ISDA-Online

December 2, 2022 15 – 17 UTC

"Land-Surface Data Assimilation"

Organizers: *Zofia Stanley (NOAA/CIRES)*
Patricia de Rosnay (ECMWF)

Program:

15:00 – 15:05	**Welcome**
15:05 – 15:25	**Recent activities on snow data assimilation for NWP and reanalysis at ECMWF *** Kenta Ochi, Patricia de Rosnay, David Fairbairn
15:25 – 15:40	**Assimilation Impacts of SMAP Soil Moisture Retrievals within Strongly Coupled Atmosphere-Land Surface Data Assimilation System** Sujeong Lim, Seon Ki Park, Milija Zupanski
15:40 – 15:55	**Ecohydrological land reanalysis by assimilating satellite microwave observations into a land surface model** Yohei Sawada, Hiroyuki Tsutsui, Hideyuki Fujii, Toshio Koike
16:05 – 16:20	**Improving sub-seasonal prediction skill of NorCPM using soil moisture assimilation** Akhilesh S. Nair, François Counillon, Noel Keenlyside
16:20 – 16:35	**Improving the Representation of Land Surface Processes using the Data Assimilation Research Testbed (DART)** Brett Raczka, Xueli Huo, Daniel Hagan, Andrew M. Fox, Moha Gharamti, Kevin Raeder, Rolf Reichle, Emmanuel Dibia, Jeffrey Anderson
16:35 – 16:55	**Improving streamflow simulation by assimilating Sentinel-1 backscatter into a land surface model with river routing *** Michel Bechtold, Sara Modanesi, Hans Lievens, Pierre Baguis, Isis Brangers, Alberto Carrassi, Augusto Getirana, Alexander Gruber, Zdenko Heyvaert, Christian Massari, Samuel Scherrer, Stéphane Vannitsem, Gabrielle De Lannoy
16:55 – 17:00	**Closing: Information on upcoming sessions**

*** Invited**

<u>Please note:</u>

- When you login to the session before 07:00 UTC, and everything is quiet, this is most likely because we muted the microphones.
- The times in UTC are approximate. In case of technical problems, we might have to change the order of the presentations.
- **Time Zones**: 15 – 17 UTC
  03 – 05 pm GMT (London) | 04 – 06 pm CET (Berlin)
  11 – 01 am CST (Shanghai) | 00 – 02 am JST (Tokyo) | 02 – 04 pm AEDT (Sydney)
  07 – 09 am PST (San Fran.) | 08 – 10 am MST (Denver) | 10 – 12 am EST (New York)

Recent activities on snow data assimilation for NWP and reanalysis at ECMWF

Kenta Ochi[1,2],
Patricia de Rosnay[1], David Fairbairn[1]

[1]ECMWF, [2]JMA

In this presentation, we present snow data assimilation activities being conducted at European Centre for Medium-Range Weather Forecasts (ECMWF). The current operational system relies on in situ SYNOP snow depth observations and the NOAA/NESDIS Interactive Multi-sensor Snow and Ice Mapping System (IMS) snow cover product and assimilates the observations by 2-dimensional Optimal Interpolation (2D OI). These observations play a crucial role to reduce systematic snow depth biases of the land model and improve forecast skill for atmospheric variables. We will present an overview of snow data assimilation at ECMWF and introduce ongoing activities related to the use of snow observations to improve both operational Numerical Weather Prediction (NWP) and future ECMWF reanalysis ERA6.

Assimilation Impacts of SMAP Soil Moisture Retrievals within Strongly Coupled Atmosphere-Land Surface Data Assimilation System

Sujeong Lim[1], Seon Ki Park[1,2], Milija Zupanski[3]

[1]Center for Climate/Environment Change Prediction Research, Ewha Womans University, Republic of Korea
[2]Department of Climate and Energy System Engineering, Ewha Womans University, Republic of Korea
[3]Cooperative Institute for Research in the Atmosphere, Colorado State University, United States of America

