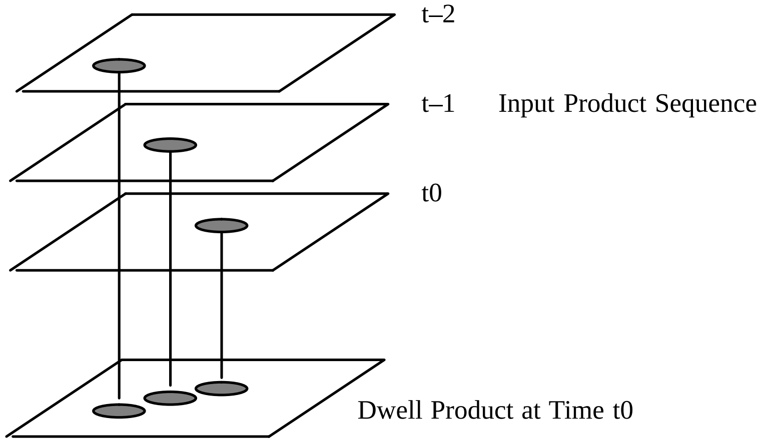
3.3 DWELL Algorithm: Composite in Time

3.3.1 Overview

The DWELL product algorithm is used to composite successive images of a product in time. Moving targets will show a “streak” of echo. The product is similar to the photographic technique of leaving the camera shutter open while photographing a moving target. The background will be fixed and the moving target will show a “blur” behind it. A schematic example is shown below.



The DWELL product algorithm is essentially a “time composite” of the input products. Because of this the product that is generated by the DWELL algorithm is of the same type as the input product. For example, if we “dwell” a PPI product, a new PPI product is generated. However, we have two choices for the type of data that are displayed in the DWELL PPI product:

- **The original input data**: e.g., if a PPI of dBZ is used as input, then DWELL makes a time composite of dBZ. This is useful for showing where precipitation has fallen during the dwell time. When animated, the life cycle of growth, decay and motion of individual echoes can be easily seen.
- **Time:** In this case, the data points in the DWELL product are coded by their age from the time of the most recent product in the DWELL. The display shows a color coded time history of echoes.

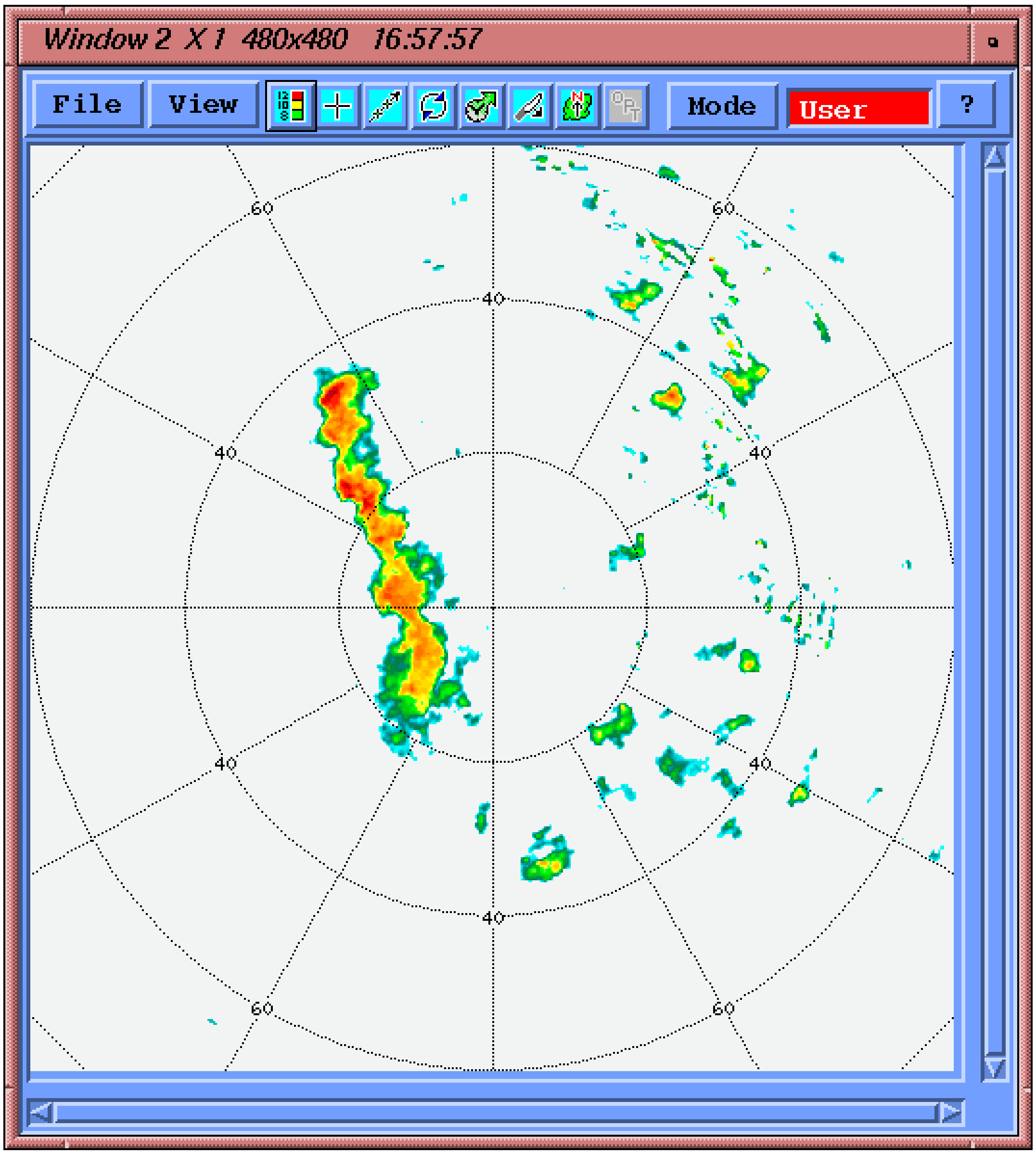
Because DWELL products show the integrated time history of echoes, they are a useful alternative to the track product. There is also a special application of DWELL for airborne target detection, which is used for tracking and automatic warning for the presence of aircraft or migrating bird flocks.

In this section is described:

3.3.2 Dwell Algorithm Examples

The DWELL algorithm takes a series of input products and composites them together in time. Either the original input data values (e.g., dBZ, rainfall rate) or the age of each point (relative to the most recent input product) can be selected for output. The example shown here is for DWELL applied to PPI products. The last (most recent) PPI product in the DWELL sequence is shown below. It shows a squall line in dBZ. The line was moving from east to west and developing/decaying as it traveled.

Figure 3–1: PPI of dBZ at a Single Time



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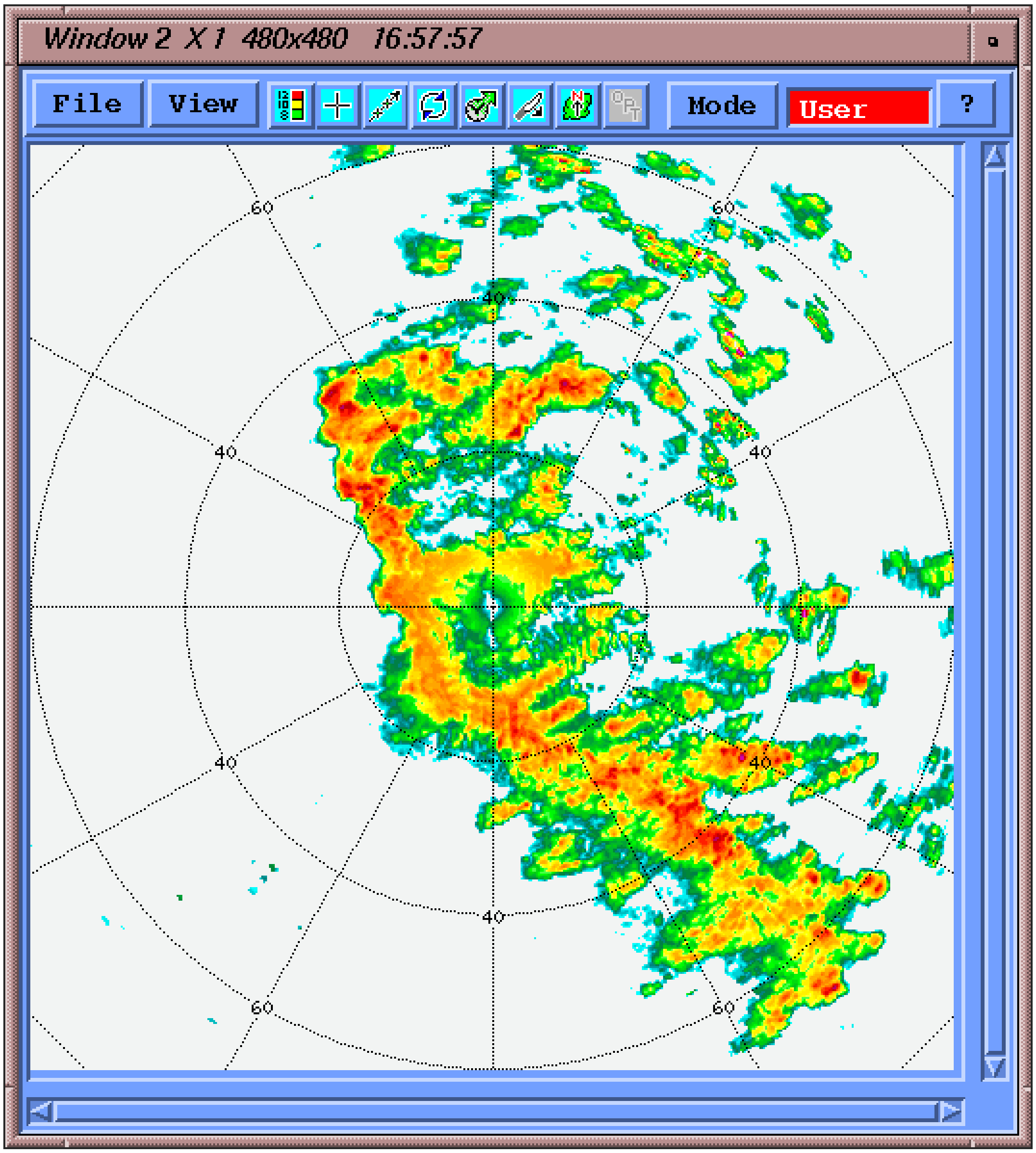
These examples are best viewed in color. See the on–line documentation using the "manuals" interface which can be accessed via IRISnet or by typing "manuals" in a UNIX terminal window.

