National Institute of Advanced Industrial Science and Technology
AIST

FREA

GSHP studies under CCOP Groundwater Project

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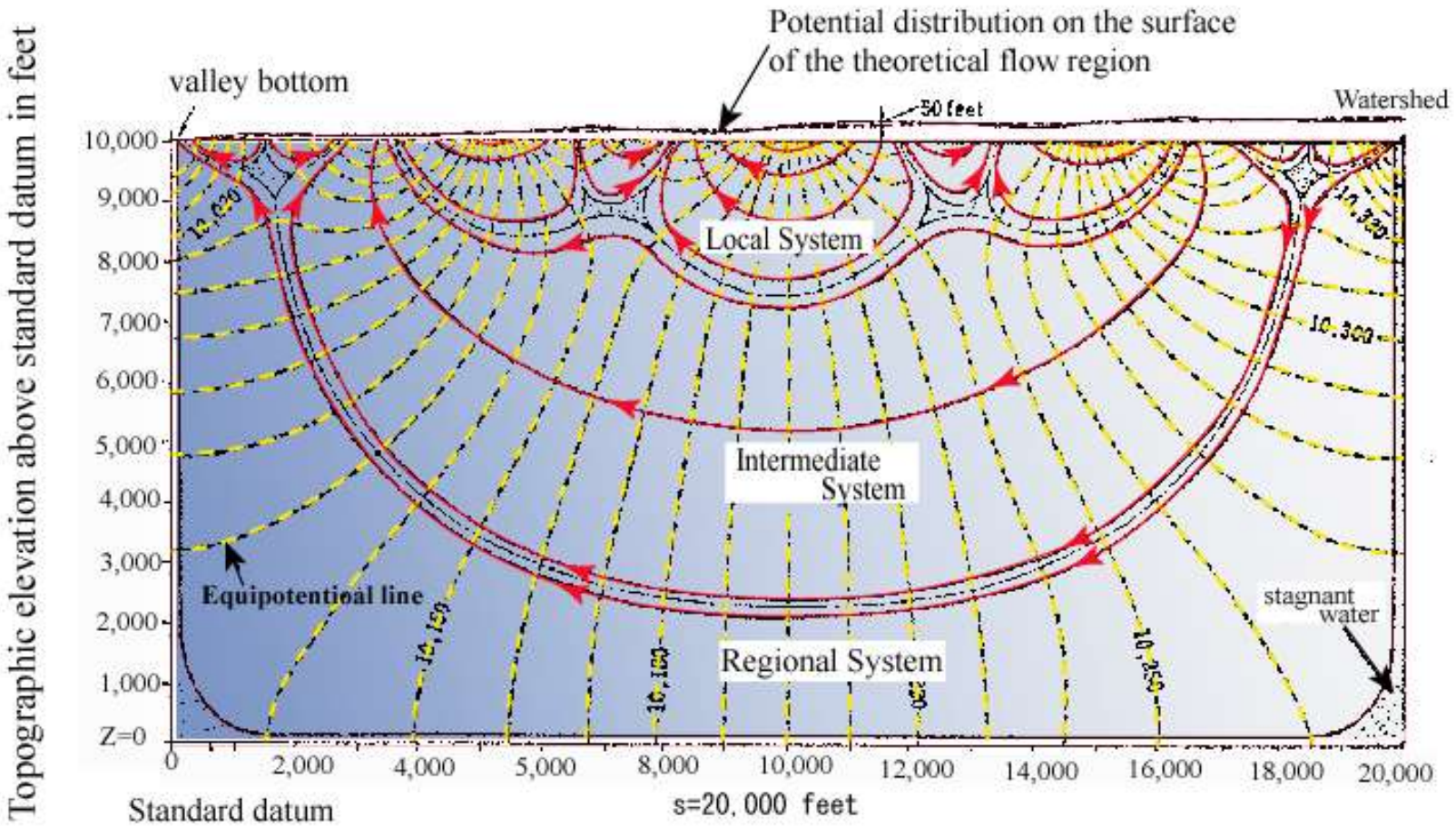
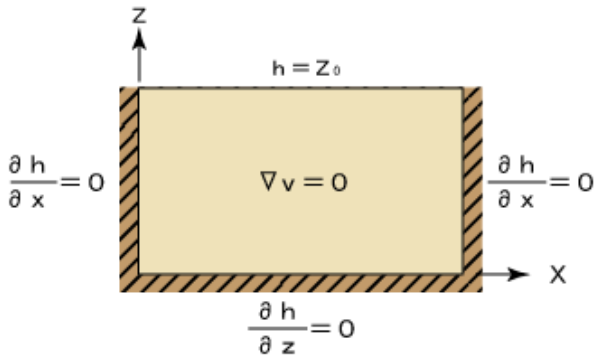
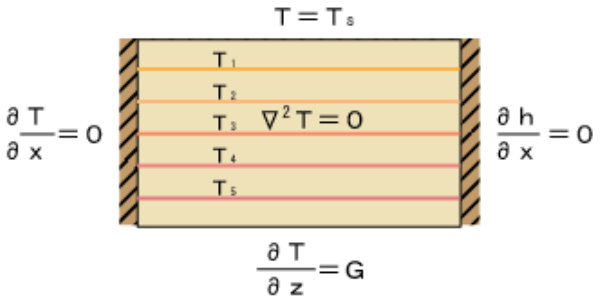
Groundwater Flow System



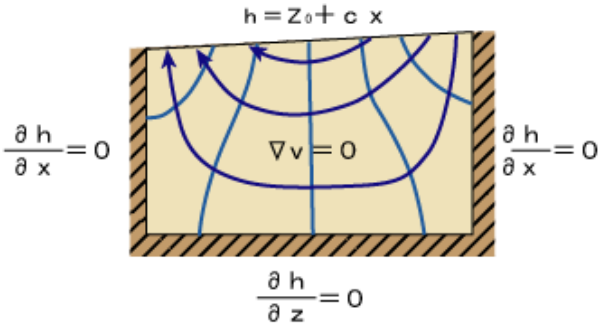
Groundwater Flow System and Subsurface Thermal Regime



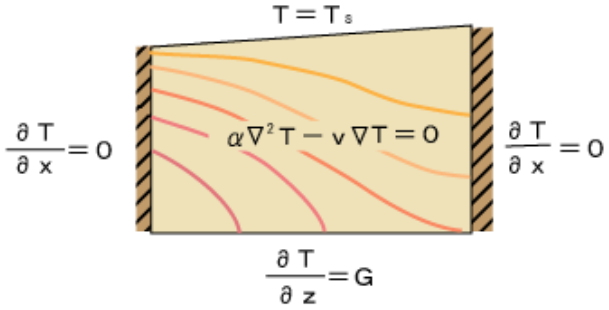
(a) static groundwater



(b) thermal regime under condition of (a)



(c) simple regional groundwater flow system



(d) thermal regime under condition of (c)

h : hydraulic head,
v : groundwater flow velocity,
T : subsurface temperature,
Ts: constant surface temperature,
G : constant temperatrue gradient,
x,z : coordinate

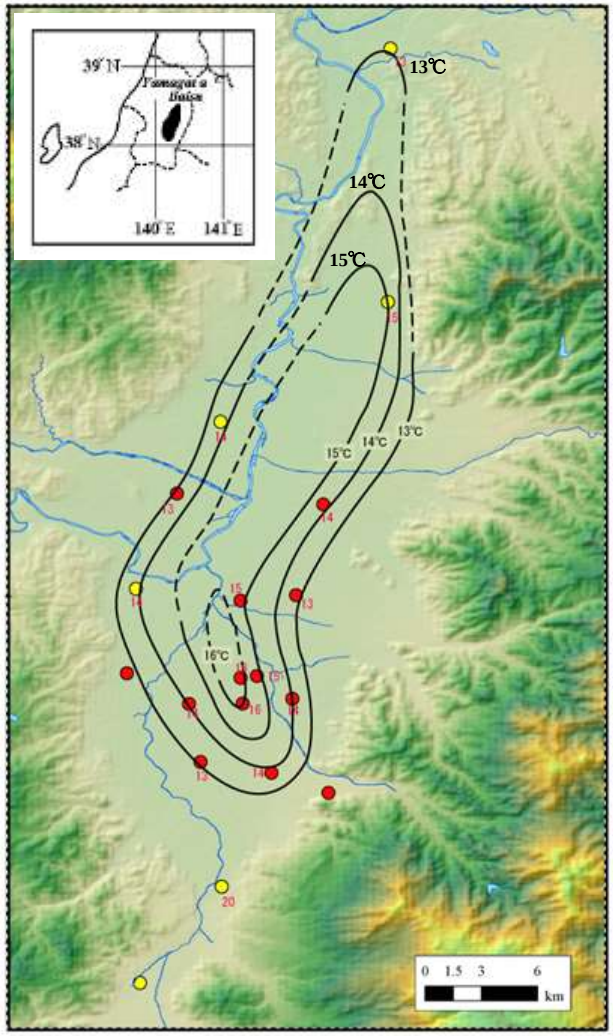
(modified from Domenico and Palciauskas, 1973)

