The use of Climate Information in Impact Assessment for Malaria Interventions

UNECA Conference Center, Addis Ababa, December 12-14,2011

Workshop Report

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Acknowledgements

Anti-malaria Association/Climate and Health Working Group of Ethiopia, and IRI convened this workshop “Use of Climate Information in Impact Assessment for Malaria Interventions” at UNECA in Addis Ababa, Ethiopia from December 12-14, 2011. The workshop was sponsored by the Google.org project “Building Capacity to produce and use climate information for improving health in East Africa” and the Presidents Malaria Initiative of USAID (Weather and Climate Information for Climate Resilient Development – IRI/EGAT-USAID Cooperative Agreement to A. Robertson) with associated subcontract to the Health and Climate Foundation (a US-based 5013c; http://hc-foundation.org).

In addition technical support and encouragement was provided by the Federal Ministry of Health of Ethiopia and the National Meteorological Services Agency of Ethiopia both of which made important data available for training purposes.

In addition support to the Google.org project came from NOAA institutional grant NA07GP0213). Satellite based products used in the workshop included those developed with NASA funding: “Cooperative Agreement Notice NN-H-04-Z-YO-010-C Enhancing Malaria Early Warning System with Earth Observation and Modeling Results, PI (USGS Subgrant 06CRAG0028 to S. Connor)”; “NNH10ZDA001N-PHFEAS” - Improving Decision-Making Activities for Malaria and Meningitis Risk Mapping to P. Ceccato).
Dedication

This report is dedicated to David Grimes, coordinator, TAMSAT research group, Senior Lecturer Department of Meteorology, Reading University who died after a short illness on 22nd Dec 2011.

David led the research activities at Reading that underpinned the creation of the Ethiopian Enhanced National Climate TimesSeries used in this workshop. He will be sorely missed.
# Building Capacity to produce and use climate information for improving health in East Africa

*Climate information for Malaria Impact Assessment 12-14 December 2011 Addis Ababa*

## Team Members

### Organizers
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- Adugna Woyessa (EHNRI)
- Hiwot Teka (PMI USAID)

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- Remi Cousin (IRI)
- Frank Zadrawecz (MSPH)
- Derek Willis (IRI/CRED)
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Acronyms

ACT  Artemisin-based Combination Therapies
AMA  Anti-Malaria Association
CHWG Climate and Health Working Group
CSMT  Climate Suitability Malaria Transmission
ENACT Enhanced National Climatology time Series
FMoH  Federal Ministry of Health
GFATM Global Fund for Aids Tuberculosis and Malaria
GIS  Geographical Information Systems
IDSR  Integrated Diseases Surveillance and Response System
IPT  Intermittent Preventive Treatment
IRI  International Research Institute for Climate and Society, Columbia University
NASA  National Aeronautics and Space Administration
HHMIS National Health Management Information System
NMA  National Meteorological Agency
NOAA National Oceanic and Atmospheric Administration, USA
PHEM (Preventive Health Emergency Management)
PMI  President Malaria Initiative
QC  Quality Control
RBM  Roll Back Malaria
UNECA United Nation Economic Commission for Africa
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Executive Summary

Background

Since the inception of the Roll back Malaria (RBM) initiative, hundreds of millions of dollars have been spent by national governments, NGOs and the international donor community to reduce the burden of Malaria in Africa. Subsequent to intervention efforts a substantial decline in malaria cases have been observed in around the world however the attribution of such decline to interventions alone in some areas has been questioned and there is increasing concern that climate variability and change may be confounding the assessment of the impact of interventions designed to achieve the malaria Millennium Development Goal targets. In particular the recent extended drought period in Eastern Africa may have contributed to malarias decline.

The recent workshop “Climate and Health in Africa – 10 years On “ (Addis Ababa April, 2011) provided a detailed list of recommendations for improving the management of climate sensitive health outcomes through the better provision of climate services as well as through building capacity in the health community to use climate information in routine decision-making.

Building on the outcomes of a recent project funded by Google.org ‘Building Capacity to produce and use climate and environmental information for improving health in East Africa’ this workshop sought to establish data and methods whereby the confounding effect of climate variability on malaria impact assessment could be removed.

Goal: to evaluate the use of Climate information in Impact Assessment for Malaria Interventions

Objectives:

Introduce ENACT climate products

To introduce the New Enhanced National Climate TimeSeries (ENACT) products to the Ethiopian Malaria community - including products available via the NMA online MapRoom (http://213.55.84.78:8082/maproom/NMA/)
Investigate association between climate and malaria

To investigate possible associations between climate variability and trends and malaria transmission in Ethiopia between July 2004 and June 2009 at sub-national levels using the comprehensive IDSR data set made available by the Ministry of Health.

Establish methodology for removing climate from impact assessments

To establish a methodology for removing the confounding effect of climate on impact evaluation for malaria interventions in Ethiopia using a range of local malaria data sets and the ENACT product.

Outcomes

At the end of the workshop participants had:

• Demonstrative capability for accessing, querying and using the NMA MapRoom for malaria analysis.

• Familiarity with specific descriptive and statistical tools used to analyze malaria and climate relationships.

• An initial assessment of the relative importance of climate as a determinant of malaria incidence in different ecological zones.

• Those individuals that brought their own data to the workshop were able to use the tools developed (including an excel spreadsheet designed to assess the degree of association between anomalies in climate and anomalies in malaria incidence) to assess the climate sensitivity of their own data and to explore in more detail impact of climate on malaria outcomes.

• Participants from NMA were able to report on the different climates of the 8 regions of Ethiopia and the climate anomalies that have occurred in these regions over the last 28 years.

