Progress toward a volumetric in-flight icing hazard system for airports which incorporates operational dual-polarization S-band radars

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Outline

In-flight Icing
- Background
- Ground-based remote sensing
- 2010/2011 Field Campaign
- Polarized S-band Icing Detection Algorithm

Study goals

Algorithm with operational radar data
- February 25th, 2012 case
- Multiple case statistics

Proposed merged algorithm

Summary

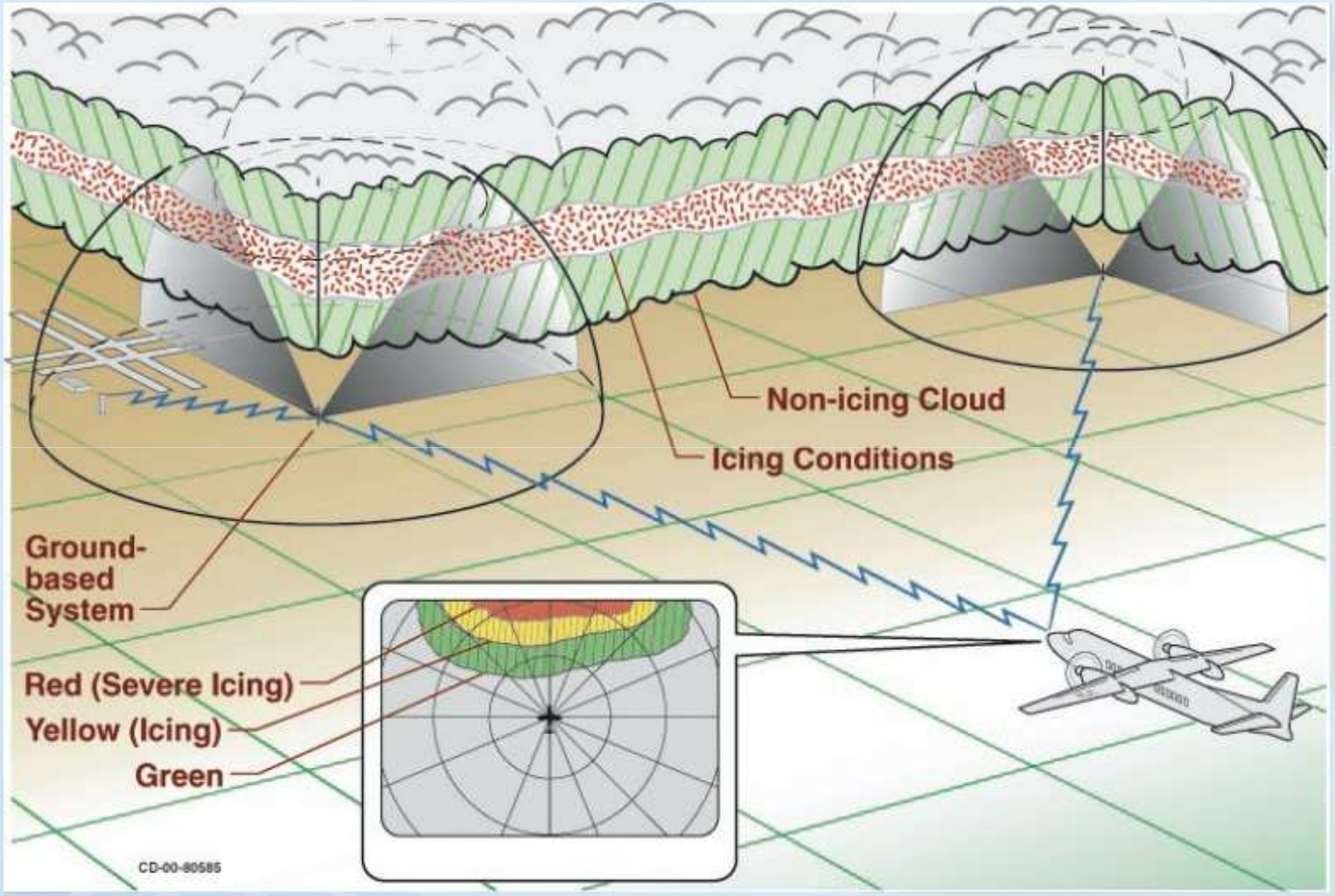
Future Work

In-flight Icing Background

- Super-cooled liquid water (SLW) instantly freezes to leading edges of aircraft
- Changes the lift and drag characteristics
- Contributing factor to many ‘uncontrolled descents’

