<u>Effect of spray on hurricane intensity</u>

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Sea water spray can produce high humidity air at temperatures up to the initial temperature of the spray. The air and the water droplets quickly come to equilibrium because the vapor pressure of the liquid spray is greater than the vapor pressure of the water vapor in the air. As the quantity of spray increases, the air temperature initially decreases to its wet bulb and then gradually approaches the initial spray temperature.

A small part of the water droplet, say 0.5%, vaporises. The latent heat of vaporization is provided by the sensible heat of the 99.5% of the drops which falls back in the sea at the wet bulb temperature of the air. The temperature of the air falling back in the sea can be 1 to 5 °C colder than that of the initial spray. The spray transfer heat from the underlying sea to the overlying air. The contribution of spray to heat transfer is far greater than the contribution of direct water surface transfer to air. Engineers use cooking towers instead of cooling ponds because they require much less area.

For a given rising air temperature and relative humidity, there is a pressure of neutral buoyancy (P3) for which the work of buoyancy is zero. P3 can be calculated with a solver. The pressure difference between distant surface air and the reduced pressure at the base of the updraft can transfer the work of buoyancy downward where it can become shaft work via turbines located at grade. There is no need for wind turbines capturing the kinetic energy of tornado wind.

The following tables show that work (Es) increases with spray temperature (T7), with spray to air mass flow ratio (F7) and with pre-hurricane air enthalpy. The required quantity of water spray increases exponentially as the water temperature approaches the air temperature. Increasing hurricane intensity increases air flow, therefore spray to air flow ratio is unlikely to exceed 300 g-water/kg-air. For a given air temperature and relative humidity, mixing ratio increases with decreasing air pressure.

<u>Notes:</u>

- Raising 24°C, 98% relative humidity air can produce 76 m/s wind (Vs) which agrees with hurricane Isabel observations.
- There is no need enthalpy or drag coefficients. The coefficient method calculates maximum wind speed of 56 m/s for the above hurricane Isabel conditions. The coefficient method underestimates maximum velocity (Vs) by 33% and underestimates maximum energy (Es) by 79%.
- The mass flow ratio required to produce 24°C, 98% relative humidity air for spray temperatures of 26°C, 29°C,and 32°C respectively are 542, 232, and 147 g-water/kg-air.
- Raising 25°C, 100% relative humidity air can produce 100 m/s wind corresponding to a specific work of 5250 J/kg. Specific work is not likely to exceed 5500 J/kg.
- Intensity increases with wind speed because spray increases with wind speed.
- See “Energy From Humid Air” article Section 5, Figures 10 and 11, for more information.

- The tables were calculated assuming that the heat transfer occurs at a single radius. Spray increasing gradually with decreasing radius would not significantly change the required the total mass flow ratio (f7).
- The effect of cold sink temperature is small because the level of neutral is always close to the 15 kPa pressure level whose elevation does not change much in the tropics.

EFFECT OT SPRAY TEMPERATURE AND FLOW ON ESERGY - Case: T3 = 24°C, RH = 75%							
Based on Jordan pre-hurricane sounding. P1 = 101.51 kPa, P4 = !5 kPa, Z4 = 14182 m,							
RH = 75 Case; T1 = 27°C, U1 = 75%, M1 = 16.95 g-w/kg-a,							
No spray: Ez = 1564 J/kg-a, Vz= 55 m/s.							
P2 = 99.73 kPa, We = 142907 J/kg-a, Wp = 2352 J/kg-a.							
T3	U3	M3	T7	F7	P3	Es	Vs
(°C)	(%)	(g-w/kg-a)	(°C)	g-w/kg-a)	(kPa)	(J/kg-a)	(m/s)
24.0	90	17.14	26.0	NA	100,26	1092	45.9
24.0	90	17.14	29.0	NA	100,26	1092	45.9
24.0	90	17.14	32.0	NA	100,26	1092	45.9
24.0	95	18.35	26.0	239	98.91	2289	66.4
24.0	95	18.35	29.0	111	98.91	2289	66.4
24.0	95	18.35	32.0	72	98.91	2289	66.4
24.0	98	19.08	26.0	542	98.13	2980	75.8
24.0	98	19.08	29.0	232	98.13	2980	75.8
24.0	98	19.08	32.0	147	98.13	2980	75.8
24.0	100	19.58	26.0	804	97.63	3429	81.2
24.0	100	19.58	29.0	322	97.63	3429	81.2
24.0	100	19.58	32.0	201	97.63	3429	81.2

EFFECT OT SPRAY TEMPERATURE AND FLOW ON ESERGY - Case: T3 = 24°C, RH = 84%
Based on Jordan pre-hurricane sounding. P1 = 101.51 kPa, P4 = !5 kPa, z4 = 14182 m,
RH1 = 84% Case- T1 = 26.3°C, U1 = 84.03, M1 = 18.20 g-w/kg-a,
No spray: Ez = 2215 J/kg-a, V= 65.4 m/s.
P2 = 98.99 kPa, We = 143731 J/kg-a, Wp = 2924 J/kg-a.

T3 (°C)	U3 (%)	M3 (g-w/kg-a)	T7 (°C)	F7 g-w/kg-a)	P3 (kPa)	Es (J/kg-a)	Vs (m/s)
24.0	90	17.14	26.0	NA	100.26	1692	45.9
24.0	90	17.14	29.0	NA	100.26	1692	45.9
24.0	90	17.14	32.0	NA	100.26	1692	45.9
24.0	95	18.35	26.0	24	98.91	2288	66.4
24.0	95	18.35	29.0	11	98.91	2288	66.4
24.0	95	18.35	32.0	7	98.91	2288	66.4
24.0	98	19.08	26.0	293	98.13	2979	75.7
24.0	98	19.08	29.0	125	98.13	2979	75.7
24.0	98	19.08	32.0	80	98.13	2979	75.7
24.0	100	19.58	26.0	525	97.63	3428	81.2
24.0	100	19.58	29.0	210	97.63	3428	81.2
24.0	100	19.58	32.0	131	97.63	3428	81.2

EFFECT OT SPRAY TEMPERATURE AND FLOW ON ESERGY - Case: T3 = 25°C, RH = 84%
Based on Jordan pre-hurricane sounding. P1 = 101.51 kPa, P4 = !5 kPa, z4 = 14182 m,
RH1 = 84% Case- T1 = 26.3°C, U1 = 84.03, M1 = 18.20 g-w/kg-a,
No spray: Ez = 2215 J/kg-a, V= 65.4 m/s.
P2 = 98.99 kPa, We = 143731 J/kg-a, Wp = 2924 J/kg-a.

T3 (°C)	U3 (%)	M3 (g-w/kg-a)	T7 (°C)	F7 g-w/kg-a)	P3 (kPa)	Es (J/kg-a)	Vs (m/s)
25.0	90	18.64	26.0	288	98.13	2981	75.8
25.0	90	18.64	29.0	123	98.13	2981	75.8
25.0	90	18.64	32.0	78	98.13	2981	75.8
25.0	95	19.95	26.0	1044	96.83	4151	89.3
25.0	95	19.95	29.0	111	96.83	4151	89.3
25.0	95	19.95	32.0	72	96.83	4151	89.3
25.0	98	20.75	26.0	1857	96.08	4823	96.2
25.0	98	20.75	29.0	545	96.08	4823	96.2
25.0	98	20.75	32.0	319	96.08	4823	96.2
25.0	100	21.28	26.0	2727	95.61	5259	100.4
25.0	100	21.28	29.0	682	95.61	5259	100.4
25.0	100	21.28	32.0	390	95.61	5259	100.4