Weather and Travel Time Decision Support

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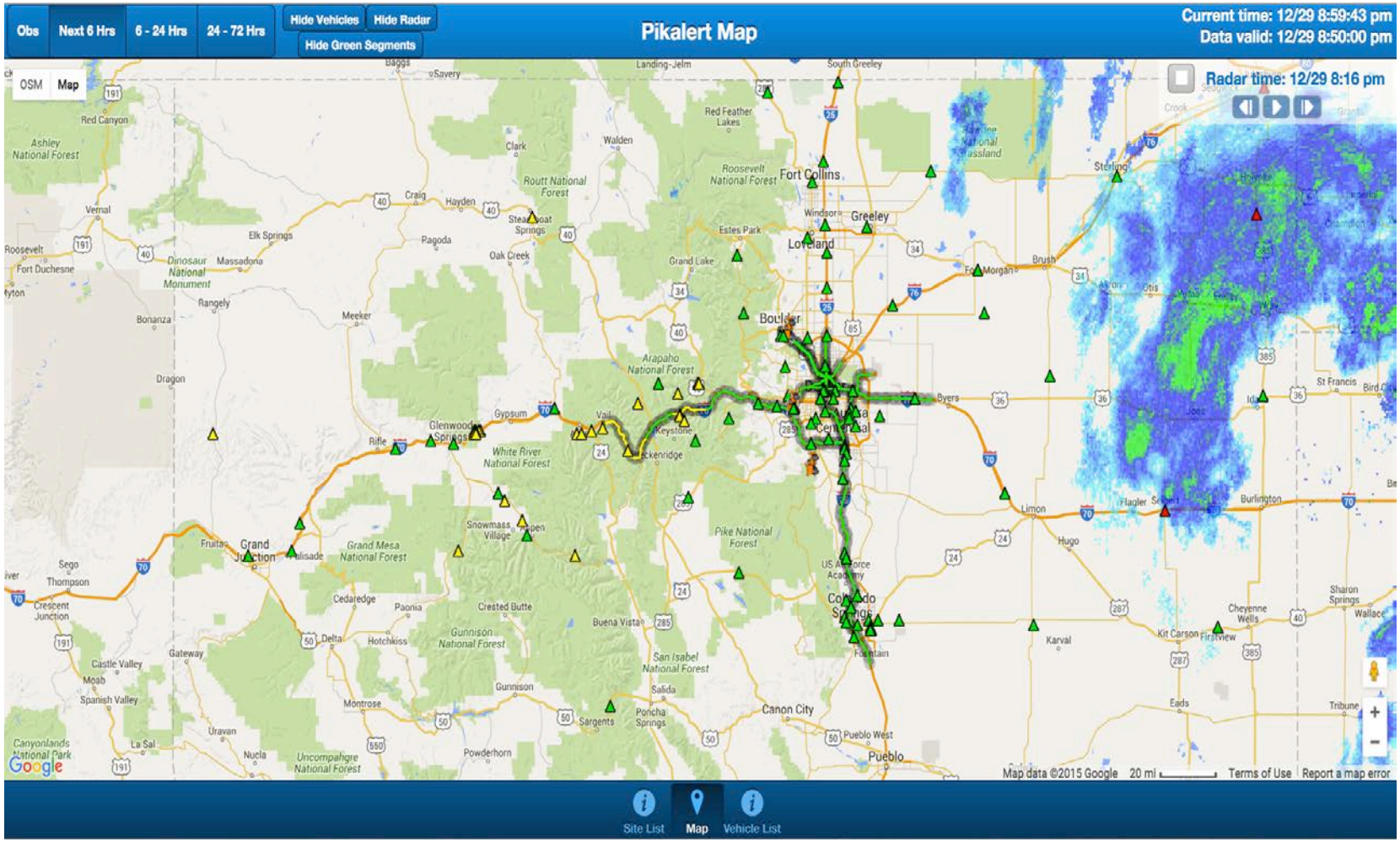
Overview

