Improving the accuracy of inter-technique ties at core geodetic sites through estimation strategies that exploit atmospheric structure

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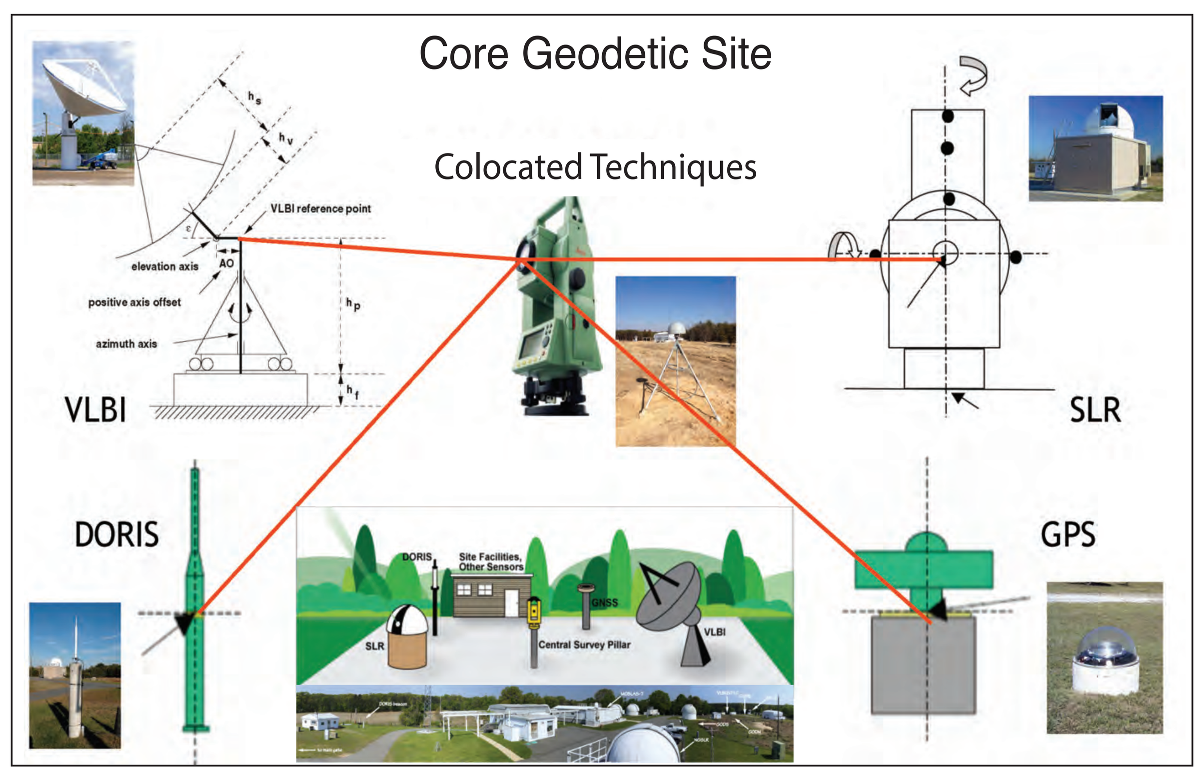
Background

Colocation of space geodetic techniques (VLBI, GPS, SLR, and DORIS) at core sites is essential for robust global reference frame realization.

Accurate inter-technique ties are required to realize a multi-technique global reference frame that is suitable for high-accuracy geophysical applications such as global sea-level change.

Disagreement between geodetic estimates and local ties at some core sites can be larger than the formal uncertainties of the local surveys.



