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HONG KONG OBSERVATORY

AvRDP HKG (May – Sep 2015)
IOP Brief and Data Manual

Revision History	
1.0	Nov 2015

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1 Introduction

The Hong Kong International Airport (HKG) is one of the participating airports in the Aviation Research Demonstration Project (AvRDP). The major weather impacts to HKG are tropical cyclones, significant convection, and low visibility. Specifically for the AvRDP, the main interest is the nowcasting/forecasting of significant convection at the aerodrome and critical air spaces in its vicinity, as well as their estimated impact to air traffic.

Key objectives for HKG's participation are to:

Phase 1

i) demonstrate the capability in nowcasting/forecasting of significant convection for tropical/sub-tropical regions;

ii) demonstrate how to tailor-make aviation specific weather products to facilitate ATM decision making;

Phase 2

iii) develop and demonstrate the application of verification algorithms for new route-based and/or trajectory-based aviation weather forecast products;

iv) demonstrate means to convert weather into ATM impact by quantitative measures, for example reduction of arrival/departure rate, traffic delay, or level of flow control;

v) research on how tailored aviation specific services can integrate with ATM decision making in objective terms.

2 Basic information of the aerodrome

The Hong Kong International Airport is located at (22 18 32 N, 113 54 53 E). The airport island (Chap Lap Kok) is built from land reclamation next to the biggest island in Hong Kong, the Lantau. With dual runways, operating at 07 and 25 orientation, the capacity of HKG is about 65 surface movements per hour (33 arrivals/32 departures).

Situated near 22N alone the coastal area of Guangdong province, China, HKG is mainly affected by southwest Asian Monsoon in the summer months, with occasional frontal system passage in late spring, and rain band associated with tropical cyclone transverses into the region. While thunderstorms occurring over the aerodrome may last less than an hour, convection over the terminal area (say 100NM from the airport ARP) could sustain for 4 hours or more. Convection blocking one or multiple tactical areas in the air space (essential arrival/departure

routes, or areas typically used as holding patterns) may severely hamper the normal air traffic and result in diversions and prolonged delay. In ATM terms, the impact is considered significant when arrival capacity drops to below 23.

Maps of the airport and its surrounding area are given in Appendix A. Appendix B tabulates the climatology of HKG for different weather phenomena and basic weather elements for year 1998-2014.

Detailed information on standard arrival/departure routes (STAR and SID) is in the AIP published by the Civil Aviation Department of Hong Kong, and is available online: (www.hkatc.gov.hk).

The Hong Kong Observatory (HKO) has been providing weather information to support the operation of HKG since the airport opens in 1998. To better monitor the weather condition within the complex terrain around the airport, a dense network of automatic weather stations together with advanced remote-sensing equipment was in place. Apart from conventional data (SYNOP, METAR, SHIP, AIREP), there are also wind information from hill tops, buoys, at the middle and both ends of runways, echo returns from long range doppler weather radars, lightning location information from lightning detection network, air balloon soundings, wind profilers, and AMDAR[1] data provided by inflight aircraft.

In order to support very short term forecasting, the observatory developed the Aviation Thunderstorm Nowcasting System **[1]** (ATNS) which is a radar nowcasting system based on HKO's renowned SWIRLS **[2]**. The system produces reflectivity forecast covering 256km range at 6 minutes intervals for the next 60mins, with a refresh rate also of 6 minutes. Besides displaying the forecast directly for ATC's reference, output from ATNS is also used for generating the 1 hour convection forecast for arrival/departure corridors. The product is tailored for tower control to adjust aircraft spacing during appraoch. For the larger area, a similar nowcasting system, ingesting additional information on convection derived from geostationary satellite channels, has been under trial to cover areas beyond the reach of existing radar as well as to extend the forecast range **[3]**.

For forecasts beyond 6 hours, HKO is operating a NWP model named RAPIDS-NHM. It is adopted from JMA's Non-Hydrostatic Model. RAPIDS-NHM runs at 2km horizontal resolution and is design for the forecasting of significant convective activities due to local terrain including land-sea effect and complex topography **[4]**.

To extend the useful forecast period of nowcasting systems, as well as mitigate spin up problem in NWP, a so-called "blending" algorithm has been developed in house to generate forecast rainfall up to the next 6 hours. The system performs merging of output from HKO's SWIRLS nowcasting system and NWP model RAPIDS-NHM by first applying intensity calibration and phase correction to NWP output, then applying a blending function which is a non-linear weighting function in time. **[5]**

Output of the blending forecast is utilized for generating first guess for significant convection forecast time series for the aerodrome and the key holding patterns within the Hong Kong air

[1] For details about the AMDAR programme: (https://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR)

space. The warning zones are typically an area of 20nm radius. For outer boundary of the HKFIR, coarser NWP model output from ECMWF at 3 hourly intervals is used. The output will then be converted, based on the percentage coverage of rainfall amount over certain thresholds within the zones at different forecast hour, into a three-level colour-coded product (green, amber, red). This product will be presented during the daily weather briefing with Hong Kong ATC for them to consider the need of imposing flow control measures and estimating the near term Airport Arrival Rate. **[6]**

To study the correlation between convection and air traffic, and to further quantify the impact, information on air traffic will be needed. All information collected were available in a shared database, the Airport Operation Database (AODB) which contains timings of every flights going in and out of HKG.

3 Data collection during IOP

The HKG IOP extended from 15 May 2015 to 15 September 2015 inclusive. During IOP, a number of significant weather events have occurred:

i) Local rainstorm warnings were issued for 20 May, 23 May, 24 May, 26 May, 12 June, 21 July, 22 July, 9 August, 15 August, and 2 September.

ii) For the 23 May rain storm case, convection blocking the departure route at runway 25 resulted in large deficit in departure to arrival, and large number of aircraft were hold on ground.

iii) On 9 July, Typhoon Linfa approached Hong Kong from the east and necessitated the issuance of gale or storm typhoon warning signal by the Hong Kong Observatory.

3.1 Observational data:

Unless specified, the area coverage is about 200km from ARP of HKG.

Surface		
METAR	Half-hourly weather report of aerodromes.	UTC
SYNOP	Three-hourly WMO standard weather reports.	UTC
SHIP	Three-hourly reports from observation marine vessels.	UTC
Automatic weather station	Wind data recorded at 1 min intervals. A limited number of stations also provide temperature, humidity, and pressure data.	HKT
Upper air		
Sounding	Reports of twice daily WMO standard weather balloons.	UTC
AMDAR	Automatic weather reports from inflight aircraft.	UTC
Remote sensing		
Lightning	Time, positional and type (CG/CC) of strike.	UTC

Radar	Reflectivity factor in volumetric scan at 6 min intervals.	HKT
Wind profiler	Upper air wind data at 10 min interval with vertical resolution of about 100m.	HKT

Table 1

3.2 Nowcasting data:

Gridded output		
ATNS	Forecast of radar reflectivity factor within 256km of HK at 6 min intervals for the next 60 min. Refresh rate at 6 min.	HKT
MSQ	Hourly forecast rainfall rate over an area of around 500km within HK for the next 9 hours. Refresh rate at 6 min.	HKT

Table 2

3.3 Forecasting data:

Text based forecast		
TAF	ICAO standard weather forecast for the aerodrome.	UTC
SIGMET (TS)	ICAO standard warning product for thunderstorm within the FIR, valid for 4 hours at most.	UTC
NWP gridded output		
NHM	Refresh rate of 3 hours. 0.02 degree resolution covering 19.8-24.8N, 111.8-116.8E. Output at hourly interval up to 15hr. Forecast element includes simulated radar reflectivity.	UTC

Table 3

3.4 Forecast data by the blending algorithm

Gridded output		
RAPIDS	Forecast of hourly rainfall rate at hourly intervals for the next 6 hours, roughly covering 128km radar range. Refresh rate at 6 min.	HKT
Textual output		
SIGCONV	Significant convection forecast time series for the aerodrome	UTC

	and key holding areas at hourly interval for the next 6 hours. Automatic output but allowed for human intervention. Refresh rate at 12 min.

