Modeling weather radar surveillance over complex terrain

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- Estimating the radar surveillance region is a basic consideration when assessing the convenience of weather radar sites. This work presents a numerical model for simulating surveillance coverage of weather radars under mountain terrains.
- A common unrealistic approximation in this type of computations is to assume that the vertical gradient of air refractive index is approximately constant in the height interval of interest (Fig. 1).
- Instead, this work considers actual changes in refractive index by discretizing its vertical profile in small finite intervals (Fig. 2). In this new approach, the refractive index is then approximated to a constant only within finite intervals (piece-wise).

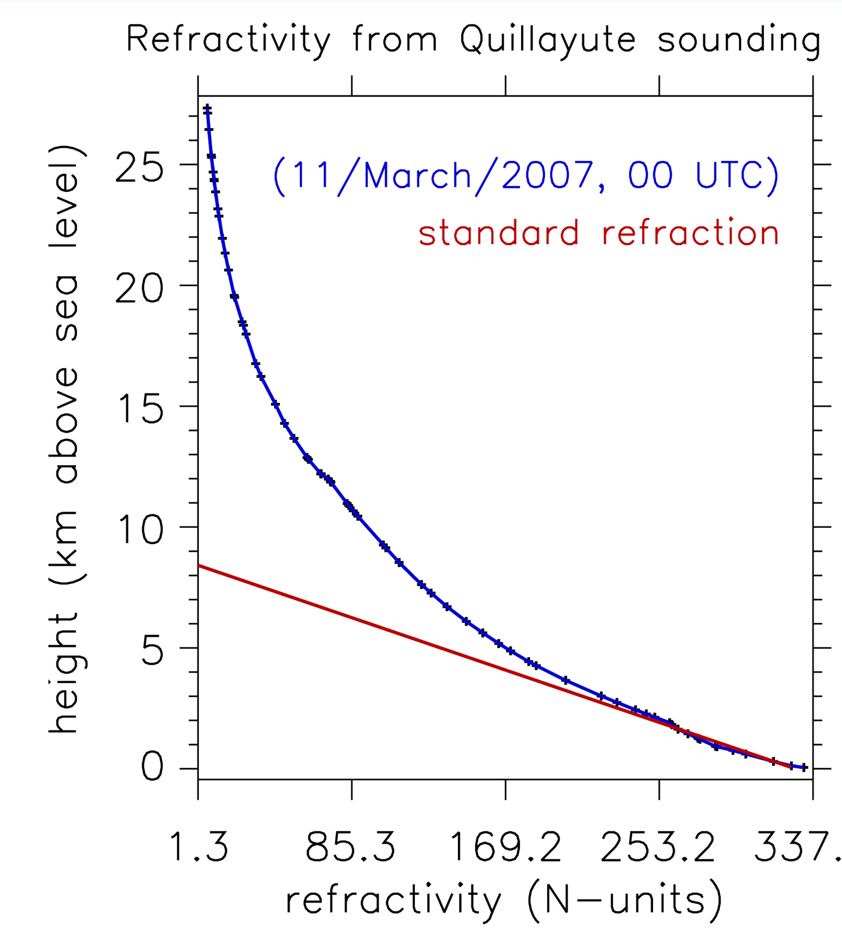

Fig. 1. Vertical gradient of refractive index over Quillayute, on 11 March 2007 at 0000 UTC. For reference, the dashed line gives the profile for standard refraction conditions.

$$\text{Blockage} = \frac{y\sqrt{a^2 - y^2} + a^2 \arcsin\left(\frac{y}{a}\right) + \frac{\pi a^2}{2}}{\pi a^2}$$

where *a* is the radius of the radar-beam cross-section and *y* is the height of the topography minus the height of the radar-beam center.

