

Loss of Cloud Cover and Precipitation on the way from 400ppm CO₂e to 1200ppm CO₂e and a Potentially Critical Hydroxyl Remedy

Viva Cundliffe

Abstract

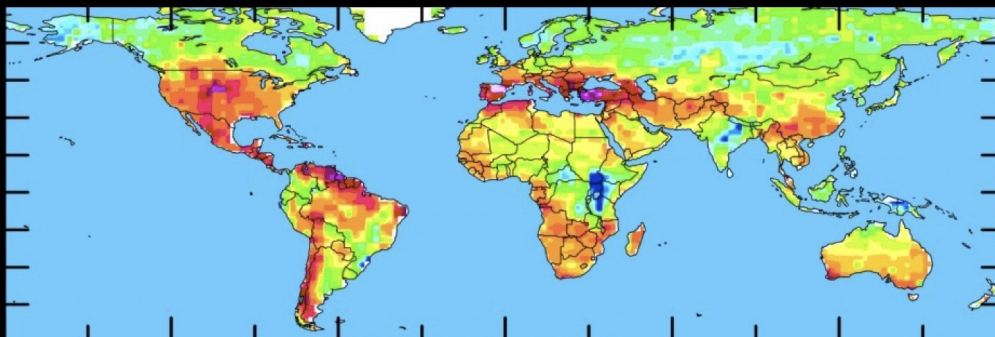
1.2% or 1200ppm CO₂ in the atmosphere causes a form of steric hindrance in saturated air, which contains from 10-23 ppm of water in normal cloud systems. Computer models show the extinction of stratocumulus cloud cover because of this effect, which will likely lead to a sudden warming of approximately 8°K. As society moves from 420 ppm CO₂ and upward, this over 0.42% CO₂ level is already changing the composition of clouds by acidifying them through the freshwater carbonate buffering system. The activation of this system reduces the oxidative capacity of clouds and naturally occurring hydroxyl, which is scavenged by CO₂ to form carbonic acid, and trace carbonate ion at 7-8pH. The rain out of CO₂ through the carbonate buffering mechanism is estimated at 6% of [CO₂] atm. Because there is a natural scavenging limit of background OH of about 3ppm, 3ppm OH into 23ppm H₂O equals 13%, with 50% losses this is a 6% CO₂ scavenging effect. The remaining 420-23ppm, or 397ppm of CO₂ is fully mixed and because it is a linear molecule with a high cp and vapor pressure, often can force water molecules apart, and increasingly cause particulate to reject moisture as the particulate is heated. This will result in decreasing precipitation on the way to CO₂ levels over 500ppm, This letter discusses briefly how artificial introduction of concentrated hydroxyl would both remedy precipitation loss, and, remove CO₂ from the atmosphere by advanced buffering, to fight climate change, and enhance gradually degrading precipitation already found on Earth.

