Clouds, Cloud Ceiling, and Visibility Technical Exchange Meeting (C&V TEM)

Overview of Visibility Estimation through Image Analytics (VEIA) on FAA Weather Camera website, operational transition process, and what's coming next

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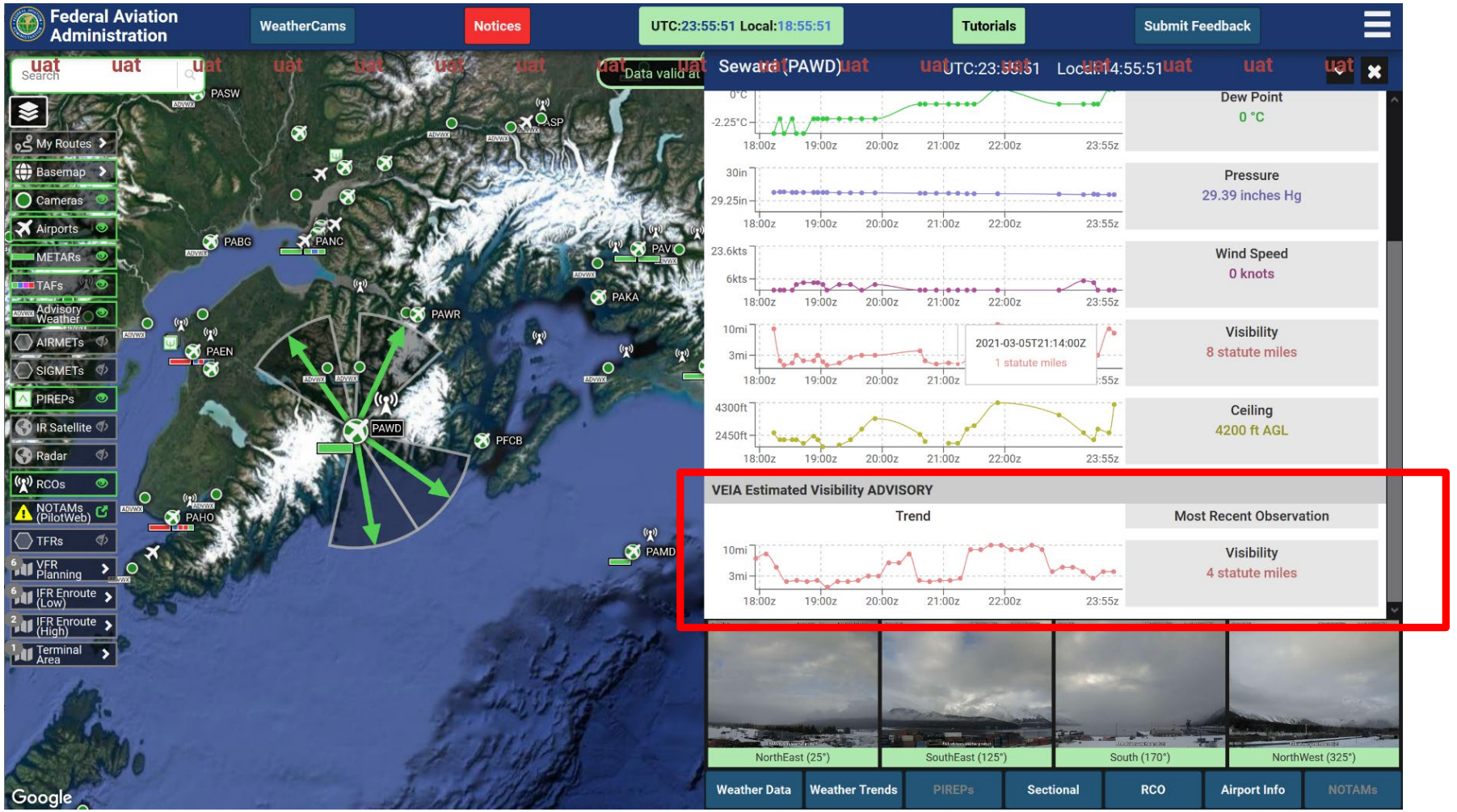
FAA Aviation Cameras Weather Display



