Weather (Ice) Flying

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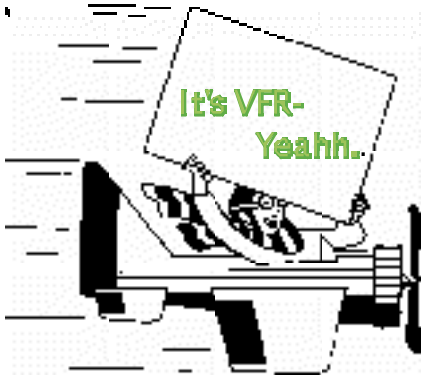
presented at SMXGIG '98, Santa Maria Ca
May 31, 1998

Weather is one of a pilot's greatest challenges

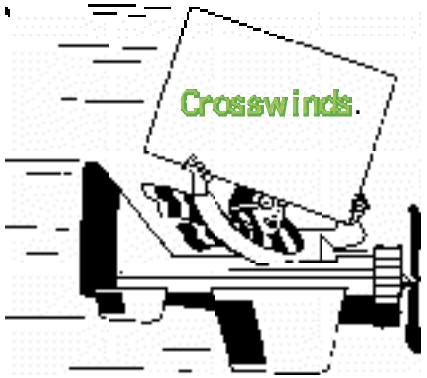


We have to plan in the face of uncertainty.

Forecasts are imperfect, and don't always tell us what we want to know.

Pilot and airplane capabilities vary widely.

The big weather challenges!

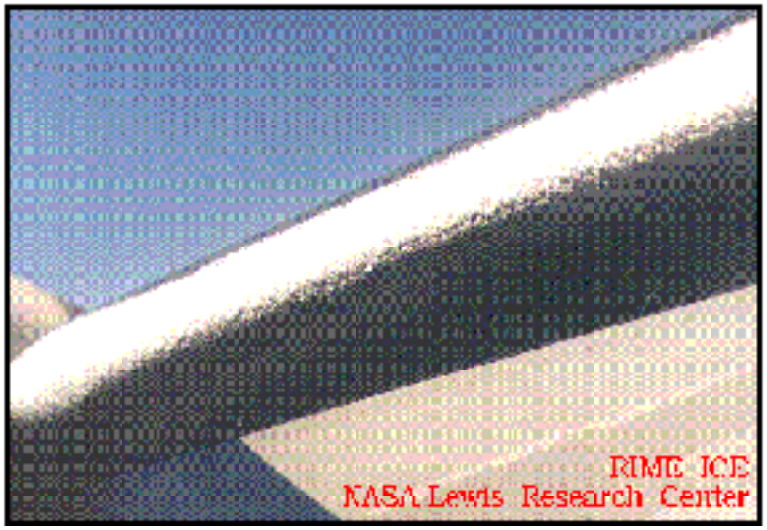


Ceilings and visibilities- IFR +Fuel

Thunderstorms- eyeballs or spherics/radar

Ice.

What is the hazard?



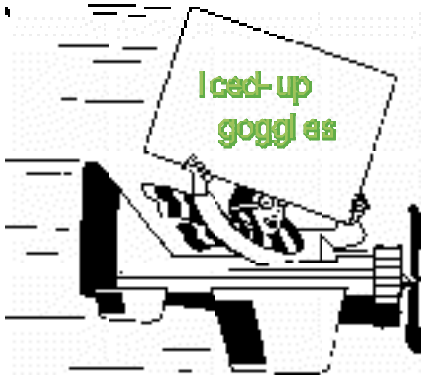
Spoils wing lift, increases drag.

Cruise speed decreases, available ROC decreases.

AIM defines trace, light, moderate and severe.

Useful measure is the spread between cruise and Vy.

What are the hazards of ice?



Spoils lift- increases drag

clean 69kts, 1/8" 80kts, 1" 84kts

ice buildups more or less conforming to the airfoil can double or triple its drag. "Horn" buildups are ~50% worse for a given thickness.

Weight is not an issue.

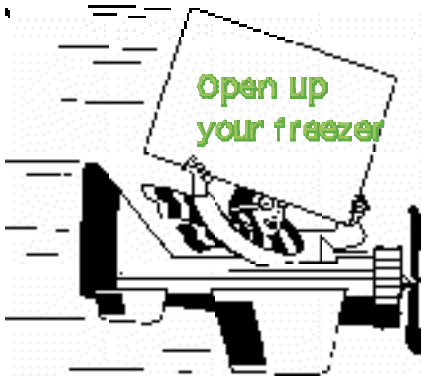
Prop loses efficiency.

Stall speed rises, cruise speed increases, available ROC decreases.

Iced-covered windshield?

Severity determined by rate of accumulation and associated rate of loss of climb capability. Cruise- Vy spread.

What is the recipe for structural ice?



The airframe must be below freezing. Mostly this means OAT's 0C and below.

Compression/expansion heating/cooling.

Cold soaking.

OAT error

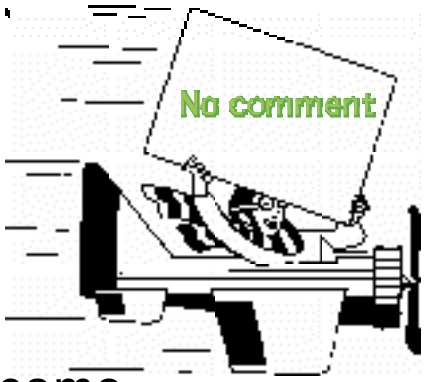
There must be visible liquid moisture present, in the form of clouds or rain/drizzle drops.

Small droplets freeze almost instantly, giving relatively slow accumulations of rime ice at the point of impact.

Large droplets freeze more slowly, giving "clear" accumulations which spread back.

Recent research has shown that drizzle size drops are the worst.

Size matters!



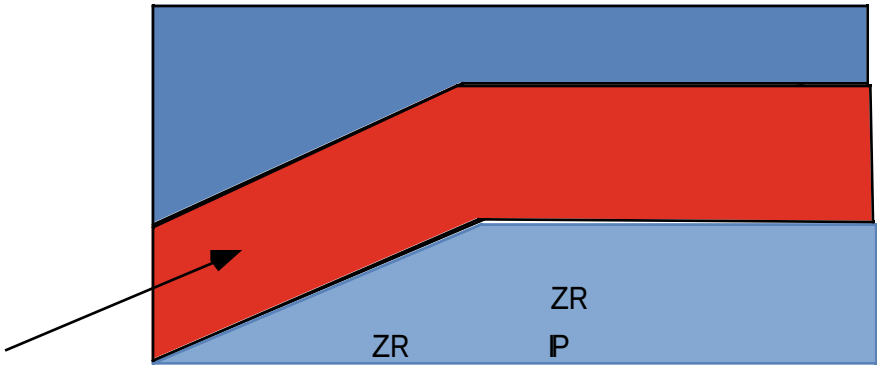
The most rapid, and thus most dangerous ice accumulations come when flying in areas of high liquid moisture content. Lots of big drops!

