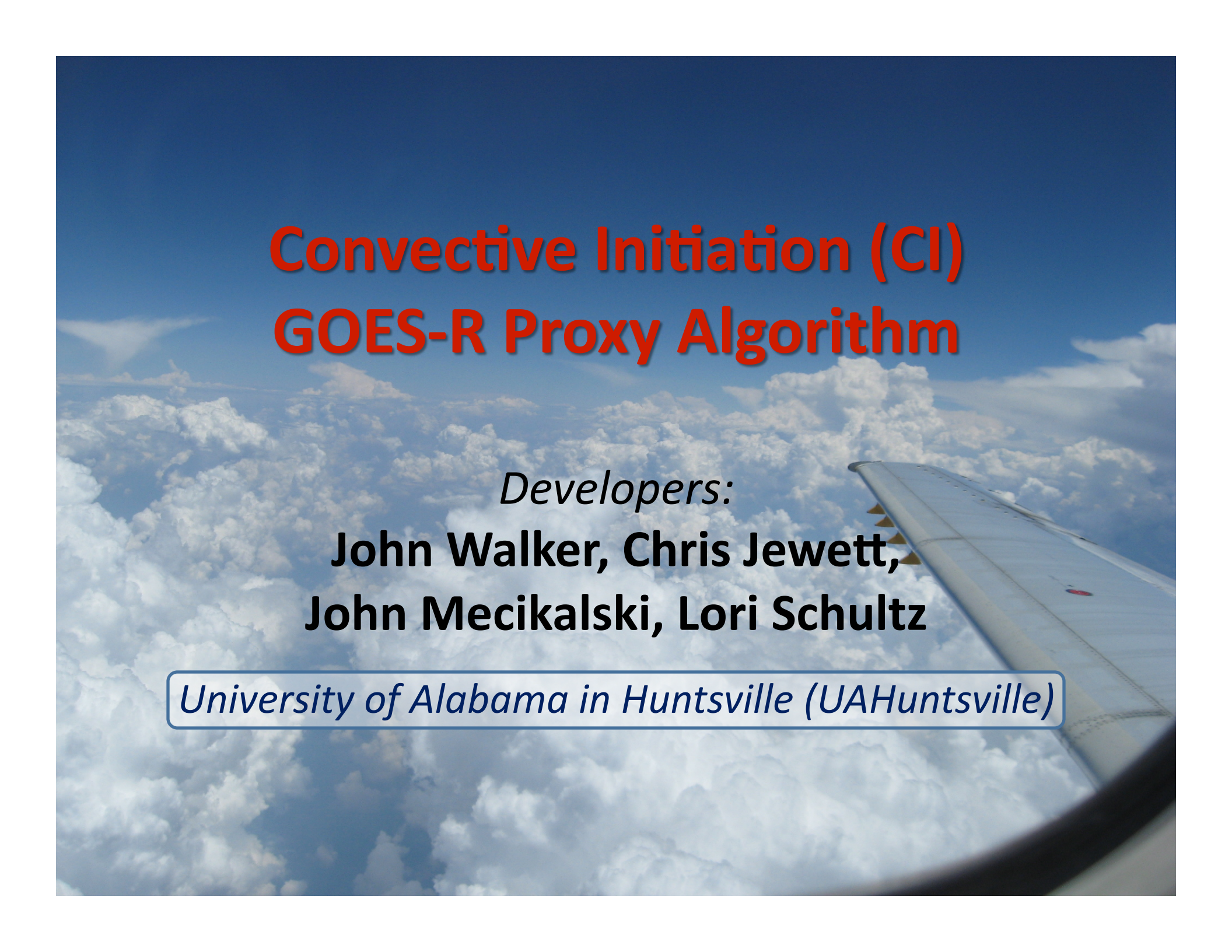




Convective Initiation (CI) GOES-R Proxy Algorithm

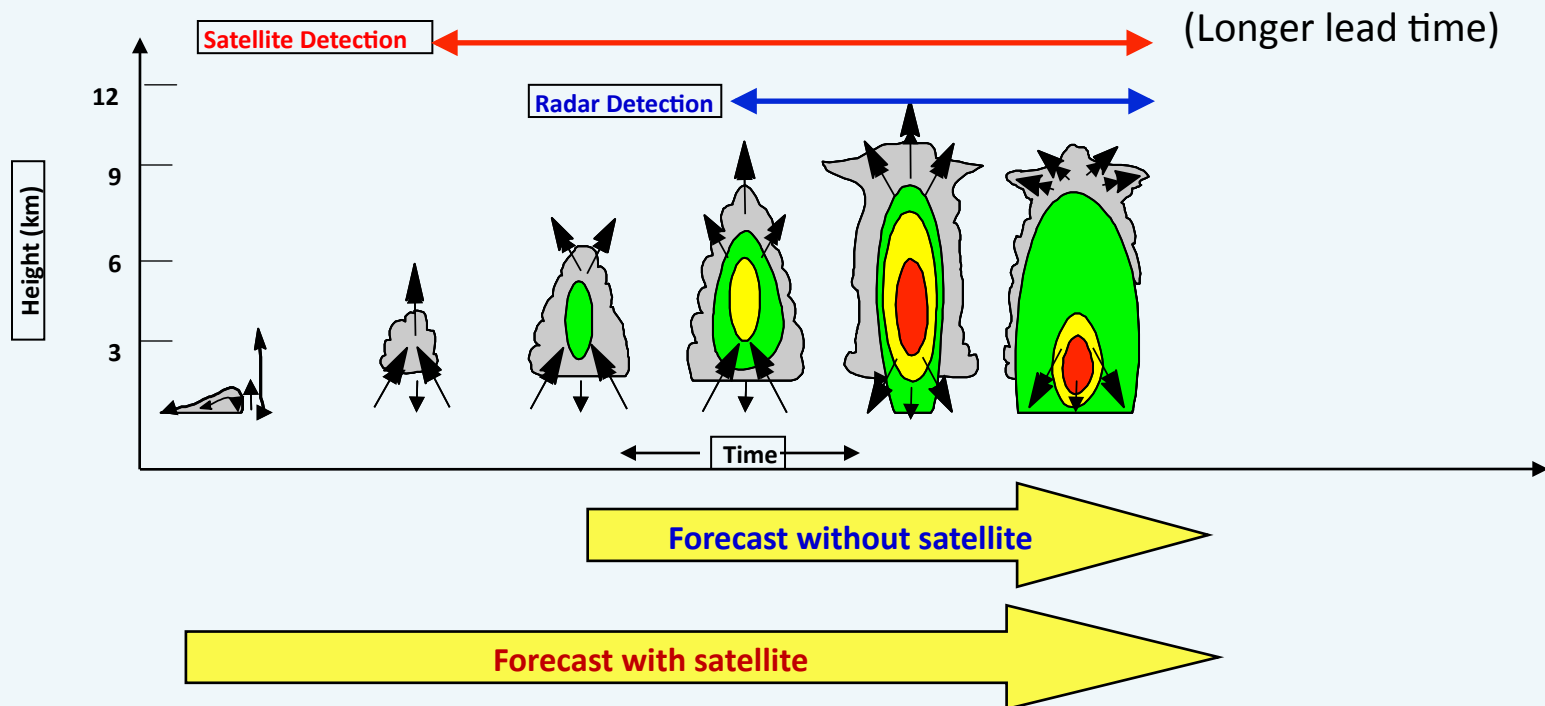
Developers:

**John Walker, Chris Jewett,
John Mecikalski, Lori Schultz**

University of Alabama in Huntsville (UAHuntsville)

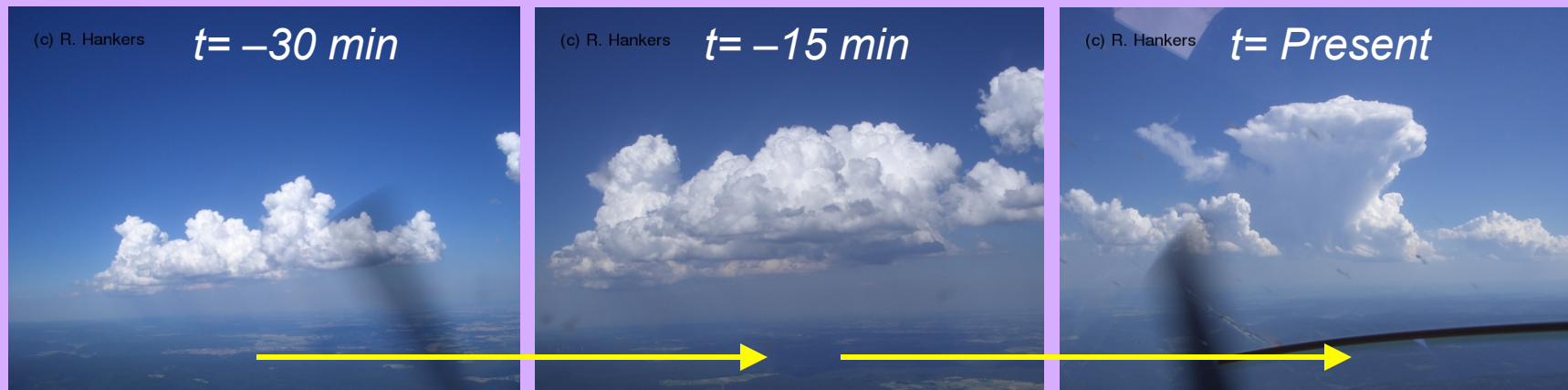
Motivation

- Mecikalski & Bedka (2006) as initial methodology
- Mecikalski et al. (2008, 2010a,b)
- MacKenzie (2008)
- Siewert (2008); Harris et al. (2010)
- Siewert et al. (2010); Walker et al. (2011)



Purpose of Satellite-based CI Algorithm

Satellites “see” cumulus before they become thunderstorms!

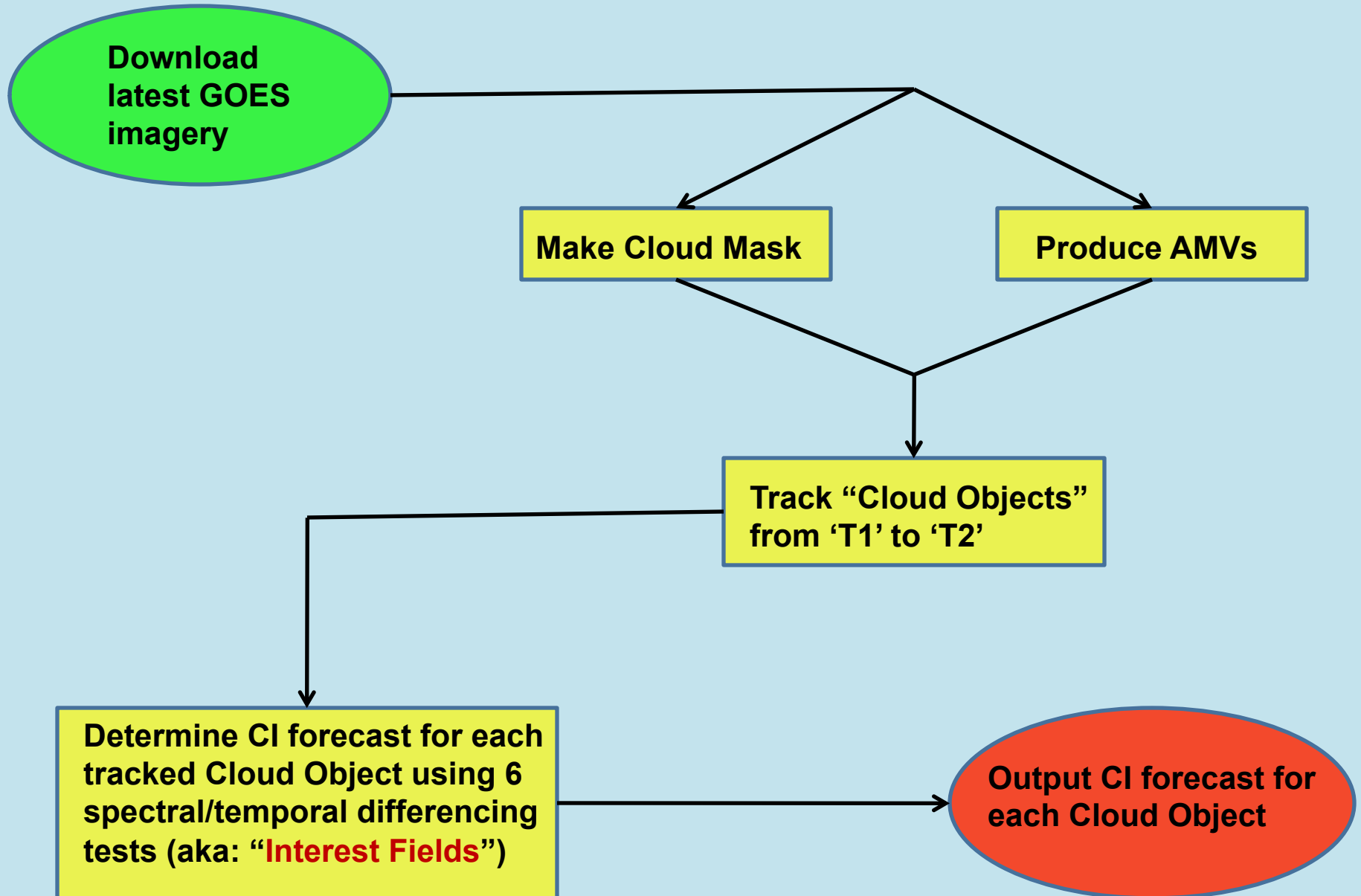


By monitoring signals of cloud growth from satellite, CI can be forecast up to ~1.5 hours in the future.

