A LARGE SCALE MICROWAVE EMISSION MODEL FOR FORESTS CONTRIBUTION TO THE SMOS ALGORITHM

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ABSTRACT

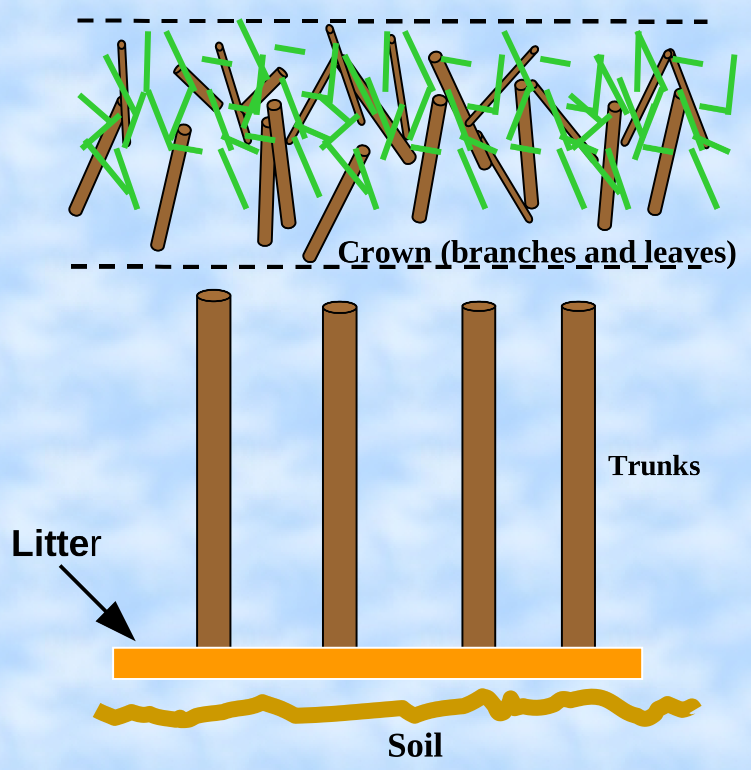
The SMOS mission will provide soil moisture and ocean salinity at global scale. The principle for soil moisture monitoring is the high sensitivity of L-band measurements to surface soil water content. Since a significant percentage of pixels contains arboreous vegetation (at least partially), a reliable estimate of forest emissivity is needed to fully exploit the potential of the mission. Moreover, soil moisture can be retrieved in areas with sparse woodland, but this requires a detailed knowledge of the variables which affect the overall emissivity. To effectively manage these problems, the electromagnetic model developed at Tor Vergata University was combined with information available from forest literature. Using allometric equations and auxiliary information, the geometric and dielectric inputs required by the model were related to global variables available at large scale, such as Leaf Area Index. Different distributions of trunk diameters are being considered. Simulations indicate that, at L-band, leaves are almost transparent, attenuation is mostly due to branches, and soil contribution can be still appreciable, unless the forest is dense.
The model is being refined, to consider seasonal variations of foliage cover, subdivided into arboreous foliage and understory contribution.

The Electromagnetic Model

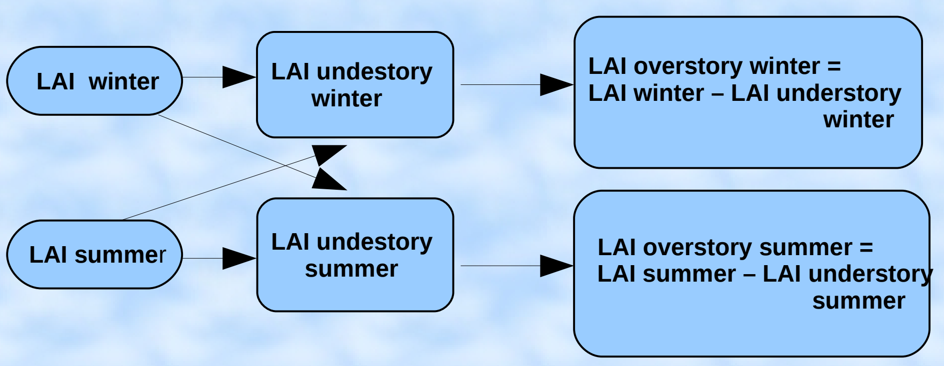
Basic aspects

(Ferrazzoli and Guerriero 1996)

