Soil Moisture Distribution at WGEW and SRER based on COSMOS Probes, Conventional Sensors, and a Simple Model

Xubin Zeng, Suzy Stillman, Jason Ninneman
Ken Cummins, Marek Zreda, Jim Shuttleworth,
Trenton Franz, Rafael Rosolem, Russell Scott
xubin@atmo.arizona.edu

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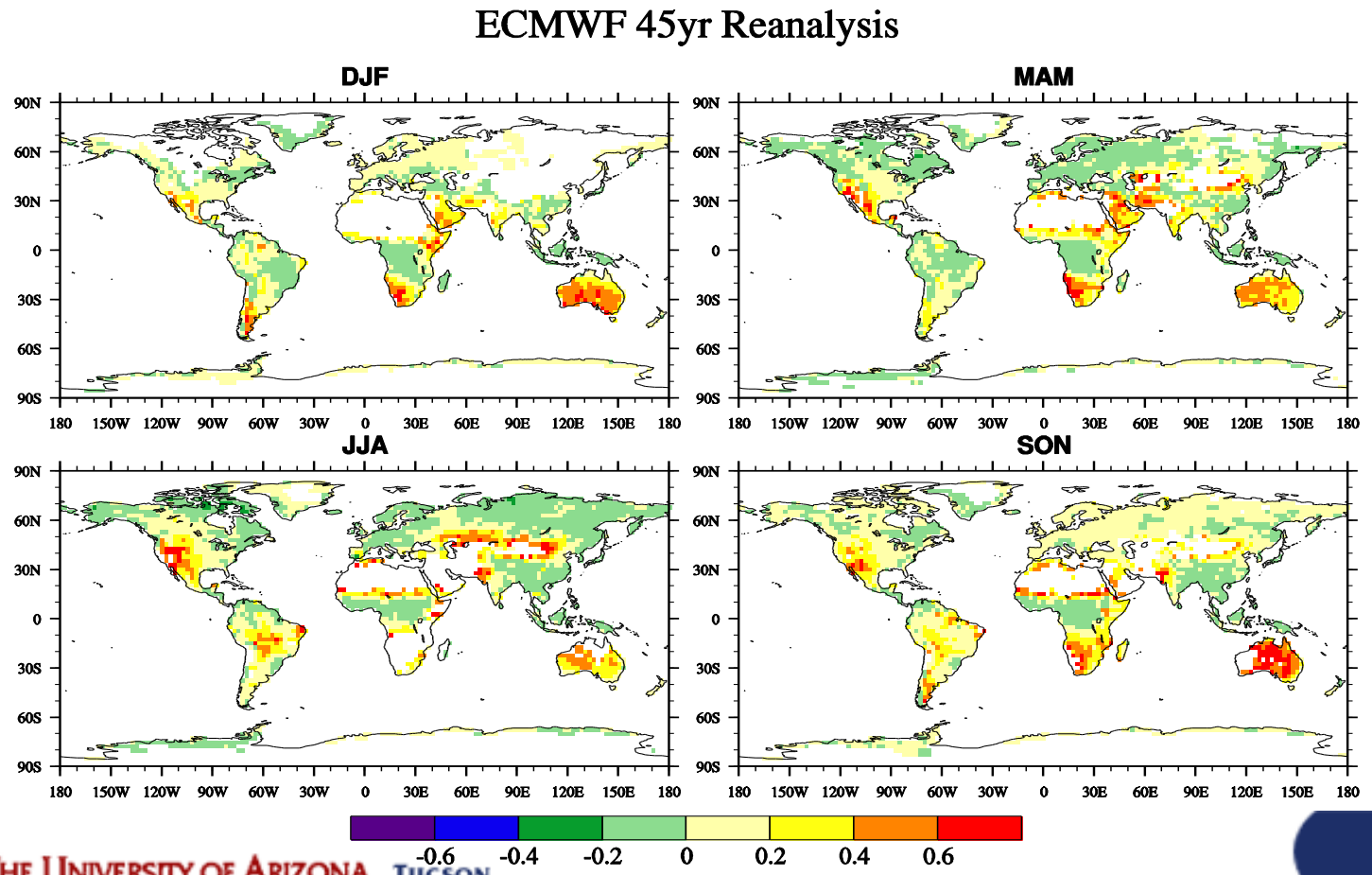
- Develop a new index to quantify the global land-precipitation coupling strength
- It can be easily applied to data analysis and regional/global model output analysis
- Warmer color in the figure indicates a stronger coupling (Zeng et al. 2010)



