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The Power of a Gap-filling Weather Radar Network

New Observation Methods
Spring 2023 Friends & Partners in Aviation Weather
Kansas City, MO, May 16, 2023

Goals for Today's Discussion

01 Need for Improved Low-Altitude Weather Radar Coverage

02 Climavision's Proprietary Weather Radar Network

03 Impacts and Use Cases in Aviation

04 Discussion

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01
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Need for Improved Low-altitude Weather Radar Coverage

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Weather Radar is a critical tool for Aviation Safety

Role of weather radar in Aviation

- Real-time up to date information on storms
- Volumetric coverage
  - Airports
  - Routes
  - Flight altitudes

- Rain intensity, visibility and turbulence
- Presence of hail
- Snow & Icing
- Downbursts
- Volcanic ash, wildfires, smoke

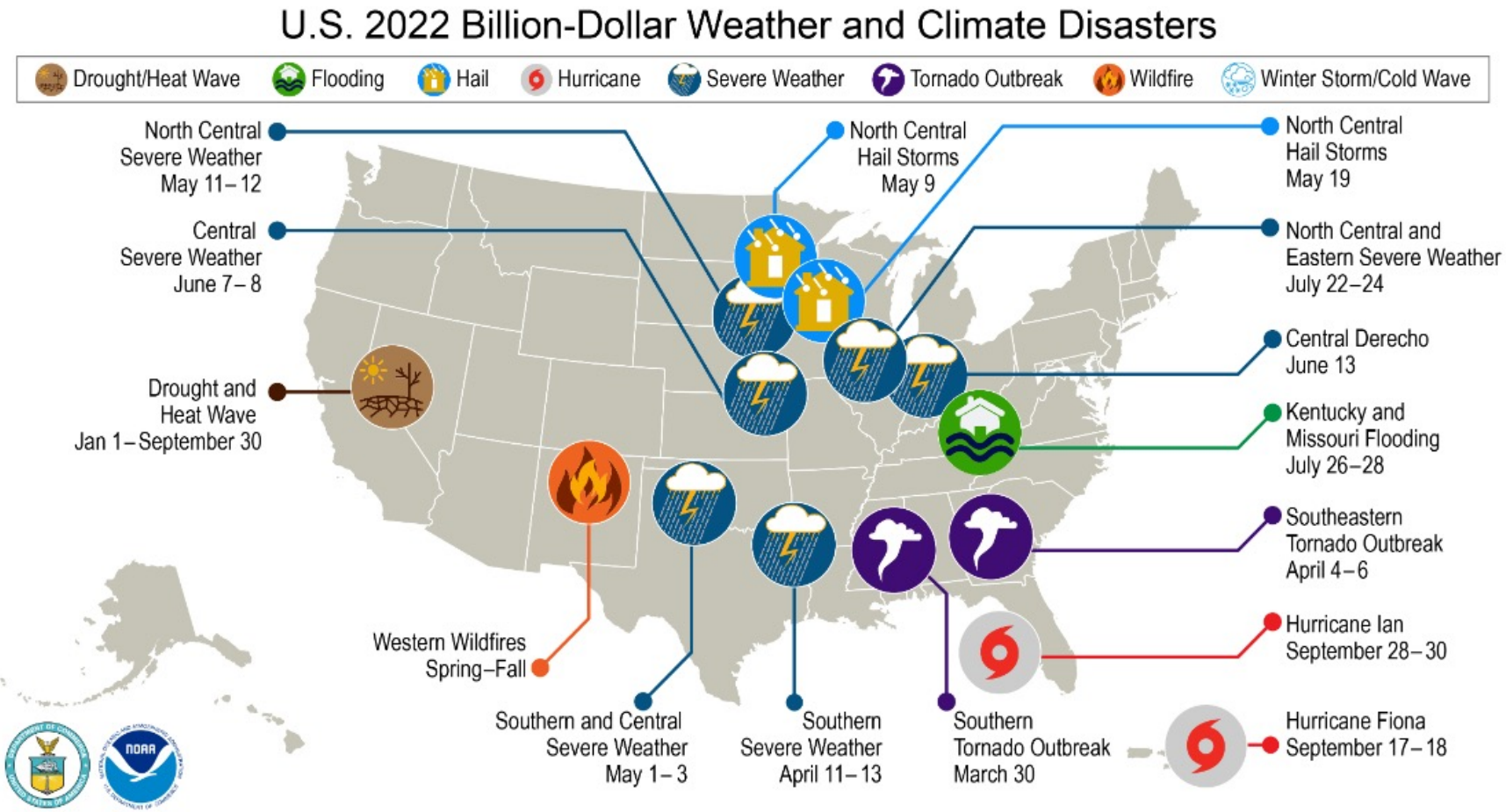
- Informs weather forecasts

Weather radars used in Aviation

- Cockpit radars
  (when equipped)
- Terminal Doppler Weather Radars
- Air Traffic Radars with weather capability
  (ASRs, ARSRs)
- NEXRAD network

Billion-Dollar Weather & Climate Disasters

US 2022



*This map denotes the approximate location for each of the **15 separate billion-dollar weather and climate disasters that impacted the United States January – September of 2022.***

$165.1B+

2022 DISASTERS PRICE TAG

3RD

COSTLIEST YEAR ON RECORD

$100B Cost

REACHED IN 5 OF THE LAST 6 YEARS (2019 THE EXCEPTION)

Cat 4 or 5

KEY COST DRIVER IS MAJOR LANDFALLING HURRICANES

Harvey, Irma, Maria, Michael, Laura, Ida, and Ian.

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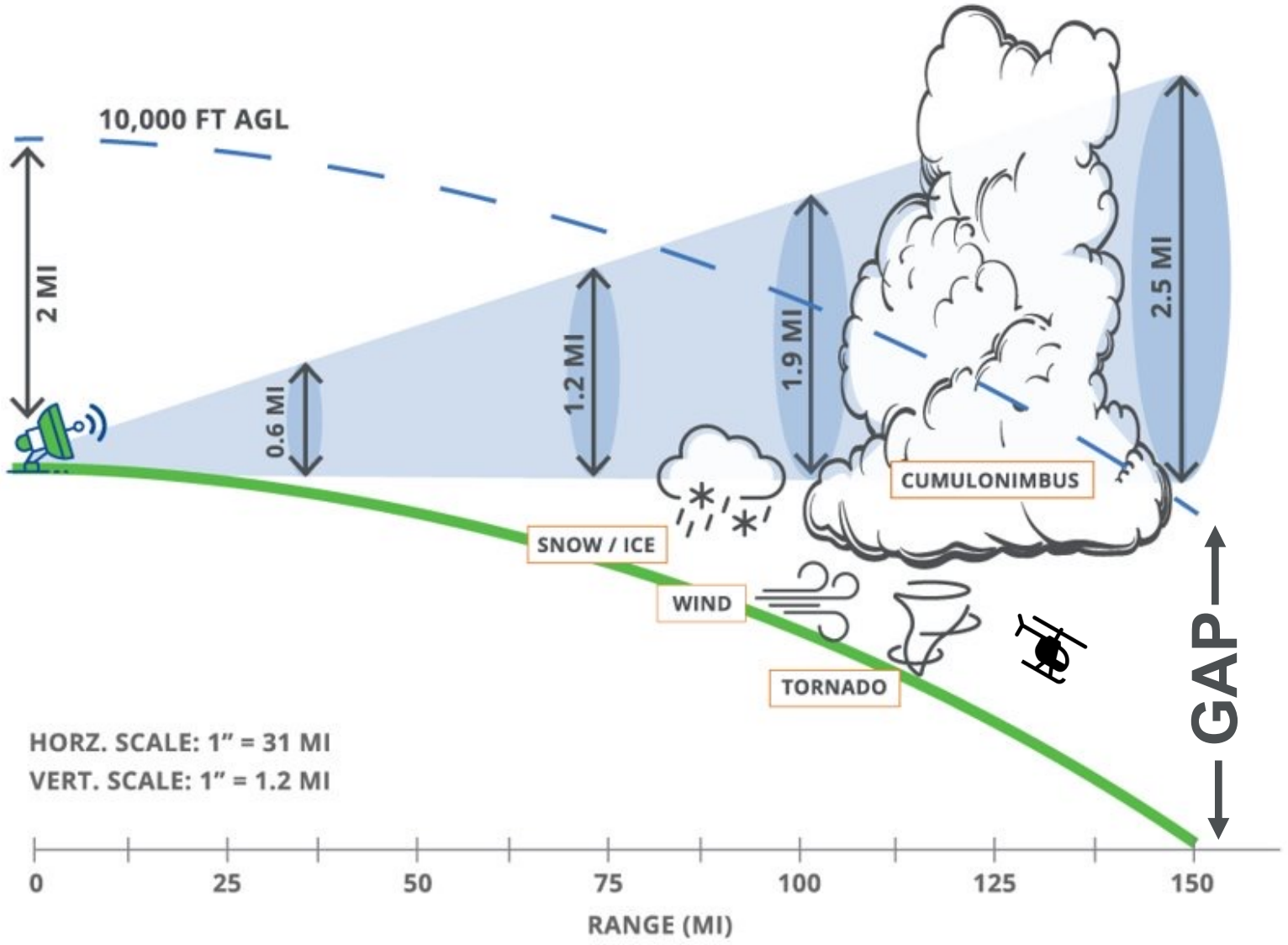

10,000 FT AGL
2 MI
0.6 MI
1.2 MI
1.9 MI
2.5 MI
CUMULONIMBUS
SNOW / ICE
WIND
TORNADO
GAP
HORZ. SCALE: 1" = 31 MI
VERT. SCALE: 1" = 1.2 MI
0
25
50
75
100
125
150
RANGE (MI)

Examining the weather radar issues behind the Survival Flight crash

On Jan. 29, 2019, a Bell 407 helicopter air ambulance operated by Survival Flight crashed near Zaleski, Ohio, killing the pilot, Jennifer Topper, and flight nurses Bradley Haynes and Rachel Cunningham.

https://verticalmag.com/news/survival-flight-crash-weather-radar-issues/

- Probable cause of accident was Survival Flight's inadequate management of safety, leading to pilot's encounter with IMC.
- Band of snow was too far away to be detected by the closest NEXRAD site.
- Precipitation data from nearest TDWR site was not available on HEMS Weather Tool.

"The only true solution would be to install many more weather radar sites across the country. This is not feasible" – VerticalMag author

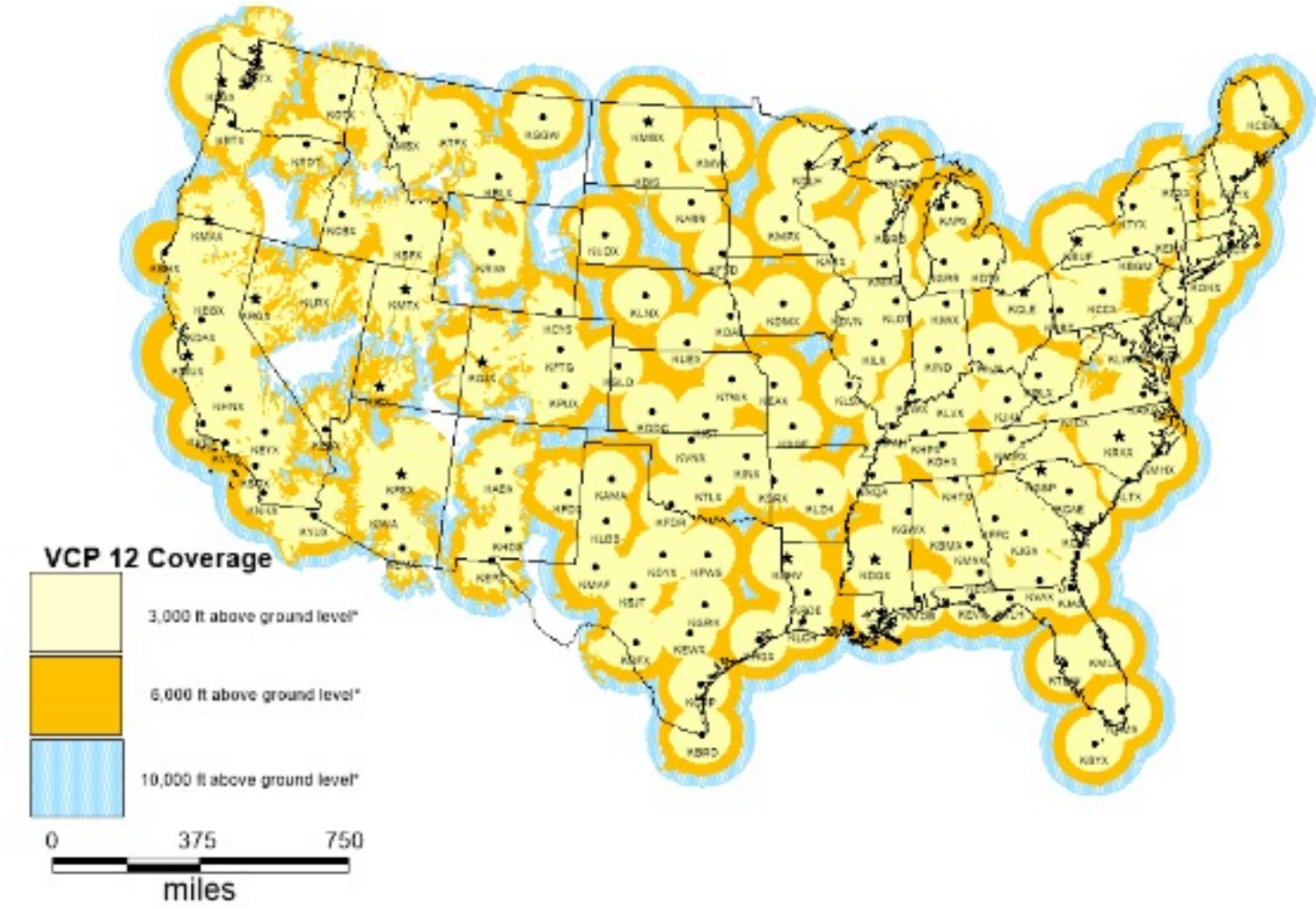
Impact on coastal transport

Seacor Power liftboat capsizes due to strong winds off Port Fourchon, April 2021

Source: NTSB.gov

- Data gaps prevented the National Weather Service from identifying and forecasting the surface wind magnitudes.
- Localized wind conditions could not be detected by weather service radars due to their elevation angles.
- NTSB recommended **lowering of radar angle**, which could improve the ability to accurately forecast weather conditions.

