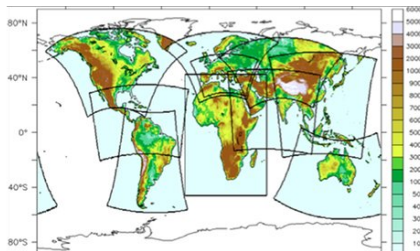


Climate change scenarios for Turkey and Germany until the end of the 21st century

P. Hoffmann



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Outline:

Global Climate Change

radiative balance * state of climate * clouds

European Weather Situations

change of “Grosswetterlagen” vs. precipitation

Climate Projections

scenarios * dynamical downscaling * CORDEX



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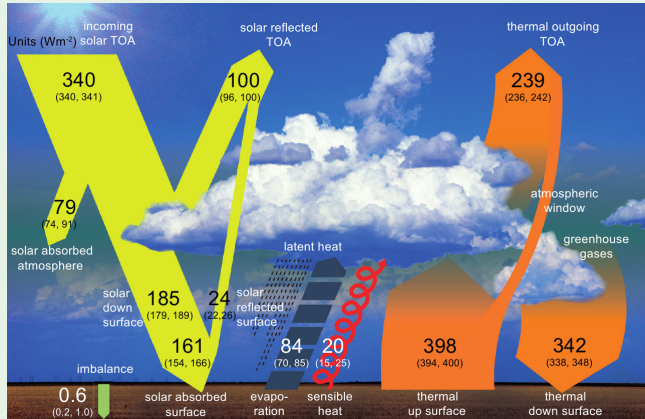
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Global Climate Change:

Radiative Balance:



IPCC, AR5

$$\text{TOA: } -340 + 100 + 239 = -1 \text{ [W/m}^2\text{]}$$

$$\text{Surface: } +161 - 398 + 342 - 84 - 20 = +1 \text{ [W/m}^2\text{]}$$



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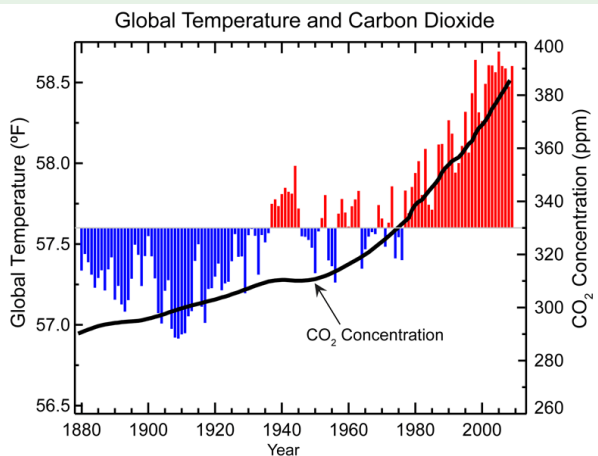
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CO₂ Concentration and Global Temperature



NOAA

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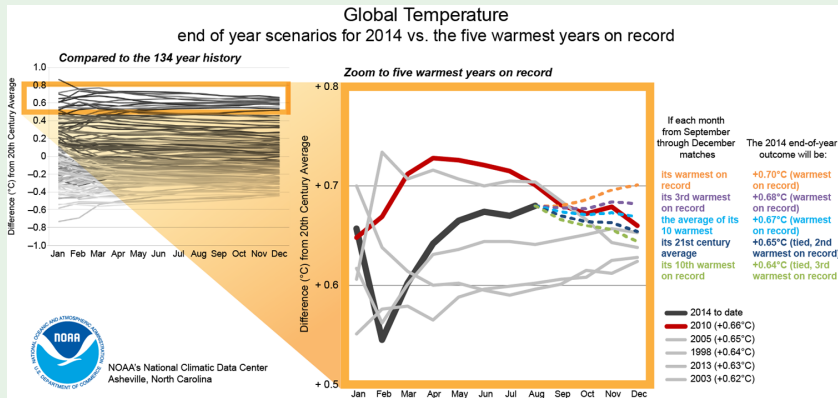
[Close](#)

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State of the Climate: Global Temperature Ranking



NOAA National Climatic Data Center, State of the Climate: Global Analysis for August 2014, published online September 2014, retrieved on October 7, 2014 from <http://www.ncdc.noaa.gov/sotc/global>.

