CEE599 Precipitation
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HW#3 Radar Precipitation – Langley Hill Radar; Chehalis Basin

The terrain blockage is derived for the Langley Hill radar over the Chehalis River basin based on geographic considerations and level 3 precipitation products. One subbasin of the Chehalis is then selected based on the results, and NWS level 3 precipitation in the subbasin is compared with NWS Stage 4 precipitation and precipitation from Drought Monitor System.

1 Detecting terrain blockage

We use two methods to detect terrain blockage in Chehalis basin – directly deriving from DEM and inferring from Level 3 radar data.

(1) Deriving from DEM

Knowing the longitude and latitude of the Langley Hill radar station, the height of radar (77m), the DEM of Chehalis basin and the tilt angle (0.5 deg), we can calculate the blocked area based on geometric relationship between the radar and the basin. The result is shown in Fig. 1. It shows that the north part of the basin is blocked because of the Olympic mountains; some small parts in the middle and south of the basin also have a little blockage problem.

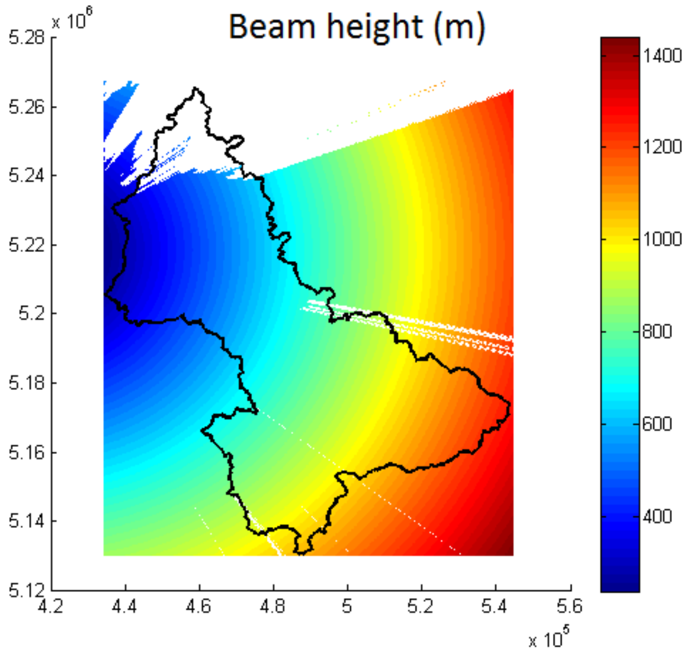

Figure 1.

(2) Inferring from Level 3 radar data

Fig. 2 shows the sum of all precipitation (9/8/2011-3/31/2014) reported by Level 3 radar data. No-rain days are reported as missing data. From Fig. 2 we can observe that there are some areas where the total amount of precipitation is abnormally small (e.g., in Olympic mountainous area, the sum of precipitation is very small while in fact the precipitation there should be high), indicating blockage or incorrect measurement. There are also some scattered points showing very-high precipitation, which is not consistent with the known climatology. These abnormal points might be caused by ground clutter, anomalous propagation (so the beam hit the ground or other objects), etc. In addition, we can observe sudden change at some azimuths (e.g. around Olympic mountains, which is located in the upper-right corner in Fig. 2), probably caused by the adjustment of tilt angle in order to overcome terrain blockage.

Considering these factors, we only plot grid cells where the total precipitation is in the range of 10-300 inch, as is shown in Fig. 3. Here we zoom to Chehalis basin. We can see that there is some blockage or invalid values in the north of the basin, and in some part of the middle and south of the basin. The result generally matches what we derived directly from DEM. The blockage problem inferred from Level 3 data seems to be less significant in the north of the basin, probably because the radar operators raise the tilt angle in order to minimize the blocking of Olympic mountains, as mentioned above.

