wege entstehen, indem wir sie gehen
paths emerge in that we walk them

Wegener Center
www.wegcenter.at

Regional and Local Climate Modeling Research Group
ReLoClim

STARC-Impact:
Prozessbasierte Evaluierung der ÖKS15 Klimaszenarien

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1) Wegener Center für Klima und Globalen Wandel, Karl-Franzens Universität Graz

2) ZAMG, Abteilung Klimaforschung

3) BOKU Wien, Institu für Meteorologie

Klimatag @ Uni Wien, 24. Mai 2017

powered by klima+energie fonds

Outline

1. Von *ÖKS15* zu *STARC-Impact*

2. Teil I: Validierung Beobachtungsdaten

3. Teil II: Validierung von ÖKS15 Szenarien

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UNI GRAZ

1) Factsheets

- Klimaänderung für das 20. und 21. Jhd mit **neuesten Klimamodellen** und **Beobachtungsdaten**
- für jedes Bundesland
- für relevante Indizes (Kühltage, Hitzewellen, …)
- probabilistische Unsicherheitsanalyse

2) ÖKS15 Szenarien

- **Zugrundeliegende Daten**: 13 state-of-the-art **regionale Klimamodelle (RCMs)** aus EURO-CORDEX - **12.5 km**
- **Post-prozessiert**: Downgescaled und Bias-korrigiert - **1 km**
- Täglicher **Niederschlag**, **Temperatur** (mean/min/max), **Globalstrahlung**
- Seit 2017 auf CCCA Server frei für Forschungszwecke verfügbar

New STARC-Impact feature!

- Kommt hinzu: PET, RCP2.6, neue CORDEX runs, MEDCORDEX

Was gebraucht wird:

1. Ausformulierung der **Grenzen** der Anwendung der ÖKS15 Szenarien
2. **Richtlinien** für Österreichische Forschungscommunity
3. **Verbinden der User und Experten** für Datenverwendung (z.B. FRECH Workshops)

Die großen Fragen:

heutiger Fokus

- Welchen Einfluß haben **Defizite von RCMs** und **Beobachtungen** auf die **Qualität der post-prozessierten** ÖKS15 Szenarien?
- Wie wirken sich diese Defizite auf **Klima-Impact-Modelle** aus?
- Was sind die Anforderungen der Impact-Modelle auf deren Antriebsdaten für **valide Schlußfolgerungen zum Klimawandel**?

Teil I: Validierung von Beobachtungsdaten

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Ziele

- Quantifizierung von Verlässlichkeit und Unsicherheit der räumlichen Klimabeobachtungsdatensätze in ÖKS15
- Grundlage für brauchbare Richtlinien für Anwender

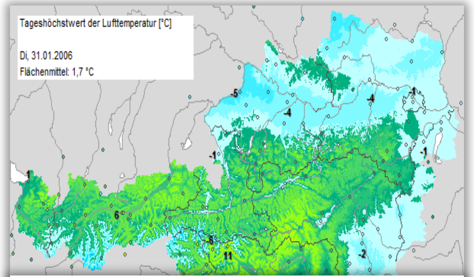
Datensätze

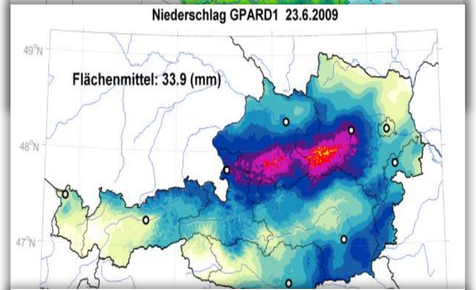
- SPARTACUS: Lufttemperatur **T**, täglich 1961–2011
- G-PARD1: Niederschlagssumme **RR**, täglich 1961–2011
- APOLIS: Globalstrahlung **G**: täglich 1981–2011
- ARET: Evapotranspiration **E**, täglich 1961–2011

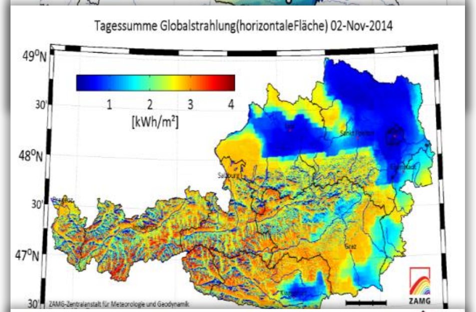
Advisory Meeting

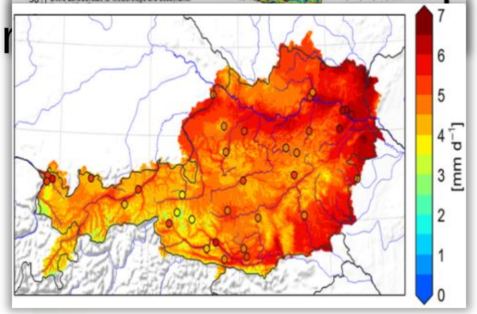
Wien, 12./13.01.2017, Dr. Christoph Frei (MeteoSchweiz, ETH Zür

→ Evaluierungskonzept









Validierung der Beobachtungen

1.	Klärung der unterschiedlichen Fehlerquellen	T RR G E	Literatur, qualitativ	×
Fehler als Punktwert:				
2.	Fehler am Gitterpunkt	T RR G	X-Val., Fehlerstatistiken, Stratifizierung, Indizes	✓
3.	Konditionaler Bias	T RR	X-Val., in Abhängigkeit der Verteilung	✓
4.	Unabhängige Stationsdaten	G	unabhängige Globalstrahlungsreihen	×
5.	Langzeitstabilität	T RR G	X-Val., Trends aus Messung vs. Interpolation	✓
6.	Räumliche Fehlerkarten	T RR G	X-Val., in Abhängigkeit von gg. Variablen	✓
Räumliche Skalenabhängigkeit des Fehlers:				
7.	Evaluierung gegen WegenerNet	RR	in Abhängigkeit der Skala	×
8.	Vergleich mit INCA	T RR G E	illustrative Fälle	×
9.	Vergleich mit E-OBS	T RR	illustrative Fälle	×
10.	Ensemble-Datensatz	RR	in Abh. d. Niederschlagsmenge als Fkt. d. Skala	✓
11.	Exemplarisch Interpretationsfehler zeigen	T RR G E	mithilfe der Punkte 7–10	×
Qualitative Beurteilung				
12.	Experts judgement	G	qualitativ, Einzelmessungen	×

Teil II: Validierung von ÖKS15 Szenarien

Warum prozessbasierte Evaluierung?