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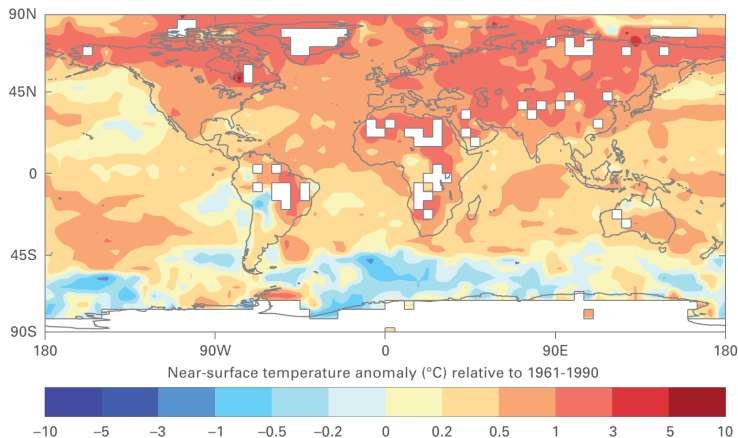
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Surface air temperature (HadCRU): 2001-10 minus 1961-90



WMO12



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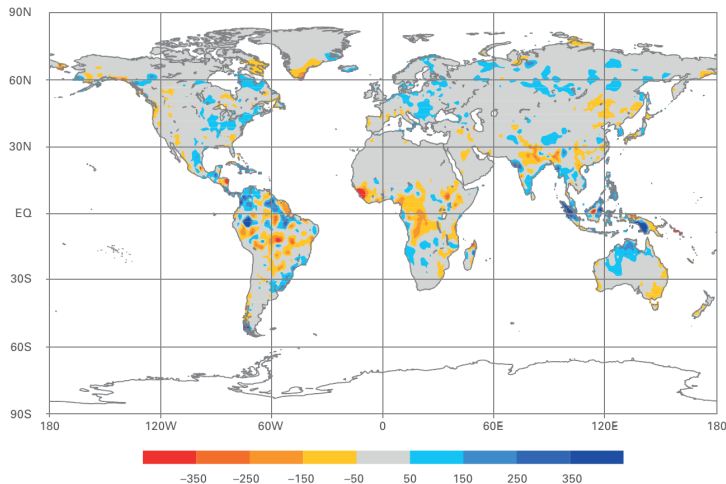
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Global Climate Change:

precipitation (GPCC-DWD): 2001-10 minus 1961-90



WMO12



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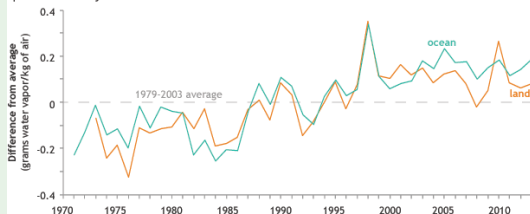
[Quit](#)



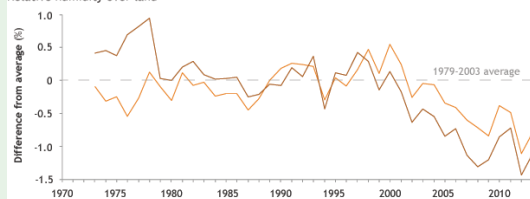
Global Climate Change:

Specific- and Relative Humidity:

Specific humidity over land and ocean



Relative humidity over land



NOAA, 2013



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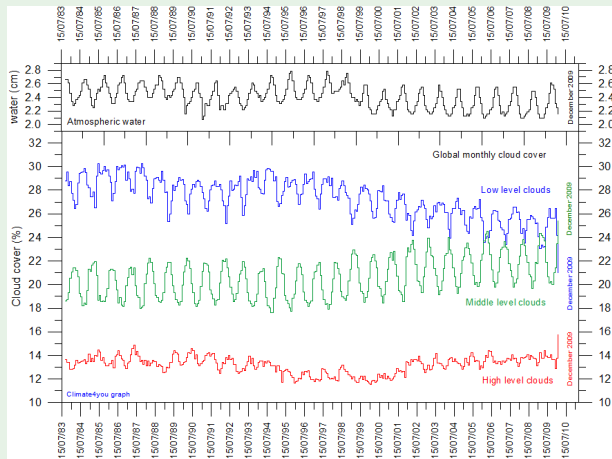
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Global Climate Change:

Global Cloud Cover Changes: low, middle & high



cloud-climate feedback: low-level clouds (cooling)
high-level clouds (warming)



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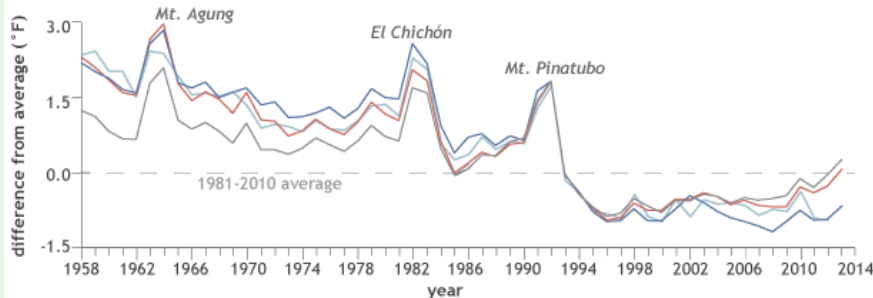
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Stratospheric Cooling

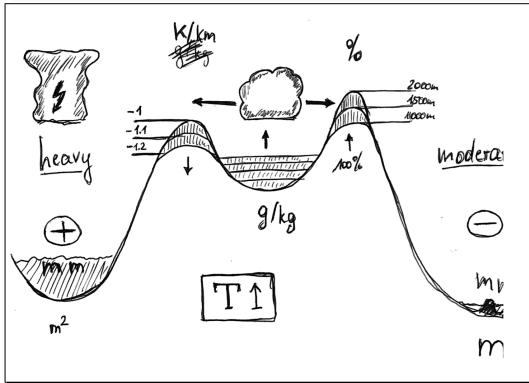
Lower stratospheric temperature



NOAA, 2013



Precipitation changed by temperature rise



- temperature rise: $T \uparrow$
- specific humidity: $q \uparrow$
 - ▶ mixing ratio \uparrow
- relative humidity: $q \uparrow$
 - ▶ condensation level \uparrow
- lapse rate: $\Gamma \downarrow$
 - ▶ labilisation
- precipitation:
 - ▶ heavy \uparrow
 - ▶ moderate \downarrow

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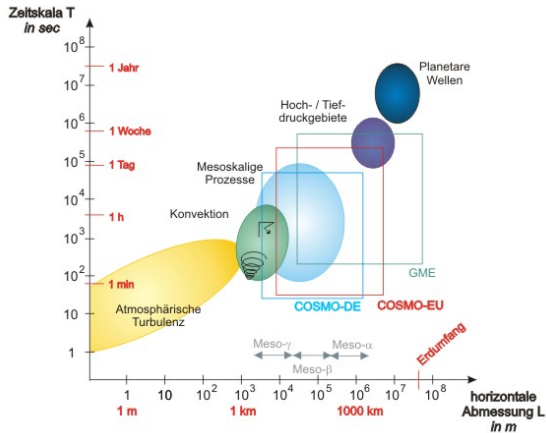
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Changes of European Weather Situations:



Scales of atmospheric Processes



DWD



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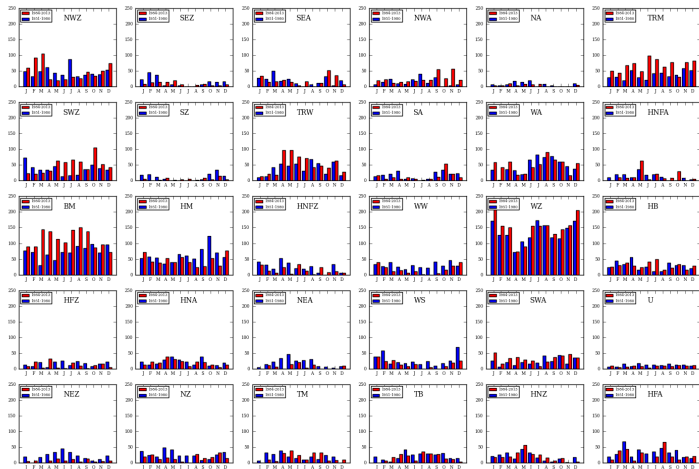
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Change of European Weather Situations:

Grosswetterlagen after Hess/Brezowsk



PIK



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Change of European Weather Situations:



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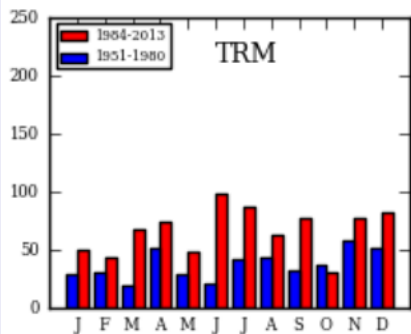
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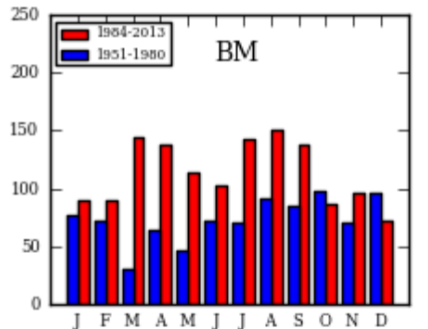
TRM: Trough Central Europe



- Large increase of TRW during the last decades

Change of European Weather Situations:

HB: High Bridge Central Europe



Hochdruckbrücke Mitteleuropa
23. Januar 1981



- Large increase of BM in the summer half during the last decades



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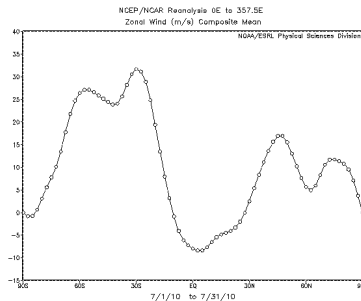
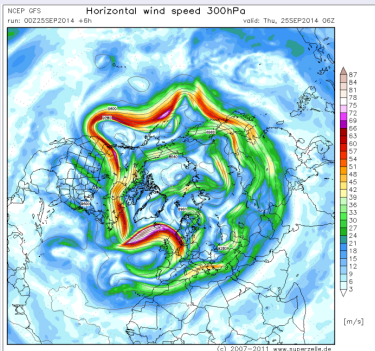
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Change of European Weather Situations:

Jetstream at 300hPa: 2010-06 (l) & 2010-07 (r)



NOAA

- Resonant planetary waves trigger stable weather situations (trapped in the Jetstream maxima)



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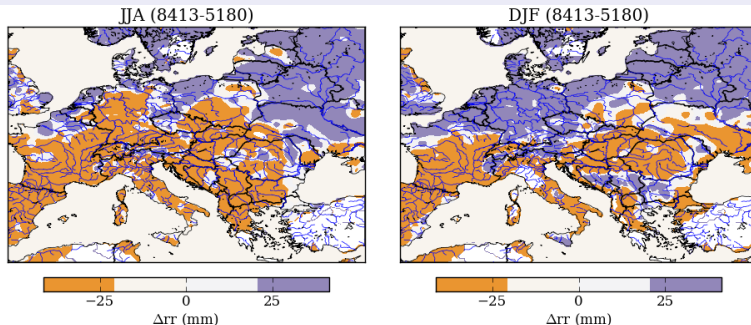
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Change of European Weather Situations:



EOBS: Change of Precipitation (Summer & Winter)



1984-2013 minus 1951-1980

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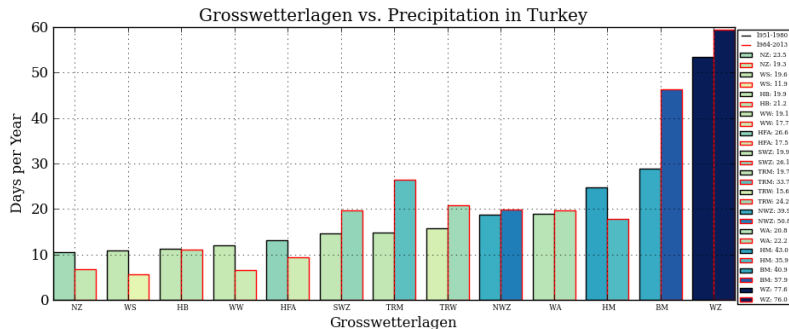
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Change of European Weather Situations:

Grosswetterlagen & precipitation: Turkey



PIK

High-Bridge over Central Europe (HB):

1951-1980

1984-2013

Frequency (days/yr)

29

46

Precipitation (mm/yr)

40.9

57.9



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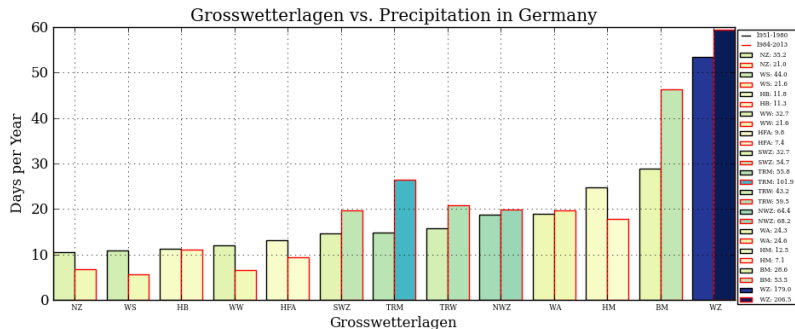
[Quit](#)



Change of European Weather Situations:



Grosswetterlagen & precipitation: Germany



PIK

Trough over Central Europe (TRM):

1951-1980

1984-2013

Frequency (days/yr)

15

26

Precipitation (mm/yr)

55.8

101.9



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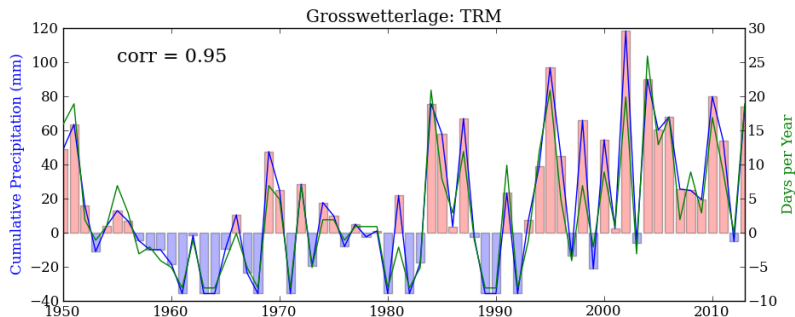
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Change of European Weather Situations:



TRM: Trough Central Europe (Apr-Sep)



PIK

- high correlation between precipitation and TRM frequency

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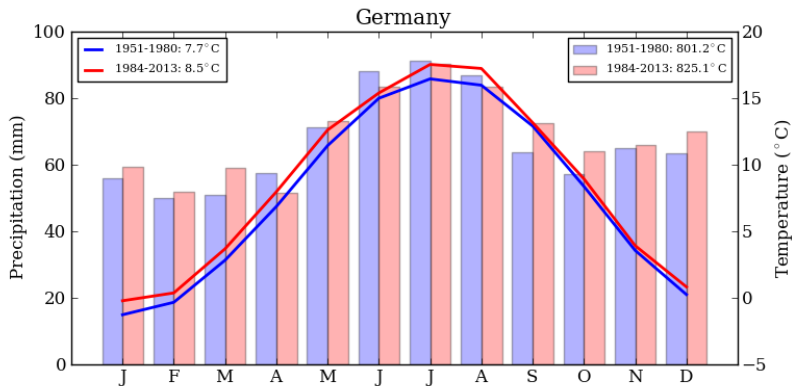
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Change of European Weather Situations:



Climate Diagram



PIK



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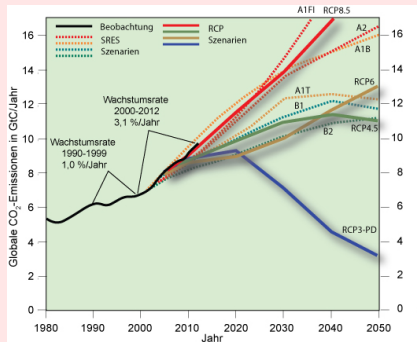
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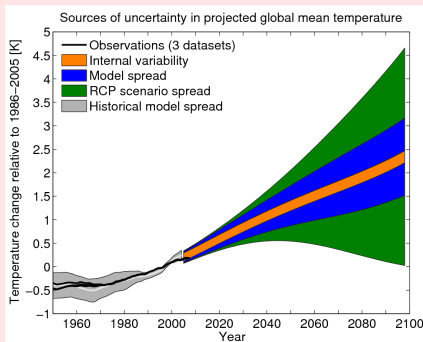
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Emission Scenarios: SRES, RCPs & Uncertainties



Bildungsserver



IPCC, AR5

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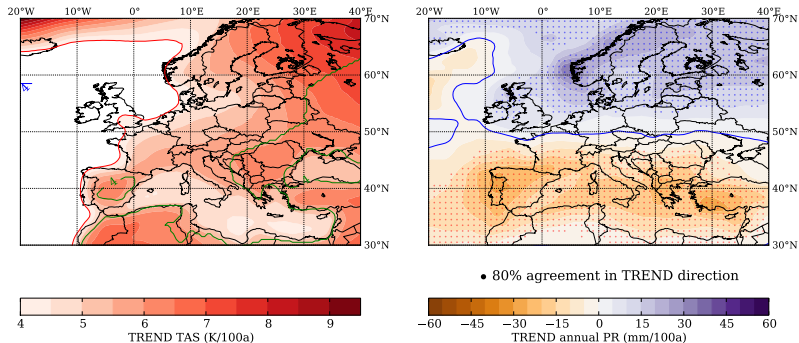
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CMIP5 Ensemble (rcp8.5)

CMIP5 GCM ENSEMBLE MEAN TREND (RCP8.5), 2006-2100



PIK

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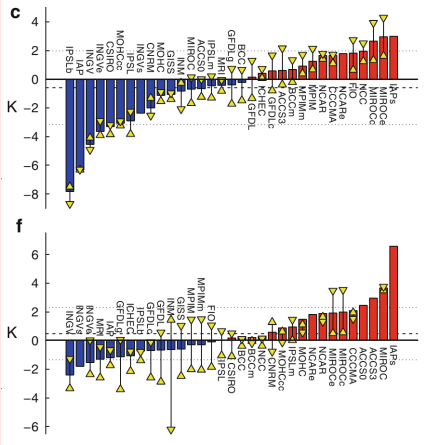
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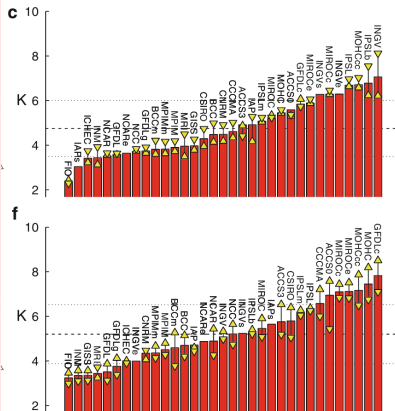
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CMIP5 Ensemble ranking: winter (c) & summer (f)

past



future



Cattiaux et al. 2013



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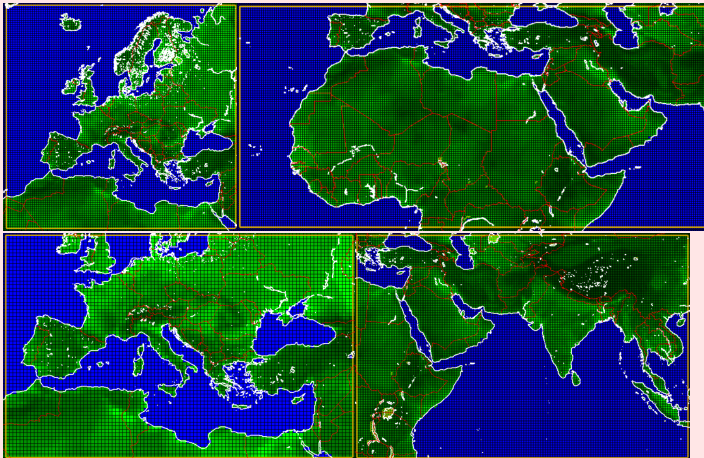
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CORDEX Domains: EUR, MENA, MED, SASIA