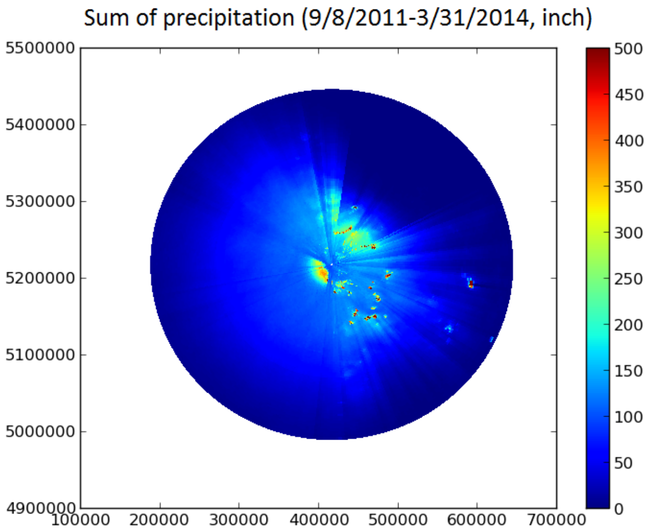

Figure 2.

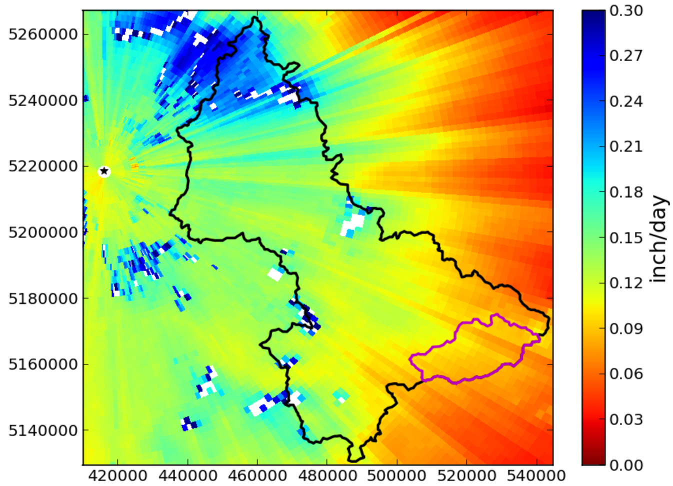

Figure 3.

Based on the above results, we select a subbasin located in the southeast of Chehalis basin (as is shown in Fig. 3).

2 Radar precipitation data evaluation

Focusing on the subbasin selected and shown in Fig. 3, we compare Level 3 radar data, Stage 4 radar data (which take into consideration correction and ground observation) with 1/16 deg gridded precipitation data used in the Drought Monitor system. 3-hourly Level 3 data, daily Stage 4 data and daily precipitation data in the Drought Monitor system are used, all during the same period of time (9/8/2011-3/31/2014).

2.1 Evaluating Level 3 data

(1) Daily mean and seasonal cycle

We calculate daily mean precipitation (average over the whole period of time, 9/8/2011-3/31/2014) for each grid cell in Level 3 data as well as in the Drought Monitor system, and plot both means on the map (shown in Fig. 4). We then take spatial average of the daily mean over the whole subbasin. The average daily mean precipitations of the two sets of data are:

Level 3: 0.0887 inch/day
Drought Monitor: 0.1774 inch/day

From both the above result and Fig. 4, we can see that the mean precipitation reported by Level 3 radar data is significantly lower than that in the Drought Monitor system. The difference is even larger in the east part of the subbasin. Looking back at Fig. 2 and Fig. 3, we can observe a polar pattern in the Level 3 observation, i.e., precipitation is generally lower in areas further away from the radar, which should not be the case in actual precipitation distribution. Thus, it is possible that precipitation in the subbasin we chose is underestimated by radar because of limitations of radar observation such as range attenuation.

