



# The Added Value of Seasonal Climate Forecasting for Integrated Risk Assessment

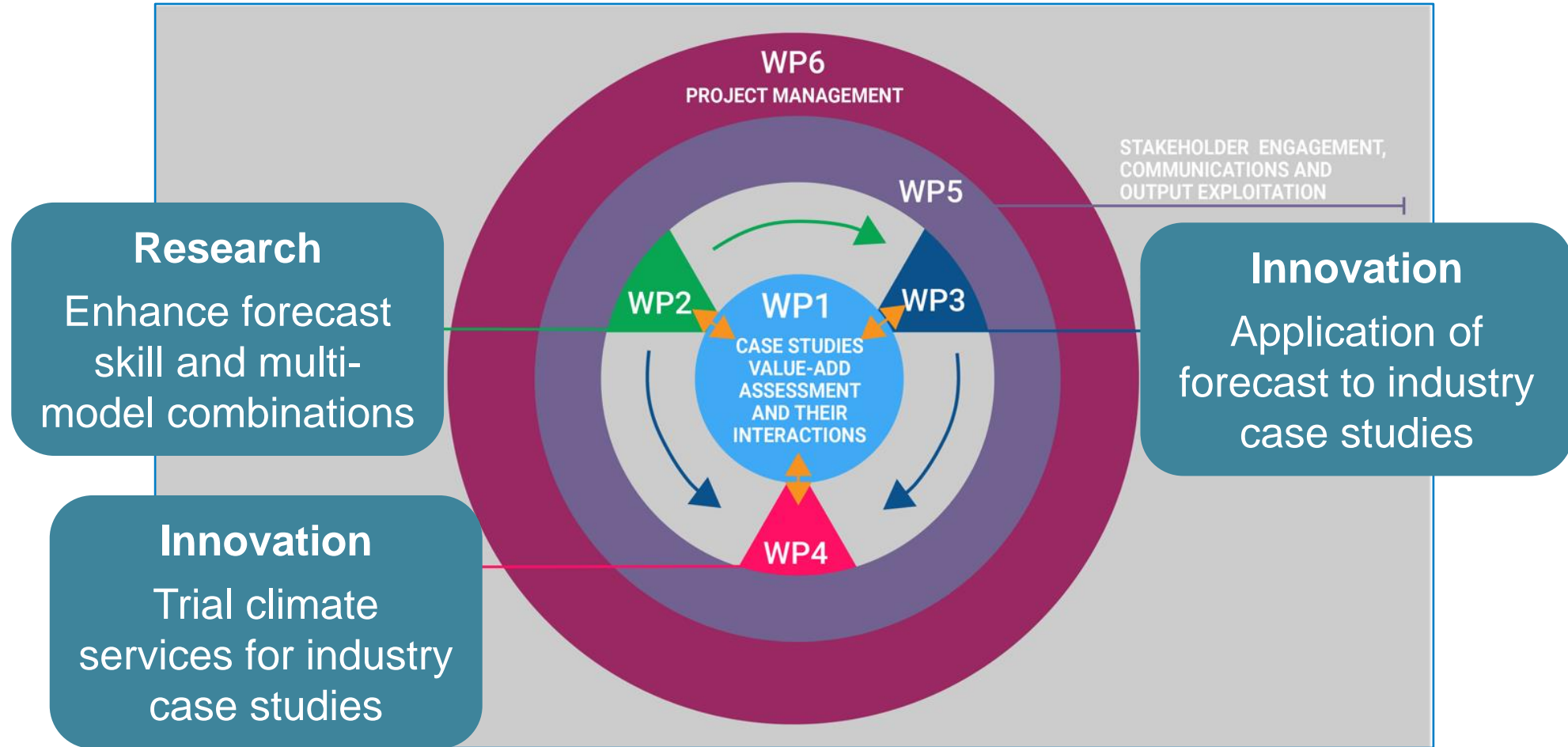
## Stakeholder Workshop

**15 June 2020 – 9:00-11:00 UTC and 12:00-14:00 UTC**

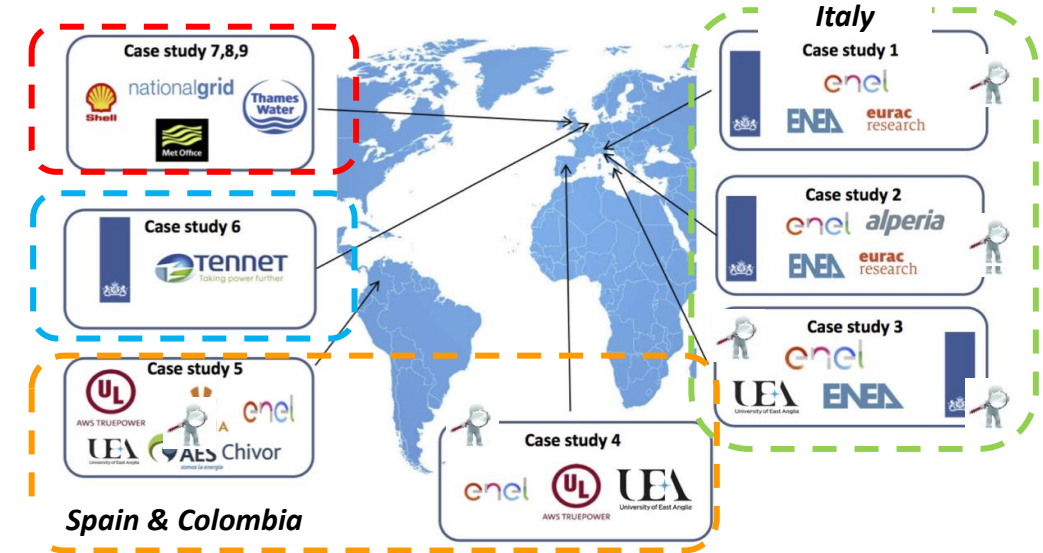
Prof. Alberto Troccoli, and the SECLI-FIRM team  
University of East Anglia, Norwich, UK

### Seasonal climate forecasts - calibration, downscaling and multi-models

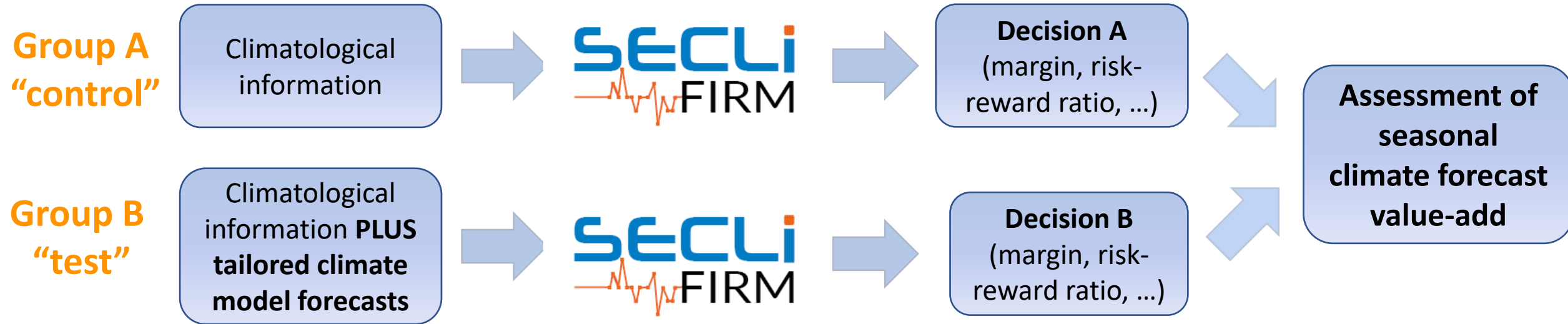
9:00-9:20	SECLI-FIRM overview and industry case studies	Alberto Troccoli (UEA/WEMC) and Case Study Leads
9:20-9:50	Seasonal climate forecasts: <ul style="list-style-type: none"> <li>• Downscaling and bias correction</li> <li>• Skill, probabilistic forecasts and bias correction</li> <li>• Multi-models</li> </ul>	Alice Crespi (EURAC) and Marcello Petitta (ENEA) Phil Bett (Met Office) Kristian Nielsen (AWST/UL)
9:50-10:50	Seasonal climate forecast multi-models discussion	Discussion – Chair: Kristian Nielsen (AWST/UL)
10:50-11:00	Summary and take home messages	Alberto Troccoli (UEA/WEMC)



Case Study	Climate events	Geography	Sectoral impact	Co-designers
CS1	Heat Wave 2015, and other similar extremes	Southern Europe	Energy – Thermal electricity plant cooling, demand model uncertainty	ENEL, ENEA, EURAC, KNMI
CS2	Dry Winter 2015-16 and other similar extremes	Northern Italy	Energy – Hydroelectric power production	ENEL, KNMI, ENEA, EURAC, Alperia
CS3	Strong Winds March 2016 and other similar extreme	Southern Italy	Energy – Wind power production	ENEL, ENEA, KNMI, UEA
CS4	Extreme Winds 2014-15 and other similar extremes	Spain	Energy – Wind power production and balancing	AWS, MO, ENEL
CS5	Strong El Niños	South America	Energy – Hydroelectric power production and other RE	AWS, UEA, AES Chivor, Celsia, ENEL
CS6	Low Winds	North Sea	Energy – Offshore operations and maintenance planning	TenneT, KNMI



Case Study	Climate events	Geography	Sectoral impact	Co-designers
CS7	Severe climate events in 'shoulder' months	North Sea	Energy – Offshore operations and maintenance planning	Shell, MO
CS8	Anomalous winter conditions	UK	Energy – Winter electricity demand	National Grid, MO
CS9	Dry Spring and Summers	UK	Water – Water use restrictions	Thames Water, MO



A control case only utilises climatological conditions based on historical averages, while a test case also considers individually optimised and tailored state-of-the-art probabilistic seasonal forecasts

## MENU OF ECONOMIC ASSESSMENT METHODS

- **\*\*DECISION THEORY MODELS\*\***
- **\*\*AVOIDED COSTS\*\***
- **\*\*ECONOMETRIC MODELS\*\***
- **\*CONTINGENT VALUATION APPROACHES\***
- PARTIAL AND GENERAL EQUILIBRIUM MODELS
- ALTERNATIVE METHODS



How are weather-related **decisions** currently made in our project **Case Studies**?



