Abstract:

In a previous paper “METAR AUTO Implementation at International Airports in New Zealand” Hartley and Quayle TECO 2014, all facets of this project and its implementation at 3 international and 27 domestic airports were described. One of the stringent requirements imposed by New Zealand Civil Aviation Authority (CAA) for full METAR automation at New Zealand International airports was: “Automated quality control at the weather station (Data Validity Cross Checking)”.

To meet this MetService New Zealand implemented an AWS quality control algorithm that de-constructed sensor present weather reports and then performed comparisons with: visibility; rainfall; air temperature; relative humidity - making appropriate changes to each present weather element and then reconstruction it into METAR code. In the two years since its implementation the METAR AUTO programme has been successful with no significant issues and during this period all AWS have kept logs of changes (or not) made to sensor reports of present weather. The implemented present weather quality control algorithms will be presented in this paper together with statics of sensor report changes made to the data from the two present weather sensors implemented by MetService – Vaisala FD12P and Vaisala PWD22. Commentary from aviation forecasters will be included on the validity of AWS quality controlled present weather included in METAR AUTO and how much subsequent manual adjustment of present weather data is required.

Abbreviations

AWS        Automatic Weather Station
CAA        New Zealand Civil Aviation Authority
ICAO       International Civil Aviation Organisation
PrWx       Present Weather

Introduction

In a previous paper “METAR AUTO Implementation at International Airports in New Zealand”, Hartley and Quayle, 12th May 2014”, the implementation of MetService AWS quality control algorithms was discussed. These algorithms are presented in this paper. In that paper one of the “CAA Regulatory Approval - Implementation Requirements” was...

✔ Automated quality control at the weather station (Data Validity Cross Checking)

Although CAA only required quality control at the 3 New Zealand International Airports, the METAR AUTO AWS upgrade was rolled out to all AWS with present weather sensor capability due to expected benefits.

To assess the effectiveness of the quality control algorithm implemented by MetService in its AWS a study of 2 years of 1-minute observation and algorithm corrections have been collected and the results are presented here.

The three international Airport sites each have co-located FD12P and PWD22 which has provided the opportunity to compare the sensors performance with regard to the Quality Control algorithm under identical conditions.

MetService also implements a PrWx Creation Algorithm in each AWS (this algorithm will not be presented or discussed here). This algorithm creates PrWx components from the same input data used to quality control the sensor PrWx. The created components are then used to determine any PrWx sensor missed components.

Forecaster manual quality control is performed on all 30 minute METAR AUTO reported from the 3 international airports. All manual changes are recorded and those that indicate incorrect PrWx reports from AWS are discussed.

ICAO has recently issued Annex 3 Amendment 1–77-A which contains code changes that will impact sensor PrWx reporting. The PrWx changes will be identified and the affect on the current MetService data evaluation will be discussed.
Evaluation Conditions

Sensor Management

All FD12P sensor configurations are the same and the PWD22 sensor configurations are the same at all sites. The FD12P and PWD22 sensor configurations are the same (as far as is practicable for the different sensor models).

PrWx sensor status monitoring and alerting were used to provide prompts to staff to perform lens cleaning before data was affected. The cleaning process is performed at times that avoid contaminating METAR AUTO data that is reviewed by forecasters, however data during the cleaning process will still be contained in the 1 minute data evaluation however the number of samples affected will be small compared to the total number of data points.

All AWS sensors are field and/or calibrated on an annual basis so that full operating accuracy specifications are maintained.

Sensor Locations

Heated Vaisala HMP155 sensors with external air temperature are used on each of the 6 AWS at the 3 dual AWS international airport sites: Auckland (NZAA); Wellington (NZWN); Christchurch (NZCH). The remaining 6 AWS use unheated Vaisala HMP155 sensors. The weather stations are given a suffix A or B to differentiate the two AWS at each site.

Nine sensor sites were used across the full length and breadth of New Zealand. Three locations have co-located FD12P and PWD22 on separate AWS (see green highlight in the table), three locations have only FD12P, three locations have only PWD22.
Algorithm Data Inputs - Sensor Sampling Regimes

The AWS sampling used in the algorithm quality control data inputs are:

- Present weather, Visibility and Rainfall – once per minute
- Air Temperature and Relative Humidity – once per 6 seconds

Each data set is independently quality controlled and then processed to produce 1 minute data values. The data values with quality control status are saved to the AWS database.

Data Capture

All 1 minute data is stored locally in each AWS for up to 61 days at which point the oldest day is automatically deleted.
The AWS databases were extracted from AWS once per month and saved to central servers (with backup).

Algorithms

The sensor PrWx reports are deconstructed into components e.g. +RASN becomes +RA and +SN, and then inter-data comparison and quality control is performed with data from other AWS sensors including 1 minute: Visibility; Rainfall; Air temperature; and Relative humidity.

Some sensor data threshold values are adjusted to allow for sensor uncertainties i.e. to err on the conservative side when deciding whether to significantly change or remove a PrWx report. Multi-step tests do not include allowance for uncertainties as these would compound and make the acceptance band too wide.

