
Aircraft Icing

December 9, 2004

National Weather Service & FAA Flight Standards

Aviation Team Of the Mid South
A.T.O.M.S



Weather Forecast Office

MEMPHIS

Center Weather Service Unit



We Will Cover

- ✓ **Types of icing**
- ✓ **A little on the cause**
- ✓ **Some effects on flight**
- ✓ **Weather map clues**
- ✓ **Sources for icing forecasts**



Ice is Bad!

“When ice is encountered, immediately start working to get out of it.

Unless the condition is freezing rain, or freezing drizzle it rarely requires fast action and certainly never panic action, but it does call for positive action.”

Capt. Robert Buck



Fact:

Ice can form on the surface of an aircraft at 0° C (32° F) or colder when liquid water is present.



Quick (trick?) Question

You are descending into an airport where the air temperature is 33° F. There is little or no risk of structural icing on your plane!

True?

False?

Temperature of the aircraft determines the degree of ice threat when air temperatures are close to freezing.



Quick (trick?) Question

It will be safe to fly through an area of icing if your plane is equipped with deicing equipment.

True?

False?

NASA found nearly 50% of the total drag from ice remained after the protected surfaces had been cleared!



Quick (trick?) Question

*What is the freezing point
(temperature) of water?*

It depends!



Fact:

- ✓ *Nearly ALL icing happens in clouds that contain 'super cooled' water droplets.*
- ✓ *Super cooled means water that is colder than 32° F.*
- ✓ *Most clouds contain supercooled water drops.*
- ✓ *Drops strike the leading edge of an airfoil*
- ✓ *Freeze on impact*
- ✓ *Worst icing occurs with big super cooled water droplets*



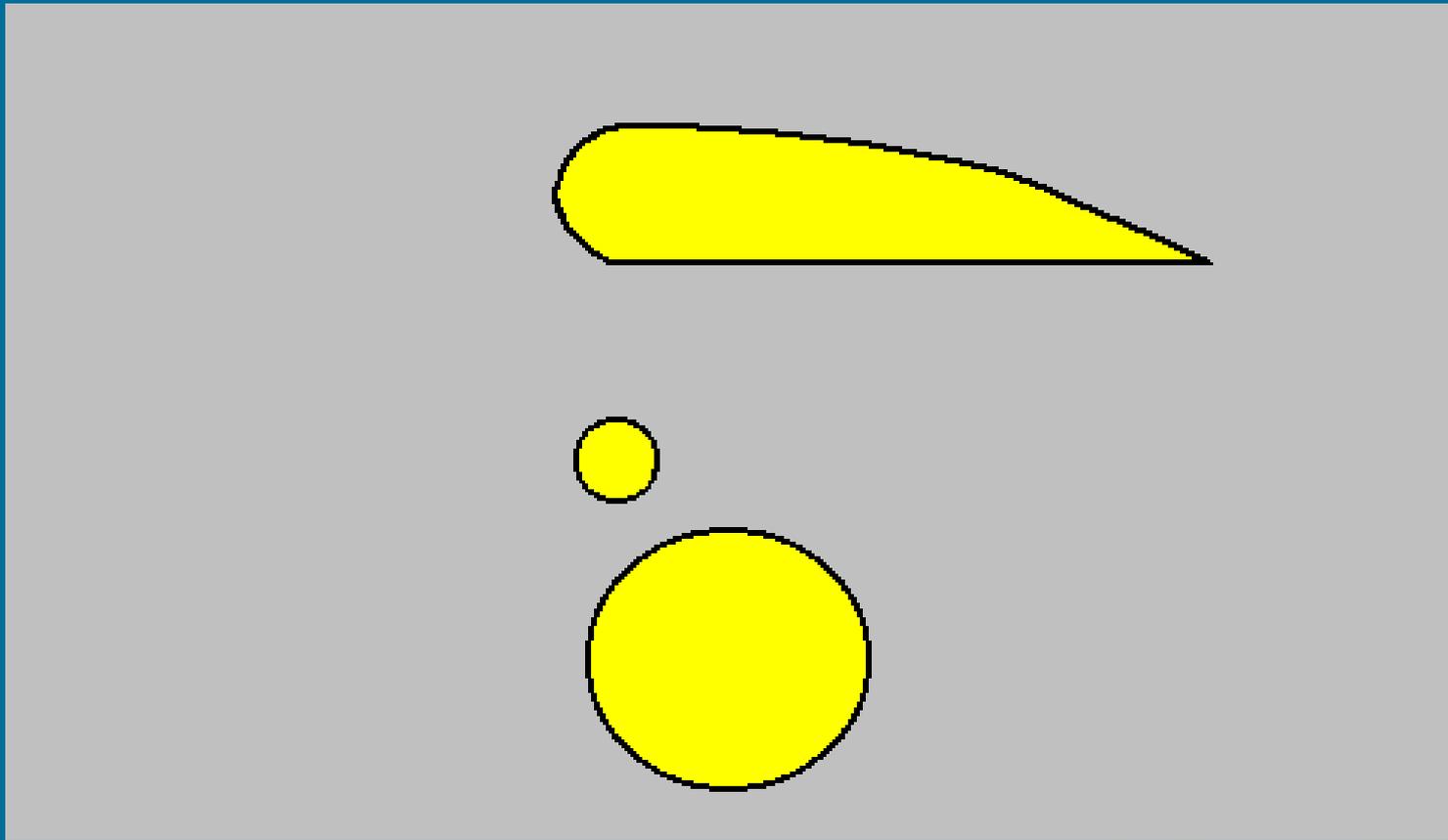
Icing Forms Most Readily:

On the Leading Edge of the airfoil

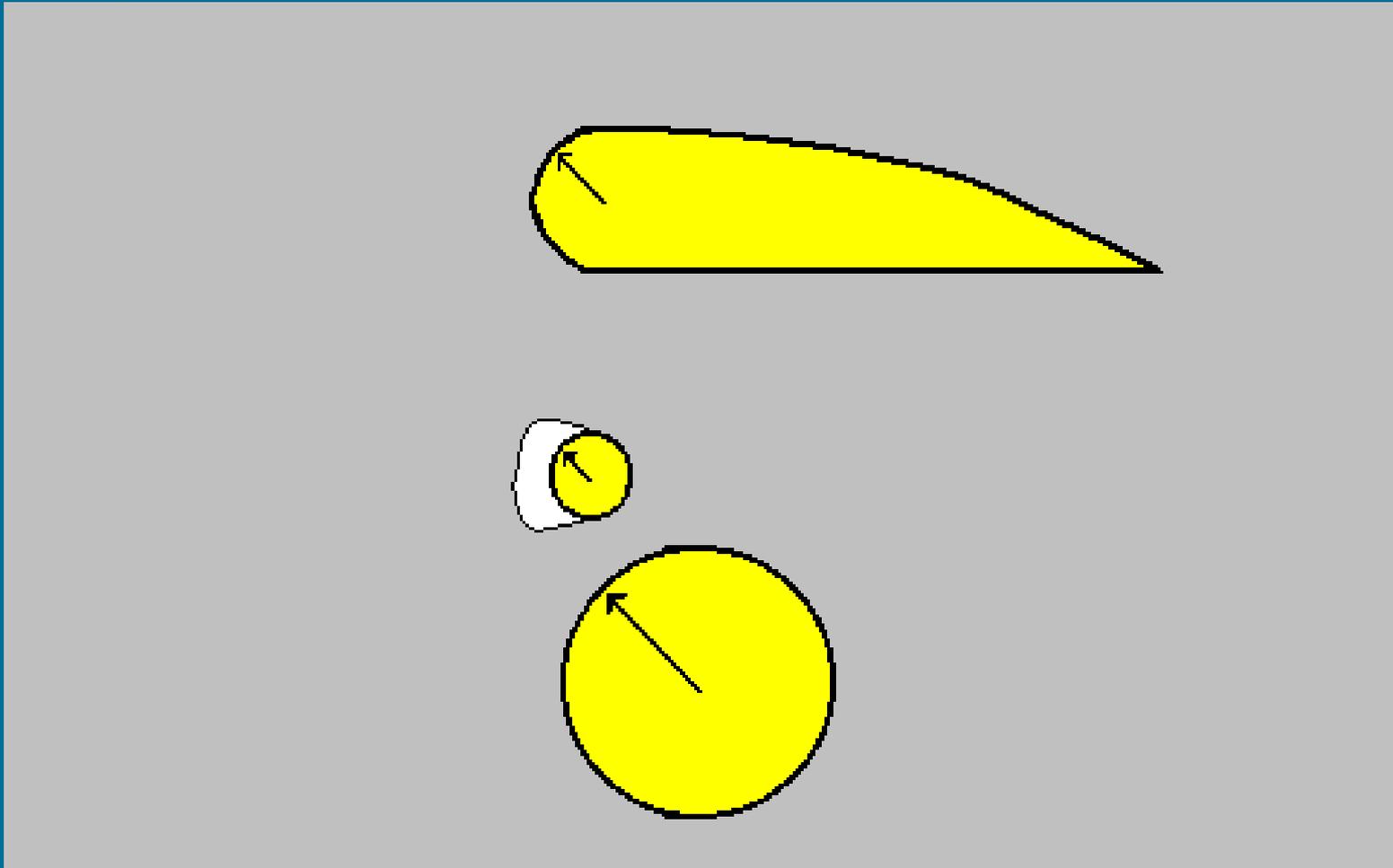
Where the Radius of Curvature is Shortest



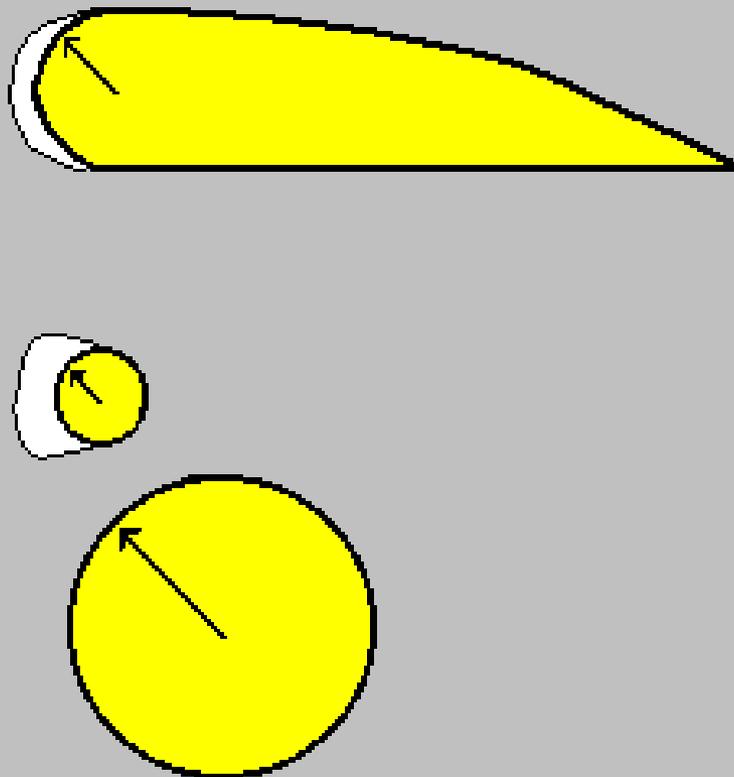
Ice forms first on the “Shortest Radius of Curvature”



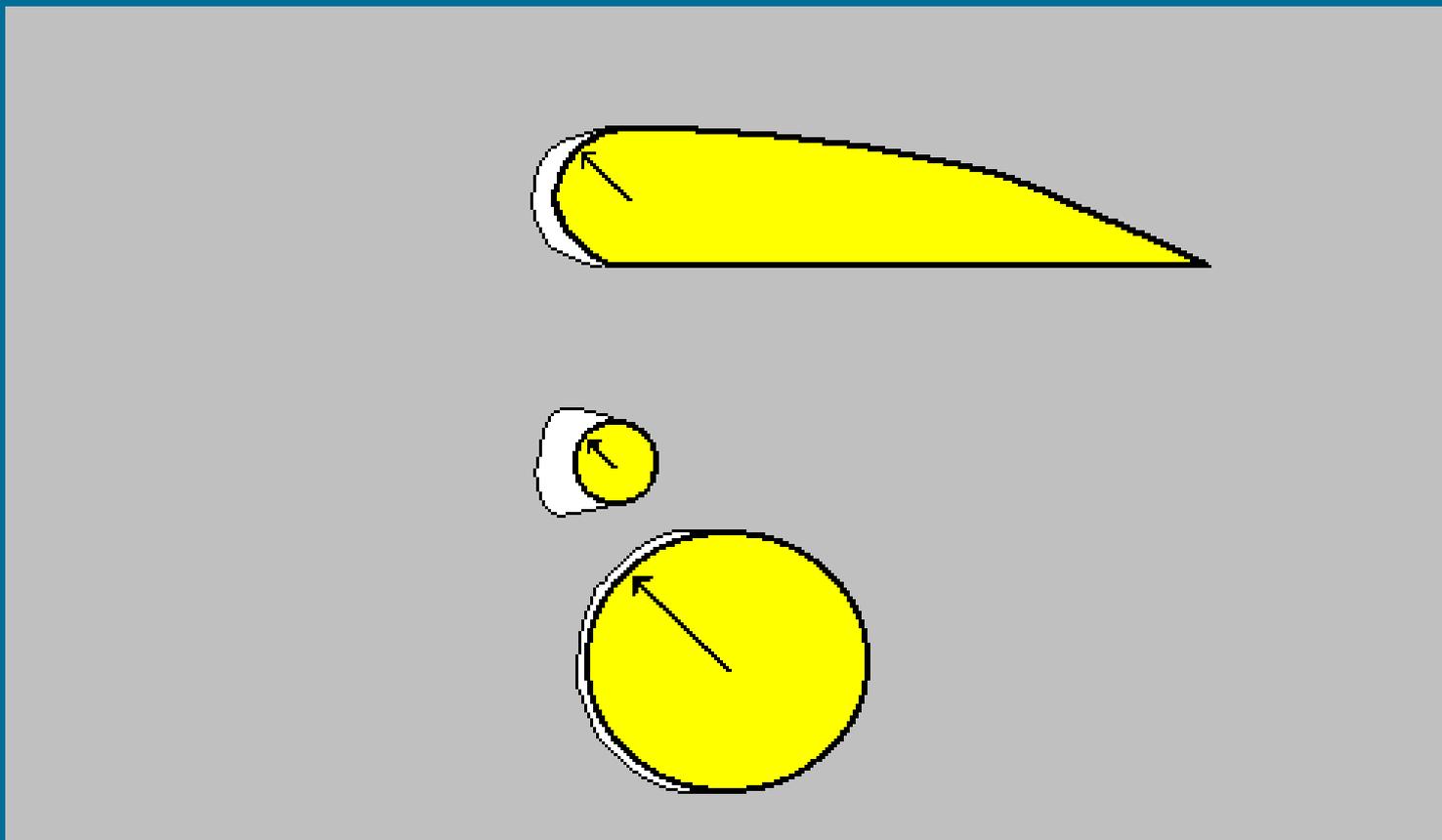
Ice forms first on the “Shortest Radius of Curvature”