ÖKS15 Daten **im klimatologischen Schnitt 0 Bias**, warum also

Heutiges Ziel:

1. Finde Wettertypen (WT) und somit die **treibenden Prozesse für Niederschlag**
2. **Evaluiere Niederschlag** der ÖKS15 Szenarien basierend auf WT

kleinskaliger Prozess

Precip	T (nass WT)	H (sonnig WT)
PR_{obs}	10 mm/d	0 mm/d

großskaliger Prozess

freq	T (nass WT)	H (sonnig WT)		Klima
X_{obs}	10%	90%	PR_{obs} X_{obs}	1 mm/d

falsches Verhalten im WT

zugrundeliegende Prozesse zu unterschiedlich

Qualität der **Bias-Korrektur** ⟺ Qualität der **physiklischen Prozesse** zugrundeliegender RCMs/GCMs

⟹ **ÖKS15 Qualität**

Wettertypen Durchschnittliche Lagen

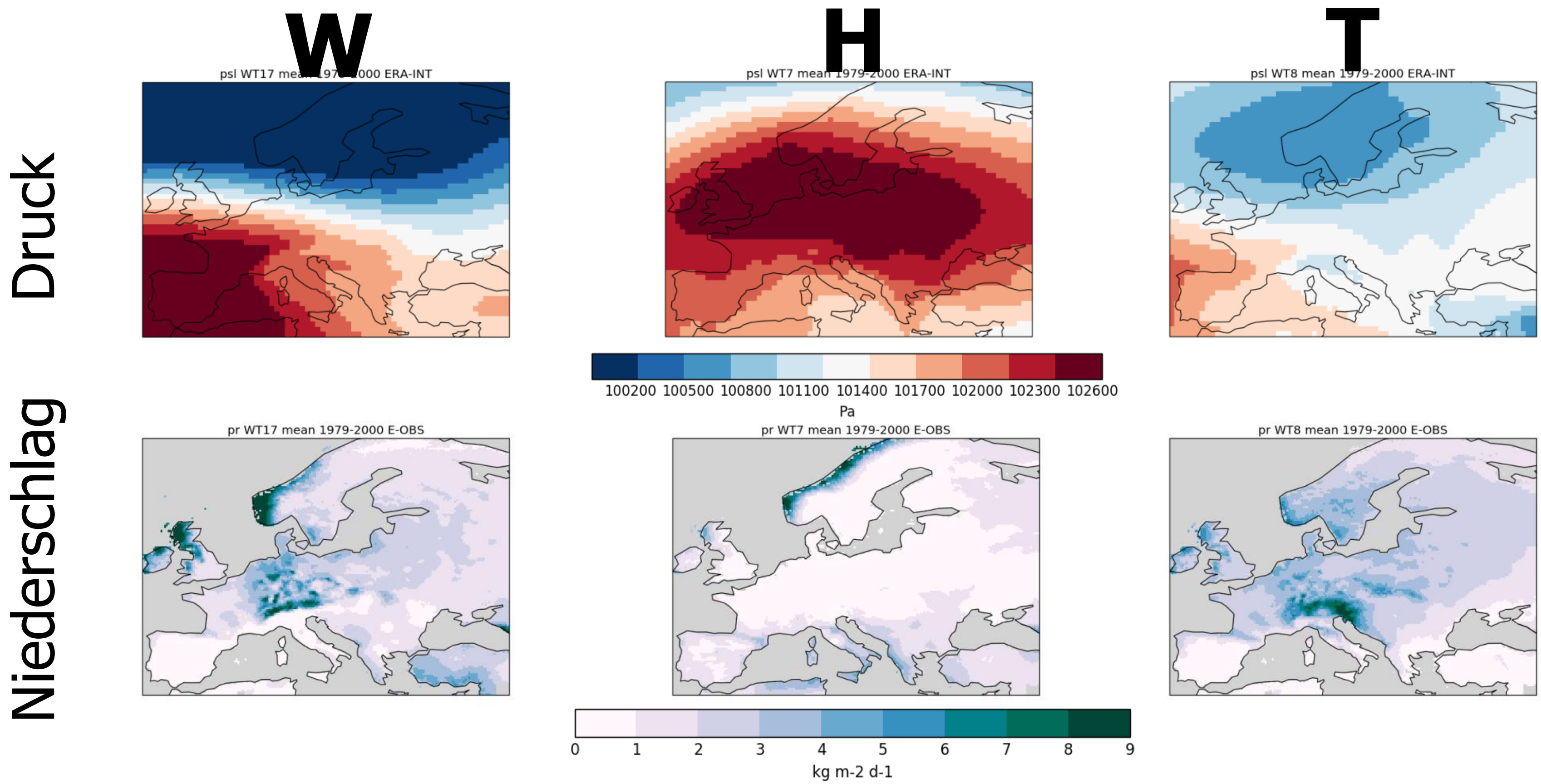
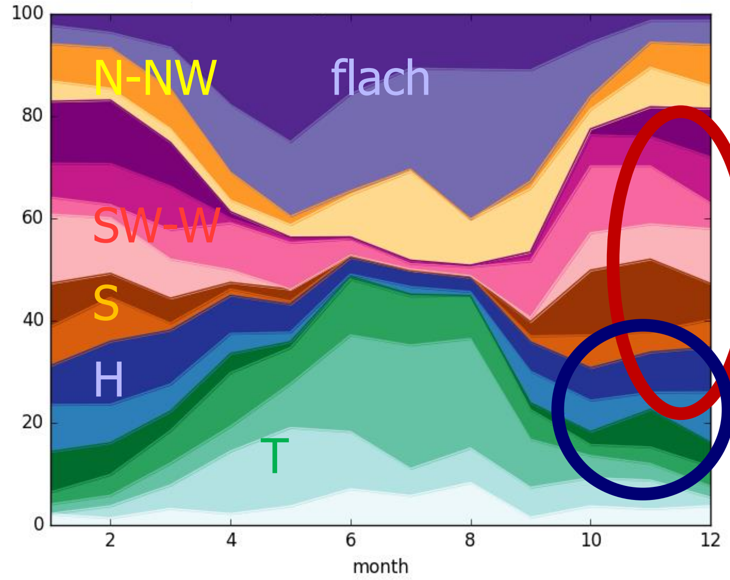


Bild: Durchschnittliche Druckfelder (ERA-INT) und dazugehörige Niederschlagsfelder (E-OBS).

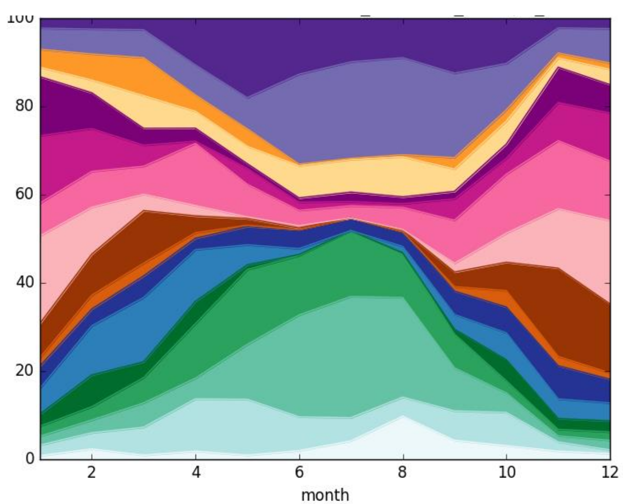
Beobachtung & RCMs

ERA-INT

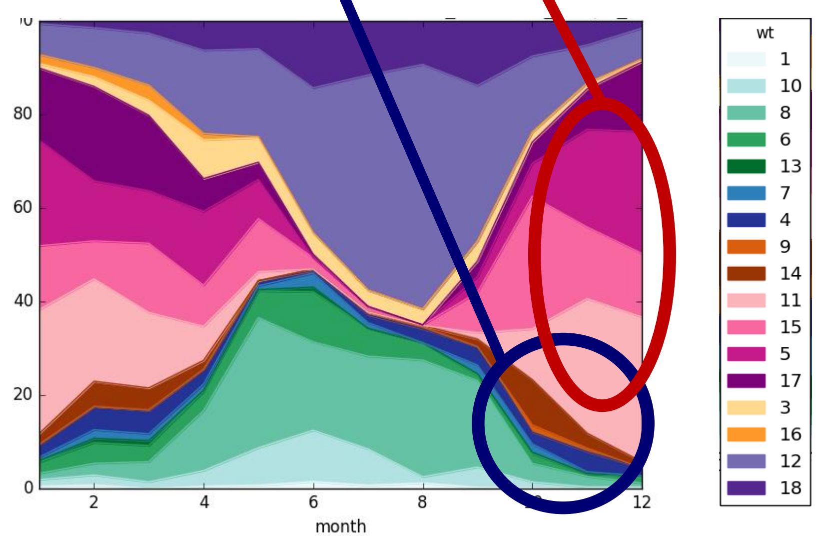


- Häufigkeit von 18 WT (1979-2005)
- **W** überrepräsentiert („+“ pr bias)
- **H** unterrepräsentiert („+“ pr bias)
- Grund für Niederschlagsbias:
  - Bias der atmosphärischen Zirkulation,
  - dieser großskalige Bias wird nicht korrigiert!

