NCAR

Science Overview of ANC for MDL Visiting Forecasters

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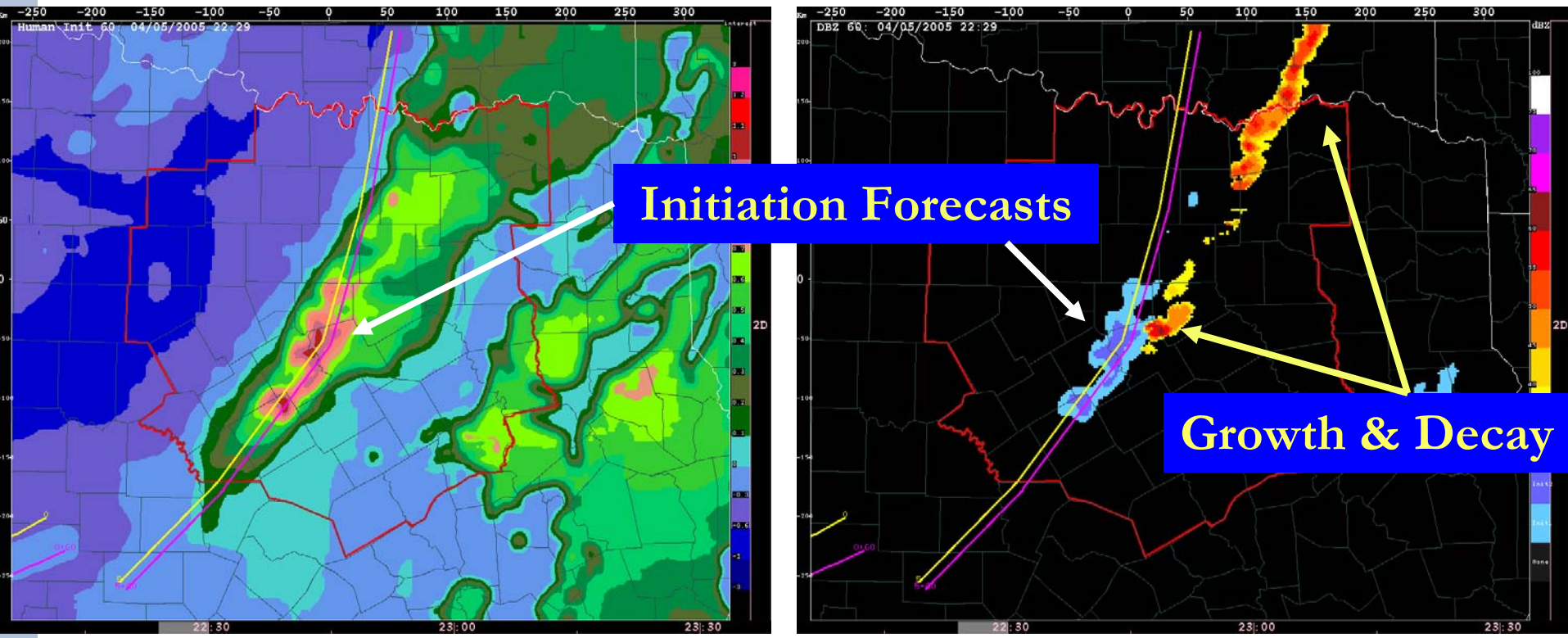
NCAR-RAL

National Center for Atmospheric Research

Training Topics

- Overview / Human Interaction
- AWIPS ANC Products
- Fuzzy Logic, FWD Predictors and Regime
- Polygon / Nudging examples

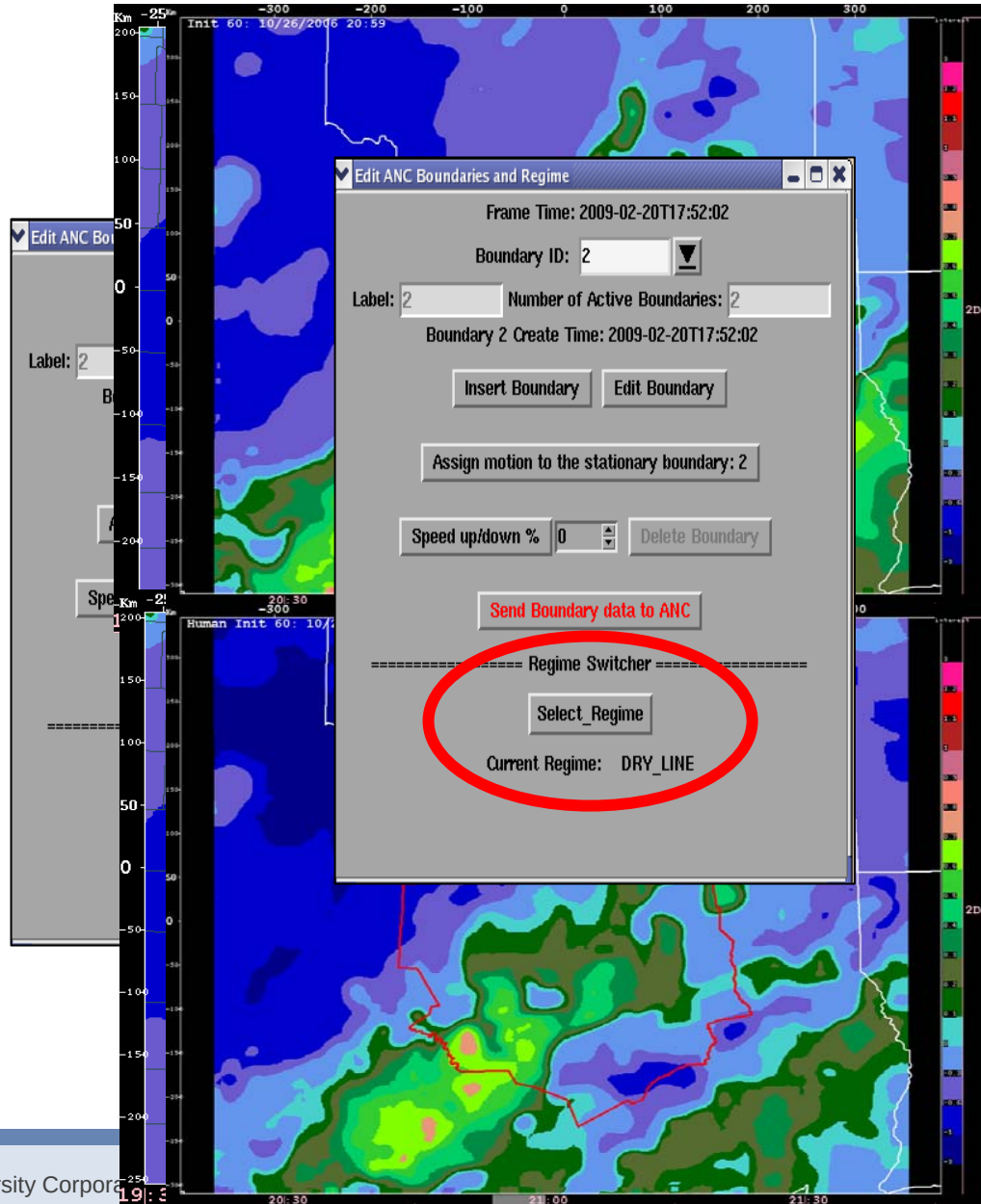
NCAR Auto-Nowcaster



- Routine (5mins) short-term (0-1hour) forecasts of thunderstorm initiation, growth and decay.
- Uses fuzzy logic to combine observations, NWP and forecaster input to generate nowcasts.

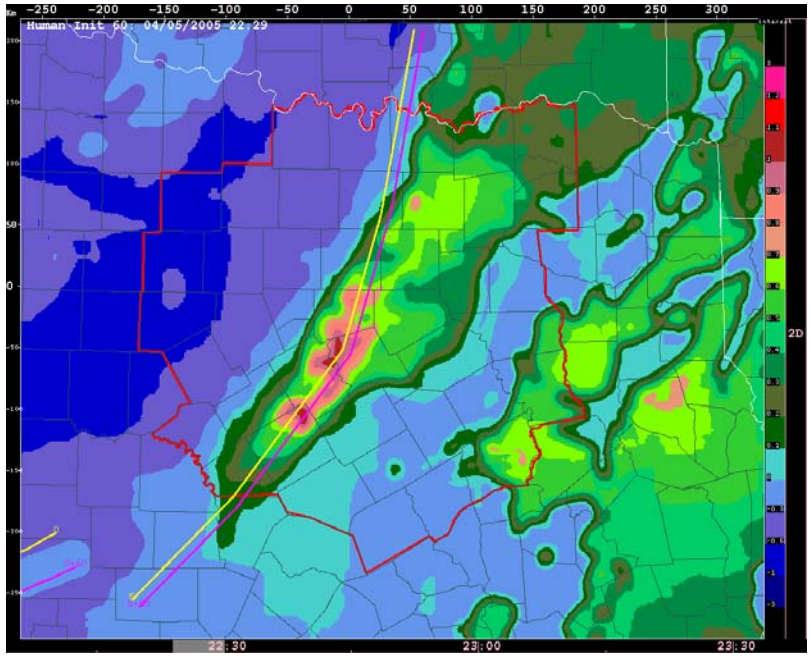
Interaction

- Boundary Entry
- Polygon Entry
- Init Field Nudging
- Regime Selection



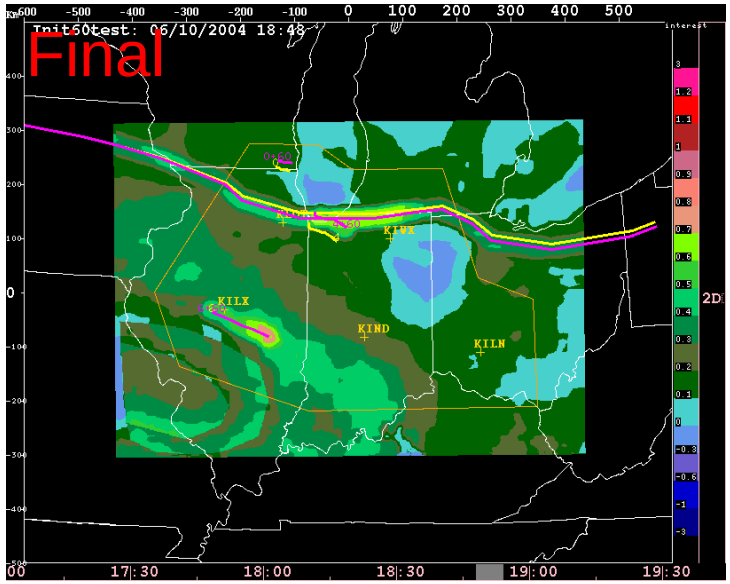
ANC 60min Initiation Final

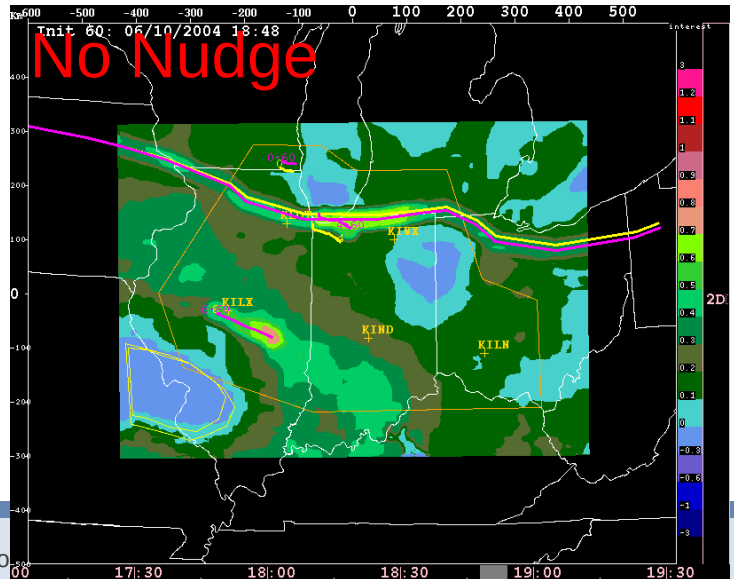
- Fuzzy logic output for likelihood for initiation at 60min.
- Warmer colors indicate higher likelihoods
- Values of .7 and higher (salmon/red) interpreted as threshold for storm initiation at 60mins.



ANC 60min Initiation No Nudge

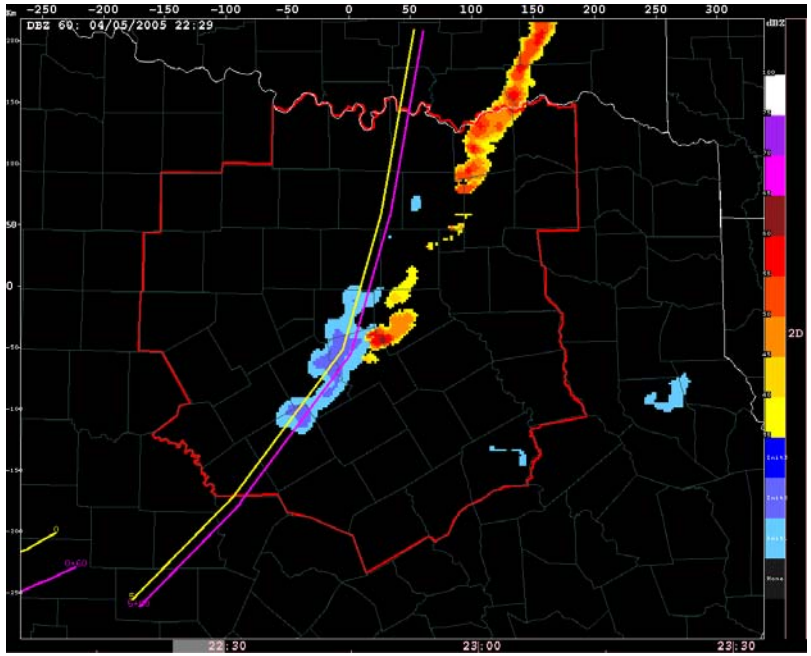
- Differs from Initiation Final
- No Nudging or Polygons used
- Boundary Predictor Fields still included
- Shows the Init60 field before human edits for comparison





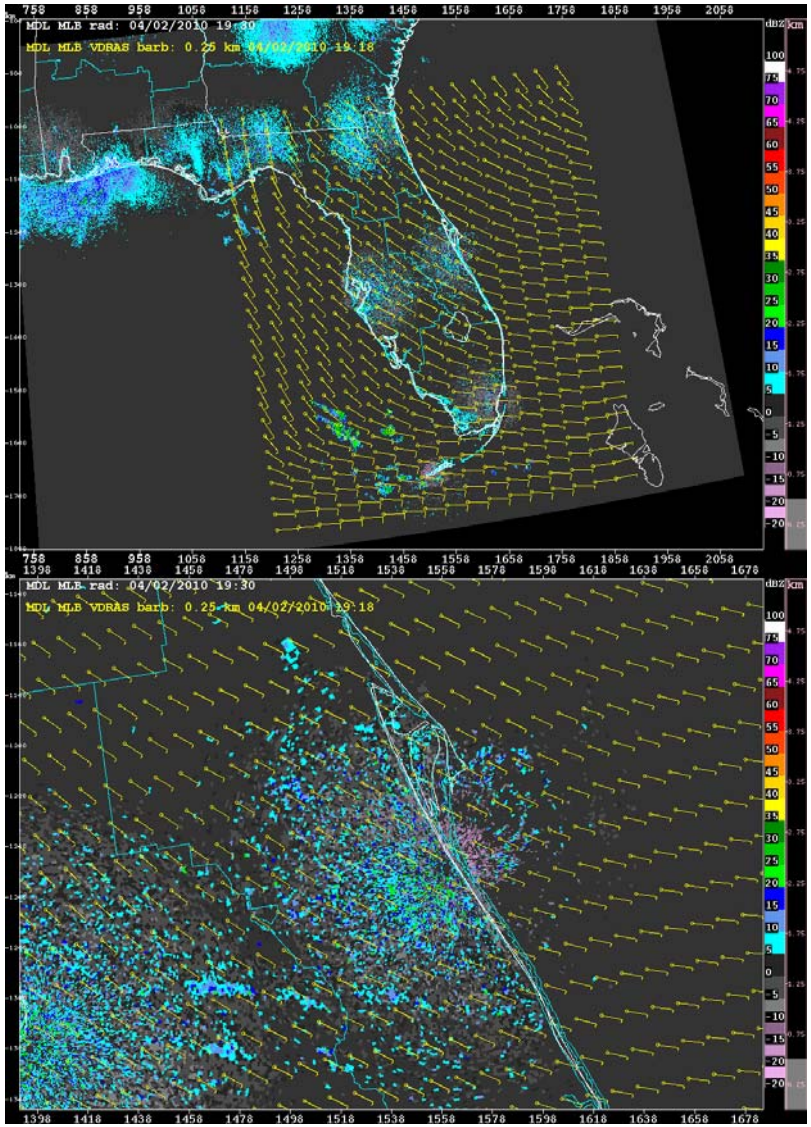
Nowcast Final

- Combined Growth/Decay and Initiation likelihood field
- Blue colors are arbitrary thresholds of initiation likelihood
- Warm colors are Growth/Decay of existing echoes.
- Existing echoes been filtered to remove stratoform precipitation



Adjoint Sfc Wind

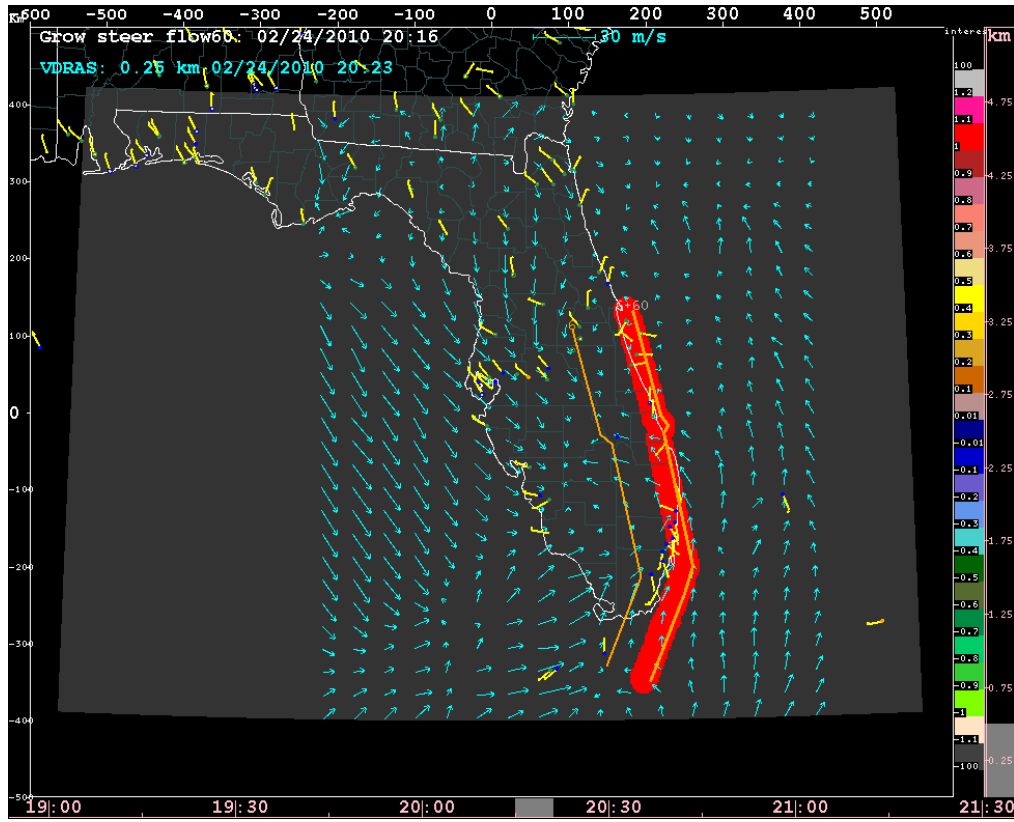
- Wind barbs for 250m from VDRAS
- Derived from background model field and radar data assimilation
- Other layers available through volume browser



VDRAS – Variational Doppler Radar Assimilation System

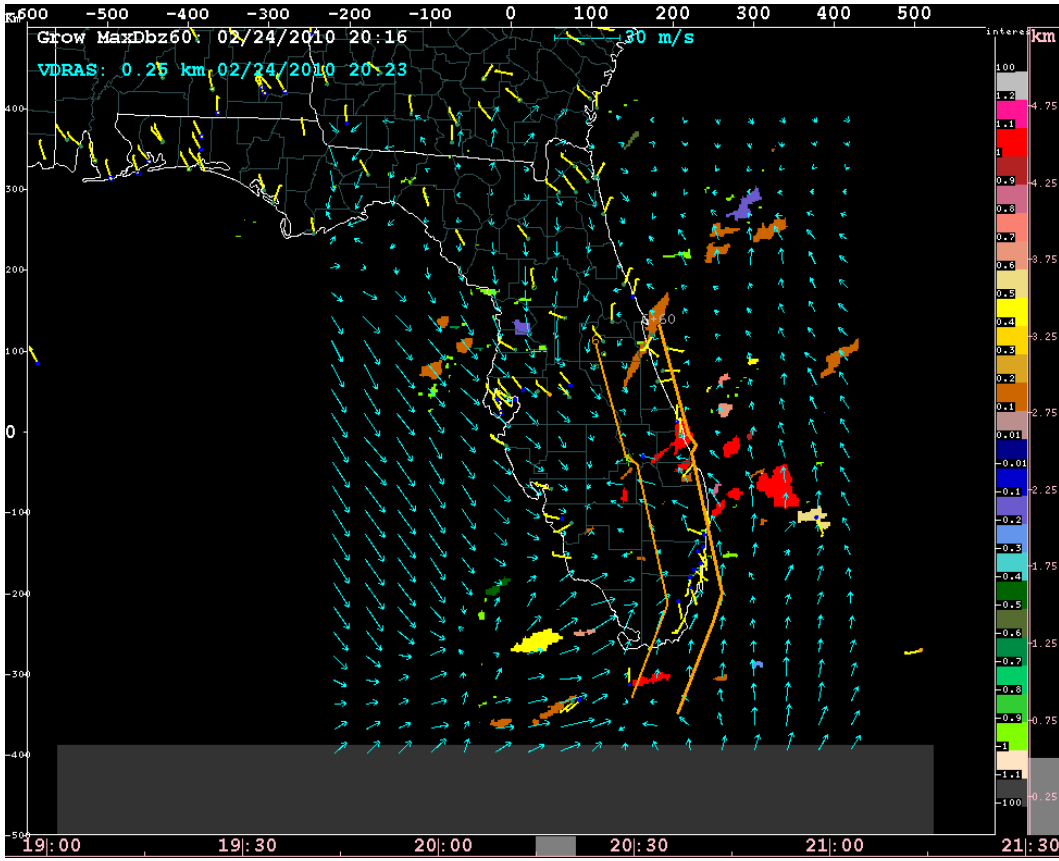
Boundary Relative Steering Flow Interest

- Steering Flow relative to human entered boundary
- Used to determine whether updrafts will stay anchored on boundary



