

# Modelling of tropospheric channel degradations on earth-space propagation

**Keywords :** Radiowave propagation; Millimeter wave; Troposphere; Ionosphere.

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**Abstract – Telecommunication, Navigation and Earth Observation systems used worldwide, have space segments operating in various frequency bands. The impairments due to the propagation of electromagnetic waves need to be evaluated accurately since system performances and sensitivity increase. The RAPIDS II software proposes a web interface to calculate the effects of the troposphere, ionosphere and environment, but also the potential interferences coming from nearby stations. The user can either use the default ITU-R Recommendation models and datasets or enter his own datasets for comparison. Examples are shown to highlight the versatility of the tool.**

RAPIDS II allows registered users to log-in, via Internet, and to perform propagation calculations. A novelty of this version is that it is addressed to system engineers, via generic systems, as well as propagation experts. The output is in the form of statistical curves or time series for tropospheric attenuation, scintillation and environment. Output files are in HDF5, MATLAB and CSV formats

The system workflows has 3 generic systems:

- Fixed Terminal Telecommunication System;
- Mobile Terminal Telecommunication System;
- GNSS.

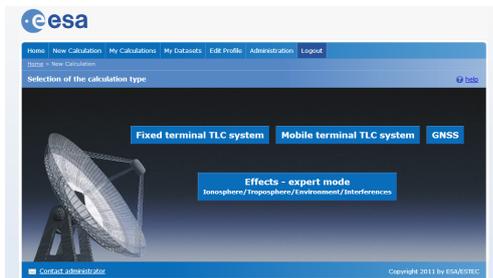


Figure 1: Screen presenting the generic systems.

For each system, a limited subset of effects is proposed by default. If the user chooses the Fixed Terminal TLC System, he chooses the satellite orbit, the atmospheric layer (Tropospheric effects ( $f > 3$  GHz) or Ionospheric effects ( $f < 3$  GHz) and the type of satellite coverage (Single Earth-station or Region). If non-GEO satellites are chosen, only Single Earth-station is available. In very specific cases where both tropospheric and ionospheric effects are needed (for example in tropical areas), the user runs the software twice, once for each layer. The advantage is that he can store its configuration in "My calculation" and recover the stations or region and satellite for the second run. The models proposed are the default ITU-R models and data.

For the Mobile Terminal TLC system, three impairments are proposed: Environment effects, Tropospheric effects and Ionospheric effects.

Only Environment effects and ionospheric effects are available for GNSS system. In the two last systems, the mean position of the mobile receiver is requested.

The expert user mode gives access to the full choice of effects, models and data, with a total of 7 different workflows.

- Ionosphere (satellite mode)
- Troposphere
  - satellite mode
  - single site mode
- Rain fields or tropospheric time series
- Environment (satellite mode)
- Interferences
  - Transmission loss
  - Coordination area

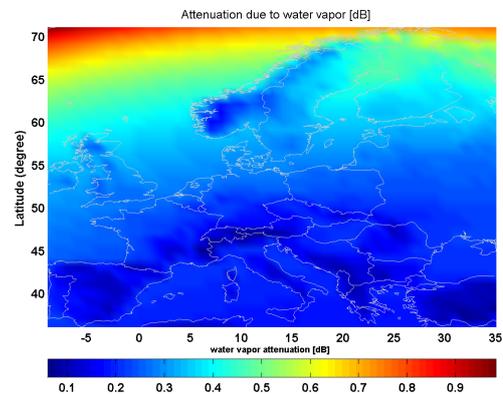


Figure 2: Attenuation due to water vapor for Europe.

In any workflow, the user chooses the effect to compute and the model that will perform the calculation. Fig. 2 shows the attenuation due to water vapor in Europe, exceeded for 0.1% of time.

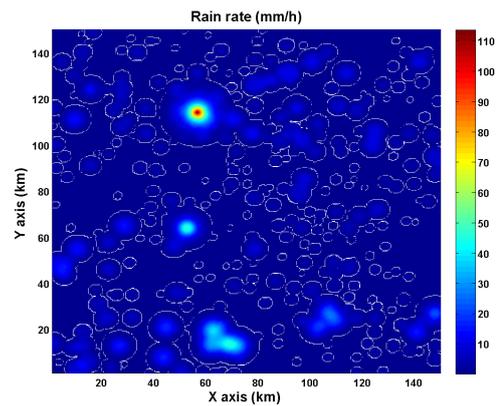


Figure 3: Generation of rain fields.

Fig. 3 illustrates the generation of rain fields over a region of 150 km by 150 km.

RAPIDS II has been delivered to European Space Agency and an access can be asked to [esa.antonio.martellucci@esa.int](mailto:esa.antonio.martellucci@esa.int).

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