Chapter 7 : OVERALL CONCLUSION AND FUTURE PLAN

7.1 OVERALL CONCLUSION

The research work described in this thesis explored microwave space-borne observations for monitoring soil moisture and biophysical parameters. For effective soil moisture monitoring, the baseline algorithm of the SMAP soil moisture product has to be improved. Single Channel Algorithm (SCA), based on the Tau-omega model, is the baseline algorithm of SMAP soil moisture product (From 2015 to 2021). In this thesis, the SCA has been enhanced in two ways; by optimizing the surface roughness parameter for agricultural fields of northern India and by improving the VWC data product. The optimization of the surface roughness parameter for SCA explains the sensitivity of surface roughness for the assessment of soil moisture, and the resulting value of the roughness parameter for the Varanasi region varies from 0.2 to 0.4. These values are found to be higher than the reported value of surface roughness for croplands (0.108) in the ATBD (Algorithm Theoretical Basis Document) of SMAP.

The VWC product has been improved in two ways; first, by substituting the low temporal resolution VWC product with daily VWC product, and second by substituting the optical VWC with microwave VWC in SCA. To estimate a daily VWC product, a different MODIS product (MOD09GA) has been utilized, which provides surface reflectance of seven bands of the electromagnetic spectrum on a daily basis. The incorporation of daily VWC product in SCA significantly enhances the accuracy of soil moisture estimation when compared to already available SMAP L2 soil moisture product.

VWC in the microwave region is estimated using microwave vegetation indices such as DPRVI (Dual Polarimetric Radar Vegetation Index), RVI (Radar Vegetation Index),

and CCR (Cross and Co-polarized Ratio), which are assessed using Sentinel-1 dual polarimetric SAR data. Each of these three vegetation indices was used as an input in three machine learning techniques, including Random Forest (RF) regression, Support Vector Regression (SVR), and Adaptive Neuro-Fuzzy Inference System (ANFIS). On comparing the performance of three microwave vegetation indices and machine learning algorithms, the DPRVI is found to be the best indicator of VWC. DPRVI shows a good accuracy with RF and SVR both in the retrieval of VWC. Then, the inclusion of this estimated microwave VWC in SCA improves the results of soil moisture estimation and the best accuracy is shown by the combination of DPRVI and SVR.

The SMAP 9 km soil moisture data product also spatially downscaled up to 1 km using multiple downscaling approaches such as the Triangle method, the Dispatch method, and the Approximation of Thermal Inertia (ATI) theory. The comparison of these algorithms indicates that the Thermal Inertia-based approach is the best-performing approach. Apart from that, a new vegetation modulated index is also developed to downscale SMAP soil moisture. This index was developed by utilizing MODIS LST and NDVI, that modulated the effects of vegetation on land surface emissions and represent the soil characteristics more precisely. This index improves the results of downscaling of SMAP soil moisture in comparison to the traditional methods.

7.2 FUTURE PLAN

The following research objective can be fulfilled in the future,

- The soil moisture estimation can also be improved by including the First-order scattering instead of the zeroth-order RTM model. This will be helpful for the measurement of soil moisture in the region of dense vegetation such as Forest.

- Development of a physical microwave model for the evaluation of VWC in SCA.
- Development of a physical microwave algorithm for the downscaling of SMAP soil moisture product
- NASA's satellite GRACE (Gravity Recovery and Climate Experiment) provides Total Water Content (TWC), which is composite information of Soil moisture and Ground Water Content (GWC), at the spatial resolution of 500 km. It is planning to downscale it up to a few kilometers.

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