Concept Note (Motivation Summary)

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

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 performance of seasonal-to-decadal (S2D) 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 and towards uncertainty reduction by better understanding/constraining the land surface processes.
Starting from the experimental strategy developed during phase II of the Global Land-Atmosphere Coupling Experiment (GLACE-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 S2D 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 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.
However, the lack of observations to constrain the model complexity has led to the development of poorly constrained and often diverging representation of

surface processes between different land surface models (e.g. Qu and Hall, 2007). Therefore, the use of multi-model is also fundamental because of the uncertainty in the representation of land surface processes and related poorly constrained parameterizations. In particular, the verification of the predictions at s2d time-scales will provide understanding and knowledge to identify the better modeling approaches in representing land surface processes of relevance to climate.

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 S2D 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.

-Participation:

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

References:

Alessandri A., and A. Navarra, 2008: On the coupling between vegetation and rainfall inter-annual anomalies: possible contributions to seasonal rainfall predictability over land areas, Geophys. Res. Lett., **35**, L02718, doi:10.1029/2007GL032415.

A. Alessandri, F. Catalano, M. De Felice, B. Van Den Hurk, F. Doblas Reyes, S. Boussetta, G. Balsamo, and P. Miller, 2016: Multi-scale enhancement of climate prediction over land by increasing the model sensitivity to vegetation variability in EC-Earth, Clim. Dyn, doi:10.1007/s00382-016-3372-4, link to-readcube document http://rdcu.be/kJuG

F. Catalano, A. Alessandri, M. De Felice, Z. Zhu, R. B. Myneni, 2016: Observationally based analysis of land–atmosphere coupling, Earth Syst. Dynam., 7, 251-266, doi:10.5194/esd-7-251- 2016

Eyring, V., Bony, S., Meehl, G. A., Senior, C. A., Stevens, B., Stouffer, R. J., and Taylor, K. E.: Overview of the Coupled Model Intercomparison Project Phase 6 (CMIP6) experimental design and organization, Geosci. Model Dev., 9, 1937-1958, https://doi.org/10.5194/gmd-9-1937-2016, 2016.

Koster, R.D., S.P. Mahanama, T.J. Yamada, G. Balsamo, A.A. Berg, M. Boisserie, P.A. Dirmeyer, F.J. Doblas-Reyes, G. Drewitt, C.T. Gordon, Z. Guo, J. Jeong, W. Lee, Z. Li, L. Luo, S. Malyshev, W.J. Merryfield, S.I. Seneviratne, T. Stanelle, B.J. van den Hurk, F. Vitart, and E.F. Wood, 2011: The Second Phase of the Global Land–Atmosphere Coupling Experiment: Soil Moisture Contributions to Subseasonal Forecast Skill. *J. Hydrometeor.,* **12**, 805–822, https://doi.org/10.1175/2011JHM1365.1

Loranty, M. M., Berner, L. T., Goetz, S. J., Jin, Y. and Randerson, J. T. (2014), Vegetation controls on northern high latitude snow-albedo feedback: observations and CMIP5 model simulations. Glob Change Biol, 20: 594–606. doi:10.1111/gcb.12391

Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H.

Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Qu, X., and A. Hall, 2007: What controls the strength of snow-albedo feedback? J. Climate, 20, 3971–3981, doi:https://doi.org/10.1175/JCLI4186.1