Space Technology for Reduction of Desert Areas on Earth and Weather Control

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Abstract: *In precedent papers the authors presented the idea of a space system composed of two opposite parabolic mirrors (large and small) having the same focal point. This system is able to concentrate solar power in a strong light beam having irradiance of hundreds or thousands of times stronger than the solar irradiance on Earth's orbit. The system can be placed on a Sun synchronous orbit around the Earth or on the Earth’s orbit around the Sun at a distance of several hundred km from ground. When the concentrated light beam is directed toward the Earth surface it can locally melt, vaporize or decomposes tones of ground in its elements. This is happening because when the ground is hit by the light beam, ground temperature can reach thousands of degrees Celsius. At such temperatures the matter is decomposed into constitutive elements. For example, the silicate oxides which are frequently found in the composition of desert ground are decomposed into oxygen and silicon. Similarly, other oxides release oxygen and other type of oxides or constitutive elements. A network of deep and large channels can be dug in this way in hot deserts as Sahara. When these channels are connected with the seas & oceans, a network of water channels is created in those deserts. In this way, the local climate of deserts will change because channel water is vaporized during daytime when air temperature reaches 50ºC and condenses during nighttime when air temperature is around 0ºC. Presence of clouds over the hot deserts can lead to a reduction of ground temperature and rain follows. The channel water can be desalinized for producing drinking water and for irrigation using simple equipment. In addition to these advantages, channel deserts can be a solution for melting of polar ice calottes and flooding of seaside areas that are inhabited areas. On the other hand, the system composed of two opposite mirrors can be used for strength decreasing or deviation of hurricanes and tornados. The power of these meteorological phenomena increased in the last time due to global warming producing disasters of tens of billions of dollars.*
The hurricane is a thermal engine working in Carnot cycle. Due to this fact, although the difference between the cold source temperature (temperature of high atmosphere) and hot source temperature (temperature of ocean surface) is of only 100 °C, the thermal efficiency is η_t=0.333 leading to increasing of hurricane's total energy at extremely high levels.

The cold source can be heated through vaporizing the system of clouds of hurricane formed in the high atmosphere by the concentrated light beam directed from space. In this way the energy of hurricane or tornado no longer increases and damages produced at ground level are limited. Another possibility is to vaporize locally the hurricane's eye-wall for its deviation far away of dense populated areas.

Key Words: *weather control, desert climate change, hurricanes' deviation, tornados' deviation*

NOMENCLATURE

E_e, irradiance in proximity of Earth, [W/m^2]	t, temperature, [ºC]
D, diameter, [m]	t', time, [s]
L, length, [m]	T, absolute temperature, [K]
M, mass, [kg]	v, specific volume, [m^3/kg]
F_d, deviation force, [N]	P, power, [W]
V, wind speed, [m/s]	Greek
Q, heat, [J/kg]	η, thermal efficiency, dimensionless
r, radius, [m]	ρ, density, [kg/m^3]
R, reflectivity, dimensionless	Γ, circulation, [m^2/s]

1. INTRODUCTION

In our days, global warming is a difficult problem leading to meteorological phenomena that strongly affect civilization development.

On one hand, desert areas are extending and on the other hand, tornados and hurricanes produce catastrophic damages or floods which devastate the seaside areas of continents. Another danger generated by the global warming is the melting of polar ice calottes.

It is estimated that ice calottes melting will lead to flooding of many seaside areas that are inhabited.

The present technological level of our civilization allows some degree of weather control.

It is now possible to deflect powerful hurricanes and tornados away from seaside and inland areas that are inhabited, to block the extension of deserts, generate rain fall etc. The next sections of this paper present the design and operation of a space system which can be used for accomplishing the above tasks.

Such a space system can be lifted in pieces to a Sun synchronous orbit in fairings of rockets.

After assembly on orbit the system is kept on that Sun synchronous orbit or it can be transported to Earth's orbit accompanying it at a distance of several hundreds of km.

2. DESIGN OF SPACE SYSTEM

In previous papers, the authors presented the concept of a space system used for protecting Earth against asteroids [1].