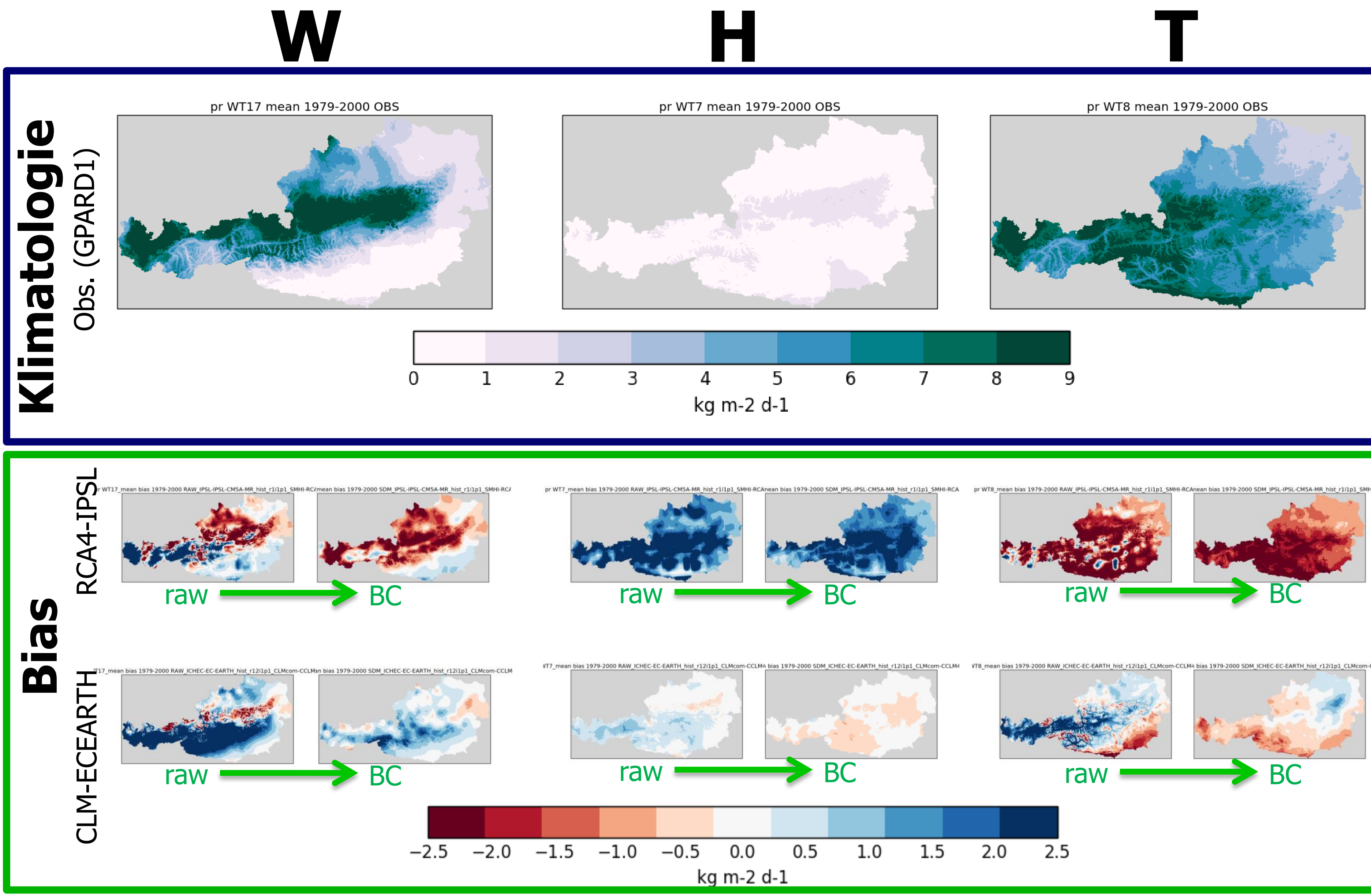
CLM EC-EARTH



RCA4 IPSL-CM5A



Process-based Bias Precipitation of ÖKS15



Zusammenfassung

Ziel:

- **Richtlinien** für ÖKS15-Daten Benutzer
- Dafür notwendig:
  - Validierung der **Beobachtungsdaten** *(ZAMG)*
  - Prozessbasierte Evaluierung der **ÖKS15 Zukunftsszenarien** *(WEGC)*
  - Vergleich von Beobachtung und Szenarien für **Beispiel-Impactmodell** *(BOKU)*

Messages:

- Zugrundeliegende RCMs stellen **physikalische Prozesse gut** dar → bias-korrigierte ÖKS15 Szenarien valide
- ... trotzdem noch viel zu evaluieren (z.B. effektive Auflösung); wo sind die **Grenzen**?
- ÖKS15: **wissenschaftlich wertvoll** und international Vorreiterdatensatz

Danke für die Aufmerksamkeit

Evaluation of WTs

- SST = SSW + SSB
- → SSB/SST = 1 - SSW/SST … explained Variance in [0,1]
  - Good clustering → SSB large (WTs far apart)
  - and/or → SSW small (weather in WTs similar)

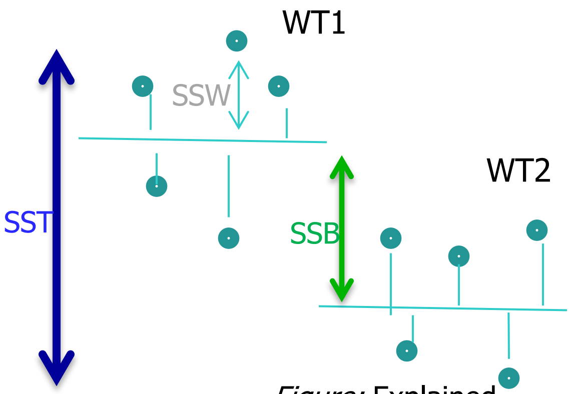


Figure: Explained Variance (EV)