Competition

At the closing session of the workshop the organizers announced that a prize would be awarded to the development of the best proposal designed to use the ENACT products in public health decision-making and operational research activities in Ethiopia (Appendix 6).
Consolidated discussion points and recommendations (see discussion section below)

Multi-disciplinary and integrated approach

- Malaria is a complex disease so a multi-disciplinary and integrated approach is therefore needed including information on climate, environment, vectors, epidemiology, as well as an understanding of local social factors.

- The 30 years of quality controlled climate data recently made available for Ethiopia by the NMA via the MapRoom is a great first step however these data need to be integrated with other data of relevance to malaria as indicated above.

Data sharing platform

- The efforts the Climate and Health Working Group/AMA Ethiopia should be reinitiated and strengthened to help solve gaps in awareness, quality control malaria data and tools. This workshop provides a key opportunity to do this.

- A technical team from the CHWG should prepare a proposal for obtaining data by clearly justifying the purpose and importance of the data to the concerned decision makers.

- Although the recent decline in malaria could be strongly attributed to interventions there should be a mechanism where by we can determine that the decline is due to the intervention or other factors like climate. A statistical tool that can integrate different information (surveillance, prevalence, quality time series facility data, climate and interventions etc.) to explore change over time will be of value.

- Data collected historically for research purposes should be accessed where possible to ensure that consistent and quality data sets can be made available for new analysis. through contacting authors and made available for further analysis.
Climate Suitability for Malaria Transmission

The results achieved indicate that the tool captures well the uni-modal or bi-model seasons and indicates where temperature, rainfall or humidity may be a limiting factor. However it could be greatly improved if:

- the relationship between CSMT and cases could be quantified across the country
- if the lag time between the malaria transmission suitability and expected cases was defined
- if the temperature threshold (currently set for *P.falciparum* at 18° c- 32 ° c) was also set for *P.vivax* 16° c- 30 ° c).

MapRoom

- It was recommended that a drop down menu for individual woredas might help the user identify the right administrative boundary in the woreda NMA MapRoom interface

Malaria and Climate Analysis

- The malaria and climate concordance tool was very however the level of concordance does not imply significance in the relationship and other statistical tools need to be developed to help further explore the data sets.
The workshop

Background

Since 1998, when Roll back Malaria (RBM) was initiated, hundreds of millions of dollars have been spent by national governments, NGOs and international donor community to reduce the burden of Malaria in Africa, estimated to be over a million deaths directly due to *Plasmodium falciparum* annually.

RBM’s key proven interventions include: indoor residual spraying, insecticide treated bed nets artemesin-based combination therapies, and intermittent preventive treatment of pregnant women. Since 2010, RBM partners (including many funding and implementing organizations, e.g. WHO, PMI, GFATM, has been involved in impact evaluation to determine where the key RBM goals for 50% reduction in morbidity and mortality have been achieved. Initial studies suggest substantive reductions in malaria morbidity and mortality in key malaria endemic countries. However there is limited documentation of impact of the numerous interventions that have been undertaken in Africa countries and where detailed assessments have been made, attributing changes in disease burden to the impact of interventions alone is not always straightforward.

Malaria is one of the most climate sensitive diseases and there in increasing concern that climate variability and change may be confounding the assessment of the impact of interventions designed to achieve the malaria targets. Given the level of funding support to malaria control in Africa including Ethiopia; the high sensitivity of the disease to climate (both rainfall and temperature); the need for robust impact evaluation methodologies to ensure long term funding justification due diligence requires new data, methods and tools which enable malaria intervention impact evaluation to adjust for climate variability and trends.

The recent workshop “Climate and Health in Africa-10 years on” provided detailed list of recommendations for improving the management of climates sensitive health outcomes through the better provision of climate services as well as through building capacity in the health community to use climate information in routine decision making (Appendix 7).

As a result of a recent project funded by Google.org (with additional support from NOAA and NASA) through a project entitled “Building Capacity to Produce and Use Climate and Environmental Information for Improving Health in East Africa” available malaria data for Ethiopia is now complemented by high resolution climate and environmental data. The ENACT products (Enhanced National Climatology TimeSeries) consists of 30 years of
quality controlled 10 day (10km) rainfall and temperature data for the region obtained from a blend of national meteorological observations and the best available satellite data. The data is made available via the Ethiopian Meteorological Agency MapRoom, (http://213.55.84.78.8082/.NMA) which uses technology from the IRI Data Library (http://iridl.ldeo.columbia.edu).

**Method of Work**

The workshop was planned as a “hands-on” data analysis opportunity where participants review malaria indicators and climate data generated from the new ENACT products and use these data to explore the impacts of climate on disease trends and test the methodology and its use is in impact evaluation for malaria interventions in Ethiopia.

The workshop was organized and conducted in such a way that presentations were made and practical sessions undertaken which began with brief introduction to the data used during the session and how they have been recorded followed by description of what is to be achieved during the session and then a guided group exercise conducted in Excel or using mapping tools available in the IRI Data Library. Each session ended with discussion of the usefulness of the analysis and implications for Ethiopia’s national malaria control program. Participants were also encouraged to propose further analyses.

The workshop was opened with an address by Mr. Abere Miherete, Executive Director of AMA and Secretariat of the Climate and Health Group of Ethiopia. This was followed an introduction on the background of the workshop by Madeleine Thomson (IRI).

The workshop was designed as a “hands-on” data analysis opportunity. Supported by a series of expert talks and group discussions each session begin with a brief introduction to the data used during the session and how they have been recorded followed by a description of what was to be achieved during the session and then a guided group exercise conducted in Excel or using mapping tools available in the IRI Data Library (led by IRI facilitators). Each session ended with a discussion with regard to the usefulness of the analysis and implications for Ethiopia’s national malaria control programme. On the third day of the workshop participants where asked to write a short report based on their experience and to present and discuss their results. The Agenda can be found in Appendix 1.