Table 4

3.5 Data related to ATM:

Air traffic information		
Airport arrival rate (AAR)	Number of aircraft scheduled to land hourly, and the number of aircraft actually landed in that hour.	HKT
Capacity forecast		
AAR estimated by ATM unit	Estimated AAR for the next few hours. Twice daily and update as necessary.	UTC

Table 5

4 File System Structure and Format on the AvRDP Data Server

Tree under user 'hkg' on the AvRDP data server [2]:

```
$ tree
.
|-- ATM
|    `-- CapacityNotification
|    `-- HourlyTraffic
|    `-- SigConvForecast
|
|-- BLEND
|    `-- 20150515Z
|        `-- rapids
:
|-- FORECAST
|    `-- 20150515Z
|        |-- sigmet
|        `-- taf
:
|-- NOWCAST
|    `-- 20150515Z
|        |-- atns
|        `-- msq
:
|-- NWP
|    `-- 20150515Z
|        |-- meso-nhm
```

[2] For how to access the AvRDP data server for data uploading/downloading, please refer to the data server user guide.

```
|       `-- rapids-nhm
:
|-- OBS
|   `-- 20150515Z
|       |-- remote-sensing
|       |   |-- lightning
|       |   |-- radar
|       |   |   `-- raw
|       |   `-- wind-profiler
|       |-- surface
|       `-- upper-air
:
|-- METADATA
|
|-- temp
|
`-- hkg_home_directory.txt
```

Table 6

Data was first grouped first into six main types, namely OBS, NOWCAST, FORECAST, NWP, BLEND, and ATM. Within the first level subfolder, data are segregated by UTC day (YYYYMMDDZ) before further delineation[3]. Since the data volume of different types varies greatly (output from NWP could easily dwarf surface observation, for example), this should facilitate retrieval of a single data type of interest. On the other hand, for case study, one can simply download the full set of data by specifying the folder name by the day.

The "metadata/" folder holds miscellaneous information useful for decoding or geo-referencing the actual data. Examples include location of radar stations, automatic weather stations, latitude-longitude information of data pixels in radar files.

There is a file "hkg_home_directory.txt" which contains a full list of all files under the directory. Players interested can simply download the file to their local storage for further viewing/searching or constructing scripts to retrieve the actual data. The data resides in the "temp" folder is, as the name implies, volatile and should not be used in any way.

Folder structure, naming convention and layout of different kinds of data are introduced below. Not all data are covered by the following sections. For example METAR, TAF…etc which are standard products that their decoding and interpretation should be straight forward for the aviation community, are excluded. However, organization of such data still follows the practice as described below.

4.1 SURFACE files

[3] Note that the actual data files, as well as the contents, may be named/recorded in local time (HKT), which is UTC+8hr. (e.g. 00UTC=08HKT, 00Z = 08H)

```
$ cd /home/airports/hkg/OBS/20150707Z/surface
$ tree
.
|-- aws_150707
|-- metar_1507062355.txt
:
:
|-- ship_1507070322.txt
|-- ship_1507070422.txt
|-- ship_1507070522.txt
|-- synop_1507070027.txt
|-- synop_1507070127.txt
:
:
|-- synop_1507072127.txt
|-- synop_1507072227.txt
`-- synop_1507072327.txt
```

Table 7

metar_* files contain METAR reports following WMO coding convection:

```
$ head metar_1507062355.txt
    VHHH 062330Z 04008KT 9999 FEW032 28/20 Q1001 NOSIG=
    VMMC 062330Z 02018KT 9999 FEW035 28/22 Q1000 NOSIG=
    ZGGG 062330Z 01004MPS CAVOK 27/22 Q1002 NOSIG=
    ZGSZ 062300Z 02007MPS CAVOK 28/19 Q1001 NOSIG=
    ZGSD 062300Z 01005MPS CAVOK 27/21 Q1001 NOSIG=
    ZSSS 062330Z 02006MPS 6000 -RA BKN007 20/19 Q1008 NOSIG=
```

Table 8

ship_* files contain SHIP reports following WMO coding convection:

```
$ head ship_1507070322.txt
 ZCZC  980 32767 FROM JP
 SNVB21RJTD 070200
 BBXX
 A8SZ7   07024 99220 11142
 41/97 40513 10290 20232 40000 53020 7//// 82/76
 22200 04270 20301 80250=
 NNNN
 ZCZC  180 32767 FROM CI
 SNVB21RJTD 070200
```

Table 9

aws_* files contain data from local automatic weather stations. It is in in-house developed binary file format consists of a series of “FIX LENGTH FORMATTED” records. The data layout is as follows:

```
Record Length = 512 bytes = 256 words

Record  1-2 : station identifier list
    word 1-508 = 254 * 4 char, station identifier
           (char 1-3 for station name, e.g. WGL, TKL, etc;
                 char 4   reserved)
         509-510 = I4 header last modified day (yymmdd)
         511-512 = I4 total no. of stations

Record    3 : number of element
    word   1-254 = 254 * I2, number of elements for
                           corresponding stations
                  as listed in Record 1-2
           255 = reserved
           256 = I2, total number of elements for all stations

Record    4 : element index & date of data
    word   1-254 = 254 * I2, start byte position
                   (in record 5-8) for
                   1st element of corresponding station as
                   listed in Record 1-2
           255-256 = I4, date of data (yymmdd)

Record  5-8 : station-element list, total 2048 bytes
    byte 1-2048 = 2048 char,
                  each char (A-Z,a-z) corresponds to an element
                  of a station, all elements for a station
                  are grouped together. The byte position of
                  the 1st element of each group (each
                  station) is indicated in Record 4.

Record    9 : station-height in 0.1 metre
    word   1-254 = 254 * I2, Height of corresponding stations
                   in 0.1m as listed in Record 1-2. 32767
                   implies H not available 255-256 = reserved

Record 10-12 : reserved

Record 13 onwards : 1-min data
    I2, 2 bytes integer 1-min data for all station-elements
        of the same time are grouped and arranged as in
        the Record 5-8.
    Number of records occupied by one 1-min data
        = INT{[(total number of station-element) + 255 ] / 256}
    The 1st 1-min data starts from Record 13,
    while the rest are appended after the first group of
    records and so on until the 1440th 1-min data group.
```

