

Calculating Icing Severity in the Current Icing Product (CIP)

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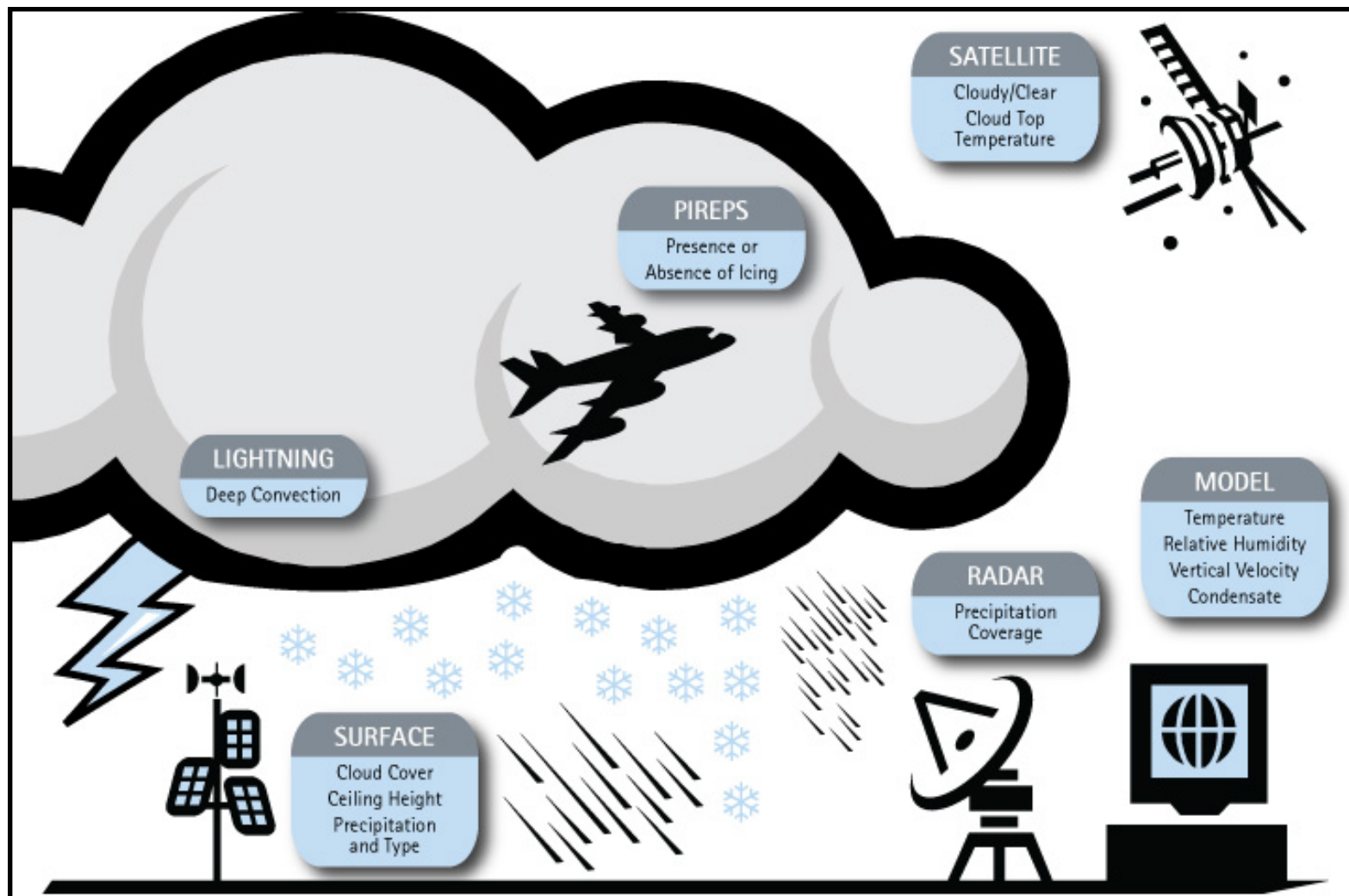


NCAR

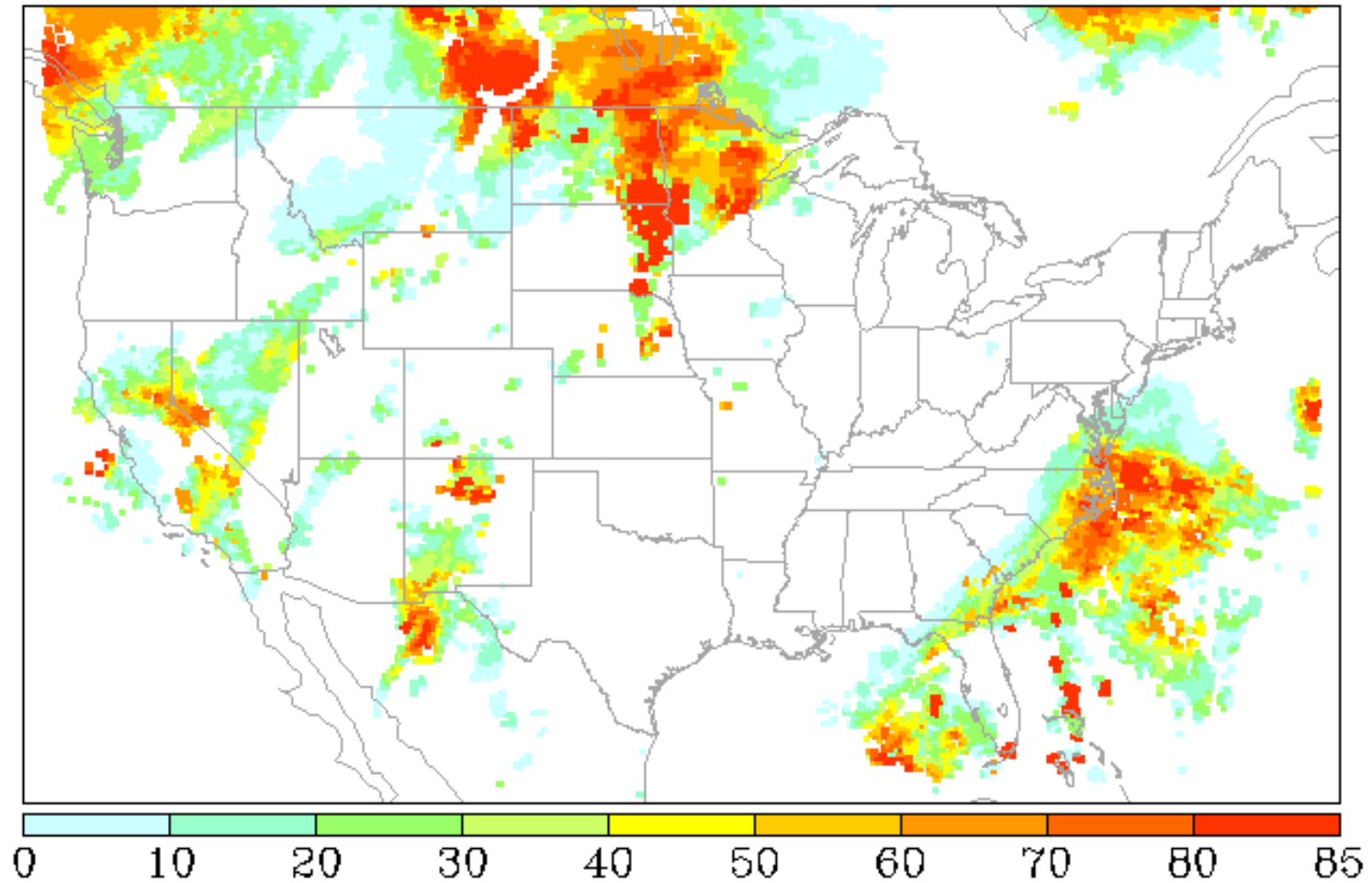
What is CIP?

