Seasonal Weather Forecast in Vietnam

Research Plan for comparison and evaluation of two seasonal weather forecast systems

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Student: M.Sc. Martin Stolpe
ETH Zurich
Institute for Atmospheric and Climate Science
Universitätstrasse 16, 8092 Zürich, Switzerland
martin.stolpe@alumni.ethz.ch

Supervisors: Prof. Dr. Phan Van Tan
VNU Hanoi University of Science
Faculty of Hydrology, Meteorology and Oceanography
334 Nguyen Trai Street, Thanh Xuan, Hanoi, Vietnam
tanpv@hus.edu.vn

Dr. Patrick Laux
Karlsruhe Institute of Technology
Institute of Meteorology and Climate Research - Atmospheric Environmental Research
Kreuzeckbahnstrasse 19, 82467 Garmisch-Partenkirchen, Germany
patrick.laux@kit.edu

1. Preface / Introduction

Vietnam faces increasing climate variability and higher risks of droughts, floods, rising sea levels and salt water intrusion into rivers and canals affecting the agricultural irrigation e.g. of rice fields due to global climate change. To increase the resilience of Vietnamese farmers against climate variability there is a strong need for improved seasonal weather forecasts.

High-resolution seasonal weather forecasts tailored to the specific needs of farmers can provide sufficient lead-time for crucial agricultural decisions such as the choice of crops, crop varieties, their planting dates and suitable locations for cropping.

During a four months research internship at the VNU Hanoi University of Science (VNU-HUS) I would like to contribute to the improvement of seasonal weather forecasts by examining which forecast system has the highest skill score on a seasonal time-scale for weather related variables relevant for Vietnamese agriculture.

2. Data

For the intended work at VNU-HUS, the NCEP Climate Forecast System Version 2 (CFSv2) and the ECMWF S4 system should be used and compared with each other. Both of these state-of-art systems provide longer-range weather forecast for the next several months. The two global forecast systems have, however, a relatively coarse resolution and this hinders the direct application of these systems for the needs of agriculture in Vietnam.

CFSv2 (Saha et al., 2014) uses a fully coupled ocean-atmosphere-land model. The atmospheric component is computed on a T126 grid which corresponds to a roughly 100 km grid resolution. The ECMWF S4 (Molteni et al., 2011) forecast system that also consists of a fully coupled global model uses a higher atmospheric horizontal resolution of T255 (grid spacing of around 60 km at the equator).

Due to the chaotic nature of weather the initial conditions for the seasonal model simulations are varied slightly and thereby large ensembles of forecasts are generated. The spread between the ensemble members is a measure of the predictability. Further, by simulating several possible realizations of seasonal weather changes, probabilities of future changes can be assessed, i.e. if a drier than average is more likely than a wetter summer.
For CFSv2 16 simulations are run every day: Four out to 9 months, three out to 1 season and nine out to 45 days (Saha et al., 2014). For ECMWF S4 the seasonal forecasts consist of a 51 member ensemble (i.e. the model is started 51 times with slightly different initial conditions in the atmospheric and oceanic fields) that simulate the ocean-atmosphere system out to 7 months. Different to CFSv2 that runs daily, ECMWF S4 is initialized once per month.

In order to make proper use of the seasonal forecasts, it is essential to know the skill and bias of different seasonal forecasting systems. This requires a set of forecasts from earlier dates. These forecasts from earlier dates are referred to as re-forecasts (sometimes also as hindcasts). For ECMWF S4 re-forecasts are made for every month for the years 1981-2010 and for CFSv2 for the years 1982-2010.

The seasonal forecasts then can be compared to either observational data or to reanalysis data. For a reanalysis, historical observational data is assimilated and used to drive a weather model. Compared to raw observational data these reanalysis products have the advantage of covering the state of the atmosphere with a high temporal and spatial resolution without missing data.

3. Research Aim and Research Questions

Together with Prof. Phan Van Tan from VNU-HUS and Dr. Patrick Laux from the Karlsruhe Institute of Technology I would like to examine the skill of re-forecasts (i.e. retrospective forecasts) of seasonal forecasting systems for agro-meteorological variables in Vietnam. These are weather related variables that are particularly relevant for agricultural purposes. Precipitation would be such a variable.
In previous research (e.g., Tan Phan Van et al., 2014) seasonal forecasting systems were already evaluated for minimum, maximum and mean temperatures in Vietnam.

We would like to address the following research questions:

- Which variables/indices are useful and relevant for farmers in Vietnam? Besides rainfall, are there other relevant variables?
- How can the skill of global and regional seasonal forecasting systems be assessed objectively? Should the skill be calculated against observational or reanalysis data?
- What is the skill of global/regional seasonal forecasting systems for variables relevant to Vietnamese agriculture?
- Which seasonal forecast system is most suitable for the intended purpose, i.e. has the highest skill with respect to the identified variables?
- Can the forecasting system be bias corrected to improve skill for seasonal precipitation forecasts in Vietnam? Can the forecast skill be increased by dynamical downscaling?

