Initialisation of the land surface component of ECMWF systems

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CM-SAF and EUMETSAT workshop, 16 November 2016

Outline

Land surface components of ECMWF systems

- Motivations for land reanalysis as support to long-term climate data records (e.g. ERA-Interim/Land and follow-on)
- Impact of land systems changes (few cases)
- The Land Data Assimilation System (LDAS) for NRT and its perspectives for future reanalysis
- Summary

Based on ERA-Interim meteorological forcing and land surface modelling component

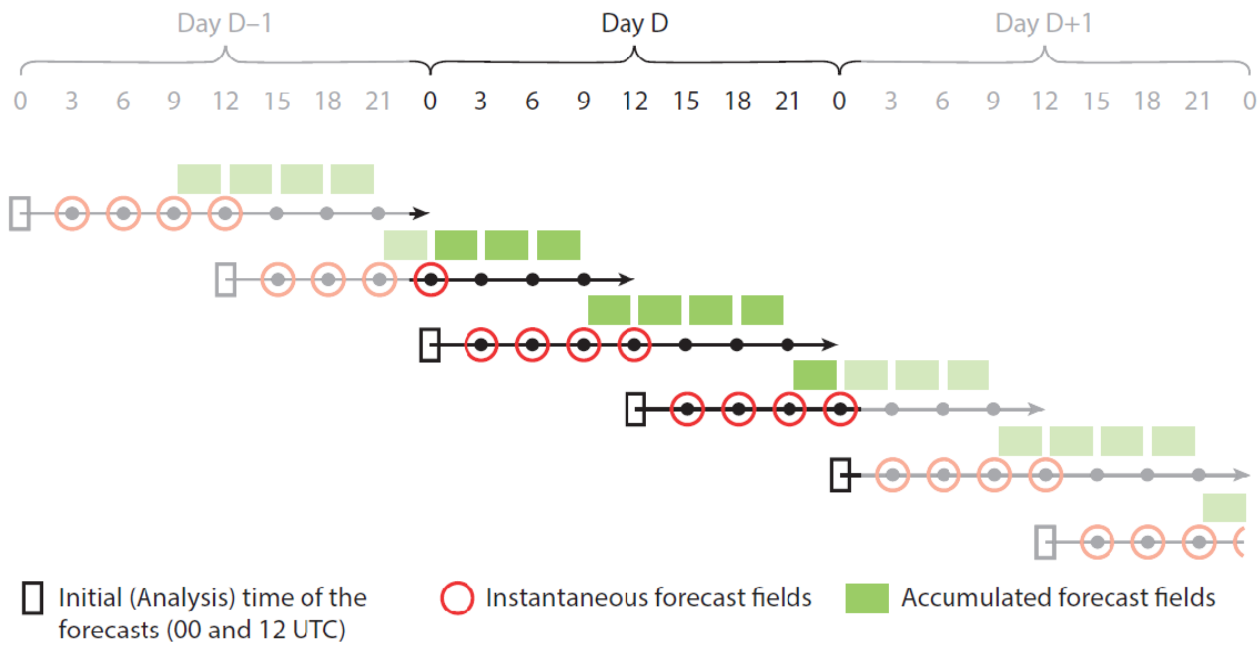


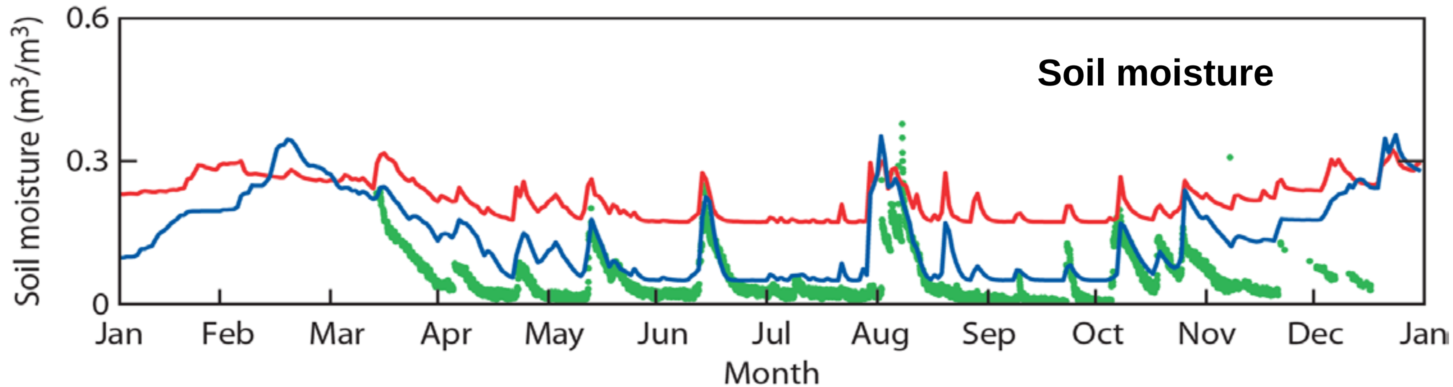
Figure 1: Schematic representation of the ERA-Interim meteorological forecasts concatenation for the creation of the 3-hourly forcing time-series used in ERA-Interim/Land for a given day. Orange circles indicate instantaneous variables valid at their timestamp: 10m temperature, humidity, wind speed, and surface pressure. Green boxes indicate fluxes valid on the accumulation period: surface incoming short-wave and long-wave radiation, rainfall, and snowfall.

