

Relations of ClimEx to CORDEX and other large ensembles



Presentation by
Fabian von Trentini (LMU)



Bavarian Environment
Agency



INRS
UNIVERSITÉ DE RECHERCHE

Centre d'expertise
hydrique
Québec

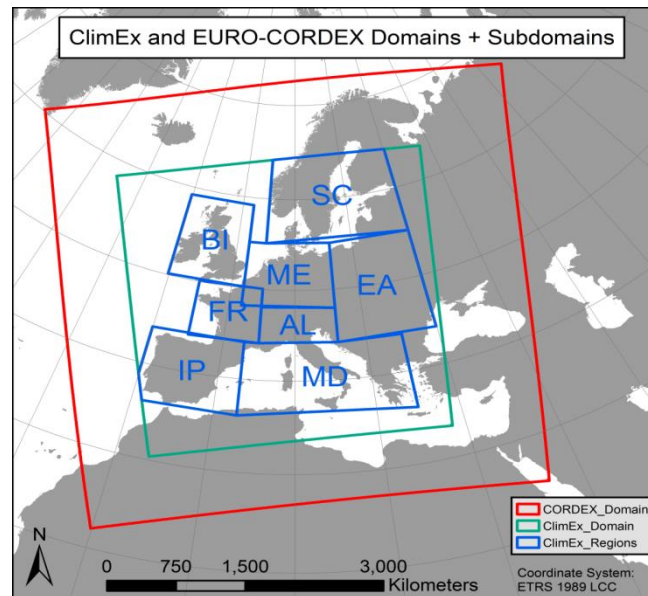


Leibniz-Rechenzentrum
der Bayerischen Akademie der Wissenschaften

gefördert durch
Bayerisches Staatsministerium für
Umwelt und Verbraucherschutz



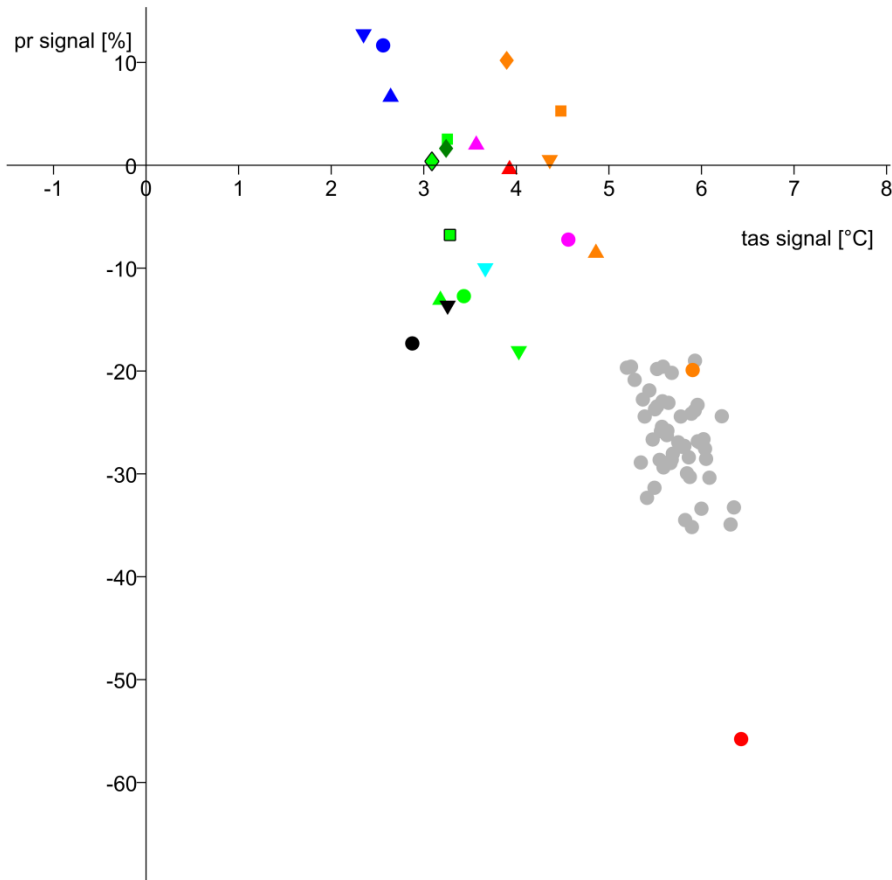
CRCM5-LE versus EURO-CORDEX



How are CRCM5 summer signals comparing to CORDEX?

