



Developing a spatially explicit, global material flow model to trace environmental impacts embodied in international trade

Stefan Giljum, Martin Bruckner, Mirko Lieber, Hanspeter Wieland

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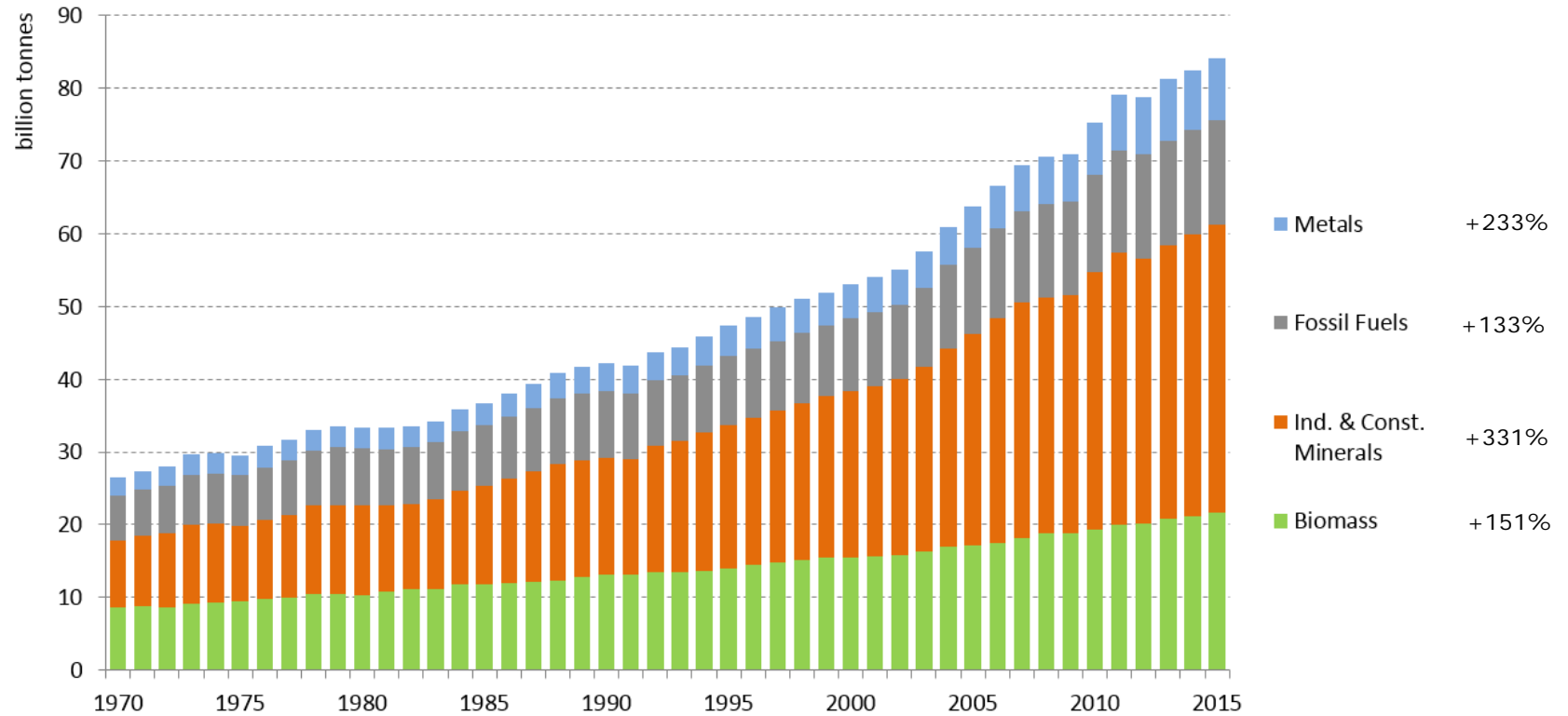
Content