Table 10

Station name and their geographical location are given below:

```
Name   ::Lat     ::Lon     ::Anemometer Height::Long name

RO     ::22.304  ::114.172 ::73.8 ::Royal Observatory
CLK::22.318  ::114.940 ::65.2 ::Chek Lap Kok Island
CCH::22.201  ::114.027 ::98.5 ::Cheung Chau
CEN::22.286  ::114.159 ::17.4 ::Cetral(Star Ferry Pier)
CPH::22.350  ::114.107 ::136.0   ::Ching Pak House, Tsing Yi
CSW::22.334  ::114.151 ::29.6 ::Cheung Sha Wan (Whilesale Market)
EPC::22.548  ::114.426 ::39.3 ::Ping Chau(Police Post)
GI     ::22.287  ::114.11  ::105.0   ::Green Island
HIT::22.336  ::114.129 ::57.7 ::Hong Kong International Terminal
HKA::22.309  ::113.922 ::13.18   ::Chek Lap Kok Airport(AMOS)
HKO::22.304  ::114.172 ::73.8 ::Hong Kong Observatory
HKS::22.248  ::114.171 ::29.6 ::Wong Chuk Hang(Police Training School)
HMZ::21.822  ::113.957 ::77.0 ::Huang Mao Zhou
HUD::22.348  ::114.084 ::42.9 ::Hong Kong United Dockyards, Tsing Yi
JKB::22.318  ::114.254 ::51.6 ::Tseung Kwan O(Hean Of Hope Hospital)
KAT::22.536  ::114.302 ::9.6  ::Kat O(Agriculture And Fisheries Office)
KLT::22.337  ::114.182 ::105.5   ::Kowloon Tsai
KP     ::22.313  ::114.171 ::89.63   ::King's Park
KSM::22.343  ::114.054 ::65.4 ::Kap Shui Mun Bridge
LFS::22.471  ::113.981 ::49.7 ::Lau Fa Shan(Police Station)
MBL::22.343  ::114.108 ::17.7 ::Mobil Oil Depot, Tsing Yi
NLD::22.433  ::113.783 ::120.0   ::NeiLingDing
NLS::22.263  ::113.911 ::757.3   ::Nei Lak Shan
NP     ::22.294  ::114.200 ::26.1 ::North Point((West)Ferry Pier)
PLC::22.477  ::114.235 ::70.8 ::Tai Mei Tuk(Police Training Centre)
SAK::22.383  ::114.267 ::41   ::Sai Kung(Sung Tsun Secondary School)
SC     ::22.346  ::113.891 ::31.0 ::Sha Chau
SE     ::22.311  ::114.211 ::16.4 ::Kai Tak Runway Southeast End
SEK::22.434  ::114.085 ::26.42   ::Shek Kong
SF     ::22.294  ::114.166 ::17.6 ::Star Ferry(Tsim Sha Tsui)
SHA::22.405  ::114.207 ::16.0 ::Sha Tin(Race Course)
SHL::22.348  ::114.084 ::42.9 ::Shell Tsing Yi Installation
SHW::22.306  ::113.979 ::14.7 ::Siu Ho Wan
SKG::22.377  ::114.272 ::31.2 ::Sai Kung(Tui Min Hoi)
SL1::22.291  ::113.907 ::70.7 ::Sah Lo Wan
SLW::22.293  ::113.905 ::70.9 ::Sha Lo Wan
SW     ::22.269  ::113.887 ::12.8 ::Sham Wat
TAP::22.473  ::114.358 ::37.1 ::Tap Mun(Police Post)
TC     ::22.359  ::114.215 ::588.0   ::Tate's Cairn
TKL::22.531  ::114.154 ::27.6 ::Ta Kwu Ling(Ping Breeding Centre)
TMB::22.351  ::114.074 ::77.5 ::Tsing Ma Bridge
TMR::22.284  ::114.163 ::15.3 ::Tamar
TMS::22.411  ::114.125 ::968.6   ::Tai Mo Shan
TMT::22.330  ::113.967 ::14.9 ::Tai Mo To
TO     ::22.253  ::113.854 ::36.13   ::Tai O(Police Station)
TPO::22.446  ::114.179 ::14.6 ::Tai Po(Island House)
TUN::22.392  ::113.974 ::69.4 ::Tuen Mun(Government Offices)
TUO::22.470  ::114.616 ::108.0   ::TuoNing Liedao
TYW::22.403  ::114.323 ::22.7 ::Tsak Yue Wu
WCN::22.281  ::114.171 ::378.0   ::Central Plaza, Wan CHai
WGL::22.182  ::114.303 ::82.1 ::Wanglan Island
```

```
WL    ::22.183  ::114.301 ::74.8 ::Wanglan Island
WLD::22.102  ::114.025 ::43.0 ::WaiLingDing
YTS::22.259  ::113.964 ::752.2   ::Yi Tung Shan
YYC::22.334  ::114.170 ::64.0 ::Yau Yat Chuen
BHD::22.1975    ::114.2119   ::94.0    ::Bluff Head
NGP::22.2583    ::113.9128   ::603.0   ::Ngong Ping
PEN::22.2912    ::114.0434   ::33.6    ::Peng Chau
SSH::22.5014    ::114.1112   ::5.0     ::Sheung Shui
VP1::22.2660    ::114.1528   ::5.0     ::Victoria Peak
WB1::22.3047    ::113.8792   ::5.0     ::Experimental Weather Buoy 1
WB2::22.2911    ::113.8822   ::5.0     ::Experimental Weather Buoy 2
WB3::22.3197    ::113.9614   ::5.0     ::Experimental Weather Buoy 3
WB4::22.3271    ::113.9488   ::5.0     ::Experimental Weather Buoy 4
WB5::22.2942    ::113.8689   ::5.0     ::Experimental Weather Buoy 5
PKA::22.2481    ::113.9419   ::380.0   ::Pak Kung Au
R1C::22.3013    ::113.9174   ::5.0     ::Middle of South runway
R1E::22.3075    ::113.9294   ::5.0     ::Eastern end of South runway
R1W::22.2968    ::113.9034   ::5.0     ::Western end of South runway
R2C::22.3166    ::113.9119   ::3.7     ::Middle of north runway
R2E::22.3211    ::113.9260   ::5.2     ::Eastern end of North runway
R2W::22.3130    ::113.9009   ::4.7     ::Western end of North runway
SCB::22.288     ::113.937    ::5.0     ::Sea Channel Bridge
SW1::22.2764    ::113.8879   ::5.0     ::Sham Wat 1
TFA::22.2481    ::113.8953   ::356.0   ::Tai Fung Au
BPT::22.4081    ::113.9031   ::129.7   ::Black Point
ELN::22.3394    ::114.0461   ::192.8   ::East Lantau
SKC::22.1969    ::113.9833   ::5.0     ::Shek Kwu Chau
R01::22.3036    ::114.1719   ::5.0     ::HK Observatory
R11::22.2556    ::113.9069   ::5.0     ::Ngong Ping
R12::22.2931    ::114.0067   ::5.0     ::Discovery Bay
R13::22.2212    ::114.1169   ::5.0     ::Lamma Island
R14::22.2100    ::114.2556   ::5.0     ::Cape D'Aguilar
R17::22.2864    ::114.1102   ::88.0    ::Green Island
R18::22.3093    ::114.2843   ::5.0     ::Sai Kung
R19::22.2932    ::114.2112   ::5.0     ::Quarry Bay
R21::22.3788    ::113.9205   ::5.0     ::Tap Shek Kok
R22::22.4874    ::114.0092   ::5.0     ::Tsim Bei Tsui
R23::22.4471    ::114.1688   ::5.0     ::Tai Po
R24::22.5391    ::114.2084   ::5.0     ::Sha Tau Kok
R25::22.4145    ::114.3269   ::5.0     ::Pak Tam Au
R26::22.4371    ::114.0819   ::5.0     ::Shek Kong
R27::22.4202    ::113.9935   ::5.0     ::Yuen Long
R28::22.4509    ::114.0505   ::5.0     ::Au Tau
R29::22.5128    ::114.0776   ::5.0     ::Lok Ma Chau
R30::22.5381    ::114.2995   ::5.0     ::Kat O
R31::22.4800    ::114.2355   ::5.0     ::Tai Mei Tuk
R32::22.3540    ::114.3499   ::5.0     ::Leung Shuen Wan
QUB::22.2911    ::114.2133   ::5.0     ::Quarry Bay
SPW::22.2203    ::113.8944   ::5.0     ::Shek Pik
TBT::22.4872    ::114.0142   ::5.0     ::Tsim Bei Tsui
TMW::22.2697    ::114.2886   ::5.0     ::Tai Miu Wan
TPK::22.4425    ::114.1839   ::5.0     ::Tai Po Kau
```

Table 11

The following is the element list:

AWS Report Element Identifier for Transmission of AWS Report
from AWS Data Acquisition Servers to HKO Main Computer System
(Last amended on 2007-03-20)

Data Element	Identifier and Meaning	Unit
A	1-min scalar mean wind direction	1 deg
B	1-min scalar mean wind speed	0.1 m/s
C	1-min max wind speed (derived from 3-sec average)	0.1 m/s
D	10-min mean wind direction	1 deg
E	10-min mean wind speed	0.1 m/s
F	10-min maximum wind speed (derived from 3-sec avera	0.1 m/s
G	60-min prevailing wind direction	1 deg
H	60-min prevailing wind speed	0.1 m/s
I	60-min max wind speed (derived from 3-sec average)	0.1 m/s
J	1-min mean dry bulb temperature	0.1 deg
K	1-min mean wet bulb temperature	0.1 deg
L	Dew point from TT and TW	0.1 deg
M	Relative humidity from TT and TW	1 %
N	Maximum of TT since midnight (HKT)	0.1 deg
O	Minimum of TT since midnight (HKT)	0.1 deg
P	Time of maximum TT (nearest min)	1 min
Q	Time of minimum TT (nearest min)	1 min
R	1-min mean station level pressure	0.1 hPa
S	1-min mean MSL pressure	0.1 hPa
T	1-min total rainfall	0.1 mm
U	15-min total rainfall	0.1 mm
V	60-min total rainfall	0.1 mm
W	Total rainfall since midnight	0.1 mm
X	1-min mean tide level	1 cm
Y	1-min mean sea temperature	0.1 deg
Z	1-min Visibility	1 m
a	15-min maximum wind speed	0.1 m/s
b	2-min scalar mean wind direction	1 deg
c	Rate of rainfall	0.1 mm/Hr
d	Dry bulb temperature (2.0m above gd) for CBRN	0.1 deg
e	Dry bulb temperature (0.3m above gd) for CBRN	0.1 deg
f	Ambient temperature (inside a radiation shield) as	0.1 deg
g	Natural wet bulb temperature (exposed to sunlight)	0.1 deg
h	Black globe temperature as recorded by the WBGT ins	0.1 deg
i	WBGT (combined temperature from 0.7 x g + 0.2 x h +	0.1 deg
j	1-min mean dry bulb temperature(AUX)	0.1 deg
k	1-min mean wet bulb temperature(AUX)	0.1 deg
l	Dew point from TT and TW(AUX)	0.1 deg
m	Relative humidity from TT and TW(AUX)	1 %
n	1-min max wind speed (1 sec)	0.1 m/s
o	Mean wave period	0.1 sec
p	Std. Dev. Of wind dir over 10 min.	1 deg