https://weathercams.faa.gov

Transitioning VEIA to Operations

- **Quality Assessment**
  - Deployed VEIA on the FAA Weather Cameras (WCams) test system
  - Conducted an Operational Demonstration in Summer 2020 including 1 year of retrospective runs
  - Independent evaluation conducted by NOAA/ESRL/GSL/Forecast Impact and Quality Assessment Services Branch

- **User Assessment**
  - Conducted an Operational Demonstration in Spring 2021
  - 32 pilots, dispatchers and meteorologist participated from the user community
  - Independent evaluation conducted by FAA Aviation Weather Demonstration and Evaluation Services Team (AWDE)

- **Safety Risk Management (SRM) Review**
  - SRM panel identified hazards, analyzed and assessed risks in Fall 2021
  - Participation from 36 SMEs, panel members, and observers across wide spectrum of expertise
  - Safety requirement: Camera images must always be viewed in conjunction with the VEIA estimate

WCAMS – FAA Weather Cameras

NOAA – National Oceanic and Atmospheric Administration
ESRL – Earth Systems Research Laboratory
GSL – Global Systems Laboratory

VEIA Quality Assessment Results

VEIA Findings

STRENGTHS

- Generally accurate in identifying VFR conditions
- Bias towards more conservative estimates of visibility in MVFR category
- Supplements METAR visibility and serves as a check against bad data
- Strongest visibility performance in interior locations with higher cloud bases

WEAKNESSES

- Bias towards riskier estimates of visibility in IFR and LIFR categories
- 10 minute camera refresh rate not enough in rapidly changing conditions during precipitation
- Cameras can be blocked by ice, rain drops, and equipment, leading to incorrect estimates
- Weakest visibility performance where low clouds obscure terrain features

Visibility Estimation and Image Analytics (VEIA) Quality Assessment; Kenneth R. Fenton, Joan E. Hart, and Matthew S. Wandishin

VEIA User Assessment Results

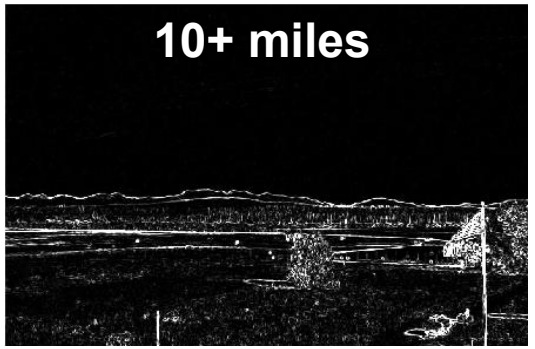
Question (Strongly Agree=5, Agree=4, Neither Agree nor Disagree=3, Disagree=2, Strongly Disagree=1)	Part 121/135 Dispatchers (N=3) Mean	GA Pilots (N=6) Mean	Meteorologists (N=7) Mean	Overall (N=16) Mean
1. The information VEIA provides is easy to use.	4.7	4.2	4.6	4.4
2. VEIA provides visibility information in a timely manner to support identifying safe and efficient routes	4.0	3.7	4.3	4.0
3. VEIA information would improve situational awareness of visibility along a route.	4.7	4.2	4.3	4.3
4. VEIA information is available when needed.	4.3	3.7	4.6	4.2
5. Information is easy to find when using VEIA.	4.3	4.2	4.3	4.3

The GA pilots rated having information in a timely manner and data availability as "Neither Agree/Disagree" due to slow data upload rates and site reliability issues.

