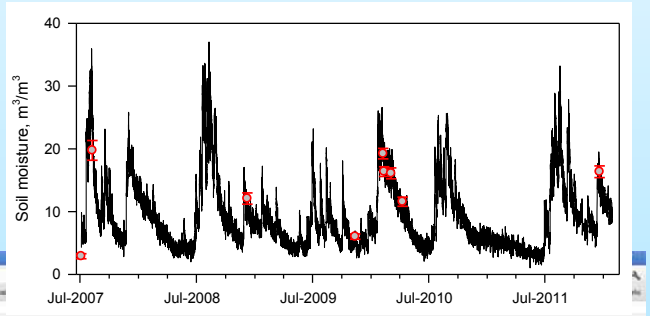
Measuring soil moisture using COSMOS probes

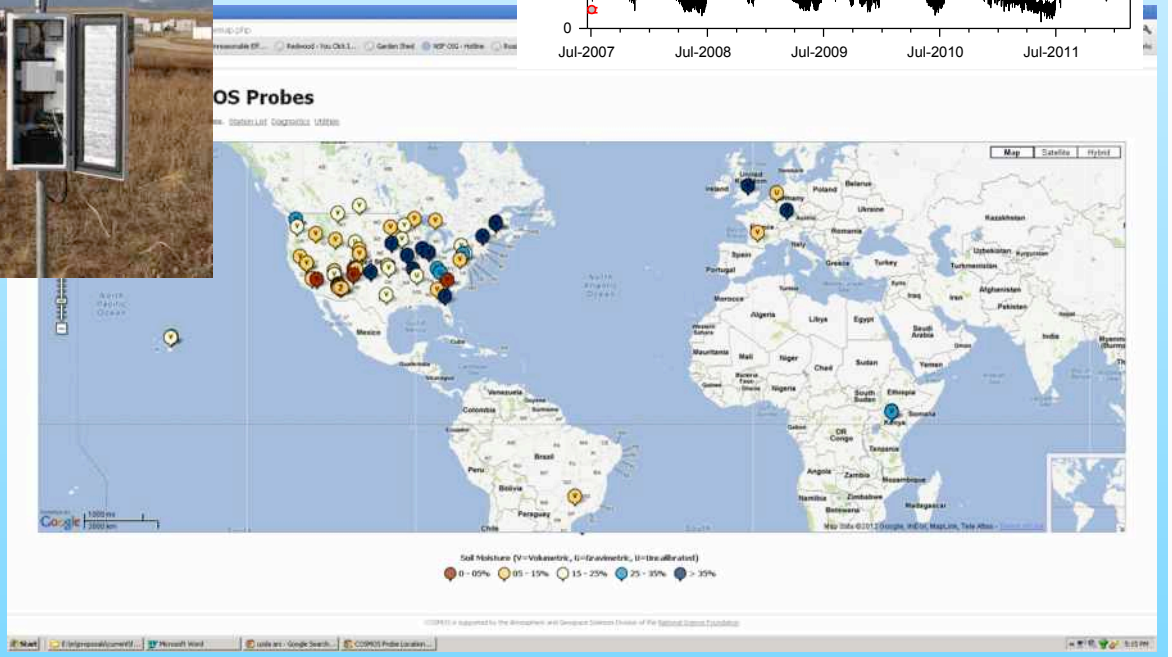
Intermediate scale between point measurements and satellite sensing

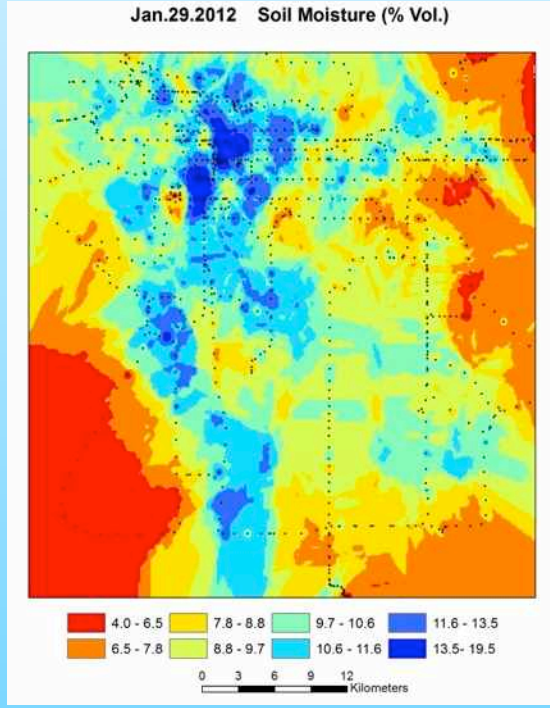
Marek Zreda and Bobby Chrisman, University of Arizona

