Reconstruction of regional distributions of electron density in the ionosphere from heterogeneous remote sensing data

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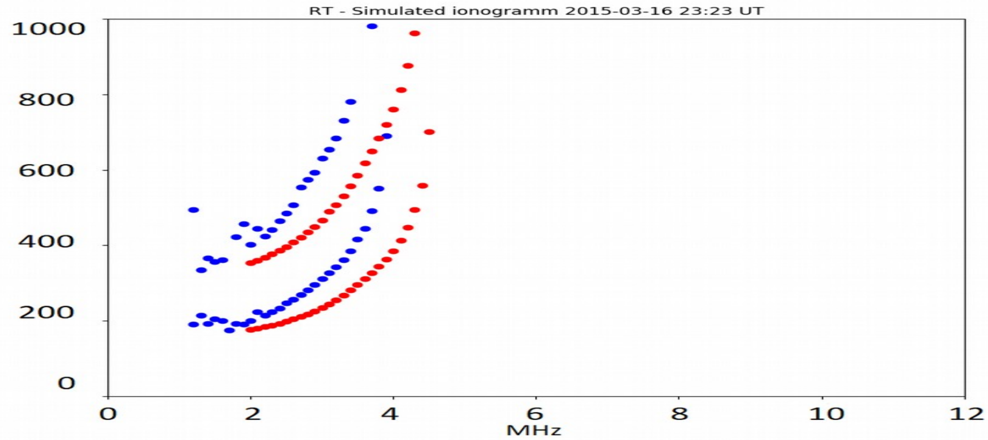
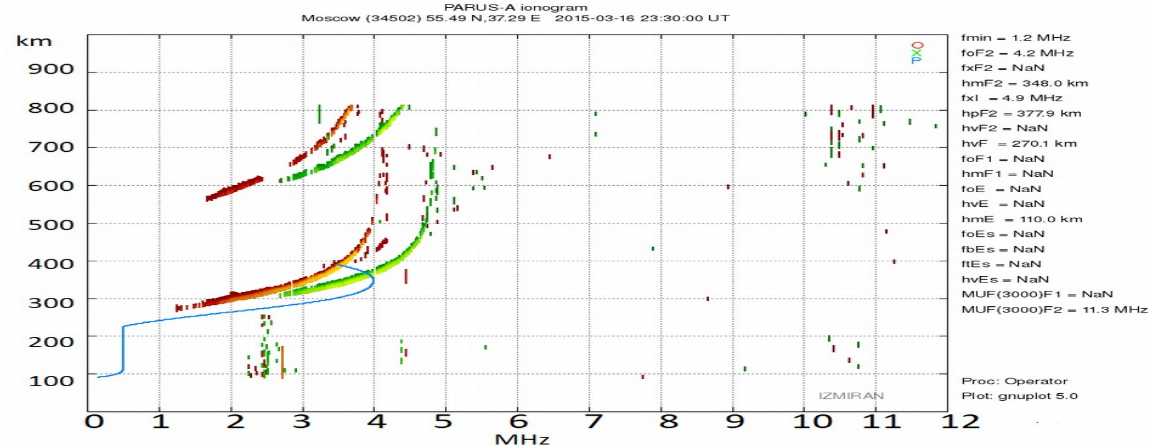
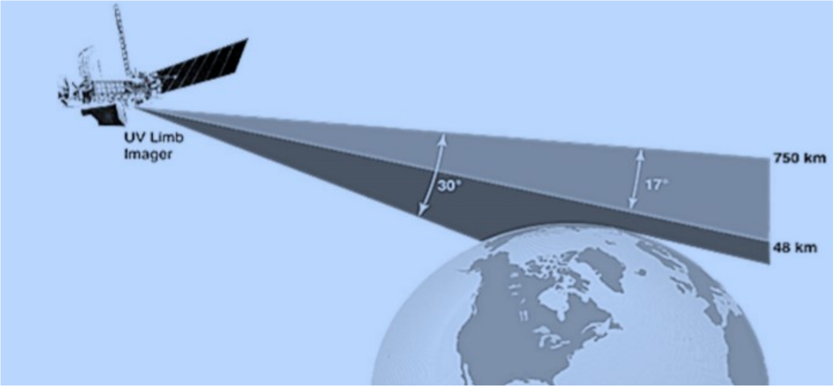
The relevance of research







The addition of quasi-horizontal rays let us improve the reconstruction of the vertical structure of the electron density in the ionosphere

Research objectives

- To develop a method for reconstructing the two-dimensional altitude-latitude distribution of electron concentration in the ionosphere from heterogeneous radio sounding data and UV spectrometry data of the atmosphere’s airglow at 135.6 nm.