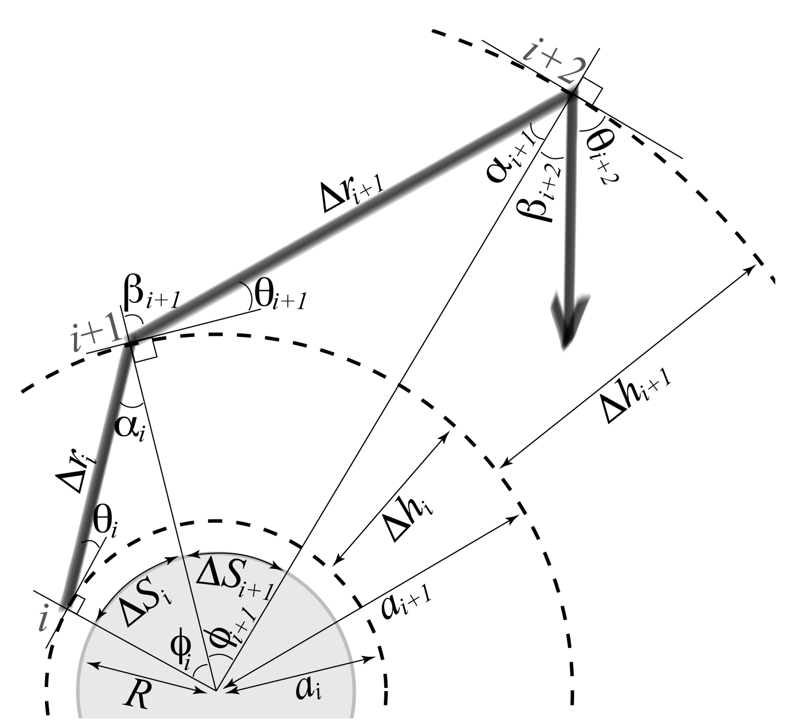

Fig. 2. A height-horizon conceptual model of a radar beam propagating in the atmosphere. The thick grey lines correspond to the radar beam as it crosses three regions of the atmosphere with three different refractive indexes. The dashed lines correspond to isolines of refractive index, with exaggerated curvature and a center of curvature at the Earth's center.

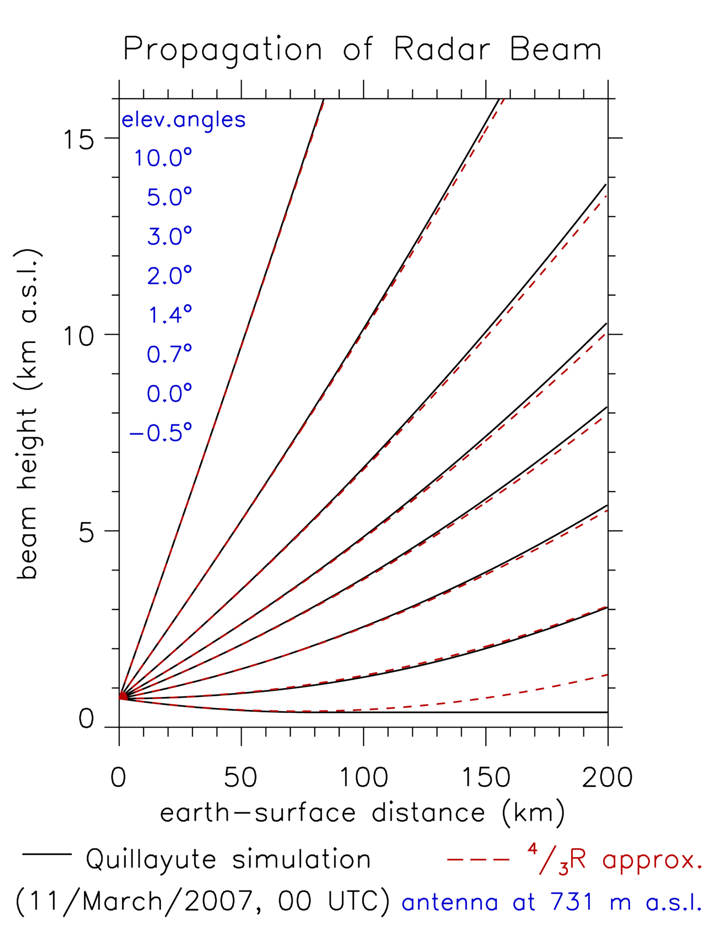

Fig. 3. Simulation of the propagation of radar beams at eight different elevation angles (from -0.5 to 10 degrees) over flat terrain. The black solid lines correspond to the atmospheric conditions for Quillayute station on 11 March 2007 at 0000 UTC. The red dashed lines correspond to the standard refraction approximation

