Climate Supercirculation of the Earth

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Introduction

The objectives of this paper are, first, to determine the thermal regime on and near the Earth's surface, second, to interpret the space-time changes of climate oscillation in accordance with its cause, trigger, feedback mechanisms and chains.

Thermal Regimes

We begin with description of contemporary air temperature and insolation regime, respectively.

New Etalons

For determination of the thermal regime on and near the earth surface, we are necessary to select the insolation and air temperature, which are most constant under any physico-geographical changes and must been measured on a point of the Earth's globe, where solar ray falls perpendicularly. There are followings as described by author [1991; 1994; Maralgoo Earth Sciences Ltd., unpublished manuscript, 1995]:

Air temperature etalon: $A_0 = +30^{\circ}C$,

Insolation etalon $Q_o = 930$ cal $d^{-1}cm^{-2}$

The fact that perpendicular solar ray does not fall continually on a fixed point of the Earth's globe. It always wanders between the tropics of Cancer and Capricorn during the year. Therefore, these etalons are simultaneously terrestrial and interplanetaric parameters, which do not change under any natural, geographical and climatic conditions.

Insolation Regime (Q_φ^n)

It is determined by geographical latitude (φ), altitude of noon sun ($h_\otimes$)and length of daylight (C_φ^n), which may be written in the next form [T.Ulaanbaatar, Insolation regime on the Earth's surface, submitted to Papers in Meteorology and Geophysics, MRI, Ibaraki, Japan 1996]:

$$Q_\varphi^n = \frac{Q_o \cdot C_\varphi^n}{718} \cdot \cos[23^o 27' \cdot \cos(0.98563 \cdot N) + \varphi] \qquad (1)$$

Here

$$C_\varphi^n = 718 - 7.977 \cdot \arcsin\{tg\varphi \cdot tg[23^o 27^I \cdot \cos(0.98 \cdot n)]\} \qquad (2)$$

(Figure 1), (Figure 2), (Table 1) [Ulaanbaatar;T.,1994]

Table 1. Calculated length of daylight by equation (2) at winter and summer solstices

φ	at winter solstice		at summer solstice	
	by equ. (2)	by Shubev	by equ. (2)	by Shube
0	$12^h 00' 00''$	$12^h 00'$	$12^h 00' 00''$	$12^h 00'$
10	$11^h 24' 55''$	$11^h 25'$	$12^h 35' 05''$	$12^h 35'$
20	$10^h 47' 20''$	$10^h 47'$	$13^h 12' 39''$	$13^h 13'$
30	$10^h 03' 59''$	$10^h 04'$	$13^h 56' 00''$	$13^h 56'$
40	$09^h 09' 16''$	$09^h 09'$	$14^h 50' 43''$	$14^h 51'$
50	$07^h 51' 01''$	$07^h 51'$	$16^h 08' 58''$	$16^h 09'$
60	$05^h 30' 25''$	$05^h 30'$	$18^h 29' 34''$	$18^h 30'$
65	$02^h 52' 19''$	$02^h 51'$	$21^h 07' 40''$	$21^h 09'$
66.5	$00^h 31' 46''$	$00^h 31'$	$23^h 28' 12''$	$23^h 29'$

