Hong Kong Observatory
The Government of the Hong Kong Special Administrative Region

INtegrated Meteorological Data Quality Assurance System (INDAS)

in Hong Kong, China

JMA/WMO Workshop on Quality Management
in Surface, Climate and Upper-air Observations in RA II, Tokyo,
27-30 July 2010

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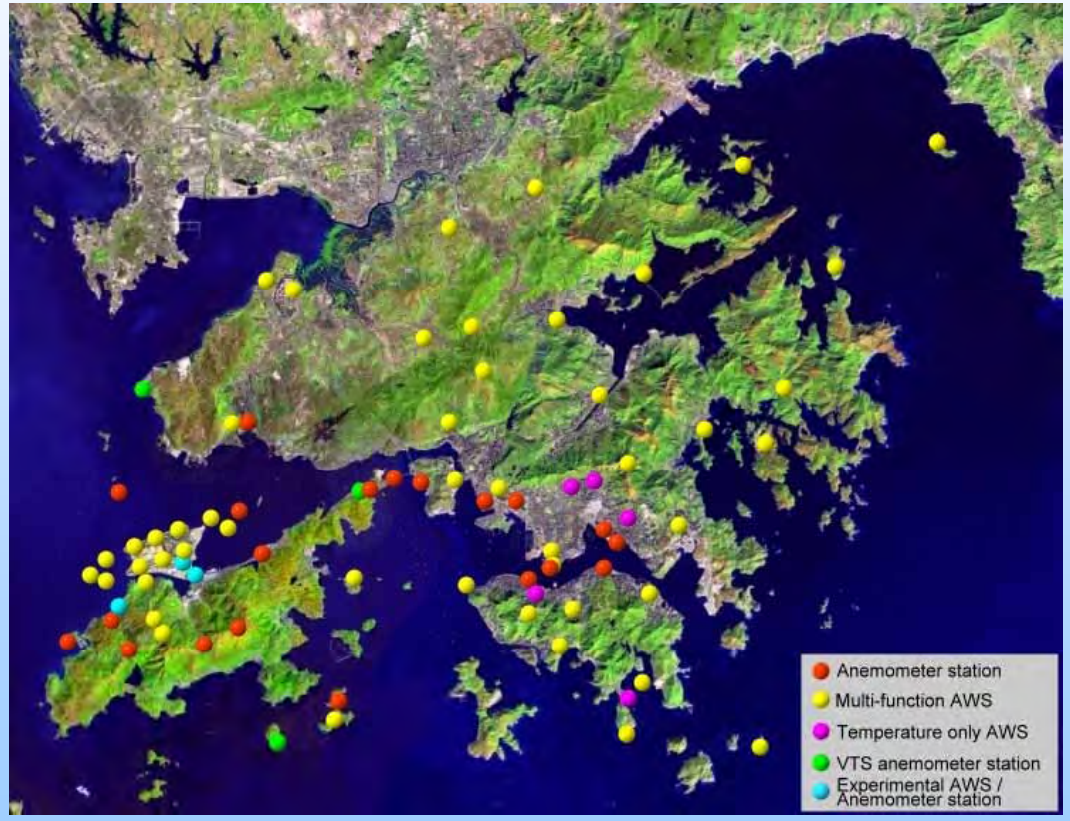
Current situation

- Need to process data transmitted independent from over 100 AWS once every minute



1 RBSN, 1 RBCN,
19 manned stations, and
a large number of AWS…

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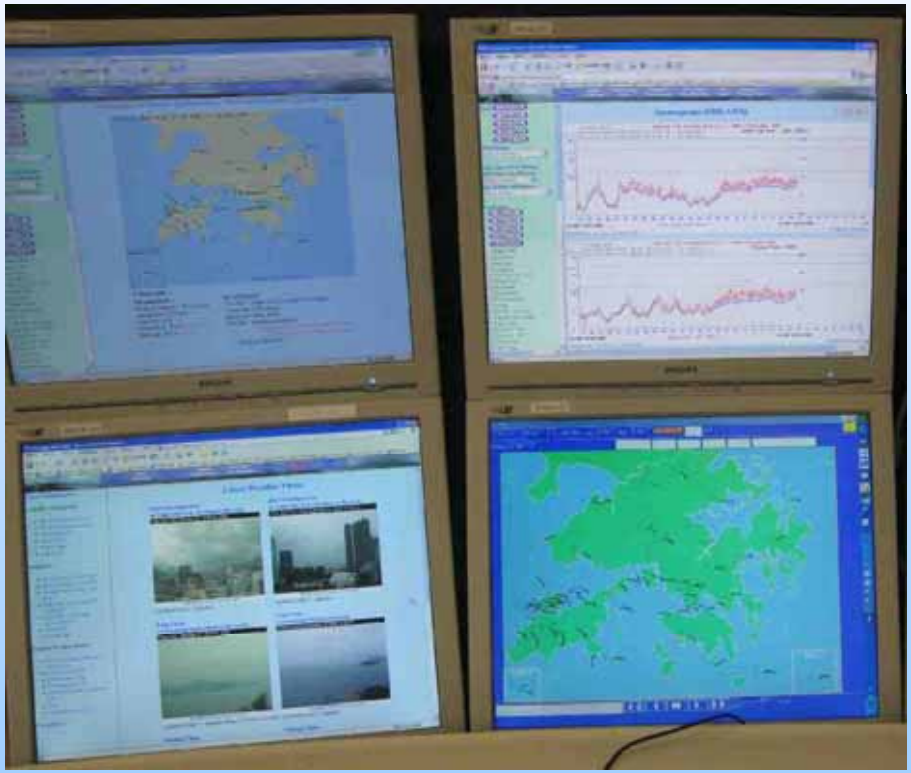
Current situation

