Impact of El Niño, La Niña, and IOD ISSTAN on climate by SPEEDY

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Abstract: The SPEEDY model has been run over the time span of six months from January 2016 with 50 years ensemble, including ocean related atmospheric phenomena. The model's results for sea surface temperature and the precipitation in the different regions. Extensive research has improved our understanding and forecast of the occurrence, evolution and global impacts of the El Niño–Southern Oscillation (ENSO), La Niña and IOD (Indian Ocean Dipole). However, they change as the global climate warms up/ cools and they exhibit different characteristics and climate impacts in the twenty-first century from the twentieth century.

1 Introduction

With global warming coming to the fore recently, the effect of ocean currents on global climate change has started to be wondered. In this report, global effects of ocean-atmospheric currents as El Niño, La Niña and IOD (Indian Ocean Dipole), which is known as Indian El Niño, in different locations were observed. During the observation, 50 years between 1910-1960 ensemble model was run. The model used for these calculations is the SPEEDY (Simplified Parameterizations, privitivE-Equation DYnamics) model, which has been developed at the International Centre for Theoretical Physics (ICTP) located in the Castello di Miramare, Italy.
The model has been set up to run over the six months time span from January 2016. Although there are various climatological impacts of the currents, sea surface temperature and precipitation parameters were simulated in this paper. Earth-atmosphere related influences of warming and cooling were assessed over six continents, except south America, so that to make more detailed observing all over the world. Over the some continents, impacts of the currents could be hardly distinguished because of being very week.

2 Implementation of SPEEDY

We run SPEEDY a total of seven times, always starting from January 1st, 2016 over a time span of 6 months with 50 ensemble members. The various runs use the following sea-surface temperature (SST) anomalies:

- control run not using any SST anomalies
- 2016 SST anomalies from HadISST (Hadley Centre Sea Ice and Sea Surface Temperature)
- 2016 El Niño SST anomalies from NOAA (National Oceanic and Atmospheric Administration)
- idealized El Niño SST anomalies from the following dataset file:

  `sst_composite_nino34_p1.grd`
- idealized El Niño SST anomalies from the following dataset file:

  `sst_composite_nino34_m1.grd`
- idealized Indian Ocean Dipole (IOD) SST anomalies from the following dataset file: `sst_composite_iod_p1.grd`
- idealized IOD SST anomalies from the following dataset file:

  `sst_composite_iod_m1.grd`

3 Results

In the following, the SPEEDY results are averaged over all ensemble members and over the time.

3.1 Comparison of the Pacific sea surface temperature

We start by comparing the sea-surface temperatures in the pacific ocean between 100 °E and 60 °W and between 30 °S and 30 °N, which is the region of the El Nino events. The results of all SPEEDY runs are illustrated in figure 1. All runs predict a high SST in the region east of Indonesia (150 °E-170 °W and 10 °S-5 °N) of over 302 K. However, in the case of the SPEEDY run using HadISST anomalies (see fig. 1a), these high temperatures extend even further east than 100 °E. The SPEEDY runs using IOD SST anomalies (see figs. 1f and 1g) predict high SST as far west as 150 °W. These two runs resemble the control run with no SST anomalies included, visualized in fig. 1e, the most. The most significant deviations from the control run can be observed for the runs using HadISST, NOAA, and idealized El Niño (m1) anomalies. While the HadISST run predicts a significantly larger region with high temperatures, NOAA and idealized El Niño (m1) anomalies predict much smaller regions of high temperature.

