Community weather observations: development, applications and benefits

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Abstract

Active participation in weather observation is an effective way to learn more about weather and climate. In order to promote weather observations at the community level, the Hong Kong Observatory, in partnership with the Department of Applied Physics of the Hong Kong Polytechnic University, launched the Community Weather Information Network (Co-WIN) in August 2007. Participating schools and community organizations operate their own automatic weather stations (AWS), and the collected weather data are displayed and shared in real-time on the Co-WIN website (http://weather.ap.polyu.edu.hk/). To further encourage members of the public to carry out weather observations anywhere and anytime, Co-WIN introduced the Community Weather Observing Scheme (CWOS) in November 2011. CWOS offers three online platforms, including website (http://co-win.org), social media page (http://www.facebook.com/icwos) and smartphone app (https://itunes.apple.com/us/app/icweatheros/id634234742?ls=1&mt=8) for participants to upload and share with others their weather observation reports, photos of weather phenomena and impacts of severe weather. As of May 2014, data from more than 90 AWS under Co-WIN have been available, while more than 6,000 weather observation reports and photos have been collected via CWOS online platforms.

This paper describes the recent development of Co-WIN and CWOS as well as the benefits they have brought in educating the public on general weather and climate with a view to raising public awareness towards weather-related hazards and climate change. Other potential applications such as using Co-WIN AWS data for urban climate studies will also be discussed.

1. Background

Weather and climate education, in particular with a view to raising the public awareness towards hazards of extreme weather and climate change, is always an important area of work of the Hong Kong Observatory (HKO). The way in which HKO promotes weather and climate education has been evolving over the years following trends in the application of technology in public communication. Examples include the development of online and multimedia educational resources in the past decade or so and the adoption of new media (e.g. Youtube channel) in recent years. Moreover, more educational activities involving elements of active public participation have been organized as learning through first-hand experience is likely more effective than the traditional uni-directional modes of delivering bookish content.

The Community Weather Information Network (Co-WIN) and its initiative, the Community Weather Observing Scheme (CWOS), which are organized by HKO in partnership with the Department of Applied Physics of the Hong Kong Polytechnic University (PolyU), well demonstrate how weather education can be promoted by engaging the public to actively take part in weather observation activities and taking advantage of various popular online platforms.

2. Community Weather Information Network (Co-WIN)

Launched in August 2007, Co-WIN (Lee *et al.*, 2012; Tam and Ong, 2012) encourages schools and community groups to install, operate and maintain automatic weather stations (AWS) at their own premises, with professional advice and assistance provided by HKO and PolyU staff. Typical weather elements measured by such AWS include air temperature, humidity, wind direction, wind speed, air pressure and rainfall, while some Co-WIN members operate more advanced AWS which also measure global solar radiation and ultraviolet radiation. Real-time data from Co-WIN

AWS are transmitted to a central server at PolyU once every minute over the Internet, and are displayed on the Co-WIN website (http://weather.ap.polyu.edu.hk/) after a basic automatic quality assurance check. It is the objective of Co-WIN that members of the community groups, especially school students, could learn more about weather and climate through their efforts in operating and maintaining their own AWS and analyzing the collected data.

As of May 2014, Co-WIN has around 140 members, most of which are primary and secondary schools, but also include other organizations such as an elderly day care centre and the Scout Association of Hong Kong. Data from over 90 Co-WIN AWS are available on the web (Figure 1). In 2011, Co-WIN achieved a major milestone when it expanded beyond Hong Kong with the support of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) / World Meteorological Organization (WMO) Typhoon Committee, as an effort to promote weather-related disaster prevention and mitigation in the Asia Pacific region. Two community AWS have been installed at schools in the Philippines and Guam respectively.

3. Community Weather Observing Scheme (CWOS)

In order to further engage members of the public from all ages and backgrounds to take part in weather observation activities, Co-WIN introduced the Community Weather Observing Scheme (CWOS; Ho *et al.*, 2013) in November 2011. CWOS has since progressively launched three online platforms for participants to upload and share their weather observations, photos or even videos. While CWOS shares the same goal with Co-WIN in promoting weather education through encouraging the public to carry out weather observations, it complements Co-WIN in that CWOS does not require participants to install an AWS. They can take part by simply making manual weather observations or taking weather photos or videos, which can easily be done given the increasing popularity of smartphones. This allows CWOS to reach an even wider community.

