Rain Attenuation Prediction Model for Satellite Communications Based on The Météo-France Ensemble Prediction System PEARP

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The paper presents a model to compute rain attenuation statistics from ensemble weather forecasting that can be used to optimize the design of satellite-based communication systems. The statistics are obtained combining the members of the PEARP ensemble prediction system and the attenuation measurements from the Ka band beacon signal of the Astra 3B geostationary satellite for the years 2014 and 2015. The model reliability is evaluated with the Astra 3B measurements in terms of forecasted and observed probability. The model resolution is investigated by resorting to the Receiver Operating Characteristic curves. The advantages of using ensemble weather forecast with respect to the classical approach based on climatological statistics (i.e., from ITU-R) are shown.

General comments

The paper is interesting, well written and well organized. My judgement is positive. However, some general minor corrections are needed and some details about the procedure are missing or not clear (see specific comments).

Specific comments

- Pag.2 (Introduction): note that the ITU-R recommendations that are cited must be updated with ITU-R 618-13, 2017 and 837-7, 2017.
- As concerning the recommendation ITU-R 618, which is further cited and adopted in the work, please check that the results are in line with the last recommendation 618-13, 2017 (e.g., the CCM results presented in section 4.1.3).
- Par. 2.1.1 (Beacon data): which is the precise frequency of Ka band signal of the Astra 3B satellite?
- Par. 2.1.2 (Weather forecast model), please add some additional details concerning the adopted PEARP system:
    - Please specify which is the total period over which the PEARP model is run: it should be over the years 2014 and 2015 (where the beacon measurements are available) but this detail should be explicated in this paragraph to give a complete presentation of the set-up of the adopted weather forecast model.
    - The lead time of the weather forecast is not specified: since the ensemble forecast F includes 70 members per day (35 computed at 06.00 UTC and 35 computed at 18.00 UTC), I guess that the we are dealing with daily weather forecast (i.e., 70 members per each day of the forecasted period) but it should be better clarified.
    - It is not clear if the PEARP members are time-series, over a certain period, of the rain accumulated every 3 hours: please, clarify this point.
    - Please write explicitly in this paragraph that the time resolution of the weather forecast is 3 hours (which is the availability of the forecasted cumulated rain).
    - Line 11, “Both lagged runs are used together”: please clarify this sentence.
- Par. 2.2 (The attenuation statistical prediction model):
    - Pag.7, line 2: it should be called “complementary cumulative distribution of attenuation” instead of “inverse cumulative distribution of attenuation”.
    - How is it computed the complementary cumulative distribution of attenuation conditioned to the PEARP classes (the right probability of eq.1)? The probability that A>A* (from the beacon measurements) is combined with the condition on PEARP classes but the procedure is not clear: measurements averaged over 5-minutes are compared with model outputs available every 3-hours.

    - Pag.7, line 8, “This methodology is equivalent to averaging the 70 rain attenuation distributions”: this is true for a certain time horizon. It is not clear if the equation (1) is computed per each day of the simulated period (2014-2015).
    - Concerning this section 2.2 and the applicability of the equation (1), some clarifications should be done. If I understood right, the available beacon measurements, combined with the forecasts (computed within the same period of measurements), are used to compute the probability $P(A>A^*|F \in ci)$. Once this probability is computed, it is stored such a “library” available in the operative context. When the satellite communication must be designed, a new forecast is produced for the target satellite-to-Earth transmission period. This forecast is used to compute $P(F \in ci)$ that, together with the probability in the library, allows the computation of the total probability in eq. (1). Please add this details in the paper.
- Par. 3.1 (Model reliability assessment):
    - Pag. 8 line 23, “Time series of $P(A>Ath|F)$ are computed”: please clarify how are obtained the time series of the probability (and how are computed the curves of fig. 5). Once fixed Ath it comes that $P(A>Ath|F)$, for a given F, is a number.
    - Fig.5: why is the climatological probability represented by a horizontal and a vertical line?
    - Fig.6: please clarify which is the rationale of the rank diagram.
- Par. 3.2 (Resolution and sharpness):
    - All the symbols (TP, FN, FP, TN, FA) must be introduced and defined before being used.
    - Fig.7: please check the block diagram, I guess that the (TN) and (FN) boxes should be inverted. Please check the consistency between the symbols used in diagram and the ones used in the equations (2) and (3): TP should be used instead of TD.
    - Pag.12: Please give a definition of Fth and explain how is it chosen.3
    - Pag.13, lines 8-9: please clarify the sentence.
- Par. 4.1.2 (Transmission strategies): the deterministic scenario is not described.
- Table 4: some details should be given regarding the decision time, especially for the scenarios 3 and 4.
- Par.4.1.3 (Results):
    - How was computed the “Mean” capacity of the different scenarios?
    - Pag.17, lines 8-10: please add some details.
- Par.4.1.4 (Economic value of the forecast):
    - It is not clear the meaning of Dth: in line 32 (pag.18) is defined as a threshold on the forecast probability but in line 1 (pag.19) it seems to be a threshold on the attenuation.
    - Pag.19, line 2: is it Ath or Dth?
    - Pag.19, eq. (4): please add a reference for the equation (4) and clarify L (I guess it is total lost data over total transmitted data).
    - Fig.10: why is the y axis a “mean” value? Is it averaged over the 2 years (2014-2015) of simulations and measurements?
    - Pag.20, line 4: please explain better.

<u>Technical corrections</u>

- Pag.2 (Introduction): please add a reference for the frequency band division in Table I.
- Pag.4, par.2.1.1, lines 25-27: the sentences are not very clear, please rephrase.
- Pag.8, line 8: the acronym ROC is introduced here for the first time but it is not defined.
- Pag.10, line 4: please check typo error.
- Pag.11, line 11-12: the sentences is not clear, please rephrase.
- Pag.14, line 23: probably the symbol A* should be replaced by A_{Th}.
- Pag.16, line 33: check typo errors and change table 3 with table 4.
- Pag.17, line 2: “transmission” instead of “transmitted”
- Fig.9: please check typo error in the caption
- Pag.21, lines 1-2: please check typo errors