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Research article

Towards benchmarking citizen observatories: Features and functioning of online amateur weather networks

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ABSTRACT

Crowd-sourced environmental observations are increasingly being considered as having the potential to enhance the spatial and temporal resolution of current data streams from terrestrial and areal sensors. The rapid diffusion of ICTs during the past decades has facilitated the process of data collection and sharing by the general public and has resulted in the formation of various online environmental citizen observatory networks. Online amateur weather networks are a particular example of such ICT-mediated observatories that are rooted in one of the oldest and most widely practiced citizen science activities, namely amateur weather observation. The objective of this paper is to introduce a conceptual framework that enables a systematic review of the features and functioning of these expanding networks. This is done by considering distinct dimensions, namely the geographic scope and types of participants, the network's establishment mechanism, revenue stream(s), existing communication paradigm, efforts required by data sharers, support offered by platform providers, and issues such as data accessibility, availability and quality. An in-depth understanding of these dimensions helps to analyze various dynamics such as interactions between different stakeholders, motivations to run the networks, and their sustainability. This framework is then utilized to perform a critical review of six existing online amateur weather networks based on publicly available data. The main findings of this analysis suggest that: (1) there are several key stakeholders such as emergency services and local authorities that are not (yet) engaged in these networks; (2) the revenue stream(s) of online amateur weather networks is one of the least discussed but arguably most important dimensions that is crucial for the sustainability of these networks; and (3) all of the networks included in this study have one or more explicit modes of bi-directional communication, however, this is limited to feedback mechanisms that are mainly designed to educate the data sharers.

1. Introduction

The term 'citizen science' was first used in January 1989 when 225 volunteer citizens from all states of the United States of America took part in a program to collect rain samples, test their acidity and report the results (Haklay, 2014). It took 25 years for this term to be added to the Oxford English Dictionary which defined it as: “the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists” (Oxford English Dictionary, 2014). However, citizen science activities in practice are much older than the creation of their name tag and actually many of the current science branches have been created thanks to curiosity and enthusiasm of amateurs (Haklay, 2015; Lankford, 1981; Mims, 1999).

During the past two decades, a shift has taken place in the general perception of the competence of citizens to participate in earth observation and environmental conservation and furthermore their potential influence on decision making processes (Wehn et al., 2015a). This shift coincided with advancements in Information Communication Technologies (ICTs) such as user-friendly and affordable sensor devices, web-platforms and mobile applications (Wehn et al., 2015b) and resulted in the formation of diverse citizen science projects in many science domains, including atmospheric and space weather studies. As an example, *Zooniverse* is a hub for

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several climate and space-related initiatives including *Solar Stormwatch* (a project for mapping eruptions from the surface of the Sun) and *Old Weather* (that tries to model the Earth's climate using historic ship logs); other notable examples are the *National Eclipse Weather Experiment* (NEWEx) that focuses on atmospheric data collection from the partial solar eclipse (Barnard et al., 2016; Harrison and Hanna, 2016; Portas et al., 2016), and *Aurorasaurus* that takes advantage of the interest and curiosity of people about aurora borealis (northern light) to improve early warning systems of geomagnetic storms (Tapia et al., 2014).

The focus of this paper is online amateur weather networks: virtual platforms that host, aggregate and visualize amateur weather data. Amateur weather observation is not a new activity and meteorology science is one of the domains that was initiated as a result of efforts, enthusiasm and interest of amateur weather observers (Bell et al., 2013; Eden, 2009). The 1970s were known as "the renaissance of organized weather observing by weather amateurs" (Eden, 2009), when the first networks of amateurs such as the Climatological Observers Link (COL) were formed and weather observers started to exchange ideas and publish bulletins and magazines. Nowadays, there are a range of online amateur weather networks that aggregate and visualize citizen-contributed weather data.

