BMKG

Climate Science and Information Priorities and Needs – Researcher and End User Perspectives

WCRP Climate Research Forum

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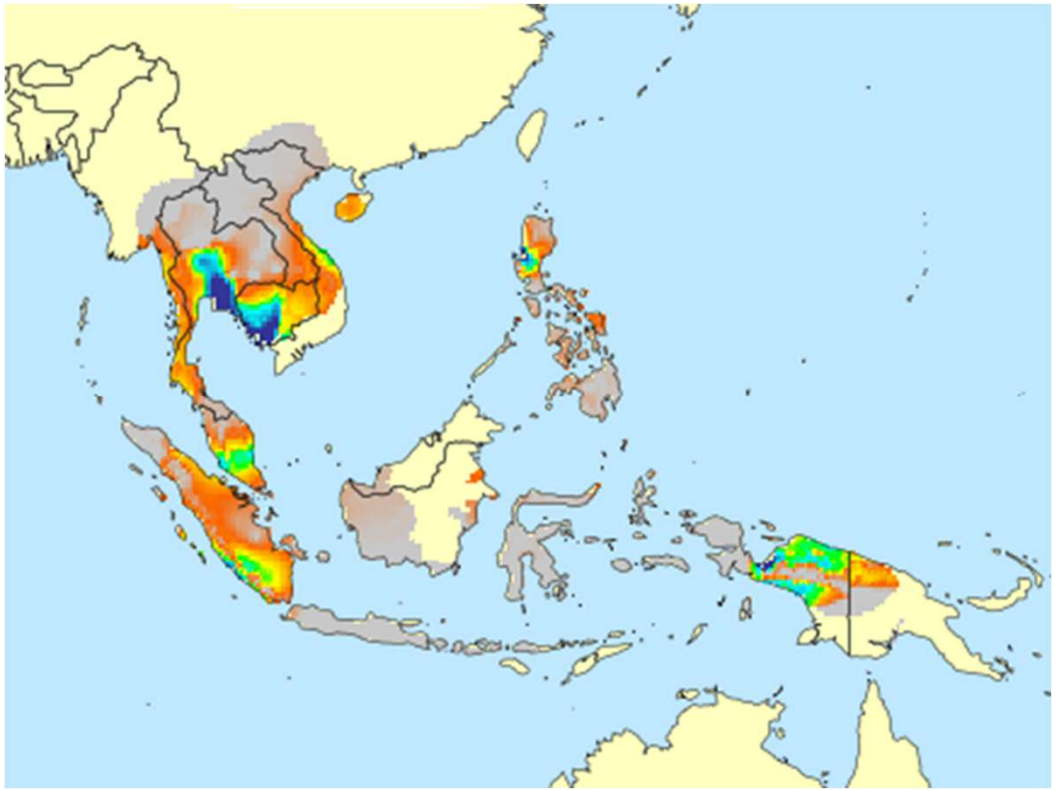
2021.05.25

South East Asia



South East Asia, influenced by:

- ENSO
- IOD
- Monsoon
- MJO
- Tropical Cyclones
- Climate change

These phenomena have caused impacts on various socioeconomic sectors

How is the SDG progressing in the region

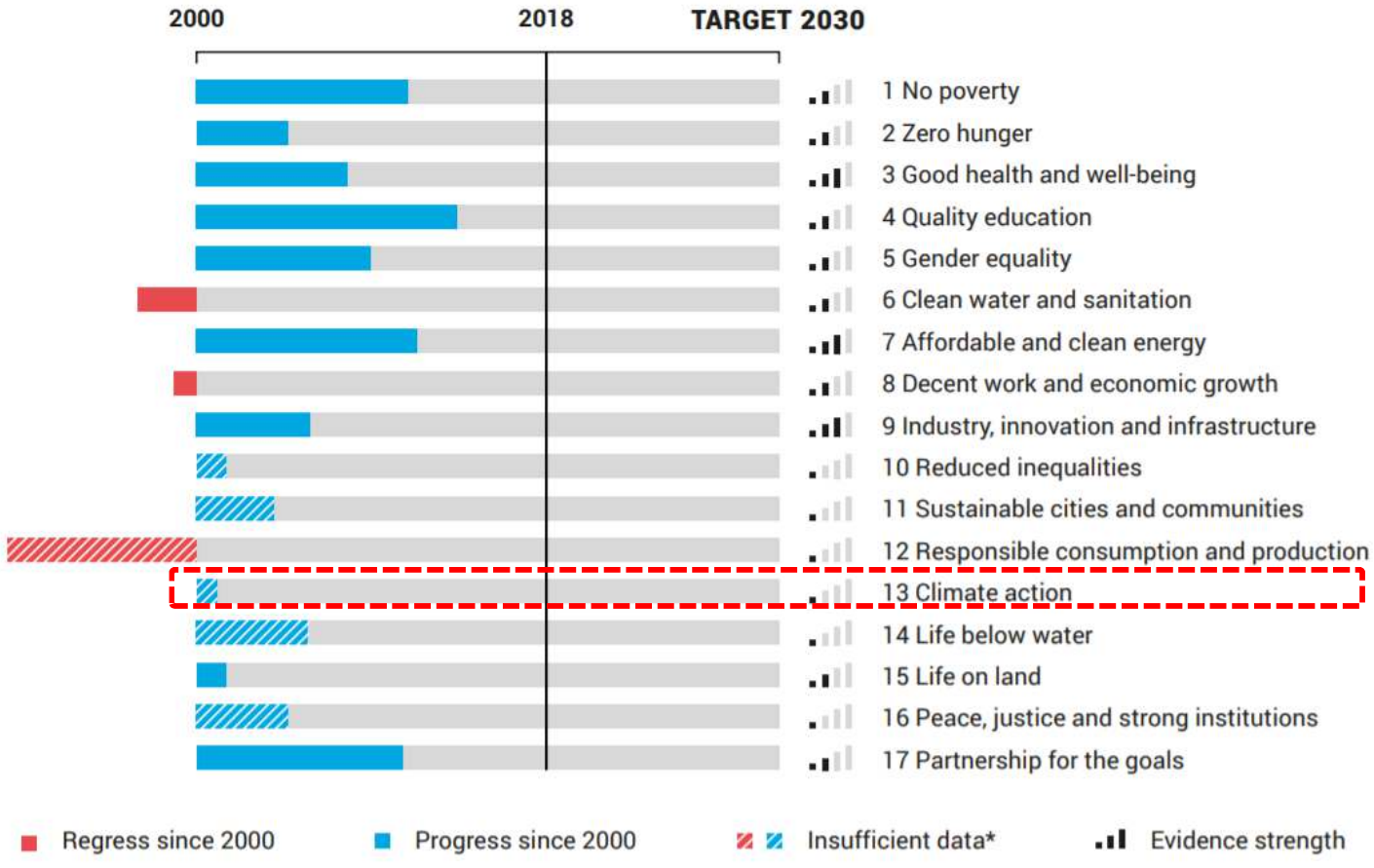


Figure 1 – Snapshot of SDG progress in 2018: Asia-Pacific region

How is the SDG progressing in the region

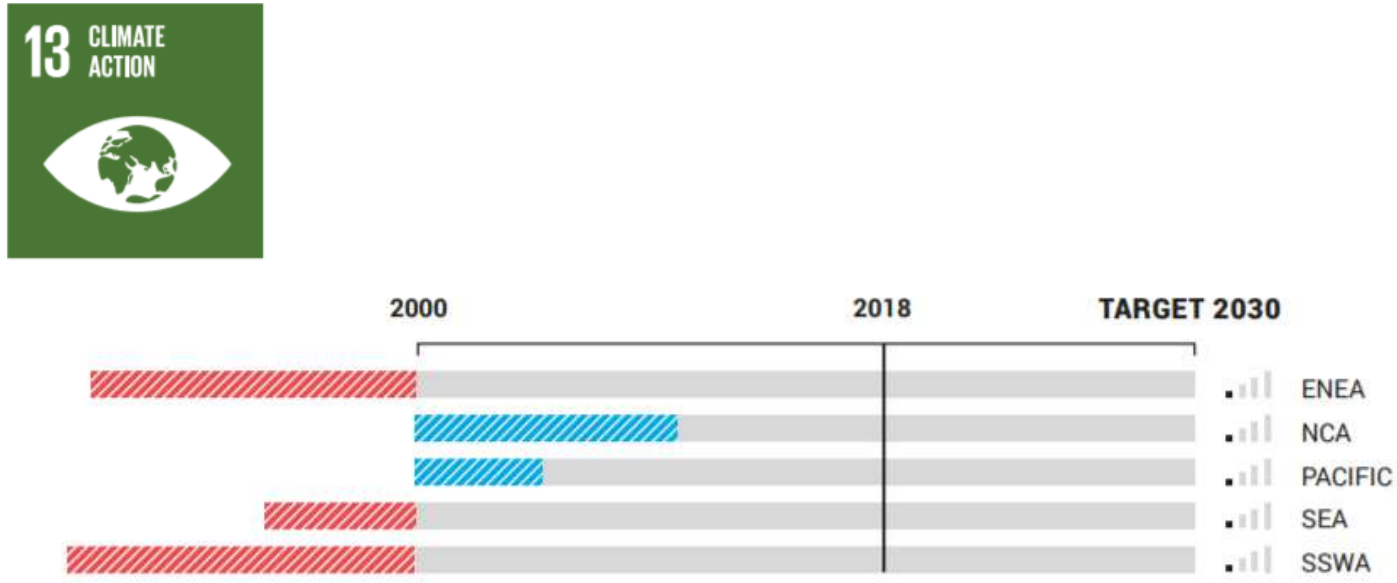


Figure 9 – Goal 13 snapshot by subregion

Figure 10 – Goal 13 dashboard by subregion

ENEA : East and North East Asia
NCA : North and Central Asia
SEA : South East Asia
SSWA: South and South West Asia

Climate sensitive sectors

3-tiered WMO operational infrastructure, can we benefit from this?