> FAA, airlines and science partners interested in SLW detection

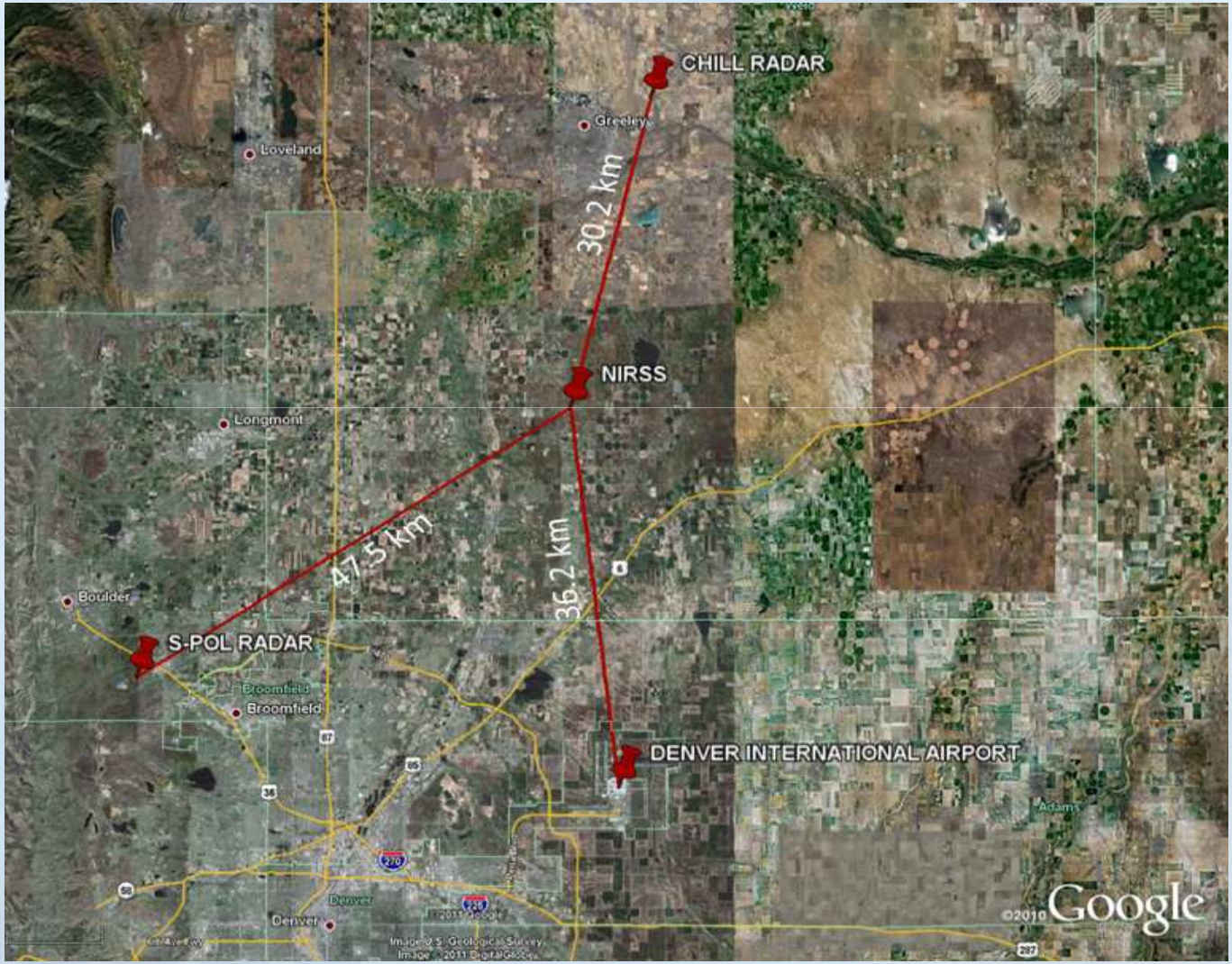
Ground-based remote sensing goal:



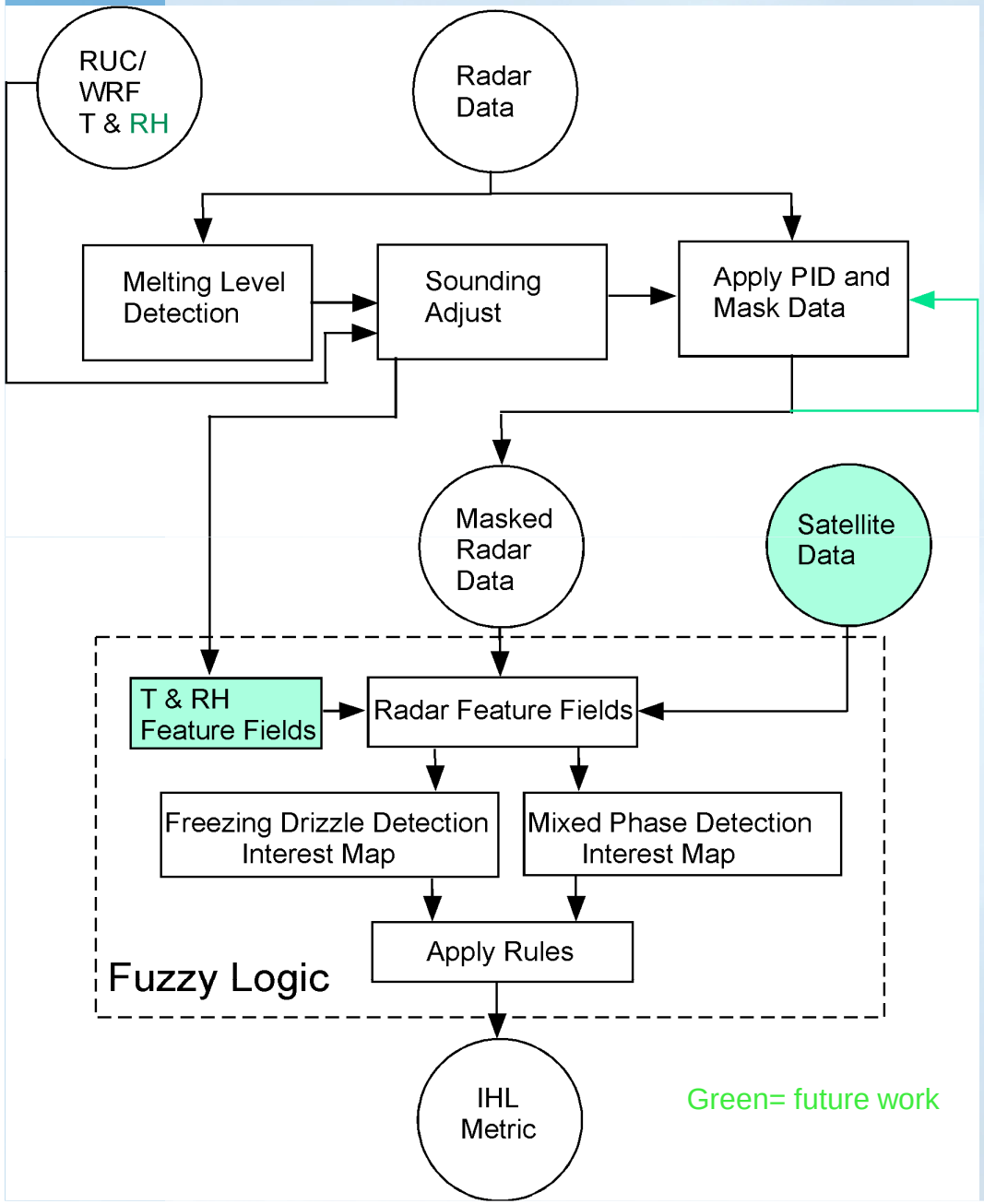
Field Campaign:
'NASA Icing Remote Sensing System'

