Independent verification of the VGAC swath projection against an archived orbit file

Technical annex to a community comment on essd-2026-339

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Summary

The swath projection described in Section 3 of essd-2026-339 was implemented independently from the published description and tested against an archived VIIRS Global Area Coverage (VGAC) orbit file, using the per-cell latitude and longitude stored in that file as the reference. The projection reproduces the archived geolocation to a median great-circle difference of 0.34 km, which is consistent with the sub-cell scatter expected because the stored coordinates are means of the contributing Visible Infrared Imaging Radiometer Suite (VIIRS) pixels within a 3.9 km cell.

Three points arise, all concerning the published description and the accompanying tutorial code rather than the archived data. The cross-track index convention in Section 3.2 is not stated, and reading it in the natural zero-based sense displaces every pixel by one full cell. The two coordinate routines supplied in the tutorial disagree with each other and with the archived file. The tutorial's inverse routine returns the originating cell for approximately half of the file's own cell centres, as a direct consequence of the first point.

None of the three concerns the geolocation stored in the archived files, which is internally consistent and which the independent implementation reproduces.

1. Purpose and method

The verification had two aims. The first was to confirm that the projection can be reimplemented from the published description alone, which is the practical test of whether a method is transferable. The second was to establish which of the available formulations reproduces the archived data, since the manuscript and the tutorial code offer more than one.

The reference file was `VGAC_VN2002MOD_A2026001_0030_n42076_K005.nc`, a NOAA-20 orbit dated 1 January 2026, obtained from the NOAA Open Data Dissemination archive. The file provides the four per-orbit projection parameters (`proj_time0`, `proj_lat0`, `proj_lon0`, `proj_rot`), the per-scan observation time, and the per-cell latitude and longitude. The stored latitude and longitude were treated as the reference throughout. Agreement was measured as great-circle distance on a sphere of radius 6371 km, sampled over 4000 randomly selected cells spanning the full 801 by 10313 array.

The implementation follows Section 3.2 directly: satellite-frame angles are converted to a unit vector, rotated into geographic coordinates, and corrected for Earth rotation by a longitude term proportional to elapsed scan time. The only quantity treated as free was the cross-track index offset, which was fitted rather than assumed.

2. The cross-track index convention

Section 3.2 gives the cross-track angle as

$$\alpha = (i - 401)\,\beta$$

without stating whether the index i is counted from zero or from one. The netCDF arrays are naturally read as zero-based.

Fitting the offset against the archived coordinates gives an unambiguous minimum, shown in Table 1. The residual is flat across the swath, varying between 0.30 km and 0.38 km from the near edge to the far edge, which indicates that the remaining difference is sub-cell scatter rather than a systematic geometric error.

Table 1: Median great-circle difference between the implemented projection and the archived coordinates, as a function of the assumed cross-track offset. The published formula corresponds to an offset of 401 under a zero-based reading.

Assumed offset	Median difference (km)
$i - 399.00$	3.91
$i - 399.50$	1.96
$i - 400.00$	**0.34**
$i - 400.50$	1.94
$i - 401.00$	3.89

The fit degrades linearly at approximately 0.97 km per quarter cell either side of the minimum, so the location of the minimum is not in doubt. The published formula is consistent with the archived data if i is understood as one-based. Read as zero-based, it displaces every pixel by one full cell, 3.89 km, with nothing in the file or the description to signal the discrepancy.

A single clause stating the convention in Section 3.2, repeated where the file layout is described in Section 4, would remove the ambiguity.

3. Disagreement between the two tutorial routines

The tutorial code accompanying the manuscript (Knapp, 2026) supplies a forward routine, `vgac_to_earth`, and an inverse routine, `earth_to_vgac`. Evaluated against the same archived file and the same sample of cells, the two differ substantially in accuracy, as shown in Table 2.

Table 2: Median great-circle difference from the archived coordinates for each formulation.

Formulation	Median difference (km)
Spherical rotation, as used by the inverse routine	0.34
`vgac_to_earth`, the supplied forward routine	17.78

The difference is consistent with `vgac_to_earth` applying an ellipsoidal conversion within an otherwise spherical formulation. Section 3.4 states that spherical coordinates were used in designing the dataset, and the spherical result is the one that reproduces the archived files, so the discrepancy appears to lie in the helper code rather than in the data. A user comparing the two routines has no indication of which to prefer.

4. Recovery of the originating cell by the inverse routine

Applying `earth_to_vgac` to the latitude and longitude stored in the archived file returns the originating cell for 50.2 percent of the sampled cells. An implementation using the offset established in Section 2 returns the originating cell for 100.0 percent of the same sample.

The cause follows from the index convention. The routine's assumed convention places the archived cell centres exactly on its own cell boundaries, so the result at a cell centre is determined by floating-point rounding and is close to an even split between the two adjacent cells. The observed 50.2 percent is consistent with that mechanism.

This point has the largest practical consequence of the three, because the ability to compute the cell containing a given Earth location, rather than searching for it, is identified in Section 2.3 as one of the motivations for defining the projection.

5. What these findings do not indicate

The archived geolocation is not in question. The independent implementation reproduces it to 0.34 km, and the residual is flat across the swath and consistent with the stated averaging of contributing VIIRS pixels within each cell.

The rotation mathematics is not in question either. Once the index convention is accounted for, the independent implementation and the published rotation agree to approximately 10^{-11} km, which is numerical noise. The two formulations are the same mathematics expressed under different conventions.

What differs in each case is a convention that is not recorded. Documenting it resolves all three points.

References

Knapp, K. R., Casey, P. N., and Rao, Y.: VIIRS Global Area Coverage (VGAC): A reduced resolution VIIRS dataset for climate data record continuity, Earth Syst. Sci. Data Discuss. [preprint], https://doi.org/10.5194/essd-2026-339, 2026.

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Knapp, K. R., Adams, B., Semunegus, H., Cao, C., and Shao, X.: Visible Infrared Imaging Radiometer Suite (VIIRS) Global Area Coverage (VGAC) (Version 1), https://doi.org/10.25921/gsef-pg81, 2024.