- Based on radiative transfer theory;
- Adoptions of a discrete approach to represent forest elements;
- Combination of contributions by a matrix algorithm which includes multiple scattering;
- Compution of the emissivity of the whole canopy, and single components.

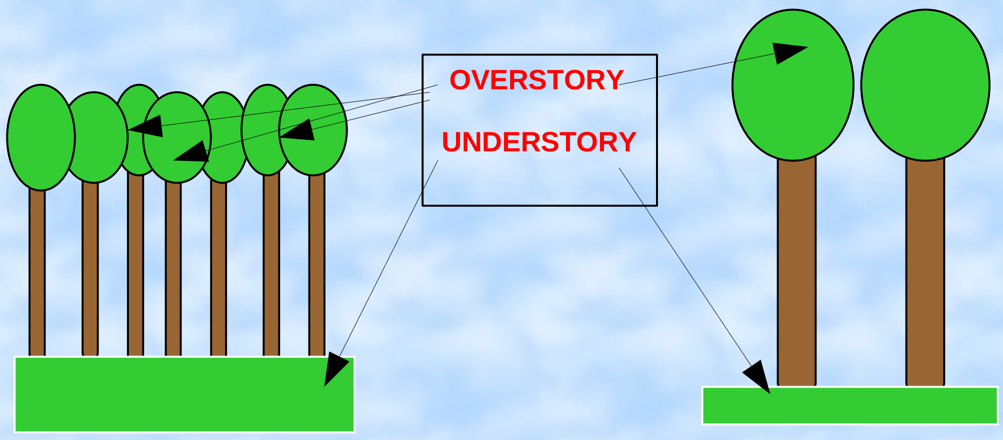


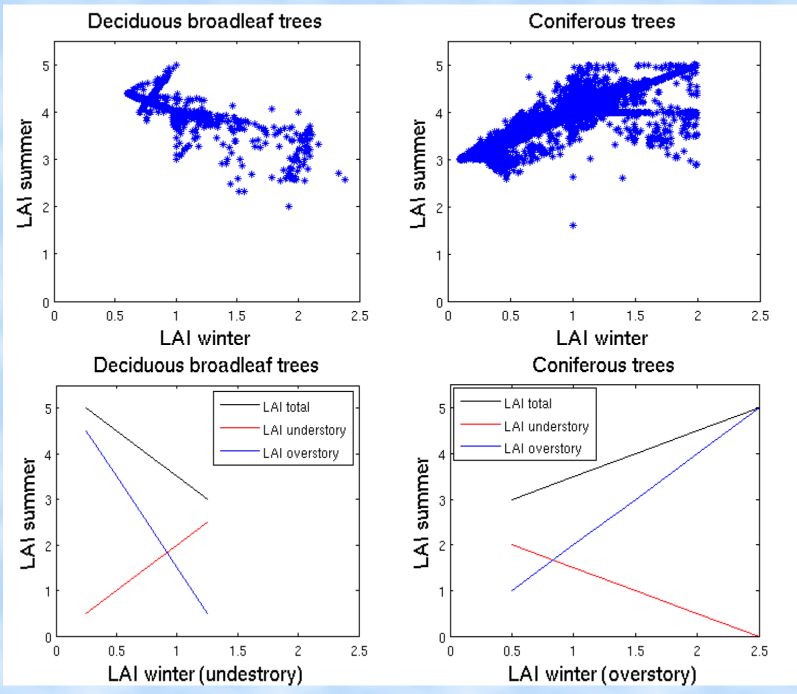
Subdivision of Leaf Area Index into overstory and understory components