Measurement of Subsurface Temperature

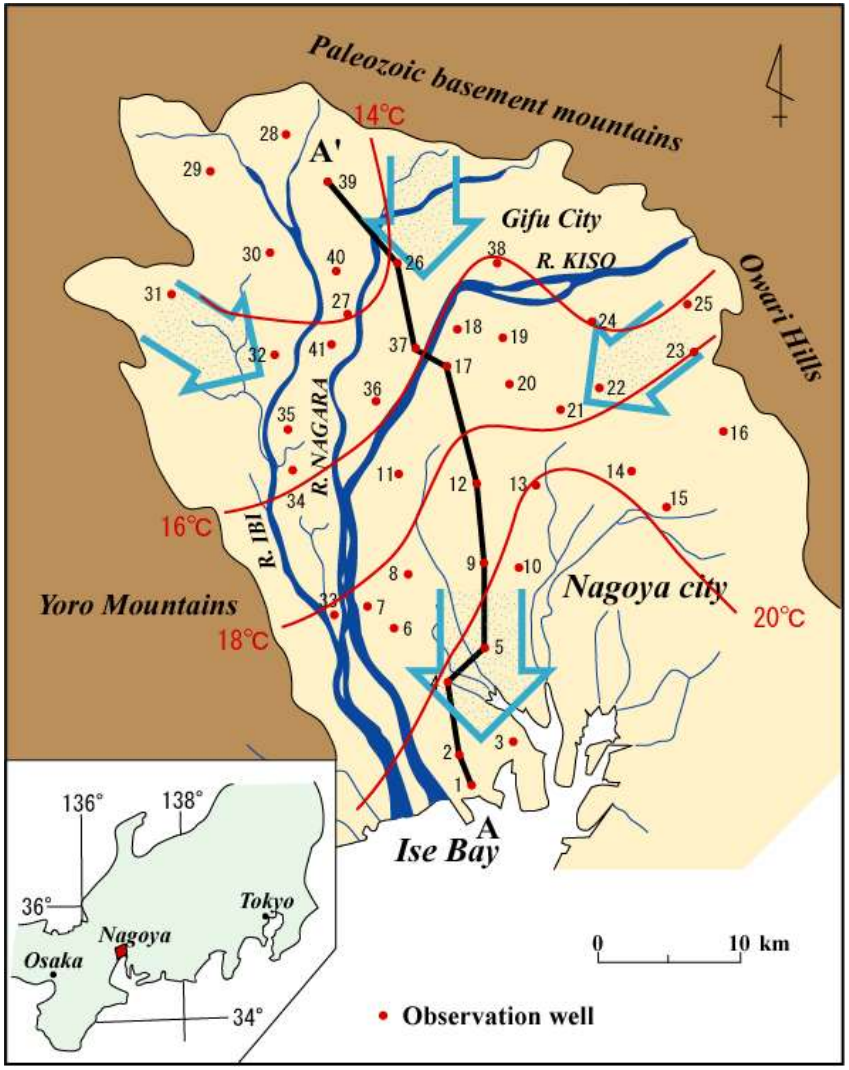
Thermometer
(Digital thermistor)

Observation well
(Monitoring for groundwater level and land subsidence)

Distribution maps of Subsurface Temperature



Subsurface temperature distribution at 50m depth from surface in Yamagata Basin



Subsurface temperature distribution at 100m depth from surface in Nobi Plain

CCOP

Coordinating Committee for Geoscience Programmes in East and Southeast Asia

Mission: Facilitate & coordinate the implementation of applied geoscience programmes

Contribution to economic development and improvement of the quality of life

13 Member Countries: Cambodia, China, Indonesia, Japan, Korea, Lao PDR, Malaysia, Papua New Guinea, Philippines, Singapore, Thailand, Timor-Leste and Vietnam

14 Cooperating Countries: Australia, Belgium, Canada, Denmark, Finland, France, Germany, Netherlands, Norway, Poland, Russian Federation, Sweden, UK and USA

CCOP Groundwater Projects

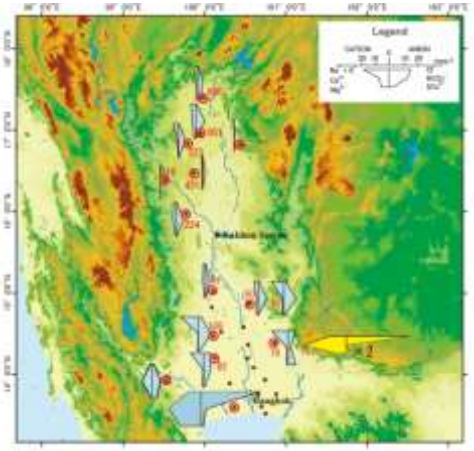
Geological Survey of Japan, AIST

Involvement of Geological Survey of Japan, AIST in the project

Phase I (2005 ~ 2008)

Phase II (2009 ~ 2013)

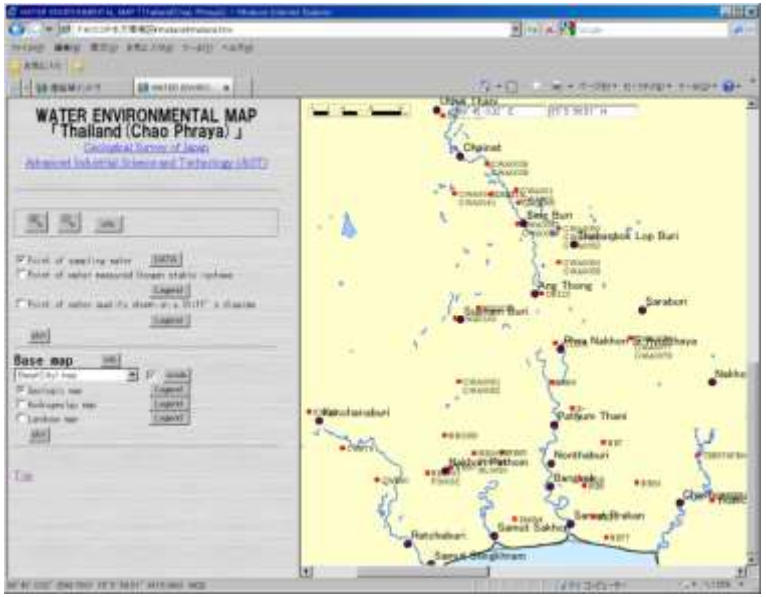
Field Survey



Hydro-geological map of Chao-Phraya Plain

CCOP-GSJ/AIST Groundwater Project Phase II (2009 ~ 2013)

- Main theme in this project is "Renewal of database for the Hydro-geological map in CCOP regions"
- To construct database and its design
- To compile data of Chao-Phraya Plain, Thailand and Red River Delta, Vietnam
- To make an Asian Standard of the Hydro-geological map



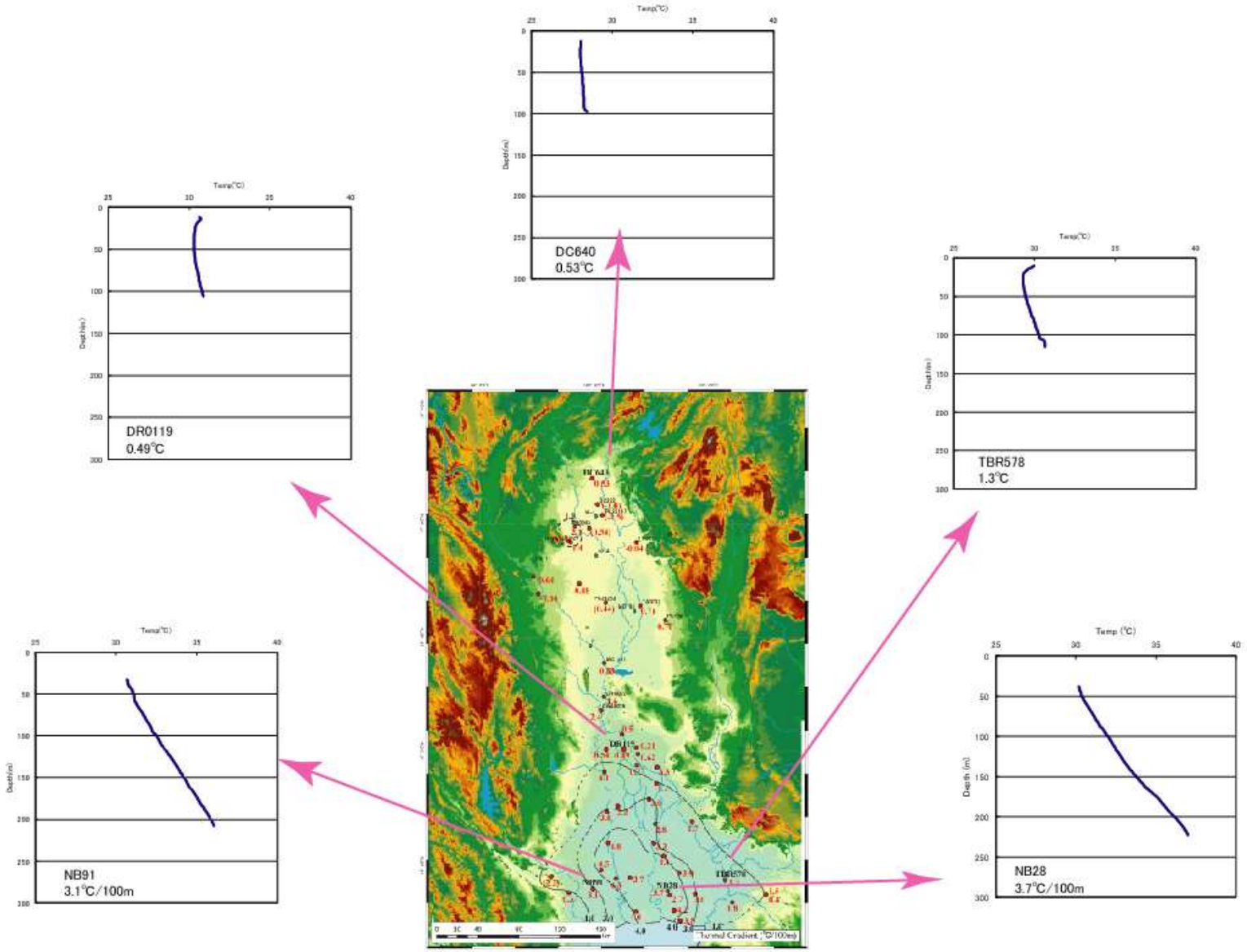
CCOP GW-Database

Measurement of hydraulic potential and groundwater temperature at observation well in Thailand

