Toward the possible groundwater management at Tokyo Metropolitan area

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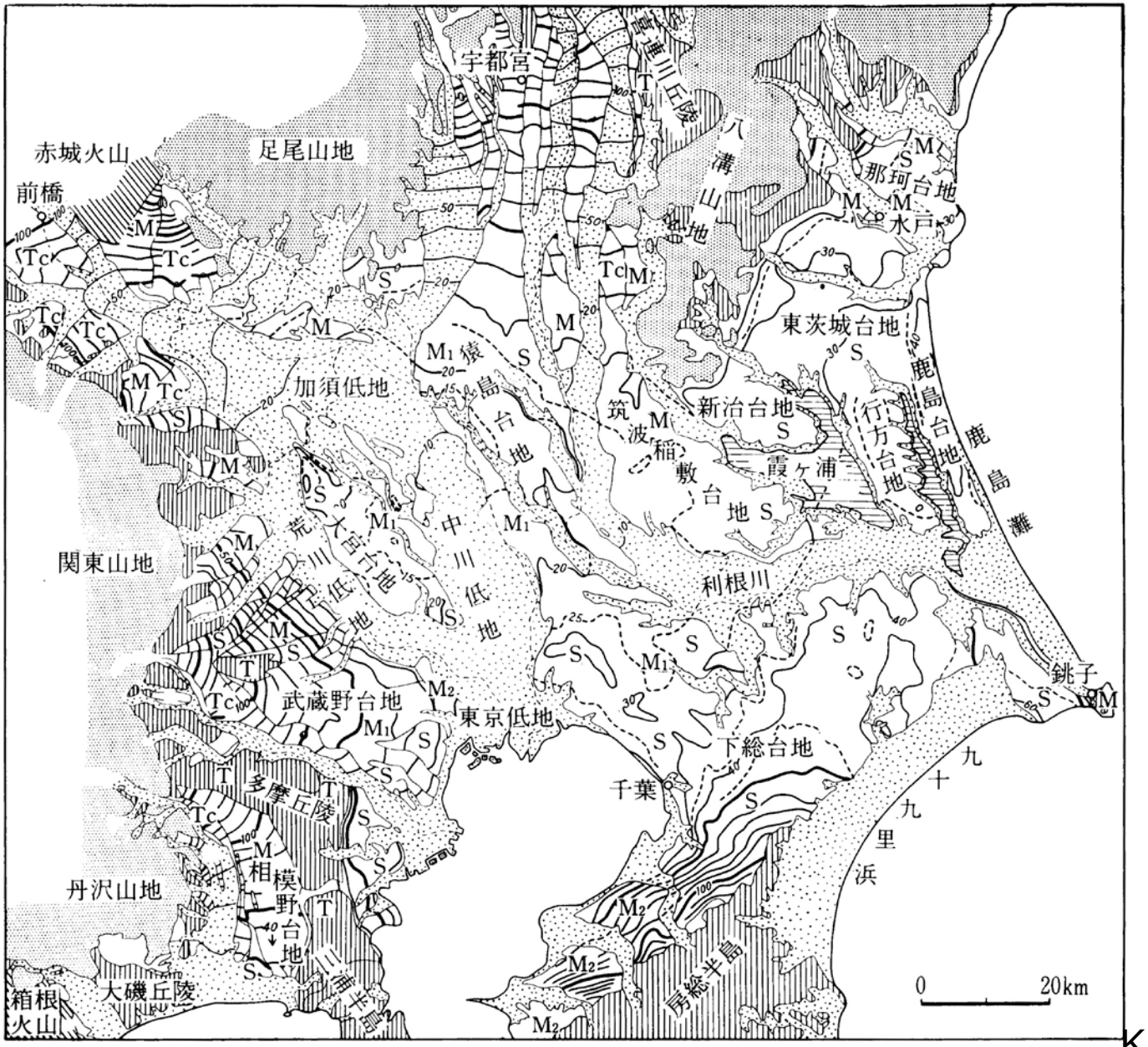
- Temporal change of groundwater conditions in the Tokyo Metropolitan Area
- Problems caused by the drop of groundwater potential in confined aquifers
- Problems of underground infrastructures due to the recovery of groundwater potential
- Necessary technological development toward the possible groundwater management and usage

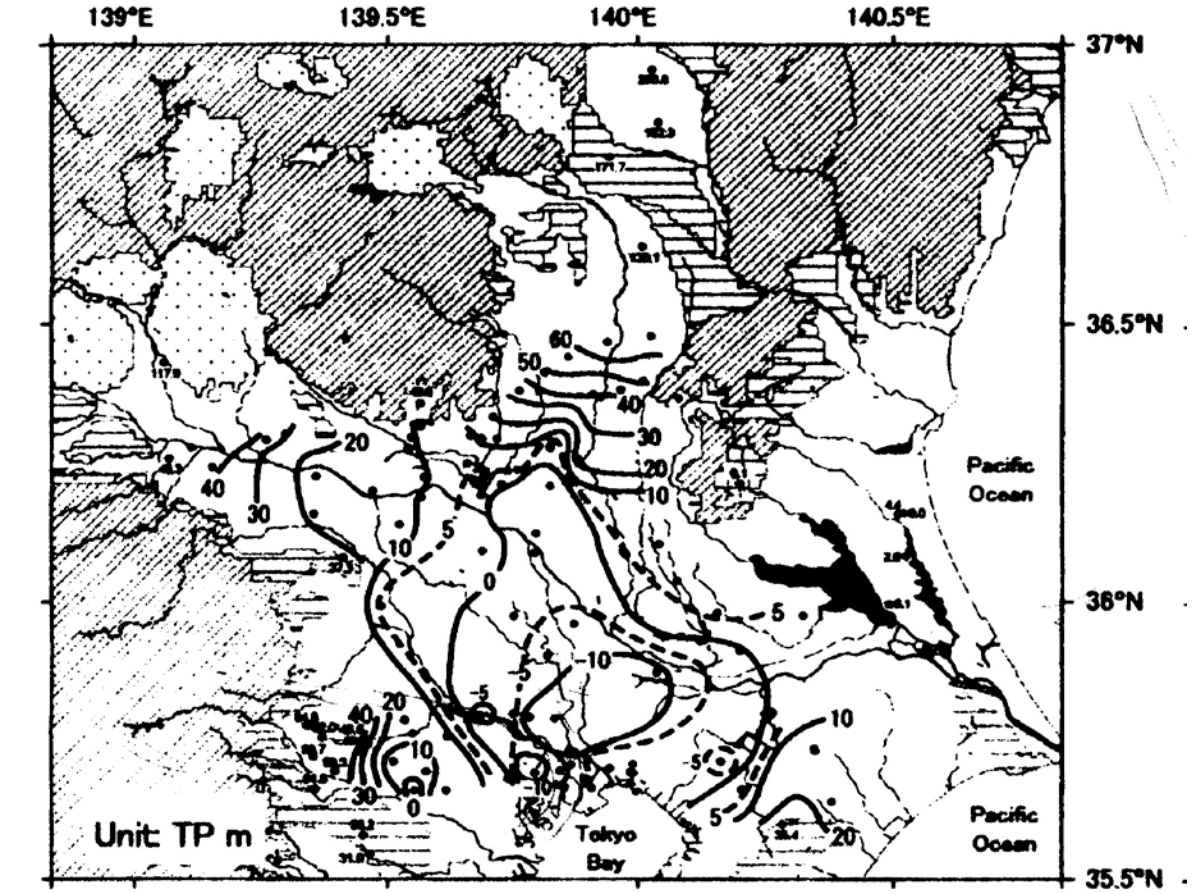
Topography of the Tokyo Metropolitan Area

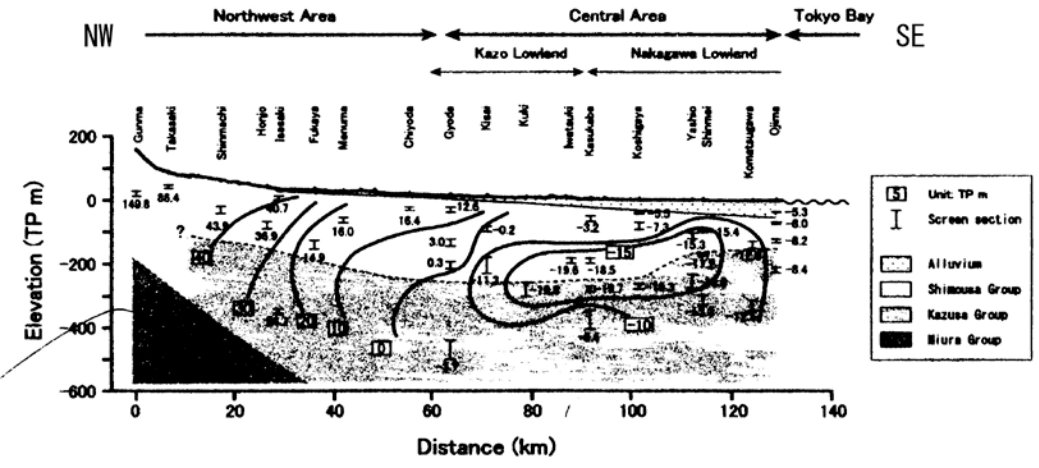


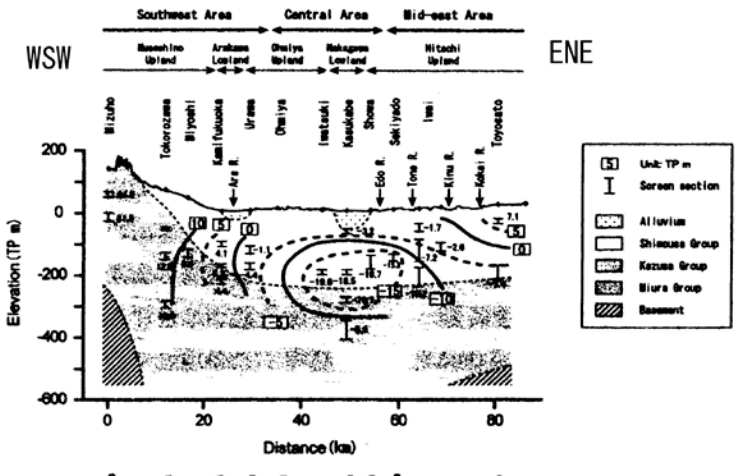
Kaizuka et al. (2000)