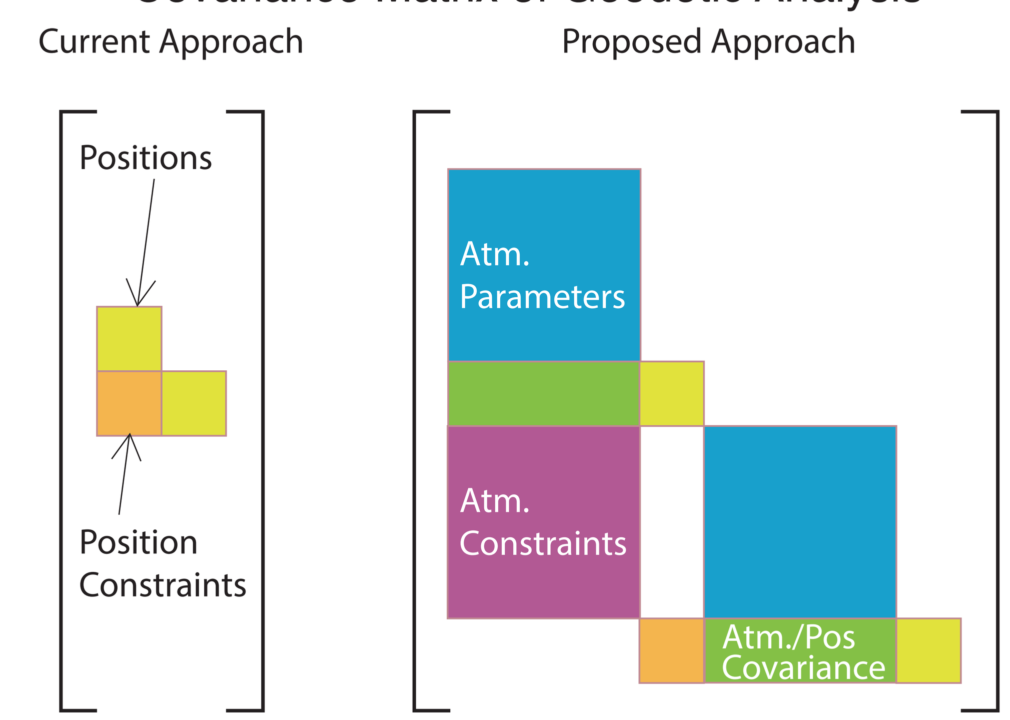
Objectives

Investigate approaches to improve the accuracy of site positions estimates and ITRF combinations using external constraints based on local atmospheric structure at core geodetic sites.

Here we focus on a GPS-based study because of data availability and simplicity. Other techniques will be incorporated in the future.

Develop software to read GAMIT normal equations and impose atmospheric constraints.