Stationary



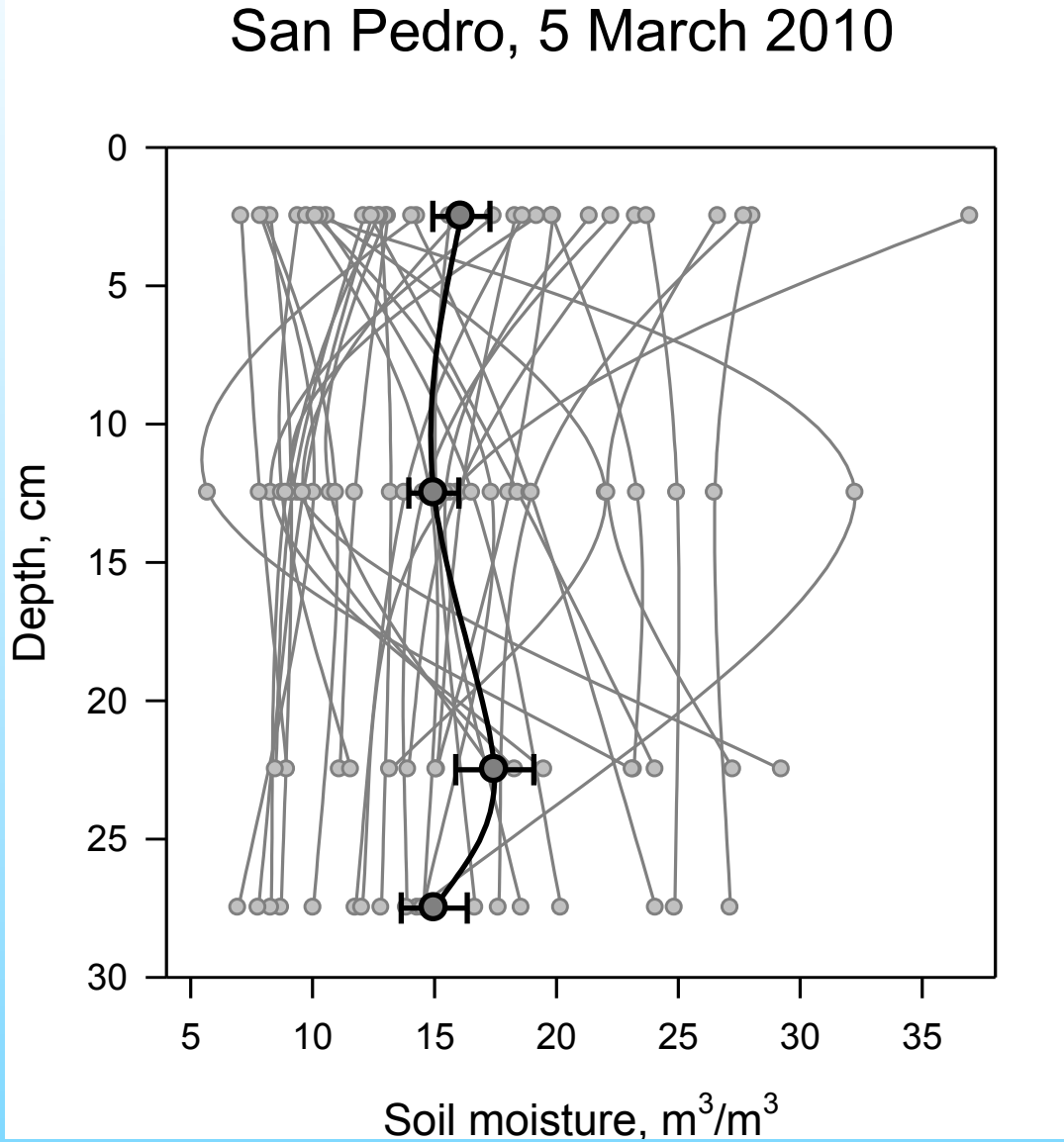
Roving



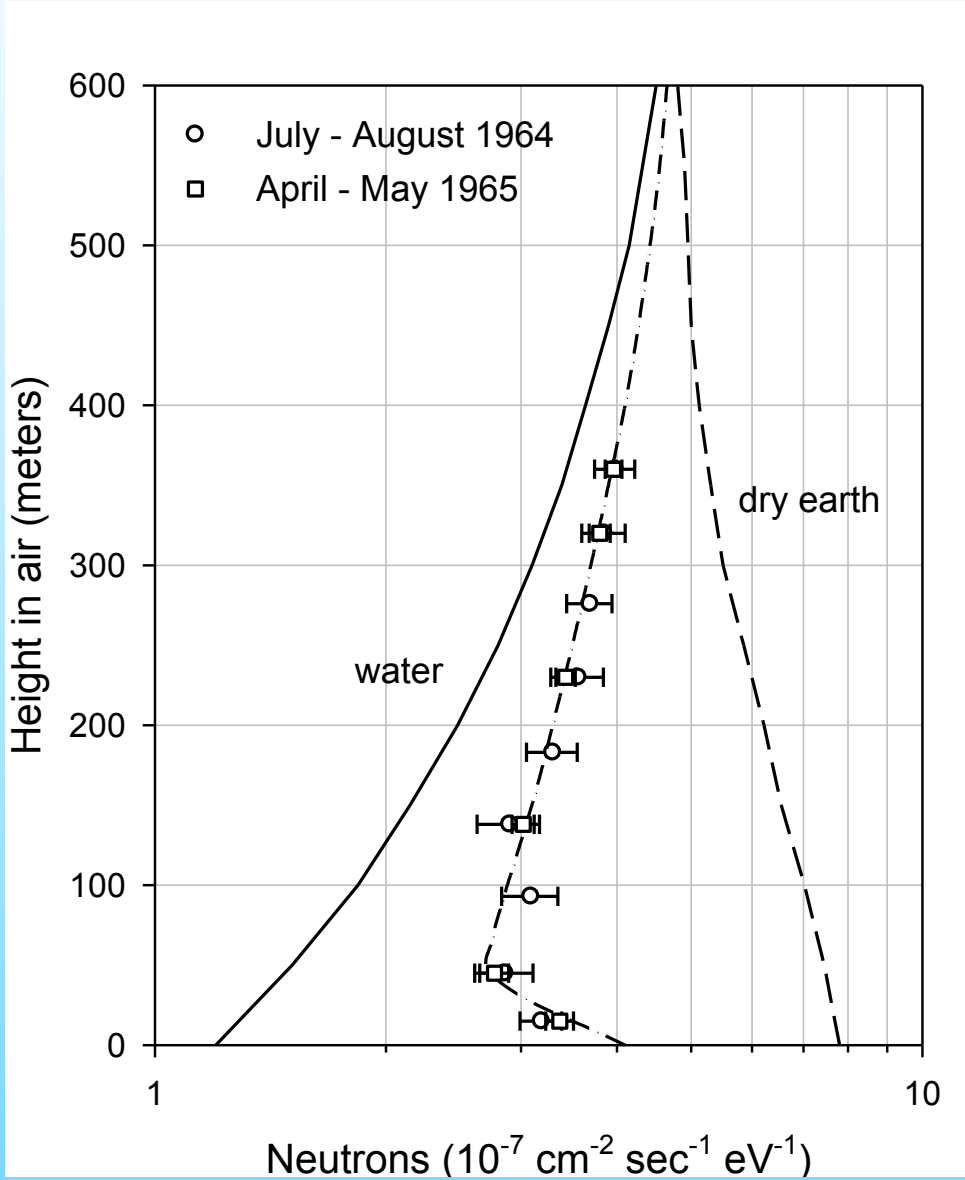


3rd SMAP cal/val workshop, Oxnard, CA, 16 November 2012

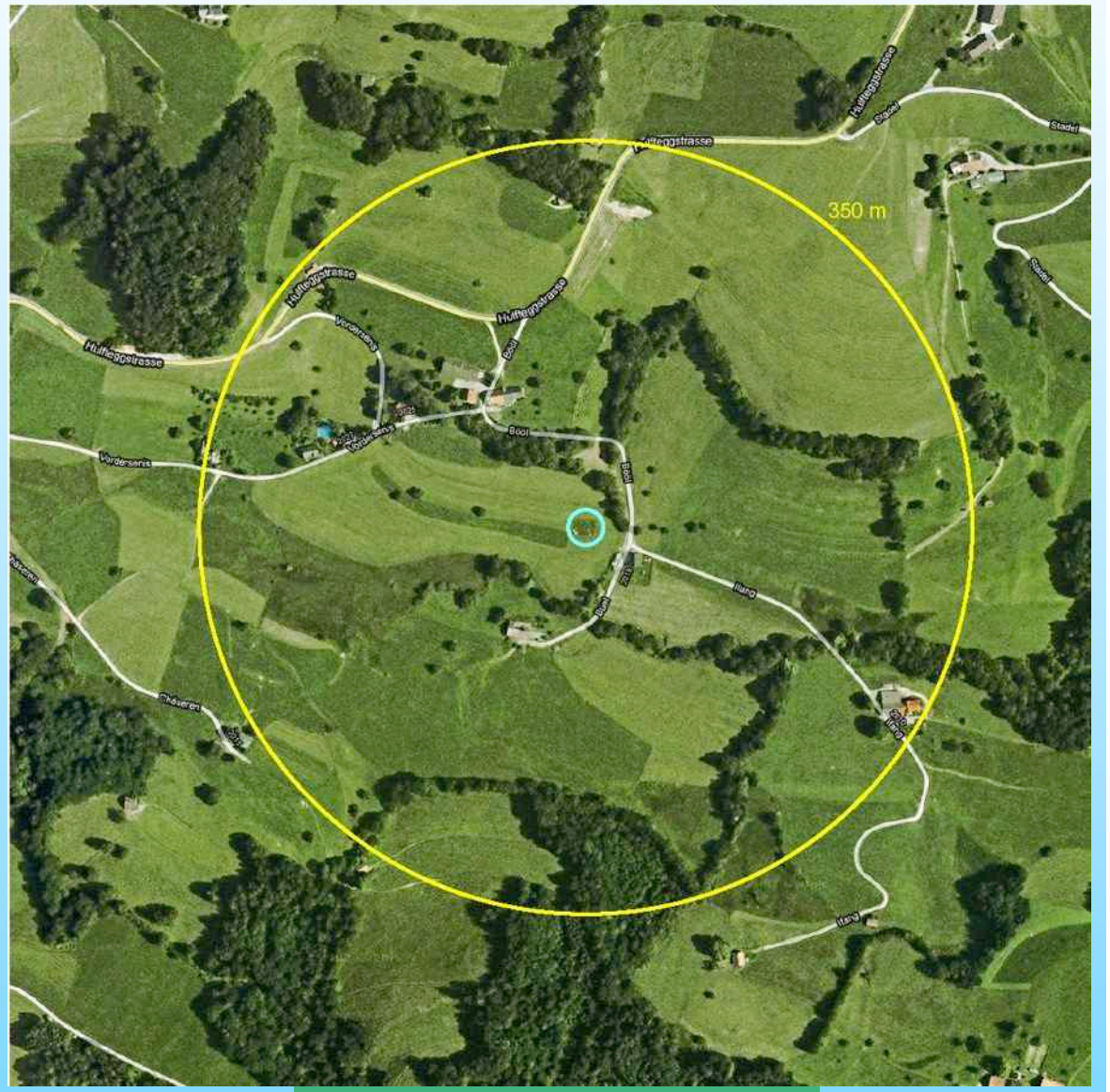
Variations in soil moisture: circle, 400 m diameter



