Karlsruhe Institute of Technology

Comparison of wet phase delay estimates derived from GNSS, InSAR, and MERIS data

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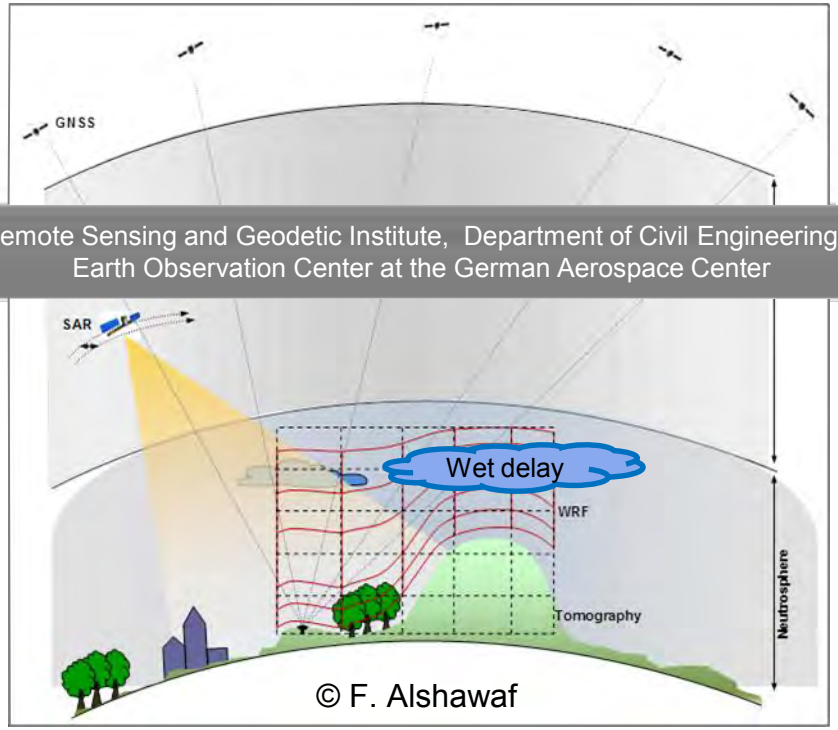
Earth Observation Center at the German Aerospace Center



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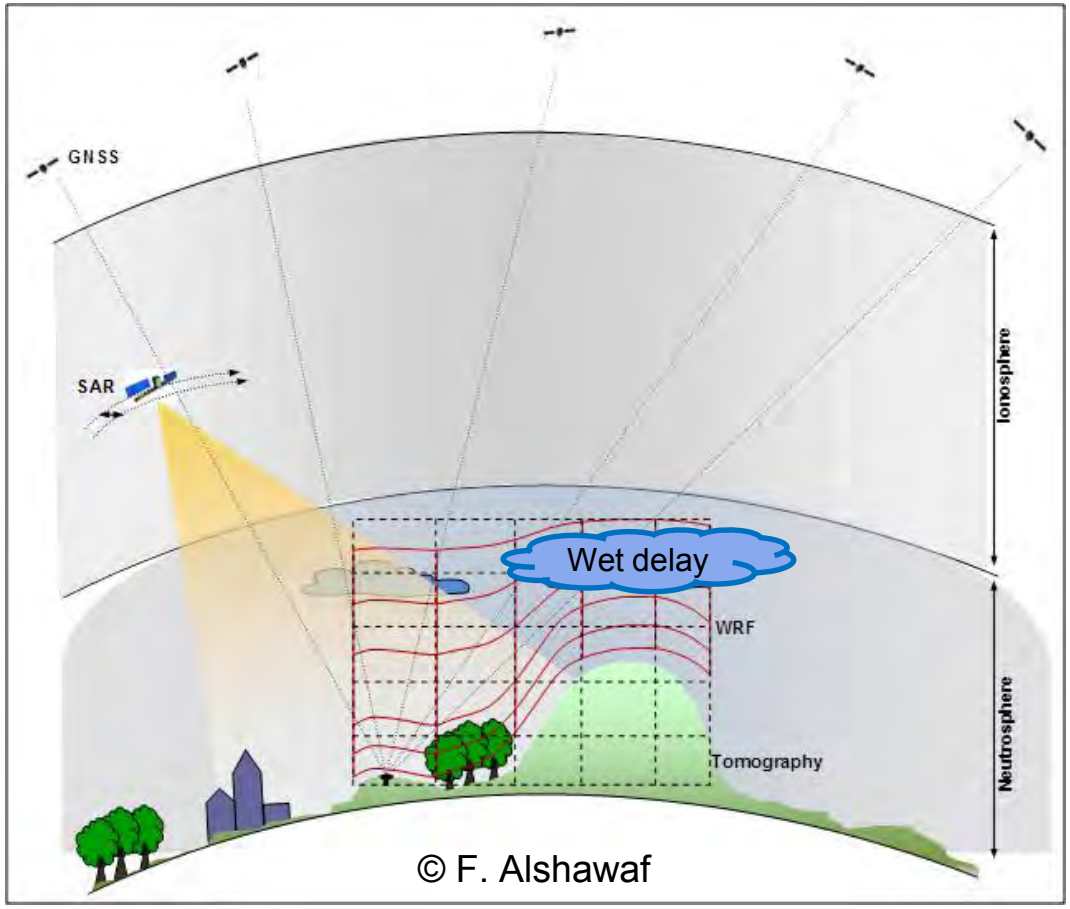
Master Thesis

Motivation



Water vapor

- Key element in
  - Meteorology
  - Climatology
- Error source in
  - GNSS
  - InSAR
- Highly variable in
  - Time
  - Space

HydroKIT: Exploitation of geodetic sensors
Reconstruction of our Earth's atmosphere