ERA-Interim/Land forcing for precipitation and radiation was validated along with a simple bias correction method using GPCPv2.0 monthly precipitation (1979-2010)

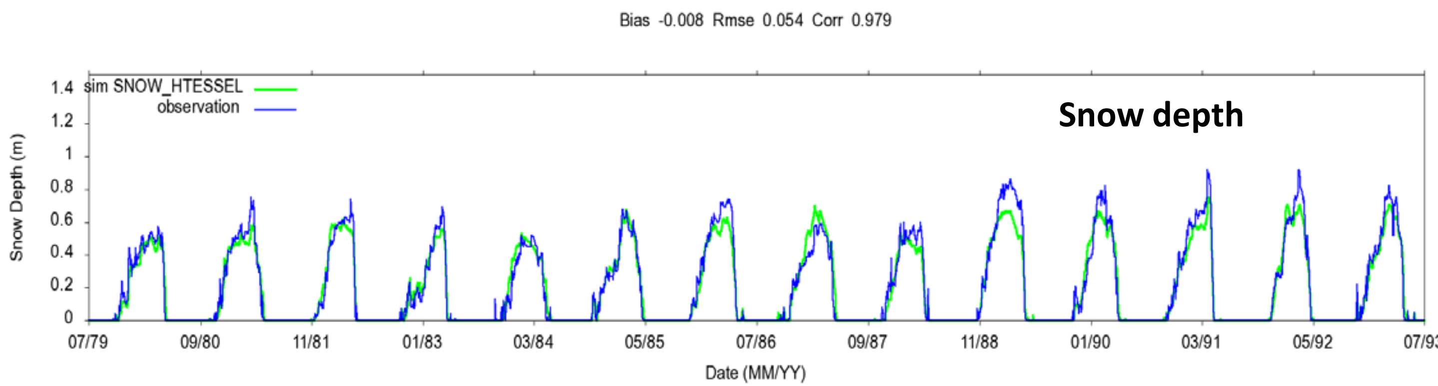
ERA-Interim/Land: storages verification

Albergel et al. (2013 JHM), Balsamo et al. (2013 HESSD)

ERA-Interim/Land integrates land surface modelling improvements with respect to ERA-Interim surface scheme and provided a balanced initial condition for the Monthly/Seasonal Re-Forecasts



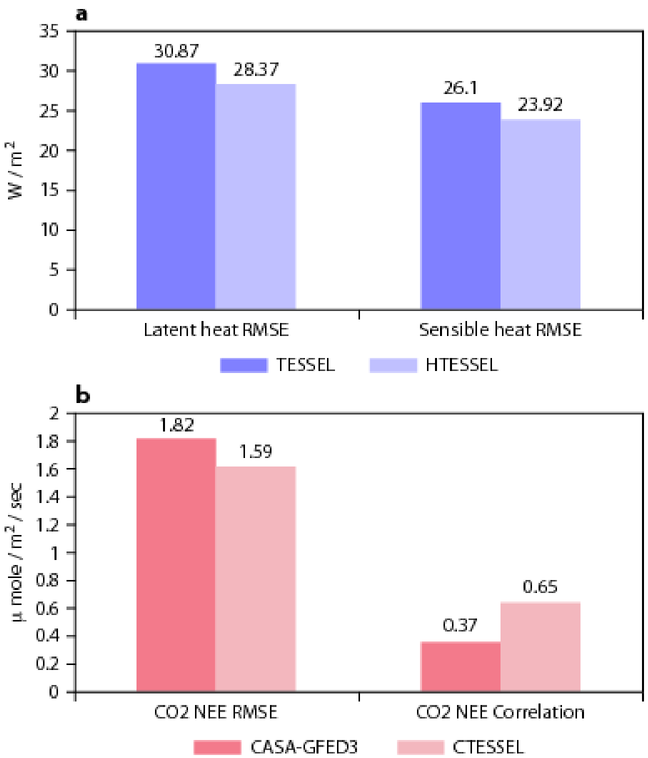
Evolution of soil moisture for a site in Utah in2010. Observations, ERA-Interim, and ERA-Interim/Land.



Evolution of snow depth for a site in Perm Siberia (58.0N, 56.5E) ERA-Interim/Land and in-situ observation between 1979 and 1993.

ERA-Interim/Land: fluxes verification

The ERA-Interim/Land fluxes are validated with independent datasets used as benchmarking.



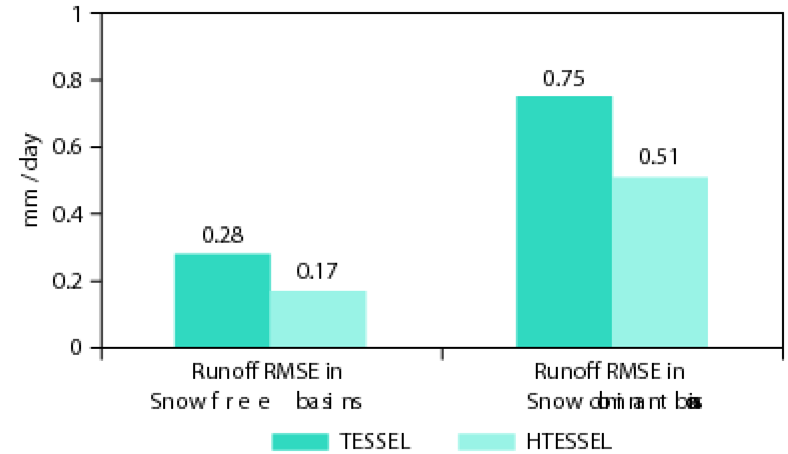
E

CO_2

GEOLAND-2 R&D support

Figure 1: Mean performance measured over 36 stations with hourly Fluxes from FLUXNET & CEOP Observations networks