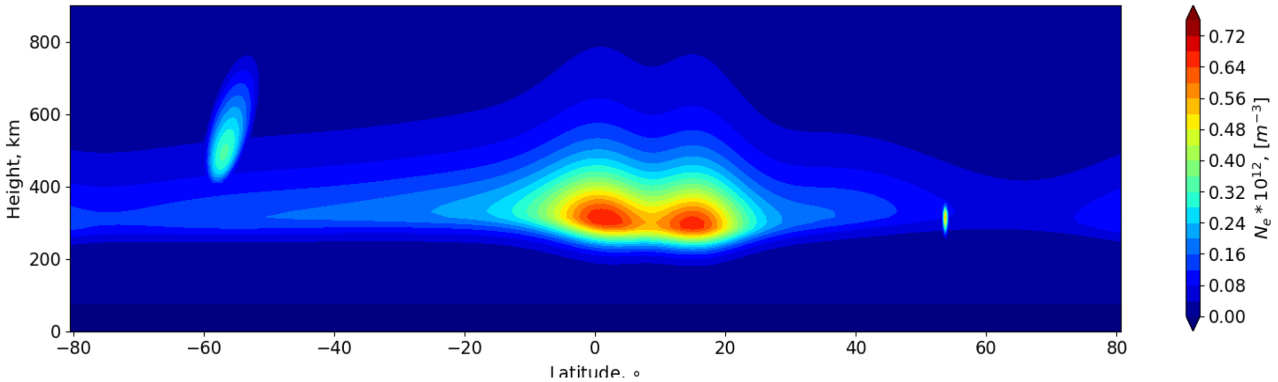
- To develop an iterative algorithm that allows to correct the solution sequentially at each step using UV data and radio sounding data.

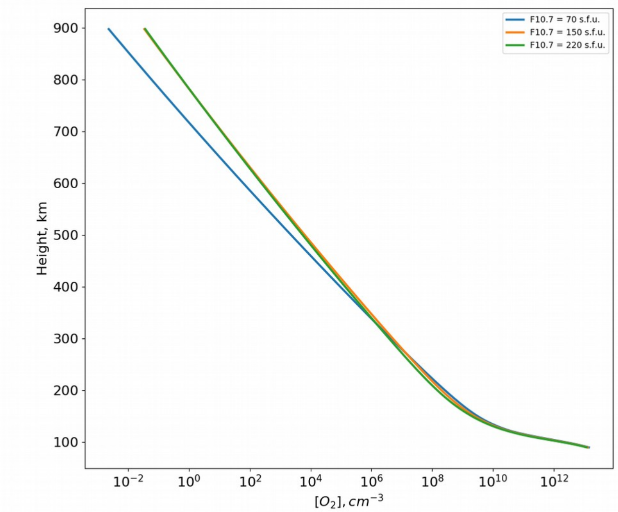
- To test the algorithm on model distributions of upper atmosphere parameters.

- To explore the influence the initial approximation on the reconstruction results.

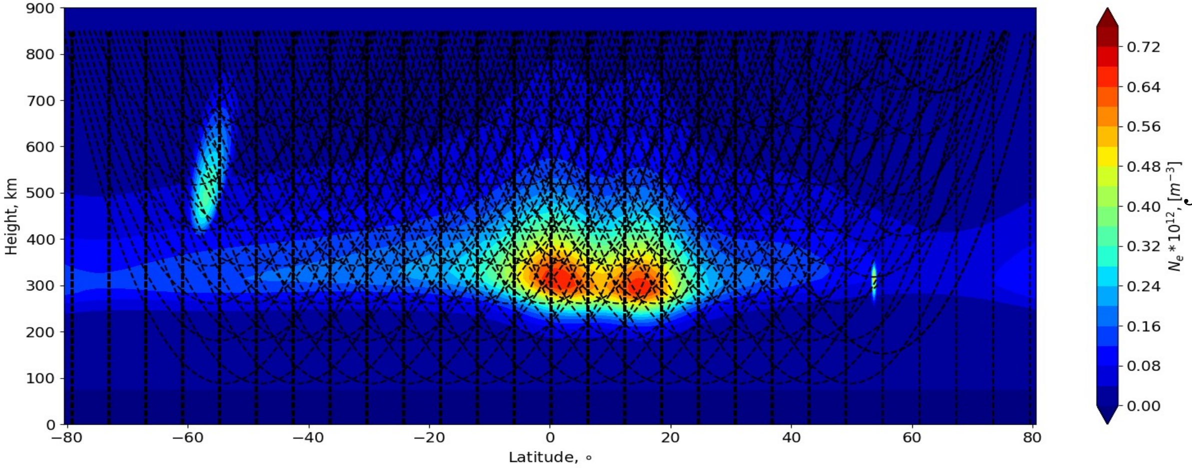
Synthetic data sources

- NeQuick2 model
- NRLMSISE00 model
- Parameters of DMSP satellite orbits
- Operating parameters of CERTO satellite beacons and SSULI UV spectrometers