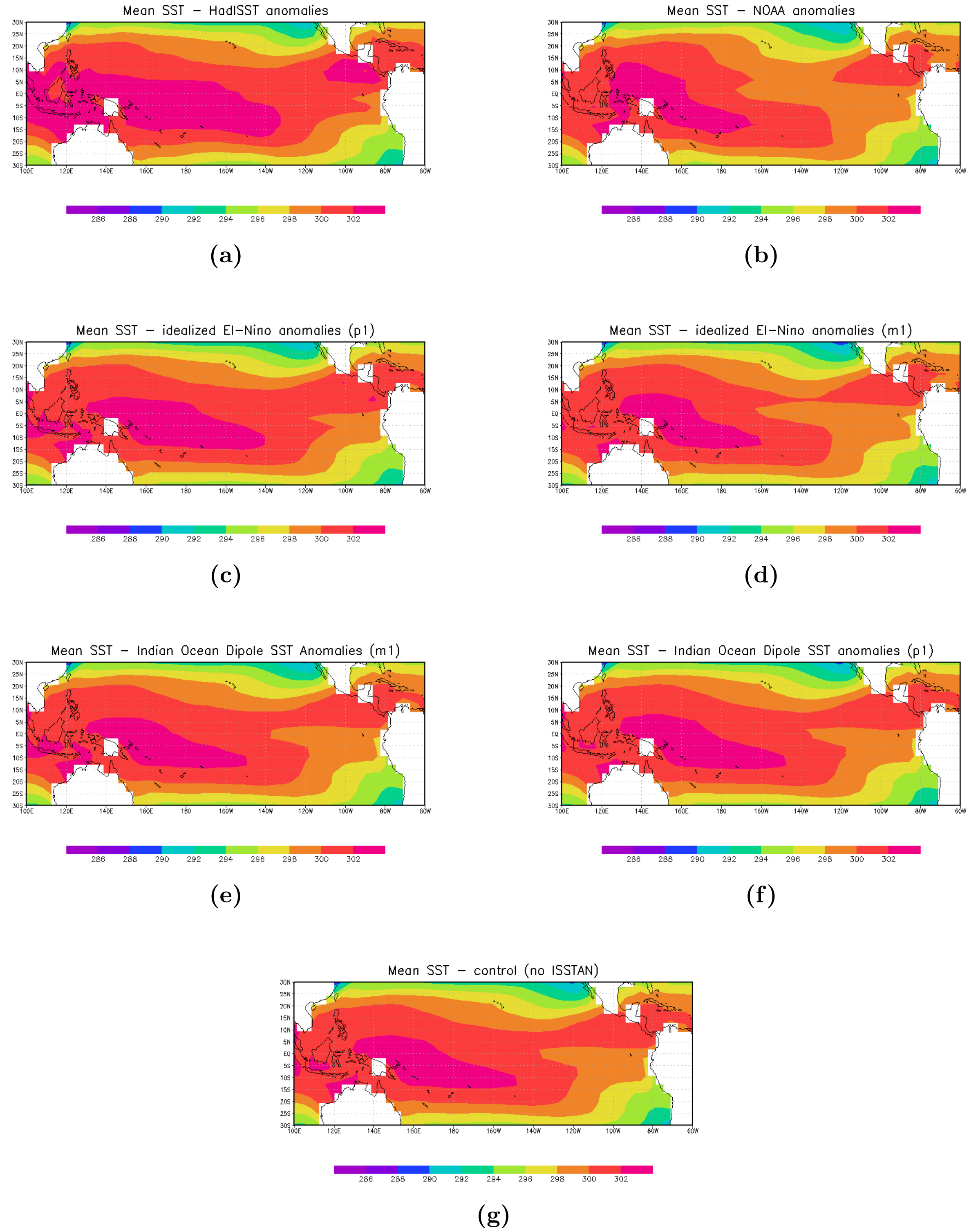
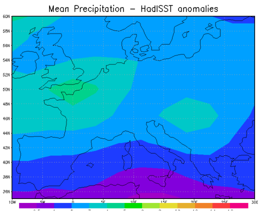


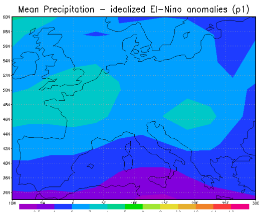
Figure 1: Predicted sea-surface temperature in the pacific ocean using (a) HadISST anomalies, (b) NOAA anomalies, (c) idealized El Niño anomalies (p1), (d) idealized El Niño anomalies (p1), (e) Indian Ocean Dipole (IOD) Anomalies (m1), (f) IOD Anomalies (p1, costum) and (g) no anomalies.

