Retrieval of Soil Moisture with Airborne and Satellite Microwave Sensors

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Introduction

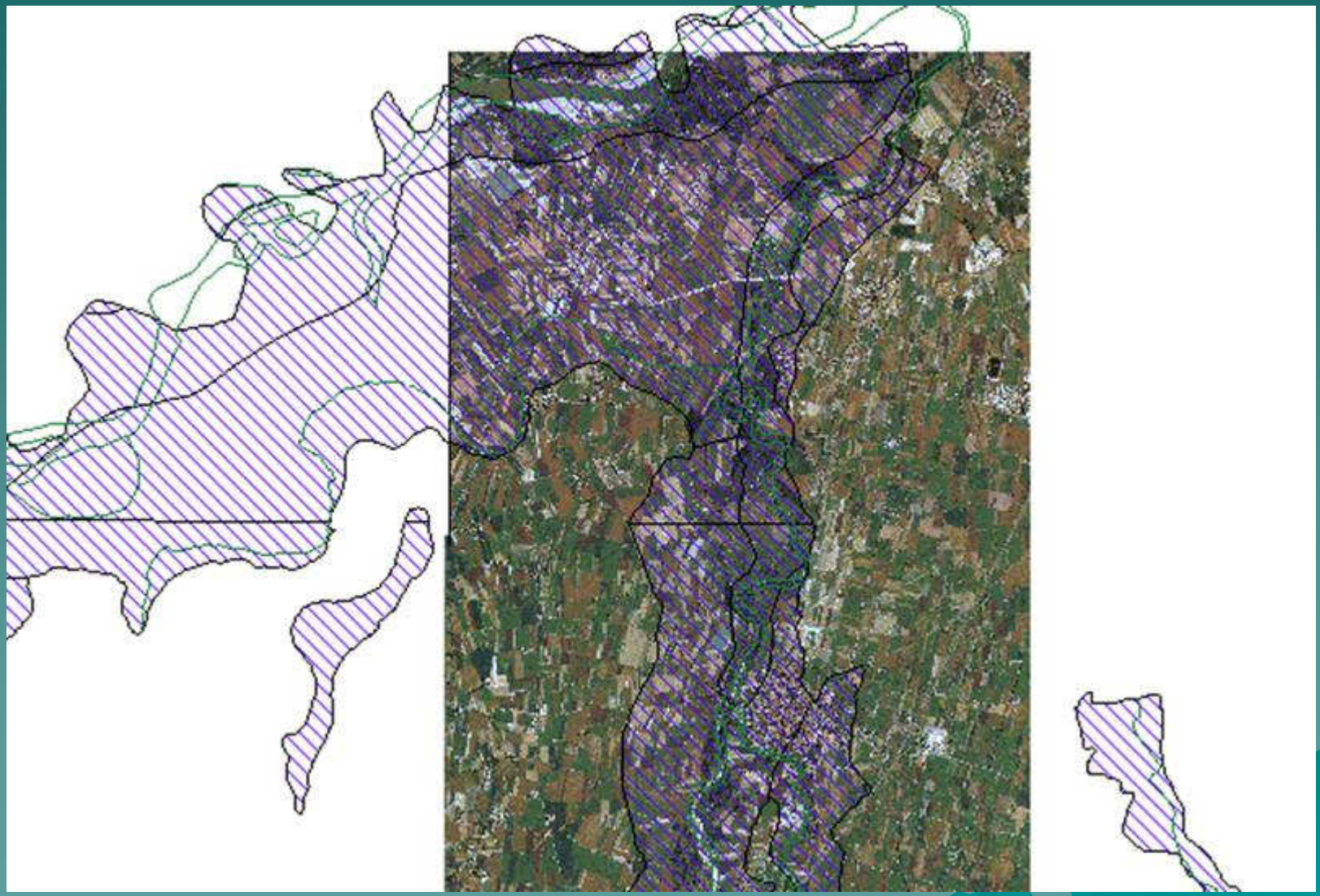
- Active and passive systems have been tested in several sites and climatic conditions during many years in order to assess the real possibility of measuring SMC on a large scale from satellite data.
- Two important missions have been planned to estimate SMC from satellite: ESA SMOS, close to launch, and NASA SMAP, planned in the next future years.
- Results obtained on an agricultural test site in Northern Italy are presented here, by using data from different microwave sensors, to validate inversion algorithms designed to retrieve SMC from AMSR-E data and ENVISAT/ASAR data.
- Both algorithms are based on ANN and will be used in the operational Italian national pilot project (PROSA) funded by the Italian Space Agency.
- The goal of the project is to deliver timely information on SMC and snow cover, derived from EO data, to be used by the Italian Department of Civil Protection in forecasting the risk of floods and landslide.