To support large droplets in a cloud, there has to be lifting. Beware of:

- cumulus buildups
- wave clouds
- upslope clouds
- stratus tops

Beware when the cloud bases are below the freezing level, which provides a liquid moisture source to be lifted. When cloud bases are colder than -5C, moderate or greater icing becomes unlikely.

Stay away from freezing rain & drizzle!



Multiple freezing levels!

Ingredients:

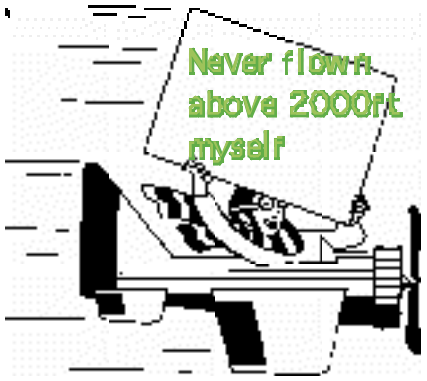
Temperature inversion
Warm, wet air aloft
Sub-freezing air below

Mostly found in winter warm fronts

Signals:

Reports of ZR, ZL or IP
Inversions in the temperature soundings
Surface temperatures drop below freezing on the cold side of the front.

Mountains are ice factories.



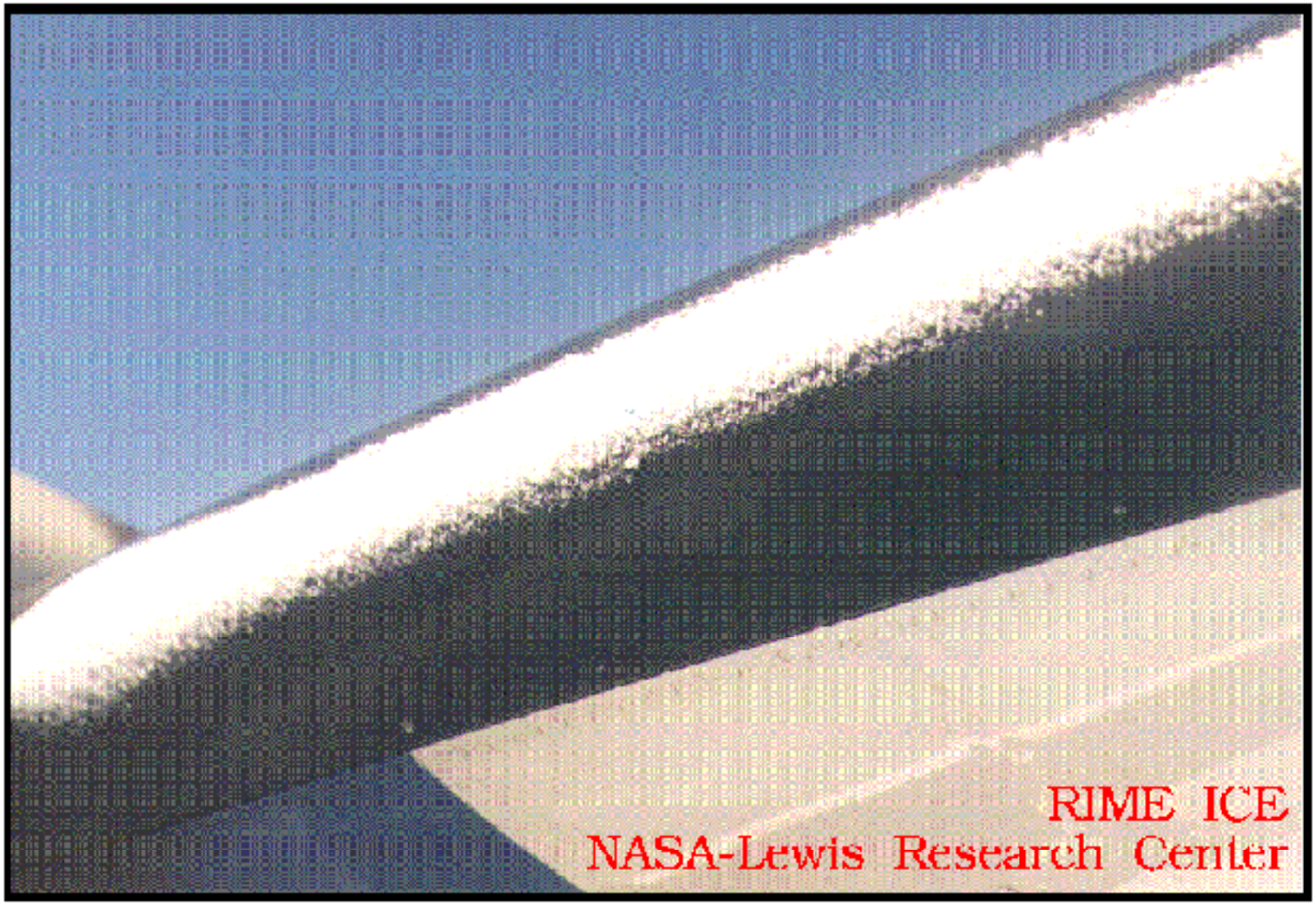
The Sierras and Cascades are notorious ice-makers because of the strong lifting. Beware of lenticulars on the lee side.

Be either below, or well above the freezing level. Preferably be well above the MEA, to improve your drift-down range, should you have to divert in a hurry.