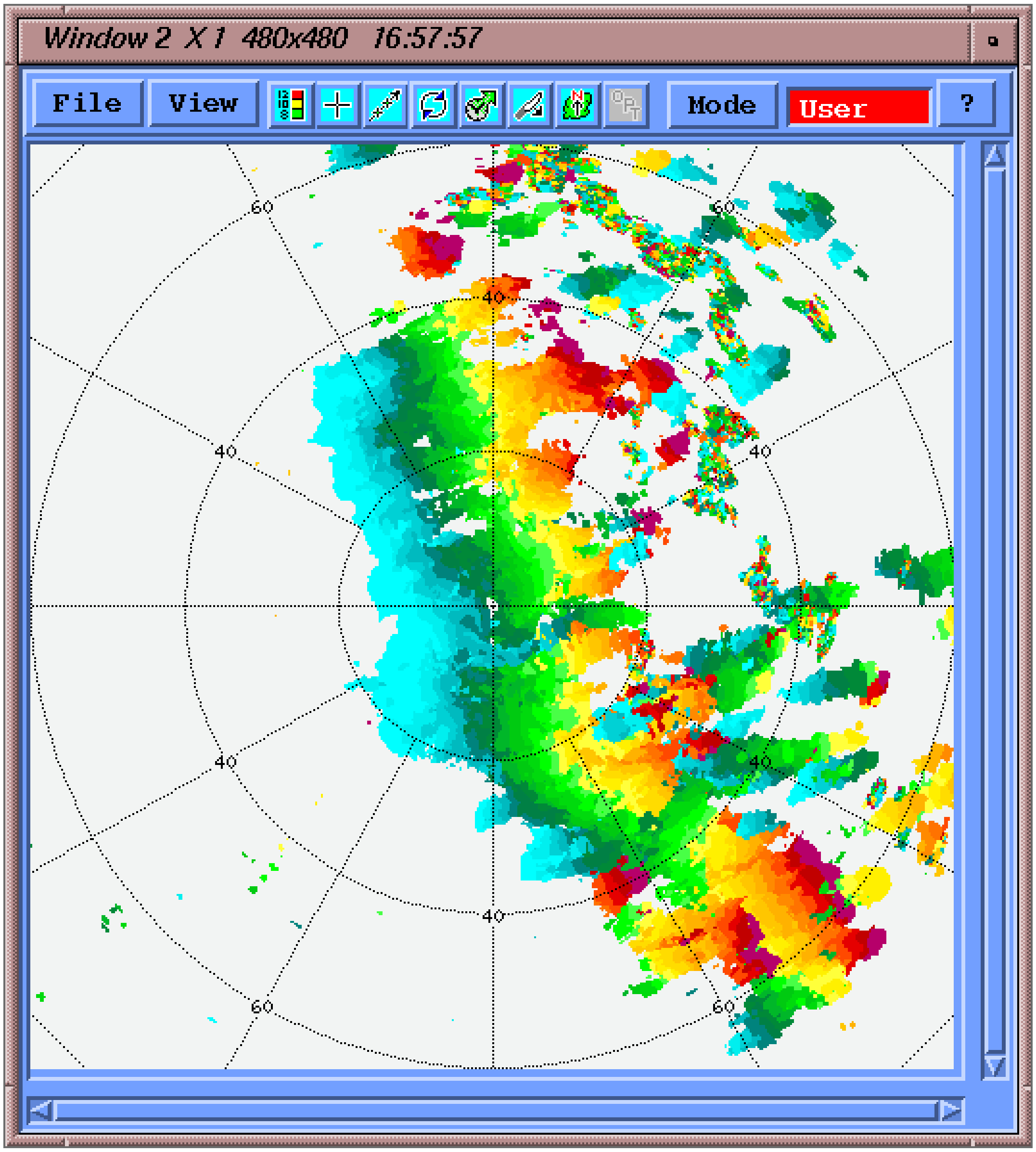
The figure below shows a DWELL of the PPI's for the preceding two hours. This is useful to show where precipitation has fallen during the DWELL period. Animation of this shows the expanding field of fallen precipitation and the echo motion.

Figure 3–2: Dwell of PPI for the Previous 2 Hours Showing dBZ



The final figure in the example shows the age of the DWELL data points, i.e., the number of minutes since the most recent PPI product in the sequence. The color scale is configured so that blue shows the most recent echoes while red shows the oldest echoes. The example shows blue on the left (west) where the current echo is located. The red echoes on the right (east) are the older echoes from earlier in the sequence. This is to be expected for general east to west motion. Residual clutter shows a speckled pattern (e.g., at 50 km to the northeast).

Figure 3–3: Dwell of PPI for the Previous 2 Hours Showing Time (Age)



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Hint: Use your <Page–Up> and <Page–Down> buttons to compare the examples.

3.3.3 DWELL Algorithm and Scheduling

The basic DWELL algorithm (without target warning) takes a series of products from the same site, of a given name and type and merges them together. This section describes how the algorithm works.

Product Scheduling

The DWELL algorithm is scheduled the same as an IRIS product, i.e., via the Product Scheduler. When the Product Scheduler detects an input product beyond the "Next Data Time", this product and all products from the same site, within the specified dwell time (e.g., the last 10 minutes), are combined together to make a new product of the same type. The data stored in the product can be either the data values of the original product or the age of each point relative to the most recent product in the series.

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i **If the DWELL is based on a PPI product where the elevation selection in the PPI product configuration is set to the wild card *, then some care must be used in scheduling since excess CPU loading and performance degradation could result. It is recommended that the Product Schedule "Skip Time" be set to the time required to complete a volume scan or longer. This avoids the DWELL product being produced on the completion of every PPI sweep.**

Input Product Filters

There are three input data filters that can be applied to each input product before it is merged into the DWELL:

- **Min Filter-** discards any pixel in the input product with data value less than the specified minimum value. For velocity, absolute value is used. For the example of a PPI in dBZ, if the minimum value is set to 10 dBZ, all pixels with values less than this are discarded.
- **Max Filter-** discards any pixel in the input product with data value less than the specified maximum value. For velocity, absolute value is used. For the example of a PPI in of dBZ, if the maximum value is set to 50 dBZ, all pixels in the input product with values greater than this are discarded.
- **Contrast Filter-** discards any pixel in the input product with data value not exceeding the corresponding data value in the computed background field plus a selectable threshold. For velocity, the absolute value of the difference between the background field and input product pixel is used. The background field is obtained by first creating a smoothed version of the DWELL product. For the example of a VIL product, if the contrast threshold is set to 3 (mm), then a pixel in an input product must have a VIL 3 mm greater than the corresponding pixel in the background field.

If a pixel fails any of these tests, then it is set to “thresholded”, i.e., no data.

Data Merge

After filtering, each pixel in the input is “merged” into the corresponding pixel in the DWELL output. In the case (for example) when there are ten input products to merge, there is the possibility that there are up to ten possible values for assigning the output value. The merge algorithm simply uses the maximum value. In the case of velocity, the absolute value is used.

Depending on the user selection, the algorithm then stores either the time of the merged pixel or its data value. Time is stored as the “age” of the pixel relative to the most recent input product in the DWELL sequence.

In the special case of merging WARN products, the centroid statistics are simply merged together, i.e., a new WARN product is created that combines all of the centroids in the time sequence of input WARN products.

Background Field

The contrast filter allows relatively strong echoes such as reflectivity cores, birds or aircraft to be isolated from relatively weak background echo. For the target warning algorithm, the contrast filter is essential to detecting airborne targets in weak clear air or weather echoes.