- Data freely available at http://cosmos.hwr.arizona.edu
- $5.5Million/4 years NSF project to develop a prototype U.S. national soil moisture network based on cosmic-ray neutron measurements
- 49 Active probes: 42-Continental USA, 2-Hawaii, 3-Europe, 1-Kenya, 1-Brazil and more to come, TX(2), AR, NC, MS, KY …

Location of COSMOS Probes

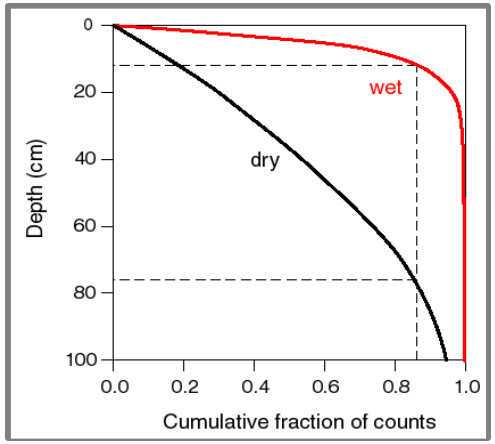
Click on balloons for site descriptions and data access (site list).

Over what soil volume does the COSMOS probe measure?

Measurement Volume

(modeled by tracking neutron collisions)

Depth

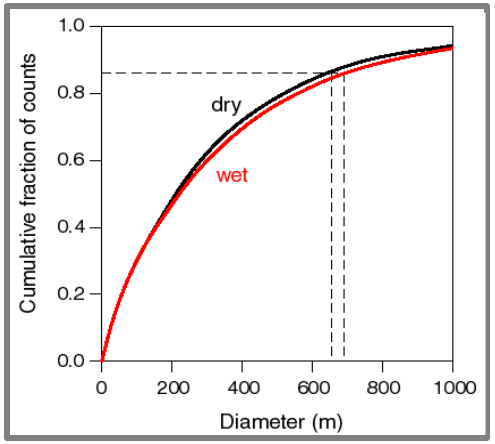


86% of neutrons from within a depth of 70 cm (dry)

Depth decreases to 12 cm in wet soils

Independent of altitude (and pressure)