- Need to provide high quality real-time AWS data to the weather forecasters



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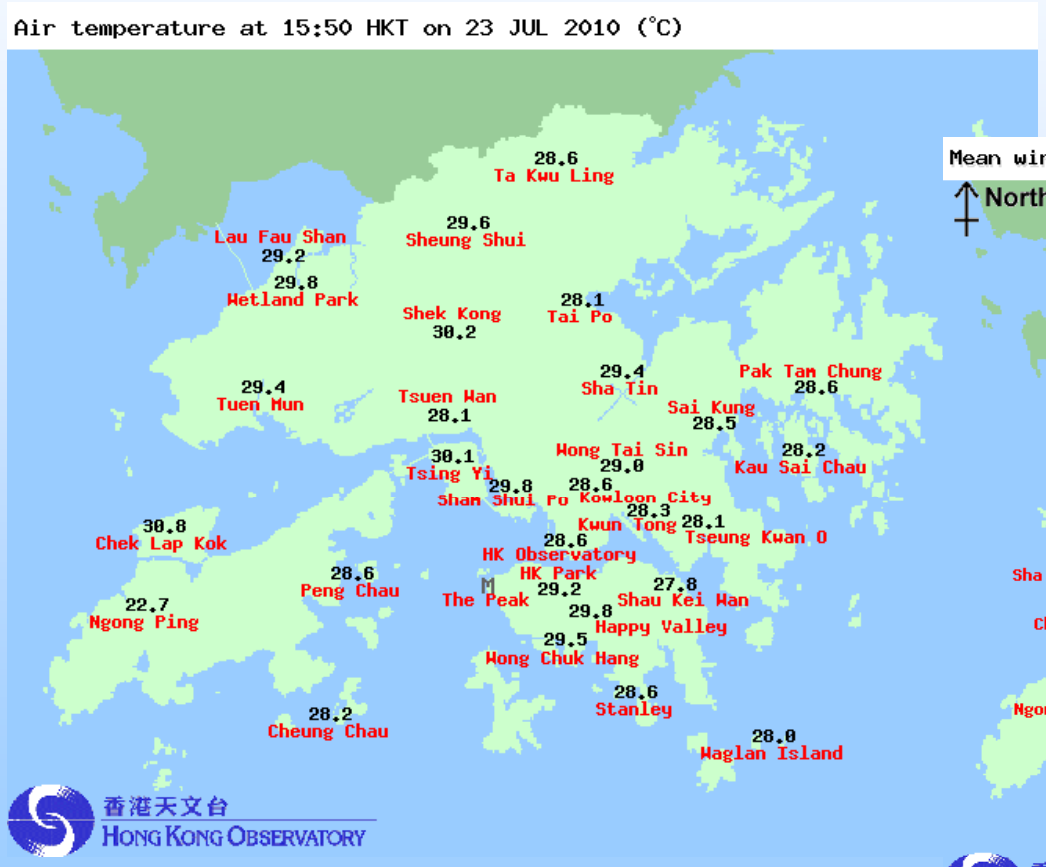
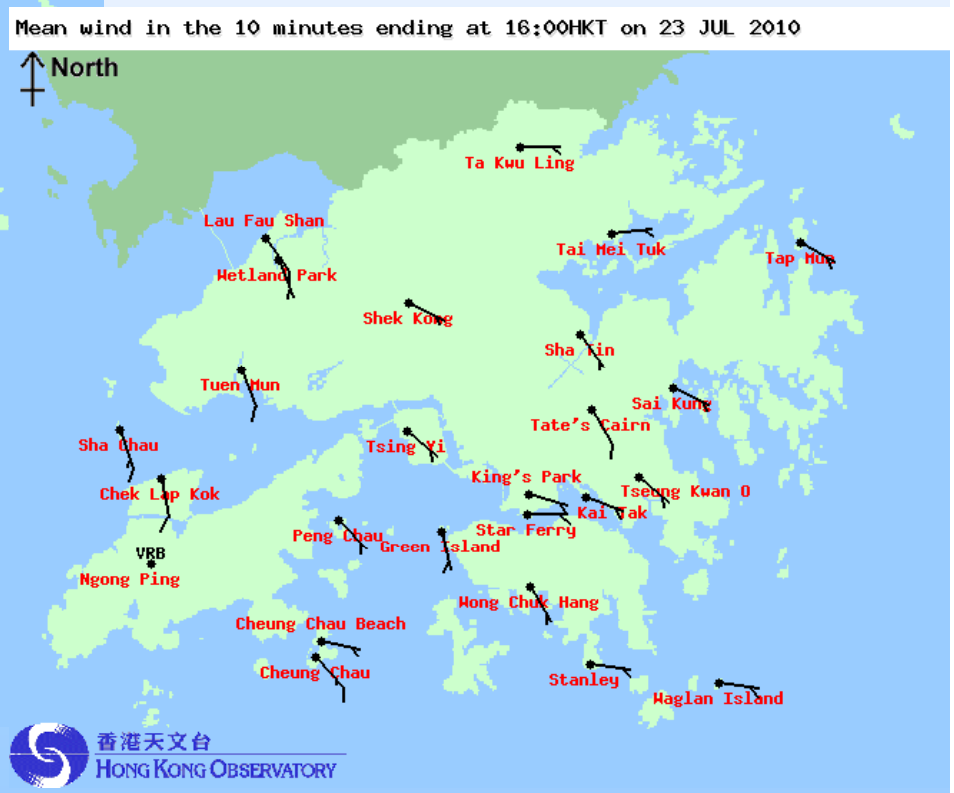
Current situation

- Need to fulfill the increasing public's demand for high quality real-time AWS data (data updated once every 10 minute on HKO website)





Functional specifications of INDAS

- Conduct objective and systematic QC tests for each data point automatically;
- Assign quality assurance flags (QC flags) to each data point based on the QC tests results;
- Filter out flagged erroneous data and alert responsible staff to take maintenance action via email (this enables early detection and diagnosis of faults and shortening the response time for corrective action and enhancing data capture rate);
- Display the status of the AWS network in real-time;
- The QC flags can be used to serve as a record of data quality for case studies and climatological research.

The following QC Tests for each data point will be conducted automatically :

- Range test
- Trend test
- Consistency test
- Persistence test
- Spatial test (not yet implemented)

Range Test

- an algorithm that determines if an observation lies within a pre-determined range;
- allowable ranges are based on sensor specifications and location, and climate extremes;
- If a data point is observed to lie outside the allowable range, it is flagged with a specific flag.