PROBLEMS

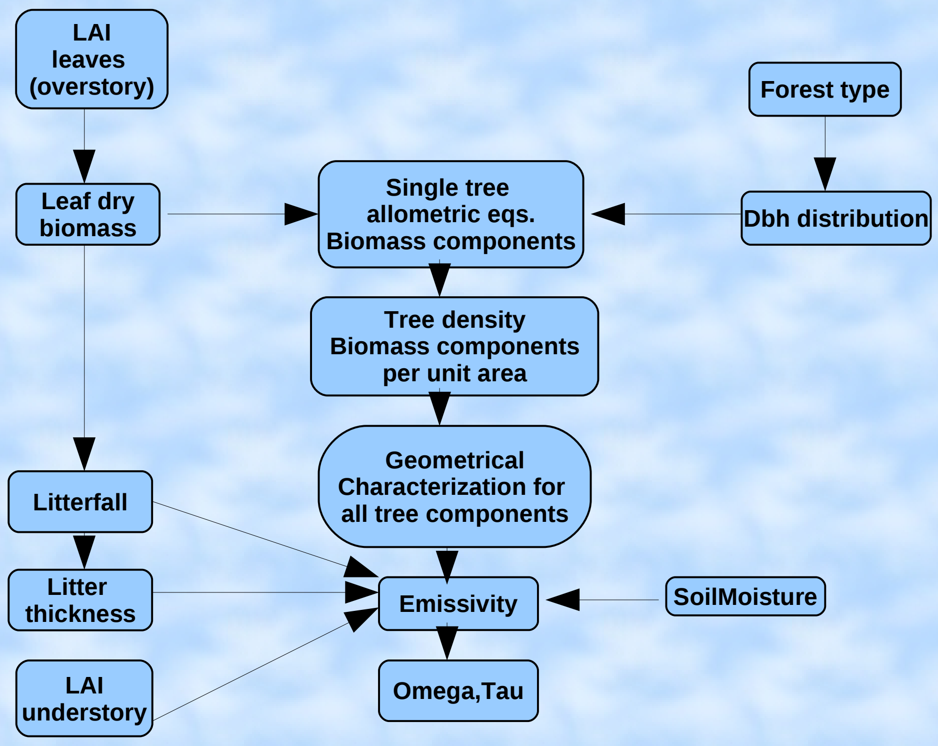
- LAI is contributed by both overstory and understory
- The overall LAI (overstory + understory) is made available by Ecoclimap
- Only the overstory contribution is related to other forest variables.
- An inverse correlation between overstory LAI and understory LAI was found.