Validation of H_2O / E / CO_2 cycles

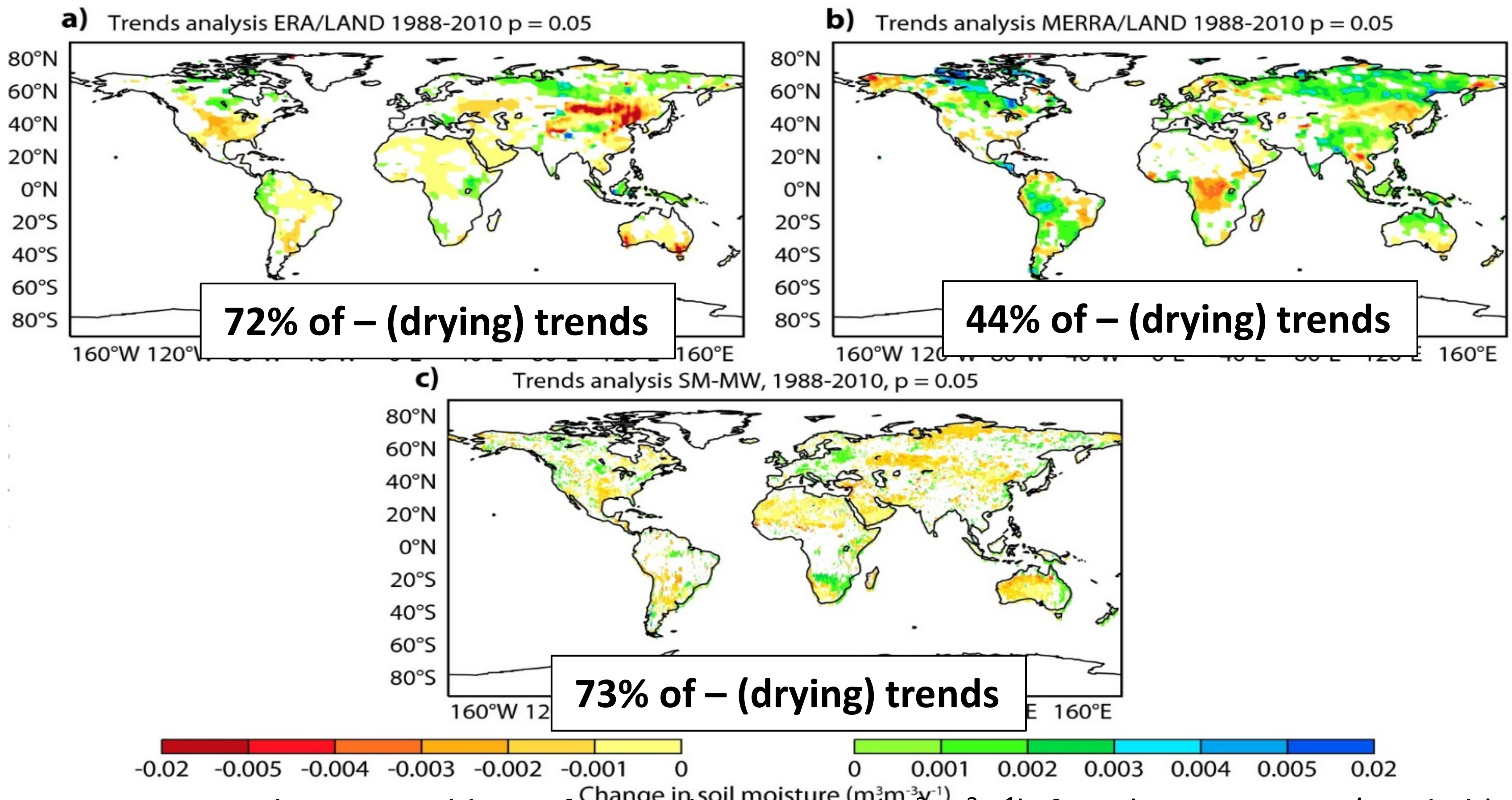


H_2O

Figure 2: Mean performance measured for the monthly rivers discharge verified with GRDC observations

Combining Land-reanalyses, In-situ, Remote-sensing for characterizing drying trends

Albergel et al. (2013)



1988-2010 trends in monthly surface soil moisture ($m^3m^{-3}y^{-1}$) for a) ERA-Interim/Land, b) MERRA-Land and c) SM-MW (ESA-CCI / ECV). Only significant trends (p=0.005) based on the Mann-Kendall test are shown.

ECMWF Land Data Assimilation System (LDAS)

Soil moisture (SM)

Methods: - 1D Optimal Interpolation in ERA-Interim

- Simplified Extended Kalman Filter (EKF) for NWP and for ERA5

Conventional observations: Analysed SYNOP 2m air rel. humidity and air temp.

