Mapping the Qinghai-Tibet railway deformation using small baseline InSAR time-series technique

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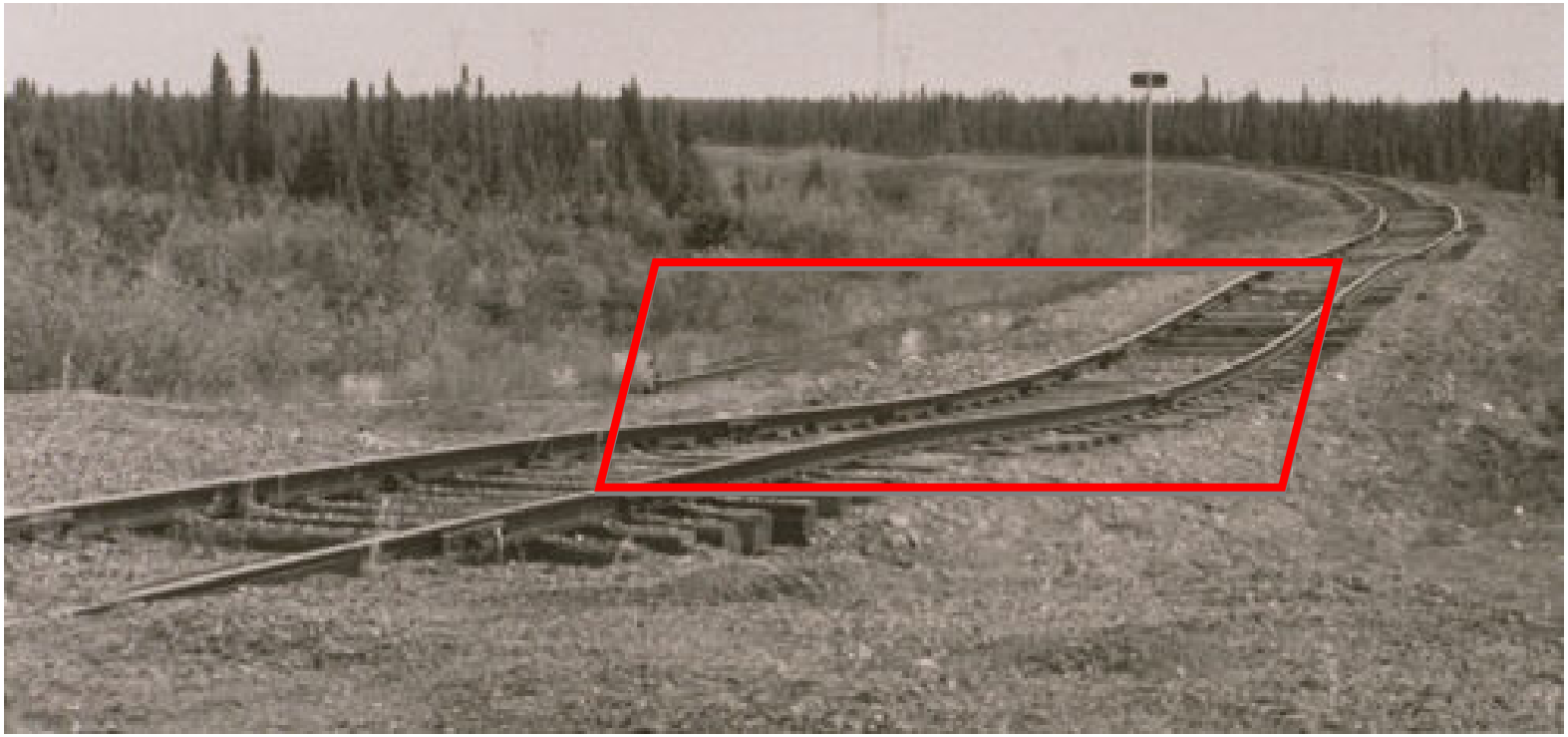
Why this research?

Permafrost deformation threat the stability of the Qinghai-Tibet



Source: http://gsc.nrcan.gc.ca/landscapes/

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Outline

- Permafrost and Qinghai-Tibet railway
- Small baseline InSAR time series technique
- Preliminary results
- Conclusion and future work

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What is Permafrost?

- **Permafrost is soil at or below the freezing point (0 °C or 32 °F) of water for two or more years**
- **Thaw settlement and frost heave in summer and winter season**

Train bridges were built on some sections of the permafrost along the railway to preserve the ecology of the area

Source:http://ecosummit.hk/

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Geocryological Regions and Classifications in China

Source:http://nsidc.org/

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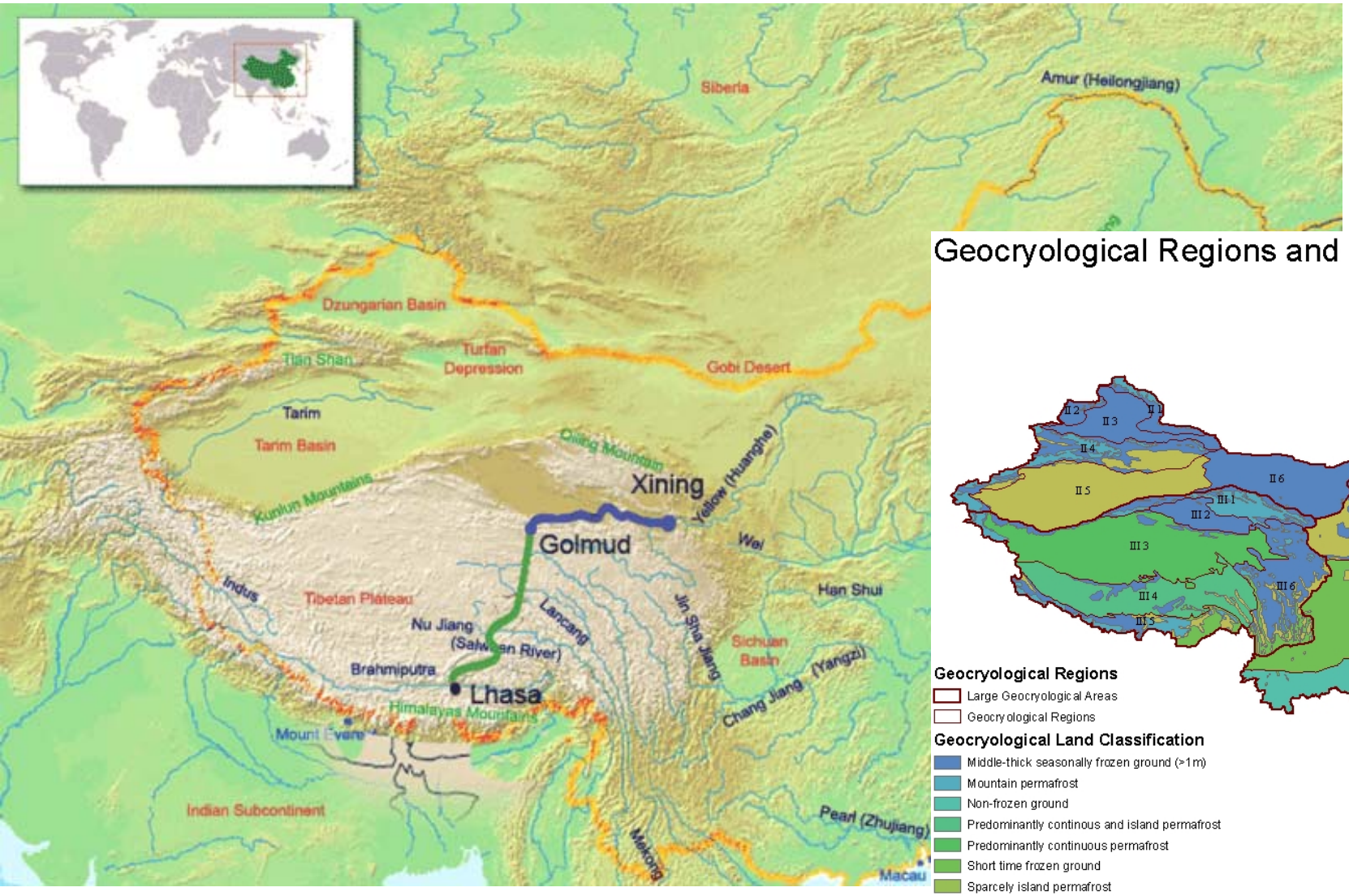
Qinghai-Tibet railway