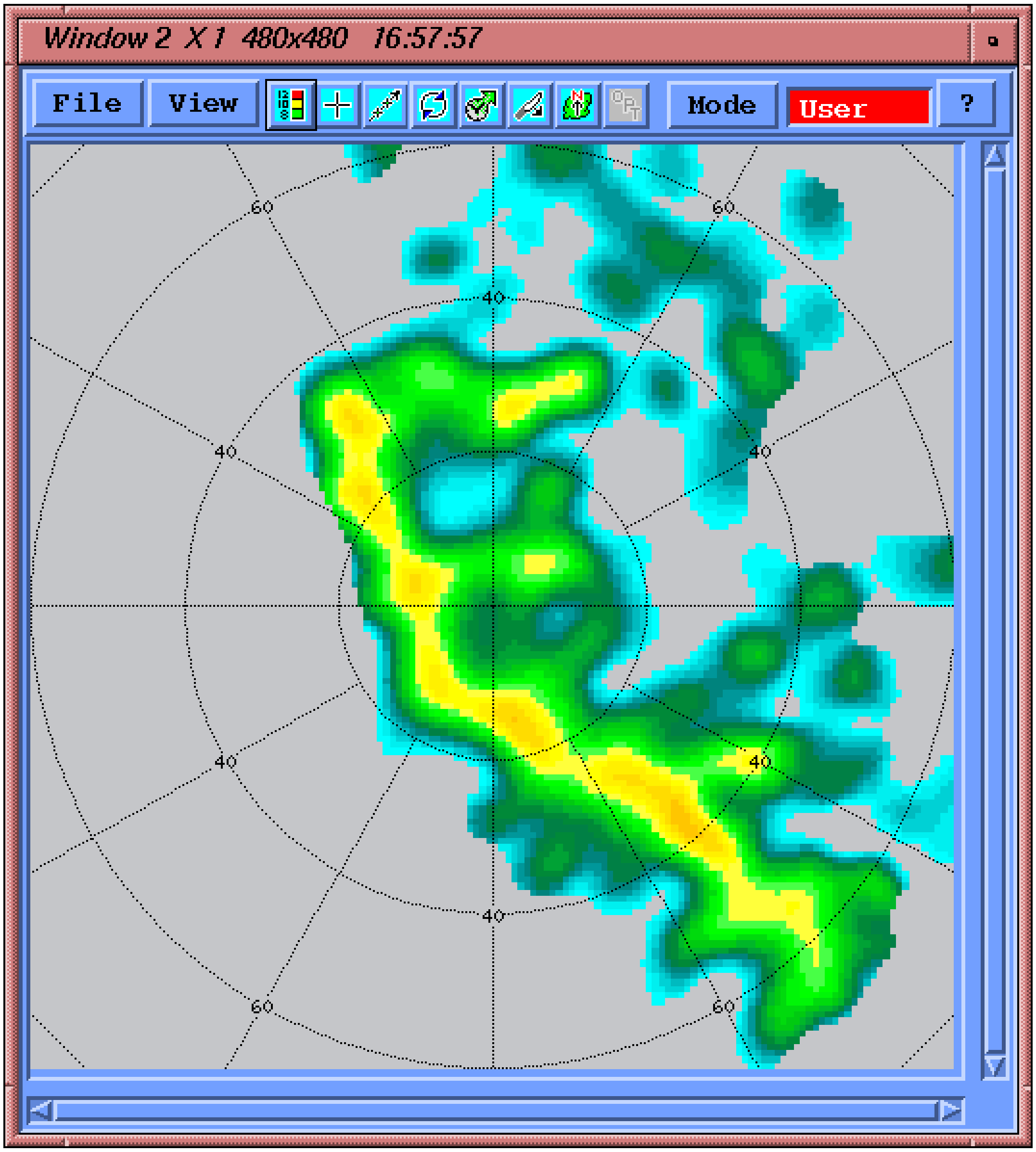
The background field is created by first running the DWELL algorithm without the contrast step and then smoothing the data with a 2D filter. Note that the Max and Min filters are used to filter the inputs to generate the background field. In the special case when the input product is PPI’s at different elevation angles, there is an option to generate the background filed separately for each PPI elevation angle as opposed to simply merging the PPI’s regardless of angle.

The merge algorithm for the creation of the background field is the same as for the main DWELL algorithm (i.e., maximum value), except that for velocity, the average value of the signed velocity is used. The reason for using the Max for everything except velocity is that weather echoes have a natural power fluctuation and these are better removed by the contrast filter if the background field is based on maximum, i.e., the background field has larger values so that fewer weather speckles are passed. In the case of velocity the average value is used to characterize the background field since it does not make sense to use the maximum when every velocity is equally likely.

After the merge, a smoothing filter is applied. This is a 2D averaging filter set to 10 by 10 km or 60 x 60 pixels (whichever is less), centered at the smoother output pixel. A triangular weighting is used to assign more weight to the center pixels. The filter requires a selectable percentage coverage to produce an average value at the center pixel, else a value of “thresholded” is assigned to the center pixel. The threshold is typically set to 20% coverage. This has the effect that isolated point targets such as birds or aircraft are excluded from the background field so that they are not filtered by the contrast filter.

An example of a smoothed contrast filed is shown below for the same case that was presented in the examples (**Section 3.3.2**).

Figure 3–4: background field for 2-Hour Dwell Showing dBZ



The smoothed background field has generally lower echo intensity as a result of the smoothing process. Note that there are no "speckles", i.e., only large scale echo features remain. Thus the background field is a representation of the average background echoes. When this is subtracted from the input products and thresholded (in applying the contrast filter), the background echoes are removed, leaving only the high intensity cores or point targets such as birds or aircraft.

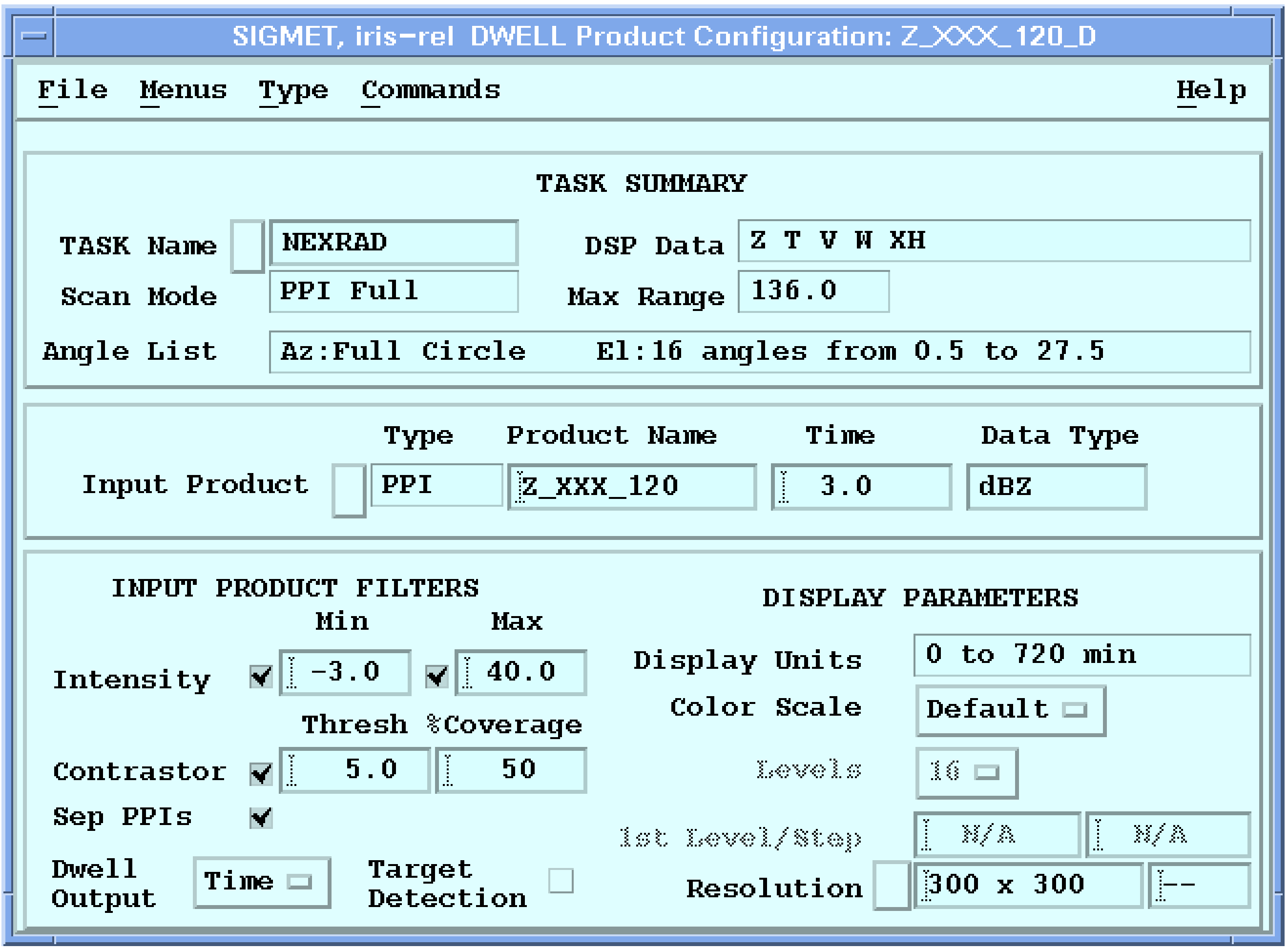
Diagnostic Output for Algorithm Verification

To assist with tuning the DWELL algorithm, especially in the case of target warning, The DWELL algorithm can produce diagnostic output. This is activated by clicking the “Diagnostic” button at the bottom of the target Warning section of the DWELL Configuration Menu. Note that diagnostic output will be produced even if target warning is subsequently disabled, as long as the diagnostic button is clicked-in.

The diagnostic outputs are stored as type USER products. The naming convention is as follows:

- **USER: <productname>DAT or TIM** - The main output of the DWELL product is a product of the same type as the input product (e.g., a PPI) for either the input product data type (e.g., dBZ) or time (age). The diagnostic USER product is for the data type that was not selected for the main output. For example, if dBZ is selected for the main output, the diagnostic USER product is for the time (TIM suffix). If time is selected for the main output, the diagnostic USER product is for the input data type (DAT suffix).
- **USER: <productname>CON -** If the contrast filter is enabled, the diagnostic USER product with the suffix CON shows the background field. An example of this is shown in the previous section.
- **USER: <productname>PIL** - If target warning is enabled, the diagnostic USER product with the suffix PIL shows the “pile” product, i.e., the number of target hits per pixel (X4) for the first in the sequence of the assumed motion vectors (i.e., the first trial). For diagnostic work, the target Warning can be configured to run a single motion vector so that any speed and direction can be isolated for study.

3.3.4 Basic DWELL Algorithm Configuration



The configuration menu for the DWELL algorithm is shown above for the case of Target Detection disabled. The various fields and options are described below.

Naming Convention for File–>SaveAs

It is recommended that the name of the DWELL product be the same as the input product with a "D" appended to the name. For example,

- Input Product Name: Z_005_250
- Dwell Product Name: Z_005_250_D

Another alternative is to put the number of minutes after the D, e.g., Z_005_250D10 to indicate a 10–minute DWELL. Recall that names are limited to 12 characters.

