

Regional Climate Change and Impacts in Central Europe

P. Hoffmann

Contents

| | | |
|----------|-------------------------------|-----------|
| 1 | Introduction | 3 |
| 2 | Observations | 6 |
| 3 | Projections | 28 |
| 4 | Climate Impacts Online | 33 |
| 5 | Climate and Mobility | 35 |

1. Introduction

Peter Hoffmann

1991-1995 practical training in the chemical industry as process control electronics

1996-1999 working in a private company

1998-1998 passed a qualification exam to study at university (no high school)

1999-2005 study of meteorology (diploma)

2005-2012 Institute for Meteorology in Leipzig (PhD)
Meteorology of the Upper Atmosphere

2012-date Potsdam Institute for Climate Impacts Research (PIK)
Research Domain 2: Climate Resilience
Working Group: Hydro-Climatic Risks

Research Topics

- Regional Climate Diagnostic (Hoffmann, 2019, in prep.)
 - analysis of European weather patterns (dynamics)
- Seasonal Forecast (Hoffmann, 2018)
 - using early season predictors (data driven)
- Future Assessments (Hoffmann et al. 2018)
 - using regional climate model ensembles for Europe
- Climate Services

Research Projects

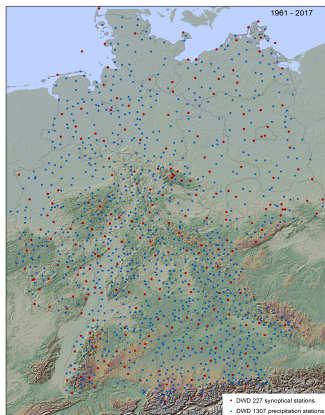
- Climate and Pathogens (2015-2018)
 - infectious diseases e.g. Pneumonia and Sepsis
- Vulnerability Study of the Tourism Sector (2018-2020)
 - relation between weather and tourist demand
- Assessment of Climatic Risk for the Deutsche Bahn (2017)
 - relation between extreme weather and train delays
- Climate Impacts Online



cross-sectoral climate services: agriculture, hydrology

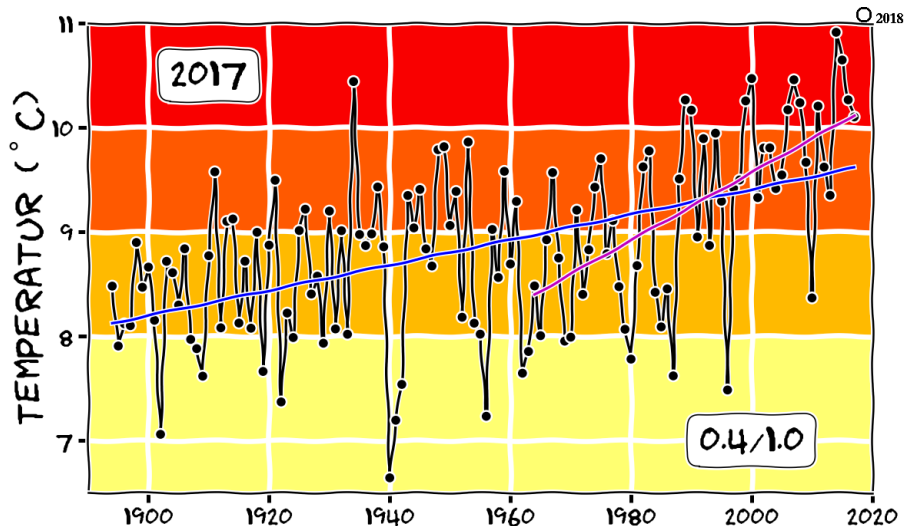
2. Observations

Climate Data & Climate Indicators



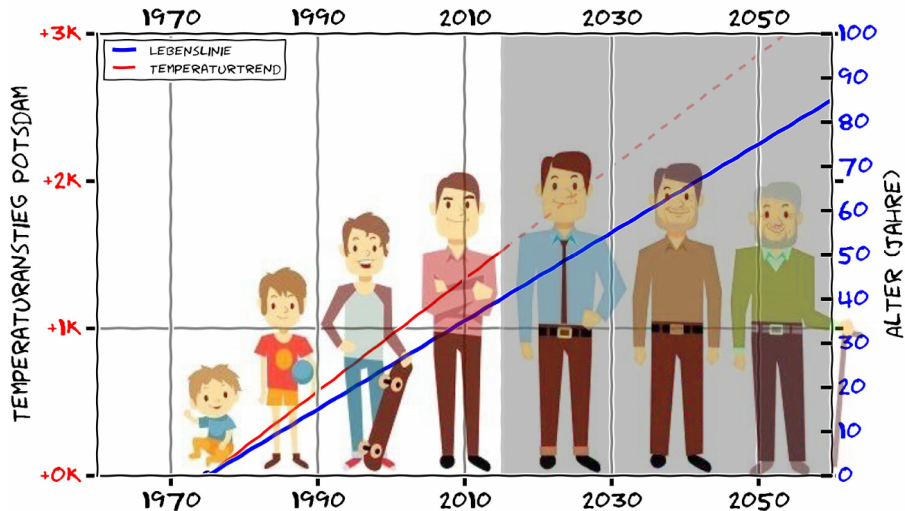
| daily | unit | seasonal | annual | Indicator | unit |
|------------------|------|-----------|-----------|-----------------|------|
| temperature | °C | mean | mean | | |
| | | — | > 30°C | hot days | days |
| | | — | 99th-perc | 3rd hottest day | °C |
| | | — | < 0°C | ice days | days |
| precipitation | mm | sum | sum | | |
| | | — | > 30mm | very wet days | days |
| | | — | 99th-perc | 3rd wettest day | mm/d |
| wind gust | m/s | — | > 25m/s | severe storms | days |
| weather patterns | cat | frequency | duration | | days |

