Commercial forcing of Convective Precipitation

Abstract:

Background: As the worst predicted scenarios of climate change manifest and intensify, modern meteorological understanding, materials, and engineering may offer strong tools for both mitigation and adaptation to the looming global challenge. The energy cycle proposed here harnesses the practically limitless energy and water production potential of the atmosphere to produce agricultural levels of water and energy. The process works by selecting the highest humidity levels of the atmosphere to heat and collocate sufficient flow to force consistent convection with sufficient and reliable precipitation efficiency. Method: The mechanics of the hypothetical process are analyzed using sounding charts and Skew-T diagrams. The cycle is applicable throughout the year at places where there is high Total Precipitable Water (TPW), bordering drylands. Analysis of operation in favorable and unfavorable conditions illustrates the concept and mechanics. Findings: Scale estimates show commercial practicality with a production-plant footprint three times larger than the successfully tested solar chimney concept. This theoretical exploration shows that instead of pollution, the byproducts and unplanned effects offer greater profit potentials than its direct water production alone. Further, since the process must work at atmospheric scale and produces energy in addition to water when fully exploited globally, it could significantly correct atmospheric CO_2 accumulation, recharge aquifers, reverse sea-intrusion salinization, help with Sea Level Rise (SLR), reverse desertification, expand arable lands, and provide controllable local Solar Radiation Management. Results: The architectural design offered works best on marginal lands and minimizes monetary and environmental costs with simplified construction solutions. However, the monetary cost factor, construction feasibility, and environmental costs, as well as meteorological validity, have yet to be professionally considered and peer-reviewed. Conclusion: Complete description and discussion of the preliminary concept need peer review before publication. More detailed engineering, environmental, and cost considerations will follow if the meteorological theory proves to be valid.

Extended Abstract:

This paper is a simplified business proposal. It argues that it is important for the meteorological community to dissect and justify this preliminary and hypothetical energy cycle because of its potential value for civilization. Showing that forcing precipitation is <u>commercially</u> <u>practical</u> means that:

1) There is sufficient water production, alone, to justify the cost.
2) Storm dynamics and precipitation efficiency are sufficient to sustain the storm mechanism.
3) Unplanned harm is small enough so as not to bankrupt the business model. Conversely,
    a. There is value in unplanned effects
    b. The value of unplanned effects is greater than in its water production alone

To justify the validity of meteorological mechanics, this paper:

1) Uses graphical analysis of the energy balances and additional heat to reach CCL and LFC.

2) Demonstrates the scale necessary to develop and retain a storm plume to dominate the working environment reliably.
3) Estimates membrane production capacity and air heating potential for plume initiation.
4) Estimates construction cost from the preliminary scale presumed.
5) Contrasts easy production conditions against challenging conditions to illustrate the cycle.
6) Offers a short present value analysis to argue for profitability on water production alone.
7) Finally, it argues how most unplanned effects are beneficial.
    a. The cycle brings additional water from the sea,
    b. Has the potential to green the desert quarter of the globe
    c. Thus, it might be a critical tool to solve our most pressing environmental problems.

Illustration for Oral Presentation:

The cycle in graphical form

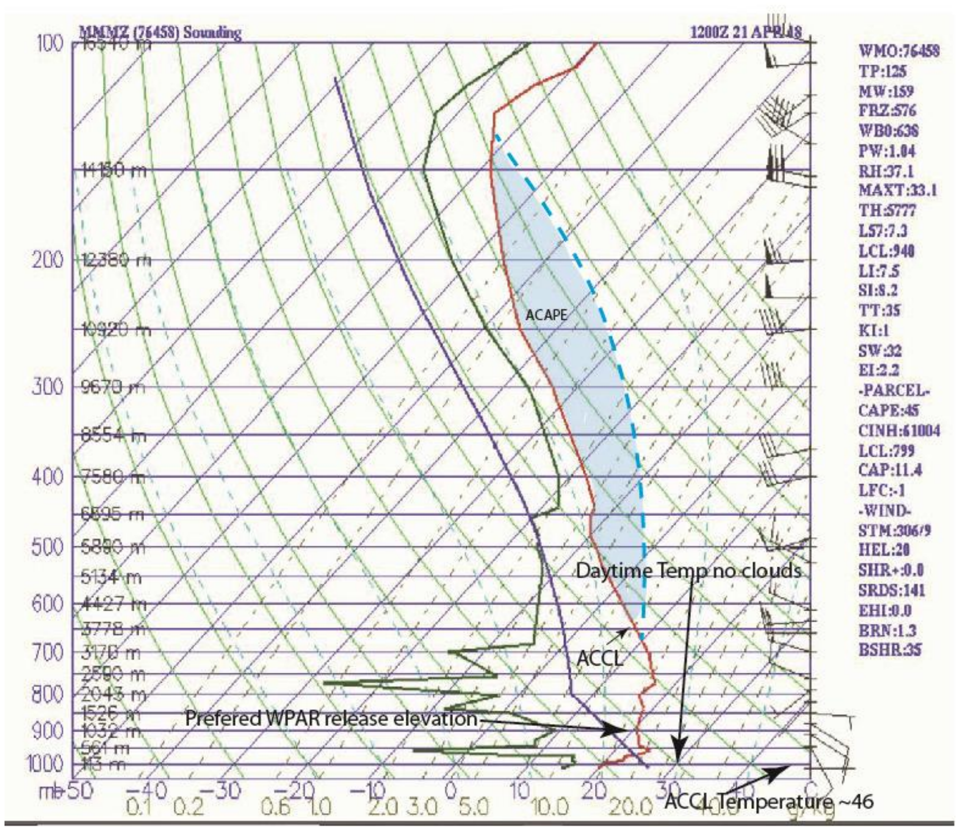

Figure 1: Illustration of challenging conditions made productive by selecting the most humid air from the lowest levels of the atmosphere below 400 m. Heating working fluid to 46C achieves CCL. Achieving LFC increases CAPE and shifts its moist adiabat 10C to the right depicted by ACAPE.

Skew-T diagrams, especially from the College of DuPage (COD,) show most of the factors to consider. We can visually estimate temperature change requirements to achieve CCL and rough in where the new moist adiabat will track. Thus, we can see how CAPE increases. It also shows us the target moisture levels to feed into the system. Underlying textural values, also from COD, detail the conditions.

