Assessment of Climatic Impact Drivers in India

Focus Districts: Ahmadnagar, Amravati, Balaghat, Dhule, Jalna, Mandla and Yavatmal

This assessment describes seven important climatic impact drivers for India, with a special focus on the districts Ahmadnagar, Amravati, Dhule, Jalna and Yavatmal in the state of Maharashtra and Mandla and Balaghat in the state of Madhya Pradesh. It shows how the climatic impact drivers are projected to change under two climate change trajectories in the future (2030, 2050 and 2080). The presented drivers are mean temperature, mean precipitation, precipitation cycle, very hot days, heavy precipitation frequency and intensity as well as extremely dry months. For further guidance and background information about the figures and analyses presented here kindly refer to the supplemental information on how to read the assessment of climatic impact drivers.

India is a country of large spatial extend and as such covers a multitude of climatic regions. Here we present projected climatic changes for the Indian subcontinent from 17° to 24° North. This region covers the seven focus districts in Maharashtra and Madhya Pradesh: Ahmadnagar, Amravati, Balaghat, Dhule, Jalna, Mandla and Yavatmal.

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Mean Temperature

The temperatures of the analyzed region show annual mean temperatures beyond 20 degrees everywhere and generally follow the topography with lower temperatures in mountainous areas and higher temperatures at the coast and in lowlands (Figure 1). The climate models project an increase of temperatures throughout the whole region. By 2030, there is a similar warming of around 0.5° to 0.9° under both climate change scenarios. By 2050, strong mitigation (RCP 2.6) keeps the average warming in a range of 0.8° to 1.4°, while warming under no-mitigation (RCP 7.0) is projected to be beyond 1° in the whole region. By 2080, the warming under no-mitigation is projected to be around double of the mitigation scenario and all districts are found to warm more than 2° compared to 2000 conditions.

This potential of mitigation policies can also be seen in the time series line plots of the target districts (Figure 2), which show an almost linear increase in temperature throughout the 21st century under RCP 7.0, while temperatures stabilize under RCP 2.6. The strongest warming is found in the districts Balaghat and Mandla, where the best estimate shows a warming of more than 2.8° by 2080, but regional differences are generally small. While all models agree on a temperature increase in the second half of the 21st century, some models, project a clear regional cooling in the first half in Amravati, Balaghat, Mandla and Yavatmal, which are in the Northeast of the analysed region.

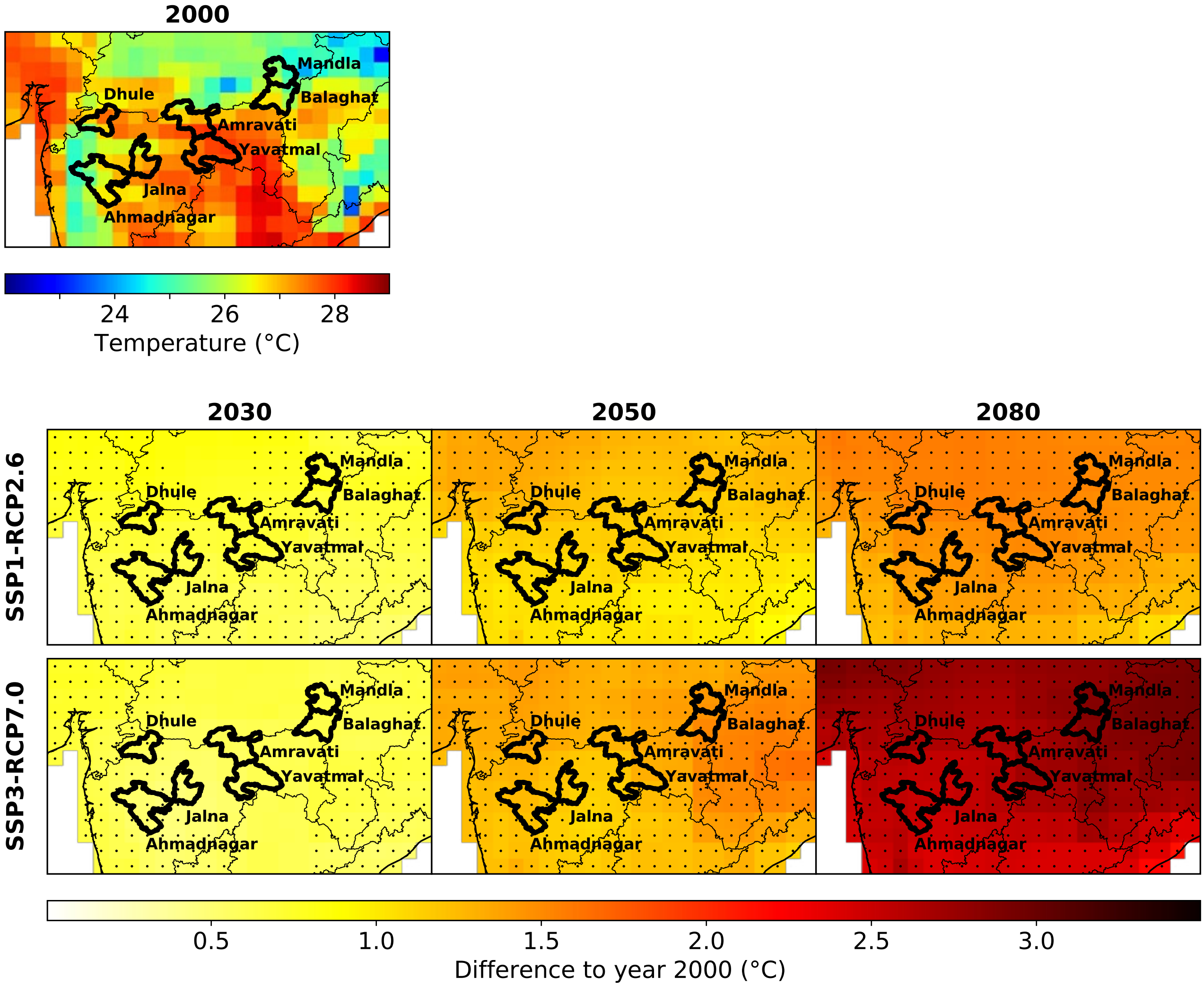

Figure 1. Projected change of mean temperature across India in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change in this location.

