Assessment of climate bridges in the world air traffic network using centrality measures

EMS2019 - Kopenhagen

by P. Hoffmann et al.

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GEFÖRDERT VOM
Bundesministerium
für Bildung
und Forschung

HYFLY

zwanzig20
PARTNERSCHAFT FÜR INNOVATION

P I K

1. Introduction

1.1 InfectControl2020

aim: developing strategies for dealing with infectious diseases in the 21st century

Consortium: prioritization of relevant topics (1) agriculture and veterinary medicine **(2) climate, mobility infrastrcture** (3) medical research and care (4) patient and public (prevention - diagnostic - therapy)

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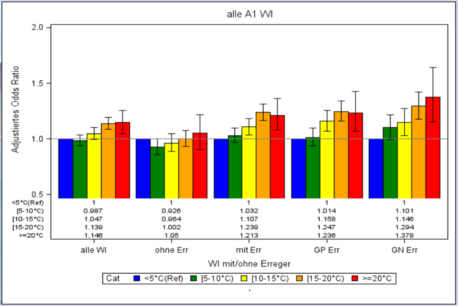

partners: Charité Berlin, Robert-Koch-Institute, PIK

study the effect of weather on nosocomial (acute care units) infections (wund infections, sepsis etc.) in Germany. **Higher temperature are associated to more wund complications!** (Deutsche Ärzteblatt, 2019)

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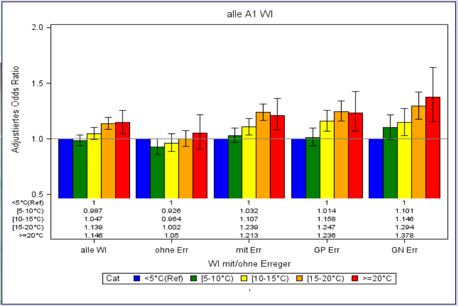

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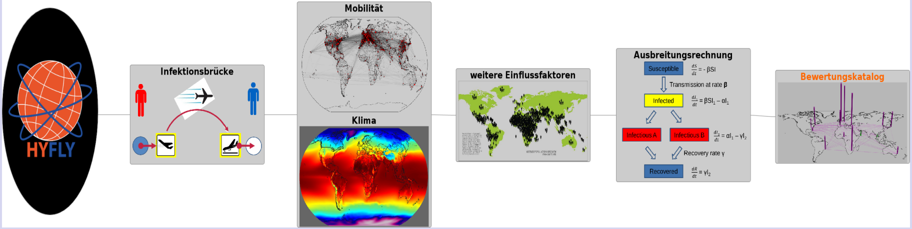

aim: interruption of transmission pathways of infectious diseases in air traffic

Transsectoral Research: (1) material scientists - *surfaces* (2) architects - *airport building* **(3) climatologists** - *climate bridges to infection bridges* (4) epidemiologists - *literature review & consulting* (5) molecular biologists - *sceening tests* (6) industrial partners - *sanitary solutions*

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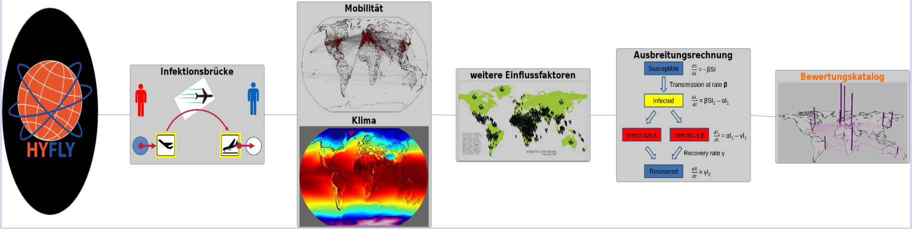

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2. Datasets

Open Flight Data and Populations:

* (1) airports (2) static daily flight connections

Daily Gridded Climate Data (0.5°x0.5°): 1979-2016

* daily maximum temperature (daily water vapor pressure)

Climate Scenarios: 2041-2070 (RCP85)

* CMIP5 bias-adjusted (ISI-MIP)

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2.1 Sub-Flight Network of 99 Airports