- Gridded, hourly, three dimensional *diagnosis* of icing conditions over the continental United States and southern Canada
 - ≡ Icing probability, SLD potential, icing severity
 - ≡ 20 km horizontal spacing
 - ≡ 1000 ft. (305 m) vertical spacing

Datasets

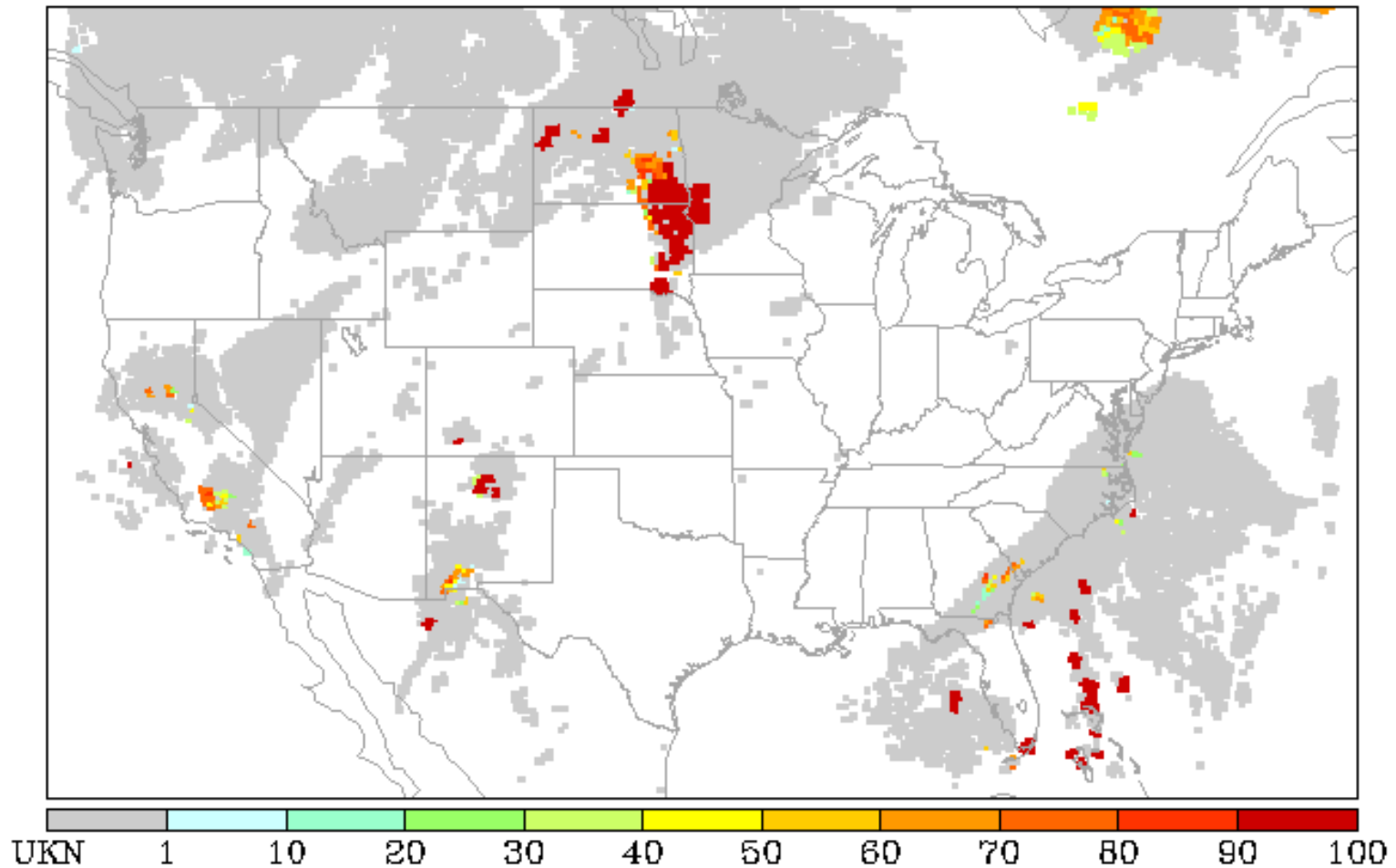


Icing Probability



Calibrated icing potential (0 – 85%)

SLD Potential



Likelihood of the presence of supercooled large drops ($50+ \mu\text{m}$)

Icing Severity

- Scenario based
- Fuzzy logic
 - ≍ Interest maps, confidence, weights
 - ≍ Based on experience, statistics, data quality
- Production and depletion of supercooled liquid water (SLW)

Icing Scenarios

- No Precipitation
 - ⌘ Cloudy, but no precipitation reports nor radar echo
- All Snow
 - ⌘ Snow is the only precipitation type reported
- Cold Rain
 - ⌘ Rain is reported and $CTT < -12\text{ }^{\circ}\text{C}$
- Warm Precipitation
 - ⌘ Collision-Coalescence forms the precipitation
 - ⌘ $CTT \geq -12\text{ }^{\circ}\text{C}$ and precipitation is not snow
- Cold Non-Snow/Rain
 - ⌘ Precipitation is something other than snow or rain and the $CTT < -12\text{ }^{\circ}\text{C}$
- Classical Precipitation Above a Melting Layer
- Classical Precipitation Below a Melting Layer
- Convection
 - ⌘ Lightning strike within 25 km
 - ⌘ No precipitation necessary

Initial Severity Calculation

$$SEV_{init} = \frac{C_1 * W_1 * i_1 + \dots + C_n * W_n * i_n}{C_1 * W_1 + \dots + C_n * W_n}$$

where c=confidence, w=weight, i=interest

- SLW production only
- Ingredients vary based on scenario
 - ≡ None have the same fields applied in the same way

Confidence

- How much the data can be trusted

0 = no confidence, field has no severity information

1 = highest confidence

Weight

- What is the influence of this field for determining severity in this scenario?

