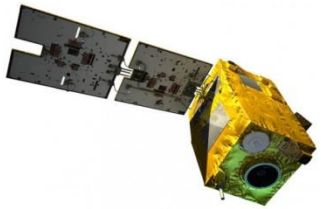
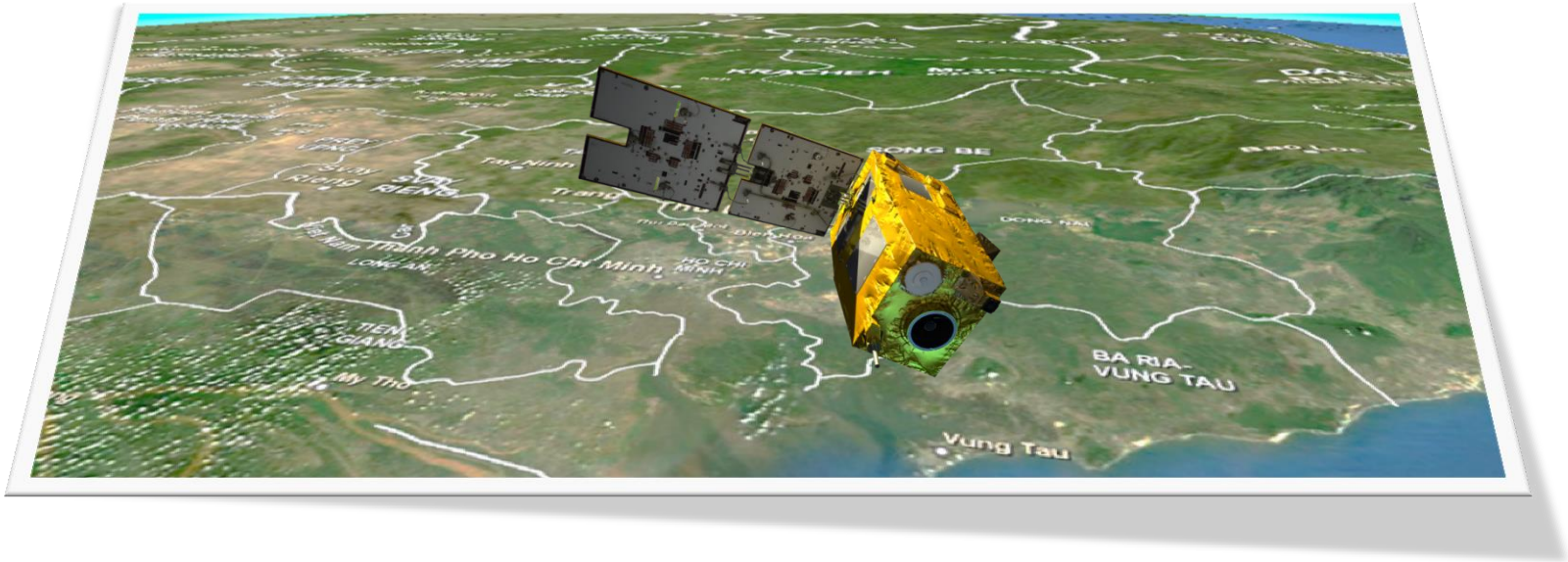
SMAP CAL/VAL CONFERENCE 2013
Pasadena - California

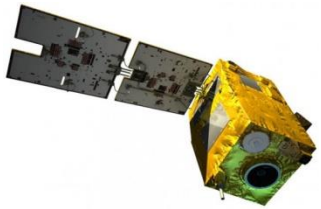


SOME RESULTS OF SOIL MOISTURE MEASUREMENTS IN VIETNAM FOR SMAP CAL/VAL



Doan Minh Chung, Space Technology Institute (STI)
Vietnam Academy of Science & Technology (VAST)

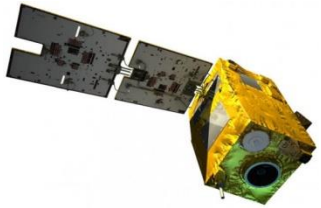
Overview



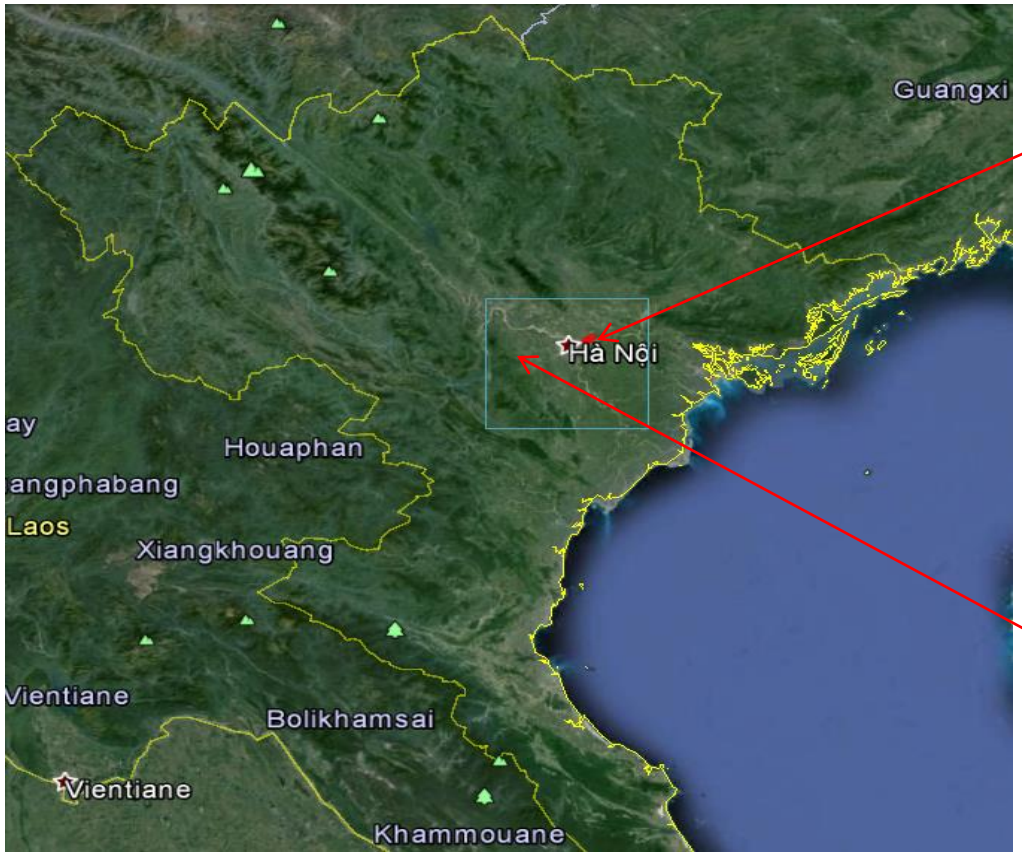
The importance of monitoring soil moisture in Vietnam

Soil moisture information can be used for reservoir management, early warning of droughts, irrigation scheduling, crop yield forecasting, index of climate change

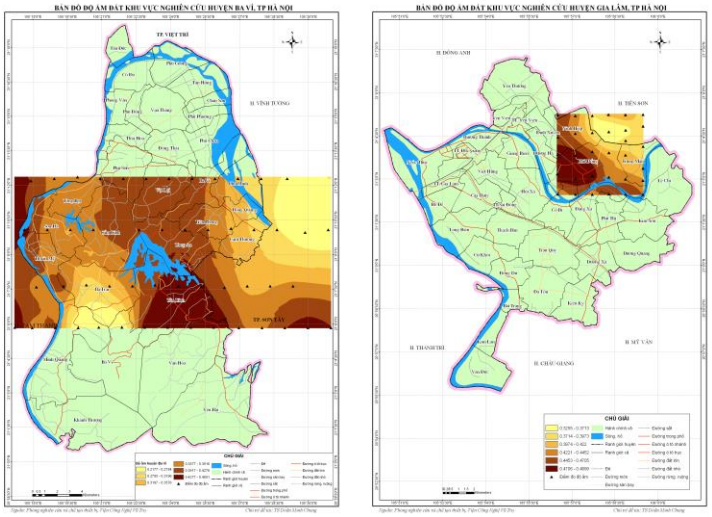
Study area:
Red river delta, Hanoi (important rice fields, SMC changes)

