STATE OF THE ART STUDY ON METEOROLOGY IN INDONESIA

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1. Introduction

Meteorology is the study of the physical processes and phenomena of the earth's atmosphere, especially the study of weather. The altitude of the earth's atmosphere from mean sea level up to the fringe of the earth (± 1000 km). Base on the profile of vertical temperature, the earth's atmosphere can be divided into : troposphere, stratosphere, mesosphere, termosphere and exosphere. Weather phenomena occur in the lower atmosphere, principally in the troposphere layer. Atmosphere over Indonesia is complex and the formation of cloud is unique. Convective clouds are dominant in Indonesia.

Indonesia is a part of the earth system as a natural unity between atmosphere, hydrosphere, litosphere and kryosphere (as on top of Mount Jaya Wijaya, Papua). The earth is a member of solar system revolting around the sun through an elliptical orbit with the excentricity 0.017 and the period of one year (365.3 days). The nearest distance of the earth from the sun is 91.5×10^6 miles, called "perihelion" and the farthest is 94.5×10^6 miles called "aphelion". The average distance of the earth from the sun is 93.0×10^6 miles (150×10^6 km), called one astronomical unit (1 AU). The earth rotates arround the imaginary axis by the period of one day (23 hours, 56 minutes, 42 seconds), so that the angular velocity of the earth's rotation is :

$$\Omega = \frac{2\pi \text{ rad}}{23 \times 60 \times 60\text{s} + 56 \times 60\text{s} + 42\text{s}} = 7.29 \times 10^{-5} \text{ rad s}^{-1}$$

The impact of the earth's revolution and rotation is season namely; winter, spring, summer, and autumn. Base on the number of rainfall per 10 days, the season in Indonesia is categorized into rainy and dry seasons. The rainfall limit of the two seasons is 50 mm per 10 days. When the monsoon is considered, the Indonesian

region has 4 seasons namely; west monsoon, east monsoon, and two transition periods indicated by variable winds.

