





An European wide meteorological data set suitable for electricity modelling

supply and demand for actual climate and climate change projections

Formayer H.¹, Leidinger D.¹, Maier P.¹, Nadeem I.¹, Schöninger F.² Resch G.^{2,3}, Hasengst F.², Suna D.³, Pardo Garcia N.³, Totschnig G.³

¹BOKU Vienna – Institute of Meteorology and Climatology ²TU Wien – Energy Economics Group (EEG) ³AIT – Center for Energy



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for electricity modelling

Motivation	Data set	Variables	Conclusion		
	Motivation				
	Europe faces g	great challange	s regarding its energ	gy system	
	The energy sy				
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	Many types of weather				g-term

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for electricity modelling

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MFT[®]

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U Institute of Meteorology and Climatelogy

Motivation

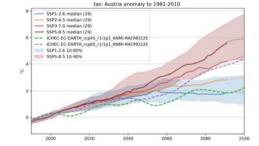
Data set

oles

Conclusior

- ERA5 and ERA5 Land → merged to one data set
- COSMO REA6 Reanalysis (150 m windspeed)
- 2 EURO-CORDEX climate scenarios: ICHEC-EC-EARTH - KNMI-RACCMO22E (RCP4.5, RCP8.5)
- eHYPE river discharge for ERA5 and scenarios

Total > 4TB input data



Data set

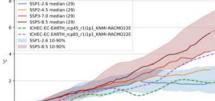
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tas: Austria anomaly to 1981-2010

2000 2020 2040 2060 2080 2100



Motivation

Data set

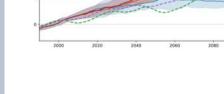
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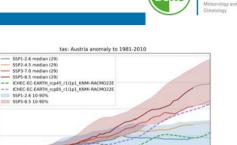
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2100

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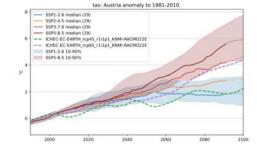
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Meteorology and

Data set

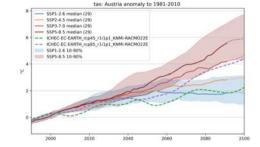
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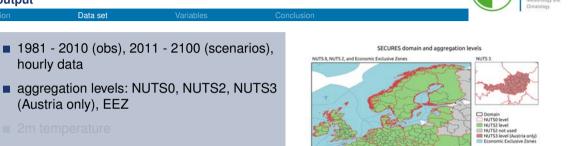


Data set



- 1981 2010 (obs), 2011 2100 (scenarios), hourly data
- aggregation levels: NUTS0, NUTS2, NUTS3 (Austria only), EEZ
- 2m temperature
- Global radiation and direct normal irradiation
- Potential wind power generation (onshore and offshore)
- Mean daily power generation from run-off-river and reservoir plants
- ca. 45 GB of uncompressed .csv files



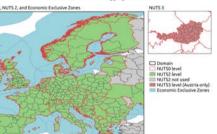


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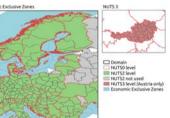


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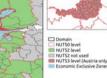


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Processing CORDEX data

Workflow

Data set

С

Regrid to ERA5L

- Provide data on same grid
- CORDEX Data is projected curvilinear
- ERA5L is on Plate Carree (lat-lon)

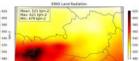
Bias correction

- Get rid of inherent model biases
- Make data compareable

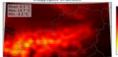
Temporal disaggregation

- Structure is preserved
- Daily temperature follows two cosine functions
- Surface wind is calculated via fractions of the historical ERA5L data Hourty wind divided by daily mean
- Solar radiation also uses statistics of historical ERA5L data

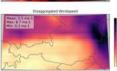
Disaggregated Radiation Max: 521 Sym2 Mix: 623 Sym2 300 -300

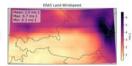


Disaggregated Temperature



ERAS Land Temperature





Mean Values of Austria of 1997

Institute of Meteorology and Climatology

Processing CORDEX data

Workflow

Data set

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Conclusio

Mean: 521 kim 2

Max: 621 kjm-2 Min: 479 ktm-2

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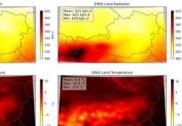
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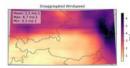
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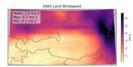
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BOKU Institute of MEET



Processing CORDEX data

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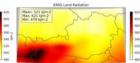
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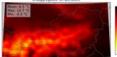
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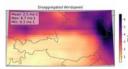


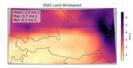
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Mean Values of Austria of 1997

Meteorology and Climatology

Formayer et al.