The experiment

- An airborne campaign with multifrequency microwave radiometers at L, C and X bands was carried out on an flat alluvial area (Alessandria) in Northern Italy, in the Po Valley, characterized by large and flat agricultural fields, at the beginning of October 2008, with the aim of improving the generation of soil moisture and vegetation biomass maps by using both active and passive sensors.
- Ground measurements of vegetation biomass, SMC, and surface roughness data were collected simultaneously with remote sensing measurements.
- Several satellite data from AMSR-E and ENVISAT/ASAR were also collected on the same area in different seasons and for several years, to test the algorithms at different spatial scales.

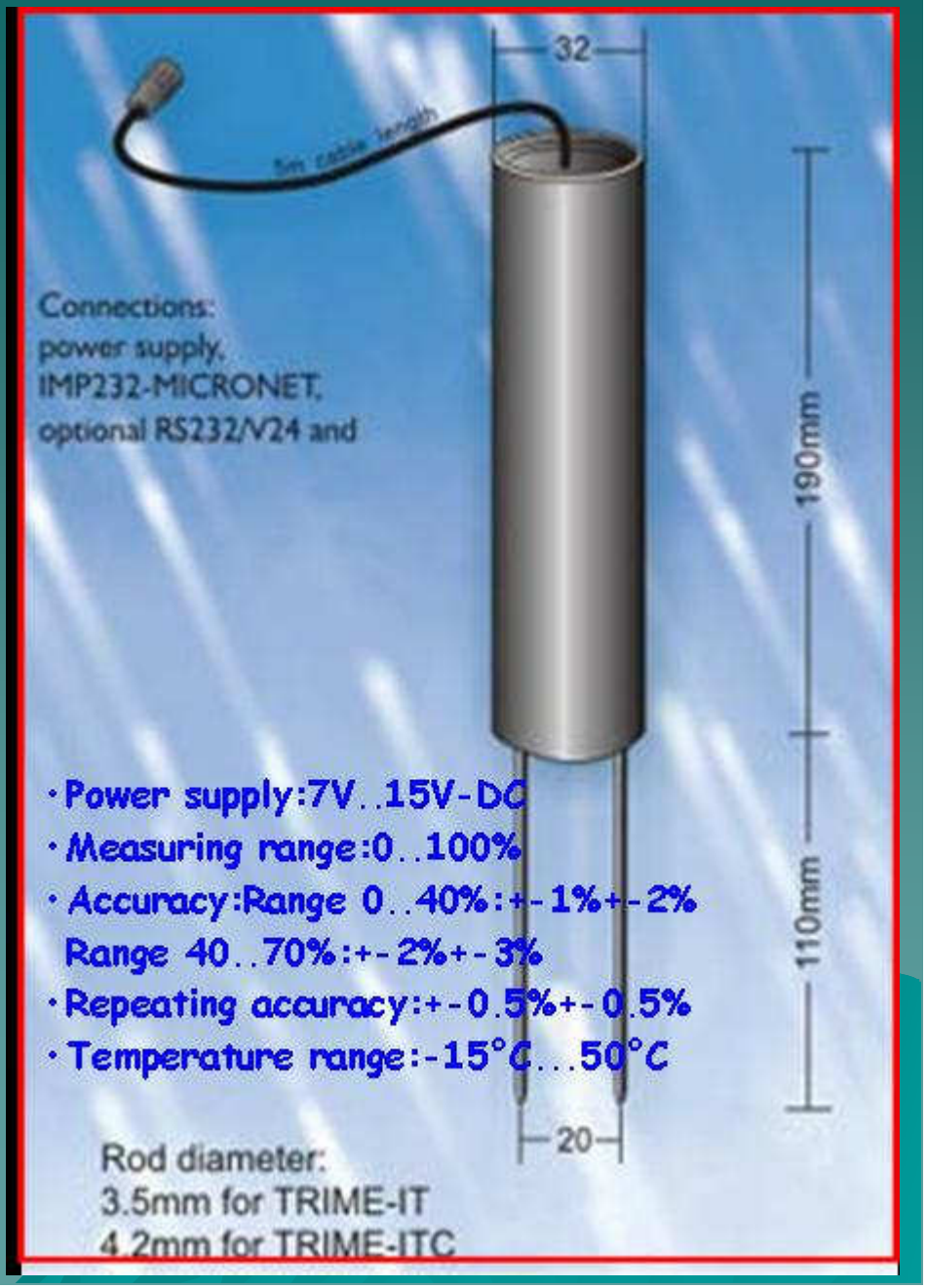
SMC investigations in Northern Italy (Alessandria area)

