# Inversion Techniques for Soil Moisture

## PASSIVE

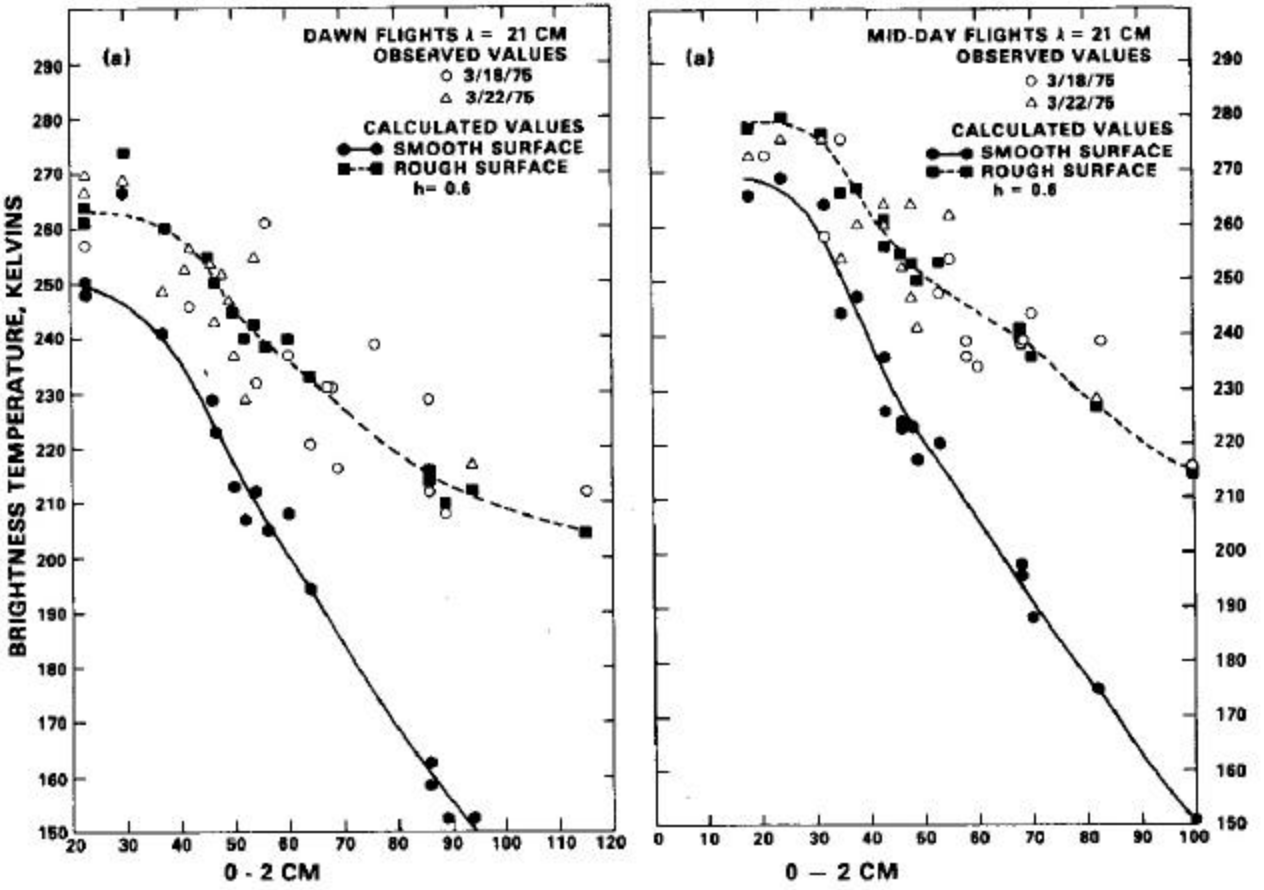