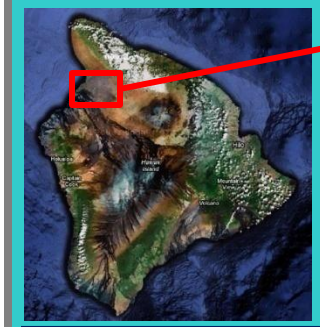
Radius

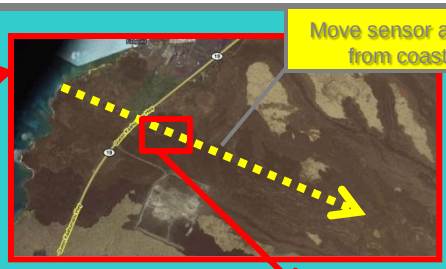


86% of neutrons from within a radius of 350 m

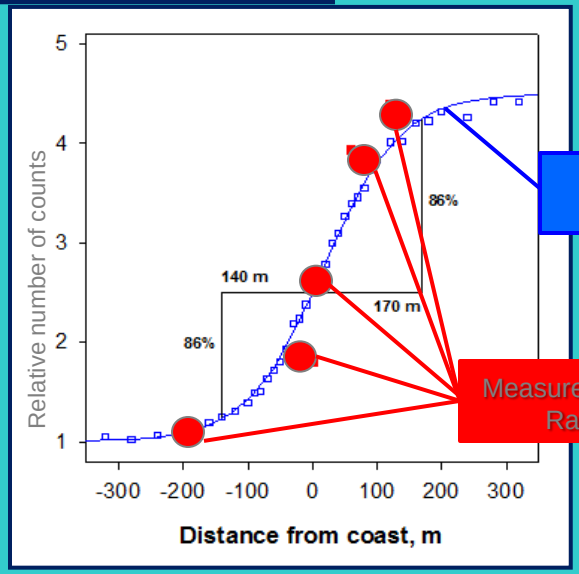
Independent of soil moisture

Increases with increasing altitude (decreasing pressure)

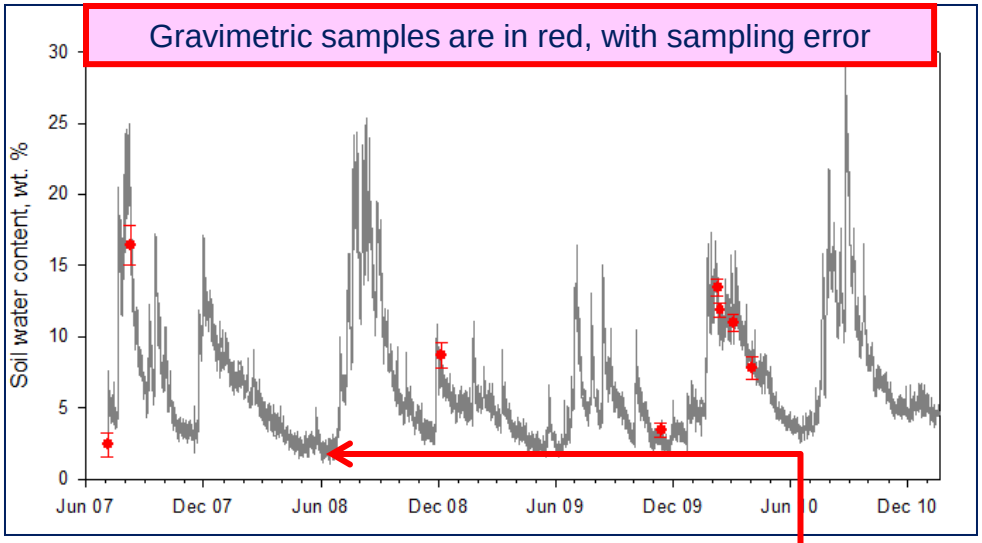




Approximate check on radius - move sensor away from the coast in Hawaii

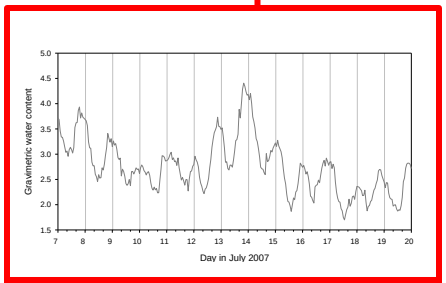


Example COSMOS Data for the San Pedro Basin



Soil moisture from cosmic-ray neutron data compared with gravimetric samples

For the (single) calibration of a COSMOS probe (made at installation), soil will be sampled at 3 depths, 8 directions, and 3 radii around the probe (i.e., 72 samples).



Diurnal Cycles (moisture redistribution**?**)

Q: How to address soil moisture heterogeneity?

a) at hundreds of meters (gravimetric samplings)

b) at tens of kilometers (COSMOS rover)