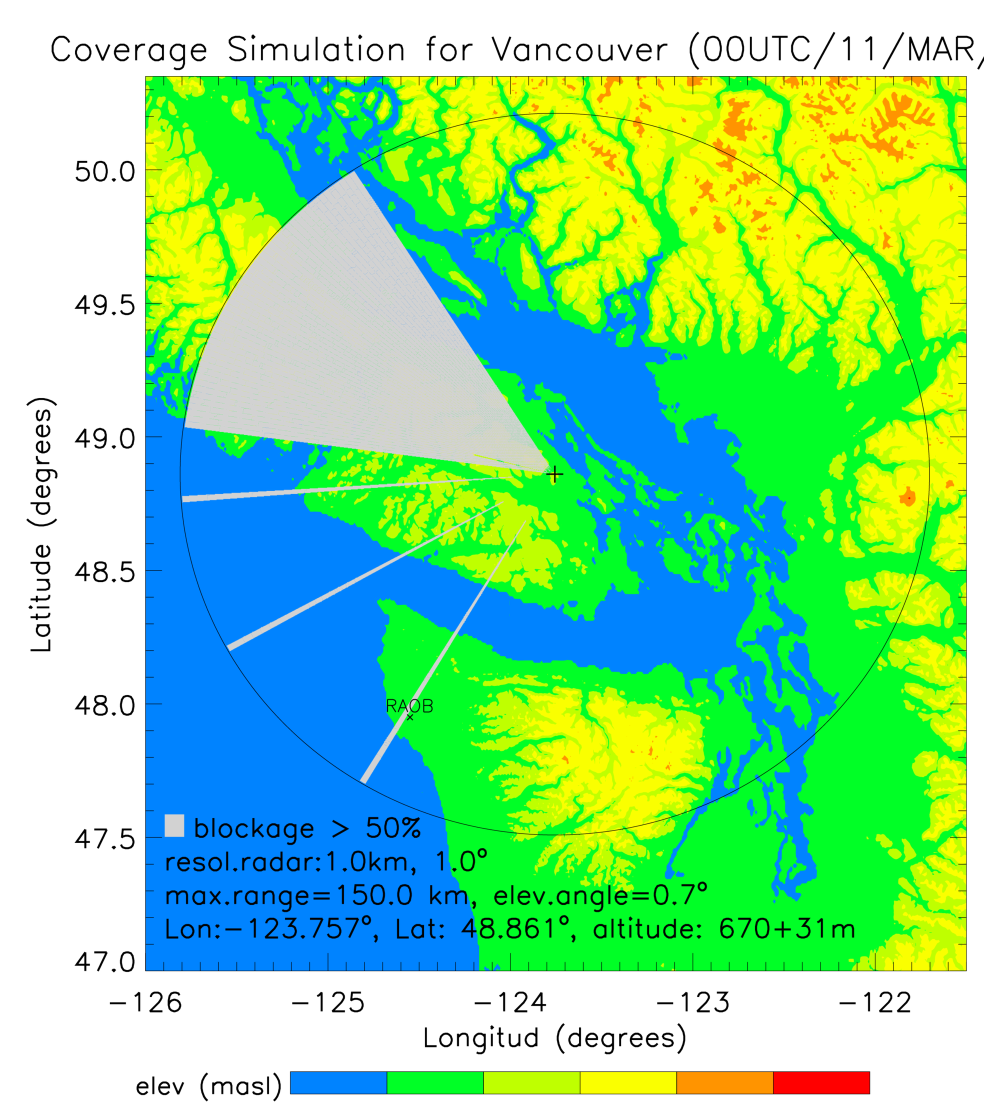

Fig. 4. Numerical simulation of radar coverage for the weather radar at Mt. Sicker. It uses the Quillayute radiosonde observations (site labeled as RAOB) from 11 March 2007 at 0000 UTC. The radar site is labeled with a cross. Grey areas correspond to regions not observed by the weather radar (total blockage). Terrain altitudes (in meters above sea level, ± 30 m at 90% confidence, from the GLOBE 1.0 km digital model) are given according to the color scale at the bottom. The external black circle corresponds to a 150 km range at 0.7 deg. elevation from the radar site.