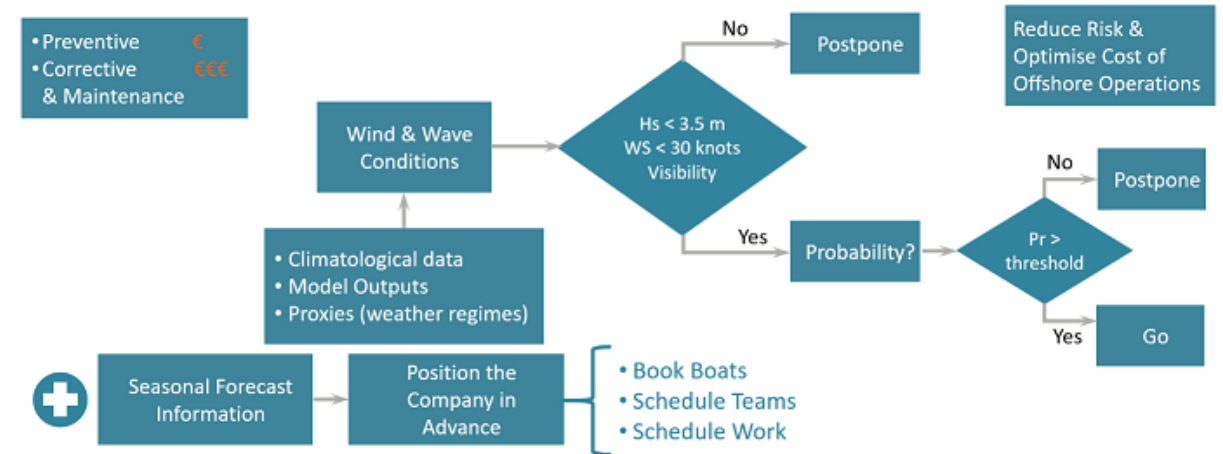
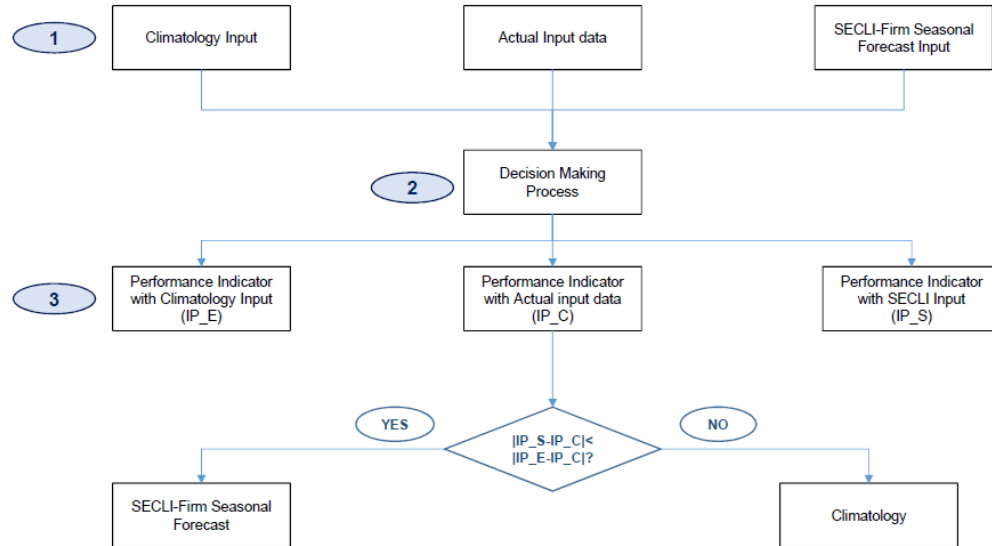
Which **Economic Assessment methods** are used, or could be used, to assess and support those **decisions**?



How can we use those methods to **quantify the potential benefits** of using **seasonal forecasts**?



What can we **learn** from each other across **Case Studies, Areas and Sectors**?





## Multi-model

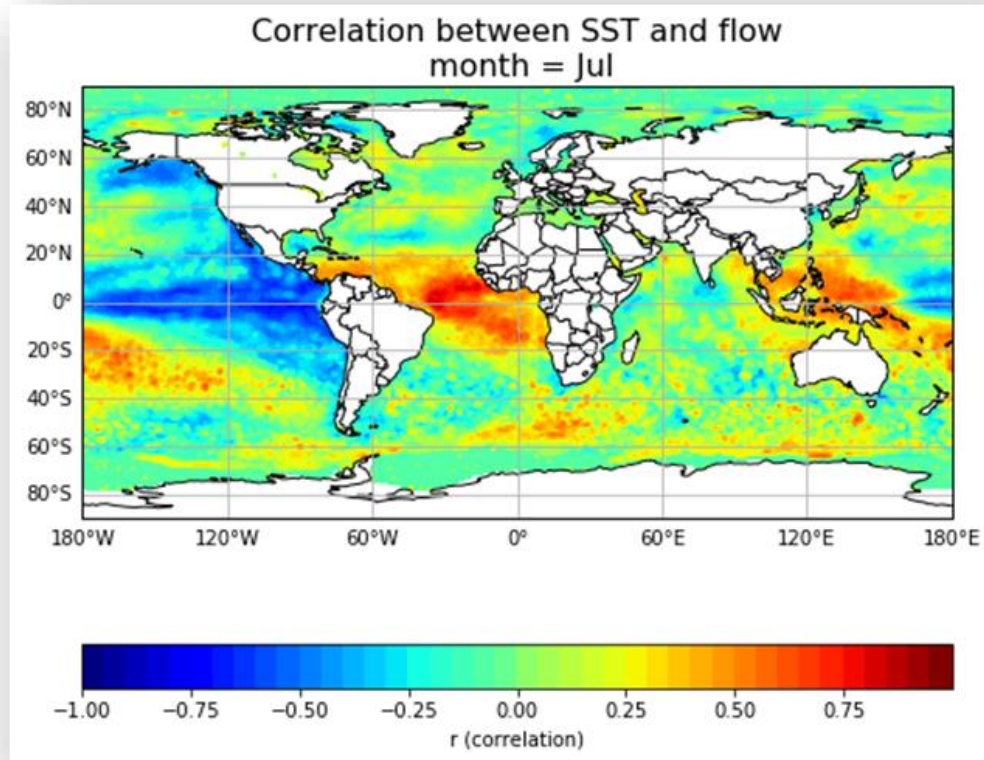
- Gathered and homogenized unprecedented data set from 15 different model/model versions in one place and format

Center	C3S-CMCC	C3S-ECMWF	C3S-DWD	C3S-MF
Dates	1993-2016	1993-2016	1993-2016	1993-2016
Variable				
Total precipitation	X	X	X	X
2m Temperature	X	X	X	X
Maximum Temperature at 2 Meters	X	X	X	X
Minimum Temperature at 2 Meters	X	X	X	X
10m u-component of wind	X	X	X	X
10m v-component of wind	X	X	X	X
10m wind speed	X	X	X	X
Mean sea level pressure	X	X	X	X
Solar irradiance downward	X	X	X	X
Snowdepth		X	X	X
Sea Surface Temperature	X	X	X	X
Latent Heat Flux		X		
Latent Heat Flux Land				
Sensible Heat Flux		X		
Sensible Heat Flux Land				
Temperature at 500 hPa			X	
Geopotential at 200 hPa				
Geopotential at 500 hPa	X	X	X	X
500hPa u-component of wind		X	X	X
500hPa v-component of wind		X	X	X
500hPa w-component of wind				

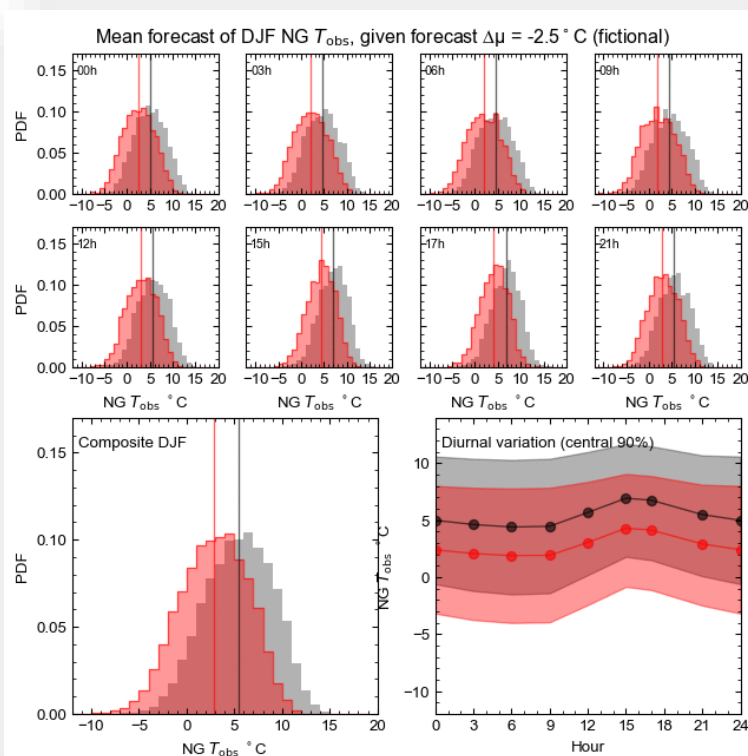




- Using teleconnection indexes as the predictand instead of the variable itself provides a better forecast



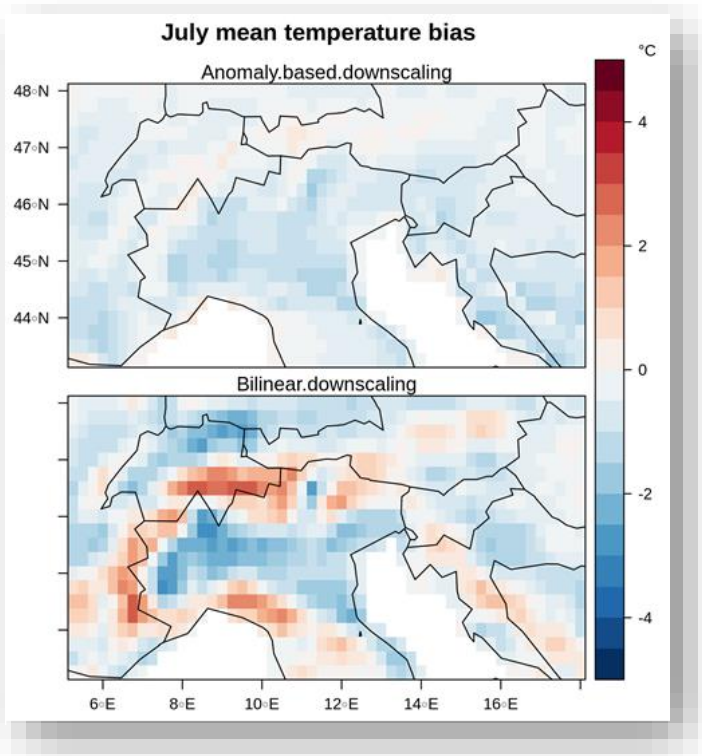
## Weather regimes



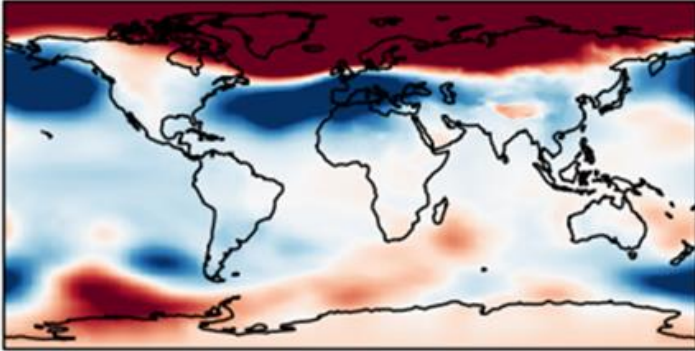
- Improve the forecasts by shifting the distribution according to forecast seasonal mean

## Statistical downscaling

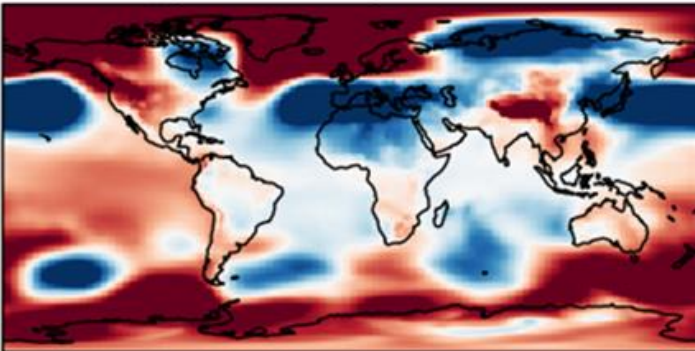
- Anomaly-based downscaling of seasonal forecasts of temperature and precipitation in complex terrain has a lower forecast error than bilinear interpolation.