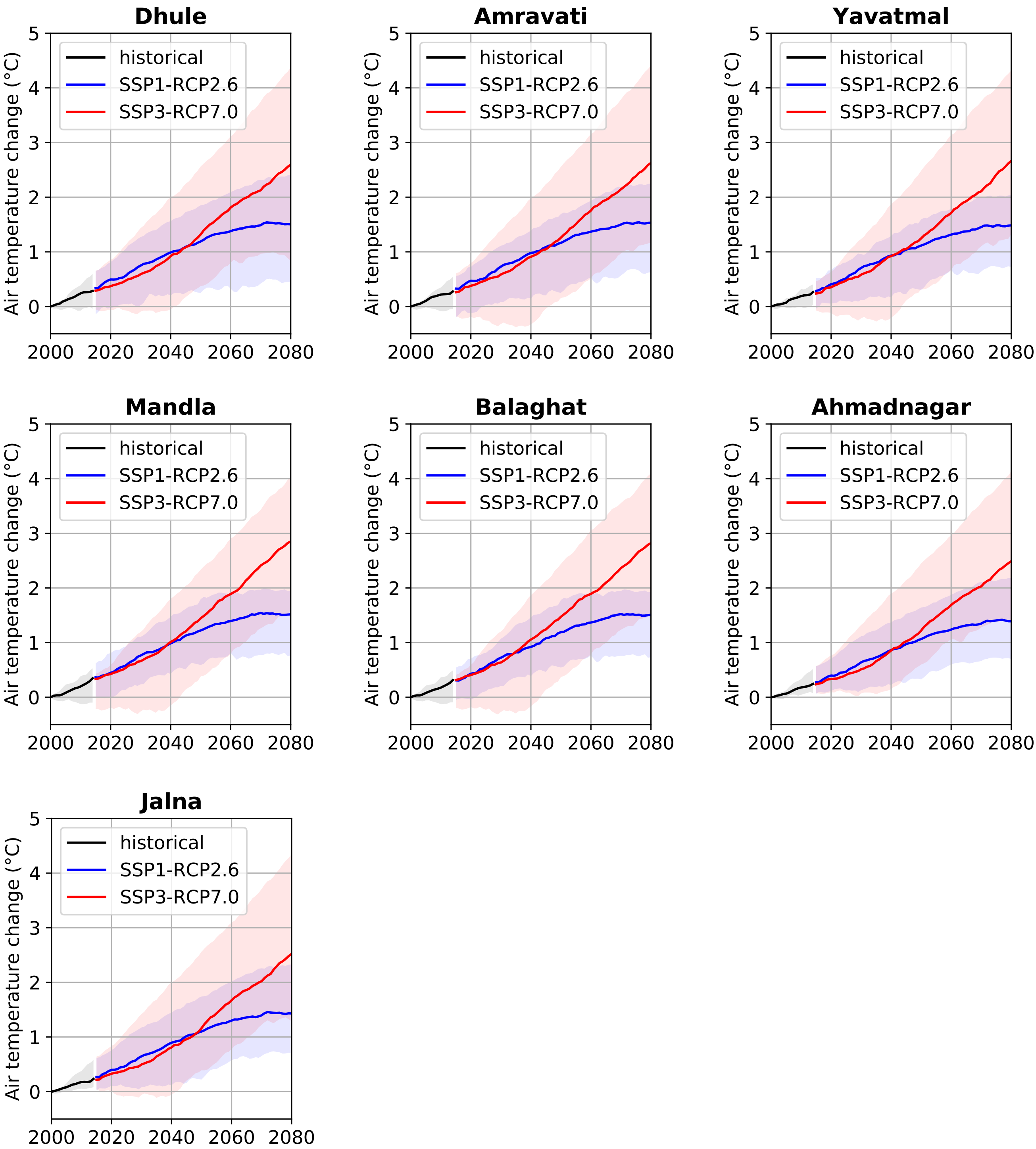

Figure 2: Projected temperature time series (difference to 2000) of the focus districts for the model medians (lines) and range of the model projections (shading) under two future trajectories.

Mean Precipitation

The spatial distribution of precipitation in the analyzed region is very diverse. Most of the annual rainfall is associated with the Southwest monsoon and precipitates along the slopes of the Western Ghats at the West Coast of India. The projections show an increase in mean rainfall in most districts (Figure 3). By 2030, the range and distribution of the precipitation increase is similar. By 2050, the strong mitigation scenario shows an increase in all districts, with maximum changes of up to 31.5%, while under the no-mitigation scenario there are some districts showing a slight decrease in precipitation by 2050. By 2080 this changes as precipitation conditions stabilize under RCP 2.6, but there is a strong increase in precipitation under RCP 7.0 with a local maximum increase of almost 50%.

The projected precipitation changes in the focus districts (Figure 4), confirm the overall picture of precipitation increase throughout the 21st century. The strongest precipitation increase is found in Dhule, where a sharp increase in the late 21st century under RCP 7.0 leads to a wetting of almost 40% by 2080. The model agreement on the wetting is generally very strong, while in some districts the range of the precipitation projections is very large. For example, for Jalna one model projects an increase of 10% under RCP 7.0 by the late 21st century, while another model projects an increase of 175%. Hence, it is uncertain by how much precipitation will increase, but it is likely that it will increase.

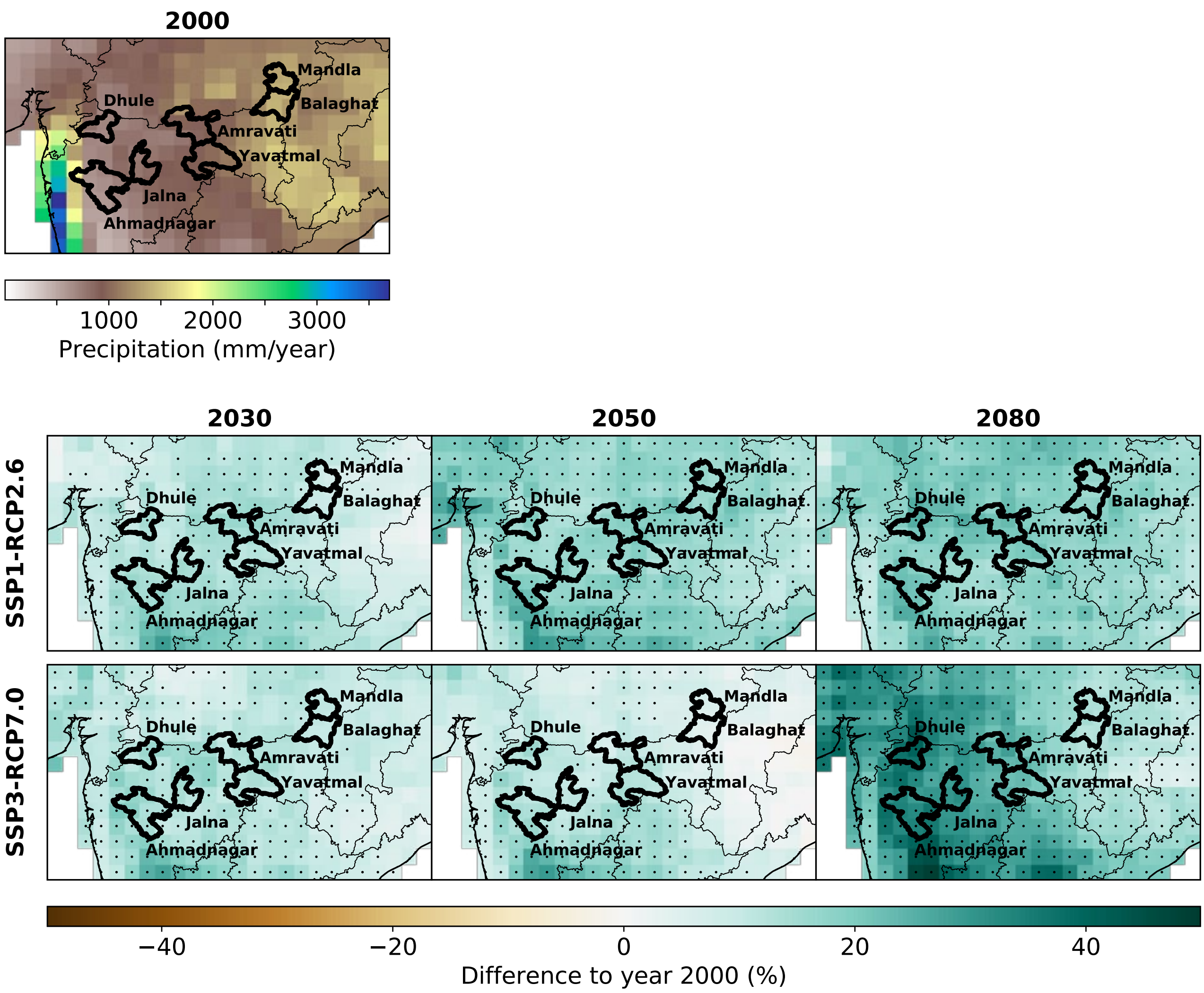

Figure 3: Projected changes of annual precipitation sums over India in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