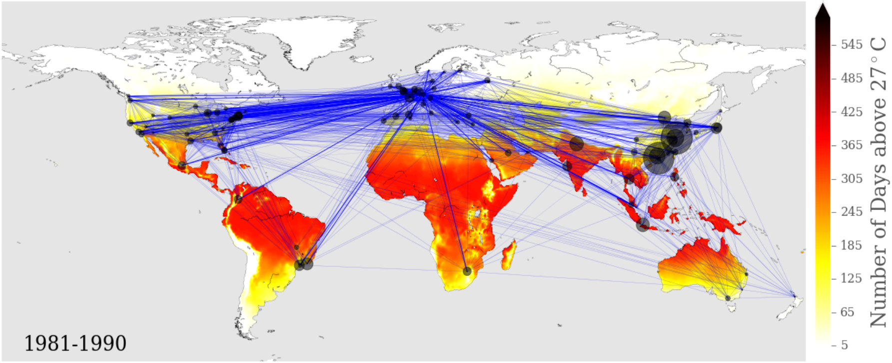

Fig.: (1) 99 selected Airports (2) population (3) 3255 daily flight connections (4) climate data - **not everyone with everyone**

3.1 Data Processing (GraphML)

nodes: Airports (99)	edges: Flights (3255)

`<node id=''ATL''>`
`<data key=city>Atlanta</data>`
`<data key=date>2016-12-29</data>`
`<data key=lat>33.636</data>`
`<data key=lon>-84.428</data>`
`<data key=population>1.839</data>`
`<data key=tasmax>15.036</data>`
`<data key=pr>5.207</data>`
`</node>`
	`<edge source=''ATL'' target=''MCO''>`
	`<data key=weight>0.311</data>`
	`</edge>`

(1) calculating daily climate bridge and network measures
(2) aggregation to monthly data to study seasonality
(3) analyzing trends and climate change signals
(4) input for propagation calculations

3. Methods

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3.2 Definition: Climate Bridge

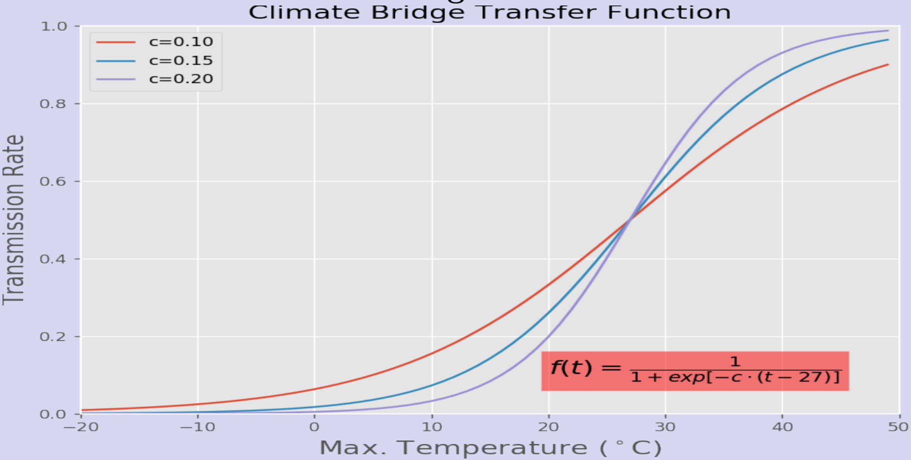

Fig.: The weight of flight connections dependent on daily maximum temperature at two connected airports (nodes): source and target

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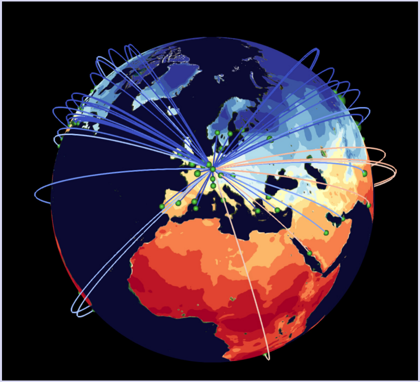
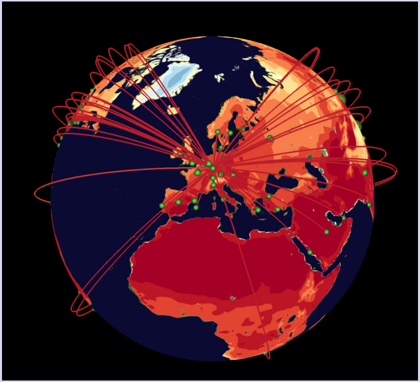
3. Methods

GTX visualization of climate bridges for FRA



winter conditions



summer conditions

3. Methods

3.3 Definition: Network Measures

Degree centrality assigns an importance score based purely on the number of links (flight connection) held by each node (airport). *For finding very connected and popular nodes, airports those are likely to hold most information or airpots those can quickly connect with the wider network.*

