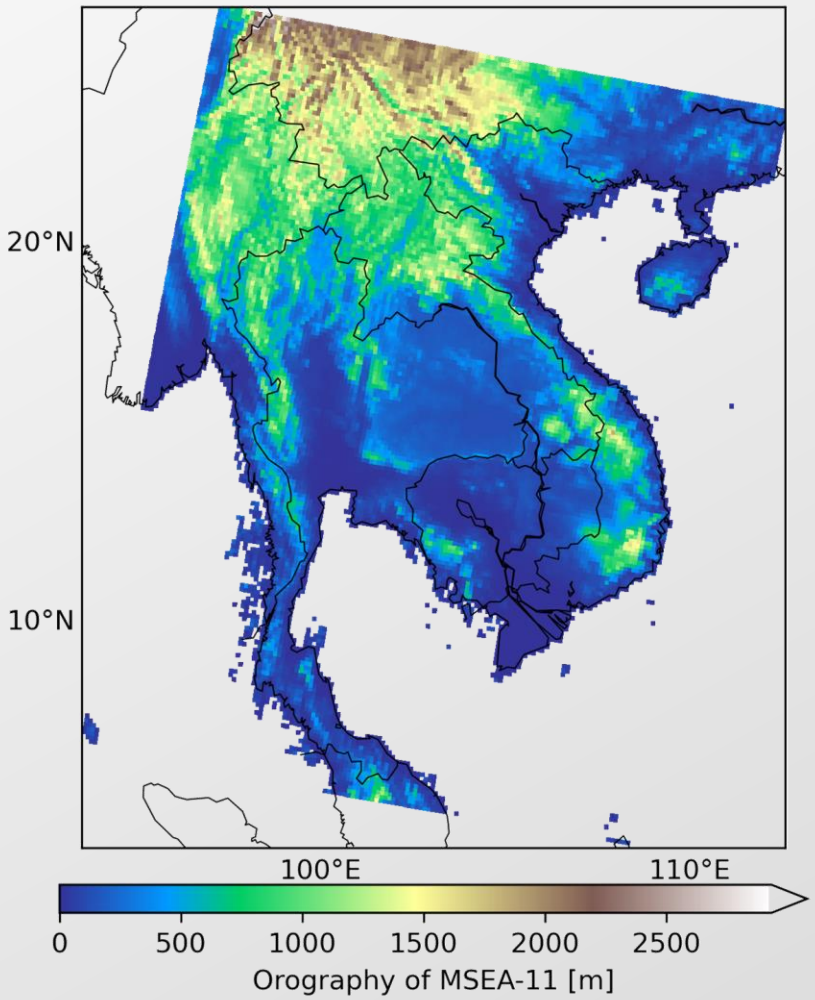

Validation of an RCM over Mainland Southeast Asia focusing on the needs of hydrological models

23.05.2022

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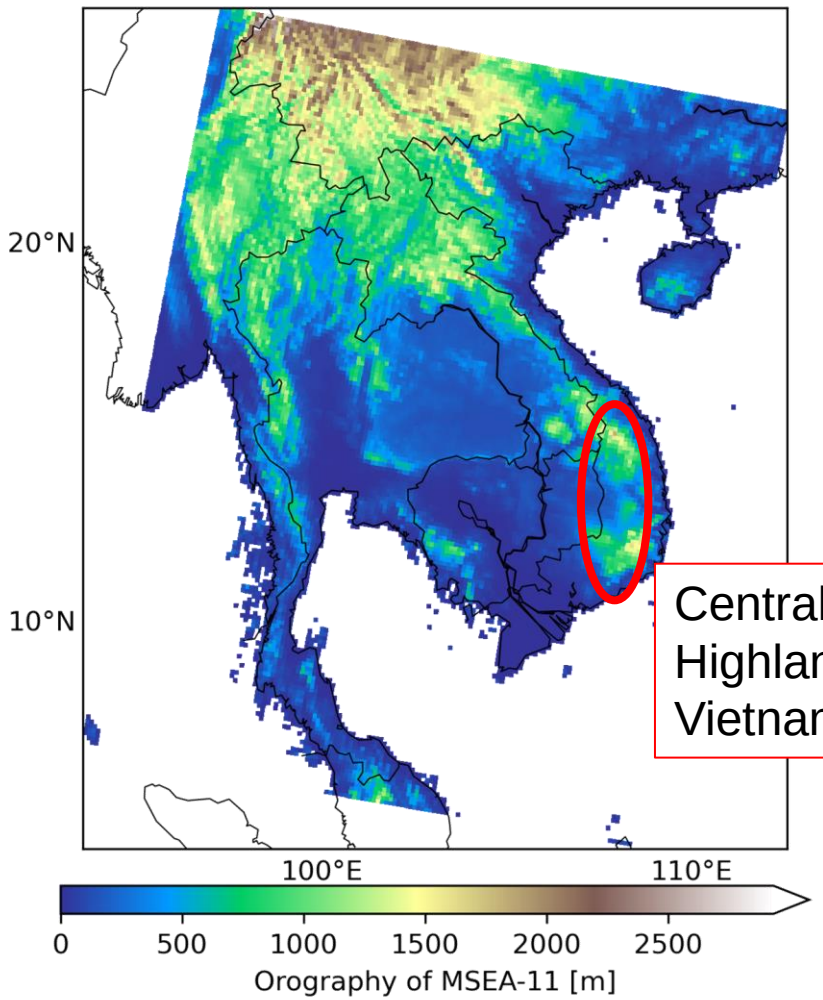
This work is a part of the Client II-Project Drought-ADAPT
sponsored by the Federal Ministry of Education and Research, Germany

Project aims

MSEA-11



- Purpose:
  - Create highly-resolved climate boundary conditions of past and future to
    1. perform hydrological modeling (HM)
    2. investigate the effect of ENSO on droughts in the Central Highlands of Vietnam
    3. provide climate services regarding drought monitoring and forecast for local stakeholders

- Requirements:
  - Highly-resolved RCM (0.11°) with adequate representation of vegetation and subsurface water movement for MSEA-11
  - CP-simulations for the study region
  - Highly-resolved validation data of daily resolution and ≤ 0.25°

- Aim of this work:
  - Validation of REMO-output over MSEA-11 needed for hydrological modeling