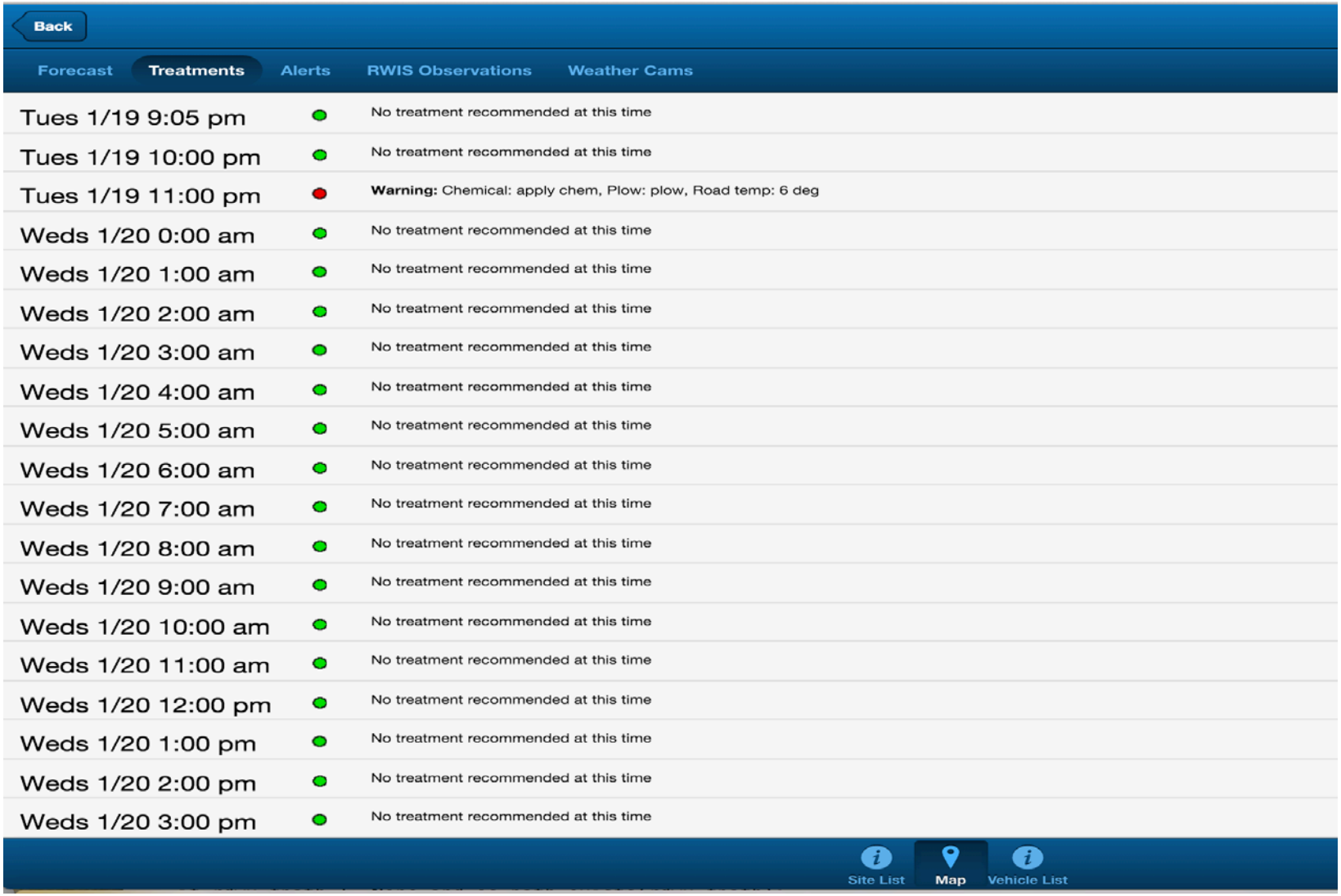
- The Pikalert System
- The value of accurate travel time information
- A domain of interest: the I-70 mountain corridor in Colorado
- Historical dataset description
- Travel time statistics on I-70
- How weather affects travel times
- How mobile observations benefit travel time prediction
- The role of machine learning in travel time prediction
- Summary