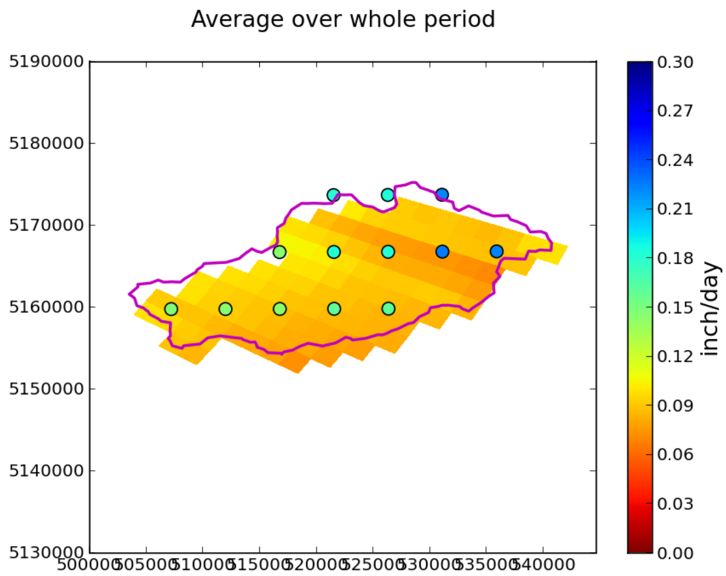

Figure 4.

We then calculate seasonal cycle of the two data sets. We calculate monthly mean of daily precipitation, as shown in Fig. 5. We can see that although the two data sets show a similar pattern of seasonal precipitation cycle, Level 3 data again shows a much lower precipitation amount, especially during raining seasons (winter and spring). These evaluation results indicate that Level 3 radar precipitation data may have significant bias and should be adjusted to minimize bias before being used in various application.

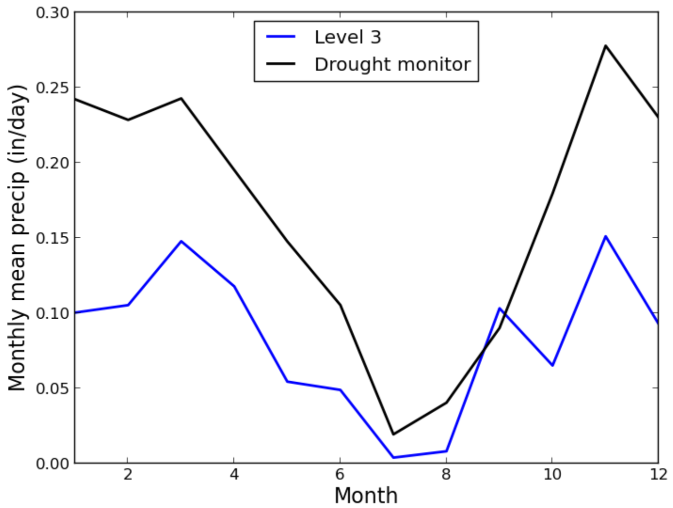

Figure 5.

(2) Segregating out stormy days

We then try to segregate our stormy days from both data sets and compare the rest of the precipitation record. Fig. 6 shows the daily precipitation in our period of study used in the

Drought Monitor system. Based on Fig. 6, we use 0.5 inch/day as the threshold to define 'stormy day'. The choice of this threshold is to exclude large storms, though the choice of number is somewhat arbitrary.

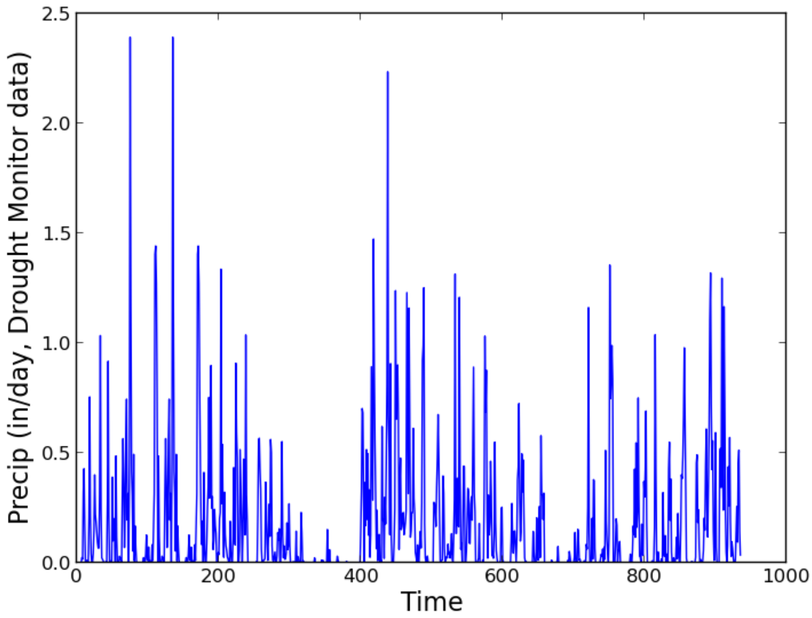

Figure 6.