Relative signals of precipitation and temperature in 2070-99 compared to 1980-2009

Summer signals of the CORDEX models (ME)



- CCCma-CanESM2_r1i1p1_CLMcom-CCLM4-8-17
- ▲ CCCma-CanESM2_r1i1p1_GERICS-REMO2015
- CNRM-CERFACS-CNRM-CM5_r1i1p1_CLMcom-CCLM4-8-17
- ▼ CNRM-CERFACS-CNRM-CM5_r1i1p1_SMHI-RCA4
- ▲ CNRM-CERFACS-CNRM-CM5_r1i1p1_GERICS-REMO2015
- ICHEC-EC-EARTH_r12i1p1_CLMcom-CCLM4-8-17
- ◆ ICHEC-EC-EARTH_r3i1p1_DMI-HIRHAM5
- ICHEC-EC-EARTH_r1i1p1_KNMI-RACMO22E
- ▼ ICHEC-EC-EARTH_r12i1p1_SMHI-RCA4
- ICHEC-EC-EARTH_r12i1p1_KNMI-RACMO22E
- ▲ ICHEC-EC-EARTH_r12i1p1_GERICS-REMO2015
- ▼ IPSL-IPSL-CM5A-MR_r1i1p1_SMHI-RCA4
- MIROC-MIROC5_r1i1p1_CLMcom-CCLM4-8-17
- ▲ MIROC-MIROC5_r1i1p1_GERICS-REMO2015
- MOHC-HadGEM2-ES_r1i1p1_CLMcom-CCLM4-8-17
- MOHC-HadGEM2-ES_r1i1p1_KNMI-RACMO22E
- ▼ MOHC-HadGEM2-ES_r1i1p1_SMHI-RCA4
- ◆ MOHC-HadGEM2-ES_r1i1p1_DMI-HIRHAM5
- ▲ MOHC-HadGEM2-ES_r1i1p1_GERICS-REMO2015
- MPI-M-MPI-ESM-LR_r1i1p1_CLMcom-CCLM4-8-17
- ▼ MPI-M-MPI-ESM-LR_r1i1p1_SMHI-RCA4
- ◆ NCC-NorESM1-M_r1i1p1_DMI-HIRHAM5
- 50 CRCM5-LE members

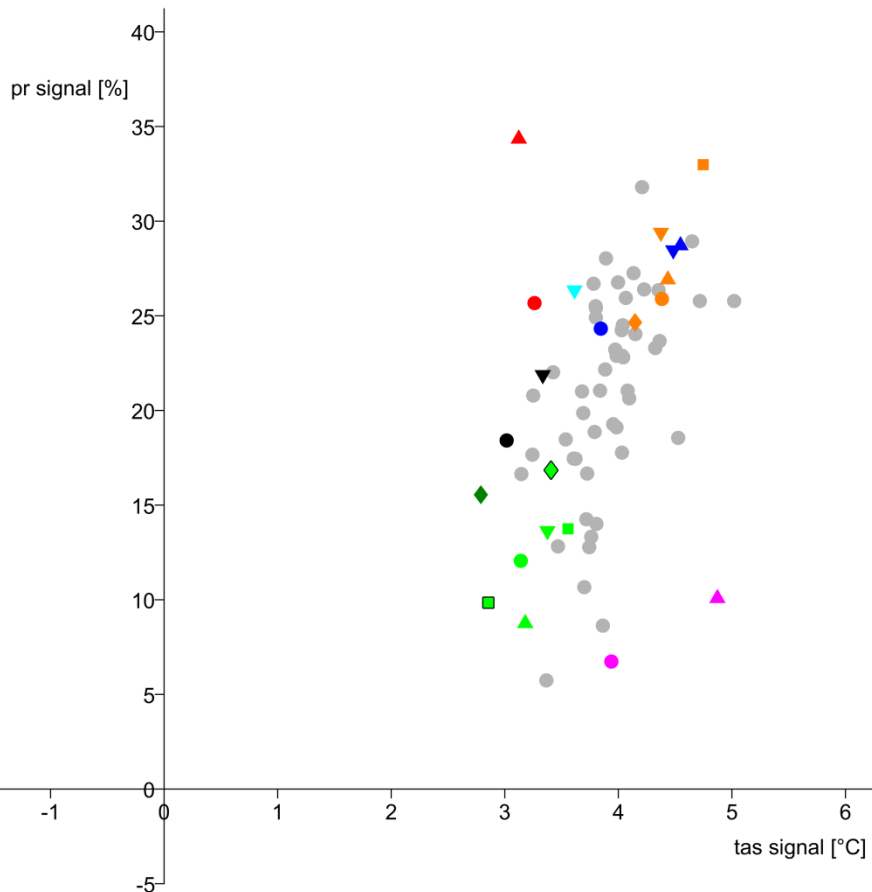
- CRCM5-LE is among the warmer and drier models
- Internal Variability is smaller than model uncertainty

von Trentini et al 2019

How are CRCM5 winter signals comparing to CORDEX?