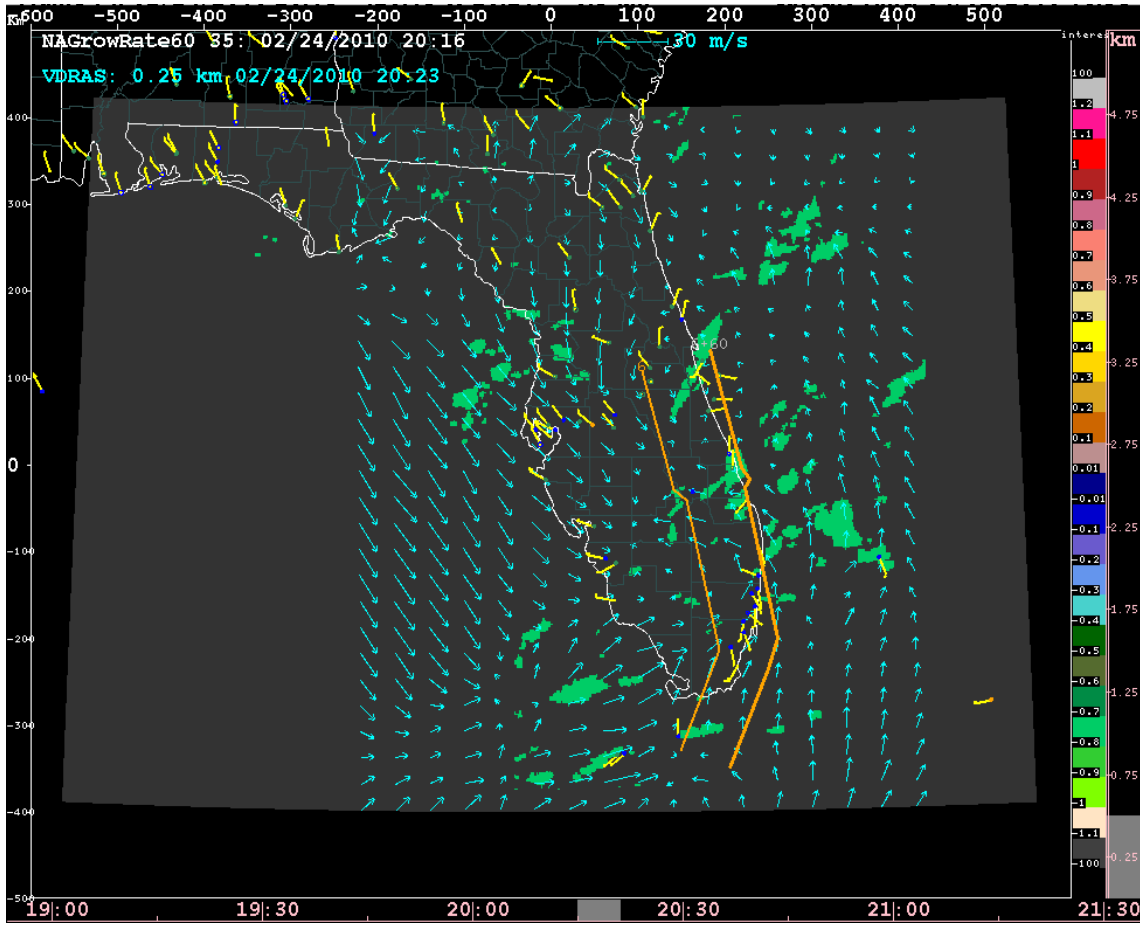
Max Reflectivity Interest Field

- Maximum observed reflectivity extrapolated 60mins



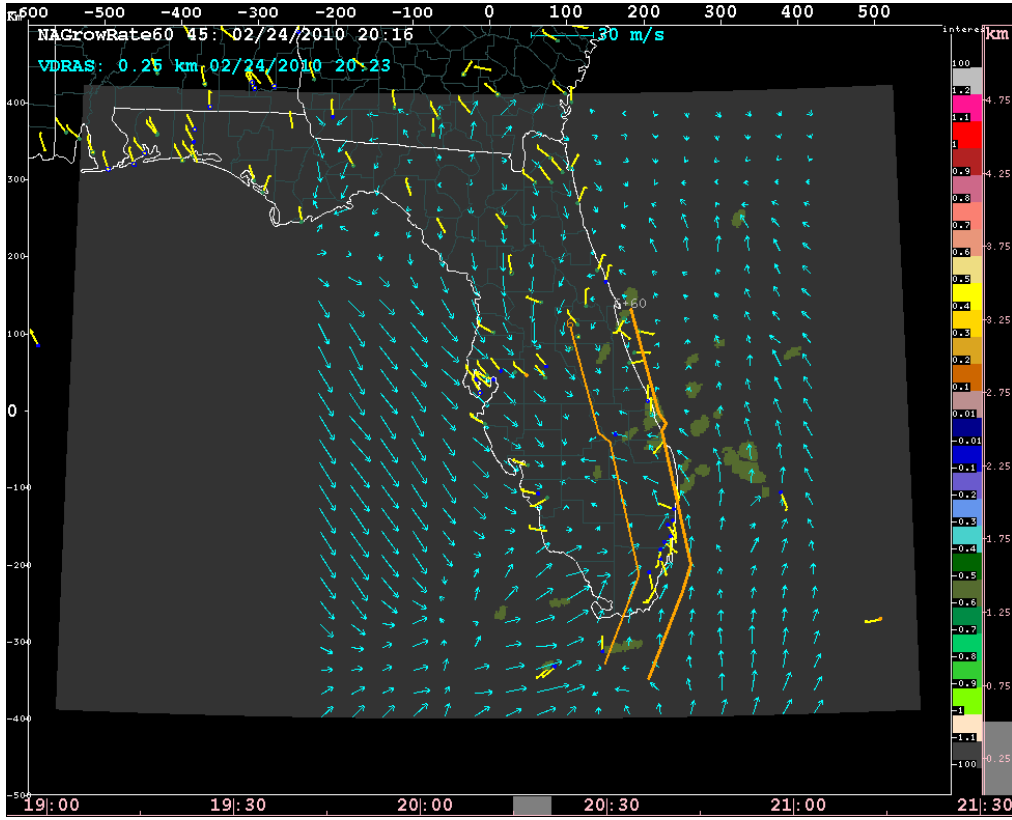
35dbz Growth Rate Interest

- Normalized Area Growth Rate for 35dbz echoes (advected)



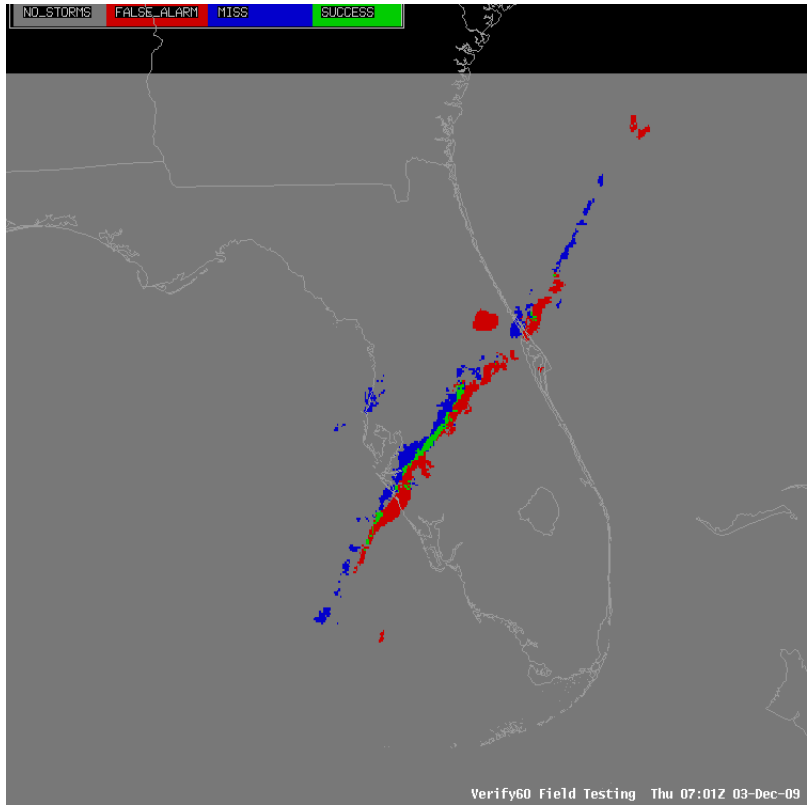
45dbz Growth Rate Interest

- Normalized Growth Rate for 45dbz echoes (advected)



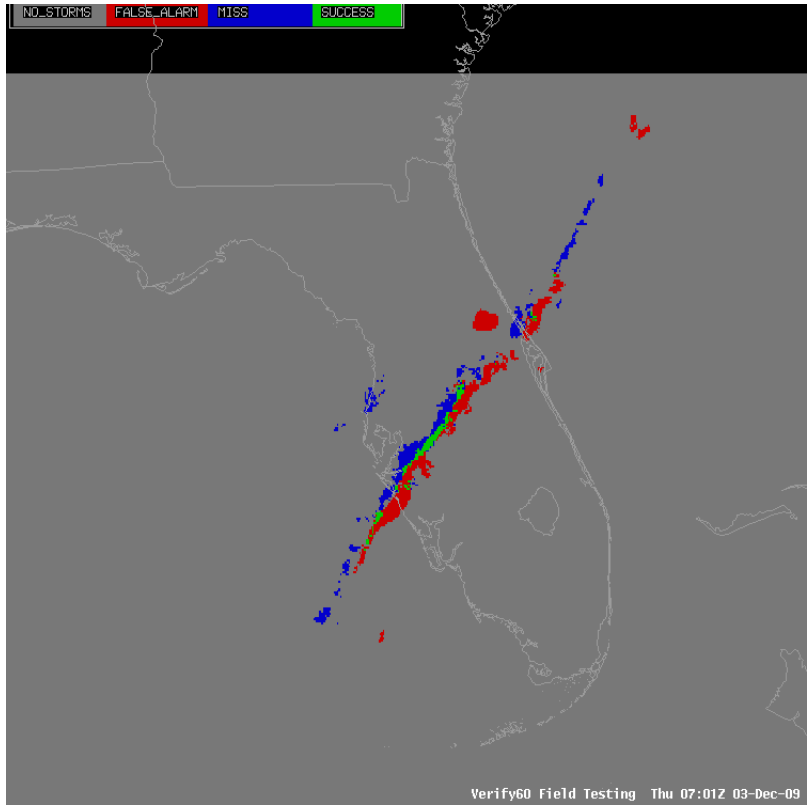
60min Verification

- Shows the T-60min forecast valid NOW.
- Green are Hits (good forecasts)
- Blue are missed forecast areas
- Red are incorrect forecast areas



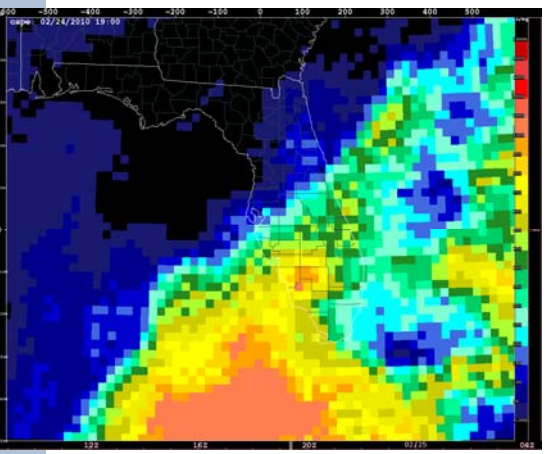
NoHuman 60min Verification

- Validation field for forecasts not including any human interaction
- No Boundaries, Nudges, or Polygons, and only using Mixed regime.

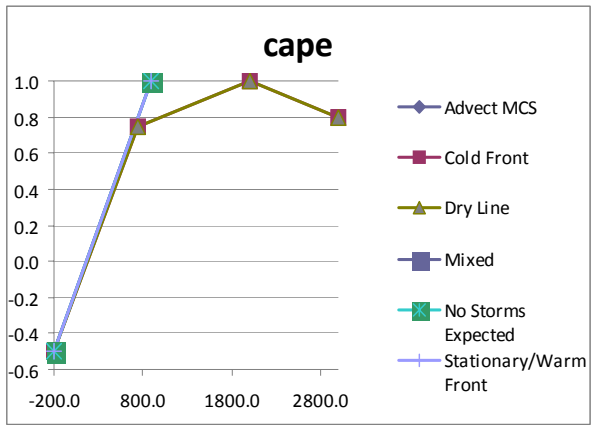


Fuzzy Logic

- Fuzzy Logic ingests predictor fields and applies a membership function to the field values to produce individual interest maps.



X



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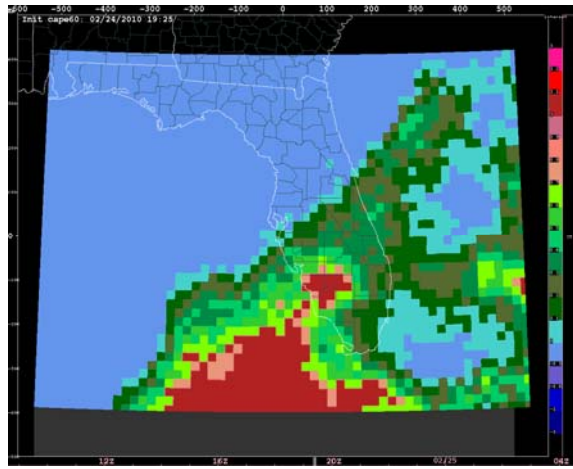
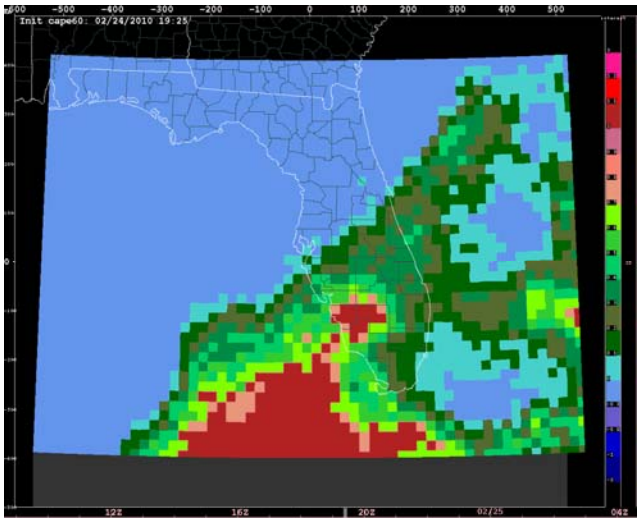


Fuzzy Logic

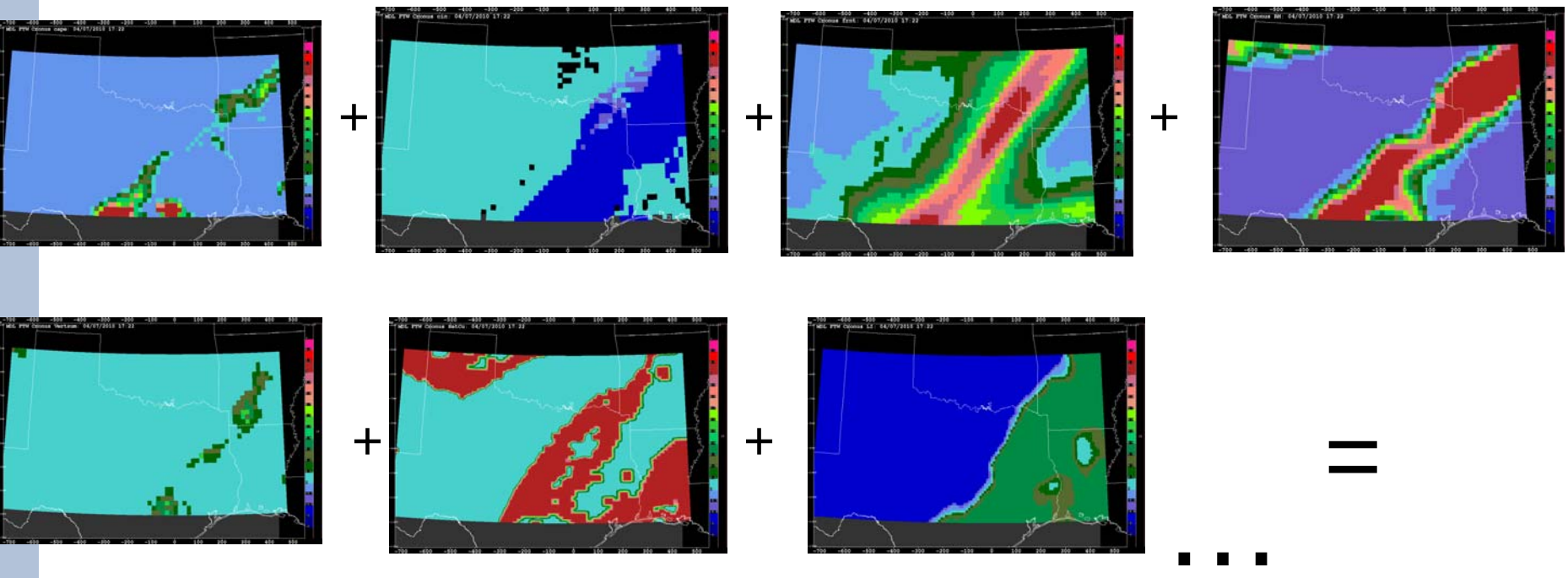
- Each Interest map is then multiplied by a weight



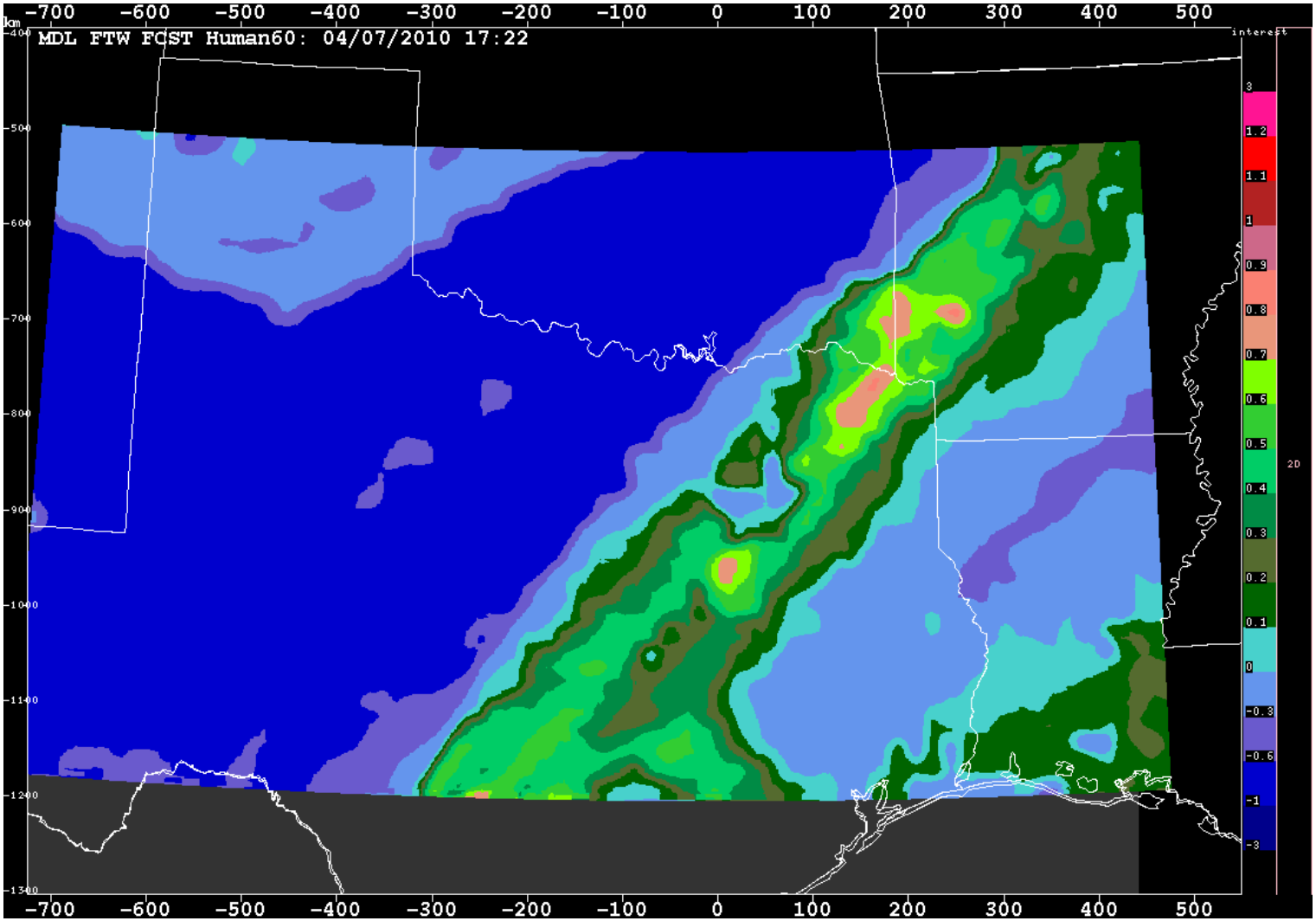
X 0.20

Fuzzy Logic

- All the weighted interest maps are then summed to produce the Init60 field

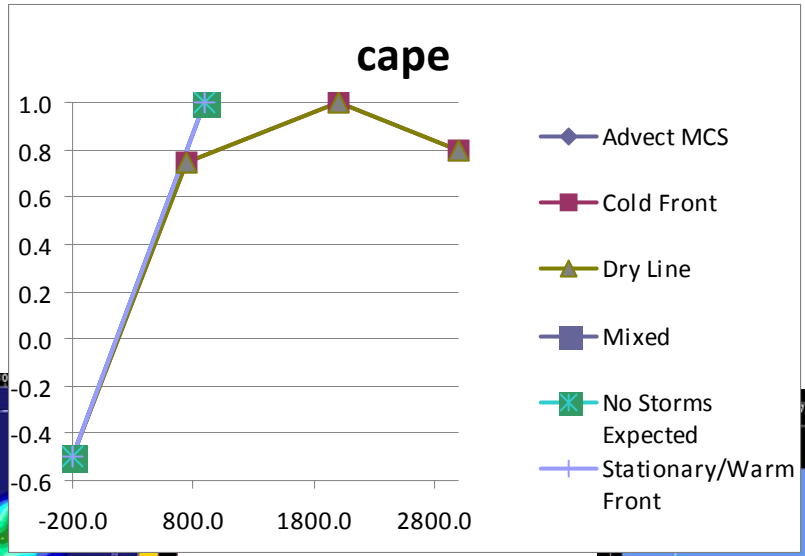


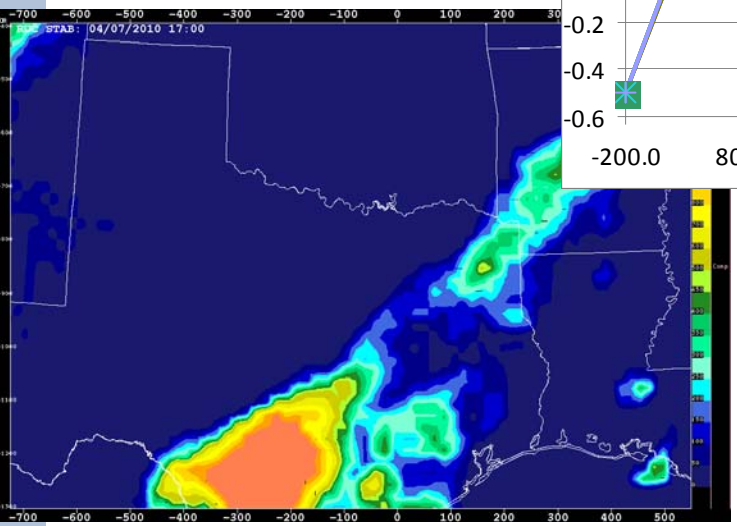
60min Initiation Likelihood

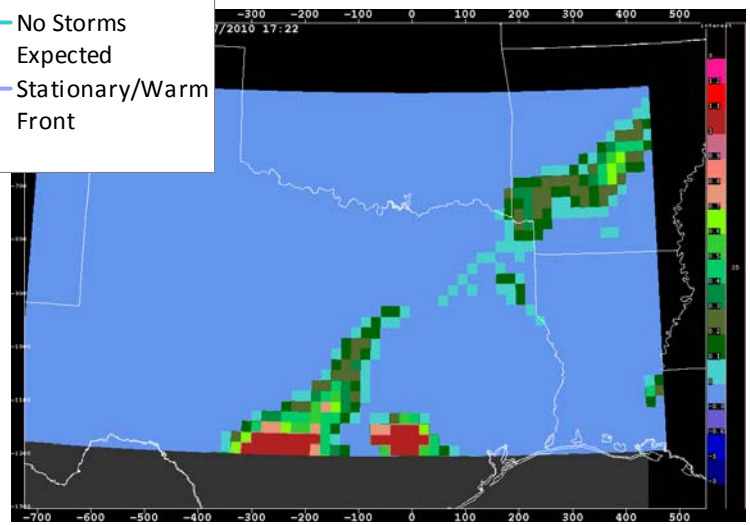


FWD Predictors

- Cape – RUC Most Unstable Cape 900mb-500mb.