Ice forms first on the “Shortest Radius of Curvature”



Ice forms first on the “Shortest Radius of Curvature”



Definition

Four classes of intensity

- **Trace**

- *Barely perceptible*
- *Not hazardous unless encountered for more than an hour*

- **Light**

- *Prolonged exposure may create a flight problem*
- *Occasional use of deicing is effective*

- **Moderate**

- *Even short encounters a potential hazard*
- *Use of deicing or diversion is required*

- **Severe**

- *Even immediate deicing is ineffective*
- *Immediate diversion is necessary*



Definitions

Three kinds of icing

- **Clear**

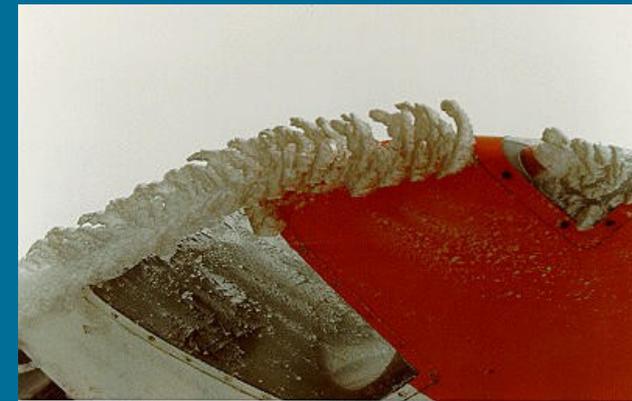
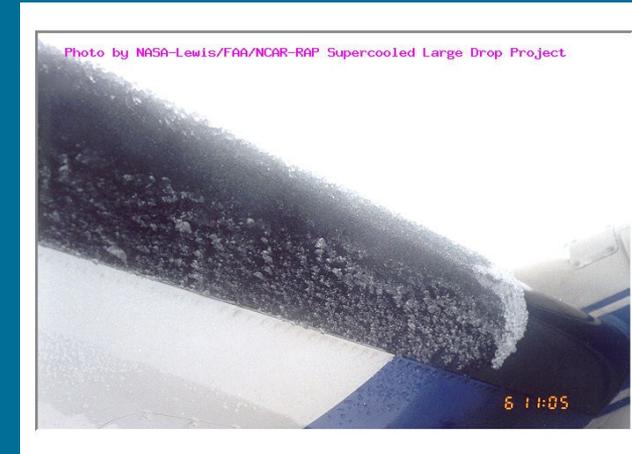
- Glossy, clear, or translucent
- Formed by slow freezing of supercooled water
- Cumulus clouds

- **Rime**

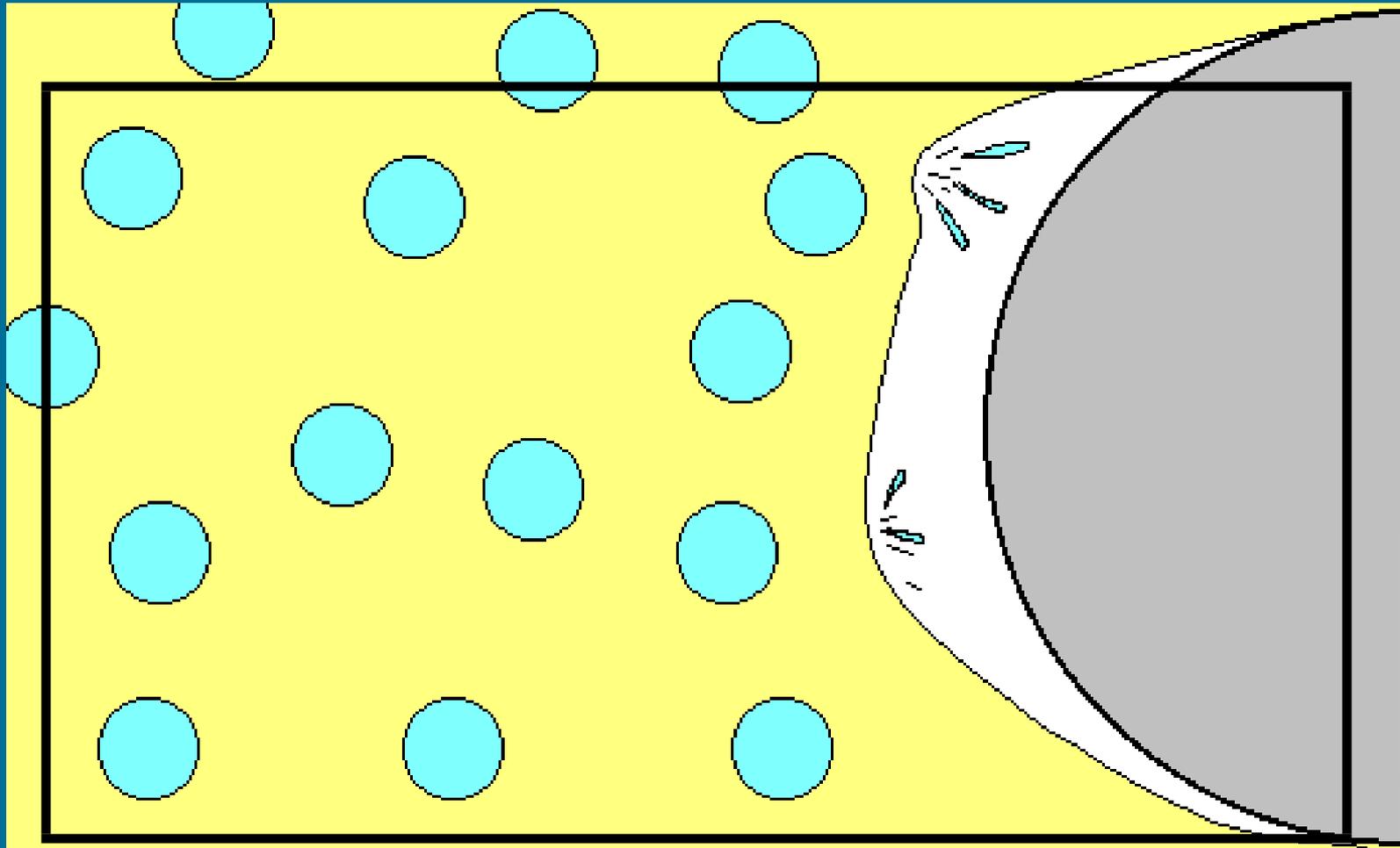
- Rough, milky, opaque – think of home freezer
- Formed by rapid freezing of small supercooled water
- Stratus clouds

- **Mixed**

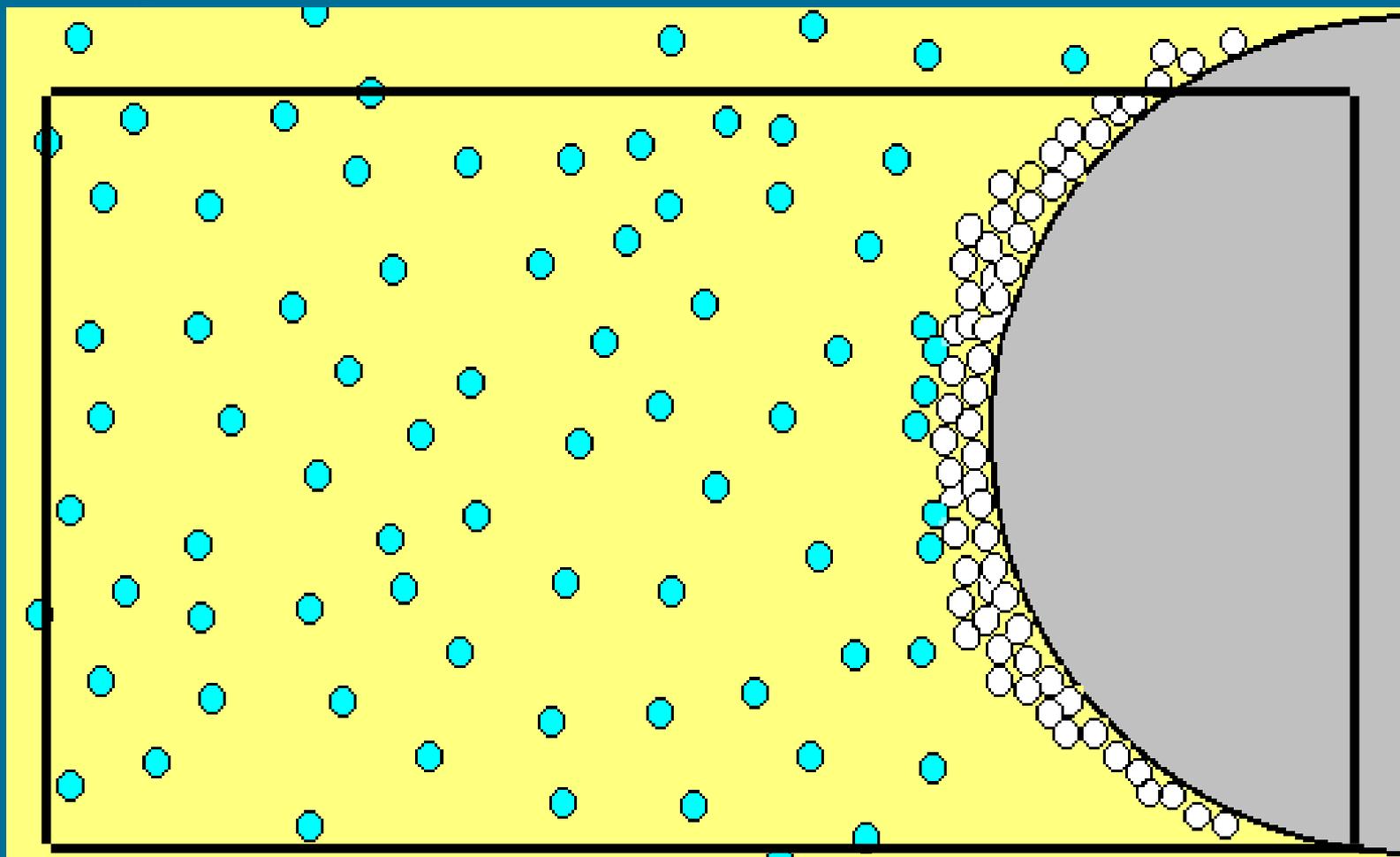
- Dual characteristics



Clear Icing – Big Drops



Rime Icing – Small Drops



Fact:

