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Abstract : There is a close relationship between climate system and ecological system. Apparently, air temperature on ecosystem , to great extent, affects the physiological and biochemical processes of the ecology, which influences the development of the ecological system, so studying the relationship between air temperature and the ecological system is very important. In this paper, the ecological system (i.e. oasis) is assumed to be all covered by plants, in terms of both Charney's desert theory(Charney,1975) and Pan et.al.'s thermal energy balance method (Pan et.al.,2001), we theoretically build a climate dynamical model, With which air temperature on underlying ground(i.e. vegetation) is calculated separately in consideration of elements(the underlying ground's albedo, resistance of stomata of plant and solar radiation flux). It is shown that changes among these elements can produce different changes of air temperature on the underlying ground, which will affect the development of ecology in return, leading to further understanding relationship between climate and oasis. And further research of these questions is on the way.

Keywords: Climate dynamical model；Air temperature；Oasis development

1．INTRODUCTION

Chinese oasis is an intrazonal landscape under control of huge basin-mountain system, also a special counterpart in the arid region of west-China, whose degeneration is extremely serious. Meanwhile degeneration process is much faster than its adverse counterpart, from former Soviet Union, ecological state degenerated within 1-3 years can be recovered within at least 15-20 years. It is well known that the development of oasis, to great extent, depends on the response of oasis to environmental condition, such as conditions of climate and water, so speculating biosphere-climate interaction is very important, but oasis development mechanism has not been known well so far. For example, relationship between oasis and climate , process of oasis formation, boundary of oasis and desert, driving force of oasis development etc. All these need to be explored in the present paper and future efforts.

In this paper, in consideration of both dynamic process of general atmosphere and important process of the energy balance in a simple system that includes vegetation (or soil)

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and atmosphere, we theoretically build a climate dynamical model to calculate air temperatures over underlying surface under some elements(underlying surface's albedo、resistance of stomata of plant and solar radiation flux), leading to further understanding relationship between climate and oasis, but we need deeper study so that an artificial theory to modify oasis will be made .

2. CONSIDERATION OF QUESTIONS

Climate is one of the most significant factors that decide vegetation distribution and types. By means of relationship between climate and vegetation, the influences of future climate on vegetation can be predicted, also the development of oasis can be predicted. The present study(Zhang,et.al.,1998) showed that local thermal circulation produced by thermal difference between oasis and desert and horizontal advection transportation caused by large scale streamline field can result in interaction of oasis and desert, therefore, it is very significant to take account into air temperature on them. But here we just consider oasis as underlying surface and analyze air temperature on which with the changes of a few elements. Coupling between oasis and desert will be researched in next step.

2.1 Temperature of Underlying Surface

Supposing oasis is completely covered by vegetation, its average albedo is α_l , the departure of temperature of the oasis is T_l'. If the oasis is conservative in the horizontal direction, T_l' in energy balance from (Pan et.al.,2001) is written as follow,

$$T_l' = \frac{C_l}{A_l} \qquad (1)$$

$$A_l = \rho_a C_p V\left(C_d + C_h\right) + 4\varepsilon\sigma T^{*3}$$

$$+\rho_a C_p L_{AE} B_e^{-1}\left(r_E + \bar{r}_s{}^a\right)^{-1} \qquad (2)$$

$$C_l = (1-\alpha_l)Q_a + \left[4\varepsilon\sigma T^{*3} + \rho_a C_p\left(r_E^{-1} + L_{AE}B_e^{-1}\left(r_E + \bar{r}_s{}^a\right)^{-1}\right)\right]T_a'$$

$$-\rho_a L_v L_{AE}\left(r_E + \bar{r}_s{}^a\right)^{-1}(1-r)q^{sat}T_a \qquad (3)$$

Where ρ_a is air density, ε is the grey body coefficient, σ is the Stefan-Boltzmann constant, Q_a is solar radiation flux, $\bar{r}_s{}^a$ is the resistance coefficient of stomata, C_p is air specific heat on constant pressure, L_v is the evaporating latent heat, L_{AE} is the leaf surface size coefficient, r_E =(C_d V)$^{-1}$, r is the air relative humidity, q^{sat} is the air saturation specific humidity, V is wind speed, C_d is the aerodynamics drag coefficient for heat, T_a is air temperature, B_e is the Bowen ratio.

We consider the above temperature as canopy height and the temperature is affected by the atmosphere on the oasis by turbulent process.