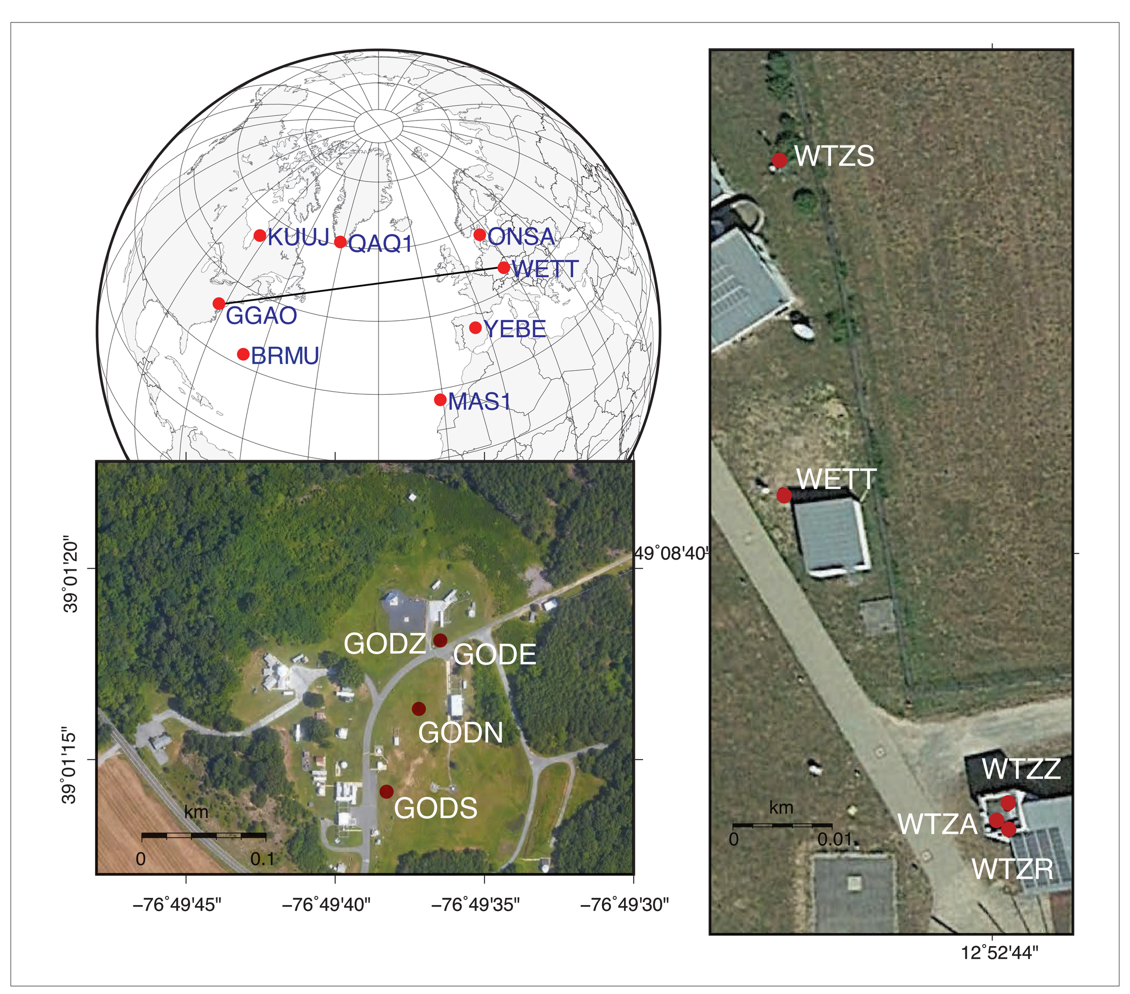
Covariance Matrix of Geodetic Analysis



Position parameters (yellow) at core sites are uncorrelated before local-tie constraints (orange) are applied

Position parameters (yellow) are further constrained by atmosphere constraints (purple) applied to local atmosphere parameters (blue) via covariance with position parameters (green)

Data and Methods (Pilot Study)



Data:
GPS from the multiple GGAO-Wettzell baselines from 2014.

Methods:
Calculate daily normal equations (both position and atmospheric parameters such as zenith delay and gradient and their fully populated covariance matrices).

Develop a method to impose position and atmospheric parameter constraints.

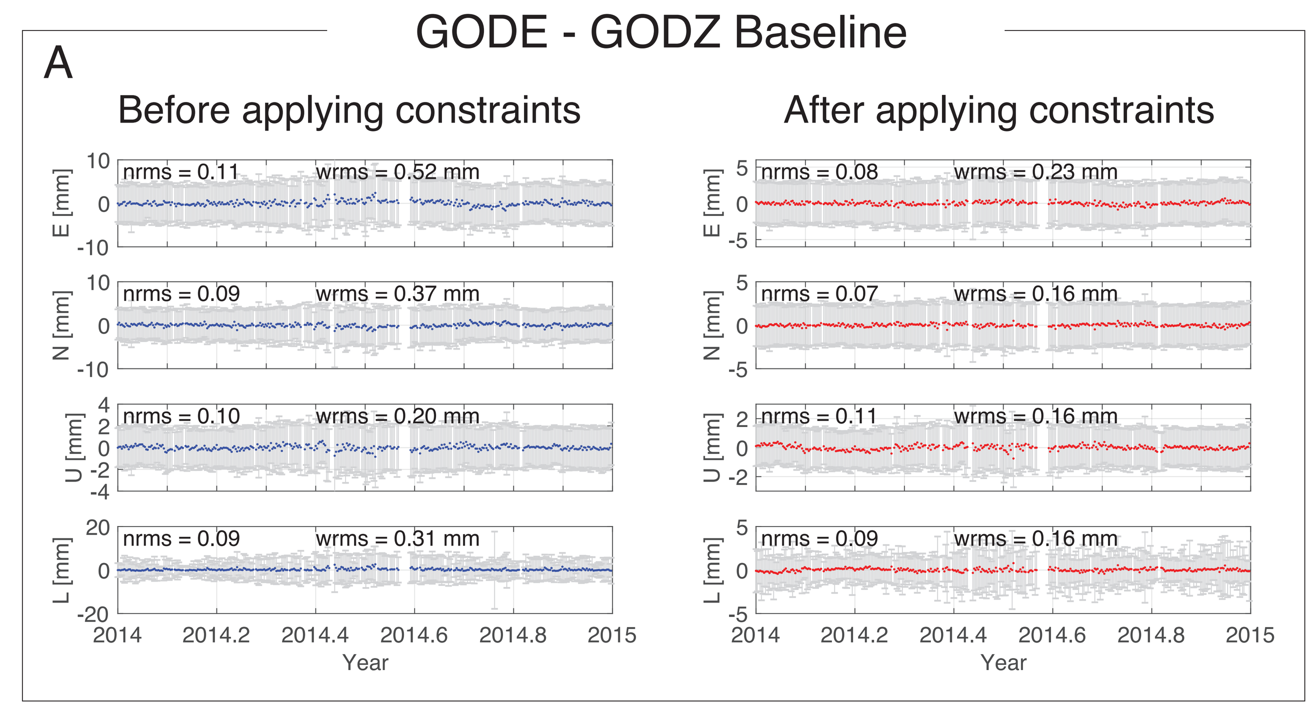
Compare the constrained and non-constrained solutions to assess the impact on site position.

