Supporting Information for "4D-Var inversion of European NH_3 emissions using CrIS NH_3 measurements and GEOS-Chem adjoint with bi-directional and uni-directional flux schemes"

Hansen Cao[1], Daven K. Henze[1], Liye Zhu[2], Mark W. Shephard[3], Karen Cady-Pereira[4], Enrico Dammers[5], Michael Sitwell[3], Nicholas Heath[4], Chantelle Lonsdale[6], Jesse O. Bash[7], Kazuyuki Miyazaki [8], Christophe Flechard[9], Yannick Fauvel[9], Roy Wichink Kruit[10], Stefan Feigenspan[11], Christian Brümmer[12], Frederik Schrader[12], Marsailidh M. Twigg[13], Sarah Leeson[13], Yuk S. Tang[13], Amy C.M. Stephens[13], Christine Braban[13], Keith Vincent[14], Mario Meier[15], Eva Seitler[15], Camilla Geels[16], Thomas Ellermann[16], Agnieszka Sanocka[14], Shannon L. Capps[17]

[1]University of Colorado, Boulder, USA
[2]Sun Yat-sen University, China
[3]Environment and Climate Change Canada, Toronto, Ontario, Canada
[4]Atmospheric and Environmental Research Inc., USA
[5]Netherlands Organisation for Applied Scientific Research (TNO), Climate Air and Sustainability (CAS), Utrecht, The Netherlands
[6]Department of Civil, Structural and Environmental Engineering, University at Buffalo, Buffalo, NY USA
[7]U.S. Environmental Protection Agency, USA
[8]Jet Propulsion Laboratory, California Institute of Technology, USA
[9]INRAE (National Research Institute for Agriculture, Food and Environment), UMR SAS, Agrocampus Ouest, 65 rue de Saint-Brieuc, 35042 Rennes, France
[10]National Institute for Public Health and the Environment, The Netherlands
[11]German Environment Agency, Germany
[12]Thünen Institute of Climate-Smart Agriculture, Germany
[13]UK Centre for Ecology & Hydrology, UK
[14]Ricardo Energy & Environment, Wantage, England, UK
[15]Forschungsstelle für Umweltbeobachtung, Switzerland
[16]Department of Environmental Science, Aarhus University, Denmark
[17]Civil, Architectural, and Environmental Engineering Department, Drexel University, Philadelphia, PA, USA

Contents

Supporting figures and tables

Corresponding author: Daven K. Henze, daven.henze@colorado.edu

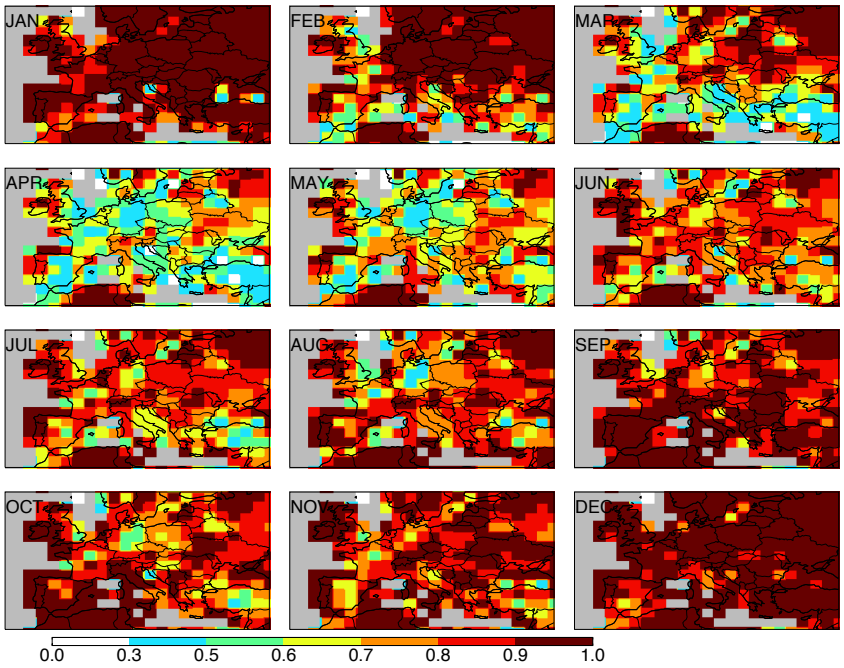

Figure S1: MASAGE-based ratio of monthly livestock NH_3 emissions to monthly total anthropogenic NH_3 emissions.

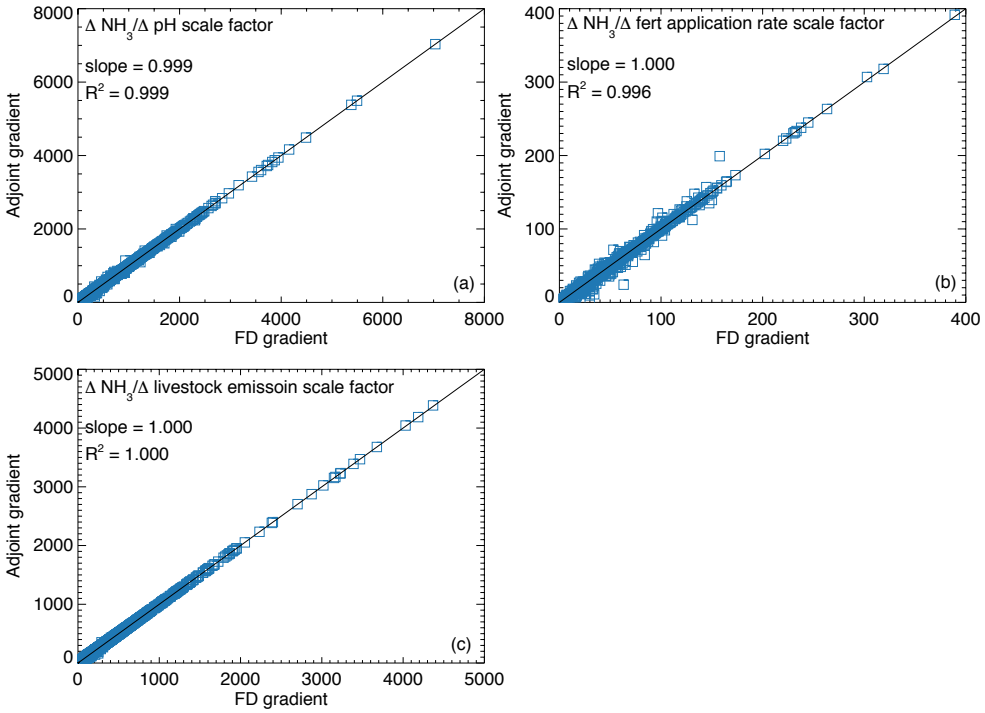

Figure S2: Scatter plot between adjoint gradient and finite difference (FD) gradient of simulated NH3 with respect to pH scale factor (a), fertilizer application rate scale factor (b) and livestock emission scale factor (c), respectively, from July 1^{st} to 7^{th} 2016 for the Europe domain at $0.3125^o \times 0.25^o$.