Annual Update to the WSR-88D Tropical Cyclone Operations Plan and Lessons Learned from the 2005 Hurricane Season

Technical Advisory Committee

21-22 March 2006

Dan Berkowitz and Dave Zittel

Outline

- 2006 update to the WSR-88D Tropical Cyclone Operations Plan

- Lessons learned from the 2005 hurricane season

2006 Update to the WSR-88D Tropical Cyclone Operations Plan (TCOP)

Dan Berkowitz,

ROC Applications Branch

Objective of WSR-88D TCOP

- Guidance on the use of the WSR-88D during tropical cyclone events
- Updated annually
- *Operational* reference
- Local modifications made as allowed by the Unit Radar Committee

The WSR-88D TCOP is considered part of the **NATIONAL HURRICANE OPERATIONS PLAN**, maintained and posted on the Internet by the Office of the Federal Coordinator for Meteorology (OFCM).

http://www.ofcm.noaa.gov/nhop/wsr-88d/nat_trop_cyc_wsr-88d_ops_plan.pdf

Major Changes in 2006

- System Changes
  - Coastal WSR-88Ds switched to ORDA by start of hurricane season
  - Use of GMAP for clutter suppression
- WSR-88D Build 8 RPG Changes
  - Main HCI window
  - Clutter suppression window
  - Mode Selection Function window
  - Precipitation Status window
  - Corrections to VCP 121 velocity measurement increment (VMI) selection and rpgdbm task
- AWIPS/WSR-88D Communications
  - WAN One Time Requests (OTRs) replace old/limited product requests by AWIPS
- TCOP Procedures
  - Velocity 256-data-level products recommended instead of 8-data-level products

AWIPS Sites Using WAN OTRs

- AWIPS OB6 sites do one-time requests (OTRs) through a special WAN port on the RPG.

- "**Sites … should be aware that … this type of connection could … [impact] the ability of other NWS users to obtain products via WAN OTR.**"

Lessons Learned from the 2005 Hurricane Season

Dave Zittel

ROC Applications Branch

Overview

- Summary of Lessons Learned
- Review of Multi-PRF Dealiasing Algorithm (MPDA) and VCP 121
- Examples of velocity dealiasing with Hurricanes Charley ('04), Emily and Katrina ('05)
- Task failures at Slidell, LA (KLIX) w/Katrina
- Communicating instructions to the field
- Human factors issues with AWIPS velocity products

Summary of Lessons Learned

- Changing velocity increment (VMI) from 0.97 kts (0.5 m/s) to 1.94 kts (1.0 m/s) caused inadvertent problems for the MPDA (VCP 121)
  - **Fixed in Build 8**

- Memory leak in "rpgdbm" task caused it to fail, and then other tasks failed
  - **Fixed in Build 8**

- Multiple dissemination paths are necessary to get important instructions to the field
  - EMRS
  - E-mails
 - Phone calls

Summary of Lessons Learned (cont'd)

- Design of velocity color tables and products is important.
  - AWIPS 8-bit velocity product doesn't show the velocity increment (VMI) in use
  - CCR for AWIPS may be needed
- More robust communications are needed.
  - Region-wide loss of communications for AWIPS and WSR-88D (narrowband and wideband) occurred.
  - Heroic efforts of ROC, NWS Southern Region Headquarters, FAA, and Navy helped restore communications
  - NWS is researching use of satellite as backup

Radars performed well under extreme conditions

MPDA Overview

- Reduces range folding (purple haze) by combining up to three sequential scans of velocity data (at the same elevation angle) each with a different PRF
  - A range gate that is folded at one PRF may not be range folded at a different PRF
  - The use of more than one PRF per range gate provides better velocity dealiasing than a single PRF
  - Time to complete scans is sufficiently short so that features are not distorted by translation or evolution

- **Recommended by the TCOP and preferred by Tropical Prediction Center during hurricane situations**

MPDA Example

✂21 m/s

✂27 m/s

✂32 m/s

VDA

VDA

VDA
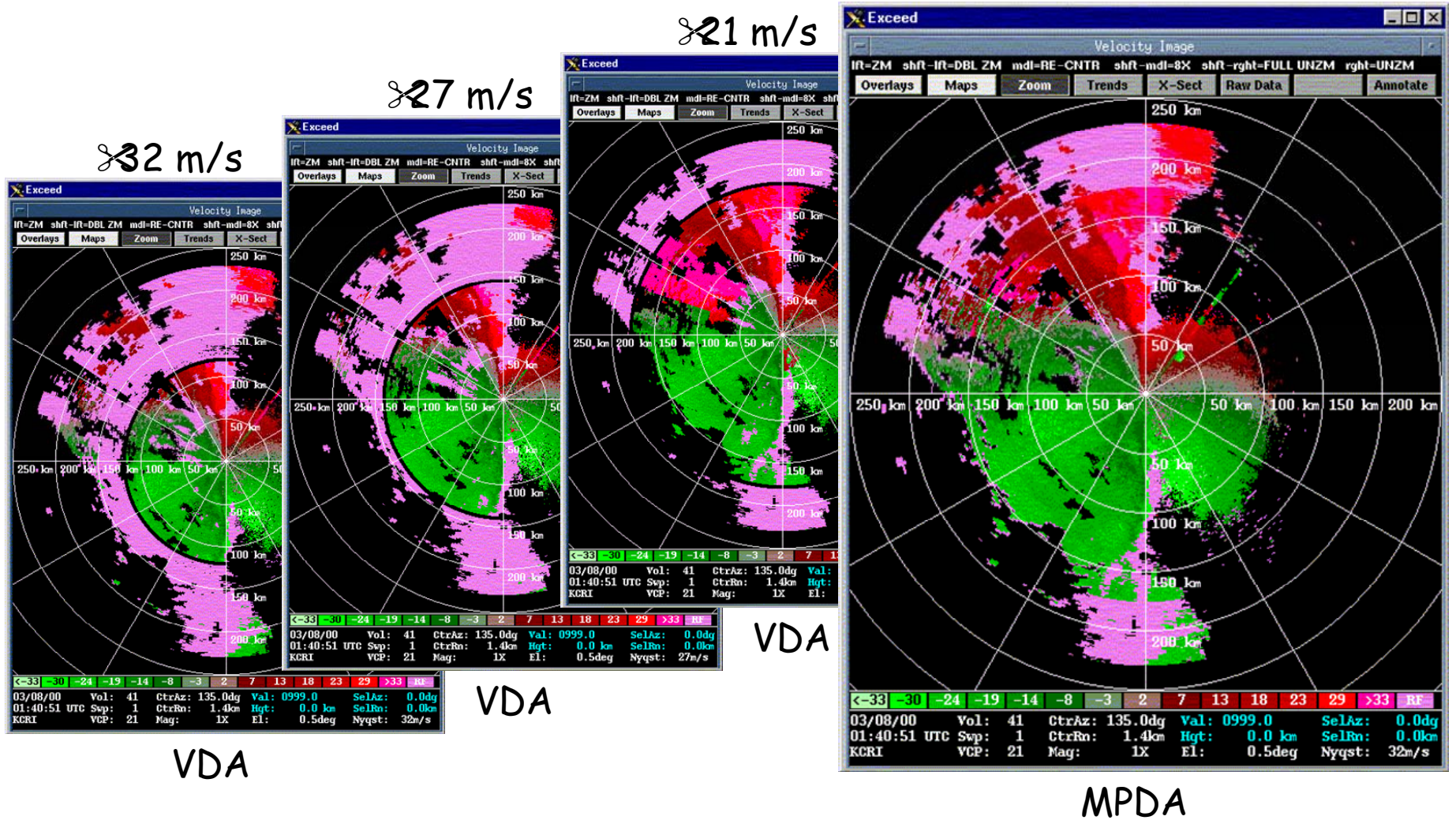
MPDA

Table of PRFs

Representative Parameter Values, 🖰 = 10 cm.

PRF #	4*	5	6*	7	8*
PRF (Hz)	857.1	1013.5	1094.9	1181.0	1282.1
PRI (ms)	1.167	0.9867	0.9133	0.8467	0.7800
Nyq. Vel (m/s)	21.4	25.3	27.4	29.5	32.0
Max Unamb. Range (km)	175	148	137	127	117

*Used by VCP 121 (MPDA)

MPDA (VCP 121) Operational History

- Build 5, spring 2004
  - First time fielded
  - MPDA limited to a velocity increment of 0.97 kts

- Build 7, spring 2005
  - Operators can change the velocity increment from 0.97 kts to 1.94 kts
  - MPDA degraded by inadvertent modification of PRFs

- Build 8, spring 2006
  - Operators can change the velocity increment without inadvertently changing the PRFs.

Hurricane
Charley as seen
by Key West
13 August 2004
19:03Z
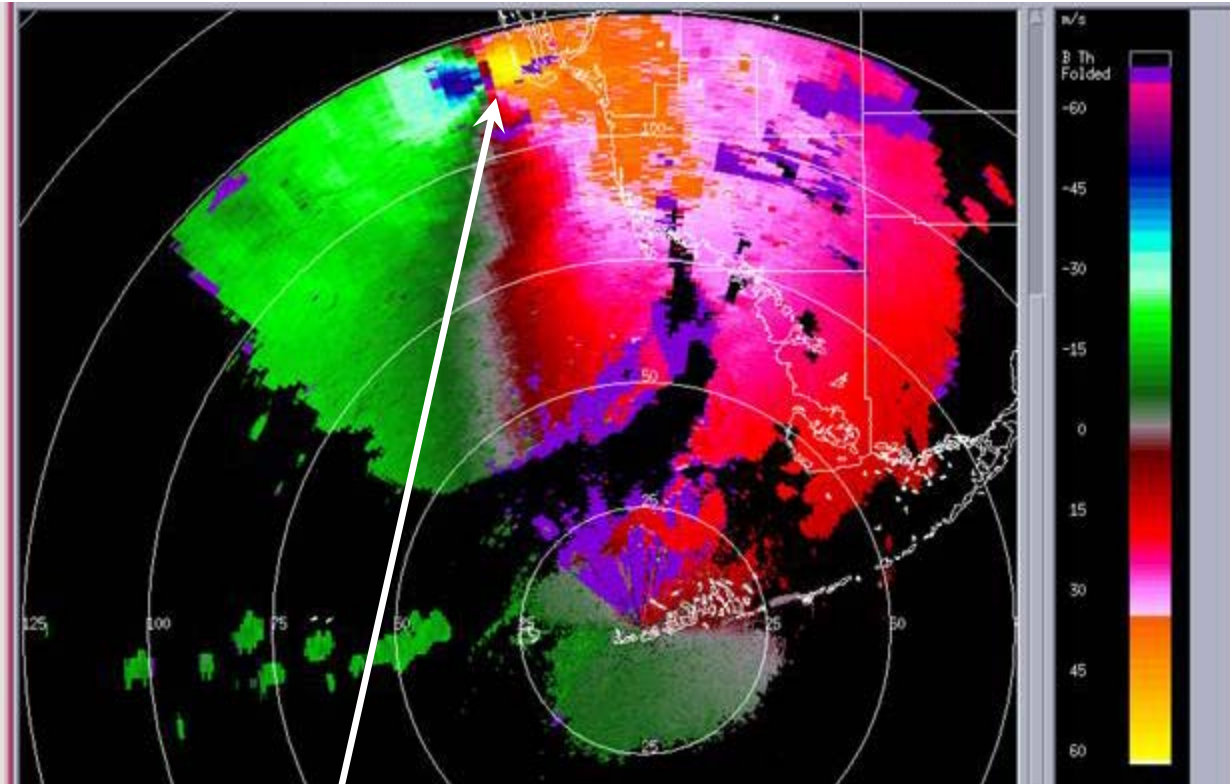
Build 5:
Note outbound
velocities are
maxed out.
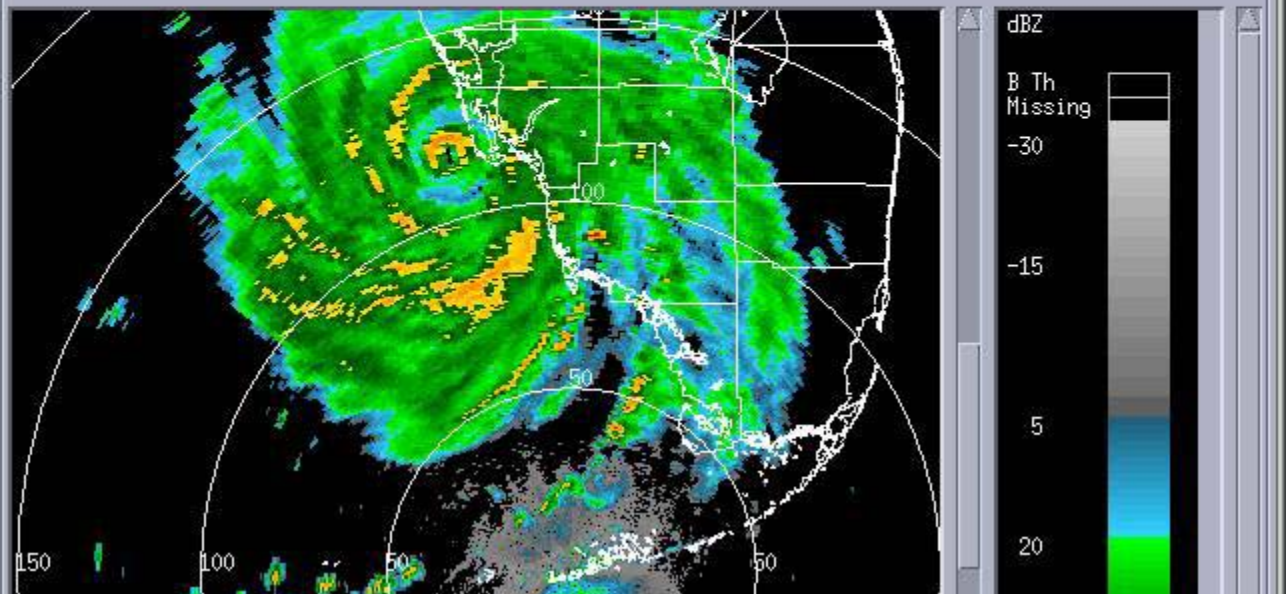
Hurricane Emily

- First noted problem changing the velocity increment from 0.97 kts (0.5 m/s) to 1.94 kts (1.0 m/s) when using VCP 121

- AutoPRF function populated "current" VCP with PRF 5 for all sweeps

Examples follow:

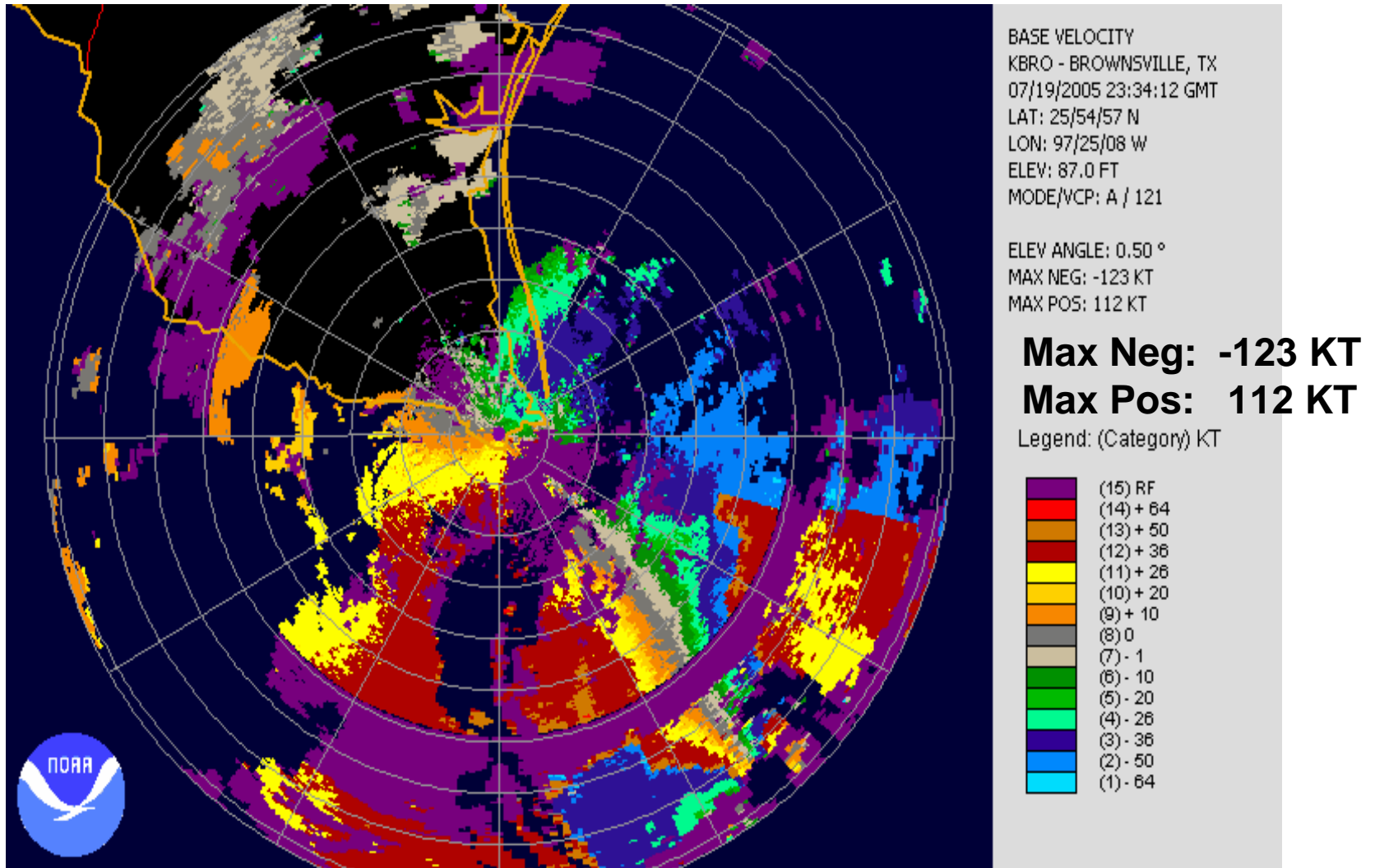# KBRO 7/19/05 23:13Z VCP 121
VMI = 0.5 m/s, PRFs are 8, 6, & 4

