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On a Simple Dynamics Model of Interaction between Oasis and Climate

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ABSTRACT

This paper constructs a coupled system of oasis and atmosphere based on an oasis evolvement model by adding atmospheric motion to discuss the problem of oasis evolvement and its effects on regional climate. The results indicate that the range and scope of the negative temperature anomalies become larger when the oasis cover fraction increases. Correspondingly, the positive temperature anomalies becomes smaller in the desert no matter in summer or spring. And the variability is more obvious in summer than in spring. So it may be concluded that the oasis not only maintains and develops itself but also develops partial air over the desert into an oasis climate.

Key words: oasis, desert, temperature anomalies

1. Introduction

Oasis and desert coexisting in the arid climate zone is an unique natural landscape that is more obvious to be seen in China's northwest Xinjiang Autonomous Region. Both the oasis and the desert affect the regional climate, especially temperature. Many scholars work in the aspect of theoretical analysis, for example Charney (1975) pointed out that a reduction of vegetation, with consequent increase in the surface albedo would enhance sinking motion, additional drying, and therefore perpetuate the arid conditions and decrease rainfall in 1975. But more researchers study numerical tests, such as Dickinson et al. (1984, 1986, 1992), Zhang and Zhao (1998, 1999), and Zhang et al. (1998). Recently, Pan and Chao (2001) constructed a simple oasis evolvement model, and calculated the total evapotranspiration rate of the oasis and the temperature of vegetation and soil in different climatic and ecological conditions by using the thermal energy balance equations of vegetation and soil, and indicated that qusasi-bifurcation and the multi-equilibrium state appear in the solutions of evapotranspiration rate in the cover fraction covered by a small part of the vegetation in some conditions.

In their paper, the temperature near the ground must be known for calculating the latent heat flux and longwave radiation because the atmospheric motion is not considered in the simple model. In fact the local air temperature may change through exchange with the underlying surface, i.e., the land and atmosphere is an interacting system.

In this paper, we construct an coupled oasis-atmosphere coupling system by considering atmospheric motion based on Pan and Chao's (2001) oasis evolvement model, and discuss the oasis evolvement problem further.

2. The energy balance of the underlying the surface

According to Pan and Chao (2001), the energy balance equation in oasis is

$$(1-\alpha_\mathrm{l})Q_\mathrm{a}-\varepsilon\sigma T_\mathrm{l}^4=\frac{\rho_\mathrm{a}c_p(T_\mathrm{l}'-T')}{r_\mathrm{E}}+\frac{\rho_\mathrm{a}L_\mathrm{v}[q_\mathrm{sat}(T_\mathrm{l})-rq_\mathrm{sat}(T)]}{(r_\mathrm{E}+r_\mathrm{C})}\,, \tag{1}$$

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where $(1-\alpha_{\rm l})Q_{\rm a}$ is the solar radiation term, $\varepsilon\sigma T_{\rm l}^4$ is the upward flux of longwave radiation,

$$\frac{\rho_{\rm a}c_p(T_{\rm l}'-T')}{r_{\rm E}}$$

is the sensible heat flux, and

$$\frac{\rho_{\rm a}L_{\rm v}[q_{\rm sat}(T_{\rm l})-rq_{\rm sat}(T)]}{(r_{\rm E}+r_{\rm C})}$$

is the latent heat flux. Further, $Q_{\rm a}$ is solar radiation, $T_{\rm l}$ and T represent vegetation and air temperature respectively, "$'$" represents anomalies, $r_{\rm E}$ and $r_{\rm C}$ represent resistance coefficients of aerodynamics and stomata respectively, and $\alpha_{\rm l}$ is the surface albedo of vegetation. The other parameters are common or found in Pan and Chao (2001).