Definitions for Light/Moderate/Heavy are different for different types of Precipitation.
The algorithm definitions and thresholds are based on information from the following sources:

- ICAO/AMOSSG - Aerodrome Meteorological Observing Systems Study Group, DRAFT AMOSSG MANUAL, AMOSSG/4-SN No. 5, Appendix B
- MetService scientist and forecaster theory and experience
- ICAO Annex 3 Annex 3 to the Convention on International Civil Aviation

AWS Top Level Process

2. PrWx sensor data split - Into base descriptor, precipitation and obscuration components.
3. Apply Tweaks - To codes that are close to correct and allowed to be varied.
4. Validate PrWx Components - Remove those that are invalid and raise status for any changes.
5. Quality Control Algorithm - Done as blocks and performed from top to bottom (see table headings). Raise status for any changes. When a Precipitation Type is changed this step is restarted to perform the Quality Control Algorithm on the newly added precipitation type.
6. Create PrWx Algorithm - If there is no sensor PrWx report then create PrWx from the base sensor data. Anything created has therefore been missed by the PrWx sensor.
7. Combine PrWx Components - Combine all PrWx components using WMO METAR coding rules. The SYNOP numeric present weather code table (4680 Present weather reported from an automatic weather station) is used to prioritise inclusion of elements where ambiguities exist.
8. Save Data and Status - Save quality controlled data and status (change records) to the AWS database. Original sensor data is not over-written i.e. pre and post quality controlled data is all retained in the AWS database.
### 3. Apply Tweaks

<table>
<thead>
<tr>
<th>Description</th>
<th>APPLY TO EACH PRWX COMPONENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+/-]IC</td>
<td>If Precipitation = “IC” Then&lt;br&gt;Precipitation = “SN”</td>
</tr>
<tr>
<td>[+/-]GR</td>
<td>If Precipitation = “GR” Then&lt;br&gt;Descriptor = “SH”</td>
</tr>
<tr>
<td>[+/-]BCFG</td>
<td>If (Descriptor = BC) And (Obscuration = FG) Then&lt;br&gt;Intensity = “”</td>
</tr>
<tr>
<td>[+/-]FZFG</td>
<td>If (Descriptor = FZ) And (Obscuration = FG) Then&lt;br&gt;Intensity = “”</td>
</tr>
<tr>
<td>[+/-]FG, [+/-]BR, [+/-]HZ, [+/-]DU</td>
<td>If Obscuration is “BR,FG,HZ,DU” Then&lt;br&gt;Intensity = “”</td>
</tr>
<tr>
<td>[+/-]BCBR, [+/-]BCHZ, [+/-]BCDU</td>
<td>If (Descriptor = BC) And (Obscuration in “BR,HZ,DU”) Then&lt;br&gt;Intensity = “” Deputy = “”</td>
</tr>
<tr>
<td>[+/-]SHFG, [+/-]SHBR, [+/-]SHHZ, [+/-]SHDU</td>
<td>If (Descriptor = SH) And (Obscuration in “BR,FG,HZ,DU”) Then&lt;br&gt;Intensity = “” Deputy = “”</td>
</tr>
<tr>
<td>[+/-]FZBR, [+/-]FZHZ, [+/-]FZDU</td>
<td>If (Descriptor = FZ) And (Obscuration in “BR,HZ,DU”) Then&lt;br&gt;Intensity = “” Deputy = “”</td>
</tr>
<tr>
<td>[+/-]BCDZ, [+/-]BCRA, [+/-]BCGR, [+/-]BCGS, [+/-]BCSN, [+/-]BCSG, [+/-]BCPL, [+/-]BCUP</td>
<td>If (Descriptor = BC) And (Precipitation in “DZ,RA,GR,GS,SN,SG,PL,UP”) Then&lt;br&gt;Descriptor = “”</td>
</tr>
<tr>
<td>[+/-]SHDZ, [+/-]SHSG, [+/-]SHPL</td>
<td>If (Descriptor = SH) And (Precipitation in “DZ,SG,PL”) Then&lt;br&gt;Descriptor = “”</td>
</tr>
<tr>
<td>[+/-]FZGR, [+/-]FZGS, [+/-]FZSN, [+/-]FZSG, [+/-]FZPL</td>
<td>If (Descriptor = FZ) And (Precipitation in “GR,GS,SN,SG,PL”) Then&lt;br&gt;Descriptor = “”</td>
</tr>
</tbody>
</table>

### 4. Validate PrWx Components

<table>
<thead>
<tr>
<th>Description</th>
<th>APPLY TO EACH PRWX COMPONENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+/-]SHRA, [+/-]SHGR, [+/-]SHGS, [+/-]SHSN, [+/-]SHUP</td>
<td>If (Descriptor = SH) And (Precipitation is in “RA,GR,GS,SN,UP”) Then&lt;br&gt;Intensity = leave as is&lt;br&gt;Precipitation = leave as is&lt;br&gt;Obscuration = “”</td>
</tr>
<tr>
<td>[+/-]FZDZ, [+/-]FZRA, [+/-]FZUP</td>
<td>If (Descriptor = FZ) And (Precipitation is in “DZ,RA,UP”) Then&lt;br&gt;Intensity = leave as is&lt;br&gt;Precipitation = leave as is&lt;br&gt;Obscuration = “”</td>
</tr>
</tbody>
</table>

### 4. Precipitation

<table>
<thead>
<tr>
<th>Description</th>
<th>APPLY TO EACH PRWX COMPONENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>[+/-]DZ, [+/-]RA, [+/-]GS, [+/-]SN, [+/-]SG, [+/-]PL, [+/-]UP</td>
<td>If Precipitation is in “DZ,RA,GS,SN,SG,PL,UP” Then&lt;br&gt;Intensity = leave as is&lt;br&gt;Descriptor = “”&lt;br&gt;Obscuration = “”</td>
</tr>
</tbody>
</table>

### 4. Obscuration

<table>
<thead>
<tr>
<th>Description</th>
<th>APPLY TO EACH PRWX COMPONENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR, DU, HZ</td>
<td>If Obscuration is in the list “BR,DU,HZ” Then&lt;br&gt;Intensity = “”&lt;br&gt;Precipitation = “”&lt;br&gt;Description = “”</td>
</tr>
<tr>
<td>FG, BCFG, FZFG</td>
<td>If Obscuration = FG Then&lt;br&gt;Intensity = “”&lt;br&gt;Precipitation = “”&lt;br&gt;Description = “” or in list “BC,FZ”</td>
</tr>
</tbody>
</table>