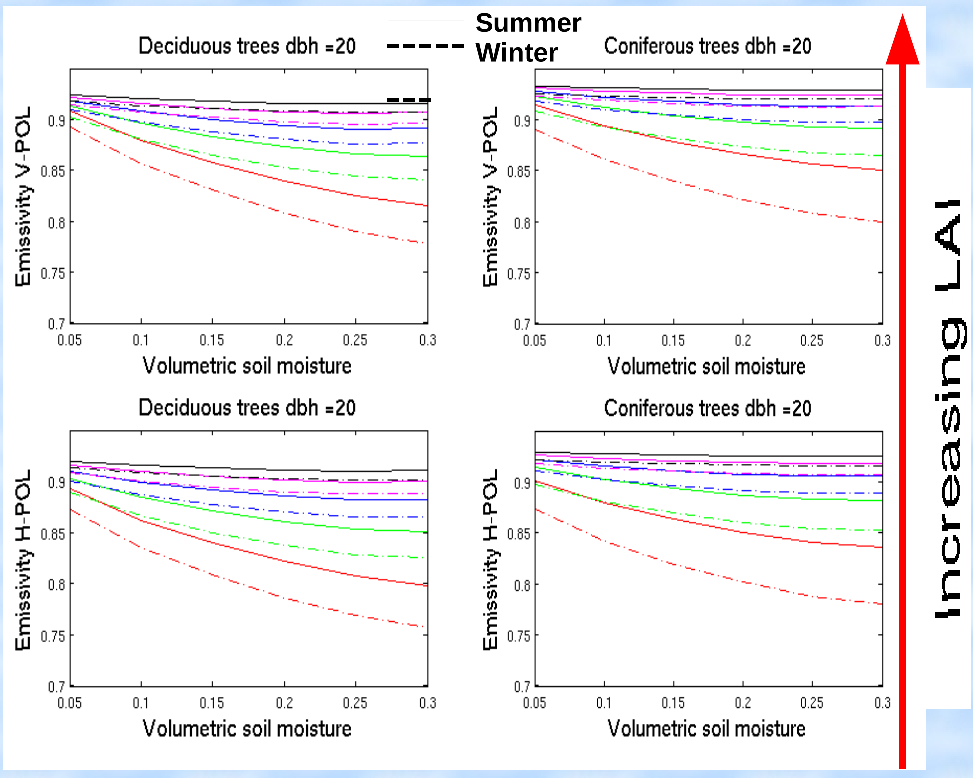


Large scale characterization

For each grid node, inputs derived by ECOCLIMAP are Leaf Area Index (LAI) and broad forest category. This information, in conjunction with allometric equations available in the literature and a large scale averaging process, provides geometrical variables required by a discrete RT model. The model, on its turn, predicts the emissivity for several values of soil moisture and incidence angles, at both polarizations. Finally, a simple parametrization gives equivalent values of optical depth and albedo as output

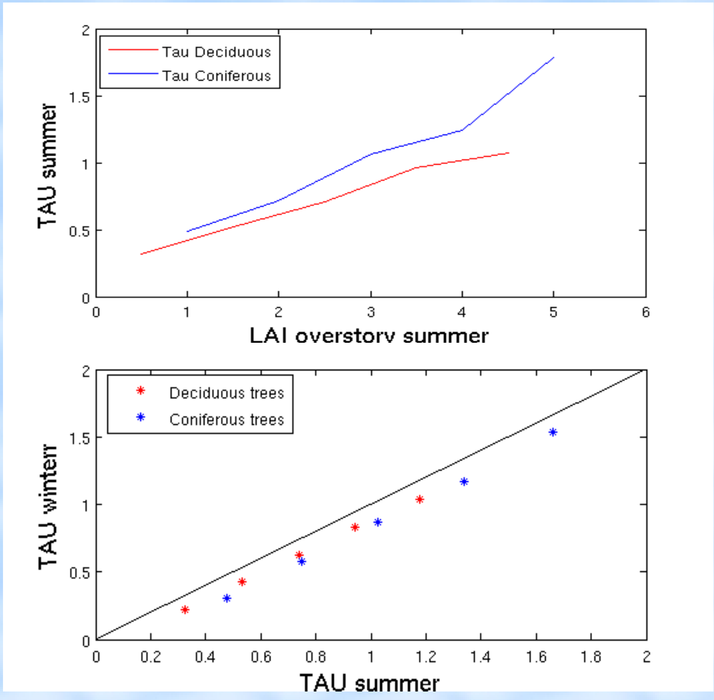


Parametric Results at L-Band



Parametrization at L-Band

Simulated emissivity values have been used to obtain the equivalent values of albedo and optical depth as a function of LAI. This "parametrization" has been made following two steps.
First of all, equations of ATBD for soil reflectivity have been considered. The constants Q, N and h have been fitted in order to represent the reflection properties computed by TVM for rough soil.
Then, equations of ATBD for vegetation emissivity have been taken. For several values of LAI, brightness temperatures values predicted by ATBD formulas have been compared against values simulated by TVM for the same physical temperature. The values of ω and τ producing the best fit have been computed.