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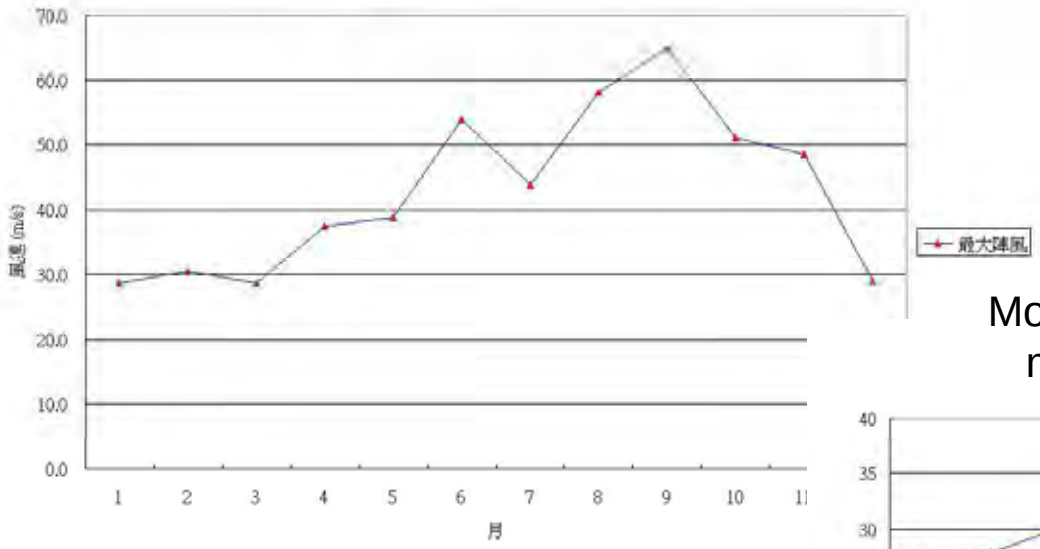
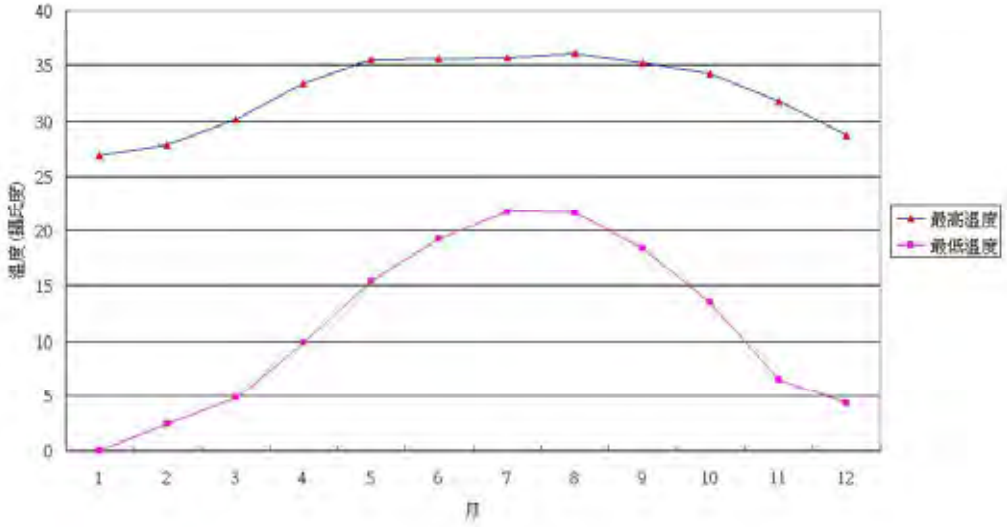
Range Test

Climatological Information for Hong Kong

Monthly extremes of maximum gust at Waglan Island



Monthly extremes of maximum and minimum temperatures at HKO



Range Test

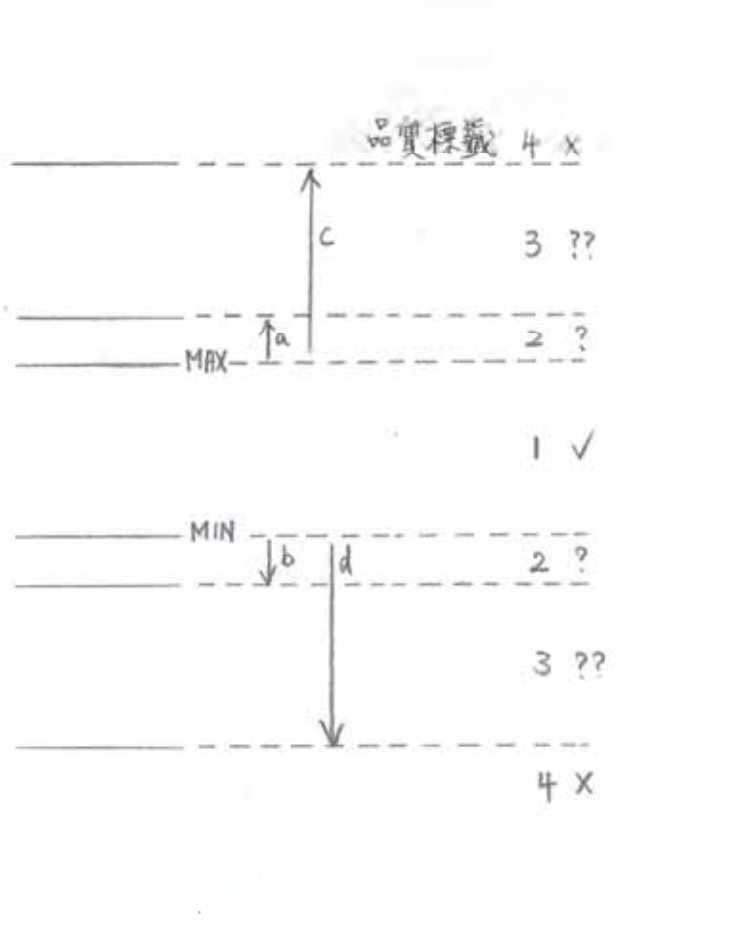
Pre-determined range

1 - passed QC

2 - suspicious

3 - warning (highly suspicious)