Satellite data: Scatterometer for NWP (ASCAT) & for ERA5 (ERS/SCAT &ASCAT)

SMOS brightness temperature in dvpt, research NASA SMAP

Snow depth

Methods: 2D Optimal Interpolation (OI) for NWP & for ERA5, Cressman interpolation for ERA-Interim

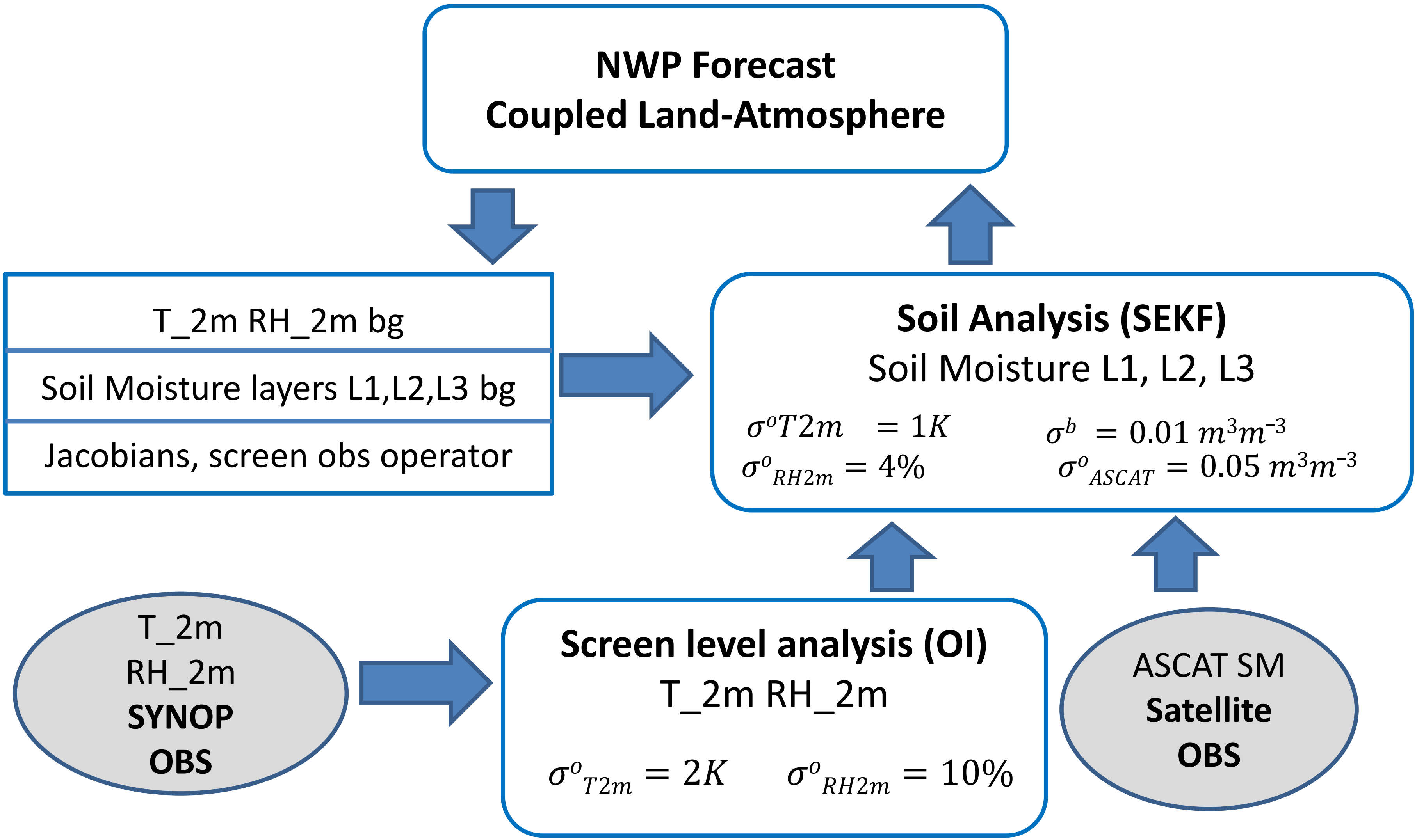
Observations: *in situ* snow depth and NOAA/NESDIS IMS Snow Cover

Soil Temperature and Snow Temperature

1D-OI using T2m analysis increments

Soil moisture analysis at ECMWF

ECMWF IFS cycle 41r2

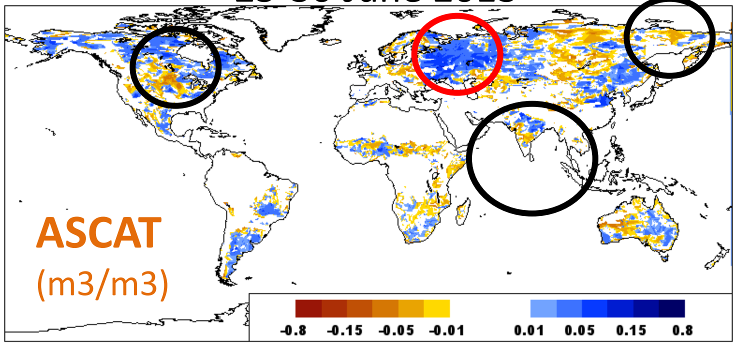


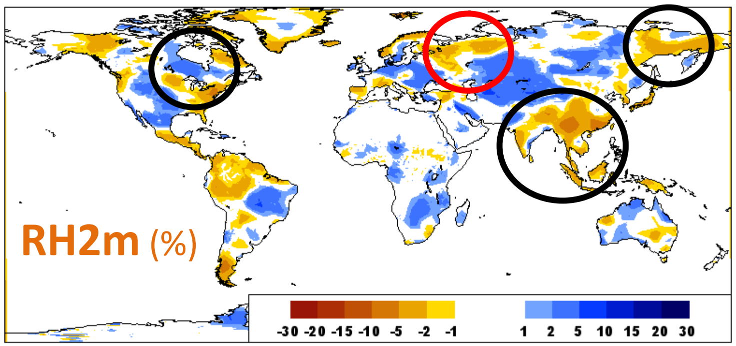
→ Operational soil moisture data assimilation: combines SYNOP and satellite data