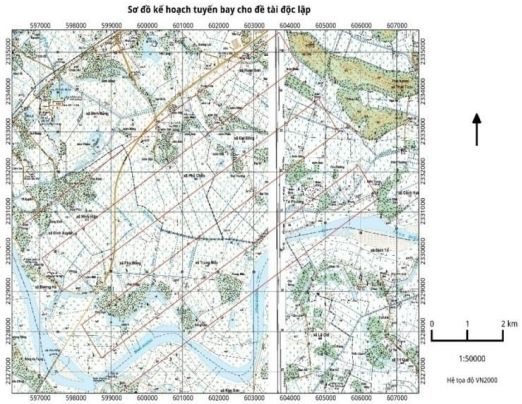


- Site Location



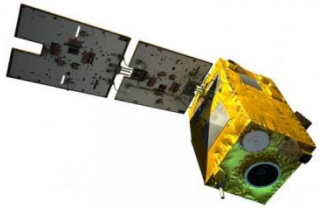
Flight experiments 2009 -2010



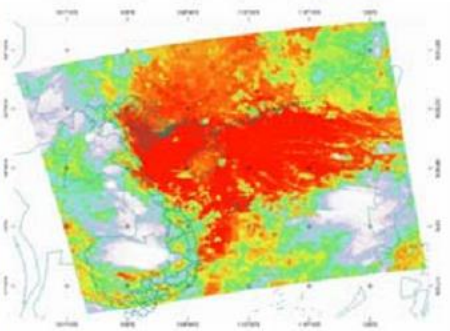


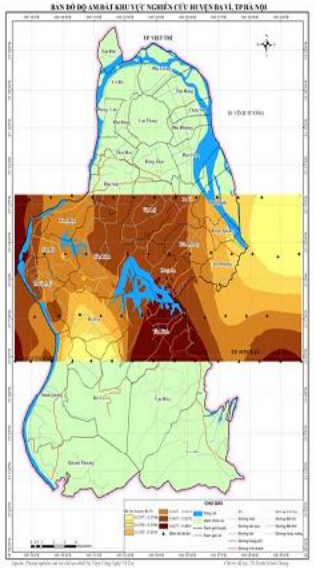
Flight Plan 2012-2013

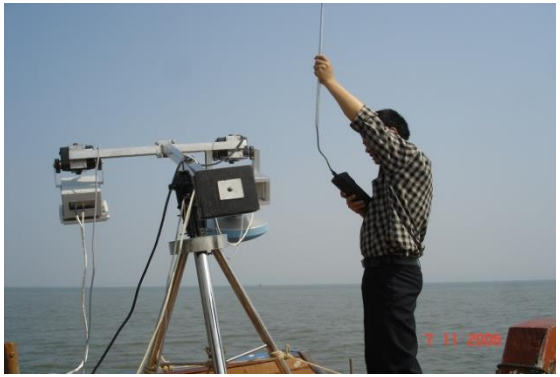
Overview(Cont.)



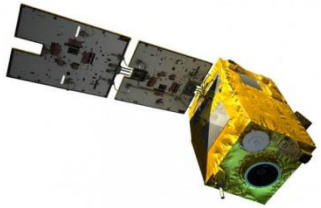
- (2009-2010): Use radiometers L,C,X bands, integrated with GPS receiver for mapping soil moisture from the aircraft (Aerial remote sensing)

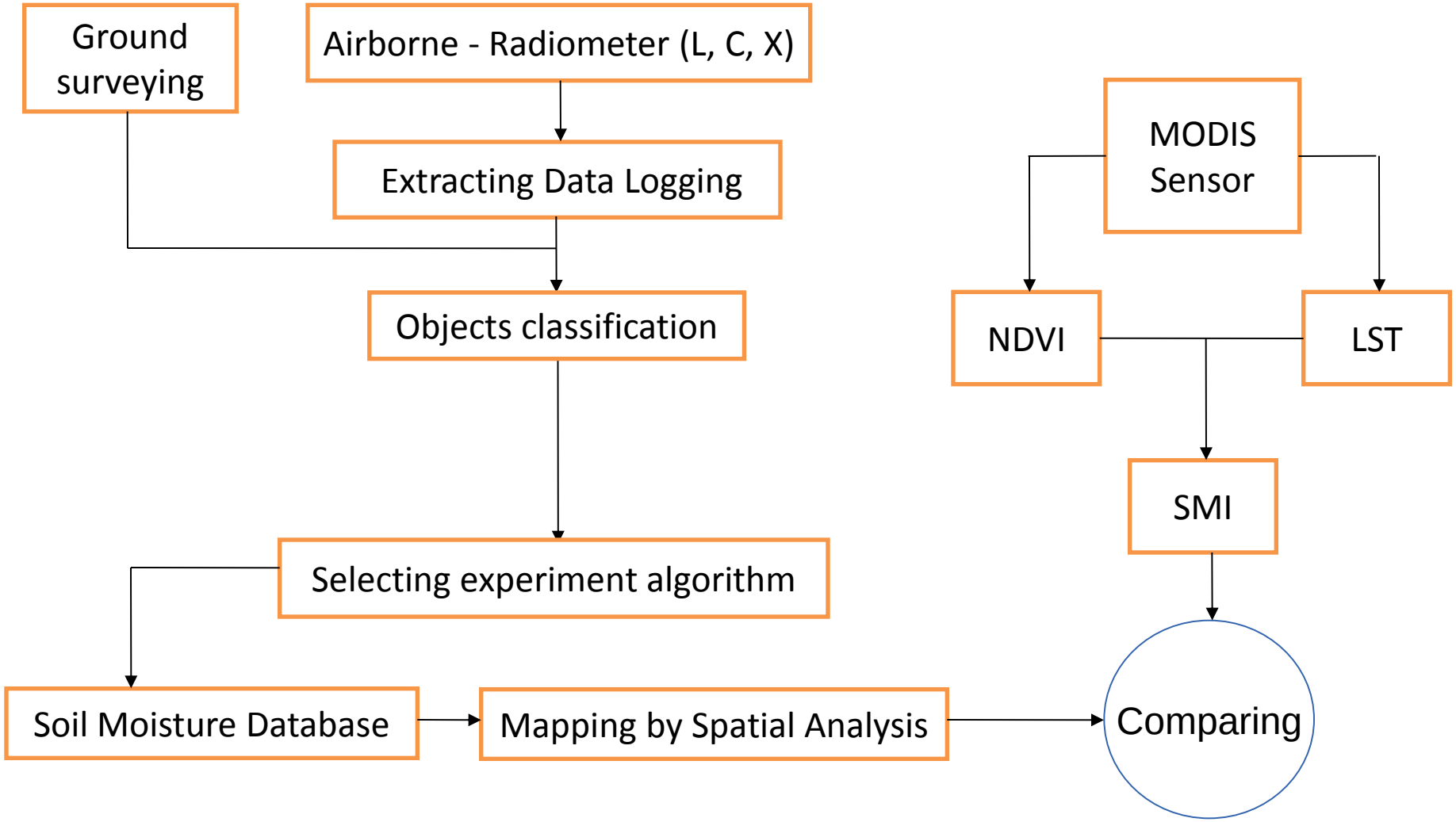




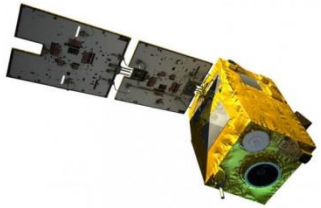


Methodology





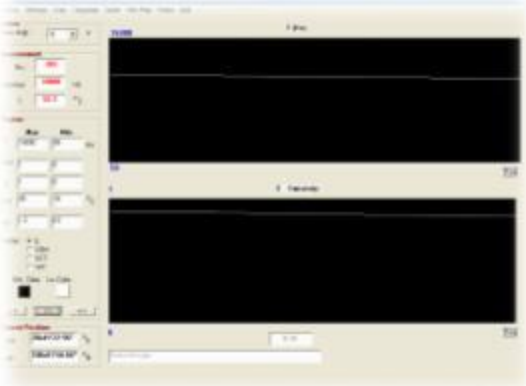
Instrument



- Radiometer

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

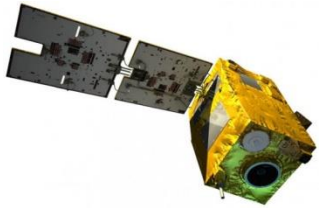


Software for RDM data receiving and processing

Field surveys 2012-2013

- Field Experiement

Soil Moisture Modelling (Cont.)



