Monitoring of interseismic creep of the Longitudinal Valley Fault (Eastern Taiwan) using Persistent Scatterer InSAR with ALOS PALSAR data

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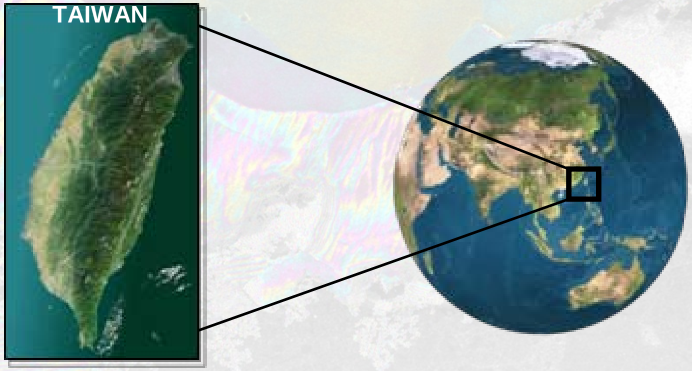
- **Complex geodynamic setting**: double inverse subduction (South and East)

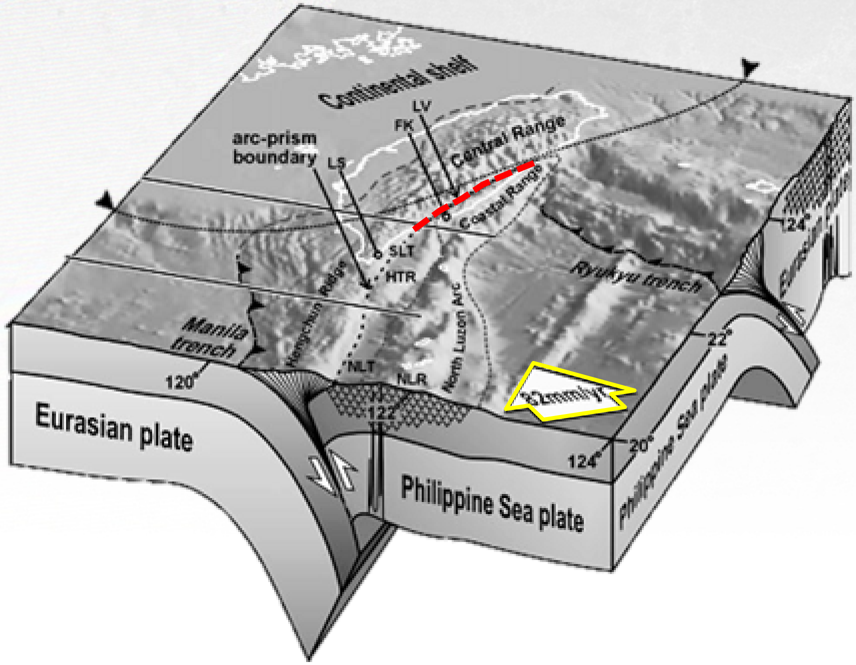
- High rate of convergence : **82 mm/year**

- About **30%** of the convergence is accomodated across the valley [*Angelier et al., 2000*]

- **Major plate boundary** in between the Eurasian and the Philippines plates

- **Location** and **characterization** of the deformation across the valley





- Horizontal shortening **~30 mm/year** across the Longitudinal Valley [Yu and Kuo, 2001]

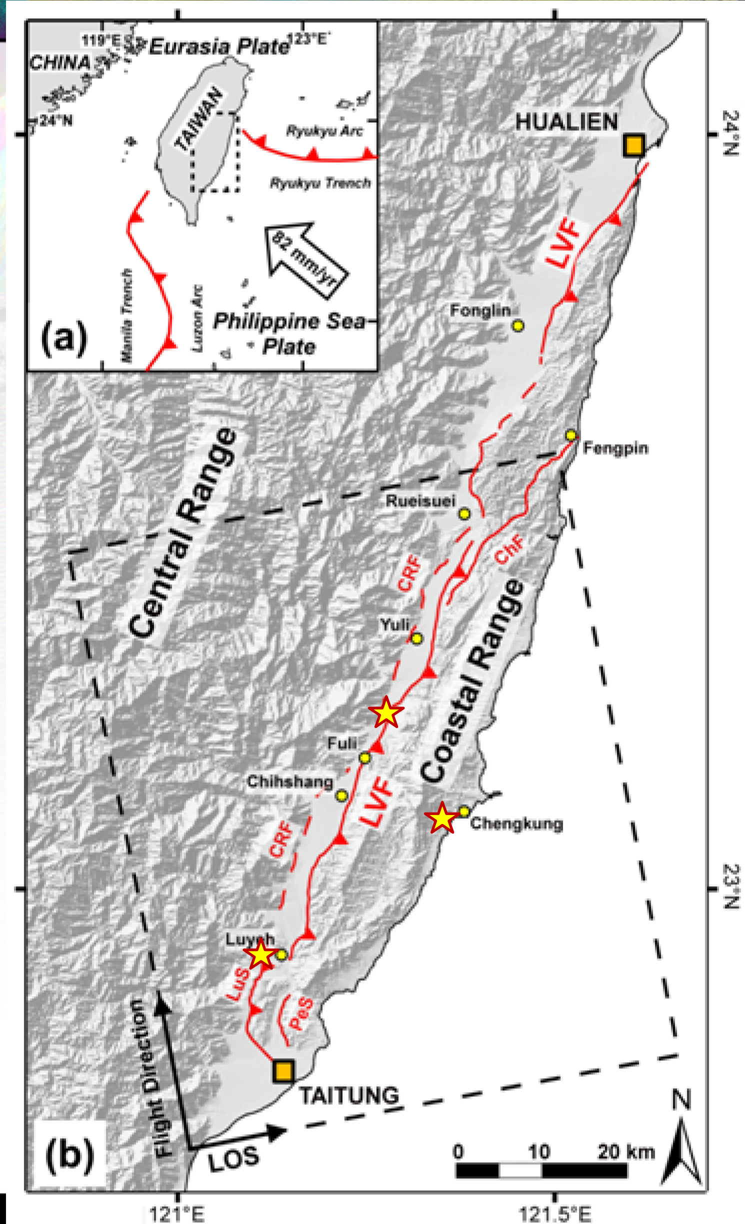
- Most active structure : **Longitudinal Valley Fault (LVF)** generating several major earthquakes

    - Chihshang en 1951, $M_L = 7.3$
    - Chengkung en 2003, $M_W = 6.8$
    - Peinan en 2006, $M_W = 6.1$

