HYDROLOGY AND BAROMETRIC TIDES

BUNYARD PETER, PLAMEN NETCHEV, CARLOS PEÑA, JOHAN MANUEL REDONDO

SERGIO ARBOLEDA UNIVERSITY

Bogotá D.C., Colombia

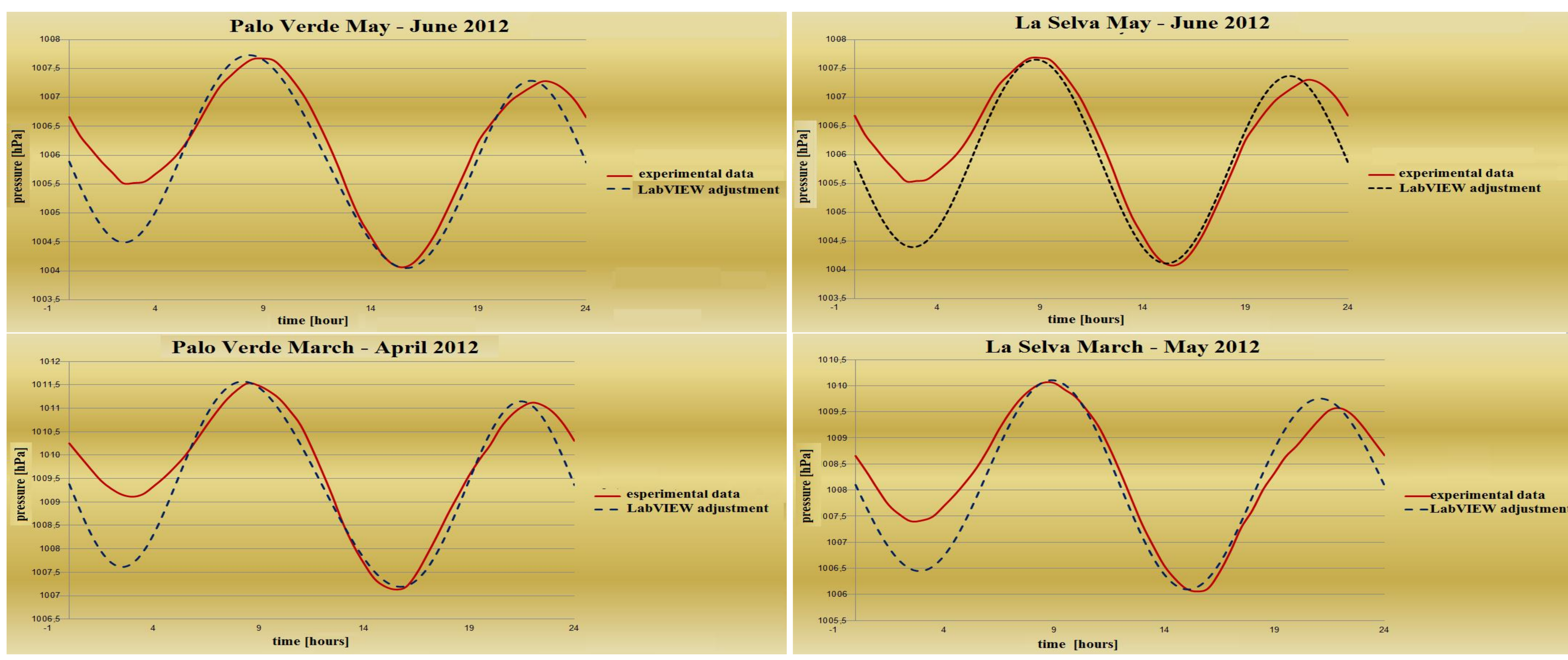
From primary meteorological data obtained at two different locations in Costa Rica, namely Palo Verde and La Selva, we have derived a simple and explicit analytical expression, for the diurnal changes in air pressure which describes the barometric tide. Through statistical methods we have been able to put into effect an easily handled mathematical formula which fits the experimental data adequately. The derived expression shows clearly that the semi diurnal harmonic rhythm of atmospheric pressure is consistent with the presence of one pseudo cycle which superimposes itself on a true diurnal cycle of 24 hours. The inherent amplitude modulation results in a perceived pattern of two almost equal periods each of 12 hours.

