TROPOSPHERIC CORRECTION FOR INSAR USING INTERPOLATED ECMWF DATA AND GPS ZENITH TOTAL DELAY FROM THE SOUTHERN CALIFORNIA INTEGRATED GPS NETWORK

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MOTIVATION

- A major error source in Interferometric Synthetic Aperture Radar (InSAR) imaging is the highly variable water vapor content in the atmosphere.
- E.g., a short-interval (105 days) interferogram should reveal little deformation, but differences in atmospheric delay is clearly visible (see Fig.1).
- This is typically mitigated by stacking several interferograms.
- However, good methods for mitigating the tropospheric effects on single interferograms are needed.

THE IDEA

- Use the high precision of the Zenith Total Delay (ZTD) estimates from the Global Positioning System (GPS).
- Combine it with ZTD from interpolated weather forecast data with high spatial resolution.
- Create better tropospheric correction maps for InSAR.

INTERFEROGRAMS

- Synthetic Aperture Radar (SAR) data from the European Space Agency (ESA) .
- Envisat track 170 at 18:00 UT during 2006 from the Los Angeles basin in the south to Death Valley in the north.
- InSAR images were processed from SAR images (see INSAR DATA, bottom margin) with the shortest possible temporal differences to exclude surface deformation:
  - June-September (105 days)
  - July-August (35 days)
  - October-November (35 days)

CORRECTION MAPS

- ZTD maps were created for each day from (see bottom margin for details):
  - I. Interpolated GPS ZTD
  - II. Interpolated weather forecast data using the Stretched Boundary Layer Model (SBLM, see bottom margin)
  - III. A combination of the two previous datasets
- The ZTD maps were converted into tropospheric correction maps for InSAR (difference between two days).

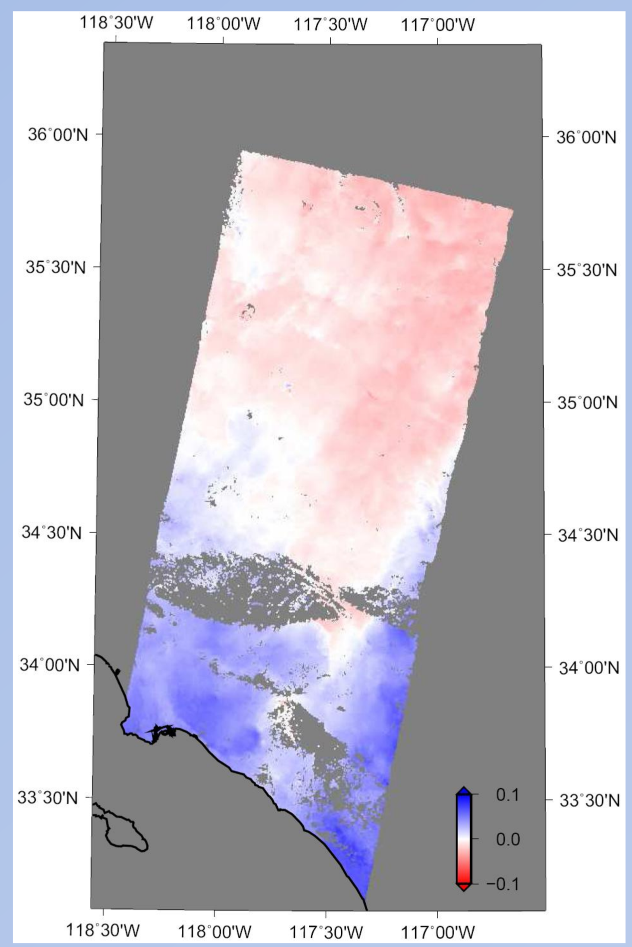

Figure 1. The original June-September 2006 InSAR image. The short-interval image consists of two SAR images with the temporal difference of 105 days.

COMBINED CORRECTION MAPS

- The difference was taken between the GPS correction map (see Fig.2, center) and the SBLM correction map (see Fig.2, left) at the locations of the GPS stations.
- The difference was interpolated (see GPS DATA, bottom margin) and added to the SBLM correction map.
- The combined correction map (see Fig.2, right) agree with the GPS ZTD at the locations of the GPS stations.