Betweenness centrality measures the number of times a node (airport) lies on the shortest path between other nodes (airports). *This measure shows which nodes (airport) act as 'bridges' between nodes (airports) in a network. It does this by identifying all the shortest paths and then counting how many times each node falls on one.*

$$g(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

NetworkX

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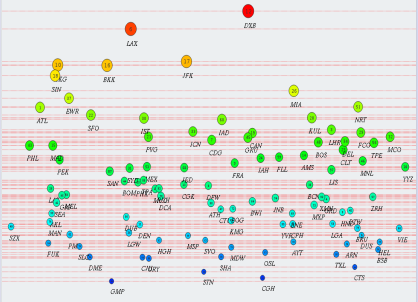
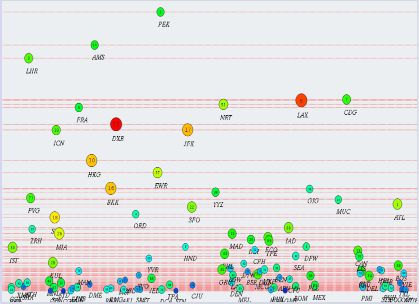
Socnetv: unweighted network

Degree Centrality



Betweenness Centrality



1. DXB (Dubai)
2. LAX (Los Angeles)
3. JFK (New York)

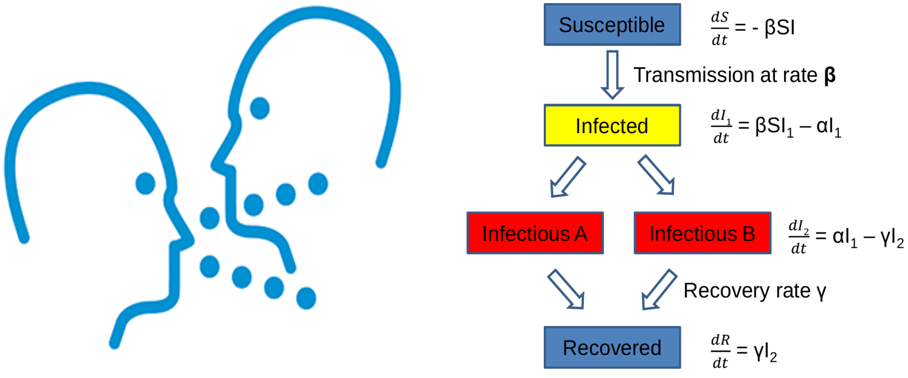
1. PEK (Peking)
2. AMS (Amsterdam)
3. LHR (London)

DXB: most flights

PEK: shortest flight connections between other airports

3. Methods

3.4 From Climate to Infection Bridges



Compartmental model in epidemiology

SEIR: Susceptible - Exposed - Infectious - Recovered - model

transmission rate = climate bridge (infection bridges)

4. Results

4.1 Assessment of Airports (interactive sorted table)

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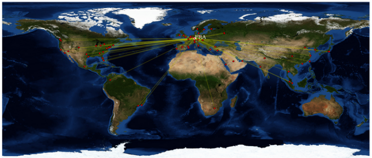
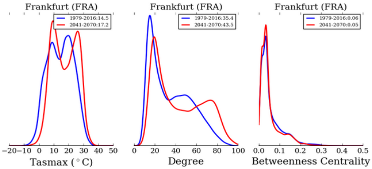
POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Assessment of Airports: 1979-2016 / 2041-2070 (RCP85)





Airport	IATA	Population	Longitude	Latitude	DG_1979-2016	DG_2041-2070	Δ	BC_1979-2016	BC_2041-2070	Δ	TX_1979-2016 [°C]	TX_2041-2070 [°C]	Δ	PR_1979-2016 [mm]	PR_2041-2070 [mm]	Δ	MAP
Dubai	DXB	0.381	55.364	25.253	58.748	66.742	7.994	0.021	0.021	0.001	33.8	37.0	3.269	91	69	-22.341	MAP
Bangkok	BKK	7.064	100.747	13.681	46.188	52.086	5.899	0.021	0.021	0.000	33.3	35.8	2.418	1474	1453	-20.316	MAP
Singapore	SIN	0.051	103.994	1.350	42.422	44.413	1.991	0.021	0.025	0.004	31.4	30.7	-0.617	2374	2565	191.077	MAP
Hong Kong	HKG	0.948	113.915	22.309	39.931	46.456	6.525	0.022	0.022	0.001	26.4	28.5	2.054	1907	1932	25.141	MAP
Los Angeles	LAX	2.390	-118.408	33.943	39.551	47.657	8.105	0.037	0.039	0.002	22.4	24.7	2.270	329	315	-14.157	MAP
Miami	MIA	2.226	-80.291	25.793	38.242	39.446	1.204	0.021	0.022	0.001	29.2	28.0	-1.218	1587	1536	-51.688	MAP
New York	JFK	3.650	-73.779	40.640	36.688	45.789	9.100	0.032	0.031	-0.002	17.3	20.5	3.176	1308	1324	16.237	MAP
Atlanta	ATL	1.839	-84.428	33.637	35.743	42.366	6.622	0.022	0.022	-0.000	23.4	25.7	2.279	1350	1424	73.743	MAP
Frankfurt	FRA	1.280	8.571	50.033	35.115	43.182	8.067	0.058	0.053	-0.005	14.4	17.1	2.701	748	744	-3.266	MAP
London	LHR	3.568	-0.462	51.471	35.020	43.108	8.088	0.086	0.098	0.012	14.3	16.6	2.338	744	807	63.182	MAP
Houston	IAH	2.512	-95.341	29.984	34.558	40.148	5.591	0.021	0.021	0.000	26.6	28.7	2.111	1415	1301	-113.809	MAP
Paris	CDG	0.246	2.550	49.013	33.987	41.835	7.848	0.051	0.051	-0.000	15.5	18.0	2.521	787	788	0.937	MAP
Tokyo	NRT	5.068	140.386	35.765	33.761	41.703	7.943	0.045	0.047	0.003	19.3	22.1	2.791	1541	1594	52.424	MAP
Beijing	PEK	11.187	116.585	40.080	33.753	41.696	7.943	0.103	0.099	-0.003	17.9	21.1	3.262	564	611	46.883	MAP