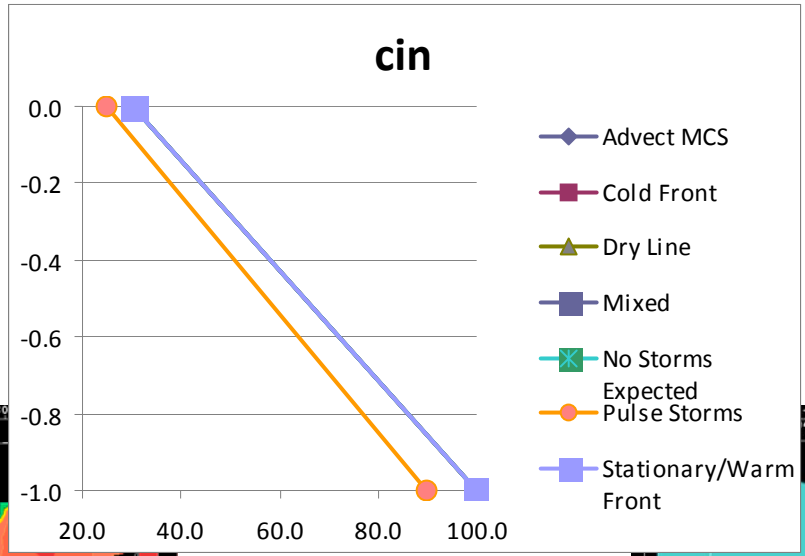


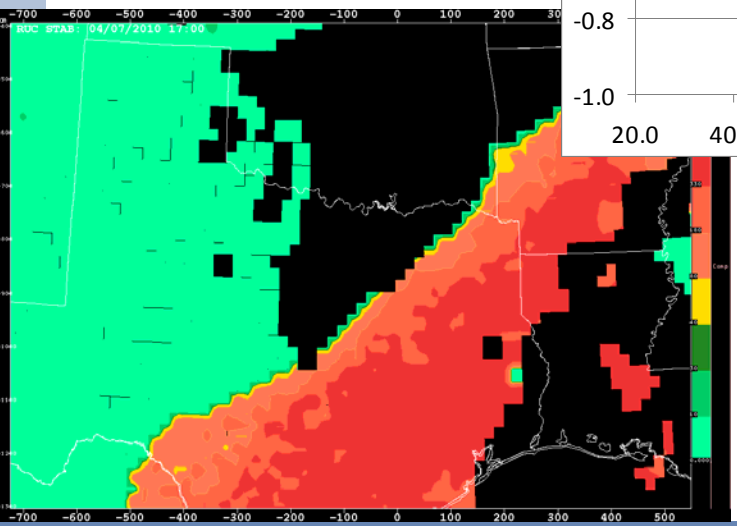


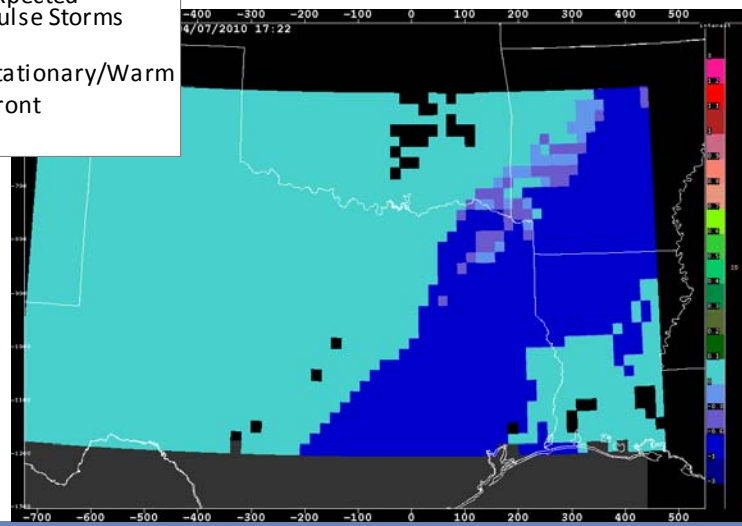


FWD Predictors

- CIN – Mean CIN between 975mb-900mb

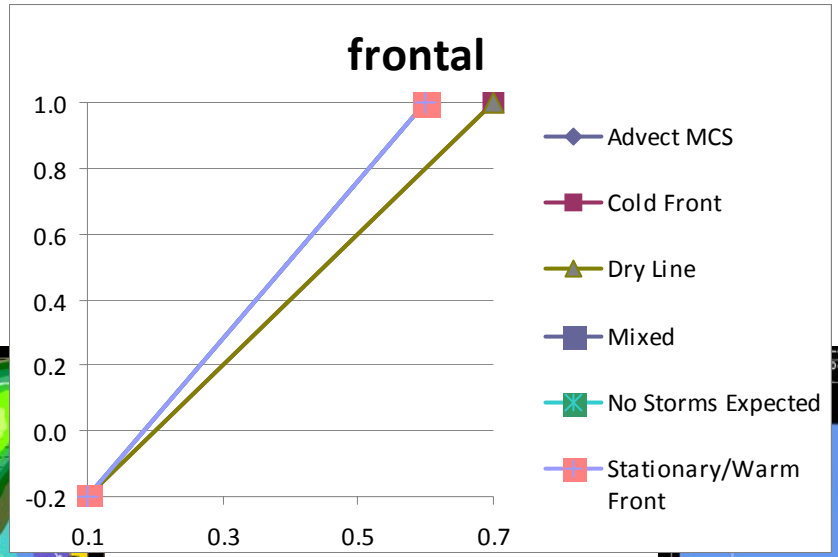


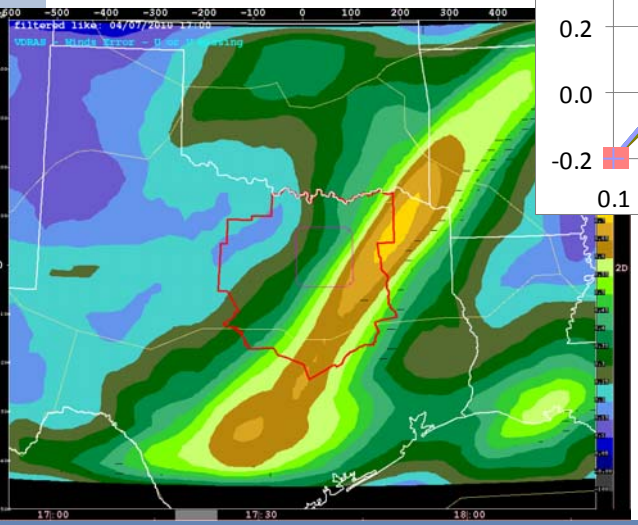


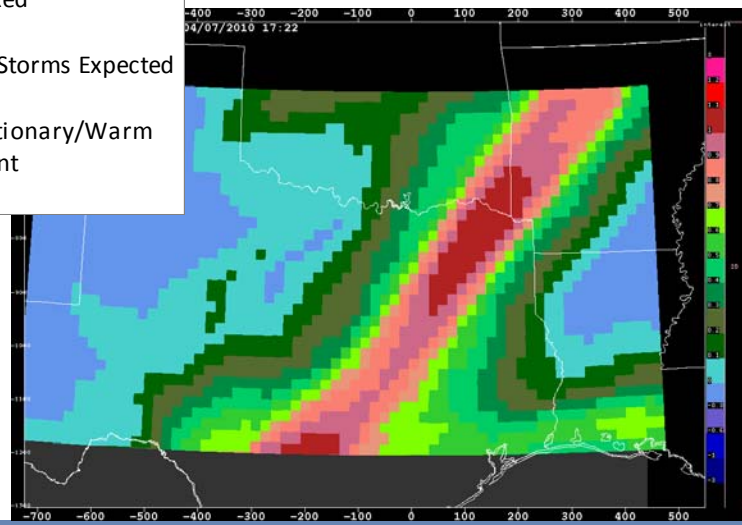


FWD Predictors

- Frontal Likelihood – Fuzzy logic field that uses RUC convergence, vorticity, and theta-e gradients to identify broad frontal zones.

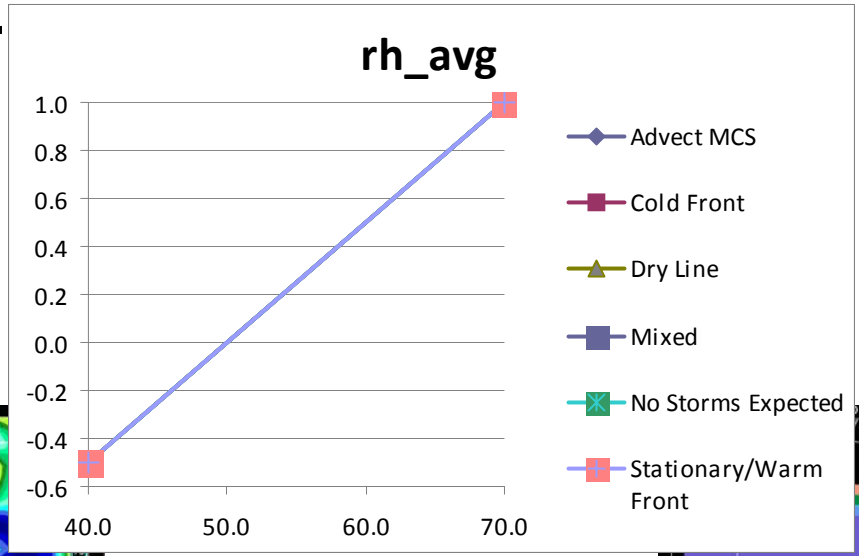


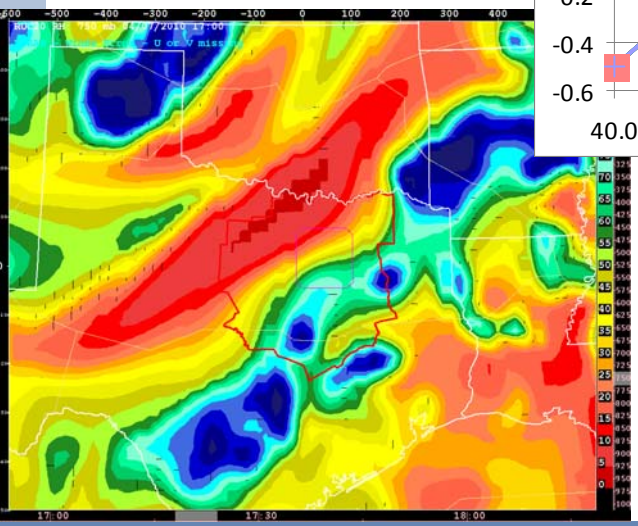


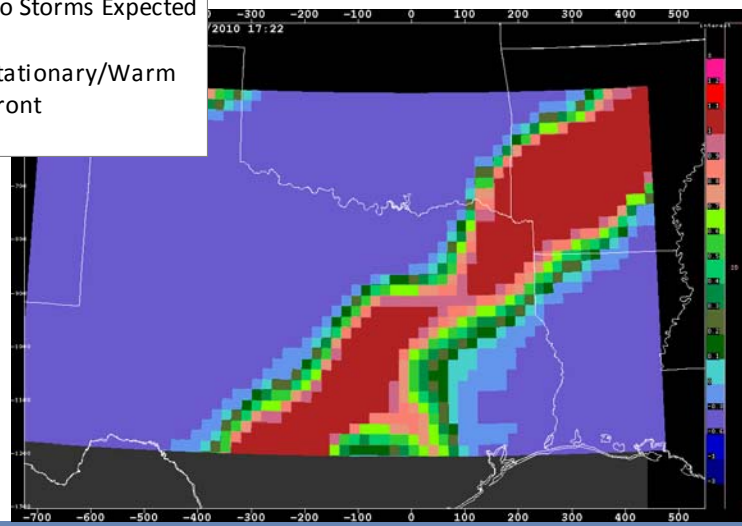


FWD Predictors

- Relative Humidity – Layer average between 875mb-625mb. Intended to assess mid-level moisture.

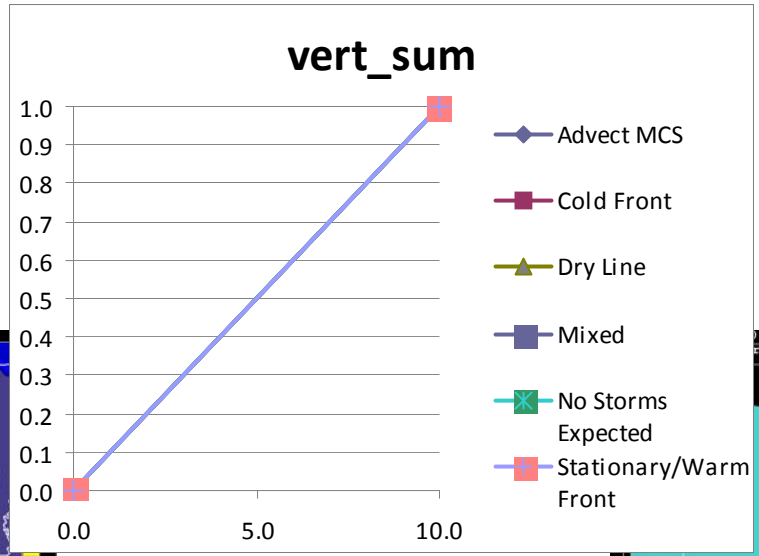


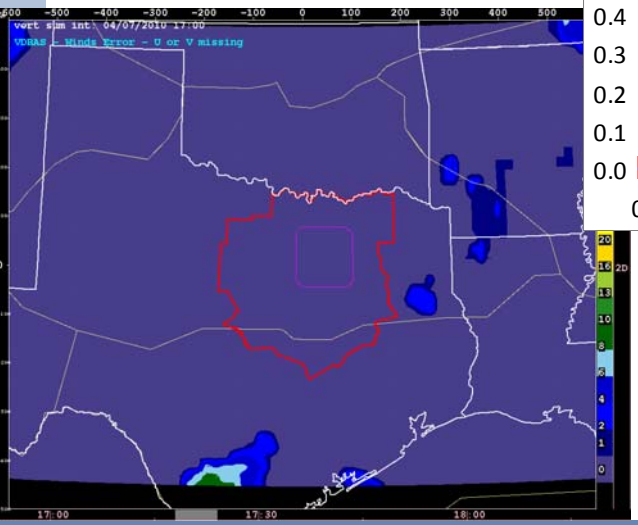


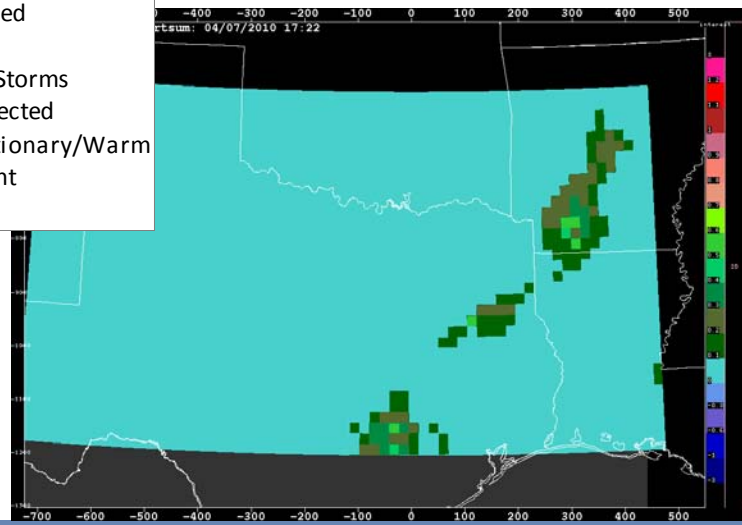


FWD Predictors

- VertSumInterest – A field derived from the RUC that looks for contiguous unstable layers. Interest is weighted based on CIN and wind shear.

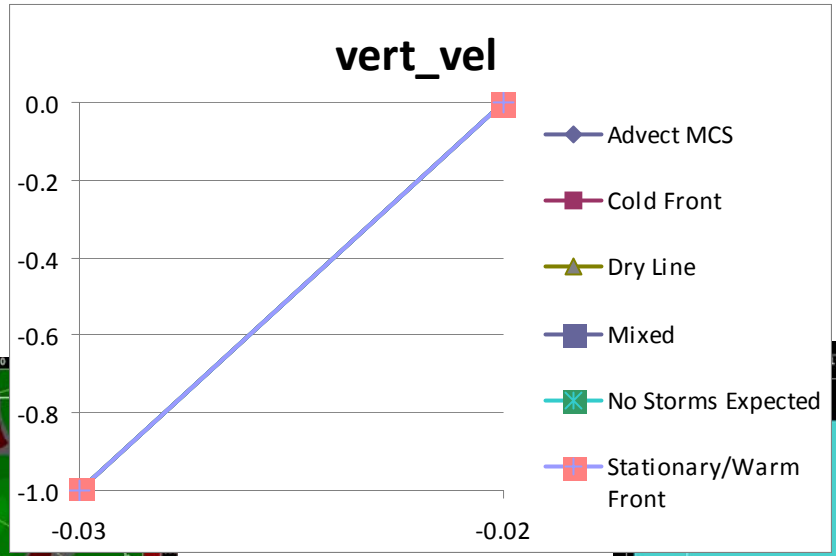


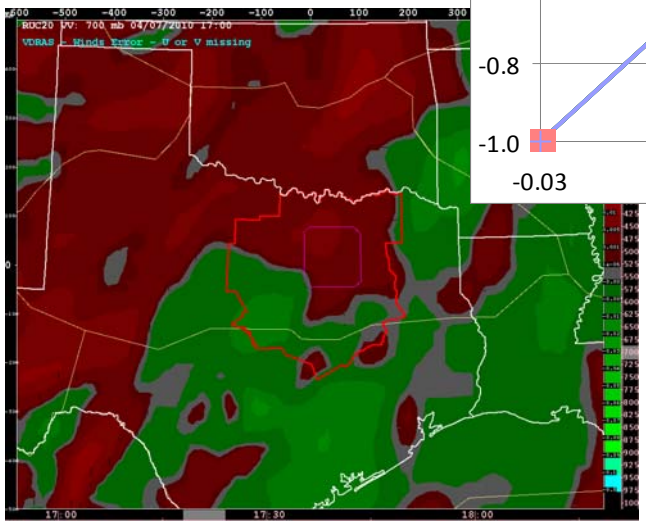


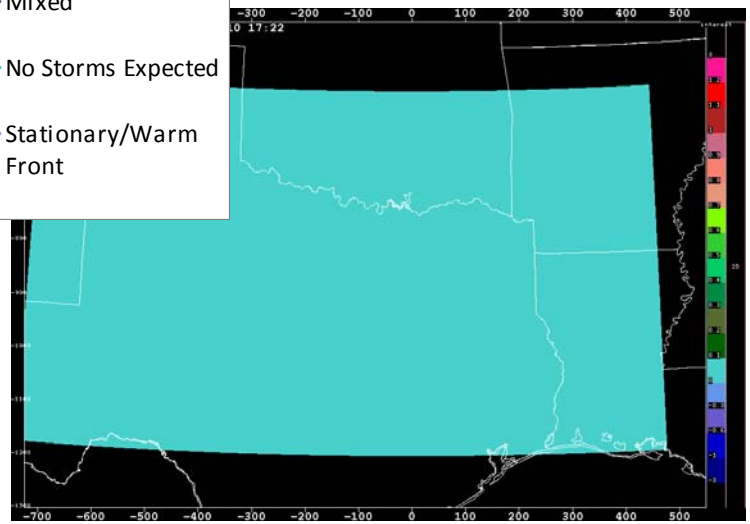


FWD Predictors

- Vertical Velocity – RUC 700mb Vertical Velocity.
- Applies negative interest in strong downward VV's

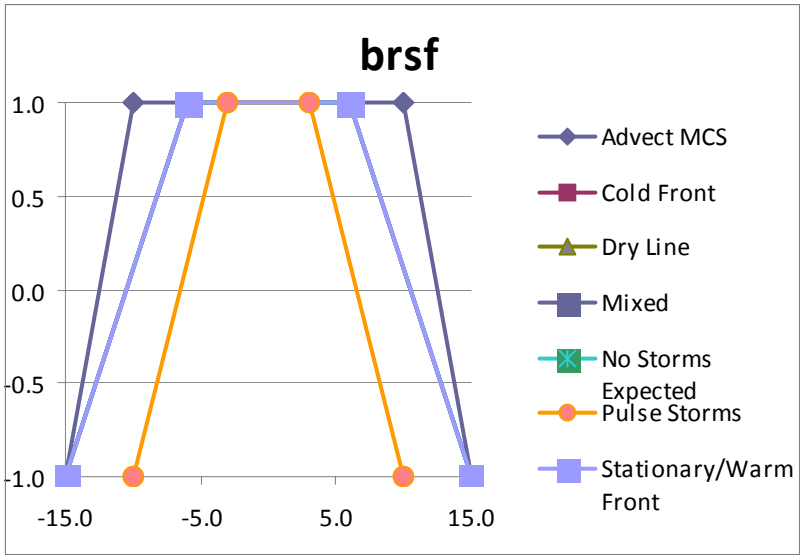


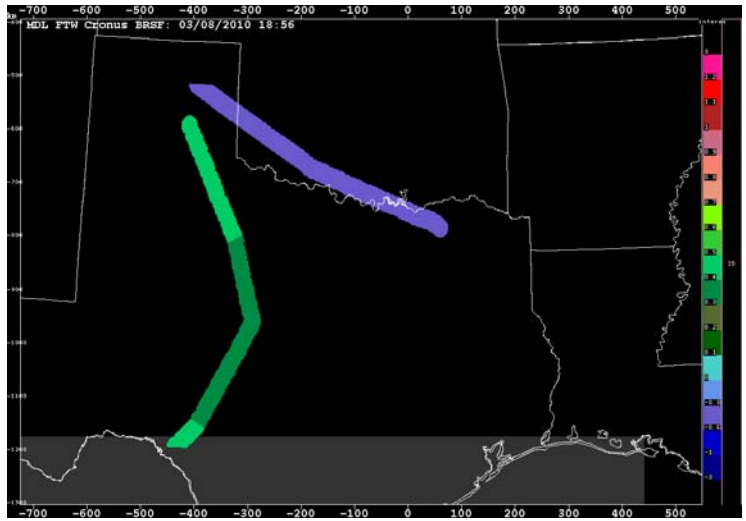




FWD Predictors

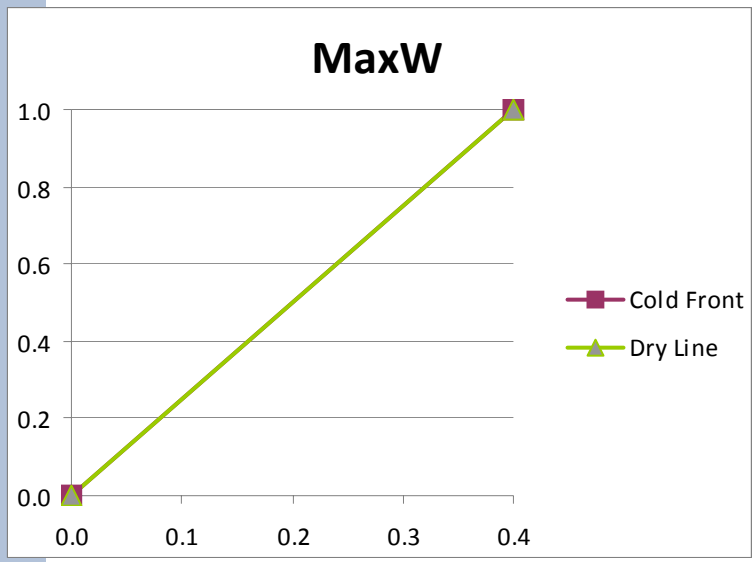
- Boundary Relative Steering Flow – This field assesses the likelihood of updrafts to remain close to boundary (if they form)