**Participants**

Twenty eight participants took part in the workshop with an additional four facilitators from the IRI and an expert contribution from Patricia Graves via GOTO-Meeting from
Australia. Participants came from a wide range of backgrounds: health practitioners from federal and regional health bureaus, researchers from universities, development organizations, donors, and the National Meteorological Services Agency of Ethiopia. A list of participants can be found in Appendix 2.

**Expert talks**

Associated publications can be found in Appendix 3

Malaria surveillance systems (with reference to Ethiopia) – Patricia Graves PhD. EpiVec Consulting (previously the Carter Center) via GOTO Meeting from Queensland, Australia

This presentation discussed the need for routinely reported surveillance data on malaria cases, inpatients and deaths. This data can be used to assess the trends in disease incidence over space and time, whether control methods are working, and the impact of climate. Cross sectional surveys provide only snapshots with some spatial variation but do not capture seasonal or interannual variation in malaria cases, inpatients or deaths.

There are three potential data sources in Ethiopia: 1) the malaria specific reporting systems maintained to a greater or lesser extent in the regions since the eradication era; 2) the newly revised National Health Management Information System, and 3) the Integrated Disease Surveillance and Response System (IDSR). All of them need to have consistent reporting units with known populations, clearly defined and useful indicators, and reasonable (not necessarily perfect) completeness. The quality of each of these varies over time, but if they show consistent patterns that gives more confidence that the observed trends are real.

Examples were presented for each data source. For the malaria information systems, the Oromia Regional Health Bureau has good data by health facility and demonstrated the peak of cases in that region in 2003 with variation in zonal incidence. The National HMIS, which reports quarterly, was a good source of annual data by region and nationally until mid 2008 after which indicators changed.

The IDSR functioned well (>80% reporting completeness) for zone level monthly data from mid 2004 until mid 2009. There was a decline in the proportion of zones reporting in early 2009. After mid 2009 there was needed reduction in the number of indicators and harmonization with the HMIS indicators in addition to change to weekly reporting.

The IDSR received reports from health centers and hospitals in each zone (also includes sub-cities, towns and special districts) for 17 malaria indicators on a monthly basis. The
reporting rate was judged good enough for the data to reflect trends by zone at least until
the end of 2008. Seasonal trends were apparent in malaria outpatient cases, with some
general decline in case numbers over the period of study. There was greater reduction
in inpatients and deaths than in outpatients between 2004 and 2009, perhaps reflecting
increased access to effective treatment. The dataset is a rich source of information to
investigate the role of climate variation on malaria, although supplementing the 5 years
with a longer time frame would be ideal.

The recommended population-based core malaria indicators, and their pros and cons
were discussed. The most valuable are:
• Incidence of total malaria cases (clinical plus confirmed)
• Incidence of confirmed malaria (RDT or slide) cases, by species
• Incidence of malaria admissions
• Mortality
• Age (<5 yrs and >5 yrs)

Various schemes for malaria stratification in
Ethiopia have been proposed, but they are all
based on altitude, climate and other sources,
rather than empirical population based disease
incidence which would be preferable. Routine
monthly data by Woreda, (or in the future even
Kebele), is an essential tool for understanding
the impact of both climate and interventions on
disease trends as well as for stratifying areas
for increased targeting of interventions.

Overview of the climate data (Enhanced
National Climate TimeSeries for Ethiopia:
ENACTs) – Tufa Dinku Ph.D. (International
Research Institute for Climate and Society,
Earth Institute Columbia University)

Long-term, temporally homogeneous time series of rainfall data with good spatial
coverage are of great importance in a number of applications. The conventional source
of climate data is weather stations.

However, reliable climate information, particularly throughout rural Ethiopia, is very
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The ability to determine the impact of malaria interventions on malaria morbidity and mortality depends on our analytic ability to parse out the attributed variability of associated phenomena. Understanding that there are naturally occurring relationships between climate variability and malaria transmission, the impact of interventions can be understood through analysis of the change in these relationships over time. The removal of complex patterns within datasets of health outcomes and meteorological predictors through simple data smoothing techniques allows elucidation of the generalized impact of these interventions.
Vectorial capacity map room - Madeleine Thomson Ph.D. (International Research Institute for Climate and Society, Earth Institute, Columbia University)

The ability of *Anopheles spp.* mosquitoes to transmit *Plasmodium spp.* is dependent upon a series of biological features, which all together are generally referred to as vectorial capacity. Vectorial capacity has been defined as the daily rate at which future inoculations could arise from a currently infected case. It is generally used as a convenient way to express malaria transmission risk, or the receptivity of an area to malaria. While vectorial capacity does not take into account parasite availability in the human (intermediate host) population, it is considered to be analogous to the environmental-biological driving force underpinning the transmission potential in an area. In this presentation the vectorial capacity model described in Ceccato et al., (in press – see Appendix 3). Products from this model are currently available on the FEWSNET site (http://earlywarning.usgs.gov/fews/africa/). The potential to develop an Ethiopian version using the ENACT products was discussed.

**Practical Sessions**

Associated documentation can be found in Appendix 4.

Exploring the MapRoom – Remi Cousin (International Research Institute for Climate and Society, Earth Institute, Columbia University)

The web page of the National Meteorology Agency has been redesigned for better presentation of its existing products and services and for the delivery of product derived from the new data set (http://www.ethiomet.gov.et/). The new web page includes a “Climate Analysis and Applications” map room (http://213.55.84.78:8082/maproom/.NMA/). This map room has five parts: Climate Analysis, Climate Monitoring, Climate and Agriculture, Climate and Water, and Climate and Health. These Map Rooms are created by IRI using IRI Data Library tools, and then transferred to NMA. The Climate Analysis and Climate Monitoring Map Rooms have been completed, while the others are still under construction. The Climate Analysis Map Room provides information on the mean climate (in terms of rainfall and temperatures) at any point or for any administrative boundary. It also shows the performance of the rainfall seasons over the years as compared to the mean. The Climate Monitoring Map Room enables monitoring of the current season. Different maps and graphs compare the current season with the mean or recent years. This information could be extracted at any point or for any administrative boundary. Data are updated every ten days, thus enabling
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close monitoring of the season. Extracting and presenting information at any administrative level enables focusing on specific area of interest.