The first online platform of CWOS is an Internet website (http://co-win.org) on which users can submit their observations (including measurements of various weather elements and a short text log) and photos via an online form (Figure 2). The submitted weather photos are then displayed on a GIS map (Figure 3). In July 2012, in view of the increasing popularity of social networking media and their capability to spread information rapidly through users' connections, CWOS set up a Facebook page as its second platform (http://www.facebook.com/icwos). The page invites Facebook users to upload their weather photos, videos and weather observations and to share them with friends on the social network and other users visiting the page (Figure 4). Recently, to provide a convenient tool for members of the public to carry out weather observations anywhere and anytime, HKO launched a smartphone app 'iCWeatherOS' (https://itunes.apple.com/us/app/icweatheros/id634234742?ls=1&mt=8) for iPhone and iPad in August 2013. This app is a one-stop platform for users to take weather photos, prepare their observation reports, upload them to the CWOS Facebook page and view submissions by fellow users (Figure 5). Furthermore, 'iCWeatherOS' features some educational materials on weather observations and phenomena.

As of May 2014, more than 6,000 weather observation reports and photos have been collected via the above three CWOS online platforms. In addition, a 'Weather Observation and Weather Photos Competition' aimed at senior secondary students was held in early 2014 to arouse their interest in weather and climate as well as to encourage them to take part in CWOS related activities. A total of 48 teams of students joined the competition. The students submitted daily weather observation reports and carried out an investigative study on a weather-related topic by making use of the observation data. During the two-month observation period of the competition, over 1,800 weather observation reports with photos were submitted. The competition concluded in a closing event held in May 2014 which featured students' presentation on their project findings, the award presentation and an interactive 'Weather Chit Chat with Young People' session hosted by the Director of HKO with a view to debunking myths surrounding various climate change and extreme weather phenomena (Figures 6 and 7).

4. Potential applications and benefits of community weather data

Apart from educational purposes, gathering community data through Co-WIN and CWOS have other potential applications and benefits. For Co-WIN, its AWS network can supplement the existing HKO operational weather observation network with more than 100 AWS installed at various locations in Hong Kong, by providing additional real-time weather information to members of the public. A major difference between HKO AWS and Co-WIN AWS is their surrounding environment. The installation of HKO operational AWS follows as far as possible the guidelines of station requirements given by the World Meteorological Organization in terms of instrument exposure and site environment. For Co-WIN AWS, it is often not possible to strictly follow those guidelines as many community organizations, especially schools, are located in densely populated areas surrounded by high-rise buildings (see Figure 8 for an example). Although the measurements of such Co-WIN AWS may not be representative over a wider area, they do provide information representative of the local conditions affected by urban development. As such, data from Co-WIN AWS may be useful for people living nearby.

For the same reason, historical data from a well-maintained Co-WIN AWS can potentially be used in research studies of the urban climate. A simple example is given in Figure 9 which shows the time series of air temperatures recorded at HKO AWS and nearby Co-WIN AWS in two different districts of Hong Kong on a winter day in 2011. Typical effects of urban development on air temperatures at Co-WIN AWS could be clearly observed – the temperatures were generally a couple of degrees higher than that at the HKO AWS during nighttime, while the difference in daytime was noticeably smaller. This demonstrates the potential use of Co-WIN AWS data in estimating the spatial distribution of the intensity of urban heat island in Hong Kong. With a range of other weather elements being continuously measured by Co-WIN AWS (as described in Section 2), the effects of urban development on wind flow, rainfall etc. may also be studied.