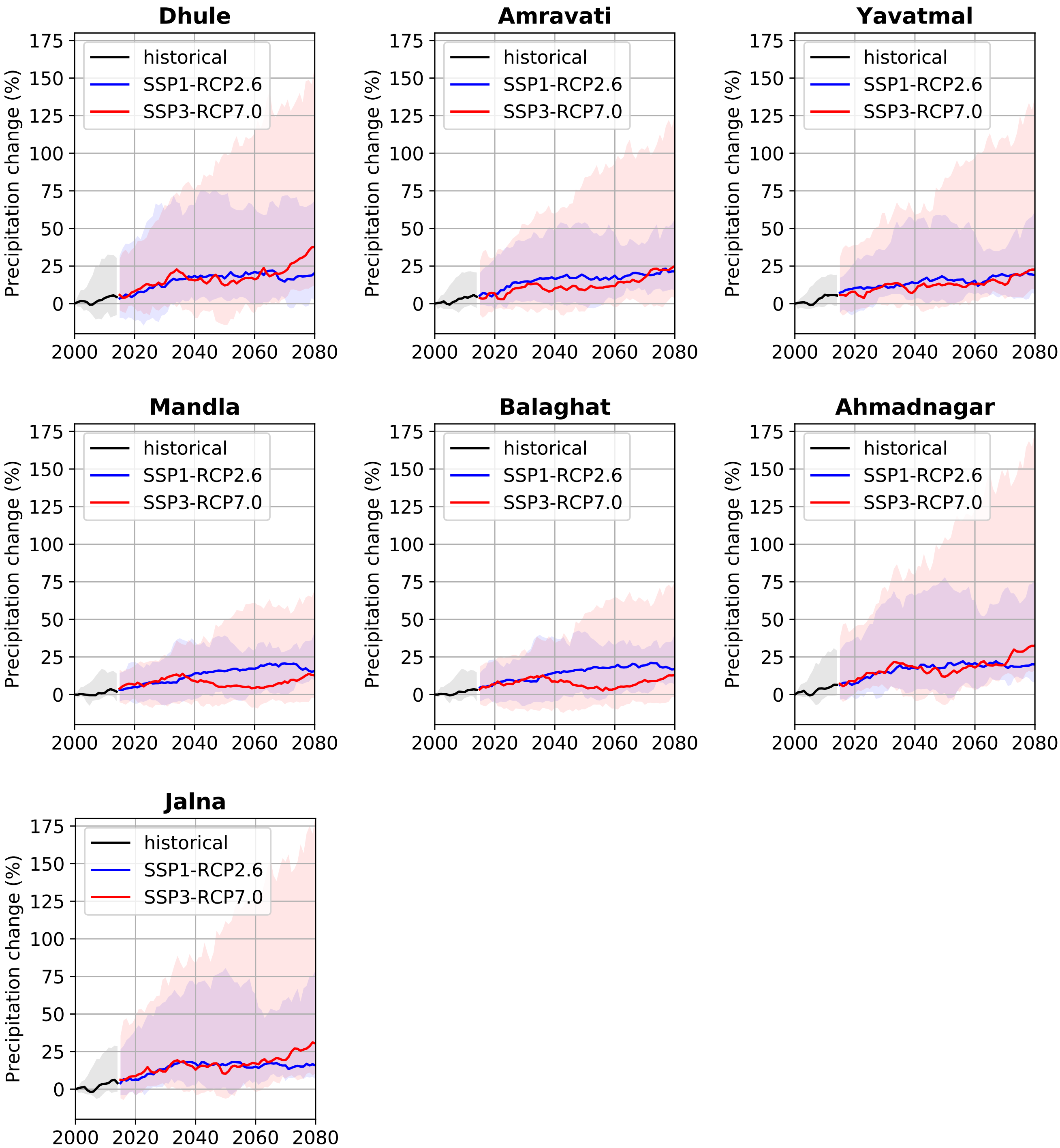

Figure 4: Projected precipitation time series of the focus districts for the model medians (lines) and range of the model projections (shading) under two future trajectories.

Precipitation Cycle

The annual cycle of precipitation in the target districts is dominated by the summer precipitation of the monsoon season (Figure 5). Generally, the strongest projected precipitation increases as well as the largest model spread is projected for the season of the strongest precipitation. In other words, rainy seasons will likely become wetter, but there are different projections on the magnitude. For most districts, the model agreement is stronger for the beginning of the monsoon season than for the end of the season. For Ahmadnagar, Dhule and Jalna, the shaded curves show that some models project a shift towards higher precipitation rates in the later monsoon season under both RCP scenarios. This can also be seen for Amravati, Balaghat and Yavatmal under RCP 7.0.

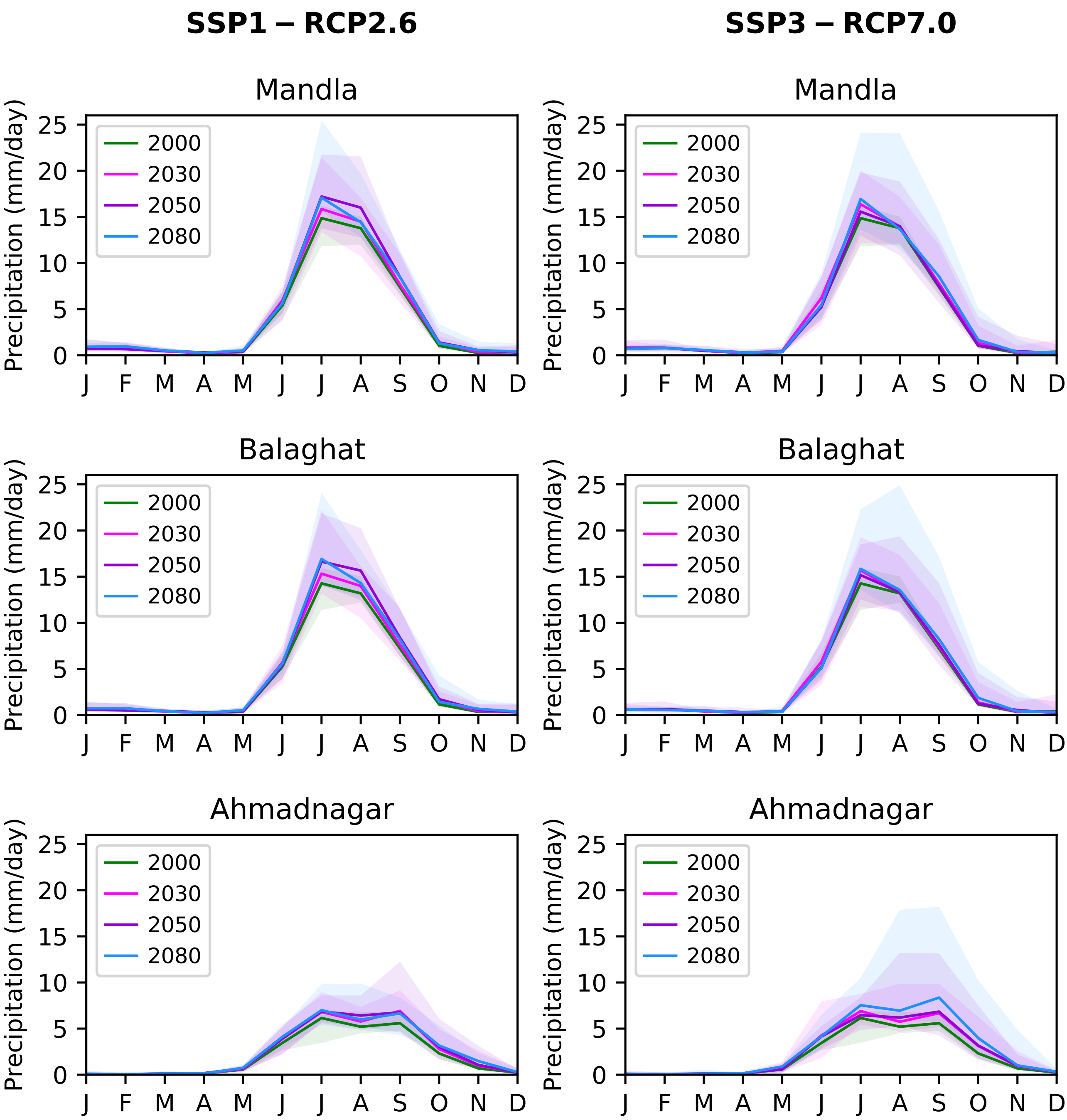

Figure 5a: Projected monthly mean precipitation rates for the focus districts, shown as the model medians (lines) and range of the model projections (shading) under two future trajectories.

