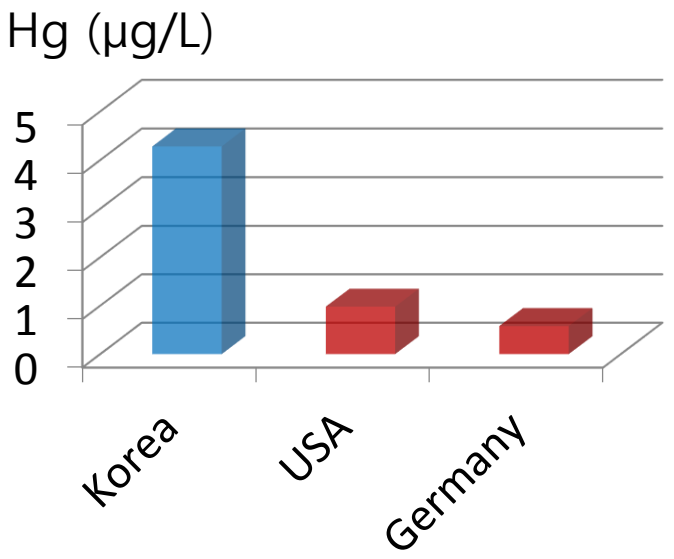
Wet Deposition and Watershed Transport of Mercury in South Korea

07. 27. 2016

Seunghee Han
Gwangju Institute of Science and Technology (GIST)
Gwangju, Korea

General Issues in Korea

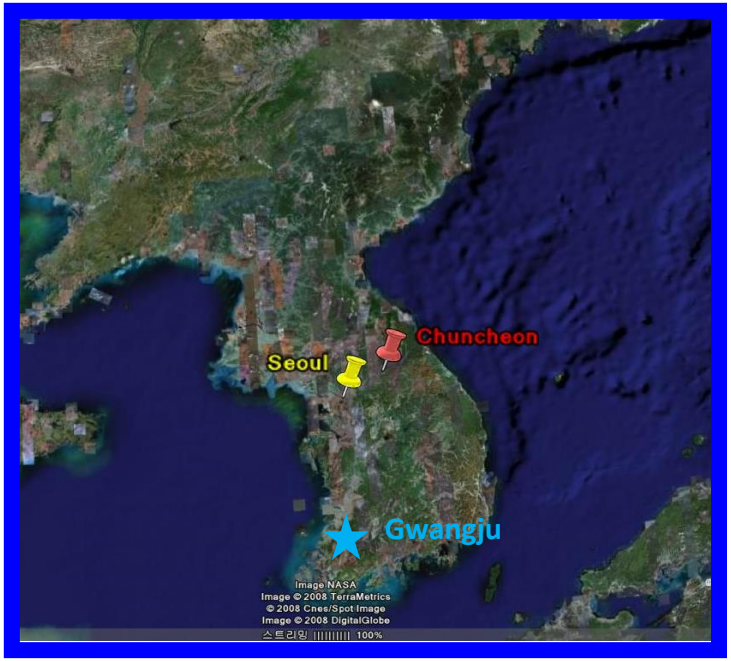
- Downwind area of China
- Seafood consumption rate is high
- 26% of Korean population has higher mercury levels than US guidelines



Outlines

- Wet deposition monitoring activities in South Korea
- Wet deposition monitoring related programs in South Korea
- Plans

➢ University monitoring sites



Seoul (population 10,000,000):

- Seoul National University

Chuncheon (population 280,000)

- Gangwon National University

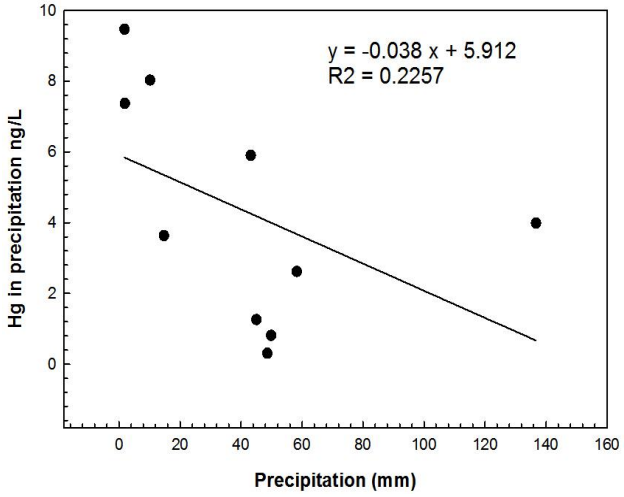
Gwangju (popuation 1,500, 000)

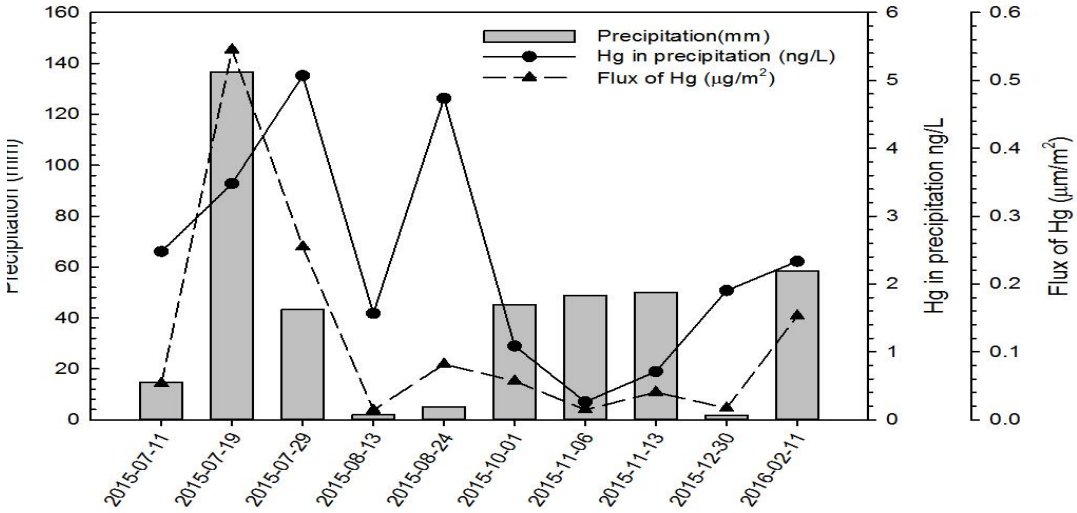
- Gwangju Institute of Science and Technology (GIST)