The NEXRAD + TDWR Network



Source: roc.noaa.gov/WSR88D/Maps.aspx

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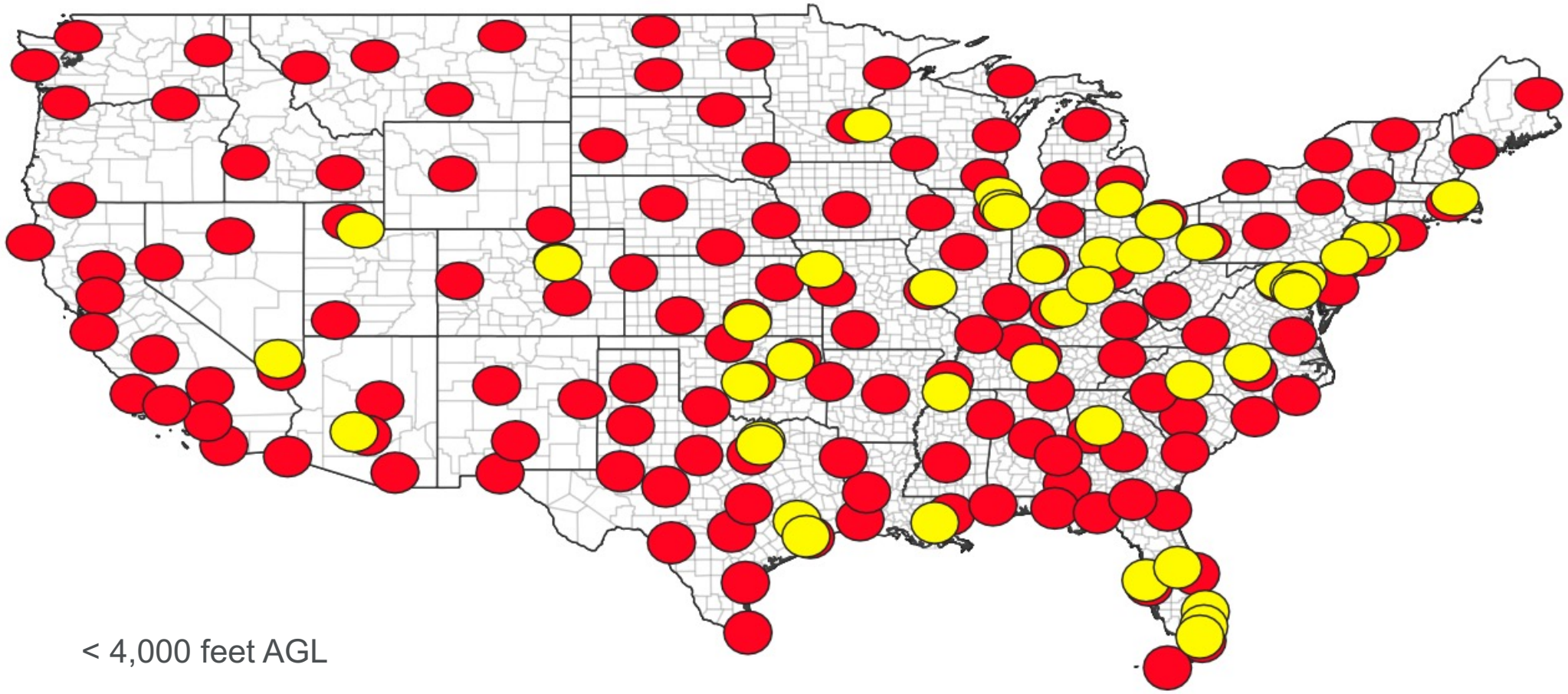
The NEXRAD + TDWR Network



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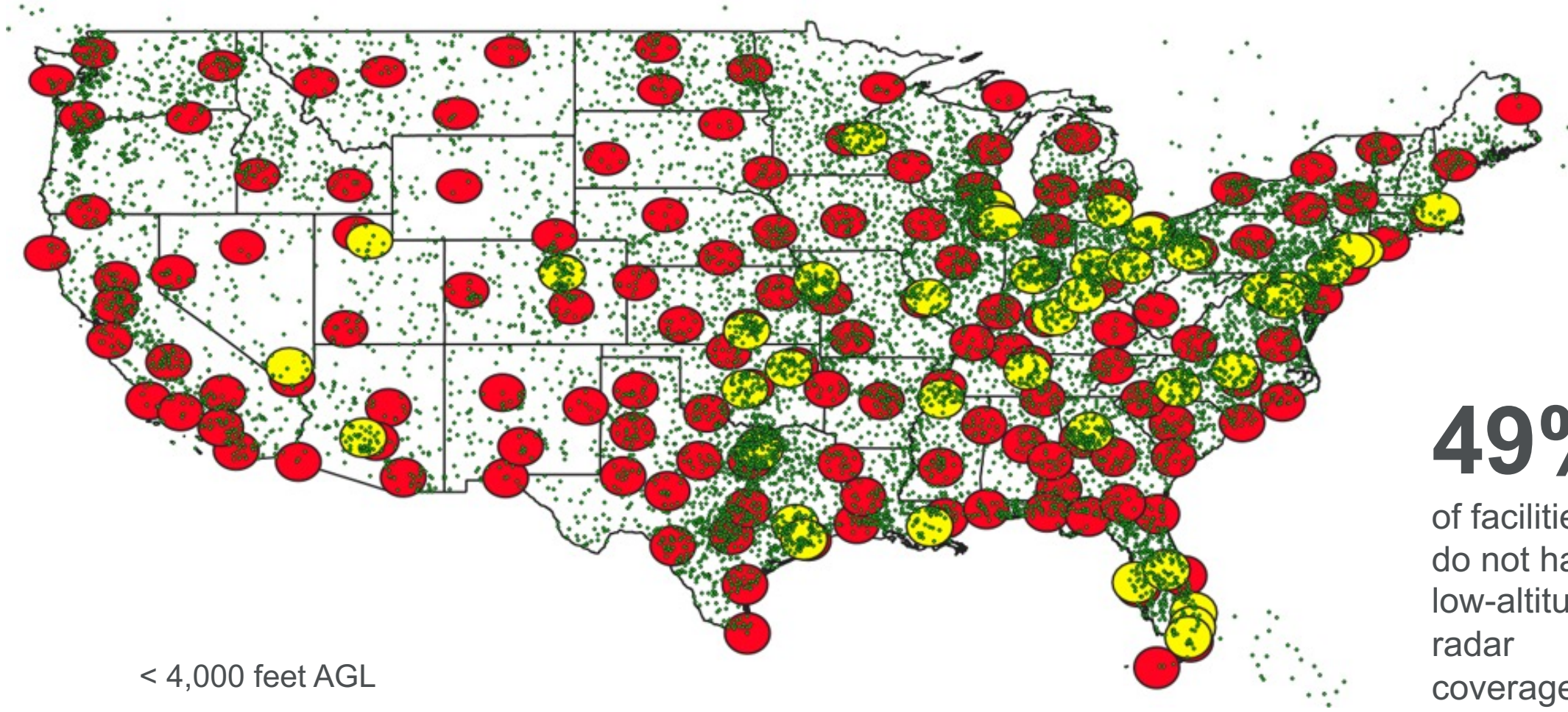
Low-altitude Coverage for Aircraft Landing Facilities



49%

of facilities do not have low-altitude radar coverage!

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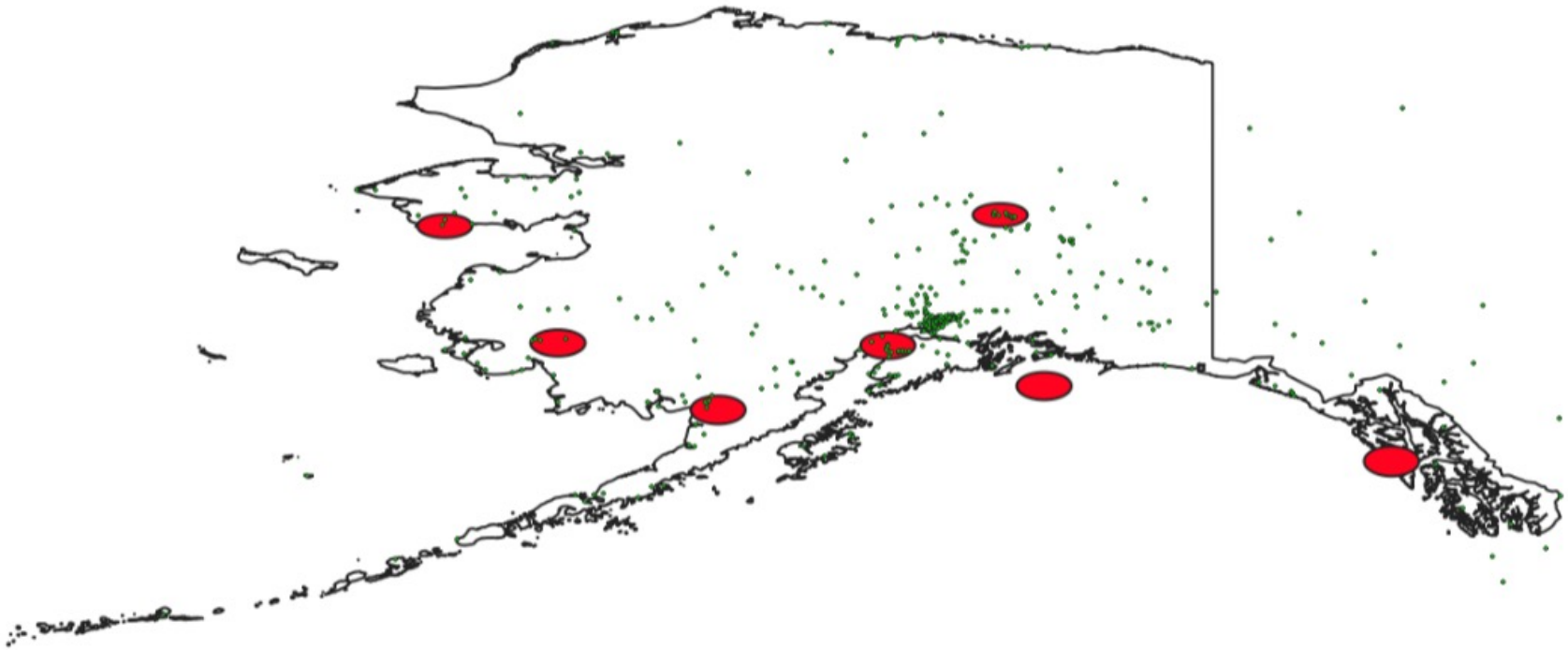
Low-altitude Coverage for Aircraft Landing Facilities



< 4,000 feet AGL

Existing NEXRAD Network Existing TDWR Network Facilities

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Aviation Safety

About Us

Mind The Gaps

No matter how well-equipped our cockpit is, ground-based radars limitations means we may not see everything.

By - **Published:** May 22, 2018 **Updated:** October 29, 2019

Sections

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Capital Weather Gang

U.S. radars have come a long way, but gaps in coverage remain a big risk

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NOAA's Efforts To Fix Critical Weather Radar Gaps Are Slow Going

Dennis Mersereau 7/11/2018 05:14:00 PM NOAA Radar Leave A Reply

Forbes

Billionaires Innovation Leadership Money Business

Weather Radar Gaps: Why They Exist And The Related Risk Factors

Jim Foerster Contributor

Science

The Washington Post
Democracy Dies in Darkness

Weather Service tells Congress radar gaps don't hurt warning accuracy, but outside scientists disagree

Meteorologists criticize the delayed report as missing important details, discounting potentially damaging weather

02
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Climavision’s Proprietary
Weather Radar Network

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We’re filling the gaps.