Exploring association between climate and malaria: Effects of Climate on Malaria: East Shewa, Ethiopia, 2004-2009- Frank John Zadravec, Jr (Mailman School of Public Health, Earth Institute, Columbia University)

The exploration of the effects of climate variability on malaria incidence is possible through the application of simple statistical and visualization tools. Participants will investigate these relationships in the East Shewa zone of Ethiopia over the years 2004-2009 through (1) familiarization with data aggregation and extraction techniques, (2) calculations of the correspondence of anomalous malaria incidence and climate predictors (rainfall frequency, maximum temperature, and minimum temperature), and (3) demonstration of the utility of the IRI Malaria Climate Suitability for Transmission tool.

Analysis of participant data sets

A number of participants brought their own data sets and, using the lessons learned in the previous two sessions, ran a number of analysis of particular interest.

Presentation of Results

Participants were asked to explore the IDSR data set, their own malaria data sets and the ENACT products and report the results to the group using a short report template that can be found in Appendix 5.
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Results of Climate analysis of the Zones of Ethiopia during the Kiremt Season presented by Girma Tsegay & Tsegaye Ketema NMA

Kiremt Season  Climatologies for Oromia Region
Kiremt Season  Climatologies for Amhara Region
Kiremt Season  Climatologies for SNNPR Region
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Kiremt Season Climatologies for Benishangul-Gumuz Region
Kiremt Season Climatologies for Gambella Region
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Kiremt Season Climatologies for Tigray Region
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Kiremt Season Climatologies for Somali Region
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Kiremt Season Climatologies for Afar Region
According to the climatological analysis from map rooms, the rainfall, maximum and minimum temperature analysis shows an increasing in trend over Amhara, Oromia and SNNPR regions.

Tigray, Benishangul-Gumuz, Afar and Somali regions show decreasing in rainfall trends. This is because stations in the regions are sparsely populated.

Except Gambella, all regions more or less show an increase in trend on maximum and minimum temperatures.

Moving from north to southwestern regions of Ethiopia the length of rainy period increases, while decreases towards south and eastern half of the country. Therefore, it is said to be the analysis of climatic parameters from the map rooms addressed the true climatology of regions.
Results from Gurage Zone: Meskan woreda, reported by Adugna Woyessa

While there is only a concordance between climate anomalies and malaria anomalies for temperature it might be that a different techniques might indicate a statistical relationship of rainfall to malaria.

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Agreement based on Rf 0

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| Agreement based on Rf | 0   |

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Overall Concordance 0.5
Agreement based on Max -0.33

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| 0.5     | 0.5     | 6           |              |               |

Overall Concordance 0.33
Due to Chance 0.50
Agreement based on Min -0.33
Results from East showa zone, Ziway woreda from Group A presented by Paulos Semunigus

Inter-annual variability of IDSR malaria data and climate data

- There is inter-annual variability in malaria and climate data in East showa zone, Ziway woreda, with peak malaria transmission in year 2006 and increasing trend in 2008. Temperature variability is negatively correlated with malaria transmission.

- The low temperature in May to June best predicts epidemic occurrence in July and afterwards.

- Rainfall variability is positively correlated with malaria transmission

- The rainfall increase in April-June best predicts epidemic occurrence from July to September.

Seasonal climate of Ziway woreda from ENACT product
Results from Malaria and Climate variability in Jimma, south west Ethiopia from University of Gonder Group presented by Abebe Alemu

Year to year variability in malaria, rainfall and temperature for the main transmission season – October to December Season.
Results from Gelana Woreda of Borena zone in Oromia region presented by Dawit Teshome

This woreda was selected because it is frequently affected by malaria epidemics. The relation observed in my analysis on climatology do agree with the reality observed.

Identification of Gelana Woreda in Borena zone in MapRoom (boundary in red)

Long term climate suitability for malaria transmission picture of Gelana woreda of Borena Zone in Oromia region (1983-2010)

Anomalies in climate variables main transmission season for the months October and November from 1983-2010.
Results from Kafta Humera Woreda, Western Tigray, Tigray, presented by Dr Wakgari Deressa

Annual anomalies in malaria correspond well with year to year changes in temperature even though this is a lowland area where one would not expect temperature to have an important impact.

In this site rainfall precedes the malaria season by two months.

a) without lag

b) with 2 month lag
Results from Zone: Wolayta from SNNPR, reported by Eskinder

Overall concordance=0.8
Due to chance=0.48
Agreement based on Rf=0.62

Figure 9

Overall concordance=1
Due to chance=0.52
Agreement based on MaxT=1

Figure 10

Overall concordance=0.6
Due to chance=0.52
Agreement based on MinT= 0.17
Results from Adama (Wonji Hospital) E. Showa, Oromia, presented by Hiwot Teka

This extensive longitudinal data set of annual confirmed cases comes from a sugar estate in E. Showa. The Hospital data includes that from 5 local clinics.

The seasonality of the cases can be investigated from the IDSR data (see fig a). The peak malaria season is in October-November but a smaller peak can also be observed in February.

However annual average rainfall indicates only one rainy season (Jul-Aug – see fig b).

