BOG Report

BOG 3 – AFOLU GHG

IPCC TFI Expert Meeting on Use of Atmospheric Observation Data in Emission Inventories

5-7 September 2022
WMO HQ, Geneva - Switzerland

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INTERGOVERNMENTAL PANEL ON climate change

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General Comments

- ✓ Focused on atmospheric observations that are used in inversion frameworks to estimate fluxes
- ✓ Verification of inventory using inversion data is not necessarily leading to direct changes in the emissions reporting (i.e., directly using the inversion results for reporting), but rather as a starting point for further investigation of the inventory methods as well as the inversion framework
- ✓ Goal is to reduce uncertainty in the GHG inventory by further investigating and improving the underlying activity data and other driver data, as well as emission rates
- ✓ Inventories may also be useful for improving atmospheric inversions

General Comments

- ✓ In general, developing country parties to the UNFCCC face more challenges to use atmospheric observations for evaluating inventories
  - ✓ Global inversions may provide some insights into key categories
  - ✓ Not clear that inversions can be used directly in evaluating inventories in developing countries, particularly smaller countries

- ✓ Questions that can be asked in these comparisons:
  - ✓ Is the inventory accurate?
  - ✓ Is the inversion accurate?
  - ✓ What are the drivers of the stock changes or GHG fluxes?
  - ✓ Are trends and spatial patterns consistent between the inventory and inversion?

Discussion Question #1

- ✓ Assess and critique recent estimation techniques that utilise atmospheric observations as well as operational systems, platforms, instruments/sensors and methods/models for their potential to be used for the verification of national inventory sectoral emission estimates, consistent with the guidance provided in the 2019 Refinement

Discussion Question #1

- ✓ Overarching conclusion: Need to gain more experience using atmospheric observations and inversions to evaluate AFOLU sectoral GHG inventories.
  - ✓ Best examples from evaluation of CH_4 and N_2O emissions in AFOLU sector

Considerations for conducting an informative analysis based on recent inversion and inventory comparisons

- ✓ Scale of inversion is important
  - ✓ Regional inversions critical for small countries, and to evaluate subnational fluxes in larger countries
  - ✓ Global inversions may be adequate for large countries
  - ✓ Regional inversions need to be consistent with the global inversions

Discussion Question #1

Considerations

- ✓ **Prior fluxes for inversions is a large source of uncertainty**
  - ✓ **Could use the inventory as a prior if adequate for purposes but will likely need data beyond the inventory to estimate the full flux, particularly for CO_2**
  - ✓ **In AFOLU, lateral fluxes associated with harvested woody products, crop harvest and transport, indirect N_2O emissions, and hydrological flows complicate the estimation of the prior**

- ✓ **Transport is another large source of uncertainty in inversion frameworks**
  - ✓ **May contribute to mismatch in inversion fluxes compared to inventory**
  - ✓ **Depends on topography and complexity of atmospheric structure**

Discussion Question #1

Considerations

- ✓ **Atmospheric observations of concentrations have considerably less uncertainty, but quality and quantity of atmospheric observations are another consideration**
  - ✓ **Tall tower and aircraft are a more direct inference on the concentrations, and need to be expanded in some regions (initiative led by WMO)**
  - ✓ **Satellite data provide additional information on atmospheric concentrations to support the inversions**
  - ✓ **In turn, satellite data are providing opportunities for inversion analysis in regions where this was not possible in the past**

- ✓ **Inventory compilers need to be actively involved in these comparisons**
  - ✓ **Providing context about the inventory analysis**
  - ✓ **Expressing needs for improving the inventory**
  - ✓ **Evaluating differences and possibly surprises from the comparison**

Discussion Question #2

- ✓ Assess and evaluate successful examples of:
  - ➢ comparisons between atmospheric observations and national inventories that are consistent with good practice provided in the 2019 Refinement that have led to implemented or planned improvements in national inventories;
    - ➢ **Several examples on next few slides**
  - ➢ available examples where emission factors derived from atmospheric observations have been incorporated into a bottom-up inventory framework
    - ➢ **No known example of this latter case in AFOLU reporting to the UNFCCC**

Discussion Question #2

- ✓ Comparison 1: New Zealand Example
  - ✓ Inversion system applied to evaluate CO_2
  - ✓ Inversion System: Surface measurements and Langragian Bayesian inversion system
  - ✓ Finding C sink in the inversion analysis that has not been identified in the inventory along coastal areas
    - ✓ May be associated with lateral flows of sediment and/or water
    - ✓ New studies initiated to investigate these possibilities
  - ✓ Publications: Steinkamp et al. 2017, ACP; Geddes et al. 2020, Report to Ministry of Primary Industries