✓ *The kind of cloud plays a big role in icing.*

✓ **Cumulus clouds**

- ✓ *Bigger drops*
- ✓ *High water content*
- ✓ *More supercooled water*



✓ **Stratus clouds**

- ✓ *Smaller drops*
- ✓ *Less water content*
- ✓ *Less supercooled water*



Icing vs. Cloud Type: Stratus

Small Cloud Droplets

Rime/Mixed most common

Usually in a layer 3,000'-4,000' thick

Weak updrafts

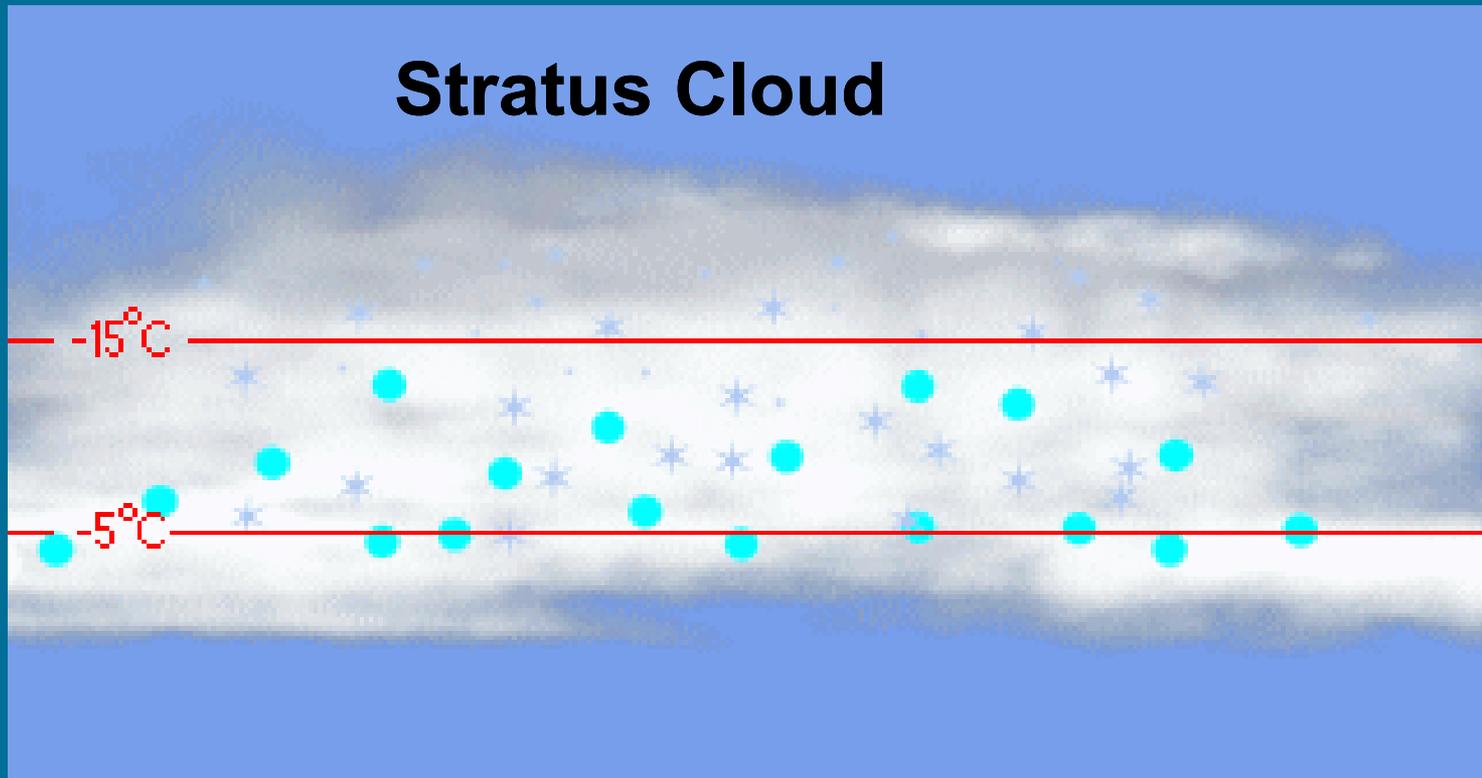
Mostly in upper part of cloud

Wide horizontal extent



More Ice, Less Water = Good

Stratus Cloud



Icing vs. Cloud Type: Cumulus

Large cloud droplets

Icing near top of cloud updraft

Heavy rime most frequently in cloud tops

Rime often found in mature thunderstorms

Clear icing most likely in growing cloud

Small horizontal extent



Big Drops Water = Bad

Cumulus Cloud



Sustained Updraft

- *Major cause of*
- *Aircraft Icing*

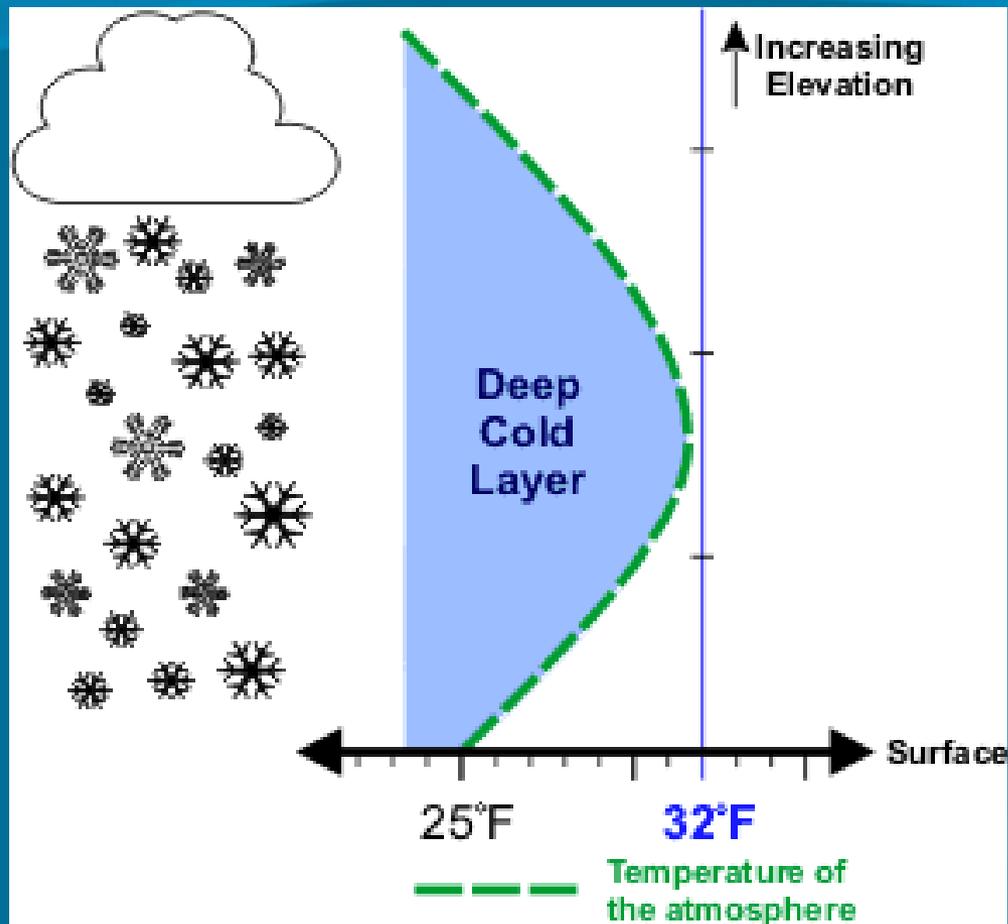
- *Key Source of*
- *Super-Cooled*
- *Large Drops (SLD)*



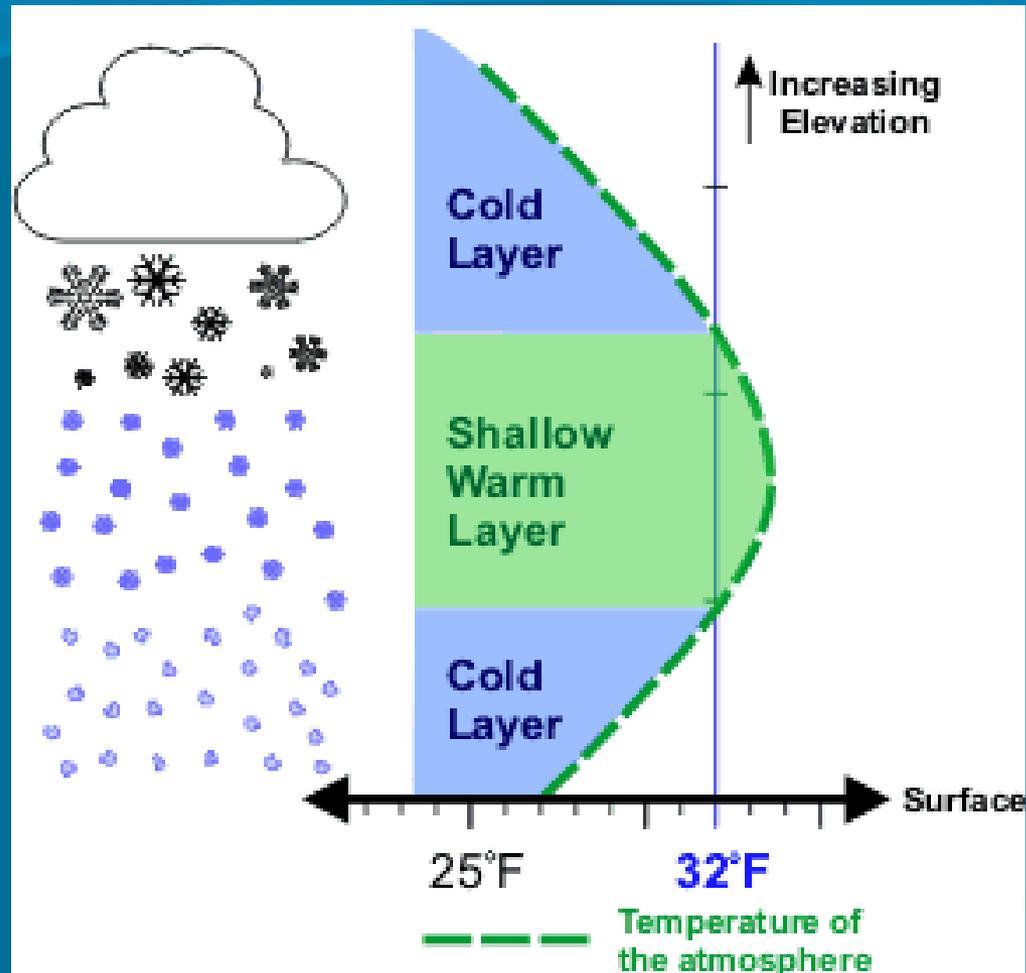
The COMET Program



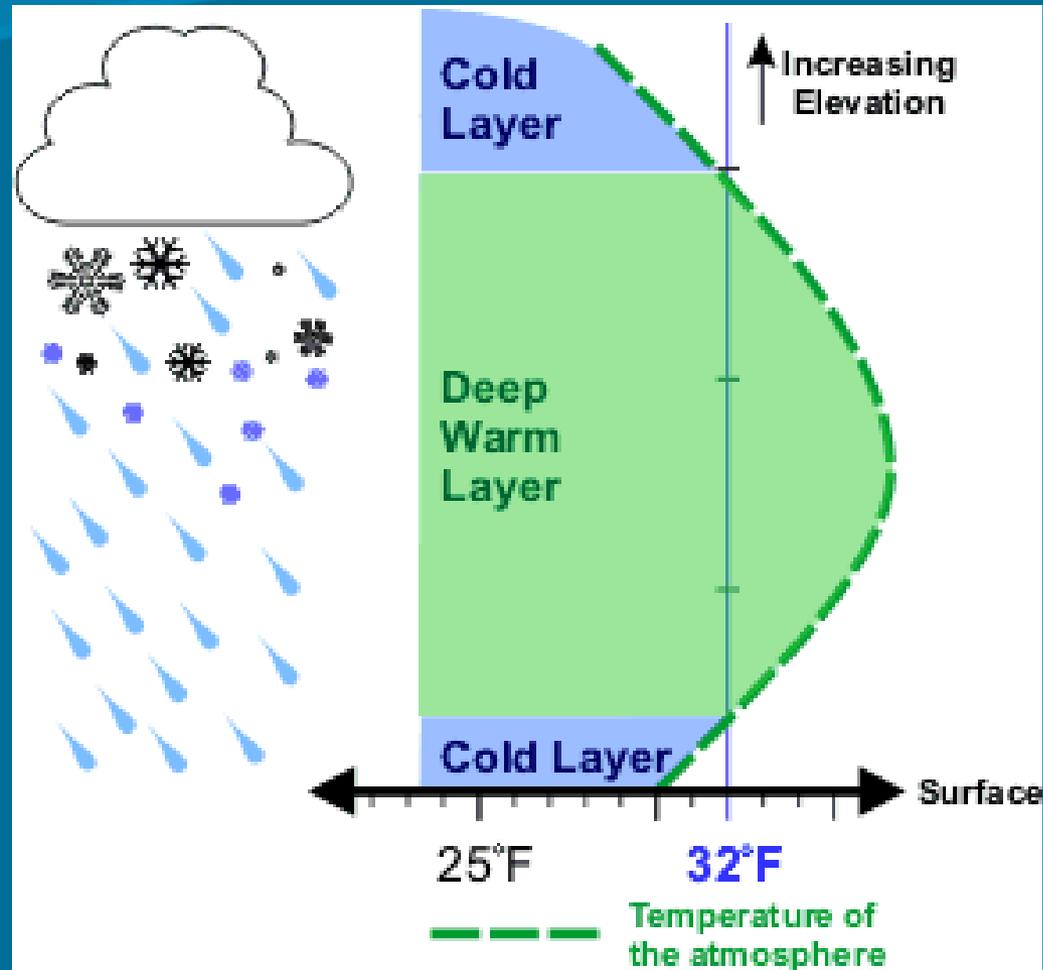
Fact: Snow



Fact: Sleet



Fact: Freezing Rain



Strategy

Preflight planning

✓ *Where are areas of active weather?*

✓ *Where are the fronts?*

✓ *Where are they moving?*

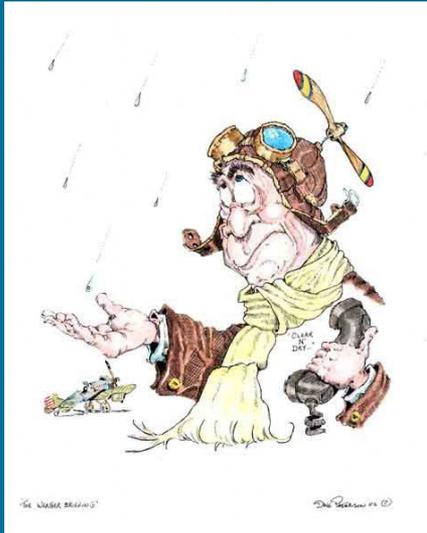
✓ **What are cloud tops?**

✓ *What kind of cloud*

✓ **Cumulus?**

✓ **Stratus?**

✓ **How high are cloud bases?**



Strategy

Preflight planning

- ✓ ***What is the freezing level?***
 - ✓ *How does that compare with cloud tops?*
 - ✓ *Are there warm layers above? Below?*
- ✓ ***Are there AIRMETs or SIGMETs out?***
- ✓ ***Will you fly across or near an active front?***
- ✓ ***Are there areas of precipitation?***
 - ✓ *Along or near planned route?*
 - ✓ *Moving toward or across route?*



Strategy

Best strategy is **AVOID** ice

- ✓ *Even if aircraft is certified / equipped don't purposely fly into an area of known icing*
- ✓ *Get a good preflight weather briefing*
- ✓ *Inspect flight surfaces carefully*
- ✓ *Clean ice / snow from plane*
- ✓ *Keep in touch with ATC*
- ✓ *Listen to PIREPs*
- ✓ *File PIREPs*



Effects of Icing Are “Cumulative”

