System 34 revisited: Faking a datum for fun and profit

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A geodetic monstrosity

The Danish "System 34" was introduced in the 1930's, intended as a universal geodetic system, encompassing the needs for both topographic and cadastral mapping. At the geodetic end of things, a very high quality re-triangulation of the first order network was in process at the time, but at the cadastral end, the authorities:

- Could not wait for a rigorous adjustment
- Could not wait for quality control of the length (= scale) determinations
- Did not care about absolute orientation
- Insisted on truncated computational models which at the time were considered "good enough for cadastral work", and simplified the work of land surveyors

Due to the cadastral lack of interest in absolute orientation, the transverse cylinder projection intended for the system, ended up being oblique, rather than transverse. And due to the general grave neglect and overall preference of rapid implementation over numerical care, the system ended up with bad tensions and a highly variable scale factor.

This resulted in recurring requests for local readjustments over the next seven decades, from surveyors reporting that "my measurements do not make sense". This slow deluge of partial reimplementations eventually resulted in what was in effect a patchwork of local systems, presumably shoveling the tensions away into the areas of least cadastral survey activity.

Fortunately, at the turn of the century, System 34 was declared deprecated, and a transformation between ETRS89 and System 34 was constructed for compatibility with historical data. Unfortunately, the transformation is hard to implement in current geospatial software. It is also entirely empirical, hence tells us nothing about the overall *nature* of the difference between System 34 and ETRS89.

With that in mind, we decided to reimplement the transformation using a bare essentials approach: A NADCON grid style datum shift in combination with a transverse mercator projection.

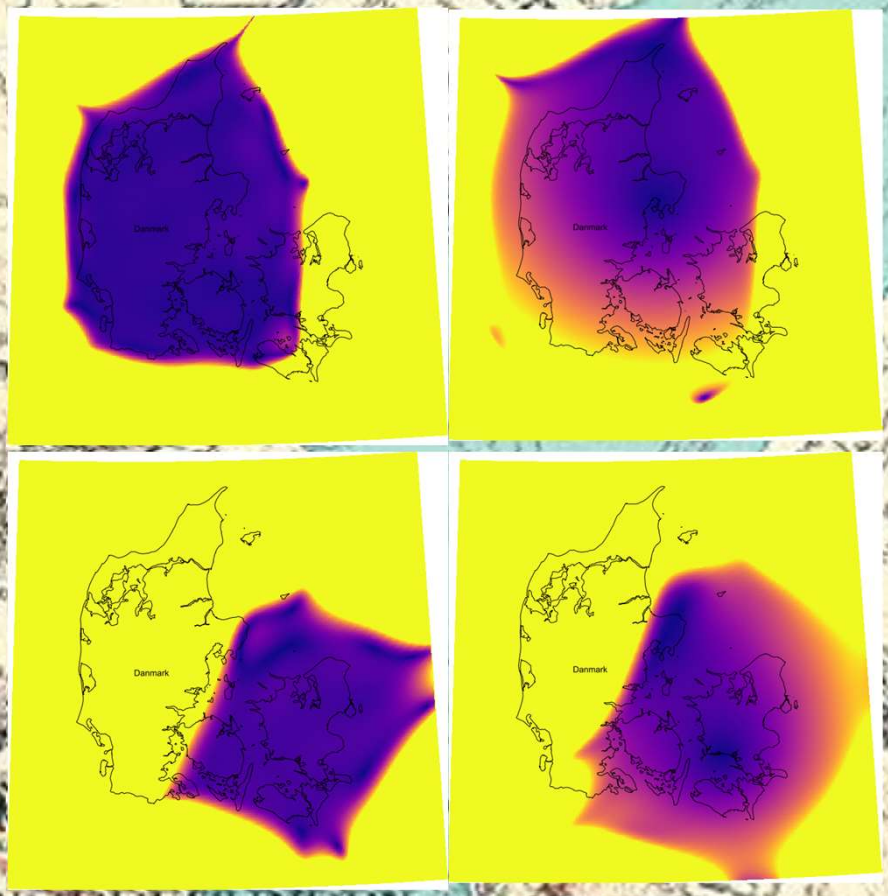
The rationale is as follows: Assume (conterfactually) that the misery of System 34 was not the result of neglect, but simply a matter of limitations in the quality of the observation material available. In that case, we should be able to retroactively reconstruct a datum, having such a relation to ETRS89, *that ETRS89 geographical coordinates transformed to this datum, and projected using the properly constructed transverse mercator projection,* will result in the correct System 34 coordinates.

Constructing the datum transformation grid is a somewhat backward operation, since the NADCON operator works on the geographical input variables, while the datum shift needed is computed from the projected coordinates. This is, however, a minor obstacle: If we let δ denote the datum shift operator from ETRS89 to the retroconstructed System 34 datum, let P denote the corresponding projection, and let C denote the canonical polynomial transformation, then for any given grid node with coordinates (φ, λ) we obtain:

$$\delta(\varphi, \lambda) = (\varphi, \lambda) - P^{-1}[C(\varphi, \lambda)]$$

The final datum shift grid, with a ground sample distance of 1/100 degree, approximates the canonical polynomium based approach to within 2 mm which, being a factor of 25 better than the legal accuracy requirements for RTK based cadastral GNSS surveys, is fully acceptable.

The final transformations and definitions are readily implementable in any reasonable transformation software, and will be submitted to the ISO and EPSG geodetic registries, to enable general accesibility through most mainstream geospatial software.



Upper panels: S34 Jutland zone, lower panel: S34 Zealand zone
Left column: Deviation from the canonical values (Blue: 0 mm, Yellow : > 2 mm)
Right column: Magnitude of the datum shift (Blue: 0 m, Yellow: 20 m).
The magnitude of the datum shift is approximately 1/10 of the corresponding ED50-to-ETRS89 shift

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