1. Background
2. From national to spatially-explicit footprints
3. Methods and data sources
4. Applications

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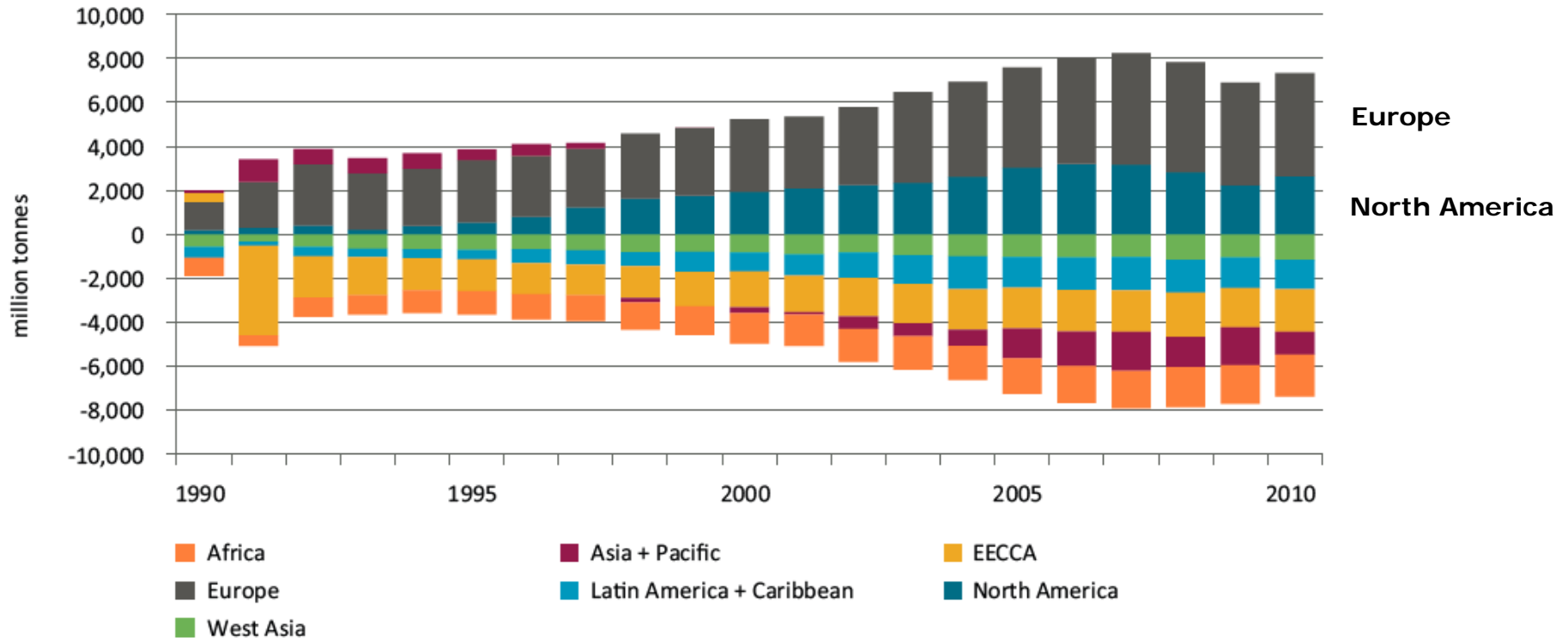
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Increasing global material consumption



Europe is the largest importer of materials

Raw material trade balance (RTB) by seven subregions, 1990–2010, million tonnes



Global impacts of European consumption

Land cover change



Water scarcity



Water pollution



Mining conflicts



Deforestation



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Impacts depend on specific location