a) Composite MSLP of 5 coldest winters



b) JRA55 reanalysis 1962/63

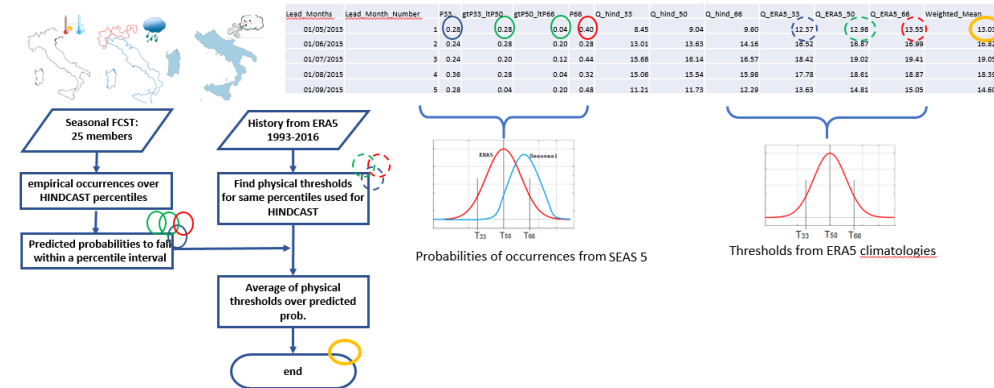
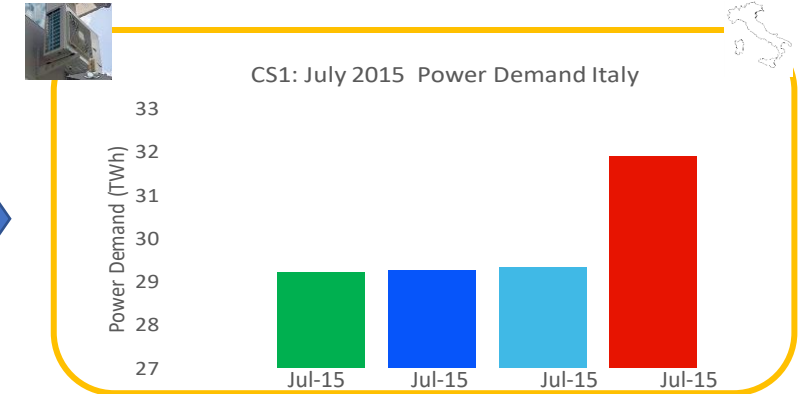
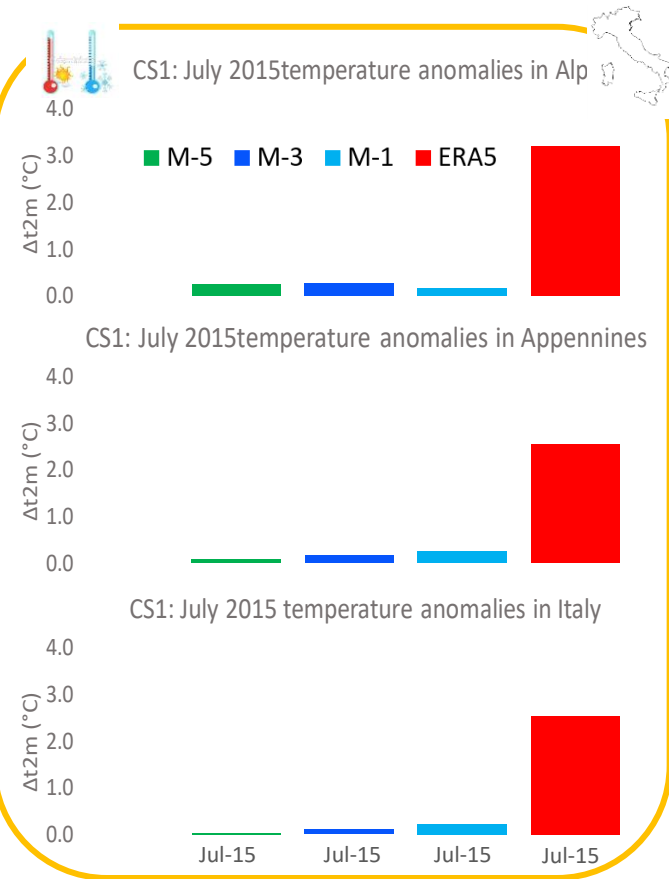
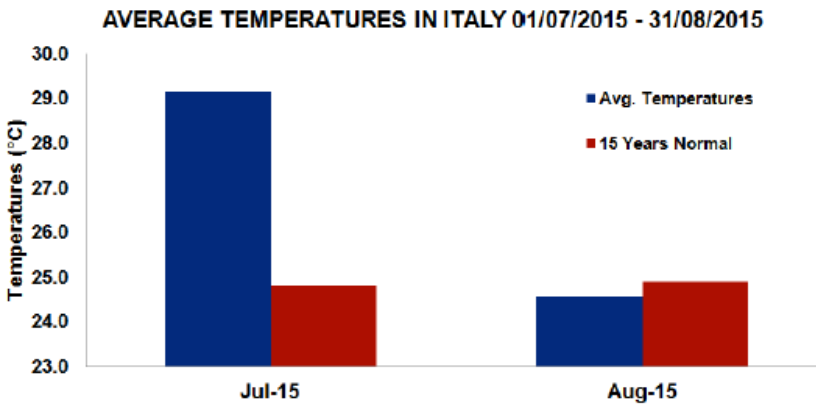
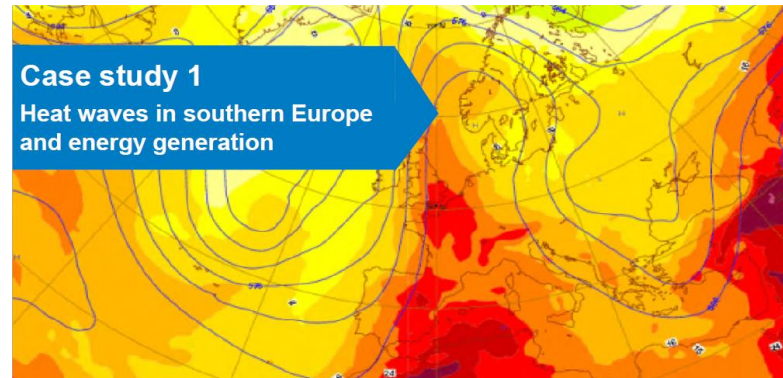


- The use of all the ensemble members provides a way to estimate the probability of unprecedented cold/warm winters

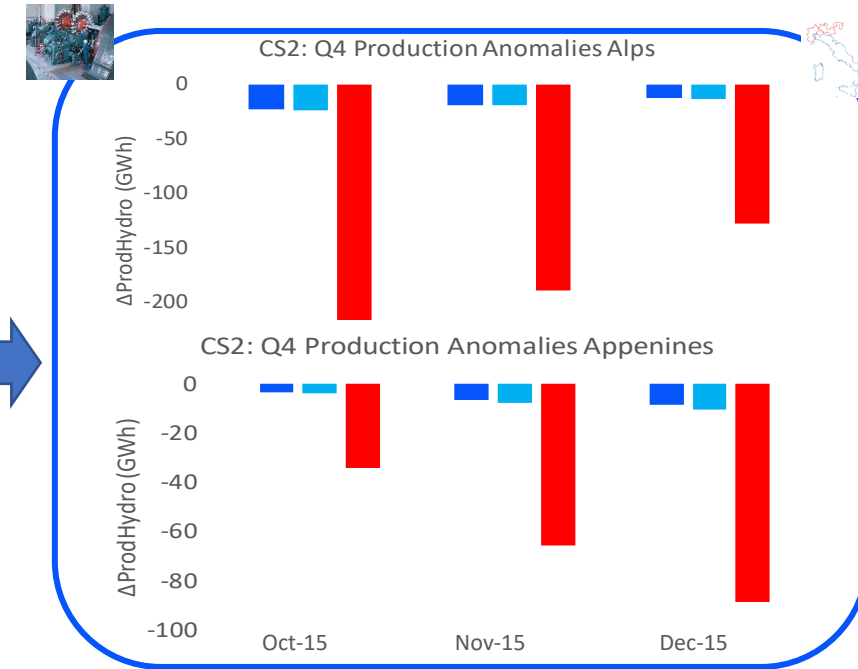
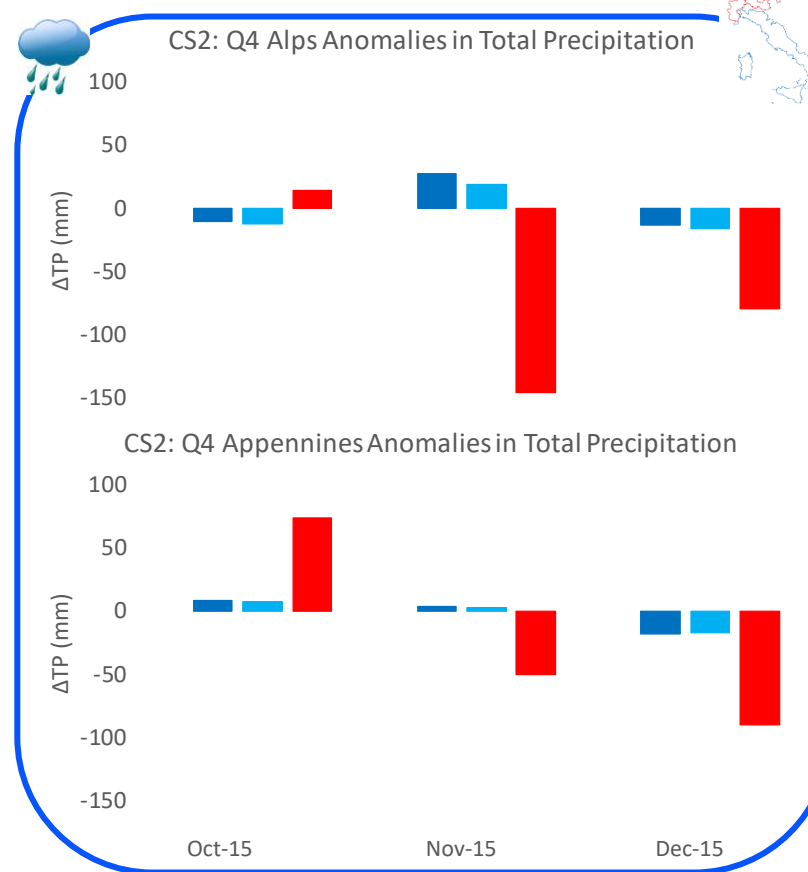
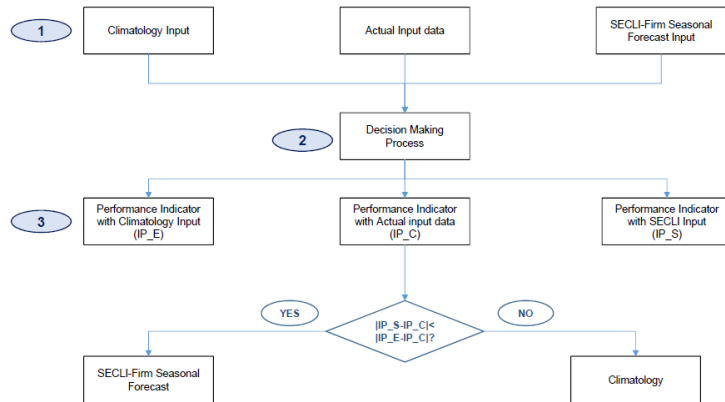
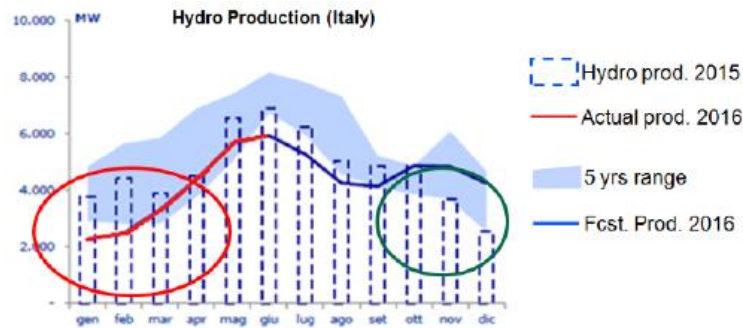