The Pikalert System

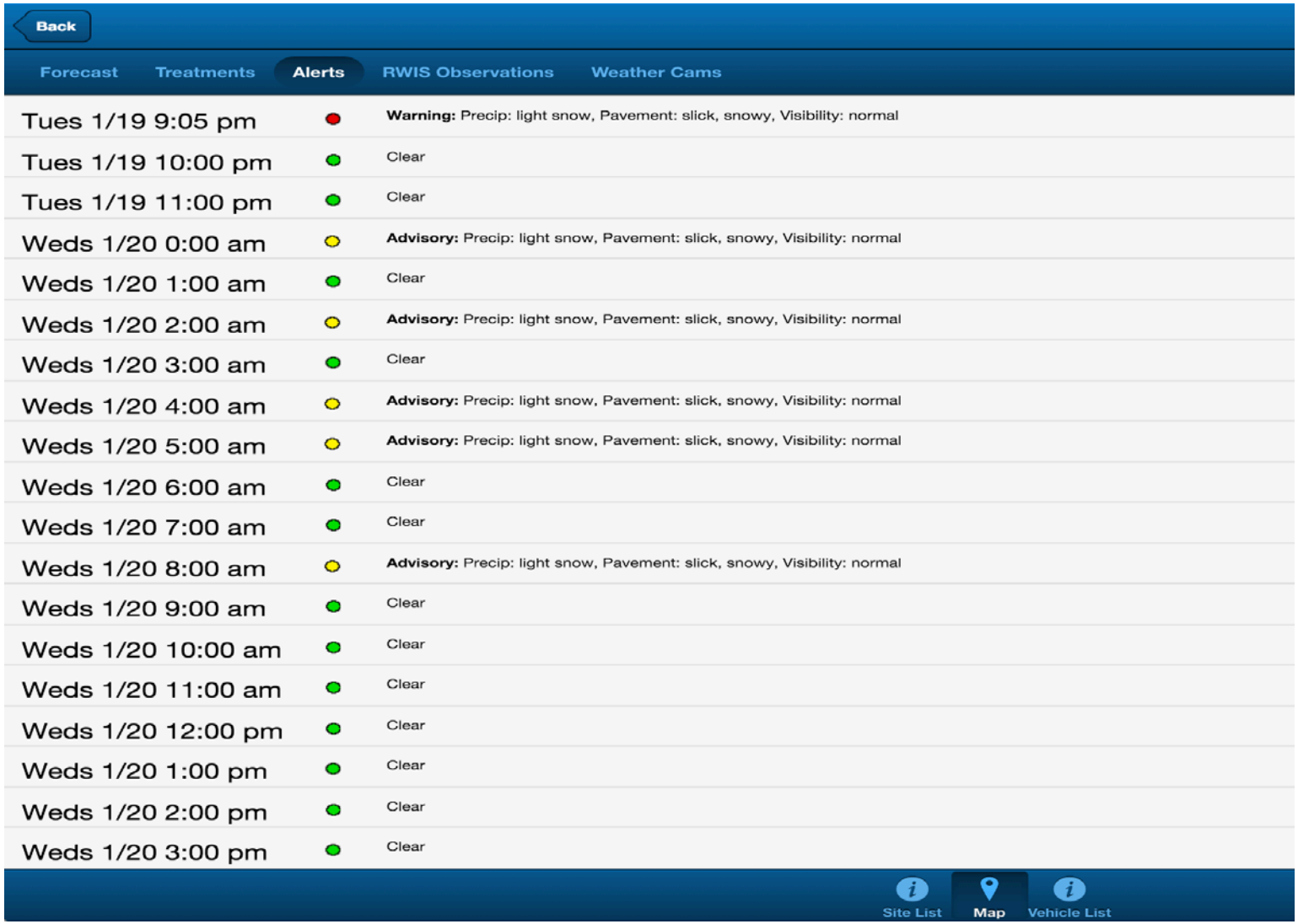


Snow, Precip, Temp and Winds

Treatments


Back
Forecast
Treatments
Alerts
RWIS Observations
Weather Cams
Tues 1/19 9:05 pm
No treatment recommended at this time
Tues 1/19 10:00 pm
No treatment recommended at this time
Tues 1/19 11:00 pm
Warning: Chemical: apply chem, Plow: plow, Road temp: 6 deg
Weds 1/20 0:00 am
No treatment recommended at this time
Weds 1/20 1:00 am
No treatment recommended at this time
Weds 1/20 2:00 am
No treatment recommended at this time
Weds 1/20 3:00 am
No treatment recommended at this time
Weds 1/20 4:00 am
No treatment recommended at this time
Weds 1/20 5:00 am
No treatment recommended at this time
Weds 1/20 6:00 am
No treatment recommended at this time
Weds 1/20 7:00 am
No treatment recommended at this time
Weds 1/20 8:00 am
No treatment recommended at this time
Weds 1/20 9:00 am
No treatment recommended at this time
Weds 1/20 10:00 am
No treatment recommended at this time
Weds 1/20 11:00 am
No treatment recommended at this time
Weds 1/20 12:00 pm
No treatment recommended at this time
Weds 1/20 1:00 pm
No treatment recommended at this time
Weds 1/20 2:00 pm
No treatment recommended at this time
Weds 1/20 3:00 pm
No treatment recommended at this time
Site List
Map
Vehicle List