Input Product Type and Name

Select the input product, i.e., the product that you want to "dwell" together. Any of the following can be selected:

- BASE
- CAPPI
- HMAX
- PPI
- RAIN1
- SRI
- TOPS
- VIL
- WARN

In the special case of combining WARN products, the centroid characteristics of all the input products are simply combined together. Therefore, most of the menu features in the DWELL product are disabled, except the DWELL time selection.

Dwell "Time"

This is the time period in minutes for which products will be dwelled-together. For example, when a new PPI product is created or received, this and all PPI's within the last 10 minutes will be included in the DWELL PPI product.

Data Type

A display-only field that shows the data type in the PPI. If you select the "Dwell Output" to be Data (e.g., in the lower left corner), then the DWELL version of the PPI will be made for this data type. In the example, a DWELL PPI of dBZ will be generated.

Input Product Filters- Intensity

Since the DWELL algorithms essentially add-together many products, it is sometimes useful to filter some of the data values that are not of interest. The intensity filter allows you to eliminate any data points that are less than the "Min" or greater than the "Max". Use the button to enable the filter and type in the value. The units are for the "Data Type" of the input product. In the example menu, this would be dBZ.

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i **Hint: It is important to look at an example of the input data to determine how to best set the thresholds.**

A useful application is to set a "Min" threshold to eliminate weak echoes so that the DWELL algorithm result will show only the strongest precipitation cores.

Input Product Filter- Contrastor

i **For target detection, the contrastor is necessary in order to pick–out an airborne target from weak clear air or weather echoes.**

The contrast filter provides a way to eliminate relatively weak echoes so that only the embedded stronger echo cores remain. It first computes a smoothed version of the DWELL (the background echo) and then subtracts this from the original input data to get the final "contrasted" version of the DWELL. Essentially the DWELL algorithm is run twice — the first time to compute the background field and the second time during which the background field is used to threshold the original input data. For more information on the contrast algorithm see **Section 3.3.3**.

The parameters to configure the contrast filter are as follows:

- **Thresh**- Each input product data pixel must be greater than the corresponding pixel in the average background field by this amount, else it is discarded.
- **% Coverage**- The background field is produced by a smoother that averages data pixels in a 10 km by 10 km box that is passed over all the pixels in the fist pass DWELL product. If the percentage of valid (non–thresholded) pixels in this box does not exceed the % Coverage limit, then a value of "thresholded" is assigned to this box, i.e., there are not enough points to compute the average.

Sep PPI's

This button selection only applies to the special case when the input product consists of PPI's at different elevation angles. For example, a PPI product that is made with a * in the elevation angle filed will have every angle in the volume scan. In this case, the background field can be in either of two ways:

- Default Method- all of the angles are simply merged together to compute the background field.
- **Sep PPI's** enabled- the background field is computed separately for each PPI elevation angle and the contrast thresholding is performed separately for each angle before merging the results. This technique is provides better results when there are vertical gradients in velocity or reflectivity. If the vertical gradients are weak then it does not really matter which approach is used.

Dwell Output

Select either one of (see the examples in **Section 3.3.2**):

- **Data-** the DWELL algorithm will produce a time composite product in the same units as the input products. In the example product configuration menu, a PPI of dBZ would be produced.
- **Time-** the DWELL algorithm will produce a product that shows the age of each point relative to the most recent input product. The display of this makes it easy to spot moving targets since they leave a streak of colors ranging from the oldest to the most recent.

Display Parameters

This will reflect the choice of either "Data" or "Time" and you are free to select the color scales as for any other IRIS product. Note that the output pixel numbers cannot be changed since it is controlled by the resolution of the input products.

3.3.5 Target Detection: Input TASK and Product Optimization

The airborne target detection, tracking and warning features of the DWELL algorithm are designed to detect aircraft or flocks of migrating birds and issue automatic warnings. Aircraft and migratory bird flocks tend to move with a fairly constant speed and direction and this property is used to distinguish between airborne targets and other targets. In many cases, targets embedded in weak weather targets or clear air echoes can be distinguished.

As with any automatic detection algorithm, there is a direct tradeoff between the probability of detection and the false alarm rate. For best performance, the scan TASK and the input product generation need to be optimized as discussed below:

Scan TASK Optimization

Target detection requires that extraneous targets such as clutter, second trip echo and noise be eliminated. The update rate should be fairly rapid to resolve the target motion and provide more continuous information on the target locations. Some knowledge of the likely altitudes of flight is required to construct the volume scan TASK. The maximum range of detection depends on the performance characteristics of the radar. Typically about 60 km detection range can be expected for a 1 to 1.5 degree beamwidth antenna.

For target detection, the scan TASK should be optimized as follows:

- Maximum range of 60 to 100 km.
- Maximum resolution permitted by the signal processor (e.g., 125 meters). This will depend on the processor performance characteristics.
- Maximum PRF and minimum pulse width.
- 2nd trip echo cancelation. On magnetron systems, SQI thresholding of the dBZ may be used in lieu of this. This will discard non-coherent targets such as 2nd trip echoes.
- Ground clutter filtering with an aggressive CSR threshold (lower value). The value depends on the radar phase stability performance characteristics but will typically be in the range 10 to 20 dB. The goal here is to completely eliminate strong clutter targets which could produce false alarms.
- SQI adjusted higher than usual (e.g., approximately 0.45). This is to eliminate velocity speckles which could produce false alarms.
- LOG adjusted higher than usual for weather. This is to eliminate speckles in intensity which could produce false alarms.
- The speckle remover should be disabled so that single bin targets are passed. These could contain a point airborne target.
- Few elevation angles covering only the heights of interest to a range of approximately 60 km. This allows more rapid updates. For example, for a 1

degree antenna beam, the 5 elevation angles of 0.5, 1.5, 2.5, 3.5, 4.5 would provide continuous vertical coverage up to 2 km (nominally 6000 feet), from 25 to 60 km. At 10 km the coverage would be to 2600 feet above the radar.

- Moderately fast scan rate (>3 RPM) consistent with rapid updates, but still allowing approximately 50 pulses per antenna beamwidth. For example a PRF of 1000 Hz and a scan rate of 3 RPM (18 degrees per second) would provide 1000/18=55 pulses for each degree of antenna motion.

Input Product Selection and Optimization

The input product types suggested for target warning are:

- PPI of dBZ or radial velocity at single or multiple sweeps.
- VIL covering the layer of interest.

Radial velocity is recommended for discriminating between airborne targets and background clear air or weak weather echoes. The reason is that airborne targets, such as aircraft or birds, move at a different velocity than the air so that, provided the targets are stronger targets, they will produce a velocity anomaly which will be passed by the contrasting algorithm. In the case when the motion of the target is perpendicular to the radar beam, the clutter filtering can remove targets so there is a possibility of some “blind” sectors because of this.

VIL is also a useful product for target warning since it integrates echo over a selected layer. Single PPI products can be used, but since they are at only one elevation angle, not all heights are covered. However, a PPI product made with the wild card * in the elevation selection can be used to combine together all the PPI’s in a volume regardless of the elevation angle. In this case, the DWELL algorithm will run at the completion of every sweep, and since the algorithm is intensive, the system may not have enough CPU power to do all of the DWELLs plus the other functions (e.g., user display, animation, other product generation, communication). The DWELL product generation would then fall behind real time. Therefore if all of the PPI’s are used, it is recommended that the DWELL product schedule entry use the “Skip Time” feature of the product scheduler, set to the time between volume scans. Thus a new DWELL product is produced on the completion of the volume scan rather than on completion of each individual PPI.

Some general tips for configuring the input products for target detection optimization are:

- The maximum range and the pixel resolution should be set so that the resolution of the original input data is preserved. For example, for 125-m bin spacing to 45 km, the product pixel size should be set to 720 X 720 (corresponding to 90 km diameter and 0.125 m per pixel).
- The product smoother must be set to 0. This is so that isolated single-bin targets are not removed.

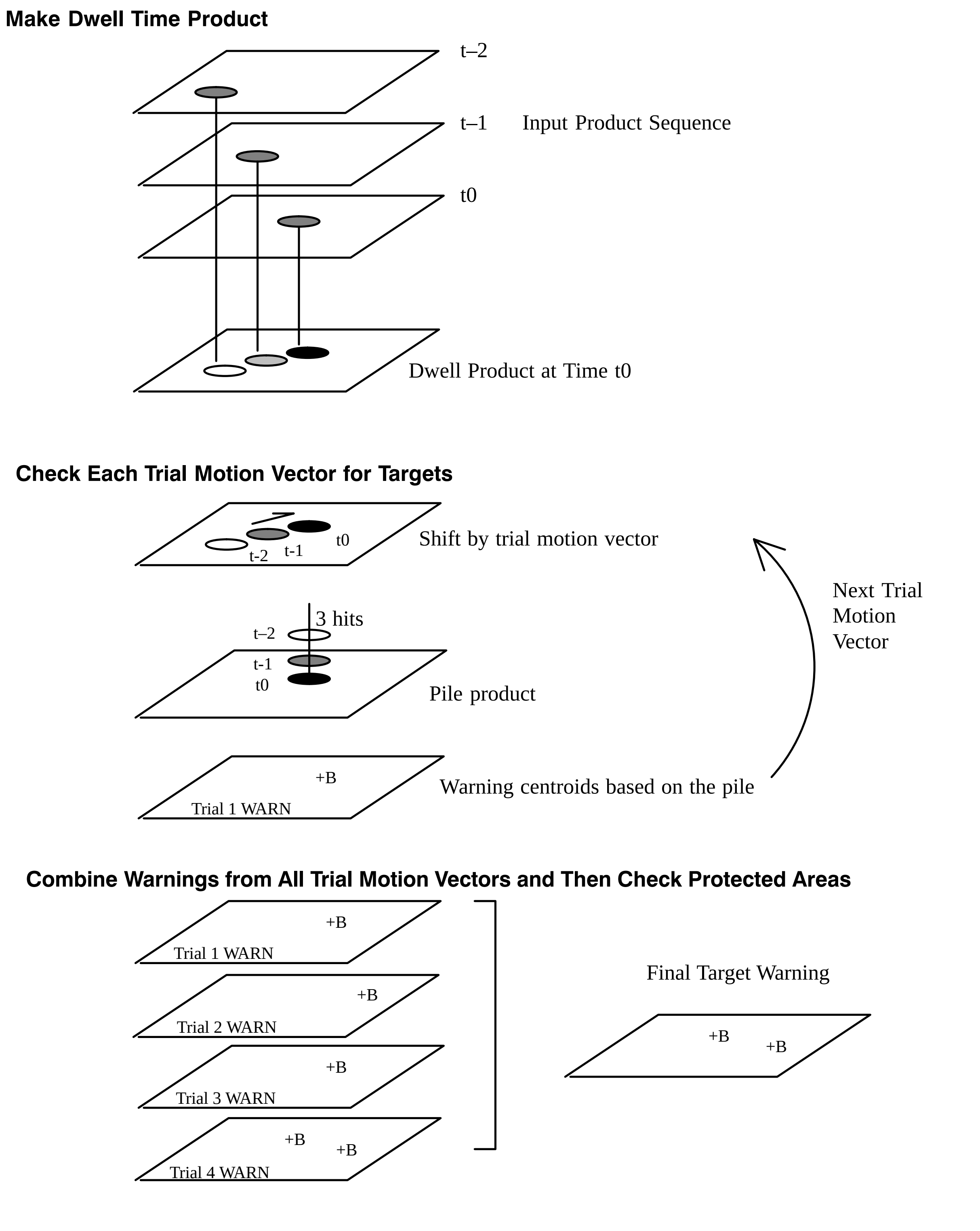
3.3.6 Target Detection: Algorithm and Configuration

