Characterizing scientific production and consumption in Physics

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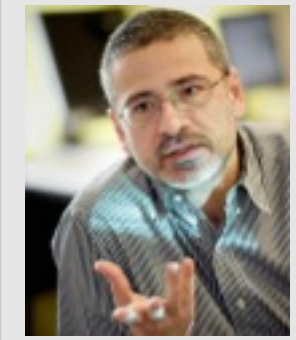

Alex
Vespignani

MoBS

Geolocation

VOLUME 84, NUMBER 22 PHYSICAL REVIEW LETTERS 29 MAY 2000

Direct Link between Microwave and Optical Frequencies with a 300 THz Femtosecond Laser Comb

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Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany
(Received 17 February 2000)

We demonstrate a great simplification in the long-standing problem of measuring optical frequencies in terms of the cesium primary standard. An air-silica microstructure optical fiber broadens the frequency comb of a femtosecond laser to span the optical octave from 1064 to 532 nm, enabling us to measure the 282 THz frequency of an iodine-stabilized Nd:YAG laser directly in terms of the microwave frequency that controls the comb spacing. Additional measurements of established optical frequencies at 633 and 778 nm using the same femtosecond comb confirm the accepted uncertainties for these standards.

PACS numbers: 42.65.Re, 06.20.–f, 42.62.Eh

VOLUME 84, NUMBER 15 PHYSICAL REVIEW LETTERS 10 APRIL 2000

Phase Coherent Vacuum-Ultraviolet to Radio Frequency Comparison with a Mode-Locked Laser

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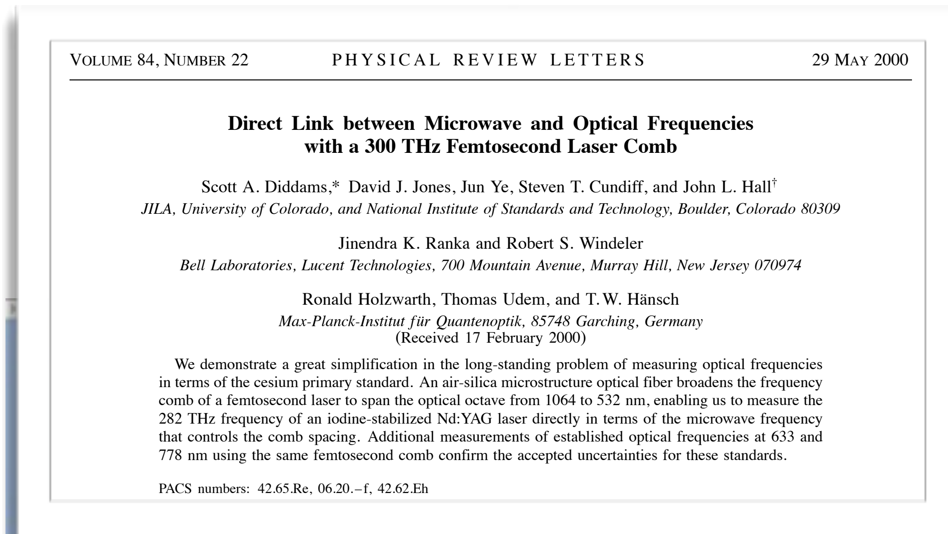
PACS numbers: 06.30.Ft, 31.30.Jv, 42.60.Fc, 42.62.Fi

Geolocation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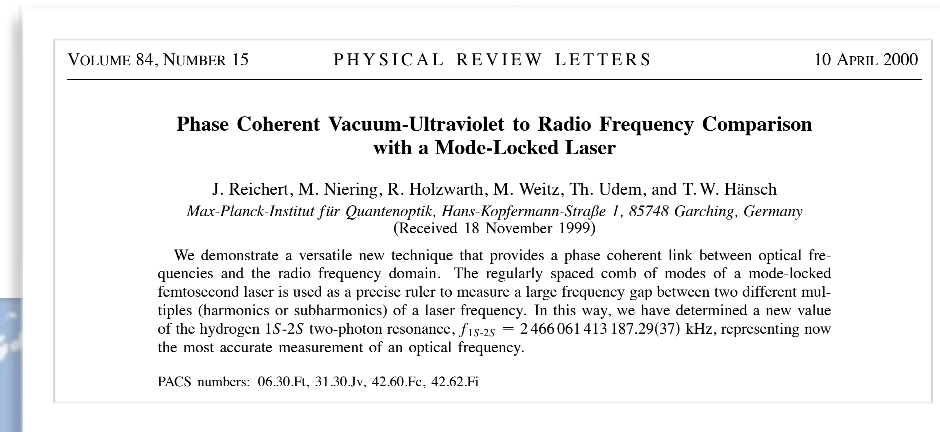
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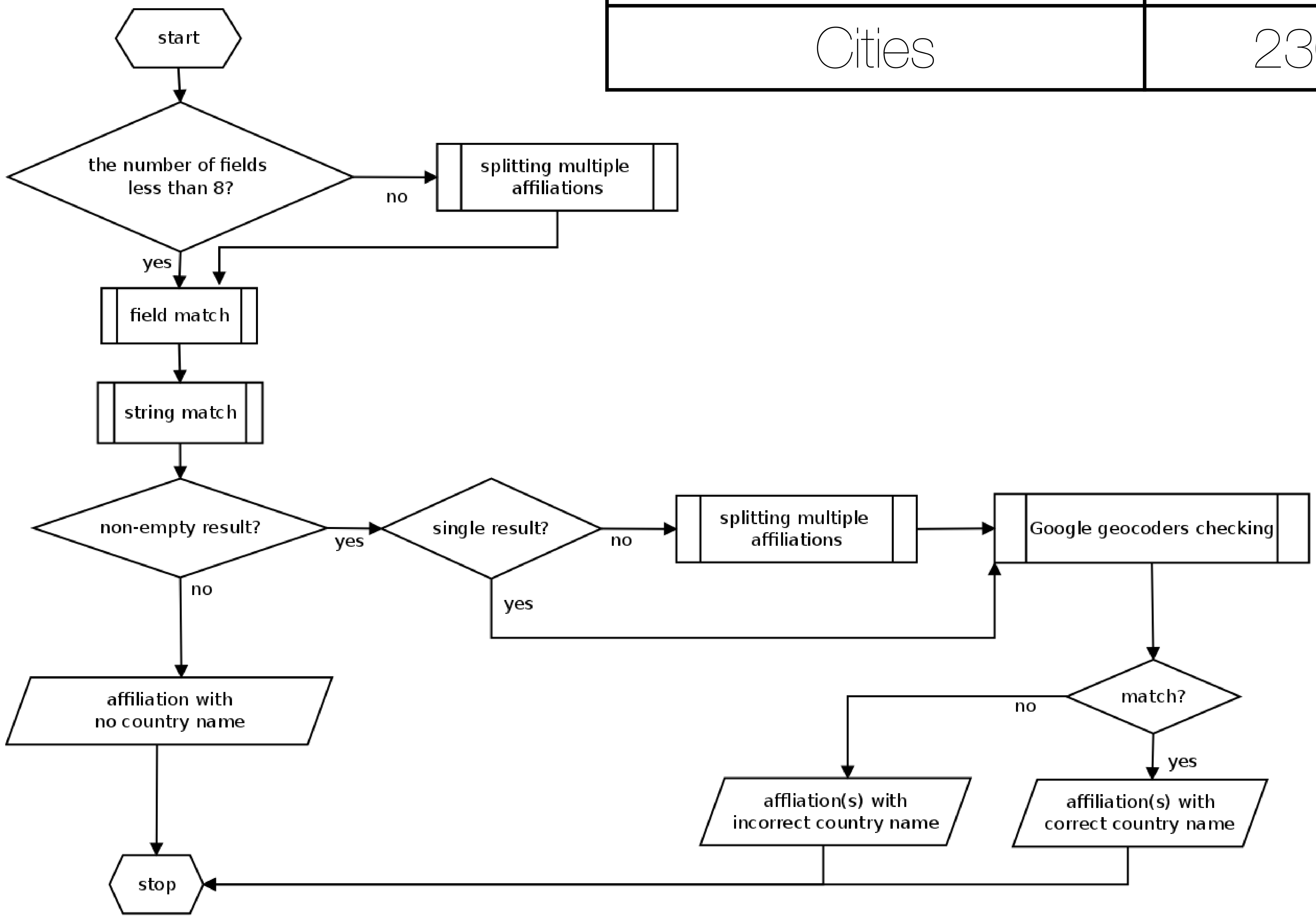
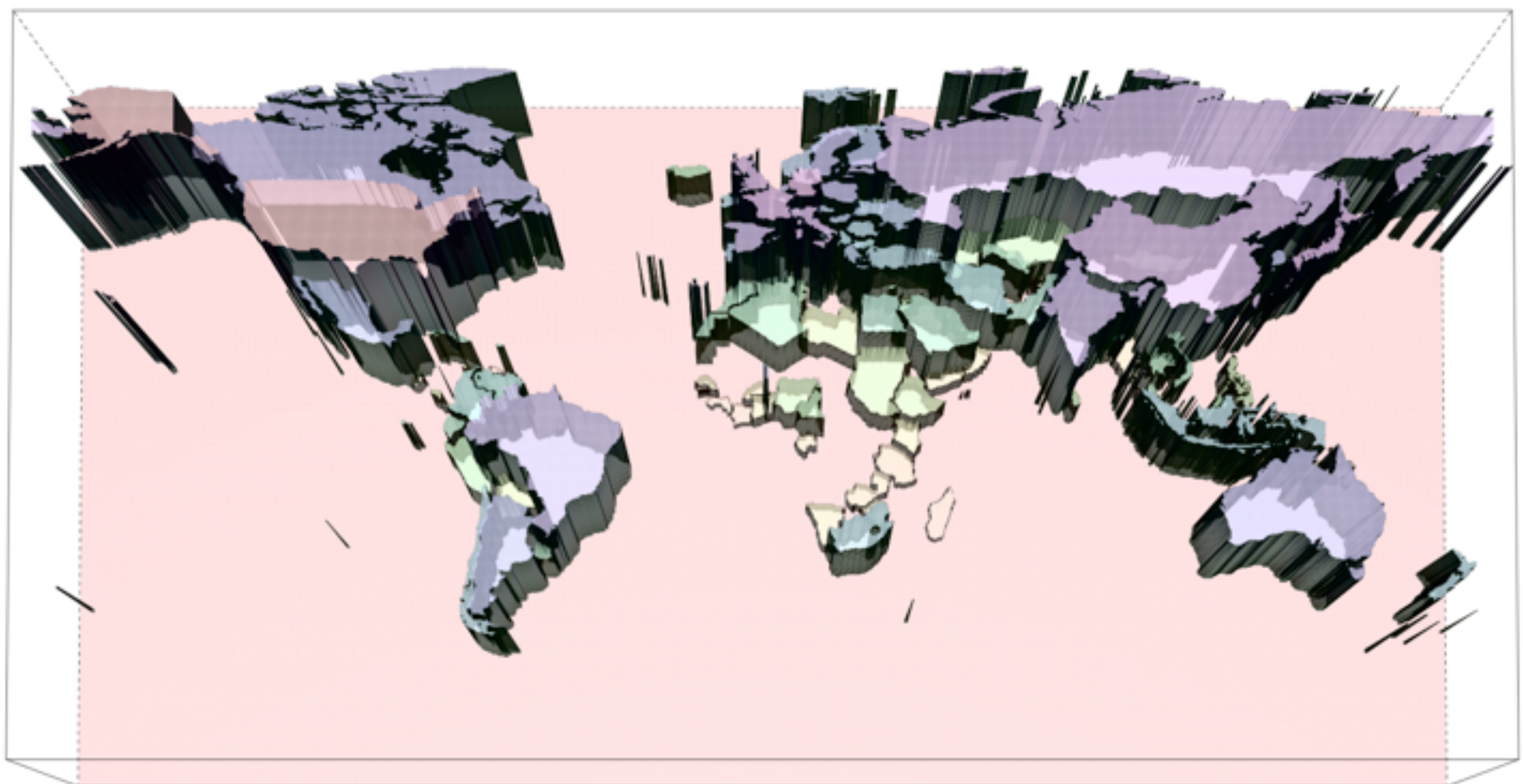
Geolocation