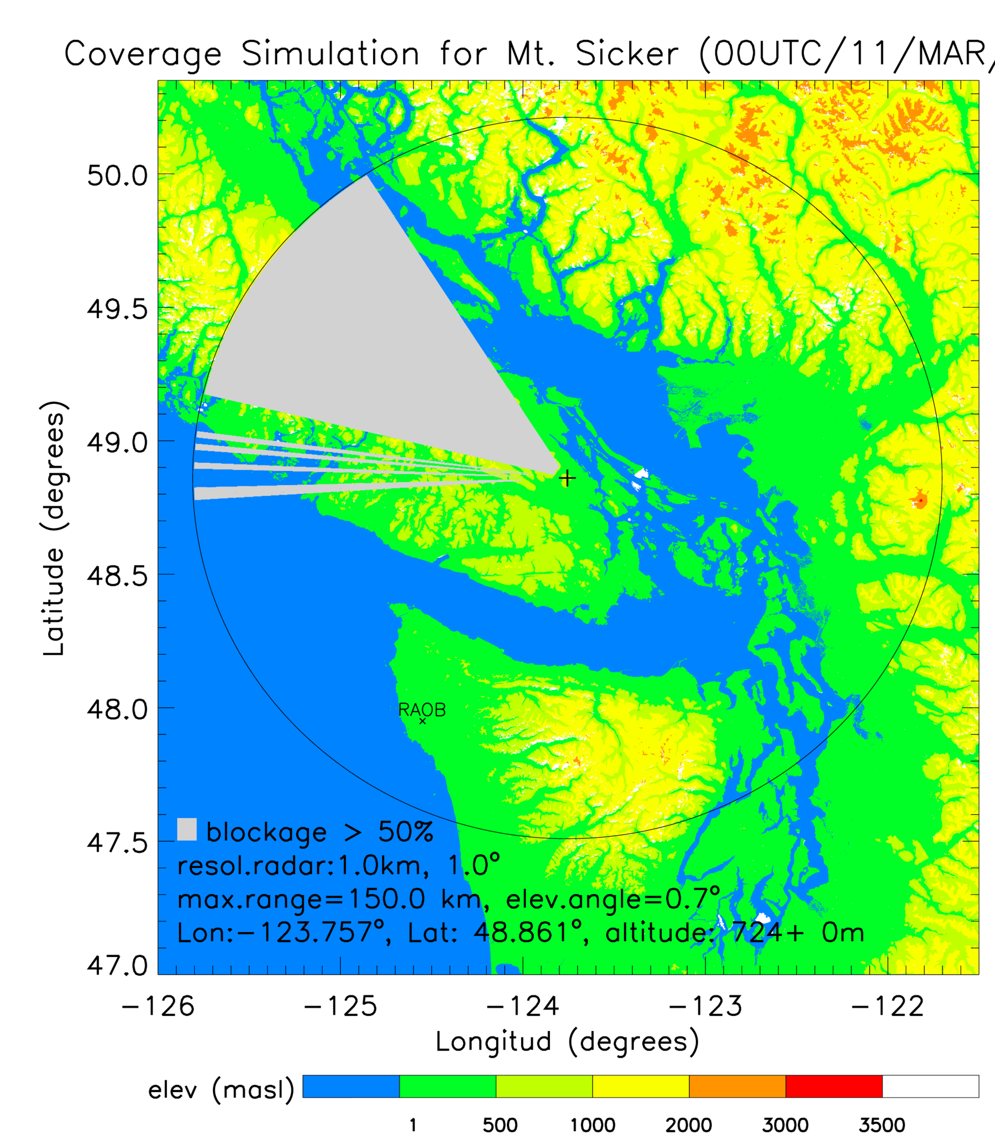

Fig. 5. Numerical simulation of radar coverage for the weather radar at Mt. Sicker. It uses the Quillayute radiosonde observations (site labeled as RAOB) from 11 March 2007 at 0000 UTC. The radar site is labeled with a cross. Gray areas correspond to regions not observed by the weather radar (total blockage). Terrain altitudes (in meters above sea level, ± 9 m at 90% confidence, from the SRTM 30 m digital model) are given according to the color scale at the bottom. The external black circle corresponds to a 150 km range at 0.7 deg. elevation from the radar site.

