

The GEPATAR project: GEotechnical and Patrimonial Archives Toolbox for ARchitectural conservation in Belgium

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Université de Liège (ULg)

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### SETTLEMENT INDUCED DAMAGE













### Differential settlement >> deformation, cracks

- Caused by ground movements
  - Consolidation of soft sediments
  - Mining activities
  - Tunnelling & excavation
  - Groundwater extraction/recharge
- Foundation failure
- Unequal distribution of load
- Creep



Traditional settlement induced damage models are costly: require in-situ measurements & many parameters (physical, mechanical, chemical, environmental, architectural, historical)





## PERSISTENT SCATTERER INTERFEROMETRY (PS-INSAR)







Aim of the **GEPATAR** project (**GEotechnical and Patrimonial Archives Toolbox for ARchitectural conservation in Belgium**): to create an online interactive geoinformation tool that allows the user to view, query & analyse information about Belgian heritage buildings at risk due to differential ground movements.

The objectives are:

- Integrate data from the archives of RBINS-GSB & RICH
- Use PS-InSAR techniques to measure ground movements
- Predict the level of damage of monuments using settlement damage models
- Combine the data in an online interactive toolbox for end-users



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Satellite	Band	Resolution (m)	Tracks	Pass	No. of Scenes	Acq. Period	Processing Software	Avg PS Density (PS/km²)
ERS 1/2	С	4 x 20	466, 194, 423, 151, 380	Descending	338	1992–2006	ROI_PAC, Doris, StaMPS	181
Envisat	С	4 x 20	466, 423, 380	Descending	188	2003–2010	ROI_PAC, Doris, StaMPS	203
TerraSAR- X	Х	3 x 3	48	Descending	74	2011–2014	Doris, StaMPS	2713
COSMO- SkyMed	Х	3 x 3	H4-04	Descending	29	2011–2014	Doris, StaMPS	934
Sentinel 1A/B	С	4 x 20	161, 88	Ascending	134	2016–2019	Sarproz	250

Table 2. Characteristics of the processed datasets.



## **PS-INSAR PROCESSING: DATASETS (2)**





### Port of Antwerp: compaction of soft sediments







GEPATAR GROUND DEFORMATIONS IN BELGIUM (2)

#### ERS1/2: 1992-2006

#### ENVISAT: 2003-2010





### Limburg coalfield: rebound after mine closures







### GEPATAR GROUND DEFORMATIONS IN BELGIUM (4)

#### ERS1/2: 1992-2006



ENVISAT: 2003-2010





### Brussels: rebound after de-industrialization of city centre









# **GROUND DEFORMATIONS IN BELGIUM (6)**







Since 1970s: rise in piezometric head in deeper aquifers.



## **DATA MINING FROM INVENTORIES**



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	Ik ben eigenaar of gebruiker van vastgoed of een vaartuig. Ik beheer vastgoed voor een eigenaar of ontwikkel vastgoed.	Ik ben bestuurder van of werknemer bij een lokale of andere overheid of een intergemeentelijk samenwerkingsverband.	Ik ben beroepsmatig of in mijn vrije tijd actief in de ontoerendertgoedsector. Ik ben notaris. Ik ben metaaldetectorist.	
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Input for settlement damage models:

- Displacement vectors: PS-InSAR velocities for a selected period (*t*)
- Typology of cultural heritage buildings (masonry, infilled frame & bare frame)
- Geometry: building polygons & high-res DTM







Settlement-related intensity parameters:

- Tilt ω
- Angular distortion β
- Deflection ratio  $\delta$







## **SETTLEMENT INDUCED DAMAGE MODELS (3)**





## **POTENTIAL DAMAGE ESTIMATION**



#### Potential damage Classification



No potential damage

Low potential damage



Moderate potential damage

High potential damage





Designed by Thibauld Croonenborghs. Funded by the Belgian Science Policy.



## **GEPATAR WEBSITE**



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Geotechnical and Patrimonial Archives Toolbox for Architectural Conservation in Belgium





- PS-InSAR is still external module; full integration requires cloud processing capacity, domain & maintenance
- Some unexplained phase differences between Sentinel-1 and previous missions
- Simplicity of current damage prediction model; does not include many building parameters
- Lack of coherence in patrimony data from the three regional catalogues



### THANK YOU...