Until we have a complete set of data we will have to wait before making generalizations pertaining to our findings. Meanwhile, we have achieved a transparent interpretation for setting the parameters of the expression and we have determined the respective values of the average pressure of the complete atmospheric layer. We are therefore able to evaluate numerically the daily changes of pressure generated by solar radiation. Moreover, our results suggest a relationship between the barometric tides and evapotranspiration processes. In particular, in the near future, we will be able to evaluate the biotic pump hypothesis by means of the effect it leaves on the barometric tide. Finally, through phenomenological statistical treatment we are able to simulate the generation of hydrological cycles associated with evapotranspiration.

We therefore present a first approximation in elaborating a theory for an atmospheric suction mechanism associated with the humid equatorial (ITCZ) rainforest. Our research has brought to light the relationship between the barometric tide, as observed specifically in equatorial tropics, and the suction mechanism, based on equilibrium thermodynamics.

Coordinates of Palo Verde 10º18'25''N 84º48'35''O

Coordinates of La Selva 10º25'53.14''N 84ºO



Computer calculation of the Fourier coefficient

Numerical development in Fourier series omitting negligible terms

$$p(t) = \frac{a_0}{2} + b_1 cos\frac{\pi t}{12} + +b_2 cos\frac{\pi t}{6} + +b_3 cos\frac{\pi t}{4} + \cdots$$

Where ***t*** is the time measured in hours.

Elementary trigonometric and algebraic transformations.

Systematic deviation interpreted as due to other type of vegetation.

Solution by inspection

$$p(t) = p_{dav} + \left[p_{ulw} - p_{evt} cos\frac{\pi t}{12}\right] sin\frac{\pi t}{12} + corrections$$

$$p(t) = p'_{dav} + p''_{dav} + \left[p_{ulw} - p'_{evt} - p''_{evt} cos\frac{\pi t}{12}\right] sin\frac{\pi t}{12} + corrections$$

PHYSICAL INTERPRETATION

BAROMETRIC TIDE TERMS

$$-p'_{evt} sin\frac{\pi t}{12} - p''_{evt} cos\frac{\pi t}{12} sin\frac{\pi t}{12}$$

are related to rainforest evapotranspiration process

The term

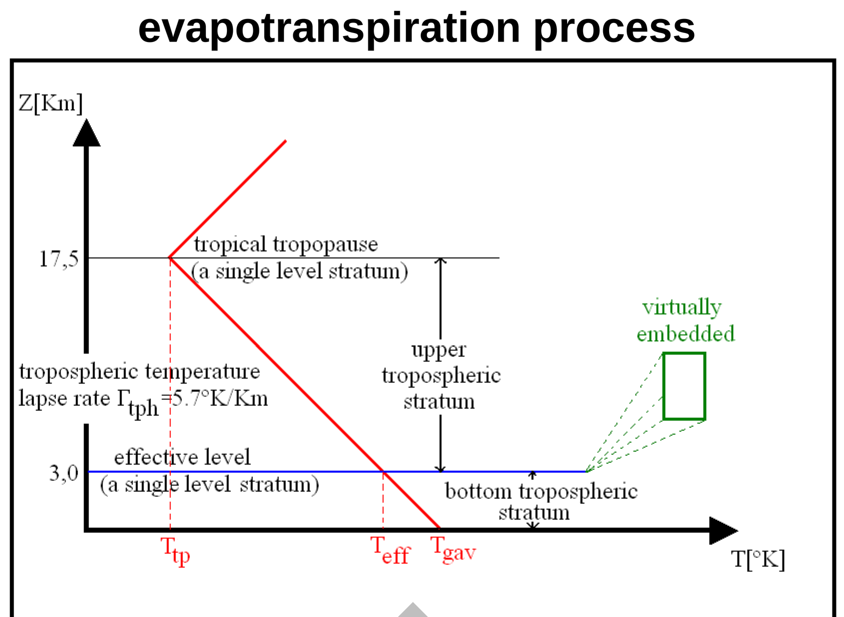
$$P'_{ulw} sin\frac{\pi t}{12}$$

is due to the sun irradiation influx on the upper atmospheric layers.