4 - erroneous



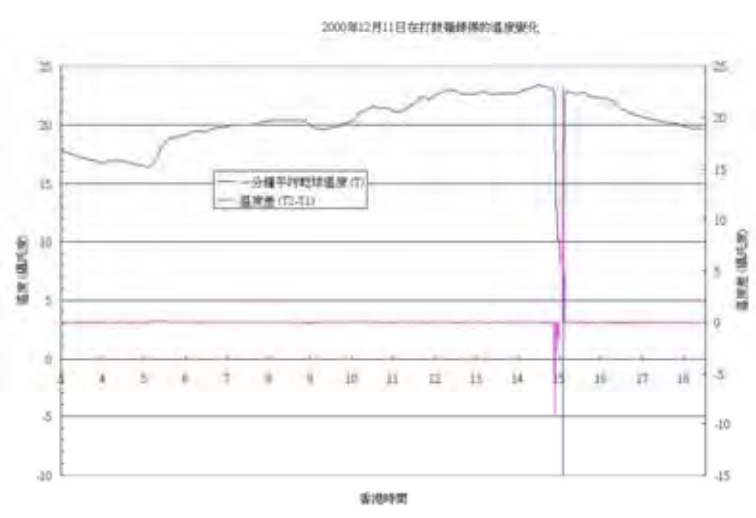
Trend Test

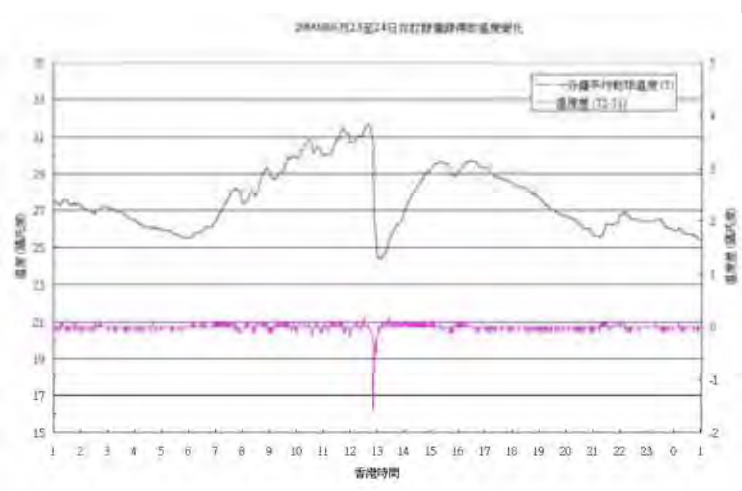
- Use sequential observations within a pre-defined time interval before a data point is collected to determine whether the data point has an unrealistic “jump”;
- Data exceeding the “jump” limit will be flagged.

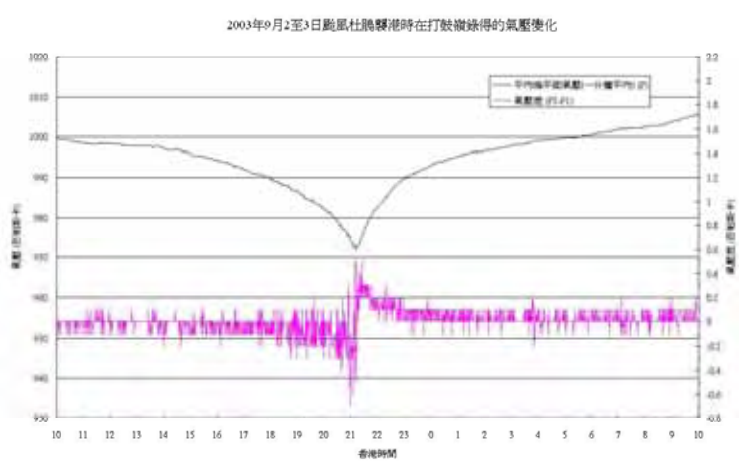
Designing a trend test

- Carry out studies of cases of system malfunction and real genuine situation;
- Compare their rates of change;
- Optimise algorithm such that the scheme is stringent enough to identify system malfunction cases without rejecting real cases.

Trend test - Examples







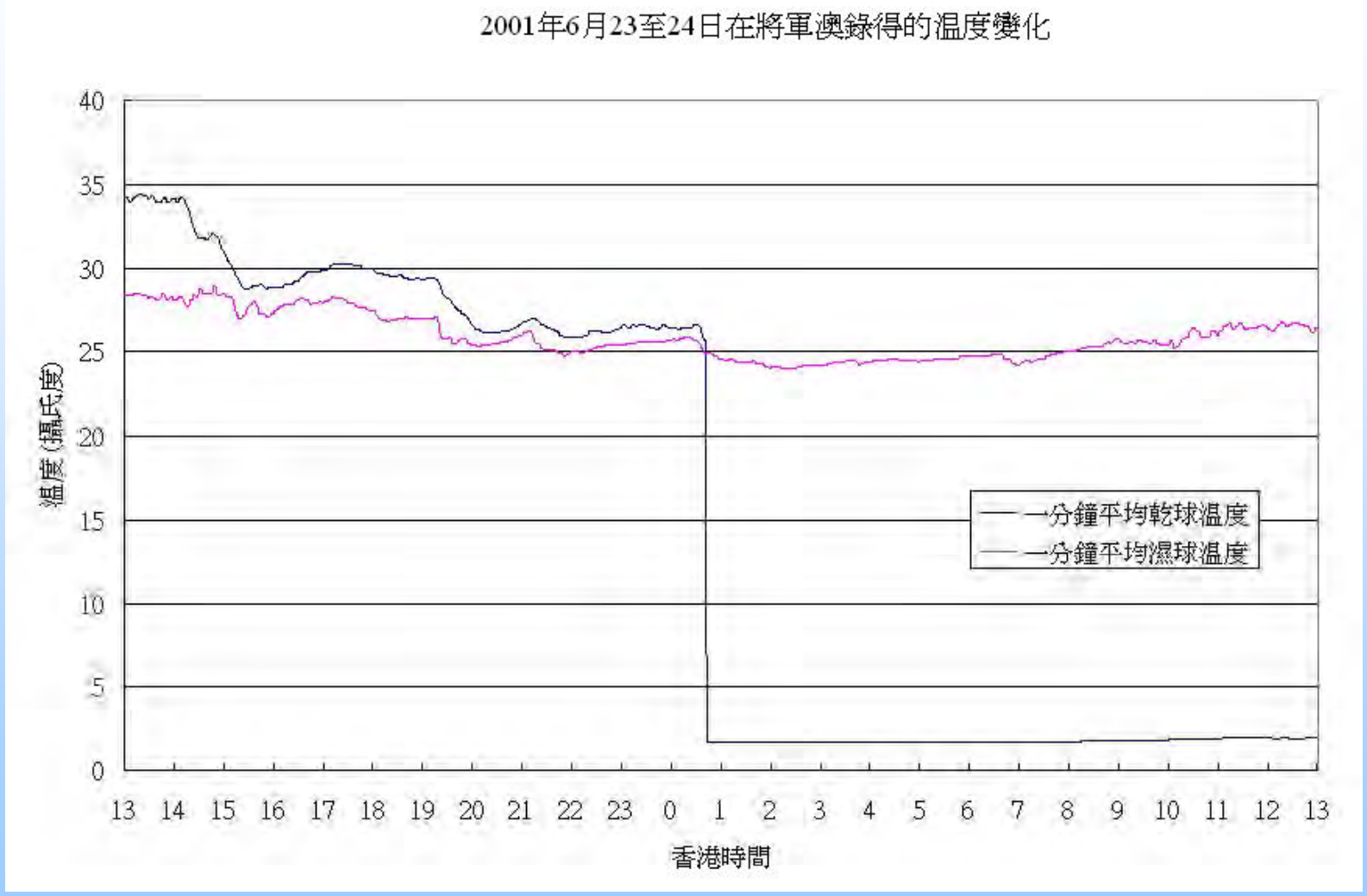
Consistency Test

- This test makes use of the internal consistency of an element against other element(s) measured at the same site.