Soil moisture is important in numerical weather prediction (NWP) model because it affects the latent and sensible heat fluxes in the land surface and propagates to atmospheric variables such as temperature and water vapor mixing ratio below the planetary boundary layer (PBL). Therefore, soil moisture observations in coupled land and atmosphere data assimilation (DA) system can provide a useful information for both land surface and atmosphere. In this study, we assimilate the National Aeronautics and Space Administration's Soil Moisture Active Passive (SMAP) soil moisture retrievals, which observe the top 5 cm of soil moisture, enabling nearly global coverage every 2-3 days with 1000 km swath width. As a strongly coupled DA system, we employ the Maximum Likelihood Ensemble Filter (MLEF) — a hybrid ensemble-variational data assimilation system — into Noah land surface model (Noah LSM or simply Noah) coupled with the Weather Research and Forecasting (WRF). The observation processing includes the quality control, thinning, bias correction, and horizontal and vertical covariance localization on the soil moisture observation as well as atmospheric observation.
To investigate the soil moisture impacts on the coupled DA system, we assimilate both soil moisture and atmospheric observations — the SMAP soil moisture retrievals and the National Centre for Environmental Prediction (NCEP) Prepared Binary Universal Form for the Representation of meteorological data (PrepBUFR), respectively. Our results indicate that the WRF-Noah-MLEF system generates analysis increments of soil moisture that provide additional information to atmospheric variables, especially in the PBL, through cross-covariance between land and atmosphere.

Ecohydrological land reanalysis by assimilating satellite microwave observations into a land surface model

Yohei Sawada[1], Hiroyuki Tsutsui[1], Hideyuki Fujii[1], Toshio Koike[1]

[1]University of Tokyo, Japan
[2]International Centre for Water Hazard and Risk Management, Public Work Research Institute
[3]Earth Observation Research Center, Japan Aerospace eXploration Agency, Tsukuba, Japan
[4]International Centre for Water Hazard and Risk Management, Public Work Research Institute

The accurate estimation of terrestrial water and vegetation is a grand challenge in hydrometeorology. Many previous studies developed land data assimilation systems (LDASs) and provided global-scale land surface datasets by integrating numerical simulation and satellite data. However, vegetation dynamics has not been explicitly solved in these land reanalysis datasets. Here we present the newly developed land reanalysis dataset, ECoHydrological Land reAnalysis (ECHLA). ECHLA is generated by sequentially assimilating C- and X- band microwave brightness temperature satellite observations into a land surface model which can explicitly simulate the dynamic evolution of vegetation biomass. The ECHLA dataset provides semi-global soil moisture from surface to 1.95m depth, Leaf Area Index (LAI), and vegetation water content and is available from 2002 to 2021. We assess the performance of ECHLA to estimate soil moisture and vegetation dynamics by comparing the ECHLA dataset with independent satellite and in-situ observation data. We found that our sequential update by data assimilation substantially improves the skill to reproduce the seasonal cycle of vegetation. Data assimilation also contributes to improving the skill to simulate soil moisture mainly in the shallow soil layers (0-0.15m depth). The ECHLA dataset will be publicly available and expected to contribute to understanding terrestrial ecohydrological cycles and water-related natural disasters such as drought. In this talk, we will present the technical details of the land data assimilation system of ECHLA. In addition, we will discuss the future prospects to globally optimize unknown parameters of land surface models using machine learning toward further improvement of land surface reanalysis.

Improving sub-seasonal prediction skill of NorCPM using soil moisture assimilation

Akhilesh S. Nair[1,2], François Counillon[1,2,3], Noel Keenlyside[1,2]

[1]Geophysical Institute, University of Bergen
[2]Bjerknes Centre for Climate Research
[3]Nansen Environmental and Remote Sensing Center

The Norwegian Climate Prediction Model (NorCPM) provides long-term reanalysis and climate forecasts ranging from seasonal to decadal timescales. It is based on the Norwegian Earth system model (NorESM) and assimilates ocean and sea ice data, using anomaly assimilation with the Ensemble Kalman Filter (EnKF). However, the added value of land data assimilation in enhancing NorCPM's subseasonal prediction skill is yet to be fully explored. Soil moisture (SM) is a crucial component of land surface dynamics, influencing water and energy exchanges between the land and the atmosphere. The variability of SM is highly intricate due to its high spatiotemporal dynamics as well as the impact of climate and anthropogenic factors. In this work, we use the blended SM from the ESA CCI (European Space Agency Climate Change Initiative) and assess the impact of improved land surface initialisation on a sub-seasonal time scale. A 30-member flux ensemble was generated from an ensemble of historical simulations of the coupled system, which forces the offline land surface Community Land Model (CLM). The EnKF updates daily the whole soil column using ESA CCI data. Results indicate significant improvement in land surface state estimates when validated using independent SM observations along with reanalysis estimates from ERA-Land. The 30-member land reanalysis product generated from our study is for 40 years, from 1980 to 2019. We further use this product for hindcast to evaluate the impact of improved land initialisation on sub-seasonal prediction. Our results have indicated significant improvement in the model forecast at lead times between one to two months for precipitation and temperature. This improvement is observed particularly over Sahel, Central India, and the continental United States.