- Thrust fault showing high **interseismic creep** rate

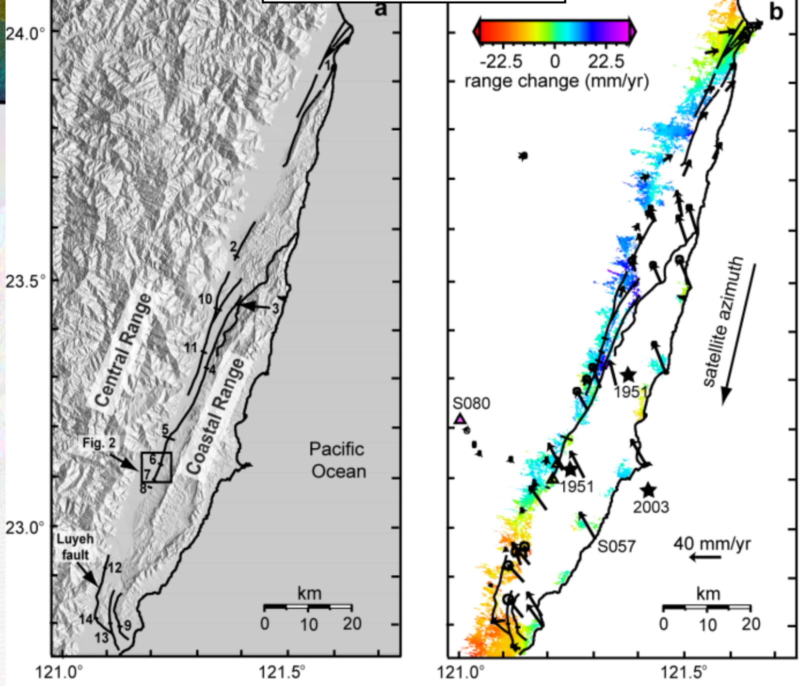
- Several studies based on **fieldwork** and **GPS network**

- **Rare and valuable case study** for understanding how faults work

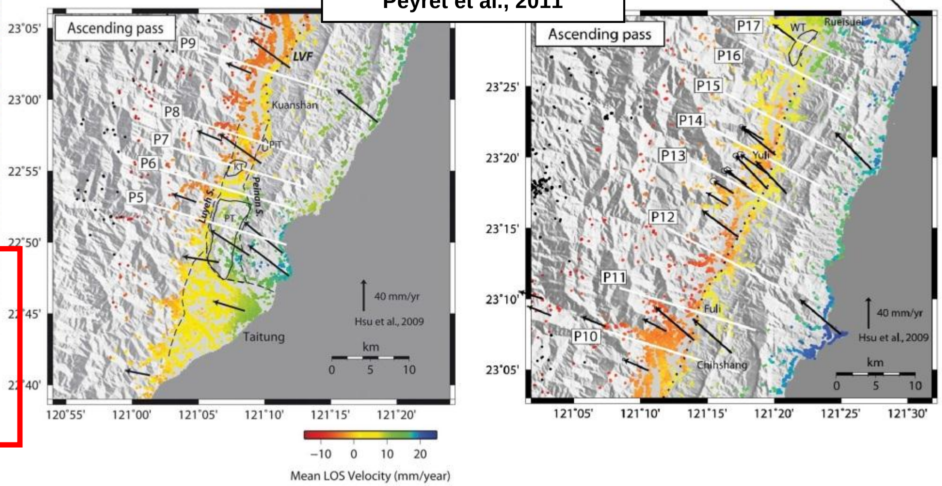


- Two previous published works using Radar Interferometry
    - One with **conventional DInSAR** [*Hsu and Bürgmann, 2006*]
    - One with **Persistent Scatterer Interferometry** (PS-InSAR) [*Peyret et al., 2011*]
- Both studies used **ERS C-band** data (λ = 5.6 cm)
- **Problems :**
    - **Low coherence** due to the luxuriant vegetation
    - **Low density of measurements**

In this study: **PS-InSAR** combined with conventional **DInSAR** using recent **ALOS PALSAR L-band** data



