October 5, 2022 Theory Working Group Call

Attendees: Glenda Wardle, Abby Lewis, Shubhi Sharma, Gerbrand Koren, Noel Juvigny-Khenafou, Mike Dietze, Jody Peters, Cole Brookson

Agenda:

1. What hypotheses from the manuscript could be explored within one or across the NEON Forecasting Challenge themes or with forecasts listed on the EFI forecasting profiles webpage or from the EFI community
    a. Hypothesis 1: The rate of decline in predictability over increasing forecast horizons differs across variables and scales
    b. Hypothesis 2: Predictability increases with biological and ecological aggregation
2. Any additional updates or ideas from the
    a. Lit review of models typically used for the NEON Forecasting Challenge themes
        i. Google doc to compile the models
    b. Figures of hypotheses that can be examined using the forecast challenge output
        i. Google slides with images
    c. Modular framework that we can use to try many different models for several challenge themes.
    d. Did people get a chance to look at specific challenge themes to get more familiar with the details about them?
3. Notes
    a. Abby has been moving around code from the EFI GitHub. Putting together a framework where you can insert a different model type and generate forecasts for the different NEON Forecasting Challenge themes.
        i. Started with a random walk model
        ii. Random walk and climatology models are already being generated for the Challenge themes
        iii. GitHub: https://github.com/abbylewis/EFI_Theory
            1. Start of code to analyze forecasts across the Challenge themes
            2. Abby has focused on code to generate forecasts
        iv. First chunk you put in team name, participants, and which challenge theme (right now you pick one, but eventually would like to have the option to do all. Not set up for beetles or ticks yet which are at weekly timescales and null model doesn't work at that scale yet()
        v. Next chunk - random walk, daily forecast code. It is a separate chunk, so you can insert your own model
        vi. It downloads data, runs the model, plots forecast, and submits it (submission is not set up yet, but it will eventually be)
        vii. Can set it up to run through GitHub actions every day
        viii. It is a simple model right now
        ix. There is a metadata section. That will need to be customized and manually filled

b. Contribution from the theory group can be coming up with models to try for the different themes
    i. Started thinking about this because there are things about predictability that we thought if we used the same model to make forecasts across themes
    ii. Ethan White's lab has pulled together a set of standard models that they are applying to their data
        1. Check to see if we can get someone from Ethan's lab
        2. Think they are basic time series models that they are fitting
        3. Also look into Eric Ward's models that Abby mentioned (Jody didn't catch the details).
    iii. Driver to pull in met forecasts - those are available
    iv. Pull in DACC info - they have done extraction for NEON sites, Ameriflux, etc
        1. ORNL DAAC subsets by network https://modis.ornl.gov/sites/?list=networks
    v. Other models - ARIMA
    vi. Look at how variation is being partitioned with the random walk model
    vii. From figures from last
        1. Look at forecast horizon and how predictability changes through time - Hypothesis 1
        2. Slide 4 or 5 - thinking about uncertainty. How uncertainty is different for different themes
            a. If we are looking at uncertainty we will need a modified model structure
            b. So if this is a key goal then we will want to start with this
            c. Could start simple with the first hypothesis and then move to more complex models.
        3. Could try different models to get the best one and then look at uncertainty to look at the number of parameters needed - this will take more than one or two models
        4. Slide 2 - looking at different species. Thinking about looking across themes and thinking is phenology more predictable than dissolved oxygen. But could also look within theme since there are multiple variables in some of them (e.g., terrestrial, aquatics)
        5. Beetles example would be a good option to look at multiple levels of aggregation
    viii. Anyone who wants to play with new models, feel free to adapt the GitHub code
        1. The goal is to have a standardized workflow that the group can plug in
        2. Shubhi is available after Oct 27. Is interested in working on the beetle models

