Sprays: A Solution to Cope with Global Temperature Rise?

P. K. Maldhure
Department of Mechanical Engineering
Sipna College of Engineering and Technology Amravati, Maharastra, India

Abstract— Global warming and global climate change is very serious problem now a days. Many international organizations are taking due efforts to cool our planet and trying to counteract with global warming. According pinker et.al [8] the corresponding increase in solar radiation by 0.10% per year from 1983. According to intergovernmental panel for climate change (IPCC) report [5], the world has just 12 years in which to cut co2 emission by half and up to 2050 to get net emission down to zero. UN emission GAP [15] report urged that "Now more than ever unprecedented and urgent action is required by all nations". And some thing that artificially engineered clouds may be one of the important solution. This article includes complete study of feasibility of proposed spray devices and questions arising from experimenting these sprays practically. The paper ends with brief discussion about implementation of sprays in the semi-arid regions like vidarbha also, study of geographical conditions which are responsible to climate in vidarbha region.

Keywords: IPCC, Sprays, Global Warming and Global Climate

I. INTRODUCTION

Due to continuous automation global warming and global temperature change is severe issues in front of world to deal with. Also due to continuous urbanization and industrialization it is very difficult to cope with global climate change. Fossil fuel burning releases 25 pg 0f co2 per year into the atmosphere, which leads to global warming (prentice et.al.) [5] . It is already proven that warming of earth is mainly due to increase in concentration of co2 and other green house gases. However it is partially countered by some back scattering of solar radiation to space, by sulfate particle which act as a cloud condensation nuclei. According to world health organization (WHO) the pollution particle affect health and lead to more than 500,000 premature deaths per year worldwide and hence this has laid some to propose environmental engineering scheme, which could be use in upcoming decade to control rapid environmental change.

It is only possible by increasing the reflectivity of solar radiation? , which is now being trapped by green house gases? , Is it safe to experiment about brighter clouds to atmosphere, We will try to find out answers for this question in the entire upcoming discussion. For that salter et al. [1] outline the novel scheme to increase the reflectivity of stratocumulus clouds over the oceans. Seawater drops are to be injected into turbulent boundary layer, after which natural circulation will transfer them to cloud layer after that due to evaporation these tiny droplets are converted into salt crystals. Twomey [2] has shown that increase in drop concentration lead to dramatically increase in cloud reflectivity. As a result of which device proposed by salter et al. could reduce solar radiation reaching the earth`s surface, which leads to decrease in global temperature.

Fig. 1: Proposed geo engineering spray vessel

This paper gives brief account of feasibility of ultrasonic atomizer proposed to create fine mist. Also the application of cloud brightening on marine regions as well as on hot regions of vidarbha, specially in summer when average temperature reaches up to 48^0c.

II. ULTRASONIC ATOMIZER PRAPOSED BY SALTER [1]

Salters proposed ultra sonic atomizer is an unmanned hydrofoil ship, computer controlled and wind powered, which is able to pumps an ultrafine mist of sea salt towards the cloud layer. It's capacity of spraying about 10 cubic meter per second could undo all global warming we have done to the world up till now. Salter et al. calculates that a fleet of 300 of his autonomous ships could reduce global temperature by 1.5c. According to them global spray rate between 30 to 70 m^3/s of 0.8 µm drops would be sufficient to control global warming effect.

However most important parameter in determining the success of atomizer is increase in drop concentration rather than volumes therefore rate of drop production is more critical. salter et al. [1] assumed that, mono disperse spray with 0.8 µm diameter drop at 30 kg/s this results in 1.1×10^7 drops/s. Each vessel contains three spray devices which results in 3.6×10^{16}drops/s per sprayer. To meet the desired goal of 0.8 µm drop size there is need to set a upper limit of drop size which should be less than 2.5µm. Since power available is very less that is 30 kw /nozzle which is reserved for the entire intake of sea water, it's processing and further spraying system. Hence the overall requirement of salter's spray device is as follows

Spray rate, n	3.6×10^{16} drops/
Drop diameter, D	≤2.5µm
Power consumption, W_{tot}	≤30 kw

Table 1:

Salter plan to etch the d=0.4 µm micro-orifices into 8µm thick layer of silicon resulting in a nozzle length to diameter ratio of 20. For this ratio and the given Re, the discharge coefficient can be estimated to be $C_D \approx 0.1$ where $m_1 = C_d\ \pi\ d^2\ (2\rho_1\pi\Delta p_1)^{0.5}/4$ and m1 is the mass flow rate per orifice [11]. Using this pressure of $\Delta p_1 \approx 9.0$ MPa is expected across the nozzle. This pressure loss may be slightly reduced

through shaping of nozzle passage. Here special precaution must be taken to avoid clogging. For that there is a need of a kind of filtration system which filters a level significantly smaller than the atomizer orifice diameter. AS sample PMC polypropylene filter capable of removing 98% of particle with sizes under about 0.3 µm and requires about 1 bar of pressure drop for 1 kg/s of liquid pumped and assuming a filter that is 1m long. This is small as compared to the orifice pressure drop.

