USE OF REMOTE SENSING TECHNIQUES AND NAVIGATION DATA FOR TROPOSPHERIC CHANNEL ASSESSMENT

S. Crewell[1], F.S. Marzano[2], V. Mattioli[3], N. Pierdicca[2], C. Capsoni[4], D. Cimini[5], E. Fionda[6], U. Löhnert[1]

[1] Institute for Geophysics and Meteorology, University of Cologne, Germany
[2] Dip. di Ingegneria dell'Informazione, Elettronica e Telecomunicazioni, Sapienza Università di Roma, Italy
[3] Dip. di Ingegneria Elettronica e dell'Informazione, Università di Perugia, Italy
[4] Dip. di Elettronica e Informazione, Politecnico di Milano, Italy
[5] IMAA, National Research Council (CNR), Tito Scalo (Potenza), Italy
[6] Fondazione Ugo Bordoni, Roma, Italy

Introduction: The objective of this contribution is the review of remote sensing and navigation data in order to provide a clear picture of meteorological related parameters that can be used as input of propagation modelling up to W band, of propagation data useful to assess the accuracy of the models and for their improvement, and of all data and satellite observations applicable for propagation impairment mitigation techniques (PIMTs).

Both ground measurements and satellite observations will be considered as for meteorological related parameters. Beacon, radiometer and radar data will be considered as for propagation related parameters. The reviewing activity will be described as for ground measurements (meteorological station, radiometer, radar, GNSS receiver) and for satellite observations (Earth observation missions). The review will take into consideration the various constituent of the atmosphere such as water vapour, cloud liquid water, rain water content, ice water content and turbulence in terms of spatial distribution and microphysical properties which impact on the radio propagation channel modelling for both terrestrial space communications.

Synergy among COST actions devoted to electromagnetic propagation (e.g., IC0802) and to tropospheric profiling (e.g., ES0702) will be also addressed.

Ground-based remote sensing data: The statistical results collected in the various beacon, radar and radiometric experiments are a valuable data set for modelling propagation impairments. In fact, several models have been developed in the past using statistical results limited in terms of observation time, frequency band and geographical significance, while the large database of statistical propagation parameters now available, from both ITU-R and from the various experimentes, can be efficiently used to evaluate the performance of the models on a more effective basis with respect to before. Moreover, meteorological measurement campaigns have been carried out concurrently with propagation experiments, producing a very effective tool to feed propagation models, whose predictions' accuracy is now not affected by the uncertainty of the meteorological input. Ground measurements, that are object of this proposal, include meteorological ancillary measurements, radiosounding vertical profiles, beacon and radiometric data and radar maps.

Since the propagation effects to be considered in the frequency bands of interest (8-90 GHz) are gases, clouds, rain, melting layer and ice, several ground measurements are fundamental. Specifically we will consider: microwave radiometric measurements; Global Positioning System (GPS) receivers; microwave radar, wind profilers plus ancillary meteorological measurements (pressure, humidity, temperature, rain gauge) and radiosounding vertical profiles.

Earth observation data: Earth Observation (EO) data may contribute to acquire information to characterize the structure and statistical behaviour of the atmospheric channel, as required for propagation studies. The use of EO satellites is foreseen, in conjunction with standard ground networks, for two different purposes:

- Provide direct inputs to propagation tool, either a physical tool requiring a detailed description of the atmospheric structure, or regressive tool requiring as input more synthetic and easily available quantities
- Provide meteorological constraints to build by a Monte Carlo approach an atmospheric database which is representative of a certain region of interest

The question we will answer shall be the following: which EO product can be valuable within propagation studies? In order to answer the question, a review of different sources of EO information, their properties (i.e., resolution, accuracy, availability) and the identification of the more suitable data sets will be preliminarily done in Task 1. Then, the possible use of EO data in future studies (beyond this project) of interest for ESA, or specifically for the purpose of this project, will be also identified.

As a first guess of what will come out from the review task, the EO systems of interest will probably be the geosynchronous satellites devoted to operational meteorology, the spaceborne atmospheric profilers and the microwave radiometers and radars capable to sense deeper into the clouds and to directly measure rainfall rate or other hydrometeors of precipitating clouds. Limb sounding techniques are limited to the upper part of the atmosphere that, although extremely interesting from geophysical point of view, is however less relevant from radiative point of view. In fact, its lower density and physical temperature make the contribution to the tropospheric attenuation and emission quite negligible. Moreover, limb sounding horizontal resolution is poor (hundreds of km). The same problem affects the radiometric sensing of the total water vapour content by emissive channels in the medium-thermal infrared band. In fact, the high absorption of water vapour around 6 km makes the weighting function of the vapour centered in the upper part of the troposphere which is again not relevant for propagation studies. Atmospheric sounders (i.e., ATOV aboard the TIROS meteorological satellites or the European MetOp) provide operational profiles of pressure, temperature and water vapour that can be used within physical propagation models, at least in case of non precipitating atmosphere.

It has to be said that in many cases such profiles are assimilated by the Meteorological Centres for weather prediction, so they are embedded into the numerical analysis or re-analysis usually exploited for propagation studies, and specifically for this study. Their independent use in this project has to be critically assessed, since they might represent redundant information which is not worth considering at least when comparing cost with benefit. Microwave radiometers estimating gross hydrometeor profiles and especially sounding radars for monitoring precipitation can also in principle provide inputs to physical models, even in case of precipitating clouds. Their use in propagation studies seems therefore quite attractive. For instance, an operational radar sounder is mounted on a satellite platform (TRMM) whose orbit limits data acquisition to the equatorial and tropical areas of the globe, well below 40 degrees of latitude (North and South). This may prevent its use for characterising the atmosphere in some of the ground station of interest in this study.

Other missions with similar characteristics (GPM, CloudSat) may be available for future studies, but they are still to be launched or have a revisit time not suitable to provide a good statistical data set for the purpose of this project. Other EO missions may provide a description of the atmosphere that, although not detailed enough to be used within physical models (i.e., RTE solutions), may however provide inputs to regressive simplified models. For instance, worldwide estimation of columnar water vapour content is an attractive EO product available throughout different missions. Besides the use of thermal infrared channel already discussed, reflective band (near infrared) may provide columnar water vapour over land, but only in clear sky conditions. Columnar water vapour in cloudy conditions complemented by the cloud liquid water content are instead typical products of spaceborne microwave radiometers (i.e., SSM/I), but in this case a main drawback is the restriction to the ocean background only, at least to ensure a good accuracy with the present technology.