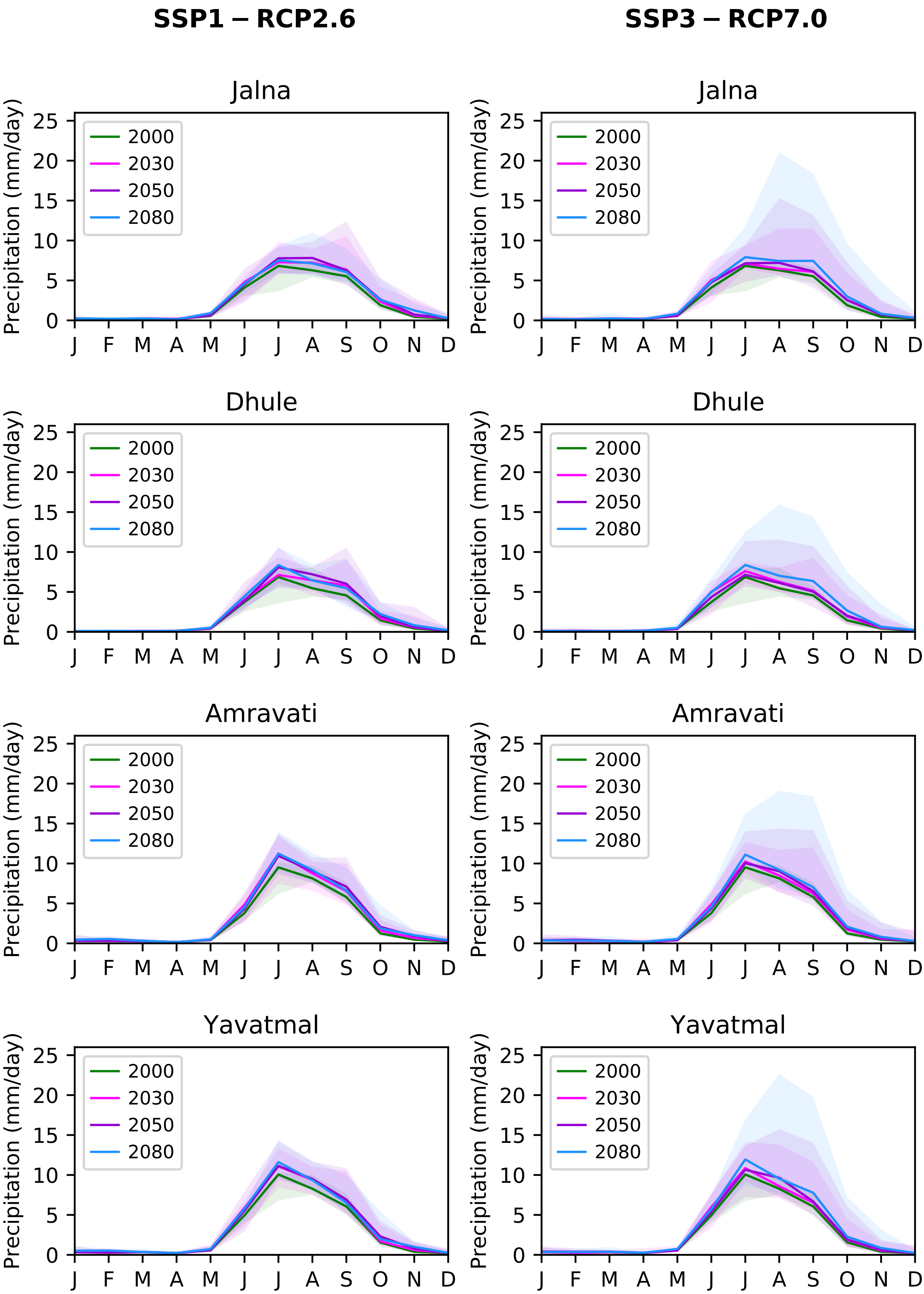

Figure 5b: Projected monthly mean precipitation rates for the focus districts, shown as the model medians (lines) and range of the model projections (shading) under two future trajectories.

Very hot days

In the focus regions, most very hot days are found in the Northwest around the Gulf of Khambhat, the lowest numbers of very hot days are found in southern and eastern coastal regions (Figure 6). The number of hot days in the focus districts is similar. Under both RCP scenarios, the climate models project an increase in very hot days. The strongest increase is found along the West Coast. Until 2050, the increase is very similar and linear under both scenarios with an increase of 4 to 34 days by 2030 and 13 to 63 days by 2050. By 2080, there is only a weak further increase under RCP2.6, while there is a sharper increase of 32 to 125 days per year under RCP 7.0.

The projections for the target districts also show a stabilization of the annual number of hot days under RCP 2.6, which is roughly around 25 extra days in all districts (Figure 7). The regional differences are stronger under RCP 7.0, where we find the strongest increase in Dhule (66 days by 2080) and the weakest in Mandla (44 days by 2080). The shaded curves show that some models project a decrease of very hot days in the first projected decades, which is mostly reversed by the end of the 21st century.