Relative signals of precipitation and temperature in 2070-99 compared to 1980-2009

Winter signals of the CORDEX models (ME)



- CCCma-CanESM2_r1i1p1_CLMcom-CCLM4-8-17
- ▲ CCCma-CanESM2_r1i1p1_GERICS-REMO2015
- CNRM-CERFACS-CNRM-CM5_r1i1p1_CLMcom-CCLM4-8-17
- ▼ CNRM-CERFACS-CNRM-CM5_r1i1p1_SMHI-RCA4
- ▲ CNRM-CERFACS-CNRM-CM5_r1i1p1_GERICS-REMO2015
- ICHEC-EC-EARTH_r12i1p1_CLMcom-CCLM4-8-17
- ◆ ICHEC-EC-EARTH_r3i1p1_DMI-HIRHAM5
- ICHEC-EC-EARTH_r1i1p1_KNMI-RACMO22E
- ▼ ICHEC-EC-EARTH_r12i1p1_SMHI-RCA4
- ICHEC-EC-EARTH_r12i1p1_KNMI-RACMO22E
- ▲ ICHEC-EC-EARTH_r12i1p1_GERICS-REMO2015
- ▼ IPSL-IPSL-CM5A-MR_r1i1p1_SMHI-RCA4
- MIROC-MIROC5_r1i1p1_CLMcom-CCLM4-8-17
- ▲ MIROC-MIROC5_r1i1p1_GERICS-REMO2015
- MOHC-HadGEM2-ES_r1i1p1_CLMcom-CCLM4-8-17
- MOHC-HadGEM2-ES_r1i1p1_KNMI-RACMO22E
- ▼ MOHC-HadGEM2-ES_r1i1p1_SMHI-RCA4
- ◆ MOHC-HadGEM2-ES_r1i1p1_DMI-HIRHAM5
- ▲ MOHC-HadGEM2-ES_r1i1p1_GERICS-REMO2015
- MPI-M-MPI-ESM-LR_r1i1p1_CLMcom-CCLM4-8-17
- ▼ MPI-M-MPI-ESM-LR_r1i1p1_SMHI-RCA4
- ◆ NCC-NorESM1-M_r1i1p1_DMI-HIRHAM5
- 50 CRCM5-LE members

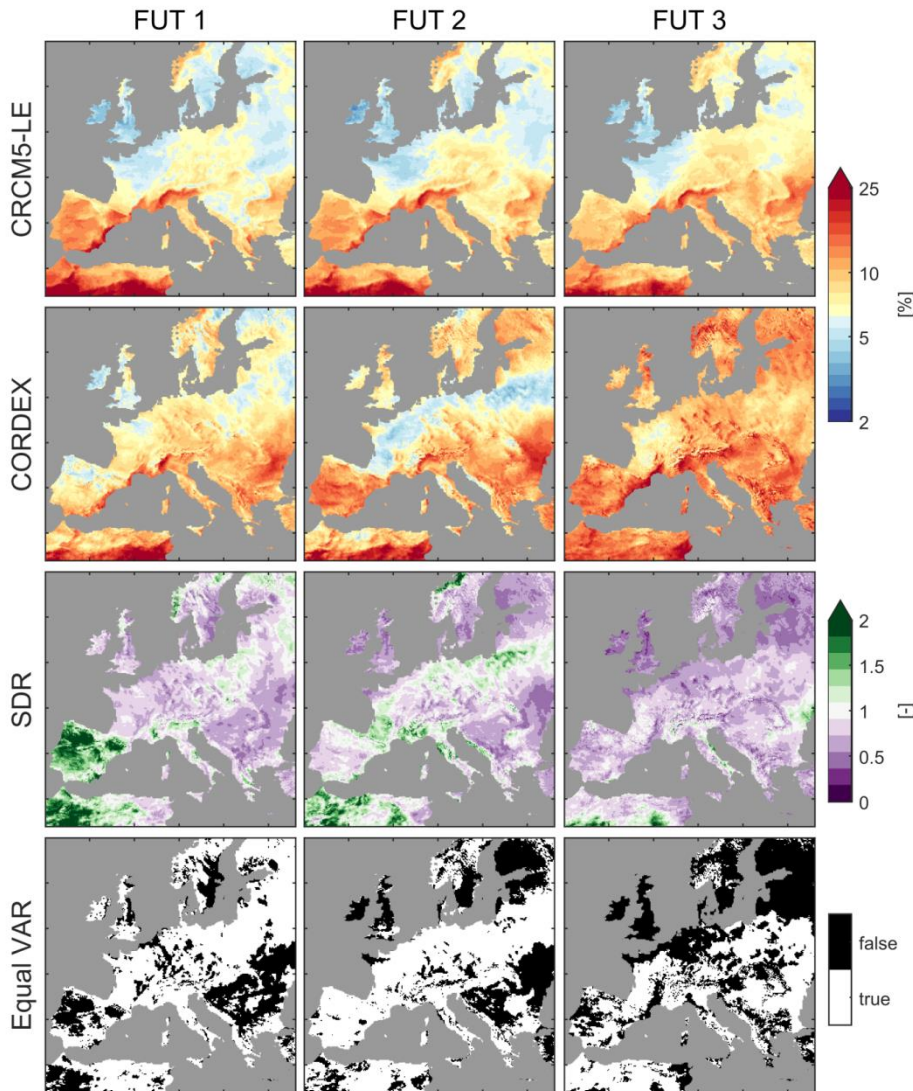
- The model spread is as large as the internal variability
- The signals are comparable

von Trentini et al 2019

Comparison to EURO-CORDEX

Can we quantify this relation?