Years	1960-2009
Geolocated Papers	445, 223
Countries	186
Cities	2307

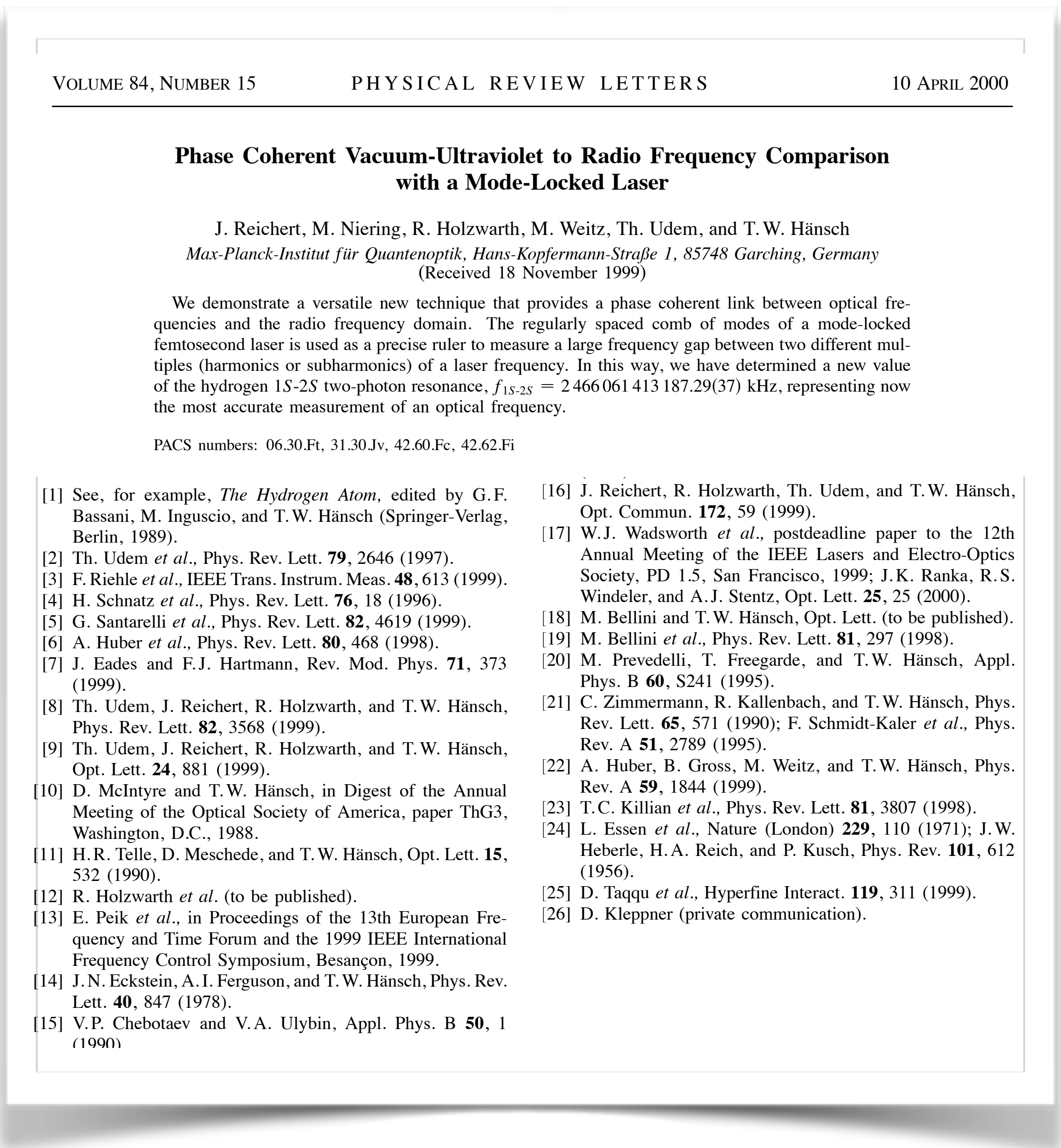


Geolocation



Dominated by the US...