➢ NIER monitoring sites

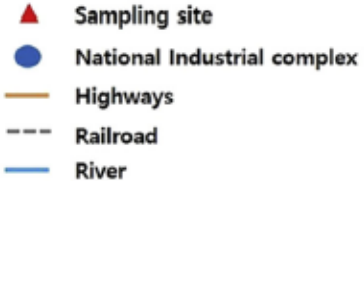
➢ Chuncheon, Gangwon province (*courtesy of Young-Ji Han*)

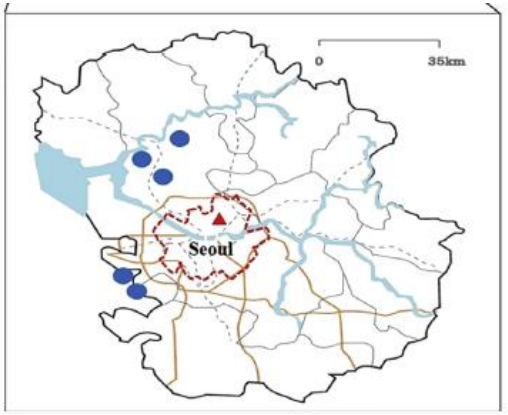
	Precipitation depth (mm)	VWM Hg (ng/L)	Flux (μg/m²)
2008 (12 month)	1210	4.2	5.1
2009 (12 month)	1314	3.5	4.6
2010 (12 month)	1020	1.1	1.7
2011 (12 month)	362	1.2	1.0
2012 (7 month, Jan-Jul)	711	0.6	0.8
2015 (8 month, Jul-Feb)	405	2.4	2.3

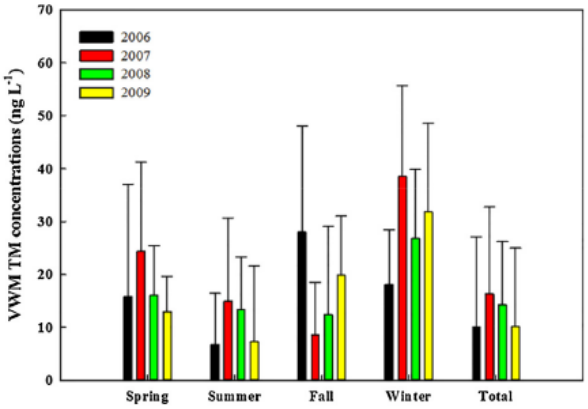


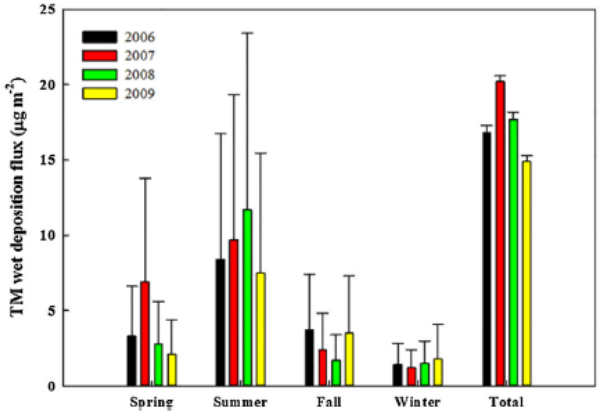


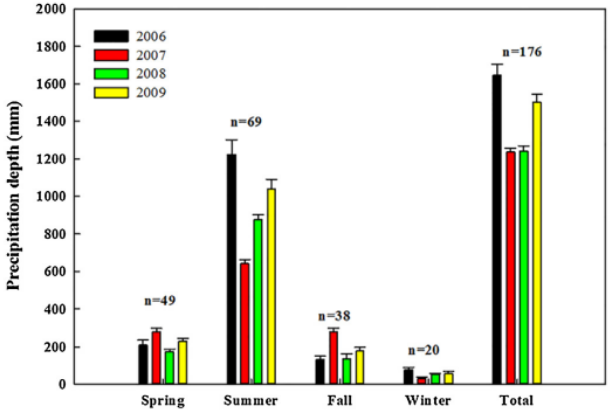
➢ Seoul (*Seo et al., 2012, 2015, Atmospheric Environment)*









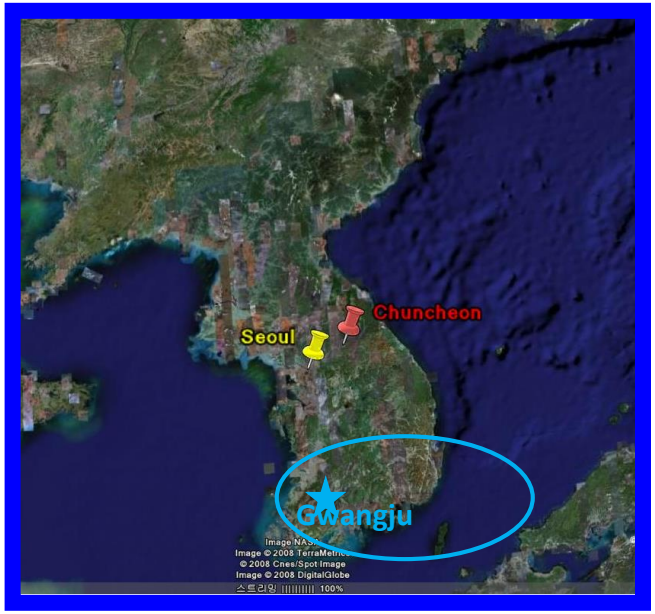


1) Seasonal variations in TM wet deposition and flux
2) Relative contributions of GOM and PBM scavenging to Hg wet deposition
3) Identifying source areas contributing to the high TM wet deposition using a LPDM