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 ($T(z) = T_S$)

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

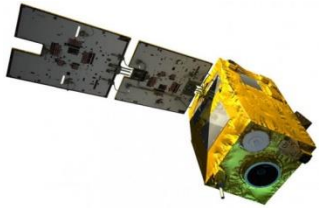
- Fresnel equation:

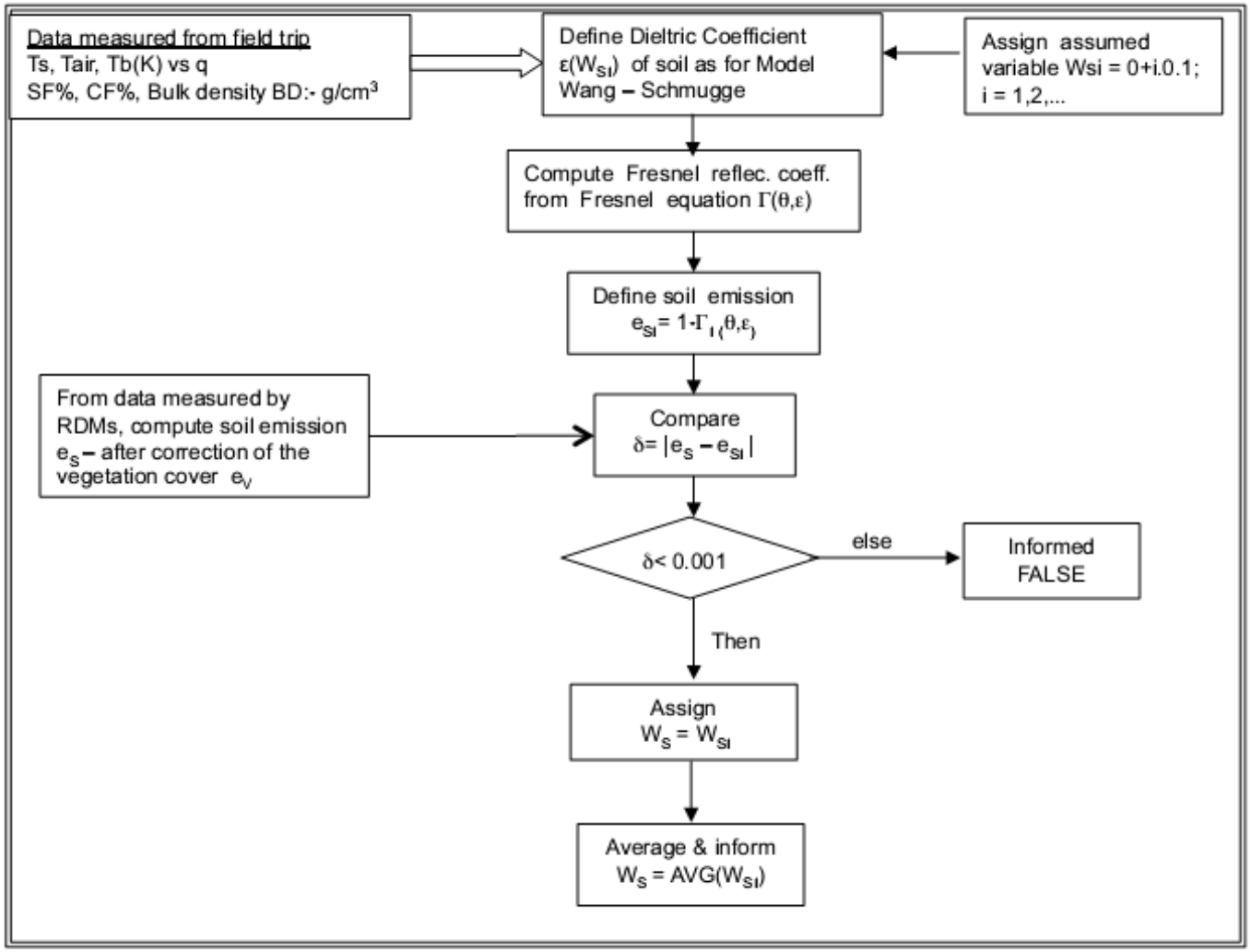
$$R_h(\theta) = \left| \frac{\cos\theta - \sqrt{\varepsilon - \sin^2\theta}}{\cos\theta + \sqrt{\varepsilon - \sin^2\theta}} \right|^2,$$

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

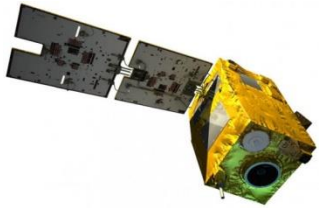
- Model dielectric coefficient Wang- Schmugge $\varepsilon = \varepsilon(Wc,T)$
  - $\varepsilon = \varepsilon' + i.\ \varepsilon'' = \varepsilon\ (W_s, SF, CF, SLF, P)$
  - $W_s < W_t \rightarrow$ $\varepsilon = m_v \varepsilon_x + (P - m_v)\varepsilon_a + (1 - P)\varepsilon_r,$
  - $W_s > W_t \rightarrow$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

Soil moisture calculation

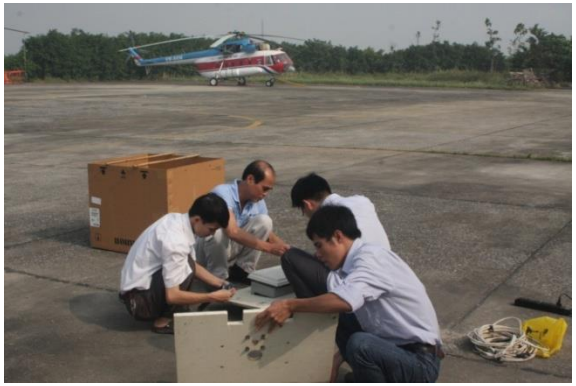




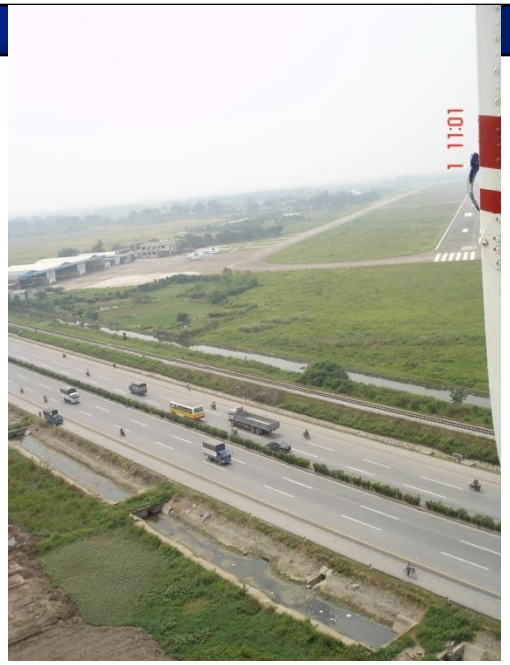
Calibration Radiometers before flying



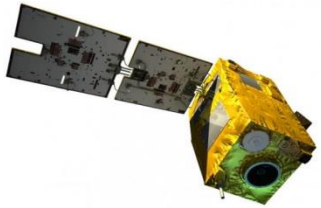
- Aerial Radiometer



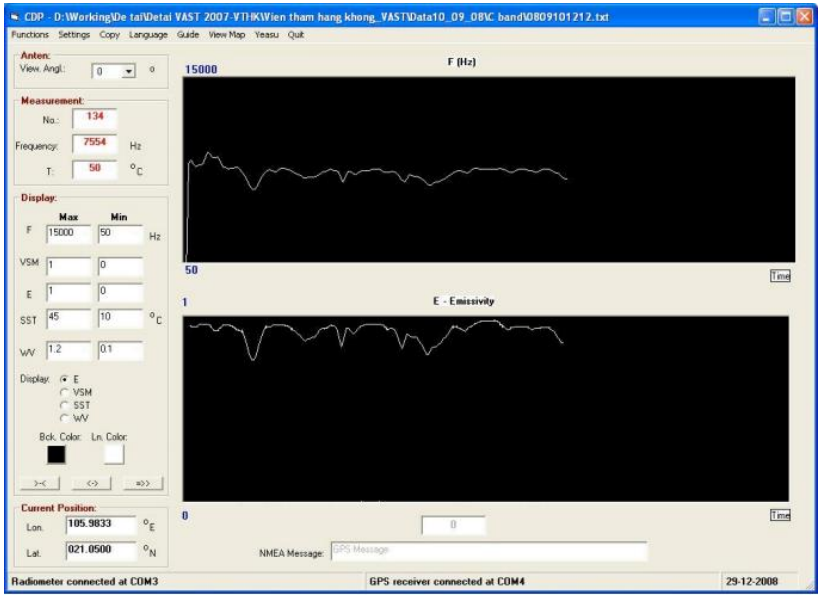
Measurements by airborn radiometers & field trip