City Citations Network



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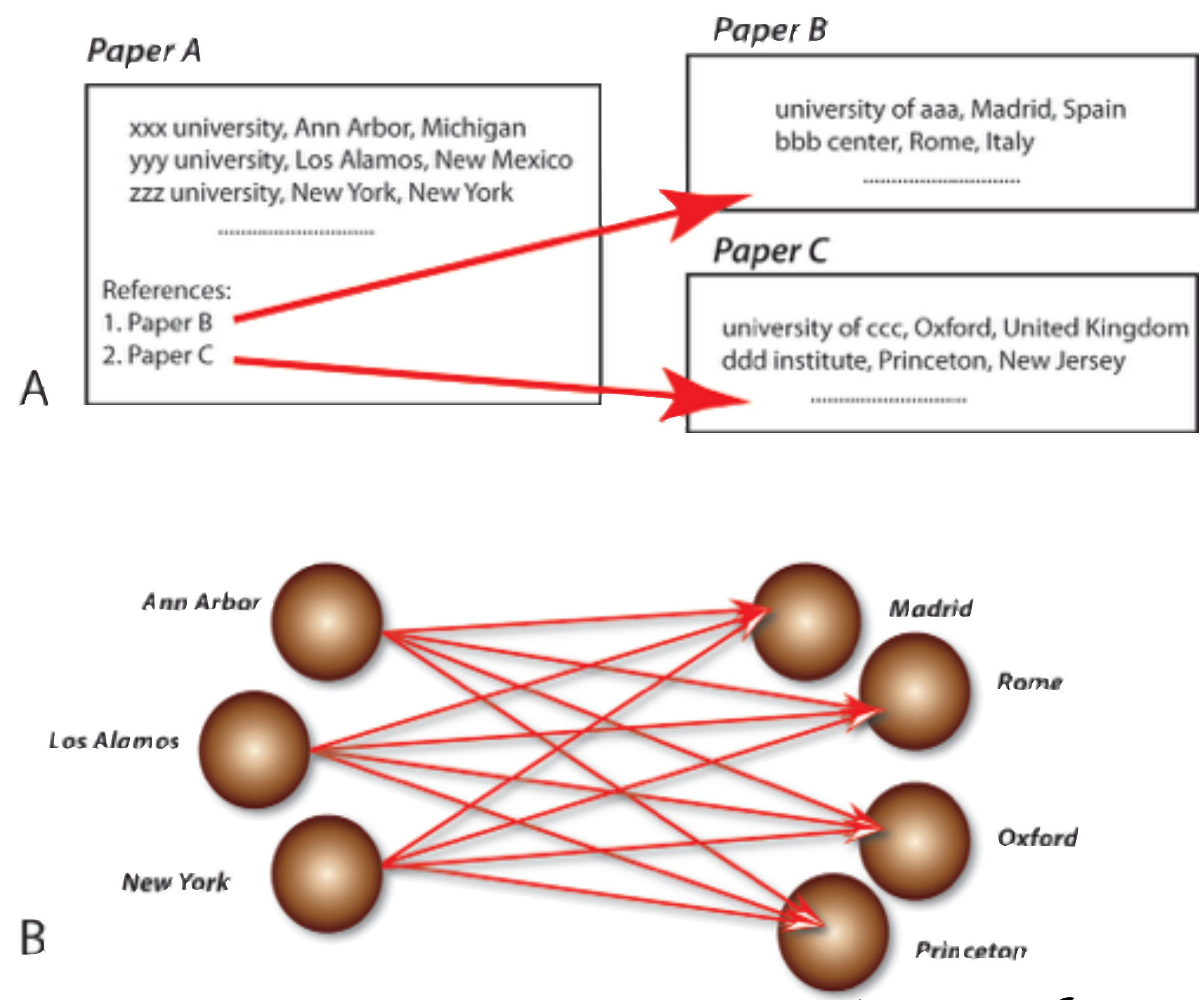
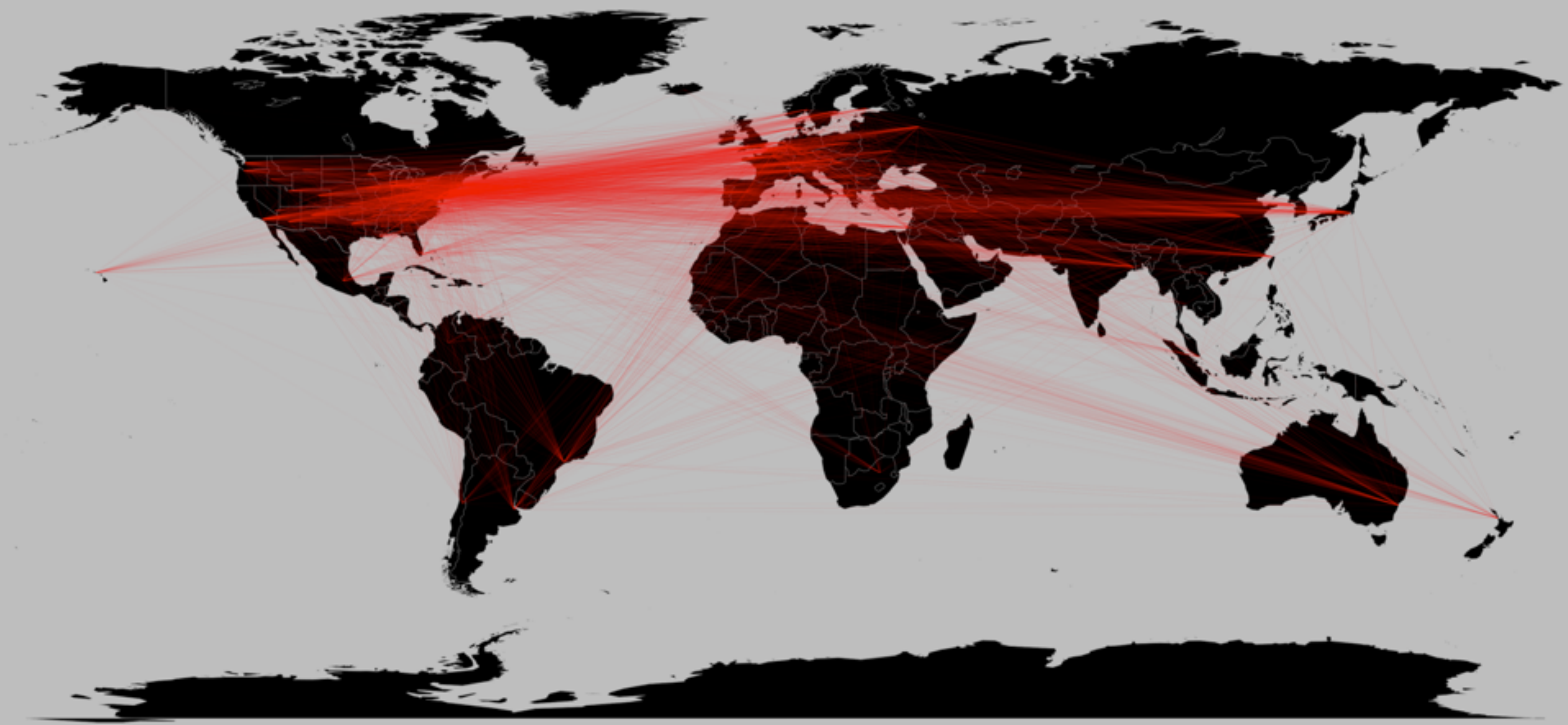
Citations represent the trade