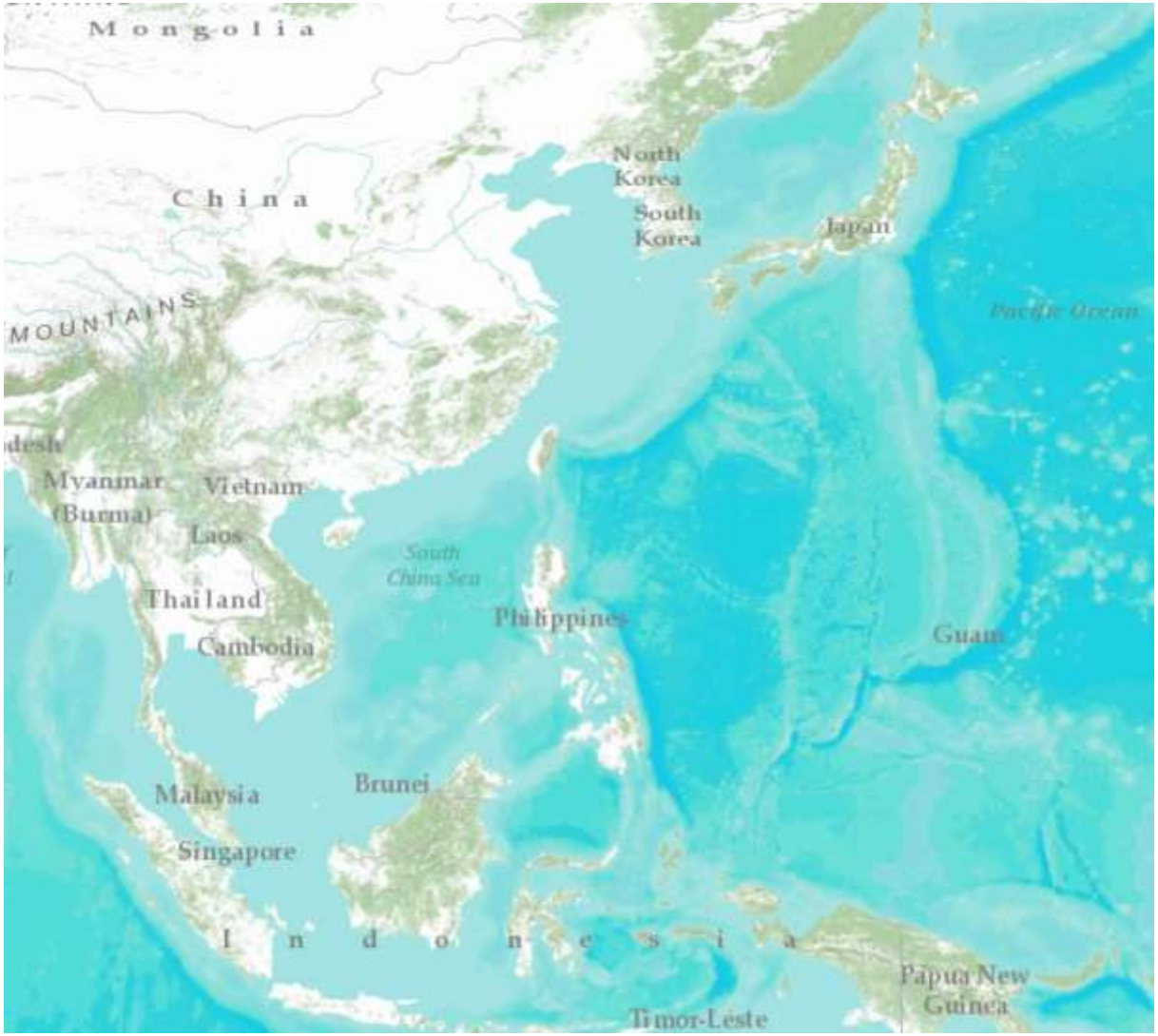
Sampling of river water for chemical analysis