Preceding Drought Conditions

2000 2000

Predicted Drought Conditions

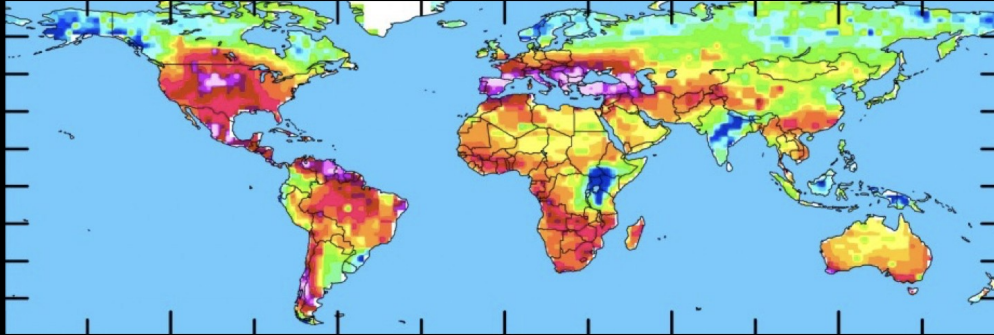
2030 – 2039



Dry Wet

Source: University Corporation for Atmospheric Research, 2012

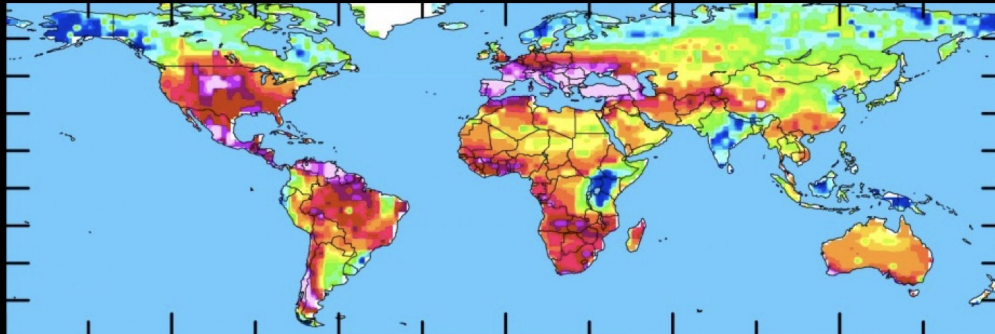
Predicted Drought Conditions 2060 – 2069



Dry  Wet

Source: University Corporation for Atmospheric Research, 2012

Predicted Drought Conditions 2090 – 2099



Dry  Wet

Source: University Corporation for Atmospheric Research, 2012

Hydroxyl is either made by UV cleaving water molecules, or by Ozone decomposing to an Oxide atom, which contacts with water, and forms 2OH^* . In precipitation dynamics, the presence of OH supplies a Hydrogen ligand which can puncture water droplets and cause many more of them to coalesce together and with particulate matter which also can use the attached OH Hydrogen ligand in the same way. Hydroxyl acts like “velcro” in this way, and assists in the collection of droplets, and CO_2 buffering which adds mass to droplets, and causes rain or snow. In the drought graphics, we can envision that where there is no water or humidity to support OH levels, these mechanisms are absent, and the absence compounds the drought’s effects. These predicted conditions include the steric hindrance effect of CO_2 for 94% of the CO_2 present in the air.

More capacity to hold moisture by the air is countered by the steric hindrance of CO_2 , which is also causing warming that leads to less water vapor condensation at typical altitudes. Even though there is more atmospheric moisture, there is a maximum natural hydroxyl production level limit of about 3ppm, with 25% of that recycling overnight. Once the added acidity of higher CO_2 levels scavenges and overwhelms the hydroxyl, a natural limit is reached where oxidants are scavenged, which removes them from the facilitating role they play in coalescence of PM, and droplets. This becomes an increasing phenomenon as heat and CO_2 are added.

This directly contributes to desertification. Desertification is a transitional state on the way to drought. Both desertification and drought expand through increased temperature and decreased water vapor condensation, lowered water content and thus hydroxyl availability caused by CO_2 forcing and buffering, cloud acidification leading to scavenging of OH which was normally being applied to droplet coalescence.

What ppm of CO_2 begins to interfere with OH at 3ppm-the stochastic ratio of OH to CO_2 is 1:1.

Globally the process towards a 1200ppm CO₂ caused stratocumulus cloud extinction feedback is already 33% underway as a somewhat linear trajectory to the extinction. As the drought graphics are viewed from present day to 2099, the at-ground impacts are incrementally shown.

Obviously, humanity is attempting to intervene in its increasing CO₂ levels, but the developing world's transition to low carbon technology before they become carbon saturated is a present and large hurdle. To respond to the already baked in warming of over 500ppm CO₂ e warming, direct GHG removal technology is a necessity according to all lead scientists and the IPCC.

If we take a survey of CO₂ sucking technology, CH₄ sucking technology, we see a very expensive, energy intensive, one dimensional remediation approach. Silver Iodide, the common form of cloud seeding may become ineffective as it passes through more vaporous, and less condensed cloud decks. With these approaches, the mechanisms may become too costly to benefit humanity through inherent inefficiencies found in needing massive global suction systems before residue-heavy chemistry is applied. An efficient dispersal of a naturally occurring compound that leaves no unwanted residues that is scalable is more desirable. If, in addition, it could immediately remedy deteriorating precipitation mechanics while removing higher levels of CO₂, we would have a great multi-pronged remedy.

Concentrated Hydroxyl dispersal technology has now been invented, and is available for multiple GHG offsetting. Hydroxyl is the main oxidant of the atmosphere, treating everything present by either oxidation, buffering, attachment and deposition, coalescence and scavenging. Natural hydroxyl levels at 3ppm, are essentially swamped by pollution pulses from all sources now. Continuous addition of CO₂ will ensure that hydroxyl remains swamped.

Adding concentrated atmospheric hydroxyl at the dose of 0.5 grams per liter, or about 5ppm, or a pH of 10.3, will ensure that carbonate ions are quickly formed with water vapor, while apportioning more hydroxyl to treat all of the other constituents, and enhance attachment and deposition, coalescence and scavenging. The immediate formation of carbonate ions changes CO₂ from a GHG to a mineral acid, which will result in cooling, and permanent deposition on the ground.