Algorithm

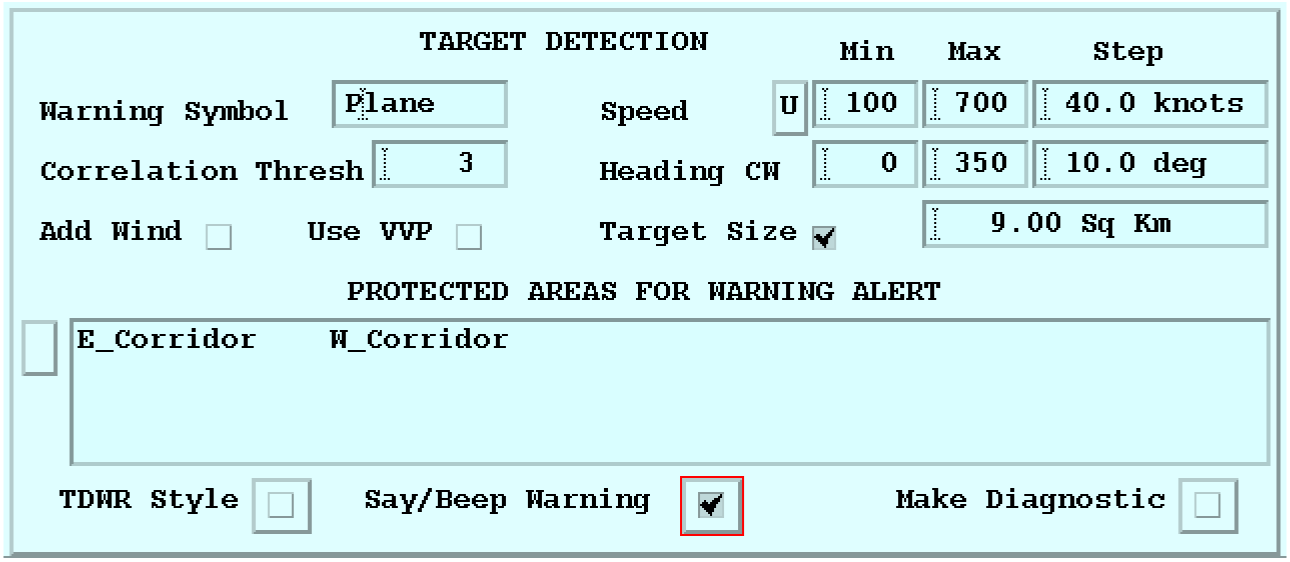
The target detection algorithm is shown schematically below. The algorithm uses a series of motion vectors, spanning the possible range of target speed and direction, to shift a time DWELL product. Targets whose motion matches the assumed motion vector will “pile-up”. The depth of the pile provides a measure of the “coherent motion” of the target. Essentially this is an autocorrelation approach. The various steps are:

- A time DWELL product is made in the usual manner. Note that if the target warning is enabled, then even if a data DWELL product were requested, the time DWELL would be created for the warning.
- The time DWELL points are shifted back in horizontal space according to a trial velocity vector. Targets that are moving at a constant velocity will be “piled” on top of each other. The output of this step is an intermediate “pile” product which has the number of data points that are accumulated (piled) on each pixel.
- A warning/centroid algorithm is then run using a selectable threshold for the number of “pile” points. The approach is identical to the standard IRIS WARN product described in **Section 2.20.** Note that the pile product units are 4X the actual number of points, e.g., for a pile of 3 points, the representation would be 12 in the diagnostic pile product (PIL).
- The previous two steps are repeated for each trial.
- After all trials have been run, the centroid products for each trial are combined to eliminate “double hits” which occur for the same flock, i.e., there may be several trial winds that produce centroids of sufficient intensity (pile number). The combination combines all centroids that are within 3 km of each other by choosing the one with the largest pile number.
- The resulting combined warning product is then checked for protected areas that have been hit.
- The final output WARN product is named using the same name as was assigned to the DWELL product.

Schematic of Target Warning Algorithm



Target Detection Configuration



The Target Warning features are activated by clicking the Target Warning button in the main DWELL Configuration Menu. A new section of the menu appears at the bottom of the main menu (see above). Some of the features are described in the WARN product configuration menu in **Section 2.20.** The special configuration options for target detection are described below:

Warning Symbol

Enter the name of an icon to display. If no icon exists by this name, then the text that is entered shall be displayed at each centroid location. The icon will be automatically rotated to point in the direction of target motion. In the example above, “Plane” is an icon of an airplane that is flying to the north. Bird icons are also provided.

Correlation Threshold

This is the threshold for the number of points in the “pile” product X4. For example, the number 8 represent 2 points. Note that the smoothing in the pile product typically reduces the number of points from the maximum value. Thus a pile product value of two would actually correspond to a greater number at very sharp maximum.

---

i **The correlation threshold is the primary tunable parameter to optimize the probability of detection and false alarm rate.**

i **The appropriate value of the correlation threshold will depend on the length of the DWELL sequence. Longer DWELL times (more input products) produce larger "piles".**

Add Wind, Use VVP, Speed and Heading Range

The track of the targets is used during the "pile" process to add up targets that are moving at the expected velocity. The velocity of the targets is the result of the target's flight (air velocity) and the wind. These fields are used to account for these effects.

Add Wind specifies whether you want the wind effect to be added to the target flight velocity vector. If this is enabled, the **Speed Range** should be interpreted as the expected range of speed of the targets in still air, i.e., their flight speed.

---

i **If you choose not to use the Add Wind feature, then the range of speeds must include the expected variation in the wind speed as well as the target speed. The greater range of speeds results in more false alarms and requires more trial winds (slower algorithm performance).**

If you select Add Wind, then the "Use VVP" button controls is where does the algorithm get the wind. If selected, then the UNFOLD VVP product is used for mean wind information. Otherwise the **setup** product section has a default wind speed and direction. In tropical maritime trade wind regions this could be set fairly reliably to a single value of speed and direction. However, for most regions of the world, the default wind would usually not be a very good value. However, it is the value that is used by IRIS when there is nothing better around to use. This value can be changed in real time using our **setup_change** utility.

Target Size

If this button is clicked–in, then the DWELL "pile" product will be further qualified to remove all large piles. The number entered is in square km. This is to reduce false positives. If there is a squall line moving in the same direction as the expected airborne targets, it will normally generate target warnings. These warnings generally have a larger area than the true targets, so you can filter them out.

Diagnostic Output

If this button is clicked–in, then DWELL will product three diagnostic products. These will be stored as USER products under the same product name assigned to the DWELL product and a suffix indicating the type of diagnostic (DAT or TIM, CON and PIL). See the description of these diagnostic products in **Section 3.3.3.**

Target Detection Data Format

The target detection algorithm generates a standard IRIS WARN product. Part of that warning_results structure are 3 data values. For normal WARN products, these contain the average and maximum data values within the detected centroid. When generated with the target detection algorithm, these contain:

- The average and maximum height of the target returns in km.
- The average and maximum pile height.
- The average and maximum elevation angle of the target returns in degrees.