WMO Global Producing Centers

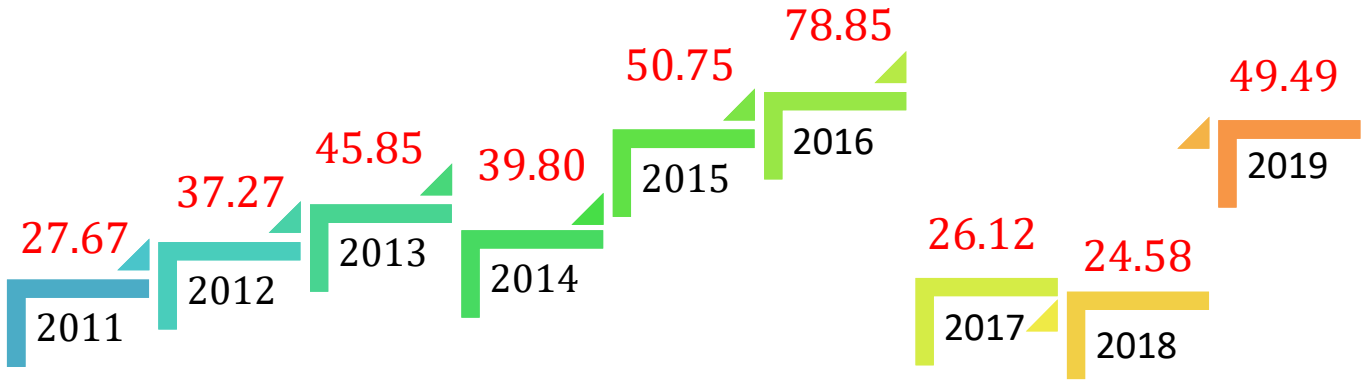
WMO Regional Climate Centers

National Centers

- Without waiting for the forecasts/projections to be ‘perfect’:
- Can we use / tailor forecasts data / products from these Centers for sectoral adaptation to climate variability and change?
- Can the climate research community also contribute in this downstream applications?

Climate Services for sectors

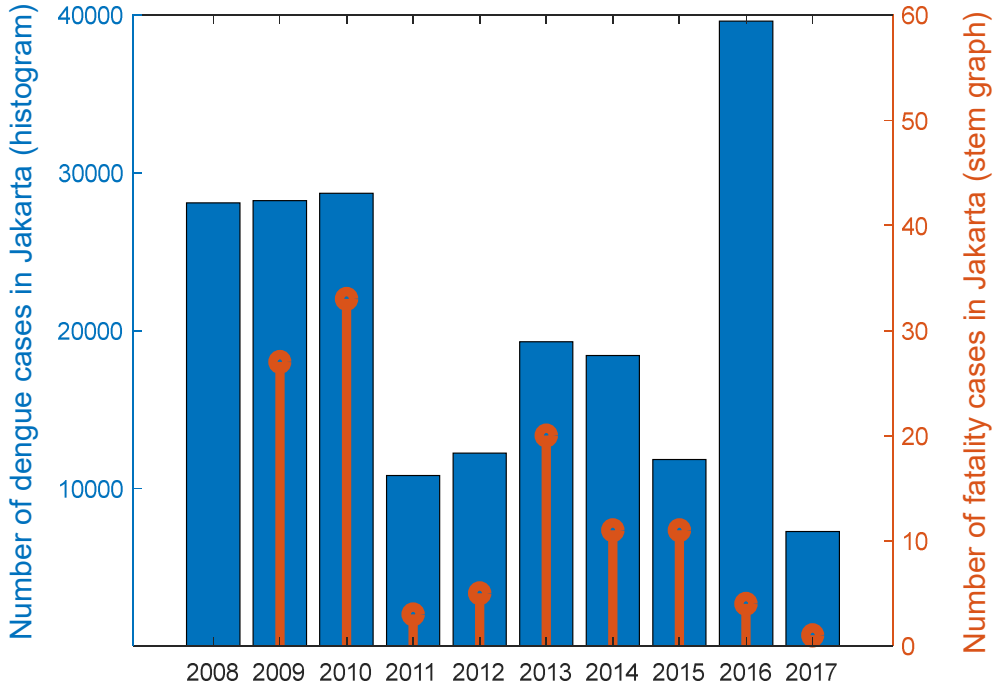
Climate information for Health: Dengue EW in Jakarta



Indicent Rate (IR) : Number of dengue cases per 100.000 population in Indonesia

Increasing IR trend in Indonesia over the past years

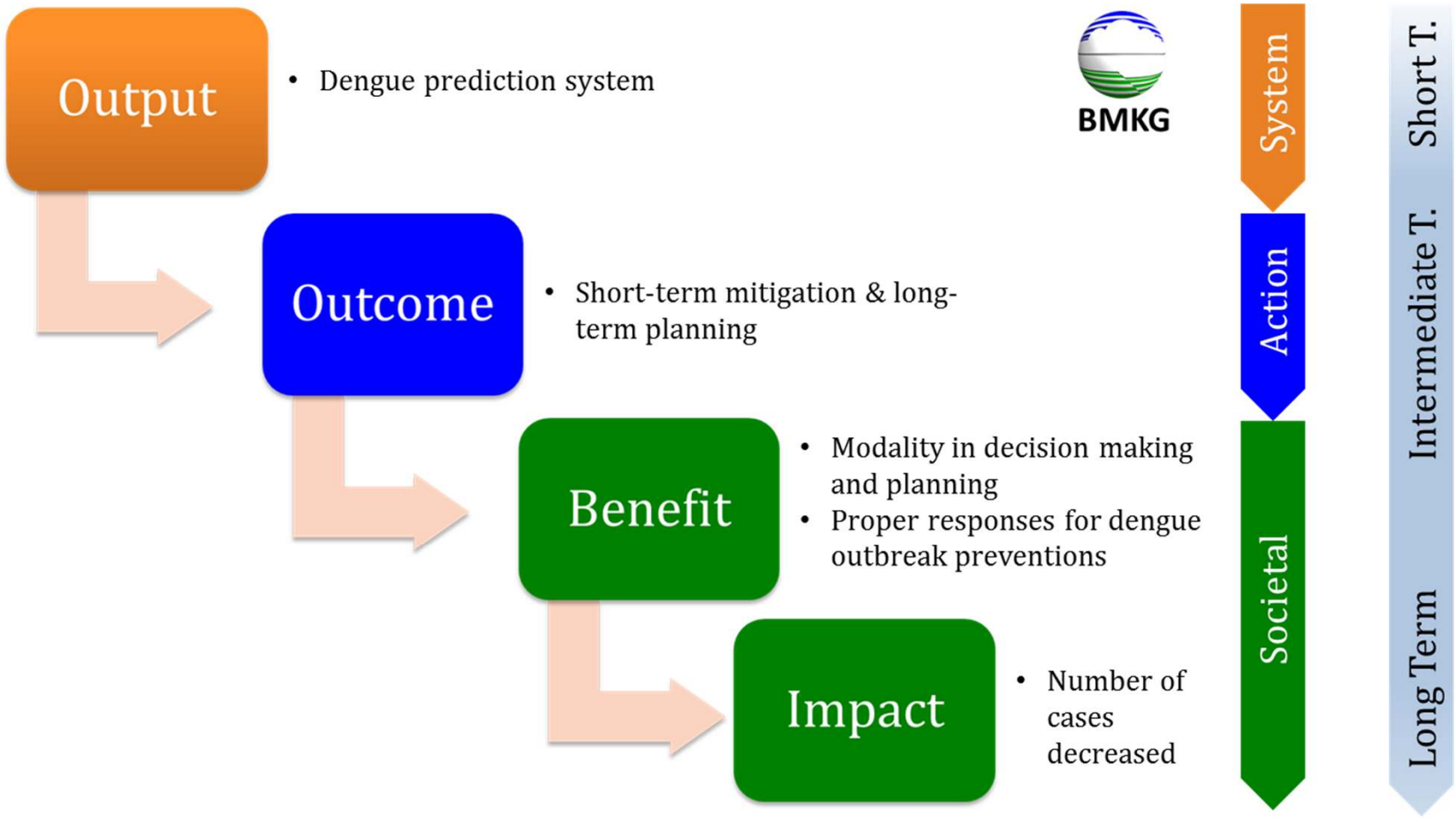
Climate information for Health



The number of dengue cases in Jakarta have been persistently high

Climate information for Health

For **mitigation and planning**, it is necessary to have an **advanced warning for dengue outbreaks**, in addition to the **existing practice of warning based on surveillance that works for immediate responses**.