CI Time:
First ≥ 35 dBZ echo
on radar (at -10°C)



Brief Algorithm Summary



Brief Algorithm Summary

The UAH CI algorithm currently employs a “**Day-time**” and a “**Night-time**” version. The main difference between them is the type of **Cloud Mask** used.

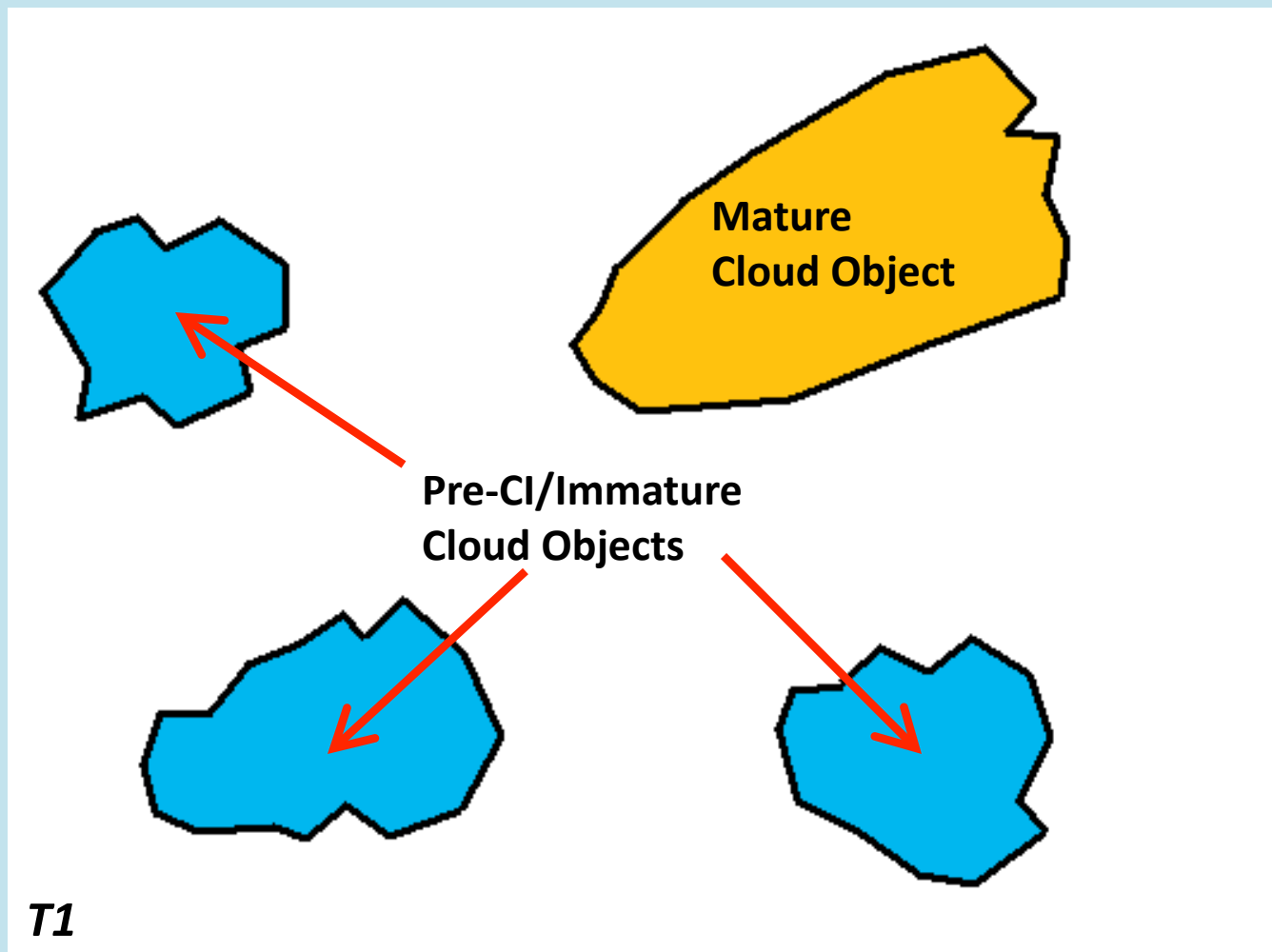
Day-time:

Advanced “Convective Cloud Type” algorithm used to define several types of clouds (Berendes et al, 2008), such as cumulus, towering cumulus, cumulonimbus, cirrus, stratus, etc. The input requires all available GOES channels (including “Visible”).

Night-time:

Regular “Cloud Mask” (no cloud types) generated from multi-day composites of GOES Infrared channels (Jedlovec and Haines, 2008).

Object Tracking Methodology



Day-time CCMask Classifications Used:

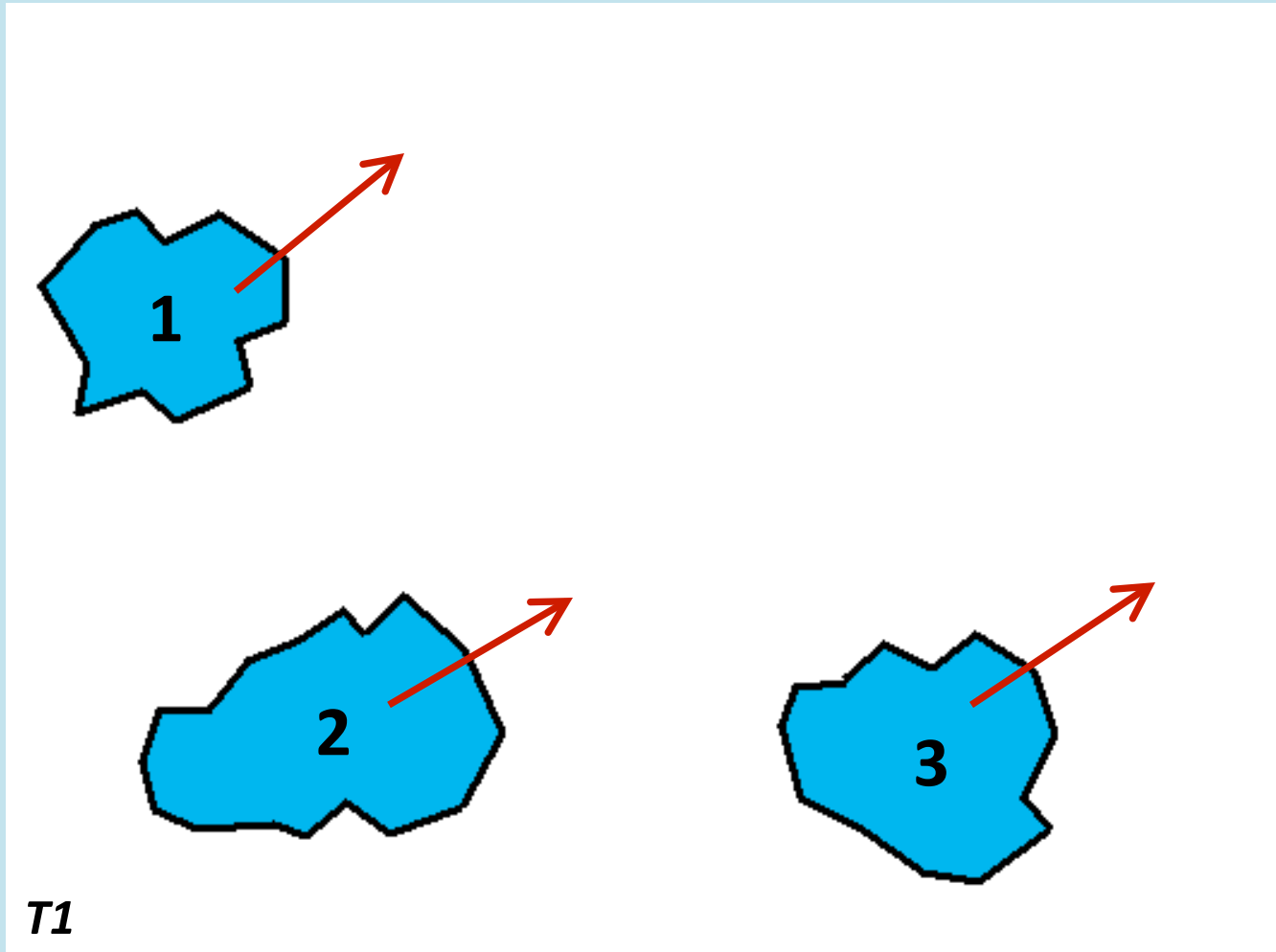
- Cumulus
- Tower Cumulus
- Warm Water Cloud
- Cold Water Cloud

Night-time CMask Portions Used :

- Any part of cloud mask > -20 C

Time 1= "T1"
Time 2= "T2"

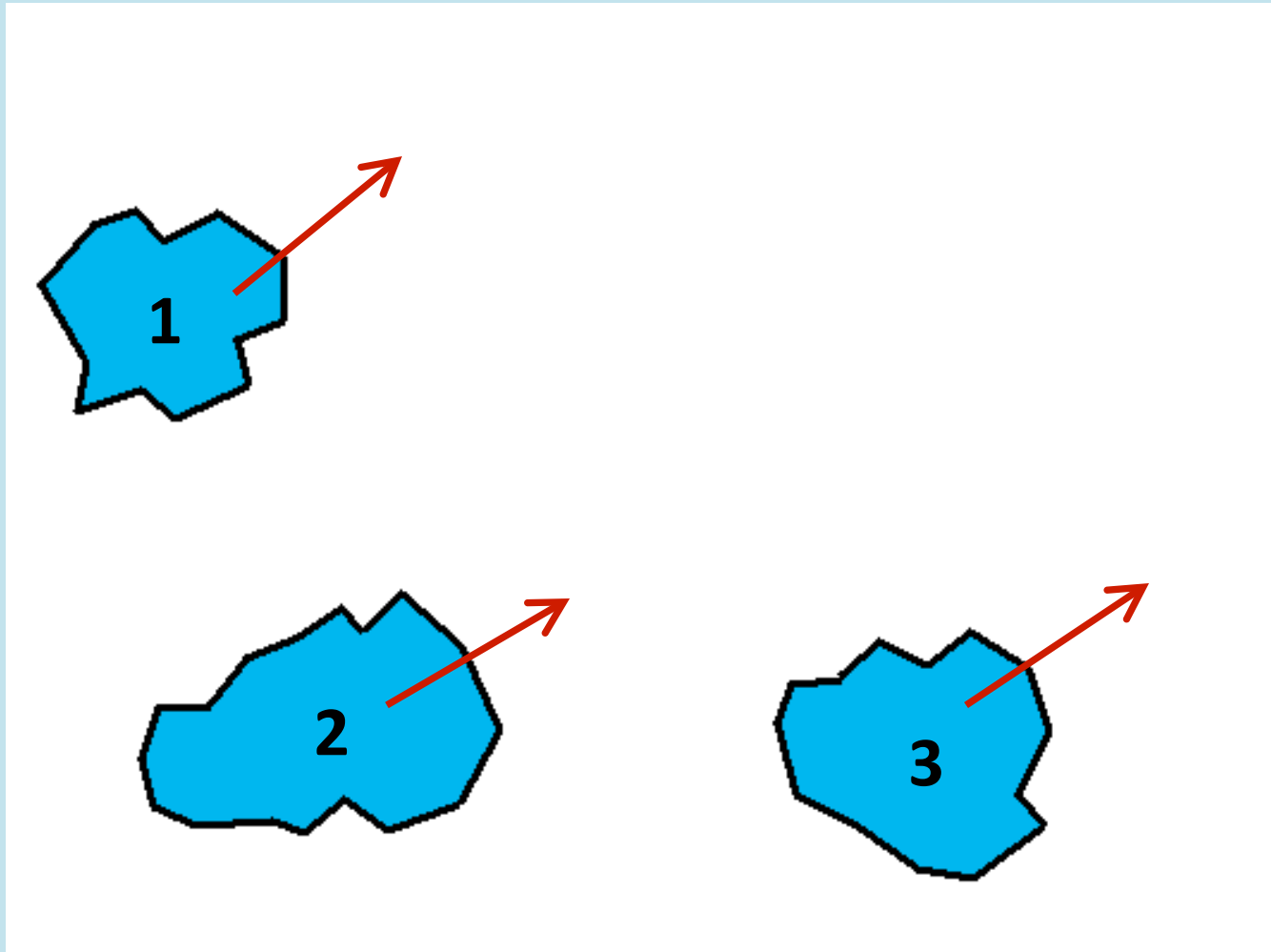
Object Tracking Methodology



Assign unique Integer IDs to each object at T1.

