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# STUDIES ON THE ANALOGOUS RHYTHM PHENOMENON IN COUPLED OCEAN-ATMOSPHERE SYSTEM*

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ABSTRACT

In this paper, the dynamical forming mechanism of analogous rhythm phenomenon is studied by using a coupled ocean-atmosphere model in form of analogous discrepance. The results show that the analogous rhythm is non-uniform oscillation of analogous discrepance disturbance which is caused by the nonlinear coupled interaction of ocean-air system and the seasonal variation of monthly mean circulation. Then, the numerical simulations and sensitivity studies are conducted by using a global coupled ocean-atmosphere dynamical-statistical seasonal long-range numerical prediction model, the results not only prove the result of theoretical analysis, but also provide the basis of making seasonal long-range numerical prediction by using this model.

**Keywords: analogous rhythm, coupled ocean-atmosphere, analogous discrepance.**

## I. INTRODUCTION

In recent years, owing to extensive and serious social and economic influences of climatic anomalies, the long-range weather forcasting are drawing more and more attention of many countries' meteorological offices. But, up to now, most work of long-range forecasting is based on statistics or experience. A few diagnostic and theoretical studies are focused on spatial structure of circulation anomaly. The temporal evolution of long-range weather anomaly, especially the evolution of seasonal scale, is less studied, and the law of long-range weather process is not clearly understood. It is due to this reason that the statistical and empirical or dynamical and thermal forecast skills are limited greatly. So, in order to build an ideal seasonal long-range prediction model, the law of formation and evolution of long-range weather anomaly must be deeply understood. According to Wang's[1] division of long-range weather process, rhythm is the main process of 3—6 months. Thus, if we want to understand the law of evolution of seasonal circulation anomaly, the formation and evolution of rhythm phenomenon must be first studied.

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Since the Mu school of the Soviet Union proposed this concept of active rhythm of large-scale weather process in the 1920s, there have been many statistical researches in this respect. The rhythm is one of the main tools of the long-range operational forecast of our country. But because "the process, reason and mechanism of rhythm formation are very difficult project," there are few theoretical and numerical simulation researches about rhythm-forming mechanism. Therefore, the formation and evolution of the analogous rhythm will be preliminarily studied from theory and numerical simulation in this paper.

## II. Definition of Rhythm Phenomenon

Rhythm is a basis concept used in operational long-range forecast. However, because of the different points of view for the long-range forecast approach, there are many kinds of rhythm definition. In this paper, only the rhythm activity of circulation evolution will be studied. Early in the 1930s, the Soviet scholars[3] had proposed the rhythm whose time interval is three or five months. Recently, Wang Shao-wu et al.[1,2] found that when the anomaly fields of two different years are analogous in a starting month, the similarity will rapidly become poor, but after about six months, it will become analogous again. This is a rhythm of circulation evolution. In order to avoid confusion with other rhythm concepts, this phenomenon of analogous reappearance is defined as analogous rhythm of the monthly mean circulation anamoly. Since this phenomenon is important for the long-range forecast, the analogous evolution of monthly mean circulation is relatively overall analysed with the strict statistical method and long time series data[1)]. The results show that there is an analogous rhythm phenomenon about six months in the evolution process of long-range weather anamoly. Because this analogous rhythm often presents uncontinuous relation, its formation process cannot be understood from atmosphere and ocean themselves.

It must be found from the coupled interaction between the ocean and the atmospheric system. For this reason, the forming process is studied by using a simple coupled ocean-atmosphere model in the form of analogous discrepance in the following theoretical analysis.

## III. Dynamical Forming Mechanism of Analogous Rhythm Phenomenon

According to the above discussion, we consider that the evolution of monthly mean circulation can be regarded as a small disturbance superposed on the historical analogous field, the ocean and atmospheric state can be divided into the basic state and the disturbance state (the former is monthly mean value of a historical analogous year, the latter is the difference of two analogous years and is called analogous discrepance disturbance). So, the formation and evolution of analogous rhythm could be changed to the evolution and stability problem of analogous discrepance disturbance. A simple coupled ocean-atmosphere model in the form of analogous discrepance disturbance is built, and the amplitude equations of discrepance disturbance

1) 黄建平等，北半球月平均环流异常演变的相似韵律现象，1988.

are further formulated in this section. Then, the probable dynamical forming mechanism of analogous rhythm is discussed by using the equations.