1 = very little influence

5 = highest influence

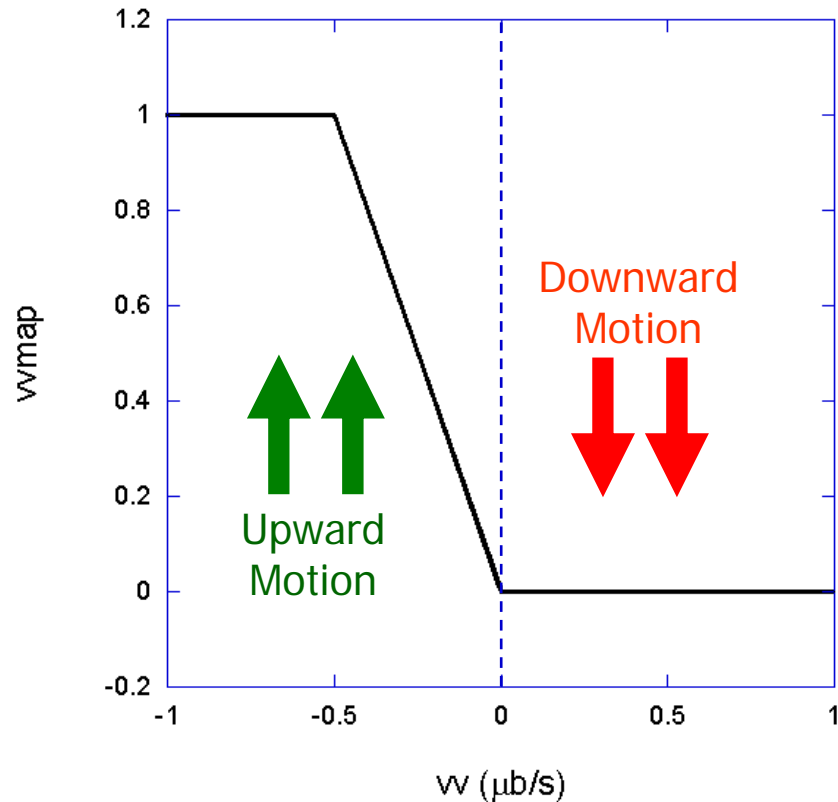
Interest

- Provides the meaning of a field's range of values in terms of icing severity

0 = no interest

1 = maximum interest

Vertical
Velocity



Damping

■ SLW Depletion

≡ Visible Albedo

- Dimmer clouds (< 55 – 60%) have less condensate

≡ Temperature

- If too cold SLW more likely to become frozen
- If too warm plane's airspeed will discourage icing

≡ Cloud Top Temperature

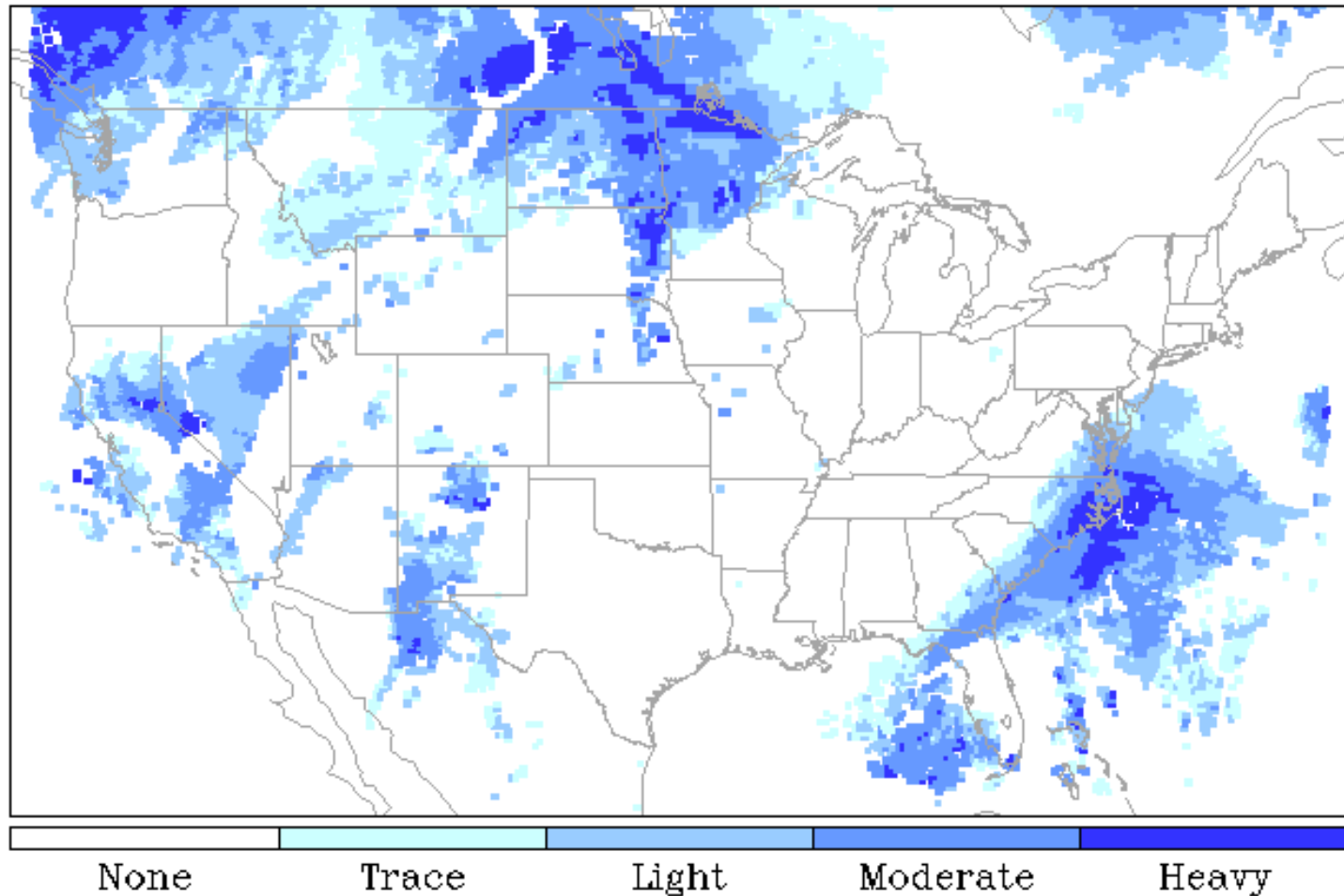
- Cold temperatures → more ice crystals
- Only applied in top 10,000 ft. of cloud

≡ Radar Reflectivity

- Indicator of ice production with increasing values
- Only applied in bottom 5000 ft. of cloud

■ Result is Final Icing Severity (0 – 1)

Thresholds Applied



Case Study - 16 February 2005

NASA Glenn Twin Otter flight near Sandusky, OH (SKY)

Near cloud top:

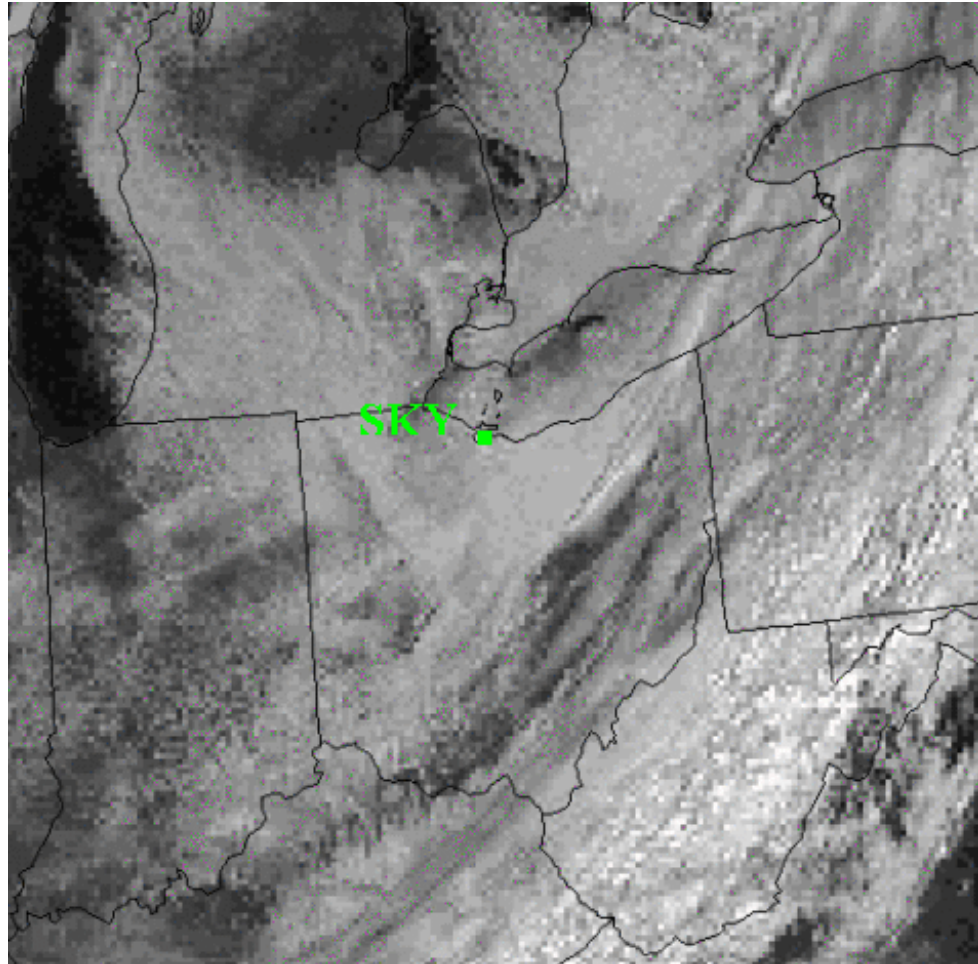
1.7 to 1.8 km

No precipitation nor
radar echo

Observed SLW:

0.3 – 0.4 g m⁻³

Reported icing as light
to moderate



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Initial Icing Severity

■ No Precipitation Scenario

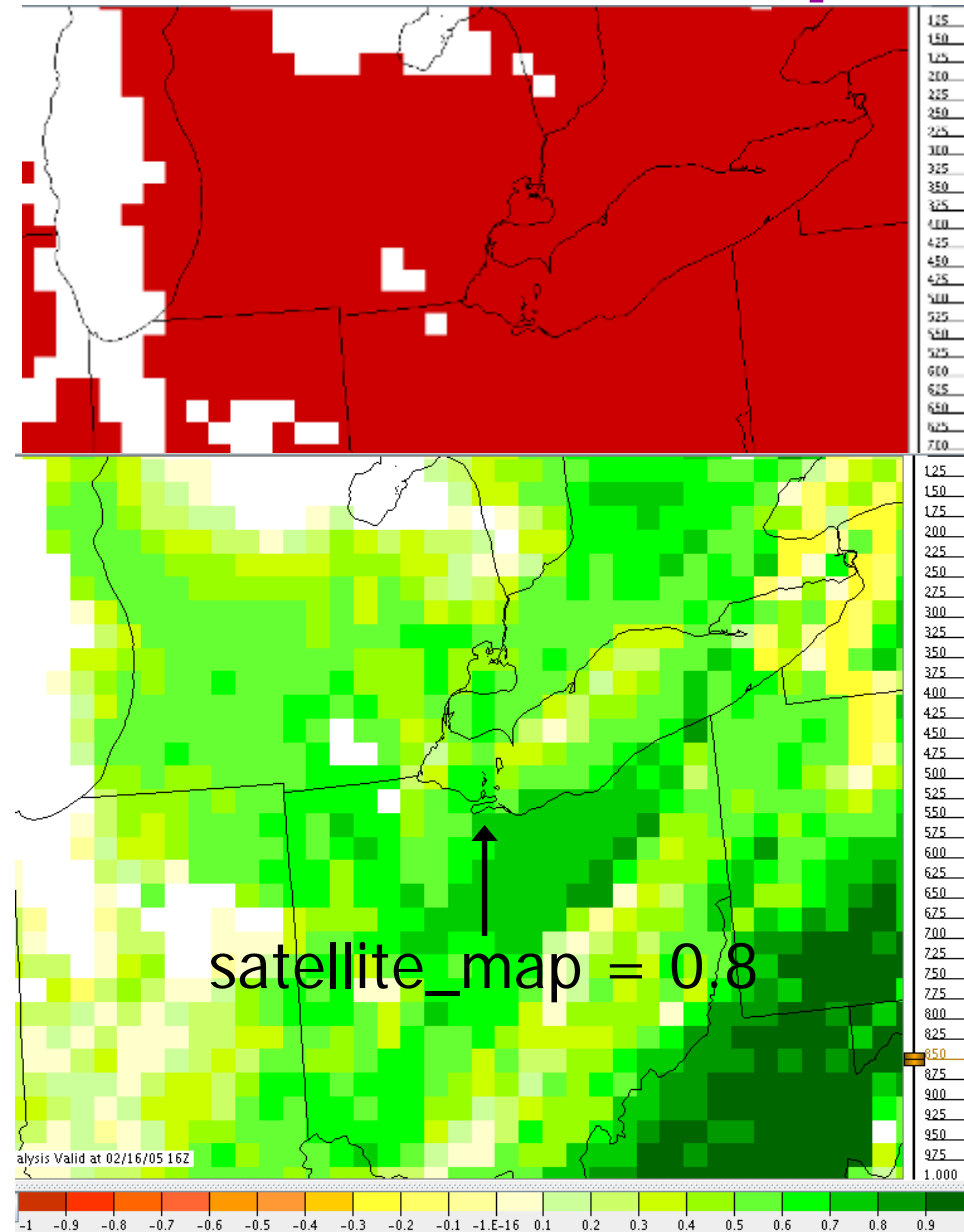
$$SEV_{init} = \frac{(sat_conf*5*satellite_map) + (1*3*dq_map) + (1*3.5*dz_np_map) + (1*4*vv_map) + (1*4*moisture_map) + (1*3*icing_pot) + (rep_conf*5*rep_sev_map)}{(sat_conf*5) + (1*3) + (1*3.5) + (1*4) + (1*4) + (1*3) + (rep_conf*5)}$$

Confidence, Weight, Interest

- Each field examined at 850 mb (approximate cloud top and altitude of the Twin Otter)

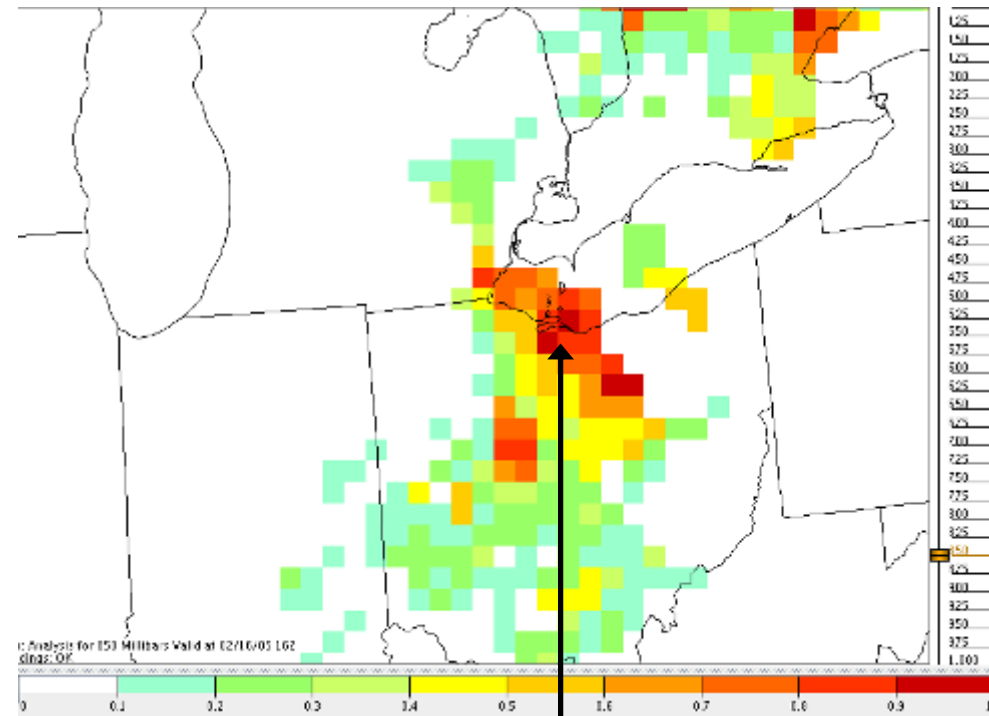
Satellite ($\text{sat_conf} * 5 * \text{satellite_map}$)