Hydrogeological situation

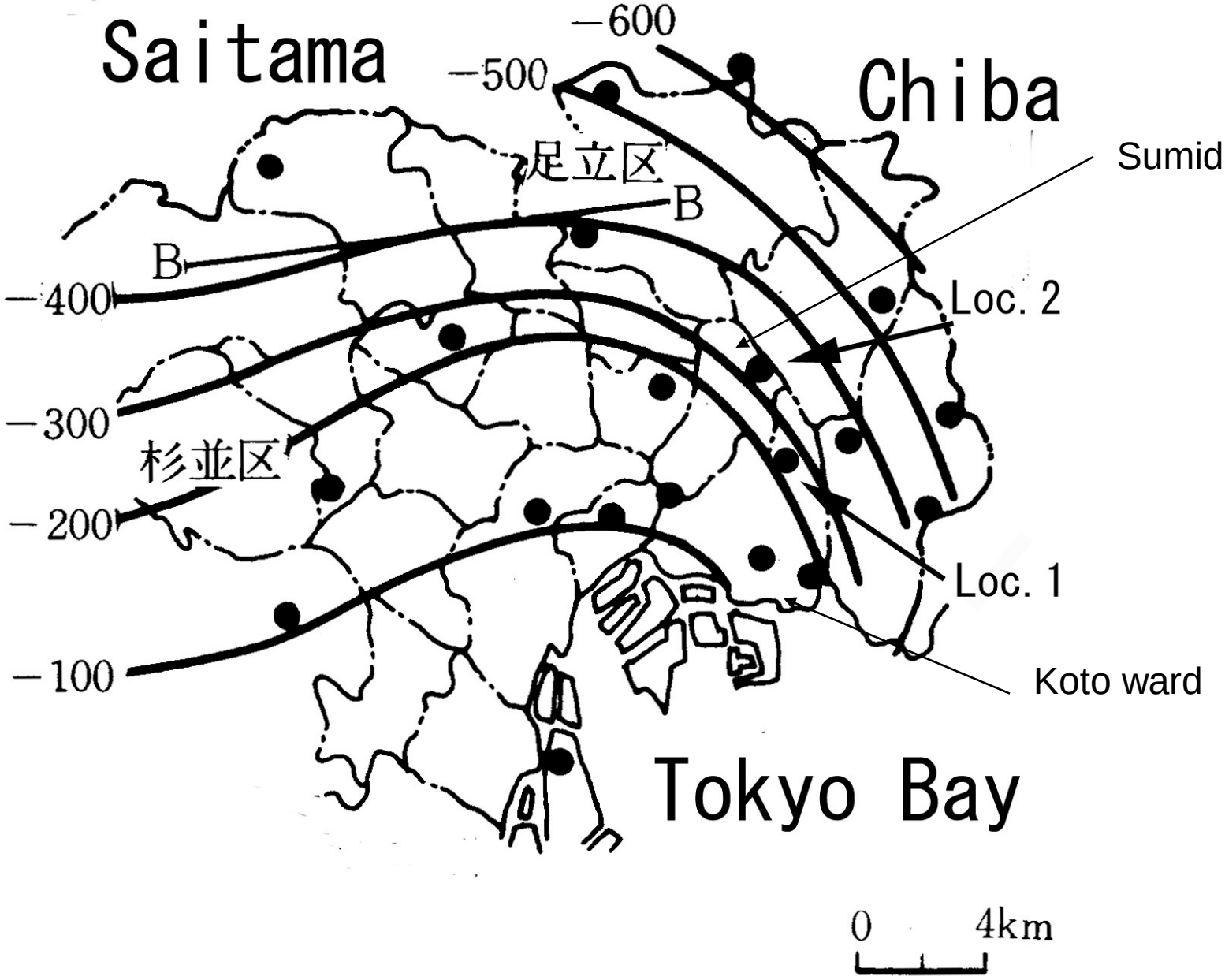
Hayashi et al. (2003)