Focussing on the February malaria peak and comparing anomalies in cases in February with rainfall in the ‘dry season (Oct-Nov) it becomes apparent that unusual rainfall in this normally dry season is highly predictive of February malaria (see fig c).

a) Seasonal occurrence of average malaria from IDSR data set

A decline in annual cases reported after 2003 (see fig c) needs further investigation to know whether or not this is a function of reporting, interventions or other factor.

b) Seasonal occurrence of average rainfall from NMA ENACT product

c) Yearly anomalies in February malaria and October – November rainfall
Building Capacity to produce and use climate information for improving health in East Africa

*Climate information for Malaria Impact Assessment 12-14 December 2011 Addis Ababa*

**Results from East Showa, Oromia presented by Mesfin Mengistu**

There is inter-annual variability in climate and malaria data across the seven years (2004-2010). The malaria incidence has been decreased/increased following the decrease/increase in climatic data. Eg. As rainfall and temperature (max & min) increased/decreased, the incidence of malaria has followed the same trend indicating that there is a direct relationship provided that the climatic elements are within the accepted range (Temp= 18° c <T< 32° c and rainfall = >80mm) for a specific area in a given period of time. Contrary to this, the relationship for rainfall and malaria occurrence in 2007 was inverse showing that the effect of high might suppressed the spread of the malaria or because of the temperature was very low during that specific year.
Discussion

Following were the key areas of discussions and recommendation:

1) Multi-disciplinary and integrated approach

a) Malaria is a complex disease. The morbidity, mortality, rainfall, temperature and relative humidity data may not be the only data we need to know to be able to assess the impact of interventions or the predictability of malaria weeks or months ahead. Data on the vector (entomological data), data on drug resistance, on interventions and on other important variables/factors should be taken into account and people working on malaria at different levels should bring up together for a broader perspective of the malaria control. **A multi disciplinary and integrated approach is therefore needed.** In addition a focus on the local knowledge and cultural practices of the local population is needed if malaria is going to be fully controlled.

b) The 30 years of quality controlled climate data recently made available for Ethiopia by the NMA through the ENACT products obtained from a blend of national meteorological observations and the best available satellite data is of great importance in building capacity to produce and use climate and environmental information for improving health. However these data need to be integrated with other data of relevance to malaria as indicated above.

   i) Altitude, vegetation, and homogeneity of the ecological setting of a given area and several other factors like land use/land cover also matter in malaria occurrences at the local level.

   ii) It is recommended that where possible the spatial resolution of the ENACT products is increased to its highest resolution.

2) Altitude, vegetation, and homogeneity of the ecological setting of a given area and several other factors like land use/land cover also matter in malaria occurrences but the challenge is it is not easy to get these information.
i) Focusing on climate, malaria epidemic coverage (geographical scale) with high morbidity and mortality is important to narrow down the wider array of ideas.

ii) For making malaria predictions the climate monitoring data in the NMA MapRoom may be useful but should also be associated with other relevant data.

1) Data sharing platform

a) **The efforts the Climate and Health Working Group/AMA Ethiopia should be reinitiated and strengthened** to help bridge the data gaps by making all aware of the problems associated with data sharing (and the lack of it) and how these problems might be overcome through using the available tools like the NMA MapRoom and networking of professionals.

b) How to make best use of the available datasets for impact assessment of interventions was discussed and it was recommended that appropriate solutions should also be looked for to challenges in the completeness morbidity and mortality data, reporting over time series.

c) The challenge in malaria information is a range of variation in data consistency and duration. **This kind of workshop could serve as a common platform to integrate the available malaria information with climate information and to develop a statistical tool that can integrate different information in collaboration with users, providers and (donors) like PMI.**

d) Limited studies are done and data is lacking on factors such as immunity, drug and insecticide resistance hence efforts should also be made in these areas. **It is recommended that creating a team to prepare a proposal for obtaining data by clearly justifying the purpose and importance of the data to the concerned decision makers.**

e) There is a good list of publications on highland malaria in Ethiopia. Good quality climate data has shown the relationship of malaria with warming. Therefore, **obtaining data from such research studies by either connecting to the authors or using any other appropriate**
means including reviews of historical publications is important to establish the historical relationship with climate.

2) Malaria data

a) Care should be taken in using the 2004 data as base line for evaluating the impacts of intervention. Because the years 2003 and 2004 were the peak periods of malaria epidemics which used to occur in a cyclic nature over five to six years time period. Although the decline in malaria could be strongly attributed to the interventions in the subsequent years, under normal condition the malaria situation could decline independently. **There should be a mechanism whereby we can determine that the decline is due to the intervention or other factors like climate.** For example if the epidemic does not occur for some longer time than the normal epidemic cycle. Another important point to note here is the usual 5 to 7 years cyclic period is currently changed and we are seeing malaria epidemic every one or two years also in different places.

b) The malaria situation and the relationship between climate and malaria before the intervention is important in evaluating the impacts post intervention.

c) The types of malaria epidemics involved should be identified and properly dealt with in trying to find correlation between malaria and climate and the interventions effects.

3) Climate Suitability for Malaria Transmission

a) The ideal months for malaria to occur since the temperature, rainfall and relative humidity in these months is suitable for the development of mosquito. This may differ depending on the climatology of a given locality. The Climate Suitability for Malaria Transmission Tool seeks to capture these broad generalities for malaria transmission across the country and may be the best information when local malaria data not available. The results achieved indicate that the tool captures well the uni-modal or bi-model seasons and indicates where temperature, rainfall or humidity may be a limiting factor. However it could be greatly improved if:
Building Capacity to produce and use climate information for improving health in East Africa

Climate information for Malaria Impact Assessment 12-14 December 2011 Addis Ababa

i) the relationship between CSMT and cases could be quantified across the country
ii) b) if the lag time between the malaria transmission suitability and expected cases was defined
iii) if the temperature threshold (currently set for P.falciparum at 18° c - 32° c) was also set for P.vivax 16° c - 30° c).

