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APPLICATIONS OF THE GROUND BASED RADIOMETERS ON SOIL MOISTURE RESEARCH IN VIETNAM

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OUTLINE

1. Brief introduction of the Space Technology in Vietnam
2. Applications of MW Radiometers for research soil moisture (SMC) & SST, SSS
3. Proposals for international cooperation

"STRATEGY FOR SPACE RESEARCH & APPLICATIONS UNTIL 2020"

- **Adopted :** in November 2006 , by Prime Minister of Vietnam
- **Objectives of the strategy :**

1 Receive then master the satellite technology until 2020

2. Promote applications of RS & GIS for natural resource, environment & disaster management

3. Develop infrastructure for space technology including: establish Space Technology Institute under VAST (11/2006), establish Vietnam Space Committee under Government (9/2010), develop ground stations, centers for satellite image processing, satellite -based communication and positioning systems, earth observation systems;

4. Promote the capacity building on human resource in space science and technology

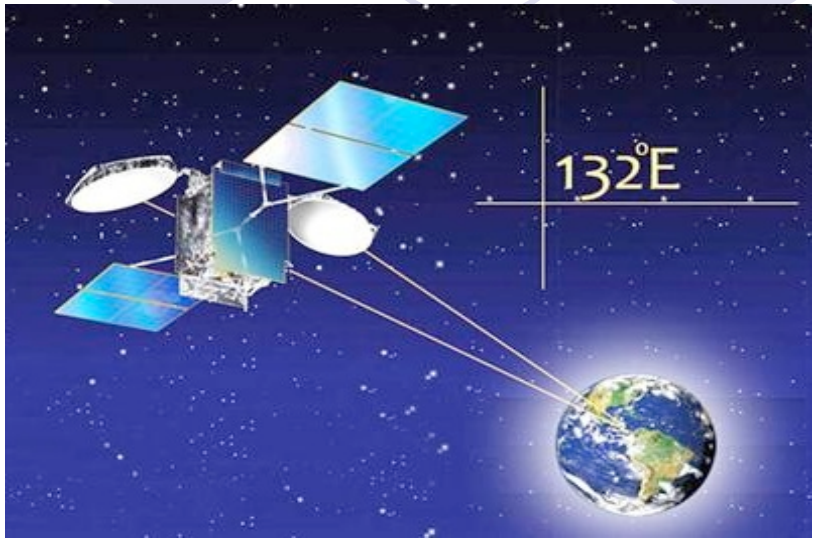
5. Promote international and regional cooperation on space S&T

SOME RECENT ACTIVITIES

Vietnam Space Center– HHTP

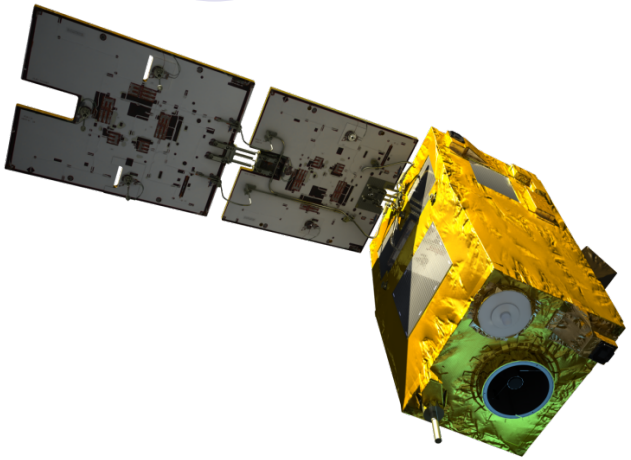
- Project for construction of VN Space Center (9ha) with blocks of R&D, AIT, test, small EO satellite, Training, Ground station, etc.
- Plan to develop & launch 2 EO Satellite (01 radar & 01 Optical) until 2020 with the support of Japan
- Financial source: Japanese ODA and Vietnamese budget
- Tentative duration of the Project: 2012-2020

Cooperation between Lockheed Martin Corp. – VNPT for manufacture & launch Communication Satellite **VINASAT-1**



- Mass: 2.800 kg. Height: 4 m.
- Launched 19/4/2008 by Ariane 5 from Kourou (French Guiana).
- Located: Geostationary orbit at 132^0E.
- Lifetime: at least 15 years.
- 12 transponders: 4 for KU - band, 8 for Extended C-band.
- Planned 2012: complete manufacture & launch VINASTA-2 with 20 transponders

Cooperation with Astrium EADS for VNREDSAT-1 project (Vietnam EO small satellite for natural resource, Environment & Disaster Management)