- Confidence = sat_conf
 - ⌘ Determined by solar angle
 - ⌘ All clouds illuminated well: $\text{sat_conf} = 1$
- Weight = 5
- Interest = satellite_map
 - ⌘ Visible: higher albedo = more condensate
 - ⌘ Ch. 2 – Ch. 4: higher values = smaller particles (i.e. water droplets)
 - ⌘ Both high in this case



Δq (1*3*dq_map)

- Confidence = 1
- Weight = 3
- Interest = dq_map
 - ≡ Δq : Maximum potential LWC using the adiabatic assumption
 - ≡ Breaks down in precipitation or stratified layers
 - ≡ Well mixed layer and no precipitation \rightarrow high Δq at cloud top

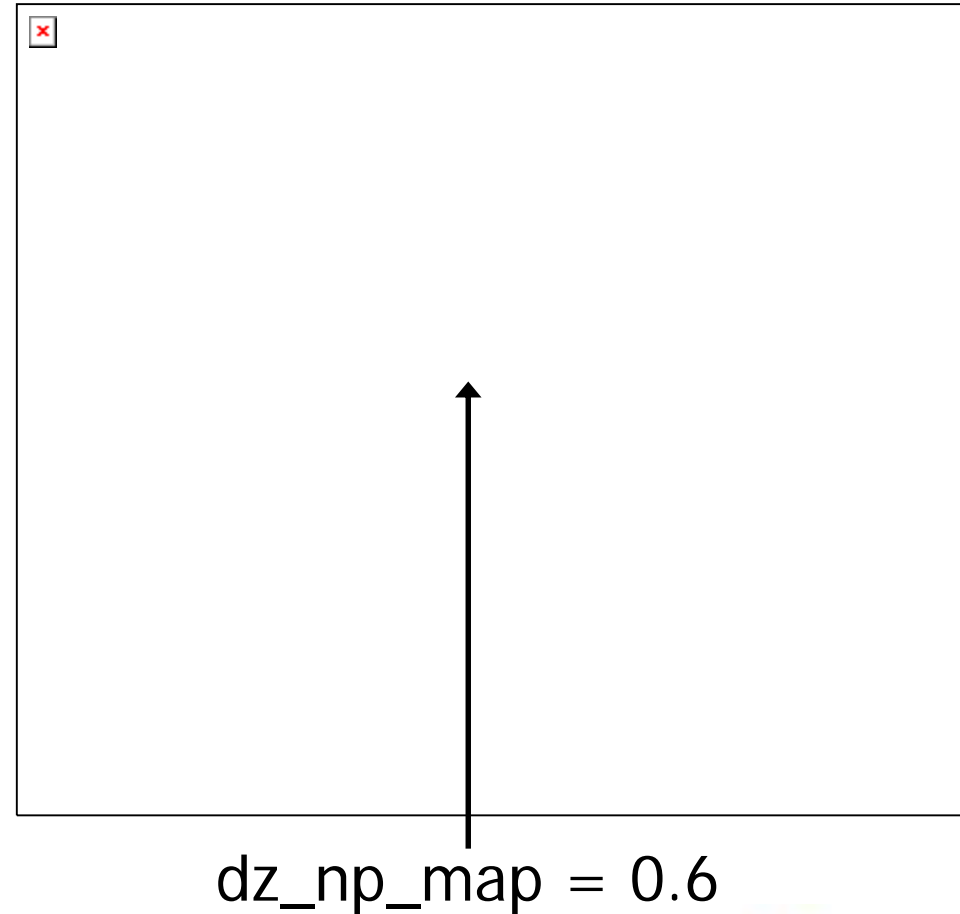


dq_map = 0.9

Height above Cloud Base

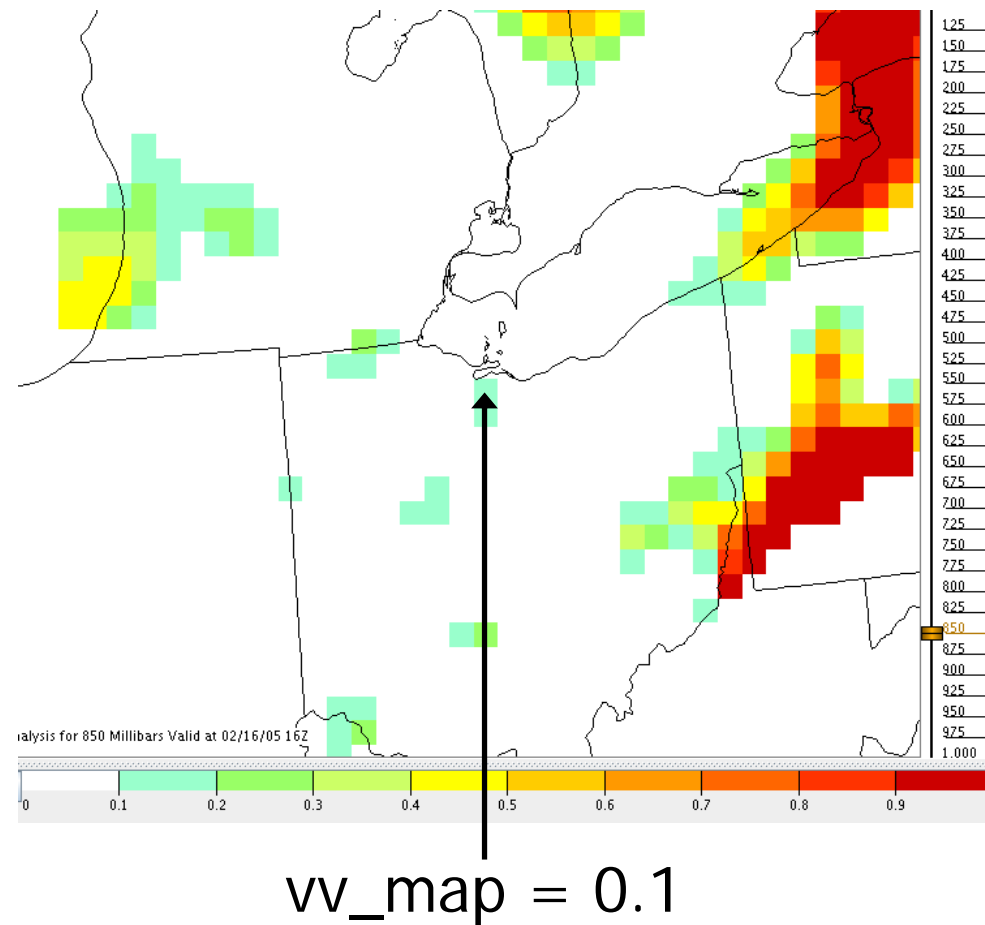
$$(1 * 3.5 * dz_np_map)$$

- Confidence = 1
- Weight = 3.5
- Interest = dz_np_map
 - ≍ Greater distance = more potential condensate
 - ≍ No model moisture or stability requirements
 - ≍ Varies with scenarios
 - ≍ At cloud top, but not a very deep cloud