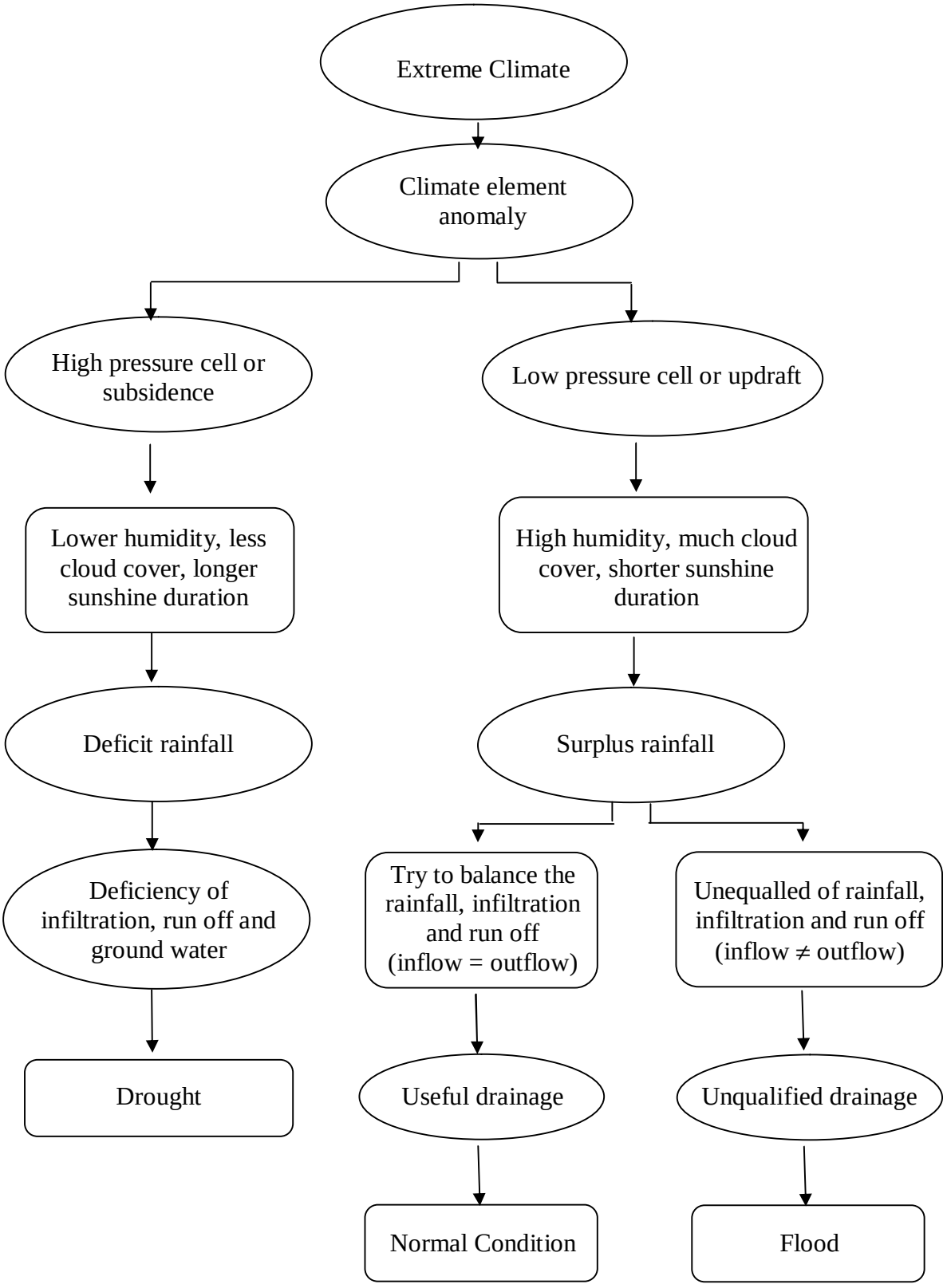

Figure 1. Diagram schematic of drought and flood events.

The Indonesian region is governed by monsoon Australasia. Monsoon Asia is more humid, it causes rainy season and frequently flood events. While monsoon Australia is less humid, it causes dry season and frequently drought events. Due to climate variation, flood and drought are meteorological disaster which alternatively to wash some places in the Indonesian region. The intensity of flood / drought increase when monsoon Asia/Australia are accompanied by La Niña / El Niño. The principle factors involved in the mechanism of flood and drought is shown in figure 1.

2. Geographical and Meteorological Position of Indonesia

The term "tropics" come from the tropics of Cancer (23.5^0 N) and tropics of Capricorn (23.5^0 S), which indicate the outer limits of the area where the sun can be in a zenith position[1]. The tropical areas may be bordered by these two lines. Another boundary of the tropics proposed by meteorologists i.e, the axis of the subtropical high pressure cells, wich is the boundary between easterlies in the tropics and westerlies winds in mid latitude of 30^0 N and 30^0 S called by horse latitude. In the horse latitude areas occur air subsidence, consequently the number of rainfall is less, so that these areas are dominated by desert or steppe regions.

Equatorial region may be defined as a region bordered by latitudes 10^0 N and 10^0 S or Coriolis parameter, $f = 2\Omega \sin \phi = 2{,}5 \times 10^{-5}\ s^{-1}$, where ϕ is geographical latitude. At the equator (latitude 0^0), the Coriolis force toward zero. From this definition, the Indonesian maritime continent may be called the equatorial region. The Indonesian region is the bigest island country in the world which has coastline about 80.8 km[2]. The Indonesian regions consist of 17,508 big and small islands with 70% is waters and only 30% island. Figure 2, shows the geographical position of the Indonesian maritime continent with respect to other oceans and continents in the world.