Standard deviation ratio (SDR) and statistical test for equal variances for winter precipitation



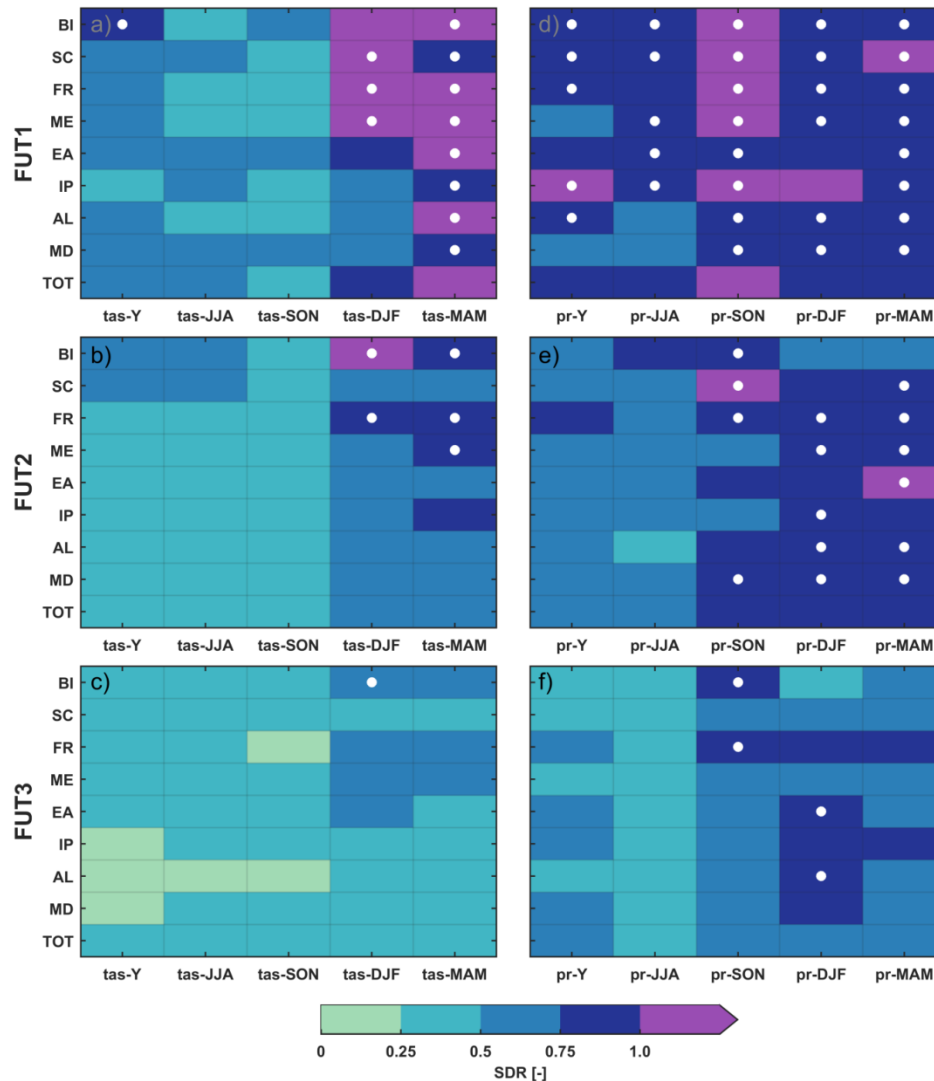
$$SDR = \frac{std(ClimEx)}{std(CORDEX)}$$

- REF: 1980-2009
- FUT1: 2020-2049
- FUT2: 2040-2069
- FUT3: 2070-2099

- Large parts of Europe show equal variances, even at the end of the 21st century

What is the broader picture?

Standard deviation ratio (SDR) and statistical test for equal variances for all seasons



$$SDR = \frac{std(ClimEx)}{std(CORDEX)}$$

- White dots show statistically equal variances for at least 2/3 of the pixels in that region
- Influence of internal variability is higher for precipitation
- It decreases for later time horizons