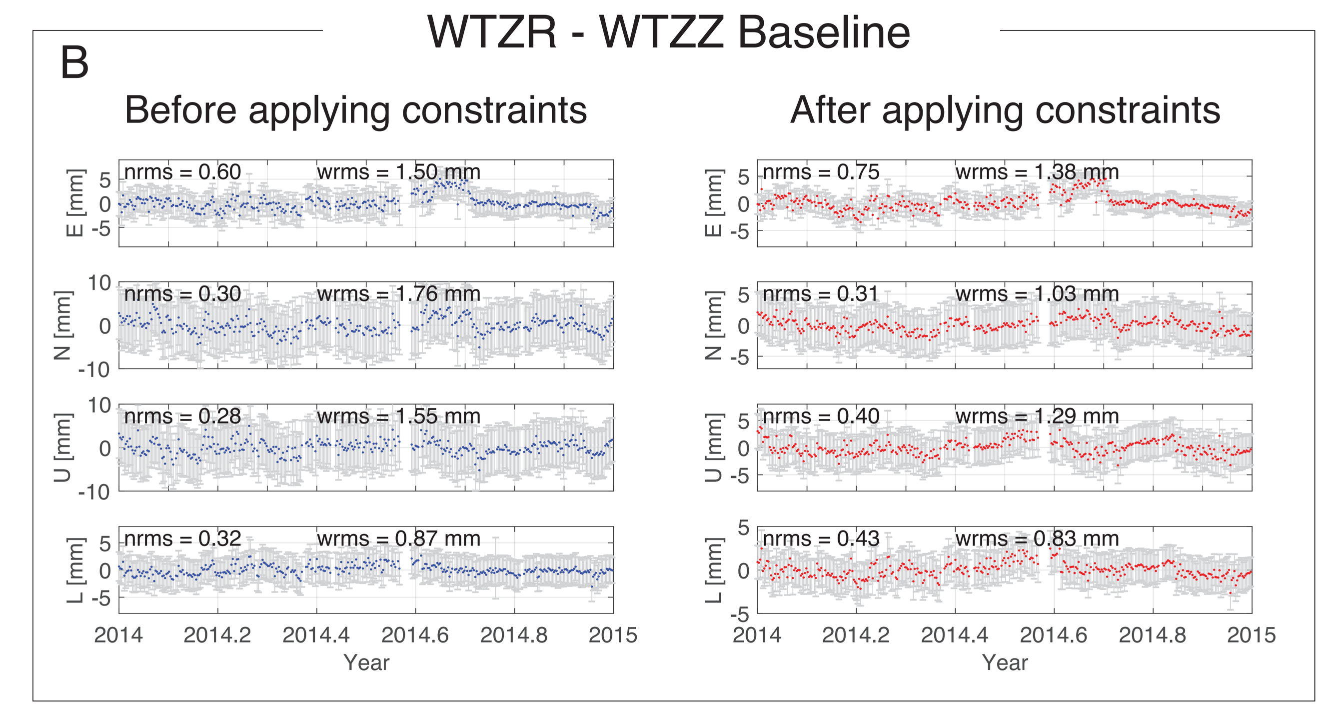
Explore estimation strategies that exploit atmospheric structure (e.g., Kolgomorov-type turbulence and frontal systems) in the combinations that lead to ITRF realizations.

