S2S4E
Climate Services for Clean Energy

CASE STUDY #4

COMBINED SNOWMELT AND HIGH PRECIPITATION IN SWEDEN

May - July 2015

BASIC FACTS

- **Area:** Sweden
- **Season:** Spring-Summer
- **Period:** May-July 2015
- **Forecast range:** Seasonal
- **Main interest:** Hydropower
- **Forecast variables:** Inflows, precipitation, temperature, and snow water equivalent

This factsheet is based on S2S4E deliverable 4.1. To access the full report, please visit s2s4e.eu.

WHAT happened

Underestimation of snow availability, in combination with precipitation volumes that were above the normal conditions for the season, resulted in inaccurate prediction of the water inflow to the reservoirs and unproductive water release, leading to significant economic loss for hydropower generators.

WHERE it affected

Delayed snowmelt, as a result of below normal temperatures, and increased precipitation occurred in the Umeälven river basin, Sweden.

WHEN it occurred

The event described in this case study occurred during the 2015 spring flood, with the peak observed in July.

Analysis of the event

Between May and July 2015, strong seasonal variability was observed over Sweden compared to the normal conditions expected for this region and period of time.

In particular, below normal conditions in surface temperature and solar radiation, and above normal conditions in precipitation were recorded in July 2015 (Figure 1).

In addition, surface wind speeds were above normal conditions in the southern parts of Sweden, whereas wind speeds below normal conditions were recorded in the rest of the country.

In the Umeälven river basin, strong weekly variability was observed during the May-July period (Figures 2 and 3).

Precipitation records showed values above normal conditions, with generally high daily and weekly temporal variability (Figure 2).

The variability in precipitation was particularly high during the end of May and beginning of June, while the weekly mean value was close to the high extreme.

The temperature was below normal conditions for almost the entire period of May-July (Figure 3).

The relatively low for the season temperature in the first weeks of July affected snow melting, with a considerable amount of water remaining in the mountains.

The subsequent snowmelt combined with high precipitation in late July resulted in large volumes of water inflows in the reservoir. As a result, the release of water from the reservoir without hydropower production was necessary.

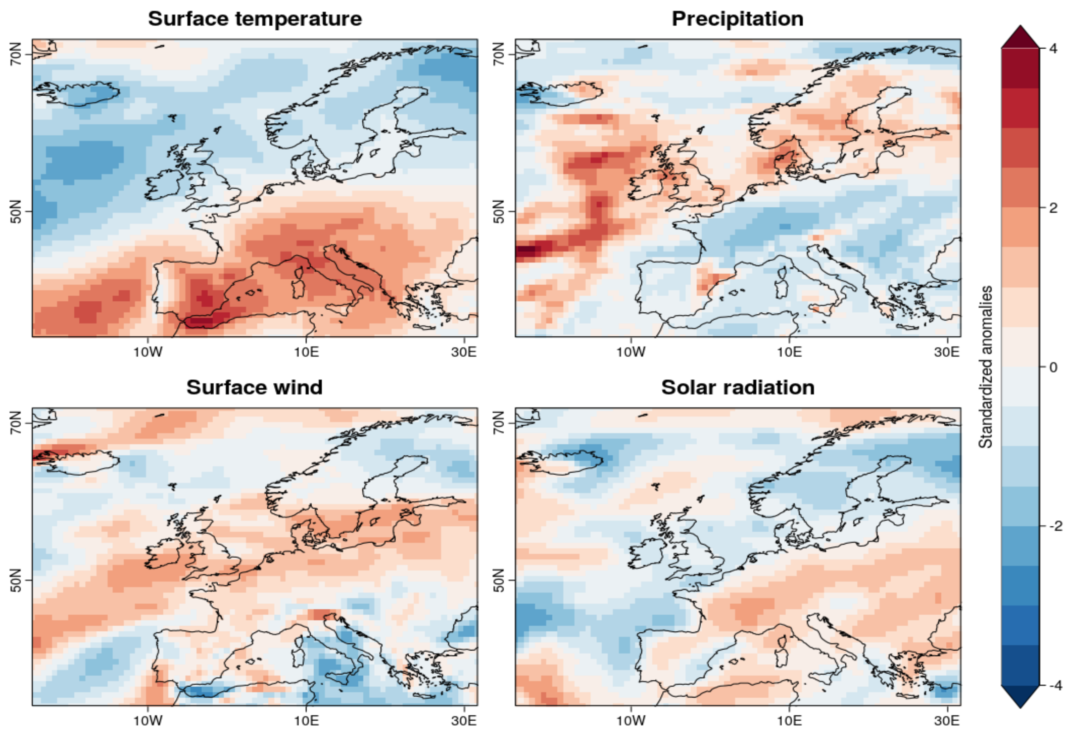

Figure 1. Anomalies in temperature, precipitation, surface wind speeds and solar radiation for July 2015 in Europe. ERA-Interim reanalysis.

Analysis of the event

Hydro-meteorological forecasts for the study period available already in February were inaccurate, which led to insufficient release of water from the reservoir.

