

Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

Maintaining the Dutch Vertical Reference System

Bas Alberts

29 may 2018



Rijkswaterstaat

- Executive agency of the Dutch ministry of Infrastructure and Water Management
- **Maintenance and development of national roads, waterways and open waters**, and supporting a sustainable environment:
 - **protection against flooding**
 - sufficient clean water
 - **a smooth and safe transport by road and water**
 - **reliable and useful information**
 - a sustainable living environment
- Role: a public-oriented network manager, a leading project manager and an effective crisis manager



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Geodetic Infrastructure

Dutch partnership for geodetic infrastructure (NSGI)

- Integration of reference systems for location, height and gravity for land and sea requires a joint approach by responsible parties
- 2013: Official collaboration between Cadaster and Rijkswaterstaat on GI -> start of NSGI
- 2015: Participation of Dutch Hydrographic Office

Mission: Ensuring the geodetic infrastructure and the realisation of the national and international coordinate reference systems (CRS) on land and at sea.

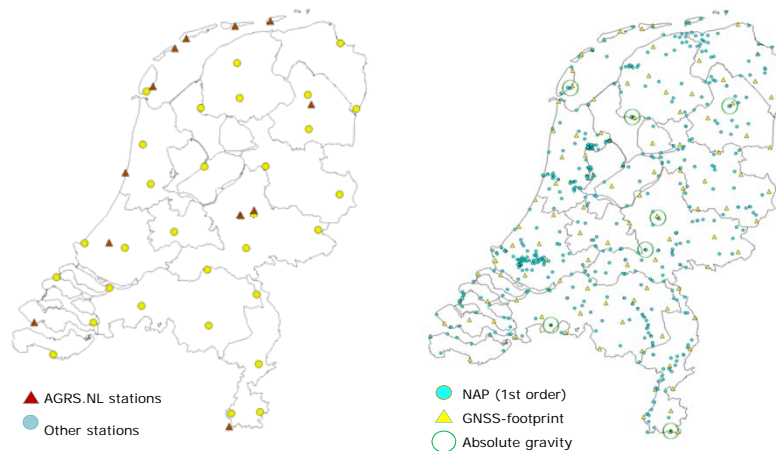
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Geodetic Infrastructure



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NAP: Dutch Vertical Reference System

1st order network

- 300 underground benchmarks (BM) and other deeply funded BM
- Stable reference heights for secondary measurements
- Precise leveling campaigns (every 15-20 years)

2nd order network

- 35000 BM
- Reference heights for objects in the terrain
- Pseudo LS connection adjustment



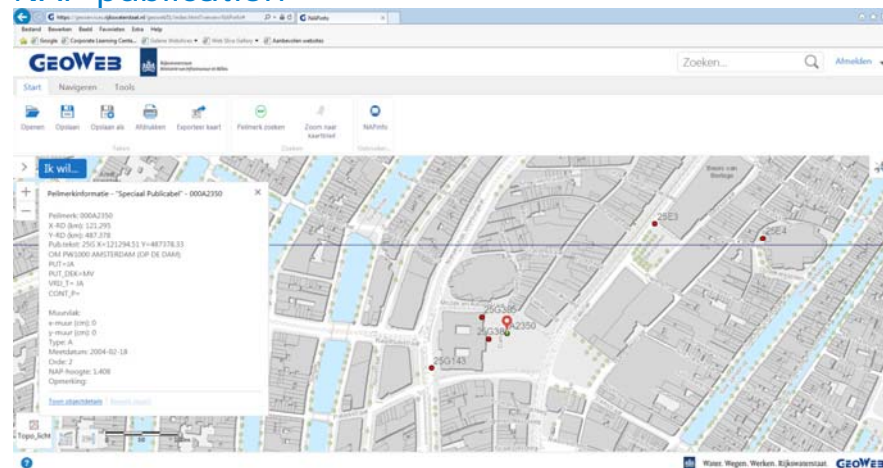
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NAP publication



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Current strategy

- Assumed stable areas: every 10 years
- Subsidence/uplift areas: every 5 years



4e planperiode MAP
Realisatie 2007 t/m 2015



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Limitations

- Limited validation of (assumed) stability 1st order BM, no trigger for a new precise leveling
- Planning secondary leveling is based on limited prior knowledge. Historical NAP data provides insufficient information about stability and reliability of published heights
- Adjustment of leveling campaigns may lead to less accurate heights at the boundaries of the leveling area, especially in deforming areas
- Leveling campaigns are very labor-intensive and take a lot of time, resulting in high costs