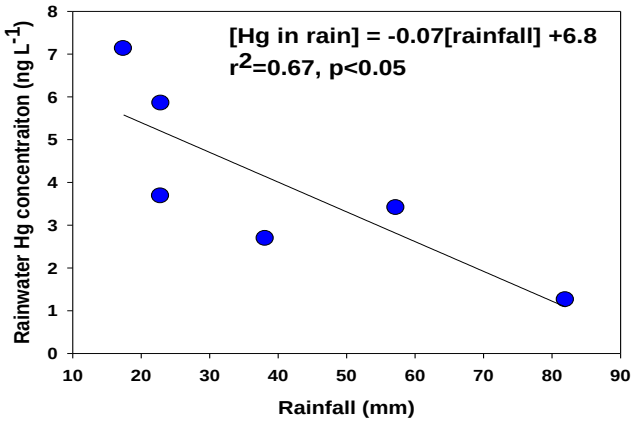
➢ Gwangju, Cheonnam province

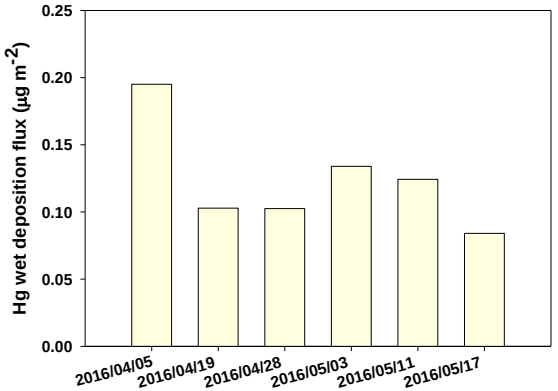
Sampling period : April 2016 – present

Model: MDN 00-125-4



	Starting	Ending	Temp	Precipitation	Hg
			℃	mm	ng/L
1	2016-04-05	2016-04-13		57	3.4
2	2016-04-19	2016-04-27	26.7	82	1.3
3	2016-04-28	2016-05-03	26.7	38	2.7
4	2016-05-03	2016-05-11	33.3	23	5.9
5	2016-05-11	2016-05-17	34.4	17	7.1
6	2016-05-17	2016-05-25	33.9	23	3.7
			31.0	241 (total)	3.1 (VWM)





➢ Summary

Site	Country	Year	Precipitation (mm)	VWM Hg (ng L^{-1})	Flux (μg m^{-2})
Bekkai, Hokkaido* (remote)	Japan	2003	1117	5.2	5.8
Kashima, Fukushima (urban)			1599	6.3	10.1
Matsuura, Nagasaki (urban)			2317	7.6	17.6
Seoul**	Korea	2006	1645	10.1	16.6
		2007	1235	16.3	20.1
		2008	1242	14.3	17.8
		2009	1502	10.2	15.3
Chuncheon	Korea	2008	1210	4.2	5.1
		2009	1314	3.5	4.6
		2010	1020	1.1	1.1
		2011	362	1.2	0.4
Gwangju	Korea	2016 (Apr-May)	240	3.1	0.7

*Sakata and Marumoto, 2005; ** Seo et al., 2015

Wet deposition related programs in South Korea

Project Title	Period	Purposes	Funding agency	Participating organization
National mercury monitoring program (water)	2013-2015 2016-2020	Establish nationwide Hg monitoring program (parameter, frequency, site..etc) Preliminary study	Department of Environment (DE)	Korea Environment Corporation EH R&C Gwangju Institute of Science and Technology
Assessment for the fate of mercury in lake ecosystems	2015-2017	Predict responses of MeHg accumulation in fish to the atmospheric deposition changes	Korea Environmental Industry & Technology Institute (KEITI)	대구대학교 DAEGU UNIVERSITY Texas A&M AgriLife Research Gwangju Institute of Science and Technology

1. Nationwide mercury monitoring program

Fate Assessment

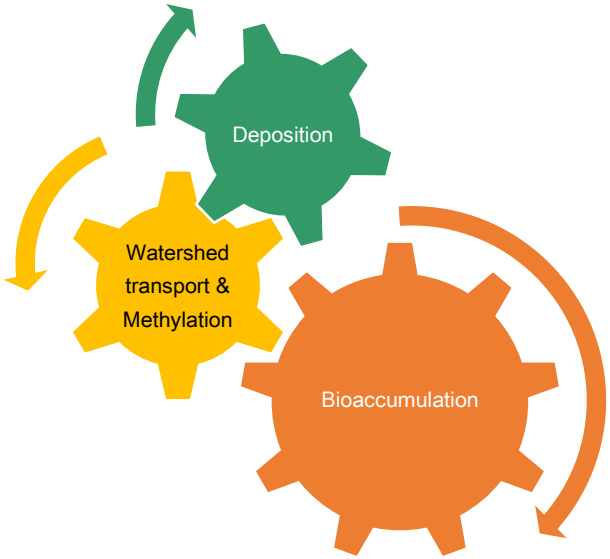
- Responses of aquatic ecosystem to the atmospheric mercury deposition

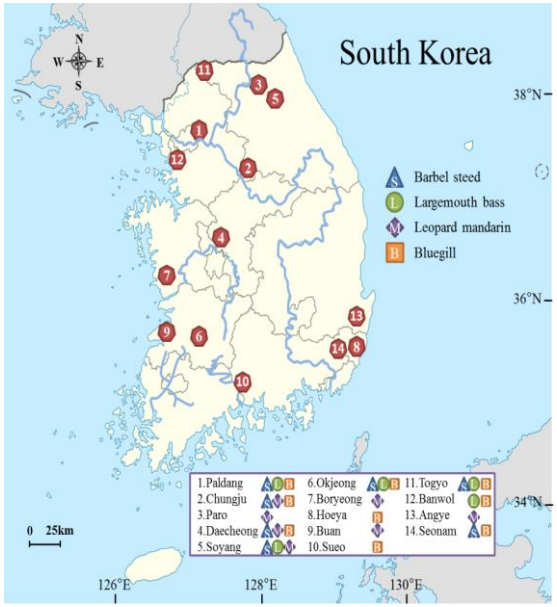
Temporal Trends

- Identification of temporal trends of Hg deposition

	Target area	Medium	Parameter	Frequency
Fate	Baekrok Lake, Hanra Mountain	Sediment	Hg, MeHg, radioisotopes for dating	1/5 year
	Five lakes	Water	Hg, MeHg, sulfate, DOC, nitrate, phosphate, pH, temp, DO, conductivity	3/ year (1~2, 5~6, 8~9)
				2/ year (5~6, 8~9)
		Sediment	Hg, MeHg, particle size	2/ year (5~6, 8~9)
		Food web	Hg, fork length, C/N stable isotopes	1/ year (5~6)
		Atmos	Wet Hg deposition	1/ year (2016.10~)
Temporal trends	Five rivers	Water	Hg, MeHg, sulfate, DOC, nitrate, phosphate, pH, temp, DO, conductivity	3/ year (1~2, 5~6, 8~9)
		Sediment	Hg, MeHg, particle size	2/ year (5~6, 8~9)
		Fish (6 species)	Hg, fork length, C/N stable isotopes	1/ year (5~6)