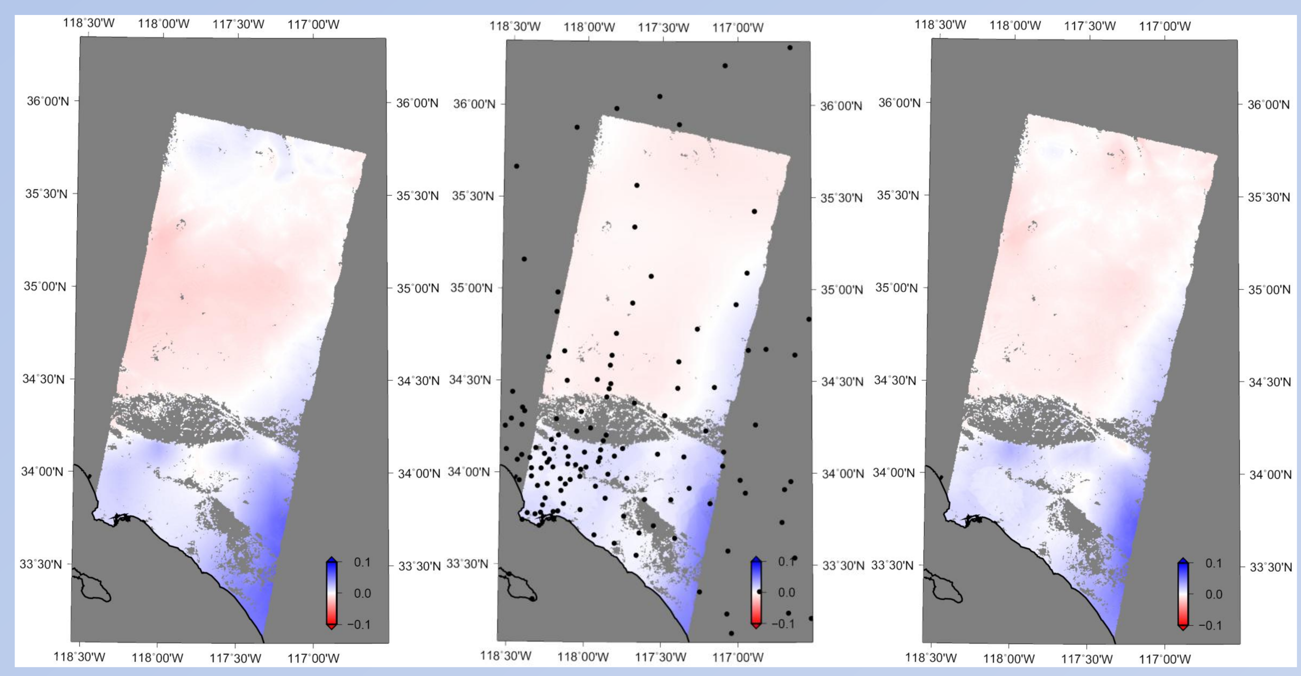

Figure 2. Three tropospheric correction maps for the June-September InSAR image. The SBLM map (left), the GPS Gaussian map (center), and the combination (right). Black dots corresponds to the locations of the GPS stations.