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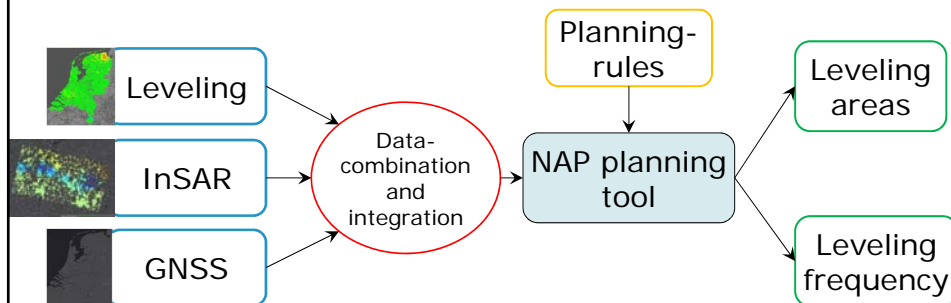
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Future strategy

Can we design our maintenance plan such that strong deforming areas are visited more frequently and stable areas less frequent?



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Future strategy

Can we design our maintenance plan such that strong deforming areas are visited more frequently and stable areas less frequent?

- How to determine the new leveling frequency?
- How to define 'strong deforming'?
- What is the minimum area size?
- Which information do we use (leveling, GNSS, InSAR, gravimetry)?
- What about the 1st order benchmarks?

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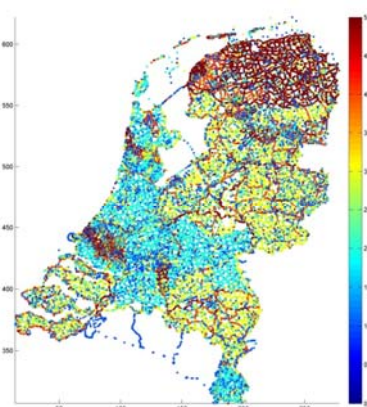
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Example: NAP data

Number of levelings since 1992



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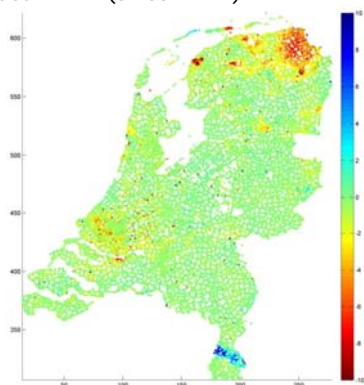
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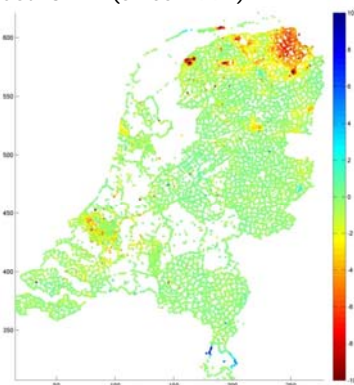


Example: NAP data

Estimated velocity [mm/yr] using at least 2 BM (since 1992)



Estimated velocity [mm/yr] using at least 3 BM (since 1992)



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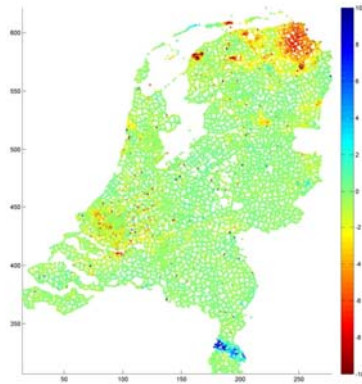
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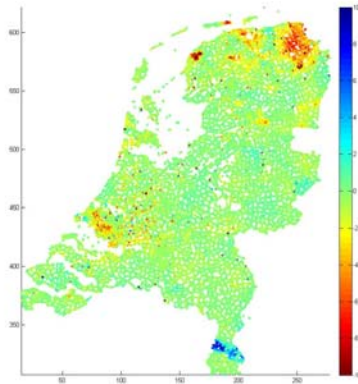


Example: NAP data

Estimated velocity [mm/yr] using at least 2 BM (since 1992)



Estimated velocity [mm/yr] using at least 2 BM (since 2000)



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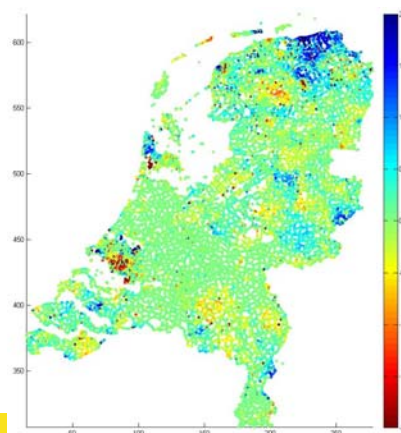
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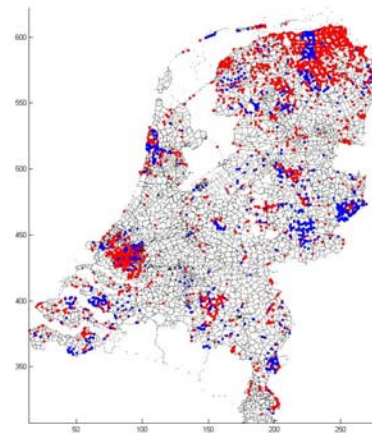


Example: NAP data

Difference in velocity [mm/yr] between estimations: since 2000 – since 1992



Change in trend
red: abs. trend change > 1mm/yr
blue: change of sign



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Why InSAR?