Decreases Lift

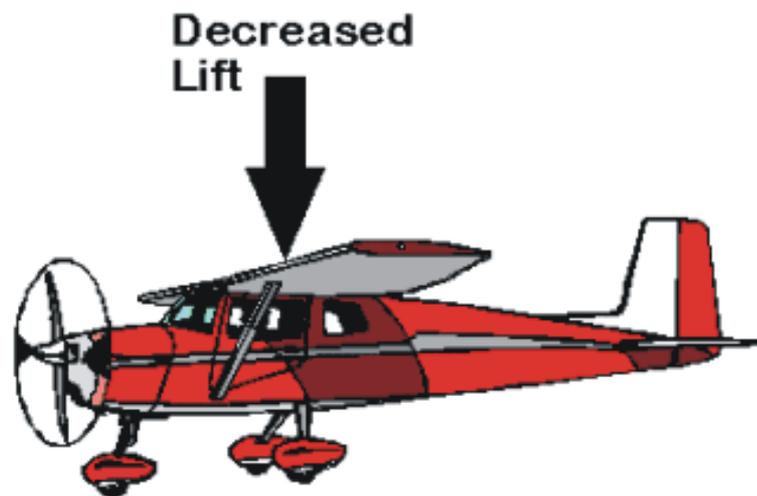
Decreases Thrust

Increases Weight

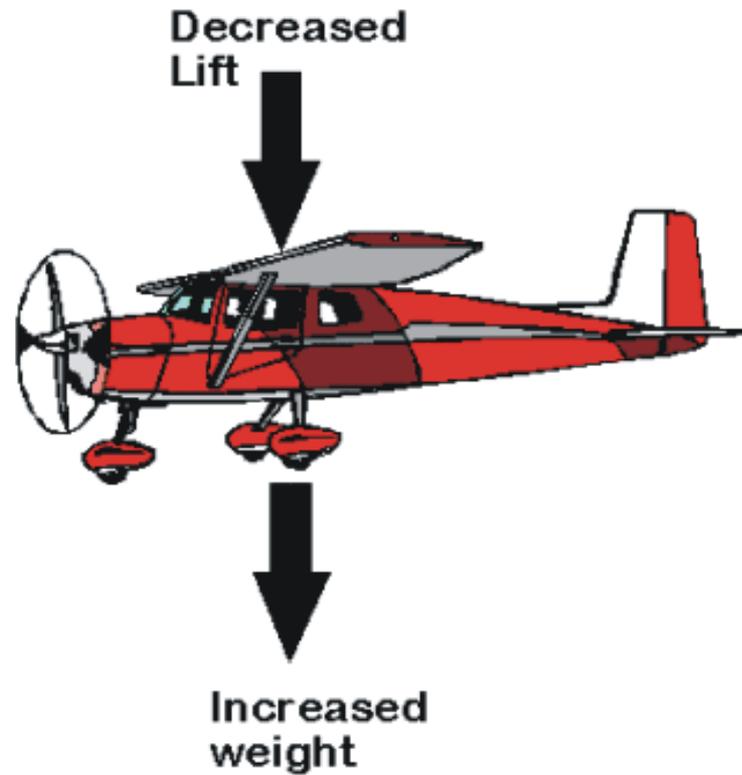
Increases Drag



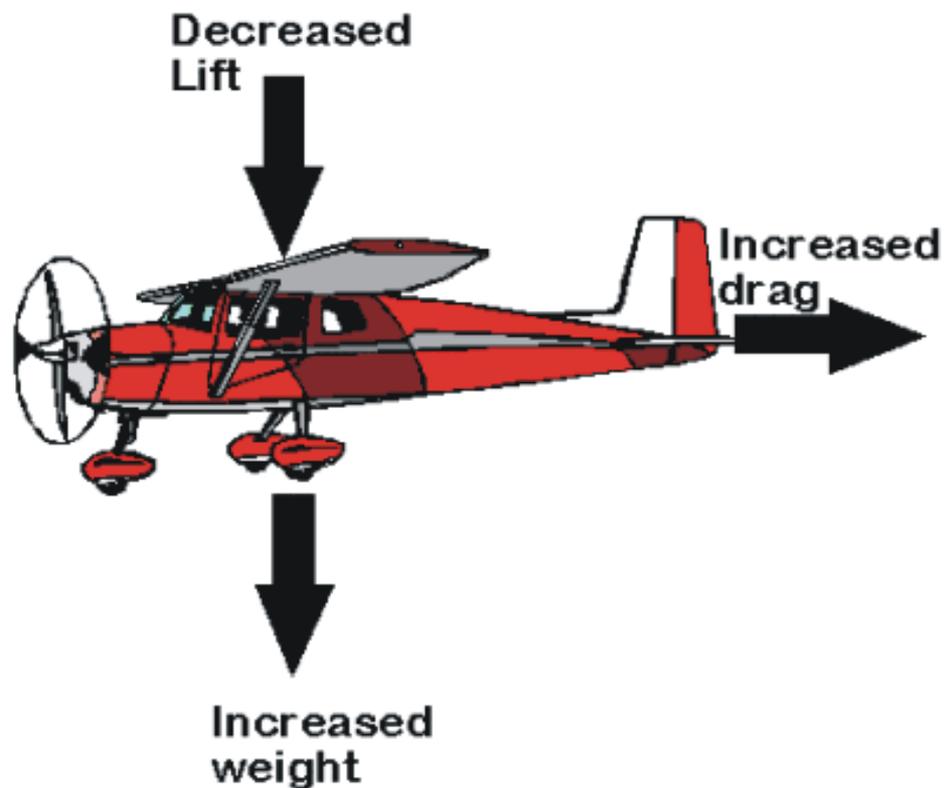
Icing Effects Accumulate



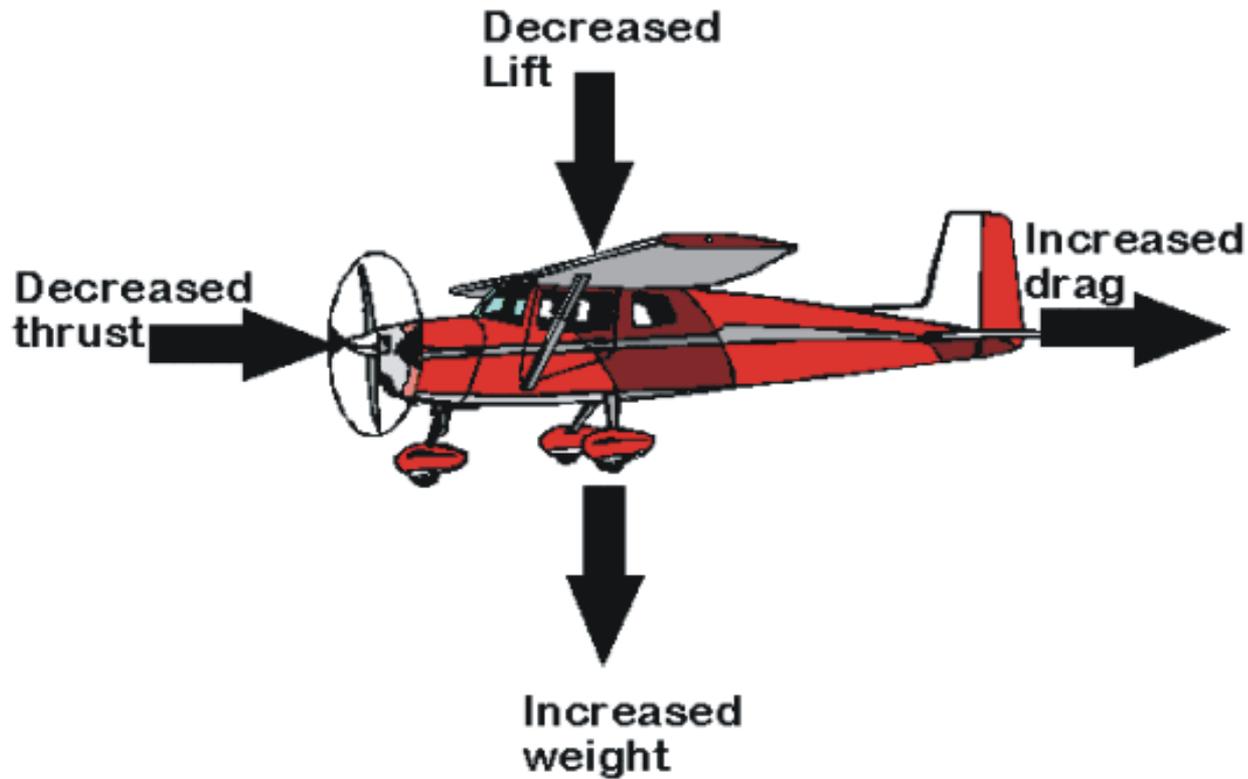
Icing Effects Accumulate



Icing Effects Accumulate

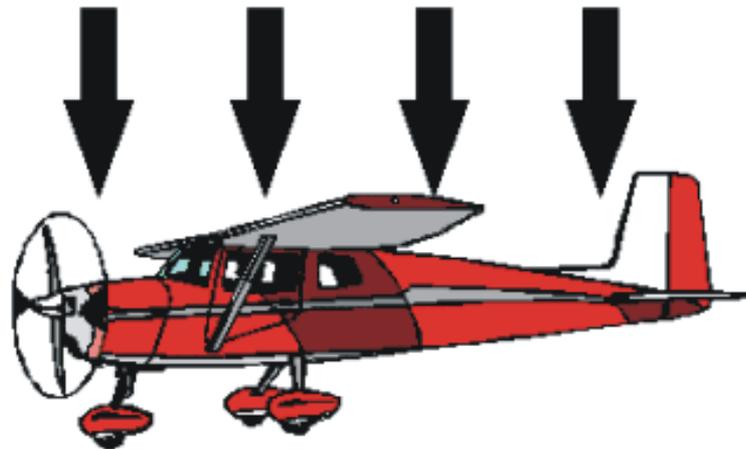


Icing Effects Accumulate



Icing Effects Accumulate

Result is all bad!



Rules of Thumb

There is no rule of thumb that always works

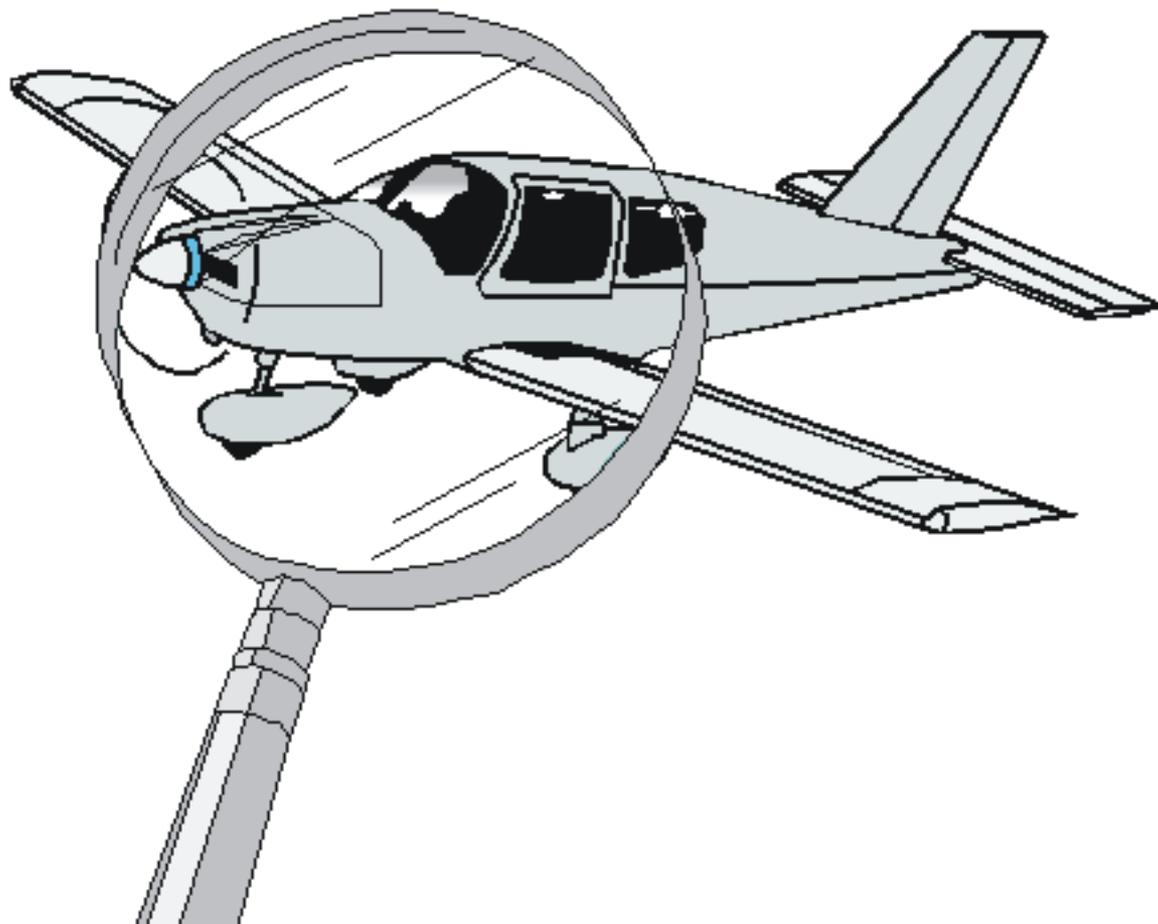
Heaviest icing is most often reported 4,000 - 6,000 ft above the freezing level.



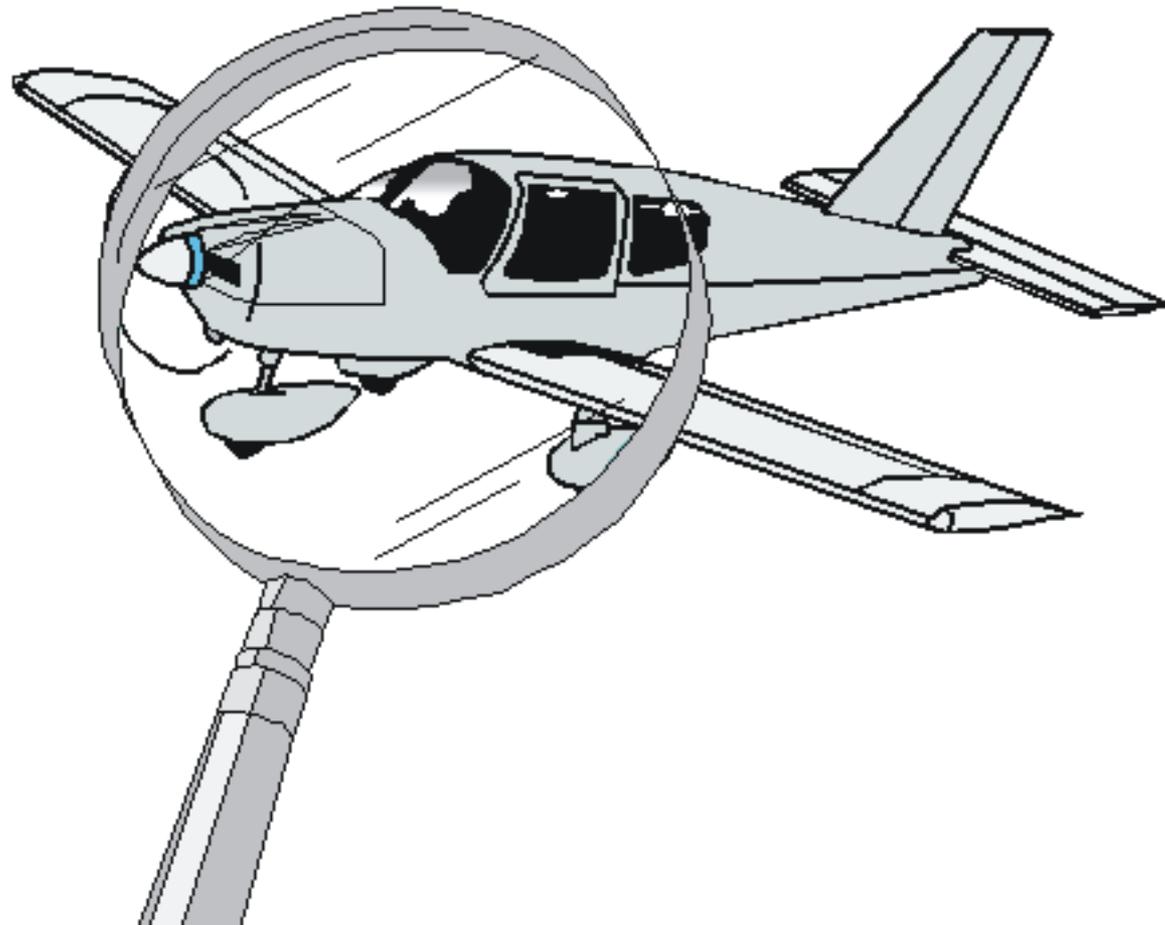
Sources of Ice in Clouds

- **Supercooled Large Drops (SLD)** –
 - By far the most dangerous
 - Typically found in freezing rain or drizzle
 - Drop sizes - 30-300 microns
- **Precipitation/cloud** -
 - The most common form of icing
 - 10 to 50 microns in diameter