Cosmic-ray neutrons above the surface

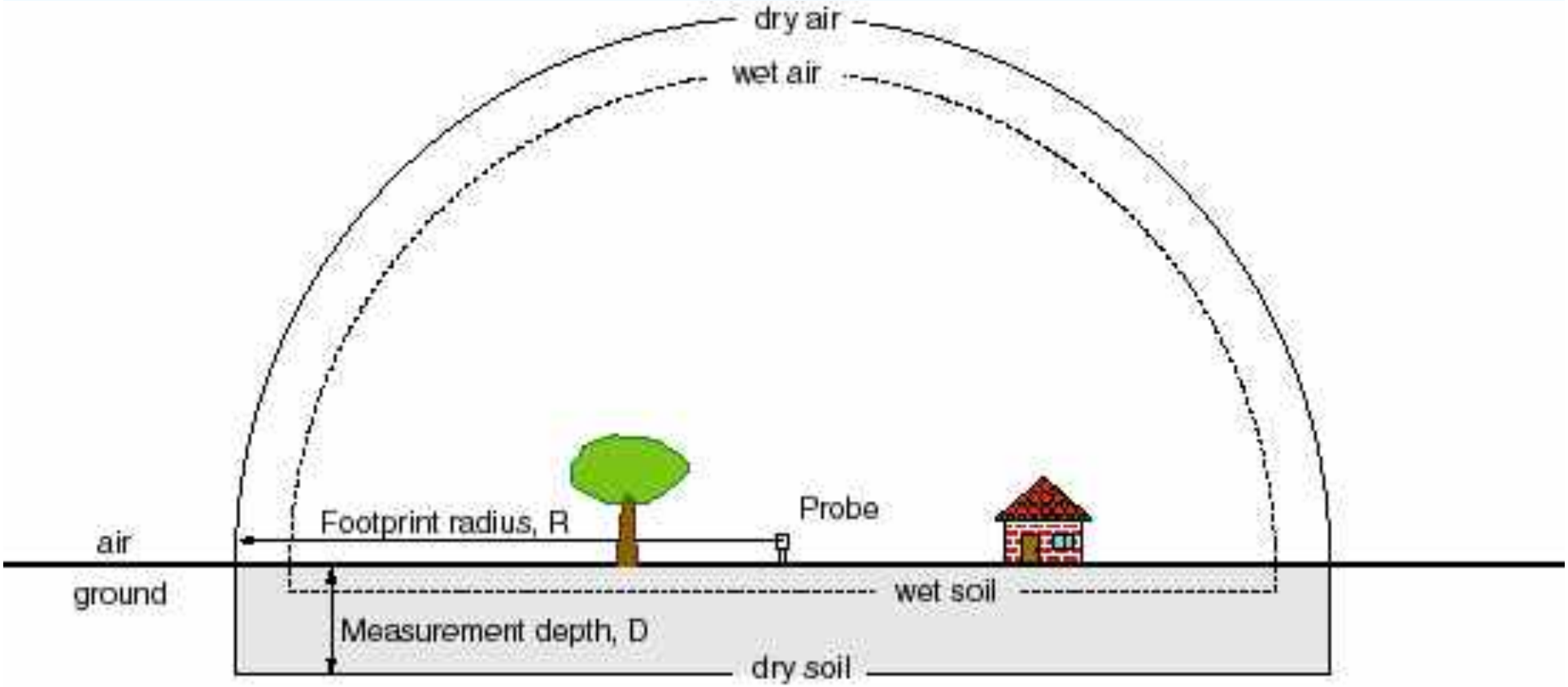


COSMOS probe and its footprint



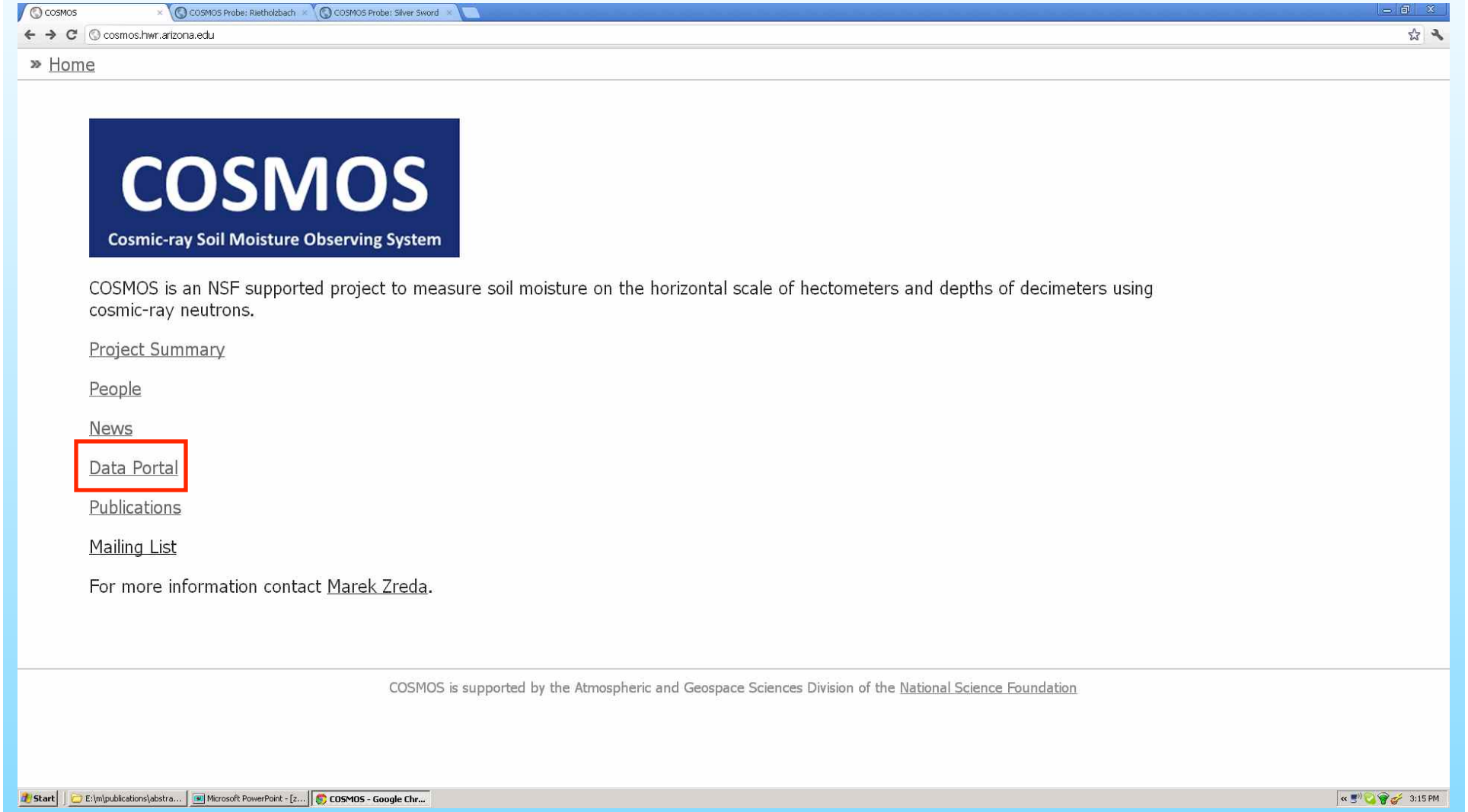
Rietholzbach, Switzerland

Pools of hydrogen within COSMOS footprint



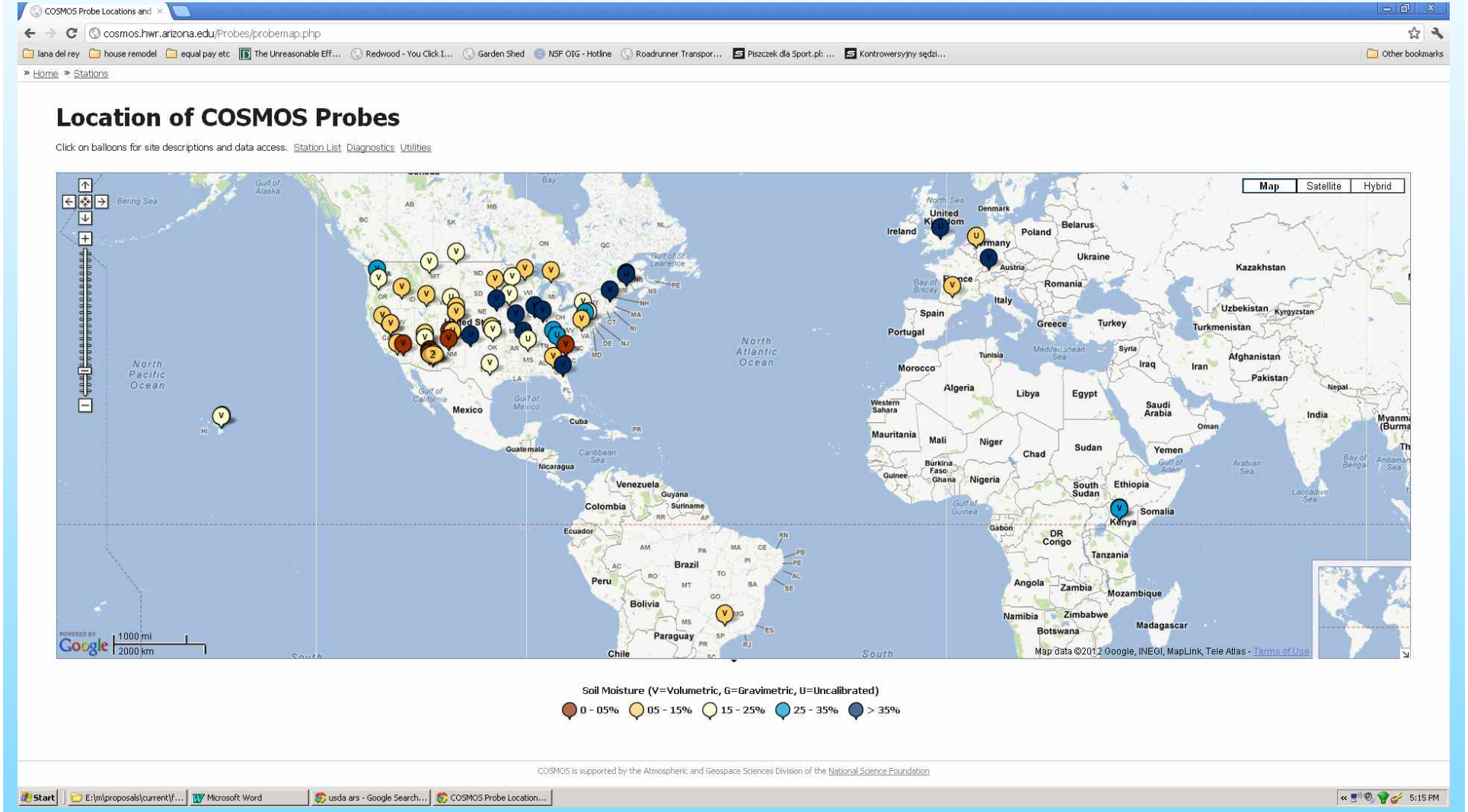
Pool (in order of importance)		Included in local calibration?
Surface water (snow)		No
Soil moisture		---
Mineral (lattice) water	Yes	
Water in organic matter in soil		Yes
Vegetation (biomass)		Yes (if constant)
Atmospheric water vapor		Yes

COSMOS web site



COSMOS public server: cosmos.hwr.arizona.edu

Global COSMOS



COSMOS public server: cosmos.hwr.arizona.edu

COSMOS web site: probe data

COSMOS | COSMOS Probe: Silver Sword

cosmos.hwr.arizona.edu/Probes/StationDat/012/index.php

» Home » Stations » **Station Information**

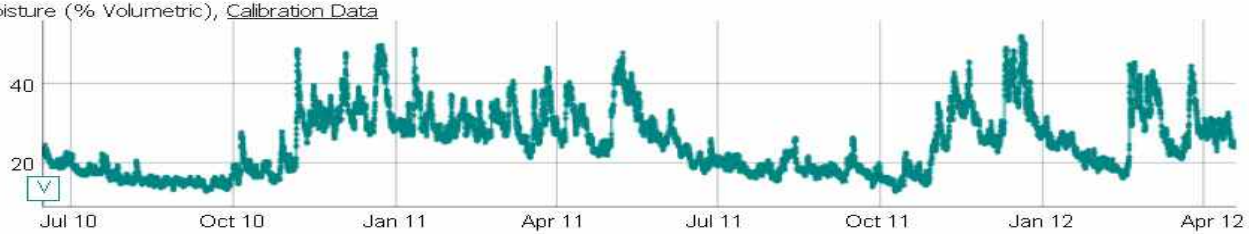
Silver Sword

Larger Photo Approx Footprint

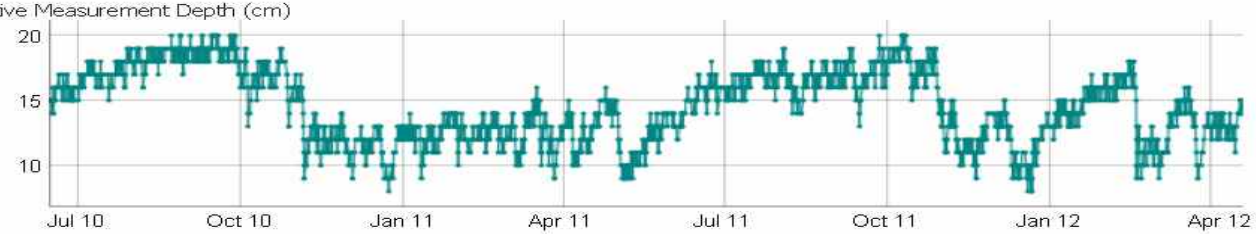
The site is co-located with the USDA National Resources Conservation Service 'Silver Sword' site.
More information regarding the USDA site can be found at
http://www.wcc.nrcs.usda.gov/nwcc/site?sitenum=2101&state=HI

Installation Date:	2010-06-15
Timezone (UTC):	-10
Cutoff Rigidity (GV):	12.87
Mean Pressure (mb):	725
Mean Bulk Density (g/cm^3):	0.78
Mean Lattice Water (% weight):	9.57
Max Count Rate (/hr):	2633

Soil Moisture (% Volumetric), Calibration Data



Effective Measurement Depth (cm)



Level 1 Data (Plots) Level 2 Data Level 3 Data Data Levels Excel (.xls) Matlab (.mat) Python (.pkl)

COSMOS data is research level and subject to change.