Examples –

- Dew point and wet bulb temperature < ambient temperature;
- Non-zero wind speed with zero wind direction variations implies wind direction sensor malfunctioned;
- Zero average wind speed and non-zero wind direction variation implies wind speed sensor malfunctioned.

Consistency test – Example



Persistence test

- Analyses data on a daily basis to determine if any element has little or no variation;
- If the standard deviation of the data on that day is less than or equal to some pre-defined threshold, all the data are flagged with a specific flag.

Spatial test

- The principle of spatial test is to compare a data point with data of the same type collected at surrounding stations at the same time;
- Based on data from surrounding stations, derive an expected value for each site;
- The expected value is compared with the actual observation at that site. If the difference is greater than a certain pre-defined threshold, the observation will be flagged with a specific flag.

Format of QA flags

EnEn Q_1 Q_2 Q_3 Q_4 Q_5 Q_6 Q_7 Q_8 vv (12 digits)

EnEn

Element code e.g. use (**A1**) to represent 1-min wind dir. (**A**)

Q_1 Q_2 Q_3 Q_4 Q_5 Q_6

Q_1 : Range test QA flag
Q_2 : Trend test QA flag
Q_3 : Persistency test QA flag
Q_4 : Consistency test QA flag
Q_5 : Spatial test QA flag
Q_6 : Other test QA flag (reserved)

QA flag values and meaning

0 - test not implemented
1 - passed auto-QC
2 - suspicious
3 - warning (highly suspicious)
4 - erroneous

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Format of QA flags

EnEn Q_1 Q_2 Q_3 Q_4 Q_5 Q_6 Q_7 Q_8 vv (12 digits)

Q_7

The composite QA flag
(based on the results of the various QA tests)

QA flag values and meaning
0 - auto-QC not implemented
1 - passed auto-QC
2 - suspicious
3 – erroneous
6 - erroneous, immediate follow-up actions required
8 - instrument under maintenance

Q_8

Reserved for manual amendment of the final QA flag by Climate Section

QA flag values and meaning
0 - QA flag not assessed (default value)
1 - data passed final QC
3 - data confirmed erroneous by final QC

vv

Version number of the QC System (01-99)
(refers to a particular set of QA algorithms)

The QA Flags $\mathbf{Q_7}$ and $\mathbf{Q_8}$

Q7

- Assigned by the system to each weather element based on the results of the various QC tests;
- = 1 if the data passes all QC tests;
- = 3 if the data fails in any of the QC tests;
- = 2 if the data is treated as suspicious by any of the QC tests;

Q8

- The QC system also allows manual editing of the QA flags by specialized QC personnel;
- The final QA flag will serve as a key for data retrieval and provide an official record for different usages.

QA flags

- Implementation of QA flag is in accordance with WMO's guidlines
- Retain raw data.
- Determine whether an AWS data can be released/used in real-time
- Bases for alerting responsible personnel

Email alert (Trend test – Data_Suspicious)

寄件者: INDAS@bianca.hko.gov.hk
日期: 2008年8月13日 上午 06:24
收件者: khtam@hko.hksarg
主旨: AWS System Operational Status Alert (Data_Suspicious)

HKO AWS System Operational Status Alert
prepared by Integrated Meteorological Data Quality Assurance System (INDAS)

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The following problem(s) has/have been found by the INDAS :

TFA C1 13/08/2008 06:17 130100-2 Data_Suspicious
TFA C1 13/08/2008 06:18 130100-2 Data_Suspicious

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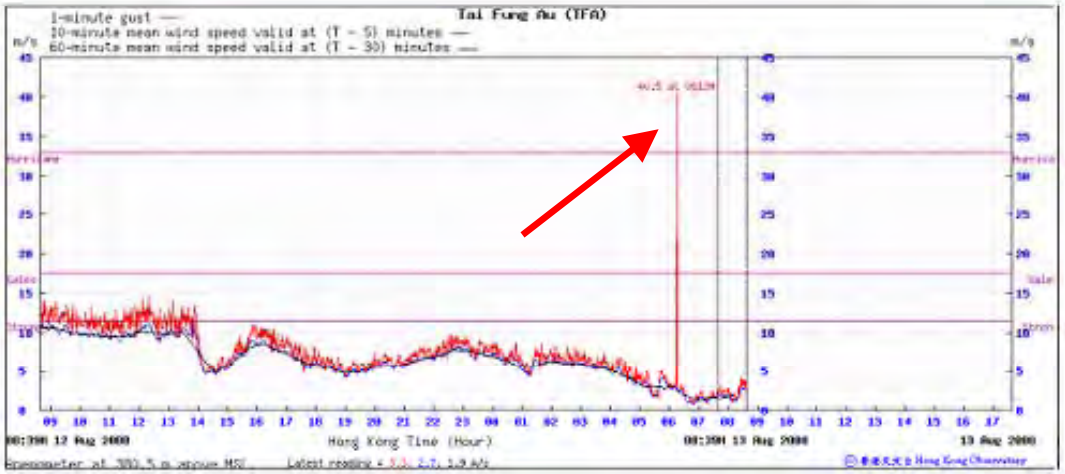

Email alert (Trend test – Data_Error)

寄件者: INDAS@bianca.hko.gov.hk
日期: 2008年10月3日 下午 01:35
收件者: khtam@hko.hksarg
主旨: AWS System Operational Status Alert (Data_Error)

HKO AWS System Operational Status Alert
prepared by Integrated Meteorological Data Quality Assurance System (INDAS)

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The following problem(s) has/have been found by the INDAS :

NLS S1 03/10/2008 13:27 140000-3 Data_Error
NLS S1 03/10/2008 13:28 140000-3 Data_Error