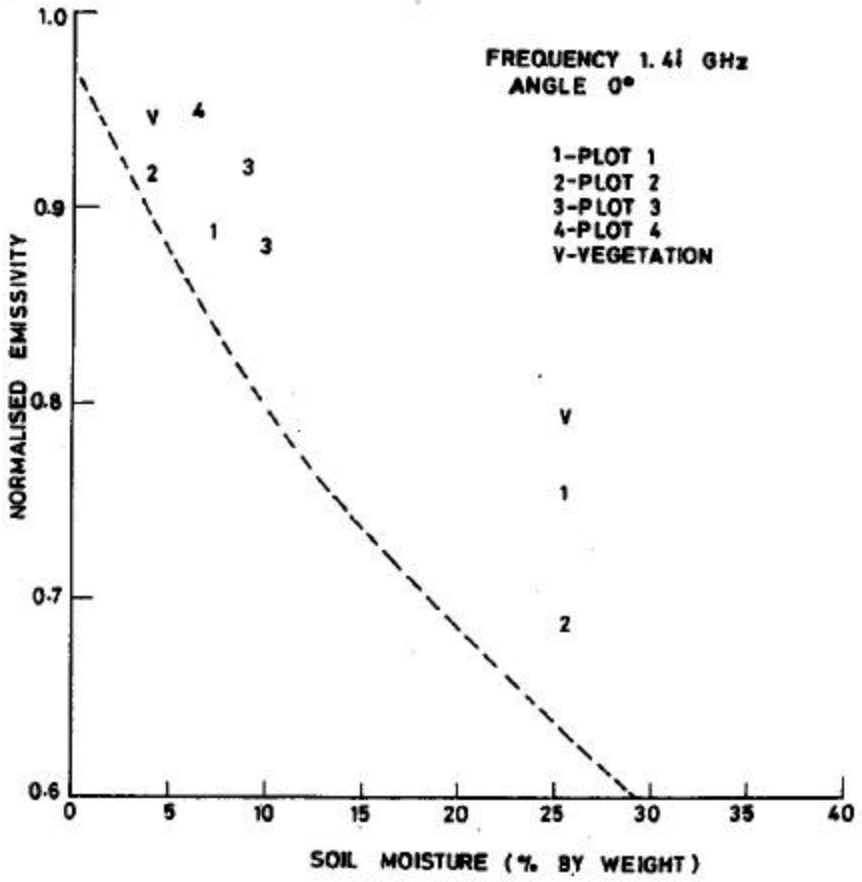
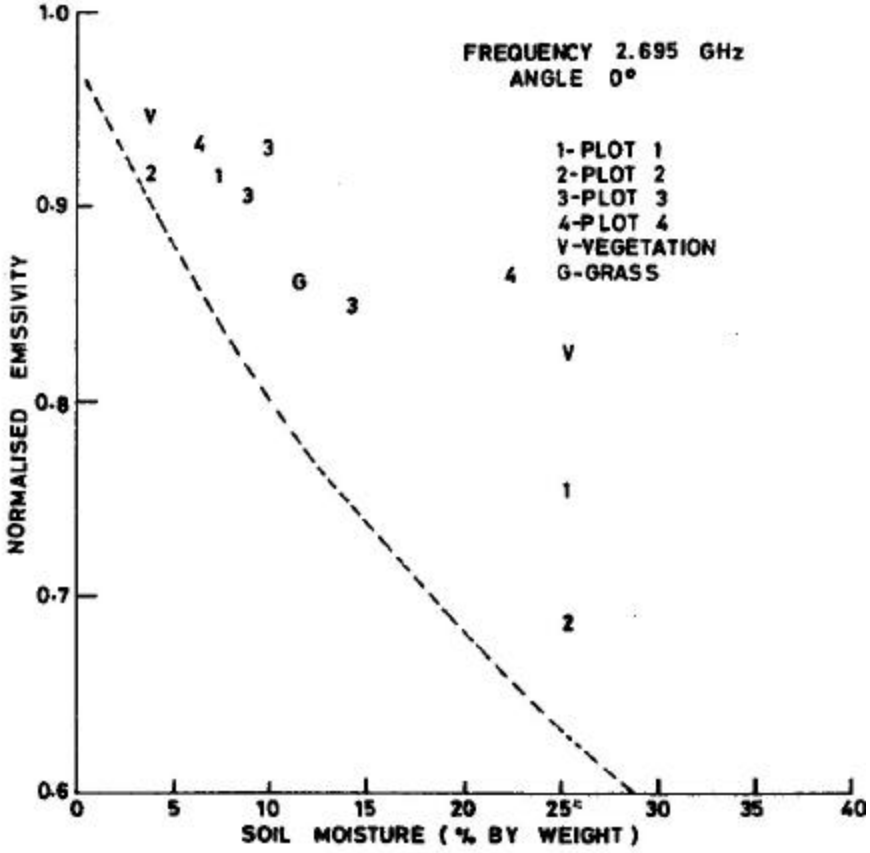