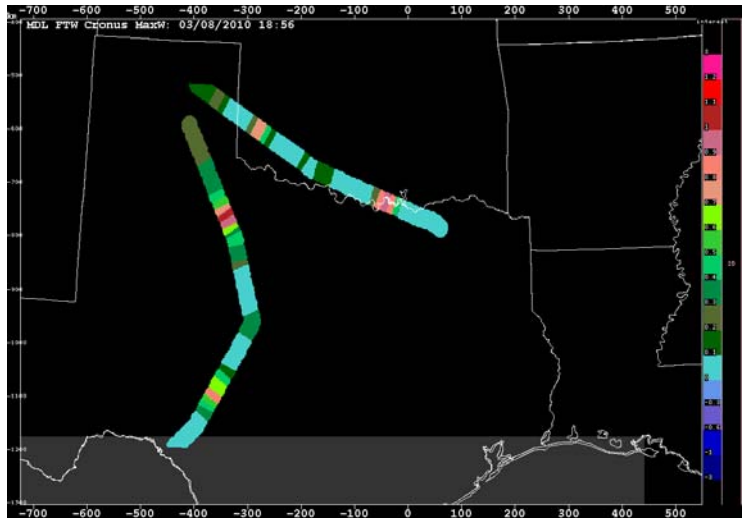




FWD Predictors

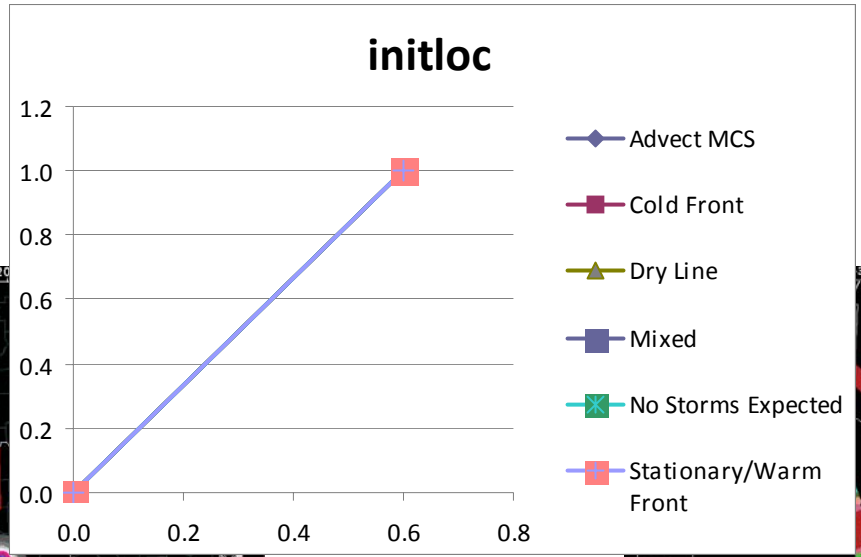
- Max W – Upward motion along human entered boundary computed from VDRAS winds.

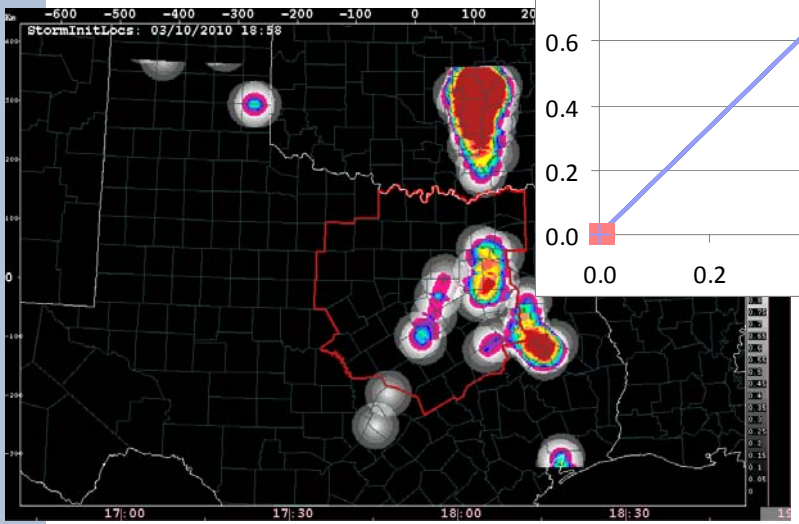


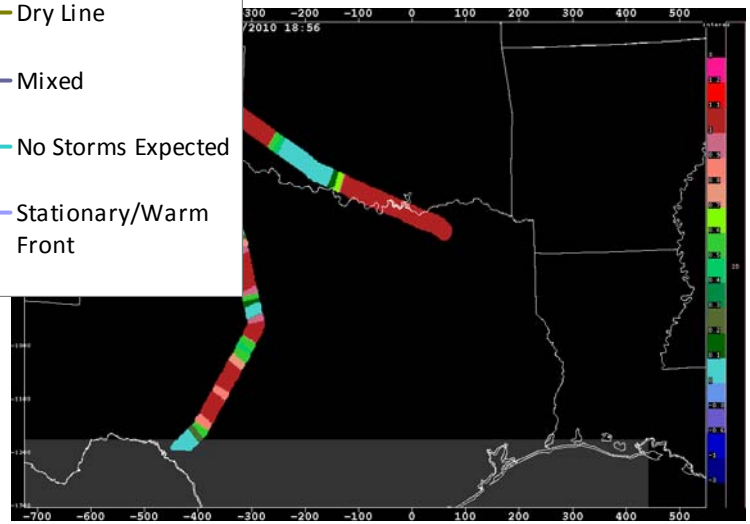


FWD Predictors

- Init Locations – Identifies areas along human boundaries close to storms that have initiated that are conducive for additional initiation.

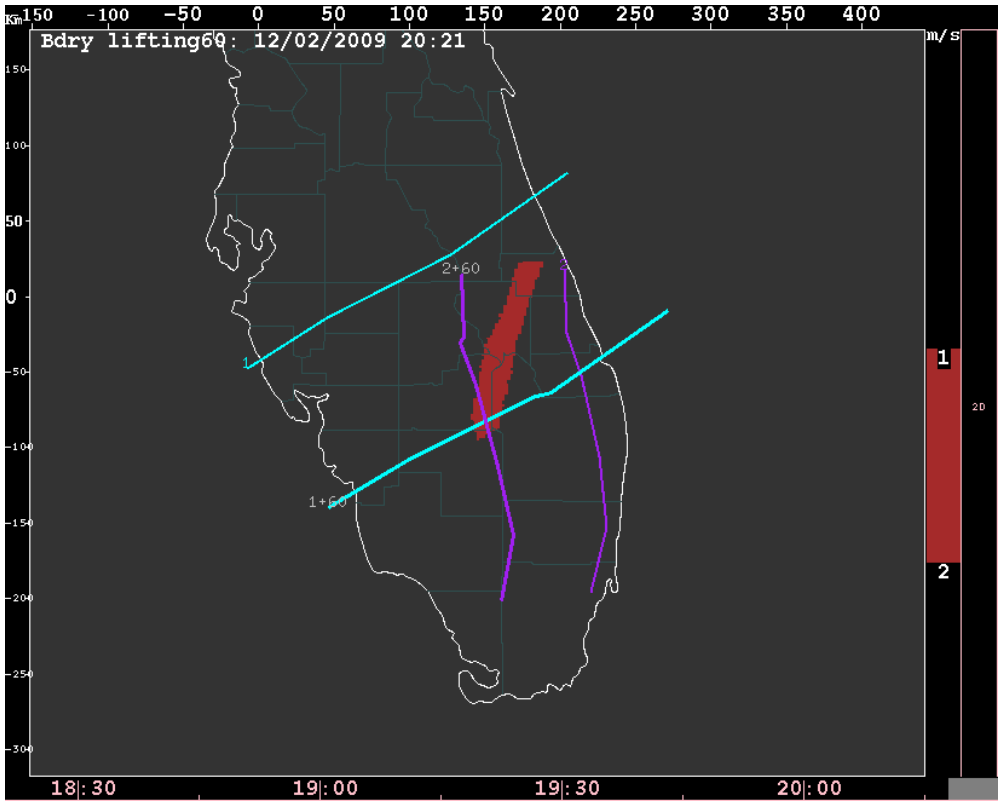






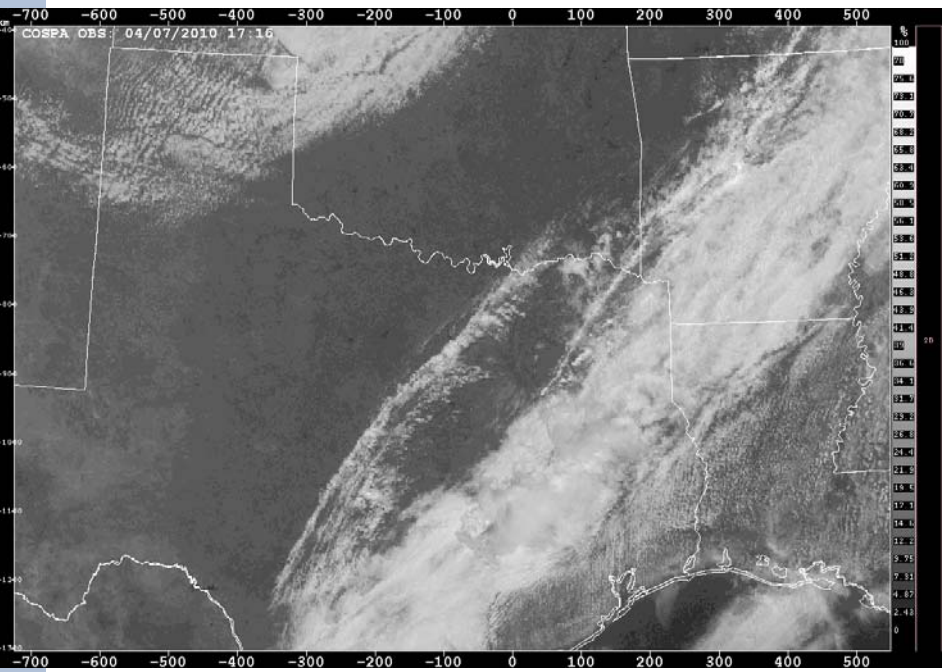
FWD Predictors

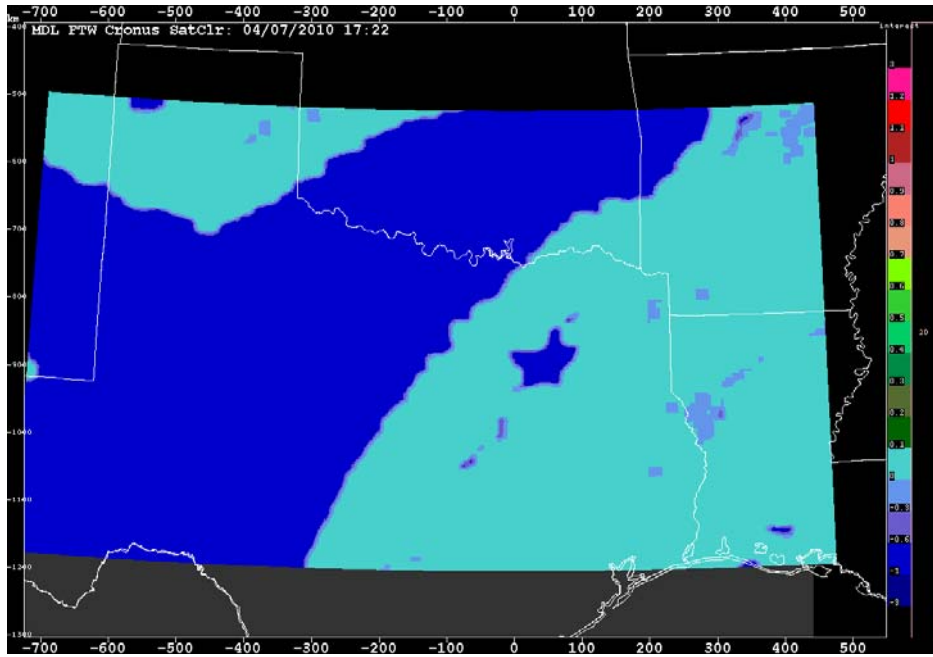
- Boundary Collisions – Identifies areas of interest that are swept out by two intersecting boundaries.



FWD Predictors

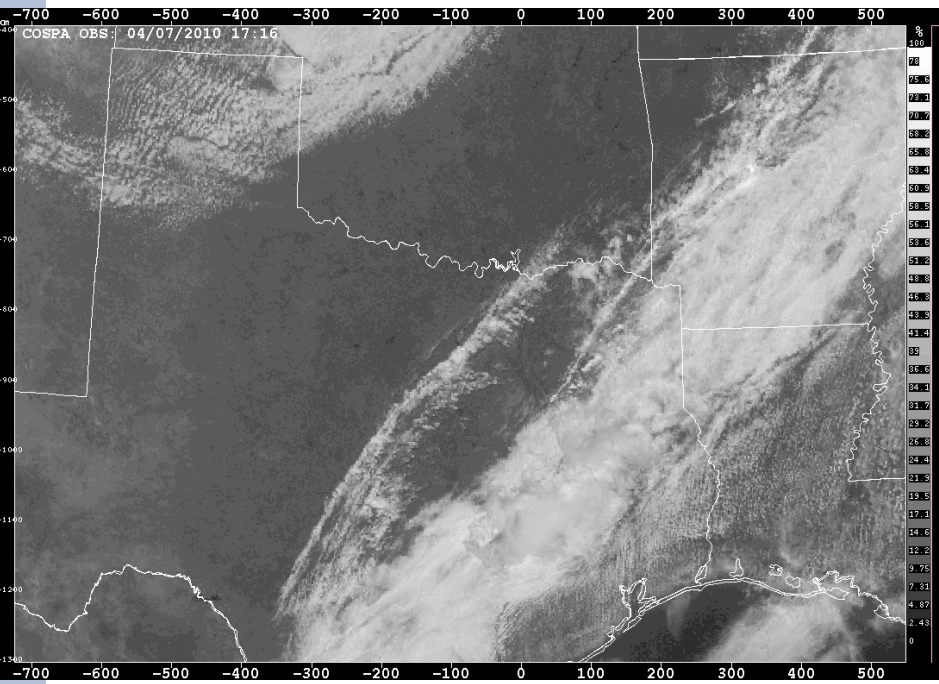
- Satellite Clear – Adds large negative interest to areas detected as having no cloud present. No positive interest from this field.

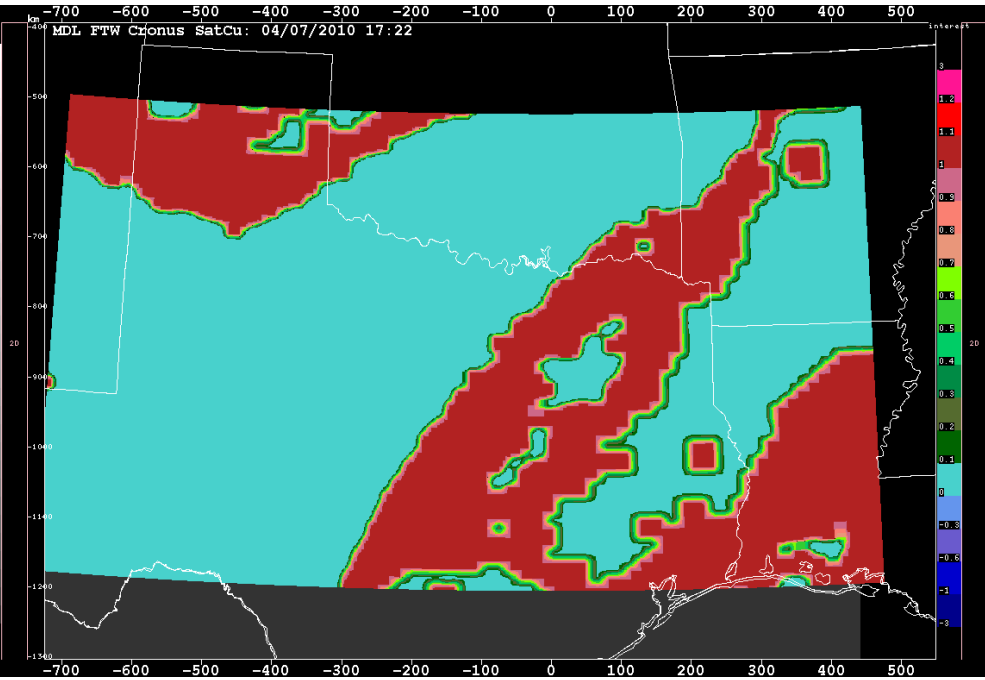




FWD Predictors

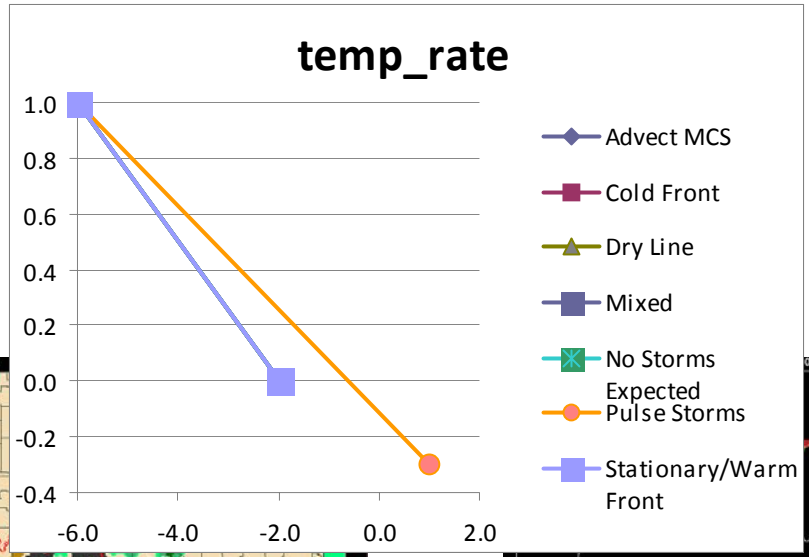
- Satellite Cu – Satellite detection of Cu and CuCongestus. Only positive interest from this field.

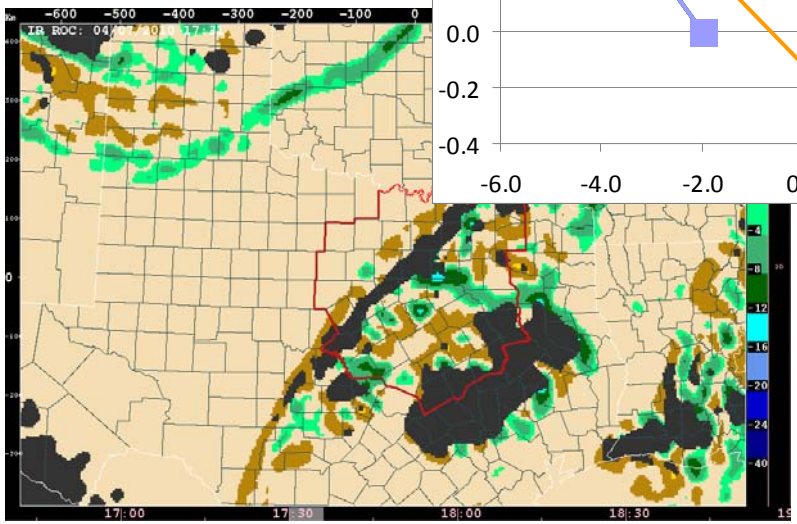


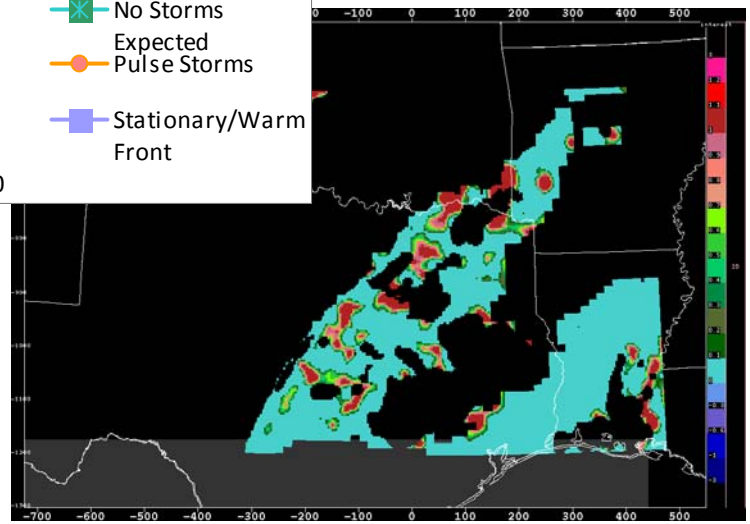


FWD Predictors

- IR-ROC – Infrared cloud top temperature rate of change, masked to Cu/CuCongestus detection areas.