The system components are shown in fig. 1. The large parabolic mirror, 1, and the small parabolic mirror, 2, have coincident axes and are positioned face to face i.e., the concave side of the large parabolic mirror is oriented toward the concave side of the small parabolic mirror.

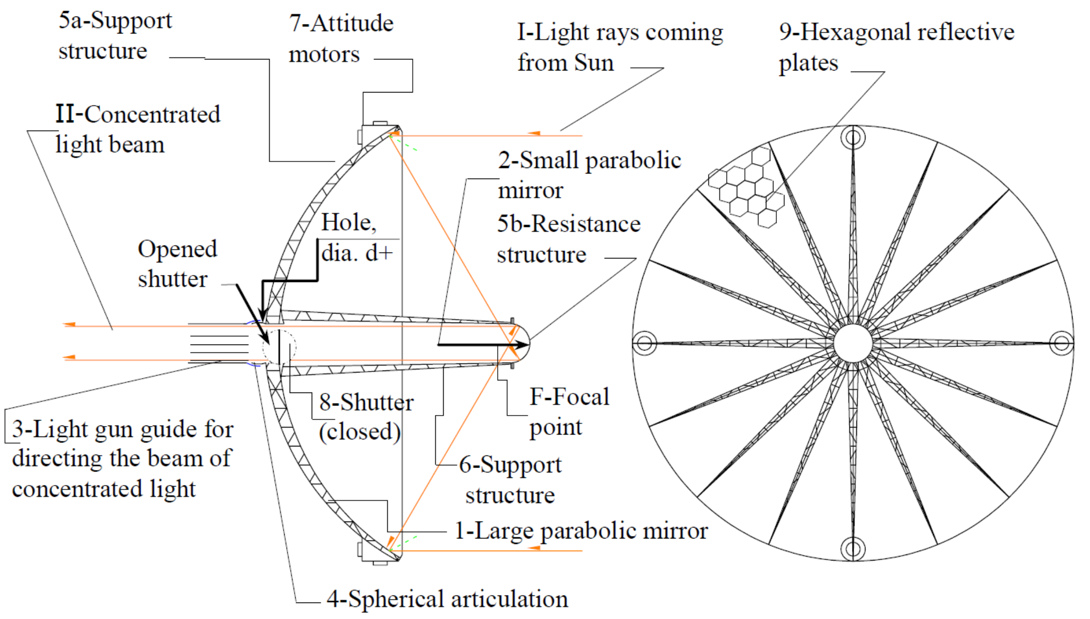

Figure 1: Design features of space system

The large and small parabolic mirrors are made of thin reflective plates, which are manufactured of composite material (graphite fiber basis) covered by a 5 microns gold film. The gold film confers good reflectivity of solar light and graphite fibers allow quick heat transmission through conductivity and mirror cooling through radiation. The reflective plates are placed on support structures, 5a, 5b, which are connected to each other by three structures, 6.

The large parabolic mirror has a central hole with diameter ‘d^+’ slightly larger than diameter ‘d’ of the small parabolic mirror. The light rays, I, coming from Sun, which are mainly composed of visible, infrared and ultraviolet light, are captured and concentrated by the large parabolic mirror into the common focal point, F.

The light rays are then reflected by the small parabolic mirror as parallel rays directed along the common axis of mirrors (this is possible because the two mirrors have a common same focal point, F).

The parallel rays reflected by the small parabolic mirror pass through the hole 'd^+' placed in the center of the large parabolic mirror.

A wave guide tube composed of reflective honeycomb cells is articulated on the convex side of the large parabolic mirror with a spherical articulation. For an increased reflectivity, the honeycomb cells are gold plated. This wave guide tube is used for directing the concentrated light beam toward the Earth surface or surface of ocean.

The system can be placed on a Sun synchronous orbit around the Earth or on the Earth’s orbit around the Sun at a distance of several hundred km from ground surface. The system components can be lifted by rockets as shown in fig. 2 and assembled by a robot as like NASA's Spiderfab (fig. 3).

Building such a large structure in space is possible because the gravitational force of Earth is balanced by the inertia force generated by rotation (the system orbit is geocentric). After assembly on geocentric orbit, the system can be accelerated by busters for placement on Earth's orbit around Sun.