Fig. 10. Aircraft observations of $T_B$ over agricultural fields around Phoenix, Arizona, from March 1975 flights for both early morning and midday flights.

$$SM_v = a_1 + a_2.e + a_3.e^2 + a_4.e^3 + a_5.e^4$$



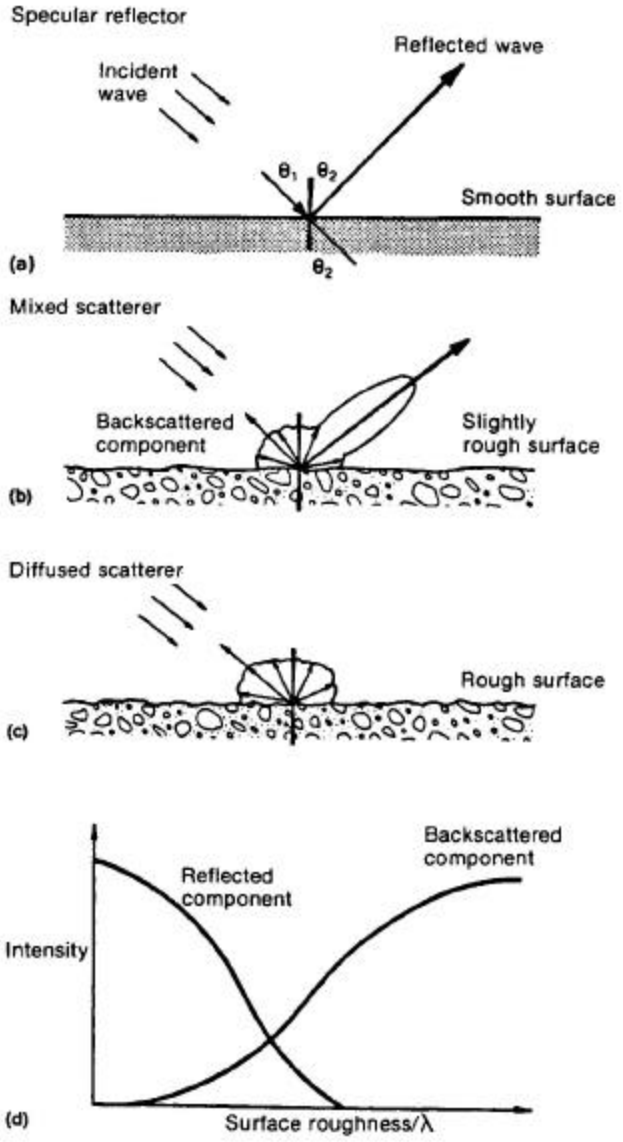
# Surface Roughness

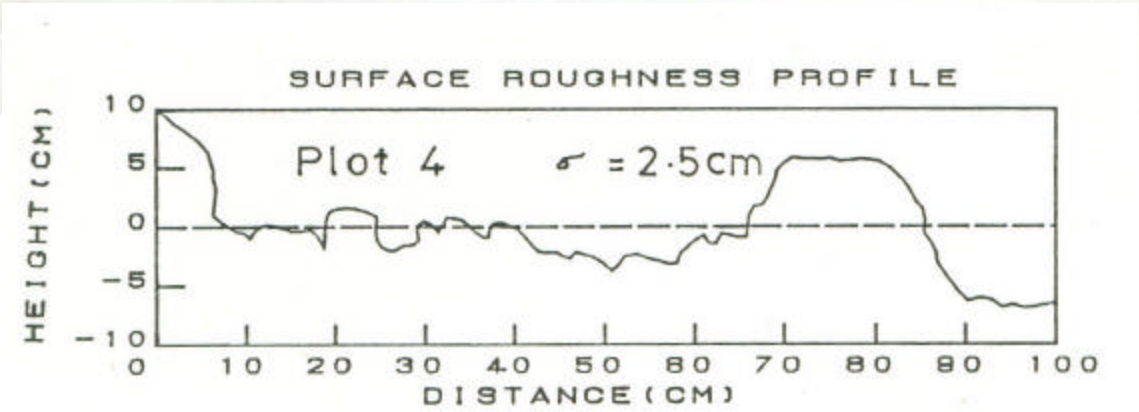
$$s = \sqrt{\frac{1}{N-1}\left(\sum (z)^2 - N(\bar{z})^2\right)}$$

$$h = 4s^2\left(\frac{2p}{l}\right)^2$$

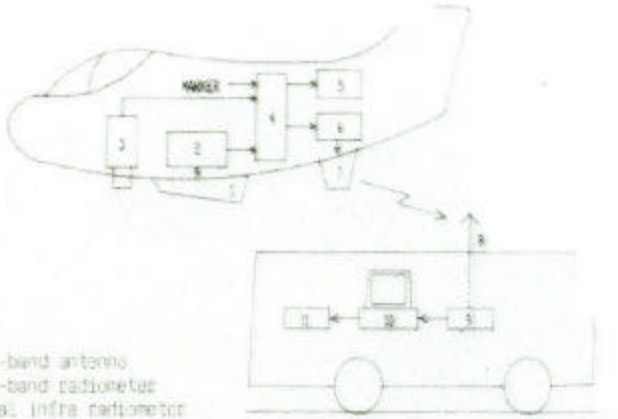
$$e_r = 1 - (1 - e_s)e^{-h\cos^2 q}$$

| s | X-band | C-band | L- |
|---|---|---|---|
| 0.05 | smooth | smooth | smooth |
| 0.5 | rough | interm. | smooth |
| 1.5 | rough | rough | interm. |
| 10.0 | rough | rough | rough |