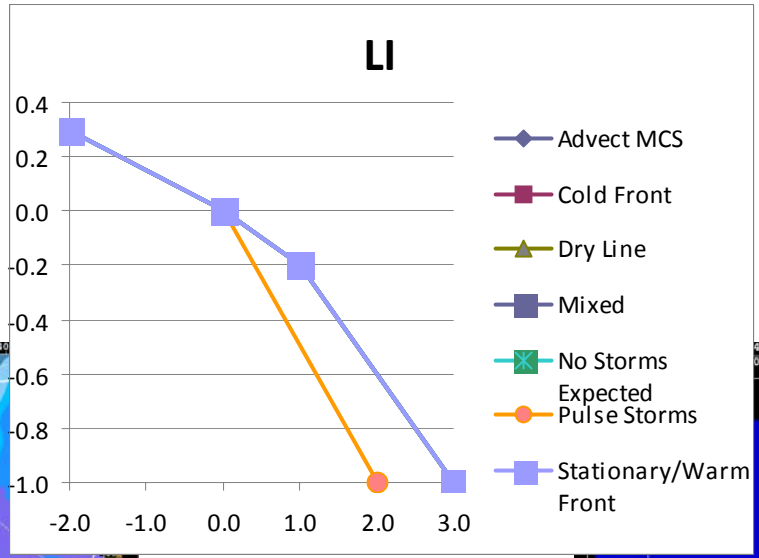


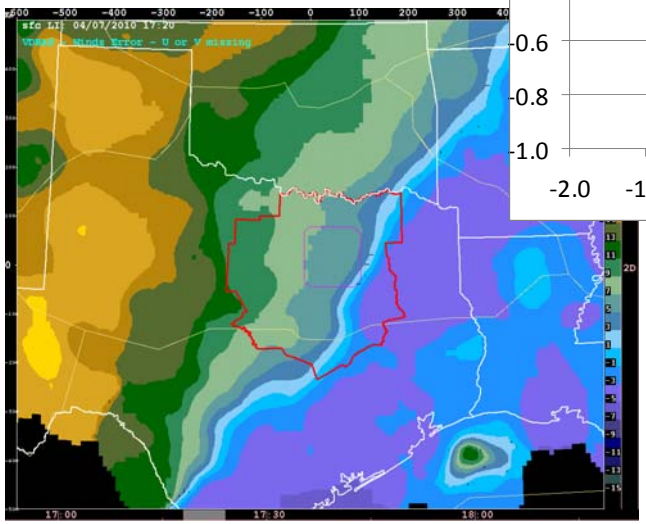


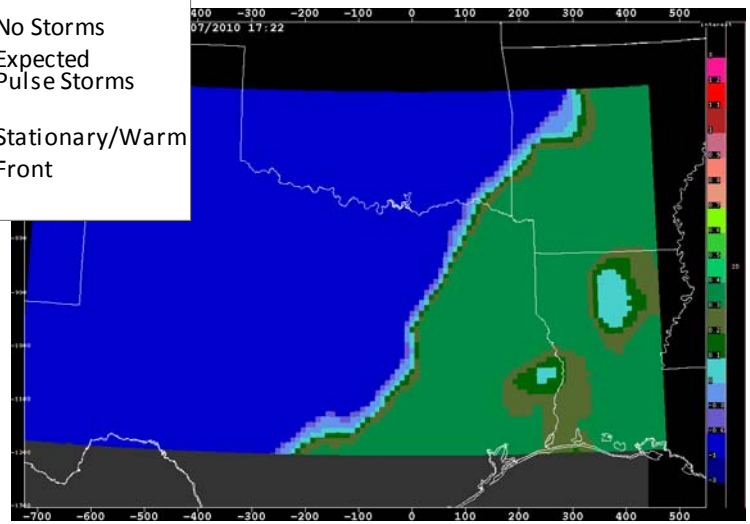


FWD Predictors

- Lifted Index – Computed from current sfc obs and RUC soundings.

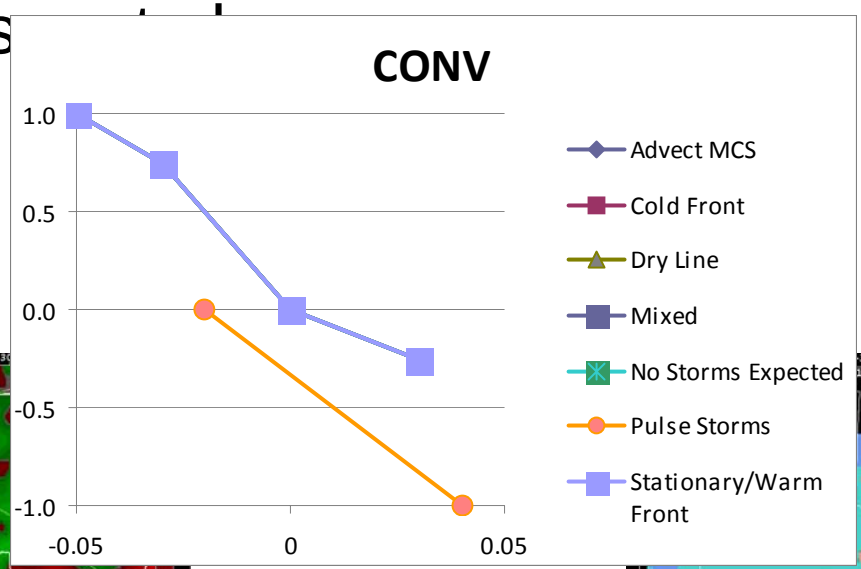


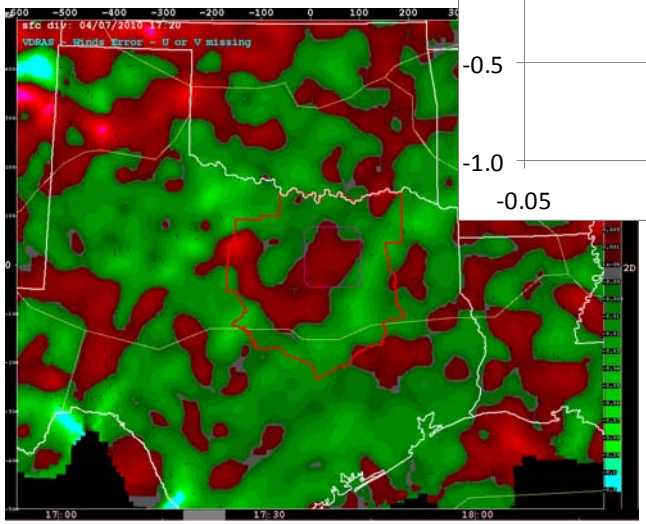


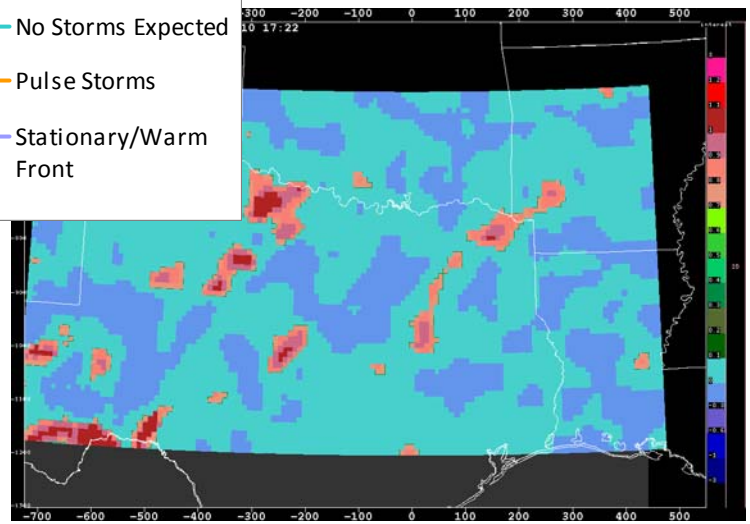


FWD Predictors

- Sfc Convergence – Objectively analyzed sfc mass convergence using standard metars and other mes

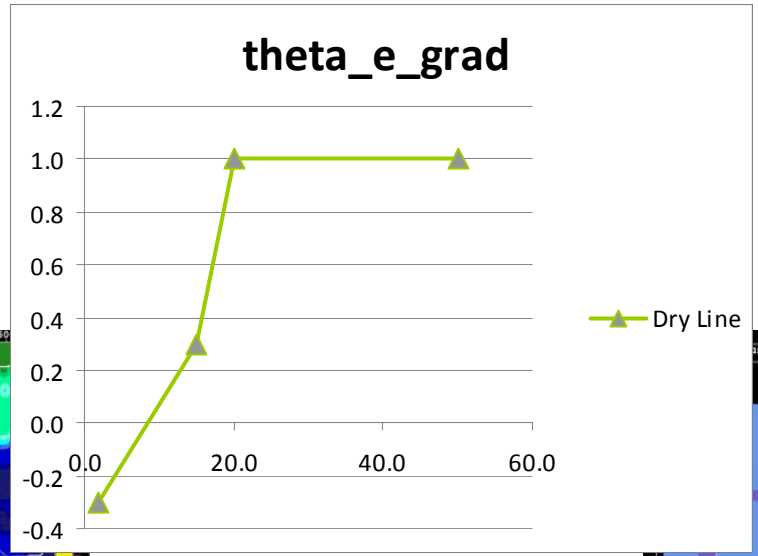


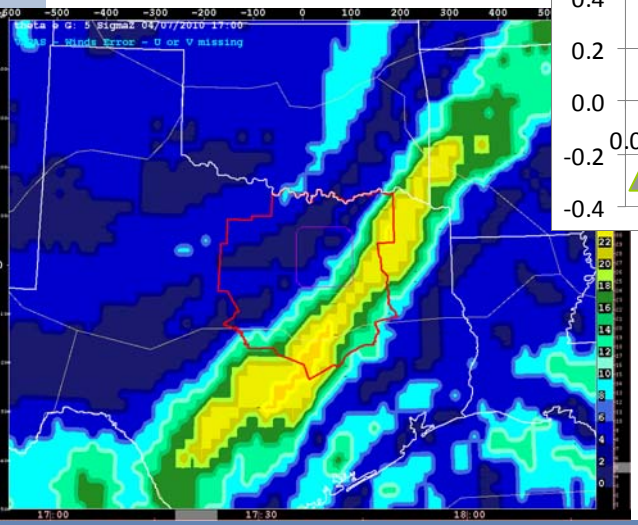


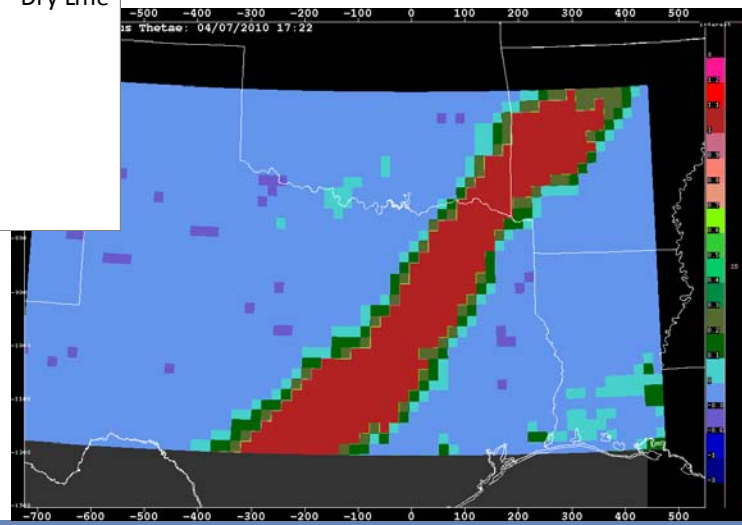


FWD Predictors

- Theta-e gradient – calculated on 5th hybrid level of RUC
- Only used in DL regime.

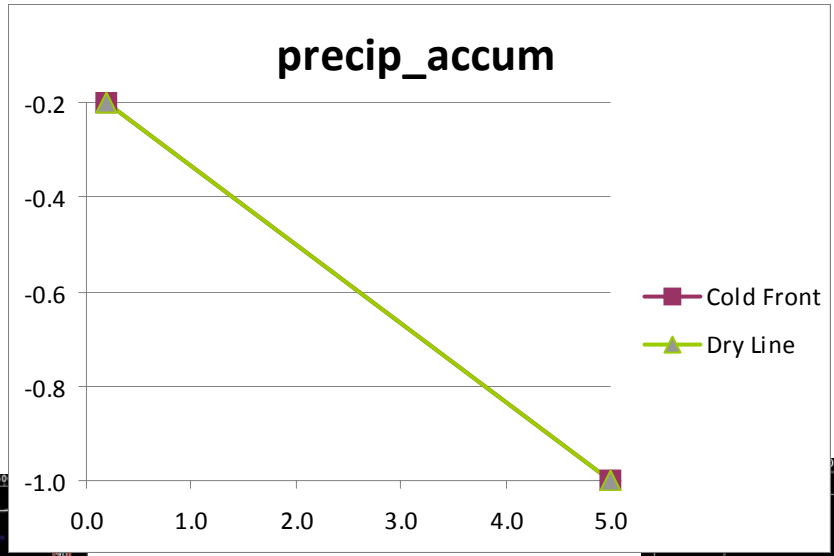


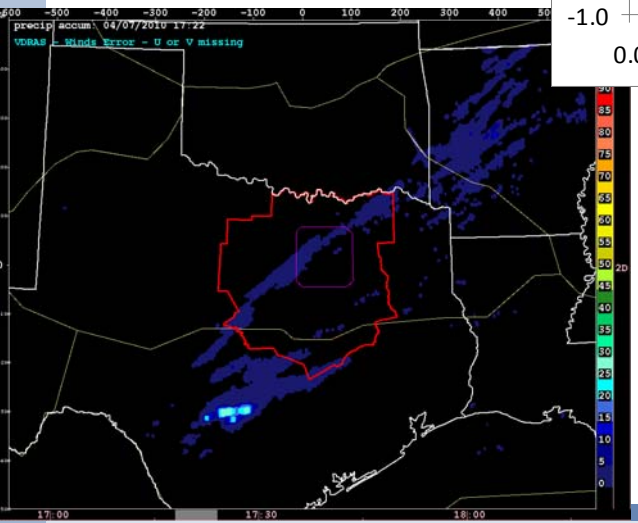


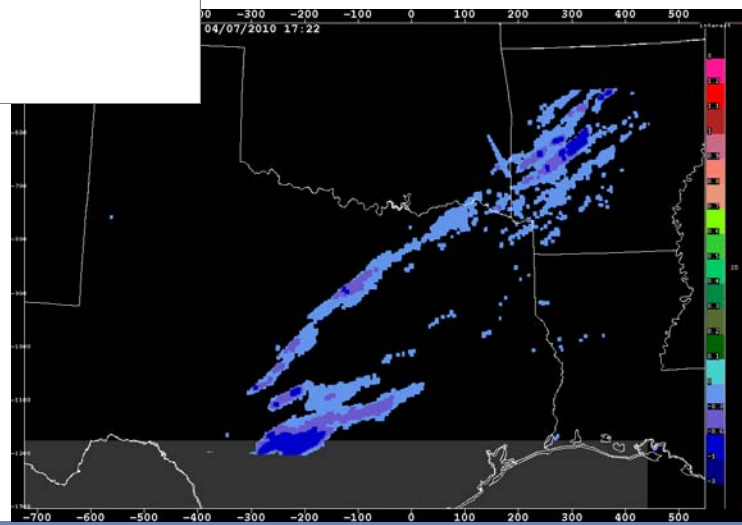


FWD Predictors

- 3hr Accumulated Precipitation







Regimes at FWD

- Cold Front
- Dryline
- Mixed
- Airmass Storms
- No Storms
- Advect MCS
- Warm Front / Stationary Front

Regimes: Cold Frontal Regime

- This regime is meant to be used when a cold-front is expected to be the primary focus for thunderstorm initiation.
- Forecast logic places emphasis on human entered boundaries and frontal likelihood field.

Cold Front Regime Components

- 0.20 Cape (900-500mb MAX)
- 0.18 CIN (975-900 MEAN)
- 0.25 Frontal Likelihood
- 0.12 Vertical Summed Interest (instability depth)
- 0.18 Mean RH (875-625mb)
- 0.08 Vertical Velocity (RUC)
- 0.14 Boundary Steering Flow
- 0.14 Max W
- 0.08 Storm Init Locations
- 0.12 Boundary Collisions
- 0.40 Satellite Clear
- 0.12 Satellite Cu identification
- 0.14 IR Rate of Change
- 0.15 Convergence (SFC)
- 0.20 Lifted Index
- 0.25 3hr Precip Accumulation

Regimes: Dry Line Regime

- This regime is meant to be used when the dryline is the primary focus for initiation.
- Special emphasis is placed on the presence or lack of theta-e gradients
- Human entered boundaries important to forecast logic as well.

Dryline Regime Components

- 0.20 Cape (900-500mb MAX)
- 0.20 CIN (975-900 MEAN)
- 0.20 Frontal Likelihood
- 0.12 Vertical Summed Interest (instability depth)
- 0.18 Mean RH (875-625mb)
- 0.08 Vertical Velocity (RUC)
- 0.16 Boundary Steering Flow
- 0.16 Max W
- 0.12 Storm Init Locations
- 0.12 Boundary Collisions
- 0.40 Satellite Clear
- 0.12 Satellite Cu identification
- 0.10 IR Rate of Change
- 0.15 Convergence (SFC)
- 0.20 Lifted Index
- 0.25 3hr Precip Accumulation
- 0.15 Theta-e Gradient

Regimes: Advecting MCS

- This regime is meant to be used for time periods when there is an existing MCS moving into the forecast domain.
- Final forecast is primarily a growth/decay forecast.
- If any initiation that is forecast is limited to any leading gust front area.

Advecting MCS regime Components

- 0.15 Cape (900-500mb MAX)
- 0.15 CIN (975-900 MEAN)
- 0.10 Frontal Likelihood
- 0.08 Vertical Summed Interest (instability depth)
- 0.12 Mean RH (875-625mb)
- 0.08 Vertical Velocity (RUC)
- 0.20 Boundary Steering Flow
- 0.15 Storm Initiation Locations
- 0.10 Boundary Collisions
- 0.40 Satellite Clear
- 0.10 Satellite Cu identification
- 0.10 IR Rate of Change
- 0.10 Convergence (SFC)
- 0.20 Lifted Index

Regimes: No Storms Expected

- This regime is meant to be used for days when the other regimes do not make sense and no storms are expected to occur.
- Initiations are possible in this regime, but the required threshold values are not easily attained.
- The choice of this regime type implies that the forecasters will probably not be actively interacting with the system.

No-storms Expected regime

- 0.15 Cape (900-500mb MAX)
- 0.18 CIN (975-900 MEAN)
- 0.15 Frontal Likelihood
- 0.10 Vertical Summed Interest (instability depth)
- 0.15 Mean RH (875-625mb)
- 0.08 Vertical Velocity (RUC)
- 0.18 Boundary Steering Flow
- 0.20 Storm Init Locations
- 0.12 Boundary Collisions
- 0.40 Satellite Clear
- 0.12 Satellite Cu identification
- 0.12 IR Rate of Change
- 0.10 Convergence (SFC)
- 0.20 Lifted Index

Regimes: Pulse/Air-Mass Type

- This regime is meant to be used for time periods when there is no large scale forcing and the expected storm type is isolated in nature.
- Initiation forecasts result when rapidly growing cumulus clouds are detected.
- This regime should not be used when there is any high or mid-level type of cloud cover since we need to be able to observe any growing Cu/Cug clouds.
- Can also be used effectively on severe clear days when there is a chance of any storms breaking the cap.

Pulse Storm Regime

- 0.12 CIN
- 0.19 Boundary Relative Steering Flow
- 0.10 Boundary Collision
- 0.10 Satellite Clear
- 0.30 Satellite Cu identification
- 0.45 IR Rate of Change
- 0.17 Lifted Index
- 0.20 Convergence

Regimes: Warm/Stationary Front Regime

- This regime is meant to be used when there is a warm or stationary front laying across the forecast domain.
- In this regime the initiation field does not focus as much on the frontal feature as was the case with the cold front and dry line regimes.
- Storms in this regime are oftentimes elevated in nature

Warm / Stationary Frontal Regime

- 0.20 Cape (900-500mb MAX)
- 0.12 CIN (975-900 MEAN)
- 0.20 Frontal Likelihood
- 0.12 Vertical Summed Interest (instability depth)
- 0.18 Mean RH (875-625mb)
- 0.08 Vertical Velocity (RUC)
- 0.20 Boundary Steering Flow
- 0.15 Storm Init Locations
- 0.12 Boundary Collisions
- 0.40 Satellite Clear
- 0.12 Satellite Cu identification
- 0.10 IR Rate of Change
- 0.12 Convergence (SFC)
- 0.20 Lifted Index

Regimes: Mixed Regime

- This regime is meant to be used on days when there are multiple synoptic triggering mechanisms in the forecast domain.
- This regime is also the preferred choice for days when the situation does not readily match the other regime types and storms are expected to develop.