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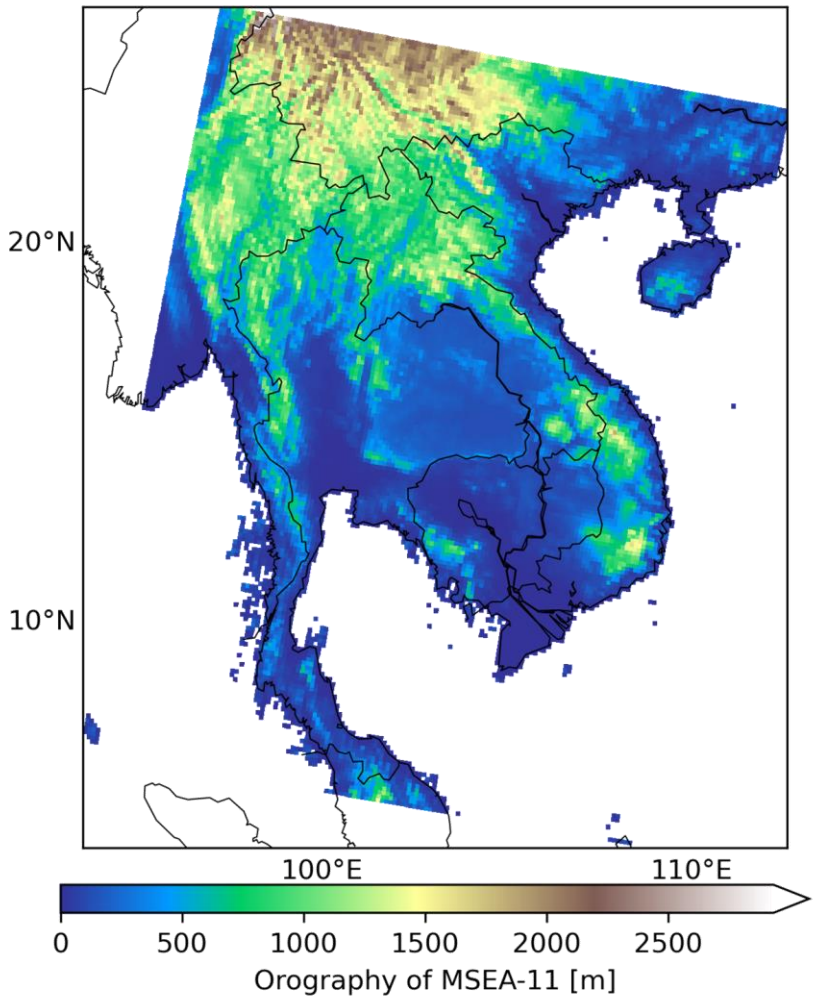
RCM-simulations and needs of HMs

MSEA-11



- REMO2015
  - 2000-2018
  - 0.11°
  - Adaptation to local tuning parameters like the convection height
- HM-needs for atmospheric forcing
  - 2 meter temperature
  - Precipitation
  - Potential evapotranspiration

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Considered validation data

Necessary conditions:

- Gridded data
- ≤ 0.25° resolution
- Daily resolution

Sufficiant conditions:

- Climatological period
- Long overlap with GRACE (2003-present) to validate the groundwater simulated by the HM

Dataset	Variable(s)	Spatial resolution	Temporal resolution	Period	Spatial coverage	Reference
APHRODITE	2t, tp	0.25°	Daily	1961-2015	Monsoon Asia	(Yatagai et al., 2012, 2020)
CHIRPS	Tp	0.25°, 0.05°	Daily	1981-present	50°S-50°N	(Funk et al., 2015)
CMORPH	Tp	0.25°	3-hourly	2002-present	60°S-60°N	(Joyce et al., 2004)
ERA5	All	0.25°	Hourly	1951-present	Global	(Hersbach et al., 2020)
ERA5/Land	All	0.09°	Hourly	1951-present	Global	(Muñoz-Sabater et al., 2021)
GLEAMv3.5a	pet, eb, et, sm_rz, sm_1	0.25°	Daily	1980-2020	Global	(Martens et al., 2017; Miralles et al., 2011)
GPCC	Tp	0.25°	Monthly	1891-2020	Global	(Schneider et al., 2020)
GPM-IMERG	Tp	0.1°	30 Minutes	2001-present	Global	(G. J. Huffman et al., 2019)
hPET	PET_PM	0.1°	Hourly	1981-present	Global	(Singer et al., 2021)
PERSIANN-CDR	Tp	0.25°	Daily	1983-present	60°S-60°N	(Ashouri et al., 2015)
SA-OBS	Tp	0.25°	Daily	1981-2017	SEA	(van den Besselaar et al., 2017)
TRMM	Tp	0.25°	Daily	1998-2019	50°S-50°N	(George J. Huffman et al., 2007)
VnGP	Tp	0.1°	Daily	1981-2010	Vietnam	(Nguyen-Xuan et al., 2016)