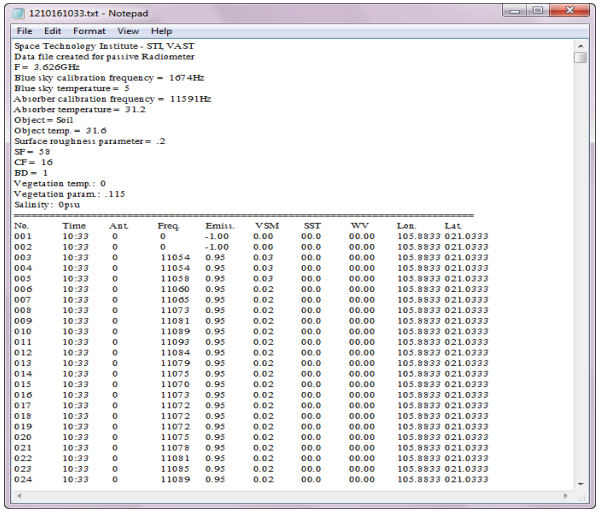
Data register & store



- Real time data



10:56:51			Ruộng lúa	10152
10:56:52			Ruộng lúa	10177
10:56:53			Ruộng lúa	10224
10:56:54			Ruộng lúa	10258
10:56:55			Ruộng lúa	10283
10:56:56			Ruộng lúa	10323
10:56:57			Ruộng lúa	10363
10:56:58			Ruộng lúa	10398
10:56:59			Ruộng lúa	10421
10:57:00			Ruộng lúa	10427
10:57:01			Ruộng lúa	10429
10:57:02			Ruộng lúa	10438
10:57:03			Ruộng lúa	10459
10:57:04			Ruộng lúa	10450
10:57:05			Ruộng lúa	10402
10:57:06			Ruộng lúa	10261
10:57:07			Ruộng lúa	10128
10:57:08	21.089926	105.954056	Ruộng lúa	10110
10:57:09			Ruộng lúa	10167



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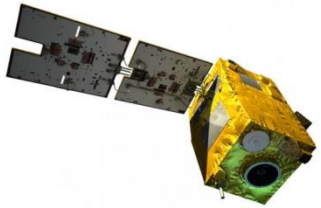
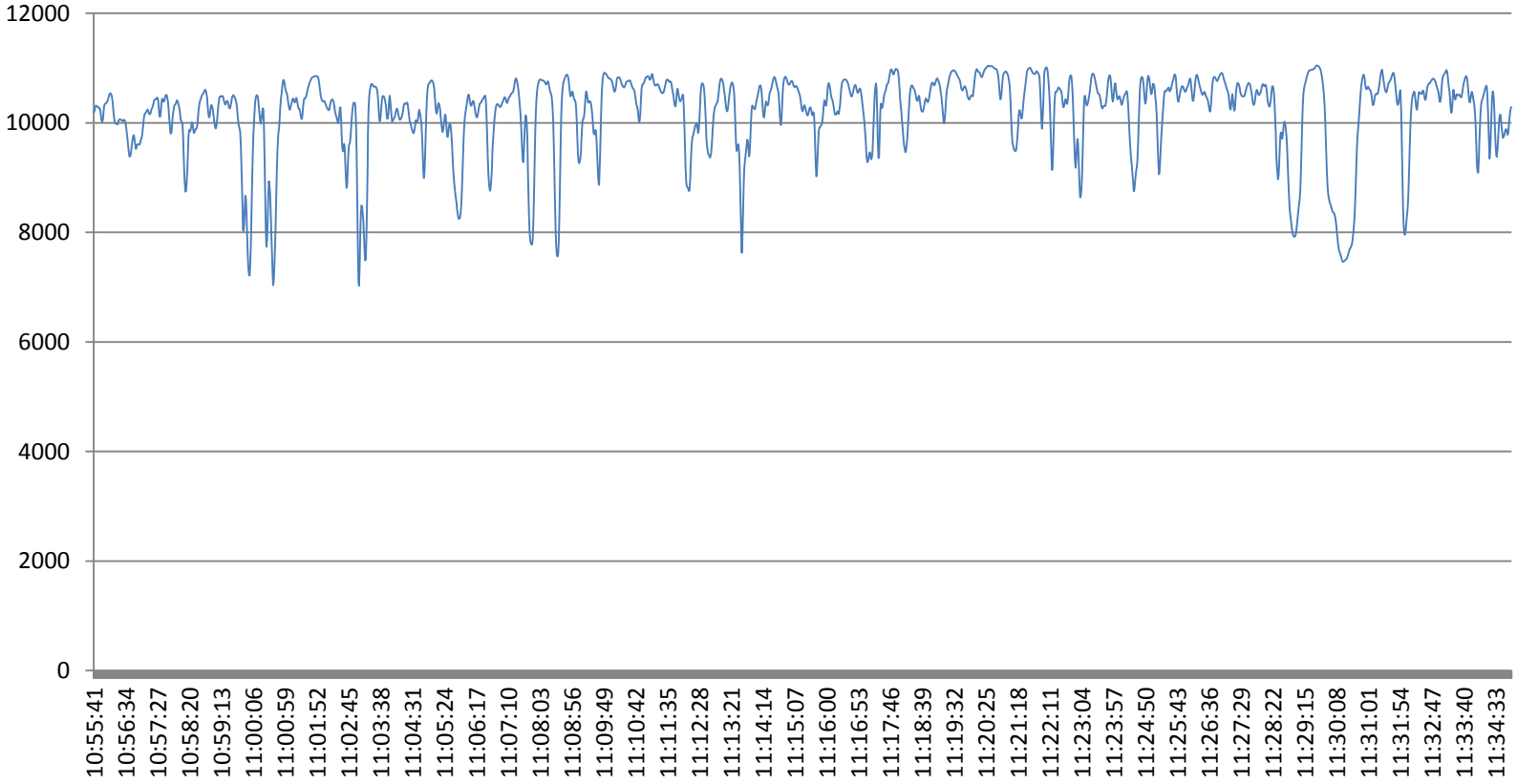
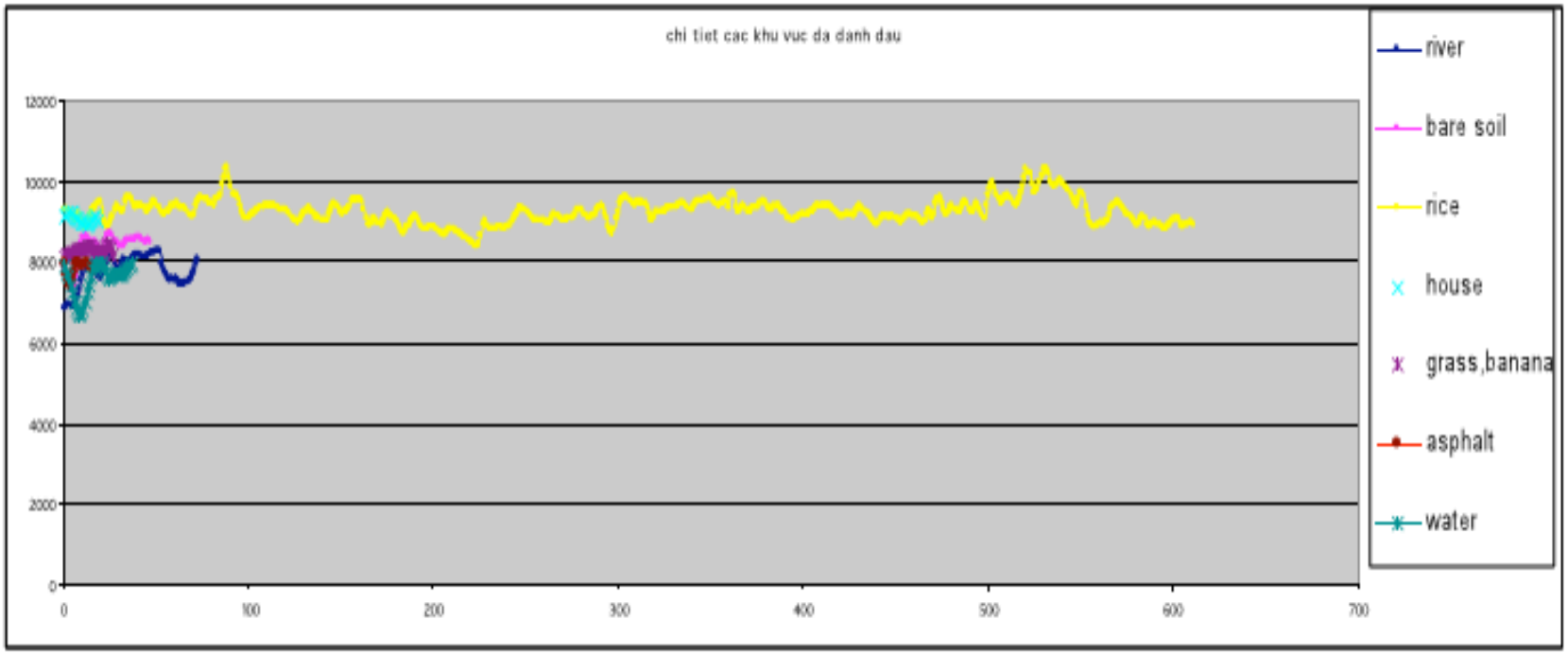