Mixed Regime Components

- 0.20 Cape (900-700mb MAX)
- 0.12 CIN (975-900 MEAN)
- 0.22 Frontal Likelihood
- 0.12 Vertical Summed Interest (instability depth)
- 0.18 Mean RH (875-725mb)
- 0.08 Vertical Velocity (RUC)
- 0.18 Boundary Steering Flow
- 0.20 Storm Init Locations
- 0.12 Boundary Collisions
- 0.40 Satellite Clear
- 0.12 Satellite Cu identification
- 0.10 IR Rate of Change
- 0.10 Convergence (SFC)
- 0.20 Lifted Index

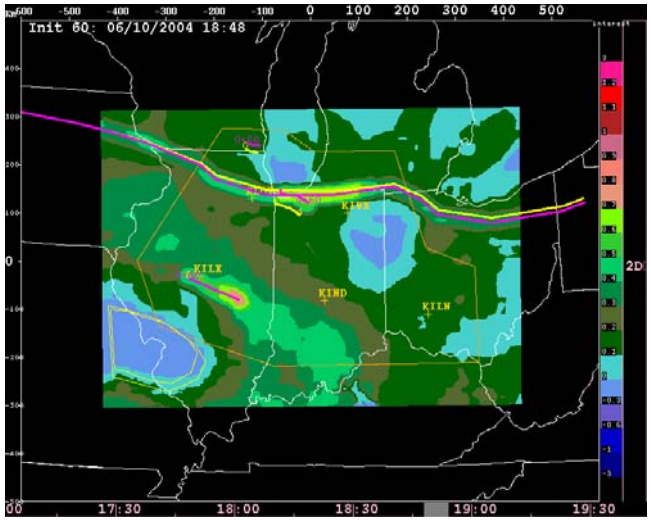
Table of Predictor Weights

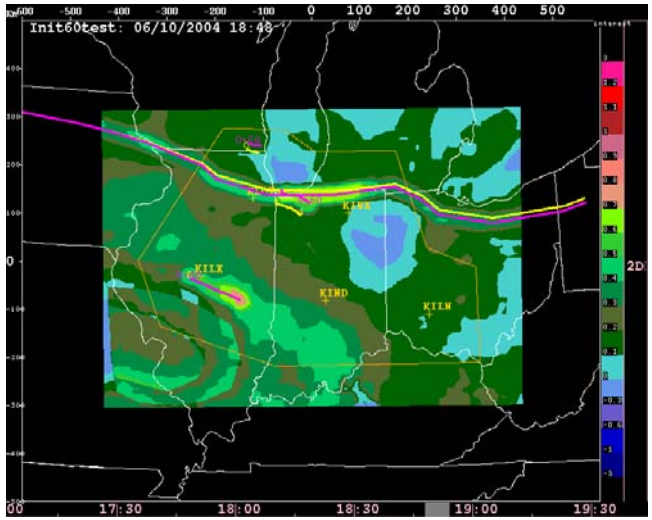
	Dryline	CF	MX	MCS	WF/SF	PULSE	NS
CAPE	0.2	0.2	0.2	0.15	0.2	X	0.15
Frontal Likelihood	0.2	0.25	0.22	0.1	0.2	X	0.15
VertSum	0.12	0.12	0.12	0.08	0.12	X	0.1
RH	0.18	0.18	0.18	0.12	0.18	X	0.15
CIN	0.2	0.18	0.12	0.15	0.12	0.12	0.18
VV	0.08	0.08	0.08	0.08	0.08	X	0.08
BRSF	0.16	0.14	0.18	0.2	0.2	0.19	0.18
Max W	0.16	0.14	X	X	X	X	X
InitLocations	0.12	0.08	0.2	0.15	0.15	X	0.2
Bdry Collision	0.12	0.12	0.12	0.1	0.12	0.1	0.12
Sat Clear	0.4	0.4	0.4	0.4	0.4	0.1	0.4
Sat Cu	0.12	0.12	0.12	0.1	0.12	0.3	0.12
IR-ROC	0.1	0.14	0.1	0.1	0.1	0.45	0.12
Lifted Index	0.2	0.2	0.2	0.2	0.2	0.17	0.2
Convergence	0.15	0.15	0.1	0.1	0.12	0.2	0.1
Precip Accumulation	0.25	0.25	X	X	X	0.15	X
Theta-e Grad	0.15	X	X	X	X	X	X

Performance Considerations and Expectations

- 8 predictor fields are dependant on RUC data
- 4 predictors are associated with human entered boundaries
- 3 predictor fields are based on the NRL Cloud Classification algorithm
- Missing any of the 3 datasets above will compromise the ANC's ability to produce good nowcasts for initiation

Human Added Value

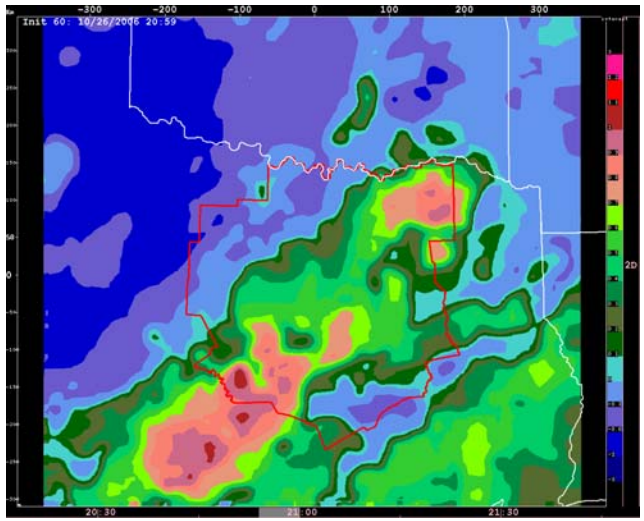


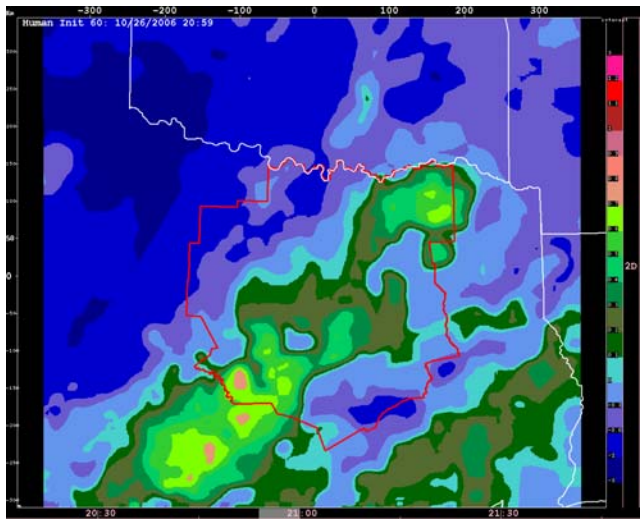


- Since the Initiation and Nowcast fields are products for external users, the nudge and polygons can compensate for missing or bad data

Which to use?

- Nudging can be used when the shape of the field is ok, but values are too low or too high
- Polygons are best for addressing localized deficiencies in the Initiation field





Boundaries: When to Interact?

- Synoptic Boundaries (Fronts and Drylines) should always be entered.
- Speed and location should be monitored regularly
- Smaller scale boundaries should be entered as workload permits AND
- Boundary is expected to exist for >60mins

Polygons and Nudging: Philosophy

- Very Subjective!!! Highly dependant on forecaster skill and experience with ANC
- Finesse: Only compensates for input deficiencies, letting other predictors do the work
- Brute Force: Forecaster actively dictates forecast initiation zones with strong polygon and nudge weights; overrules system logic

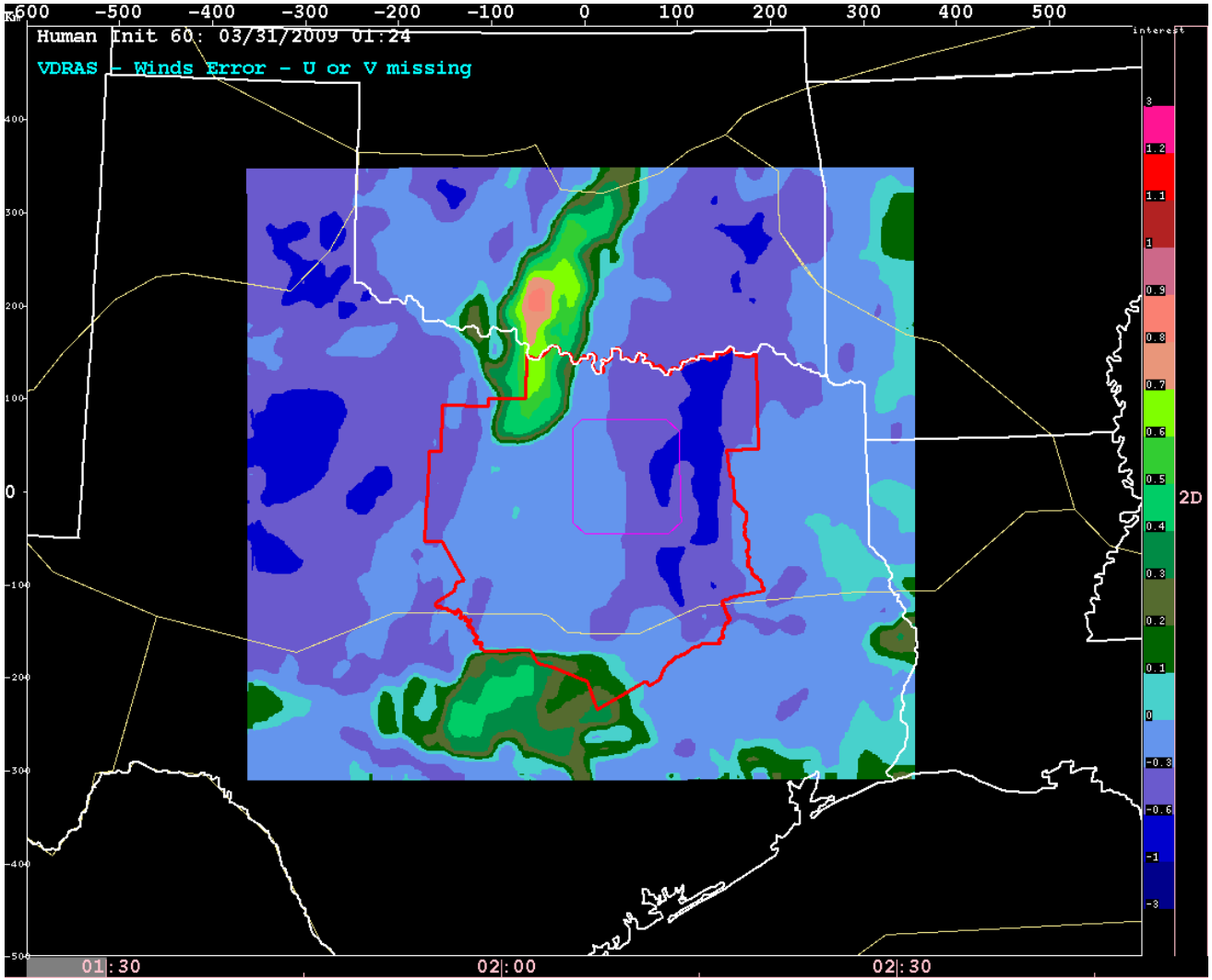
Polygons: When to Interact?

- Polygon interest should be applied to small areas where specific initiation interest adjustments are needed
- Can be used to enhance or suppress interest
- Commonly needed if frontal or dryline position in RUC is out of phase with obs
- Can be used if cloud detection algorithm struggling with high/mid overcast
- Needs to be closely monitored and removed as soon as reasonable
- Elevated convection initiation may need large polygons

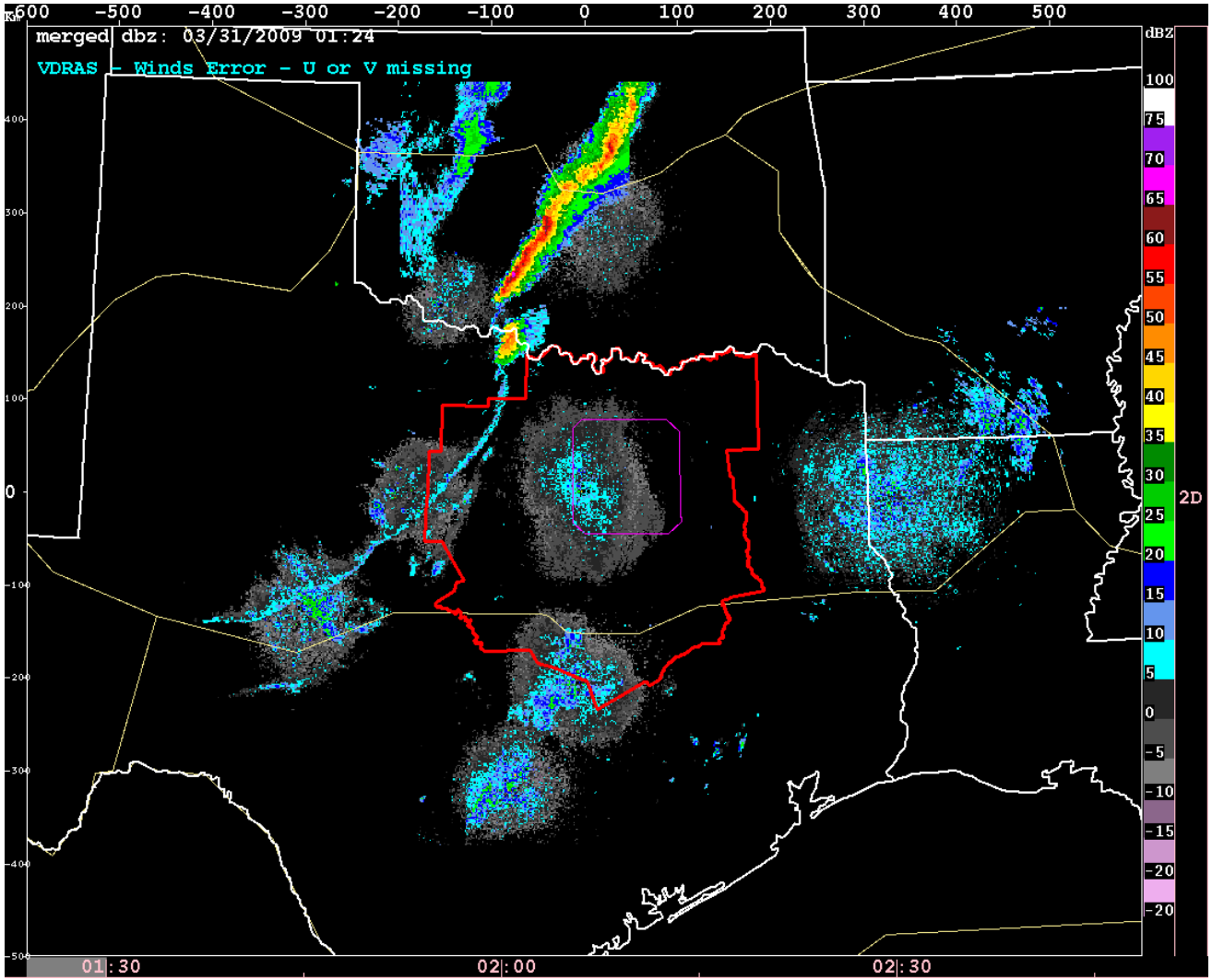
Whole Field Nudges: When to Interact

- Whole field nudges used when character of Initiation Likelihood is reasonable, but magnitude is deficient
- Commonly used if RUC is not representing instability or CAP adequately
- May need to suppress interest if atmosphere is unstable and overcast is present

