

LAND SUBSIDENCE CHARACTERISTICS OF BANDUNG BASIN (INDONESIA) BETWEEN 2000 AND 2005 AS ESTIMATED FROM GPS SURVEYS

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Land Subsidence

Types of Subsidence :

- subsidence due to groundwater extraction,
 - subsidence induced by the load of constructions (i.e. settlement of high compressibility soil),
 - subsidence caused by natural consolidation of alluvium soil, and
 - geotectonic subsidence.
- In Indonesia, land subsidence of urban coastal areas are usually caused by excessive groundwater extraction.
- The already observed subsidence areas :
 ➔ Jakarta, Semarang and Bandung
- The expected subsidence areas
 ➔ Denpasar, Surabaya and Medan

Land Subsidence in Indonesian Cities



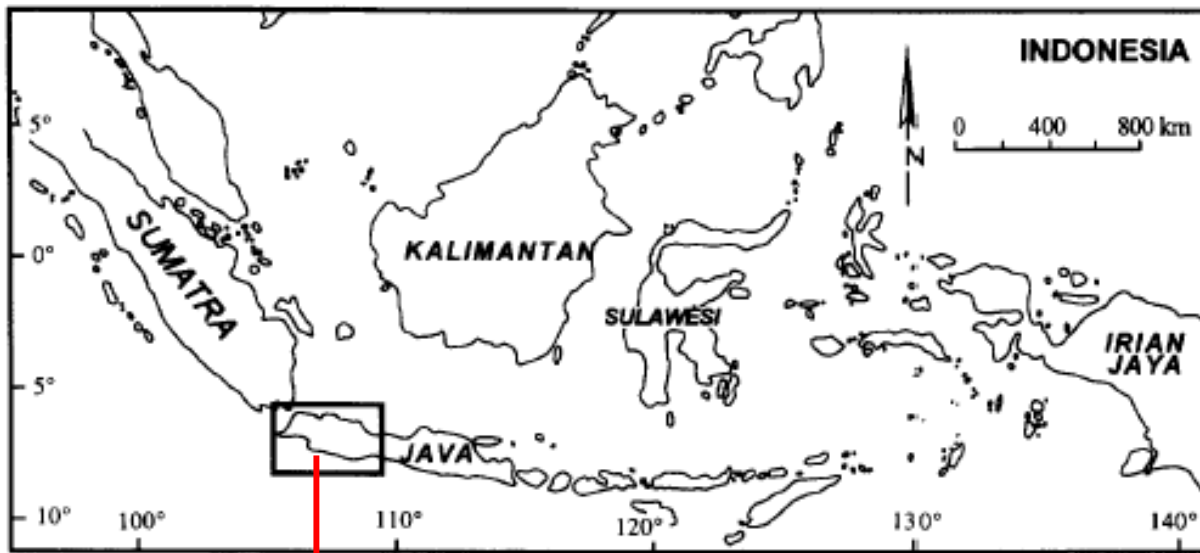
Observed land subsidence :

- Jakarta
- Bandung
- Semarang

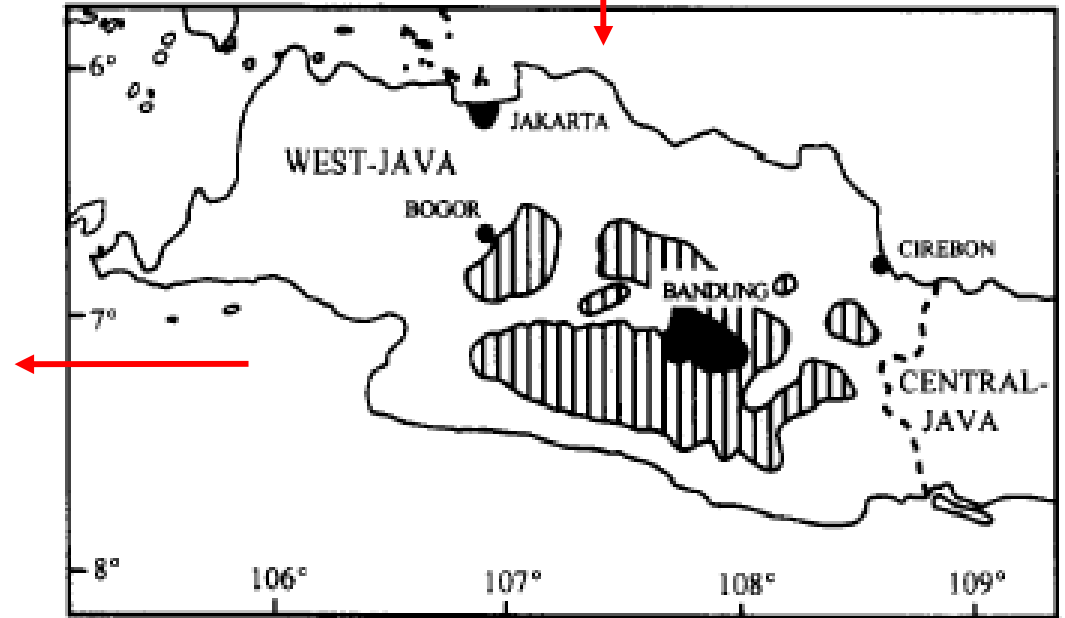
Expected land subsidence :