- Frequency measured during flight

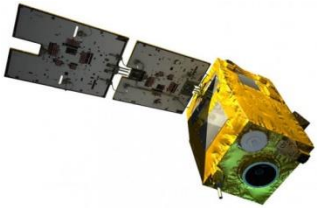


Objects classification

- Classification and treatment of emission objects



Data Processing



- Calculate Soil Moistrue

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Data file created for passive Radiometer — Gia Lâm 16/10/2012

$$A = \frac{Tb(Sky) - Tb(Abs)}{f(Sky) - f(Abs)}$$

F=	3.626	GHz				
Fbluesky=	1674	Hz		RM coeff.		
Tbluesky=	5	deg. K		0.0302		
Fabsorber=	11591	Hz			He so A=	0.03017
Tabsorber=	31.2	deg. C				
Object	Soil					
Object temp.	33	deg. C	Object temp.			
Sur. Roughne	.2		Rice	33.1	deg.C	
SF	58		Soil	33	deg.C	
CF	16		River		deg.C	
BD	1					

$$Tbi = Tb(Sky) + \frac{Tb(Sky) - Tb(Abs)}{f(Sky) - f(Abs)}(fi - f(Sky))$$

Receiving data						Processing data				
No.	Time	Freq.	Lat.	Lon.	Object	Tb(K)	Tbn	Emiss	Vmest	do am %
1166	11:14:43	10656			ruộng	275.9907	275.991	0.9016	0.33000	33
1167	11:14:44	10652			ruộng	275.8700	275.87	0.9012	0.33000	33
1168	11:14:45	10665			ruộng	276.2622	276.262	0.9025	0.33000	33
1169	11:14:46	10674	21.0988631	106.012026	ruộng	276.5337	276.534	0.9034	0.32000	32
1170	11:14:47	10667			ruộng	276.3225	276.323	0.9027	0.33000	33
1171	11:14:48	10650	21.0985065	106.012078	ruộng	275.8096	275.81	0.901	0.33000	33
1172	11:14:49	10617			ruộng	274.8140	274.814	0.8978	0.35000	35
1173	11:14:50	10580			ruộng	273.6977	273.698	0.8941	0.36000	36
1174	11:14:51	10552			ruộng	272.8529	272.853	0.8914	0.38000	38
1175	11:14:52	10516			ruộng	271.7668	271.767	0.8878	0.40000	40
1176	11:14:53	10472			ruộng	270.4393	270.439	0.8835	0.42000	42
1177	11:14:54	10396			ruộng	268.1464	268.146	0.876	0.47000	47
1178	11:14:55	10292			ruộng	265.0086	265.009	0.8658	0.50000	50
1179	11:14:56	10230	21.0953988	106.013099	ruộng	263.1381	263.138	0.8596	0.50000	50
1180	11:14:57	10212			ruộng	262.5950	262.595	0.8579	0.50000	50
1181	11:14:58	10243			ruộng	263.5303	263.53	0.8609	0.50000	50

Space Technology Institute - STI, VAST

THỰC NGHIỆM HOÀI ĐỨC-HÀ NỘI-20-6-2013

File EMIS_WS.XLS

band L

	Angle =	60
Exp. data	Emiss_h	VSMest
	0.6481	0.120
	0.6107	0.145
	0.6257	0.135
	0.5738	0.170
	0.5552	0.185
	0.5337	0.205
	avg =	0.160

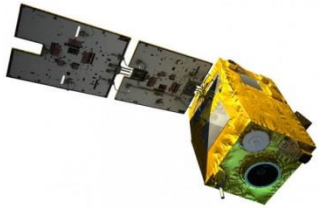
Input data		Freq, Hz		
Freq, GHz =	1.4	1.40E+09	EPSr' =	5.5
Temp, °C =	35.3		EPSr'' =	0.2
SF, % =	55.14		EPSi' =	3.2
CF, % =	22.86		EPSi'' =	0.1
BD, g/cm3 =	1.06	Angle, rad	EPSa' =	1
Angle, deg =	60	1.047	EPSw~=	4.9
h =	0.1			

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

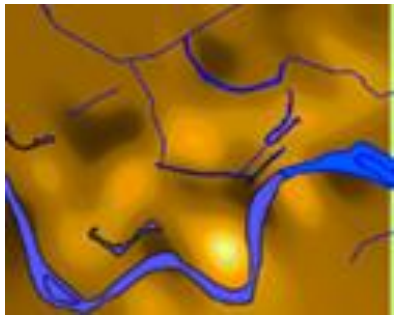
EPSw0(T)	TAUw(T)	ZNAM	EPSw'	EPSw''
74.663	6.3886E-12	1.003	74.444	3.908
WP	FC	G	WT	P
0.142	0.287	0.400	0.234	0.600

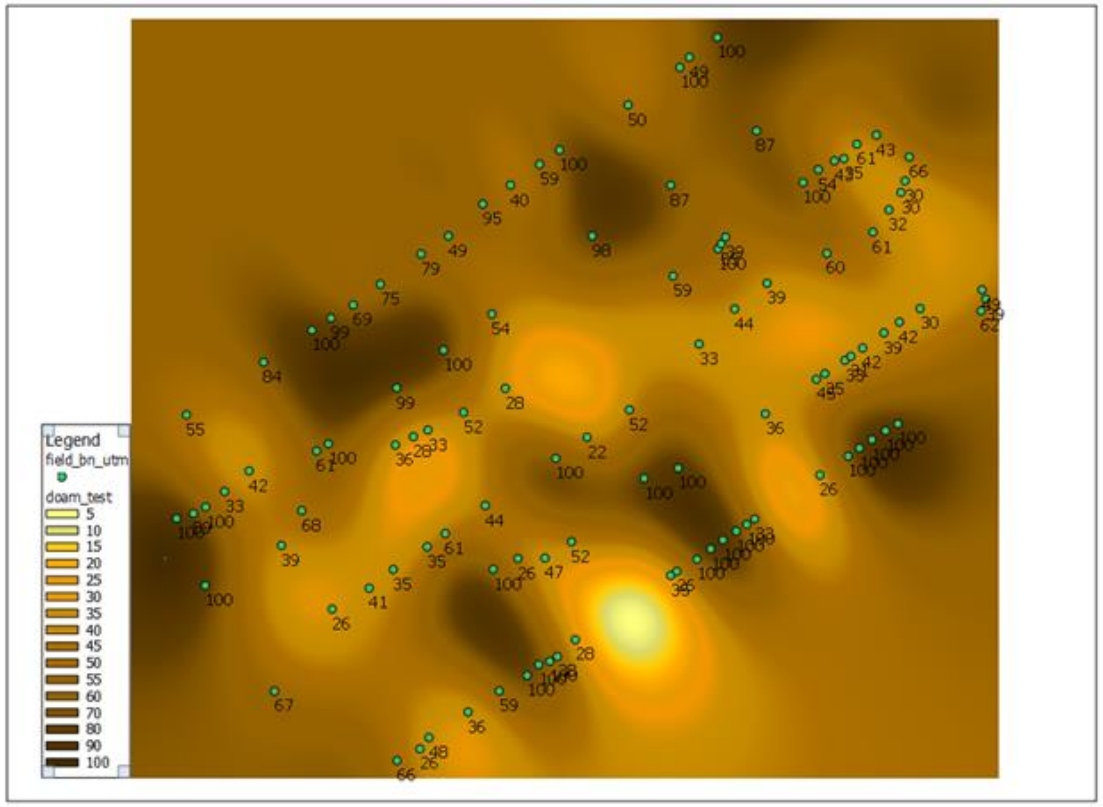
Wc=VSM	EPS'x,r1	EPS''x,r1	EPS'x,r2	EPS''x,r2	EPS's	EPS''s	A=sin^2	C=cos(tita	r	Re(B)	Im(B)	Re(Sqrt(B	IM(Sqrt(B	ZNAMh	ZNAMv	TCHISv^2
0	3.20	0.10	31.71	1.62	2.80	0.08	0.750	0.500	2.052	2.050	0.080	1.432	0.028	3.734	8.025	0.01
0.01	4.42	0.17	31.71	1.62	2.83	0.08	0.750	0.500	2.086	2.084	0.082	1.444	0.028	3.780	8.190	0.00
0.02	5.63	0.23	31.71	1.62	2.89	0.08	0.750	0.500	2.144	2.143	0.085	1.464	0.029	3.858	8.475	0.00
0.03	6.85	0.30	31.71	1.62	2.98	0.09	0.750	0.500	2.227	2.225	0.089	1.492	0.030	3.969	8.885	0.00
0.04	8.06	0.36	31.71	1.62	3.08	0.09	0.750	0.500	2.335	2.333	0.094	1.528	0.031	4.112	9.424	0.00
0.05	9.28	0.43	31.71	1.62	3.21	0.10	0.750	0.500	2.466	2.464	0.101	1.570	0.032	4.286	10.101	0.01
0.06	10.50	0.49	31.71	1.62	3.37	0.11	0.750	0.500	2.622	2.620	0.109	1.619	0.034	4.491	10.923	0.04
0.07	11.71	0.56	31.71	1.62	3.55	0.12	0.750	0.500	2.802	2.800	0.119	1.674	0.036	4.726	11.902	0.12
0.08	12.93	0.62	31.71	1.62	3.75	0.13	0.750	0.500	3.007	3.004	0.130	1.734	0.037	4.991	13.049	0.26
0.09	14.15	0.69	31.71	1.62	3.98	0.14	0.750	0.500	3.236	3.233	0.142	1.799	0.039	5.285	14.377	0.53
0.1	15.36	0.75	31.71	1.62	4.24	0.16	0.750	0.500	3.490	3.486	0.155	1.868	0.041	5.607	15.900	0.99