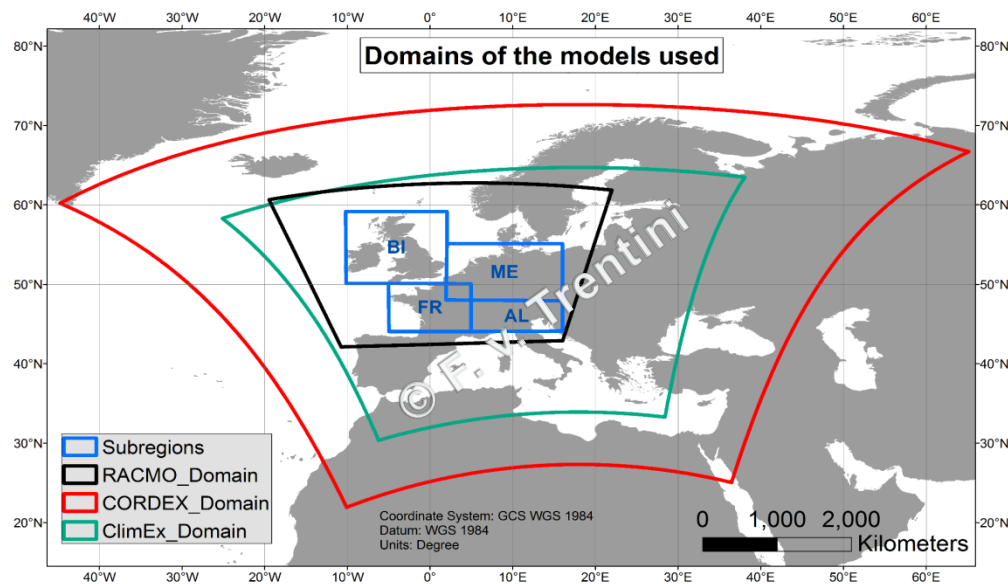
von Trentini
et al 2019

Comparison to other large ensembles

Comparison to other large ensembles

What data are we using?

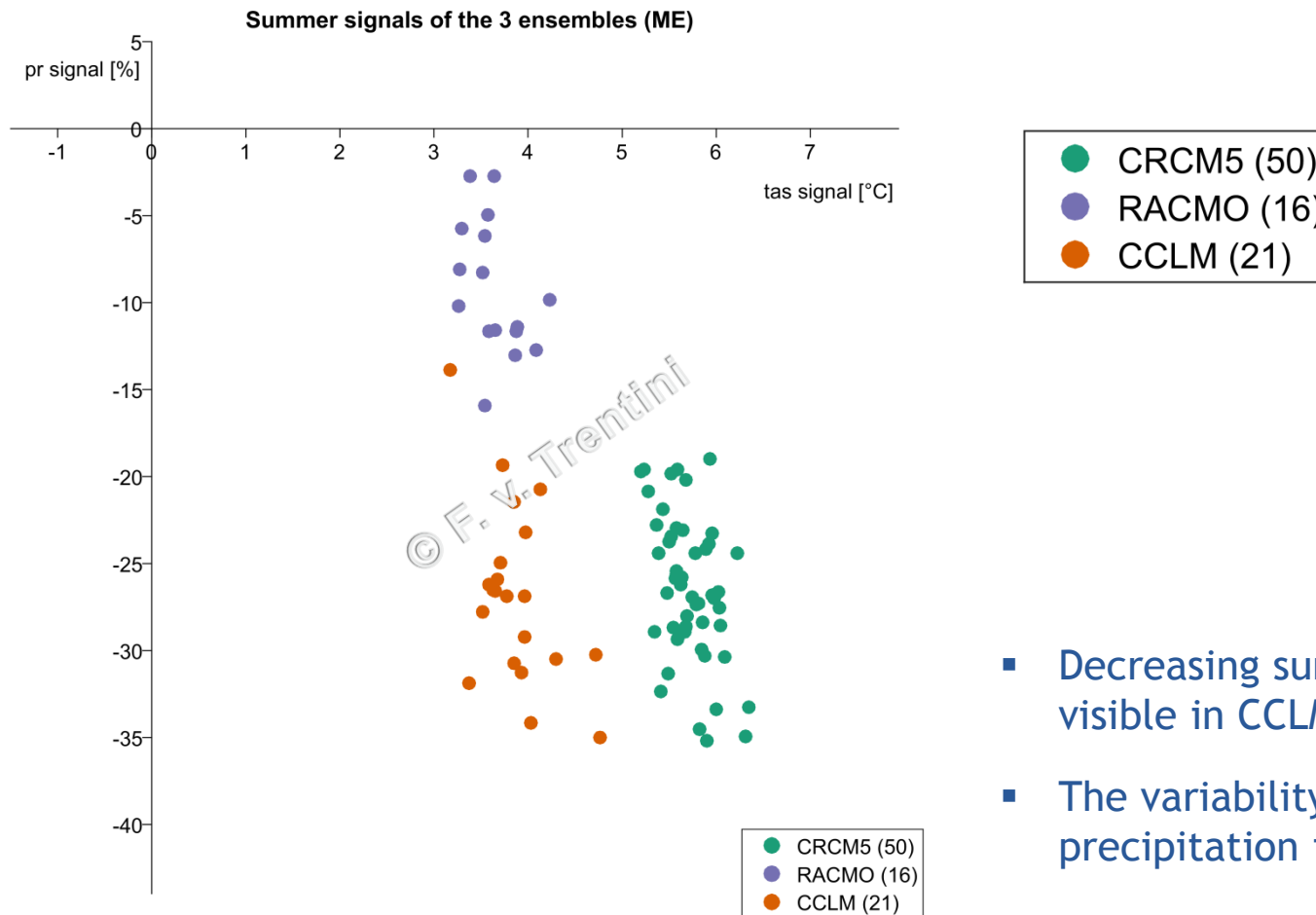
RCM	GCM	Resolution	members
CRCM5	CanESM2	0.11°	50
RACMO	EC-EARTH	0.11°	16
CCLM	CESM	0.44°	21



von Trentini et al, in prep

How are CRCM5 summer signals comparing to 2 other LE?