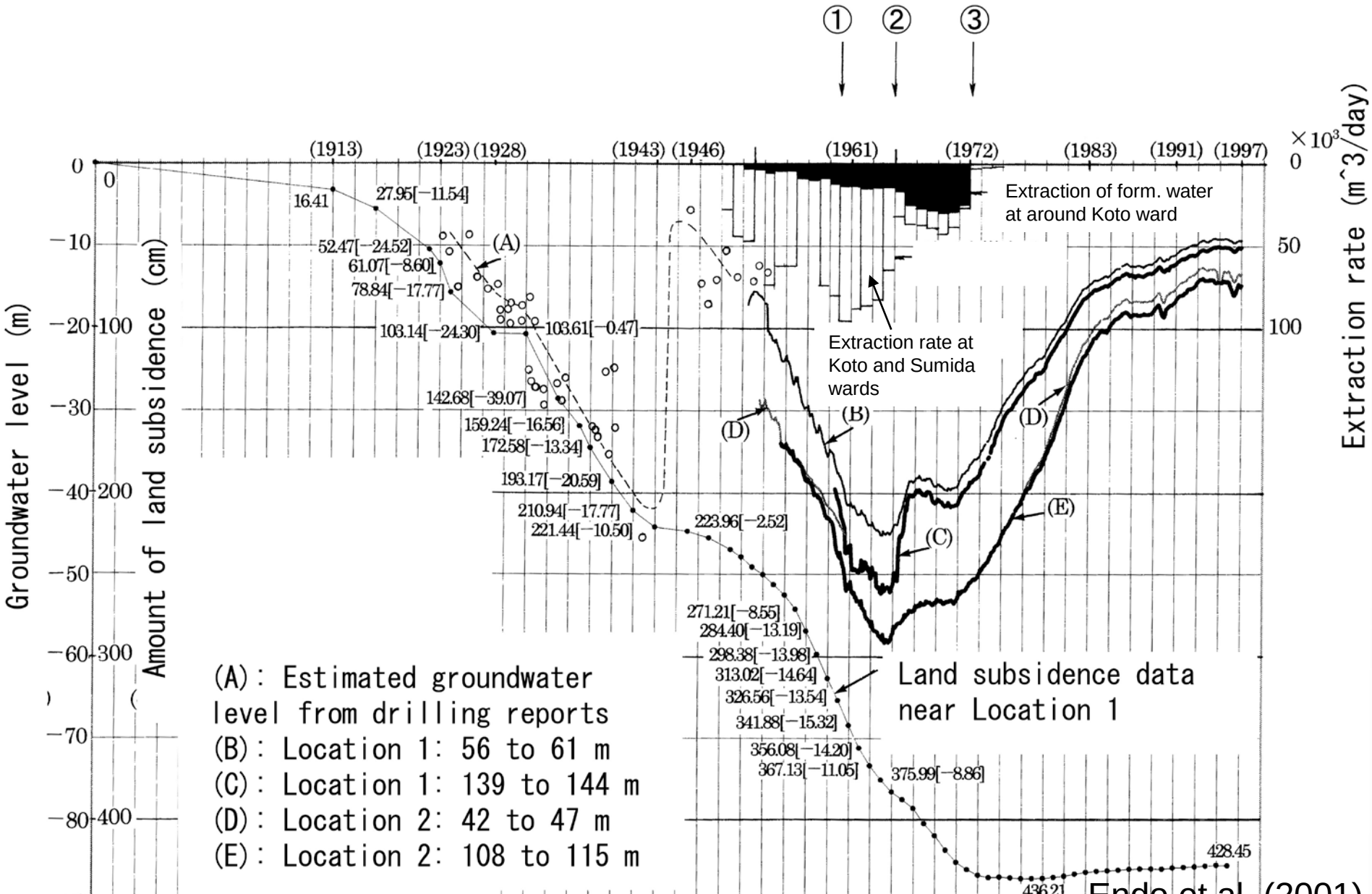




Depth to the bottom of the aquifer

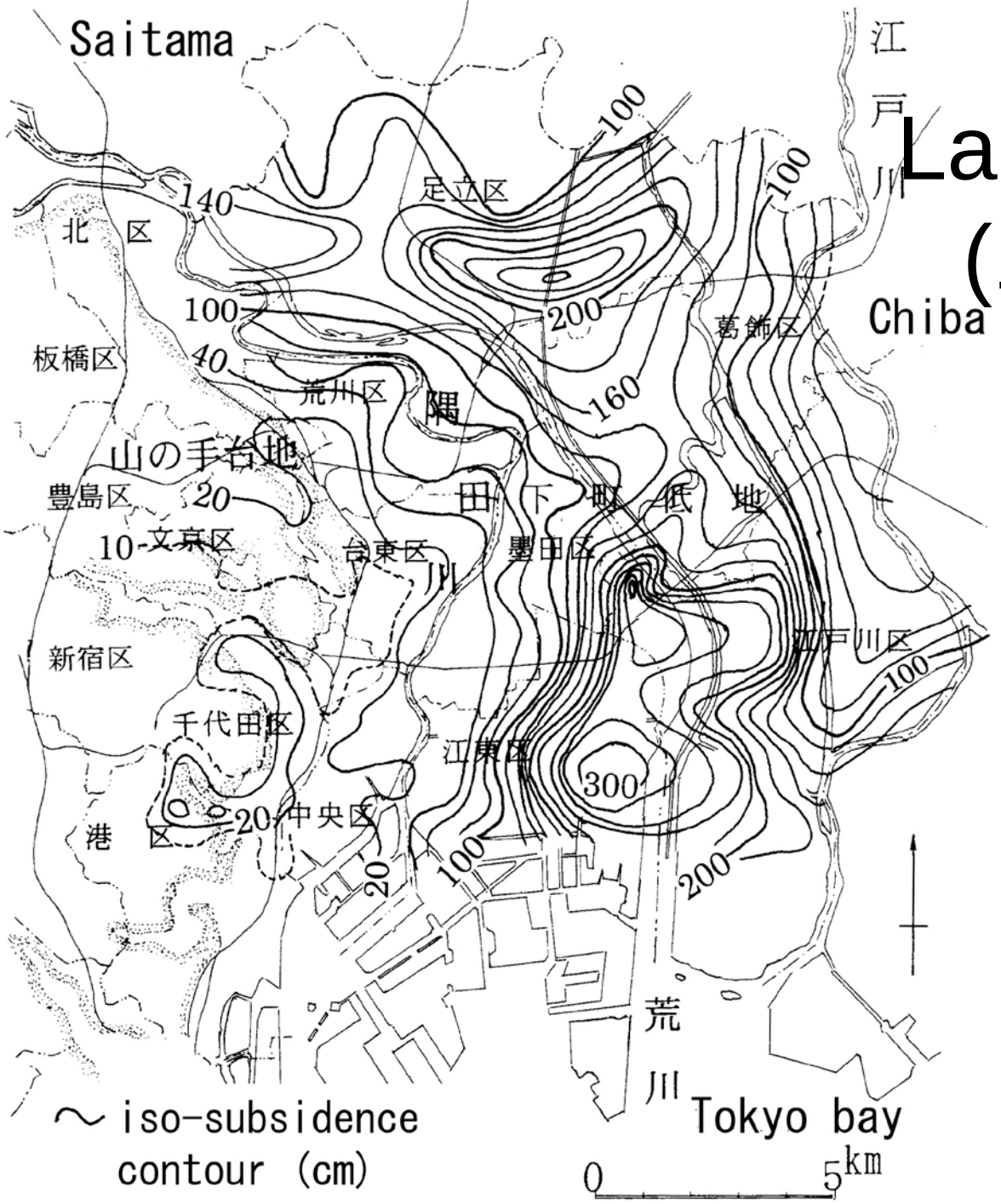


Temporal change of groundwater potentials of confined aquifers



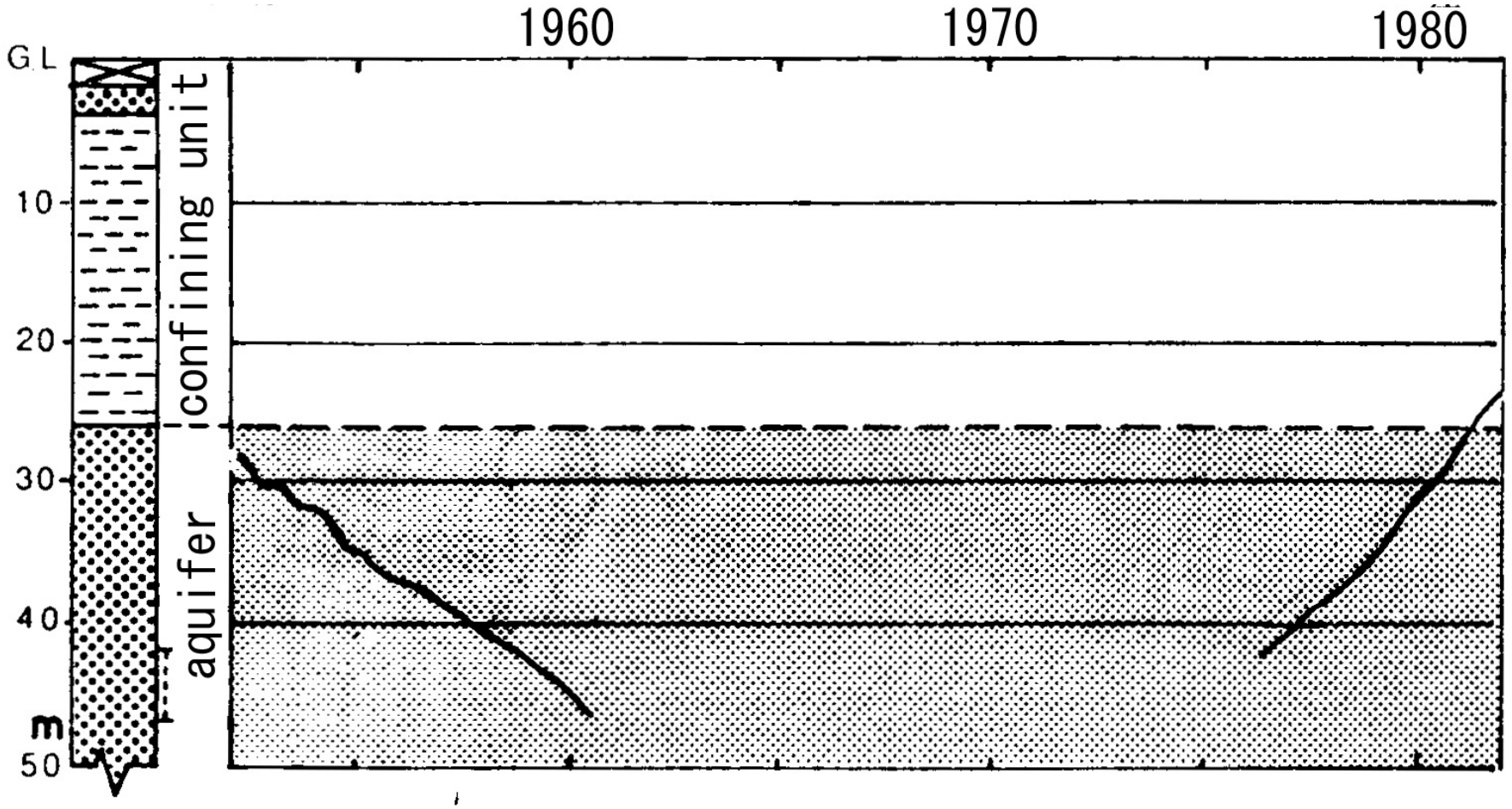
Endo et al. (2001)

Land subsidence (1938 ~ 1977)

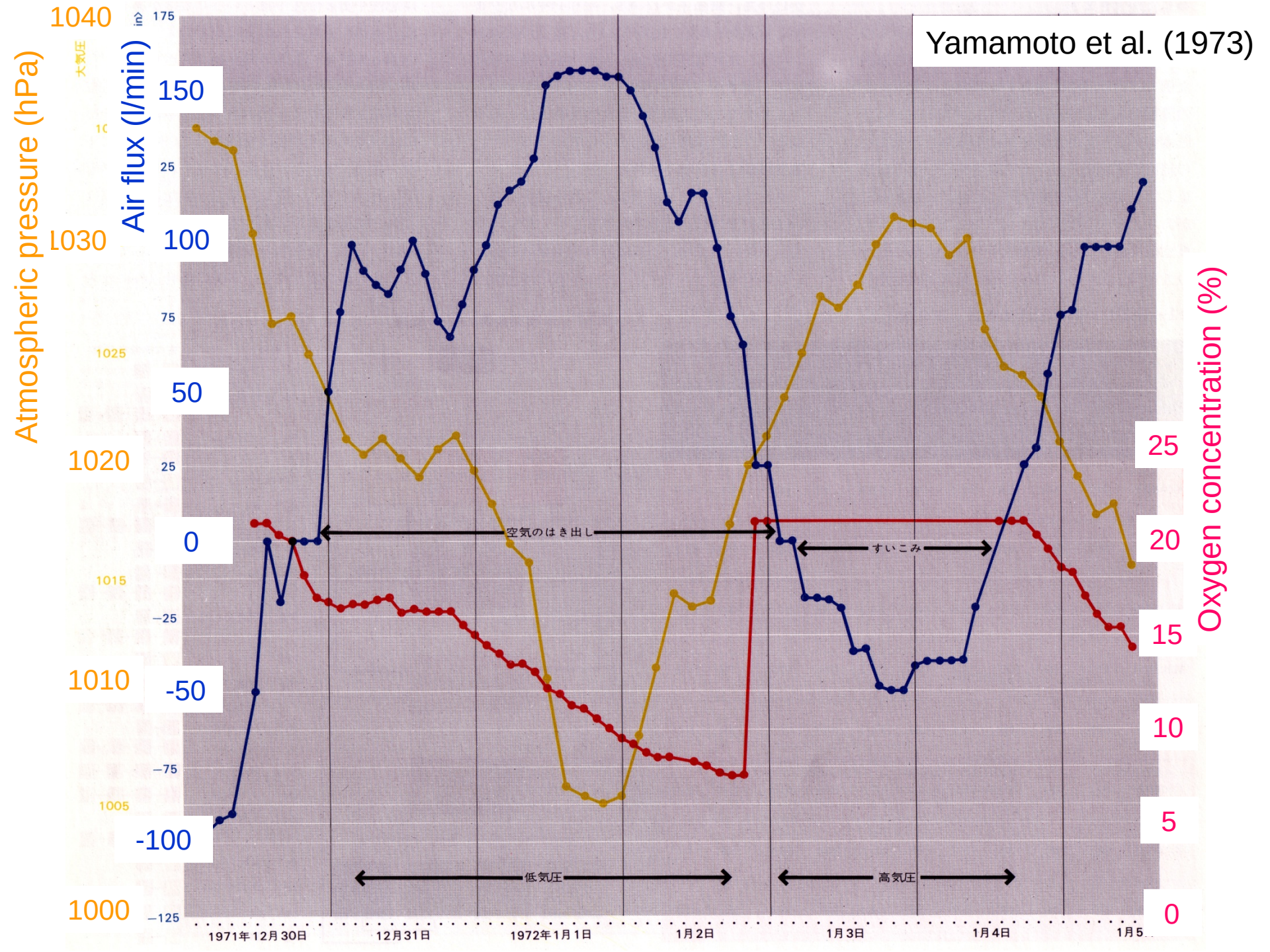


Endo et al. (2001)

Change from confined-to-unconfined aquifer



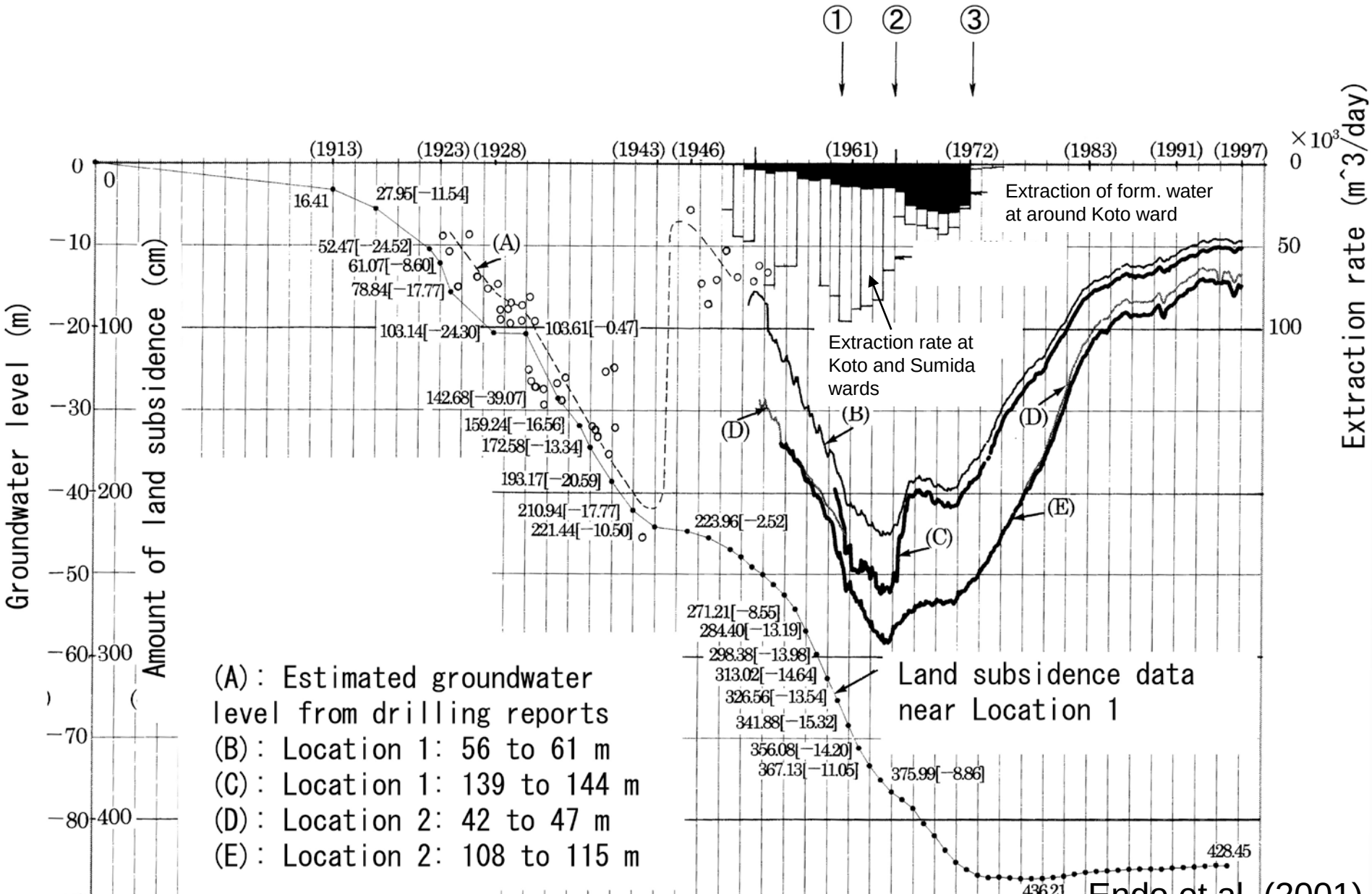
Endo and Ishii (1984)