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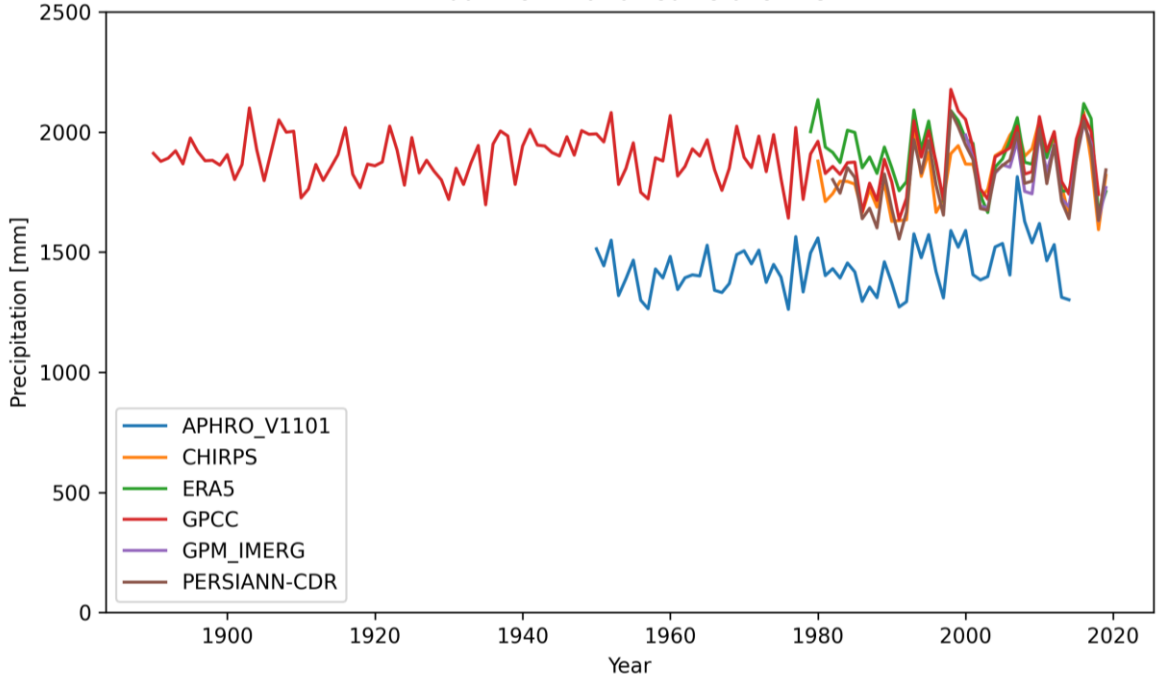
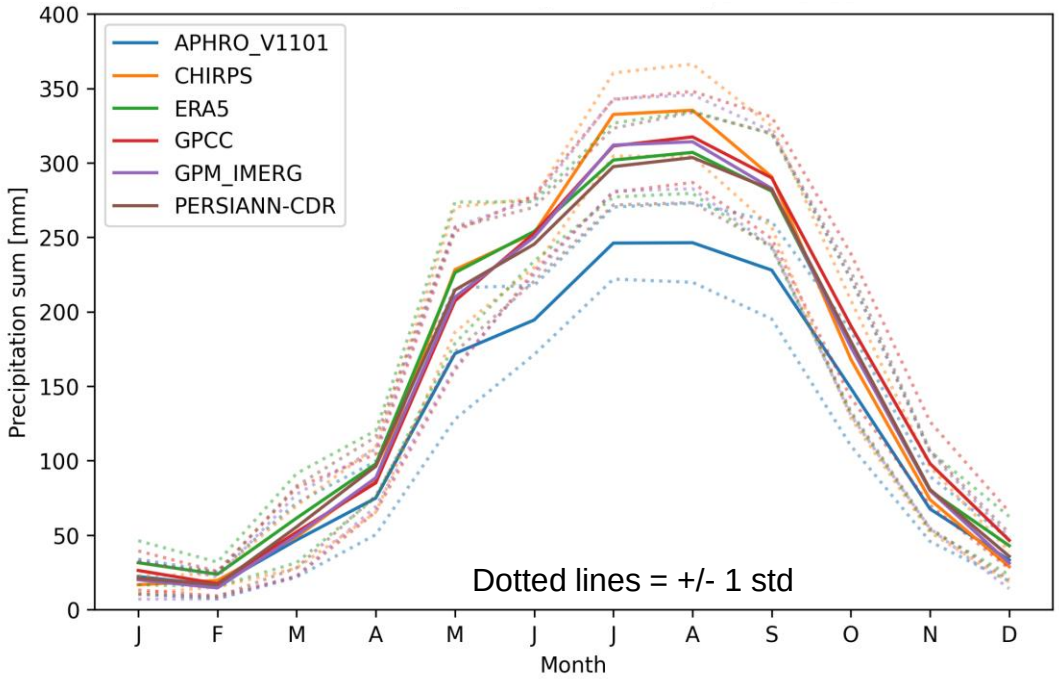
Validation data – precipitation

Time series (left) and climatology (right) of selected gridded precipitation data over MSEA-11 for their overlapping period 2001-2015





- Systematic underestimation of the widely used and station-based APHRODITE dataset caused by the underrepresentation of heavy precipitation events (also stated by, e.g., Chen et al. 2017) common for station-based gridded precipitation (Sun et al. 2018)