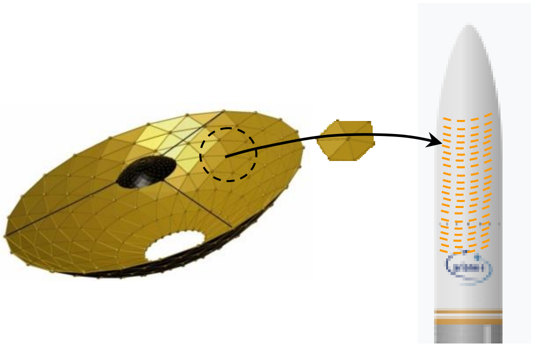

Figure 2: Orbital insertion of system in space

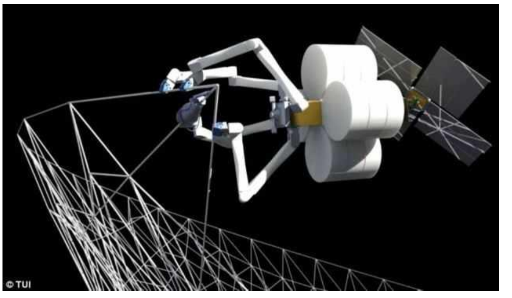

Figure 3: NASA's Spiderfab robot

The large parabolic mirror is oriented with the concave surface to the Sun.
The maximum power of such a system depends on solar power collected by the large parabolic mirror. Table 1 shows the total collected solar power, P_{lpm}, (solar irradiance on orbit of Earth was taken E_e=1360W/m^2) and the total available power, P_e (reflectivity coefficient of gold plated mirrors was taken R=0.98) as a function of the radius of large parabolic mirror, r_{lpm}.

Table 1-Power of system as a function of radius of large parabolic mirror

Case. no.	Radius of large parabolic mirror, r_{lpm} [m]	Collected solar power, P_{lpm} [MW] (irradiance was taken as E_e=1360 W/m^2)	Available power P_a [MW] (Reflectivity coefficient of gold was taken as R=0.98)
1	50	10.7	10.3
2	60	15.4	14.8
3	70	20.9	20.1
4	80	27.3	26.2
5	90	34.6	33.2
6	100	42.7	41.0
7	200	170.9	164.0
8	400	683.6	656.5
9	500	1068.14	1025.8

3. DISSIPATION AND DEFLECTION OF HURRICANES

3.1 The main physical phenomena occurring in a hurricane

According to theory, a hurricane is a thermal machine working according to Carnot cycle (fig. 4, 5) [2]. This cycle is composed of two isothermal and two isentropic evolutions:
-Evolution 1-2 (fig. 4) is a reversible expansion of gas on isothermal T_h (temperature of the hot source; on this evolution gas absorbs heat Q_{in} from the hot reservoir. As a result, gas entropy increases). In the case of hurricane (fig. 5):
The air follows a spiral path toward the lower pressure from the centre of the storm accumulating water vapours; temperature of ocean surface = $T_h \approx 300$ K);
-Evolution 2-3 (fig. 4) is a isentropic (adiabatic, reversible) expansion of the gas which produces mechanical work (on this evolution the system is thermally insulated: no heat is exchanged with the surroundings. At the end of evolution the temperature T_c is smaller than the temperature T_h);

In the case of hurricane (fig. 5):
-Hot air ascends very quickly on a spiral path to a height of 15-16 km performing mechanical work while ascending in the gravitational field of Earth;
-Evolution 3-4 (fig. 4) is a reversible isothermal compression of the gas at the cold temperature T_c where the system loses heat Q_{out} which is transferred to the cold reservoir. As a result, its entropy decreases. On this evolution an external mechanical work is used for gas compression.
In the case of hurricane (fig. 5):

