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Discussion on El Nino

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Abstract
As of October 12, 2023 the Climate Prediction Center [1] says there is an 80% El Nino for March 2024 to May 2024. However, as of October 21, 2023, there is predicted very little rain in Berkeley, California according to www.weather.com. El Nino comes from the fact that it starts around Christmas (El Nino = "The Boy"). In this short paper, the author will size up the phenomenon and try to say why it is hard to predict (onset of rain). For one thing, weather cannot be predicted more than ten days in advance, even though the most advanced data collection and supercomputers are employed.

Keywords: Sea Surface Temperature, Thermocline, Deep Ocean Temperature, El Nino Prediction, El Nino, La Nina, SST

Introduction
In the Bible, "rain and snow come down from heaven" (ISAIAH 55:10), but the cloud chemist would say that classical nucleation theory dictates the process [2]. Many scientists are atheists and say that mathematics is the language of science! This author tries to think God's thoughts after Him when he does science. My first paper was data having to do with nucleation of polymer solutions [3].
There are books on El Nino and I'll try here to summarize some of the science they present. An El Nino is predicted when the sea surface temperature (SST) is over 0.5 C above the average for three months and that is currently the case.

Results 1
In Fig 1a [4] has for the tropics the thermocline is 100 meters below the surface with temperature 10 °C and at the surface = 25 °C. This yields:

$$T = -(0.15)\, d + 25 \tag{1}$$

Where:
T = temperature Centigrade
d = meters below surface

Eq. (1) is general because it appears in Fig 1a that the temperature gradient is linear, thus T is linear in d. For El Nino, as aforementioned, it is predicted if there is a rise in equatorial sea surface temperature (SST) of 0.5 °C or more for three months.

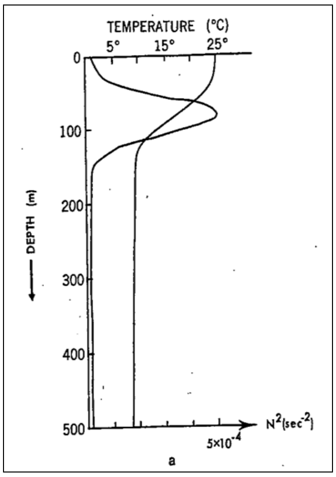

Fig 1: (a) A representative profile of the temperature and Brunt-Vaisala frequency in the tropics. This profile, with the temperature decreasing linearly to zero below 500m, is used as initial condition in the model that provides the results in fig. 4.5 to 4.9 and 4.16. (b) The structure of the three gravest vertical modes associated with the stratification in (a). (figure continues)

Results 2

Since rain has started in Berkeley as of October 22, 2023, California expects more relief in addition to the bumper crop of rain and snow during 2022-2023.

"One of the primary effects of the evolution of tropical Pacific SSTs and related changes in air-sea interaction is found in the strong interannual variation of rainfall throughout the global tropics." [5] However, here is some mathematics that attempts to outline what drives El Nino. [6] However, [6] only has a few citations and is a hard to interpret model.

This El Nino analytical model [6] is approximated as a linear feedback system. There are two boxes: 1) Western Pacific box with temperature Tw and 2) Eastern Pacific box, with temperature Te. The magnitude of El Nino, Tm, is the difference. Thus,

$$Tm \approx Tw - Te \quad (2)$$

In this model, it is noted that El Nino warming is due to an eastward displacement of the warm pool. During La Nina, the thermocline is basically exposed to the surface in the Eastern Pacific. So, Te(Nina) ≈ Tsub and Te(Nino) ≈ Tw in a normal year, so the following is obtained.

$$Te \approx (1/2)\,(Tw + Tsub) \quad (3)$$

Combining (2) and (3), we have

$$Tm \approx (1/2)\,(Tw - Tsub) \quad (4)$$

The western surface ocean (120°E-155°W) is at temperature T1 and the eastern surface ocean (155°W-70°W) is at temperature T2. Then the heat budget of the surface ocean is given as:

$$dT1/dt = (Q1A/Cp\rho V) + sq(T2 - T1) \quad (5)$$

$$dT2/dt = (Q2A/Cp\rho V) + q(Tsub - T2) \quad (6)$$

Where Q1A and Q2A are respectively the net heat flux into the western surface ocean and into the eastern surface ocean and A is the surface area of each region. Cp and ρ are the specific heat and density of water respectively. V is the volume of each surface area box. H1 is the depth of the surface ocean for both. Thus, V = A H1. q = w H1, where w is the upwelling velocity. sq = u Lx with u and Lx being respectively the zonal velocity and half zonal width of the tropical Pacific Ocean. Finally, 1/c is the timescale of removing an SST anomaly by surface fluxes.

$$Q1 = Cp\rho H1c(Tw - T1) \quad (7)$$

and

$$Q2 = Cp\rho H1c(Tw - T2) \quad (8)$$

Using [7] and [8] and the information above [5] and [6] are rewritten as

$$dT1/dt = c(Tw - T1) + sq(T2 - T1) \quad (9)$$

$$dT2/dt = c(Tw - T2) + q(Tsub - T2) \quad (10)$$

[9] and [10] are coupled differential equations and it is maintained that it is possible to get the "equilibrium SST of the coupled system as a function of deep ocean temperature, Tc" [6] Fig 2.

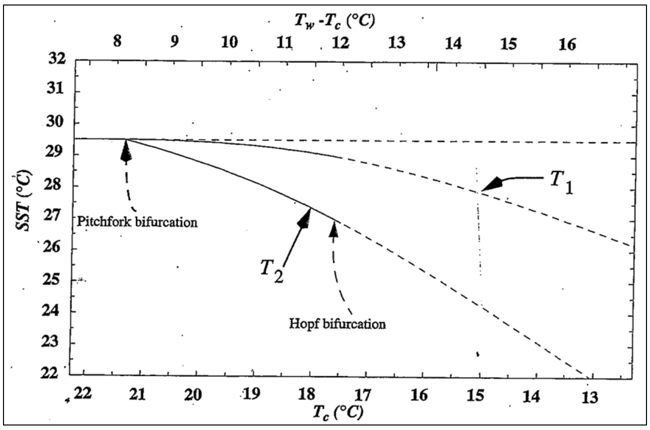

Fig 2: Equilibrium SST of the coupled system as a function of deep ocean temperature T_C. Warm-pool SST T_W is fixed at 29.5 ^{0} C. Dashed lines indicate that the equilibrium is unstable. The system has a pitchfork bifurcation at T_C~21.3 ^{0} C and a Hopf bifurcation at T_C~17.5 ^{0} C. After the Hopf bifurcation, the system starts to oscillate. Parameters used are:
$1/c = 150$ days, $1/r = 300$ days, $\alpha/a = 3.0 \times 10^8\,K^{-1}s^{-1}$, $\alpha/b^2\, H_1/2H_2(1 + H_1/H_2) = 11.5\,mK^{-1}$, $H^* = 65$ m, $H_1 = 50$ m, and $z_0 = 75$ m.

Conclusion

Obviously this is a very brief study of El Nino and just one model for El Nino. At this time, California needs more relief in terms of rain and snow, so the author notes that this paper is being submtted right at the time when the state's rain and snow has begun. The author finds this math attractive, but admits that [6] was published 23 years ago and hardly has been noticed.

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