1. *A Coupled Ocean-Atmosphere Model in the Form of Analogous Discrepance*

The atmospheric and ocean variable is divided into basic state and disturbance state, i.e.

$$\psi = \tilde{\psi} + \hat{\psi},$$
$$T_s = \tilde{T}_s + \hat{T}_s,$$

where $\psi$ is the stream function of atmospheric motion, $T_s$ the sea-surface temperature, syboml "$\sim$" indicates the atmospheric and ocean basic state, "$\wedge$" the disturbance state. If the atmospheric motion is described with equivalent barotropic model which includes condensation, radiation and sensible heat, a simple variation equation of the sea-surface temperature is taken as the ocean model and the ocean current is described by the Sverdrup[4] flow. Therefore the coupled ocean-atmosphere non-dimensional model in the form of analogous discrepance is as follows[1]:

$$\frac{\partial}{\partial t}(\nabla^2 - \lambda_1^2)\hat{\psi} + J(\tilde{\psi}, \nabla^2\hat{\psi}) + J(\hat{\psi}, \nabla^2\tilde{\psi}) + J(\hat{\psi}, \nabla^2\hat{\psi}), + \beta_a \frac{\partial \hat{\psi}}{\partial \lambda}$$
$$= E_1\hat{\psi} - E_s\hat{T}_s - E_2\nabla^2\hat{\psi} - K_h\nabla^2\hat{\psi}, \tag{1}$$

$$\frac{\partial \hat{T}_s}{\partial t} + \delta\left[\frac{\tilde{U}_s}{\sin\theta}\frac{\partial \hat{T}_s}{\partial \lambda} - \frac{\beta_s\nabla^2\tilde{\psi}}{\sin\theta}\frac{\partial \hat{T}_s}{\partial \theta} - \frac{\beta_s\nabla^2\hat{\psi}}{\sin\theta}\frac{\partial \tilde{T}_s}{\partial \theta} - \frac{\beta_s\nabla^2\hat{\psi}}{\sin\theta}\frac{\partial \hat{T}_s}{\partial \theta}\right]$$
$$= F_2\hat{\psi} - F_1\nabla^2\hat{\psi} - F_s\hat{T}_s, \tag{2}$$

where $\delta = 1$ for the ocean, $\delta = 0$ for the land, and

$$J(A, B) = \frac{1}{\sin\theta}\left[\frac{\partial A}{\partial \theta}\frac{\partial B}{\partial \lambda} - \frac{\partial A}{\partial \lambda}\frac{\partial B}{\partial \theta}\right],$$

$\lambda_1$ is the non-dimensional stratification parameter, $\beta_a = 2\Omega\tau$, $\tau$ the characteristic time, $E_1$, $E_2$, $E_s$, $F_1$, $F_2$, and $F_s$ are the parameters with relation to diabatic parameterization, $K_h$ is a friction coefficient, $\beta_s = \frac{C_D V_0 \rho_0}{2\Omega D \rho_s}\alpha_1$, and $\alpha_1$ is the correction coefficient.

2. *The Amplitude Equation of Analogous Discrepance Disturbance*

To analyse the physical mechanism, we further simplify Eqs. (1) and (2), assuming

$$\hat{\psi}(\lambda, \theta) = A(t)H_a(\lambda, \theta), \tag{3}$$
$$\hat{T}_s(\lambda, \theta) = W(t)H_s(\lambda, \theta), \tag{4}$$

where $A(t)$ and $W(t)$ are the amplitude of atmosphere and ocean analogous discrepance disturbance, respectively. $H_a(\lambda, \theta)$ and $H(\lambda, \theta)$ are the spatial structure