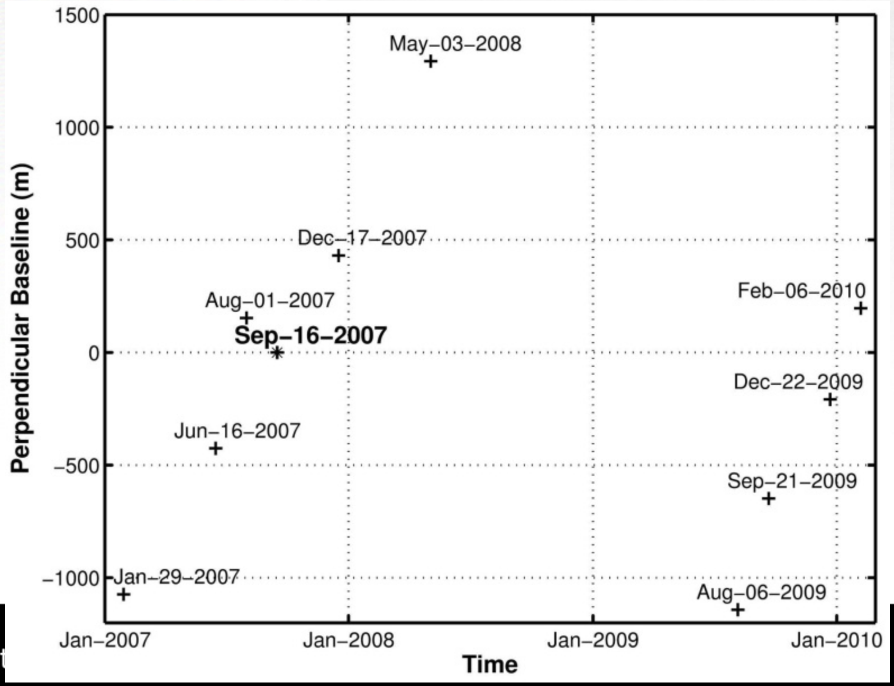
Hsu and Bürgmann, 2006



Peyret et al., 2011

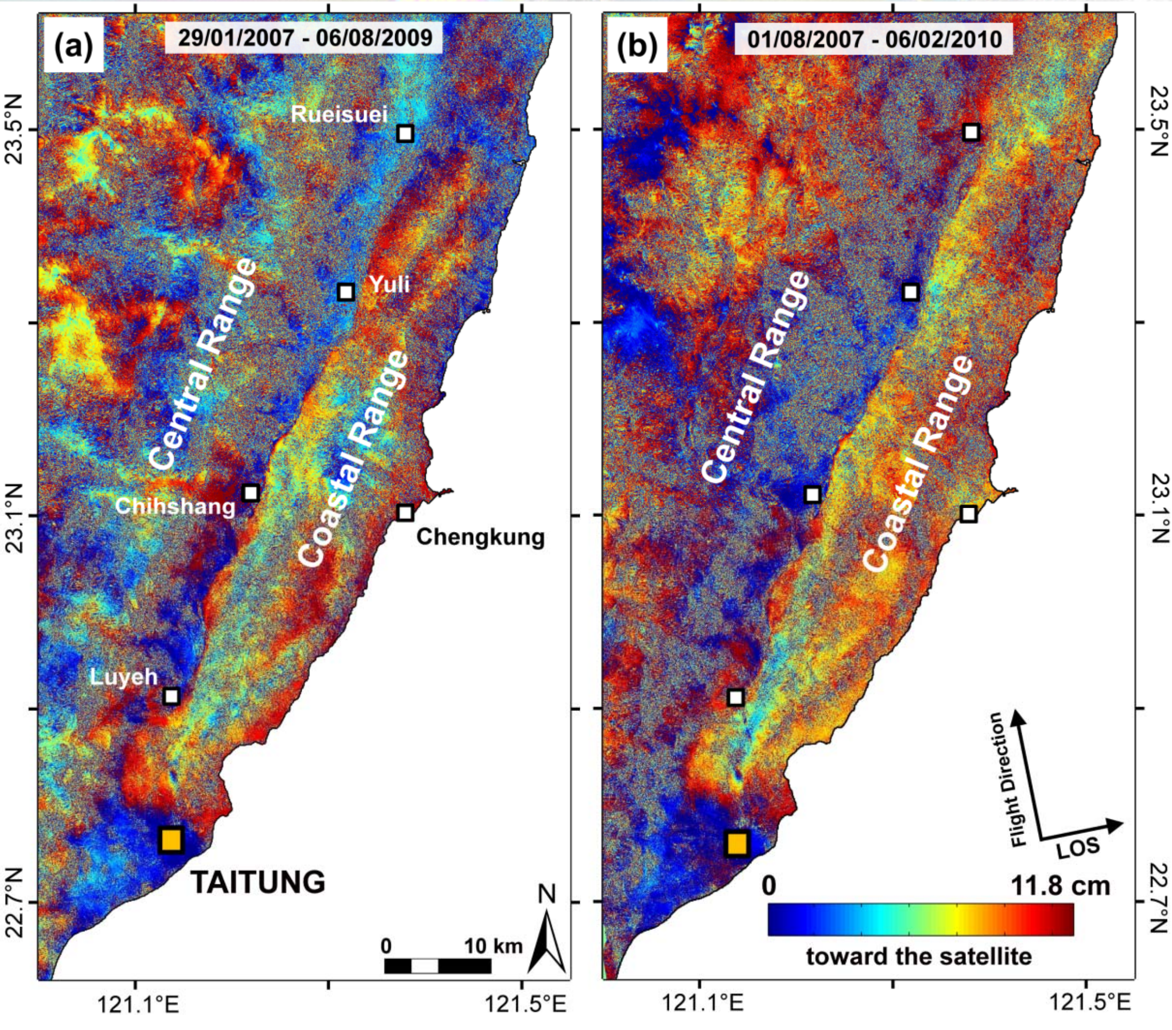
Methods and SAR data

- **DInSAR: conventional Differential Interferometry Radar**
  - Software : ROI_PAC (JPL, Caltech)
- **PS-InSAR**
  - Selection of scatterers with a **stable phase** over the whole period of study
  - Stack of interferograms with respect to one **« Super Master » image**
  - Processing chain used : **StaMPS** (Stanford Method for Persistent Scatterers) developed by Andy Hooper
    - **Use both phase and amplitude information** during the selection of the Persistent Scatterers
    - **No linear a priori of the deformation** for the re-construction of the time series of displacement
- **SAR Data**
  - **10 ALOS PALSAR** data in **L-Band** (λ = 23.6 cm), between January 2007 and February 2010



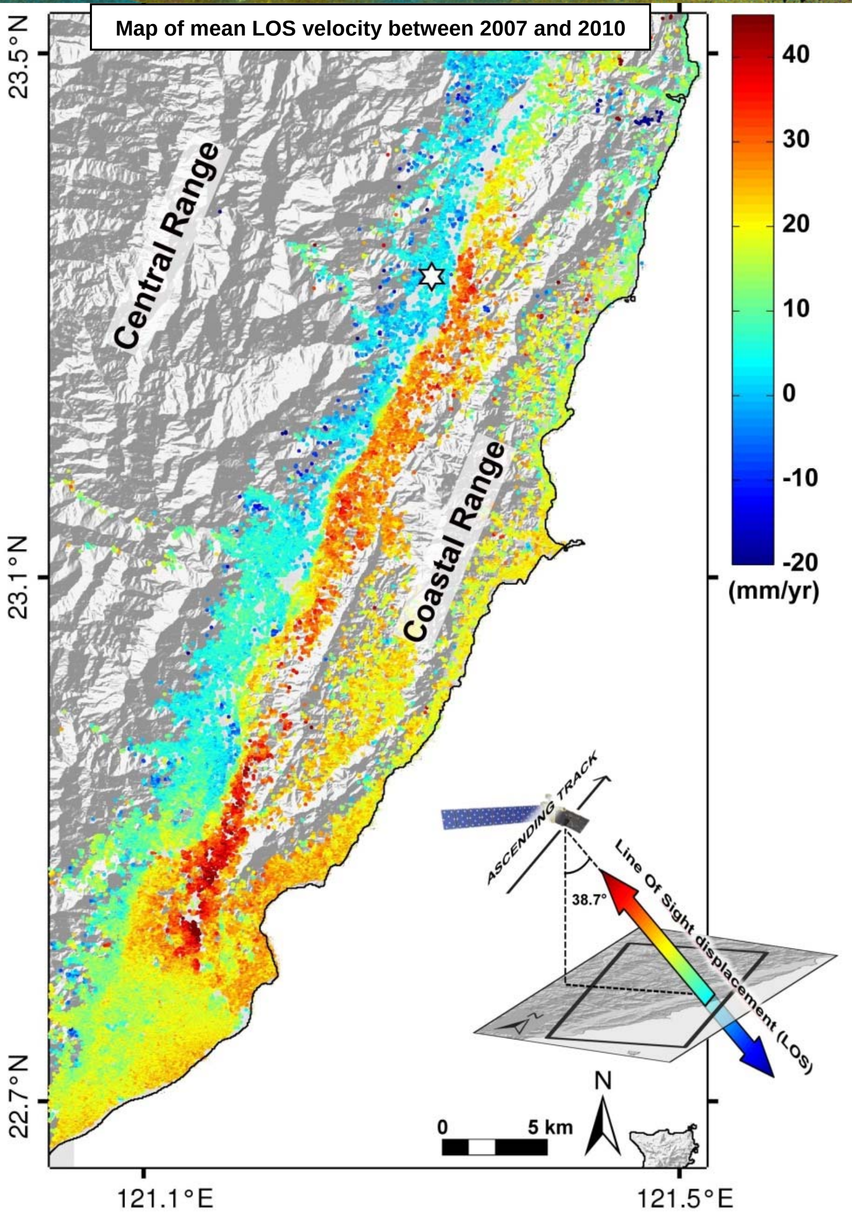
DInSAR results

- Example of **two independent interferograms**
  - B_{perp} < 100 meters
  - B_{days} = 920 days (2.5 years)
- **High coherence** on both interferograms
- **Clear discontinuity** between the Central Range and the Coastal Range close to the LVF
- **Interseismic creep of the LVF**