4) MapRoom
a) It was suggested that a drop down menu for individual woredas might help the user identify the right administrative boundary in the woreda NMA MapRoom interface

5) Malaria and Climate Analysis
a) The malaria and climate concordance tool was very useful and is important to confirm the empirical knowledge on malaria with regard to the three variables (temperature Min, Max and rainfall) and also to see which variable plays a significant role as expressed in a positive-positive or negative-negative concordance. However the level of concordance does not imply significance in the relationship and other statistical tools need to be developed to help further explore the data sets. We also need to check the correlation between variables and make relevant statistical applications for multi co linearity. Incorporating the variables like the relative humidity could also increase the correlation.

b) It is important to use de-trended and de-seasonalised variations (anomaly data) of climate and meteorological data sets

c) In selecting a tool to analyze the contribution of climate or any other variable on malaria, it is important to the relationship with malaria, the variables involved and the sample consider the quality of data (better if it is more in time and less in space), size.
The Closing Session

After closing remarks by Mr. Abere Miheretie, Executive Director, AMA, and Secretary of the Climate and Health Working Group (CHWG/AMA) of Ethiopia Dr. Madeleine Thomson and Dr Tufa Dinku (IRI) concluded the workshop appreciating the advances that are being made in Ethiopia and emphasizing a continuing working together with the Ethiopian government and the Climate and Health Working Group. A vote of thanks was given to the Google.org project, in particular the PI, Stephen Conner, and the many IRI staff that have contributed to the project over the last three years including Judy Omumbo, Barbara Platzer, Remi Cousin, Brad Lyon and Frank Zadrawecz. The AMA was also recognized for its role as key partner in the Google.org project and in chairing the Climate and Health Working Group and supporting the Google.org project in Ethiopia. Special acknowledgement was made to David Grimes from Reading University for the tremendous support to the project that he and his TAMSAT team had made over the years that have enabled the Google.org project to achieve its objectives. Madeleine Thomson then formally closed the workshop.

….. the follow up...

• The workshop results were presented at the “Stakeholder Meeting on improving and expanding surveillance for malaria in low-transmission settings” December 19 and 20, 2011 Ghion Hotel, Addis Ababa, Ethiopia organized by the Continental School of Public Health, Tulane University and the Presidents Malaria Initiative – USAID Ethiopia. The focus of this meeting was the development of an expanded set of sentinel sites for the long term monitoring of malaria in Ethiopia.

• The workshop purpose and outcomes were presented at the public launch of the ENACT products and the new NMA website which took place at the NMA, Addis Ababa on the 20th December 2011
Appendices

Appendix 1. Agenda

DAY 1 – 12\textsuperscript{th} Dec 2011
8.30-9.00am
Registration (sign in)

9:00-9:30am
Welcome: Introductions – Abere Mihretie
•  The Google.org project “Building Capacity to produce and use climate and environmental information for improving health in East Africa” achievements to date

Background to the workshop – Madeleine Thomson
•  Introduce concept behind use of climate in malaria impact assessment
•  Introduce option for use of own data sets
•  Expected outcome and presentations on final afternoon

9:30-10.15am
Malaria surveillance systems (with reference to Ethiopia) – Patricia Graves

10.15 -10.45
Overview of the climate data – Tufa Dinku

10:45-11:15am
Coffee Break

11:15-1.00pm
Practical session: exploring the NMA MapRoom and Climate Suitability for Malaria Transmission tool. Downloading results for their area of interest.

1.00-2.00pm
Lunch

2.00-3:30pm
Introduction to IDSR dataset and methodology for time series smoothing and lagging (in MS Excel) – Frank Zadrawecz

3:30-4:00pm
Coffee Break

4:00-5:00pm
Practical session: Correlation between malaria and rainfall using ISDR data set

5:00-5:30pm
Summary of the day – Adugna Woyessa
DAY 2 13th Dec 2011
9:00-10.30am
Recap on Day 1 Discussion- facilitated by Hiwot Teka

10.45-11.15am
Coffee Break

11:15-1.00pm
Practical session: Continue with analysis using IDSR Data Set

1.00-2.00pm
Lunch

2:00-3.00pm
Practical session cont.

2.30-4.00pm
Practical session: including analysis of participant data sets

4.00-4.30pm
Coffee Break

4.00-5.00pm
Presentation: assessing the impact of interventions - Frank

5.00-5.30 Discussion

DAY 3 14th Dec 2011
9:00-10:45am
Practical session: Continue with analysis of participant data

10.45-11.5
Coffee Break

11.15-1.00pm
Practical session: Continue with analysis of participant data

1.00-2.00pm
Lunch

2:00-3.00pm
Practical session: Continue with analysis of participant data and prepare presentation

3.00-4.00
Present results (5 groups)

4.00-4.30
Coffee Break

4.30-5.30
Wrap up and closing
**Appendix 2. Participant List**

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Organization</th>
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Climate variability and change are serious challenges to sustainable development in Africa. The current famine crisis in the Horn of Africa is yet another reminder of how fluctuations in the climate can destroy lives and livelihoods. Ethiopia, one of the countries impacted by the current drought, has been suffering from climate fluctuations for decades. Climate variability has been one of the major hindrances to development in Ethiopia. Droughts and floods have reduced Ethiopia’s annual growth potential by more than one-third (Grey et al., 2006).

The 1984-1985 drought reduced Ethiopia’s agricultural production by about 21 per cent with a 9.7 per cent fall in the Gross Domestic Product (GDP) (World Bank, 2006). The effect of climate variability is, of course, felt more by poor households (Stern, 2007). The 1998-2000 drought cost each household over north-eastern parts of the country more than 75 per cent of its average annual income in crop and livestock losses (Carter et al., 2004).

Credible information

Building resilience against the negative impacts of climate and maximizing the benefits from favourable conditions will require the design and implementation of effective climate risk management strategies. This cannot be accomplished without the availability of decision-relevant climate information. Credible information about the past climate, recent trends and swings, likely future trajectories and associated impacts is very important for climate risk management. Long-term climate time series are critical in many applications including:

- Putting observed and anticipated climate into context;
- Assessment of climate related risks under current conditions;
- Understanding and modelling of climate impacts on different socio-economic activities;

and

- Improving predictions at different time and spatial scales.

