

# CHAPTER 1

## INTRODUCTION

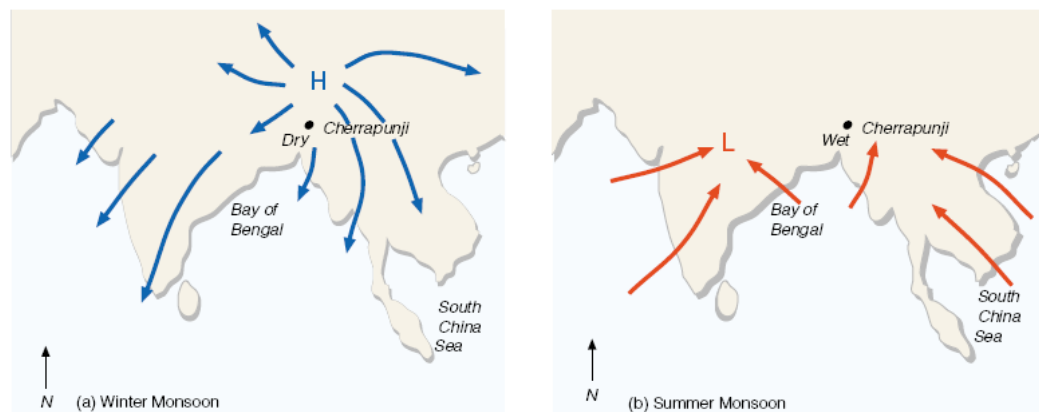
### 1.1 Rationale/State Problem

Monsoon plays a vital role in the economy and society of Southeast Asia. Monsoon is a seasonal prevailing wind that dominates for several months. It is caused by a large amplitude of the seasonal cycle of the difference between land and ocean temperature. There are two predominant monsoons over Southeast Asia, namely summer and winter monsoons. Summer monsoon lasts from about May through mid-October. Major summer monsoon's behaviors over Southeast Asia are active and break of the monsoon. The active and break periods of the monsoon are characterized by precipitation maxima and minima. The active/break phases have a large impact on agriculture over this region (Clift, 2008). In general, Southeast Asian Summer Monsoon (SEASM) is the combination of South Asian Summer Monsoon (SASM) and East Asian Summer Monsoon (EASM). The Southeast Asian summer monsoon is characterized by strong land-sea contrast and high-rising terrain in the north. The East Asian monsoon is a combination of thermal contrasts between the Asian continent and the Indo-Pacific Ocean. The EASM components are East Asian subtropical front, Western North Pacific subtropical high and Western North Pacific monsoon trough (Yihui and Chan, 2005).

In this research, a shallow water model is used to investigate the characteristics of active and break cycles over SEASM. The atmosphere has a finite limit of predictability because instabilities of the system, even if the model is perfect, and the initial conditions are known almost completely. This statement can be proved by an "identical twin" experiment that compares two model runs with the same model but slightly different in initial conditions (Lorenz, 1962, 1963). If the initial conditions are differed only slightly, after a little period of time, the two solutions and incorporation with the round-off errors effect could cause two different forecasts to appear as two random patterns of weather (Krishnamurti et al., 1998). To improve the model forecast, ensemble forecast using singular vector to generate the set of initial conditions is applied in this research. Ensemble model provides outputs that represent a wider range of possibility on SEASM in the future.

## 1.2 Monsoon

The monsoon is a seasonal wind which is caused by the large amplitude of the seasonal cycle of land temperature compared to that of nearby oceans. In winter, the air over the continent becomes much colder than the air over the ocean. A large, shallow high-pressure area develops over continental Siberia, producing a clockwise circulation of air that flows out over the Indian Ocean and South China Sea (Figure 1.1a). In summer, the wind flow pattern reverses itself as air over the continents becomes much warmer than air above the water. A shallow thermal low develops over the continental interior. The heated air within the low rises and the surrounding air respond by flowing counterclockwise into the low center (Figure 1.1b) (Ahrens, 2000).



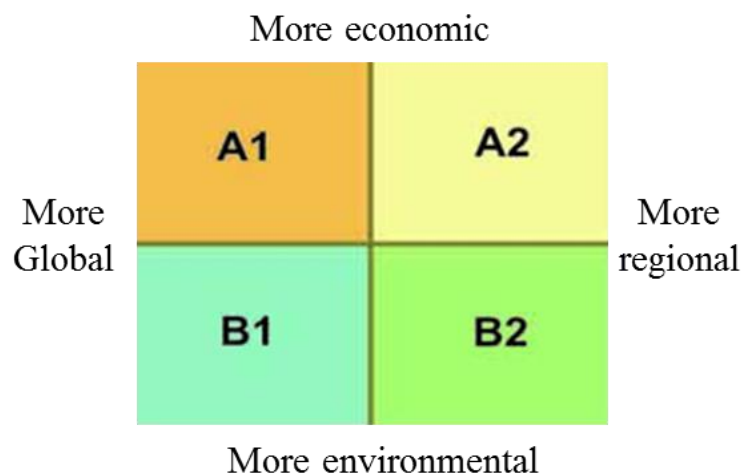
**Figure 1.1** Changing annual wind flow patterns associated with the winter and summer Asian monsoons (Ahrens, 2000).