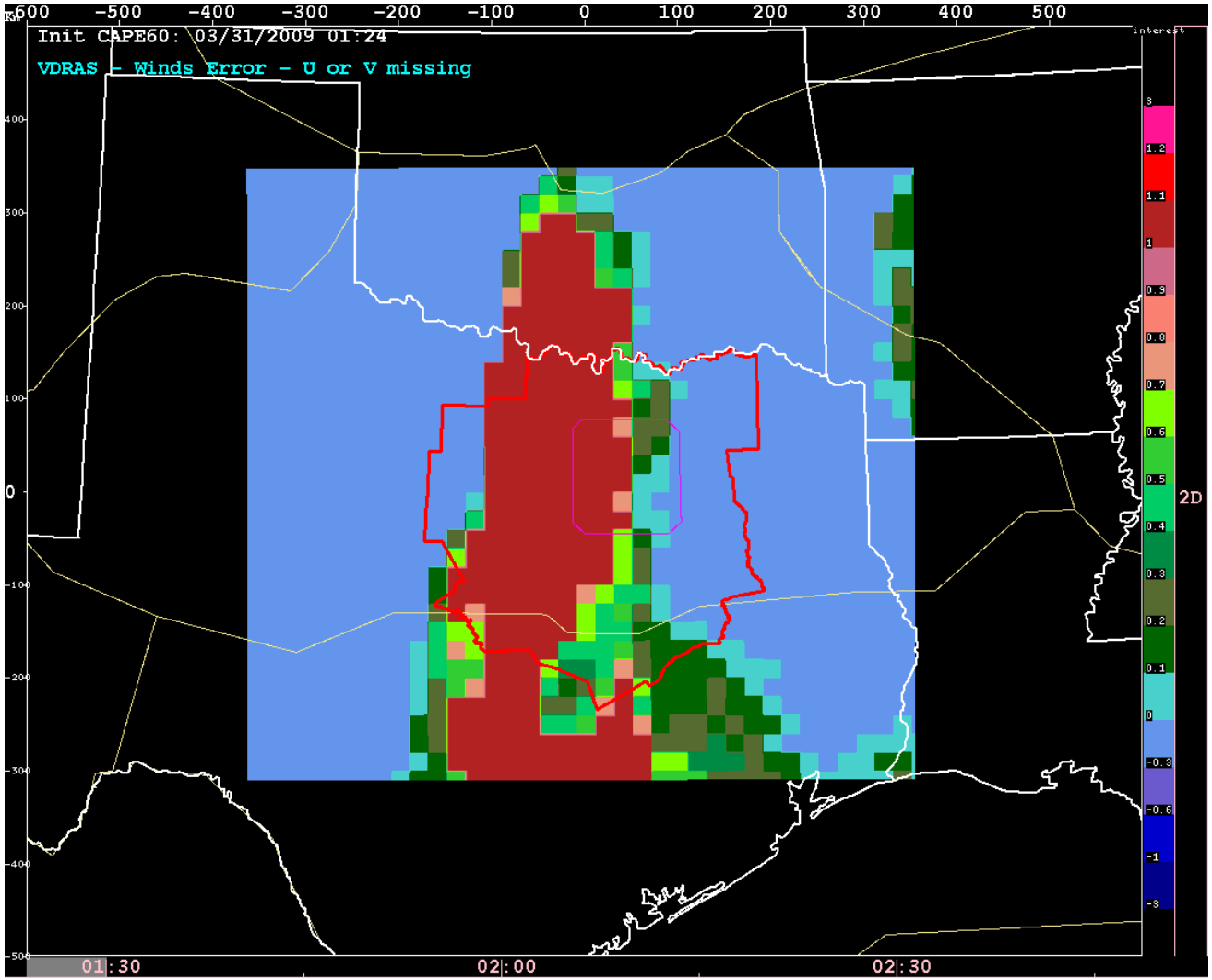
Polygon example: Init60



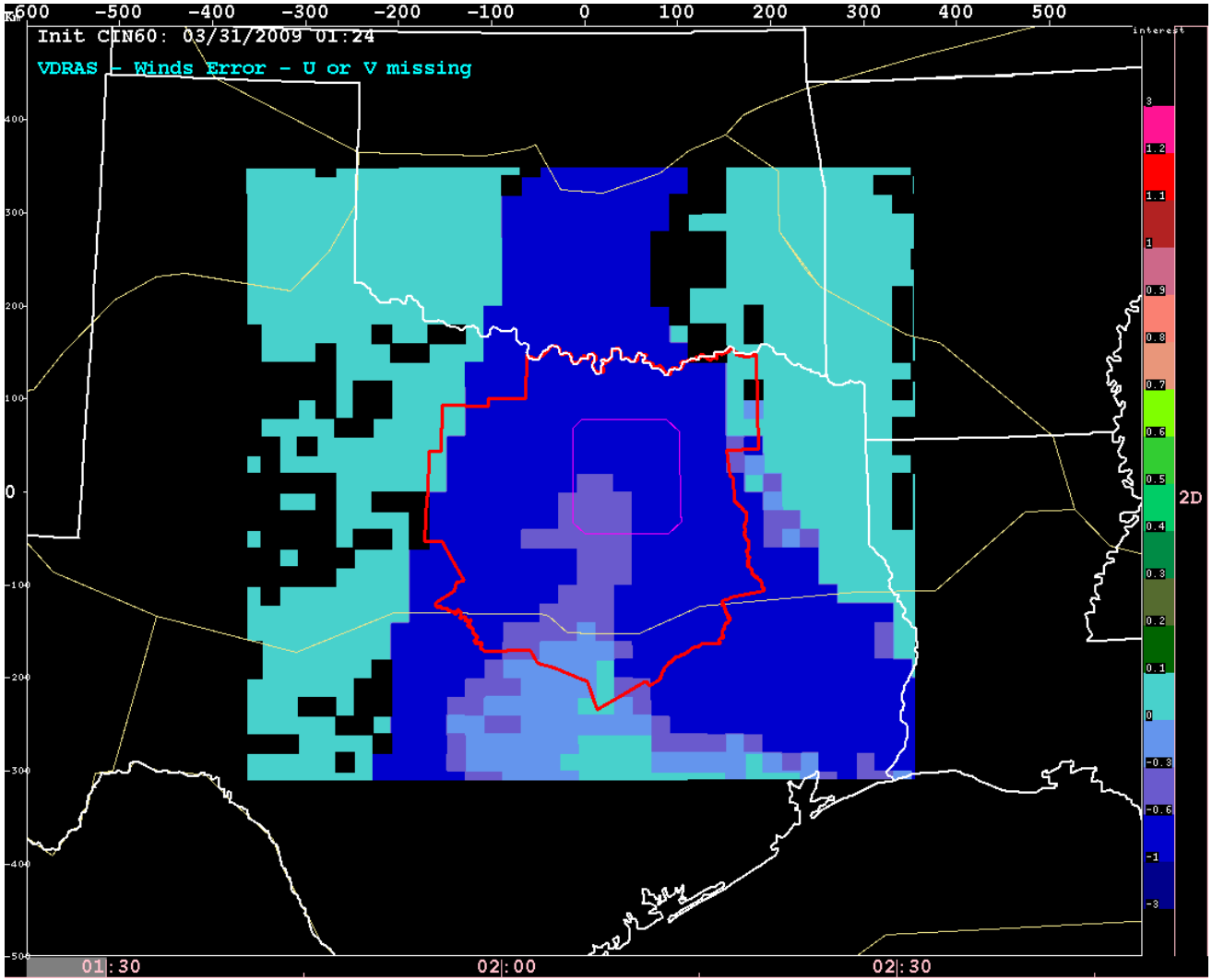
Polygon example: Radar Mosaic



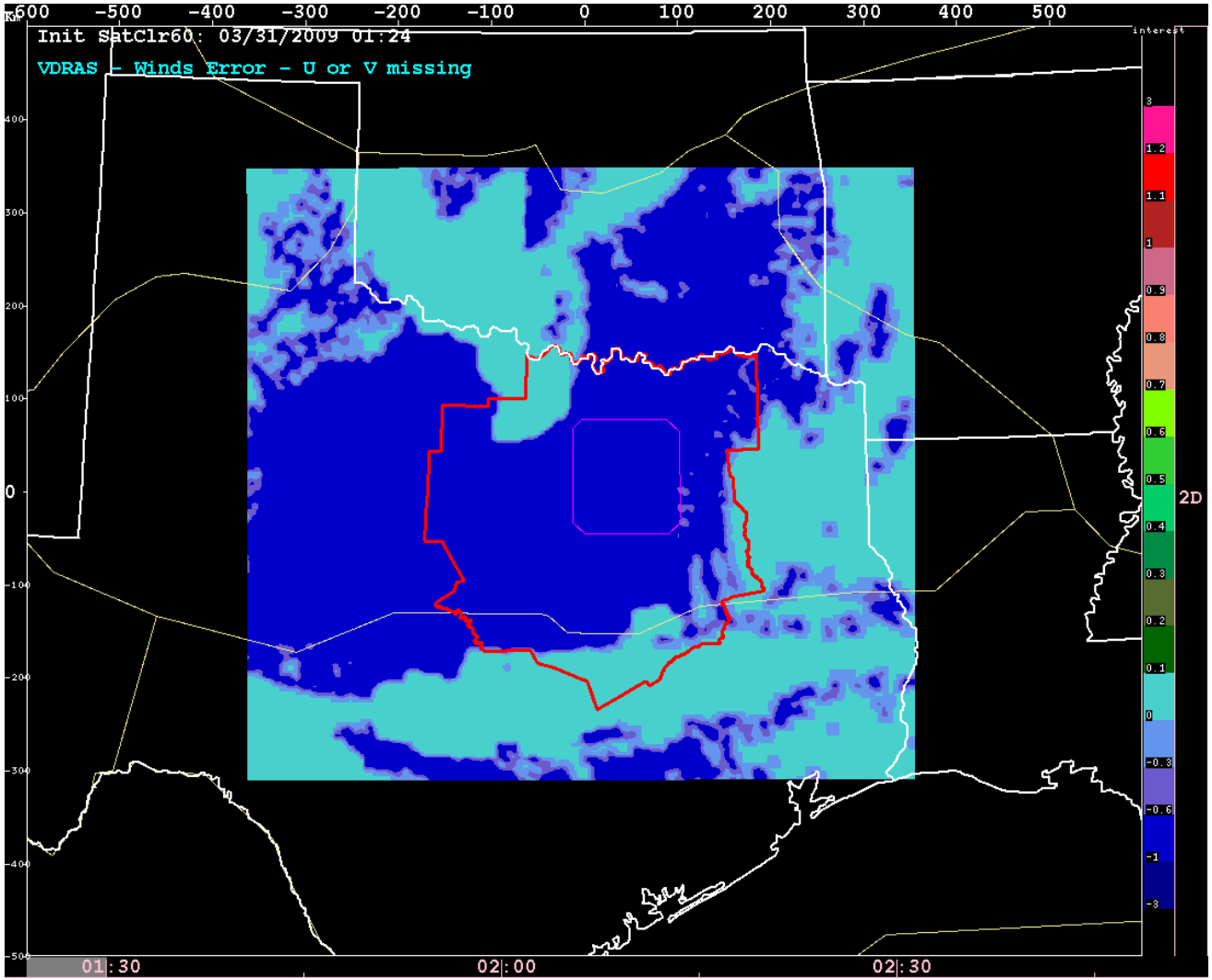
Polygon example: Cape Interest



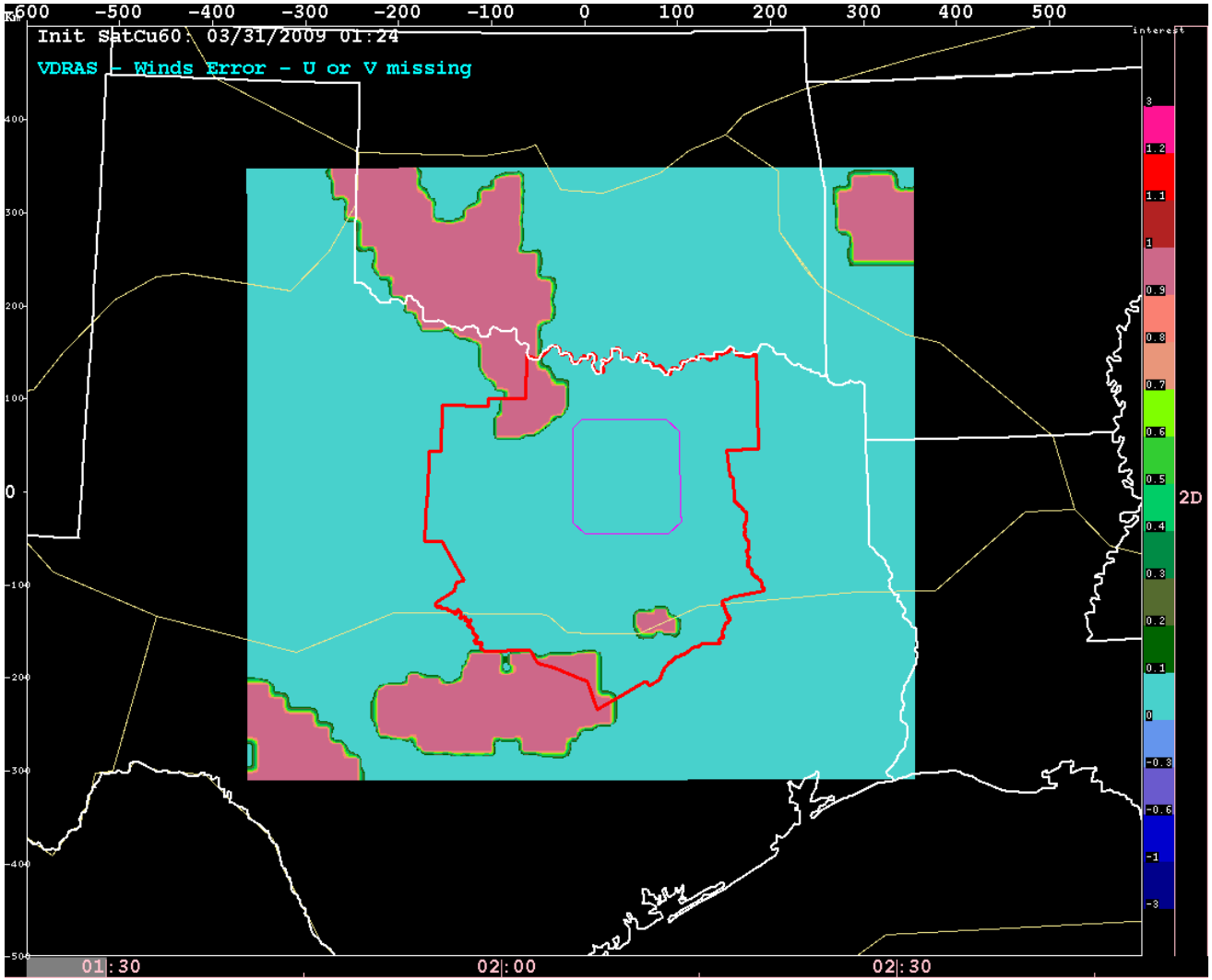
Polygon example: CIN Interest



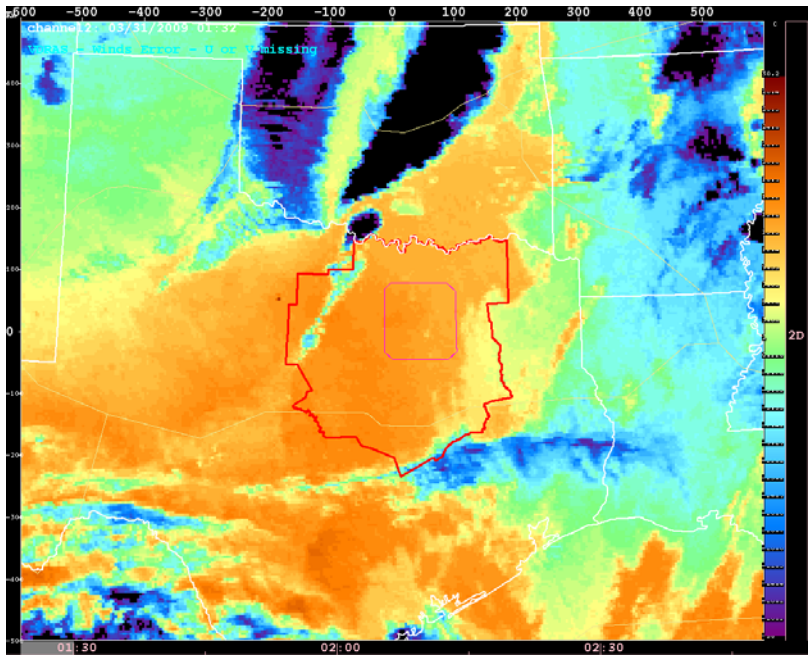
Polygon example: SatClear Interest

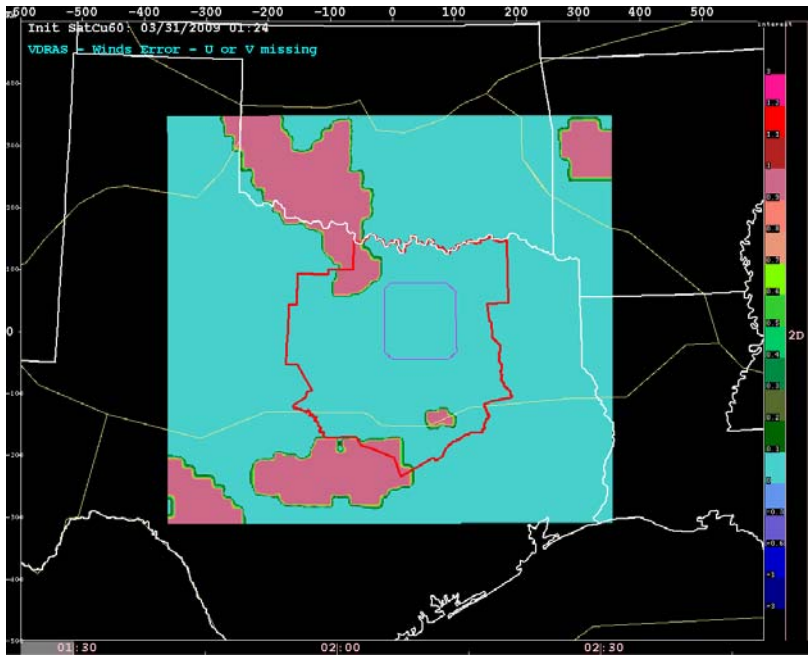


Polygon example: SatCu Interest

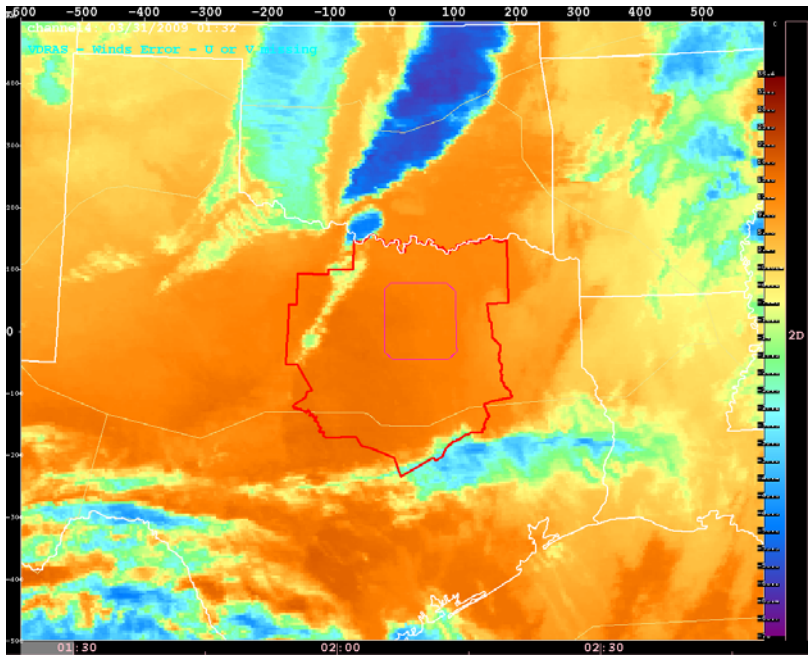


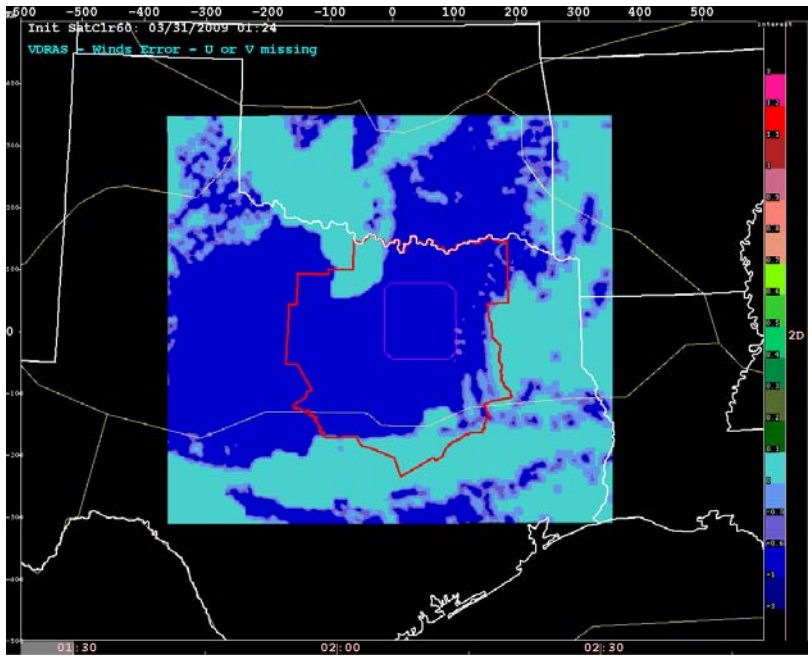
Polygon example: SW-IR and SatCu Int



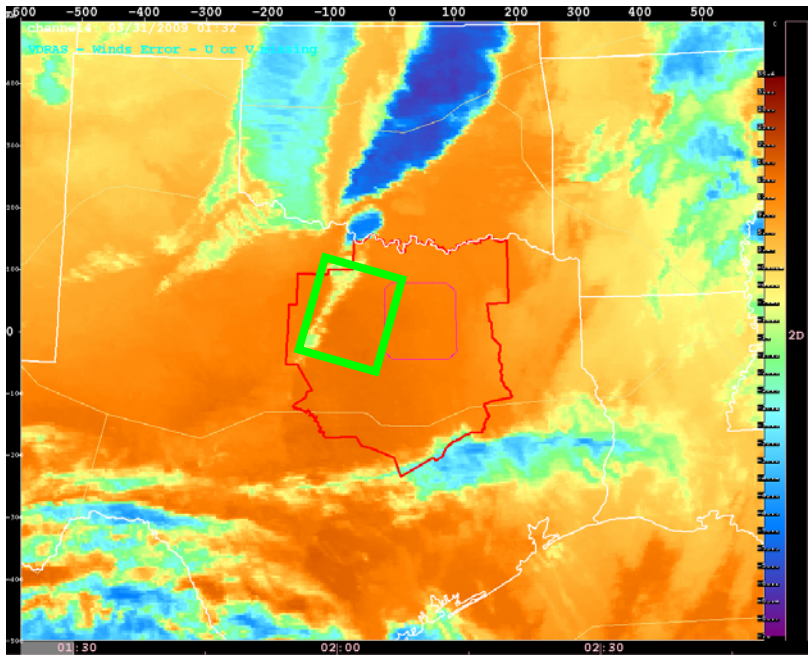


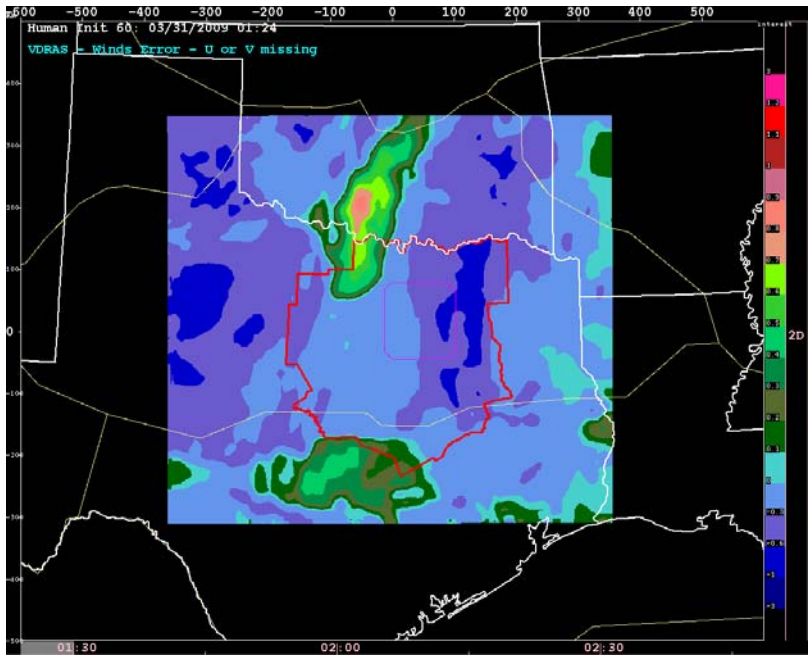
Polygon example: LW-IR and SatClr Int



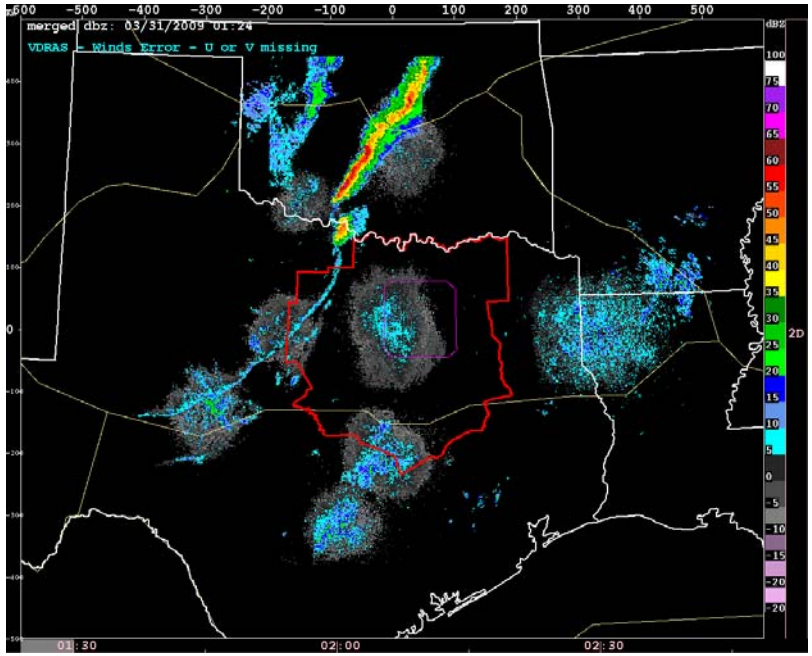


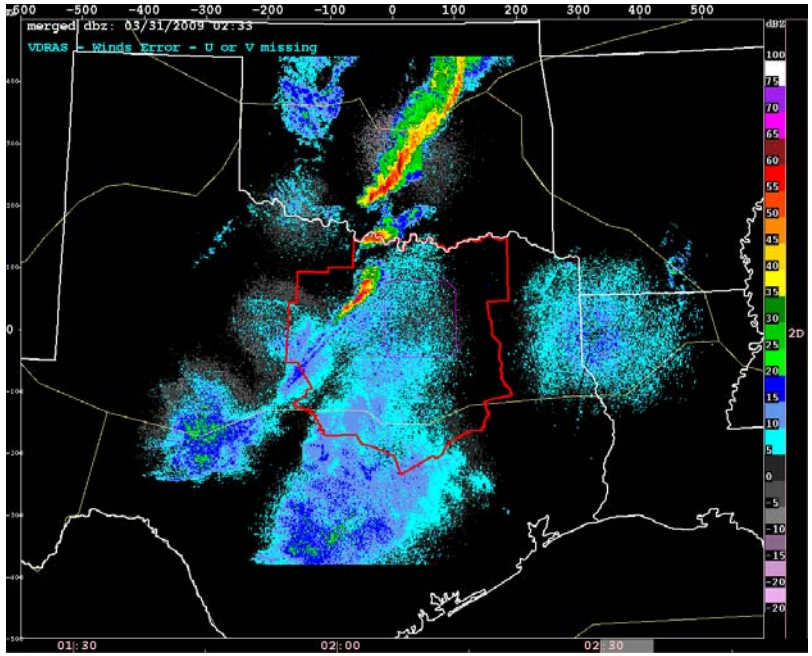
Polygon example: Where To Draw



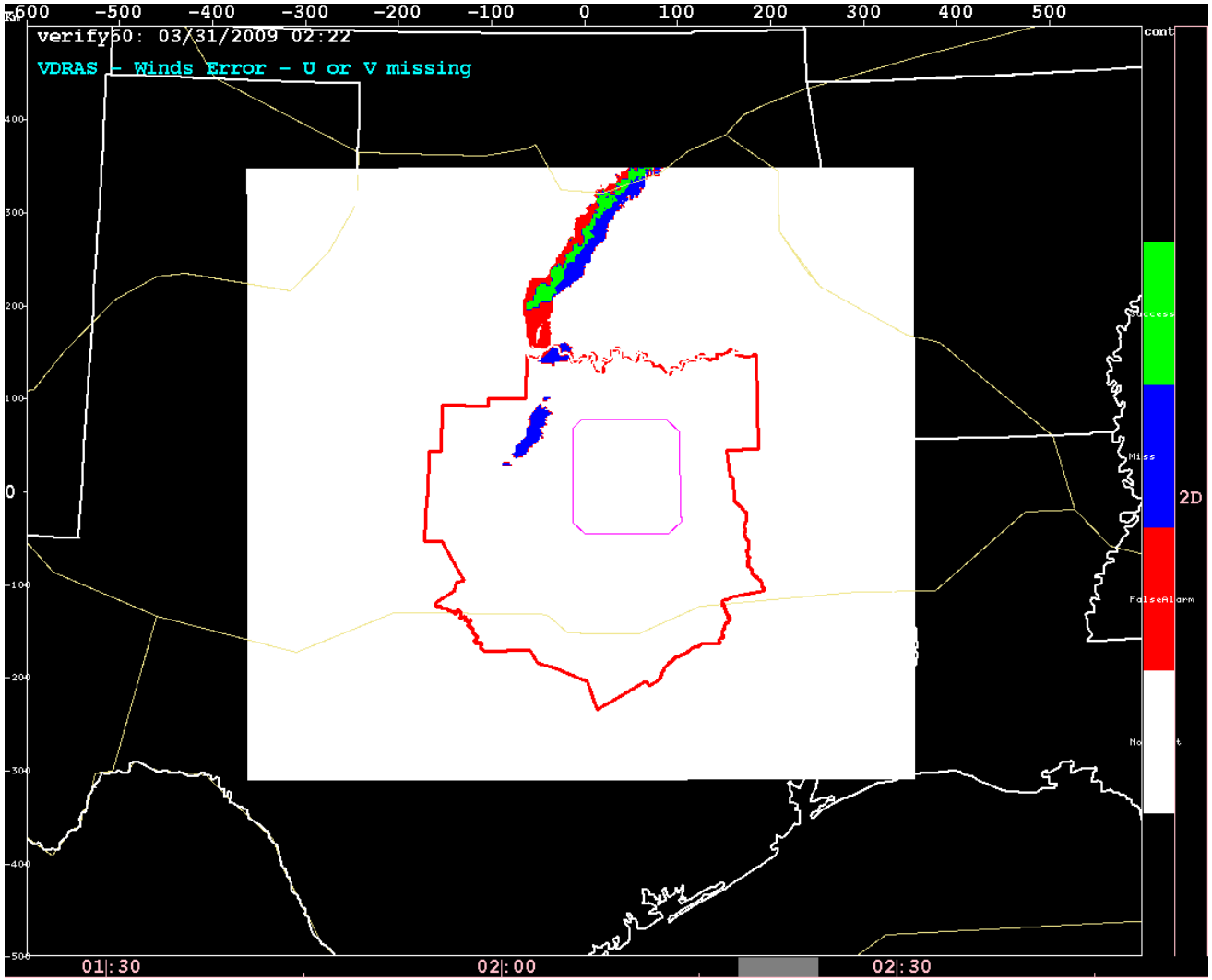


Polygon example: Radar Initial and Validation Times

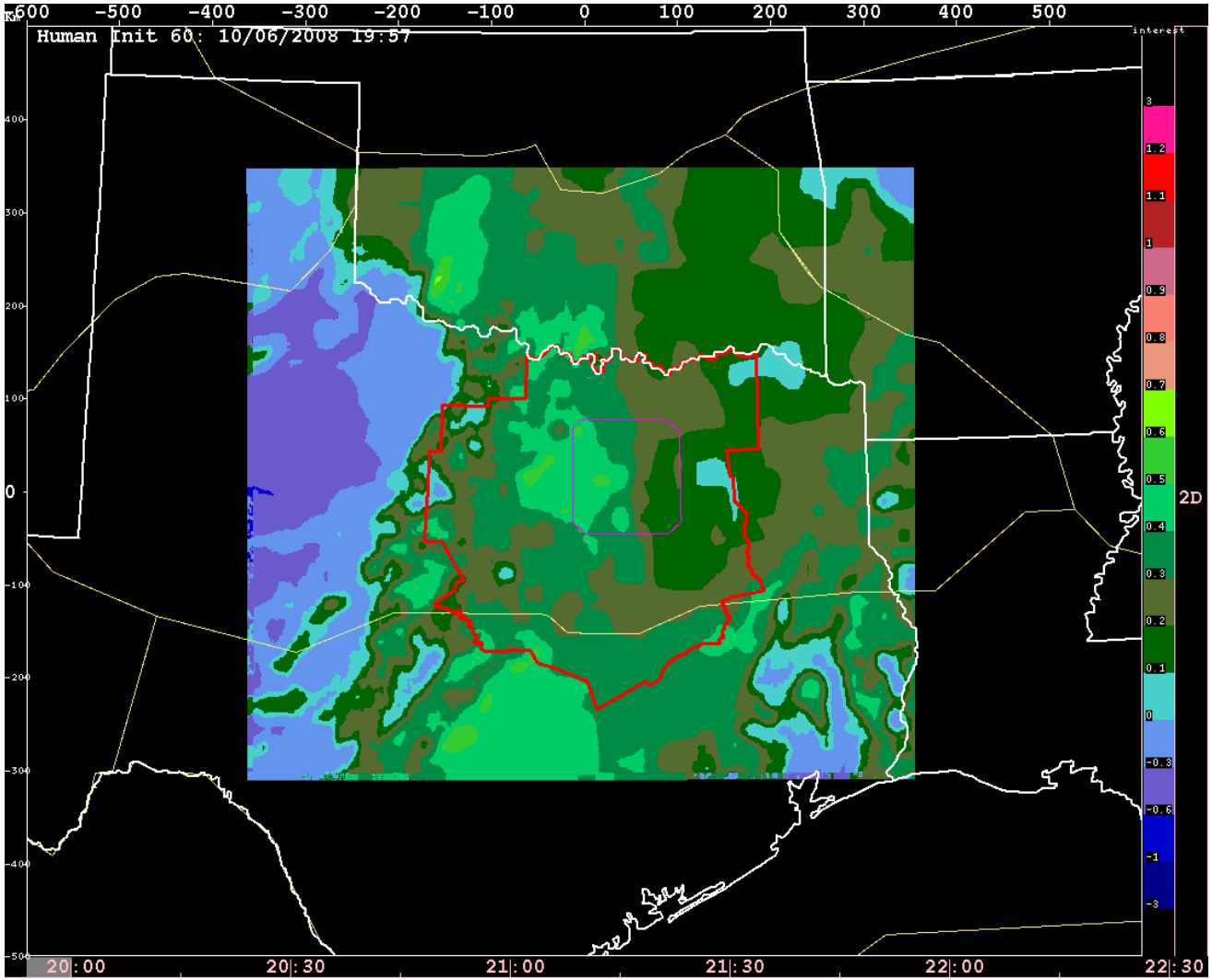




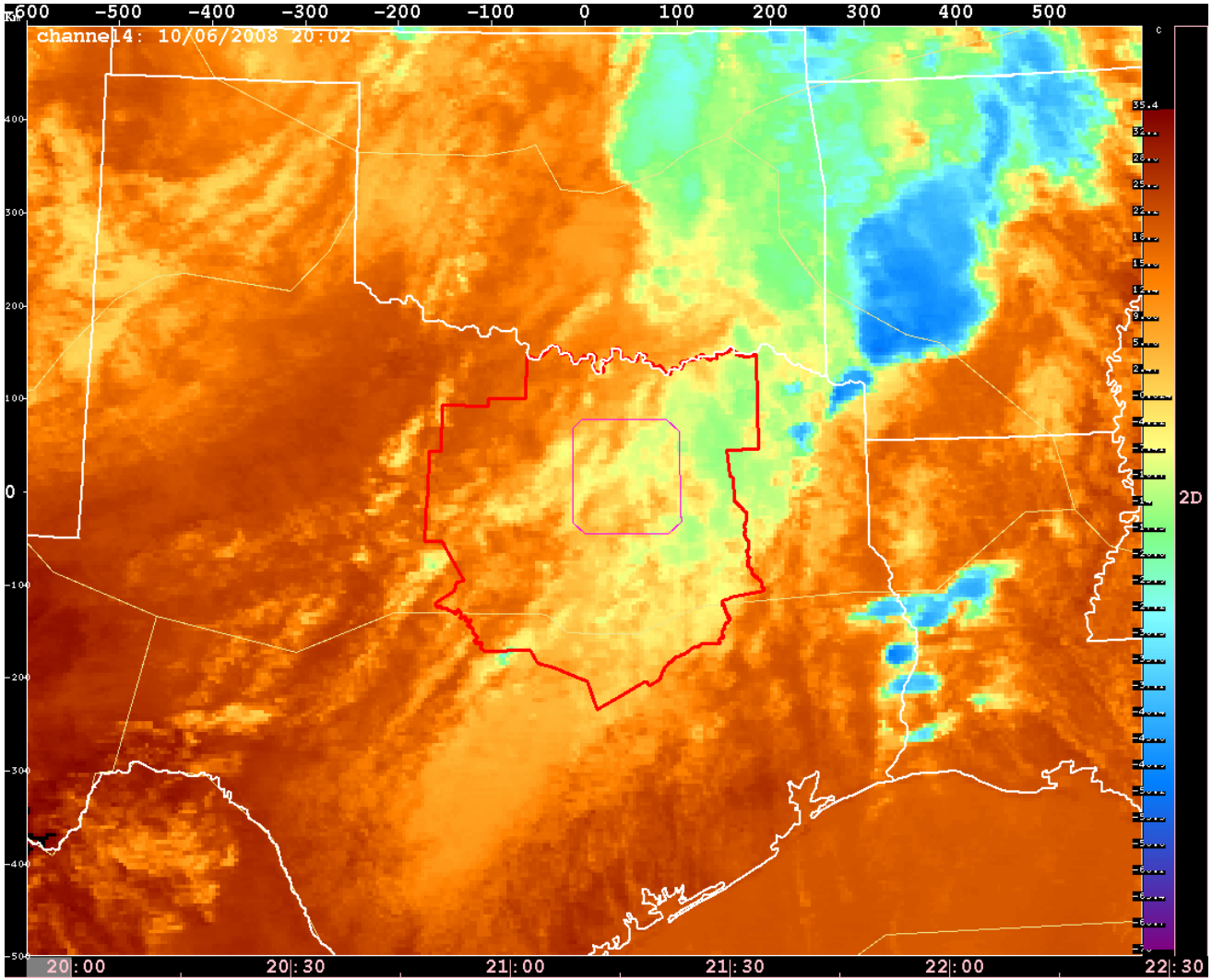
