Rijkswaterstaat
Ministerie van Infrastructuur en Waterstaat

A deformation-based planning tool for regional levelling campaigns

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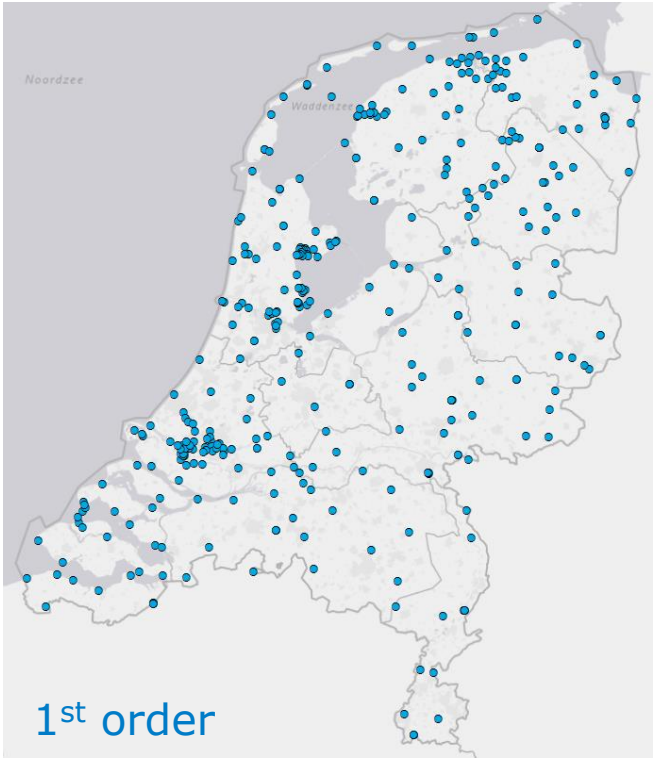
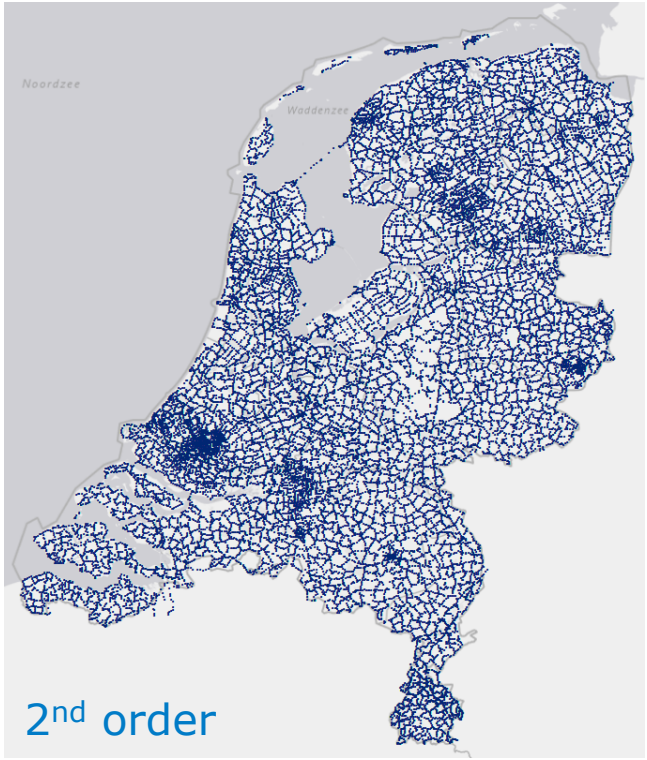
NSGI - Rijkswaterstaat

EUREF symposium 2024

NAP network

NAP


Noordzee
Waddenzee
1st order


Noordzee
Waddenzee
2nd order

NAP network

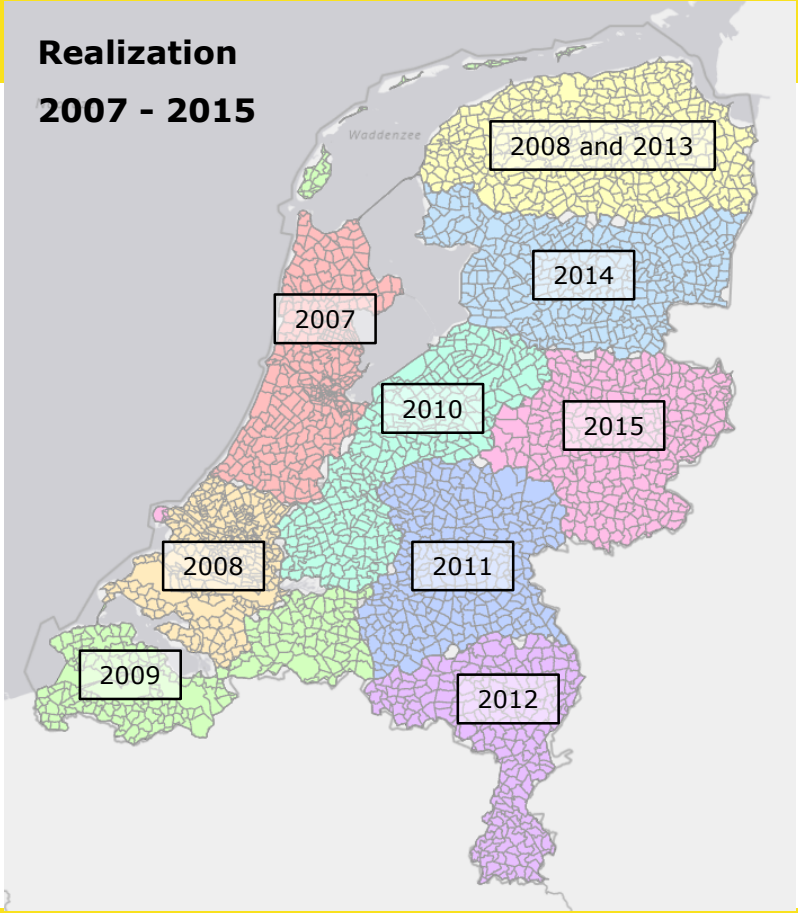
Regional densification by 2nd order levelling

Original strategy:

- 10 year repeat cycle
- 3000 km levelling per year

But:

- Actual realization depends on budget
- Not optimized w.r.t. deformation



NAP network

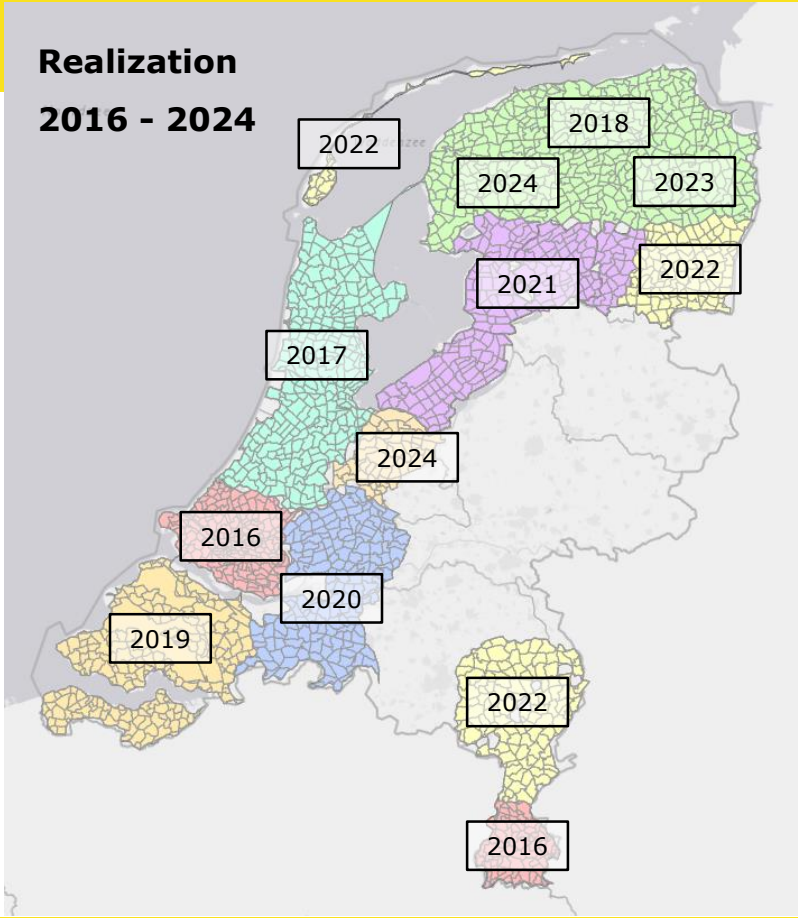
Regional densification by 2nd order levelling

Adapted strategy (since 2018):

- Transition to deformation-based planning
- 2500 km levelling per year

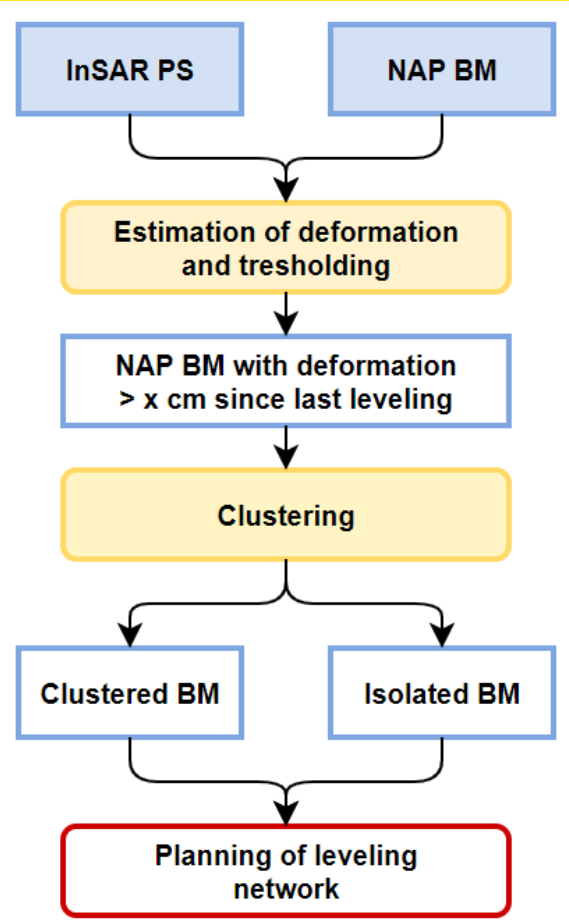
But:

- Annual assessment of region, no multi-year planning



Deformation-based planning

General idea: deforming areas are visited more often and stable areas less

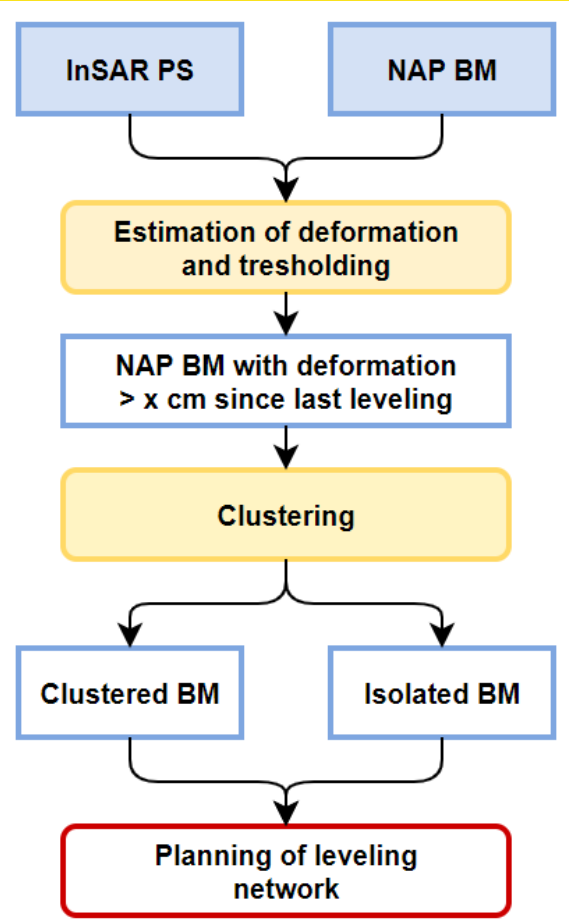


Deformation-based planning

General idea: deforming areas are visited more often and stable areas less

Initial strategy based on deformation of individual NAP benchmarks

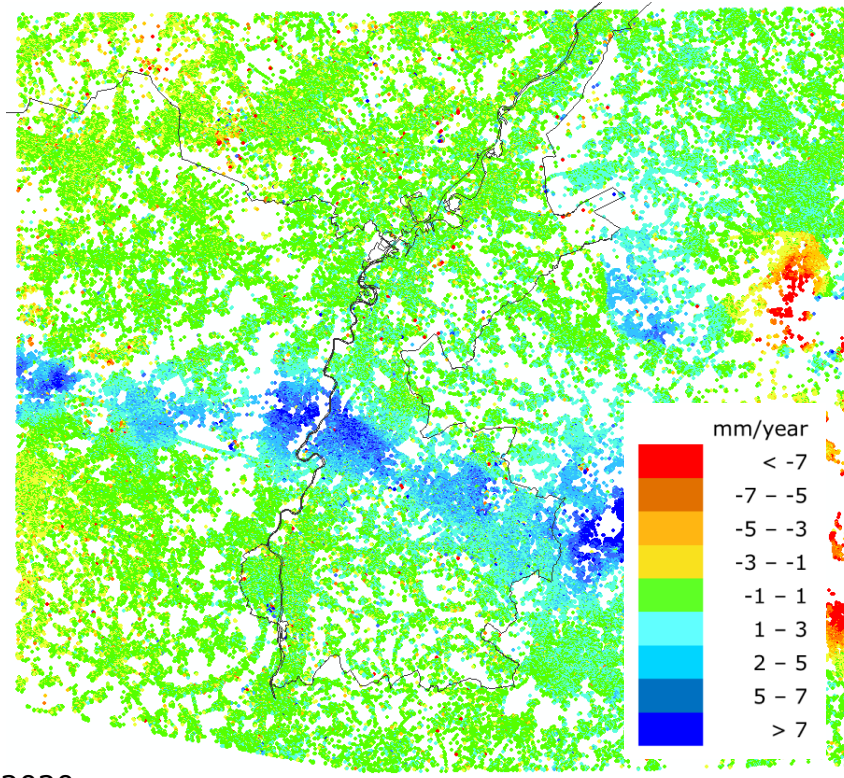
1. Estimation of deformation using nationwide InSAR deformation map
2. Tresholding: find BM with more than x cm since last measurement
3. Clustering of BM
4. Network planning and survey



Case study: Limburg

Input data:

- Deformation rates estimated from RADARSAT-2 data
- NAP benchmark information
- Building outlines to distinguish between deep and shallow deformation



see: Alberts et al. (2020), https://doi.org/10.5194/piahs-382-25-2020

Case study: Limburg

Input data:

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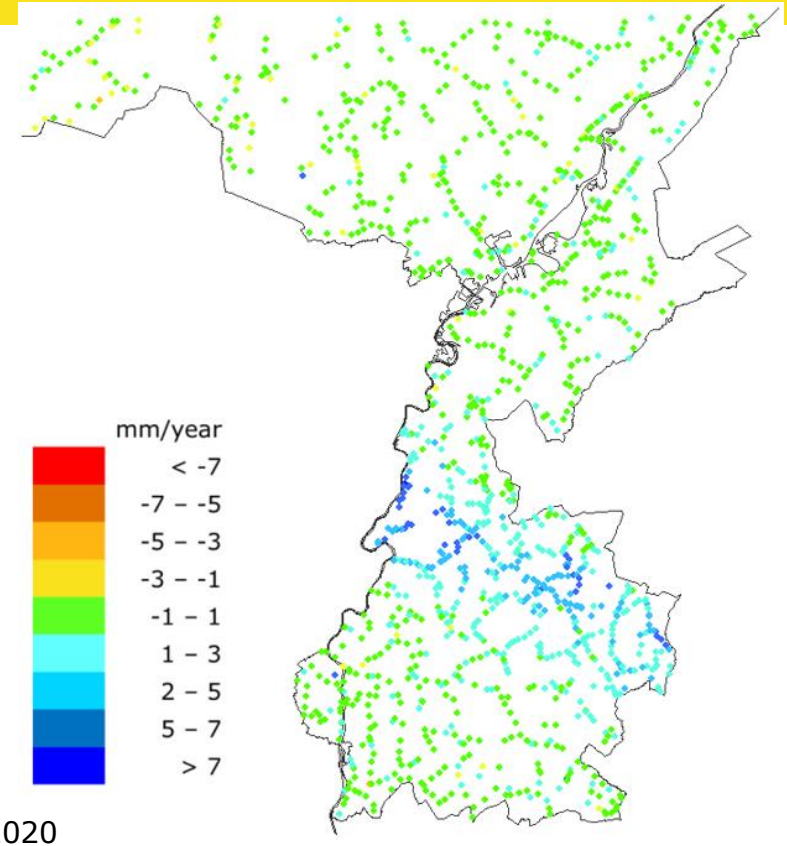
Deformation at NAP BM estimated using Squared-IDW (max distance 50 m)

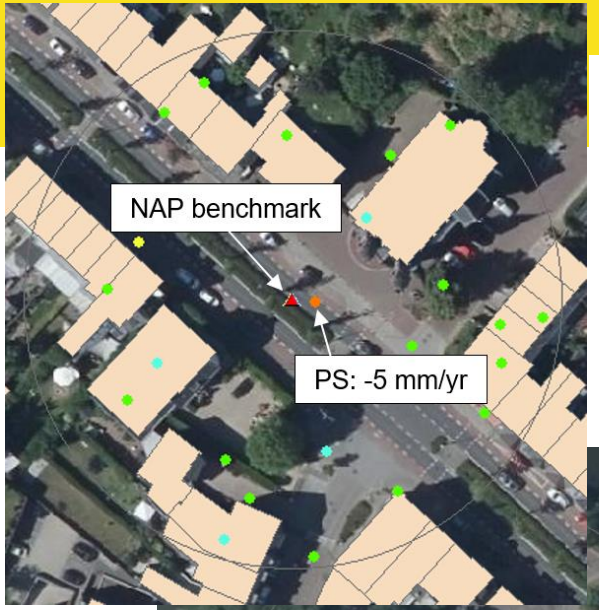


see: Alberts et al. (2020), https://doi.org/10.5194/piahs-382-25-2020

Case study: Limburg

Challenges:

- Impact of outliers in InSAR data near NAP BM
- Inaccuracy of the XY-location of NAP BM
- No InSAR PS near NAP BM