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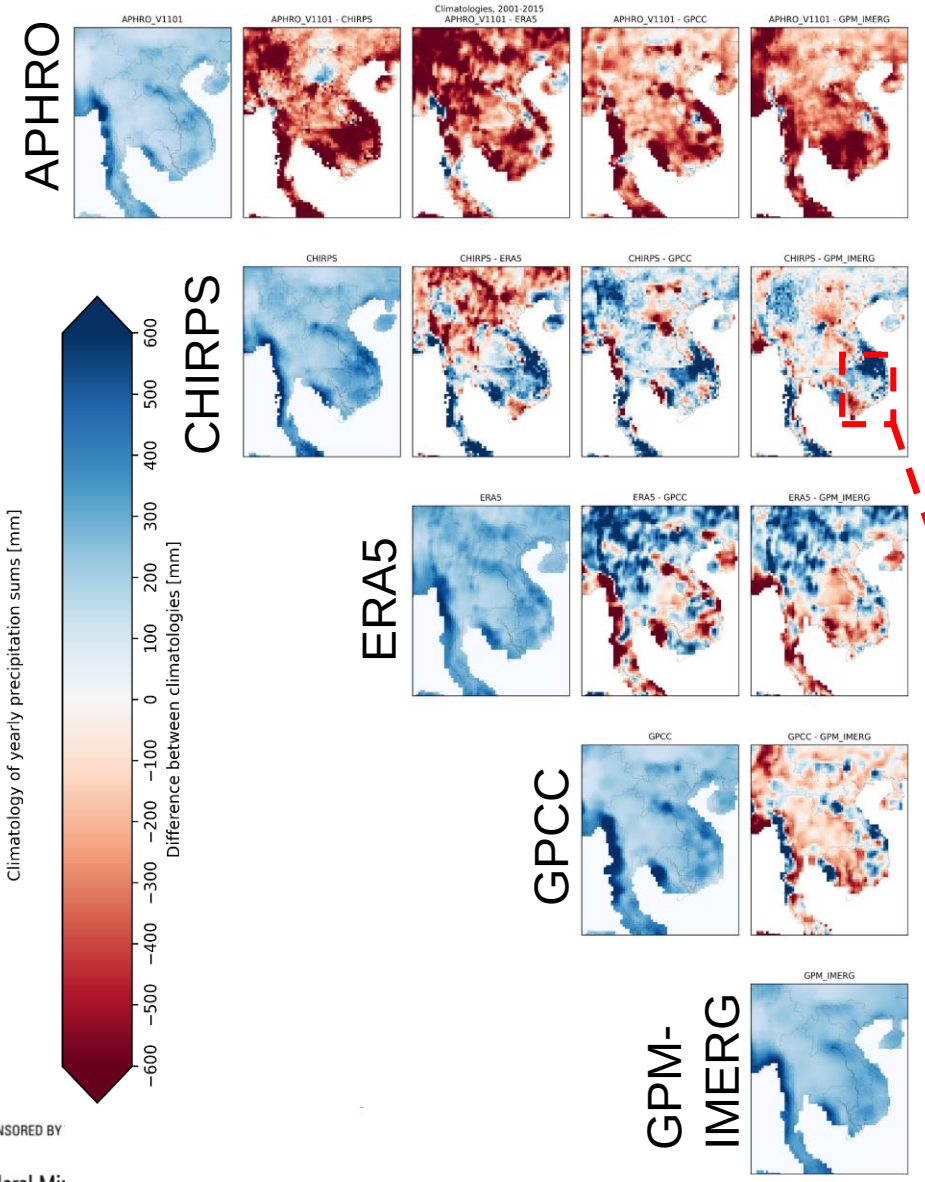
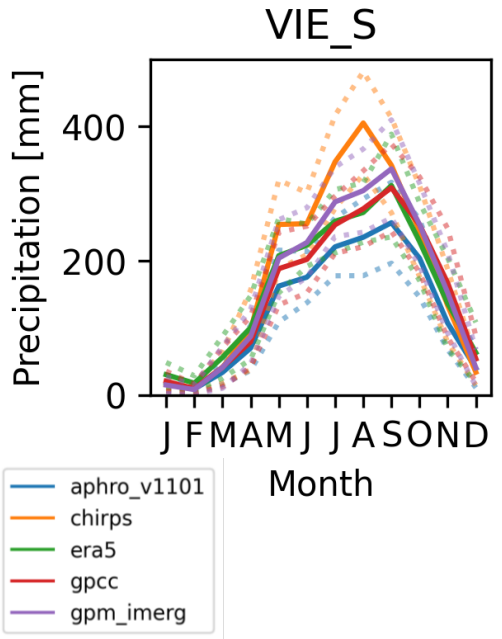
Validation data – precipitation



Spatial mean (first plot of each line) of selected gridded precipitation data and the differences among the data (line-column), 2001-2015

- Underestimation of APHRODITE is highlighted
- ERA5 shows systematic overestimation in the North
- CHIRPS, GPCC, GPM-IMERG show good accordance with underestimation of GPCC compared to GPM-IMERG



- CHIRPS is too wet in orographic regions of Southern Vietnam (VIE_S)
- Might be caused by its high resolution (0.05°) that could represent orographic and thus convective precipitation better than coarser datasets
- To proof this, station data or higher resolved model simulations are necessary

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Validation data – precipitation-based climate indices

- Consider climate indices of precipitation (Zhang et al. 2011)

Index	Name	Definition	Unit
rr1	Rainy days	Day with precipitation > 1mm	Days
cdd_max	Longest duration of consecutive dry days	Maximum number of consecutive days with precipitation < 1mm	Days
cdd_nr	-	Number of cdd periods >= 5 days	No.
cwd_max	Longest duration of consecutive wet days	Maximum number of consecutive days with precipitation > 1mm	Days
cwd_nr	-	Number of cwd periods >= 5 days	No.
r10mm	Days with heavy precipitation	Day with precipitation > 10mm	Days
r20mm	Days with very heavy precipitation	Day with precipitation > 20mm	Days

- Consider monsoon onset (ons) and cessation (ces) based on aggregated precipiation anomalies (A_n) (Liebmann et al. 2007)

$$A_n = \sum_{i=1}^{n} R_i - \bar{R}$$

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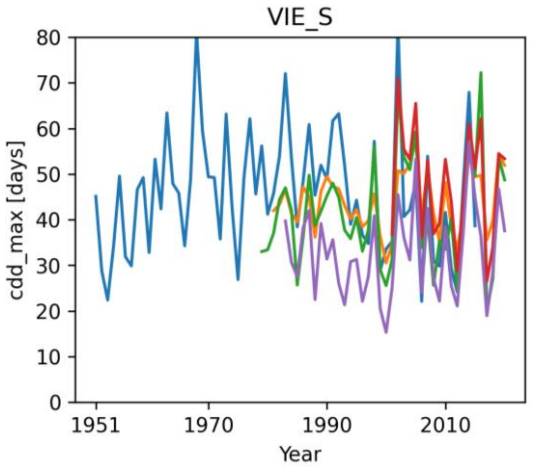
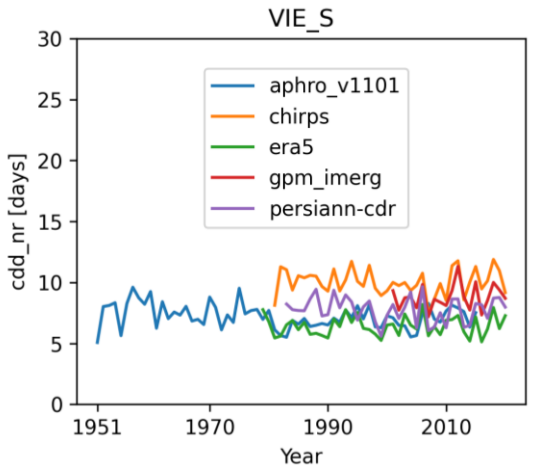
Validation data – precipitation-based climate indices in VIE_S