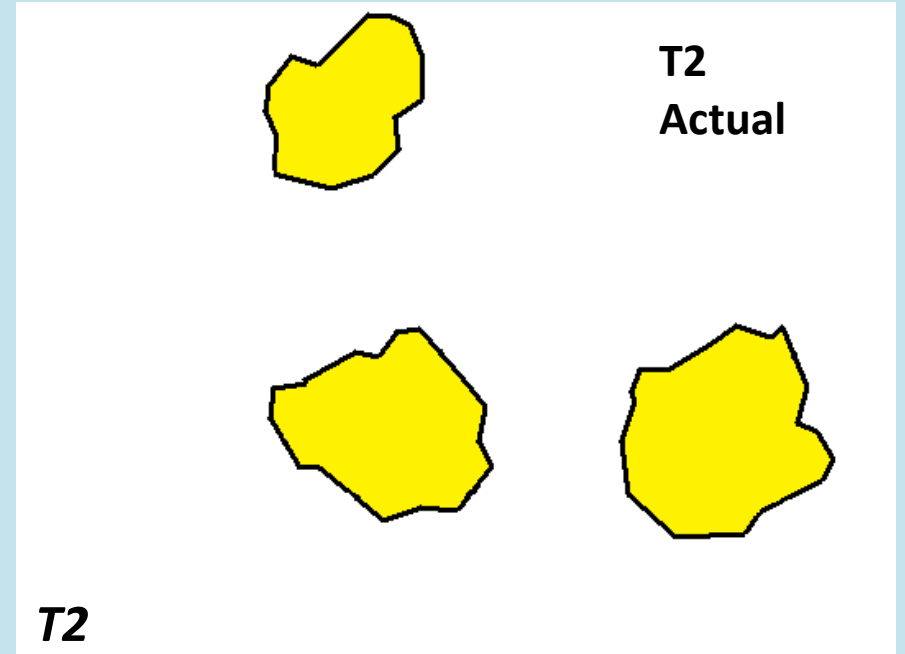
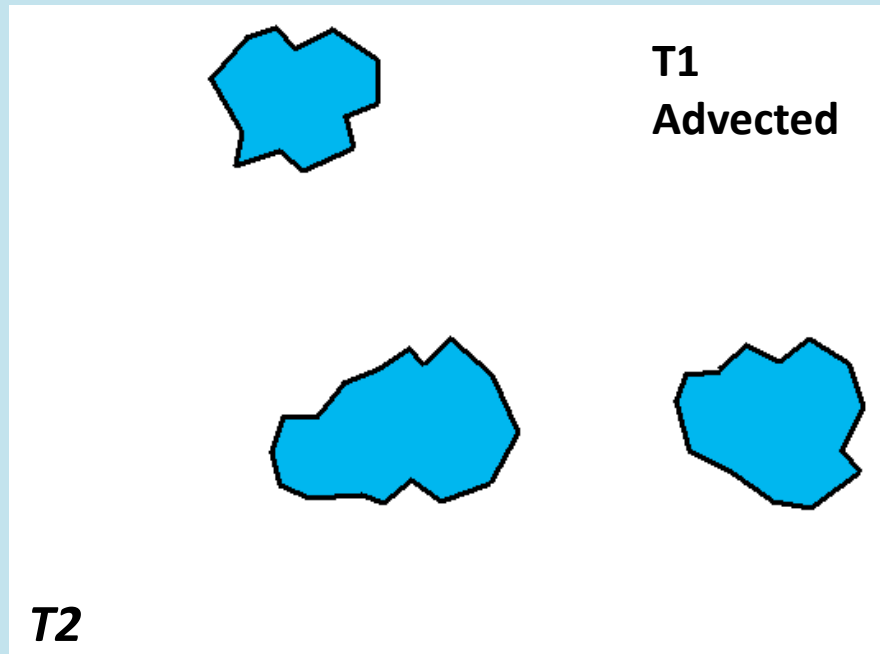
Apply AMVs to objects at “T1”

Object Tracking Methodology

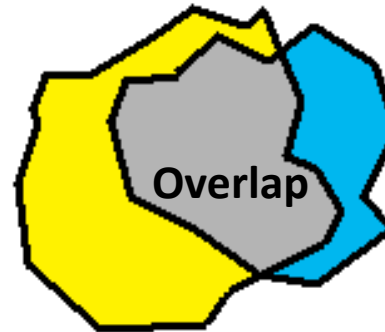


**Advect T1
objects to
projected
locations at T2**

Object Tracking Methodology

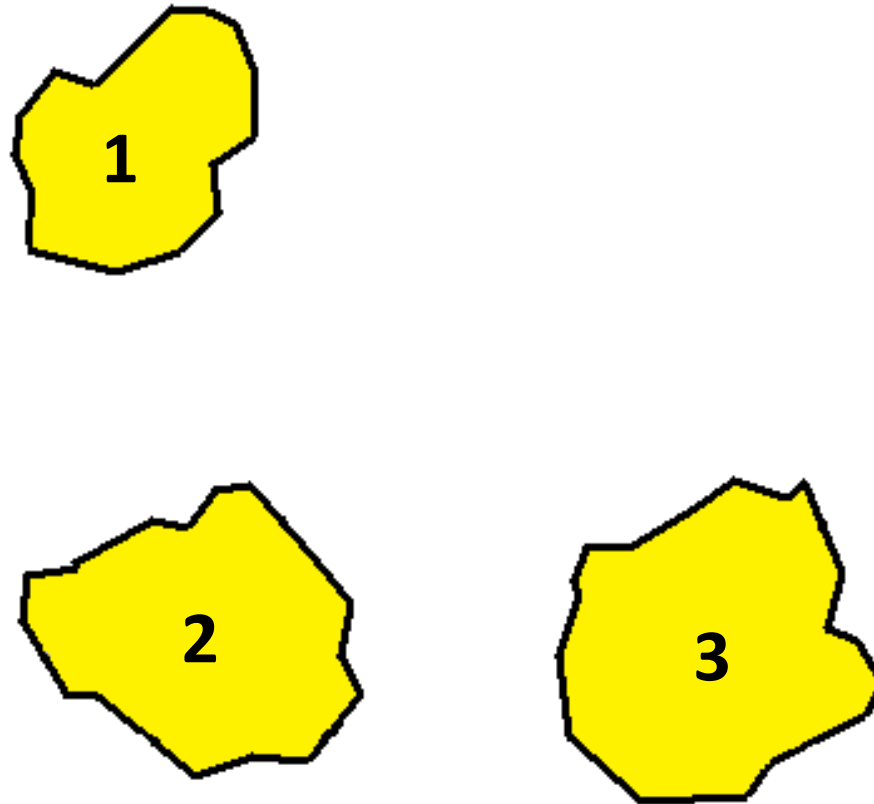


Object Tracking Methodology



**Look for
overlap
between
Actual T2
objects and
those
projected
from T1**

Object Tracking Methodology



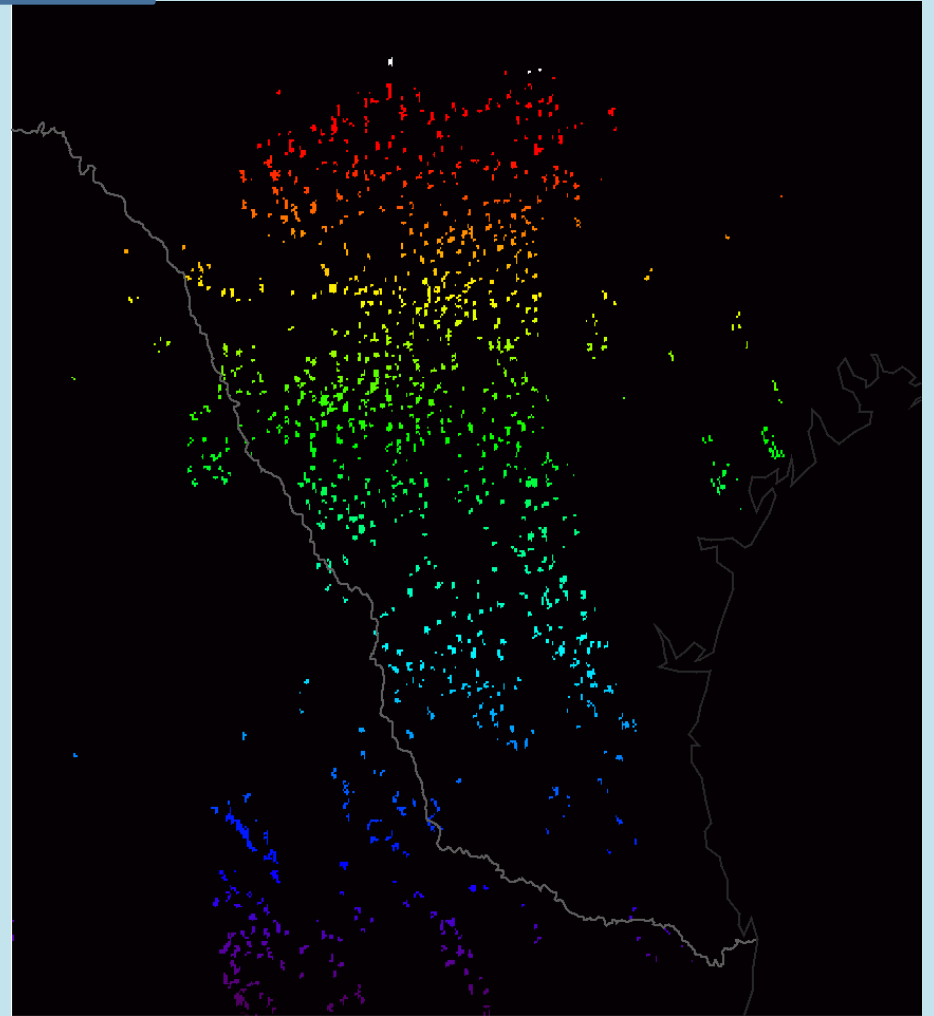
T2

Where there is object overlap, have the “actual” T2 objects inherit the same, unique Integer ID number as at T1.

The objects are now tracked!

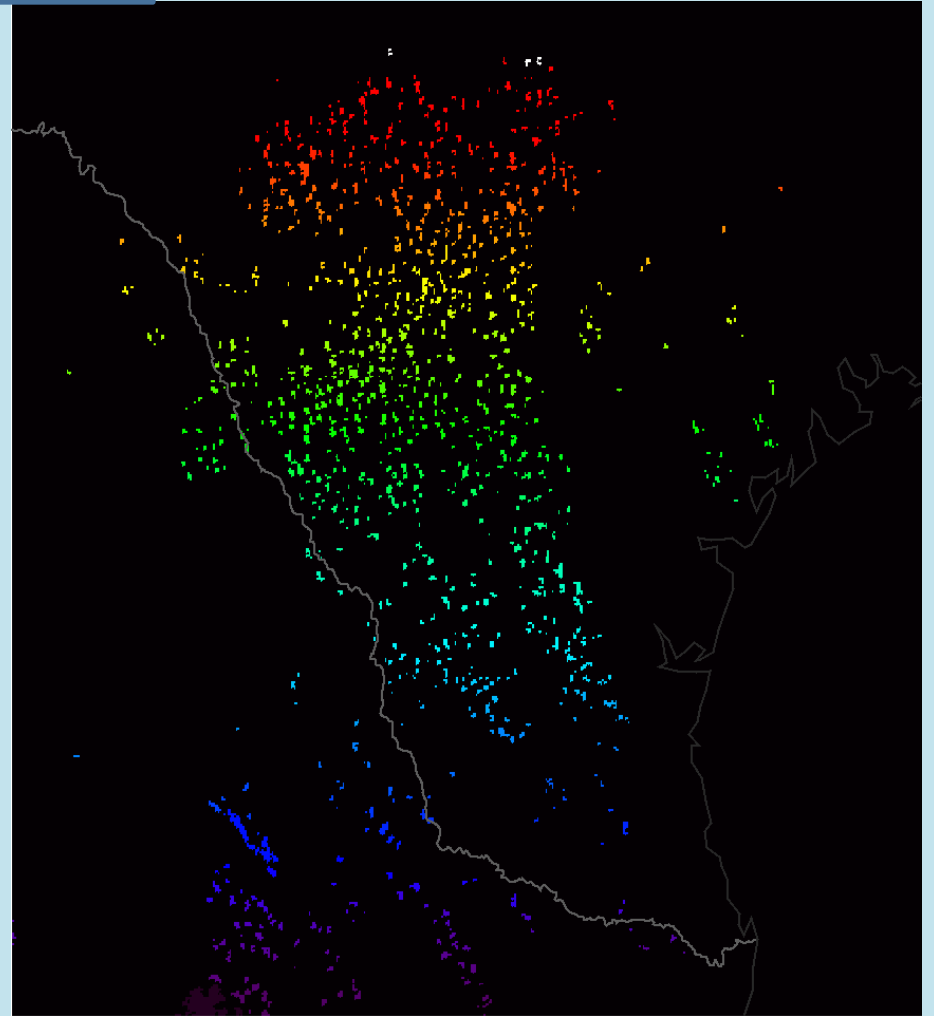
Object Tracking Methodology

Time 1 (T1)