If we define

$$q_{\rm sat}(T_{\rm l})=q(\bar{T}_{\rm l})_{\rm sat}+\left(\frac{\partial q}{\partial T}\right)_{\rm sat}T_{\rm l}'\ ,$$

$$q_{\rm sat}(T)=q_{\rm sat}(\bar{T})+\left(\frac{\partial q}{\partial T}\right)_{\rm sat}T'\ ,$$

and we assume $T=\bar{T}+T'$, where $\bar{T}$ and T' are environment temperature and temperature anomalies respectively, so

$$T^4\approx\bar{T}^4+4\bar{T}^3T'\ ,$$

then

$$T_{\rm l}'=\frac{C_{\rm l}^{*(1)}}{A_{\rm l}}+\frac{C_{\rm l}^{*(2)}}{A_{\rm l}}T'\ , \tag{2}$$

where

$$A_{\rm l}=\frac{\rho_{\rm a}c_p}{r_{\rm E}}+4\varepsilon\sigma\bar{T}_{\rm l}^3+\frac{\rho_{\rm a}L_{\rm v}}{(r_{\rm E}+r_{\rm C})}\left(\frac{\partial q}{\partial T}\right)_{\rm sat}\ ,$$

$$C_{\rm l}^{*(1)}=(1-\alpha_{\rm l})Q_{\rm a}-\varepsilon\sigma\bar{T}_{\rm l}^4-\frac{\rho_{\rm a}L_{\rm v}[q_{\rm sat}(\bar{T}_{\rm l})-rq_{\rm sat}(\bar{T}_{\rm a})]}{(r_{\rm E}+r_{\rm C})}\ ,$$

$$C_{\rm l}^{*(2)}=\frac{\rho_{\rm a}c_p}{r_{\rm E}}-\frac{\rho_{\rm a}L_{\rm v}}{(r_{\rm E}+r_{\rm C})}\left(\frac{\partial q}{\partial T}\right)_{\rm sat}\ .$$

The above equations are Pan and Chao's (2001) energy balance equation in the horizontal direction, but furthermore, there is heat exchange between the oasis and the air over it. We assume there is energy balance among solar radiation, longwave radiation, sensible heat, and evaporation latent heat at the top of the vegetation. Then

$$\rho_ac_pK_{\rm l}\frac{\partial T'}{\partial z}=(1-\alpha_{\rm l})Q_{\rm a}-\varepsilon\sigma\bar{T}_{\rm l}^4-4\varepsilon\sigma\bar{T}_{\rm l}^3T_{\rm l}'-\frac{\rho_{\rm a}L_{\rm v}}{(r_{\rm E}+r_{\rm C})}\left\{\left[q_{\rm sat}(\bar{T}_{\rm l})+\left(\frac{\partial q}{\partial t}\right)_{\rm sat}T_{\rm l}'\right]-rq(\bar{T})_{\rm sat}-r\left(\frac{\partial q}{\partial T}\right)_{\rm sat}T'\right\}\ . \tag{3}$$

Substituting (2) into (3), we have

$$-\rho_{\rm a}c_pK_{\rm l}\frac{\partial T'}{\partial z}+\left[4\varepsilon\sigma\bar{T}_{\rm l}^3\frac{C_{\rm l}^{*(2)}}{A_{\rm l}}+\rho_{\rm a}L_{\rm v}(r_{\rm E}+r_{\rm C})^{-1}\times\left(\frac{\partial q}{\partial T}\right)_{\rm sat}\frac{C_{\rm l}^{*(2)}}{A_{\rm l}}-r\frac{\rho_{\rm a}L_{\rm v}}{r_{\rm E}+r_{\rm C}}\left(\frac{\partial q}{\partial T}\right)_{\rm sat}\right]T'$$
$$=(1-\alpha_{\rm l})Q_{\rm a}-\varepsilon\sigma\bar{T}_{\rm l}^4+4\varepsilon\sigma\bar{T}_{\rm l}^3\frac{C_{\rm l}^{*(1)}}{A_{\rm l}}+\frac{\rho_{\rm a}L_{\rm v}\left[q_{\rm sat}(\bar{T}_{\rm l})+\left(\frac{\partial q}{\partial T}\right)_{\rm sat}\frac{C_{\rm l}^{*(1)}}{A_{\rm l}}-rq_{\rm sat}(\bar{T})\right]}{(r_{\rm E}+r_{\rm C})}\ . \tag{4}$$

Eq. (4) will be the lower boundary condition of atmospheric motion when the underlying surface is oasis. It considers interaction between the climate system and the ecological system under it to some extent.