Temperature and radiation

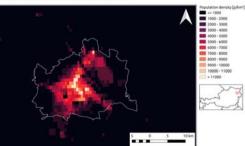
Motivation	Data set	Variables	Conclusion	\smile	

motivation and methods

- electricity demands increase with population density



Population density in the region of Vienna (ISOPOP)

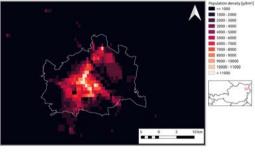


Temperature and radiation

Motivation	Data set	Variables	Conclusion	\smile	

motivation and methods

- electricity demands increase with population density
- solar panels are more likely on roofs
- people tend to live in the valleys, where the temperatures are higher
- thus temperature and radiation were additionally weighted with population
- temperature was regridded using an elevation correction to the 1 km ISOPOP raster before aggregating





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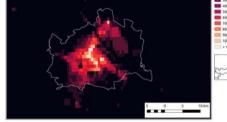
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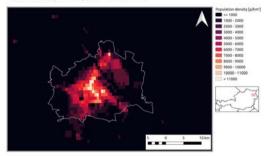
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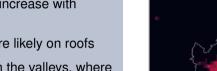


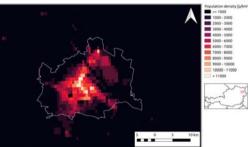
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Motivation Data set Variables Conclusion
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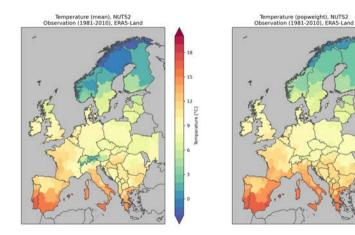


Population density in the region of Vienna (ISOPOP)



arithmetic mean vs. population weighting

Motivation	Data set	Variables	Conclusion	-





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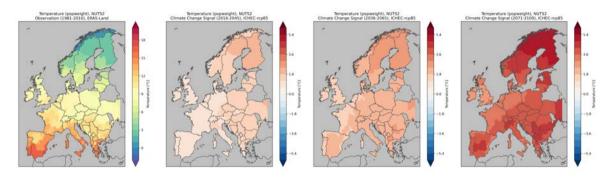
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Temperature **RCP 8.5 - population weighted**



Meteorology and



Global radiation

RCP 8.5 - population weighted

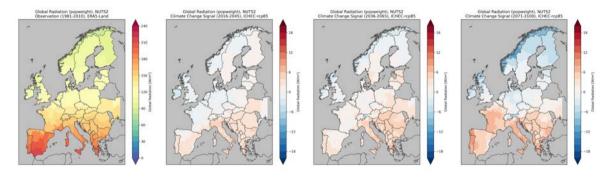


Motivation

set

Variables

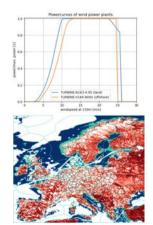
Conclusior





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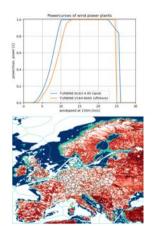
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- for onshore and offshore representative turbine types were choosen
- the normalized power was calculated by applying the power curves
- weights for aggegating are the fraction of suitable area for wind power plants





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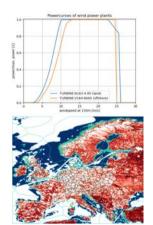
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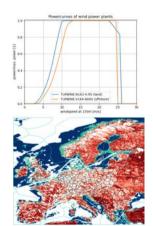
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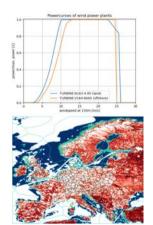
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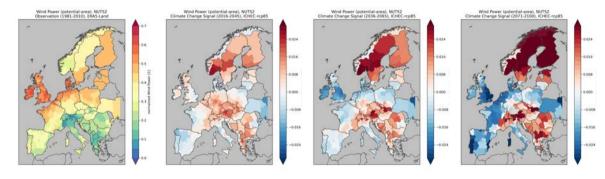
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Wind power onshore RCP 8.5 - potential area



