LOSS Symposium, November 5th, 2021
Work Package 1:
Measuring and Monitoring

LOSS Living on Soft Soils Subsidence & Society

Disentangling and parameterizing the total signal of subsidence

An inversion approach applied to various case studies in the Netherlands

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Introduction

The objectives of the study are to determine the key parameters of subsidence and describe ongoing subsidence. All subsidence processes have a characteristic pattern in space and time. Disentangling the different causes of subsidence is important to be able to make reliable historic matches and forecasts of the movement of the (sub)surface and to develop management strategies to mitigate subsidence.

The subsidence processes

Figure 1 shows all the possible sources of subsidence to consider. The total signal measured at the surface consists of the sum of processes in the subsurface. Important drivers outside built-up areas are drainage of surface water and extraction of hydrocarbons (and groundwater). Drainage of surface water causes oxidation of peat, shrinkage of clay and compaction of all layers. Extraction of hydrocarbons causes compaction of the reservoir which results in subsidence. A model has been developed that calculates the contribution of subsidence of a.o. those processes by taking into account the lithology, groundwater level changes and pressure fields in gas reservoirs.

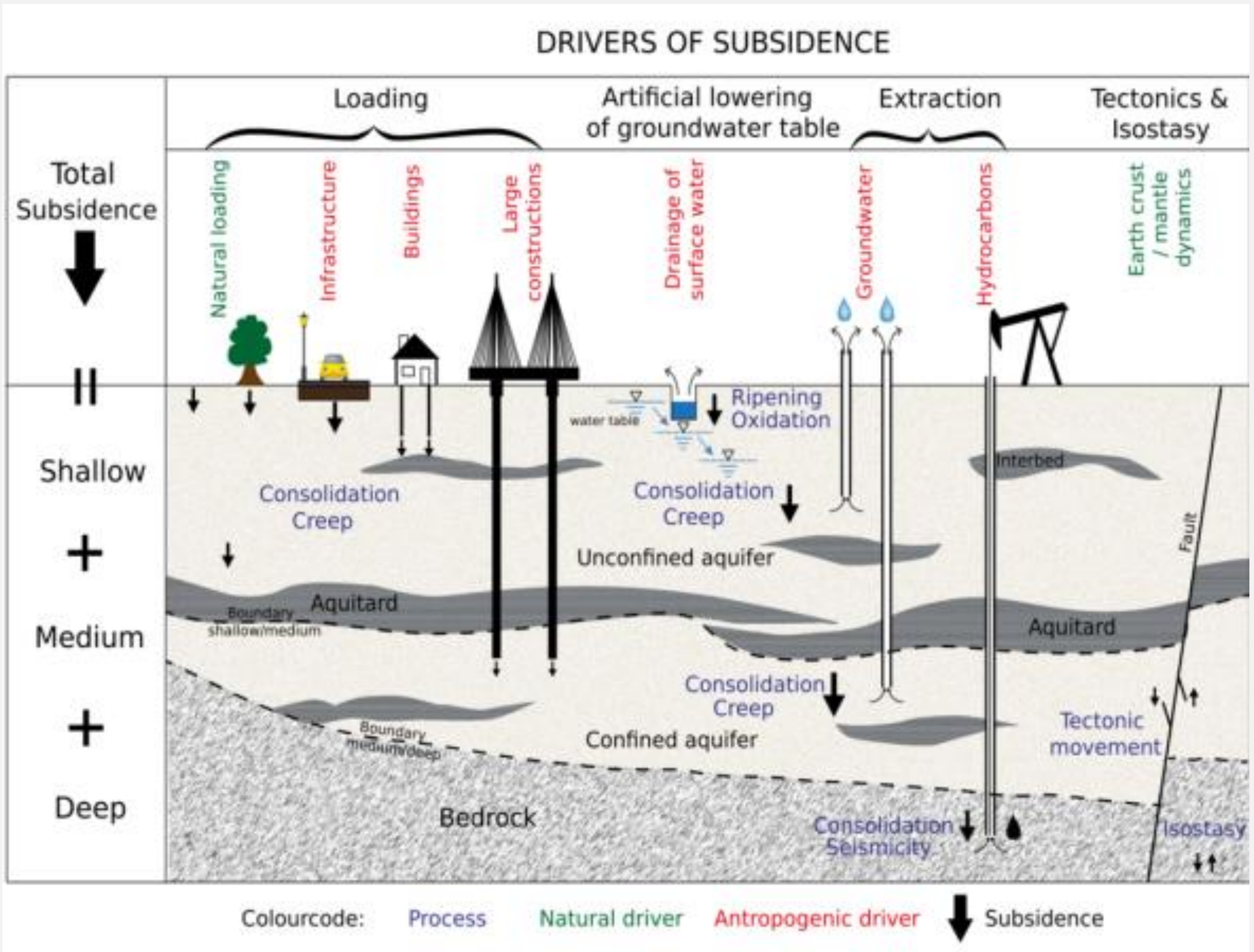

Figure 1
This figures shows the different processes and drivers of subsidence. The processes contribute to the total signal dependent on the spatiotemporal location of the subsidence measurement. Unknown source LOSS website

The data

The date for this study consists amongst others of:

- Groundwater measurements (DINOloket, 2021a) and models (Dabekaussen et al., 2020)
- Lithological data from the GeoTOP model (DINOloket, 2021b)
- Two types of surface elevation measurements; radar satellite data (Sky-Geo, 2021) (**Fig. 2**) and levelling data (Brand and Ten Damme, 2004).