1. Nationwide mercury monitoring program



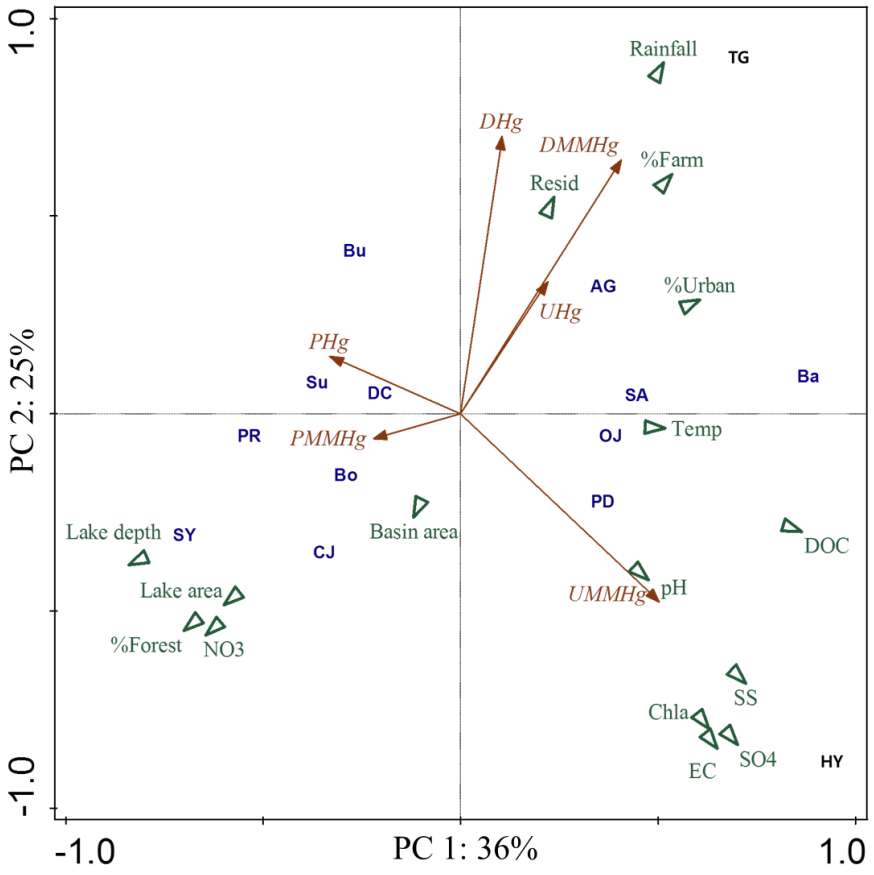


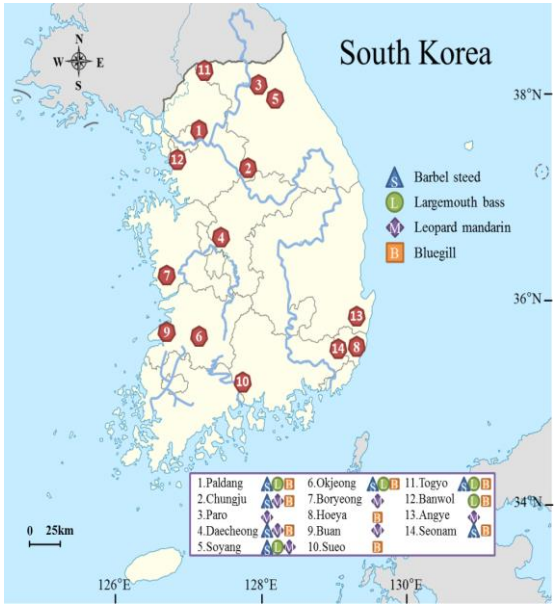
Reservoir name	TSI(chl-a)[a]	TS	Limiting factor
Paldang	54	Eutrophic	Zooplankton grazing
Chungju	38	Oligotrophic	Light
Paro	35	Oligotrophic	Light
Daecheong	52	Mesotrophic	Phosphorus
Soyang	49	Mesotrophic	Phosphorus
Okjeong	44	Oligotrophic	Light and phosphorus
Boryeong	47	Mesotrophic	Phosphorus
Hoeya	59	Eutrophic	Zooplankton grazing
Buan	42	Oligotrophic	Light and phosphorus
Sueo	48	Mesotrophic	Phosphorus
Togyo	35	Oligotrophic	Light
Banwol	56	Eutrophic	Zooplankton grazing
Angye	46	Mesotrophic	Light and phosphorus
Seonam	54	Eutrophic	Zooplankton grazing