We do the same calculation and plot spatial maps and seasonal cycles for both Level 3 and Drought Monitor system data sets, but for non-stormy days only. The spatial average of daily mean precipitation on non-stormy days calculated from the two data sets are:

Level 3: 0.0819 inch/day
Drought Monitor system: 0.0897 inch/day

From this result and Fig. 7 and Fig. 8 we can see that Level 3 data is very close to Drought Monitor system data on non-stormy days. The daily mean precipitation does not show obvious spatial pattern within the subbasin, but the general values calculated from the two data sets are very consistent. The seasonal cycles of the two data sets also match each other fairly well.

These results indicate that large storms are significantly underestimated by radar, perhaps because of the insufficient temporal resolution of radar in terms of detecting short-duration storms, the complex cloud structure of large storms, etc. In contrast, the radar observation of relatively-low precipitation is more accurate.

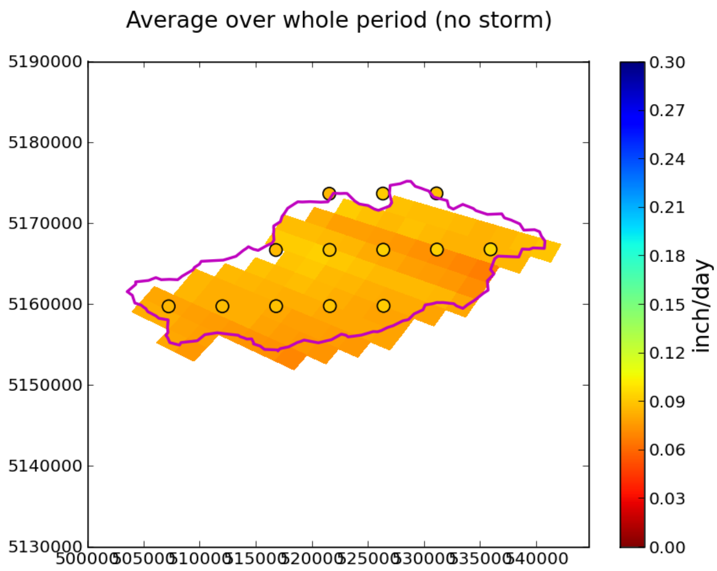

Figure 7.

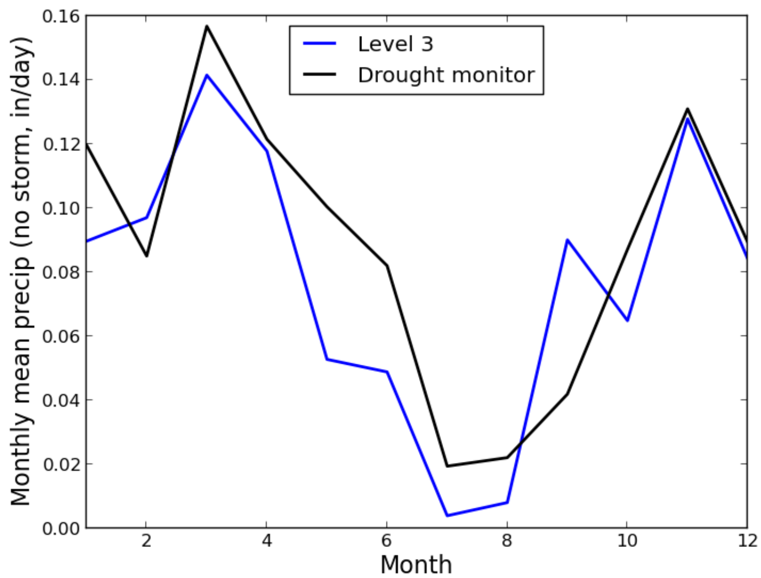

Figure 8.

