Case study 5

Strong El Niños and energy mix planning

Focus: Strong El Niños in a South America context and energy mix planning

Industry partners

The SECLI-FIRM project aims to demonstrate how improving and using long-term seasonal climate forecasts can add practical and economic value to decision-making processes and outcomes, in the energy and water sectors. To maximise success, each of the nine SECLI-FIRM case studies is co-designed by industrial and research partners.

For this case study, two approaches/users are addressing the same problem. For the first approach, the industrial partner is Emgesa, part of the ENEL group, while Celsia is the user for the second approach – both big utilities with important assets in Colombia. The main research partner working with Celsia is UL, a company which brings expert knowledge in the use of meteorological information for the renewable energy industry. The University of East Anglia (UEA) is also a research partner.

Boosting decision making

- The main objective of this case study is to illustrate the benefits of designing adequate decision-support products to predict the expected amount of flow of the hydro resources.
- As a complementary study, the case study will estimate how an optimum mix of hydro, wind and solar technologies can be achieved in Colombia. This could help to overcome the negative effects of events such as strong El Niños when relying on a single energy source.

The seasonal forecasting context

- This case study focuses on demonstrating the impact of using seasonal forecast rainfall information for big utilities with a large proportion of hydro power in their portfolio.

Sectoral challenges and opportunities

- To plan the future hydro resources during El Niño-La Niña events.
- To buy fossil fuels options in advance at lower prices to compensate for low hydro generation.
- To design a future energy mix adapted to the local climate variability and based on renewable sources.

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El Niño and La Niña phenomena

El Niño (La Niña) is a phenomenon in the equatorial Pacific Ocean that can be characterized by a five consecutive 3-month running mean of sea surface temperature anomalies in the Niño 3.4 region (Figure 1) that is above (below) the threshold of +0.5°C (-0.5°C). This standard measure is known as the Oceanic Niño Index (ONI).

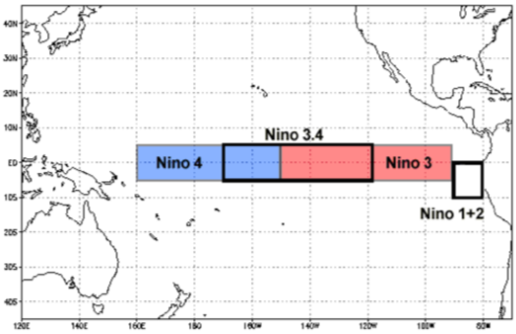


Figure 1: The Niño 3.4 region of the Pacific Ocean

Figure 2: The regions of Colombia

The El Niño phenomenon effects in Colombia are strongest in the north of the Pacific region (west of the country), parts of the Andean region (center) and the Caribbean region (north) (Figure 2), drastically decreasing the levels of rainfall accompanied by an increase in temperature, affecting the agricultural and electricity sectors, among others.

The 2015-2016 El Niño event

In this case study the focus is on the severe drought in 2015-2016, which, in March 2016, led to an emergency plan requesting the Colombian population to reduce daily electricity consumption by 5-10% in order to avoid a complete blackout. During 2015 and 2016, the Colombian electricity system faced one of the longest and most intense dry seasons ever registered, putting pressure on and testing the Colombian energy regulation framework. With such critical hydrological conditions, the average share of thermoelectric generation went from 49 GWh/day (28% of total energy) in the first half of 2015, to 88 GWh/day (48%) in Q1/2016, and later it exceeded 100 GWh/day. Given the low levels of the reservoirs reached by early March 2016, XM (Colombian TSO and Wholesale Electricity Market Operator) recommended a program of energy cuts for at least six weeks in order to save 5% of the daily demand.

The industry context

In Colombia, the deregulation of the electricity sector started in 1994, and the spot market initiated operations in July 1995. This deregulation process has faced some particular challenges in Colombia. The Colombian electricity system has an important penetration of traditional renewable energy technologies. In terms of installed capacity, 64% is hydro-generation, and nearly 80% of its energy consumption is covered by hydro resources.

Climate event

El Niño and La Niña: The El Niño-Southern Oscillation (ENSO) cycle

Severe drought between 2015-2016 in Colombia the result of a strong El Niño event

Sector impact

Scarcity of water resources in a market with a high dependency on hydro-power increases the prices and the risk of a blackout

Industry context

The energy sector in Colombia relies mostly on renewable energy technologies

APPROACH 1
Progress update - Enel & Emgesa: evaluation of reanalysis data

The 2015/16 El Niño event brought severe drought in Colombia, and heavily affected the inflow of Enel's catchment areas of interest in terms of total precipitation. Therefore, the performance of the ECMWF ERA5 model – spatially aggregated on Enel's areas of interest – is evaluated through comparison with in- situ data of 2m temperature and total precipitation (Figure 3). The application of ECMWF seasonal forecast system (SEAS5) to Enel's areas of interest will be implemented after downscaling SEAS5 to ERA5 resolution.