Investing in the Future

THE RISE FUND WORKS WITH GROWTH-STAGE, HIGH POTENTIAL, MISSION-DRIVEN COMPANIES THAT HAVE THE POWER TO CHANGE THE WORLD:

CLEAN ENERGY

DECARBONIZED TRANSPORT

ENABLING SOLUTIONS

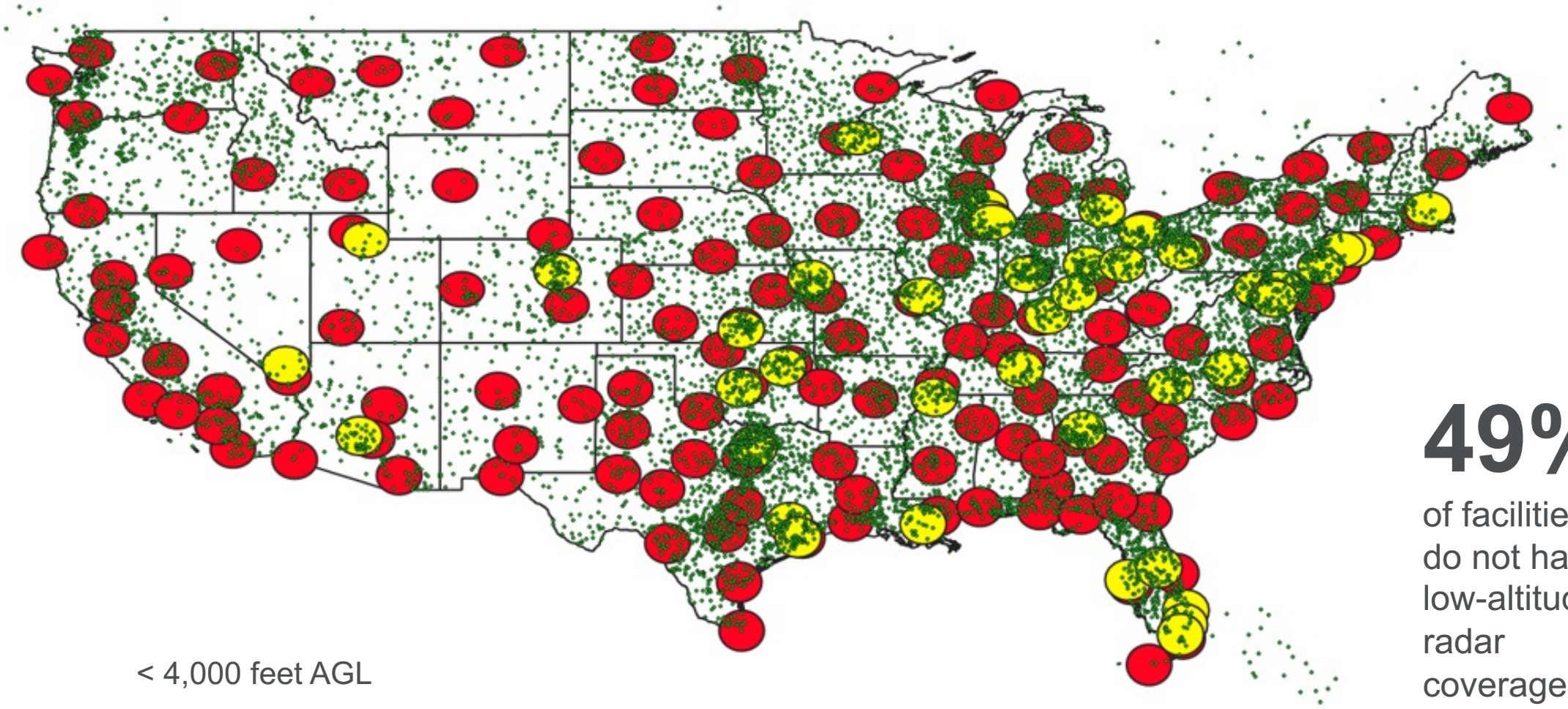
GREENING INDUSTRIALS

AG & NATURAL SOLUTIONS

THE RISE FUND + TPG

Climavision is the recipient of a **$100 million strategic investment** from The Rise Fund, TPG's global impact investing platform and the world's largest impact investing platform committed to achieving measurable, positive social and environmental outcomes alongside competitive financial returns.

Low-altitude Coverage for Aircraft Landing Facilities



49%

of facilities do not have low-altitude radar coverage!

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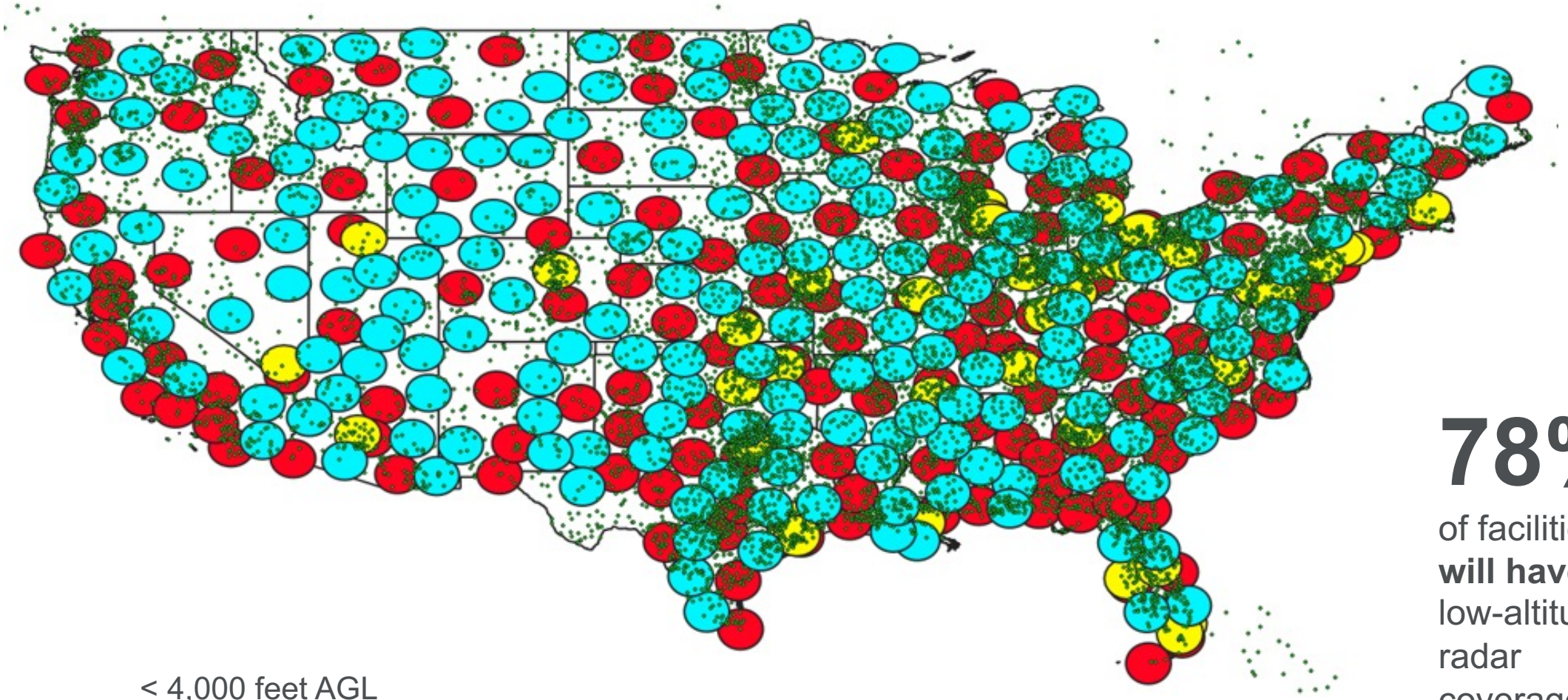
Climavision Supplementary Radar Network



< 4,000 feet AGL

78%

of facilities **will have** low-altitude radar coverage!

200+ radars over next 4 years!

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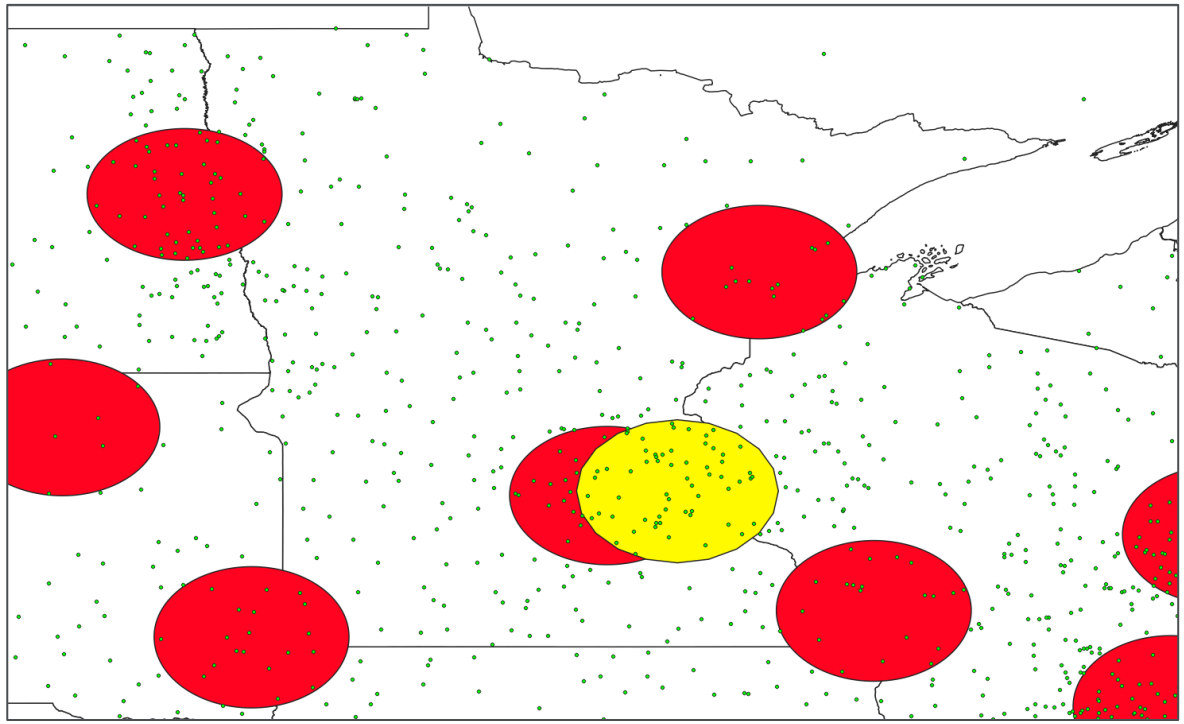
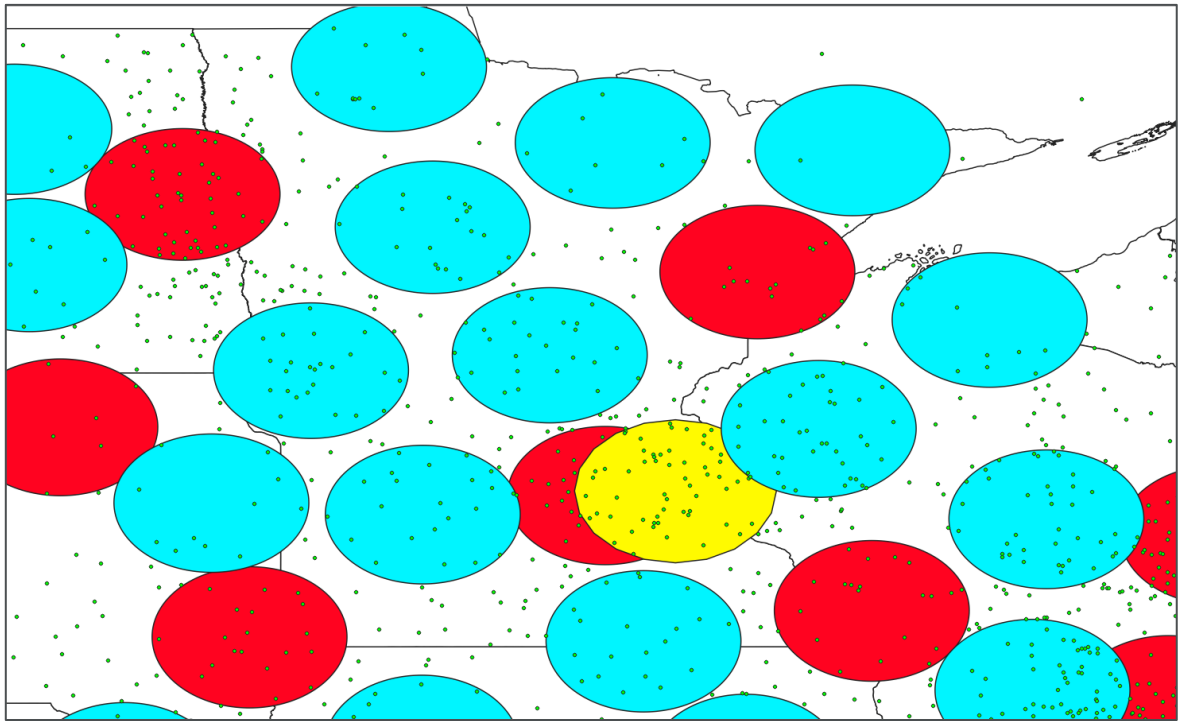
Serving Rural Landing Facilities