## Case study 1 ENEL: Heat Wave in Italy: results from SEAS5

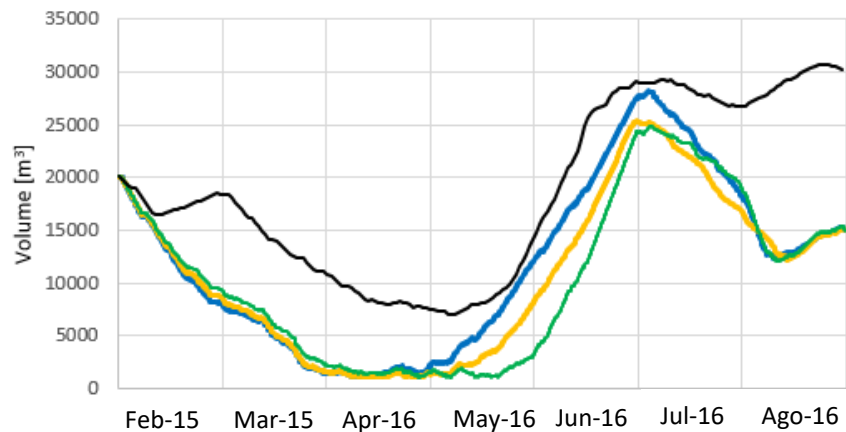


## Case study 2 ENEL: Drought in Italy: results for Q4 2015 October-November-December from SEAS5





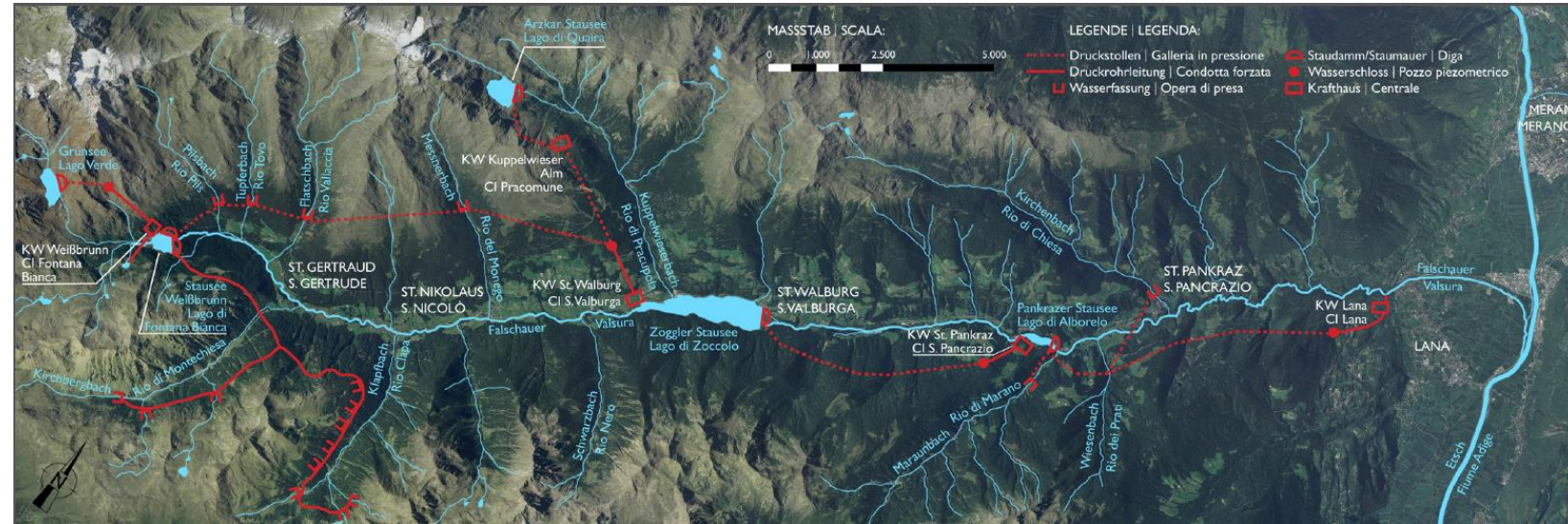
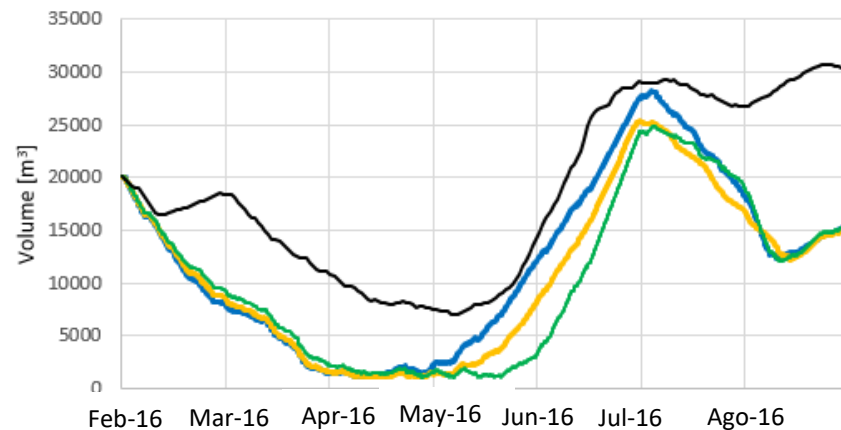
### ***Case Study 2 Alperia: Mild/dry winter in Ulten Valley (2015-2016)***



- using historical mean runoff as model input
- using estimated runoff as model input
- using runoff forecast as model input
- Measured water volume

## Case Study 2 Alperia: Mild/dry winter in Ulten Valley (2015-2016)

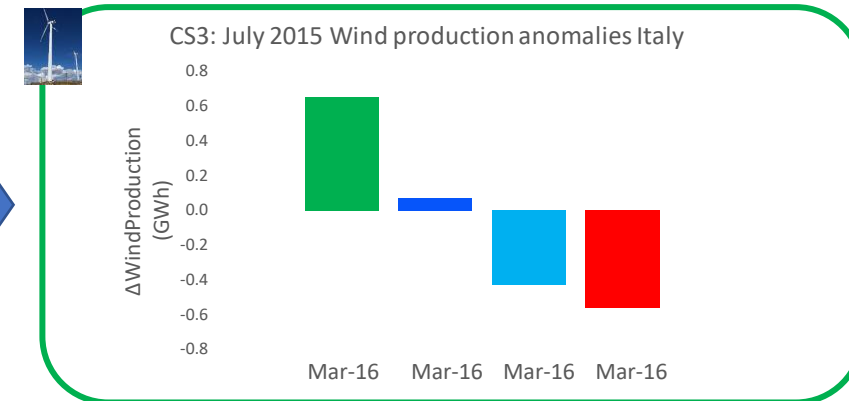
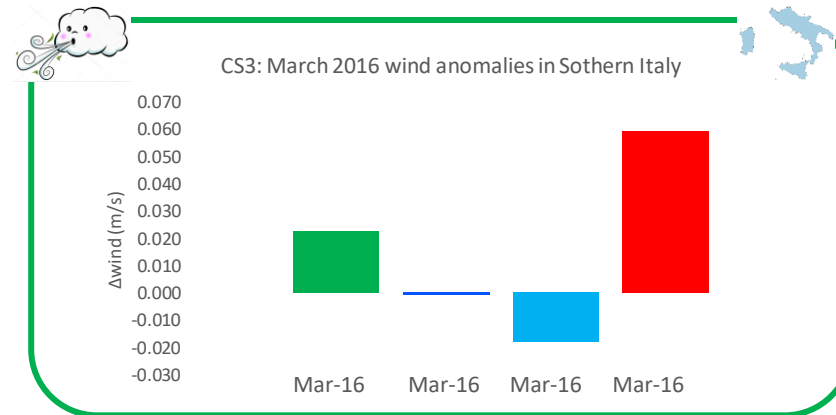
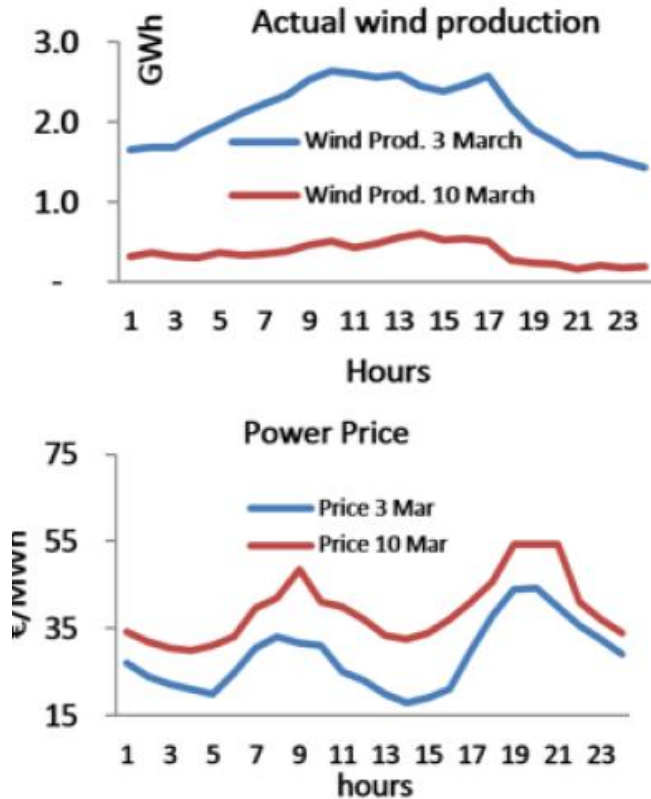
- using historical mean runoff as model input
- using estimated runoff as model input
- using runoff forecast as model input
- Measured water volume



The case study 2 is applied by Alperia to a system of 6 hydropower plants in series in a valley (the Ulten Valley) that is 40 km long. Alperia is comparing the results obtained by means its management model by using as input the climatology data and the new EURAC forecast model.