Temperature: Potsdam



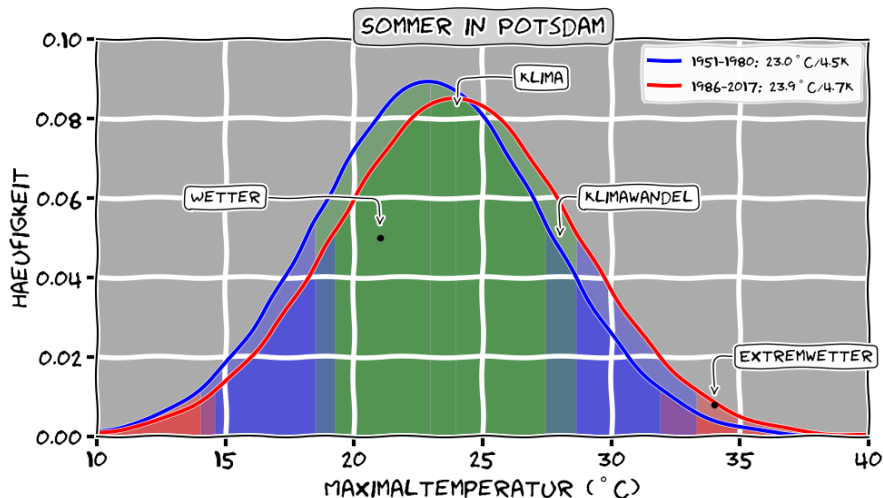
+1.4°C since 1893 / +1°C per 30 yr since 1961

Temperature: life cycle



+3°C within one life

Temperature: distribution

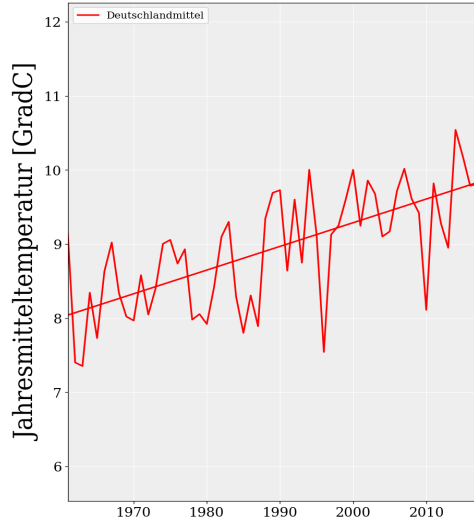
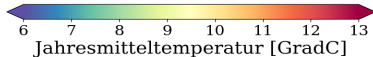
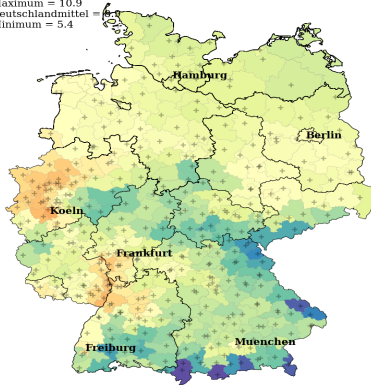


shifting temperature distribution / heat extremes more likely

Temperature: annual mean

Beobachtung_Jahresmitteltemperatur_1961-2017_Zeitreihe

Maximum = 10.9
Deutschlandmittel = 9.4
Minimum = 5.4



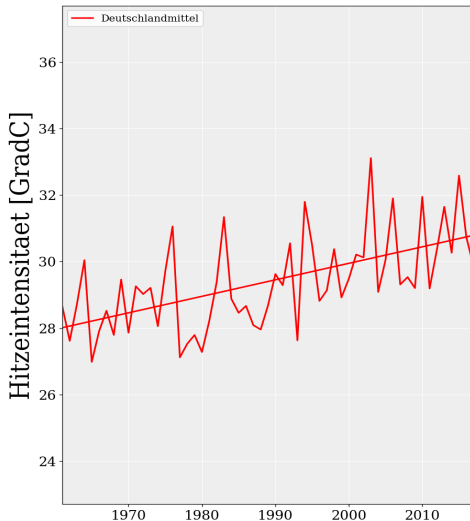
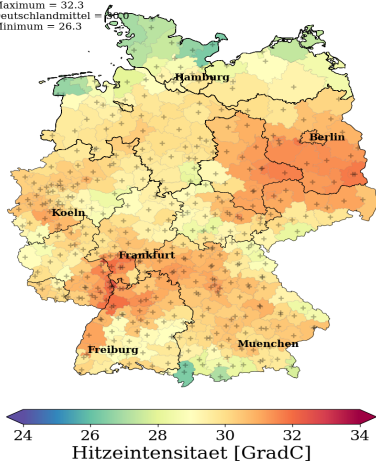
linear trend 1961-2017: 8.0°C - 9.8°C ($\Delta = +1.8^\circ\text{C}$)



Temperature: 3rd hottest day of year

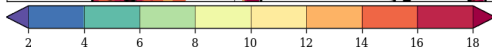
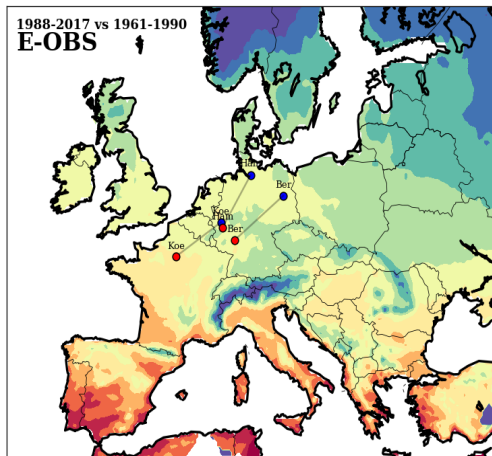
Beobachtung_Hitzeintensitaet_1961-2017_Zeitreihe