Max Neg: -121 KT
Max Pos: 102 KT
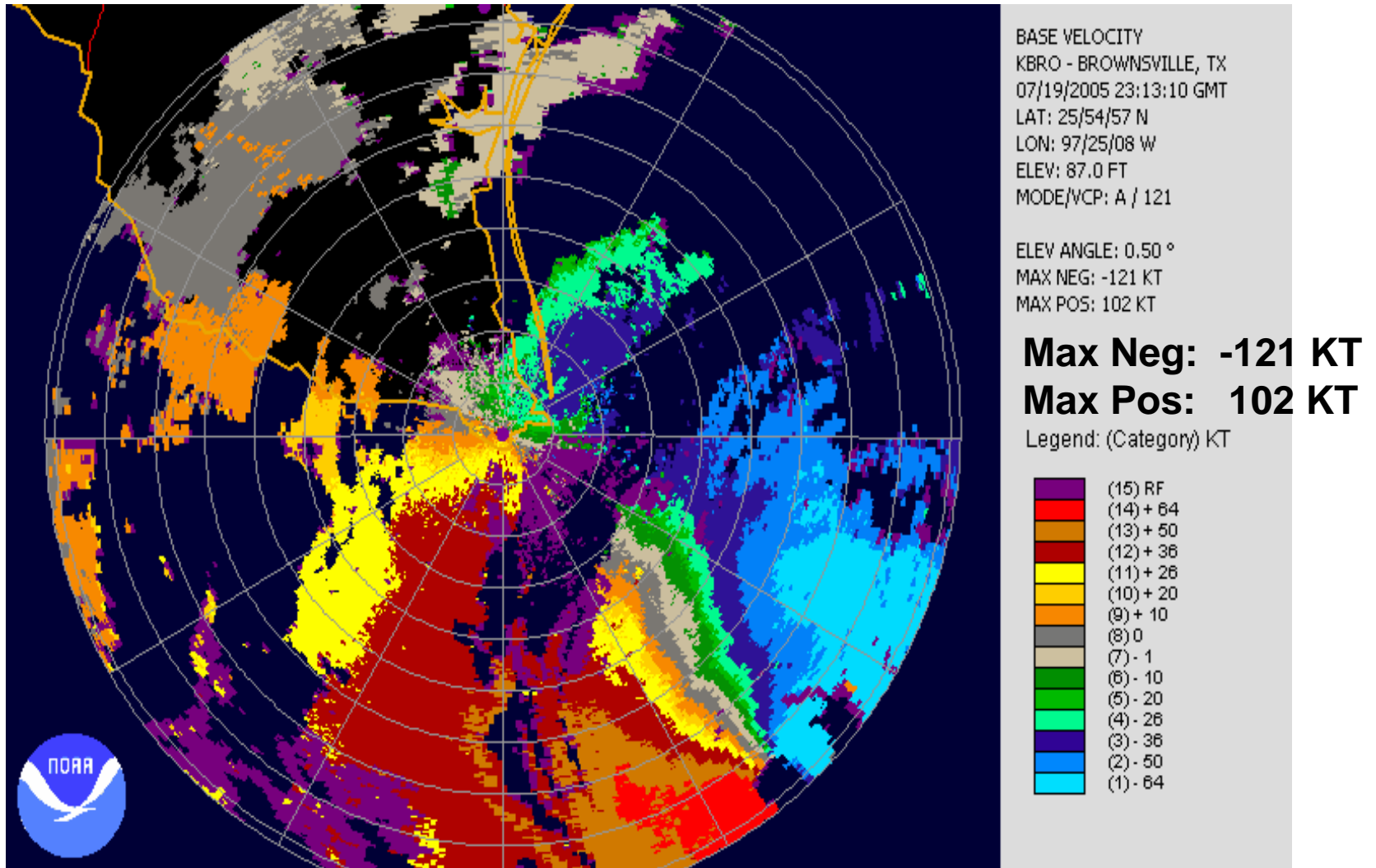
KBRO 7/19/05 23:18Z VCP 121
VMI = 1.0 m/s PRFs are all set to 5
Note use of Saffir-Simpson scale in legend

BASE VELOCITY
KBRO - BROWNSVILLE, TX
07/19/2005 23:18:34 GMT
LAT: 25/54/57 N
LON: 97/25/08 W
ELEV: 87.0 FT
MODE/VCP: A / 121

ELEV ANGLE: 0.50 °
MAX NEG: -152 KT
MAX POS: 107 KT

Max Neg: -152 KT
Max Pos: 107 KT

Legend: (Category) KT

(15) RF
(14) + 135
(13) + 114
(12) + 96
(11) + 83
(10) + 64
(9) + 50
(8) 0
(7) - 1
(6) - 50
(5) - 64
(4) - 83
(3) - 96
(2) - 114
(1) - 135
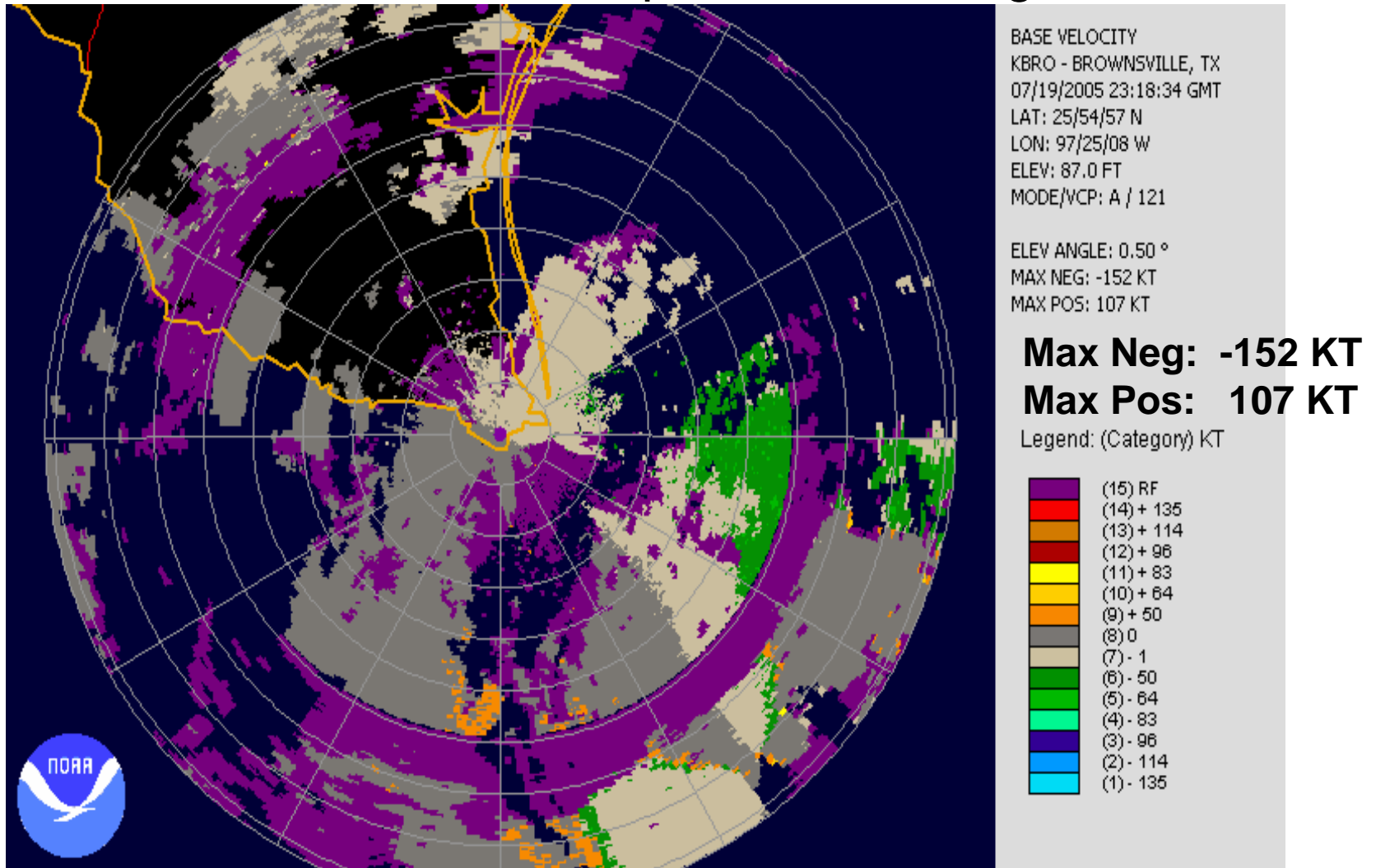
KBRO 7/19/05 23:34Z VCP 121
VMI = 0.5 m/s PRFs are all set to 5

Max Neg: -123 KT
Max Pos: 112 KT

KBRO 7/20/05 04:10Z VCP 12

VMI = 0.5 m/s PRF is 5

BASE VELOCITY
KBRO - BROWNSVILLE, TX
07/20/2005 04:10:22 GMT
LAT: 25/54/57 N
LON: 97/25/08 W
ELEV: 87.0 FT
MODE/VCP: A / 12

ELEV ANGLE: 0.50 °
MAX NEG: -123 KT
MAX POS: 85 KT

Max Neg: -123 KT
Max Pos: 85 KT

Legend: (Category) KT

(15) RF
(14) + 64
(13) + 50
(12) + 36
(11) + 26
(10) + 20
(9) + 10
(8) 0
(7) - 1
(6) - 10
(5) - 20
(4) - 26
(3) - 36
(2) - 50
(1) - 64
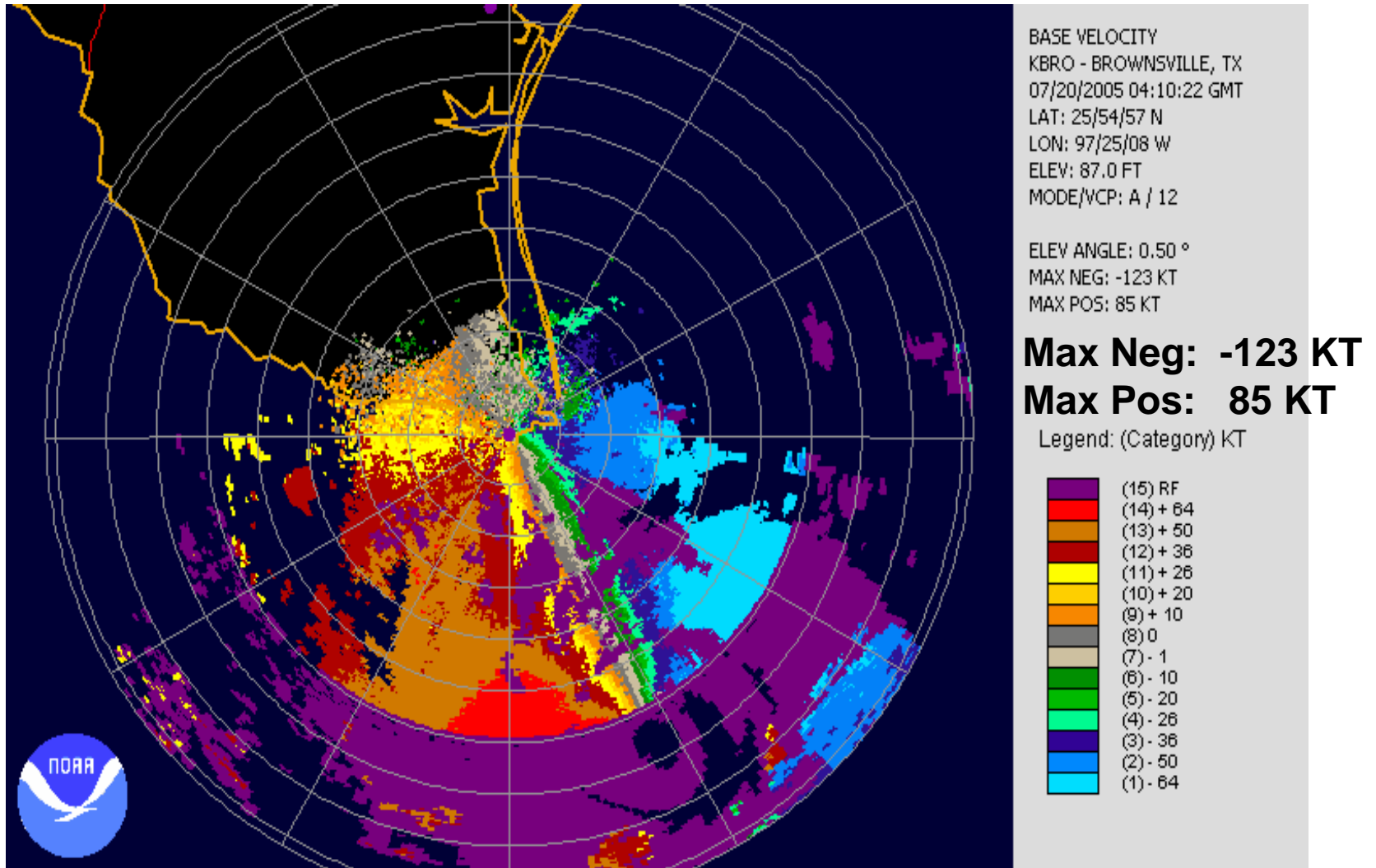
KBRO 7/20/05 05:02Z VCP 121
VMI = 0.5 m/s PRFs are 8, 6, & 4
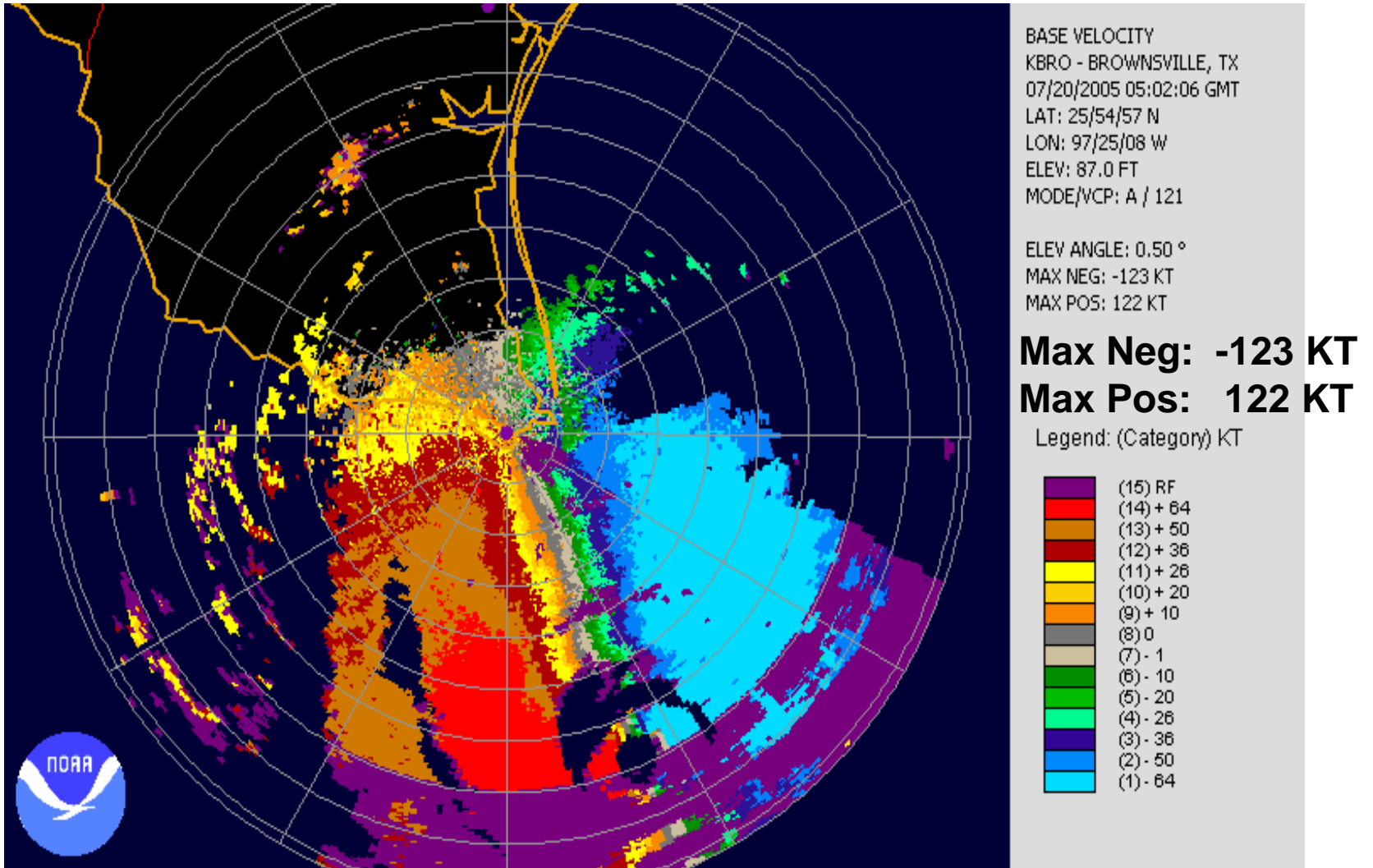
Hurricane Katrina

- Mobile, AL (KMOB)

- Slidell, LA (KLIX)