- Surabaya
- Denpasar
- Cilegon
- Medan

*observed decrease
in groundwater level*



Bandung West Java Indonesia

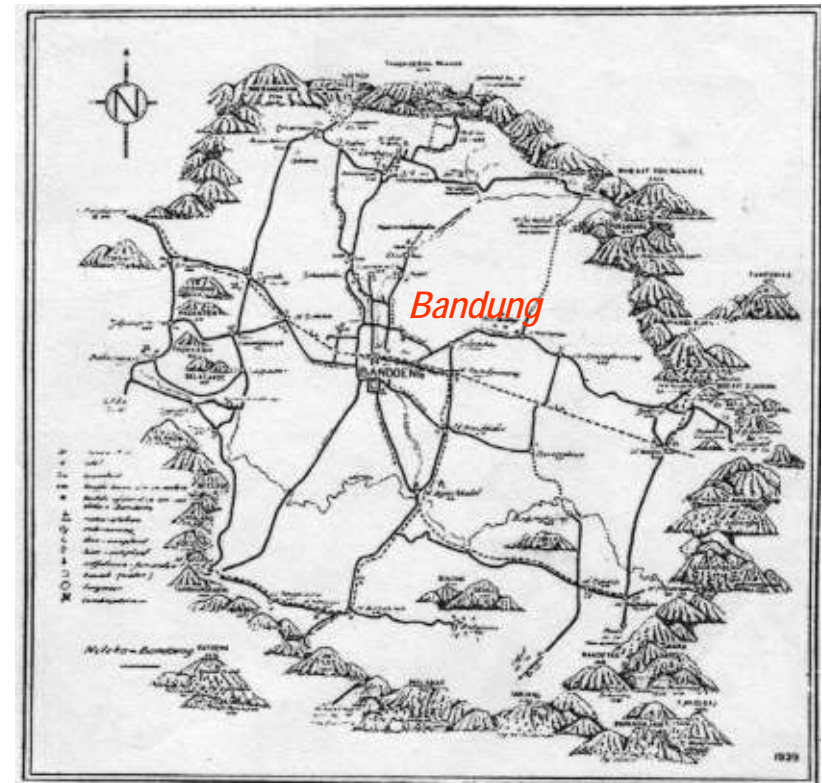


Bandung Basin

- Bandung is the capital of West Java Province and has a population about of 2.5 million (1995). It is surrounded by several medium sized towns which formed the Greater Bandung, and has a total population of about 3.5 million.
- The Greater Bandung lies in the catchment area of the upper Citarum river and is surrounded by range of hills and volcanoes: some of which are still active, formed the inter-montane basin, and has an area of about 2250 km².
- The central part of the basin, where most of which occupied by urban and industrial areas, is a plain measuring about 40 km East-West and about 30 km North-South



[Http://www.bandungcity.homepage.com/](http://www.bandungcity.homepage.com/)



Ref. : Soetrisno, 1996

DFO Event # 2005-022 - Indonesia - Western Java - Citarum River, Bandung area - Rapid Response Inundation Map

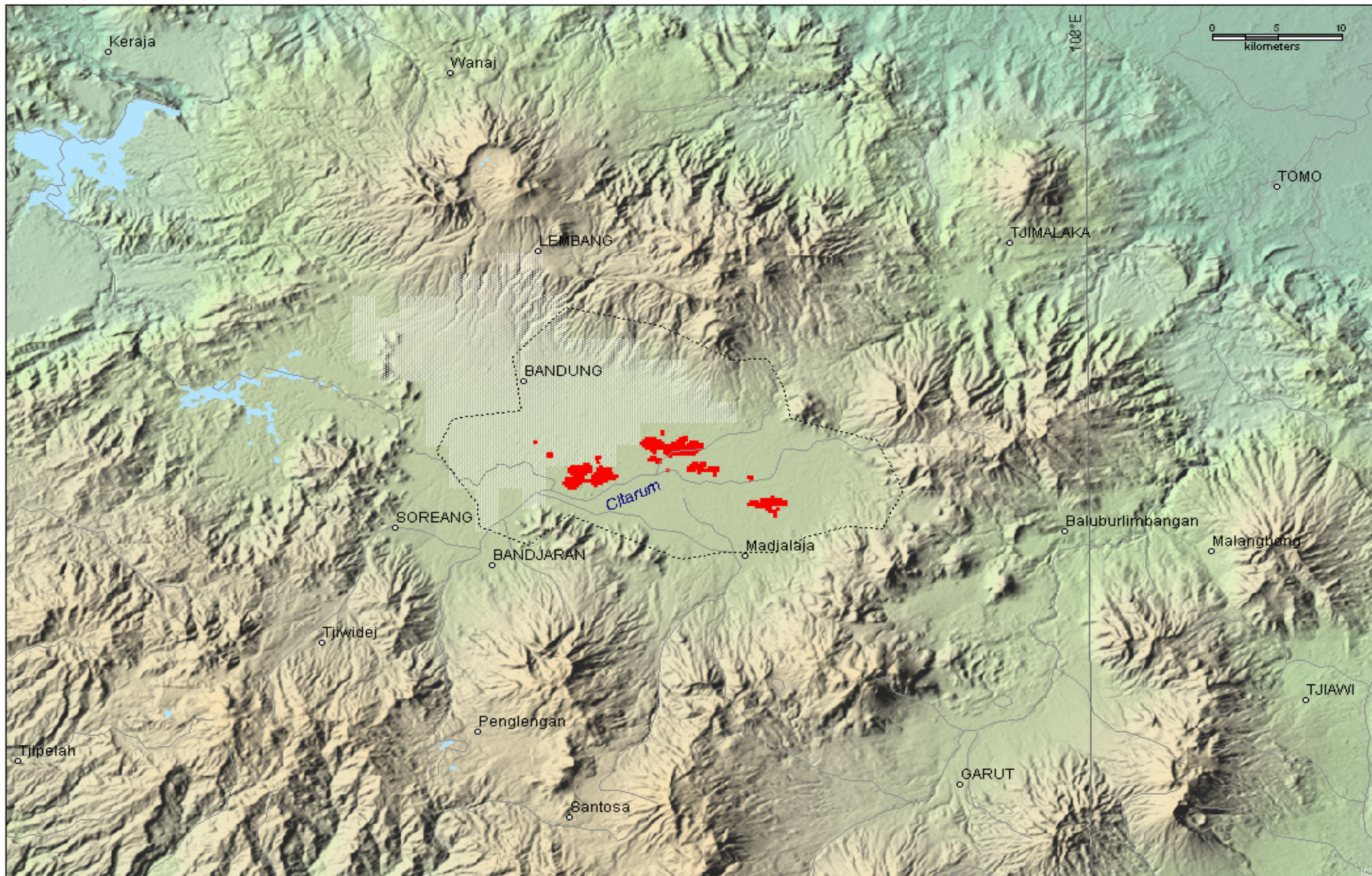
Work supported by
NASA grant NAG5-9470
Ebine K Anderson
G. R. Brakenridge

MODIS flood inundation limit
February 23, 2005: ■

MODIS data cloud free area
February 23, 2005:

MODIS reference water:
DCW Rivers ■
Urban Areas

Universal Transverse Mercator - UTM Zone 49 South - WGS 84 - Graticule: 2 degrees
Copyright 2005 Dartmouth Flood Observatory - Dartmouth College - Hanover NH, 03755 USA
Shaded relief from SRTM data