WPRC-CORDEX



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Euro-CORDEX: simulation matrix

EUR-11		ccsm4	csiro-mk3-6-0	mpi-esm-lr	gfdl-esm2m	ipsl-cm5a-mr	miroc5	hadgem2-es	ec-earth	noresm1-m	cnrm-cm5	canesm2	access1-0	miroc-esm-chem	ERA-Interim
		1	2	3	4	5	6	7	8	9	10	11	12	13	
1	REMO			xxx											x
2	WRF331			xx-		xxx			x						x
3	CCLM48			xxx			x	xxx	xxx		xxx			-x-	x
4	HIRHAM								x						
5	RACMO			x					xxx						x
6	ARPEGE														x
7	RCA4			x-x		x-x		xxx	xxx		x-x				x
8	PROMES														x
9	RegCM41														-
10	ALADIN														

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Reklies-De: a German model comparison project

	<i>CCLM</i>	<i>REMO</i>	<i>STARS</i>	<i>WETTREG</i>	<i>WRF</i>
MPI-ESM-LR run1, RCP 2.6	BTU	EURO-CORDEX	PIK	PIK	UHOH
MPI-ESM-LR run1, RCP 8.5	EURO-CORDEX	EURO-CORDEX	PIK	PIK	EURO-CORDEX
HadGEM2- ES, RCP 8.5	EURO-CORDEX	HZG	PIK	PIK	UHOH
EC-EARTH run12, RCP 8.5	EURO-CORDEX	HZG	PIK	PIK	UHOH
CNRM-CM5 run1, RCP 8.5	BTU already finished	HZG	PIK	PIK	
CCSM4 run6, RCP 8.5	DWD	HZG	PIK	PIK	UHOH
MIROC5 run1, RCP 8.5	DWD	HZG	PIK	PIK	

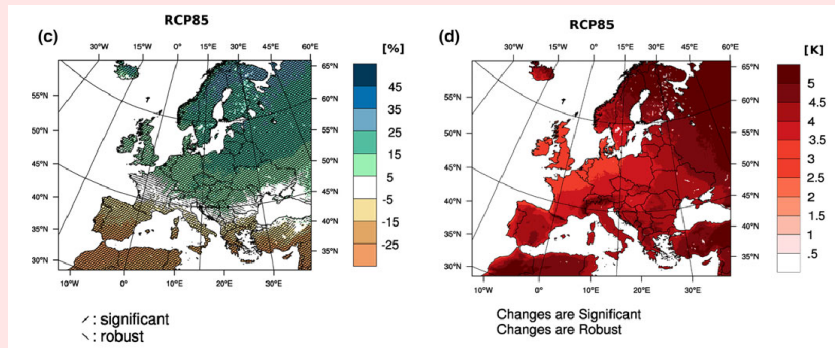
Table 1: Planned global/regional simulation matrix (grey Boxes -> simulations already covered by EURO-CORDEX. PM = person months). For each combination 1 run, 150 years.

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Projections (2071-2100): precipitation (l) & temperature (r)

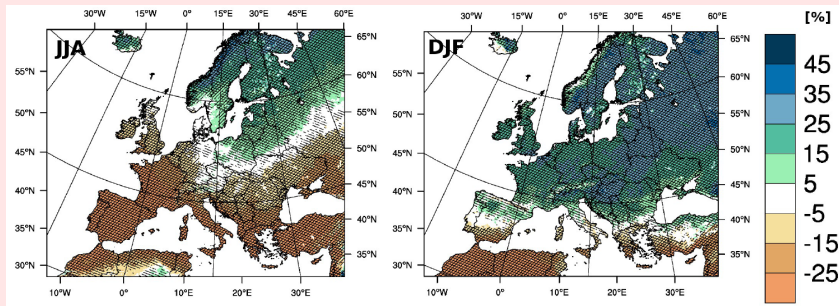


Jacob et al. 2013

Turkey: annual mean precipitation (decreasing: -5% to -15%)