Hurricane Katrina – KMOB, 29 Aug 2005

VMI = 0.97 kts, Max inbound = -95 kts

VMI = 0.97 kts, Max inbound = -95 kts
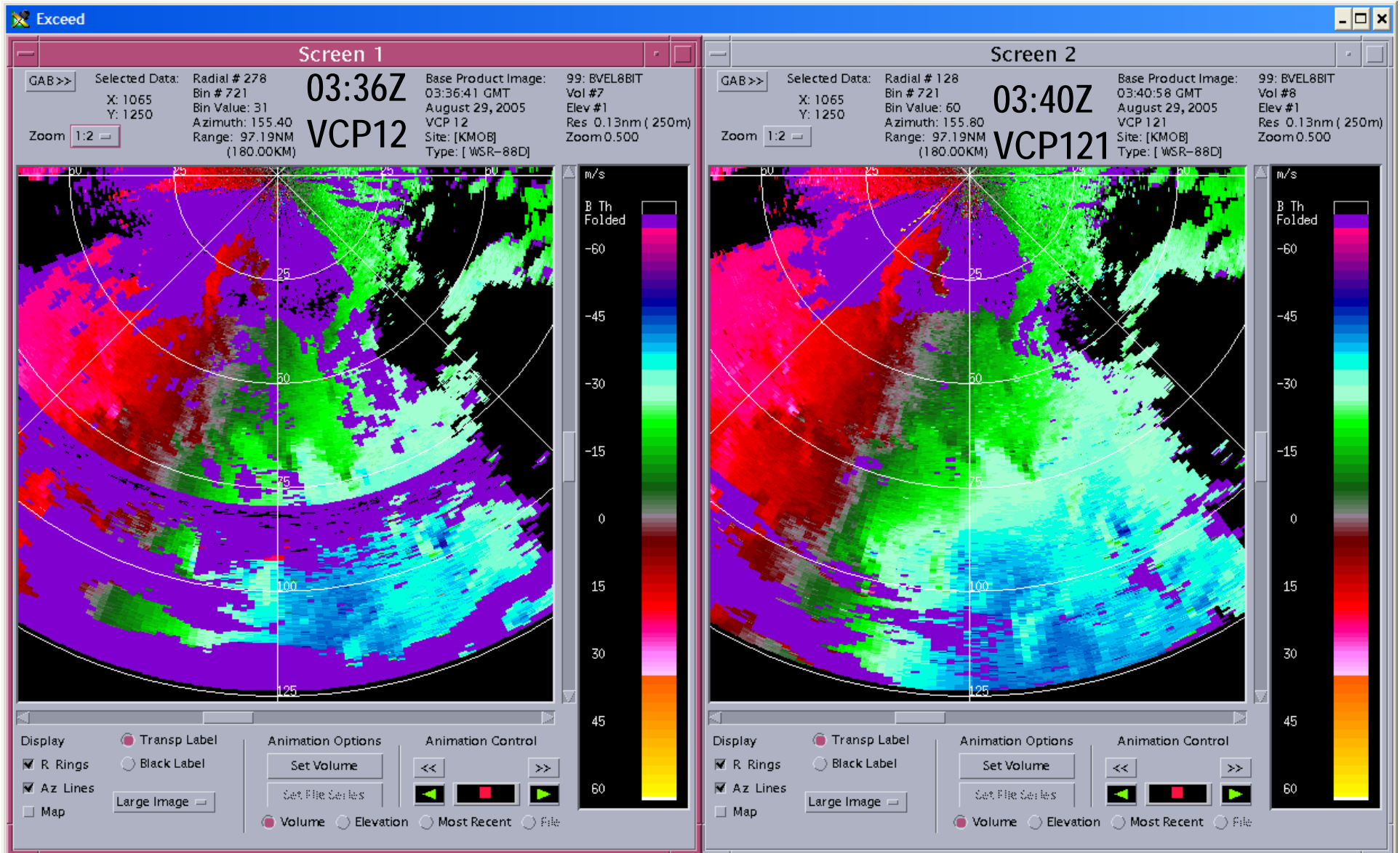
Hurricane Katrina – KMOB, 29 Aug 2005

VMI = 0.97 kts, Max inbound = -95 kts   VMI = 1.94 kts, Max inbound = -115 kts
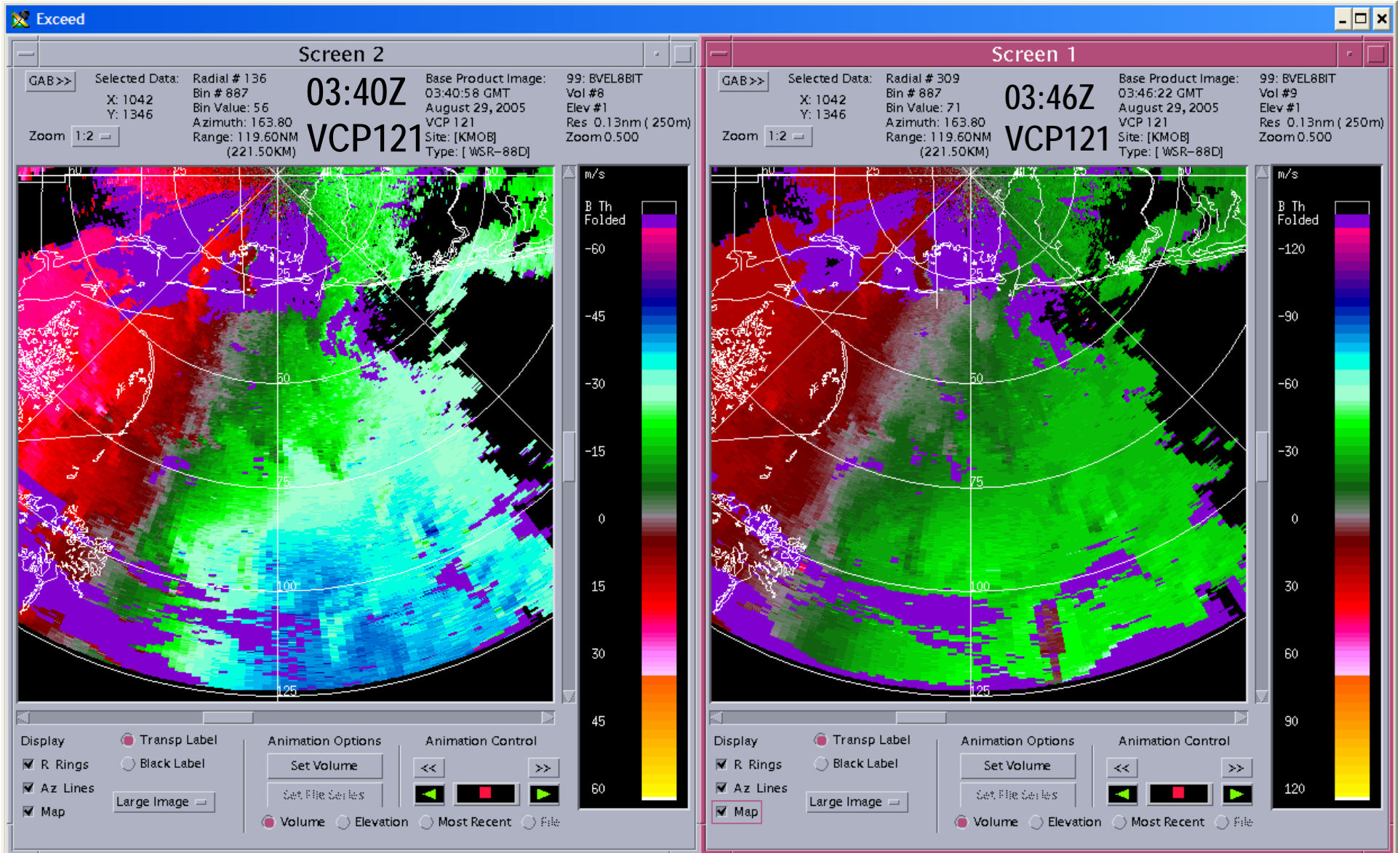
Hurricane Katrina – KLIX, 29 August 2005

VMI = 0.97 kts, Max inbound = -123 kts

Post Analysis with modified code
VMI = 1.94 kts, Max inbound = -142 kts
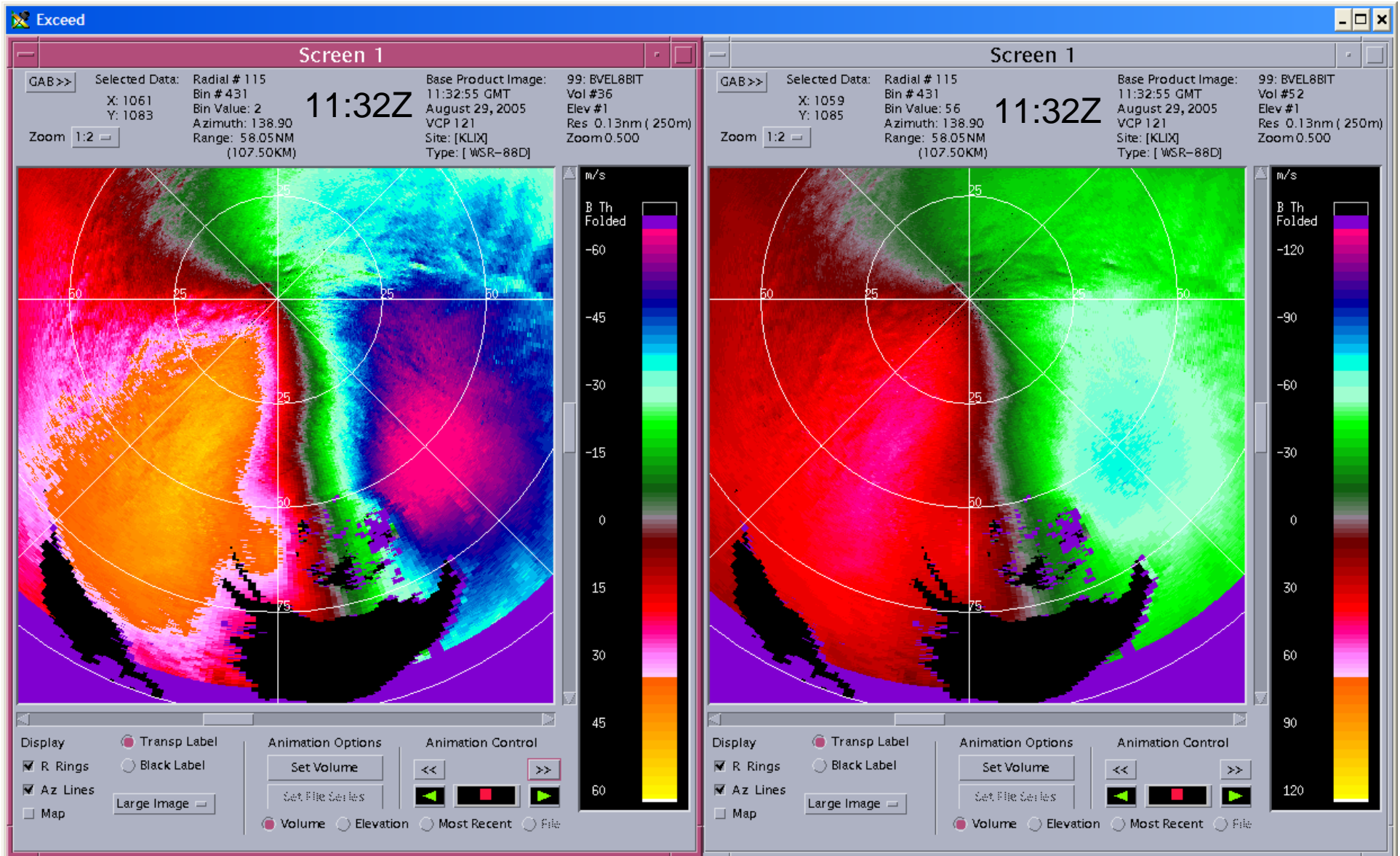
ORPG "rpgdbm" Task Failure at KLIX During Katrina

- Rpgdbm (rpg data base manager) task failed
  - Task clears old products out of product data base linear buffer
  - Memory not released properly
  - Task killed by rpg when it gets too large
  - When rpgdbm task fails, old products aren't removed
  - Linear buffer fills up
  - New products cannot be added to linear buffer so product/algorithm tasks fail
  - Unless cleared, more tasks will fail
- **Call to ROC/Hotline quickly fixed problem**
- **Build 8 corrects the problem**

Summary of Task Failures at KLIX

Time (UTC)	Failed Tasks
07:31:46	Rpgdbm
09:55:39	Basreflct, rpgdbm
10:00:31	Basrflct, bref8bit
10:01:09	Basrflct, basspect, basvlcty, bref8bit, bvel8bit, mesoruprod, recclprods, srmrmrv, tda2d3dru
10:02:23	Basrflct, basspect, basvlcty, bref8bit, bvel8bit, epre, mesoruprod, recclprods, srmrmrv, tda2d3dru
10:11:02	Basrflct, bref8bit
10:11:58	Basrflct, basspect, basvlcty, bref8bit, bvel8bit, mesoruprod, recclprods, srmrmrv, tda2d3dru
10:13:02	Basrflct, basspect, basvlcty, bref8bit, bvel8bit, epre, mesoruprod, recclprods, srmrmrv, tda2d3dru
10:16:14	Basrflct, basspect, basvlcty, bref8bit, bvel8bit, cmrflct, combattr, crapeprd, epre, hailprod, hireseet, hiresvil, lcrap, lcrflct, mdaprod, mesoprod, mesoruprod, recclprods, srmrmrv, stmtrprd, strucprod, tda2d3dru, tvsprod, viletalg, vwindpro

Communicating Instructions to the Field

- Irene & Katrina
  - Work-around for VMI change
- Rita
  - Work-around for VMI
  - Work-around for rpgdbm task failure
- Wilma – nothing new

4-Step Work-around Developed for Changing Velocity Increment (VMI) in VCP 121

- Ensure AutoPRF is off at the RPG
- Re-download default VCP 121 from RPG to RDA to put good PRFs into current VCP
- Change VMI in current VCP at the RPG from 0.5 m/s to 1.0 m/s
- Download current VCP from the RPG to the RDA

Changing VMI for VCP 121 Instructions Transmitted Via Multiple Routes

- Engineering Management Reporting System (EMRS):
  - Friday, August 12th, before Hurricane Irene, EMRS sent to:
    - NWS SOOs
    - WSR-88D Focal Points
    - ALL Operational Users of WSR-88D
- Telephoning:
  - Sunday August 28th:
    - Lake Charles
    - Slidell, LA
    - Mobile, AL were called.
    - None remembered seeing EMRS
    - Verbal instructions given
- E-mail with instructions sent Sunday, August 28th, to Mobile, AL

Results from Hurricane Katrina

- KLCH didn't try to change the VMI

- KMOB successfully changed the VMI in VCP 121 to 1.0 m/s

- KLIX thought they had changed the VMI but hadn't actually

Problems changing the velocity increment in VCP 121 occurred with Hurricanes Rita and Wilma, too.
Sites occasionally intentionally changed PRFs in VCP 121 with adverse results.
ROC staff pro-actively monitored sites for problems

Human factors issues with AWIPS velocity products

- AWIPS 8-bit (256 level) velocity products
  - Same color always represents the same velocity
  - Does not indicate which VMI is in use
  - Cursor read-out provides max values
  - Color table is editable but wasn't done
- Color tables for the RPG 16- and 8-level products
  - Colors can represent a different velocity depending on VMI
  - Color legend is editable at the RPG
  - Displayable by AWIPS to show VMI indirectly
- CODE cvg display tool
  - Used by ROC/Apps and other developers
  - Used in this presentation
  - Changes color when the VMI changes

16-Level Velocity Product Mobile, AL
VCP 121, 19 August 2005
Post Analysis by Apps: note change of scale in legend
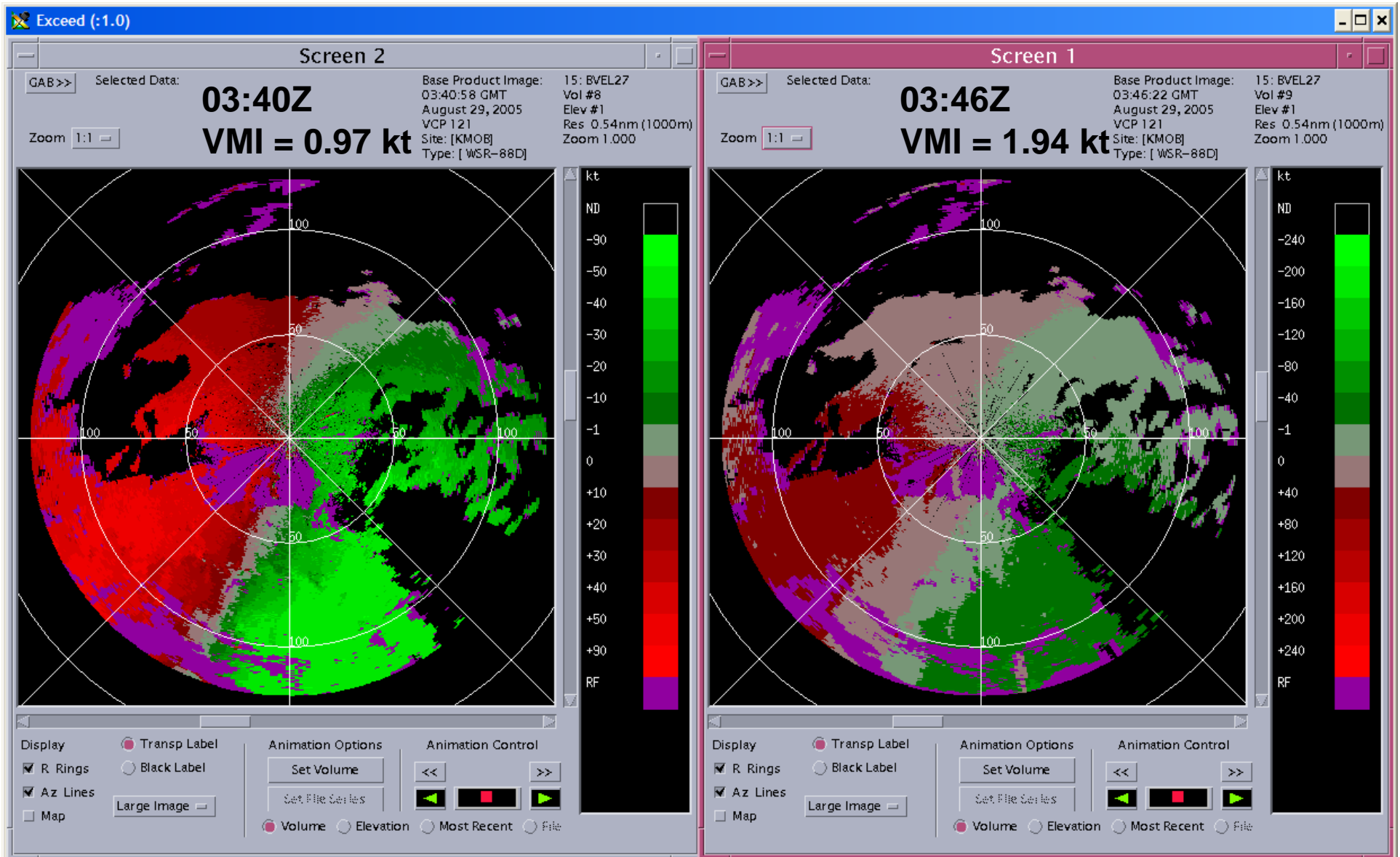
Hurricane Wilma – KAMX, 24 October 2005, 11:08Z