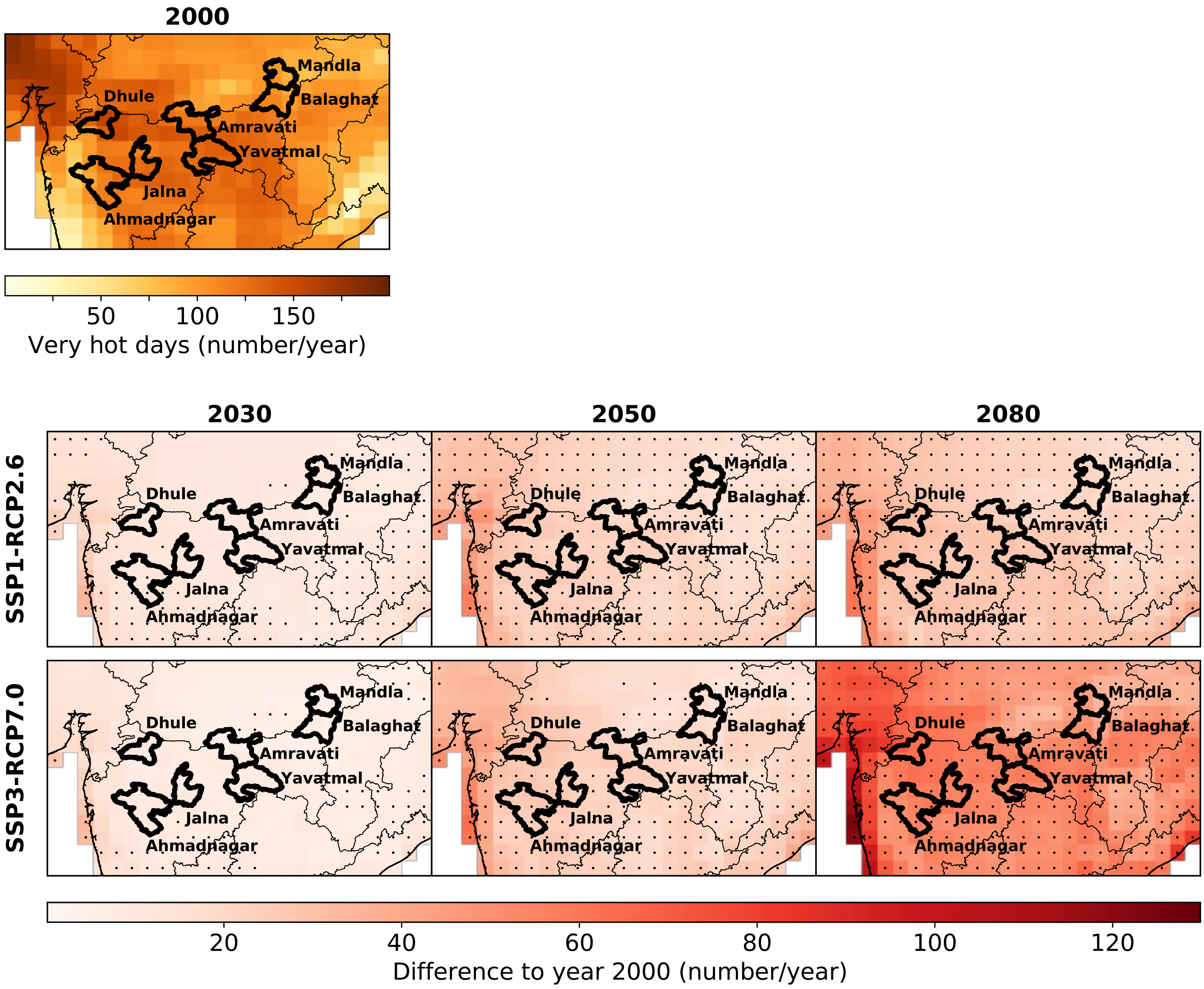

Figure 6: Projected changes in the number of very hot days across India in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

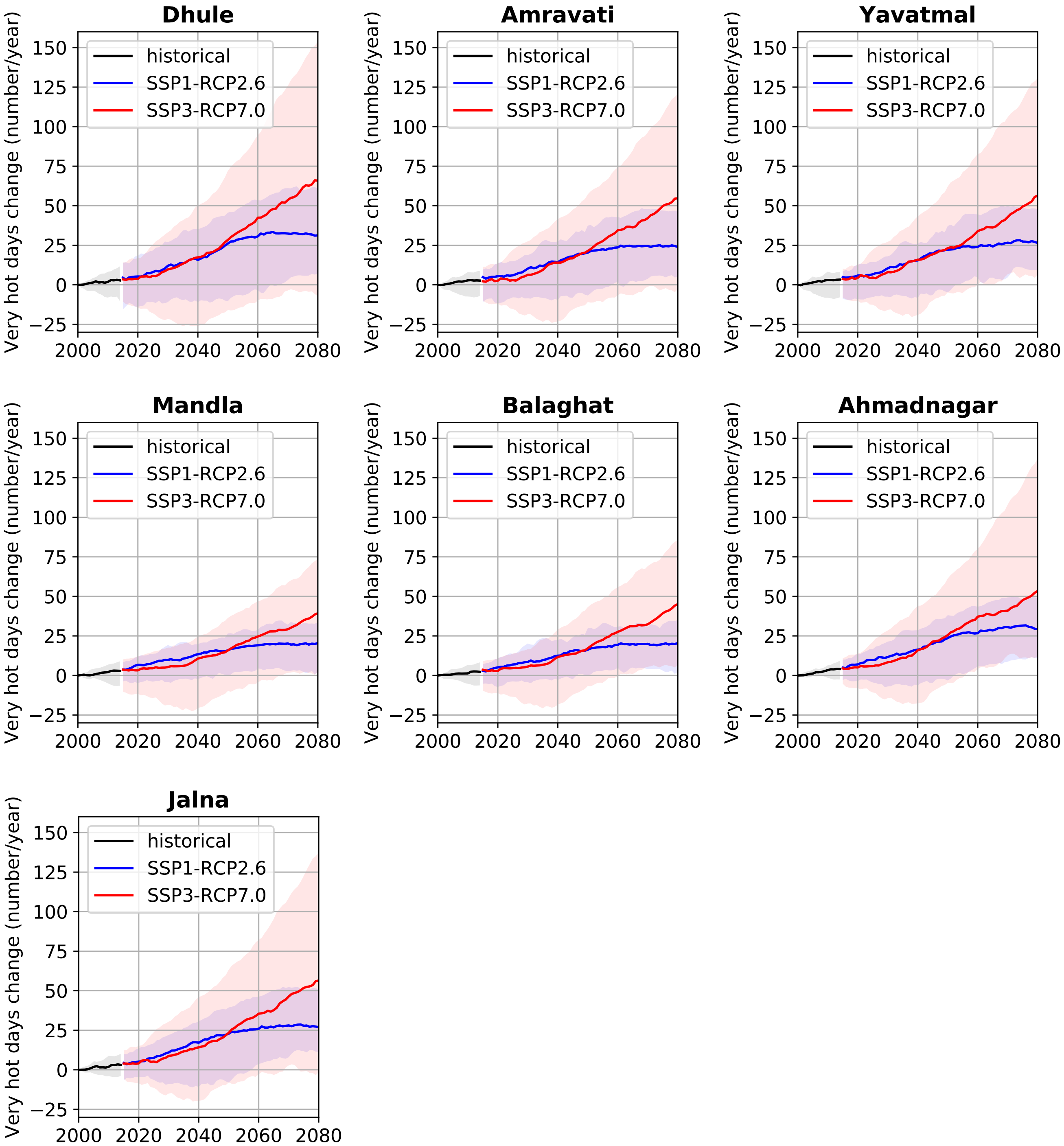

Figure 7: Projected number of hot days per year in the focus districts, model medians (lines) and range of the model projections (shading) under two future trajectories.

Heavy precipitation frequency

The climate model ensemble projects an increase of heavy precipitation days in most of the focus districts (Figure 8). The changes' signal is very similar to the changes in the precipitation mean, with a similar picture by 2030 under both RCP scenarios, wetter conditions under the strong mitigation scenario by 2050, and distinctly wetter under the no-mitigation scenario. While the number of heavy precipitation events stabilizes under RCP 2.6 in the middle of the 21st century with maximum increase around 3 days per year, it continuously increases under RCP 7.0 to maximum values of 5.7 days more by 2080.

For all the focus districts the model ensemble projects an increase in heavy precipitation events throughout the 21st century, but not all models agree on this change (Figure 9). In particular for Balaghat, the shaded curves show that at least one model projects a decrease in heavy precipitation events for most of the 21st century under RCP 7.0 and for the middle of the 21st century under RCP 2.6. The time series also show that by 2080, the differences of the projection under the two scenarios are rather small, with the clearest differences as well as the strongest increase under RCP 7.0 for Ahmadnagar and Dhule.