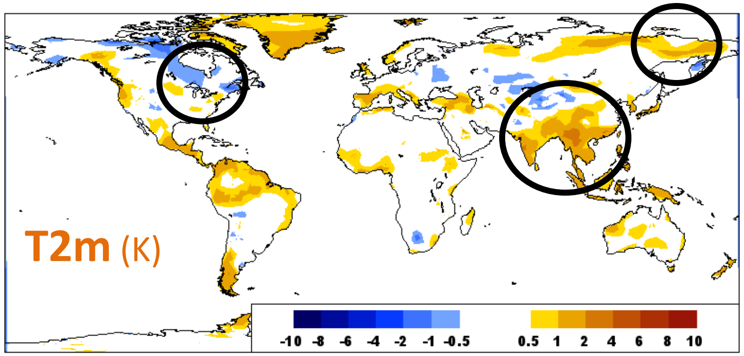
Inclusion of ASCAT Soil Moisture in data assimilation

Innovation (Obs- model)

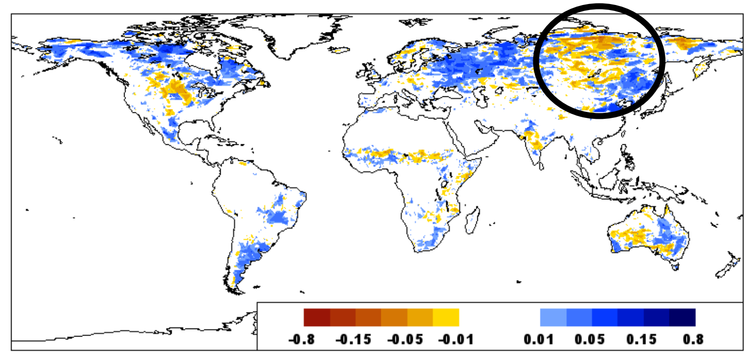
25-30 June 2013



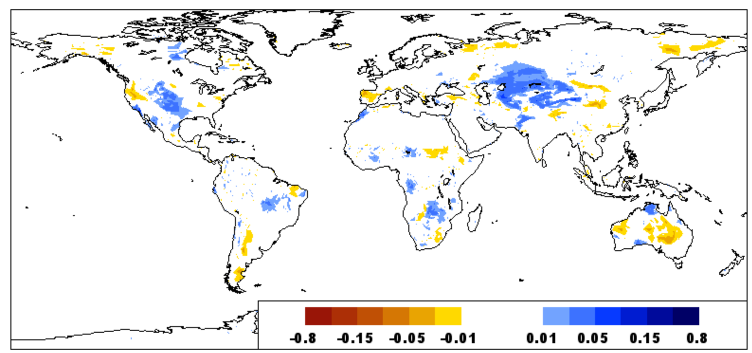




Accumulated Increments (m^3/m^3) in top soil layer (0-7cm)



Due to ASCAT



Due to SYNOP T2m and RH2m

Future ECMWF Re-analysis (ERA5)
Assimilation of Scatterometer soil moisture data
ERS/SCAT and MetOpA/B ASCAT

Use of EUMETSAT ASCAT-A reprocessed data (25km sampling)

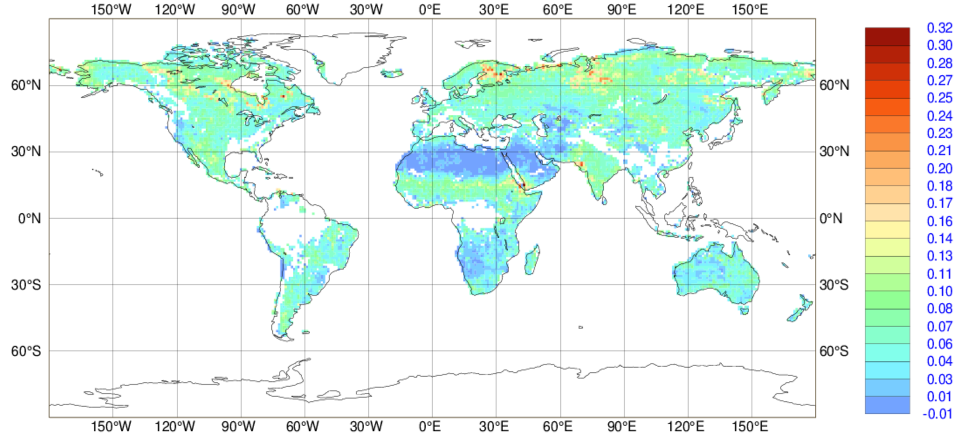
	FG departure Mean m^3m^{-3}	**FG departure StDev** m^3m^{-3}
Using NRT ASCAT	0.013	0.05
Using Reproc ASCAT	0.006	0.044

(FMA 2010)

→ Reprocessed ASCAT has reduced background departure statistics both in mean and Stdev

ERA5 production (C3S) started (will be available end of 2017)

ASCAT surface soil moisture first guess departure (Obs-Model) in m3/m3 for JJAS 2014