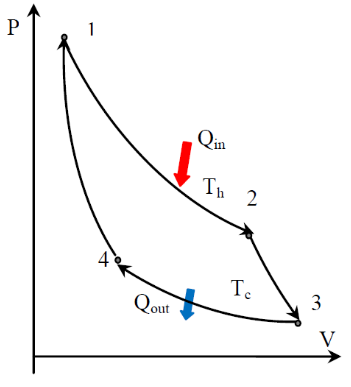

Figure 4: Carnot cycle

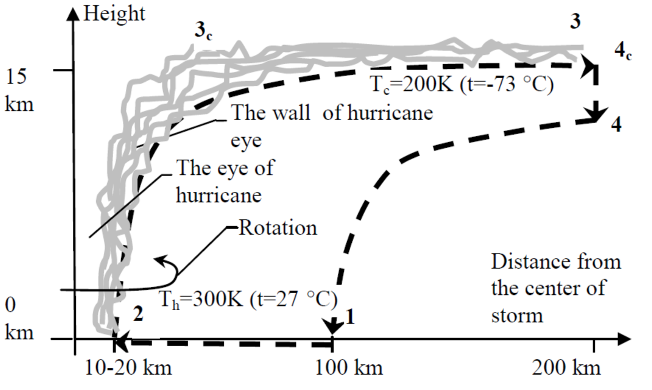

Figure 5: Structure of a hurricane

-Air is cooled through convection by surrounding air and electromagnetic radiation at the temperature of atmosphere at a height of 15-16 km (temperature of cold reservoir $T_c \approx 200$K).
- Evolution 4-1 (fig.4) is an isentropic compression (adiabatic, reversible). During this step, an external mechanical work is used for gas compression. At the end of evolution the internal energy is higher than in the point 4 and the temperature of gas is again T_h. At the end of this evolution the gas is in the same state as at the start of expansion 1-2.
In the case of hurricane (fig. 5):
-Air loses altitude quickly flowing downwards.
-According to the authors' opinion point 3 should be positioned in position 3_c and point 4 in position 4_c because it seems that 3_c-4_c is the natural isothermal evolution (when gas temperature is kept about constant at T_c=200K) and 4_c-1 should be the adiabatic compression.

3.2 The stages of a hurricane

The hurricane is the final result of a process having the following stages:
Stage 1-**Tropical Wave**-These are tropical disturbances. In this stage there is no closed circulation, practically winds are blowing in every direction and have speeds of less than 0 m/s.
Stage 2-**Tropical Depression**-The tropical wave transforms into a tropical depression when air circulation becomes closed and winds exceed 0 m/s. In this stage the rotational system is not yet well organized.
Stage 3-**Tropical Storm**-In this stage, wind speed exceeds 18 m/s, rainfall begins and thunderstorm occur above the closed circulation of air. The tropical storm causes only minimal damages.
Stage 4-**Hurricane**-In this stage the eye appears in the center of the closed circulation and winds exceed 33 m/s. At this level, significant damages can be produced.

The problem is that after stage 4, the storm continues to intensify. Five categories of hurricane intensity are defined (labeled 1 to 5) according to Saffir-Simpson scale. Maximum wind speeds (in the eye's wall) are V_{ew_max}= 42m/s, 49m/s, 58m/s, 70m/s and over 70 m/s respectively.

3.3 Dissipation of hurricanes

Observations show that a hurricane dissipates when: [3]
1-it moves over land
2-it loses source of moisture and heat
3-when meeting rough surfaces which cause reduction of wind speed
4-the pressure in the hurricane centre increases
5-when it moves to cooler ocean surfaces
6-when moving northwards (for example along the east coast of the U.S.)

3.4 Solutions proposed by now for dissipating hurricanes

Some solutions have been proposed to artificially dissipate hurricanes. One was tried: project Stormfurry (1962-1983, USA Government). [4] In this project, silver iodide was seeded in the clouds of several Atlantic hurricanes to freeze the super-cooled water and thus disrupt the inner structure of the hurricane. The hurricane failed to dissipate because hurricanes do not contain enough super-cooled water. Other solutions as cooling of ocean surface with icebergs, covering the ocean with a substance that inhibits evaporation, dropping ice in high quantities in the hurricane eye and even blasting hurricanes with nuclear bombs were proposed. None of these methods were effective because hurricanes have large areas and are short lived.