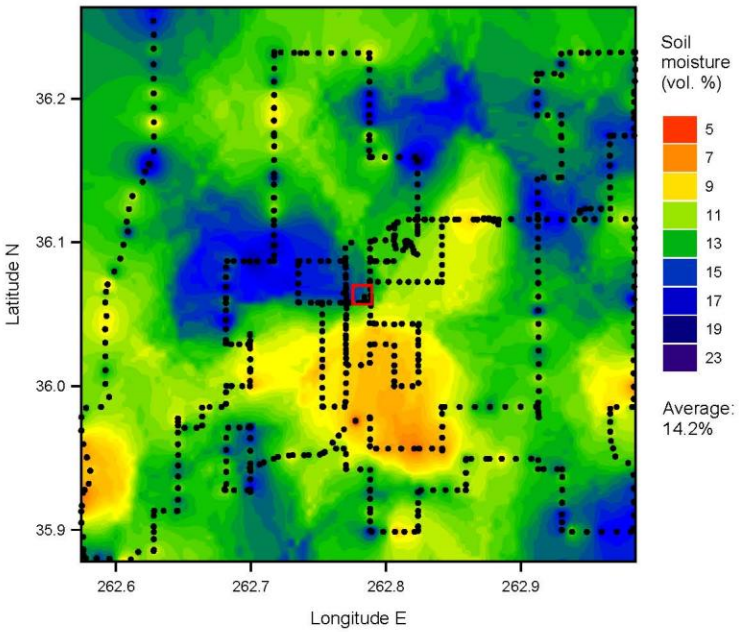
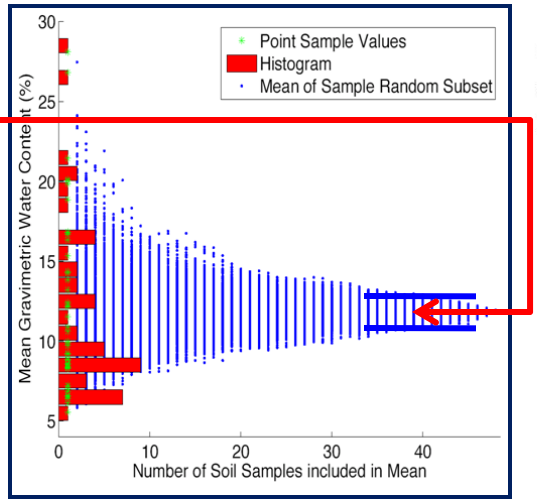


Fig. 6. Soil moisture over a SMAP-sized area (37 km x 42 km) in Oklahoma derived from cosmic-ray neutron measurements taken with the COSMOS rover. Black dots mark the route. Red square is the location of the stationary COSMOS probe.

How many point measurements are needed to get a similar (2%) precision in area-average soil moisture?

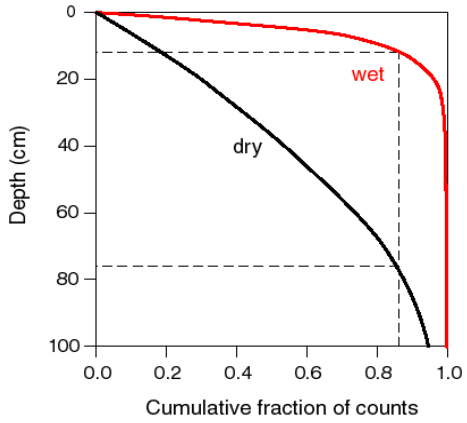


COSMOS soil moisture and gravimetric measurements over Walnut Gulch agree with each other very well.

Q: How about Santa Rita site?

Q: How to obtain the vertical weighting for the COSMOS measurements?

For uniform soil moisture



Q: How do we obtain the spatial distribution of soil moisture over the WGEW?

A:

- Using COSMOS rover
- using TDR measurements at 5 cm depth (but there are only 18 sites)
- there are many more (88) raingauge sites (but we need to use a simple water-balance model to derive soil moisture at 5 cm depth)

Conclusions

- COSMOS probes provide a new and robust approach for soil moisture measurements
- Tens of point samples are needed to robustly represent area-averaged soil moisture
- Spatial distribution of soil moisture over tens of kilometers can be provided by COSMOS rover in general.
- Over the WGEW, the spatial distribution of soil moisture can also be obtained using the TDR measurements or raingauge data along with a water-balance model
- Raise some issues about
  the comparison between point soil moisture measurements and COSMOS results; and
  vertical weighting function of COSMOS soil moisture