# SSHCZO Metadata Worksheet

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| Data File Name | **COSMOS\_GR.txt** |
| Date Prepared | 10/12/2015; updated 2019-12-05 |
| Descriptive Title | Garner Run COSMOS data |
| Update Frequency | Hourly |
| Abstract | Hydroinnova Cosmic-Ray Soil Moisture/Snow Sensing System (COSMOS), Model CRS-1000/B, non-invasively measures moderated neutron count among an averaged area (around 700 meters in diameter (Franz et al., 2013)), which can indirectly represent soil moisture in the top 50 cm of soil. This file includes level 1 data measured directly from COSMOS. The neutron count can be affected various elements in surroundings, where hydrogen is often the dominant one (Zreda et al., 2012). The neutron rate counted by the MOD column of COSMOS therefore can be used to determine soil moisture after a standard correction and point calibration, the results of which are COSMOS Level 2 and Level 3 data.  |
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| Data Value Descriptions | Level 0 Raw Data* COL1: label = TmStamp; Time zone=UTC, neutron count interval
* COL2: label = N1 [cph]; neutron count, used to calculate soil moisture
* COL3: label = N2 [cph]; bare counts; not used at this time
* COL4: label = T1 [C]; Unit = degree centigrade, the temperature inside the logger
* COL5: label = H1 [%]; Unit = percent; internal relative humidity
* COL6: label = P1 [mb]; Unit = mb; backup pressure sensor (not in use)
* COL7: label = Batt [V]; Unit = V, the battery voltage
* COL8: label = P4 [mb]; Unit = mb, milibars; preferred pressure sensor
* COL9: label = NMcounts; Unit = count rate per hour; Jungfrau neutron monitor
* COL10: label = fbar, pressure factor based on COL8 – P4 [mb]
* COL11: label = fsol, solar correction factor based on COL9 - NMcounts
* COL12: label = CR VWC; Unit = ; volume water content calculated on Hydroinnova webserver
* COL13: label = AirTemp\_C; Unit = celsius; air temperature from nearby site – same location as COL14 data
* COL14: label = RelativeHumidity; Unit = percent; relative humidity from nearby site – same location as COL13 data

Levels 1 and 2 * COL1: label = TmStamp; Time zone=UTC, neutron count interval
* COL2: label = abs\_hum; Units = g/m3, computed absolute humidity
* COL3: label = Corr\_LVL1; probe count rate corrected for all scaling factors
* COL4: label = SM\_Lvl\_2; Units = %, estimated soil moisture in % volumetric
* COL5: label = SM12H; Units = %; soil moisture filtered using a 12 hr robust boxcar average
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| Keywords | COSMOS, Soil Moisture |
| Methods | Data collected using Hydroinnova Cosmic-Ray Soil Moisture/Snow Sensing System. These data transmitted to Hydroinnova Webservices using satellite telemetry. An R script and cron job pull the data from the Hydroinnova server and writes to our Penn State database once per day. Data are processed using R (R Core Team, 2019).Variables required in computations. phi = 3335.76a\_0 = 0.0808a\_1 = 0.372a\_2 = 0.115Probe\_gr = 1SANPE = 2.486Scale = 2.654L = 133PO = 956I\_0 = 158.5489w\_lat\_gr = 0.040rho\_b = 0.81Computing Level 1 data (Level 2 in COSMOS terms):The following equation is used to compute the absolute humidity values needed to achieve corrected level 1 data:Abs\_hum = 6.112 \* exp(17.67 \* gr AirTemp\_C/(gr AirTemp\_C + 243.5)) \* gr RelativeHumidity \* 2.1674/(273.15 + gr AirTemp\_C)$Corr\\_LVL1= (MOD \* Probe \* PRESS \* SANPE \* OTHER)/ SCALE \* INTEN)$ Where :MOD = N1 [cph]; COL2, fast neutron countsPROBE = 1; scale factor for specific probe typePRESS = $\frac{\left(P0 – P4 \left[mb\right]\left(COL8\right)\right)}{L}$; pressure scaling factorSANPE = 2.486OTHER = not used at this time; other scaling factorsSCALE = 2.654INTEN = scaling factor to account for temporal changes in cosmic ray intensity as a function of time Two methods used due to data types. Method 1 used from 2015 to 2018-08-29.  This method used the INTEN value directly from the Shale Hills COSMOS system. Method 2: Garner Run NMcounts (COL9)/I\_0; I\_0 computed during initial installComputing Level 2 data:Equation to calculate soil moisture based on neutron counts:Dong et al (2014)$$SM\_{v}=\left(\frac{a\_{0}}{\frac{ϕ}{ϕ\_{0}}-a\_{1}}-a\_{2}-w\_{lat}\right)ρ\_{b}$$ Where:  $ϕ=Corr\\_LVL1$ |
| Sites | COSMOS GR: WGS84, Lat 40.695831; Lon -77.920969 |
| Publications | Xiao, D., Shi, Y., Brantley, S. L., Forsythe, B., DiBiase, R. A., Davis, K. J., Li, L. (2019): Predominant control of soil properties in storage-discharge relationship and threshold behavior in catchments derived from contrasting lithologies. Water Resources Research. |
| Citation | The following acknowledgment should accompany any publication or citation of these data: Logistical support and/or data were provided by the NSF-supported Susquehanna Shale Hills Critical Zone Observatory. |
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