

Annex C04

Specification of Variables and File Structure

Applicable to the European open tender for InSAR based deformation service for the Dutch built environment (2026)

N.B. Tenderer should not enclose this page upon submission of the Tender

Reference : WS2916555872
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This section explains the level-2 and level 3 product definition and how the product results must be organised, which variables it must contain (not limited to), what each variable means, and in which units they must be provided for the level-2 and level-3 deliveries. Where the Tenderer proposes additional variables beyond those specified in this Annex, the tenderer shall describe each proposed variable in the tender proposal (see preferences 8.2.2.3, 8.2.3 and requirement 8.1.39). This description shall include the exact column name, its meaning and purpose, and the unit of measurement.

These variables should be compatible with the overall data model and may be refined in agreement with the TNO prior to delivery.

Data delivery Level-2

The level 2 data is point cloud data and needs to be delivered in table format presented in comma separated values (.csv) format, in order to remain consistent with previous deliveries. For clarity, all time-series need to be of the same length to match the date columns. Excluded epochs can be marked by a NaN value (or integer ID). For each track a separate file needs to be delivered. The filename should be generated as follows:

<projectName>_<satelliteCode>_<acquisitionMode>_<orbitDirection>_t_<orbitNumber>_<firstAcquisitionDate>_<lastAcquisitionDate>.<extension>.

Example: LMBRG_TSX_SL_ASC_t_095_20150101_20251231.csv

(See requirement 8.1.40 for details)

Name	Header	Description	Unit
Point identifier	ID	Unique code for each measurement point;	-
x coordinate	x_lon	x coordinate in ETRS89 (EPSG: 4258), min. 5 fractional digits;	Decimal degrees East
y coordinate	y_lon	y coordinate in ETRS89 (EPSG: 4258), min. 5 fractional digits;	Decimal degrees North
x coordinate	x_rd	x coordinate in RD (EPSG: 28992);	m East
y coordinate	y_rd	y coordinate in RD (EPSG: 28992);	m North
height	h_e	height with respect to ellipsoid;	m
height	h_m	height with respect to ground level (i.e. with respect to provided DEM);	m
Geoid height	h_g	Geoid height using the EGM2008 model;	m
Amplitude dispersion index	amp_disp	Amplitude dispersion index (ADI) or	-

		comparable PSI stability indicator;	
Classification ground and building	f_h	1: measurement point refers to ground measurement; 2: measurement point refers to building; 0: measurement point height classification is uncertain;	-
Classification ground building uncertainty	f_h_error	Uncertainty of the ground height classification;	m
Local incidence angle	i_loc	Local incidence angle, the angle between the radar beam and the normal to the terrain at the actual target location (taking into account it accounts for the local topography);	Decimal degrees
Track angle	t_ang	Angle between the satellite track and the geographic North (it is the heading direction of the satellite path projected onto the ground with respect to North;	Decimal degrees
LOS North	los_n	Line of Sight in northern direction;	-
LOS East	los_e	Line of Sight in eastern direction;	-
LOS Up	los_u	Line of Sight in up direction from the ground to the satellite;	-
scatterer flag	f	number of similar neighbours (if 0: PSI point and larger for DSI. If DSI, the number (different than 0) indicates the number of brothers;	-
Number of looks	n_l	For DS if adaptive multilooking is used;	-

Average coherence	coh_avg	Average coherence over multiple interferograms;	-
Size of the averaging/multilooking area		For DS if adaptive multilooking is used;	-
velocity 1	vel_los_1	mean velocity over the entire acquisition period in LoS;	mm/year
velocity 2	vel_los_2_yyyymmdd_YYYYMMDD	mean velocity over the last 6 months in LoS. Between date yyyymmdd and YYYYMMDD ;	mm/year
Annual velocity	vel_los_yyyy	Annual velocity in LoS that occurred during yyyy year;	mm/year
Annual cumulative deformation in the line-of-sight	cum_los_defo_yyyy	Total amount of LoS displacement that has occurred during the yyyy year;	mm
acceleration	a_los	Mean LoS acceleration over the entire acquisition period	mm/year ²
Annual acceleration	a_los_yyyy	Mean LoS acceleration that has occurred during the yyyy year;	mm/year ²
seasonal amplitude	amp_seas	Seasonal amplitude over the entire acquisitions period	mm
temporal coherence	coh_tmp	estimate of the decorrelation noise	-
RMSE	rmse_mod	RMSE of the applied temporal model with respect to the InSAR time series	mm
Unwrapping reliability	f_unw	Unwrap reliability flag or ambiguity indicator	-
Time series	d_los_yyyymmdd	Displacement estimate in LoS with respect to first acquisition. Negative displacement in the direction away from the satellite.	mm
Time series accuracy	d_los_acr	Time series	mm

		accuracy	
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Data delivery level-3

Gridded product

The delivered information per grid cell has to be derived from the existing Level-2 parameters of all the scatterers within that grid cell, hence no new temporal model fitting is requested here.

The following naming conventions² have to be applied to the deliverable:

< projectName >_< satelliteCode >_grd>_< firstAcquisitionDate >_< lastAcquisitionDate >.< extension >

(See requirement 8.1.41 for details)

The required extension is geotiff and has to be a multi-band geotiff in which the following information layers are stacked. The proposed alternative extension shall have the same information layers.

