PAMS Continuous VOC Monitoring

AutoGC

Overview of Chromatographic Applications

Carol J. Meyer
carol@orsat.com

Orsat, LLC
www.orsat.com
Not-so-continuous VOC Monitoring: AutoGC
~1 Hour Composite Sample

- Sample Collection on Sorbent Trap (composite sample to correlate with hourly criteria measurements)
- Chromatographic separation of target compounds (generally separation occurs during collection of next sample)
- Detection of separated target compounds by one or more detection methods (FID, PID, MS)
- Data analysis to identify and quantitate separated targets compounds (Chromatographic data system supplied with each instrument)
Sample Collection Methods

- Collection on a single trap
  - Cryogenically cooled trap to capture C2-C12 VOCs
  - Dual adsorbent trap for full range collection
  - Single sample injected to multidimensional gas chromatograph
- Separate C2-C6 and C6+ traps
  - C2-C6 single adsorbent trap cryogenically cooled to trap C2 VOCs
  - C6+ single adsorbent trap for C6+ VOCs
  - Each trap injected into separate gas chromatograph
NMHC Monitoring Strategies: Analytical Choices

GC-FID

- Low cost
- Stable < 2% drift over 1 month
- Response relative to carbon content
- Linear detector response
- Not sensitive to O$_2$, N$_2$ or H$_2$O
- Possible interferences

GC-PID

- Low cost
- Uses lamp which can age and require cleaning
- Non-uniform detector response
- Reduced Linear range
- Sensitive to H2O interference
- Not sensitive to interferences

GC-MS

- More complex data
- More complex operation
- Requires more frequent calibration
- Non-uniform detector response
- Sensitive to O2, N2 or H2O interference
- Not sensitive to interferences
AutoGC Systems: Single Trap Systems

- Dual adsorbent cryogenically cooled trap
- Detection by Dual FID, MS or FID-MS
- Single Data System
AutoGC Systems: Dual Trapping Systems

- Dual Chromatographic Systems - separate samples
- Detection by Dual FID, PID
- Single Data System
Ancillary Equipment Requirements

- Carrier gas - Helium ~10-15 mL/min
- Air supply - Compressor
  - Purification Systems to supply
    - Dry air or N2 < 1ppm moisture for Peltier cooler and Nafion™ drier ~ 350 mL/min
    - Hydrocarbon-free air for FID support gas ~ 800 mL/min
    - Dilution gas for dilution system ~150 - 300 mL/min
- Hydrogen if FID
  - Cylinder gas or Hydrogen generator ~80 mL/min
- Sample manifold and sample pump
- Canisters and dilution system
  - Calibration curves
  - Check standards
Sampling System

- **Standard glass manifold systems**
  - Glass with blower to bring sample from outside
  - Heated to eliminate condensation
  - Cleaned regularly with only de-ionized water

- **Sample lines from manifold**
  - Flow rates < 50 sccm should be 1/8” or smaller
  - Heated stainless steel - chromatographic grade only
  - Silco treated stainless steel

- **Problems associated with sample lines**
  - Losses of heavy compounds - inadequate humidification
  - Contaminations - inadequately cleaned tubing
  - Carry-over of heavy compounds - inadequate humidification or condensation (may require heating)
Chromatography Data Systems

Requirements:

- Data portability
- Ability to reconstruct the original processing method from result
- Use of Retention time references to accommodate diurnal shifts
- Use of response factors and calibration by reference for unidentified HCs
- Ability to name files for easy identification of site, date, time, hour and sample type
- Ability to schedule and control introduction of routine quality control samples
- Ability to recover from simple power failures and continue hourly sampling
- Remote operation
Method Development
TotalChrom Chromatography Data System
Calibration

**Carbon Response Factor**
- Single Response factor for each column
- Response factor based on response (peak area) per ppbC
- Requires certified standard for only Propane and Benzene
- Used only on FID systems
- Easy for validators to check for errors

**Target Specific Regression**
- Linear regression for each target component
- Response based on ppbv
- Requires standard containing all targets
- Required on PID and MS systems which do not have uniform response across targets
- Difficult to achieve and validate
Calibration

**Mass Spectrometry or Photoionization Detector:**
- May require calibration across larger dynamic range due to non-linear response (6 points)
- Generally requires target specific calibration
- Will require standards for each target to be calibrated