Yamamoto et al. (1973)
Atmospheric pressure (hPa)
Air flux (l/min)
Oxygen concentration (%)
1040
1030
1020
1010
1000
150
100
50
0
-50
-100
25
20
15
10
5
0
空気のはき出し
すいこみ
低気圧
高気圧
1971年12月30日
12月31日
1972年1月1日
1月2日
1月3日
1月4日
1月5

Sequence of major regulations

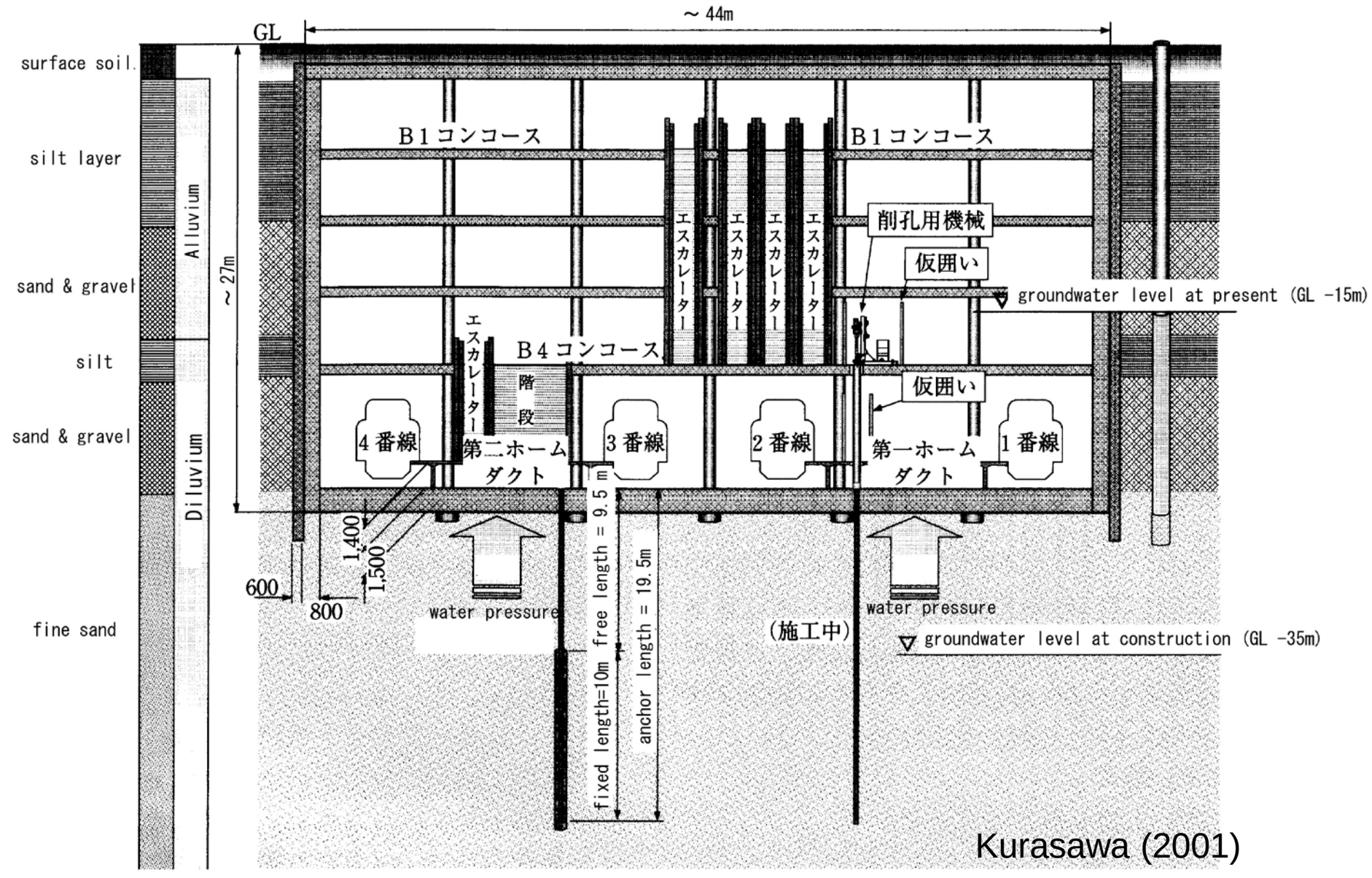
- 1961: no new wells were to be installed for industrial use in southern part of alluvial lowland
- 1963: no new wells were to be installed for air conditional use
- 1966: pumping of groundwater for industrial use in southern part was restricted
- 1971: pumping of groundwater for industrial use in northern part was restricted
- 1972: extraction of methane gas dissolved in water (formation water) was suspended

Temporal change of groundwater potentials of confined aquifers



Endo et al. (2001)

Problems of underground infrastructures (Tokyo station)



Is it possible for us to re-start using groundwater?

- Better to reduce the damage to existing infrastructures
- Possible to improve urban environment (especially mitigating heat island phenomena)

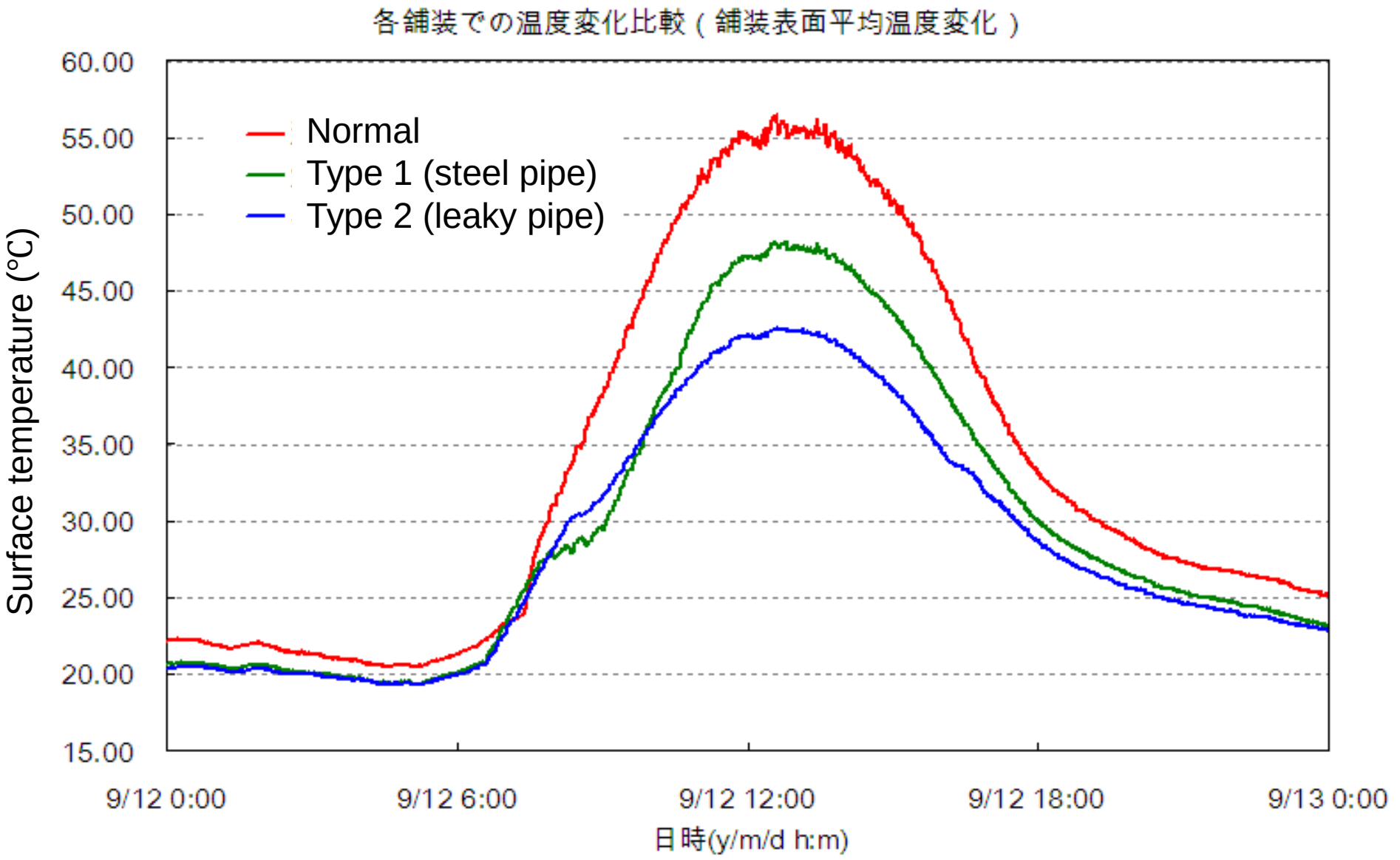
  → ex. Cool city project (2006-2011)