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Geocryological Regions and Classifications in China

Permafrost deformation threat the stability of the Qinghai-Tibet railway

- **History data showed that the permafrost caused:**
  - a damage ratio of 31.7% of the Qinghai-Tibet highway
  - as high as 40% damage ratio on railway in the northeast of China

❑ **Measurements are acquired to assess the possible damage of the Qinghai-Tibet railway on area with permafrost**

Traditional measurements of the permafrost deformation and its disadvantages

- **Measurements**
  - Leveling
  - GPS
  - Mechanical probing
  - Inference from temperature measurements
- **Disadvantages**
  - Limited spatial coverage
  - Limited time scale/interval
  - In situ at a single site
  - May provide incomplete information on the permafrost system (seasonal changes)

Why use small baseline InSAR?

- **Advantages**
  - SAR sensors operate in any weather conditions
  - Capability of observing inaccessible area
  - High accuracy (few millimeter)
  - Large spatial coverage (e.g. 100km×100km)
  - High resolution (e.g.1m×1m)
  - Short time scale (e.g. 4 days)
  - Reduce the effect of temporal and spatial decorrelation

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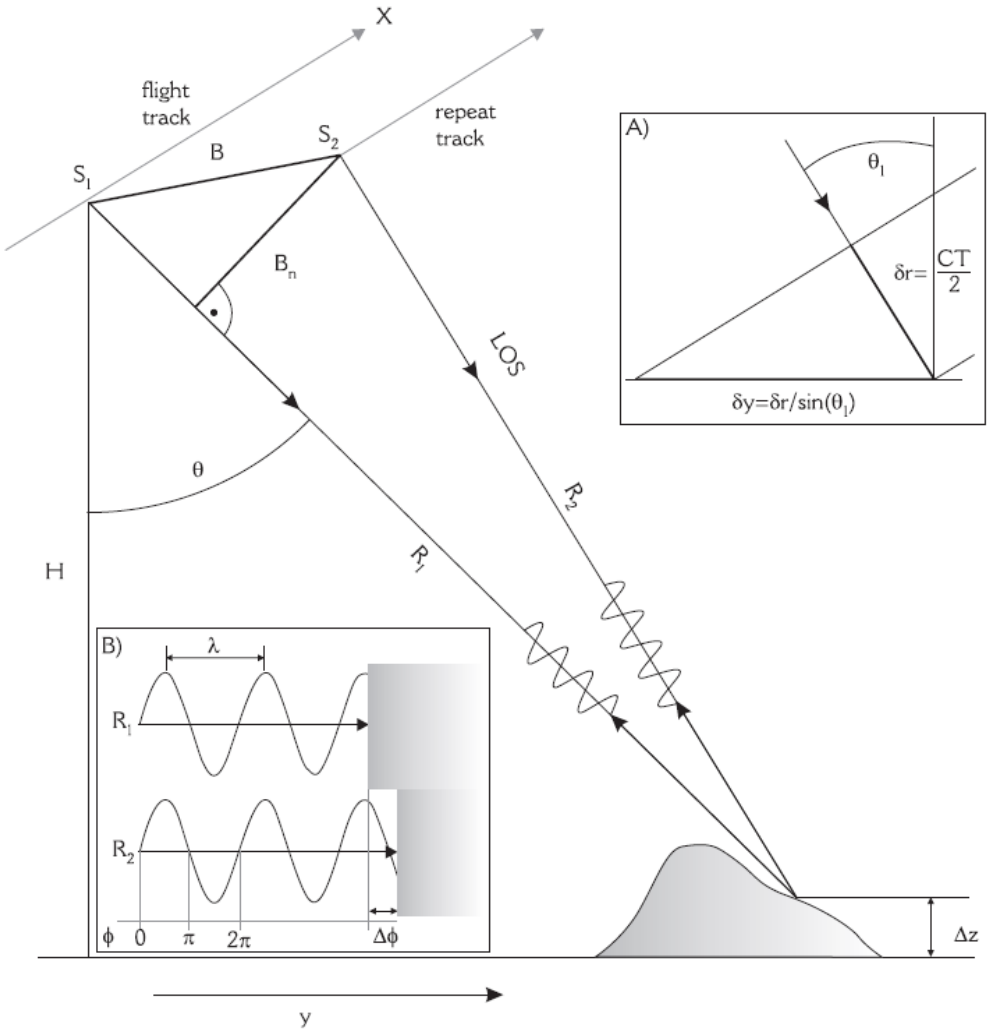
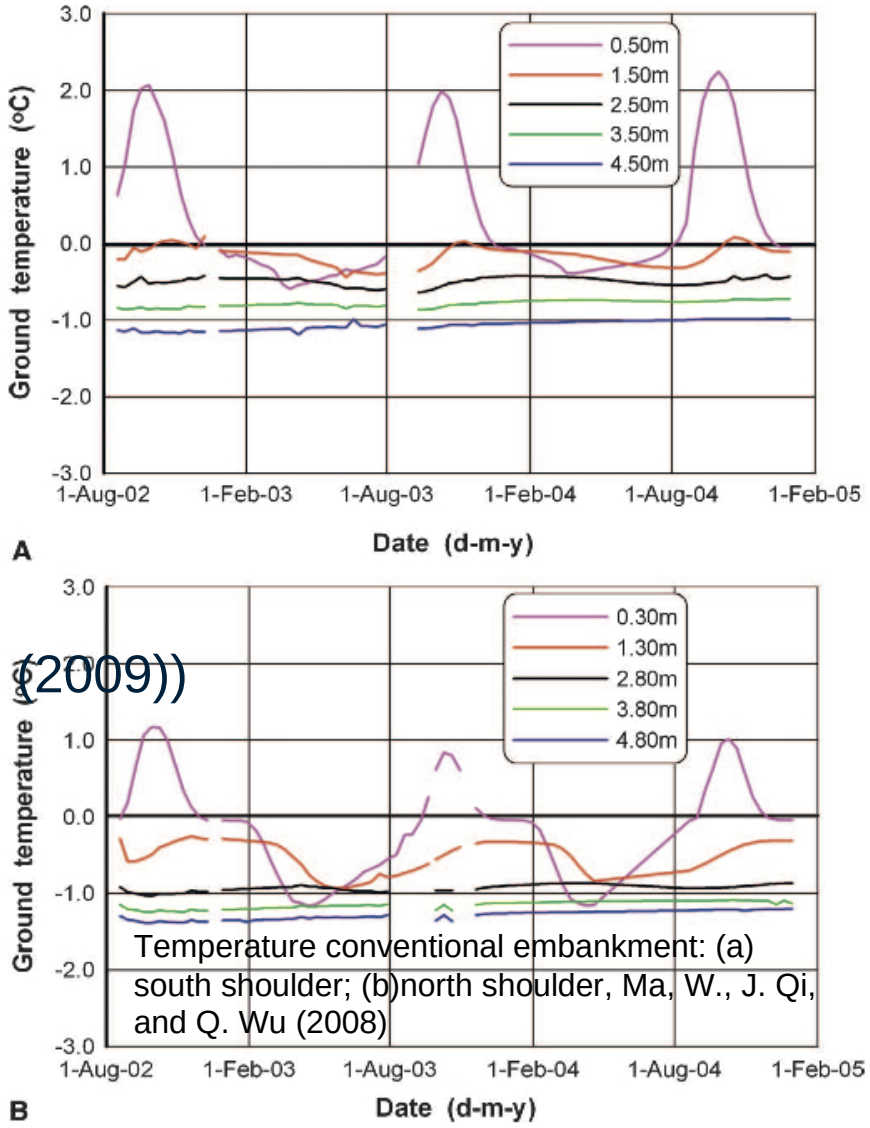
How InSAR works?