**FID Detector**
- Has mostly uniform response based on Carbon-Hydrogen bonds
- Extremely linear and may be calibrated with fewer points (1 - 3)
- Only requires standard with propane and benzene for calibration
C2-C6 Alumina PLOT Separation

Ethane to 1-Hexene

0.5 ppbv PAMS Standard

3.0 pA fs
C6+ Dimethylsiloxane (Boiling Point) Separation

n-Hexane to n-Dodecane

0.5 ppbv PAMS Standard

3.0 pA fs
Analytical Blank

PLOT column
3.0 pA fs

Boiling point column
3.0 pA fs
Ambient Air - PLOT Column

16.0 pA fs
Ambient Air - Boiling Point Column

16.0 pA fs

3.0 pA fs
Recoveries in Daily Check Standard at 0.5 ppbv

Check Standard % Recovery - C3/C6 Average Response Factor

PLOT Column

BP Column

% Recovery

0 20 40 60 80 100 120 140 160 180 200

C3/C6 Average Response Factor
Ambient Data - Carbon Response Factor Calibration

Ambient Data - C3/C6 Average Response Factor

35% < 1 ppbC

National Ambient Air Monitoring Conference - PAMS Workshop August 8, 2016
Sources of Data Losses and Poor QC Results

**Data Losses**
- Power failures
- Sample collection time errors
- Shelter AC failures
- Compressor failures
- “Wet” air

**Poor QC Results**
- Canisters
- Sample lines
- Sample pumps/flow
  - Trap icing
- Losses of light gases
  - Failure of trap cooling
  - Sample or dry purge flow too high
- Contaminants in Blank
# Sources of Carry-over and Interferences

<table>
<thead>
<tr>
<th>Carry-over</th>
<th>Interferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely high ambient</td>
<td>Canisters</td>
</tr>
<tr>
<td>Nafion™ Driers</td>
<td>Failing Air system</td>
</tr>
<tr>
<td>Sample lines</td>
<td>Site specific interferences</td>
</tr>
<tr>
<td>Heated SS</td>
<td>Leak testing solutions</td>
</tr>
<tr>
<td>Treated Steel</td>
<td>Baseline issues</td>
</tr>
<tr>
<td>Trap failure resulting in trap material in system</td>
<td>Detector ferrules</td>
</tr>
<tr>
<td>Ferrules</td>
<td>Air supply</td>
</tr>
<tr>
<td></td>
<td>Electrical</td>
</tr>
<tr>
<td></td>
<td>Vibration</td>
</tr>
</tbody>
</table>
Sources of Carry-over and Interferences

Daily Check Standard
1/8” SS Sample line un-heated

N-HEXANE - 9.37 - 9.93 - 11.70
BENZENE - 12.46
METHYLCYCLOHEXANE - 18.58 - 20.00
TOLUENE - 21.21
3-METHYLHEPTANE - 22.77 - 23.54 - 25.94
N-PROPYLBENZENE - 31.78
P-ETHYLTOLUENE - 32.42
1,3,5-TRI-M-BENZENE - 33.33
O-ETHYLTOLUENE - 39.04
1,2,4-TRI-M-BENZENE - 40.47
N-DECANE - 34.06
1,2,3-TRI-M-BENZENE - 34.66
M-DIETHYLBENZENE - 35.66
P-DIETHYLBENZENE - 37.22
N-DODECANE - 41.02

National Ambient Air Monitoring Conference - PAMS Workshop
August 8, 2016
Sources of Carry-over and Interferences

Blanks

1/8” SS Sample line un heated
Sources of Carry-over and Interferences

Results of heating sample line, check standard and blanks
Sources of Carry-over and Interferences

1/8” Silco Treated Sample line
un-heated
Data Quality Objectives

- Data completeness
- Data representative of ambient concentration
- Minimize contributions from the system

Operations

- Well defined Operating Procedures
- Well documented instrumental parameters
- Fully automated system to reduce errors in operator activities
- Easily identifiable and transportable data files
- Fully automated Quality Checks