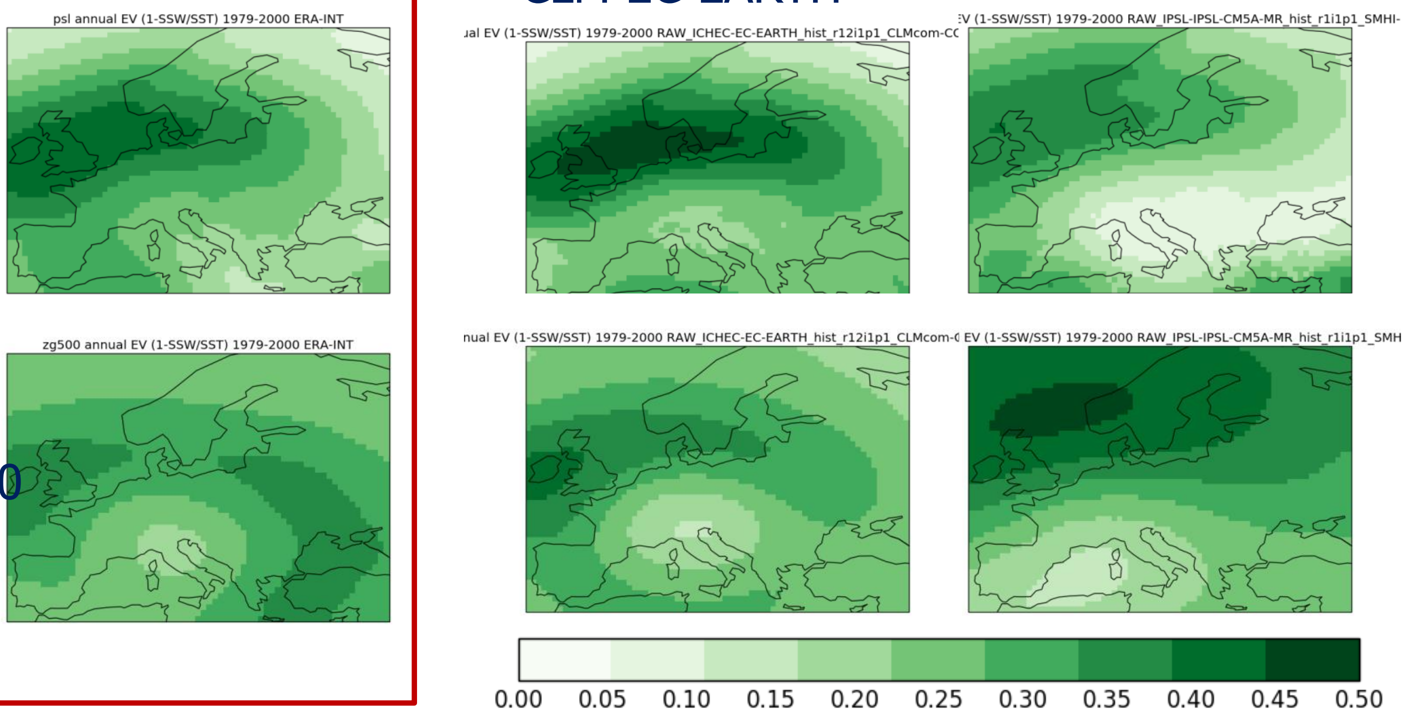
ERA-INT

CLM EC-EARTH

RCA4 IPSL-CM5A

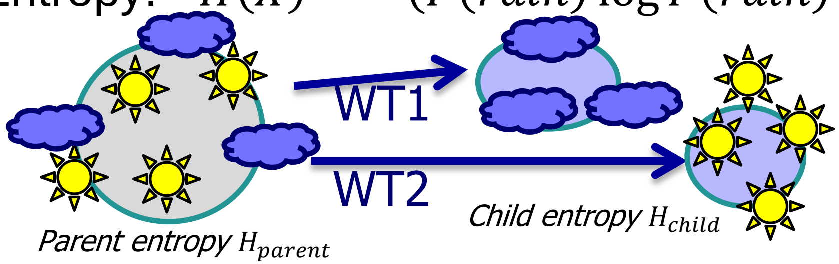
PSL

ZG500



Weather Type performance Precipitation

- Entropy as information („***surprisal***“) of precip event $X \in \{rain, sun\}$
- Entropy: $H(X) = -(P(rain)\log P(rain) + P(sun)\log P(sun))$,



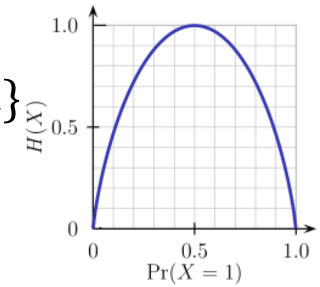


Figure: Entropy curve

- ***Entropy gain***: $H_{gain} = 1 - \frac{mean(H_{child})}{H_{parent}} \in [0,1]$
  0 … $P(rain)$ within WTs same as in annual climatology (no information gain)
  1 … $P(rain) \in \{0,1\}$, perfect classification

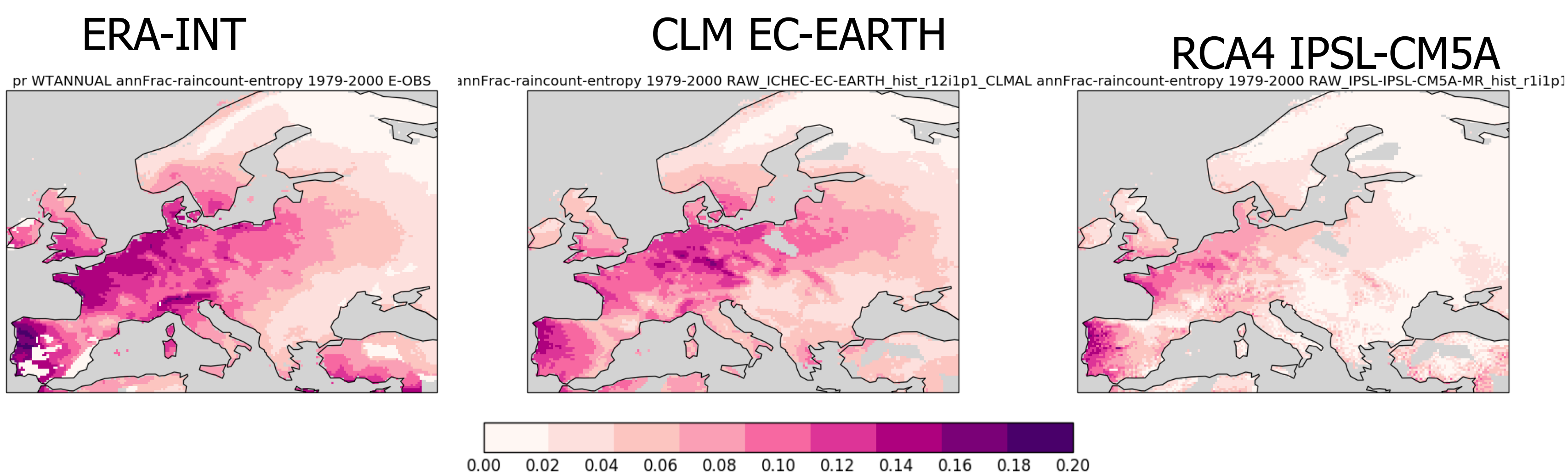
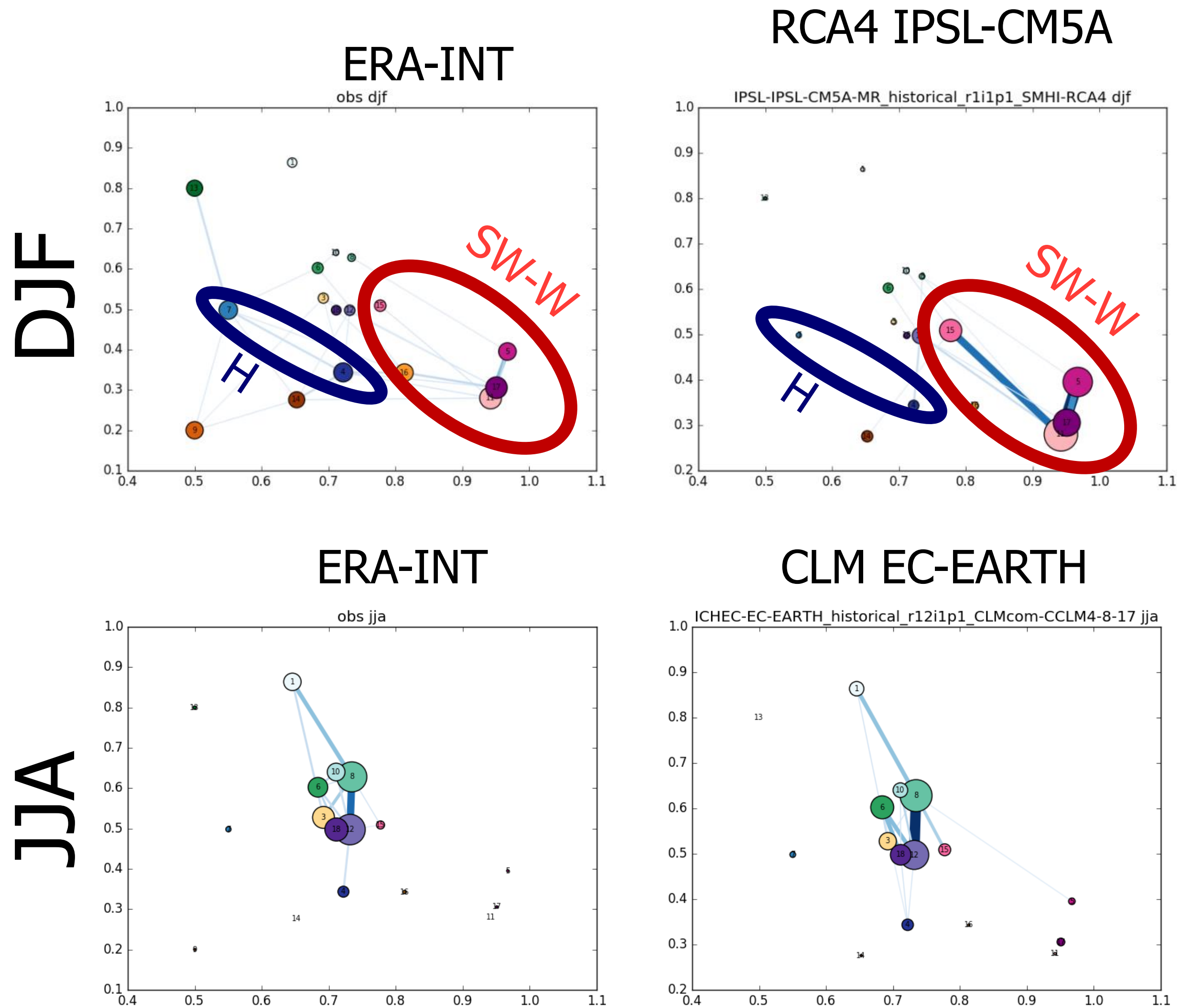