Alerts


Back
Forecast
Treatments
Alerts
RWIS Observations
Weather Cams
Tues 1/19 9:05 pm
Warning: Precip: light snow, Pavement: slick, snowy, Visibility: normal
Tues 1/19 10:00 pm
Clear
Tues 1/19 11:00 pm
Clear
Weds 1/20 0:00 am
Advisory: Precip: light snow, Pavement: slick, snowy, Visibility: normal
Weds 1/20 1:00 am
Clear
Weds 1/20 2:00 am
Advisory: Precip: light snow, Pavement: slick, snowy, Visibility: normal
Weds 1/20 3:00 am
Clear
Weds 1/20 4:00 am
Advisory: Precip: light snow, Pavement: slick, snowy, Visibility: normal
Weds 1/20 5:00 am
Advisory: Precip: light snow, Pavement: slick, snowy, Visibility: normal
Weds 1/20 6:00 am
Clear
Weds 1/20 7:00 am
Clear
Weds 1/20 8:00 am
Advisory: Precip: light snow, Pavement: slick, snowy, Visibility: normal
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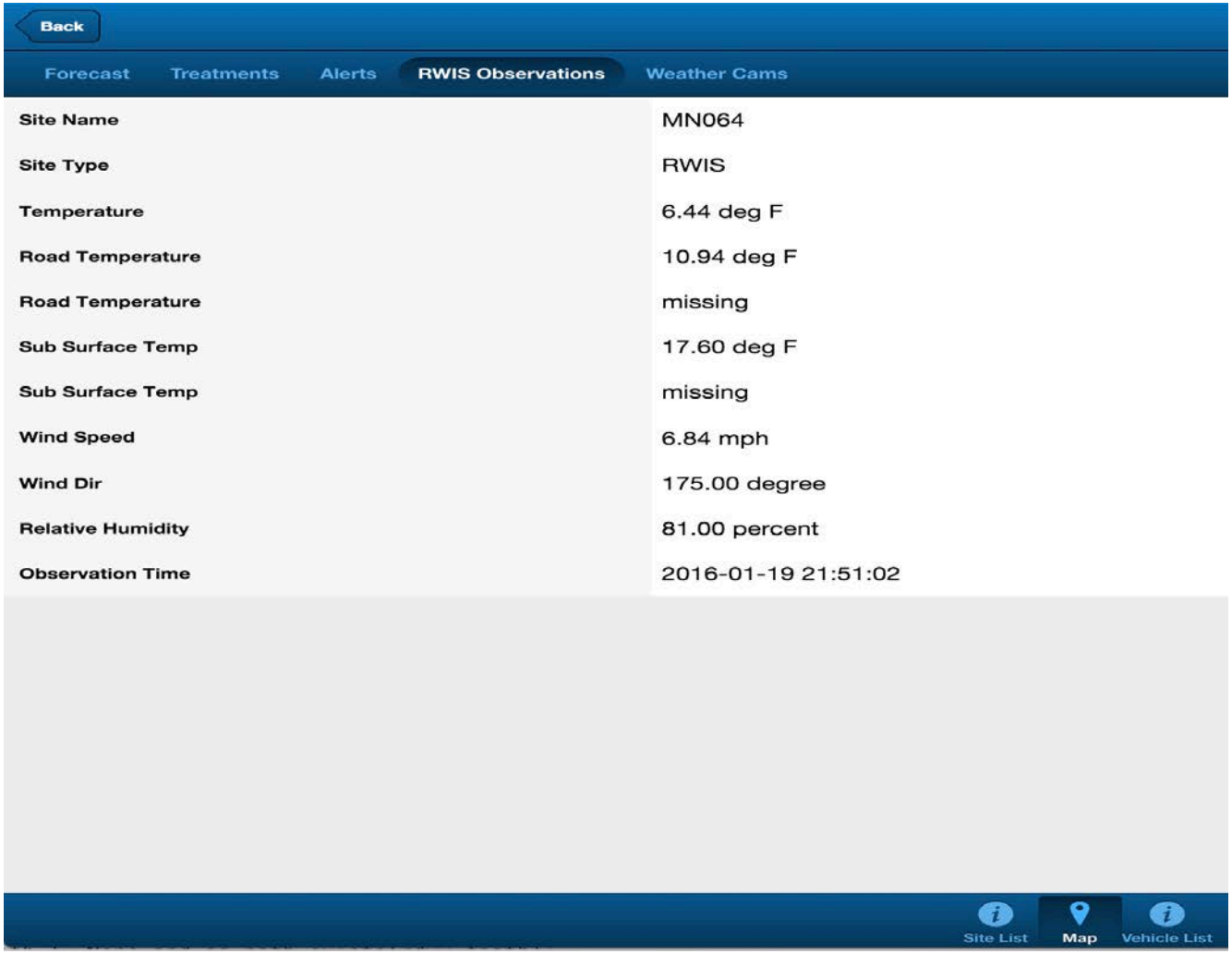
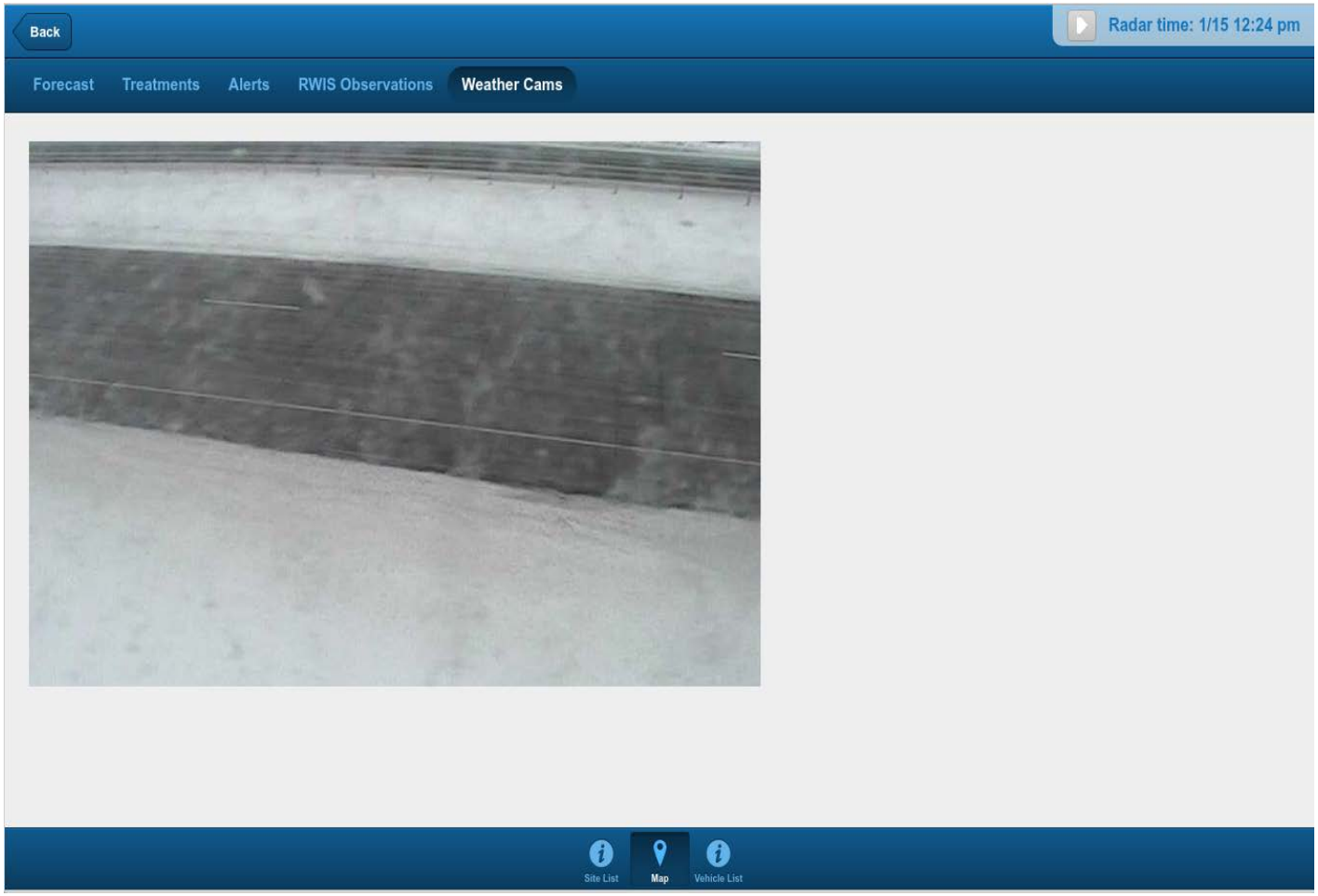
Clear
Weds 1/20 10:00 am
Clear
Weds 1/20 11:00 am
Clear
Weds 1/20 12:00 pm
Clear
Weds 1/20 1:00 pm
Clear
Weds 1/20 2:00 pm
Clear
Weds 1/20 3:00 pm
Clear
Site List
Map
Vehicle List

