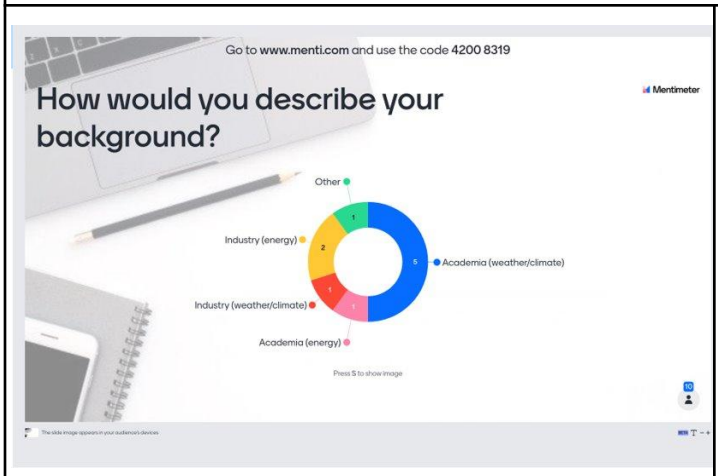
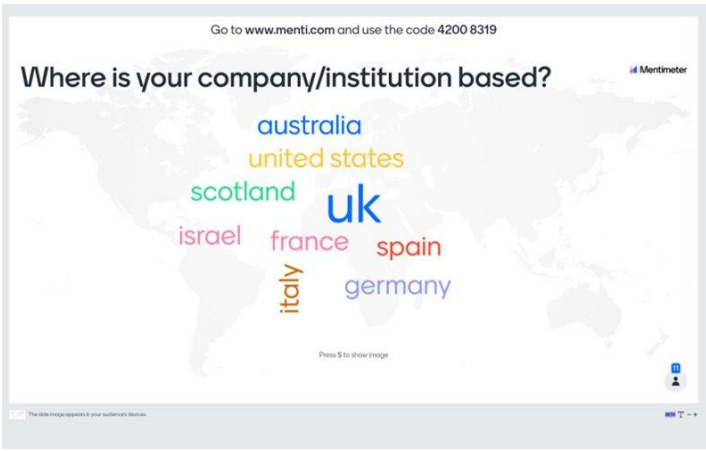
THEME 4
Added value of subseasonal-to-seasonal (S2S) forecasting for energy

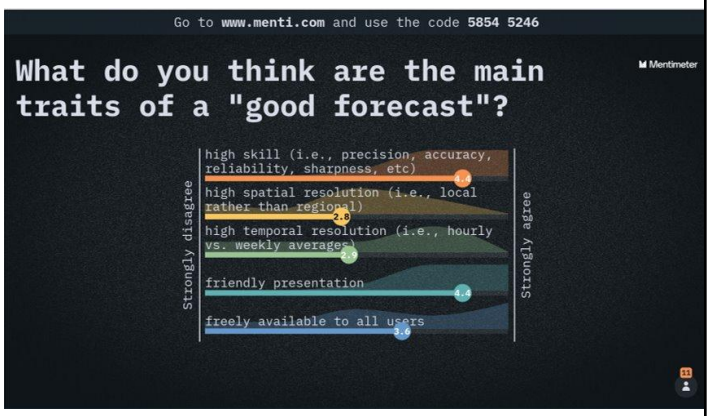
This BOG had 12 participants throughout, including 2 invited speakers. We started the session with 2 short menti polls to get a general picture of the audience's background and some preconceptions about the application of forecasts. Results (leaders excluded) are presented below:

Poll 1: participants' origin and background





Poll 2: what makes forecasts 'good' and why aren't they more widely used



Within the limited number of participants, the majority was European, half were academics with a weather/climate focus. The skill and the presentation were identified as important qualities of 'good' forecasts. In addition to skill and presentation, the 'inertia' of end users were identified as

limiting factors in the uptake of new forecasting products. Even though the small bias towards the weather.climate community might imply a bias in the identification of this later factor, our industry-focused speaker agreed with this perception. The mismatch between the forecasts and the decision making scheme (e.g., in terms of threshold definitions, probabilistic vs. deterministic, etc) was also seen as an important limiting factor.