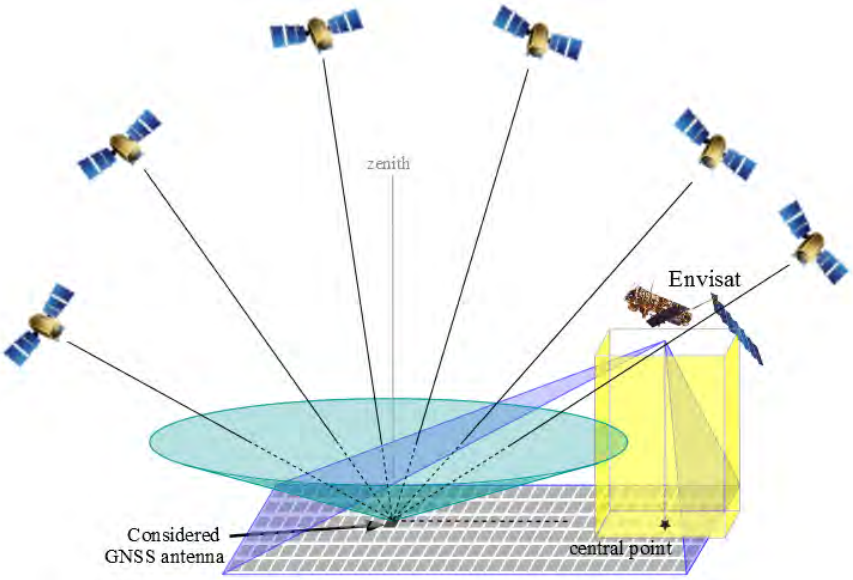
Database

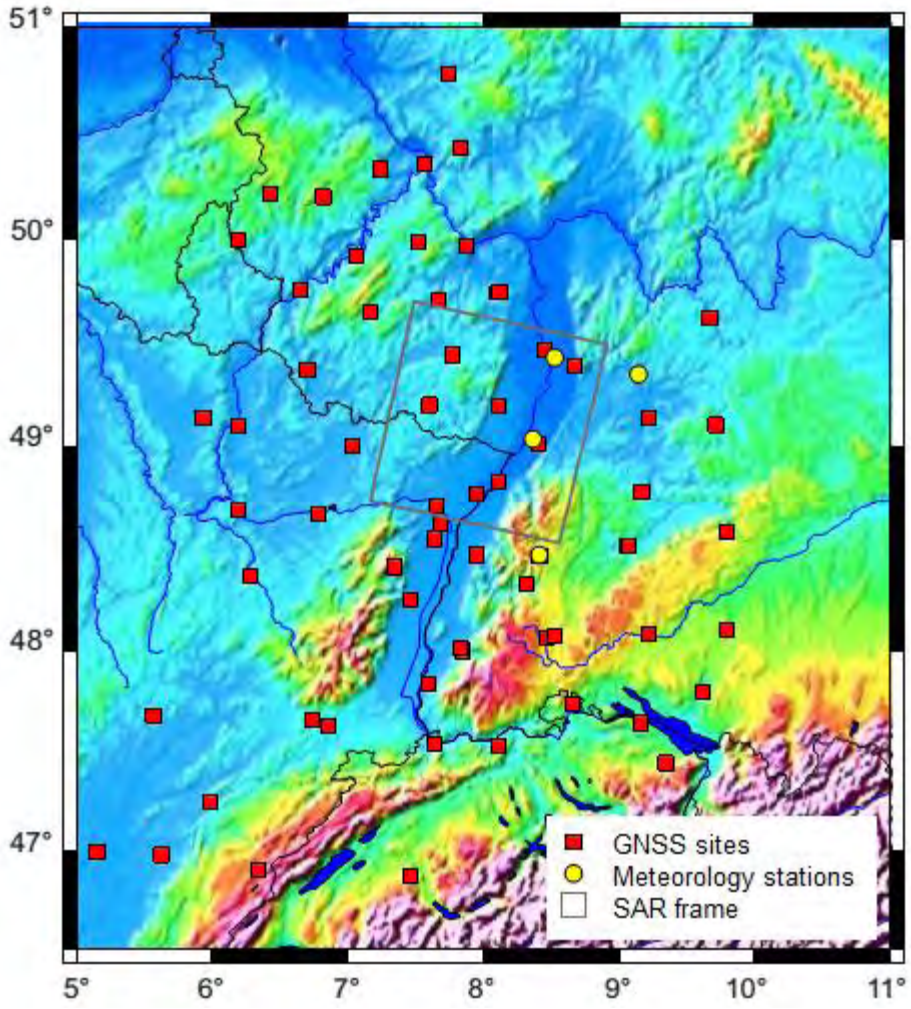
- **GNSS (PPP)**

  inter-site distance: 40-60 km
- **PS-InSAR (from Envisat)**

  SAR frame ≈ 100 x 100 km²
- **MERIS** (reference)

  resolution of 300 x 300 m²

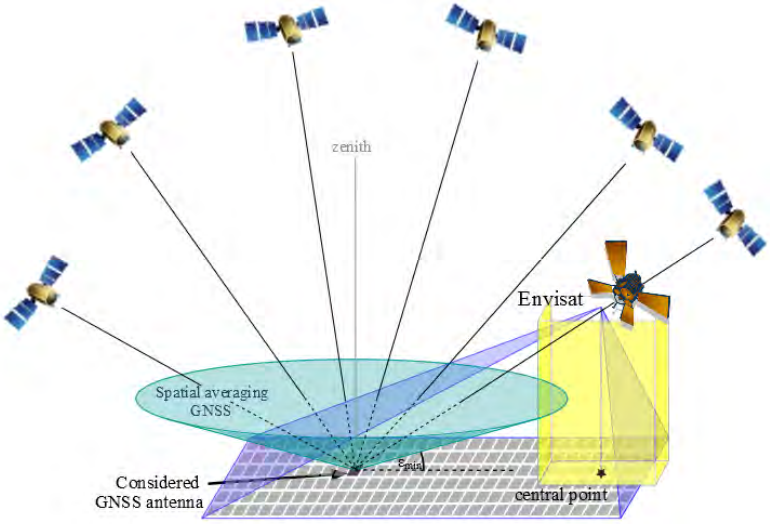


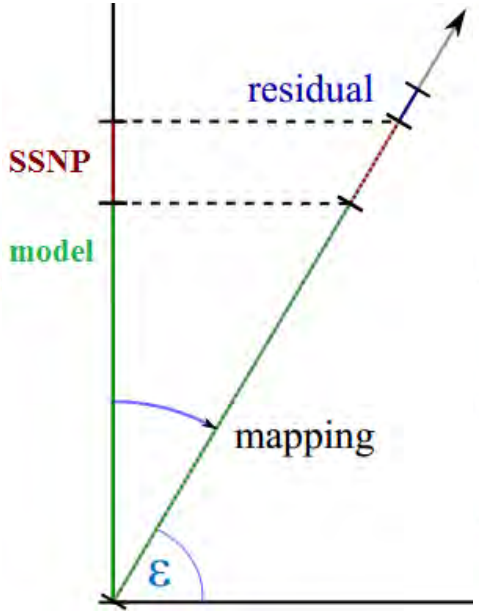


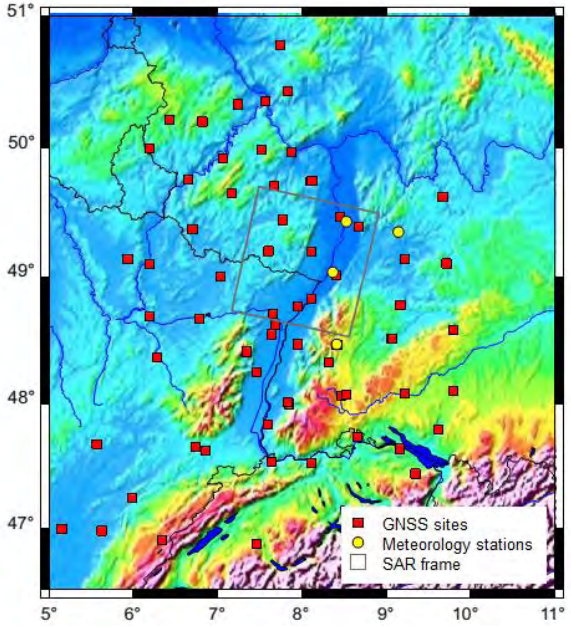
Study region: Upper Rhine Graben

Sensor Characteristics

	Spatial resolution	Temporal resolution	Observation geometry	Deduced delay
GNSS	-	++	point-wise	total integrated
PS-InSAR	++	-	laminar	short-scale integrated wet
MERIS	+++	-	column-wise	integrated wet