  by Ministry of Environment

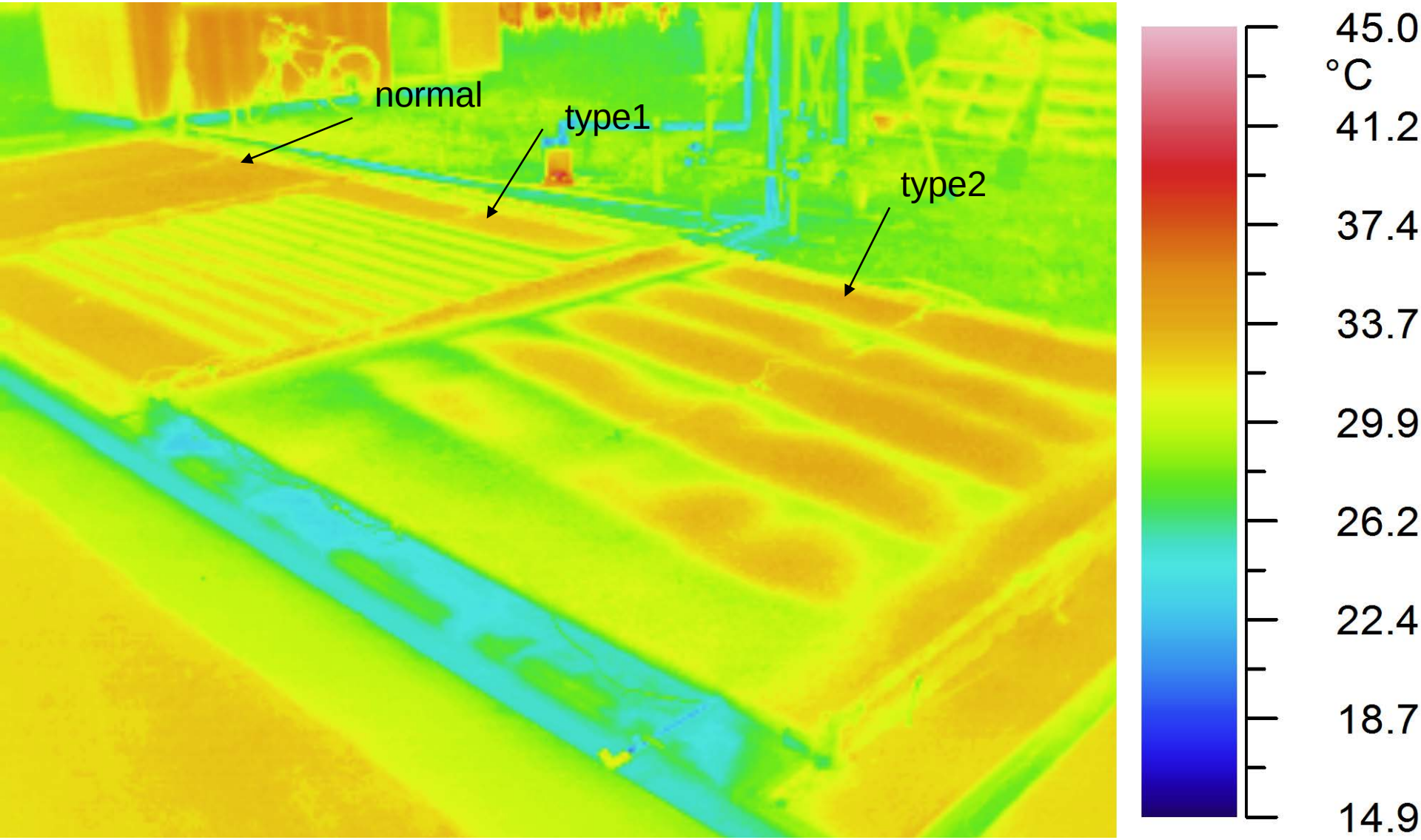
An example of using (ground)water for improving surface environment

- By providing groundwater through permeable pavement, it is possible to reduce the surface temperature and storage of heat in ground.

Reduction of mean surface temperature



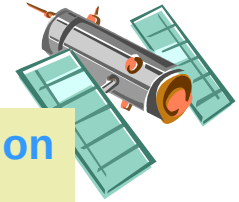
Surface temperature distribution



Necessary technology development for sustainable groundwater use

- Better understanding of the groundwater flow system
  - Re-analyzing the groundwater information and construct regional groundwater flow model
- Development of a monitoring system for sustainable use
  - High-quality surface deformation monitoring through satellite
  - Coupled groundwater/deformation model

satellite



Permanent scatters

Regional surface deformation monitoring by PSInSAR (or D-InSAR+GPS)

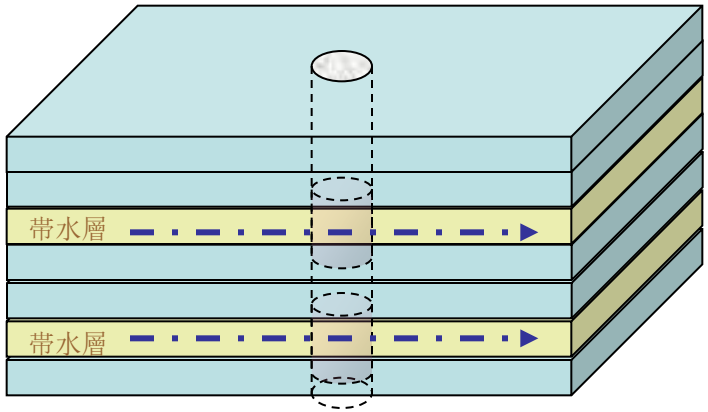
Mt.

Subsidence by groundwater extraction

sea

Gw potential

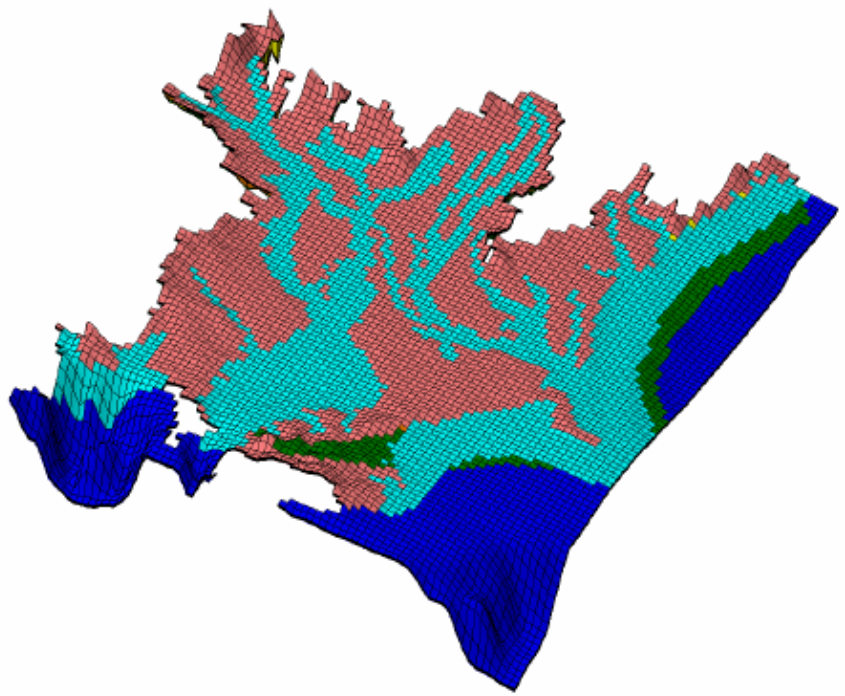
Increase of groundwater potential of confined aquifers

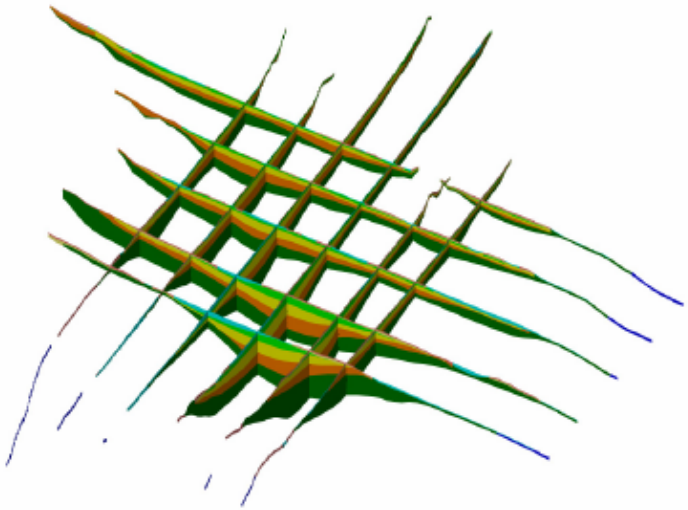


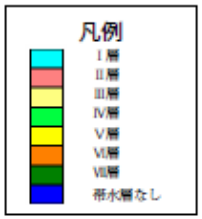
Monitoring for ground truth

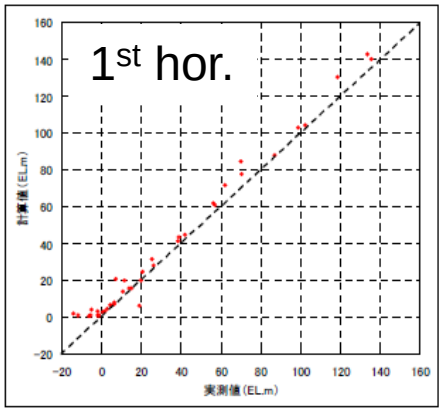
Coupled groundwater/deformation modeling plus monitoring

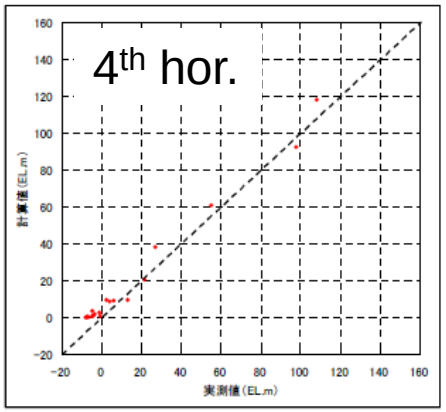
Developing regional groundwater flow model