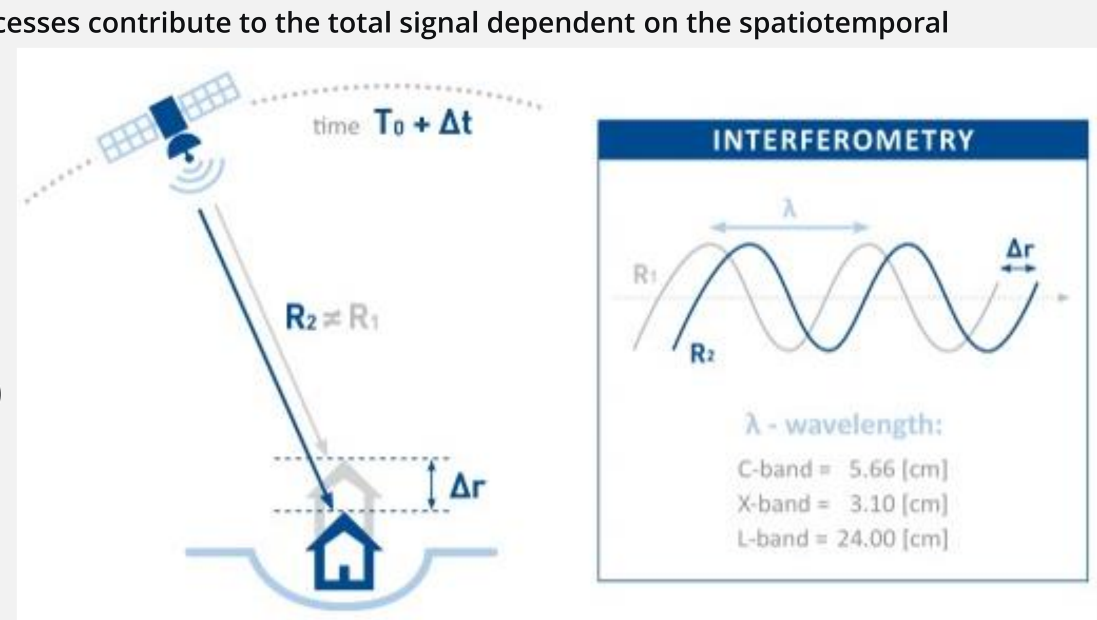

Figure 2
This figure schematises how displacement of the surface areas is measured with SAR data (after: TRE Altamira, 2021).

The disentangling approach

- A data assimilation approach will be used to determine which parameter settings match the subsidence observations (surface elevation measurements) best.
- A machine learning approach is included in association with the data assimilation approach to identify patterns and subsidence processes to include in the data assimilation model.

The case studies

- To reduce complexity, regional parameters of subsidence are searched for in areas where the behaviour of single subsidence driver does not vary too much on the spatial scale.
- From Verberne (2021) it is clear that engineering compaction (due to loading by anthropogenic drivers, see **figure 1**) needs special attention. A case study will be conducted on the N31 south of Leeuwarden (**Fig. 3**).
- Model development for shallow subsidence and its relation to groundwater and precipitation will get special attention.
- Disentanglement of the different sources of subsidence, both deep and shallow, will initially be applied on the area around the gas field of Tietjerksteradeel, Friesland.

Figure 3
Aerial photo of the N31 south of Leeuwarden, after Leeuwarden Vrijbaan, 2021.

The research presented on this poster is part of the project Living on soft soils: subsidence and society (grantnr.: NWA.1160.18.259). This project is funded by the Dutch Research Council (NWO-NWA-ORC), Utrecht University, Wageningen University, Delft University of Technology, Ministry of Infrastructure & Water Management, Ministry of the Interior & Kingdom Relations, Deltares, Wageningen Environmental Research, TNO-Geological Survey of The Netherlands, STOWA, Water Authority: Hoogheemraadschap de Stichtse Rijnlanden, Water Authority: Drents Overijsselse Delta, Province of Utrecht, Province of Zuid-Holland, Municipality of Gouda, Platform Soft Soil, Sweco, Tauw BV, NAM.

References

G.B.M. Brand and J.H. Ten Damme. De waterpasmetingen van de 5e NWP, 2004. URLAGI/GAP-2004-15

Dabekaussen W. Lourens, A. and W.J. Zaadnoordijk. Simulation of groundwater heads for the Think or Sink project. TNO Report, unpublished, page 12, 2020

DINOloket. BRO, Soil and Groundwater, 2021a. URLhttps://www.dinoloket.nl/en/bro-soil-and-groundwater.

References

DINOloket. Detailing the upper layers with GeoTOP, 2021b. URLhttps://www.dinoloket.nl/en/detailing-the-upper-layers-with-geotop

SkyGeo. InSAR sattelite data, 2020. URLhttps://skygeo.com/insar/.

M. Verberne. Toward and improved methodology for data assimilation to disentabgle the processes leading to susbidence. Msc thesis, Utrecht University, 2021.

www.nwa-loss.nl