Else

<table>
<thead>
<tr>
<th>Description</th>
<th>APPLY TO EACH PRWX COMPONENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PrWx Component is invalid so set&lt;br&gt;Intensity = “”&lt;br&gt;Precipitation = “”&lt;br&gt;Description = “”</td>
<td></td>
</tr>
</tbody>
</table>
### 5. Quality Control Algorithm

<table>
<thead>
<tr>
<th>Apply to each PrWx component from top to bottom - order important</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>To avoid getting stuck in algorithm</strong></td>
</tr>
<tr>
<td><strong>Obscuration</strong></td>
</tr>
<tr>
<td>Exclude from Tests i.e. Do NOT perform Obscuration tests if Phenomena = FU, VA or SA</td>
</tr>
<tr>
<td>No Continuous Obscuration</td>
</tr>
<tr>
<td>FG FZFG</td>
</tr>
<tr>
<td>BCFG</td>
</tr>
<tr>
<td>BR</td>
</tr>
<tr>
<td>HZ DU</td>
</tr>
<tr>
<td><strong>Precipitation Type</strong></td>
</tr>
<tr>
<td><strong>To avoid getting stuck in algorithm</strong></td>
</tr>
<tr>
<td>Exclude from Tests i.e. Do NOT perform Precipitation tests if Phenomena ≠ Precipitation</td>
</tr>
<tr>
<td>Precipitation Restart</td>
</tr>
<tr>
<td><strong>Any Liquid or Solid Precipitation</strong></td>
</tr>
<tr>
<td><strong>Solid to Liquid Precipitation</strong></td>
</tr>
</tbody>
</table>
### Liquid to Solid Precipitation

<table>
<thead>
<tr>
<th>[+/-]RA</th>
<th>[+/-]DZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>If (Phenomena = RA or DZ) And (10 min Precip ≤ 0.0mm) Then</td>
<td></td>
</tr>
<tr>
<td>If (AT &lt; -5°C) Or (AT &lt; -0.5°C) And (RH &lt; 80%RH)) Then</td>
<td></td>
</tr>
<tr>
<td>Intensity = unchanged</td>
<td></td>
</tr>
<tr>
<td>If (Descriptor = FZ) Then</td>
<td></td>
</tr>
<tr>
<td>Descriptor = &quot;&quot; i.e. remove FZ</td>
<td></td>
</tr>
<tr>
<td>EndIf</td>
<td></td>
</tr>
<tr>
<td>Phenomena = SN</td>
<td></td>
</tr>
<tr>
<td>ElseIf (Air temp &lt; -0.5°C) Then</td>
<td></td>
</tr>
<tr>
<td>Intensity = unchanged</td>
<td></td>
</tr>
<tr>
<td>Descriptor = FZ</td>
<td></td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
<td></td>
</tr>
<tr>
<td>EndIf</td>
<td></td>
</tr>
<tr>
<td>If PassCount &lt; 5 Then GoTo Precipitation Restart</td>
<td></td>
</tr>
<tr>
<td>EndIf</td>
<td></td>
</tr>
</tbody>
</table>

### Snow

<table>
<thead>
<tr>
<th>[+/-]SN</th>
</tr>
</thead>
<tbody>
<tr>
<td>If Phenomena = SN Then</td>
</tr>
<tr>
<td>If (Air temp ≥ 5°C) Or (Air temp &gt; (-0.1 RH + 11.5)) Then</td>
</tr>
<tr>
<td>Intensity = unchanged</td>
</tr>
<tr>
<td>Phenomena = RA</td>
</tr>
<tr>
<td>If PassCount &lt; 5 Then GoTo Precipitation Restart</td>
</tr>
<tr>
<td>Else</td>
</tr>
<tr>
<td><strong>This block is currently disabled until agreed thresholds are determined</strong></td>
</tr>
<tr>
<td>If (10 min Vis &lt; 500m) Then</td>
</tr>
<tr>
<td>Intensity = Heavy</td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
</tr>
<tr>
<td>ElseIf (500m ≤ 10 min Vis &lt; 8000m) Then</td>
</tr>
<tr>
<td>Intensity = Moderate</td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
</tr>
<tr>
<td>ElseIf (8000m ≤ 10 min Vis) Then</td>
</tr>
<tr>
<td>Intensity = Light</td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
</tr>
<tr>
<td>EndIf</td>
</tr>
<tr>
<td>EndIf</td>
</tr>
</tbody>
</table>

### Freezing Precipitation

<table>
<thead>
<tr>
<th>[+/-]FZDZ</th>
<th>[+/-]FZRA</th>
<th>[+/-]FZUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>If (Descriptor = FZ) And (Phenomena = DZ or RA or UP) Then</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Air temp &gt; 0.5°C Then</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.5 allows for sensor uncertainty)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity = unchanged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Descriptor = &quot;&quot; i.e. remove FZ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If PassCount &lt; 5 Then GoTo Precipitation Restart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EndIf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EndIf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EndIf</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Precipitation Intensity

<table>
<thead>
<tr>
<th>++/--DZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>If (Phenomena = DZ) And (Descriptor ≠ FZ) Then</td>
</tr>
<tr>
<td>If (0.0 mm ≤ 10min Precip ≤ 0.4 mm) Then</td>
</tr>
<tr>
<td><strong>This block is currently disabled until agreed thresholds are determined</strong></td>
</tr>
<tr>
<td>If (10 min Vis &lt; 500m) Then</td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
</tr>
<tr>
<td>Intensity = heavy</td>
</tr>
<tr>
<td>ElseIf (500m ≤ 10 min Vis &lt; 8000m) Then</td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
</tr>
<tr>
<td>Intensity = Moderate</td>
</tr>
<tr>
<td>ElseIf (8000m ≤ 10 min Vis) Then</td>
</tr>
<tr>
<td>Phenomena = unchanged</td>
</tr>
<tr>
<td>Intensity = Light</td>
</tr>
<tr>
<td>EndIf</td>
</tr>
<tr>
<td>ElseIf (10min Precip &gt; 0.4 mm) Then</td>
</tr>
<tr>
<td>Phenomena = RA</td>
</tr>
<tr>
<td>If PassCount &lt; 5 Then GoTo Precipitation Restart</td>
</tr>
<tr>
<td>EndIf</td>
</tr>
</tbody>
</table>