2.2 Boundary Condition of Canopy Height (condition of energy balance)

Supposing in the canopy height **:** received solar radiation flux is equal to summation of long wave radiation flux , sensible and latent heat, hence,

$$-\rho_a C_p k_i \frac{\partial T_a'}{\partial z} = (1-\alpha_l)Q_a - \left(4\sigma\bar{T}^3 + \rho_a C_p C_d V B_e^{-1}\right)\left(T_l' - T_a'\right)$$

(4)

Omitting subscript a, and taking account into

$$q^{sat}T = q^{sat}\bar{T} + \left(\frac{\partial q}{\partial T}\right)^{sat}\left(T - \bar{T}\right) = q^{sat}\bar{T} + \left(\frac{\partial q}{\partial T}\right)^{sat}T'$$

(5)

（3）can be taken as ,

$$C_l = (1-\alpha_l)Q_a - \rho_a L_v L_{AE}\left(r_E + \bar{r}_s{}^a\right)^{-1}(1-r)q^{sat}\bar{T}$$

$$+[4\varepsilon\sigma\bar{T}^3 + \rho_a C_p\left(r_E^{-1} + L_{AE}B_e^{-1}\left(r_E + \bar{r}_s{}^a\right)^{-1}\right)$$

$$-\rho_a L_v L_{AE}\left(r_E + \bar{r}_s{}^a\right)^{-1}(1-r)\left(\frac{\partial q}{\partial T}\right)^{sat}]T'$$

$$= C_l^{*(1)} + C_l^{*(2)}T' \qquad (6)$$

$z \approx 0$,

$$\rho_a C_p k_l \frac{\partial T'}{\partial z} + \left(4\sigma \overline{T}^3 + \rho_a C_p C_d V B_e^{-1}\right)\left(1 - \frac{C_l^{*(2)}}{A_l}\right)T' =$$

$$\left(4\sigma \overline{T}^3 + \rho_a C_p C_d V B_e^{-1}\right)\frac{C_l^{*(1)}}{A_l} - (1-\alpha_l)Q_a \qquad (7)$$

The above formulation is taken as the lower boundary condition of atmosphere motion, in this way, we have considered interaction of climate system and ecological system(here means vegetation system)。

2.3 Coupling on Motion of Free Atmosphere

2.3.1 Motion Equation in Free Atmosphere

Taking account into the theory from(Charney,1975) in（x, z）section, also assuming the scale of the background climate field is much bigger than the analog of the oasis, so to be even in the horizontal direction, hence,

$$u = -K_v \frac{g}{f^2 \overline{T}} \frac{\partial^2 T'}{\partial x \partial z} \qquad (8)$$

$$w = K_v \frac{g}{f^2 \overline{T}} \frac{\partial^2 T'}{\partial x^2} \qquad (9)$$

Where u , v , w mean velocity component along the x-axis, y-axis and z-axis respectively, K_v is momentum eddy exchange coefficient, g is gravitational acceleration, f is geostrophic parameter.

Now we can calculate movement field in the light of the air temperature.

2.3.2 Heat Transport Equation

Based on the above relationship, in the stable situation among the radiative transfer, vertical sensible heat transport and vertical motion, and according to solution of dealing with long wave radiation process from (Kuo, 1973) and (Chao, 1979), When $z \to \infty$, $C_1 = 0$, if $T = \overline{T} + T'$, $T^4 \approx \overline{T}^4 + 4\overline{T}^3 T'$, C_o equals average value, so

The heat balance equation is

$$\left(\frac{N}{f}\right)^2 K_v \frac{\partial^2 T'}{\partial x^2} = \left(K_T + \frac{8\sigma r^* \overline{T}^3}{\alpha_s' \rho_s}\right)\frac{\partial^2 T'}{\partial z^2}$$

$$-8\left(1-r^*\right)\alpha_w' \sigma \rho_c \overline{T}^3 T' + \alpha'' \rho_s Q_a \qquad (10)$$

Where $N = \left(\frac{g}{\Theta}\frac{\partial \Theta}{\partial z}\right)^{\frac{1}{2}}$ is Brunt-Vaisaila frequency, α_j' , α'' are absorption coefficients of long wave radiation and solar radiation to the wavelength of λ_j respectively, A_j , B_j are downward and upward long wave radiation fluxes in the wavelength of λ_j respectively, E_j is the black body radiative energy in the wavelength of λ_j , ρ_c is density of absorbing medium, K_T is heat exchanging coefficient of vertical turbulent.

The above formulation is a basic equation of coupling model of dynamical radiation, the lower boundary condition is (14), the upper boundary condition is

$$z \to \infty , \qquad T' \to 0 \qquad (11)$$

The model shows that interaction between climate system and ecological system.