Bandung Basin

Propinsi Jawa Barat



Image © 2005 MDA EarthSat
Image © 2005 DigitalGlobe

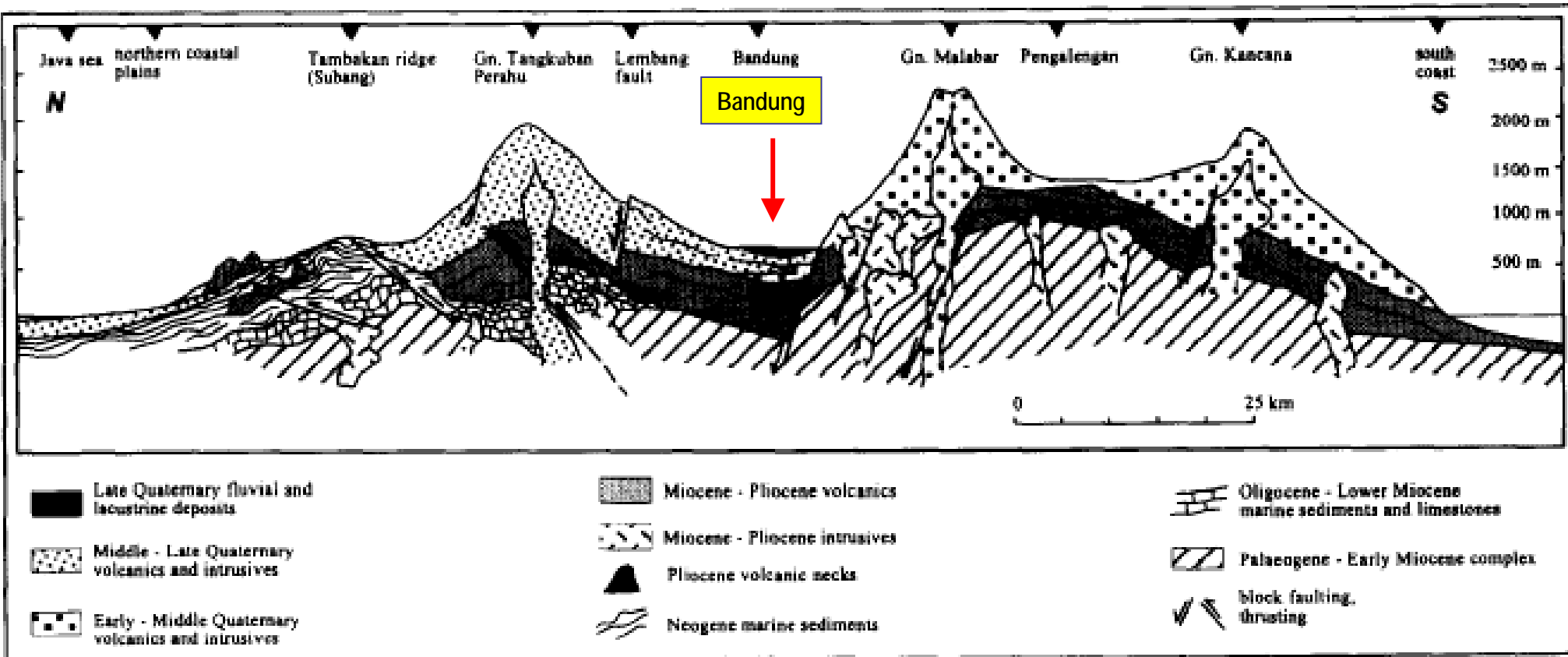
© 2005 Google

Pointer 6°56'05.28" S 107°36'14.01" E

Streaming ||||| 100%

Eye alt 37.31 mi

Structural Setting of Bandung Basin



Ref: [Dam et al., 1996]

INITIAL AIMS OF STUDY

- IS LAND SUBSIDENCE A REAL PHENOMENON IN BANDUNG ?
- IF YES, WHY LAND SUBSIDENCE IS HAPPENING ?
- HOW IS THE MECHANISM OF LAND SUBSIDENCE ?

