Project: **1068**

Project title: **ViWA - Virtual Water Values**

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Summary: The aim of the BMBF-project ViWA is to provide information from the local to the global scale in order to develop praxis-relevant solutions for the efficient and sustainable use of the global water resources. Within ViWA a multi-disciplinary monitoring and modelling framework is developed and applied. HZG-GERICS contributes to ViWA by providing high-resolution global-scale climate information using a multi-domain downscaling approach (WP 2.1) as well as by sophisticated analysis of natural climate variability effecting global water resources (WP 5.1). After approval of the required amount of storage space proposal for the ViWA-project on 21.12.2018 by the scientific steering committee (WLA) for the period 01.01.-31.12.2019, high-resolution climate simulations with the limit area model REMO driven by ERA-Interim are continued and completed on the HPC-mistral for all 9 selected CORDEX-domains[1] Europe, Africa, Australia, North America, Middle America, South America, East Asia, Central Asia and Southeast Asia. A selection of post-processed REMO data fields was completely transferred to the ViWA project partner LMU. They use this dynamically downscaled dataset, having a spatiotemporal resolution of 0.11° and 1 hourly output, for the period 2015-2018 as input for the agro-hydrological model PROMET. This model simulates prototypically four recent years with a spatial resolution of 1 km to investigate globally the water cycle in view of the efficiency and sustainability of the agricultural production and compare the results with satellite based observations in framework of UN SDG 6.

In the analysed time period (1979-2018) the results, obtained so far from the reanalysis Era-interim, show that each El-Nino, La-Nina event and its global effects on regional precipitation patterns underlies variations. Depending on the El-Nino/La-Nina forming, an additional interaction with the climate variability IOD (Indian Ocean Dipole) may modify the regional precipitation characteristics (e.g. rainfall period, monsoon) in the ENSO-sensitive regions by weakening or reinforcing them. Modulations of precipitation quantities lead to uncertainties in crop yields in the agricultural sector.

Analyses show that in the ENSO-sensitive areas the precipitation and temperature patterns in the El-Nino/La-Nina phases agree well between the high-resolved REMO model data and observations (NOAA).

Results: In year 2019 our focus was on the second work package WP 5.1 (analysis of natural climate variability) for the ViWA project. The ENSO (El-Nino Southern Oscillation) phenomenon is one of the strongest natural and inevitable climate fluctuations which regularly induce regionally varying impact on water cycles worldwide. For this reason the precipitation, which was an important component of the atmospheric water cycle, was subject to a more in-depth and extended scientific investigation.

In order to better classify the last El-Nino event of 2015/2016 (ViWA analysis-period) and its worldwide influences on regional precipitation patterns in a medium to long-term climate context, a Hovmoeller-diagram (see figure 1a) for the SST anomalies over the equatorial Pacific region for the period 1979-2018 was prepared from the reanalysis data ERA interim. It turns out that the El-Nino of 2015/2016 belongs to the three strongest 3 El-Nino events of the last 40 years. However, its maximum SST anomaly with Δ3.5° K is below those values of 1982/1983 with 4.5° K and 1997/1998 with Δ5.5° K .The corresponding global distribution of SST anomalies can be seen in figures 1b for the years 1982/1983 (not shown), 1997/1998 and 2015/2016.

In order to show where these so-called ENSO-sensitive regions are located, the SOI (<u>S</u>outhern <u>O</u>scillation <u>I</u>ndex) values for a period of the last 4 decades were related to the global seasonal relative precipitation sums. This is a composite analysis in which a case distinction of the SOI (SOI ≤ -7 “El-Nino" or ≥ +7 “La-Nina") is carried out and the associated precipitation deviations are assigned. The results are shown in figure 2 for El-Nino phases (left) for and for La-Nina phases (right) for the winter seasons (DJF). Brown bordered regions have a significance of 95 % probability with the t-test. ENSO-sensitive areas include for example southern USA, Mexico, many parts of South America, eastern and southern Africa, eastern China, as well as Indonesia and west Australia. It can be stated that the El-Nino and La-Nina events have a significant increasing or decreasing influence on precipitation worldwide.

