

INGV



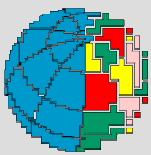
www.sigris.it



OPERATIONAL SERVICES BASED ON SPACE DATA IN SUPPORT OF SEISMIC RISK MANAGEMENT

Stefano Salvi
SIGRIS Scientific manager

Istituto Nazionale di Geofisica e Vulcanologia – Rome, Italy



INGV



www.sigris.it

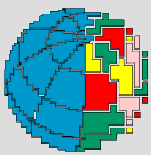


The SIGRIS system

SIGRIS is a HW/SW infrastructure devoted to the generation of information products to support Civil Protection activities for Seismic Risk management.

SIGRIS products are based on satellite imagery (mainly from the COSMO-SkyMed constellation) and integrate ground data where available.

SIGRIS is operated by INGV (scientific institution).



INGV



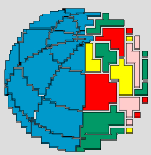
www.sigris.it



The SIGRIS product families

Knowledge & Prevention, i.e. support to the
Seismic Hazard assessment

Warning & Crisis, i.e. support to the
Emergency management



INGV



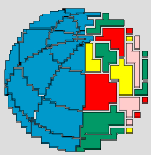
www.sigris.it



The SIGRIS demonstration

Knowledge & Prevention products are demonstrated for the Italian territory

Warning & Crisis products are demonstrated worldwide



INGV



www.sigris.it

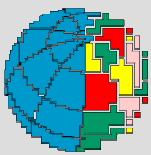


SIGRIS demonstration for earthquake crises in New Zealand and Japan

The Darfield earthquake of September 4, 2010

The Christchurch earthquake of February 22, 2011

The Tohoku earthquake of March 11, 2011



INGV



www.sigris.it



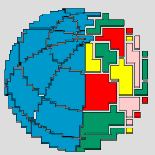
The Darfield and Christchurch earthquakes

The Darfield earthquake:

Magnitude 7.1, occurred September 4, 2010

The Christchurch earthquake:

Magnitude 6.3, occurred February 22, 2011



INGV



www.sigris.it

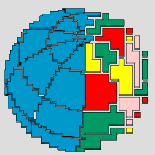


The Darfield earthquake, NZ

Magnitude 7.1

September 4, 2010

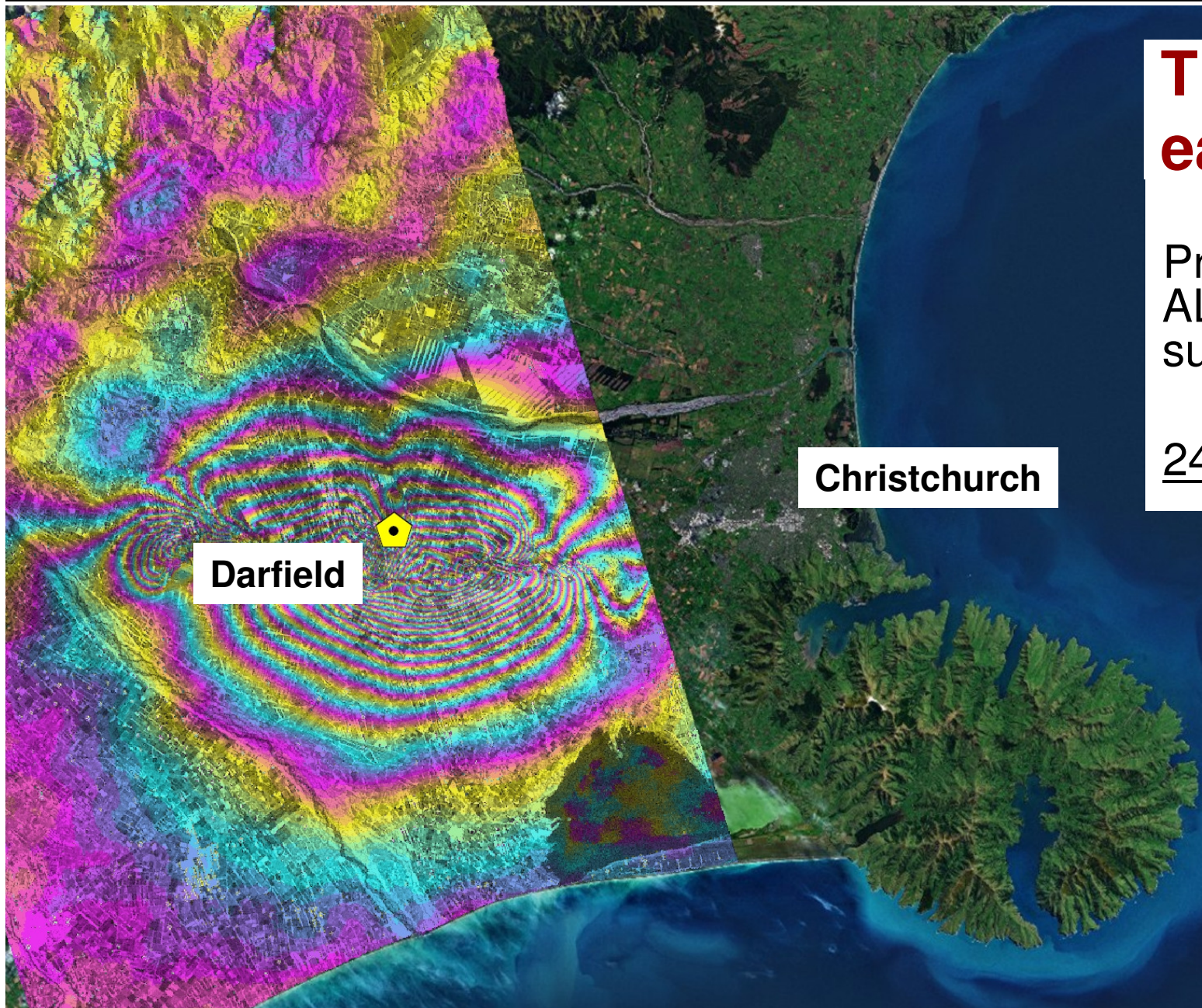




INGV



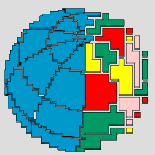
www.sigris.it



The Darfield earthquake, NZ

Pre- and post-seismic
ALOS imagery detect
surface deformation

24 days later



INGV

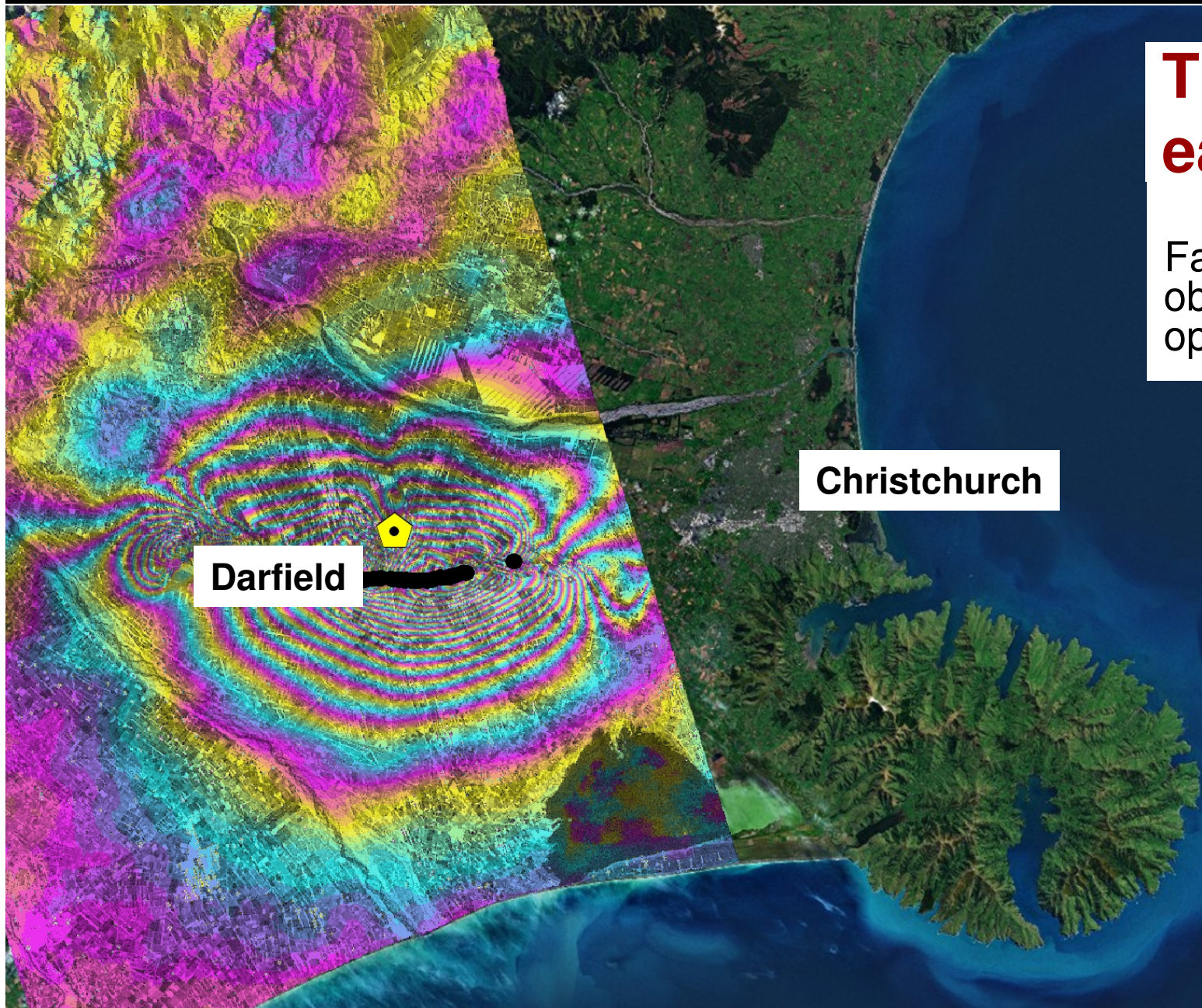


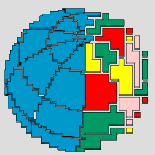
www.sigris.it



The Darfield earthquake, NZ