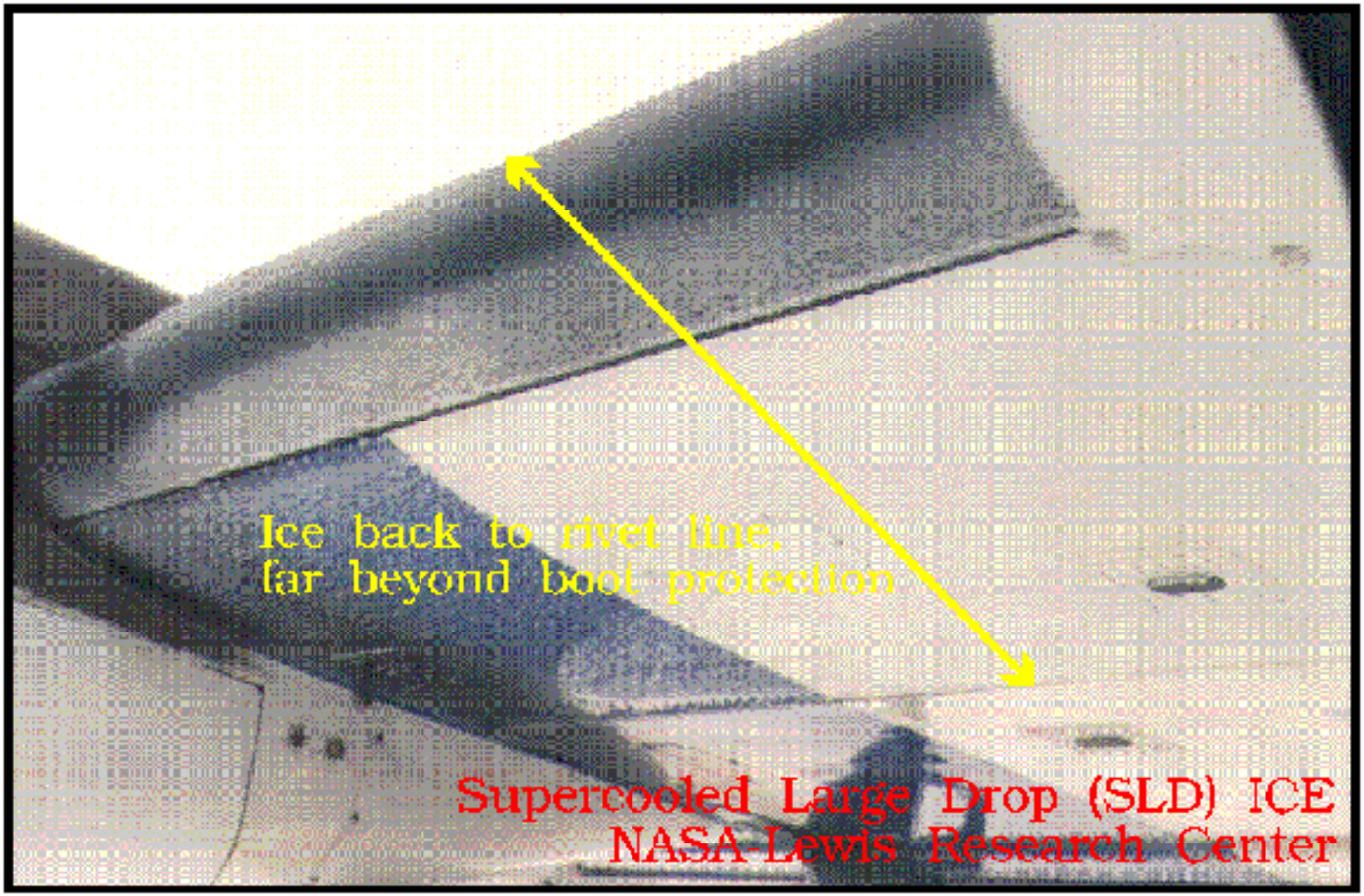
Avoid mountainous routes. If you have to cross the mountains, fly directly across, not along the range.

The situation typically improves as one gets further from the coast, further removed from sources of liquid moisture.

Rime ice forms from the near-instantaneous freezing of small cloud droplets

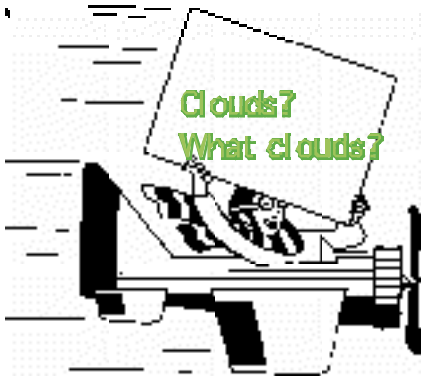


Large droplet icing is more dangerous- responsible for the Roselawn ATR Commuter crash.



http://www.rap.ucar.edu/largedrop/sld.gif

Do icy clouds look any different?



Glaciated clouds have a "fuzzier" look. Clouds with sharp, well-defined edges are more likely to be wet and therefore ice laden.

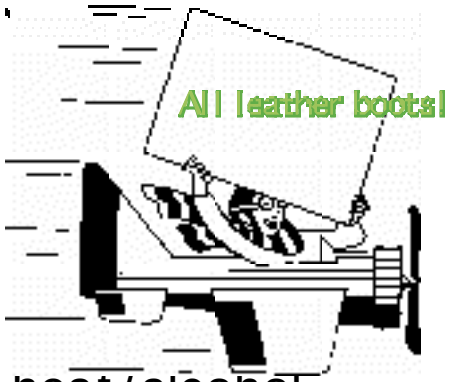
Looking down on the clouds, if your airplane's shadow has a "glory" around it, the clouds are wet. Conversely, looking towards the sun, a brilliant reflection of the sun (a "sub-sun") comes from ice crystals.

Inside the clouds, be alert for the first accumulations of ice- on the OAT probe, the wheelpants, the corners of the windshield, wherever it characteristically forms first.

If you encounter turbulence, check for ice.

Early detection gives you a head start on getting out of the ice. Change altitude?

Anti and de-ice is nice, but not a total panacea



Anti- ice equipment prevents ice-formation: pitot heat, prop heat/alcohol TKS...

De-ice equipment attempts to remove ice that has formed: ie boots

with boots, timing is important
cruise climb
clear ice, SCDD ice may form beyond the boots
they may takeout your vacuum system

Having boots doesn't (shouldn't) change the way you plan. It just improves your margin of error. If you really *needed* the boots, you screwed up!

Basic strategy:

Stay out of fights:

Plan to fly where the ice isn't.

Choose your battles:

Limit exposure to icing conditions to the times and places of your choice.

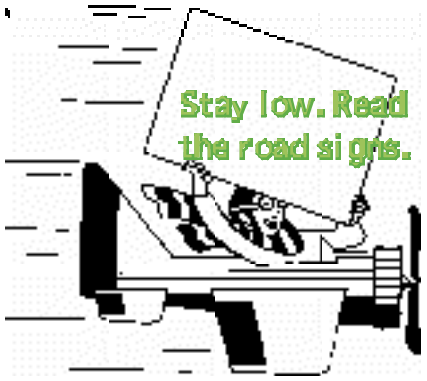
Be prepared for change:

Always have a plan B in case plan A doesn't pan out. Ice is fickle stuff.

Be suspicious of the data:

Where *is* the freezing level? Where is that front?

Enroute options: high road or low road?



The key questions are:

"Where is the freezing level relative to the MEA?"

"Where are the clouds and precip?"

These determine the possible options.

Stay below the freezing level.

Fly above the freezing level with the option of descending if ice is encountered.

Fly on-top or in clear air between layers.

Get high enough that it is "too cold" for ice.

Fly another route with lower MEAs and/or better weather?

Await a better day?

A turbocharger and O_2 is a near necessity in the mountainous West.

Most of your icing options involve having a wide choice of altitudes.

With minimal ROC available, you can carry very little ice.

The "on top" and "too cold" options may be completely out of reach.

IMO, here, a turbocharger is worth a lot more than boots. Without a turbcharger, brute power is worth more than a clean airframe.

Where *is* the freezing level?

Simple question... Hard to get a good answer!

Area forecasts are broad brush. Winds aloft forecasts are iffy, especially near fronts, where actual temperatures vary more rapidly.

PIREPs are worth looking at. I hope you report temperatures *accurately*!

Balloon soundings are excellent, but are sparsely distributed and are only performed at 12Z and 00Z.