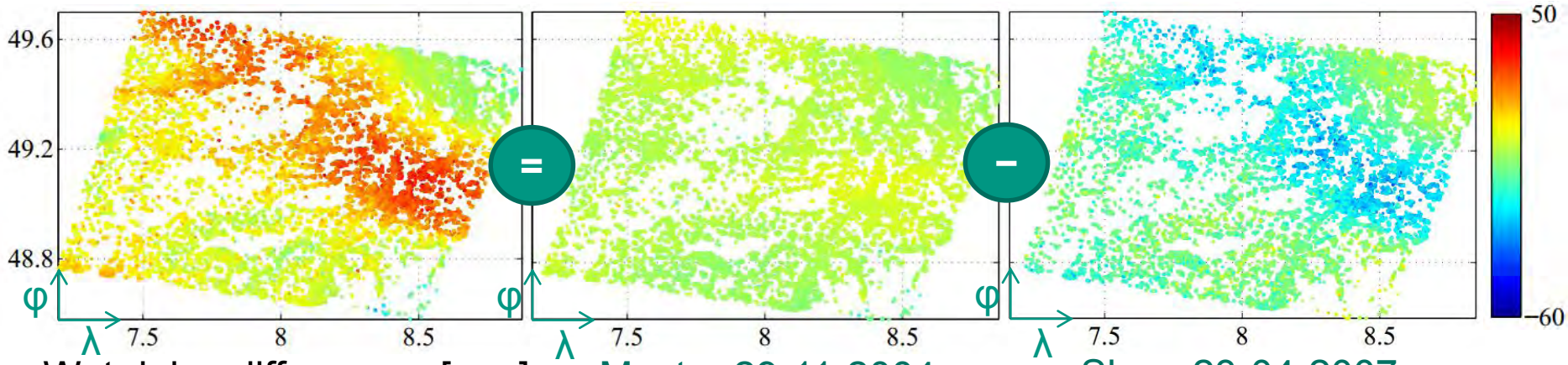






Wet Delay from InSAR

Measured: $\Phi_{slave} - \Phi_{master} \triangleq \Delta_{master} - \Delta_{slave}$



Wet delay differences [mm] | Master 29-11-2004 | Slave 23-04-2007

- **Partial** wet delays without
  - Topography-dependent part
  - Linear trend
- Inversion yields phases per acquisition ⚠ small # of acquisitions
- Conversion from phase to delay $\Delta_{acq_i}^{slant} = -\phi \cdot \frac{\lambda}{4\pi}$

Master Selection: Approach of Hooper (2007)

Master acquisition:

- Sum of decorrelation → min
- Sum of correlation → max

thermal noise (assumed to be constant)

Correlation:

$$\rho = \rho_{temporal} \cdot \rho_{spatial} \cdot \rho_{doppler} \cdot \rho_{thermal}$$

temporal baseline B_{temp}

perpendicular baseline $B_{\perp}$

difference ΔDC in Doppler centroid

Maximal baselines in our case:

$$B_{temp} \approx 4\ years,\ B_{\perp} = 1300\ m$$

Master Selection: ∑Correlation → max ?

- Standard deviations of the delays per acquisition
- RMS values of the difference maps MERIS minus InSAR
- Correlation between InSAR and MERIS

Master Selection: ∑Correlation → max ?

Hooper

1. ~~18-04-2005~~
2. 29-11-2004

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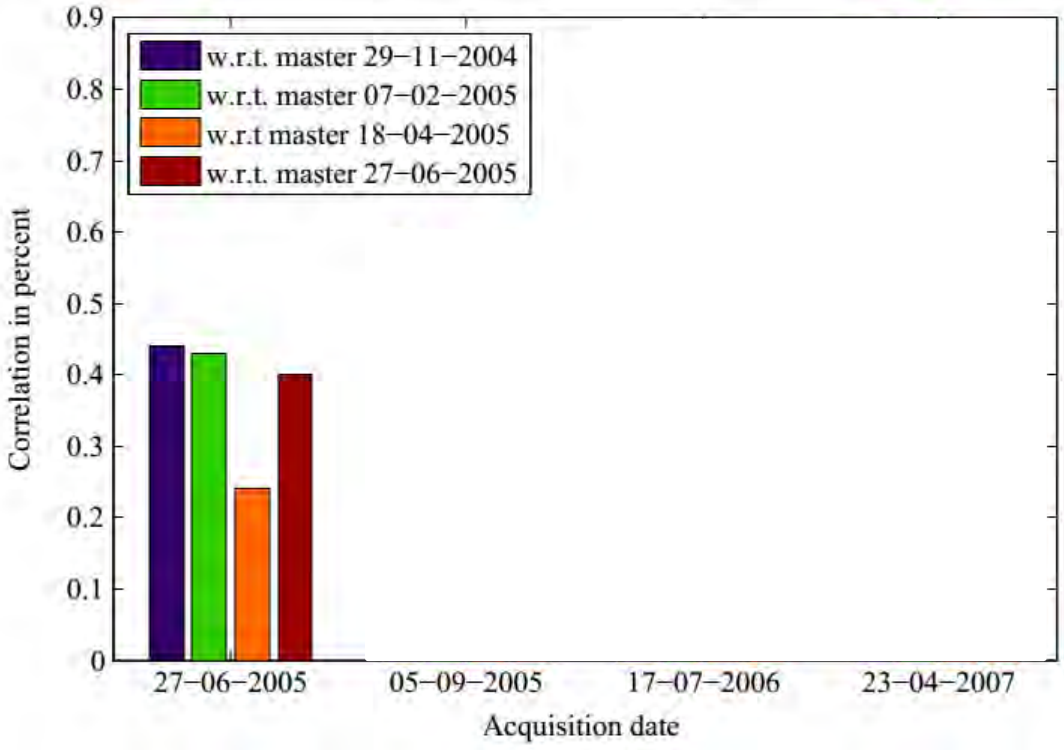

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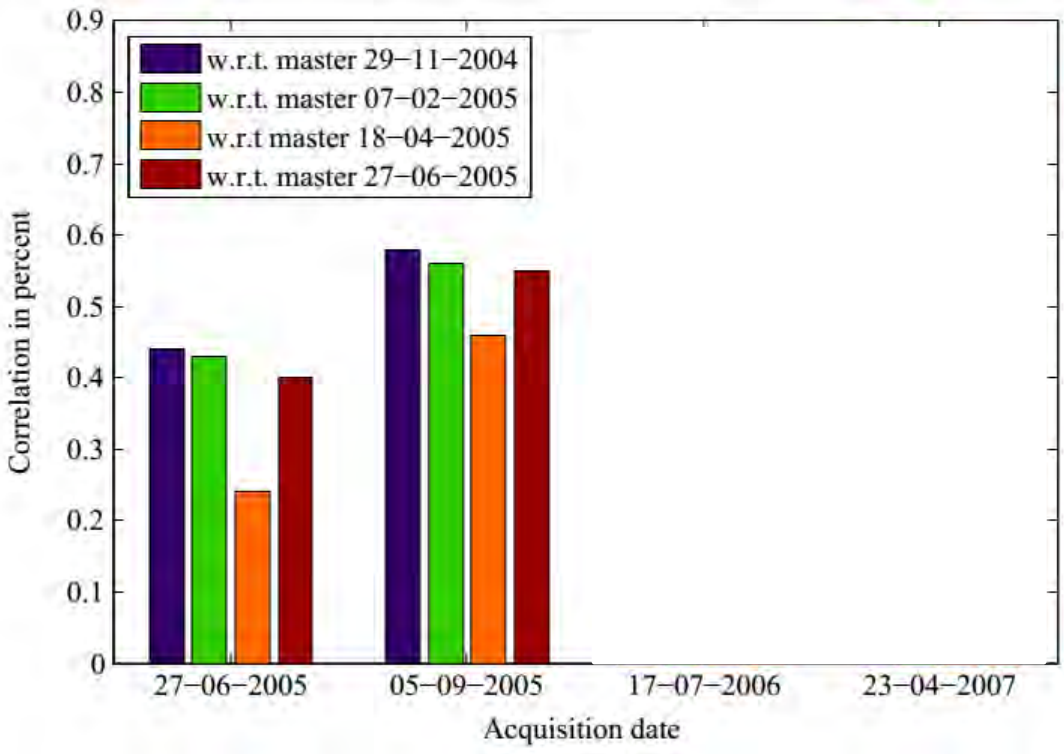