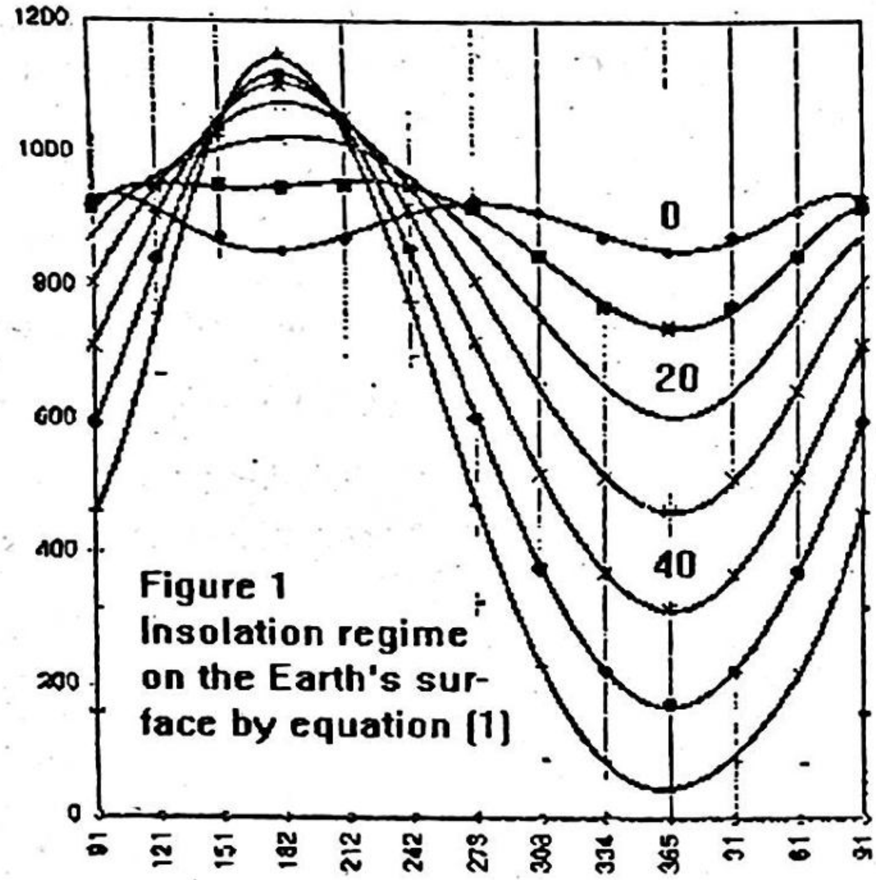

Figure 1
Insolation regime on the Earth's surface by equation (1)

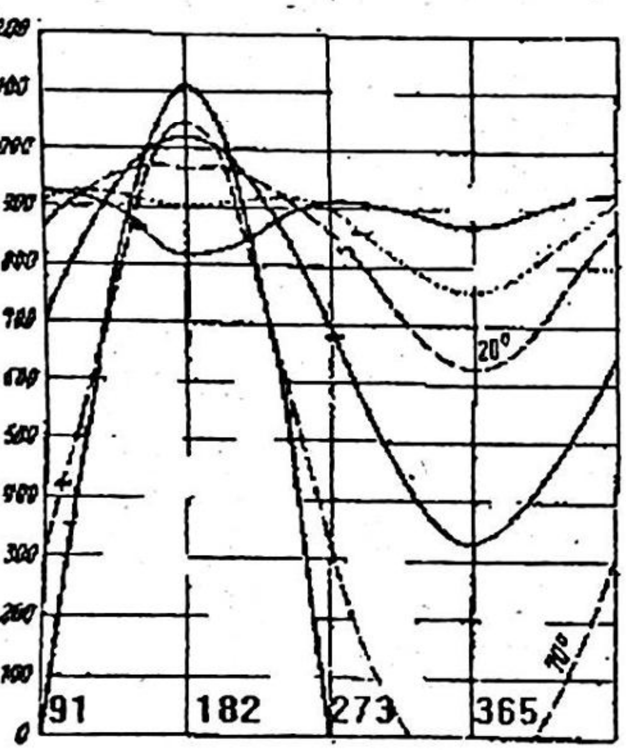

Figure 2. Insolation regime on the earth surface by Detre L.

The model result of the insolation regime (Figure 1) may be compare with observation (Figure 2).

Air Temperature Regime on and near the Earth's Surface (A_{φ}^{n})

It depends on main four factors:

- Geometrical distribution on the Earth's globe,
- The atmospheric temperature decreasing with height,
- The solar rays passing through the different thickness of atmosphere,
- Large snow/ice albedo at polar region and high latitudes.

Therefore, the air temperature regime (A_{φ}^{n}) is described in the next form [Ulaanbaatar, T., 1994]:

$$A_{\varphi}^{n} = A_0 \cdot \cos[23^0 27' \cdot \cos(0.98563 \cdot N) + \varphi] -$$

$$-0.005 \cdot H - A_{\varphi}^{n}(E) - A_{\varphi}^{n}(\alpha) \qquad (3)$$

Here, H denotes the terrain altitude measuring from sea level, n is the interannual number of day, which begins from winter solstice, φ is the geographical latitude, $A_{\varphi}^{n}(E)$ denotes the atmospheric impact on air temperature regime, $A_{\varphi}^{n}(\alpha)$ is the impact of albedo on air temperature regime.

To determine the terms $A_{\varphi}^{n}(E)$, $A_{\varphi}^{n}(\alpha)$ of equation (3), we use the graphic manner, which is based on the observation data as described by previous scientists [Budyko, M.I., 1971, 1974; Mamontov, N.V., 1984; etc.].

The first term presents the geometrical distribution of the air temperature on the Earth's globe, and second term shows the spatial regime of heat including isotherms around the Earth.