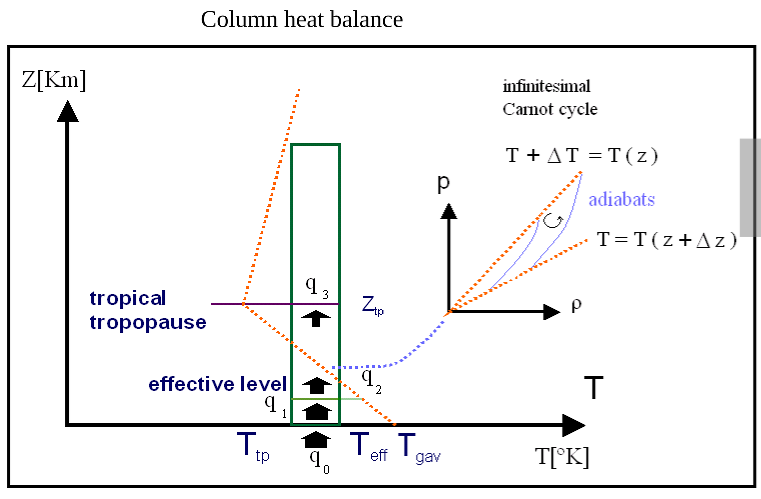
For example, the correction

$$P_{ear} sin^3\frac{\pi t}{12}$$

is an earth irradiation influence, etc.



Column heat balance



For the upper stratum

$$\frac{T(z+\Delta z)}{T(z)} = \frac{q(z+\Delta z)}{q(z)}$$

$$\frac{dq}{q} = -\frac{\Gamma_{tph}}{T(z)} dz$$

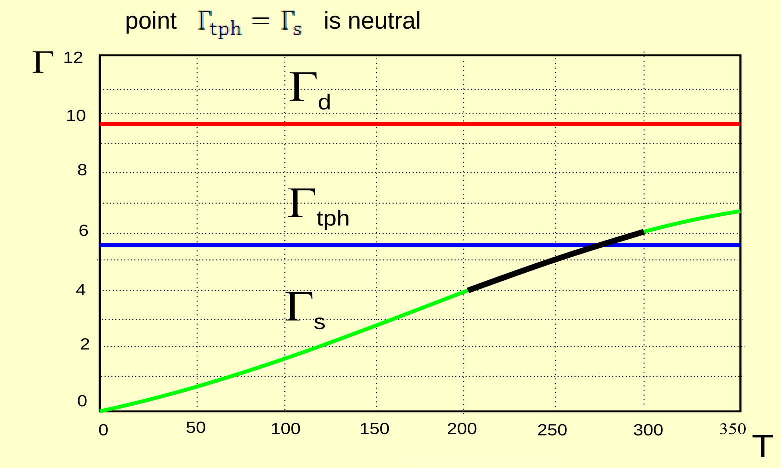
$$q(z_{tp}) = q(z_{eff}) \left[\frac{\frac{T_{tp}}{T_{gav}}}{1 - \left(1 - \frac{T_{tp}}{T_{gav}}\right)\frac{z_{eff}}{z_{tp}}}\right]$$

$$q_3 = q(z_{tp}) = 0.71 q_2$$

$$q_2 - q_3 = \Delta w_{upp}, \quad q_2 = q(z_{eff})$$

$$q_1 - q_2 = \Delta w_{eff}$$

$$q_0 = q_1$$



The stability condition is $\Gamma_{tph} < \Gamma_s$, the coincidence point $\Gamma_{tph} = \Gamma_s$ is neutral

There is vapour instability when $\Gamma_{tph} > \Gamma_s$

According to the diagram that occurred within the black interval.

$$\Gamma_s(T) = \Gamma_d \frac{1 + \frac{\lambda w_s}{R_d \cdot T}}{1 + \frac{\lambda^2 w_s}{c_{pd} \cdot T^2}}$$

where Γ_d = 9.81ºK/km is the *adiabatic (dry air) lapse rate*, λ = 2455 kJ/kg – the *H_2O latent heat* under meteorological conditions, $R_d = R/M_d$ = 287 $JK^{-1}kg^{-1}$, being M_d = 28.964 g/mol a standard density for the *average molar mass of dry air*, $R_v = R/M_v$ = 462 $JK^{-1}kg^{-1}$, being M_v = 18.015 g/mol, a standard density for the *average molar mass of water vapour*, R = 8.314 $JK^{-1}mol^{-1}$, w_s = 0.0066 (6.6 g/kg) is an approximate value for the *saturated mixing ratio* (see §6 for more explanations) and *T* means the *current temperature Kelvin*. The specific heat of dry air c_{pd} = 1005 $JK^{-1}kg^{-1}$.