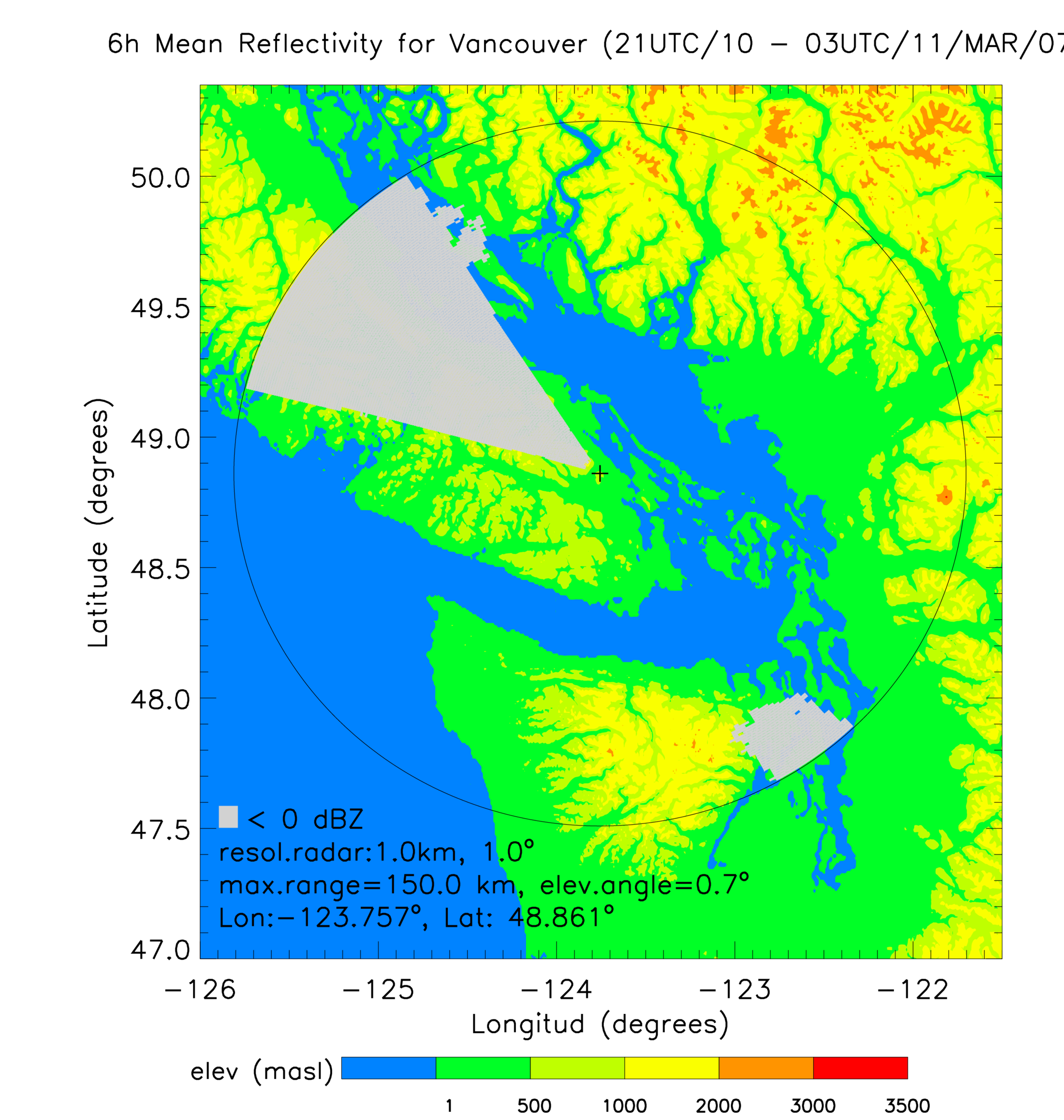

Fig. 6. Reflectivity observations for the weather radar at Mt. Sicker (provided by Norman Donaldson, Environment Canada). Each radar pixel (1 km per 1 degree) gives the mean reflectivity over a 6 h period (average computed in mm^6m^{-3} and plotted in dBZ). These correspond to 37 radar scans at 0.7 elevation angle, from 2100 UTC 10 March 2007 to 0300 UTC 11 March 2007. Grey areas correspond to mean reflectivities smaller than 0 dBZ (a proxy for total blockage). Terrain altitudes (from the GLOBE 1.0 digital model) follow the color scale at the bottom. The light gray area in the south east direction is due to the lack of precipitation (from leeward, down-slope flow).

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