(Export and Import)

of knowledge between cities



Citation Network



Trade Imbalance

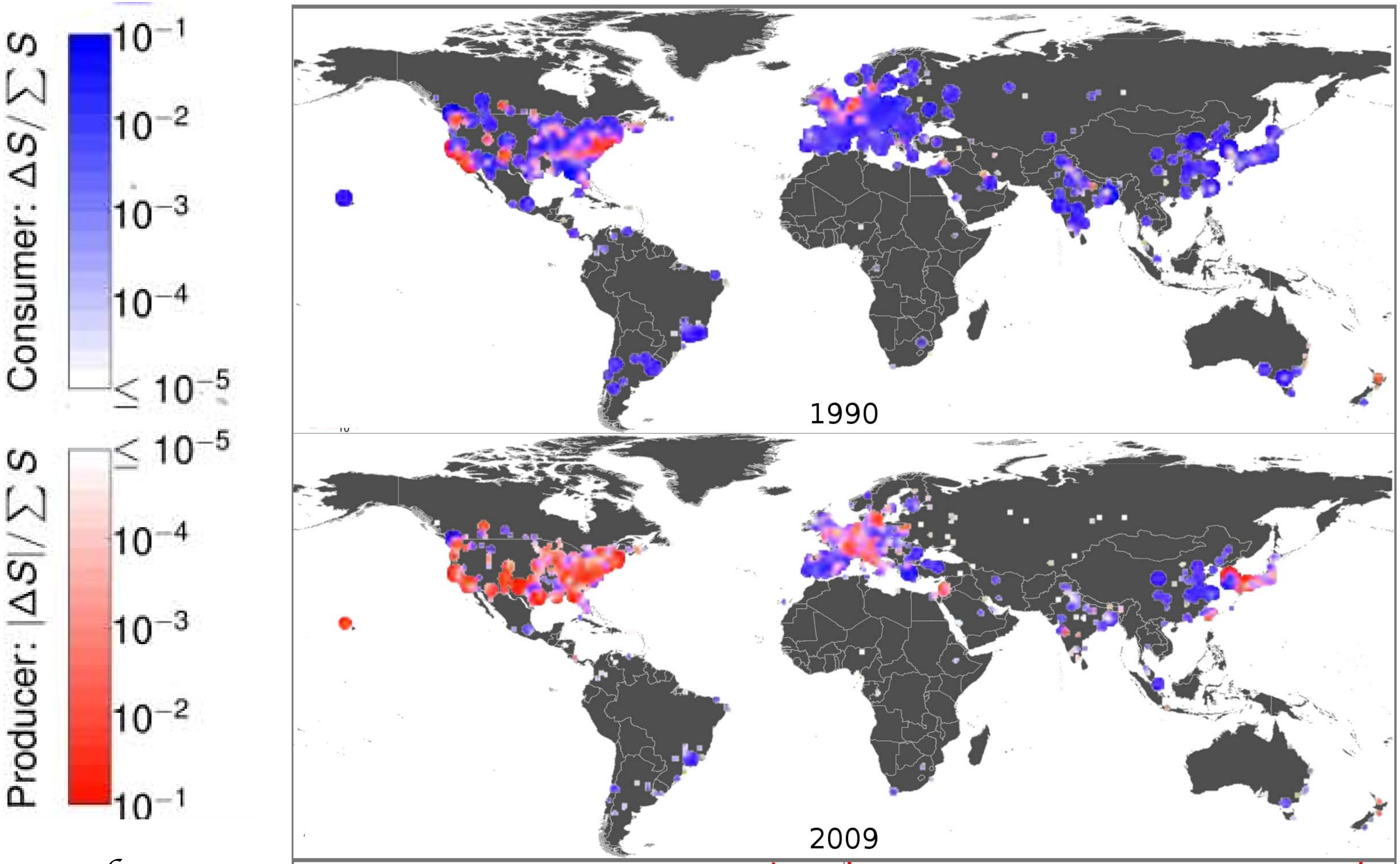
Incoming citations - Outgoing citations

$$\Delta S = S_{in} - S_{out}$$

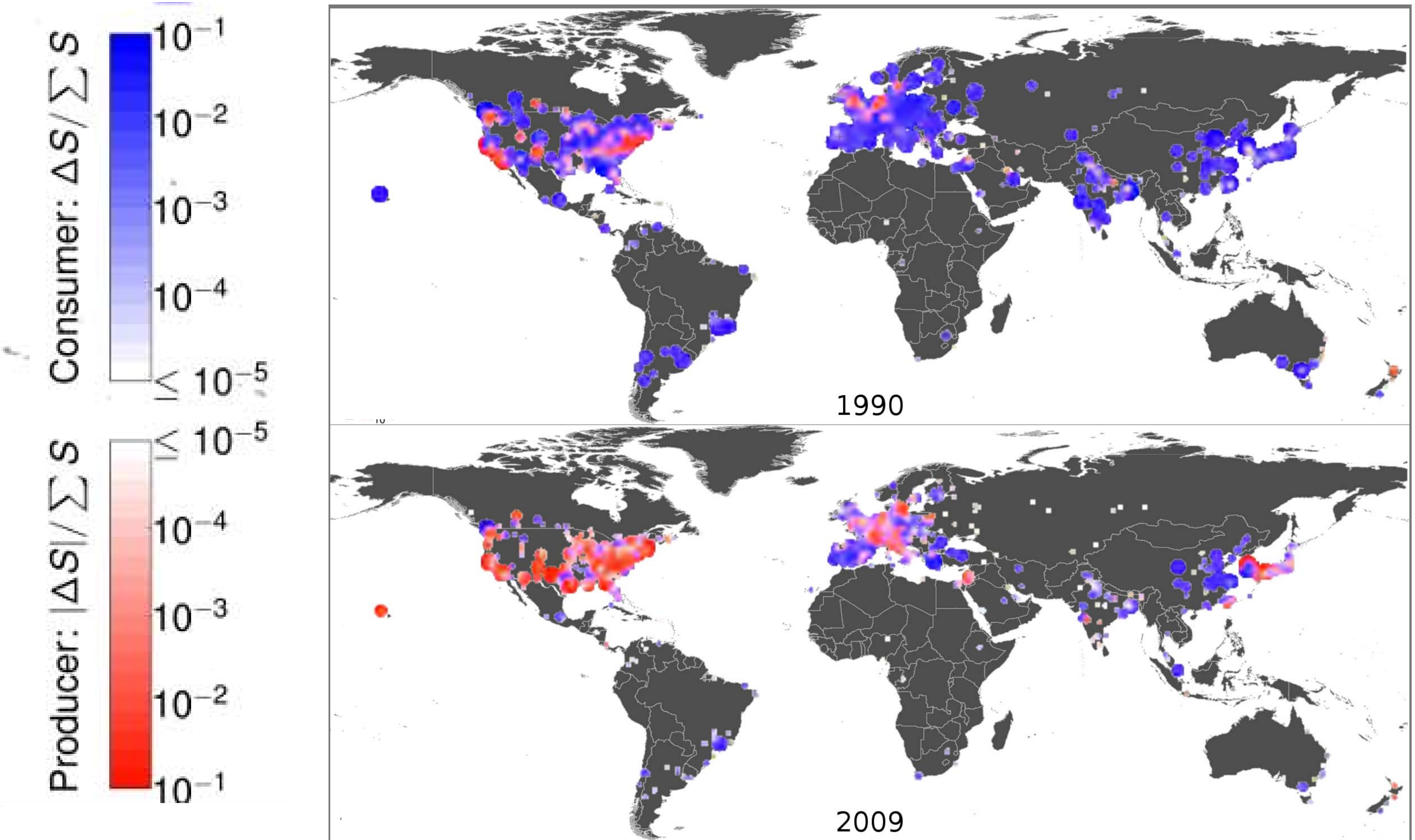
$\Delta S > 0$ "Exporter" - Source of Knowledge