Object Tracking Methodology

Time 2 (T2)



CI Interest Fields

A series of **six*** different “**interest field**” tests are performed for each tracked object, utilizing various available GOES channels:

* 12 tests will be used for the GOES-R algorithm

CI interest field	Critical value	
10.7- μm T_B (one score)	$<0^\circ\text{C}$	1
10.7- μm T_B time trend (two scores)	$<-4^\circ\text{C} (15 \text{ min})^{-1}$ $\Delta T_B (30 \text{ min})^{-1} < \Delta T_B (15 \text{ min})^{-1}$	2
Timing of 10.7- μm T_B drop below 0°C (one score)	Within prior 30 min	
6.5 (or 6.7)–10.7- μm difference (one score)	-35° to -10°C	3
13.3–10.7- μm difference (one score)	-25° to -5°C	4
12.0–10.7- μm difference	-3° to 0°C (GOES-11)	
6.5 (or 6.7)–10.7- μm time trend (one score)	$>3^\circ (15 \text{ min})^{-1}$	5
13.3–10.7- μm time trend (one score)	$>3^\circ (15 \text{ min})^{-1}$	6
12.0–10.7- μm time trend	$>2^\circ (5 \text{ min})^{-1}$ (GOES-11)	

Table from Mecikalski and Bedka 2006

CI Interest Fields

Cloud-top Glaciation

Cloud-top growth

Cloud height, relative to mid-troposphere (Ackerman, 1996; Schmetz et al, 1997)

Cloud height (Inoue, 1997; Prata, 1989; Ellrod, 2004)

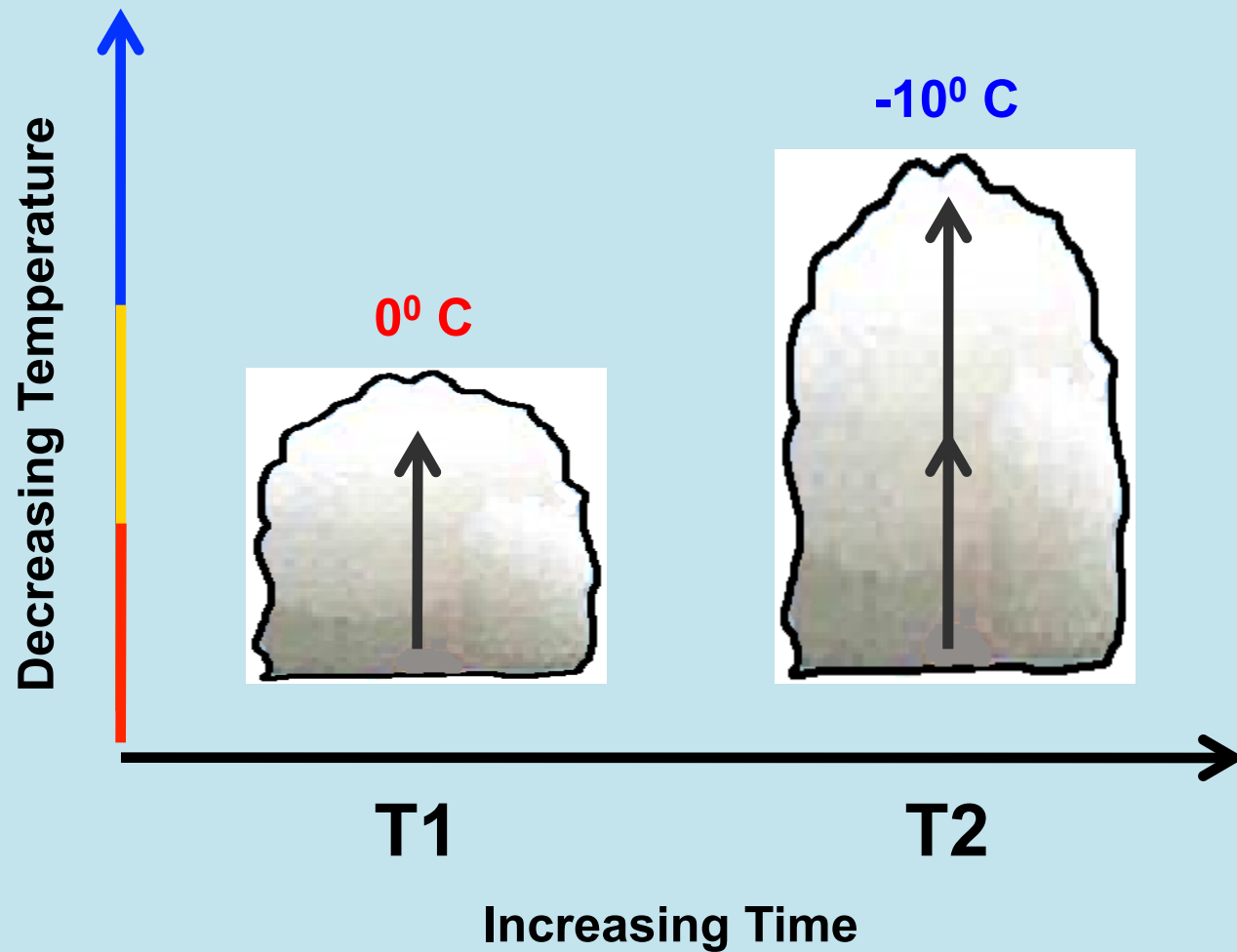
Cloud-top height changes

CI interest field	Critical value	
10.7- μm T_B (one score)	$<0^\circ\text{C}$	1
10.7- μm T_B time trend (two scores)	$<-4^\circ\text{C (15 min)}^{-1}$ $\Delta T_B (30 \text{ min})^{-1} < \Delta T_B (15 \text{ min})^{-1}$	2
Timing of 10.7- μm T_B drop below 0°C (one score)	Within prior 30 min	
6.5 (or 6.7)-10.7- μm difference (one score)	-35° to -10°C	3
13.3-10.7- μm difference (one score)	-25° to -5°C	4
12.0-10.7- μm difference	-3° to 0°C (GOES-11)	
6.5 (or 6.7)-10.7- μm time trend (one score)	$>3^\circ (15 \text{ min})^{-1}$	5
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12.0-10.7- μm time trend	$>2^\circ (5 \text{ min})^{-1}$ (GOES-11)	

Table from Mecikalski and Bedka 2006

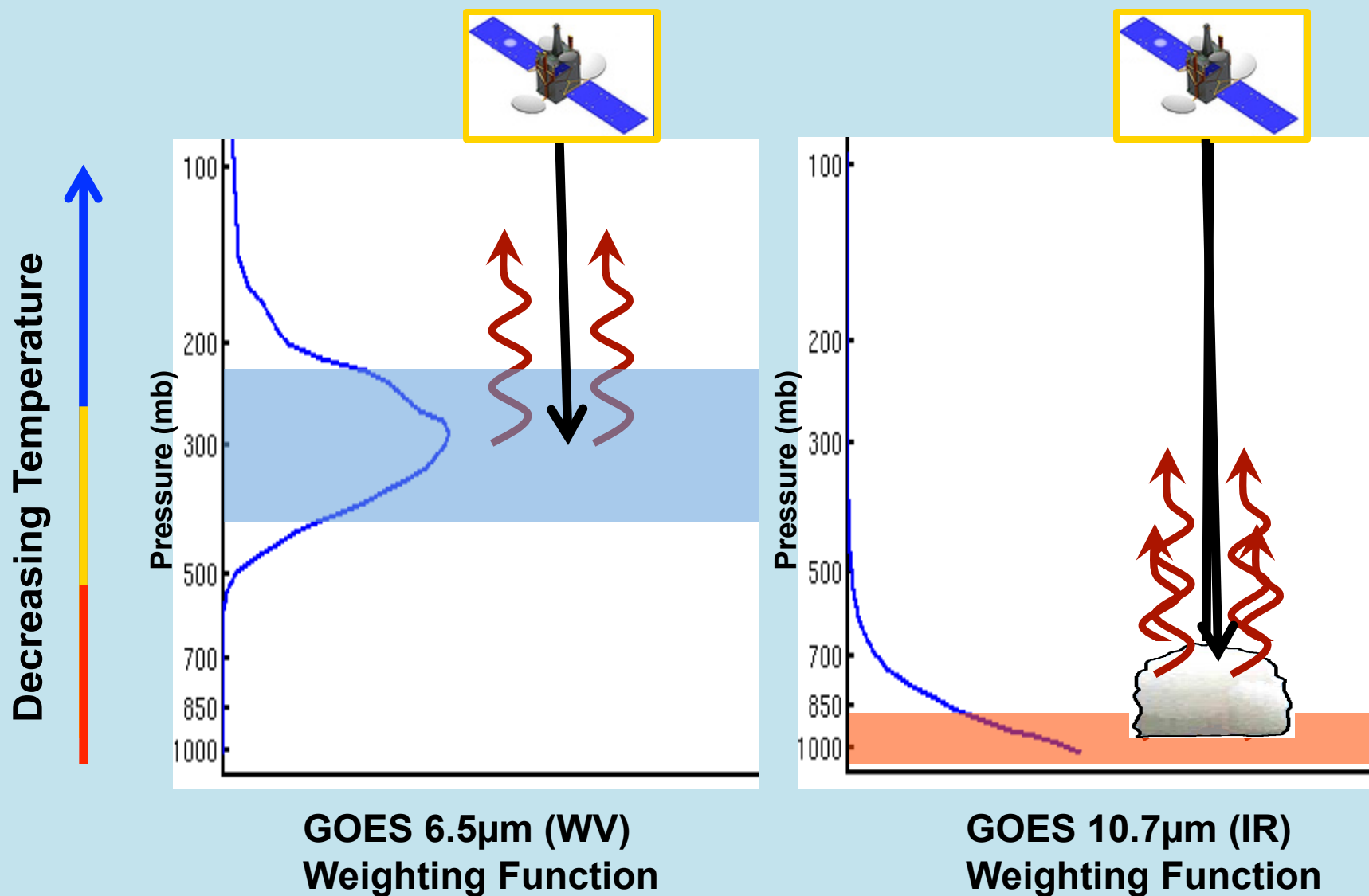
CI Interest Fields: EXAMPLES

10.7 μ m Cooling Rate



CI Interest Fields: EXAMPLES

6.5-10.7 μm (WV – IR) Channel Difference



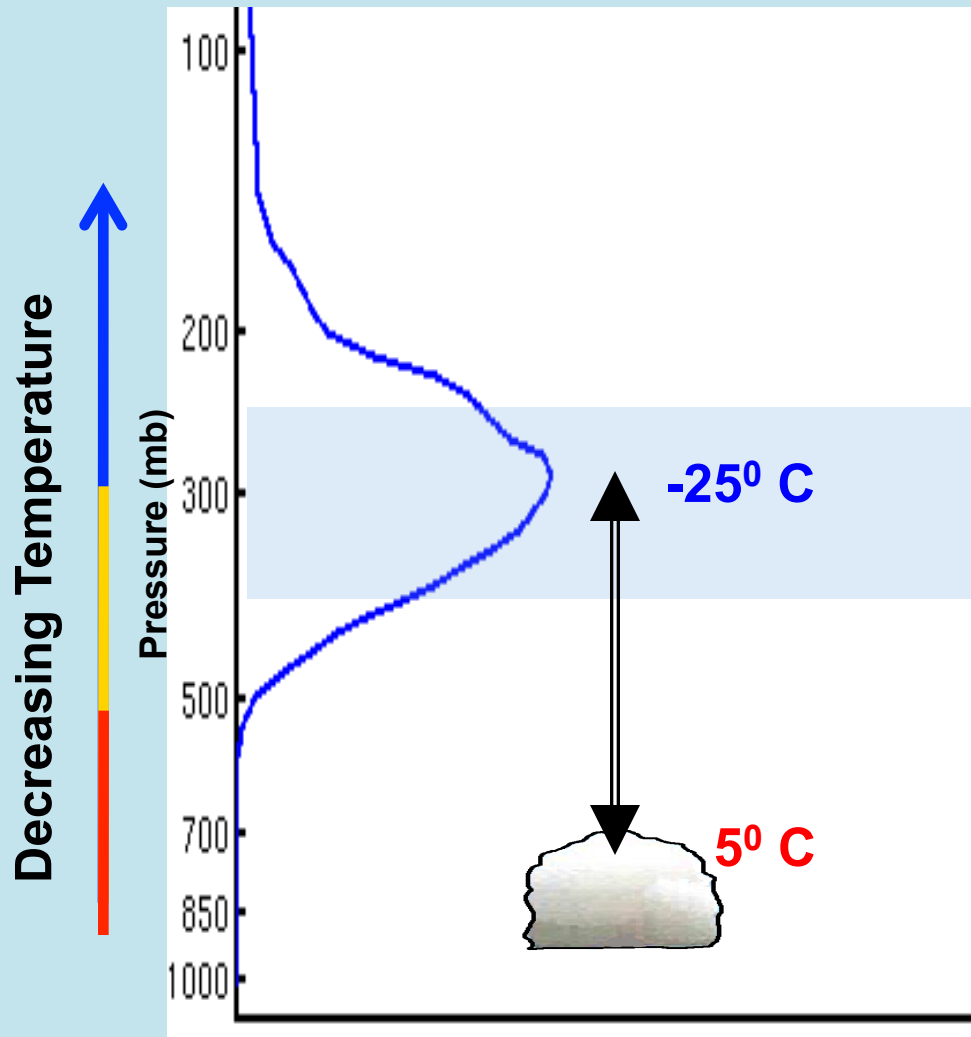
CI Interest Fields: EXAMPLES

6.5-10.7 μ m (WV – IR) Channel Difference

Example:

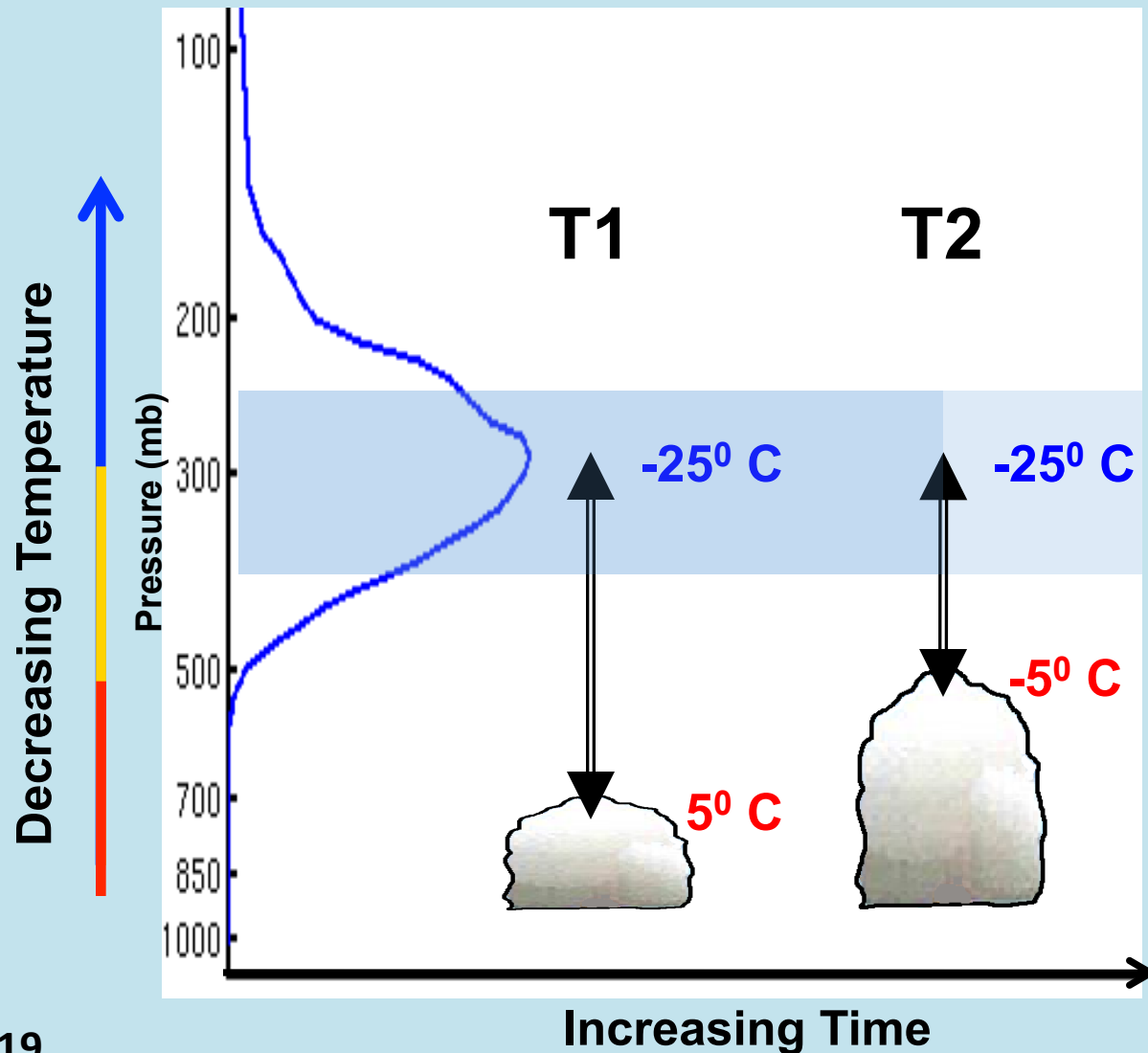
$$\text{WV} - \text{IR} = -30^{\circ}\text{C}$$

*Channel differences < 0 indicate cloud top height is less than the mid-troposphere height. The magnitude of this value indicates just **how high** the cloud top is, relative to the mid-troposphere.*



CI Interest Fields: EXAMPLES

6.5-10.7um (WV – IR) Channel/Temporal Difference



Example:

$$WV_{T1} - IR_{T1} = -30^{\circ}\text{C}$$

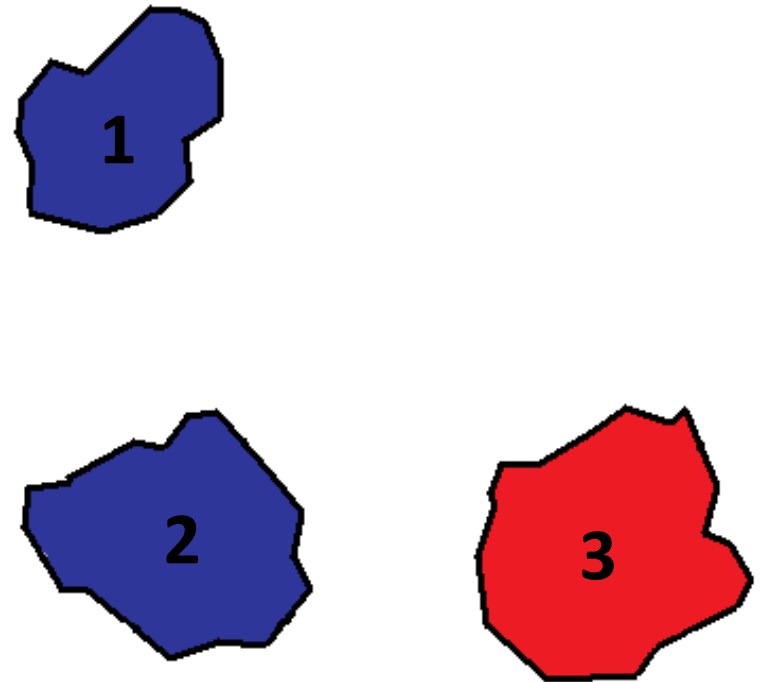
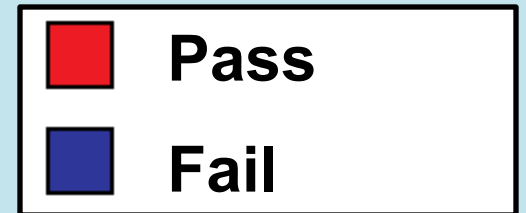
$$WV_{T2} - IR_{T2} = -20^{\circ}\text{C}$$

$$T2 - T1 = 10$$

*Temporal differences >0 indicate cloud top is growing upward, toward the mid-troposphere. The magnitude of this value indicates just **how fast** the cloud top is growing.*

CI Interest Fields

5 out of the 6
interest field tests
must be passed in
order for an object
to be forecast to
convectively
initiate.



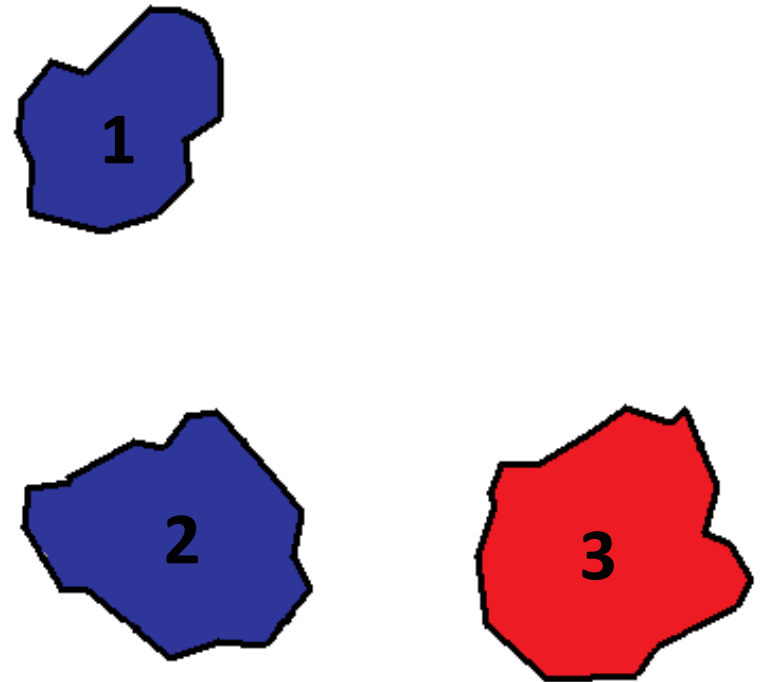
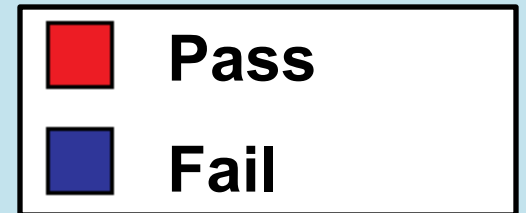
CI Interest Fields

Output:

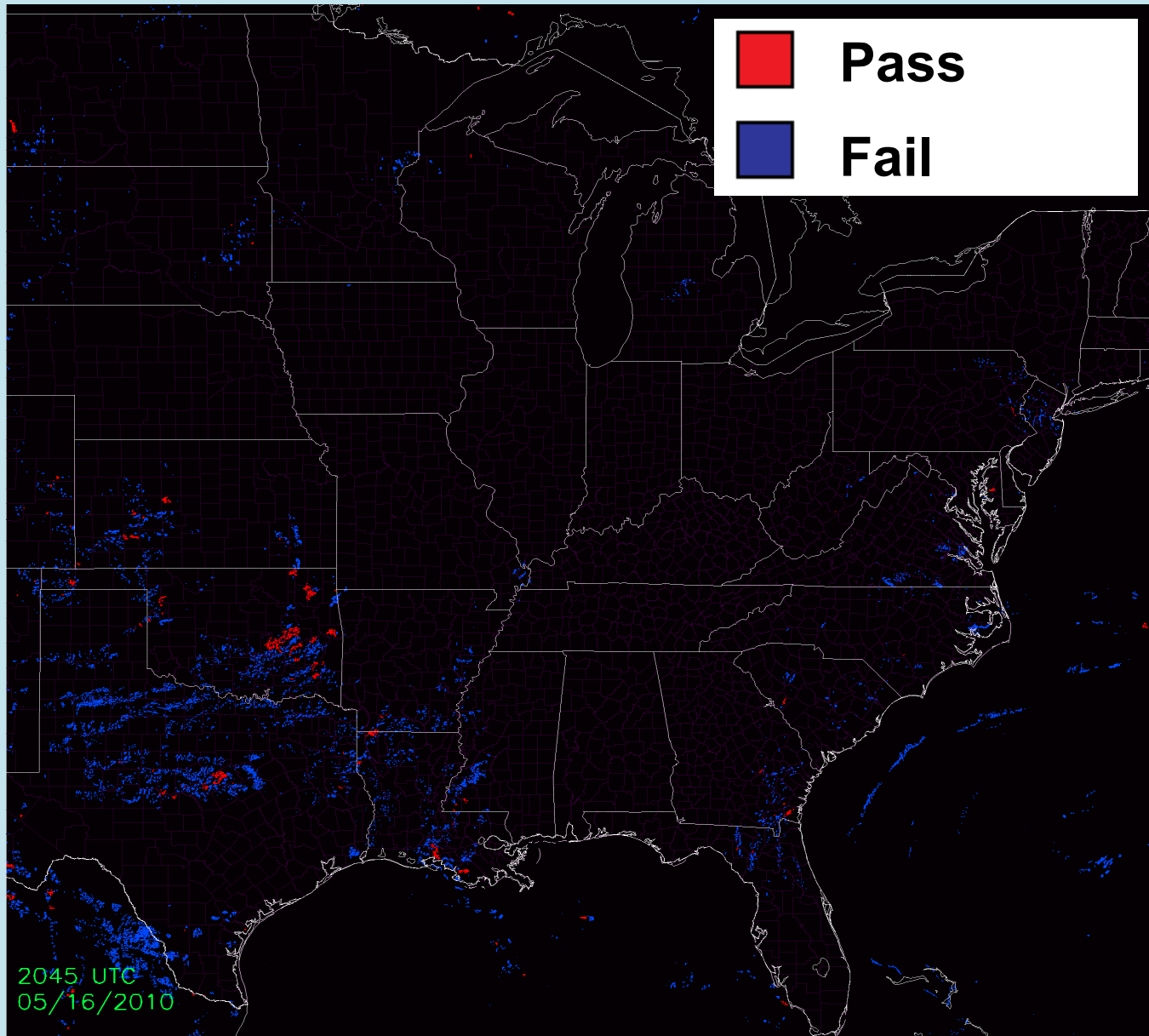
“0”= No Object/
No Forecast

“1”= Object forecast to
not CI, based on
input images

“2”= Object forecast to
CI within next
~2 hours.