Underlying conditions Text

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Date: 1200Z 21 APR 18                                   Station: MMMZ
Searching for MMMZ...                                   WMO ident:  76458
Searching the city database file for: MMMZ ...          Latitude:   23.20
Date:1200Z 21 APR 18                                    Longitude: -106.42
                                                        Elevation:   4.00
```

LEV	PRES	HGHT	TEMP	DEWP	RH	DD	WETB	DIR	SPD	THETA	THE-V	THE-W	THE-E	W
	mb	m	C	C	%	C	C	deg	knt	K	K	K	K	g/kg
SFC	1012	4	19.8	14.8	73	5.0	16.6	90	2	292.0	293.8	289.3	321.8	10.51
1	1000	113	20.2	16.1	77	4.1	17.5	130	4	293.4	295.4	290.7	326.4	11.58
2	998	130	20.0	16.1	78	3.9	17.4	131	4	293.3	295.4	290.7	326.4	11.60
3	995	156	20.8	16.2	75	4.6	17.8	132	5	294.4	296.5	291.1	327.9	11.72
4	988	218	22.2	15.2	65	7.0	17.6	134	5	296.4	298.4	291.2	328.3	11.05
5	978	307	22.0	15.0	64	7.0	17.4	138	6	297.0	299.0	291.4	329.0	11.02
6	975	333	22.2	15.2	65	7.0	17.6	139	7	297.5	299.5	291.7	330.0	11.20
7	971	369	23.6	4.6	29	19.0	12.9	140	7	299.3	300.3	287.3	315.5	5.48
8	959	478	24.8	-7.2	11	32.0	9.9	145	8	301.5	302.0	284.8	308.7	2.32
9	942	635	22.6	8.6	41	14.0	14.1	149	10	300.8	302.2	289.6	323.0	7.46
10	925	794	21.8	7.8	41	14.0	13.4	140	8	301.6	302.9	289.7	323.0	7.19
11	897	1061	20.4	9.4	49	11.0	13.6	120	9	302.8	304.3	291.0	327.5	8.28
12	850	1526	19.0	1.0	30	18.0	9.3	90	4	306.0	307.0	289.0	320.9	4.84
13	839	1637	18.8	-8.2	15	27.0	6.4	139	3	307.0	307.4	287.0	314.8	2.45
14	803	2011	16.4	-2.6	27	19.0	6.8	231	4	308.3	309.0	288.9	320.6	3.93
15	774	2323	17.2	-27.8	3	45.0	2.6	268	7	312.4	312.5	286.8	314.2	0.50
16	755	2534	15.8	-5.2	23	21.0	5.4	289	9	313.1	313.8	290.0	324.1	3.44
17	703	3134	12.6	-13.4	15	26.0	1.7	285	16	316.1	316.4	289.5	322.5	1.93
18	700	3170	12.2	-14.8	14	27.0	1.1	285	16	316.0	316.3	289.3	321.8	1.73
19	682	3388	10.8	-4.2	35	15.0	3.2	279	17	316.8	317.6	291.7	330.0	4.11
20	532	5404	-4.5	-12.5	54	8.0	-7.7	295	15	321.8	322.3	292.0	331.0	2.75
21	500	5890	-7.7	-15.7	53	8.0	-10.6	265	12	323.7	324.1	292.0	331.3	2.25
22	486	6108	-9.5	-16.5	57	7.0	-12.0	255	12	324.1	324.5	292.1	331.4	2.17
23	456	6594	-12.1	-20.1	51	8.0	-14.6	257	18	326.8	327.1	292.4	332.7	1.70
24	442	6831	-12.7	-17.5	67	4.8	-14.3	257	20	329.0	329.4	293.4	336.5	2.19
25	400	7580	-17.7	-21.4	73	3.7	-18.8	260	29	332.0	332.3	293.9	338.1	1.73
26	312	9393	-31.3	-34.5	73	3.2	-31.8	268	39	337.5	337.6	294.3	339.9	0.66
27	300	9670	-33.3	-36.7	71	3.4	-33.8	270	41	338.4	338.6	294.4	340.5	0.55
28	250	10920	-44.9	-49.4	61	4.5	-45.2	265	42	339.3	339.3	294.3	340.0	0.17

Chart 1

Chart 1 demonstrates Favorable Atmospheric Stacking, defined as the concentration of a large portion of TPW at the lowest and accessible atmospheric levels. Equilibrium Level (EL) is only 7500m, according to Theta-w plus 10C, but it is sufficient for efficient precipitation.

Figure 2 demonstrates Brimming Bowl (BB) concept, defined as the limiting edge of high TPW contrasted to much drier conditions, usually limited by a geologic obstruction, such as the coastal mountains on the West Coast of Mexico and the Arabian Peninsula along the Red Sea.

At the time of this sounding in Mazatlán, TPW has a high concentration on the lowest level of the Planetary Boundary Layer (PBL), levels 6 and below. The forcing cycle creates precipitation on what is the usual rain-shadow zone on the other side of the mountains, creating the BB phenomenon, which facilitates water and energy harnessing by this proposed cycle.

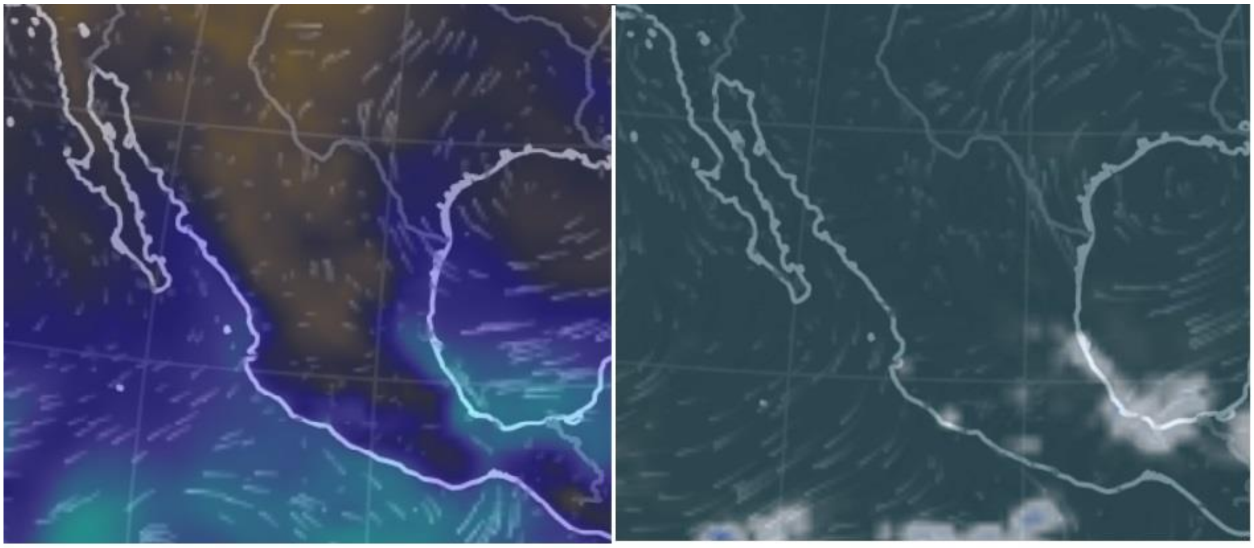