1) 黄建平，月平均环流异常的观测、理论和数值模拟，1988.

function of analogous discrepance of atmosphere and ocean. Eqs. (3) and (4) are equal to the idea that the atmosphere and ocean analogous discrepance field is approximately taken as the first characteristic vector of EOF and the spatial function is obtained from many years' data. Then, let

$$\tilde{\psi} = -\tilde{U}_m(t)\cos\theta, \tag{5}$$

$$\tilde{T}_s = \tilde{T}_{s0} - \tilde{T}_{sm}(t)\cos\theta. \tag{6}$$

Substituting (3)—(6) into (1)—(2), we obtain the following amplitude equations of analogous discrepance disturbance:

$$\frac{dA}{dt} + R_u A + R_N A^2 = Q_{a1} A - Q_{a2} W - R_f A, \tag{7}$$

$$\frac{dW}{dt} + R_s W - R_{s1} A - R_{sN} AW = Q_{s1} A - Q_{s2} W. \tag{8}$$

Eqs. (7) and (8) are basic equations which are used to discuss the temporal evolution. Although the equations are highly simplified, some basic physical features of the analogous evolution still can be revealed.

### 3. *The Evolution of Disturbance Amplitude in Uncoupled System*

The uncoupled system is to assume that $\frac{dW}{dt} = 0$ in Eq. (8), the action of ocean to atmosphere is equally a stationary forcing, and the evolution of the discrepance disturbance with time can be written as:

$$\frac{dA}{dt} + R_u A + R_N A^2 = Q_{a1} A - Q_{a2} W - R_f A. \tag{9}$$

In this system, the discrepance disturbance is infinitely growing on exponent in linear unstable cases. However, in nonlinear unstable cases, the amplitude of disturbance grows monotonically and then tends to the steady state amplitude, i.e. $t \to \infty$,

$$A(\infty) = \frac{Q_{a1} - R_u - R_f}{R_N}.$$

The solution shows that the nonlinear action of atmosphere itself restrains the growth of analogous disturbance amplitude.

Since the analogous evolution of sea temperature field has obvious persistence, the uncoupled system can well explain the initial analogous evolution of circulation anomaly. But the uncoupled system cannot explain why the anomaly field becomes analogous again after a certain period. However, when the interaction between ocean and air is considered, the feature of evolution will produce essential variation.

### 4. *Non-uniform Oscillation of Analogous Discrepance Disturbance in Coupled System*

In the coupled ocean-air system, the evolution of amplitude are described with full Eqs. (7) and (8). Because the analysis solution of the system cannot be sought, the Rugo-kuta numerical integral approach is used to study the concrete characteristics of solution. Assume that

$$R_u = R_{uc} + R'_{uc}\cos(\Omega_0 t + \phi),$$
$$R_s = R_{sc} + R'_s\cos(\Omega_0 t + \phi),$$
$$R_{s1} = R_{s1c} + R'_{s1}\cos(\Omega_0 t + \phi),$$

where $\Omega_0 = \frac{2\pi}{12\ \mathrm{mon}}$, $\phi$ is the phase of initial month. Considering or not the seasonal variation of monthly mean circulation, the numerical results are shown in Fig. 1. The time step $\Delta t$ is taken as 0.001. For the case of considering the forcing of seasonal variation, the non-uniform oscillation solutions of amplitude are strong (see the solid line of Fig. 1). It is due to instability that all of the amplitudes $A$ and $W$ increase at the initial time. Because of the heat inertia of ocean, its growth rate is slower than atmosphere. With the increasing of the amplitude $A$, the nonlinear term $R_N A^2$ will become more important. It restrains the continued growth of amplitude $A$ and reaches its maximum. Meanwhile, the amplitude $W$ has increased to certain extent, it causes the amplitude $A$ to be unable to retain its maximum and to begin to decrease. The time of the full process is about half a year.