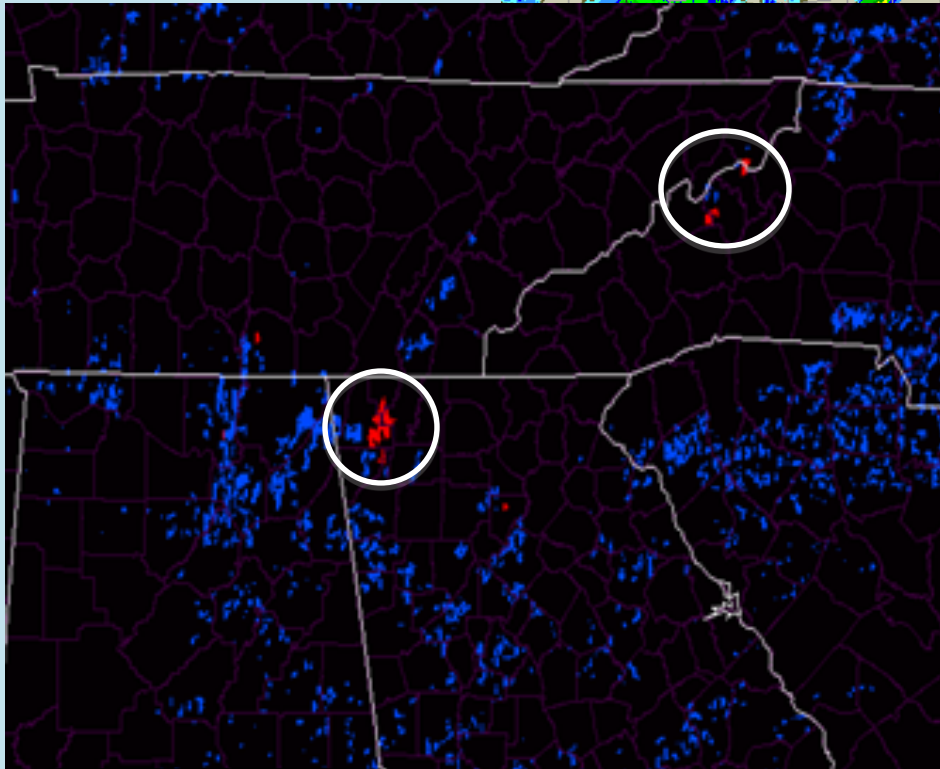


CI Interest Fields

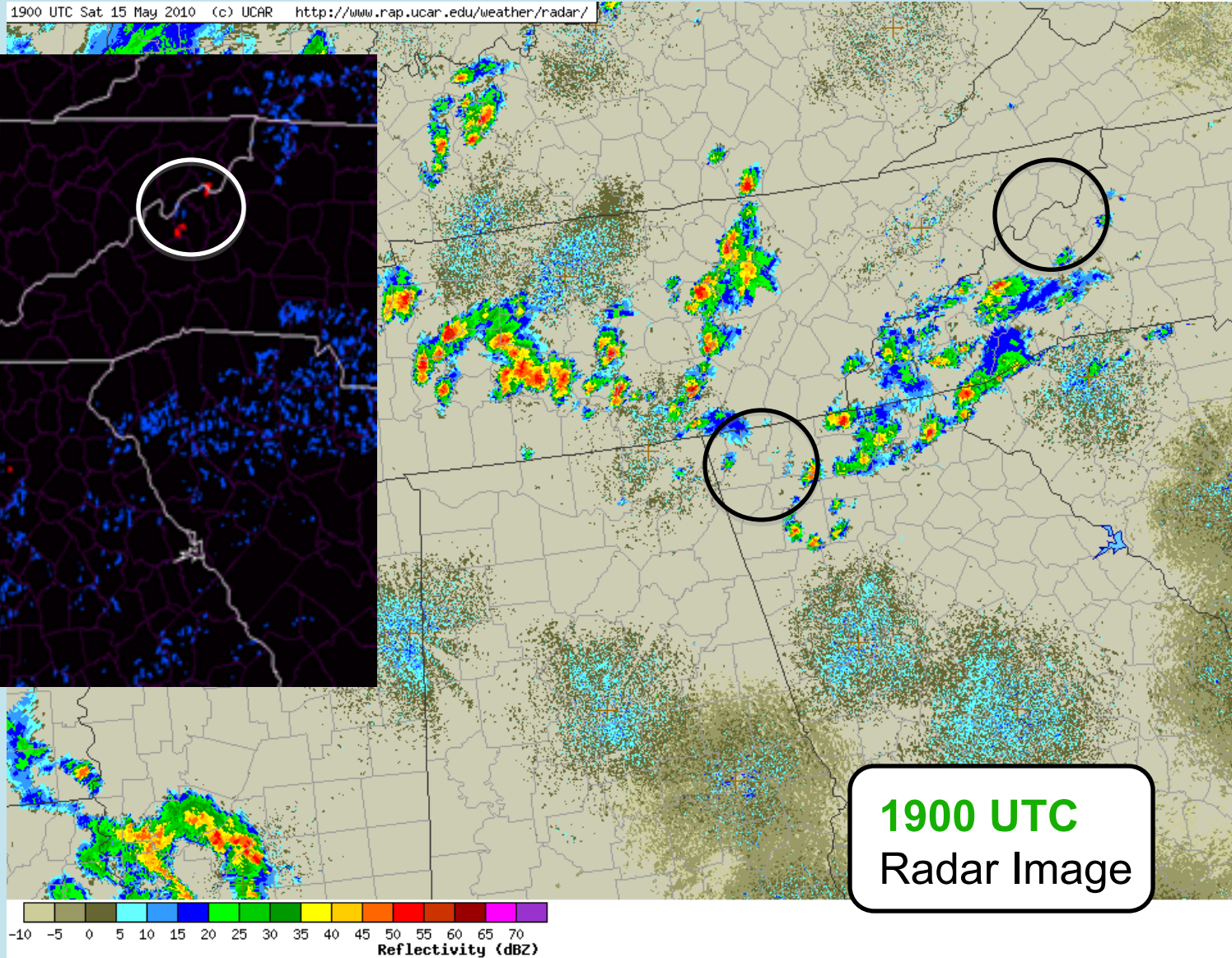


Nowcast: 15 May 2010 – 1902

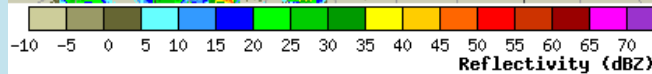
1900 UTC Sat 15 May 2010 (c) UCAR <http://www.rap.ucar.edu/weather/radar/>



1902 UTC
Timestamp

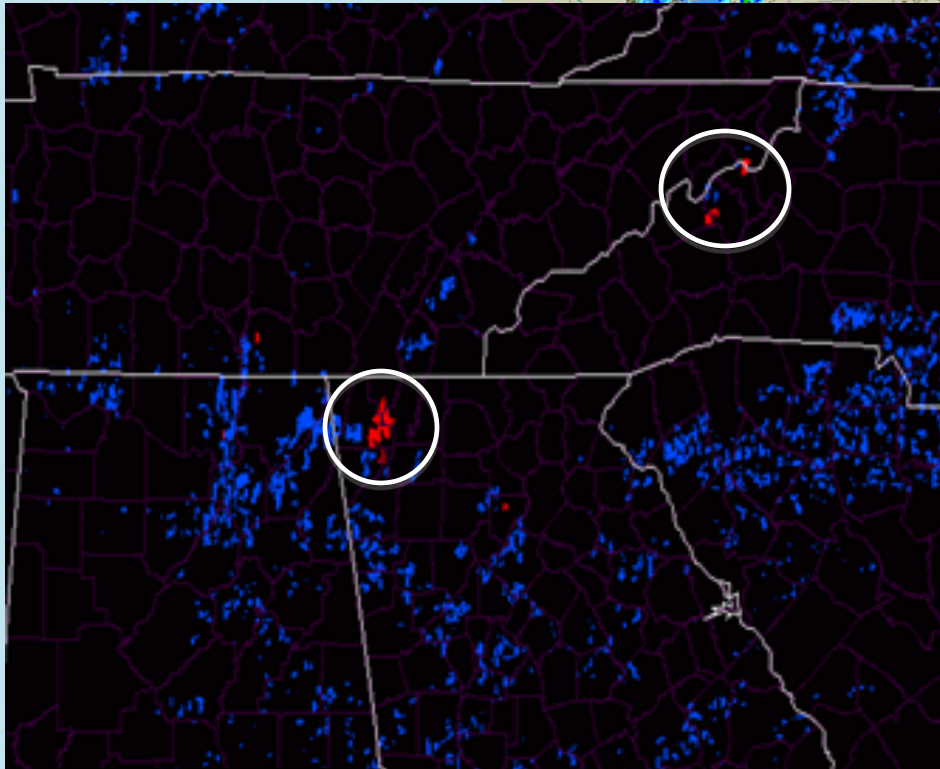


1900 UTC
Radar Image

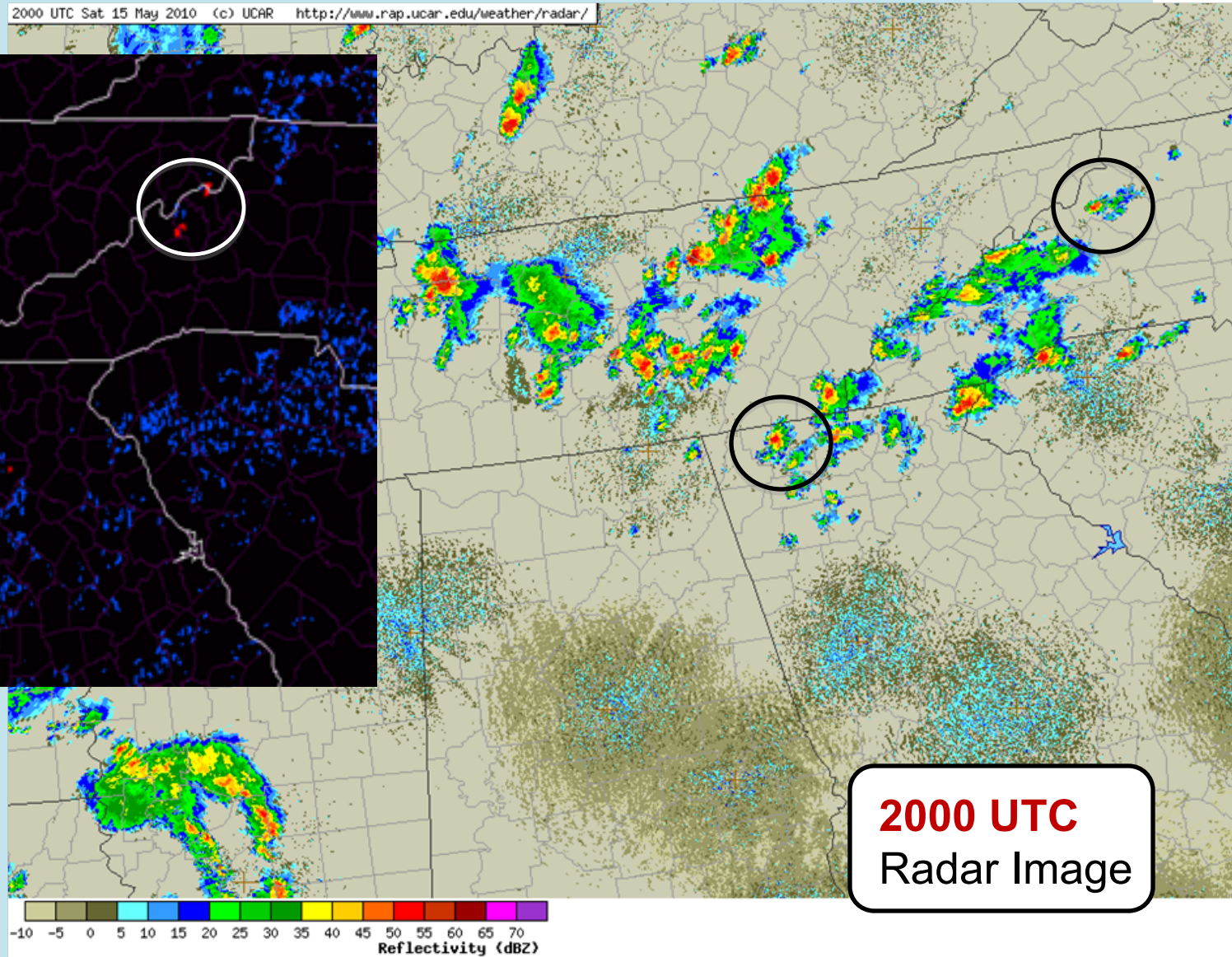


Validation: 15 May 2010 – 1902

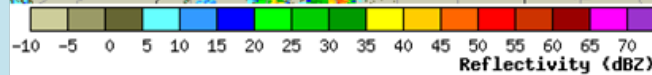
2000 UTC Sat 15 May 2010 (c) UCAR <http://www.rap.ucar.edu/weather/radar/>



