AIR MONITORING NETWORK OPTIMIZATION METHOD USING CHEMICAL TRANSPORT MODEL AND METAHEURISTICS

Shin ARAKI[1)2)], Hikari SHIMADERA[2)], Kouhei YAMAMOTO[3)], Akira KONDO[2)]
1) Otsu City Public Health Center, 2) Osaka University, 3) Kyoto University

1. Introduction

The conventional optimization method utilizes observations on the assumption that the target network sufficiently represents the concentrations of the domain of interest.

The new method using metaheuristics integrated with WRF/CMAQ output is proposed for observation-free approach and the performance is evaluated.

2. Methods

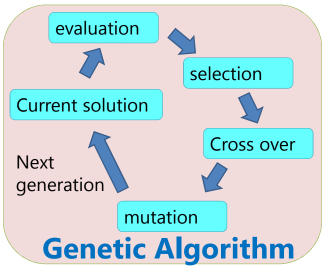
Chemical transport model

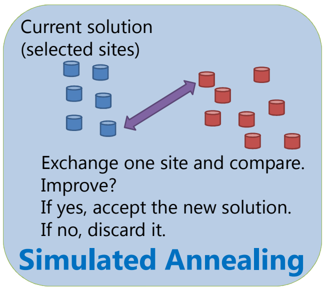
CMAQ ver 5.0.1 is driven with WRF ver 3.5.1.
The configurations and settings are detailed in Shimadera et al. (*H16-104*).

Optimization algorithms

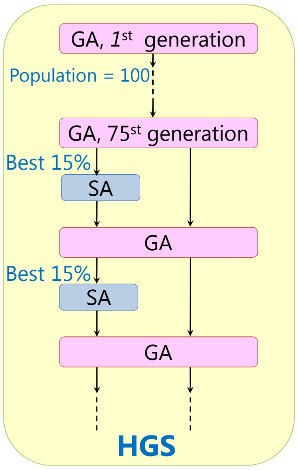
The Hybird GA and SA is developed to deal with the huge and continuous search space of WRF/CMAQ output.

	Search ability	
	Global search	Local search
Genetic algorithm (GA)	Excellent	Fair
Simulated annealing (SA)	Fair	Excellent
Hybrid GA+SA (HGS)	Excellent? (expected)	Excellent? (expected)





Evaluated by kriging variance.
The smaller, the better.



3. Application to $PM_{2.5}$ network in Japan

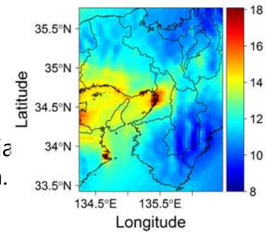
Study area and setups

- Kinki region with megacities (Osaka, Kyoto, Kobe) in Japan
- $PM_{2.5}$ monitoring network is under development. (57 stations in 2011 to 116 stations in 2013)
- Calculation period is from April 2010 to March 2011.
- The horizontal domains are domain 1 (Northeast Asia), domain 2 (Japan) and domain 3 (the study area).
- The resolution is 4 km with 68 × 72 grids in domain 3.

3. continued

WRF/CMAQ performance

- Underestimation in annual mean due to that in summer time.
- Sufficient quality for the optimization input given the spatial uniformity of the underestimation.

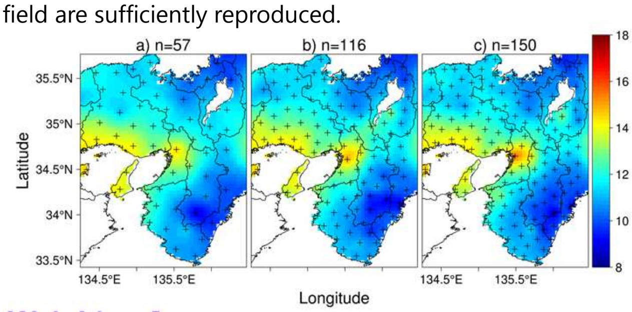


Optimization results

The performances of the three algorithms are compared with each other by the indicators calculated from 20 realizations for the network of the size n=57, 116 and 150 .

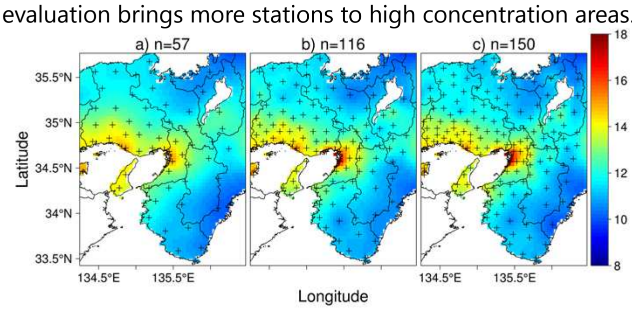
	GA			SA			HGS (Best)		
n	Min.	Mean	SD	Min.	Mean	SD	Min.	Mean	SD
57	1692	1704	8.6	1650	1662	15.6	1645	1650	2.6
116	1199	1204	2.9	1159	1171	9.5	1155	1158	1.7
150	1049	1055	2.8	1017	1027	7.9	1013	1014	1.0

The concentrations fields are generated by kriging with WRF/CMAQ simulated values at gauged sites. The simulated field are sufficiently reproduced.



Weighing factor

The concentration based weighing factor for the network evaluation brings more stations to high concentration areas.



4. Conclusion

- The new observation-free optimization method for air monitoring networks is successfully developed using WRF/CMAQ output and Hybrid GA and SA algorithm.
- The HGS combines the advantages of the GA and SA, and outperforms the rest two algorithms.
- The weighing factor can deal with various placement strategy.