IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

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| **Project Title:** | **Passive Microwave Remote Sensing of Soil Moisture and Vegetation** | |
| **Project Number** | **IMURA0937** | |
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## Research Clusters:

**Highlight which of the Academy's CLUSTERS this project will address?**
*(Please nominate JUST **one**. For more information, see www.iitbmonash.org)*

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| 1 | *Material Science/Engineering (including Nano, Metallurgy)* |
| 2 | *Energy, Green Chem, Chemistry, Catalysis, Reaction Eng* |
| 3 | *Math, CFD, Modelling, Manufacturing* |
| 4 | *CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control* |
| 5 | ***Earth Sciences and Civil Engineering (Geo, Water, Climate)*** |
| 6 | *Bio, Stem Cells, Bio Chem, Pharma, Food* |
| 7 | *Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng* |
| 8 | *HSS, Design, Management* |

## Research Themes:

**Highlight which of the Academy's Theme(s) this project will address?**
*(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

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| ***1*** | *Advanced computational engineering, simulation and manufacture* |
| 2 | *Infrastructure Engineering* |
| 3 | *Clean Energy* |
| 4 | ***Water*** |
| 5 | *Nanotechnology* |
| 6 | *Biotechnology and Stem Cell Research* |
| 7 | *Humanities and social sciences* |
| 8 | Design |

## The research problem

Water content in soil and vegetation are the important land surface variables which influence the land-atmosphere interactions. Soil moisture has applications in precipitation estimation, irrigation water quantification, weather forecasting, and modeling of heatwaves and extreme events such as floods and droughts. The Vegetation Water Content (VWC) affects the vapor transport to the atmosphere, contributing to subsequent precipitation patterns.

Passive microwave remote sensors can estimate soil moisture and VWC at global scales. The passive microwave sensors (radiometers) measure the electromagnetic radiations naturally emitted from the Earth's surface as brightness temperatures (Tb). These measurements are sensitive to the dielectric properties of target media, which predominantly include soil and vegetation. Generally, a retrieval algorithm is used to determine these variables. This algorithm consists of a Radiative Transfer Model (RTM) that estimates the target emissivity information. The goal of an efficient RTM would be to decompose the emission contributions accurately from soil and vegetation. In the case of soil, it is essential to characterize the emissivity from soil moisture and soil roughness. In the case of vegetation, it is necessary to resolve the VWC (represented as Vegetation Optical Depth – VOD) and the scattering effects of vegetation. Soil roughness and vegetation scattering are generally characterized through certain parameters in an RTM. With the advent of operational passive microwave missions, Advanced Microwave Scanning Radiometer 2 (AMSR2), Soil Moisture Active Passive (SMAP), and Soil Moisture Ocean Salinity (SMOS), efforts are being made to retrieve soil moisture and VOD at global scales. However, current RTMs have certain algorithm limitations, which affect the retrieval accuracy. The VOD has the potential to characterize vegetation from ground to top-of-canopy. There are challenges involved in the estimation and validation of VOD. Besides, the footprint scale of L-band Tb measurements (of operational SMOS and SMAP missions) is too coarse (in the order of tens of kilometres) for applications involving heterogeneous agriculture landscapes, and high-resolution land surface modelling. In this aspect, various attempts are being made to disaggregate the satellite soil moisture retrievals.

Recently, efforts are underway to develop science to retrieve soil moisture using P-band radiometer. This enables retrieval of soil moisture from deeper soil layers compared to that of L-band. There is a need to assess the influence of vegetation and roughness parameterization on soil moisture retrievals. The P-band Tb also has the potential to retrieve VWC more realistically given the deeper depth of penetration compared to that of L-band Tb.

## Project aims

This project shall aim to develop/improve RTMs in an attempt to obtain high accuracy, high-resolution soil moisture, and VOD retrievals. The following objectives shall be attempted:

1. To resolve the parameter dependency on soil moisture and VOD retrievals in the case of L- and P- band radiometers. Assess the possibility of decoupling the roughness and vegetation effects in the zeroth-order RTM to determine a temporally varying roughness parameter along with VOD.
2. To determine if a temporally varying single scattering albedo parameter can improve the characterization of soil moisture and VOD.

3. To use multi-temporal and spatial information of Tb to improve the quality of soil moisture and VOD retrievals. Here, the possibility of including temporally varying model parameters shall be explored.
4. To downscale soil moisture and VOD retrievals using high-resolution model simulations and influential satellite datasets along with in-situ and airborne data.

The soil moisture data available through airborne and field campaigns in OzNet and SMAPEx networks shall hold a key role in retrieval evaluations. The analysis shall focus on SMAP L-band, and P-band airborne missions.

**Expected outcomes**

The following are the expected outcomes of this project:

1) To improve the understanding of the parameterization of RTM.
2) To develop a new RTM that can retrieve soil moisture and VOD with improved accuracy.
3) To develop high-resolution soil moisture product
4) To develop high-resolution VOD product that has high temporal resolution unlike optical/thermal vegetation products.

**How will the project address the Goals of the above Themes?**

Through this project, we shall attempt to develop better soil moisture and vegetation products. Improved soil moisture characterization can help in multitude of areas including agriculture, weather forecasting, drought modelling, etc. It will also contribute to understand the role of soil moisture in land-atmosphere feedback mechanisms. Through VOD product, we can determine the VWC, which is essential to assess how the growth patterns influence the hydrological cycle.

**Capabilities and Degrees Required**

1) Bachelors in Civil Engineering or Agricultural Engineering or Electrical Engineering or any relevant field of Earth Sciences
2) Masters in Remote Sensing and GIS or Water Resources Engineering or Agricultural Engineering or Electrical Engineering or any relevant areas
3) Ability to do programming (Python, R, MATLAB etc.)

**Potential Collaborators**

*Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.*

1) Prof. J. Indu, Department of Civil Engineering, IIT Bombay
2) Prof. M. Sekhar, Department of Civil Engineering, IISc Bangalore