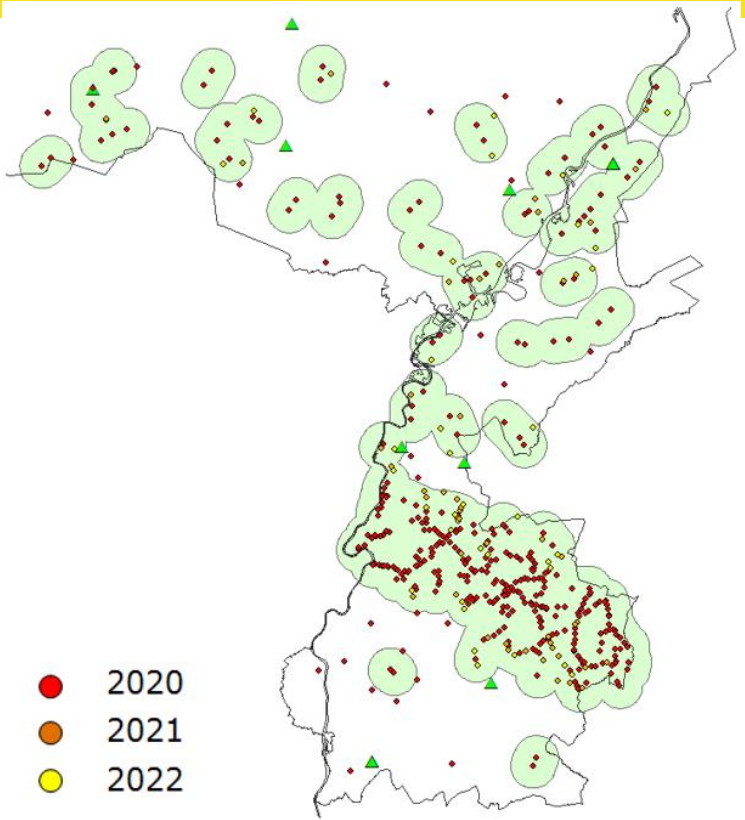


Case study: Limburg

1. Identification of BM that show deformation > 1cm since last levelling (in 2020)

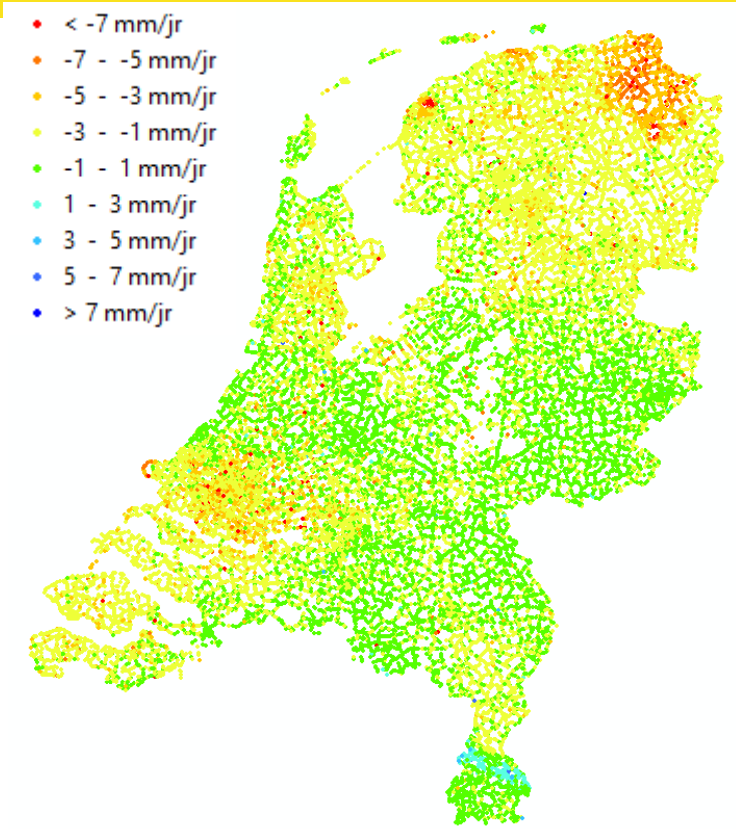
2. Clustering of BM that exceed treshold + adding BM that would be selected in next years (2021 and 2022)

3. Use clusters and scattered BM to plan levelling network



Nationwide planning

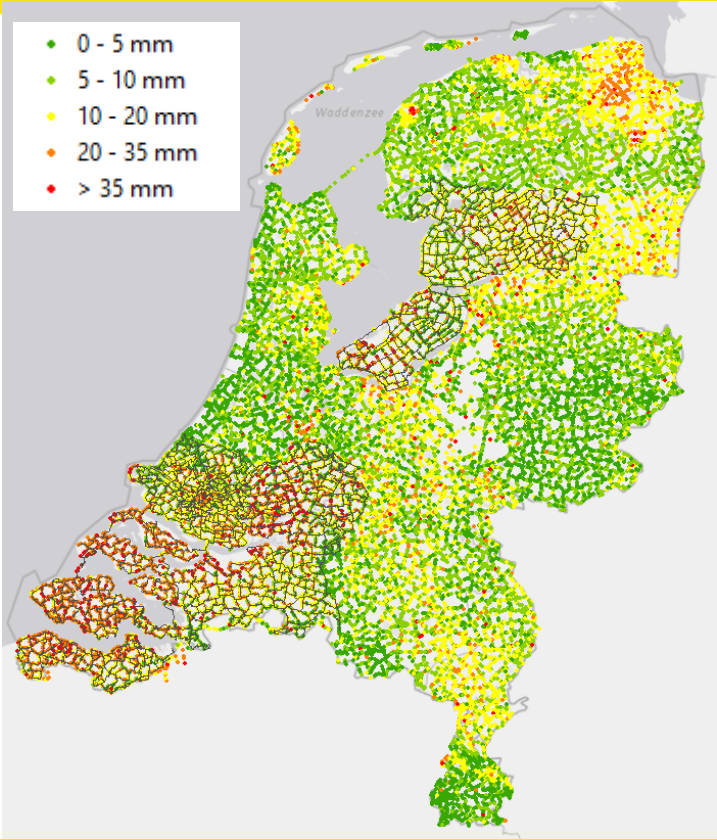
Deformation at benchmarks estimated from nationwide InSAR deformation map



Nationwide planning

Deformation at benchmarks estimated from nationwide InSAR deformation map

→ Total deformation since last levelling (estimated for 2022)