Germany: annual mean precipitation (increasing: +5% to 15%)

Projections (2071-2100): precipitation (summer/winter)

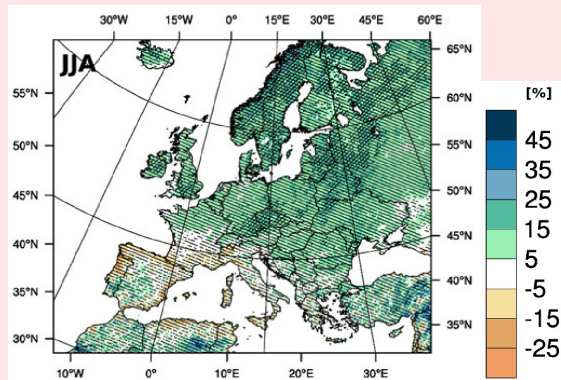


Jacob et al. 2013

Turkey: winter (uncertain, N-S) and summer (drier)

Germany: winter (wet) and summer (uncertain, E-W)

Projections (2071-2100): heavy precipitation in summer



Jacob et al. 2013

Turkey: -5% to 5%

Germany: increase of 5% to 15%

robust and significant over south-east Germany



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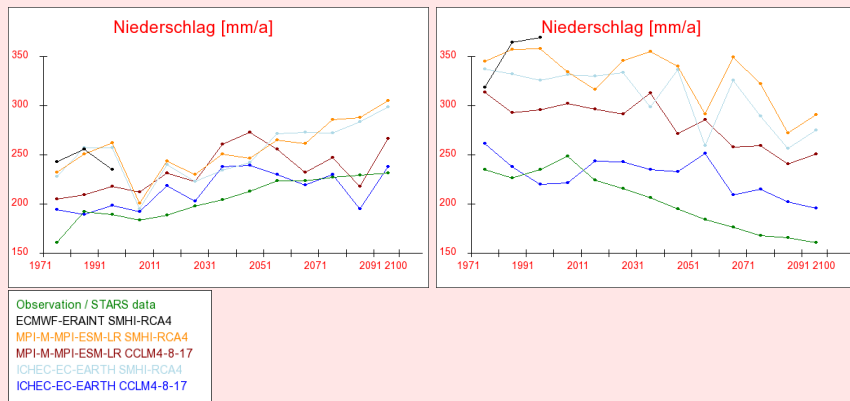
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Projection of precipitation in Germany: winter & summer



- dynamical- and statistical models show similar tendencies
- dynamical models overestimate the intensities, but are physical consistent

Summary:



- Global Climate Change:

- ▶ stronger warming at higher latitudes
- ▶ specific- and relative humidity show opposing trends
- ▶ shifting of rainfall intensities to higher values

- European Weather Situations:

- ▶ significant changes of European weather situations (TRM, BM)
- ▶ caused by changes of the upper troposphere circulation (Jetstream)

- Climate Projections:

- ▶ Euro-Cordex provides regional climate ensembles
- ▶ one possible scenario:
 - ★ drier summer
 - ★ intensification of local heavy rainfall events

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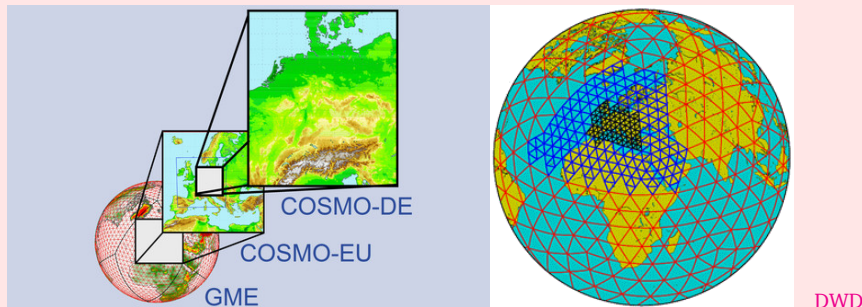
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A new generation of global weather and climate models:



ICON: (Icosahedral non-hydrostatic) multiscale general circulation model

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