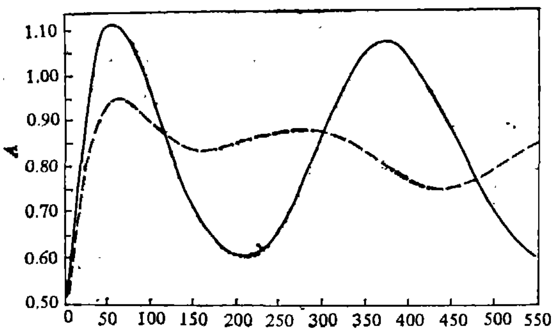

Fig. 1(a). Temporal evolution of $A(t)$ in the coupled system at $\phi = 0$, $Q_{a1}-R_{uc}-R_f = 0.15$, $R_n = 0.1$, $Q_{a2} = 0.1$. Solid line, $R_{uc} = 0.03$; dotted line, $R_{uc} = 0$.

When the seasonal variations of monthly mean circulation are not considered (see dotted line of Fig. 1), the variation range of amplitude is much smaller, especially that of the atmosphere. It shows that the seasonal variation of monthly mean circulation also plays an important part in the formation of analogous rhythm. So we suggested that the production of the analogoue rhythm is due to the non-uniform oscillation of the analogous discrepance disturbance which is caused by the nonlinear coupled interaction of the ocean-atmosphere system and the seasonal variation of monthly mean circulation.

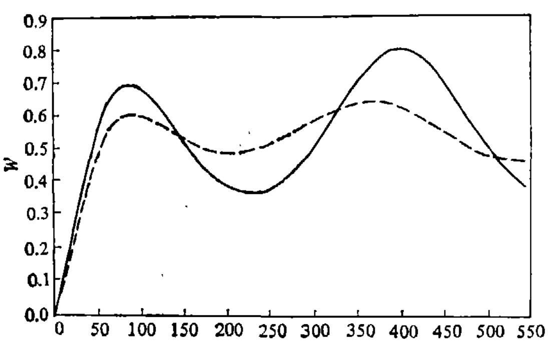

Fig. 1(b). Temporal evolution of $W(t)$ in the coupled system at $\phi = 0$, $Q_{s1}-R_{su} = 0.08$, $R_s = 0.01$, $R_{s1} = 0.02$, $R_{sc} = 0.05$, $R_{sn} = 0.001$. Solid line, $R_{uc} = 0.03$; dotted line, $R_{uc} = 0$.

Of course, the model is highly simplified. Thus, the numerical simulation is conducted by using a global ocean-atmosphere coupled dynamic-statistical seasonal long-range numerical prediction model in the following study.

## IV. The Numerical Simulation Study on Analogous Rhythm

### 1. *Basic Principle of Model*

As stated in the above discussion, the evolution of the monthly mean circulation anamoly starting from similar states (i.e. the initial and boundary condition) always becomes similar after a certain interval period. So, similar to the theoretical model, the forecasting field is regarded as a small disturbance superposed on the historical analogous field. The meteorological variable $X$ can be expressed as

$$X = \widetilde{X} + \hat{X},$$

where $\widetilde{X}$ is the basic state, which is the monthly mean value of a historical analogous year that is selected from historical data according to similarity criterion and its evolution has already been known. $\hat{X}$ is the disturbance state, which is the difference of two analogous years' states. Substituting $X = \widetilde{X} + \hat{X}$ into the global coupled ocean-atmosphere model's equations and the boundary condition, the analogous discrepancy equations which describe analogous evolution of monthly mean circulation can be written as follows[1]:

$$\frac{\partial}{\partial t}\nabla^2\hat{\phi} + \frac{1}{a^2}J(\nabla^2\tilde{\phi},\hat{\phi}) + \frac{1}{a^2}J(\nabla^2\hat{\phi},\tilde{\phi}) + \frac{1}{a^2}J(\nabla^2\hat{\phi},\hat{\phi})$$
$$+ \frac{2\Omega}{a^2}\frac{\partial}{\partial\lambda}\hat{\phi} + \left(2\Omega\cos\theta\nabla^2 - \frac{2\Omega\sin\theta}{a^2}\frac{\partial}{\partial\theta}\right)\hat{\chi} = \mu\nabla^4\hat{\phi} + \hat{G}_d, \tag{10}$$