Geometry of SAR interferometry

Study area and data

- **Bailuhe region**
  - Size ~12km×35km
  - Continuous permafrost
  - Elevation:4500~4700m
  - Average temperature:-4.4°C
  - Ground temperature
  - Winter season (~September - April)
  - No main active faults (Taylor, M., and A. Yin (2009))



Temperature conventional embankment: (a) south shoulder; (b)north shoulder, Ma, W., J. Qi, and Q. Wu (2008)

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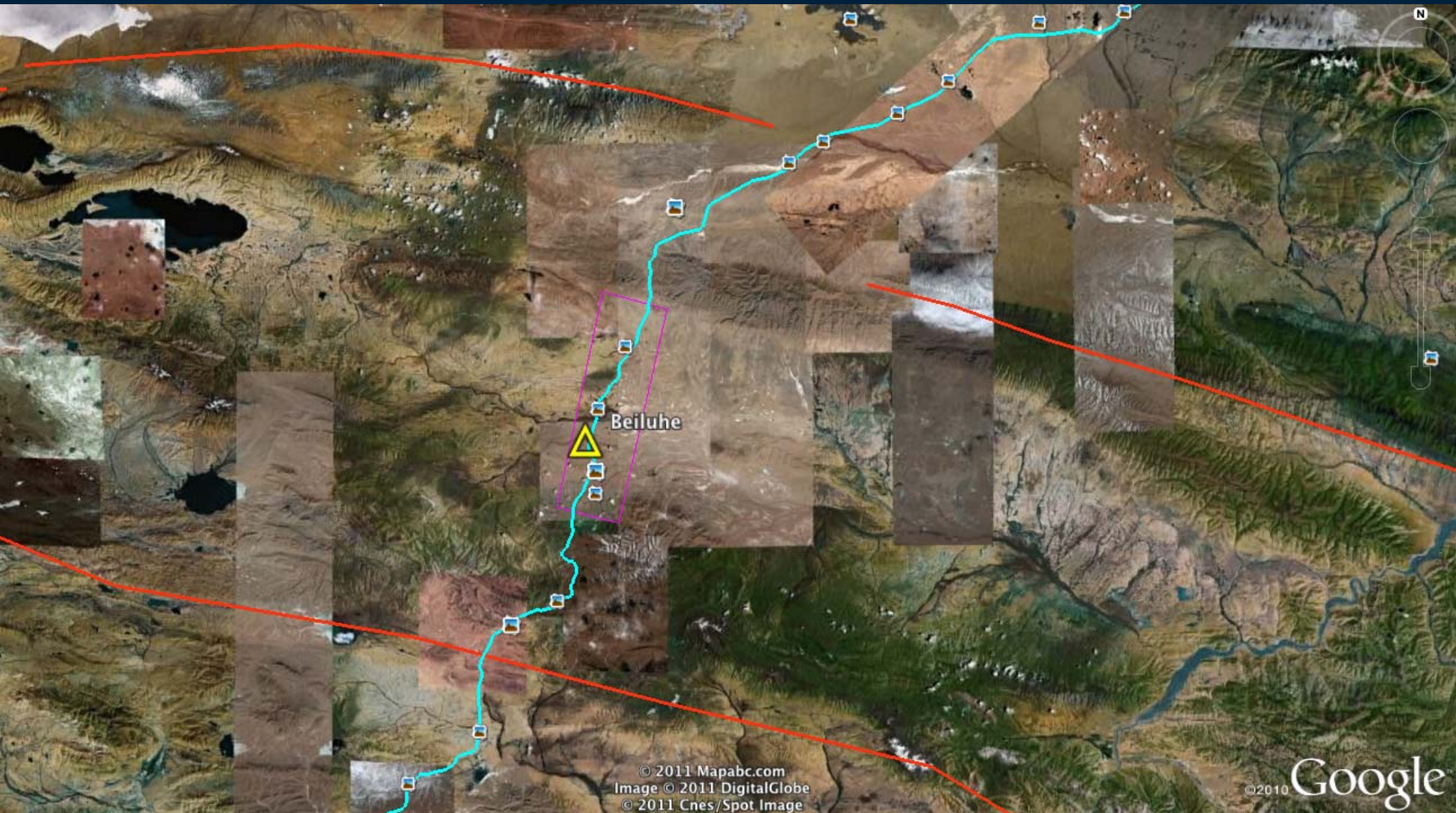
Active faults



