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Probing terpenoid chemistry from space using IASI measurements

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Introduction

Formic acid (HCOOH) is the simplest acid in the atmosphere, present in air and precipitation and major contributor to rain acidity in remote environments. Direct sources of formic acid include human activities, biomass burning and plant leaves. Aside from these direct sources, photo-oxidation of non-methane hydrocarbons, most likely of biogenic origin, is probably the largest, yet largely unknown source. Past model studies[1,2], reporting significant underpredictions of observed HCOOH concentrations, suggested the existence of unknown sources. The distribution and magnitude of these sources remained, however, so far unexplored.

Global-scale constraints on the budget of HCOOH are provided by measurements of column abundances obtained for the first time from space by the IASI instrument[3]. Here we use one complete year of satellite observations to constrain model simulations of the HCOOH global source through an inverse modelling scheme based on the IMAGESv2 global CTM.

Performed simulations and source inversions

F1	**Standard simulation**
F2	**includes production of HCOOH in the heterogeneous oxidation of OA by OH**
F3	**includes production of HCOOH in the photolysis of hydroperoxy-enones from isoprene**
Opt1	**infer a primary HCOOH biogenic source using IASI**
Opt2	**infer a secondary biogenic HCOOH source**

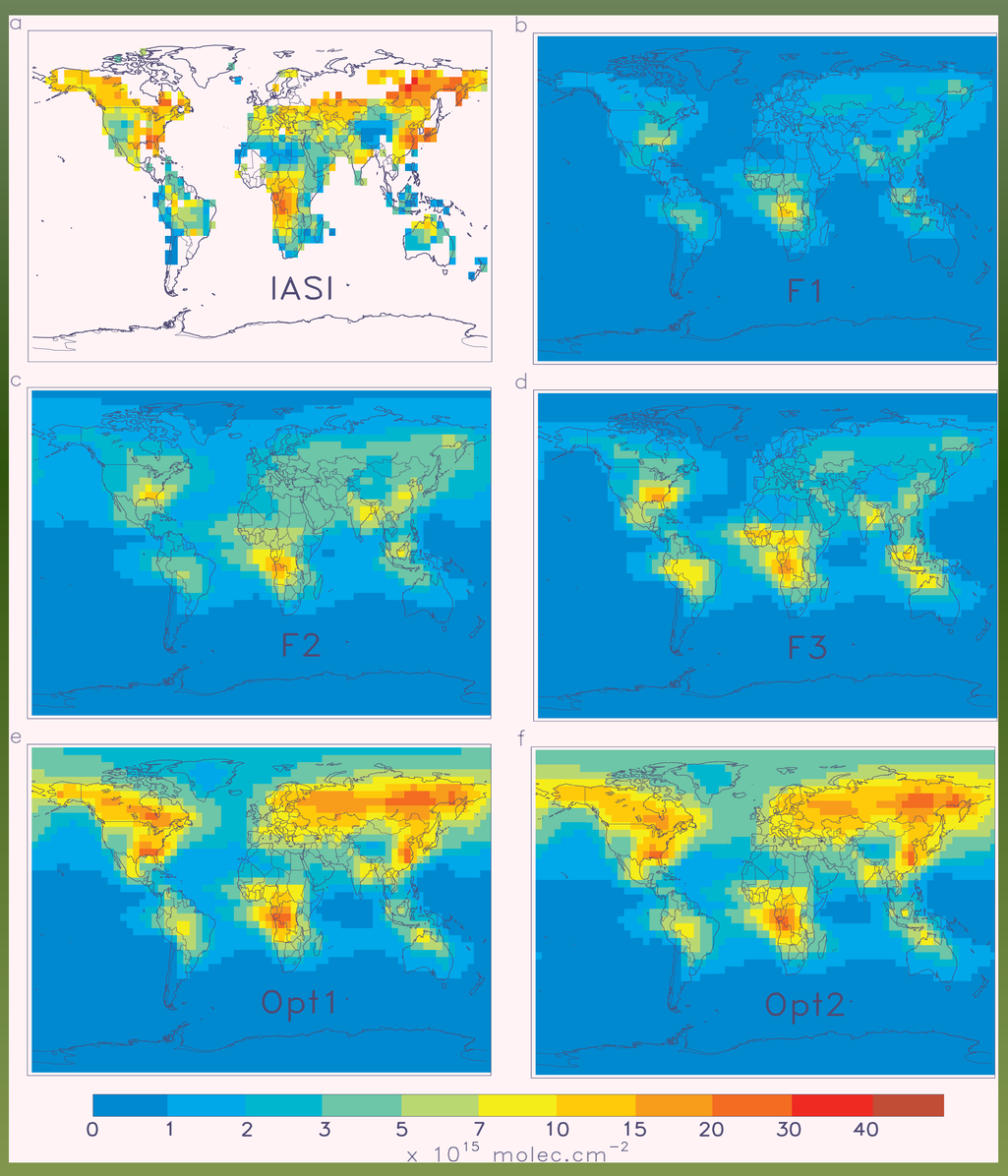
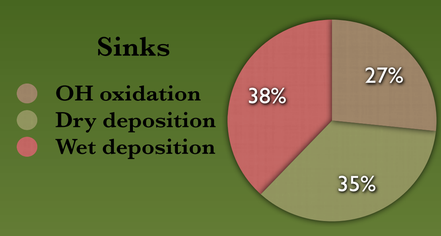


