Monitoring crustal movement in Hong Kong using GPS: preliminary results

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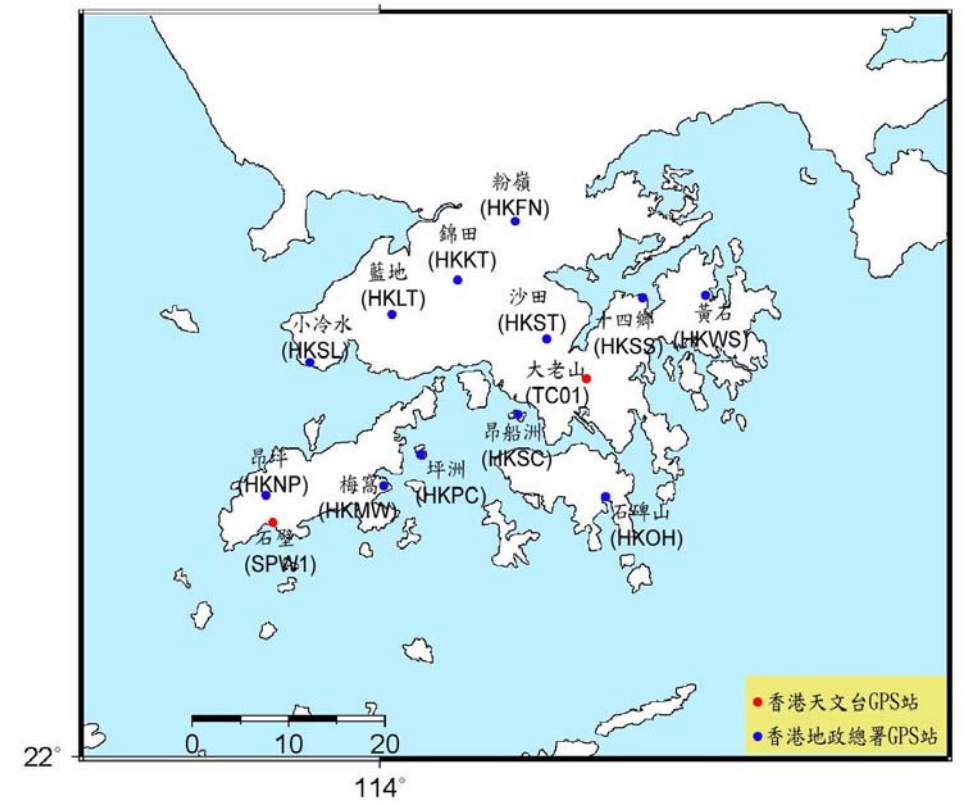
Continuous high precision GPS observing stations established by the Hong Kong Observatory

Aims:

- Monitor the long term crustal movement of Hong Kong
- Investigate geological faults

Continuous GPS observing stations in Hong Kong

- HKO established TWO continuous GPS observing stations Tate's Cairn (TC01) and Shek Pik (SPW1) in early 2006



(HKO's stations - RED spots shown on the map)

Tate’s Cairn GPS continuous observing station

- Well established in the bedrock of Tate’s Cairn hill
- Altitude: 583 metres
- Leica GPS AT504, Choke-Ring antenna
- Suitable for monitoring long term crustal movemer

Shek Pik GPS continuous observating station

- Establish in the Shek Pik tide gauge station
- LEICA GPS AT1202, dual frequency antenna
- Monitor crustal vertical movement
- Useful to monitor long term sea level change in Hong Kong