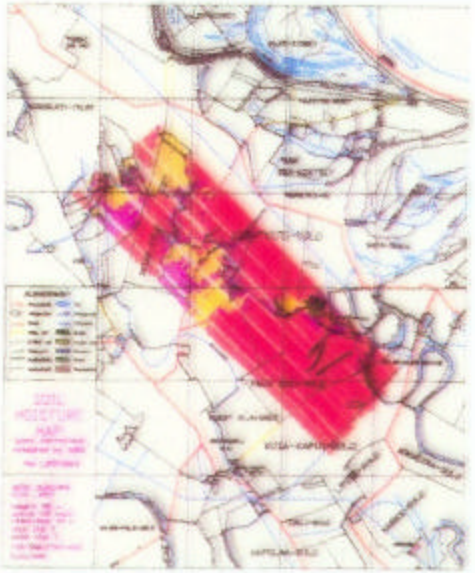


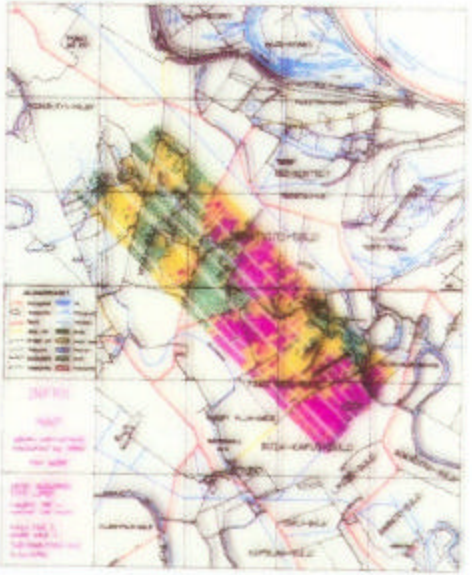

SURFACE ROUGHNESS PROFILE
Plot 4
σ = 2·5cm
HEIGHT (CM)
10
5
0
−5
−10
0
10
20
30
40
50
60
70
80
90
100
DISTANCE (CM)

# Passive Microwave Remote Sensing of Soil Moisture



1. L-, S-band antenna
2. L-, S-band radiometer
3. Thermal infra radiometer
4. Airborne data collection system
5. Airborne data recorder
6. Telemetry transmitter
7. Telemetry antenna
8. Telemetry receiver antenna
9. Telemetry receiver
10. IBM PC/AT computer
11. Printer/plotter