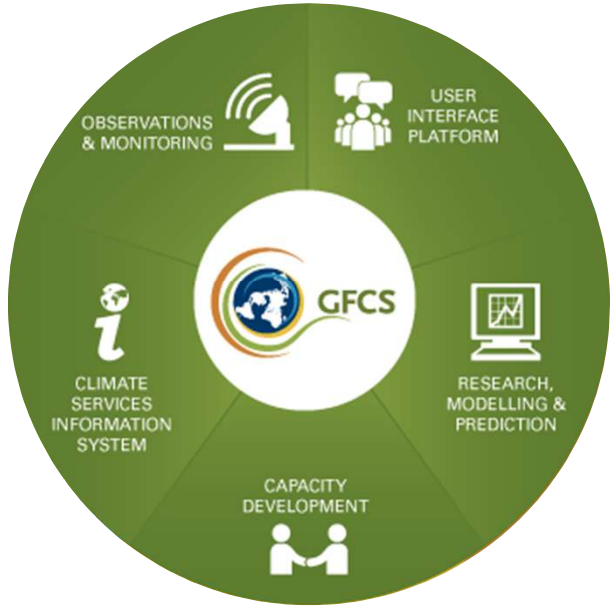


Climate information for Health

Developing Information following the Pillars of GFCS

Climate & health data (dengue cases)

FGD, stakeholders meeting, climate outlook forum



Dengue prediction service

Joint research with universities

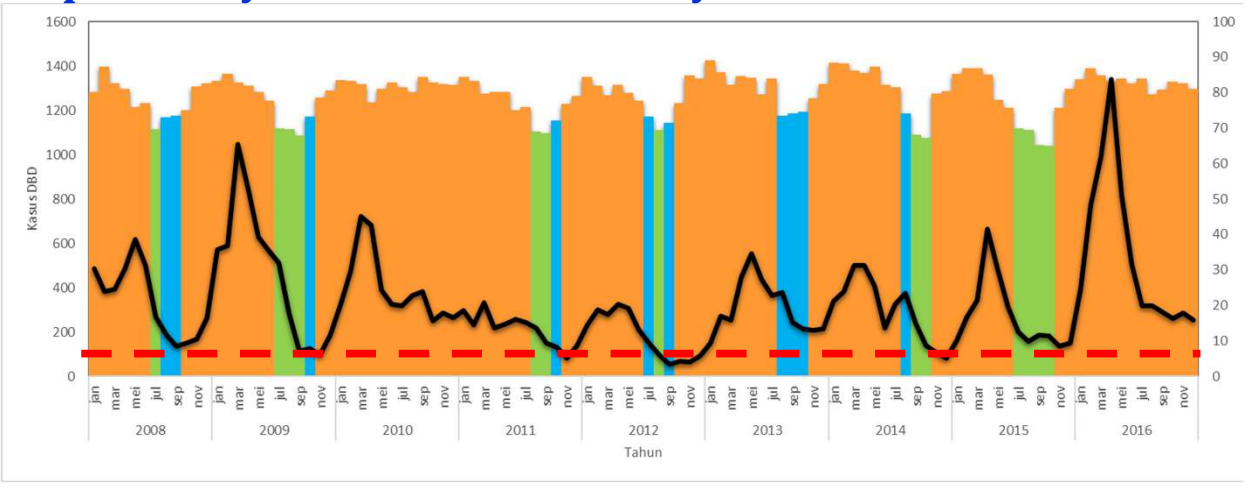
Training for internal and external users

Climate information for Health

Engaging academia through joint research.
Graduate and postgraduate research topics on dengue fever phenomena
(with Bandung Institute of Technology (ITB)).

Climate information for Health

Dependency on Relative Humidity



RH < 70%

RH 70% -75%

RH> 75%

Dengue case

- **Strong correlation with Relative Humidity**
- **Conditions favorable for dengue outbreak is found to be correlated with a certain relative humidity threshold.**
- **Incidence increase (above baseline level) when RH > 75**
- **Incidence sustain (above baseline level) when RH > 75:**

  La Nina in 2010 and 2016

Climate information for Health

Simple model based on negative binomial regression

$$\text{Model 1:} \quad Y_t = \prod_{i=1}^{2} Y_{t-i}^{\alpha_i} . e^{\beta . CLIM_t} e^{\gamma}$$

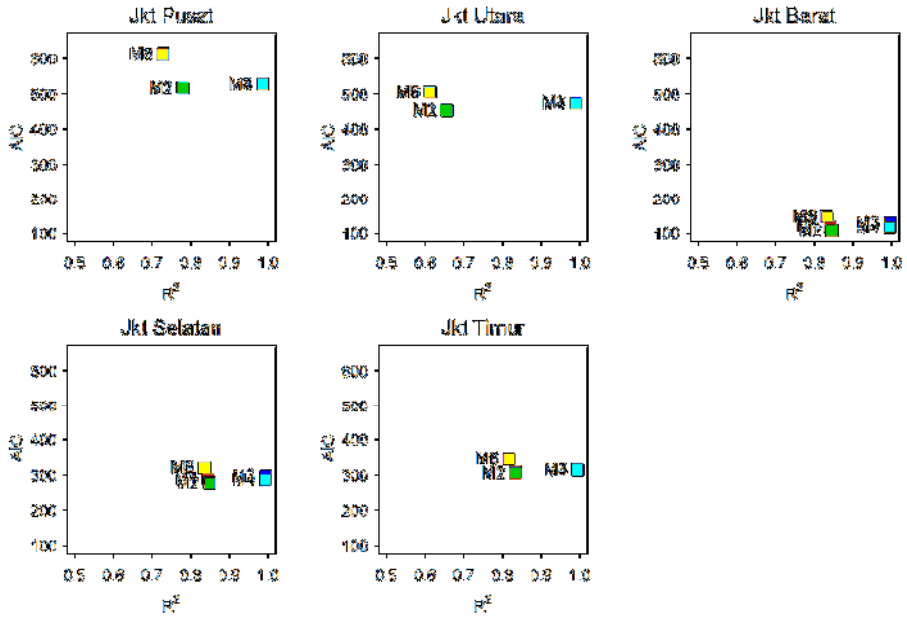
$$\text{Model 2:} \quad Y_t = \prod_{i=1}^{2} Y_{t-i}^{\alpha_i} . e^{\beta . CLIM_{t-1}} e^{\gamma}$$

$$\text{Model 3:} \quad Y_t = \prod_{i=1}^{2} Y_{t-i}^{\alpha_i} . e^{\beta . CLIM_t}$$

$$\text{Model 4:} \quad Y_t = \prod_{i=1}^{2} Y_{t-i}^{\alpha_i} . e^{\beta . CLIM_{t-1}}$$

$CLIM = RR\ , RH\ , T$

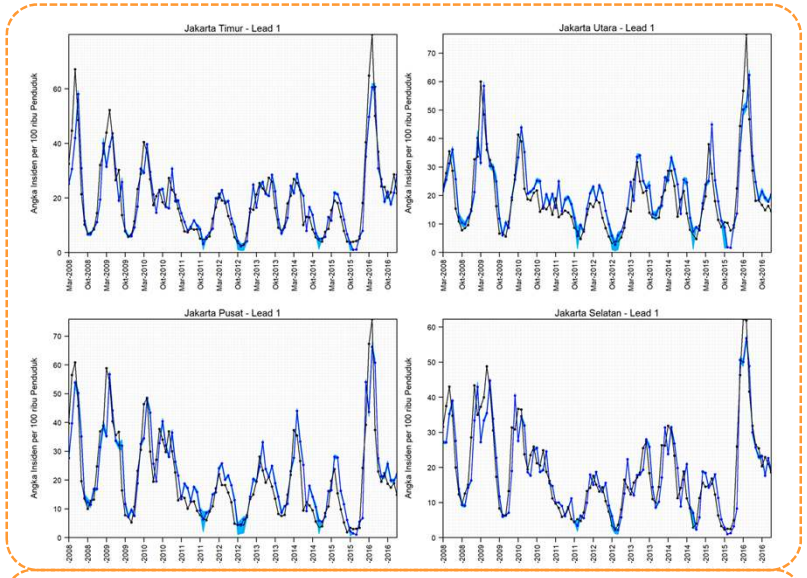
Several alternatives of lag-lead time dependencies on dengue and climate were explored.