Polygon Example: Real-time Verify60



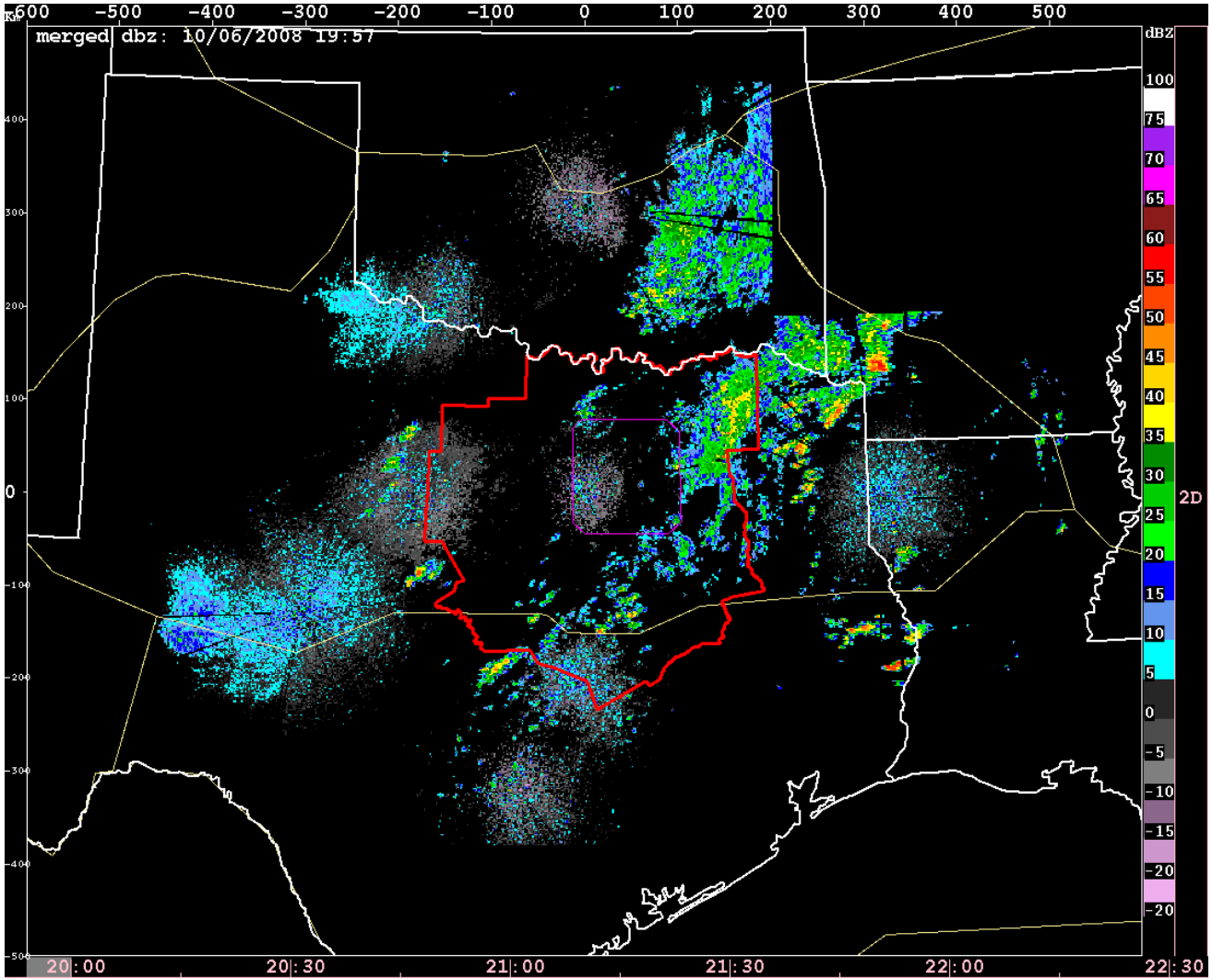
To Nudge or Not to Nudge?



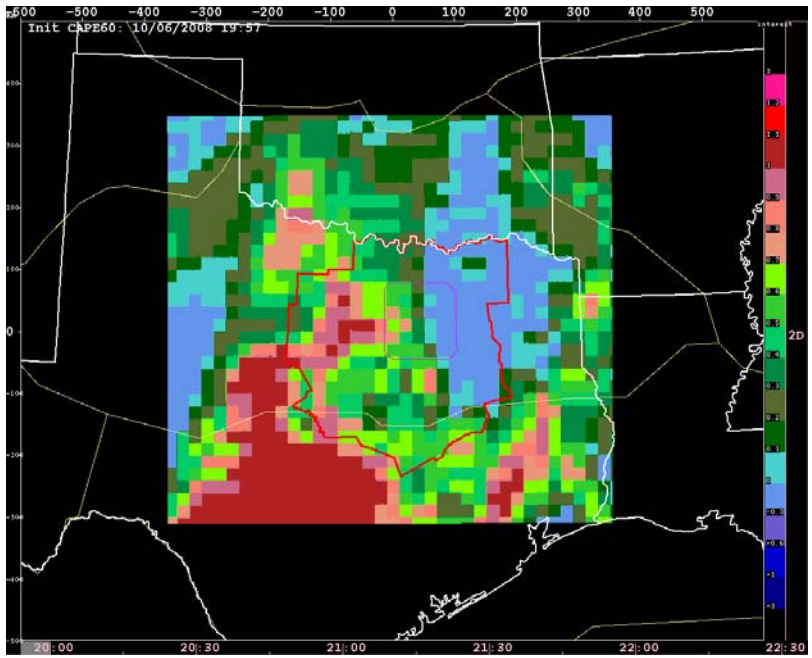
Nudging: IR at Forecast Time

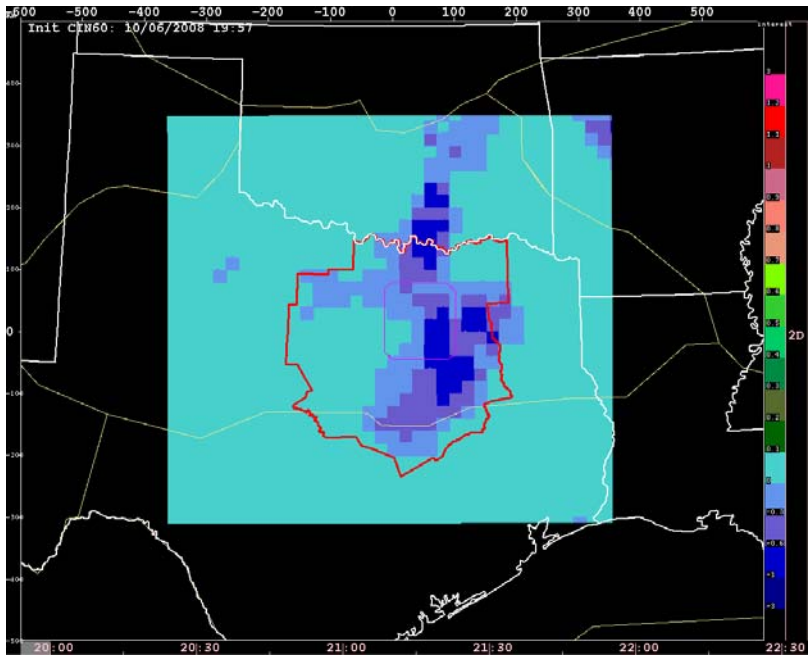


Nudging: Radar at Forecast Time

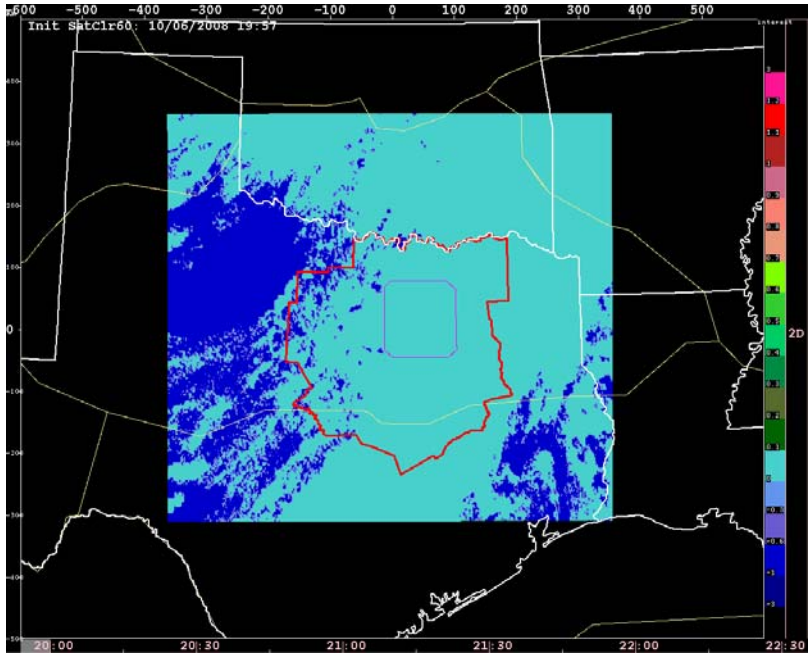


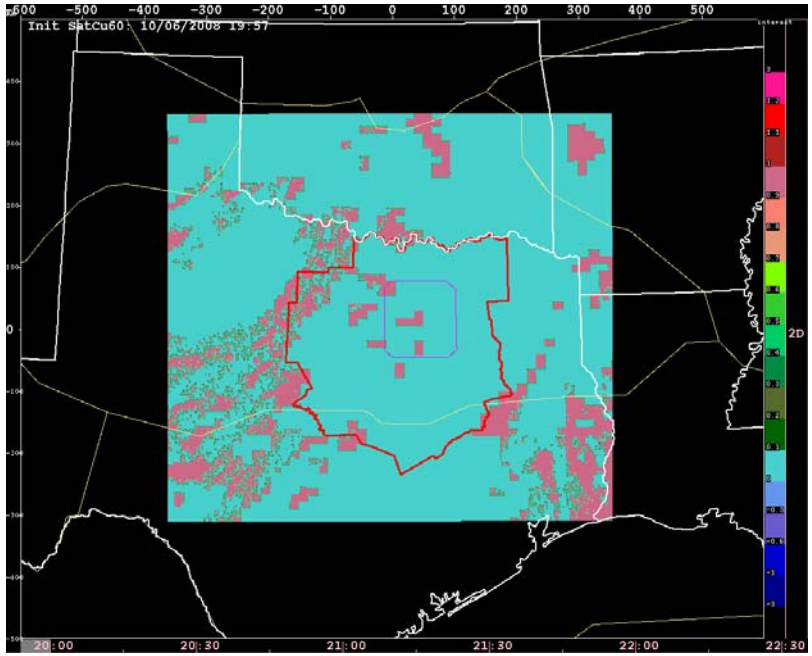
Nudging: Cape and CIN Int



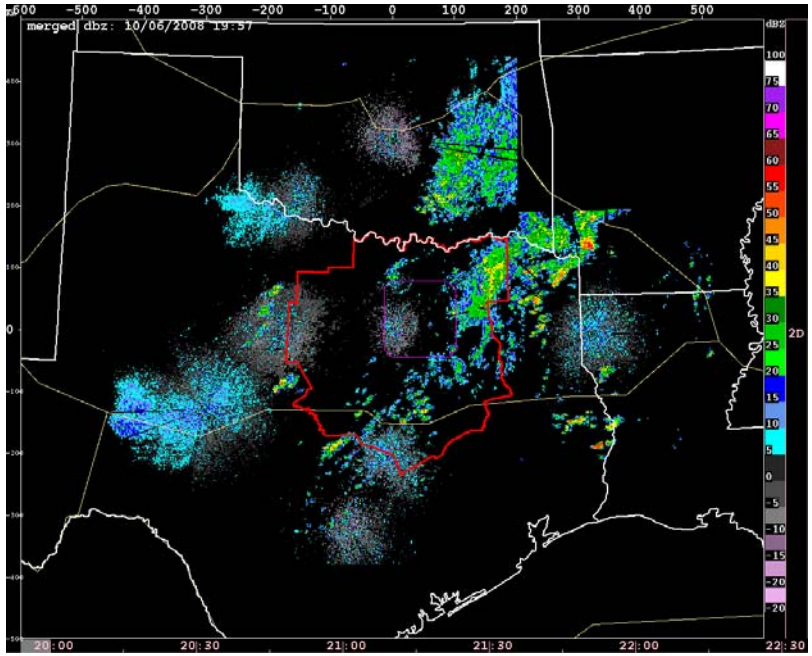


Nudging: SatClr and SatCu Int

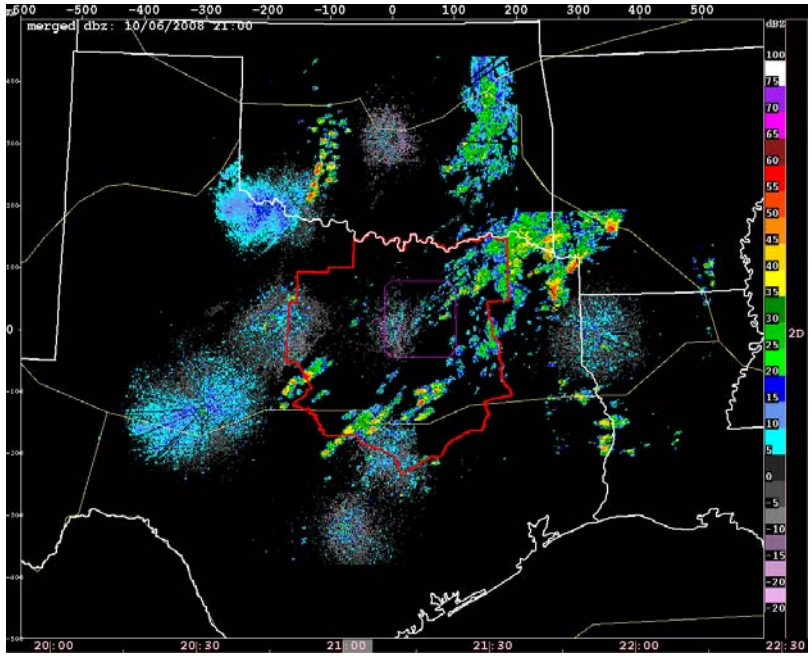




Nudging: Radar Initial and Valid Time

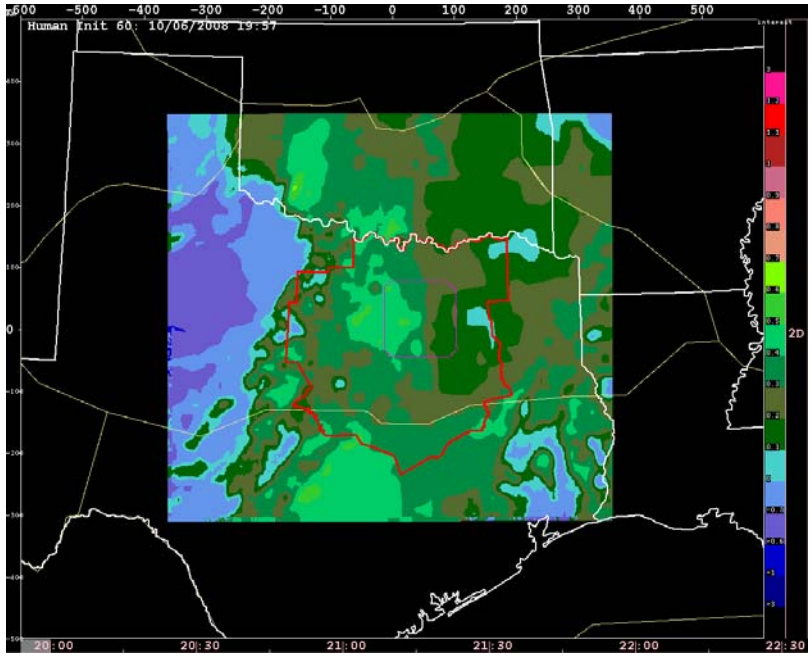


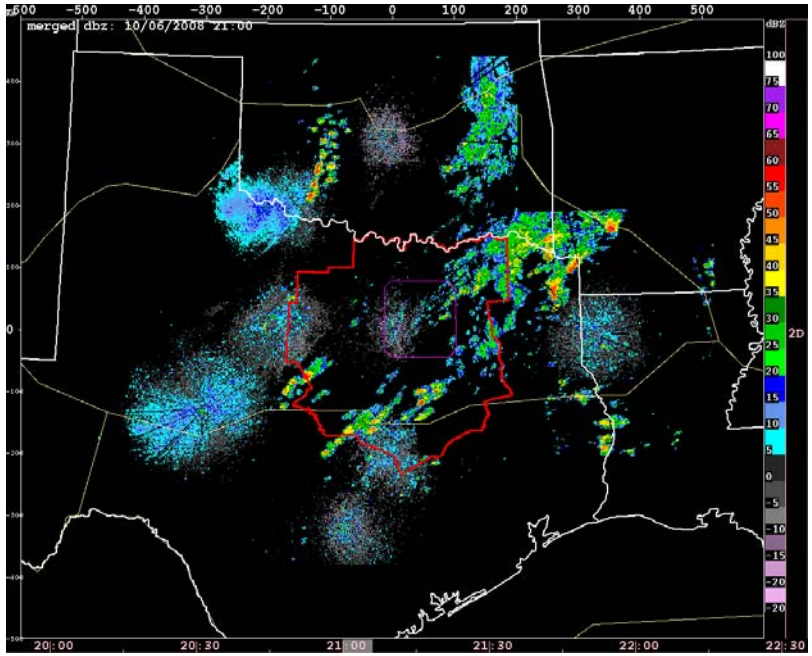
T=0



T+60

Nudging: Init60 and Radar Validation





Nudges and Polygons

- No hard and fast rules when to use each tool
- Amount of interest to add or suppress relies on judgment of forecaster
- Nudges and polygons MUST be monitored closely and removed when corrective interaction no longer needed
- Use of polygons and nudges are not required during FTW validation experiment