NASA Icing Remote Sensing

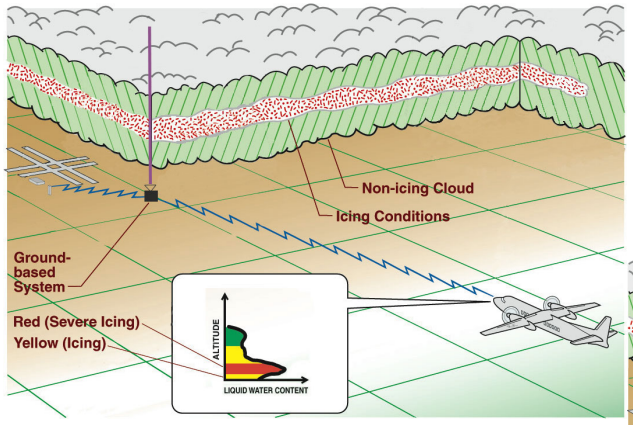
Andy Reehorst (GRC)

Topics

1. Goals
2. Past Achievements
3. Current Status
4. Planned Testing

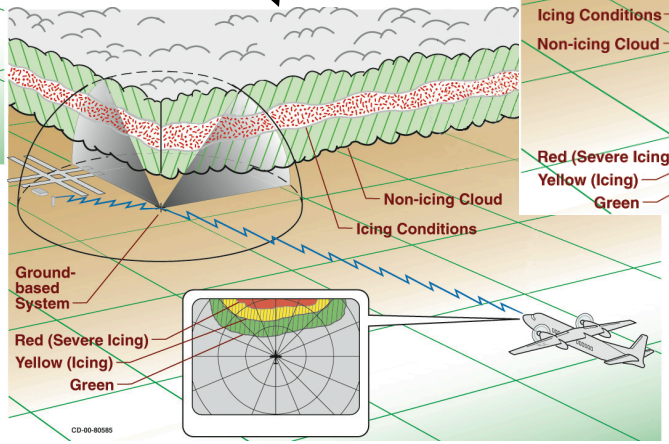
1. Goals

Develop technologies that will enable terminal area sensing and airborne sensing. Implement through incremental development starting at ground-based vertical staring.