Figure: Entropy gain for rainday prediction.

Weather Type performance

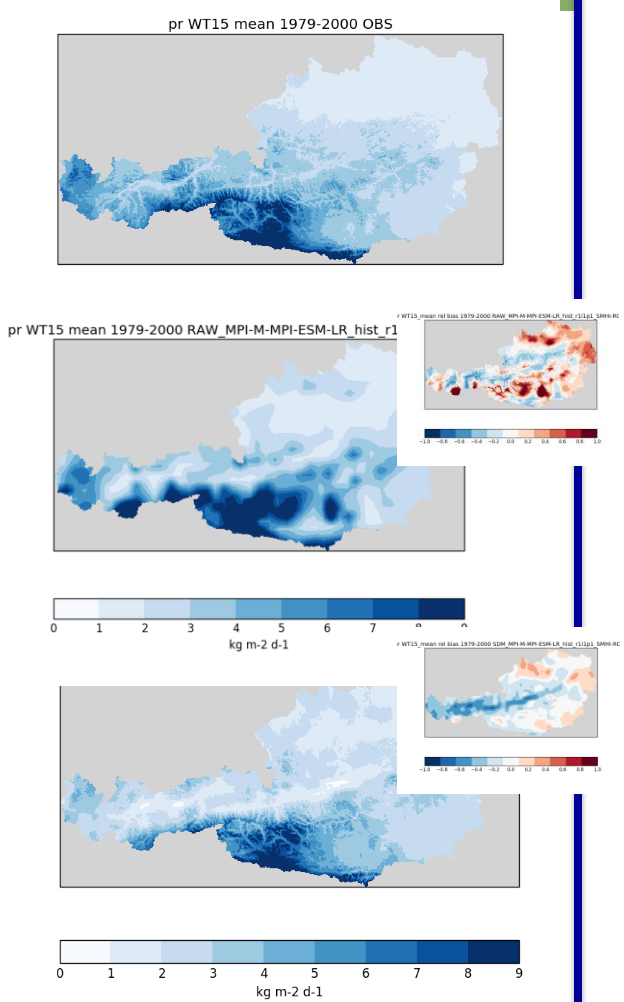
- Close nodes (WTs) more similar
- Thick *blue edges*: frequent WT transition
- *Big nodes*: High persitence of WT



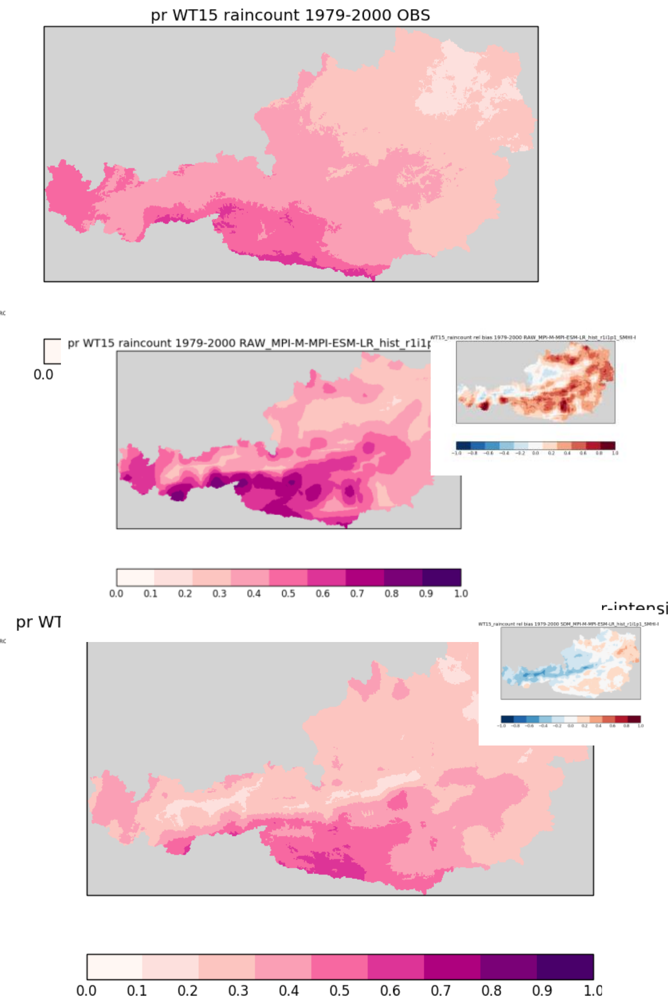
- ***DJF***: RCMs different behavior than ERA
- ***JJA***: RCMs smaller WT biases