GPS data flow

modem

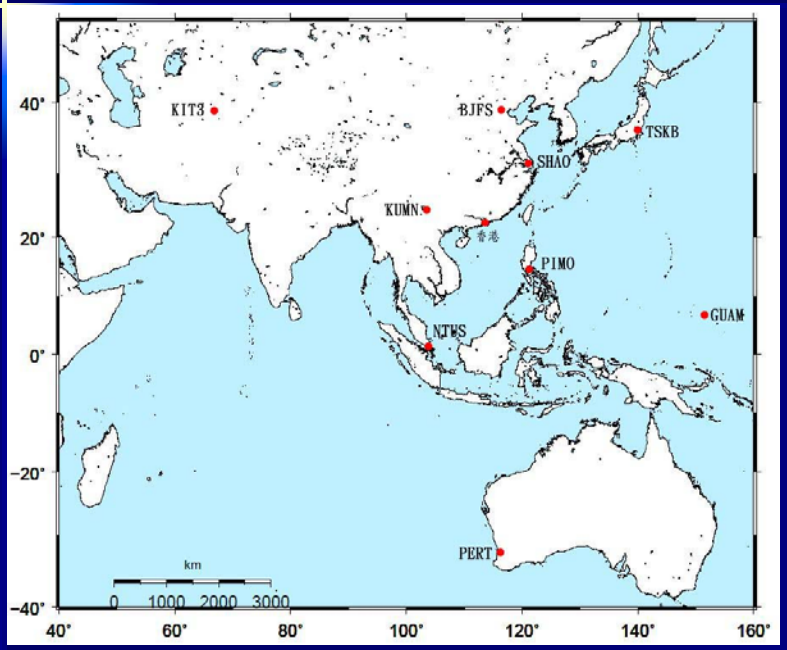
HKO
Headquarter

modem

GPS antenna

LEICA GRX 1200
PRO

Data Processing



GPS RINEX data

- March 2006 to July 2009 daily observation data
- 2 HKO GPS stations, TC01 and SPW1
- 12 Lands Dept GPS stations
- 9 IGS stations
- Final orbit navigation files

Processing Software

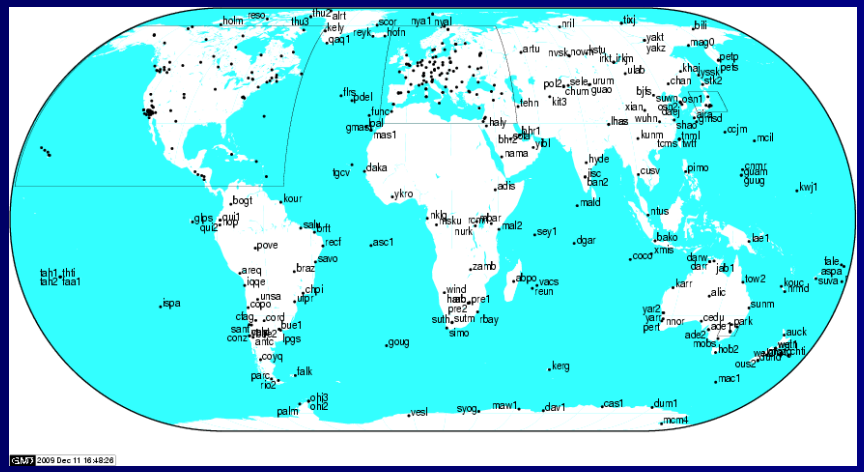
GAMIT/GLOBK Ver.10.35

=> estimated initial coordinates

9 IGS stations :
TSKB, GUAM, SHAO, KUMN, BJFS, PERT, NTUS, KIT3 and PIMO

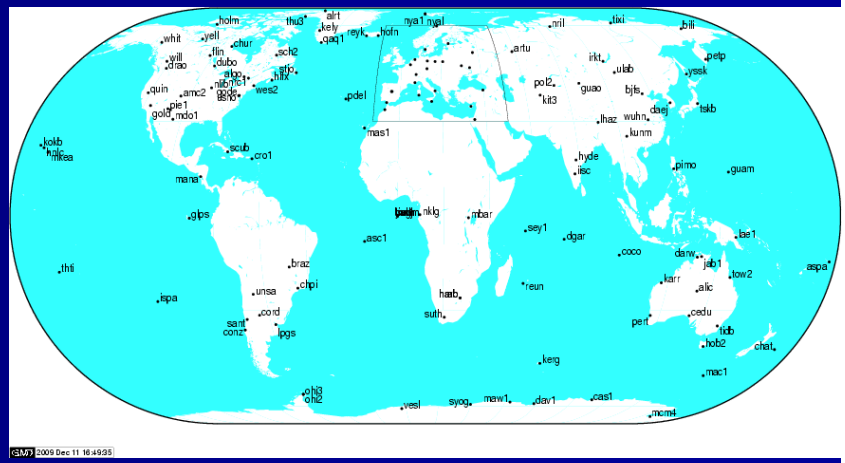
Data Processing

- Conjunction with the global GPS data from International GNSS Service (IGS)
- Reference to International Terrestrial Reference Frame (**ITRF05)**
- Apply GLOBK - Kalman Filter
- Calculate precise coordinates and velocities