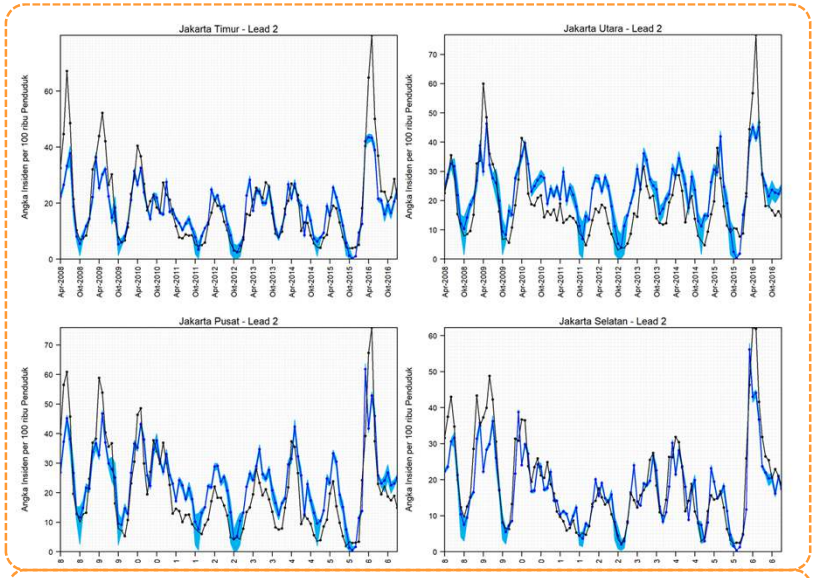
Models were compared in describing the number of dengue cases for 5 municipalities of Jakarta and 'the best' one was selected using R^2 and AIC

Climate information for Health

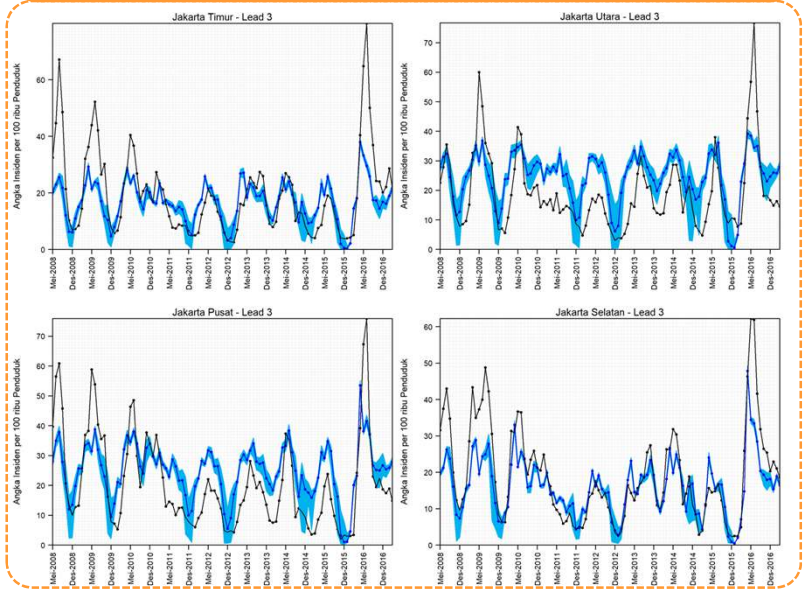
LEAD 1



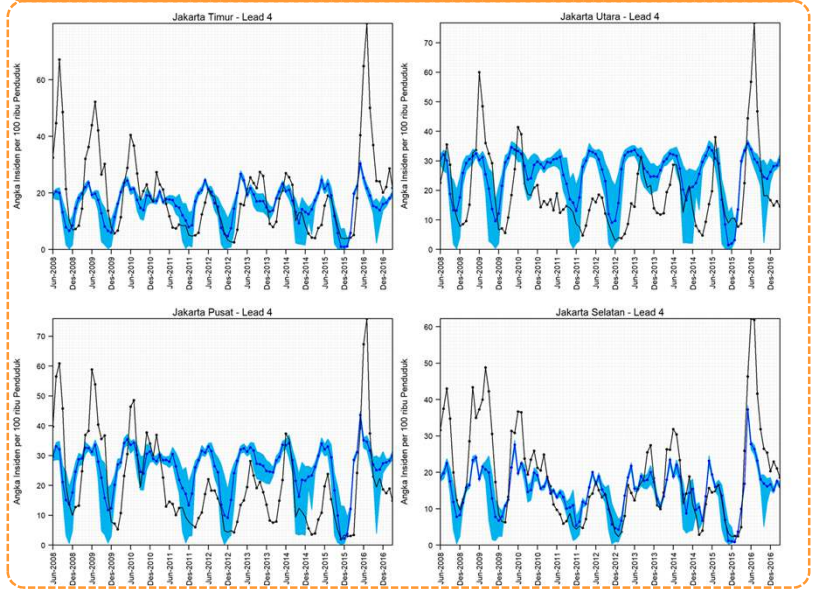
LEAD 2



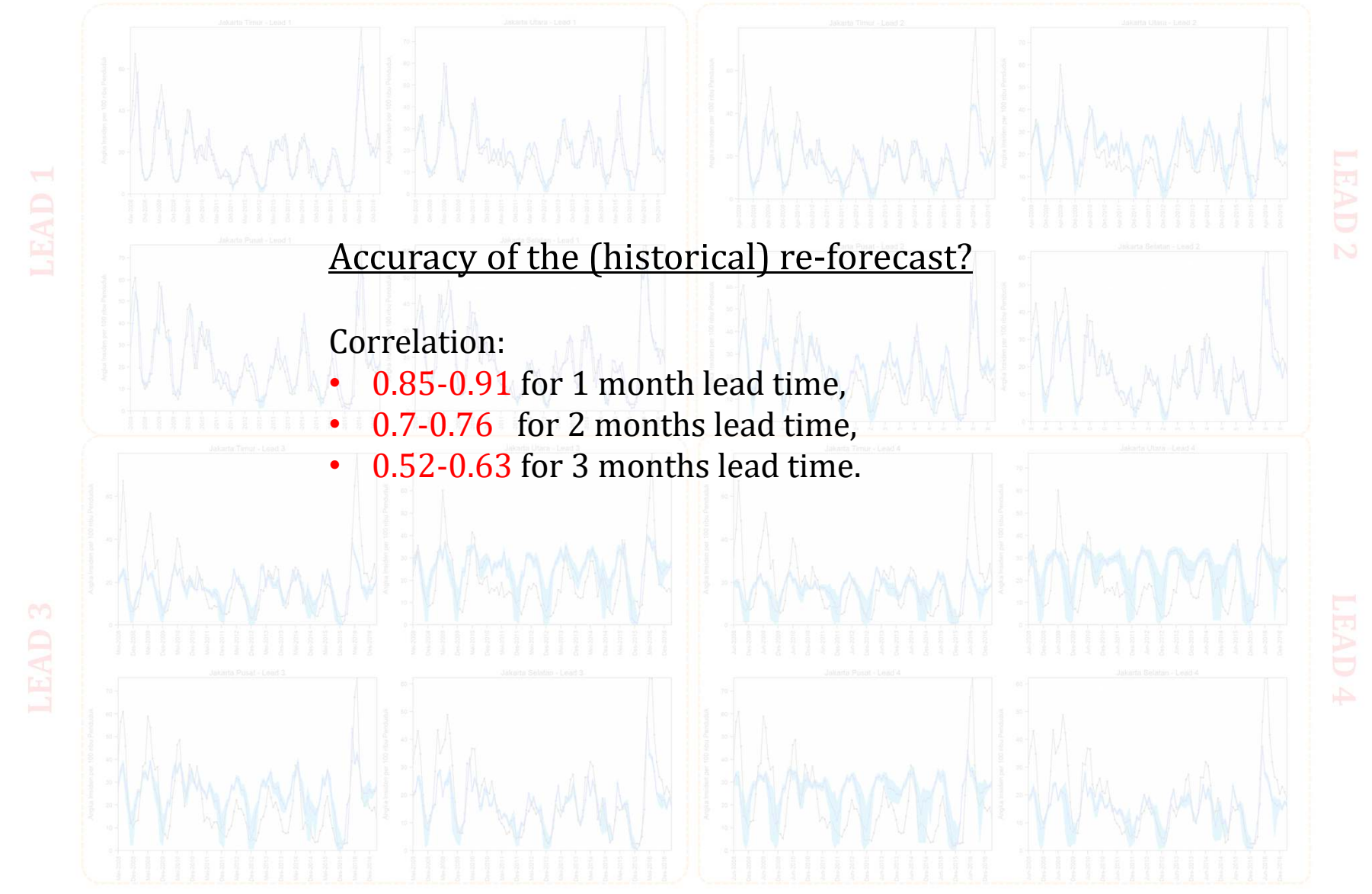
LEAD 3



LEAD 4



Climate information for Health



Accuracy of the (historical) re-forecast?