Then the BOG moved onto the invited talks. In the first place, we had Alberto Troccoli (Founder & Managing Director, WEMC / Visiting professor, UEA, UK), who presented a talk titled “How Can we Overcome Some of the Barriers in the Use of Seasonal Climate Forecasts for the Energy (& most sectors): Some Lessons from the EU Project SECLI-FIRM”. In his talk, Alberto stated that weather/climate scientists are very ‘conservative’ by nature, and quite strict in the assessment of forecast skill (e.g., aggregated metrics vs single events, etc). He posited that the public is used to ‘vaguer’ predictions coming for example from the economic sector (e.g., projected GDP, housing market, etc) and that scientists should perhaps learn to be a little bit less risk-averse. He also discussed the benefits of a co-design, co-development and co-production (co-co-co) approach when it comes to climate services, highlighting the importance of communication between the sectors involved. The co-co-co approach helps to develop a closer engagement with stakeholders, which is critical in transferring knowledge and increasing confidence in seasonal climate products. Finally, he also mentioned that in his experience, a user-friendly presentation of the products has proved very beneficial, in agreement with the initial perception of the BOG (“forecast delivery”).

We then moved onto a presentation by Giacomo Masato (Lead Analyst & Senior Meteorologist, Illumia, IT, Former Meteorologist/Research Analyst, Marex Spectron, UK) whose talk was titled: “S2S: Two relevant points, an end-user perspective.” Giacomo highlighted that forecast skill and forecast interpretation are equally relevant to the industry. Additionally, he explained that even with the S2S forecasting range, different lead times will inform different processes and decisions in the sector. For example forecasts a few weeks in advance typically inform ‘weekly energy contracts’, whereas lead times longer than 3 weeks inform monthly contracts. Depending on the specific system, it might be the case that at the monthly contract scale, the system is less sensitive to the weather forcing and skewed by non-meteorological conditions (e.g., more or less gas or coal available), and thus the forecasts are less relevant. In terms of the interpretation, he remarked that equal weather conditions have different impacts in the energy systems according to their composition. Additionally, the high-level of complexity of a typical forecast (multiple variables, probabilistic presentation, etc) limits the uptake by end-users, confirming again the initial perceptions of the group. He advocated for looking into ways to simplify and condense the forecasts’ information, both in terms of assessing their skill (e.g., aggregated or ‘converted’ metrics) and in terms of the product presentation. For example, he discussed widely the benefit of using weather regimes that effectively ‘condense’ information about multiple variables (e.g., wind and temperature) and that can be associated with typical energy sector impacts (i.e., in terms of energy demand and weather-dependent supply). Additionally, he advocated for the conversion of meteorological forecasts into energy-relevant

variables. He finished his talk presenting an example where an ensemble forecast was categorized in terms of specific likely impacts or 'scenarios' (i.e., 'bull potential', 'bear potential', etc) and discussing how this presentation might be beneficial to the end users (NOTE FROM PAULA: very much along the lines of the 'storylines' approach). Another point that was highlighted by Giacomo is that the need of the energy sector for weather and climate information is relatively new and increasing. Historically, the reliance on temperature information was strong (because of its role on conditioning demand), but this role and the sensitivity of the system to other meteorological variables is continually changing due to CC and the penetration of renewable energies. This, as a result, is a challenge in terms of the uptake of forecasts. Nonetheless, Giacomo posited that the advances in S2S forecasting, both in methodologies (e.g., multi-model prediction, machine learning, etc) and the representation of dynamical processes (e.g., MJO , stratospheric drivers, sea-ice impacts) are encouraging for the energy sector.