An increase in all of the following reactions will occur by increasing the OH reactant because many of these co-reactants have increased:

Table 1. Temperature-dependent parameters C and D in $k = CT^2e^{-D/T}$ for the group rate constants for H-atom abstraction from $-\text{CH}_3$, $-\text{CH}_2-$, $>\text{CH}-$ and $-\text{OH}$ groups, together with 298 K group rate constants for H-atom abstraction from $-\text{CH}_3$, $-\text{CH}_2-$, $>\text{CH}-$, $-\text{OH}$ groups and initial OH radical addition to $-\text{C}(\text{O})\text{OH}$, $-\text{ONO}_2$ and $-\text{NO}_2$ groups

Group	$10^{18} \times C^a$ ($\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$)	$D(\text{K})^a$	$10^{12} \times k(298 \text{ K})$ ($\text{cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$)
$-\text{CH}_3$	4.49 (4.47)	320 (303)	0.136 (0.144)
$-\text{CH}_2-$	4.50 (4.32)	-253 (-233)	0.934 (0.838)
$>\text{CH}-$	2.12 (1.89)	696 -711	1.94 (1.83)
$k_{\text{abs1}}(-\text{OH})$	2.1 ^b (1.89) ^b	85 (460)	0.14 (0.036)
$k_{\text{add}}(\text{R}-\text{C}(\text{O})\text{OH})$			0.52
$k_{\text{add}}(\text{R}-\text{ONO}_2)$			0.36
$k_{\text{add}}(\text{R}-\text{NO}_2)$			0.13

^a Data in parentheses are the previous values of Atkinson (1987).

^b Assumed equal to the value for H-atom abstraction from the $>\text{CH}-$ group (see text).

Table 2. Substituent factors $F(X)$ at 298 K^a

X	$F(X)$ at 298 K ^b
-CH ₃	1.00 (1.00)
$\left. \begin{array}{l} -\text{CH}_2- \\ >\text{CH}- \\ >\text{C}- \end{array} \right\}$	1.23 (1.29)
-F	0.094 (0.099)
-Cl	0.38 (0.38)
-Br	0.28 (0.30)
-I	0.53
$\left. \begin{array}{l} -\text{CH}_2\text{Cl} \\ -\text{CHCl}_2 \\ -\text{CHCl}- \\ >\text{CCl}- \end{array} \right\}$	0.36 (0.57) ^c
$\left. \begin{array}{l} -\text{CHBr} \\ -\text{CHBr}- \end{array} \right\}$	0.46 (0.57) ^c
-CCl ₃	0.069 (0.090)
-CF ₃	0.071 (0.075)
-CHF ₂	0.13 (~ 0.10)
-CH ₂ F	0.61 (~ 0.85)
-CF ₂ Cl	0.031 (~ 0.025)
-CFCl ₂	0.044
-CHF-	0.21
-CF ₂ -	0.018
= O	8.7 (8.8)
$\left. \begin{array}{l} -\text{CHO} \\ >\text{CO} \end{array} \right\}$	0.75 (0.76)
$\left. \begin{array}{l} -\text{CH}_2\text{C(O)-} \\ >\text{CHC(O)-} \\ \rightarrow \text{CC(O)-} \end{array} \right\}$	3.9 (4.4)
$\left. \begin{array}{l} -\text{C}_6\text{H}_5 \\ >\text{C} = \text{C} \\ -\text{C} \equiv \text{C}- \end{array} \right\}$	~ 1.0 (~ 1.0)
-OH	3.5 (3.4)
-OR (R = alkyl)	8.4 (6.1)
$\left. \begin{array}{l} -\text{OCF}_3 \\ -\text{OCF}_2- \\ -\text{OCHF}_2 \\ -\text{OCH}_2\text{F} \end{array} \right\}$	0.17
-C(O)Cl	0.067 (~ 0.5)
$\left. \begin{array}{l} -\text{OCH}_2\text{CF}_3 \\ -\text{OCH}(\text{CF}_3)_2 \\ -\text{OCHClCF}_3 \end{array} \right\}$	0.44
-C(O)OR (R = alkyl)	0.74 (0.0)
-OC(O) (R = alkyl)	1.6 (1.5)
-C(O)OH	0.74
-C(O)CF ₃	0.11
$\left. \begin{array}{l} -\text{CH}_2\text{ONO}_2 \\ >\text{CHONO}_2 \\ \rightarrow \text{CONO}_2 \end{array} \right\}$	0.20 (0.21)
-ONO ₂	0.04 (0.10)
-CN	0.19 (0.14)
-CH ₂ CN	~ 0.12 (0.5)
-NO ₂	0.0