As for desert, latent heat flux is different from that of the oasis. Here, the bowen ratio is abbreviated as $B_{\rm e}$, then

$$\frac{\rho_{\rm a}c_p(T_{\rm s}'-T_{\rm a}')}{r_{\rm E}B_{\rm e}}$$

is latent heat flux, thereby the energy balance equation is:

$$(1-\alpha_{\rm s})Q_{\rm a}-\varepsilon\sigma T_{\rm s}^4=\frac{\rho_{\rm a}c_p(T_{\rm s}'-T_{\rm a}')}{r_{\rm E}}+\frac{\rho_{\rm a}c_p(T_{\rm s}'-T_{\rm a}')}{r_{\rm E}B_{\rm e}}\ . \tag{5}$$

Lastly, we obtain the equation similar to that in the oasis

$$A_{\rm s}T_{\rm s}'=C_{\rm s}\ , \tag{6}$$

where

$$A_{\rm s}=\frac{\rho_{\rm a}c_p}{r_{\rm E}}+4\varepsilon\sigma\bar{T}_{\rm s}^3+\rho_{\rm a}c_pr_{\rm E}^{-1}B_{\rm e}^{-1}\ ,$$

$$C_{\rm s}=(1-\alpha_{\rm s})Q_{\rm a}-\varepsilon\sigma\bar{T}_{\rm s}^4+\frac{(\rho_{\rm a}c_p+\rho_{\rm a}c_pB_{\rm e}^{-1})}{r_E}T'=C_{\rm s}^{*(1)}+C_{\rm s}^{*(2)}T'\ ,$$

or

$$T_{\rm s}'=\frac{C_{\rm s}^{*(1)}}{A_{\rm s}}+\frac{C_{\rm s}^{*(2)}}{A_{\rm s}}T'\ . \tag{7}$$

Similarly, when $z\approx0$

$$\rho_{\rm a}c_pK_{\rm s}\frac{\partial T'}{\partial z}+\left(\frac{\rho_{\rm a}c_pB_{\rm e}^{-1}}{r_{\rm E}}-4\varepsilon\sigma\bar{T}_{\rm s}^3\frac{C_{\rm s}^{*(2)}}{A_{\rm s}}-\frac{\rho_{\rm a}c_pB_{\rm e}^{-1}}{r_{\rm E}}\frac{C_{\rm s}^{*(2)}}{A_{\rm s}}\right)T'$$
$$=-(1-\alpha_{\rm s})Q_{\rm a}+\varepsilon\sigma\bar{T}_{\rm s}^4+4\varepsilon\sigma\bar{T}_{\rm s}^3\frac{C_{\rm s}^{*(1)}}{A_{\rm s}}+\frac{\rho_{\rm a}c_pB_{\rm e}^{-1}}{r_{\rm E}}\frac{C_{\rm s}^{*(1)}}{A_{\rm s}}\ . \tag{8}$$

Equation (8) will be the lower boundary condition of atmospheric motion when the underlying surface is desert.

3. Atmospheric motion equation

The atmospheric motion equations on (x,z) are

$$fu = K_v \frac{\partial^2 v}{\partial z^2}\ , \tag{9}$$

$$f\frac{\partial v}{\partial z} = \frac{g}{\bar{T}}\frac{\partial T'}{\partial x}\ , \tag{10}$$

$$\frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} = 0\ . \tag{11}$$

We may obtain from Eq. (11)

$$w = \frac{\partial \psi}{\partial x}\ ,\ \ u = -\frac{\partial \psi}{\partial z}\ . \tag{12}$$