Survey members

Subsurface Temperature Gradient in the Chao Phraya Plain, Thailand

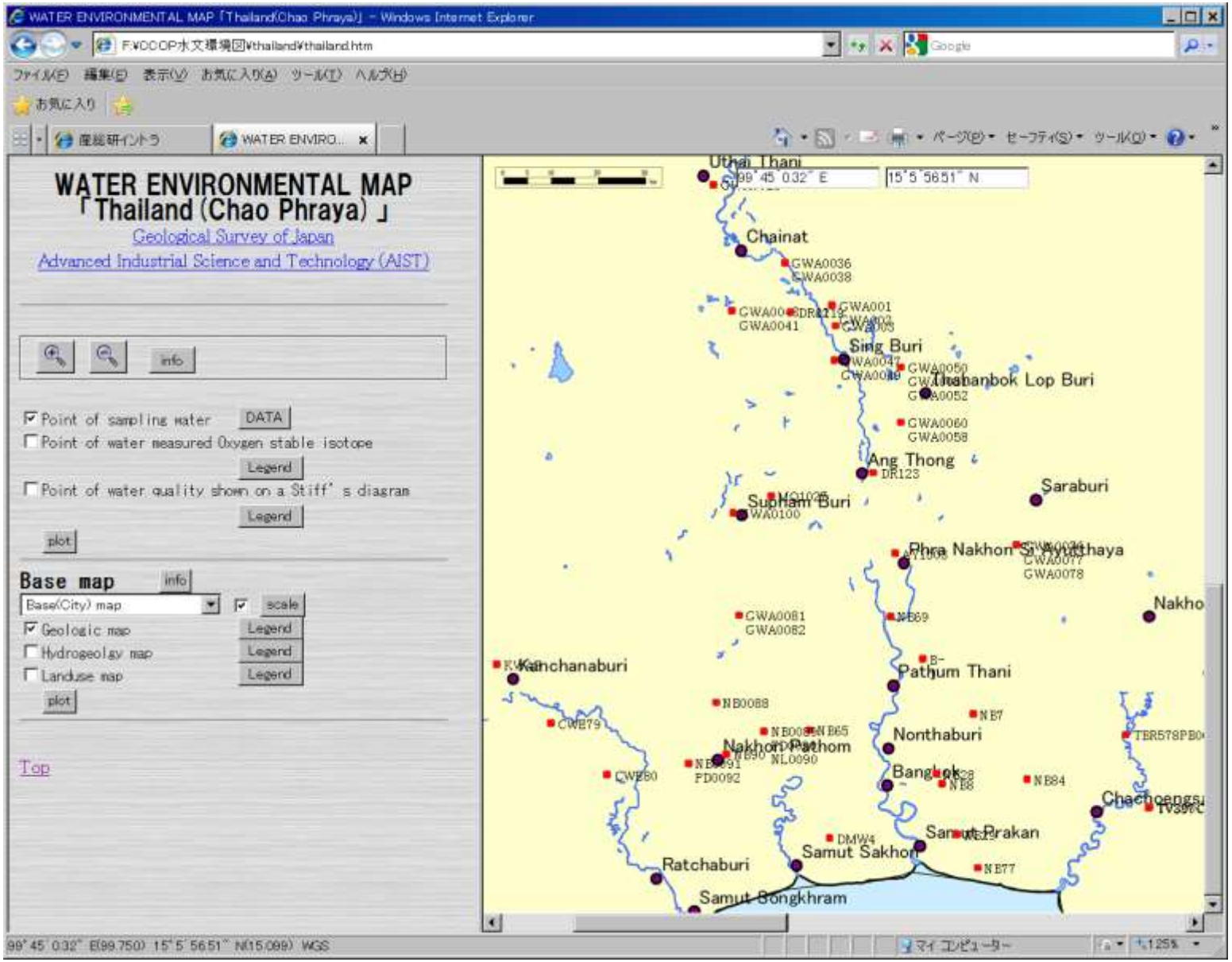


Design of CCOP Hydro-Geological Map

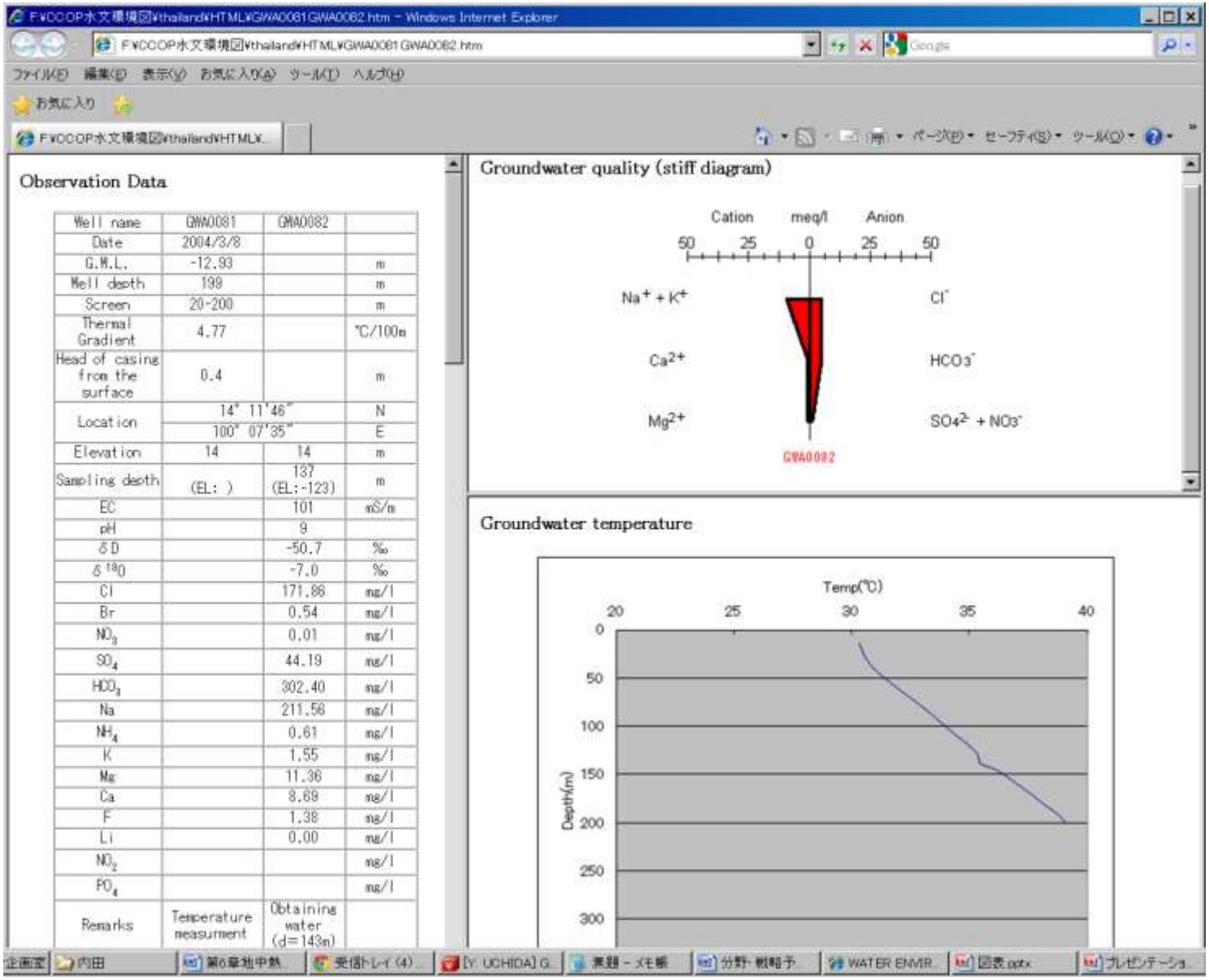


- GW data of Chao Phraya Plain in Thailand, and Red River Delta in Vietnam are compiled
- By clicking country name on starting page, data area is displayed

- Magnified view around Thailand
- By clicking “Thailand”, map of Chao-Phraya Plain is displayed

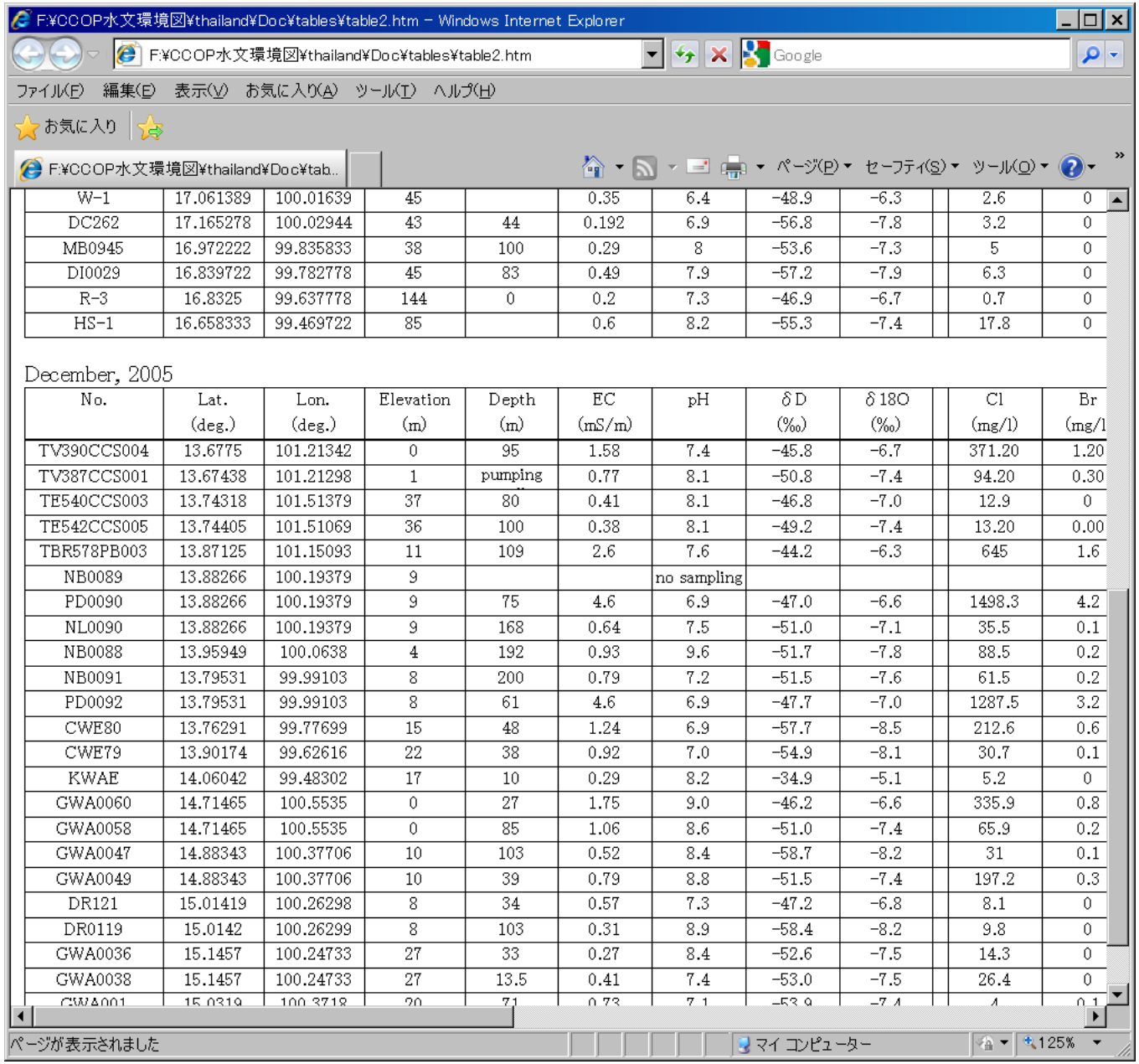


- Hydro-geological database of Chao Phraya Plain
- By clicking on observation point, observation data is displayed



Well name	GWA0081	GWA0082	
Date	2004/3/8		
G.W.L.	-12.93		m
Well depth	199		m
Screen	20-200		m
Thermal Gradient	4.77		℃/100m
Head of casing from the surface	0.4		m
Location	14° 11'46"		N
	100° 07'35"		E
Elevation	14	14	m
Sampling depth	(EL:)	137 (EL:-123)	m
EC		101	mS/m
pH		9	
δD		-50.7	‰
$\delta^{18}O$		-7.0	‰
Cl		171.86	mg/l
Br		0.54	mg/l
NO_3		0.01	mg/l
SO_4		44.19	mg/l
HCO_3		302.40	mg/l
Na		211.56	mg/l
NH_4		0.61	mg/l
K		1.55	mg/l
Mg		11.36	mg/l
Ca		8.69	mg/l
F		1.38	mg/l
Li		0.00	mg/l
NO_2			mg/l
PO_4			mg/l
Remarks	Temperature measurment	Obtaining water (d=143m)	

Observation data includes well information (location, well depth, screen depth), EC, pH, isotopes etc., groundwater quality plotted by stiff diagram and groundwater temperature.



W-1	17.061389	100.01639	45		0.35	6.4	-48.9	-6.3	2.6	0
DC262	17.165278	100.02944	43	44	0.192	6.9	-56.8	-7.8	3.2	0
MB0945	16.972222	99.835833	38	100	0.29	8	-53.6	-7.3	5	0
DI0029	16.839722	99.782778	45	83	0.49	7.9	-57.2	-7.9	6.3	0
R-3	16.8325	99.637778	144	0	0.2	7.3	-46.9	-6.7	0.7	0
HS-1	16.658333	99.469722	85		0.6	8.2	-55.3	-7.4	17.8	0