-Low orbit EO satellite, M = 120kgs

- Optical payload with spatial resolution : 10m/Multispectral and 2.5m/Panchromatic

- Revisit time: 3 days

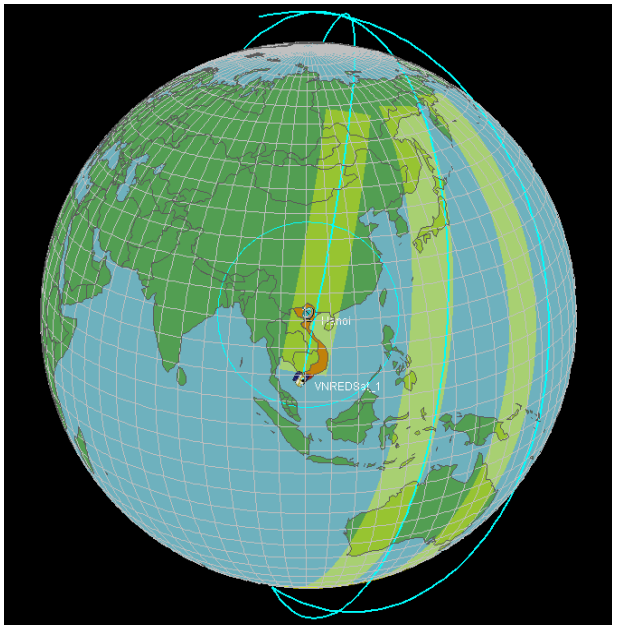
- Sun synchronous orbit, altitude 680 km

- Life time : 5 years

- The Project's budget opened 11/2010

-Team of 15 VN engineers will arrive Toulouse for training: 8/2011

- Tentative launched: 2013 – 2014



VNREDSAT-1 Project

The Project is underway

National Research Program on Space Science and Technology

Purpose: Promote human resource & infrastructure on Space S&T of Vietnam

From 2008-2010: MOST - VAST funded ~ 1.5 millions USD for 17 research projects with the main topics:

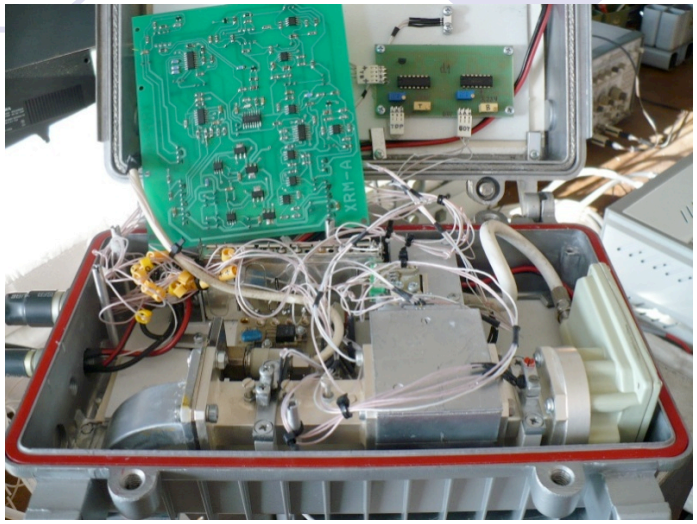
- Small satellite technology.
- GPS, launching techniques.
- RS,GIS applications for natural resource, environment & disaster management
- Legislation basis for peaceful use of outer space.
- Instruments and ground receiving station technique.
- Fundamental research on space science and technology.

Project topics have been approved:

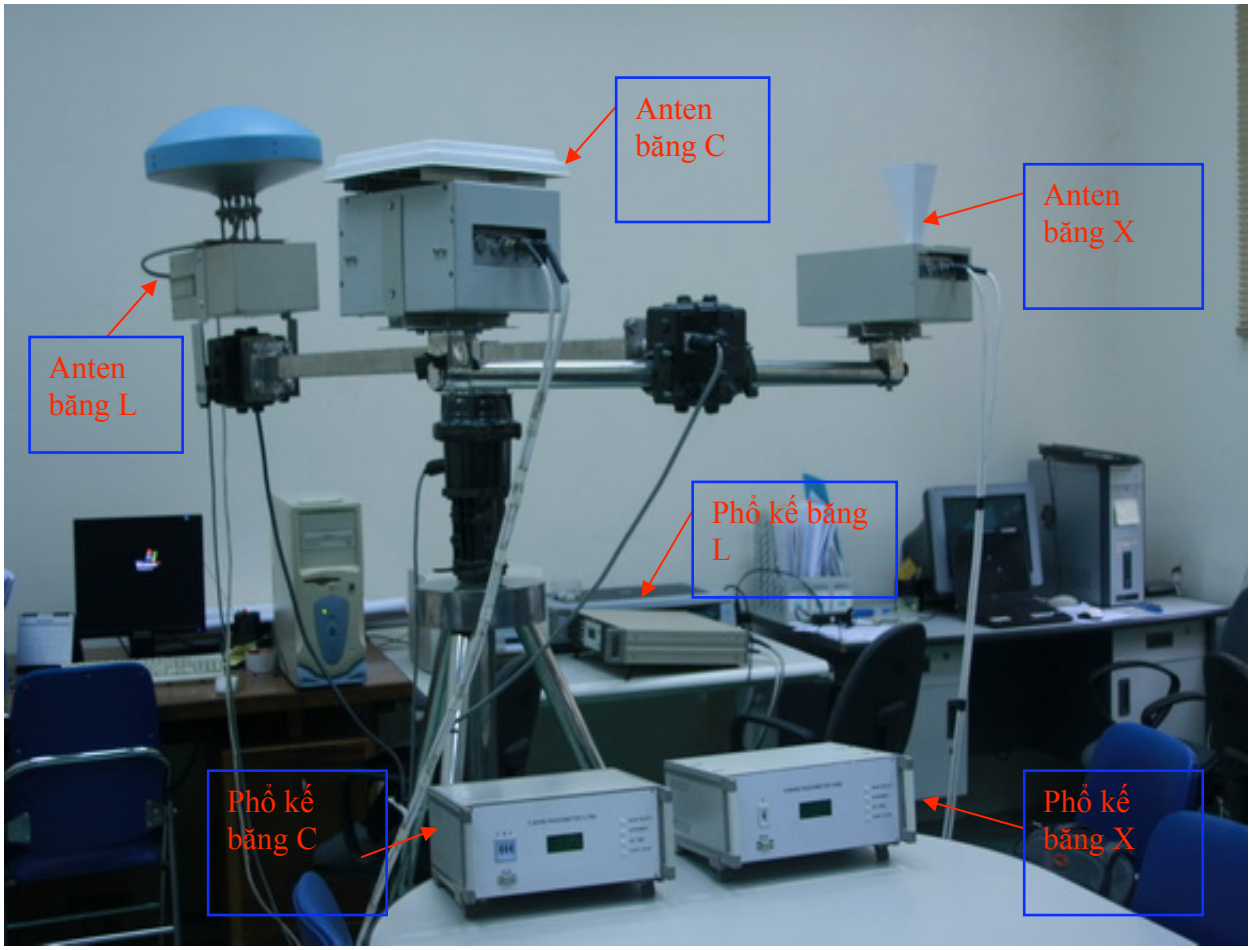
- Simulation and software for small satellite technology
- Testbeds for testing vibration, posture of small satellite
- Optical payload low resolution
- Highly accurate GPS applications for construction
- GRASS software for images processing
- Magnetic sensors used for spacecraft control
- Launching technique
- Research on a legal framework for peaceful use of outer space
- Energy transference from space
- Nano materials used in space environment

- *Soil moisture monitoring using A/P remote sensing ?*

Cooperation with Bulgarian Academy of Sciences for manufacture of MW Radiometers



MW Radiometers (L,C,X-bands) of STI, VAST - 2010

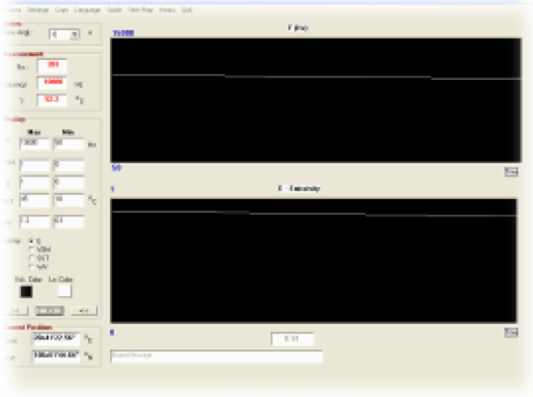


Applications of RDMs for research of soil moisture, vegetation water content & SST, SSS

- Since 2000 – 2010: design and manufacture 03 microwave radiometers (L, C, X bands).