$$\%M_v = -119.05\ e + 115.45$$

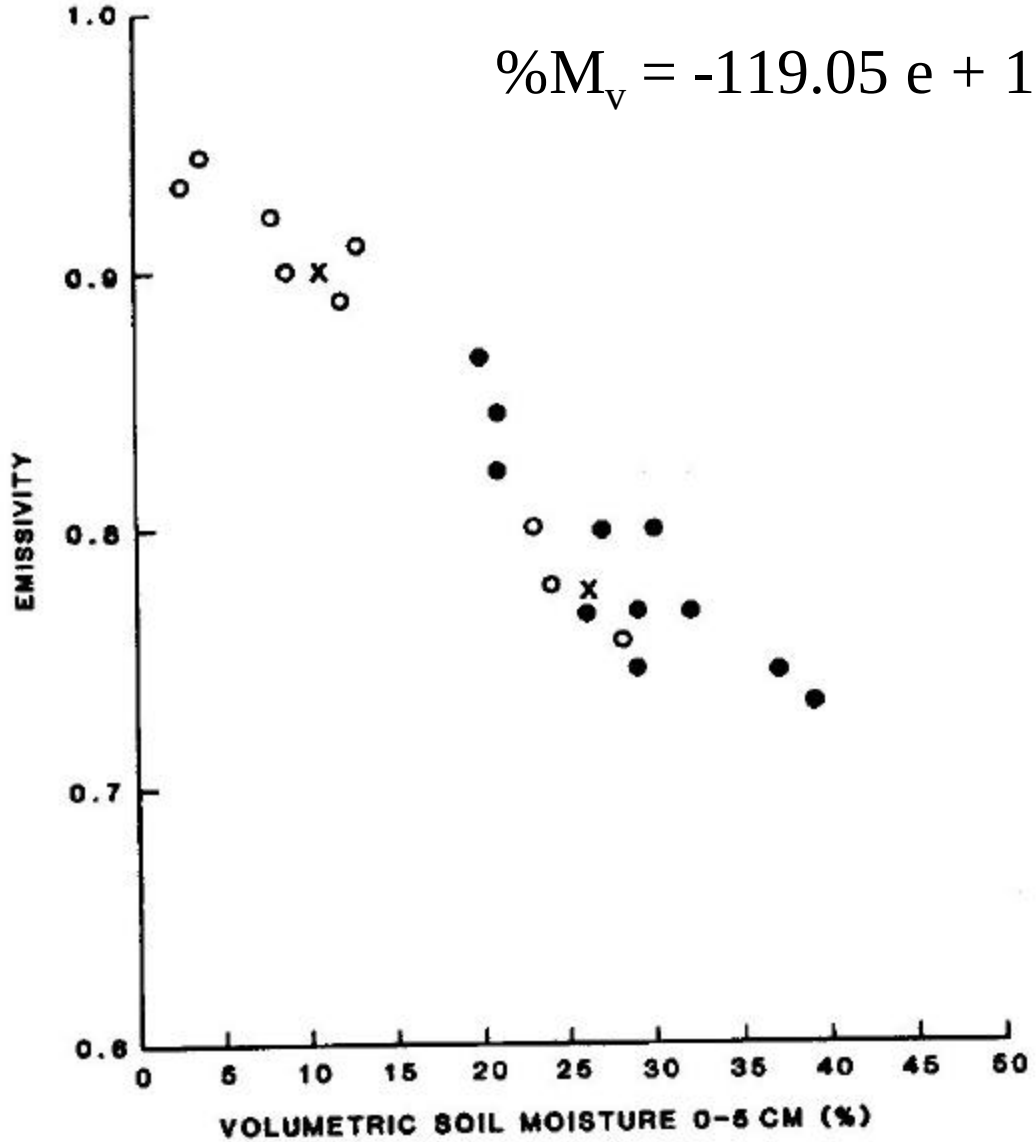



FIG. 11. Aircraft emissivity and soil moisture observations over rangeland watersheds; $\lambda = 21$ cm, $\theta = 0°$, H polarization. ●, 1978 data; ○, 1980 data; X, high-altitude data. [From Jackson *et al.* (1984).]

