

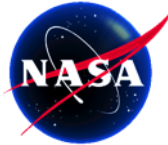
# AirMOSS

Airborne Microwave Observatory of Subcanopy & Subsurface Mission



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## Science Team (in alphabetical order):

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Rolf Reichle (GSFC), Sassan Saatchi (JPL)

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UAVSAR Workshop

March 26, 2013



USC University of  
Southern California



Oregon State  
UNIVERSITY



PURDUE  
UNIVERSITY

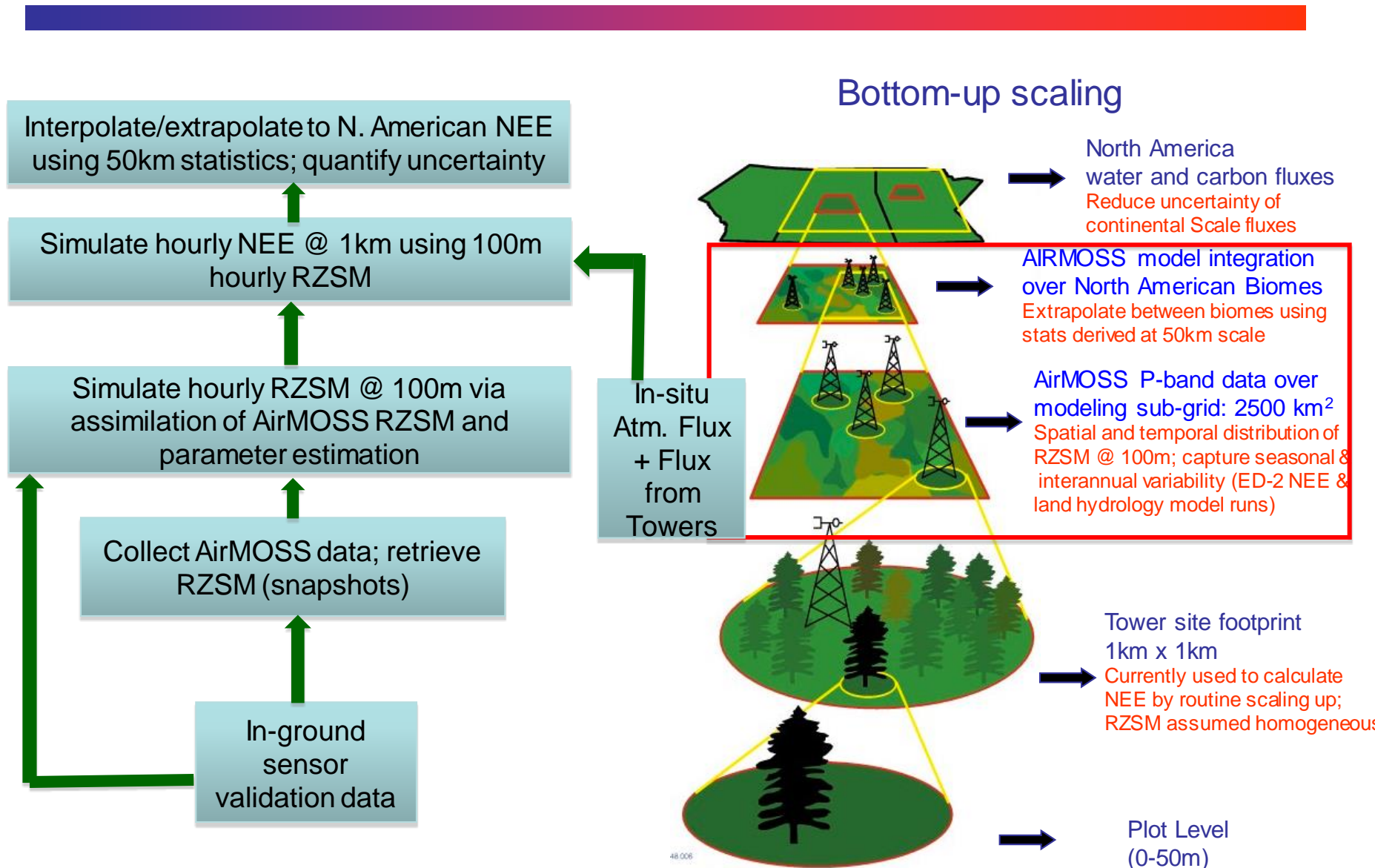


## Questions:

- Quantitatively, what are the local-, regional-, and continental-scale heterogeneities of root-zone soil moisture (RZSM) in North America?
- Quantitatively, how does RZSM control ecosystem carbon fluxes at each of these scales?
- By how much will the estimates of North American net ecosystem exchange (NEE) improve with the accurate knowledge of both the mean and the variance of RZSM?

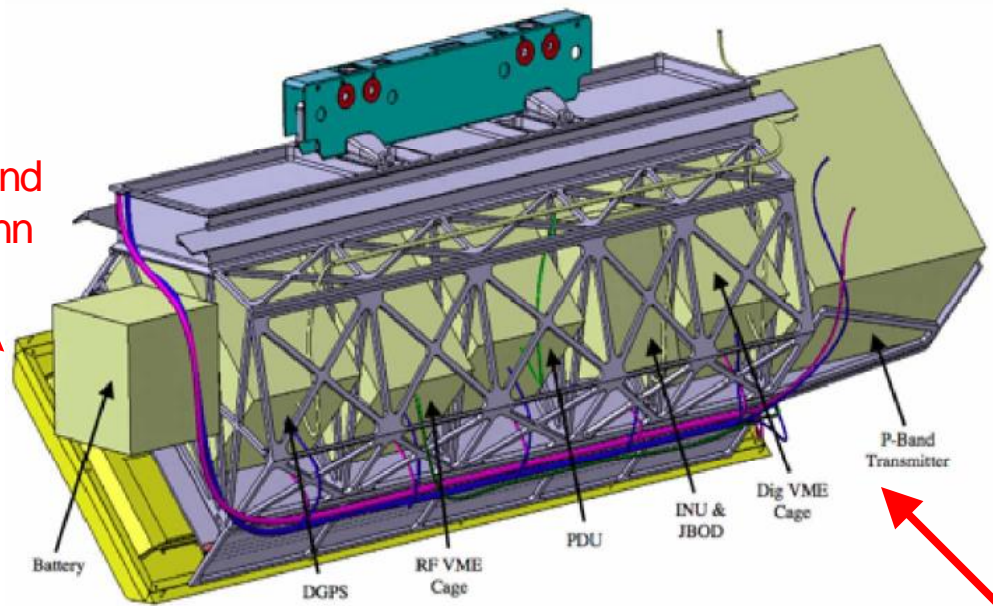
**Objective:** Provide a new NEE estimate for North America with a reduced uncertainty by

- Providing high-resolution observations of RZSM over regions representative of the major North American biomes
- Quantifying the impact of RZSM on the estimation of regional carbon fluxes
- Upscaling the reduced-uncertainty estimates of regional carbon fluxes to the continental scale of North America