As for CWOS, one of its advantages is its mobility. Weather observations, photos and videos may be taken anytime and anywhere. Therefore CWOS provides the opportunity to gather images and videos of special weather phenomena, for example waterspouts, hailstorm and optical phenomena which may somehow be difficult to be captured even by HKO's network of over 20 fixed weather cameras in Hong Kong. Since many of these photos and videos are submitted shortly after taken and they are displayed and disseminated on various CWOS platforms in real-time, members of the public can better appreciate the latest weather changes, in particular the approach of severe weather. This is evident from the historical 'reach' figures of the CWOS Facebook platform (Figure 10) which showed significant increases during severe weather episodes in Hong Kong. Furthermore, weather forecasters can also make use of the photos and videos to assess latest weather situation. Following a major weather event, such as the passage of a tropical cyclone or a rainstorm, photos and videos collected on the CWOS platforms will also be useful in evaluating its severity and impacts.

5. Concluding remarks and future developments

Since 2007, HKO and PolyU have jointly promoted weather observations at the community level through Co-WIN and CWOS. While the main objective of these projects is to educate the public on weather and climate, especially raising their awareness towards weather-related hazards and climate change, community weather data gathered through Co-WIN and CWOS, including measurements of various weather elements as well as photos and videos of weather phenomena, have a number of other potential applications in the provision of weather information to the public, forecast operation and climate research.

In view of the opportunities offered by community weather observations, Co-WIN and CWOS will be further developed in order to encourage more community organizations to install their AWS and members of the public to participate in weather observation activities. In addition to an Android version of iCWeatherOS under development, CWOS will continue to follow the latest trends in technology in exploring new platforms for members of the public to submit and share their weather

observations. On the other hand, studies evaluating the quality of historical Co-WIN AWS data will be carried out with a view to identifying those suitable for further research purposes.

In recent years, technological advances have favoured the development of community weather observations. The advent of smartphones enables people to take weather photos conveniently while on the move. New models of smartphones are even equipped with built-in or external sensors for measuring various weather elements, which allow users to essentially operate a mobile weather station. Meanwhile, the development of social media enables the dissemination of weather observations made by members of the public even more rapid than ever. It is anticipated that the involvement of the community would play an increasingly significant role in weather observations in the future, and the volume of available community weather data would greatly increase in the years to come. The pursuit ahead for meteorological services is to explore means of building up such potential 'Big Data' and harness information in novel ways to produce useful weather services for the public. Such task is no doubt very challenging.

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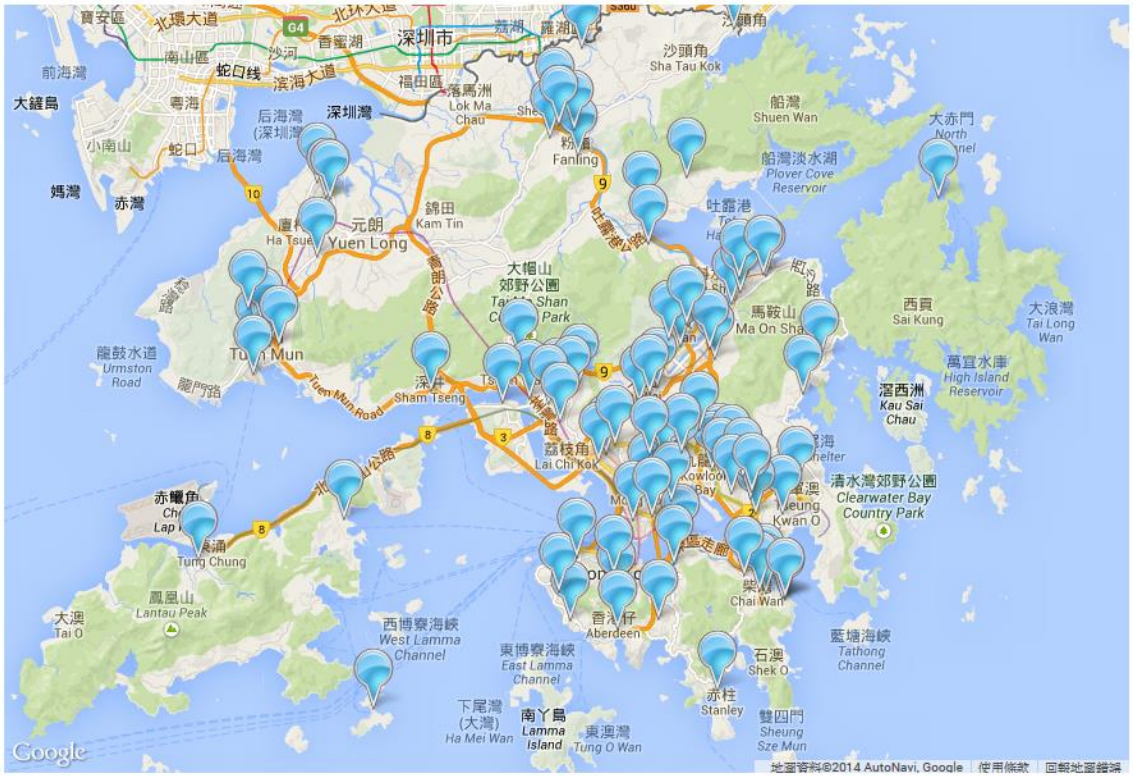
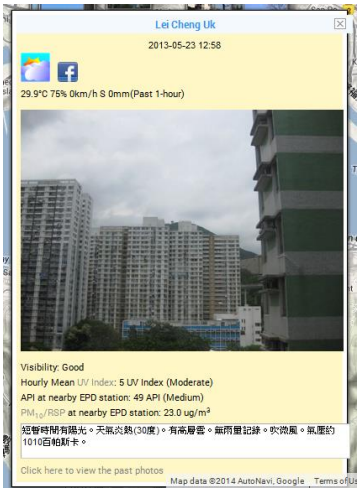