2.3.3 Coordinate Transformation—Optics Thickness

By using of optics thickness,

$$\xi = \frac{\alpha''}{\alpha_s' \xi_o} \int_z^{\infty} \alpha_s' \rho_c dz \qquad \xi_o = \frac{\alpha''}{\alpha_s'} \int_o^{\infty} \alpha_s' \rho_c dz \qquad (12)$$

Integration of solar energy transfer equation is as follow,

$$Q_a = Q_a^o e^{-\xi_o \xi} \qquad (13)$$

Q_a^o is solar radiation flux in the aeropause.

From another hand, (7) becomes,

$$\xi = 1, \quad \frac{\partial T'}{\partial \xi} - N_{1,l} T' = -N_{2,l} + N_{3,l} \qquad (14)$$

Where $N_{1,l} = \left(4\sigma \overline{T}^3 + \rho_a C_p C_d V B_e^{-1}\right)\left(1 - C_l^{*(2)} / A_l\right) / D^*$

(15)

$$N_{2,l} = \left(4\sigma \overline{T}^3 + \rho_a C_p C_d V B_e^{-1}\right) C_l^{*(2)} / A_l / D^* \qquad (16)$$

$$N_{3,l} = (1-\alpha_l) Q_a^o e^{-\xi_o \xi} / D^* \qquad (17)$$

$$D^* = \left(\frac{\alpha^{"}\rho_c}{\xi_o}\right)\left(\rho_a C_p k_l\right) \qquad (18)$$

Another boundary condition is,

$$\xi \to 0 \ , \ T^{'} \to 0 \text{ or } \frac{\partial T^{'}}{\partial \xi} \to 0 \qquad (19)$$

So far, the model of questions is over.

2.3.4 Vertical Average Model

Defined vertical average value:

$$T^{'*} = \int_1^o T^{'} d\xi \qquad (20)$$

And assuming $T^{'}_{\xi=1} = aT^{'*}$, finally, (10) is

$$M_1 \frac{\partial^2 T^{'*}}{\partial x^2} + \left(M_2 + aN_{1,l}\right)T^{'*}$$

$$= \left(N_{2,l} - N_{3,l}\right) - M_3 \frac{1}{\xi_o}\left(1 - e^{-\xi_o}\right) = F(x) \qquad (21)$$

3. SOLUTION OF THESE QUESTIONS

Assuming the oasis's horizontal scale i.e. $(0, l)$ is (-50km,50km), and the air temperature on oasis at the horizontal border is ambient temperature, that is,

$$x = 0 \ , \ l \qquad T^{'*} = T_c^{'*} \qquad (22)$$

By means of Green function, to solve the above question, and construct figure of analytical solution of air temperature on the oasis(omitting figure).

In order to more conveniently analyze difference and development of oasis and desert, we take up difference method to solute (21) and construct figure of the results that is like figure of the analytical solution, so it is credit to use the model to theoretically analyze relationship of climate and oasis.

From studies(Pan, et.al.,2001and Pan,2001), ecological system will be broken with a little change of albedo or resistance of stomata of plant etc. The unstable ecological system can be developed to direction of oasis or desert.

Therefore, here some elements i.e. changing of underlying surface's albedo、resistance of stomata of plant and solar radiation flux under the same other parameters are considered into the model to calculate air temperatures on the oasis respectively. The results are given as follow .

The same other parameter values used here are:

ρ_a =1.293kg/m^3, ε =0.5, σ =5.673*10^{-8}J/s • m^2 • K^4, C_p =1004J/(kg • K), L_v =2.5*10^{16}J/kg, L_{AE} =0.5, B_e =1.0, r_E $^{-1}$=(C_d V)=5.5x10^{-3}sec/m , r =0.5, q^{sat} =0.5, V =2.0m/s, C_d =2.75x10^{-3}, C_h =2.75x10^{-3}, T^* =273K, ρ_c =6*10^{-6}g/cm^3, ξ_o =0.4, $\alpha^{"}$ =0.25cm^2/g, $\alpha_w^{'}$ =1.25cm^2/g, $\alpha_s^{'}$ =100 cm^2/g, r^* =0.5, g =9.8m/sec^2, Ω=7.2921152*10^{-5}, Φ=(40*π)/180(here latitude is 40 °N), f=2ΩsinΦ.

3.1 Influences of Different Values of Albedo of the Oasis under the Same Circumstances of Resistance of Plant Stomata and Solar Radiation Flux

When Q_a^o =500w/m^2, $\bar{r}_s^{\,a}$ is 600sec/m, albedo of the oasis i.e. α_l is 0.15, 0.20, 0.23, 0.25, 0.30 respectively, to calculate air temperature on the oasis and to get figure 1 .