The solar energy, of course, impacts on the heat of shallo layers of lithosphere, calculation of which is based on the equati (3). So, on the whole, the space-time distribution of the a temperature in these three mediums as earth surface, tropo phere, and the shallow layers of lithosphere build a four-dimer sional sphere so-called thermal field of Earth as described b author [1994, Figure 25, Figure 26].

In this paper we describe neither thermal field of the Eart nor thermal regime of the shallow layers of lithosphere. But whe we compare the model result to accurate data, they are see approximately in enough coincidence (Table 2,3, Figure 3,4). W should see the trivial air temperature anomalies between the calculation or model result and observation. I think these offer a reasonably satisfactory picture about the regional and local

Table 2. Air temperature regimes on the altitude-latitude cross section (at summer solstice)

	0	1000	2000	3000	4000	5000	6000
0	27.5	22.5	17.5	12.5	7.52	2.52	-2.52
10	29.2	24.2	19.2	14.2	9.18	4.18	-0.82
20	29.9	24.9	19.9	14.9	9.95	4.95	-0.05
30	29.8	24.8	19.8	14.8	9.80	4.80	-0.20
40	27.7	23.1	18.1	13.1	8.06	3.06	-1.94
50	23.3	18.3	13.3	8.34	3.34	-1.66	-6.66
60	19.1	14.1	9.1	4.10	-0.9	-5.90	-10.9
70	9.13	4.13	-0.87	-5.87	-10.9	-15.9	-20.9
80	3.13	-1.87	-6.87	-11.9	-16.9	-21.9	-26.9
90	1.26	-3.74	-8.74	-13.7	-18.7	-23.7	-28.7

(at winter solstice)

φ	0	1000	2000	3000	4000	5000	6000
0	26.2	21.2	16.2	11.2	6.22	1.22	-3.78
10	21.0	16.4	11.0	6.04	1.04	-3.96	-8.96
20	11.4	6.38	1.38	-3.62	-8.62	-13.6	-18.6
30	4.37	-0.63	-5.63	-10.6	-15.6	-20.6	-25.6
40	-2.2	-7.19	-12.2	-17.2	-22.2	-27.2	-32.2
50	-11	-16.3	-21.3	-26.3	-31.3	-36.3	-41.3
60	-14	-19.4	-24.4	-29.4	-34.4	-39.4	-44.4
70	-18	-23.3	-28.3	-33.3	-38.3	-43.3	-48.3
80	-23	-28.5	-33.5	-38.5	-43.5	-48.5	-53.5
90	-28	-33.4	-38.4	-43.4	-48.4	-53.4	-58.4

Table 3. Annual average air temperature regime on the altitude-latitude cross-section

	0	1000	2000	3000	4000	5000	6000
0	28.7	23.67	18.67	13.67	8.67	3,67	-1.33
10	28.1	23.09	18.09	13.09	8.09	3.09	-1.91
20	26.2	21.16	16.16	11.16	6.16	1.16	-3.84
30	21.4	16.41	11.41	6.41	1.41	-3.59	-8.59
40	12.5	7.53	2.53	-2.47	-7.47	-12.5	-17.5
50	5.76	0.73	-4.27	-9.27	-14.3	-19.3	-24.3
60	0.59	-4.41	-9.41	-14.4	-19.4	-24.4	-29.4
70	-11	-15.8	-20.8	-23.3	-25.8	-33.3	-35.8
80	-15	-19.6	-24.6	-29.6	-34.6	-39.6	-44.6
90	-17	-21.6	-26.6	-31.6	-36.6	-41.6	-46.6

geographical impacts (geographical location of land and sea, their interacting with other geographical factors so on) on the air temperature regime.