## Case study 3 ENEL: Wind variability in Southern Italy: results

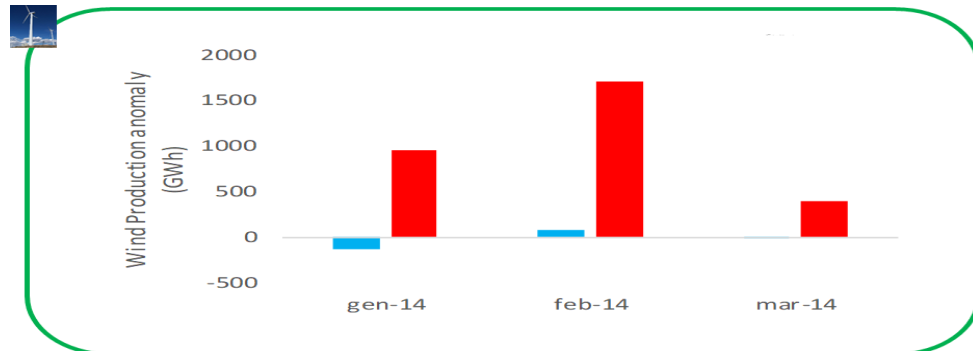
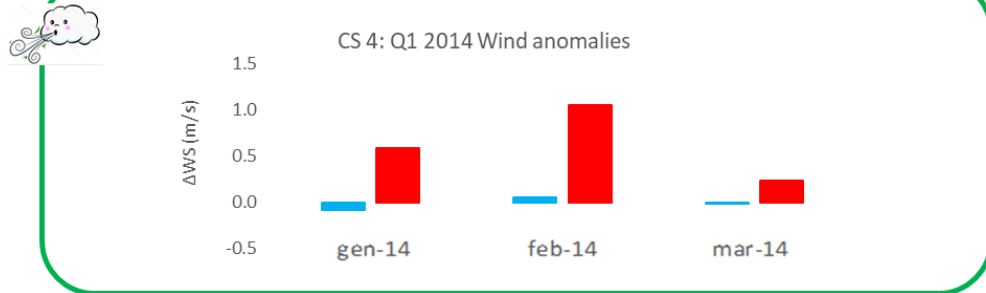


## Case study 4 ENEL: High/low winds in Spain and energy generation: approach

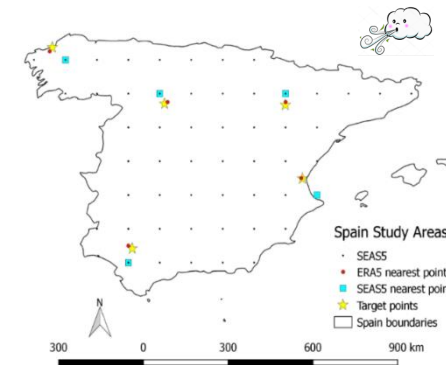
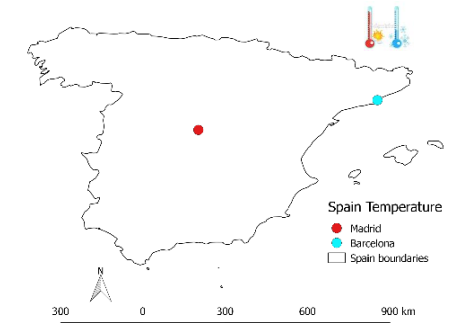
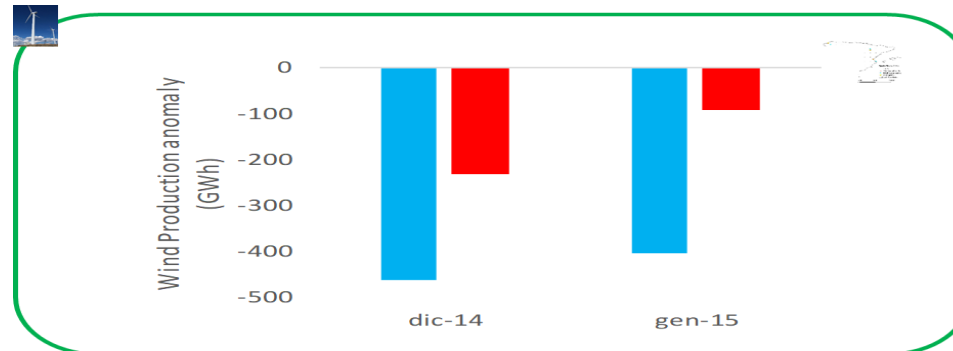
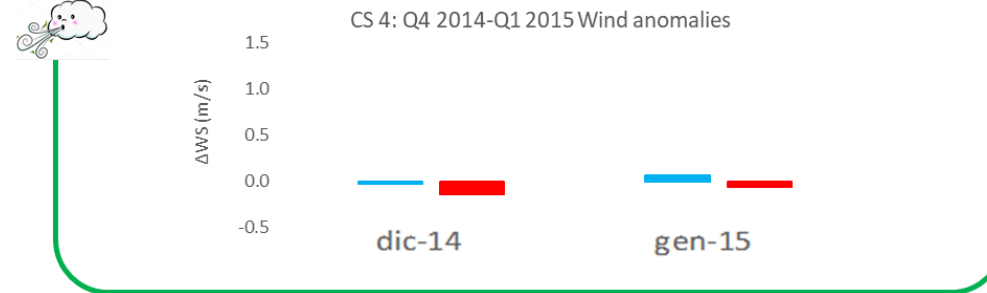
- A. January 2014 – march 2014: High production from wind.
- B. December 2014 – January 2015: Low wind production

*We are working on the downscaling of the SEAS5 data to the ERA5 grid.*

Case A: January 2014 – march 2014: High production from wind.

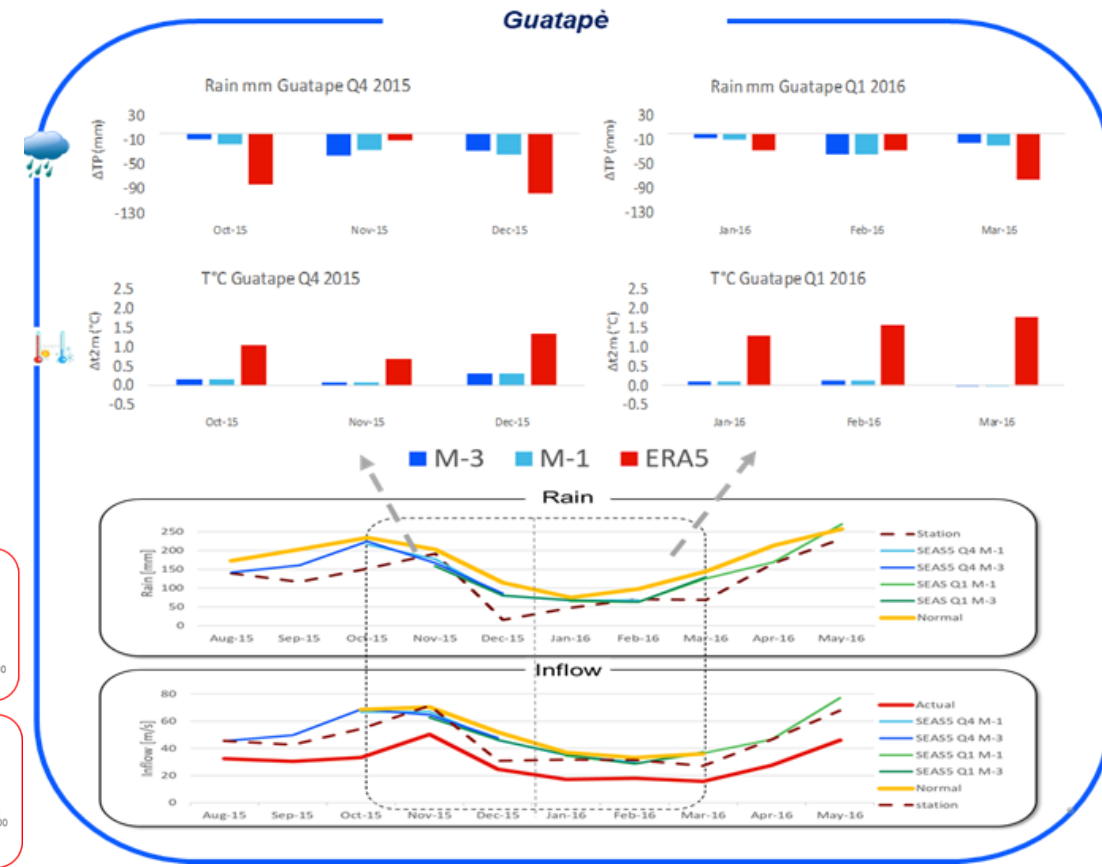
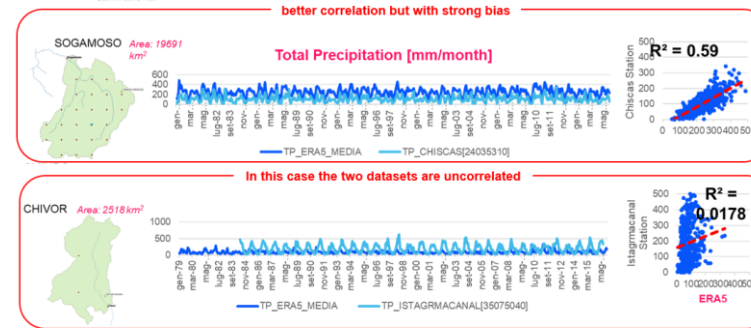
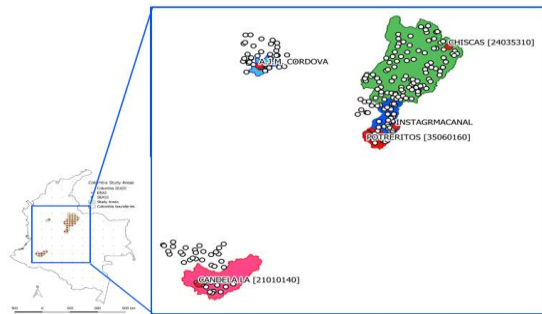
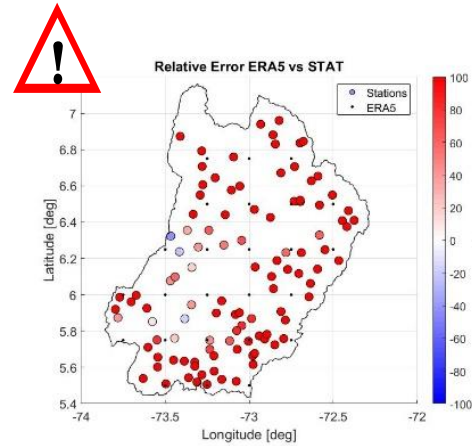
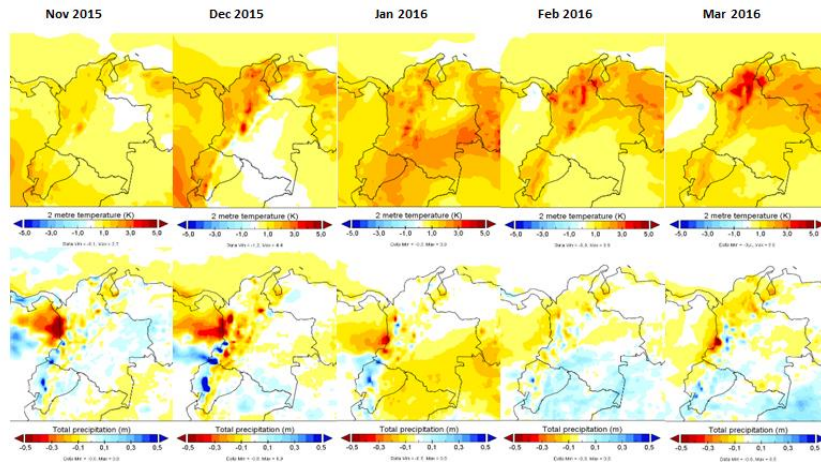


Case B: December 2014 – January 2015: Low production from wind.



