NEUTRON PROBE CALIBRATION CORRECTION BY TEMPORAL STABILITY PARAMETERS OF SOIL WATER CONTENT PROBABILITY DISTRIBUTION

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ABSTRACT: **A neutron probe calibration correction is proposed in order to reduce soil water content variability, assumed to be a consequence of improper calibrations relations. The time stability of spatially measured soil water content data is used to correct the intercepts of linear calibration relations. This procedure reduced the coefficients of variation of soil water content data from 4 to less than 2% in a Rhodic Kanhapludalf.**
Key Words: **soil water content, neutron probe, calibration, time stability, spatial variability**

CORREÇÃO DA CALIBRAÇÃO DE SONDAS DE NÊUTRONS POR MEIO DE PARÂMETROS DE ESTABILIDADE TEMPORAL DA DISTRIBUIÇÃO DE PROBABILIDADE DO CONTEÚDO DE ÁGUA NO SOLO

RESUMO: **É proposta uma correção para a calibração de sondas de nêutrons para reduzir a variabilidade de dados do conteúdo de água no solo, suposta como consequência de relações de calibração impróprias. A estabilidade temporal de dados espaciais de conteúdo de água no solo é usada para corrigir os coeficientes lineares de curvas de calibração. Esse procedimento reduziu coeficientes de variação de medidas de umidade do solo de 4 para valores menores que 2% em uma Terra Roxa Estruturada.**
Descritores: **umidade do solo, sonda de nêutrons, calibração, estabilidade temporal, variabilidade espacial**

INTRODUCTION

During the last four decades, neutron probes have extensively been used to monitor soil water content in the field. Being a practically non-destructive method, it allows the measurement of soil water content at the very same point over and over, and being quick, it meets the requirement of large numbers of observations (Nielsen *et al.*, 1973) for spatial variability analysis. Eventhough its main constraint, the calibration, is not a solved problem. Calibration is laboreous and difficult to be performed, and in general regression coefficients between count-ratio (CR) and soil water content (q, $m^3.m^{-3}$) are not very high, most of them ranging between 0.80 and 0.95. Greacen (1981) discusses in depth the problem of soil water assessment by neutron probes and points out the major difficulties of calibration, which coalesce to the point of sample representativeness and to the fact that the volume "sampled" by the thermalized neutrons is unknown and different of that one sampled by gravimetric methods. Furthermore, the effect of other soil characteristics like sand, silt and clay contents, bulk density, porosity, particle composition, on the neutron thermalization process, are not sufficiently known.

MATERIALS AND METHODS

In this study an improvement is suggested to make a better use of the calibration procedures and to eliminate part of the total variability of collected data, assumed to be a consequence of a non- satisfactory calibration.

Data here presented were collected at a field site consisting of a Rhodic Kanhapludalf of the county of Piracicaba, SP, Brazil. In order to calibrate the SOLO-25 neutron probe, a "representative" plot of 5m x 5m was choosen, in which 6 aluminum access tubes were installed down to the depth of 1.50 m. In the dry season, when field water contents reached minimum values, 3 of the access tubes were used for calibration. Counts were made first, at the depths of 0.25, 0.50, 0.75, 1.00, 1.25 and 1.50 m and afterwards samples were collected for volumetric and gravimetric soil and water content measurements, in a large pit. This procedure was repeated later, after closing the pit and flooding the area until water reached the 1.50 m depth. After three days with the soil surface covered with a plastic sheet, samplings were made to obtain calibration points on the wet side. The results, published by Turatti *et al.* (1990) are reproduced in Figure 1.