Fault rupture is clearly observed on SAR and optical images





INGV

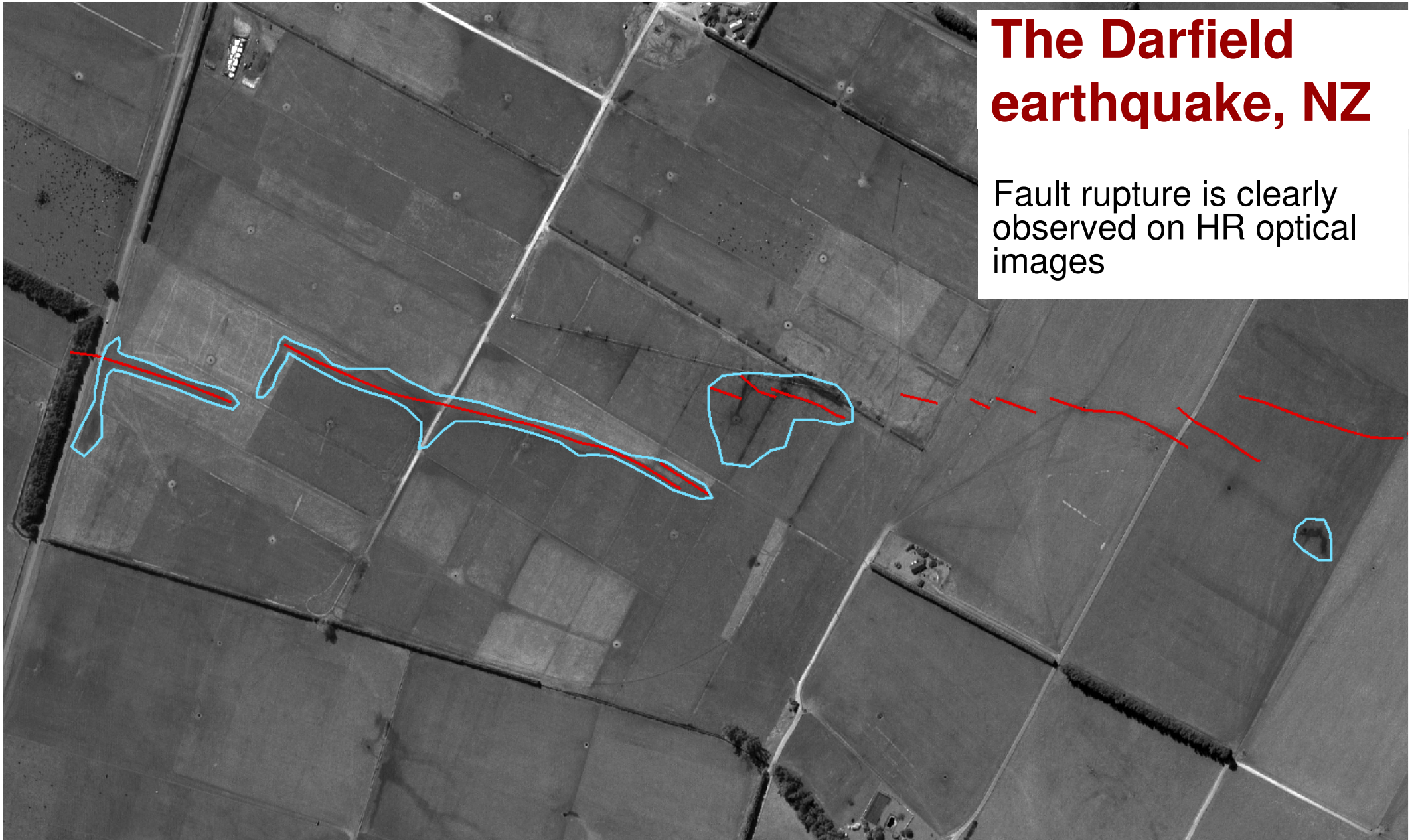


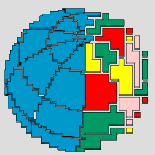
www.sigris.it



The Darfield earthquake, NZ

Fault rupture is clearly observed on HR optical images





INGV

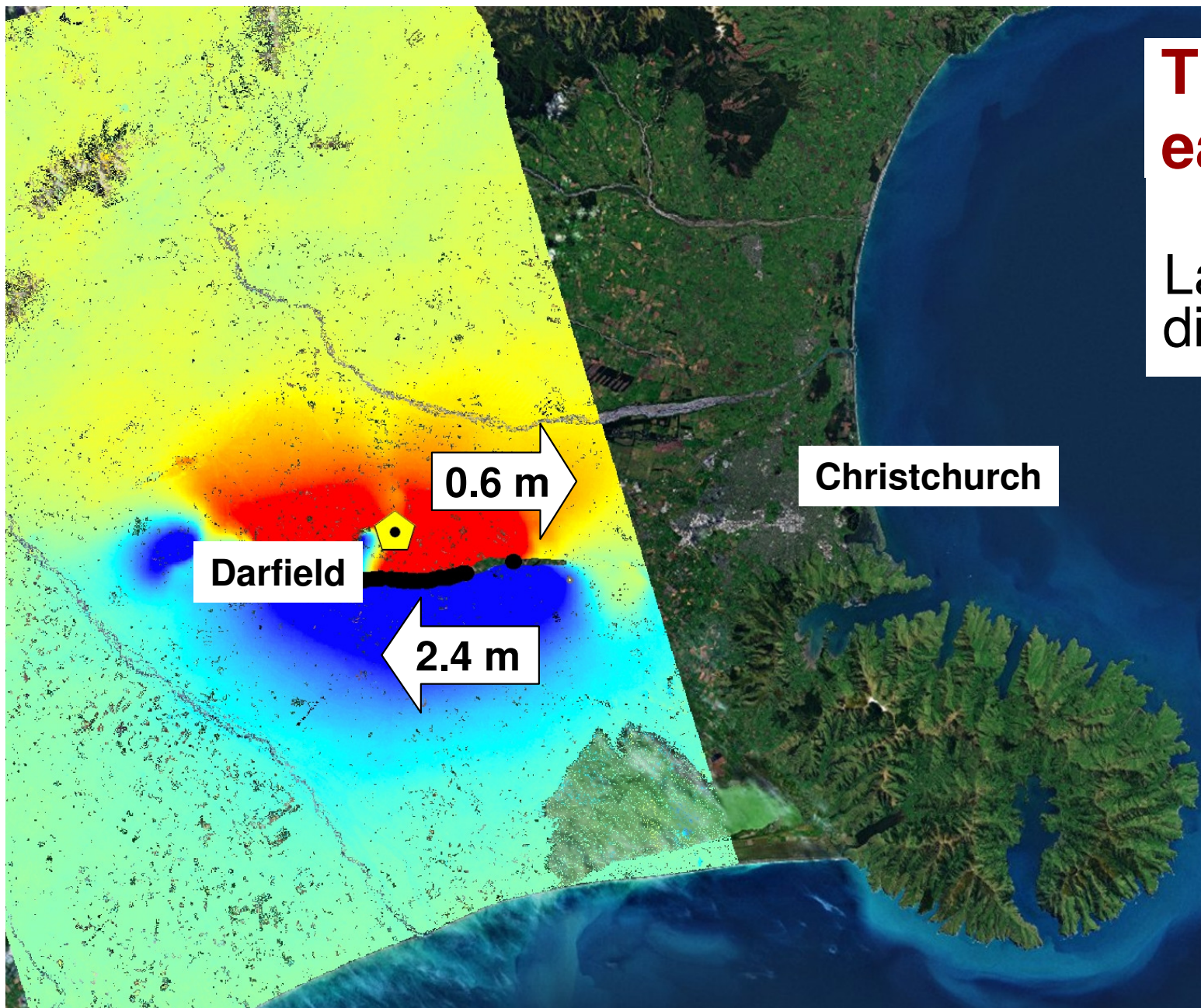


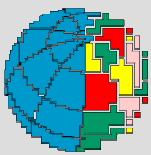
www.sigris.it



The Darfield earthquake, NZ

Large ground displacement





INGV

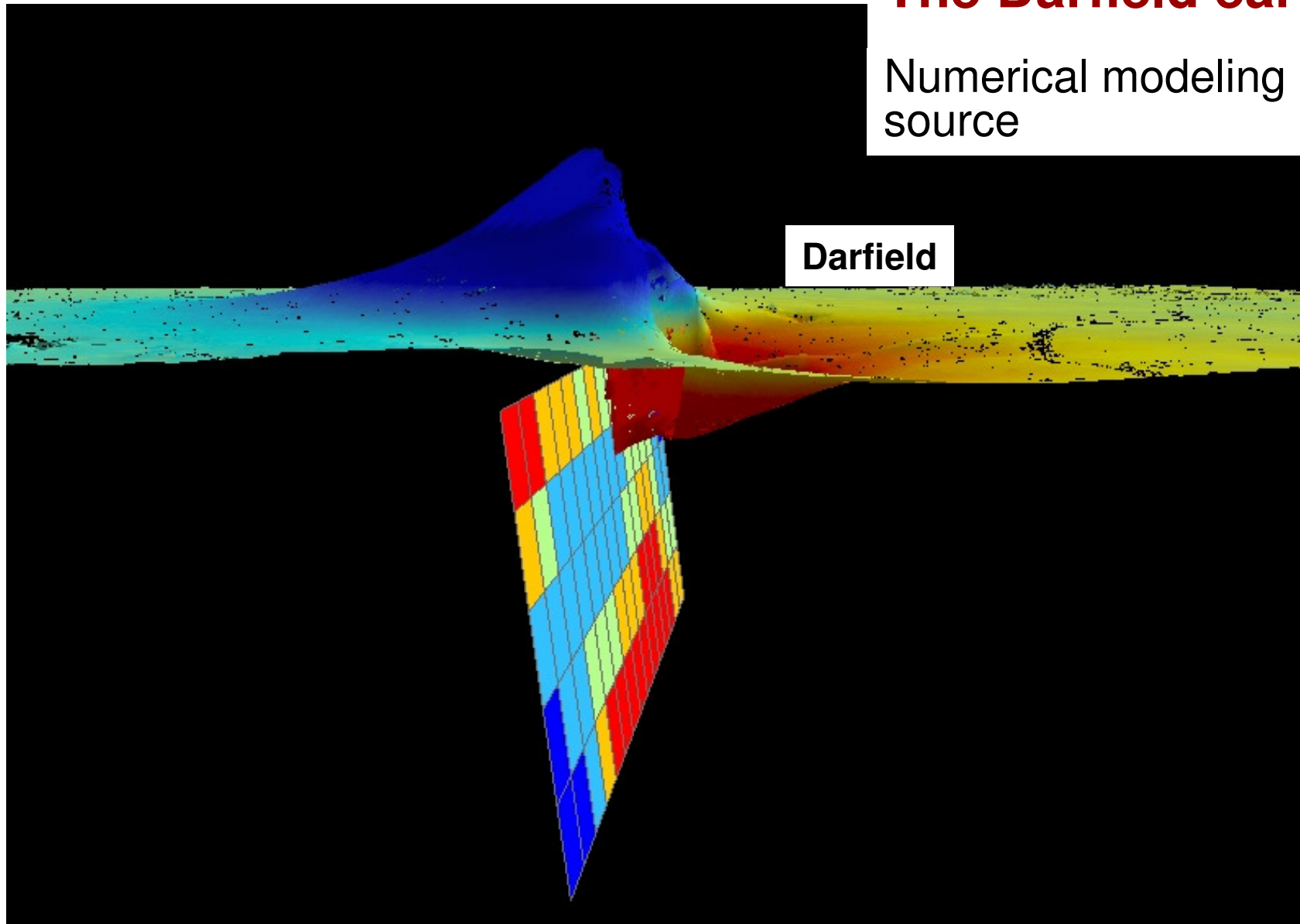


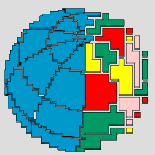