IGS network

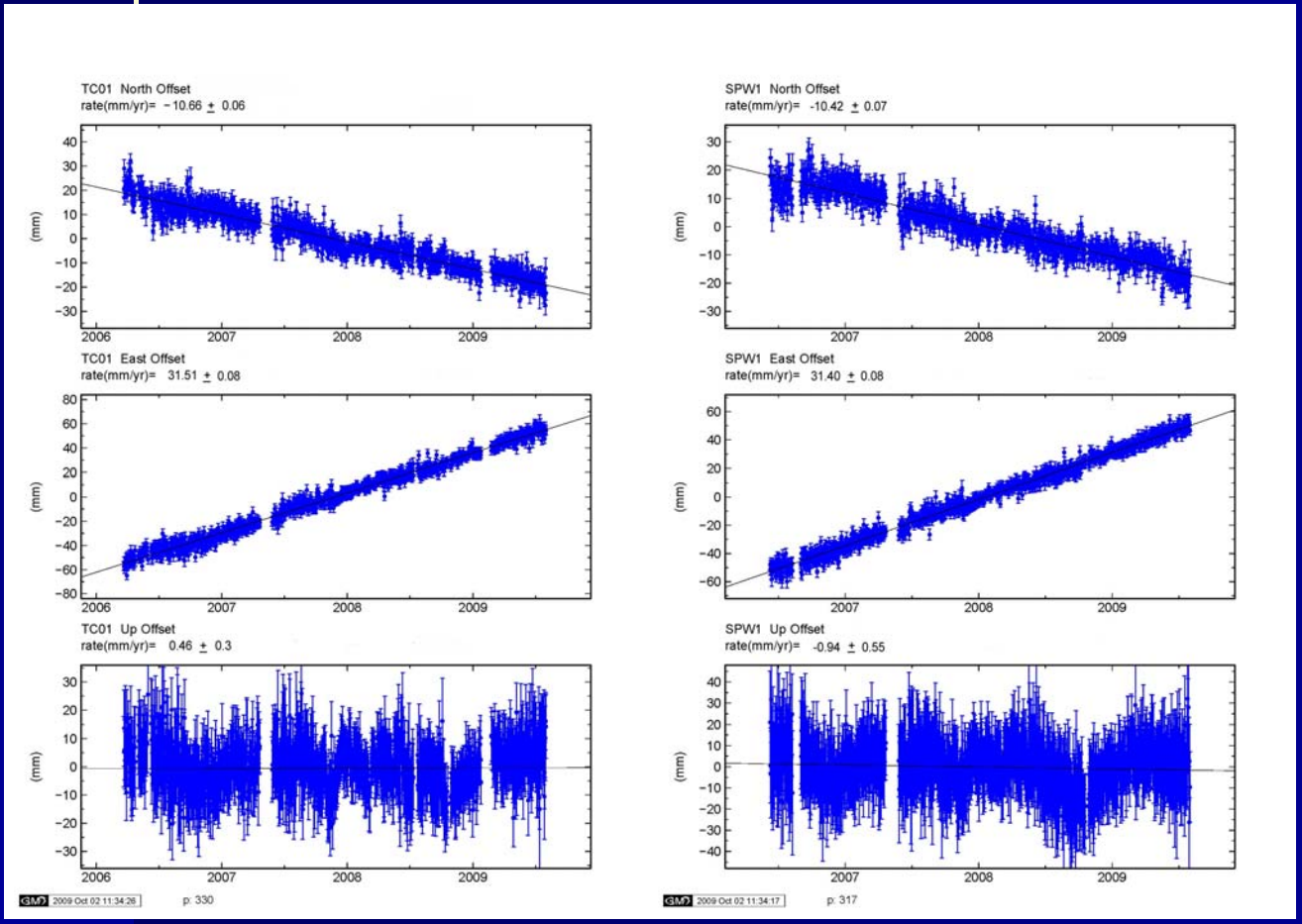
http://igscb.jpl.nasa.gov/network/complete.html



ITRF05

http://igscb.jpl.nasa.gov/network/refframe.html

Time series of day-to-day repeatability of Tate's Cairn and Shek



Tate's Cairn (TC01)

Shek Pik (SPW1)