3.5 Using of the space system with concentrated light for dissipating hurricanes

The mentioned space system can be used to destabilize the hurricane structure.
Method 1: Reduction of hurricane efficiency
As we specified above, a hurricane is a thermal machine following the Carnot cycle. For this reason, efficiency is large although the temperature difference between the hot reservoir T_h and the cold reservoir T_c is low [2]

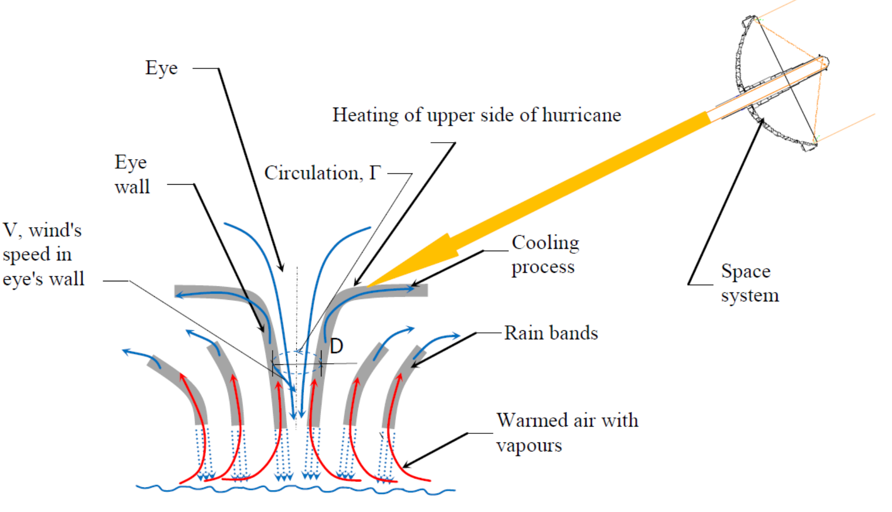

Figure 6: Reduction of hurricane efficiency through heating of superior structure

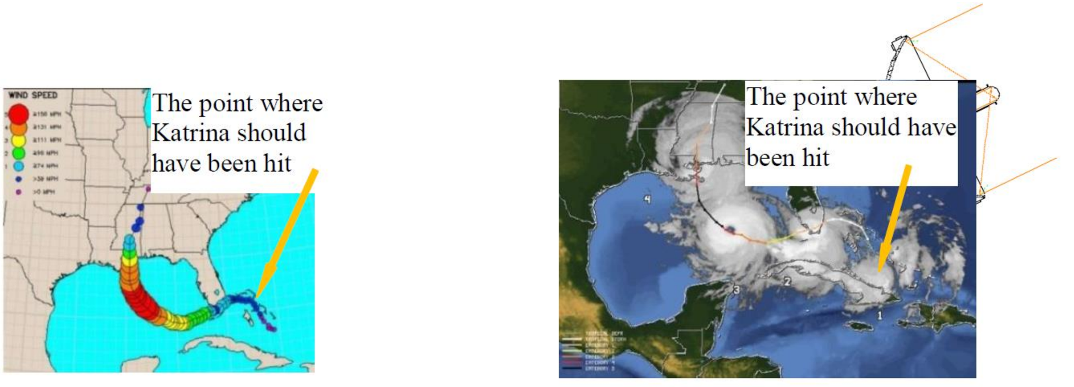

Figure 7: Position where hurricane Katrina should have been hit from space with concentrated light beam

$$\eta = 1 - \frac{T_c}{T_h} \approx 1 - \frac{200}{300} = \frac{1}{3} \tag{1}$$

Such efficiency (0.333) is very high for a thermal engine. This explains why the energy of hurricane increases continuously to very high levels.
Looking at equation 1, one can see that hurricane efficiency can be reduced if T_c-->T_h or vice versa. This can be done if the concentrated light beamed from space spans the upper part of the hurricane starting from the eye wall and going to the extremity of cloudy area (fig.6). [5]
For example if the T_c is increased by 25 °C, the thermal efficiency of 'hurricane engine' reduces from η_t=0.333 to η_t=0.25 i.e., the power decreases by about 25%. This means the hurricane will need more time to reach a higher category.
The hurricane must be hit before becoming too strong i.e., while still a tropical depression, or storm or hurricane of category 1 because it is difficult to stop energy increase when hurricanes expand too much. For example hurricane Katrina should have been hit, while located in position shown in fig.7. [6] [7].
The heating capacity of the space system depends obviously on the diameter of the large parabolic mirror. Considering the largest parabolic mirror (Table 1, pos.9, r_{lpm}=500 m), one sees that heating power is 1025.8 MW, and during a period t'=10h=36000 s the mass of air which can be heated by Δt=25 °C is:

$$M_a = \frac{P_a \cdot t'}{c_p \cdot \Delta t} = \frac{1.0258 \cdot 10^9 \cdot 36000}{1000 \cdot 25} = 1477152000\,kg \tag{2}$$

The massive presence of water in form of droplets in clouds eases the heating of the upper part of hurricane because droplets are vaporized by concentrated light beam and mix with the surrounding cold air.