**A Vectorial Capacity Product to Monitor Changing Malaria Transmission Potential in Epidemic Regions of Africa**


http://www.hindawi.com/journals/jtm/aip/595948/
Abstract
Despite the considerable progress that has been made to reduce the malaria burden in sub-Saharan Africa through the introduction of control measures, malaria remains a major public health threat to the African continent and a potential obstacle toward the achievement of the Millennium Development Goals in this region. Malaria Early Warning and Detection Systems were advocated as a means of improving the ability of malaria control communities to prepare for timely response to impending epidemics. Rainfall and temperature are two of the major factors triggering epidemics in warm semi-arid (desert-fringe) and high altitude (highland-fringe) epidemic risk areas. The ability of the mosquitoes to transmit Plasmodium spp. is dependent upon a series of biological features generally referred to as vectorial capacity. In this study, the vectorial capacity model (VCAP) was expanded to include the influence of rainfall and temperature variables on malaria transmission potential. Data from two remote sensing products were used to monitor rainfall and temperature and were integrated into the VCAP model. The expanded model was tested in Eritrea and Madagascar to check the viability of the approach.

The analysis of VCAP in relation to rainfall, temperature and malaria incidence data in these regions shows that the expanded VCAP correctly tracks the risk of malaria both in regions where rainfall is the limiting factor and in regions where temperature is the limiting factor. The VCAP maps are currently offered as an experimental resource for testing within Malaria Early Warning applications in epidemic prone regions of sub-Saharan Africa. User feedback is currently being collected in preparation for further evaluation and refinement of the VCAP model.

Web-based climate information resources for malaria control in Africa
Emily K Grover-Kopec, M Benno Blumenthal, Pietro Ceccato, Tufa Dinku, Judy A Omumbo and Stephen J Connor
http://www.malariajournal.com/content/5/1/38

Abstract
Malaria remains a major public health threat to more than 600 million Africans and its control is recognized as critical to achieving the Millennium Development Goals. The greatest burden of malaria in Africa occurs in the endemic regions where the disease pathogen is continuously present in the community. These regions are characterized by an environment that is conducive to interactions between the Anopheles mosquito, malaria parasites and human hosts, as well as housing of generally poor quality, which offers little protection from mosquito-human contact. Epidemic malaria tends to occur along the geographical margins of endemic regions, when the equilibrium between the human, parasite and mosquito vector populations is occasionally disturbed and a sharp but temporary increase in disease incidence results.
When malaria control measures are inadequate, as is the case in much of sub-Saharan Africa, the disease distribution is closely linked with seasonal patterns of the climate and local environment. In the absence of good epidemiological data on malaria distribution in Africa, climate information has long been used to develop malaria risk maps that illustrate the boundaries of 'climatic suitability for endemic transmission.' The best known of these are produced by the Pan-African-based MARA Collaboration. This paper describes the development of additional malaria suitability maps which have been produced in an online, interactive format to enable temporal information (i.e., seasonality of climate conditions) to be queried and displayed along with spatial information. These maps and the seasonal information that they contain should be useful to the malaria control and health service communities for their planning and operational activities.
Appendix 4. Exercise documentation

Instructions for the Exercises

Analyzing IDSR data

Section 1

Open the Excel document. Choose one of the 5 Zones pre-filled with climate information. Locate the malaria data and compute and plot the climatology. Identify if there is one or two epidemiological season and define the 3-month long period of each. Report to Section 1 of the Report Template. Guiding questions: Describe the seasonality of malaria. Include the figure of the malaria climatology.

Overlay the Zones’ boundaries for better reading of the map. Choose and click one pixel in your Zone of interest. Explore the local results of the Climate Suitability for Malaria Transmission. Identify what season(s) and months are suitable for malaria transmission and what climate variables seem to drive the CSMT. Report to Section 1. Guiding questions: Describe the seasonality of the CSMT components. Include the graphs of the CSMT Maproom.

Compare the CSMT to the malaria climatology you plotted in Excel. Report to Section 1. Guiding questions: Does the CSMT seasonality match the malaria seasonality? Or does it match it with a lag? Discuss the matching. If not matching, discuss the reasons why they don’t match (data sampling error, interventions, other influential factors...)

Section 2

In Excel, select the 3-month epidemiological season (repeat the process if multiple seasons) and copy them in the appropriate spot in the Excel sheet to compute the yearly anomalies of seasonal averaged incidence. Plot the yearly anomalies of seasonal incidence with each of the yearly anomalies of seasonal climate variables pre-computed for you. Report to Section 2. Guiding questions: In what years took place positive/negative malaria anomalies? Does the variability of climate variables seem to explain the variability of malaria? Include the multiple-line graphs.

Fill up the contingency table for each variable. Report to Section 2. Guiding questions: Can you identify more likely co-occurrence of malaria and rainfall variability. Include contingency table.
Once filled up, a coefficient is calculated; interpret the results and discuss whether climate variables anomalies influence malaria anomalies.
Report to Section 2.

Repeat the anomalies analysis with the 5 Zones compiled together (see appropriate sheet) – this will increase the size of the sampling and therefore increase the significance of the statistics analysis.
Report to Section 2. Include relevant graphs.

Analyzing your own data (or other ISDR Zones)

Section 3

Open the Excel document.
Choose the sheet with no data pre-selected or pre-computed.
Enter your malaria data in the same format (12-month lines by years columns) and compute and plot the climatology.
Identify if there are one or two epidemiological seasons and define the n-month long period for each.
Report to Section 3. Guiding questions: Describe the seasonality of malaria. Include graph of malaria climatology.