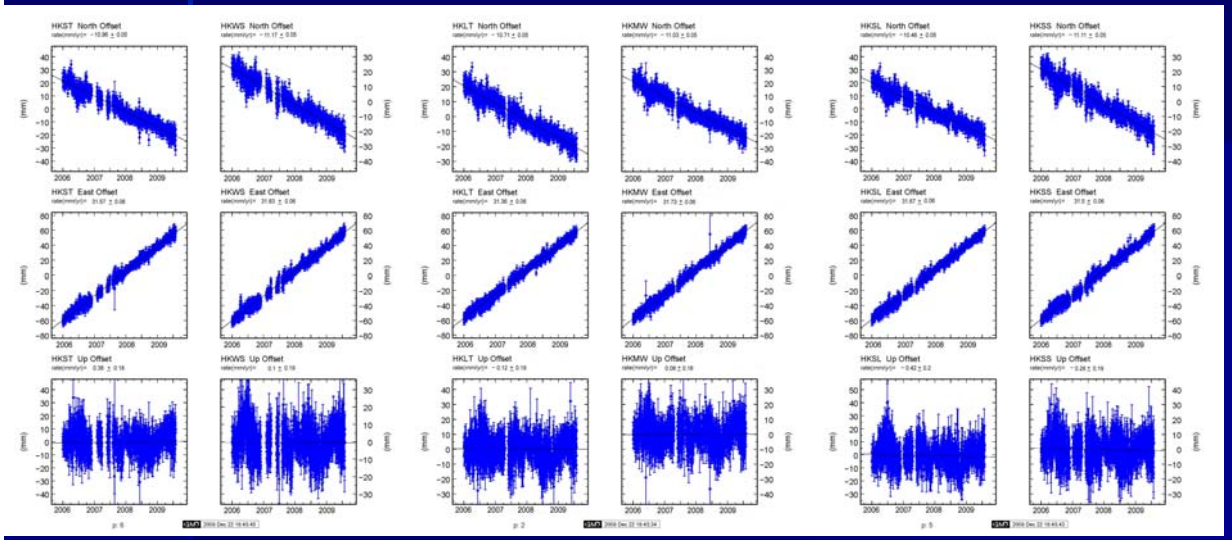
GPS Station	North offset mm/yr	East offset mm/yr	Up offset mm/yr
TC01	-10.7	31.5	0.5
SPW1	-10.4	31.4	-0.9