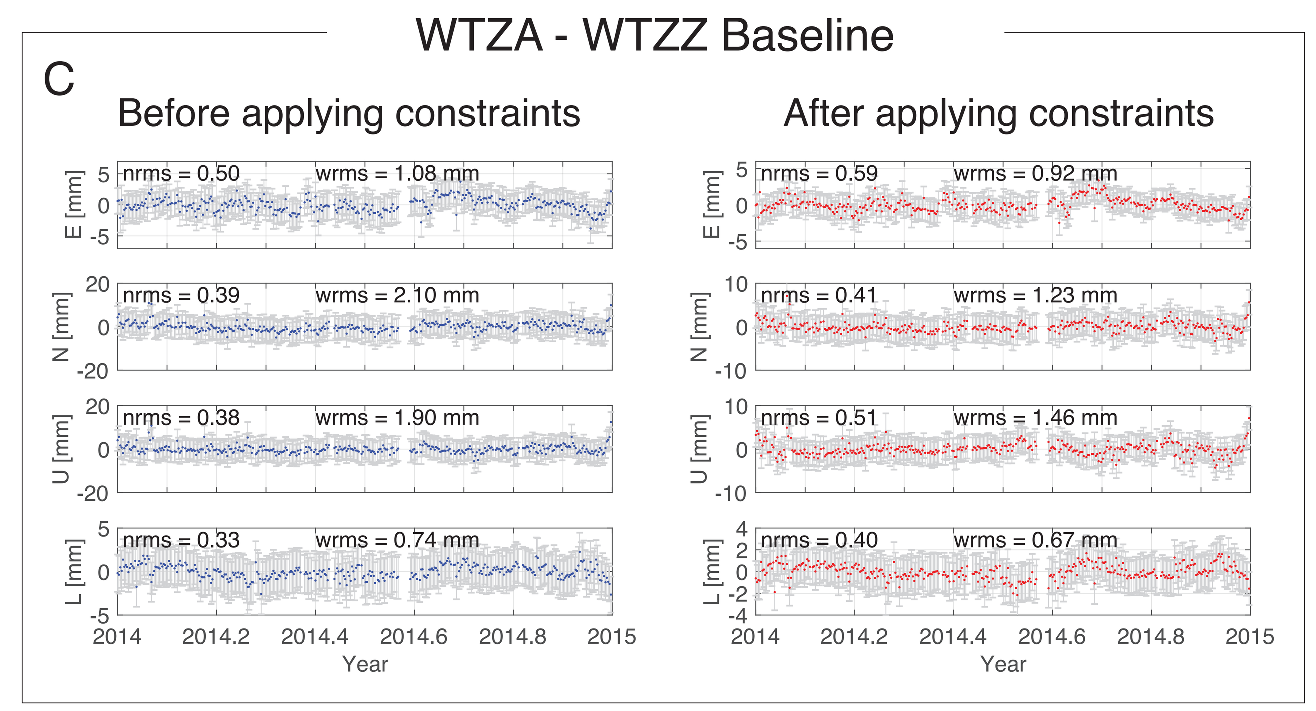
Effect of atmospheric constraints on geodetic solutions