Go to NMA Climate and Health Maproom:
Overlay the Zones’ boundaries for better reading of the map.
Choose and click one pixel in your Zone of interest.
Explore the local results of the Climate Suitability for Malaria Transmission. Identify what season(s) and months are suitable for malaria transmission and what climate variables seem to drive the CSMT.
Report to Section 3. Guiding questions: Describe the seasonality of the CSMT components. Include the graphs of the CSMT Maproom.

Compare the CSMT to the malaria climatology you plotted in Excel.
Report to Section 3. Guiding questions: Does the CSMT seasonality match the malaria seasonality? Or does it match it with a lag? Discuss the matching. If not matching, discuss the reasons why they don’t match (data sampling error, interventions, other influential factors...)

Section 4

In Excel, select the n-month epidemiological season (repeat the process if multiple seasons) and compute the yearly anomalies of seasonal averaged incidence.
Report to Section 4. Guiding questions: In what years took place positive/negative malaria anomalies?

Go to NMA Climate Analysis Maproom:
Select Zone in the **Local time series** pull-down menu.
Refresh the map.
Click your Zone of interest.
The Maproom will then pull out 6 graphs.
The 3 first ones are respectively the rainfall, maximum temperature and minimum temperature monthly climatologies for that Zone. Identify the rainy season(s).
Report to section 4. Guiding questions: When is (are) the rainy season(s)? Describe the seasonality of maximum and minimum temperature. Include climatological graphs from the Maproom.

The 3 following graphs show the yearly anomalies of seasonal total for rainfall and seasonal average for maximum temperature and minimum temperature. By default the time series span all the years available, that is from 1983 to 2010; and for the January-to-March season.
Select the start and end year that match the availability of your malaria data (for ISDR: 2004 to 2009) and the season you defined as the rainy season looking at the rainfall monthly climatology above.
Validate your choices by clicking the refresh map button.
For each variable, click the **data in graph** link.
This will take you to another page where you can click the **Columnar Table** link to download the time series to your Excel sheet.
Plot the yearly anomalies of seasonal incidence with each of the yearly anomalies of seasonal climate variables you downloaded.
Report to Section 4. Guiding questions: Does the variability of climate variables seem to explain the variability of malaria? Include graphs.

If your time series are long enough (about 15 years or more), compute the correlation between malaria anomalies and each climate variable anomalies.
Report to Section 4. Guiding questions: Is the correlation coefficient significant?

Fill up the contingency table for each variable.
Report to Section 4. Guiding questions: Can you identify more likely co-occurrence of malaria and rainfall variability? Include the contingency tables.

Once filled up, a coefficient is calculated; interpret the results and discuss whether climate variables influence malaria anomalies.
Report to section 4.

Repeat the contingency analysis distinguishing the years with interventions and the years without.
Report to Section 5. Guiding questions: Do you see a difference in the influence of climate variables for the years with intervention compared to the years without intervention? Is there less co-occurrence for those years? Include contingency tables.
Appendix 5 Short reports

Report Template

Section 1: Seasonality of ISDR malaria data and climate data

Section 2: Inter-annual variability of ISDR malaria data and climate data

Section 3: Seasonality of participant malaria data and climate data

Section 4: Inter-annual variability of participant malaria data and climate data

Section 5: Impact of interventions
Appendix 6. Competition

Competition for best proposal that uses the new NMA climate time series in health

Background
As a result of a project funded by Google.org ‘Building Capacity to produce and use climate and environmental information for improving health in East Africa’ the National Meteorology Agency, in collaboration with the International Research Institute for Climate and Society (IRI) at Columbia University, has generated high-resolution rainfall and temperature time series. These Enhanced National Climate Time Series (ENACT) goes back of 30 years at 10-daily time scale and grid resolution of 10km. Products generated from these data are made available via NMA’s Maproom (http://213.55.78.8082/maproom/NMA/), which uses tools from the IRI Data Library. There is a great interest for these data to be used in as many applications as possible. One of these applications could health. Thus, this competition is to encourage proposals to use the new climate time series to improve health outcomes. Selected proposal will be awarded some small amount of money. The proposals may also be submitted for funding.

Objective
To encourage use of the newly generated NMA climate time series in health

Steps:
1. Select 5 concept notes to write full proposal with some demonstration;
2. Select up to three proposals for award.

Award
For the first three proposals depending on the points they get on the evaluation criteria a total amount US$2,200 is allocated which will be divided as follows. US$1,000 for the first, US$ 700 for the second and US$ 500 for the third. The committee has the right to decide the amount of payment for each depending on the level of the quality of the proposal. It is also possible that no award is given if the points obtained are all below 50%.

Ownership
The owners of the proposals are the winners. However, IRI and AMA can submit the proposals for support with the consensus of the winners

Selection criteria
• Originality: Has this been done before?
• Feasibility: Is it doable?
• Is health data available?
• Is it fundable?
• Value of the research: Does it solve a specific problem on the ground?
• Use of climate information: How critical is climate data in the proposed research?
The project will exploit the new Enhanced National Climate TimeSeries (ENACT). Multidisciplinary projects that bridge institutions will be preferred.
Facilitator: AMA (submission could be sent through chwg.ama@gmail.com and or a hard copy with soft copy should be deposited in the AMA office located Chilot Adebaby (Quechenie).

Selection committee
Addis: Hailay Desta, Adugna Woyessa, Hiwot Teka, IRI: Madeleine Thomson, Tufa Dinku

Deadline for submission of Concept Notes: 20/01/2012 Selection of Abstracts by: 25/02/12 Final proposal submission by: 25/04/12 Award by the first week of June.

The concept note should follow the following outline.

**Project Title**
**PI Institutions**

I. Problem description
II. Relevance to improving health practices in Ethiopia
III. Data and Methodology
IV. Activities
V. Expected Outputs
VI. Time frame:
VII. Budget estimate
Appendix 7 Climate and Health in Africa: 10 years on

Report and recommendations:

Available online at: http://iri.columbia.edu/publications/id=1090