III. Basic Energy Calculations

The effect of injecting 3o Kgs^{-1} of seawater as 0.8 µm drops but confining it to just one of the equal area cells will be increase the number of new nuclei per cell by $1.12\times10^{17}s^{-1}$. Also it will take some time (may be 2 hours) for turbulence to disperse the evaporated spray residue through the boundary layer, but cleanliness of the mid ocean air will make them effective condensation nuclei. A large fraction of those that reach the high humidity at the cloud base will form newer but smaller drop with the same total liquid water content as before.

If we consider the mean 24hours equinoctial solar input at the equator is give 440 Wm^{-2}. If spray source can migrate with seasons, a typical value of $340Wm^{-2}$ seems reasonable and even conservative. The resulting change of albedo will increase reflected power by 30.26 Wm^{-2} or 2.33 Tw over the $7.72\times10^{10}m^2$ area of one cell.

From the above conclusion it is possible to implement this research practically. Such step by step research effort, would take a decade at least. But due to controversy it attracts, this hasn't even started yet. Not one cloud has yet been purposefully brightened by academics, although cargo shipping still does this unintentionally, with dirty particles, every single day. Now let us see implementation of brightened clouds over the tropical regions like vidarbha.

IV. Need of Artificial Cloud Brightening in the Tropical Regions Like Vidarbha

Before understanding the need of artificial cloud brightening in vidarbha regions, first of all we need to understand the geographical conditions of vidarbha region. Vidarbha region is the eastern part of the maharastra, India. According to times India report [15], among all eleven districts in vidarbha regions, 5 districts (chandrapur, Nagpur, akola, wardha and Amravati) are figure in the top 15 hottest cities in the world. Vidarbha's maximum temperature varying between 47 to 48 degree Celsius. Vidarbha is the most vulnerable region to climate change in india. According to World Bank, this region is deeply agrarian and lacks of the infrastructure in terms of electricity and irrigation to cope with any increase in temperature. Since vidarbha region came under semi-arid climate zone where agriculture is mainly depends on rain-fed farming (about 93%of the net cultivable land). Also vidarbha is located near the equatorial regions of the earth and such regions are called as tropical regions. Since the equator receives the most sunlight throughout the year, which generates rising air currents that helps in formation of clouds over equatorial regions. Which then cause rain and thunderstorm, this is why areas lying on equator experience lower temperature and tropical regions experience higher temperature. Vidarbha region located on tropic of cancer as highlighted in the picture below.

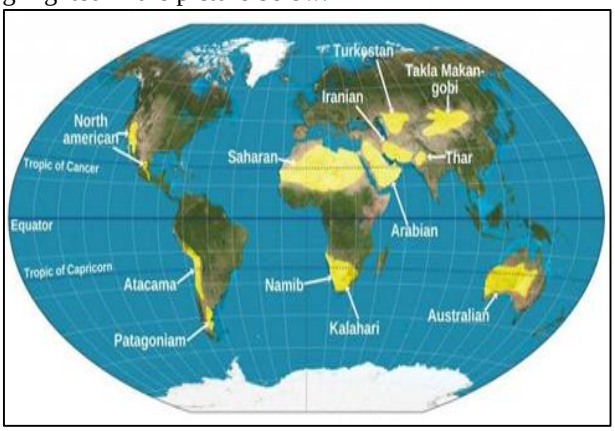

Fig. 2: Showing imaginary line passing through the earth's centre (equator) and the another imaginary line, tropic of cancer showing the tropical regions. The highlighted part shows tropical region "vidarbha".

Hence, artificially engineered clouds may be the only rapid solution to control rapid temperature change. Let us see the easiest method to control temperature rise.

V. Cloud Brightening by the Stratospheric Sulfur Injection

Albedo modification scheme by self-propelled ships, are feasible only for marine regions. It will be messy operation on actual land hence a strong alternative is needed. An easiest alternative is may be to release s-containing gas at earth's surface or better from balloons in tropical stratosphere a gas one might think of is COS, which is main source of stratospheric sulfate layer during low activity volcanic periods (crutzen, 1998) [6]. However, about 70%of the COS emitted will be taken up by plant, 25%is removed by reduction with OH and only 5% reaches to stratosphere to produce so_2 and sulfate particles (chin and davis 1993) [7]. Consequently, releasing COS at the group is not recommended. However it may be possible to manufacture a special gas that is only photo-chemically in the stratosphere to yield sulfate, but the compound should be nontoxic, insoluble in water and nonreactive with OH, and should not contribute to green house warming.

An interesting alternative could be to release soot particles to create minor "nuclear winter conditions". In this case earth's albedo would actually decrease, but surface temperature would nevertheless decline only 1.7%of mass of sulfur would be needed to effect similar cooling at earth's surface making the operation much cheaper and less messy.