1. Nationwide mercury monitoring program

	Sample collection date	Sample #	UHg	DHg	PHg	UMMHg	DMMHg	PMMHg
		n	ng L^{-1}	ng L^{-1}	ng g^{-1}	pg L^{-1}	pg L^{-1}	ng g^{-1}
Paldang	Sept. / 2015	5	0.45±0.15	0.25±0.034	44±26	29±4.8	11±0.94	4.0±0.86
Chungju	Sept. / 2015	5	0.33±0.044	0.23±0.026	29±5.1	96±16	9.0±2.7	25±3.8
Paro	June / 2013	6	0.85±0.14	0.26±0.034	567±102	20±2.2	8.4±2.1	11±0.10
Daecheong	Sept. / 2015	5	0.24±0.024	0.13±0.049	44±10	13±5.8	7.2±4.3	2.3±0.60
Soyang	Oct. / 2014	5	0.40±0.098	0.25±0.018	54±29	10±2.3	6.3±0.78	1.3±0.54
Okjeong	June / 2013	5	1.1±0.19	0.36±0.065	91±15	28±15	8.0±2.3	2.5±1.6
Boryeong	July / 2014	4	0.22±0.020	0.13±0.059	64±28	19±2.4	11±4.0	5.7±1.1
Hoeya	July / 2014	5	0.62±0.12	0.24±0.016	14±3.9	80±27	13±2.9	2.5±0.89
Buan	July / 2014	5	0.63±0.061	0.31±0.019	168±22	14±1.2	10±1.2	2.1±0.01
Sueo	Sept. / 2013	3	0.68±0.051	0.34±0.054	115±1.0	16±7.1	3.3±0.26	4.3±2.3
Togyo	Aug. / 2013	5	0.99±0.11	0.58±0.078	136±11	65±8.0	31±7.4	11±0.20
Banwol	July / 2015	3	0.74±0.046	0.22±0.040	35±0.40	18±2.4	12±3.6	0.40±0.08
Angye	Sept. / 2015	3	0.21±0.051	0.18±0.049	16±1.1	51±7.1	25±0.28	14±3.6
Seonam	Sept. / 2015	3	0.63±0.20	0.16±0.067	53±15	50±5.9	15±3.3	4.0±0.30

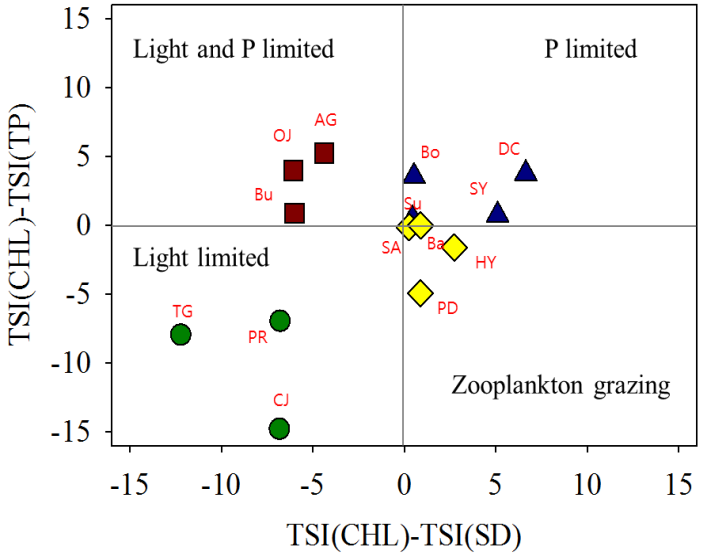
1. Nationwide mercury monitoring program