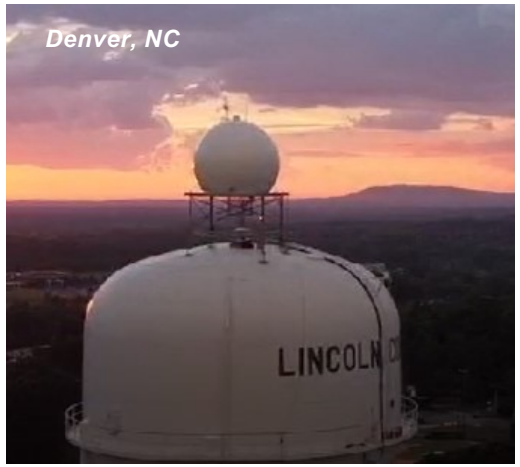
BEFORE

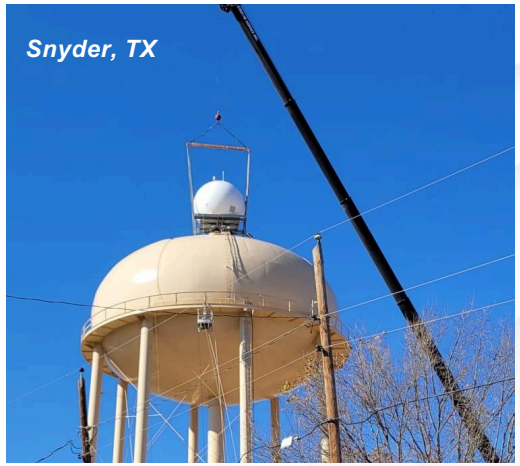


AFTER

< 4,000 feet AGL

Radars in Motion – Recent Installations





11 radars installed as of 5/15; 50 radars by Memorial Day 2024

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03
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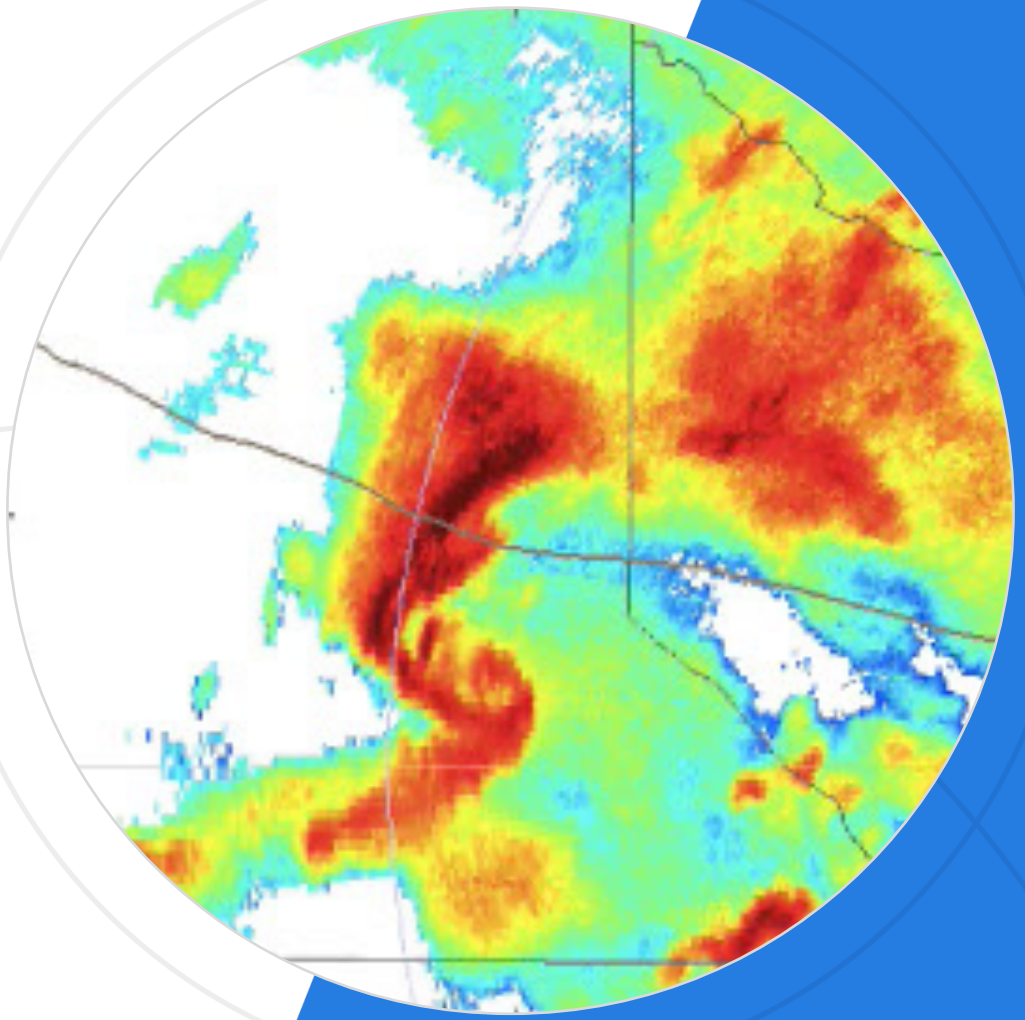
Impacts & Use Cases in Aviation

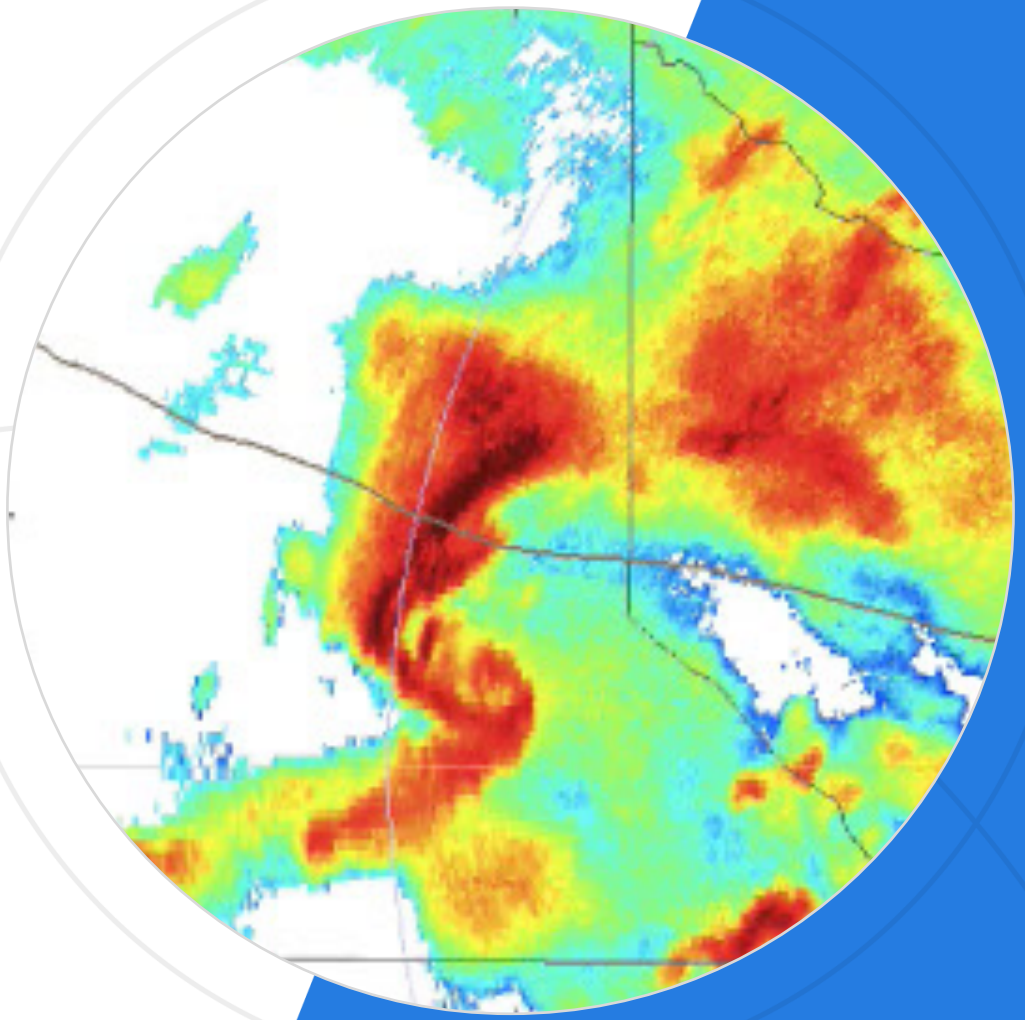
Climavision Radar-As-A-Service

- **Owned and Operated by Climavision**
- Data available as a **Subscription**
- Monetized over **Several Different** weather-dependent users.



Designed for Supplemental Coverage

- **Dual Polarization**, **X-band**, solid state weather radars (<1 deg beamwidth)
- **Higher resolution, one minute updates** on storm development
- Focus on **low-level scanning of the atmosphere**



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Gap-filling to improve short-term forecast accuracy

		All Forecasters	Often Forecasters
Default	Fire		
	Flood	✓	✓
	Hurricane	✗	
	Severe thunderstorm		
	Lake effect snow		✓
	Winter precipitation	✓	✓
Additional	Air quality		✓
	Blowing dust		
	Icing	✓	✓
	Temperatures	✗	✗
	Turbulence	✓	
	Visibility	✓	✗
	Waves	✓	
	Winds		✓

Phenomenon principally impacted by data gaps

Ranking	Ranked characteristics	
	Based on mean priority score	Based on highest-priority votes
1	Temperature profile in mixed precipitation	Radar gaps
2	Hydrometeor type in winter	Temperature profile in mixed precipitation
3	Radar gaps	Hydrometeor type in winter
4	Near-storm vertical wind profile	Ground conditions for flooding
5	Ground conditions for flooding	Snow accumulation
6	Snow accumulation	Near-storm vertical wind profile
7	Wind shear of the preconvective environment	Wildfires
8	Wildfires	Nocturnal thunderstorms
9	Nocturnal thunderstorms	Storm damage
10	Storm damage	Wind shear of the preconvective environment

Prioritization of specific weather-related characteristics that need to be observed to fill data gaps

630 NWS forecasters surveyed to assess critical data gaps that impact short-term forecast accuracy.

“National Weather Service Data Needs for Short-Term Forecasts and the Role of Unmanned Aircraft in Filling the Gap: Results from a Nationwide Survey”, Houston et al, 2021

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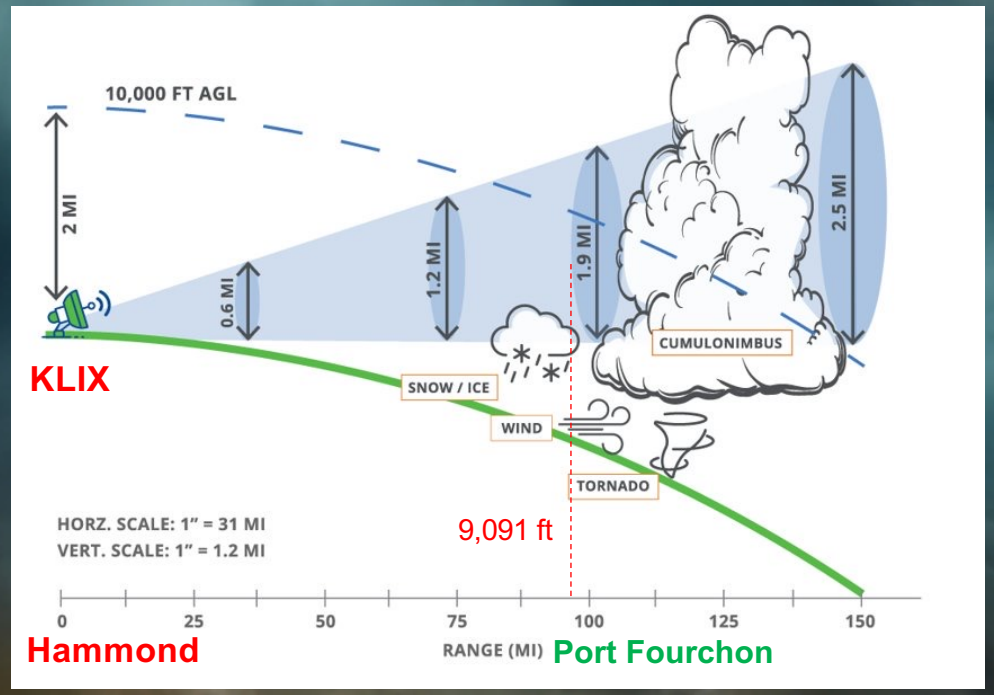
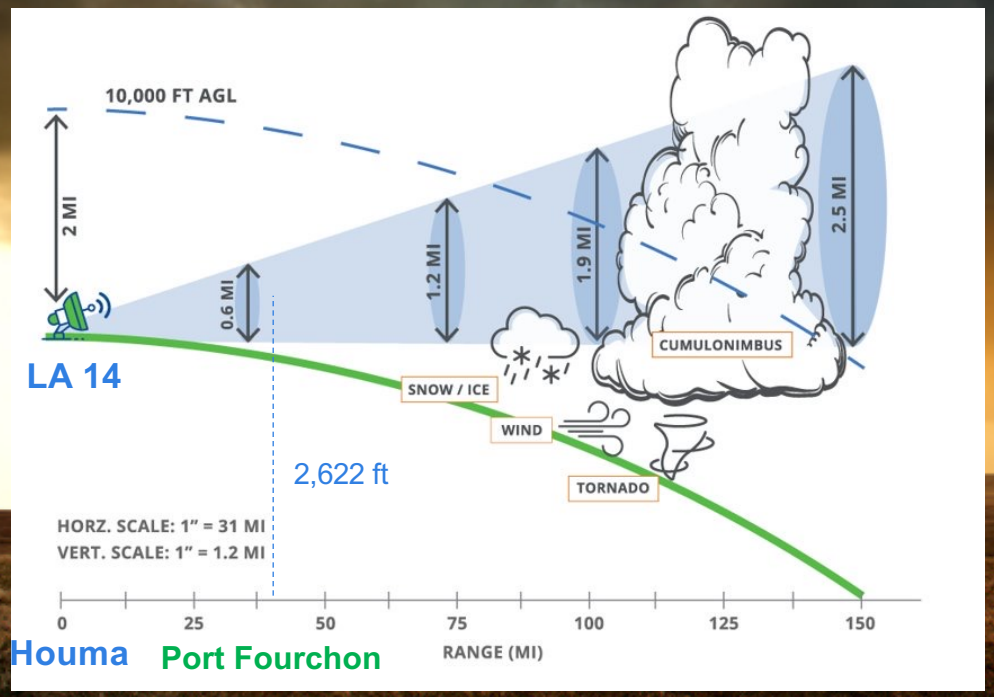
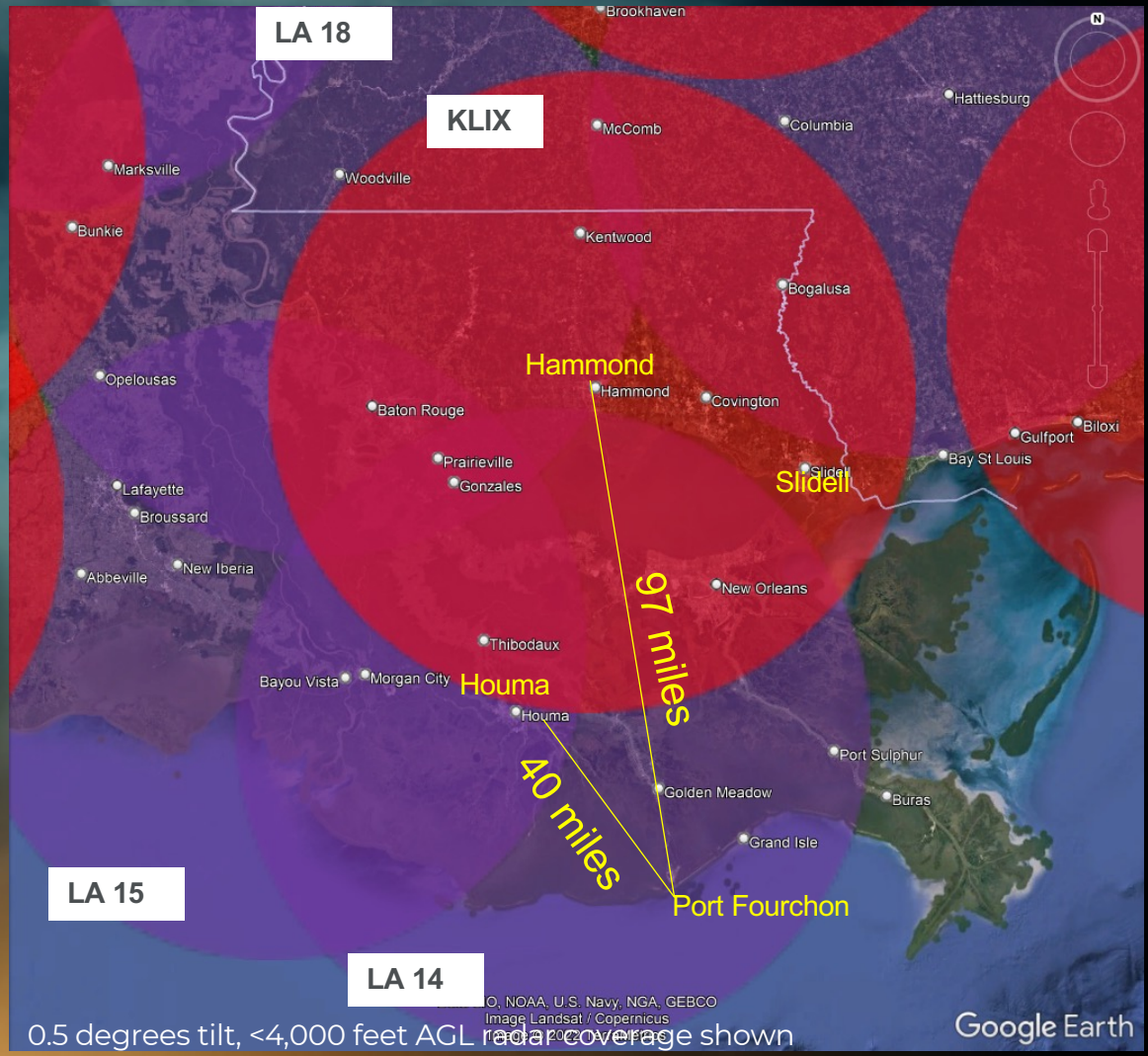