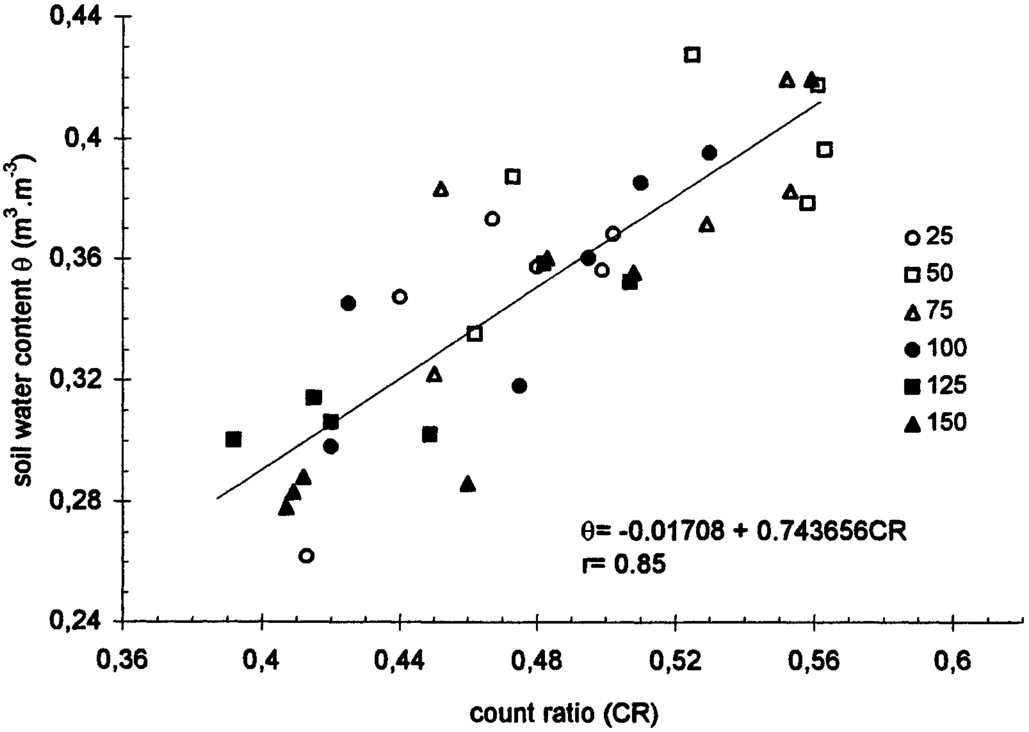


Figure 1 - Neutron probe calibration line for a Rhodia Kanhapludalf of Piracicaba.

RESULTS AND DISCUSSION

It can be noted in Figure 1 that there is no consistency of the points for each depth, and that there is also no consistency with respect to soil bulk density. Therefore, the best way to use the available data is to consider one single calibration curve for all depths, which is given by

$$\theta = -0.01708 + 0.743656\ CR \qquad r = 0.85 \qquad (1)$$

This calibration line was used in a long range experiment (Villagra, 1992), consisting in a transect of 25 neutron access tubes, in which the variation of soil water content in space and time was studied for several components of the water balance. The two years of continuous measurements of soil water content, in situations of bare soil, corn crop, fallow land with weeds, internal drainage with soil surface covered with straw, showed a very significant time stability of the data, within the same concept given by Vachaud *et al.* (1985). This means that, on the sampled transect, points of high soil water content in relation to the field average were, regardless of the above described situations, were always above average. All points have, in time, a consistent deviation from the average, as illustrated in Figure 2 for a 15 day period of an internal drainage experiment, at the depth z = 150 cm (Villagra, 1992) carried out to determine soil hydraulic conductivity functions K(θ). It can be seen, for example, that access tube 20 has the largest negative deviation, tubes 8, 22 and 4 represent best the field average, and that tube 9 has the largest positive deviation.