Biases - SW

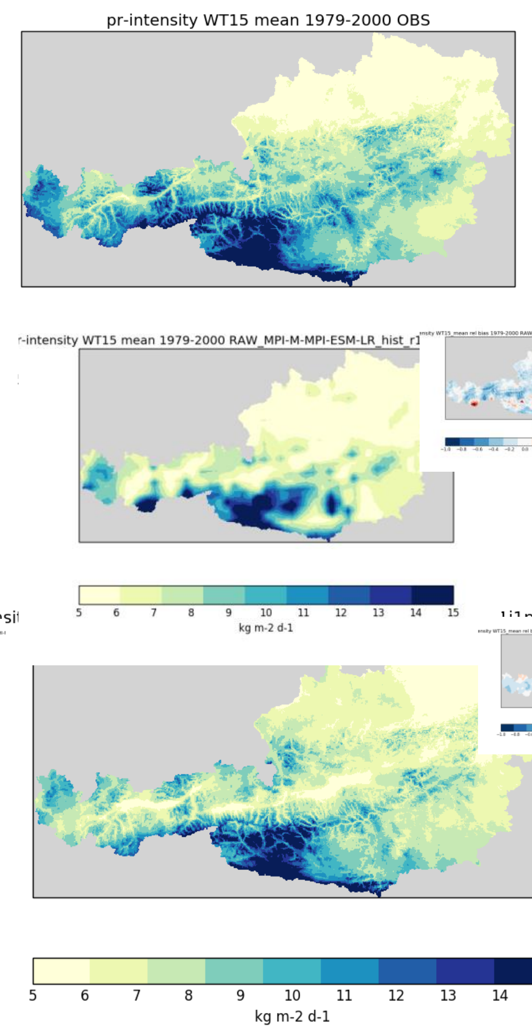
mean



#raindays



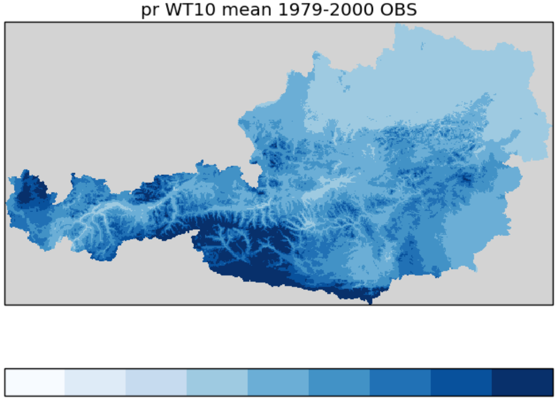
intensity



Climatology OBS

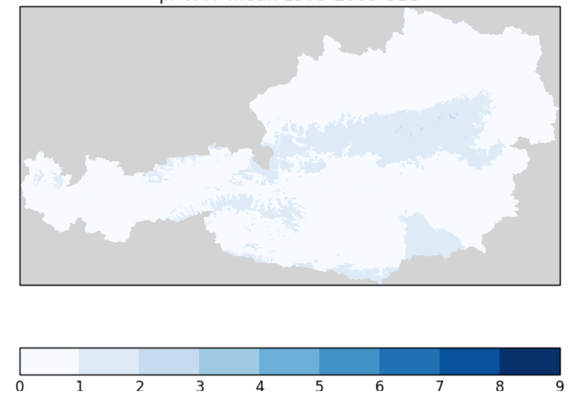
L

pr WT10 mean 1979-2000 OBS

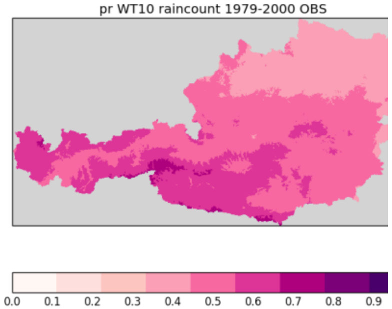


H

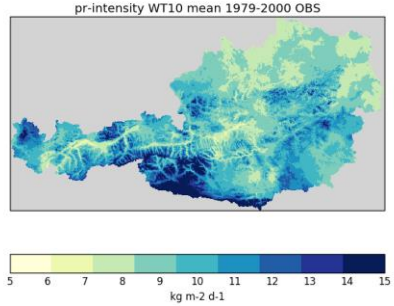
pr WT7 mean 1979-2000 OBS



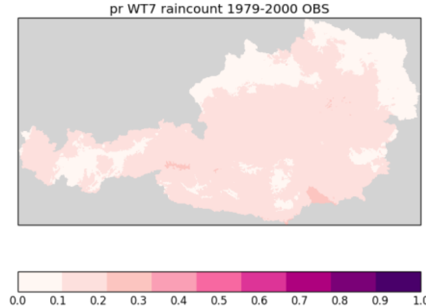
pr WT10 raincount 1979-2000 OBS



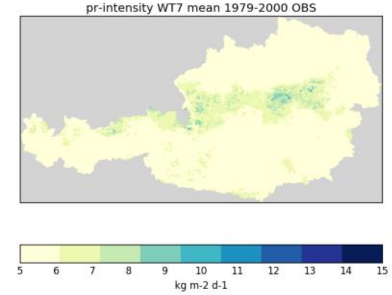
pr-intensity WT10 mean 1979-2000 OBS



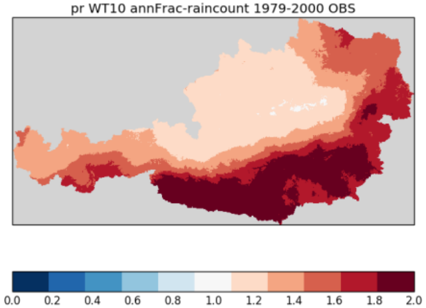
pr WT7 raincount 1979-2000 OBS



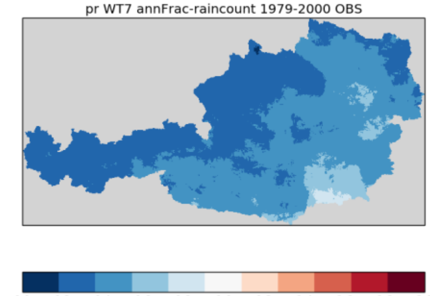
pr-intensity WT7 mean 1979-2000 OBS



pr WT10 annFrac-raincount 1979-2000 OBS



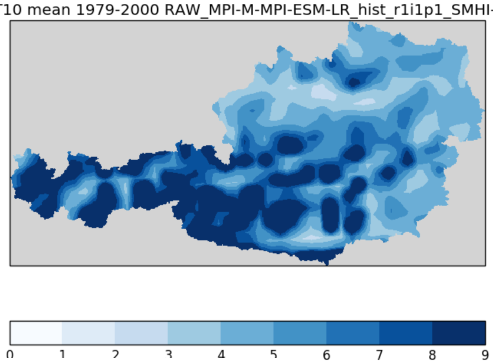
pr WT7 annFrac-raincount 1979-2000 OBS



Climatology RCM

L

pr WT10 mean 1979-2000 RAW_MPI-M-MPI-ESM-LR_hist_r1i1p1_SMHI-RCA4



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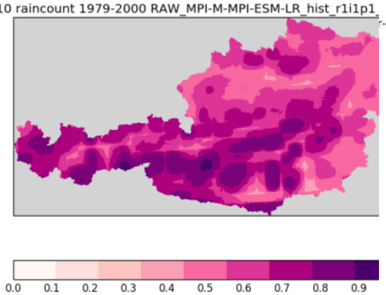
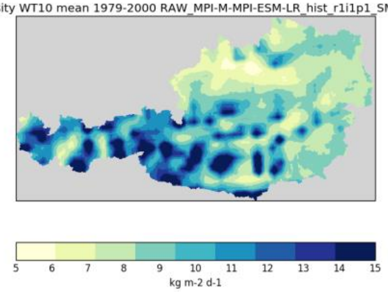


-intensity WT10 mean 1979-2000 RAW_MPI-M-MPI-ESM-LR_hist_r1i1p1_SMHI-R



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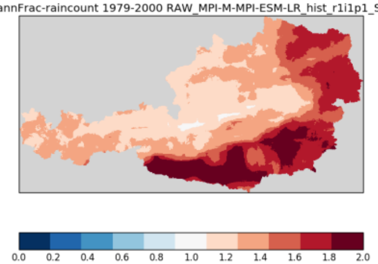

