Nonlinear data assimilation:

Particle filters from a Bayesian perspective

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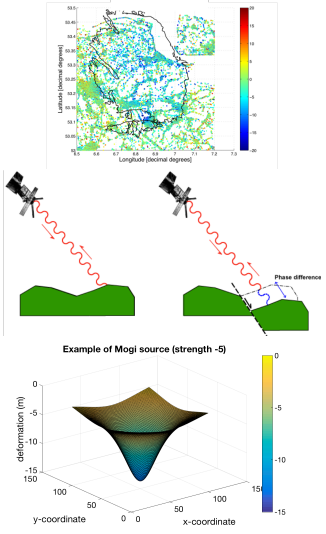
Based on the book available from

https://github.com/geirev/Data-Assimilation-Fundamentals.git

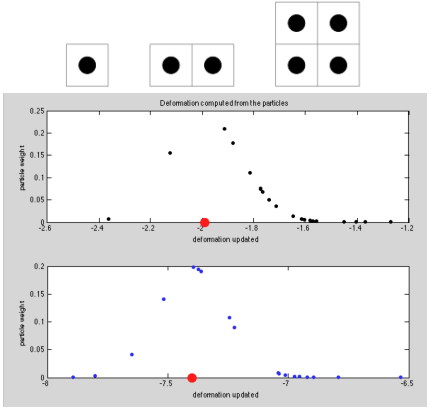
Case I: Subsidence in Groningen

- Studying induced subsidence over the Groningen gas field
- Methodology: particle filter with importance resampling. note: strictly speaking not a filter, because the model is (quasi-)static!
- Estimating the strength using a nucleus of strain (Mogi source) with uncertain strength at the locations of producing wells
- Assimilating InSAR data

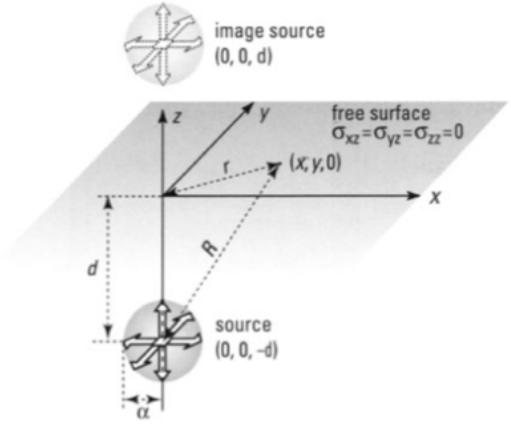


Mogi-source strength estimation

- The approach was tested on synthetic experiments
- In each experiment, the number of Mogi sources was increased (1,2,4,16,...)
- If no resampling is applied, degeneracy starts to occur with ... numbers of Mogi sources, and with ... ensemble sizes
- You will find out in the practical!

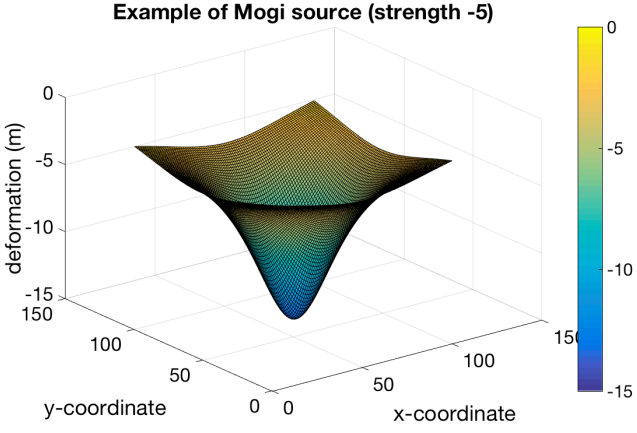


Mogi source



A Mogi source is a point source of deformation, used to model subsidence or uplift as a result of compaction or expansion in the subsurface, originally for volcanics. Deformation u_z is modelled as a function of the radial coordinate r and the distance to the Mogi source R: $u_z = C\frac{r}{R^3}$.

Mogi source



The resulting deformation is bell-shaped.

Exercise Importance Sampling (1)

With the practical partner from yesterday:

- Open DataAssimilation-ImportanceSampling.ipynb
- Run the notebook step by step for "Part I: Numerical model and observations (data)"
- Make an estimate of the Mogi source strengths and discuss this with your practical partner

Exercise Importance Sampling (2)

With the practical partner from yesterday:

- Open DataAssimilation-ImportanceSampling.ipynb
- Run "Part II: Importance Sampling algorithm" and "Part III: Plots and analysis of the results"
- What is an appropriate value for the number of particles, given the number of Mogi sources that you are simulating? Discuss with your partner

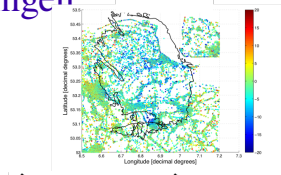
Exercise Importance Sampling (3)

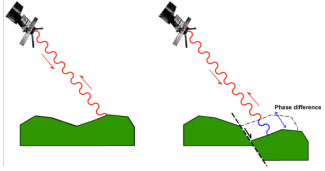
Again, with your practical partner:

- In the second part of DataAssimilation-ImportanceSampling.ipynb
- After playing with the number of particles and Mogi sources, vary the number of observations
- Discuss how this affects degeneracy