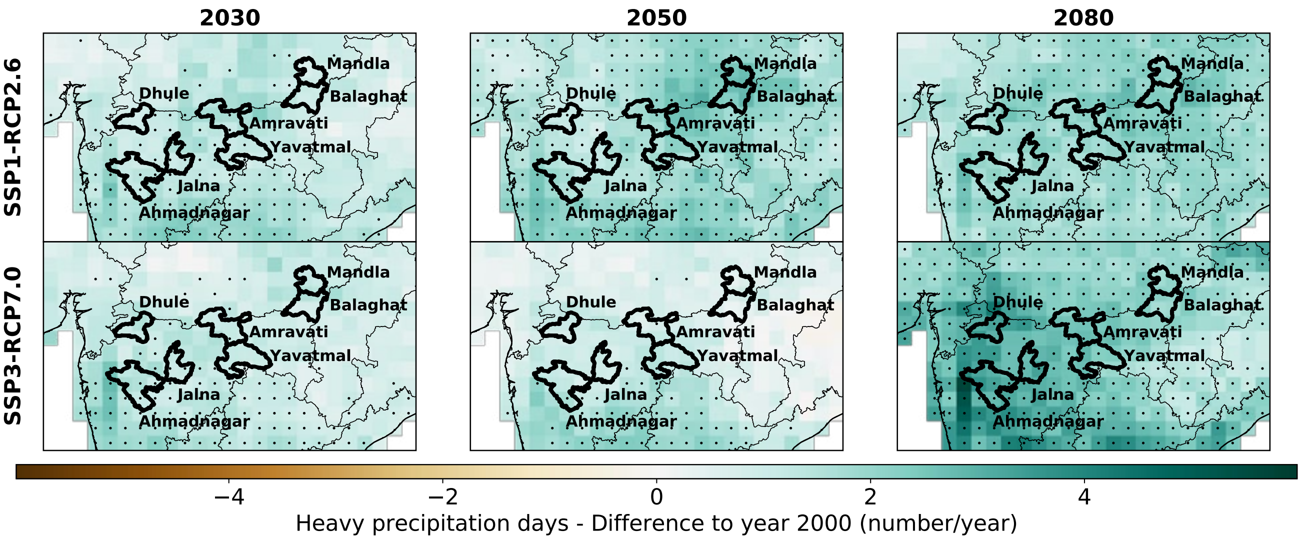

Figure 8: Projected changes in heavy precipitation events across India in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

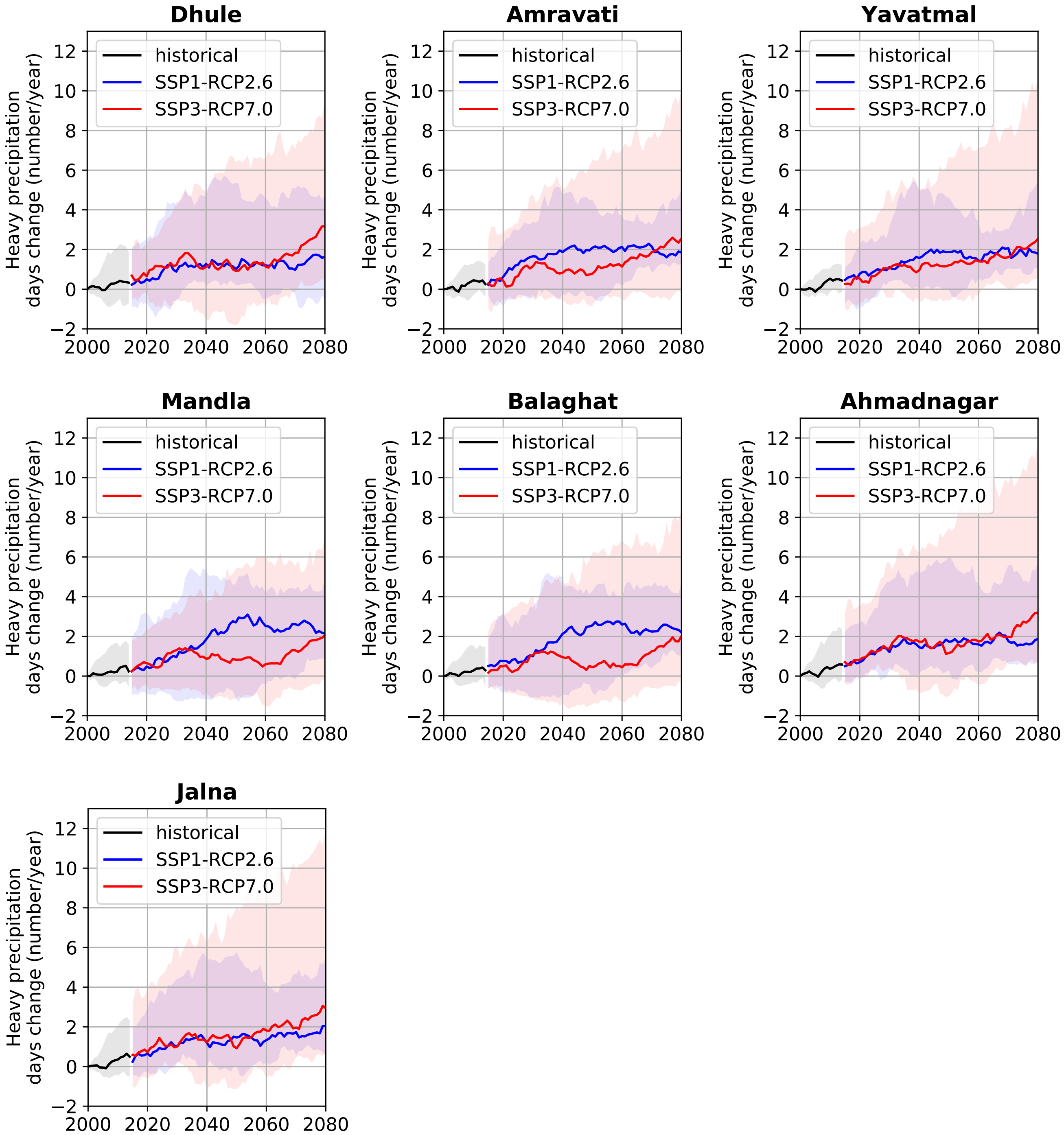

Figure 9: Projected number of heavy precipitation events per year in the focus districts, model ensemble medians (lines) and range of the model projections (shading) under two future trajectories.

Heavy precipitation intensity

The spatial pattern of the heavy precipitation intensity is very similar to mean precipitation with the highest precipitation rates at the western coast and slopes of the Western Ghats (Figure 10). In agreement with the other precipitation indices, heavy precipitation intensity is projected to increase in most of the districts. Also in line with mean precipitation projections, in the nearer future the increase is stronger under RCP 2.6 (5–28% by 2050), whereas in the further future heavy precipitation increases stronger under RCP 7.0 (3–43% by 2080).

Also, the time series of the average heavy precipitation intensity of the Indian focus districts show a clear intensification of precipitation (Figure 11). The best estimate of the intensification is in a similar range for all districts and stays below 40% under both RCPs for the whole 21st century. On the other hand, the model spread varies strongly between the districts. For example, all models project an intensification below 45% for Mandla by 2080, while at least one model projects an increase over 120% for Jalna.