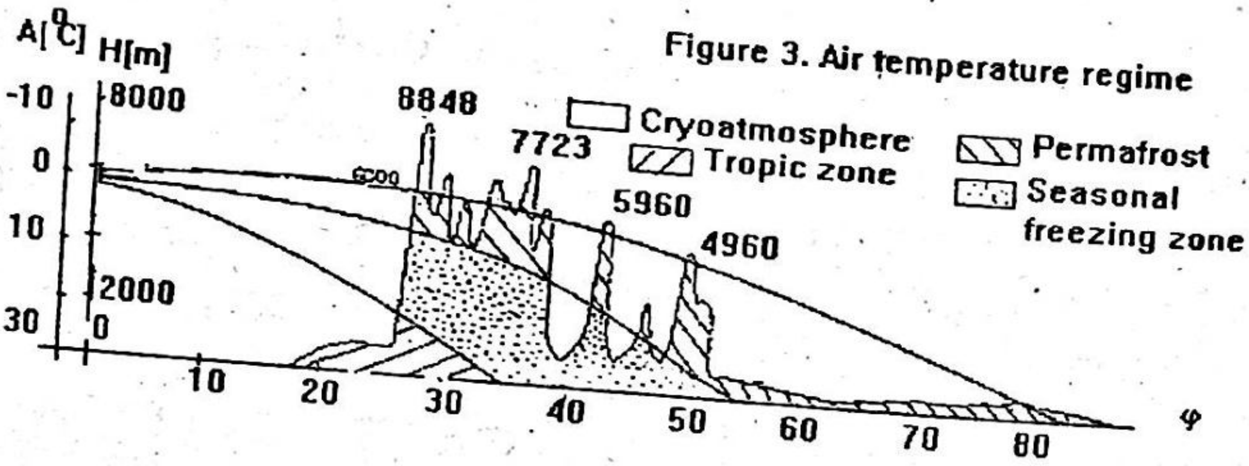

Figure 3. Air temperature regime

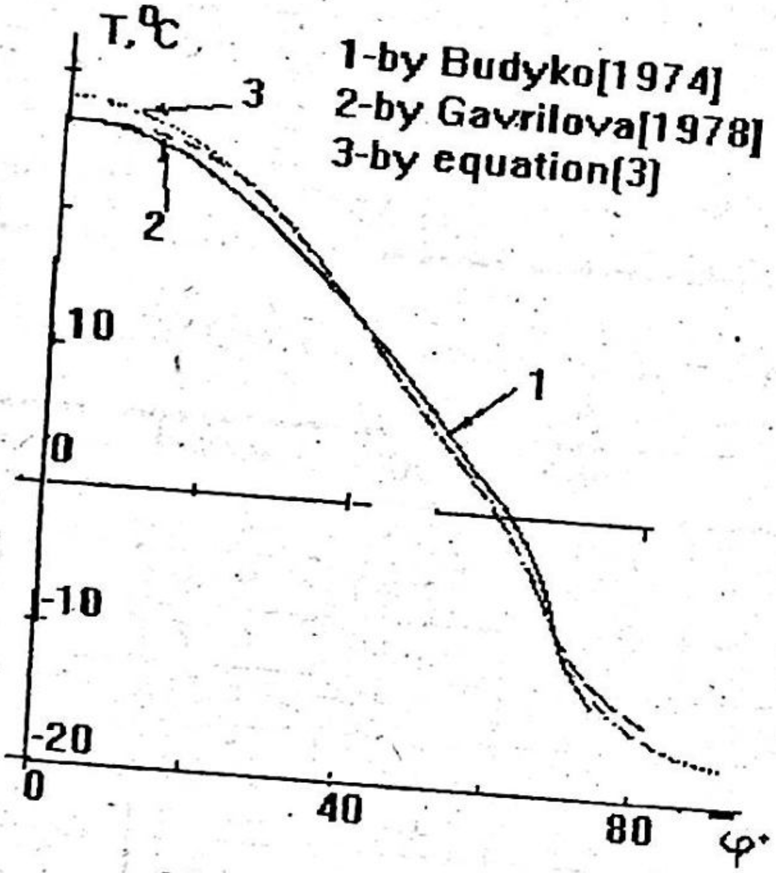

Figure 4. Zonal average air temperature

What we should conclude from all this? The fact that thermal regimes and their transpiration space-time changes are determined perfectly according to the study and draft witness that the selected etalons are correct and effective. For instance, from equations (1), (2), (3) we can calculate theoretically the global average air temperature of planet, zonal average air temperature in different time interval, zonal total insolation in the year or in a concrete time interval, degradation or agradation of geographical, climatic, and permafrost zones so on by geographical latitude and terrain altitude. Furthermore, models include the mathematical formulas: the altitude of noon sun, length of daylight, duration of polar daylight. Also models determine the thermal field, and show the reconstruction, estimation, and prediction of the geographical, climatic, and natural pictures of the Earth in global, hemispheric, regional and local level. In aspect of thermodynamics and climatology the air temperature regime is more important and shows the geographical distributions of other parameters: evaporation,, precipitation and cloudiness or wind speed so on.