Maximum = 32.3
Deutschlandmittel = 30.0
Minimum = 26.3

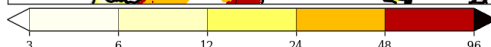
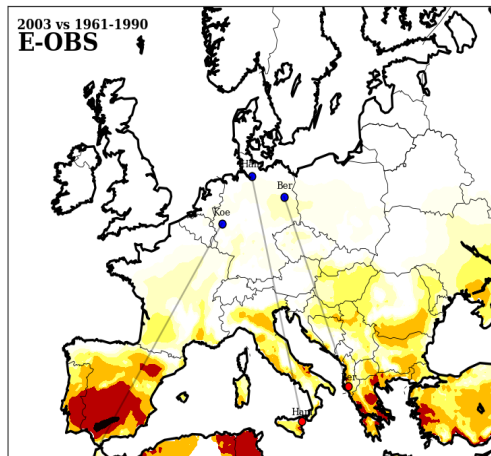


linear trend 1961-2017: 28.0°C - 30.8°C ($\Delta = +2.8^\circ\text{C}$)

Temperature: climatic shift



1961-1990 Mitteltemperatur [°C]

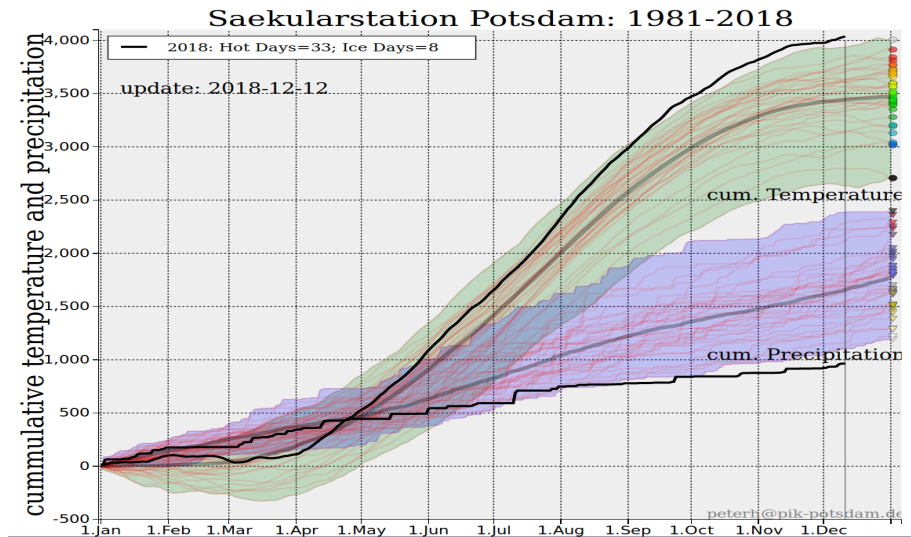


1961-1990 Hitzetage



today climate of Berlin similar to the climate of Freiburg in the 80s

Temperature & Rainfall: cumulative

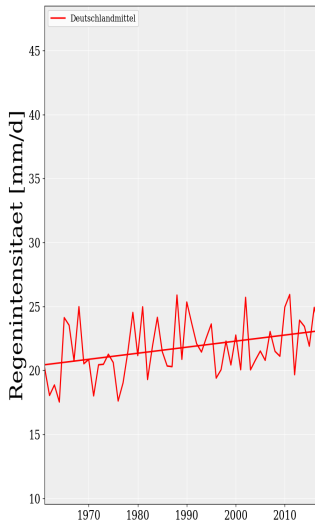
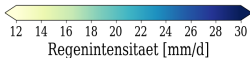
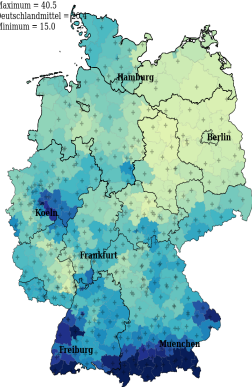


2018 was the warmest and driest year on record

Rainfall: 3rd wettest day of year

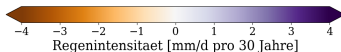
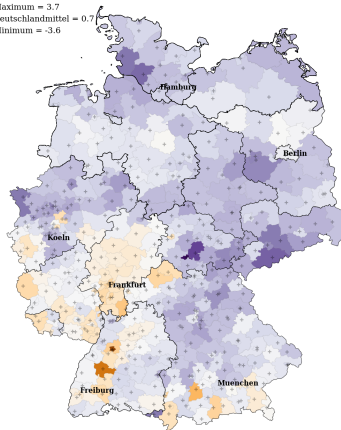
Beobachtung_Regenintensitaet_1961-2017_Zeitreihe

Maximum = 40.5
Deutschlandmittel = 20.7
Minimum = 15.0



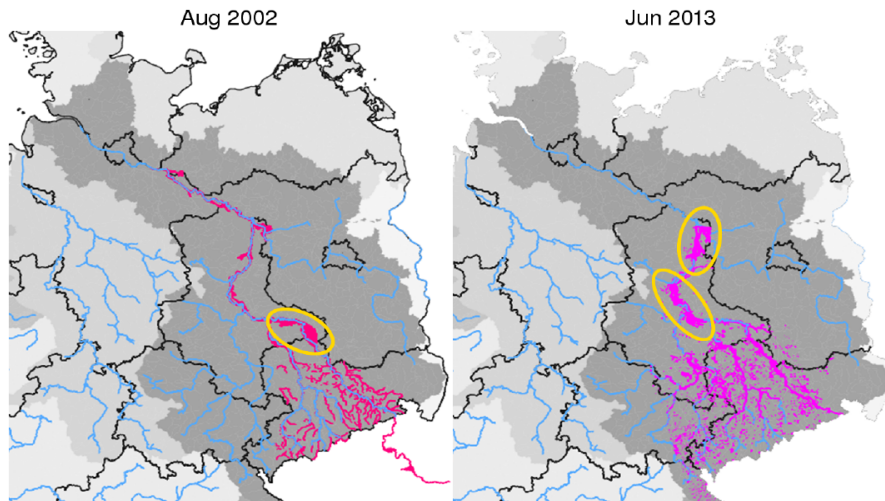
Beobachtung_Regenintensitaet_1961-2017_Trend