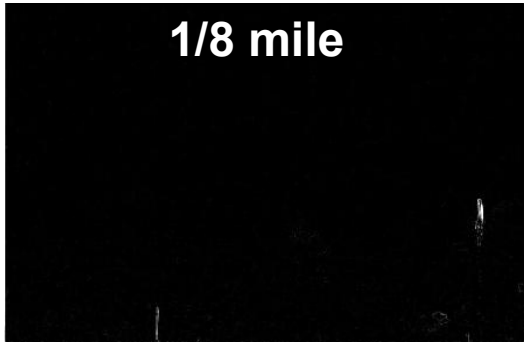
VEIA received highly favorable results by the user community for increasing situational awareness

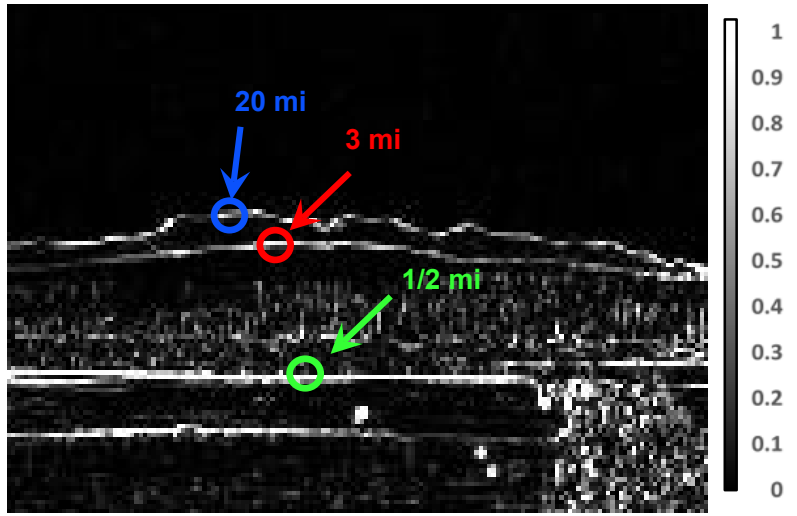
Technical Concept: Relate Visibility to Image Edge Strength