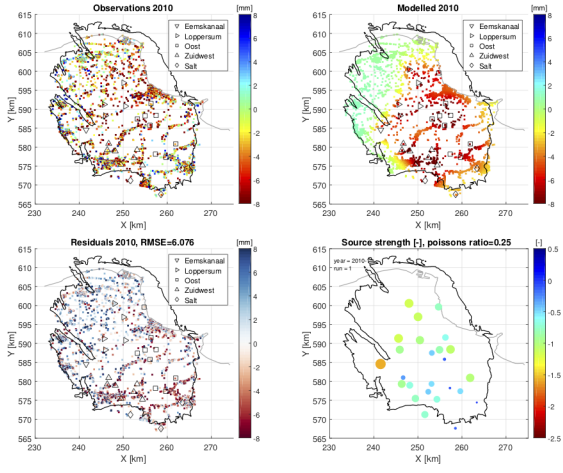
Subsidence case: estimating compaction in Groningen

- Studying induced subsidence over the Groningen gas field
- Methodology: particle filter with importance resampling. note: strictly speaking not a filter, because the model is (quasi-)static!
- Estimating the strength of compaction using a nucleus of strain (Mogi source) with uncertain strength at the locations of producing wells
- Assimilating InSAR data



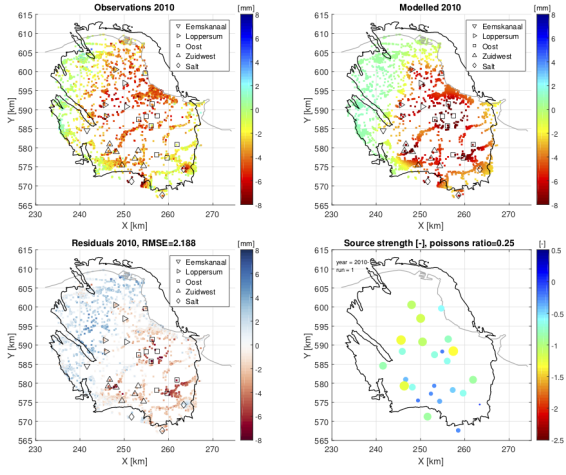


Assimilation actual InSAR data (unfitted)



Available from: https://github.com/geirev/Data-Assimilation-Fundamentals

Assimilation actual InSAR data (fitted)



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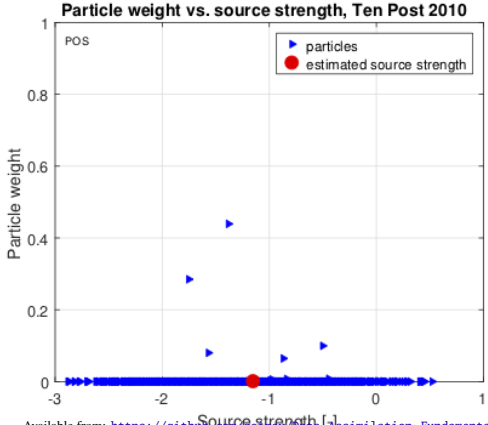
Particle weights

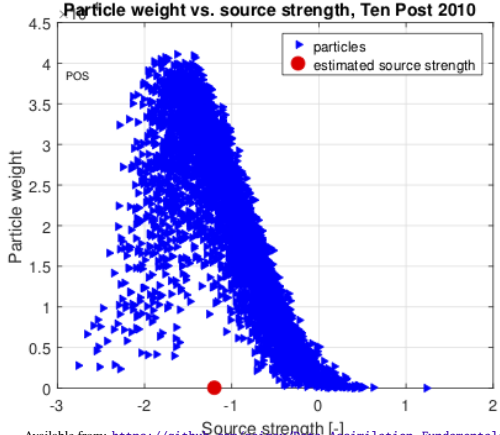
Even with 5000 ensemble members, we observe degeneracy



Available from: https://github.com/geoffer/DataAssimilation-Fundamentals

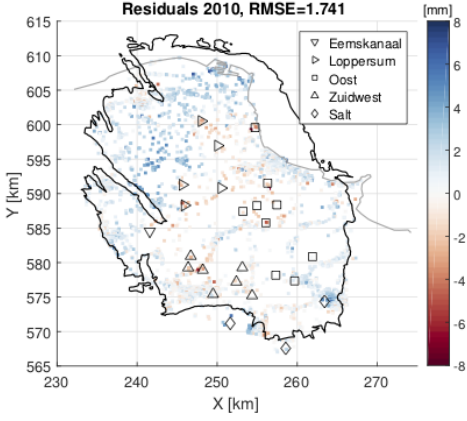
Particle weights with localisation

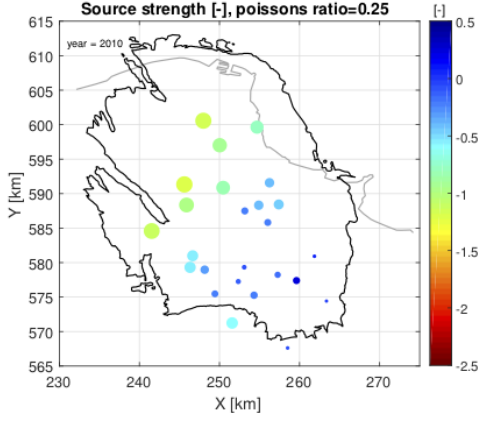
Degeneracy solved with localisation



Available from: https://github.com/gerler/Data-Assimilation-Fundamentals

Assimilation actual InSAR data (fitted, localised)





Subsidence in Groningen

- Importance Sampling can be used to estimate Mogi-source strengths as a representation of reservoir compaction
- For synthetic experiments, increasing the number of particles helps to avoid degeneracy
- For realistic experiments, an ensemble size of 5000 particles still leads to degeneracy
- Localisation can help to overcome this