COSMOS is supported by the Atmospheric and Geospace Sciences Division of the National Science Foundation

COSMOS public server: cosmos.hwr.arizona.edu

COSMOS data levels

Current

Level 1	Raw count rates, basic met data
Level 2	Corrected and normalized count rates
Level 3	Soil moisture and measurement thickness

Future

Level 4	Soil moisture profiles (DA, LSM)

Considerations for potential use in SMAP cal/val

Positives

Area-average soil moisture (integrates small-scale variations)

Each site calibrated locally on moisture form multiple soil samples

Data available in the public domain in real time

Latency: 1 hour

Negatives

Measurement thickness larger thyan SMAP

- need to produce profiles

Measurement area smaller than SMAP

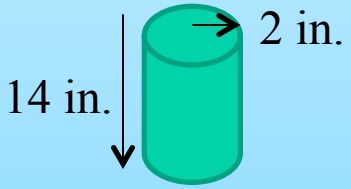
- need to upscale

Possible upscaling solution

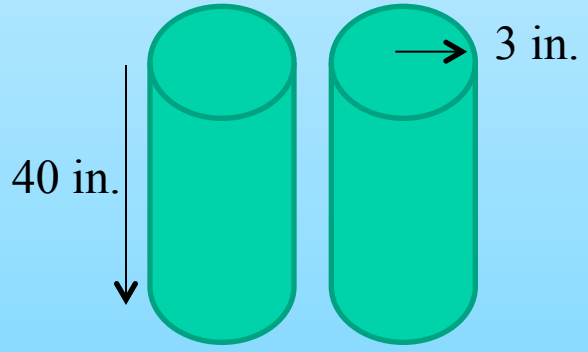
COSMOS rover

COSMOS rover

stationary counter



COSMOS rover



14x neutron count

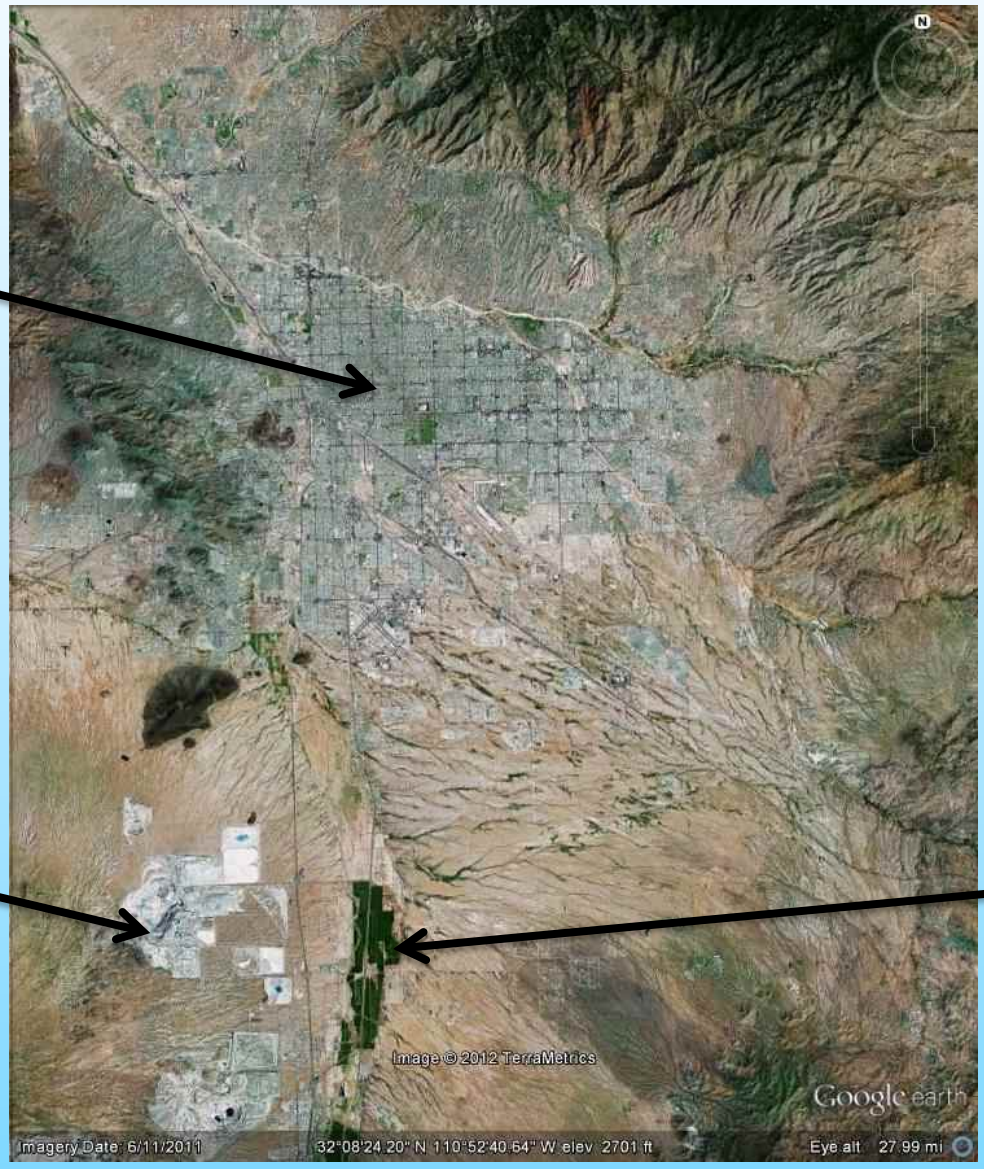
Objective and Reasoning:

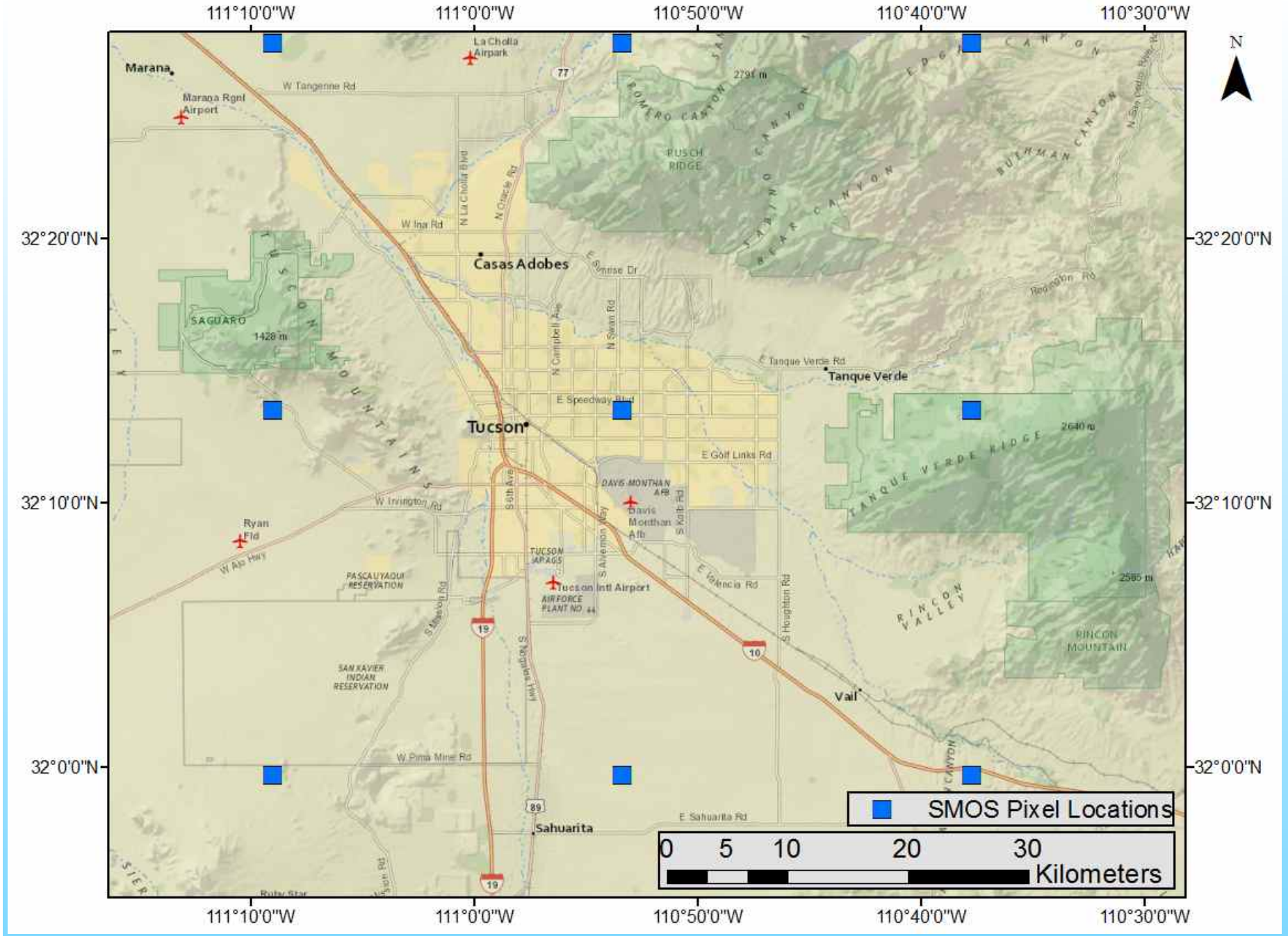
- Mobile application allows spatial scale matching of satellite pixels
- Compare average of COSMOS rover values to satellite pixels
- Physical up-scaling
- As long as the land is accessible, the rover can match many satellite pixels with varying land cover types!