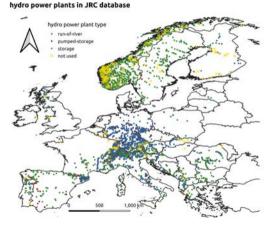
Meteorology and





hydro power plant data: JRC data base

Variables

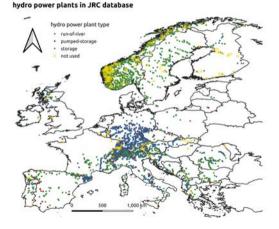




 hydro power plant data: JRC data base
 river discharge data (*Q*): SMHI eHYPE (ERA5 and ICHEC-RACMO22E driven)

Variables

- **assumption**: $P = s_0 Q$
- however hydro plants have got limited capacity P_{max} and cut-off runoff Q_{max=}Q(P_{max}) is unknown
- Q_{max} can be estimated in an iterative process
- if annual production is unknown, representative full load hours for each country are assumed

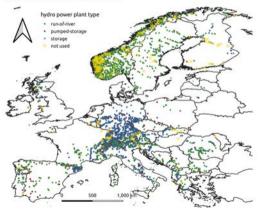




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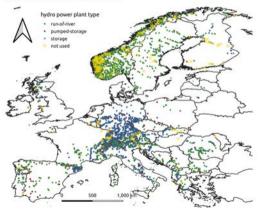


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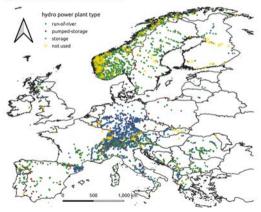




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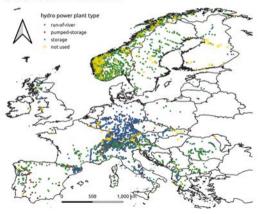




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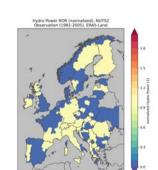
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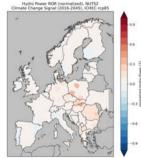


Hydro power from run-of-river plants **BCP 8.5** - normalized

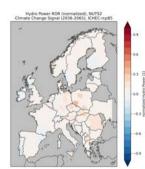


Meteorology and





Variables



Hydro Power ROR (normalized), NUT52 Climate Change Signal (2071-2100), ICHEC-rcp85 03 E 00 -0.3 \$ -0.6

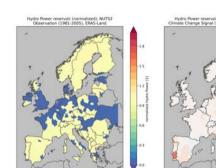
-0.3 8

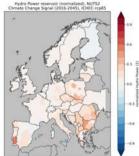
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Hydro power from reservoirs **BCP 8.5** - normalized

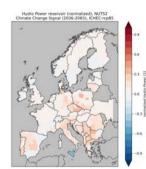


Meteorology and





Variables



Hydro Power reservoir (normalized), NUTS2 Climate Change Signal (2071-2100), ICHEC-rcp85 03 = 00 -0.3 \$ -0.6

Extreme heat

Maximum temperature

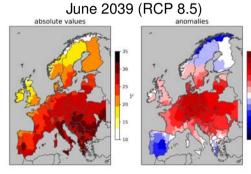


Motivation

Variables

Conclusion

Monthly mean maximum temperature



Anomalies	Austria	Europe
T [℃]	5.3	4.0
Tmax [°C]	6.3	4.4
Tmin [℃]	4.0	3.4
WP [%]	56.3	95.5
WP offshore [%]	-	92.1
Radiation [%]	120.1	110.6
HP [%]	58.2	107.5

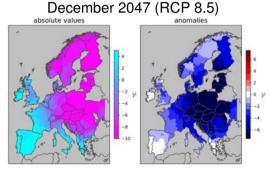
Dark doldrum (extreme cold)

Minimum temperature



Monthly mean minimum temperature

Variables



Anomalies	Austria	Europe
T [℃]	-5.1	-3.3
Tmax [°C]	-5.0	-3.6
Tmin [℃]	-5.5	-2.9
WP [%]	117.1	90.0
WP offshore [%]	-	94.3
Radiation [%]	98.3	93.7
HP [%]	78.8	142.7

Motivation Data set Variables Error modelling the energy system of

BCKU MET Institute of Meteorology and Climatelogy

-	For modelling the energy system of Europe long-term, high quality climate data for the past and future is required

Conclusion

Con	clusions			
ivation	Data set	Variables	Conclusion	
	•		tem of Europe long- future is required	term, high quality
	 We created a purpose 	comprehensive	e data set specificall	y designed for this
	The data will be a state of	pe made availat	ole to the communit	y in 2023

An European wide meteorological data set suitable for electricity modelling

Con	clusions			BOX
Motivation	Data set	Variables	Conclusion	
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An European wide meteorological data set suitable for electricity modelling

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Thank you! Any questions?



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