---

**Precipitation Intensity MUST occur AFTER the Precipitation Type section**

**Data Required... 10 minute accumulated Precipitation (Precip)**
RA

If (Phenomena = RA) And (Descriptor ≠ FZ) Then
    If 0.0 mm ≤ 10 min Precip ≤ 0.4 mm) Then
        Intensity = Light
        Phenomena = unchanged
    ElseIf (0.4 mm < 10 min Precip ≤ 1.6 mm) Then
        Intensity = Moderate
        Phenomena = unchanged
    ElseIf (1.6 mm < 10 min Precip) Then
        Intensity = Heavy
        Phenomena = unchanged
    EndIf
EndIf

Shower

Shower processing MUST occur AFTER the Precipitation Intensity section.

Data Required...

60 minutes PrWx preceding latest 15 minutes PrWx

Exclude from Tests

If (Descriptor = "", FZ or SH) And (Phenomena = RA, SN, GS or UP) Then
    Perform Shower tests
EndIf

Shower Precipitation

If (Phenomena = RA or SN or GS or UP) And
   (in last 60 minutes PrWx has ≥ 2 transitions “xx to No xx” Or “No xx to xx”)
   Intensity = unchanged
   Phenomena = unchanged
   Descriptor = SH
EndIf

Not Shower Precipitation

If (Descriptor = SH) And (Phenomena = RA or SN or GS or UP) And
   (in last 60 minutes PrWx has < 2 transitions “xx to No xx” Or “No xx to xx”)
   Intensity = unchanged
   Phenomena = unchanged
   Descriptor = ""
   i.e. remove SH
EndIf

Data Analysis

Remembering Lessons from Previous Experience

Over the 8 years of operational experience prior to the implementation of the quality control algorithm the following PrWx sensors limitations had already been identified from fault reports:

- Visibilities are low and precipitation is over reported due to dirty sensor lenses.
- FZFG is falsely reported when visibilities are too high or air temperatures are too warm.
- SN is falsely reported as -RASN when air temperatures too warm.
- Obscuration falsely reported when insects are present.

The Collected 1 Minute Data Set

Data points were collected for the 24 month period from August 2014 to July 2016.

Data points: 12 million in total, 6 million per PrWx sensor model, 1.5 million per season, 1 million per AWS.

Refer to the tables at the end of this paper for summary statistics of the data sets.
Algorithm Performance - Full Data Set

Noting that the PWD22 sensor does not have the capability to report the PrWx: SG, IC, GR, SHGR.

PrWx Quality Creation Algorithm Performance - Missed Reports: Full data Period

- All sensors: 86% of reports had no PrWx. Of these 0.28% were changed to have PrWx (mainly HZ & BR).

PrWx Quality Control Algorithm Performance – Sensor Over/Under Reporting: Full data Period - All Sensors

- Data for all sensors: 14% of observations had present weather and of these 0.5% were changed to // (only the FD12P detects IC)
- There were no reports of FZUP or IC.
- All observations of GR were converted to SHGR - ICAO requirement. (only the FD12P detects GR, SHGR)

PrWx Quality Control Algorithm Performance - Adjustments by category: Full data Period - All Sensors

- Data for all sensors: 14% of observations had present weather and of these 30% were adjusted
- Due to differences in PrWx sensor RH detector and the HMP155 sensor performances:
  - Changes from BR to HZ (25%).
  - Changes from BCFG to HZ (4%).
- Due to differences in timing thresholds between the sensors and the quality control algorithms:
  - Changes from BR to BCFG (14%).
  - Changes from SHUP (58%), SHRA (40%), SHSN (34%) to precipitation without SH.
  - Changes from UP (21%), RA (18%), SN (14%) to SH of precipitation.
  - Changes from BCFG to FG (48%).

- Due to differences in PrWx sensor Air Temperature detector and the HMP155 sensor performances:
  - Changes from FZFG to HZ (18%), BR (2%), FG (3%), BCFG (4%).
  - Changes from FZDZ to DZ (22%).
  - Changes from FZRA to RA (20%) and from FZRA to SHRA (40%).
  - Changes from PL to RA (4%) and from PL to SHRA (24%).
  - Changes from SG to RA (2%). (only the FD12P detects SG)
  - Changes from FZRA to SN (6%).
  - Changes from FG to FZFG (4%).
  - There were no changes from precipitation to FZ precipitation.
- Due to the differences in visibility thresholds between the sensor and the quality control algorithms:
  - Changes from BCFG to BR (9%).
- Other:
  - Changes to RA intensity (21%) and SHRA intensity (5%).

- Differences in Performance attributable to Heated and Non-Heated HMP155
  - Heated HMP155: BR to HZ (24%), FG to HZ (0.4%), BCFG to HZ (1%), FZFG to HZ (0%).
  - Non-heated HMP155: BR to HZ (27%), FG to HZ (4%), BCFG to HZ (11%), FZFG to HZ (23%).
  - There were no changes for either sensor from (DU or HZ) to (BR or FG).
  - The heated HMP155 equipped AWS had less algorithm changes from wet obscuration to dry obscuration. This was not expected. A non-heated RH sensor will at times read higher than a heated one after sensor saturation conditions. A heated HMP155 will therefore reach thresholds earlier in algorithm tests so more corrections would be expected. A further review of the locations of all the heated HMP155 reveals that they are all at climatologically moderate air temperature sites, so the data set is skewed and not valid for drawing any heated/non-heated sensor conclusions. The number of changes being performed does however indicate that the HMP155 Relative Humidity is of great value in correcting the sensor PrWx reports.
Comparison of Sensors - FD12P and PWD22 - Full Data Set

PrWx Quality Creation Algorithm Performance - Missed Reports: Full data Period

- All FD12P: 86% of reports had no PrWx. Of these 0.18% were changed to have PrWx (mainly HZ & BR).
- All PWD22: 86% of reports had no PrWx. Of these 0.40% were changed to have PrWx (mainly HZ & BR).