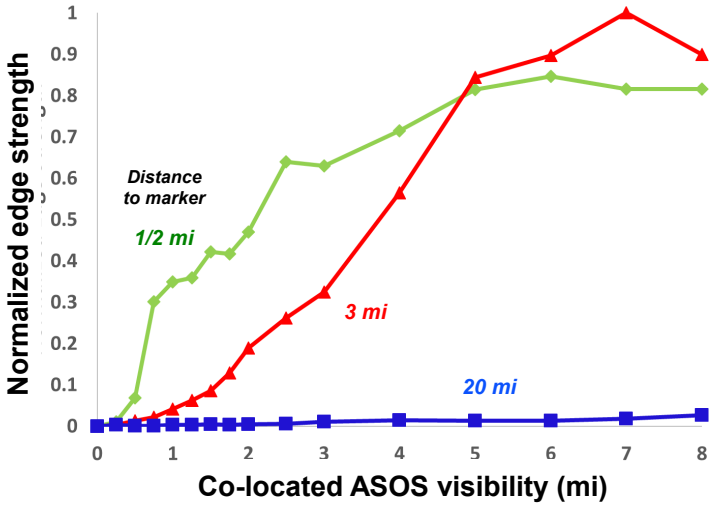
Edge Detection Algorithm



Edge Detection Algorithm



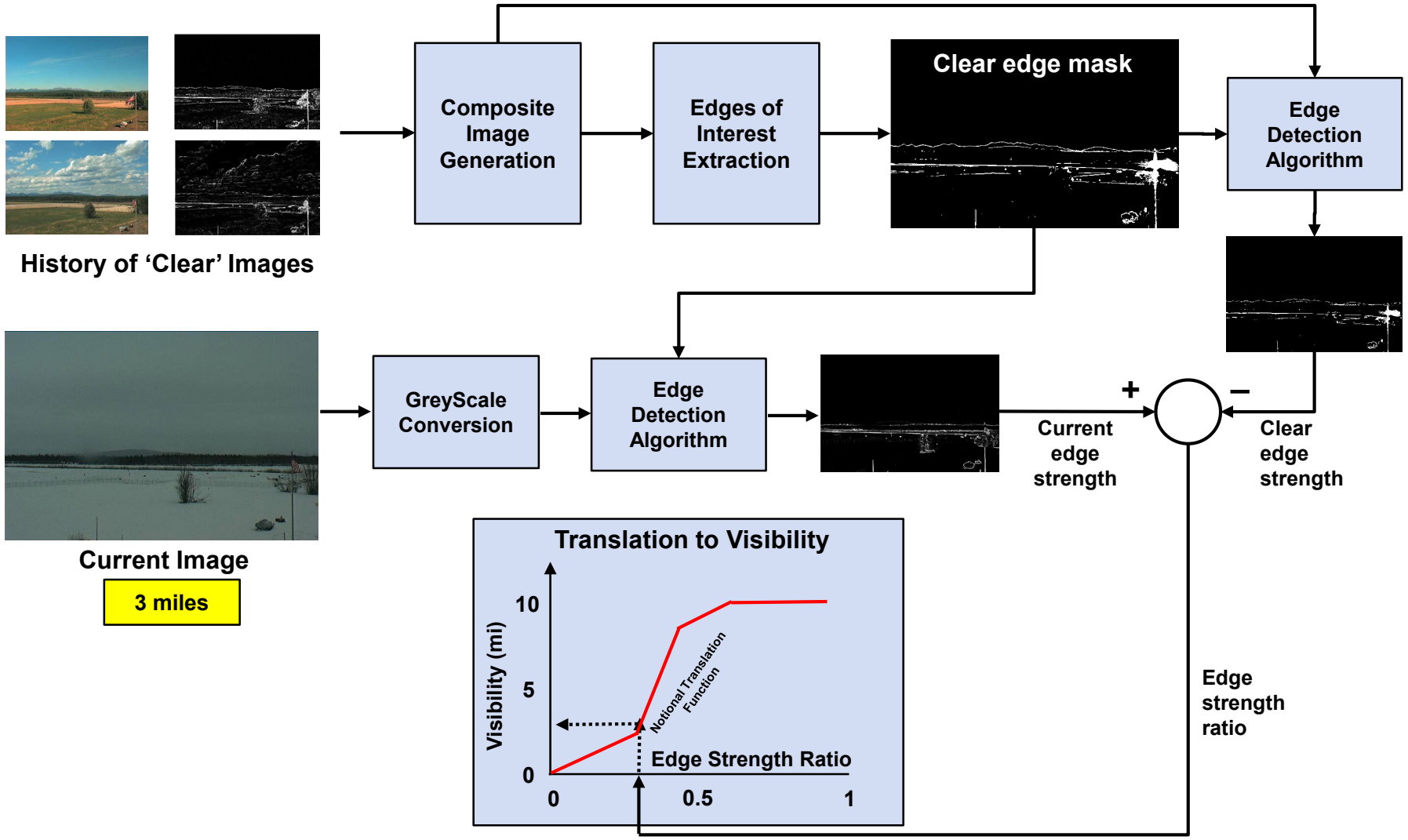




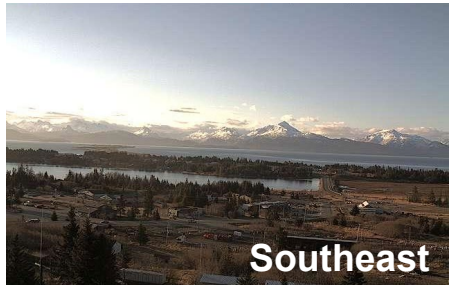
Edge strength is a function of marker distance and visibility