# Vegetation Covered Soil

$$e_v = 1 + (e_s - 1)\exp(-bW)$$

b is a constant and depends on crop type and frequency

W – Vegetation water content $g/m^2$

# Soil Moisture Estimation using Passive Microwave Data

$$c^2 = \sum_{i=1}^{6} \left( \frac{T_{Bi}^{obs} - \Phi_i(x)}{s_i} \right)^2$$

$$c = \begin{bmatrix} m_e \\ w_e \\ T_e \\ q_v \end{bmatrix}$$

**$T_{bi}$ – Observed Brightness Temperature at 6.6, 10.7 and 18 GHz (HH, VV polarizations)**

**$F_i$ – Calculated $T_B$ values**

**$s$ - Measurement noise Standard deviation for each channel**

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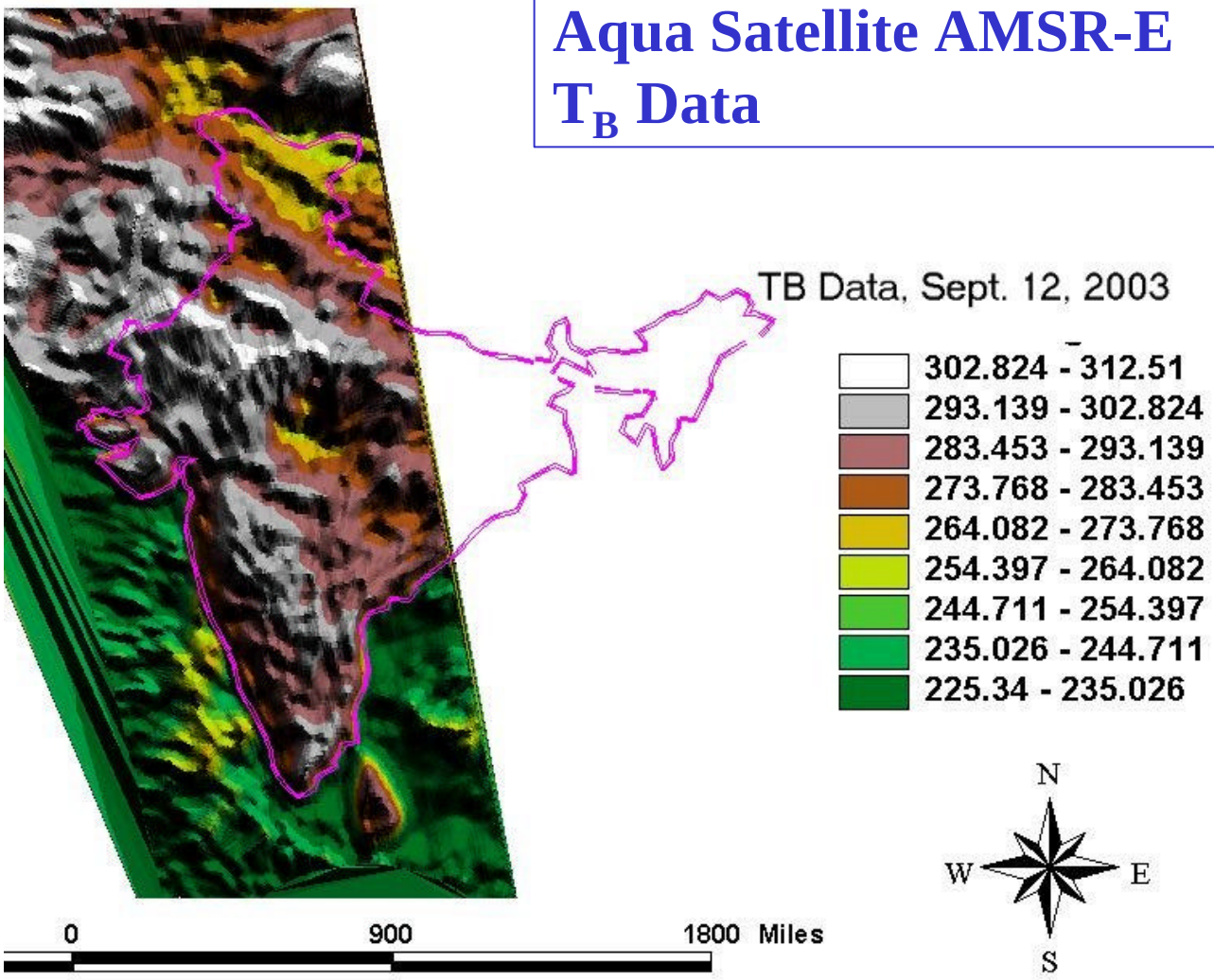
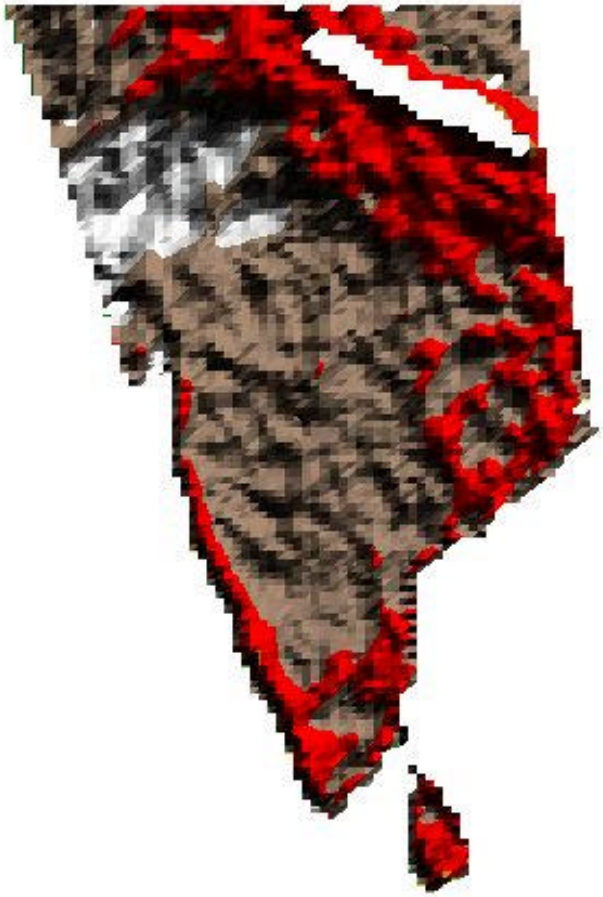
6.9TBH in Sep 2003