RDM type	L - band	C - band	X -band
Frequency	1.4 GHz	3.5 – 3.7 GHz	10.9–11.2 GHz
Bandwidth	<40 MHz	<30 MHz	<30 MHz
Sensitivity	<0.3K	<0.3K	<0.3K
Integ.time	1 s	1 s	1 s
Antenna beam width	30^0	15^0	17^0
Input range	0-320 K	0 – 320 K	0 – 320 K

MW Radiometers

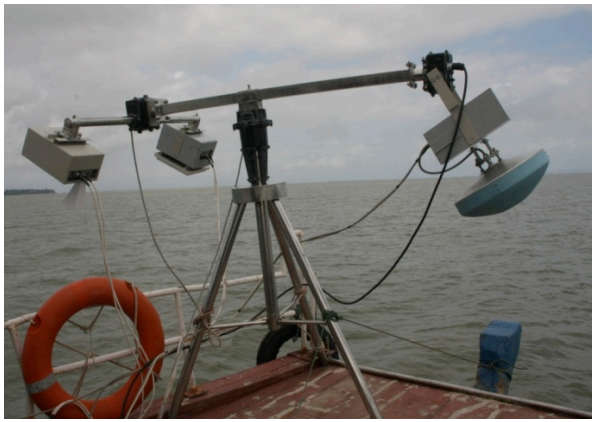


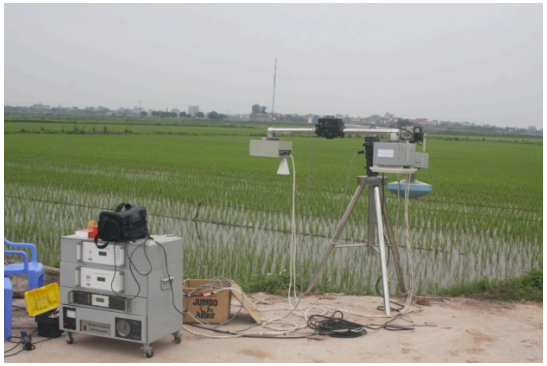
Software for RDM data receiving and processing

- Develop hardware & software for:
  - Programmed control Antenna (Incident, Azimuth angles)
  - Automatic receiving & processing data from radiometers
  - Integration GPS signal to RDM data processing

Applications of radiometers (RDMs) for RS of soil moisture in STI, VAST Vietnam

- 2000 – 2011: Manufacture RDMs & investigate them:
  - Soil moisture monitoring
  - Vegetation water content (rice, corn)
  - Sea surface temperature (SST), salinity (SSS)
  - Aerial remote sensing of soil moisture (SM mapping)