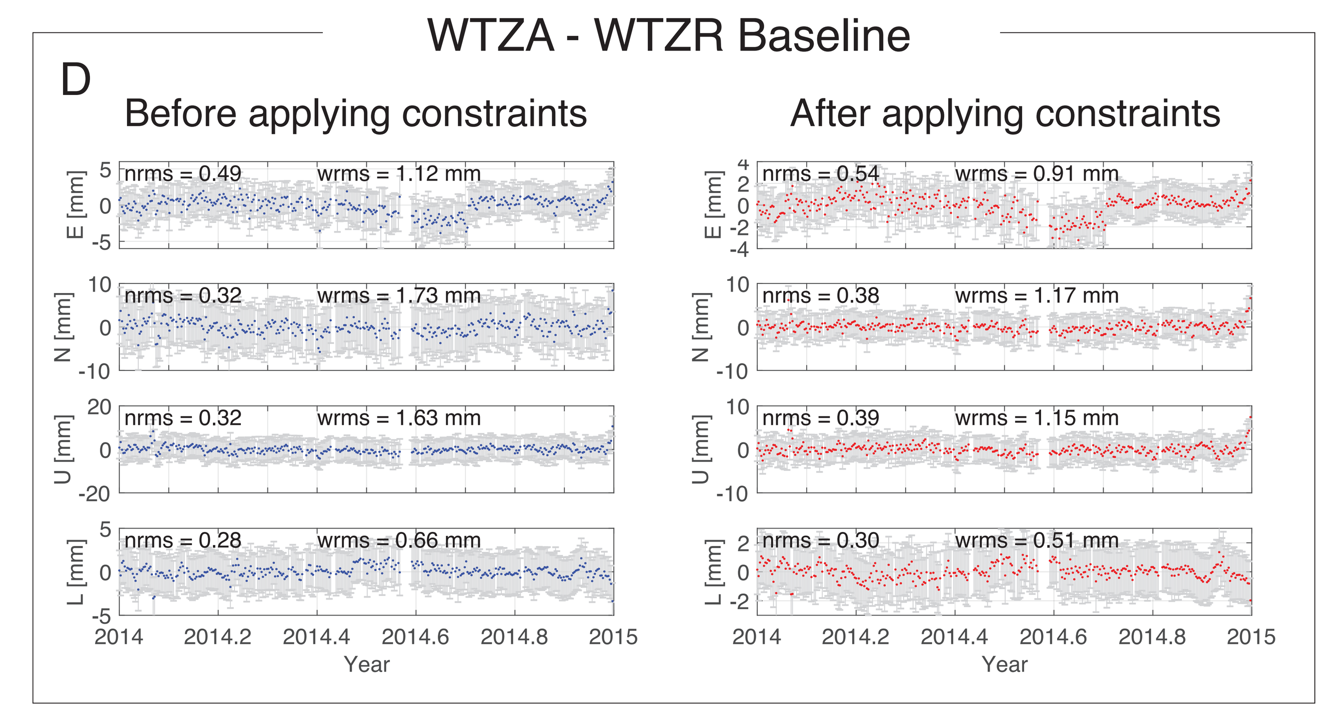
Constrained atmospheric parameters difference between colocated GPS stations GODE and GODZ at GGAO (Fig. A), and stations WTZA, WTZR, and WTZZ at Wettzell (Figs. B-D).

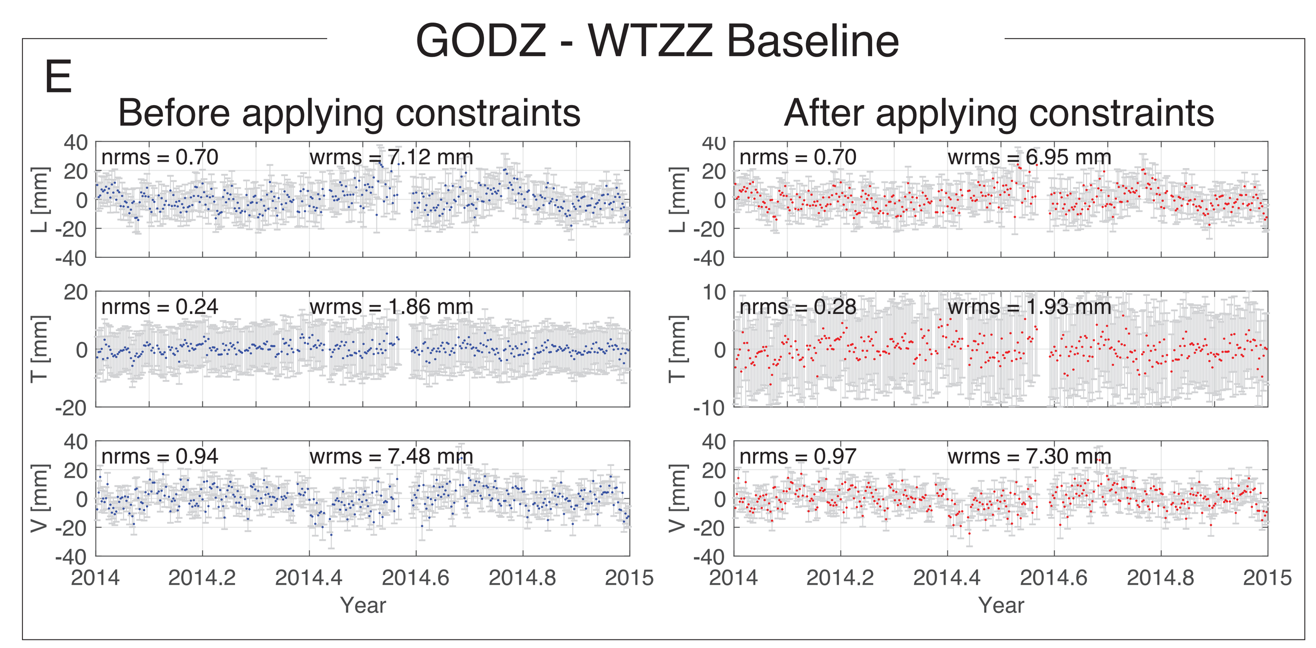
Compared scatter of baseline component estimates before and after applying atmospheric constraints, shown in a topocentric (i.e., east, north, and up) and baseline-centric (length, transverse, and vertical) coordinates for short and long baselines, Figs. A-D and Fig. E respectively.