December, 2005

No.	Lat. (deg.)	Lon. (deg.)	Elevation (m)	Depth (m)	EC (mS/m)	pH	δD (‰)	δ18O (‰)	Cl (mg/l)	Br (mg/l
TV390CCS004	13.6775	101.21342	0	95	1.58	7.4	-45.8	-6.7	371.20	1.20
TV387CCS001	13.67438	101.21298	1	pumping	0.77	8.1	-50.8	-7.4	94.20	0.30
TE540CCS003	13.74318	101.51379	37	80	0.41	8.1	-46.8	-7.0	12.9	0
TE542CCS005	13.74405	101.51069	36	100	0.38	8.1	-49.2	-7.4	13.20	0.00
TBR578PB003	13.87125	101.15093	11	109	2.6	7.6	-44.2	-6.3	645	1.6
NB0089	13.88266	100.19379	9			no sampling				
PD0090	13.88266	100.19379	9	75	4.6	6.9	-47.0	-6.6	1498.3	4.2
NL0090	13.88266	100.19379	9	168	0.64	7.5	-51.0	-7.1	35.5	0.1
NB0088	13.95949	100.0638	4	192	0.93	9.6	-51.7	-7.8	88.5	0.2
NB0091	13.79531	99.99103	8	200	0.79	7.2	-51.5	-7.6	61.5	0.2
PD0092	13.79531	99.99103	8	61	4.6	6.9	-47.7	-7.0	1287.5	3.2
CWE80	13.76291	99.77699	15	48	1.24	6.9	-57.7	-8.5	212.6	0.6
CWE79	13.90174	99.62616	22	38	0.92	7.0	-54.9	-8.1	30.7	0.1
KWAE	14.06042	99.48302	17	10	0.29	8.2	-34.9	-5.1	5.2	0
GWA0060	14.71465	100.5535	0	27	1.75	9.0	-46.2	-6.6	335.9	0.8
GWA0058	14.71465	100.5535	0	85	1.06	8.6	-51.0	-7.4	65.9	0.2
GWA0047	14.88343	100.37706	10	103	0.52	8.4	-58.7	-8.2	31	0.1
GWA0049	14.88343	100.37706	10	39	0.79	8.8	-51.5	-7.4	197.2	0.3
DR121	15.01419	100.26298	8	34	0.57	7.3	-47.2	-6.8	8.1	0
DR0119	15.0142	100.26299	8	103	0.31	8.9	-58.4	-8.2	9.8	0
GWA0036	15.1457	100.24733	27	33	0.27	8.4	-52.6	-7.5	14.3	0
GWA0038	15.1457	100.24733	27	13.5	0.41	7.4	-53.0	-7.5	26.4	0
GWA001	15.0319	100.3718	20	71	0.73	7.1	-53.9	-7.4	4	0.1

List of Hydro-geological data

Outcomes of Groundwater Phase II

CCOP Project Report

- GW-1 : FY2009 Bangkok meeting
- GW-2 : FY2010 Xian meeting
- GW-3 : FY2012 Hanoi meeting
- GW-4 : FY2013 Bandung meeting

CCOP Groundwater DB

- Chao Phraya Plain, Thailand
  (76 points, 186 samples)
- Red River Delta, Vietnam
  (63 points, 254 samples)
- Other areas (by Excel Format)

CCOP Groundwater Sub-Project "Development of Renewable Energy for Ground-Source Heat Pump System in CCOP Regions"

- New sub-project under CCOP GW Project using CCOP GW DB started from April 2013
- Title of the sub-project is "Development of Renewable Energy for Ground-Source Heat Pump System in CCOP Regions"
- Chulalongkorn University (Thailand), Akita University (Japan) and GSJ have cooperation program under the CCOP sub-project and installed GSHP System on premise of Chulalongkorn University

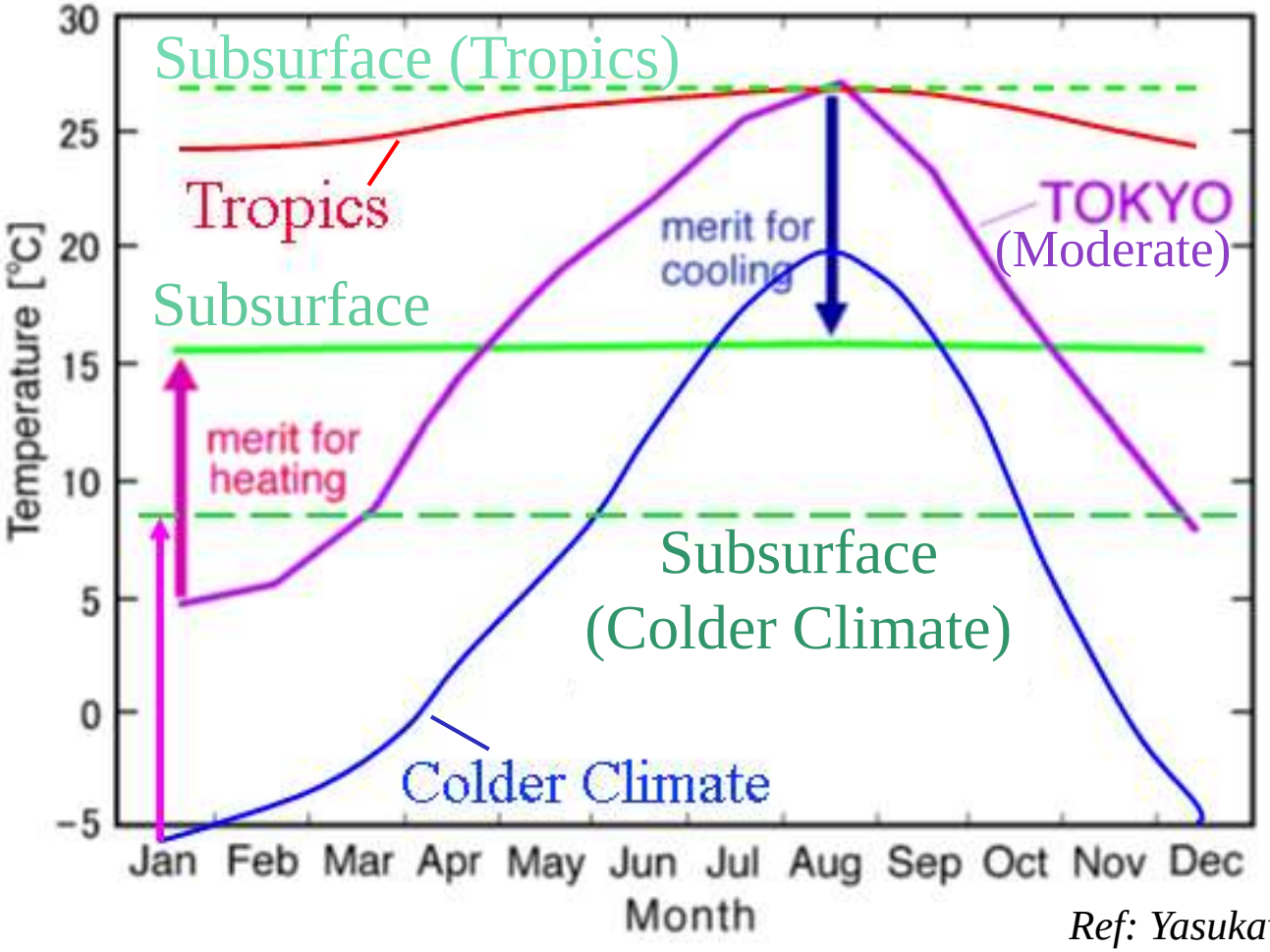
Continued

Objectives of this sub-project are;

- To demonstrate GSHP system in Bangkok City, Thailand
- To find out adjustment and modifications needed for GSHP system in tropical region
- To develop suitable maps for GSHP system in Thailand reflecting large-scale groundwater flow/heat transport model

Atmospheric and subsurface temperature variation at different climatic regions

Is GSHP applicable everywhere? Not really in tropics…



Ref: Yasukawa et al., 2009

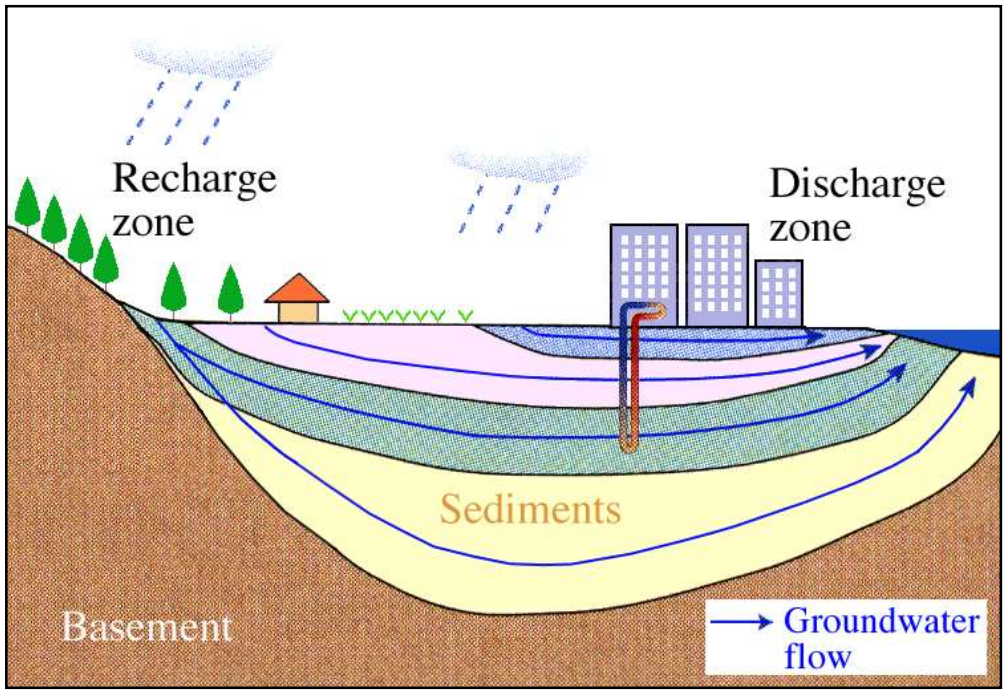
Monthly mean atmospheric and subsurface temperature

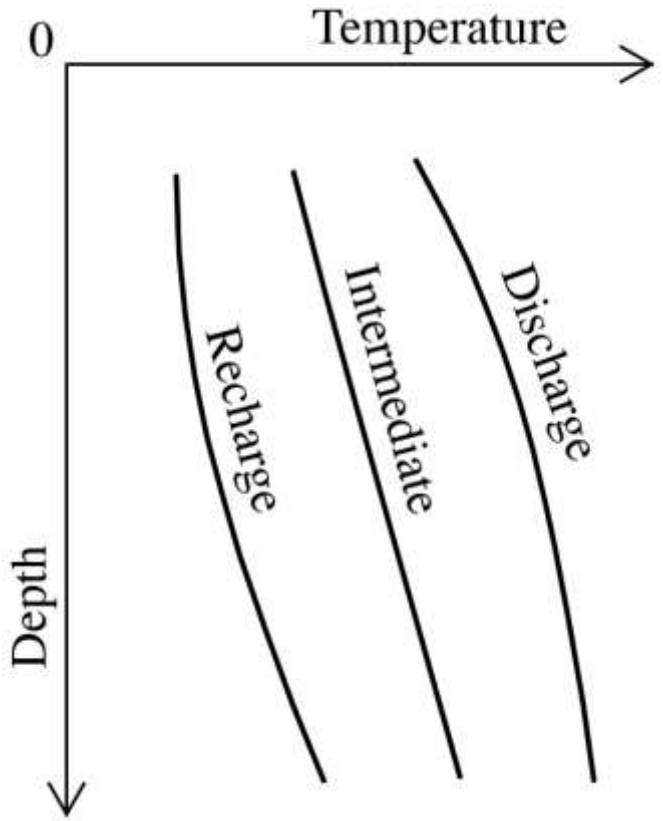
Can we use GSHP System in tropics?