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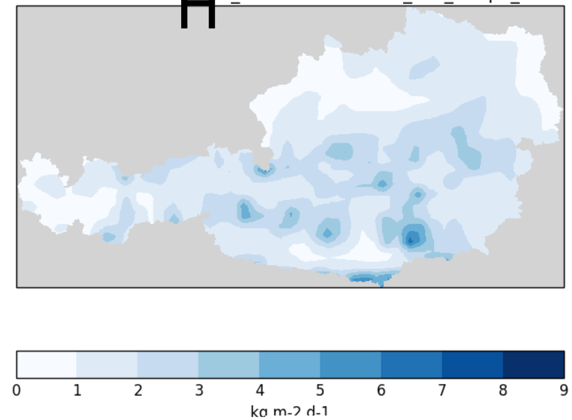

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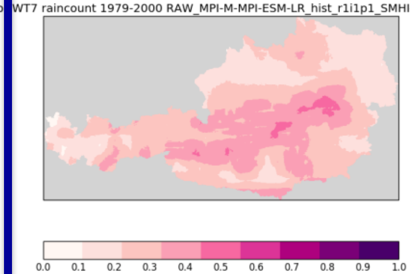

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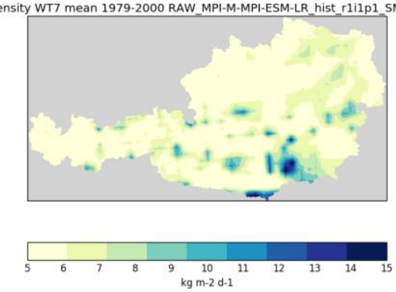
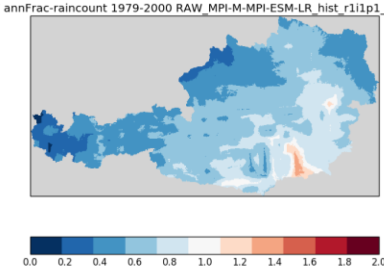


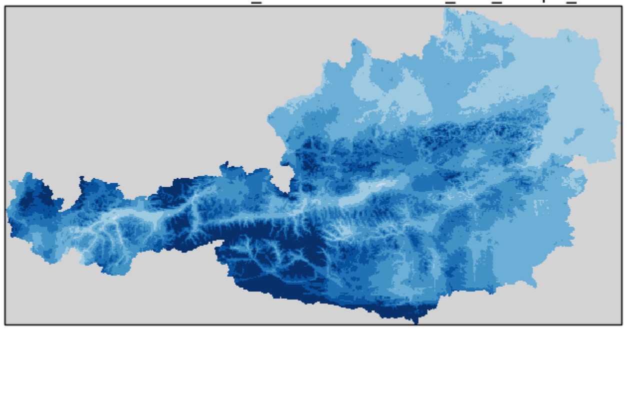
WT7 annFrac-raincount 1979-2000 RAW_MPI-M-MPI-ESM-LR_hist_r1i1p1_SMHI-F



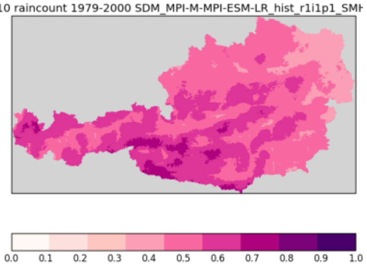
Climatology BC

L

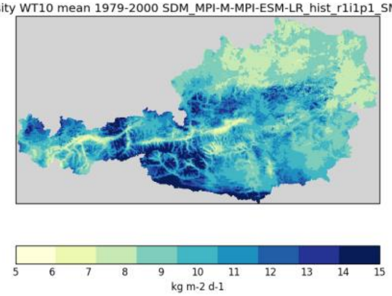
pr WT10 mean 1979-2000 SDM_MPI-M-MPI-ESM-LR_hist_r1i1p1_SMHI-RCA4



pr WT10 raincount 1979-2000 SDM_MPI-M-MPI-ESM-LR_hist_r1i1p1_SMH



r-intensity WT10 mean 1979-2000 SDM_MPI-M-MPI-ESM-LR_hist_r1i1p1_SMHI-R



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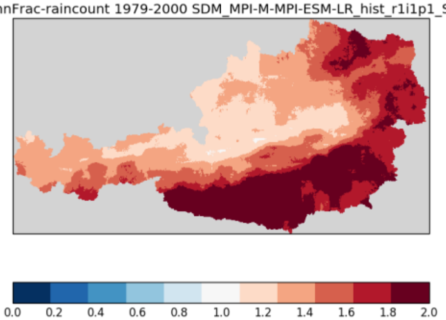

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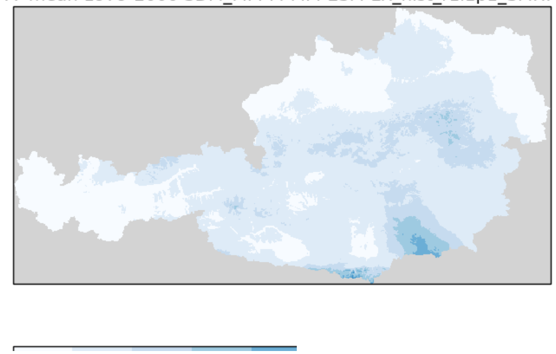

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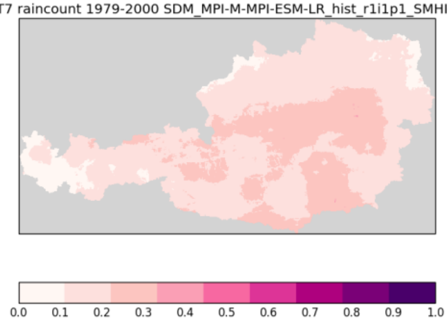
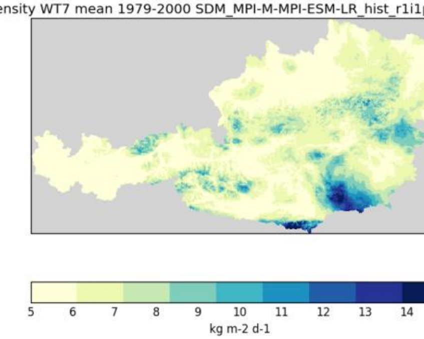


r-intensity WT7 mean 1979-2000 SDM_MPI-M-MPI-ESM-LR_hist_r1i1



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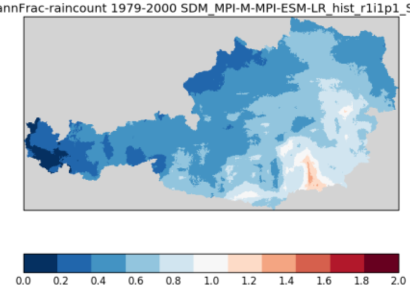
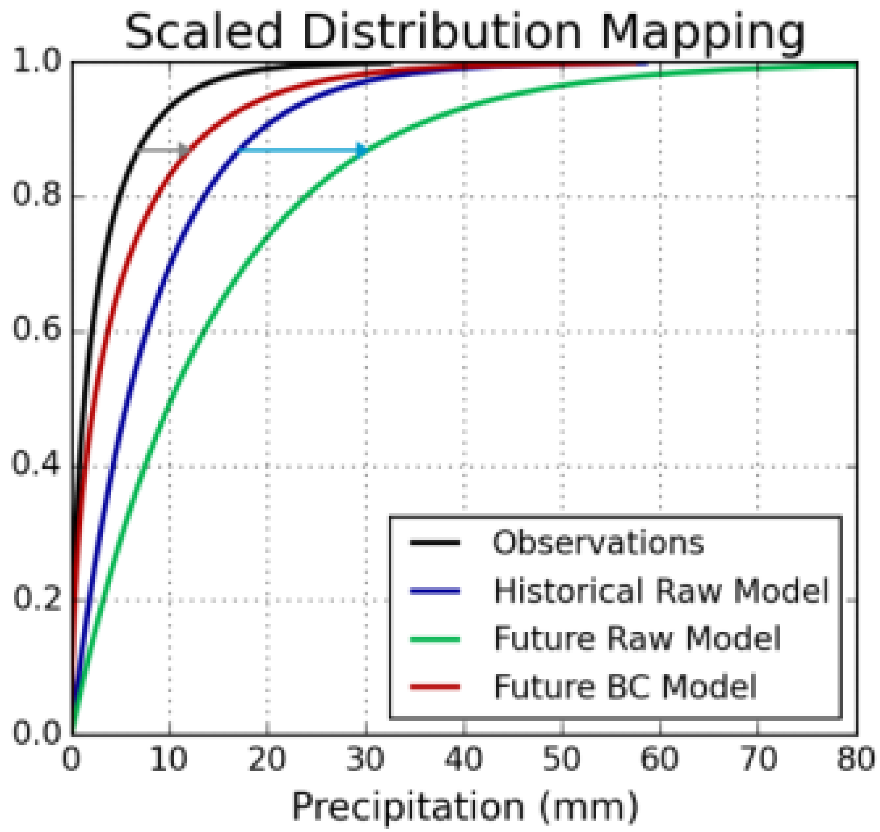