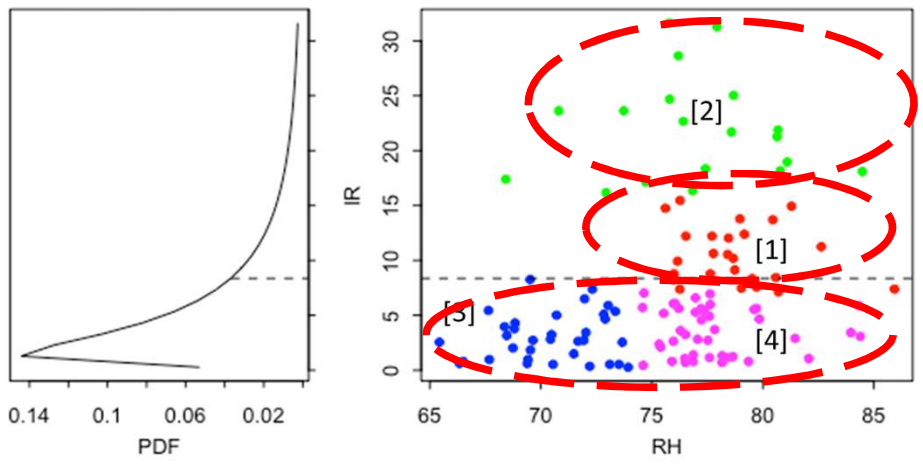
Correlation:

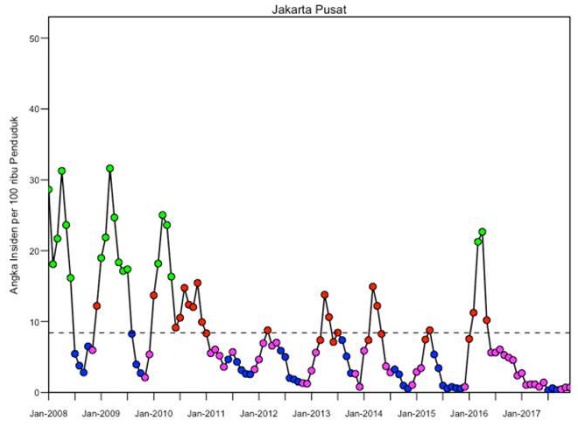
- 0.85-0.91 for 1 month lead time,
- 0.7-0.76 for 2 months lead time,
- 0.52-0.63 for 3 months lead time.

Climate information for Health

Threshold for warning categories?

Clustering with relative humidity





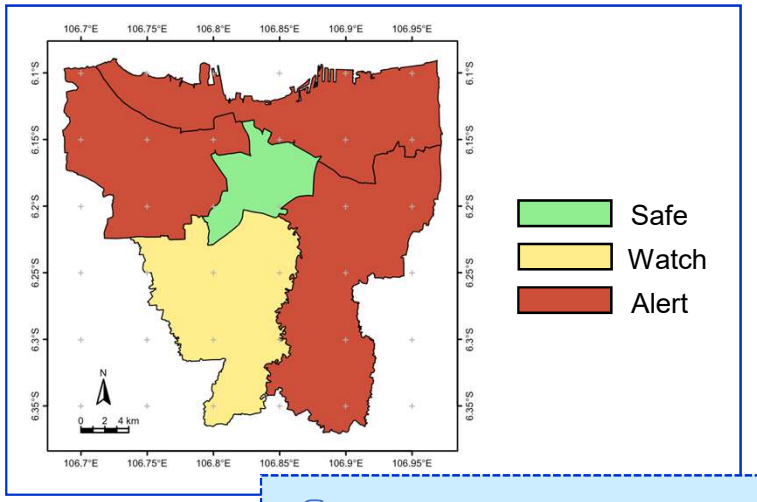
- Although IR is to be predicted, but to take action in the field, information should be based on **"warning categories"**.
- Need to determine thresholds for IR categories.
- The thresholds should be set so that it is not too low (that may cause frequent alarms) or too high (that may cause no alarm).

The agreed thresholds were discussed in a stakeholder meeting (dialogue) with result as follows:

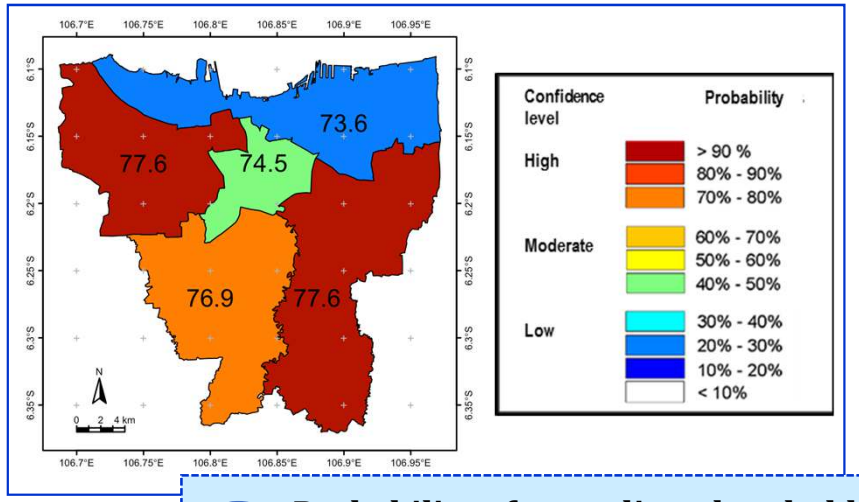
Safe : IR < 3
Watch : 3 ≤ IR < 10
Alert/Outbreak : IR ≥ 10

Climate information for Health

Two products were co-developed for the dengue early warning:



1 **Prediction of dengue incidence rate** (IR) level, up to three months lead time.



2 **Probability of exceeding threshold of a climate index (RH)** indicating conditions **favorable for dengue outbreak**, up to five months lead time.

SAFE
INCIDENT RATE < 3
- Epidemiological investigation
- Outreach and education
- Removal of mosquito breeding sites
- Selective larvaciding

WATCH
INCIDENT RATE 3 - 10
- Epidemiological investigation
- Outreach and education
- Removal of mosquito breeding sites
- Selective larvaciding
- Focused fogging

ALERT
INCIDENT RATE > 10
- Epidemiological investigation
- Outreach and education
- Removal of mosquito breeding sites
- Selective larvaciding
- Focused fogging

The follow-up actions corresponding to each warning level/category that will be taken by the Jakarta Regional Health Agency are also provided as a **general guidance.**

Scientific results

Geophysical Research Abstracts
Vol. 21, EGU2019-**PREVIEW**, 2019
EGU General Assembly 2019

The way of dengue prediction via climate factor; a case study in Jakarta, Indonesia

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Dengue incidence has been increasing dramatically in the last few years. It is indicated that this wide-spread of dengue is due to climate variability and population density in the affected regions. Climate change impacts on ecosystem have been indicated as the main factor in the unpredictability of vector breeding behavior. It is necessary that this climate factor should be well integrated into the dynamical model of dengue outbreak. This paper aims to construct an early warning model for predicting dengue incidence based on rainfall, relative humidity, and dengue incidence data in Jakarta. The data used are dengue data in Jakarta obtained from Jakarta City Health Office and climate data from Meteorology, Climatology and Geophysics Agency (BMKG) in the period 2008-2016. Cross-correlation is used in determining time-lag and analyzing the relationship between rainfall, humidity and dengue incidence. With time-lag multiple regression model which is based on rainfall, temperature, and relative humidity, the approximation of time-dependent dengue incidence constructed. Further improvement is made with correction terms involving one preceding month accumulating dengue incidence. The various models with a combination of factors are analyzed based on the best curve fitting and factor significance. The four best models are obtained and presented as consideration by decision makers. This result can provide early warning dengue incidence quite accurately, which could be used for initial prevention strategy by the health authority.

Keyword: Dengue, climate, correlation, regression

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Assessing the interplay between dengue incidence and weather in Jakarta via a clustering integrated multiple regression model

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ARTICLE INFO

Keywords:
Dengue
Rainfall
Humidity
Cross-correlation
Clustering
Multiple regression.

ABSTRACT

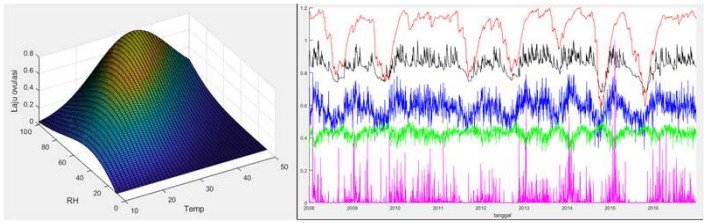
Dengue incidence has been increasing dramatically in last few years with nearly four hundred million annual cases worldwide. It has been postulated that the wide-spread of dengue be due to climate change and increased exposure following the increasing human population in the affected regions. Climate change impacts on ecosystem have also set a critical role in the unpredictability of vector breeding behavior. A compelling strategy in the modeling of dengue outbreak must therefore integrate climate factors inasmuch as they determinedly govern incidence patterns. The aim of this paper is to construct a clustering integrated multiple regression model for predicting dengue incidence rate based on incidence, rainfall, and humidity data, which renders early warning information. The data used were dengue incidence data in Jakarta obtained from Jakarta Health Office and meteorological data from Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) in the period 2008–2016, defined on weekly basis. Cross-correlation was used to determine the interrelationship between dengue, rainfall, and relative humidity in Jakarta. Further improvement of the model was done by instrumenting the accumulated preceding one-month dengue incidence as an additional correction term in the model. The best fittings in terms of outbreak catchment and minimal mean squared error were obtained from the model variants involving the accumulated original and logarithm of the incidence rates respectively. Both the historical incidence rate locale and centroids of the meteorological data related to the clustering as well as the accumulated incidence rate serve as the key determinant for the upcoming incidence rate. An optimal clustering was determined in a way that the mean squared error achieves its foremost minimum, which almost coincides with the division into tertiles. These clustering strategies can be utilized to provide a more accurate forecast of the ominous dengue incidence for a few weeks' lead-time.