# Aqua Satellite AMSR-E $T_B$ Data



# SoilMoisture, 26th Feb, 2004



Breaklines

Hard

Soft

Elevation Range

40 - 50

35 - 40

30 - 35

25 - 30

20 - 25

15 - 20

10 - 15

5 - 10

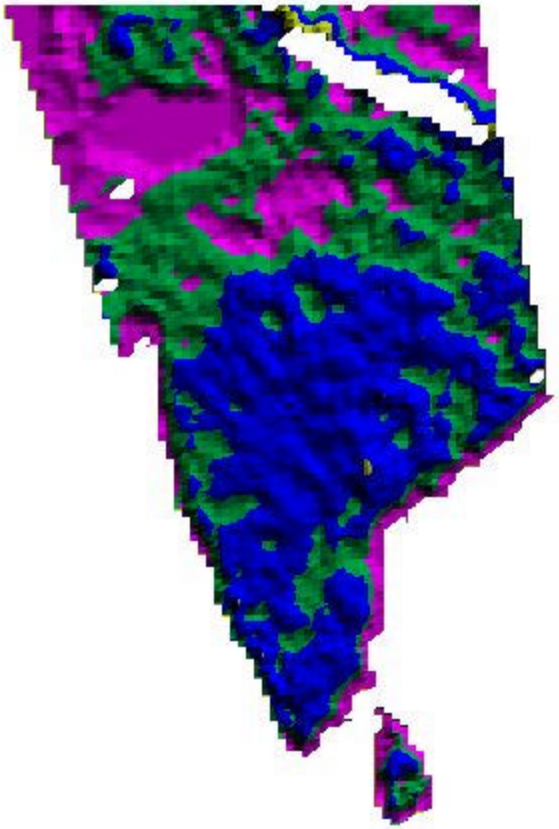
0 - 5

N

W

E

# Veg_water, Kg/m2, 26th Feb. 2004



**Breaklines**

Hard

Soft

**Elevation Range**

8 - 10

7 - 8

6 - 7

4 - 6

3 - 4

2 - 3

1 - 2

0.5 - 1

0 - 0.5

N

W E

S

00 0 900 1800 Miles

# Soil Moisture Estimation using Active Microwave Data

## ACTIVE

## IEM Model (ERS-2 SAR Data, $c_{vv}$ )

$$s^{0}_{pq} = \frac{k^{2}}{2}\exp(-2k_{z}^{2}s)\sum_{n=1}^{\infty} s^{2n}\left|I^{n}_{pq}\right|^{2}\frac{W^{n}(-2k_{x},0)}{n!}$$

$$sm_{v} = (-530 + 292e - 5.5e^{2} + 0.043e^{3})\times 10^{-4}$$

# Empirical Retrieval Model (ENVISAT)

**C-hh and C-vv**

$$s^0_{hh} = 10^{-2.75} \frac{\cos^{1.5} q}{\sin^5 q} 10^{0.028 e \tan q} (kh \sin^{1.4} q)^{l^{0.7}}$$

$$s^0_{vv} = 10^{-2.35} \frac{\cos^3 q}{\sin^3 q} 10^{0.046 e \tan q} (kh \sin^3 q)^{1.1 l^{0.7}}$$

ε = Real part of Dielectric Constant

h = r.m.s. surface height

$$e = \frac{C_{vv}\left(s_{hh} - A_{hh}\right) - C_{vv}\left(s_{vv} - A_{vv}\right)}{\tan q\,(B_{hh}C_{vv} - B_{vv}C_{hh}}$$

$$h = \frac{l}{2p\sin q} 10^{\{[B_{hh}(s_{vv} - A_{vv}) - B_{vv}(s_{hh} - A_{hh})]/[B_{hh}C_{vv} - B_{vv}C_{hh}]\}}$$

$$A_{hh} = 1.5\log(\cos q) - 5\log(\sin q) + 0.7\log(l) - 2.75$$

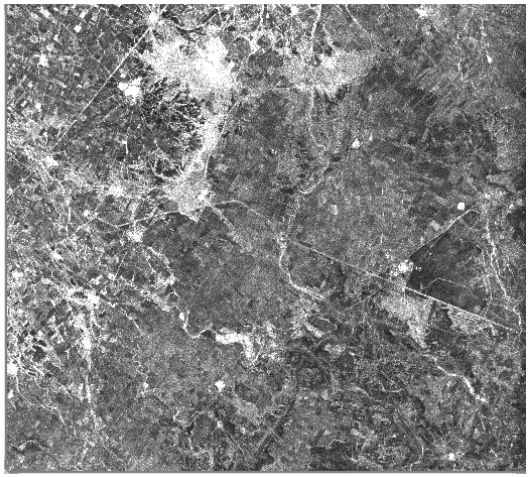
$$A_{vv} = 3\log(\cos q) - 3\log(\sin q) + 0.7\log(l) - 2.35$$