To summarize, we hope to figure out with this work which long-range weather forecast system is most suitable for the needs of Vietnamese agriculture and if the forecast skill can be increased by bias corrections and eventually by dynamical downscaling.

However, some important prerequisites have to be fulfilled to successfully complete the proposed research questions. These prerequisites include the availability of data sets, resources for computational power (for carrying out the simulations with the regional model (if they are not yet completed) and for processing the large data sets), and the availability of required programming tools. Further, it has to be clarified if the whole research project can be completed within the intended time frame. Maybe parts of the research can be shared with other researchers if the time is not sufficient to complete the work within the stay in Vietnam.

4. Workflow and Schedule

1. **Literature research**
   Literature research about the global and regional seasonal forecasting systems and reanalysis products used for this study. Further, literature research about different possible skill scores is required and a literature review of similar work as the one proposed here.
2. **Prerequisites and Schedule**
   We plan to include the following working steps into the work schedule. As explained in Section "Research Aim and Research Questions" some prerequisites have to be fulfilled and possibly the work schedule has to be adjusted accordingly. Therefore, we will have to discuss which of the following steps can be completed during my stay in Hanoi and where we set priorities.
   - **Gather and get to know datasets**
     Several large datasets are required for the work (see Section "Data"). These have to be downloaded. Further, some time will be needed to understand the structure of the datasets.
   - **Decision on variables**

It has to be decided which variables, besides precipitation, are useful for farmers in Vietnam. Are there additional variables to provide extra benefit to farmers? This will be done by a review of the relevant literature.

- **Analysis of forecast skill**
  The skill of the global and regional forecast systems will be evaluated. Therefore we need to decide with which method we want to quantify the forecast skill and against which dataset we want to quantify the error. Possibly, reanalysis or raw observations could be used. After this decisions are made, the skill of the simulations will be compared to the chosen dataset.
- **Error correction / Downscaling**
  Examine if bias correction helps to increase the skill of seasonal forecasting systems. Tan Phan Van et al. (2014) used a regional model, RegCM4.2, to downscale the global forecasting systems. Possibly a similar concept could be followed for precipitation instead of temperature.

3. **Working on the proposed research questions**
   Working on the research questions as specified under 2. "Prerequisites and Schedule". Where are the priorities and which research questions can be addresses during the stay in Vietnam?
4. **Report**
   The research stay at VNU-HUS will be ended with a written report (and possibly a peer-reviewed journal paper depending on the progress and results), summarizing the results of the analyses.

Activity	November			December				January				February			
Week		47	48	49	50	51	52	1	2	3	4	5	6	7	8
1 - Literature Review															
2 – Prerequisites and Schedule															
3 – Working on the proposed research questions															
4 - Report															

In February 2015 the Tết Nguyên Đán, the New Year celebration, will take place. During these days I will focus on writing the report.

5. Risks

Different problems could occur and hamper the completion of the work such as proposed above. Some possible problems are identified and discussed below:

- The work requires large data sets. Namely, CFSv2, ECMWF-S4, observational and or reanalysis data to compare the model output with. Hence, the data must be available or made accessible to work efficiently with it.
- Is has to be decided how the skill of the model output is assessed. Is the output of the seasonal forecast systems compared to observational data or to reanalysis data? Are these data sets available?
- So far I haven't worked with the data sets described above and I also don't yet have experience in evaluating the forecast skill of weather forecasts. Hence, this might cause unexpected troubles.
- Depending on which programming language is used at VNU-HUS, it will also require time for me to get to know a possibly new programming language. So far I have experience with Matlab, R and CDO. As I have a Matlab license provided by ETH I might continue to use Matlab.
- There is the risk that I can't finish the project within the given time. Therefore, it should be clarified if someone else can finish the project if I can't finish it myself.

Given that Prof. Phan Van Tan and Dr. Patrick Laux already worked with similar methods and concepts (cf. Tan Phan Van et al., 2014), I am optimistic that such possible problems can be overcome with their help.

6. References

Elguindi et al., (2007), RegCM3.1 Version 3.1, User's Guide, online: https://users.ictp.it/RegCNET/regcm.pdf

Molenti et al., (2011), The new ECMWF seasonal forecast system (System 4), ECMWF Technical Memorandum, 656.

Saha et al., (2014), The NCEP Climate Forecast System Version 2, Journal of Climate, Vol. 27, doi: 10.1175/JCLI-D-12-00823.1.

Tan Phan Van, Hiep Van Nguyen, Long Trinh Tuan, et al. (2014), Seasonal Prediction of Surface Air Temperature across Vietnam Using the Regional Climate Model Version 4.2 (RegCM4.2), Advances in Meteorology, vol. 2014, Article ID 245104, 13 pages, 2014. doi:10.1155/2014/245104