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eEarth Discussions

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Interactive Comment

Interactive comment on "Inflation of Aira Caldera (Japan) detected over Kokubu urban area using SAR interferometry ERS data" *by* D. Remy et al.

D. Remy et al.

Received and published: 25 October 2006

Your comments have been carefully analyzed and helped us to improve and clarify significantly the new version that we will send to the editor. Both manuscript and figures have thus been modified to account for your main recommendations. The proposed revised paper has been read by a native English speaker. - Major comments : In order to provide more convincing evidence showing that the observed deformation signal is real we added two figures. The first one shows a panel of three JERS interferograms for a various periods during 1993-1998 used in the study carried out by Murakami et al (2001) et Okuyama et al (2001) (see figure 1 attached with this text). The second one shows various examples of ERS interferograms using different master images (see figure 2 attached with this text). We think that the examination of these differential SAR interferograms computed over time separations from one year to three years

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clearly reveals that Kokubu urban area exhibits a time dependant but perpendicular baseline independent phase pattern. We agree with you that we cannot rule out a possible contribution of residual transient tropospheric effects in the observed signal which can bias our results. So, in a new paragraph we analyze the InSAR noise and we examine what influence the covariance function has on results of modeling. The technique proposed by Lundgren et al (2001) makes it possible to estimate the effect of processing errors, which can be considered as independent in each interferogram. Obviously as you mentioned it, this procedure only gives the uncertainties of the phase measurement. The real accuracy should include bias estimates, in our case mainly related to the phase delays induced by tropospheric effects. So in the revised version of the paper, based on the noise analysis, we give an estimation of the bias of about 8 mm which could be induced by noise effects in our estimation of relative displacement between the north and the south of Kokubu city. As the deformation source cannot be well constrained due to the low spatial resolution, we decided to fix the location and the depth of the source using the values proposed by Murakami et al. (2001) and Okuyama et al. (2001). We assume a constant source location to infer the volume change of the source. As you mentioned it we had forgotten to mention that the model included an additional offset parameter to account for the uncertainty in identifying the fringe corresponding to zero displacement. Consequently the text has been modified to take this remark into account. In this section we developed a new paragraph which explains why we did not use all the coherent areas in the inversion process. Figure 3 shows a noisy interferogram obtained from addition of a simulated source at 10 km depth with volume change of 25x106 m3 and a simulated noise using noise structure similar to those observed in the study area. Visual inspection and quantitative analysis reveals that significant measurements are only available in the Kokubu urban area (variance of the signal of about 41 mm2). For example, in Kajiki urban area the surface deformation signal power is about 16 mm2. Clearly, this value is below the detection threshold estimated to be roughly two or three times the local noise variance observed in the study area. This explains why the observation of the interferogram series does

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not reveal a clear deformation pattern over these two disconnected areas and why we renounced to the use of these patches in the modeling of the displacement source. In the original version we presented only the inversion solution for point source model for a subset of interferograms computed using the same master image (orbit 20503) and the root mean square between observed and computed data. In the revised version, we give the inversion solution for point source model for the subset of the 15 coherent interferograms which span more than one year. Furthermore, as you recommended we give for each interferogram the variance explained by the model and the variance calculated from the residuals (observed-best modeled). We improve significantly the discussion about the comparison between our results and those obtained by previous study. For instance, figure 8 makes it possible to compare without ambiguity our results with those obtained by Kriswati and Iguchi (2003) based on the analysis of GPS data during 1995-2000 period. - Other comments : We added in the introduction information regarding the Sakurajima activity and the seismicity observed in the study area during 1995-2000 period. We detailed the procedure proposed by Usai and Lundgren in the section “Analysis of the DinSAR time series”. We added the outline of the Aira Caldera and a bar with a km scale in figure 1. We added a bar scale in different figures. As you required the residual are showed over the whole area. We followed your recommendations in the writing of the text.

Interactive comment on eEarth Discuss., 1, 151, 2006.