48.006

## NASA Gulfstream-III



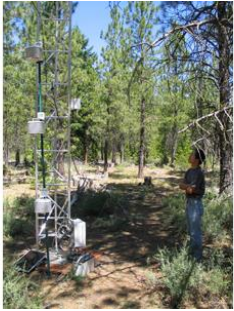
P-band antenna



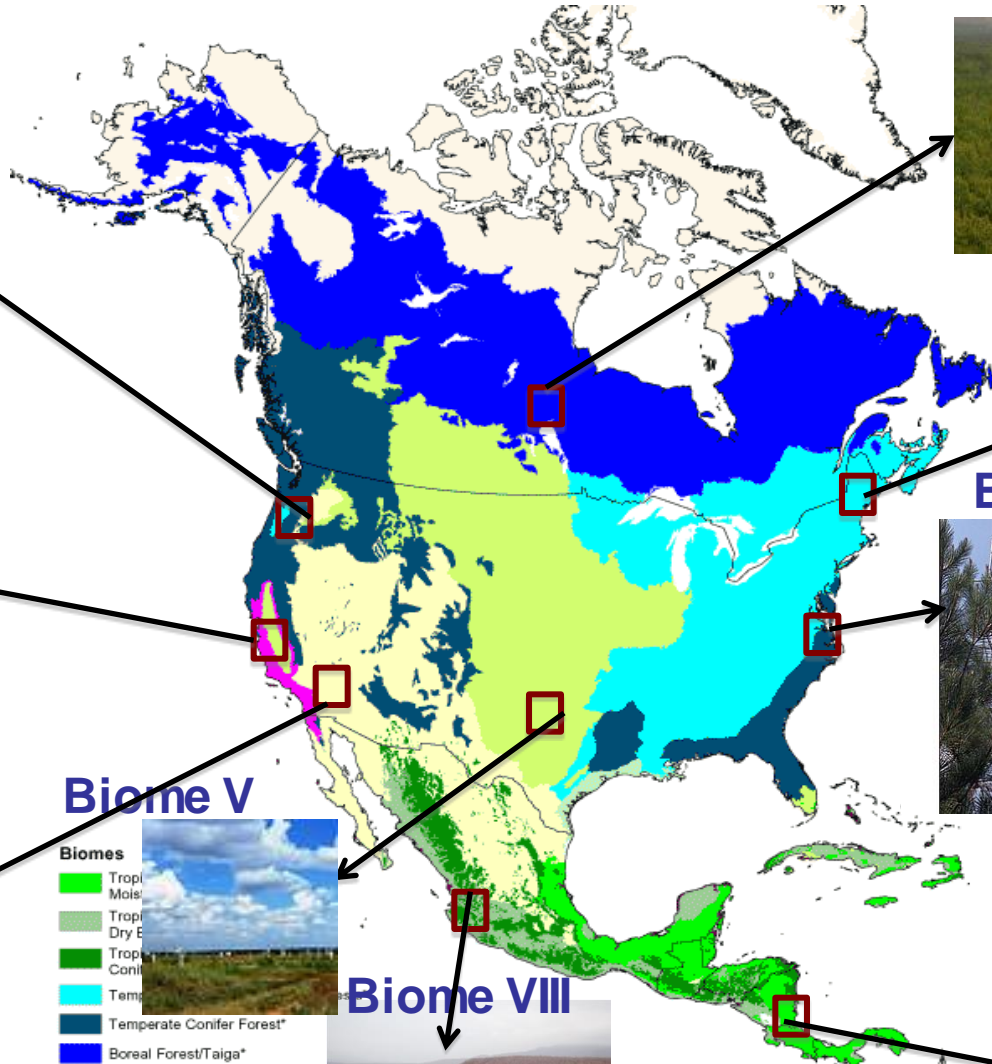
# North American Biomes to Cover



### Biome IV

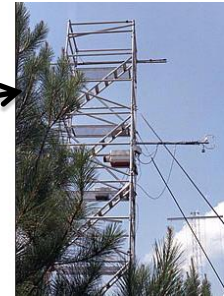


### Biome I

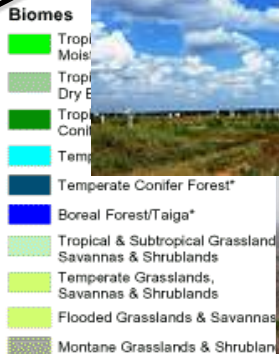


### Biome II

### Biome III



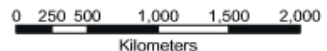
### Biome V



### Biome VIII



### Biome IX



### Biome VI



### Biome VII



# Flight Planning Example

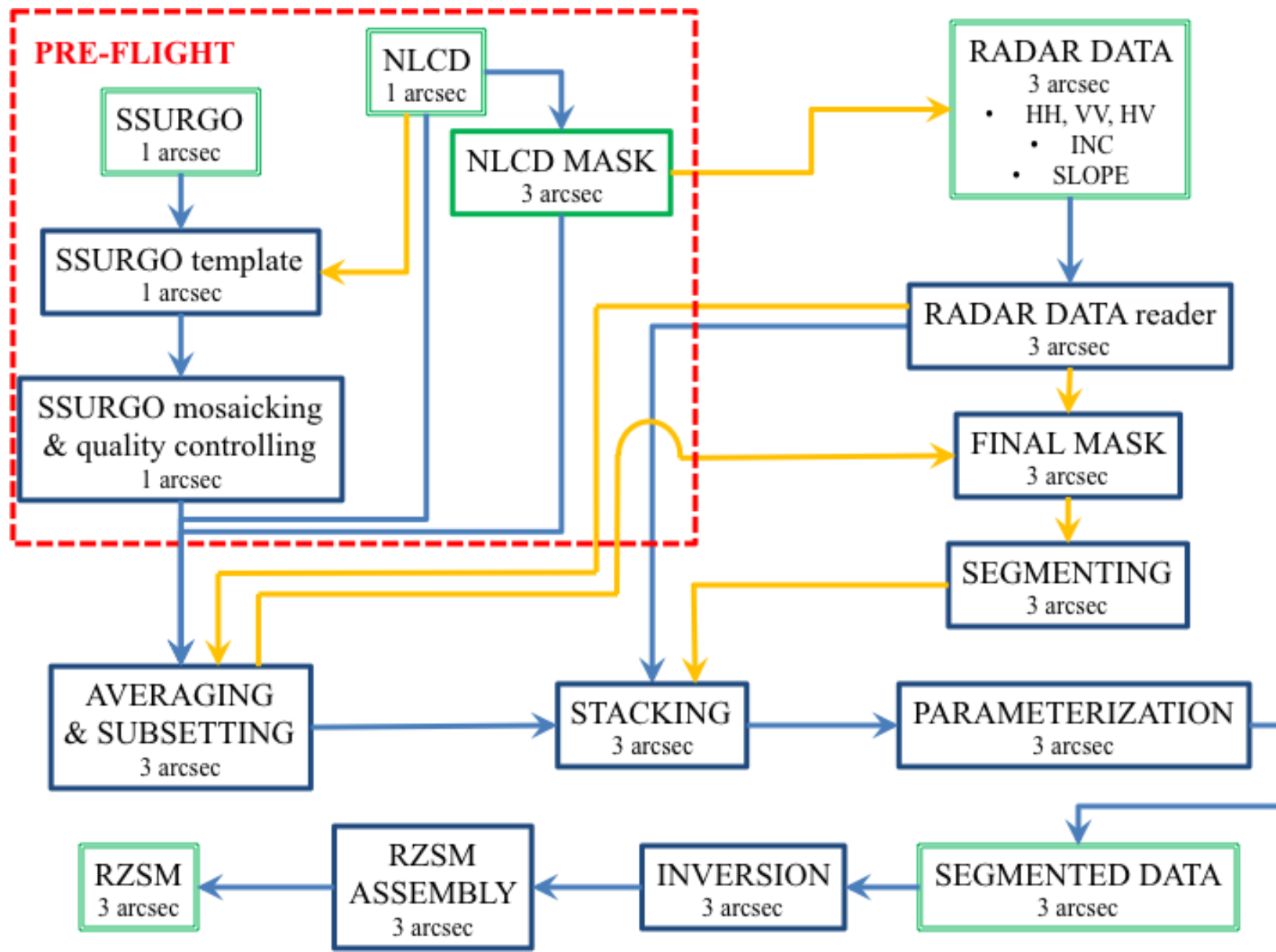
## Walnut Gulch, Arizona, USA

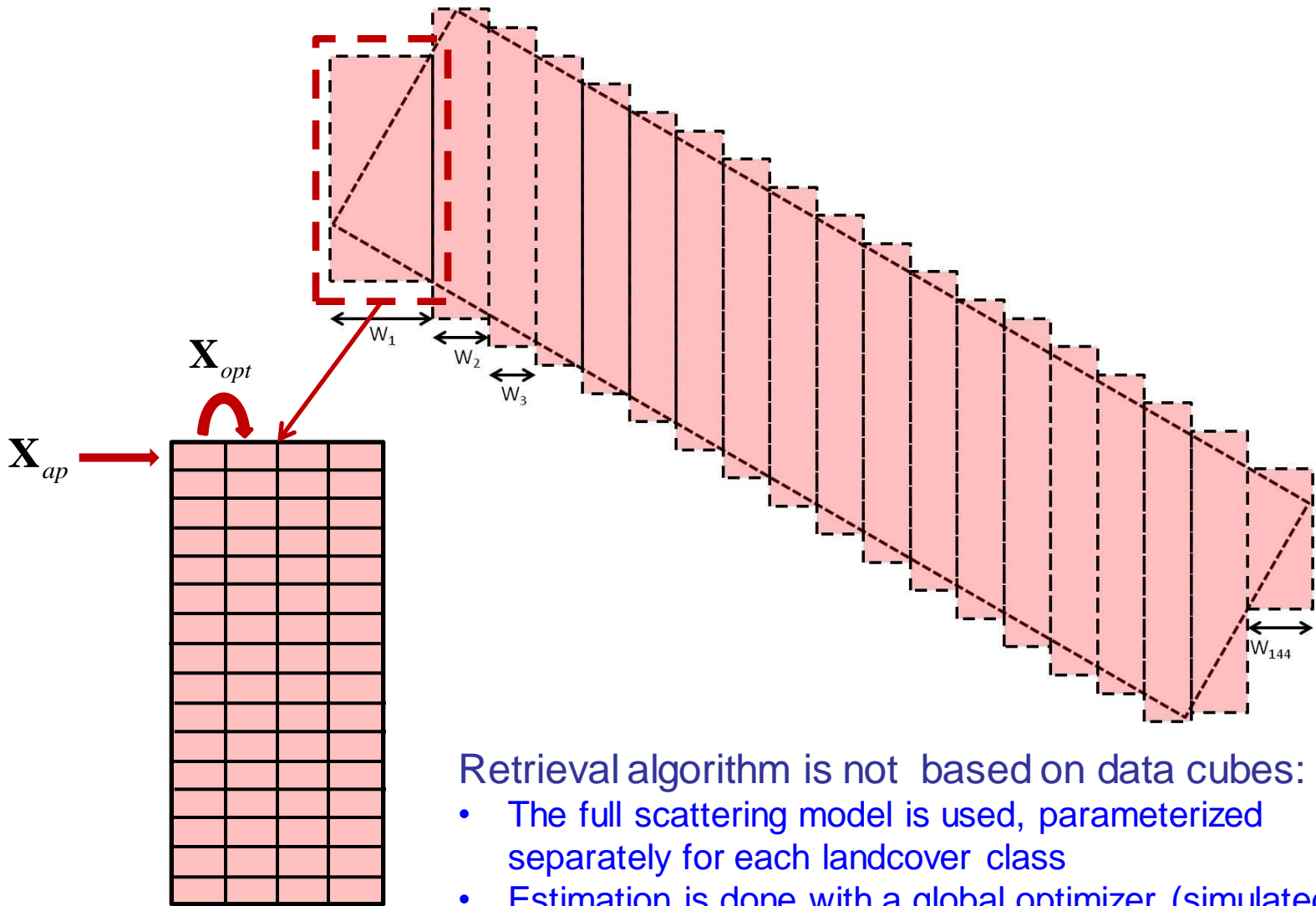


Product Name	Product Description	Latency (Acquisition + )
L1-S0	Level 1 polarimetric backscattering coefficient ( $\sigma_0$ ), multilook complex, polarimetrically calibrated, 100 m resolution, georeferenced	45 days
L2/3-RZSM	Level 2/3 RZSM, daily composite, 100 m resolution, Earth grid	3 months
L4-RZSM	Level 4 assimilated RZSM, 100 m–1000 m spatial resolution, hourly temporal resolution, Earth grid	6 months
L4A-NEE	Level 4 modeled NEE, 1 km spatial resolution over each biome's coverage, Earth grid	6 months
L4B-NEE	Level 4 modeled NEE, 50 km spatial resolution N. America, up-scaled from L4A-NEE	Closeout
L2-Precip	Precipitation measurements	2 months
L2-IGSM	In-Ground soil sensor measurements	2 months
L2-CFlux	Atmospheric tracer flux measurements	Closeout

- Flew 7 sites in September and October 2012, at least three times each
  - Included joint flights with UAVSAR in Arizona and Oklahoma
  
- AirMOSS radar team began delivery of calibrated L1-S0 products in Feb 2013
  - Based on 4.8m corner reflector analysis, radar gain stability is  $\sim 0.6$  dB; more still under evaluation
  
- Detailed frequency coordination is necessary each time we fly, due to other P-band services especially those belonging to the DoD
  - Often we have to fly at night or very early morning
  
- Flights scheduled at Chamela in February did not happen since Mexico flight clearance was not granted in time; trying again for June
  
- Flew in Costa Rica (La Selva) but had problems with radar; radar came back to JPL for repairs and will be shipped back this week; plan to go back to La Selva in early April