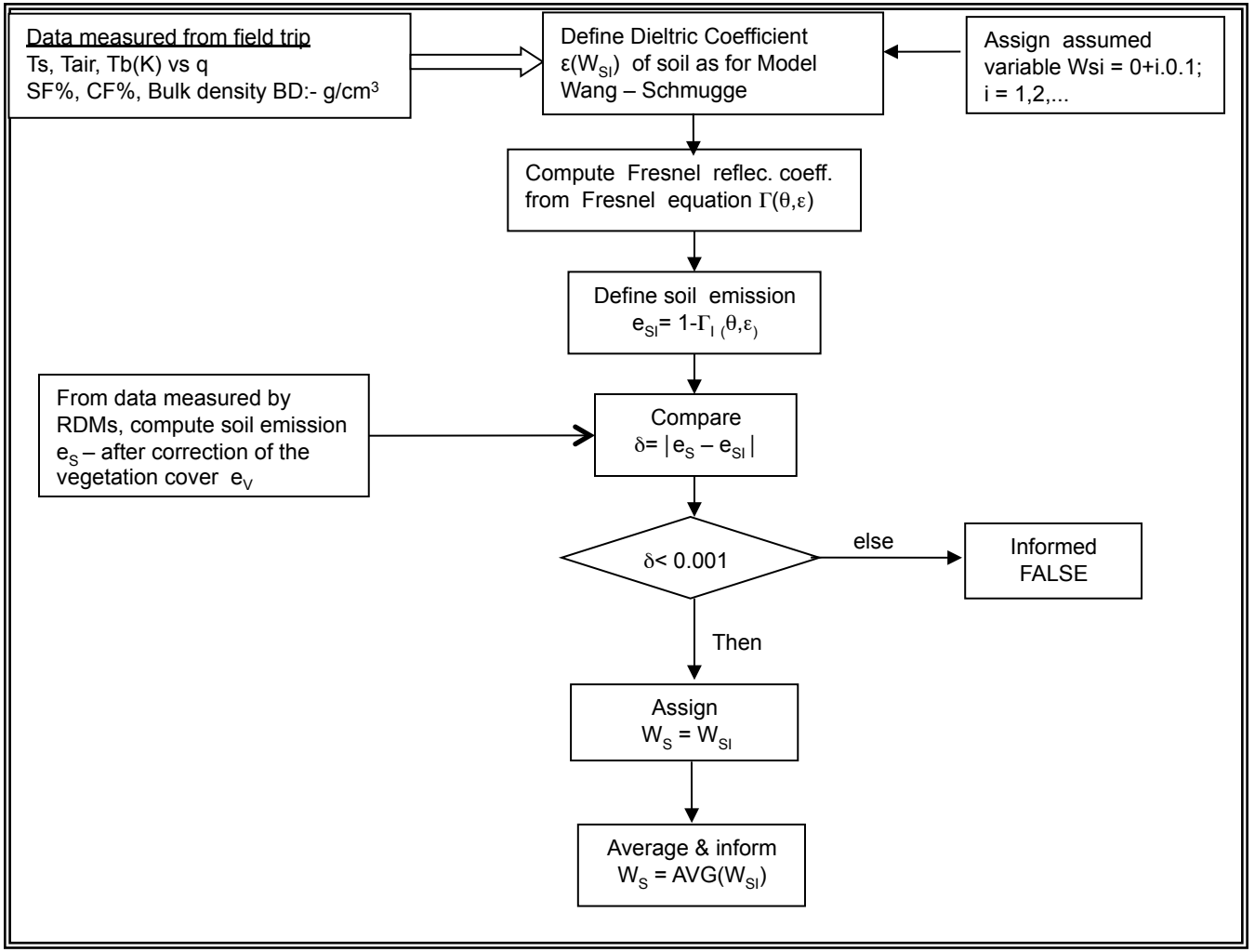




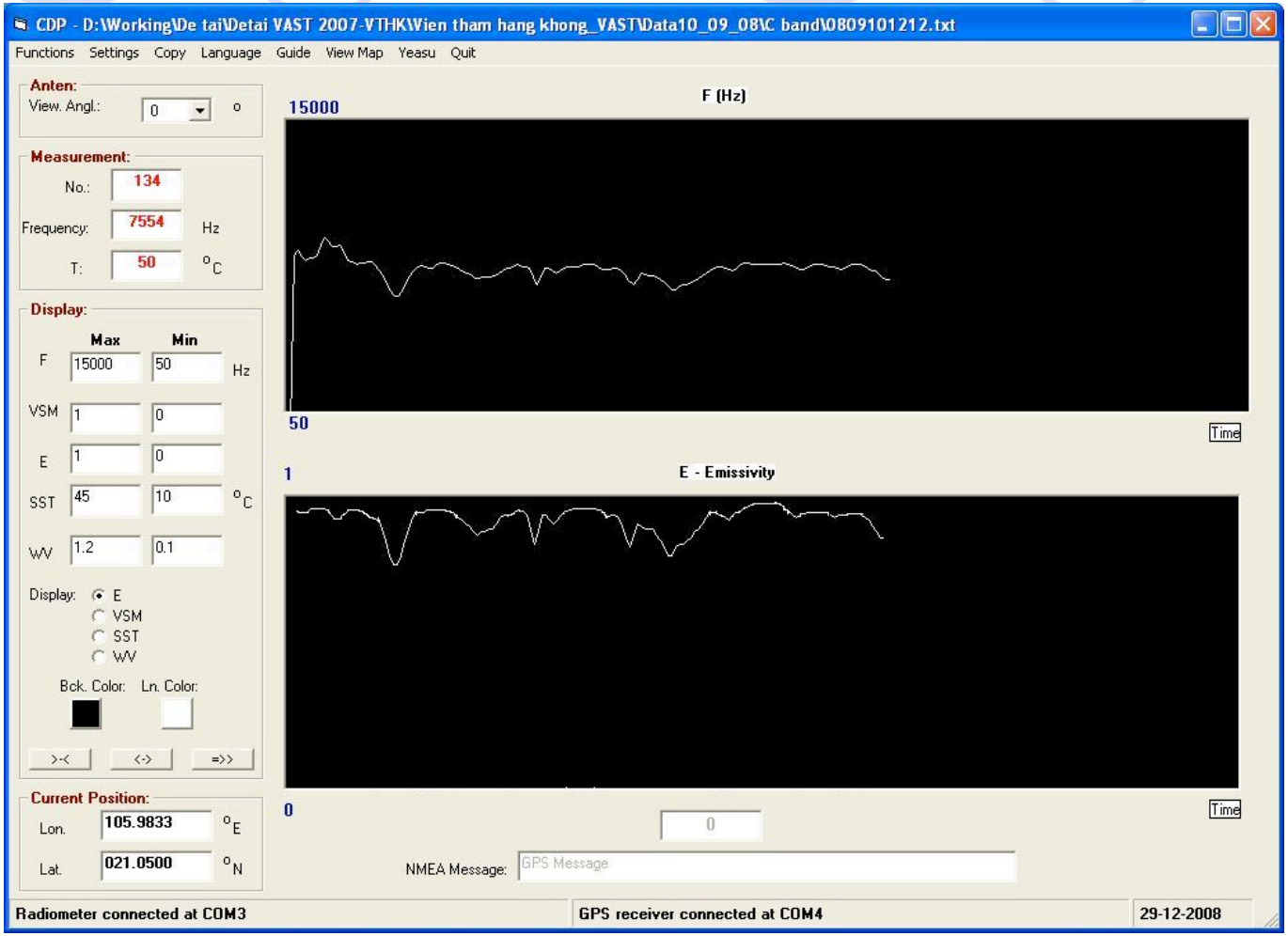
Experiment on rice & corn field

PASSIVE MW RS OF SOIL MOISTURE CONTENT (SMC)

Flowchart to estimate SMC (RDMs – Model)



- Program for automatic receive & process “on-line” data measured from RDMs - *Radiometer 4.0*



Models for compute SMC based on measured data of radiometers

- Schmugge and Choudhury

$$T_{Bp}(\theta) = [1 - R_p(\theta)]\, T_{eff}(\theta),$$

- Brightness Temperatue of soil (T(z) = T_S)

$$T_{Bp}(\theta) = e_p(\theta) T_S = [1 - R_p(\theta)] T_S,$$

- Fresnel equation:

$$R_h(\theta) = \left| \frac{\cos\theta - \sqrt{\varepsilon - \sin^2\theta}}{\cos\theta + \sqrt{\varepsilon - \sin^2\theta}} \right|^2,$$

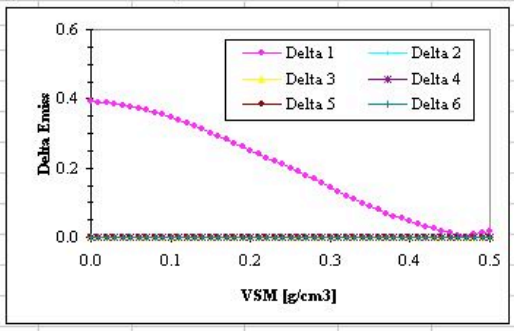
$$R_v(\theta) = \left| \frac{\varepsilon\cos\theta - \sqrt{\varepsilon - \sin^2\theta}}{\varepsilon\cos\theta + \sqrt{\varepsilon - \sin^2\theta}} \right|^2.$$

- Model dielectric coefficient Wang- Schmugge ε = ε(Wc,T)
  - ε = ε' + i. ε'' = ε (W_s,SF,CF,SLF,P)
  - $W_s < W_t$ → $\varepsilon = m_v \varepsilon_x + (P - m_v)\varepsilon_a + (1 - P)\varepsilon_r,$
  - $W_s > W_t$ → $\varepsilon = W_t \varepsilon_x + (m_v - W_t)\varepsilon_w + (P - m_v)\varepsilon_a + (1 - P)\varepsilon_r$

Program for computation of SMC with model Wang-Schmugge

File WS_SM_Site1.XLS

Experimental field: Gia Lam district - **Site 1(November 9, 2008)**



	Angle =	0
Exp. data	Emiss_h	VSMest
	0.6098	#DIV/0!
	0.6555	0.445
	0.636	0.480
	0.626	0.495
	0.617	#DIV/0!
	0.590	#DIV/0!