3.2 Comparisons of precipitation in various continents

3.2.1 Europe



(a)



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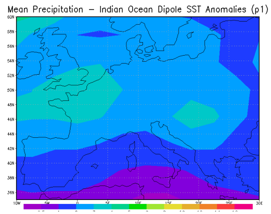

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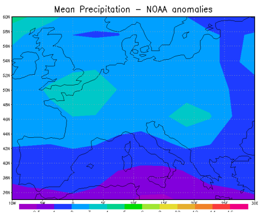

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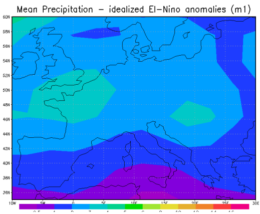

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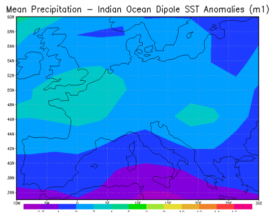
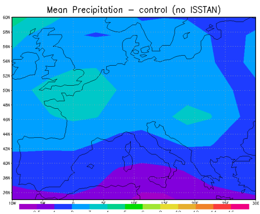


(f)



(g)

Figure 2: Mean precipitation over Europe for different SST Anomalies, visualized as a contour plot [100 mm / 6 months], where purple represents low amounts of precipitation and magenta equals high amounts of precipitations. Upper Line: a) HadISST, b) idealized El Niño (p1), c) IOD SST (p1). Middle line: d) NOAA, e) idealized El Niño (m1), f) IOD SST (m1). Lower line: g) control run - no anomalies.

In figure 2 the precipitation output of the SPEEDY ensemble run is visualized for the six different SST anomalies data sets as well as for the control run without such anomalies. Instantly, it can be observed that the structure of precipitation distribution is similar for all the data with the most precipitation in the north-west of France and Belgium as well as Hungary and north-west of Great Britain with up to 350 - 400 mm / 6 months, while the least amount of precipitation is calculated for southern Italy and the Mediterranean area with less than 100 mm / 6 months. Intercomparison between the contour area sizes of different colors show that most data sets with SST anomalies lead to slightly more precipitation than if such anomalies are not integrated in the model. Most notably, using the HadISST anomalies (figure 2a) leads to more precipitation to a point that a different color scale is used with an upper limit at 500 mm. Only the usage of the NOAA anomalies (figure 2d) results in a precipitation output below the level of the control run.

3.2.2 North America

Figure 3 displays the corresponding model output for North America. Again, a repeating structure of the precipitation can be seen in the different plots, with maximal values in the eastern part of the United States and nearby the Bermuda archipelago with up to 600 mm and minimal values in the northern part of central Canada and the Arctic as well the Mexican peninsula of Baja California with less than 100 mm during the six month period. Like for the evaluation of the European region, most of the anomalies sets lead to a stronger precipitation in the model output compared to the control run with the exception again being the NOAA run. But for this continent, there is one region, where the control run and the NOAA SST anomalies data yield more precipitation than under the usage of the other data sets, which is the Canadian west coast.