Horizontal velocity
33 mm/yr in ESE

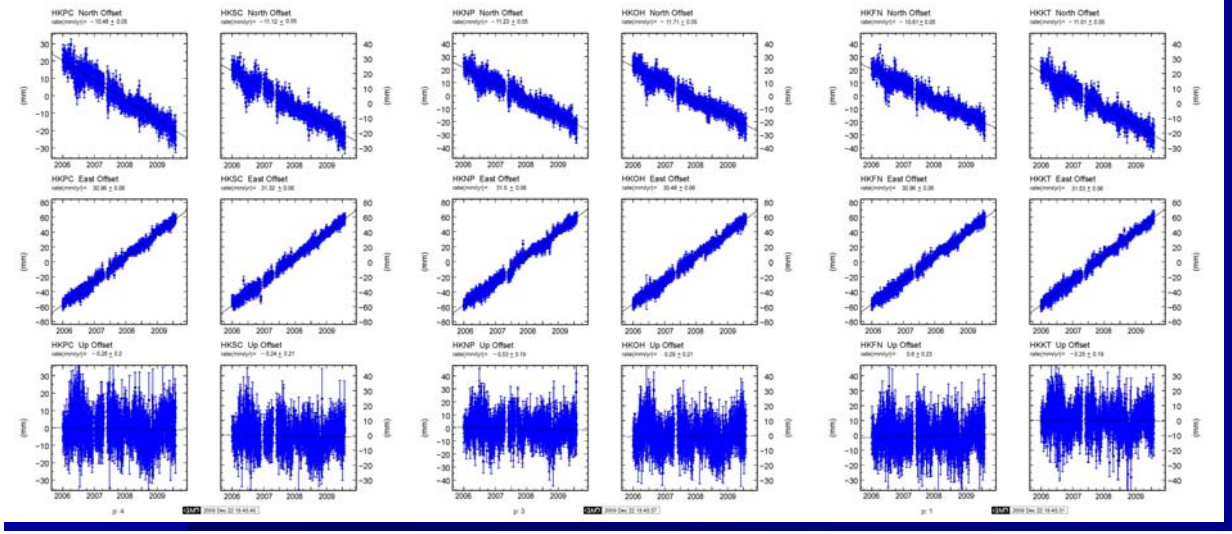
Vertical velocity
Insignificant

Time series of day-to-day repeatability of other stations in Hong Kong

HKST HKWS HKLT HKMW HKSL HKSS



HKPC HKSC HKNP HKOH HKFN HKKT

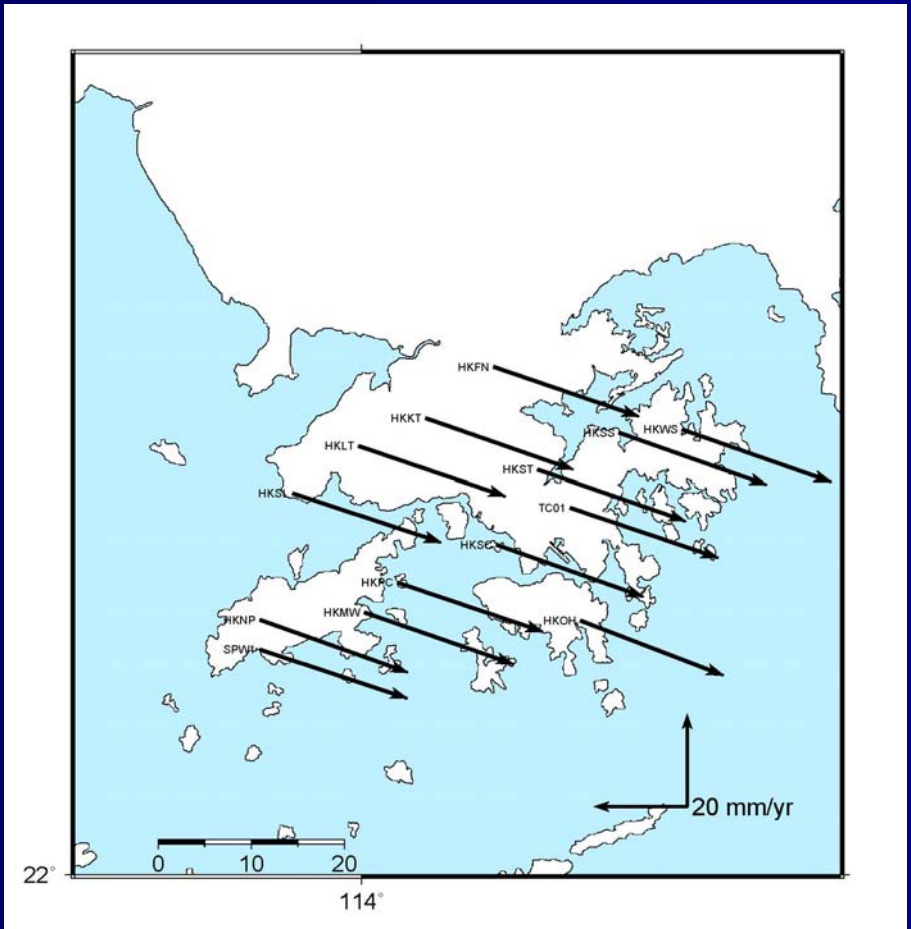


GPS Station	North offset mm/yr	East offset mm/yr	Up offset mm/yr
HKST	-11.0	31.6	0.4
HKWS	-11.2	31.8	0.1
HKLT	-10.7	31.4	-0.1
HKMW	-11.0	31.7	0.1
HKSL	-10.5	31.7	-0.4
HKSS	-11.1	31.5	-0.3
HKPC	-10.5	31.0	-0.3
HKSC	-11.1	31.3	-0.2
HKNP	-11.2	31.5	-0.5
HKOH	-11.7	30.5	0.3
HKFN	-10.6	31.0	0.6
HKKT	-11.0	31.5	-0.3

Horizontal velocity:
33 mm/yr in ESE

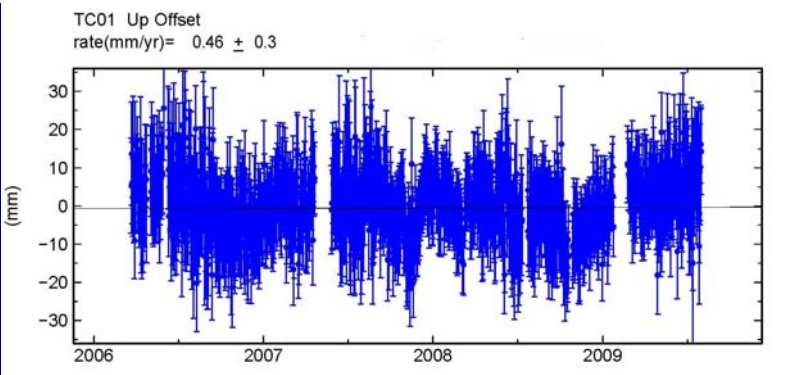
Vertical velocity:
Insignificant

Velocity field of GPS stations in Hong Kong

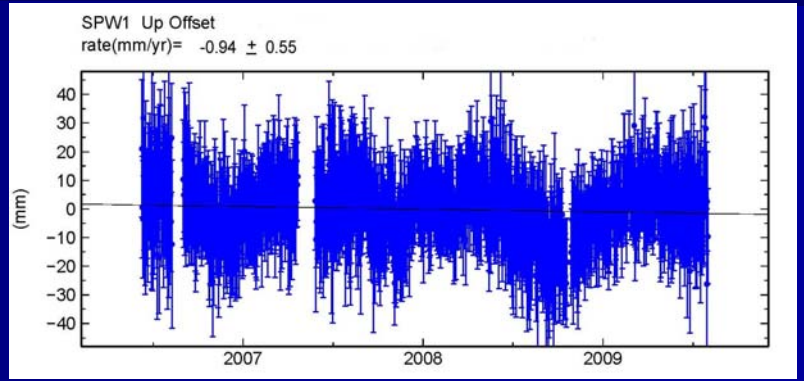


- Horizontal movement: 33 mm/yr in East-southeast
- No significant relative horizontal motions among each stations in Hong Kong