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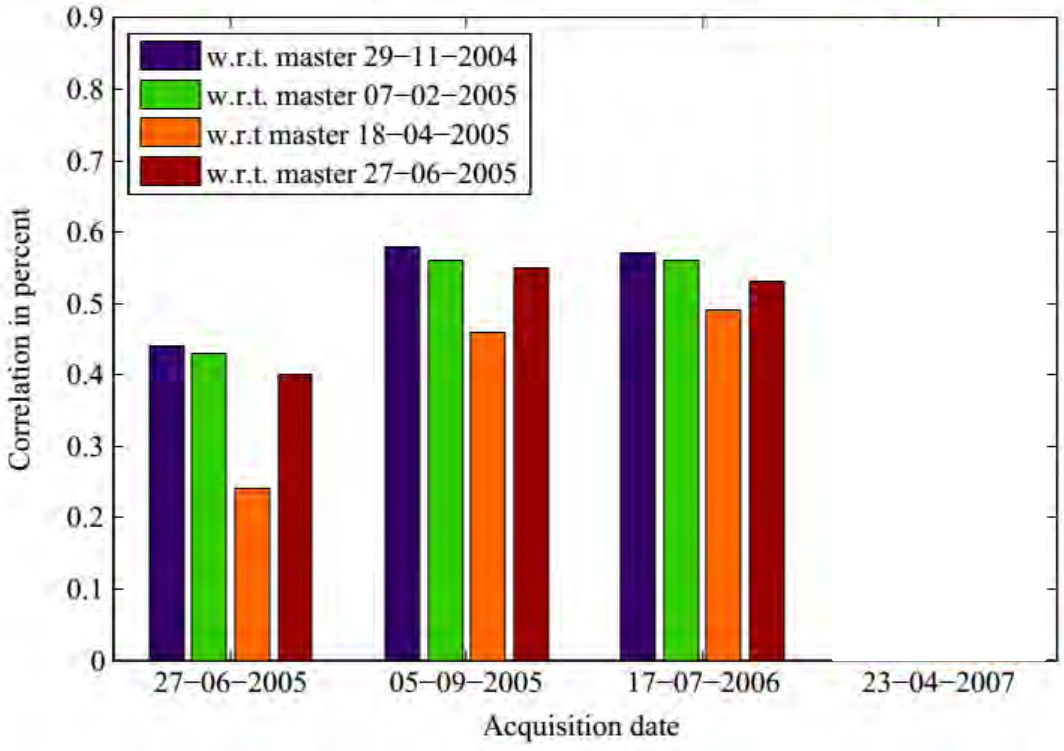

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