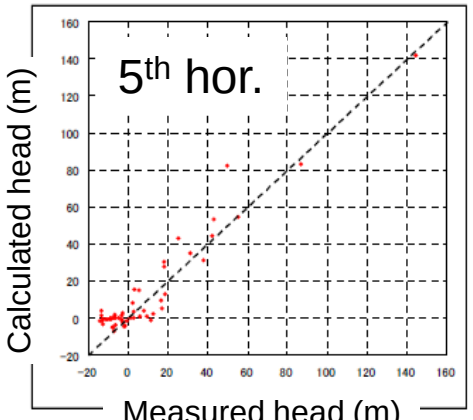




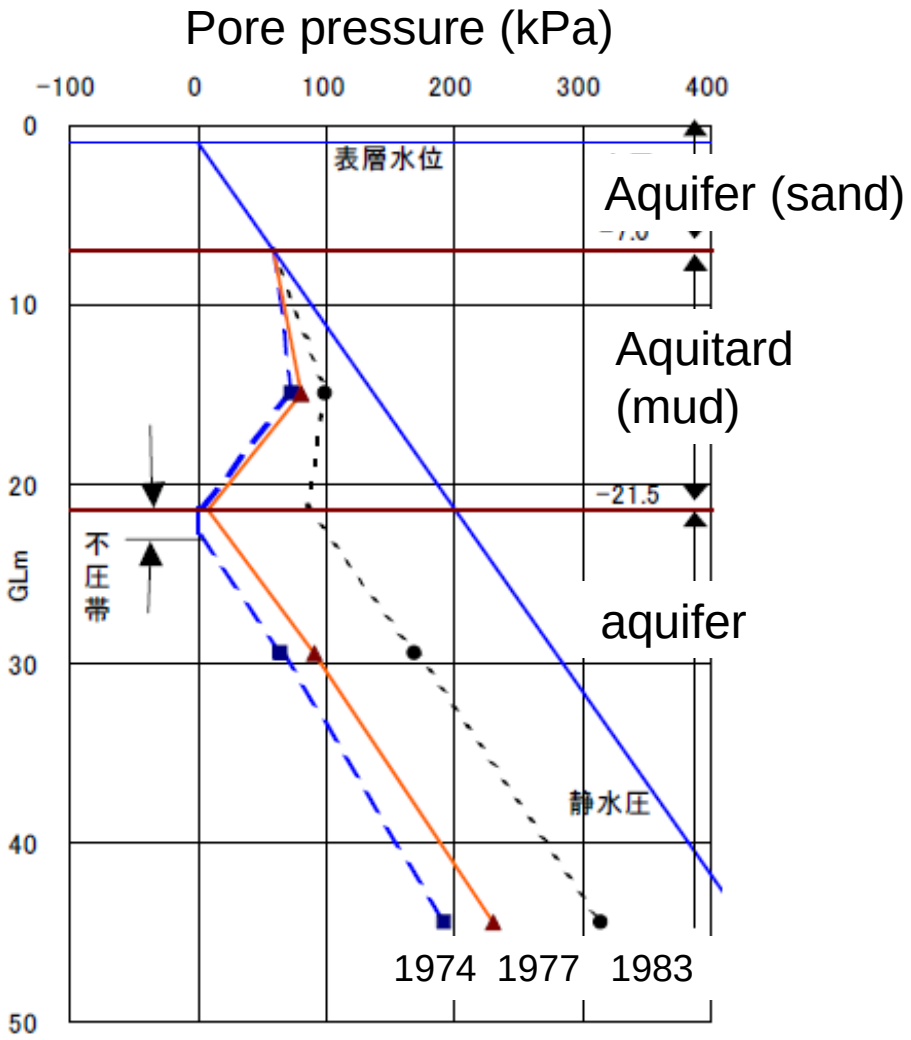








Potential of possible subsidence



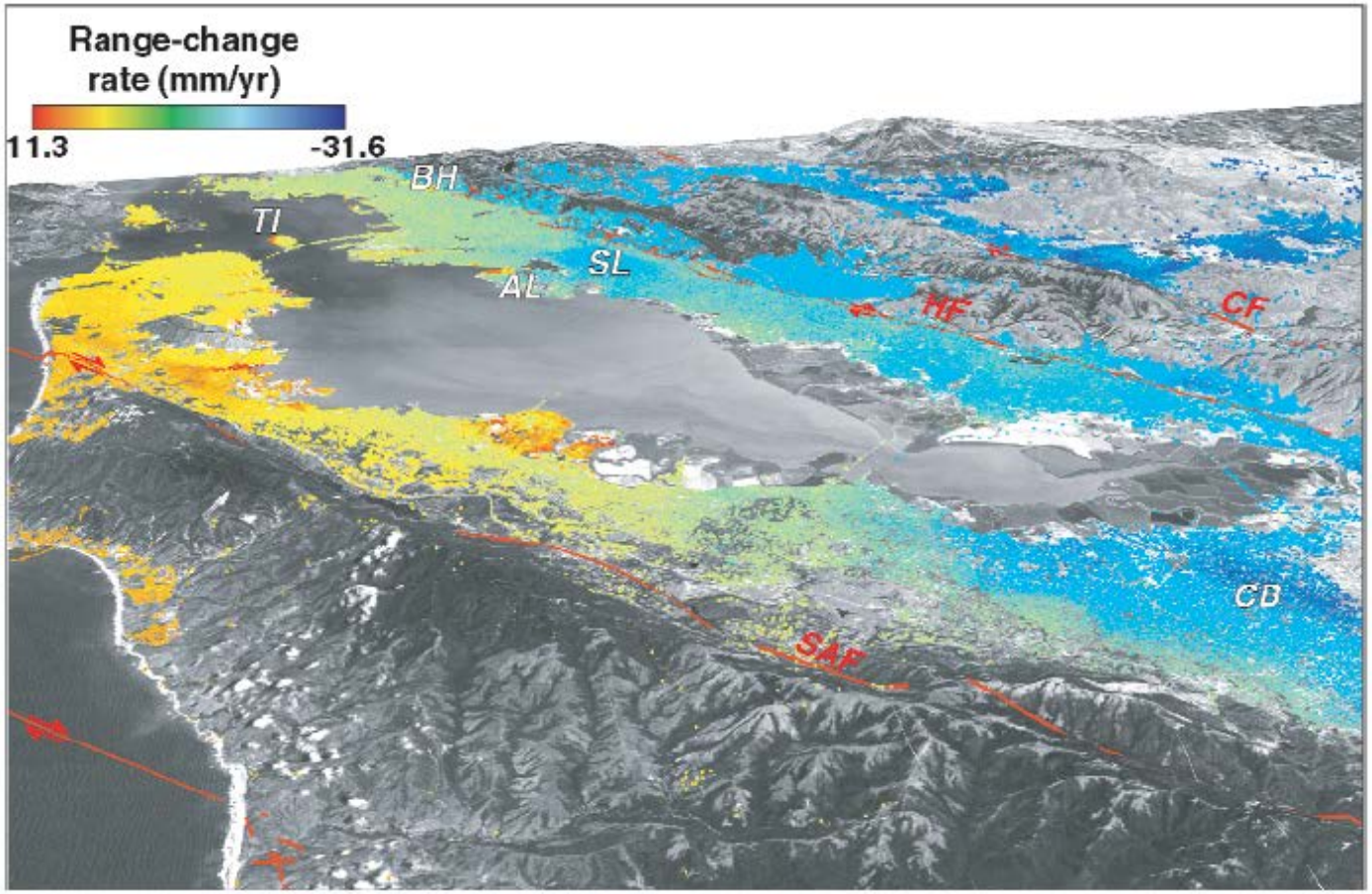
Hirose et al. (2004)

Unconsolidate mud layer had not completely drained during low pore pressure period.

↓

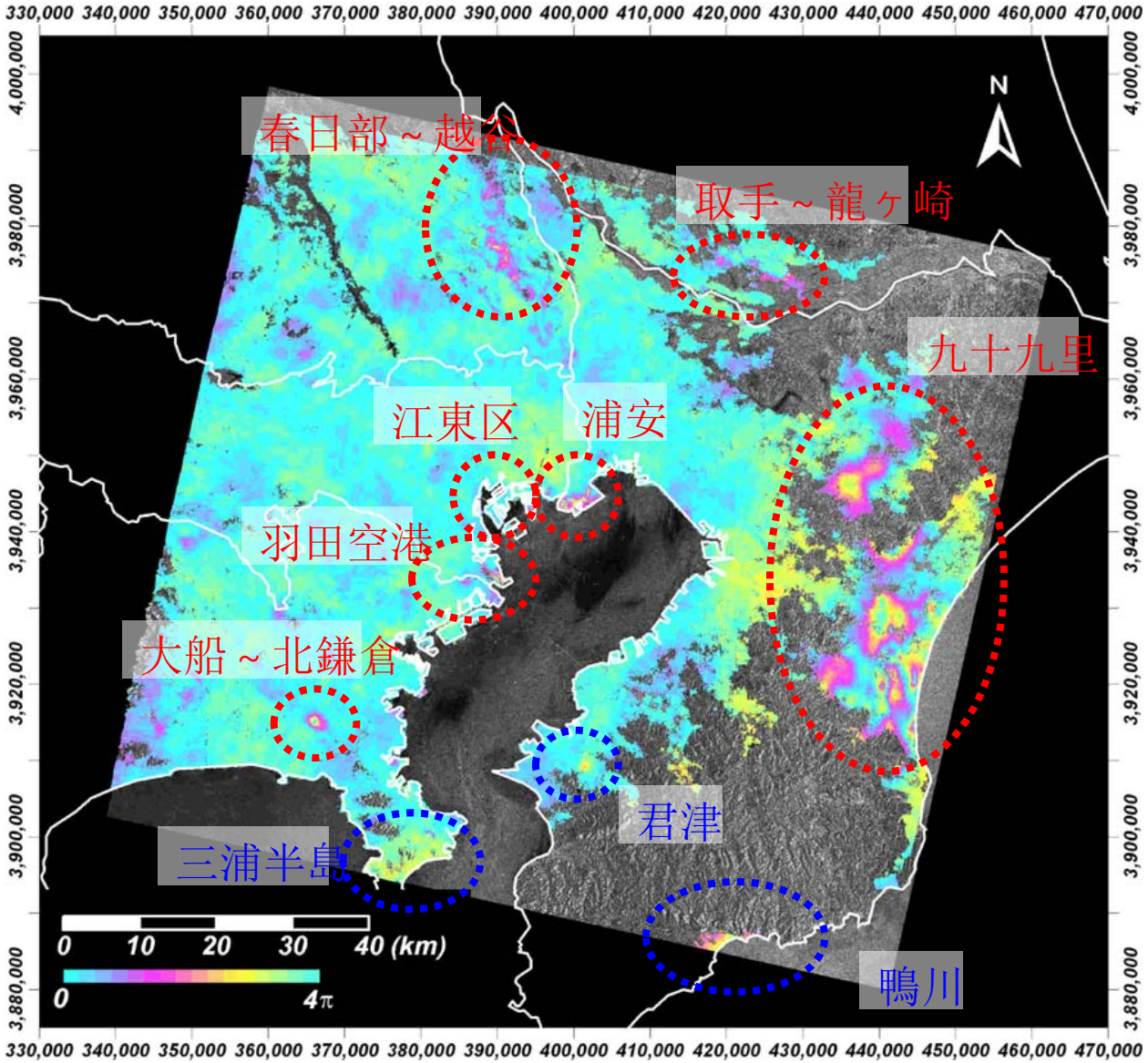
Potential of possible subsidence by re-starting groundwater usage and drawdown

An example of satellite monitoring



Ferretti et al. (2004)