Chile:
Copper mining



Brazil:
Soybean production



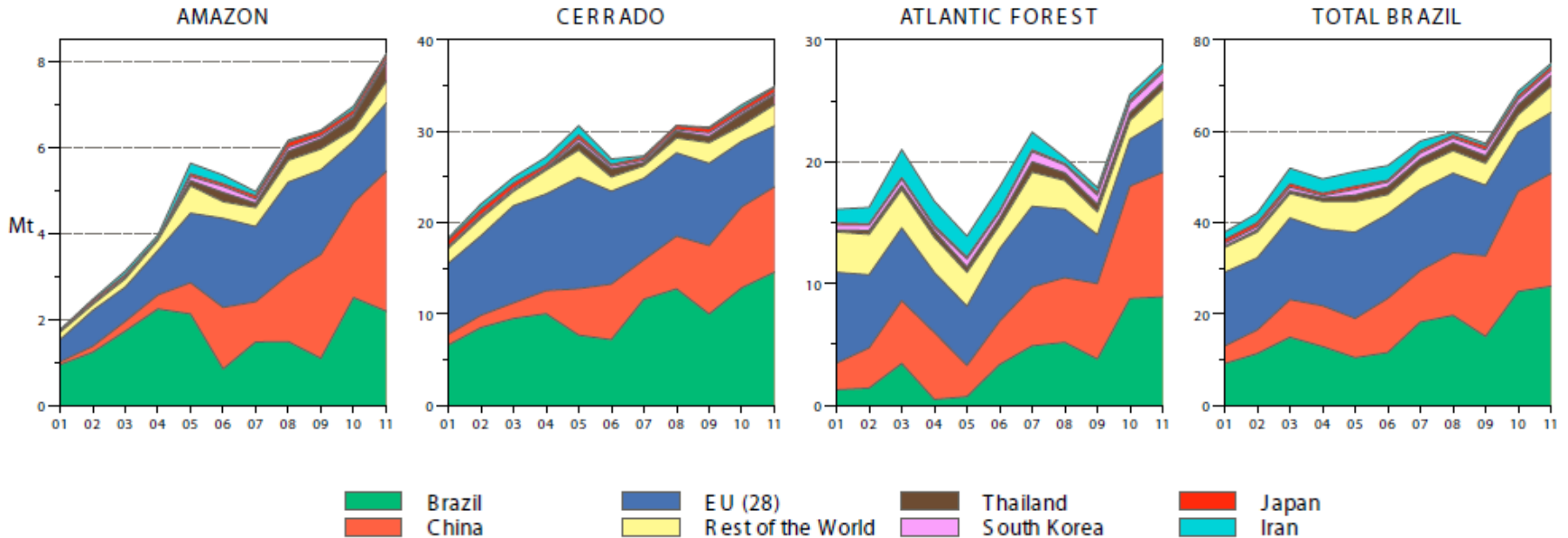
Spatially-explicit footprints: state of the art

Map of PM₁₀ footprint of the USA, 2008



Spatially-explicit footprints: state of the art

Global soy consumption from different Brazilian biomes, 2001–2011





ERC Consolidator Grant: 'FINEPRINT'

- Spatially explicit material footprints: fine-scale assessment of Europe's global environmental and social impacts
- July 2017 – June 2022
- Team of 7-8 researchers
- Budget of 2 million Euro



Key innovations

- Spatially explicit, global footprint model to trace material flows and related impacts
- At least 60 raw materials on a world-wide scale
- Linking volumes/pressures and impacts, including
 - Biodiversity
 - Deforestation
 - Water scarcity, ...
 - Violent conflicts, ...