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AIRMET ICE...WA OR CA ID MT NV
FROM YQL TO BZN TO PIH TO TWF TO ILC TO BTY TO BFL TO 30SW RNO TO
YDC TO YQL
LGT OCNL MOD RIME/MXD ICGICIP BTN FRZLVL AND FL200. FRZLVL 065
OVR WRN SXNS SLPG TO 120 OVR ERN SXNS. CONDS OVR WRN HALF AREA
SPRDG EWD AND SEWD OVR RMNDR AREA 02Z. CONDS CONTG BYD 02Z THRU
08Z.
.
FRZLVL...WA/OR...040-050 WRN SLPG TO 070-090 ERN
         CA...045-065 NRN CA
              055 N SLPG TO 090 SE OVR CNTRL CA
              100-130 SRN CA
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FT  3000    6000   9000    12000   18000   24000  30000  34000  39000
BIH      2816    2315+06 2221+01 2327-14 2534-25 264042 253853 233460
BLH 2815 2605+14 9900+08 2308+04 2616-10 2524-25 253041 252850 252858
FAT 3016 2611+09 2419+06 2325+00 2434-14 2543-25 264442 264252 243362
FOT 3116 2717-01 2428-05 2337-12 2355-24 2364-31 247044 246548 245448
ONT 3118 2906+13 2405+08 2610+04 2620-11 2723-25 263042 253451 243660
RBL 2911 2515+03 2328-01 2240-07 2357-19 2367-29 237244 236950 245654
SAC 2810 2415+05 2329+02 2338-03 2453-16 2462-27 246643 256451 255459
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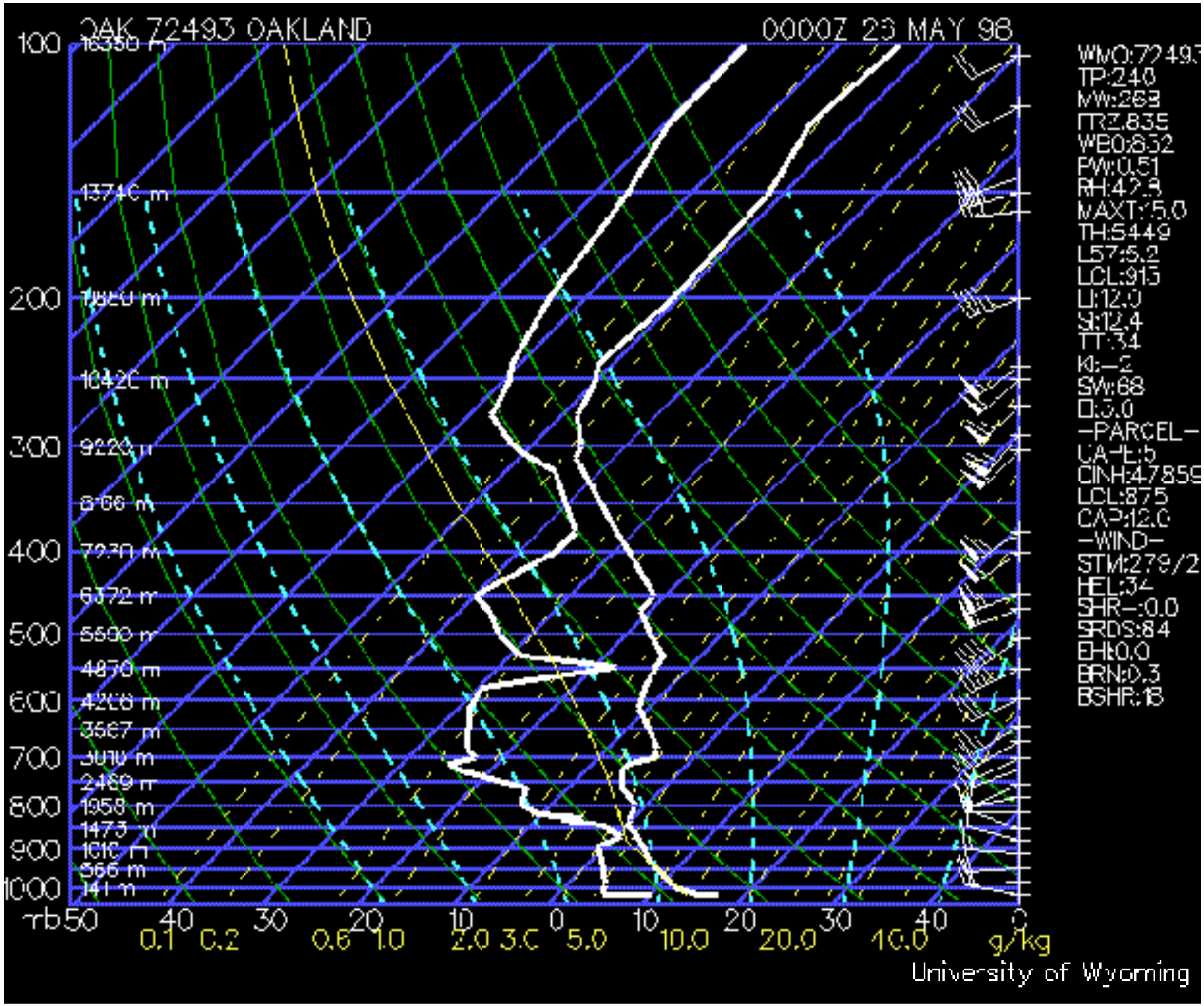
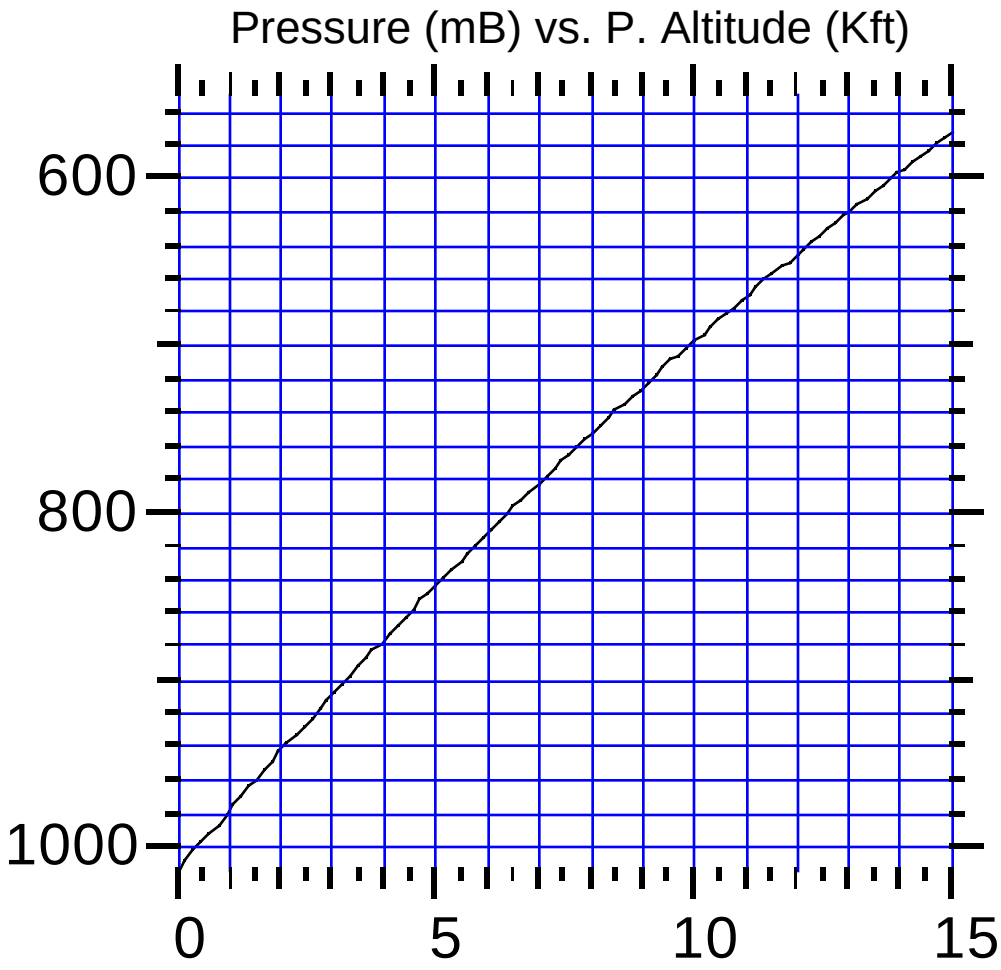
OAK Upper Air (Radiosonde Balloon) Sounding