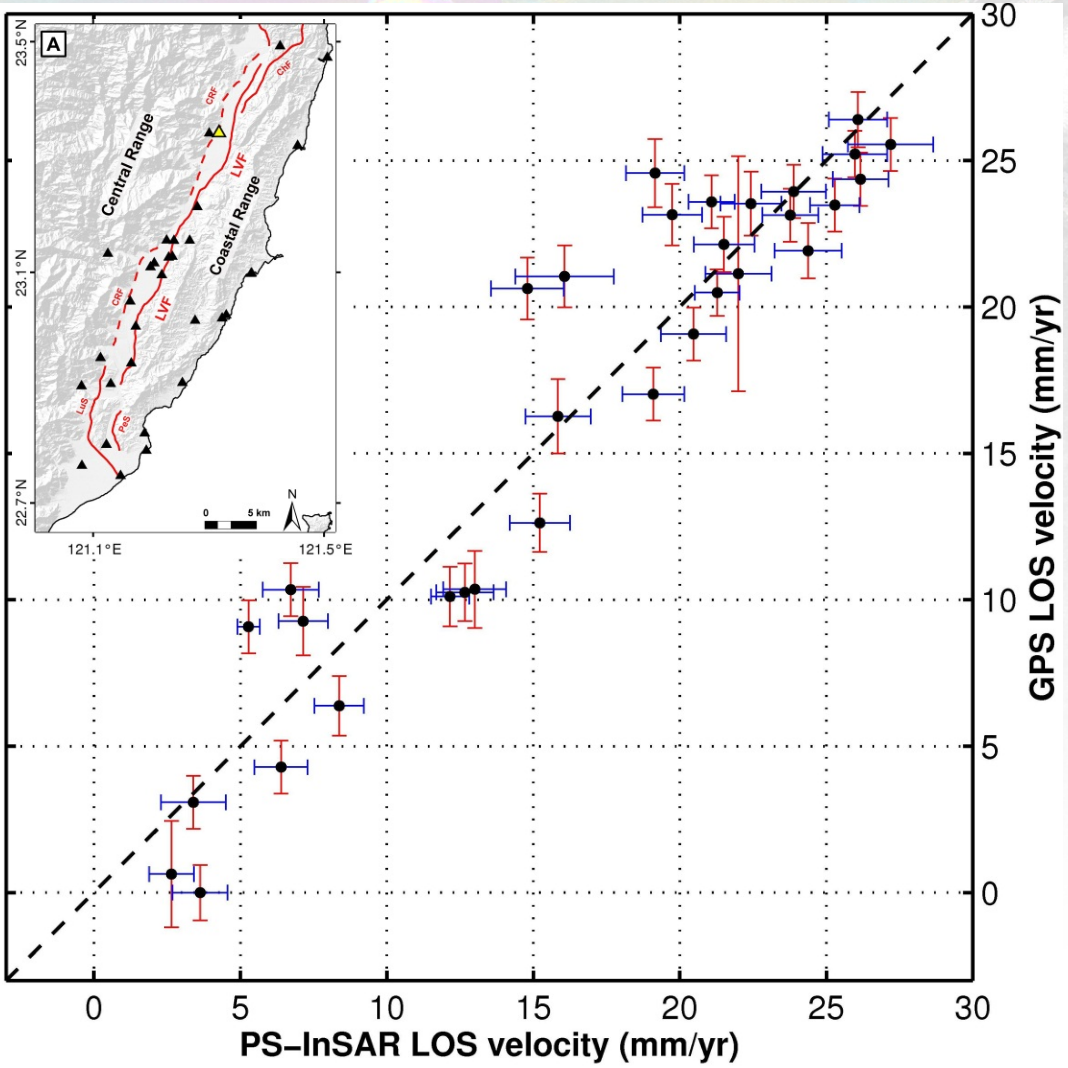
PS-InSAR results

- More than **73 300 PS** found
- PS density higher than **42 PS per km²**
- **Impressive density of measure** for such area of luxuriant vegetation
- **Two blocks** with different behaviours separated by the LVF
  - the **Coastal Range** which is clearly uplifting
  - the **Central Range and the valley** which are stable
- No significant deformation across the Coastal Range or the Central Range
- Allows a more **precise mapping** of the LVF



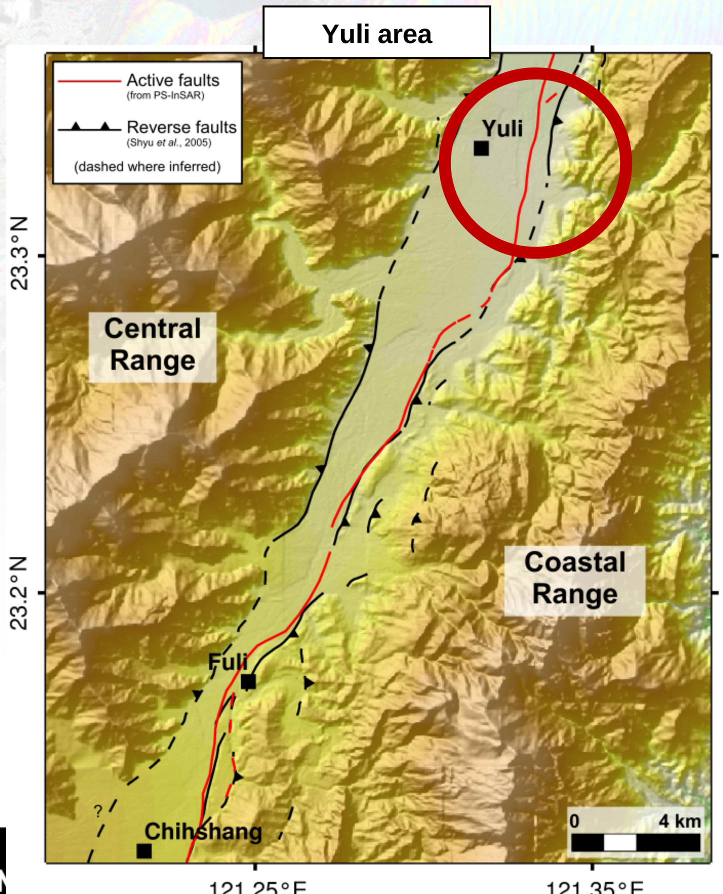
GPS comparison

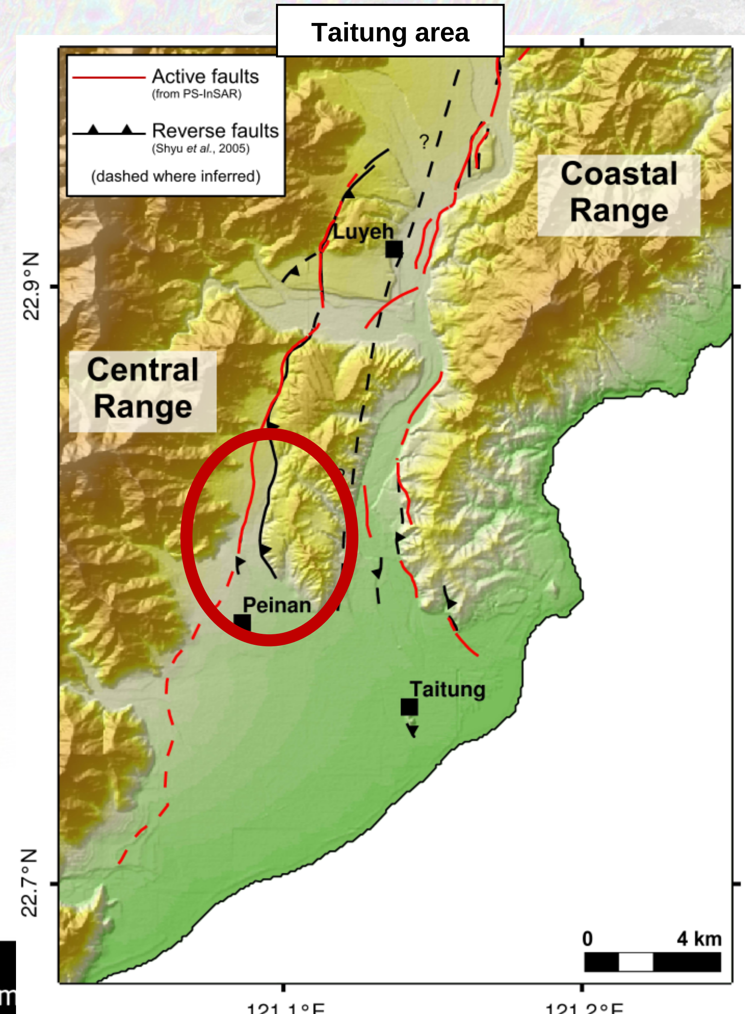
- **33** Continuous GPS stations
- **Same period of study** (2007-2010)
- **Conversion** of the three components into Line Of Sight velocities
- **Correction of PS mean LOS velocities** from this comparison
- **Very good agreement between both methods** (after correction)