Ongoing:

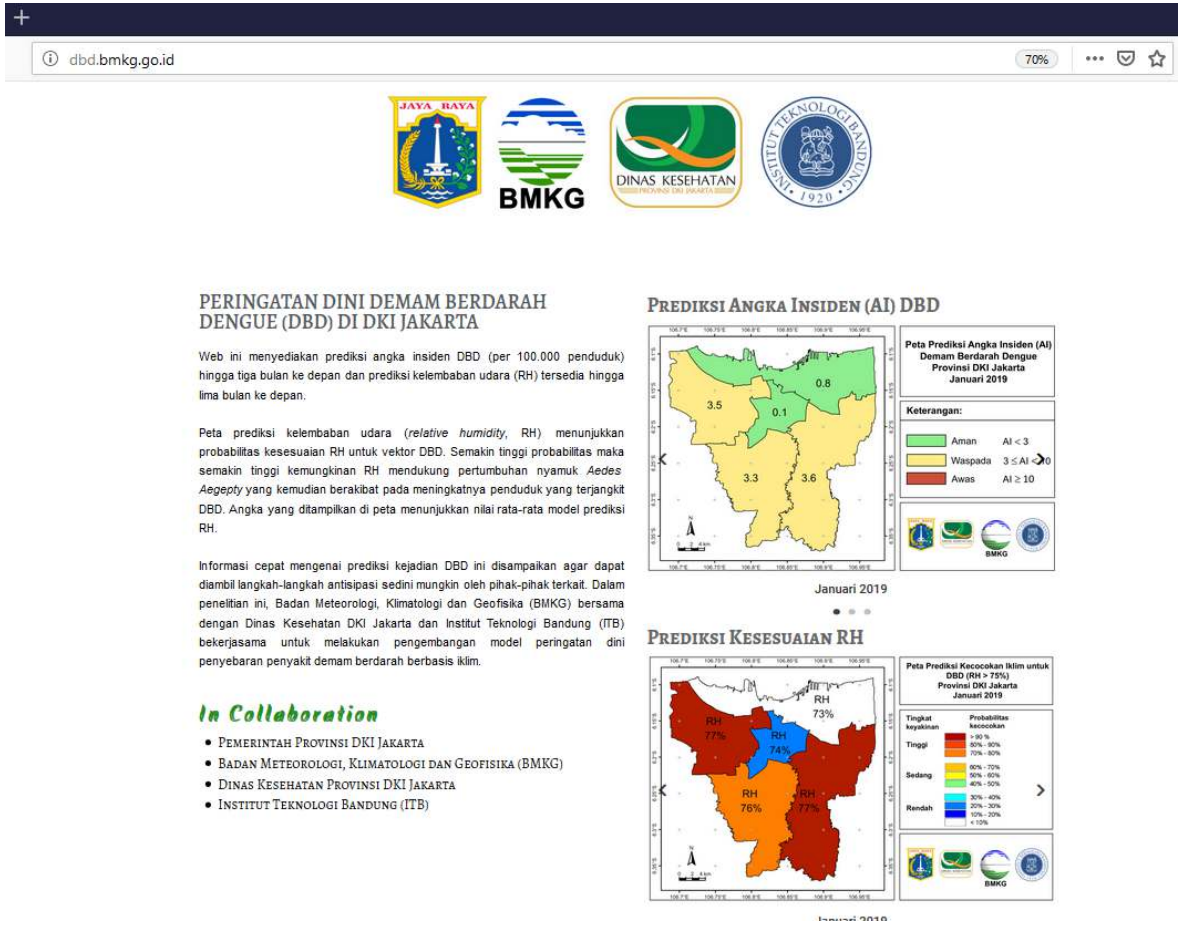
Climate Factor Influencing the Spatio-Temporal Population Dynamics of Ae. Ageypti

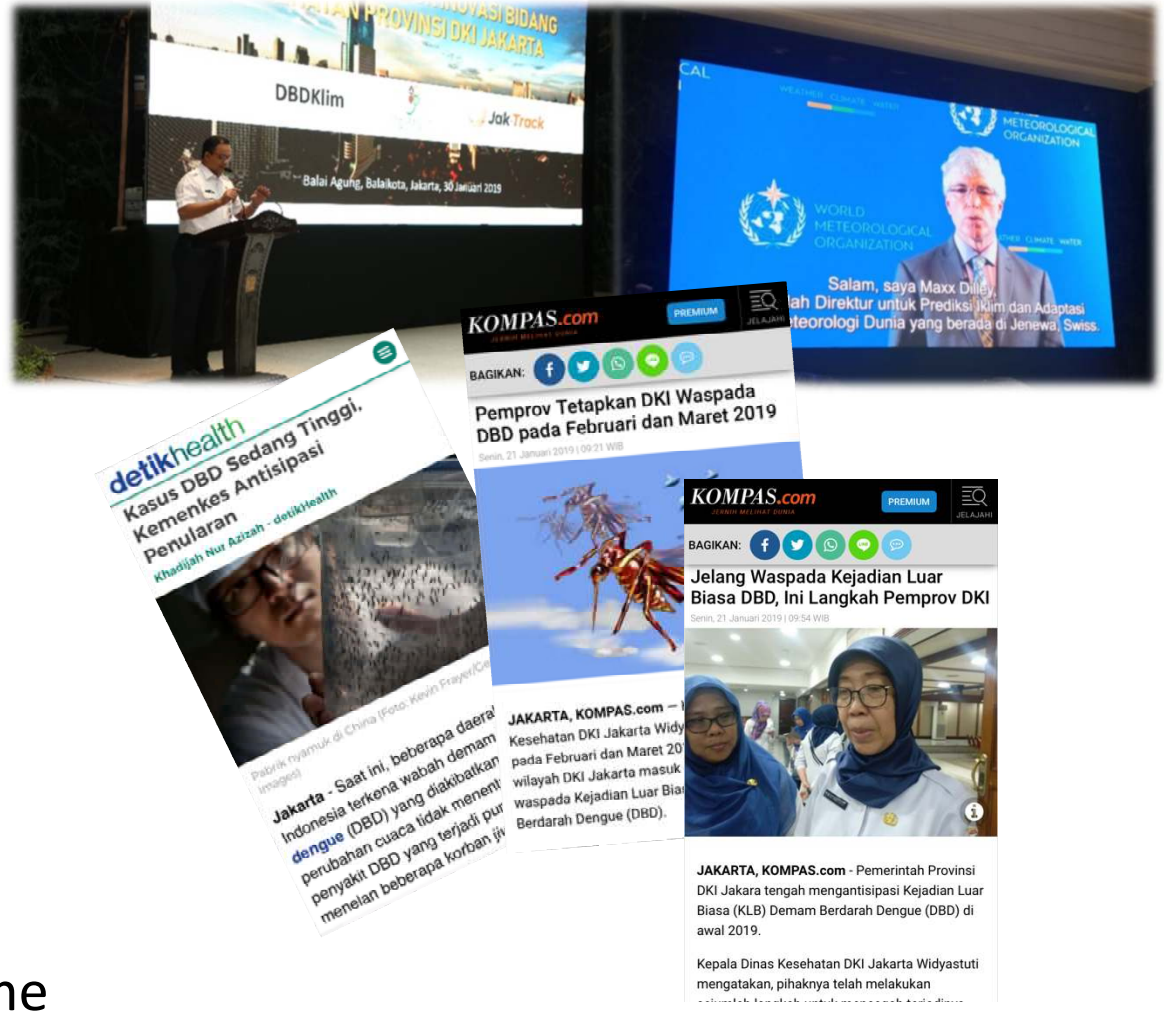
Larvae – Mosquito model

$$\frac{dL(t)}{dt} = \gamma\phi\rho M(t)\left[1 - \frac{L^p}{C^p}\right] - \delta_m L(t) - \mu_l[L(t) - \delta_m L(t)]$$
$$\frac{dM(t)}{dt} = \delta_m L(t) - \mu_m M(t)$$