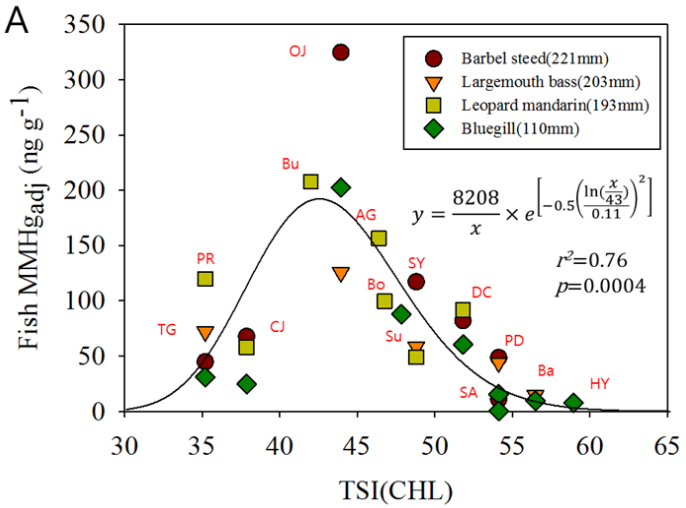


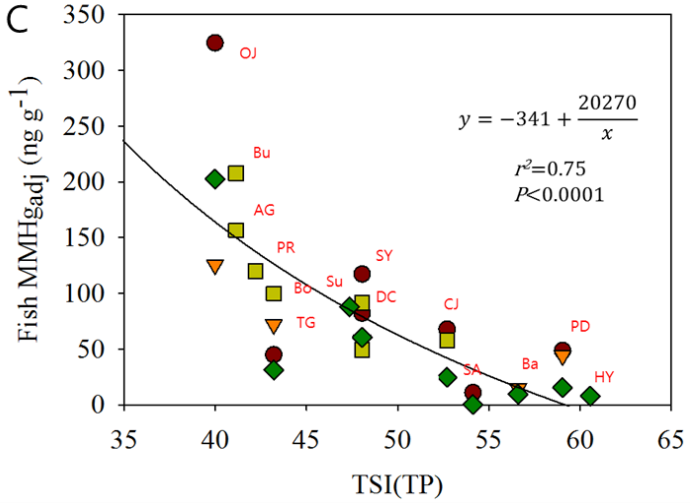


Sampling period: June 2013 - September 2015
Sample number: 70 samples

1. Nationwide mercury monitoring program



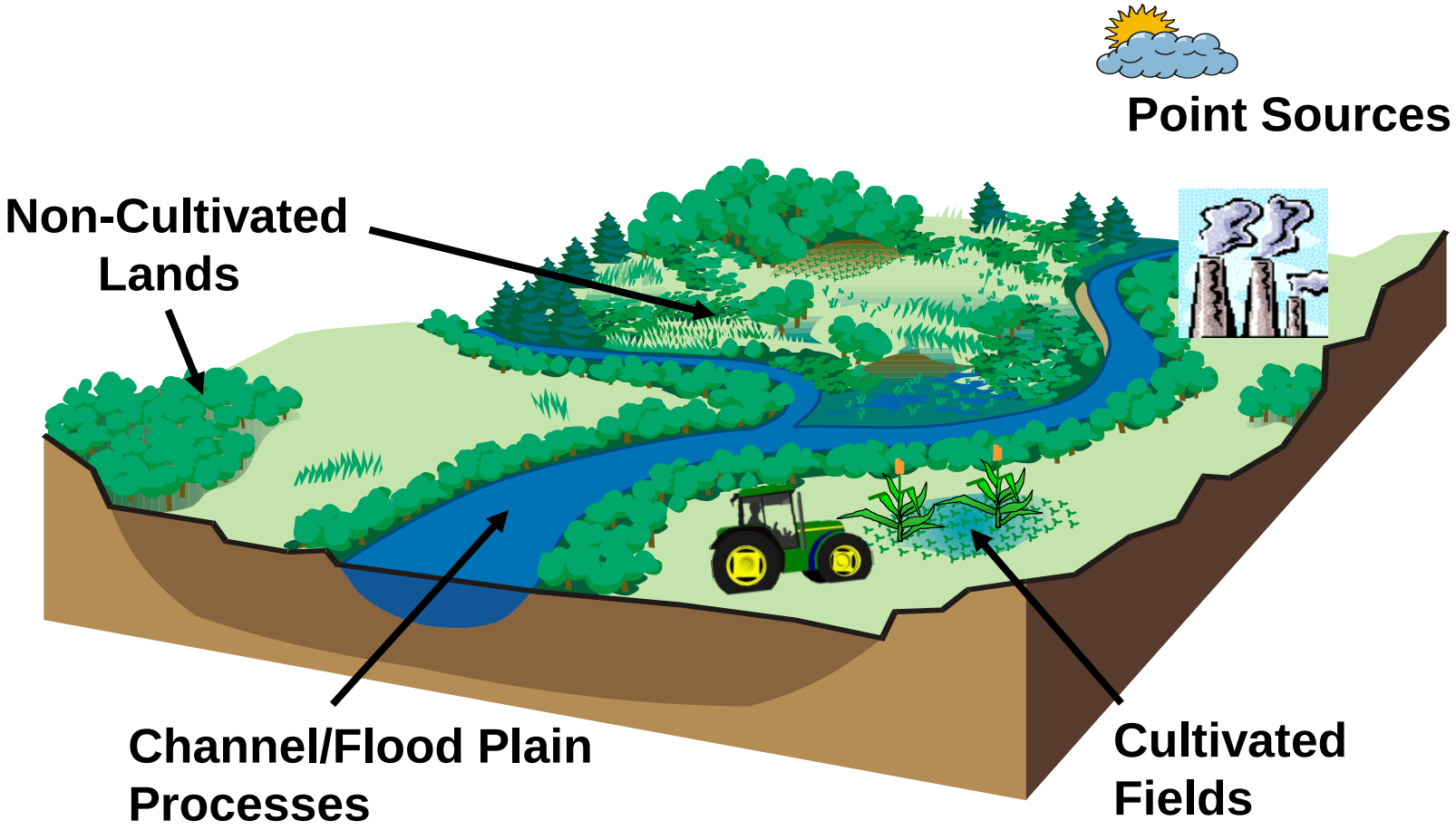




Sampling period: June 2013 - September 2015
Sample number: 70 samples

2. Assessment for the fate of Hg in lake ecosystems

Soil & Water Assessment Tool (SWAT)