q	Std. Dev. Of wind speed over 10 min.	0.1 m/s
r	1-min solar radiation	1 W/m/m
s	60-min solar radiation	1 W/m/m
t	Precipitation alarm status	
u	Fore 5-min total rainfall (Pearl River AWS)	0.1 mm
v	5-min rainfall	0.1 mm
w	1-min mean grass min temperature	0.1 deg
x	10-min mean visibility	1 m
y	Battery output voltage/special rf group	0.1 Volt
z	Cabinet/Soil temperature	0.1 deg
j	1-min Visibility	10 m
m	10-min mean visibility	10 m

a. 9999 - variable wind direction, 0000 - calm wind direction .
b. When pressure >= 1000 hPa, the thousandth digit will be deleted (i.e. 1015.5 hPa will be represented by 0155; 1000.0 hPa will show 0000).
c. Precipitation alarm status equals '0000' implies no precipitation.
d. If data not available, the four ASCII characters data will be "////".

Table 12

4.2 UPPER AIR file

```
$ cd /home/airports/hkg/OBS/20150707Z/upper-air
$ tree
.
|-- airep_1507070105.txt
|-- airep_1507070205.txt
:
:
|-- amdar_IUAC01VHHH_1507061940.buf
|-- amdar_IUAC01VHHH_1507070205.buf
:
:
|-- pilot_1507070012.txt
|-- pilot_1507070112.txt
:
:
|-- temp_1507071917.txt
`-- temp_1507072017.txt
```

Table 13

airep_* files contain air reports:

```
$ head airep_1507070105.txt
                 AIREP INFORMATION
  COMPILED BY THE HONG KONG METEOROLOGICAL OFFICE
              AT 070100 UTC Jul 2015

KAL734 2100N 14036E 1926 F380 MS46 044/28=
DAL598 38N 160E 1341 F370 MS48 280/65KT CODE 2 OCNL FBL TURB FR60.2=
KAL733 3000N 14021E 1403 F390 MS50 310/15=
```

Table 14

amdar_* files contain AMDAR data in WMO BUFR format.

temp*_ files and pilot_* files contain upper air sounding data in WMO TEMP and PILOT code form.

4.3 LIGHTNING files

```
$ cd /home/airports/hkg/OBS/20150707Z/remote-sensing/lightning
$ tree
.
|-- llis_201507070000
|-- llis_201507070001
:
:
|-- llis_201507072234
`-- llis_201507072341
```

Table 15

llis_* files contain data of lightning strike registered in the minute as indicated by the file name. The time stated in the file name is in HKT, whereas in the data it is in UTC.

```
$head llis_201507070001
0        2015    7        7        0        1        1        22328687
19.1833 114.0087          -4304         5         162.70   5.10     0.60
2.30    3.8     30.2    -0.0    0       1       0       1
0        2015    7        7        0        1        13       808166727
19.0850 114.7627          -5303         3         158.00   4.80     0.50
1.60    4.8     30.2    -0.0    0       1       0       1
0        2015    7        7        0        1        13       970605766
18.9765 114.8145          -7907         8         157.00   4.40     0.50
2.70    2.6     30.2    -0.0    0       1       0       1
0        2015    7        7        0        1        24       638738226
18.6052 116.2171          -1680         3         3        145.50   9.40
0.60    2.20    6.6     30.2    -0.0    0       1       0  1
0        2015    7        7        0        1        24       735645797
18.5816 116.2516          -7105         7         145.80   6.30     0.60
3.10    2.2     30.2    -0.0    0       1       0       1
0        2015    7        7        0        1        34       238363762
19.1467 114.7434          -5303         3         152.70   7.20     0.70
1.70    2.6     26.2    -0.0    0       1       0       1
0        2015    7        7        0        1        34       325798348
19.1231 114.7574          -5104         5         152.20   6.60     0.60
2.70    3.2     30.2    -0.0    0       1       0       1
0        2015    7        7        0        1        52       45898447
19.1352 114.2589          -3404         5         159.10   5.40     0.60
2.80    1.4     30.2    -0.0    0       1       0       1
```

Table 16

The lightning record follows the Universal ASCII Lightning Format (UALF) of Vaisala. Interpretation of the data columns is as follows:

Field v 0 (LF)	Description	Acceptable Values
1	Zero or a positive integer denoting the UALF version number. Whenever fields are added or changed in the UALF, the version number will be incremented, allowing a client application to determine if it is capable of reading the given UALF record.	0, 1
	Network type (LF = 0, VHF = 1)	0, 1
2	The year, including the century.	1970 to 2032
3	Month, January = 1 to December = 12	1 to 12
4	Day of the month	1 to 31
5	Hour of the day. UTC is default. Use the TZ environment variable to set time to the local time zone.	0 to 23
6	Minute	0 to 59
7	Second	0 to 59
8	Nanosecond	0 to 999999999
9	Latitude of the calculated location in decimal degrees, to 4 decimal places	-90.0000 to 90.0000
10	Longitude of the calculated location in decimal degrees, to 4 decimal places	-180.0000 to 180.0000
	Altitude in meters	-4950 to +60535
11	Estimated peak current in kiloamperes (kA)	-9999 to 9999
	VHF RNP in dBm (0 if network type = LF)	-9999.0 to 9999.0
12	Multiplicity for flash data. Stroke data = 0	0 to 99
13	Number of sensors participating in the solution	2 to 99
14	Degrees of freedom when optimizing location	0 to 99
15 [1]	Ellipse angle as a clockwise bearing from 0 degrees North	0 to 180.0
16 [1]	Length of semi-major axis of ellipse in kilometers (km)	0 to 60.0
17 [1]	Length of semi-minor axis of ellipse in kilometers (km)	0 to 50.0
18	Chi-square value from location optimization	0 to 999.99
19	Rise time of the waveform in microseconds	0 to 99.9
20	Peak-to-zero time of the waveform in microseconds	0 to 999.9
21	Maximum rate-of-rise of the waveform in kA/µsec	0 to 999.9
22	Cloud indicator. Cloud discharge = 1, Cloud-to-ground discharge = 0	0, 1
23	Angle indicator. Sensor angle data used to compute position. 1 = Yes, 0 = No	0, 1
24	Signal indicator. Sensor signal data used to compute position. 1 = Yes, 0 = No	0, 1
25	Timing indicator. Sensor timing data used to compute position. 1 = Yes, 0 = No	0, 1

Table 17 UALF record fields

4.4 RADAR files

```
$ cd /home/airports/hkg/OBS/20150707Z/remote-sensing/radar
$ tree
.
|-- tcr-amo4150515070704.RAW2589
|-- tcr-amo4150531150707.RAW7106
:
:
|-- tcr-amo4150707235504.RAW3868
`-- tcr-amo4150707235749.RAW3869
```

Table 18

tcr-amo4* files contain the radar volume scan. These are raw output of volume scans from the SIGMET IRIS software. To read the data values without installing SIGMET software, there are two alternatives: The Radar Software Library (RSL) developed by NASA TRMM Satellite Validation Office (http://trmm-fc.gsfc.nasa.gov/trmm_gv/software/rsl/); and the Python ART Radar Toolkit (PyART) developed by Atmospheric Radiation Measurement (ARM) Climate Research Facility (http://arm-doe.github.io/pyart). For the former, there also exists a python wrapper for easier data handing: (https://ams.confex.com/ams/91Annual/webprogram/Paper184197.html).