Maximum = 3.7
Deutschlandmittel = 0.7
Minimum = -3.6



increase of rainfall intensity in almost every region: +3mm/d

Rainfall: river floods

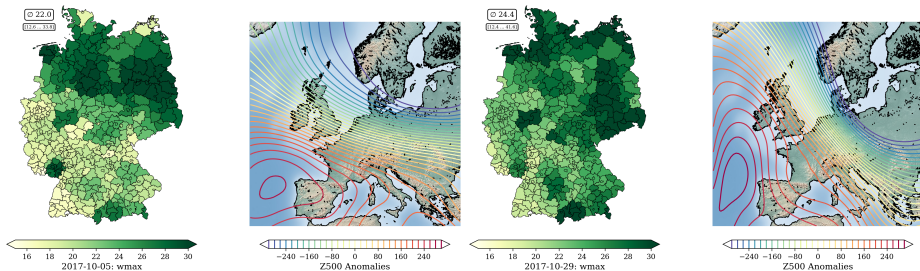


flooding maps of the 100 yr events 2002 and 2013 in the river Elbe catchment

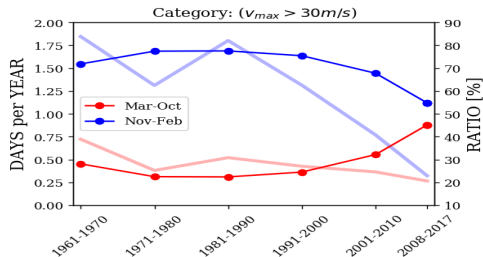
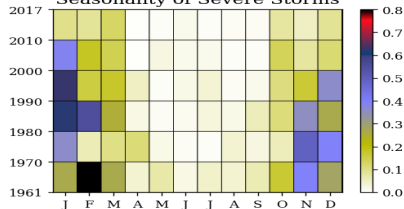
Radar climatology of intens hourly rainfall events (2001-2017)



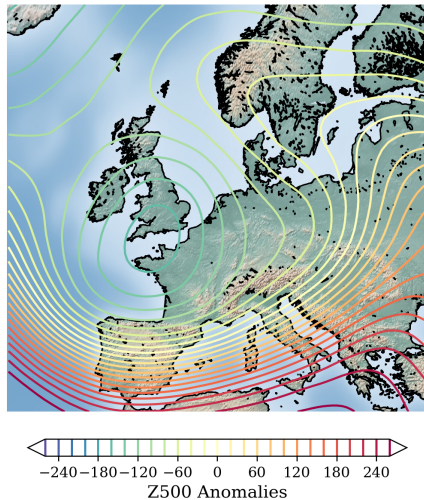
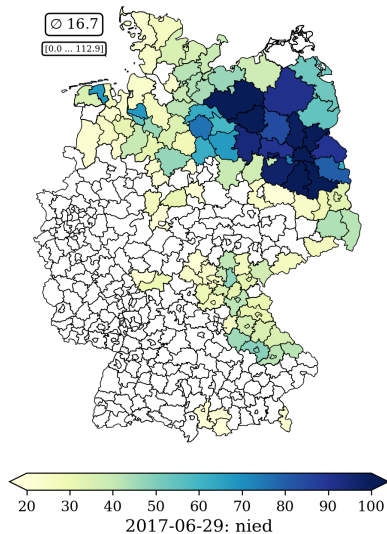
Wind Speed: severe storms



Seasonality of Severe Storms

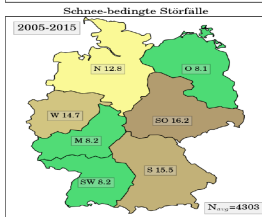
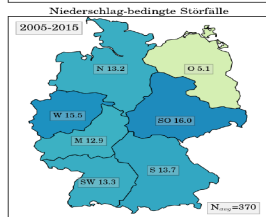
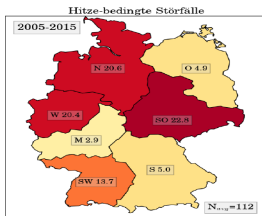
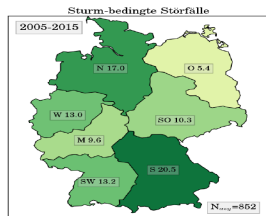


Extreme Weather



persistent weather pattern favored extreme rainfall in North-East Germany 2017

Extreme Weather: Impacts for Deutsche Bahn



Deutsche Bahn: Interruptions
2005-2015

storms: $n=852$ (S, N)

heat: $n=112$ (SO, N, W)

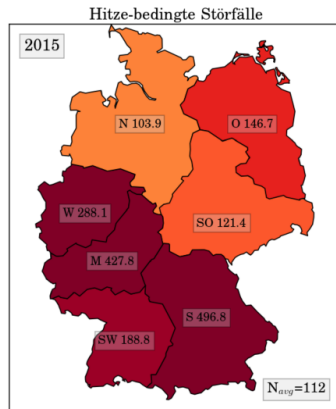
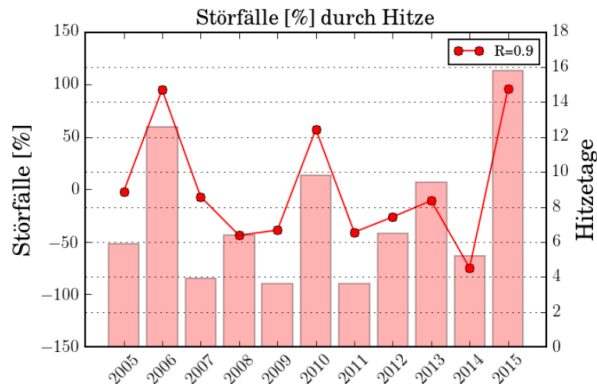
rain: $n=370$ (SO, W)

snow: $n=4303$ (SO, S)

total: SO!