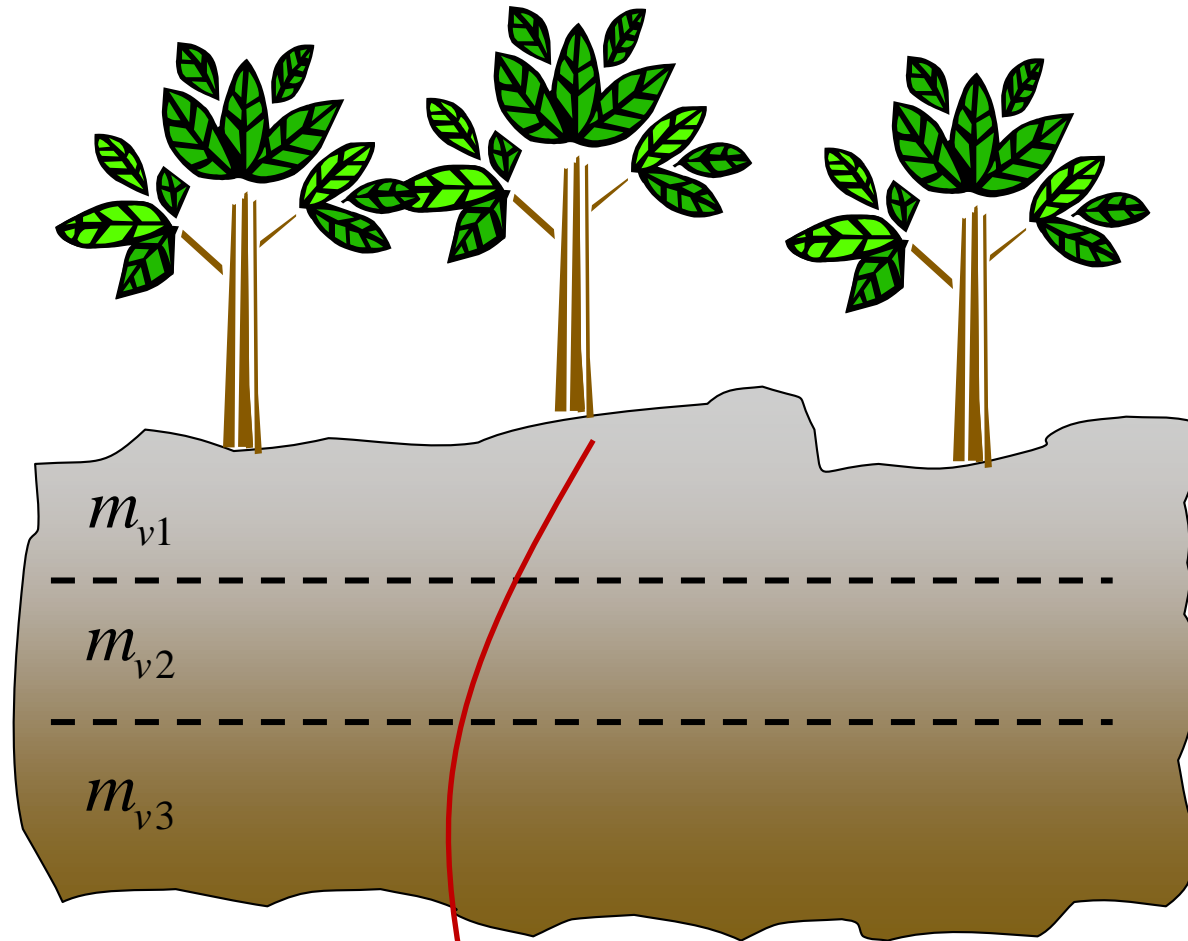






Retrieval algorithm is not based on data cubes:

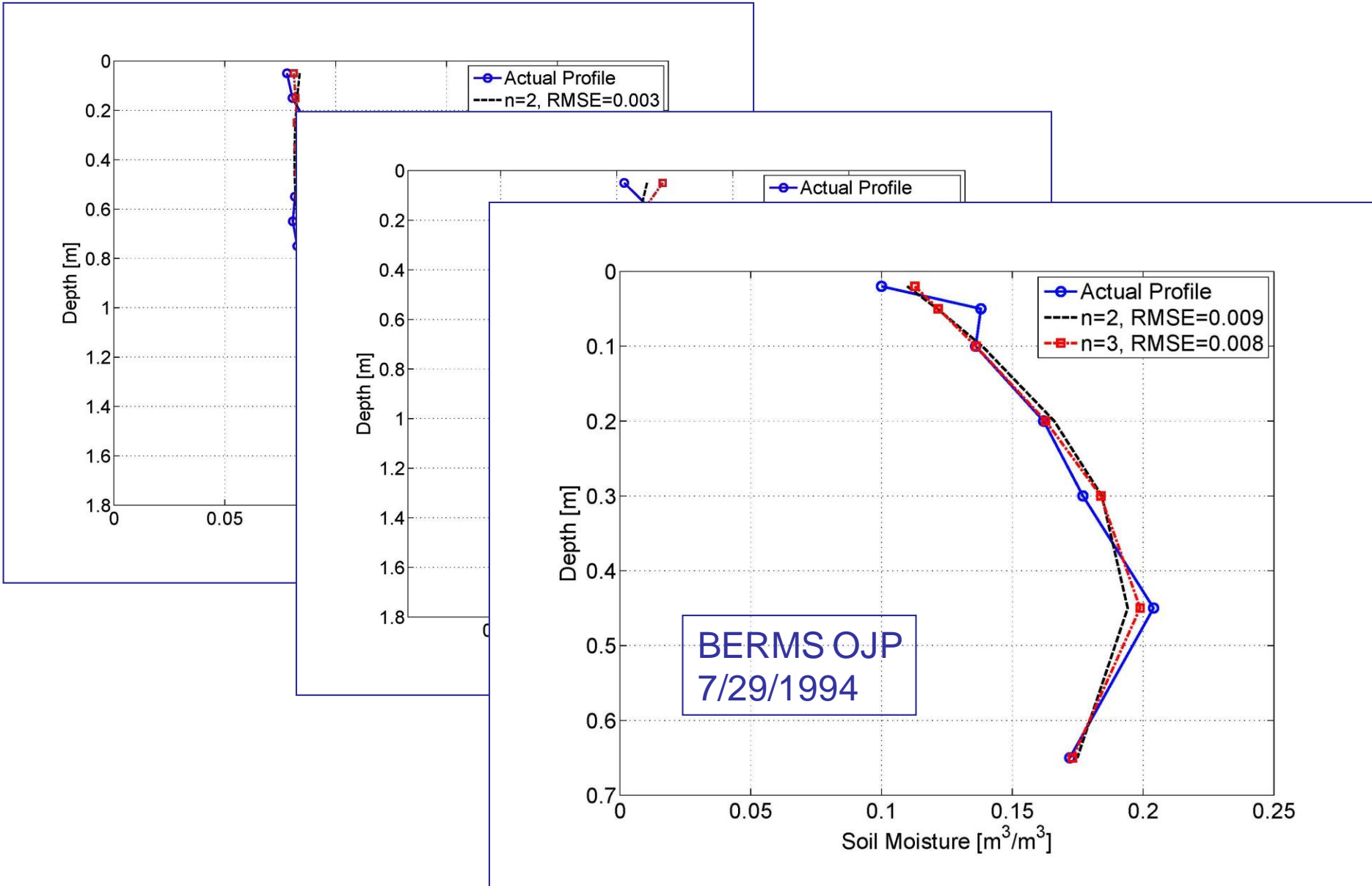
- The full scattering model is used, parameterized separately for each landcover class
- Estimation is done with a global optimizer (simulated annealing)



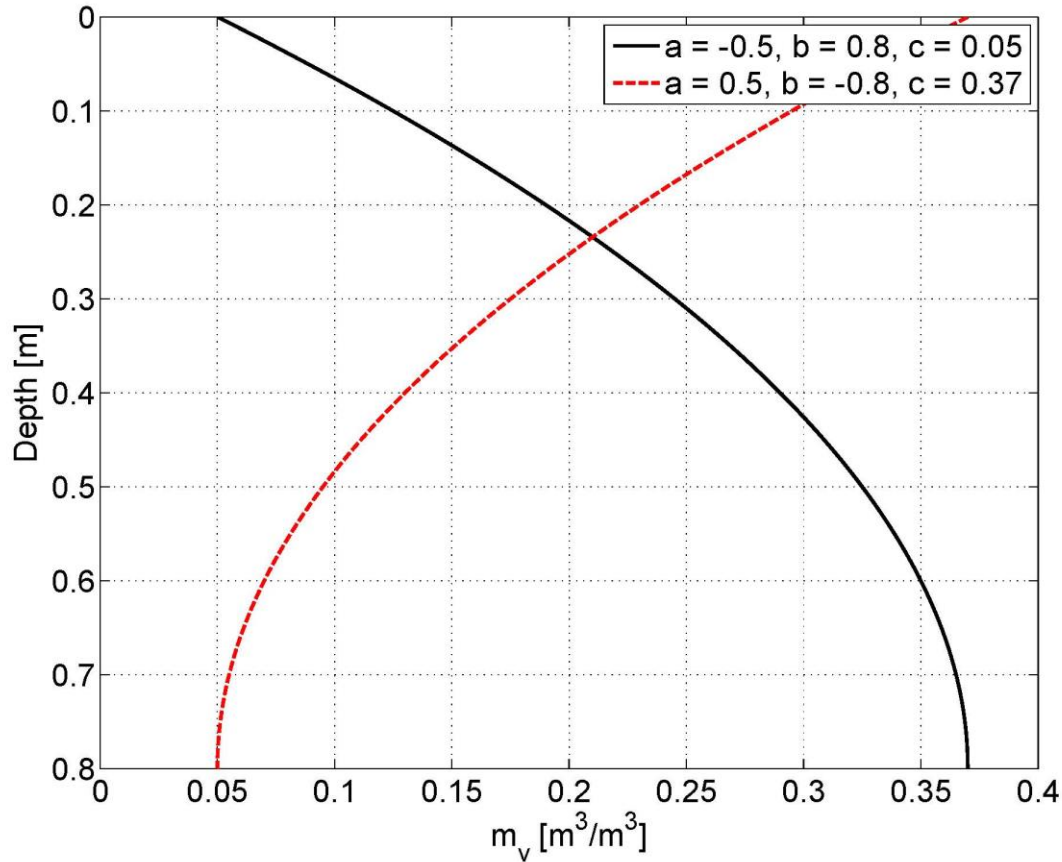
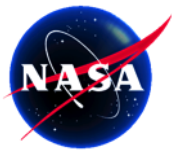
$$m_v = \underline{a}z^2 + \underline{b}z + \underline{c}$$