Fig.1. Monthly averaged HCOOH columns in June 2009 observed by IASI (a), and predicted by the model in the F1, F2, and F3 simulations. Opt1 and Opt2 results are deduced from inverse modelling assuming either a primary (Opt1) or secondary (Opt2) biogenic HCOOH source

Sources (Tg/yr)	**F1**	**F2**	**F3**	**Opt1**	**Opt2**
Anthropogenic	4	4	4	4	4
Pyrogenic	2,9	2,9	2,9	4	4
Biogenic primary	5,6	5,6	5,6	88	5,6
Photochemical					
Biogenic	19,3	19,3	58,3	19,3	84
OA+OH	0	27	0	0	0
Anthrop/pyr.	4,2	4,2	4,2	4,6	4,6
Total	36	63	75	120	102



Global lifetime : ca. 4 days

➥ **F2 and F3 simulations lead to significant enhancements in HCOOH concentrations allowing for some improvement in the model predictions, especially in tropical regions, but are inadequate to reconcile the model with the high observed columns in mid and high latitudes**

➥ **The optimizations improve the agreement by inferring a strong extra source of HCOOH (64 Tg annually)**

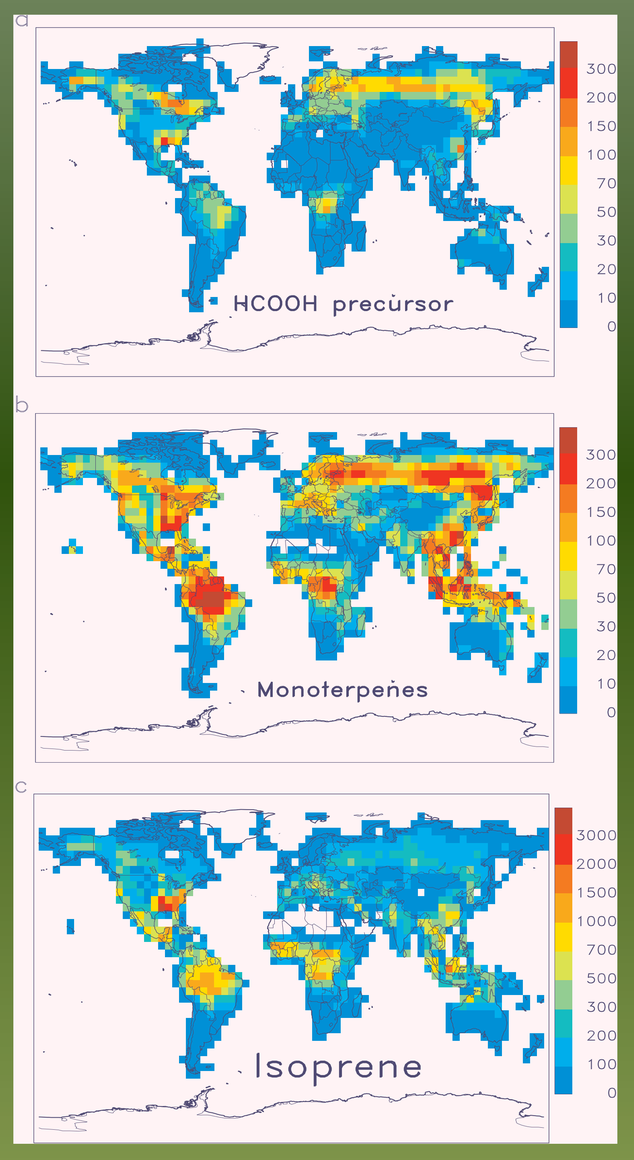


Fig.2. Distribution of biogenic emissions (µg C/m^2/s) in July 2009. HCOOH precursor derived from the Opt2 inversion (top), monoterpene and isoprene emissions from the MEGAN inventory in middle and bottom panels

Conclusions

➥ **The IASI-derived HCOOH source is ca. 3x higher than estimated from known sources, 90% of the extra source comes from tropical and boreal forests, and is most likely of secondary origin**

➥ **A large contribution of primary HCOOH emission cannot be excluded, although it is less likely, as it is not supported by reported flux measurements[5]**

➥ **In essence, these findings suggest that HCOOH is a high-yield product in the oxidation of organic compounds emitted from plant ecosystems, such as monoterpenes and terpenoids**

➥ **Should this be further confirmed, HCOOH could serve as a proxy for detecting emissions of terpenoids from space, and underscores the need for further research on the emissions and chemistry of biogenic precursors**

References

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