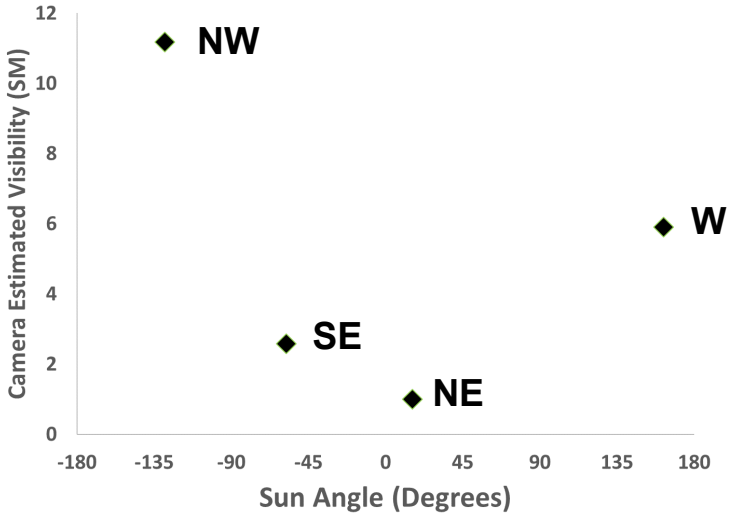
ASOS = Automated Surface Observing System

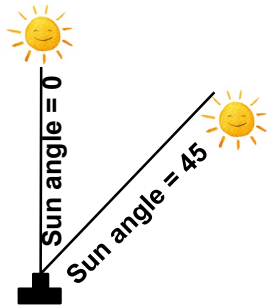
VEIA Flow Chart for a Single Camera

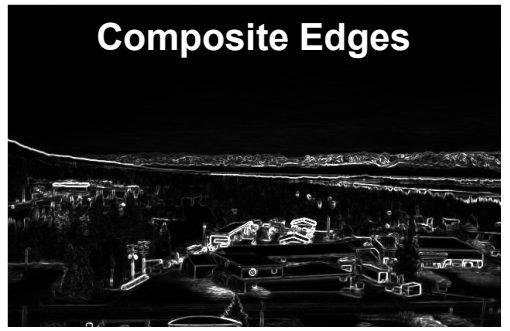


Solar Glare Impact on Camera Visibility









Solution: Implement weighting scheme based upon sun angle and agreement between co-located cameras