Figure 2: The blue shading, from Null School images, depicts 25 kg water kg^{-1} air TPW, of the BB along the West Coast of Mexico, yet the green and gray panel shows no rain. The aqua color depicts over 40 kg water, yet no rain on the North East coast of Mexico with only 0.8mm over 3 hours precipitation south of Saltillo Coahuila, Mexico, which could produce regular runoff on a large scale.

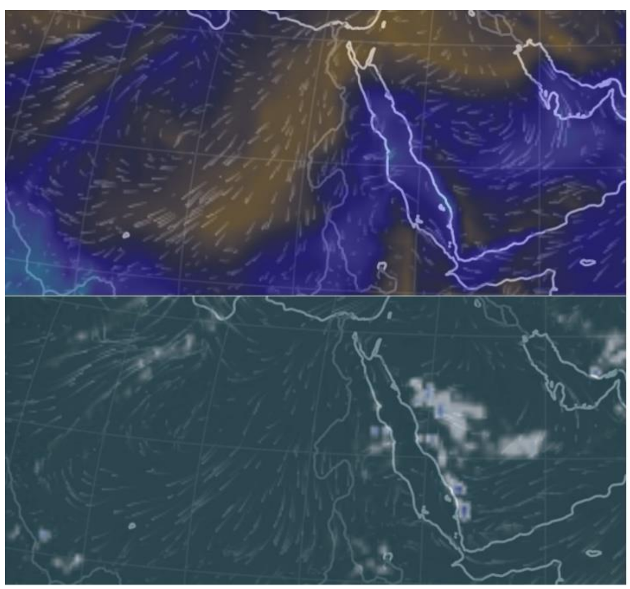

Figure 3: BB effects indicate high TPW with little or no rain near Niamey, Blue Nile Watershed, Arabian Peninsula Mountains, and the Persian Coast. Highest rate near Abha, Arabia, is only 14mm over a 3-hour period.

Systems are cost-effective all over the world.

Available moisture in the atmosphere in some dry and desert areas such as Sudan, Ethiopia (Via the Blue Nile, and Takkazzi Rivers), and Yemen indicate these areas can continually export almost limitless amounts of water.

In the ideal conditions of these sites, construction is inexpensive yet highly productive because of favorable BB and geologic conditions.

Because high energy conditions are found all over the world, it seems most of the planet can be forested or farmed, when environmental effects are appropriately considered.

Collector area is very large, yet it is cost-effective

The surface area of 80,000 m^2 for convection system is about three times larger than the Circular area for a 200 MW Solar Chimney System (SCS); about 25,000m^2.

Figure 4:

Collector area regardless of shape is the main cost driver. The collector area for a system to force convection is about three times larger than the collector area for a solar chimney system.

Solar Chimney experiments show cost-effective construction requires less than 1% of collector energy efficiency. Although this paper cost-justifies the construction of the project on water production alone, it might also be cost-justifiable on its energy production alone.

It is possible to harvests updrafts and downdraft wind energy, and since this architecture costs about the same, and perhaps a quarter as much as the smaller Solar Chimney System, it might offer greater profit potential on energy without considering the water benefit.

The system has many other benefits, which could cost justify the project several times over again.

Other Monetizable Benefits

Precipitation is the fundamental source of wealth for most civilizations. It is natural to expect greater benefits than simply water or energy from managing precipitation.

Besides the more obvious benefits of rain, we may be able to monetize other potential benefits.

- Significant control of atmospheric CO2
- Aquifer recharging, and creation of new aquifers
- Reversal of saltwater intrusion and desalinization of lands
- Significant control of Sea Level Rise (SLR)
- Desertification reversal

- Expansion of arable lands
- Significant and controllable local Solar Radiation Management (SRM)
- Energy production, greater than hydroelectric potential, with modified Energy Tower concept
- Local cooling and humidification for agricultural production in high-temperature lands (Using Energy Tower waste)
- Improved Favorable Atmospheric Stacking (FAS) by recycling the humid flow into water production

Taping atmospheric energy may offer the best tools to repair the damage caused by our carbon energy regimes. Meteorology is best able to understand the limitless potential of the atmosphere for energy and water production if it is possible. It is meteorology on which civilization calls on now for help.