Projected climate change

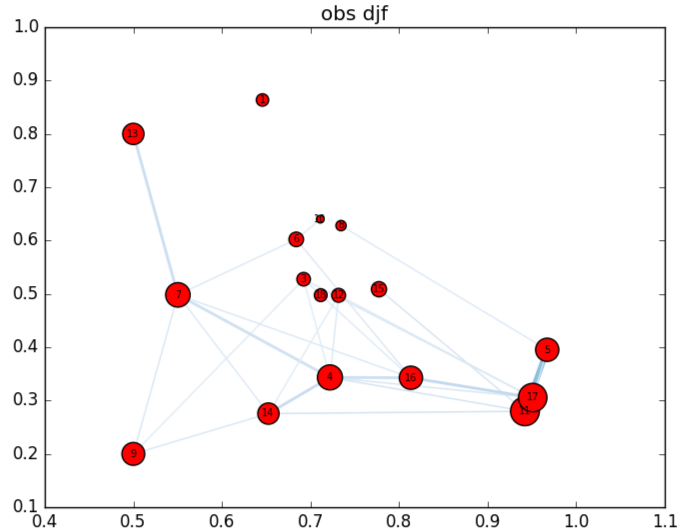


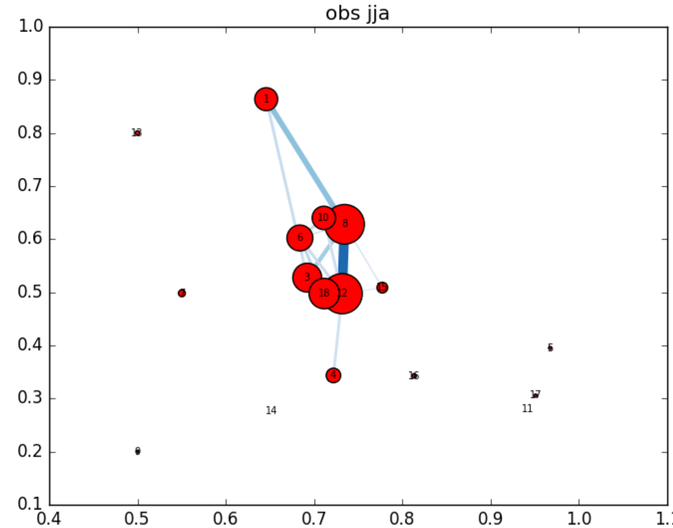
Frequencies + transitions

DJF

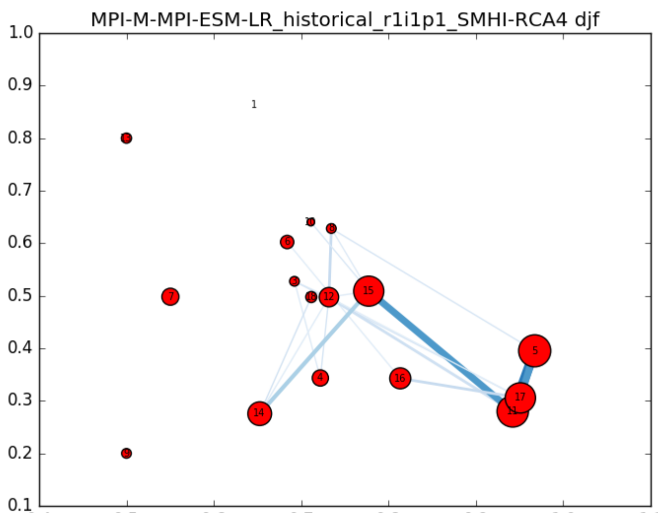
JJA

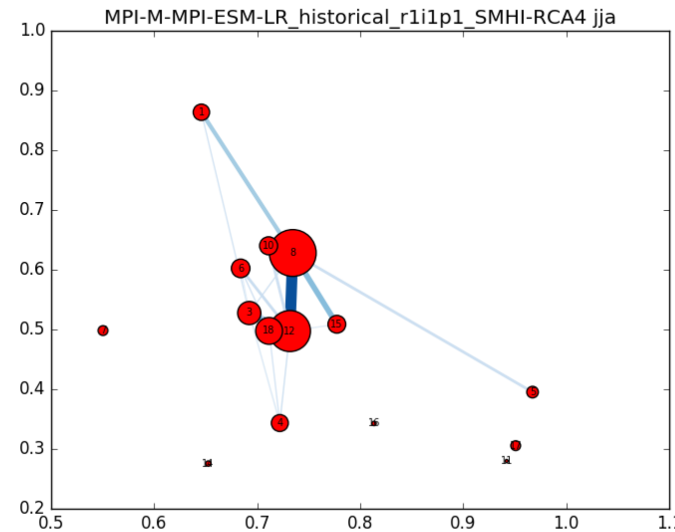
Obs

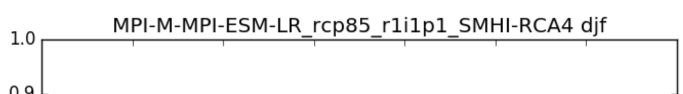


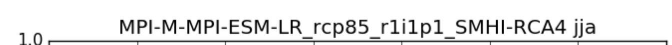


rcial









Why Processed-based evaluation?

Wegener Center
www.wegcenter.at

UNI GRAZ

- Why process-based eval (because statistically trivially 0 bias)
  - Limitations of datasets
  - Can we trust the data?
  - Are biases related to WTs? Is bias altered after BC? → impact on CCS
  - BC est no causality between distributions, WTs here to establish causality of pr (BC should map spatially and phys corr distr to each other, else baaaaad (but BC is brainless))
- About bias
  - 1) Large-scale biases (circulations)
  - 2) Biases on PBL (tas, pr) (orographic…)
  - „Marginal“ bias is sum of 1) and 2)
  - → BC corrects marginal bias (Ax = By)
  - large scale wrong (diff WT distr/spatial misplace) → small scale wrong
  - → we check on large scale biases and biases given WTs (small scale?)
  - Argue that BC makes only sense if underlying phys processes (large scale) modelled adequately (x should be similar to y)
- Idea of Ax = By after BC →
  - x,y unchanged, if similar, then maybe brainless BC does the right thing, A might be close to B
  - If comletely different, might get worse (conditioned on WT)

→BC should not make bias|Wt worse (physical consitsency)