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

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Director, Space Technology Institute (STI)
Vietnam Academy of Science and Technology (VAST)
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°E.
- 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
Applications of RDMs for research of soil moisture, vegetation water content & SST, SSS


<table>
<thead>
<tr>
<th>RDM type</th>
<th>L - band</th>
<th>C - band</th>
<th>X - band</th>
</tr>
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<tbody>
<tr>
<td>Frequency</td>
<td>1.4 GHz</td>
<td>3.5 – 3.7 GHz</td>
<td>10.9–11.2 GHz</td>
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<tr>
<td>Bandwidth</td>
<td>&lt;40 MHz</td>
<td>&lt;30 MHz</td>
<td>&lt;30 MHz</td>
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<tr>
<td>Sensitivity</td>
<td>&lt;0.3K</td>
<td>&lt;0.3K</td>
<td>&lt;0.3K</td>
</tr>
<tr>
<td>Integ.time</td>
<td>1 s</td>
<td>1 s</td>
<td>1 s</td>
</tr>
<tr>
<td>Antenna beam width</td>
<td>30°</td>
<td>15°</td>
<td>17°</td>
</tr>
<tr>
<td>Input range</td>
<td>0-320 K</td>
<td>0 – 320 K</td>
<td>0 – 320 K</td>
</tr>
</tbody>
</table>

- Develop hardware & software for:
  - Programmed control Antenna (Incident, Azimuth angles)
  - Automatic receiving & processing data from radiometers
  - Integration GPS signal to RDM data processing
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)
PASSIVE MW RS OF SOIL MOISTURE CONTENT (SMC)
Flowchart to estimate SMC (RDMs – Model)

Data measured from field trip
Ts, Tair, Tb(K) vs q
SF%, CF%, Bulk density BD: g/cm³

Define Dieltric Coefficient ε(WSi) of soil as for Model
Wang – Schmugge

Compute Fresnel reflec. coeff. from Fresnel equation Γ(th,ε)

Define soil emission eSI = 1-ΓI(th,ε)

Compare δ = |eS - eSI|

δ < 0.001

Then
Assign WS = WSI

Average & inform WS = AVG(WSI)

Informed FALSE

From data measured by RDMs, compute soil emission eS – after correction of the vegetation cover eV

Assign assumed variable Wsi = 0+i.0.1; i = 1,2,...
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 Temperature 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 \( \varepsilon = \varepsilon(Wc,T) \)
  - \( \varepsilon = \varepsilon' + i \varepsilon'' = \varepsilon(W_s, SF, CF, SLF, P) \)
  - \( W_s < W_t \rightarrow \quad \varepsilon = m_\nu \varepsilon_x + (P - m_\nu)\varepsilon_a + (1 - P)\varepsilon_r, \)
  - \( W_s > W_t \rightarrow \quad \varepsilon = W_t \varepsilon_x + (m_\nu - W_t)\varepsilon_w + (P - m_\nu)\varepsilon_a + (1 - P)\varepsilon_r \)
Program for computation of SMC with model Wang-Schmugge

File WS_SM_Site1.XLS
Experimental field, Gia Lam district - Site 1 (November 9, 2008)

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<tr>
<th>Angle (°)</th>
<th>0</th>
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<tbody>
<tr>
<td>Emiss_H</td>
<td>0.6098 #D12/01</td>
</tr>
<tr>
<td>Emiss_L</td>
<td>0.6555 #D12/01</td>
</tr>
<tr>
<td>Emiss_L</td>
<td>0.636 #D12/01</td>
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<tr>
<td>Emiss_L</td>
<td>0.626 #D12/01</td>
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<tr>
<td>Emiss_L</td>
<td>0.617 #D12/01</td>
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<tr>
<td>Emiss_L</td>
<td>0.590 #D12/01</td>
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Input data

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<th>Freq. GHz</th>
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<tr>
<td>Temp. °C</td>
<td>34</td>
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<tr>
<td>SF. %</td>
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<tr>
<td>CE. %</td>
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<td>BF. g/cm3</td>
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<tr>
<td>Angle, deg</td>
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<tr>
<td>lambda</td>
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Pure water dielectric model (see Ulaby et al., vol. 3, (E.14)-(E.19))

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<thead>
<tr>
<th>Eps'</th>
<th>Eps''</th>
<th>Eps''''</th>
<th>Eps''''''</th>
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<td>1.00</td>
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<td>3.00</td>
<td>4.00</td>
<td>5.00</td>
<td>6.00</td>
<td>7.00</td>
<td>8.00</td>
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<table>
<thead>
<tr>
<th>Delta 1</th>
<th>Delta 2</th>
<th>Delta 3</th>
<th>Delta 4</th>
<th>Delta 5</th>
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<tr>
<td>WSM [cm教]</td>
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<td>0.4200</td>
<td>0.6300</td>
<td>0.8600</td>
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<table>
<thead>
<tr>
<th>H-pol</th>
<th>H-pol</th>
<th>V-pol</th>
<th>V-pol</th>
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<tr>
<td>smooth</td>
<td>smooth</td>
<td>rough</td>
<td>rough</td>
<td>smooth</td>
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<td>0.962</td>
<td>0.968</td>
<td>0.971</td>
<td>0.978</td>
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<table>
<thead>
<tr>
<th>EMISSb</th>
<th>EMISSb</th>
<th>r</th>
<th>Re(E)</th>
<th>Im(E)</th>
<th>Re(Sq=E)</th>
<th>IM(Sq=E)</th>
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<tbody>
<tr>
<td>0.948</td>
<td>0.959</td>
<td>0.962</td>
<td>0.968</td>
<td>0.971</td>
<td>0.978</td>
<td>0.983</td>
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</table>
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 wind speed & coordinates by GPS receiver
- Measure SSS
- 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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