ECMWF Land Data Assimilation System (LDAS) description

The land-surface analysis includes the screen-level parameters analysis, the snow depth analysis, the soil moisture analysis, the soil temperature and snow temperature analysis.

- The screen level parameters analysis and the snow analysis rely on a 2-dimensional Optimal Interpolation (2D OI).
- The soil moisture analysis is based on a simplified Extended Kalman Filter (EKF).
- The soil and snow temperature analysis uses a 1-dimensional OI (1D OI).

The structure of the land surface analysis components and their dependencies are shown in Figure 1. Firstly, a screen-level analysis is performed for temperature and humidity. Secondly, the snow analysis and the soil moisture analysis are conducted. Then the soil temperature and snow temperature analysis is performed. Analysed screen-level temperature and relative humidity as well as the ASCAT surface wetness data are assimilated in the simplified EKF soil moisture analysis. Screen-level analysis temperature increments are used as inputs of the 1D OI soil and snow temperature analysis.

Land analysis is run separately from the upper-air analysis. It feedbacks to the upper-air analysis of the next cycle through its influence on the short forecast that propagates information from one cycle to the next. Reciprocally, the 4D-Var influences through the short forecasts the land surface analysis from one cycle to the next. The OI analyses of screen level parameters, snow depth, snow and soil temperature are performed at fixed times at 0000, 0600, 1200, and 1800 UTC. The simplified EKF analysis runs at the same time as the 4D-Var windows for both the delayed cut-off and the early delivery analyses.
Snow analysis

Snow water equivalent, soil temperature, snow temperature and soil water content are prognostic variables of the forecasting system and, as a consequence, they need to be initialised at each analysis cycle. The ECMWF soil moisture, soil temperature and snow temperature analyses rely on SYNOP relative humidity and temperature at screen-level (2 metres) available on the GTS (around 12,000 reports over the globe are provided every 6 hours). The snow analysis relies on SYNOP and national ground observations of snow depth available on the GTS, as well as on the NOAA/NESDIS (National Oceanic and Atmospheric Administration - National Environmental Satellite, Data, and Information Service) Interactive Multi-sensor Snow and Ice Mapping System (IMS) snow cover information. More information on the snow analysis is available in the ECMWF Newsletter no 143, article pp 26-31, Spring 2015.

Radiative Transfer Modelling

In the past few years several new space-borne microwave sensors have been developed that give information on surface soil moisture. The use of satellite data from passive microwave instruments to analyse soil moisture relies on an accurate and efficient radiative transfer model. The Community Microwave Emission Modelling Platform (CMEM) has been developed at ECMWF for Land Data Assimilation activities. The latest version of CMEM (4.1) was released in May 2012, opening the possibility to use multi-layer emission model that is relevant to account for the soil moisture vertical profile contribution to the signal. CMEM is used by a large community involved in the use of passive microwave data at a range of frequency (L-band from SMOS and SMAP), C-band and X-band from (AMSR-E and GCOM-W). The code and a complete documentation is available at the CMEM webpage.

SMOS Monitoring and Data Assimilation

The European Space Agency (ESA) Soil Moisture and Ocean Salinity (SMOS) mission was launched in 2009. Based on L-band passive microwave measurements, SMOS is the first mission dedicated to providing information about soil moisture globally at about 40km resolution. SMOS brightness temperatures have been monitored at ECMWF in near-real time since November 2010. More information on SMOS activities are available at the SMOS ECMWF web page.

ASCAT Monitoring and Data Assimilation
The C-band active sensor ASCAT on MetOp was launched in 2006. The EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) ASCAT surface soil moisture product is the first operational soil moisture product. It is available in near-real time on EUMETCast (which is the EUMETSAT near-real time dissemination system) and it has been monitored operationally at ECMWF since September 2009: http://www.ecmwf.int/en/forecasts/quality-our-forecasts/monitoring/soil-moisture-monitoring

H-SAF Project

In the framework of the EUMETSAT H-SAF project, a dedicated ASCAT assimilation chain, using the EKF analysis, has been used to produce continuous soil moisture products. The H08/SM-ASS-1 ASCAT root zone product is a volumetric soil moisture profile product. It is available for for 2008-2010. Its successor, the H-SAF H14/SM-DAS-2 product, is the ASCAT Root Zone Soil Moisture Profile Index. It has been available as a demonstration data set since September 2010 and it is available on a routine basis since January 2012.

A crucial component of H-SAF concerns validation activities. In situ measurements of soil moisture are an indispensable source of information for evaluating soil moisture products obtained from satellites, from land surface models and from data assimilation systems. A data base with in situ soil moisture observations from several networks across the world, under different biome and climate conditions, was collected to evaluate various ECMWF soil moisture products from the deterministic analysis, ERA-Interim, or the H-SAF H14 product, as well as remotely sensed soil moisture products from SMOS and ASCAT. More information on H-SAF activities is available at the H-SAF ECMWF web page.

LDAS team membership:

- COST action ES1404
- A European network for a harmonised monitoring of snow for the benefit of climate change scenarios, hydrology and numerical weather prediction
- Snow Watch group of Global Cryosphere Watch
- surface expert team of the SRNWP (Short Range Numerical Weather Prediction)
- NASA SMAP Early Adopters Team
- SMOS Quality Working Group
- Global Land/Atmosphere System Study (GLASS) panel
- Satellite Application Facility (SAF) on support to operational hydrology (H-SAF) Project Team

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Converting from grib to netCDF with cdo
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cmem_v6.1.tar.gz
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