Name	Header	Description	Unit
number of scatterers	num_scat	number of scatterers grid cell;	-
mean vertical velocity 1	m_vert_v_1	mean of the vertical velocities over the entire acquisition period;	mm/year
standard deviation vertical velocity 1	std_m_vert_v_1	standard deviation of the vertical velocities over the entire acquisition period;	mm/year
Mean annual vertical velocity	m_vert_annual_v_yyyy	Mean annual vertical velocity that occurred during yyyy year;	mm/year
Annual velocity standard deviation	Std_m_vert_annual_v_yyyy	Standard deviation of the mean annual vertical velocity that occurred during yyyy year;	mm/year
mean East-West velocity 1	m_ew_v_1	mean of the East-West velocities over the entire acquisition period;	mm/year
standard deviation East-West velocity 1	std_m_ew_v_1	standard deviation of the East-West velocities over the entire acquisition period;	mm/year
Mean annual east-west velocity	m_ew_annual_v_yyyy	Mean annual vertical velocity that occurred during yyyy year;	mm/year
Standard deviation of the mean annual velocity in the east-west	std_m_ew_annual_v_yyyy	Standard deviation of the mean annual vertical velocity that occurred during yyyy year;	mm/year
mean vertical acceleration	m_v_a	mean of the accelerations over the entire acquisition period in vertical	mm/year ²

		direction	
standard deviation of the mean vertical acceleration	std_m_v_a	standard deviation of the accelerations over the entire acquisition period in vertical direction;	mm/year2
mean East-West acceleration	m_ew_a	mean of the accelerations over the entire acquisition period in East-West direction;	mm/year2
standard deviation of the mean East-West acceleration	std_m_ew_a	standard deviation of the accelerations over the entire acquisition period in East-West direction;	mm/year2
mean vertical seasonal amplitude	m_amp_seas_v	mean of the seasonal amplitudes over the entire acquisitions period in vertical direction;	mm
standard deviation of the mean vertical seasonal amplitude	std_m_amp_seas_v	standard deviation of the seasonal amplitudes over the entire acquisitions period in vertical direction;	mm
mean East-West seasonal amplitude	m_amp_seas_ew	mean of the seasonal amplitudes over the entire acquisitions period in East-West direction;	mm
standard deviation of the East-West seasonal amplitude	std_mamp_seas_ew	standard deviation of the seasonal amplitudes over the entire acquisitions period in East-West direction;	mm
mean temporal coherence	m_coh_tmp	mean of the estimates of the decorrelation noise of the scatterers within a grid cell or object polygon;	-
standard deviation temporal coherence	std_m_coh_tmp	standard deviation of the estimates of the decorrelation noise of the scatterers within a grid cell or object polygon;	-
Mean annual cumulative deformation in the vertical direction	m_defo_annual_v_yyyy	Mean of the total amount of ground or structural displacement that has occurred over a continuous 12-month;	mm

		period in the vertical direction during yyyy year;	
Mean annual cumulative deformation in the East-West direction	m_c_defo_annual_ew	Mean of the total amount of ground or structural displacement that has occurred over a continuous 12-month period in the east/west direction during yyyy year;	mm
Time series vertical	d_v_yyyymmdd	Vertical displacement estimate with respect to first acquisition. Negative displacement in the direction away from the satellite;	mm
Time series East-West	d_ew_yyyymmdd	East-West displacement estimate with respect to first acquisition. Negative displacement in the direction away from the satellite;	mm

Building data

This product delivers, per-building, estimates of and not limited to tilt and curvature components, capturing differential deformation patterns across each building footprint. Additional building-level metrics will be defined in consultation with TNO at the start of the project and shall be proposed by the Tenderer. The following variables (not limited to see Requirement 8.1.31) and units are required to be included in the data exported for each building request:

- Vertical displacement rate (mm/year) with displacement time series evolution
- Plane- or polynomial-fit to extract derived values and statistics of displacement field

Derivatives of surface deformation:

- Curvature (radial or [mm/year]/m²).
 - Tilt rate and azimuth of maximum slope.
- Tilt (degrees/year or % slope/year).
 - Curvature (min/max, directions, average, Gaussian).

The following naming conventions must be applied to the deliverable:

<projectCode>_<satelliteCode>_grd_<firstAcqDate>_<lastAcqDate>_<buildingID>_statistics.csv

(See requirement 8.1.42 for details)

Example: LMBRG_TSX_grd_20150101_20251231_1234-AB-00001.csv

Name	Header	Description	Unit
Tilt component x	tilt_comp_x	Tilt component in the x direction	mm/km
Tilt component y	tilt_comp_y	Tilt component in the y direction	mm/km
Magnitude of the tilt	tilt_mag	Magnitude of the tilt combining the x and y components of tilt	-
Direction of tilt	tilt_dir	Direction of tilt	

Directional curvature component in x	curv_x	Directional curvature in x direction;	km ⁻¹
Directional curvature component in y	curv_y	Directional curvature in y direction;	km ⁻¹
Total curvature	Curv_total	Total mean curvature;	