Challenge:

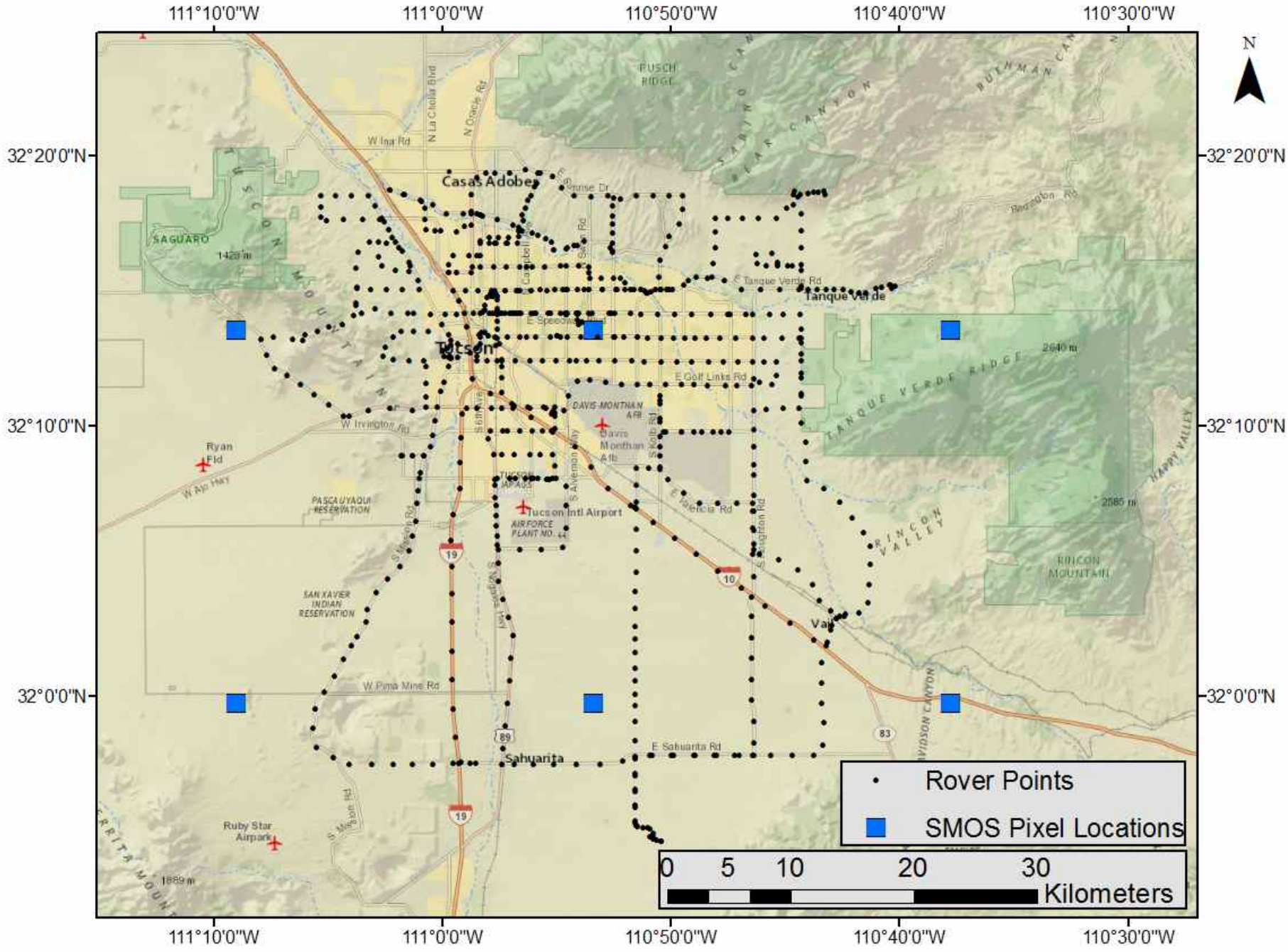
- Disconnect in vertical depth penetration