$$\frac{\partial}{\partial t}\hat{T} + \frac{1}{a^2}J(\tilde{\phi},\hat{T}) + \frac{1}{a^2}J(\hat{\phi},\widetilde{T}) + \frac{1}{a^2}J(\hat{\phi},\hat{T}) - \frac{c^2}{RP}\hat{\omega}$$
$$= \mu\nabla^2\hat{T} + \frac{\partial}{\partial P}\nu\left(\frac{gP}{R\overline{T}_0}\right)^2\frac{\partial\hat{T}}{\partial P} + \frac{\hat{\varepsilon}}{c_P} + \hat{G}_T, \tag{11}$$

$$\left(2\Omega\cos\theta\nabla^2 - \frac{2\Omega\sin\theta}{a^2}\frac{\partial}{\partial\theta}\right)\hat{\phi} = \nabla^2\hat{\phi}, \tag{12}$$

$$\nabla^2\hat{\chi} + \frac{\partial\hat{\omega}}{\partial P} = 0, \tag{13}$$

$$\frac{R}{P}\hat{T} = -\frac{\partial\hat{\phi}}{\partial P}, \tag{14}$$

$$\frac{\partial\hat{T}_s}{\partial t} + \delta\left[\frac{\widetilde{U}_s}{a\sin\theta}\frac{\partial\hat{T}_s}{\partial\lambda} - \frac{\beta_s}{a\sin\theta}\nabla^2\tilde{\phi}_0\frac{\partial\hat{T}_s}{\partial\theta} - \frac{\beta_s}{a\sin\theta}\nabla^2\hat{\phi}_0\frac{\partial\widetilde{T}_s}{\partial\theta}\right.$$
$$\left.- \frac{\beta_s}{a\sin\theta}\nabla^2\hat{\phi}_0\frac{\partial\hat{T}_s}{\partial\theta}\right] = \frac{1}{\rho_s C_{Ps} D}[\hat{R}_s - \hat{F}_0 - \hat{L}_E], \tag{15}$$

the boundary condition is

$$P = P_T,\ \hat{\omega} = 0,\ \frac{\partial\hat{T}}{\partial P} = 0, \tag{16}$$

1) See footnote on page 853.

$$P = P_s,\ \hat{\omega} = -\frac{\rho_0 C_d g |\boldsymbol{V}_0|}{f_0^2} \nabla^2 \hat{\psi}_0,\ \frac{\partial \hat{T}}{\partial P} = -\alpha_s(\hat{T}_0 - \hat{T}_s), \tag{17}$$

where $\psi$ is the stream function of atmospheric motion, $\chi$ the velocity potential, $\phi$ the geopotential height, $T$ the atmospheric temperature, $T_s$ the sea-surface temperature, $\rho_0$, $\rho_s$ are the atmospheric and ocean density; $C_P$, $C_{Ps}$ the specific heat of atmosphere and ocean, $D$ the thickness of mixture layer, $C_D$ the drag coefficient, $\alpha_s$ the surface albedo, $\boldsymbol{V}_0$, $\psi_0$, $\phi_0$ the surface velocity, stream function, and geopotential height. $\hat{G}_d$ and $\hat{G}_T$ are the discrepancy terms of the transient eddy transport. Because their annual variation are not obvious, $\hat{G}_d$ and $\hat{G}_T$ are approximately set to be zero.