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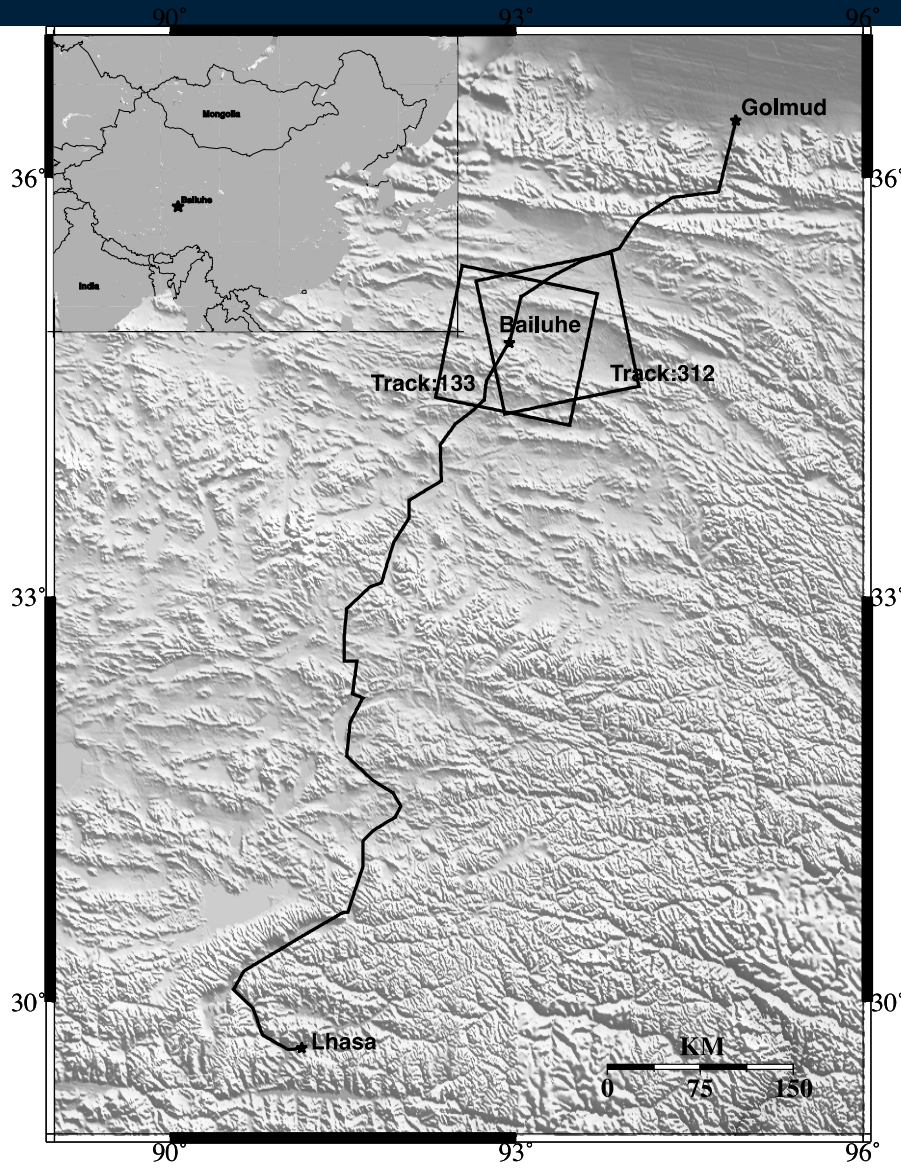
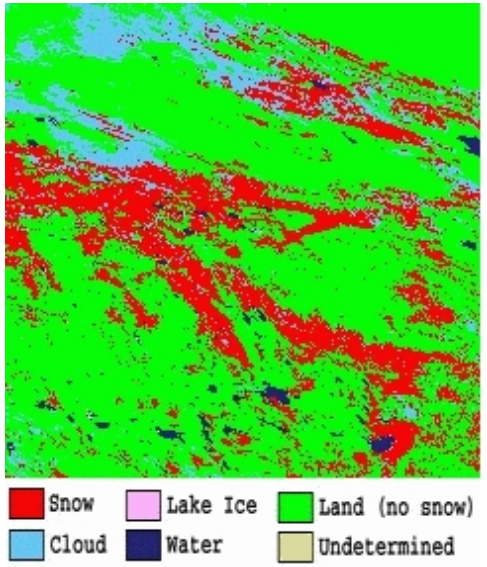
Study area and data

- **Two independent adjacent Envisat tracks**
  - Ascending track 312, 22 images (10/2006~08/2010)
  - Descending track 133,35 images (11/2004~06/2010)
  - Validate each other



Processing steps 1

- **Images covered by snow were excluded by checking MODIS daily snow coverage images**
- **Results are generated by StaMPS package**



Data set: MODIS/Terra Snow Cover Daily L3 Global 500m SIN Grid V005
Granule: SC:MOD10A1.005:28046989
Local granule ID: MOD10A1.A2006304.h25v05.005.2008275073401.hdf
Acquired: between 2006-10-31 03:15:00.000Z and 2006-10-31 05:00:00.000Z
Center lat/lon: 34.9519° Lat, 92.5172° Lon