RWIS


Back
Forecast
Treatments
Alerts
RWIS Observations
Weather Cams
Site Name
MN064
Site Type
RWIS
Temperature
6.44 deg F
Road Temperature
10.94 deg F
Road Temperature
missing
Sub Surface Temp
17.60 deg F
Sub Surface Temp
missing
Wind Speed
6.84 mph
Wind Dir
175.00 degree
Relative Humidity
81.00 percent
Observation Time
2016-01-19 21:51:02
Site List
Map
Vehicle List

RWIS Camera Image



The Pikalert System

- What does Pikalert do?
  - Integrates mobile observations, weather observations, and weather forecasts to provide road maintenance decision support and guidance to the travelling public out to 72 hours
- Why does Pikalert leverage mobile observations?
  - To assist in assessing current road conditions
  - For road weather, condition, treatment forecast tuning

The Pikalert System

- The Pikalert display contains:
  - Current and forecast road conditions
  - Current vehicle observations
  - RWIS observations
  - Road segment information
- Pikalert supports:
  - Drilling down to road conditions on a particular road segment based on mobile and other meteorological observations

Scheduled Pikalert Enhancements

- Improved display functionality
  - Radar overlays and looping
  - RWIS camera images
- Refinements to precipitation and road slickness forecasting
- Dual polarization radar
- Desired Enhancement:
  - Travel time support