8.57

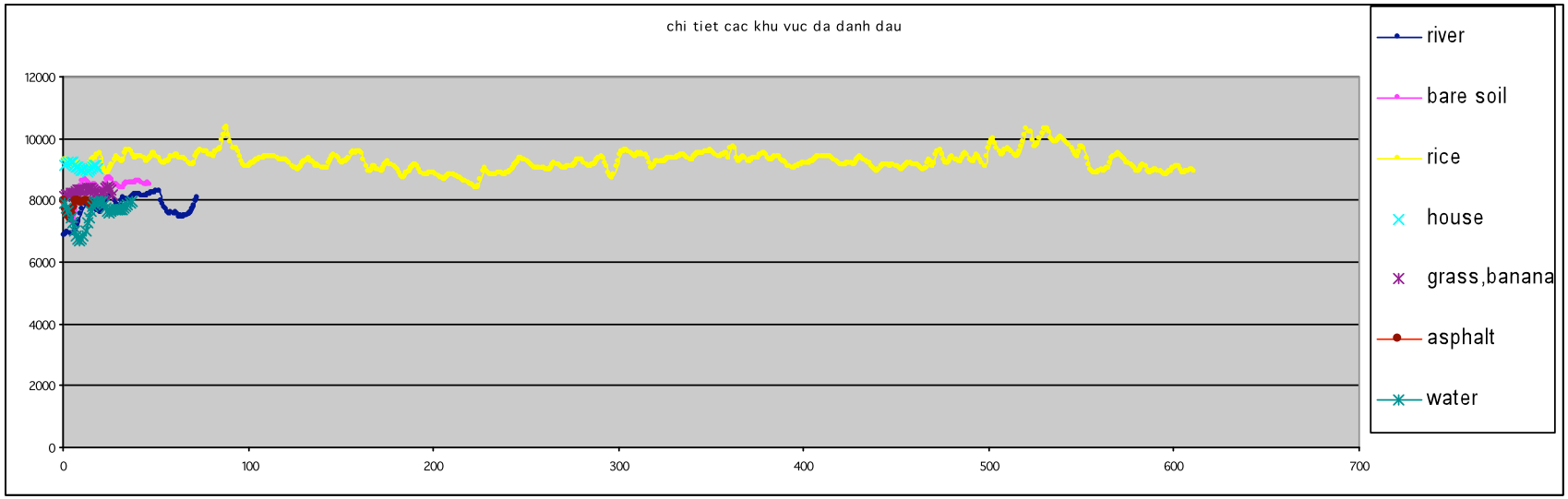
Input data		Freq, Hz		
Freq, GHz =	3.5	3.50E+09	EPSr' =	5.5
Temp, °C =	34		EPSr" =	0.2
SF, % =	23		EPSi' =	3.2
CF, % =	37		EPSi" =	0.1
BD, g/cm3 =	0.9	Angle, rad	EPSa' =	1
Angle, deg	0	0.000	EPSw~=	4.9
h =	0.20	Dev (cm) =		1
lamda	8.57			

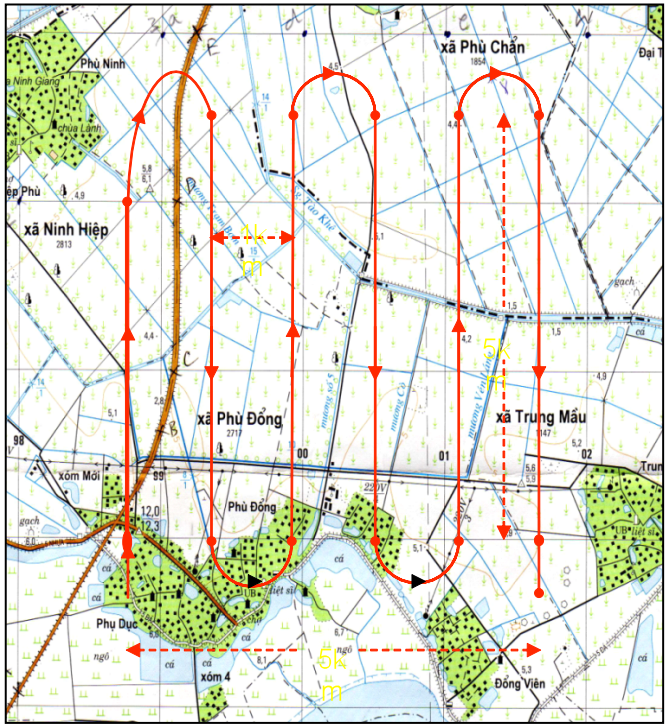
Pure water dielectric model (see Ulaby et al., vol. 3, (E.14)-(E.19))

EPSw0(T)	TAUw(T)	ZNAM	EPSw'	EPSw"
75.095	6.565E-12	1.021	73.662	9.927
WP	**FC**	**G**	**WT**	**P**
0.230	0.432	0.350	0.278	0.660