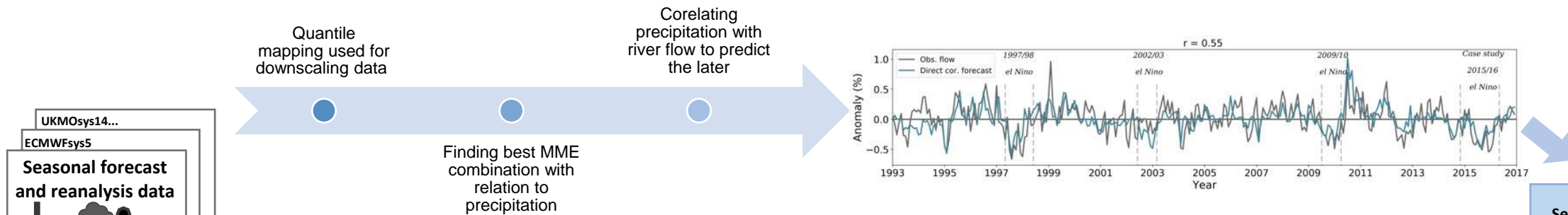
## Case study 5 ENEL: Strong El Niños and energy mix planning: approach

We used the best weather station inside each basin from IDEAM\* dataset.



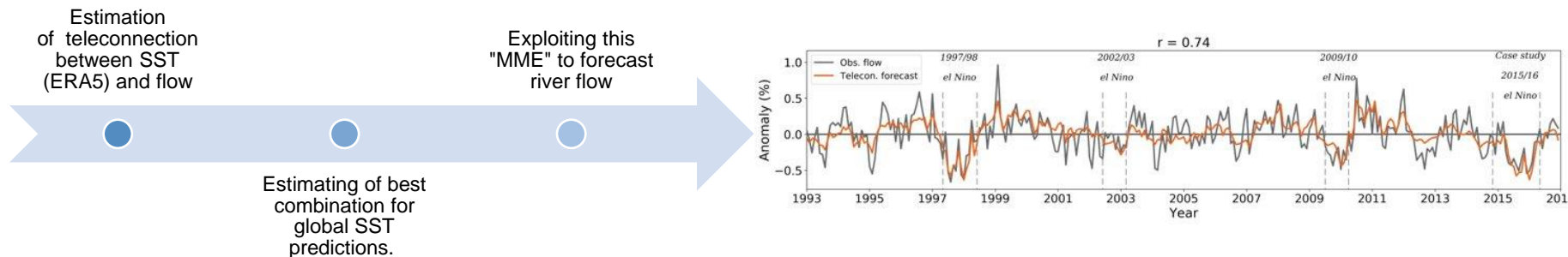
## Case study 5 UL AWS: Strong El Niños and energy mix planning: approach

### "Direct" forecast of river flow from relation with precipitation over catchment area



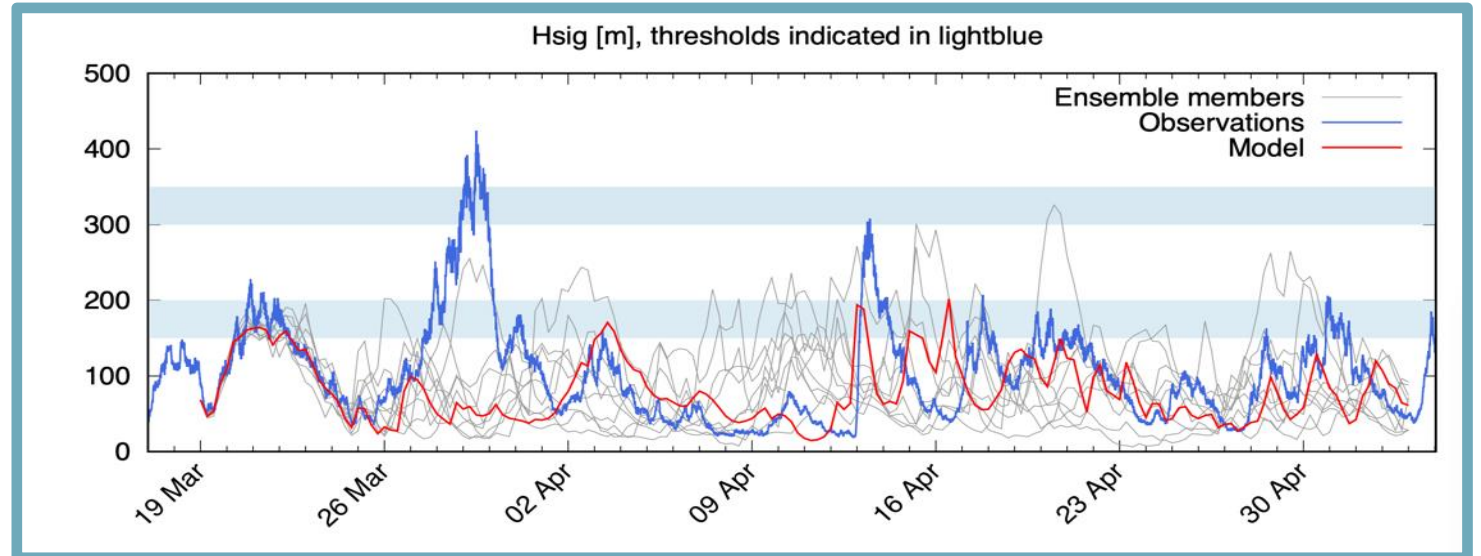
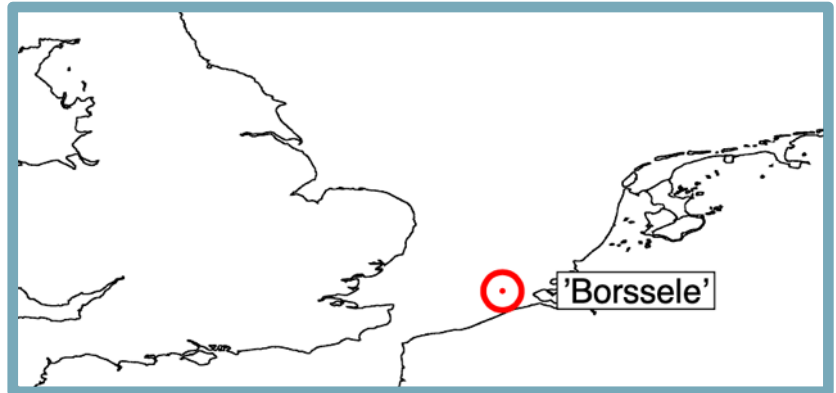
Selection of method and comparison with Celsia's internal model and first estimation of added value

### Teleconnection forecast of river flow from utilization of teleconnection patters for SST





## Case study 6: North Sea waves and winds



Borssele March-April 2020:  
**Blue** the observations,  
**Red** the reference model forecast,  
**Grey** 10 ensemble members.

Overlap is quite good, except for  
26 March – 02 April, though one  
of these members shows a good  
overlap also in this period.



## Case study 7: North Sea weather windows in seasonal shoulder months

Ensemble forecast (MSLP)

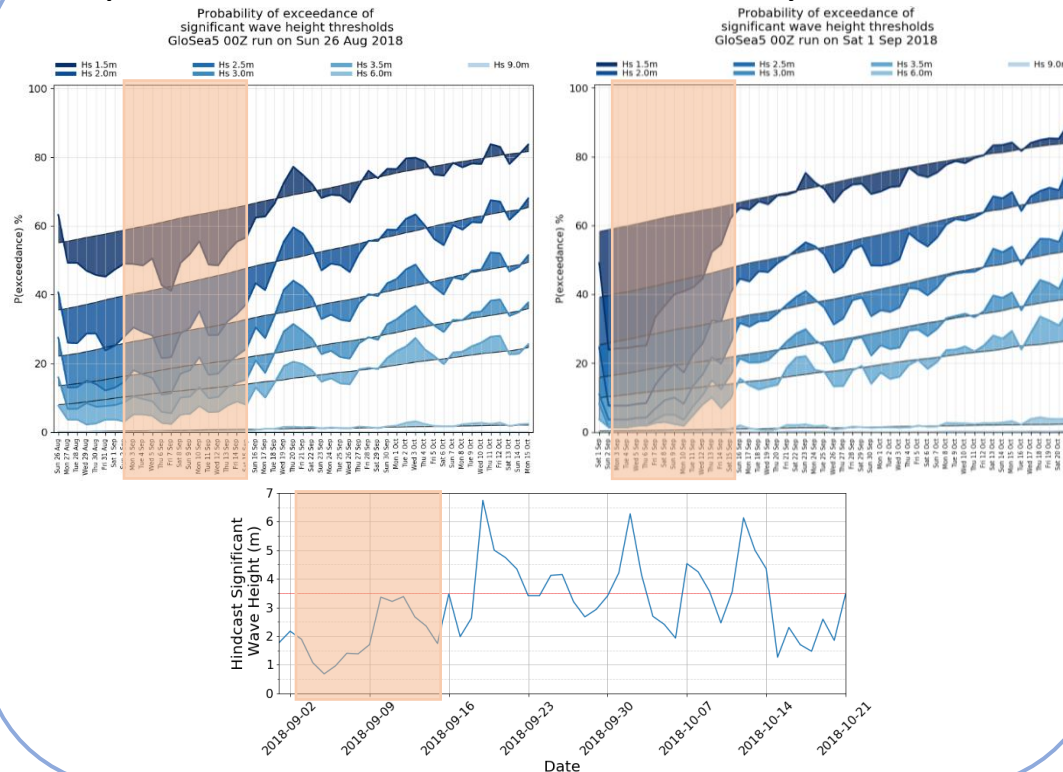
Weather pattern forecast

Downscaling using 101-day  
wave climatology centred  
on each day

Probability of (non-)  
exceedance of operational  
limits

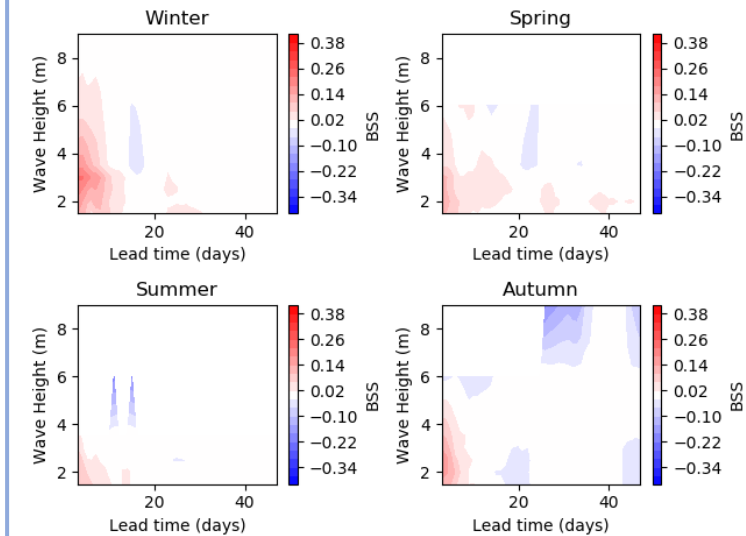
Local climatology modified  
by predicted weather

### September 2018 downtime case study



### Long-term verification

- e.g. Brier Score, Brier Skill Score



+ comparisons of weather pattern  
verification with direct simulation  
verification (to link to CS6)

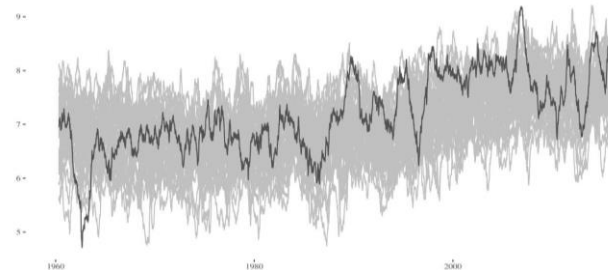
## Case study 8: - Anomalous winter conditions on energy demand in the UK as assessed by National Grid (NG).