The present oxygen column in air can supply a 42%/vol stream of oxide,

Table 2. (Continued)

X	$F(X)$ at 298 K ^b
-CH ₂ NO ₂	0.14
3-member ring	0.020 (0.017)
4-member ring	0.28 (0.22)
5-member ring	0.64 (0.80)
7- and 8-member rings	~ 1.0 (~ 1.0)

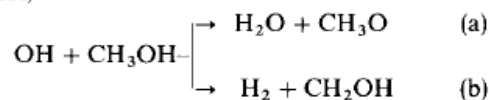
^a Values of E_X can be calculated from $F(X) = e^{E_X/T}$ [equation (1)].

^b Values in parentheses are those of Atkinson (1987).

^c Values of $F(X)$ for X = -CH₂Cl, -CHCl₂ and -CH₂Br only obtained previously.

For compound classes other than the alkanes, substituent factors $F(X)$ were derived using the rate constants given in the reviews of Atkinson (1989, 1994), as updated with those from the recent studies of Schmoltner *et al.* (1993) for haloalkanes and Scollard *et al.* (1993) for halogenated aldehydes. The substituent factors $F(X)$ were derived from nonlinear least-squares analyses (Atkinson, 1986, 1987), using only the room temperature rate constants since the determination of the factor $F(X)$ at 298 K defines the temperature dependence of $F(X)$ through equation (1). Based on the presently available experimental data (Atkinson, 1989, 1994), initial OH radical addition to -ONO₂ groups in alkyl nitrates, -NO₂ groups in nitroalkenes and -C(O)OH groups in carboxylic acids was assumed and these initial addition rate constants at room temperature and atmospheric pressure of air are given in Table 1. While Hynes and Wine (1991) have shown that OH radical reaction with CH₃CN proceeds by both H-atom abstraction and initial OH radical addition at room temperature and atmospheric pressure of air, only H-atom abstraction has been assumed here in order to fit the data for CH₃CN and C₂H₅CN.

H-atom abstraction from O-H bonds is almost always a minor reaction pathway. The group rate constant k_{OH} was obtained from the branching ratio for the two pathways in the OH radical reaction with methanol,



of $k_a/(k_a + k_b) = 0.15$ at 298 K (Atkinson, 1989), combined with an assumed value of C in the temperature-dependent expression $k_{\text{OH}} = CT^2 e^{-D/T}$ identical to that for H-atom abstraction from the >CH- group. This leads to the group rate constant given in Table 1. This rate constant for H-atom abstraction from -OH groups is significantly higher than previously derived (Atkinson, 1987, 1988b) (the difference being due to the lower rate constant ratio k_a/k_b obtained from the previously available data), but

when mixed with water will form hydroxyl at a 2:1 ratio. The powerfulness of the hydroxyl dispersal is very significant, and, the movement of less than 1/500th of the atmosphere is needed to effect global corrections over several decades, it will be highly efficient.

The PFC-CFC gases are identified below, and can form a major pillar of the offsetting impacts.