VEIA Combines Multiple Cameras into a Site Estimate

Single Camera VEIA

Single Camera VEIA

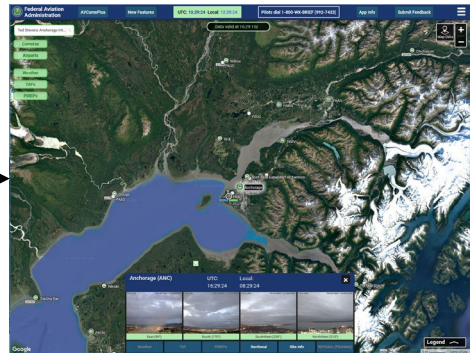
Single Camera VEIA

Single Camera VEIA

Site Combiner VEIA

Visibility

WXCAMS+

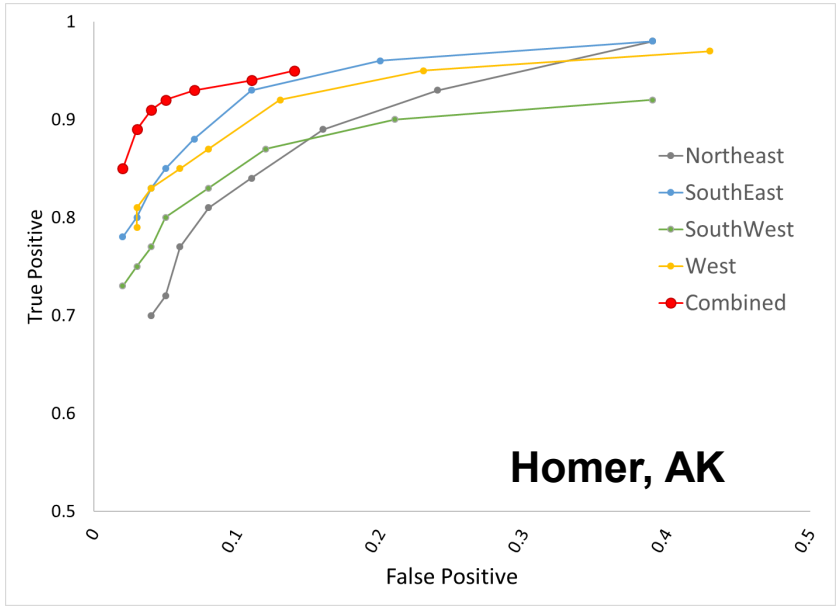


- 'Single Camera' and 'Site Combiner' hosted on WCAMS System
- Each site can host anywhere from two to four cameras

If all cameras agree and sunZenith > 45
  all cameras weighted equally
Else
  weight equals 1 - $SunAngle^2 / 180^2$

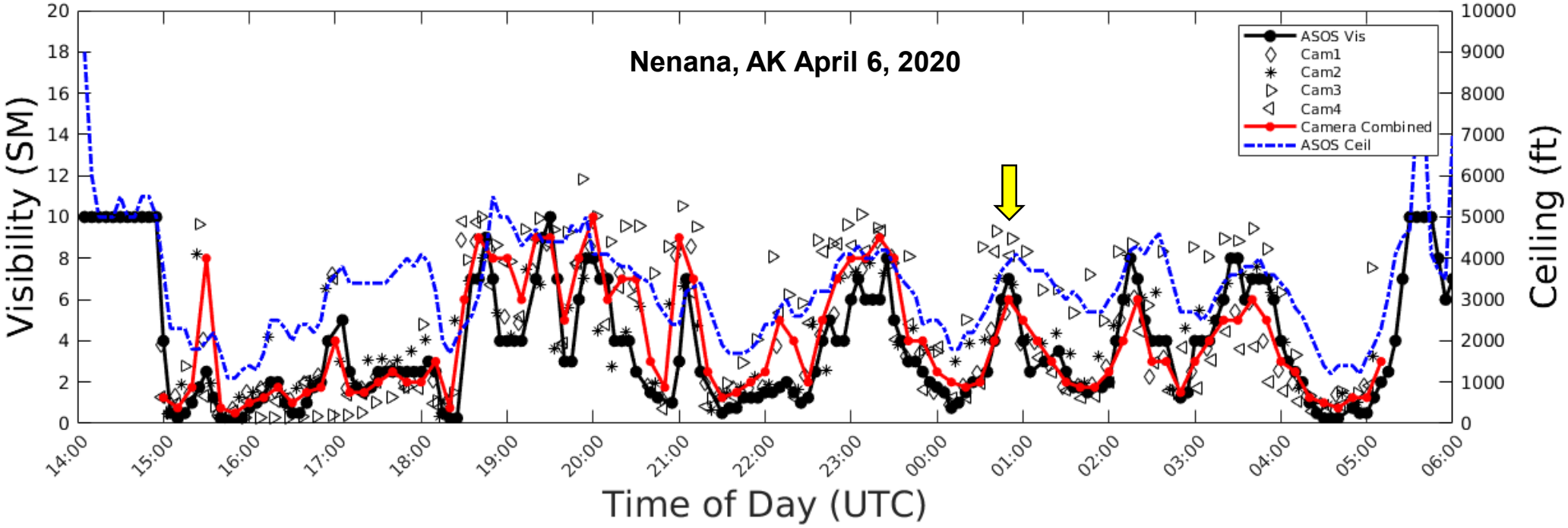
Improved Performance Using Multiple Cameras

ROC for detection of Instrument Meteorological Conditions



ASOS = Automated Surface Observing System
ROC = Receiver Operating Characteristics