3.6 Using the space system with concentrated light for hurricane deflection

Here is an interesting question: is it possible to change the path of a hurricane?
A hurricane can be considered a vortex having a circulation, Γ. According to Kutta-Jukowsky theorem, such a vortex should be subject to an aerodynamic force when meeting an air stream.
As it is known, the strongest circular winds appear in the eye's wall. Labeling this speed of wind with V_{ew} and the length element on average diameter D of eye's wall with dL, and taking into account that the speed V is tangent to the circle having diameter D, the elementary circulation is given by

$$d\Gamma = V_{ew} \cdot dL \tag{3}$$

where positive sense for circulation Γ was taken conventionally as in fig. 6 and direction of speed *V* is the real one.
The circulation per 1 m of height is given by: [8]

$$\Gamma = \oint_{C_D} V_{ew} \cdot dL = V_{ew} \cdot \oint_{C_D} dL \tag{4}$$

Because air speed is a constant and the integration curve C_D is a circle having diameter *D*, the final value of circulation per 1 m is

$$\Gamma = \pi \cdot D \cdot V_{ew} \tag{5}$$

The Kutta-Jukowsky theorem gives the following force for 1 m height of a hurricane [9]:

$$F_d = \rho_a \cdot V \cdot \Gamma \tag{6}$$

where ρ_a is air density. The direction of force is given by the product of vectors $\overrightarrow{V}$ and $\overrightarrow{\Gamma}$ i.e.,

$$\vec{F_d} = \rho_a \overrightarrow{V} \times \overrightarrow{\Gamma} \tag{7}$$

For example, in fig. 8 one can see that if wind is blowing from east to west with speed *V*, the deflection force F_d exerted on hurricane will be to the north and if wind is blowing from west to east, with speed *V'*, the deflection force applied to hurricane F'_d is directed to the south.
A local wind having speeds *V* or *V'* can be created, if the concentrated light beam alternately sweeps path L_E or L_w. The lines L_E or L_W are tangent to the eye wall.
Taking *D*=30 km the average diameter of eye's wall and wind speed for category 1 hurricane, V_{ew}=42 m/s, using equation (6) one can find Γ=4x10^6 m^2/s.
Table 2 shows the values of deflection force F_d per 1 m of height calculated using equation (8) for various wind speeds created by the concentrated light beam through vaporization of eye-wall's water droplets (air density was taken at the sea level for a temperature *t*=100°C, $\rho_{0,100°C}$=0,9467 kg/m^3).

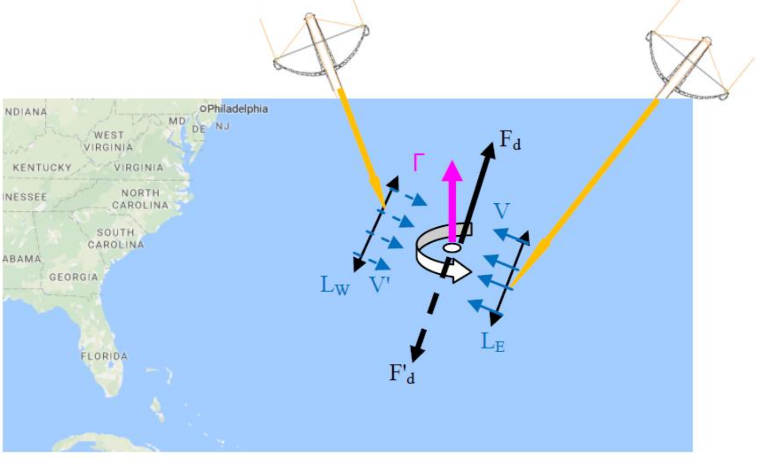

Figure 8: Hurricane deviation

Table 2-Deflection force per 1 m of hurricane height

Case no.	Wind speed created by concentrated light beam, m/s	Circulation, Γ, m^2/s	Deflection force, F_d, N
1	1	4 x 10^6	3.8 x 10^6
2	3	4 x 10^6	11.4 x 10^6
3	6	4 x 10^6	22.7 x 10^6
4	9	4 x 10^6	34.1 x 10^6
5	12	4 x 10^6	45.4 x 10^6