IMPORTANCE OF LAND SUBSIDENCE INFORMATION IN BANDUNG

Groundwater
extraction
regulation

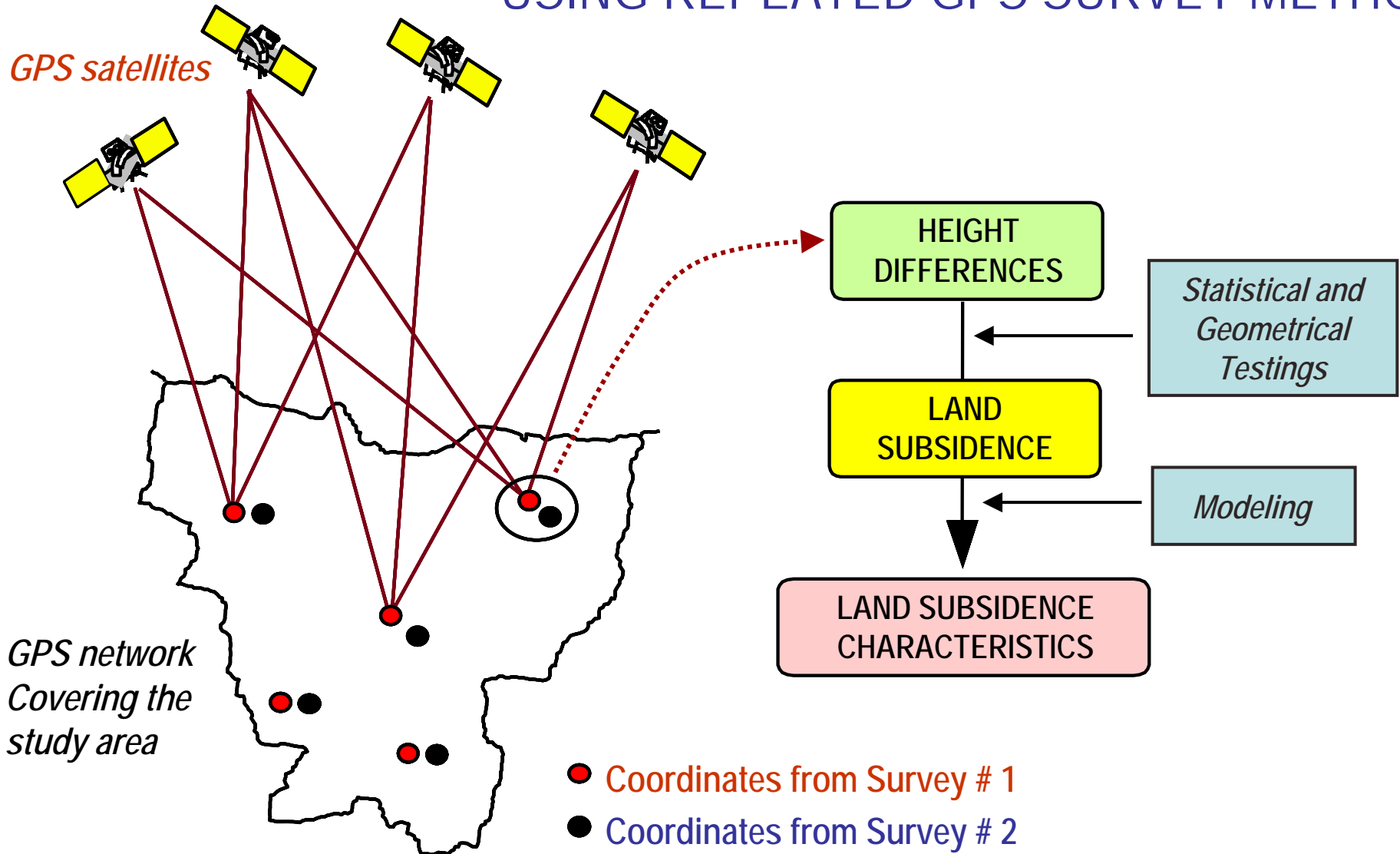
Flood
control

Environmental
conservation

Spatial
planning

Infrastructure
design and
construction

PRINCIPLE OF LAND SUBSIDENCE MONITORING USING REPEATED GPS SURVEY METHOD

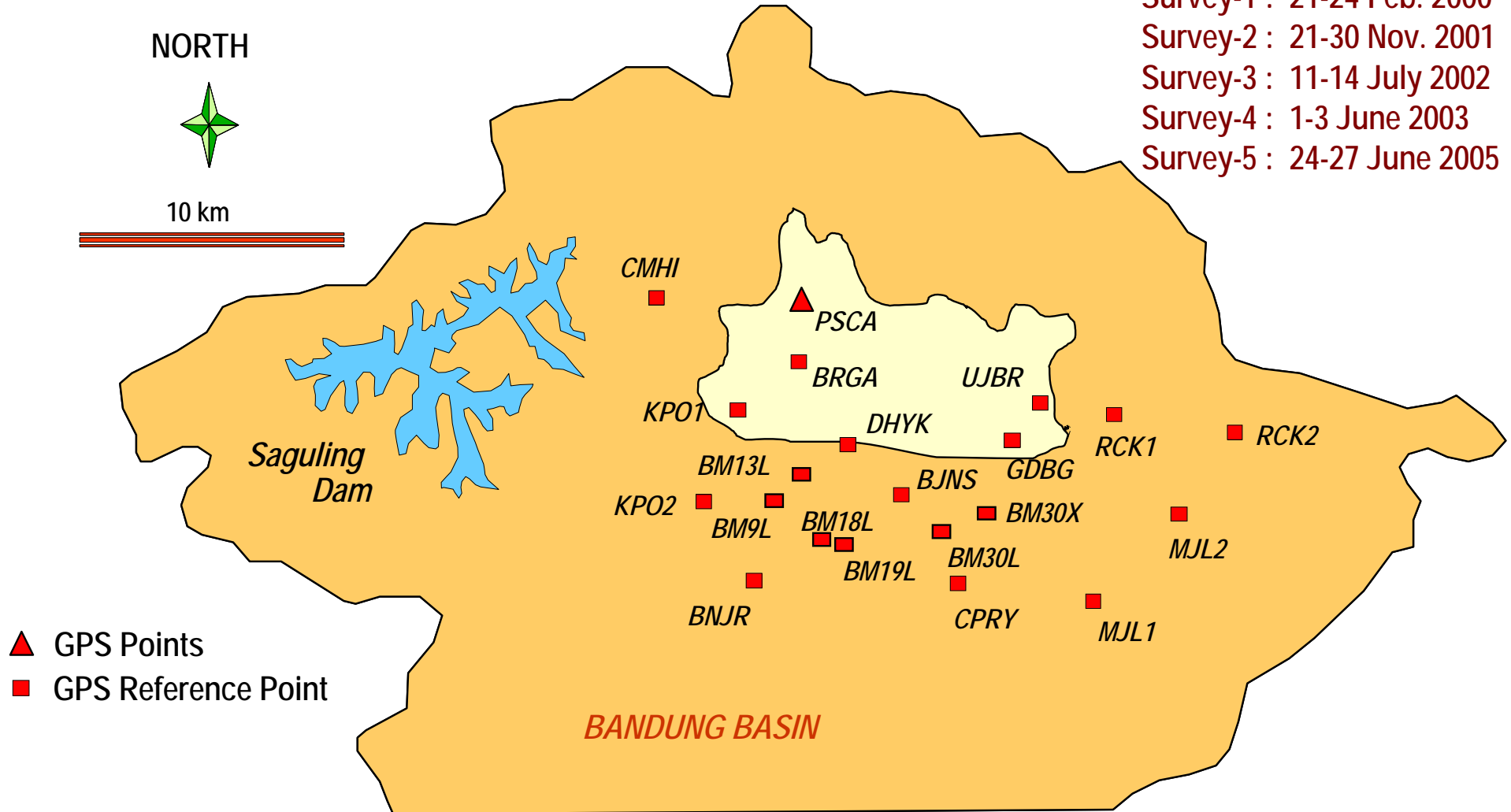


GPS network
Covering the
study area

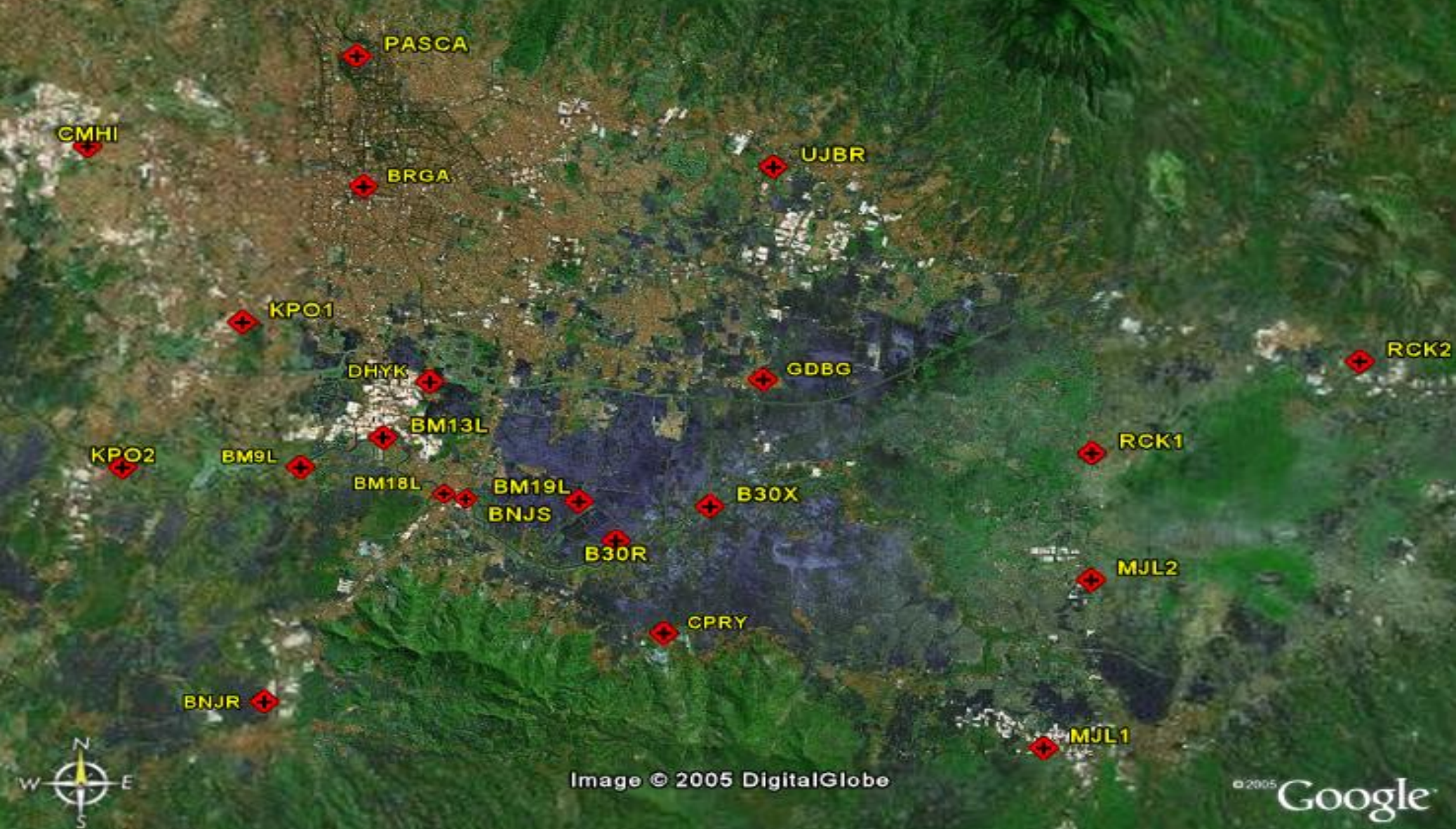
- Coordinates from Survey # 1
- Coordinates from Survey # 2

