Concept Note

Towards GLACE-ESM experiments

Towards an international project aimed at quantifying the impact of land Earth System processes and feedbacks on seasonal forecasts.

Andrea Alessandri (KNMI, ENEA, ECMWF)
Royal Netherlands Meteorological Institute (KNMI)
Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)
European Centre for Medium Range Weather Forecasts (ECMWF)[1]
contact: andrea.alessandri@knmi.nl

The aim of this initiative is to evaluate the impact of including Earth System processes over land (from the latest Earth System Model developments in the frame of CMIP6) on the skill of seasonal forecasts by state-of-the-art dynamical prediction systems. As a result, this effort is also expected to be a contribution towards new frontiers in the development of Earth system predictions.
Starting from the experimental strategy developed during phase II of the Global Land-Atmosphere Coupling Experiment (GLACE-2[2]) experiment (Koster et al. 2011) and building from the ongoing efforts in SNOWGLACE, PROCEED (projects.knmi.nl/proceed), LS3MIP and LUMIP, a set of soil-moisture and snow initialized hindcasts will be taken as the reference to further quantify the added value of including the representation of the Earth System processes and feedbacks that can suitably contribute to seasonal forecasts.

Several works have been showing the importance of the land biosphere (i.e. vegetation/land cover including anthropogenic effects and land-use changes) in forcing interannual climate anomalies (Alessandri and Navarra 2008) and in modulating the forcing from soil moisture (Catalano et al., 2016) or snow (Loranty et al., 2014). In particular, a recent paper by Alessandri et al. (2017) showed significant effects of the representation of realistic vegetation-cover anomalies in the prediction of temperature and precipitation at multiple time-scales. Large effects have been shown at multiple time-scales [seasonal hindcasts, decadal (5-years) potential predictions and in a 4-day NWP case-study for spring 2015] over boreal winter middle-to-high latitudes due to the implemented time-varying shadowing effect by tree-vegetation on snow surfaces. Significant multi-scale improvements of the prediction of 2m

[1] Secondment in the frame of the PROCEED Marie Curie individual Grant.

[2] It is quite some time now since phase II of the Global Land-Atmosphere Coupling Experiment (GLACE-2) experiment (Koster et al. 2011). That international coordinated experiment allowed an examination/quantification, with a wide variety of global climate models, the degree to which monthly precipitation and temperature forecasts improve through the proper initialization of soil moisture. Robust results evidenced transition zones between wet and dry climate as the most affected by initialized soil moisture.

temperature and rainfall have been also shown over transitional land surface hot spots (Alessandri et al., 2017).

Earth System Models (ESMs) development has seen in the last decade an accelerated effort for the land biosphere and the atmosphere chemistry components [e.g. Myhre et al., 2013; Eyring, et al., 2016.]. Up to date land surface models prepared for the forthcoming CMIP6 exercises are therefore implementing detailed description of (i) interactive or prescribed dynamics of natural vegetation, (ii) prescribed changes of anthropic land cover and land use changes from historical reconstructions, and (iii) including anthropogenic forcings such as representation of CO2 fertilization, of water flux from irrigation over croplands, of anthropogenic crop fertilizers and of the effects from atmospheric nitrogen deposition.

Building from already established efforts (e.g. SNOWGLACE) a set of soil-moisture and snow initialized hindcasts (covering some portion of the satellite-era) will be taken as the reference to further quantify the impact of land Earth System processes on seasonal forecasts. Long memory biophysical states or processes will be either persisted (from available satellite observations prior of the onset of the hindcast) or (optionally) initialized and dynamically simulated by the land models. These states or processes will include:
-Natural Vegetation density (Leaf Area Index) and effective vegetation fractional covers
-Interannual Land cover/Land use changes from historical reconstructions
-Water flux from irrigation over crop areas
-Anthropogenic CO2 fertilization and use of crop fertilizers
-Nitrogen deposition (optional)
-Fire occurrences (optional)

-Experimentation:
Multi-model seasonal hindcasts, covering some portion of the satellite-era (e.g. 1982-201?), will be performed with and without the inclusion of the realistic inter-annual land biosphere conditions (either prescribed or optionally initialized & simulated); start dates at least for 1st of May and 1st of November.
-(optional) Multi-model decadal (at least 5-years) hindcasts

-Participation:
It is expected that a good representation of the groups previously involved in GLACE-2 will participate in GLACE-ESM. Preliminary contact and indication of possible interest has been received by the European groups involved in LS3MIP (i.e. METEOF, CMCC, EC-Earth).

-Time Frame:
Building from the ongoing experiences from CMIP6, PROCEED, LS3MIP, LUMIP, GSWP-3 and GLACEWSNOW, the details of experimental protocol will be implemented during 2018 and to be presented at the international Workshops on Subseasonal to Decadal Prediction at NCAR in Boulder (17-21 September 2017). Concurrently, engagement of all possible international seasonal-

prediction institutions will be pursued; simulations expected to begin sometime towards the end of 2018 or beginning of 2019.
-To foster international discussion and engagement, GLACE-ESM is here intended and proposed as a WGSIP initiative. In this respect, I could be available to help WGSIP efforts in any possible form; also I'm available to join as a member if that can be retained useful by the panel. In this context, I could try to do my best to help in pushing the established climate prediction community towards the new frontiers in Earth System prediction developments.

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