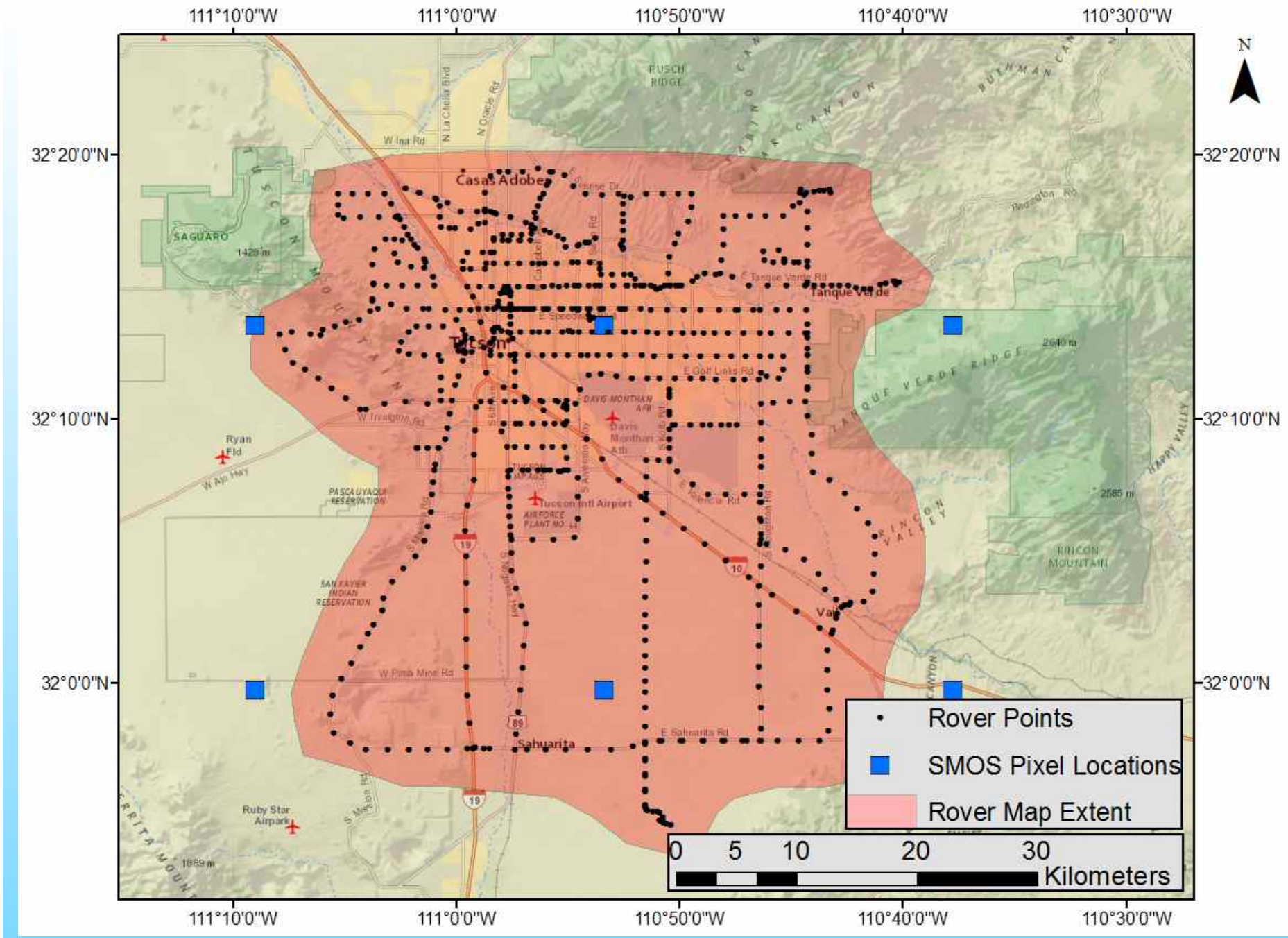
Tucson Basin I



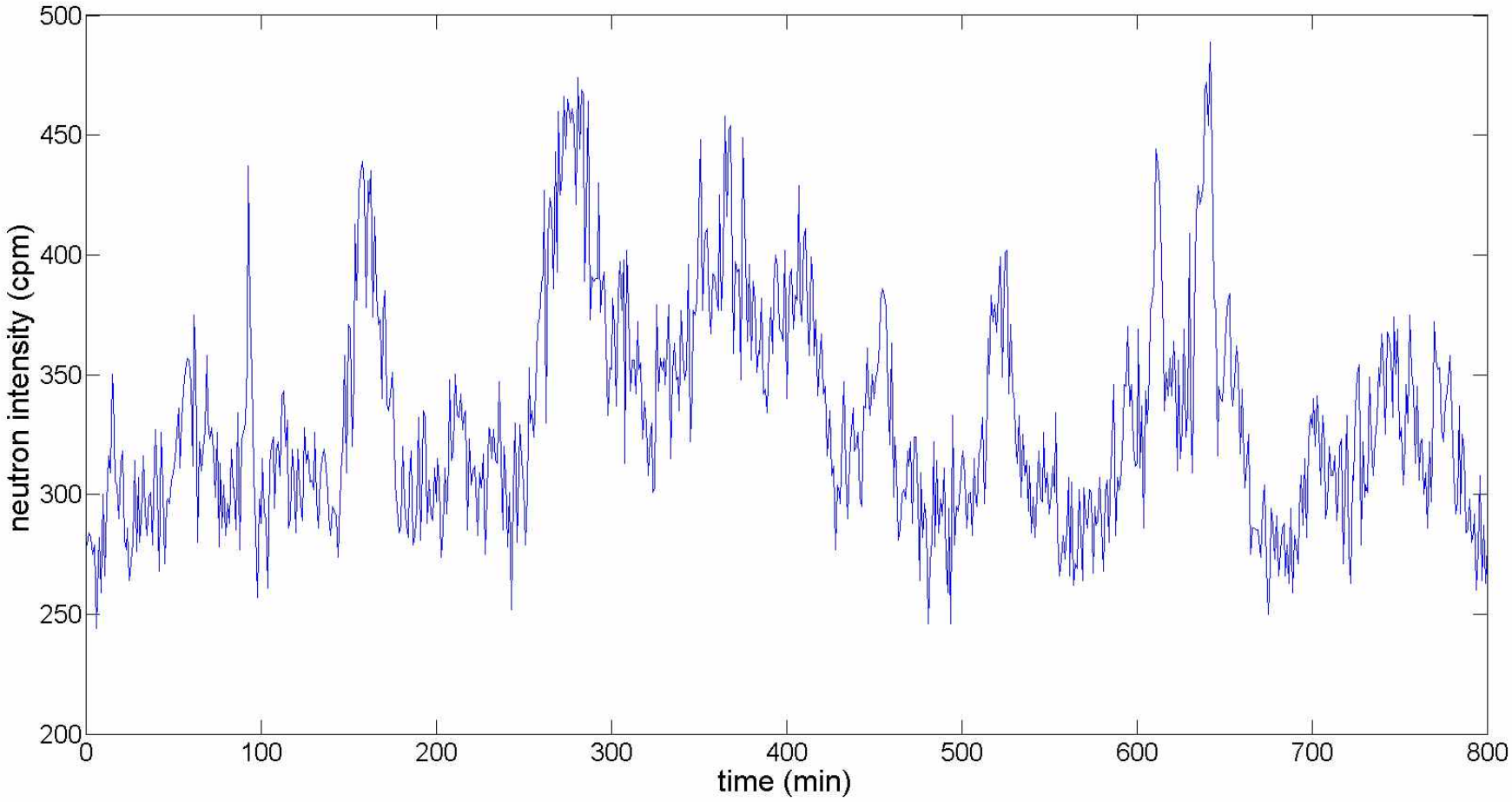


111°10'0"W
111°0'0"W
110°50'0"W
110°40'0"W
110°30'0"W
32°20'0"N
32°10'0"N
32°0'0"N
N
Marana
Marana Rgnl Airport
La Cholla Airpark
W Tangerine Rd
W Ina Rd
Casas Adobes
SAGUARO
1428 m
Tucson
E Speedway Blvd
E Golf Links Rd
Tanque Verde
E Tanque Verde Rd
TANQUE VERDE RIDGE
2640 m
DAVIS MONTHAN AFB
Davis Monthan Afb
W Irvington Rd
Ryan Fld
W Ajo Hwy
PASCAUYAQUI RESERVATION
TUCSON JAPAGS
Tucson Intl Airport
AIRFORCE PLANT NO. 44
E Valencia Rd
RINCON VALLEY
RINCON MOUNTAIN
2585 m
SAN XAVIER INDIAN RESERVATION
Vail
W Pima Mine Rd
E Sahuarita Rd
Sahuarita
SMOS Pixel Locations
0 5 10 20 30
Kilometers

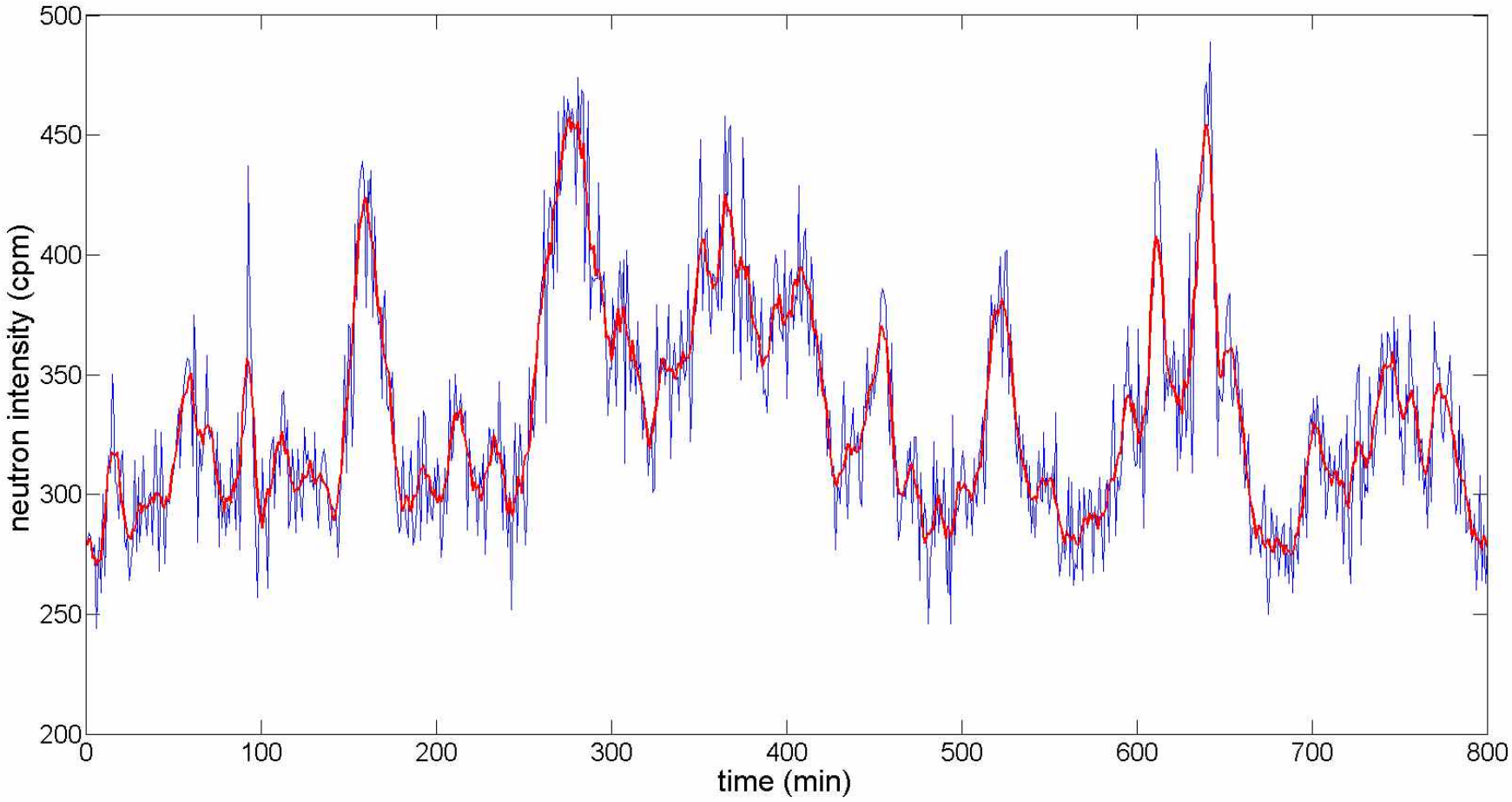

111°10'0"W
111°0'0"W
110°50'0"W
110°40'0"W
110°30'0"W
32°20'0"N
32°10'0"N
32°0'0"N
N
Rover Points
SMOS Pixel Locations
0 5 10 20 30
Kilometers
Tucson
Casas Adobes
Tanque Verde
Vail
Sahuarita
Tucson Intl Airport
Davis-Monthan AFB
Ryan Fld
Ruby Star Airpark
SAGUARO
PUSCH RIDGE
TANQUE VERDE RIDGE
RINCON MOUNTAIN
RINCON VALLEY
HAPPY VALLEY
SAN XAVIER INDIAN RESERVATION
PASCUA YAQUI RESERVATION
W Ina Rd
N La Cholla Blvd
N Oracle Rd
E Tanque Verde Rd
E Golf Links Rd
W Irvington Rd
W Ajo Hwy
E Valencia Rd
W Pima Mine Rd
E Sahuarita Rd
S Wilmot Rd
S Kolb Rd
S Houghton Rd
S Nogales Hwy
S Mission Rd
1423 m
2640 m
2585 m
1889 m


111°10'0"W
111°0'0"W
110°50'0"W
110°40'0"W
110°30'0"W
32°20'0"N
32°10'0"N
32°0'0"N
N
Rover Points
SMOS Pixel Locations
Rover Map Extent
0 5 10 20 30
Kilometers
Tucson
Casas Adobes
Tanque Verde
Sahuarita
Vail
Ryan Fld
Tucson Intl Airport
Davis Monthan Afb
Ruby Star Airpark
SAGUARO
RINCON MOUNTAIN
SAN XAVIER INDIAN RESERVATION
PASCUA YAQUI RESERVATION