Thermal Regimes on and near the Earth's Surface in Geologic Time Scale

In geologic time the equations of thermal regimes are the simple versions of above mentioned mathematical models. They may be written in the next forms[Ulaanbaatar T., 1994; Maralgoo Earth Sciences LTD., unpublished manuscript,1996a]

$$pA_{\varphi}^{n} = A_0 \cdot \cos\left[\left(90^0 - \lambda\right) \cdot \cos\left(\frac{360^0}{N'} \cdot n\right) + \varphi\right] - -H \cdot \mathrm{grad}T - A_{\varphi}^{n}(E) - A_{\varphi}^{n}(\alpha) \qquad (4)$$

When A_0 denotes the air temperature etalon mentioned above, λ is the angle of Earth's rotational axis to ecliptic plane, N' denotes the number of daylight from winter solstice, n shows the geographical latitude in given geological time, H denotes the terrain height, gradT is the air temperature gradient from the sea level, $A_{\varphi}^{n}(E)$ denotes the atmospheric extinction impact on air temperature regime, $A^{n}_{\varphi}(\alpha)$ denotes the albedo's impacts on air temperature regime

If we can determine the data of ATSM terms geochronologically, we shall take enormous informations about the physical-geographical, climatic zones, their space-time changes, and that, which we have interest to know. I believe that this method can facilitate many times the difficulty of paleoclimatological and paleogeocryological reconstructions.

Length of daylight in given geological time scale as follows

$$C' = \frac{k}{2} - 4 \cdot \frac{360^0}{N'} \cdot \arcsin\left\{ tg\varphi \cdot tg\left[\left(90^0 - \lambda\right) \cdot \cos\left(\frac{360^0}{N'} \cdot n\right)\right]\right\} \quad (5)$$

Where k denotes the length of diurnal in that geological stage. And the duration of polar daylight:

$$Z' = \frac{N'}{180^0} \cdot \arccos\left(\frac{90^0 - \varphi}{90^0 - \lambda}\right) \quad (6)$$

Insolation regime on the earth surface of given geological time [T.Ulaanbaatar, Maralgoo Earth Sciences LTD, unpublished manuscript, 1996b]:

$$Q^{n}_{\varphi} = Q_0 \cdot \frac{C}{\ell} \cdot \cos\left[\left(90^0 - \lambda\right) \cdot \left(\frac{360^0}{N'} \cdot n\right) + \varphi\right] \quad (7)$$

When Q_o denotes the new solar constant, Q_0 =930 cal day^{-1} cm^{-2}, which is not changed in any geologic time, ℓ denotes the length of daylight in equinox in geologic time. To describe equations (4), (5), (6), (7) we must to select the main conditions of interested geologic stage as follows:

- Planet's revolution period around the Sun is unchanged,

- Air temperature gradient has not different than present day,
- Recent geographical coordinates are been transformed to paleocoordinates,
- Direction of Earth's axis is unchanged during the geologic stage,
- Physical-geographical and climatic zones are determined in paleocoordinates every geologic time, according to the continental drifts.

To supply these conditions we need to know something about prior achievements of Earth Science. So, these models of thermal regimes can determine the nature of the Earth's Climate Supercirculation, which heretofore has not been well known. (Layout #1)

The Nature of the Climate Supercirculation

The vertical solar rays fall to each square of Earth's globe. Warmed air, and water vapor rise from every square of the Earth's surface. They also Among these predominates the powerful atmospheric vertical current going upwards from the equatorial region in accordance with large oceanic area. In these regions the vertical solar rays fall perpendicularly and their energy has spent approximately 100 percent for evaporation and increasing of kinetic energy of ocean. In the consequence of gigantic energy, this vertical current raises with a big amount of water and makes the primary atmospheric circulation, which can create itself the secondary and tertiary atmospheric circulations.

Atmospheric circulations deliver a trivial piece of the wetness, water vapor of equatorial region to polar region and high latitudes. For a long time, it is accumulated in forms of snow and ice. Then the polar ice sheet expands from polar region to middle latitudes. As a result, sea level fall off (Regression). The continental area may be larger than in other climatic epochs. The evaporation, precipitation, and cloudiness decrease enoughly for glaciation stopping. Solar rays fall intensively throughout the Earth's surface. Heat energy accumulates in hydrosphere and lithosphere. Glaciation has been repealed sooner or later, finally, permafrost too. The global average temperature of planet increases slowly. When the volcanoes are active, the global average temperature of planet increase rapidly. Polar ice sheet and permanent snow melt. Sea level rises.On the other hand, in accordance with air temperature model, the sea level upwells, therefore, the thermal field of the Earth expands due to its isotherms accounting from sea level.