Substituting Eq. (12) into Eq. (9) we get

$$f\frac{\partial \psi}{\partial z} = -K_v\frac{\partial^2 v}{\partial z^2}\ , \tag{13}$$

and assuming

$$z \to \infty\ ,\ \ \psi \to 0\ ,\ \ K_v\frac{\partial v}{\partial z} \to 0\ , \tag{14}$$

then

$$f\psi = -K_v\frac{\partial v}{\partial z}\ . \tag{15}$$

And substituting Eq. (15) into Eq. (10) gives

$$f^2\psi = -K_v\frac{g}{\bar{T}}\frac{\partial T}{\partial x}\ , \tag{16}$$

from which we derive

$$u = K_v\frac{g}{f^2\bar{T}}\frac{\partial^2 T'}{\partial x\partial z}\ , \tag{17}$$

$$w = -K_v\frac{g}{f^2\bar{T}}\frac{\partial^2 T'}{\partial x^2}\ . \tag{18}$$

4. The radiation energy transfer equation

The above streamline flow of the atmospheric motion is described by T', so a control equation to decide T' needs to be constructed. We may obtain the following heat balance equation by using the radiative-conductive heat transfer equation of Kuo (1973) and Chao and Chen (1979),

$$\left(N^2\frac{\bar{T}}{g}\right)w = K_T\frac{\partial^2 T}{\partial z^2} + \sum_j \alpha'_{\mathrm{j}}\rho_{\mathrm{c}}(A_{\mathrm{j}} + B_{\mathrm{j}} - 2E_{\mathrm{j}}) + \alpha''\rho_{\mathrm{c}}Q_{\mathrm{a}}\ , \tag{19}$$

where A_{j} and B_{j} are the upward and the downward radiation of longwave radiation respectively, E_{j} is black body radiation, α_{j} and α'', whose density is ρ_{c}, are absorption coefficients for longwave and shortwave radiation respectively, N is the Brunt-Väsälä frequency, and K_T is the heat exchange coefficient. According to Kuo and Chao's schemes to deal with the longwave radiation process and using Eq. (18), Eq. (19) is changed into

$$\left(\frac{N}{f}\right)^2 K_v\frac{\partial^2 T}{\partial x^2} + K_T\frac{\partial^2 T}{\partial z^2} + \frac{8\sigma r^*\bar{T}^3}{\alpha'_{\mathrm{s}}\rho_{\mathrm{s}}}\frac{\partial^2 T}{\partial z^2} - 2\left(1-r^*\right)\alpha'_{\mathrm{w}}\sigma\rho_{\mathrm{c}}T^4 + \alpha''\rho_{\mathrm{s}}Q_a + C_0 + C_1 z = 0\ . \tag{20}$$

When $z \to \infty$, the physical quantity is limited, so $C_1 = 0$, and $C_0$is balanced by the average quantity. Then the anomaly equation is given by

$$\left(\frac{N}{f}\right)^2 K_v\frac{\partial^2 T'}{\partial x^2} + \left(K_T + \frac{8\sigma r^*\bar{T}^3}{\alpha'_{\mathrm{s}}\rho_{\mathrm{s}}}\right)\frac{\partial^2 T'}{\partial z^2} - 8\left(1-r^*\right)\alpha'_{\mathrm{w}}\sigma\rho_c\bar{T}^3T' + \alpha''\rho_{\mathrm{s}}Q'_{\mathrm{a}} = 0\ . \tag{21}$$

Equation (21) is the basic dynamical radiation coupled model equation; its lower boundary condition is Eq. (4) or Eq. (8) and the upper boundary condition is

$$z \to \infty\ ,\ \ T' \to 0\ . \tag{22}$$

The climate system and the ecological system (including oasis and soil) exist in obvious interaction in the model, i.e., they form a simple coupled system.