# Soil Moisture Profile Model

## Rationale for polynomial representation



# Inversion of Soil Moisture: Noise Analysis (1)

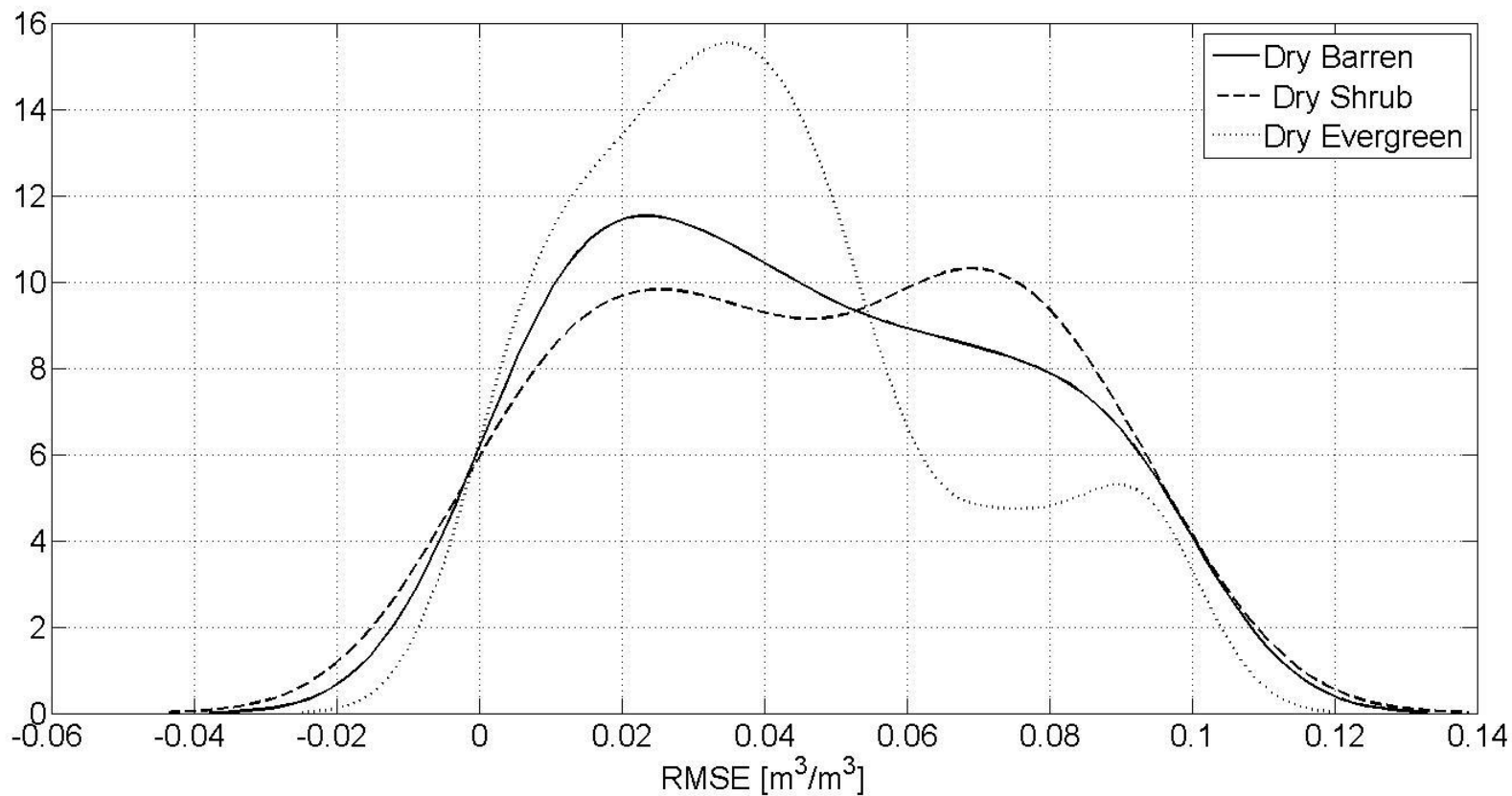


Red: wet profile  
Black: dry profile

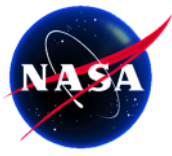
# Inversion of Soil Moisture: Noise Analysis (2)



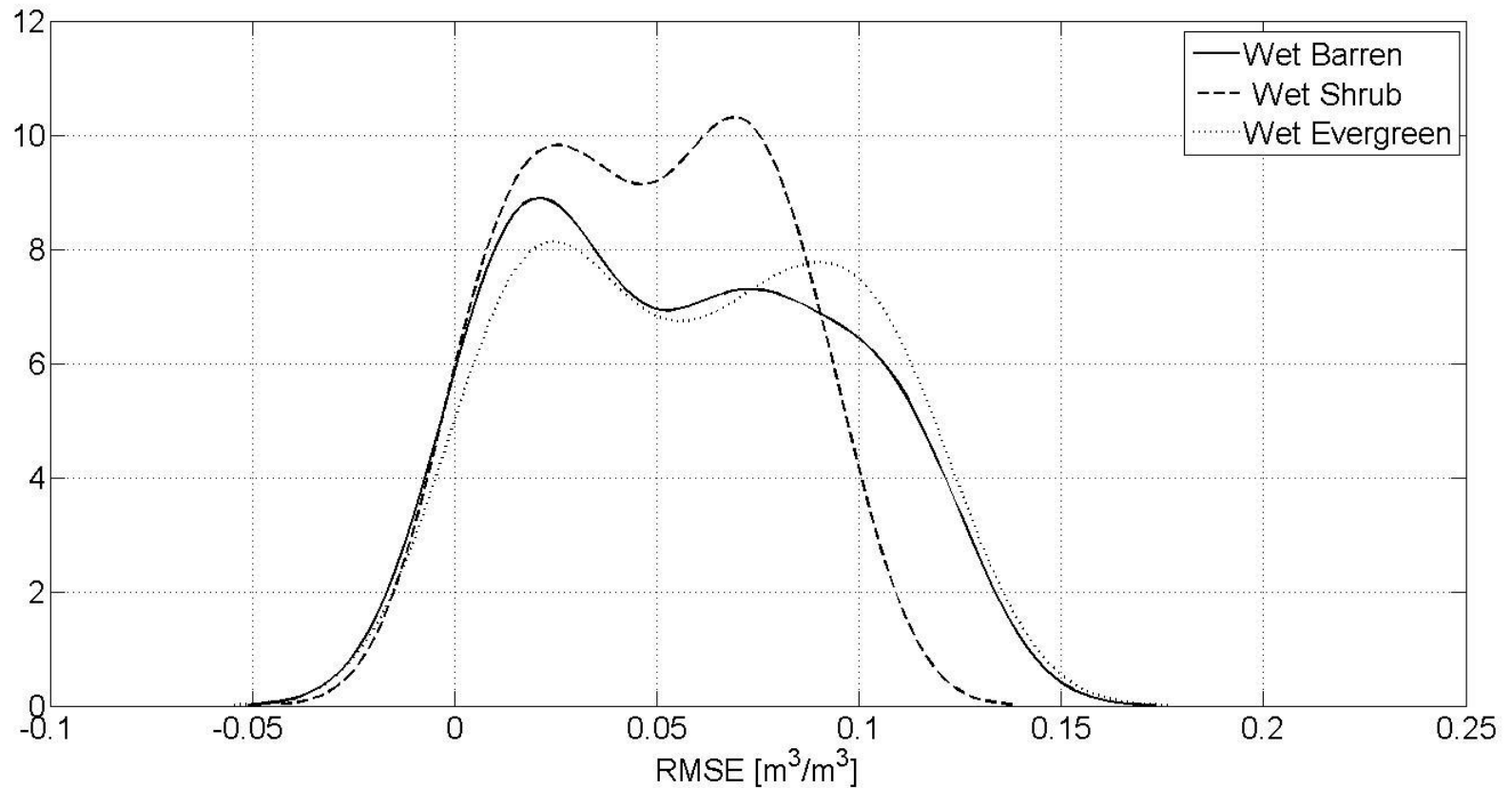
$$\sigma = \sigma + 1.0r, r \in [-1, 1]$$



# Inversion of Soil Moisture: Noise Analysis (3)



$$\sigma = \sigma + 1.0r, r \in [-1, 1]$$

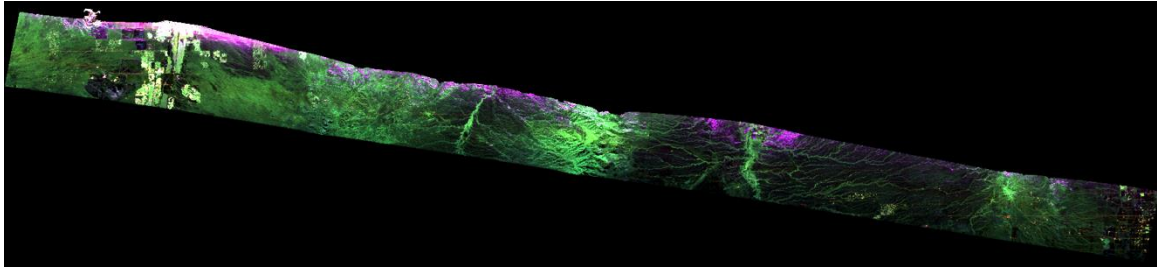


# Flight Planning Example

## Walnut Gulch, Arizona, USA



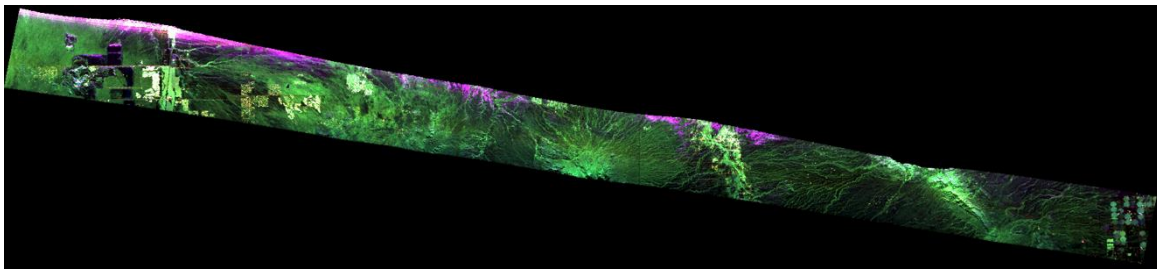
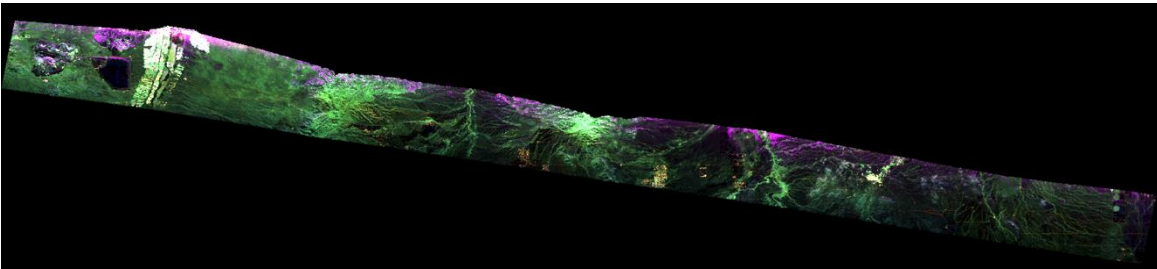




Area of roughly 25 km x 100 km covered by 6 flight lines (3 shown at left)