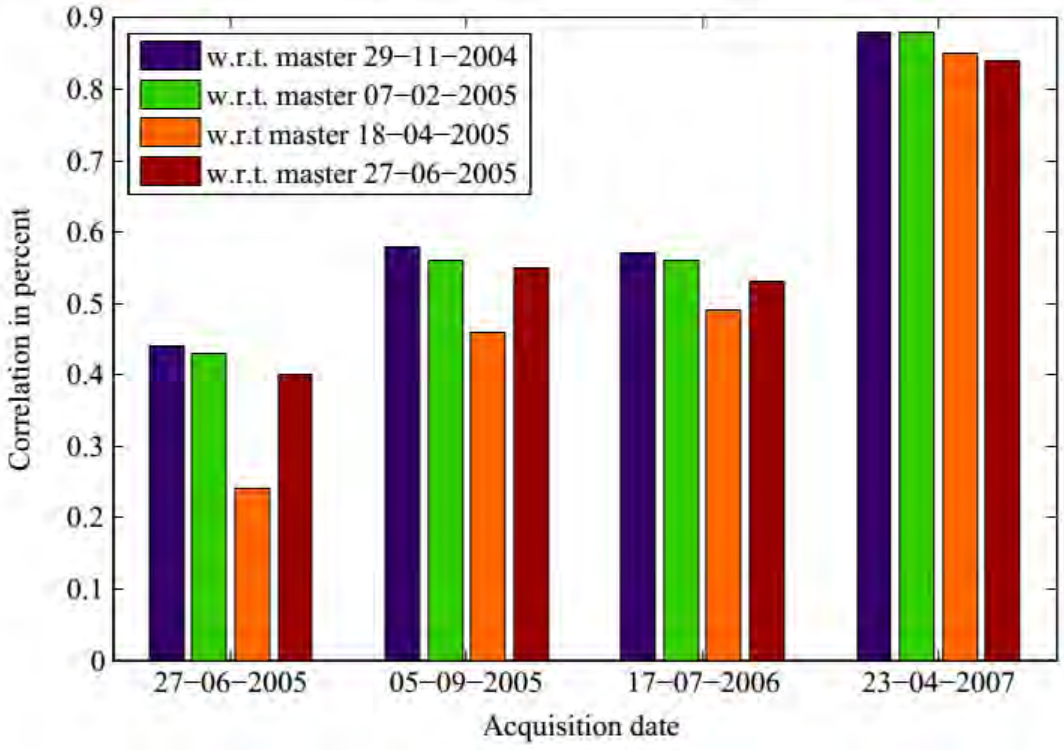
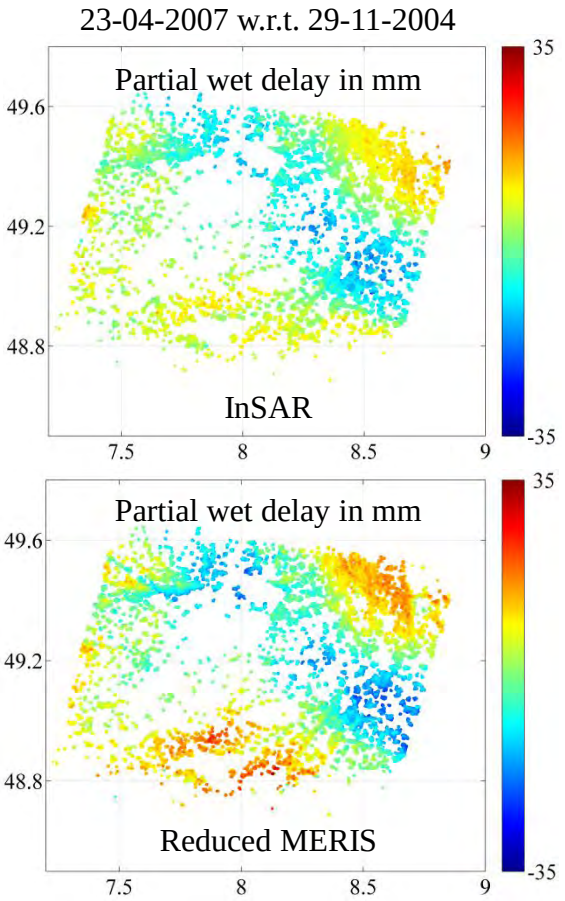
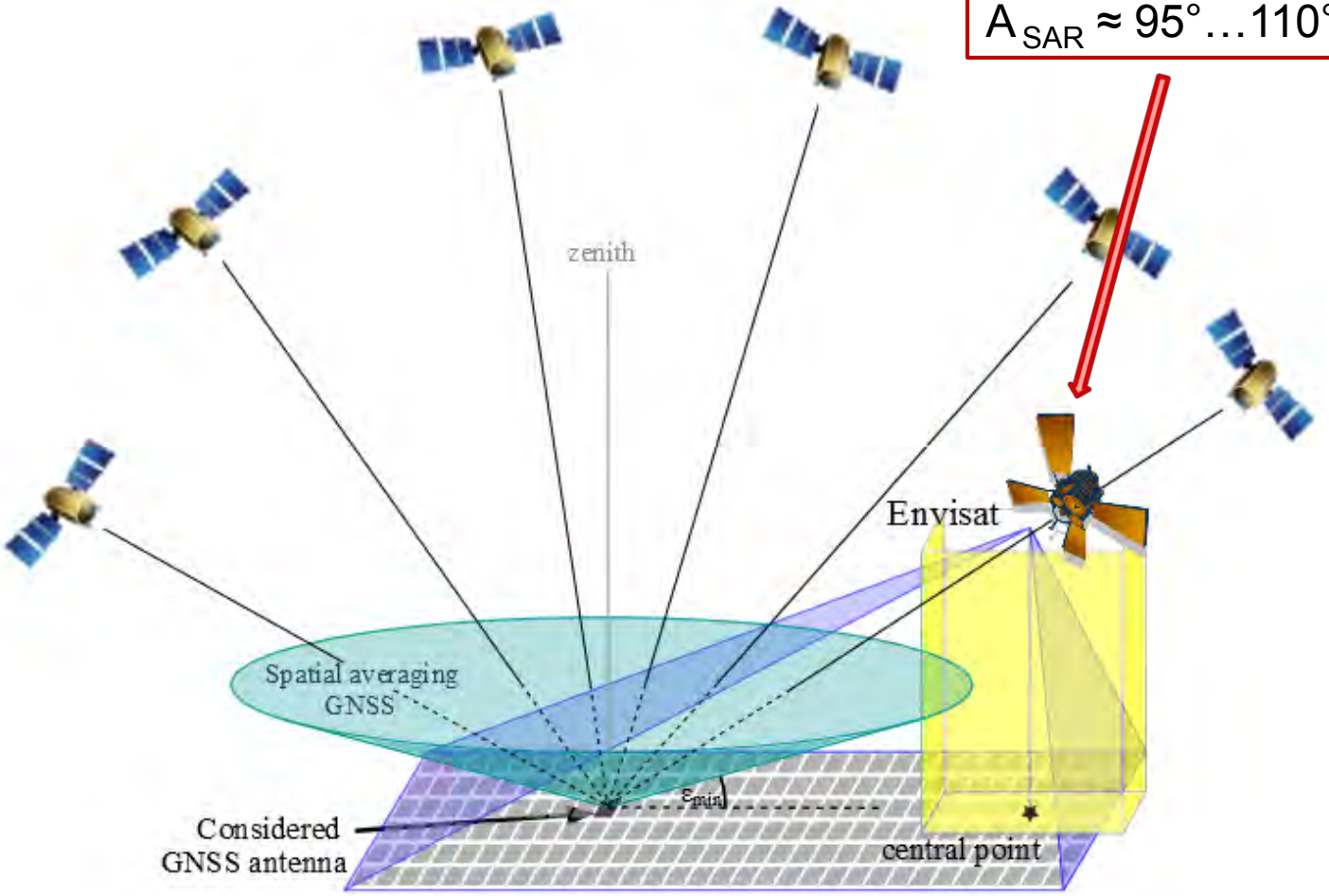