Now the optical depth is introduced

$$\xi = \frac{\alpha''}{\alpha'_{\mathrm{s}}\xi_0}\int_z^\infty \alpha'_{\mathrm{s}}\rho_{\mathrm{c}}dz\ ,\ \ \xi_0 = \frac{\alpha''}{\alpha'_{\mathrm{s}}}\int \alpha'_{\mathrm{s}}\rho_{\mathrm{c}}dz\ , \tag{23}$$

considering

$$\frac{\partial}{\partial z} = -\left(\frac{\alpha''\rho_{\mathrm{c}}}{\xi_0}\right)\frac{\partial}{\partial \xi}\ ,\ \ \frac{\partial^2}{\partial z^2} = \left(\frac{\alpha''\rho_{\mathrm{c}}}{\xi_0}\right)^2\frac{\partial^2}{\partial \xi^2}\ , \tag{24}$$

so Eq. (21) becomes

$$M_1\frac{\partial^2 T'}{\partial x^2} + \frac{\partial^2 T'}{\partial \xi^2} - M_2 T' + M_3 e^{-\xi_0\xi} = 0\ , \tag{25}$$

where

$$M_1 = \left(\frac{N}{f}\right)^2 K_v/C^*\ ,$$

$$M_2 = 8\left(1-r^*\right)\alpha'_{\mathrm{w}}\rho_{\mathrm{c}}\sigma\bar{T}^3/C^*\ ,$$

$$M_3 = \alpha''\rho_s Q_a^0/C^*\ , \tag{26}$$

and

$$C^* = \left(K_T + \frac{8r^*\sigma\bar{T}^3}{\alpha'_{\mathrm{s}}\rho_{\mathrm{s}}}\right)\left(\frac{\alpha''\rho_{\mathrm{c}}}{\xi_0}\right)^2\ . \tag{27}$$

On the other hand, Eq. (4) and Eq. (8) are changed into

$$\xi = \xi_0\ ,\ \ \frac{\partial T'}{\partial \xi} - N_{1,\mathrm{l,s}}T' = -N_{2,\mathrm{l,s}} + N_{3,\mathrm{l,s}}\ , \tag{28}$$

where the parameters N with three indices are universal forms, but when the underlying surface is desert, they only have two indices as follows,

$$N_{1,\mathrm{s}} =[(-4\varepsilon\sigma\bar{T}^3 + \rho_{\mathrm{a}}c_p r_{\mathrm{e}}^{-1}B_e^{-1})\frac{C_{\mathrm{s}}^{*(2)}}{A_{\mathrm{s}}} + \rho_{\mathrm{a}}c_p r_{\mathrm{e}}^{-1}B_e]/D_{\mathrm{s}}^* \;, \tag{29}$$

$$N_{2,\mathrm{s}}=[(4\varepsilon\sigma\bar{T}^3+\rho_{\mathrm{a}}c_p r_{\mathrm{e}}B_{\mathrm{e}}^{-1})\frac{C_{\mathrm{s}}^{*(2)}}{A_{\mathrm{s}}}+\varepsilon\sigma\bar{T}^4]/D_{\mathrm{s}}^* \;, \tag{30}$$

$$N_{3,\mathrm{s}} = (1-\alpha_{\mathrm{s}})\,Q_a e^{-\xi_0}/D_{\mathrm{s}}^* \;. \tag{31}$$

When the underlying surface is oasis,

$$N_{1,\mathrm{l}} = \left[-4\varepsilon\sigma\bar{T}^3 + \rho_{\mathrm{a}}L_{\mathrm{v}}(r_{\mathrm{E}}+r_{\mathrm{C}})^{-1}\left(\frac{\partial q}{\partial T}\right)_{\mathrm{sat}}\frac{C_l^{*(2)}}{A_{\mathrm{l}}} - r\frac{\rho_{\mathrm{a}}L_{\mathrm{v}}}{r_{\mathrm{E}}+r_{\mathrm{C}}}\left(\frac{\partial q}{\partial T}\right)_{\mathrm{sat}}\right]/D_{\mathrm{l}}^* \;, \tag{32}$$

$$N_{2,\mathrm{l}} = \left\{4\varepsilon\sigma\bar{T}^3 - \rho_{\mathrm{a}}L_{\mathrm{v}}(r_{\mathrm{E}}+r_{\mathrm{C}})^{-1}\left(\frac{\partial q}{\partial T}\right)_{\mathrm{sat}}\frac{C_{\mathrm{l}}^{*(1)}}{A_{\mathrm{l}}} - \frac{\rho_{\mathrm{a}}L_{\mathrm{v}}}{r_{\mathrm{E}}+r_{\mathrm{C}}}\left[\left(\frac{\partial q}{\partial T}\right)_{\mathrm{sat}} - rq_{\mathrm{sat}}(T)\right]\right\}/D_{\mathrm{l}}^* \;, \tag{33}$$