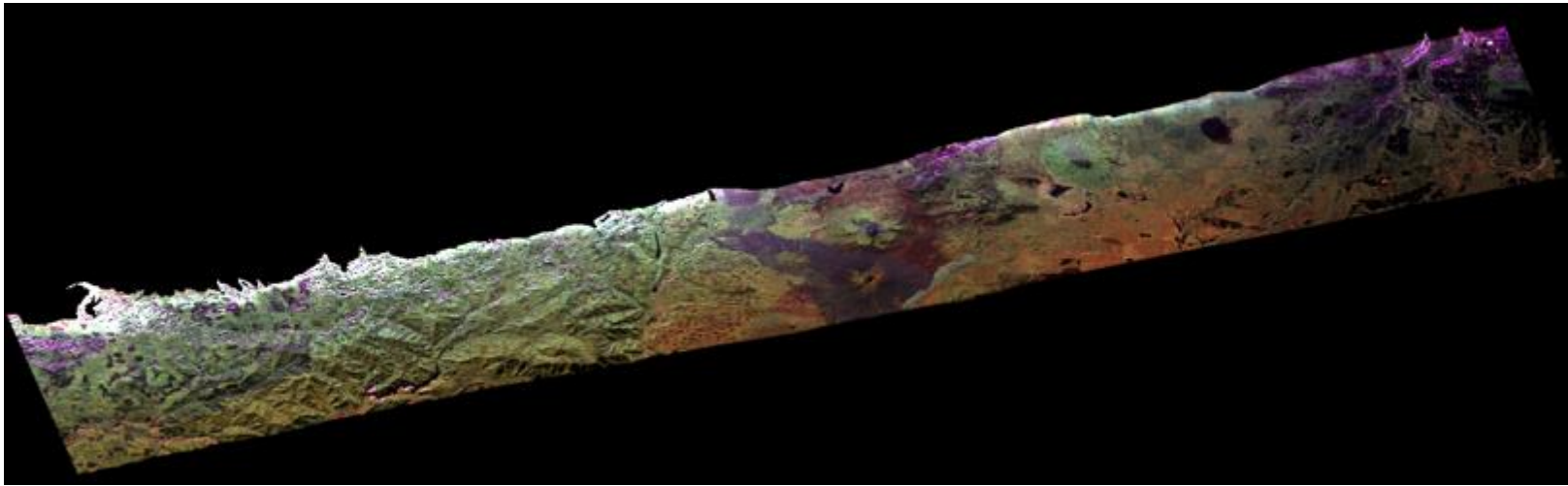
9/20/2012

HH/HV/VV RGB overlay

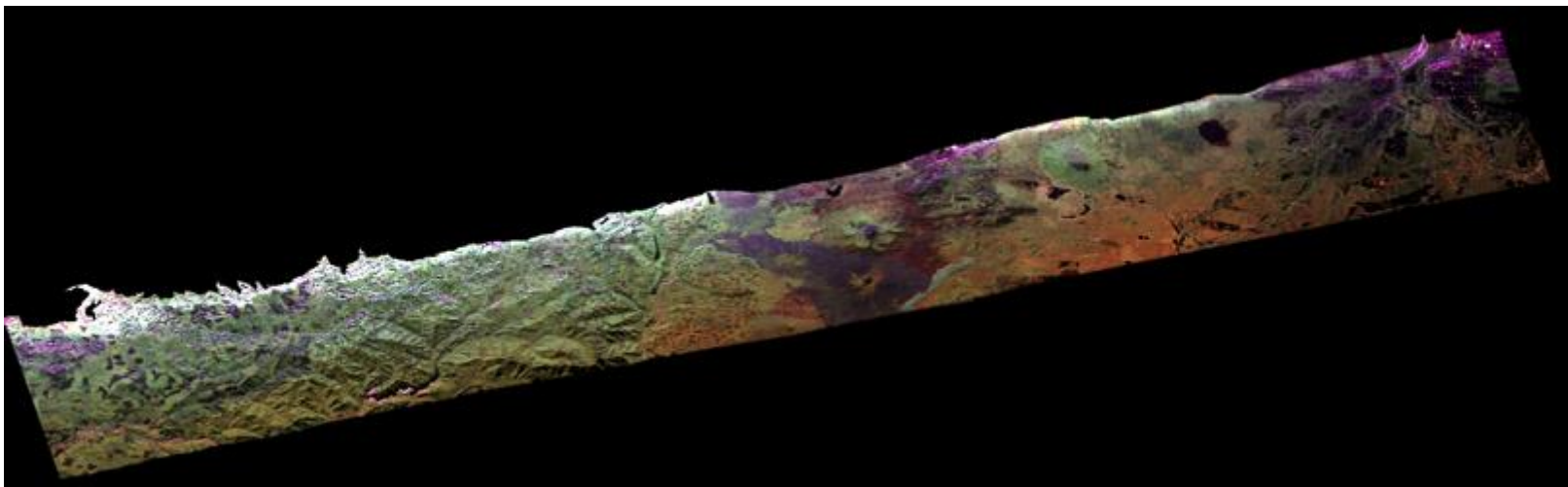


# Metolius Images

Metolius, Oregon: 10/7/12

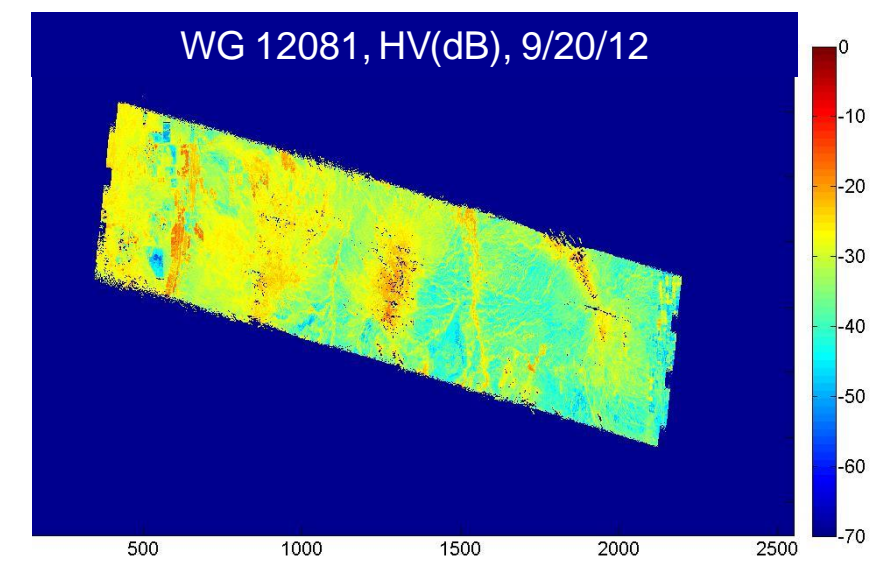
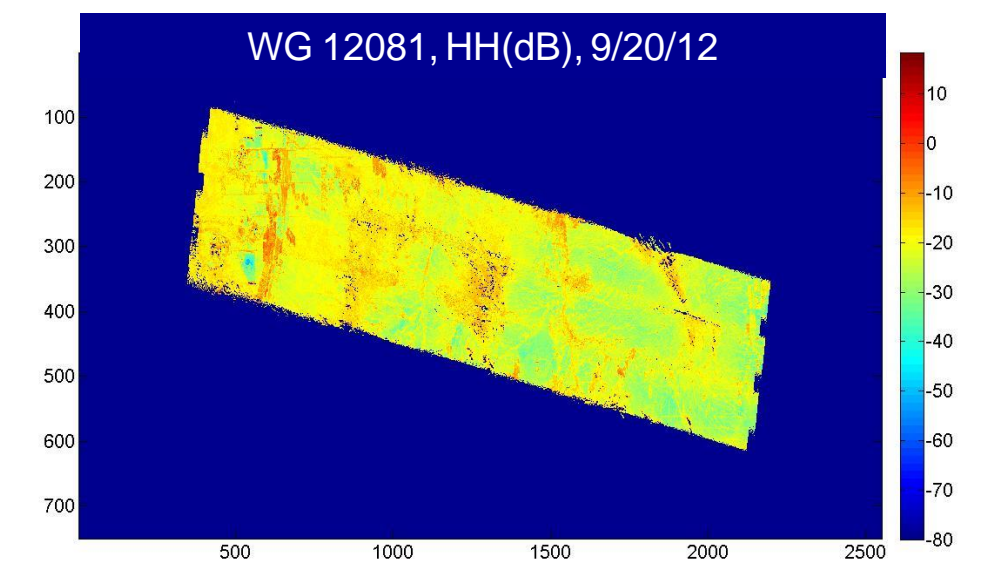
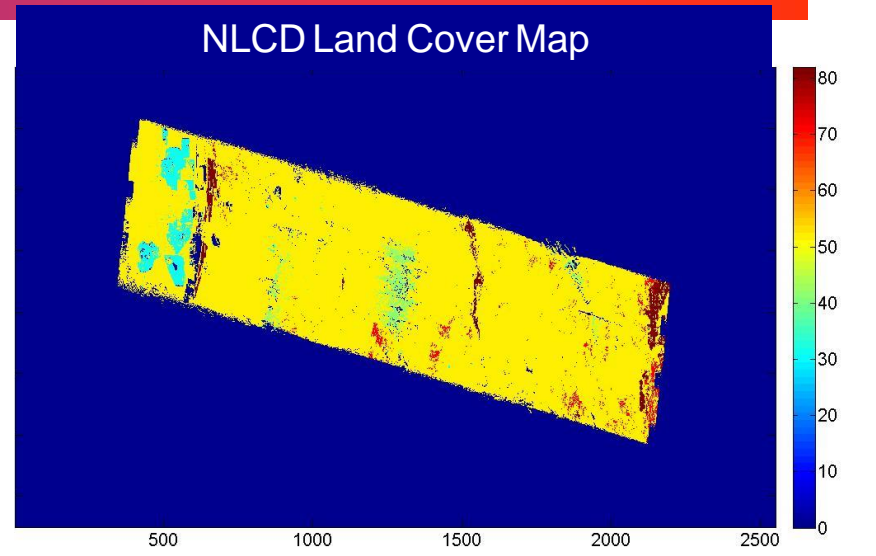
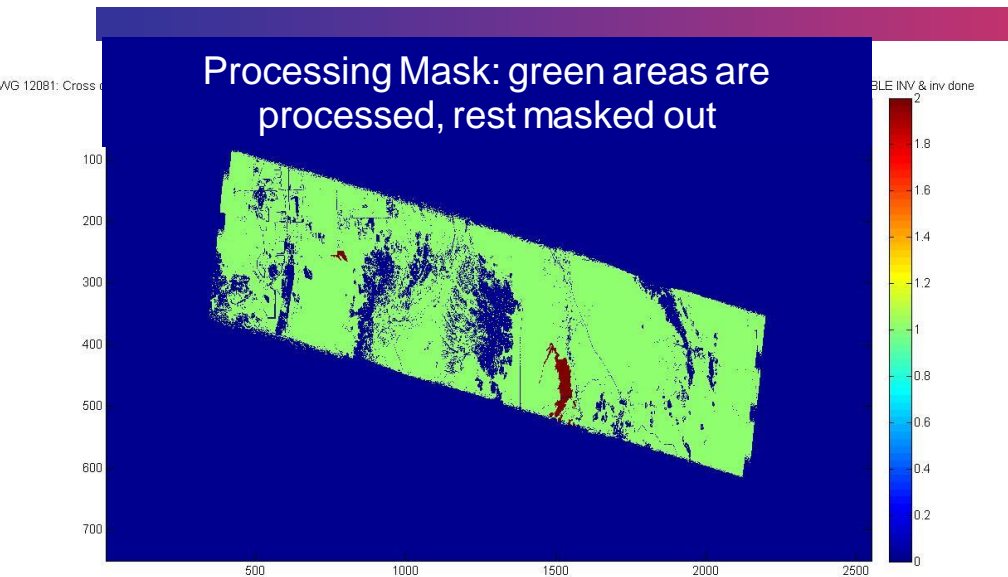