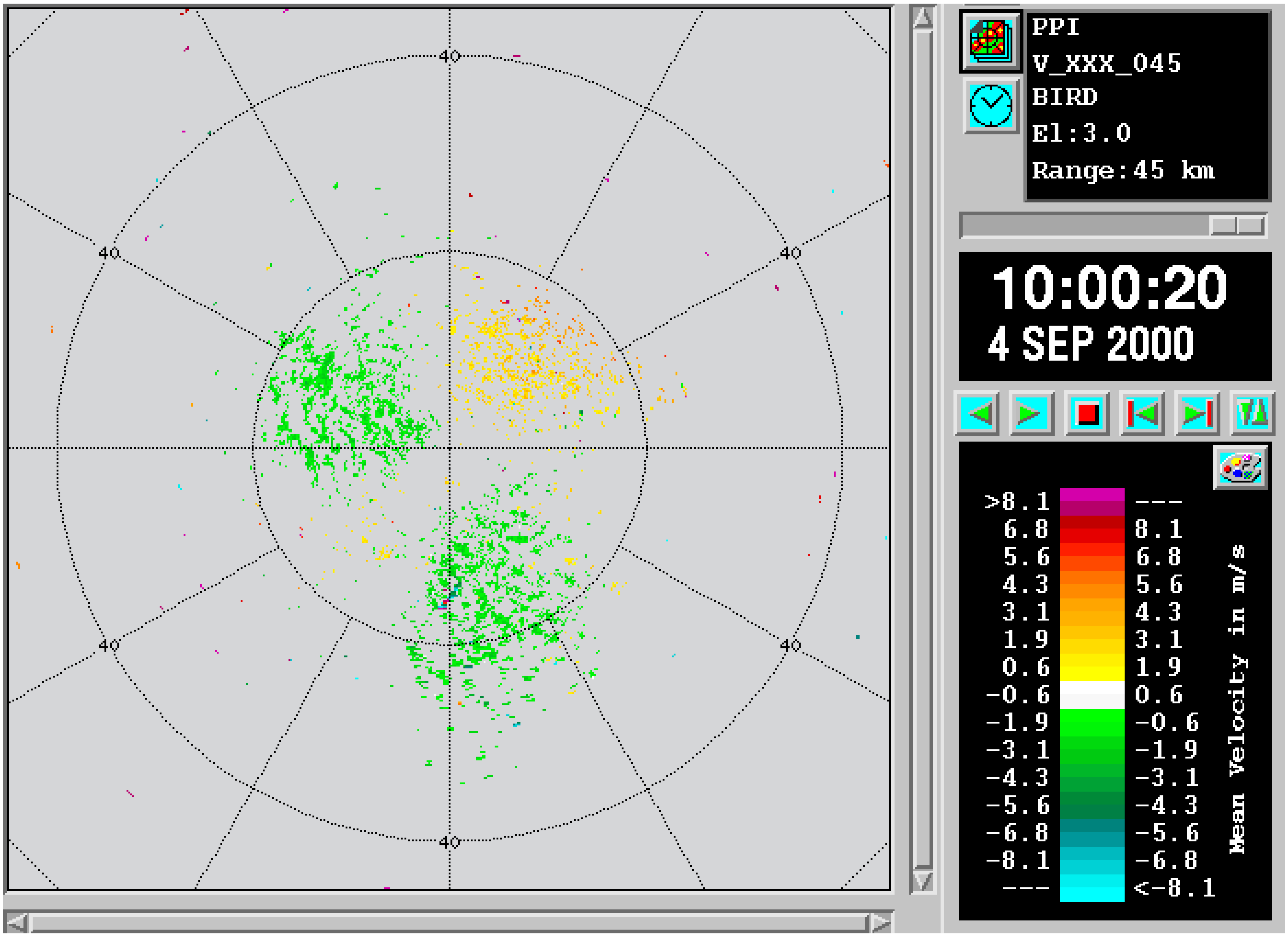
3.3.7 Target Detection: Migratory Bird Examples

The following examples are for bird tracking during a fall migration. Targets are primarily flocks of large storks comprised of 30 or more individuals. These were traveling from northeast to southwest (heading range of 200 to 250) at about 12m/s (speed range of 8 to 16 m/s).

These figures show various products and displays produced by the Target Algorithm.

i **Note: These examples are best viewed in the on–line manuals in color.**

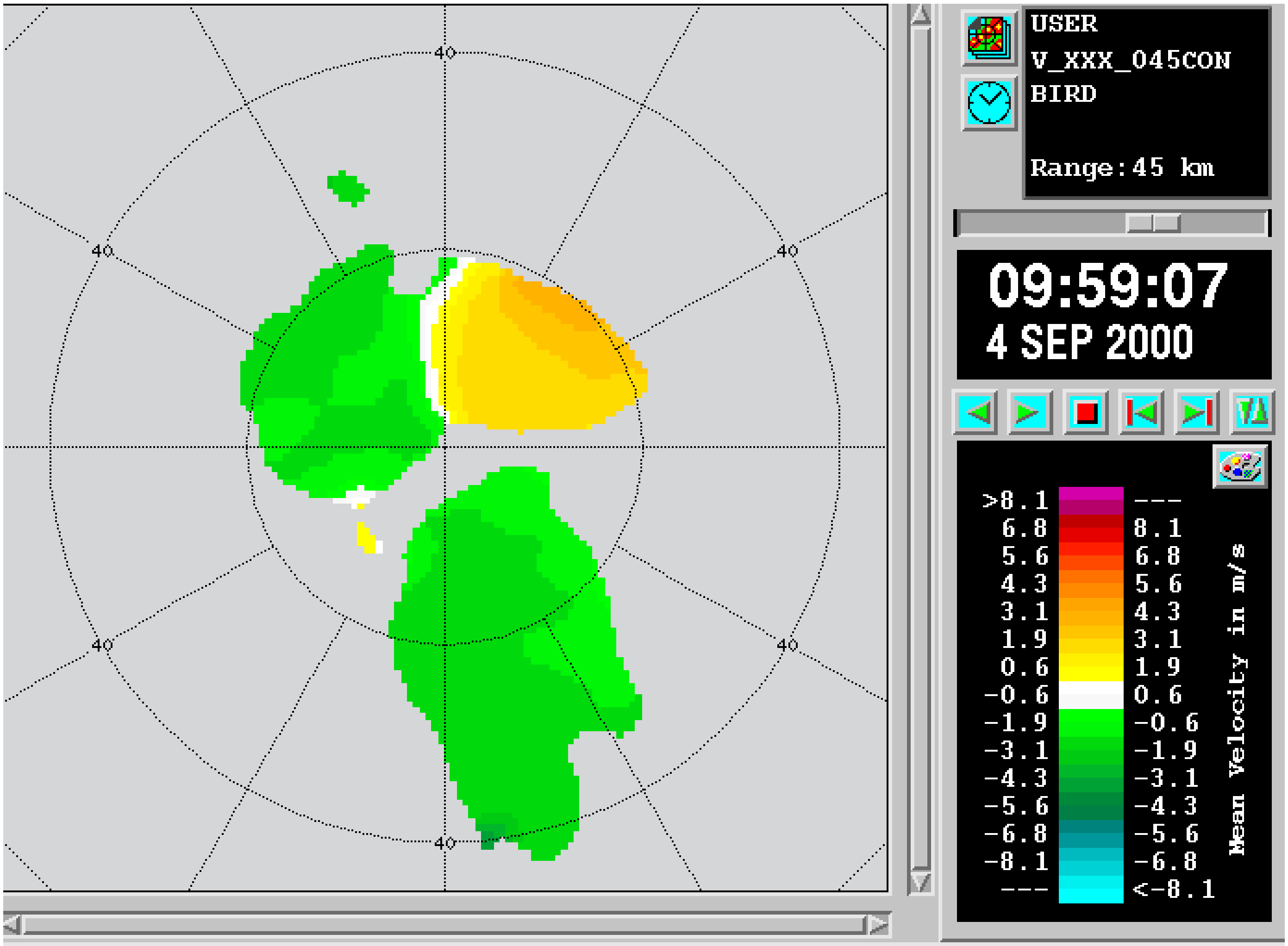
Input PPI's of radial velocity



The input data were based on a volume scan of four elevation angles at 0.5, 1.0, 2.0 and 3.0 degrees elevation angle. The input resolution is 125m. PPI's of radial velocity to 45 km range for all angles are used, i.e., a product named V_XXX_045 is generated with the wild card * in the elevation selection. A product pixel resolution of 720 by 720 is used to match the 125–m input data resolution.

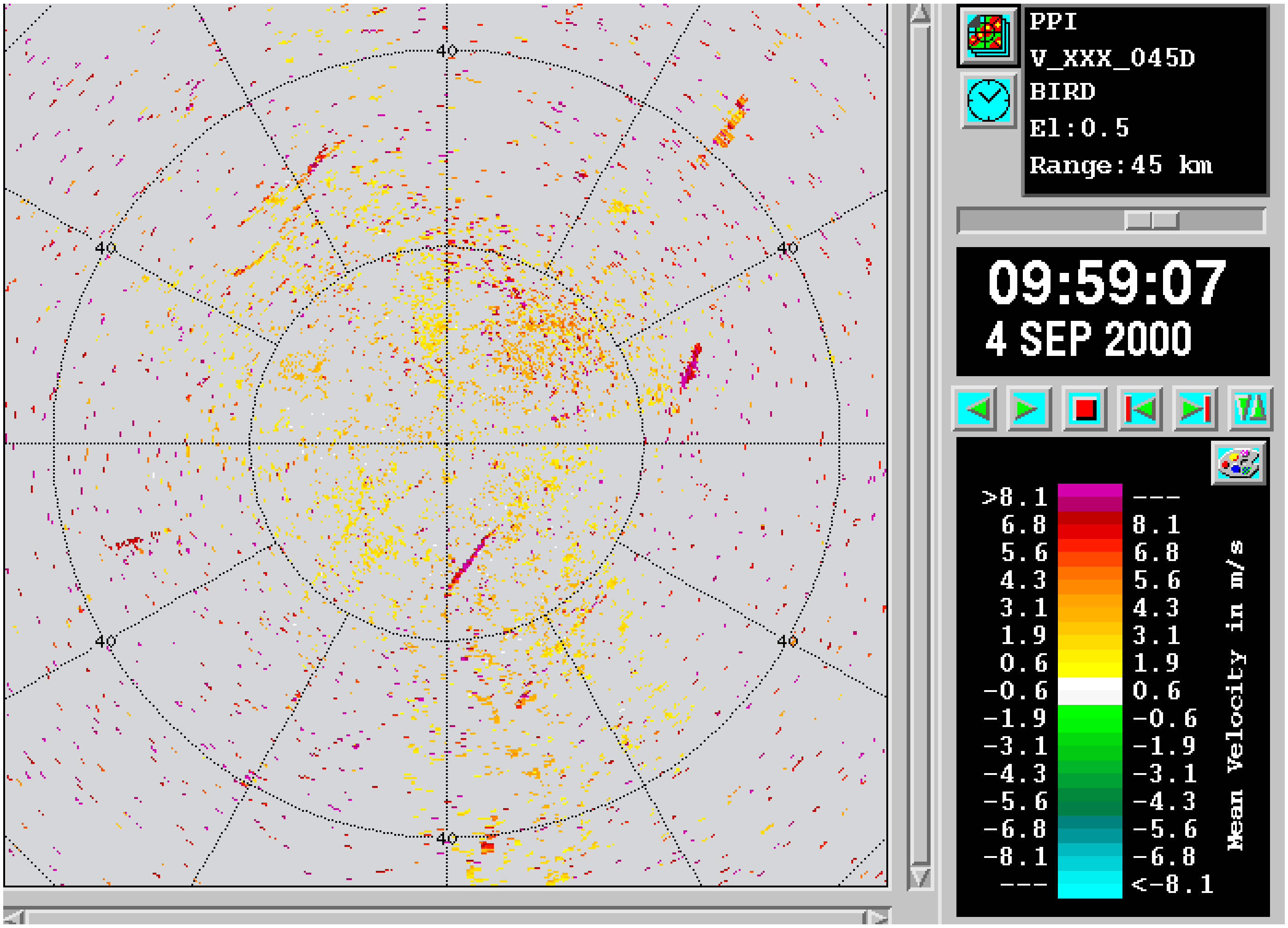
The figure below shows an example of a 3 degree elevation PPI. There is clear air echo only and winds are generally weak. At 15 km south of the radar there is a velocity anomaly that will later be identified as a bird flock. There are other airborne targets as well, but since they may only be 1 or 2 pixels, it is difficult to separate these from the background noise and clear air echo.