Therefore, SEASM which lasts from about May through Mid-October, means wet, rainy weather (wet season) with winds that blow from sea to land. The onset of summer monsoon gives indication of the building up of the cross-equatorial flow.

The active monsoon is defined primarily in relation with the amount of rainfall recorded over the various meteorological stations in Thailand. During the summer monsoon season it is the monsoon trough, the only synoptic scale system, which contributes towards rainfall activity. Any low pressure area embedded in the monsoon trough would further increases the activity of monsoon. The period during which the monsoon rainfall decreases considerably or even stops over the plains of Thailand is referred to as “break in monsoon” (Matsumoto, 1997).

### 1.3 Climate Change Scenarios

Climate change scenarios are reasonable and often simplified representation of the future climate, based on an internally consistent set of climatological relationships (IPCC, 2001). Scenarios are developed from differences between future climate and a reference climate. There are two major different scenarios; A and B. Scenario A emphasizes stronger economic values, scenario B stronger environmental values. However, scenarios A and B can be further divided by increasing globalization and regionalization. Scenario 1 is a relationship between country or more global. In the same way, Scenario 2 is a relationship between regional countries. Figure 1.2 shows the International Panel on Climate Change Scenarios (IPCC) A1, A2, B1, and B2 scenarios.



**Figure 1.2** IPCC scenario labeling (IPCC, 2001).

Meaning of A2 is strong economic in regional domain and B1 emphasizes more environment in global domain. In addition, COMMIT represents atmospheric environment burned of long-live greenhouse gasses. This research considers only A2 and COMMIT scenarios.

### 1.4 Simulation

Every model has several variables such as temperature, wind velocity, precipitation, relative humidity, pressure and sea level pressure. Using unreal data instead of observed data for initial condition is called “simulation”. If a phenomenon is simulated by initial

data set which show most possible scenarios then it is called “ensemble forecast”. Only few papers have studied the influence of global warming on active/break of summer monsoon by ensemble technique. Hence, it is a good idea to apply ensemble forecasts to A2 and COMMIT scenarios over Southeast Asia during the summer monsoon period.

### **1.5 Ensemble Forecasting**

Ensemble forecasting is a numerical prediction method that takes into accounts the uncertainties and error in the forecast models. Because of the model forecasts are only as good as the initial conditions which are loaded with errors. These errors will generate other errors that grow in size as the model progresses further into future. Development of ensemble initialization can create various ensemble perturbations as many ensemble members as required. However, the ensemble forecast members are limited by computational cost. Many techniques can be used to generate the initial perturbations of the analysis data. Major forecast centers have developed ensemble forecasting such as, the National Center for Environment Prediction (NCEP), the European Center for Medium-Range Weather Forecasts (ECMWF) (Molteni et al., 1993).

### **1.6 Literature Review**

Krishnamurti et al. (1998) propose a generalized ensemble forecast procedure for tropical latitudes and an empirical orthogonal function (EOF)-based procedure for the definition of a seven-member ensemble. The wind and temperature fields are perturbed over the global tropics. The work is on a South China Sea monsoon. The amplitudes of these initial perturbations are comparable to the typical observational errors in the temperature and wind measurements. The study shows an improvement of forecasting skill through day-6 of forecasts arising from the use of EOF-based perturbations, physical initialization and ensemble averaging.

Atger (1998) studies the performance of ensemble prediction by the probability distribution of geopotential height at 500 hPa over Europe. Half Brier score is used for verification the quality of probability forecast. Reliability and resolution are main forecast performance. Performance of ECMWF ensemble prediction systems (EPSs)

comes from the ensemble mean. As a result, the ensemble mean contribution to skill decrease when reduce size down to 11 members.

Ehrendorfer (1996) applies singular vectors (SVs) to a primitive equation model with moist physics. Two problems are appeared in the explicit condensation of moist physic; first, the tangent linear explains the moist physics, second, the appropriate measure norm in the moist physics is designed. Singular vectors are computed by a Lanczos algorithm for three norms in 24 hours that based on a relation with total perturbation energy. Cyclogenesis is the selected case study. Perturbation in moist event is faster growth than the dry event. In addition, moist event processes provide new mechanisms for error and it is difficult for applying singular vectors. Therefore, the linearized process is considered for revealing all structure that will grow in moist primitive equation model.