Metolius, Oregon: 10/10/12



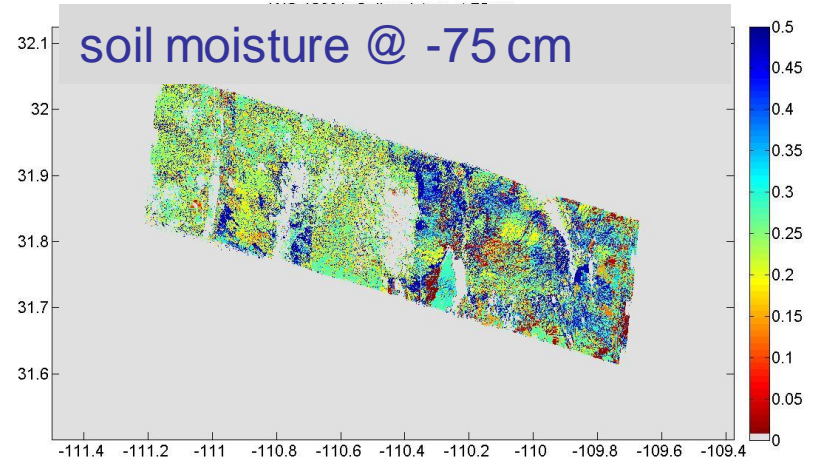
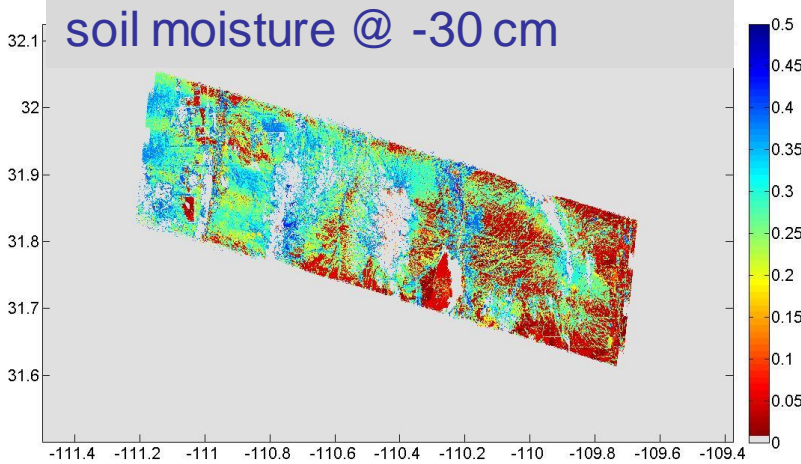
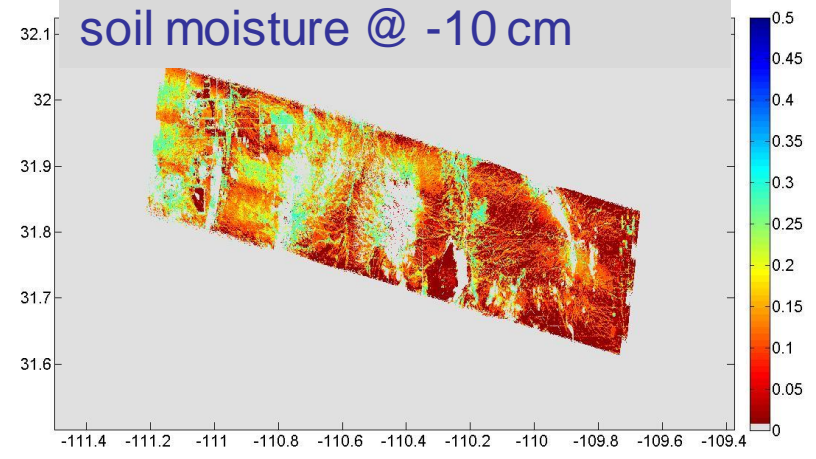
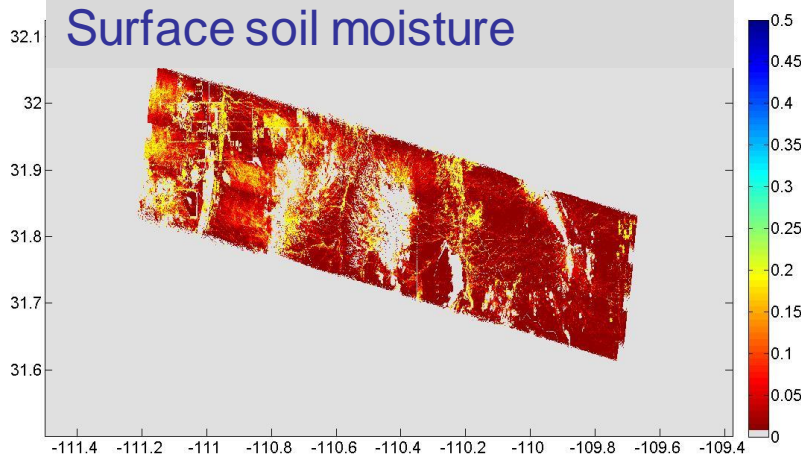
# Walnut Gulch Retrievals (1)

Mask, Land cover, Radar data



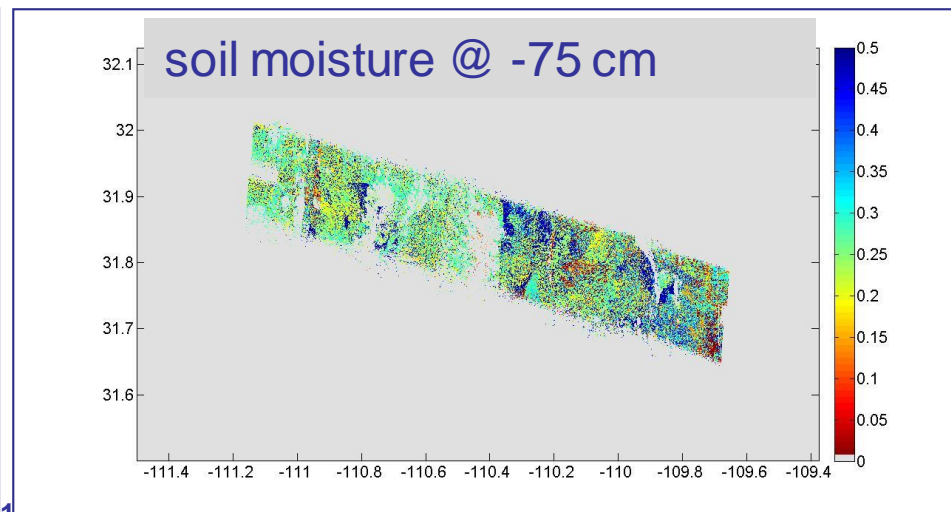
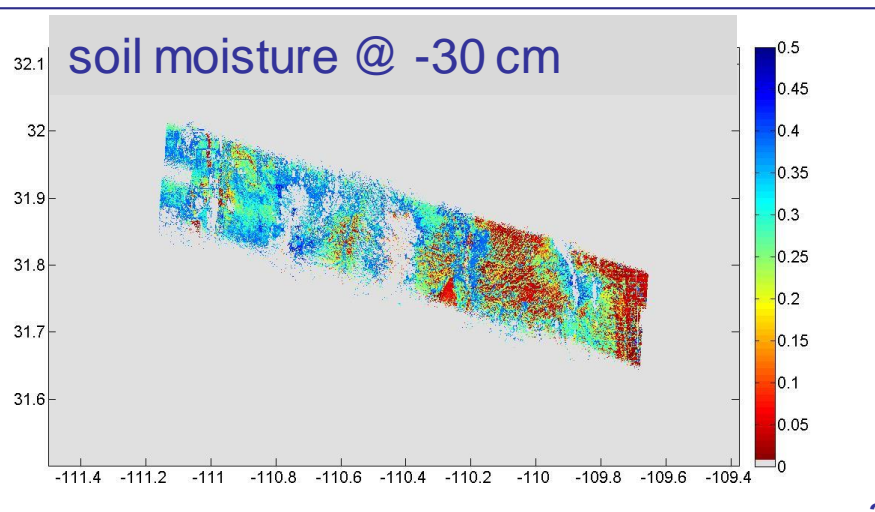
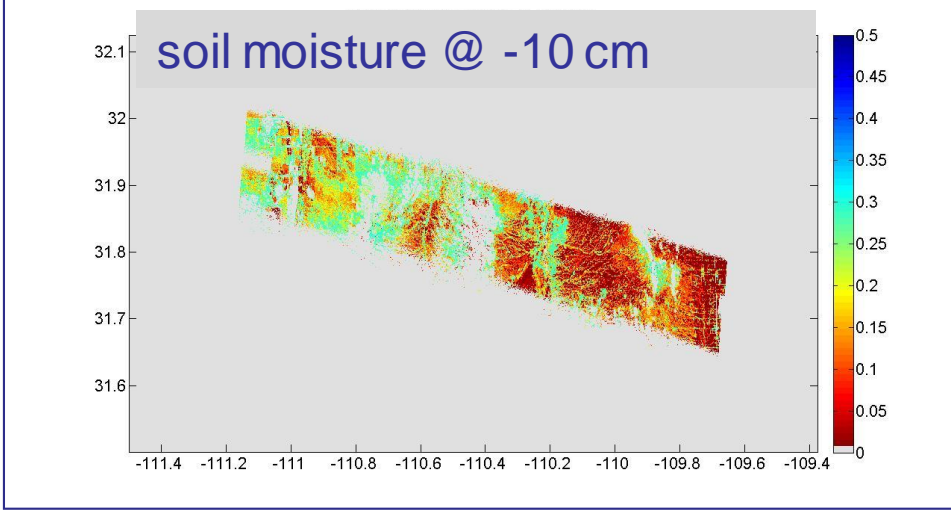
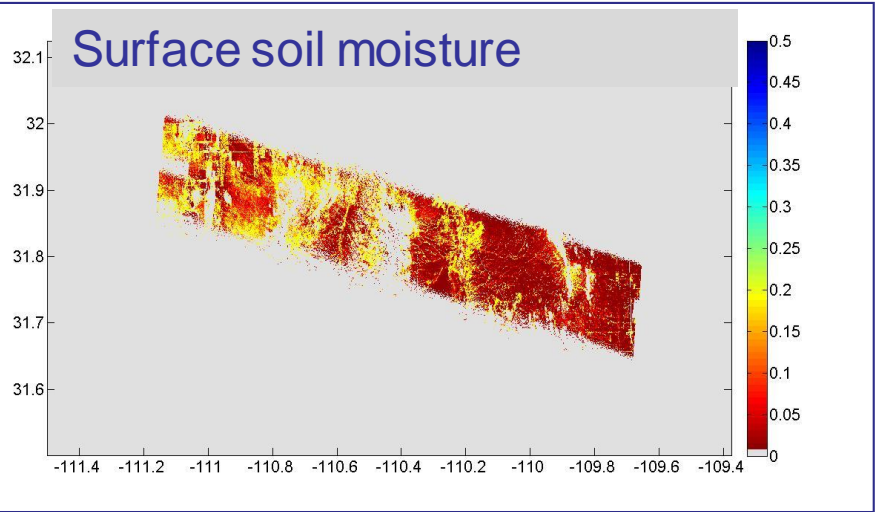
# Walnut Gulch Retrievals (2)

