Integrated urban Greenhouse Gas Information System (IG³IS): Advances in the urban GHG monitoring implementation plan and results of previous and current city-scale studies

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The Lima-Paris Action Agenda of the Paris Agreement has formalized a role for sub-national entities such as cities (large urban source regions) as leaders in greenhouse gas mitigation and climate adaptation. Currently, over half of the world's population lives in metropolitan areas and

future population growth is also predicted to occur mostly in these urban centers. Therefore, implementation plan of Integrated Global Greenhouse Gas Information System (IG³IS) of WMO/UNEP has identified urban GHG emission as a core action area where scientific information can be expected to respond to stakeholder needs in the near future. The IG3IS activities aim to help create the framework to provide diagnosis of urban emissions at scales relevant to urban decision making and enable identification of low-carbon or carbon mitigation opportunities.

Complexity of	Identify major emitters and anomaly detection	Quantification of total GHG emissions	Assessment of GHG emissions per sector	Tracking annual and long-term emission changes	Understand short-term emission changes and spatial patterns	Process understanding of emissions and tracking of mitigation impacts
	Inventory validation (A1)	Inventory or emission model (A2)	Sector-specific inventory or emission model (A3)	Continuously updated inventory or emission model (A4)	Temporally and spatially disaggregated inventory or emission model (A5)	Process-based emission mode using real-time emission data
Colution	Mobile surveys (B1)	Mass-balance (B2) Radon tracer method (B3)	Multi-tracer ratio observations (B4)	Radon tracer method (B5) Multi-tracer observations (B6)	Mobile surveys (B7) Repeated mass- balance	<u>Dedicated field</u> campaigns (B8)
	Remote sensing (C1)	DAS using short- term observations (C2)	DAS using dense observations(C3) DAS using multi- species data	DAS using long-term observations (C4)	DAS using dense observations (C5)	FFDAS DAS using multi species

Demonstrated skills
Theoretically tested skills
Future potential skills

DAS = data assimilation system

Here, we present the current status of the IG³IS implementation plan and report on the identified (widely varying) needs of city stakeholders. IG³IS will provide a tiered approach to help address those needs ranging from basic to most detailed emission information. Many research groups have worked on different data-driven, observational and (inverse) modelling techniques for city-scale GHG studies that can become core elements of a future IG³IS framework after a harmonisation of techniques can be achieved. This study will also give a (short) overview of key elements of a potential tiered system and results from test-bed experiments e.g. Indianapolis, Paris, Recife, etc. where novel techniques (total column CO₂, lower-cost sensors, multi-species observations and modelling, etc.) have been tested.

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