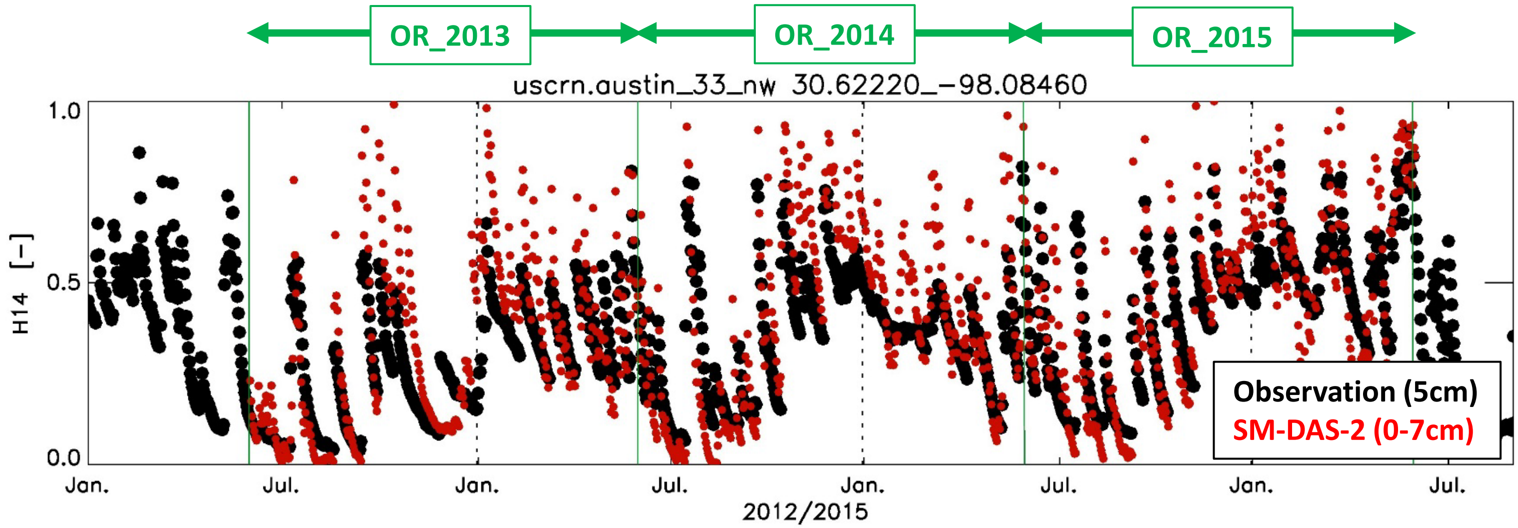


EUMETSAT H-SAF soil moisture

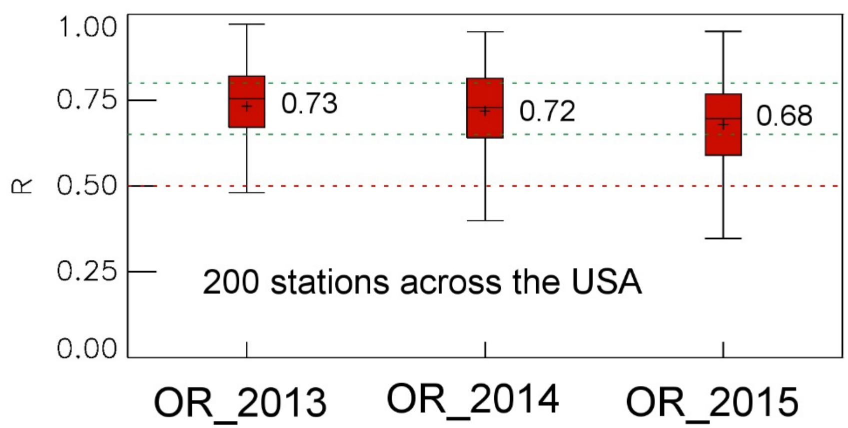
Scatterometer root zone soil moisture products based on data assimilation in dedicated LDAS suites

Evaluation of SM-DAS-2/H14

Surface and root zone liquid soil moisture content



Accuracy requirements for product SM-DAS-2 [R]			
Unit	**Threshold**	**Target**	**Optimal**
Dimensionless	0.50	0.65	0.80



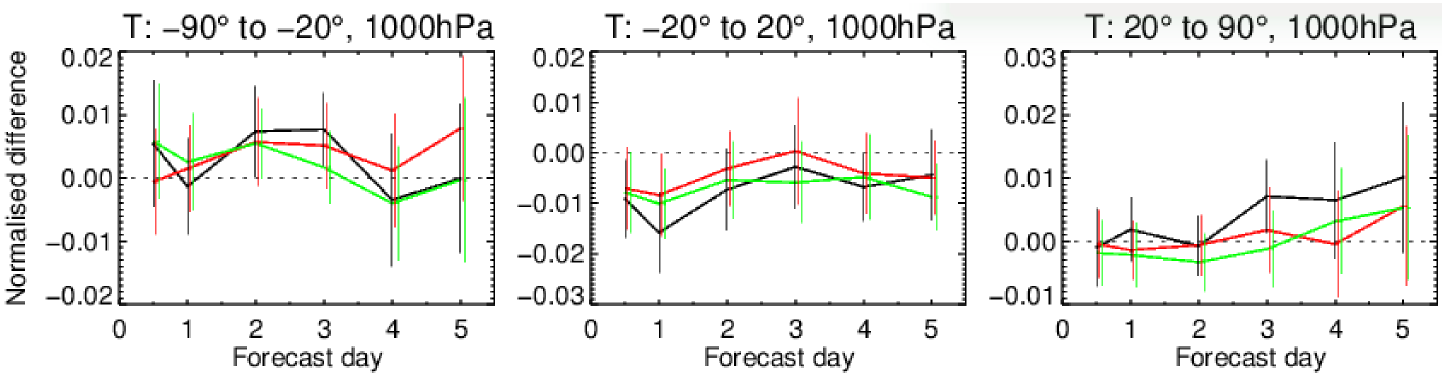
ESA-SMOS data assimilation in the IFS

Normalized change in rms of fc error:

Config.1

Config.2

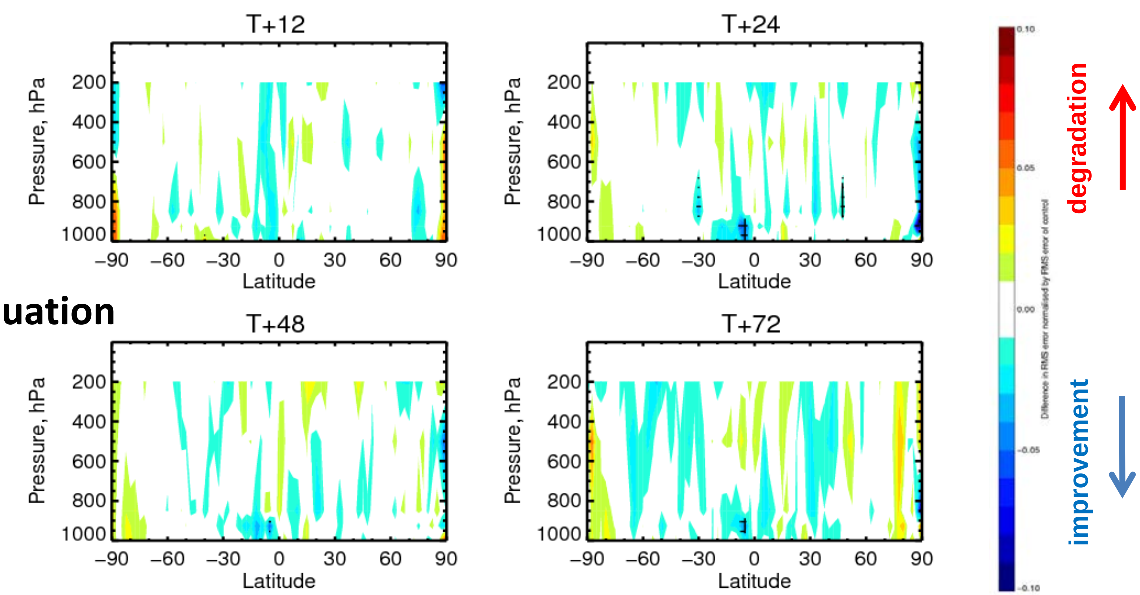
Config.3



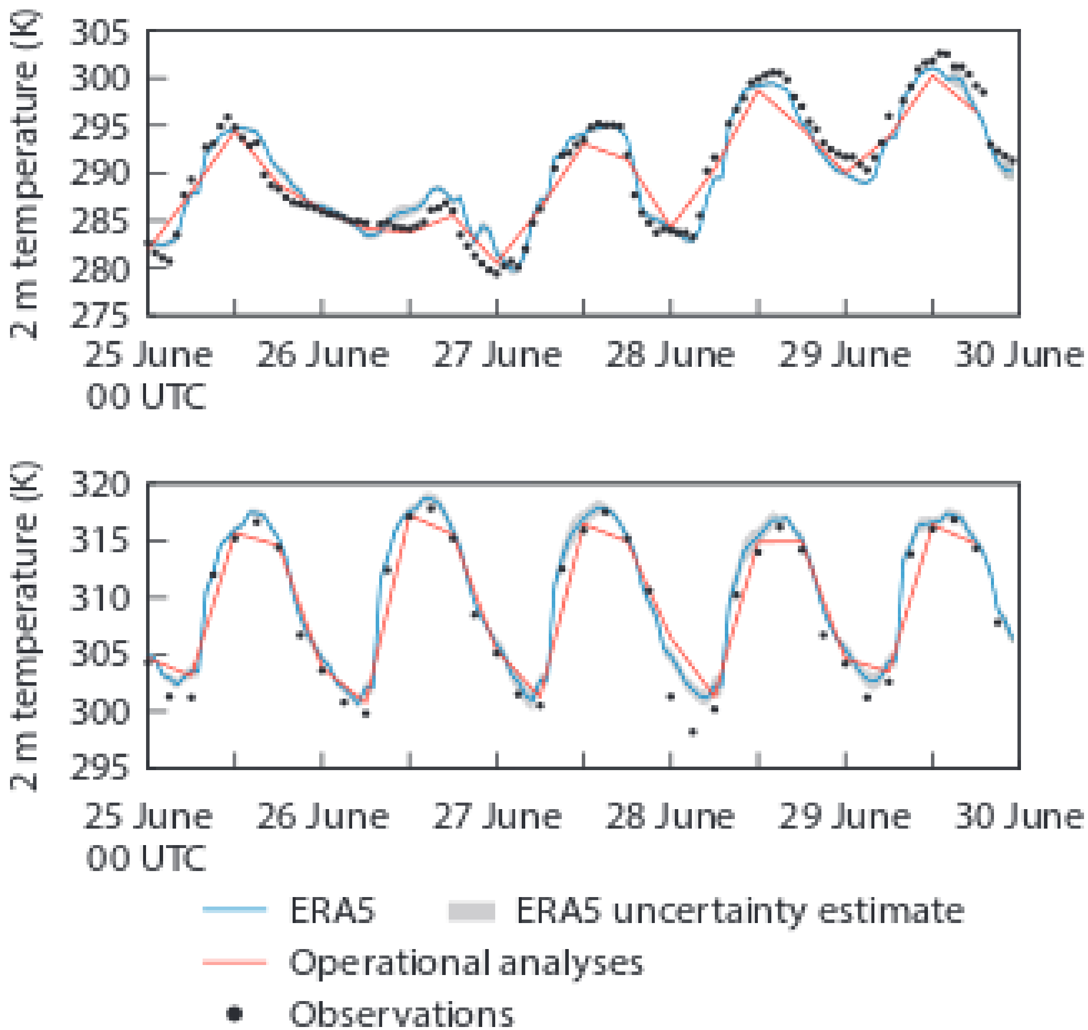
SH- extratropics ***Tropics*** ***NH- extratropics***