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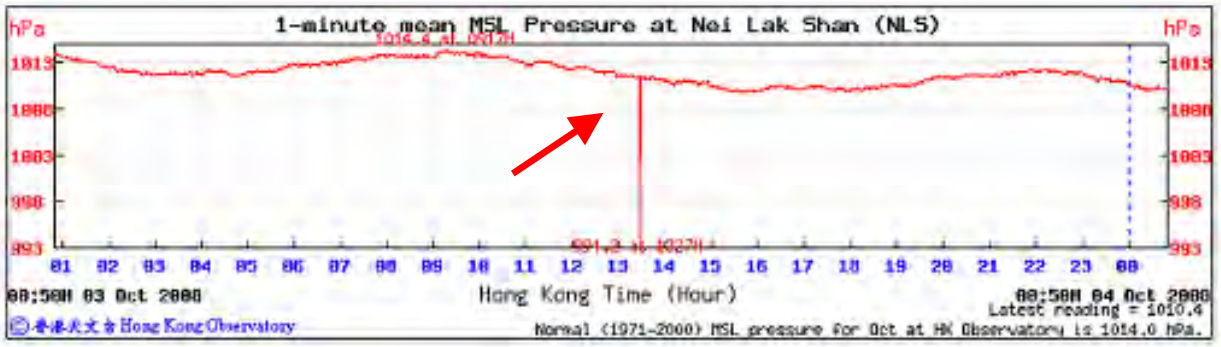

Email alert (Consistency test – Data_Error)

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香港天文台

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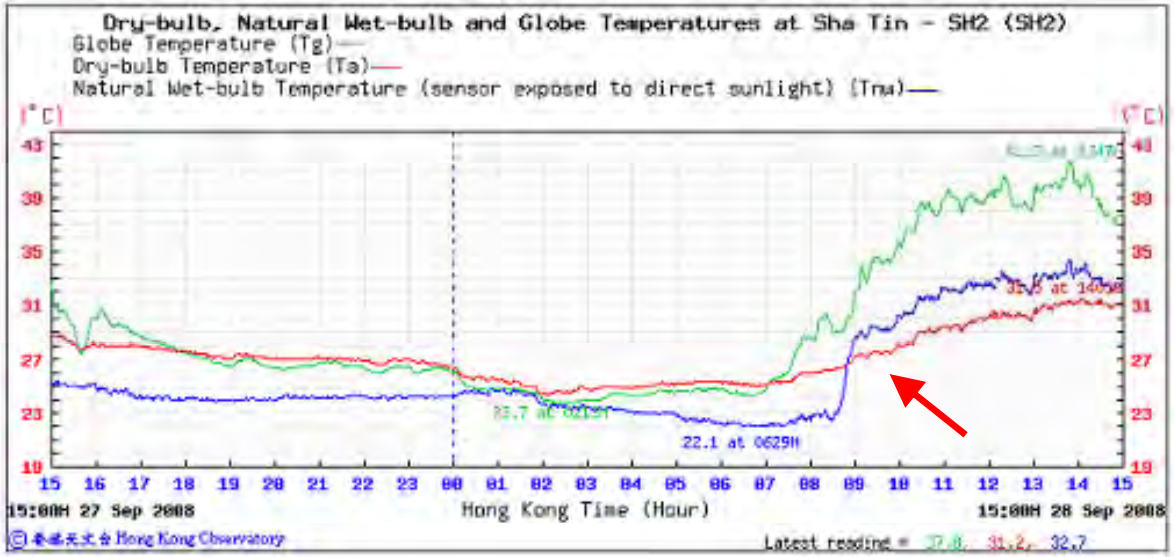

寄件者: INDAS@bianca.hko.gov.hk
日期: 2008年9月28日 上午 10:05
收件者: khtam@hko.hksarg
主旨: AWS System Operational Status Alert (Data_Error

HKO AWS System Opera
prepared by Integrated Meteorologic

The following problem(s) has/have b

SH2	g1	28/09/2008 09:57	110400-3	Data_Error
SH2	g1	28/09/2008 09:58	110400-3	Data_Error
SH2	g1	28/09/2008 09:59	110400-3	Data_Error
SH2	g1	28/09/2008 10:00	110400-3	Data_Error
SH2	i1	28/09/2008 09:57	000400-3	Data_Error
SH2	i1	28/09/2008 09:58	000400-3	Data_Error
SH2	i1	28/09/2008 09:59	000400-3	Data_Error
SH2	i1	28/09/2008 10:00	000400-3	Data_Error

Email alert (Range test - Data_Error)

寫件者: INDAS@bianca.hko.gov.hk
日期: 2008年9月13日 上午 02:55
收件者: khtam@hko.hksarg
主旨: AWS System Operational Status Alert (Data_Error)

HKO AWS System Operational Status Alert
prepared by Integrated Meteorological Data Quality Assuran
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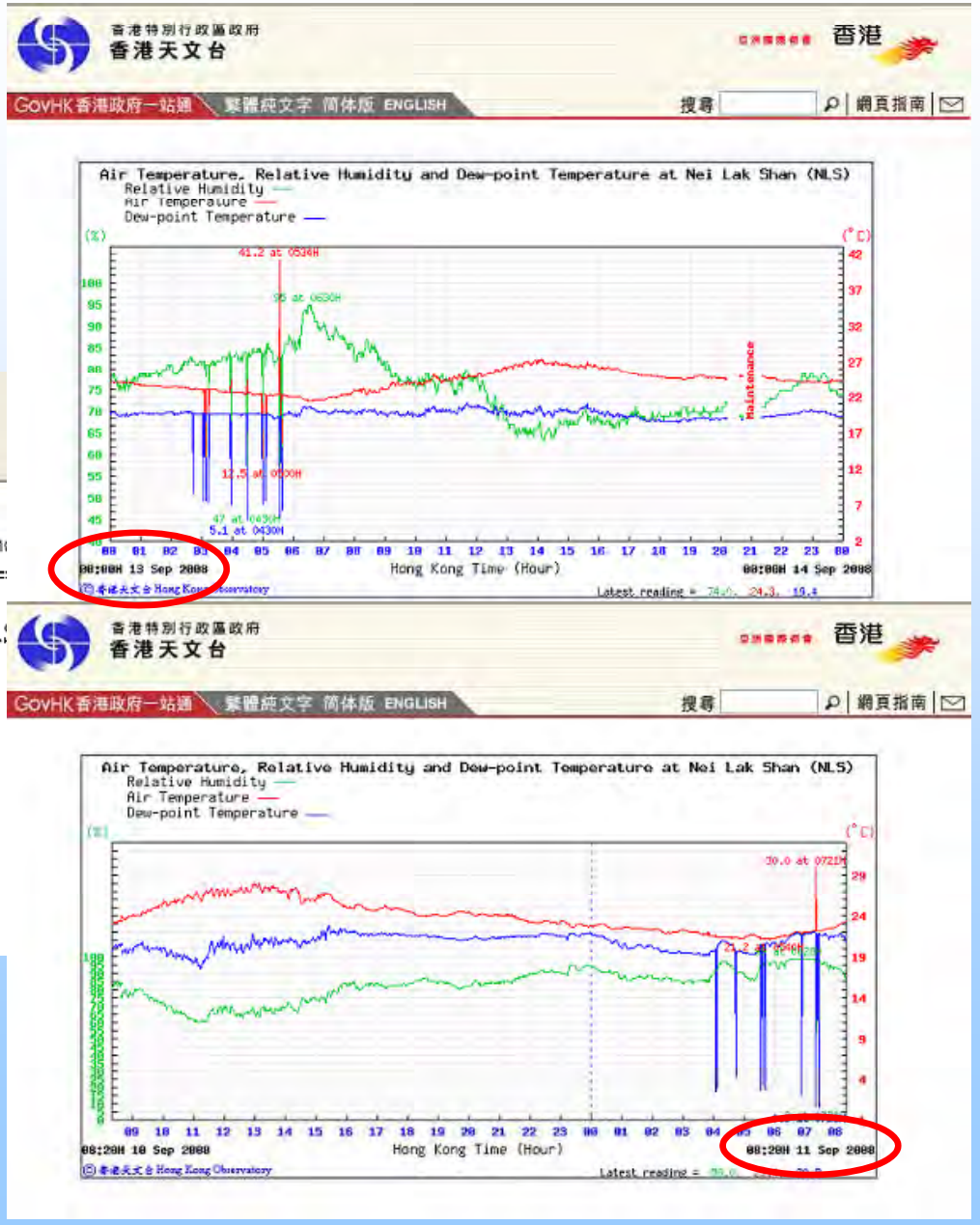
The following problem(s) has/have been found by the INDA