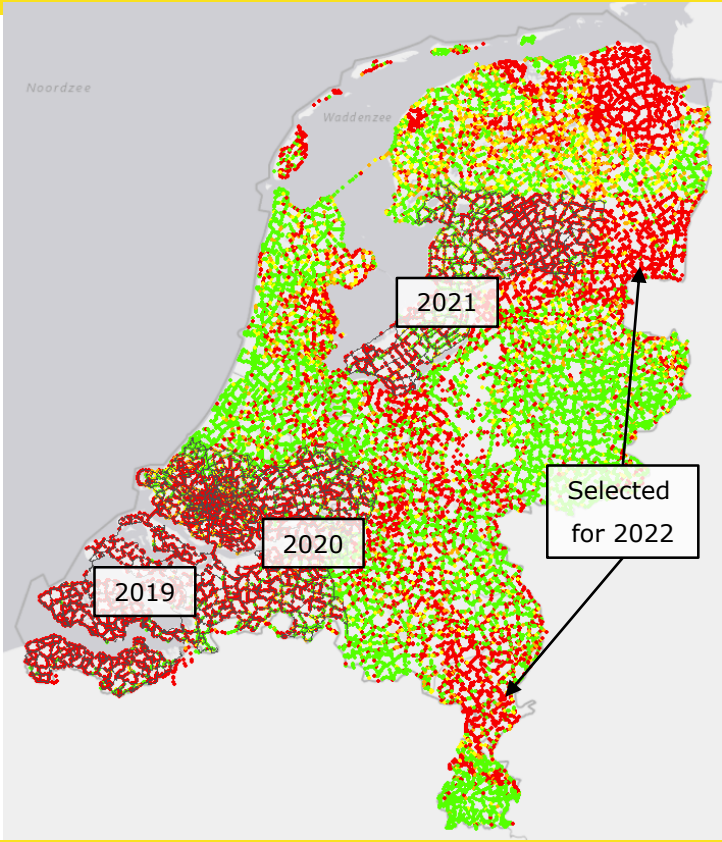


Nationwide planning

Deformation at benchmarks estimated from nationwide InSAR deformation map

→ Total deformation since last levelling (estimated for 2022)

→ Benchmarks with a deformation > 1 cm in 2022 since last levelling

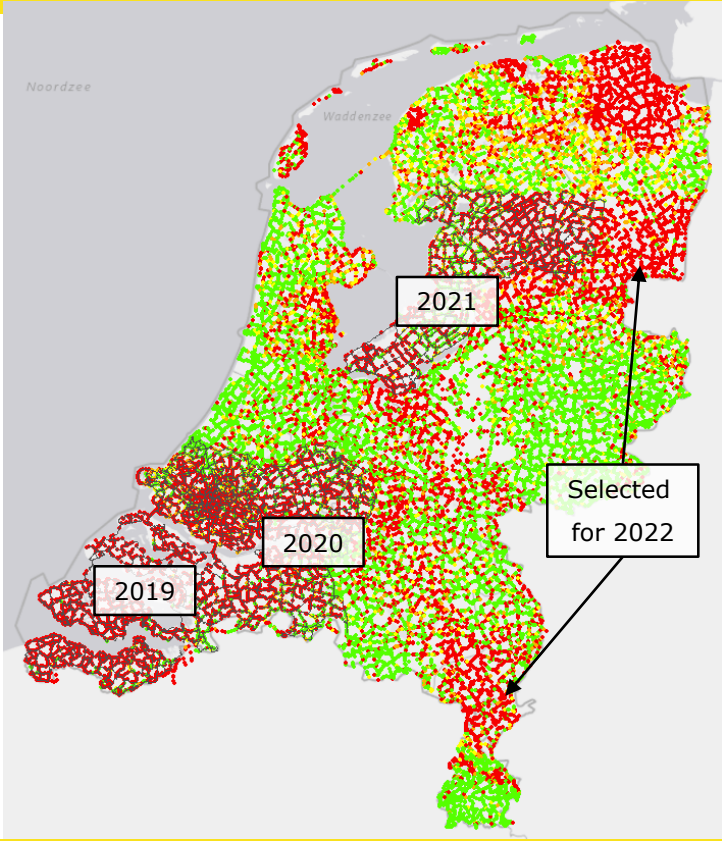


Nationwide planning

Limitations of this approach:

- Benchmarks that have exceeded the threshold may be scattered all over the country
- Resulting levelling networks may be too small to connect to stable primary benchmarks

⇒ Annual assessment of region, no tool for multi-year planning



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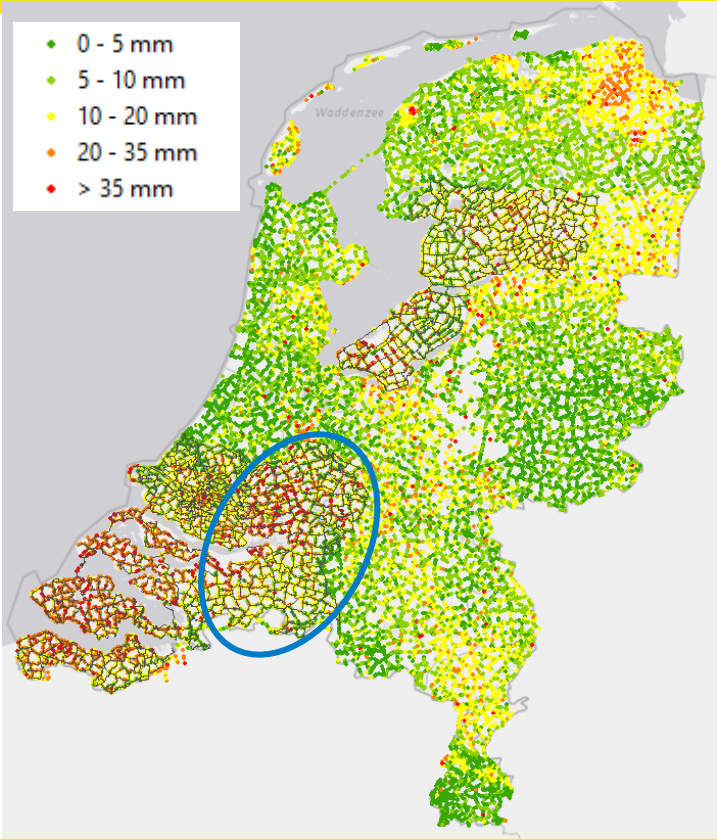
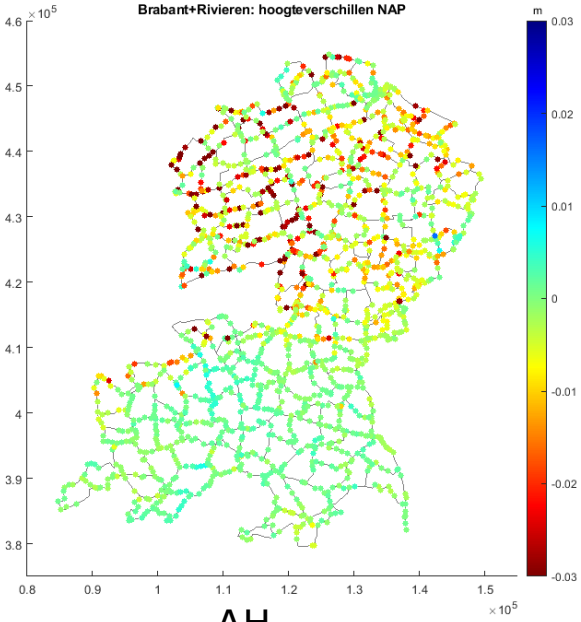