The forecasts failed to accurately predict the snow water equivalent, and strongly underpredicted precipitation and reservoir inflows during the May-July period.

This lack of accurate information on snow availability and precipitation resulted in significant economic loss for the hydropower producers.

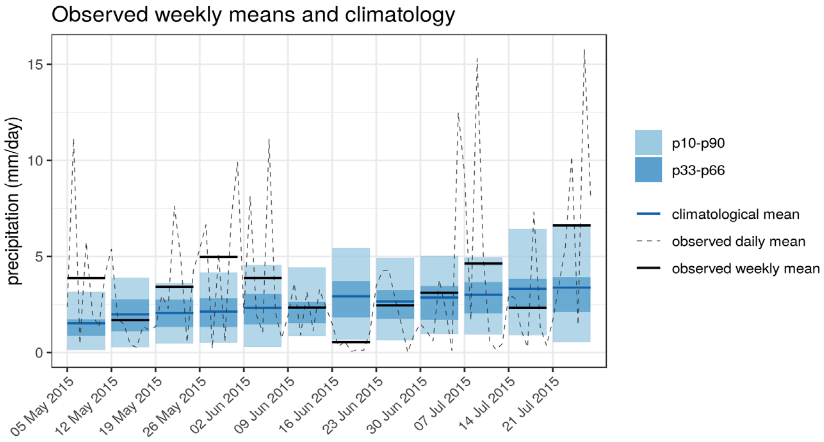

Figure 2. Weekly evolution in precipitation compared to the climatological distribution for May to July 2015 in the case study area (13-21.5°E, 63-66°N). ERA-Interim reanalysis.

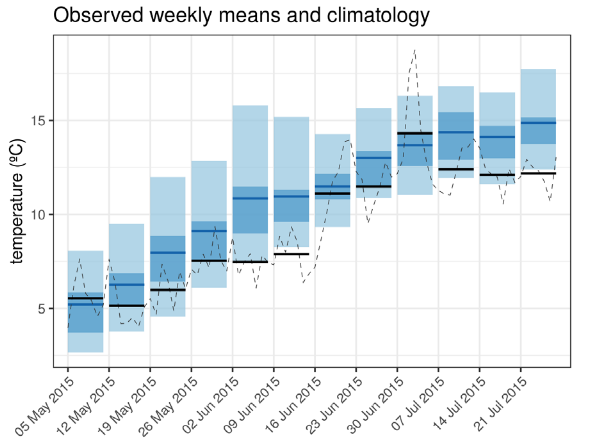

Figure 3. Weekly evolution in temperature compared to the climatological distribution for May to July 2015 in the case study area (13-21.5°E, 63-66°N). ERA-Interim reanalysis.

Available forecasts

In the S2S4E project, seasonal forecasts for precipitation, inflows and snow water equivalent were produced for 1, 2 and 3 months in advance of the spring flood period (May-July).

Climate predictions were based on the ECMWF SEAS5 system, and after bias-adjustment, they were used to force the E-HYPE hydrological model in order to predict snow water equivalent and inflows.

As presented in Figure 4, the precipitation forecasts with lead time of 1, 2 and 3 months were able to capture with high probability (77%, 86% and 92%, respectively) the above normal precipitation conditions that occurred in the study period. Whereas the forecast for precipitation produced with a lead time of 3 months presented a negative skill (-0.06), forecasts produced 1 and 2 months in advance presented a positive skill (0.13 and 0.10, respectively; Table 1).

Although the precipitation forecasts issued 1 and 2 months in advance predicted the above normal conditions with high probability, the precipitation amount predicted was much lower than the observed values, which can be challenging for incorporating such forecasts in the decision-making processes of the hydropower producers.

Available forecasts

River inflow forecasts with a lead time of 1, 2 and 3 months predicted that the inflow values will exceed the normal conditions, with 93%, 73% and 61% probability, respectively, and with high skill scores (0.67, 0.48 and 0.27, respectively; Figure 5 and Table 1). However, similarly to the precipitation forecasts, despite the fact that the inflow forecasts could predict the extreme conditions, the observed inflows during May-July were much higher than the forecasted inflows.

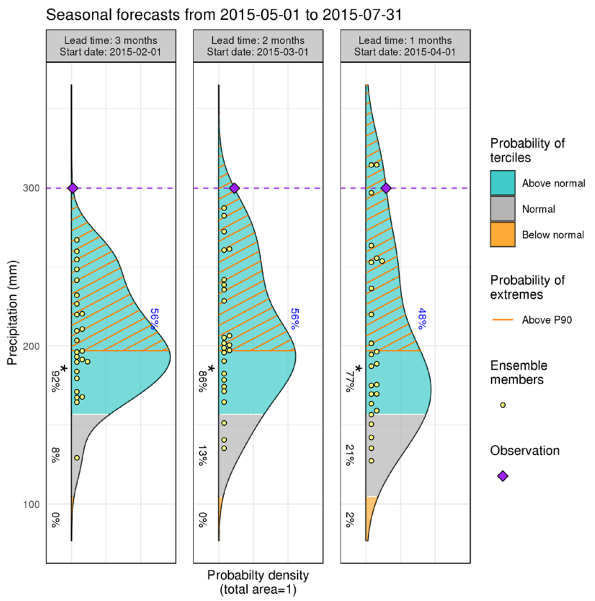

Figure 4. Forecasts for precipitation for May to July 2015, based on bias-adjusted ECMWF SEAS5 forecasts. Lead times range from 1 to 3 months.