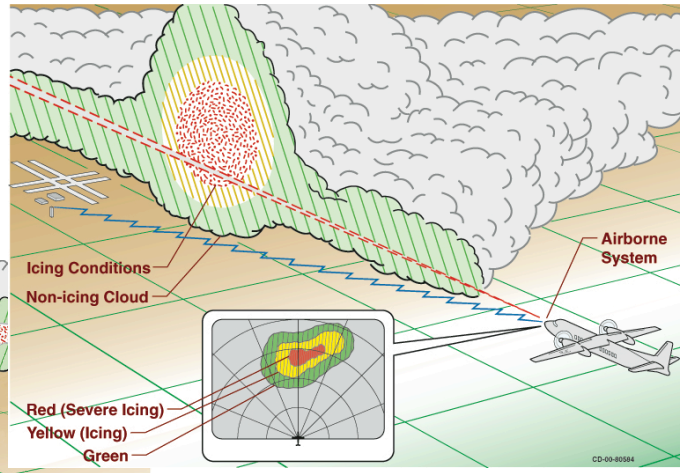


Current Capability

Current Focus



Ground-based goal

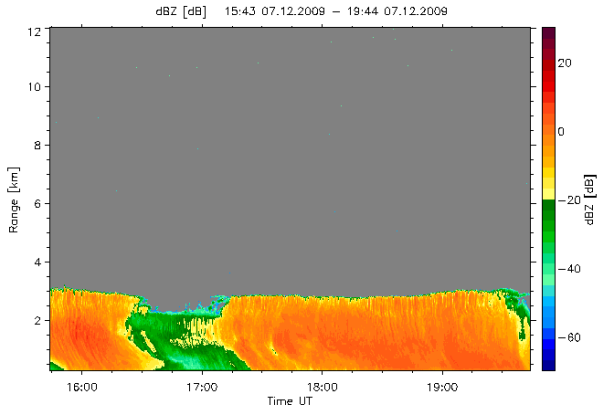


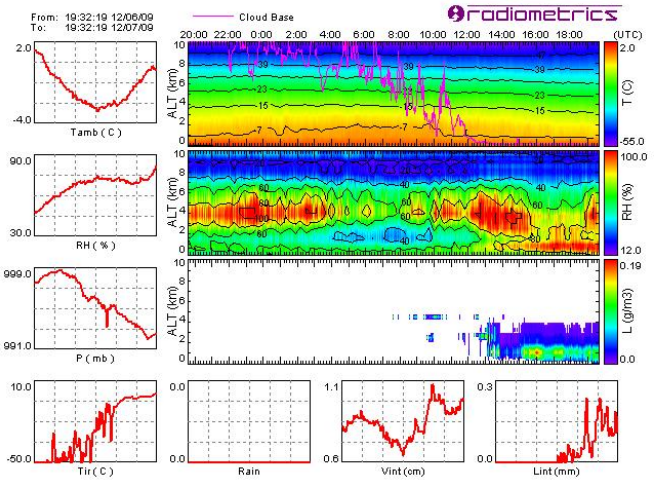
Airborne goal

2. Past Achievements

2.1 Vertical pointing Icing R-S

- NASA Icing Remote Sensing System (NIRSS) Technologies
  - Radar
    - Provides cloud boundaries
  - Multi-frequency Microwave Radiometer
    - Provides Temperature Profile
    - Provides Integrated Water Content
  - Ceilometer
    - Refines cloud base boundary

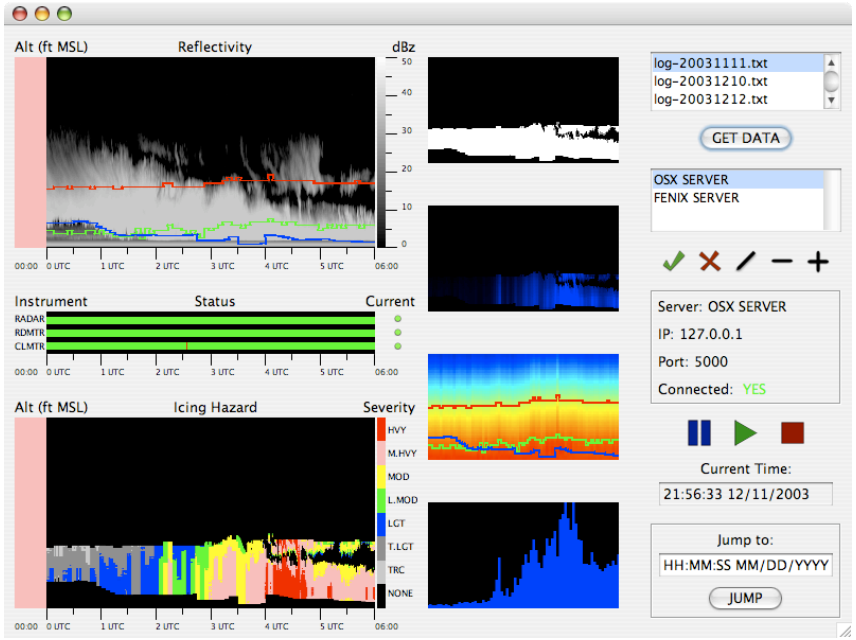




2.2 NIRSS algorithm

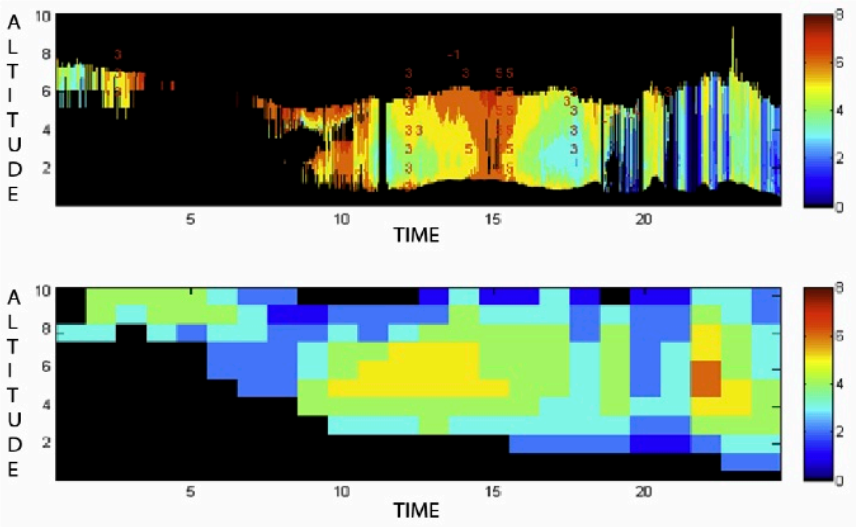
Simplified NIRSS algorithm:

- Radar provides cloud profile
- Radiometer provides temperature profile
- Radiometer provides integrated liquid water path
- Distribute liquid water over cloud extent for LWC
- Derive droplet size
  - Reflectivity is a function of both cloud droplet size and liquid water content
  - Can do this because our water content and radar reflectivity are independent measurements
- Use temperature, water content, droplet size to determine icing hazard



2.3 NIRSS Assessment

- Recent comparison of NIRSS and CIP relative to PIREPS
  - Based upon 3 years of NIRSS data (operating at GRC)



Altitude/Time plots of NIRSS (top), PiReps (top, red numbers), and CIP (bottom)
Note the larger warning band for CIP

	N vs. P	C vs. P
POD_y	0.78	0.90
POD_n	0.71	0.29

NIRSS (left) and CIP (right) Probability of Detection (POD) (positive and negative) compared to PIREPS.

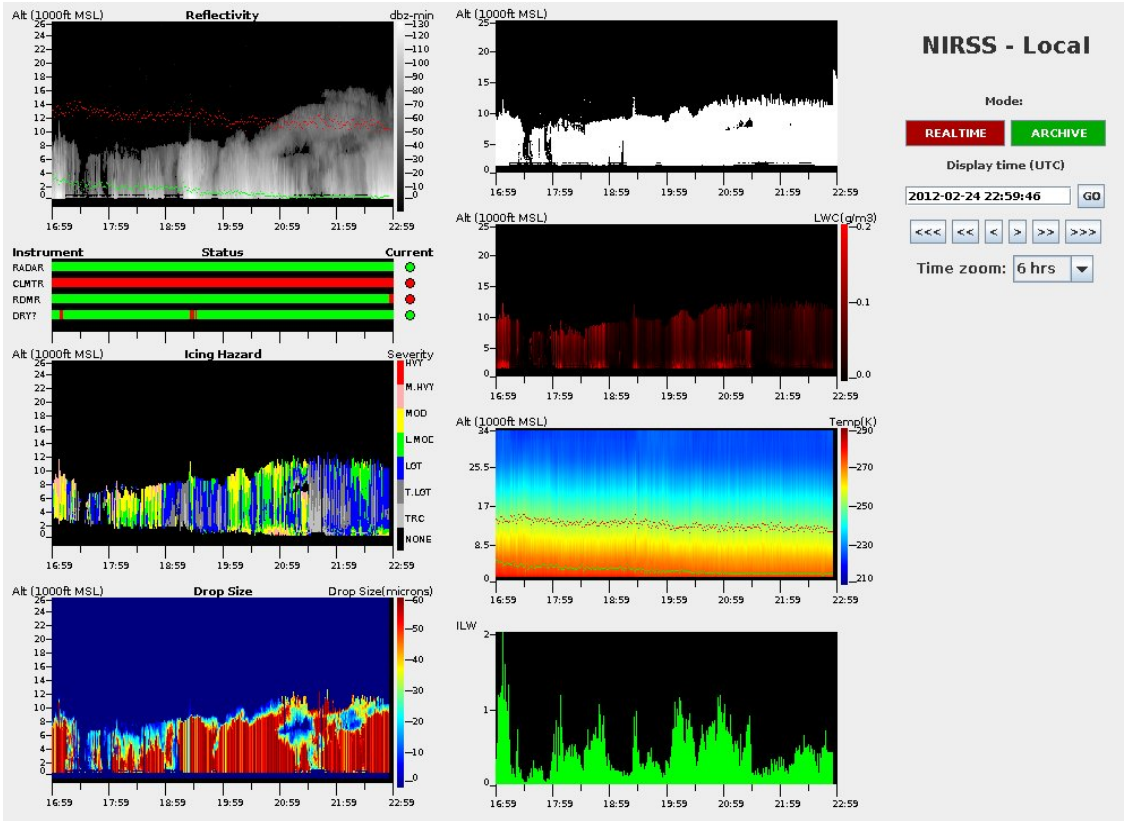
"NIRSS detected almost 80% of positive PIREPs and over 70% of negative PIREPs in a relatively smaller warning volume. CIP detected slightly more positive PIREPs than NIRSS but did fairly poor in detecting negative PIREPs."
From: Johnston, C.J., et al, "Comparison of In-Situ, Model and Ground-Based Inflight Icing Severity", NASA /TM-2011-217141, Dec 2011.