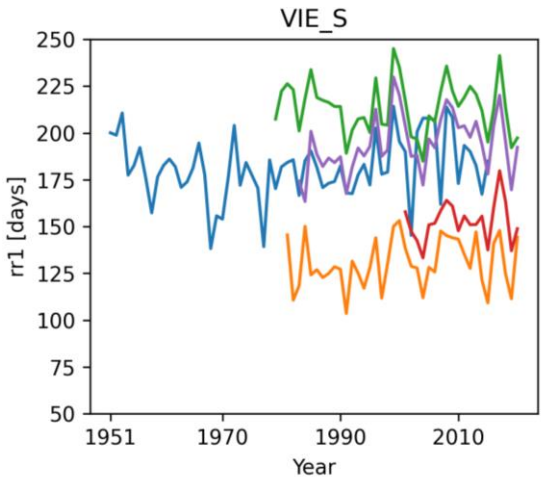
cdd_max



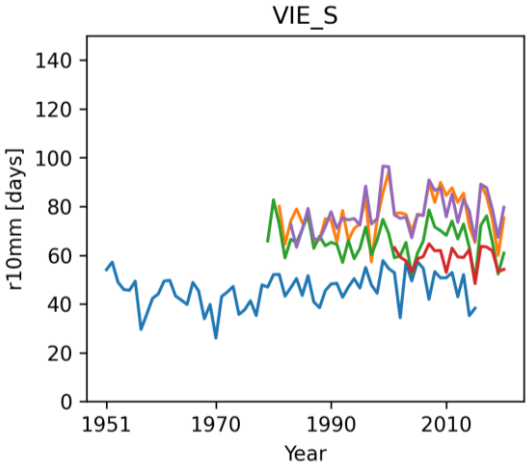
cdd_nr



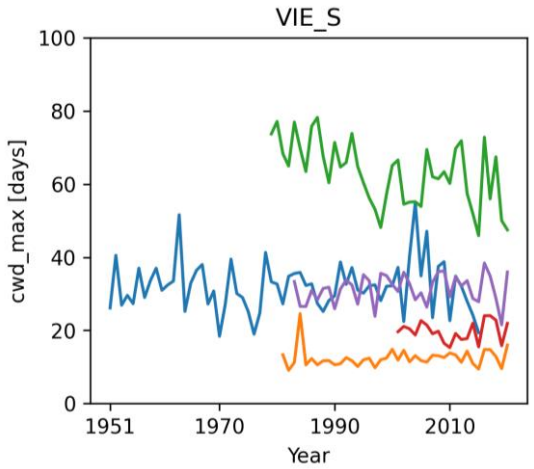
rr1



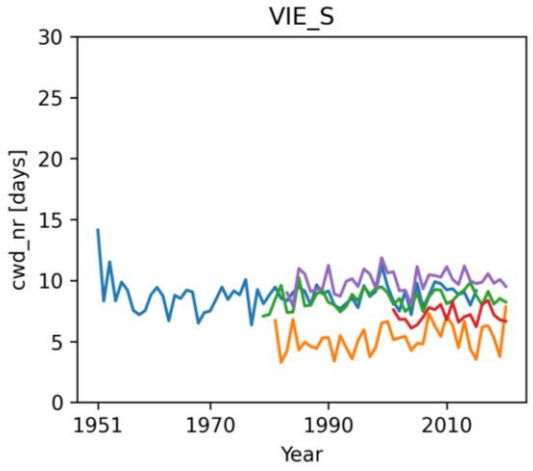
r10mm



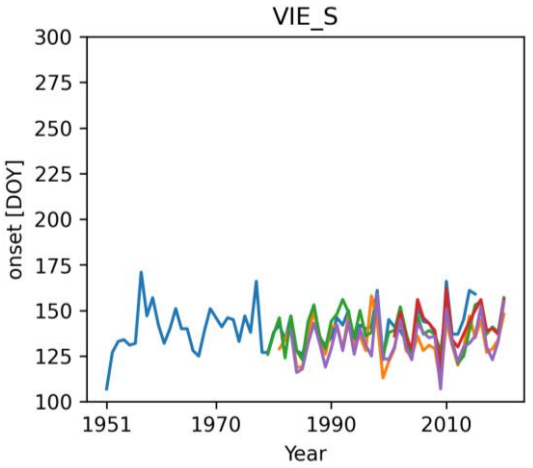
cwd_max



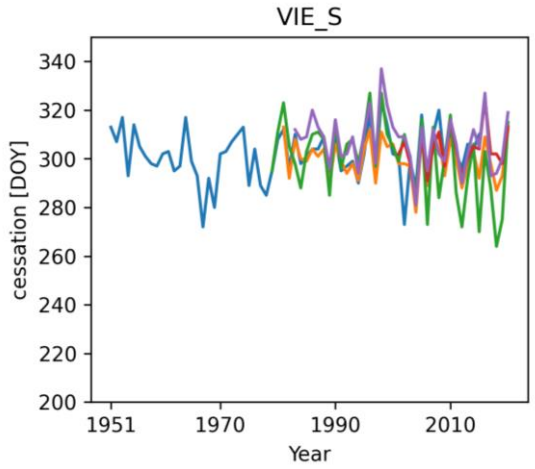
cwd_nr



ons



ces



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Validation data – which to use as a baseline

- Monsoon onset and cessation show good agreement the data
- However, some indices like rr1, cwd_max, cwd_nr or cdd_nr show large discrepancies

- Data to choose for validation:
  - CHIRPS:
    - 0.05° => highest spatial resolution
    - Based on station and satellite data
    - Frequently used and validated
  - ERA5 and subsequent products:
    - Reanalyses: Broad range of variables for a consistent validation between variables
    - 0.09° with ERA5/Land
    - Frequently used for various purposes in the context of climatology and hydrology