Comparison with Experimental Data

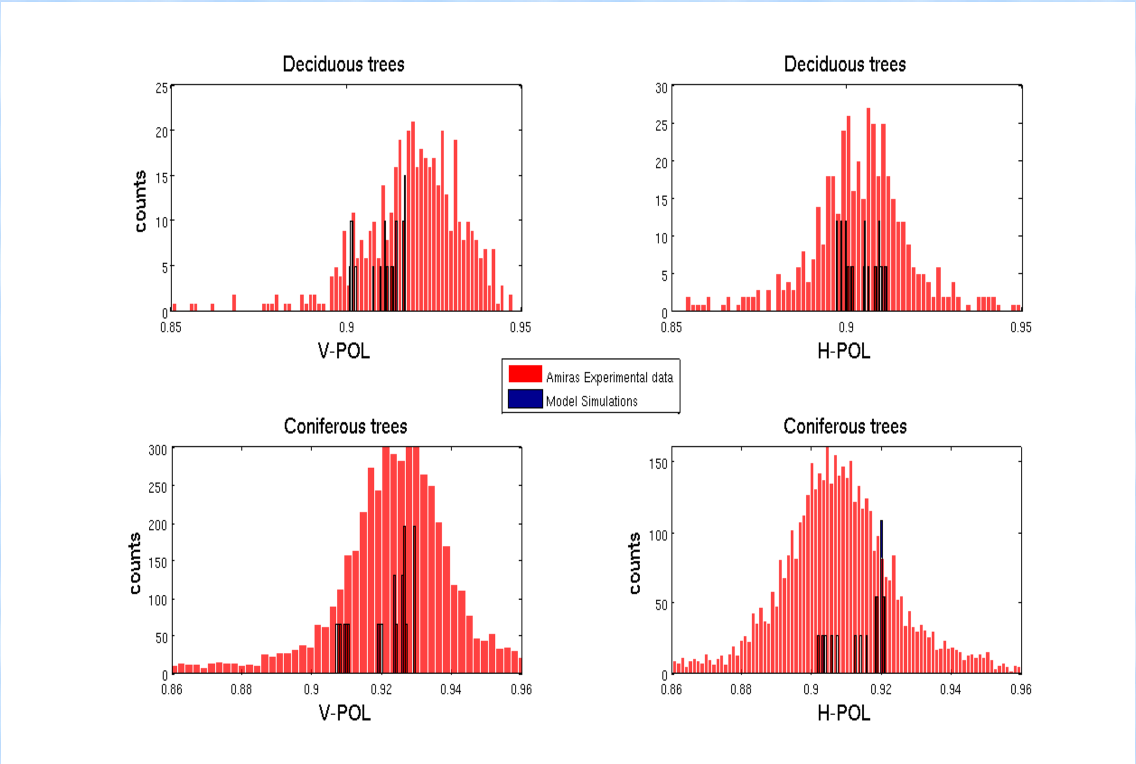
The model was tested against radiometric measurements carried out by towers and aircraft's in Italy, France and Germany. A new test has used the brightness temperatures measured over forests in Finland by the AMIRAS radiometer, which is an airborne demonstrator of the MIRAS imaging radiometer onboard SMOS.

Comparison at L-Band: "AMIRAS Experiment over Deciduous & Coniferous forests, Finland"

A classification was made for different land categories overflown by AMIRAS using ECOCLIMAP database and the corresponding values of LAI for forest areas.

Using the values of physical temperature and soil moisture extracted from ECMWF, we computed the values of the emissivity for a range of incidence angles between 20° and 30°.

For forests, we made a comparison between measured emissivity values and simulated ones for a range of dbh between 5 and 35 cm and incidence angle between 20° and 30°.



Planned research works

The outputs produced by the model are used to fit the parameters of the simple radiative transfer model which will be used in the Level 2 soil moisture retrieval algorithm of SMOS. It is planned to compare model outputs with L1C data, which will be made available during the commissioning phase. To this end, a number of adequate extended forest sites are being selected: the Amazon rain forest, Zaire Basins, Argentina Chaco forest, Finland, and Polynesia