3. Current Status

3.1 Ground-based Systems

Revised NIRSS software/display

Algorithms and display modified to output an equivalent cloud droplet size based on calculated LWC and reflectivity.



Narrow-beam Radiometer Development

NASA Narrow-beam Multi-frequency Microwave Radiometer (NNMMR)

Developed by Radiometrics, Inc. of Boulder, CO under an SBIR and Aviation Safety Program funding

OBJECTIVE

- Beam widths matched with NOAA's NEXRAD weather radars.
- Using recently derived algorithms from Dr. Ulrich Lohnert from the University of Cologne, can measure integrated liquid water.
- Elevation and azimuth scanning capability provides potential for terminal area icing detection and warning.

ACCOMPLISHMENTS

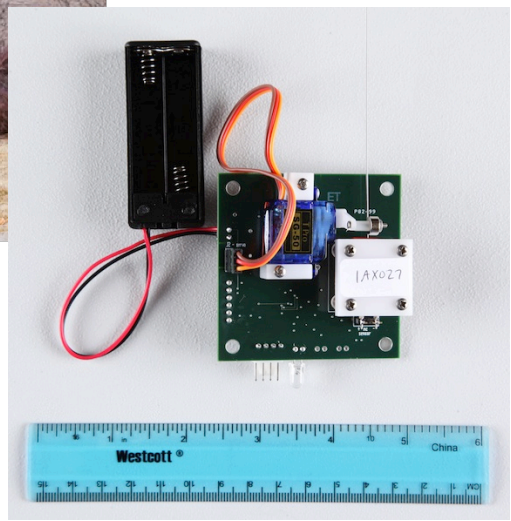
- System fabrication completed summer 2009
- Field test assessment performed cooperatively with NCAR at CSU radar site in Greeley CO - summer 2009.
- Operational assessment located at NASA GRC, 2010-11
- Positioner and beam alignment mod, 2012
- System reinstalled at NASA GRC for winter checkout

TECHNICAL SPECIFICATIONS

Freq/Channels: 21 in Ka-band (22-30 GHz)
2 in W-band (89V, 89H GHz)
Antenna Beam: 1˚

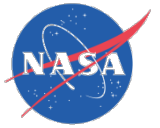
3.2 Radiosonde Instrumentation

- Desired to have an alternative to aircraft for in-situ calibration/ validation
- Anasphere, Inc, of Bozeman, MT developed SLWC sonde with SBIR and Aviation Safety Program funding.
- Phase I version tested by NCAR/ NOAA/Radiometrics team in Feb/ Mar 2012
- Current version development completed in November 2012
  - Hardware redesign
  - Preliminary calibration
  - Delivered 40 to NASA
- NASA procuring InterMet sonde system



4. Planned Testing

- NASA is defining a new flight campaign to support Icing Remote Sensing.
- NASA's Icing Remote Sensing activity needs detailed, accurate in-situ data for development/ calibration/validation of ground-based systems.
- Our Remote Sensing needs can be satisfied with a limited duration flight test with the NASA Twin Otter
- Targeting Winter of 2014-15
- Specific dates and flight hours YTBD



Twin Otter Test Scope

- Plans include operations from and in the area of Cleveland Hopkins airport (CLE).
  - NASA's GRC is located at CLE
  - CLE has an updated (dual polarization) NEXRAD system
- Instrumentation needs satisfied by AIRS II-type equipage.
  - Expect an updated suite of similar instruments
  - Require: LWC, droplet sizing spectra , temperature, humidity, 4-D position/time
- Flight maneuvers will likely include:
  - terminal area transects (constant heading/altitude overhead passes at multiple altitudes)
  - climbing or descending spirals
  - missed approach (low altitude) passes.

Currently planned primary Twin Otter instruments

PMS OAP-2DGrey	Particle Sizing 15-960 μm
PMS FSSP-100	Particle Sizing 3-45 μm
SEA WCM	Liquid Water Content
Edgetech Vigilanet 137	Dewpoint
Rosemount 871FA2188	Ice Detector
Aero Service Pitot/Static w/ Rosemount Transducer	Air Speed/ Altitude
Rosemount OAT	Air Temperature
Garmin 430	Position
SEA M300	Data System

Radiosonde System

- Anasphere SLWC Sonde Sensor
  (40 in-hand)

- InterMet iMet-3150 Ground Station
- InterMet iMet-1-RSB Sondes
  (20 ordered)