干渉SARと時系列解析による経時的地盤変動解析



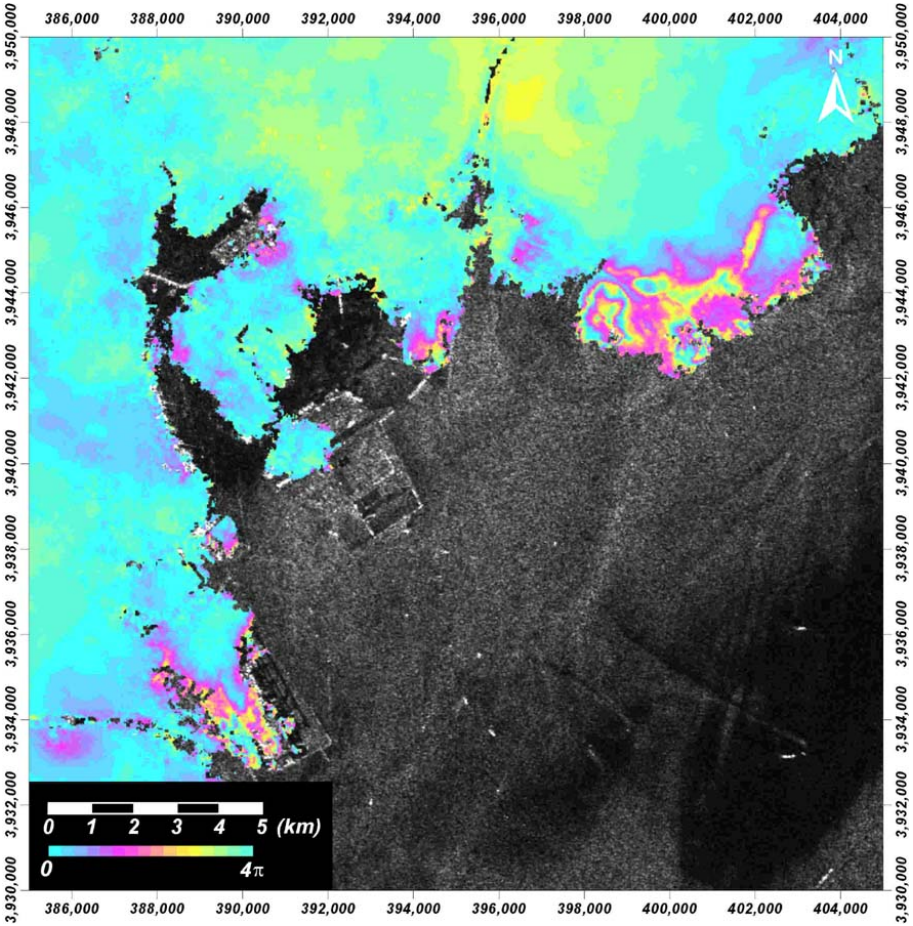
✓38シーン，54ペアを使用して，2003年1月13日から2008年4月21日までの約5年3ヶ月の間に発生した地盤変動の経時変化を計測