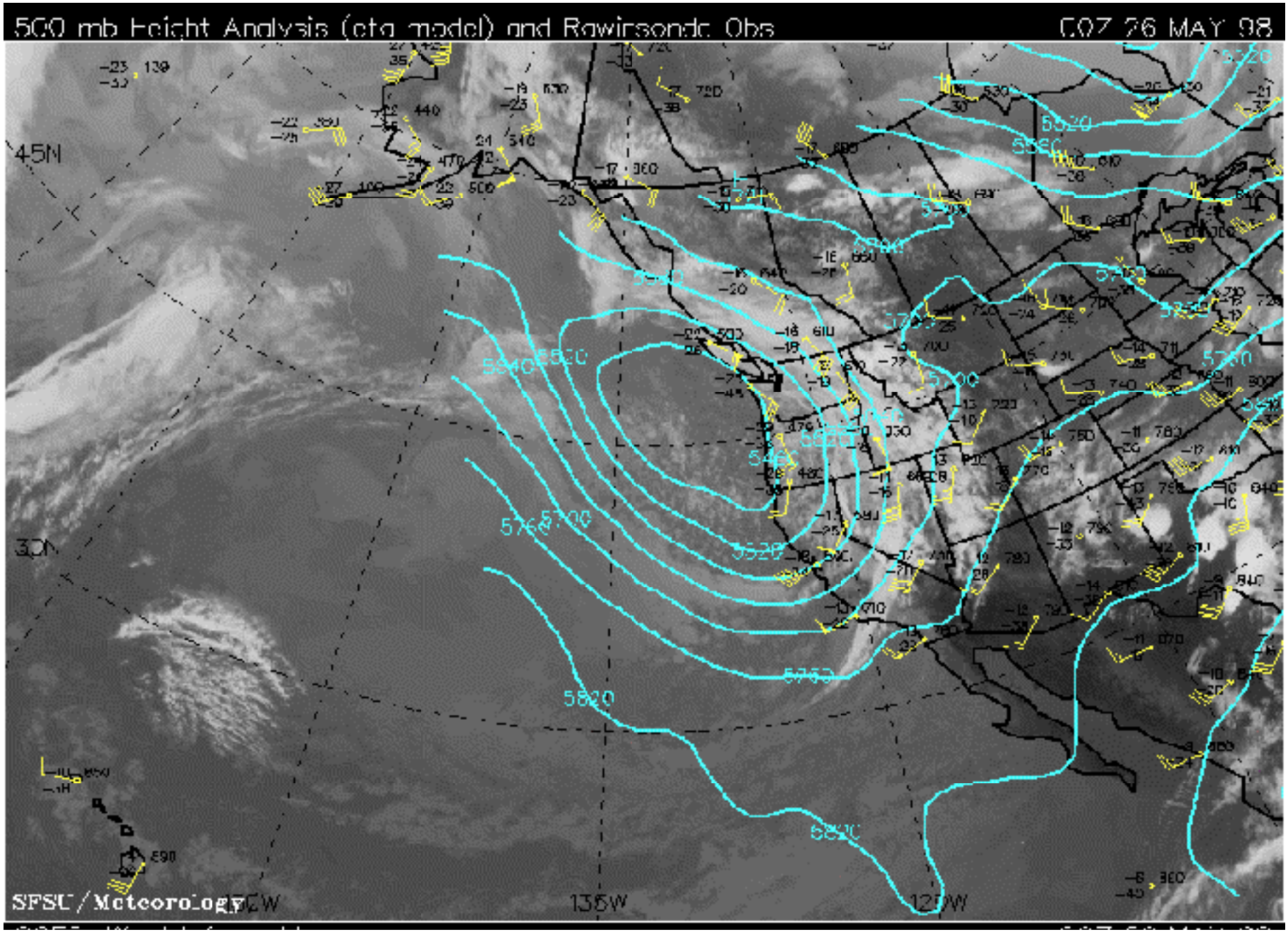


Freezing levels in mbar must be converted to pressure altitudes

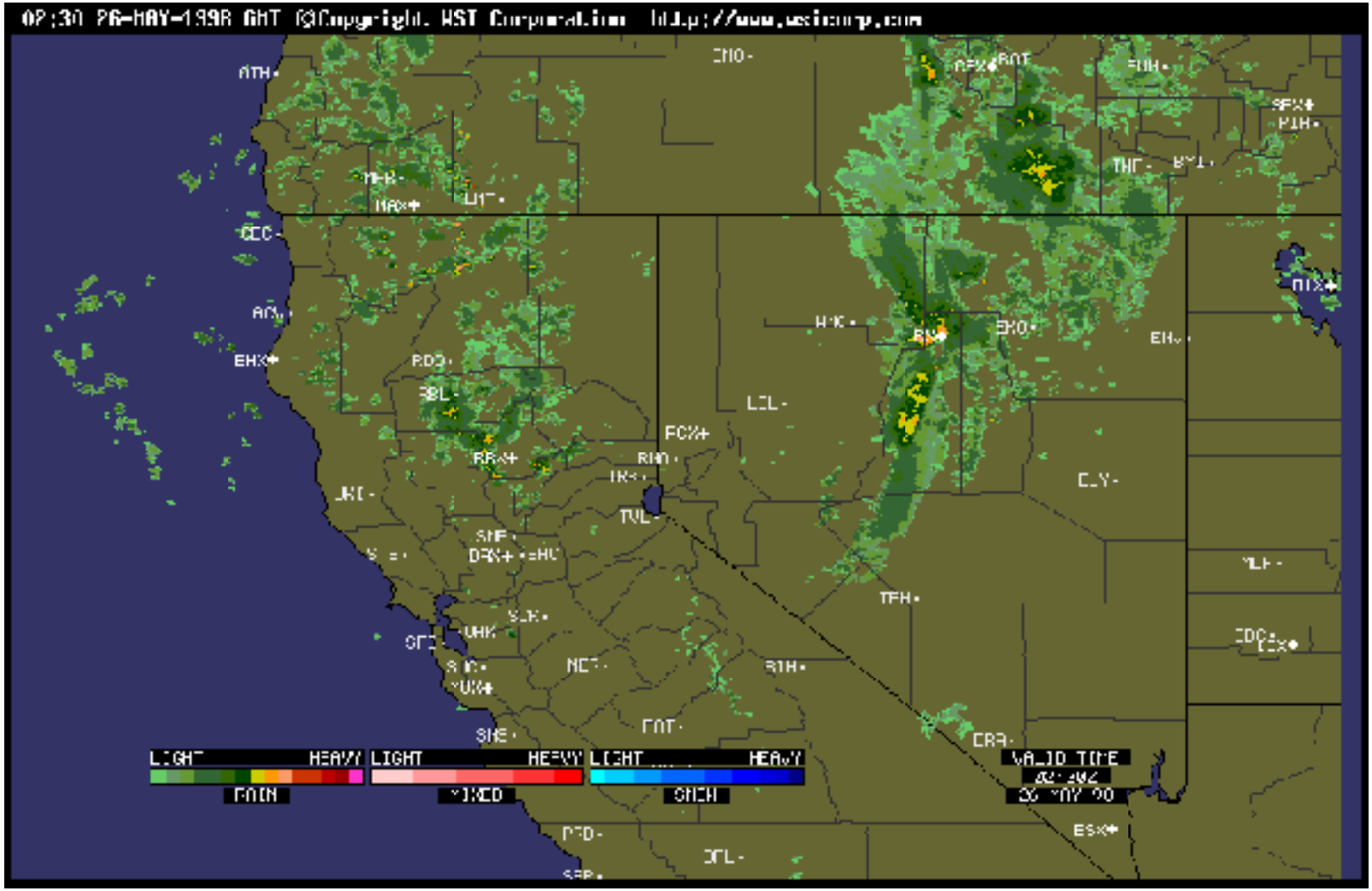


Palt	mbar
0	1013
1	977
2	942
3	908
4	875
5	843
6	811
7	781
8	752
9	724
10	696