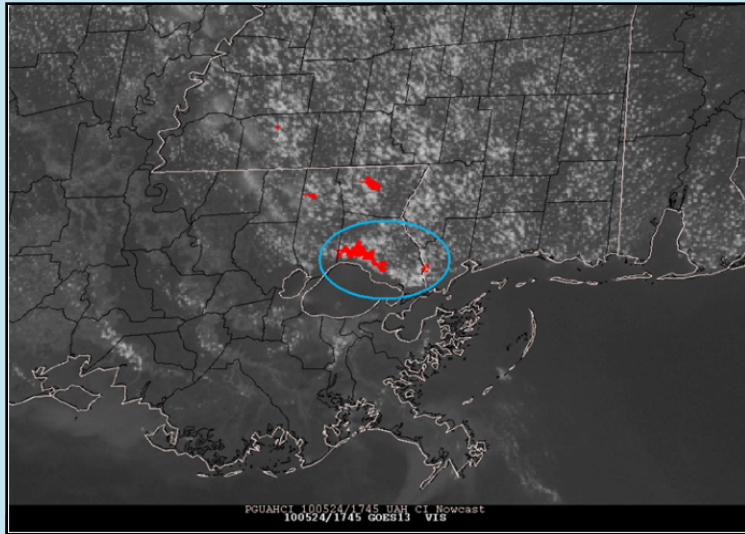
1902 UTC
Timestamp



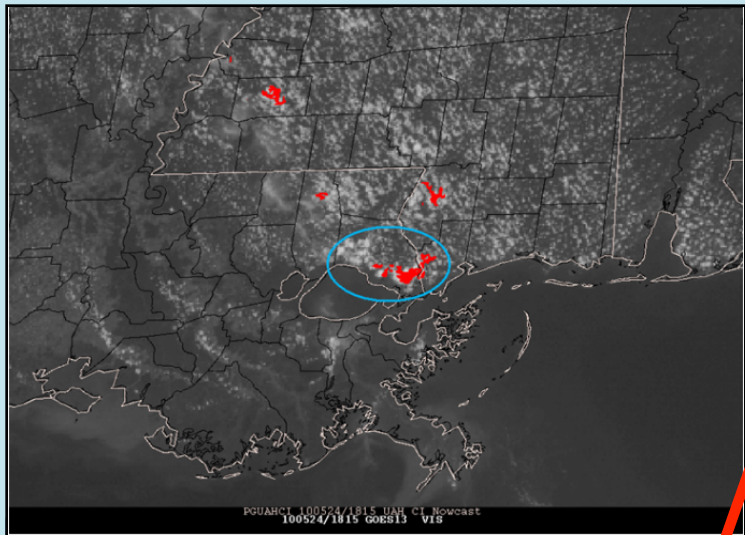
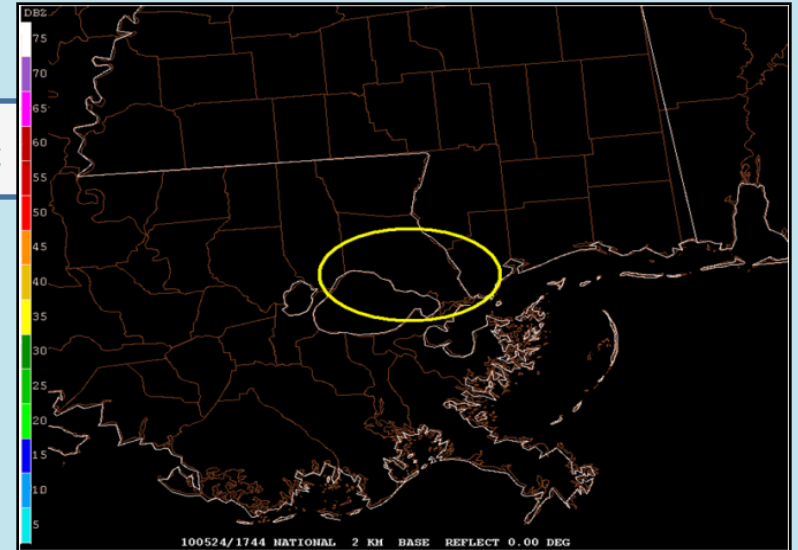
2000 UTC
Radar Image



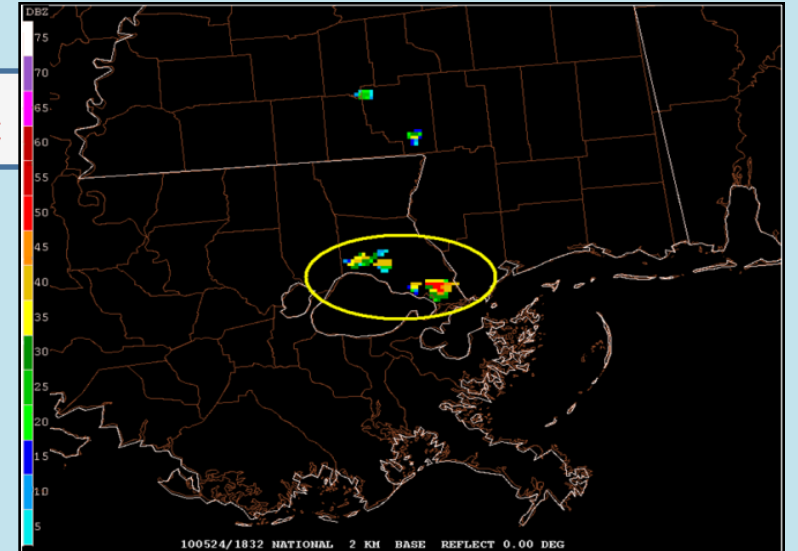
Example of CI Forecast in HWT Display



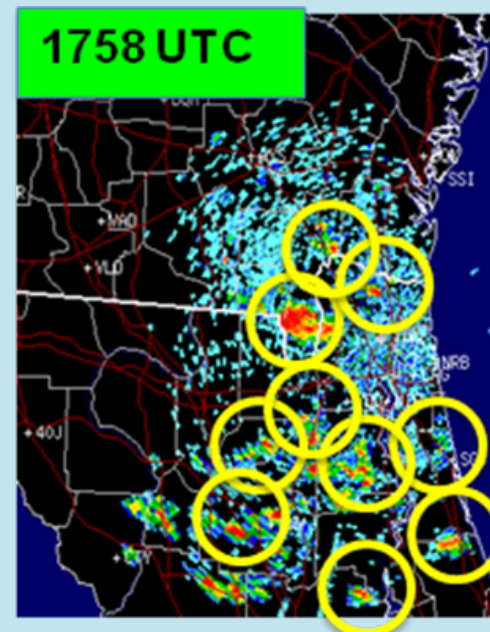
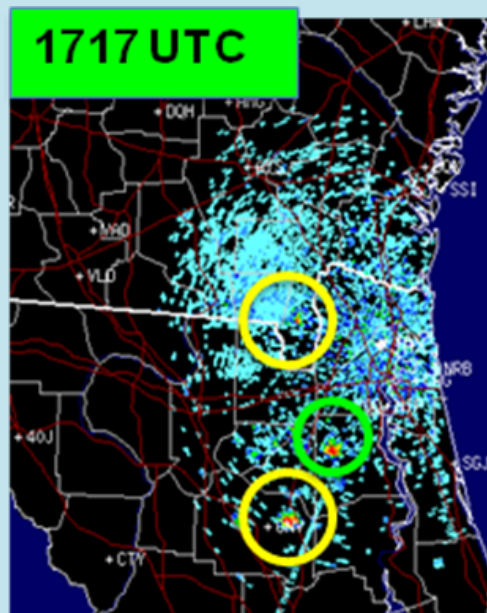
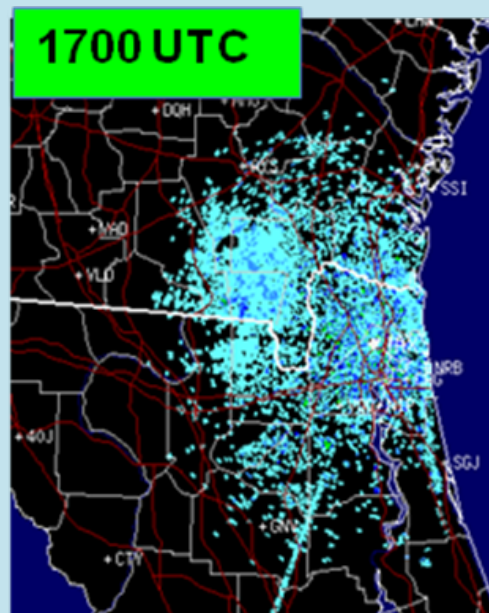
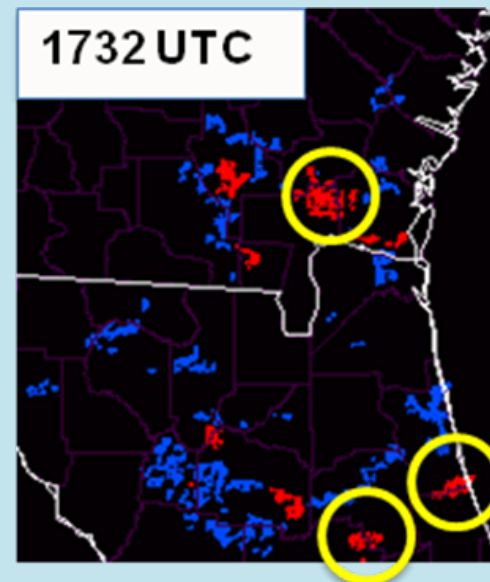
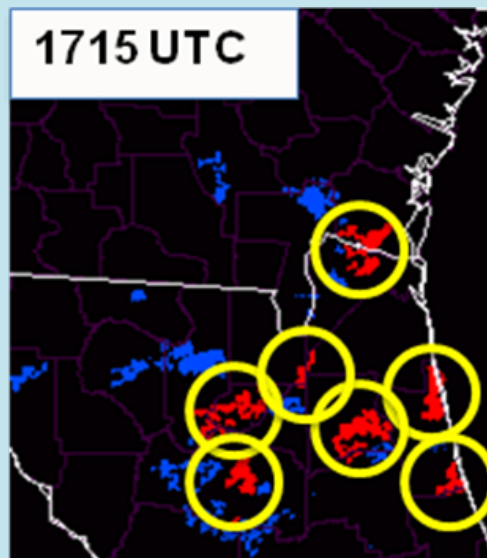
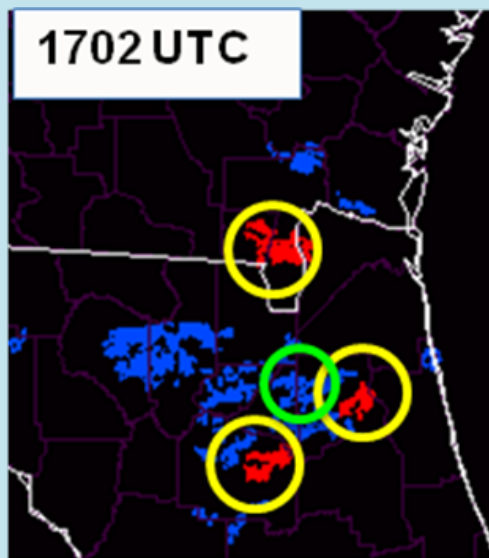
1744 UTC



1832 UTC



Example of CI Forecast Output



Product Overview

-Runs **DAY** and **NIGHT**

-Includes GOES Rapid Scan Operations data

-Data is Parallax-corrected to ensure accurate spatial placement over mapped domain.

-Run-time: Output forecast produced...
... **~1.5 minutes** after GOES data download at NIGHT
... **~2.5 minutes** after GOES data download in DAY

-Average lead time ~30 minutes before 35+ dBZ echo detected on radar... Up to ~2 hours.

Known Limitations

1) Cirrus-contamination

- A. No cloud objects, no tracking, no forecast...
- B. "False" vertical cloud growth with undetected thin cirrus above low level clouds

2) Newly Developing Clouds

- Example: Cumulus field*
- Because the satellite spectral signature of newly forming clouds is the same as rapidly growing clouds that already exist, False Alarms can be found in these situations.
- 2 km spatial resolution of IR on GOES-R instrument will help.**

3) High CAPE / Low Cap environments.

