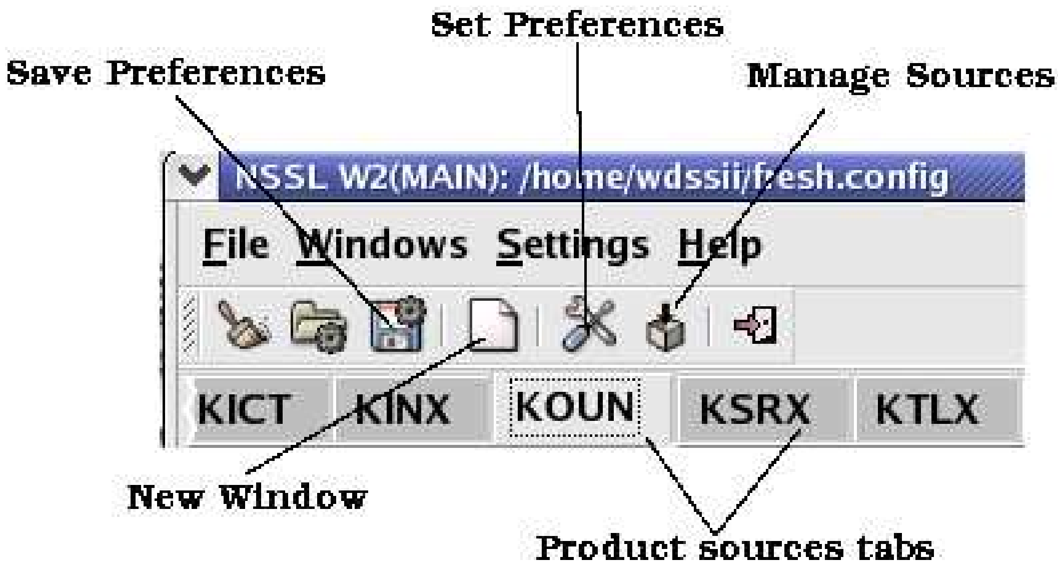


Figure 5. Other Product Selection Functions.

- **New Window** Launch a new display window.
- **Set Preferences** A way to set display preferences (Fig. 6). There are 9 tabs for particular preference settings. We recommend only the advanced user to use these for now.

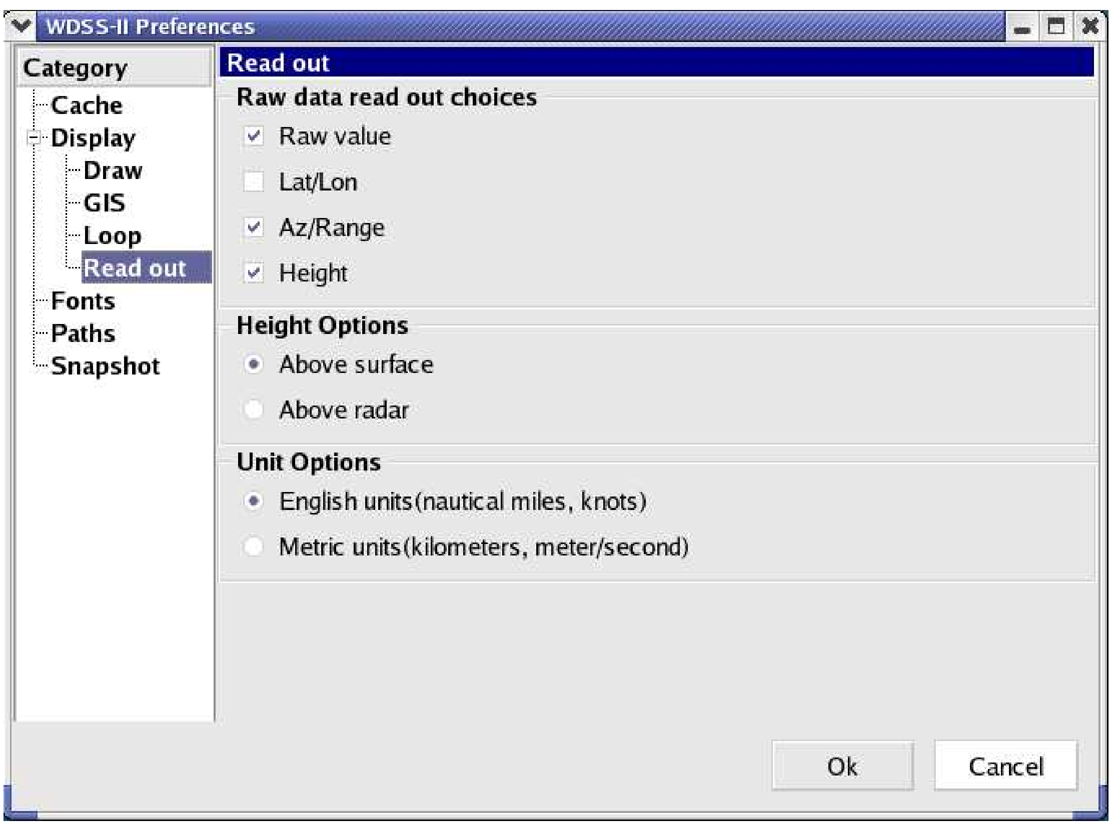
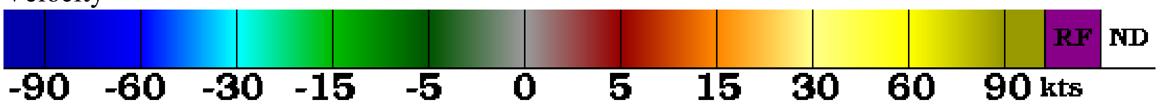