Relative signals of precipitation and temperature in 2070-99 compared to 1980-2009



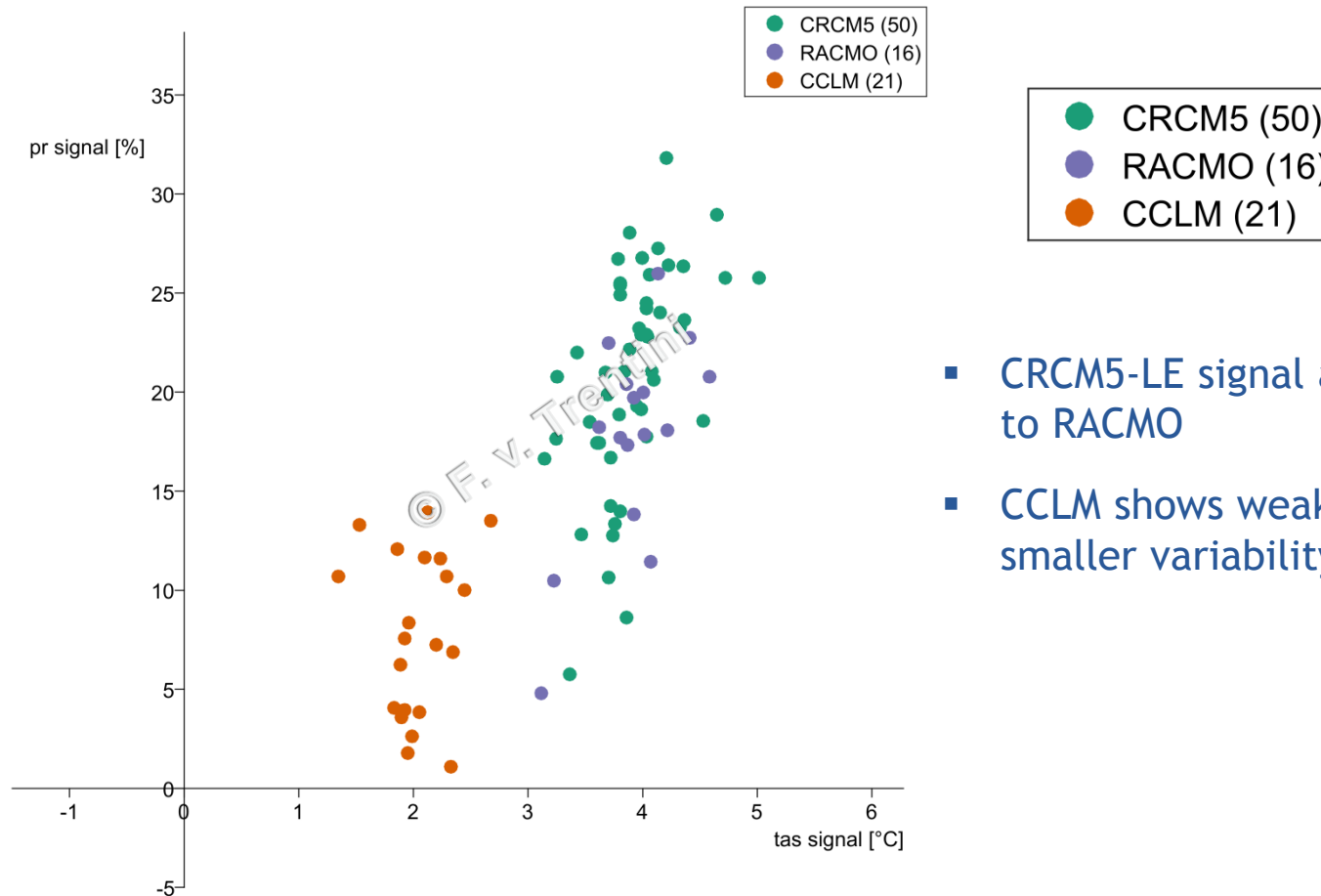
- Decreasing summer precipitation also visible in CCLM
- The variability of temperature and precipitation is similar to other LE

von Trentini et al, in prep

How are CRCM5 winter signals comparing to 2 other LE?

Relative signals of precipitation and temperature in 2070-99 compared to 1980-2009 (CEUR)

Winter signals of the 3 ensembles (ME)



- CRCM5-LE signal and variability similar to RACMO
- CCLM shows weaker signals and slightly smaller variability in precipitation

von Trentini et al, in prep

Comparison to other large ensembles

How similar is the internal variability of 3 large ensembles?