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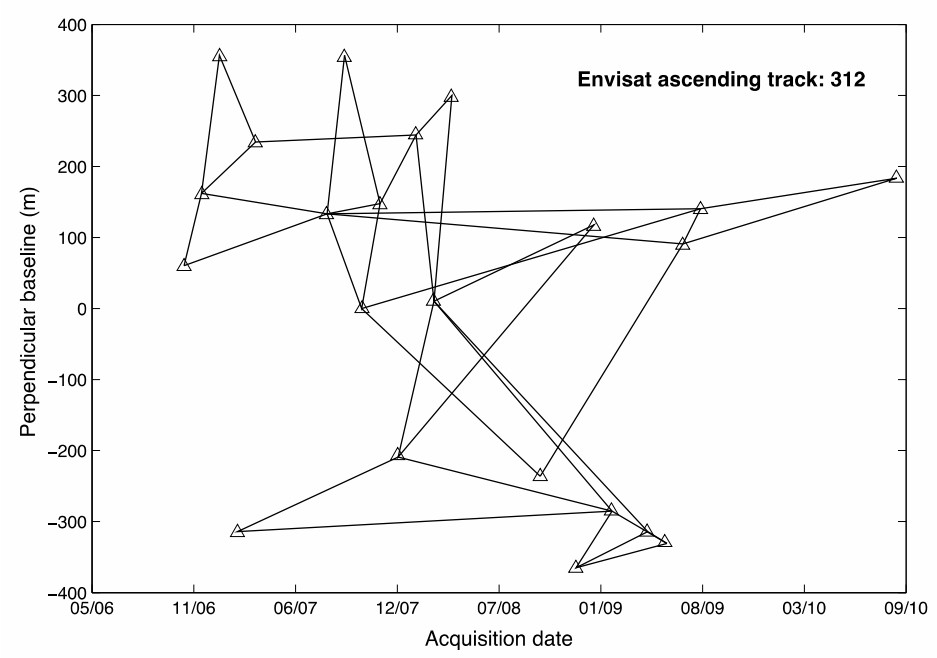
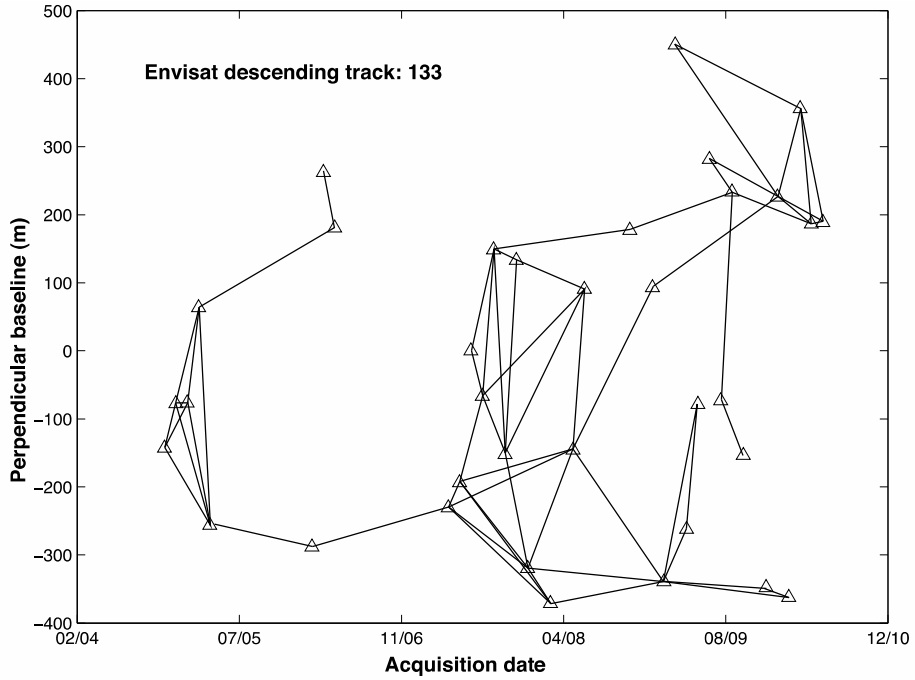
Processing steps 2

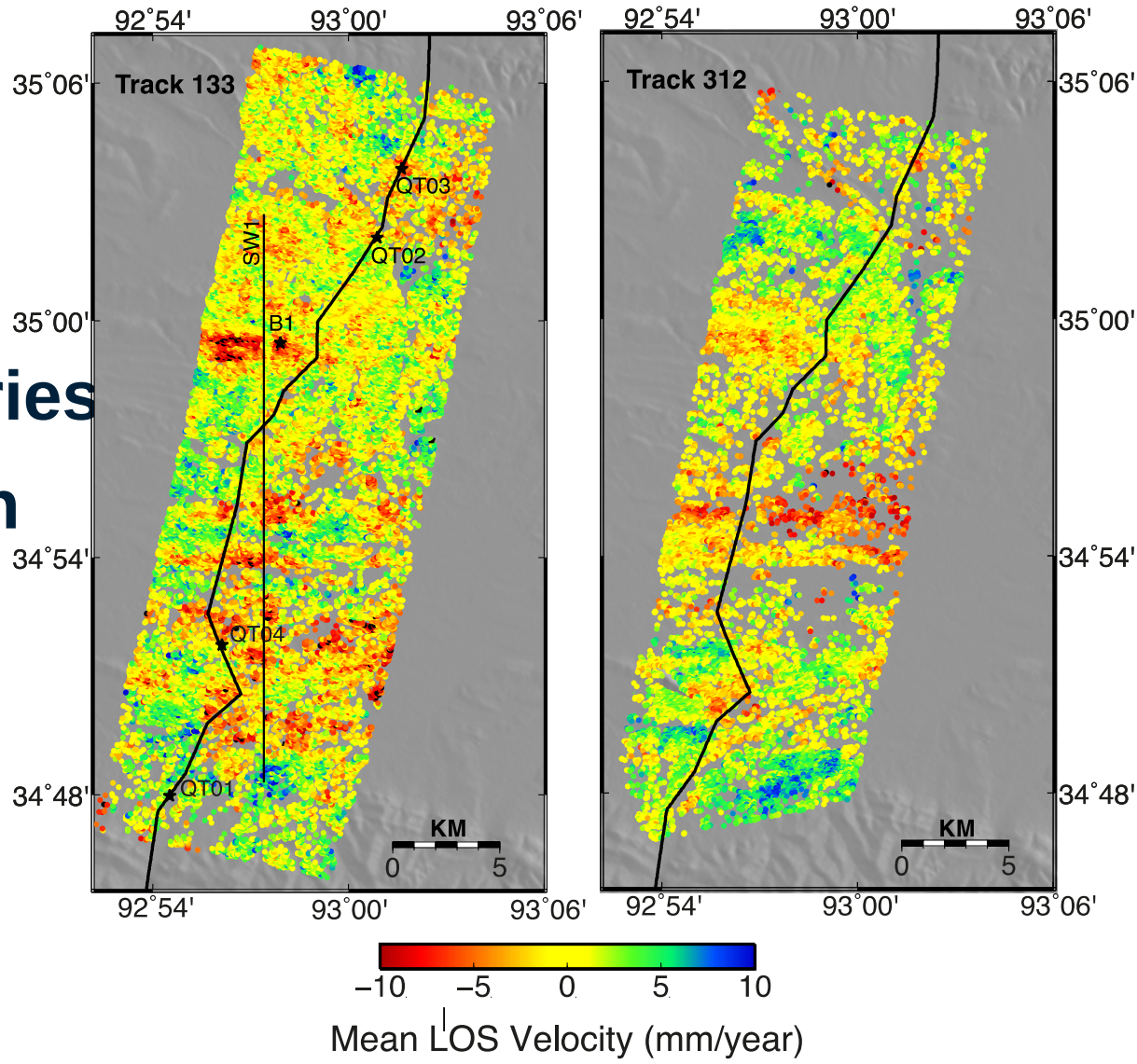
- **Small baseline subset**





Mean velocity maps

- **Four sites on the railway for time-series**
- **One site on the permafrost for time-series**
- **One 2km-width swath profiles**