Can we use InSAR deformation map to update NAP heights?

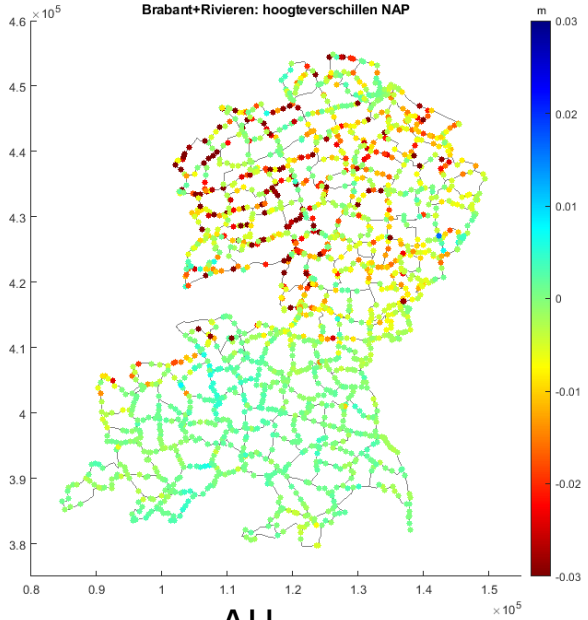
Use InSAR to update NAP heights?



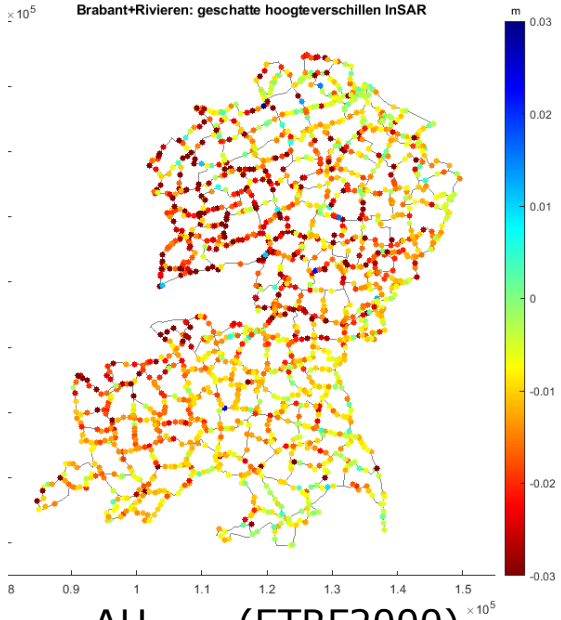
ΔH_{NAP}

Use InSAR to update NAP heights?

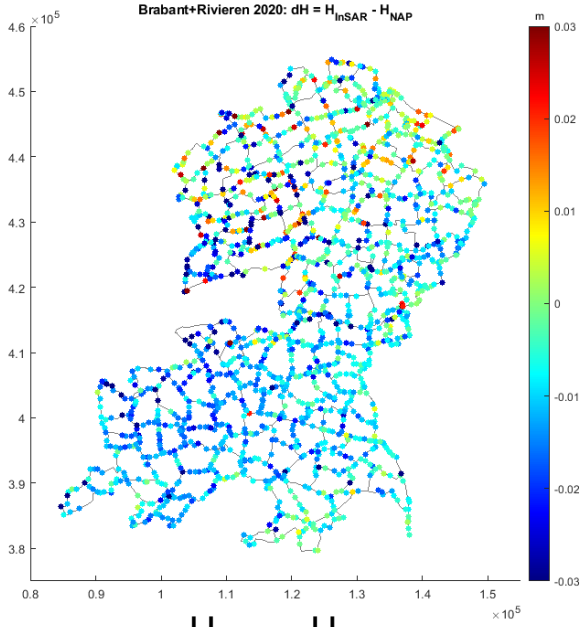
Mean diff: 0.9 cm
Std diff: 1.3 cm



ΔH_{NAP}



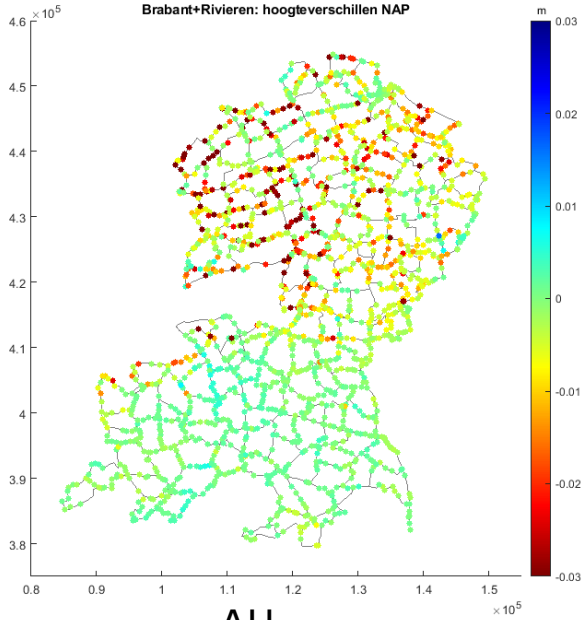
ΔH_{InSAR} (ETRF2000)



