Derivation of surface subsidence information in Bangkok (Thailand) by PS analysis of a limited number of interferograms

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Subsidence in Bangkok

- Principal cause: extensive groundwater withdrawal
- Surface subsidence mechanism
- Subsidence Characteristics:
  - high and temporally varying subsidence rates
- Mitigating strategies:
  - Control of groundwater extraction
  - Extension of surface water infrastructure

- Groundwater withdrawal
- Porewater's pressure reduction
- Compaction of compressible AQs (Subsurface deformation)
However

- Monitoring subsidence in Bangkok lacks for an efficient tool able to provide **reliable, high resolution** subsidence information.

- To improve our understanding of spatially, temporally varying subsidence as a result from aquifer system compaction
Persistent Scatterer Interferometry (PSI)

- General requirement:
  - PSI requires a large number of images to achieve high precision subsidence estimation

- Conditions in this study:
  - Limited number of SAR acquisitions (20, 16 scenes)
  - High and temporally varying subsidence rates
  - the study site is strongly affected by the atmospheric disturbance
    - difficult to achieve with the classical DInSAR

Under these challenging conditions, we aim to

- quantify the subsidence rates in the study site, south of Bangkok, averaged over the period of 1996-2000 with high spatial detail
• DLR-IMF PSI processing system was used.
• Two IFGM stacks of the test area were analysed.
• based on the Spatial Temporal Unwrapping Network (STUN) algorithm (Kampes, 2005)
  ‣ which utilizes the integer least squares estimator + a displacement model
• The linear displacement model was applied.

• Estimated parameters:
  ‣ displacement rates
  ‣ DEM error estimates
• Atmospheric phases contribution are treated as noise.
• Spatial and temporal baseline distribution of the two data stacks

- a) Baseline range ± 1000m
   - avg. temp sampling = 20 scenes/4 yrs
   - (left stack)

- b) Baseline range ± 900m
   - avg. temp sampling = 16 scenes/7 yrs
   - (right stack)
Obtaining a priori information

\[ s_{\text{max}} = \frac{\lambda}{4} \cdot \frac{K}{\Delta T} \]

- \( K \) is number of IFGMs
- \( \Delta T \) is the time span of all acquisitions
- \( \frac{K}{\Delta T} \) is the average temporal sampling, \( \lambda \) is the radar wavelength
- Subsidence rates in the study site approx. range from 1-45 mm/y

\[
\frac{K}{\Delta T} = \frac{19}{4}; \quad s_{\text{max( left)}} \approx 67 \text{ mm / y} \\
\frac{K}{\Delta T} = \frac{15}{7}; \quad s_{\text{max( right)}} \approx 30 \text{ mm / y}
\]
Success rate assessment

- To evaluate the relationship between noise level (at PS) and the probability to obtain the right estimates (percent of success) with different data configurations.
- is particularly useful when the number of IFGMs are marginal
PS analysis result: LOS displacement estimates

15 IFGMs
36 PS/km²

19 IFGMs
28 PS/km²
Deviation of the estimates can be due to

- Unwrapping error
- Suitability of the (Linear) model used
Quality control of unwrapping results
Correlation coefficient and difference of estimates

The graph depicts the relationship between the difference of estimates (mm/y) on the y-axis and the R^2 value on the x-axis. The data points are clustered into three groups labeled A, B, and C, each with different correlation values.

- Group A: R^2 values of 0.50, 0.60, 0.70, and 0.80, with corresponding difference of estimates of -0.72.
- Group B: R^2 values of 0.90, 0.93, 0.94, and 1.00, with corresponding difference of estimates of 0.95.
- Group C: R^2 values of 0.87, 0.94, 0.94, and 0.97, with corresponding difference of estimates of 0.97.
**BM ID (W to E)**

<table>
<thead>
<tr>
<th>BM ID</th>
<th>R²</th>
<th>Differences of Leveling-PS (mm/yr)</th>
<th>No. of Leveling measurements (1993-2000)</th>
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<td>BMS 8308</td>
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<td>DRM 14</td>
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PSI subsidence estimates: South of Bangkok
Conclusion

- It has been demonstrated that, it is feasible to derive the highly precise subsidence estimates by means of PS analysis of limited SAR acquisitions under a certain data configuration even under the less than ideal conditions.

- For the location subsides at approximately constant rates, the achievable precision is better than ± 1.5 mm/yr compared to the linear reference leveling.

- Preliminary assessments like success rate assessment, estimation of max. subsidence rate are useful to anticipate whether or not, the PS analysis is likely to deliver a positive result.