4.5 Wind Profiler files

```
$ cd /home/airports/hkg/OBS/20150715Z/remote-sensing/wind-
profiler
$ tree
.
|-- CLK50715.W1B
|-- shw50715.w1b
`-- shw50715.w3b
```

Table 19

xxx5${MMDD}_* files contain the wind profiler data. In extensions ‘w1b’ and ‘w3b’, ‘1’ stands for ‘Low mode’ and ‘3’ stands for ‘High mode’; while ‘b’ stands for ‘QC data’. The content of the wind data files should be self explanatory.

```
$ head - 40 CLK0715.W1B
CDF Type:  Wind            Program:        LapXM-CDF         Version:  1.1
HKO - Sha Lo Wan


Station:            Sha Lo Wan - Chek Lap Kok Airpt.
Date:               07/15/15            Julian Day:        196
Filename:           CLK50715.W1B        Validation Level:  0.5
Created by:         LAPQC.FOR  v3.0     Created on:        07/15/15  2351
Elev. (m msl):      0028                Elev. (ft msl):    00091
Lat (dec deg):      22.3       N        Long (dec deg):    113.9      E
```

```
UTMN (km):           432.1                UTME (km):          123.4
Time Zone:           HKT                  Diff. to UTC (hr): -08
Mode Number:         1                    Mode Title:         60 meter


Avg. Int. (min):     06                   Time Convention:    End
Pulse Len. (m):      0057                 Spacing (m):        0057
Max. Samples:        003 003 003          Req. Samples:       002 002 002
Ant. Azimuth (deg): 020 290 290           Ant. Elev. (deg):   074 074 090


QC Code Definition:     0=Valid,   1=Estimated,   7=Suspect,   8=Invalid
Data Code Definition: -940=Failed QC,   -950=Failed Consensus,
                      -960=Exceeded Nyquist Vel., -980=Flagged by Reviewer
                      -999=Missing or Not Reported




Time     # of Gates  Radar Parameter Changes
HHMM     NNN         9
QC    Height     WS      WD       u        v        w     No. in Cns       SNR (db)
Code (m agl) (m/s)   (deg)    (m/s)    (m/s)    (m/s)    N   W   V     N     W     V
0010      25         9
 0     116       3.9    156.   -1.62     3.60    -0.70    3   3   3    -6   -10    -7
 0     174       4.5    156.   -1.78     4.08    -0.70    3   3   3    -3    -6    -3
 0     231       3.4    157.   -1.35     3.16    -0.60    3   3   3    -4    -9    -4
 0     289       4.3    147.   -2.33     3.59    -0.70    3   3   3    -1    -3     1
```

Table 20

Here only selected fields (marked in red) which may not be very obvious are explained below:

'Failed Consensus' – can be treated as invalid data
'HHMM' – HH: local time in hour, MM: local time in minutes
'WS' – wind speed; 'WD' – wind direction; 'u v w' – vector components of winds
'No. in Cns' – No. of consensus profiler beams;
'N W V' – north, west and vertical beams respectively

4.6 ATNS files

```
$ cd /home/airports/hkg/NOWCAST/20150526Z/atns

$ tree
.
|-- 201505260000.tar.gz
|-- 201505260006.tar.gz
|-- 201505260012.tar.gz
|-- 201505260018.tar.gz
|-- 201505260024.tar.gz
|-- 201505260030.tar.gz
|-- 201505260036.tar.gz
|-- 201505260042.tar.gz
|-- 201505260048.tar.gz
:
:
:

$
```

Table 21

Note that these *tar.gz files are labelled by local time (HKT).

```
$ tar tvfz 201505260000.tar.gz
drwxr-xr-x atns/atns         0 2015-05-26 00:07 201505260000/
drwxr-xr-x atns/atns         0 2015-05-26 00:07 201505260000/forecast/
-rw-r--r-- atns/atns     31221 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_256ref.png
-rw-r--r-- atns/atns     28880 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_128ref.png
-rw-r--r-- atns/atns     14213 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_128vil.png
-rw-r--r-- atns/atns     31463 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_256ref.png
-rw-r--r-- atns/atns     32903 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_128top.png
-rw-r--r-- atns/atns     50073 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_128max.png
-rw-r--r-- atns/atns     14625 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_256vil.png
-rw-r--r-- atns/atns     15444 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_256vil.png
-rw-r--r-- atns/atns     29013 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_256top.png
-rw-r--r-- atns/atns     48831 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_128max.png
-rw-r--r-- atns/atns     14072 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_128vil.png
-rw-r--r-- atns/atns     28687 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_128top.png
-rw-r--r-- atns/atns     31511 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_256ref.png
-rw-r--r-- atns/atns     15166 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_256vil.png
-rw-r--r-- atns/atns     42786 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_128top.png
-rw-r--r-- atns/atns     11490 2015-05-26 00:07 201505260000/forecast/COM201505260000_trec_v_256.png
-rw-r--r-- atns/atns     35140 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_256top.png
-rw-r--r-- atns/atns     14712 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_256vil.png
-rw-r--r-- atns/atns     13642 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_128vil.png
-rw-r--r-- atns/atns     32661 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_256top.png
-rw-r--r-- atns/atns     45131 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_256max.png
-rw-r--r-- atns/atns     33720 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_256top.png
-rw-r--r-- atns/atns     44271 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_256max.png
-rw-r--r-- atns/atns     52803 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_128max.png
-rw-r--r-- atns/atns     28172 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_128ref.png
-rw-r--r-- atns/atns     30921 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_256ref.png
-rw-r--r-- atns/atns     31368 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_256ref.png
-rw-r--r-- atns/atns     34125 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_128top.png
-rw-r--r-- atns/atns     30704 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_256ref.png
-rw-r--r-- atns/atns     30064 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_128top.png
-rw-r--r-- atns/atns     51814 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_128max.png
-rw-r--r-- atns/atns     29601 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_256top.png
-rw-r--r-- atns/atns     14899 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_256vil.png
-rw-r--r-- atns/atns     46733 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_256max.png
-rw-r--r-- atns/atns     50827 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_128max.png
-rw-r--r-- atns/atns     36020 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_128top.png
```

```
-rw-r--r-- atns/atns     14594 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_256vil.png
-rw-r--r-- atns/atns     37083 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_256top.png
-rw-r--r-- atns/atns     12418 2015-05-26 00:07 201505260000/forecast/COM201505260000_trec_u_256.png
-rw-r--r-- atns/atns     13618 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_128vil.png
-rw-r--r-- atns/atns     31853 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_128top.png
-rw-r--r-- atns/atns     28540 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_128ref.png
-rw-r--r-- atns/atns     14495 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_128vil.png
-rw-r--r-- atns/atns     33496 2015-05-26 00:07 201505260000/forecast/COM201505260000_polygon_128_act.txt
-rw-r--r-- atns/atns     14937 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_256vil.png
-rw-r--r-- atns/atns     30823 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_256ref.png
-rw-r--r-- atns/atns     13788 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_128vil.png
-rw-r--r-- atns/atns     31223 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_256ref.png
-rw-r--r-- atns/atns     20710 2015-05-26 00:07 201505260000/forecast/COM201505260000_polygon_128.txt
-rw-r--r-- atns/atns     14683 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_256vil.png
-rw-r--r-- atns/atns     27863 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_128ref.png
-rw-r--r-- atns/atns     30908 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_128top.png
-rw-r--r-- atns/atns     31060 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_256ref.png
-rw-r--r-- atns/atns     46139 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_256max.png
-rw-r--r-- atns/atns     43812 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_256max.png
-rw-r--r-- atns/atns     57110 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_128max.png
-rw-r--r-- atns/atns     43375 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_256max.png
-rw-r--r-- atns/atns     14699 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_256vil.png
-rw-r--r-- atns/atns     43064 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_256max.png
-rw-r--r-- atns/atns     45737 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_256max.png
-rw-r--r-- atns/atns     55422 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_128max.png
-rw-r--r-- atns/atns     14953 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_128vil.png
-rw-r--r-- atns/atns     30385 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260018f_128ref.png
-rw-r--r-- atns/atns     29750 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_128ref.png
-rw-r--r-- atns/atns     30559 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_256ref.png
-rw-r--r-- atns/atns     31520 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_128ref.png
-rw-r--r-- atns/atns     42759 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_256max.png
-rw-r--r-- atns/atns     68011 2015-05-26 00:07 201505260000/forecast/COM201505260000_polygon_256_act.txt
-rw-r--r-- atns/atns     38720 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_128top.png
-rw-r--r-- atns/atns     30927 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_256top.png
-rw-r--r-- atns/atns     59479 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_128max.png
-rw-r--r-- atns/atns     16288 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_128vil.png
-rw-r--r-- atns/atns     31043 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_128ref.png
-rw-r--r-- atns/atns     15569 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260012f_128vil.png
-rw-r--r-- atns/atns     44681 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_256max.png
-rw-r--r-- atns/atns     59959 2015-05-26 00:07 201505260000/forecast/COM201505260000_polygon_256.txt
-rw-r--r-- atns/atns     29193 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260030f_128ref.png
-rw-r--r-- atns/atns     39647 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260006f_256top.png
-rw-r--r-- atns/atns     49603 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_128max.png
-rw-r--r-- atns/atns     31697 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260036f_256top.png
-rw-r--r-- atns/atns     29281 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_128top.png
-rw-r--r-- atns/atns     53974 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260024f_128max.png
-rw-r--r-- atns/atns     30230 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260048f_256top.png
-rw-r--r-- atns/atns     27570 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260100f_128ref.png
-rw-r--r-- atns/atns     14810 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260054f_256vil.png
-rw-r--r-- atns/atns     13988 2015-05-26 00:07 201505260000/forecast/COM201505260000_201505260042f_128vil.png
-rw-r--r-- atns/atns    340863 2015-05-26 00:07 201505260000/COM201505260000_256.txt
-rw-r--r-- atns/atns     35067 2015-05-26 00:07 201505260000/201505260000.256.actout
drwxr-xr-x atns/atns         0 2015-05-26 00:07 201505260000/actual/
-rw-r--r-- atns/atns     22541 2015-05-26 00:07 201505260000/actual/COM201505260000_128vil.png
-rw-r--r-- atns/atns     51812 2015-05-26 00:07 201505260000/actual/COM201505260000_128ref.png
-rw-r--r-- atns/atns     36730 2015-05-26 00:07 201505260000/actual/COM201505260000_256ref.png
-rw-r--r-- atns/atns     44443 2015-05-26 00:07 201505260000/actual/COM201505260000_256max.png
-rw-r--r-- atns/atns     43834 2015-05-26 00:07 201505260000/actual/COM201505260000_256top.png
-rw-r--r-- atns/atns     70244 2015-05-26 00:07 201505260000/actual/COM201505260000_128max.png
-rw-r--r-- atns/atns     16049 2015-05-26 00:07 201505260000/actual/COM201505260000_256vil.png
-rw-r--r-- atns/atns     66543 2015-05-26 00:07 201505260000/actual/COM201505260000_128top.png
-rw-r--r-- atns/atns    309890 2015-05-26 00:07 201505260000/COM201505260000_128.txt
-rw-r--r-- atns/atns     27832 2015-05-26 00:07 201505260000/201505260000.128.out
-rw-r--r-- atns/atns     33610 2015-05-26 00:07 201505260000/201505260000.256.out
-rw-r--r-- atns/atns     31086 2015-05-26 00:07 201505260000/201505260000.128.actout
```