Climate information for Health





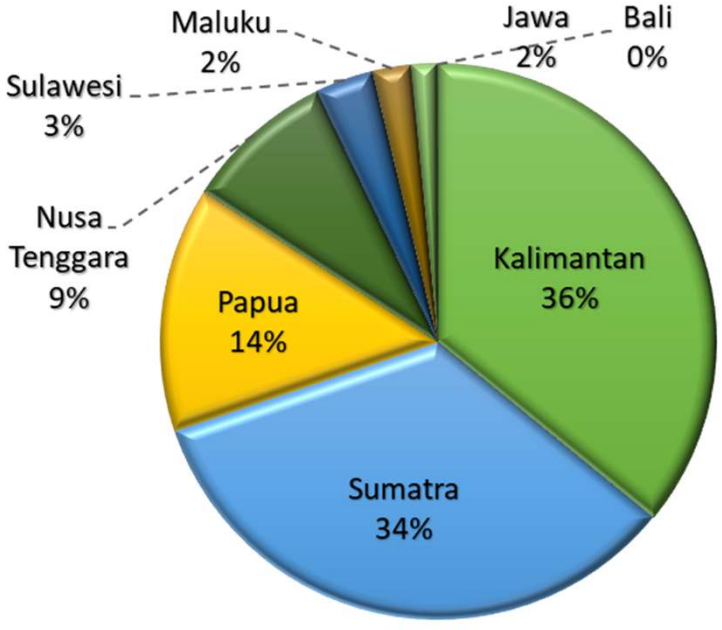
- Early warning for dengue, 3 months lead time
- http://dbd.bmkg.go.id

Climate information for Health

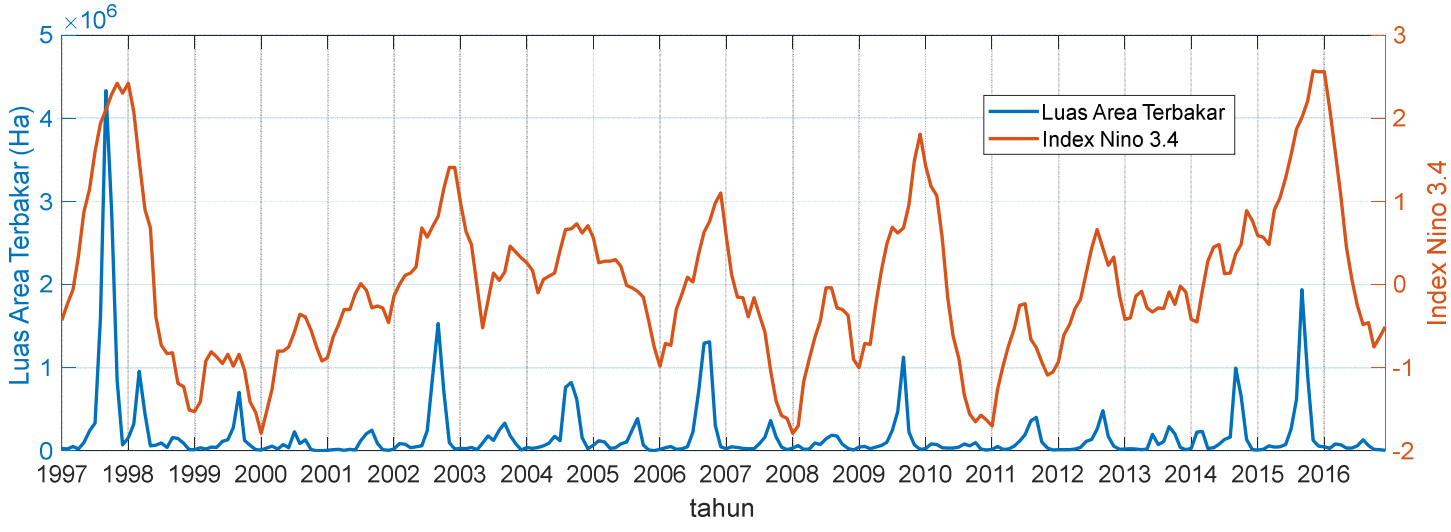
Field actions based on warning information

Climate Services for sectors

Climate Information for Forestry: EW for wildfire



Percentage of wildfire in Indonesia 2015-2020 (Sipongi, Min. Env & Forestry, 2021)



Burnt area using satellite derived estimate GFED5 (blue) and Nino3.4 index (red) for the year 1997-2016

Major wildfire event much related to strong climate signal (El Nino and positive IOD)

Climate Information for Forestry

- **Multivariate approach using Copula (climate and sector indices / number of hotspots)** for climate information for forestry.
- **Why this approach:** possible to 'connect" probabilistic seasonal forecast to probabilistic sectoral information.
- **In WMO's term:** probabilistic seasonal forecast – inline with objective seasonal forecast

❑ Copula

If X is a random variable with vector $X_1, X_2, \dots, X_m$ and marginal CDF $F_{X_1}, F_{X_2} \dots, F_{X_m}$

- Copula is defined as a function with connects multivariate distribution F_X and their univariate marginals $F_{X_i}(x_i)$, as follows

$$F_X = C_X\left(F_{X_1}(x_1), \dots, F_{X_m}(x_m)\right)$$

with $C_X : [0,1]^m \rightarrow [0,1]$.

- Assume that $F_{X_1}, \dots, F_{X_m}$ is continuous and differentiable, then C_X is unique as follows

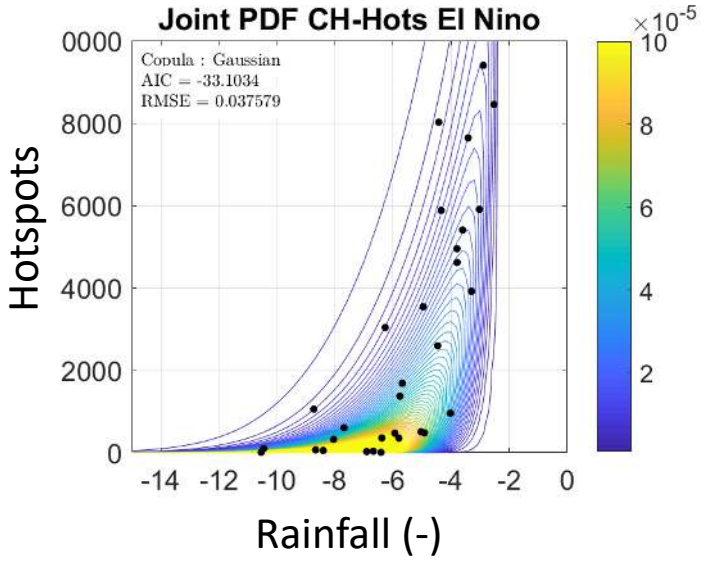
$$C_X(u_1, \dots, u_m) = \int_0^{u_1} \cdots \int_0^{u_m} c_X\,(u_1', \dots, u_m')du_1' \cdots du_m'$$

with $u_j = F_{X_j}(x_j)$. The function C_X is the Copula function and c_X is the pdf.

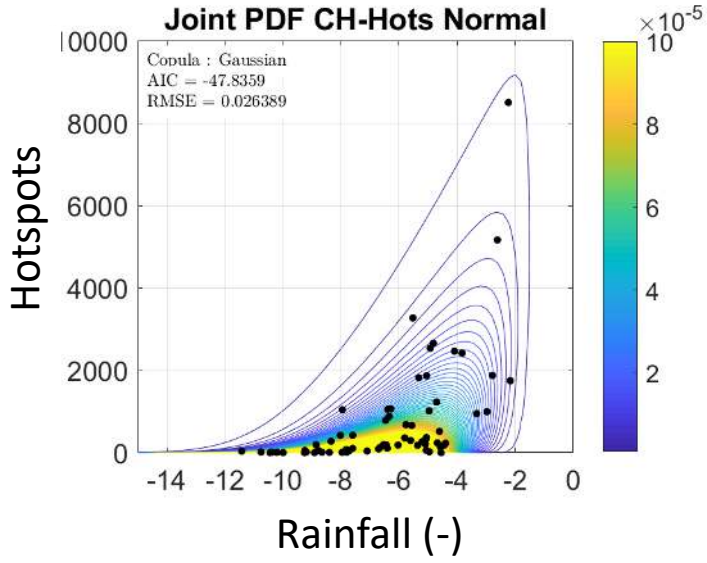
$$f_X(x) = f_{X_1}(x_1) \cdots f_{X_m}(x_m) \cdot c_X(u_1, \dots, u_m)$$

- Joint pdfs can be written as a product of marginals $f_{X_1}, \dots, f_{X_m}$ and the pdf of copula c_x,