Spatial Analysis

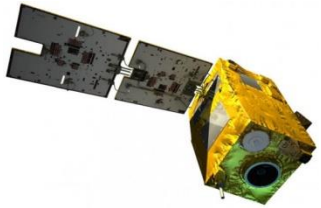


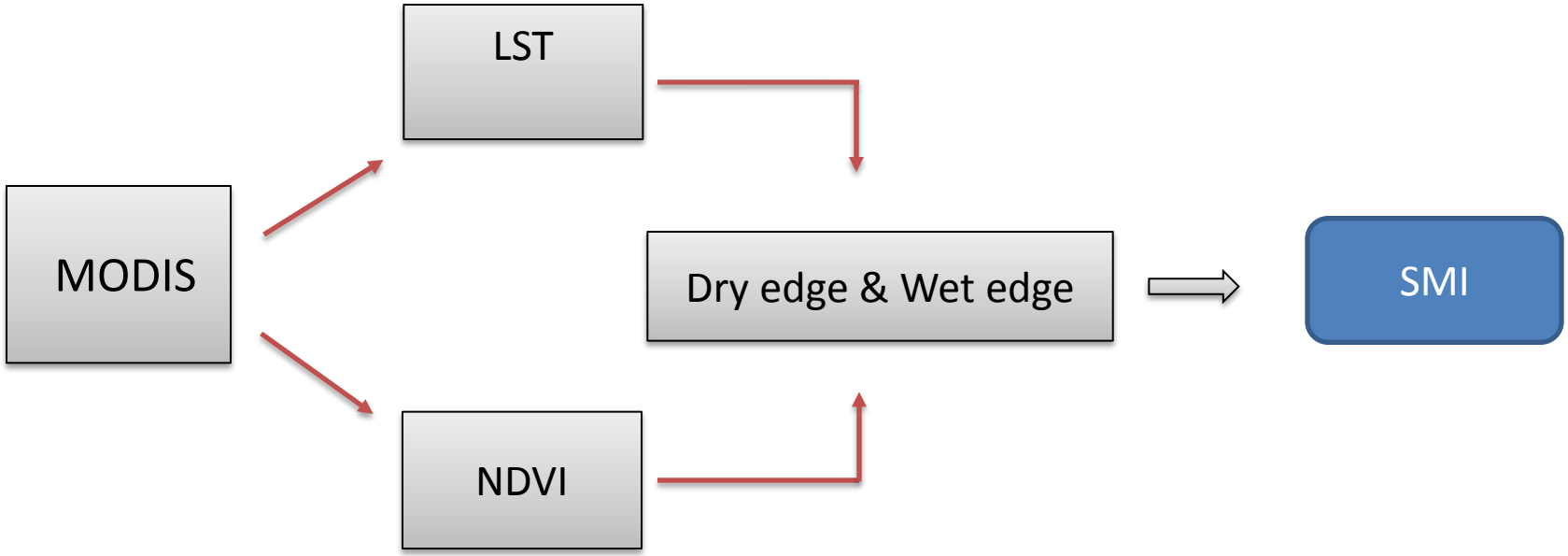
- Mapping soil moisture from aerial remote sensing