Note the outbound velocity on right is at a maximum value of +123 kts
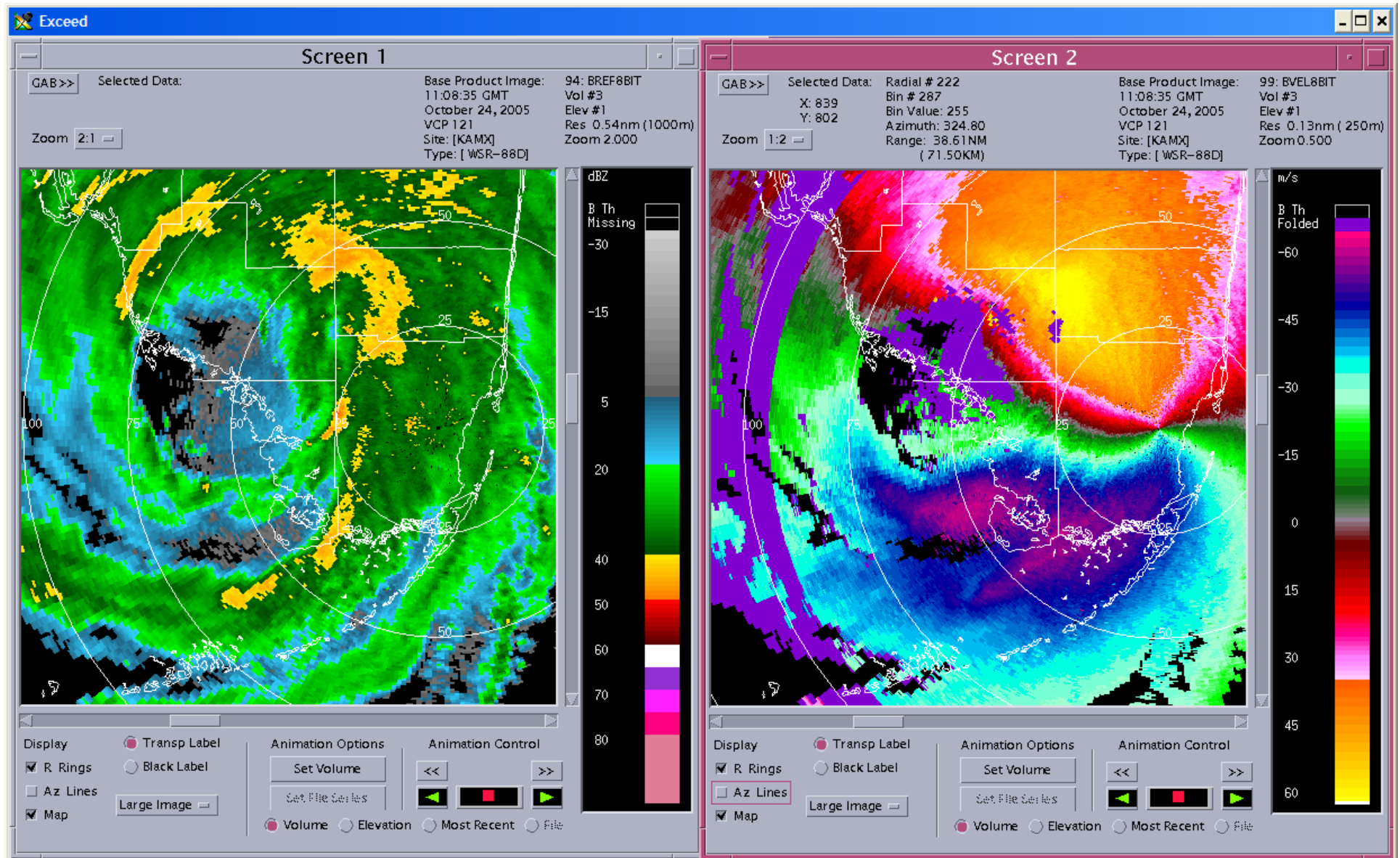
Hurricane Wilma – KAMX, 24 October 2005

16-Level Product with Saffir-Simpson Scale
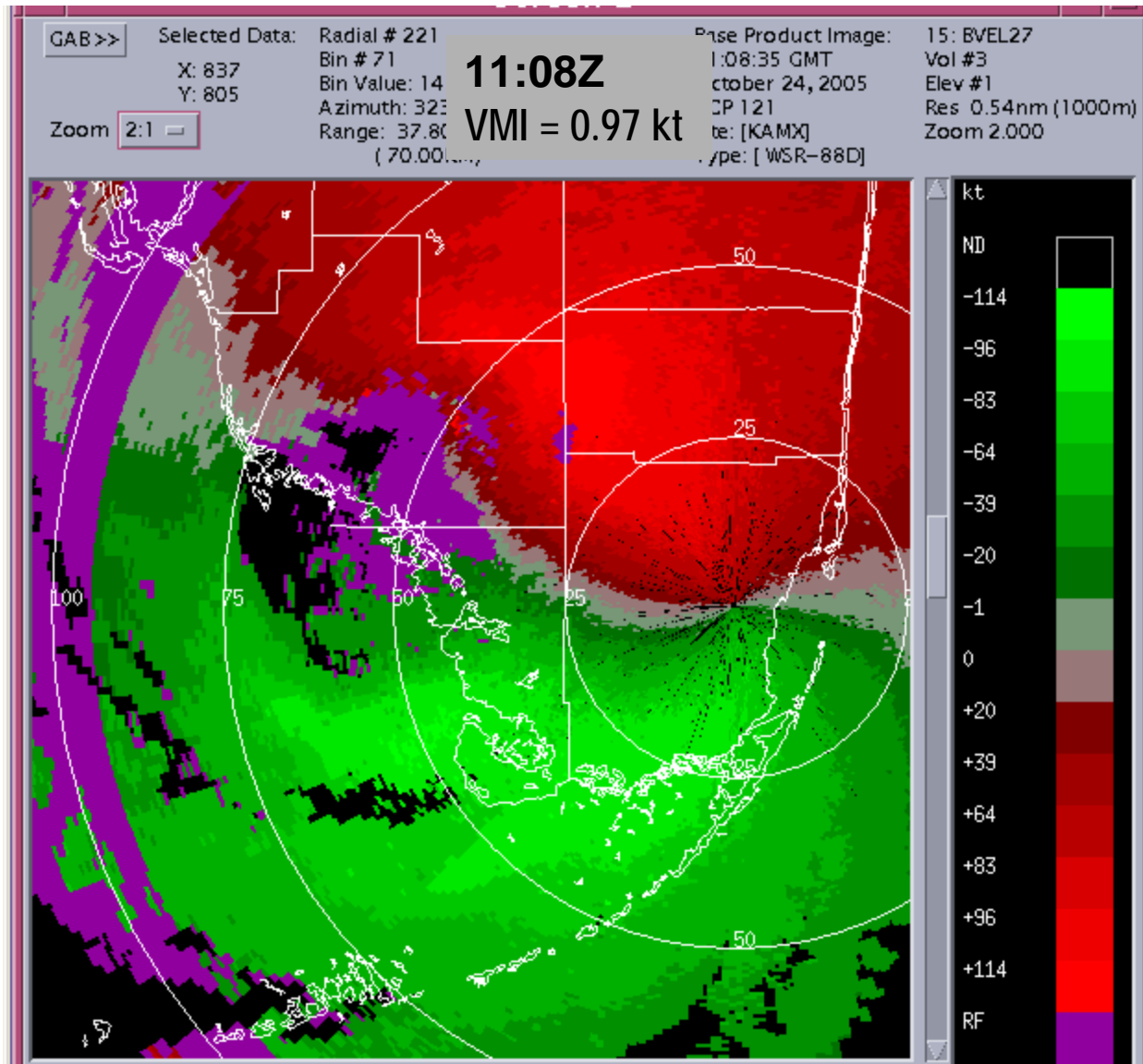
Hurricane Wilma – KAMX, 24 October 2005

Post Analysis Modified Dealiasing Code
16-Level Product with Saffir-Simpson Scale

Hurricane Wilma – KAMX, 24 October 2005

VMI = 1.94 kts, Max outbound = 138 kts

Post Analysis with modified code
16-Level Product with Saffir-Simpson Scale
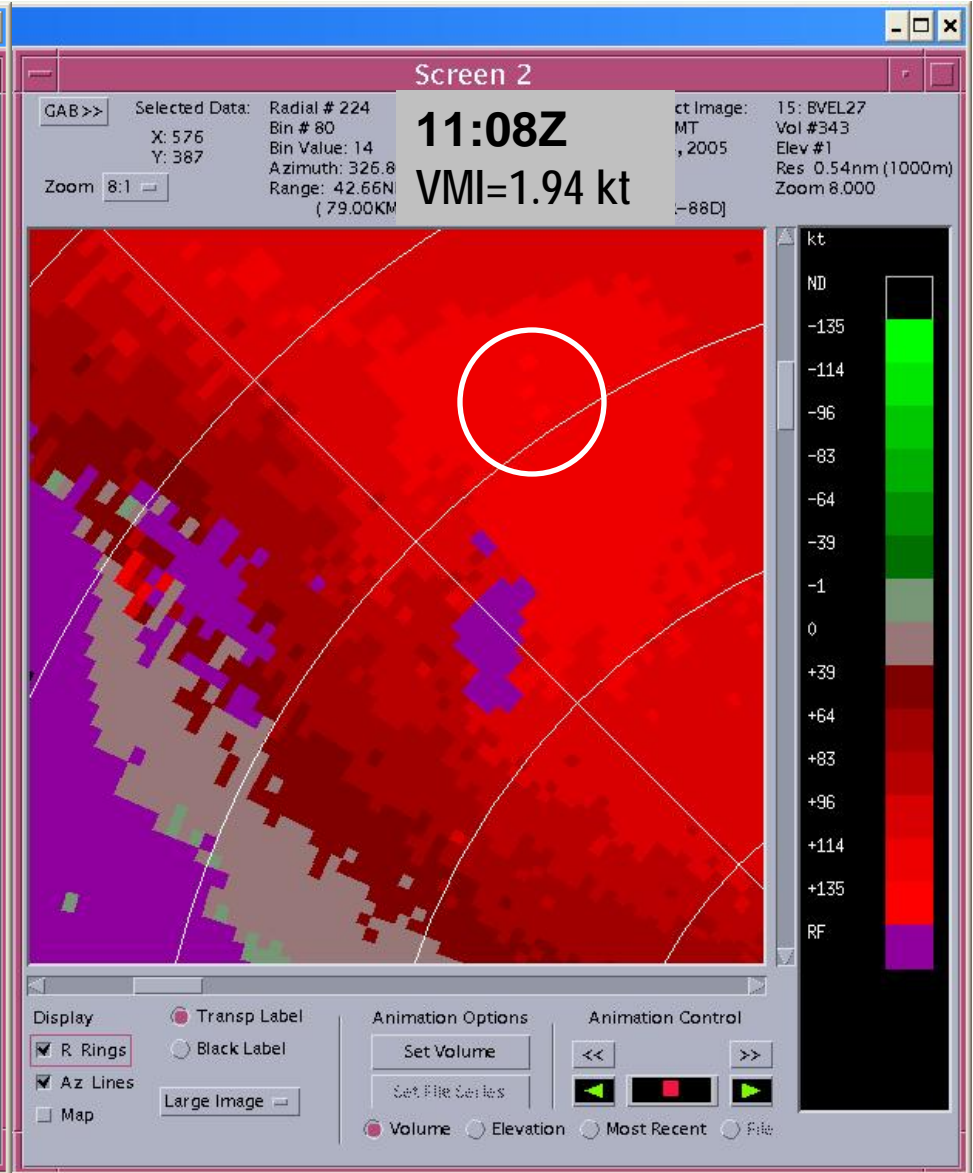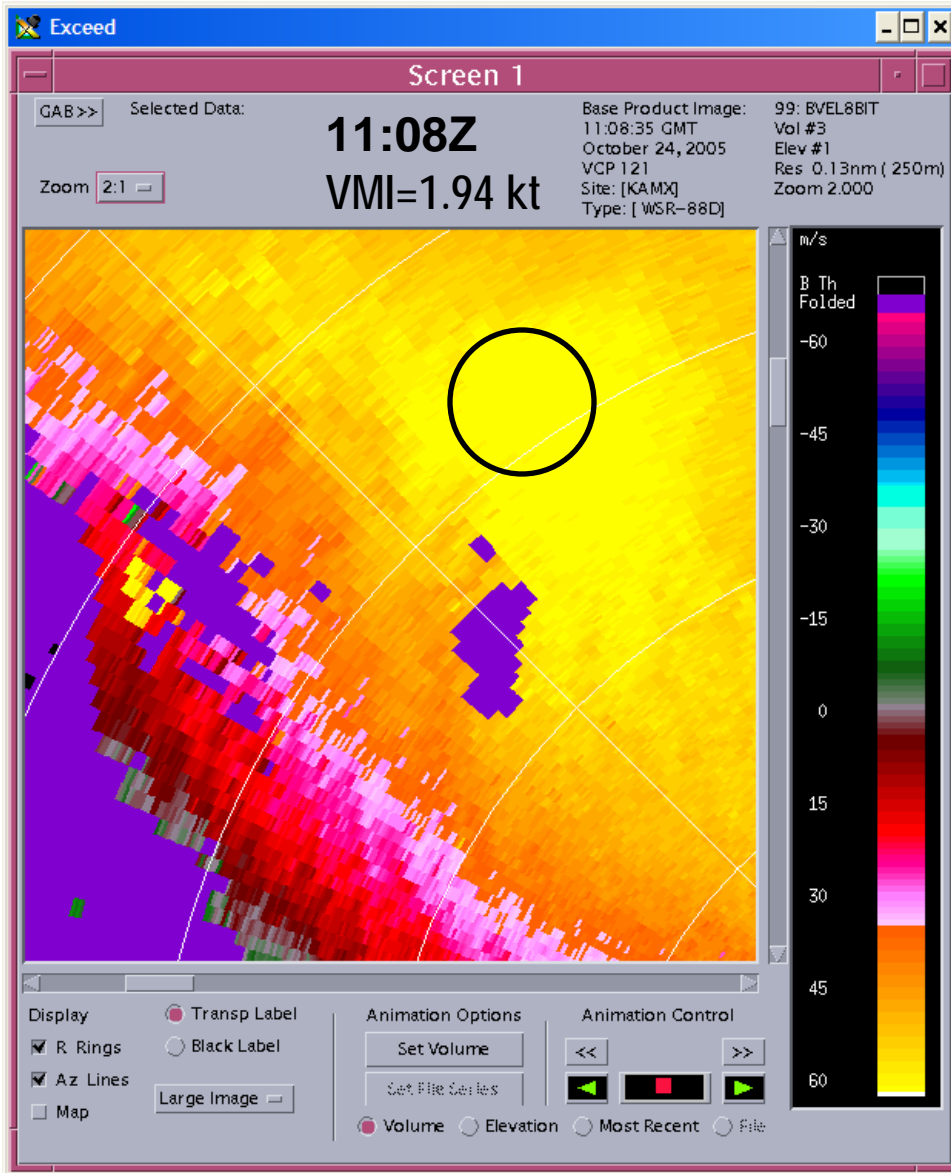
Summary

- MPDA/VCP 121 worked well with either VMI when the correct PRFs were used
- ROC/Apps working with NWSHQ on AWIPS velocity product display issues
- 2006 TCOP recommends use of 16-level velocity products set to Saffir-Simpson scale to complement the 256-level velocity products
- Personal contact with field site followed by transmission of instructions seems to work best
- **Known problems with Build 7 have been corrected in Build 8**

Questions?