NCAR

Field Campaign: Siting

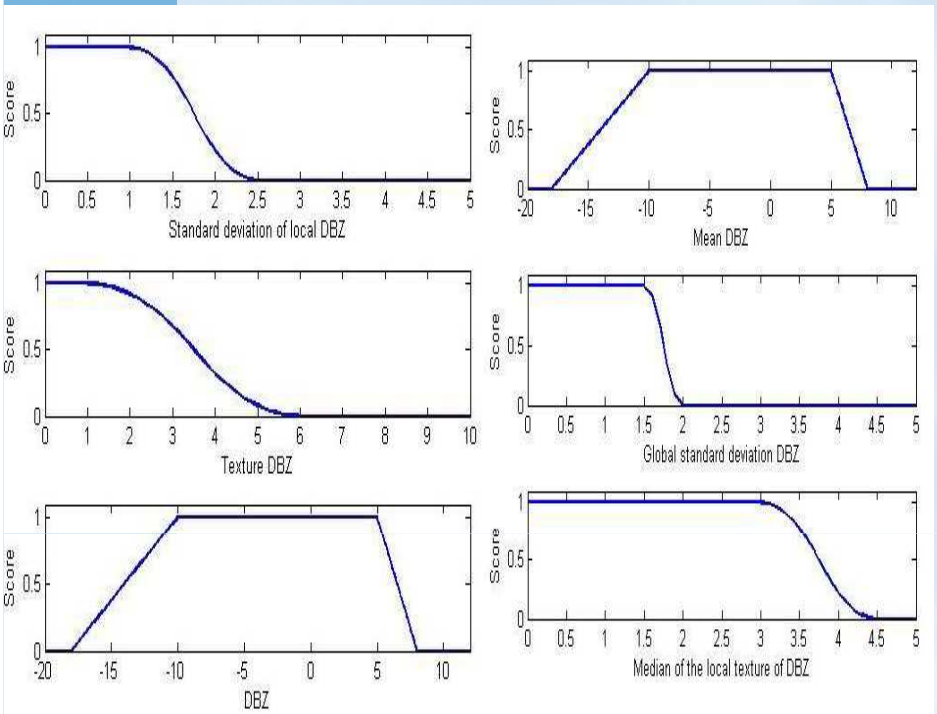


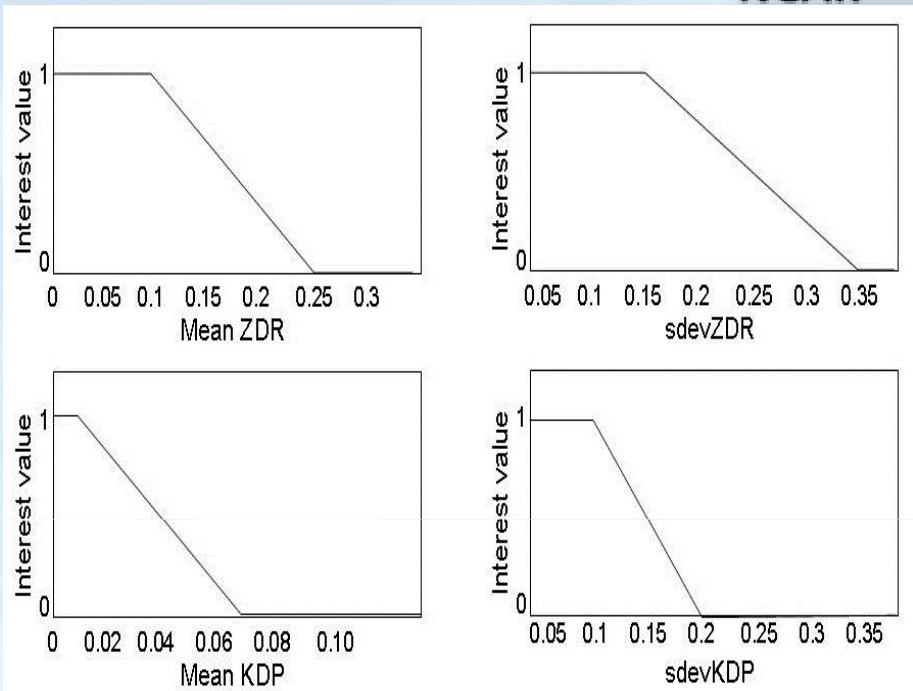
Brief 'Icing Hazard Level' (IHL) Overview



