Ground deformation induced by a strong squall line: A case study in the Weihe Basin, North China

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During 31 July to 1 August 2013 a severe squall line crossed the Weihe Basin, Shaanxi Province, which caused hazardous weather. The aim of this work is to investigate the influences characteristics of squall line on the measurements of fixed-point crustal deformation in detail, and to improve our understanding of atmospheric pressure loading signals in pendulum tiltmeter, watertube tiltmeter, extensometer and borehole dilatometer observations during the passage of squall line. In the present work, we systematically analyze the tilts and strains with 1-minute resolution of the shallow crust at Baoji, Qianling, Xi’ an and Huayin observatories induced by the passage of a squall line using the Doppler radar, atmospheric pressure and outdoor air temperature records so on. The results show that: (1) The atmospheric pressure jump over a short time span produced by squall line is the dominant driving force for the pressure-induced crustal deformations, the maximum magnitudes in pressure-induced tilt and strain mostly reach up to 10.8×10^{-3}″and 28.48×10^{-9}, respectively. (2) It is observed that the relationship between the variation in amplitude of atmospheric pressure and the magnitude of elastic deformation of shallow crust shows a good linear variation, their durations are almost same, which range from 2 to 4 hours. Further, the atmospheric pressure coefficient of crustal deformation can reach up to 4.52×10^{-9} /hPa. (3) The responses of observatories Baoji, Qianling and Huaying to atmospheric pressure loading are much better than Xi’ an observatory, which imply that the rock cover of Xi’ an observatory has low modulus of elasticity. Meanwhile, the effective physical transfer mechanisms for atmospheric loading are strongly influenced by the controlling factors, such as rock integrity, rock strength, cavity and topographic effects. (4) Quasi-synchronous responses of signals in vertical pendulum tiltmeter, extensometer, and borehole dilatometer data to atmospheric pressure loading are very well excepting the watertube tiltmeter. The results obtained can be used for identifying and determining reasonably the physical mechanism of anomalous changes in measurements of crustal deformation as a result of squall line aiming to avoid wrong interpretation. Furthermore, the results can contribute to the selection of future observation sites, and give helpful indications for the location of instrument sites promising a low atmospheric pressure influence as well as for evidencing the atmospheric loading models on various spatial scales. In addition, the results also provide the crucial constraints for further numerical modeling with regard to physical transfer mechanisms.

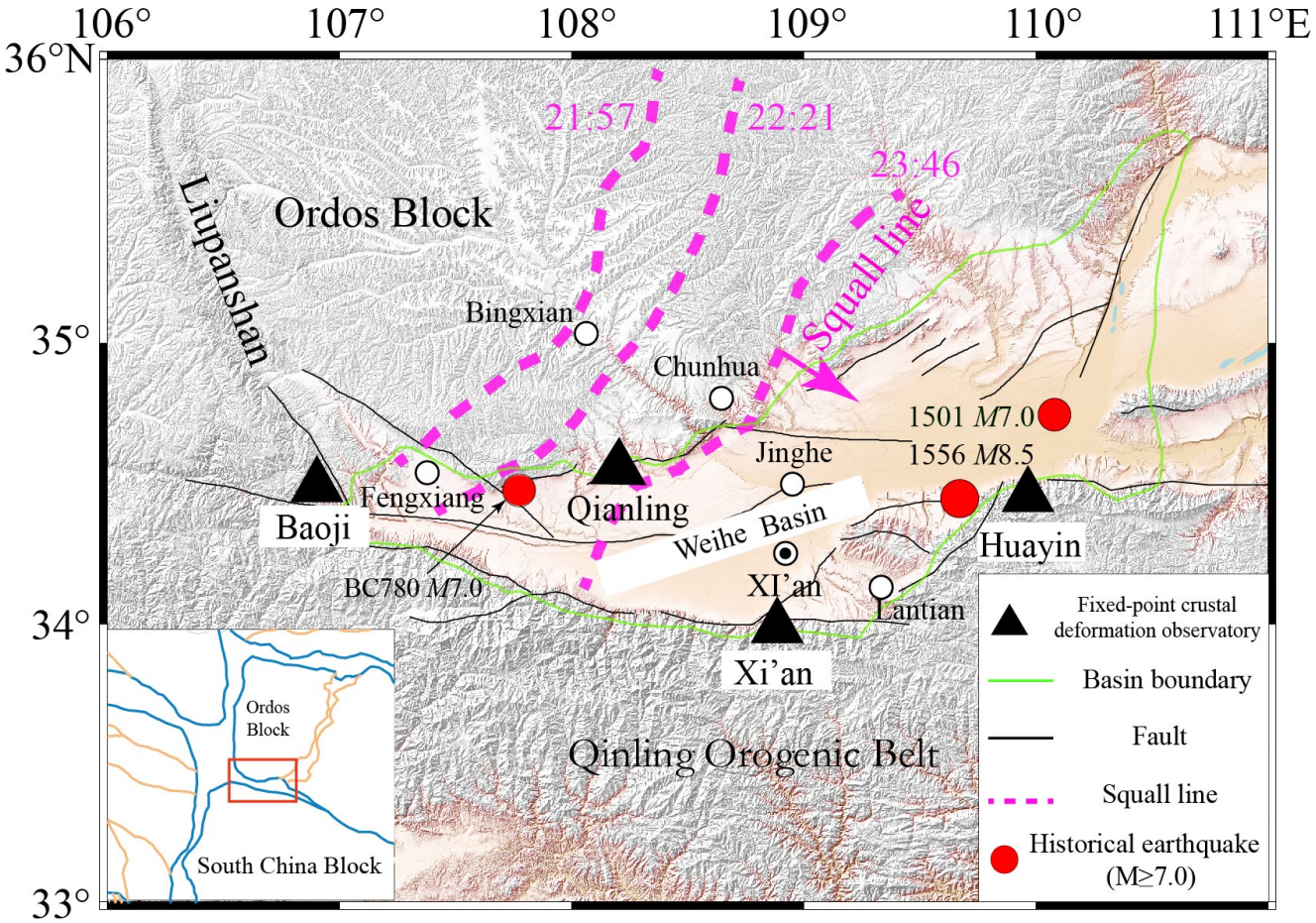

Fig. 1. Schematic depiction of the approximate position and extension of the strong squall line on 31 July 2013 (simplified and modified from Niu, et al, 2014), red circles, and black triangles denote epicentral distribution of the large historical earthquakes as well as locations of the fixed-point crustal deformation observatories, respectively. Inset map (lower left corner) shows the tectonic setting of the Weihe Basin.