- Clouds grow too fast, which leads to 'Zero' or 'Negative' lead times.
- Partly a limitation of the low temporal resolution current GOES instrument.
- 5-minute resolution GOES-R instrument will help.**

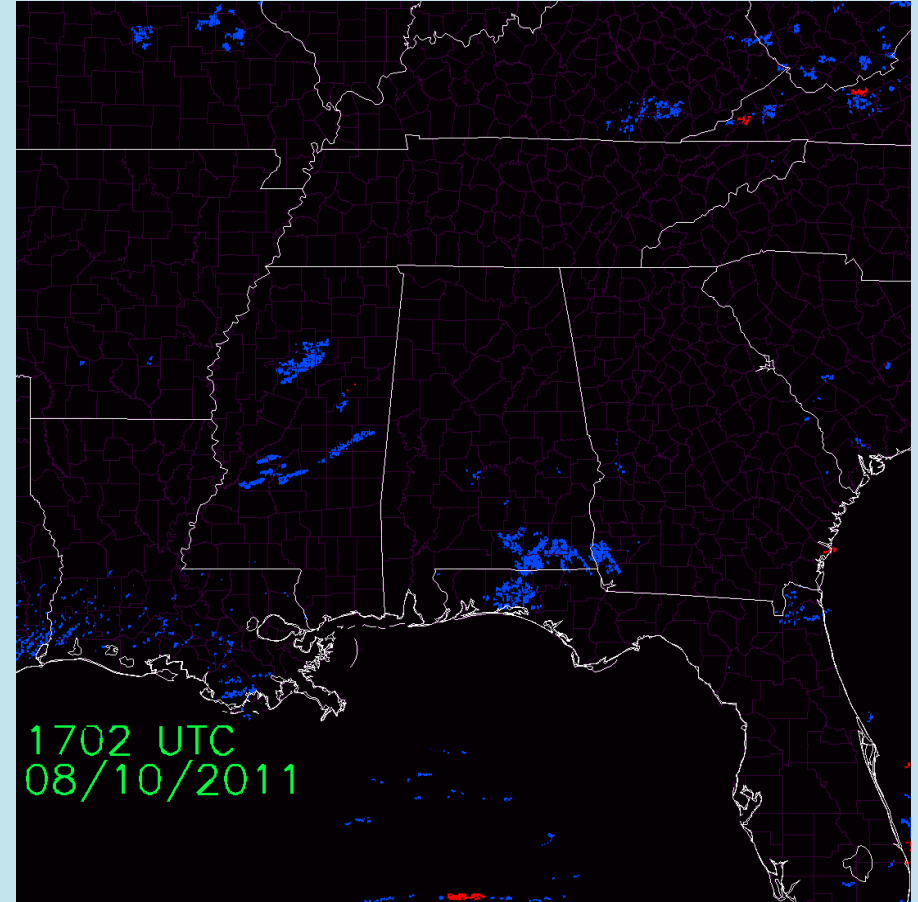
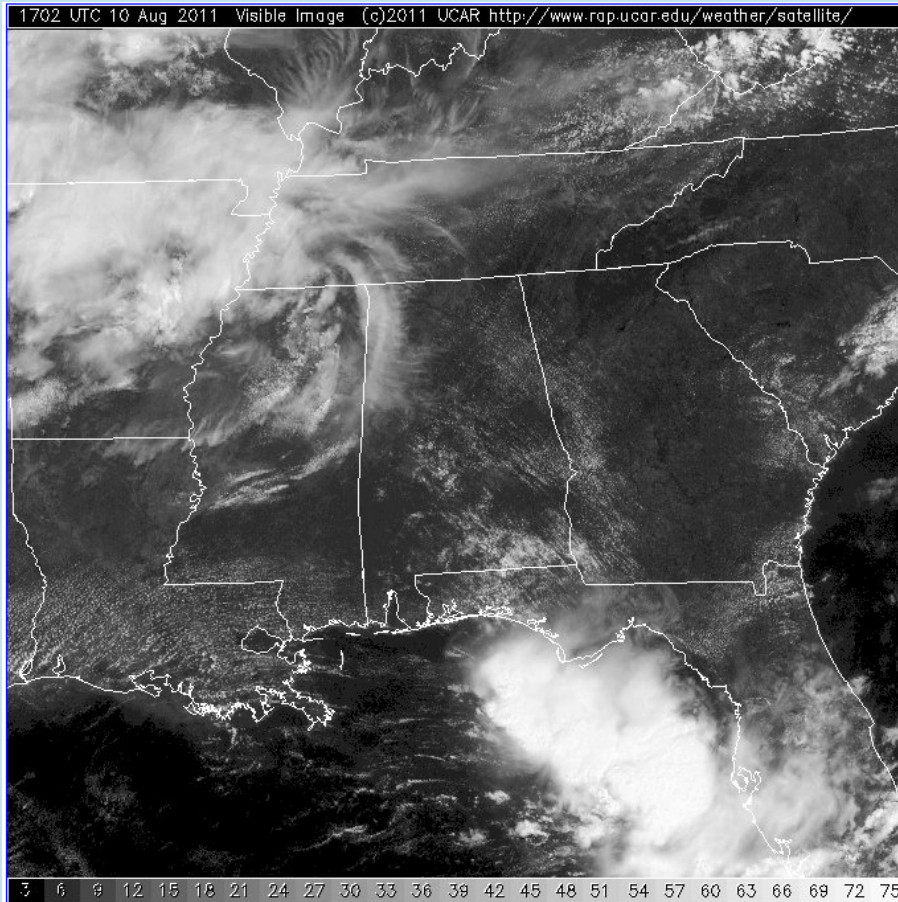
4) Object tracking errors/issues

- Mismatched objects / False overlap
- Object present at 'T1' but not 'T2', due to Cloud Mask reclassification... An object cannot be tracked if not classified as a "pre-CI/Immature" cloud in two consecutive images (This, too, is sometimes due to the low temporal resolution GOES instrument).

5) Night-time Product Needs Work!

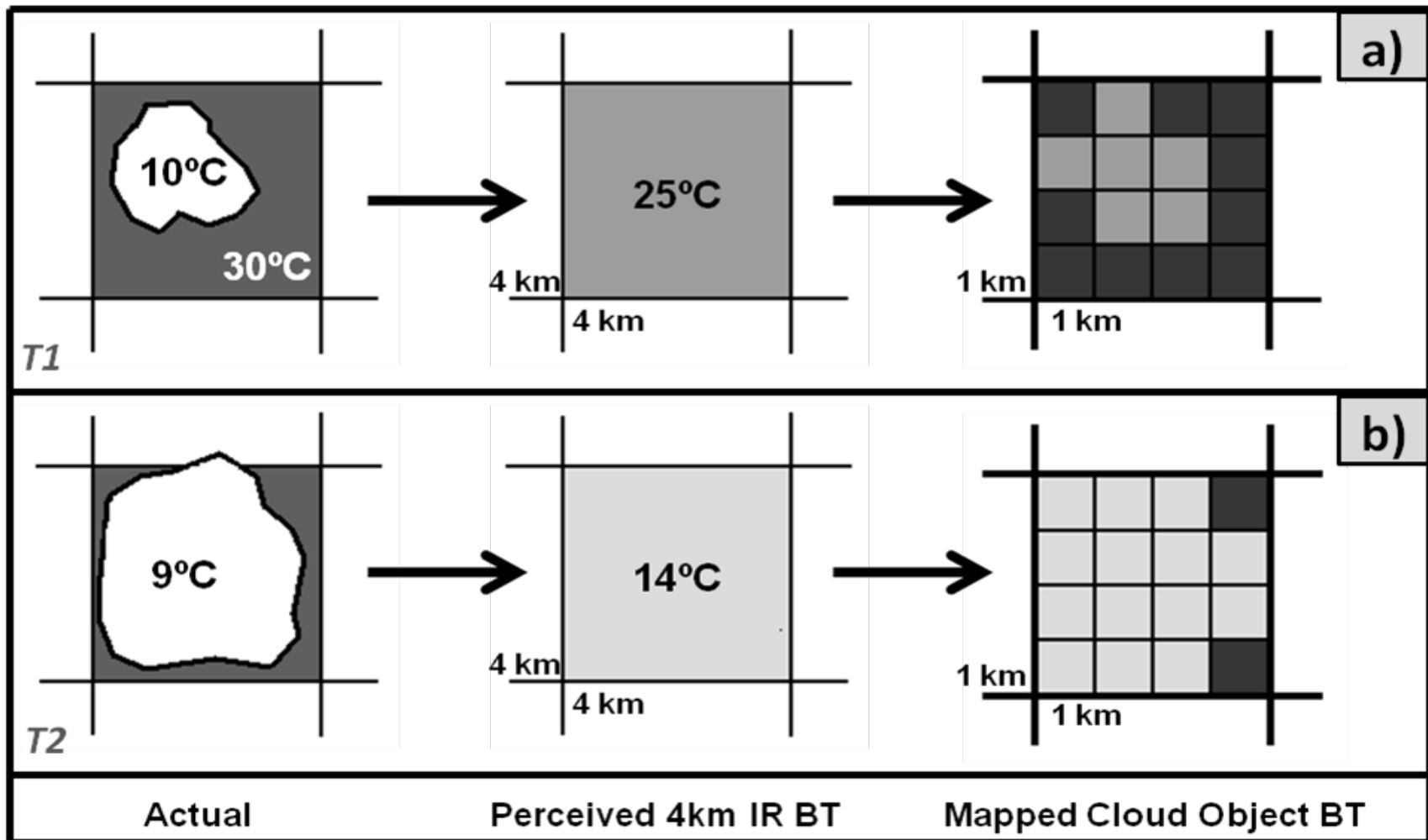
- Due to reduced quality of cloud mask (and, therefore, definition of input "cloud objects")

Known Limitations (Cirrus Contamination)



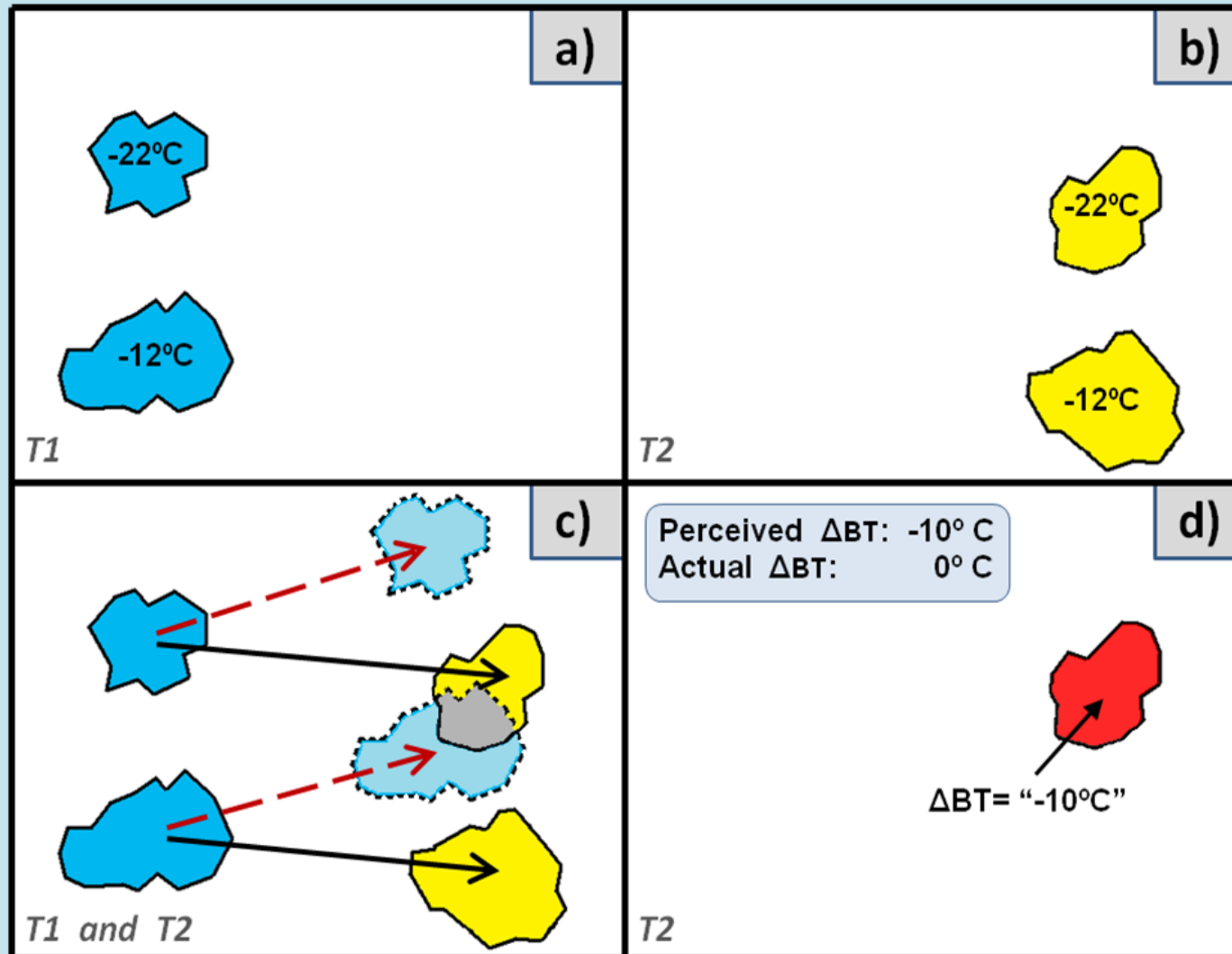
Known Limitations

(Sub-grid New Cloud Formation)



Known Limitations

(Incorrect Object Tracking)



Convective Initiation (CI) Nowcasting Product Overview

Any Questions?