- Icing detection with radar difficult
  - * SLW overlaps with ice
  - * ice dominates mixed phase
  - > dual-pol gate-by-gate values not enough
- Spatial statistical properties?
  - * FRZDRZ detect Ikeda et al. (2009)
  - * MIXPHA detect Plummer et al (2010)
- Results with research radars (Ellis et al. 2012 ERAD poster)
- Realtime, modular and stand-alone
- Tested versus pilot reports and results from prototype NASA Icing Remote Sensing System

Brief IHL Overview (continued)





Membership functions....

for FRZDRZ (Ikeda et al., 2008)

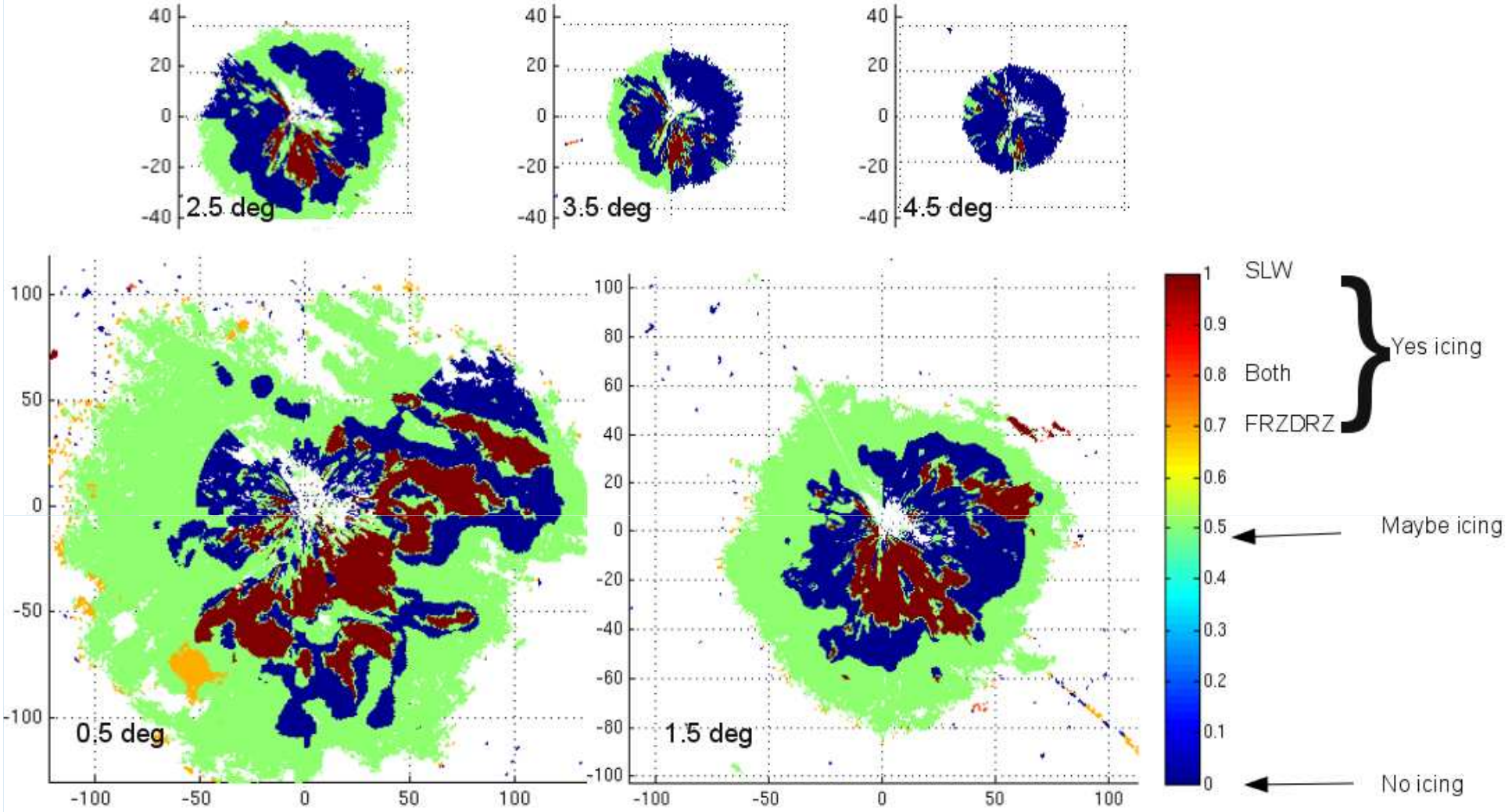
for SLWA (Plummer et al., 2010)

