Decision support tool for flood risk assessments: Early warning system for flooding and inundations in the city of Tel Aviv, Israel

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Abstract

Urban flooding is a major growing concern for many places and also at the Southern parts of the Mediterranean. Previous studies showed an increasing trend in precipitation intensities in this region mostly in coastal regions during the transition seasons due to convective developed in the warm sea. Together with land-use changes and rapid increase in urbanization that leads to a decrease in infiltration, runoff generation is higher and urban flooding becomes more common and intense.

The Israeli Fire and Rescue Authority reports reveal that rescue operations due to urban flooding in the central Israeli coast increased from 15,000 calls a year to 30,000 during the last years in respect to the long-term average. In addition, during the last two years there were several rare extreme urban flooding events causing damages to property and casualties. There is a growing need to develop advanced tools, improve preparedness for extreme weather events and by that providing the "First responders" Authorities the possibility to take proactive approach and make better decisions.

We present here a forecasting system, focusing on urban flooding at coastal Israel. The system integrates streamflow predictions from the GEOGloWS ECMWF Streamflow Service and precipitation thresholds from a local high resolution (1 km) WRF model.

The forecasting system provides alerts for the variable places in the metropolis (poor drainage areas) based on the combined effect of high River discharge/water level (the GEOGloWS return periods calculations) and rainfall thresholds for different time steps. This streamflow-precipitation threshold modeling system was used successfully in the rainy season of 2020/21 also for neighboring municipalities in Israel like the cities of Ramat Gan, Ashdod, and Nes Ziona.

Introduction

- The GEOGloWS ECMWF Streamflow Services (GESS) provides probabilistic forecasting (Ensemble forecasting) based on 51 members – up to 15 days ahead (figure 1A).
- The model is based on meteorological input from the Global ECMWF model.
- The Hydrological model runs globally and calculate the flow routing for basins from 150 square km and larger.
- The model output provides the expected flow return periods in addition to the discharge values (figure 1B).

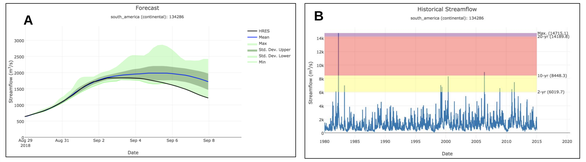

Figure 1A-B: The GEOGloWS ECMWF Streamflow pprobabilistic forecasting Services (A) and its return period calculations based on historical, deterministic simulations

The study area

- 4 million residence are leaving in the city of Tel Aviv and the surrounding metropolitan area. The 52 Km2 Area of the City is experience Rapid urban renewal and growth (See figure 2B).
- Flooding and inundations in the city of Tel Aviv are results of direct heavy rainfall in poor drainage urban areas, in addition to high water level in the Rivers crossing the city of Tel Aviv: The Ayalon and Yarqon Rivers.

Figure 2A-B: The location of the city of Tel Aviv (A) and the its urban landscape

Methodology

- The Ayalon River outlet was defined in the GEOGloWS Streamflow system (Reach id 612368, see figure 3).
- The GEOGloWS ECMWF Streamflow model was run on historical, deterministic simulation mode, based on the ERA5 reanalysis, for the period 1980 to 2020. Based on the observed flow time serious, bias correction was made for the model results.
- The GEOGloWS model return period output were corrected according to the observed values.
- Thresholds form hourly up to 24h precipitation intensity were set based on historical observations.
- 3 alert/warning levels were calculated for the city according to severity levels: Yellow, Orange and Red. Those alerts levels were set based on a combined conditions: precipitation intensities thresholds (for example, over 20 mm/h) and in addition the discharge return periods (for example, a flow return period of 1:10 years).
- Different threshold were set for different places across the city (for example, the drainage system in the Northern parts of the city can transfer higher discharges so the thresholds are higher).

Results

Figure 4 display the GEOGloWS ECMWF Streamflow deterministic simulations for the Ayalon River for the period 1980-2020 based on the ERA5 reanalysis data (in red), the simulated data after bias correction based on observations (in green) and the observed flow at the period 2018-2020 (in blue). Figure 5 shows the probabilistic model simulation for a flood event in the Ayalon basin during January 18-20th, 2021. The observed peak discharge in the event was 46 cubic meter per second.

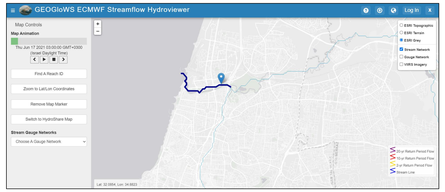

Figure 3: The Ayalon River in the GEOGloWS Streamflow system

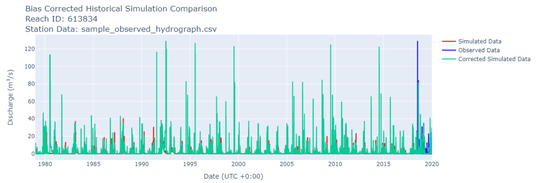

Figure 4: The GEOGloWS ECMWF Streamflow simulation for the Ayalon River (in red), the corrected simulated data based on observations (in green) and the observed flow (in blue).

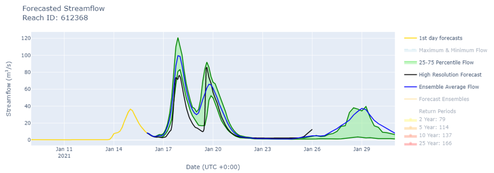

Figure 5: The GEOGloWS ECMWF Streamflow simulation for the Ayalon River (in red), the corrected simulated data based on observations (in green) and the observed flow (in blue).

Conclusion

- The GEOGloWS ECMWF Streamflow model simulated discharge showed relatively good agreement with the observed flow at the Ayalon River for the period 2018-2020 , after bias correction
- Using the model output (flow return periods) was found to be very useful tool for decision making.
- Authorities like the Israeli Fire and Rescue Authority and the Tel Aviv municipality drainage department are using GEOGloWS data (expected return periods) in addition to other forecasts (precipitation intensities and amounts from local, high-resolution NWP)
- Translating of the forecast into Insights and operational actions, allow the "first responders" agencies to be pro-active and take better decision on time and space.
- The result in this study shows that tools like the GEOGloWS ECMWF Streamflow system can saving property and lives.

Acknowledgements

The GEOGloWS ECMWF Streamflow Services has been developed through the leadership of the Hydroinformatics Lab at Brigham Young University and developed from the experts in meteorological predictions at the European Centre for Medium-range Weather Forecasts (ECMWF) together with the European Commissions Joint Research Centre (JRC). They received support through the Copernicus Emergency Management Service Program. The NASA SERVIR and NASA GEOGloWS programs provided grants and opportunities to test and develop the services with support from Aquaveo, Esri and the World Bank to help make the services operational. There have been many other partners in the GEOGloWS Initiative led by Angelica Gutierrez of NOAA and early implementers who have made additional valuable contributions.