$\Delta S < 0$ "Importer" - Sink of Knowledge

Trade Imbalance

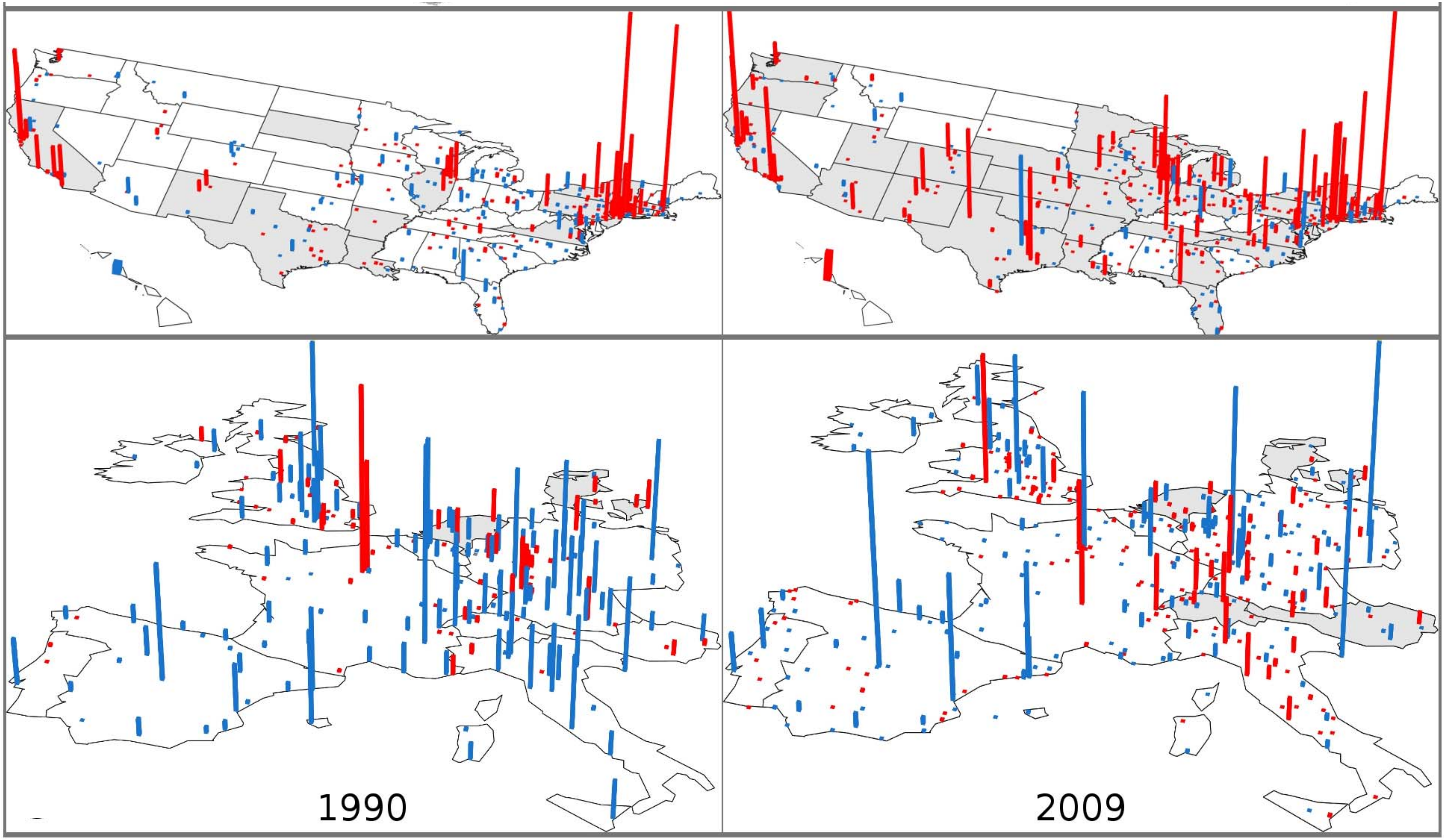


Trade Imbalance

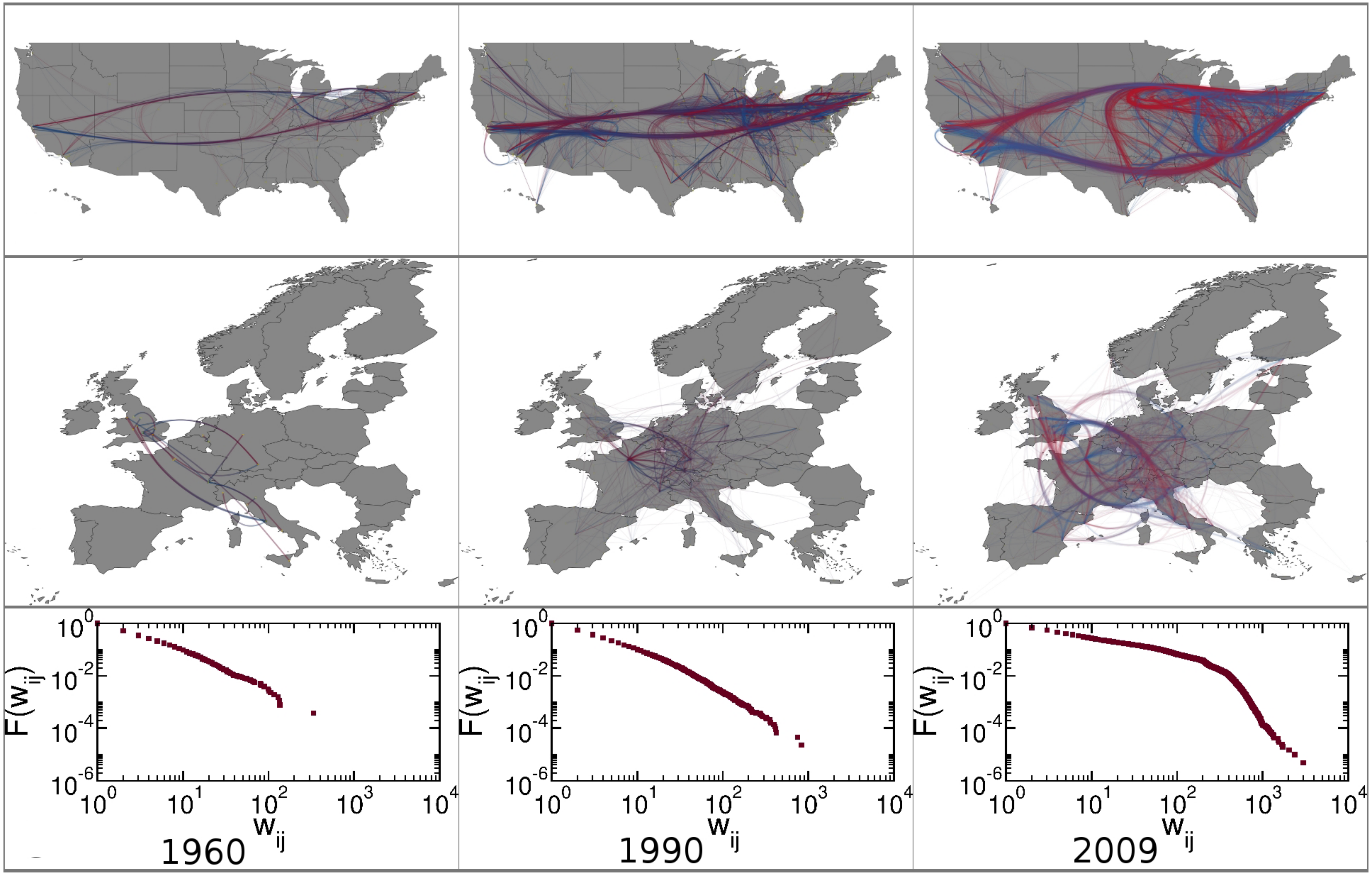


Trade Imbalance

Consumer
Producer



Network Evolution



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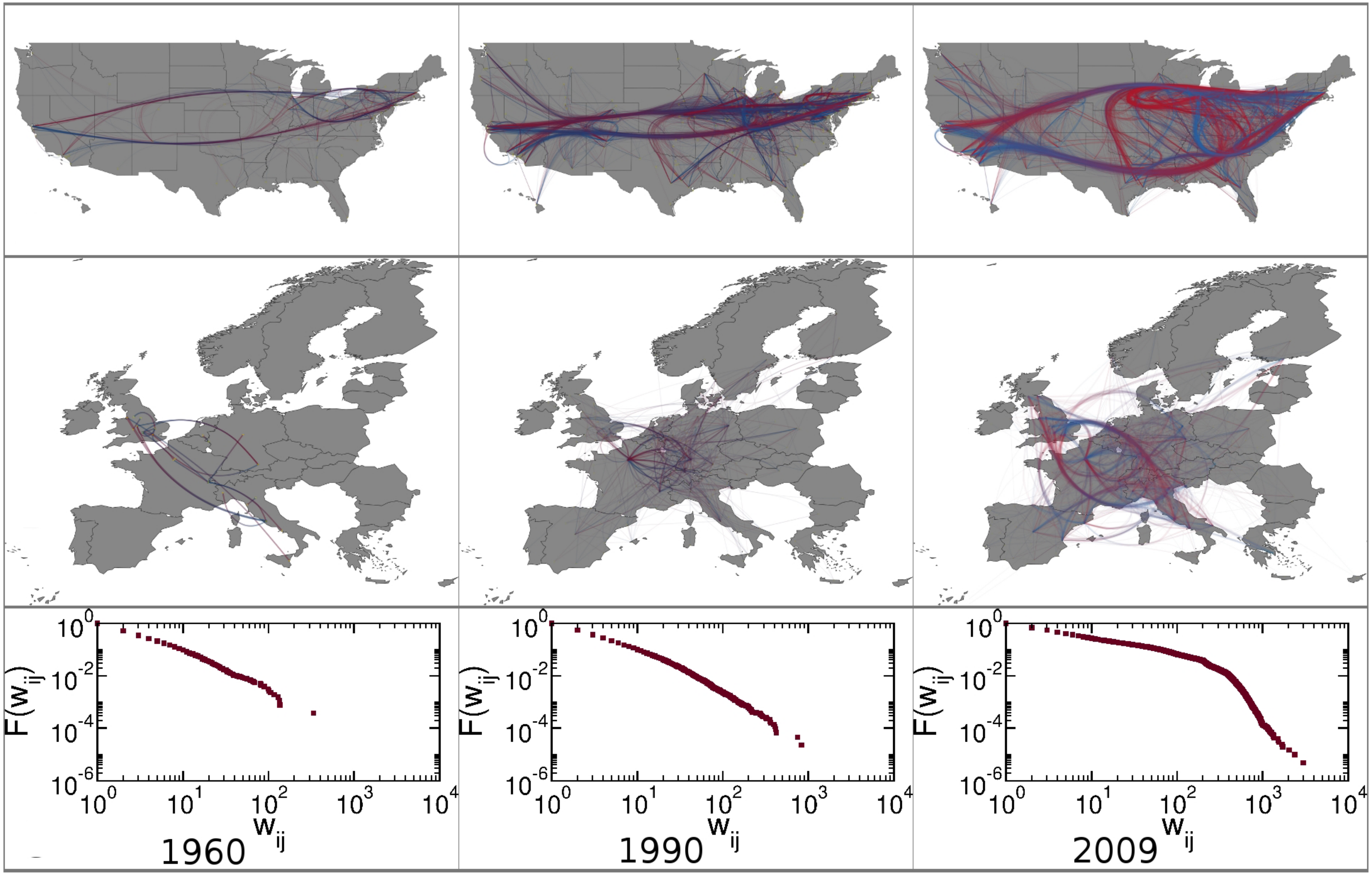