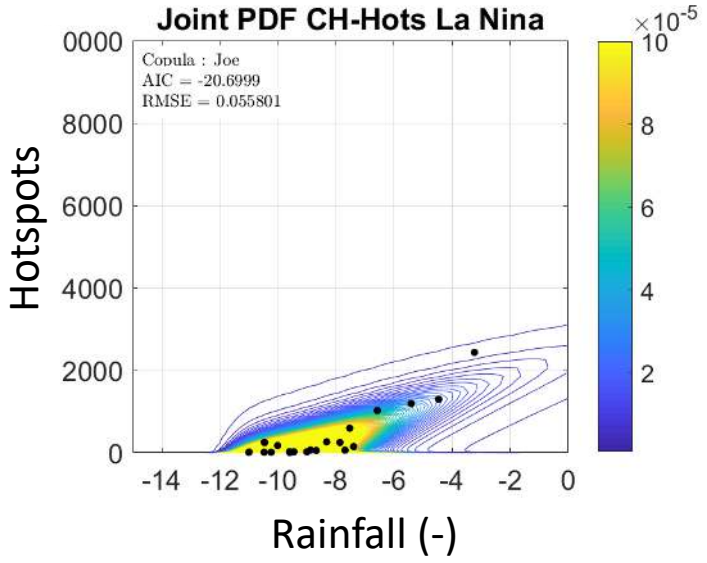
Climate Information for Forestry



EL NINO



NORMAL



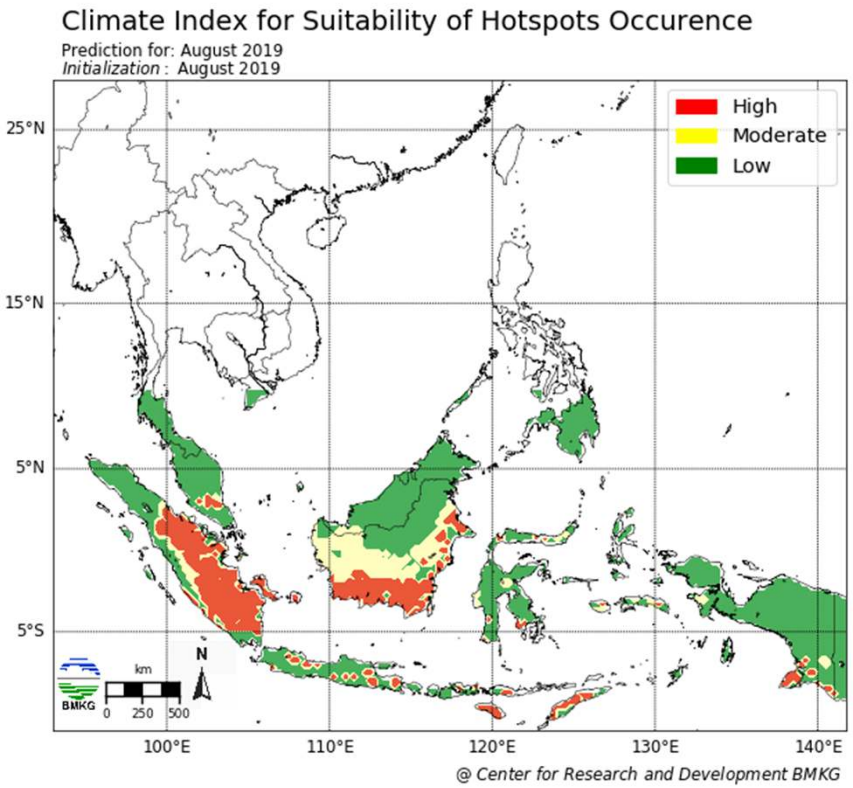
LA NINA

Probabilistic information on rainfall → **probabilistic information on hotspots risk** through conditional probability

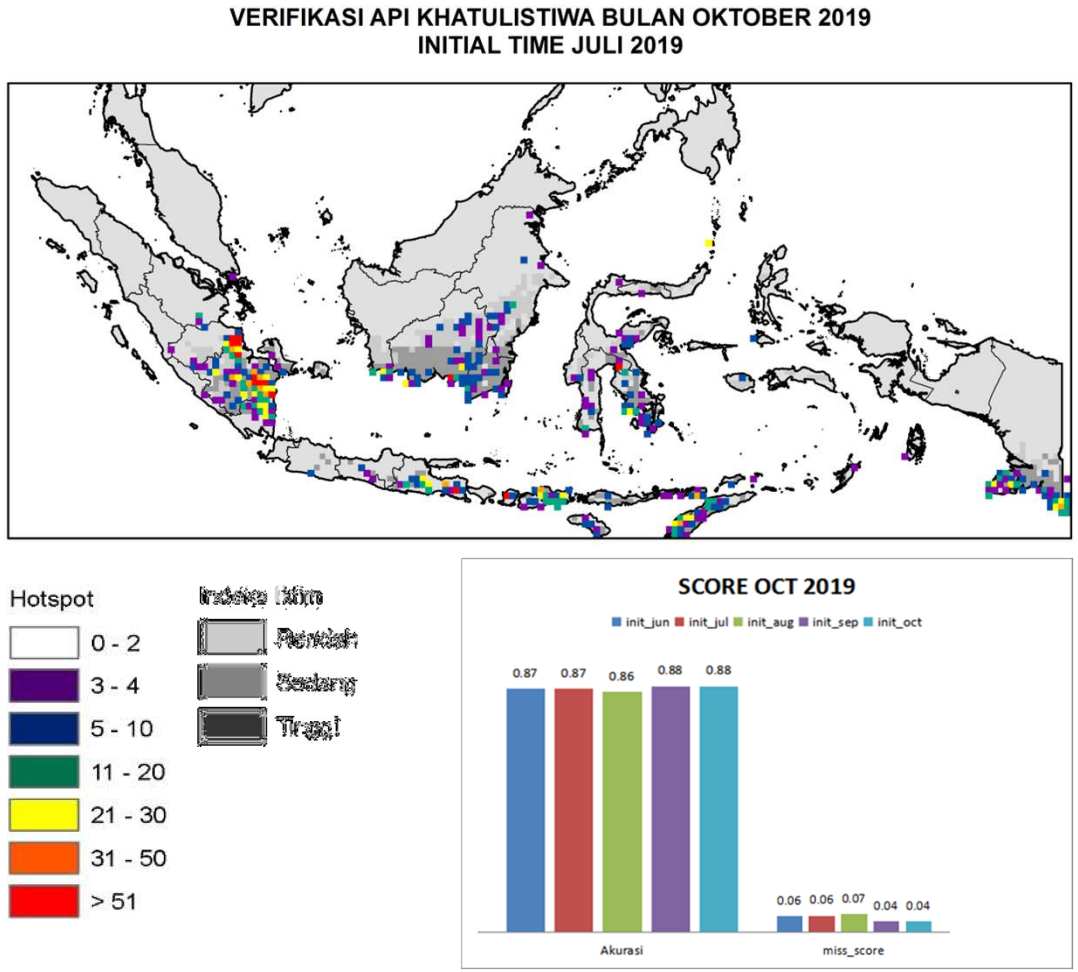
Climate Information for Forestry

"API KHATULISTIWA"

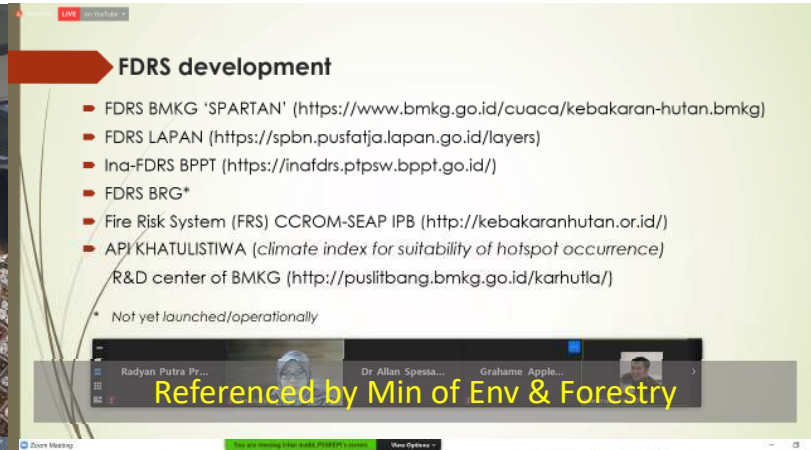
(Aplikasi Peringatan Dini Kebakaran Hutan dan Tutupan Lahan Berbasis Hotspot dan Iklim Wilayah ASEAN)

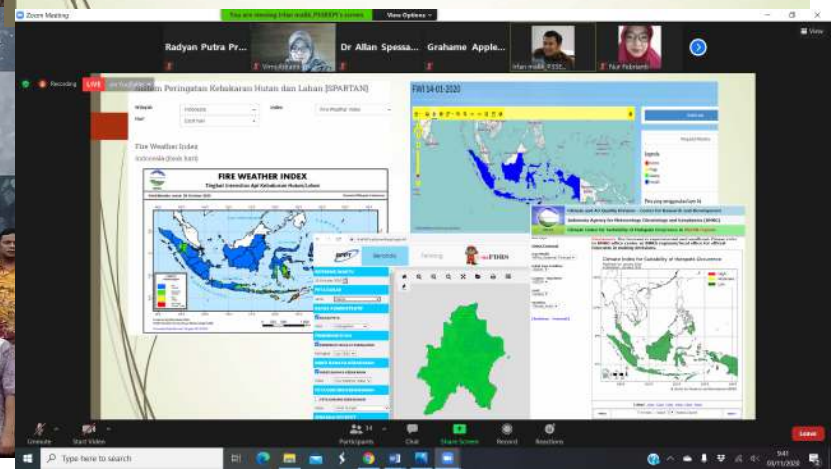


Verification for 4 month lead time



Outreach of this information to the users





Closing pointers

- General agreement: urgency to adapt to climate variability and change, now.
- There is still ample opportunities for climate services application in South East Asia.

Questions:

- How can the society benefit from data and products from the operational centers (and research results), to make sectoral / tailored products for adaptation and mitigation?
- How can the research community help in expediting operationalization of research results to operation?
- A WCRP research theme on application of climate information for sectors?

BMKG

Thank You

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