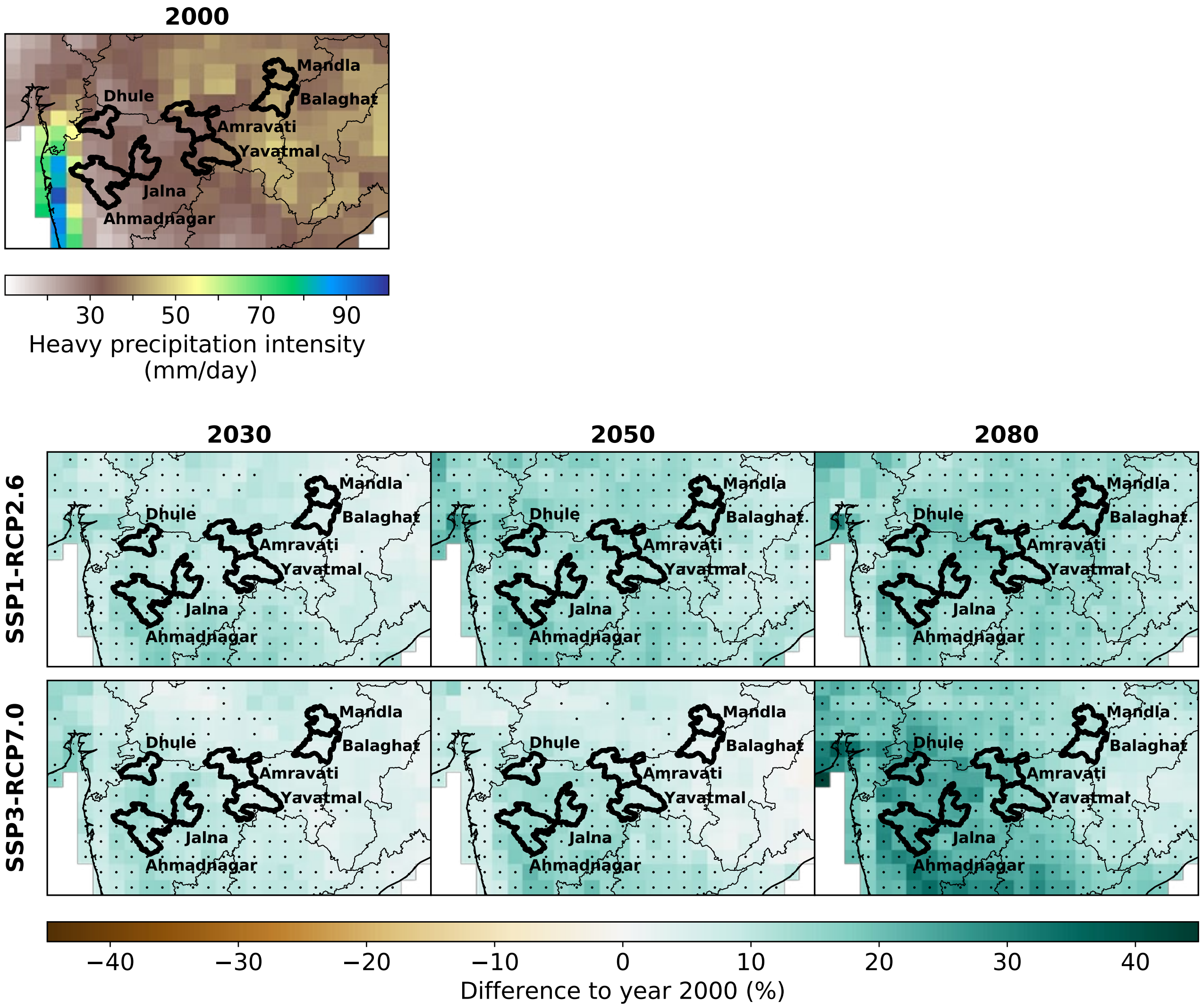

Figure 10: Projected changes in heavy precipitation intensity across India in 2030, 2050 and 2080 compared to 2000 under two different trajectories. Dots indicate that at least 9 out of 10 models agree on the sign of change.

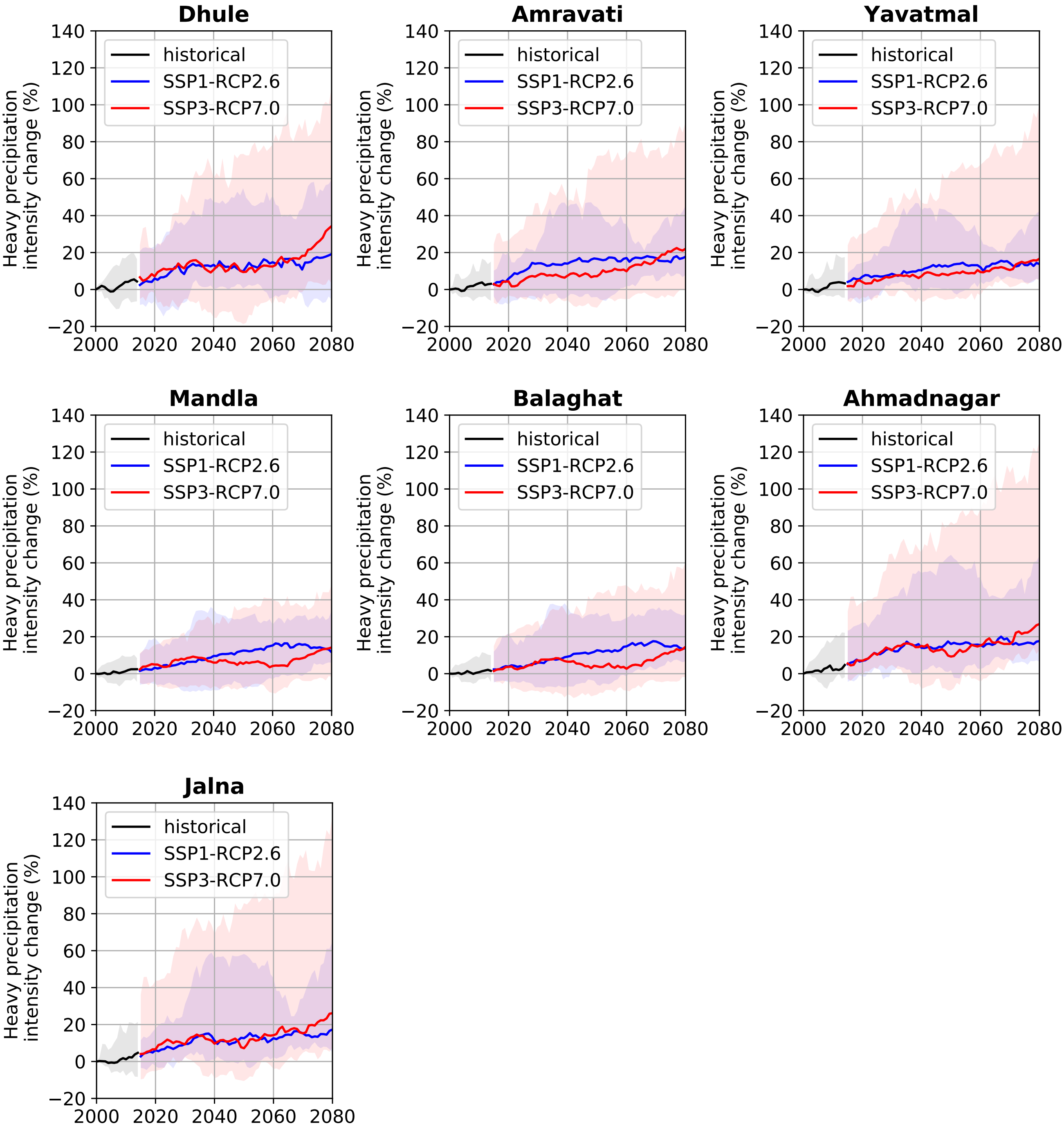

Figure 11: Projected intensity of heavy precipitation in the focus districts, model ensemble medians (lines) and range of the model projections (shading) under two future trajectories.