www.sigris.it



The Darfield earthquake, NZ

Numerical modeling of the seismic source





INGV

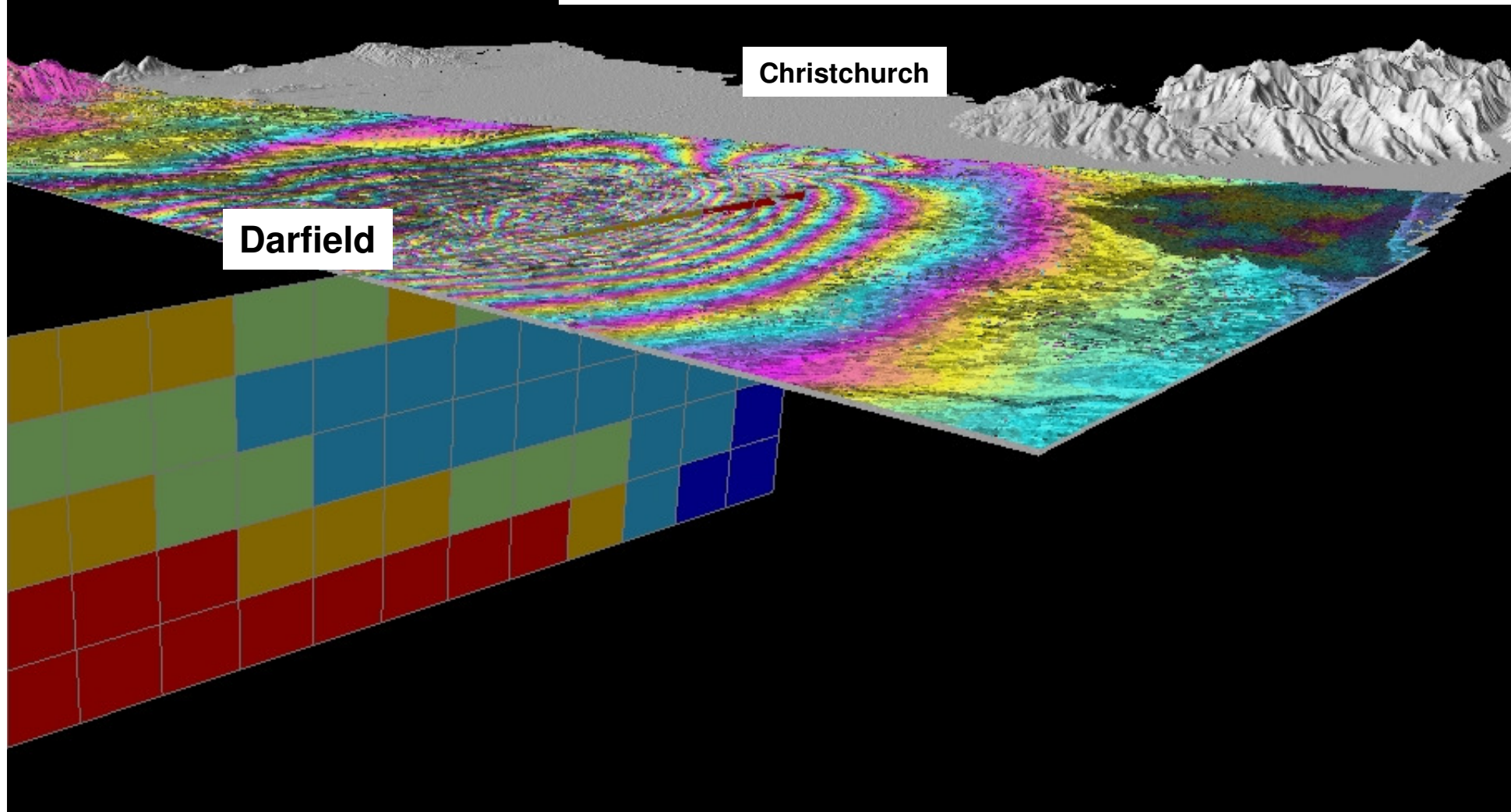


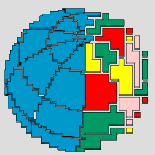
www.sigris.it



The Darfield earthquake, NZ

Numerical modeling of the seismic source

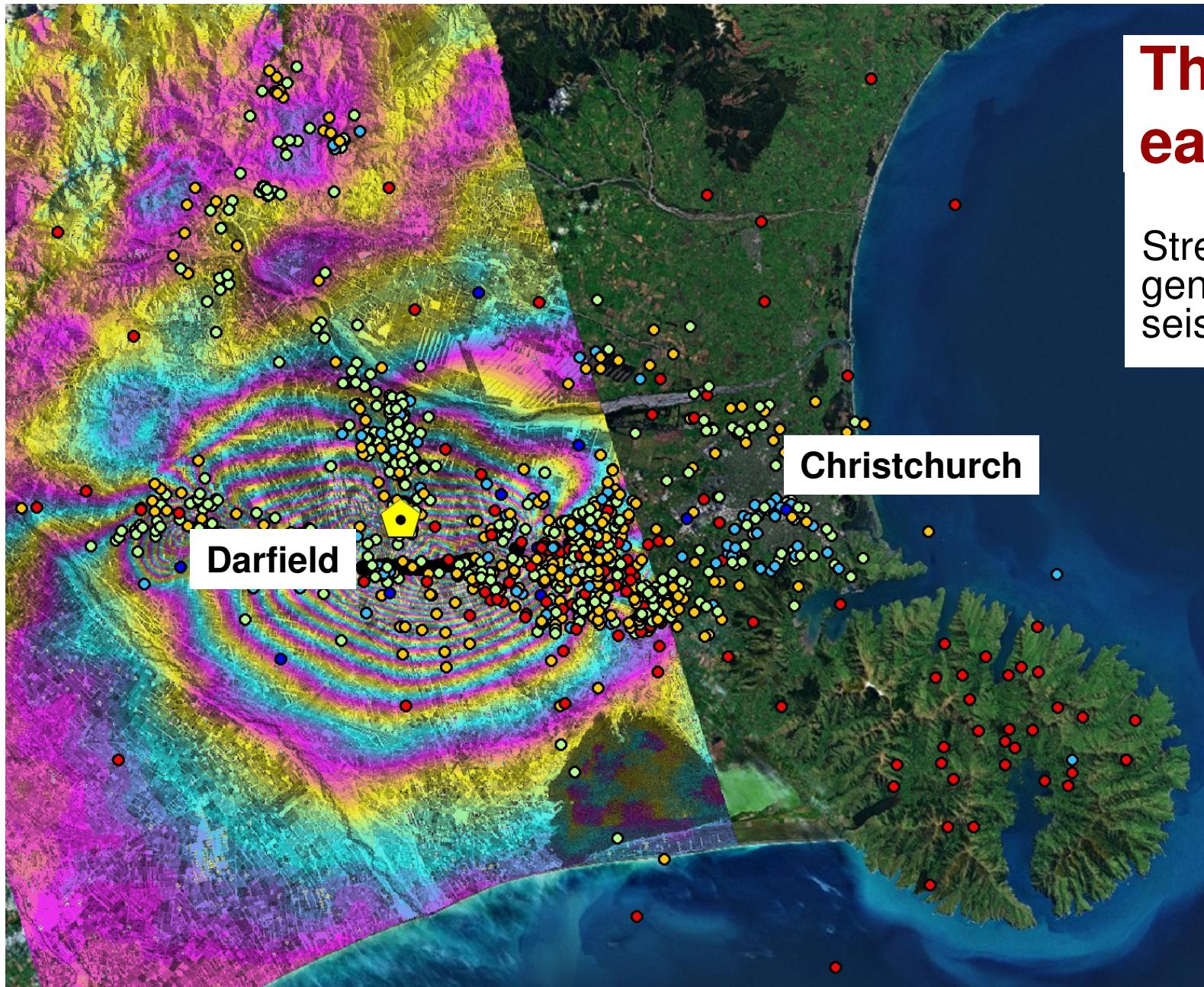




INGV

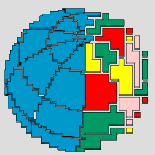


www.sigris.it



The Darfield earthquake, NZ

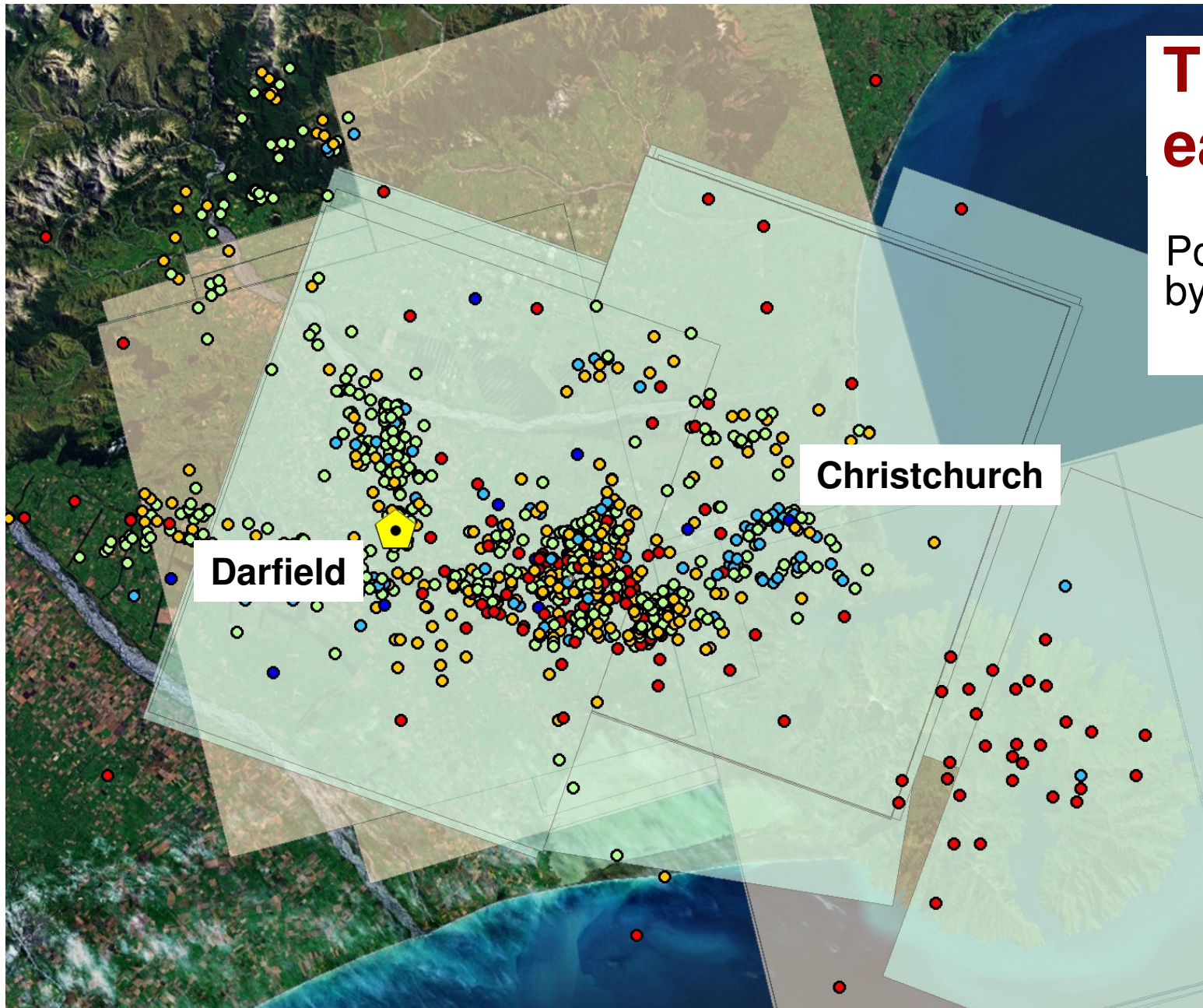
Stress increase nearby
generate further
seismicity to the East