Table 2 shows the aerodynamic force is considerable and able to change the direction of hurricane to areas of colder sea surface or along beaches where its power is progressively dissipate through friction with the ground.

3.7 Using of the space system with concentrated light for deflection of tornados

The mechanism of tornado is similar with that of a hurricane with the exception of water vaporization. Obviously, in this case, both methods 3.4, 3.5 can be used but the technology must be applied with prudence due to the proximity of populated areas.

4. REDUCTION OF DESERT AREAS

It is known that desert areas represent about 50% Earth's lands and are defined as areas where rainfall is less than 50 cm/year (hot and dry, semiarid, coastal and cold deserts). For example, in Sahara desert, which has a surface of 4619260 km^2, the rain fall is less than 1.5 cm/year.

Using the space system presented in section 2, all types of deserts except the cold one can be transformed by increasing humidity. For this purpose, the small parabolic mirror of the system presented in fig. 1 is modified to focus the light onto a small area. In this way, when the light beam impacts on a desert surface, very high temperatures are reached. When the whole energy is focused onto a point, theoretically, temperature can reach infinite values.

At very high temperature, the ground composed mainly of oxides and carbonates is decomposed in constitutive elements or other oxides. For example, $2BaO_2$ is converted into $2BaO$ and O_2, $2Li_2O_2$ in $2LiO_2$ and O_2, $4FeO$ in Fe and Fe_3O_4, etc.

Most of oxides are extremely heat resistant i.e., thermally decompose at very high temperatures. For example Al_2O_3 is decomposed at over 3000 °C and MgO at over 2800°C:

$$3Al_2O_3 \xrightarrow{t>3000\ ^\circ C} 4Al+3O_2$$

$$MgO \xrightarrow{t>2800\ ^\circ C} O_2+2Mg$$

Other oxides are decomposed at lower temperatures:

$$2BaO_2 \xrightarrow{t=700\ ^\circ C} O_2+2BaO$$

$$2Li_2O_2 \xrightarrow{t=195\ ^\circ C} O_2+2LiO_2$$

$$4FeO \xrightarrow{t=575\ ^\circ C} Fe+Fe_3O_4$$

For example, Sahara sand is composed of 21.26% SiO_2 (quartz), 14,58% $(CaMg)(CO_3)_2$ (dolomite), 14.21% $CaCO_3$ (calcite), 9.10% Si_3O_4 and Al_3O_4 (smectite), 7.99% NaCl (halite), 7.89% $Al_2Si_2O_5(OH)_4$ (kaolinite). [10] The solution for desert humidification is the cutting of a network of sufficiently deep and large channels through the whole surface of that desert. This network can be created if the beam of concentrated solar power is directed toward the desert surface. Practically it is not necessary to thermally decompose the ground matter because the focused ray partially liquefies and vaporized the ground and then the still solid particles together with liquefied matter are pushed away by vapors.

When these channels are connected with seas and oceans, a network of water channels is created in those deserts (fig.9). In this way, the local climate of deserts will change because the water of channels is vaporized during day when air temperature is usually over 50 ºC and condenses during night when air temperature is around 0ºC. Presence of clouds over deserts can lead to a reduction of ground temperature and rainfall. The water from channels can be used for production of drinking water and water for irrigations. To desalinize water for the local needs of people and animals, simple equipment can be used. This equipment captures a part of water vapors, which then condense during night due to low temperatures. Such equipment can be seen in fig.10.