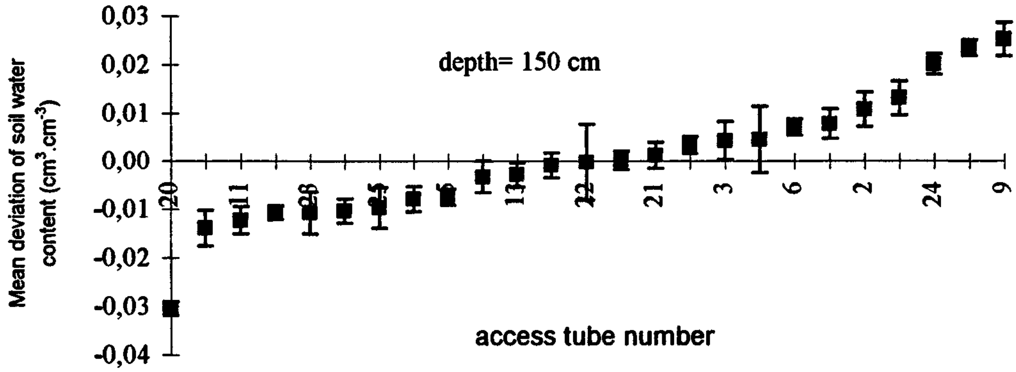
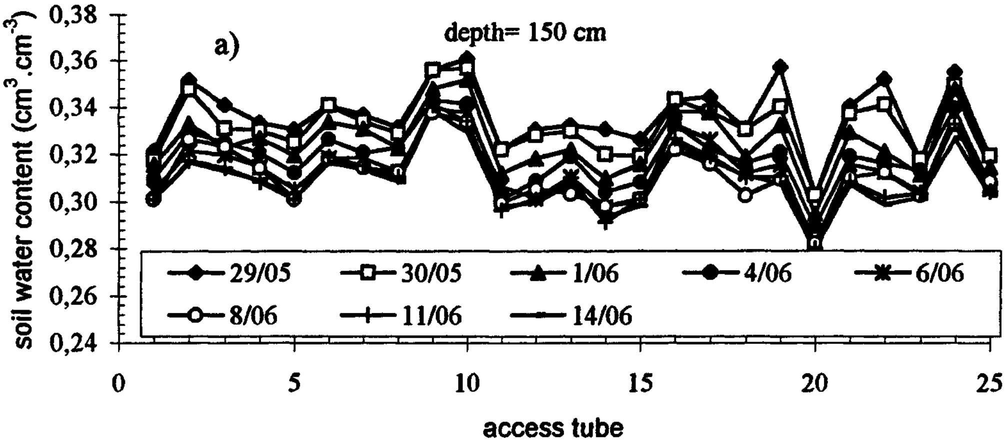


Figure 2 - Ranking of mean deviations of the average soil water content, for 25 observation points along a transect. Vertical bars represent standard deviations.

Vachaud et al. (1985) characterize very well this time stability phenomenon and try a physical interpretation by analysing their data using the scaling procedure proposed by Simmons *et al.* (1979). On the other hand, it is difficult to understand how wet and dry spots can coesist in the soil over long periods of time, even separated by only one lag of the order of one meter. One way to explain this fact, would be, at least for neutron probe θ measurements, the use of inadequate calibration relations. Since at a given location the neutron probe "samples" always the same volume, which has its own characteristic (bulk density, structure, texture and chemical composition, mainly) which is stable in time, the use of a given calibration relation can lead to sistematic errors. Greacen (1981) discusses multiple factor calibrations which include the effect of soil bulk density. Although soil bulk density might influence the slope of the calibration relation, its major effect is on its intercept. Therefore, in this paper, a correction of calibration relation is suggested, which deals only with its intercept.

Data of Figure 2 were calculated from neutron probe measurements, using one single calibration relation (equation 1). Assuming that the averages of the 25 points along the transect of 125 m represent well the field, it can be said that calibration equation for access tube 22, which has zero deviation from the expected mean, is adequate. For the other 24 access tubes i, new calibration equations could be written, with new intercepts a_i, by adding or subtracting the respective mean deviations from the mean. This procedure would yield new θ data, with less variability, without changing significantly the mean.