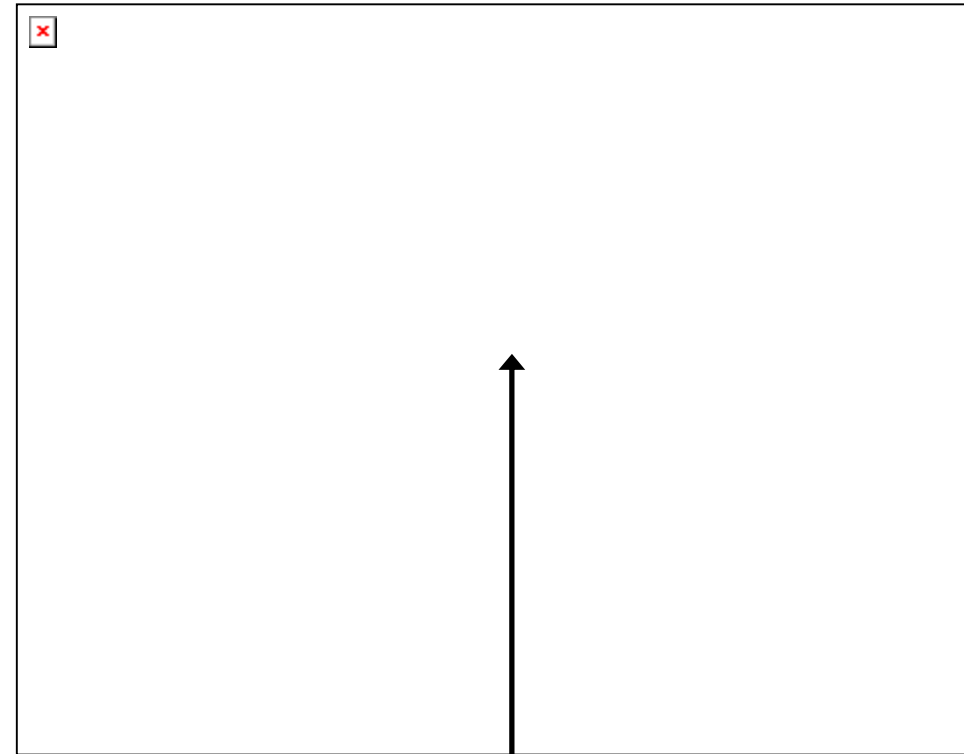
Vertical Velocity ($1 * 4 * vv_map$)

- Confidence = 1
- Weight = 4
- Interest = vv_map
 - ≡ Upward motion increases RH resulting in condensation that can produce SLW
 - ≡ Can suspend larger drops
 - ≡ Very little upward motion at cloud top



Moisture (1*4*moisture_map)

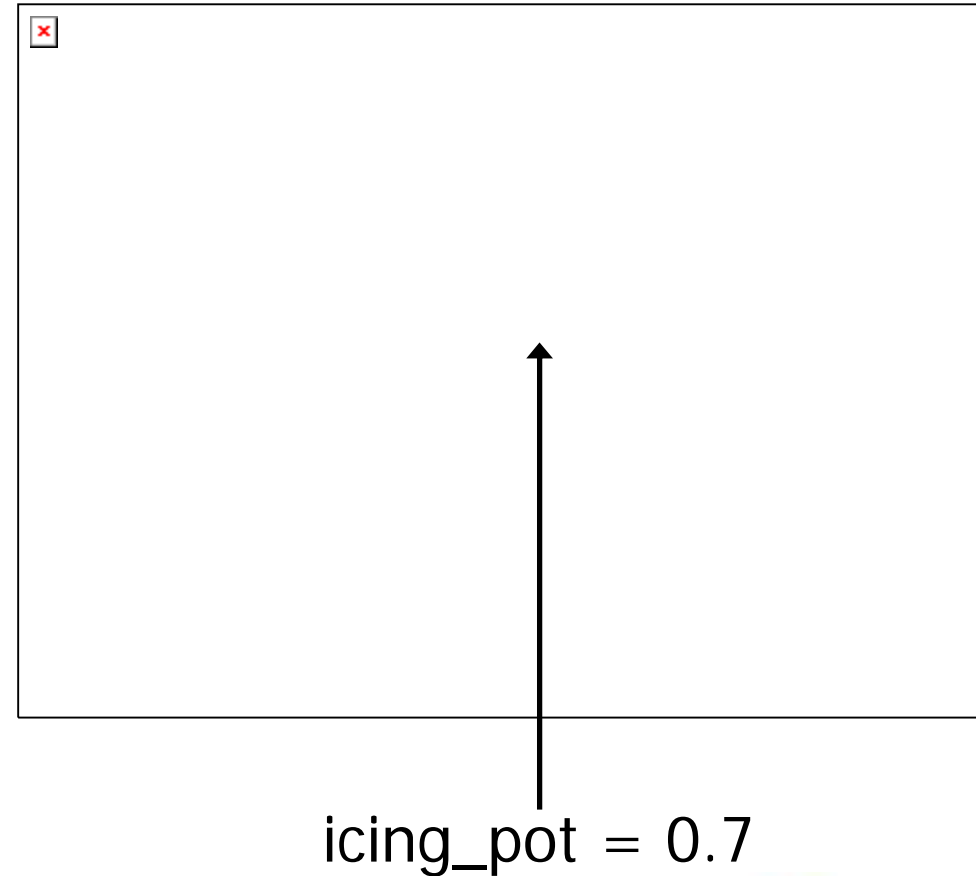
- Confidence = 1
- Weight = 4
- Interest =
moisture_map
 - ≍ Combination of relative humidity and model condensate
 - Liquid and ice
 - ≍ Clouds in reality, but $RH < 100\%$ and no model condensate



moisture_map = 0.3

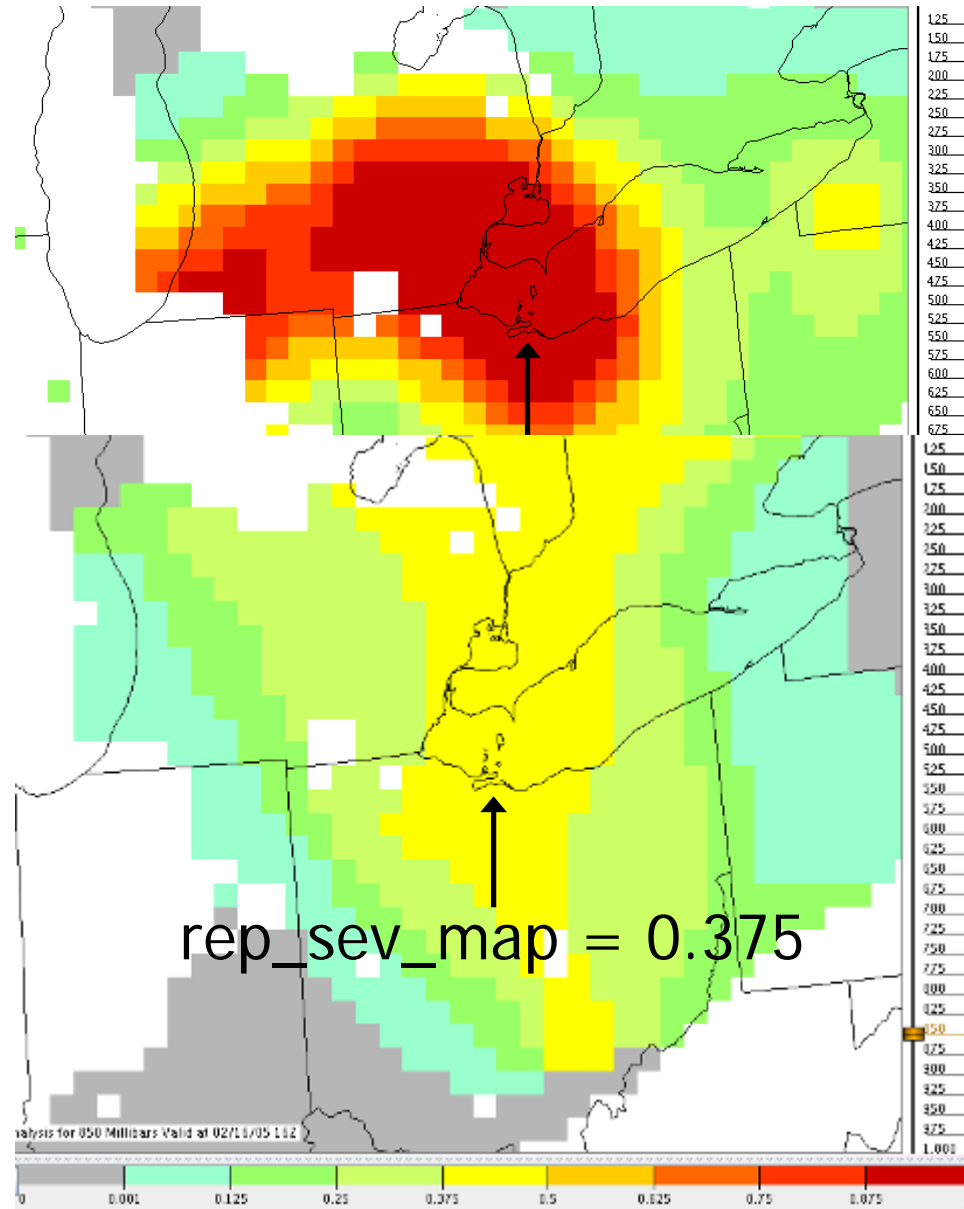
Icing Potential ($1 * 3 * \text{icing_pot}$)