2.2 Evaluating Stage 4 data

(1) Daily mean and seasonal cycle

We calculate daily mean precipitation (average over the whole period of time, 9/8/2011-3/31/2014) for each grid cell in Stage 4 data as well as in the Drought Monitor system. We then take spatial average of the daily mean over the whole subbasin. The average daily mean precipitations of the two sets of data are:

Stage 4: 0.1644 inch/day

Drought Monitor: 0.1774 inch/day

We can see that the mean precipitation reported by Stage 4 radar data is close to that in the Drought Monitor system. Given the significant difference of daily precipitation between Level 3 and Drought Monitor System, this makes sense, because Stage 4 data was generated from both radar and observed data.

We then calculate seasonal cycle of the two data sets. We calculate monthly mean of daily precipitation, as shown in Fig. 9. We can see that stage 4 data is much closer to data from Drought Monitor System than Level 3 precipitation.

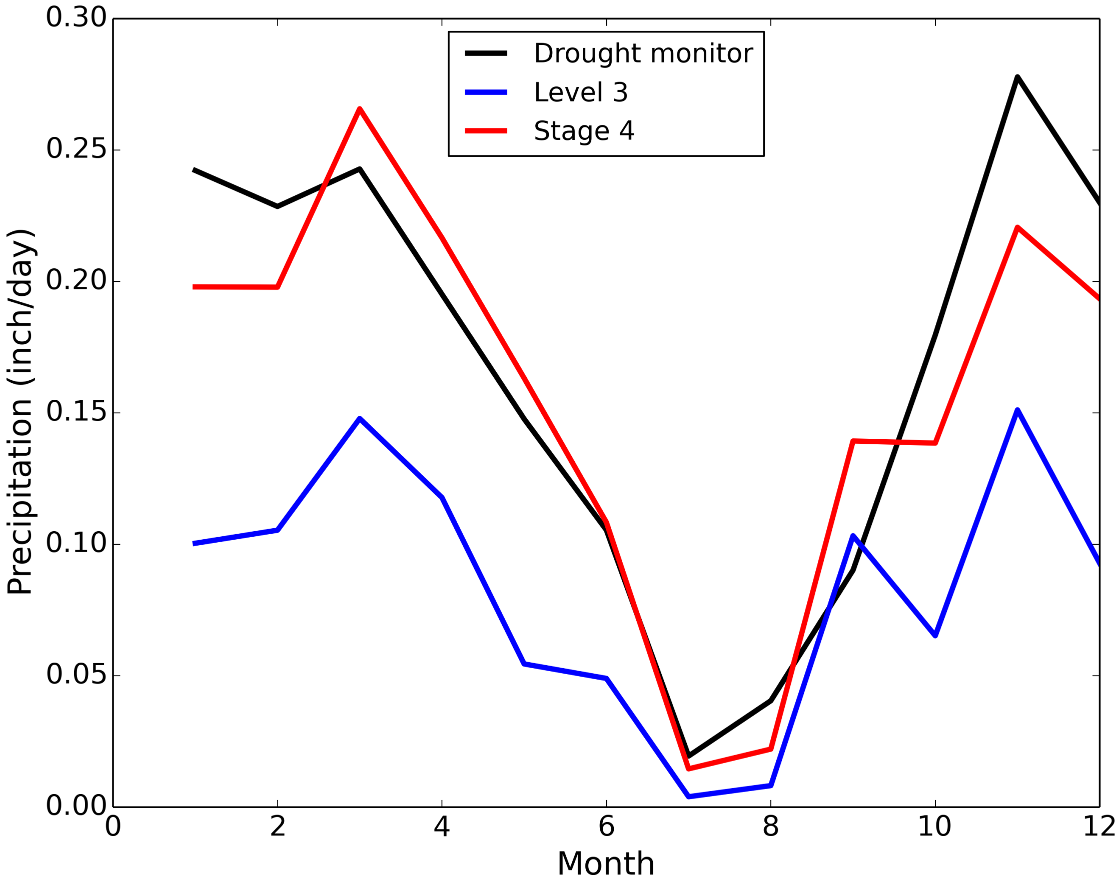

Figure 9

(2) Segregating out stormy days

We then also segregate our stormy days from both data sets and compare the rest of the precipitation record. Based on Fig. 6, we use 0.5 inch/day as the threshold to define 'stormy day'.