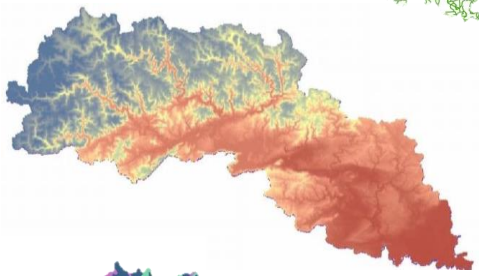


Courtesy of Jaehak Jeong

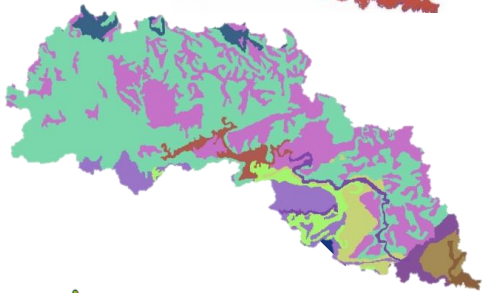
Data Layers and Model Construction

Hydrographic network

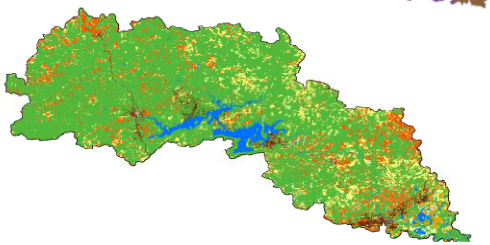
Digital elevation model

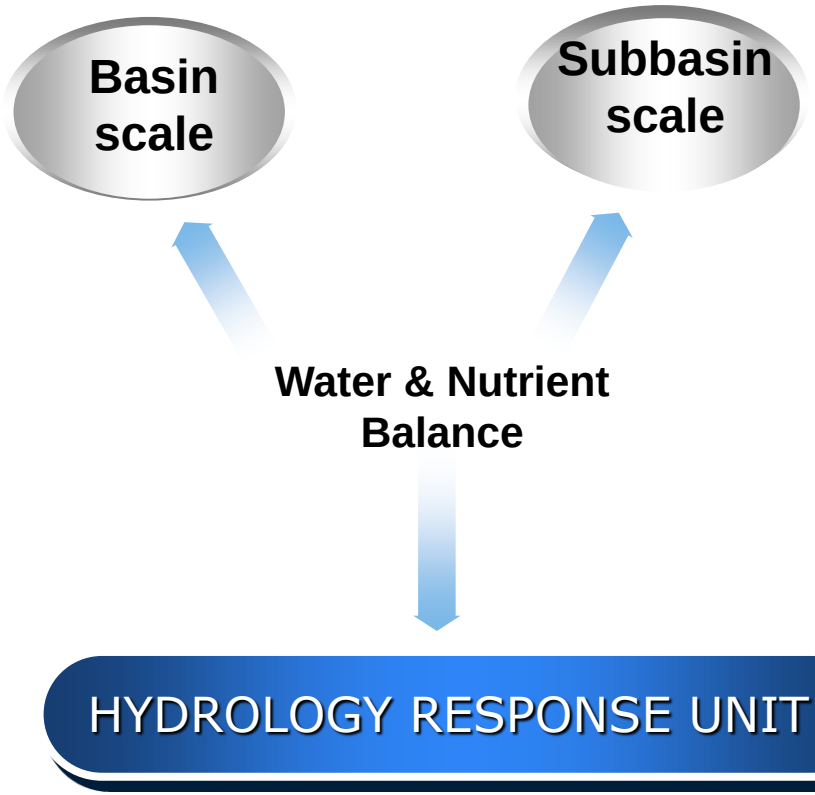


Soil map



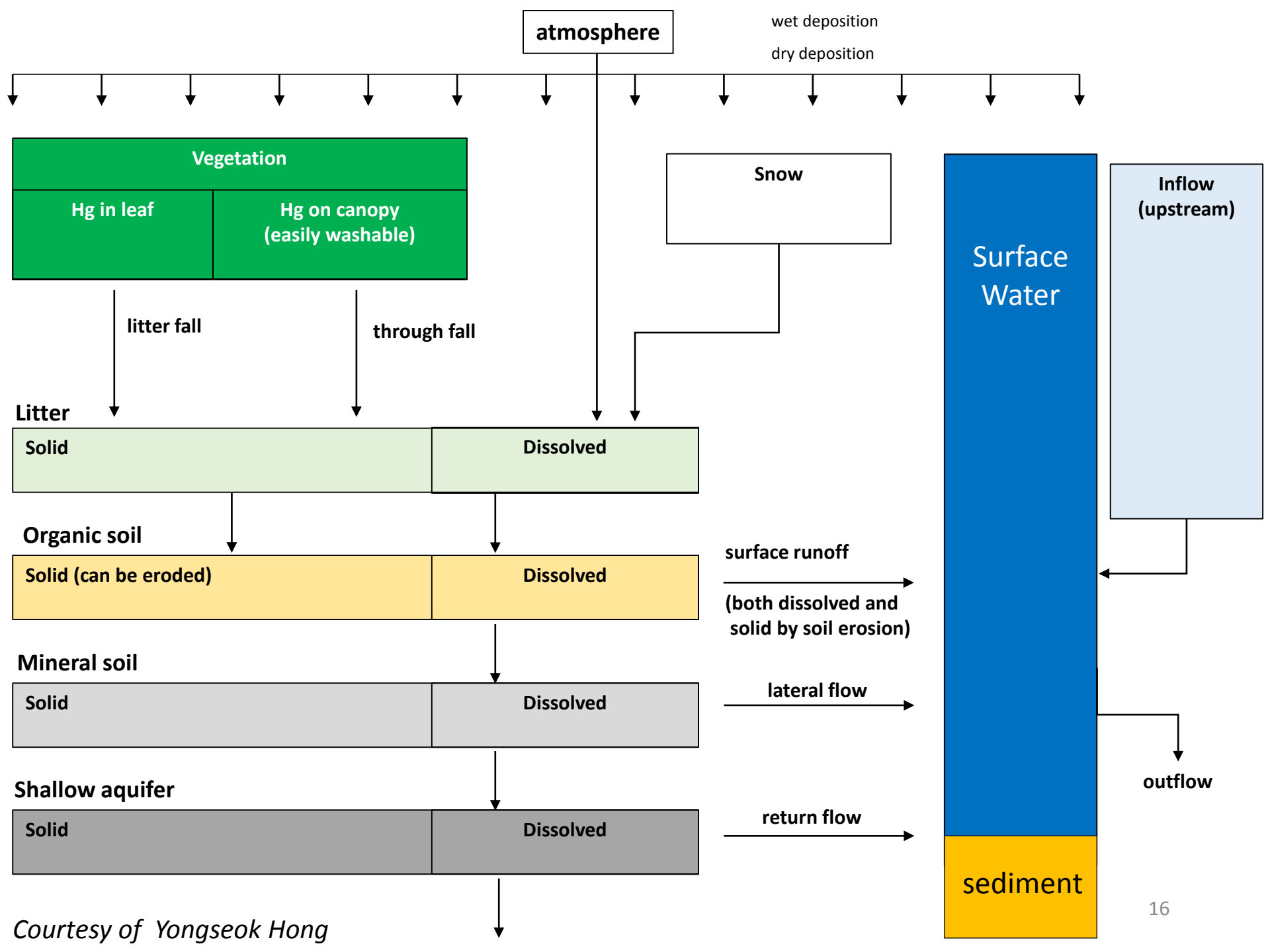
Land use map





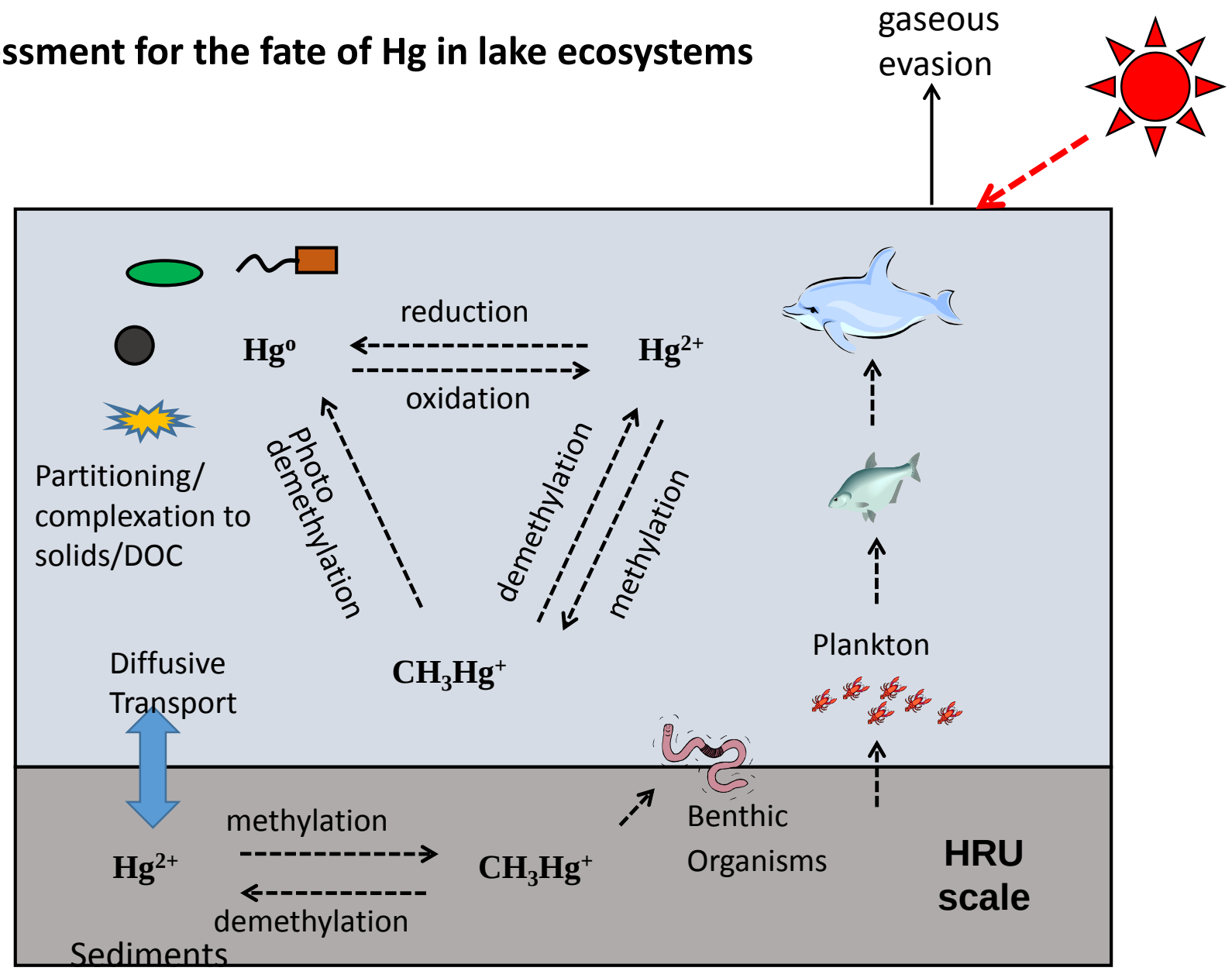
Courtesy of Jaehak Jeong

Texas A&M AgriLife Research



Courtesy of Yongseok Hong

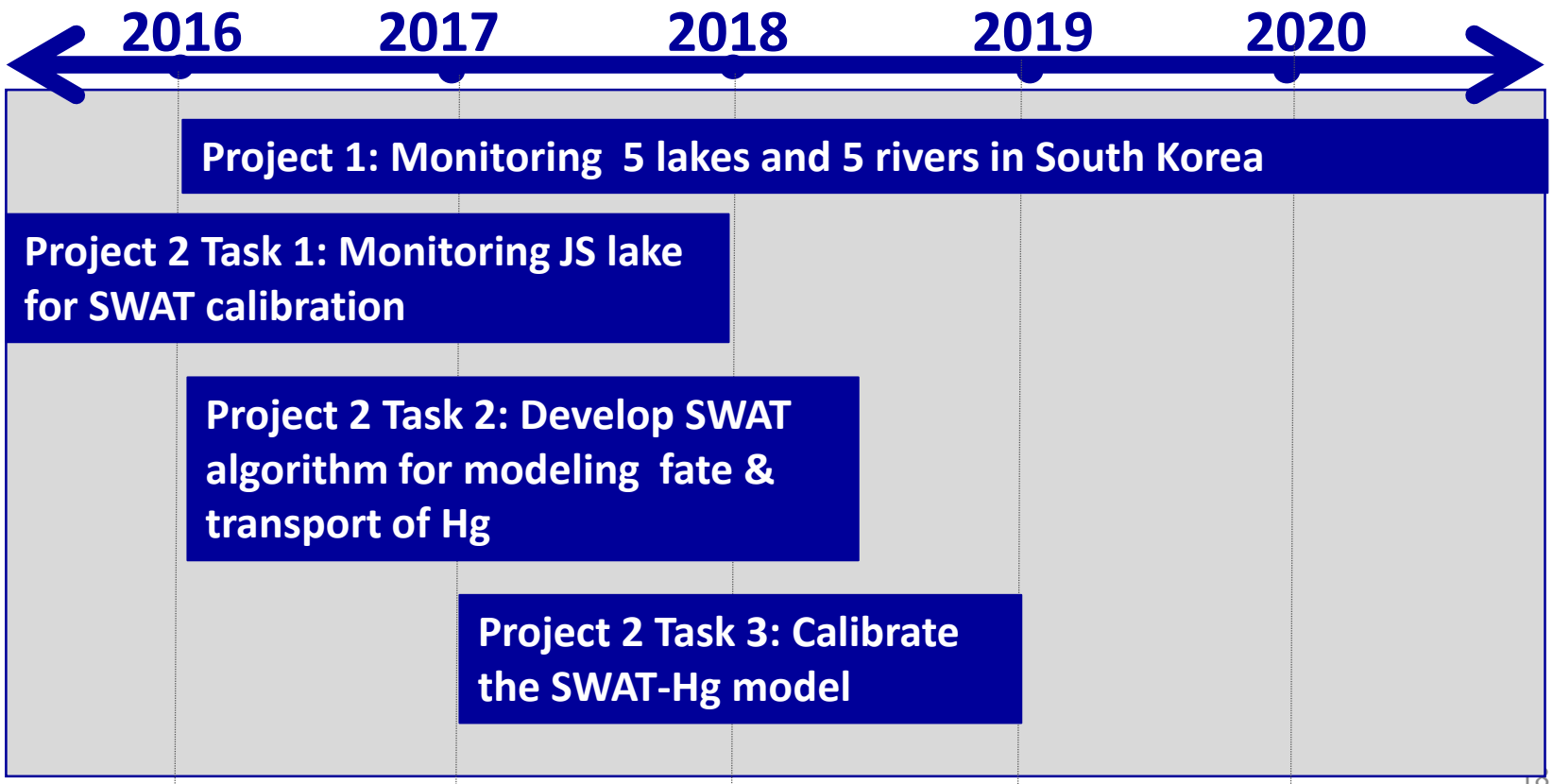
2. Assessment for the fate of Hg in lake ecosystems



Courtesy of Yongseok Hong

Future Plans

1. Monitoring and source identification of wet deposition of Hg
2. Apply wet deposition flux of Hg to statistical interpretations of the nationwide monitoring data for identifying methylation-related factors
3. Apply wet deposition flux of Hg to SWAT-Hg model for simulating fish MeHg in response to atmospheric Hg reduction



Special thanks to:

Yongseok Hong in Daegu University

Jaehak Jeong in Texas A&M University

Young-Ji Han in Gangwon National University