Castelnuovo Scrivia test area



Castelnuovo Scrivia test area: ground measurements

Ground campaigns: SMC measurements

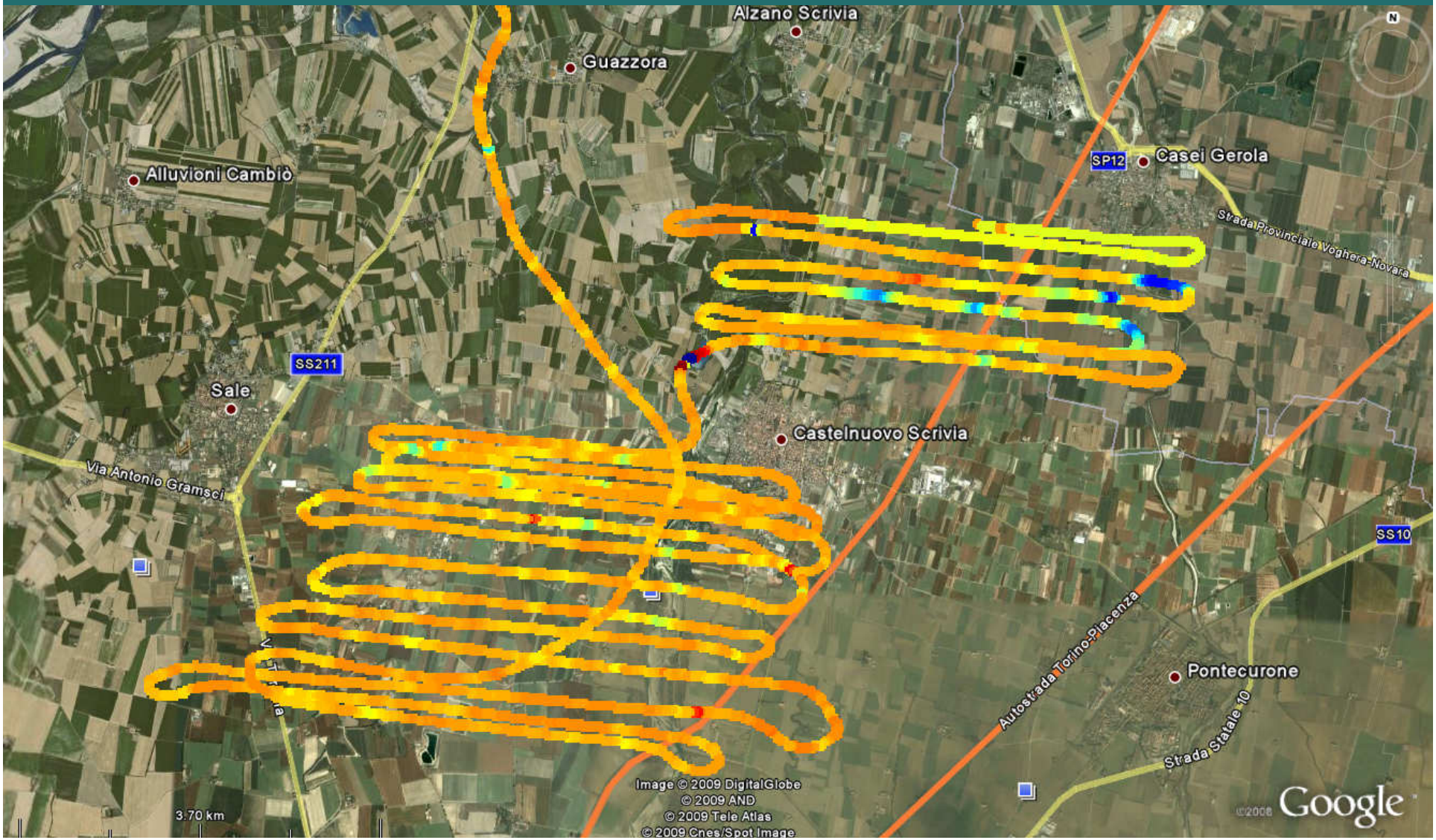


Airborne IROE MW sensors