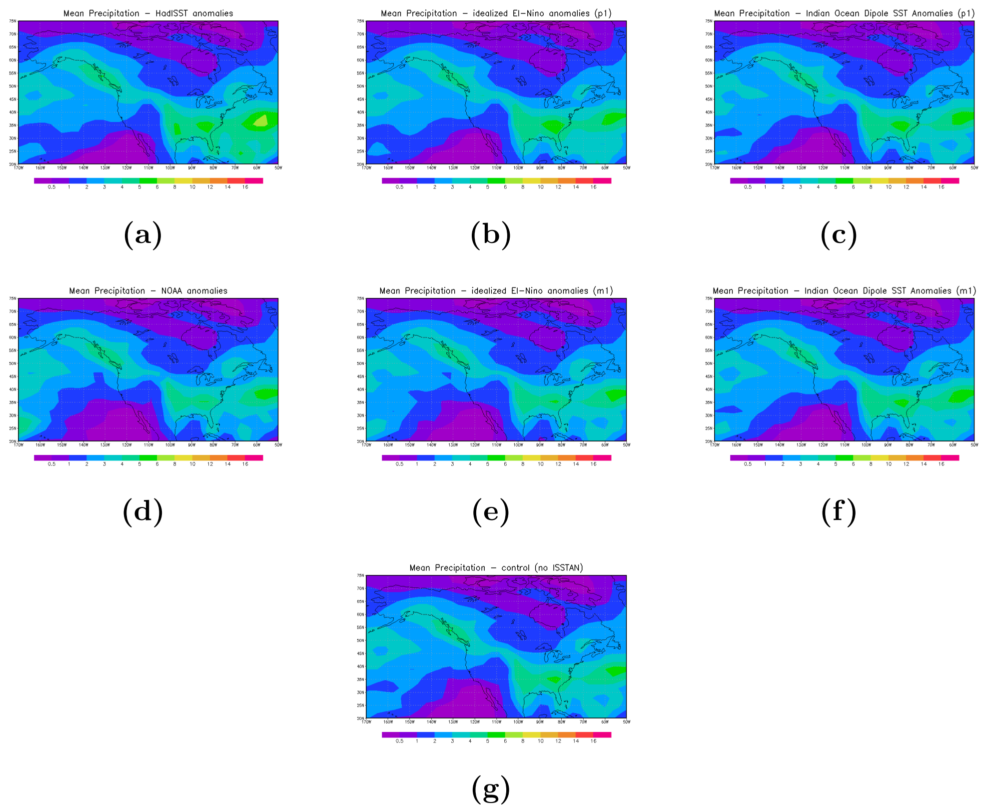
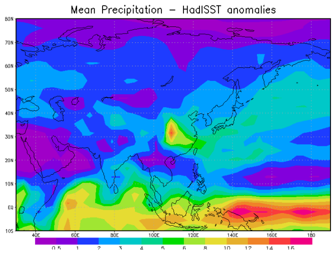
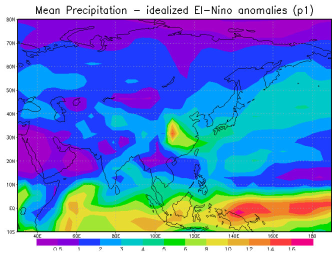


Figure 3: Mean precipitation over North America for different SST Anomalies, visualized as a contour plot [100 mm / 6 months], where purple represents low amounts of precipitation and magenta equals high amounts of precipitations. Upper Line:
a) HadISST, b) idealized El Niño (p1), c) IOD SST (p1). Middle line: d) NOAA,
e) idealized El Niño (m1), f) IOD SST (m1). Lower line: g) control run - no anomalies.

3.2.3 Asia



(a)



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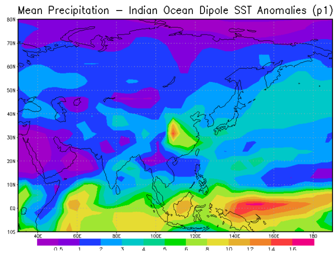

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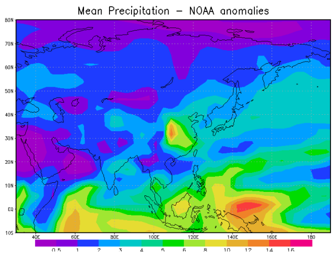

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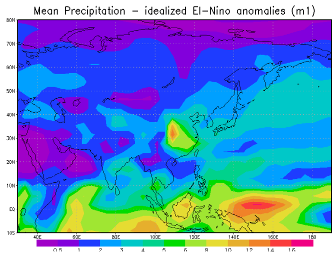
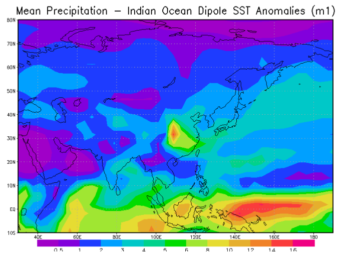