Finding “Close” Satellites

$\varepsilon_{SAR} \approx 66.5°$
$A_{SAR} \approx 95°…110°$



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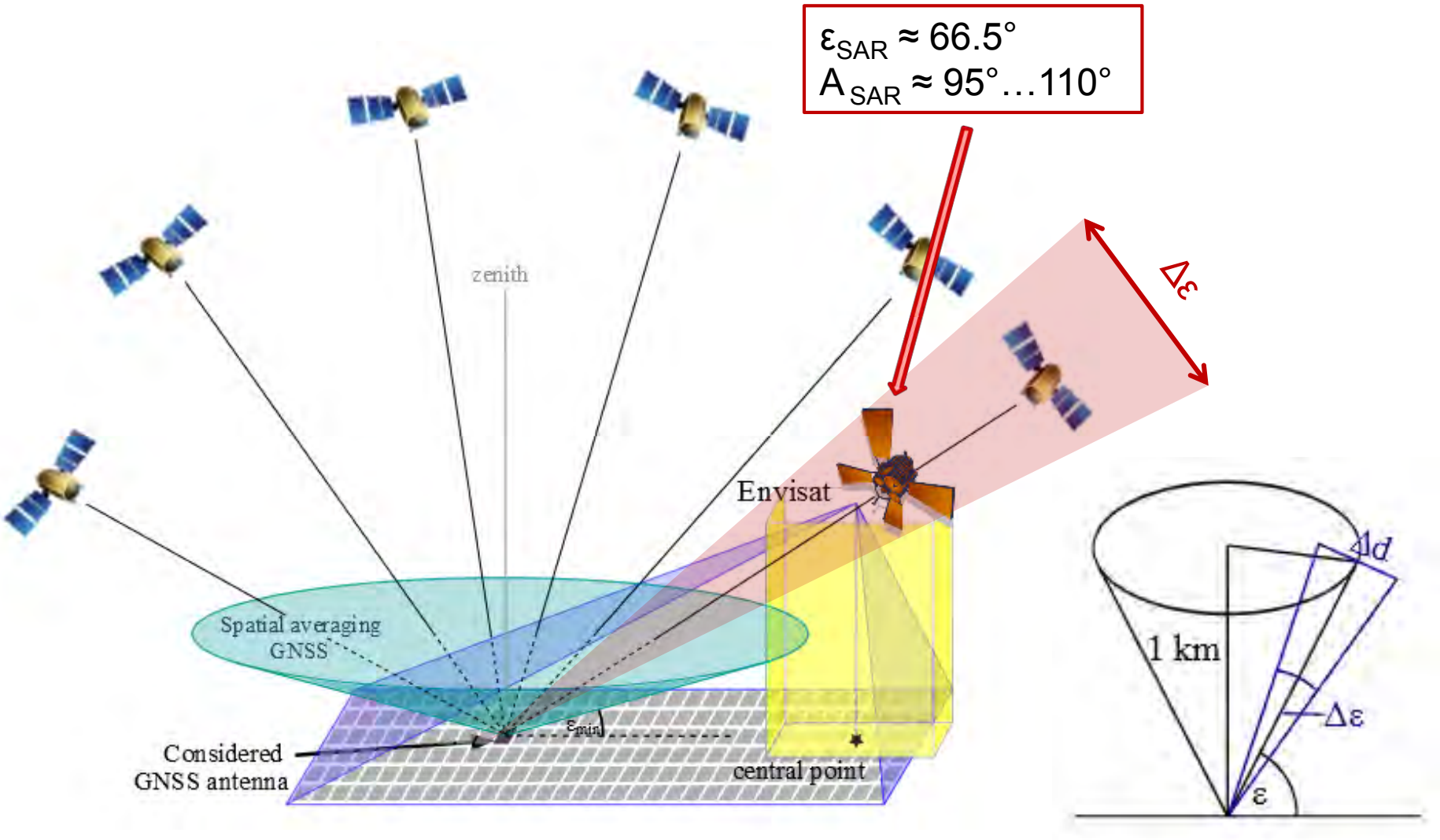
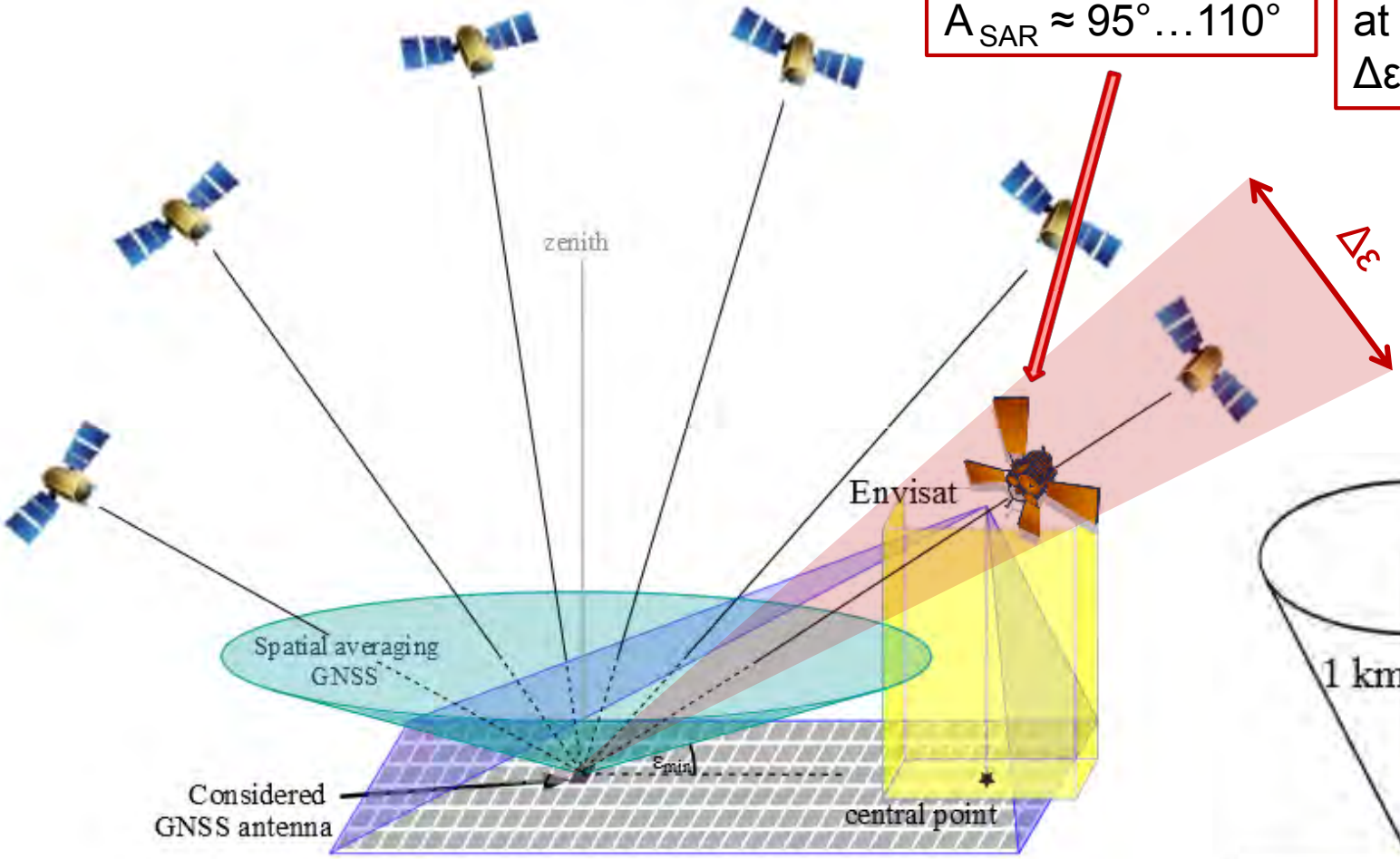
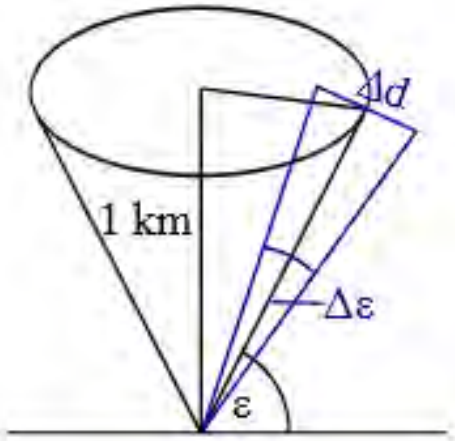


