**Supplementary information** for the paper

**Improved accuracy and reduced uncertainty in greenhouse gas inventories by refining the IPCC emission factor for direct N₂O emissions from nitrogen inputs to managed soils**

Kristell Hergoualc’h¹*, Nathan Mueller²,³, Martial Bernoux⁴, Åsa Kasimir⁵, Tony J. van der Weerden⁶, Stephen M. Ogle²,⁷

¹ Center for International Forestry Research (CIFOR), Lima, Peru
² Department of Ecosystem Science and Sustainability, Colorado State University, Fort Collins, CO, USA
³ Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO, USA
⁴ Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
⁵ University of Gothenburg
⁶ AgResearch Ltd, Invermay Agricultural Centre, Mosgiel, New Zealand
⁷ Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO, USA

* Corresponding author. Kristell Hergoualc’h, Center for International Forestry Research (CIFOR) c/o Centro Internacional de la Papa (CIP), Av. La Molina 1895, La Molina, Apdo Postal 1558, 15024 Lima, Peru. Email: k.hergoualch@cgiar.org
TABLE S1 Sample size, mean, and uncertainty range of the EF1 as influenced by climate, fertilizer form, land cover, and topsoil texture class, and C content. A and B indicate a significant difference between means for a given factor based on LSD Fisher test.

| Factor          | Class                  | n  | Mean   | 95% C.I.     |
|-----------------|------------------------|----|--------|--------------|
| Climate         | Temperate/boreal wet   | 524| 0.014  | B 0.008 – 0.020 |
|                 | Temperate/boreal dry   | 121| 0.007  | AB -0.002 – 0.015 |
|                 | Tropical wet           | 117| 0.015  | AB 0.011 – 0.018 |
|                 | Tropical dry           | 86 | 0.004  | A -0.004 – 0.013 |
| Fertilizer form | Synthetic              | 602| 0.014  | B 0.007 – 0.020 |
|                 | Mixed synthetic and organic | 48 | 0.014  | AB 0.011 – 0.017 |
|                 | Organic                | 162| 0.007  | A 0.003 – 0.012 |
| Land cover      | Annual croplands       | 543| 0.014  | B 0.011 – 0.018 |
|                 | Bare soils             | 74 | 0.012  | AB 0.004 – 0.019 |
|                 | Perennial systems      | 231| 0.009  | A 0.005 – 0.013 |
| Texture class   | Fine                   | 131| 0.023  | B 0.018 – 0.028 |
|                 | Medium                 | 571| 0.010  | A 0.007 – 0.013 |
|                 | Coarse                 | 30 | 0.006  | A -0.005 – 0.016 |
| Soil C content  | High (≥ 2%)            | 265| 0.015  | B 0.012 – 0.019 |
|                 | Medium (1-2%)          | 241| 0.007  | A 0.003 – 0.010 |
|                 | Low (< 1%)             | 159| 0.009  | A 0.004 – 0.013 |
**TABLE S2** Global agricultural fertilizer N consumption, and also countries with the largest inputs of fertilizer N to croplands (synthetic – manure). The dataset combines synthetic N application rates by Mueller *et al.* (2012) and manure N application rates by West *et al.* (2014) from circa 2000

| Fertilizer N application (Gg N) | Total Fertilizer | Synthetic Fertilizer | Manure Fertilizer |
|-------------------------------|------------------|----------------------|--------------------|
| Global Agriculture            | 103,499.3        | 69,624.3             | 33,875.0           |
| China                         | 26,183.5         | 19,927.8             | 6,255.7            |
| India                         | 15,059.2         | 9,312.9              | 5,746.3            |
| United States                 | 13,515.6         | 9,521.7              | 3,993.9            |
| Brazil                        | 2,948.0          | 1,517.7              | 1,430.3            |
| Pakistan                      | 2,754.2          | 2,067.4              | 686.8              |
| Indonesia                     | 2,331.3          | 1,647.4              | 683.9              |
| France                        | 2,206.7          | 1,707.5              | 499.2              |
| Mexico                        | 2,087.3          | 1,167.5              | 919.8              |
| Canada                        | 1,971.8          | 1,564.2              | 407.6              |
| Germany                       | 1,865.1          | 1,372.4              | 492.7              |
FIGURE S1 Direct soil N$_2$O emissions from global agricultural croplands using the Tier 1 method from the 2019 IPCC Methods Refinement to the 2006 IPCC National GHG Inventories Guidelines (2019 IPCC MR) (a) and the 2006 IPCC National GHG Inventories Guidelines (2006 IPCC GL) (b). The top Figures display emissions from both synthetic and manure application (total), the middle and bottom Figures refer to synthetic and manure application separately.