- In East-Asia, where significant economical growth in this century is expected, energy saving and environmental protection are major matters of importance
- Promotion of GSHP may contribute to energy (electricity) savings and protection of the environment
- However, in tropics where space-cooling is needed, subsurface temperature is generally higher throughout a year and the underground is not suitable for heat exchange
- Nevertheless in tropical regions, underground may be used as a cold source, if there exist seasonal and areal variation in atmospheric temperature, and subsurface temperature is rather low

Shallow subsurface temperature affected by groundwater flow

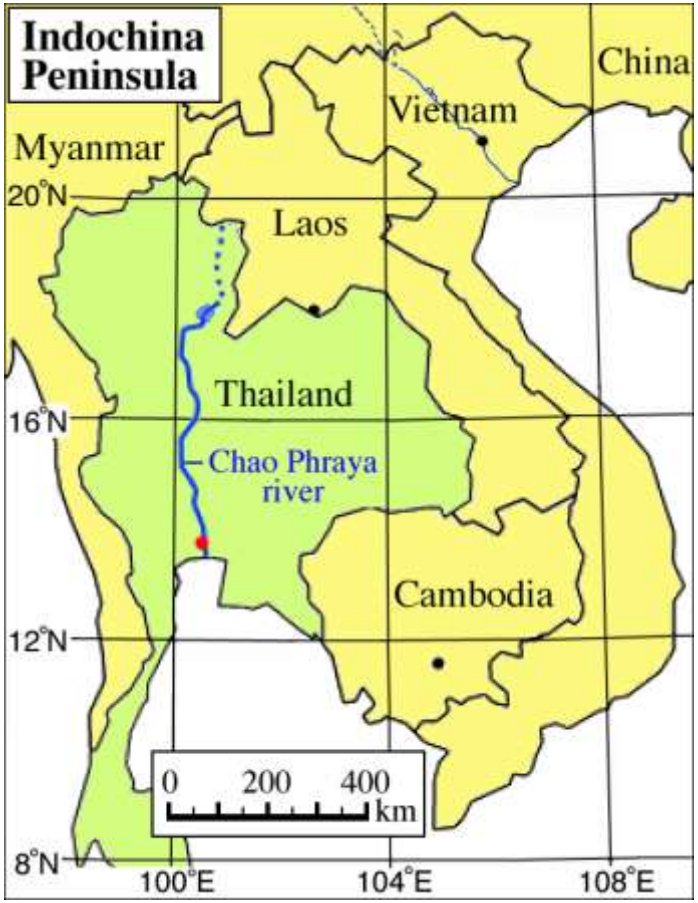
- At recharge zones (high elevation), shallow temperature is lower, while it is higher at discharge zones
- At recharge zones, underground may be used as cold source in tropics