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Project structure



Production

Work Package 1



Trade

Work Package 2

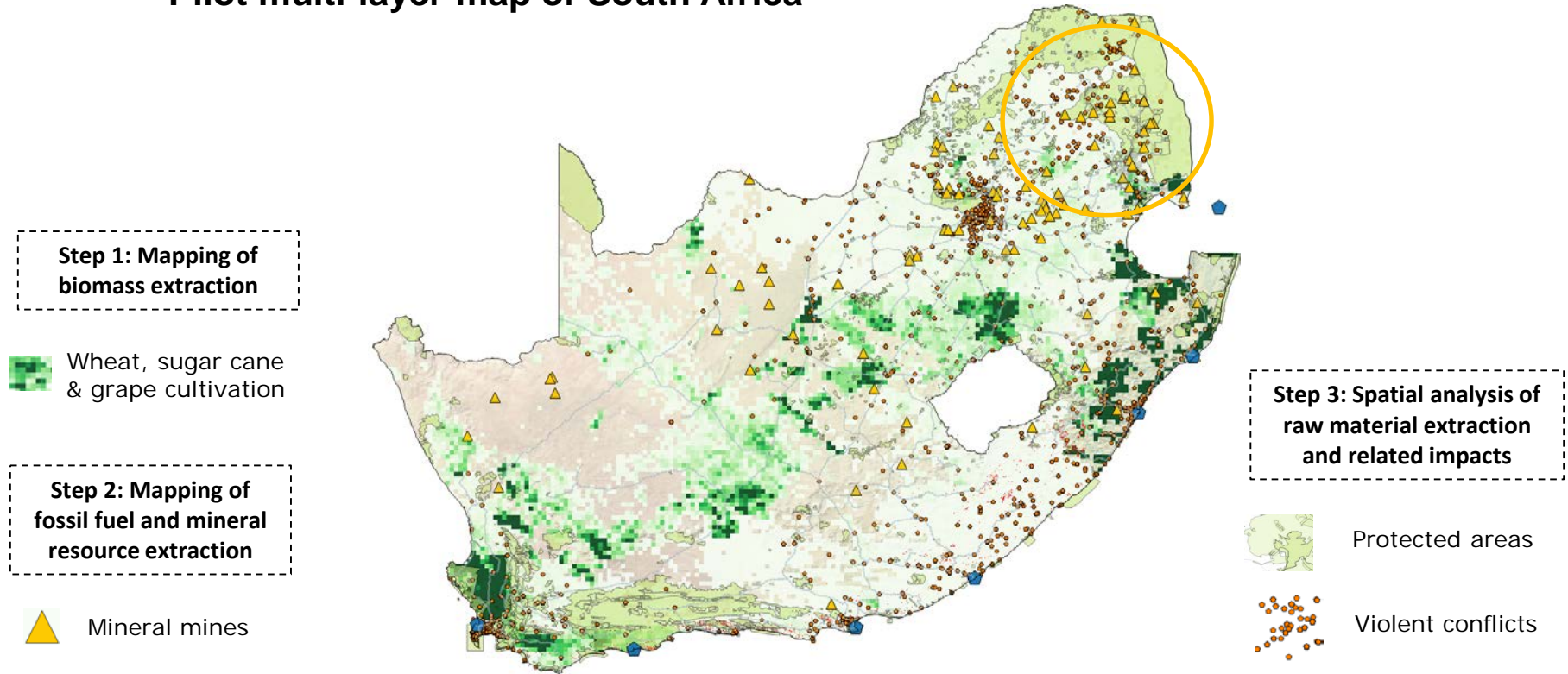


Consumption

Work Package 3

Spatial distribution of material extraction

Pilot multi-layer map of South Africa



Data availability: spatially-explicit material extraction

Biomass extraction

Model	Number of crops	Time series
MIRCA 2000	26 irrigated + 26 rainfed + 2 types of "other crops"	2000
SPAM	20 crops + "other crops"	2000
GAEZ	21 crops + "other cereals" + "forages"	2000 2005 2010
M3	175 crops	2000