INGV

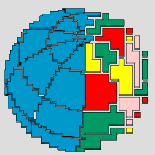


www.sigris.it



The Darfield earthquake, NZ

Post-seismic acquisitions
by COSMO-SKYMED



INGV

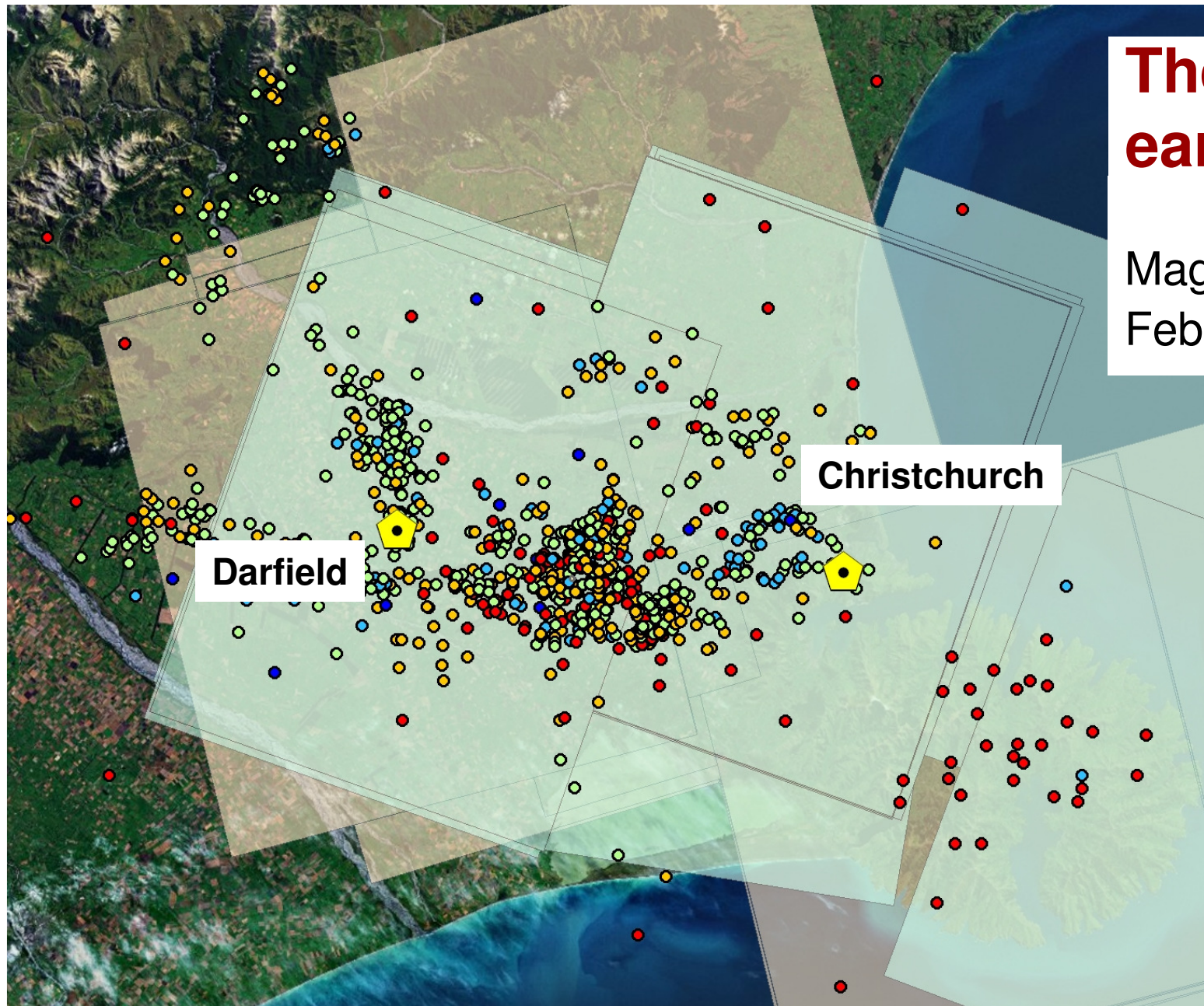


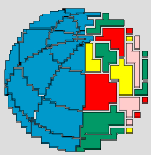
www.sigris.it



The Christchurch earthquake, NZ

Magnitude 6.3
February 22, 2011





INGV



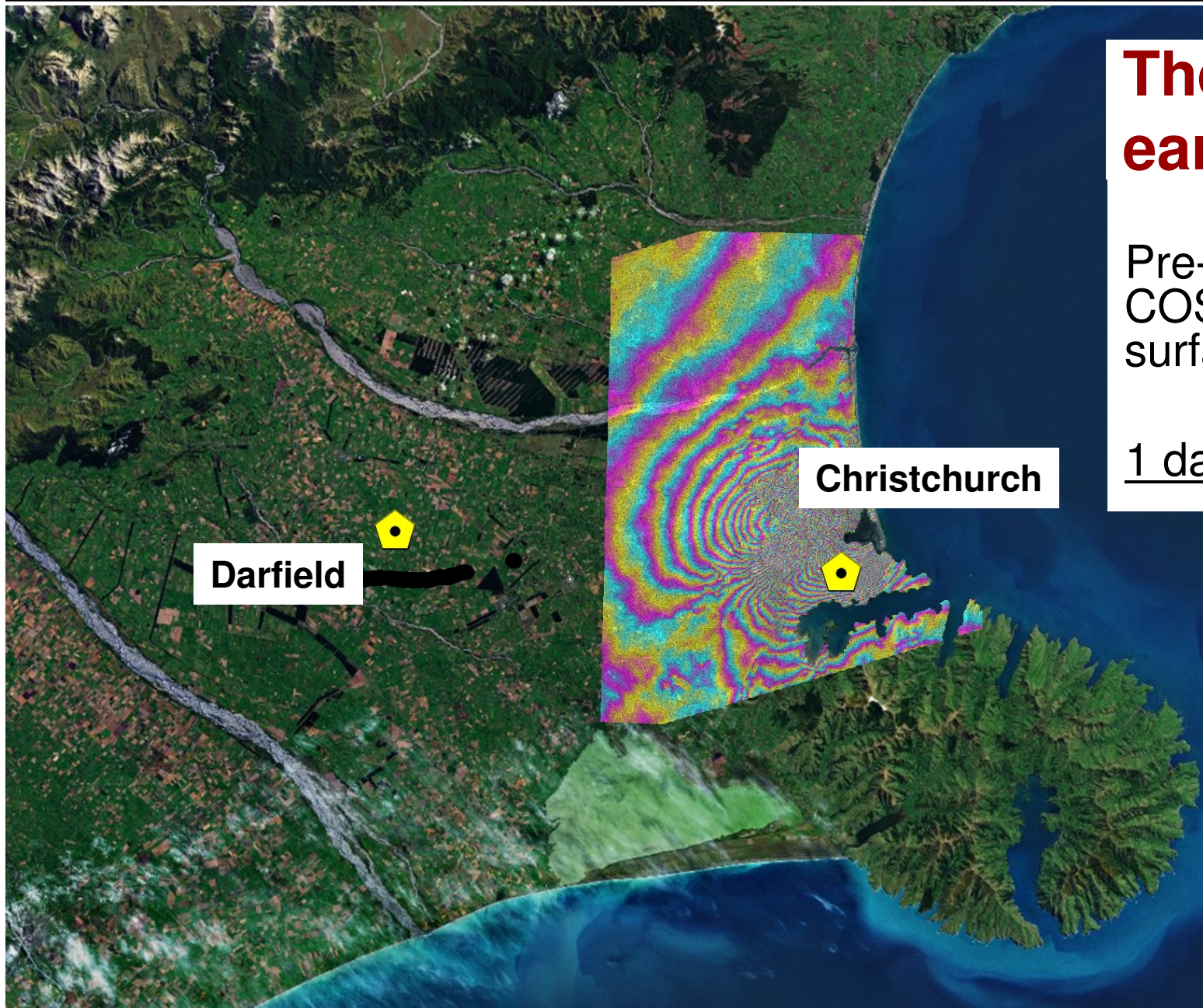
www.sigris.it

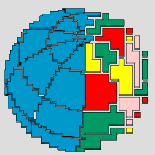


The Christchurch earthquake, NZ

Pre- and post-seismic
COSMO imagery detects
surface deformation

1 day later





INGV

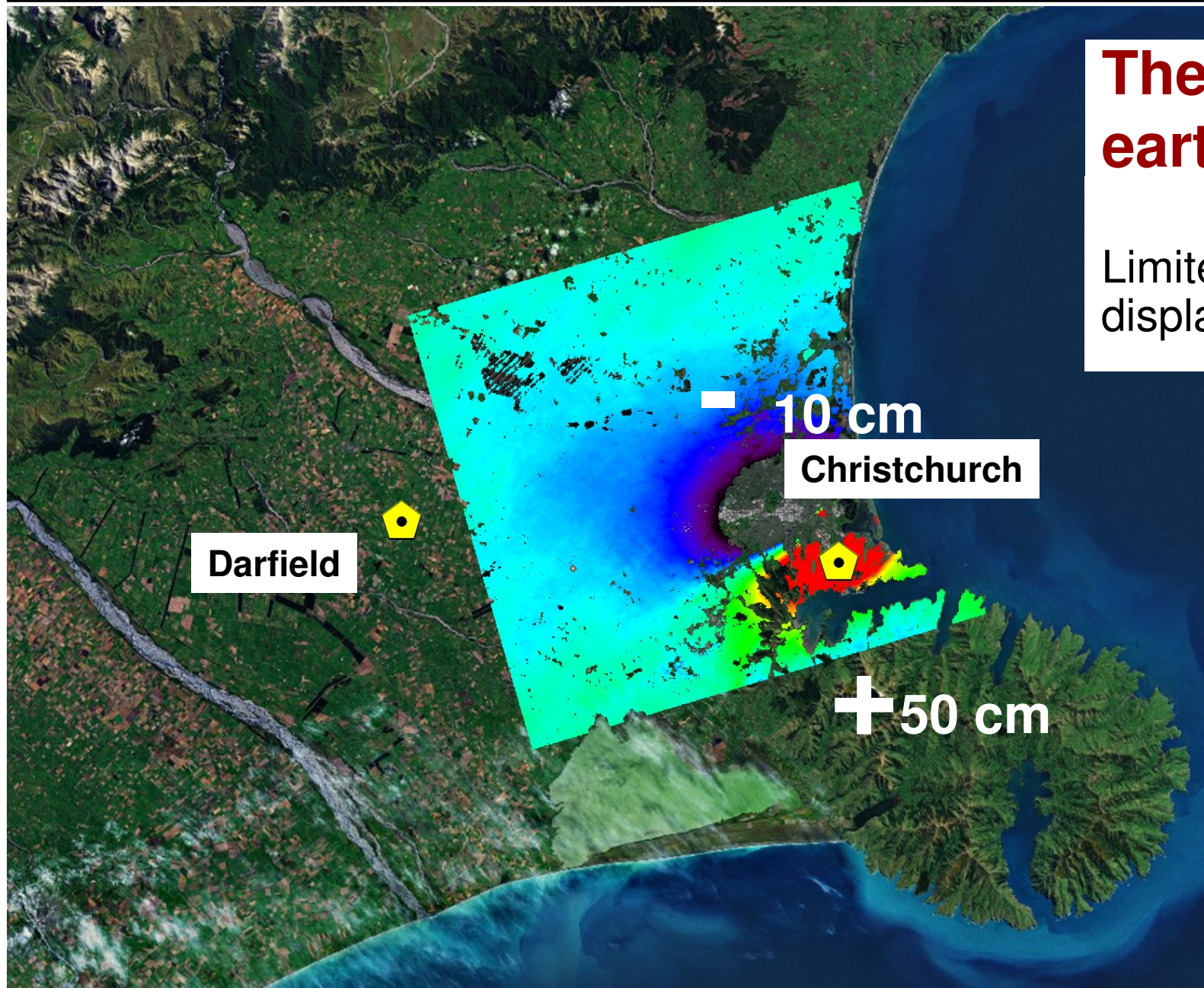


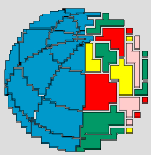
www.sigris.it



The Christchurch earthquake, NZ

Limited ground displacement (60 cm)





INGV



www.sigris.it



+50 cm

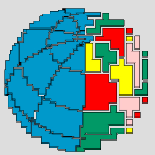
The Christchurch earthquake, NZ

Numerical modeling of the seismic source

Darfield

Christchurch

10 cm



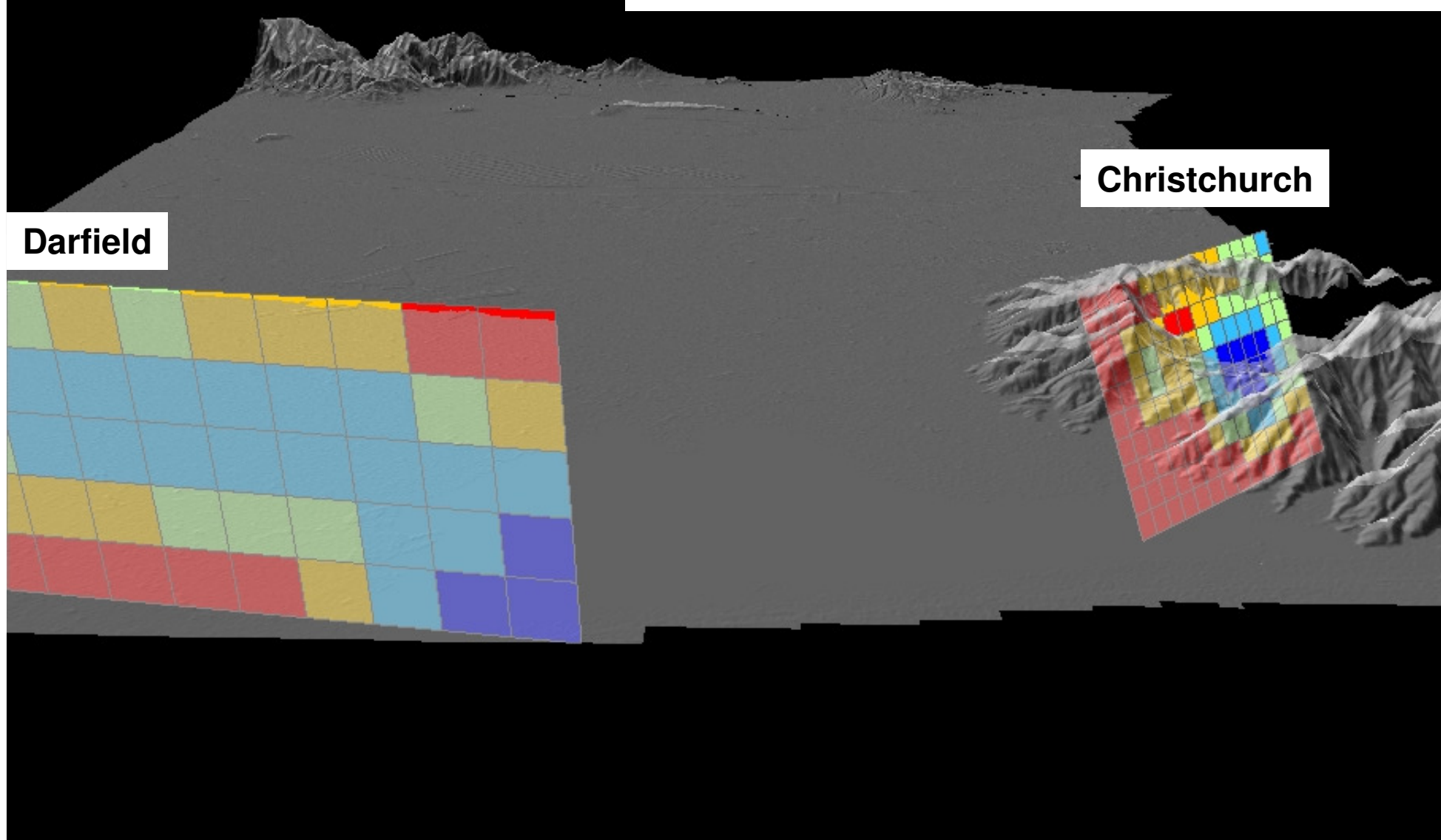
INGV

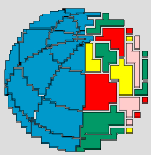


www.sigris.it



The two seismic sources





INGV

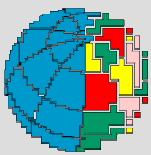


www.sigris.it



Earthquake triggering ?