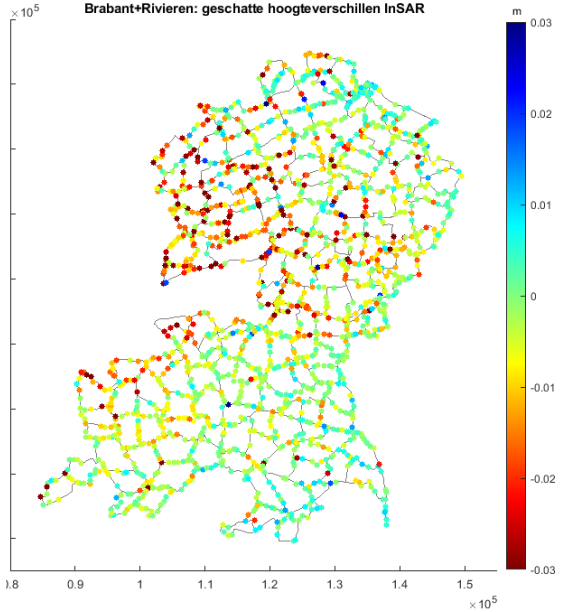
H_{InSAR}-H_{NAP}

Use InSAR to update NAP heights?

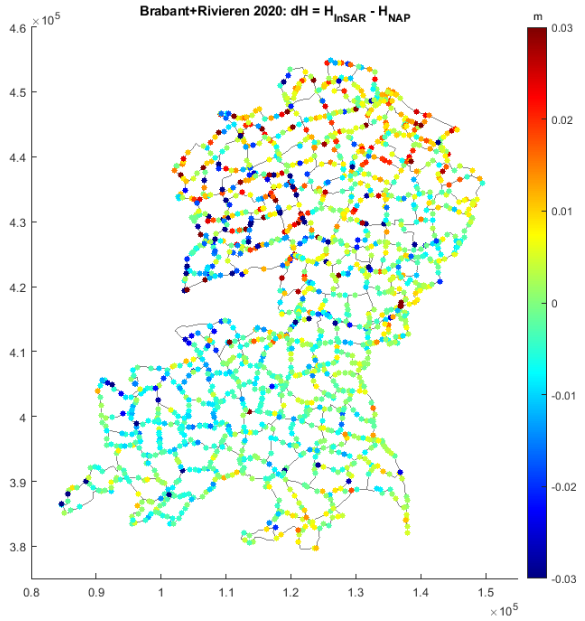
Mean diff: 0.0 cm
Std diff: 1.3 cm



ΔH_{NAP}



ΔH_{InSAR} (ITRF2014)