Table 22

Within each archive file, there is a “forecast” and an “actual” folder, holding respectively the actual radar parameters (REF, TOP, VIL, MAX) and forecast parameters in 6 minutes intervals up to 60 minutes ahead.

Each of the data field is stored as a grey scale 8-bit “PNG” file. No matter the radar range (128km or 256km), the size of the PNG is 480x480 pixels. The layout of the PNG is exactly same as the radar CAPPI data section from the IRIS workstation at HKO. To facilitate processing,

corresponding latitude-longitude information for all pixels in the PNG are listed out in metafiles as "480x480_128_LL" and "480x480_256_LL". These two files can found under the "METADATA" folder.

Interpretation of the data values varies with the radar data type. One should refer to the equations below when converting the gray-scale value to actual radar parameters:

REF (in dBZ) Reflectivity factor at 3KM CAPPI	Grey level = 0 or 255:	0
	Grey level between 1 and 254:	(grey level – 64.0) / 2.0
TOP (in km) Echo TOP of 10dBZ	Grey level <=10 or >=254:	-9999
	Grey level between 11 and 253:	(grey level – 1.0) / 10.
VIL (in mm) Vertical Integrated Liquid	Grey level = 0 or 255:	0
	Grey level between 1 and 254:	(grey level -1) / 4.0
MAX (in dBZ) Column maximum reflectivity	same as REF	

Table 23

4.7 MSQ files

```
$ cd /chroot/avrdp/home/airports/hkg/NOWCAST/20150715Z/msq
$ ls
201507150000  201507150300  201507150600  201507150900  201507151200  201507151506  201507151806  201507152124
201507150006  201507150306  201507150606  201507150906  201507151206  201507151512  201507151812  201507152130
201507150012  201507150312  201507150612  201507150912  201507151212  201507151518  201507151824  201507152136
201507150018  201507150318  201507150618  201507150918  201507151218  201507151524  201507151830  201507152142
201507150024  201507150324  201507150624  201507150924  201507151224  201507151530  201507151848  201507152148
201507150030  201507150330  201507150630  201507150930  201507151230  201507151536  201507151854  201507152154
201507150036  201507150336  201507150636  201507150936  201507151236  201507151542  201507151900  201507152200
201507150042  201507150342  201507150642  201507150942  201507151242  201507151548  201507151906  201507152206
201507150048  201507150348  201507150648  201507150948  201507151254  201507151554  201507151912  201507152212
201507150054  201507150354  201507150654  201507150954  201507151300  201507151600  201507151918  201507152218
201507150100  201507150400  201507150700  201507151000  201507151306  201507151606  201507151924  201507152224
201507150106  201507150406  201507150706  201507151006  201507151312  201507151612  201507151930  201507152230
201507150112  201507150412  201507150712  201507151012  201507151318  201507151618  201507151936  201507152236
201507150118  201507150418  201507150718  201507151018  201507151324  201507151624  201507151942  201507152242
201507150124  201507150424  201507150724  201507151024  201507151330  201507151630  201507151948  201507152248
201507150130  201507150430  201507150730  201507151030  201507151336  201507151636  201507151954  201507152254
201507150136  201507150436  201507150736  201507151036  201507151342  201507151642  201507152000  201507152300
201507150142  201507150442  201507150742  201507151042  201507151348  201507151648  201507152006  201507152306
201507150148  201507150448  201507150748  201507151048  201507151354  201507151654  201507152012  201507152312
201507150154  201507150454  201507150754  201507151054  201507151400  201507151700  201507152018  201507152318
201507150200  201507150500  201507150800  201507151100  201507151406  201507151706  201507152024  201507152324
201507150206  201507150506  201507150806  201507151106  201507151412  201507151712  201507152030  201507152330
201507150212  201507150512  201507150812  201507151112  201507151418  201507151718  201507152036  201507152336
201507150218  201507150518  201507150818  201507151118  201507151424  201507151724  201507152042  201507152342
201507150224  201507150524  201507150824  201507151124  201507151430  201507151730  201507152048  201507152348
201507150230  201507150530  201507150830  201507151130  201507151436  201507151736  201507152054  201507152354
201507150236  201507150536  201507150836  201507151136  201507151442  201507151742  201507152100
201507150242  201507150542  201507150842  201507151142  201507151448  201507151748  201507152106
201507150248  201507150548  201507150848  201507151148  201507151454  201507151754  201507152112
201507150254  201507150554  201507150854  201507151154  201507151500  201507151800  201507152118
```

```
$ cd 201507150300
[avrdp@ftp 201507150300] $ tree
.
|-- 201507150306.radar.zip
|-- 201507150312.radar.zip
|-- 201507150318.radar.zip
|-- 201507150324.radar.zip
|-- 201507150330.radar.zip
|-- 201507150336.radar.zip
|-- 201507150342.radar.zip
|-- 201507150348.radar.zip
|-- 201507150354.radar.zip
|-- 201507150400.radar.zip
|-- 201507150406.radar.zip
|-- 201507150412.radar.zip
|-- 201507150418.radar.zip
|-- 201507150424.radar.zip
|-- 201507150430.radar.zip
|-- 201507150436.radar.zip
|-- 201507150442.radar.zip
|-- 201507150448.radar.zip
|-- 201507150454.radar.zip
|-- 201507150500.radar.zip
|-- 201507150506.radar.zip
|-- 201507150512.radar.zip
|-- 201507150518.radar.zip
|-- 201507150524.radar.zip
:
:
```

Table 24

*Note that the MSQ files are also labelled by local Hong Kong Time (UTC+8).

Under each daily folder, there should be 240 sub-directories, each corresponding to nowcasting model run at 6 minutes interval. The forecast output files are also in 6 minutes interval, up to 9 hours ahead. Therefore, there are totally 90 files produced by every run. The format of the forecast output is simply text-based flat files containing radar reflectivity factor, and rainfall amount on a 960x960 grid. Latitude-longitude information of each grid point is described by the metafile "MSQ_960x960_LL" in the "METADATA" folder.

```
$ zcat 201505150430.radar.zip
RADAR DATA 201505170848.radar
201505150430
ref3
240
960
CAPPI
    0.00    0.00
    0.00    0.00
    0.00    0.00
:
:
```

Table 25

4.8 NHM files

```
$ cd /home/airports/hkg/NWP/20150820Z/rapids-nhm
$ tree
.
```

```
|-- 20150820000000.RAPIDS-NHM_2015082000_00_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_01_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_02_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_03_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_04_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_05_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_06_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_07_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_08_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_09_CAAC.grb
|-- 20150820000000.RAPIDS-NHM_2015082000_10_CAAC.grb
:
:
```

Table 26

The files are in WMO GRIB-1 format and should be fairly easy to process.