GPS NETWORK FOR MONITORING LAND SUBSIDENCE in BANDUNG BASIN

Survey-1 : 21-24 Feb. 2000
Survey-2 : 21-30 Nov. 2001
Survey-3 : 11-14 July 2002
Survey-4 : 1-3 June 2003
Survey-5 : 24-27 June 2005



GPS NETWORK FOR MONITORING LAND SUBSIDENCE in BANDUNG BASIN



SOME GPS POINTS IN BANDUNG



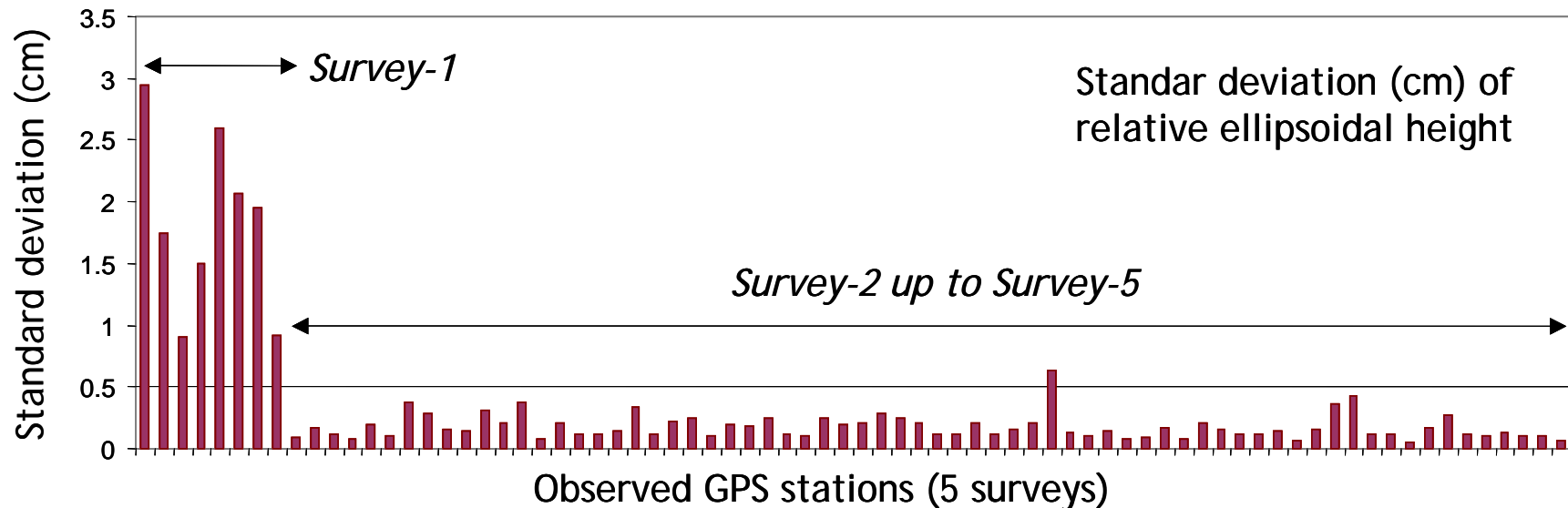
GPS SURVEYS IN BANDUNG

GPS receiver : dual-frequency geodetic-type

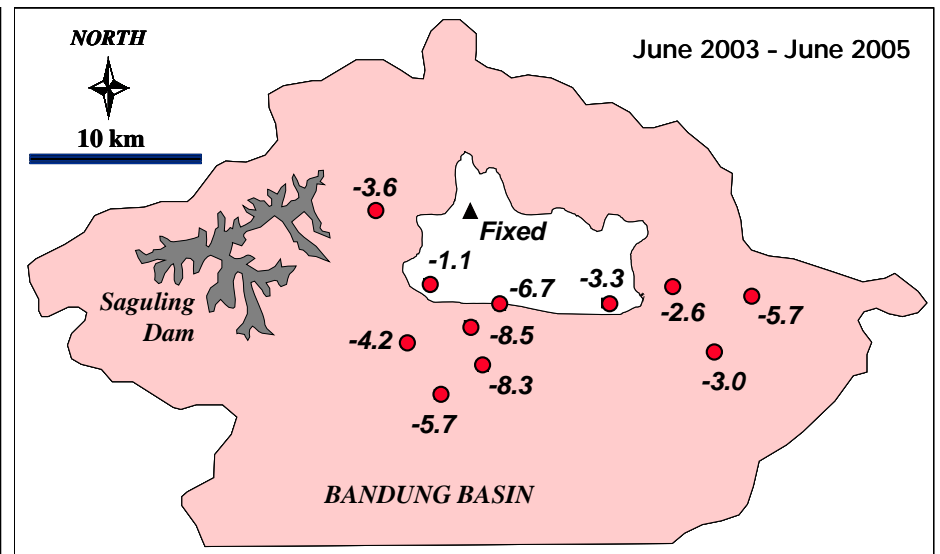