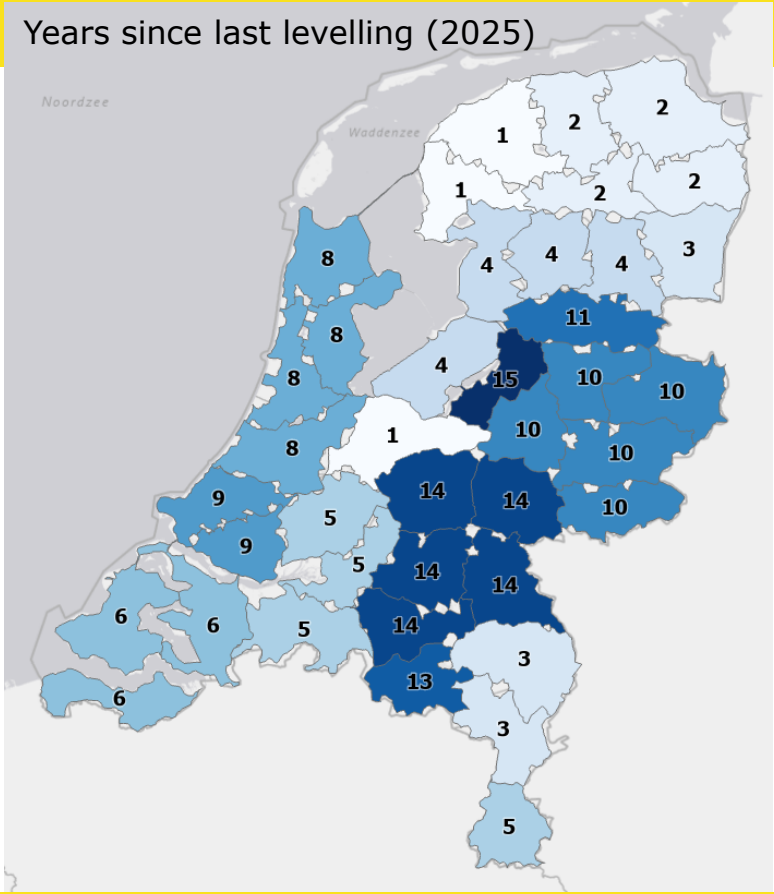


H_{InSAR}-H_{NAP}

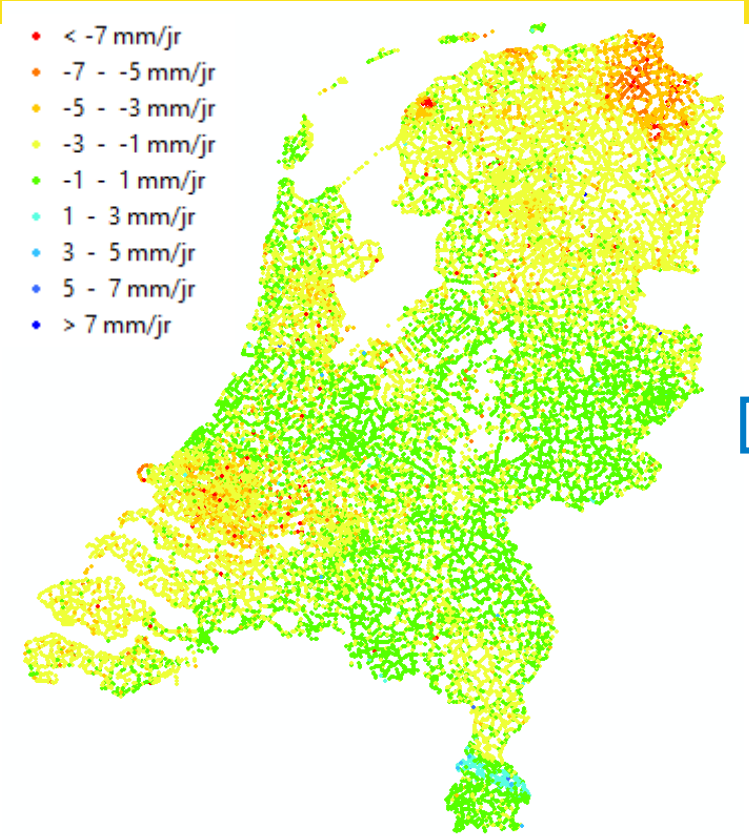
Planningtool

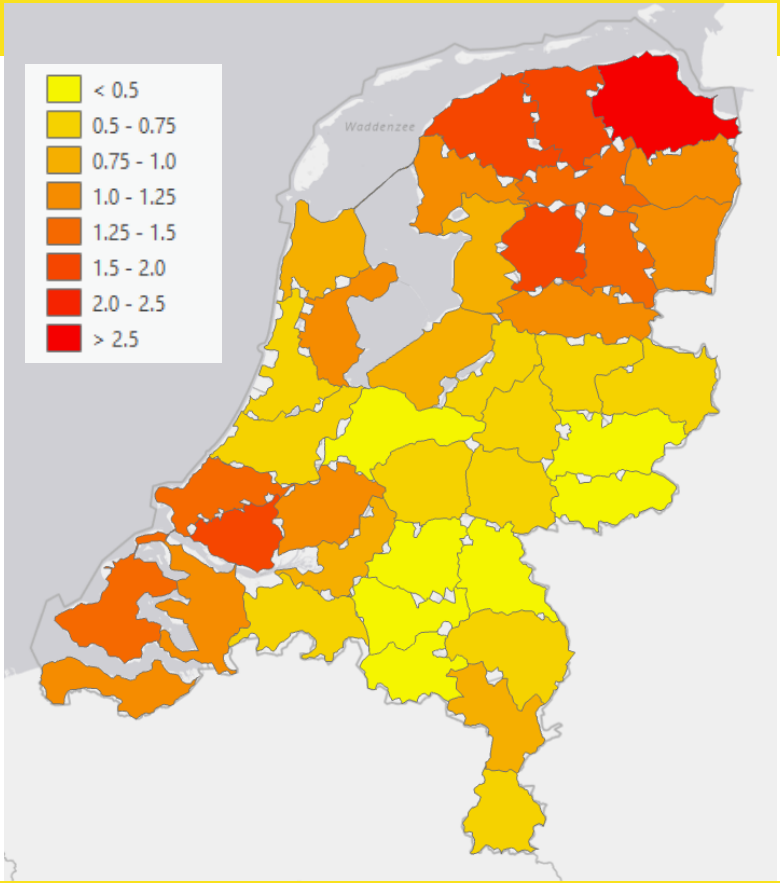
Region-based approach that allows for multi-year planning:

- 40 regions
- 600 – 650 km levelling per region
- At least 4 primary BM
- Average deformation estimated from InSAR data



Tool developed by P. Steenkamp (internship report, 2022)


< -7 mm/jr
-7 - -5 mm/jr
-5 - -3 mm/jr
-3 - -1 mm/jr
-1 - 1 mm/jr
1 - 3 mm/jr
3 - 5 mm/jr
5 - 7 mm/jr
> 7 mm/jr

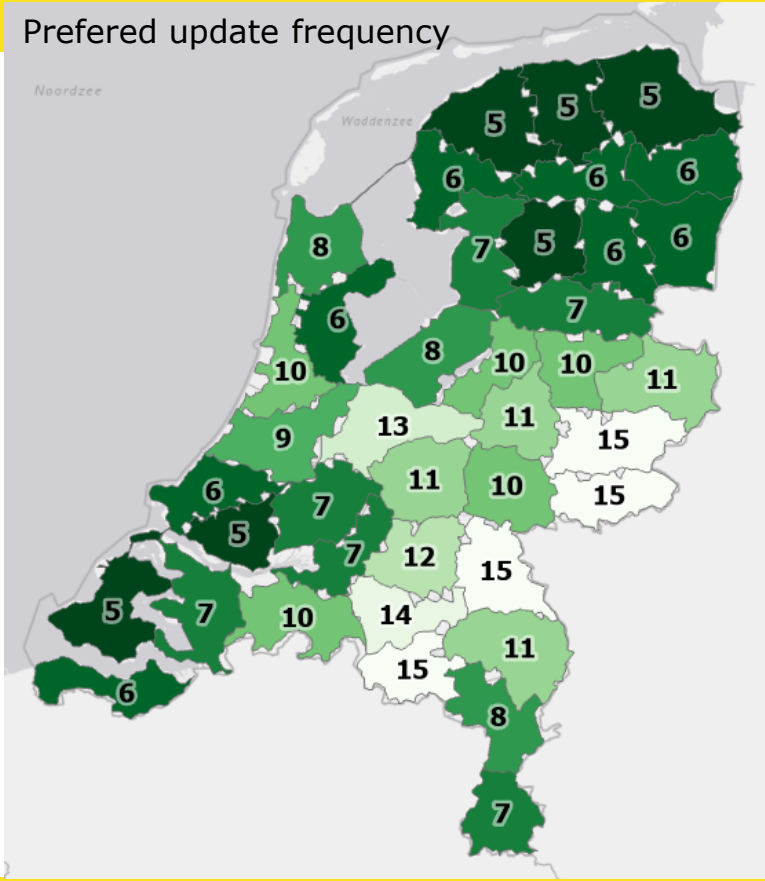

< 0.5
0.5 - 0.75
0.75 - 1.0
1.0 - 1.25
1.25 - 1.5
1.5 - 2.0
2.0 - 2.5
> 2.5
Waddenzee

Planningtool

Region-based approach that allows for multi-year planning:

- Estimated deformation *d* used to determine prefered update frequency:

  F=5 [mm]/ d [mm/yr]
- Ranking of regions based on index *i* computed from *F* and number of years since last levelling: *i=Δy/F*
- Constrained to minimum 5 and maximum 15 years



Planningtool

Region-based approach that allows for multi-year planning:

- 4 regions selected per year
- Planning may be optimized

Planningtool

Region-based approach that allows for multi-year planning:

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- Planning may be optimized

To do:

- Finetuning of parameters
- Use EGMS to estimate deformation
- Communication to users
- Add deformation information to BM info