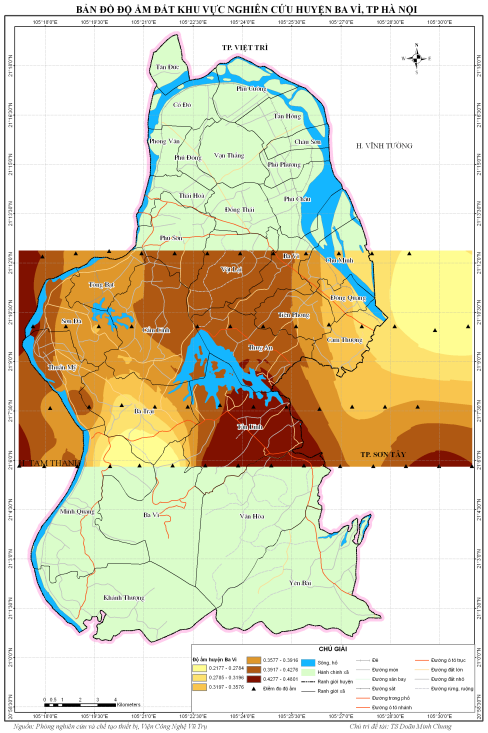
Wc=VSM	EPS'x,r1	EPS"x,r1	EPS'x,r2	EPS"x,r2	EPS's	EPS"s	A=sin^2	C=cos(tita	r	Re(B)	Im(B)	Re(Sqrt(B)	H-pol smooth EMISSh	*H-pol rough* EMISSh,r	V-pol smooth Re(GAMAv	V-pol rough Re(GAMAv	V-pol smooth EMISSv
0	3.20	0.10	27.86	3.54	**2.53**	**0.07**	0.000	1.000	2.529	2.528	0.068	1.590	**0.948**	*0.958*	0.052	0.042	**0.948**
0.01	4.09	0.22	27.86	3.54	**2.56**	**0.07**	0.000	1.000	2.560	2.559	0.070	1.600	**0.947**	*0.956*	0.053	0.044	**0.947**
0.02	4.98	0.35	27.86	3.54	**2.61**	**0.07**	0.000	1.000	2.609	2.608	0.075	1.615	**0.945**	*0.955*	0.055	0.045	**0.945**
0.03	5.86	0.47	27.86	3.54	**2.67**	**0.08**	0.000	1.000	2.675	2.674	0.082	1.636	**0.942**	*0.952*	0.058	0.048	**0.942**
0.04	6.75	0.60	27.86	3.54	**2.76**	**0.09**	0.000	1.000	2.760	2.758	0.092	1.661	**0.938**	*0.949*	0.062	0.051	**0.938**
0.05	7.64	0.72	27.86	3.54	**2.86**	**0.10**	0.000	1.000	2.862	2.860	0.104	1.692	**0.934**	*0.946*	0.066	0.054	**0.934**
0.06	8.53	0.84	27.86	3.54	**2.98**	**0.12**	0.000	1.000	2.982	2.980	0.119	1.727	**0.929**	*0.942*	0.071	0.058	**0.929**
0.07	9.42	0.97	27.86	3.54	**3.12**	**0.14**	0.000	1.000	3.120	3.118	0.136	1.766	**0.923**	*0.937*	0.077	0.063	**0.923**

2007-2008: Integration of GPS to RDMs; Aerial RS for soil moisture mapping





- Measured spectrum of Tb registered by C-band RDM from helicopter
- Soil moisture map of rice field areas - Hanoi



Measurement of SST with Radiometers & Validation by MODIS image (2005-2006)

Radiometer calibration with Blue sky

Receiving data on ship board

Measure SSS

Measure wind speed & coordinates by GPS receiver

Validation SST with MODIS image

PROPOSAL FOR COOPERATION ON SPACE SCIENCE & TECHNOLOGY WITH NASA & OTHERS

Main topics:

- Satellite technology R&D
- Space Applications (climate change, natural resource, environment & disaster management); SMAP/VAL campaign
- Space science & education (Universities/ engineers, Mas, PhD)
- Capacity building (exchange, trainings, joint projects)
- Space legislation

Proposals:

1. *"Research on the Active/Passive Remote sensing technology and applications for soil moisture monitoring"* – USDA-STI/VAST
2. *"Estimation of the relation between forestry cover with natural hazards in mountainous areas using RS & GIS"* - Michigan State University – STI/VAST

Cooperation: Governmental, Academic, Institution, Join project, professor visiting, Conference, Exchange (ODA, Trade source, self-financial budget)

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INFORMATION NOTE: UN/VAST Workshop "Space Technology Applications for Socio-Economic Benefits" held in Hanoi, Vietnam from 10-14/10/2011.
Co-organized: UN-VAST / ESA – ISPRS - NASA
Registration deadline: 31/8/2011
Website: http://www.unoosa.org; or www.sti.vast.ac.vn/conference
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