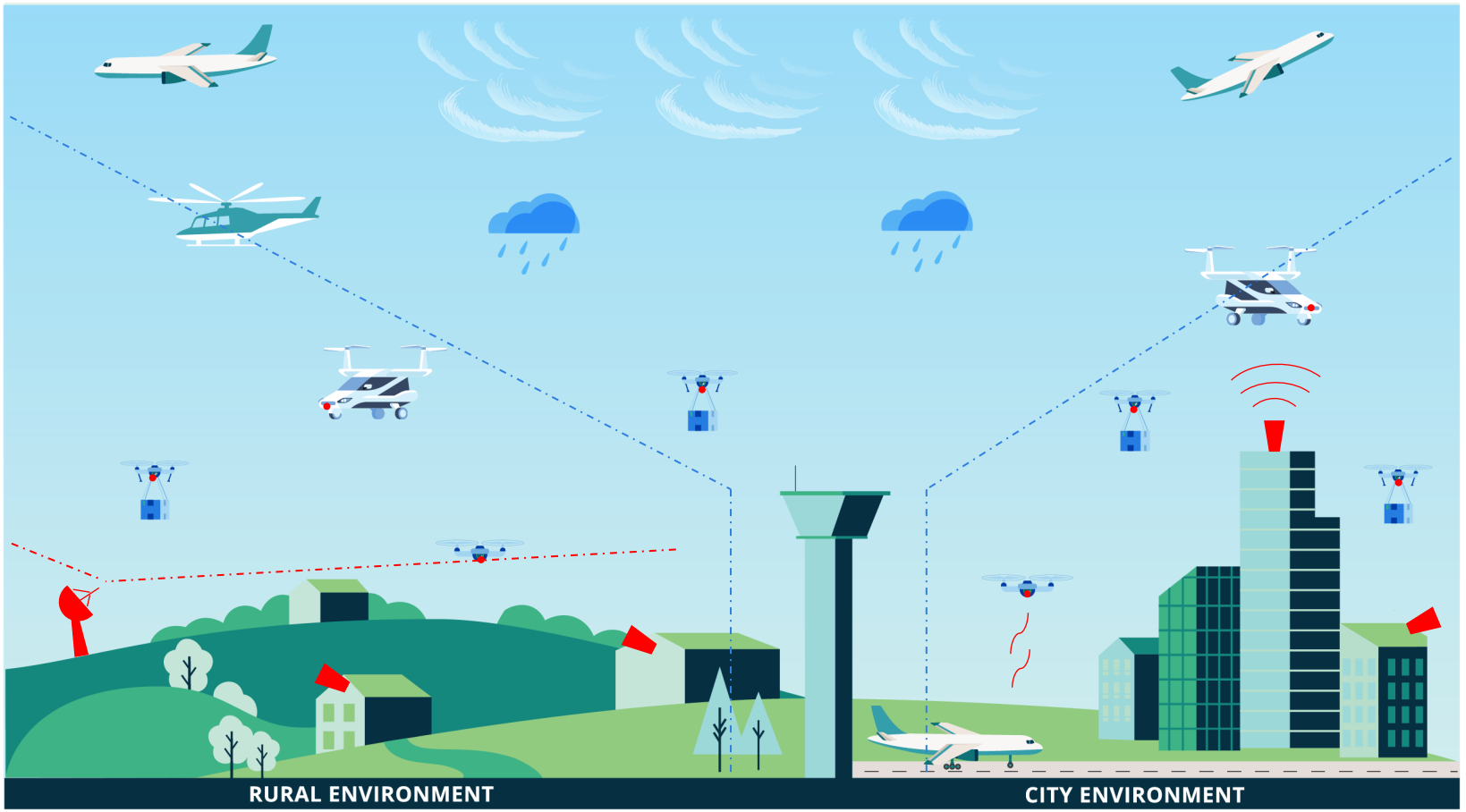
0.5 degrees tilt, <4,000 feet AGL radar coverage shown

NWS Weather Radars (S-band)

Climavision Supplementary Weather Radars (X-band)

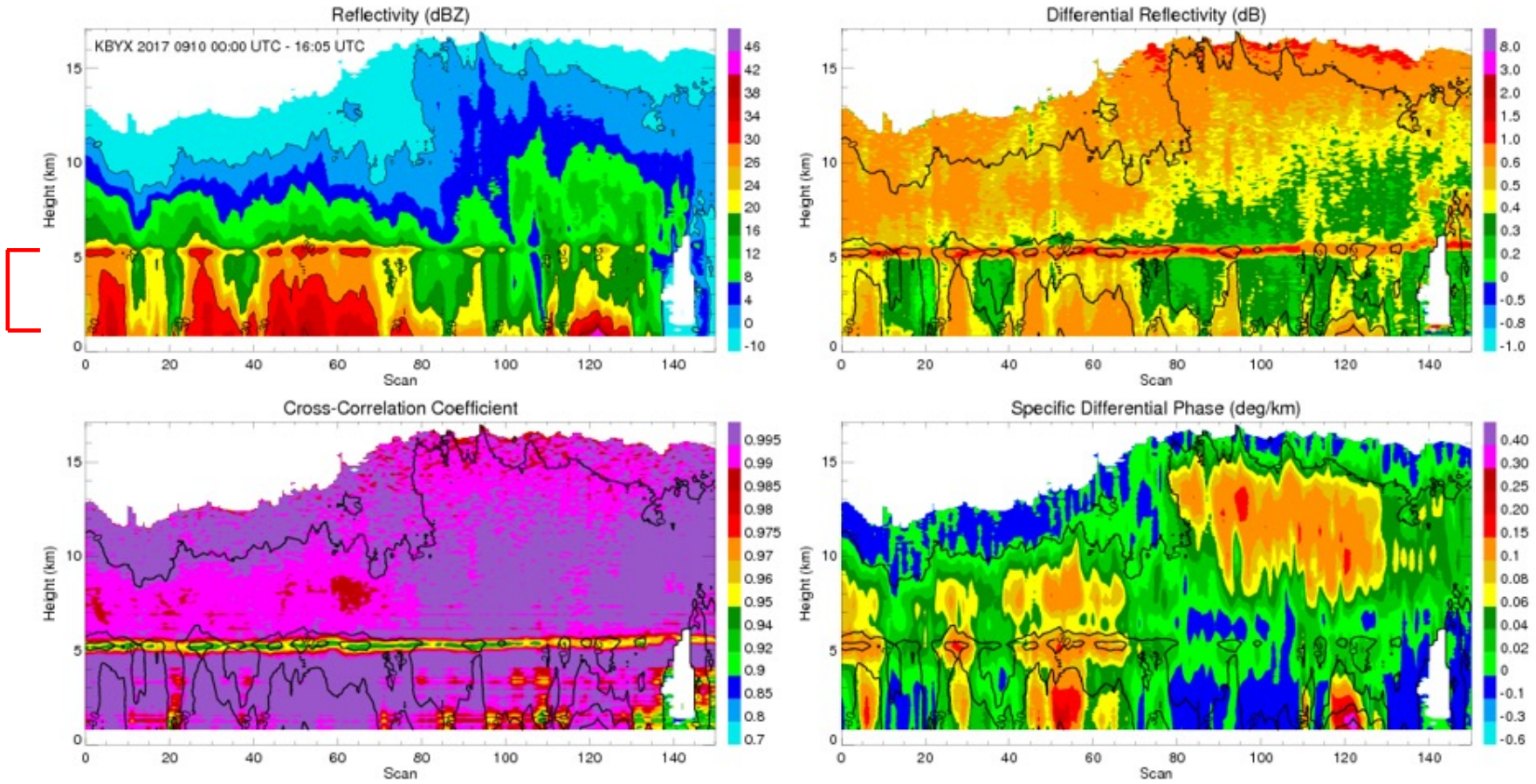
Observation System for UAS/AAM

Focus on boundary layer observations



Hurricane Rain Measurements

Strong vertical gradient of rain rate causes underestimation of rainfall near the surface if radar sampling volume is 2-4km off the ground.



NEXRAD dual-polarization weather radar observations of Hurricane Irma (2017)

Source: National Severe Storms Laboratory

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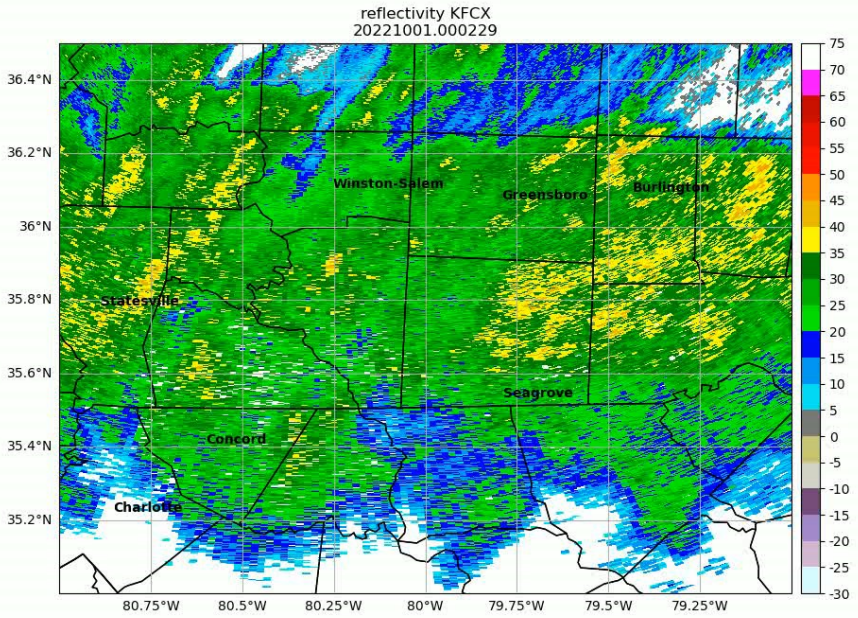
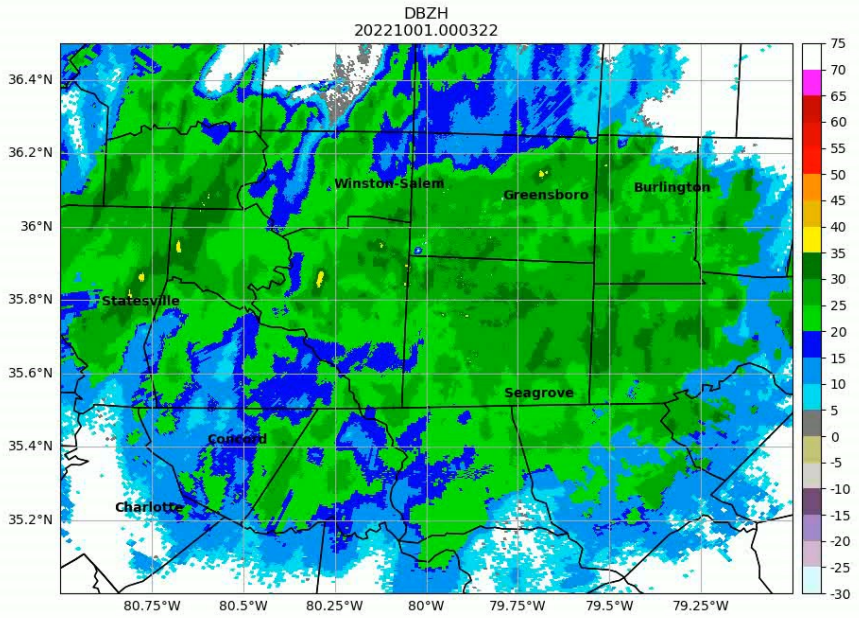
Hurricane Ian Use Case – Oct 1, 2022



NEXRAD



CLIMAVISION HIGH POINT RADAR

X-Band low-altitude radar continues to observe rain at lowest levels on Oct 1, 2022.