Mapping faults and field investigations

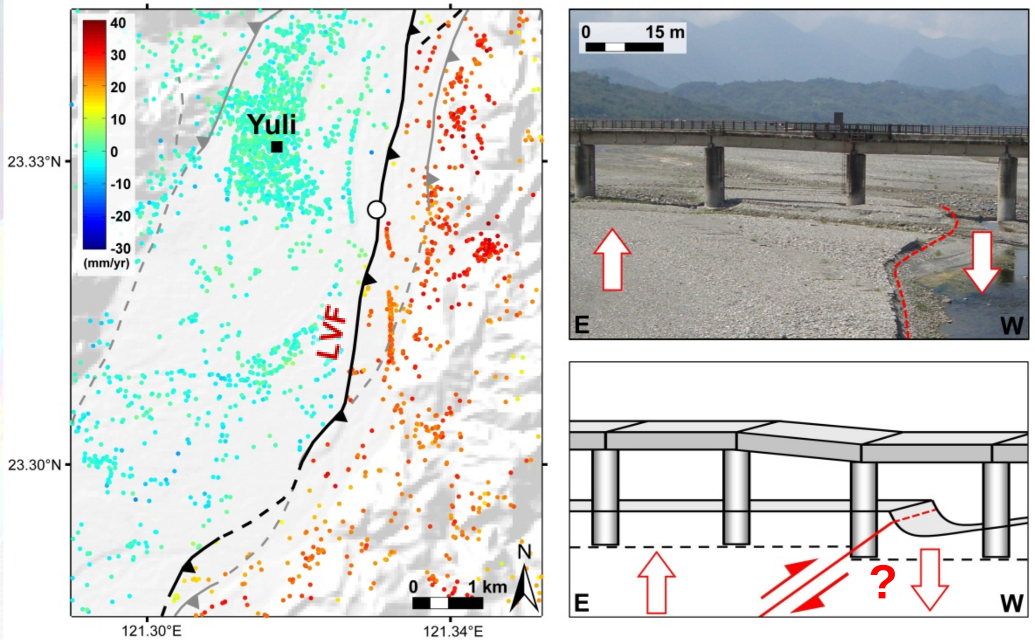
- **One previous map** of actives structures: Shyu et al., 2005
- **2 missions** on the field (2009 & 2010) → validate our updated faults map
- More than **35 markers of deformations** found

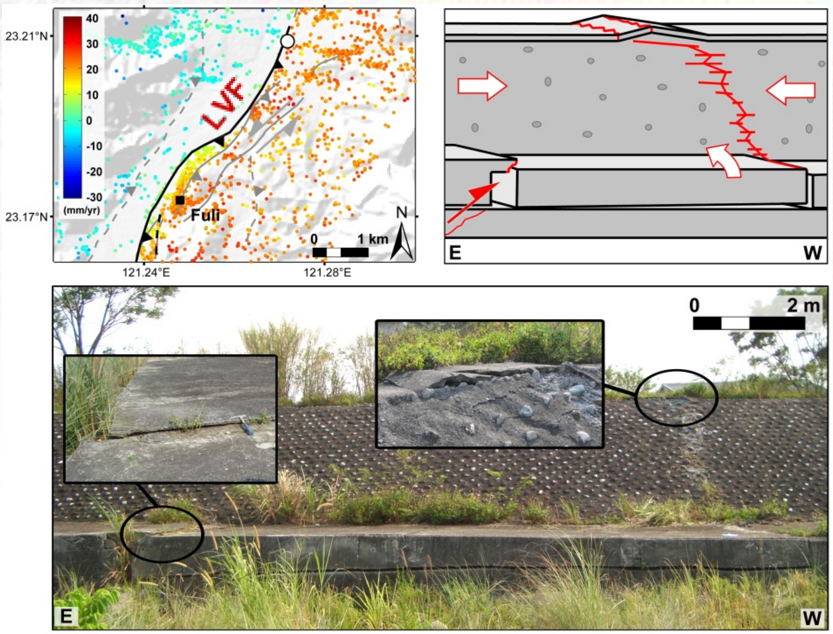




a) Yuli area

- Famous place of deformation: **Yuli Bridges**
- The two bridges are deformed by the LVF
- **Localized** surface deformation





b) Fuli area

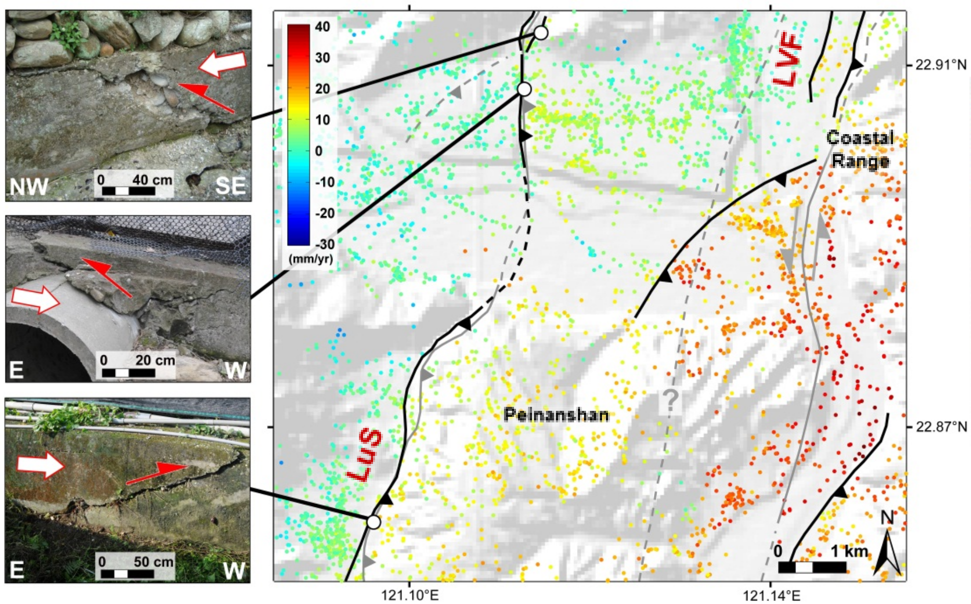
- Compressive deformation across a dike
- **Most narrow** place of the Valley (< 1km)
- **Highest rate** of deformation: ~32 mm/year