✓半数の27ペア以上で位相アンラップができたピクセルを有効とする

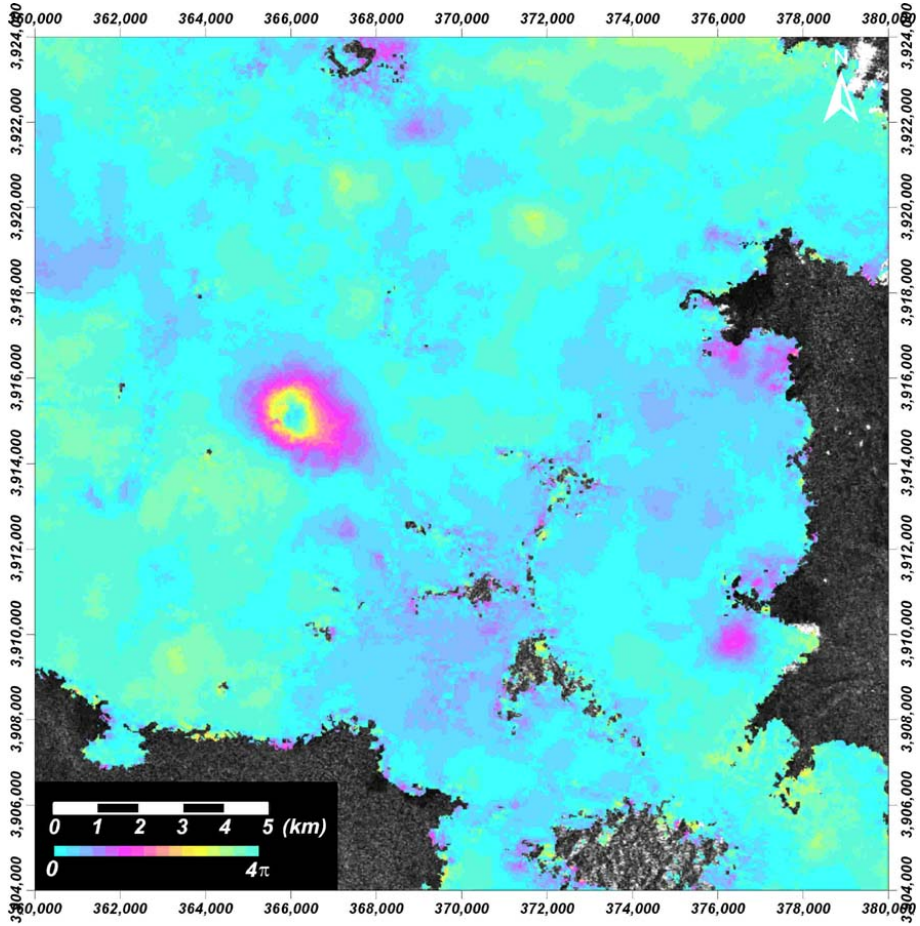
✓平滑化は二回差分

✓重みは平均変位速度からの乖離量を使用

干渉SARと時系列解析による経時的地盤変動解析

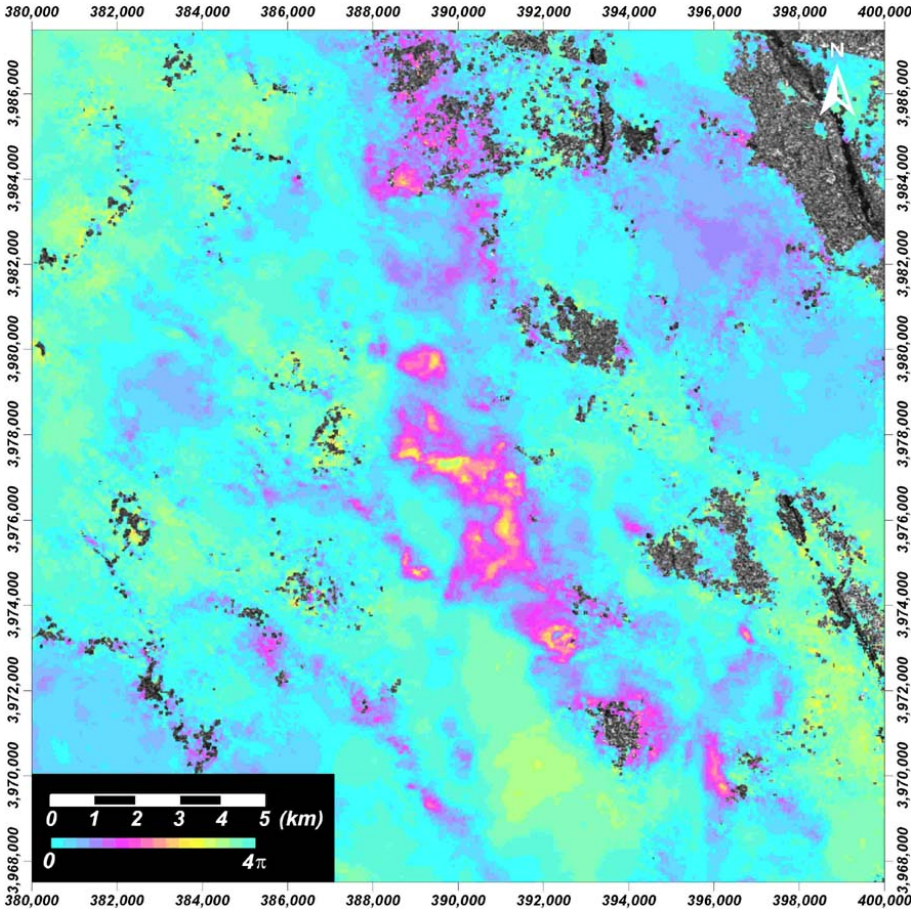


羽田空港～浦安～江東区

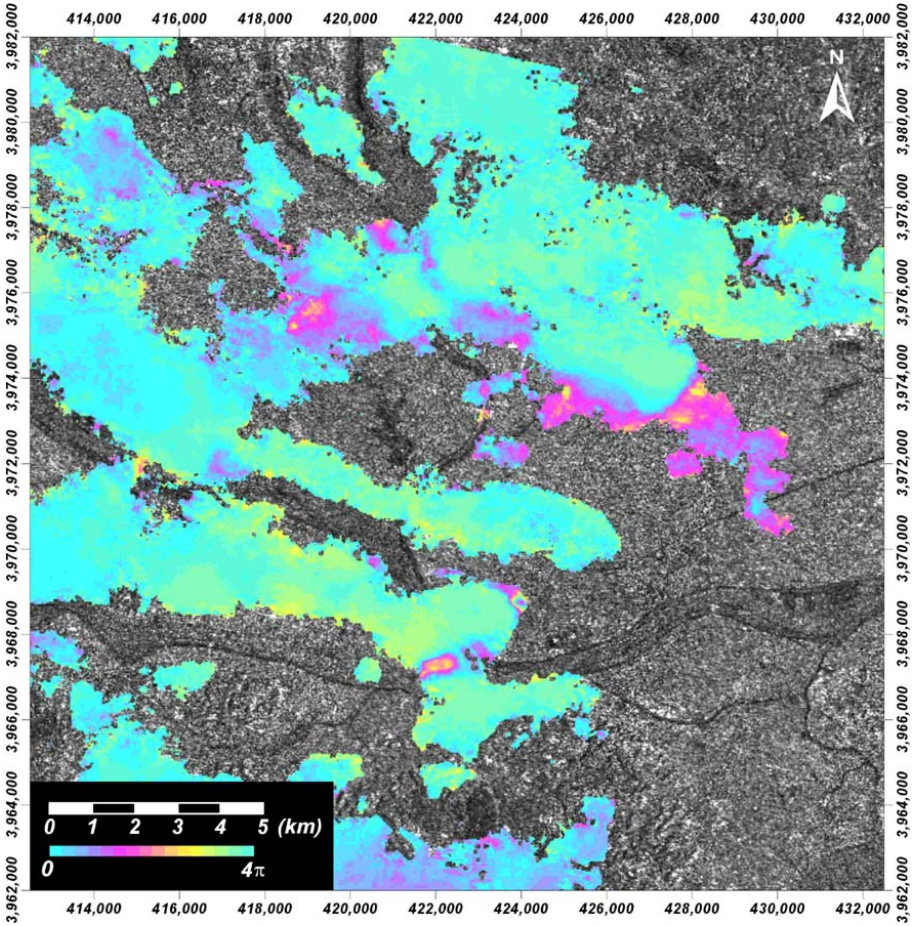


大船～北鎌倉

干渉SARと時系列解析による経時的地盤変動解析

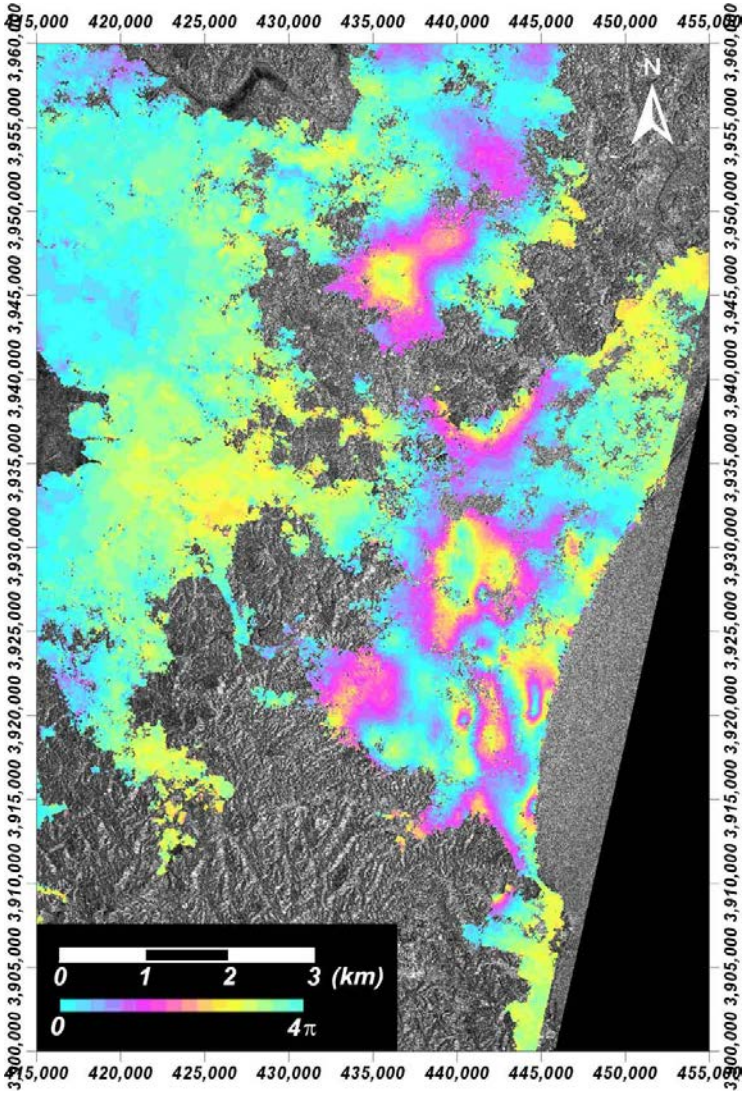


春日部～越谷

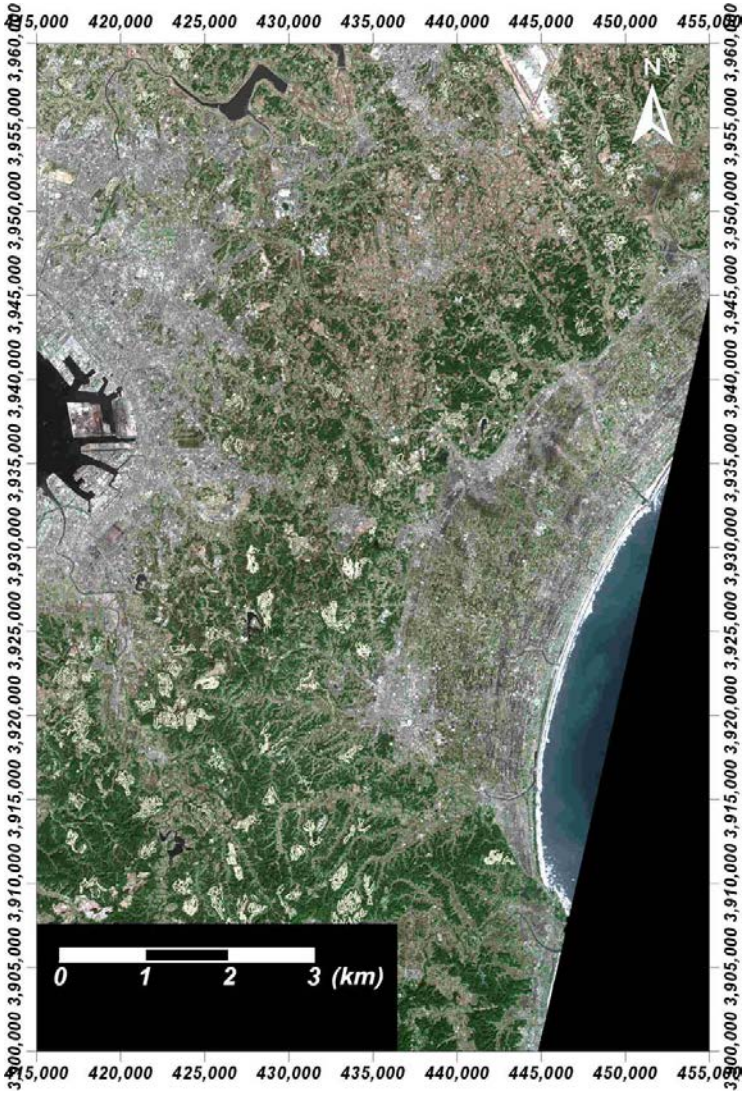


取手～龍ヶ崎

干渉SARと時系列解析による経時的地盤変動解析

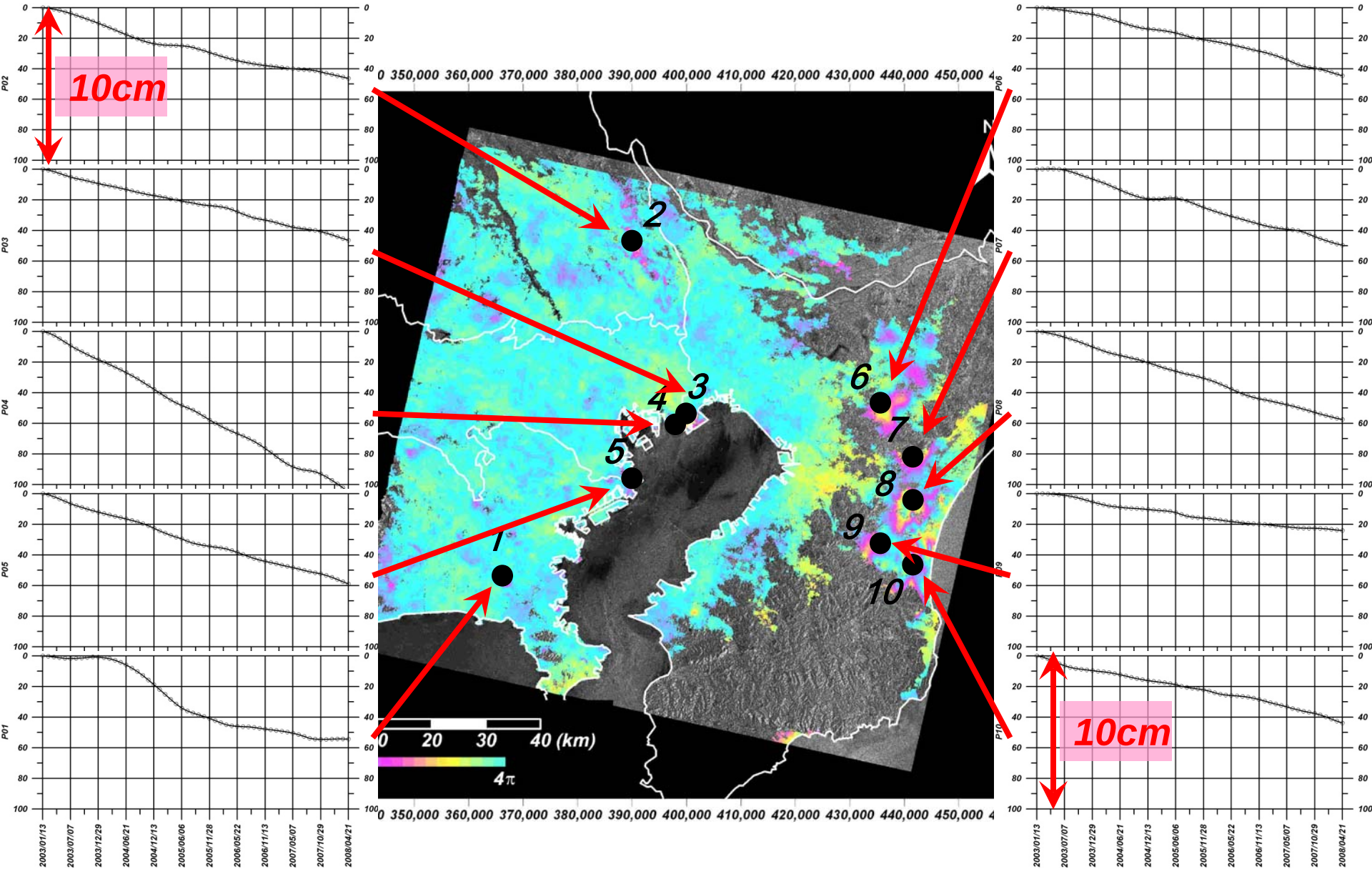


九十九里平野



ASTER画像（2007年3月1日）

干渉SARと時系列解析による経時的地盤変動解析



conclusions

- Temporal change of groundwater condition at the Tokyo Metropolitan Area can be divided into three stages;
  - Deterioration of underground and surface environments due to over-extraction of groundwater
  - Regulation of groundwater extraction to the absolute minimum and the recovery of groundwater potentials
  - Damaging underground infrastructures by buoyant force and increase of groundwater seepage due to the recovery of groundwater potentials

- Necessary technologies development to make it possible re-start using groundwater are proposed. These are;
  - Re-analyzing the groundwater information and construct regional groundwater flow model
  - Development of high-quality surface deformation monitoring through satellite such as PS-InSAR
  - Development of coupled groundwater/deformation model to properly evaluate/predict the effect of groundwater extraction to surface deformation