$$N_{3,\mathrm{l}} = (1-\alpha_{\mathrm{l}})Q_{\mathrm{a}}e^{-\xi_0}/D_{\mathrm{l}}^* \;, \tag{34}$$

$$D_{\mathrm{l,s}}^* = \left(\frac{\alpha''\rho_{\mathrm{c}}}{\xi_0}\right)(\rho_{\mathrm{a}}c_pK_{\mathrm{l,s}}) \;. \tag{35}$$

Another boundary condition is

$$\xi\to 0\;,\;\; T'\to 0\;,\;\; \text{or}\;\; \frac{\partial T'}{\partial\xi}\to 0\;. \tag{36}$$

5. The vertical average model of the temperature

We define the vertical average quantity as

$$T'^* = \frac{1}{\xi_0}\int_0^{\xi_0} T' d\xi \;. \tag{37}$$

Substituting Eq. (36) into the differential equation of Eq. (25) in the vertical direction, we have

$$M_1\frac{\partial^2 T'^*}{\partial x^2} - M_2T'^* = -\left(\frac{\partial T'}{\partial\xi}\right)_{\xi=\xi_0} - M_3\frac{1}{\xi_0^2}\left(1-e^{-\xi_0^2}\right) \;. \tag{38}$$

Using Eq. (28), and assuming

$$T'_{\xi=\xi_0} = aT'^* \;,$$

then Eq. (38) is changed into

$$M_1\frac{\partial^2 T'^*}{\partial x^2} + (-M_2 + aN_{1,\mathrm{l,s}}/\xi_0)\,T'^* = \frac{1}{\xi_0}\,(N_{2,\mathrm{l,s}} - N_{3,\mathrm{l,s}}) - M_3\frac{1}{\xi_0^2}\left(1-e^{-\xi_0^2}\right) = F\,(x) \;. \tag{39}$$

6. Experimental result

The parameter values used here are: v=2.4 m s^{-1}, $C_{\mathrm{d}} = C_{\mathrm{h}}$=2.75e^{-3},
σ = 5.673e^{-8} J s^{-1} m^{-2} K^{-4},
ρ_{a}=1.293 kg m^{-3}, c_p=1004 J kg $^{-1}$K^{-1},
L_{v}=2.5e^6 J kg^{-1}, r_{c}=150 s m^{-1},
α_{l} =0.15, α_{s}=0.2, ε=0.95,
r=0.5, K_T=50.53×4.1868e^2 J m^{-1},
B_{e}=1, R=0.5, K_{l}=1, K_{s}=1.5
α_{s}=10 m^2 kg^{-1}, α_{w} = 0.125 m^2 kg^{-1},
α''=0.025 m^2 kg^{-1}, $r_{\mathrm{e}} = 1/C_{\mathrm{d}}v$,
ξ_0=0.4, $f = 2\Omega\sin\varphi$, K_v=3×4.1868e^8 J m^{-1},
g=9.8 m s^{-2},
q_{sat} = 0.622×6.11e^{-3}× $10^{7.45t/(237.3+t)}$,
φ=45° = $\frac{45\pi}{180}$rad,
Ω=7.292e^{-5} rad s^{-1}, T = (273.15 + t)K,
N=1.16e^{-2} s^{-1}, ρ_{c}=6e^{-3} kg m^{-3},
r^*=0.5, and Q_{ao}=1370 W m^{-2}.

In China, most of the oases and deserts are located near, so we select 40°N as the latitude, and with test, 8°C and 22°C representing the spring and summer environment temperatures respectively. We calculate the relationship between the oasis cover fraction (or horizontal scale x) and the temperature anomaly (T') by using the model [Eq. (39)], the following figures show the results.

