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Supporting Information for

InSAR bias and uncertainty due to the systematic and stochastic tropospheric delay

Heresh Fattahi[1,2], Falk Amelung[1]

[1]Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL, USA, [2]Now at the Seismological Laboratory, California Institute of Technology, Pasadena, California, USA.

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1- Introduction

This supporting Information provides Figures S1 to S4. Figure S1 shows for each pixel the number of cloud free images out of a total of 3163 MODIS acquisitions for 2002 to 2011. Figure S2 is the network of interferograms for the Envisat ASAR data used in this paper. Figure S3 compares the velocity uncertainty obtained from the difference of MODIS and ERA-I (Figure 6.b) with the uncertainty obtained from the InSAR range-change time-series (Figure 6.c). Figure S4 demonstrates the standard deviation of InSAR velocity between all possible pairs of a sample of pixels (~ 500 for each track) as a function of distance for different tracks and for all tracks obtained from the InSAR range-change time-series using equation (10). In section 2 of this supporting information we show how a full variance-covariance matrix of InSAR displacement time-series between two pixels may be propagated to the velocity.

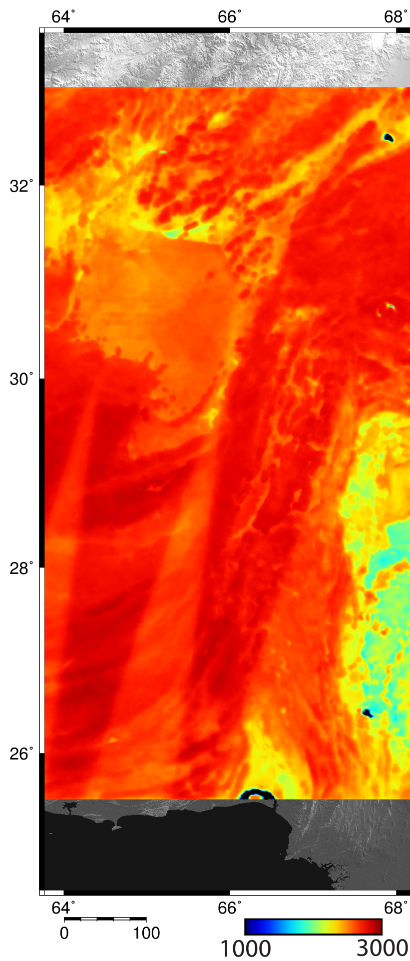

Figure S1: Map showing for each pixel the number of cloud free images out of a total of 3163 MODIS acquisitions for 2002 to 2011 (only ~10:00 am acquisitions). 75% of the study area has at least 2500 cloud free acquisitions.