=> Both represent the spread of validation data regarding the climate indices

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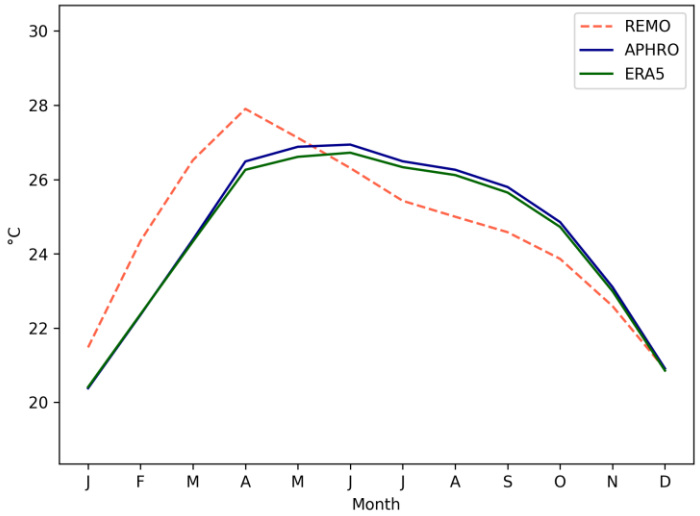
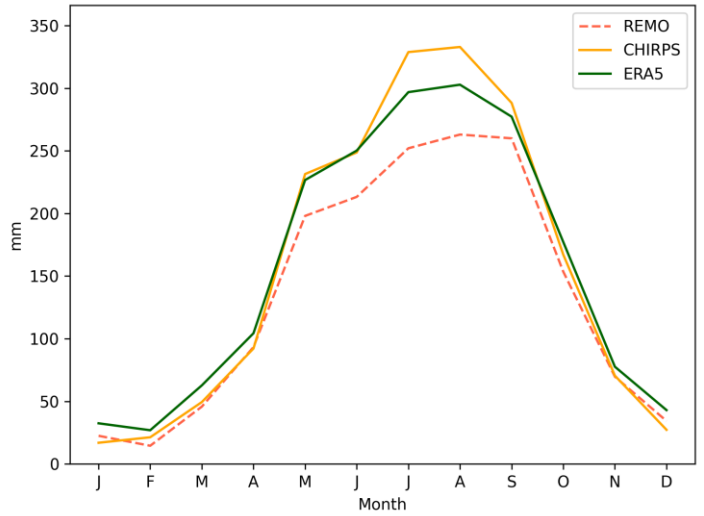
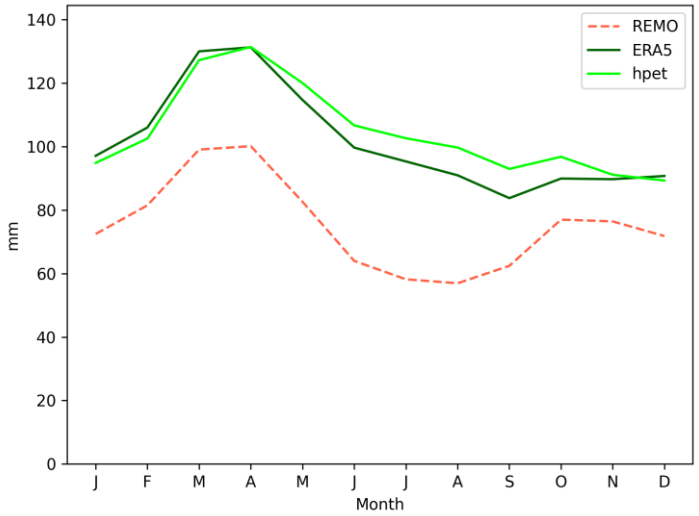
Validation of REMO – climatologies 2001-2015

Temperature | Precipitation | PET (Penman-Monteith)

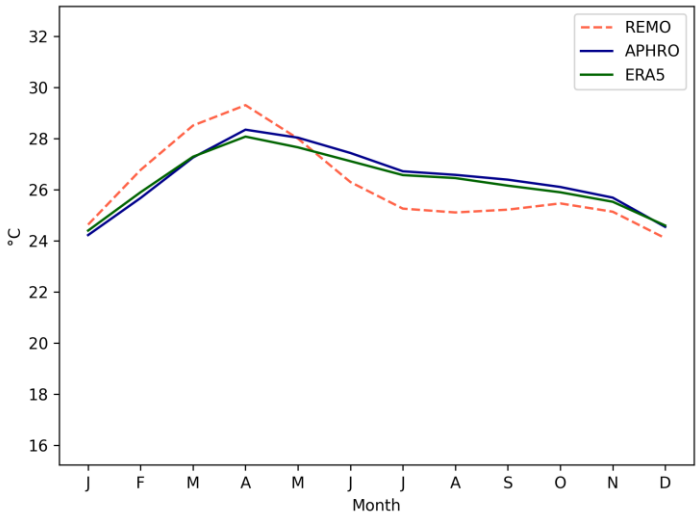
MSEA-11

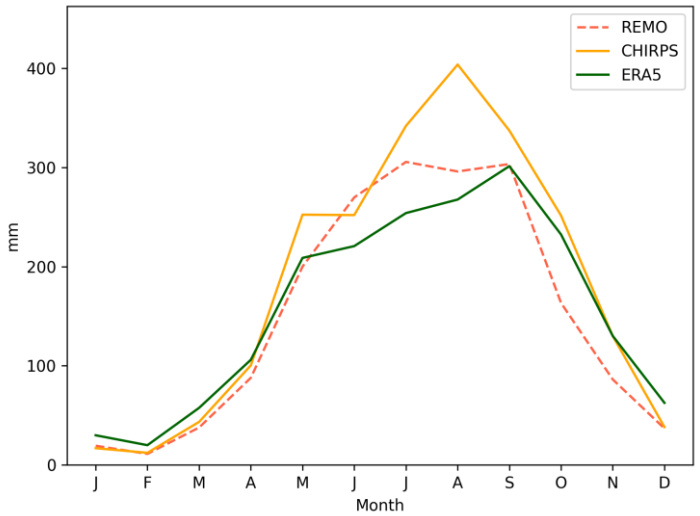


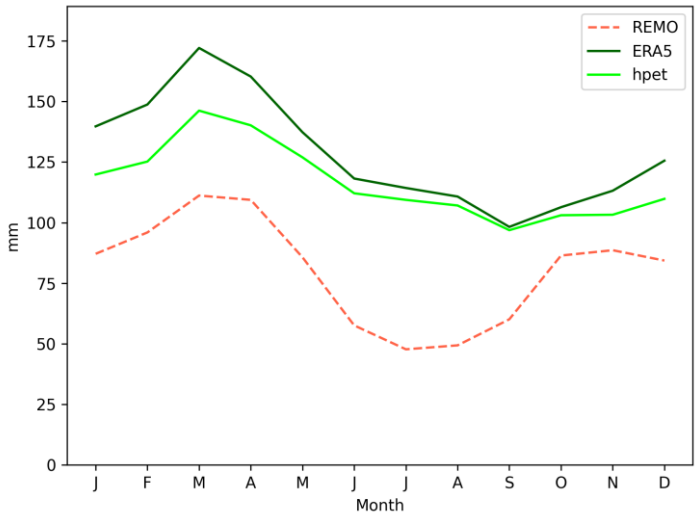




VIE_S







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Institut für GEOGRAPHIE & GEOLOGIE Physische Geographie
Julius-Maximilians-UNIVERSITÄT WÜRZBURG