NLS	J1	13/09/2008 02:44	400000-3 Data_Error
NLS	K1	13/09/2008 02:44	400000-3 Data_Error
NLS	O1	13/09/2008 02:44	400000-3 Data_Error
NLS	O1	13/09/2008 02:45	400000-3 Data_Error
NLS	O1	13/09/2008 02:46	400000-3 Data_Error
NLS	O1	13/09/2008 02:47	400000-3 Data_Error
NLS	O1	13/09/2008 02:48	400000-3 Data_Error
NLS	O1	13/09/2008 02:49	400000-3 Data_Error
NLS	O1	13/09/2008 02:50	400000-3 Data_Error



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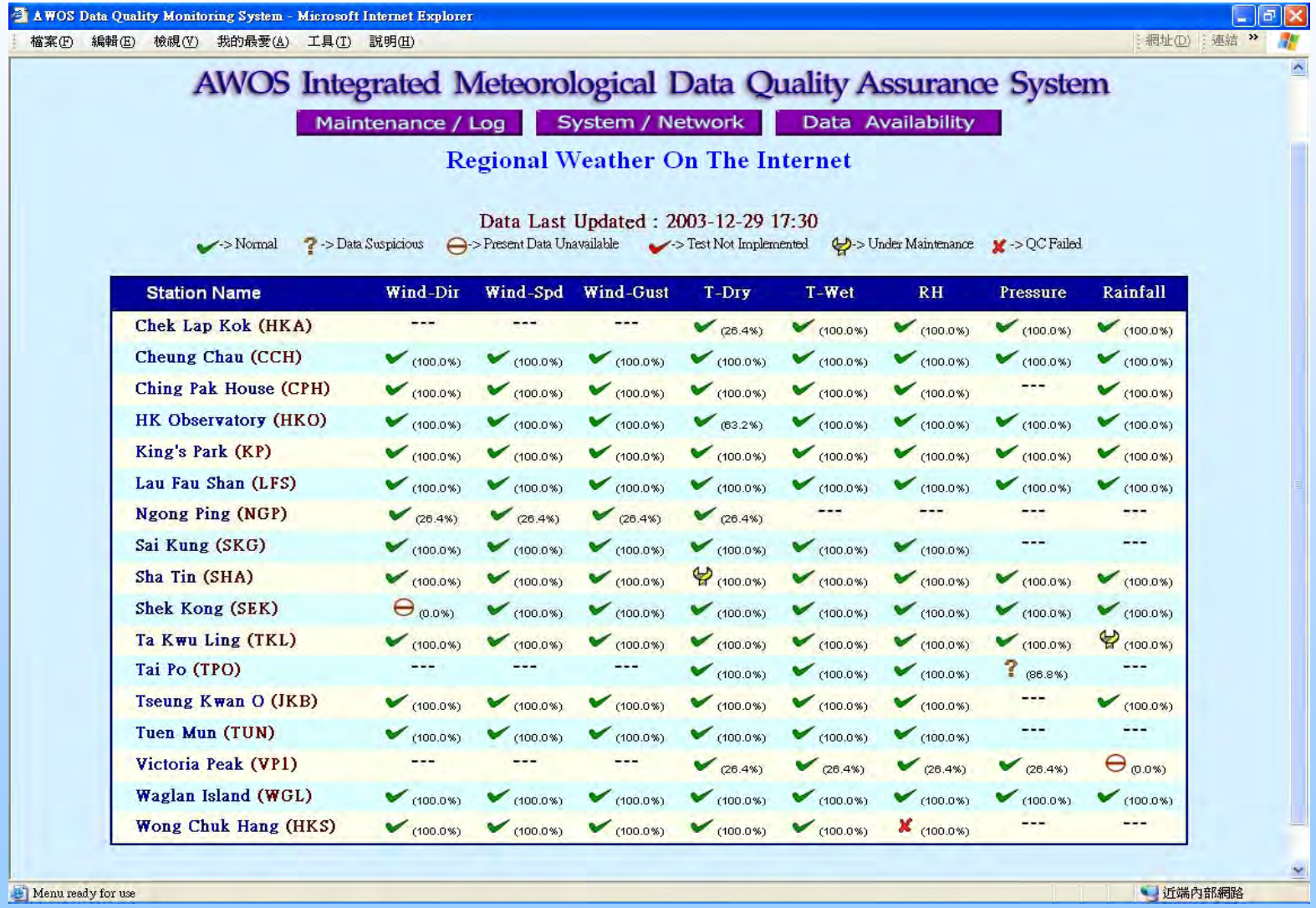
Monitoring data quality of the AWS network in real time