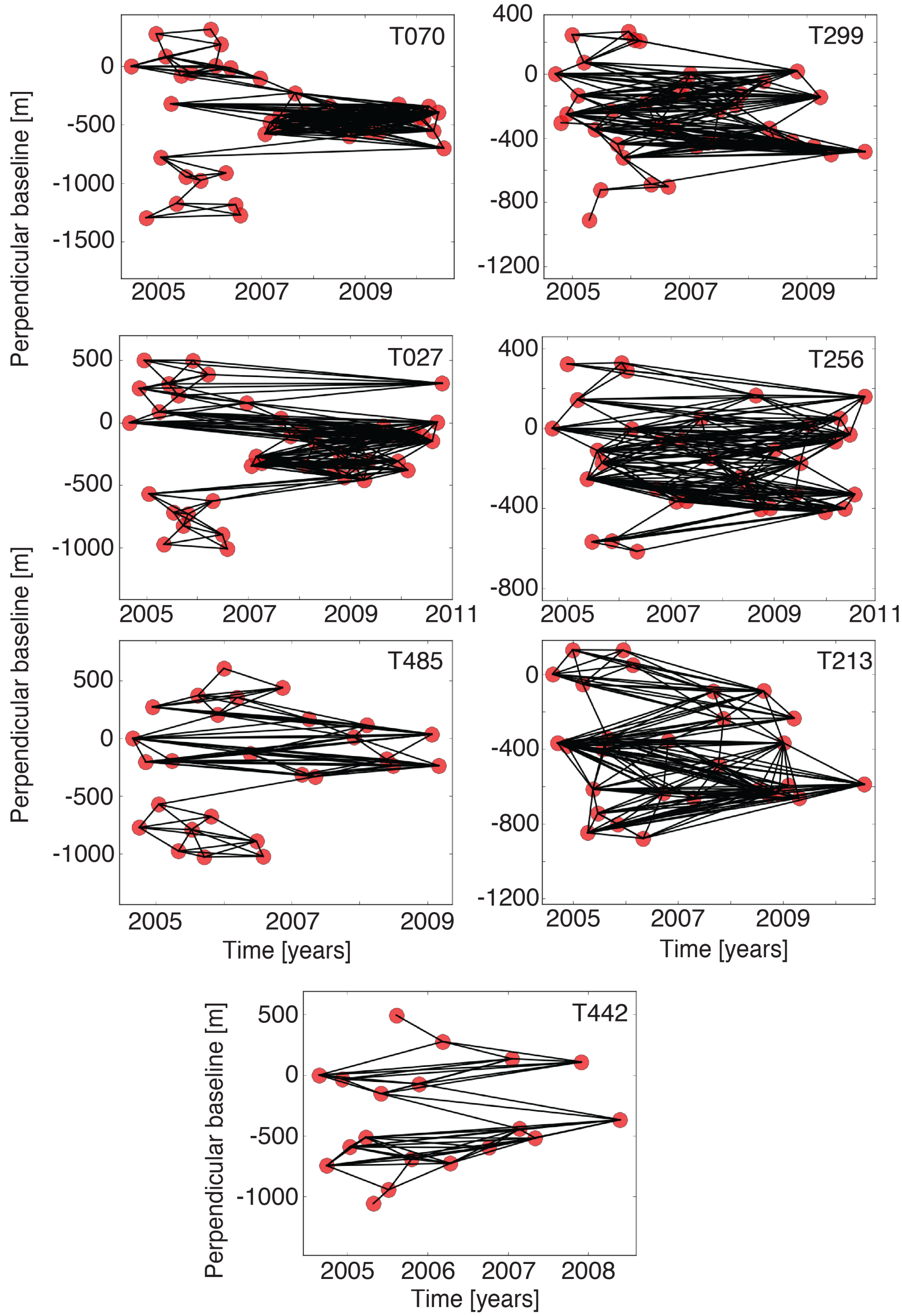

Figure S2: Network of interferograms for 7 Envisat ascending tracks in Figure 1. The acquisition times of these tracks were used to obtain the uncertainty of InSAR velocity field in Figure 6.

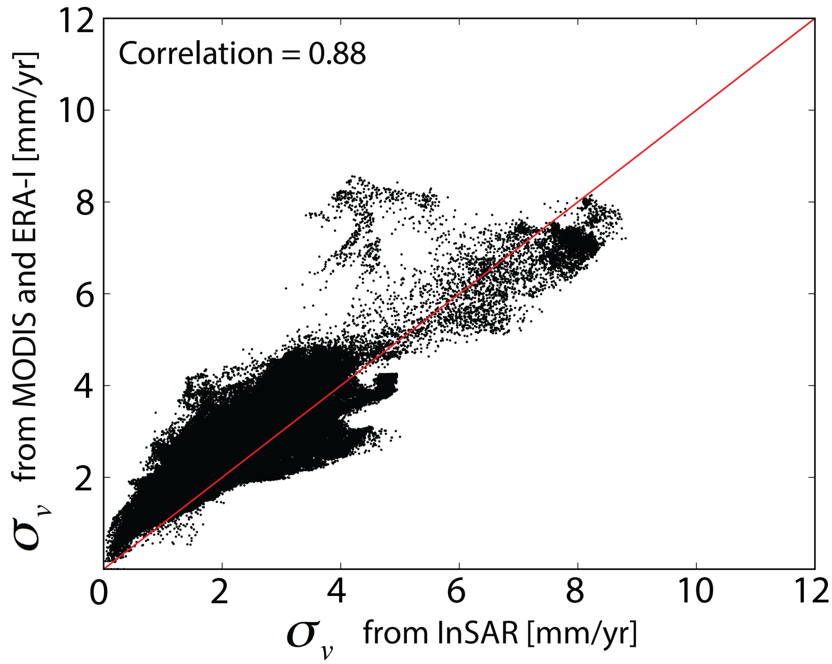

Figure S3: Velocity uncertainty obtained from the difference of MODIS and ERA-I (Figure 6.b) compared with the uncertainty obtained from the InSAR range-change time-series (Figure 6.c).