Brown-Forsyth Test on different variances of all 3 RCM large ensembles

REF	'BI'	'FR'	'ME'	'AL'	FUT1	'BI'	'FR'	'ME'	'AL'		
'tas-TM-DJF'		0.10	0.96	0.78	0.76	'tas-TM-DJF'		0.18	0.97	0.53	0.82
'tas-TM-JJA'		0.00	0.00	0.00	0.00	'tas-TM-JJA'		0.05	0.36	0.14	0.28
'pr-DJF'		0.02	0.04	0.18	0.48	'pr-DJF'		0.00	0.72	0.09	0.78
'pr-JJA'		0.06	0.00	0.25	0.04	'pr-JJA'		0.21	0.21	0.70	0.43

FUT2	'BI'	'FR'	'ME'	'AL'	FUT3	'BI'	'FR'	'ME'	'AL'		
'tas-TM-DJF'		0.22	0.02	0.85	0.10	'tas-TM-DJF'		0.88	0.13	0.16	0.01
'tas-TM-JJA'		0.41	0.73	0.08	0.88	'tas-TM-JJA'		0.84	0.78	0.87	0.46
'pr-DJF'		0.02	0.50	0.03	0.48	'pr-DJF'		0.14	0.21	0.12	0.33
'pr-JJA'		0.31	0.01	0.48	0.13	'pr-JJA'		0.03	0.30	0.10	0.54

p<0.05

- Variances tend to become more similar in the future
- No clear pattern → random noise?

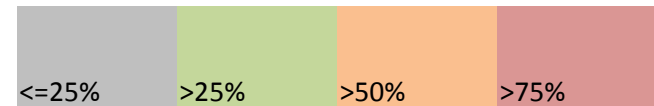
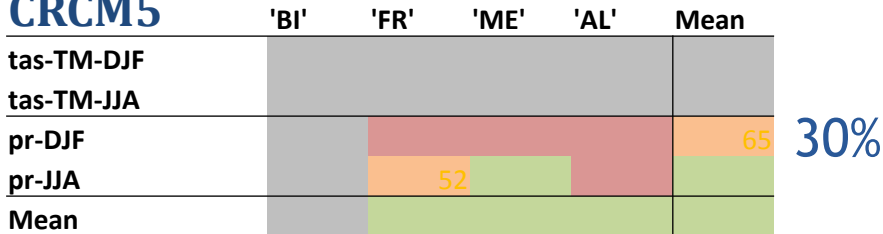
von Trentini et al, in prep

Comparison to other LE

How similar is the interannual variability of large ensembles to observations?

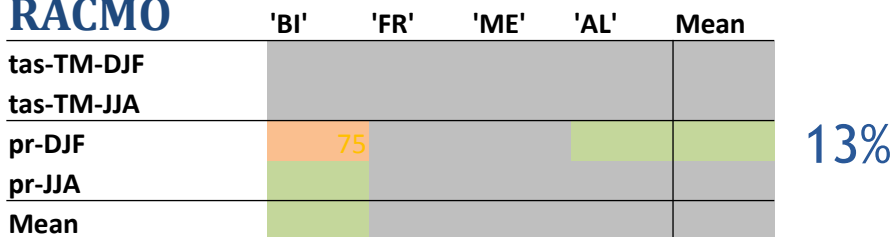
Two sample F-Test on equal variances of each ensemble and E-OBS (1980-2009)

CRCM5



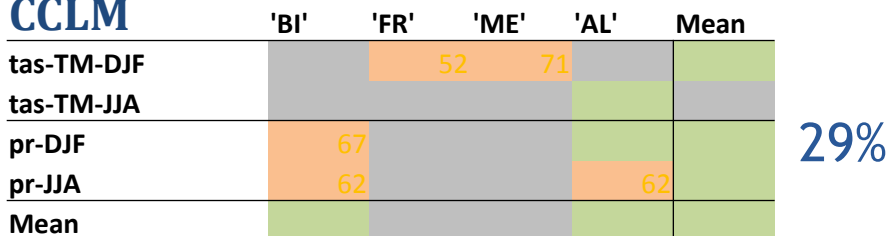
% of members with **different** variances than E-OBS