Common Name Equation Global Warming Potential (CO2e) Destroyed 1 ton of each of these GHGs with the appropriate O2- dose				
Inputs Outputs Net Reduction GWP				
		CO2 e	lbs of Oxide	
1 Methane CH4 + H2O+ 3O2- CO2 + 3H2O 1t CH4 = GWP 21	2.44t	18	2531.25	
2 Nitrous Oxide N2O + 3O2- +H2O N2O4 + H2O 2HNO3 +O 1t N2O = GWP 310 0t CO2e 310		310		
3 Perfluoromethane CF4 + 6O2- CO2 + 2OF2 1t CF4 = GWP 6,500 0.50t CO2e 6,499		6499	3860	
4 Perfluoroethane C2F6 + 7O2- 2 CO2 + 3OF2 1t C2F6 = GWP 9,200 0.64t CO2e 9,199		9199	811	
5 Sulphur Hexafluoride SF6 + 5O2- SO2 + 3OF2 1t SF6 = GWP 23,900 0t CO2e 23,900		23900	547.94	
6 HFC-23 CHF3 + 6 O2- CO2 + H2O+ 2OF2 1t HFC -23 = GWP 11,700 0.63t CO2e 11,699		11699	1371	
7 HFC-134a CHF3CHF + 8 O2- 2CO2 + 2OF2 +2H2O 1t HFC-134a = GWP 1,300 0.85t CO2e 1,299		1299	1242.7	
8 HFC-152a CH3CHF2 + 8 O2- 2CO2 + 2H2O +OF2 1t HFC-152a = GWP 140 0.66t CO2e 139		139	1939.39	
9 CFC-11 CFC13 + 9 O2- CO2+ OF2 +3ClO2 1t CFC-11 = 3,800 0.32t CO2e 3,799		3799	1090.9	
10 Nitrogen Trifluoride 2NF3 + 6O2- 2NO2 + 2OF2 12t NF3= GWP 12,300 0t CO2e 12,300		12300	1352	
11 CFC-12 CCl2F2 + 5O2- CO2 + Cl2 + 2OF2 1t CCl2F2 = GWP 8,100 0.36t CO2e 8,099.64		8099.64	667	
12 CFC-13 CF3Cl + 6 O2- CO2 + 2OF2 + ClO2 1t CFC-13 = GWP 10,800 0.42t CO2e 10,799		10799	905.7	
13 CFC-113 CF2ClCFC12+ 11 O2- 2CO2 + 2OF2 + 2ClO2 1t CFC-113 = GWP 4,800 0.47t CO2e 4,799		4799	946.24	
14 CFC-114 CF2ClCF2Cl + 10 O2- 2CO2+ 2ClO2 + 2OF2 1t CFC-114 = GWP 8,040 0.51t CO2e 8,049		8049	941.18	
15 CFC-115 CF3CF2Cl + 9 O2- 2CO2 + ClO2, + 2OF2 1t CFC-115 = GWP 5,310 0.57t CO2e 5,309		5309	935	
16 Carbon Tetrachloride CCl4 + 9 O2- CO2 + 2ClO2 1t CCl4 = GWP 1,400 0.28t CO2e 1,399		1399	947.37	
17 Methyl Chloroform CH3CCl3 + 12 O2- 2CO2 + 2H2O, + 2ClO2 1t CH3CCl3 = GWP 506 0.66t CO2e 505		505	1454.55	
18 HCFC-22 CH3CFC12 + 11 O2- 2CO2 + 2H2O + OF2 + 2ClO2 1t HCFC - 22 =GWP 1,500 0.75t CO2e 1,499		1499	1517.24	
19 HCFC-141b CH2CF2Cl + 9 O2- 2CO2 + 2H2O+ OF2+ ClO2 1t HCFC-141b = GWP 2,250 0.76t CO2e 2,249		2249	919.54	
20 HCFC-142b 2CHClF2 + 5O2- CO2 + ClO + OF2 +H2O 1t HCFC-142b = GWP 1,800 0.25t CO2e 1,799		1799	597.01	
21 Halon-1211 CF3Br + 6 O2- CO2 + 2OF2 + BrO2 1t Halon-1211 = GWP 4,750 0.29t CO2e 4,749		4749	644.3	
22 Halon-1301 CF2BrCF2Br + 10 O2- 2CO2 + OF2+ 2BrO2 1t Halon-1301 = GWP 5,400 0.16t CO2e 5,399		5399	754.72	
23 Halon-2402 CF2ClBr + 7 O2- CO2 + OF2 + ClO2+BrO2 1t Halon-2402 = GWP 3,680 0.27t CO2e 3,679		3679	678.79	
CO2 e total		127495.64	24123.57 lbs Oxide used in 22 t of LLGHG	
Per ton CO2 equivs		5795.2563636	12.061785 tons Oxide per 22 tons of these gases	
		480.46424005	CO2 eq per ton	
		528.51066405	CO2 eq per Tonne	
		13212.766601	\$ per Tonne @ \$20 per tonne	
		6606.3833006	50% efficiency	
		\$6,606.38	per Tonne value	
		264.25533203	CO2e per Tonnes	

Humanity's best approach is necessary in the dangerous existential battle for a livable, equitable climate. Hydroxyl has all of the desired remedial attributes: it's scalable to a plethora of different issues, handles CO₂ when concentrated, has fast reaction rates, leaves no unwanted residues, complies with the highest chemical, sustainability and offsetting standards and costs \$25 per CO₂e.

Urge your government to learn about hydroxyl dispersal as a major GHG offsetting technology that is ready to scale globally.

<https://www.ReductionTech.com>

twitter: @ReductionTech

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