The quality of a satellite derived gravity field solution depends critically on the spatial and temporal sampling of the signal. Undersampling leads to aliasing in either the spatial or the time domain. Typically, the Colombo-Nyquist rule of thumb is used to specify the maximum resolvable degree $L$. However, this rule can be demonstrated to be wrong, e.g. by analysing gravity solutions from CHAMP during repeat-mode periods. For near-polar missions like CHAMP, GRACE and GOCE we show that one can consider the sampling in longitude and latitude direction independently. The sampling in latitude direction is governed by the measurement rate of the observations. The sampling in longitude direction is connected to the geometry of the ground track, which can be expressed by the number of equator crossings. Using Nyquist-type criteria in both directions, we demonstrate that restrictions exist mostly on the maximum resolvable order $M$ and not on the maximum resolvable degree $L$ as the Colombo-Nyquist rule predicts. Further, a dependency on the parity of the difference of the number of revolutions and the number of nodal days exists. A stable solution till degree $L-1$ can be derived for both cases, but the results of even parity are degraded due to a poorer conditioning of the normal matrix. Since this cannot be neglected for highly precise applications like e.g. GRACE, a new type of criterion is introduced which connects the maximum resolvable order to the number of equator crossings.