Mobile Vehicle Road and Weather Observation Quality Check Methods

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Outline

- Motivation for developing quality checks for maintenance trucks
- Development of the quality check tests
- Case Studies
- Results
- Summary
- Next Steps
Motivation

- Current road weather observations are in static locations leaving data gaps in between RWIS.
- Many maintenance trucks have been equipped with Mobile Data Collection and Automatic Vehicle Location (MDC/AVL) units that collect data. The shortcoming of these data is the unverified accuracy of the received data.
# Data Collected from MDC/AVL Vehicles

The most common data elements that are recorded from the MDC/AVL units include **Vehicle Identifier, Time, Location, Lane Identifier, Maintenance Data and Observations.**

<table>
<thead>
<tr>
<th>Maintenance data:</th>
<th>Observation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Plow position</td>
<td>• Road condition</td>
</tr>
<tr>
<td>• Material applied</td>
<td>• Road Temperature (Optional)</td>
</tr>
<tr>
<td>• Material Form</td>
<td>• Precipitation (Optional)</td>
</tr>
<tr>
<td>• Application rate</td>
<td>• Visibility and Obstruction</td>
</tr>
<tr>
<td>• Application rate units</td>
<td>• Air Temperature (Optional)</td>
</tr>
</tbody>
</table>

- **Bolded** items are used in the quality checking algorithm.
## Quality Check Comparison

<table>
<thead>
<tr>
<th>Clarus System Quality Checks</th>
<th>Proposed Mobile ESS Quality Checks</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sensor range test</td>
<td>• Speed Check (*Time Step)</td>
</tr>
<tr>
<td>• Climate range test</td>
<td>• Gross Check (*Sensor Range)</td>
</tr>
<tr>
<td>• Time step test</td>
<td>• Persistence Test</td>
</tr>
<tr>
<td>• Like instrument test</td>
<td>• Inter-Quartile Range (IQR) Test for ESS</td>
</tr>
<tr>
<td>• Persistence test</td>
<td>• Barnes Spatial Test for ESS</td>
</tr>
<tr>
<td>• IQR spatial test</td>
<td>• Truck-to-truck-Spatial Test</td>
</tr>
<tr>
<td>• Barnes spatial test</td>
<td>• Truck-to-Model-Spatial Test**</td>
</tr>
<tr>
<td>• Dew point temperature test</td>
<td></td>
</tr>
<tr>
<td>• Sea level pressure test</td>
<td></td>
</tr>
<tr>
<td>• Precipitation estimation test</td>
<td></td>
</tr>
</tbody>
</table>

* Denotes different name but similar test.

**Computer troubles have caused this test to not be run.
The quality check algorithm begins with primary tests.

- If they pass then secondary tests are performed.
Primary Tests

• Speed Test

<table>
<thead>
<tr>
<th>Observation occurred in the last 15 minutes?</th>
<th>(True) Continue</th>
<th>(False) Error-observation old.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude and Longitude Data?</td>
<td>(True) Continue</td>
<td>(False) Error-no location data</td>
</tr>
<tr>
<td>Distance traveled between observation is &gt; 0.1 km?</td>
<td>(True) Continue</td>
<td>(False) Error-not moving</td>
</tr>
<tr>
<td>Speed is over 5 mph and under 90 mph?</td>
<td>(True) Pass</td>
<td>(False) Fail-speed test</td>
</tr>
</tbody>
</table>
Primary Tests (Cont.)

- Gross QC Test

<table>
<thead>
<tr>
<th>Observation in sensor range?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(True) Pass</td>
</tr>
<tr>
<td>(False) Fail-out of sensor range</td>
</tr>
</tbody>
</table>

Continue to Secondary QC Testing
Secondary Tests

- Truck-to-Truck Spatial Test
- IQR Test for ESS
- Persistence Test
- Barnes Spatial Test for ESS
## Truck-to-Truck Spatial Test

<table>
<thead>
<tr>
<th>Condition</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least 2 neighboring MDC/AVL Vehicles less than 69 miles from target</td>
<td></td>
</tr>
<tr>
<td>(True) Continue</td>
<td>(False) Error - not enough close observations</td>
</tr>
<tr>
<td>Temperature is between the Barnes spatial interpolation of neighboring MDC/AVL Vehicles.</td>
<td></td>
</tr>
<tr>
<td>(True) Pass</td>
<td>(False) Fail - out of range</td>
</tr>
</tbody>
</table>

**Notes:**
- 
- 
- 
-
IQR Test For RWIS

At least 5 neighboring RWIS less than 69 miles from target

(True) Continue  (False) Error-not enough close observations

Temperature is between the median of RWIS and the adjust IQR or minimum tolerance bound.