Figure 1 Map showing the location of Co-WIN AWS in Hong Kong.

Figure 2 Online form on the CWOS website for users to upload their weather observation reports. In addition to a weather photo, users may also submit information on various weather elements measured and a short text 'weather log' in their reports.

(a)



(b)

Figure 3 (a) GIS Map on the CWOS website displaying weather photos taken by CWOS participants. (b) An example of observation report with a weather photo displayed on the CWOS website.

(a)

(b)

Figure 4 (a) CWOS Facebook page. (b) Examples of posts on the page with weather photos submitted by users.

(a) 

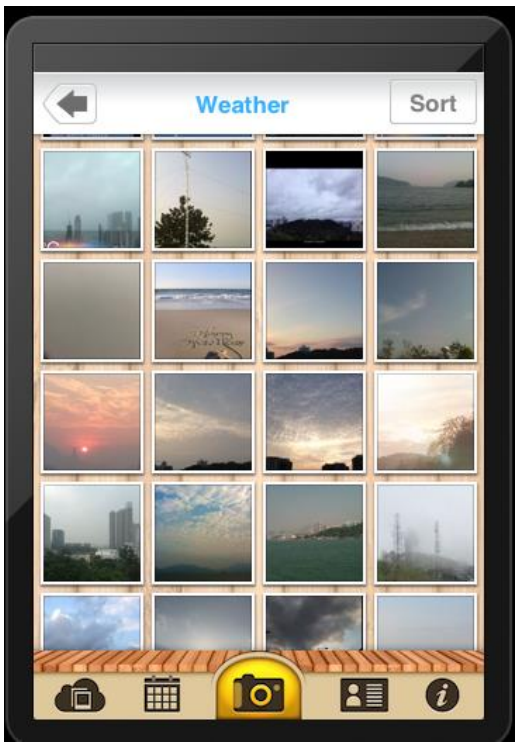
(b) 

Figure 5 Screenshots of smartphone app iCWeatherOS.

Figure 6 Photo of the 'Weather Chit Chat with Young People' session, hosted by the Director of HKO, Mr SHUN Chi-ming (left), during the closing event of 'Weather Observation and Weather Photos Competition' on 10 May 2014.