As a result, the oceanic transgression follows. At that moment, the evaporation increases, because of large oceanic regions, and continual, thick cloudiness has formed intensively over the equatorial region. It has been a stumbling-block for this region. When the Earth's surface receives no energy, it cools quickly and temperature falls. So, the secondary glaciation exists in these tropic zones, which signalizes a precursor of a new glacial epoch. At the same time, climate is wet and warm at middle, and high latitudes. The continual cloudiness extents over the larger area. But the center of continual cloudiness thinners out, where is neither receipt of evaporation nor solar energy. Therefore, continual cloudiness has divided into two large blocks at the Northern and Southern Hemispheres.They transfer to middle and then to high latitudes. Climate becomes wet and warm at tropic zones, but wet and cold at middle latitudes, later on at high latitudes. Under the continual cloudiness the secondary glaciation exists always. When it wanders to high latitudes and polar region the secondary glaciation becomes the primary glaciation, which extents powerfully to middle latitudes. This process continues for a long time, the sea level reaches the regression. Evaporation, cloudiness and precipitation decrease, so on... So, all these processes show a gigantic World Water Supercycle, under which the water is constantly transferring from equatorial region to polar region and backs to equatorial, such as Hydrologic Cycle from ocean to air to land and back ocean. The World Water Supercycle interacts with all the geographical objects and geosphere as well as biosphere. The result of this interacting is sensed for us as climate. In my opinion, this self-excited process of Earth's Climate is suitable so-called the Climate Supercirculation of the Earth. Now,- we should conclude from all this is that the cause of Climate Supercirculation is the World Water Supercycle and its trigger or dynamics is the perpendicular falling solar rays on the Earth's globe. According to the thermal regime mentioned above and thermodynamics, the Climate Super-circulation continues constantly on the normal conditions of phy-sico-chemistry, geology, geography, and astronomy. Other terres-trial, and extraterrestrial factors impacting on the climate oscilla-tion play only secondary role in Supercirculation, in result of which would have been only repeated in different time intervals

Feedback mechanisms

For the steering of self-excited process of Climate Supercirculation and confining, stabilizing of the chain reactions play main role the feedback mechanisms. There are some main feedback mechanisms:

Insolation-Evaporation[1],
Insolation-Water[1],
Insolation-Cloudiness[1],
Insolation-Albedo[1],
Isotherms of Earth's thermal field-Global average temperature of planet,
Glaciation-Cooling,

Flow of substance in Crust-Permafrost,
Volcanic activity-Warming,
Proportion of areas in World Ocean-Continents,
Cooling-Precipitation, etc.

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[1] by Houghton, J.T.,[1987]

Chain Reactions

The chain reactions are the most important details o Climate Supercirculation, which are followings:

Insolation,
Air temperature,
Evaporation and water vapor,
Continual cloudiness,
Precipitation,
Trade wind,
Atmospheric circulations,
Primary and secondary glaciations,
Regression,
Transgression,
Ice sheets,
Ice and snow accumulation,
Heat accumulation,
Permafrost,
Albedo,
Volcanic activity,
Upwelling and lowering the isotherms of thermal field off,
Atmospheric and oceanic chemical contents,
Oceanic current,
Wetness transportation by atmospheric circulations so on

If Climate Supercirculation has not a chain or feedback mechanism, it would continue a very long time, or perhaps stops only.

Climate Supercirculation is the largest natural law on the Earth, which governs the natural selection.

Timing of Climate Supercirculation

Duration of the Earth's Climate Supercirculation

Climate Supercirculation continues for millions of years to hundred millions of years. Its duration depends on the timing, magnitude of every chain reaction and feedback mechanism.