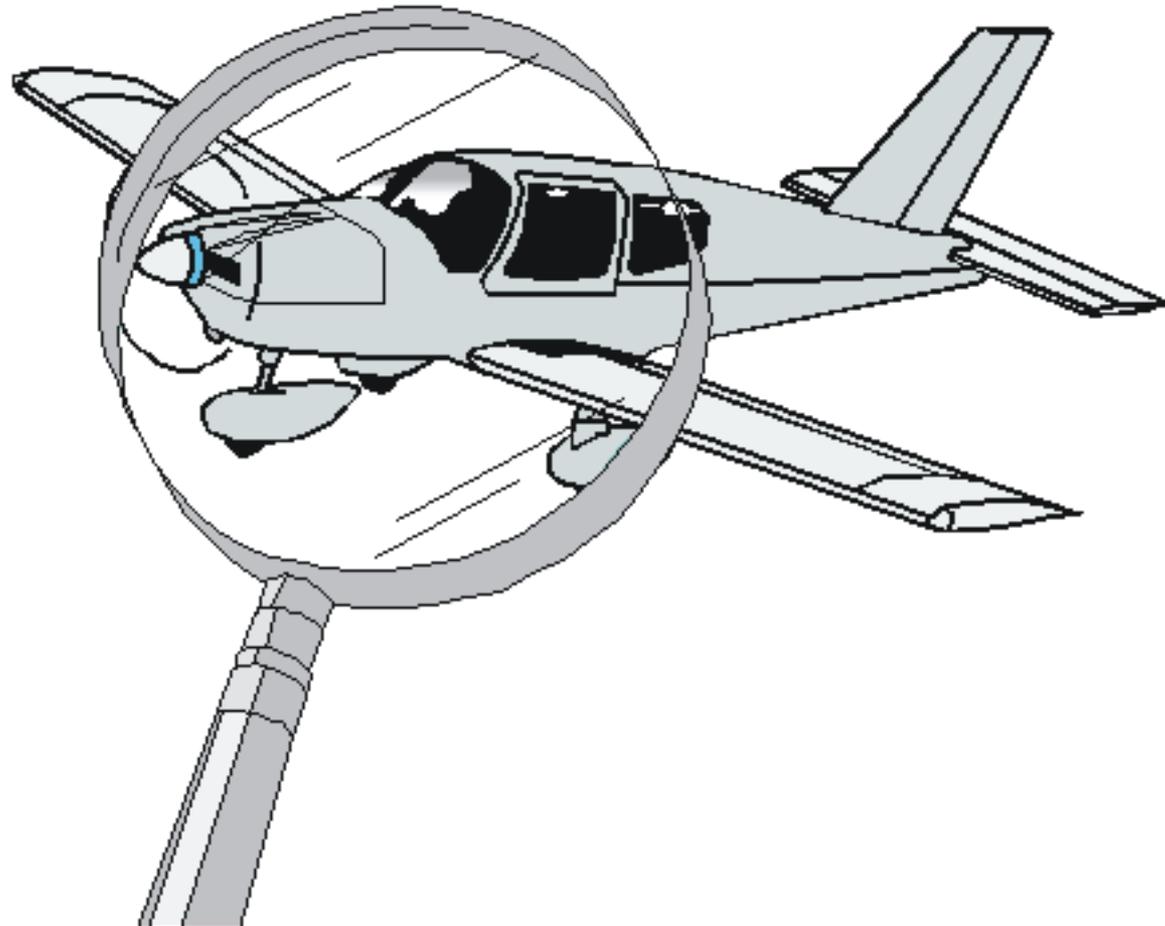


Temp: 32° to 15° F



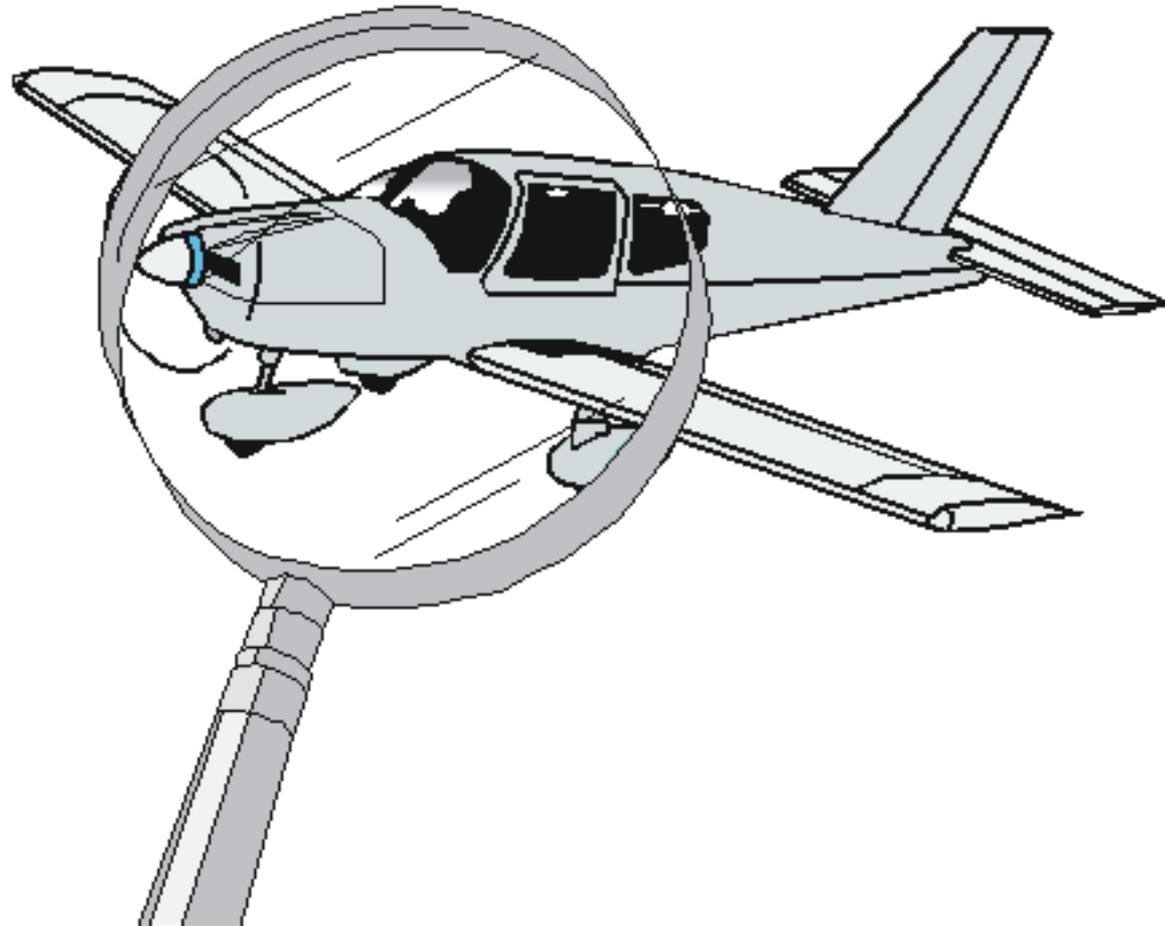
Temp: 32° to 15° F

High RH



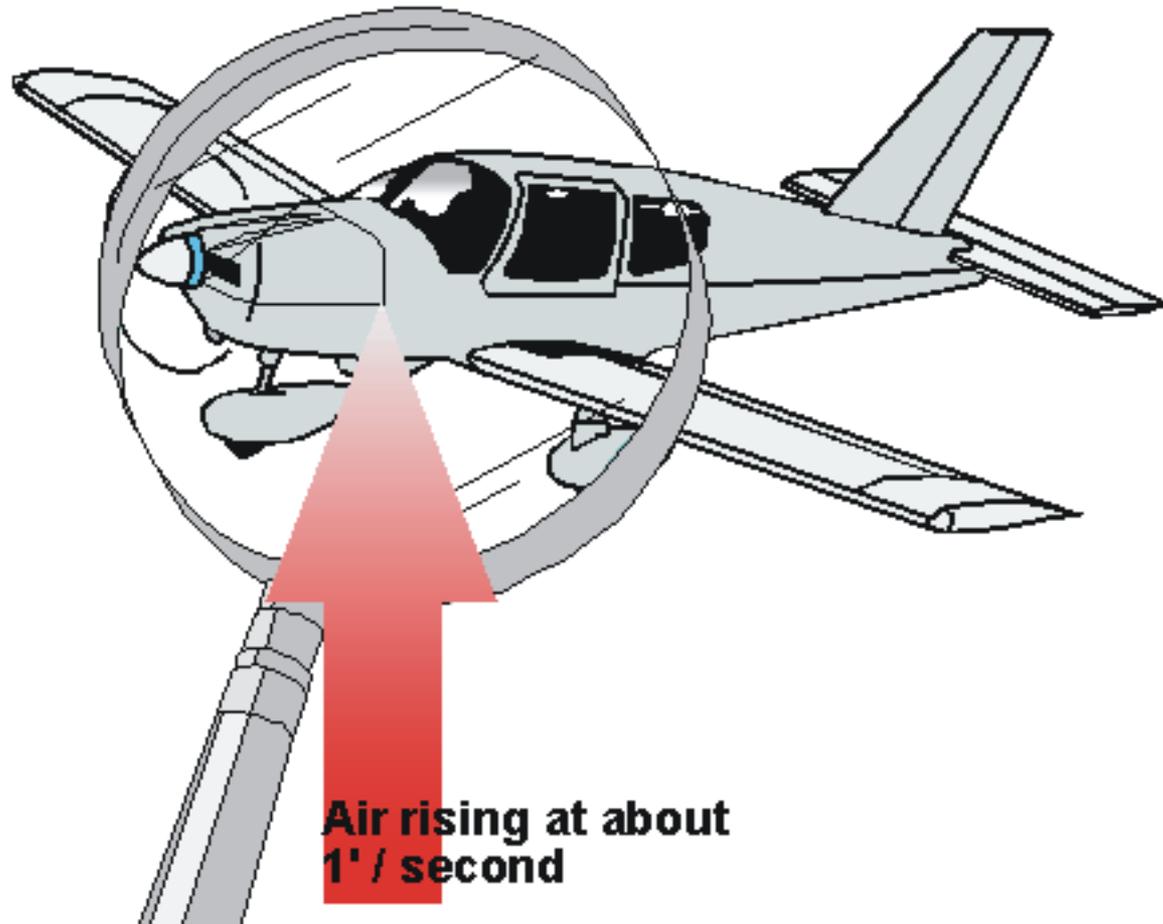
Temp: 32° to 15° F

High RH



Temp: 32° to 15° F

High RH



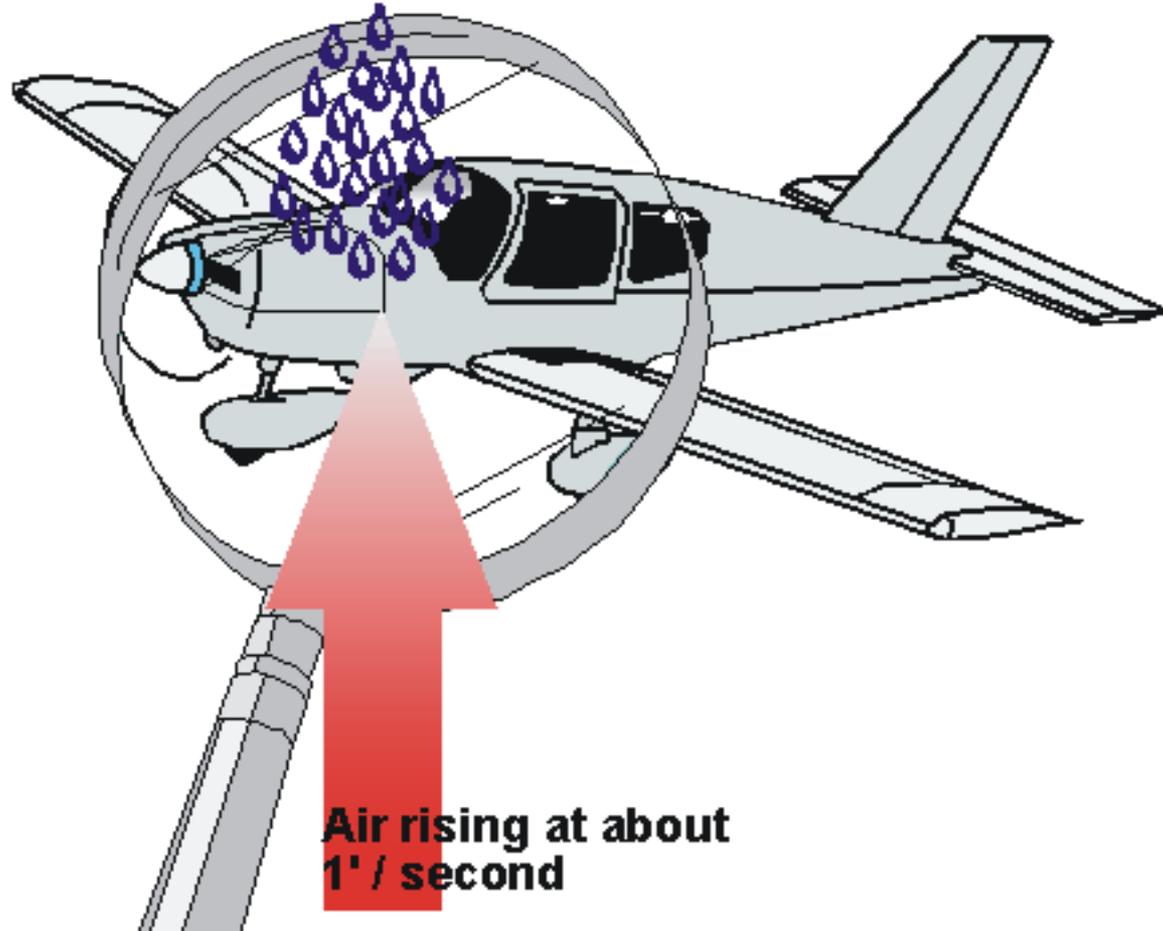
**Air rising at about
1' / second**



Temp: 32° to 15° F

High RH

**Creates water drops
300 microns diameter**



**Air rising at about
1' / second**

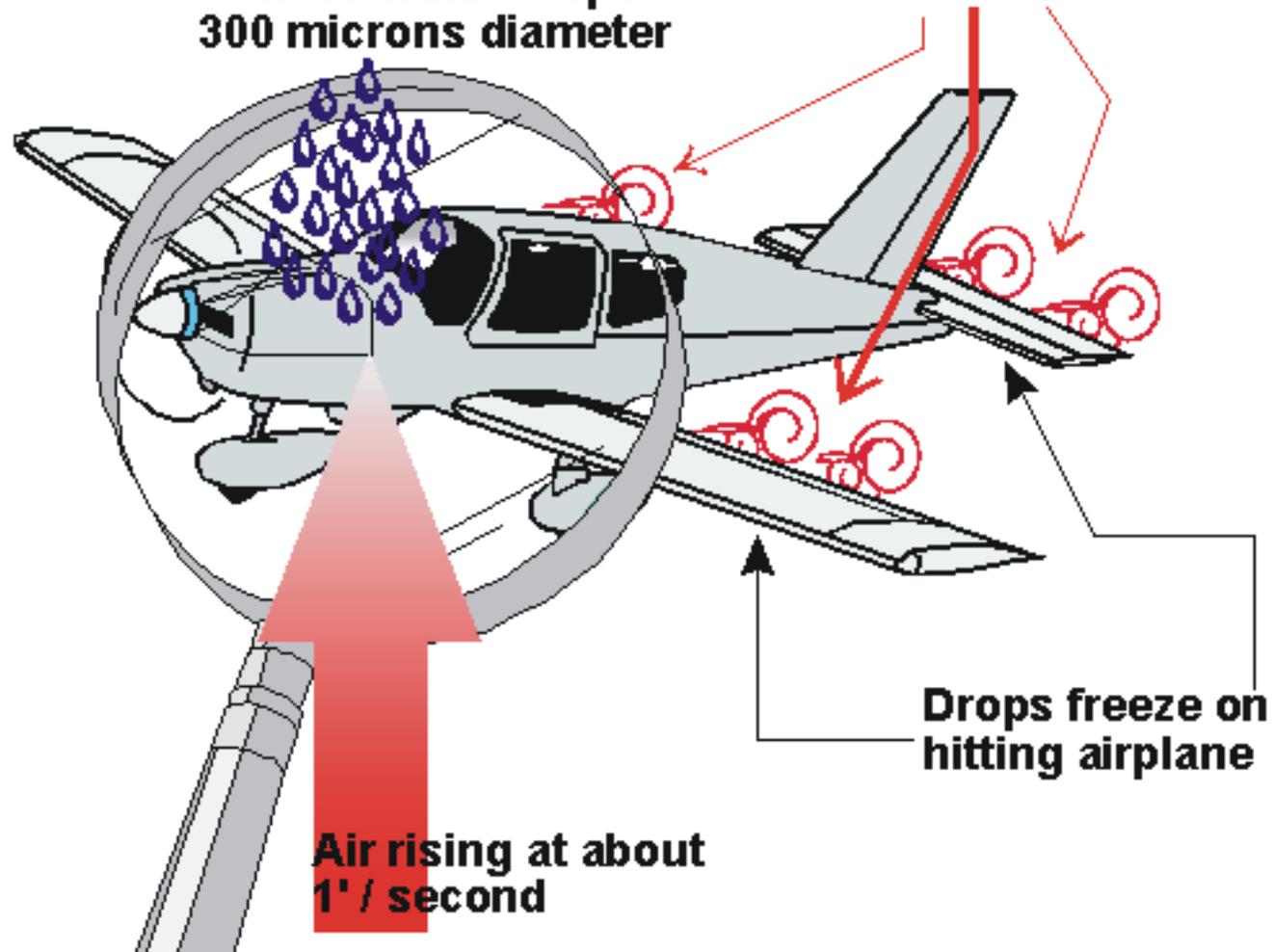


Temp: 32° to 15° F

High RH

Creates water drops
300 microns diameter

Rough ice coating
disrupts air flow



Air rising at about
1' / second

Drops freeze on
hitting airplane



Where is Icing Worst?