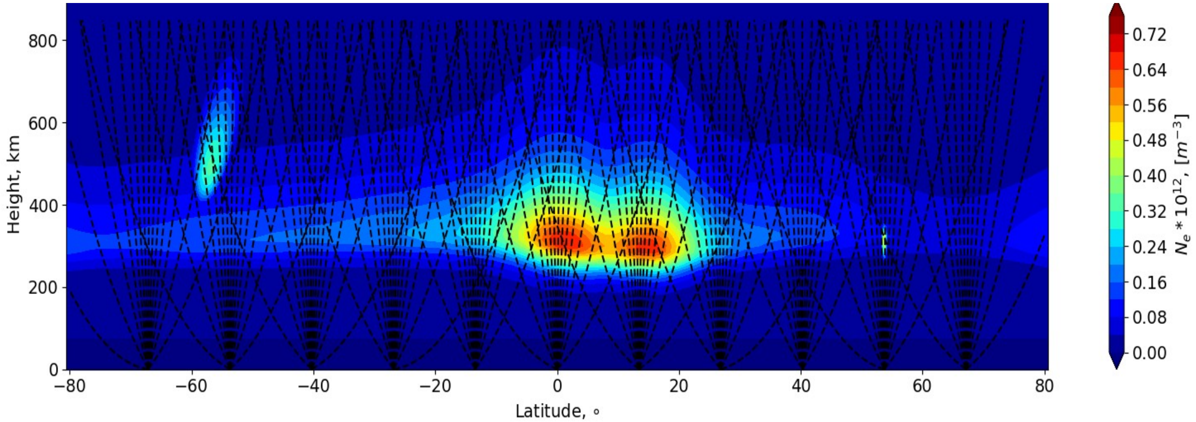
Problem Formulation



1. Satellite based data

$$\int_{l_k} \varepsilon(\phi, h) \left(exp[-\int_{l'_k} \rho(l'_k) dl'_k] \right) dl_k = I_k$$