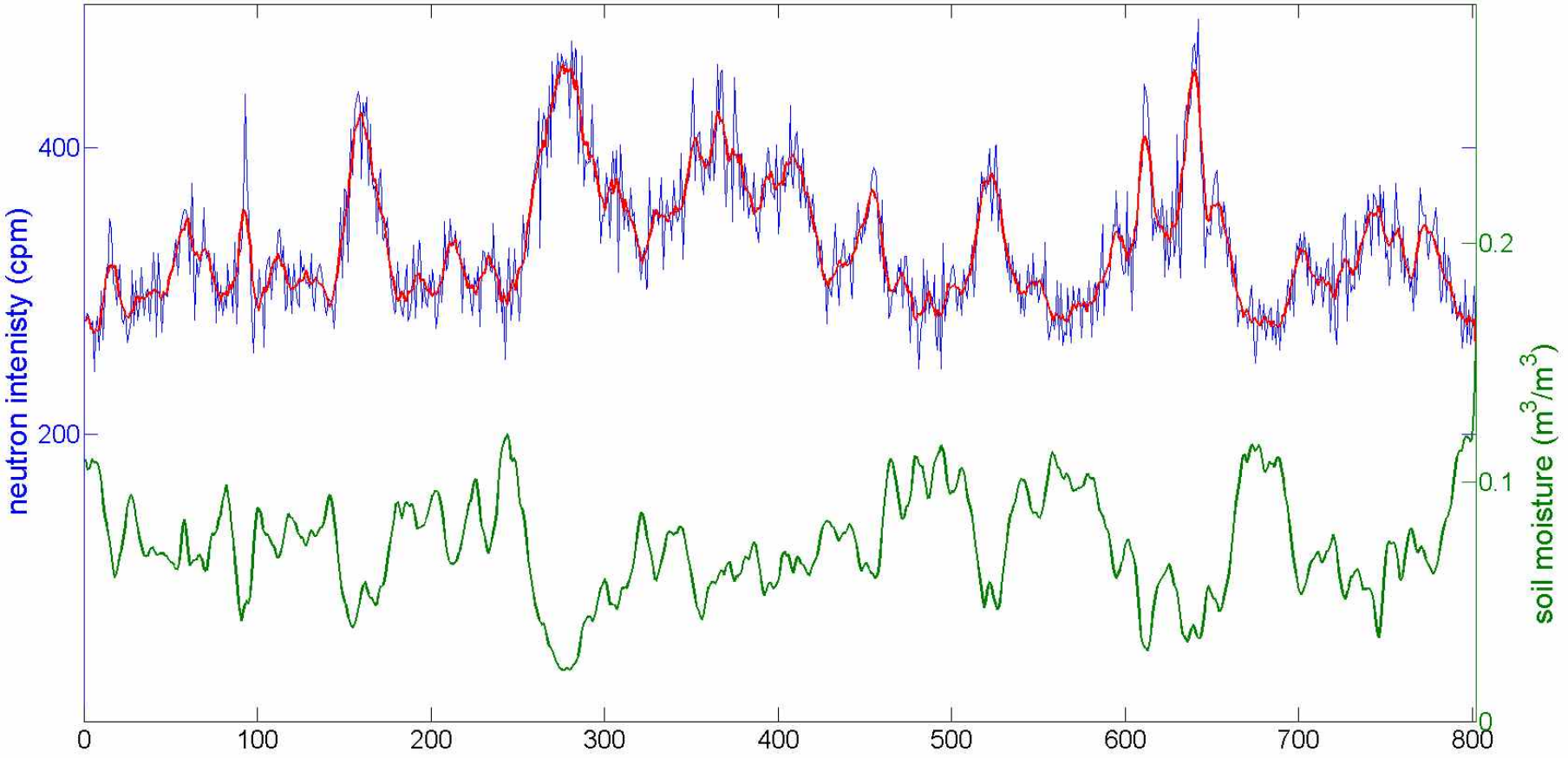
COSMOS rover neutron intensity: raw data

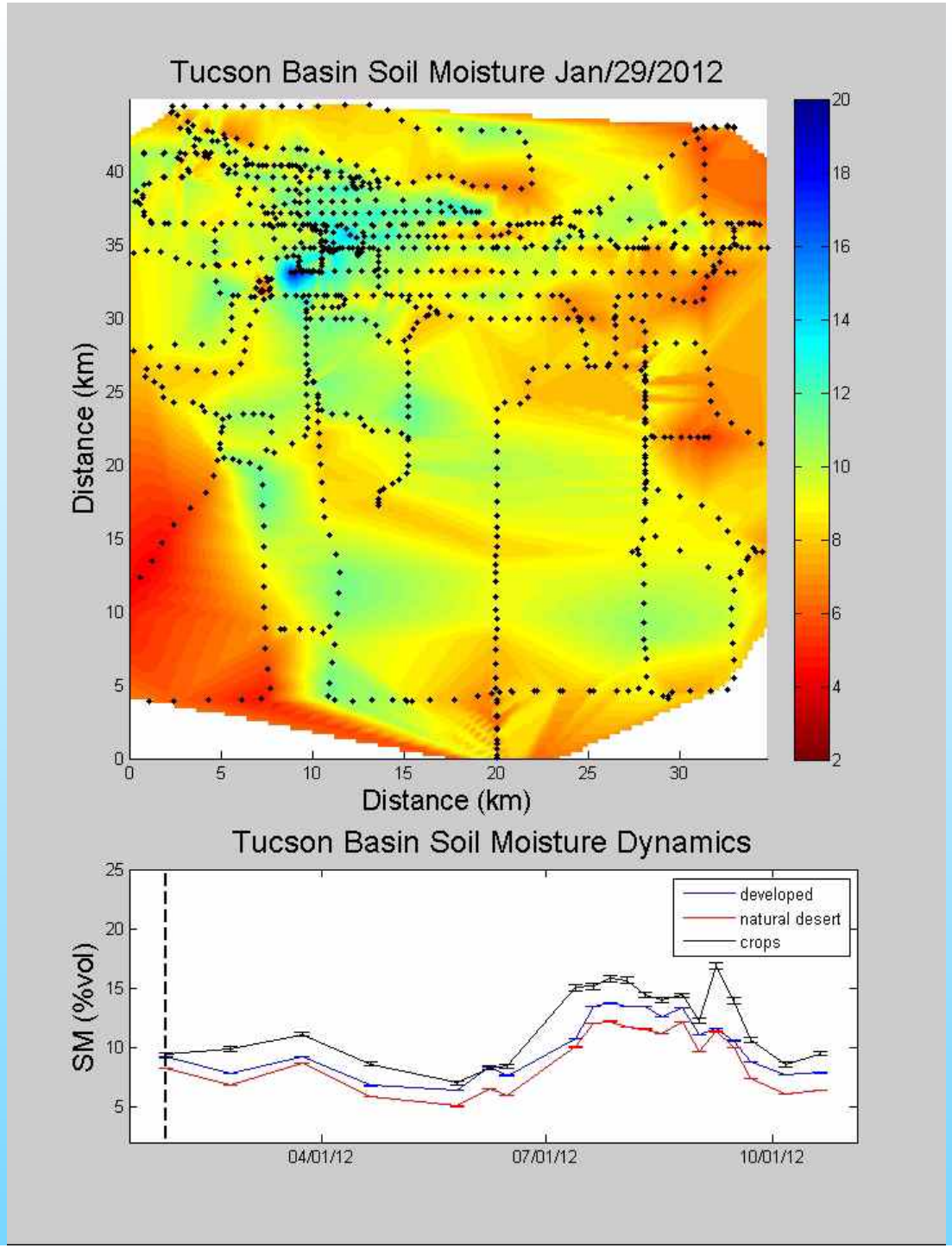


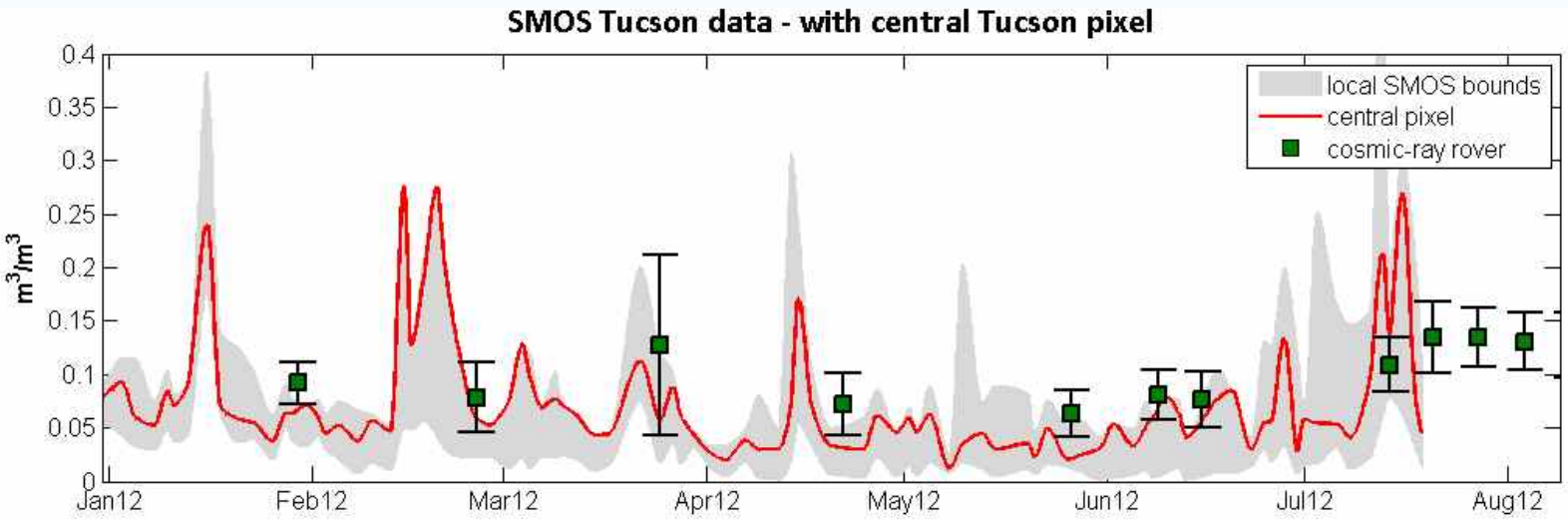
COSMOS rover neutron intensity: smoothed data