- Near the tops of clouds (larger drops)
- In freezing precipitation (SLD) - usually below 100

Mainly when not expected!!

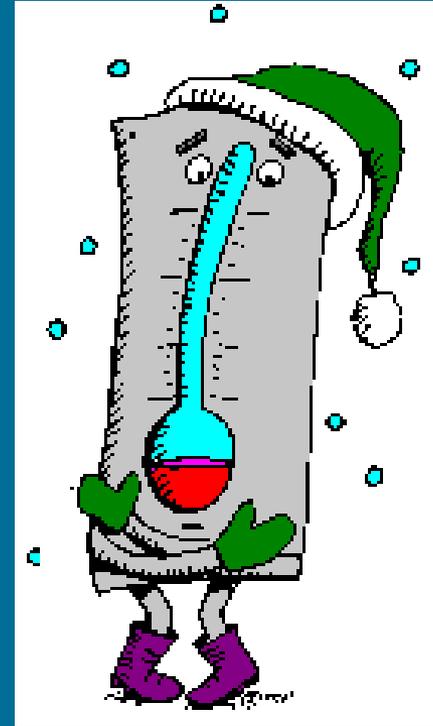


Icing Temperatures

33° F to -4° F

Warmer – No Ice

Colder – water droplets
become ice crystals

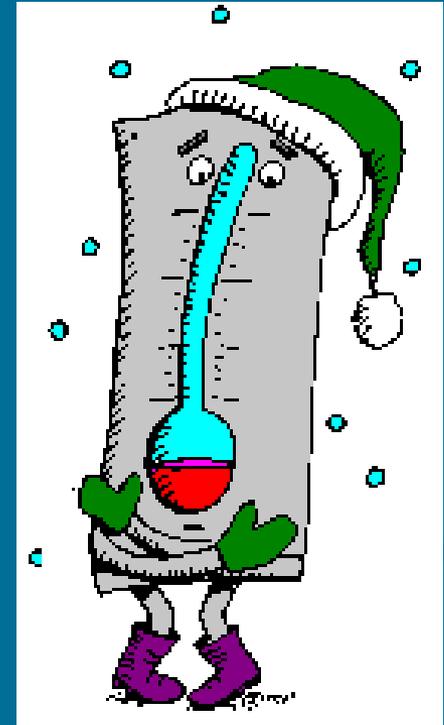


Icing Temperatures

But... (*isn't there always a catch?*)

Sometimes even colder than -25°C

**Especially in thunderstorms
because drops are big and the
updrafts so strong**



Thunderstorm – Severe Icing

20 miles!!

At least 20 miles from
Severe Thunderstorm
Such as this

Overshooting Top

↓
Mixed Icing

Hard Edges

Clear Icing
Severe or Extreme Turbulence

Area with Low Visibilities
Hail, Wind Shear

←
Microbursts



ATR Icing Accident

On October 31, 1994, ATR-72 crashed near Roselawn, Indiana, killing 64 passengers and 4 crew.

NTSB tied the aircraft's loss of control to a unexpected movement of an aileron after a ridge of ice formed behind the deice boots.

The plane went into an uncommanded roll that resulted in a rapid decent. The aircraft had been in a holding pattern with autopilot engaged.

Result of SLD!!



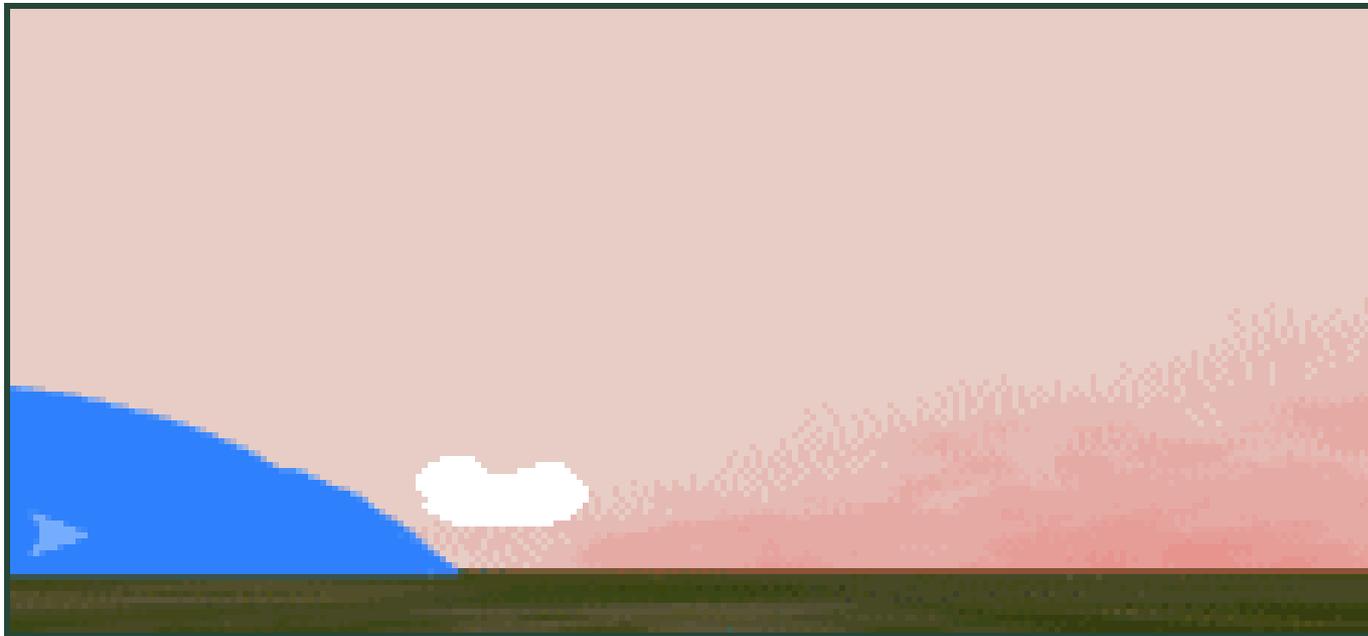
Weather Map Clues

Or, where you might find likely areas of ice by just looking at the weather maps

Some Terms:

1. **Frontal Systems**
2. **Overrunning**
3. **Lake Effect**
4. **Wrap Around**



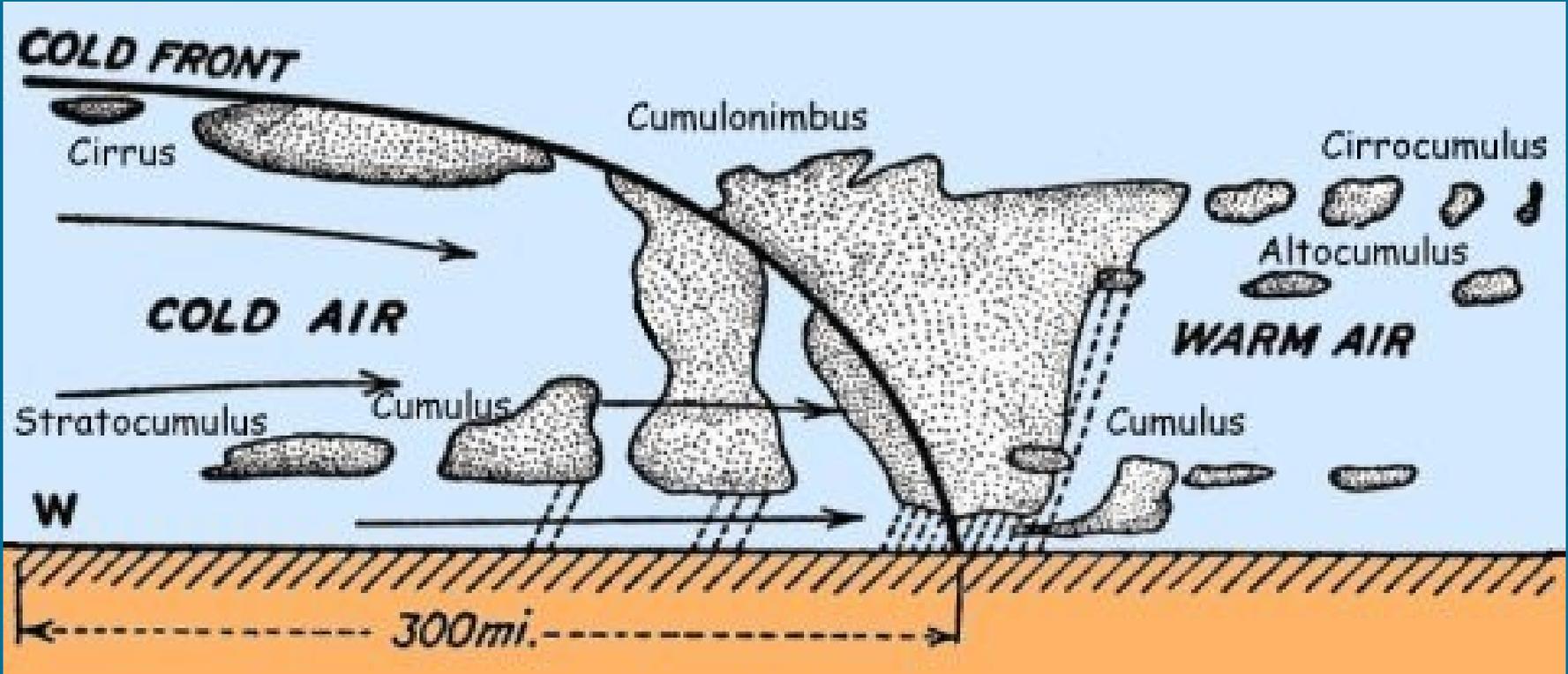


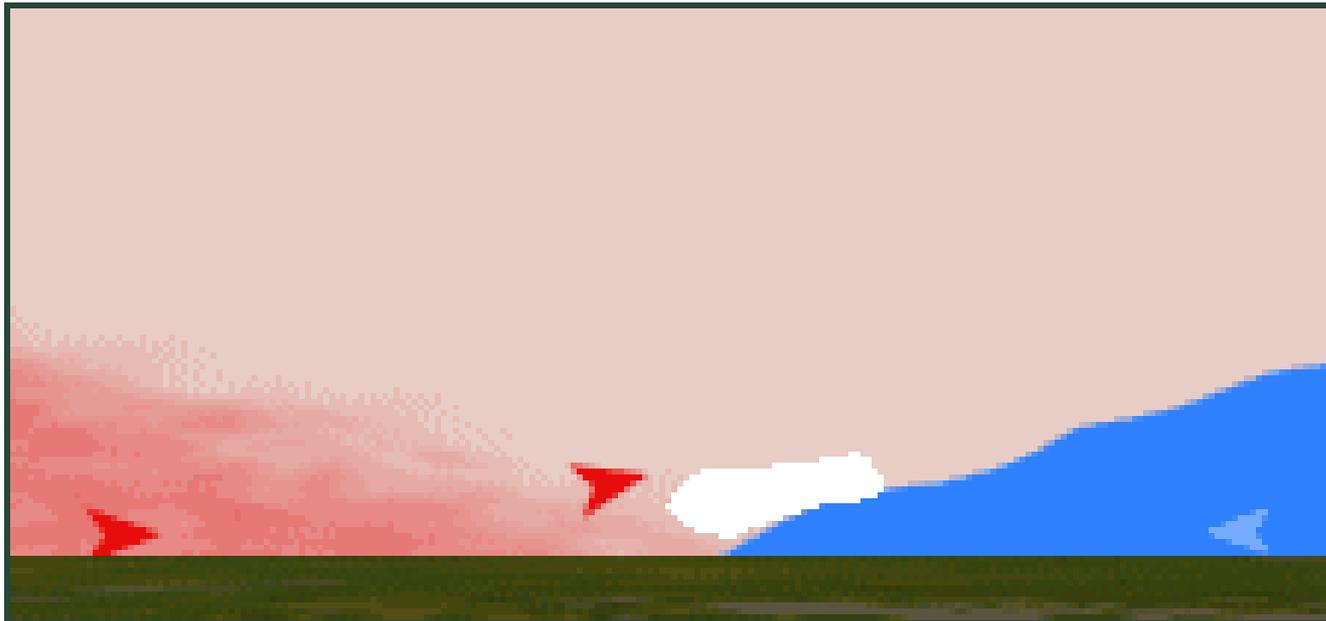
Cold Front

-  Cold Air
-  Warm Air
-  Warmer Air

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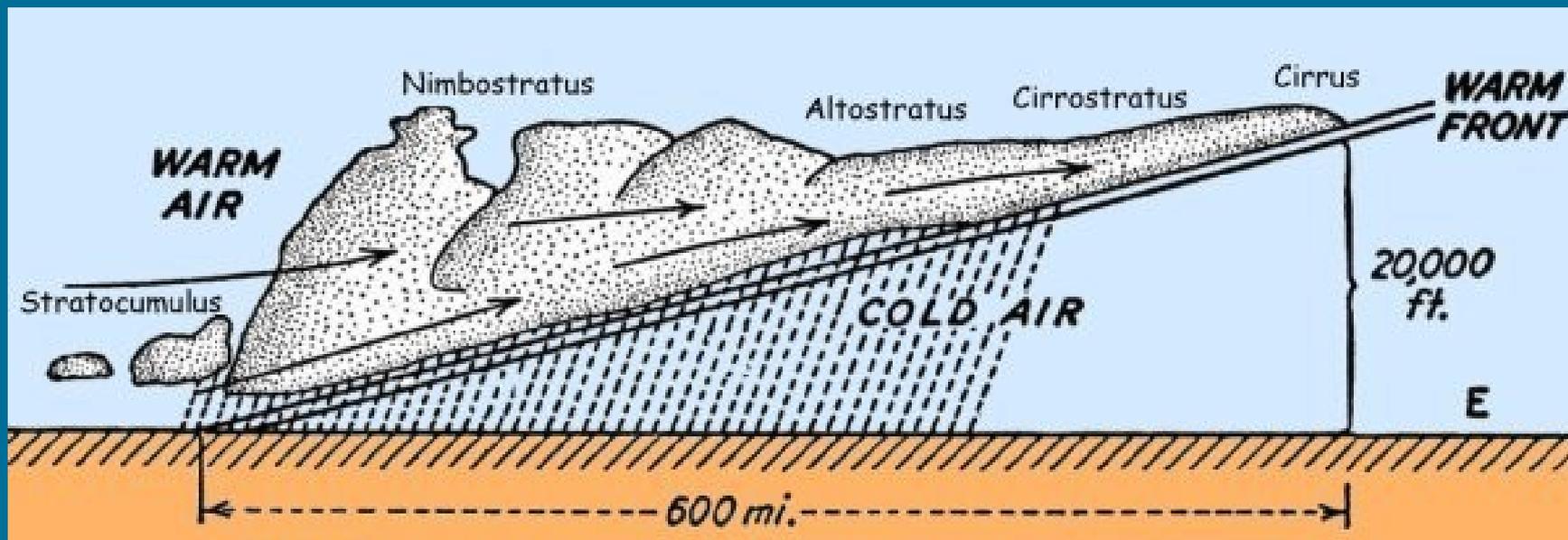