Example VEIA Comparison on a Variable Day



Visibility trends are accurately captured by VEIA in rapidly changing conditions

ASOS = Automated Surface Observing System

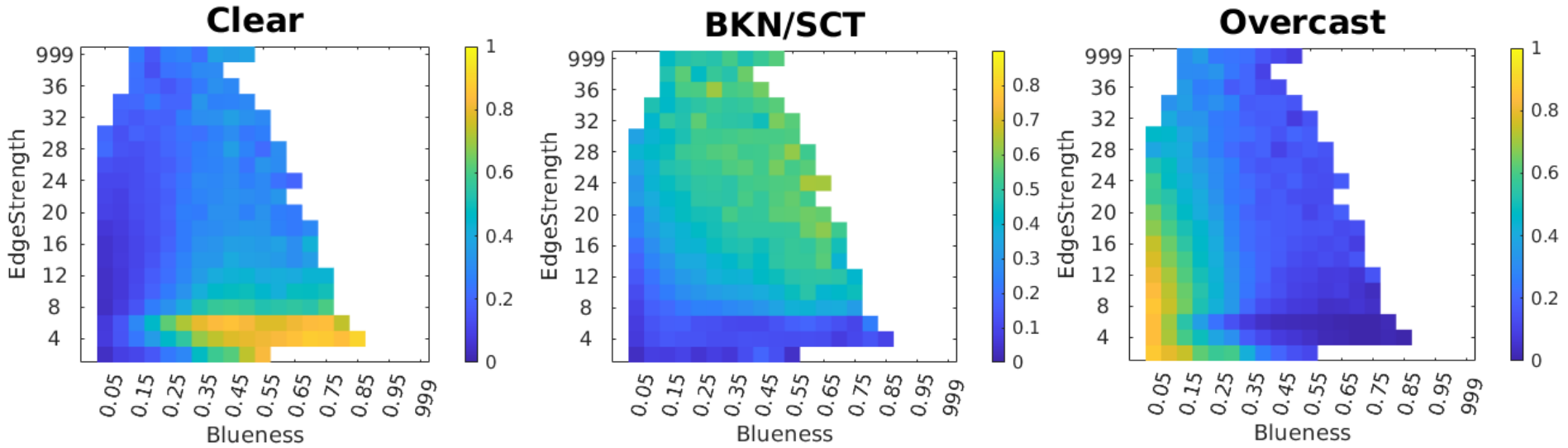
VEIA Future Plans

- VEIA Transition to Operations, March 2023
- Improve Algorithm Using Scene Clustering
  - Evaluate FAA Weather Camera images to divide them into clusters or groups with similar scene characteristics or performance measures. Modify VEIA using enhanced techniques or parameterization and perform off-line testing on sample data to demonstrate improved performance
- Adapt to 360 Degree Cameras
- Cloud Estimation through Image Analytics (CEIA)
  - Develop capability to estimate cloud cover or other cloud properties from weather cameras

Current Cloud Cover Estimation Development

- Adapted VEIA to mask out all non-sky pixels
- Performed initial feature extraction
  - Sky texture from edge strength
  - Sky 'blueness' (multiple methods)
- Initial evaluation shows promise

Homer, AK (NE)



Summary

- VEIA uses the strength of edges in an image to estimate the visibility
  - Identification of “edges of importance” to serve as benchmarks (e.g., mountains, buildings, roadways)
  - Multi camera weighting scheme provides one estimate

- VEIA to become an operational capability in March 2023
  - Conducted Operational Demonstration to support the Quality Assessment, a User Assessment, and a Safety Risk Management Review
  - Performance of VEIA is generally good and conservative towards lower visibility estimates
  - Users identified a need for VEIA and a safety review acknowledged minimal risk

- Next Steps/Future Work
  - Improve performance through scene clustering and modification to translation functions
  - Research on algorithm to estimate cloud coverage