$$\varepsilon \sim n_e^2$$ *for OI 135.6 nm*



2. Ground based data

$$\int_{l_k} n_e(\phi, h) dl_k = TEC_k$$

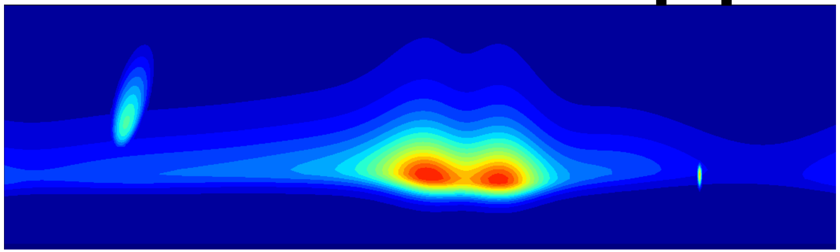
ART Algorithm

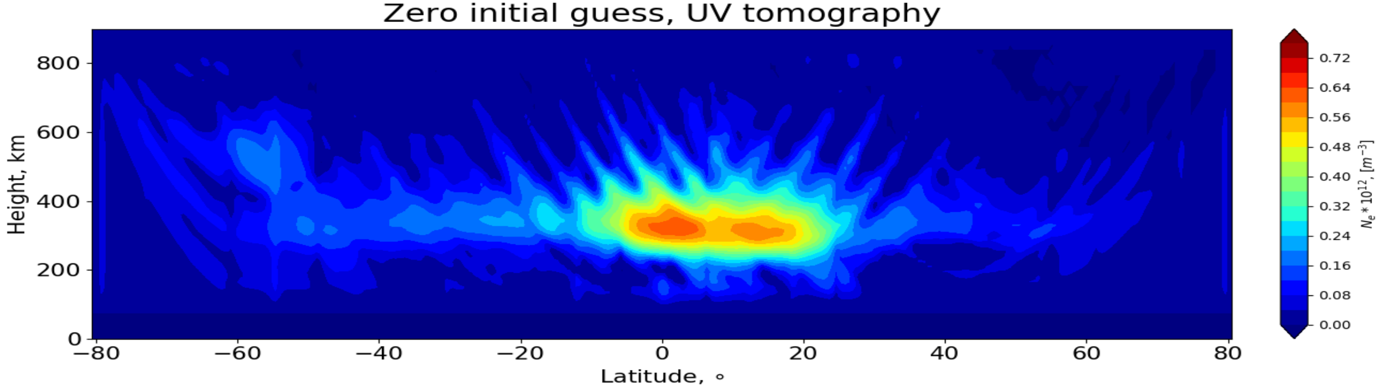
$$\sum_m A_{km} x_m = y_k$$

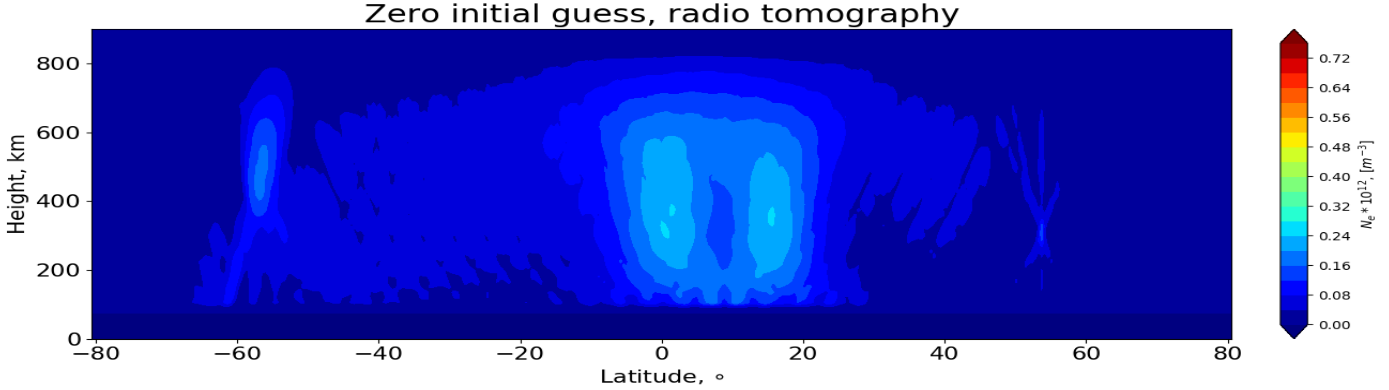
$$\min_{\mathbf{x}} ||A\mathbf{x} - \mathbf{y}||^2$$

$$\mathbf{x}^{m+1} = \mathbf{x}^m + \frac{y_k - \langle \mathbf{A}^k, \mathbf{x}^m \rangle}{\langle \mathbf{A}^k, \mathbf{A}^k \rangle} \mathbf{A}^k$$