Hamil et al. (1999) study the statistical properties of analysis and forecast errors using ensemble perturbation. A quasigeostrophic channel model is used with 3D-variation data assimilation scheme. A model is assumed perfect. Three perturbations are studied; singular vector (SV), breeding, and breeding singular-vector. The perturbed observation (PO) approximates a random sample from probability density function (PDF). Initial condition for PO is calculated from independent, parallel data assimilation cycles. Each assimilation data is perturbed by random noise and started from a distinct initial condition. The rank histogram for all variables at all lead time, skill correlation, calibrated, and reduce-error probability forecast are considered to find relation between breeding and SV. The result shows that the ensemble mean of the PO initial condition is more correct than the mean of the bread or SV. Meanwhile the PO ensemble initial condition provides realistic variations from day to day but the bread or SV did not.

Wei et al. (2000) find that the initial singular vectors depend sensitively on the specified norm. After a few days, the structures of the leading evolved singular vectors in the Kalman Ensemble (KE) norms are in general quite similar to some of the dominant finite time normal modes that are norm independent.

Wei et al. (2002) introduce perturbation versus error correlations analysis (PECA). PECA is a verification by quality and compare ensemble generating by using different

schemes. Ensemble perturbation from NCEP and ECMWF are evaluated. The variance error is increased with the number of members and the lead time. The dynamically conditioned NCEP and ECMWF perturbations are more efficient than both randomly perturbations and difference lagged forecast. The root-mean-square (RMS) error indicates that in a perfectly reliable ensemble forecast the spread of ensemble members is large; however RMS spread is not guarantees the good ensemble forecast patterns.

Khade et al. (2004) apply singular value to finite time error and they use singular values over the Lyapunov number for finite time scale. Linearization applied to error growth in non-isotropic cases shows that it is quite different from isotropic cases. The influence of model on error growth is delineated.

Stephen (2004) investigates possible methods which are used to generate the ensembles themselves and in particular the truncate singular vector approach used at ECMWF. The results in ensemble forecasts require the mean and the variability of the uncertainty to be calibrated separately. With this model it is possible to calculate both the exact uncertainty and the uncertainty predicted by singular vector methods.

Prasad et al. (2007) derive diagnostic criteria from the variability in the horizontal zonal wind shear at the 850 hPa level to retrospectively assess the active, weak and break phases of the Indian summer monsoon. This offers several advantages as this procedure depends on fields that are better observed and modeled than rainfall and is also found to be related to both anomaly of rainfall distribution and the synoptic situation.

Leutbecher (2005) studies an effect on the ECMWF ensemble prediction by singular vector. The 34 cases in November-December 1999 and 28 cases in September 2003 are performed for the experiments. Singular vector started from a 12-hours forecast. Ensemble score and spread measure are close to mean of the geopotential height. In case of the spread in tropical cyclone track, it is not significantly decreased if singular vector is calculated from 12-hrs forecast.

Stephen (2004) investigates perturbation of the initial condition of the forecast using subset of the singular vector of linearized propagator. Results show that the probabilistic

forecast from the ECMWF ensemble is better forecasts if the mean of the spread and variability of the spread are separated.

Magnusson et al. (2008) estimate the forecast uncertainty based on perturbation initial conditions. Singular vector and breeding vector (BV) methods are used. The empirical orthogonal function (EOF) is explained by breeding vector for initial perturbation of the model. A normal mode perturbation is performed for the experiment. Evaluation of the results emphasizes the fastest growth of a perturbation. Results show a large improvement for the Bred Vector-Empirical Orthogonal Function (BV-EOF) perturbation compared to the non-orthogonal BV. A large perturbation of the BV-EOF grows faster than singular vectors of the system, except for the short time-scale. The second BV-EOF is found to be the highest growth rate for the long time scale.

In numerical weather prediction (NWP), ensemble forecasting is an important method to manage uncertainly error of forecast model. Krishamurti et al. (1998), Atger (1998), and Hamil et al. (1999) are some of many papers interested in ensemble forecast. The widely used perturbed methods are breeding vector, singular vector, and breeding singular-vector. However, a singular vector is a popular method. Ehrendorfer (1996), Wei et al. (2000), Khade (2004), Leutbecher (2005), Stephen (2004), and Magnusson et al. (2008) discussed singular vector. Also, Prasad et al. (2007) studied characteristic of active and break monsoon. Therefore singular vector is an appropriate method for applying to active and break of summer monsoon over Southeast Asia.

In this research, singular vector is applied to a shallow water model to generate initial condition for ensemble forecast.

## **1.7 Objective**

To investigate characteristics of the active and break of the summer monsoon over Southeast Asia under climate change scenarios.