The Value of Accurate Travel Time Information

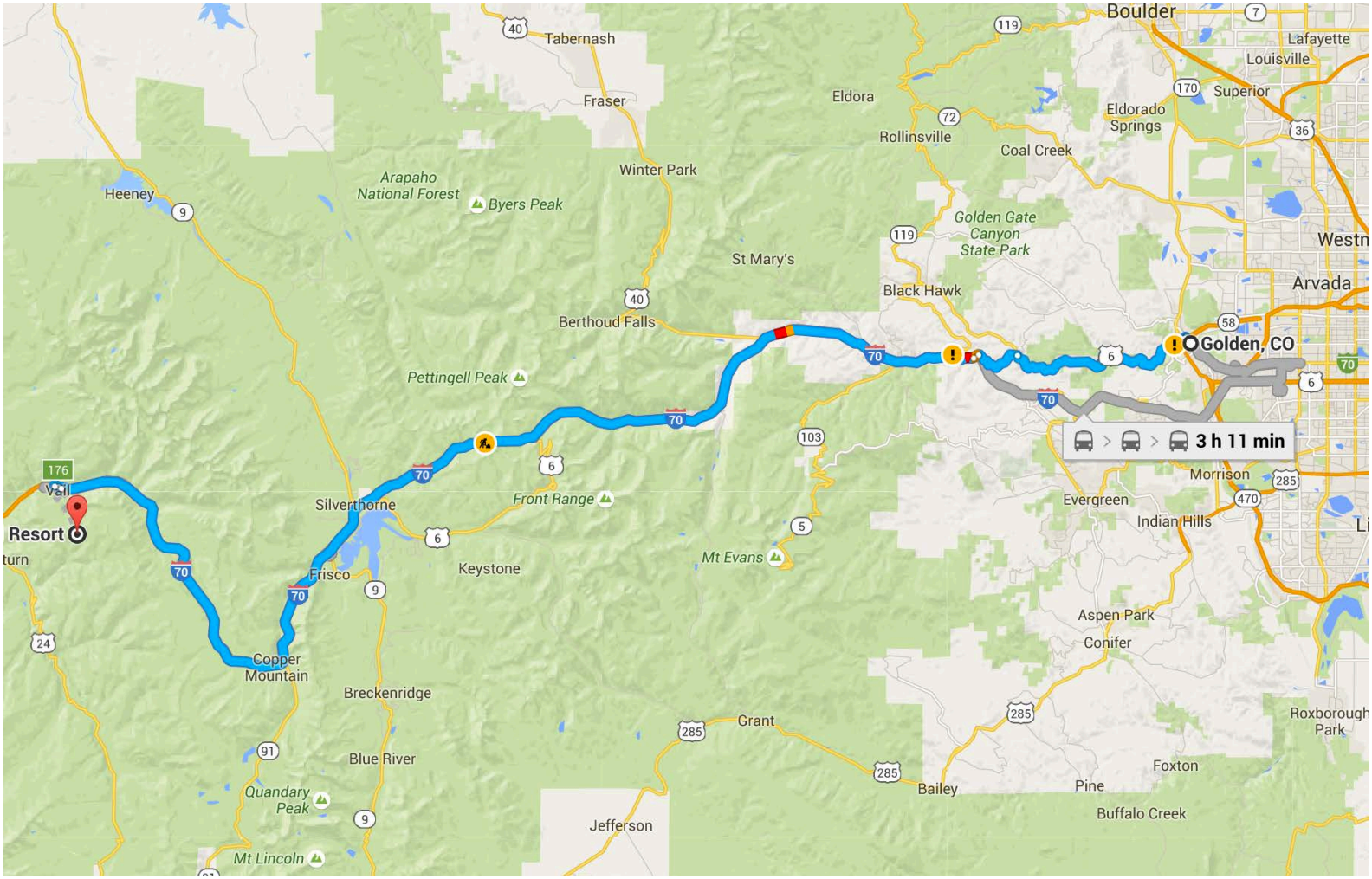
Accurate Travel Time Information

- Supports making better travel decisions and effective use of time
  - Route selection
  - Departure scheduling
  - Mode of transportation
  - Maintenance guidance
- Reduces uncertainty with regard to arrival time
- State DOTs are interested in making use of better highway travel time forecasts in conjunction with hazardous weather prediction
- Should be augmented with traffic and weather information

Domain of Interest

- I-70 mountain corridor from Golden to Vail (mile markers 261 through 176)
  - Golden
    - 5674 feet (mm 261)
  - Idaho Springs
    - 7524 feet (mm 240)
  - Georgetown
    - 8530 feet (mm 228)
  - Eisenhower Tunnel
    - 11,158 feet (mm216)
  - Silverthorne
    - 9035 feet (mm205)
  - Copper Mountain
    - 9712 feet (mm195)
  - Vail Pass
    - 10,662 feet (mm 190)
  - Vail
    - 8150 feet (mm176)

Domain of Interest



Domain of Interest

- 34 westbound and eastbound road segments between Golden and Vail
- Distance: 84.5 miles
- Travel time: approximately 90 minutes
- Road segments vary from approximately one mile to twelve miles in length

Tunnel Traffic

- ~11 million vehicles traveled through the Eisenhower Tunnel in 2013
- On the 4 day Martin Luther King Jr holiday weekend in 2013, ~162000 vehicles traveled through the tunnel
- ~200 accidents per year occur at the tunnel

Historical Dataset Description

- Traffic and qualitative road condition information were obtained from Colorado Department of Transportation (CDOT)
- Historical dataset consists of both traffic and observed weather information
- Quantitative weather information was gathered from the National Weather Service
- Data set covers Jan 1, 2014 through Aug 30, 2015 (~5 GB of ASCII data)

Historical Dataset Description

- Date, time
  - Two minute data
- Solar zenith, azimuth
- Road segment information
  - Id, length, start mile marker, end mile marker
- Travel time in seconds (target of interest)
- Road condition information
- Temperature
- Dew point
- Wind speed and direction
- Precipitation rate
- Precipitation accumulation
- Visibility
- Road temperature
- …