Extremely dry months

Extremely dry months are projected to increase in all Indian focus districts under both RCP scenarios (Figure 12). As the definition of a dry months is based on the difference of precipitation and evapotranspiration (based on temperature), this increase in dry months indicates that the increase in precipitation cannot balance the increased atmospheric water demand from increasing temperatures. The pattern of the increase in extremely dry months is similar under both scenarios by 2030, while the increase is already stronger under the no-mitigation scenario by 2050. By 2080, the local increase in extremely dry months is between 0.2 and 3.9 days per year under RCP 2.6 and between 1.5 and 6.4 days per year under RCP 7.0. The strongest increase is generally found inland, while the western coast only shows a weak increase.

The projected changes for the focus districts are very similar, with all models projecting an increase in extremely dry months in all districts under both scenarios (Figure 13). The strongest increase in extremely dry months found for Yavatmal (2.7 months by 2080 under RCP 2.6 and 5.5 months by 2080 under RCP 7.0) and the weakest increase is found for Mandla (1 month by 2080 under RCP 2.6 and 3.4 months by 2080 under RCP 7.0).

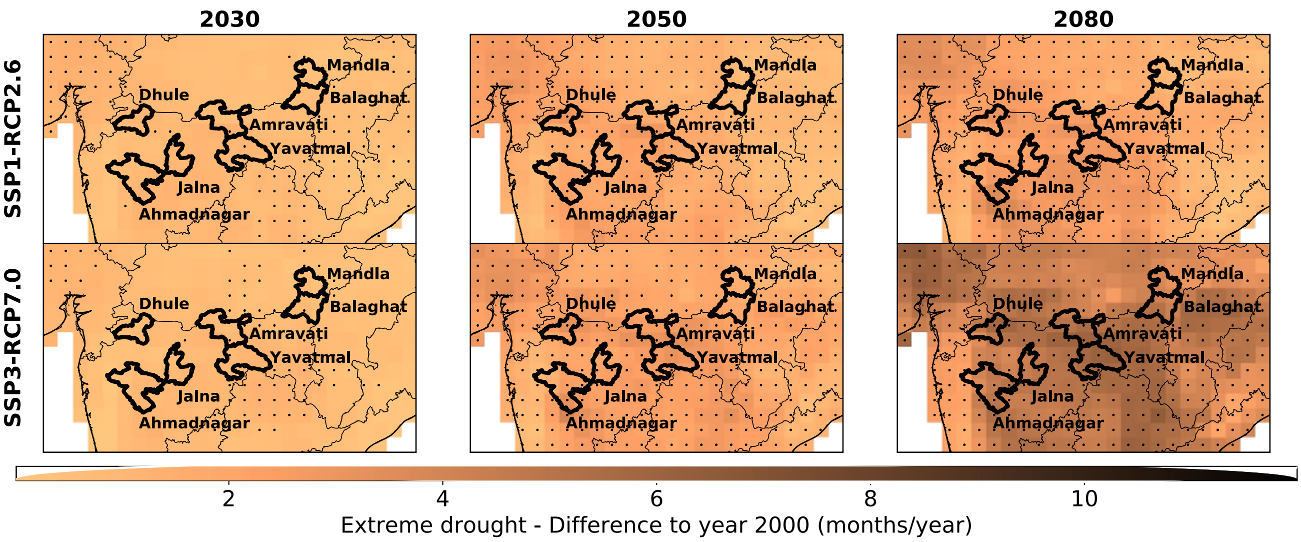

Figure 12: Projected changes in extremely dry months across India in 2030, 2050 and 2080 under two different trajectories compared to 2000. Dots indicate that at least 9 out of 10 models agree on the sign of change.

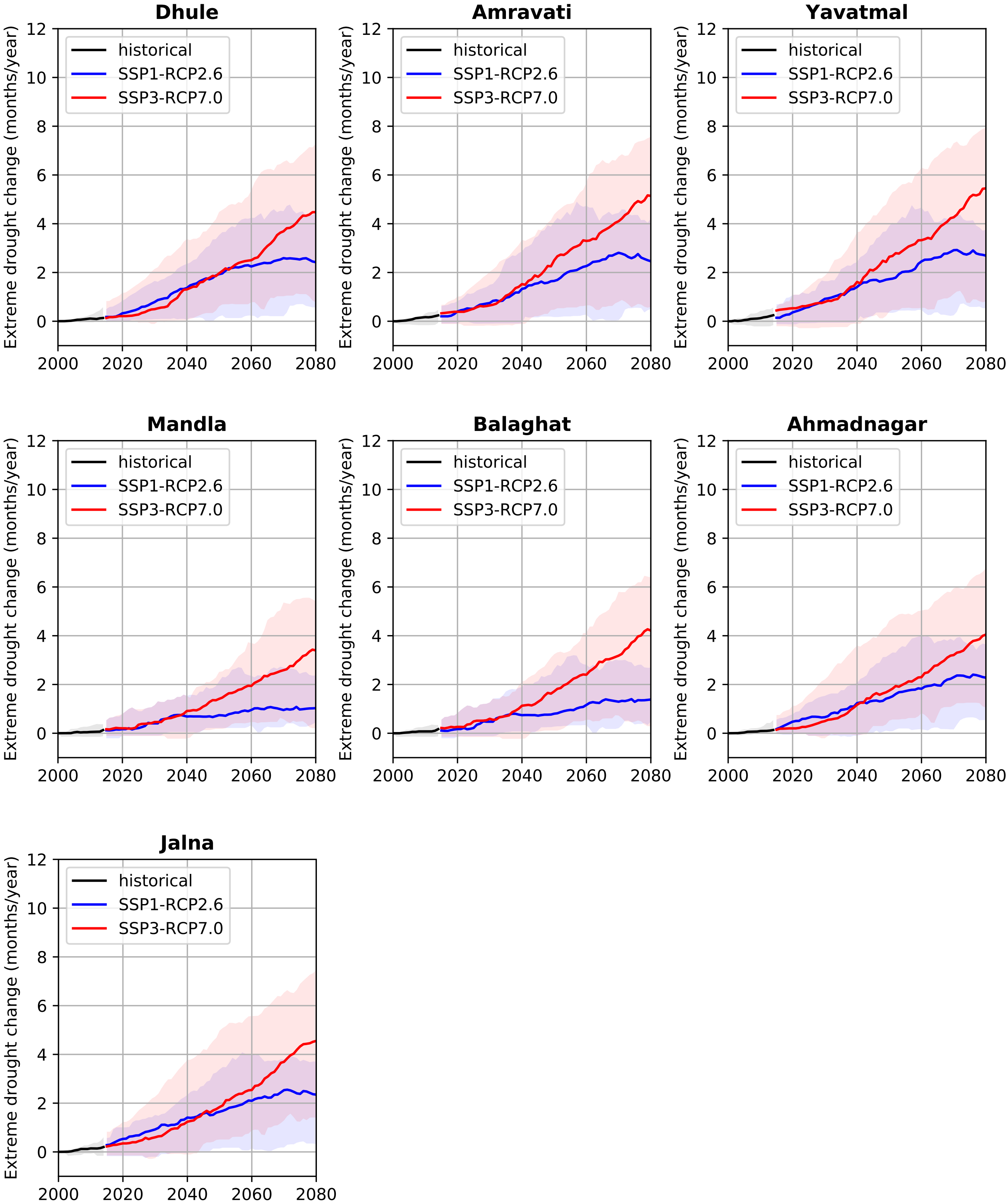

Figure 13: Projected changes in extremely dry months in the focus districts, model ensemble medians (lines) and range of the model projections (shading) under two future trajectories.

The assessment is based on data and analysis generated as part of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP), which is gratefully acknowledged. Background information about the figures and analysis presented in this profile is available in the supplemental information.

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