Questions related to Alberto's talk:

1. Alberto described how scientists tend to be conservative by nature. Do you think that by being too focused on uncertainty and probabilistic forecasts we are being negative?
   AT: Yes. It is similar to the message of Climate Change => there is uncertainty here and there, but eventually you need to make decisions.

2. A participant asked Alberto for some more details into the co-production process. What is a good way to do this? Workshops with users?
   AT: it comes down to communication. If you keep people in the loop about what's happening they will be able to tell you what's going on and what they need. There needs to be a push on scientists, who tend to be conservative and not very communicative.

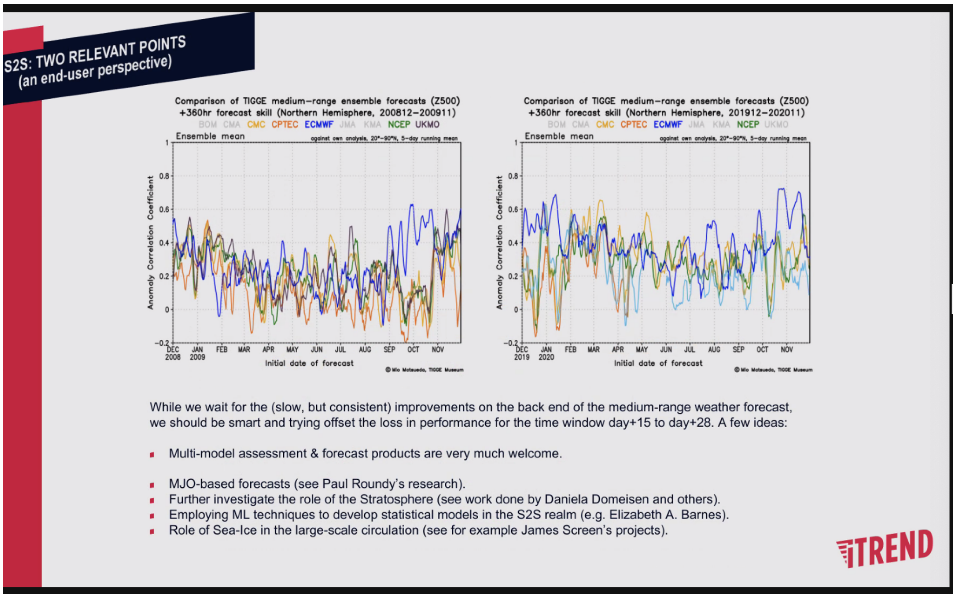
3. Question for Alberto: about the provocative statement that scientists are conservative by nature, what do you propose forward in the building (co-co-co) of climate services? Should we forget about skill? What should we focus in?
   AT: my view is that as part of the dialogue with users (the co-co-co) one needs to find a middle ground (as in most things in live: *In medio stat virtus; 'virtue stands in the middle'*). This doesn't not mean jeopardise the science (your *forget about skill*) rather taking it to a level which is approachable by users without being too strict on formalism/terminology, while of course highlighting limitations of the data/forecasts. I hope the general suggestion I was trying to convey is clearer now.

4. Another one was raised about the fact that some parts of the Australian energy sector seem to be as risk-averse as the scientists. Any comments on that? Is it any different than in other countries/regions?
   AT: I don't think there is anything special about the Australian energy market. As in most things it takes time to digest and accept new concepts, it's just human nature. Tu put things into context seasonal forecasts have been around for 20+ years, but

the uptake hasn't reached maturity yet. For instance we held a summer school and subsequently wrote a book ca 15 years ago (http://www.albertotroccoli.org/CapacityBuilding/nato_asi/index.html), when we thought seasonal forecast was at the cusp of flying off the shelves but in practice there have been some higher waves, and while some regions (in lower latitudes, though often these activities are Gov't funded rather than by private) have seen better adoption there is still quite bit of work to do to reach a sustained use of seasonal forecasts. This is part due to new people entering the field, on both sides, needing training, for a subject which isn't straightforward to grasp.