Hurricane Katrina - KLIX

29 August 2005
08:31Z – 13:54Z

Side by Side Comparison of

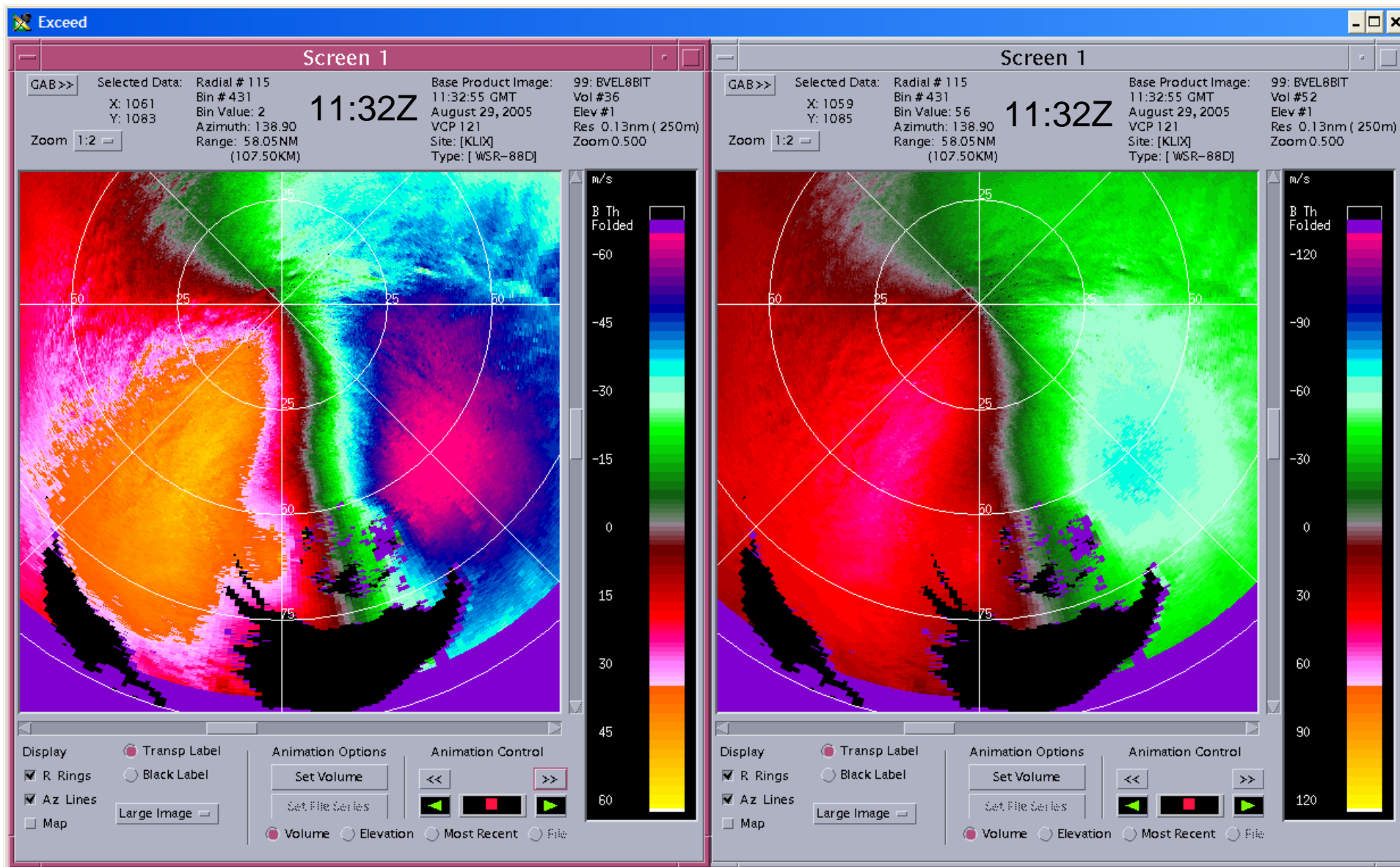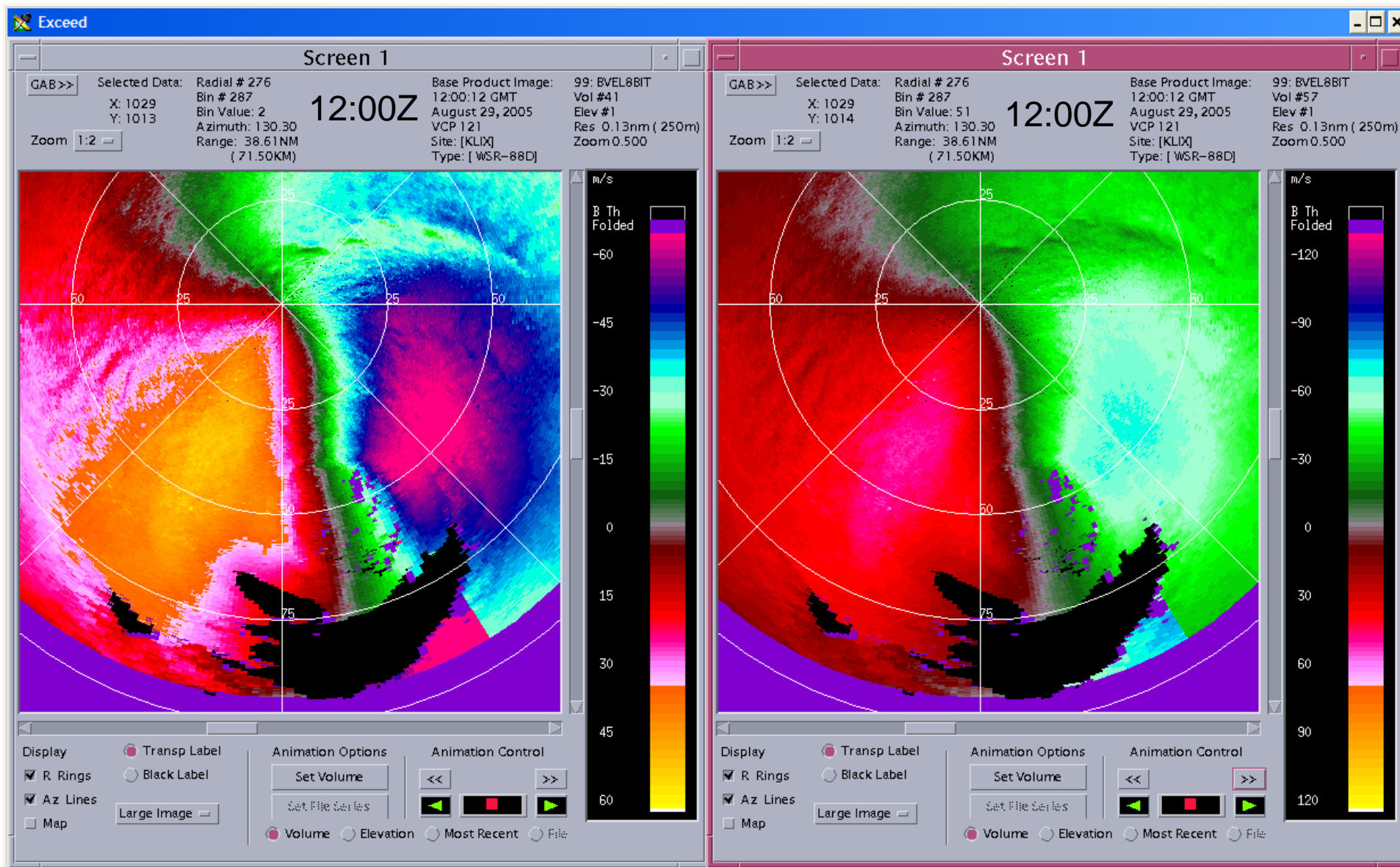VMI = 0.97 kts and 1.94 kts