(e)



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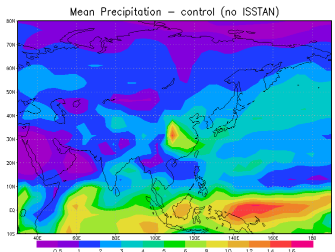


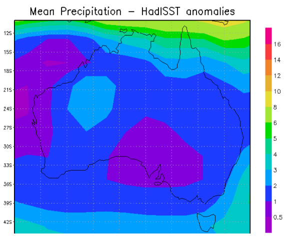
(g)

Figure 4: Mean precipitation over Asia for different SST Anomalies, visualized as a contour plot [100 mm/6 months], where purple represents low amounts of precipitation and magenta equals high amounts of precipitations. Upper Line: a) HadISST, b) idealized El Niño (p1), c) IOD SST (p1). Middle line: d) NOAA, e) idealized El Niño (m1), f) IOD SST (m1). Lower line: g) control run - no anomalies

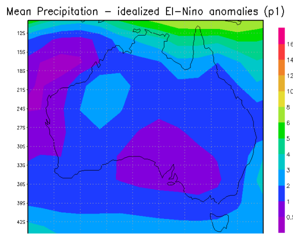
All the plots seem to look quite similar. The plots 4a-4f are now compared to figure 4g. The general contribution of the mean precipitation is quite similar in all the plots. Figure 4a considers the precipitation with HadISST anomalies. The general areas which

show high precipitation are the same. Figure 4a seems to overestimate the regions with the highest precipitation a little in the south-east, but underestimates it over the Pacific. It is also noticeable that the red region with high precipitation in figure 4a are a bit more distributed.
Figure 4b shows the mean precipitation considering the idealized El Niño anomalies. The region over east Asia is almost the same in both plots. It is noticeable that the area with the maximum precipitation in the east (over the Pacific) is distributed differently. Figure 4b shows a little less precipitation than figure 4g, the difference is only about 100 mm/6 months.
Figure 4c shows the mean precipitation with the consideration of the Indian Ocean Dipole anomalies (IOD SST anomalies). The general distribution of the precipitation is quite similar over the whole region, with small differences over the Pacific. The differences in the south east region of the plots are almost not distinguishable. The IOD SST underestimates the precipitation a little in the east.
Figure 4d shows the mean precipitation with the NOAA anomalies. At 60E between the equator and 10S the precipitaton is a little overestimated. In the south-east between 140E and 180E where the maximum precipitation is located, figure 4d underestimates the values.
Figure 4e considering the idealized El Niño anomalies (m1). In this case the precipitation seems to get underestimated especially in the south-east in the area with the most precipitation.
Figure 4f shows the mean precipitation considering the Indian Ocean anomalies (m1). Compared to figure 4g at 100E, 10S the precipitation is a little underestimated. The area in the south that displays the highest precipitation (the red area) is almost the same in both plots.

3.2.4 Australia



(a)



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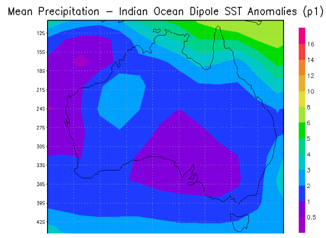

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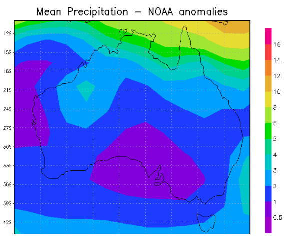

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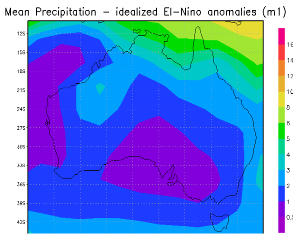