Extraction of fossil fuels and minerals

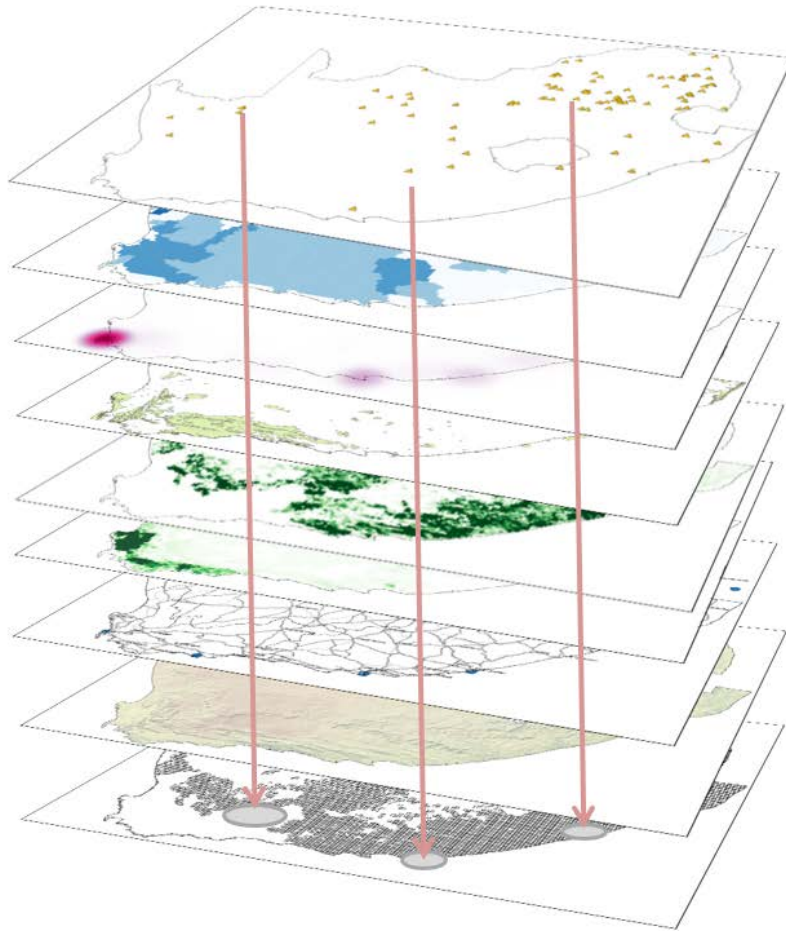
Database	No. sites	Reported commodities			Time series
		Metals	Minerals	Fossils	
USGS	3,400	29	52	3	2003-2008
SNL Metals & Mining	36,000	21	4	1	Annual since 2000
Mining Atlas	13,000	30	9	2	Most recent year available

Model	Number of fishing areas	Time series
FAO	322 (Maritime) 982 (Inland)	2000

Data availability: Impacts

Impact category	Name of data set	Institution	Level of detail	Time series
Water scarcity	Water stress index	ETH Zurich	> 11,000 watersheds	2000-2010
Biodiversity	Species occurrence	Global Biodiversity Information Facility	> 565m occurrences	10-years steps 1900-2010
	Red List of Threatened Species	IUCN	> 73,600 species	2000 – 2016
Protected natural areas	World Database on Protected Areas	IUCN and UNEP	> 237,000 areas	Year of designation
Deforestation	Global Forest Change	University of Maryland	30 meter grids	2000-2015
Environmental conflicts	Environmental Justice Atlas	Environmental Justice Organisation	> 1,600 cases	Year of conflict
Armed conflicts	ACLED Version 6	Armed Conflict Location and Event Data Project (ACLED)	> 118,000 events	1997-2016
Children malnutrition	Global Subnational Prevalence of Child Malnutrition	Socioeconomic Data and Applications Center (SEDAC)	Quarter-degree grid	1990-2002