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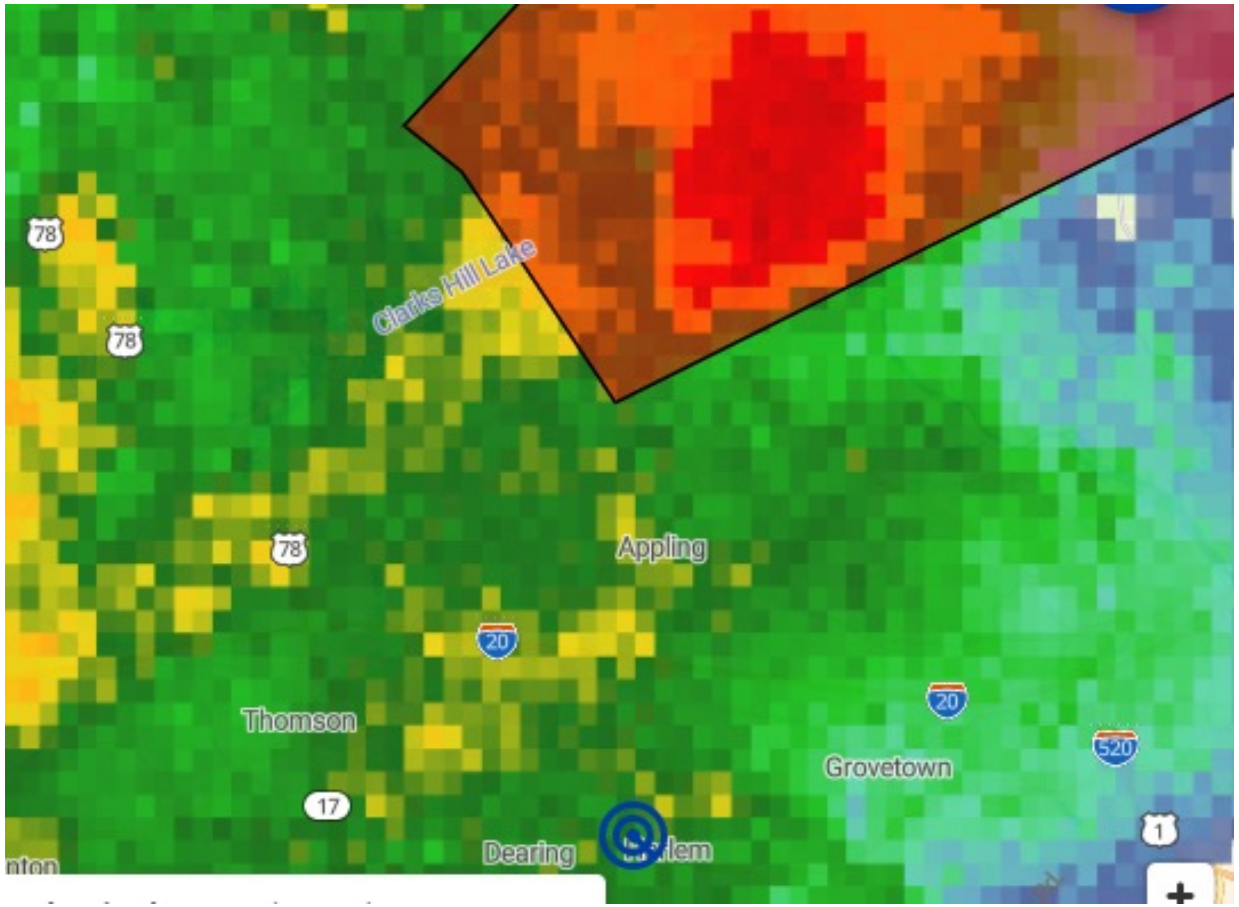
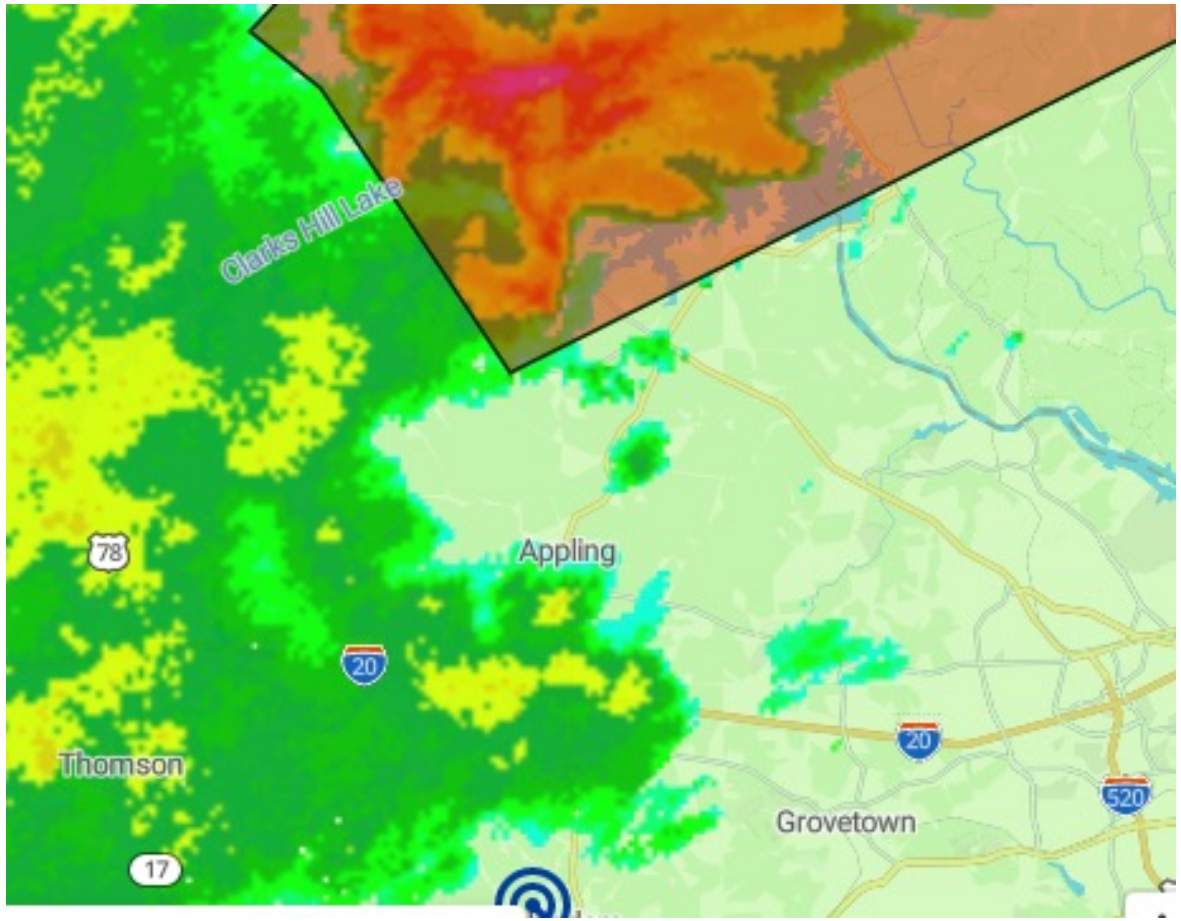
Tornado Outbreak – Georgia – Jan 12, 2023



NEXRAD



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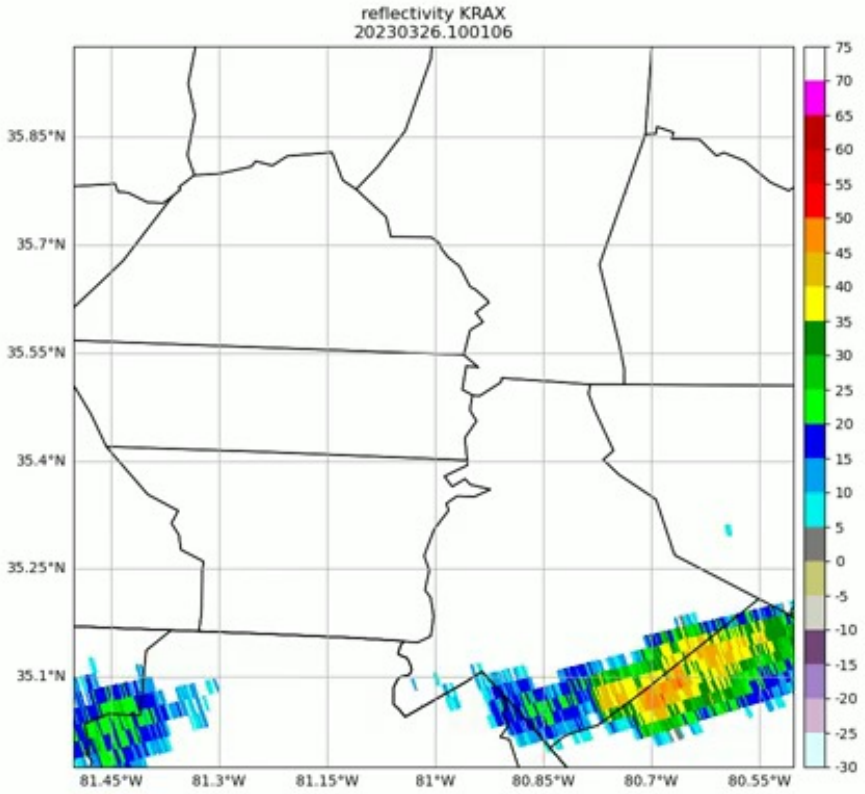
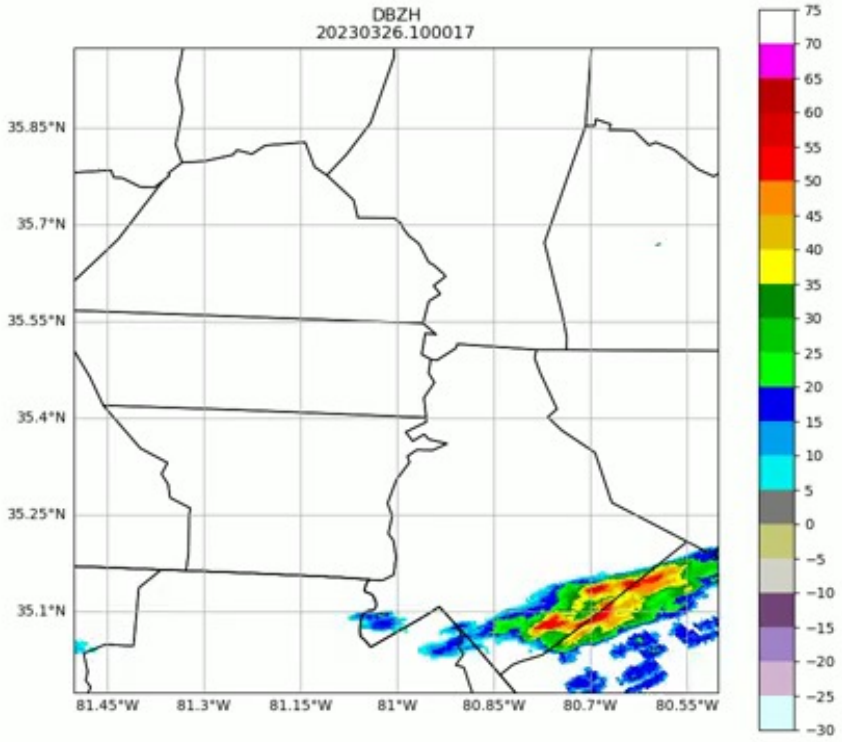
High resolution radar data – March 26, 2023





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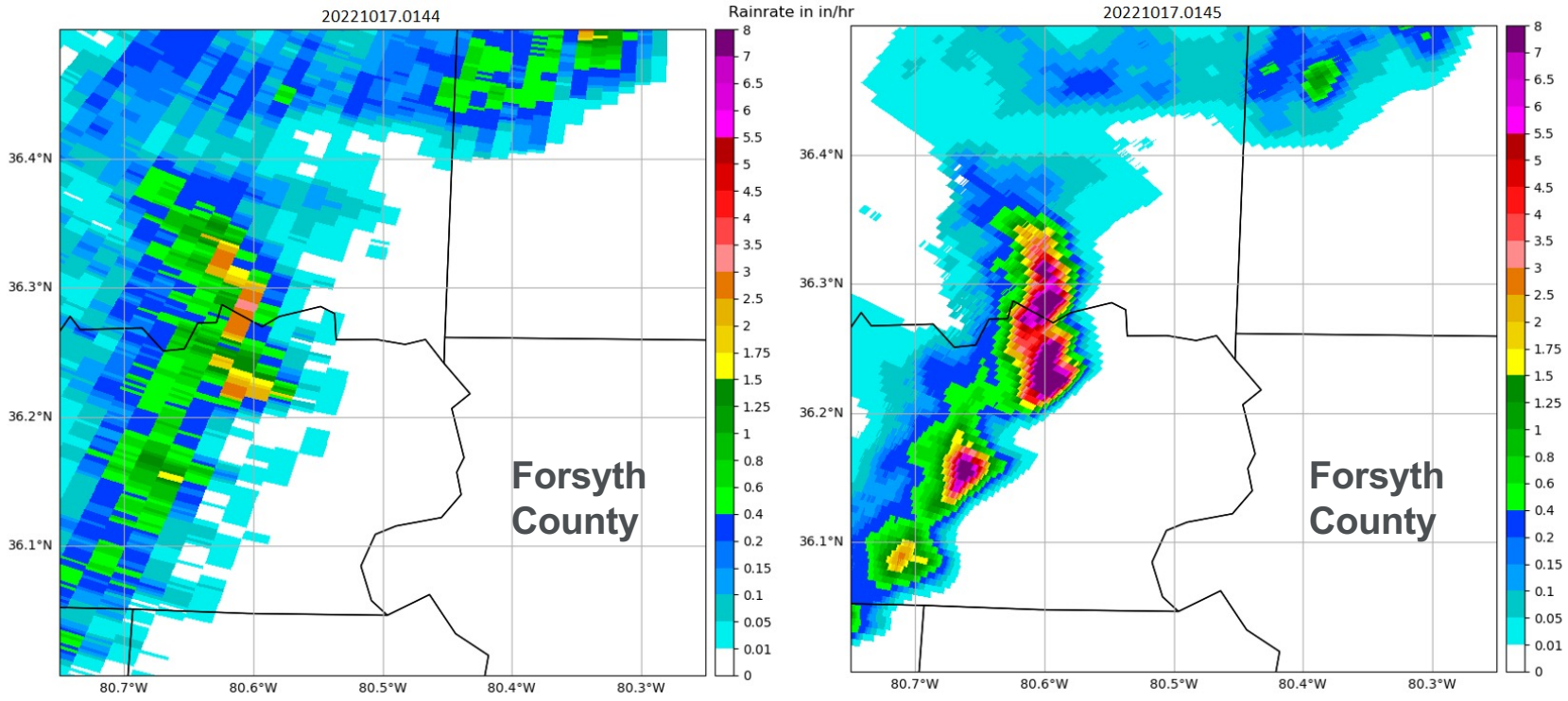
High Resolution Rain Data - Oct 17, 2022