11	670
12	644
13	619
14	595
15	571

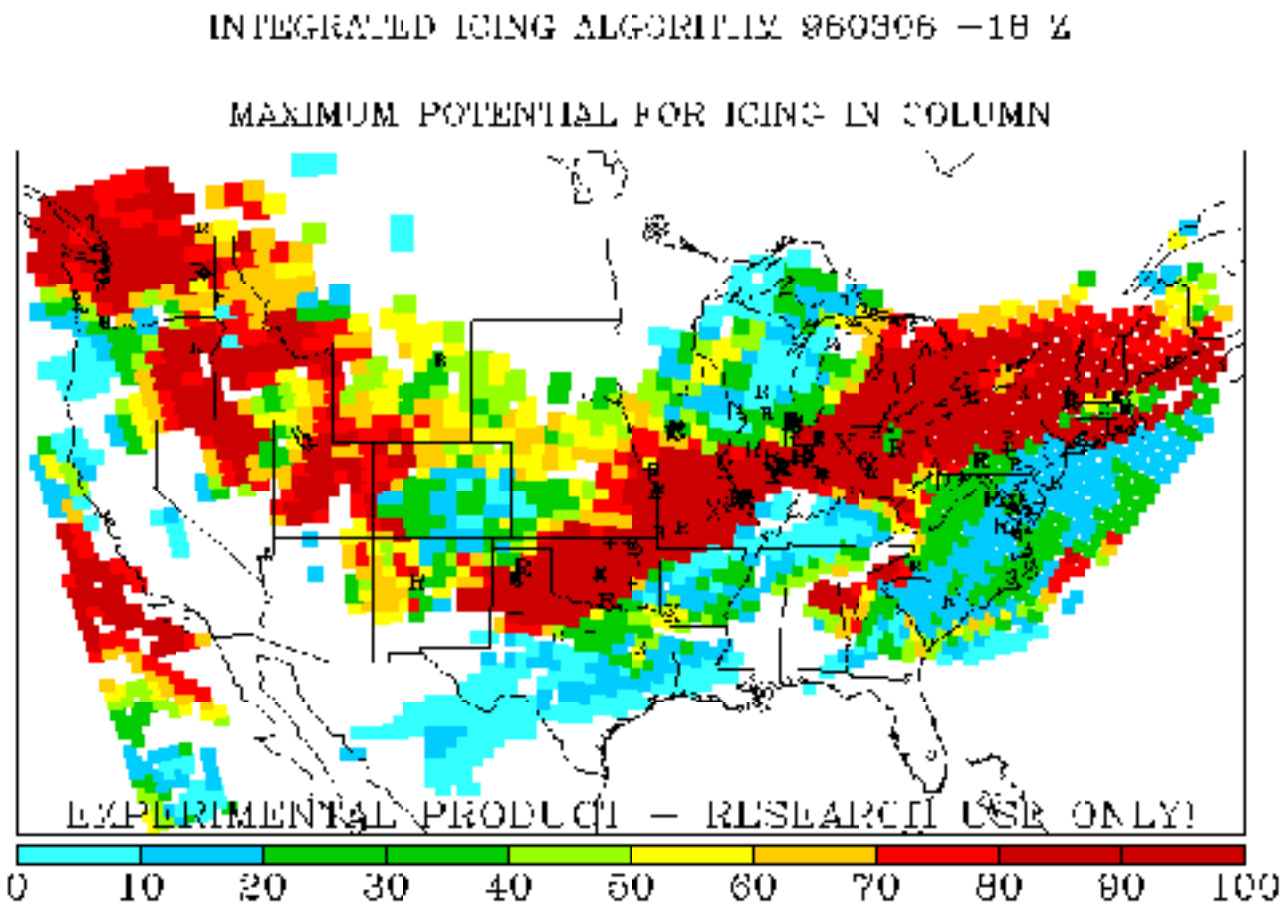
IR satellite plus 500mb RAOB observations



NEXRAD gives superb high-res precip images



NASA research may lead to more useful icing forecasts.



