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Autoscaled MUF assimilation in RATIM

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A combined vertical and oblique radio-soundings data assimilation procedure is proposed for the Regional Assimilative Three-dimensional Ionospheric Model (RATIM). As described in a previous paper [1], RATIM has demonstrated a good degree of adaptability to different ionospheric conditions, when vertical plasma frequency profiles $f_p(h)$ over the Italian area are ingested. The $f_p(h)$ assimilation procedure consists in minimizing the root-mean-square deviation *RMSD* between the observed and modeled profiles at the locations where observations are available. This enables the model to adjust the values of some ionospheric parameters previously described on empirical bases, testing a wide set of values for their variations. Hence, such variations are effectively RATIM free parameters, as they are varied until the best fit for the available profiles is obtained.

A Maximum Usable Frequencies (MUFs) ingestion technique has been subsequently introduced in RATIM. A simple HF ray-tracing technique has been used to model the ground range *D* of a particular radio-link, evaluating the skip distance for a signal obliquely transmitted towards a specific ionosphere, when the signal frequency is set equal to the MUF for the radio-link itself. A simplified ionosphere between the transmitter and the receiver is assumed, extending the same parabolic $f_p(h)$ to the whole radio-propagation channel. This profile is constrained to some F_2 characteristics linked to the RATIM free parameters. A comparison between the real and simulated *D* values is then performed for each combination of the free parameters tested during the $f_p(h)$ ingestion, introducing a further condition to the $f_p(h)$ *RMSD* minimization.

Preliminary studies of the application of this method are presented, when the MUF-ingesting version of RATIM has been applied to the Japanese-South Korean region, and the MUF values ingested have been obtained by the Oblique Ionogram Automatic Scaling Algorithm (OIASA) [2, 3]. RATIM adaptability has been tested, comparing the percentages of success of the adjustment procedure when only $f_p(h)$ are ingested and applying the MUFs assimilation with different thresholds for the $\Delta D=|D_{[real]}-D_{[RATIM]}|$ values to be acceptable. The minimized $f_p(h)$ *RMSD* values have been also compared in such conditions, along with the ΔD values obtained in adapting conditions. The RATIM ability to reject incorrect data has also been tested, when $f_p(h)$ and MUF values are validated by an expert operator.

1. D. Sabbagh, C. Scotto, and V. Sgrigna, "A regional adaptive and assimilative three-dimensional ionospheric model", *Adv. Space Res.* **57**, 5, March 2016, pp. 1241-1257, doi: 10.1016/j.asr.2015.12.038.

2. A. Ippolito, C. Scotto, M. Francis, A. Settimi, and C. Cesaroni, "Automatic interpretation of oblique ionograms, *Adv. Space Res.* **55**, 6, March 2015, pp. 1624-1629, doi: 10.1016/j.asr.2014.12.025.

3. A. Ippolito, C. Scotto, D. Sabbagh, V. Sgrigna, P. Maher, "A procedure for the reliability improvement of the oblique ionograms automatic scaling algorithm", *Radio Sci*. **51**, 5, May 2016, doi:10.1002/2015RS005919.