NEXRAD

CLIMAVISION HIGH POINT RADAR

Highlights importance of higher resolution data (8-10 times higher)

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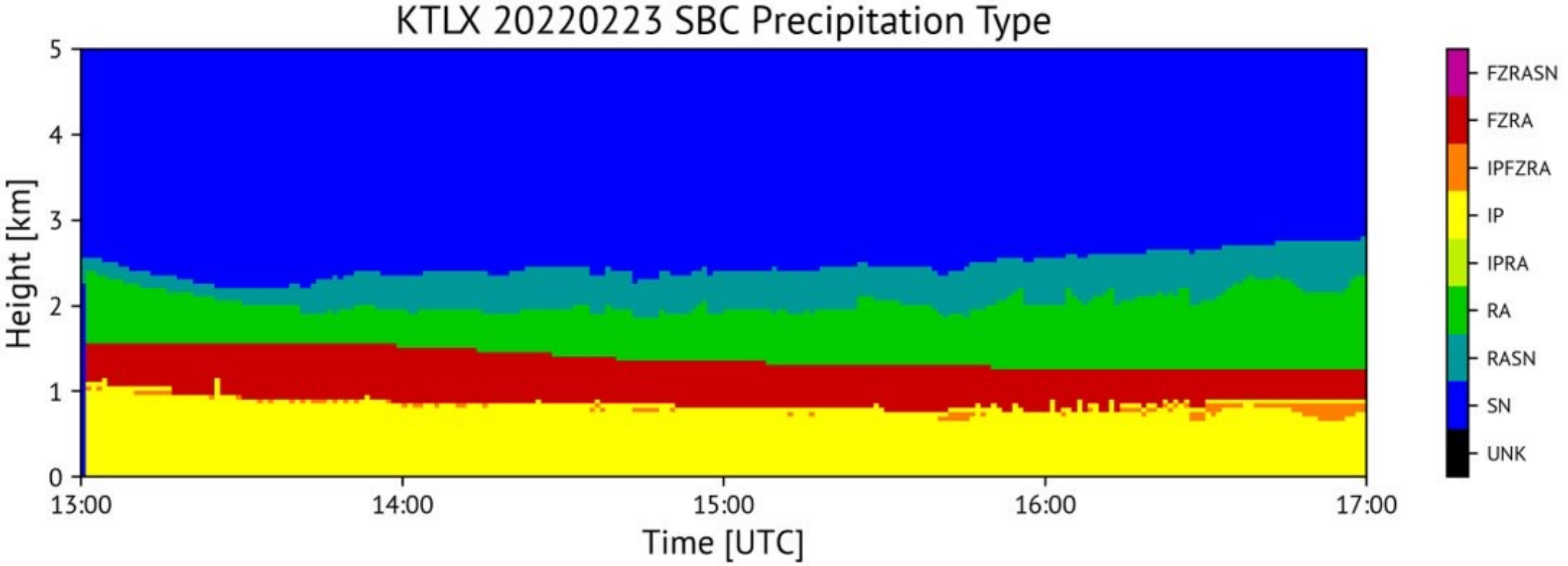
Winter Weather Classification



Radar-based Hydrometeor Classification Algorithm 23 February 2022 Ice Pellet Storm

Source: CIRA/ National Severe Storms Laboratory

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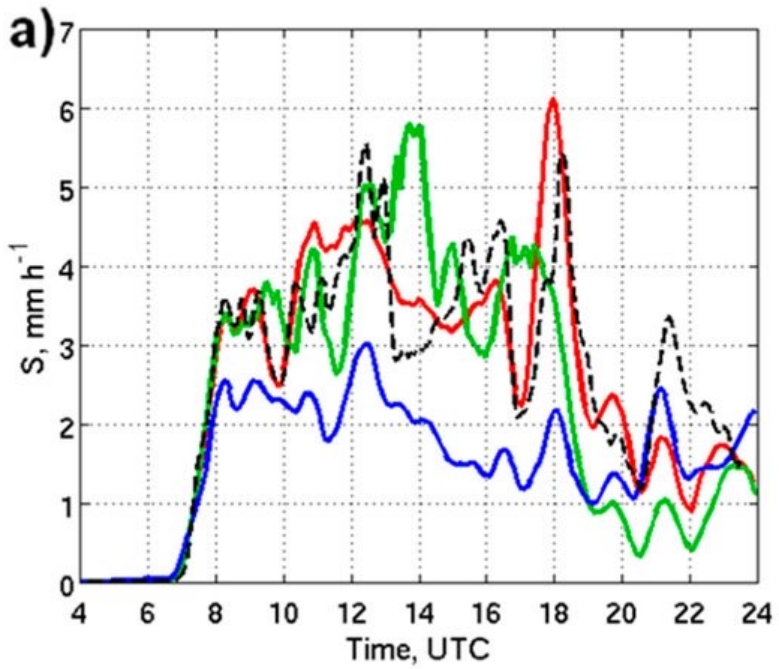
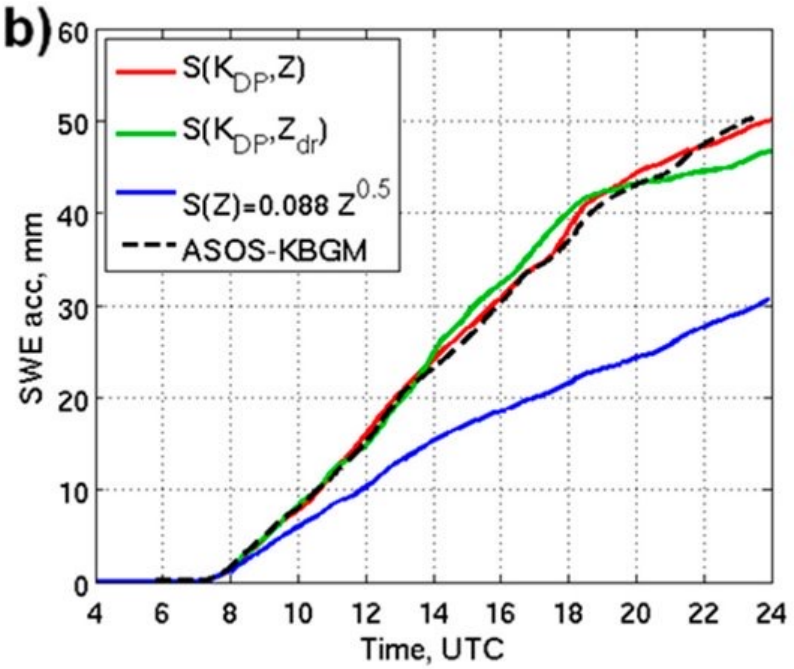
Estimating snow rates

Estimating snowfall rates has been a challenge as, typically, only reflectivity has been used which has issues in frozen precipitation amounts. **Utilizing KDP which is more sensitive at X-band compared to S-band** should provide more **accurate estimates of snowfall** within the winter. KDP can be used be improving short-term prediction of snowfall intensities (look for high KDP values!)



Snow rate



Snow water equivalent

Source: CIRA/ National Severe Storms Laboratory

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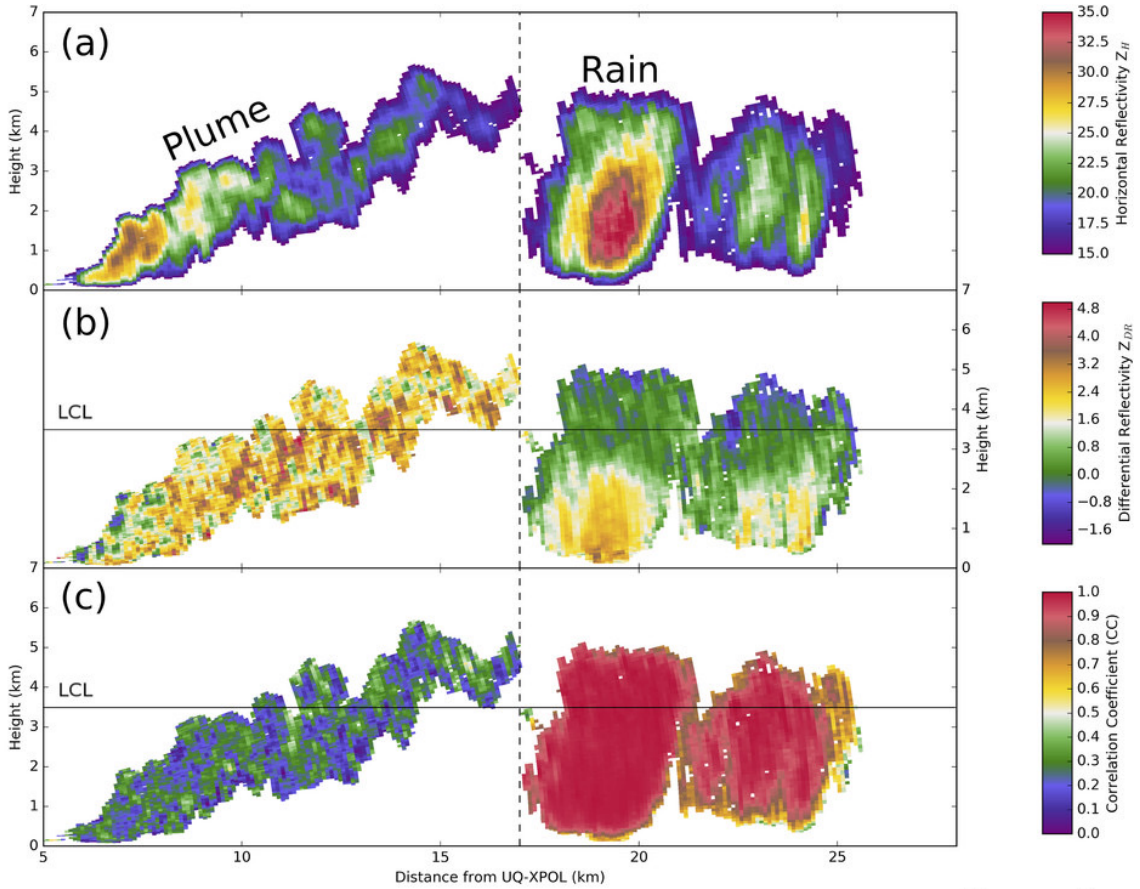
Wildfire detection

Weather radars are being used for detection of wildfire in CONUS and around the world. X-band radars can fill gaps in rugged terrain.



UQ-XPOL radar observations of grass fire in Australia (McCarthy et al, 2018)

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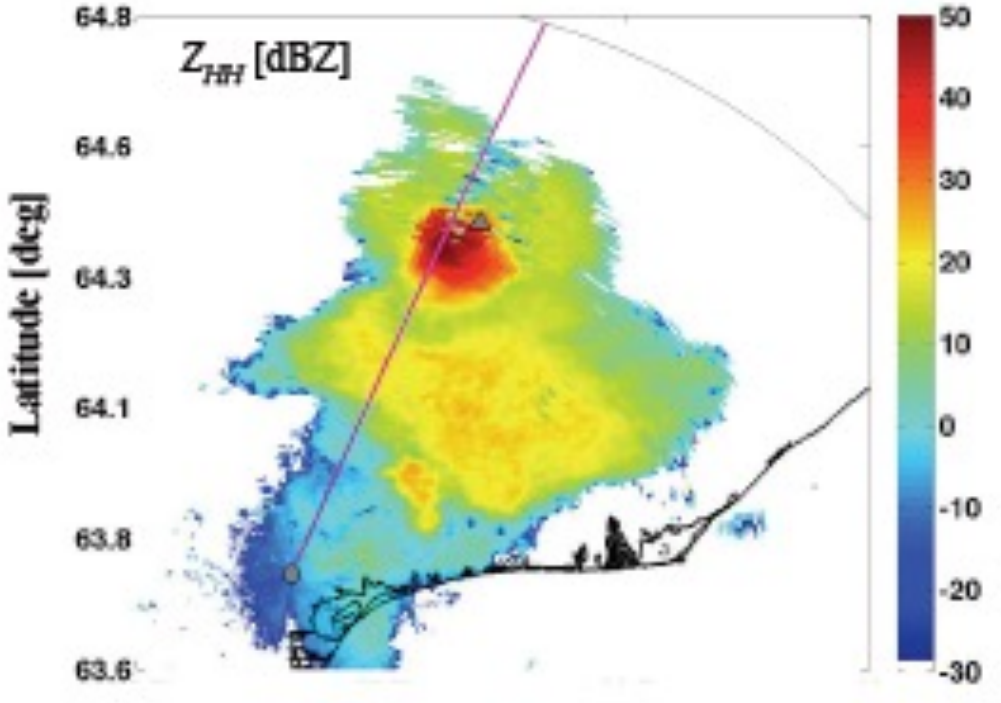
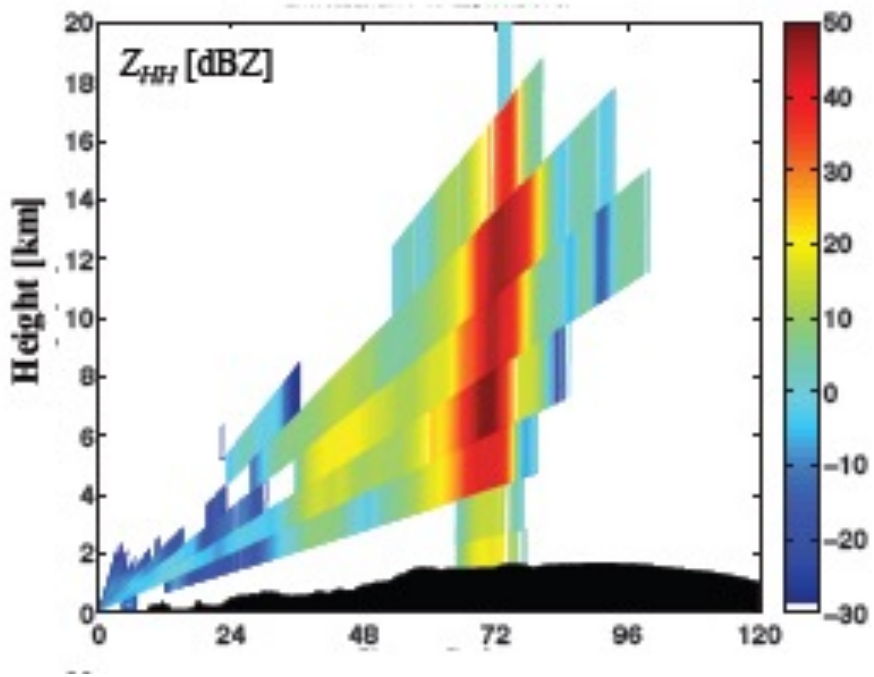
Volcanic ash detection