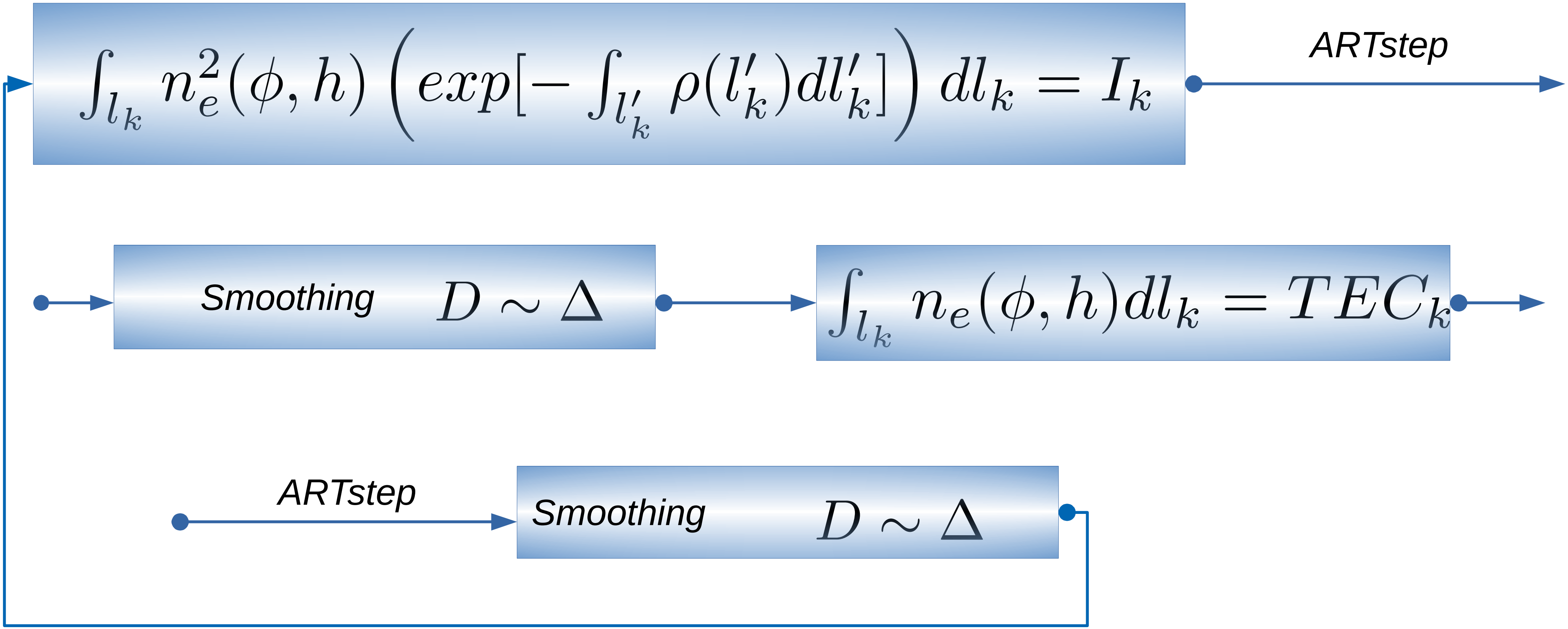
Importance of initial approximation



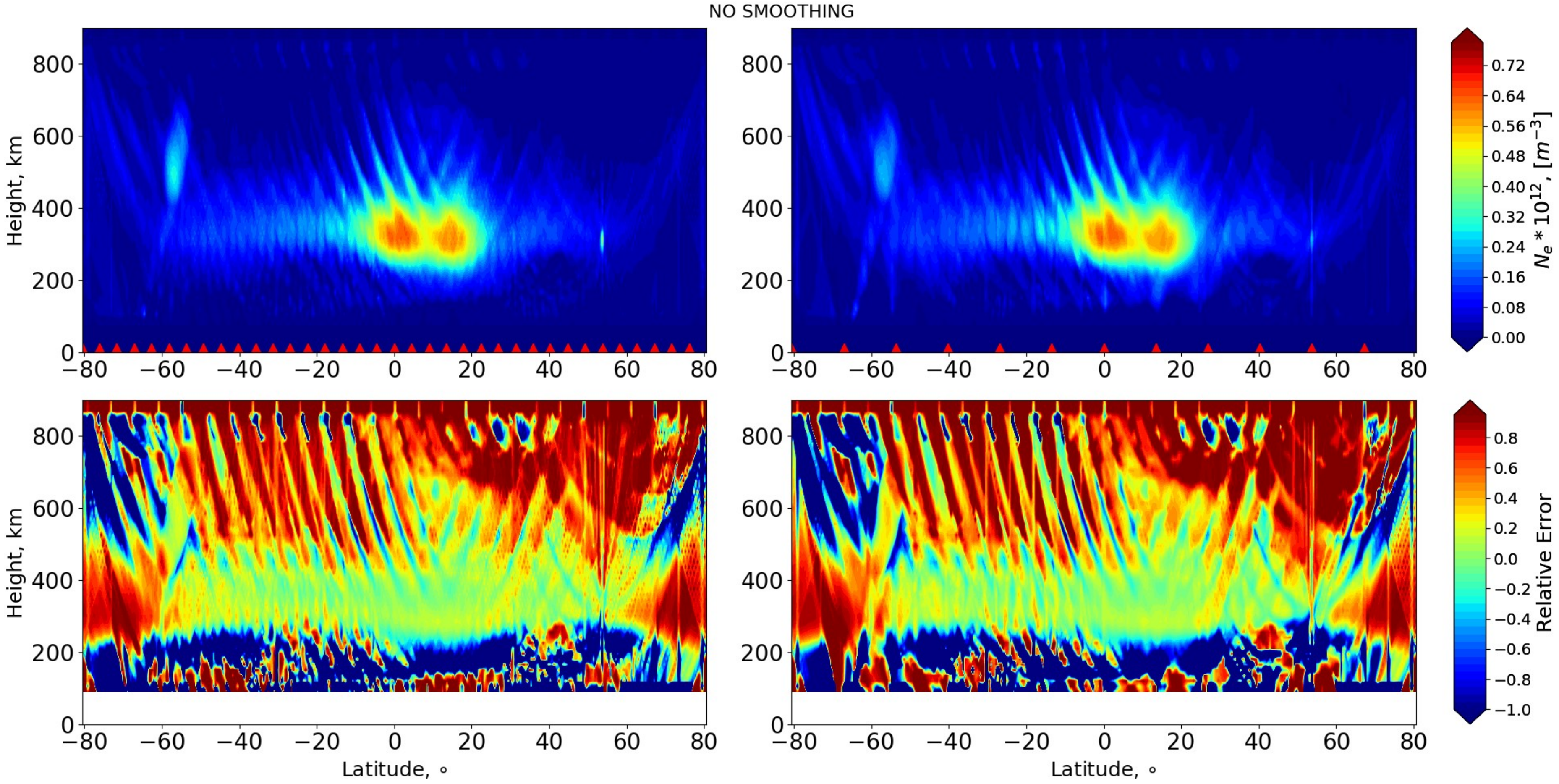




Approach to the solution