Warm Front

-  Cold Air
-  Warm Air
-  Warmer Air

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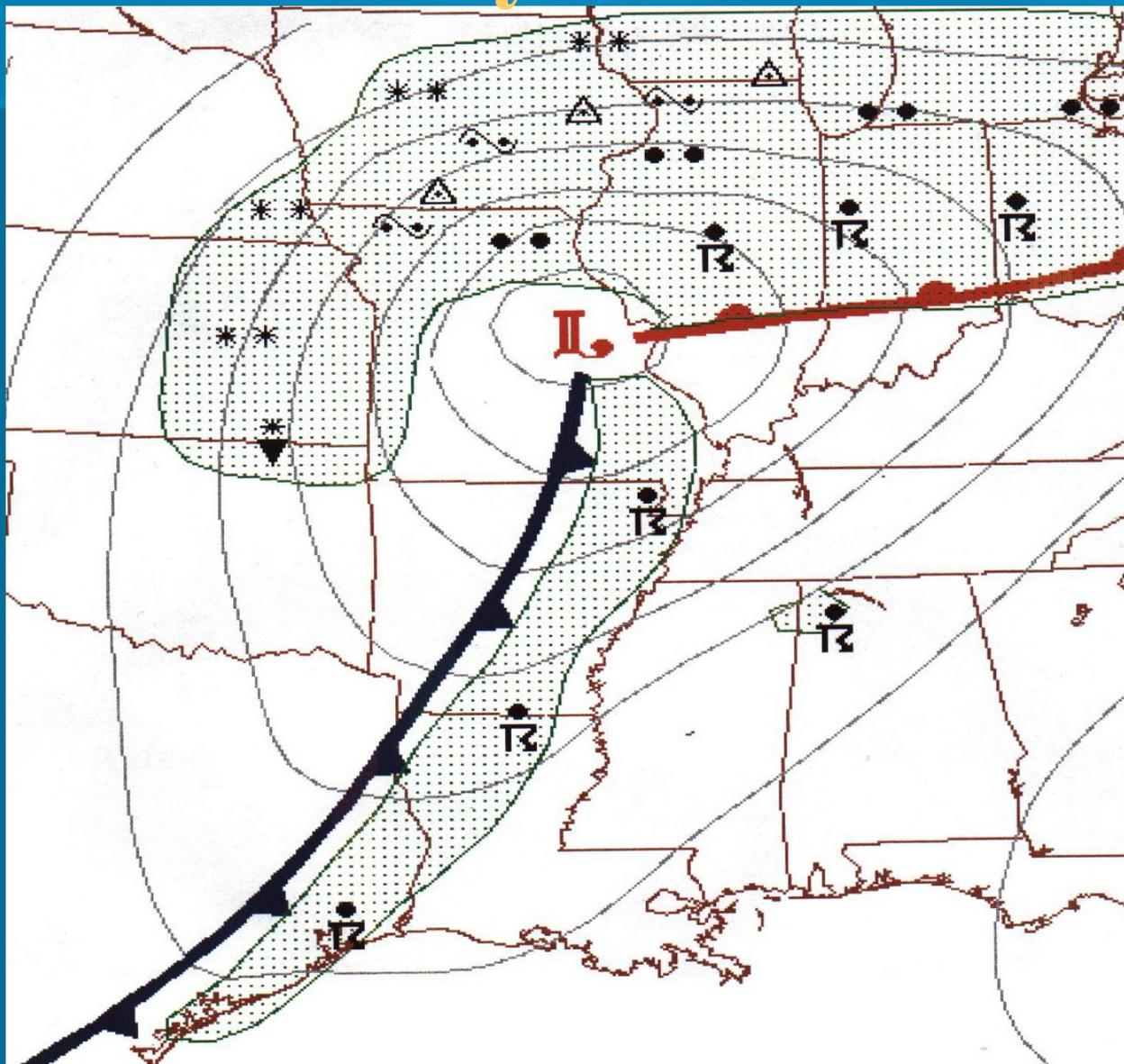


Frontal Systems

- Large areal coverage
- Big variation in condition both
 - East-west
 - North-south
- Conditions change quickly



Frontal System



Quick (trick?) Question

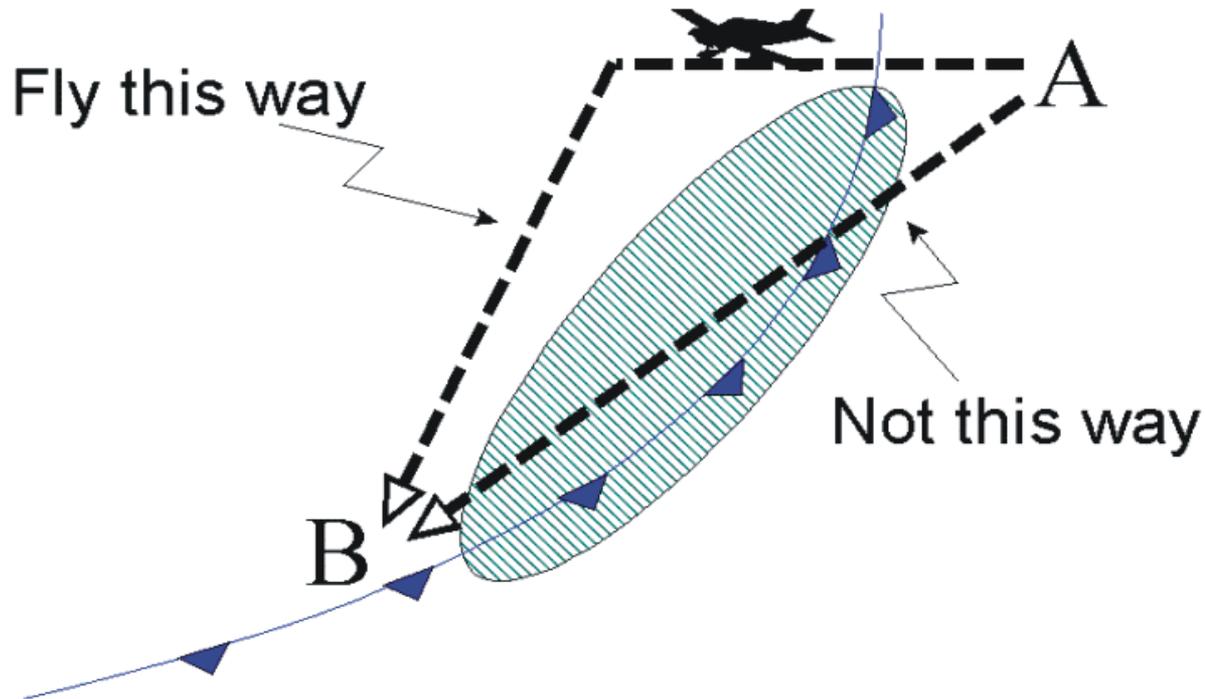
When flying near a frontal system, flying the shortest route through the front is best to avoid prolonged exposure to icing conditions.

True?

False?



Pick a Safe Route



Weather Map Clues

OVER-RUNNING

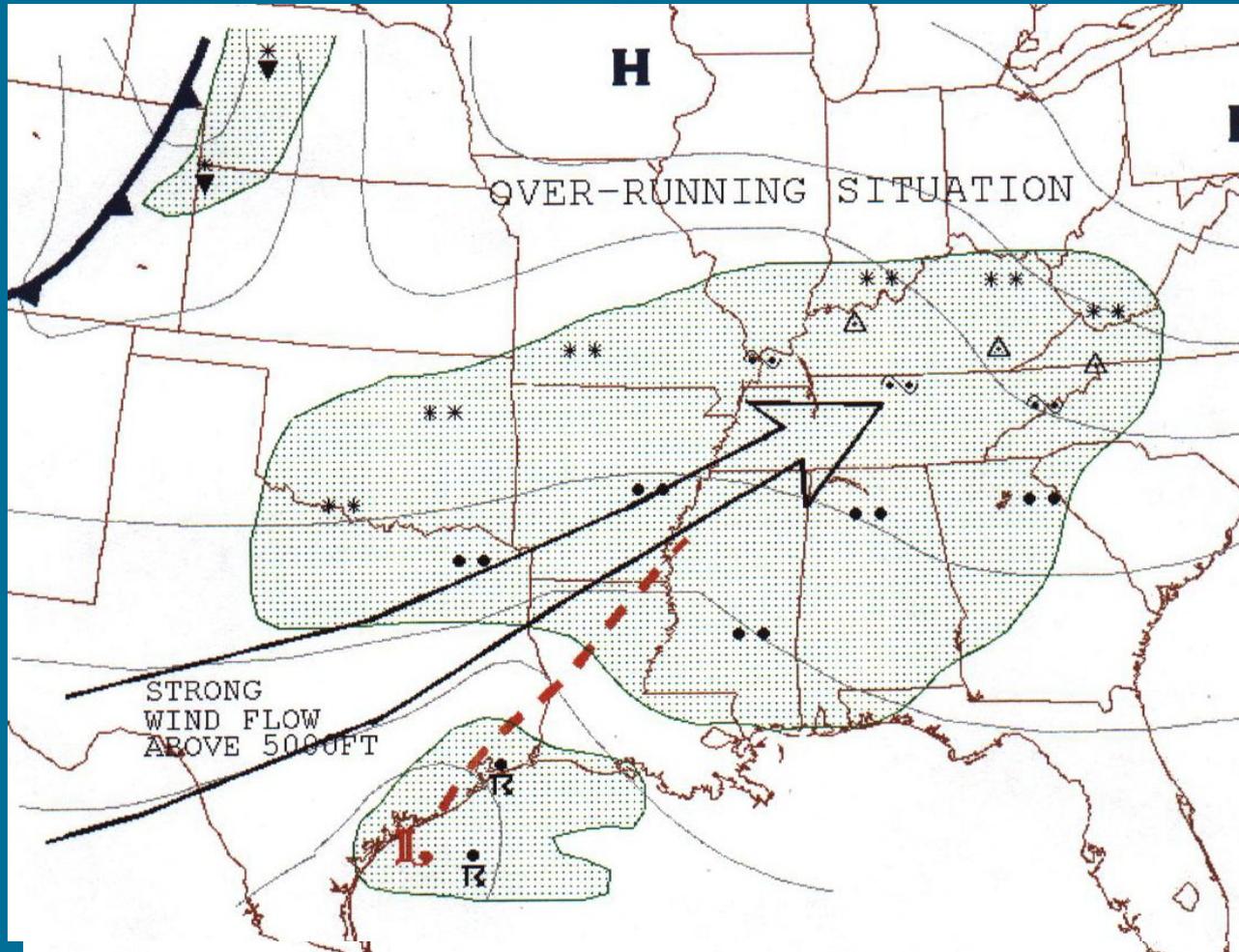
Very common in the southern states in winter...

Another good way to find ice!

- Large coverage area
- Little east-west variance
- Gradual north-south variance
- Mainly stratiform precipitation
- Some embedded thunderstorms possible



Overrunning

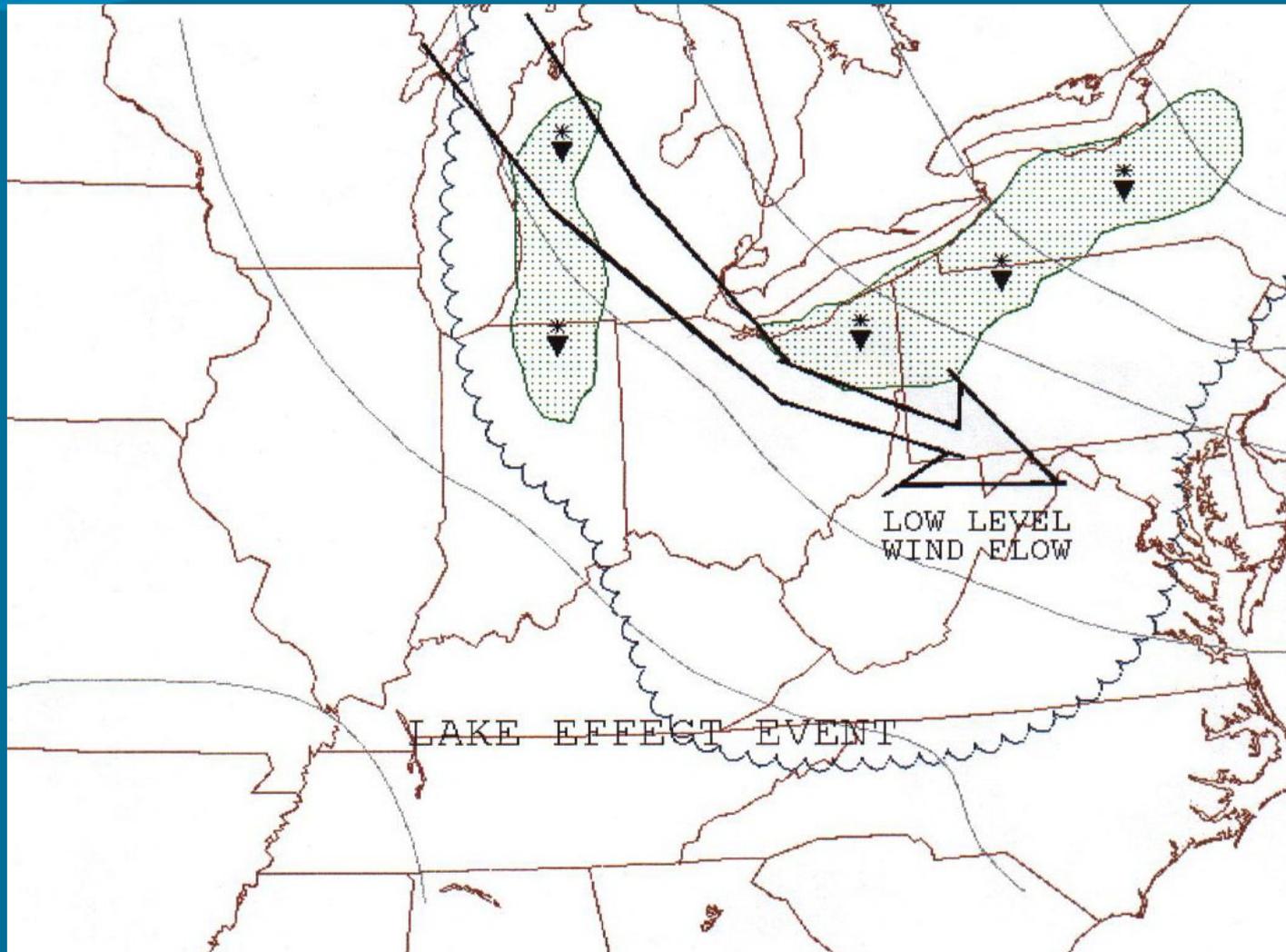


Lake Effect

- **Downwind of large lakes**
- **In winter**
- **Small area affected**
- **Confined to 50-100 miles from source**
- **Low cloud tops**
- **Occasionally embedded thunderstorms**
- **Occasional SLD**