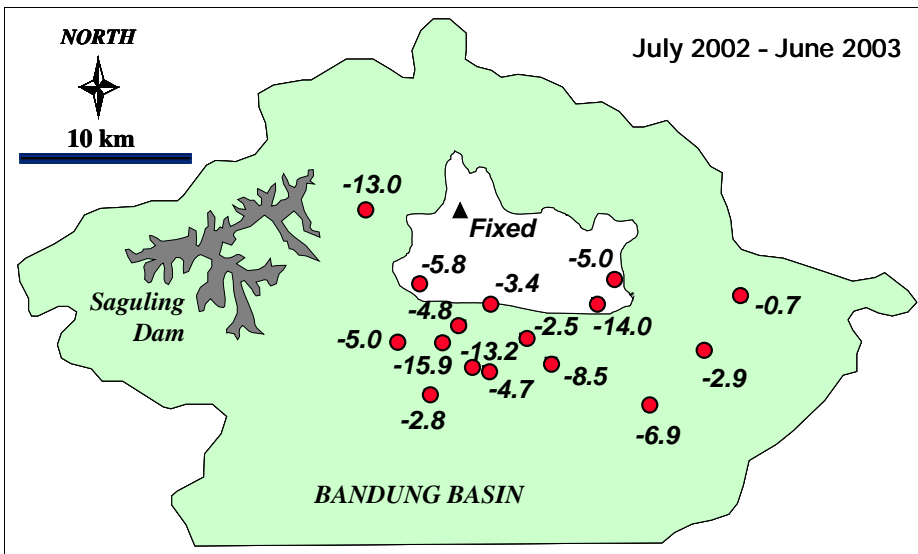
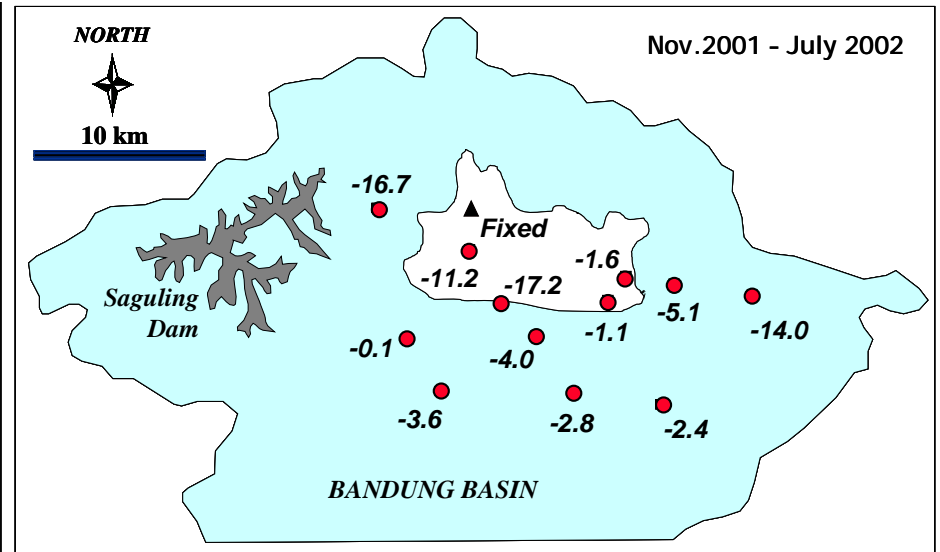
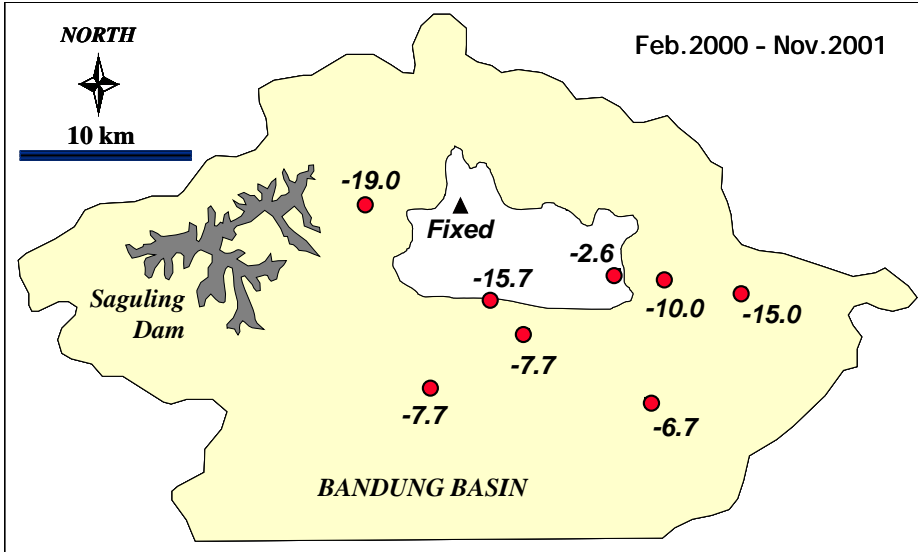
Session length : in general 10 to 12 hours

Data rate : 30 seconds, Mask angle : 15°

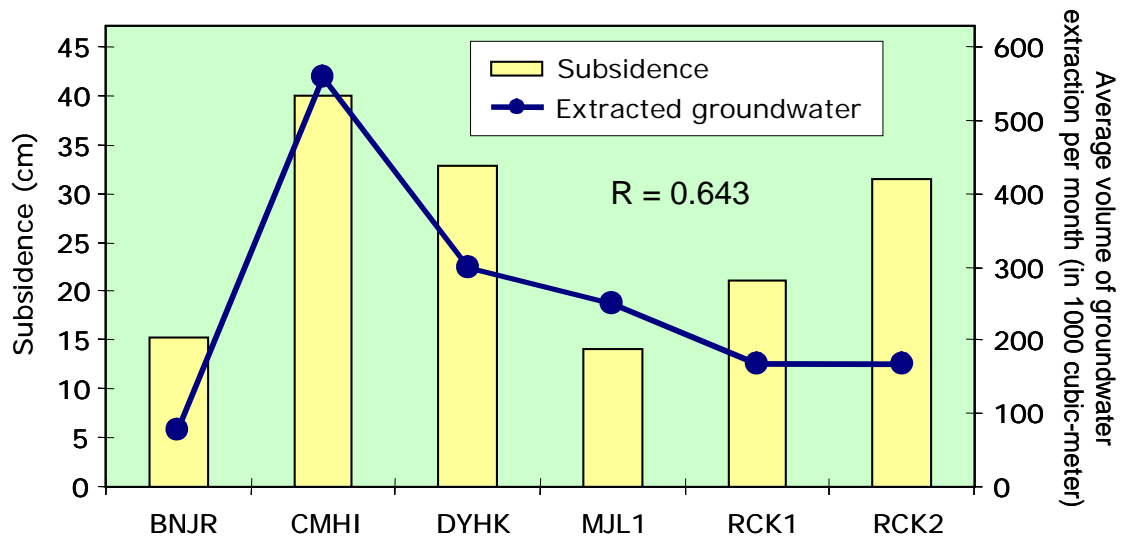
Processing : SKIPro, precise ephemeris, Saastamoinen tropospheric model, ionospheric free linear combination after fixing the integer ambiguities of L1 and L2 signals