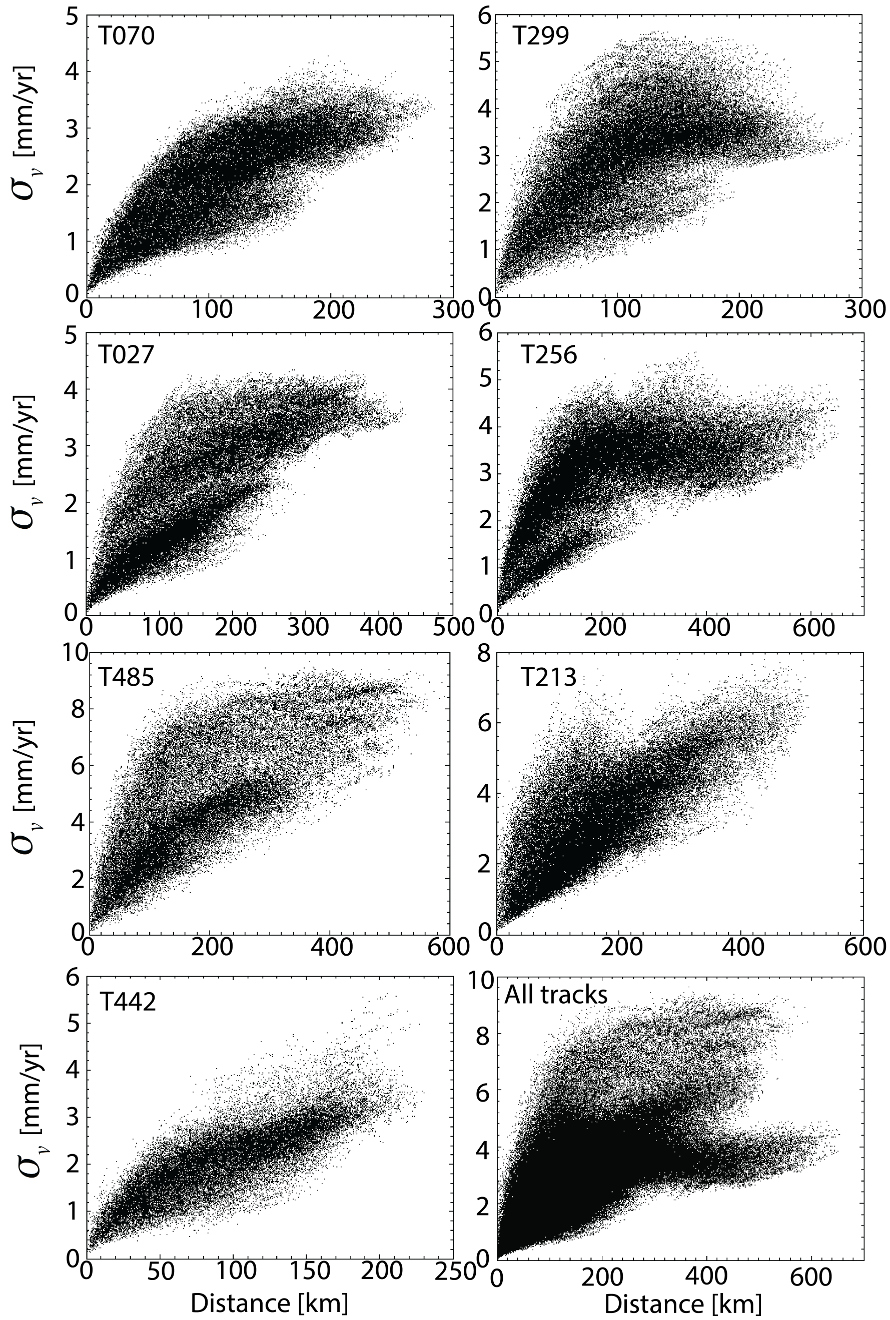

Figure S4: Standard deviation of InSAR velocity between all possible pairs of a sample of pixels (~ 500 for each track) as a function of distance for different tracks. The last plot shows the standard deviation for all the tracks.

2- propagating the time-series covariance matrix to the velocity covariance matrix

Given a vector of displacement time-series between two pixels (p and q), the following linear model should be solved to estimate the rate of displacement

$$d = Bm \quad \text{(A1)}$$

where d is the observation vector as $d = \left[d_{pq}^{1}, d_{pq}^{2}, ..., d_{pq}^{N}\right]^{T}$ with d_{pq}^{i} the displacement between pixels p and q at time t_i relative to a reference epoch, $B = \left[[t_1, t_2, ..., t_N]^T, [1,1,...,1]^T\right]$ is the design matrix and $m = [v, c]$ is the unknown vector with two elements; v the rate of linear displacement between the two pixel and c the intercept. The variance-covariance matrix of the displacement time-series due to the stochastic tropospheric delay is expressed as

$$C_{pq} = \begin{bmatrix} \eta_{pq}^{1,1} & .. & \eta_{pq}^{1,N} \\ : & & : \\ \eta_{pq}^{N,1} & .. & \eta_{pq}^{N,N} \end{bmatrix} \quad \text{(A2).}$$

where $\eta_{pq}^{i,j}$ is the covariance of stochastic tropospheric delay between pixels p and q at times ti and tj. The full variance-covariance matrix of the displacement time-series in equation (A2), takes in to account the spatial correlation of noise between the two pixels as well as the possible temporal correlation of noise among the epochs; It can be used to estimate the covariance matrix of the unknown vector as $C_m = (B^T C_{pq}^{-1} B)^{-1}$.

Although the approach in this paper for estimating the relative uncertainties takes in to account the spatial correlation of noise between the two pixels, it neglects the possible temporal correlation of the stochastic delay. Therefore assuming temporal white noise, all non-diagonal elements become zero and the data covariance matrix is simplified to the following diagonal matrix

$$C_{trop} = \begin{bmatrix} \sigma^2_{d^1_{pq}} & 0\ldots & 0 \\ 0 & & : \\ : & & 0 \\ 0 & \ldots 0 & \sigma^2_{d^N_{pq}} \end{bmatrix} = \sigma^2_{RSWD(p)-RSWD(q)} I \qquad \text{(A3)}$$

where I is an NxN unity matrix. Using this covariance matrix to estimate the covariance matrix of the unknown parameters in equation (A1) as $C_m = (B^T C^{-1}_{pq} B)^{-1}$ results in equation (8) for the uncertainty of the estimated velocity.