ratios of train interruption per DB regional area and extreme weather category

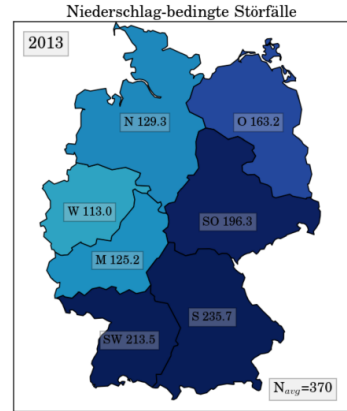
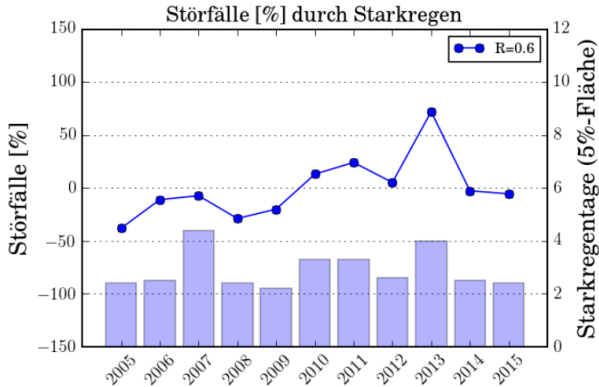
Extreme Weather: heat



hot summers cause more interruption: 2006, 2010, 2015

2015: 16 hot days and 200% more train interruptions in South-West

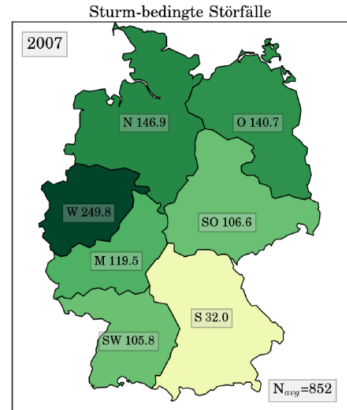
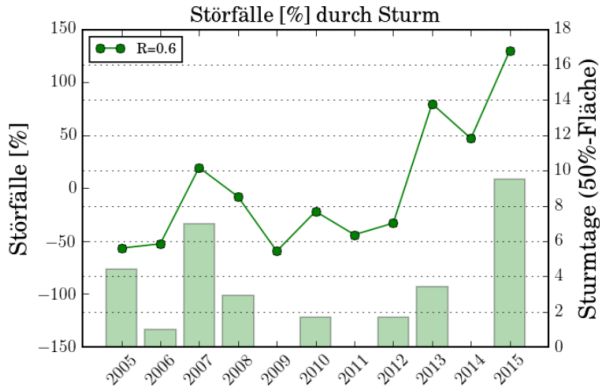
Extreme Weather: rain



heavy rain and floodings cause interruptions: 2007 and 2013

2013: 200% more train interruptions in South and South-East

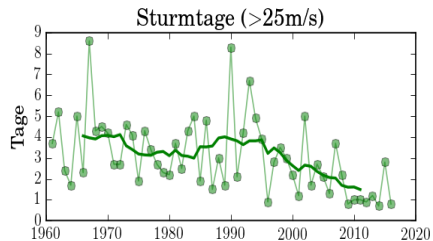
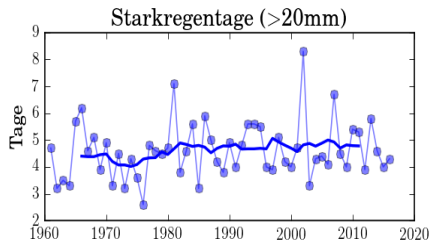
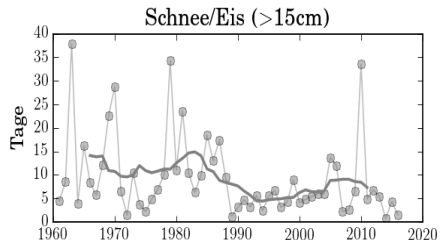
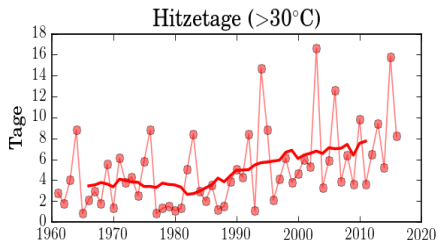
Extreme Weather: storms



severe storms cause interruptions: 2007 (Kyrill) and 2015 (Niklas)

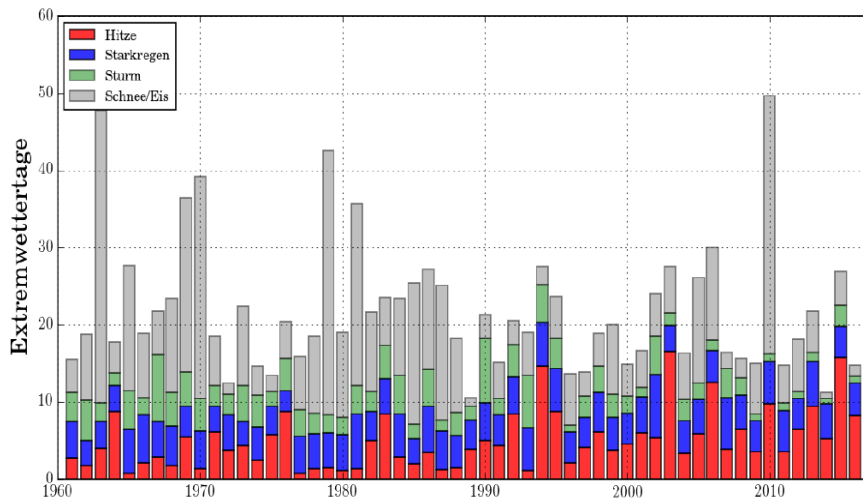
2015: 200% more train interruptions in West

Extreme Weather



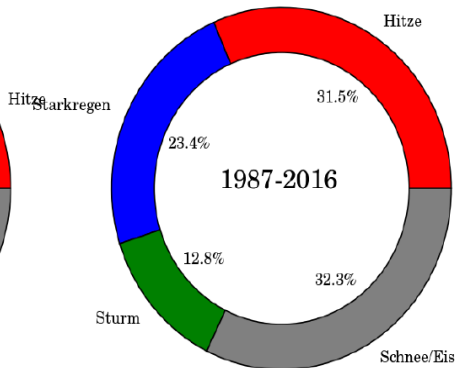
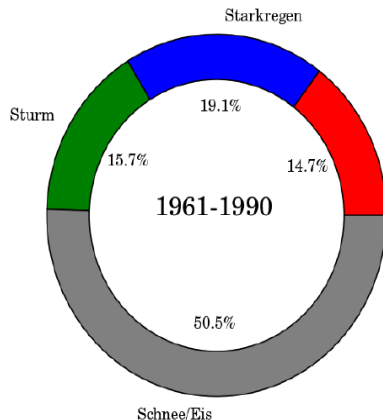
1961-2016: categories of extreme weather - observed evolution