GPS Derived Subsidence Rates (mm/month)

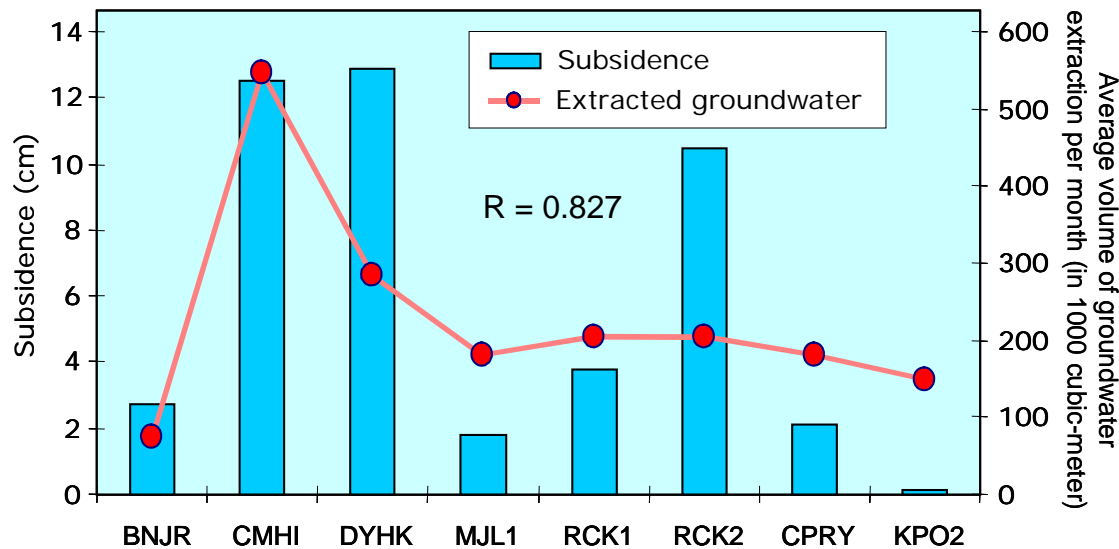


Land Subsidence and Groundwater Abstraction



INITIAL HYPOTHESIS :
Land subsidence observed in several locations in Bandung basin is caused by an excessive groundwater abstraction.

GPS survey results show that this hypothesis is not always true for all observed stations.

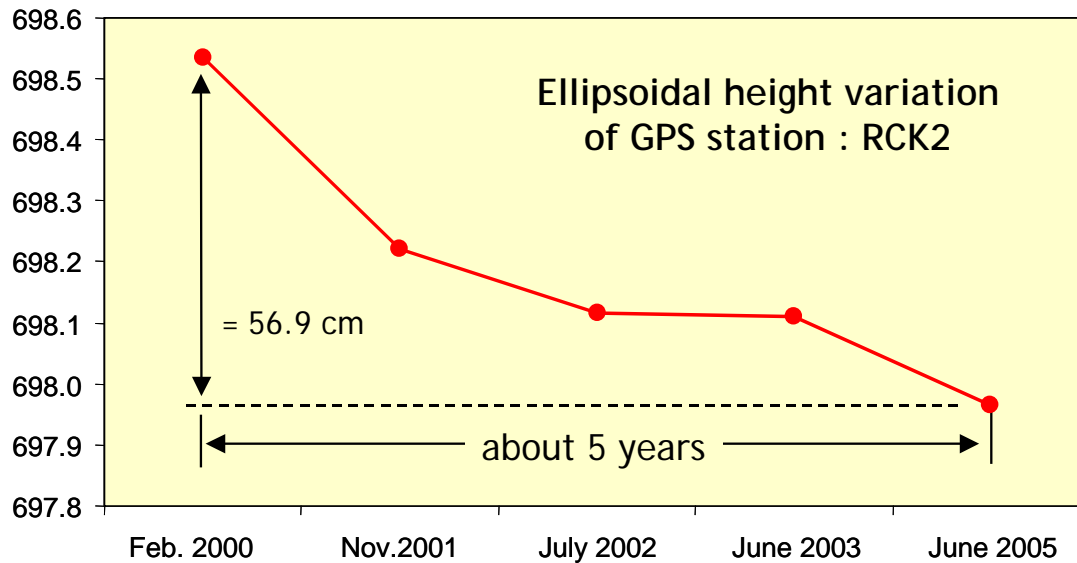


WHY ?