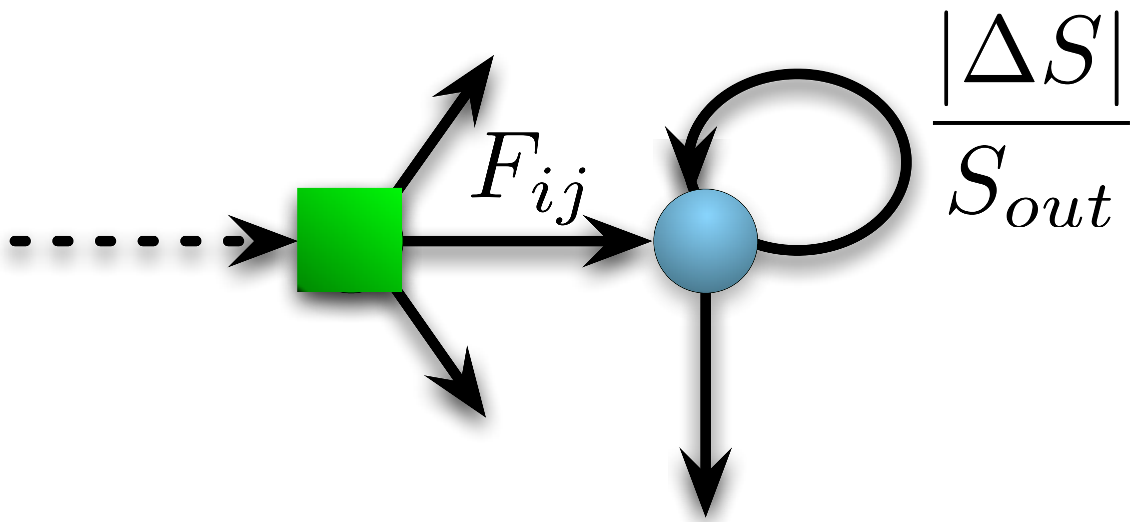


Knowledge Diffusion Proxy



$$T_{ij} = w_{ij} - w_{ji}$$

$$F_{ij} = \begin{cases} |T_{ij}| & \text{if } \mathrm{T_{ij}} < 0 \\ 0 & \text{otherwise} \end{cases}$$

Knowledge Diffusion Proxy

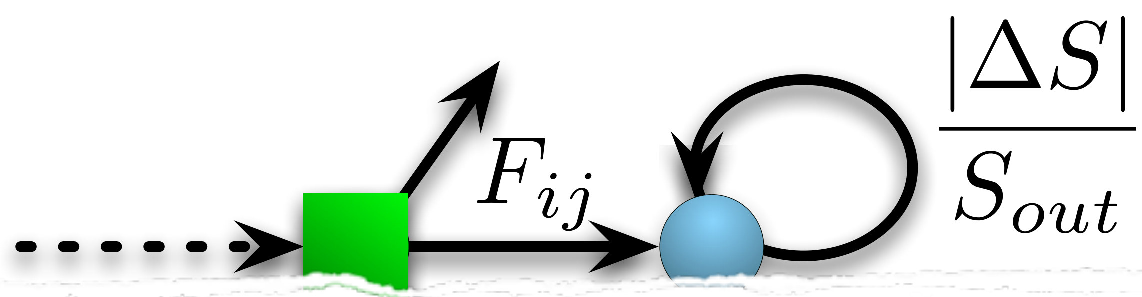
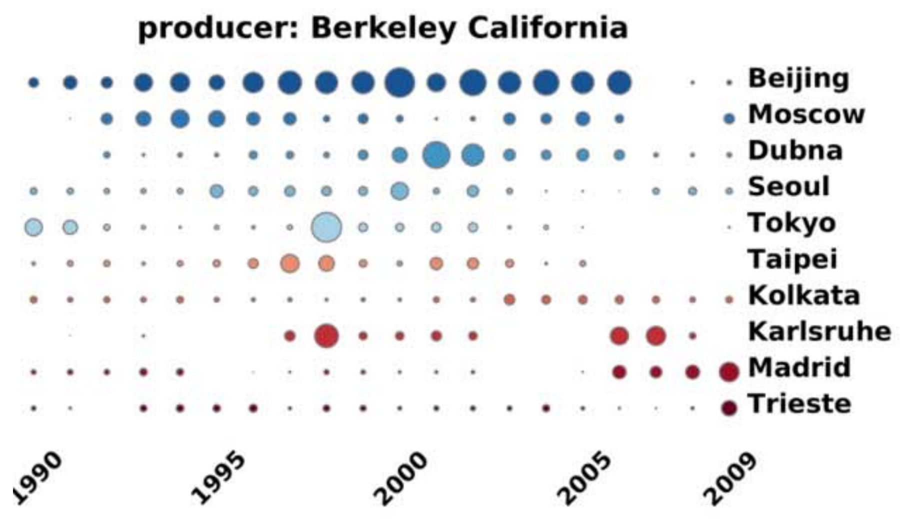
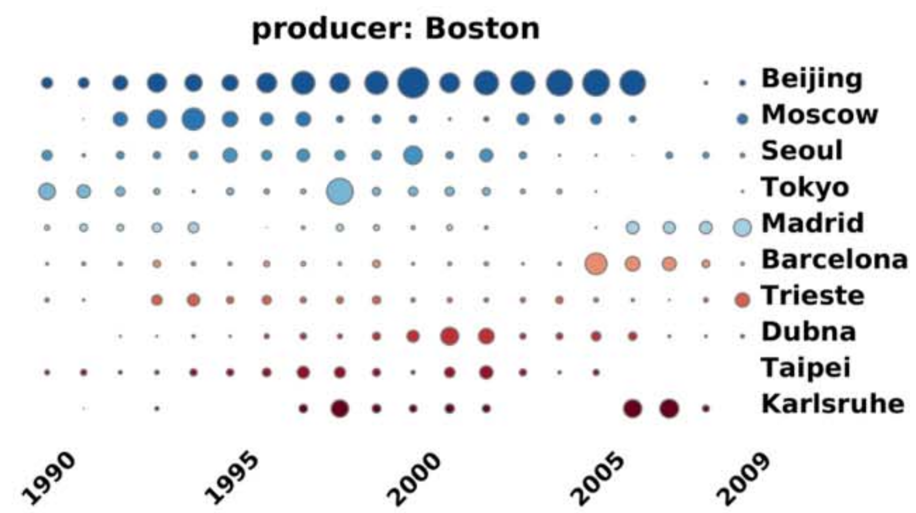