- Confidence = 1
- Weight = 3
- Interest = icing_pot
 - ≍ Found to have some skill in icing severity
 - ≍ Uses fields in different ways than the severity algorithm
 - ≍ Fairly high icing potential in this case



PIREPs ($\text{rep_conf} * 5 * \text{rep_sev_map}$)

- Confidence = rep_conf
 - ≧ Determined by number, recency, and proximity of PIREPs
 - ≧ Plenty of recent PIREPs in area: rep_conf = 1
- Weight = 5
- Interest = rep_sev_map
 - ≧ Consensus severity from recent, nearby PIREPs
 - ≧ Light in this case

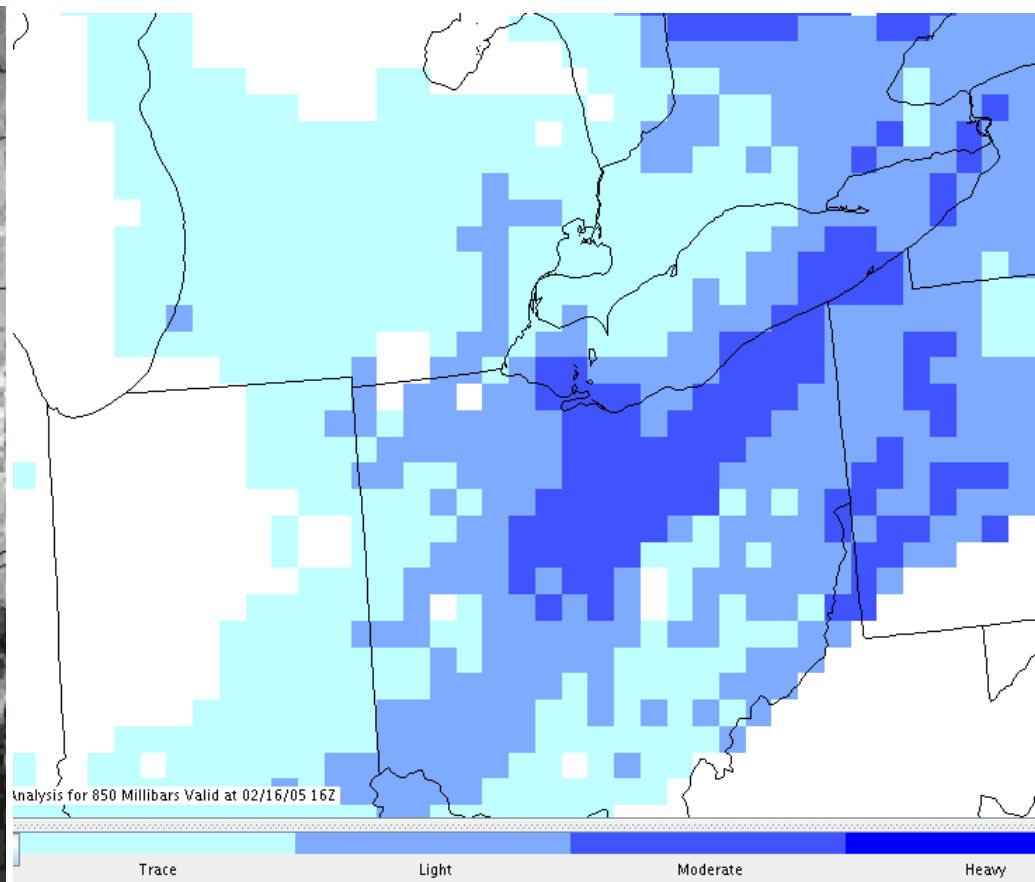
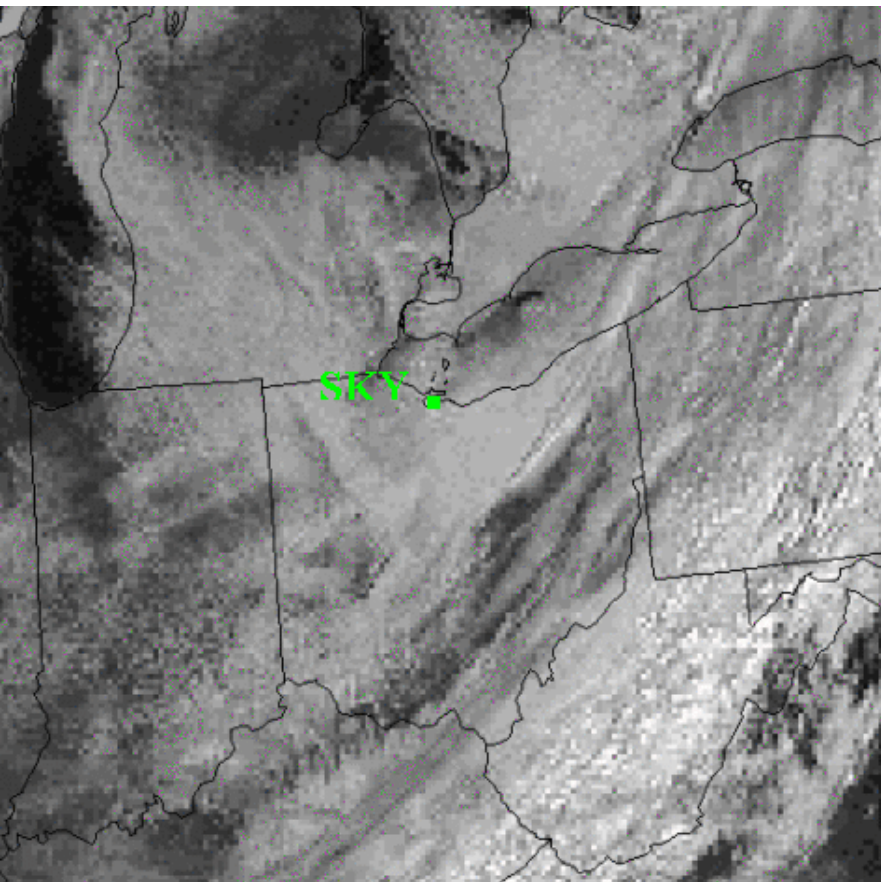