4.9 RAPIDS files

```
$ cd /home/airports/BLEND/rapids/20150515/201505150248
$ tree
.
|-- SWIRLS_RA.201505150248.dat.gz
|-- nhmrf1_adj.201505150248.tgz
|-- nhmrf1_dsl.201505150248.tgz
|-- rapids_rf1.201505150248.tgz
`-- swirls_sl_rf.201505150248.tgz
```

Table 27

The above compress files are:

SWIRS_RA.*.dat.gz: QPE from nowcasting system SWIRLS
nhmrf1_adj.*.tgz: NWP forecast rainfall after intensity calibration and phase correction
nhmrf1_dsl.*.tgz: NWP rainfall forecast from direct model output
swirls_sl_rf.*.tgz: nowcasting system rainfall forecast
rapids_rf1.*.tgz: blended rainfall forecast

Each tgz file contains the hourly rainfall forecast for the next 6 hours:

```
$ tar tvfz rapids_rf1.201505150248.tgz
-rw-r--r-- rapids/wnc  1916707 2015-05-15 03:01 RAPIDS_RF1.201505150248_01.dat
-rw-r--r-- rapids/wnc  1916707 2015-05-15 03:01 RAPIDS_RF1.201505150248_02.dat
-rw-r--r-- rapids/wnc  1916707 2015-05-15 03:01 RAPIDS_RF1.201505150248_03.dat
-rw-r--r-- rapids/wnc  1916707 2015-05-15 03:01 RAPIDS_RF1.201505150248_04.dat
-rw-r--r-- rapids/wnc  1916707 2015-05-15 03:01 RAPIDS_RF1.201505150248_05.dat
-rw-r--r-- rapids/wnc  1916707 2015-05-15 03:01 RAPIDS_RF1.201505150248_06.dat
```

Table 28

Layout of the ".dat" is simply a row of rainfall amount (mm/hr). The latitude-longitude information of each row is listed in file "rapids-out.LL" in the "METADATA" folder.

4.10 SIGCONV files

```
$ cd /home/airports/hkg/ATM/SigConvForecast
$ tree
.
|-- emaillog.Aug2015
|-- emaillog.Jul2015
|-- emaillog.Jun2015
|-- emaillog.May2015
`-- emaillog.Sep2015
```

Table 29

The SIGCONV forecasts are recorded in monthly log files in plain text. The records are separated by a header line starts with "## Issued at: yyyymmddhhmm UTC". Each record contains hourly significant convection forecast for key areas up to 6 hours ahead and 3-hourly significant convection forecast for key areas up to 12 hours ahead. Forecast values indicate the level of severity (G: Green, Y: Yellow/Amber, R: Red) of convection affecting the respective area. In the operational environment, the forecasts are updated every 12 minutes. However, the log file only registers a new forecast when its content is different than the one previously issued.

```
$ cat emaillog.May2015
===Sent to  xxxx@hko.gov.hk  at:2015050205:5803
===Sent to  xxxx@cad.gov.hk  at:2015050205:5804
===Sent to  xxxx@cad.gov.hk  at:2015050205:5806
## Issued at: 201505012157 UTC
6hr TS/CB forecast:
#forecast_start_time_in_UTC=201505012200
#hourly intervals
20NM G G G G G G
ABBEY G G G G G G
CANTO Y Y Y G G G
BETTY Y Y Y G G G

12hr Significant Convection Forecast Time Series:
#forecast_start_time_in_UTC=2015050121
#3-hourly intervals
ABBEY=GGGG
CANTO=YYGG
GAMBA=GGGG
BETTY=YYGG
HOCKY-DOVAR=GGGG
FISHA=GGGG
:
```

Table 30

4.11 Airport capacity notification

```
$ cd /home/airports/hkg/ATM/CapacityNotification
$ tree
.
|-- emaillog.Aug2015
|-- emaillog.Jul2015
|-- emaillog.Jun2015
|-- emaillog.May2015
`-- emaillog.Sep2015
```

Table 31

Capacity notifications were issued by ATM unit and were recorded in monthly log files. The messages all follow a template and the contents are human readable plain text with relatively loose syntax. Every record is separated by header lines, starts with “CAPACITY RELATED INFORMATION VHHH (FOR ARRIVALS)” and ends with “Prepared at: xxxxUTC dd MMM YYYY”.

```
$ head -40 emaillog.May2015
#Total: 378
```

```
#=======================================
CAPACITY RELATED INFORMATION VHHH (FOR ARRIVALS)

VALID: 010000 to 010800 UTC

CAPACITY LEVEL: 1

AIRPORT ACCEPTANCE RATE: 32 flights per hour

EXPECTED DELAY: Up to 15 mins

REASON: -

REMARK: Expect up to 20 mins delay from 0400 UTC


Prepared at: 2208UTC 30 Apr 2015
#---------------------------------------
#Total: 379
#=======================================
CAPACITY RELATED INFORMATION VHHH (FOR ARRIVALS)

VALID: 010800 to 011600 UTC

CAPACITY LEVEL: 1

AIRPORT ACCEPTANCE RATE: 31 flights per hour

EXPECTED DELAY: Up to 15 mins

REASON: -

REMARK: Isolated CB over HKIA, expect holding up to 25 min bewteen
0800-1200


Prepared at: 0524UTC 01 May 2015
#---------------------------------------
#Total: 379
```

4.12 Air Traffic files

```
$ cd /home/airports/hkg/ATM/HourlyTraffic
$ tree
.
|-- arr-201505.txt
|-- arr-201506.txt
|-- arr-201507.txt
|-- arr-201508.txt
```

```
`-- arr-201509.txt
```

Table 32

The monthly files contain the hourly actual arrival rate at HKIA. Times shown are in HKT.

```
$ cat arr-201505.txt
2015050100 23
2015050101 15
2015050102 3
2015050103 2
2015050104 6
2015050105 12
2015050106 22
2015050107 15
2015050108 14
2015050109 23
:
:
```

Table 33

5 References

[1] Li, P. W., 2009: Development of a thunderstorm nowcasting system for Hong Kong international airport. First AMS Aviation, Range, Aerospace Meteorology Special Symposium on Weather-Air Traffic Management Integration, Phoenix, Arizona, p16. [Available online at https://ams.confex.com/ams/89annual/techprogram/paper- 146911.htm]

[2] Li, P. W., and E. S. T. Lai, 2004a: Applications of radar-based nowcasting techniques for mesoscale weather forecasting in Hong Kong. Meteor. Applications, 11, 253-264.
Li, P. W., and E. S. T. Lai, 2004b: Short-range quantitative precipitation forecasting in Hong Kong. J. Hydrology., 288, 189-209.