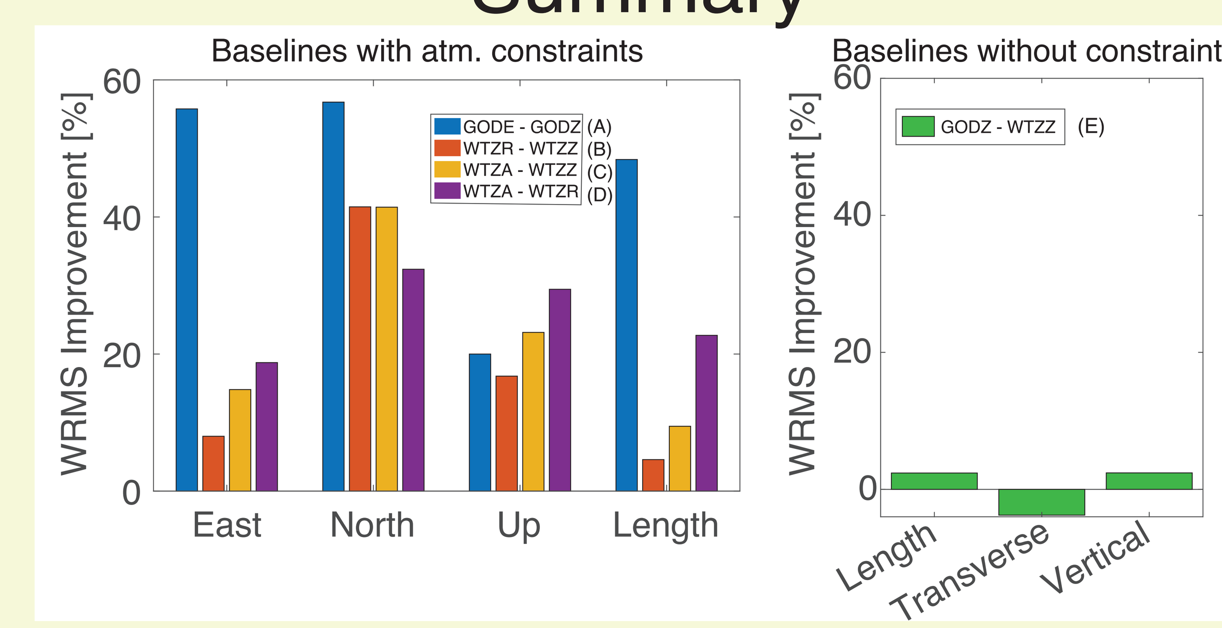


Examples of baseline scatter before and after applying atmospheric constraints for baseline lengths spanning between 0 and 6500 km, in 2014.

Here, we constrained the zenith total delay and multiple zenith delay differences between GODE and GODZ to be zero (Fig. A). This represents a ground-truth test because the two stations share the same GPS antenna; hence it is a zero-baseline length.

Similar constraints were applied to WTZA, WTZR, and WTZZ, because being only 3 m apart in practice they share the same atmosphere.

Summary



Our initial test suggest that atmospheric constraints results in reduced scatter of topocentric baseline component and length estimates.

Future Steps

Analyze the multi-year solutions.

Incorporate atmosphere constraints from meteorology and atmospheric dynamics.

Incorporate data from the other geodetic techniques.

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