Data Validation

- Well defined Data Quality Objectives
- Real-time data transfer and review
- Well defined validation operating procedures
- Good annual audits to review instrument performance across network.
# Network Quality Control

| Quality Control Check                  | Composition                                                                 | Purpose                                                        | Frequency     | Acceptance Criteria                                                                 |
|---------------------------------------|-----------------------------------------------------------------------------|                                                              |              |                                                                                      |
| Retention Time Standard (RTS)          | Mixture containing all target compounds ideally between 1-5 ppbC             | To help assess retention time shifts and optimize processing methods | Twice a month or weekly | 100% of the compounds are identified correctly in the multicomponent RTS              |
| Calibration Verification Standard (CVS)| Mixture of 15 reference compounds including Propane and Benzene used for calibration | To assess the instrument drift and ensure continued instrument calibration | Daily         | 1) Propane and Benzene % recoveries within 75% - 125% and all other calibrants within 55 - 145%  
                                         |                                                                             |                                                               |              | 2) Data must be bracketed by valid CVS                                                |
| Method (Analytical) Blank              | Humidified, clean air                                                       | To assess system contribution to the measurement              | Daily         | 1) All target compounds < 2.0 ppbC                                                   |
|                                       |                                                                             |                                                               |              | 2) TNMHC < 20 ppbC                                                                    |
|                                       |                                                                             |                                                               |              | 3) Data must be bracketed by valid blanks                                             |
| Precision Check                       | Mixture used for CVS                                                       | To assess analytical precision                                | Weekly        | Propane and Benzene %RPD < 20% in two consecutive CVS runs                           |
| Laboratory Calibration Standard (LCS)  | Mixture of 15 reference compounds including Propane and Benzene used for calibration | Second source standard, statically blended 5 ppbv             | Twice a month or weekly | Propane and Benzene % recoveries within 70-130%                                     |
Data Review - Data Validation

**Data Review - Daily**
- Site Operations
  - On-time collection
  - Correct identification
  - Equipment parameters
- Quality Controls
  - Passing Blanks
  - Passing check standard recovery

**Data Validation - Monthly**
- Review of Quality Controls
  - Passing check standard recoveries - flagging
  - Passing blanks - flagging failed targets
  - Retention time checks
- Chromatography review
  - Review of high hours or other issues
Electronic Logbooks

### AutoGC Operator Log Entry

<table>
<thead>
<tr>
<th>Site:</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator:</td>
<td>Comment</td>
</tr>
</tbody>
</table>

#### Pressures, Flows, and other Checks

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Flow</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero Air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RT2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MDL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QC Cut</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Calibrations

- **RF:** Response Factor
- **RSD:** Relative Standard Deviation

<table>
<thead>
<tr>
<th>Calibration</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singlepoint</td>
<td>PLOT RF</td>
</tr>
<tr>
<td>Multipoint Curve</td>
<td>PLOT RF</td>
</tr>
</tbody>
</table>

#### Preventive Maintenance (PAM)

<table>
<thead>
<tr>
<th>PM Type</th>
<th>Start Date</th>
<th>End Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Routine PM</td>
<td>06-23</td>
<td>06-23</td>
<td></td>
</tr>
</tbody>
</table>

#### Blower Settings

- **Span:** | **Zero:** | **RSD:** | Comment |
- **Reset PM:** | **Zero:** | **RSD:** | Comment |
- **New Blower Settings:** | | | |
- **New Blower Ratio:** | | | |

#### Method & Sequence Optimization

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Start Date</th>
<th>End Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Sequence</td>
<td>06-23</td>
<td>06-23</td>
<td></td>
</tr>
</tbody>
</table>

#### Batch Reprocessing

<table>
<thead>
<tr>
<th>Batch</th>
<th>Start Date</th>
<th>End Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch 1</td>
<td>06-23</td>
<td>06-23</td>
<td></td>
</tr>
</tbody>
</table>

### QC Sample Check

- **QC Result:** | **Detection:** |
- **Blind Fails:** | Comment |
- **Audit Fails:** | Comment |