~30 min intervals

Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts   VMI = 1.94, Max inbound = -134 kts
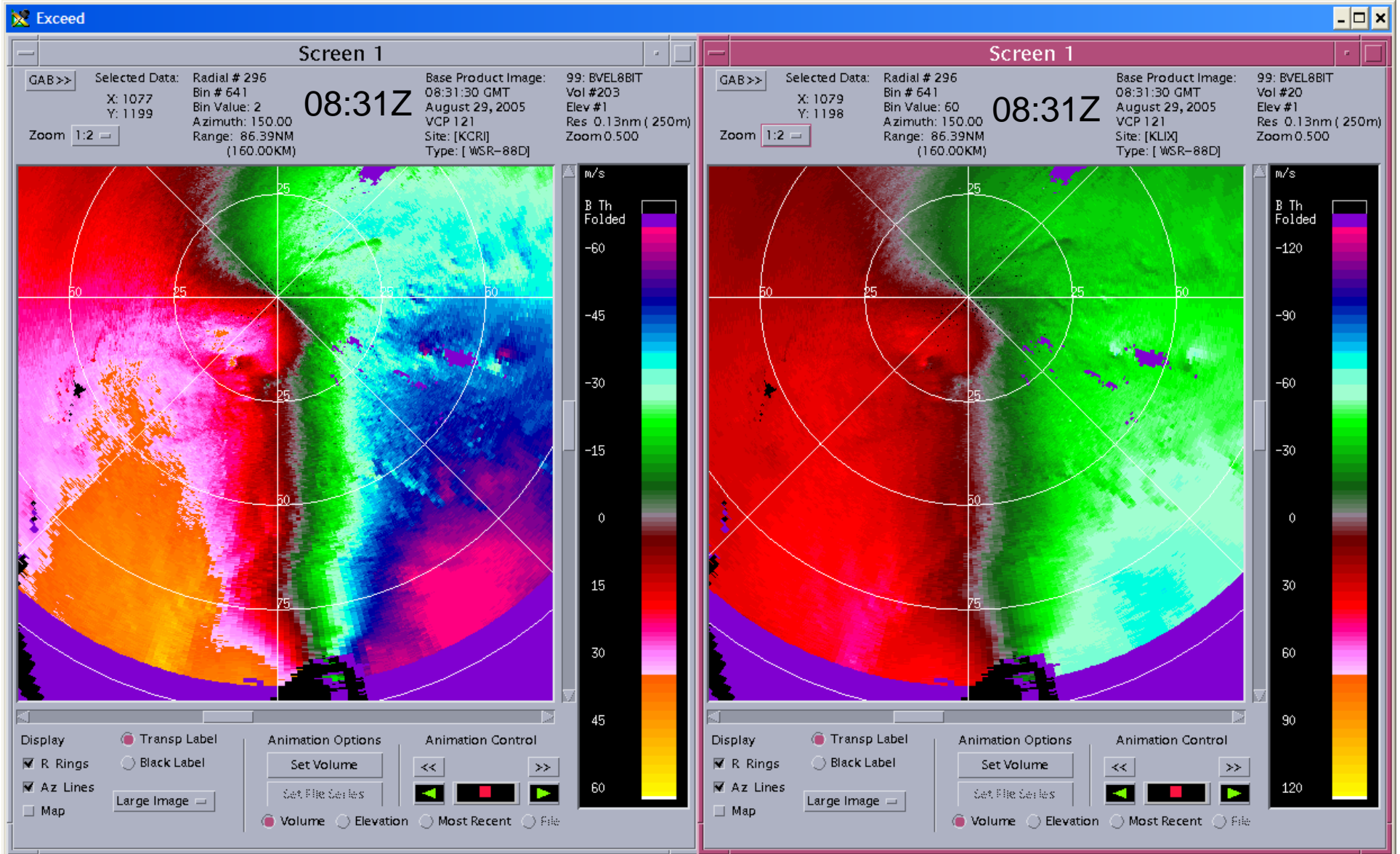
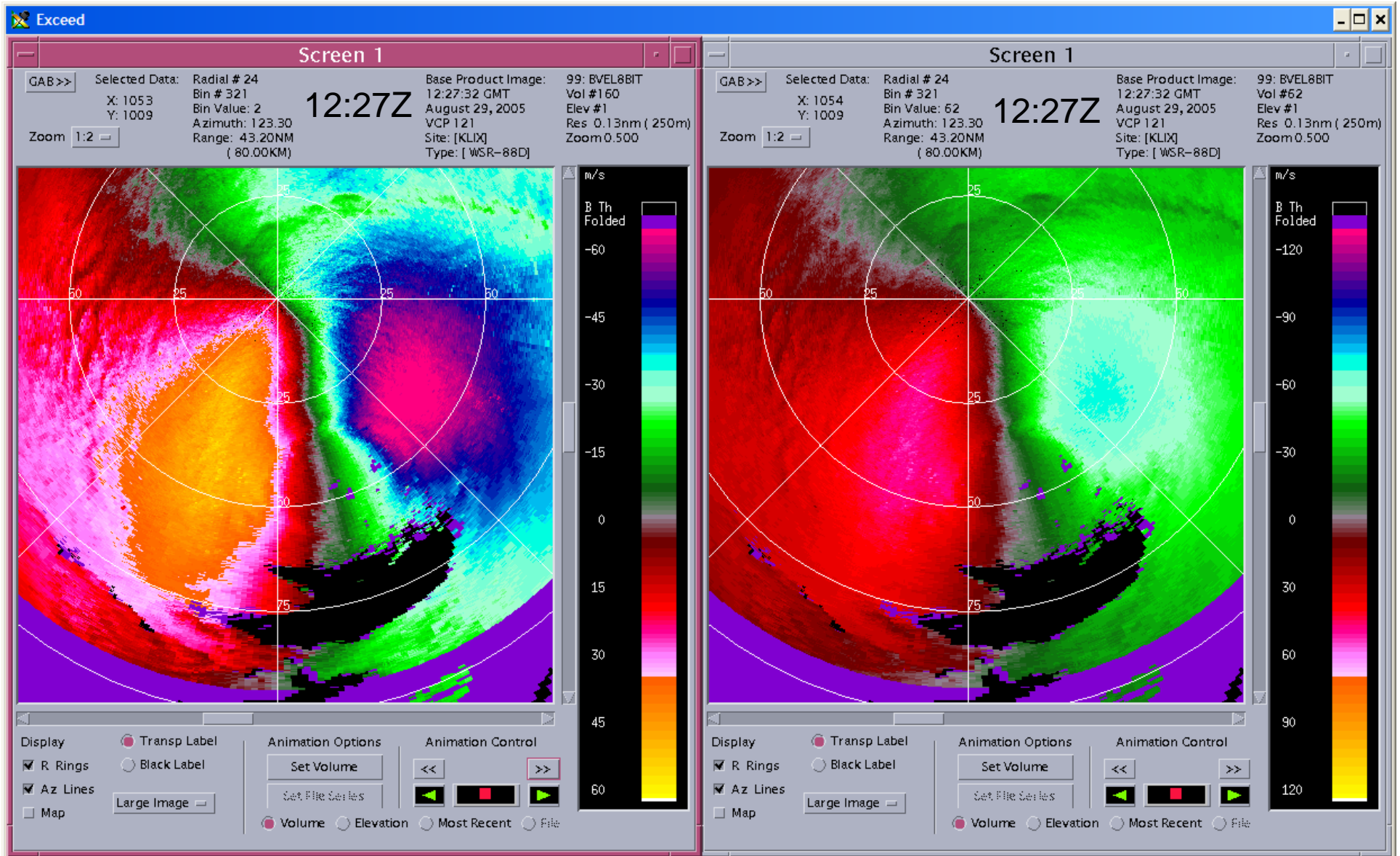# Hurricane Katrina - KLIX
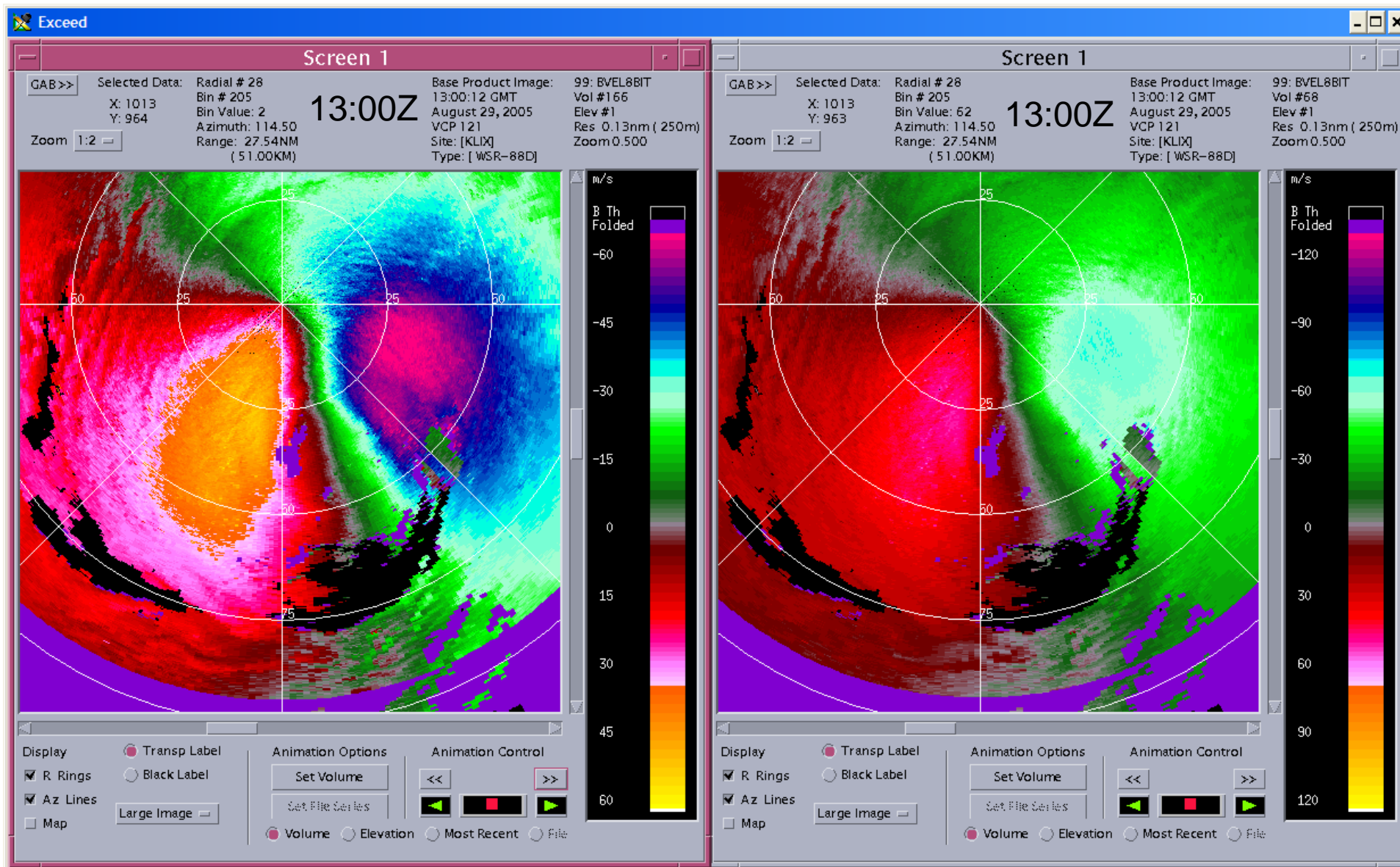
VMI = 0.97, Max inbound = -123 kts   **VMI = 1.94, Max inbound = -134 kts**
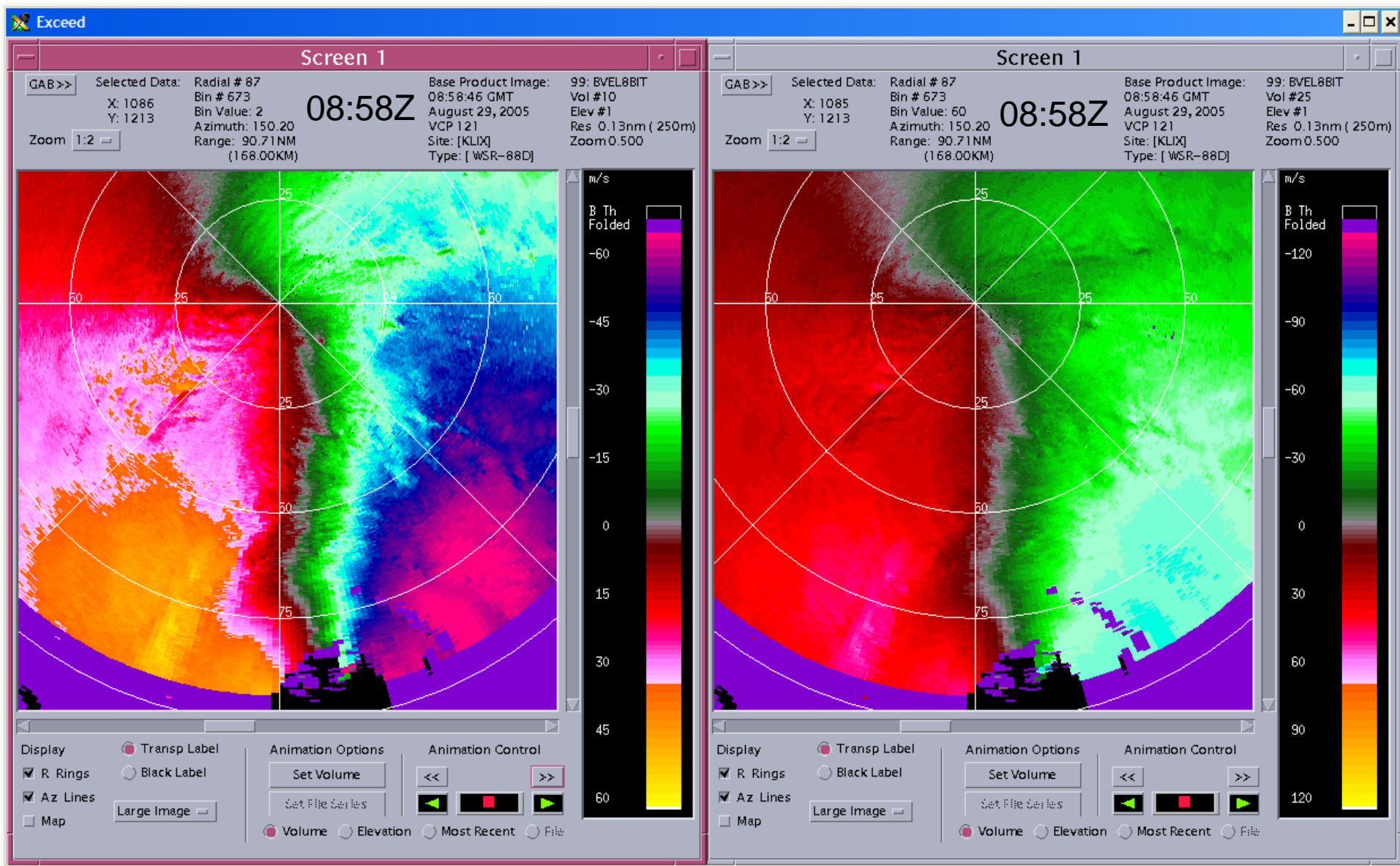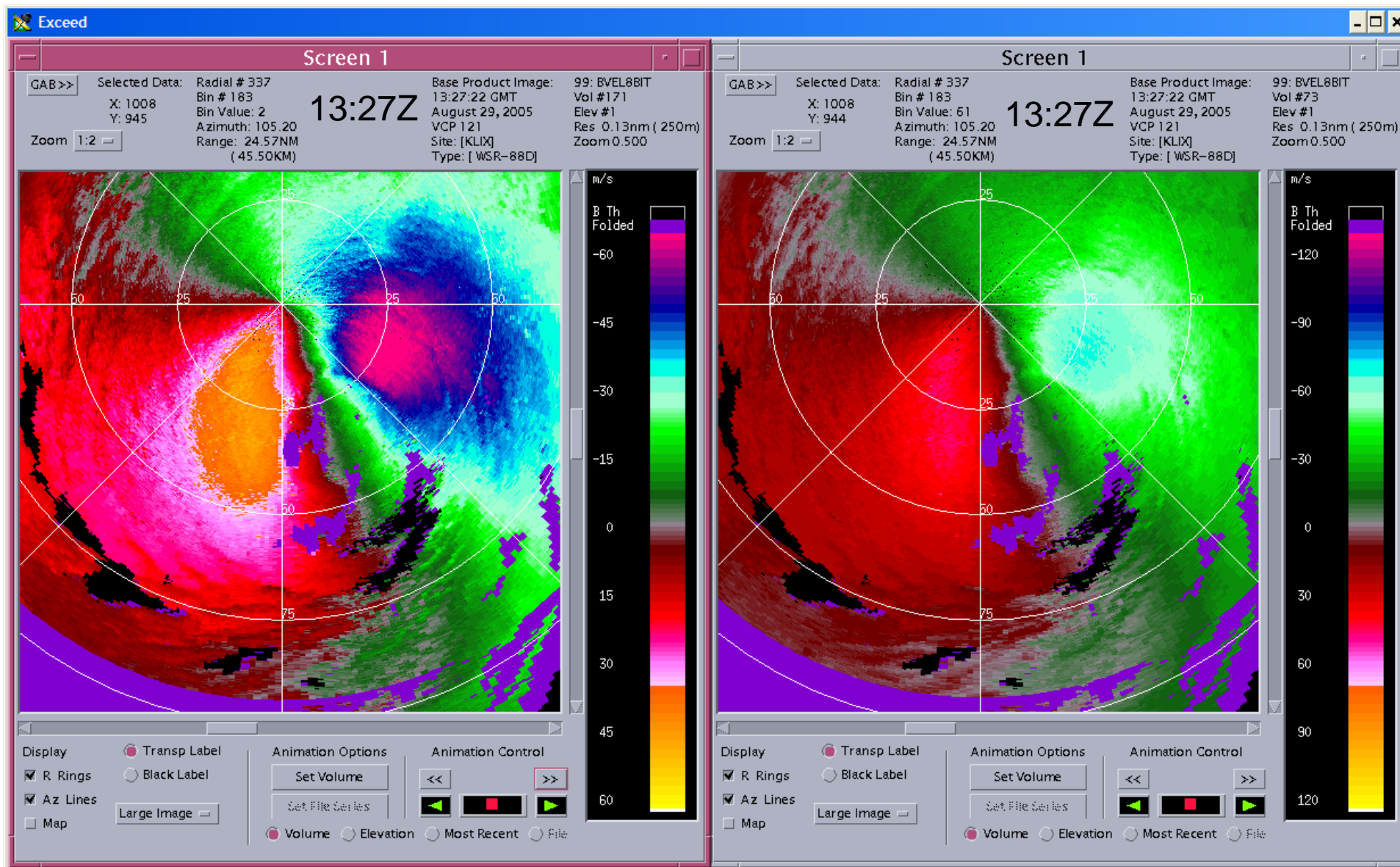
Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts   **VMI = 1.94, Max inbound = -126 kts**
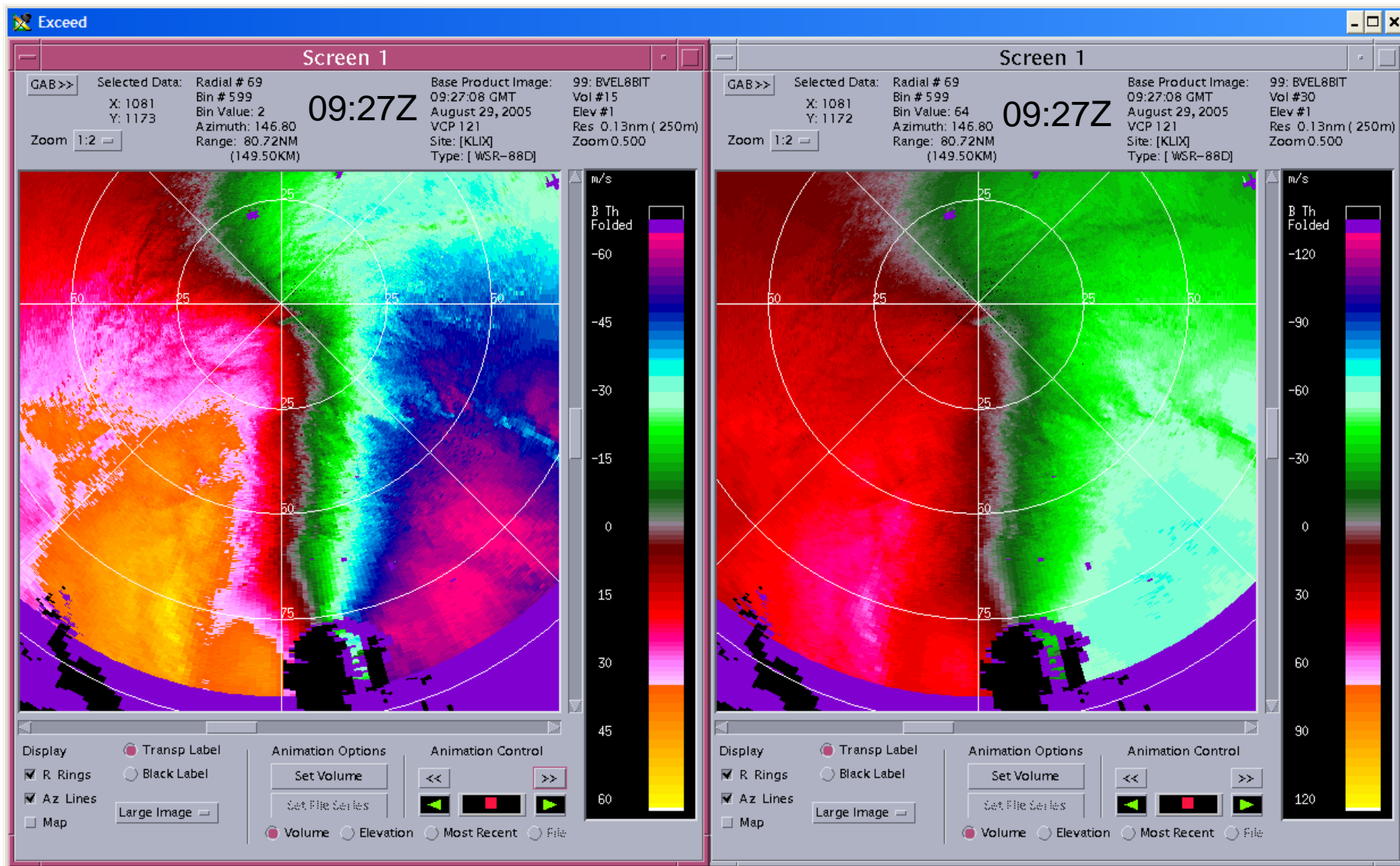
Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts **VMI = 1.94, Max inbound = -128 kts**
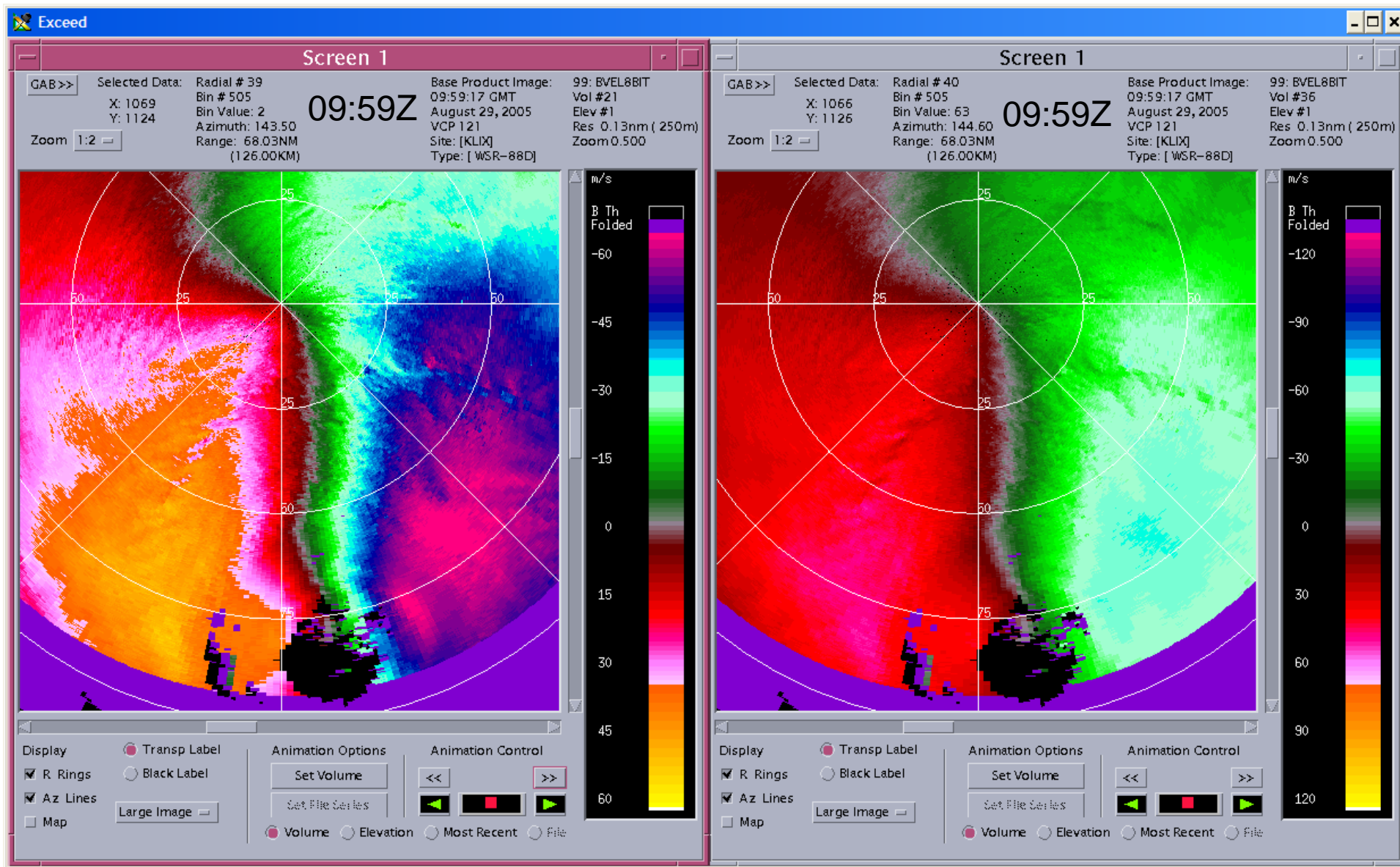
Hurricane Katrina - KLIX
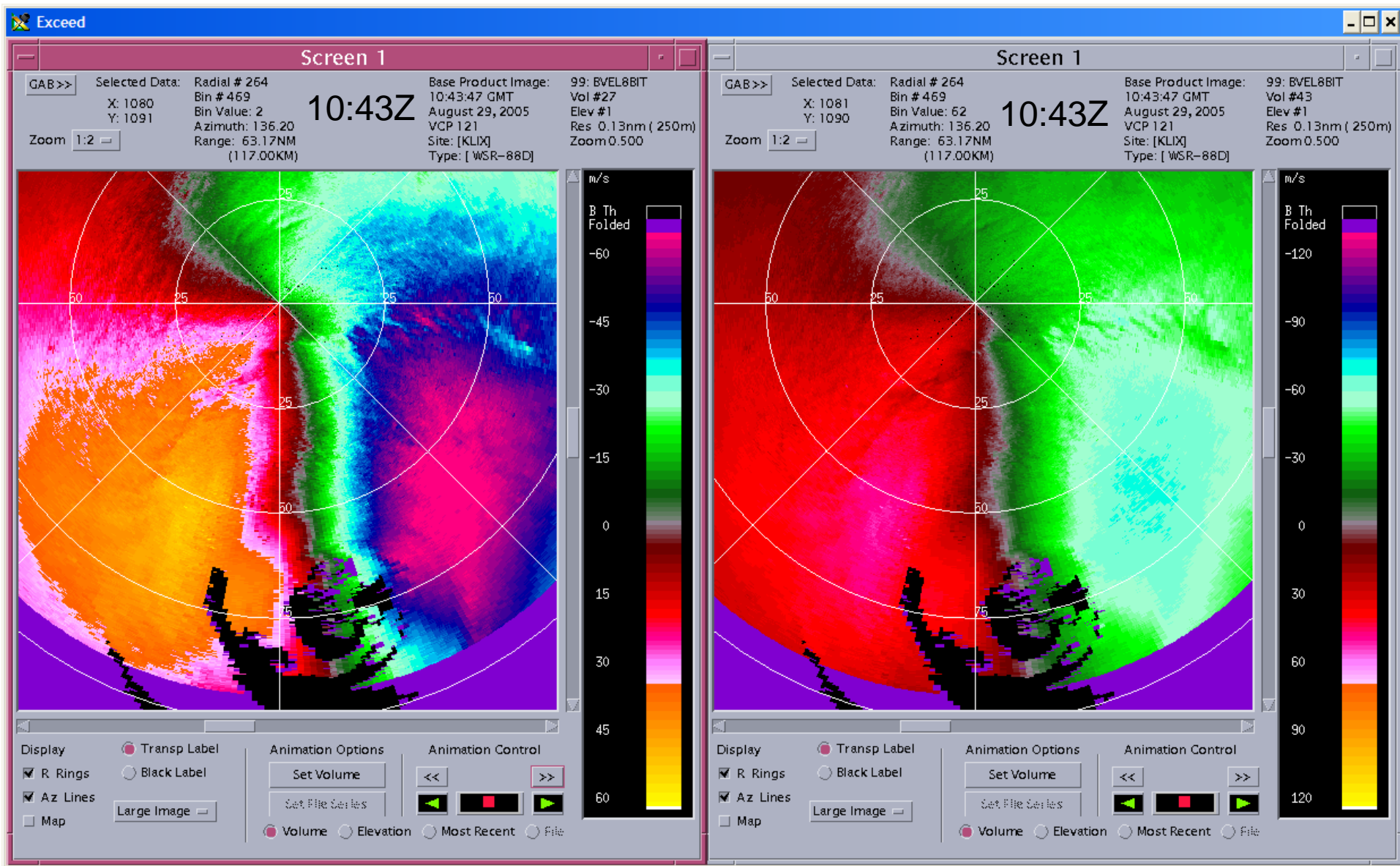
VMI = 0.97, Max inbound = -123 kts   **VMI = 1.94, Max inbound = -130 kts**