Multi-layer analyses → patterns of materials & impacts



Mining activities

Water depletion levels

Hotspots of social conflicts

Protected areas

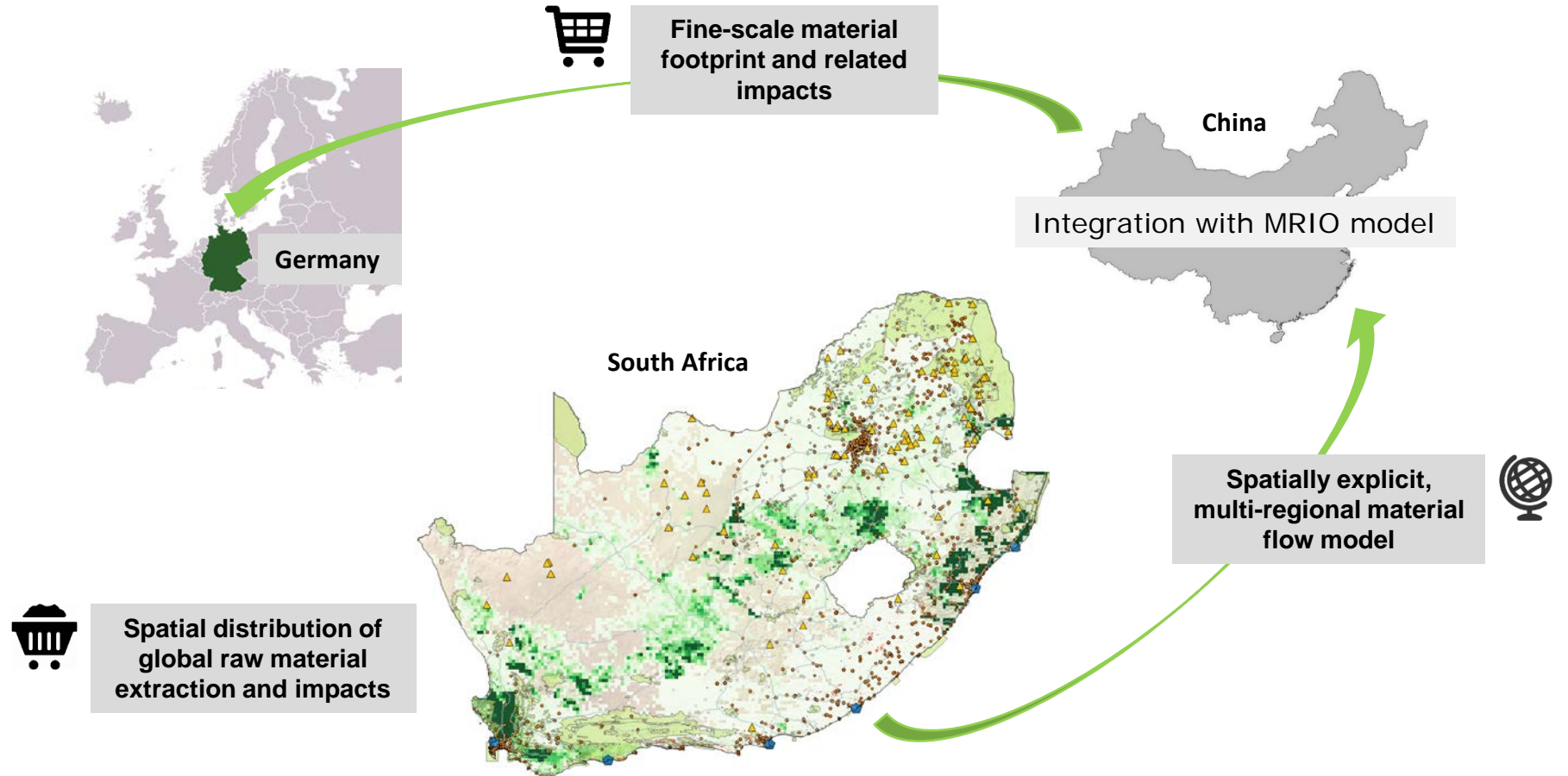
Crop production / Harvested area

Infrastructure

Land cover

Geographic entities

Spatially-explicit, multi-regional material flow model



Selected challenges and risks (and possible solutions)

- **Limited data availability** on the global level
 - Modular approach (detailed statistical data vs. estimation models, e.g. transportation model; maritime trade model)
 - Limit number of countries and time periods
- **Heterogeneity of data** / conflicting data
 - Cross-check e.g. national versus sub-national data
 - Prioritising primary data sources by quality criteria
 - Using balancing techniques (e.g. RAS for trade data)

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Fine-scale footprints and related impacts



Applications beyond the project

- **Research:** empirical basis to address a wide range of sustainability-related questions
 - **Industrial ecology:** fine-scale material flow assessments; impact footprints
 - **Ecological economics:** socio-economic implications of specific material extraction and consumption patterns
 - **Economic geography:** spatial patterns of material and trade flows
 - **Political ecology:** environmental justice; resource fairness
- **Policy making:** global hot-spots of impacts related to EU material consumption → targeted policy measures
 - EU Resource efficiency & Circular Economy
 - SDGs: Sustainable Production and Consumption, ...

Thank you very much for your attention!



VIENNA UNIVERSITY OF
ECONOMICS AND BUSINESS

DEPARTMENT SOCIOECONOMICS

Institute for Ecological Economics
Welthandelsplatz 1, 1020 Vienna, Austria

DR. STEFAN GILJUM

T +43-1-313 36-5755

stefan.giljum@wu.ac.at
www.wu.ac.at

Assessment procedure: from extraction to footprints