Grimsvotn (Iceland) eruption on 22 May 2011

X-band radar observations



Z_{max} > 50 dBZ



From Montopoli et al. (2013)

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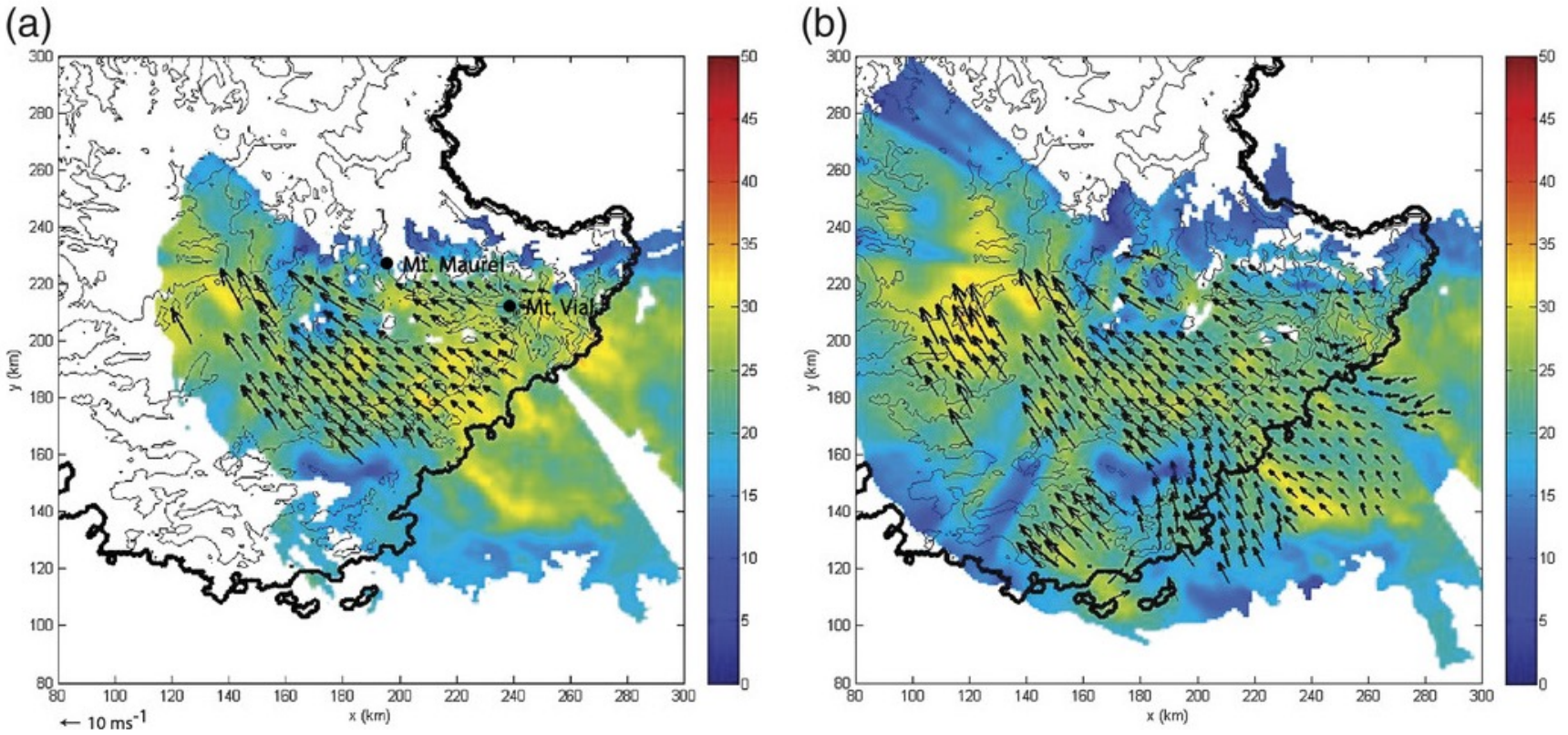
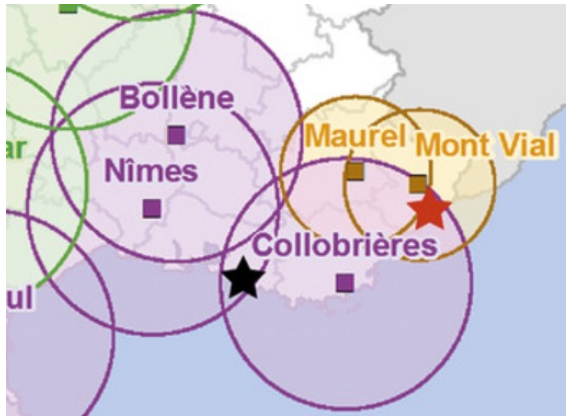
Wind analyses – Multi-radar retrievals





Using Gap-Filling Radars in Mountainous Regions to Complement a National Radar Network: Improvements in Multiple-Doppler Wind Syntheses, Beck et al, 2013

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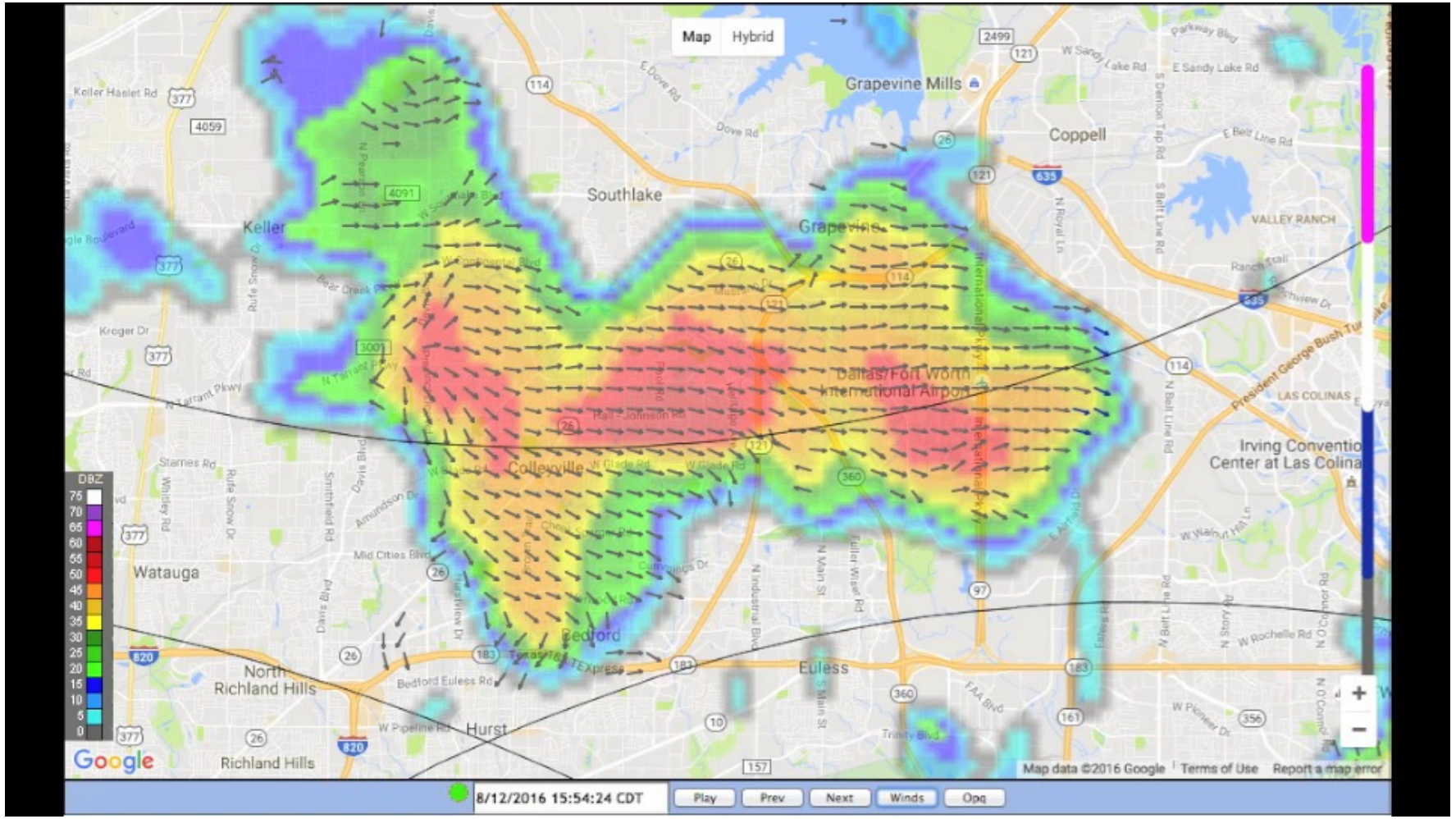
Wind analyses – Multi-radar retrievals



Downbursts visualized by the CASA X-band radar network near DFW Airport (2016)

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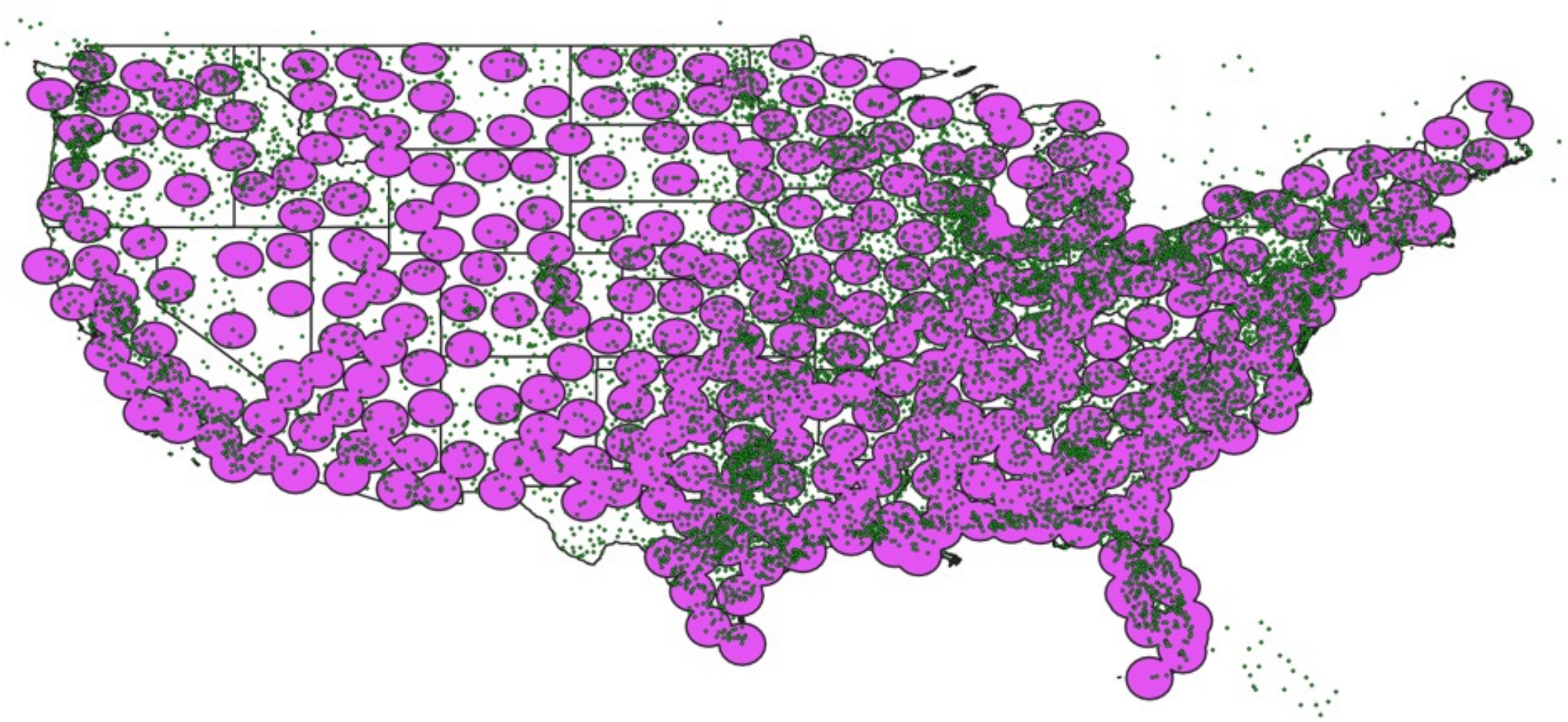
Combined Low-altitude Weather Radar Coverage



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Discussion

01 How could your operations benefit from this new network?

02 How will you integrate low-level radar data into your platforms?

03 Importance of human factors, training and pilot programs

CONTACT
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Commercial Partners: filipe.silva@climavision.com

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