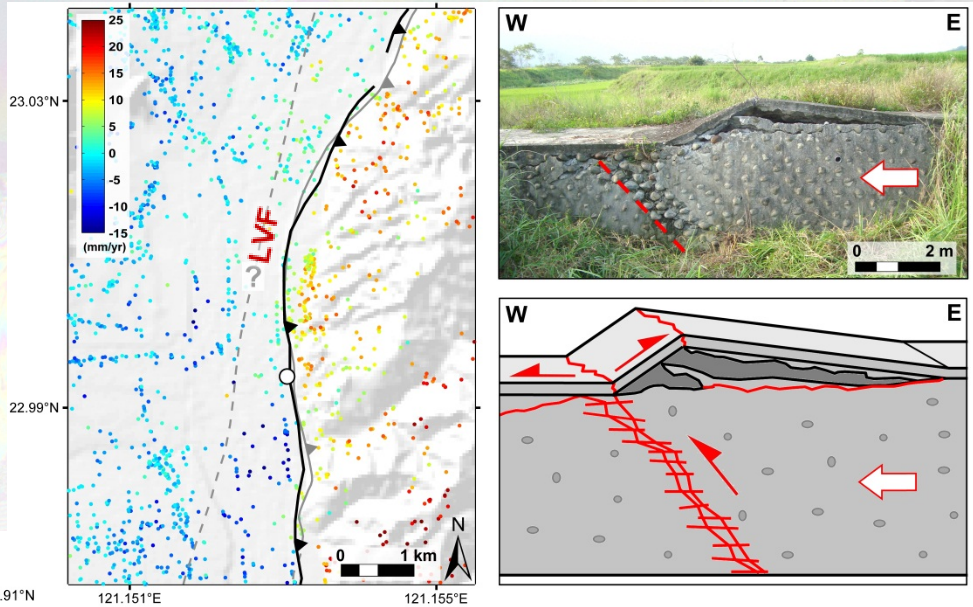
c) Chihshang area

➢Clear marker of a **thrust fault deformation**

➢**No doubt concerning the localization** of the LVF in this place

➢Would be interesting to **install a creepmeter** on this dike





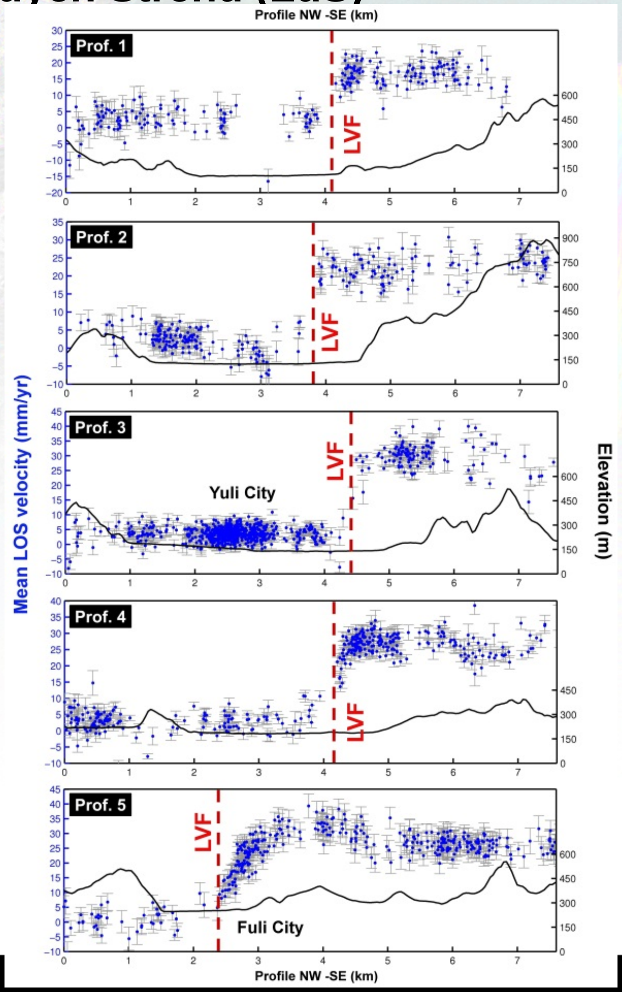
d) Luyeh area

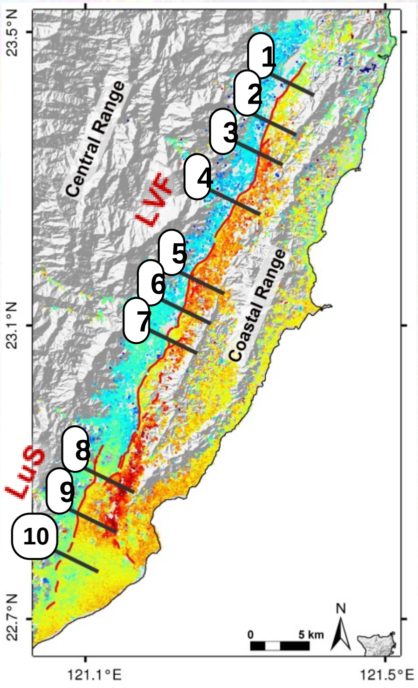
➢**Complex tectonic area** with the presence of two majors structures: LVF and LuS

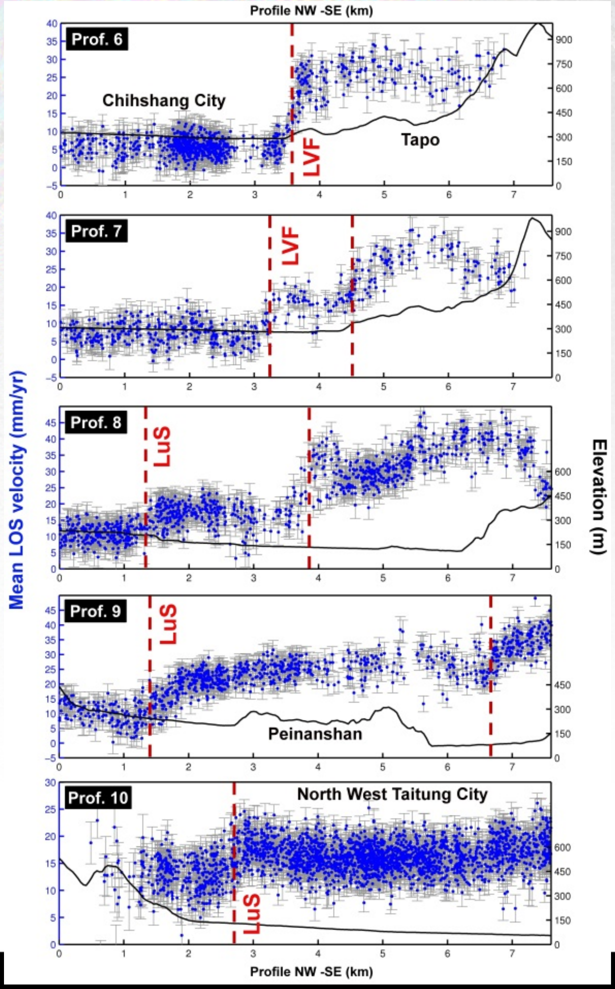
➢Clear evidence of the fault connecting the Coastal Range and the mountains of Peinanshan

Series of profiles

- Series of **51 close profiles** perpendicularly to the **Longitudinal Valley Fault (LVF)** and the **Luyeh Strend (LuS)**