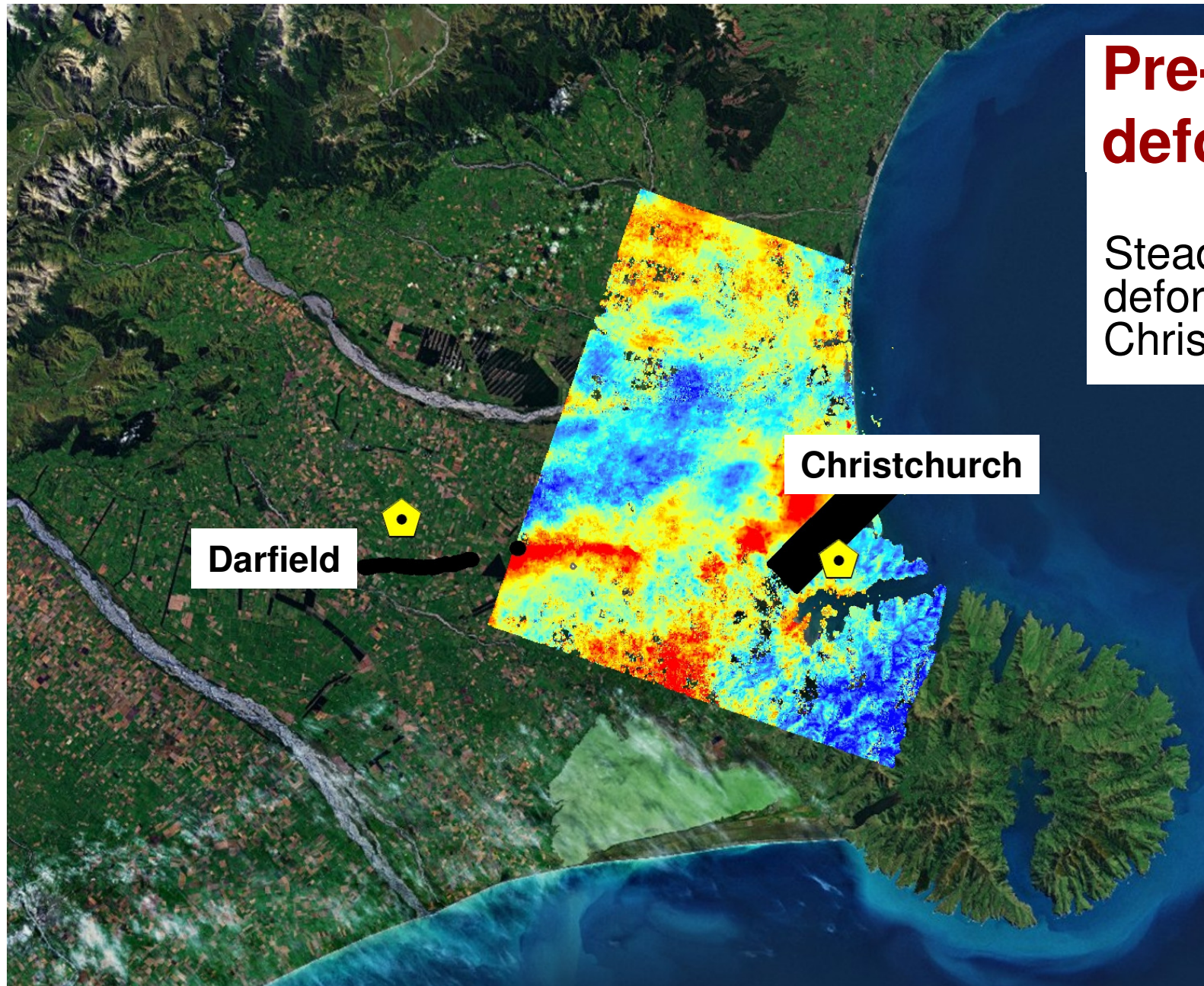
A time-series of 16-day repeat COSMO-SKYMED images, suggests that the Christchurch earthquake **has been triggered** by the Darfield earthquake.



INGV

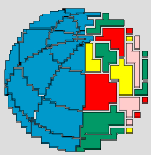


www.sigris.it

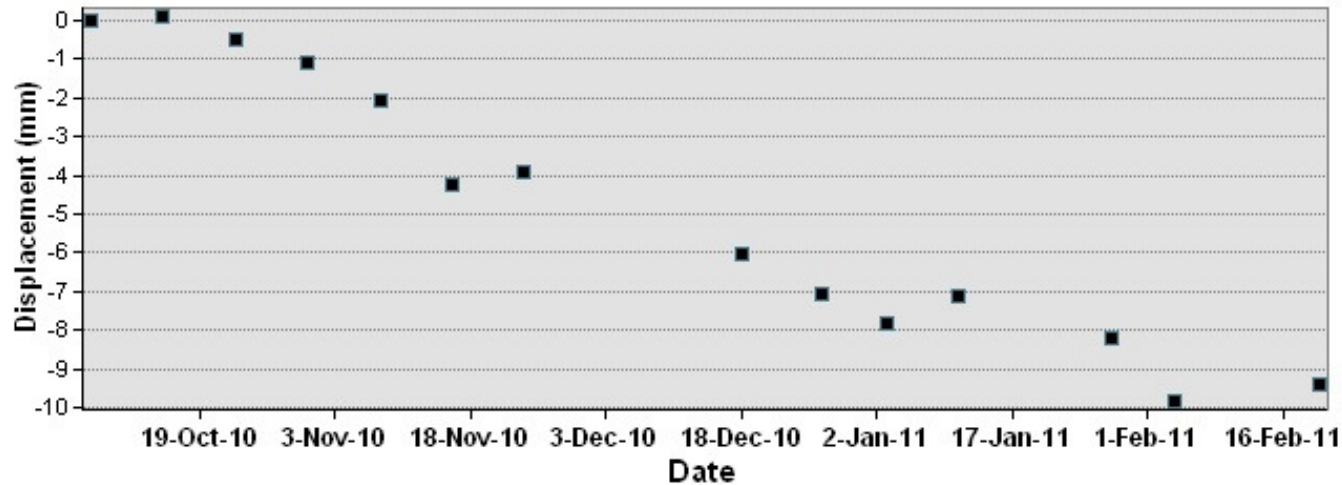


Pre-seismic deformation

Steady increase of deformation **prior** to Christchurch earthquake



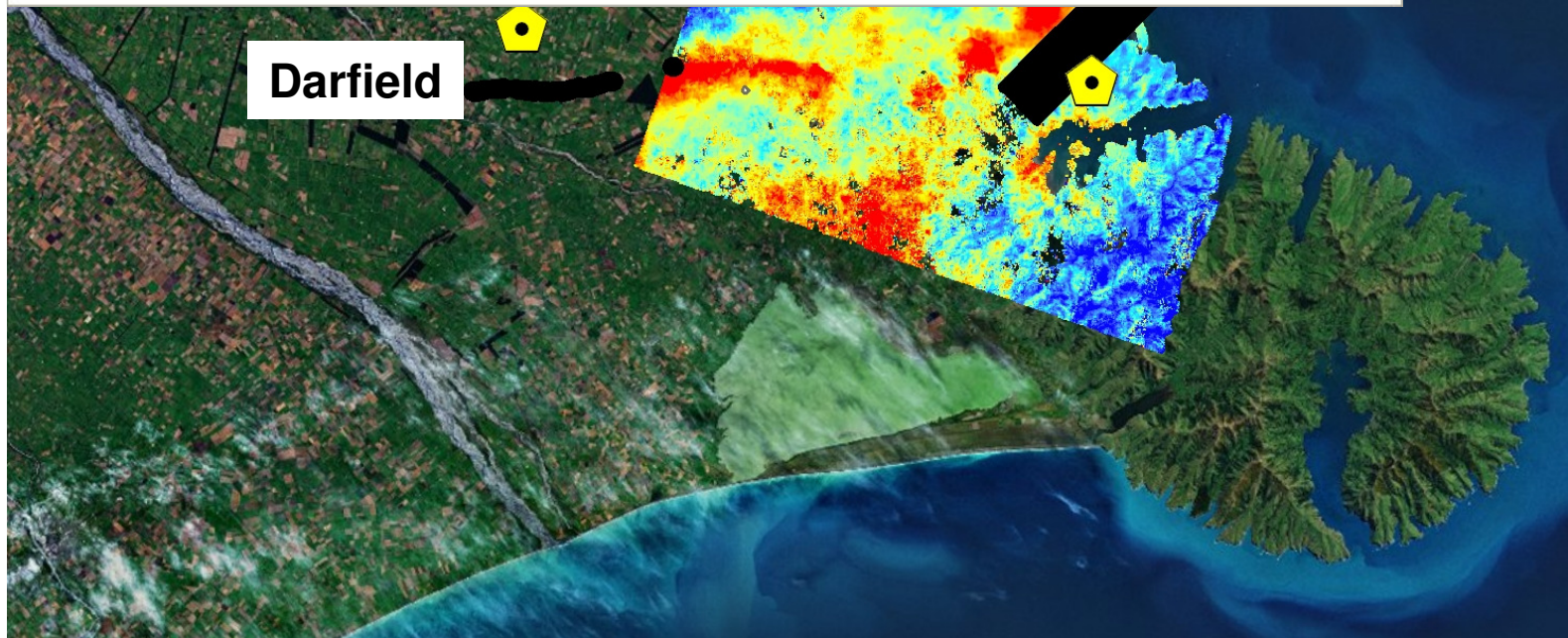
Pre-seismic COSMO-SKYMED displacement time series