Figure 7 **Group photo of award recipients with representatives of organizers of the 'Weather Observation and Weather Photos Competition' in the competition closing event on 10 May 2014.**

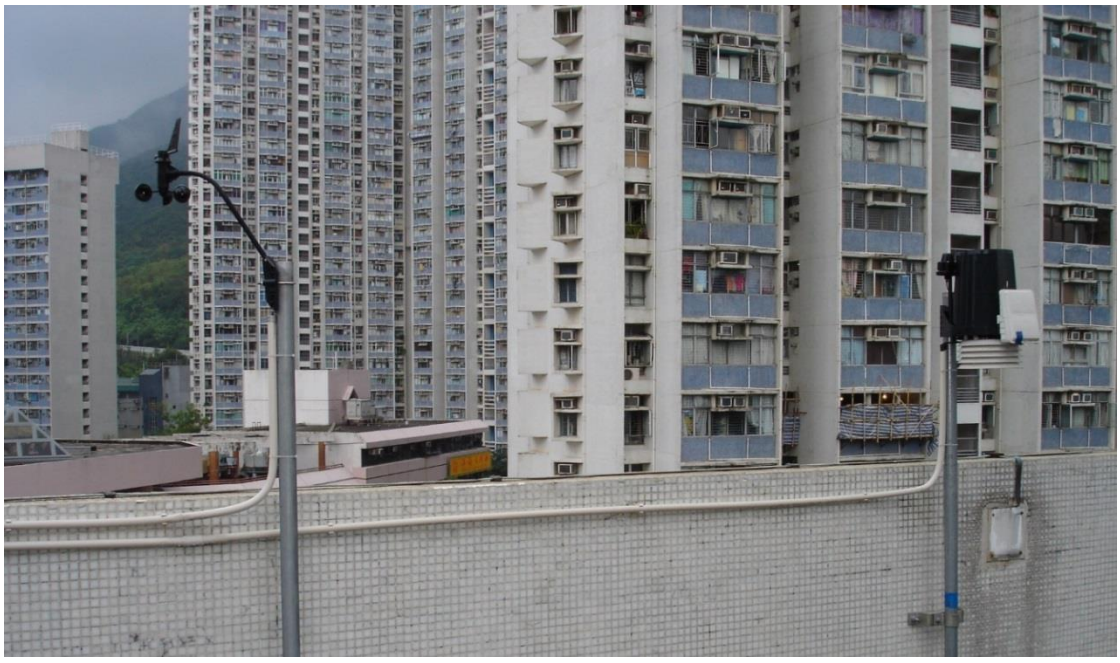


Figure 8 **A Co-WIN automatic weather station installed at the rooftop of a local school and its surrounding environment.**

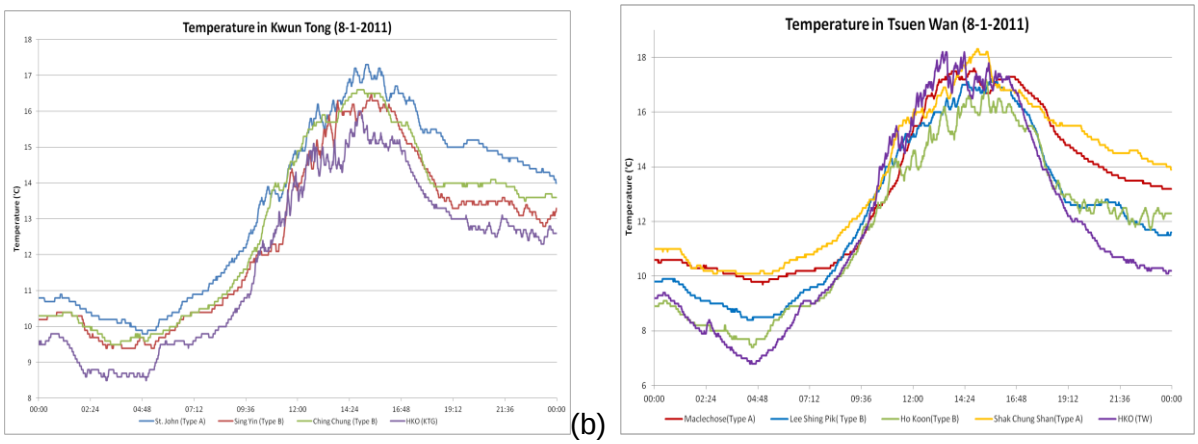


Figure 9 Comparison of air temperatures recorded by HKO AWS (purple line) and nearby Co-WIN AWS (lines of other colours) in (a) Kwun Tong district and (b) Tsuen Wan district in Hong Kong on 8 January 2011.