MODEL DESCRIPTION

Adjustment ITCZ temperature $T = (T_{tp} - T_{gav})\frac{z}{z_{tp}} + T_{gav}$

The pressure changes according to the following formulae

$$p_v(z) = p_v(0)\left[1 - \left(1 - \frac{T_{tp}}{T_{gav}}\right)\frac{z}{z_{tp}}\right]^{\frac{g}{R_v \Gamma_{tph}}}$$

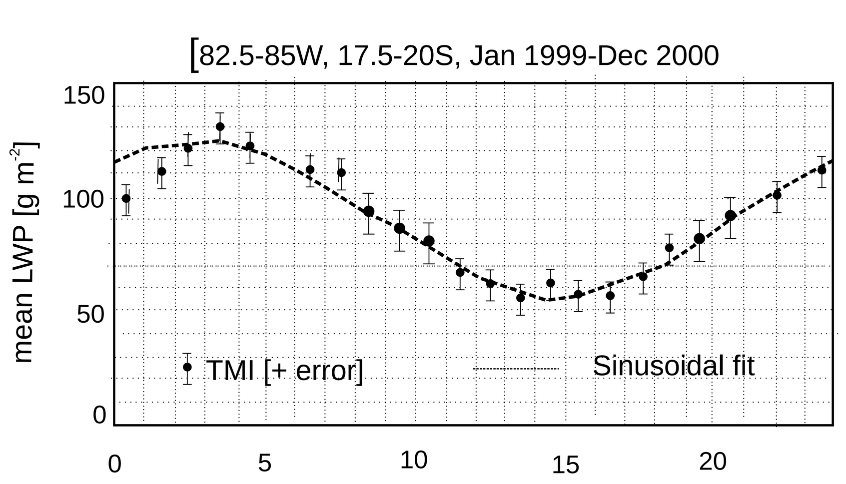
For a uniform process of condensation can be write:

$$\frac{m_w}{m_v} = \frac{V_v - V}{V - V_w} \leftrightarrow \frac{m_w}{m} = \frac{\Delta\zeta}{\Delta\zeta_{mav}} \leftrightarrow \delta w_{eff} = p_{v,s}\Delta\zeta = p_{v,s}\Delta\zeta_{mav}\frac{\delta m_w}{\Delta m}$$

Where ζ are some respective heights. Therefore:

$$\frac{\Delta m}{\Delta\zeta_{max}} \frac{\delta w_{eff}}{\delta m_w} \frac{area}{area} = p_{v,s} \rightarrow \rho(t)\frac{\delta W_{eff}}{\delta m_w} = \left(-p'_{evt} sin\frac{\pi t}{12} - p''_{evt} cos\frac{\pi t}{12} sin\frac{\pi t}{12}\right)\left[1 - \left(1 - \frac{T_{tp}}{T_{gav}}\right)\frac{z}{z_{tp}}\right]^{\frac{g}{R_v \Gamma_{tph}}}$$

At effective level the graph



Graph taken from R. Wood, C. S. Bretherton & D. L. Hartmann, 2002. Diurnal cycle of Liquid path water over the subtropical and tropical oceans Geophysical Research Letters, Vol. 29, No. 23, 2092.

gives the following density $\rho_v(t) = \rho_{constant} + \rho_0 \cos\frac{\pi t}{12}$

$W_{eff} = W_{const} + W_{amp} cos\frac{\pi t}{12}$ is a solution if are satisfied:

$$-\rho_{constant} \cdot \frac{\pi}{12} \sin\frac{\pi t}{12} W_{amp} = -p'_{evt} \cdot \sin\frac{\pi t}{12} \cdot constant \cdot \left[1 - \left(1 - \frac{T_{tp}}{T_{gav}}\right)\frac{z}{z_{tp}}\right]^{\frac{g}{R_v \Gamma_{tph}}}$$

$$-\rho_0 \cdot \frac{\pi}{12} \cos\frac{\pi t}{12} \sin\frac{\pi t}{12} W_{amp} = -p''_{evt} \cdot \cos\frac{\pi t}{12} \sin\frac{\pi t}{12} \cdot constant \cdot \left[1 - \left(1 - \frac{T_{tp}}{T_{gav}}\right)\frac{z}{z_{tp}}\right]^{\frac{g}{R_v \Gamma_{tph}}}$$

$$\frac{\delta m_v}{\delta t} = constant$$

In conclusion, it is reasonable to believe that we have achieved a satisfactory construction of a rainforest suction mechanism, in which the numerical results coincide well with existing experimental data obtained through meteorological observations.