Besides it is passed by geographical equator, the Indonesian region is also passed by climatological equator namely the Intertropical Convergence Zone (ICZ) deplacing toward northern and southern hemisphere follows vice versa apparent deplacement of the sun from tropic of cancer on 22nd June to tropic of capricorn on 22nd December. The minimum of Coriolis parameter (f) in which tropical storm emerge is in latitude 5^0 ($f = 1{,}3 \times 10^{-5}\ s^{-1}$) or more[3]. Due to the Coriolis parameter is

small, so that the tropical cyclone emerge rarely in Indonesia, but tropical depression may occur in the Indonesian waters, for example in Arafuru sea[4].

A main characteristic of the Indonesian region is the mixture of land and sea surface, which makes it a “maritime continent”. The mixture of sea and land, and the mountainous character of most islands, creates a large variety of local climates mainly depending on exposure to the monsoon and elevation. The Indonesian region is home to arround 205 million people. Most of these people live derectly or indirectly from what the land produces, so the climate is a very important factors in their lives.

3. Role of the Indonesian Region against Global Climate

a. Indonesia as an Equatorial Region

As an equatorial region, Indonesia has maximum insolation and latent heat of condensation released by change of water phase from liquid to vapor. Each gram of water vapor condensed to water droplet will released latent heat of about 2450 joule. On 21 March and 23 September occur equinoxes i.e., the position of the sun at the equator twice in one year. The impact of the equinoxes is marked in the monthly rainfall distribution showing double maxima, for instance for stations of Padang, Sumatera and Pontianak, Kalimantan, see figure 3. The equatorial region receives surplus energy in summer and winter, as it is shown in figure 4. Convergence occurs where air flows decelerate as occurs is the trades as they approach equatorial latitudes. Confluence also results in vertical air movements and thus instability indirectly. This confluence is expressed in the Intertropical Convergence Zone (ICZ) where the moist humid trade winds from either hemisphere meet.

b. Indonesia as a Mountainous Region

During a sunny day, mountain slopes heat up rapidly due to large radiation receipts, while atmosphere over the lowlands remains less affected by these large insolation inputs and is slightly cooler than air over the mountain slopes. Mountain slope air therefore becomes unstable and tends to rise up the slope. This upslope flow is called valley wind or anabatic flow. At night, a reverse tempereture difference develops, as the highland cool off rapidly[2]. This cooler air then moves downslope under influence of gravity, it is called mountain wind or katabatic flow, see figure 5.

Orographic lifting is particularly efficient where monsoonal winds are force to rise and converges with valley wind and sea breeze, as illustrated by the nothern coast of Java in the region of Mount Muria in December is 1919 mm for station of Jepara (3 m, a.s.l), and 2367 mm for station of Bangsri (80 m, a.s.l), see figure 6. Mountain and highlands receive more rainfall than nearby lowlands due to orographic effect, especialy on their windward sides[3]. Generally rainfall increases up to about 1500 m but beyon this, it generally decreases with height. The height of the rainfall maximum for a location generally coincide with the mean cloud base height.

c. Indonesia as a Monsoon Region

The term "monsoon" means "season" or "mausim" in Arabian language or "musim" in Indonesian language. The main characteristics of the monsoon regions are; the prevailing wind direction shifts by at least 120^0 between January and July, the average frequency of prevailing directions in January and July exceeds 40%, and the mean resultant winds in at least one of the months exceeds 3 ms^{-1}. Figure 7, shows areas with monsoon circulations ascording to the criteria of Ramage (1971). It is clear from the figure 7 that Indonesia belong to monsoon region[4].

The monsoon can be described as a giant sea breeze phenomenon by meridional (north – south) heat contrasts related to the annual migration of the sun. The Indonesian region experiences giant sea breeze in consequence of it lies in between the two oceans (Pacific and Indian oceans) and the two continents (Asia and Australia Continents). Indonesia is affected by Australasia monsoon having seasonal periods, it is longer than the periode of sea breeze as local winds. In summer the ocean to continent pressure gradient indicates availability of potential energy, on the contrary in winter occurs the continent to ocean pressure gradient due to the difference of heat capacity between ocean and continent. Monthly rainfall distribution of monsoon, equatorial and local types are shown in figure 3.