Damping

- None in this case
- Visible albedo was high
- Temperature ($-6\text{ }^{\circ}\text{C}$) and cloud top temperature ($-10\text{ }^{\circ}\text{C}$) were in acceptable ranges
- No radar echo (no precipitation scenario)

Final Severity

- $SEV = 0.53 = \text{Moderate}$ (after thresholding)



Special Scenario Inputs

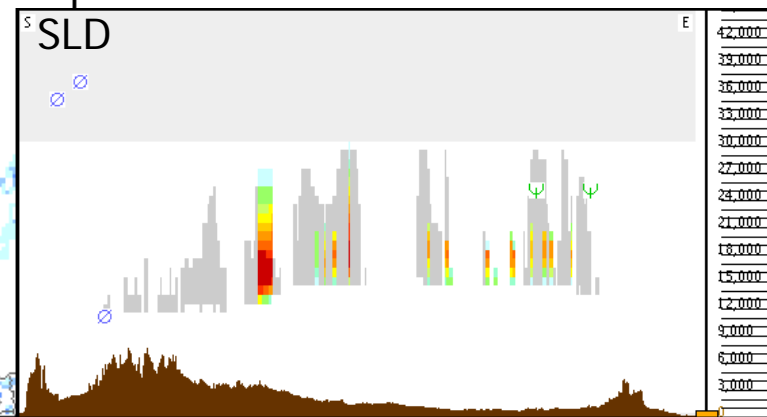
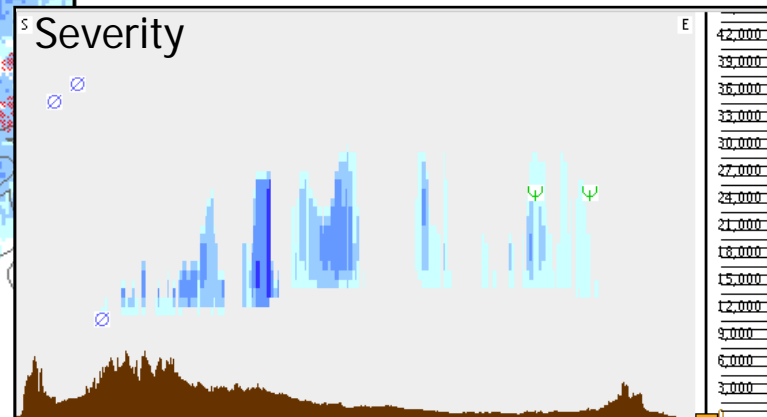
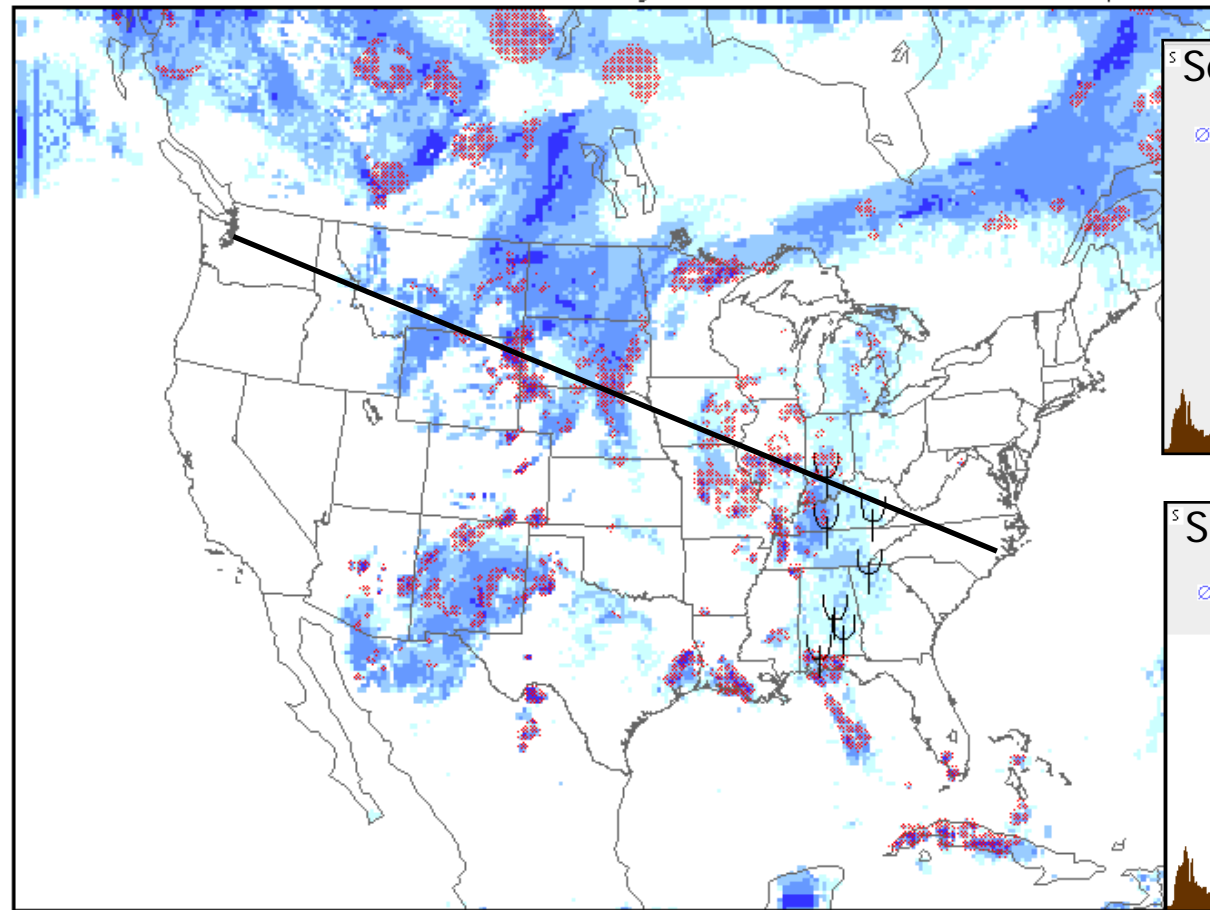
- Classical Precipitation Below a Melting Layer
 - ≧ Vertical velocity in the dendritic formation layer
 - ≧ Radar reflectivity
 - ≧ Cloud top temperature
- Convection
 - ≧ Number of lightning strikes
 - ≧ Distance to lightning
 - ≧ 75th percentile – 25th percentile reflectivity

Flight Planning

By FAA policy CIP is a Supplementary Weather Product for enhanced situational awareness only and must be used with one or more primary products (safety decision) such as an AIRMET or SIGMET (see AIM 7-1-3).

Maximum icing severity (1000 ft. MSL to FL300)

Analysis valid 2000 UTC Thu 06 Sep 2007



SLD threat

None Trace Light Moderate Heavy

Trace-Light Light-Moderate Moderate-Severe

Icing PIREP Symbols

Trace Light Moderate Severe

Thank You

CIP Severity: <http://adds.aviationweather.gov/icing>

Flight Path Tool: <http://adds.aviationweather.gov/java>