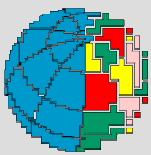


Error = 0

Pre-seismic deformation

1 cm of ground displacement accumulated before the earthquake





INGV



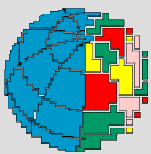
www.sigris.it



The Great Tohoku earthquake

Magnitude 9, occurred on March 11, 2011

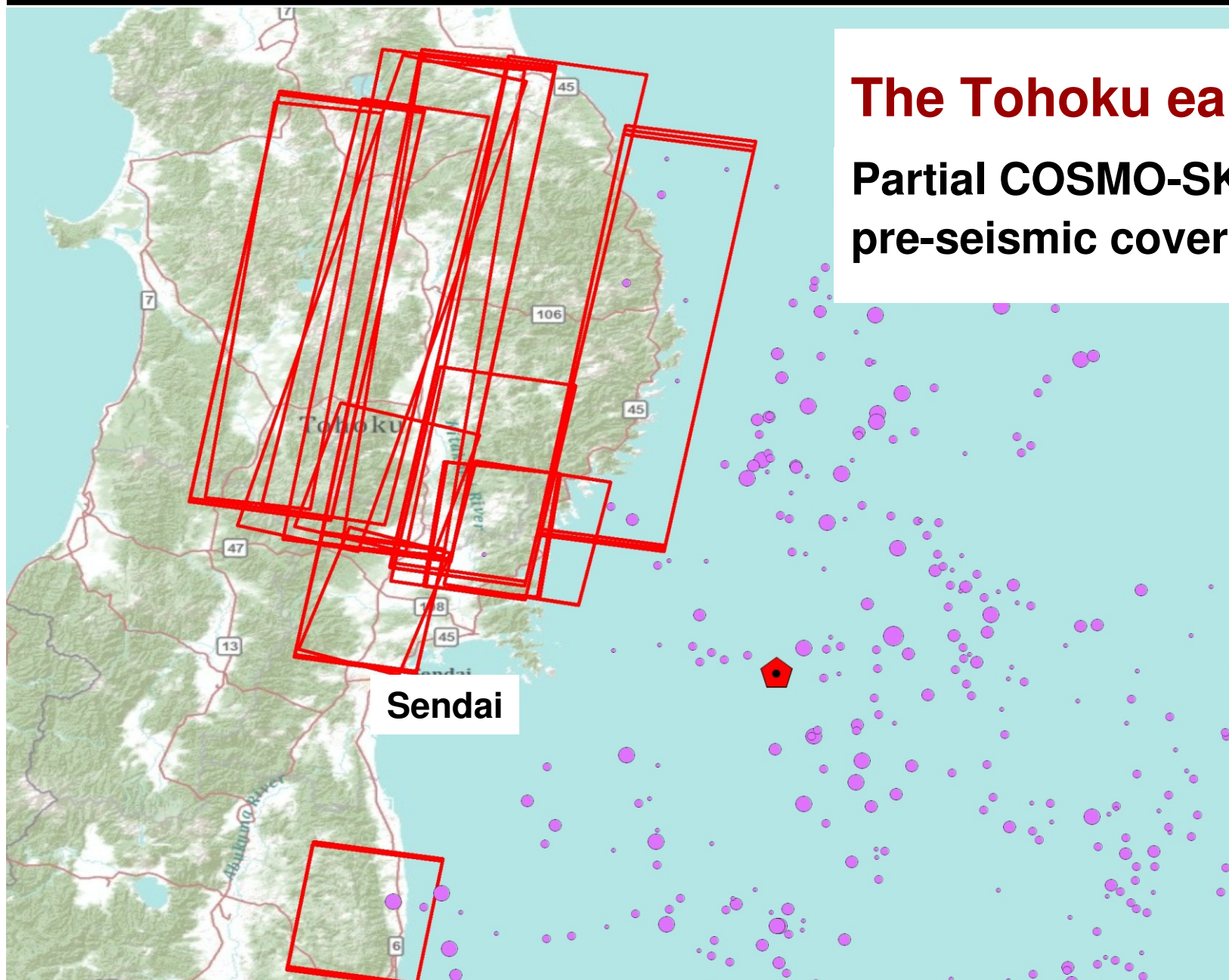




INGV

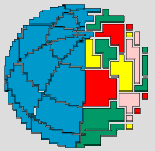


www.sigris.it



The Tohoku earthquake, JP

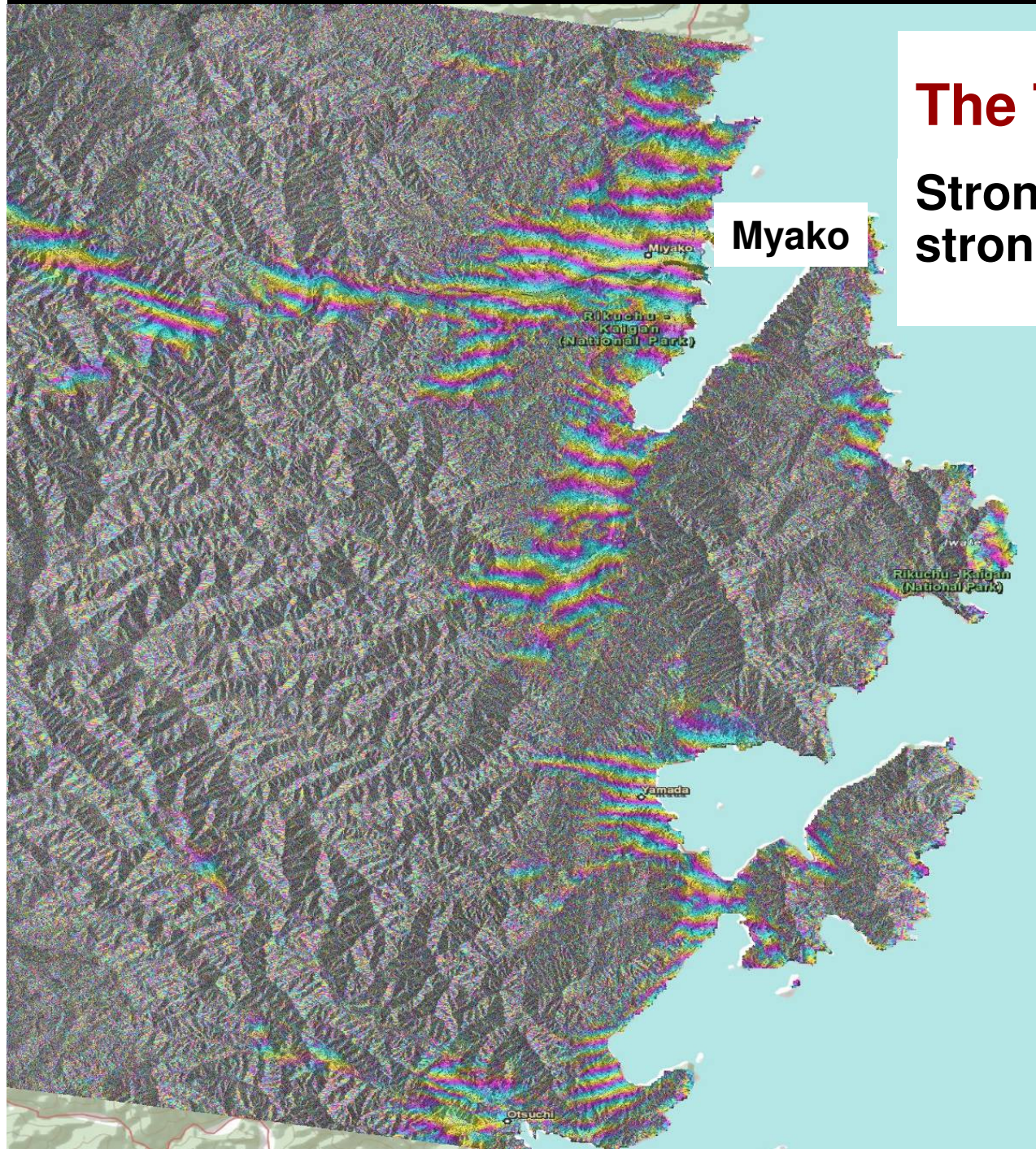
Partial COSMO-SKYMED
pre-seismic coverage



INGV

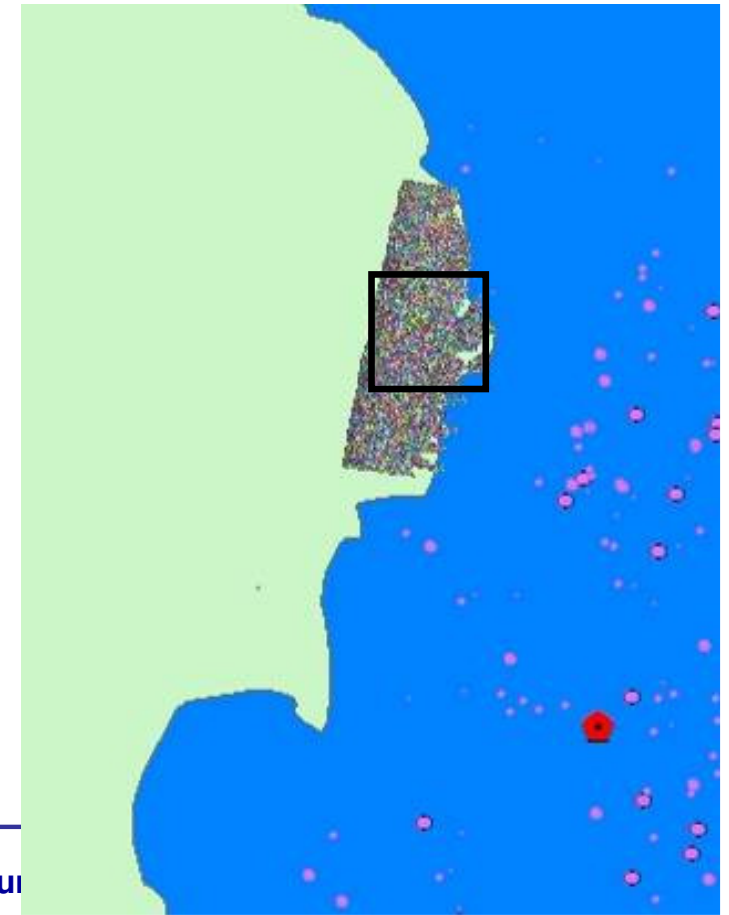


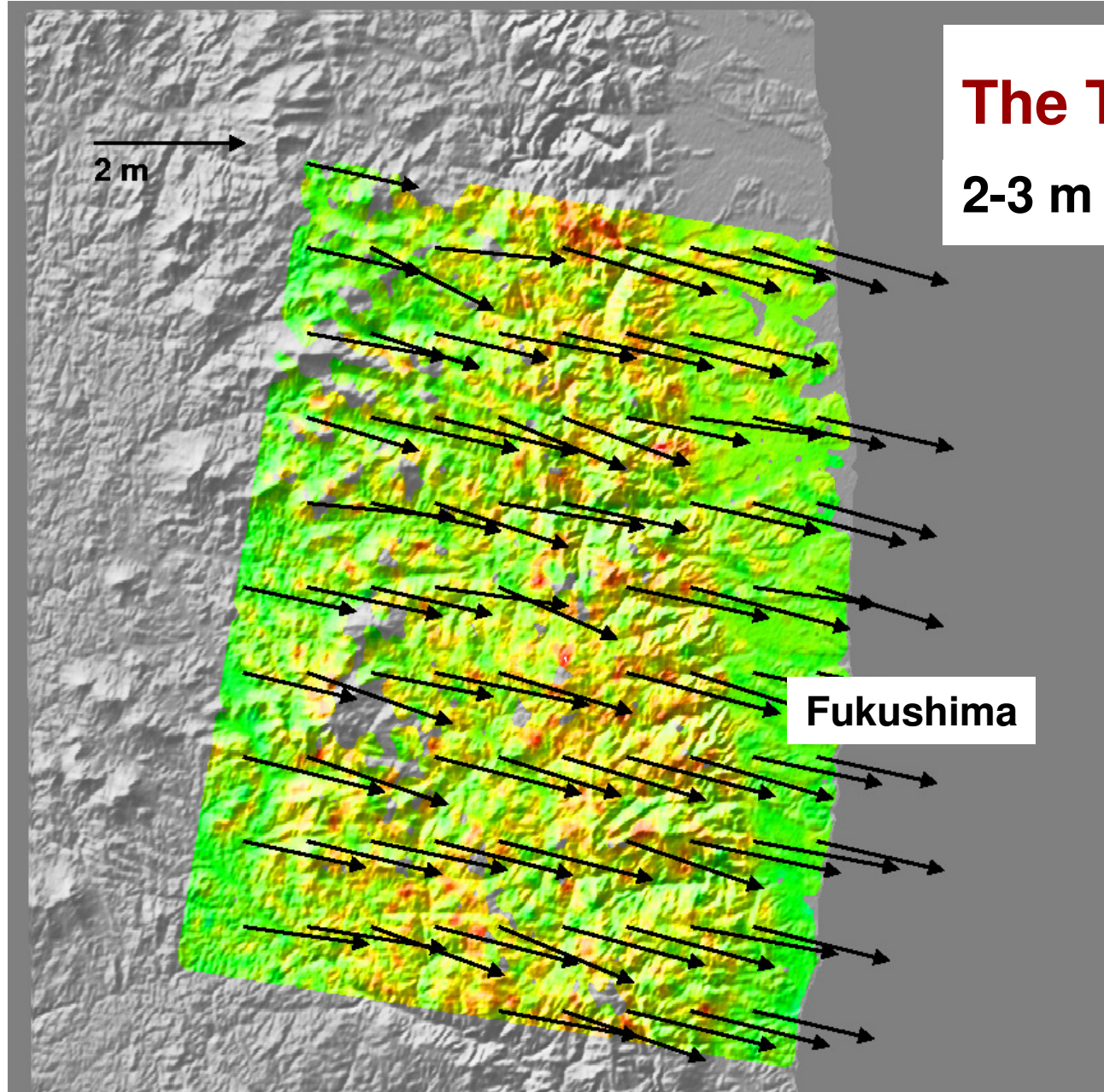
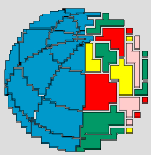
www.sigris.it