PrWx Quality Control Algorithm Performance - Adjustments: Full data Period

- All FD12P: 14% of observations had present weather and of these 29% were adjusted.
- All PWD22: 14% of observations had present weather and of these 31% were adjusted.

PrWx Quality Control Algorithm Performance - Over Reporting: Full data Period - All Sensors

- All FD12P: 14% of observations had present weather and of these 0.4% were changed to //.
- All PWD22: 14% of observations had present weather and of these 0.5% were changed to //.

Other

- The PWD22 sensor very infrequently (only 16) reports UP and had no reports of SHUP.
- Both sensors had no reports of FZUP.
- The FD12P had no reports of IC (the PWD22 can not report this).

Comparison of Sensors - FD12P and PWD22 - Co-located only

PrWx Quality Creation Algorithm Performance - Missed Reports: Full data Period

- All FD12P: 88% of reports had no PrWx. Of these 0.22% were changed to have PrWx (mainly HZ & BR).
- All PWD22: 87% of reports had no PrWx. Of these 0.27% were changed to have PrWx (mainly HZ & BR).

PrWx Quality Control Algorithm Performance - Adjustments: Full data Period

- All FD12P: 12% of observations had present weather and of these 29% were adjusted.
- All PWD22: 13% of observations had present weather and of these 31% were adjusted.

PrWx Quality Control Algorithm Performance - Over Reporting: Full data Period - All Sensors

- All FD12P: 12% of observations had present weather and of these 0.6% were changed to //.
- All PWD22: 13% of observations had present weather and of these 0.4% were changed to //.

PrWx Quality Control Algorithm Performance - Adjustments by category: Full data Period

- Due to differences in PrWx sensor RH detector and the HMP155 sensor performances:
  - Changes from BR to HZ - No significant difference.
  - Changes from BCFG to HZ - No significant difference.

- Due to differences in timing thresholds between the sensors and the quality control algorithms:
  - Changes from BR to BCFG - No significant difference.
  - The PWD22 did not report any UP or SHUP.
  - The FD12P reported 0.02% observations as UP or SHUP and typically 50% of these were converted
  - The FD12P and PWD22 reported similar total numbers of liquid precipitation (~10%) but the FD12P reported more of the precipitation as DZ (1.5%) than the FD12P (0.6%) - indicating the two sensor thresholds for DZ and RA are somewhat different.
  - The PWD22 reported more SN and SHSN than the FD12P. The algorithm adjusted less of the PWD22 reports - indicating the PWD22 has better SN and SHSN discrimination than the FD12P.
  - Changes from BCFG to FG - No significant difference.

- Due to differences in PrWx sensor Air Temperature detector and the HMP155 sensor performances:
  - The FD12P over-reports FZFG compared to the PWD22, and the FD12P had more algorithm adjustments.
  - There were no reports from either sensor of FZDZ, FZRA, PL, NG, IC.
  - The FD12P over-reports FZFG with significantly more reports (3,541 compared to just 422 from the PWD22). The algorithm adjusted 23% of the FD12P reports and only 11% of the PWD22 reports.
The PWD22 slightly under-reports FZFG as there were several percent of conversions from FG and BCFG to FZFG. There were no adjustments of FD12P to FZFG.

For both sensors there were no changes from precipitation to FZ precipitation.

- Due to the differences in visibility thresholds between the sensor and the quality control algorithms:
  - Changes from BCFG to BR - No significant difference.

- Other:
  - Changes in precipitation intensity - No significant difference.

**PrWx Quality Control Algorithm Performance - Adjustments by category**

- The data sets were also analysed on a seasonal basis (3 months for each of Summer, Autumn, Winter, Spring) however no additional insights were gained over and above the sensor differences already found from the full data set.

**Forecaster PrWx Changes – What did the Sensors/AWS Quality Control Miss?**

For the 3 international airports NZAA, NZWN, NZCH there is head office Forecaster vetting of all 30 minute interval METAR AUTO using other available information sources e.g. RVR, ATIS, Web camera, Lightning detection network, Radar and Satellite imagery. Anecdotally the consistent changes required are:

- Removing RVR if visibility > 1500m, and/or changing the visibility (e.g. if there is shallow fog)
- Changing FG to MIFG or BCFG
- Adding in VCSH (the most common)
- Adding in CB to a cloud group

Noting that present weather sensors or AWS cannot detect “VC” (in the vicinity), “MI” (shallow) and “CB” (cumulonimbus cloud type) then the common changes made by forecasters are currently not possible by an AWS. The exception is the change from FG to BCFG.