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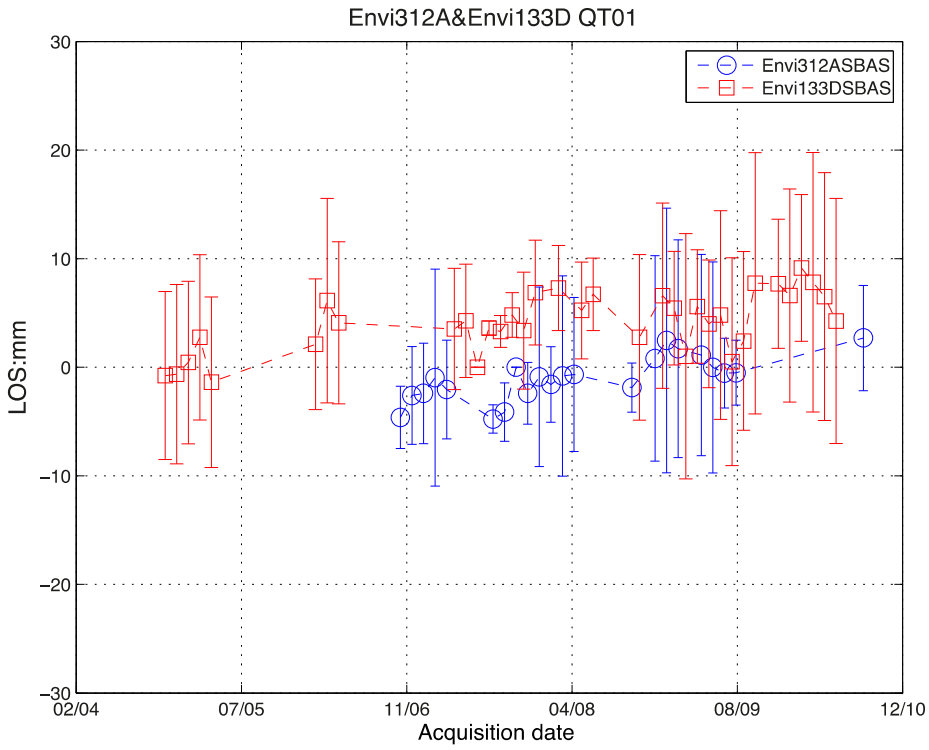
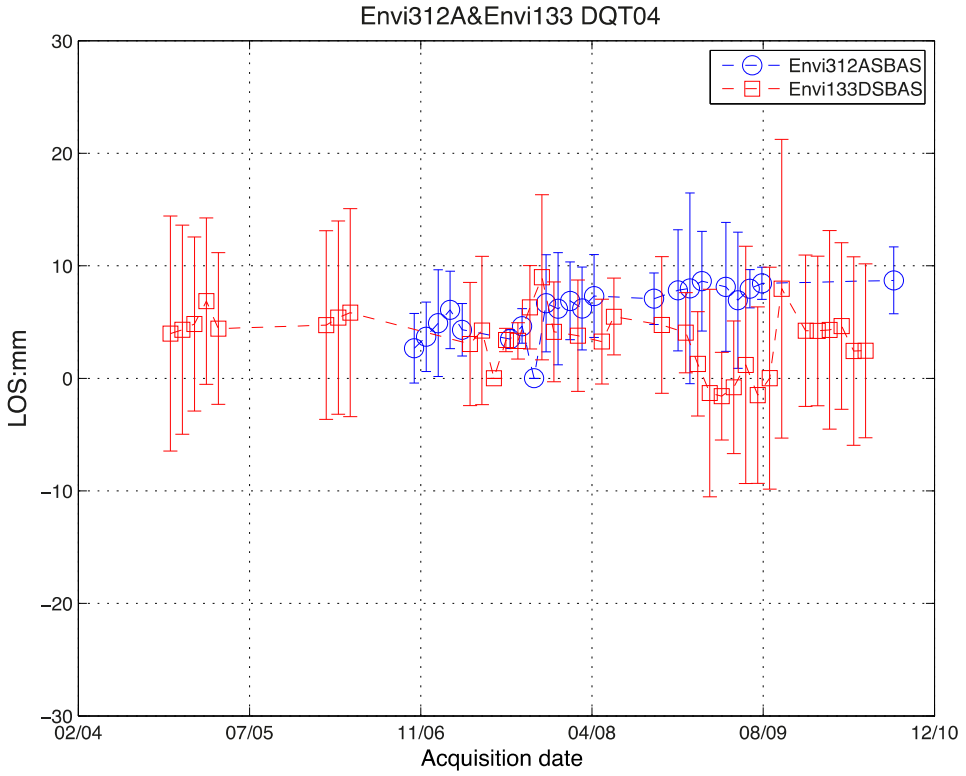
Time-series maps





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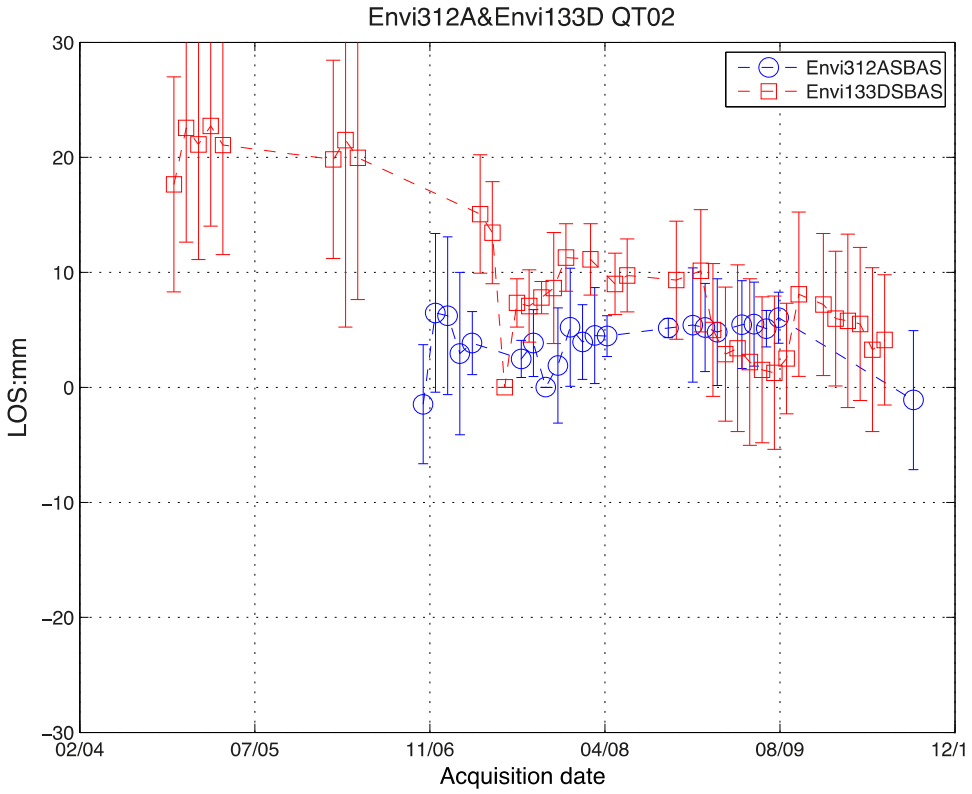
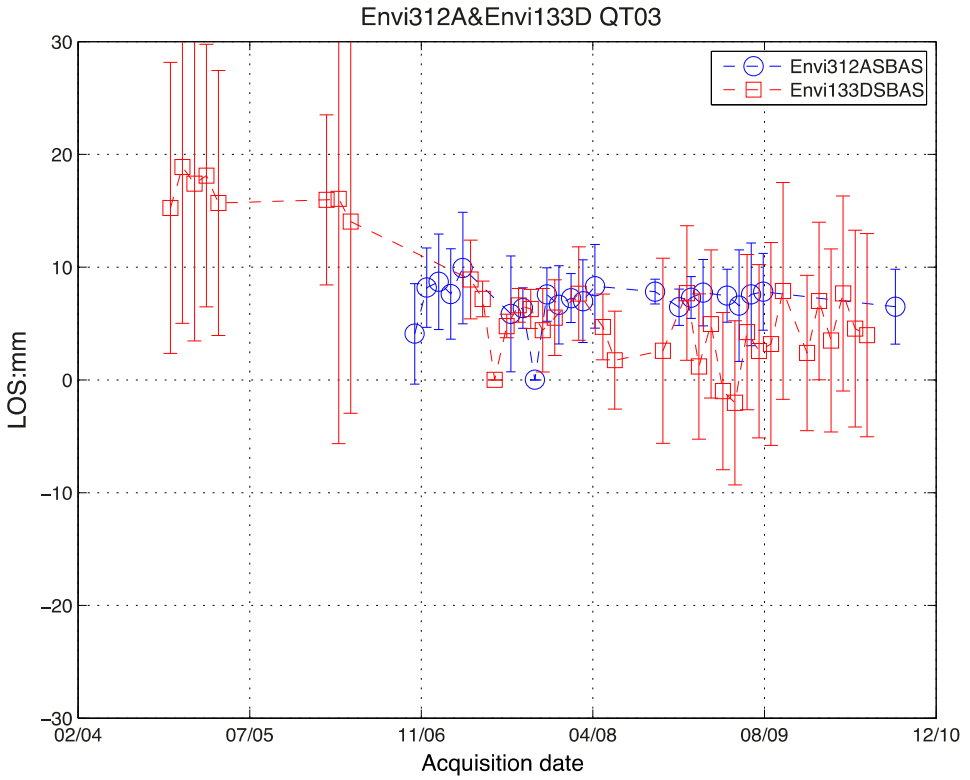
Time-series maps