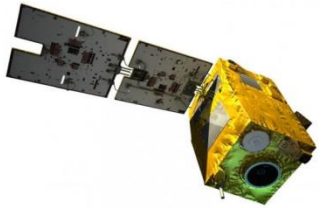


Soil Moisture Index using MODIS data

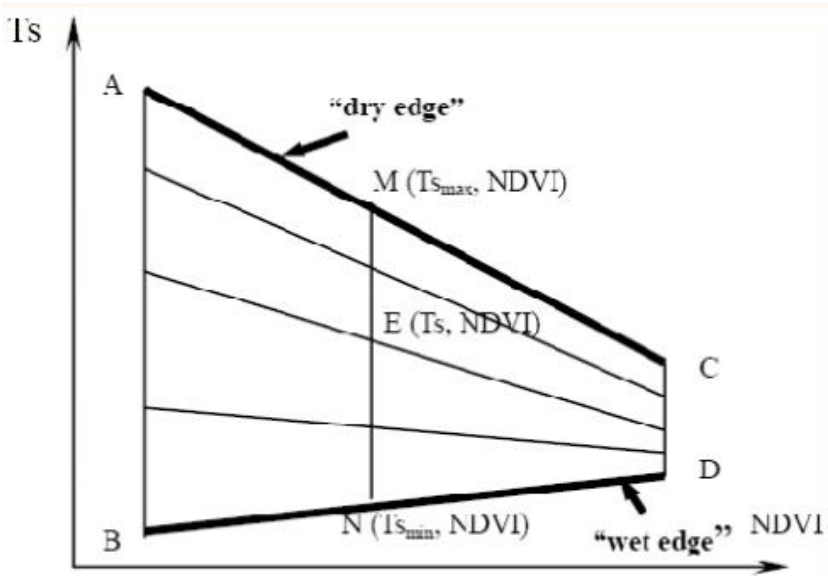


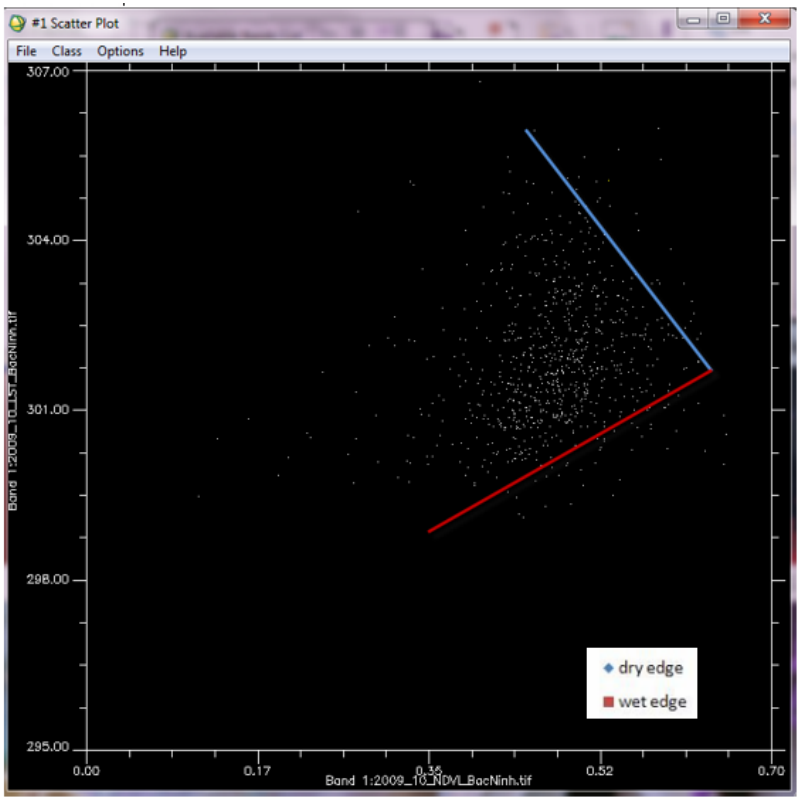


SMI Methodology

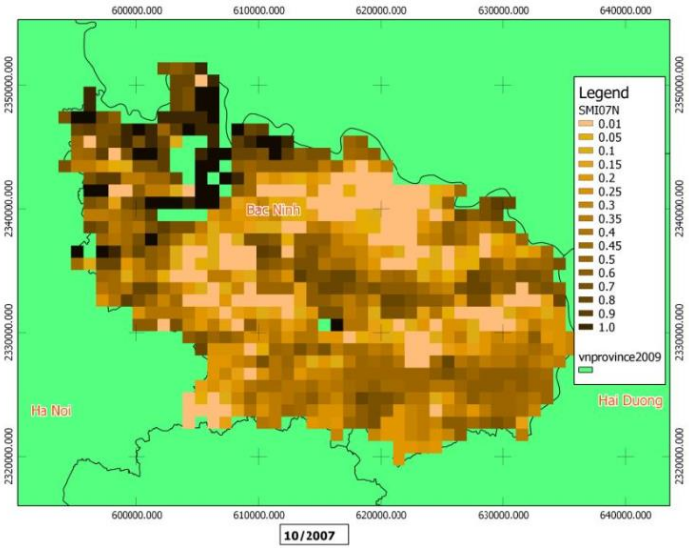


- Dry edge and Wet edge detection based on scattering of LST and NDVI using MODIS data





SMI Mapping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0.15
0.2
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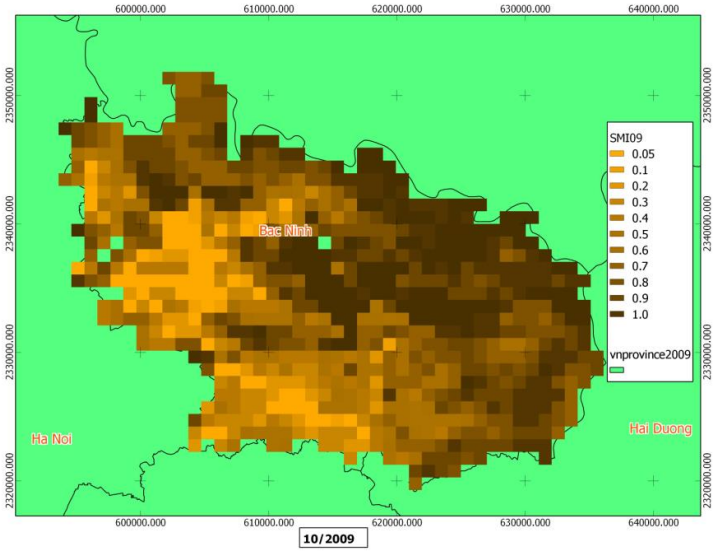
0.3
0.35
0.4
0.45
0.5
0.6
0.7
0.8
0.9
1.0
vnprovince2009
Bac Ninh
Ha Noi
Hai Duong
10/2007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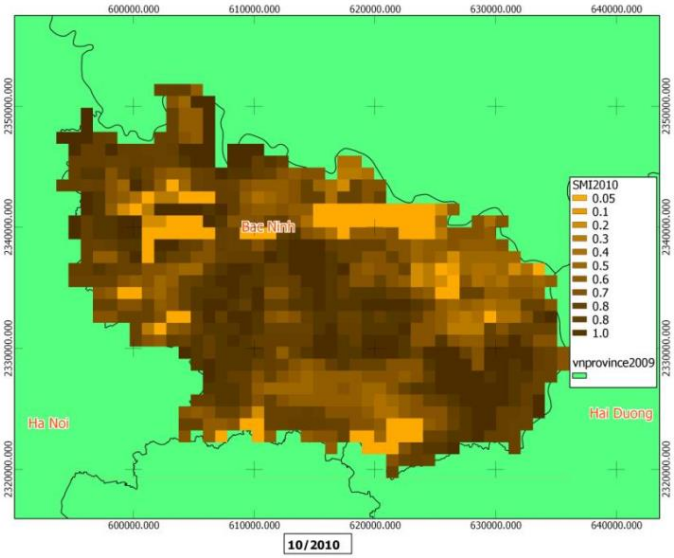
Bac Ninh
Ha Noi
Hai Duong
10/2009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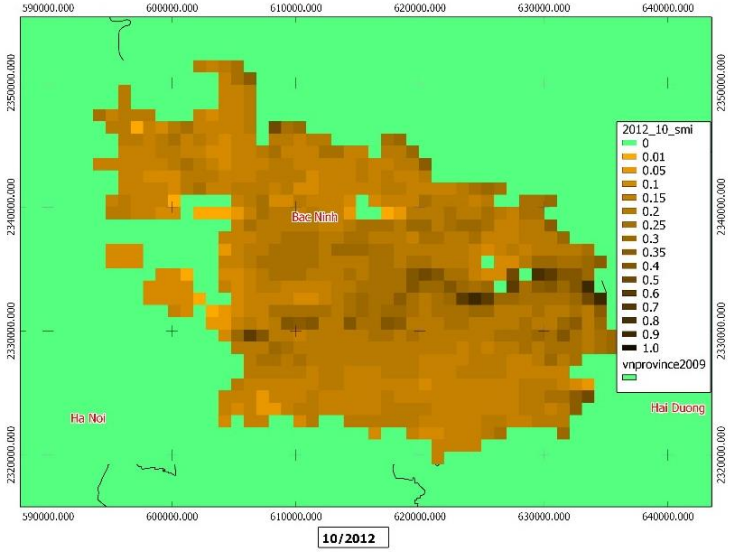
vnprovince2009
Bac Ninh
Ha Noi
Hai Duong
10/2010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0.4
0.5
0.6
0.7
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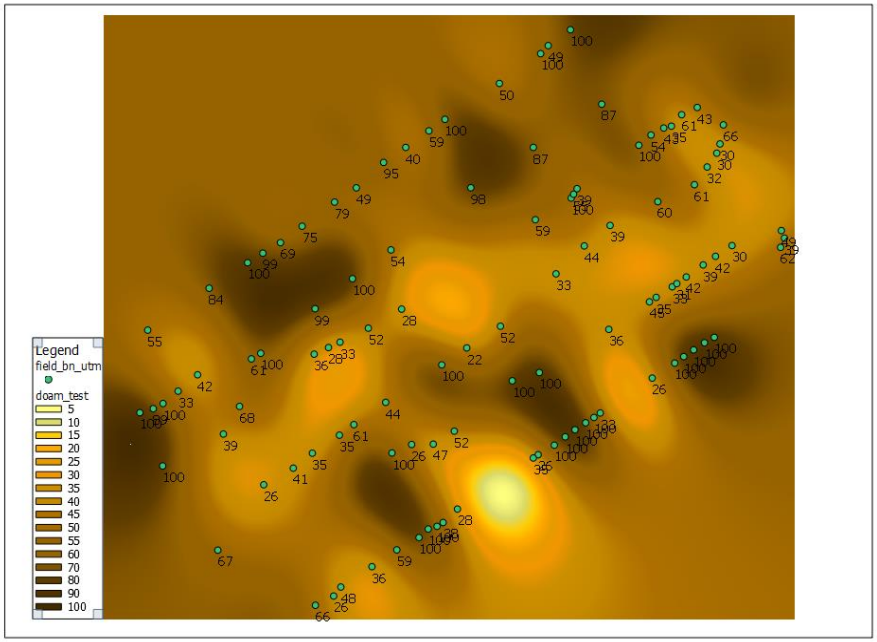
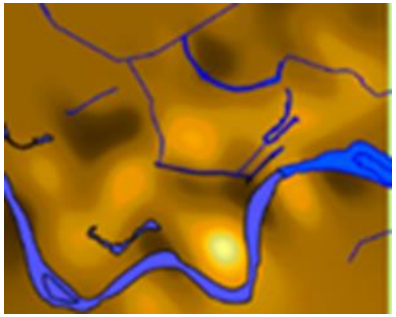
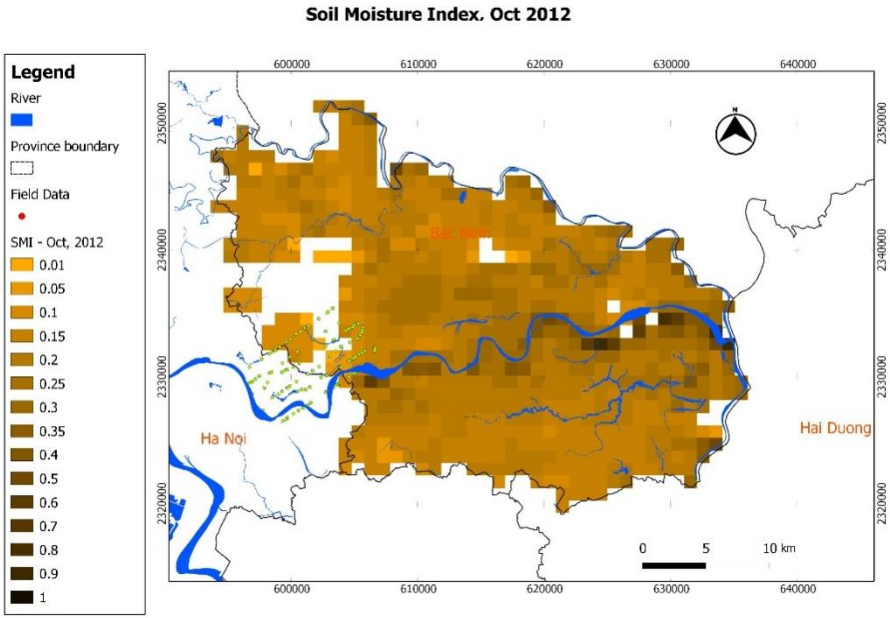
vnprovince2009
Bac Ninh
Ha Noi
Hai Duong
10/2012