We do the same calculation and plot map of seasonal cycles for both Stage 4 and Drought Monitor system data sets, but for non-stormy days only. The spatial averages of daily mean precipitation on non-stormy days calculated from the two data sets are:

Stage 4: 0.0717 inch/day
Drought Monitor system: 0.0897 inch/day

From this result and Fig. 10 we can see that Stage 4 data is very close to both Drought Monitor system data and Level 3 on non-stormy days. The seasonal cycles of the three data sets match each other fairly well.

These results indicate that large storms are significantly underestimated by radar. In contrast, processed radar data are much more accurate both on stormy days and non-stormy days.

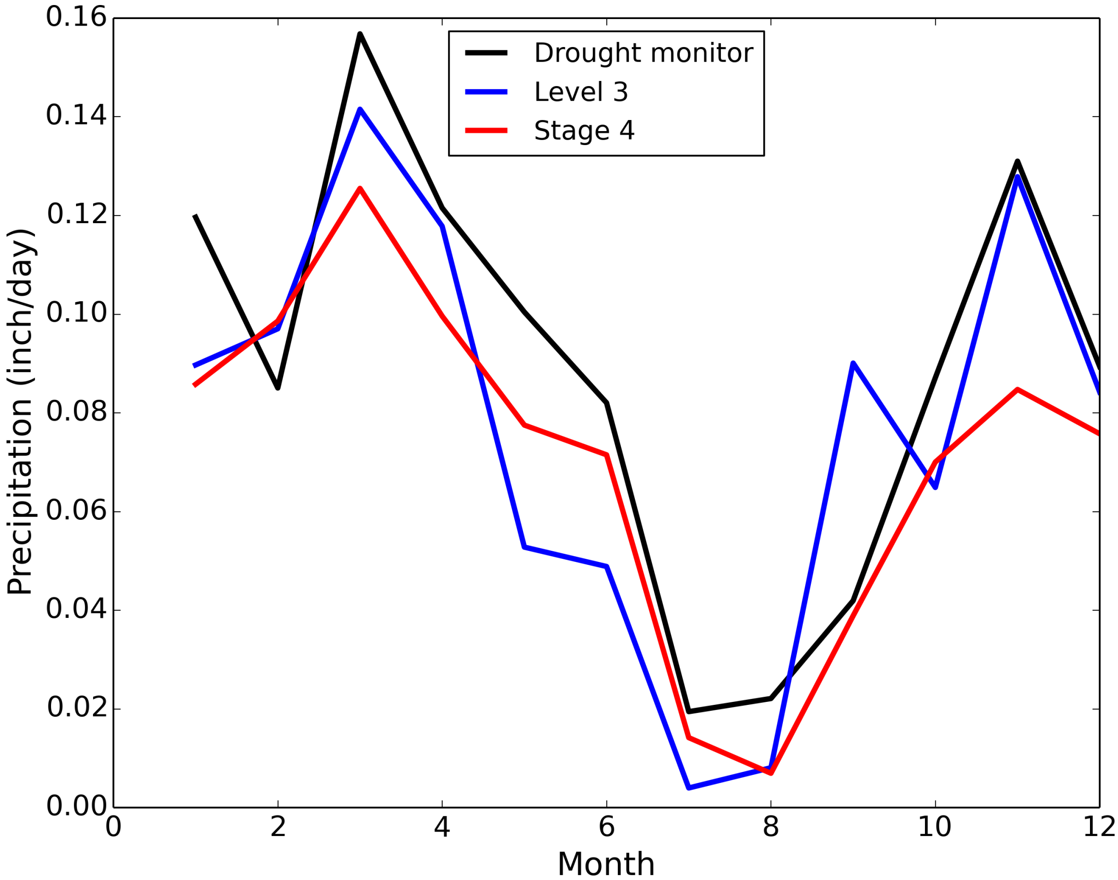

Figure 10