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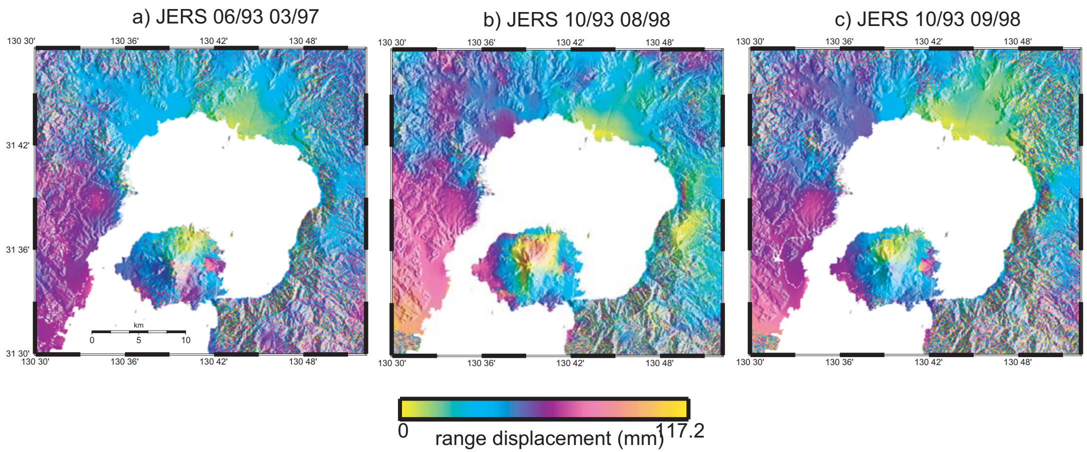

Figure 1: Recorded differential JERS interferograms over the Aira Caldera encompassing the 1993-1998 period. a) Interferogram spanning four years from June 1993 to March 1997. b) Interferogram spanning five years from October 1993 to August 1998. c) Interferogram spanning five years from October 1993 to September 1998. A complete cycle of phase (purple, blue yellow) represents a decrease in range of 11.73 cm between the ground surface and the satellite.

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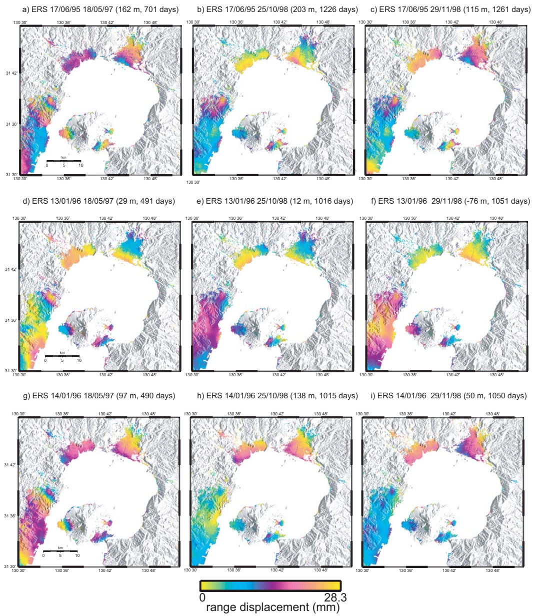

Figure 2: Recorded differential ERS interferograms over Aira Caldera encompassing the 1995-1998 period: a) interferogram orbits 20503-10850 (period 95/06/17-97/05/18, Perpendicular Baseline 162 m, 701 days); b) interferogram orbits 20503-18365 (period 95/06/17-98/10/25, Perpendicular Baseline 203 m, 1226 days), c) interferogram orbits 20503-18866 (period 95/06/17-98/11/29, Perpendicular Baseline 115 m, 1261 days), d) interferogram orbits 23509-10850 (period 96/01/13-97/05/18, Perpendicular Baseline 29 m, 491 days); e) interferogram orbits 23509-18365 (period 96/01/13-98/10/25, Perpendicular Baseline 12 m, 1016 days), f) interferogram orbits 23509-18866 (period 23509-98/11/29, Perpendicular Baseline -76 m, 1051 days), g) interferogram orbits 03836-10850 (period 96/01/14-97/05/18, Perpendicular Baseline 97 m, 490 days); h) interferogram orbits 03836-18365 (period 96/01/14-98/10/25, Perpendicular Baseline 138 m, 1015 days), i) interferogram orbits 03836-18866 (period 96/01/14-98/11/29, Perpendicular Baseline 50 m, 1050 days). A complete cycle of phase (purple, blue yellow) represents a decrease in range of 2.83 cm between the ground surface and the satellite.