Background Field



The contrast filed is a smoothed version of the DWELL data which is used as a dynamic threshold for the contrast filter. For this example a minimum coverage criterion of 25% was used. The DWELL is 10 minutes. Note that aggressive clutter filtering has removed nearly all of the clear air echo at zero velocity. Also not that only the large scale echoes are included in the background field. This is important, otherwise airborne targets would be removed during the contrast step when this background velocity is subtracted.

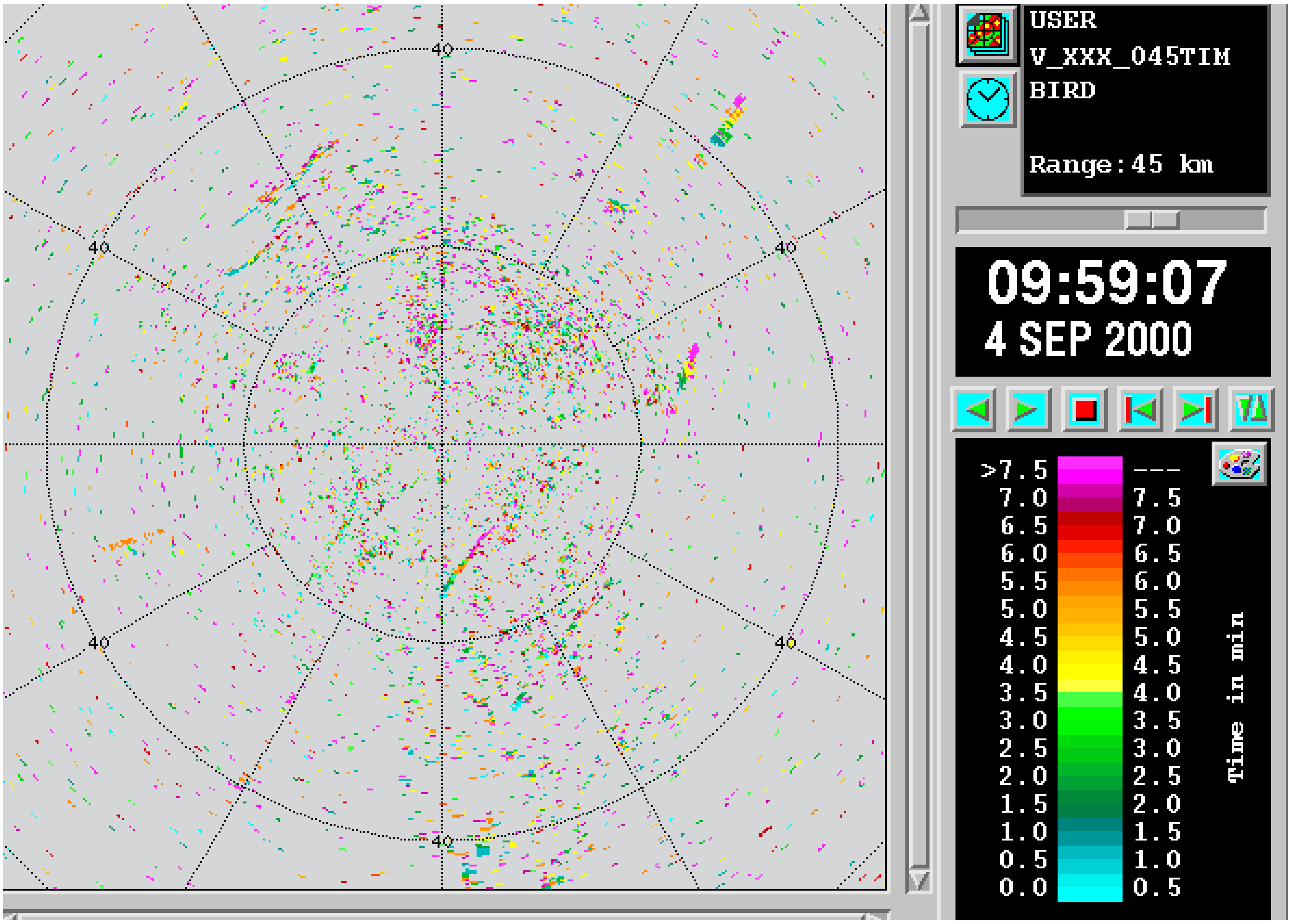
Data Dwell Product



The data DWELL product (data was selected as the primary output) is a PPI product combining all of the PPI's from all elevation angles for the prior 10 minutes (22 PPI's in this case). Only positive values are included since the output is the absolute value of the velocity anomaly as compared to the background field. A contrast threshold of 1 m/s was used, i.e., only data points that differ from the background field by more than 1 m/s are included in the DWELL PPI product.

This shows streaks of velocity anomaly which are likely bird targets. Note that all of the speckles in all of the PPI's are unfortunately passed through the DWELL algorithm. Also note that most of the clear air echo has been effectively removed by the contrast filter.

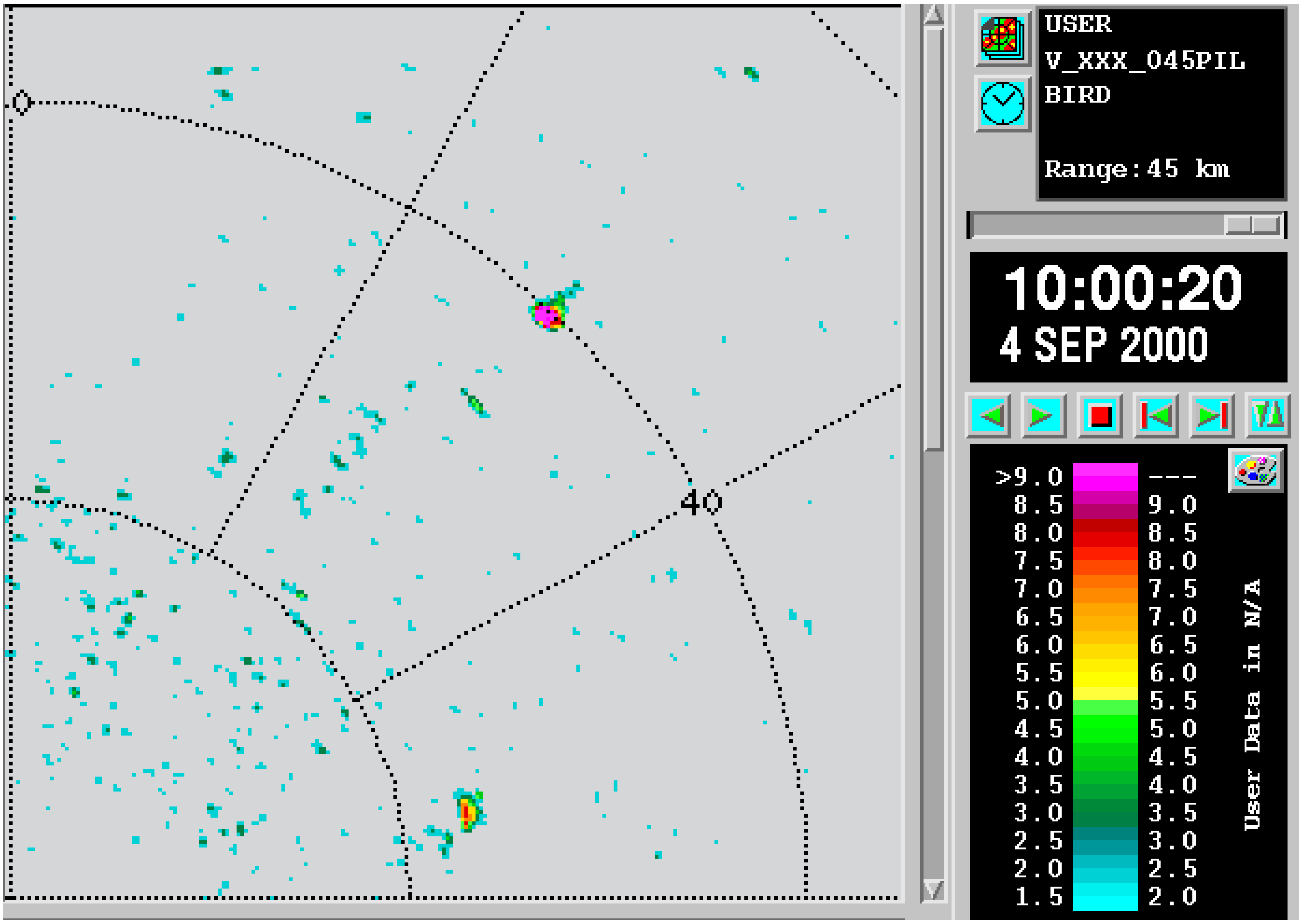
Time Dwell Product



The time DWELL product shows the age of the points in minutes. The most recent points are represented in blue and the older points in red. This clearly shows the streaks of motion from northeast to southwest. This is even more apparent in animation since the streaks move across the screen to the southwest.