VI. Effects of Cloud Brightening on the Atmosphere of Vidarbha

As to save the biodiversity of tropical regions artificial brightening is the only solution. But on the other hand some researchers have claimed that, artificial cloud brightening may potentially affect agricultural production. Also they have substantial impact on weather patterns. Like intensity of hurricanes, change in the patterns of rainfalls such as drought in vulnerable regions or may be an year without summer. The

deflections of sunlight had a negative impact on the yields of many staple crops, including rice, wheat, cotton and maize which are one of the principle crops that are abundantly grown in vidarbha region. But during summer there is mostly drought in many regions of vidarbha and hence agricultural practices are almost stopped. Hence there is a chance to practice artificial cloud brightening mainly in summer. Which protects water reservoirs from evaporating as well as crops from burning due to extreme temperature.

Nevertheless, I must stress here that albedo modification scheme should only be deployed when there are proven net advantages and in particular where rapid climate warming is developing. Lot of research is till needed before practical application of this scheme.

VII. Conclusion

Based on the analysis presented here is seems unlikely that any spray device can be created which meet all requirements discussed earlier. If the salter's interpretation about twomey work is correct, then a few hundred vessel will be able to correct the thermal effects. Ultrasonic atomizer thus play a very important role in implementing estimated results. While a major efforts should be put into the study of all the possible side effects of keeping sea temperature at present values. Many of the side effects appear to be benign and less dangerous than those of large unbridled temperature rise unsuitable places are avoided and spraying can be stopped instantly with all the effects removed in few days.

When we talked about vidarbha, conditions and views are critically changing. Some regions are already came under the hottest places in the world. Hence quick implementation of above discussed methods are needed. Due to high temperature rise biodiversity of vidarbha regions are now endangered. It is such an important that we need to start thinking about it.

Nevertheless, I must say that the albedo enhancement scheme should only be deployed when there are proven net advantages and in particular when rapid climate warming is developing. There are many preferable ways to reduce climate change than solar geo engineering, planting trees, re-forestation are proven conservation friendly method of taking carbon out of the atmosphere .

Building trust between scientist and the general public would be needed to make such a large scale climate modification acceptable. Even if it would be judged to be advantageous. Finally I repeat it will be perfect if emission of green house gases could be reduced so much that the stratospheric sulfur release experiment would not to take place, currently this looks like a pious wish.

Acknowledgement

Dr. Stephan salter work on marine cloud brightening makes me curious about this subject. Also Tim smedley provides valuable data on global climate change. Special thanks goes to my parents and my teachers who motivates me to work.

References

[1] Salter, s.,sortino, G.,Latham, J., Philosophical Transactions of the royal society of London series A, 366:3989-4006 (2008).
[2] Towmey,s ., Journal of the atmospheric sciences, 34(7): 1149-1152 (1977).
[3] Rayleigh, L., proceedings of the London Mathematical society, s 1-10(1): 4-13 (1878)
[4] Nel, A.: 2005, 'air pollution related illness: Effects of particles', Science 308, 804
[5] Prentice, I. C. et. al.: 2001, 'The carbon cycle and atmospheric carbon dioxide', chapter 3, pp.183-238, Third assessment report of intergovernmental panel on climate change, Houghton, J. T.et al. (eds.), Cambridge university press, U.K. and New York, USA.
[6] Crutzen, P.J. and Ramanathan, V.: 2003, 'The parasol effect on climate', Science 302, 1679-1681
[7] Chin, M. and Davis, D.D.: 1993, 'Global source and sinks of OCS and CS2 and their distributions', globe. Biogeochem. Cycles 7, 321-337.
[8] Pinker, R. T., Zhang, B., and Dutton, E. G.: 2005,'Do satellites detect trends in surface solar radiation?', Science 308, 850-854.
[9] Schwarts, S. E. and Slingo, A. 1996 Enhanced shortwave radiative forcing due to anthropogenic aerosols. (Intelligible even to enginers.) In clouds chemistry and climate (eds. P. crutzen and v. ramanathan), pp. 191-236. Heildelberg, Germany: Springer.
[10] Bennartz, R. 2007 Global assessment of marine boundary layer cloud droplet number concentration from satellite. J. Geophys, Res. 112. D02201.
[11] Lefebvre, A.H., Atomization and sprays, Hemisphere pub. Corp. (1989)
[12] Mittal, S. 2004 Three dimensional instabilities in flow past a rotating cylinder. ASME J. Appl. Mech. 71, 89-95.
[13] Padmanbhan, R., Guildenbecher, D. R., Hirleman, E.D., Sojka, P.E., 23rd Annual conference on liquid atomization and spray systems, Brno, Czeh republic (2010)
[14] www.timesofindia.indiatimes.com
[15] https://timesofindia.indiatimes.com/city/nagpur/six-of-worlds-15-hottest-cities-were-in-vidarbha/articleshow/69064564.cms
[16] https://www.unenvironment.org/interactive/emissions-gap-report/