$$B_{hh} = 0.028 \qquad B_{vv} = 0.046$$

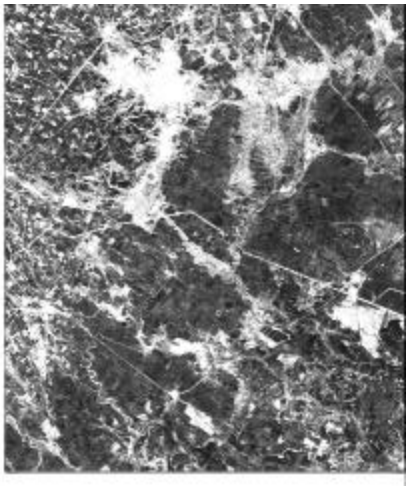
$$C_{hh} = 1.4 \qquad C_{vv} = 1.1$$

$$s_{hh} = \log(s^{0}_{hh}) \qquad s_{vv} = \log(s^{0}_{vv})$$

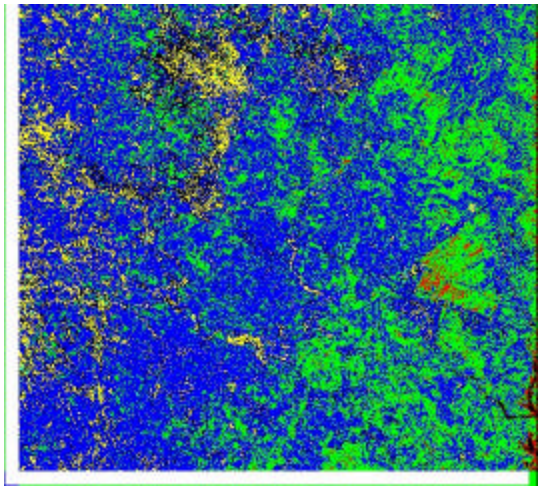
April 14, 1994

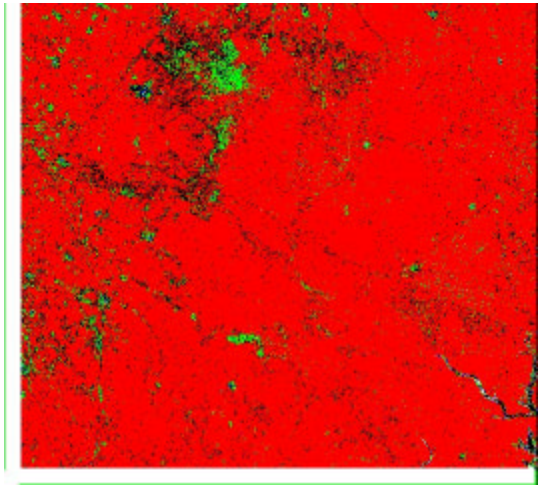


Oct. 5, 1994

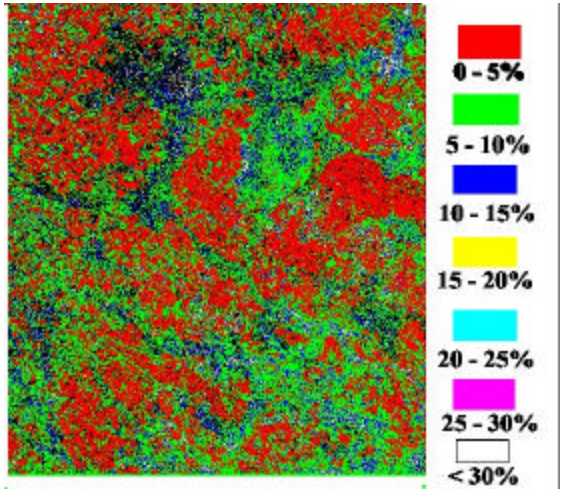


Soil Roughness

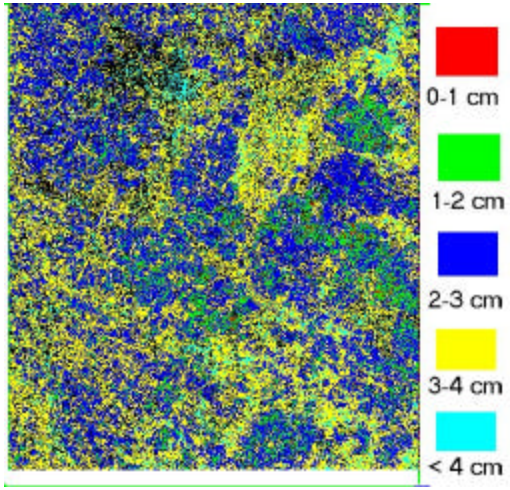




Soil Moisture




Soil Moisture




Soil Roughness