A NEW DATABASE OF ITALSAT ATTENUATION DATA FOR TROPOSPHERIC CHANNEL SIMULATIONS IN GENERIC LOCATIONS

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ABSTRACT

In this work we present a new method to transform the attenuation time series collected during the ITALSAT experiment into new time series utilizable for simulation purposes in the design of radio systems operating in different conditions and locations. After identifying the "attenuation events", an event database is set up by sorting the events into classes identified by peak attenuation. The events of each class are then scaled in frequency, elevation etc. and associated to a particular weight aimed at providing climatological significance for a generic site. Main features of the simulator are described in the paper.

INTRODUCTION

The ITALSAT experiment has come to its end of life in January 2001 leaving a huge amount of Ka and V band attenuation data [1]. As for any propagation experiment, the problem is now the one of maximize the possible utilization of the results by part of potential users operating in different experimental conditions (frequency, elevation etc.), with different systems or in different climates. In other words the aim appears now the one of collecting and storing these data so as to ease their use for a variety of different purposes.
In this paper we will show a particular approach to this problem: it basically consists in setting up a particular database in which the time series can be easily reworked and conditioned so as to allow their use in a generic satellite-link simulators, i.e. a simulator operating in experimental and climatic conditions different from the ones of the original ITALSAT experiment. In other words this database executes the same task of a time-series simulator but guarantees to preserve the features of a genuine time series scaled to different conditions and forced to be reasonably representative of the climate under examination.
For this purpose the rain attenuation time series are characterised with their peak attenuation and sorted into classes according to this identifier; then they are scaled in frequency, polarization, elevation, rain height etc. to take into account the conditions existing in a different location. Finally a particular procedure that determines the weights of the different classes of events so as to fit the total statistical cumulative distribution to the one of the location in question, is applied.
In this paper we show how the rain attenuation events are collected, treated, and the weights determined.

ITALSAT DATA: FORMAT AND FIRST TREATMENT

Italsat data consist in direct measurements of satellite link attenuation collected since 1993 to the whole 2000. Samples are taken every second and results are stored in one-day files containing attenuation values in dB for the three beacons at 18.7 GHz, 39.6 GHz and 49.5 GHz [1].
The first operation applied to the rough data has been to remove errors due to system malfunctions, artefacts or phenomena not attributable to the tropospheric propagation.
Attenuation was then cleaned up from system biases by using a set of radiometers for establishing the correct "zero" reference and the "clean" data were stored.
The successive step was to separate rain from scintillations, a necessary step for correctly applying the frequency scaling procedure, when necessary: this was accomplished by filtering out scintillations with a low pass filter with a cut off frequency of 0.025 Hz. Scintillations can be properly frequency-scaled and added to the rain attenuation at a second time.

RAIN EVENTS ACQUISITION AND STORAGE: THE DATABASE

The first issue to address for this purpose has been the one of defining a "rain event"; the decision was to assume a threshold value over which the attenuation was declared "rain attenuation"; this value was set to 0.5 dB at 20 GHz.

Having done this, automatically it was possible to extract the so called "events" defined by the time intervals in which this level was reached and passed.
All data extracted in this way contain all the observed rain events but in many cases are affected by phenomena other than rain; a successive step of the process was then the separation of real rain events from other effects (artefacts etc.), a task hardly executable in automatic.
Once this "cleaning" operation was executed, the events had to be sorted in classes. To do this a separation criterion had to be defined: according to this, the events were considered different when separated by at least 5 minutes of not raining conditions.
A head and a tail of 3 minutes were added to the event in order to smoothen the general trend and to account for the lower values of attenuation just preceding and following a rain event.
In fig. 1 a three frequency example of rain event is shown as stored in the database.
At this point the stored events could be partitioned into classes characterized by a given peak attenuation. For each class the cumulative distribution functions were then calculated, so as to make it possible determining the weights to be assigned to each class as explained in the next section.