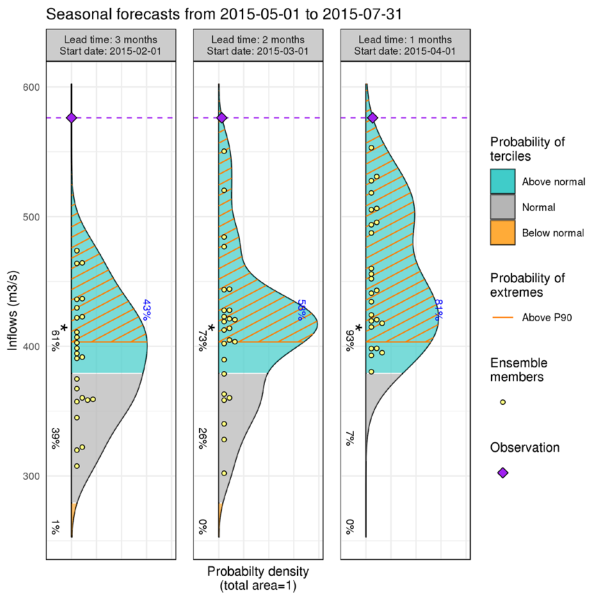

Figure 5. Forecasts for inflows for May to July 2015, based on bias-adjusted ECMWF SEAS5 forecasts and the E-HYPE hydrological model. Lead times range from 1 to 3 months.

Forecasts of snow water equivalent at lead times of 1, 2 and 3 months indicated below normal values with high probability (87%, 94% and 80%, respectively), which is in agreement with the observed conditions during May-July (Figure 6). In this case study, snow water equivalent was better forecasted as compared to meteorological variables, with high skill scores for lead times of 1, 2 and 3 months (0.81, 0.43 and 0.21, respectively; Table 1). Since snow can have a strong impact on inflows, accurate predictions on this variable are important for decision-making.

Table 1. Forecasting skill for precipitation, inflows and snow water equivalent for May-July 2015 in the Umeälven river basin, Sweden.

	Forecast lead time		
Skill (fRPSS)	**1 month** (issued in April)	**2 months** (issued in March)	**3 months** (issued in February)
Precipitation	0.13	0.10	-0.06
Inflows	0.67	0.48	0.27
Snow water equivalent	0.81	0.43	0.21

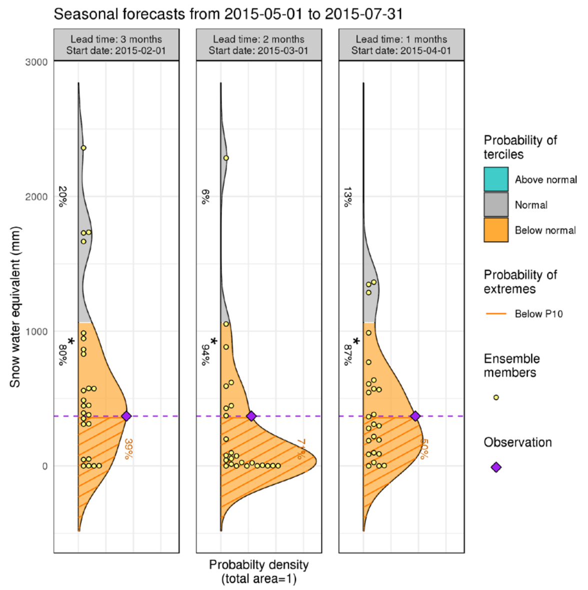

Figure 6. Forecasts for snow water equivalent for May to July 2015, based on bias-adjusted ECMWF SEAS5 forecasts and the E-HYPE hydrological model. Lead times range from 1 to 3 months.

Conclusions

In this case study, the hydrological forecasts (river inflows and snow water equivalent) achieved high skill scores and are therefore considered to be robust for decision-making.

For precipitation, forecasts with a lead time of 1 and 2 months showed a positive skill and a high probability of exceeding the normal conditions. However, precipitation forecasts with high lead times (3 months) are shown to be unreliable.

The seasonal hydro-meteorological forecasts correctly predicted at all lead times that the indicators (snow water equivalent and river inflows) would not have values that are observed under normal conditions for the study period (May-July 2015) and region (Umeälven river basin). Therefore, these forecasts are considered to be robust for use in decision-making in this context.

However, it is important that these forecasts are treated with caution when the actual forecasted values are used in decision-making, rather than the divergence from the normal conditions (above or below normal) expected for the specific region and period of time.

This project has received funding from the Horizon 2020 programme under grant agreement n° 776787. The content of this factsheet reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.