Validation of REMO – differences of climatologies 2000-2015

Temperature

REMO – ERA5

Precipitation

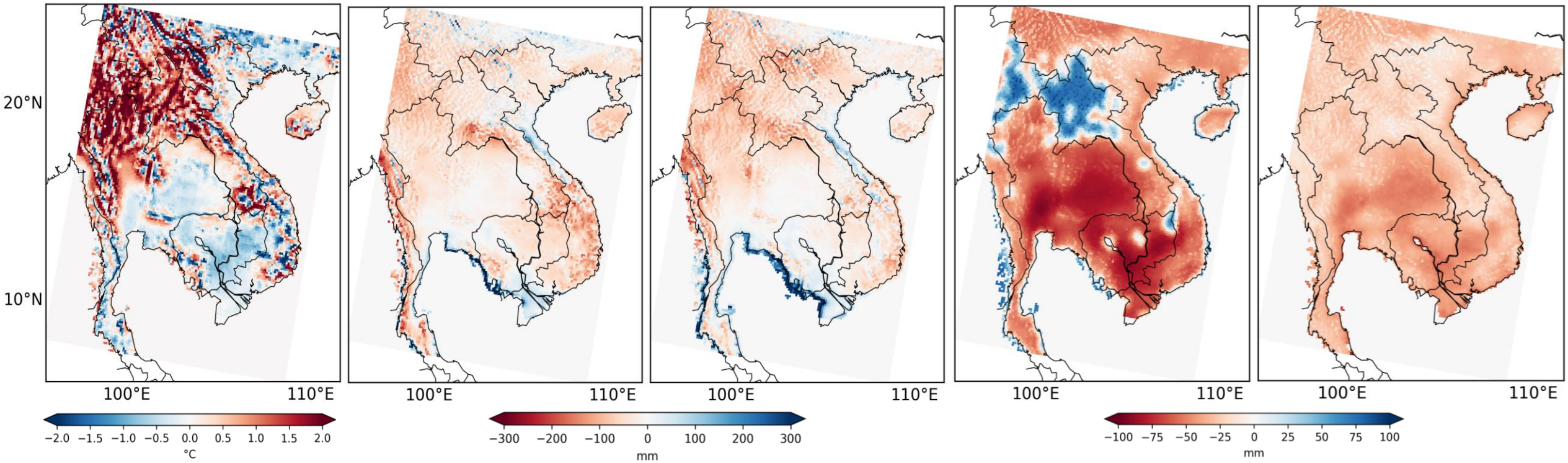
REMO – CHIRPS

REMO – ERA5

PET_PM

REMO – ERA5

REMO – hpet



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Validation of REMO – on the model performance

- Temporal aspects: Generally good representation of the annual cycle

Temperature	Precipitation	PET
• Systematic error with different sign before and after monsoon onset	• Underestimation of precipitation by the model in MSEA-11 => unusual behavior of the the model • Good representation in VIE_S with underestimation after monsoon cessation • No clear peak like in the validation data	• General underestimation • Larger descrepancies during monsoon

- Spatial aspects: Patterns of precipitation and PET are met well

Temperature	Precipitation	PET
• Bipolar structure of the bias: Lowlands show systematic under-, Highlands and Mountains overestimation	• Overestimation in coastal areas • Lower underestimation in Lowlands of Cambodia and Thailand than in Highlands	• General understimation is not always represented in the maps • Overestimation of PET (REMO-ERA5) caused by a systematic error in ERA5 since the difference with hpet (based on ERA5/Land) as well as with GLEAM (not shown) do not show this pattern • Bias is larger with higher absolute values