ranking of airports by columns ...

4. Results

Summary

#	DG 1979-2016	DG 2041-2070	△
1.	DXB	DXB	JFK
2.	BKK	BKK	LAX
3.	SIN	LAX	LHR
FRA	**9.**	**7.**	**4.**

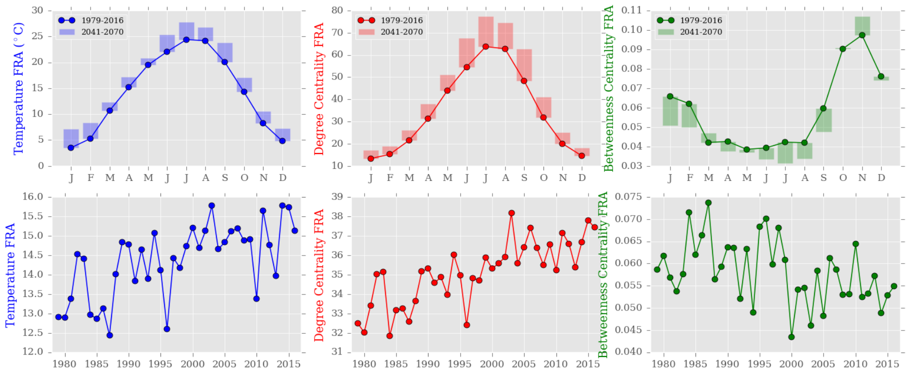
(1) ranking of airports by the network measure: weighted degree centrality

(2) comparing recent (1979-2016) and future (2041-2070) conditions

(3) What does it means for Frankfurt (FRA)?

4. Results

4.2 Statistics for FRA



(1) Temperature: seasonal shift to higher temperatures

(2) Degree Centrality: climate effect in the order of additional 10 flights

(3) Betweenness Centrality: increasing seasonality

4.3 Outbreak

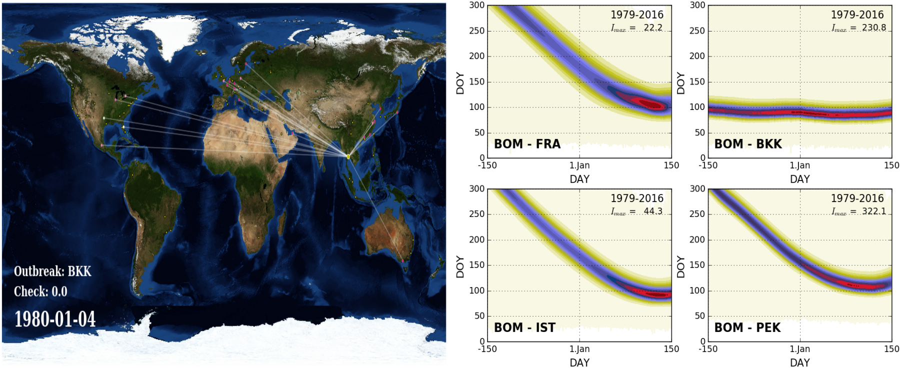


Fig.: Number of days until outbreak (source=BOM) reaches (target=FRA) over the initial date. An outbreak in spring shows the shortest time of less than 100 days.

5. Final Remark

By the definition of climate bridges in the air traffic network every single flight gets a weight according to the prevailing weather conditions.

This changes the network characteristics and the centrality measure of airports in the entire network.

The possible effect on human and human health can be estimated.

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Thank you for your attention!