Seasonal signature in vertical movement



Tate's Cairn (TC01)



Shek Pik (SPW1)

Reasons may due to:

- Atmospheric pressure
- Ocean tides
- Gravitational excitation, mostly from the Sun and Moon
- Seasonal polar motion
- Effect of temperature on the antenna
- Thermal effect on bedrock
- Wind pressure , ground water , multipath etc

Atmospheric Loading

Corrected by applying atmospheric loading
(ATML) grid model provided by NCEP to GAMIT processing

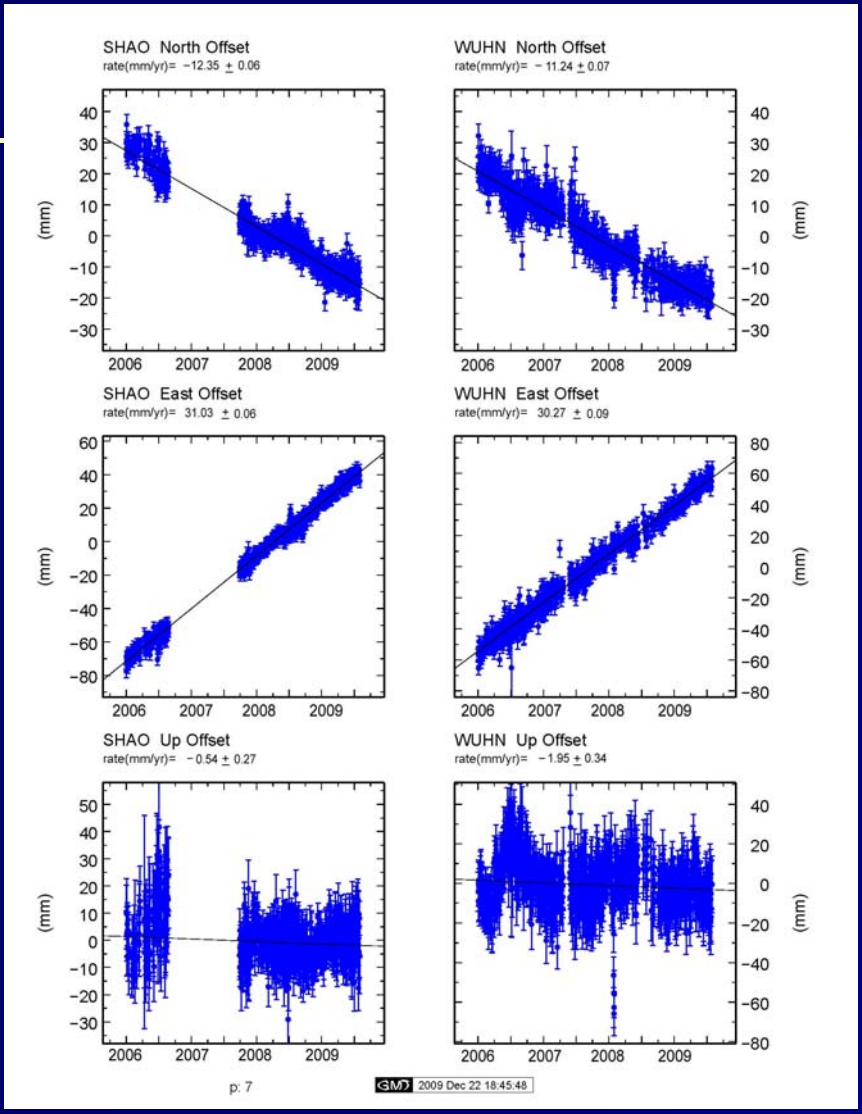
Results：

- Daily vertical coordinate error reduced from 7.3 mm to 7.0 mm at Tate's Cairn
- Daily vertical coordinate error reduced from 9.1 mm to 8.8 mm at Shek Pik
- Similar results were obtained in other GPS stations in Hong Kong

