Present-day deformation of anticlines in an active foreland fold and thrust belt measured from ALOS-1 InSAR and GPS: the Southwestern Taiwan case.

Erwan Pathier¹, Bénédicte Fruneau⁴, Jyr-Ching Hu³, Marie-Pierre Doin¹,², Yu-Tsu Liao⁴, J. Champenois⁵

¹ University of Grenoble, ISTerre (France)
² CNRS, ISTerre (France)
³ National Taiwan University, Dpt. Geosciences, Taipei (Taiwan)
⁴ University Paris-Est, GTMC (France)
⁵ IRSN, Fontenay aux Roses (France)
Taiwan Seismicity (1991-2006)  
Source: CWB

SW Taiwan Seismicity:

- South of Tainan city: almost no instrumental shallow (0-15km) seismicity.
- Seismicity can not be used to identify upper-crustal tectonic structures.

Alternatively, geodetic strain map may give some clues on where elastic energy accumulates.
GPS velocity map relative to Penghu
Chen et al., 2014

SW Taiwan Extrusion Model (e.g., Lu C.Y. and Malavieille 1994, Lacombe et al. 2001)
Ching et al. EPSL 2007
InSAR Processing

- 18 ALOS-1 PALSAR ascending images 2007-2011
- Track 447.

- Small Baseline approach (NSBAS, Doin et al. 2011)
  - including DEM correction before unwrapping
  - ERA-I atmospheric correction

Preliminary results on overlapping track 446 show consistent results.
ALOS-2 Data
Mean velocity map (2007-2011)
Ascending orbit.
Comparison with GPS and Levelling

[Graph showing GPS/INSAR LOS velocity comparison with GPS and Levelling data, with labeled points and data points indicating elevation and vertical velocity over distance.]
As in levelling data, there is an spatial offset between the pic of LOS velocity and the location of the Lungchuan ridge.
Lungchuan ridge
Comparison with geological structures

InSAR deformation centered at the apex of a ramp duplex anticline

Huang et al. 2004
4 March 2010  M. 6.4 Jiashian Earthquake
(occurring during the ALOS-InSAR observation period 2007-2011)

From Shiann-Jong Lee et al.
(http://www.earth.sinica.edu.tw/)

From Rau R-J. et al. 2012
From fluvial terraces study, Hsieh et al. 2001, have shown that over the last several thousands years, some areas show tectonic uplift (with an average rate of several mm/year).

Example of the Lungchuan anticline.

Comparison with geodetic observation with long-term (Holocene) deformation.

Comparison with INSAR data.

Hsieh et al. 2001
• 1km-width velocity discontinuity from Jinan Mt. to Shaoshan:
• Primarily right-lateral
• Associated with mud-volcanoes

Shyu et al. 2005
On-shore / Off-shore structures prolongation

As shown in several previous studies, onshore tectonic structures extend off-shore (e.g. Liu C.S. et al 2004)

From Chen Song-Chuen et al. 2014 (adapted from Lin et al. 2009)
Several active structures accommodating the southwestern Taiwan deformation can be precisely identified during the interseismic period:

- A series of en-echelon Folds that seems to be controlled by a N-S detachment ramp with a gradient of deformation from south to North.

- More frontal folds that seems to continue off-shore.

- Right-lateral shearing continuing off-shore accommodating the extrusion. May be controlled by WNW-ESE steep lateral ramp at depth. (inherited normal fault ?)

- High rate of aseismic deformation (up to several cm/y), suggesting creep on the detachment.

- At least a part of the aseismic interseismic deformation is consistent with long-term deformation: suggests part of permanent deformation and not only elastic deformation.

- However several strike-slip faults do not show a localized deformation signal => they may be locked during the interseismic period and are then possible candidates for Earthquakes.