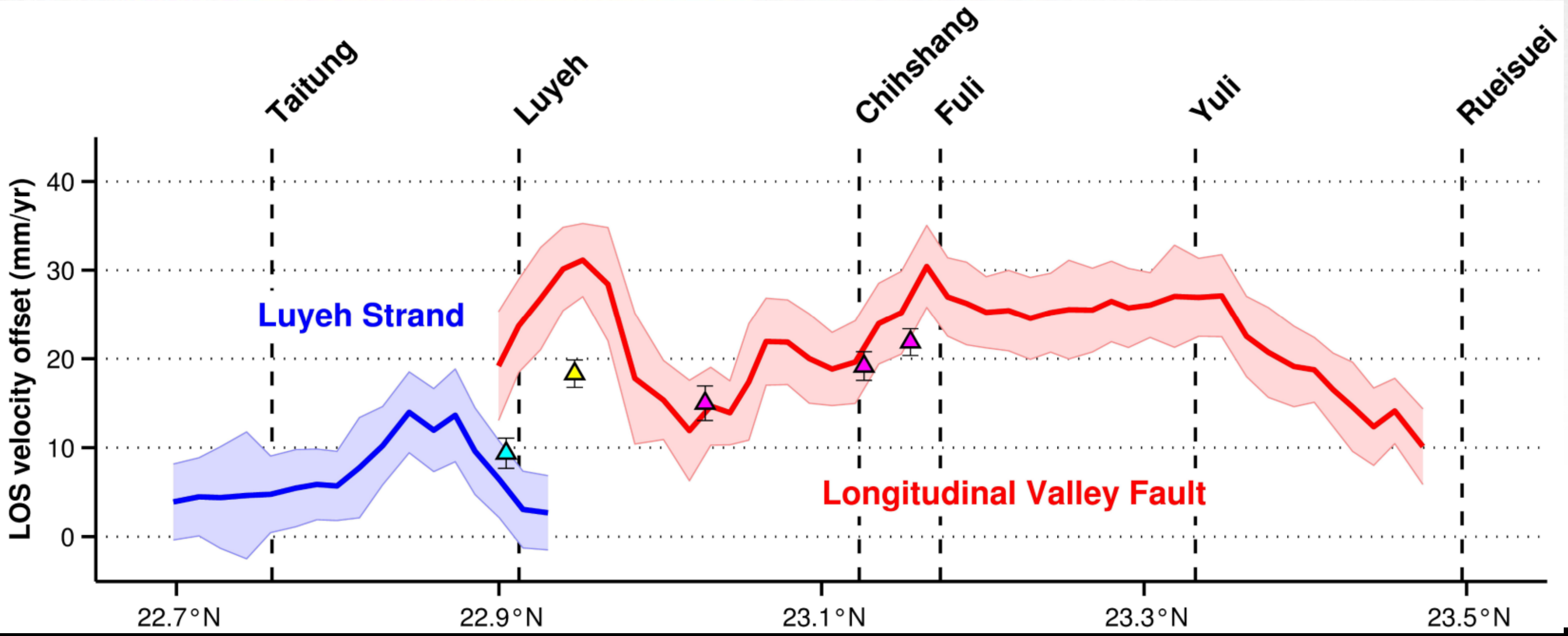






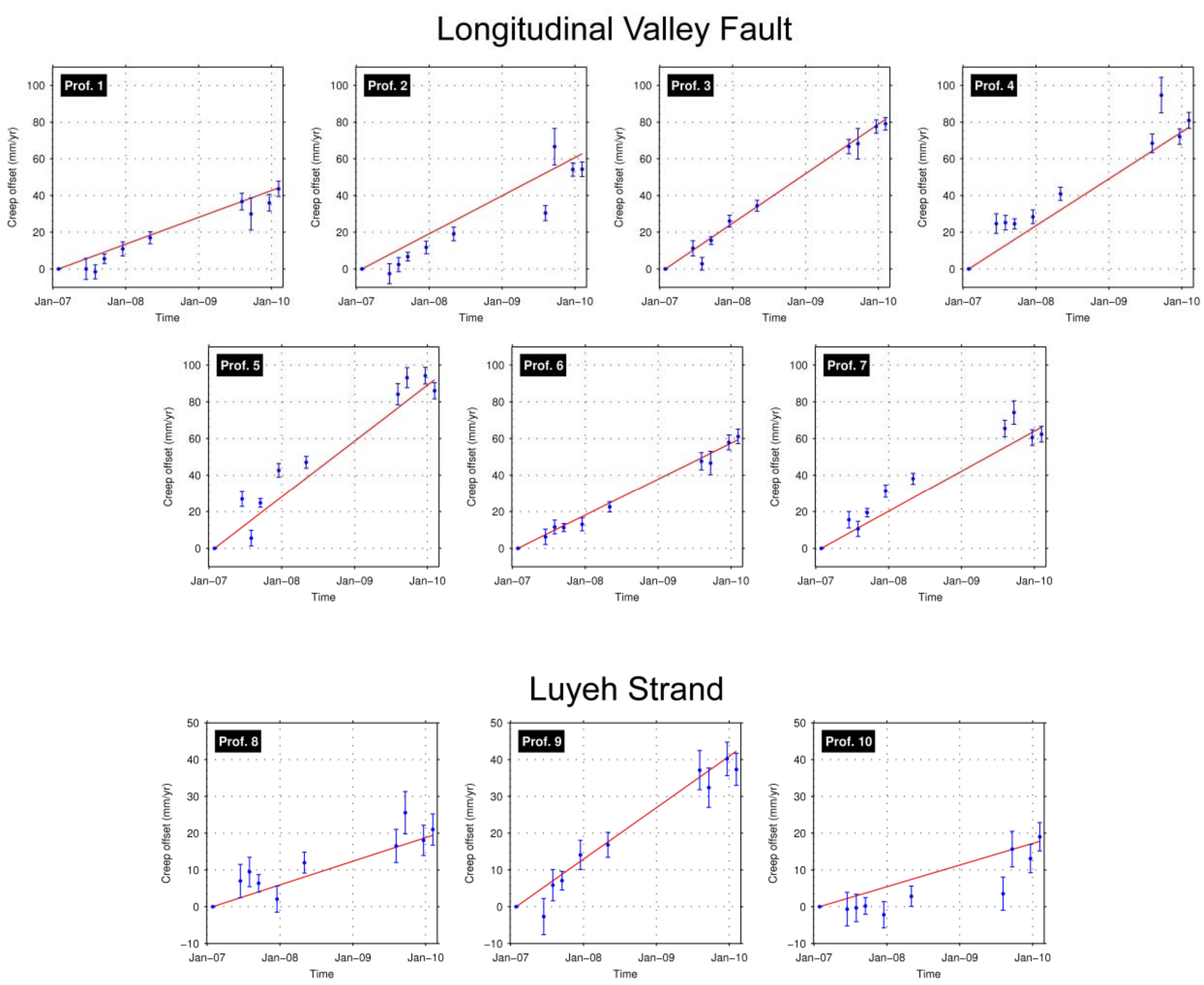
Fault creep estimation

- **Important variation** with the latitude
- Highest rate of deformation between Yuli and Fuli : ~ 26 mm/yr
- **Considerable spatial resolution** of measure allowing a better knowledge of the behaviour of both **LVF** and **LuS**
- Comparison with **creep rates estimated from GPS** data (triangles)