RESULTS

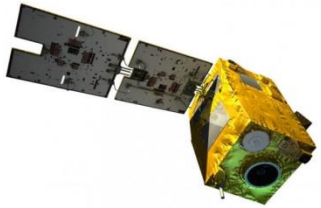
SMC map of Red river delta, Hanoi - 2013



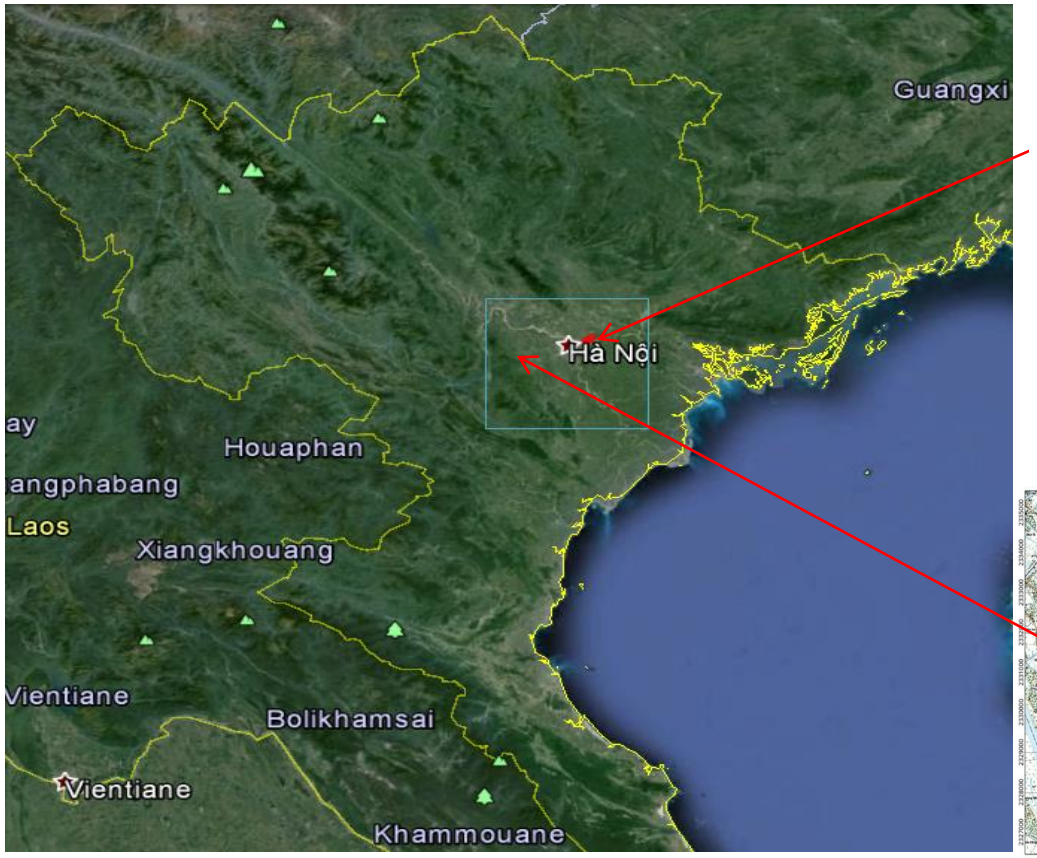




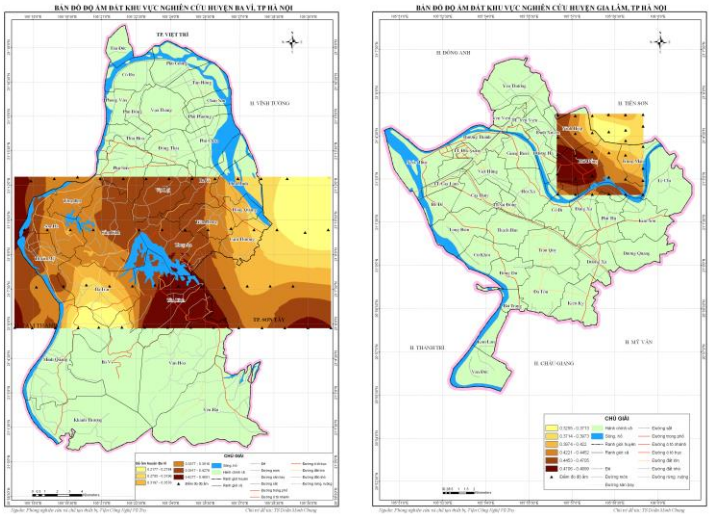
Study area:
Red river delta, Hanoi (important rice fields, SMC changes)

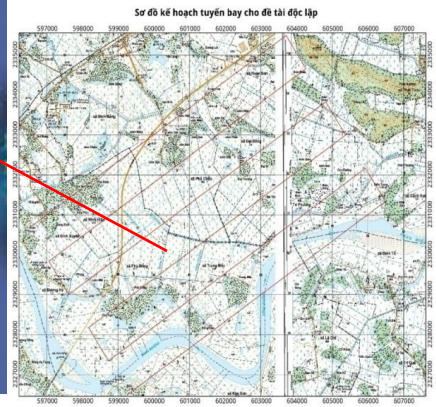


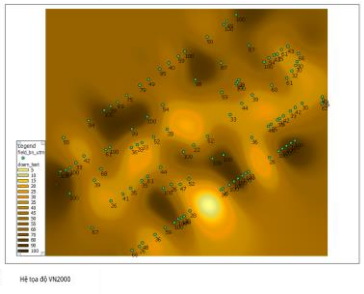
- Site Location



SMC results in 2009 -2010

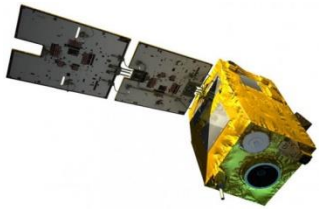






SMC results in 2012-2013

Future work for SMAP CAL/VAL



Cooperation with UPC (Universitat Politècnica de Catalunya-Spain) or other for Radiometer sensor ?
Using UAVs for monitoring soil moisture on wide areas (rice, coffee plantation, etc)

UAV(VAST)

UPC radiometer UAV

THANK YOU FOR YOUR ATTENTION !

Contact: dmchung@sti.vast.vn
chung_sti@yahoo.com