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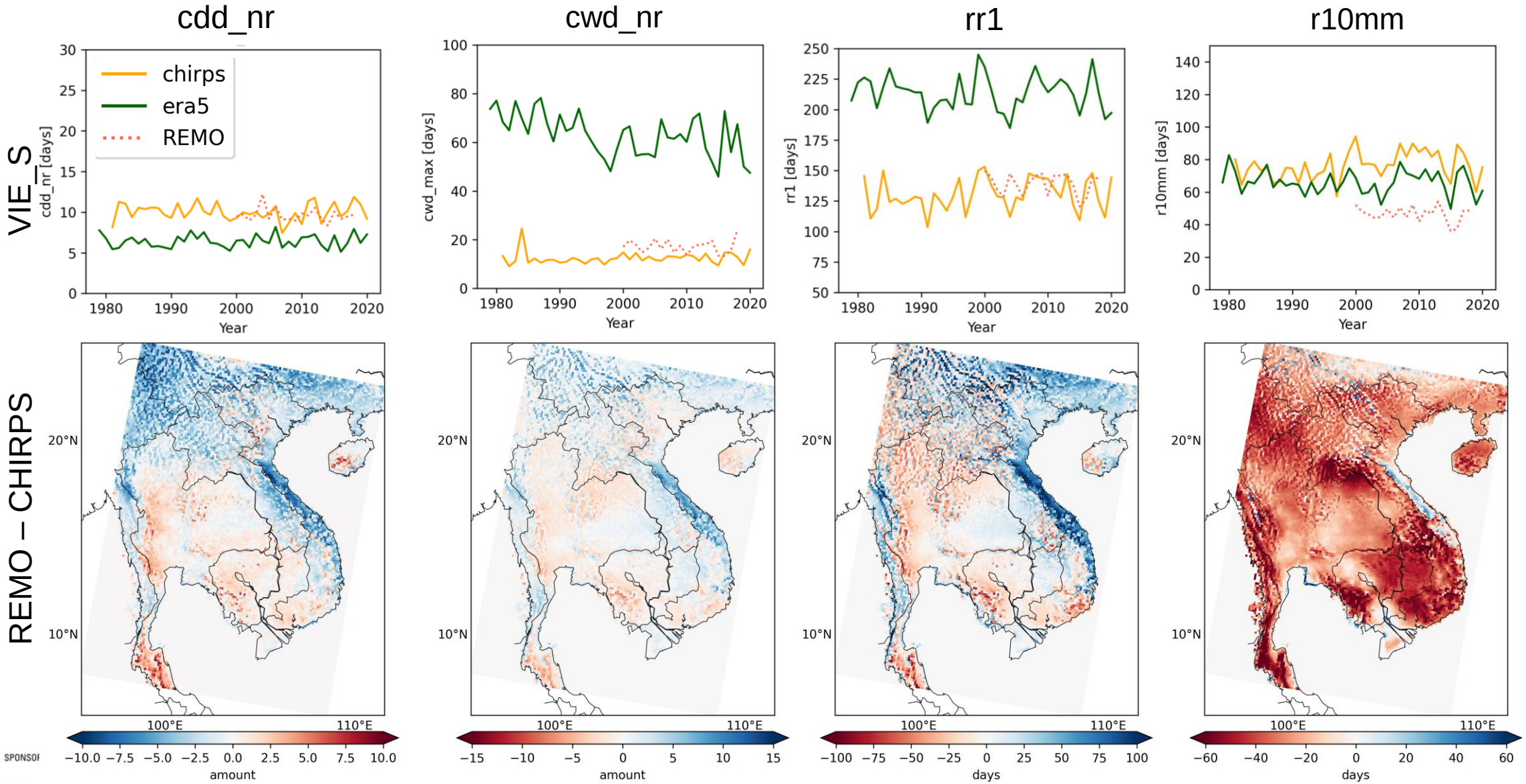
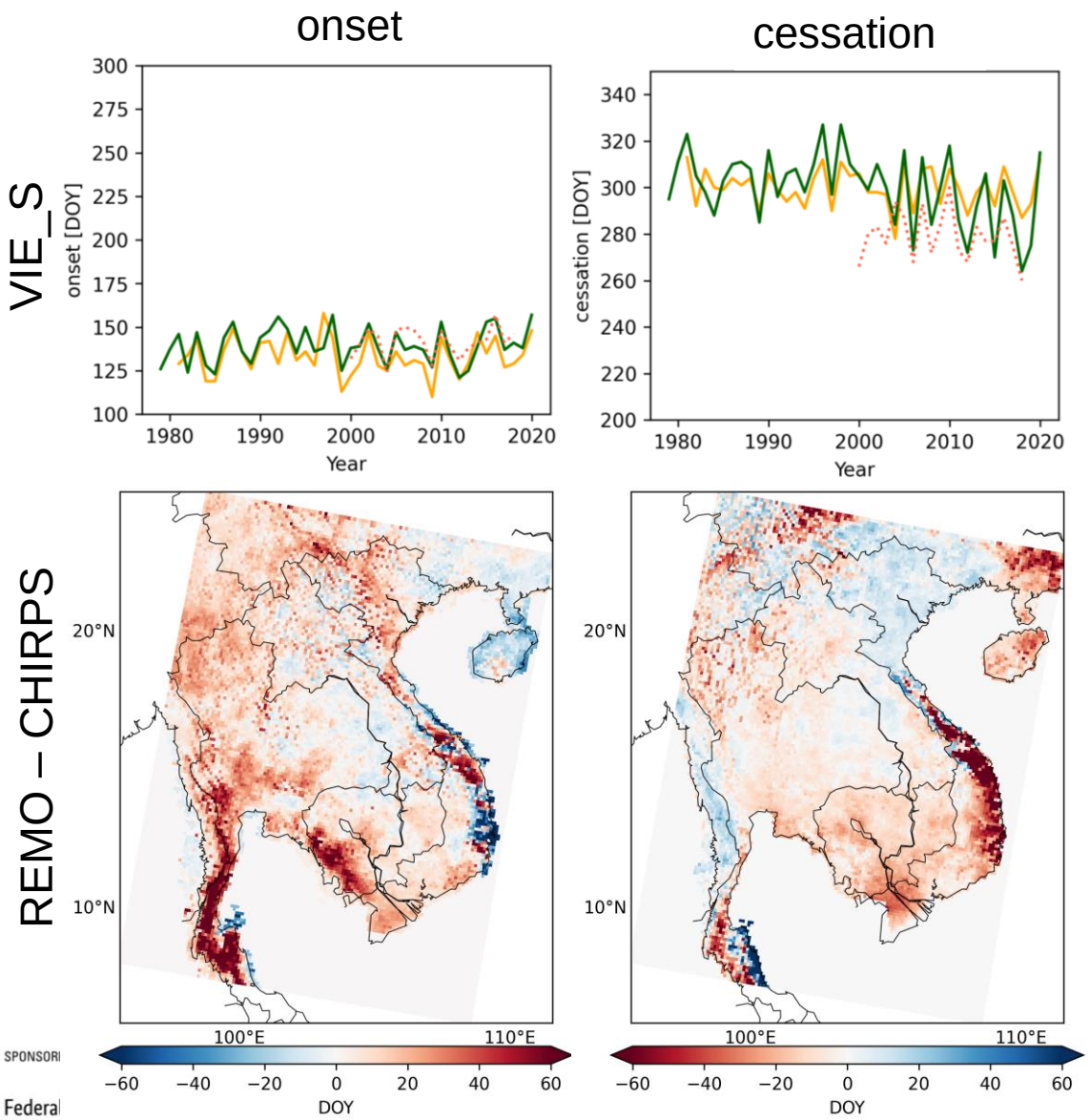
Validation of REMO – precipitation-based climate indices



Validation of REMO – monsoon onset and cessation



Climate indices:

- Good accordance of REMO with CHIRPS
- Largest discrepancies in the narrow Central Vietnam
- Underestimation of heavy precipitation

Monsoon characteristics:

- REMO is closer to ERA5 regarding the time series of onset and cessation
- Monsoon season generally too short caused by both, too late onset and too early cessation
- Complex picture for Vietnam

Conclusion

Validation data:

- Precipitation and PET show partially large differences, especially when it comes to climate indices
- CHIRPS offers the best conditions for the RCM
- Systematic bias of ERA5‘s PET

REMO validation:

- Systematic biases for all three variables
- Depending on the season and subregion, REMO is within or without the spread of the selected validation data
- Good accordance of REMO with CHIRPS for most climate indices
- Underestimation of precipitation and heavy precipitation compared to CHIRPS and ERA5
- Might be caused by the too short rainy season

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