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An Adaptive Direct Variational Approach to Propagation through TIDs

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1. Extended Abstract

Accurate and efficient point to point ray tracing is an essential ingredient in the simulation of HF communication channels and in coordinate registration for OTH radar. Such ray tracing is relatively easy in a benign ionosphere, but the addition of travelling ionospheric disturbances (TIDs) can pose a severe challenge. TIDs are of particular importance as they are frequently present and give rise to the phenomenon of fading in HF communication and target wander in OTH radar. Homing techniques provide an effective method for 3D point to point ray tracing (see [1] for example), but require a good estimate of the initial ray direction, especially when. TIDs are present. One approach is to use a simpler 2D homing ray trace to obtain an initial estimate of the ray direction. The existence of a 2D ray trace, however, introduces another possibility. We could, instead, use this 2D trace as initial guess for a direct solution to Fermat's principle [2]. Such an approach treats the full 3D ray trace as an iterative correction to a 2D ray trace. This approach, however, has a further advantage. When discretising Fermat's principle, we chose a number of points (N say) to represent the ray. Because of the homogeneous nature of the integrand, however, Fermat's principle does not uniquely determine these points. This can be seen from the fact that any set of N points along the ray path would represent a legitimate approximation. In Coleman [2], the problem was solved by choosing the discretisation points to have suitably chosen ground ranges. An alternative is to constrain the distance between the sample points to be approximately constant. It would be preferable, however, to choose a constraint that improves the accuracy of the discretisation. In the current work we investigate a discretisation which is constrained to have an approximately constant change in ray direction between sample points. This ensures that the discretisation is suitably refined in those parts of the ray that are particularly demanding. The two figures below show the same scenario simulated under the two different constraints (both X and O rays are shown). These figures demonstrate that we can considerably reduce the number of sample points when the constant angle increment approach is used. An important feature of the approach is that we do not need to know, *a priori,* where the demanding parts of the ray are located since the solution process automatically adapts the sample points to the ray geometry. The talk will illustrate the technique through a variety of ray tracing involving TID disturbed ionospheres.

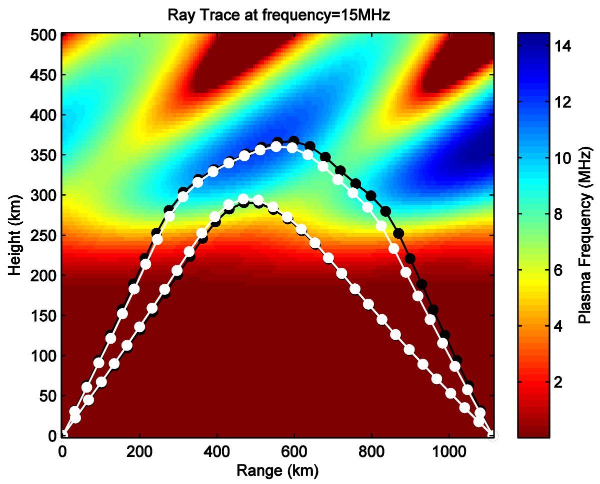

Figure 1. A constant distance increment between samples.

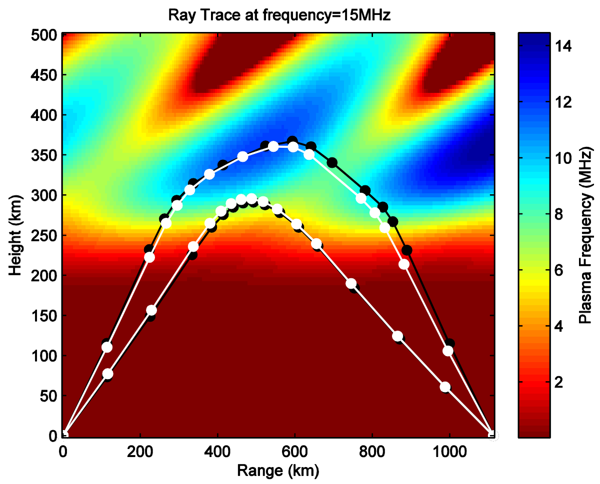

Figure 2. A constant angle increment between samples.

2. References

1.Strangeways,H.J. , 'Effects of horizontal gradients on ionospherically reflected or transionospheric paths using a piecewise homing-in method', J. of Atmos. Solar-Terr, Phys, 62, 1361-1376, 2000.

2.Coleman, C.J., 'Point to Point Ionospheric Ray Tracing by a Direct Variational Method', Radio Science, vol. 46, RS5016,7PP., doi:10.1029/2011RS004748, 20011.