The Tohoku earthquake, JP

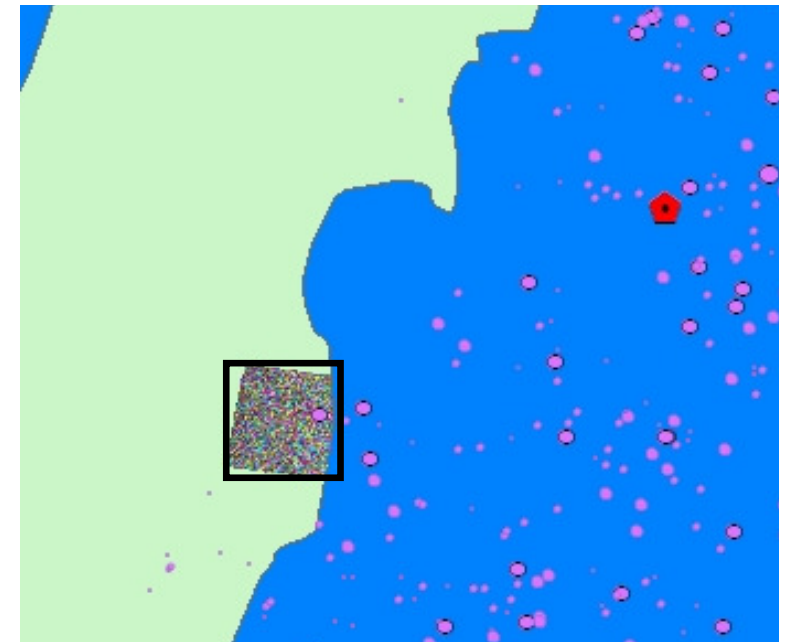
Strong deformation but also strong noise

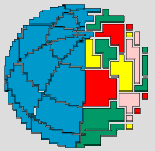




The Tohoku earthquake, JP

2-3 m ground displacement





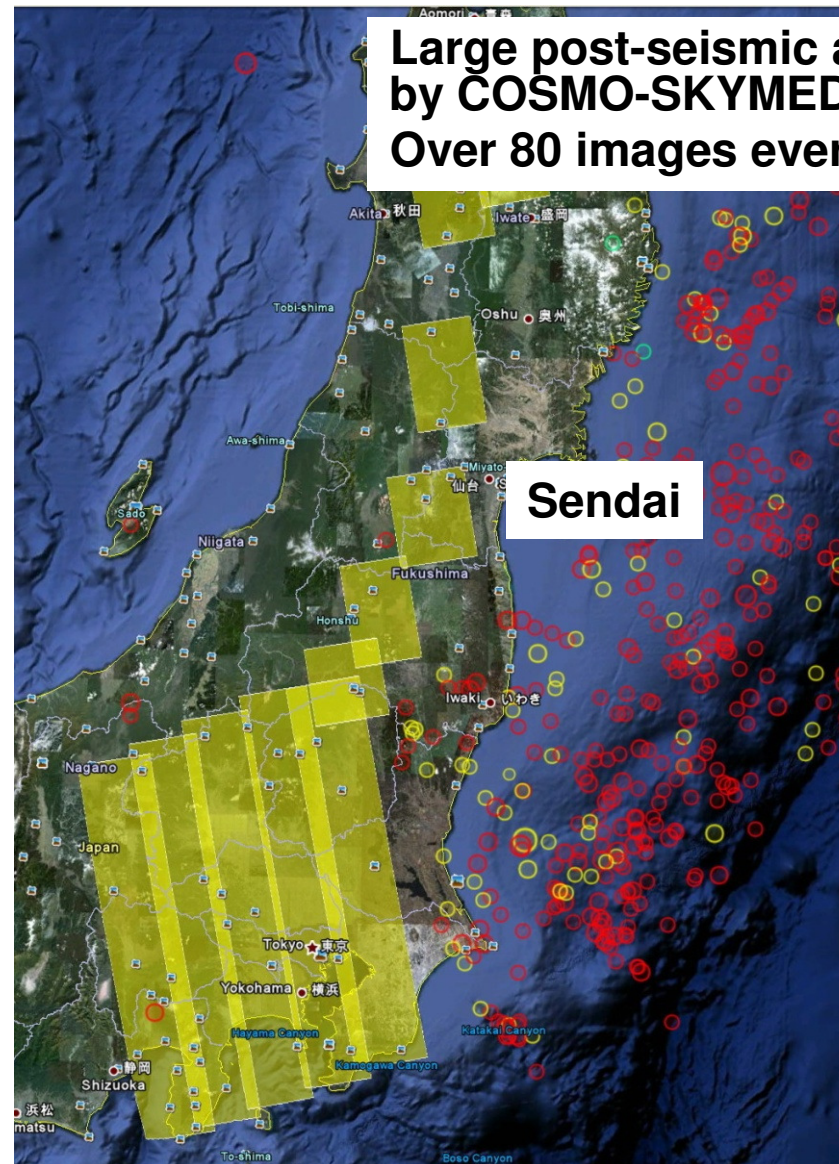
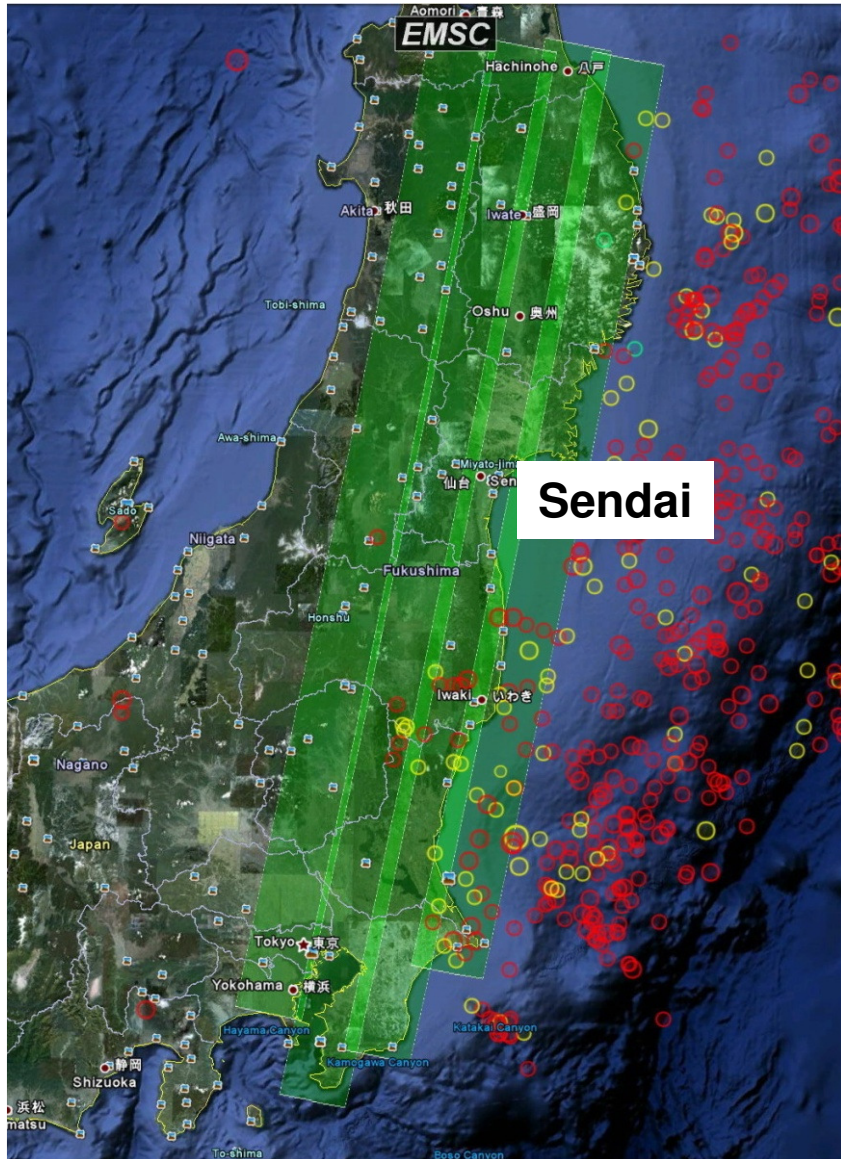
INGV



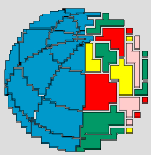
www.sigris.it



The Tohoku earthquake, JP



Large post-seismic acquisition plan
by COSMO-SKYMED
Over 80 images every 16 days



Conclusions

1. The frequent revisiting times of the COSMO constellation allow a timely generation of information products (2 days for the Christchurch earthquake)
2. COSMO image archives should be maintained for the highest risk areas of the world
3. COSMO time series allow to monitor possible seismic precursors
4. SIGRIS has demonstrated that the operational monitoring of seismic risk is now feasible with satellite imagery