## Soil moisture at 0, 10, 30, 75 cm on 9/20/2012



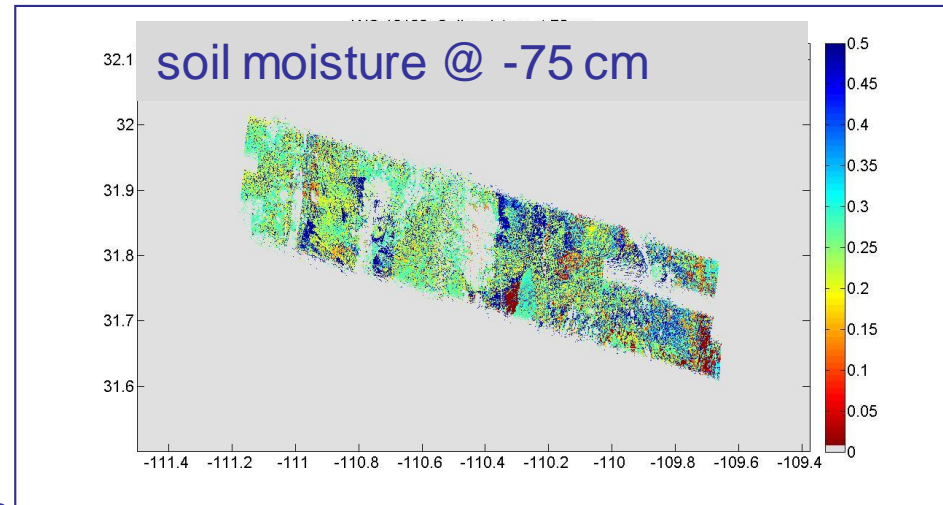
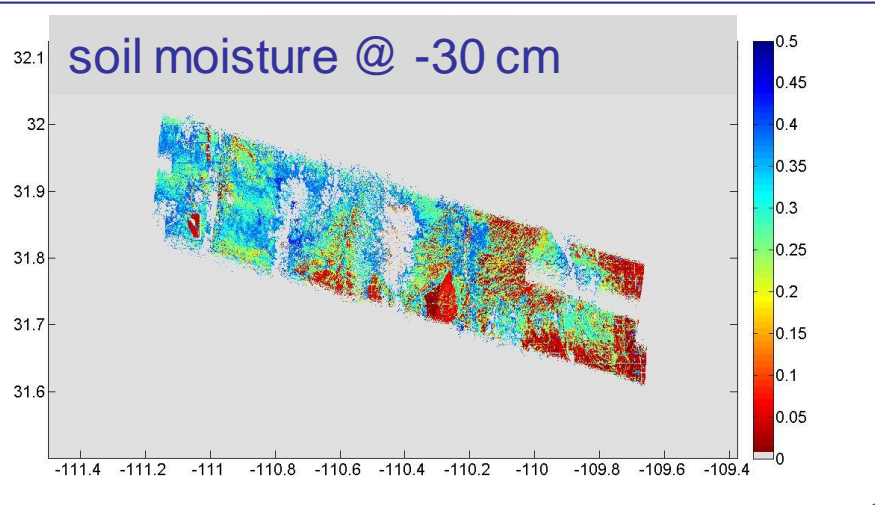
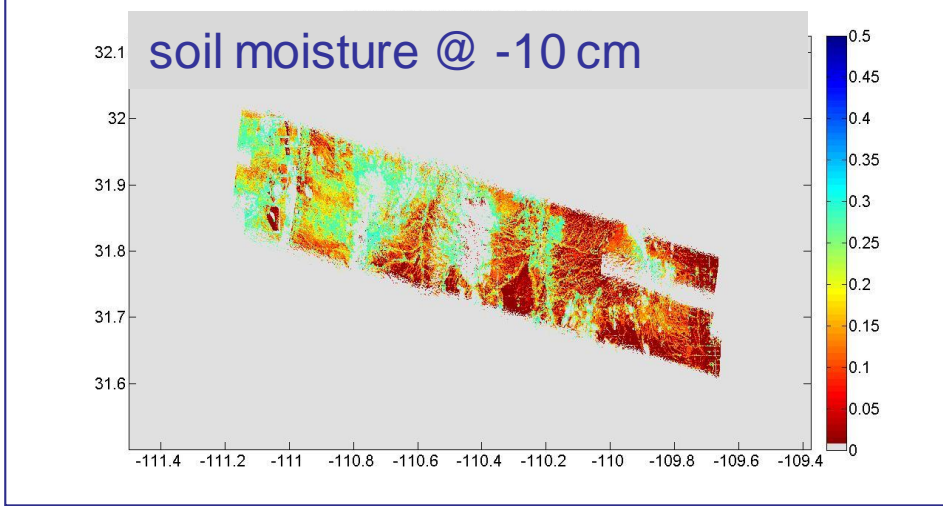
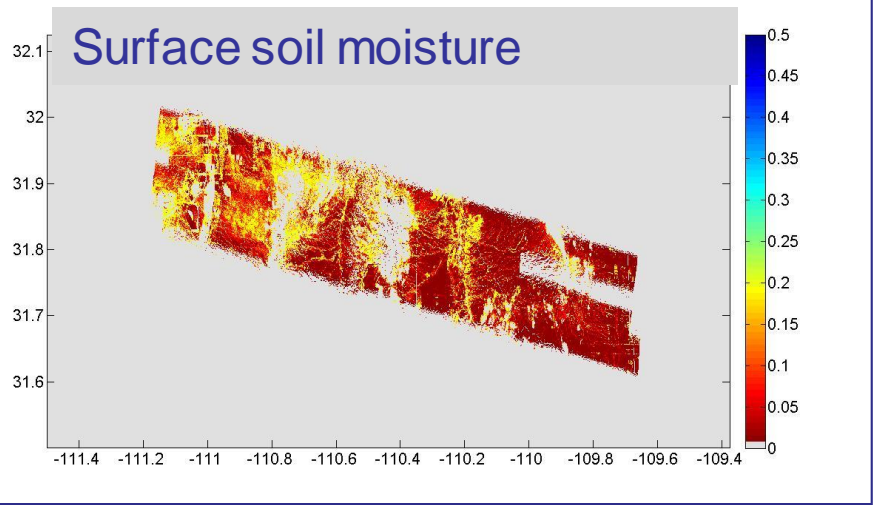
# Walnut Gulch Retrievals (3)

## Soil moisture at 0, 10, 30, 75 cm on 10/23/2012



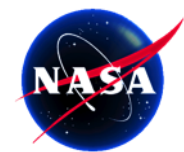
# Walnut Gulch Retrievals (4)

## Soil moisture at 0, 10, 30, 75 cm on 10/29/2012

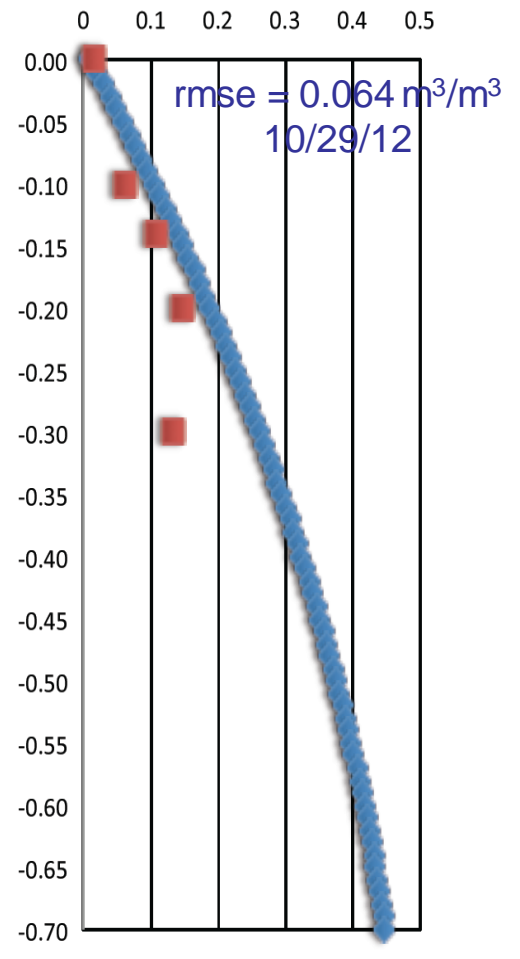
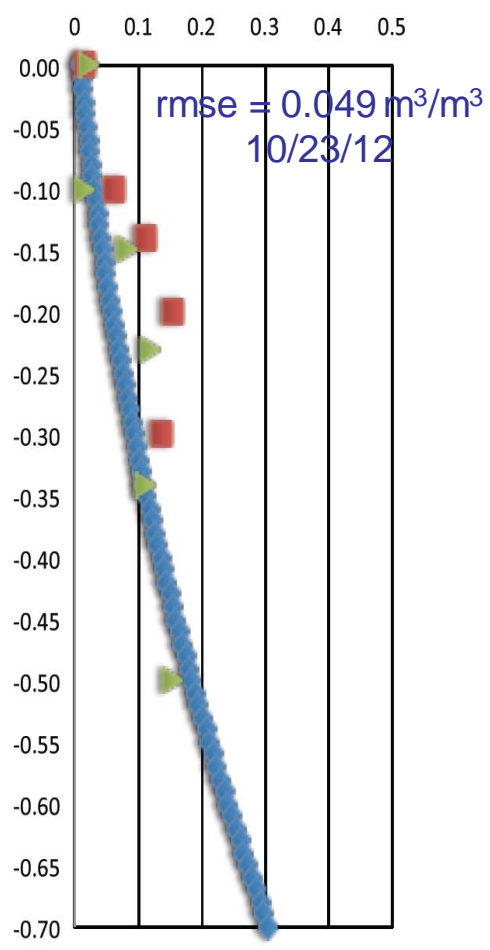
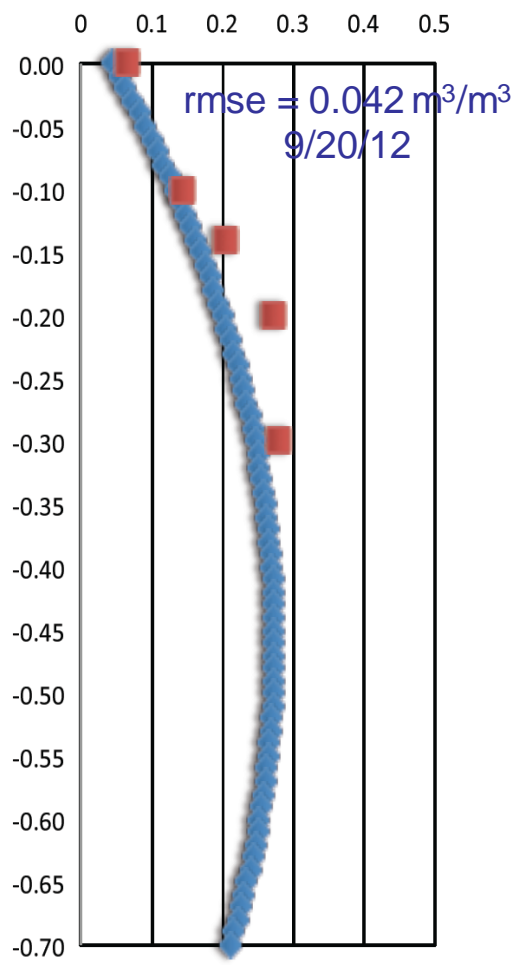