The random noise shows a chaotic speckled pattern in time. There is a streak of interference echo which shows only a single color (to the southwest at 30 km).

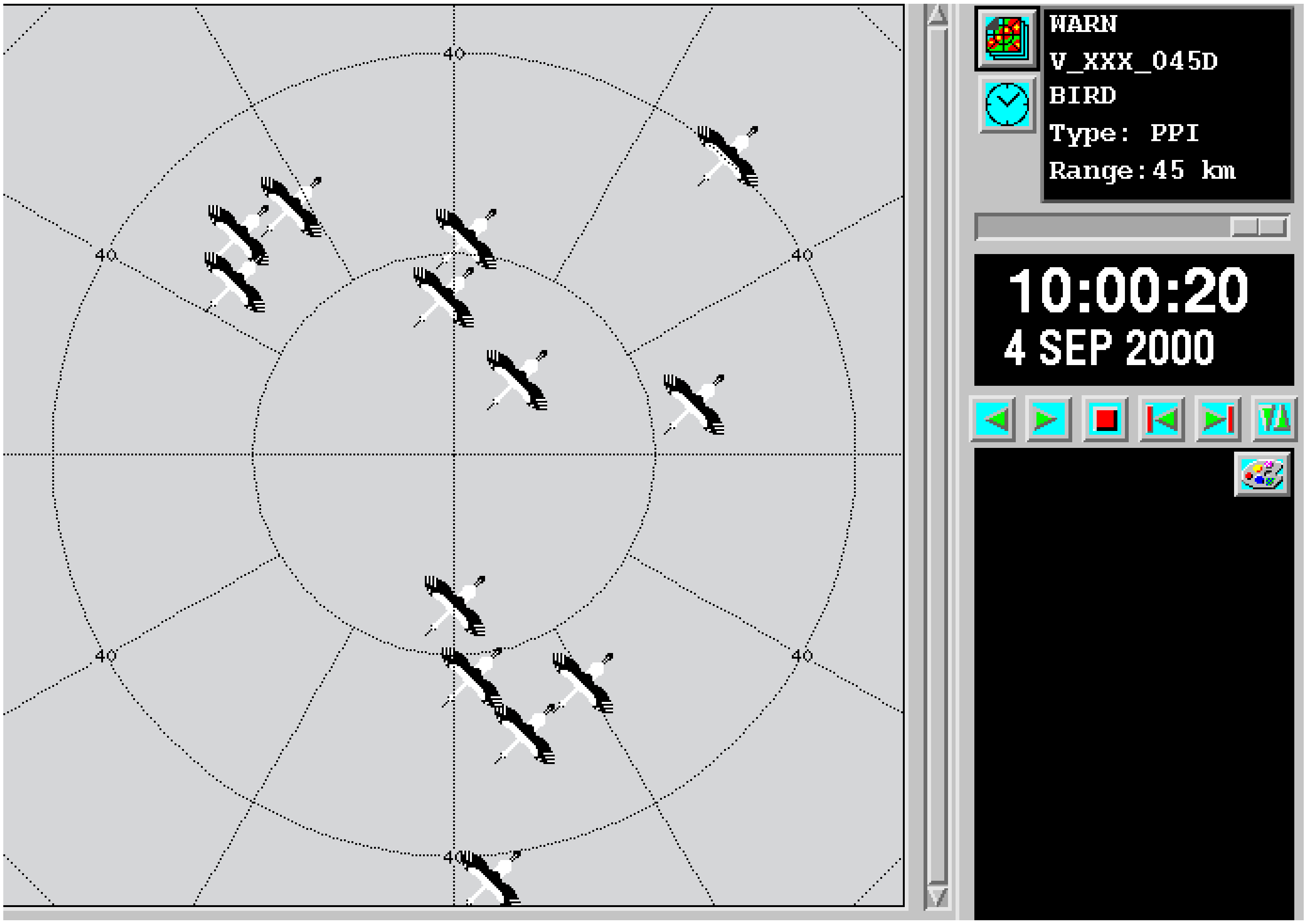
Pile Product (2X Zoom example)



This shows the result of correlation step in which the time DWELL points are "piled". Since each trial wind produces a different pile product, the diagnostic output only shows the pile product for the first trial wind. In this case the result for the particular trial wind of 210 degrees and 12 m/s was selected by inputting only these values into the limits for for the speed and direction ranges.

The results show that the coherent streaks of echo as seen in the DWELL time display are effectively "piled-up" by this trial wind, while background noise produces only weak values. Not all streaks produce a large value since the targets may be moving at a different velocity. This is why it is important to use a spectrum of trial winds.

WARN Product

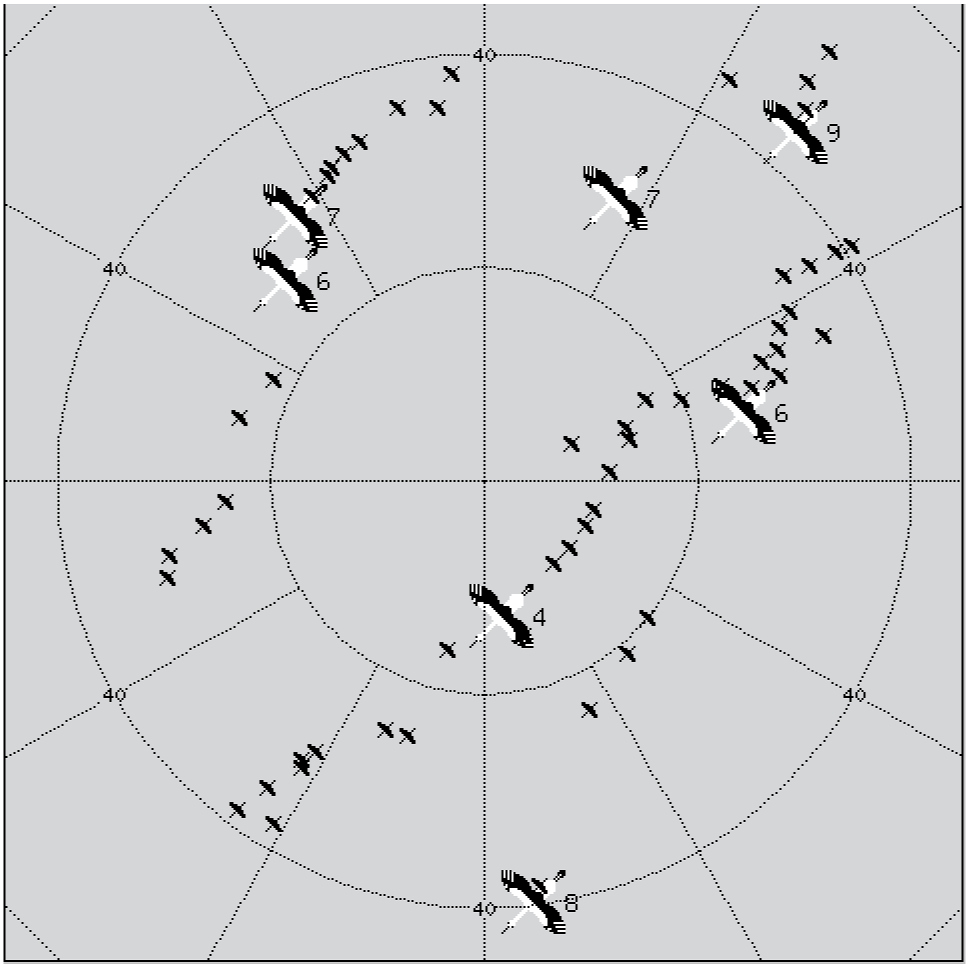


The final result is a warning product based on a composite of all warnings for all trial winds. This example used a threshold of 8 for the correlation threshold (pile product value). The icon here is drawn to make a clear indication of the type of warning.

Alternatively, the warning display can be configured via the output options button to display the numerical value of the height in Kfeet of the bird flock beside the icon, or to display the speed in knots of the flock. The height information is only available for track detection based on PPI input products since there is no height information available from the other input products that can be used for DWELL (e.g., VIL and TOPS).

When this is animated, the birds appear to fly across the screen at their proper velocity. Some icons may drop in/out if they are small flocks on the edge of detection. Occasional false alarms will show as isolated flashes during animation. The primary tuning parameter to balance the probability of detection and false alarm rate is the Correlation Threshold (pile height).

Dwell WARN Product



The example above shows the results of the DWELL algorithm run on WARN products generated by the bird warning feature. This display is recommended for use by air traffic controllers who must advise pilots of possible bird activity. In the example above, the individual bird warnings are dwelled for 45 minutes. The display shows the selected icon (in this case a large bird) at the position of the most recent warning in the dwell sequence. Prior warnings are shown using a different icon which is also rotated to the direction of motion. The prior warning icon name is made by appending “d” (short for dwelled) to the primary icon. In this case we get “birdd.xbm”.

The result is a track style display that shows the bird activity over the dwell time. Inactive tracks do not have the large bird icon at the end. Tracks can become inactive if the birds fly into an obscured region or if the flock is small near the threshold of detection or if the birds stop to roost or perhaps “funnel” in a local thermal to gain altitude. However, even inactive tracks show controllers that there is confirmed bird activity in the area near the last sighting.