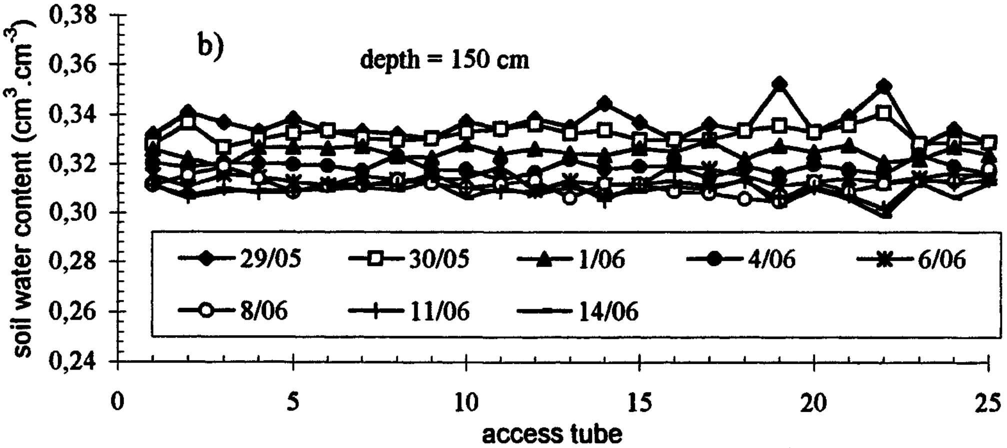


Figure 3 - Soil water content distributions during water redistribution, along the 25 point transect: a) using one single calibration curve, and b) using one calibration for each observation point.

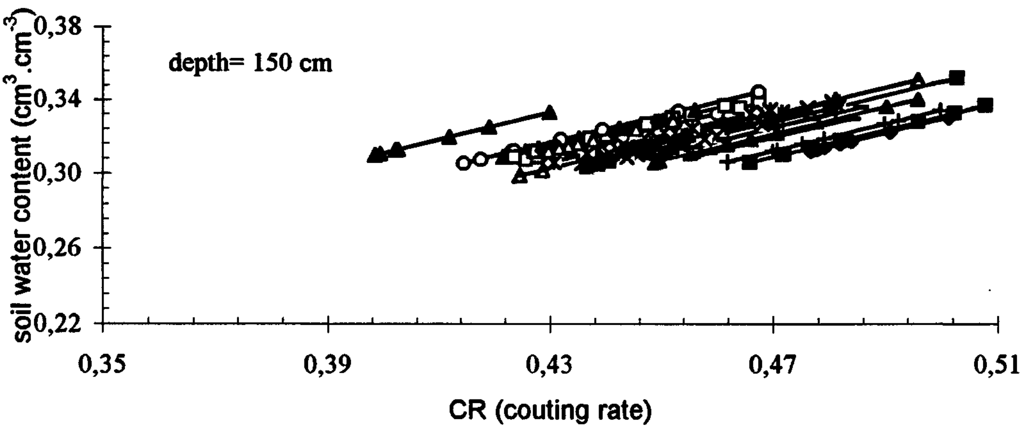


Figure 4 - Calibration relations for the 25 observation points, based on the mean deviations from the average soil water content.

The above procedure was applied to the soil water content data of the internal drainage experiment carried out by Villagra (1992). The space variability of θ values along the 25 point transect, using one single calibration relation (equation 1) for all sites and depths, had coefficients of variation (CV) ranging between 3.8 to 4.2, and its distribution can be seen in Figure 3a. The correction of this calibration relation using the mean deviations from the mean as "scaling factors", reduced the CV to a range of 0.78 to 1.80, and its distribution can be seen on Figure 3b. Figure 4 consists of the 25 calibration relations.

CONCLUSION

The correction of calibration relations here suggested also permits the introduction of θ data from other sets of neutron access tubes installed in the same field, if their mean deviations from the mean are known.

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