In Eq. (11), the discrepancy of diabatic heating rate $\hat{\varepsilon}$ is as follows:

$$\hat{\varepsilon} = \hat{\varepsilon}_s + \hat{\varepsilon}_R + \hat{\varepsilon}_L,$$

where $\hat{\varepsilon}_s$ denotes the discrepance of the sensible heating from ocean to atmosphere, the formula is taken as[5]

$$\frac{\hat{\varepsilon}_s}{C_P} = g_1(\hat{T}_s - \hat{T}_0),\ g_1 = \frac{2g}{P_0}\left(\frac{P}{P_0}\right) \rho_0 C_D V_0. \tag{18}$$

$\hat{\varepsilon}_R$ denotes the discrepance of the radiation heat. It includes solar short wave radiation which is simply expressed by an empirical formula and atmosphere long wave radiation which is given by Newton's cooling law. It can be written as follows[6]:

$$\frac{\hat{\varepsilon}_R}{C_P} = \frac{\bar{I}}{\rho C_P}(1 - C_s\hat{n})(1 - \alpha_s)\eta/(1 + \eta) + \frac{\partial}{\partial P} K_R \frac{\partial \hat{T}}{\partial P} - \frac{1}{\tau_R}(\hat{T} - \hat{T}_s), \tag{19}$$

where $\eta$ is the absorbance of atmosphere and ocean to solar short wave radiation, $C_s$ the empirical constant, the discrepance of the amount of clouds $\hat{n}$ is considered as indirect proportion to the relative discrepance of precipitation[7], i.e.

$$\hat{n} = C_n \hat{R}_w / \tilde{R}_w, \tag{20}$$

where $\hat{R}_w$ is the discrepance of precipitation, $\tilde{R}_w$ the monthyly mean precipitation, and $C_n$ the empirical constant.

The condesation rate of long-term process for a certain period average may be expressed by precipitation[8]. the discrepance of condesation heat is calculated as follows:

$$\frac{\hat{\varepsilon}_L}{C_P} = \frac{L}{C_P} \hat{R}_w, \tag{21}$$

where $L$ is the latent coefficient, the new variable $\hat{R}_w$ in Eqs. (20) and (21) is taken similar to the formula in Ref. [9], i.e.

$$\hat{R}_w = -m_c\left(J(\hat{\psi}, \tilde{q}) + \hat{\omega}\frac{\partial \tilde{q}}{\partial P}\right), \tag{22}$$

$m_c = \frac{K_w}{g}(P_S - P_T)$, $\tilde{q}$ is the monthly mean of specific humidity. The discrepance formula of surface radiation equilibrum in Eq. (15) is as follows[6]:

$$\hat{R}_s = [R_*^0 C_I - \bar{I} C_s (1 - \alpha_s)/(1 + \eta)]\hat{n} - 4\varepsilon\sigma_R \bar{T}_s^3 (\hat{T}_s - \hat{T}_0). \tag{23}$$

The discrepance formula of the sensible heat flux of surface is

$$\hat{F}_0 = \rho_0 C_P C_D V_0(\hat{T}_s - \hat{T}_0). \tag{24}$$

The evaporation heat flux of surface is supposed to be

$$\hat{L}_E = K_f K_e B_r \hat{F}_0, \tag{25}$$

where $B_r$ is Bowen ratio, $K_f$ the correction factor[10], $K_e$ the available factor of water vapour. Suppose $K_e = 1$ for the ocean and $K_e = 0.5$ for the land.

The model atmosphere is divided into two vertical layers. The difference approach is used for numerical solution and the central differencing with three time layers for the initial step and time filtering are used for the time integration.

## 2. *The Numerical Experiment Design and Analysis*

To examine the physical mechanism of analogous rhythm formation, two groups of numerical experiments are conducted: uncoupled and coupled experiments. The purpose of the uncoupled experiments is to examine the response of analogous evolution of the monthly mean circulation anomaly to the fixed SST forcing. The coupled experiments are to examine the relative contribution of different physical processes to the analogous evolution, which include the full factor and several sensitivity experiments.

Because the numerical simulation of the analogous evolution is mainly conducted, the basic state is built by superposing an ideal anomaly field on the climate mean field. According to the similarity criterion with the ideal anomaly field, the initial field for the disturbance state may be obtained.