Extreme Weather



1961-2016: categories of extreme weather - observed evolution

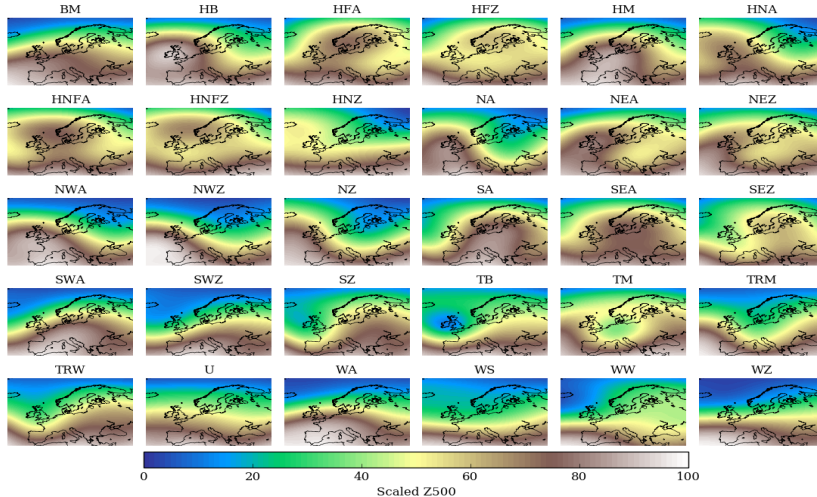
Extreme Weather



1961-2016: categories of extreme weather - observed evolution

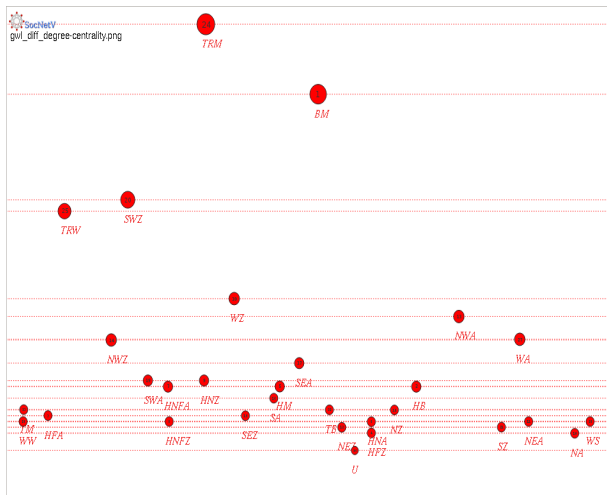
Heat & Heavy Rain: 33.8% (1961-1990) 54.9% (1987-2016)

Weather Patterns

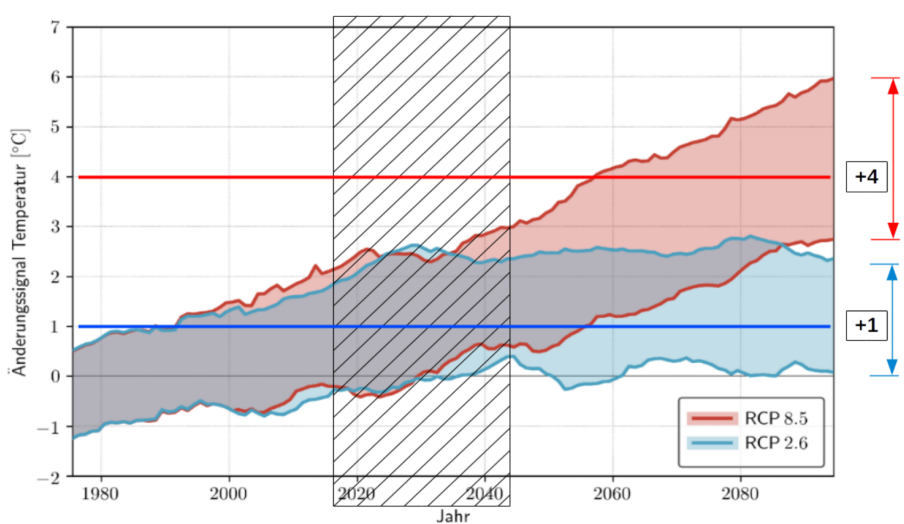


categorical data: shapes of the circulation over Europe

Weather Patterns: changes

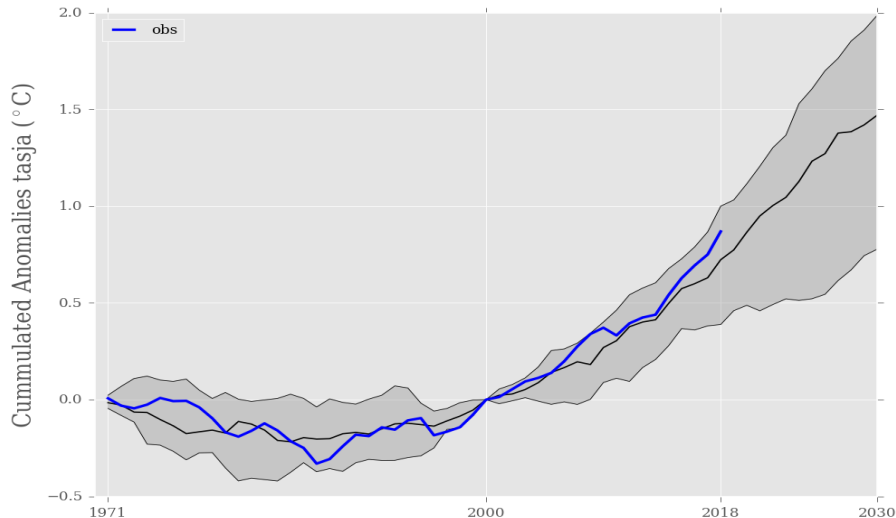


3. Projections



scenarios: "climate protection" (+1°C) or "business as usual" (+4°C)