RACMO



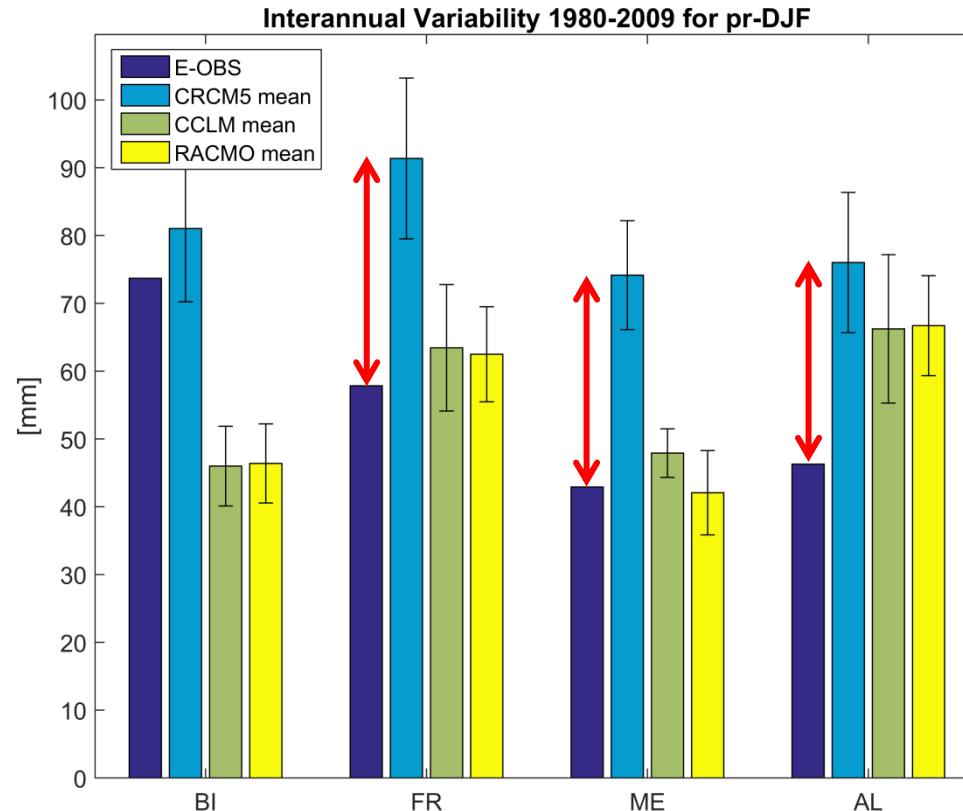
- High agreement for temperature
- Lower agreement for precipitation
- Overall: Satisfying

CCLM



von Trentini et al, in prep

How similar is the interannual variability of large ensembles to observations?
Interannual variabilities of the 3 LEs and E-OBS

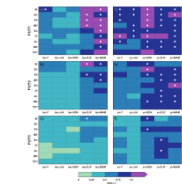
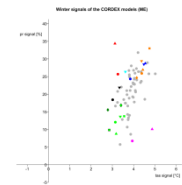
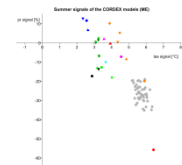


- CRCM5-LE: Wet bias in winter can explain higher standard deviation in [mm] to a certain degree

von Trentini et al, in prep

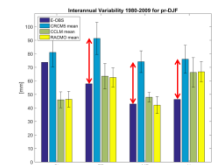
Summary

- In summer, the internal variability of CRCM5-LE is smaller than the CORDEX variability and shows a strong decrease in precipitation
- The internal variability of the CRCM5-LE is quite similar to the variability of the corresponding CORDEX ensemble in winter
- General: Large parts of the uncertainty of a multi-model ensemble can be explained by internal variability, especially for precipitation and early future periods
- The internal variabilities of 3 large ensembles become more similar for later future periods; But: no clear pattern
- A comparison with E-OBS showed high agreement for temperature and diverse results for precipitation, that may be explained by the bias of the models



REF	'W'	'YR'	'ME'	'AL'	FUT1	'W'	'YR'	'ME'	'AL'
'No-TM-DP'	0.32	0.36	0.78	0.76	'No-TM-DP'	0.31	0.37	0.33	0.32
'No-TM-IR'	0.32	0.35	0.68	0.68	'No-TM-IR'	0.36	0.34	0.34	0.23
'Yr-DP'	0.32	0.35	0.18	0.43	'Yr-DP'	0.31	0.72	0.09	0.73
'Yr-IR'	0.05	0.31	0.25	0.39	'Yr-IR'	0.21	0.21	0.70	0.43

FUT2	'W'	'YR'	'ME'	'AL'	FUT3	'W'	'YR'	'ME'	'AL'
'No-TM-DP'	0.22	0.35	0.35	0.10	'No-TM-DP'	0.33	0.13	0.14	0.35
'No-TM-IR'	0.42	0.37	0.05	0.28	'No-TM-IR'	0.31	0.78	0.37	0.45
'Yr-DP'	0.32	0.30	0.35	0.43	'Yr-DP'	0.11	0.21	0.12	0.33
'Yr-IR'	0.31	0.31	0.48	0.13	'Yr-IR'	0.31	0.30	0.10	0.54



- The natural variability within ClimEx can explain large parts of overall uncertainty of multi-model ensembles like CORDEX, especially for precipitation
 - Natural variability is similar in different large ensembles
 - Natural variability in large ensembles is similar to observed natural variability
→ This strengthens the concept of large ensembles
- More large ensembles need to be computed, compared and set into context!