Finding “Close” Satellites

$\varepsilon_{SAR} \approx 66.5°$
$A_{SAR} \approx 95°…110°$

$\Delta d_{max} = 500$ m at 1km height
$\Delta\varepsilon_{max} \approx 29°$





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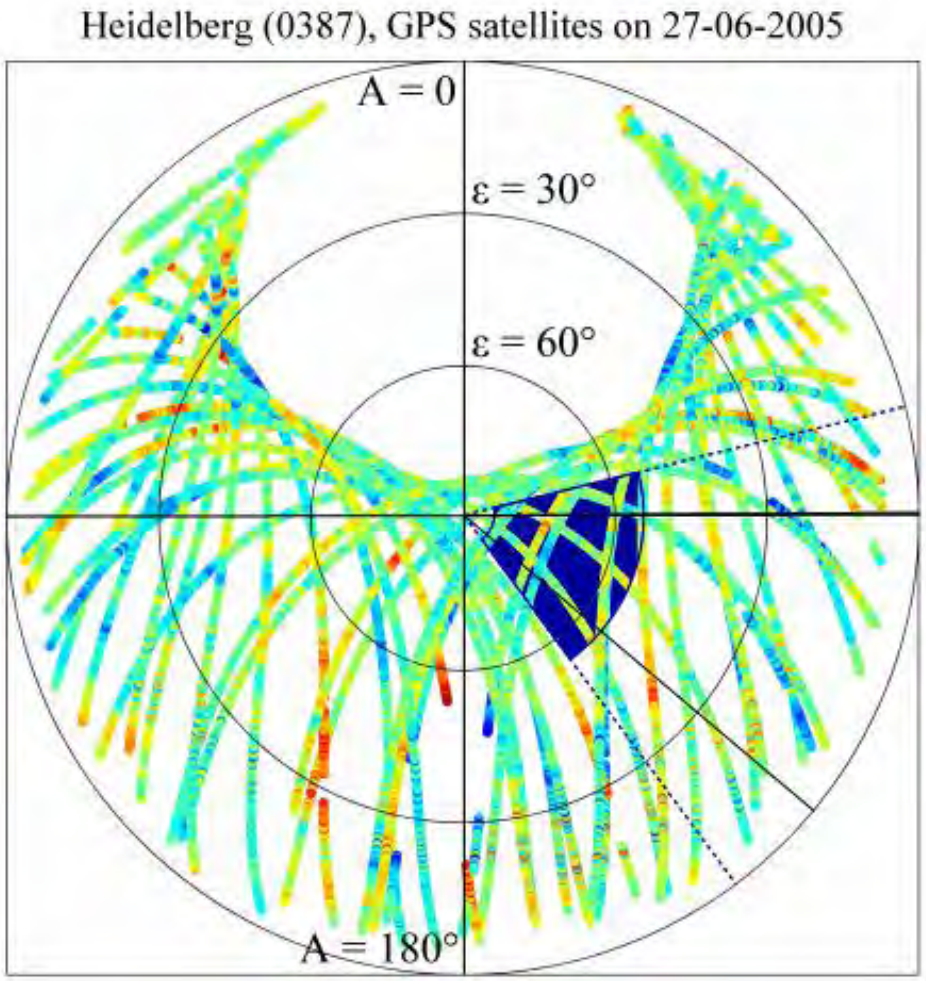
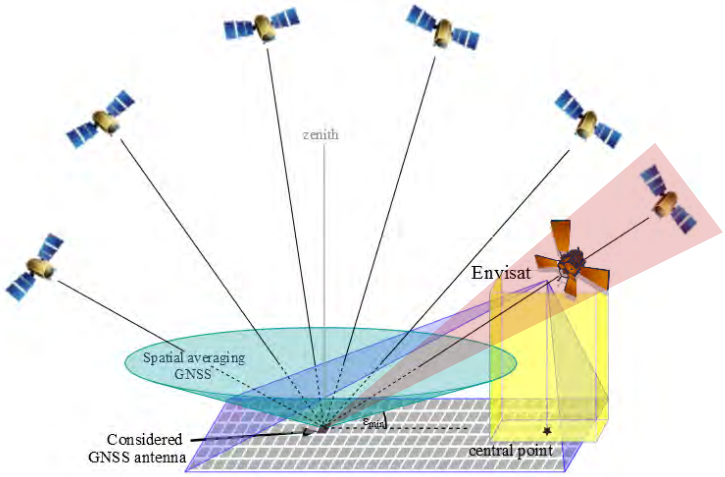
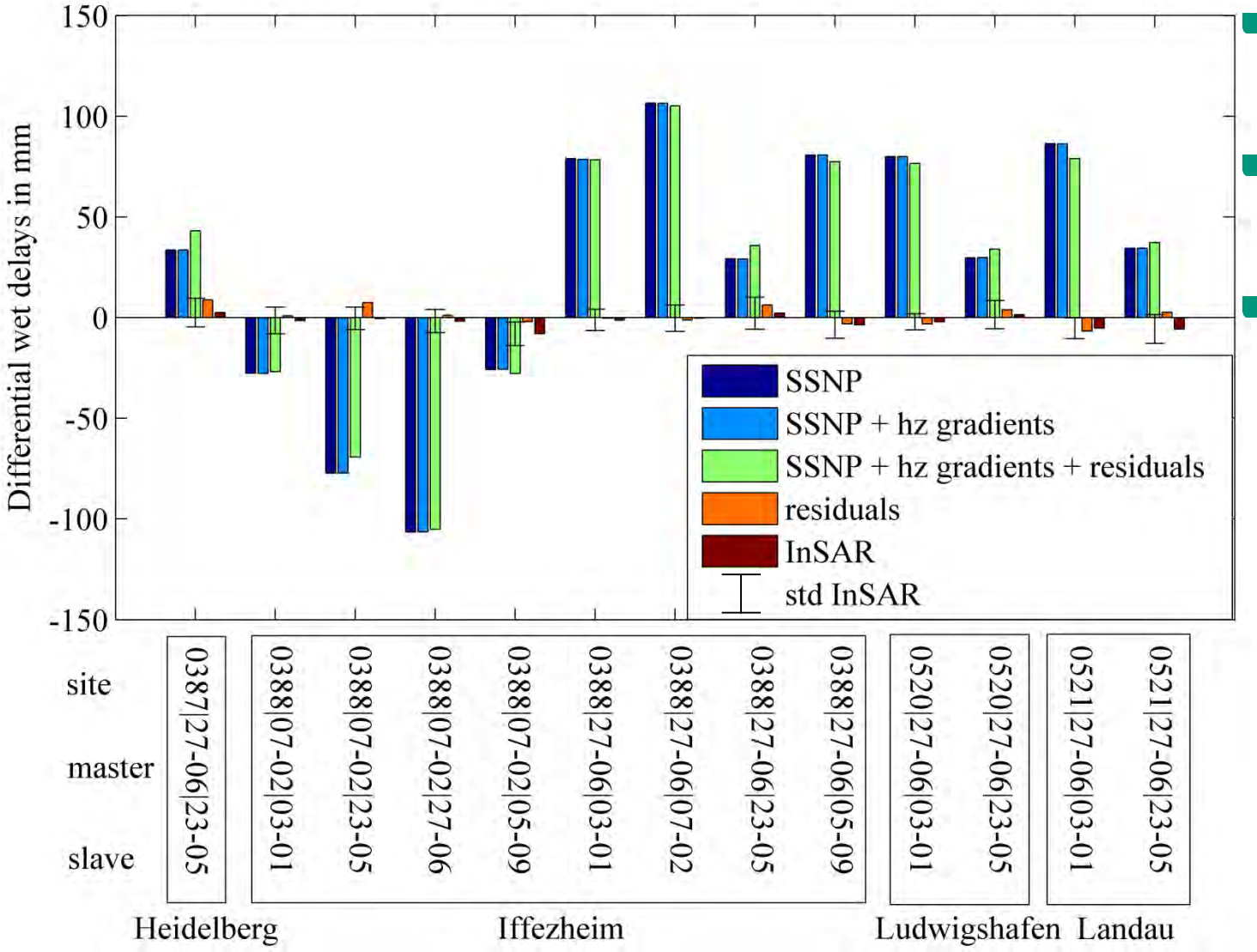