**Forecaster change records for** NZAA, NZWN, NZCH **Winter 2016 (17 May to 11 Aug, 86 days):**

<table>
<thead>
<tr>
<th>Description</th>
<th>Most Common Examples</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation reported when there was none</td>
<td>DZ, -UP</td>
<td>2</td>
</tr>
<tr>
<td>Precipitation the was missed</td>
<td>DZ, RA, SHRA</td>
<td>13</td>
</tr>
<tr>
<td>Precipitation type and/or intensity change</td>
<td>-DZ to -RA, -DZ to SHRA, -SHRA to SHRA</td>
<td>23</td>
</tr>
<tr>
<td>Precipitation timing change (add SH)</td>
<td>-RA to -SHRA</td>
<td>2</td>
</tr>
<tr>
<td>Obscuration reported when there was none</td>
<td>BCFG, BR, FG</td>
<td>6</td>
</tr>
<tr>
<td>Obscuration reported when none during precipitation</td>
<td>-RA BR to RA, -SHRA BR to RADZ, BR to DZ</td>
<td>16</td>
</tr>
<tr>
<td>Obscuration that was missed</td>
<td>MIBR</td>
<td>1</td>
</tr>
<tr>
<td>Obscuration type change</td>
<td>excluding changes of X...X to MIX...X</td>
<td>3</td>
</tr>
<tr>
<td>Visibility (MOR) that was too low</td>
<td>150 -&gt; 2000, ≥4000 -&gt; 9999</td>
<td>51</td>
</tr>
<tr>
<td>Visibility (MOR) that was too high</td>
<td>4100 -&gt; 4000, 4200 -&gt; 3000</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>SHRA to RA</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total for the above</strong></td>
<td><strong>16 changes per station/month (3.2%)</strong></td>
<td><strong>135</strong></td>
</tr>
</tbody>
</table>

For the above there were:

- 31 changes where SH was added to precipitation or was created;
- 6 changes where SH was removed from precipitation.
**ICAO Code Change (10th November 2016)**

Annex 3 - Meteorological Service for International Air Navigation  
Nineteenth edition 2016, Amendment 1-77-A  
4.4.2.7 In automated local routine and special reports and METAR and SPECI when showers (SH) referred to in 4.4.2.6 cannot be determined based upon a method that takes account of the presence of convective cloud, the precipitation should not be characterized by SH.

MetService AWS have no ability to characterize cloud which means for the above change all present weather reports containing SH will simply have the SH removed at the "Apply Tweaks" stage in the current algorithm - Except for SHGR i.e. GR can only be reported from a convective cloud as SHGR (previous ICAO amendment). It is worth noting that the FD12P can report GR but the PWD22 cannot.

**Will removing SH have any significant affect on the evaluation of the evaluation?**

The AWS Quality Control algorithm performed significant changes from SH precipitation (UP, RA, SN) to precipitation and vice-versa. Removing all SH (excluding SHGR) will simplify the AWS Quality Control algorithm. i.e. There will be no changes from precipitation to SH precipitation, but the number of SH precipitation to precipitation changes will increase.

Converting all SH precipitation to precipitation in the AWS will mean that Forecasters, who do have access to other data that allows them to identify cloud type, will need to make more changes of adding SH to precipitation (that the AWS Quality Control Algorithm may have removed). i.e. AWS Quality Control Algorithm removed 498,000 SH events (4% of the observations) and some of these will need to be re-instated by Forecasters. This compared to the 6 of the 135 (4%) changes Forecasters removed SH and 31 changes of 135 (23%) where SH was added to precipitation or it was created. So the change in workload will be balanced... 4% of SH removal will be replace by 4% SH addition.

**Conclusions**

When reading the following it should be kept in mind that the AWS Quality Control algorithm thresholds used by MetService are generally based on international best practice, however some are based on forecaster experience in relation the climatology of New Zealand. Any application of these algorithms in other countries should include a review of the algorithm thresholds for local application. Due to the moderate climate in New Zealand some sensor reportable PrWx code conditions were not experienced and reported during the evaluation so these results are not all encompassing for the sensor or algorithm operation.

AWS PrWx Creation algorithm: This added a small amount of value with 0.28% creation of PrWx when there was none from sensors (predominantly HZ and BR) i.e. both sensor models did not miss many PrWx obscuration situations, and in particular the sensors do not miss many reports of FG and BCFG which are the most significant to aviation.

Quality Control Algorithm: The algorithm added a small amount of value by rejecting 0.5% of the 14% of sensor present weather reports. Of the observations made 14% had PrWx and the number of algorithm adjustments made to these reports was 30%. The relatively small numbers of subsequent forecaster changes being required after this was only 3.2%, indicating that the quality control algorithm is adding significant value to the AWS PrWx reporting process.

Co-located FD12P and PWD22: At the three co-located sensor sites the data indicated that both sensors have very similar rates of: missed reports (~0.5%); positive detections (~13%); and false reports (~0.25%). But noting:

- The PWD22 has better DZ/RA discrimination than the FD12P.
- The PWD22 has better SN/SHSN discrimination than the FD12P.
- The PWD22 sensor very infrequently reports UP and had no reports of SHUP so it is likely this sensor is better than the FD12P at discrimination actual precipitation type.
- The FD12P over-reports FZFG compared to the PWD22.
- The PWD22 slightly under-reports FZFG compared to the FD12P.

There were minor differences in algorithm sensor performance with season however these were not significant enough to warrant inclusion here or any algorithm changes that are time/season based.

Analysis of algorithm performance in relation to using a heated or non-heated HMP155 relative humidity sensor was not possible as a review of the sensor locations of revealed that all the heated HMP155 were at climatologically moderate air temperature sites, so the data set is skewed and not valid for drawing any heated/non-heated sensor conclusions.

Potential to add further value: In the future MetService plans to expand the PrWx creation and quality control algorithms by: 1) Creation of PrWx precipitation [±]RA and improvement of precipitation intensity quality control by implementing a 0.01mm resolution weighing rain gauge; 2) Implementing PrWx precipitation quality control based on visibility (MOR).
Results Charts

Only table cells that are white are possible to be created/checked/changed by the Creation and Quality Control Algorithms. Some rows or columns are fully grey and could be omitted from the tables, however to retain table symmetry they are still included.

The PWD22 sensor does not have the capability to report the PrWx: SG, IC, GR, SHGR. Therefore these rows and columns are greyed on the PWD22 tables. For the FD12P and PWD22 combined tables these rows and columns are white but data in these cells is only from the FD12P sensor.