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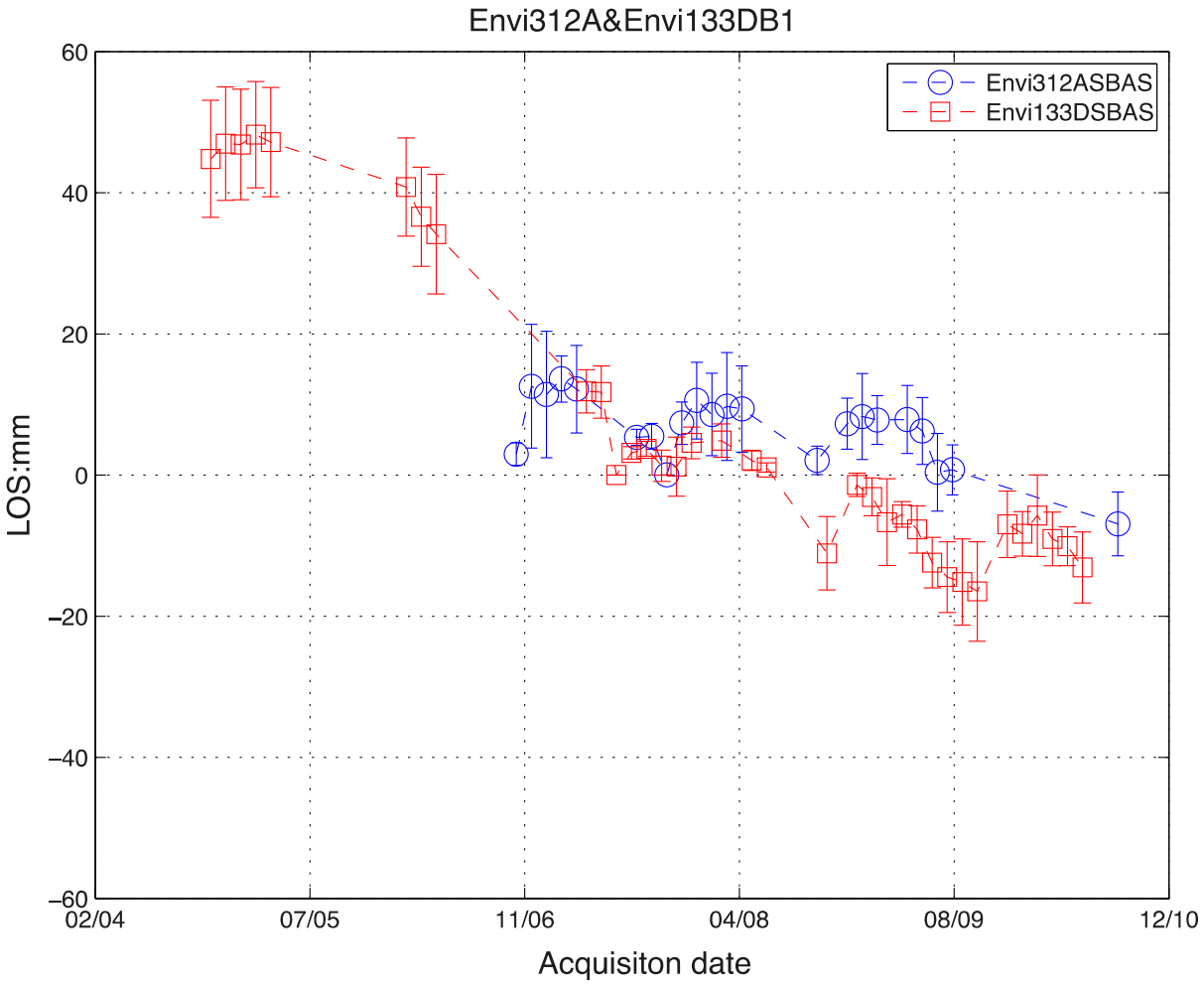
Time-series maps