Search window

- Azimuth and elevation: 29°
- Time: 1 minute



Satellite-Directed Comparison of the Delays

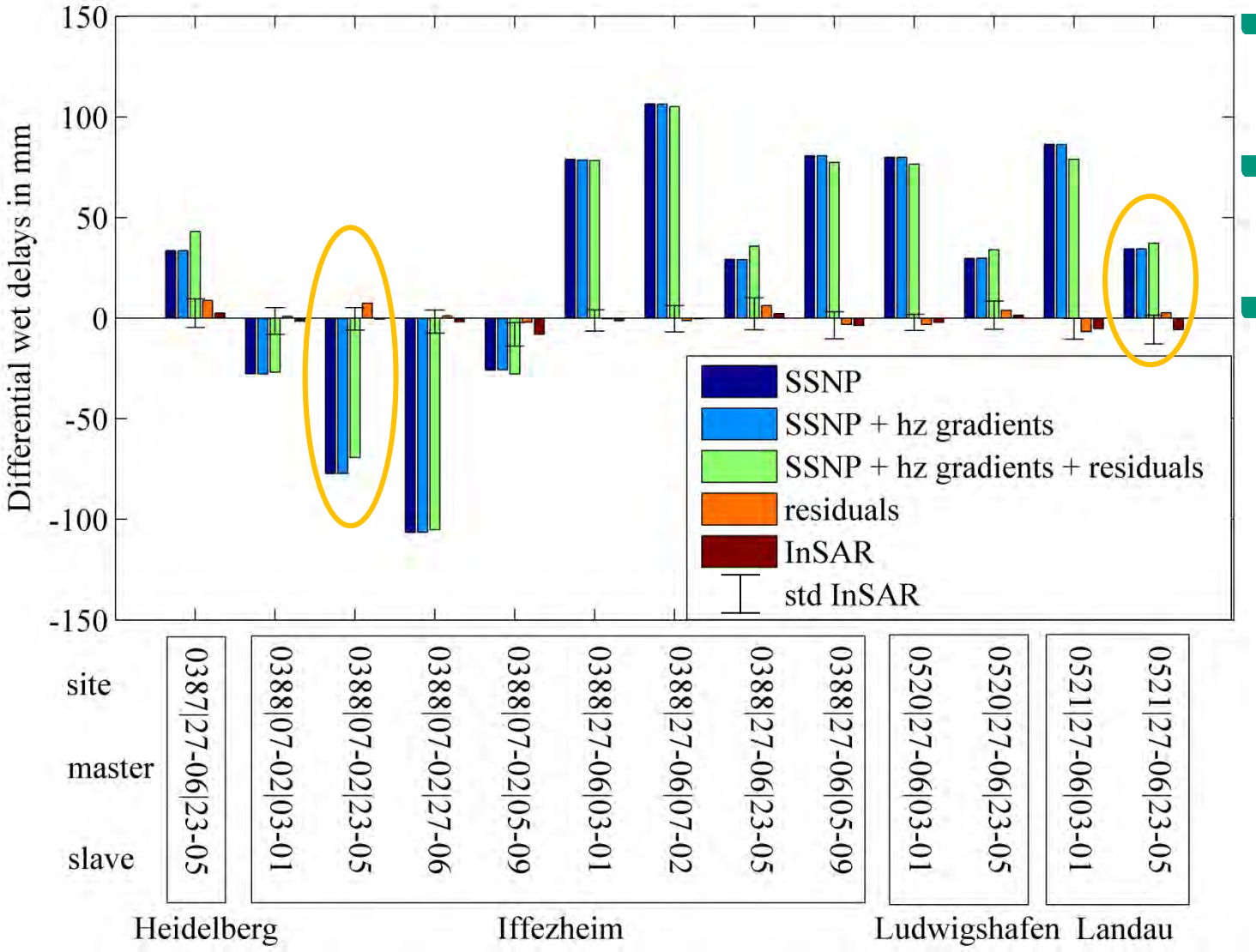


- **SSNP:** important
- **Residuals:** important
- **Horizontal gradients:** negligible

GNSS:
wet delay differences

InSAR:
short-scale wet delay differences

Satellite-Directed Comparison of the Delays



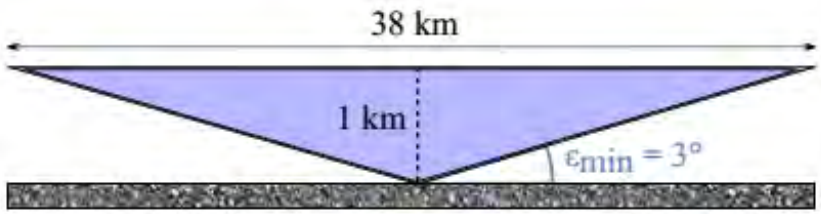
- **SSNP:** important
- **Residuals:** important
- **Horizontal gradients:** negligible

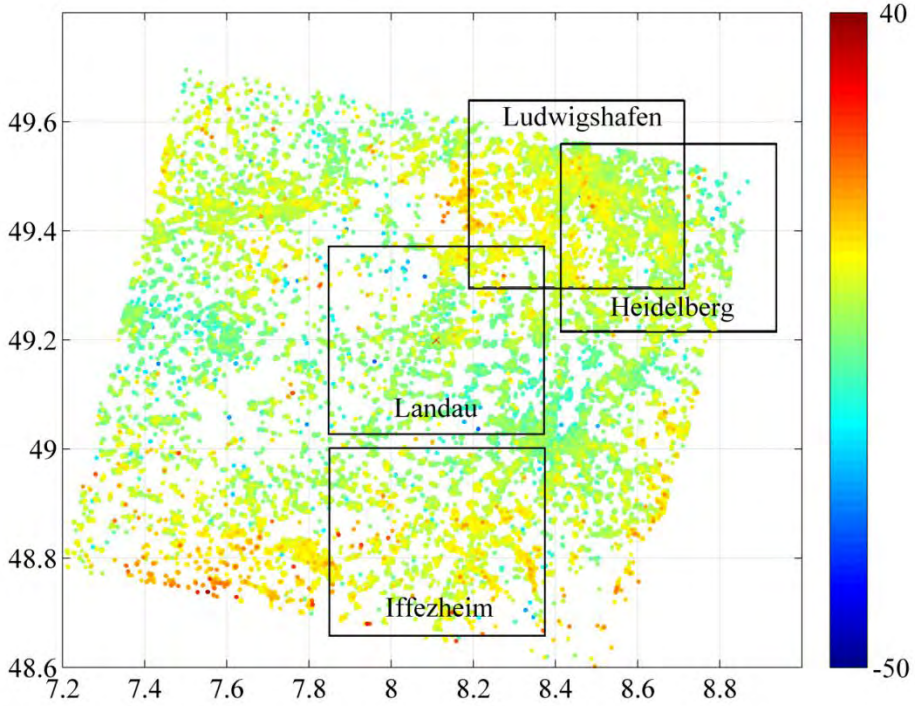
GNSS:
wet delay differences

InSAR:
short-scale wet delay differences

Conclusion and Outlook of the Master Thesis

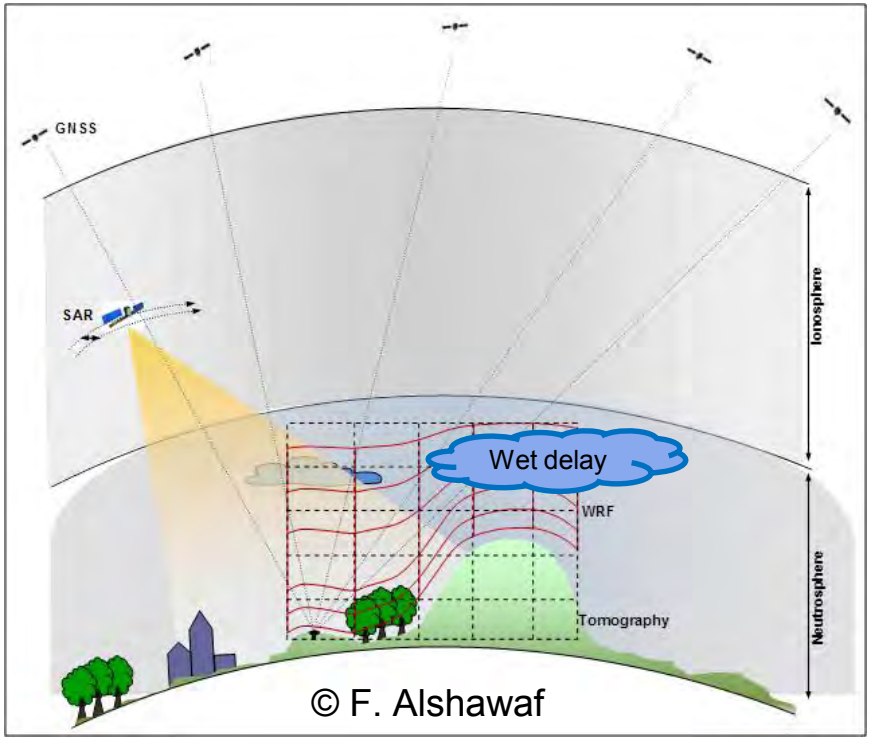
- Assumptions within GNSS observations:
  - No site-specific effects (MP, antenna) ⟶ Residual stacking?
  - Anisotropy of the residuals ⟶ Water vapor ✓
- Topography-dependent component and linear trend ⟶ Importance?
- Spatial averaging ⟶ Effect on comparison?





GNSS | InSAR | MERIS | Comparison

Conclusion and Outlook of the Master Thesis



- More GNSS observing sites
- More SAR acquisitions
- WRF
- Tomography?

- Enhanced master selection for water vapor retrieval; based on
  - Hooper's approach
  - External information
- InSAR water vapor maps
  - Difference maps
  - Partial nature
- Phase residuals:
  Anisotropic component of the wet delay deduced from GNSS
- Combination of the assets of each data set

Thank you for your attention.