Figure 6. Preferences Control Window.

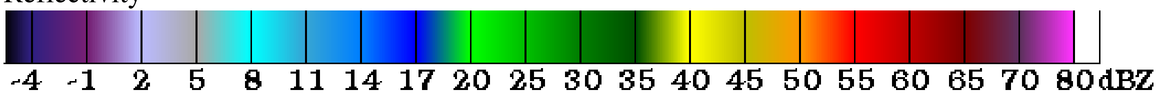
- **Manage sources** Don't use this. We've got this all set up when you start w2.
- **Save Preferences** For the advanced user, you can save your preferences. We can show you how to load up w2 with your personal preferences if you wish or create a new desktop icon just for you

APPENDIX 3: OPERATIONAL COLOR SCALES IN WDSS-II

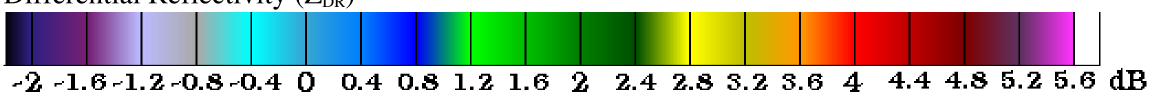
Velocity



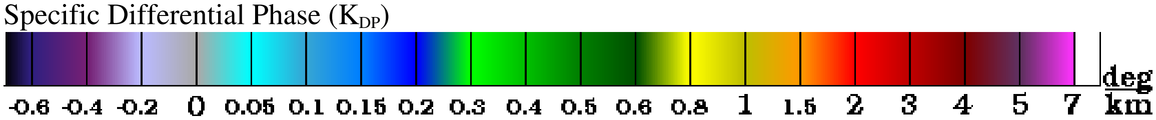
Reflectivity



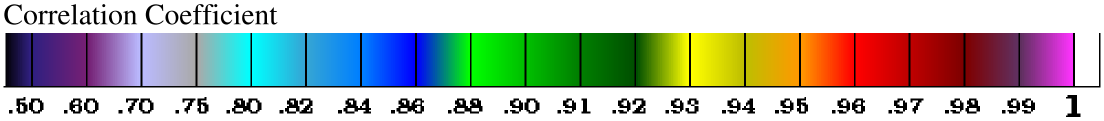
Differential Reflectivity (Z_{DR})



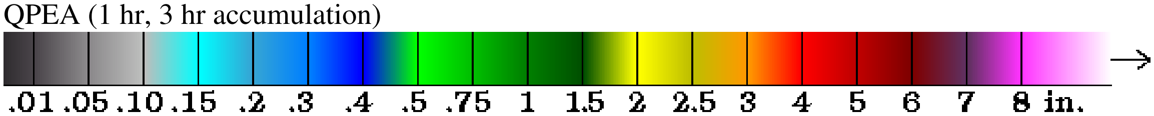
Specific Differential Phase (K_{DP})



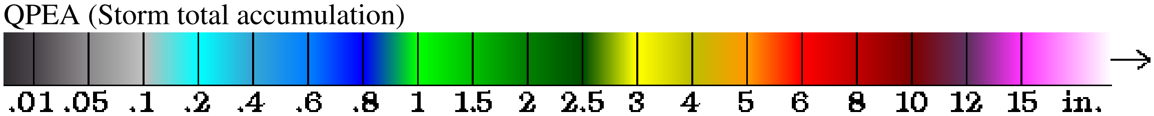
Correlation Coefficient



QPEA (1 hr, 3 hr accumulation)



QPEA (Storm total accumulation)



HCA