Main points from Giacomo's talk:

1. Forecast skill. S2S time window is divided into two (up to 3 weeks, and beyond). The markets behave similarly (i.e. weekly contract vs monthly contracts in Germany). The exercise of predicting the weather isn't that different to predicting the price in the market. The price is a snapshot of the Demand vs Supply. The weather forecasting and the energy market forecasting share similar characteristics. The first part of the forecast (up to week 3) is the most relevant for price definition purposes, the seasonal forecast is more of a boundary-condition problem. The price of the 4th week will depend on the price of the first 3 weeks. In the case of the boundary-condition problem=> price will forget what happened in the first 3 weeks the longer down you go through the timeline. While we get to the seasonal part of the price market, we also have the problem of the signal being skewed by non-climate factors. *In summary,* the longer down the line we are, the less relevant is the climate as a factor to define the energy market price. But the climate factor is always there, just has a smaller weight in the equation.
2. Forecast interpretation. The way we convey information is important for the energy market. The energy market is more familiar with weather variability than before. The energy side of the forecast=> every market in the EU is associated with a particular energy-type. The structure of the production of electricity is very different.
3. Skill. Anomaly Correlation Coefficient=> 10 years ago the skill of the forecast was lower than today. Progression of the skill. A lot of variability in the skill in different models throughout time. We can see in the slide a large multimodel spread but also a seasonal cycle, particularly for the ECMWF model. What can we do to improve the forecast from day 15 onwards? a) Multimodal assessments; b) MJO-based forecasts; c) ML techniques; d) others (in the ppt).



The renewable energy brought to the market new elements with a lot of information that seemed difficult to digest for the electricity market. Weather regimes are very useful, in a single snapshot you have the areas of the weather variable of interest (from the producers side and users side). They also show information on variability. But these weather regimes are weather construction with its own limitations, the weather regime for Supply and Demand could be very different. (France relies on Hydro rather than wind, which opposes Germany's energy production regime, that relies on wind; etc.).

In summary, these talks highlighted the relevance of three important processes:

- Skill assessment (done in a user-relevant way)
- Forecast presentation (less risk-averse, condensing or 'converting' information)
- Communication between the parts (throughout the process… tailored, relevant, skillful and user-friendly products)

After these talks, we moved into questions to speakers and open discussion. Alberto had to leave quite promptly but Giacomo was available for questions through the 2 BOG sessions and most of the time was spent that way.

Additional points that came up during these discussions were:

- A participant asked Giacomo if he thought the users are open to receiving forecasts alongside their estimated skill, and he thought that they were.

- As a follow-up he was asked if he thought that skill was more relevant than the likely impact, and he replied that he thought they were both relevant to the users.

- When asked about the sensitivity of the energy sector to the forecasts, he illustrated it by saying that the energy price forecasts visibly react on the dates where CFS and ECMWF forecasts are released. He explained that the price market will react to the forecast based on the skill of the forecast. If you go into the market on a specific date, you can see when the ECMWF runs publicly, and the price adapts immediately. To some extent the market does not care too much about the skill of the forecast. If you, as a system, know 2-3 days before that the fundamental of the energy is coming to a specific equilibrium, then that info becomes very relevant because the system adapts itself. Depending on the timeline you are after, the skill might be more relevant.

- Another point that was discussed was the idea of 'flow dependent skill' and 'windows of opportunity' in S2S forecasting. Giacomo stated that the sector is very likely to benefit from it and that energy forecasters like himself are 'informally' already profiting from them. However, he thought that it would be beneficial for the different actors to collaborate and design 'joint' products. In his opinion, the academia, the met agencies and the industry are three distinct sectors and they all need to collaborate to develop robust and operational products that can be beneficial to the community. GM explained that the windows of opportunity (timeframe from lead time 14d up to a month) have the potential to connect physical forcing drivers and merge them into the medium range weather forecasting. Weather agencies might be doing it already. But there is room for exploring this further. The academic world could have a big impact here. Dividing the MJO into a frequency division, low frequency forcing and high frequency forcing. Keen on MJO side, but also the stratosphere. Other forcing drivers might also be useful.
- PG: What type of format of these drivers can be useful? It is not only about knowing the face of the MJO… GM: the kind of interaction that I see for delivering the forecast, 1) working with the skill to support the back end of the S2S forecast; 2) smart ways of interpreting the content. There are quite a few of us with met background in the energy sector, but the vast majority are called to interpret weather maps for users, not to do research. We need to translate for the energy users maps and information, they need numbers and tools to understand.