- Monitoring of large areas
- Weather independent
- Historical data available (1990's – present)
- High acquisition frequency (weekly – monthly)
- Complementary to traditional geodetic techniques
- No need to visit points in the terrain
- Less labor-intensive

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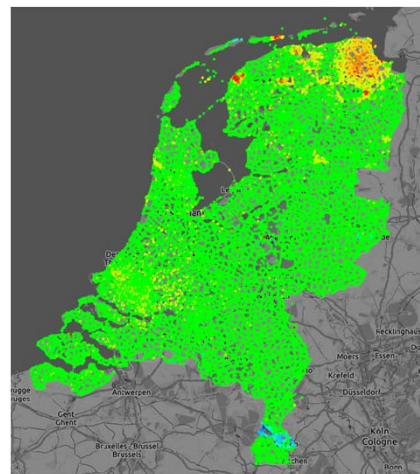
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Why a nation wide deformation map?

- Wide scale deformation patterns (cross-border), mainly subsiding, and sea level is rising
- Harmonisation of deformation products
- Centralised quality control
- Provide baseline map on medium resolution SAR data



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RWS as host

- Administrator of multiple nation-wide data sets
- Potential largest user of InSAR data and strong link to other users (water boards, provinces and municipalities)
- Cooperation with all partners in the National Initiative Surface Movement (NIB)
- Purchasing (wide area) InSAR deformation data is costly and requires expert knowledge



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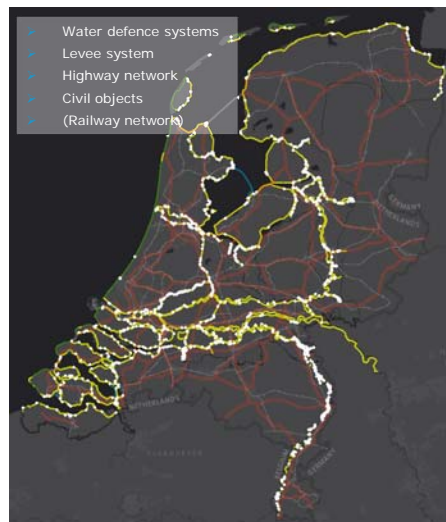
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RWS as user

- Validate (assumption of) stability of:
 - buried benchmarks
 - well-funded civil infrastructure
 - end-of-life civil infrastructure
 - critical civil infrastructure
 - settling of newly built civil infrastructure
- Targeted deformation measurements and on-site inspection of civil infrastructure
- Provide background deformation to contractors



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Example



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Lessons learned

InSAR provides lots of information!

But we have to teach users how to deal with InSAR limitations ...

- InSAR does not provide the same measurements as in-situ
- Some objects are not “visible” in InSAR results (material, cover, orientation ...)
- InSAR is not sensitive to North-South deformation.
- Extra post-processing step needed to translate deformation data into information needs from RWS

Transition:

Local pilots → Nation-wide operational use

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Developments at RWS

- Refinement of the description of the product specifications, including the validation and accuracy determination strategy
- Coupling to neighbouring countries and European initiatives
- Development of InSAR –based tools: Targeted levelling tool for NAP maintenance
- Collaboration with water authorities and other ministries
- R&D, such as soft soil deformation (signal interpretation)

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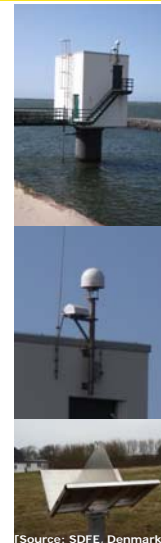
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Corner reflectors and transponders

- Research active transponders
 - Analysis of long term phase stability
 - Datum connection: close to or co-located with permanent GPS station
- Design and installation of network of corner reflectors
 - Validation and accuracy determination: swath and burst overlap of Sentinel-1 images (consistency from different orbits)
 - Placement at RWS property (if possible)
 - Close to permanent GNSS station and NAP BM



[Source: SDFE, Denmark]

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Corner reflectors



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Summary

- RWS is working towards a nationwide deformation product of both hard and soft surfaces
- RWS aims on providing its first national deformation baseline map on medium resolution SAR data in 2019
- First targeted leveling of NAP, based on deformation, in 2020
- RWS is setting up a national network of corner reflectors to validate the quality of the nationwide deformation map



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