Oasis albedo reflects condition of the vegetation covering area, if know air temperature on the vegetation, we may know change and type of the vegetation , in this way, we can obtain more information in order to supervise oasis very well.

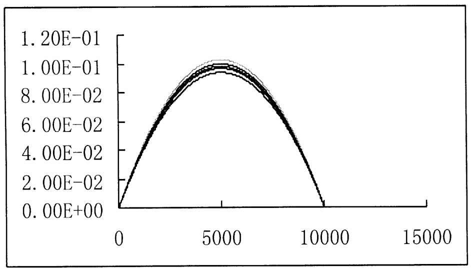

Figure 1. Distribution of air temperature on the oasis with change of the oasis's albedo.

The same resistance of plant stomata and solar radiation flux, that means no change of transpiration rate, from figure 1, air temperatures on the oasis (or bare soil) descend as their albedo increase (omitting figure of change of air temperature on bare soil) . But their changing range is different, mainly because vegetation in the oasis can adjust air temperature by means of transpiration.

3.2 Influence of Resistance of Plant Stomata under the Same Circumstances of Albedo and Solar Radiation Flux

When α_l =0.23, Q_a^o =500w/m^2, $\bar{r}_s^a$ is equal to 400, 600, 800, 1000, 1200sec/m, to obtain figure2.

Different resistance of plant stomata from different plants can cause the change of transpiration rate, whereas air temperature on plants directly affects values of resistance of plant stomata. When air temperature increases, transpiration rate of plant weakens, and resistance of plant stomata descends, verse, the same. So according to the relationship, oasis development can be further comprehended.

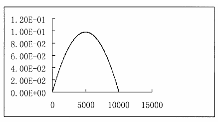

Figure 2. Distribution of air temperature on the oasis with change of resistance of plant stomata.

Under the circumstances of the same albedo of the oasis and solar radiation flux, from figure 2, we can see, with the resistance of plant stomata rising, air temperature on the oasis increases slightly. This phenomenon shows that latent heat in the heat balance of the oasis surface plays a role so that the heat capacity of the oasis surface increases, the result consists with conclusion of (Zhang, 1998).

3.3 Influence of Solar Radiation Flux under the Same Circumstances of Resistance of Plant Stomata and Albedo

Solar radiation flux is one of the most important factors of affecting plant-growing, when α_l =0.23, $\bar{r}_s^a$=600sec/m, Q_a^o is 100, 300, 500w/m^2 respectively (here Q_a^o is given artificially), to obtain figure3.

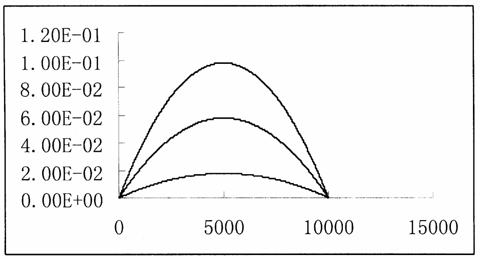

Figure3. Distribution of air temperature on the oasis with change of solar radiation flux.

From figure 3, air temperature on oasis obviously increases by growth of solar radiation flux under the same circumstances of resistance of plant stomata and albedo. Changing of solar radiation flux can result in air temperature on the oasis, which further causes change of the oasis(i.e. vegetation).

4. CONCLUSION

Oasis development is an important environmental problem. The well oasis develops, the good the environment is, verses, the same. It is worthy theoretically studying air temperatures on oasis and bare soil in the states of considerating the three elements, in the way, we may obtain relationship between oasis and atmosphere so that we can predict oasis development and control it. But we need further research these questions by the model, for example, the departure of the air temperature over the oasis can cause the change of streamfield which further affects the development of oasis.

In this paper, we mainly theoretically build a climate dynamical model on oasis development, theoretically analyze relationship of oasis (vegetation) and air temperatures on the oasis, **1.** air temperatures on the oasis (or bare soil) descend as their albedo increase under the same circumstances of resistance of plant stomata and solar radiation flux. **2.** with the resistance of plant stomata rising, air temperature on the oasis increases slightly. This phenomenon shows that latent heat in the heat balance of the oasis surface plays a role so that the heat capacity of the oasis surface increases under the same circumstances of albedo and solar radiation flux. **3.**air temperature on oasis obviously increases by growth of solar radiation flux under the same circumstances of resistance of plant stomata and albedo.

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