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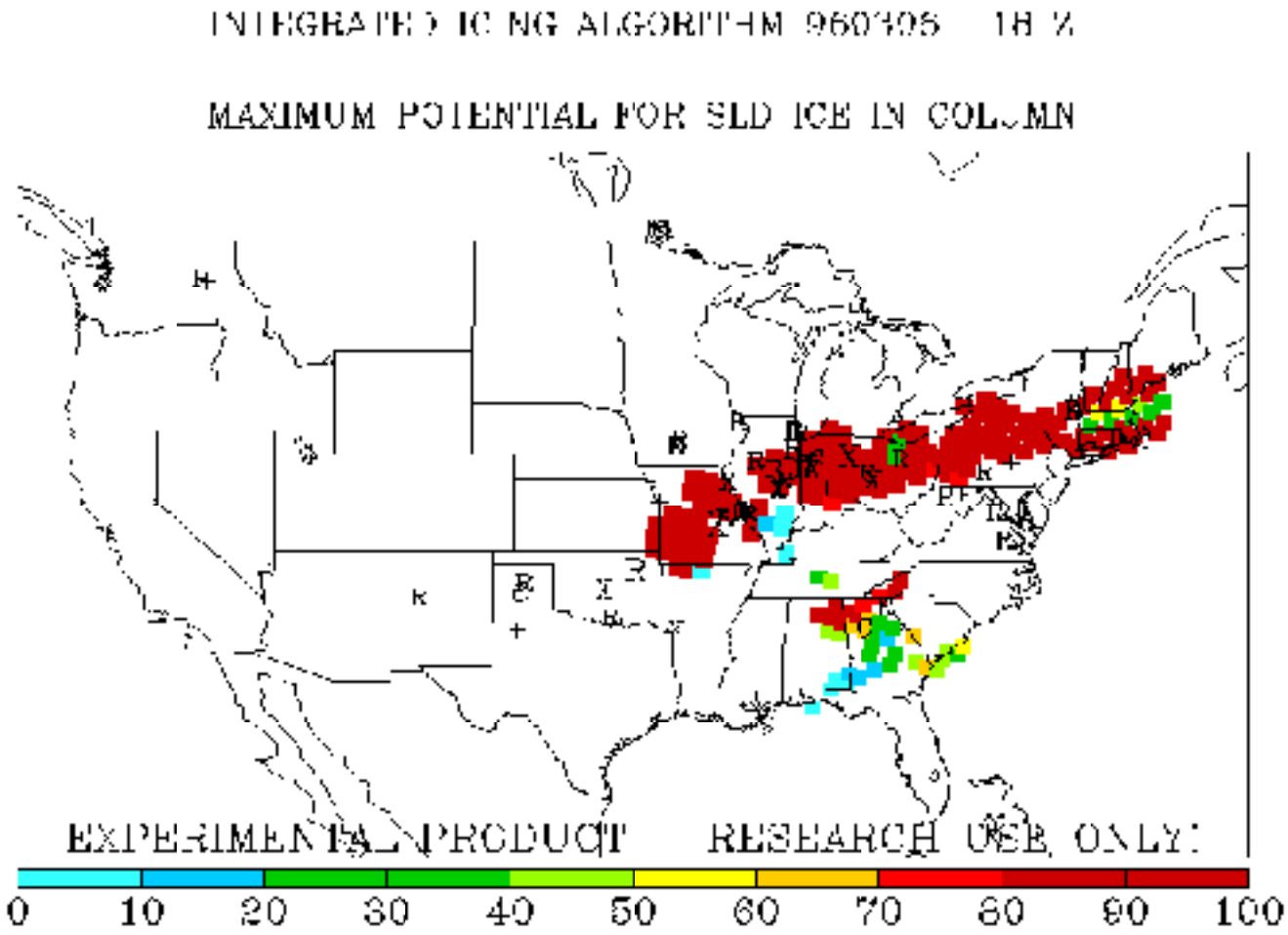
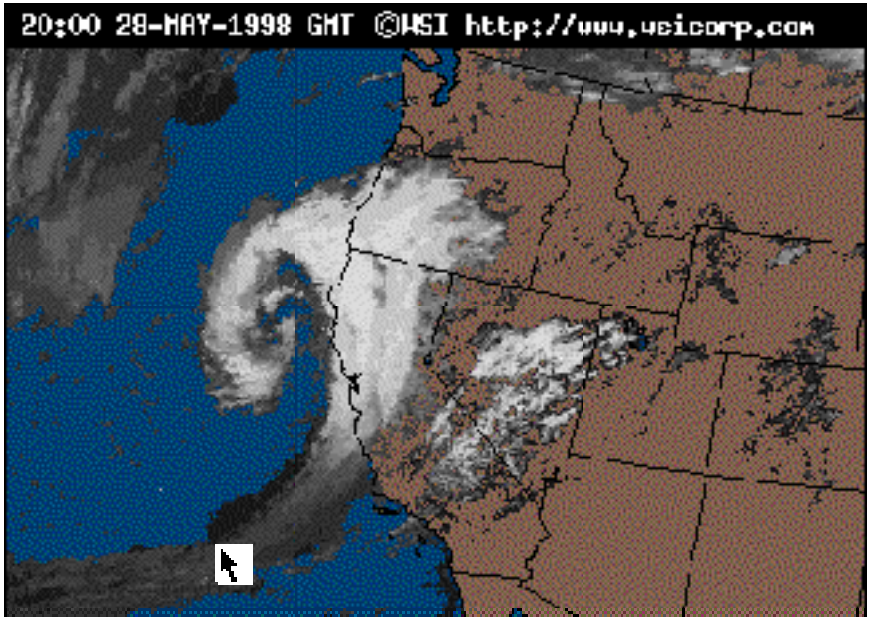


Area of ZR depicted.