The following figures 3a and 3b show the global winter variations for the months December, January and February for seasonal precipitation sums [mm] and seasonal average temperatures in El-Nino year 2015/2016 compared to the La-Nina year 2016/2017, arising from the REMO-model 0.11° data basis. The shown deviations of global precipitation and temperature changes from the REMO simulation data of all CORDEX areas correspond very well with the regional climatic effects observed worldwide (NOAA) [1] with regard to the El-Nino event.

[1] https://www.ncdc.noaa.gov/sotc/global/201604

1 CORDEX = COordinated Regional Downscaling EXperiment

Hovmoeller-Diagram for the SST (sea surface temperature) anomalies [Δ°K]

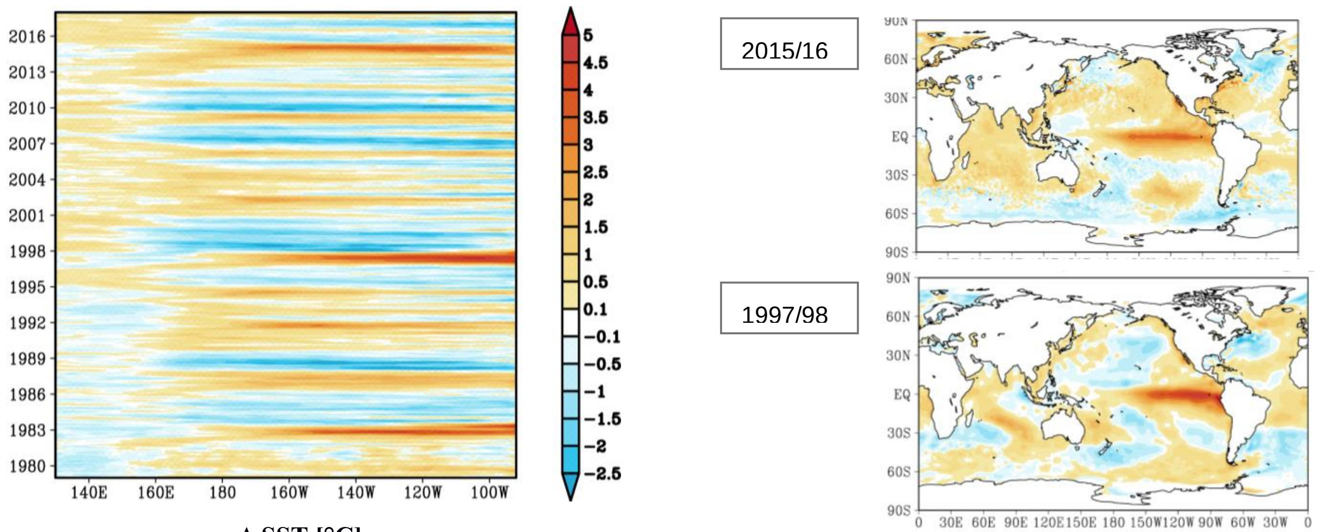

Fig. 1: Figure (left) shows a Hovmoeller diagram showing the temporal evolution of the monthly SST anomaly [°C] from ERA-Interim reanalysis data for the period 1979 to 2018 for the Pacific equator from 130° East to 90° West. Positive values in the eastern Pacific represent El-Nino while negative values are associated with La Nina. The figures (right side) show a corresponding global distribution of SST anomalies in the December months of 2015 (top) and 1997 (bottom).