### Feedback from industry partners includes:

- Importance of being able to easily integrate any new data into NG's current processes.
- Focus on integrating seasonal forecast data into NG's standard methodology for forecasting the risk of peak demand in the winter.

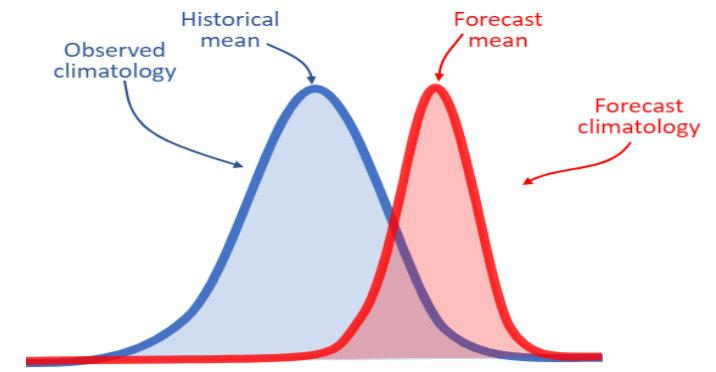
### Tailoring of data

1. Tailoring and evaluation of new dataset for the improvement of current risk management calculation (ACS)



### 2. Tailoring of seasonal forecast input to generate weekly peak demand forecast

To allow NG to use a seasonal forecast,  
With only **minimal changes to their current methodology**,  
We propose shifting the **current observed climatology**  
According to the **forecast seasonal mean**



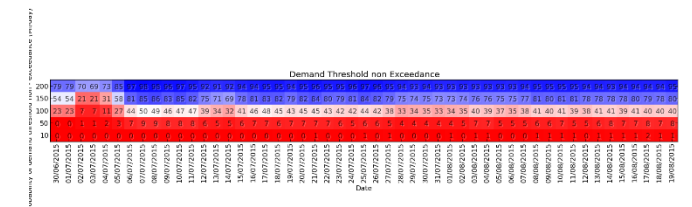
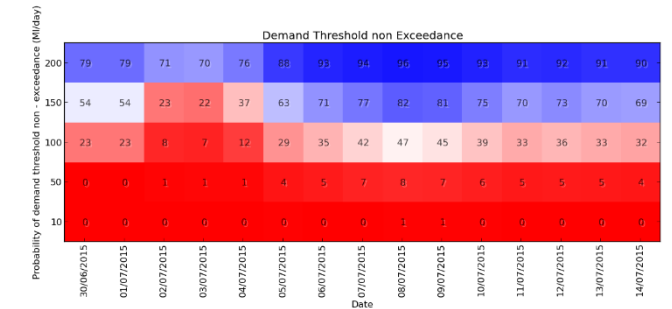
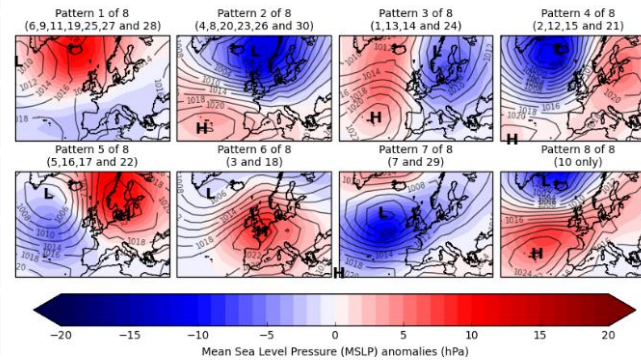
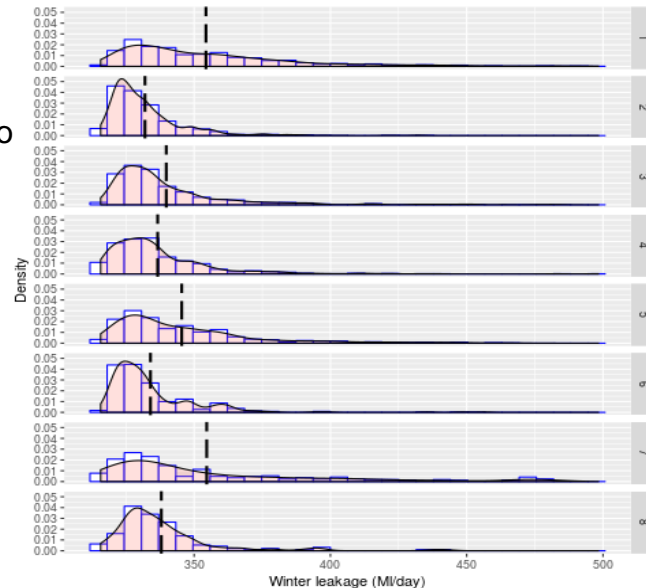
## Case study 9: Managing the water supply and demand balance including Summer fluctuations in demand e.g. June/July 2017

### Feedback from industry partners :

### Tailoring data –Understanding the relationship between broad scale circulation patterns and demand

### Extended probabilistic demand forecast using forecasts of Weather patterns

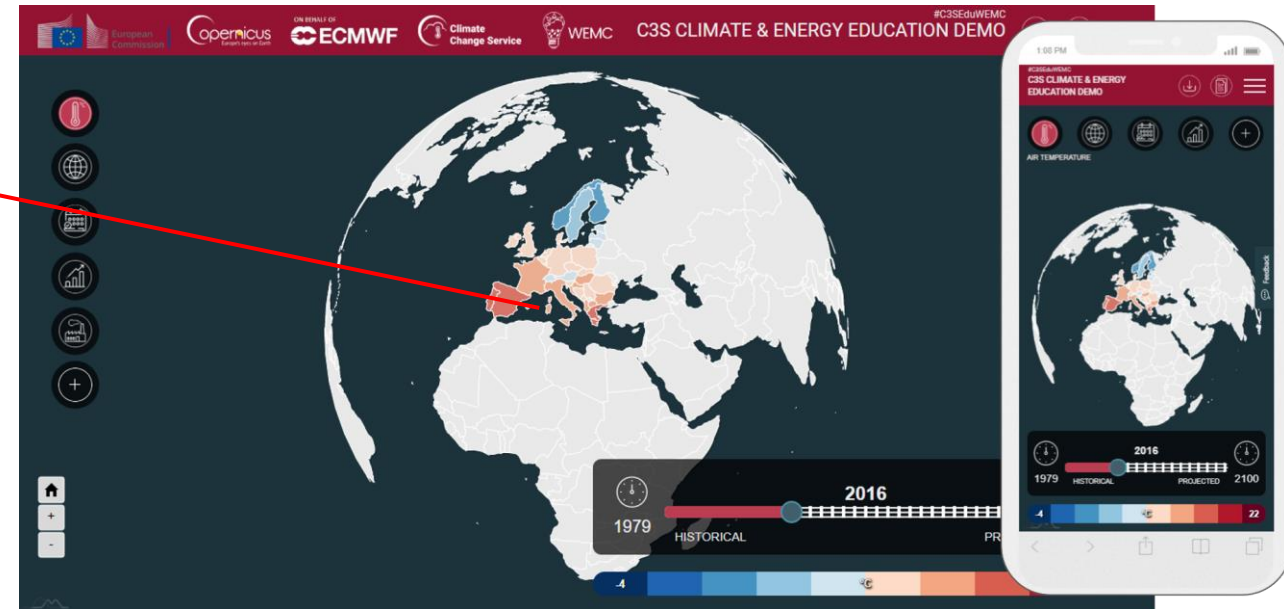
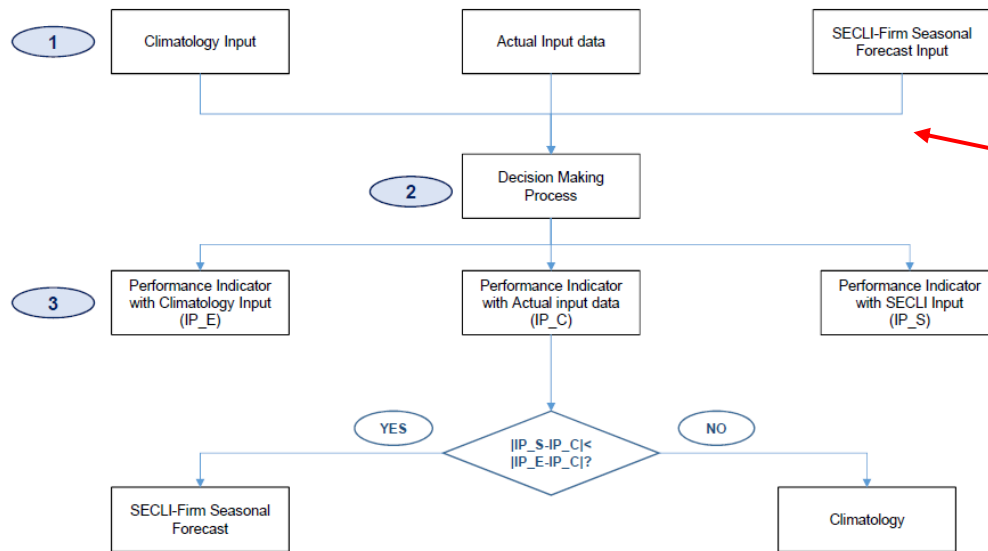
- seamless approach to integrating seasonal forecast information into the water industries decision processes - Focus on extending current 10 day ahead demand forecast.
- Need to understand feature of the weather causing changes in demand



- Agreement on the use of **'trial climate service'**
- The climate service delivery methods for the case studies decided in consultation with industry users
- Detailing the co-design of the trial climate services
  - Documenting the engagement and interactions with industry partners
  - Sharing ideas with other project partners
  - How the industry decision making processes are being incorporated into the co-design
- Considering the approach to evaluation of trial climate services
- Understanding the wider opportunities presented by the case studies