Station Name	Wind-Dir	Wind-Spd	Wind-Gust	T-Dry	T-Wet	RH	Pressure	Rainfall
Chek Lap Kok (HKA)	---	---	---	✔ (26.4%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
Cheung Chau (CCH)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
Ching Pak House (CPH)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	---	✔ (100.0%)
HK Observatory (HKO)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (63.2%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
King's Park (KP)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
Lau Fau Shan (LFS)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
Ngong Ping (NGP)	✔ (26.4%)	✔ (26.4%)	✔ (26.4%)	✔ (26.4%)	---	---	---	---
Sai Kung (SKG)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	---	---
Sha Tin (SHA)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	(100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
Shek Kong (SEK)	⊖ (0.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
Ta Kwu Ling (TKL)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	(100.0%)
Tai Po (TPO)	---	---	---	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	? (86.8%)	---
Tseung Kwan O (JKB)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	---	✔ (100.0%)
Tuen Mun (TUN)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	---	---
Victoria Peak (VP1)	---	---	---	✔ (26.4%)	✔ (26.4%)	✔ (26.4%)	✔ (26.4%)	⊖ (0.0%)
Waglan Island (WGL)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)
Wong Chuk Hang (HKS)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✔ (100.0%)	✘ (100.0%)	---	---

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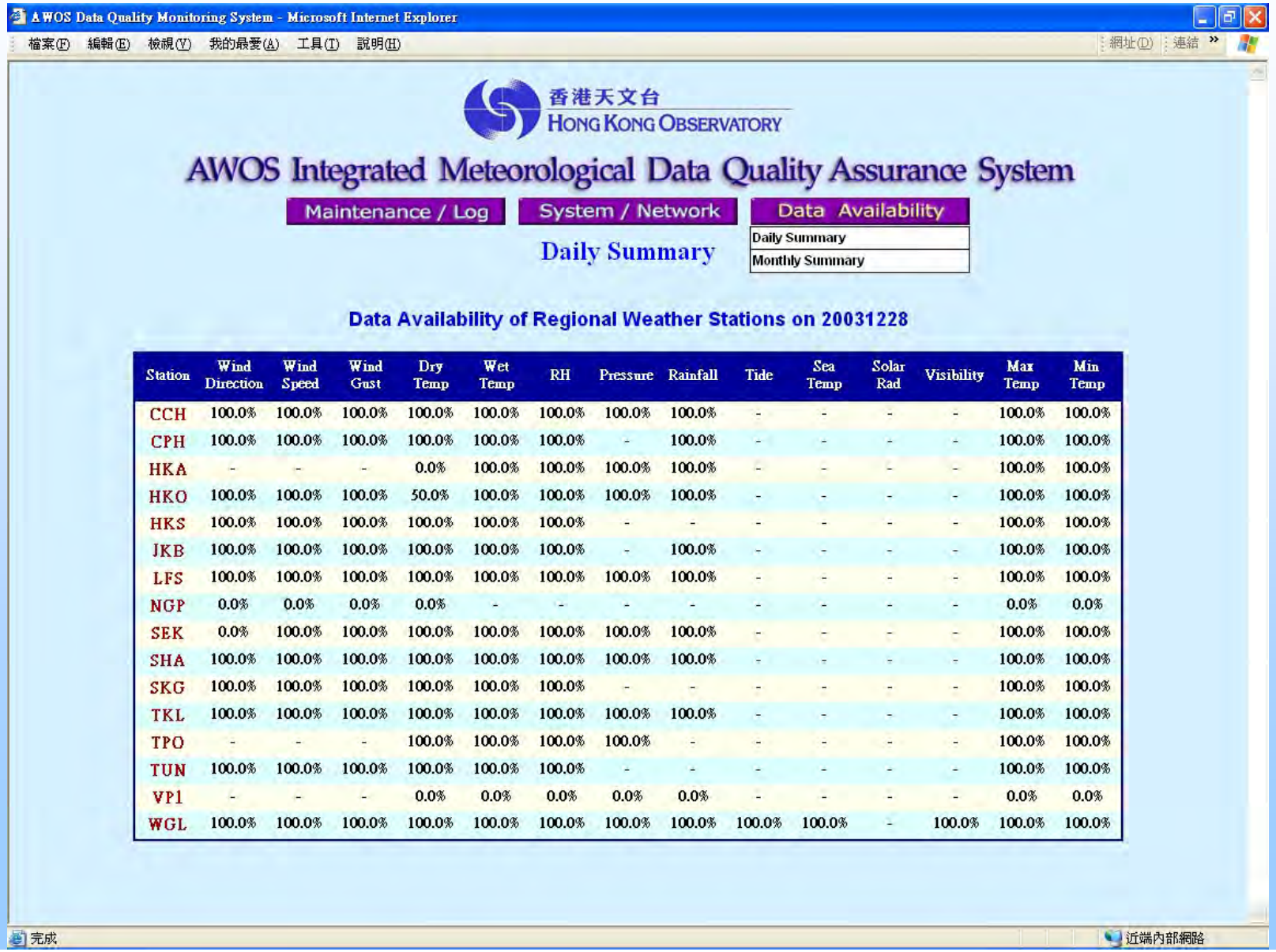
Automatically compile the data availability of the AWS Network



Station	Wind Direction	Wind Speed	Wind Gust	Dry Temp	Wet Temp	RH	Pressure	Rainfall	Tide	Sea Temp	Solar Rad	Visibility	Max Temp	Min Temp
CCH	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	100.0%	100.0%
CPH	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	100.0%	-	-	-	-	100.0%	100.0%
HKA	-	-	-	0.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	100.0%	100.0%
HKO	100.0%	100.0%	100.0%	50.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	100.0%	100.0%
HKS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	-	-	100.0%	100.0%
JKB	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	100.0%	-	-	-	-	100.0%	100.0%
LFS	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	100.0%	100.0%
NGP	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-	-	-	0.0%	0.0%
SEK	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	100.0%	100.0%
SHA	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	100.0%	100.0%
SKG	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	-	-	100.0%	100.0%
TKL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	100.0%	100.0%
TPO	-	-	-	100.0%	100.0%	100.0%	100.0%	-	-	-	-	-	100.0%	100.0%
TUN	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	-	-	-	-	-	100.0%	100.0%
VP1	-	-	-	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	0.0%	0.0%
WGL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	-	100.0%	100.0%	100.0%

Future Development

- Further enhancement of real-tme QA algorithms by conducting more case studies (to optimize the thresholds to maximize the error detection rate and minimize the false alarm rate)
- Increase data availability by increasing the redundancy (dual sensor, independent communication links, etc.)
- Improve the communication protocol to enable effective spatial test to be conducted within a limited time frame in real-time

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Thank You !