The surface pressure is equivalent to the weight of air column from mean sea level to the top of the atmosphere per unit area. Assume that cold air in the southern hemisphere is separated by warm air in the northern counterpart by a wall standing at the equator, as schematically shown in figure 8. The south to north pressure gradient is indicative of availability of potential energy. When the wall is taken away, cold air begins to subside and move northward, warm air ascends and moving southward, thus

increasing kinetic energy at an expense of potential. Such vertical overturning is season dependent, occuring in the some reason of the calender year and, thus, defining the monsoon circulation[5].

d. Indonesia as a Maritime Continent

The Indonesian maritime continent consist of thousands large and small island. It occurs an interaction between island and sea that are sea – land breezes. The intensity of sea – land breezes depends on land – sea temperature difference. Figure 9 shows the land – sea temperature difference and its relation to the speed of sea breeze. Sea breeze in the bay of Jakarta is the strongest. This sea breeze can penetrate as far as 60 km into inland (Bogor area).

A main characteristic of the Indonesian region is the mixture of land and sea surface, wich makes it a “maritime continent”. The mixture of sea and land, and the mountainous character of most islands, creates a large variety of local climates, mainly dependeing on exposure to the monsoons and elevation.

The Indonesian maritime continent is home to arround 200 million people, or approximately 5% of the total world population. Most of these people live directly or indirectly from what the land produces, so the climate is a very important factor in their lives. Climate of this region are controlled by two major factors that are marine influences and the monsoon.

Tropical Asia can be subdivided into three major climatic region :

a. Equatorial monsoon climates, where both monsoons bring rainfall and no dry season occurs. A conventional limit is that the mean rainfall of the driest month is over 60 mm. These climates are found in the most of the Indonesian areas.
b. Dry and wet monsoon climates, where one monsoon bringes most of the rainfall, while the other one is relatively dry. The mean rainfall of the driest month is under 60 mm.
c. The dry tropics, where both monsoons bring little or no precipitation, in the extreme north – west and south – east of the region, see figure 10.

APPENDIX

Study Program of Meteorology in Indonesia

There are two study programs belonging to Department of Geophysics and Meteorology. The first is at the Institute of Technology Bandung (ITB), and the other one is at the Institute of Agriculture Bogor (IPB). The Study Program of Meteorology at ITB emphasizes in Physical Meteorology, while at IPB emphasizes in Agrometeorology. The development of Meteorology at ITB may be described as follows :

a. Before 1998

Department of Geophysics and Meteorology is grouped into 3 groups of expertise i.e., Geophysics, Meteorology and Oceanography in one Study Program and one Curriculum of undergraduate program. The department belong to Faculty of Mathematics and Natural Science and the study is oriented to natural sciences. In 1996, it was founded graduate program namely : Master Program of Oceanography and Atmospheric Sciences which is divided into three special programs, among other things, **special program of Atmospheric Sciences**.

b. Since 1998

Since 1998, the Department of Geophysics and Meteorology joined into Faculty of Earth Sciences and Mineral Technology and the study is oriented to terrestrial sciences. The department is divided into 3 study programs, namely : Study program of Geophysics, Meteorology, Oceanography, and 3 curriculum of undergraduate programs. In this year (2004), the Department receives 111 new undergraduate students or each study program will accept 37 new students.

In 2003, it was proposed **Doctoral Program** in Earth Sciences with 3 special programs in Oceanography, **Atmospheric Sciences** and Seismology. In 2003, the number of graduate students in this Doctoral Program are 4 students : 3 students for Atmospheric Sciences, and one student for Seismology program. The curriculum of Master and Doctoral, Special program in **Atmospheric Sciences** as follows :

1. M.Sc. Program in Atmospheric Sciences

Semester 1				Semester 2		
No.	**Name of subjects**	**scu**		**No.**	**Name of subjects**	**scu**
1	Advanced Geostatistics	3		1	Advanced Signal Analysis	3
2	Physical Oceanography	2		2	Advanced Numerical Analysis	3
3	Atmospheric Science	2		3	Structure and Material of The Earth	2
4	Electives	5		4	Electives	4
		12				12