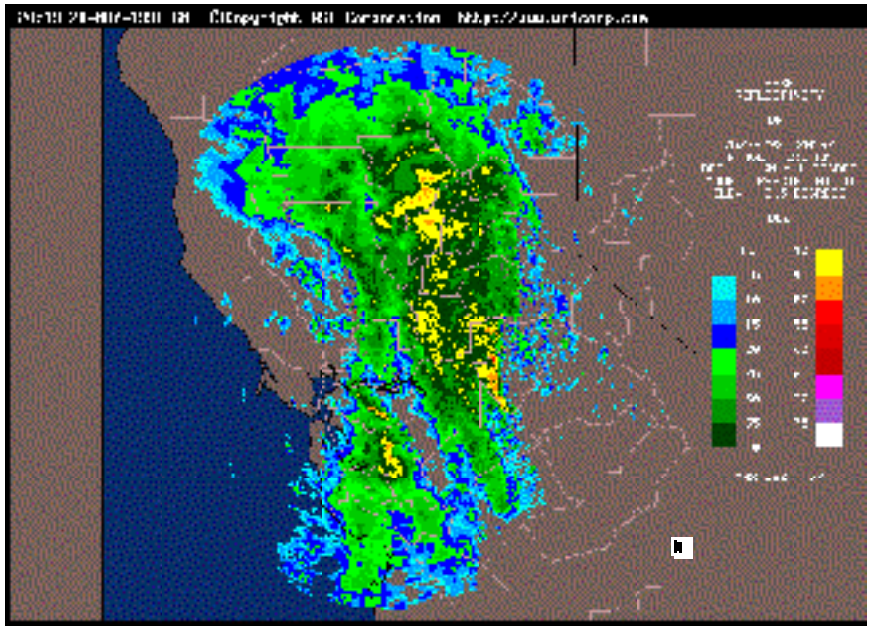
icing PIREPS superimposed

http://www.rap.ucar.edu/largedrop/

Big picture wx can be very clear via radar/satellite pix

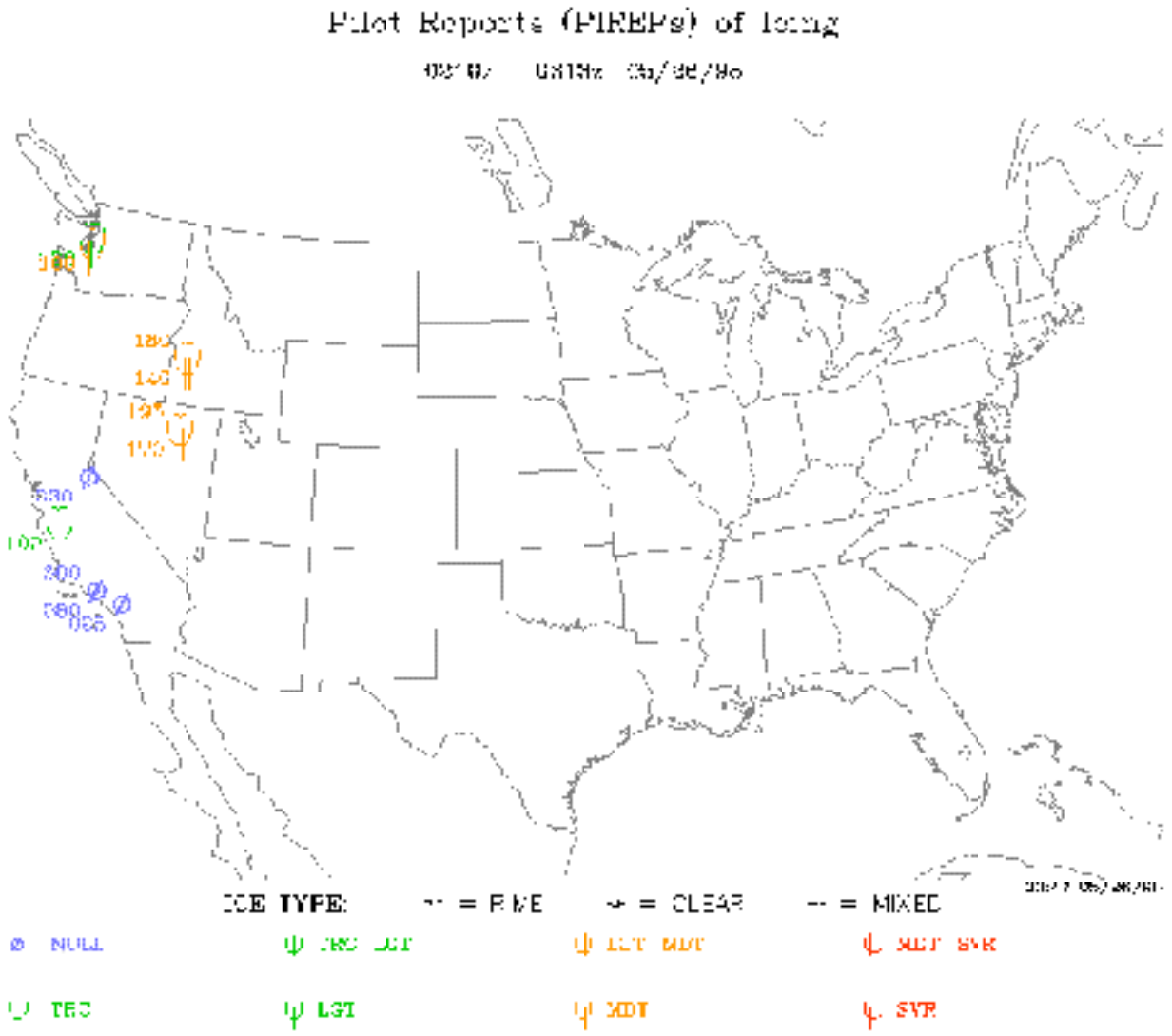


Visible Satellite



Sacramento Nexrad

Here are the icing PIREPS corresponding to the radar and satellite images:



smx98.23.cv5

http://www.rap.ucar.edu/largedrop/pireps_IC.gif

The low road- beneath the freezing level.

If it works, it is flawless- but it can fail spectacularly.

PRO

Indisputably legal
Ice free.

CON

ATC may not want you at the MEA.
In a marginal case, it's difficult to get accurate enough ZL info.
If you get squeezed between the MEA and the ZL, you are in a box canyon.
Can't go down. Going up takes you through the entire layer over the worst terrain.
Turning around might the only viable option.

TIPS

With rising MEAs, get to your cruise altitude in advance.
Are you flying towards warmer air?

The high road- on top, or between layers.

PRO

Ice free.
In the sunshine, accumulated ice will eventually sublimate.
Greater radius of action.
Stored energy is insurance.
Favorable winds.

CON

You have to get up and down!
Top reports may be unavailable. Solicit them.
Tops rise and layers merge approaching fronts.
Tops rise over higher terrain.
Cloud tops are icy- don't skim!
Unfavorable winds.

TIPS

Don't forget your O2

In the clouds, "too cold" for ice.

PRO

Last resort if the other options look worse.

CON

No guarantees. Have to continuously track alternatives.
Even light icing can become a problem over time.
Problematic if there are Cu buildups you can't avoid.

TIPS

Higher is better.
Climb while you can.
  Colder -> lower icing probability
  Higher -> greater drift-down radius of action.
< -10C generally sufficient in normal stratus
< -20C in normal Cu, but in TRWs bets are off.
Icing less likely if it is snowing
Icing less likely if the cloud bases are colder than -5C.

Don't just close your eyes, be decisive!

If you encounter icing in cruise, you can rarely afford to ignore it.
You should normally do something constructive:

- Climb
- Descend
- Turn back
- Divert

You should have this plan in mind *before* the ice forms.

Descending to warmer air is an option only if you are *certain* that is above freezing.

If in doubt, climb.

Arrival

Think twice if there's a chance you could miss the approach. It may be safer to divert to an airport with better weather.

If there are traffic delays, negotiate to take them up high. You don't want to hold down in the icing levels.

If the freezing level is below the freezing level, delay descent and use higher approach speeds and rates of descent to minimize ice exposure.
Leave the flaps up, and keep your speed up if you are heavily iced. This is not compatible with short runways!

If the freezing level is high enough, get an early descent to below the freezing level. It may take a few minutes to shed an ice accumulation.

Departure

The big decision is whether to depart or to delay/abandon your trip.

Think very carefully if you cannot return to your departure point.

Solicit PIREPs. Look for guinea pigs in the pilot lounge!

The greatest exposure is while climbing through the icing levels. Try to get an unrestricted climb.

Choose your battlefield carefully:

- Stay close to the IAF to facilitate a return? Have the approach plate ready and briefed.
- Stay over low terrain.
- Maybe a VFR climb is possible, with IFR pickup at altitude?

Watch your OAT on the climb. You'll want to know where the ZLevel is.

Some parting thoughts

Get a good briefing before you launch. Once in the air, keep track of the weather. Monitor ATIS's, check with Flight Watch, have ATC solicit PIREPs if you need them. (tops, temperatures, conditions)

When the weather is marginal, you have to take your flight one leg at a time.

Keep track of your potential diversion airports- wx, approach in use, minimums. You need to be spring-loaded to divert if conditions are not as planned. This is hard work for new IFR pilots.

The golden rules of ice flying:

Never fly where the icing could be severe.
Minimise exposure.
Pick your battlefields.
ALWAYS HAVE AN OUT.

Be conservative. The weather has no respect for ratings or hours.
Remember Hale Boggs.