2a) **El-Nino (SOI-Index ≤ -7) DJF**

2b) **La-Nina (SOI-Index ≥ +7) DJF**

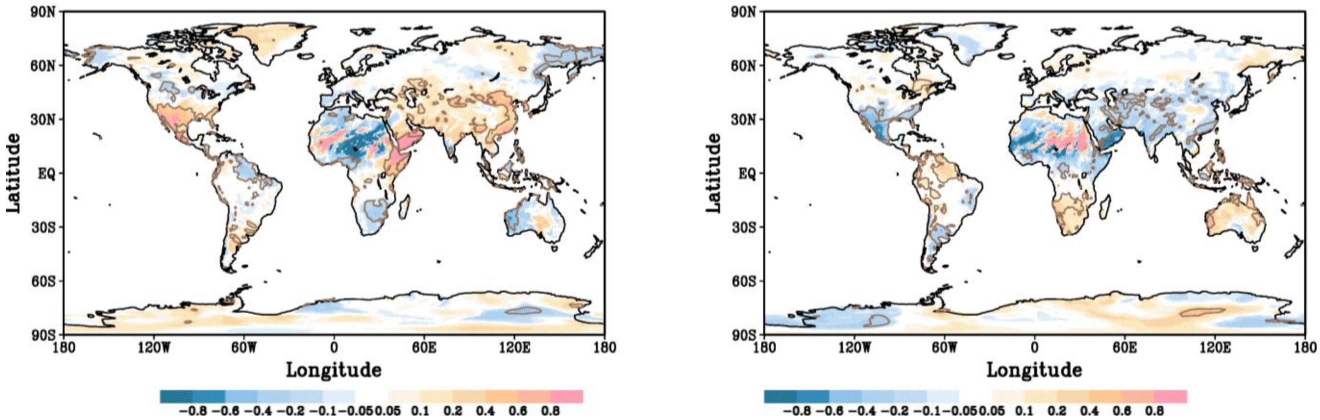

Fig. 2: Fig. 2a (left) shows the relative seasonal precipitation anomalies for winter (DJF) to the El-Nino events (SOI≤ -7) and Fig. 2b (right) corresponding to the La-Nina phases (SOI≥+ 7) of the last 40 years from the ERA interim reanalysis. Negative precipitation deviations [%] are shown in blue colors, positive deviations in red colors. Brown marked areas are significant (t-test) with a 95% probability.

El-Nino phase in the DJF winter season: difference 2015/2016 - 2016/2017

3a) Δ Precipitation [mm]

3b) Δ Temperature [K]

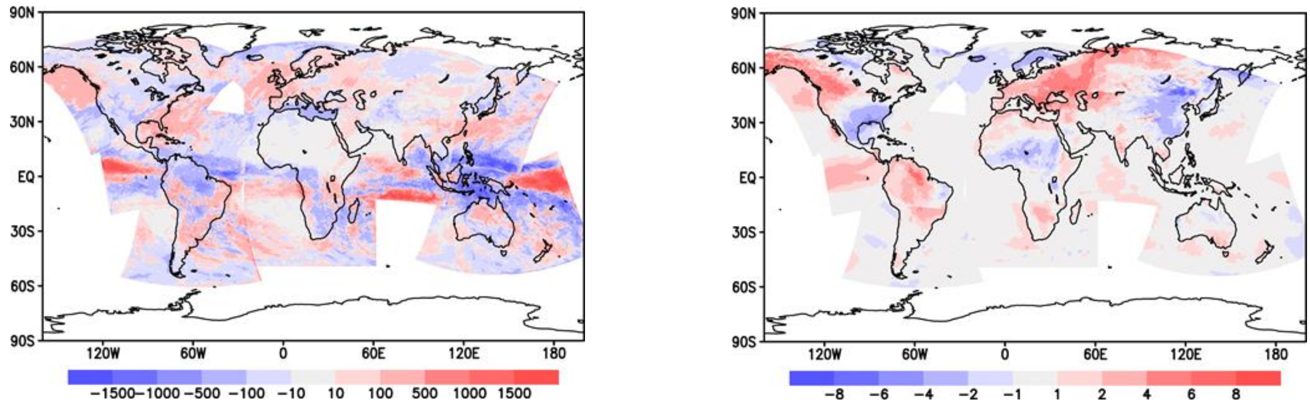

Fig. 3a-b: Figure 3a and 3b show the differences in seasonal total precipitation and seasonal temperature averages for winter between the El-Nino year 2015/2016 and the La-Nina year 2016/2017 in units [mm] and [K] for all CORDEX domains Europe, Africa, Australia, North-, Central- and South-America and Central-, East- and South-Asia in 0. 11° REMO model resolution.