iDEWS Summary Report, Fiscal Year 2016

1. Title of Research and Development: Establishment of an Early-warning System for Infectious Diseases in Southern Africa Incorporating Climate Predictions
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4. Results of Research and Development:

With the use of malaria case data collected since 1998, it was revealed that the risk was higher on the east side of the lowlands. On a spatial scale, there was low correlation between risk of infection with rainfall and vegetation cover. As for on the temporal scale, the change of the number of cases was seen to be correlated between rainfall, especially during the rainy season, with a gradually decreasing yearly trend. In the long term, there was an indication that there would be an association with large-scale climate phenomena, such as El Nino.

On the other hand, in recent years, there is a downward trend of malaria incidence, with case numbers in 2014-15 reaching those comparable to 15 years ago. This also suggested the relevance of the large-scale climate phenomena that occurs at a decadal timescale. An observational analysis reveals that the southern African rainfall undergoes a decadal variability as well as seasonal-interannual variability. In order to investigate the low-frequency rainfall variability, we conducted a long-term integration using SINTEX-F2 model with sea-ice model. The model output clearly shows that the low-frequency rainfall variability has a strong relation with the decadal variability of sea surface temperature and sea level pressure, which slowly propagates from the South Atlantic to the southern Indian Ocean (Morioka et al. 2015). Further advances in data mining of infectious disease, such as malaria, would most likely reveal a long-term relationship between infectious diseases and climate variability.

The development of a mathematical model for malaria infection was based on improving the classical Ross model. This model, with the use of the malaria case data from Limpopo province, was successful in estimating the Malthus coefficient for each fiscal year, which characterizes the occurrence of epidemic events for that year. In addition, based on next generation matrix theory, the basic reproduction number was calculated, which led to the derivation of its relationship with the Malthus coefficient using the Euler–Lotka equation. The model will further be improved with the use of field surveillance data of the vector mosquitoes as well as experiments investigating the relationship between mosquito growth and temperature.

As for diarrhea and pneumonia, we were able to obtain hospital data from 2002 for two major hospitals, in which malaria cases are known to be highly abundant. Additionally, insurance companies maintain information about their applicants, such as pharmaceutical sales statistics. With the provision of the hospital and insurance company data, analysis will be initiated.

In regards to the development of the climate model, we achieved a prototype of a new seasonal prediction system called SINTEX-F2, which is based on a high-resolution version of a climate model embedded with a dynamic sea-ice model. We found that the SINTEX-F2 system is more skillful in predicting the Indian Ocean Subtropical Dipole relative to the previous system. It contributes to enhancing prediction skills of the summer rainfall over southern Africa. In addition, the dynamical downscaling using the SINTEX-F2 reforecast experiments successfully improved the regional rainfall distributions over southern Africa. The outcome was already published by Ratnam et al. (2016, J. Climate, http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-15-0435.1).

The recent symposium held in Pretoria, South Africa on 12 October 2015 detailing our research progress in relation to the SATREPS project was published in a meeting report on Eos.org (Ikeda et al., 2016, *Eos, 97,* doi:10.1029/2016EO051401, https://eos.org/meeting-reports/climate-predictions-and-infectious-diseases-in-southern-africa), which is a bi-weekly magazine organized by American Geophysical Union. This site is accessed by AGU members, researchers from other fields as well as the general public, thus giving good exposure to the SATREPS project on a global scale.

In South Africa, there is no seasonal prediction system that includes a sea-ice model. This means that the newly developed SINTEX-F2 prediction system will act as the main driver for the seasonal prediction system for South Africa. Currently, experiments are being conducted. Furthermore, we are in the process of developing an ensemble prediction system using a multi-model approach that combines the seasonal predictions of the South African and Japanese seasonal prediction systems. To ensure smooth operation of the early-warning system, we have assembled a committee for initial provisioning. In addition, we continue to carry out workshops to inform the local community about our research activities for this project.