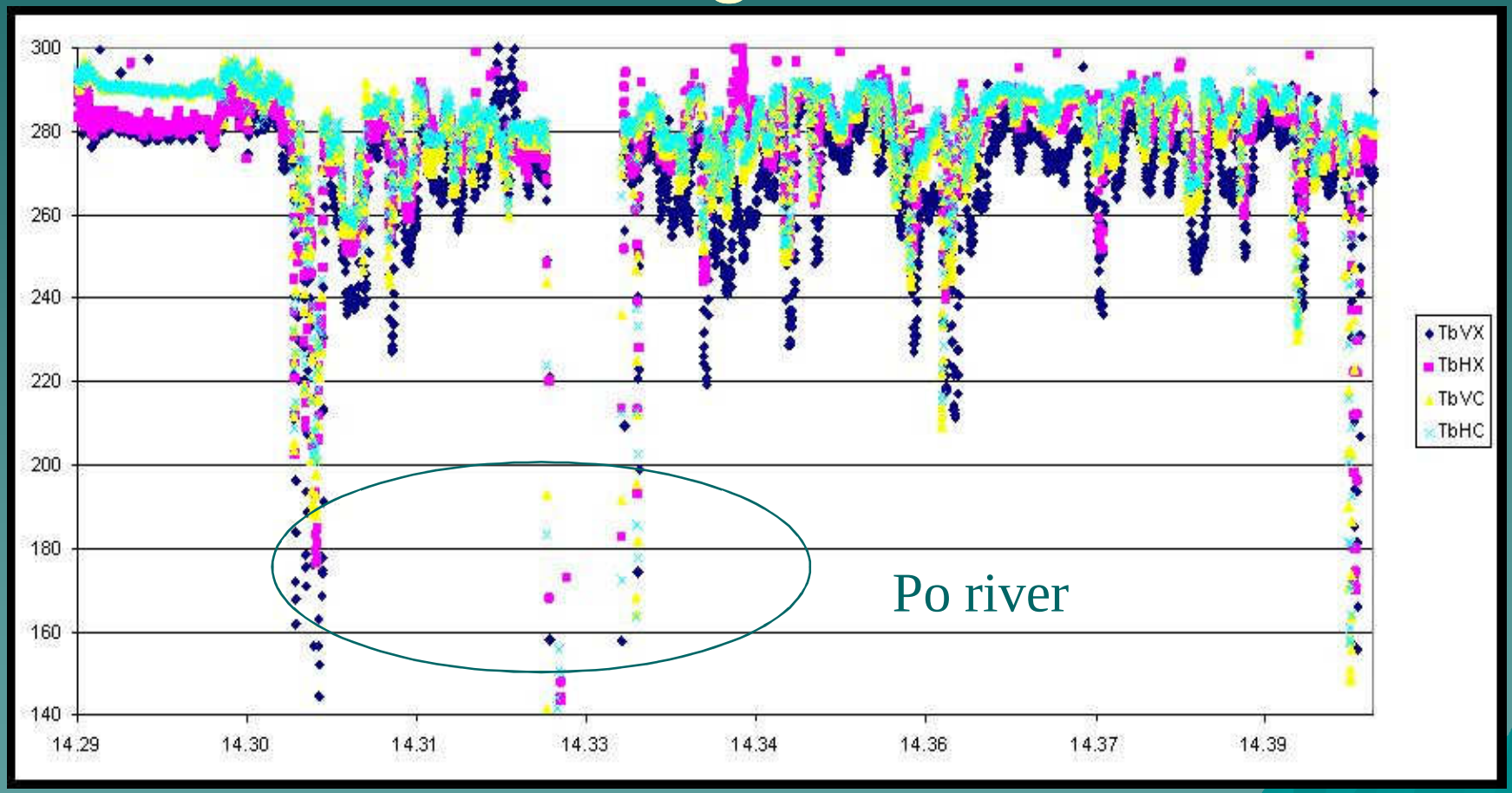
IROE Airborne Experiments

Frequency	Pol.	Incidence Angle	Accuracy
1.4 GHz	V, H	20°	± 0.5 K
6.8 GHz	V,H	20°	
10 Ghz	V,H	50°	

