Impact of initialized land temperature and snowpack on subseasonal to seasonal prediction

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1. Motivation of this project

Intraseasonal to seasonal (S2S) prediction, especially the prediction on extreme climate events such as droughts and floods, is scientifically challenging and has substantial societal impacts and economic consequences. It is therefore important to understand the sources of such predictability and develop more reliable monitoring and prediction capabilities. Various mechanisms have been attributed to the S2S predictability. The connection between sea surface temperature (SST) [e.g., El Niño Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), and Atlantic Multidecadal Oscillation (AMO)] and the associated predictability has been extensively studied for decades. Despite significant correlations, numerous studies consistently show that SST is only able to partially explain the phenomena of S2S predictability (e.g., Schubert et al., 2009; Scaife et al., 2009; Pu et al., 2016; Xue et al., 2016a,b). For instance, the 2016-2017 La Niña event has been associated with record rainfall that effectively ended the 5-year Californian drought, contrary to its expected SST-drought/flood relations. While atmospheric internal variability contributes (Hoerling et al., 2014), such exceptions underscore the need to seek explanations beyond SST's influence alone.

The possible remote effects of large-scale spring land surface/subsurface temperature (LST/SUBT) anomalies in geographical areas upstream and closer to the areas of late spring-summer drought/flood have largely been ignored. Preliminary studies have been carried out to explore the relationship between spring LST/SUBT anomalies and summer precipitation anomaly in downstream regions in North America and East Asia (Xue et al., 2012, 2016b, 2017). The analyses based on observed summer precipitation and spring temperature data over these two continents have shown the significant correlation between these two variables, comparable to the well-known SST and precipitation correlations. Meanwhile, the modeling studies using the NCEP Global Forecast System (GFS) and the regional climate model, WRF, have suggested that the long-distance effect of land temperature changes in the Northwestern U.S. and Tibetan Plateau on its respectively downstream region is probably as large as the more familiar effects of SSTs and atmospheric internal variability. Consideration of LST/SUBT anomalies has the potential to add value to S2S prediction of dry and wet conditions, especially extreme drought/flood events. Although the current studies focus on two continents, it also motivates testing those relationships and general physical principles in other continents with similar geographic settings. This project with multi-model will further examine the potential of the LST/SUBT effect in adding value to S2S prediction, especially extreme drought/flood events in different continents.

Snow is another land factor that contributes to the S2S variability. Snow in the Eurasian continent and Tibetan Plateau has been considered as one of the factors affecting the Asian monsoon variability for many decades (e.g., Yasunari et al., 1991). Snow in North America has also shown that it may add value on the intraseasonal to seasonal prediction (e.g., Gutzler and Preston, 1997). A recent study (Broxton et al., 2017) shows that the CFS model produced systematic differences in snow water equivalent (SWE) and surface air temperature, depending on the forecast lead time. Furthermore, SWE differences in earlier versus later forecasts are found to much more strongly affect April–June temperature forecasts than the SST differences over different regions, suggesting the major role of snowpack in seasonal prediction during the spring–summer transition over snowy regions. Furthermore, the aerosols in snow albedo have also shown substantial impact on the seasonal surface temperature simulation (e.g., Oaida et al., 2016; Lau et al., 2018) and will be investigated at the second stage of the project.

2. Project Goals

This project intends to address two questions:

- What is the impact of the initialization of large scale LST/SUBT and snow pack, including the aerosol in snow, in climate models on the S2S prediction over different regions?
- What is the relative role and uncertainties in these land processes versus in SST in S2S prediction? How do they synergistically enhance the S2S predictability?

3. Preliminary timeline for the project

We intend to have several phases in this project and each phase may focus on one continent or one specific issue. We are considering to have East Asia as the focus in the first phase because the high elevation Tibetan Plateau and large scale snow cover there plus more available observational data probably provide an ideal geographical location for initial test. The North America may be the second phase's focus. This issue will be discussed and finalized in the first workshop on this project.

a) We plan to have a workshop in late 2018 to start the project. A short training class will be provided during the workshop to help the modeling groups to conduct the LST/SUBT simulations. A set of experiments will be conducted to test LST/SUBT effects on the drought/flood prediction. We will impose the initial LST/SUBT anomalies as the initial condition on May 1st to test its impact on the summer temperature and precipitation. A dry year with the cold LST/SUBT in the spring and a wet year with warm LST/SUBT in the spring will be selected initially. Most modeling groups will use the global earth system model (ESM) but some groups may also use regional climate models (RCM). More tests will be designed based on the first set of experiments.

Meanwhile, the initial snow condition in April 1st will also be assigned to test its impact on the summer surface temperature and climate.

b). A workshop will be planned during the 2018 AGU Annual meeting to discuss the progress, preliminary results, and problems to be solved. We will discuss possible papers in BAMS and other journals and a session in 2019 AGU for the project. More experiments based on the 1st set of experiment will be discussed.

c). 2019 AGU Session for this project and discussion on the 2nd phase.

d). The workshops in 2019 and 2020 summer will be considered for this project based on the project progress.

e). 2021 AGU Session for the 2nd phase results, prepare papers for a special issue, and further studies.

4. Data

The field data from the Third Pole Experiment (TPE) - the Third Atmospheric Scientific Experiment for Understanding the Earth-Atmosphere Coupled System over the Tibetan Plateau, and Zeng et al.'s (2018) snow data, and other available data, such as reanalyses data, will be used for this project.

5. Major Participants

The Third Pole Experiment (TPE) will organize the TPE ESM inter-comparison project. Part of its major work and milestone will be the same as listed in Section 3, but will include model validation, and water management and snow and glacier melting using the ESM or RCM outputs for the offline experiments. The TPE will sponsor the workshops, training class, and some major activities. Several Chinese institutions and universities (Chinese Meteorological administration, Institute of Atmospheric Physics, Chinese Academy of Sciences (CAS), Nanjing University, Nanjing University of Information Science & Technology, and Tsinghua University), Japan MRI and another two institutions have confirmed to participate. ECMWF, Indian and South Korean institutions have shown their interest in this model comparison.

We will also contact various modeling centers (e.g., NCAR, NCEP, GFDL, GISS, DOE/E3SM, UK Hadley Center, Germany Max Planck Institutions, and Meteorological Service of Canada) for their participations.

Organizers of this project include: Yongkang Xue (UCLA); a representative from the Institute of Tibetan Plateau Research (ITPR), CAS; Additional representatives from Japan and U.S. (e.g., NCEP) and other countries will be considered pending on the progress of this project preparation

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