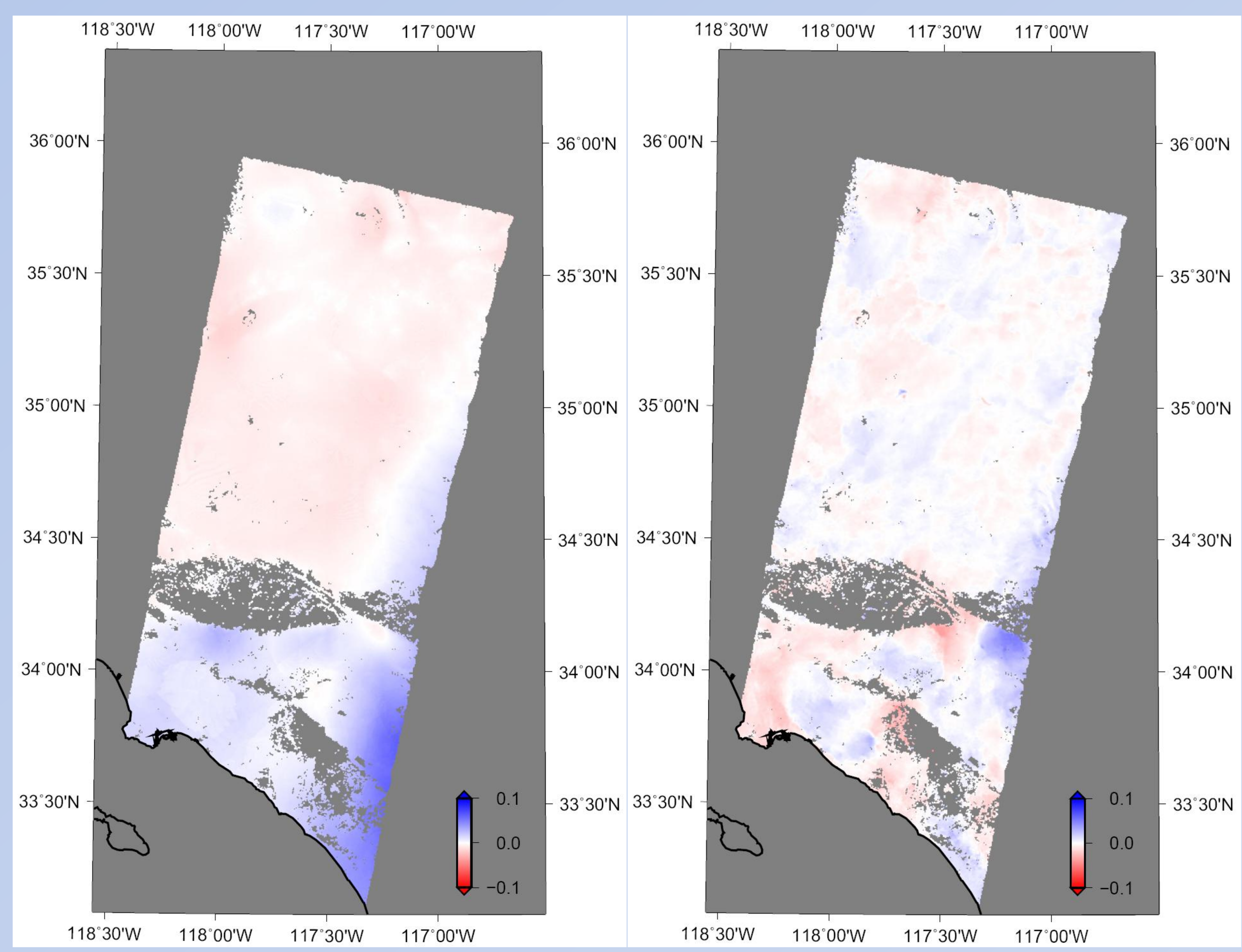

Figure 3. The combined SBLM and GPS Gaussian correction map (left) for June-September and the troposphere and orbit (reprocessed) corrected InSAR image for the same dates (right).

RESULTS

- The tropospheric correction maps were applied to the three short-interval InSAR images.
- In both short-time (35 days) InSAR images gradients of different magnitudes were seen, indicating residual orbit errors.
- Therefore the InSAR images were reprocessed with the tropospheric corrections, estimating new orbits.
- The tropospheric corrections where then applied to the reprocessed InSAR images (see Fig.3, left).
- The Root-Mean-Square (RMS) errors of the reprocessed and tropopsphere corrected InSAR images decreased with 15-68% compared to the RMS errors of the original InSAR images (see Tab.1).

Table 1. RMS reduction in percent as compared to the RMS of the original short-interval InSAR images. The RMS reduction is presented for the tropospheric and orbit (reprocessed) correction applied separately and together. The values are from tropospheric correction with the GPS (both IDW and Gaussian interpolation), SBLM, and the combined (both IDW and Gaussian) tropospheric corrections.

	Jun-Sep	Jul-Aug	Oct-Nov
Trop. Corr.	26-32%	15-20%	(-8)-3%
Orb. Corr. (reproc.)	42-45%	30-39%	(-66)-(-52)%
Trop. & Orb. Corr.	58-66%	48-68%	15-32%

CONCLUSIONS

- The results show that it is possible to reduce tropospheric errors in InSAR images using available data sets together with simple algorithms.
- Furthermore, the tropospheric correction enables a better orbit correction through reprocessing.
- By correcting for both errors, the quality for the InSAR images increased significantly.

FUTURE WORK

- Further developing the combination of ZTD from GPS and weather models.
- Implementing the product into the GPS Explorer portal in the project Real-Time In Situ Measurements for Earthquake Early Warning and Spaceborne Deformation Measurement Mission Support (http://geoapp03.ucsd.edu/gridsphere).
- Ongoing work of studying algorithms for elevation-based interpolation of weather model data with the AIST project Online Services for Correcting Atmosphere in Radar.

INSAR DATA

- Interferograms were processed using the Repeat Orbit Interferometry package (ROI_pac) software version 2.3 with SNAPHU unwrapping and the topographic component of the interferometric phase was removed.
- Low correlation data were removed from the InSAR images if the corresponding pixel values in the coherence images were less than 0.3.

GPS DATA

- Data from the Southern California Integrated GPS Network (SCIGN).
- All of the available stations inside the track + several adjacent stations. In total: 132-135 stations (see black dots in Fig.2, center).
- Data were processed for each day estimating ZTD using the GIPSY-OASIS II software in Precise Point Positioning mode with JPL's Flinn final precise orbit solution. A 7° elevation cutoff was applied together with the Global Mapping Function.
- ZTD data for each station were interpolated into ZTD maps for each day using Inverse Distance Weighted (IDW) interpolation and Gaussian interpolation, separately.

WEATHER FORECAST DATA

- Profiles with the 4-hour deterministic forecasts of precipitable water vapor, temperature, and pressure from the European Centre for Medium-Range Weather Forecasts (ECMWF).
- Digital Elevation Model (DEM) was provided by the USGS National Elevation Database, resolution: 1 arcsec (horizontal) and 15 m (vertical).
- The ECMWF data were interpolated to the DEM grid using the Stretched Boundary Layer Model (SBLM).

STRETCHED BOUNDARY LAYER MODEL

- Assumes that the water vapor and temperature profiles are unchanged above the boundary layer.
- Within the boundary layer, the shape of the profiles are also unchanged: profiles are stretched to fit the topography.
- The Total Precipitable Water vapor (TPW) is obtained by integration of the topography corrected water vapor profiles.
- The TPW maps from the SBLM were converted into ZTD maps for each day using surface temperature and pressure from the SBLM.

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