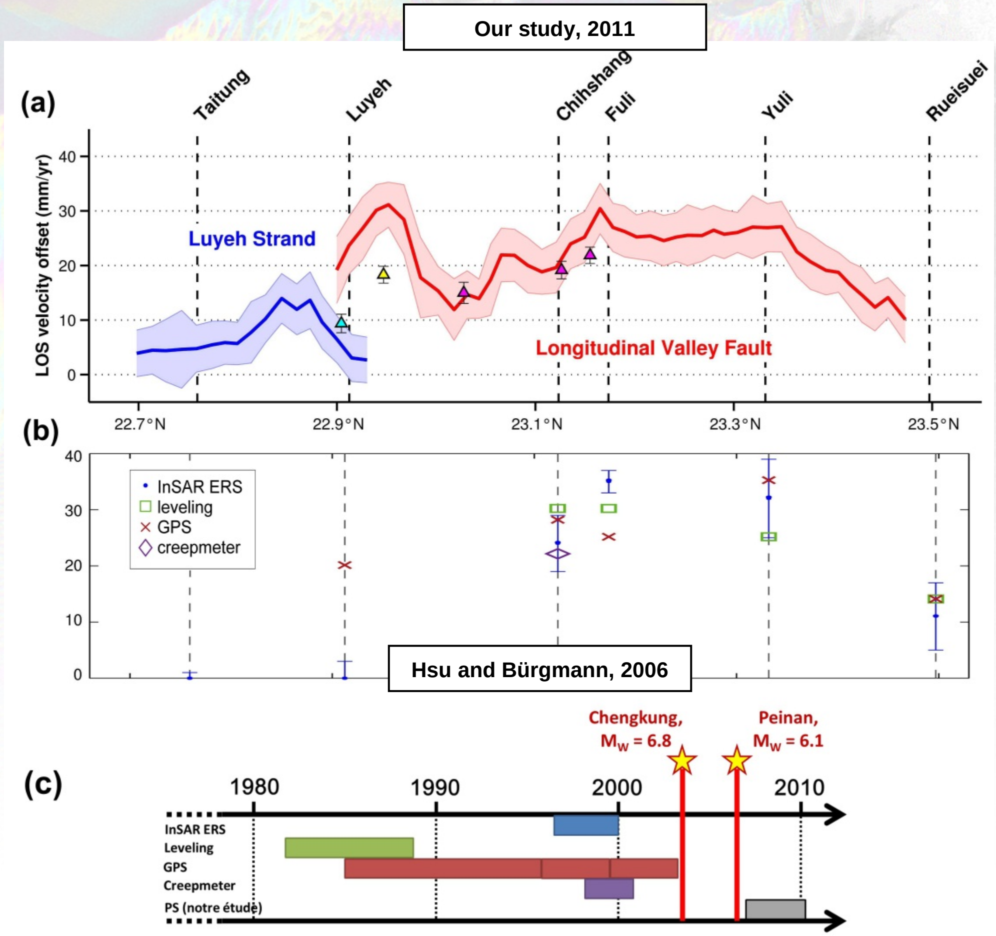
What about the temporal variation ?

- **Temporal series of creep** for each profile
- Mainly **linear deformations**
- **Not enough SAR data** to detect the unlinear component of the creep (seasonnal effect)



Comparison with Hsu and Bürgmann, 2006

- **Creep rates are comparable** to the other available data
- **High spatial resolution** allowing a better knowledge of the interseismic behaviors of the LVF and LuS.
- Characterization of the displacement only on a **3 year period** (01/2007 to 03/2010)
- **Two important seismic events** occurred between both studies



Comparison with Peyret et al., 2011

(preliminary results)

- Quantitative analysis :

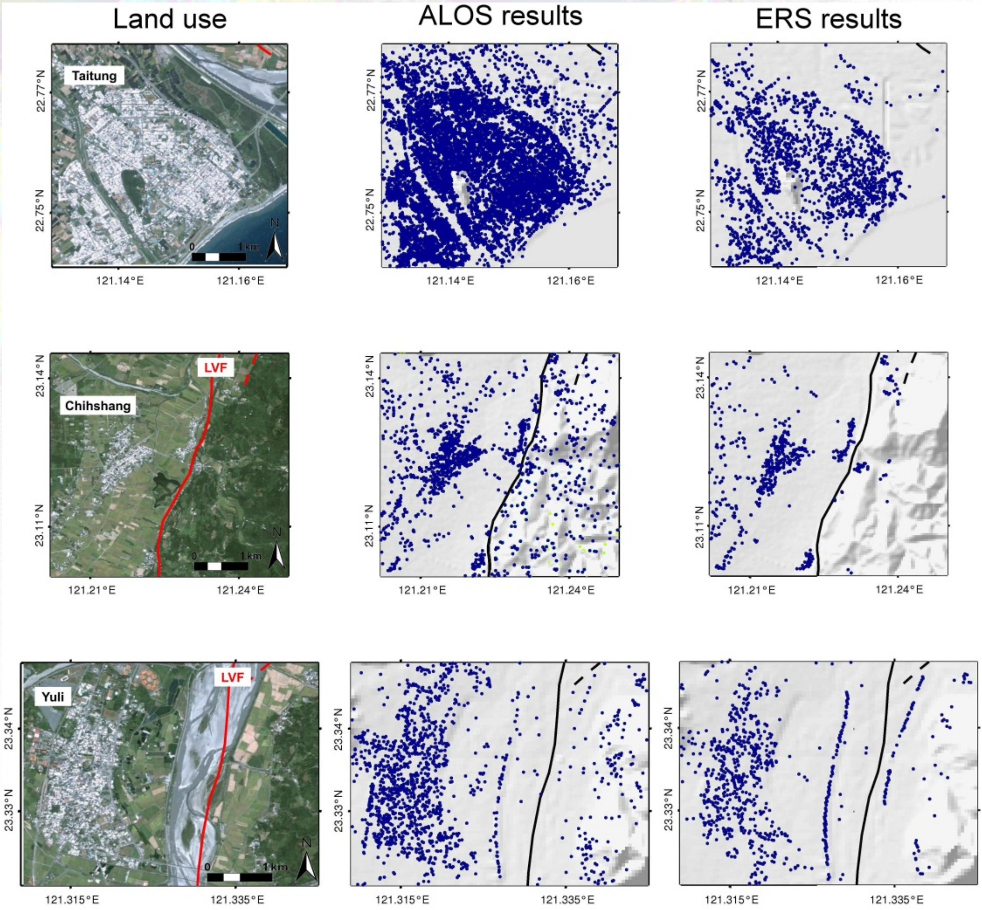
	ALOS		ERS		
Area	Nb. of PS	D (PS/km²)	Nb. of PS	D (PS/km²)	Factor
Taitung	*7834*	*489*	*1739*	*108*	***4.5***
Chihshang	*1429*	*57*	*537*	*21*	***2.7***
Yuli	*1410*	*117*	*787*	*65*	***1.8***

  - ALOS PS density higher than ERS PS density
  - More PS in areas of vegetation with ALOS

- **Qualitative analysis** : mean LOS velocity uncertainty
  - About **2-3 mm for ERS**
  - About **4-5 mm for ALOS**

Our study, 2011

Peyret et al., 2011



Conclusions

- L-band ALOS PS-InSAR in the Longitudinal Valley allows a dramatic improvement with respect to previous C-Band studies
- Correction and validation with GPS data
- Evidence of interseismic creep for the period 2007 - 2010 leading to an improved trace of the active sections of the LVF and the LuS (100 m accuracy)
- Field investigations to confirm our updated faults map
- Spatial creep rate estimation shows important variations that must be explained
- More SAR data are needed to detect and extract the nonlinear component of the deformation

THANK YOU

Creepmeter close to Chihshang

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