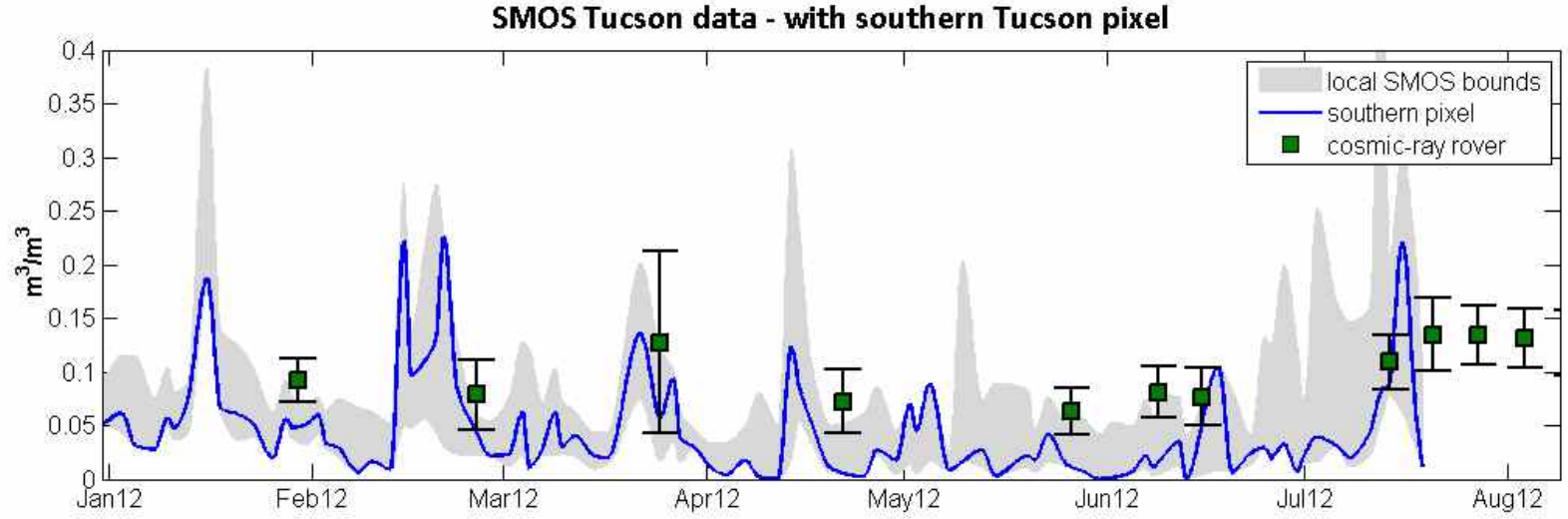


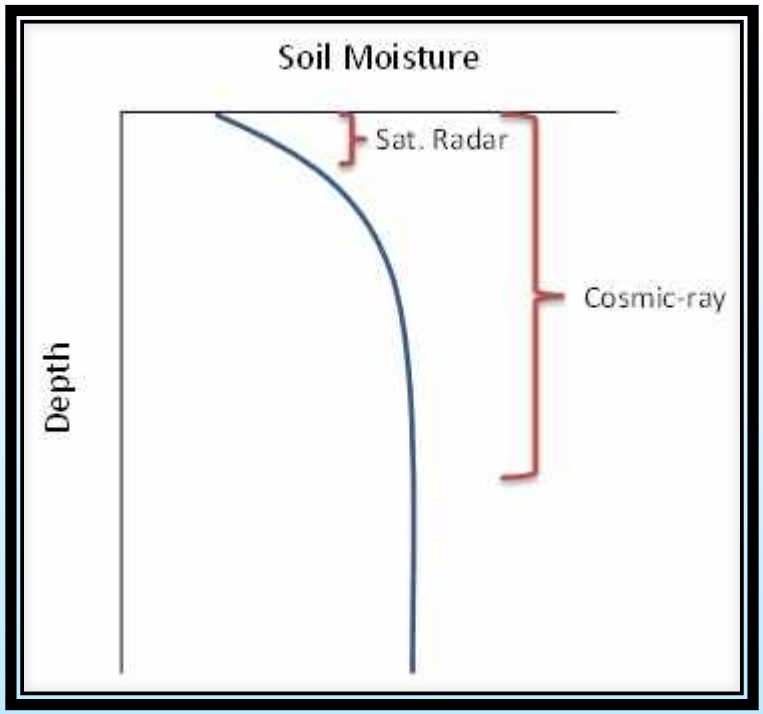
COSMOS rover neutron intensity: processed data

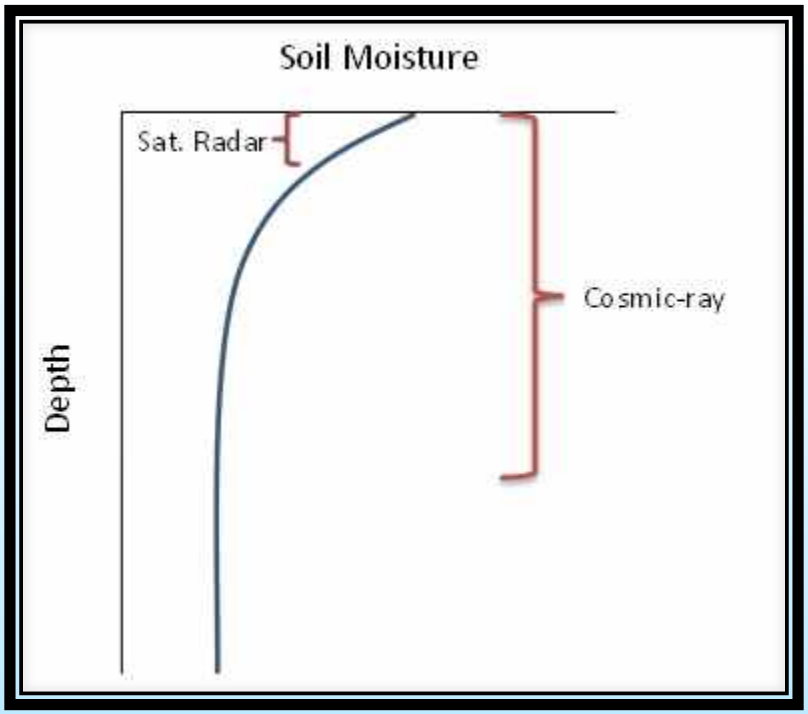


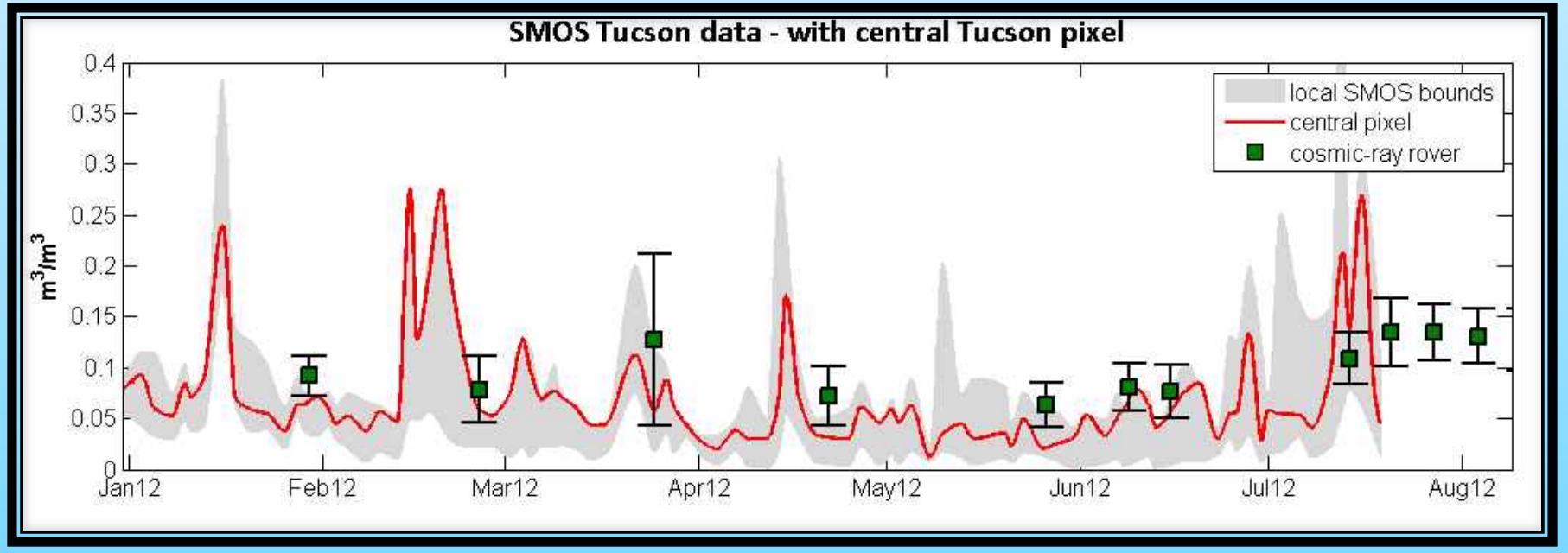

Tucson Basin Soil Moisture Jan/29/2012
Distance (km)
Distance (km)
0
5
10
15
20
25
30
35
40
2
4
6
8
10
12
14
16
18
20
Tucson Basin Soil Moisture Dynamics
SM (%vol)
developed
natural desert
crops
04/01/12
07/01/12
10/01/12


SMOS Tucson data - with central Tucson pixel
local SMOS bounds
central pixel
cosmic-ray rover
m3/m3
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan12
Feb12
Mar12
Apr12
May12
Jun12
Jul12
Aug12


SMOS Tucson data - with southern Tucson pixel
local SMOS bounds
southern pixel
cosmic-ray rover
m3/m3
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan12
Feb12
Mar12
Apr12
May12
Jun12
Jul12
Aug12


Soil Moisture
Sat. Radar
Cosmic-ray
Depth


Soil Moisture
Sat. Radar
Cosmic-ray
Depth


SMOS Tucson data - with central Tucson pixel
local SMOS bounds
central pixel
cosmic-ray rover
m3/m3
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Jan12
Feb12
Mar12
Apr12
May12
Jun12
Jul12
Aug12

Cal/Val Issues

- Major obstacle
  - Overcoming the depth disconnect between the two methods for direct comparison
- Proposed future work
  - Cal/Val with extrapolated L4 SMAP data
  - Cal/Val with extracted surface value from COSMOS produced SM profile

- Thank you!
- Questions?