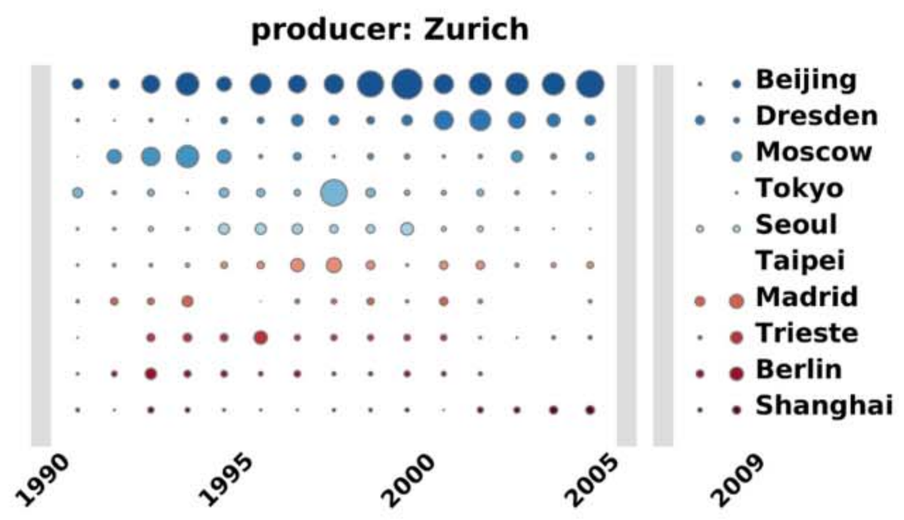
Table 1 | Rankings from Knowledge diffusion proxy algorithm for top 3 producer cities in 2009. In bold, we highlight cities that are present in top 10 consumers ranked according to the knowledge diffusion proxy but do not appear in top 10 cities ranked according to local citation unbalance

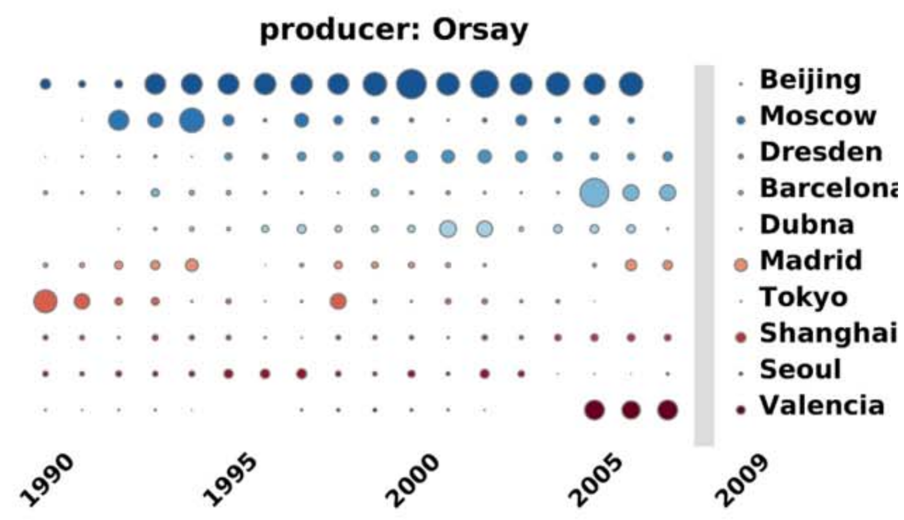
Boston		Berkeley		New Haven	
Diffusion proxy	Citation unbalance	Diffusion proxy	Citation unbalance	Diffusion proxy	Citation unbalance
Athens	Madrid	Athens	Athens	**Berlin**	Vancouver
Madrid	Athens	Gwangju	Madrid	Athens	Paris
Vancouver	Vancouver	Bratislava	Bratislava	**Mainz**	Trieste
Gwangju	Moscow	Madrid	Paris	Vancouver	Athens
Bratislava	Paris	Vancouver	Vancouver	Gwangju	Gwangju
Berlin	Tokyo	Trieste	Gwangju	Trieste	Bratislava
Trieste	Trieste	Waco	Moscow	Bratislava	Madrid
Mainz	Beijing	Paris	Trieste	**Coventry**	Liverpool
Paris	Berlin	**Berlin**	Seoul	**Valencia**	Oxford
Waco	Gwangju	**Mainz**	Waco	**Madrid**	Santa Barbara

Top Producers and Consumers









Scientific Production Ranking

Continent	1990	2009
Asia	4.0%	11.0%
Europe	24.0%	33.0%
N. America	72.0%	56.0%

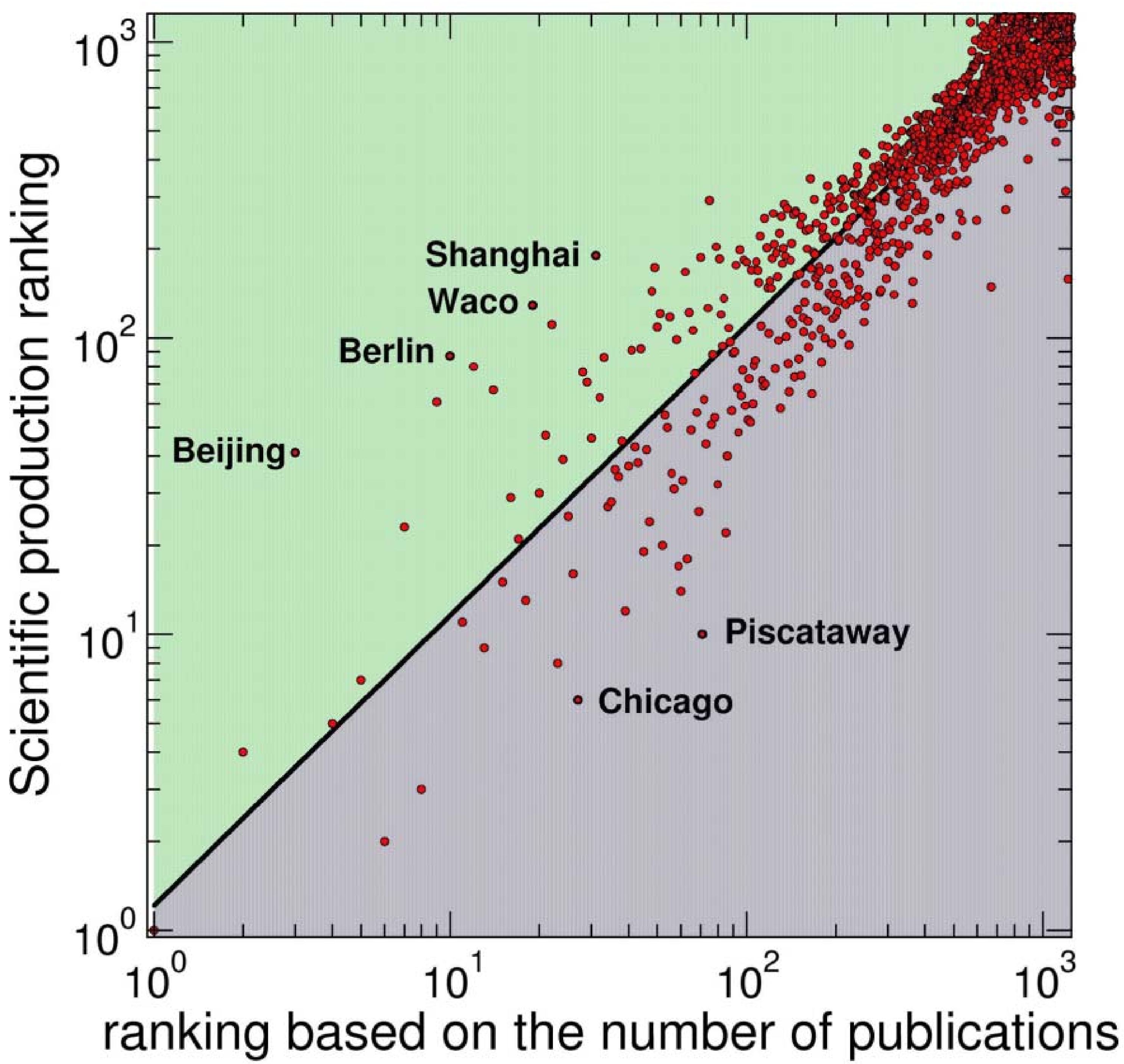
Table 3 | Percentage of top 100 ranked cities in continents in 1990 and 2009

How do you diffuse scientific credit?