Figure 1 shows therelationship between the oasis cover fraction and the temperature anomaly when the environment temperature is 8°C, and (a), (b), (c), and (d) are the results when the oasis cover fraction is 20%, 40%, 60%, and 80% of the region cover fraction respectively. It may be found from Fig. 1 that the temperature anomalies are negative in most of the oasis cover fraction, however, they are positive in the desert, and the variable range of temperature anomalies becomes correspondingly larger when the oasis cover fraction increases. Moreover, the variable range of temperature becomes smaller in the desert. With the oasis cover fraction enlarging, the scope of the negative temperature anomalies increases, then the scope of the positive temperature anomalies correspondingly decreases.

Figure 2 shows the relationship between the oasis cover fraction and the temperature anomaly when the air temperature is 22°C, and (a), (b), (c), and (d) are the results when the oasis cover fraction is 20%, 40%, 60%, and 80% of the region cover fraction respectively. The results of Fig. 2 are similar to those of Fig. 1. In comparing Fig. 1 and Fig. 2, an obvious difference is

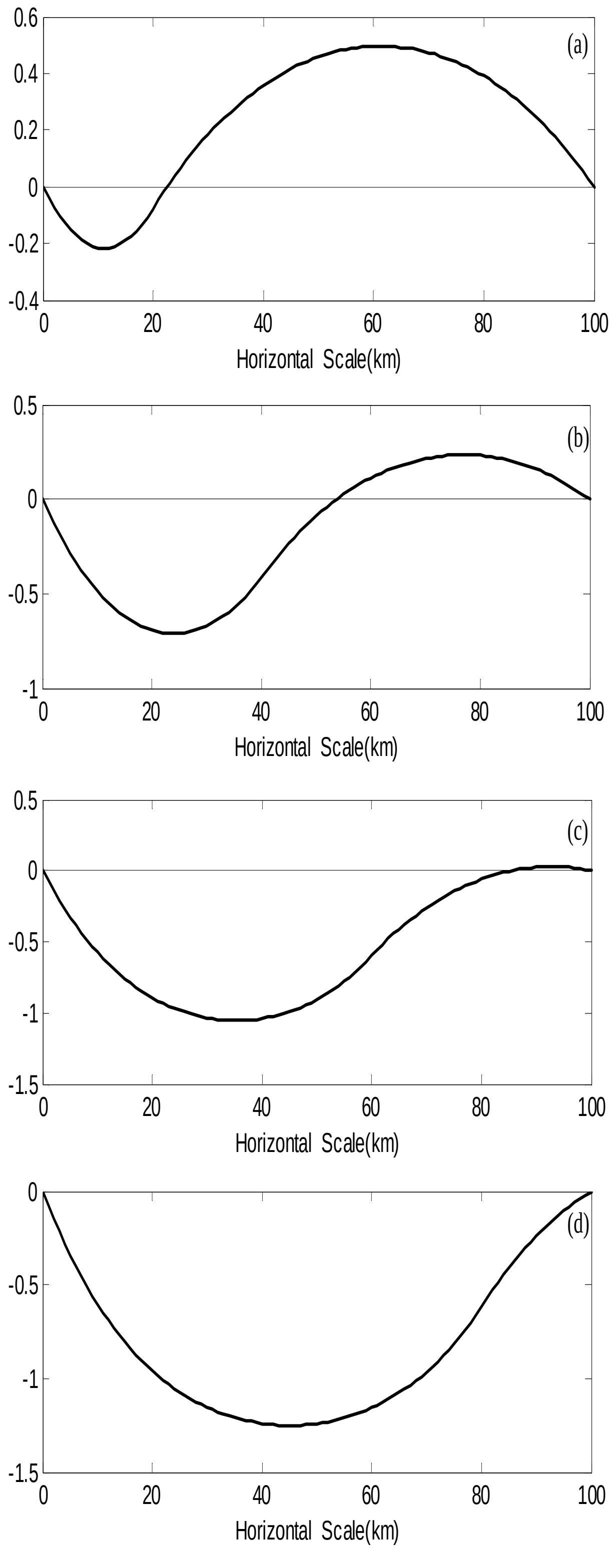

Fig. 1. The relationship between the oasis cover fraction and the temperature anomaly (°C) in spring. The oasis cover fraction is (a) 20%, (b) 40%, (c) 60%, and (d) 80%.

