Transionospheric SAR

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We will discuss some recent (intriguing) findings that pertain to the imaging of the surface of the Earth by spaceborne synthetic aperture radars (SAR). SAR is a coherent imaging technology that uses microwaves for reconstructing the ground reflectivity as a function of spatial coordinates. Ionospheric turbulence brings an additional dimension into the SAR analysis that accounts for randomness. The overall error now has two components, deterministic and stochastic, that are fundamentally different. The stochastic component becomes larger as the synthetic aperture gets smaller compared to the outer scale of turbulence. Then, why in the ultimate case of very short apertures it appears that the stochastic error can be disregarded? The Doppler effect in fast time is neglected when using the start-stop approximation. Yet it can make the images prone to distortions, unless special corrections are implemented in the matched filter. Why does it turn out that the imaging regime most susceptible to distortions is the frequency modulated continuous wave (FMCW) SAR that corresponds to low chirp rates? Radar targets are typically modeled via the first Born approximation. However, the assumption of weak scattering is inconsistent with that of scattering off the surface only, because the latter implies that radar signals do not penetrate under the surface of the target. How can one take into account the proper physics of the target and construct a scattering model that would be free of inconsistencies yet remain linear and thus amenable to SAR wave field inversion? We will outline the approaches to answering those questions and identify the outstanding issues that require further attention.