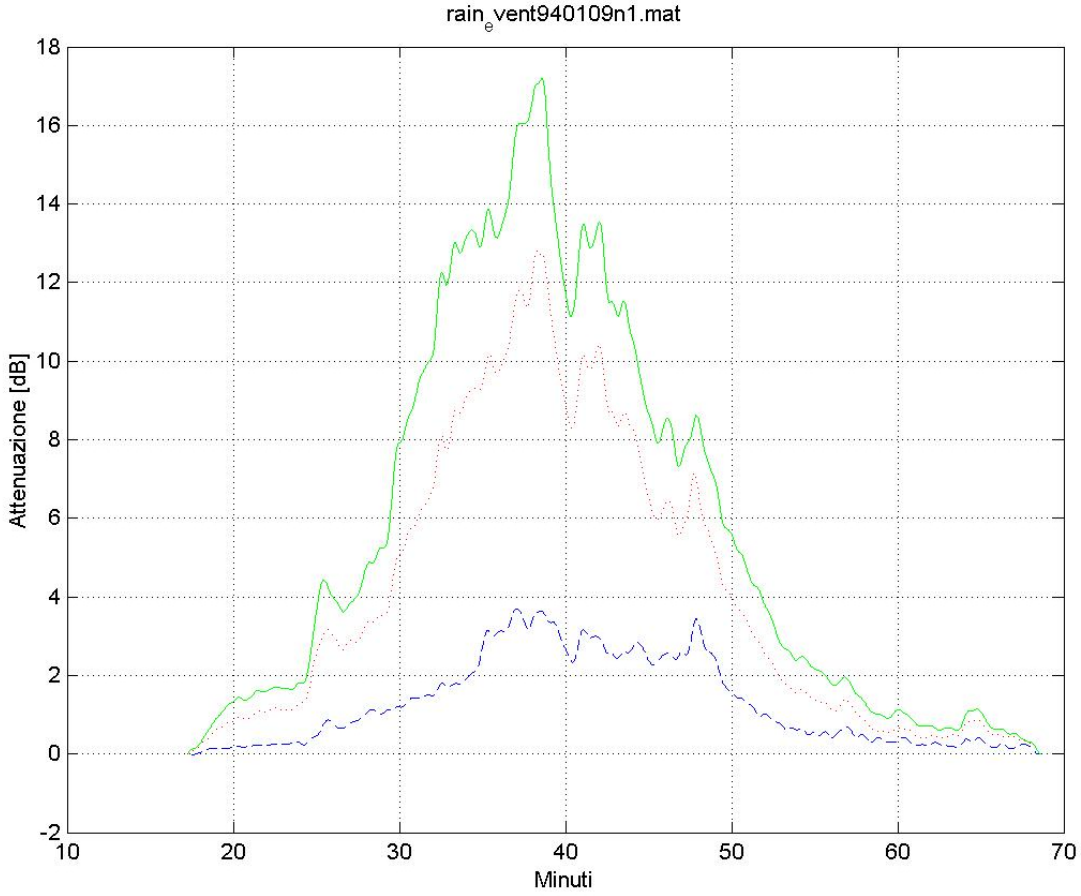

Fig. 1. A time series representing a rain attenuation event as stored in the database; the three curves refer to 17.8, 39.6 and 49.5 GHz.

THE MAIN FEATURES OF A GENERAL-PURPOSE SIMULATOR

The database built as explained above allow us to design a general-purpose link simulator to be used, either directly or indirectly, by validating the numerous time series simulators currently developed in several research centres of the world.

The simulator algorithm is shown in figure 2. It starts by assuming that the probability cumulative distribution function (CD) is known (an objective which can be reached by means of some of the many prediction methods existing in the literature); this is said "objective function". Then the objective function is reconstructed at best by re-combining the classes after assigning to them of a set of optimized weights. In other words this corrwsponds to a translation (on a probability log-axis) to be imposed to the cumulative function of each class in order to overlap at best to the objective function in the assigned interval.
The principle upon witch this system is based is that the statistical characteristics of the rain events sharing the same peak are not too different all over the world; what makes the difference is the frequency of occurrence of the various types of events.