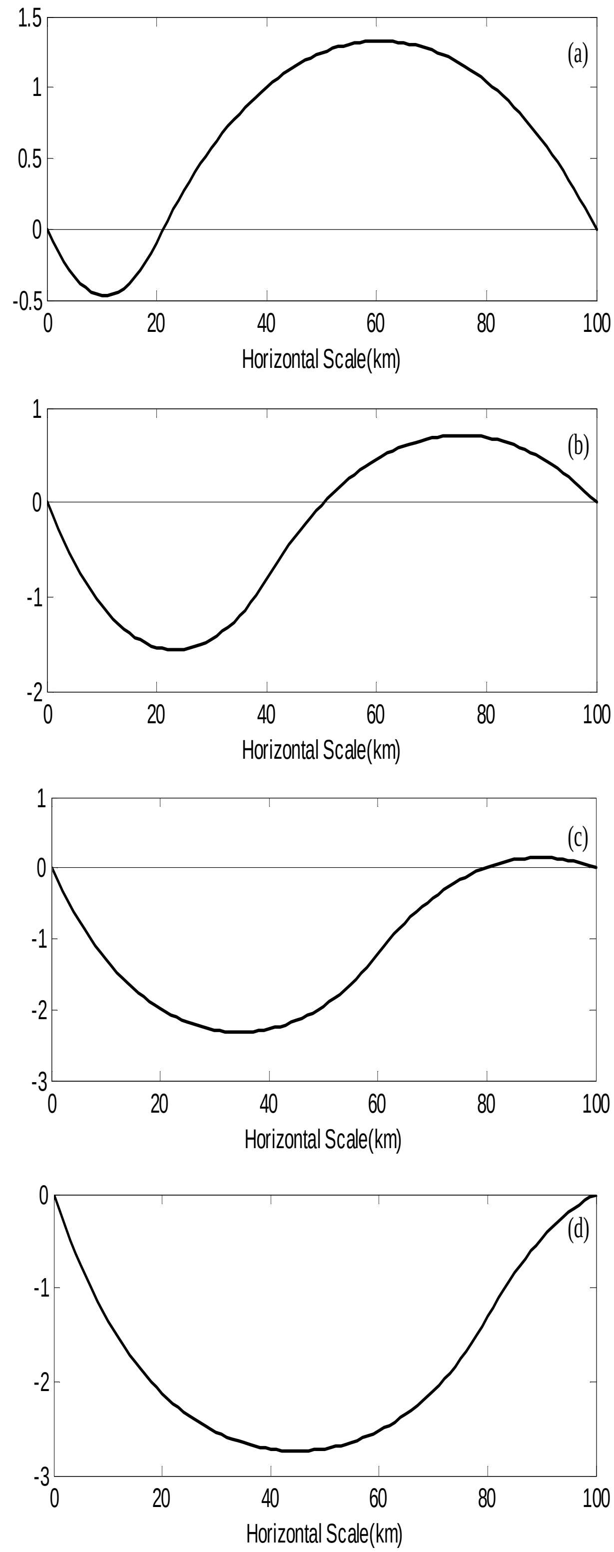

Fig. 2. The relationship between the oasis cover fraction and the temperature anomaly (°C) in summer. (a)–(b) as in Fig. 1.

that the variable range of temperature is larger than that of spring when the oasis cover fraction increases, and the variable range of temperature is smaller than that of spring in the desert, and even exceeds 1.5°C when the oasis cover fraction is 80% of the region cover fraction.

7. Discussion

Though the model is a highly simplified, land-atmosphere coupling model, it reveals a positive feedback process between the oasis and climate. And the above results also indicate that the oasis not only maintains and develops itself, but also develops partial air over the desert into an oasis climate, so it is a problem which deserves to be studied further.

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