3. Abby did the ticks challenge for a class so has some code for that. There is a step to translate from daily to the week
4. For the weekly challenges do we functionally treat the same as the daily challenges from the models perspective and treating each timestep the same? Insert it into the model calling it a daily timestep even though it is 52 weeks? If you have drivers, you'll need to figure out something. But could call it a timestep
5. If we build the models - how will we define support for our hypotheses? How will we gather set of evidence that supports a hypothesis or are we developing more specific ideas about variance for a specific example, this is the shape we expect - if our results follow shape, it fits our hypothesis if not, it doesn't
    a. One question that is tractable is how predictability varies based on forecast horizon and levels of aggregation.
        i. If we use the same model across all themes, then can see how well it forecasts the different variables.
        ii. Abby anticipates that the beetles/ticks predicting one week in the future will do poorly due to uncertainty and observational error. Where things like phenology over the seasons
        iii. There is a prediction that physical or chemical variables are more forecastable
6. From Glenda: I am thinking about long-term data analyses on ants we have done and trying to translate to what non-complex models would look like. A couple of papers on ants
    a. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2656.13052
    b. https://royalsocietypublishing.org/doi/10.1098/rsbl.2022.0314
7. Comparison of terrestrial and aquatic forecasts
8. Should we try to come up with a guess for how different the forecast horizon will be?
    a. Is it interesting and is it possible to come up with a quantitative prediction of that decline? If so, then compare your prediction to the predicted decline in forecast horizon
9. Write down hypotheses of what we predict will happen based on the amount of data and the kind of data available
    a. Could do plots of the raw data
10. What would be a standardized language to analyze forecast skill?
    a. Looking at Slide 4 - there is a function in theory that determines the curve. Can we come up with a function that describes the decline in skill at a particular forecast horizon? Or even say it is exponential (or some other shape of the curve)?

   b. Any model that is dynamic where the predicted state depends on the previous state, that component of the model will cause increase or decline exponentially.
      i. See Mike's paper here: https://esajournals.onlinelibrary.wiley.com/doi/10.1002/eap.1589
      ii. If you don't have feedback from initial conditions you expect to see the curve in Slide 4
      iii. In chaotic system, it will be dominated by initial conditions

11. In early version of the manuscript - some processes are unpredictable during some periods of time then they become predictable - e.g., leaf phenology. Can we decouple those or are they intertwined?
   a. They are intertwined. Drawing an average curve over time averages over the shifts. There are cool papers that show that in disease systems where you switch from periods of high unpredictability to periods of predictability measured in different ways.
      i. See the measles example in Mike's book
      ii. Early period of measles epidemic have high instability in the system, but have small sample sizes, so have high sensitivity to process error. So early outbreaks are hard to predict. But once the disease has peaked and you are on the backside, the law of large numbers applies and the system is stable so it is very deterministic decline of an epidemic until something changes (e.g., next variant)
12. Thinking about beetles and keeping models simple.
   a. Most observations are the beetles, but won't have data for the predators of the beetles, so won't have those additional data as opposed to the environmental covariates
   b. Glenda has long term records of beetles from desert system. Have to use a lot of biological interactions. The general inverts don't pattern of each other
   c. When you have the longer term data how do you change mindset from the longer term data to the forecast mindset
   d. Problem is the beetle dataset is not long term
   e. Beetles are diverse but don't have their interactions well understood
   f. If we use a more complex model - population dynamic model, would that improve the forecast

g. Think of it as a food chain with beetles in the middle so have forces impacting below and above and that isn't what will be available from the Challenge
h. If assuming populations are in equilibrium and use today's population to predict tomorrow' population. Would that work?
i. From Glenda's desert experience there is a blinking in and out of the beetle populations
j. Concept of aggregation is interesting, because it might not matter what beetle species you have as long as you have a beetle included
k. Aggregation is done by default due to the lack of info about the species and being able to ID them - often go with Order

c. Next Steps
    i. If people can add models, that will be good to check in next month
    ii. Anyone who is interested in working on the code can reach out to Abby and Shubhi
    iii. Recheck expectations for questions we want to answer
        1. In the past the group has come up with expectations for the Challenge themes
            a. Here is the example for the Phenology Challenge
    iv. Spend time in the next meeting talking about expectations
    v. Think through similar way to get feedback about each Challenge theme and the predictability questions we are thinking about.
        1. Would want a new spreadsheet
    vi. Would like to get a summary for what has been submitted for the Challenge
        1. Shubhi will work on this for the next meeting