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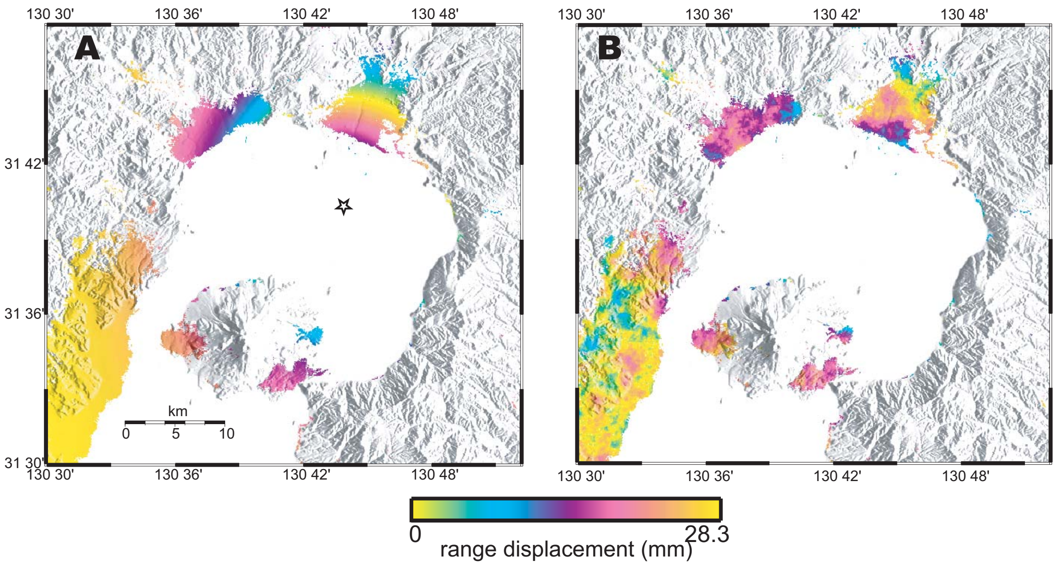

Figure 3: Simulated interferogram of a Mogi source at 10 km depth with volume change of 25x106 m3. Black star indicates the localisation of the deformation source.b) A noisy interferogram obtained from addition of (a) and a simulated noise using interferogram noise structure similar to those observed in the study area (variance of 15 mm2 and correlation length scale of 1600 m). Note that only Kokubu urban area exhibits a phase pattern induced by the volume change within the source. In other areas, the surface deformation signal power is below the detection threshold estimated roughly two or three times the noise variance (30-45 mm2).

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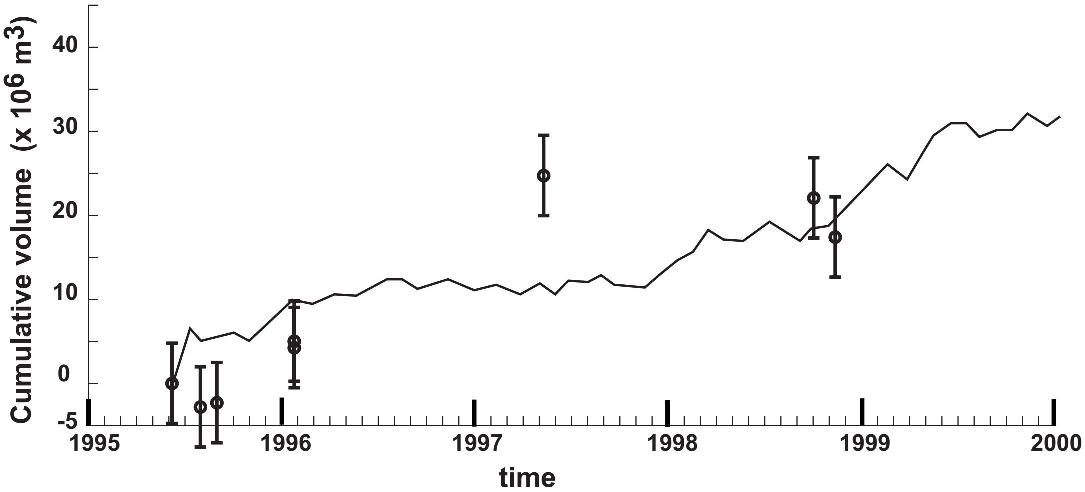

Figure 4: Thick line shows volume inferred from the analysis of the permanent GPS network (Kriswati and Iguchi, 2003) assuming zero volume at the beginning of the survey (May 1995). Black circles show volume inferred from ERS satellite radar interferometry assuming zero volume at the time of the first SAR images (June 1995). Using the overlapping interferograms, we estimate the rate of deformation between each pair of SAR images with a linear least square inversion. We plot the result as the cumulative volume within the source at the time of each SAR image. We assume a constant error for each measurement of 5 x 106 m3. As both times series began nearly at the same date, they are directly comparable. Note the agreement between volume inferred from GPS data and those inferred from ERS satellite radar interferometry.

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