Influence of Iteration Smoothing



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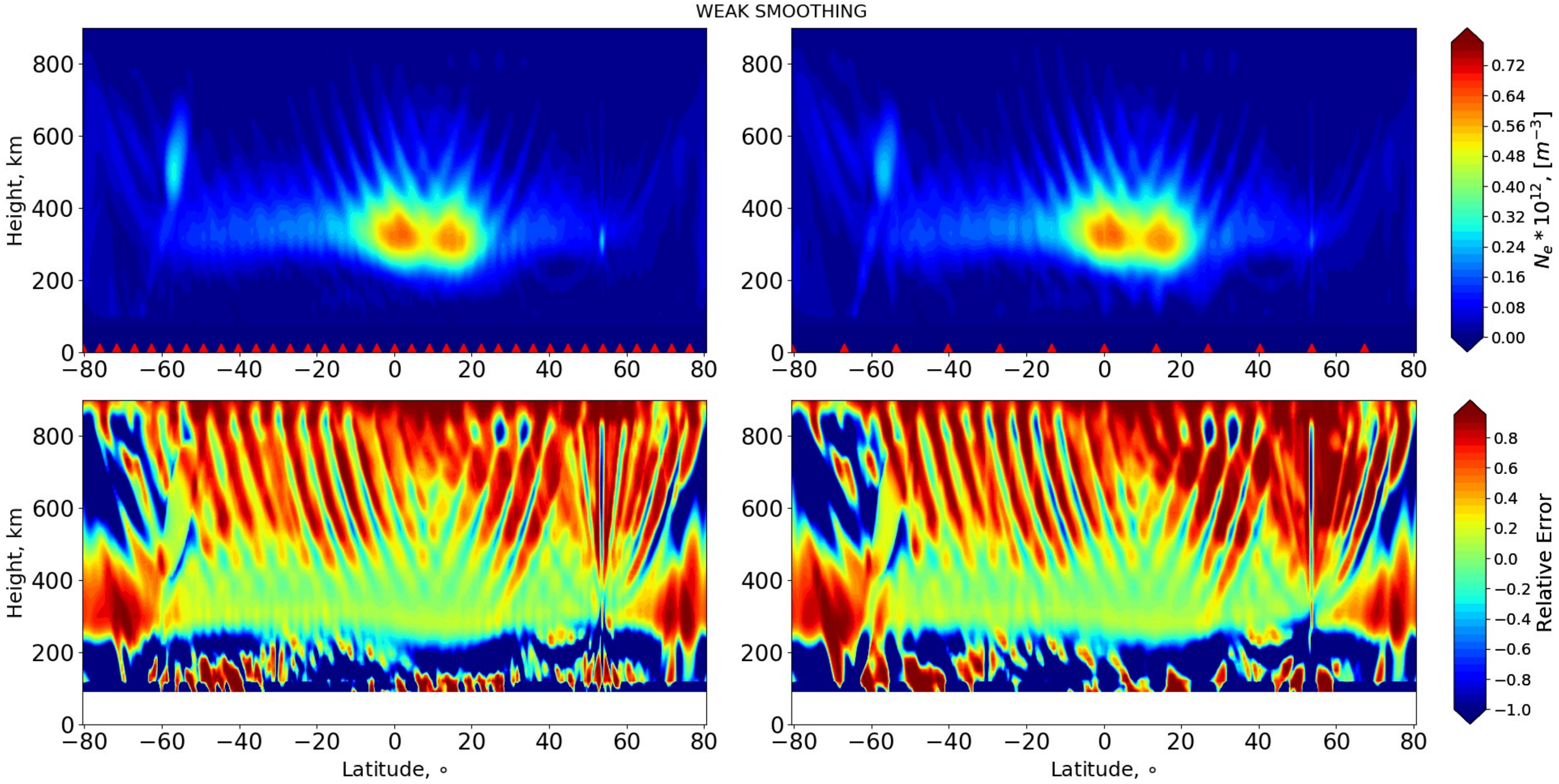