- Permanent profile data provided by USDA-ARS in Arizona
- USC also measured soil moisture over two transects during overflights on 9/20/12
- 2<sup>nd</sup> order polynomial profile model seems to be suitable for the depths considered
- In-situ data are patchy; need to look into missing points in profile
- In-situ profiles shown are from the flux tower locations needed for baseline validation. Still have two other permanent profiles in the area that can be used for further validation; also have several sample points on the overflight day, so will have plenty of other validation points
- Retrievals are over-estimates w/r to 10/29/12 but under-estimates w/r to 9/20/12 and 10/23/12; residual calibration errors are not yet ruled out

# L2/3-RZSM Walnut Gulch Validation (1)



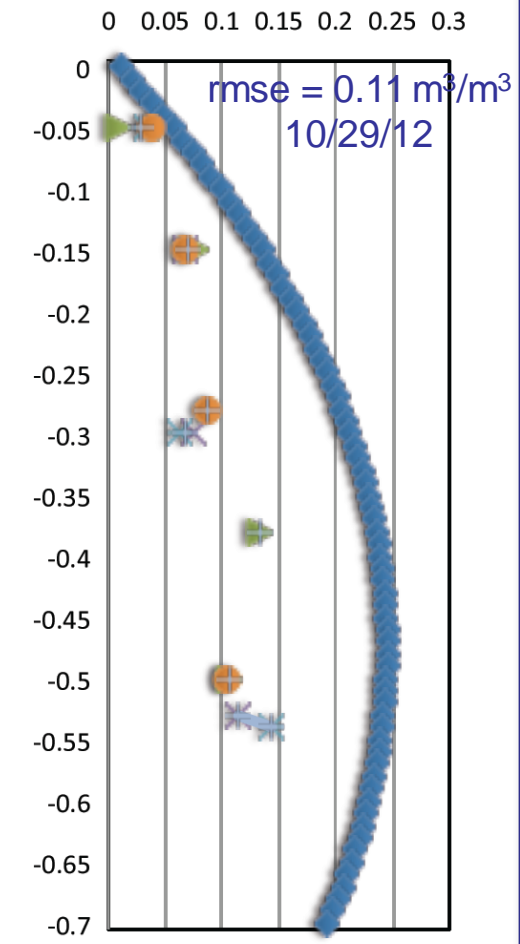
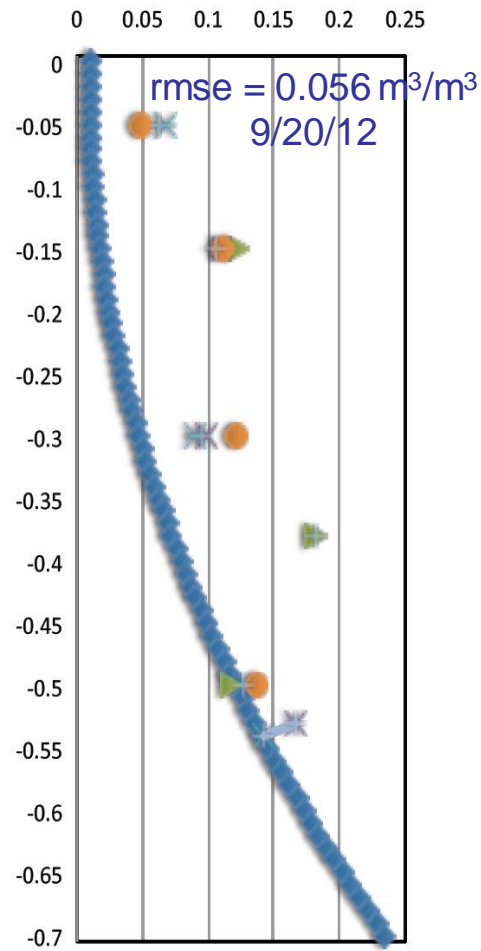
## Kendall Grassland









Retrieved Profile 4 (Ungrazed) Profile 6 (Ungrazed)



## Lucky Hills Shrubland

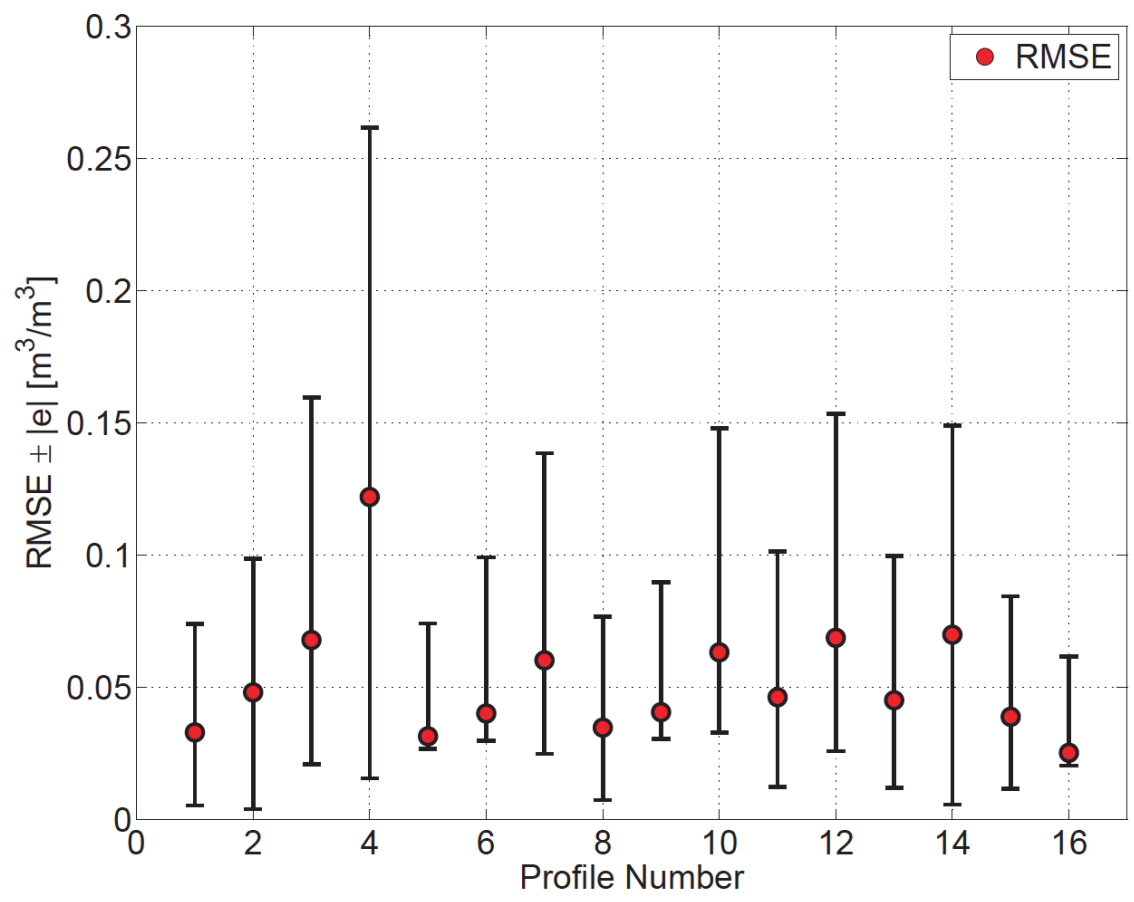


-  Retrieved
-  Profile 3 (Bare)
-  Profile 4 (Shrub)
-  Profile 5 (Shrub)
-  Profile 6 (Bare)
-  average

# L2/3-RZSM Walnut Gulch Validation (4)



Results shown here are RMSE values between retrievals and manual sampling during overflights on 9/20/12 at Lucky Hills; 16 locations were sampled, each to 30-40 cm depth.










- Will repeat retrievals jointly with L-band UAVSAR as soon as data are available
- USC L2/3-RZSM processor is in full production mode
  - Computation time for each RZSM profile map is on the order of two days on the Ames NEX cluster
  - Walnut Gulch processing for the 2012 campaign is done but we may want to re-run to improve the accuracy, after the other sites are done; also waiting for UAVSAR release to do dual-frequency retrievals
  - All other sites are currently awaiting soil layer ancillary data set; first version was found to have some inconsistencies and is being re-generated at Oregon State U
- JPL L2/3 processing team, responsible for mixed forest site retrievals, is using a different algorithm and is expected to release their products soon
- L2/3-RZSM products will be released publicly as they are processed and validated

# 2013 Campaign Schedule



Biome	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Calibration flights at Rosamond												
Tonzi Ranch, CA												
La Selva, Costa Rica												
Chamela, Mexico												
Metolius, OR												
BERMS, Saskatchewan												
MOISST, OK												
Walnut Gulch, AZ												
Howland & Harvard Forests, ME/MA & Duke Forest, NC												

-  Desirable period for science observation
-  Tentative placeholder for flights, which falls in the desirable period
-  Not suitable for science observation
-  G-III not available
-  only in 2013 and 2014 since already had one campaign in 2012
-  Beale compatibility tests at Tonzi ranch
-  Window for calibration flights at Rosamond