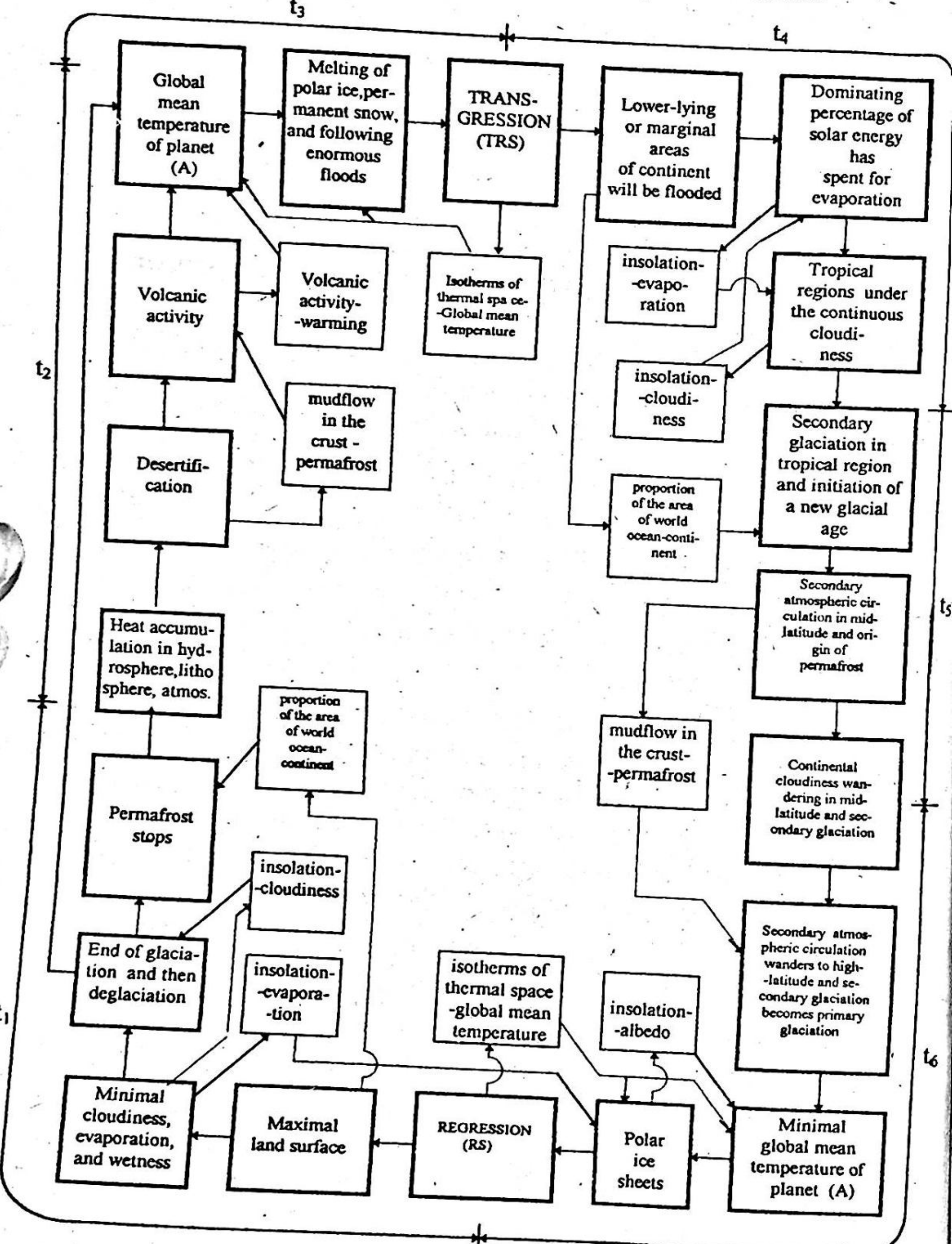
According to the present basic scientific concept it is divided into two large epochs: glacial and interglacial. I think it must been divided into the next divisions:

1. Periods
2. Phases or World Seasons
3. Stages

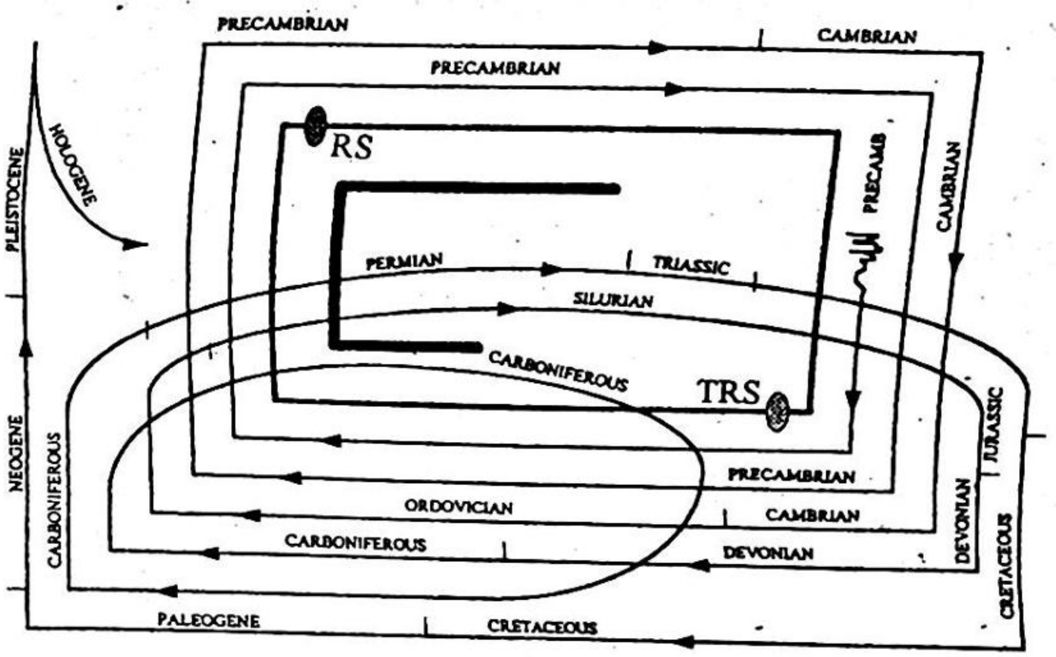
One Period equals a full revolution of Climate Supercirculation. Period is divided into four phases or World Seasons, which is like year's seasons in aspect of climatology. But World Seasons by the fact that they occur at the same time throughout the Earth's surface. The phases of Climate Supercirculation may be compare to the year's seasons.