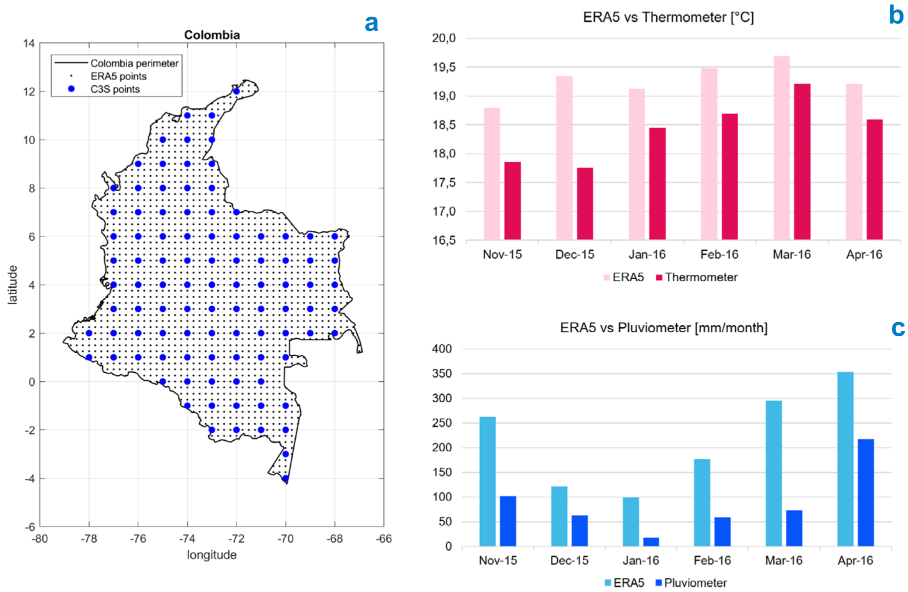


Figure 3: (a) Map of Colombia with ERA5 and SEAS5 points. (b & c) Comparison between ERA5 and observations during severe drought periods for (b) temperature and (c) precipitation.

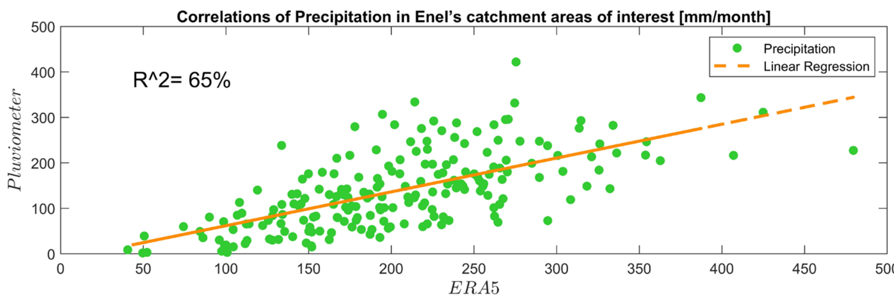


Figure 4: Scatter plot between in situ (y-axis) and ERA5 (x-axis) precipitation for Enel's catchment areas.

Forecast Evaluation

Tailored forecasts are now ready to be run in Enel's econometric models

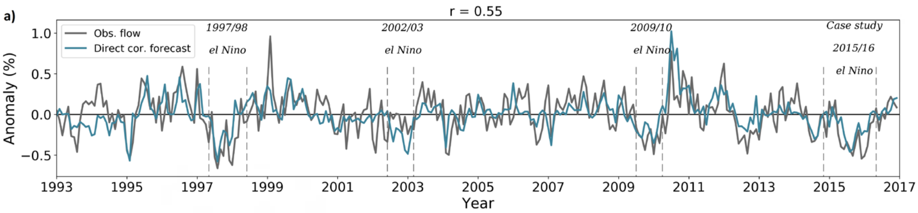
APPROACH 2
Progress update - UL & Celsia: river flow forecasts

The first way of integrating seasonal forecasts in the decision process of Celsia is to provide a forecast of river flow. This method builds on a simple average of the average of all ensemble members from each model for the variable used to derive flow. The two methods currently under investigation are:

Direct correlation between precipitation and river flow
All forecast data has been downscaled from a 1x1 to a 0.25x0.25 deg. grid by the widely used method of quantile mapping method. This improves the representation of possible important orographic features and corrects systematic biases. ERA5 reanalysis is used as observational data for precipitation and river flow observations are obtained from Celsia and IDEAM. The correlations between these are computed on a monthly basis for the period 1993-2014 leading up to the drought under investigation in the case study. These correlations are then used to forecast river flow from the downscaled forecasted precipitation data from the multi-model ensemble (Figure 5a).