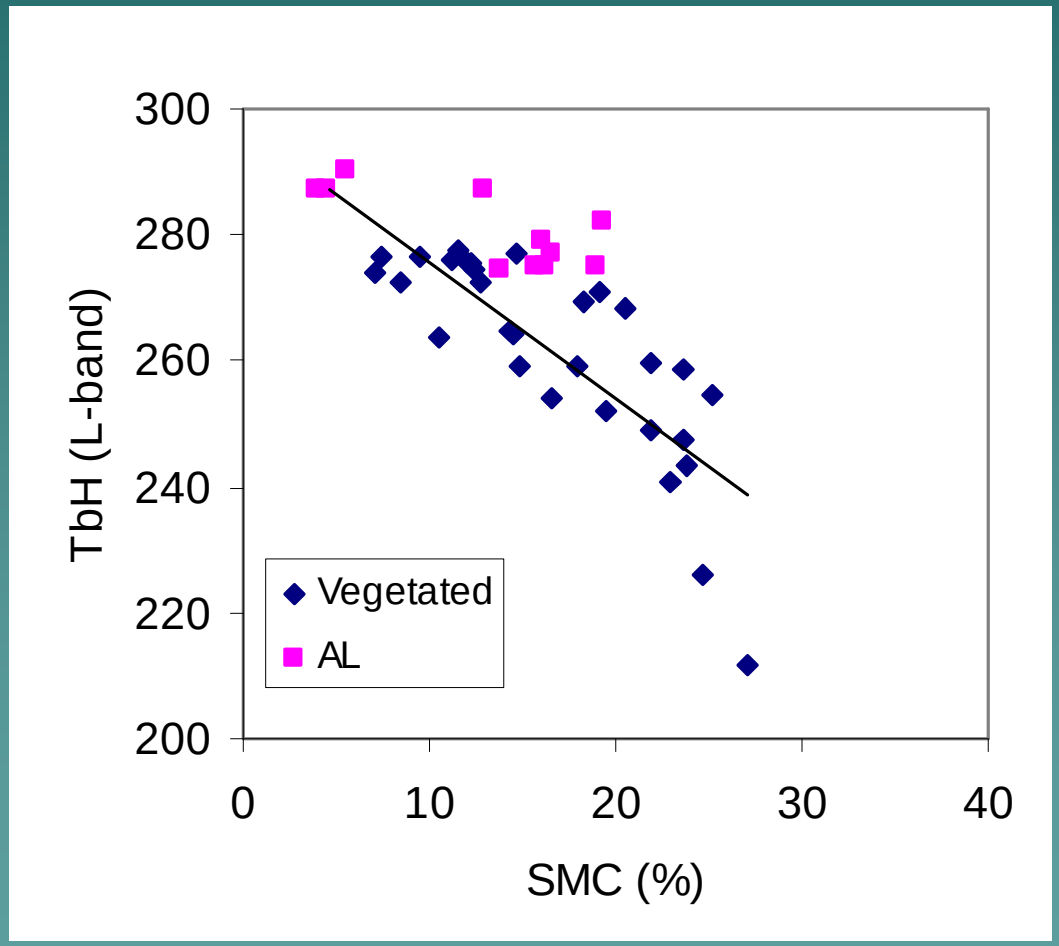
Flight Tb lines at C-band



Example of Tb variations along a flight line



Correlation between Tn(L) and SMC and comparison with previous data



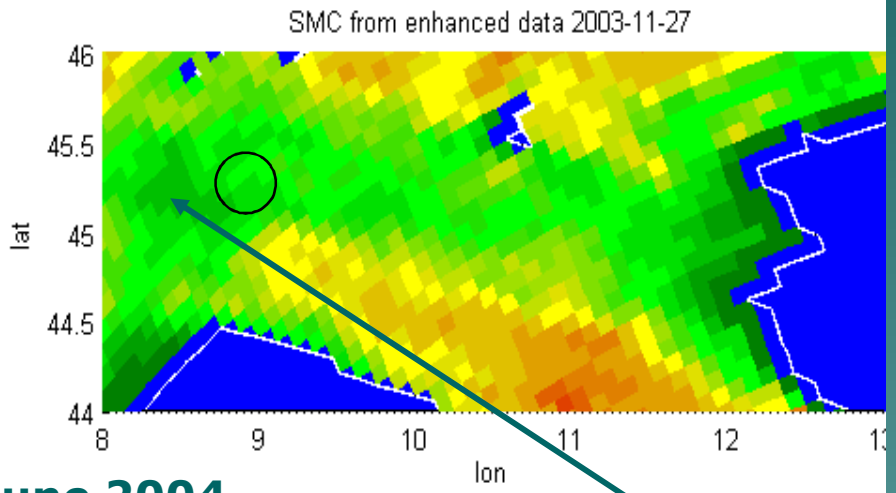
Tb=-2.17SMC + 297.65
R^2 = 0.6402

Retrieval Algorithms

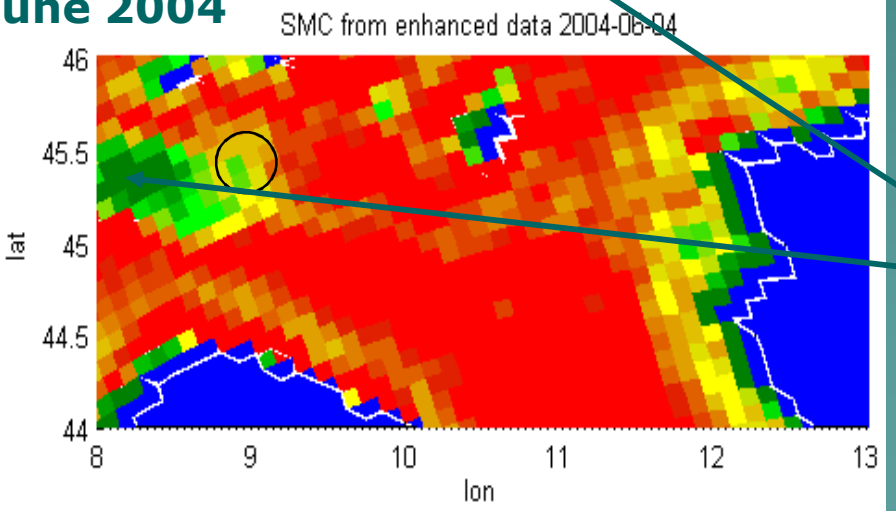
- The algorithms developed for generating the SMC maps from both radiometric and SAR data are based on ANN method and use a feed-forward multi-layer perceptron (MLP), with some hidden layers of neurons between the input and output.
- The training method of the two ANN was based on the omega-tau model for radiometric data and on the AIEM model for SAR data
- An example of the results obtained by the two retrieval algorithms is shown in the following:
  - global SMC maps of Northern Italy obtained by using AMSR-E data at C and X bands
  - local SMC maps of Alessandria area produced by using ENVISAT/ASAR C-band images collected in the same period

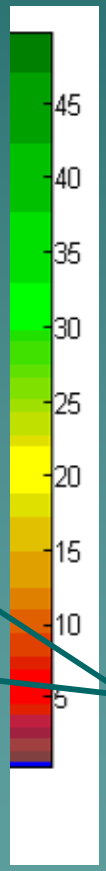
SMC maps from AMSR-E data (Northern Italy)