Wiggins and Crowston (2011) identified five mutually exclusive types of citizen science initiatives and labeled them as Action, Conservation, Investigation, Virtual, and Education. Based on this classification, online amateur weather networks match the description for 'Investigation' initiatives as they focus on a scientific goal (i.e. improving local weather information and forecasts), depend on the contribution of citizens to observe the physical environment (i.e. weather attributes), range from regional to international in geographic scope, and highly depend on the spatial distribution of the participants. Although all online amateur weather networks fall within the same typology, each of these platforms has its own combination of characteristics in terms of geographic scope, goals, origin and underlying processes of operation. We refer to these comparable features as 'dimensions' since each of them provides a common basis for comparison between different platforms, and, as a whole, they represent each network as a distinct entity. Building on the previous efforts in conceptualizing the dimensions of e-participation and citizen science initiatives, this paper introduces a framework that can be utilized to systematically review these expanding networks. A systematic review of different online amateur weather networks is valuable for benchmarking purposes by researchers, platform operators and also weather enthusiasts. Such evaluations can generate valuable insights about the features and functioning of different networks that may consequently help enhance citizen participation in these networks. Moreover, the framework of this research can be utilized by researchers and platform operators as a tool to monitor the changes of the weather networks over time. In this paper, we review six of the most popular weather networks using publicly available data, namely; (1) Citizen Weather Observer Program (CWOP),[1] (2) the UK Met Office Weather Observation Website (WOW),[2] (3) Weather Underground (WU),[3] (4) Davis WeatherLink (DWL),[4] (5) European Weather Network (EWN)[5] and (6) Het Weer Actueel (HWA).[6]

[1] http://wxqa.com/.
[2] http://wow.metoffice.gov.uk/.
[3] http://www.wunderground.com/.
[4] http://www.weatherlink.com/.
[5] http://euweather.eu/.
[6] http://www.hetweeractueel.nl/.

This paper is structured as follows. Section 2 presents a review of relevant theoretical contexts regarding e-participation and citizen science initiatives and introduces the conceptual framework developed in this study. In Section 3, we present the details of the methods used for applying the framework. The results of the research are presented in Section 4. Section 5 is dedicated to the discussion and conclusions; this section presents a number of recommendations on how to improve the current state of online amateur weather networks and, consequently, enhance citizen participation in meteorological observations.

2. Theoretical context

2.1. Dimensions of e-participation and citizen science initiatives

Conceptualizing ICT-enabled citizen participation is a relatively new practice since such activities have existed only for the past two decades. A number of previous studies have identified and defined 'dimensions' for e-participation (Macintosh, 2004), citizen science (Haklay, 2015; Roy et al., 2012), and citizen observatories (Ciravegna et al., 2013; Wehn et al., 2015b).

In 2004, Macintosh characterized e-participation using ten dimensions (row 1 in Table 1) and recognized such activities as a novel way of citizen engagement in democratic debates (Macintosh, 2004). This categorization was based on earlier research, including a study that was conducted on behalf of the Organisation for Economic Co-operation and Development (OECD) e-government group (Macintosh and Coleman, 2003). The discussion was centered around the concept of 'e-democracy' and included examples of top-down participatory activities, defined by authorities for citizens like e-petitioning and e-voting. Although the conclusions of this research were based on several case studies and e-participation activities in Europe, it did not capture important aspects such as the overarching goals, the communication paradigm, nor the revenue streams of such initiatives. Moreover, this study seems to have a pro-technology bias; this is evident from multiple arguments in the text; for example "such a framework has the potential to demonstrate how ICTs have contributed to specific democratic processes and to describe the conditions under which best practice can emerge" (Macintosh, 2004, p. 10).

With the advancements in ICTs and the emergence of new citizen observatory projects, similar attempts to depict different dimensions of such projects have been made. In 2012, a team of biologists and ecologists analyzed 234 citizen science projects using publicly available data and published their findings in a collaborative report (Roy et al., 2012). The results included two distinct dimensions; (1) 'degree of mass participation' and (2) 'degree of investment'. They further broke down these dimensions into detailed 'attributes' (row 2 in Table 1) to provide a basis for comparison between these projects. Based on information from publicly available data, the study has a neutral view about the strengths and weaknesses of each project but at the same time is limited to the dimensions that the research could discuss and score. In this regard, they state that "we could not reliably assess the source of funding, amount of funding received, the motivation of the project leaders, or the 'success' of the project" (Roy et al., 2012, p. 15). Investigating financial aspects of managing such platforms is highly important as it helps explaining critical issues such as the motivations behind running these networks, sustainability of the platforms, data ownership and level of access for the general public. The data collection method in this research may have limited the number of dimensions that the researchers could 'reliably' analyze, but, at the same time, allowed them to study a larger collection of projects that would be very difficult to assess otherwise.

Another instance of such a categorization can be found in Haklay

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