In order to facilitate comparison with the observational data, the simulation results of geopotential height on 500 hPa are mainly discussed. The measure of the similarity (called analogous index) is defined as

$$R_a = \frac{\|\hat{\phi}_{500}\|}{\|\hat{\phi}_{500}^{(0)}\|},$$

where $\hat{\phi}_{500} = \frac{1}{2}(\hat{\phi}_{300} + \hat{\phi}_{700})$, $\hat{\phi}_{500}^{(0)}$ is the initial value of 500 hPa discrepance field.

## 3. *The Result of Numerical Experiments*

The linear and nonlinear experiments forced by fixed SST are conducted to examine the linear and nonlinear response of the analogous evolution. In the linear case, the increasing velocity of analogous discrepancy disturbance is fast and increases from beginning to end. It is shown that the analogous discrepancy disturbance is dynamically unstable. In the nonlinear experiment (NL experiment, see dash line in Fig. 2), the increasing velocity is slower than the linear case, the increment of Ra is small after the 5th month and has slightly decreased in the 7th month. It is shown that the nonlinear action can restrain the development of the discrepancy disturbance.

The governing experiment (CST experiment) which includes all physical factors is first conducted in the coupled experiments (see solid line in Fig. 2). By comparing the CST experiment with the NL experiment, it is seen that in the CST experiment, the analogous discrepancy disturbance does not increase monotonously with time, the discrepancy disturbance has obviously decreased from the 6th month, but has increased again from the 8th month. This is to say that if the circulation anamoly is analogous in the initial time, it will become analogous again after half a year, which is basically the same with the observation. It is shown that the coupled ocean-atmosphere interaction plays an important part in the formation and evolution process of analogous rhythm.

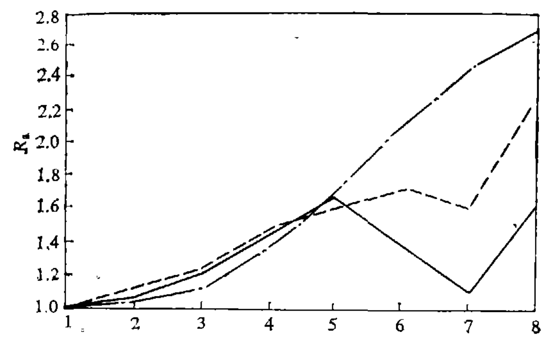


Fig. 2. Temporal variations of $R_a$.
Dashed line represents the NL experiment, solid line the CST experiment and dotted line the NSV experiment.

The sensitivity experiment (NSV experiment, see dotted line in Fig. 2) does not consider the seasonal variation of the monthly mean circulation. The basic state is taken as the monthly mean field of the 1st month from beginning to end. From Fig. 2, we can find that NSV and CST experiments are different. The analogous discrepancy disturbance increases monotonously from beginning to end. The seasonal variation of the monthly mean circulation also plays an important part in the formation and evolution process of analogous rhythm.

This is to say that both seasonal variation and ocean-atmosphere coupled interaction are considered at the same time, the analogous rhythm could be simulated. This furthur verifies the above result of theoretical analysis.

## V. Conclusion and Discussion

In this paper, the formation and evolution of analogous rhythm is studied from theory and numerical simulation. The purpose of the studies is to explore a new approach of seasonal long-range numerical prediction. Because the evolution of atmospheric state starting from the similar initial and boundary condition always becomes similar after a certain interval period, the historical analogous approach is one of the main tools in the operational forecast of many countries, meteorological offices. Unfortunately, the historical analogous approach imagines the future to be a simple repetition of the history. It limited greatly the forecast skill. Considering from the dynamics, the forecasted field can be regarded as a small disturbance superposed on the historical analogous field, and thus the statistics could be combined with the dynamics[11]. According to this reason, a long-range numerical prediction model in discrepance form was built. The analogous discrepance which mirrors the analogy of monthly mean circulation was taken as the model variable. This model not only has the advantage of the anomaly model, but also can remedy partially the defects of model with the information provided by historical data, meanwhile, it can combine the analogous approach of statistical forecast with the dynamical one. From the numerical experiments, the results are encouraging. It is necessary to study how this model may be used in the operational prediction and improved in future, and it is full of promise.

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