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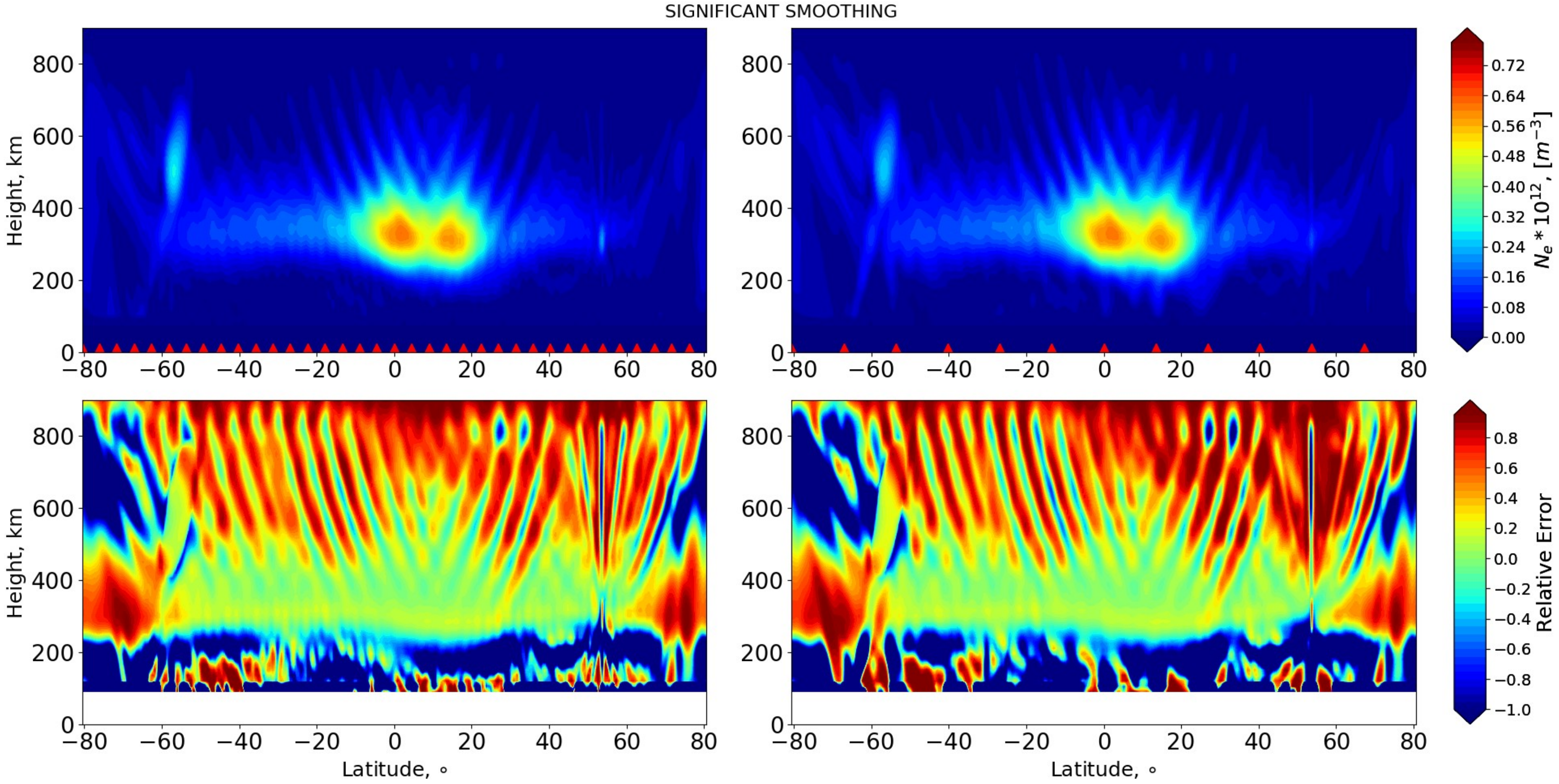