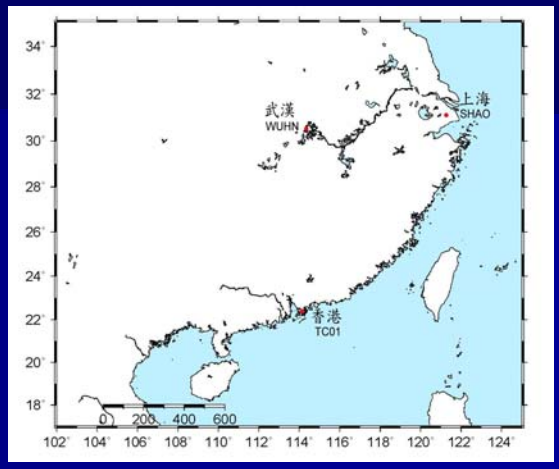
(*Tregoning et. al., 2005*)

http://rses.anu.edu.au/geodynamics/gps/atm_gamit/index.html

Results comparison



Shanghai Wuhan

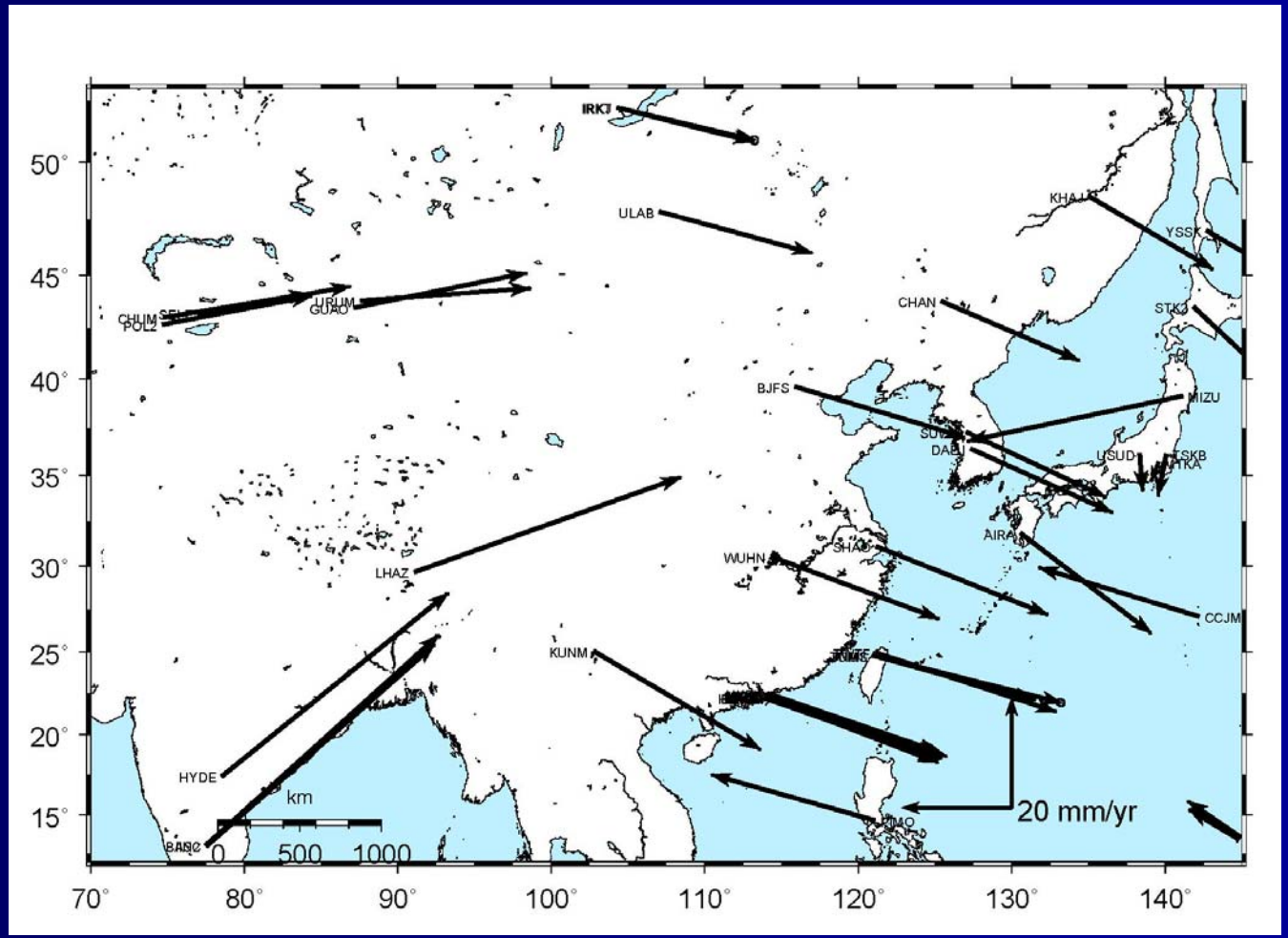


GPS Station	North offset mm/yr	East Offset mm/yr	Up offset mm/yr
SHAO	-12.4	31.0	-0.5
WUHN	-11.2	30.3	-2.0