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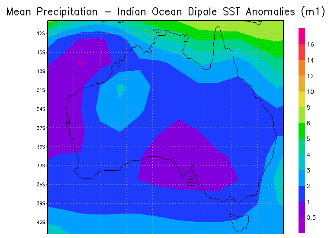

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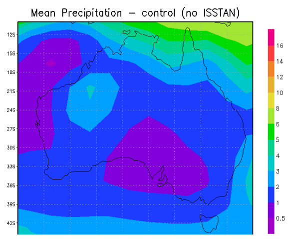

(g)

Figure 5: Mean precipitation over Australia for different SST Anomalies, visualized as a contour plot, where purple represents low amounts of precipitation and magenta equals high amounts of precipitations. Upper Line: a) HadISST, b) idealized El Niño (p1), c) IOD SST (p1). Middle line: d) NOAA, e) idealized El Niño (m1), f) IOD SST (m1). Lower line: g) control run - no anomalies

The plots 5a-5f are now compared to figure 5g. The general distribution is quite similar in the plots. Figure 5a considers the HadISST anomalies. The distribution in the north is similar in the control plot (figure 5g). In the northwest of Australia the precipitation is underestimated. In the south over the ocean the precipitation between 150E and 155E

is overestimated.
Figure 5b shows the mean precipitation considering the idealized El Niño anomalies. The precipitation in the northwest of the continent is underestimated. In the north in the farthest right corner of the plot the precipitation is underestimated becuase the color distribution is a little shifted.
Figure 5c shows the mean precipitation with the consideration of the Indian Ocean Dipole anomalies (p1)(IOD SST anomalies). Compared to figure 5g the plots look very similar. The precipitation in the northwest of the continent is a little underestimated.
Figure 5d shows the mean precipitation with the NOAA anomalies. The precipitation in the northwest, the north and the northeast over Australia is overestimated with the NOAA anomalies. The precipitation in the north over the ocean is overestimated.
Figure 4e considering the idealized El Niño anomalies (m1). In this case the precipitation seems to get overestimated in the north-east and in the north of the continent.
Figure 5f shows the mean precipitation considering the Indian Ocean anomalies (m1). Compared to figure 5g the plots are look almost the same as there are no differences that are obvious aside from the width of the different lines at the top of the plots.

4 Discussion

After observing the plots resulting from the SPEEDY ensemble runs executed using different SST anomalies sets one can try to link the output to the El Niño phenomenon, which was present in 2016. Since the variations between the different runs in respect to the control run were not very severe, they will be treated as approximately representative for one another for the moment.
The temperature plots in figure 1 show a pool of warm sea surface temperature (over 302 K) east of Indonesia, while a tongue of slightly less warm sea surface temperature extends across the whole Pacific so that values of at least 298 K are reached at the west coast of Middle America and the northern parts of South America. This transport of warm water is significant for El Niño events and is more or less forecasted by all model runs.
The predicted precipitation for North America and Europe does not seem to change much by selecting different SST anomalies sets with an active El Niño phenomenon. Therefore one could argue that the El Niño phenomenon does not have a big influence on that meteorological parameter in these particular regions. This correlates well with general observations. In comparison there are more variations between the different runs for (southeast) Asia and most notably Australia, which analogously might yield a bigger influence of El Niño in these regions. One further indication for this is that both Australia and southeast Asia are close to the warm pool observed in the plot 1.

5 Conclusion

The influence of different SST anomalies with an active El Niño condition on the Pacific sea surface temperature and the precipitation over Europe, North America, Asia and Australia were predicted for a SPEEDY ensemble run over the first half of 2016. Some quantitative differences can be spotted when using a different data set, but qualitatively, the results are quite similar to each other. Some elements that need to be addressed in the future to have the ability to judge which run is closest to an optimal prediction of the El Niño phenomenon include the comparison of the model data against observational data, as well as calculating an anomaly from said observations.