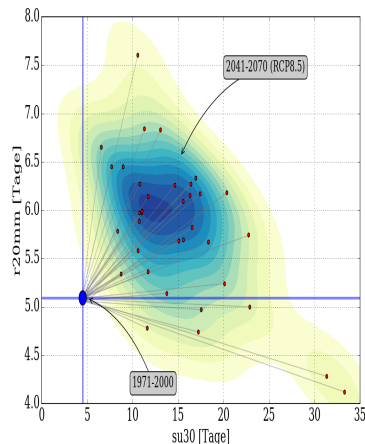
Historical Simulations



observed changes are reproduced by climate models

Germany in Numbers: 2071-2100 vs. 1971-2000

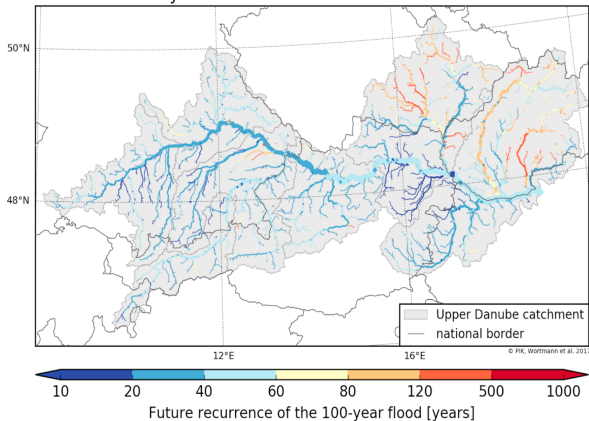
| Klimaparameter | “Ist” | “Klimaschutz” | “Weiter-wie-bisher” |
|---------------------------|-----------|---------------|---------------------|
| Jahresmitteltemperatur | 8.0°C | +1.0°C | +3.8°C |
| Hitzetage | 4.3 Tage | +3.7 Tage | +19.4 Tage |
| Eistage | 24.8 Tage | -7.2 Tage | -18.9 Tage |
| Starkregentage | 4.9 Tage | +0.3 Tage | +1.1 Tage |
| Länge d. Wachstumsperiode | 247 Tage | +21 Tage | +67 Tage |
| Trockentage | 236 Tage | +1.7 Tage | +9.1 Tage |
| Sommerniederschlag | 2.9 mm/d | -3.8 % | -12.6 % |
| Extremniederschlag | 55.5 mm/d | + 5.4 mm/d | +33.6 mm/d |



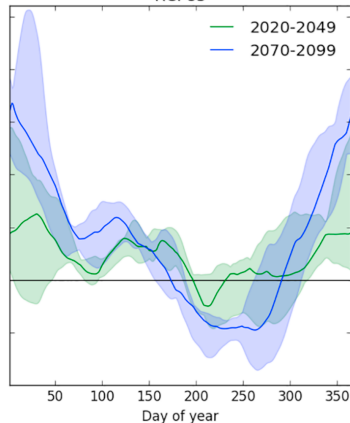
more heat, more intense rain, more drought, less frost