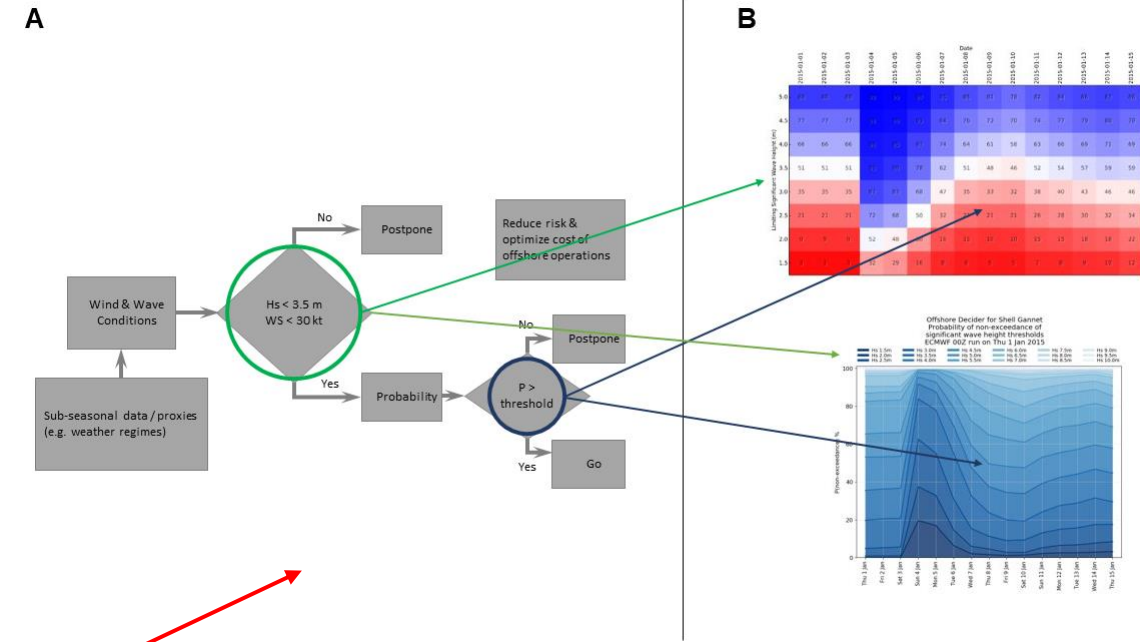
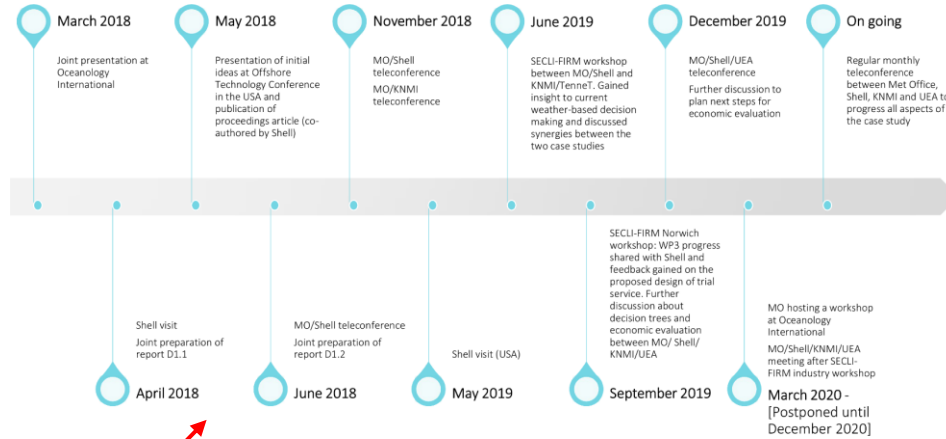
	Delivery methods					
	Demonstrator	Visualisation	Briefing document	Teleconference / webinar	Post-processed data (relevant indicators)	Training (with WP5)
CS1	✓	✓			✓	✓
CS2	✓	✓			✓	✓
CS3	✓	✓			✓	✓
CS4	✓	✓			✓	✓
CS5	✓	✓			✓	✓
CS6		✓			✓	✓
CS7		✓			✓	✓
CS8			✓	✓	✓	✓
CS9		✓		✓	✓	✓

SECLI-FIRM will deliver trial climate services to demonstrate how the use of improved seasonal climate forecasts can be used in management decisions



<https://c3s-edu.wemcouncil.org/>





- Case study 7 has benefitted from extensive knowledge sharing (via frequent e-mail, face-to-face meetings and user workshops)
- The iterative nature of the developments has been documented, which charts the evolution of the proposed visualisation, from a simple table of the probability of non-exceedance to a plot of the deviation of probability of exceedance for key industry thresholds
- The latest visualisation supports the decisions defined in a typical offshore industry decision tree



## Case study 1 Heat waves in southern Europe and energy generation

**Focus:** Heat waves in southern Europe  
for energy generation and demand

- Boosting decision making**
- The main objective of this case study is to illustrate the benefits of products for the identification of extreme summer heat wave power system.
  - How can ENEL effectively manage the risks associated with extreme weather conditions?

### The seasonal forecasting context

- This case study focuses on seasonal forecasts of surface temperature and extreme summer weather such as occurred in Italy in July 2015.

### Sectoral challenges and opportunities

- Electricity price dynamics associated with air conditioning demand (production).
- Power price management and hedging of generation portfolio – with a focus on the impact of extreme weather events.
- How are market and asset portfolio decisions affected by the (un)planned cooling?
- Accommodating enhanced demand model uncertainty due to extreme weather events.



## Case study 2 Dry winters in northern Italy and energy generation

**Focus:** A mild, dry winter 2015/16 due  
pressure system over the Mediterranean  
France - the impacts on energy generation

- Boosting decision making**
- The main objective of this case study is to illustrate the benefits of products to identify winter conditions in the Alps and Apennines.
  - How can ENEL and Alperia effectively manage the risks associated with extreme weather conditions?

### The seasonal forecasting context

- This case study focuses on seasonal forecasts of precipitation and forecasts of precipitation and snow pack will be used to forecast potential energy stored by snow and ice.

### Sectoral challenges and opportunities

- Power price management and hedging of generation portfolio – with a focus on the impact of extreme weather events.
- Prediction of gas price movements in a context of low hydroelectric demand net of total renewables.
- Optimising efficiency in hydropower production management (Alperia).



## Case study 3 Wind strength variability in Italy and energy generation

**Focus:** During the first days of March 201  
variability in the wind regime over Italy  
synoptic systems over the Mediterranean  
implications for supply-demand balance

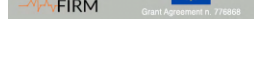
- Boosting decision making**
- The main objective of this case study is to illustrate the benefits of products to predict the expected amount of the hydroelectric production.
  - How can ENEL effectively manage the risks associated with extreme weather conditions?

### The seasonal forecasting context

- This case study focuses on seasonal forecasts of precipitation and forecasts of precipitation and snow pack will be used to forecast potential energy stored by snow and ice.

### Sectoral challenges and opportunities

- Power price management and hedging of generation portfolio – with a focus on the impact of extreme weather events.
- Managing variable wind power production in a multi-asset system.



## Case study 4 Highflow winds in Spain and energy generation

**Focus:** Sustained high and low wind  
energy generation in high penetration markets

- Boosting decision making**
- The main objective of this case study is to illustrate the benefits of products to predict the expected amount of the hydroelectric production.
  - How can ENEL effectively manage the risks associated with extreme weather conditions?

### The seasonal forecasting context

- This case study focuses on demonstrating the impact of using sea big utilities with a large proportion of hydro power in their portfolio.

### Sectoral challenges and opportunities

- To know in advance the expected energy production from renewable generation with conventional plants.
- When will I need higher generation from nuclear or gas plants? How can I complement the wind energy? Can I reduce my fossil fuel costs by optimizing the operation of my energy assets to increase my revenues?



## Case study 5 Strong El Niños and energy mix planning

**Focus:** Strong El Niños in a South American  
mix planning

- Boosting decision making**
- The main objective of this case study is to illustrate the benefits of products to predict the expected amount of the hydroelectric production.
  - As a complementary study, the case study will estimate how an energy mix can be achieved in Colombia. This could help to overcome 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 sea 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 fuel options in advance at lower prices to compensate the operation of my energy assets to increase my revenues.
- To design a future energy mix adapted to the local climate variability.



## Case study 6 North Sea wind and wave impact on maintenance planning and logistics

**Focus:** North Sea wind and wave  
for maintenance

- Boosting decision making**
- The main objective of this case study is to illustrate the application of the use of vessels for offshore maintenance or supply operations.

### The inter-seasonal to seasonal forecasting

- For offshore maintenance planning meteorological parameters height and mean wave period are important. This case study forecasts of wind (at 10m up to 100m height), and wave conditions in the North Sea, from a climatological and forecast.
- This case study will assess the skill and value of forecasts of possible (i.e. at long-lead times beyond 15 days ahead).

### Sectoral challenges and opportunities

- Optimising the scheduling of vessel hire and personnel man operations and maintenance planning.
- When should the vessel hire take place, and for what period, specific offshore operation that is scheduled within the summer.



## Case study 7 Energy logistics: wind and wave conditions

**Focus:** Wind and wave conditions during  
months in the North Sea and energy logistics

- Boosting decision making**
- The main objective of this case study is to illustrate the application of the use of vessels for offshore maintenance or supply operations.

### The seasonal forecasting context

- Seasonal forecast evaluation will consider the skill of predicting calm (September to November) and spring (March to May) months in the North Sea.
- This will be illustrated from the point of view of the Asset Manager or M operations such as those involving drilling, large infrastructure installation.

### Sectoral challenges and opportunities

- The expense of working in the offshore environment places special emphasis on reducing supply chain costs, such as those related to vessel charter and efficient operation.
- At present, the application of the latest weather science developments in the industry is traditionally very conservative, with limited use of forecasting outputs, or even climate projections and teleconnections.



## Case study 8 Winter weather and energy system balancing

**Focus:** The use of seasonal forecasts  
Grid Operator

- Boosting decision making**
- The main objective of this case study is to illustrate the benefits of the use of vessels for offshore maintenance or supply operations.

### The seasonal forecasting context

- This case study focuses on demonstrating the impact of using seasonal forecast information for the United Kingdom (UK) National Grid.
- The climate forecasts will be translated into energy information, to demand and wind power.

### Sectoral challenges and opportunities

- The grid network has a central role to play in the future energy mix. National Grid is working to meet ambitious low carbon energy targets for the people who use them, and to develop innovative ways to enable the grid to meet this demand.
- Ahead of each winter, the UK grid operator must estimate the demand for electricity, and the weather conditions. This is to ensure there is enough capacity to meet this demand.
- By identifying potential risks to the system ahead of the winter, we can reduce balancing costs over the winter period.



## Case study 9 Water management to identify periods of stress to the supply-demand balance

**Focus:** The use of seasonal forecasts for water management  
to identify periods of stress to the supply-demand balance

- Boosting decision making**
- The water industry case studies will explore the application of seasonal forecasting to identify periods of stress to the UK supply-demand balance. These seasonal signatures may highlight chronic or acute periods of stress many weeks out, which will affect the operational management of the water system and the experience of the consumer through supply restrictions.

### The seasonal forecasting context

- This case study will explore the ability to identify periods of chronic stress (prolonged excessively high demand driven by either leakage or consumption). Climatologically, these will include conditions indicative of dry and hot summers, or drought conditions, or peaks in demand due to long periods of below average winter temperatures. If such conditions were predictable at seasonal timescale, it would help to better predict the UK winter mean electricity demand and wind power.

### Sectoral challenges and opportunities

- The United Kingdom (UK) water supply market operates within the private sector comprising of a number of autonomous water companies. The sector is overseen by the Office of Water Regulation (OFWAT), which focuses on consumer regulation. The Environment Agency focuses on environmental regulation. The water businesses constantly balance supply of raw water with demand. Both supply and demand have a significant dependency on the weather.
- By timely identification of potential risks, we will explore whether it is possible to secure customer supply and optimise operational costs.



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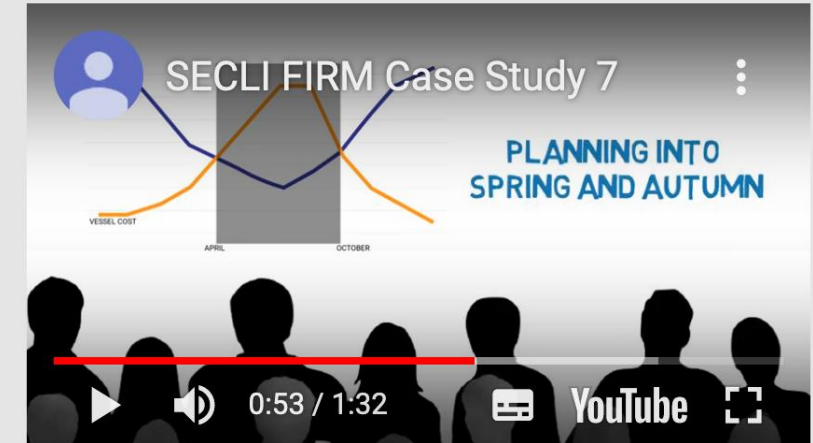




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