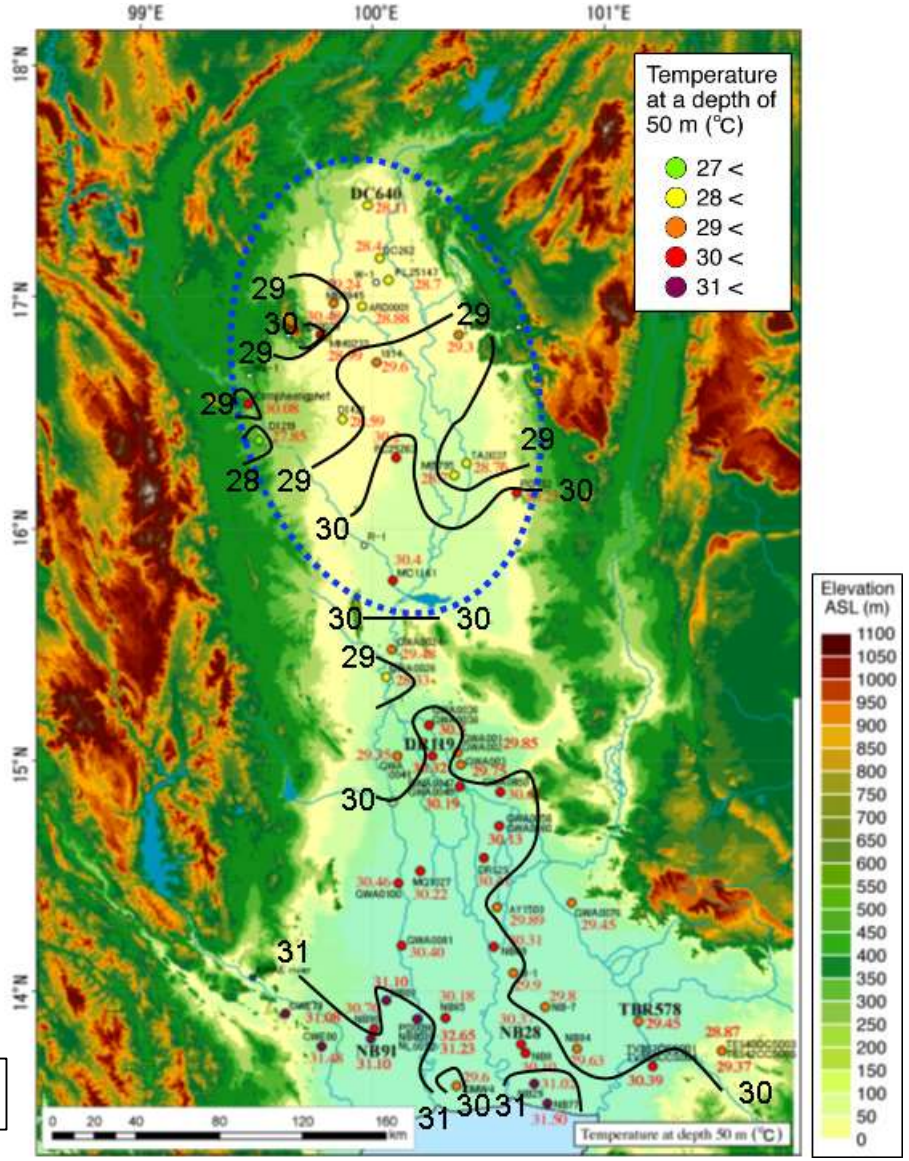




Subsurface temperature profile with groundwater flow

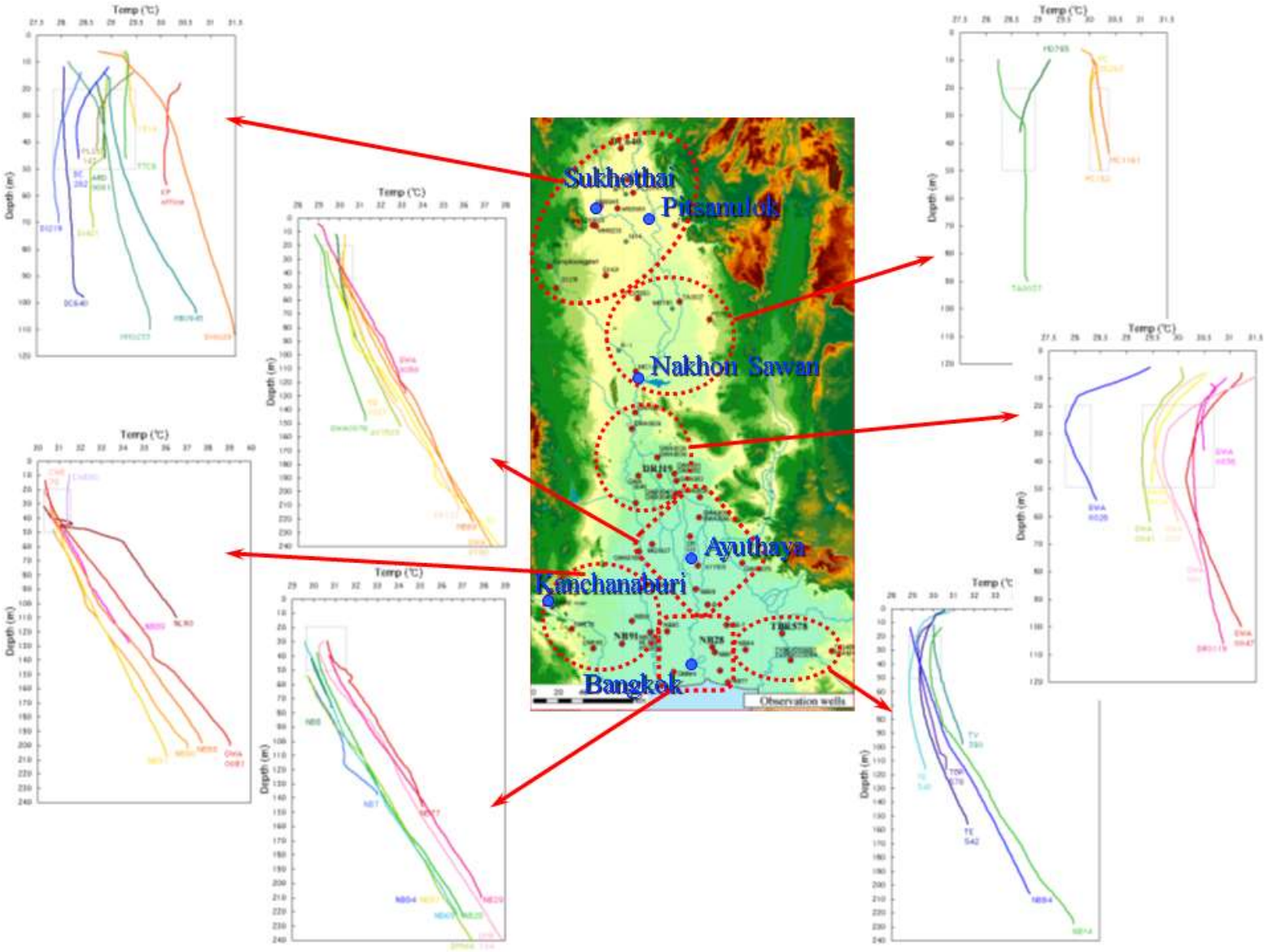
Temperature measurements in Thailand





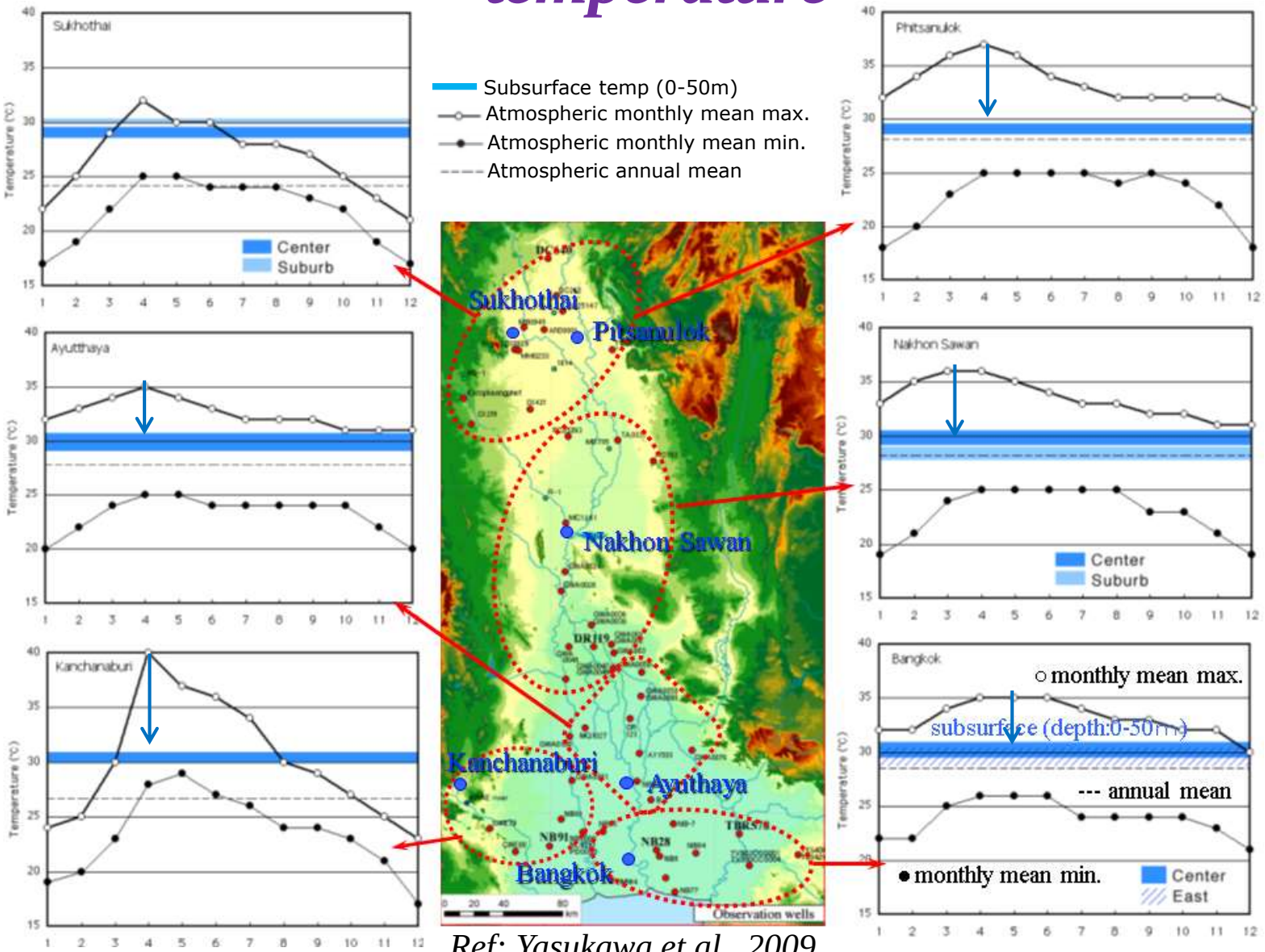
Department of Groundwater Resources of Thailand