### Hardware CI

- **Plot:** | **Column:** |
- **BP:** | **Column:** |
- **CPU:** | | |

### Other Comments

- **Submit Entry:** | | |
- **Reset to Default:** | | |
# Electronic Logbooks

## AutoGC Operator Log Report

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>Username</th>
<th>Source</th>
<th>Log Entry</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D</td>
<td>07/29/2016</td>
<td>Rice</td>
<td>Remote Visit</td>
<td><strong>Pressures, Flows, and other Checks</strong></td>
<td>Methods and Blanks look good</td>
</tr>
<tr>
<td></td>
<td>07:22</td>
<td></td>
<td></td>
<td><strong>Verified Sample Timing:</strong> system is on time with files ending @32 and corrected row (315)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>QC Sample Check</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CVS: Propane=100, Benzene=99</td>
<td></td>
</tr>
<tr>
<td>2D</td>
<td>07/28/2016</td>
<td>Rice</td>
<td>Site Visit</td>
<td><strong>Pressures, Flows, and other Checks</strong></td>
<td>Methods look good</td>
</tr>
<tr>
<td></td>
<td>10:40</td>
<td></td>
<td></td>
<td>Helium: 1100 µg [G60]</td>
<td>Fuses: 4 lights</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hydrogen: 2300 µg [G65]</td>
<td>All green lights on roster</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CVS: 25 µg [G7800]</td>
<td>RMS noise</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LCS: 15 µg [G3919]</td>
<td>Plot: 5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RTS: 30 µg [G4440]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GC Cut Time: 10:00 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Brass Temp: 73 F</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[High 9 Low 70 Humidity: 48% High 48% Low 25%]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Methane Flow: 25 cc</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TOC Flowmeter: 49 cc</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[G80 psi]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TD Sample Pump: 15 min/lin</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TD Column Pressure: 42.4 µg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>GC Adiabatic Pressure: 10.5 µg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Other: 55 psi [zero air output]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Verified Sample Timing:</strong> system is on time with files ending @32 and corrected row (155)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Canister Installation</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RTS: 12240, GC-328/284</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[Renamed Can=1224]</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Blender Settings</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PART Not Reset: to 5.0 µg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ZERO Not Reset: to 40.0 µg</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Method &amp; Sequence Optimization</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Modified Sequence: [setup RTS (spike) in sequence]</td>
<td></td>
</tr>
<tr>
<td>2D</td>
<td>07/27/2016</td>
<td>Rice</td>
<td>Remote Visit</td>
<td><strong>Pressures, Flows, and other Checks</strong></td>
<td>Methods and Blanks look good</td>
</tr>
<tr>
<td></td>
<td>08:32</td>
<td></td>
<td></td>
<td><strong>Verified Sample Timing:</strong> system is on time with files ending @32 and corrected row (120)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>QC Sample Check</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CVS: Propane=102, Benzene=102</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[2D*C523C]</td>
<td></td>
</tr>
</tbody>
</table>
Electronic Logbooks

Markes Logbook

06/09/2016 14:15 /gcoldwell
Rerouted output of zero air to feed blender and gc detector flows
Measure relative humidity off the blender output after the zero air source was rerouted.
Measure as follows:
20 psi = 37.3
40 psi 31.0
60 psi 27.0
Checked for moisture in dropout and also ballast tank all looks good so far.

06/10/2016 15:00 gcoldwel
Performed 3 pt curve using 16 component CC-344433
results: Plot 6140 3 % rsd  BP 5979 4 % rsd
Enter into methods I HOPE
When modifying sequence saved ezchrom sequence all appeared to be correct but when files were written ezchrom did not change the file extension to reflect the file changes that were made.

06/14/2016 12:15/gcoldwell
HE = 550 psi
System has lost power td was stuck trap purge and software was not responding so cycled power on TD and all looks good now
Corrected rows on both sequences and set up another round of QC
Tools to Monitor Performance

- Automation of routine quality control samples
- Remote Access via broadband connections
  - Applications for remote control (remote desktop)
  - FTP - polling and file transfer automation
- Email alerts
  - Power failures
  - No data (polling)
Tools to Monitor Performance: Control Charts
LEADS® Leading Environmental Analysis & Display System

CVS Recoveries - All Calibrants
DISH Airfield C1013 (Site 2D) 06/29/2016-07/30/2016

LCS Recoveries - All Calibrants
DISH Airfield C1013 (Site 2D) 06/29/2016-07/30/2016
Tools to Monitor Performance: Control Charts

Daily CVS

Weekly LCS
<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Value</th>
<th>Unit</th>
<th>Notes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/30/15</td>
<td>Galena Park</td>
<td>34.0</td>
<td>ppmV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05/30/15</td>
<td>Galena Park</td>
<td>32.5</td>
<td>ppmV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05/25/15</td>
<td>Galena Park</td>
<td>1.0</td>
<td>ppmV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>Value</th>
<th>Unit</th>
<th>Notes</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/30/15</td>
<td>Galena Park</td>
<td>34.0</td>
<td>ppmV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05/30/15</td>
<td>Galena Park</td>
<td>32.5</td>
<td>ppmV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05/25/15</td>
<td>Galena Park</td>
<td>1.0</td>
<td>ppmV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure:**