All GR are converted to SHGR as this is a ICAO coding requirement i.e. all GR originates from convective cloud forms so therefore must be of type SH.

To avoid expanding the tables beyond what is practicable to display, all intensity changes have been omitted except for RA where the orange cells are used to indicate the number of intensity changes that have taken place, but without the detail of what the intensity was or has become.

### All FD12P and PWD22 sensors - 24 month period

<table>
<thead>
<tr>
<th>All Systems</th>
<th>PrWx Counts</th>
<th>Changes (%)</th>
<th>Aug 2014 to July 2016</th>
<th>Number of PrWx Quality Control Algorithm Changes (as a % of the sensor PrWx Counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>//</td>
<td>DU</td>
<td>HZ</td>
</tr>
<tr>
<td></td>
<td>10,927,104</td>
<td>0.280</td>
<td>0.124</td>
<td>0.153</td>
</tr>
<tr>
<td>DU</td>
<td>24</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>HZ</td>
<td>122</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>155,376</td>
<td>39</td>
<td>0.1</td>
<td>25</td>
</tr>
<tr>
<td>FG</td>
<td>78,144</td>
<td>7</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>BCFG</td>
<td>24,066</td>
<td>77</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>FZFG</td>
<td>17,175</td>
<td>29</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>UP</td>
<td>1,320</td>
<td>21</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>FZUP</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHUP</td>
<td>998</td>
<td>58</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>DZ</td>
<td>120,634</td>
<td>0.2</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>FZDZ</td>
<td>125</td>
<td>22</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>RA</td>
<td>507,038</td>
<td>18</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>FZRA</td>
<td>241</td>
<td>67</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>SHA</td>
<td>821,535</td>
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<td>SN</td>
<td>5,896</td>
<td>44</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>SHSN</td>
<td>6,305</td>
<td>62</td>
<td>27</td>
<td>0.6</td>
</tr>
<tr>
<td>PL</td>
<td>85</td>
<td>27</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>SG</td>
<td>159</td>
<td>2</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>IC</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td>1,047</td>
<td>100</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>SHGR</td>
<td>918</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All PrWx</td>
<td>1,741,208</td>
<td>30</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>12,688,312</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: These cells indicate rain intensity changes and therefore are NOT included in the ‘Total Type Changes’ results.
### All FD12P and PWD22 sensors located with a heated HMP155 sensor - 24 month period

<table>
<thead>
<tr>
<th>Heated HMP155 Sensors</th>
<th>Aug 2014 to July 2016</th>
<th>Number of PrWx Quality Control Algorithm Changes (as a % of the sensor PrWx Counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>/ 5,563,324 0.243/0.096 0.143/0.003</td>
</tr>
<tr>
<td>DU</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>HZ</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>66,774</td>
<td></td>
</tr>
<tr>
<td>FG</td>
<td>32,377</td>
<td></td>
</tr>
<tr>
<td>BCFG</td>
<td>16,929</td>
<td></td>
</tr>
<tr>
<td>FZFG</td>
<td>3,963</td>
<td></td>
</tr>
<tr>
<td>UP</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>FZUP</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SHUP</td>
<td>273</td>
<td></td>
</tr>
<tr>
<td>DZ</td>
<td>64,693</td>
<td></td>
</tr>
<tr>
<td>FZDZ</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>RA</td>
<td>222,165</td>
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</tr>
<tr>
<td>FZRA</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SHRA</td>
<td>374,590</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>790</td>
<td></td>
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<tr>
<td>SHSN</td>
<td>849</td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SG</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td>524</td>
<td></td>
</tr>
<tr>
<td>SHGR</td>
<td>152</td>
<td></td>
</tr>
<tr>
<td>All PrWx</td>
<td>784,406</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>6,347,730</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: These cells indicate rain intensity changes and therefore are NOT included in the 'Total Type Changes' results.

### All FD12P and PWD22 sensors located with non-heated HMP155 sensor - 24 month period

<table>
<thead>
<tr>
<th>Non-Heated HMP155 Sensors</th>
<th>Aug 2014 to July 2016</th>
<th>Number of PrWx Quality Control Algorithm Changes (as a % of the sensor PrWx Counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>/ 5,363,780 0.318/0.152 0.163/0.001 0.002</td>
</tr>
<tr>
<td>DU</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>HZ</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>88,602</td>
<td></td>
</tr>
<tr>
<td>FG</td>
<td>45,767</td>
<td></td>
</tr>
<tr>
<td>BCFG</td>
<td>7,137</td>
<td></td>
</tr>
<tr>
<td>FZFG</td>
<td>13,212</td>
<td></td>
</tr>
<tr>
<td>UP</td>
<td>1,057</td>
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</tr>
<tr>
<td>FZUP</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SHUP</td>
<td>725</td>
<td></td>
</tr>
<tr>
<td>DZ</td>
<td>55,941</td>
<td></td>
</tr>
<tr>
<td>FZDZ</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>RA</td>
<td>284,873</td>
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<tr>
<td>FZRA</td>
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<td></td>
</tr>
<tr>
<td>SHRA</td>
<td>446,945</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>5,106</td>
<td></td>
</tr>
<tr>
<td>SHSN</td>
<td>5,456</td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>85</td>
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<tr>
<td>SG</td>
<td>159</td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td>523</td>
<td></td>
</tr>
<tr>
<td>SHGR</td>
<td>766</td>
<td></td>
</tr>
<tr>
<td>All PrWx</td>
<td>956,802</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>6,320,582</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: These cells indicate rain intensity changes and therefore are NOT included in the 'Total Type Changes' results.
### All FD12P sensors - 24 month period