Flood Risks: Danube

100-year flood in 2020-2049 under RCP-8.5

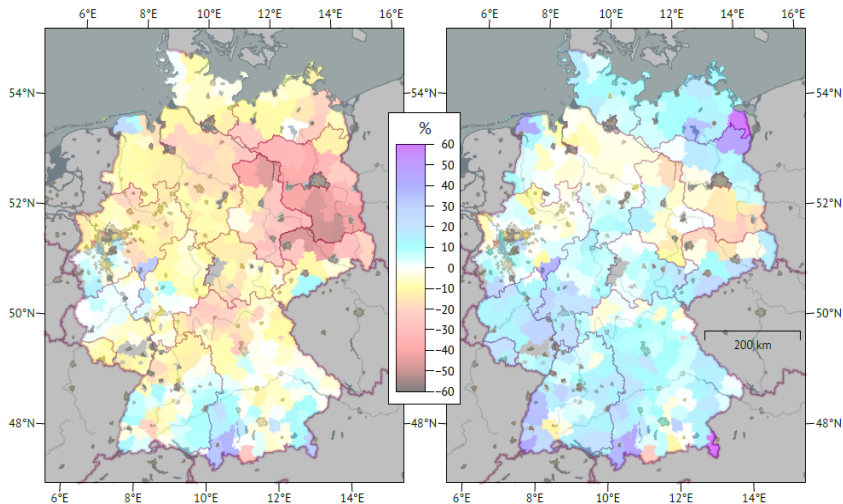


RCP85

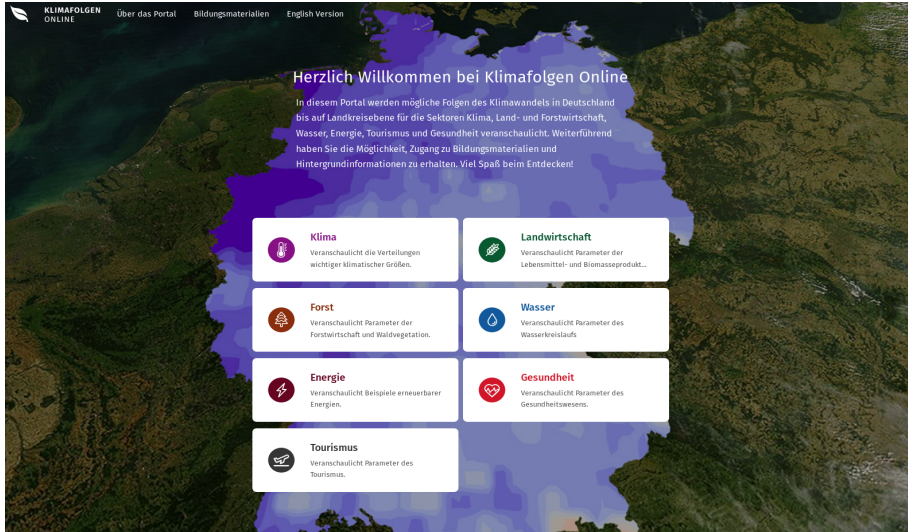


shortening of recurrence of 100-yr flood events and low water

Crop Failure

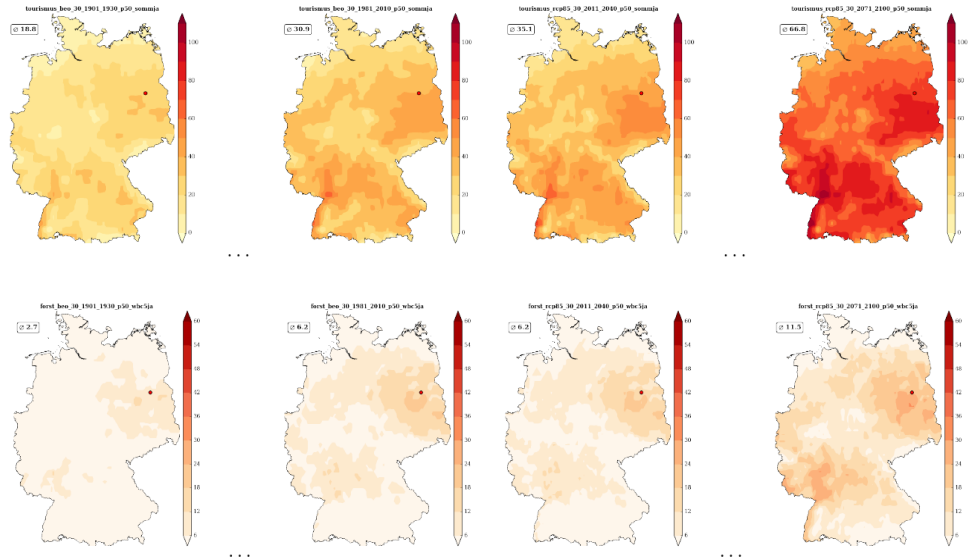


4. Climate Impacts Online



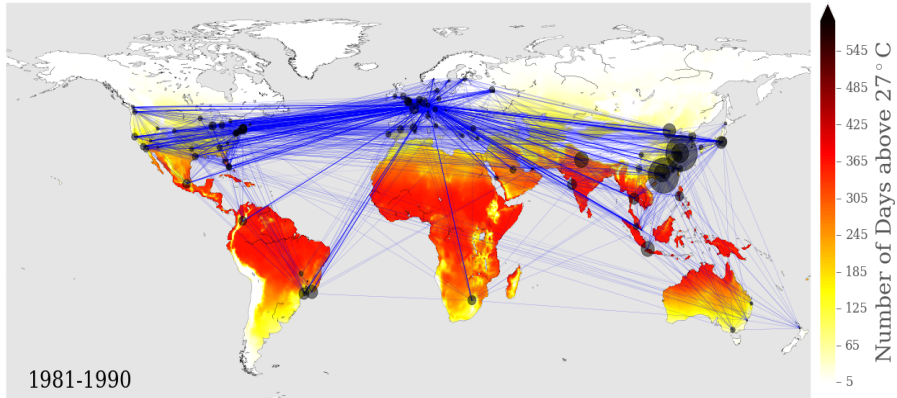
climate services across sectors for decision makers & public

summer days & fire risk (cat5)



observed and simulated climate and climate impact indicators (1901-2100)

5. Climate and Mobility



climate and mobility network: assessment of airports

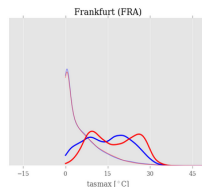
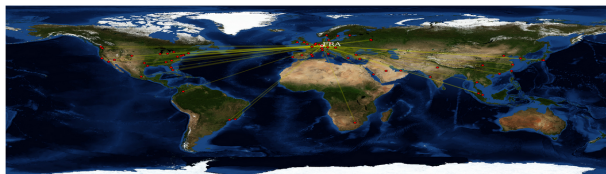


flight connections weighted by departure and arrival temperature: climate bridges

Assessment of Airports



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 | 0.301 | 55.364 | 25.253 | 58.748 | 66.742 | 7.994 | 0.021 | 0.021 | 0.000 | 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 | 8.106 | 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 | 36.608 | 45.789 | 9.100 | 0.032 | 0.031 | -0.002 | 17.3 | 20.5 | 3.176 | 1306 | 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 | 0.088 | 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 | -113.009 | 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 | 0.048 | 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 | 0.089 | -0.003 | 17.9 | 21.1 | 3.262 | 564 | 611 | 46.083 | MAP |
| Dallas-Fort Worth | DFW | 1.293 | -97.038 | 32.897 | 33.334 | 39.360 | 6.026 | 0.021 | 0.021 | 0.000 | 25.7 | 28.5 | 2.782 | 946 | 961 | 15.159 | MAP |
| Kuala Lumpur | KUL | 2.222 | 101.710 | 2.746 | 33.191 | 37.472 | 4.282 | 0.021 | 0.021 | 0.000 | 31.0 | 33.2 | 2.141 | 2330 | 2773 | 442.519 | MAP |
| Newark | EWR | 5.057 | -74.169 | 40.693 | 32.841 | 40.845 | 8.004 | 0.026 | 0.026 | 0.000 | 17.6 | 20.8 | 3.208 | 1323 | 1346 | 23.518 | MAP |
| Seoul | ICN | 0.308 | 126.451 | 37.469 | 32.586 | 40.070 | 7.484 | 0.072 | 0.066 | -0.006 | 17.7 | 20.9 | 3.195 | 1282 | 1447 | 165.050 | MAP |

LINK

sorted table: centrality of airports under consideration of climate bridges

Thank You for Your Attention!