Subsurface Temperature Profiles



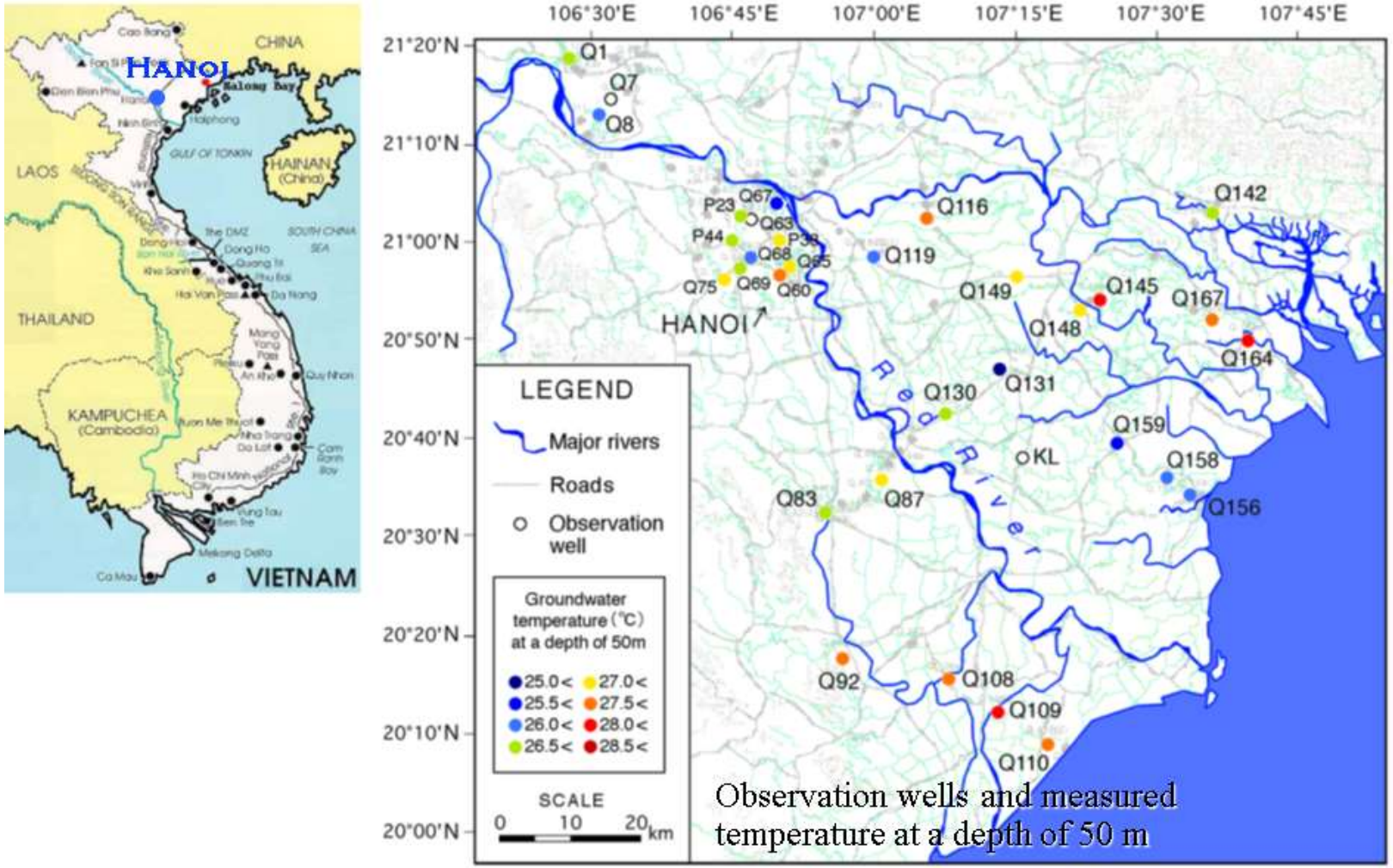
Ref: Yasukawa et al., 2009

Merit for cooling
Comparison between subsurface and atmospheric temperature



Ref: Yasukawa et al., 2009

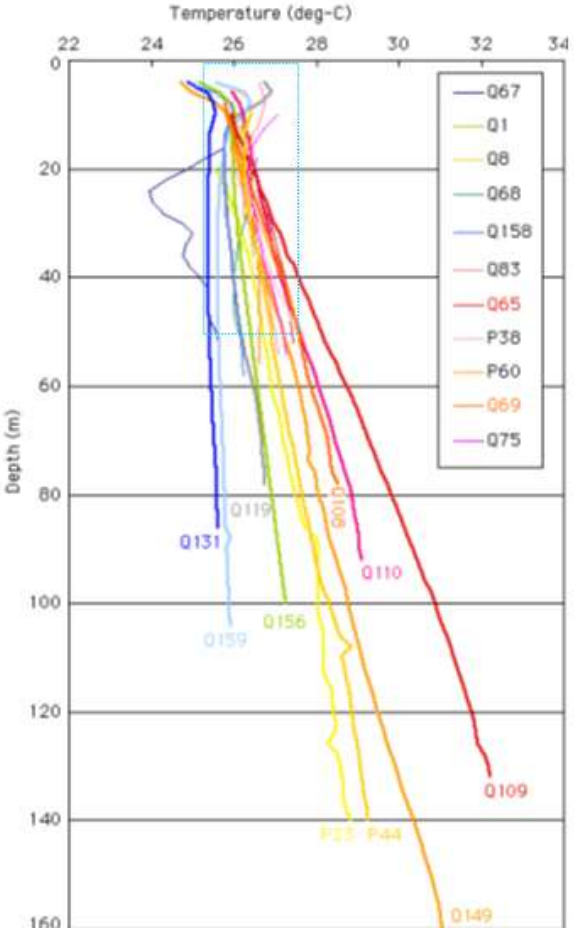
Temperature measurements in Vietnam

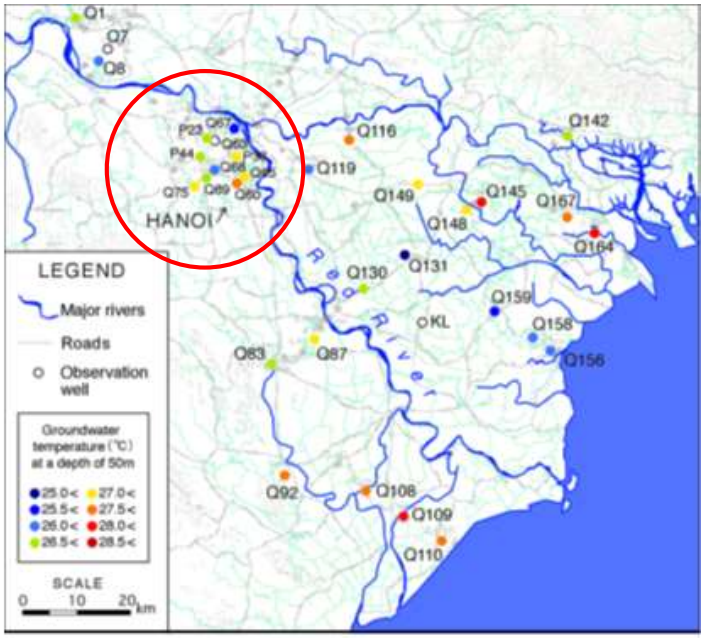


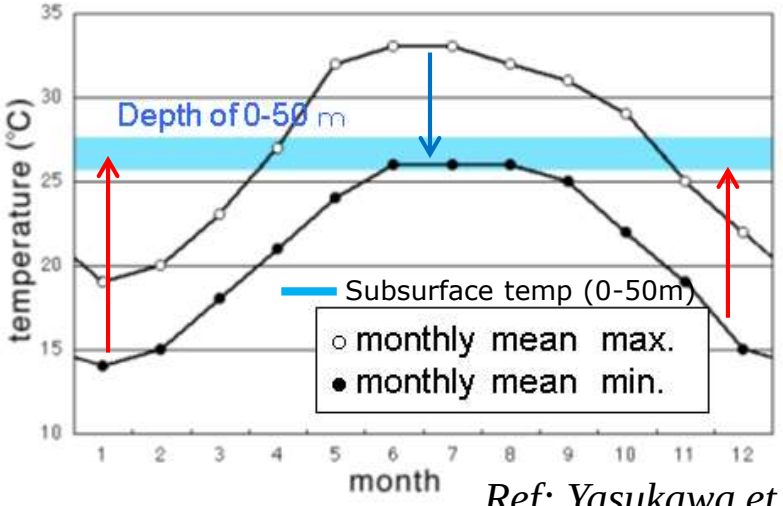
Department of Geology and Minerals of Vietnam

Merit for cooling

Comparison between subsurface and atmospheric temperature in Hanoi







Ref: Yasukawa et al., 2009

Construction of GSHP System in Chulalongkorn University

Guest house in Chulalongkorn Univ.

Continued

Drilling for installation of heat exchanger

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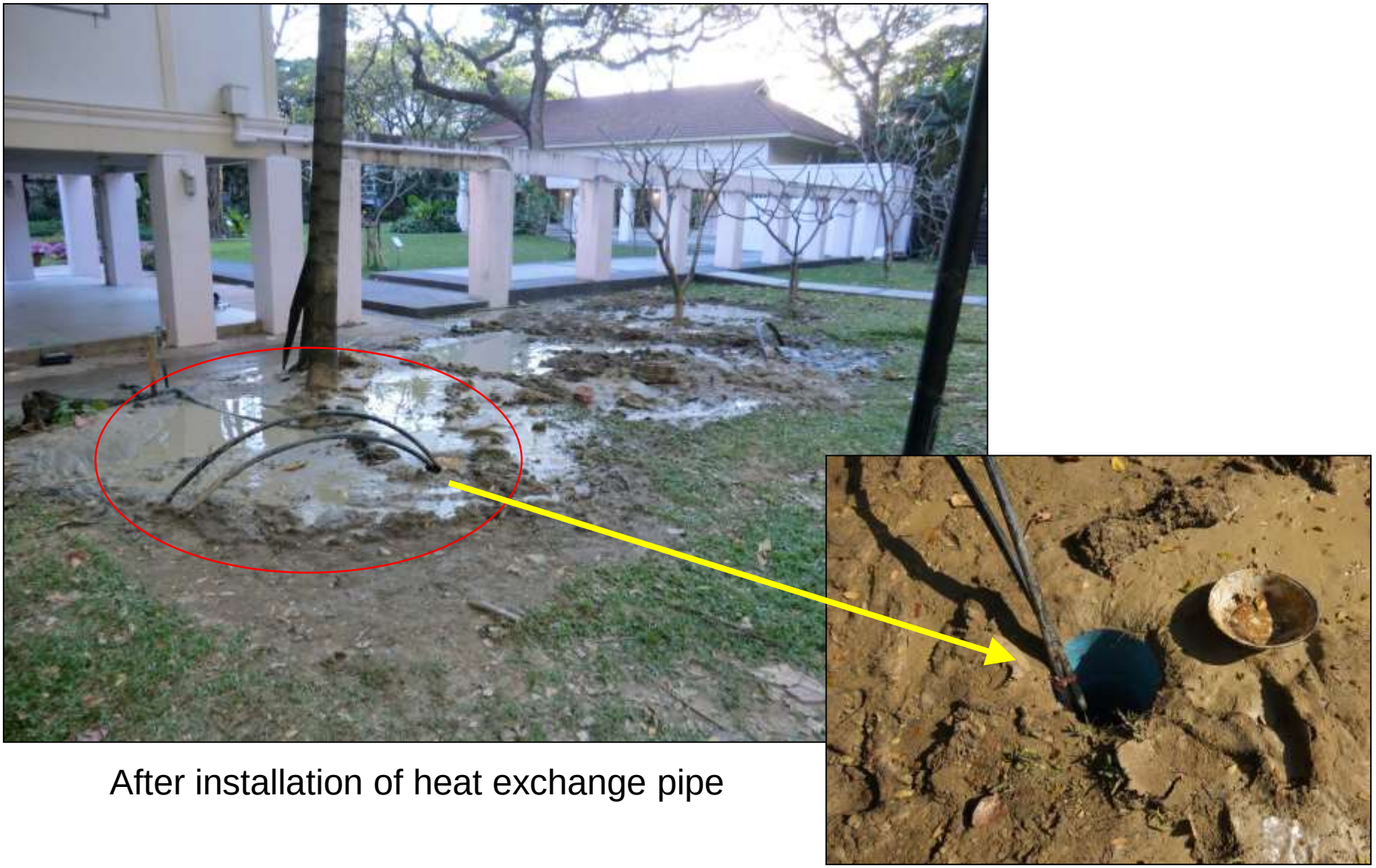

After installation of heat exchange pipe

Continued

Ductwork from borehole to guest house

GSHP and cooling fan

Continued

Conclusions

Temperature observation results in Thailand and Vietnam show possibility of GSHP application for space cooling at places where subsurface temperature becomes lower than atmospheric temperature in some season.

Hanoi, Vietnam is not a tropical region. However, the observation results would be valuable as base data for potential resource mapping. GSHP as heating system may also be useful for drying in humid winter season in Hanoi. Thus, new application of GSHP may be found through climatic and subsurface data.

System performance depends not only on subsurface temperature but also on the operation plans and subsurface thermal parameters. Nevertheless, our temperature data will be essential as base data for GSHP promotion.


Thank you for your kind attention