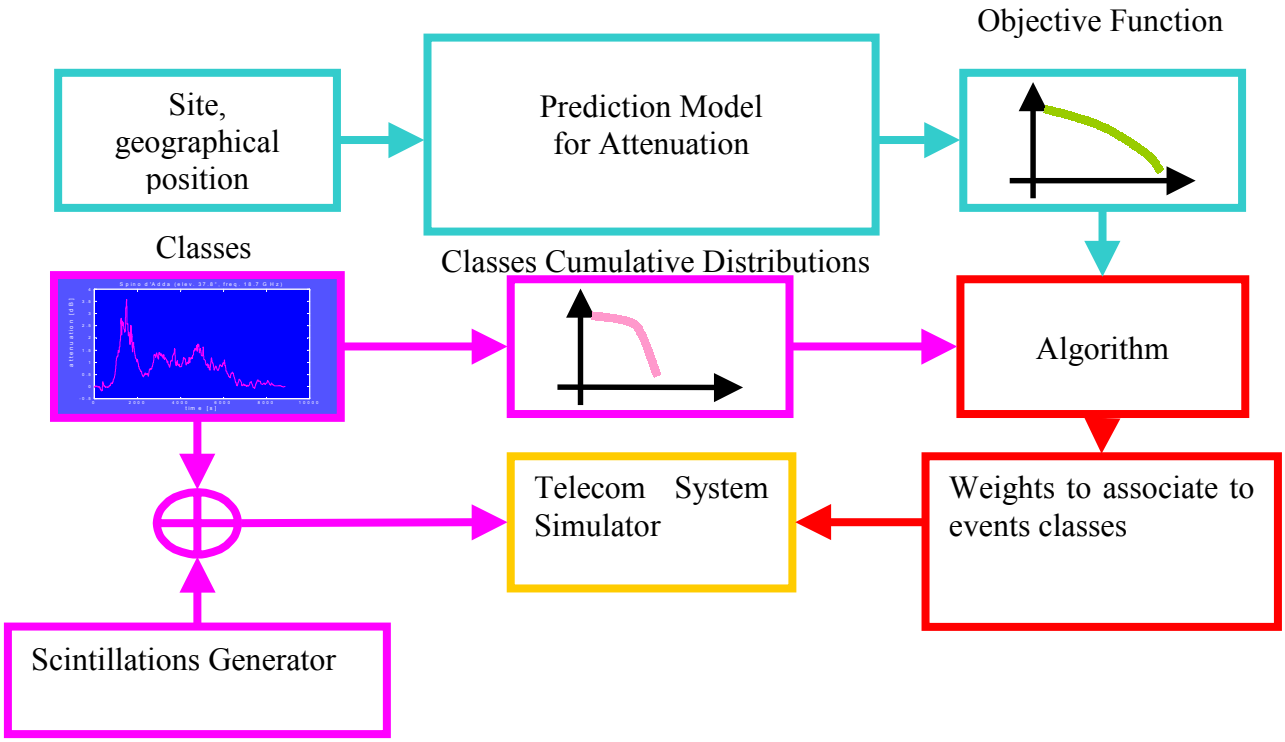

Fig. 2. The simulator algorithm.

The time series reconstructed with this method can then be used for simulation purposes in the design of transmission systems operating in generic conditions. An alternative use is the one of checking the statistical properties of a fully mathematical time-series generator; finally a further advantage is the possibility to render statistically homogeneous different experimental data bases therefore making it possible to pool data coming from different parts of the world and reducing the statistical fluctations of the data base.
In figure 3 it is shown how this process works and the reconstructed statistical cumulative distribution function.

CONCLUSIONS

The general lines to design an earth-satellite channel simulator based on real attenuation time series have been described. The simulator has the advantage, over similar simulators based solely on synthetic data, of starting from real data scaled with well established algorithms, both for rain and scintillations. The particular procedure consisting in

combining various classes of events characterized by a different peak value allows adapting the data base also from the "climatic" point of view to a generic location and system configuration.