- Tools to Monitor Performance
- QuickLook Email Report

**Notes:**
- Galena Park
- Tools to Monitor Performance
- QuickLook Email Report
- National Ambient Air Monitoring Conference - PAMS Workshop
- August 8, 2016
| Date       | Temperature | Pressure | Humidity | Wind Speed | Wind Direction | Air Quality Index | Particulate Matter | Ozone | NO₂ | CO | SO₂ | Temperature | Pressure | Humidity | Wind Speed | Wind Direction | Air Quality Index | Particulate Matter | Ozone | NO₂ | CO | SO₂ | Temperature | Pressure | Humidity | Wind Speed | Wind Direction | Air Quality Index | Particulate Matter | Ozone | NO₂ | CO | SO₂ |
|------------|-------------|----------|----------|------------|--------------|-----------------|------------------|------------------|-------|-----|----|-----|-------------|----------|----------|------------|-----------------|-----------------|------------------|-------|-----|----|-----|-------------|----------|----------|------------|-----------------|-----------------|------------------|-------|-----|----|-----|-------------|----------|----------|------------|-----------------|-----------------|------------------|-------|-----|----|-----|-------------|----------|----------|------------|-----------------|-----------------|------------------|-------|-----|----|-----|-------------|----------|----------|------------|-----------------|-----------------|------------------|-------|-----|----|-----|
| 30/05/15   | 20°C        | 1013 hPa | 30%      | 5 kph     | NNE          | 50              | 40               | 60               | 80               | 100  | 200 | 100 | 50  | 20°C        | 1013 hPa | 30%      | 5 kph     | NNE            | 50              | 40               | 60               | 80               | 100  | 200 | 100 | 50  | 20°C        | 1013 hPa | 30%      | 5 kph     | NNE            | 50              | 40               | 60               | 80               | 100  | 200 | 100 | 50  | 20°C        | 1013 hPa | 30%      | 5 kph     | NNE            | 50              | 40               | 60               | 80               | 100  | 200 | 100 | 50  |
| 01/06/15   | 24°C        | 1012 hPa | 40%      | 8 kph     | W            | 60              | 35               | 70               | 90               | 100  | 200 | 100 | 50  | 24°C        | 1012 hPa | 40%      | 8 kph     | W              | 60              | 35               | 70               | 90               | 100  | 200 | 100 | 50  | 24°C        | 1012 hPa | 40%      | 8 kph     | W              | 60              | 35               | 70               | 90               | 100  | 200 | 100 | 50  | 24°C        | 1012 hPa | 40%      | 8 kph     | W              | 60              | 35               | 70               | 90               | 100  | 200 | 100 | 50  |
| 02/06/15   | 30°C        | 1011 hPa | 50%      | 10 kph    | SSW          | 70              | 40               | 80               | 100              | 200 | 200 | 100 | 50  | 30°C        | 1011 hPa | 50%      | 10 kph    | SSW            | 70              | 40               | 80               | 100              | 200 | 200 | 100 | 50  | 30°C        | 1011 hPa | 50%      | 10 kph    | SSW            | 70              | 40               | 80               | 100              | 200 | 200 | 100 | 50  | 30°C        | 1011 hPa | 50%      | 10 kph    | SSW            | 70              | 40               | 80               | 100              | 200 | 200 | 100 | 50  |
| 03/06/15   | 25°C        | 1013 hPa | 20%      | 6 kph     | N             | 30              | 10               | 20               | 40               | 60   | 80  | 100 | 50  | 25°C        | 1013 hPa | 20%      | 6 kph     | N              | 30              | 10               | 20               | 40               | 60   | 80  | 100 | 50  | 25°C        | 1013 hPa | 20%      | 6 kph     | N              | 30              | 10               | 20               | 40               | 60   | 80  | 100 | 50  | 25°C        | 1013 hPa | 20%      | 6 kph     | N              | 30              | 10               | 20               | 40               | 60   | 80  | 100 | 50  |

**NOTE:** ppbC levels < 0.4 are not listed.