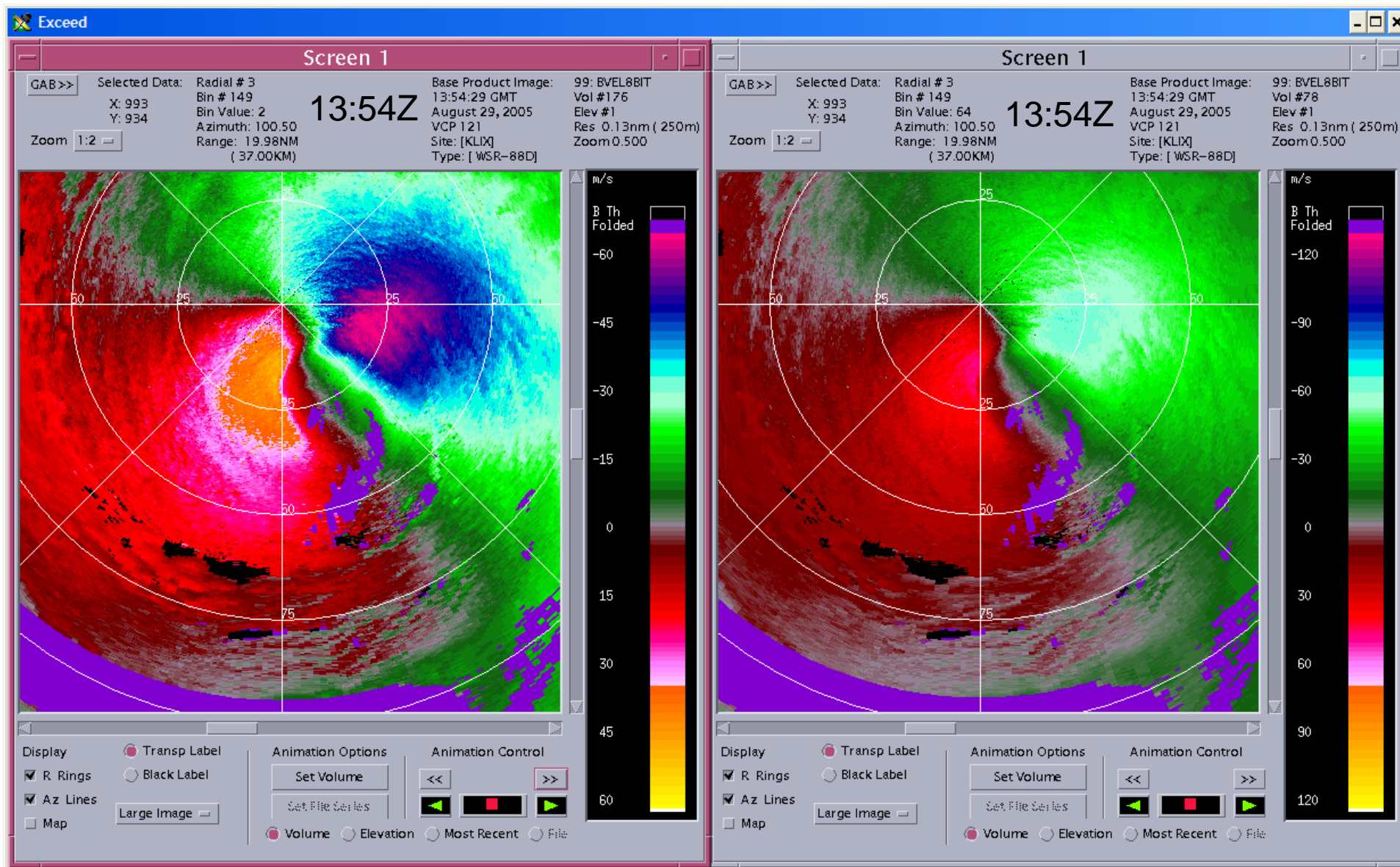# Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts   **VMI = 1.94, Max inbound = -132 kts**
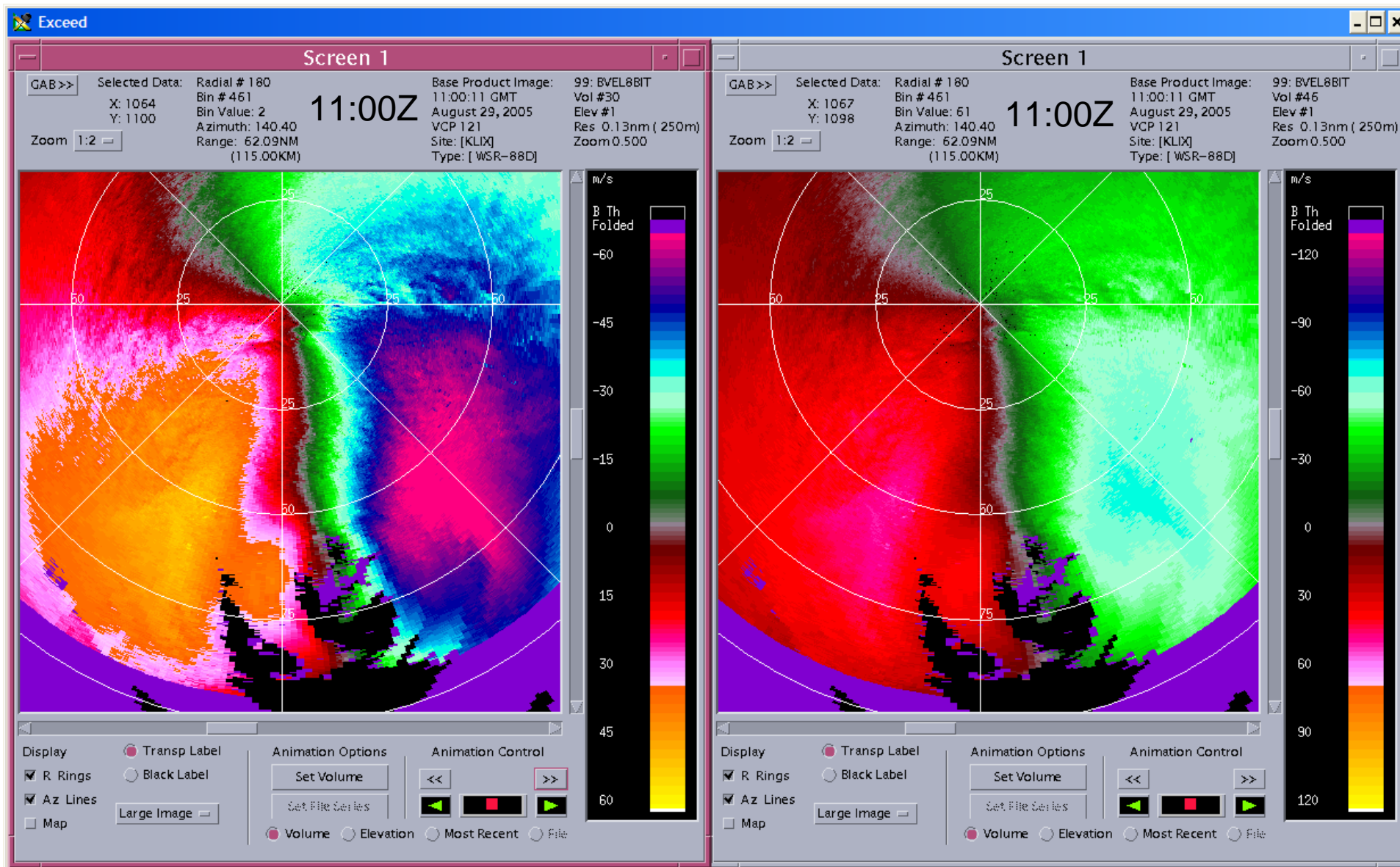
Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts   **VMI = 1.94, Max inbound = -142 kts**

Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts   VMI = 1.94, Max inbound = -152 kts

Hurricane Katrina - KLIX

**VMI = 0.97, Max inbound = -123 kts**   **VMI = 1.94, Max inbound = -130 kts**

Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts   **VMI = 1.94, Max inbound = -130 kts**

Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts **VMI = 1.94, Max inbound = -132 kts**

Hurricane Katrina - KLIX

VMI = 0.97, Max inbound = -123 kts   **VMI = 1.94, Max inbound = -126 kts**

Hurricane Katrina - KMOB

29 August 2005
08:29Z – 13:00Z

Reflectivity and Velocity (VMI =1.94 kts)
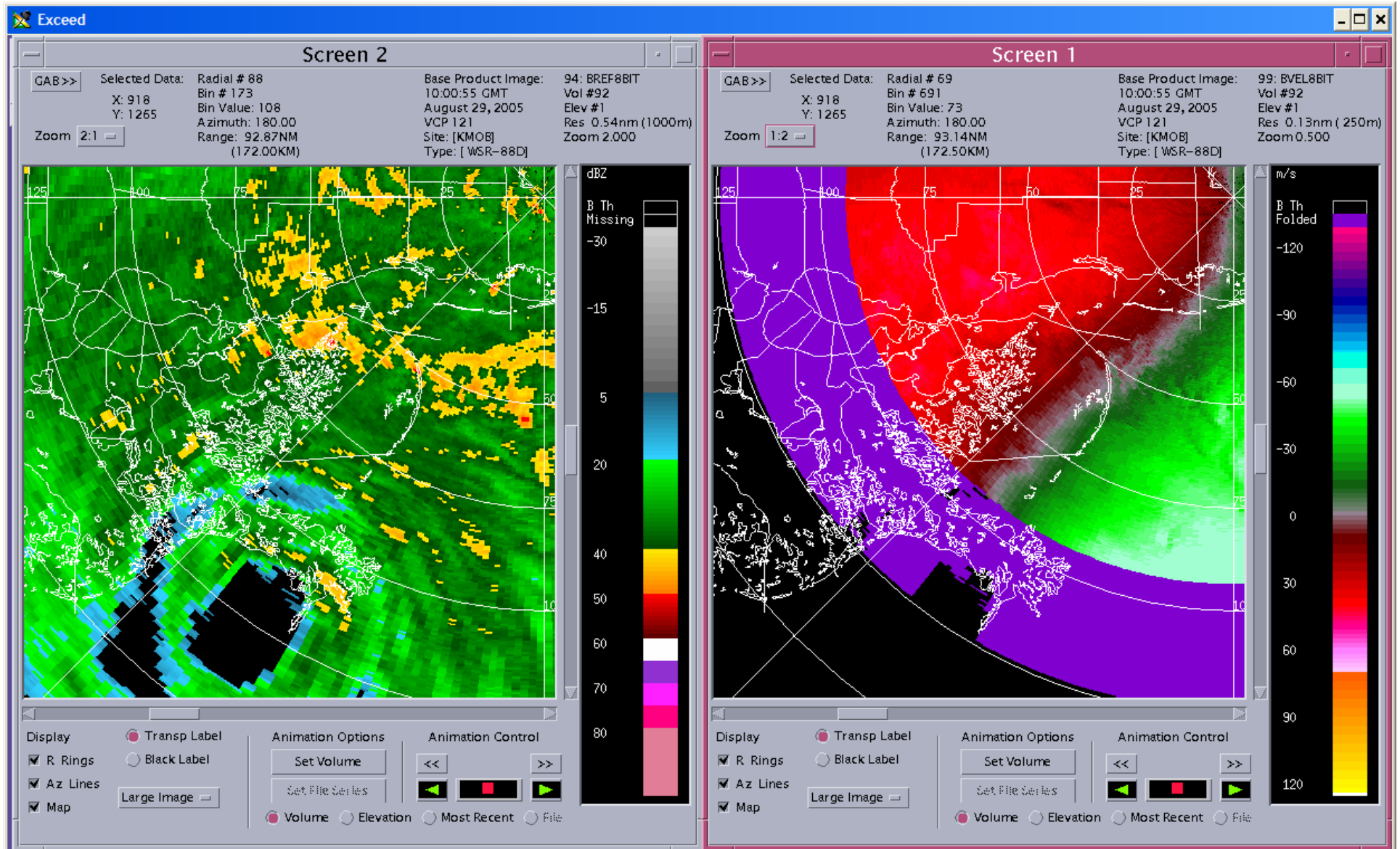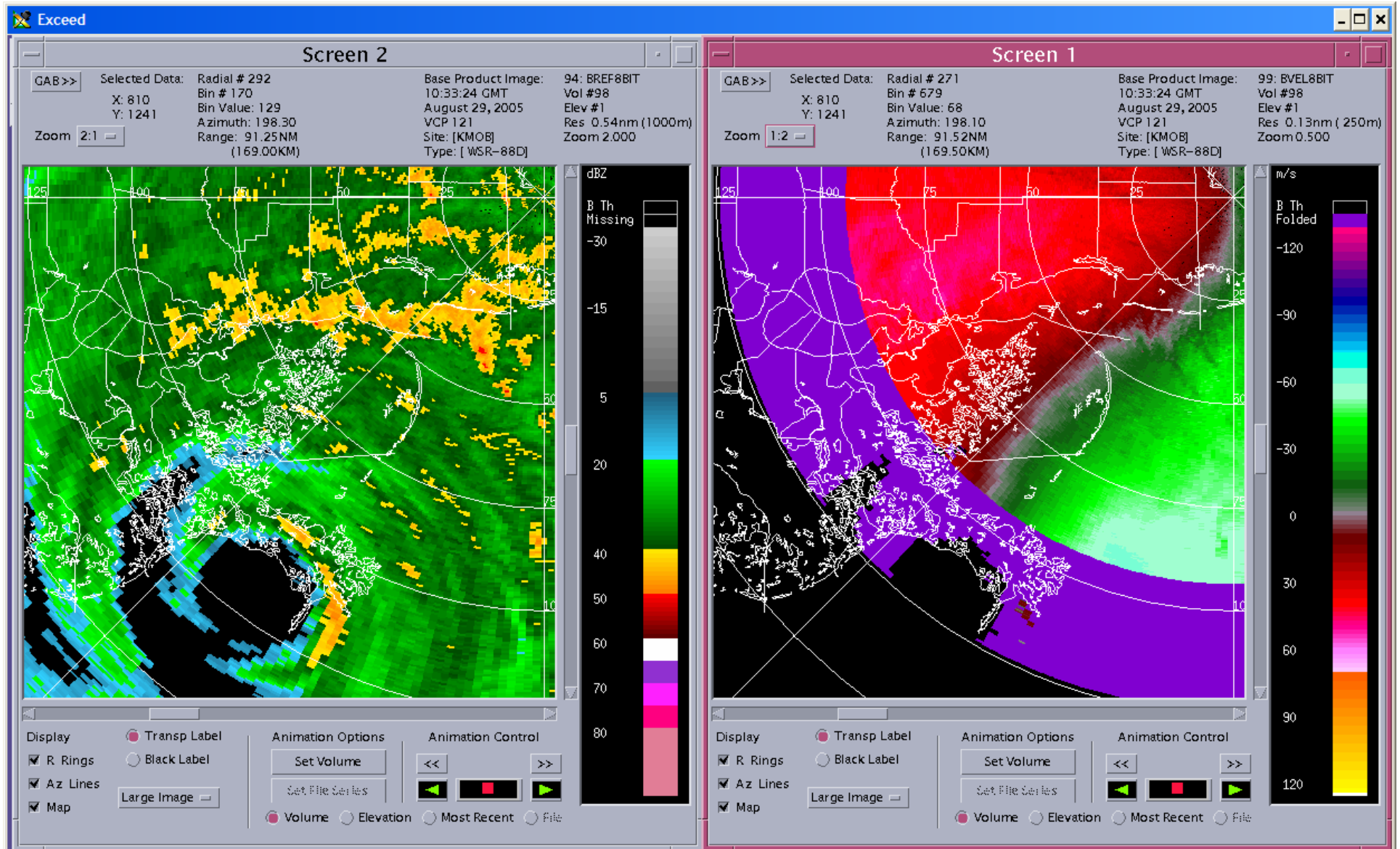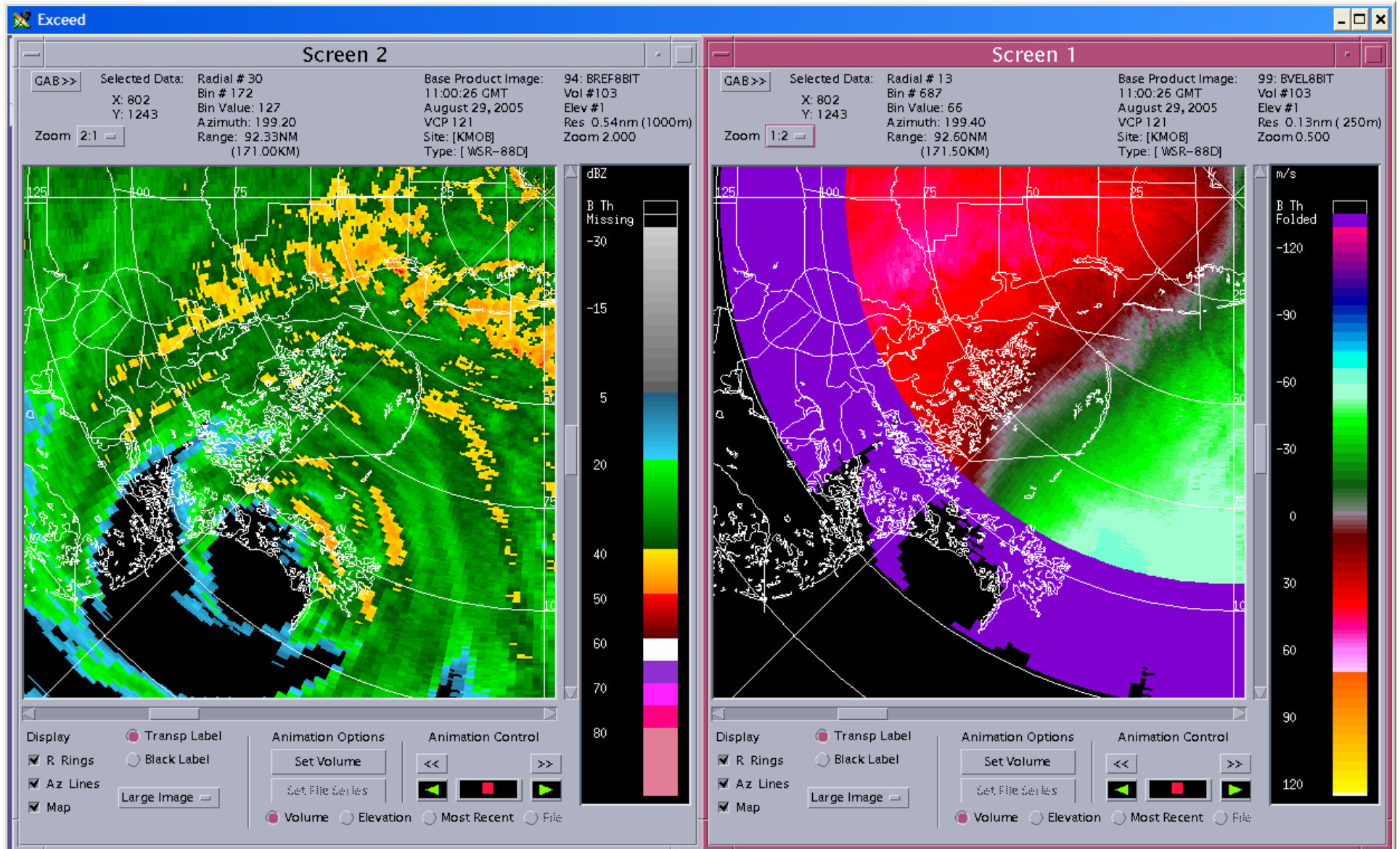
~30 min intervals
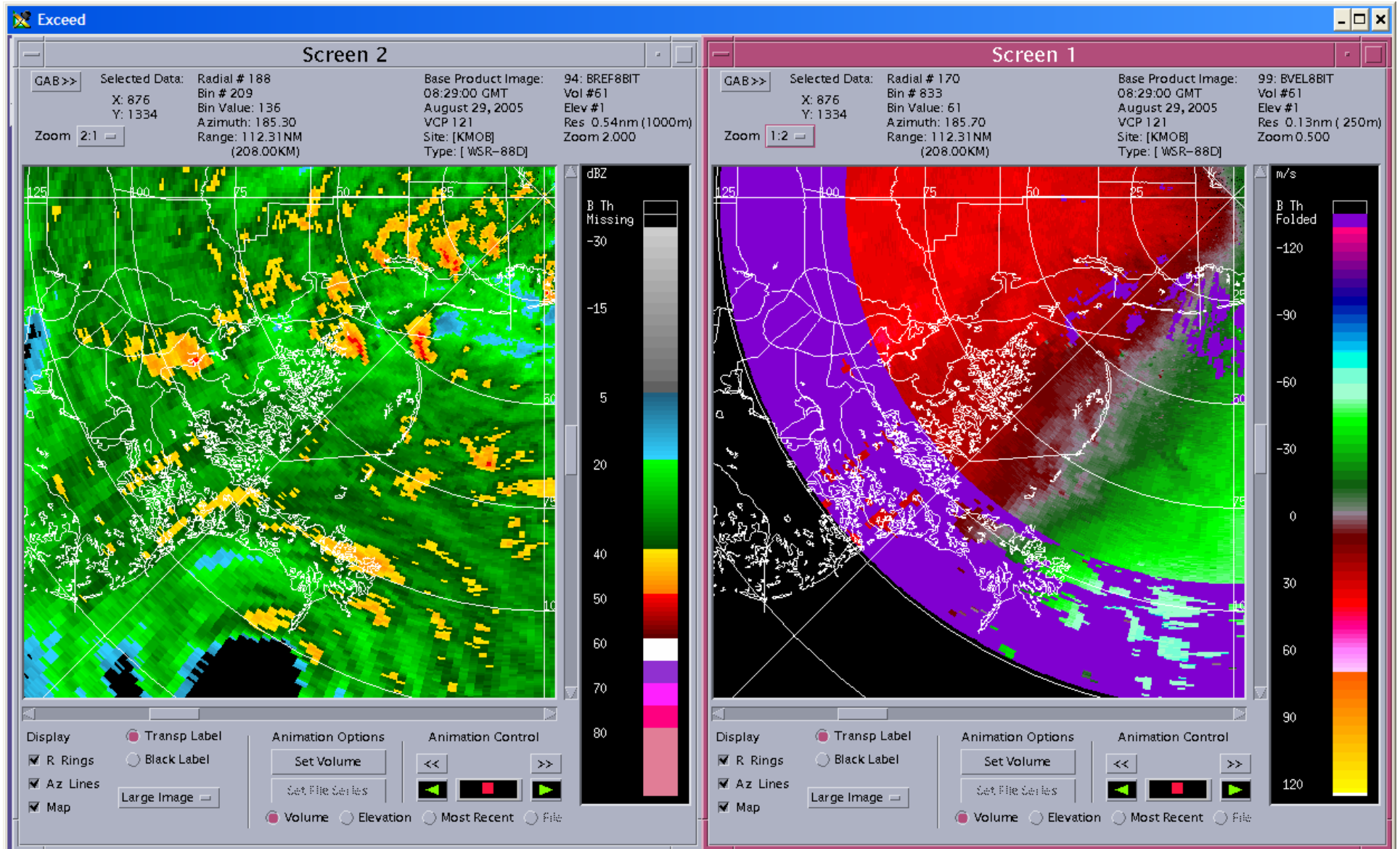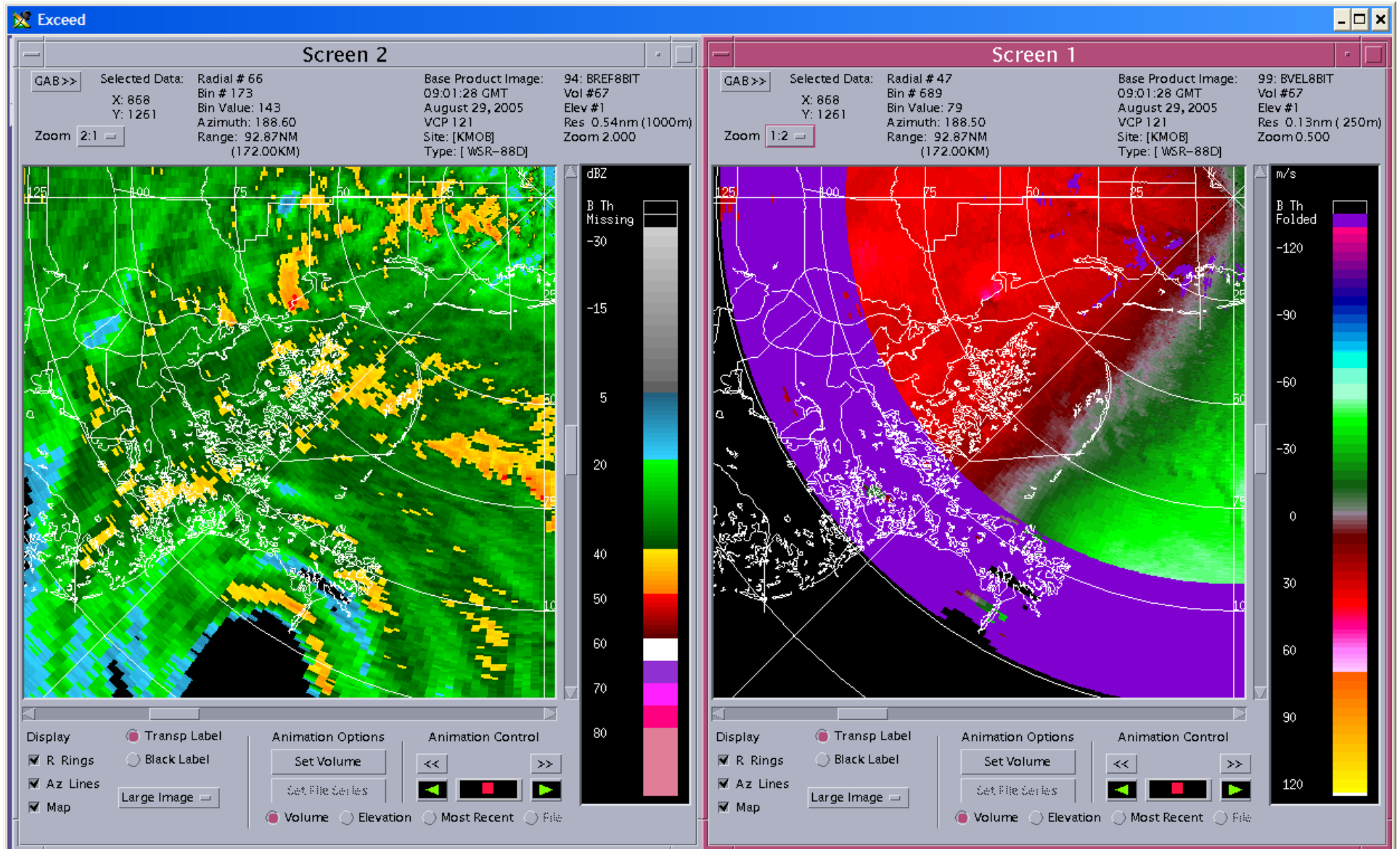
Hurricane Katrina - KMOB