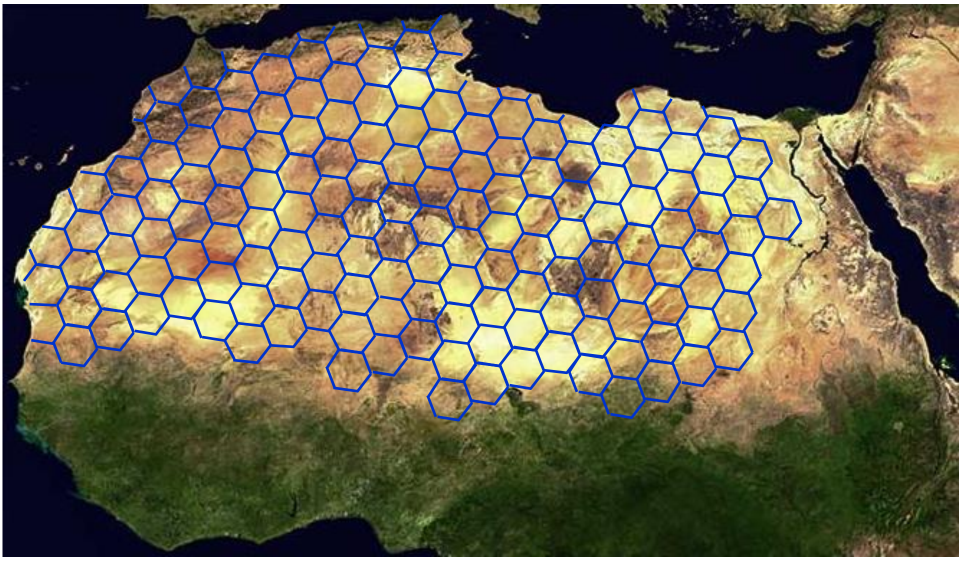

Figure 9: Channel network created in Sahara using focused light beam directed form space

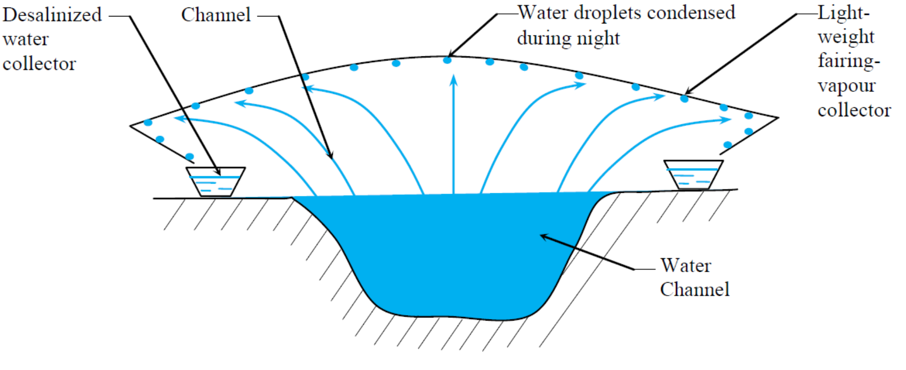

Figure 10: Simple technology for obtaining desalinized water in the desert

5. CONCLUSIONS

▪The space system which concentrates solar light can be used for preventing of disasters produced by extreme weather-hurricanes and tornados.

▪The power of hurricane or tornado can be reduced if the temperature of cold reservoir, T_c, is increased through vaporization of upper system of clouds or these storm can be deflected if the concentrated light beam sweeps along a tanhent to the eye's wall creating an air flow which interacts with the hurricane's or tornado's vortex.

▪In the case of hot deserts such as Sahara, a network of channels can be dug by concentrated light beams, which melt, vaporizes or decomposes the groundinto elements. These channels can be filled with water when the network is connected with seas and oceans. Due to the fact that during night the desert temperature is about 0ºC, the vapors of water produced by chanels during daytime condense during nighttime umecting the soil and favorising plant growth.

▪The vapors leads to the dveleopment of cloud systems over the desert, which reduce ground temperature during daytime.

▪Simple equipment can be designed to desalinize water for people and animals. The water vapors produced and colected by light-weight fairings during daytime are condensed during nighttime when temperature drops to 0ºC

▪The presence of channel networks in deserts will be beneficial for managing the water runoff caused by the melting of polar glaciers in order to avoid seaside flooding.

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