- Another participant asked Giacomo about his concerns about the use of ML/AI methods as 'black boxes'. Giacomo agreed that it is risky and that he believed that most of the benefit from such methods would arise from their use in the post-processing of NWP predictions (e.g., multi-model combinations, clustering, etc.) as a way of extracting useful information and reducing dimensions and complexity.

- Two other points that were discussed dealt with the variability in the sensitivity of the energy sector. Giacomo gave the example of the potential changes due to advances in the storage technology, and how the impact of a specific single storm could change massively in a system with or without storage. Additionally, the group also discussed how seasonal variability (and maybe even interannual, depending on the market) can change the sensitivity of the system too. Giacomo gave the example of how the

European seasonal climate had been conditioned towards low wind situations for months (5 to 8) and that had impacted the prices, even more so than the pot-pandemic reactivation.

- The group also discussed, using the perspectives from different countries, how the products and technologies might not be very 'transferable' (e.g., more or less regulated markets, water rights, etc). This also reinforces the need for co-design and co-production. When discussing the experiences from countries other than the UK, Australia was given as an example of having an energy industry completely different from the EU (energy rules/law,..) all these tools developed are spoken to the particular market. GM: True. The EU energy market is the most advanced globally due to historical reasons. The US is relatively simple in comparison. Weather forecasting can or cannot be useful for the energy sector, and must be tailored to each geographical domain. But it doesn't defy the purpose. The trend remains the same across all regions. We need to identify the market and the systems because they are very different from each other.

- A participant asked Giacomo whether he thought there was use for Weather regimes impacting high supply and high demands for sub seasons at the seasonal scale. Giacomo replied that he thinks it is very useful to monitor WRs' season variability. The seasonal component is live and the market will react, especially in winter and summer. The more we are moving towards the mid century, the more the summer season will become more important because of Climate Change and Global Warming will put a strain into the system. The renewables are changing the entire landscape of the energy sector. On top of the high demand you will have significant issues in the demand side (less hydro), but also in the nuclear realm. In summer we will see a big imbalance between the two fundamentals. There is skill in the seasonal forecast and the community is willing too. The flexible approach can be employed in several time frequencies.

- Giacomo also highlighted that the weather/climate community needs to be aware of the presence of very different users within the energy sector when designing and presenting forecasts. For example, traders can be very speculative and would easily adapt to being presented with probabilistic predictions and windows-of-opportunity type of products. On the other hand, suppliers are very much concerned about the reliability of the system for meeting demand and are a lot more risk-averse.
- In terms of the specific presentation of the forecasts, Giacomo pointed that in his view the effort of converting the forecasts to energy variables is very important for promoting the products, even more so that the development of 'case studies'. Such case studies can be useful, but they have to be jointly designed so that they properly reflect the interests and needs of the users.
- Later on the group picked up again the idea of the advances in storage, and how the impact could be extremely significant. It would move the focus to large-scale energy droughts and minimize the impact of local extremes. [Note by Paula: I do however need that the sensitivity might still be there in price markets, depending on how storage is managed!]

- We also discussed the idea of the ‘skill perception’ of the forecasts, and how their valuation by the community is negatively impacted by ‘bust events’. Giacomo mentioned that the system is self-regulated to ‘keep track’ of these events and that it ‘develops antibodies’, so in the long run they are not less likely to welcome the forecasts in their decision making process.