Hurricane Katrina - KMOB

Hurricane Katrina - KMOB
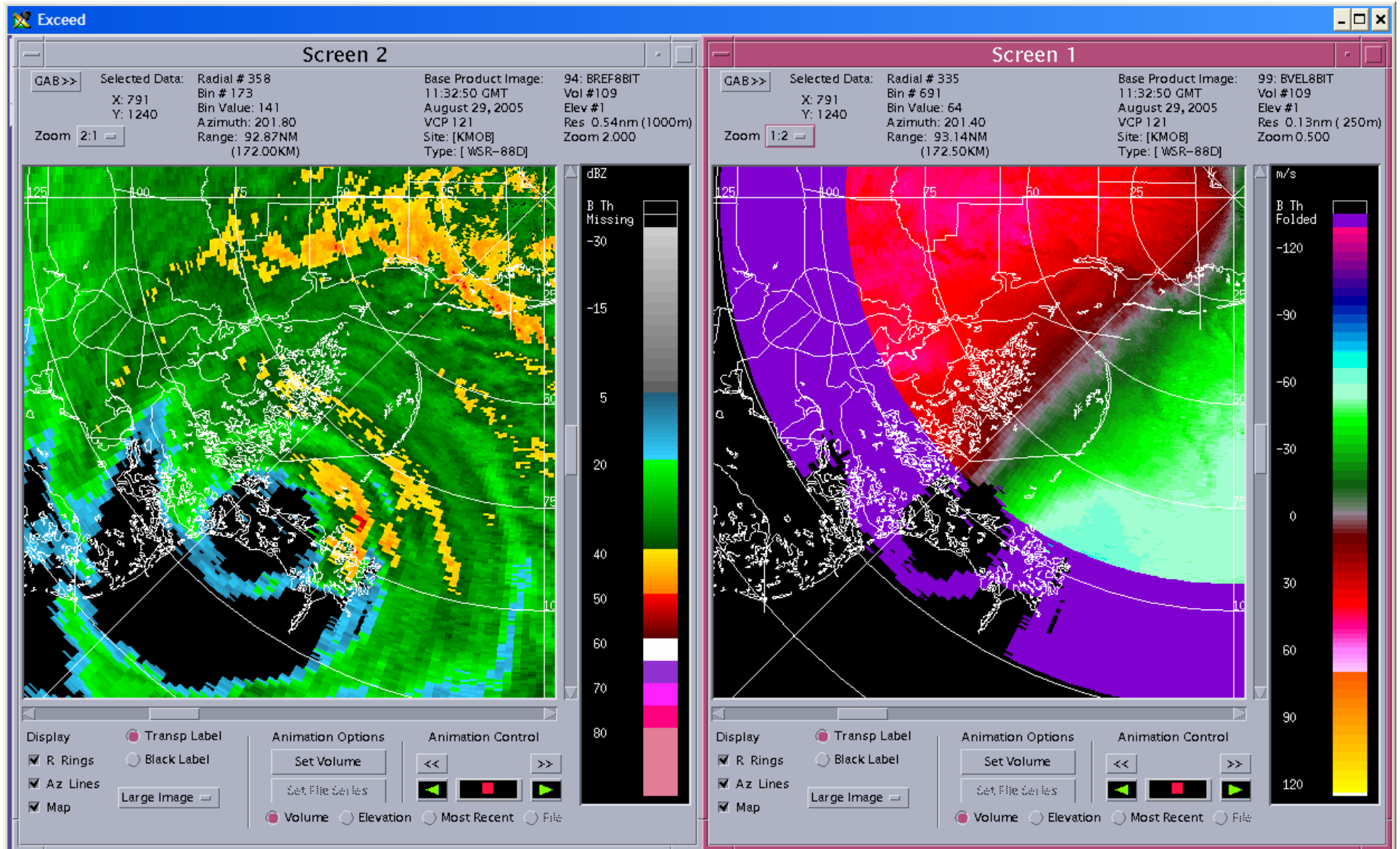
Hurricane Katrina - KMOB
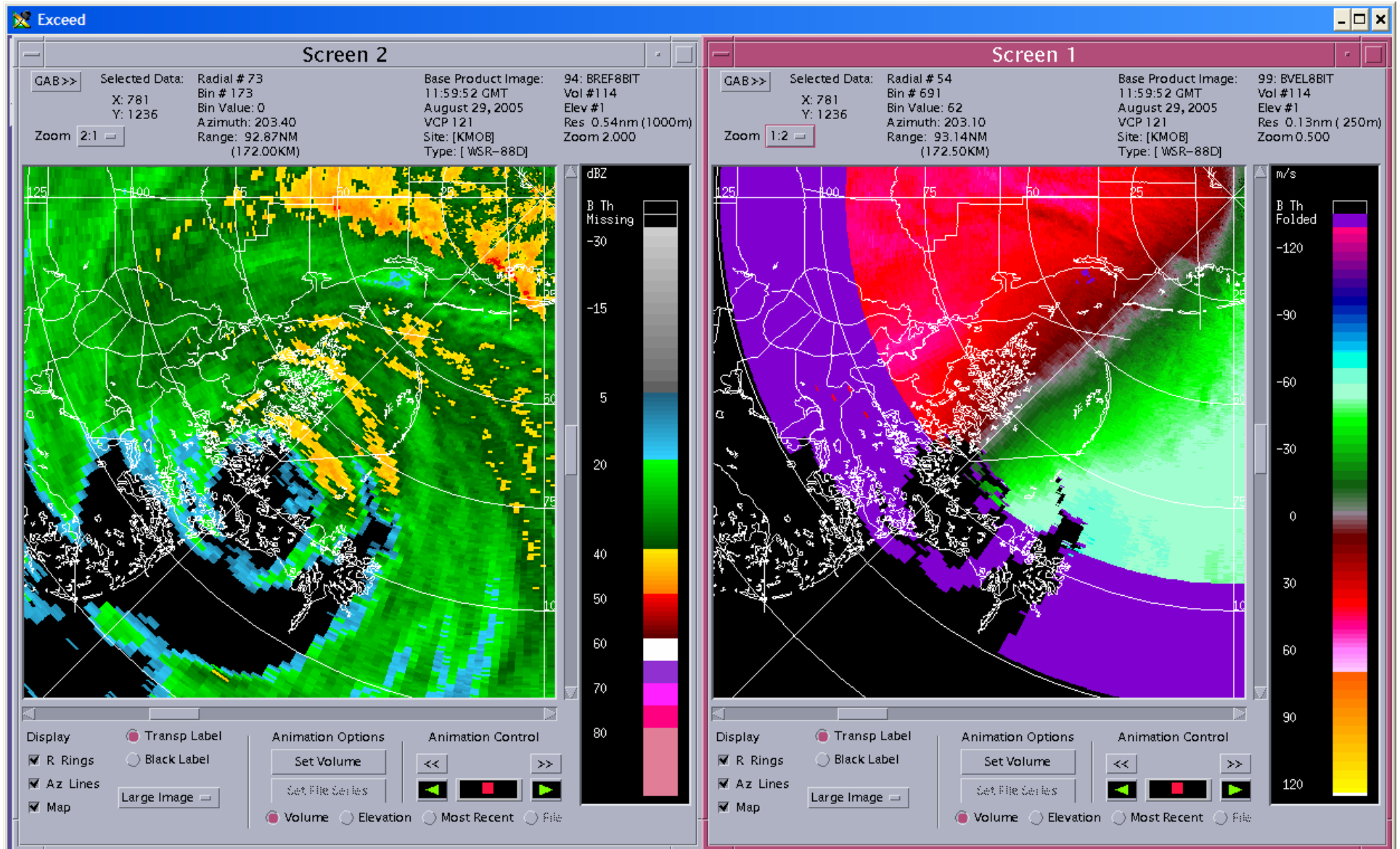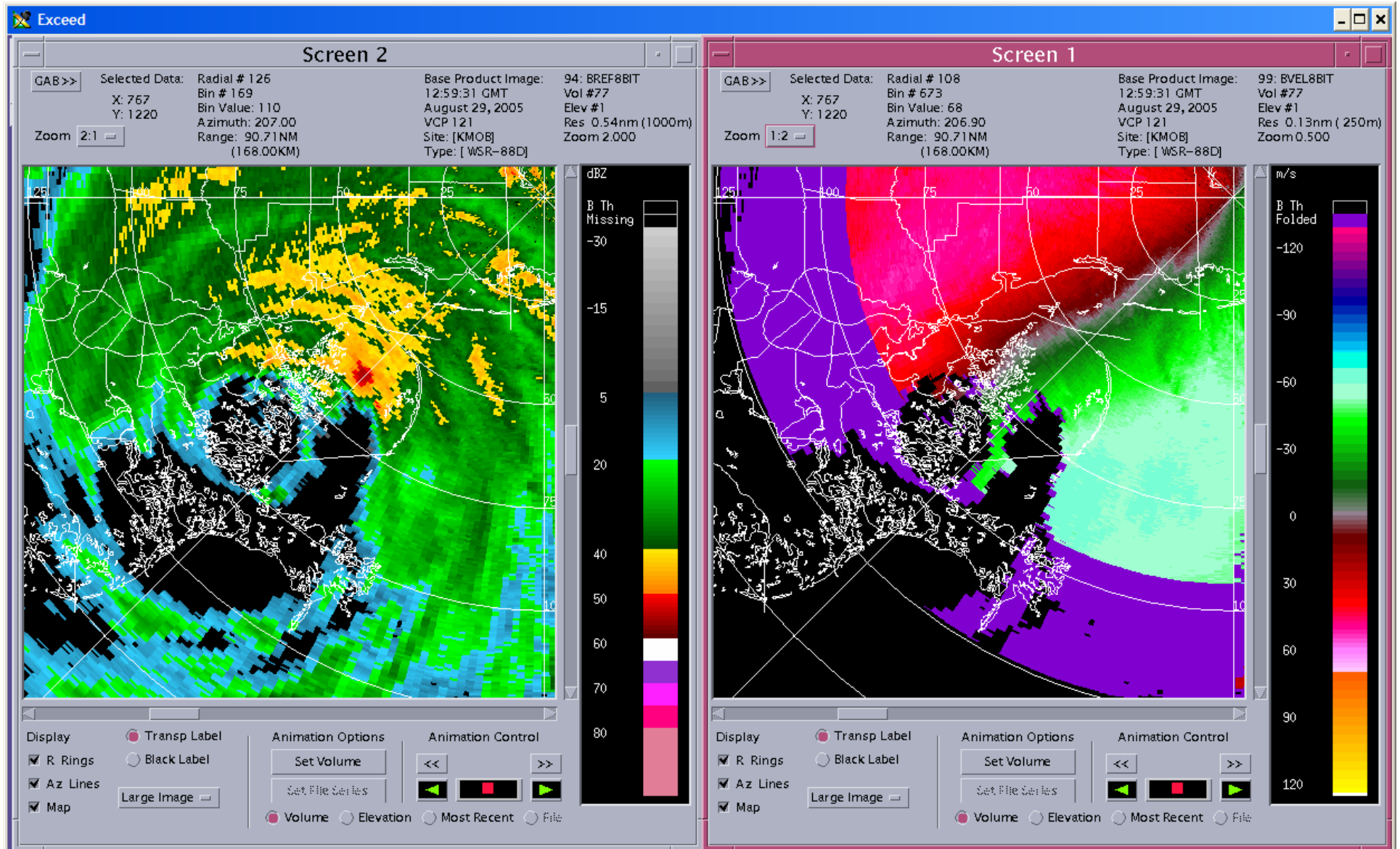
Hurricane Katrina - KMOB

Hurricane Katrina - KMOB

Hurricane Katrina - KMOB

Hurricane Katrina - KMOB

Saffir-Simpson Scale

Category		Miles Per Hour (mph)	Knots (kt)	Kilometers Per Hour (km hr^{-1})	Meters Per Second (m s^{-1})
Tropical Storm		39-73	34-63	63-118	18-33
Hurricane Category	*1*	74-95	64-82	119-153	33-43
Hurricane Category	*2*	96-110	83-95	154-177	43-49
Hurricane Category	*3*	111-130	96-113	178-209	49-58
Hurricane Category	*4*	131-155	114-135	210-249	58-69
Hurricane Category	*5*	>155	>135	>249	>69