The stages, of course, denotes the time interval for main occurrences of climate in a period or some phases.

Layout #1. The Earth's Climate Supercirculation



Layout #2. Earth's Climate Supercirculation in geological time scale



Probabilities For Durations of Main Events in Climate Supercirculation

If Earth has not any geographical relief, and if it is a homogen object, the Climate Supercirculation repeats in a fixed time interval. But its timing is impacted by many factors: reliefs, inhomogen contents of geospheres, geophysical, geological, and geochemical events. So, we can describe only the probabilities of every main event's duration of Climate Supercirculation in percentage (Layout #2).

Conclusions

Based on the thermal regimes and Climate Supercirculation described above, the major conclusions can be summarized.

1. Separated etalons of thermal regimes are more precise than familiar solar constant.
2. Air temperature regime depends on four factors: geographical distribution on the Earth's globe, terrain altitude, atmospheric thickness and albedo of polar ice sheet.
3. General formula of all time insolation regime depends on the geographical latitude, altitude of noon sun, and length of daylight.
4. The cause of Climate Supercirculation is the World Water Supercycle, and its trigger is the perpendicular falling solar rays on the Earth's globe.
5. The best way to explain the nature of climate oscillation and to determine the conditions of climate change, their space-time understandings is the geometrical cogitation.

References

Brian, S.J. *The winters of the world: Earth under the Ice ages*, Russ.Transl., 36-296 pp., Mir, Moscow, 1982,

Budyko, M.I., Climate and life, (in Russian), 18-20 pp. Gidrometeoizdat, Leningrad, 1971,

Budyko, M.I., *Climate change*, (in Russian), 280 pp., Gidrometeoizdat, Leningrad, 1971,

Detre, L., *Signals from Universe*, (in Hungarian), Kiralyi Univ. Press, 34 pp., Budapest, 1939,

Houghton, J.T.,(Eds.), The climate feedback mechanisms, *The global climate*, Russ. Transl., pp. 21-22, Cambridge Univ., 1986,

Mamontov, N.V., *Variability of air temperature in diverse time of day at territory of USSR*, (in Russian), 40-55 pp., Gidrometeoizdat, Leningrad, 1984,

Shubaev, L.P., *Earth Science*, (in Russian), 80-81 pp., Visshaja shcola, Moscow, 1969,

Ulaanbaatar, T., and N.Lonjid, On the theory of cryosphere, *Proc. Acad. Sci. Mongolia*, 2, 31-35, Academic, Ulaanbaatar, 1991,

Ulaanbaatar, T., Mathematical modeling for the thermal regime of the Earth's surface, and cryosphere (in Mongolian), *Ph.D.Thesis*, 16-86, 108-127 pp., Mong.Univ. of Technology, Ulaanbaatar, December 1994,

Ulaanbaatar, T., Climate Supercirculation of the Earth, *Global Biogeochemical Cycles*, (in press), AGU, (in press), Washington,

Ulaanbaatar, T., Tugjsuren, N., Legden, M., Insolation regime on the Earth's surface, *J. Geoph. Res.*, AGU (in press), Washington, Ulaanbaatar, T., Tugjsuren, N., Air temperature regime on and near the Earth's surface, *J. Geoph. Res.*, AGU, (in press), Washington,

Товчлол

Энэхүү өгүүлэлд Дэлхийн гадаргуугийн дулааны горим болон Дэлхийн Уур Амьсгалын Суперциркуляци үүсэх шалтгаан, түүнд нөлөөлөх хүчин зүйлс, зарим гол эргэх холбоо, гинжин урвлуудыг тодорхойлсон. Цаашилбал эртний уур амьсгалын дүр төрхийг Дэлхийн түүхэн хөгжлийн зүй тогтлоор нь сэргээн тогтоох, өнөөгийн төлөв байдалд үнэлгээ өгөх, ирээдүйг прогнозлох шинэ бололцоонуудыг үзүүлсэн болно.