Semester 3		
No.	**Name of subjects**	**scu**
1	Geo-hazards	2
2	Thesis	6
3	Electives	4
		12

Elective Subjects

1	Atmosphere Dynamics	3 scu		6	Special Topics in Atmospheric Science	2 scu
2	Cloud and Rain Microphysics	3 scu		7	Sea – Air Interaction	2 scu
3	Monsoon Meteorology	2 scu		8	Advanced Remote Sensing and GIS	2 scu
4	Weather Prediction	3 scu		9	Geo-resources and Environmental Management	2 scu
5	Global Climatology	2 scu				

The curriculum of master program in Atmospheric Sciences is designed for 3 semesters or 1.5 years with 36 scu (semester credit units) as follows :

a. Compulsory subjects 17 scu
b. Electives 13 scu
c. Thesis 6 scu

2. Doctoral Program in Atmospheric Sciences

Semester 1				Semester 2		
No.	**Name of subjects**	**scu**		**No.**	**Name of subjects**	**scu**
1	Climate Change	3		1	Writing of Proposal	6
2	Equatorial Atmosphere	3		2	Qualifying Exams	2
3	Atmospheric Radiation	3				
4	Electives	3				
		12				8

Semester 3				Semester 4		
No.	**Name of subjects**	**scu**		**No.**	**Name of subjects**	**scu**
1	Development of Method I	3		1	Experiment/Survey and Analysis II	6
2	Experiment/Survey and Analysis I	6		2	Electives	6
3	Electives	3				
		12				12

Semester 5				Semester 6		
No.	**Name of subjects**	**scu**		**No.**	**Name of subjects**	**scu**
1	Writing of Dissertation I	6		1	Dissertation (closed) Exams	3
2	Electives	3				
		9				3

Distribution of elective subjects

Semester 1				Semester 2		
No.	**Name of subjects**	**scu**		**No.**	**Name of subjects**	**scu**
1	Extremes Weather	3		1	Development of Method II	3
2	Turbulences	3		2	Development of Method III	3
3	Philosophy of Knowledge	3				
4	Regional and Global Oceanography	3				

Semester 3				Semester 4		
No.	**Name of subjects**	**scu**		**No.**	**Name of subjects**	**scu**
1	Writing of a Paper in National Proceedings	1		1	Experiment/Survey and Analysis	6
2	Writing of a Paper in International Proceedings	2		2	Writing of a Paper in National Journals	3
3	Experiment/Survey and Analysis	6		3	Writing of a Paper in International Journals	6

Semester 5		
No.	**Name of subjects**	**scu**
1	Writing of Dissertation II	6

The curriculum of doctoral program in Atmospheric Sciences is designed for 6 semesters or 3 years with 56 semester credit units (scu) as follows :

1.	Comprehensive Subjects	12 scu
2.	Writing of Proposal and Qualifying Exams	8 scu
3.	Development of Method	3 scu
4.	Experiment/Survey and Analysis I, II	12 scu
5.	Electives	12 scu
6.	Writing Dissertation	6 scu
7.	Dissertation Exams	3 scu
	Total	**56 scu**

The number of new student in undergraduate, Master and Doctoral special Programs, in Meteorology and Atmospheric Sciences as follows :

Year	Number of new students			Year	Number of new students		
	Undergraduate	Master	Doctoral		Undergraduate	Master	Doctoral
1996	70 *)	3	–	2001	20	2	–
1997	70 *)		–	2002	20	3	–
1998	20		–	2003	20	5	3
1999	20		–	2004	37 **)		
2000	20		–				

*) New students of the Department of Geophysics and Meteorology (field of Geophysics, Meteorology and Oceanography).

**) New students of the undergraduate program in Meteorology proposed to the ITB.

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Art Study