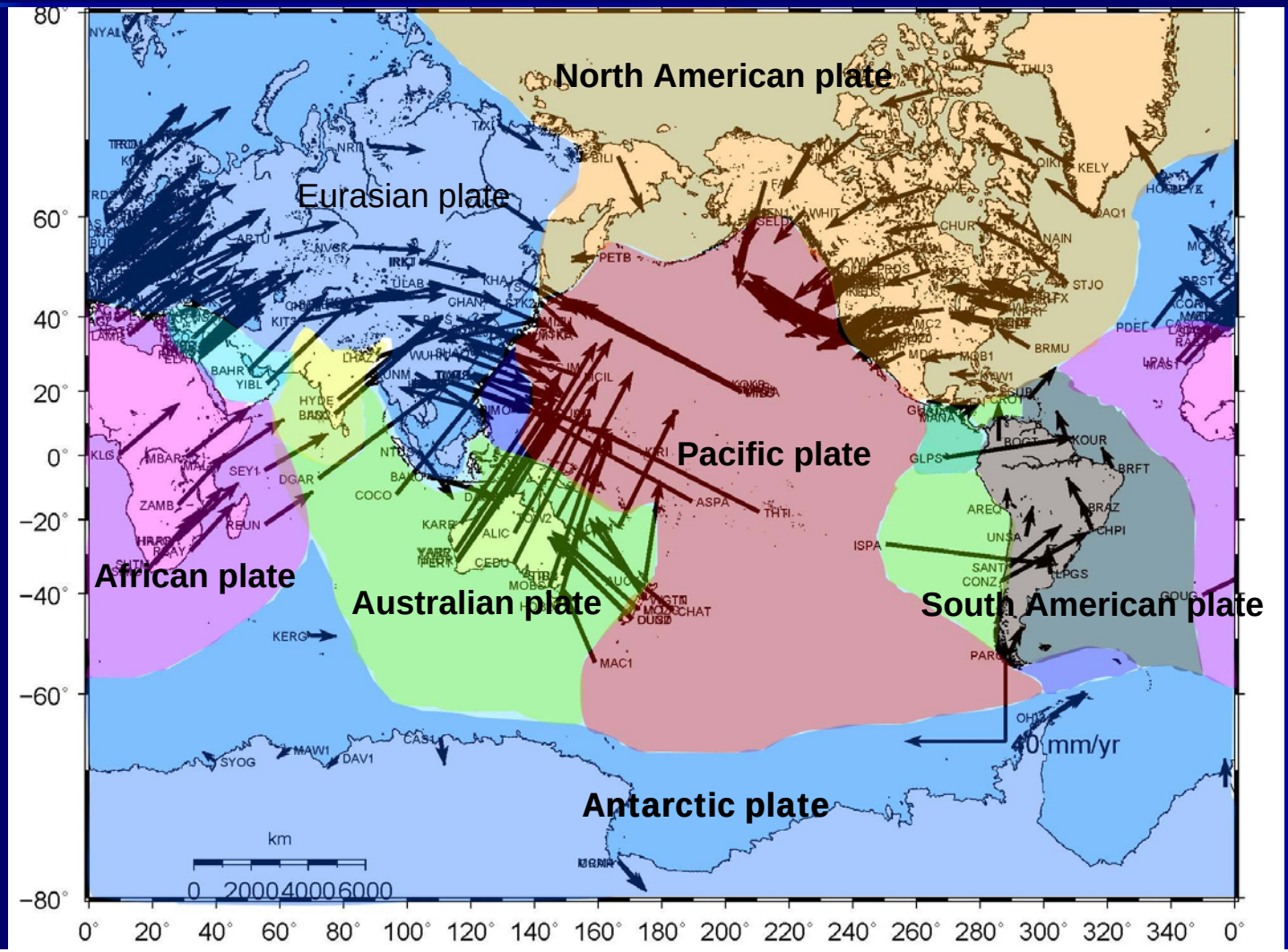
Shanghai (SHAO)
Horizontal velocity 33mm/yr in ESE

Wuhan (WUHN)
Horizontal velocity 32mm/yr in ESE

Velocity field of GPS stations under ITRF05 in China and neighboring region



Velocity field of global IGS stations in ITRF05



Conclusion

- Horizontal velocities of Tate's Cairn and Shek Pik are more or less the same at 33 millimetres per year in the east-southeast direction in the International Terrestrial Reference Frame (ITRF05)
- Vertical crustal movement of Hong Kong is insignificant
- No relative horizontal motions among each stations in Hong Kong
- The velocity is very close to those of the Shanghai and Wuhan continuous GPS stations, suggesting that the earth crusts of Hong Kong, Shanghai and Wuhan may be on the same geological block with little relative motions among each other.

Thank you