Lake Effect

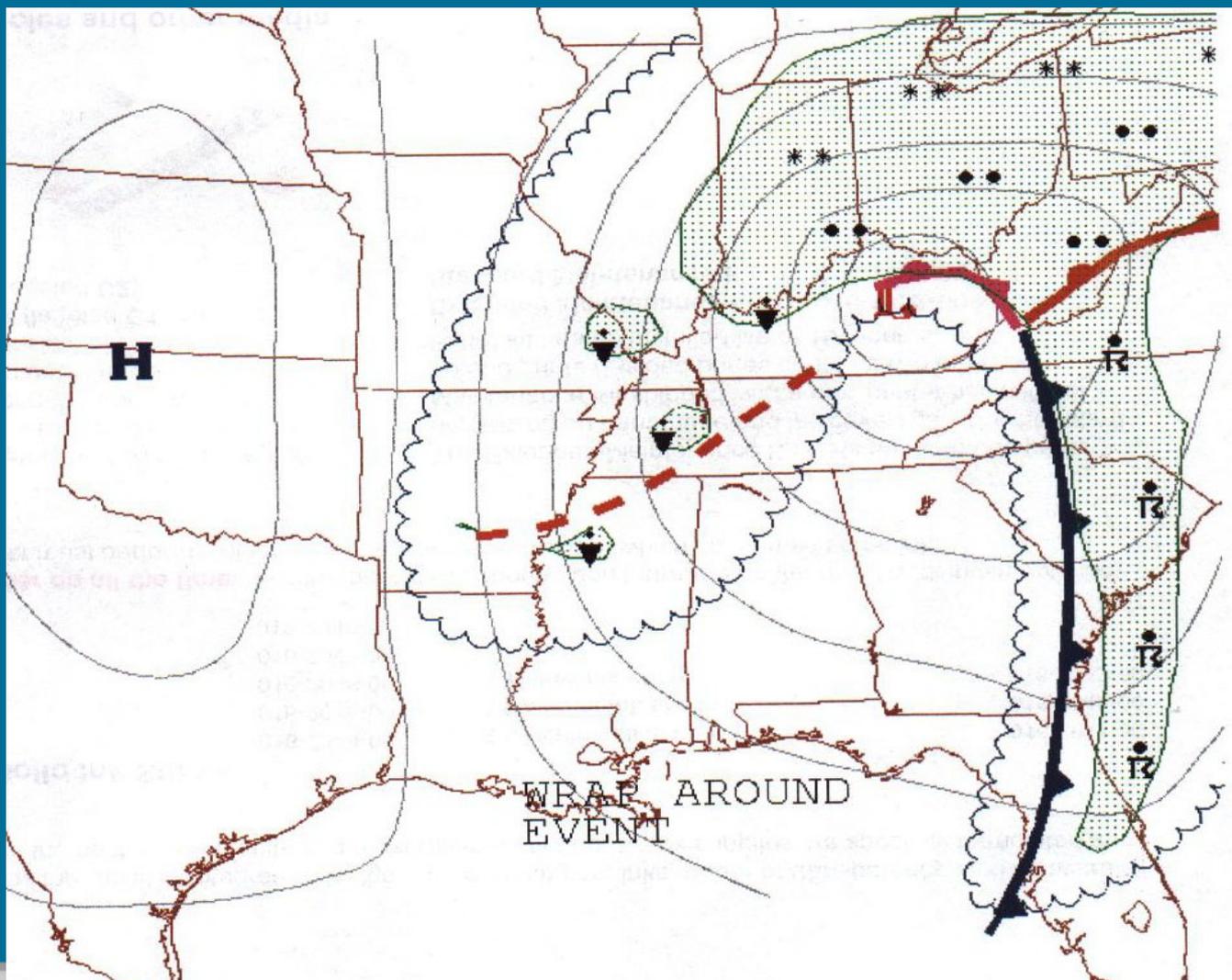


Wrap Around Effect

- Found on the west side of large lows
- Large area affected
- Low cloud tops
- Falling freezing levels
- Isolated SLD



Wrap Around Clouds



Information Sources

- 1) **Flight Service Stations 1-800-WX BRIEF**
- 2) **ADDS Site <http://adds.aviationweather.gov>
Current Icing Potential & Forecast Icing Potential
Charts (CIP/FIP)**
- 3) **DUATS**



More Information Sources

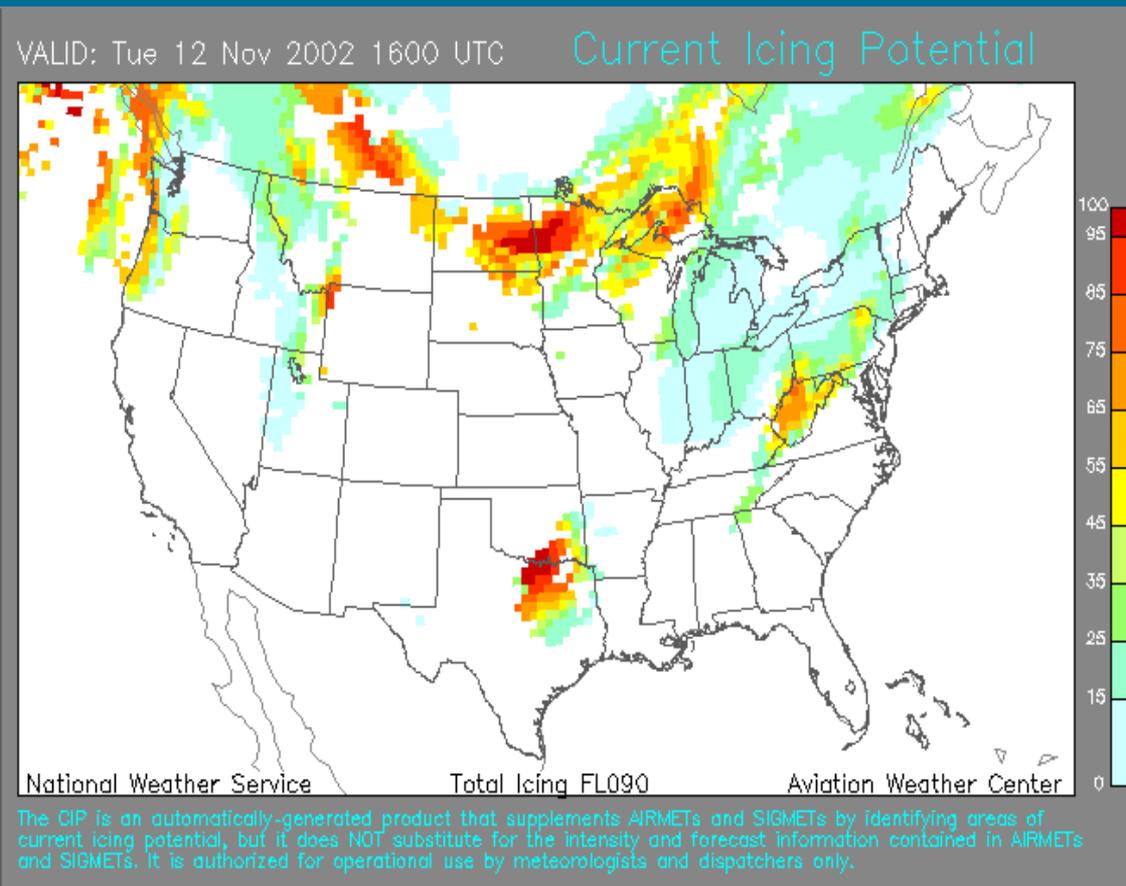
1. *PIREPs - get em, give em*
2. *Electronic Icing Handbook (training!!! Free!!)*

<http://www.aar400.tc.faa.gov/programs/FlightSafety/icing/eaihbk.htm>



Icing Forecasts (Experimental)

CIP – Current Icing Potential



Automatically
generated

Probability of icing
in percentage

SLD



Official Icing Forecasts:

AIRMETS - ZULU

**Miami AIRMET Zulu
Icing and Freezing Levels**

MIAZ WA 121445 AIRMET ZULU UPDT 2 FOR ICE AND FRZLVL
VALID UNTIL 122100 . AIRMET ICE...NC SC GA FL AND CSTL
WTRS FROM 170E ORF TO 140SSE ILM TO CRG TO 50SW
ABY TO GQO TO HNV TO 170E ORF **OCNL MOD RIME/MXD
ICGICIP BTN 140 AND FL270**. CONDS CONTG BYD 21Z THRU
03Z. . **FRZLVL...100-120 NW OF MGM-ORF LN SLPG TO 140-
160 S OF 180SSW CEW-140SSE ILM LN.**



Other Sources

TAF

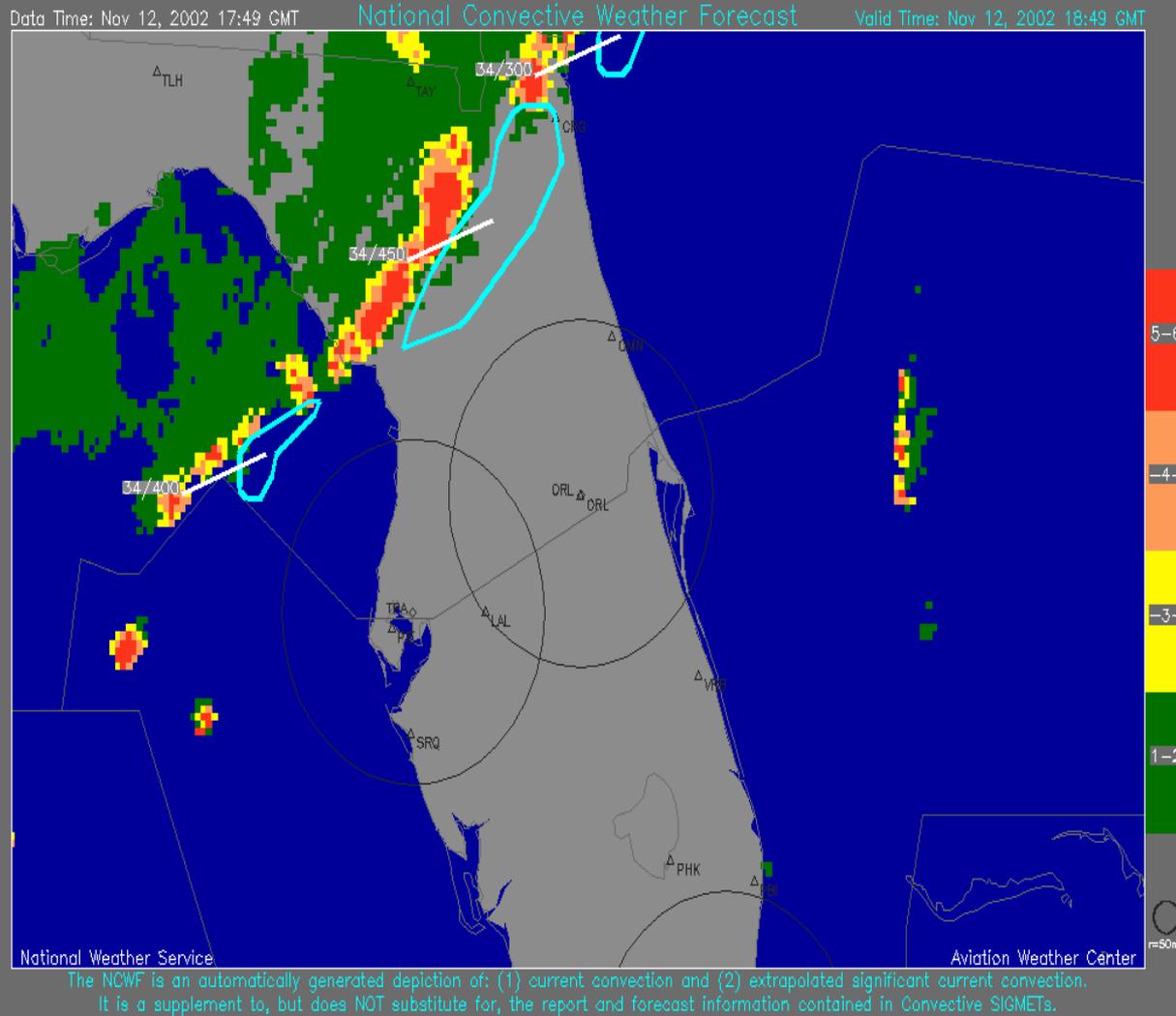
TAF KMEM 121130Z 061212 36014KT 3SM **-FZDZ** BR OVC020

Winds and Temps Aloft

	3000	6000	9000	12000	18000.....	39000
LBB	3409+03	3410- 03	3314- 10	3475- 12	3387-24	



Other Sources



National Convective
Weather Forecast

NCWF



Other Sources

PIREP

JFK UA /OV JFK180005/TM 1649/FL250/TP LR25/IC MOD RIME=

Use PIREPS thoughtfully

1. Not all ice is reported...
2. Ice can appear and disappear rapidly
3. What kind of aircraft reported the ice?

(A fast jet may encounter no ice while you run into light icing in Cessna 172.

Why? Friction!)



We Covered

- ✓ **Types of icing**
- ✓ **A bit on the cause**
- ✓ **Some effects on flight**
- ✓ **Weather map clues**
- ✓ **Sources for icing forecasts**



Questions or Comments?