Travel Time Statistics on I-70

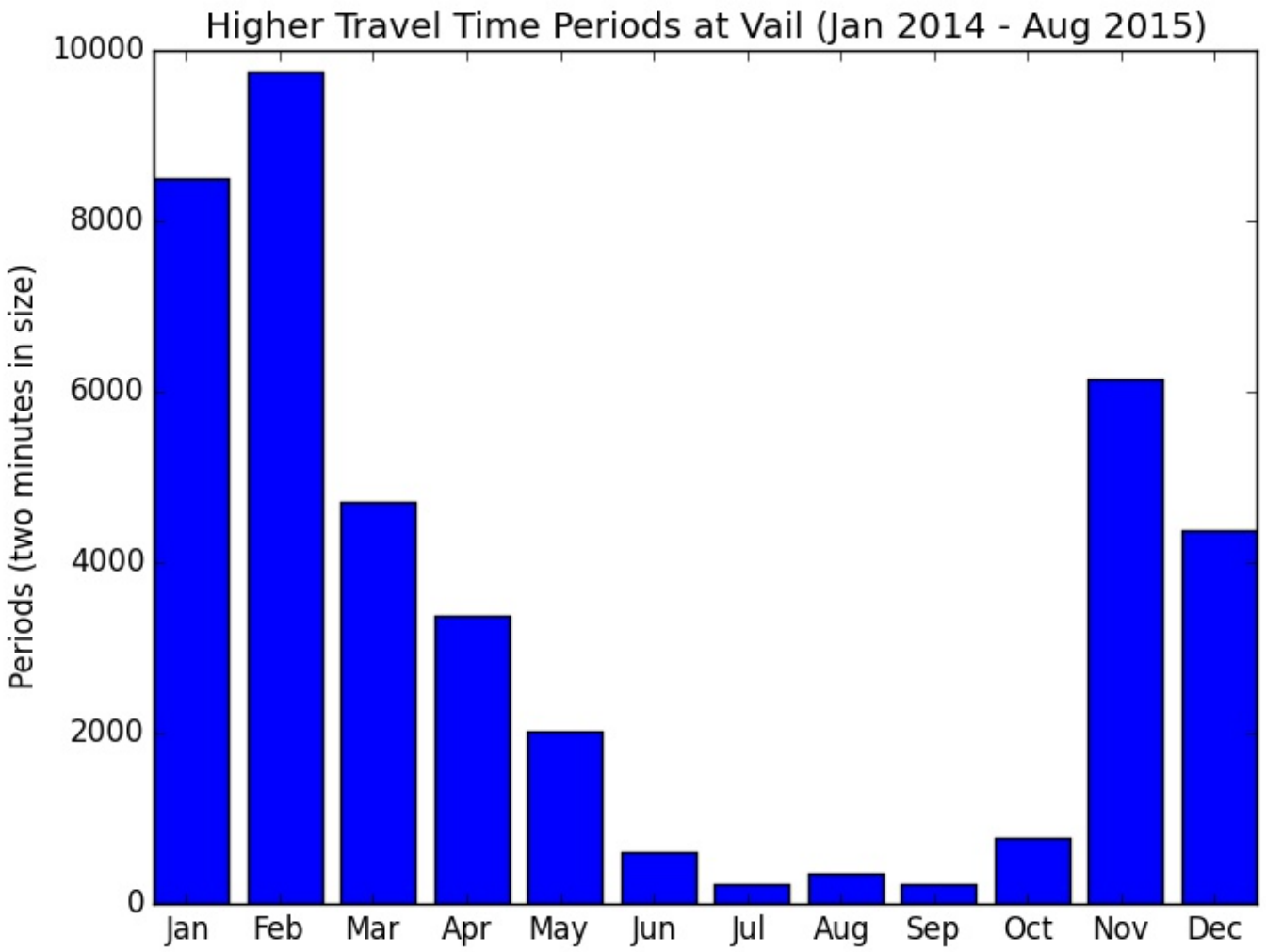
- Average travel times on road segments vary from 1 to 14 minutes (corresponds to segment lengths)
- The 99th percentile travel times vary from 1½ minutes to 24 minutes depending on the road segments
- The maximum travel times vary from 7½ minutes to 6.6 hours (< 1 percent of the time)
  - On March 7, 2014 Eastbound traffic was shut down due to multiple accidents and westbound traffic was at a standstill between Georgetown and the Eisenhower Tunnel.