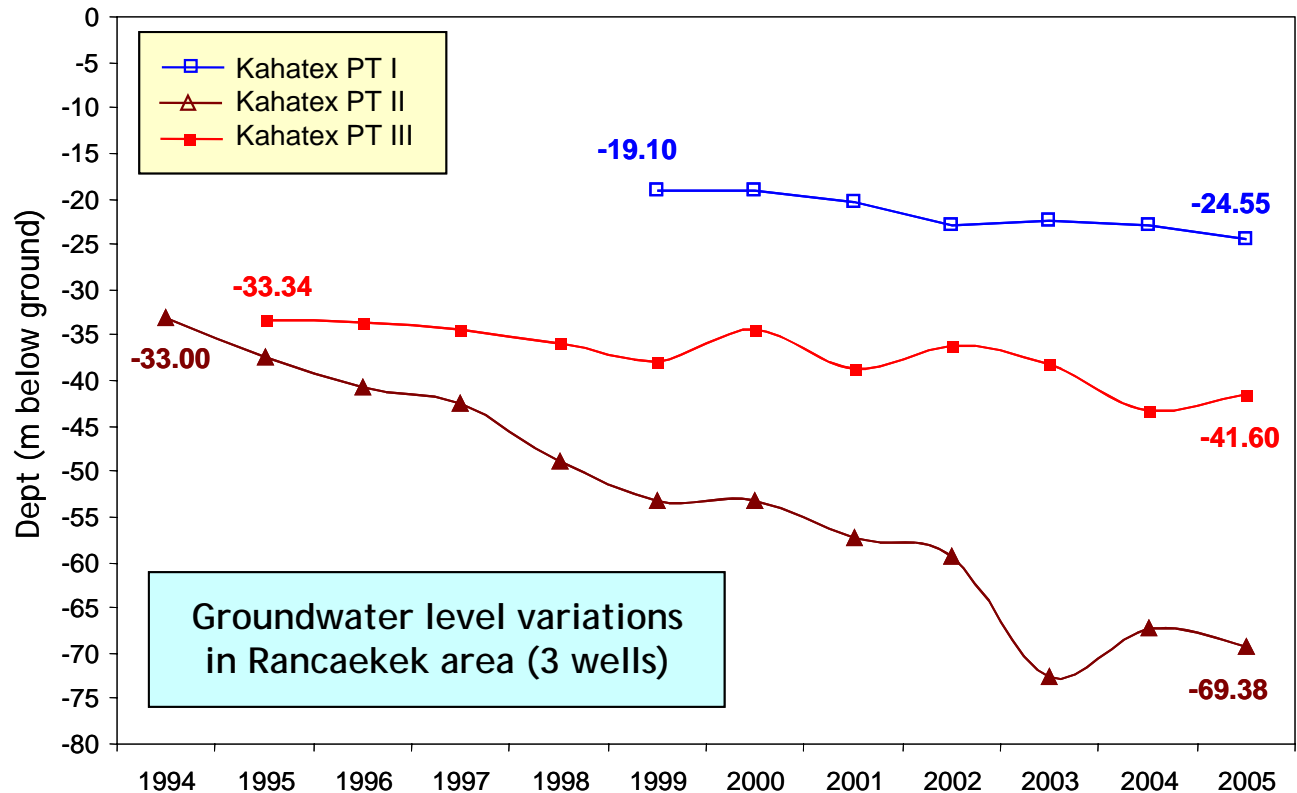
- the registered groundwater abstraction volume does not reflect the real groundwater abstraction, **and/or**
- the land subsidence is also governed by other factors.

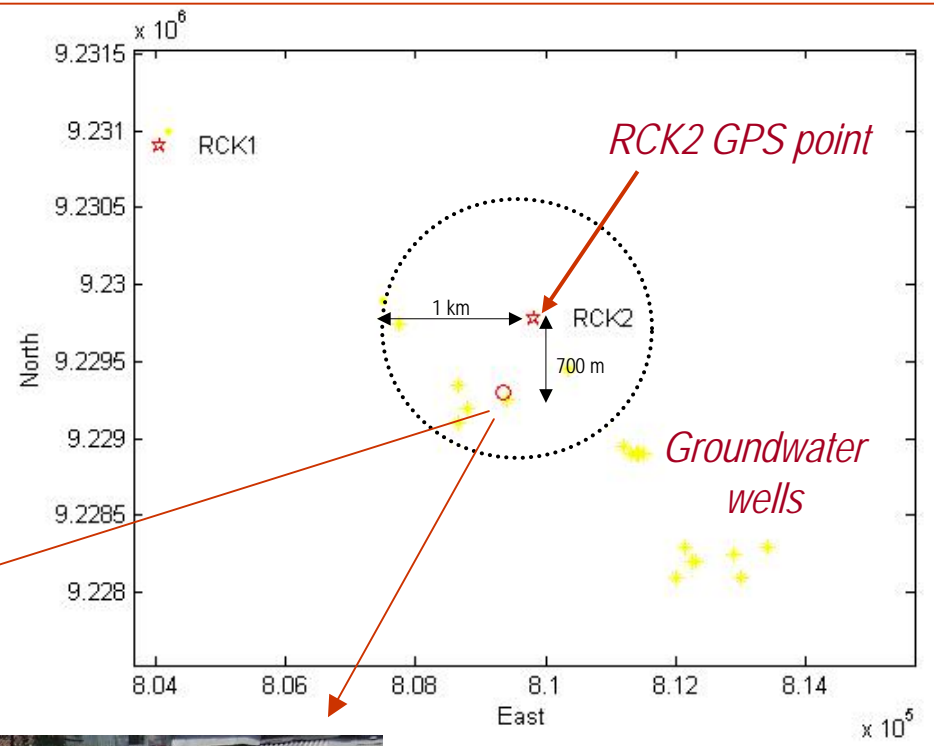
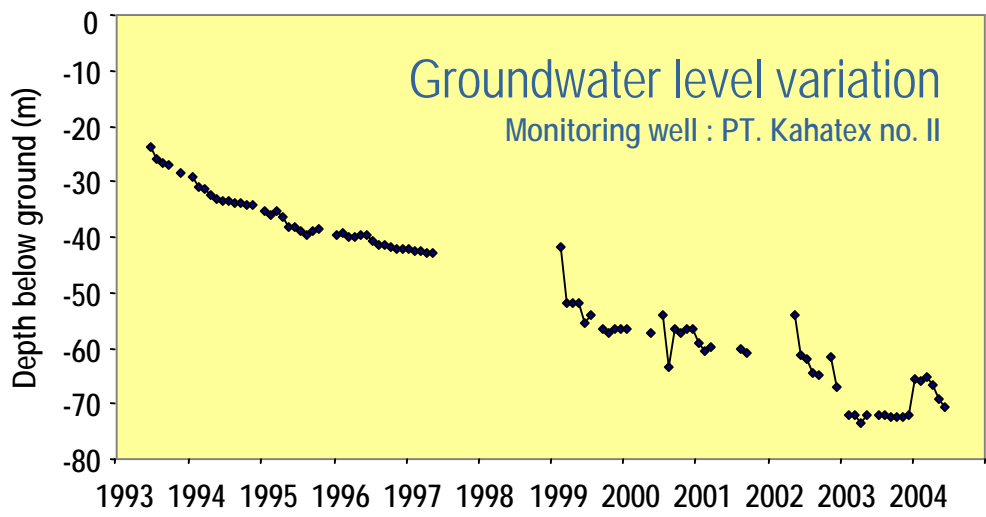
SUBSIDENCE AND GROUNDWATER ABSTRACTION

in Rancaekek area



There is
correlation !!





Water inundation in the road



Cracking and tilting of road

**IMPACT OF
SUBSIDENCE AND
in Rancaekek area**

IMPACT OF SUBSIDENCE AROUND CMHI GPS STATION



Water Inundation

Tilting of Infrastructures



CLOSING REMARKS

- GPS survey method is a reliable method for studying and monitoring land subsidence → *should also be integrated with results obtained by Leveling, INSAR and Automatic Water Level Recorder.*
- Land subsidence in Bandung =
f { excessive groundwater abstraction,
building load (?), tectonics (?),
natural compaction (?), $x_1(?)$, ... , $x_n(?)$ }
- Further research is needed to clarify the real mechanism and pattern of land subsidence phenomena in Bandung.