Which cities have the most impact?

$$P_i = qz_i + (1-q)\sum_j \frac{P_j}{s_j^{out}} w_{ji} + (1-q) z_i \sum_j P_j \Delta\left(s_j^{out}\right).$$

$$z_i = \frac{\sum_p \Delta_{p,i} 1/n_p}{\sum_j \sum_p \Delta_{p,j} 1/n_p},$$



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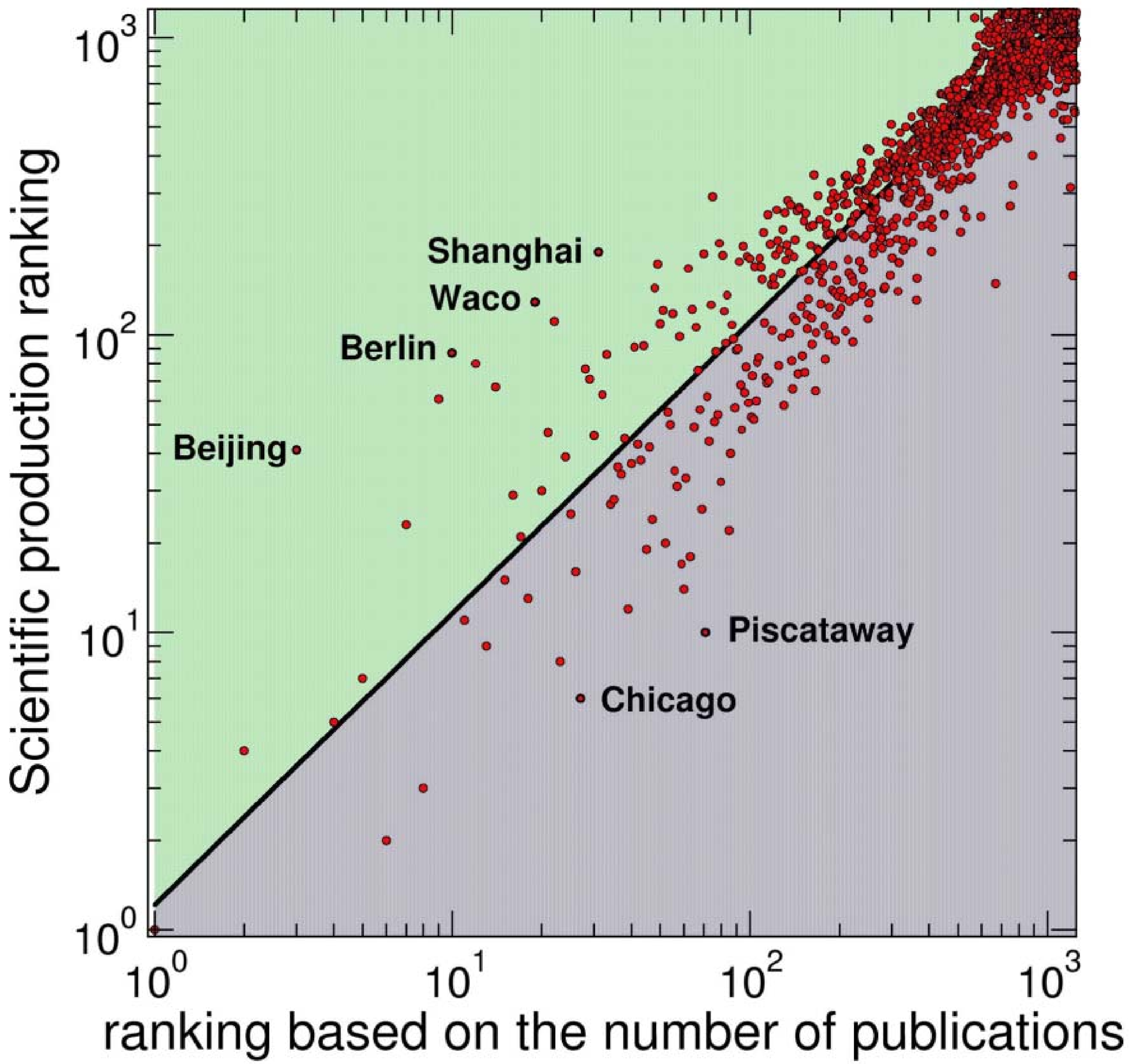
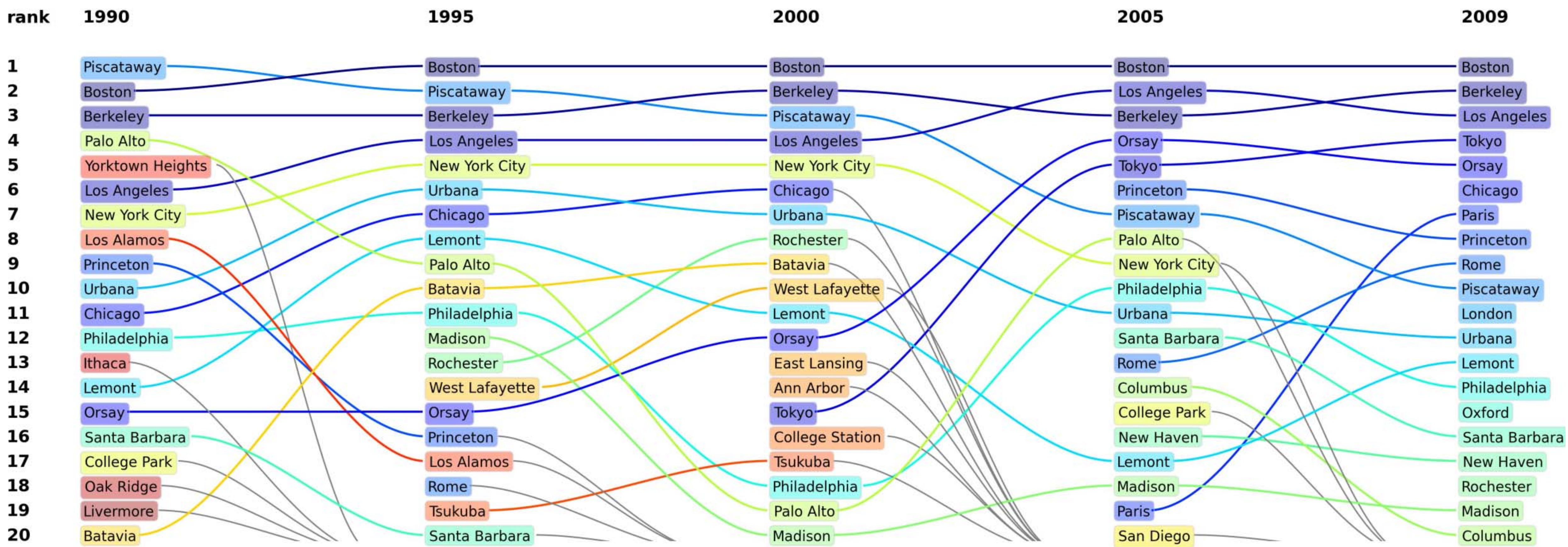


City Ranking Over Time



Discussion

Sci. Rep. 3, 1640 (2013)

- We analyze over 50 years of APS citation data;
- The addition of geolocation information allows for new analyses and insights;
- The knowledge diffusion proxy can chart the diffusion of knowledge, going beyond local measures.
- We can observe the rise of new Physics production centers, indicating a less US centric era;
- Network measures are required to provide a global view of scientific production and impact;
- Our methodologies can be easily applied to other fields and datasets.