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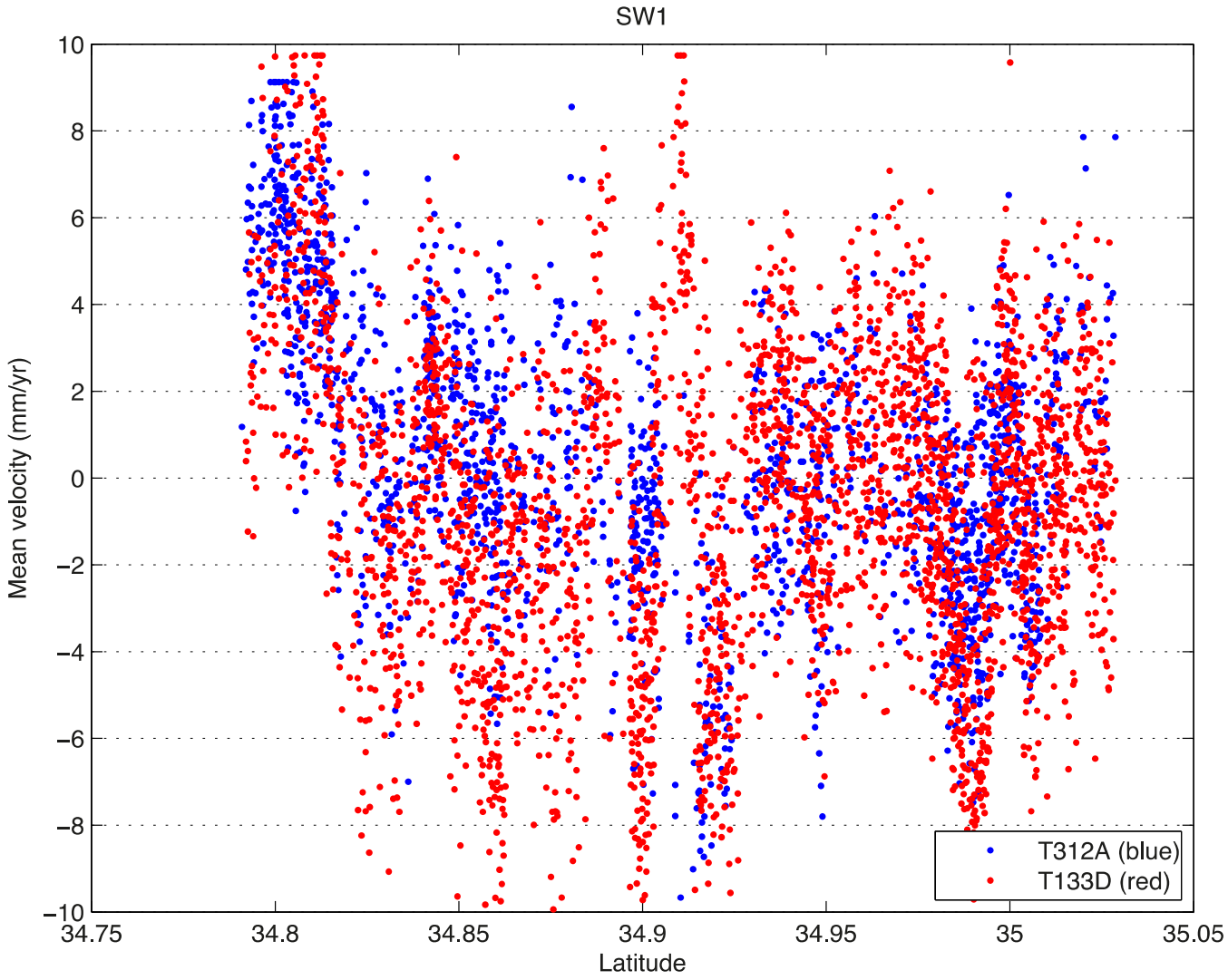
Mean velocity swath profile



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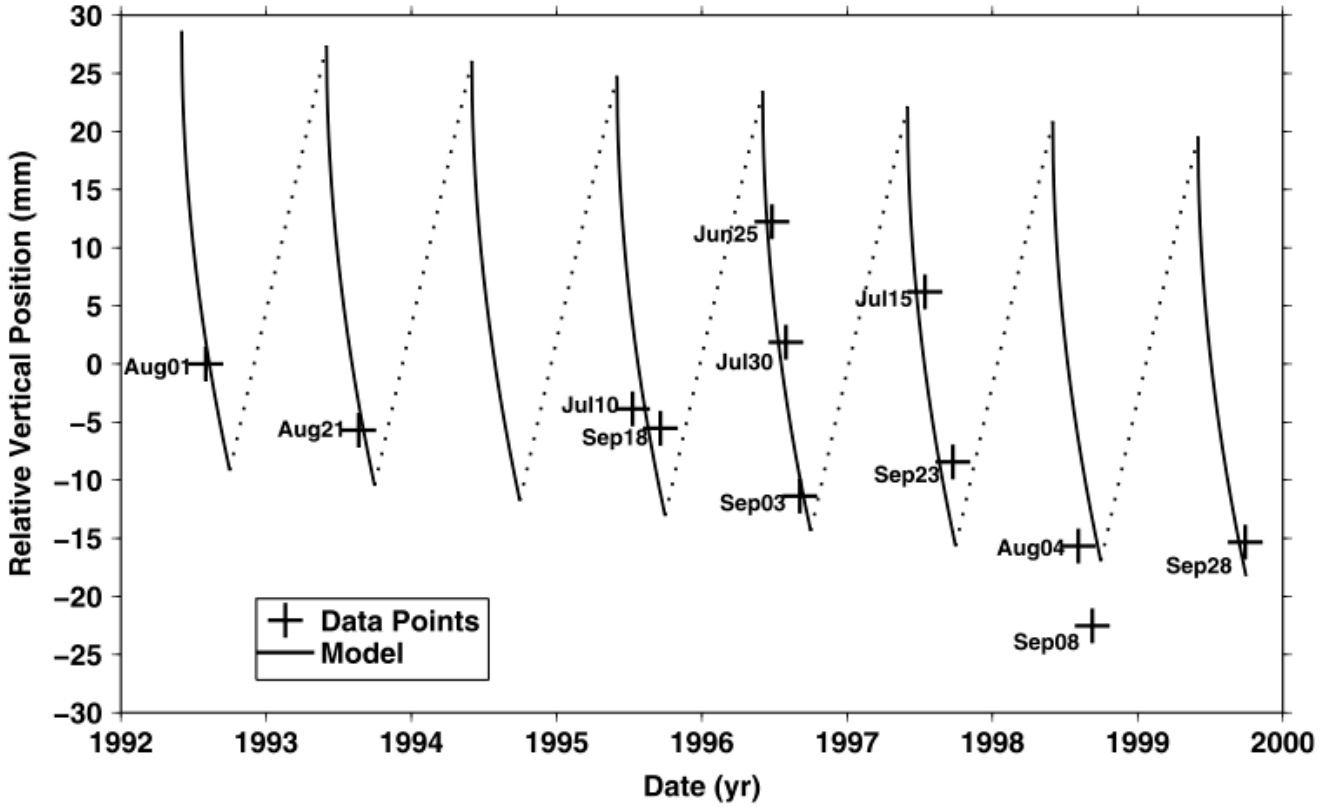
Very preliminary model

$$D = R(t_2 - t_1) + A(\sqrt{t_2^{thaw} - t_1^{thaw}})$$



Source: Liu, L., T. Zhang, and J. Wahr (2010)

Conclusion and future work

- **Mean velocity map and associated time-series plots of the railway were generated by analyzing one ascending and one descending Envisat ASAR images**
- **The seasonal frost heave and thaw settlement**

Combining these suggests that InSAR has potential to monitor the deformation of Qinghai-Tibet railway on area with permafrost

•Future work

- **Modeling the deformation and assessing the damage**

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Thank you for your attention!

Question?

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