Heavy Traffic at a Standstill on I-70 March 7, 2014

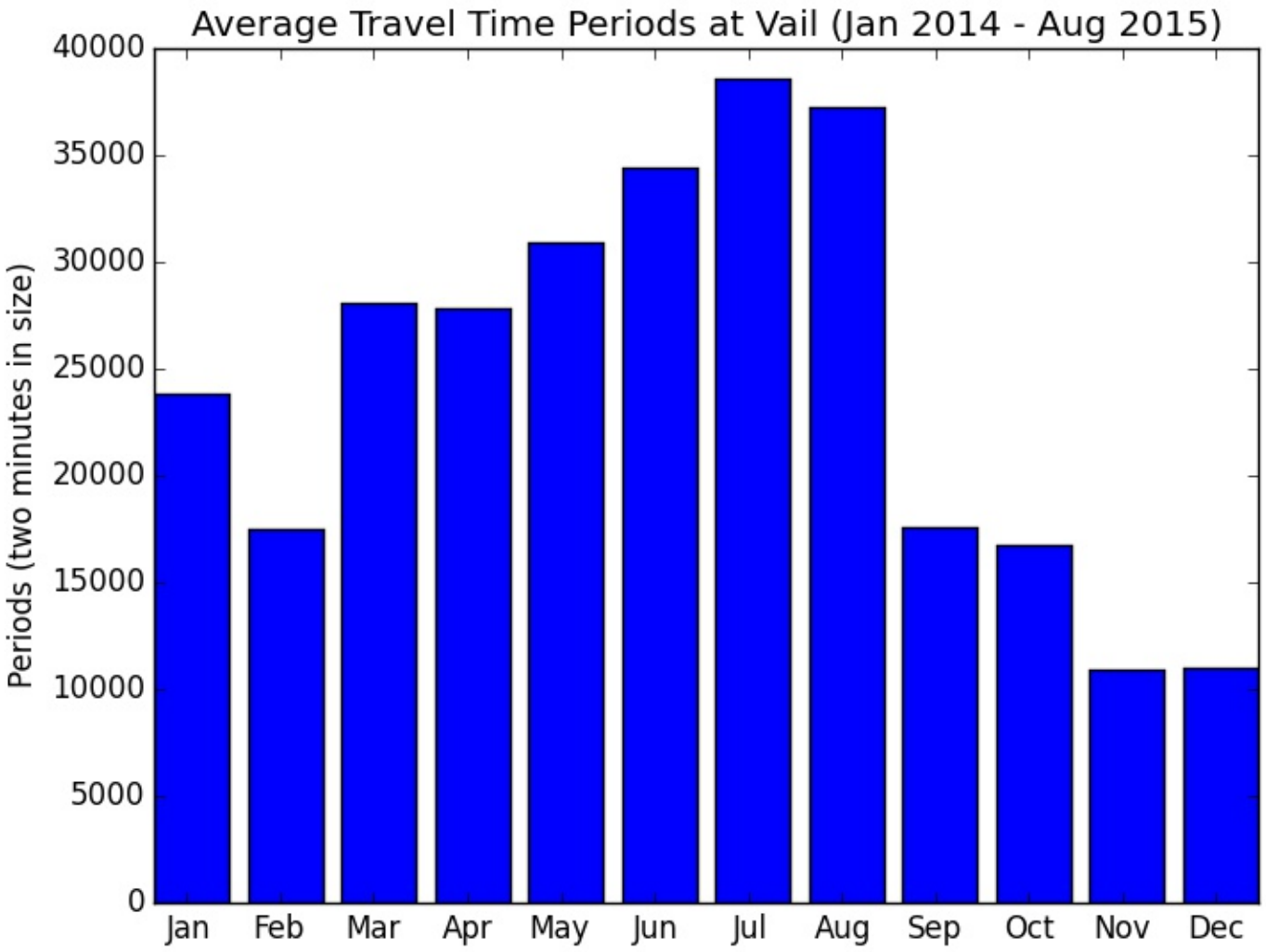
How Weather Impacts Travel Times

- Consider Vail at mm 176
  - Westbound road segment from mm 189.4 to 177 (12.4 miles)
  - Average travel time in seconds: 785 (~13 min)
  - 25th percentile: 698 seconds
  - 75th percentile: 805 seconds
  - 90th percentile: 970 seconds (~16 min)
  - 99th percentile: 1404 seconds (~23 min)
  - Max: 8929 seconds (~149 minutes)

How Weather Impacts Travel Times



How Weather Impacts Travel Times



How Weather Impacts Travel Times

- Long term winter month average low, high temperatures at Vail weather station from 1981 to 2010
  - Oct: 25, 54 deg F
  - Nov: 15, 37 deg F
  - Dec: 7, 27 deg F
  - Jan: 5, 28 deg F
  - Feb: 9, 33 deg F
  - March: 16, 41deg F
  - April: 23, 49 deg F

The Role of Mobile Observations in Travel Time Prediction

- Mobile observations provide high resolution road condition information
- Methods for knowing the weather?
  - RWIS
  - Radar (if available)
  - Video cameras
  - Mobile Observations
    - Wipers (Off, on, low, medium, high)
    - Speed
    - Automatic braking system (ABS)
    - Traction control
    - Fog lights
- Knowing the weather on the road can be used in tuning road weather prediction models

The Role of Machine Learning in Travel Time Prediction

- What is machine learning?
  - Subfield of computer science
  - Pattern recognition
    - For example:
      - Classifying email as spam or non-spam
      - Classifying an image of a road as snowy or clear
  - Uses statistical and algorithmic techniques
  - Supervised learning involves establishing a set of predictors and a target variable to be predicted.

The Role of Machine Learning in Travel Time Prediction

- Our intuition tells us that the following should have an effect on travel time (potential predictors):
  - Time of day
  - Day of week
  - Month of year
  - Holidays
  - Snowfall
  - Heavy rain
  - Fog (low visibility)
  - Icy roads
  - Accidents
  - Construction
- Machine learning can assist in modeling these effects

The Role of Machine Learning in Travel Time Prediction

- A common sense predictor of travel time:
  - The previous hour's travel time
  - Would not be a good predictor when road conditions are changing quickly
  - Would not want to use previous hour's travel time in the following scenarios:
    - Hour prior to rush hour => rush hour
    - No snow => snow
    - Clear => thunderstorm
    - No fog => fog

The Role of Machine Learning in Travel Time Prediction

- A combined model:
  - Use a model based on recent hour travel time information when conditions on the road are expected to be stable and change slowly
  - Utilize a different model when significant road condition changes are expected such as significant changes in weather

Summary

- Pikalert provides enhanced decision support and guidance by integrating mobile observations with road weather, condition and treatment forecasts
- Mobile observations are important in assessing current road conditions and support tuning of weather forecast models
- Accurate travel time, road weather and traffic information have significant value to the travelling public
- Adverse weather has a significant impact on travel times
- Machine learning techniques can be utilized in modeling travel especially when road conditions are changing quickly
- Multiple travel time models are beneficial in addressing stable conditions versus rapidly changing conditions

Questions

- Please email:
  - gerry@ucar.edu