Category Name	Description	Value	IHL Icing
High SLW	SLWA output >0.55	1.0	Yes
High FZDZ	FRZDRZA output >0.70	0.7	Yes
Both high	Category 1 and 2 apply	0.8	Yes
Both low	SLWA and FRZDRZA output both <0.45	0.0	No
Below SNR	When mean dBZ < -31 dBZ	-0.1	Unknown
Both medium	Not categories 1 through 5	0.5	Maybe

Goals

1. Test whether IHL output with OPERATIONAL polarized S-band network seems reasonable
2. Learn strengths and shortcomings of such a product
3. Begin building conceptual model for polarized radar/radiometer based in-flight icing hazard detection product

Case Study: February 25th, 2012



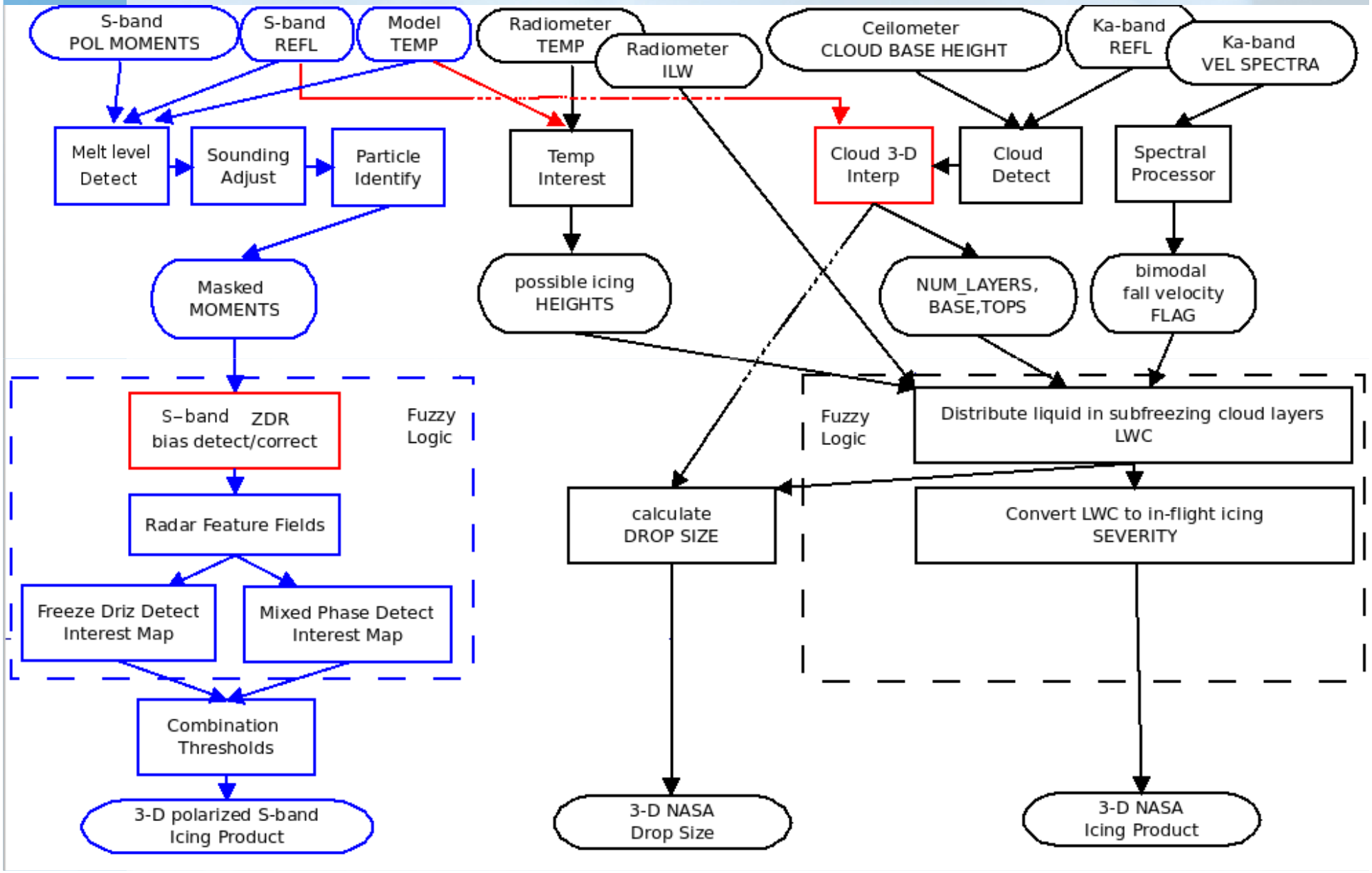
- Several 'moderate severity' pilot reports at this time
- Operational polarized S-band algo seems to work
- Need to recognize/flag/compensate for canted ice particle cross-coupling (as in Hubbert et al, 2010 part 1 and 2)

Multiple case statistics

PIREP Icing Severity	Number of Cases	Icing Warning Category 'maybe'	'no'	'yes'	FRZDRZ	SLW	Both
'MOD or greater'	4	51.4%	18.8%	29.8%	9.2%	86.8%	4.0%
'NULL'	3	57.9%	31.2%	10.9%	62.3%	18.4%	19.3%

- Significantly more mean volumetric area warned as 'yes' when moderate or greater PIREPs present
- This study needs expansion to more cases, focus on quadrants instead of full volumes
- Membership functions need tuning for operational radars.... possibly especially for FRZDRZ algorithm

Proposed NIRSS & polarized S-band algorithm



Summary

- NIRSS does well at all types of in-flight icing, but is vertically pointing → need volumetric capability
- Polarized S-band algo. with research radars does well detecting MOST in-flight icing → misses small drop cases

- Same algo. with operational S-band also appears workable → needs tuning, needs mitigation for canted particles

- Optimal solution? Merge NIRSS and S-band icing algos
  - interpolate volumetric cloud layers from S to K-bands
  - independent volumetric in-flight icing measures made

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Future Work

Explore 'High ZDR' module development as per Ellis et al. (ERAD 2012)

Future work with Anasphere Inc. SLW balloonsonde probes

Coding effort to encorporate realtime spectral processing

Continue conversion to airport volumetric coverage with NIRSS

Thank You!

Questions?