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Can Cell-Phone Tower Signals Help Fight Malaria in Africa?

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Abstract

Malaria is one of the major causes of mortality in the world today. Sub-Saharan African countries suffer most acutely from outbreaks of the disease and some 90% of cases of death (hundreds of thousands of people each year) occur in this region. High intensity rainfall is a central parameter leading to severe outbreaks of the disease, which typically lag the rain event by several weeks. However, current rainfall monitoring tools deployed in Africa do not provide sufficient response due to very limited spread in the continent.

During the last dozen years, the ability to monitor rain using microwave communication networks has been demonstrated. However, the tens of research papers published thus far have shown the contribution of the method mainly for hydro-meteorological needs.

This note points to the potential of microwave communication networks for providing rainfall information critically required to predict malaria outbreaks and to support planning of preventive measures.

Keywords: Malaria, Africa, Rainfall, Commercial microwave links

1. On the connection between malaria and rainfall

Malaria is one of the main causes of death in the world today. The disease is caused by parasites transmitted to humans through the bite of infected female *Anopheles* mosquitoes. The World Health Organization notes that in 2015 some 3.2 billion people, nearly half of all humans on Earth, were under risk of contracting the disease. According to recent estimates provided, from December 2015, there were 214 million cases of malaria, and 438,000 deaths from the disease in that year alone. Sub-Saharan Africa continues to suffer from a disproportionately high percentage of global malaria cases. In 2015, 88% of cases and 90% of malaria deaths occurred in the region.

The lack of reliable data and the simplistic approaches to estimating the spread of the disease, however, mean that the effect of malaria interventions across the different epidemiological settings in Africa is still poorly understood. The abundance of the *Anopheles* vector, and the extrinsic cycles of the parasites inside the mosquitoes are impacted considerably by climatic and meteorological factors, such as, precipitation, temperature and relative humidity. Since tropical areas have relatively constant temperature and humidity, precipitation is probably the primary meteorological parameter responsible for the outbreak of an epidemic (Krefis et al., 2011). Particularly, in semi-arid and desert-fringe areas of Southern Africa, the Greater Horn and the Sahel, rainfall is a major factor affecting variability in malaria transmission. Previous research has shown that reliable rainfall monitoring may provide early warning of the danger (Grover-Kopec et al., 2005). After intensive rains, explosive epidemics often occur, lagging several weeks behind the rains, a period of time in which mosquito vector populations, as well as infections increase dramatically. However, as the poorest continent on the globe, specialized rainfall monitoring instruments are only sparsely deployed in Africa, if at all. A limitation that adversely affects the ability to cope with outbreaks of malaria.

2. Traditional rainfall monitoring techniques

Due to both practical and technical constraints, conventional monitoring instruments often don't have the capacity to collect surface level precipitation information extensively and reliably across areas that are prone to malaria outbreaks in Africa.

Satellites can acquire large spatial rain observations. However, this technique is often unable to provide accurate rainfall estimates near the Earth's surface due to possible interference in the atmospheric medium between space and the ground-adjacent layer.

Ground-based radars and rain gauges can provide reliable precipitation measurements from surface level. However, due to the costs involved in creating radar and gauge networks, these tools are not available in sufficient numbers in Africa. Furthermore, even in the relatively rare cases where a rain gauge is already installed at a certain location, these instruments provide a point measurement that cannot reliably represent the spatial distribution of rain. Thus, for example, it is possible for such a spot gauge to completely miss the rain from an entire storm domain. Ground radars are particularly problematic for measuring remote areas because the observation is taken from high altitude, in a manner that does not represent the intensity in proximity to the ground due to the angle of the radar beam respective to the surface combined with the curvature of the earth as the distance from the location of the radar grows.

3. Rainfall monitoring using commercial microwave link networks

Commercial Microwave Links (CMLs) form the infrastructure for wireless data transmission in cellular communication networks. Rain drops induce attenuation of the millimeter waves that are transmitted at frequencies of tens of GHz, and thus the system is, in effect, a low cost sensor network for monitoring ground level phenomena (e.g. Alpert et al., 2016; David and Gao, 2016) and particularly rain (e.g. Messer et al., 2006; Overeem et al., 2013).

The principle of calculating the rainfall estimates using CMLs is based on the difference between measurements taken by each link during times of rain and times without rain. The rainfall induced attenuation - γ *(dB)* can then be estimated and accordingly the rainfall intensity *R (mm/hour)* using the following formula:

$$\gamma = aR^{b} \cdot L$$

Where:

a, b – Known parameters (dependent on link frequency, polarization and the rainfall drop size distribution).

L – Link length (km)

While using multiple links per unit area, these networks have been proven suitable for mapping precipitation across wide regions (e.g. Overeem et al., 2013).

CMLs are frequently deployed across wide areas of Africa. Hoedjes et al. (2014), for example, demonstrates the potential spatial advantage of monitoring rain using thousands of CMLs spanning the range from single kilometer lengths, and up to 80 kilometers per link across Kenya, including in areas that are particularly prone to malaria epidemics (e.g. see figure 1 in Kibret et al., 2015) This, compared to the few tens of operative rain gauges (that can provide real time measurements) deployed very sparsely across the entire country by the Kenya Meteorological Department.

4. Summary

During the last dozen years, the ability to monitor rain using CMLs has been demonstrated, including in Africa (Doumounia et al., 2014; Hoedjes et al., 2014). However, the tens of research papers published during this period have demonstrated the possible contribution of this method mainly for meteorological, hydrological, and water management needs. Here we point to the potential of the technique to help combat malaria in areas prone to outbreaks of the disease across Africa. The use of CMLs only for rain mapping in Africa requires further research and development, especially since the nature of the rain in the region is convective, meaning that its intensity varies greatly across space. However, comparing to the very limited rain gauge network and radar systems that exist, the deployed microwave network exhibits tremendous observational power. Naturally, combining the microwave measurements with those of conventional rain monitoring instruments (gauges, radars, satellites), in cases where those are available, will allow for better spatial and temporal monitoring of rainfall and its patterns. In cases where dedicated instruments don't exist, the technique can constitute an alternative. Notably, the newly available data produced can potentially be used by models that provide early warning against malaria (Grover-Kopec et al., 2005; Krefis et al., 2011). While further research is required on this concept, the outcomes of the proposed application could lead directly to improving the ability to deal with malaria control and may provide an invaluable contribution to public health in Africa.

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