Improving the Representation of Land Surface Processes using the Data Assimilation Research Testbed (DART)

Brett Raczka[1], Xueli Huo[2], Daniel Hagan[3], Andrew M. Fox[4], Moha Gharamti[1], Kevin Raeder[1], Rolf Reichle[5], Emmanuel Dibia[6], Jeffrey Anderson[1]

[1]National Center for Atmospheric Research (NCAR)
[2]University of Arizona
[3]Nanjing University of Information Science & Technology
[4]Joint Center for Satellite Data Assimilation
[5]NASA Goddard Space Flight Center
[6]University of Maryland

The land surface is a critical part of the earth system as processes related to water, carbon, energy and nitrogen cycling have important implications for climate forcing, air quality, water availability and seasonal atmospheric forecasting. Despite advances in land surface modeling, land surface model performance is often limited because of errors related to initial and boundary conditions, model structure, and parameters. Data assimilation (DA) techniques combined with an expanding network of earth system observations present an opportunity to reduce these errors and improve simulations. Here we apply an Ensemble Kalman Filter DA system as part of the Data Assimilation Research Testbed to a variety of land surface simulations using the Community Land Model. First, we describe the use of remotely sensed biomass observations to provide improved simulations of plant phenology and carbon cycling for regions highly sensitive to climate change (Western US, China, and Arctic). Next, we explore the impact of soil moisture and snow water equivalent observations upon constraining the hydrological cycle and discuss to what extent this influences carbon cycling.

Improving streamflow simulation by assimilating Sentinel-1 backscatter into a land surface model with river routing

Michel Bechtold[1], Sara Modanesi[2], Hans Lievens[3], Pierre Baguis[4], Isis Brangers[1], Alberto Carrassi[5], Augusto Getirana[6], Alexander Gruber[7], Zdenko Heyvaert[1], Christian Massari[8], Samuel Scherrer[7], Stéphane Vannitsem[4], Gabrielle De Lannoy[1]

[1]Department of Earth and Environmental Sciences, KU Leuven, Belgium
[2]Research Institute of the Geo-Hydrological Protection, Perugia, Italy
[3]Department of Environment, Ghent University, Belgium
[4]Royal Meteorological Institute of Belgium, Brussels, Belgium
[5]Department of Meteorology and NCEO, University of Reading, United Kingdom
[6]Hydrological Sciences Laboratory, Goddard Space Flight Center, NASA
[7]Department of Geodesy and Geoinformation, TU Wien, Austria
[8]Research Institute of the Geo-Hydrological Protection, Perugia, Italy

Accurate streamflow simulations rely on good estimates of the catchment-scale soil moisture distribution. Here, we evaluated the potential of Sentinel-1 backscatter data assimilation (DA) to improve soil moisture and streamflow estimates. Our DA system consisted of the Noah-MP land surface model coupled to the HyMAP river routing model and the water cloud model as backscatter observation operator. The DA system was set up at 0.01° resolution for two contrasting catchments in Belgium: i) the Demer catchment dominated by agriculture, and ii) the Ourthe catchment dominated by mixed forests. We present results of two experiments with a one-dimensional ensemble Kalman filter updating either soil moisture only or soil moisture and Leaf Area Index (LAI). The DA experiments covered the period January 2015 through August 2021 and were evaluated with independent rainfall error estimates based on station data, LAI from optical remote sensing, soil moisture retrievals from passive microwave observations, and streamflow measurements. Our results indicate that the assimilation of Sentinel-1 backscatter observations can correct surface soil moisture for rainfall errors and overall improve surface soil moisture estimates. However, updating soil moisture and LAI simultaneously did not bring any benefit over updating soil moisture only. Our results further indicate that streamflow estimates can be improved through Sentinel-1 DA in a catchment with strong soil moisture-runoff coupling, as observed for the Ourthe catchment, suggesting that there is potential for Sentinel-1 DA even for forested catchments.