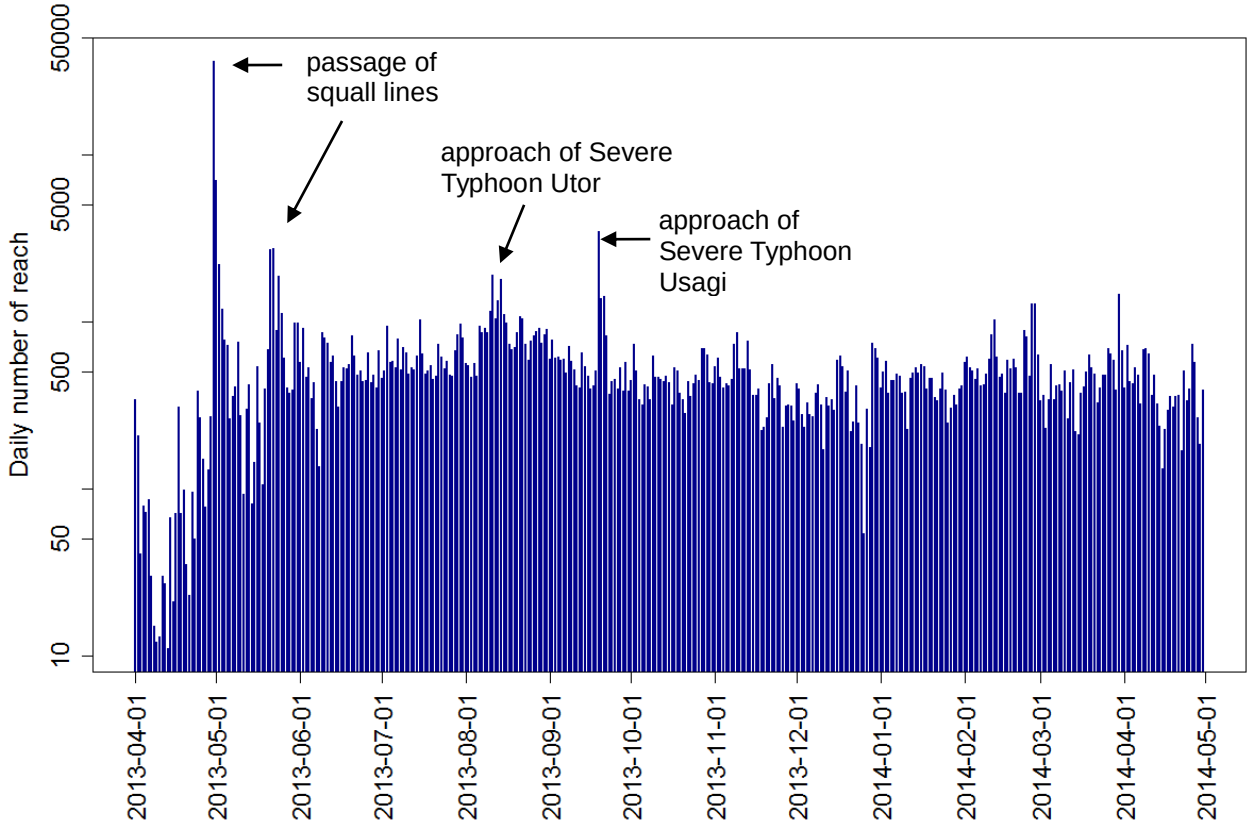


Figure 10 Daily number of reach of CWOS Facebook page (defined as number of unique users who have viewed any content of the page) from 1 April 2013 to 30 April 2014.