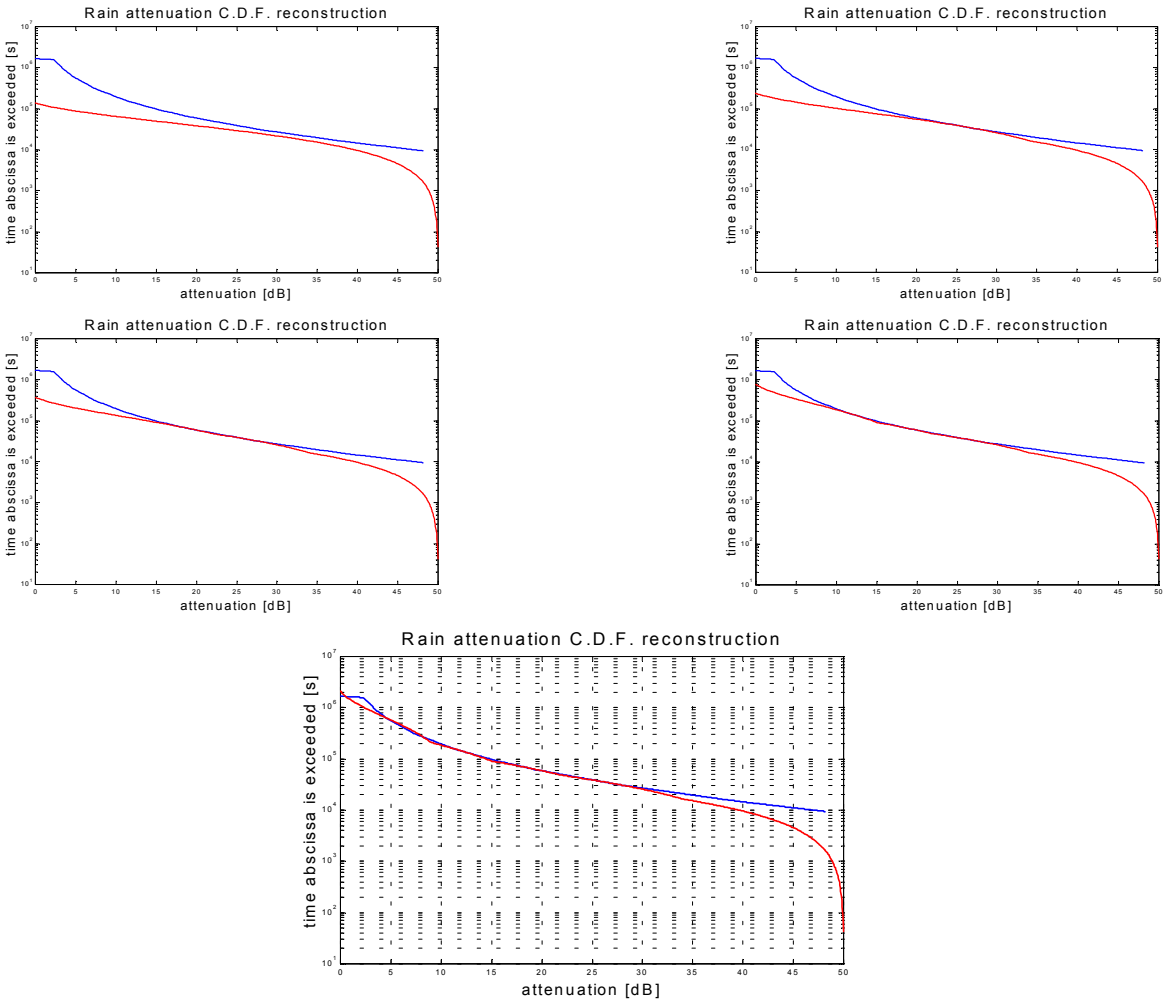

Fig. 3. The various pictures show the progressive improvement in the approximation by adding successive classes of events.

REFERENCES

[1] A. PARABONI, C. RIVA, L. VALBONESI, M. MAURI, "Eight Years of ITALSAT Copolar Attenuation Statistics at Spino d'Adda", *7th Ka Band Utilization Conference*, Santa Margherita Ligure (GE), 26 – 28 September 2001.