Teleconnections between sea surface temperature and river flow
Past studies show that SST anomalies in the Tropical Pacific play an important role for the precipitation patterns over Colombia. Therefore, SST anomalies from ERA5 data in these areas, from the period 1993-2014, are used to determine a linear correlation with the observed river flow. These correlations are then used to predict future river flow from the forecasted anomalies. For optimization of this process, global teleconnection patterns between SST anomalies and river flow in the catchment areas are found. This allows for exploitation of any signal from outside the well-established NIÑO areas (Figure 5b).

a



b

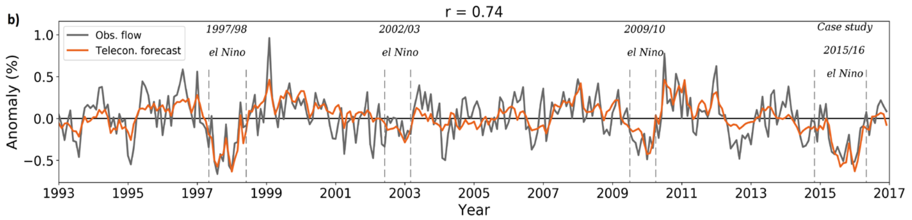


Figure 5 - (a) forecast flow from the direct correlation method for 1993-2016. Grey line: Observations. Coloured line: Forecasted flow. (b) Same for the teleconnection method

Forecast evaluation

Evaluation of river flow forecasts using two methods

Directly from precipitation and indirectly from teleconnections

Decision trees

To evaluate the impact of seasonal climate forecasting models on the Enel decision-making process, the following steps shall be implemented (Figure 6):

1. Define three input data based on the same information set except for weather variables. The input data set used shall be:
   I. Climatology input for a given delivery period
   II. Seasonal forecasts developed within SECLI-FIRM
   III. Reanalysis ERA 5 (as Actual Weather Data)
2. Perform the decision tree three times based on input data of point 1.
3. Compute the associated Performance Indicator.

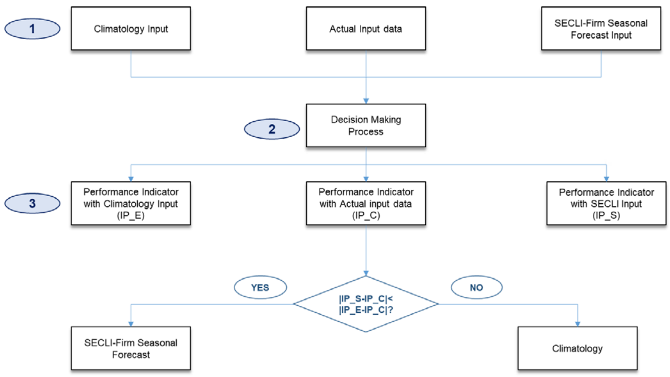


Figure 6: Enel Decision Tree: Performance Indicator Comparison

Next steps - Enel

- Application of downscaled seasonal forecasts to smaller catchment areas of interest
- Application of seasonal forecasts to internal econometric models
- Error analysis of multi-model seasonal forecast combination
- Application of seasonal multi-model forecast to internal econometric model
- Estimate the added value from the decision tree with the new SECLI-FIRM weather input

Next steps - UL

- Finalisation of the decision tree together with Celsia.
- Optimization of deterministic forecast by optimal MME combination and further work on downscaling and bias correction.
- Integration of deterministic forecast data in Celsia's internal econometric models, and first estimate of added value.
- Investigation of possible integration of probabilistic forecast information in Celsia's decision process.

The Added Value of Seasonal Climate Forecasting for Integrated Risk Management (SECLI-FIRM)

For more information visit:

www.secli-firm.eu or contact us at: **info@secli-firm.eu**

Decision trees

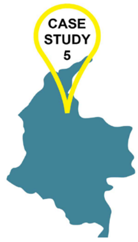
Evaluating the impact of seasonal forecasting models

Let us denote with IP_E, IP_S and IP_C performance indicators linked to climatology, SECLI-FIRM seasonal forecast and Actual Weather Data, respectively.

The impact of the seasonal climate forecasting model has added value to the decision tree if $[IP_S-IP_C]<[IP_E-IP_C]$.

Indeed, seasonal forecasts add value, even when the decision taken is as similar as possible to the one that would be taken knowing the exact weather variables actually measured at delivery.

For more about this and the eight other case studies, visit www.secli-firm.eu



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