<table>
<thead>
<tr>
<th>FD12P</th>
<th>Aug 2014 to July 2016</th>
<th>Number of PrWx Quality Control Algorithm Changes (as a % of the sensor PrWx Counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PrWx Counts</td>
<td>Changes (%)</td>
</tr>
<tr>
<td>// 5,473,237</td>
<td>0.175</td>
<td>0.056</td>
</tr>
<tr>
<td>DU 10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>HZ 24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>BR 56,801</td>
<td>43</td>
<td>0.1</td>
</tr>
<tr>
<td>FG 30,022</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>BCFG 15,911</td>
<td>79</td>
<td>16</td>
</tr>
<tr>
<td>FZFG 6,568</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>UP 1,304</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>FZUP 0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SHUP 998</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>DZ 81,789</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>FZDZ 125</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>RA 241,934</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>FZRA 209</td>
<td>62</td>
<td>5</td>
</tr>
<tr>
<td>SHRA 420,450</td>
<td>36</td>
<td>5</td>
</tr>
<tr>
<td>SN 3,232</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>SHSN 3,477</td>
<td>57</td>
<td>14</td>
</tr>
<tr>
<td>PL 71</td>
<td>32</td>
<td>4</td>
</tr>
<tr>
<td>SG 159</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>IC 0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>GR 1,047</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>SHGR 918</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All PrWx 865,049 | 29 | 0.5 | Note: These cells indicate rain intensity changes and therefore are NOT included in the ‘Total Type Changes’ results.

Total 6,338,286 | 4 |

### All PWD22 sensors - 24 month period

<table>
<thead>
<tr>
<th>PWD22</th>
<th>Aug 2014 to July 2016</th>
<th>Number of PrWx Quality Control Algorithm Changes (as a % of the sensor PrWx Counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PrWx Counts</td>
<td>Changes (%)</td>
</tr>
<tr>
<td>// 5,453,867</td>
<td>0.385</td>
<td>0.191</td>
</tr>
<tr>
<td>DU 14</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>HZ 98</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>BR 98,575</td>
<td>37</td>
<td>0.1</td>
</tr>
<tr>
<td>FG 48,112</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>BCFG 8,155</td>
<td>71</td>
<td>12</td>
</tr>
<tr>
<td>FZFG 10,607</td>
<td>29</td>
<td>0.3</td>
</tr>
<tr>
<td>UP 16</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>FZUP 0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SHUP 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DZ 38,840</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
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<tr>
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<tr>
<td>SHSN 2,828</td>
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</tr>
<tr>
<td>PL 14</td>
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</tr>
<tr>
<td>SG 0</td>
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<tr>
<td>IC 0</td>
<td></td>
<td></td>
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<tr>
<td>GR 0</td>
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<td></td>
</tr>
<tr>
<td>SHGR 0</td>
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<td></td>
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</tbody>
</table>

All PrWx 876,159 | 31 | 0.4 | Note: These cells indicate rain intensity changes and therefore are NOT included in the ‘Total Type Changes’ results.

Total 6,330,026 | 5 |
Auckland, Wellington and Christchurch - Co-Located FD12P sensors - 24 month period

<table>
<thead>
<tr>
<th>FD12P</th>
<th>Aug 2014 to July 2016</th>
<th>Number of PrWx Quality Control Algorithm Changes (as a % of the sensor PrWx Counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PrWx Counts Changes (%)</td>
<td>DU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA,WN,CH</td>
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<td>0.065</td>
</tr>
<tr>
<td>DU</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>HZ</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>BR</td>
<td>35,832 38 0.1</td>
<td>23</td>
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<tr>
<td>FG</td>
<td>14,312 1</td>
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<tr>
<td>BCFG</td>
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<tr>
<td>FZFG</td>
<td>3,541 32 9</td>
<td>4</td>
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<tr>
<td>UP</td>
<td>263 20</td>
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<tr>
<td>FZUP</td>
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<tr>
<td>SHUP</td>
<td>273 70</td>
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</tr>
<tr>
<td>DZ</td>
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</tr>
<tr>
<td>FZDZ</td>
<td>0</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>SHRA</td>
<td>173,085 33</td>
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<tr>
<td>SN</td>
<td>342 44 22</td>
<td></td>
</tr>
<tr>
<td>SHSN</td>
<td>189 81 49</td>
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<tr>
<td>PL</td>
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</tr>
<tr>
<td>SG</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>0</td>
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<tr>
<td>GR</td>
<td>524 100</td>
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<td>SHGR</td>
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<td>All PrWx</td>
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<tr>
<td>Total</td>
<td>3,172,640 4</td>
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</tbody>
</table>

Note: These cells indicate rain intensity changes and therefore are NOT included in the 'Total Type Changes' results.

Auckland, Wellington and Christchurch - Co-Located PWD22 sensors - 24 month period

<table>
<thead>
<tr>
<th>PWD22</th>
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<th>Number of PrWx Quality Control Algorithm Changes (as a % of the sensor PrWx Counts)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PrWx Counts Changes (%)</td>
<td>DU</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.128</td>
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<tr>
<td>BR</td>
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<tr>
<td>FG</td>
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<tr>
<td>BCFG</td>
<td>6,038 69 13</td>
<td>0.6</td>
</tr>
<tr>
<td>FZFG</td>
<td>422 15 4</td>
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</tr>
<tr>
<td>UP</td>
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<td></td>
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<tr>
<td>FZUP</td>
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<td></td>
</tr>
<tr>
<td>SHUP</td>
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</tr>
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<td>RA</td>
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</tr>
<tr>
<td>FZRA</td>
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</tr>
<tr>
<td>SHRA</td>
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<tr>
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<tr>
<td>SHSN</td>
<td>660 83 72</td>
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</tr>
<tr>
<td>PL</td>
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<tr>
<td>SG</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>IC</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>GR</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>SHGR</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>All PrWx</td>
<td>403,518 31 0.4</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3,175,090 4</td>
<td></td>
</tr>
</tbody>
</table>

Note: These cells indicate rain intensity changes and therefore are NOT included in the 'Total Type Changes' results.