(True) Pass  (False) Fail-out of range
Barnes Spatial Test for RWIS

At least 2 neighboring RWIS less than 69 miles from target

(True) Continue  (False) Error-not enough close observations

Temperature is between the Barnes spatial interpolation of neighboring RWIS.

(True) Pass  (False) Fail-out of range
Barnes Spatial Analysis

• The Barnes spatial test uses neighboring observations and weights them based on their distance from the target sensor.
• The weights from the neighboring observations drop exponentially as the distance from the target increases.
• Observations outside of the radius of influence receive a weight of zero.
Persistence Test

Observation occurred in last 30 minutes

(True) Check if value changed from last 15 observations

(True) Pass value changed
(False) Fail-value didn’t change

(False) Check if the observation is same as last reported value

(True) Fail-same as previous trip
(False) Pass Value changed
Test Cases

- **Eastern ND Cases:**
  - November 29-30, 2010
  - Dec 30, 2010 - Jan 1, 2011
  - March 11-12, 2011
  - March 22-23, 2011
  - April 15-16, 2011

- **Black Hills, SD Cases**
  - Dec 30, 2010 - Jan 1, 2011
  - January 15, 2011
  - February 24, 2011
  - March 8, 2011
  - March 26, 2011

- **St. Cloud, MN Cases**
  - November 22, 2010
  - December 11, 2010
  - February 20-22, 2011
  - March 22-23, 2011
  - April 20, 2011

- **Sisseton Moraine, SD**
  - Dec 30, 2010 - Jan 2, 2011
  - February 2-3, 2011
  - February 8-9, 2011
  - February 13-14, 2011
  - February 17-18, 2011
Cases Location
Case March 22-23, 2011

• Focuses on Eastern ND and St. Cloud, MN area
• Trucks that were processed include:
  – ND-9303, ND-9311, ND-9372, ND-9519, ND-9644, ND-9757, ND-9784
• Trucks ND-9372 and MN-AT-208562 show a sample of some results.
ND-9372 Results

![Graph showing various scores over different date and time intervals.](image-url)

- Speed
- Gross_Air
- Gross_Pvt
- IQR_Air
- Station_Air
- IQR_Pvt
- Station_Pvt
- Truck to Truck Air
- Truck to Truck Pvt
- Persis_Air
- Persis_Pvt

Date and Time (UTC):
- 3/22 23:45
- 3/23 3:21
- 3/23 6:57
- 3/23 10:33
- 3/23 14:09
- 3/23 17:45
Notes for ND-9372

- ND-9372 experienced an issued during the snow event.
- At 12:20 UTC (6:20 am CST) on March 23, the sensors “got stuck” at a 32.2°F for Air temperature and 52.8°F for Pavement Temperature for 40 minutes.
- At 13 UTC (7 am CST) on March 23, those values switched over to 0°F for both of the sensors until the end of the run at 19 UTC (1 pm CST).
Notes for MN-AT-208562

- MN-AT-208562 shows that the tests were able to complete without any errors.
- The pavement sensor compared well against surrounding stations and trucks.
- The air temperature sensor on board did not fair as well.
  - Reported temperatures were typically 5-20 F degrees warmer than surrounding observations.
Summary

• Amount of included data
  – Frequency of GPS Data VS. Observation data
• Timing of data
  – Data collection from third party data is delayed
• Data “Getting Stuck” at 0°F
• Significant figures in data (xxx.xxx F or xxx F)
• Missing observations for comparison and/or differentiation between surface observation types
  – No pavement/surface temperature sensors installed
  – Missing “reference locations” i.e. bridge or roadway
• Limitations
  – Post or Real time analysis.
Next Steps

• Study the quality check algorithm against other trucks and other wintertime events.

• Determine alternative way to run the quality checks to improve algorithm performance for high volumes of mobile observations.
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Questions?

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