November 2003



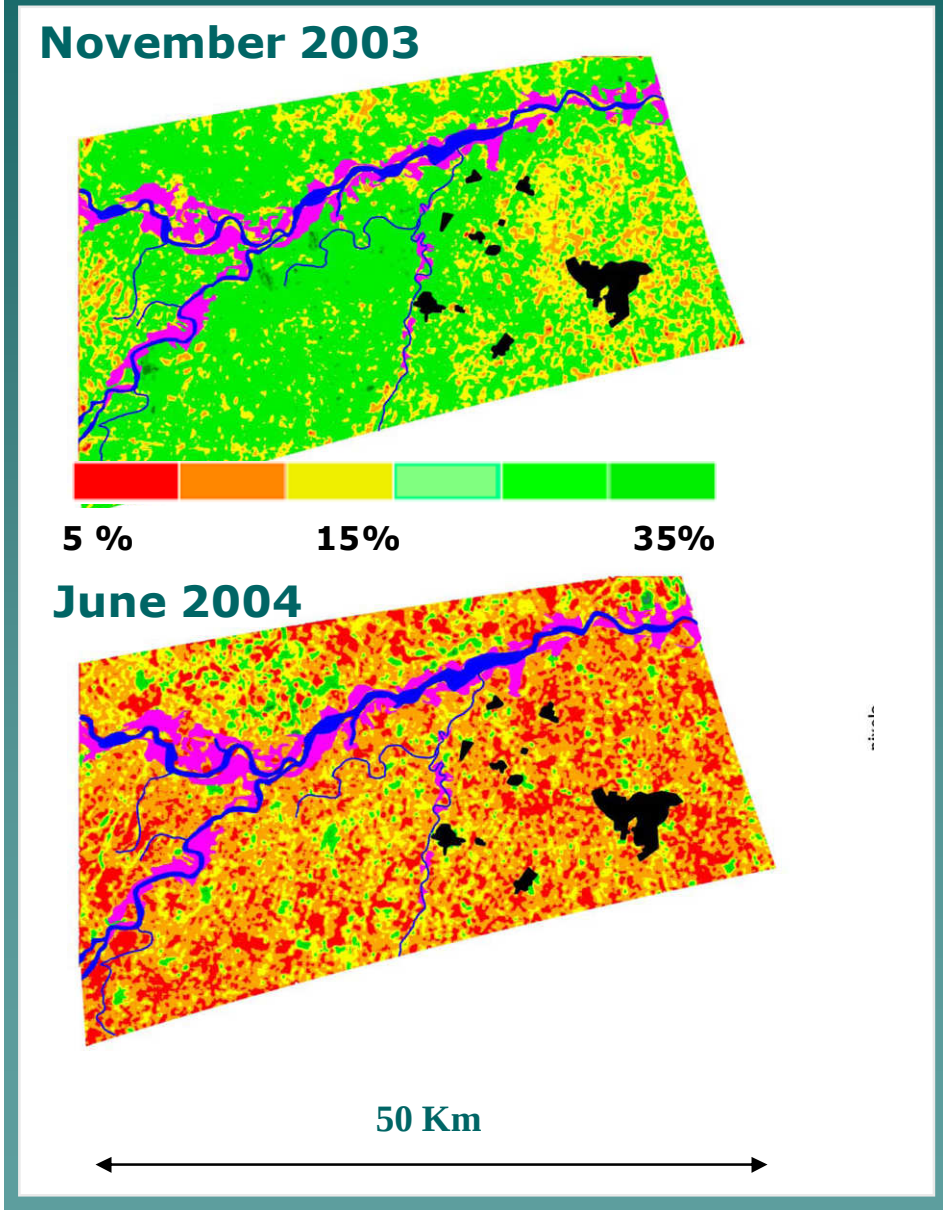
June 2004





- SMC maps obtained in November 2003 and June 2004 from AMSR-E data at C and X bands.
- In spite of the coarse ground resolution, a marked difference in SMC is visible and in agreement with the meteorological conditions.
- In November, the weather was wet with frequent rainfalls, whereas in June a severe drought occurred.
- An area of rice fields in the north-west of the image was wetter in June than in November, when the rice fields were flooded.

Comparison with SAR data



- For the specific area of Alessandria, SMC maps were produced by using ENVISAT/ ASAR images collected in the same months.
- Due to the great difference in ground resolution of two sensors, the maps derived from ASAR cover a very small portion of the maps obtained from AMSR-E (50 kmx20 Km).
- In spite of the disparity of products obtained, both maps show SMC values in reasonably accordance with the rainfall data recorded on the area.
- The levels of SMC are almost the same and are of the order of 20-25% in November and 10% in June.

Summary

- Experimental investigations carried out on a test site in Northern Italy with airborne and satellite sensors made it possible to put together a significant set of experimental data.
- These data were used for validating two algorithms designed to retrieve soil moisture at regional and field scales, based respectively on microwave radiometers and SAR.
- Both algorithms are based on an ANN and will be used in the operational Italian national pilot project (PROSA), funded by the Italian Space Agency.
- The goal of the project is to deliver timely information on soil moisture and snow cover to the Italian Department of Civil Protection in forecasting the risk of floods and landslide.
- The SMC maps produced from both microwave radiometers and SAR for the Northern Italy region showed a good agreement with meteorological data.
- Although with a great difference in ground resolution and in swath of two sensors, the σ° data of ENVISAT/ASAR images and the microwave radiometric data of AMSR-E gave rather similar results.