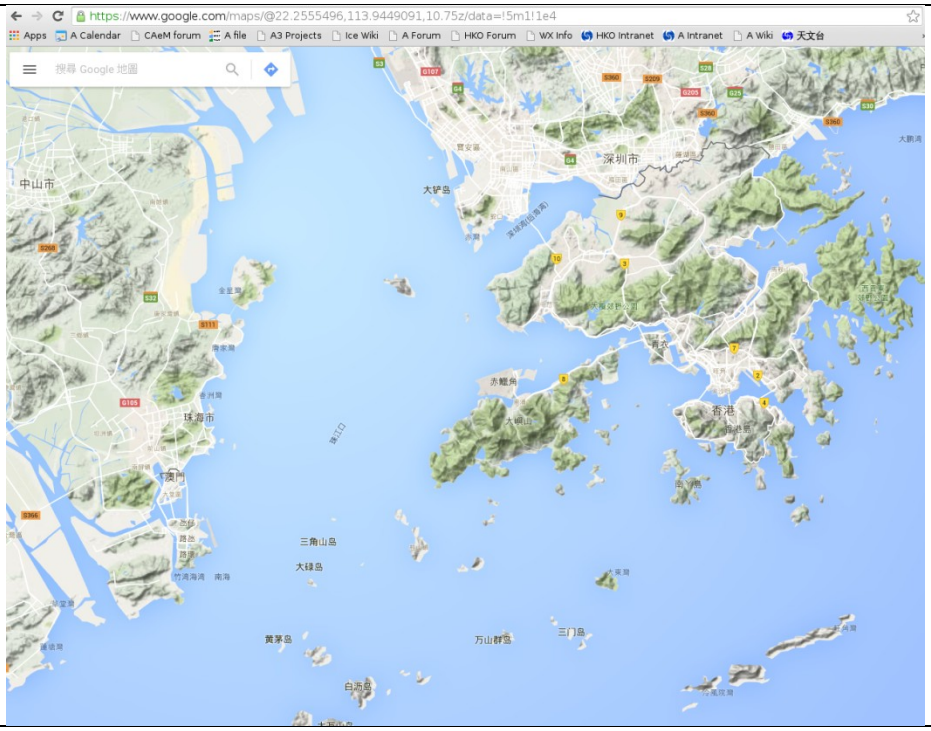
[3] Yeung, H. Y., C. W. Ng, Development of Radar-Satellite Blended QPE Technique and Application to Rainfall Nowcasting, 27th Guangdong-Hong Kong-Macao Seminar on Meteorological Science and Technology, Shaoguan, Guangdong, 9-10 January 2013. [Available online at http://www.hko.gov.hk/publica/reprint/r1058.pdf]

[4] Wong, W. K., 2011: Development of operational rapid update non-hydrostatic NWP model and data assimilation system in the Hong Kong Observatory. Technical Reports of the Meteorological Research Institute No. 65: International Research for Prevention and Mitigation of Meteorological Disasters in Southeast Asia, 87-100.

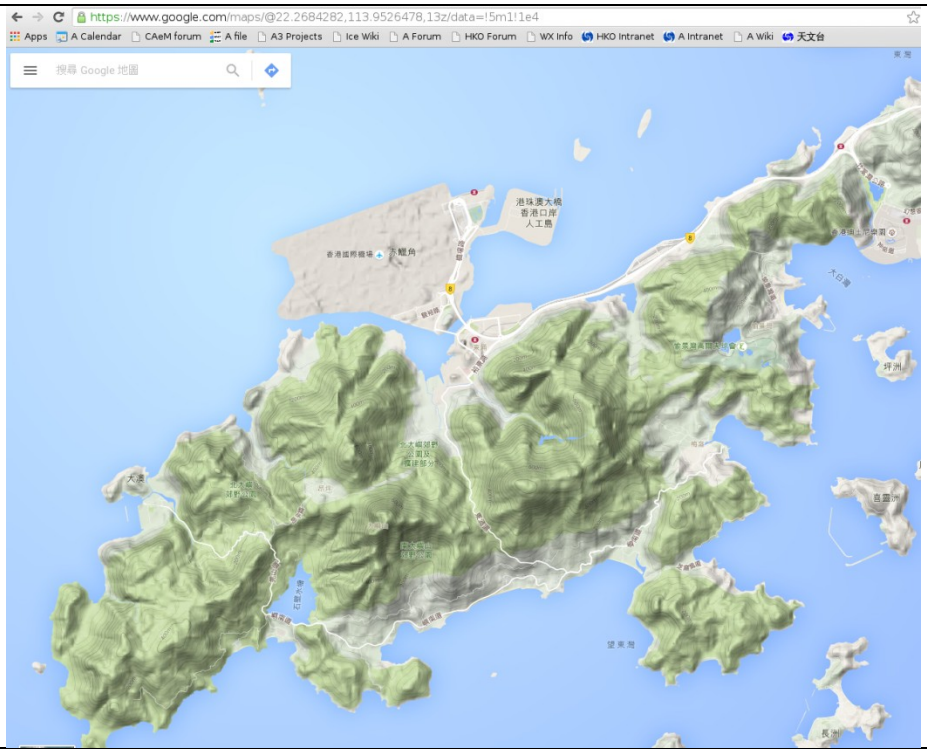
[5] Li, P. W., W. K. Wong, and E. S. T. Lai, 2005: RAPIDS - A new rainstorm nowcasting system in Hong Kong. WMO/WWRP International Symposium on Nowcasting and Very-short-range Forecasting, 5-9 September 2005 Toulouse, France. [Available online at http://www.meteo.fr/cic/wsn05/]
Yeung, H. Y., Y. C. Wang et al., 2009: Towards the blending of NWP with nowcast-operation experience in B08FDP. 2nd WMO International Symposium on Nowcasting and Very-Shat-rangt Foreccsting, 30 August-4 September 2009, Whistler, Canada.

[6] Cheung, P., C. C. Lam, Development of Significant Convection Forecast Product and Service for Air Traffic Flow Management in Hong Kong, The Second Aviation, Range and Aerospace Meteorology Special Symposium on Weather-Air Traffic Management Integration, 23-27 January 2011 in Seattle, WA. [Available online at https://ams.confex.com/ams/91Annual/webprogram/Paper183127.html]

Appendix A
Map of HKG



Map of HKG and surrounding area with terrain



Zoom-in map of HKG and surrounding area with terrain and height

Appendix B
HKG Climatology

Mean Number of Days with Specified Weather Phenomenon
at the Hong Kong International Airport
January 1998 - December 2014

Month	Mist	Haze	Fog	Drizzle	Rain	Shower	Lightning	Thunderstorm
Jan	8.2	11.3	0.7	1.7	8.2	0.2		0.1
Feb	10.1	8.2	1.2	1.5	11.4	0.5	0.1	0.3
Mar	11.6	5.5	1.3	2.2	13.2	1.9	0.2	1.1
Apr	9.0	4.5	0.4	1.1	12.6	7.8	0.5	2.9
May	3.3	1.9	0.1	0.3	6.2	16.2	2.9	6.1
Jun	1.2	1.1			2.2	22.5	4.1	8.1
Jul	0.6	1.3	0.1		1.0	20.6	3.6	7.4
Aug	1.8	3.6			0.4	18.9	4.8	8.8
Sep	1.2	4.3			2.2	14.1	2.5	4.1
Oct	0.5	6.0		0.1	6.8	3.5	0.5	0.5
Nov	2.8	5.9	0.1	0.6	8.9	0.8	0.1	0.1
Dec	3.6	10.6	0.2	0.9	7.8	0.1	0.1	0.1
Annual	53.8	64.3	4.2	8.5	81.0	107.2	19.4	39.5

Monthly Means of the Meteorological Elements at the Hong Kong International Airport
January 1998 - December 2014

Month	Atmospheric Pressure (MSL)	Absolute Maximum Temp *	Mean Maximum Temp *	Mean Temp	Mean Minimum Temp *	Absolute Minimum Temp *	Diurnal Range in Temp	Dew Point	Wet Bulb	Amount of Cloud	Relative Humidity
	hPa	℃	℃	℃	℃	℃	℃	℃	℃	%	%
Jan	1020.1	27.2	19.4	16.3	13.7	4.8	5.7	9.6	12.7	59	67
Feb	1018.1	29.6	20.9	17.8	15.3	6.0	5.6	12.6	14.8	67	73
Mar	1015.7	31.4	23.5	20.2	17.7	7.7	5.7	15.2	17.1	71	74
Apr	1012.5	33.5	27.2	24.0	21.6	12.2	5.7	19.2	20.8	74	76
May	1008.8	34.6	30.3	27.2	24.7	17.5	5.6	22.2	23.7	73	75
Jun	1005.6	36.6	32.0	29.0	26.6	20.4	5.4	24.2	25.5	76	76
Jul	1005.3	37.1	33.0	29.8	27.2	23.6	5.8	24.6	25.9	69	74
Aug	1005.3	36.9	32.9	29.6	26.9	23.5	6.0	24.5	25.8	68	75
Sep	1008.5	36.0	32.0	28.7	26.2	20.2	5.8	22.7	24.4	61	71
Oct	1013.9	34.2	29.8	26.5	24.1	15.9	5.7	19.0	21.4	51	65
Nov	1017.1	33.4	25.8	22.5	19.9	8.8	5.9	15.0	17.9	54	65
Dec	1020.1	29.6	21.2	18.0	15.2	4.8	6.0	9.7	13.5	52	61
Year	1012.6	37.1	27.3	24.1	21.6	4.8	5.7	18.2	20.3	65	71

* The maximum and minimum temperatures are taken between 0001 HKT (1601 UTC) and 2400 HKT (1600 UTC)