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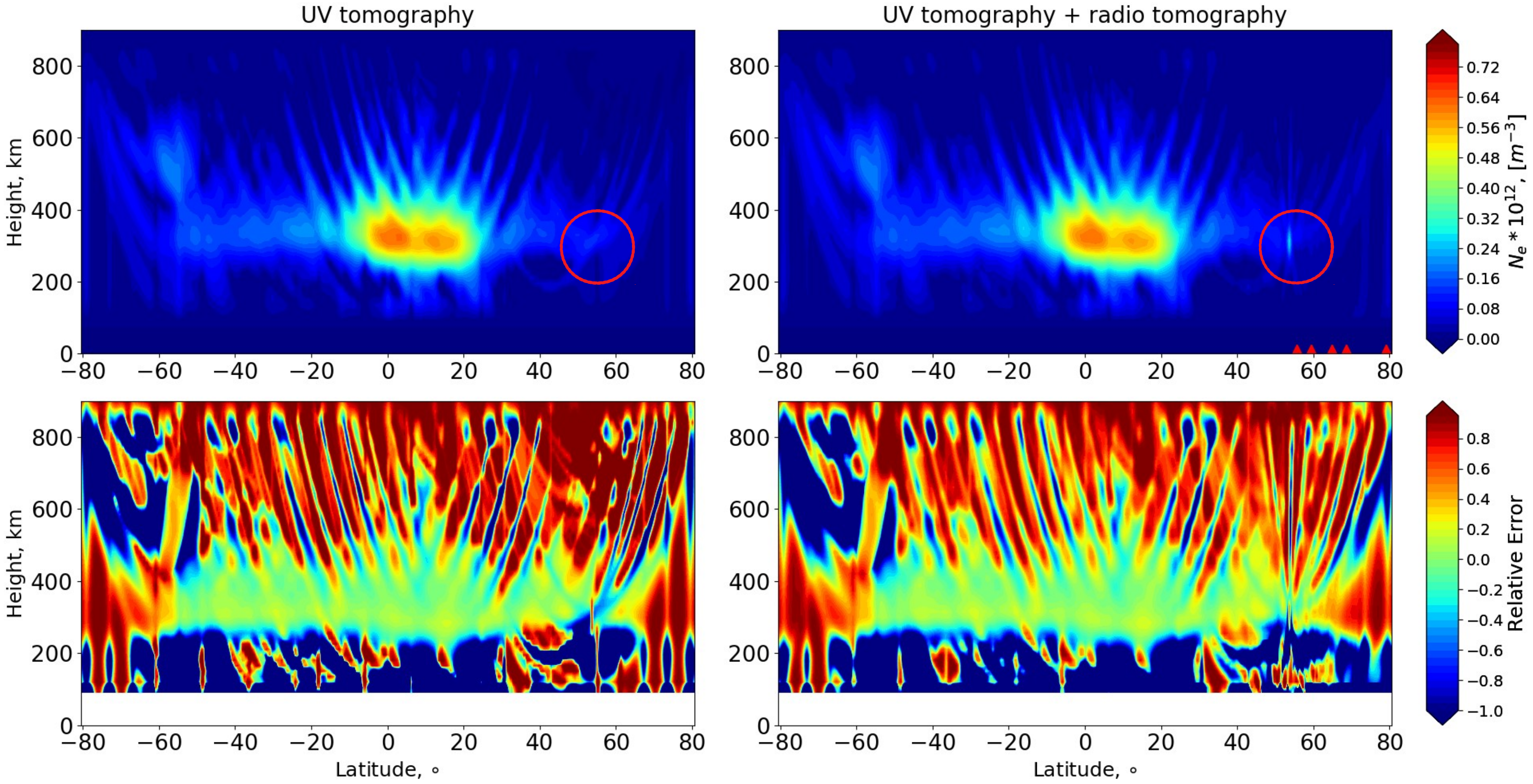

Conclusions

- The developed iterative algorithm allows to correct the solution at each step sequentially using UV data and radio sounding data.
- Reconstruction based on UV atmospheric airglow radiation data can be effectively used as an initial approximation for a radiotomography problem.
- The location of ground receivers determines reconstruction errors and the ability to reconstruct small-scale structures.
- The smoothing parameter allows to correct the artifacts of the reconstruction algorithm and achieve a solution with less error.
- Further include vertical/oblique sounding data or GNSS radio occultation in the inversion.