Discussion Question #2

- ✓ Comparison 2: Australia Example
  - ✓ Inversion system applied to evaluate CO_2
  - ✓ Inversion System: OCO-2 Satellite data with Data Assimilation
  - ✓ Finding a sink in rangelands that has not been identified in the inventory
    - ✓ Maybe associated with precipitation patterns, woody encroachment, and/or management
    - ✓ Planning to further investigate these differences with inventory team
  - ✓ Publications: Villalobos et al. 2020, ACP; Villalobos et al. 2021, ACP; Villalobos et al. 2022, ACP

Discussion Question #2

- ✓ Comparison 3: United States Example
  - ✓ Inversion system applied to investigate impact of freeze-thaw process on soil N_2O emissions
  - ✓ System: Tower observations with Carbontracker Lagrangian Bayesian Inversion
  - ✓ Findings showed that freeze-thaw periods coinciding with large emission pulses consistent with the small set of experimental data.
  - ✓ Inversion informed model development leading to an improvement in the inventory that has been incorporated into UNFCCC reporting
  - ✓ Publication: Nevison et al. 2018, GBC; Del Grosso et al. 2022, PNAS

Discussion Question #2

- ✓ Comparison 3: Subnational Example from US State of California
  - ✓ Inversion system applied to emissions from dairy operations
  - ✓ Inversion System: Lagrangian Bayesian Inversion System
  - ✓ Inversion suggested that they were under-estimated
  - ✓ Mobile and airborne measurements confirmed that the inventory emission factors were accurate and the inversion was not accurate in this case.
  - ✓ Publication: Amini et al. 2022, ES&T

Discussion Question #3

- ✓ Assess the possibility that emerging datasets from atmospheric observations could be used to test and verify particular IPCC default values (emission factors) and associated uncertainties

Discussion Question #3

- ✓ Tier 1 Emission Factor Evaluation: Soil N_2O emissions
  - ✓ Inversion system applied to estimate N_2O fluxes in Brazil, United States, China, South Asia, and Europe
  - ✓ Estimated implied emission factors based on N inputs (i.e., dividing the emissions by the inputs) combining direct and indirect emissions
  - ✓ Found that Tier 1 factors from the 2006 GL were lower than implied emission factors from the inversion analysis
  - ✓ Note: 2019 Refinement has updated these factors so could be further investigation
  - ✓ Regardless, example of how atmospheric data could be used to evaluate default factors
  - ✓ Publication: Thompson et al. 2019, Nature Climate Change

Discussion Question #4

- ✓ Discuss the use of gridding (spatial and temporal) of NGHGIs to allow comparison with atmospheric observation data

Discussion Question #4

- ✓ Inventory compiler needs sufficient resources and time to participate in the gridding of inventory data
  - ✓ Compiler has the detailed understanding of these data and should be involved in this process even if the compiler is not gridding the data
- ✓ Need to determine the appropriate spatial and temporal scales for comparing the inversion and inventory before gridding the inventory data
  - ✓ e.g., comparisons at finer scales may not be informative if uncertainties are large
- ✓ Need to determine where uptake and release are occurring, particularly the lateral flows of materials that may lead to spatial separation in processes driving uptake and release of the GHGs

Discussion Question #5

- ✓ Discuss terminology and classifications of sources/sinks and associated natural and anthropogenic GHG fluxes to find a common understanding of consistency and differences in atmospheric observation data and GHG inventory estimates

Discussion Question #5

- ✓ Anthropogenic GHG Emissions
  - ✓ Managed land proxy leads to inconsistency between inversion and inventory estimates
- ✓ Differences in application of inventory methods
  - ✓ Particularly differences among inventory Tier methods
  - ✓ Tier 1 v. Tier 3 for soil N_2O has a different level of estimation and can lead to inconsistencies
- ✓ Missing sources in the inventory
  - ✓ Some sources may not be estimated depending on policy relevance but leads to inconsistencies with the inversion
  - ✓ e.g., Herbaceous biomass and dead organic matter

Discussion Question #5

- ✓ Attribution of inversion flux to individual source categories
  - ✓ Fluxes are based on gases but source categories are often further subdivision of gases into categories such as direct and indirect soil N_2O emissions
  - ✓ Inversions may provide some information on emissions if separation of activities across the country (e.g., pixels dominated by forest, cropland etc., rice fields, may provide some insight on sources categories)
  - ✓ However, more heterogeneous land use patterns will be difficult to disaggregate and also evaluating livestock systems in this sector which are more mobile across the landscape
- ✓ Interannual variability
  - ✓ Not always addressed in the inventory whereas this is part of the inversion, leading to inconsistencies
  - ✓ Longer term climate change is imposed on these patterns, but may not be addressed in the inventory
  - ✓ May be able to extract interannual variability out of the atmospheric data as the time series increase in length

Thank you

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