Based on short experiments

Longer experiment under evaluation

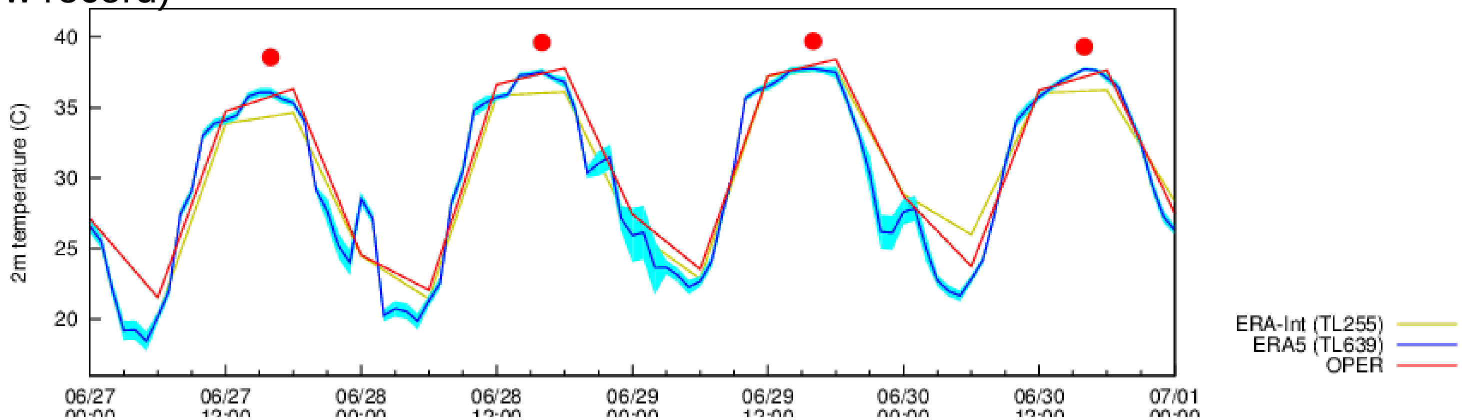


ERA5 a first look

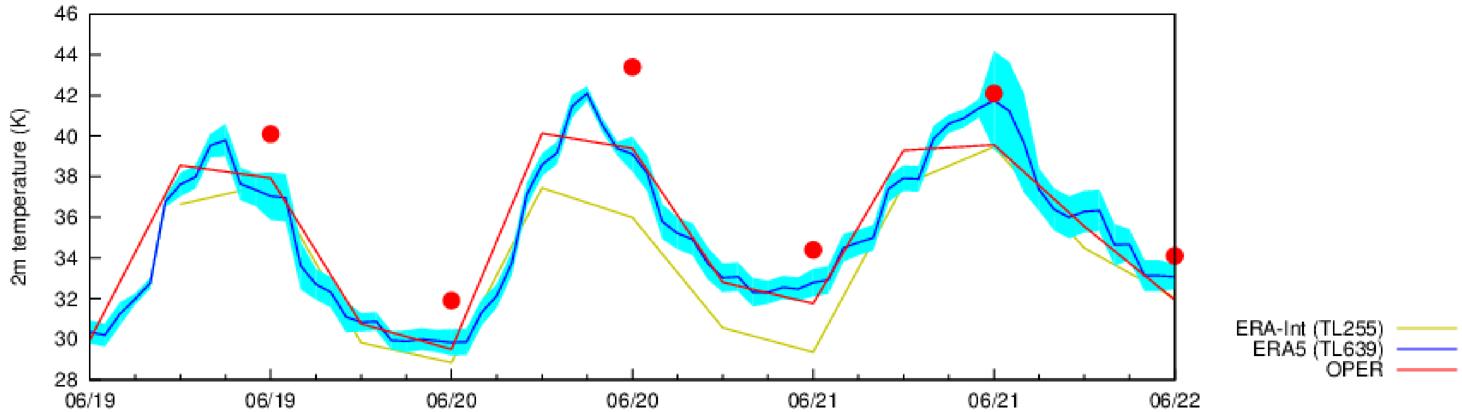


ECMWF operational analyses and ERA5 reanalysis. The charts show hourly data from 25 to 30 June 2014 from ECMWF's operational analyses and the ERA5 reanalysis of 2-metre temperature compared to in-situ observations at the Instytut Meteorologii i Gospodarki Wodne near Krakow in Poland (coordinates: 50.03°N, 20.25°E) (top) and a location in the Sahara Desert (coordinates: 26.5°N, 8.42°E) (bottom).

- **Heatwave in SouthWest Europe, 2015:**
  - Madrid, Area ~ 650 km², Population ~ 4 million (Parque el Retiro, 29 June, Tmax= 39.9°C (new record)



- **Heatwave in Pakistan, June 2015:**
  - Karachi, Area ~ 3,600 km², Population ~ 24 million (20 June Tmax=43.4°C, Tmin= 34°.2C)

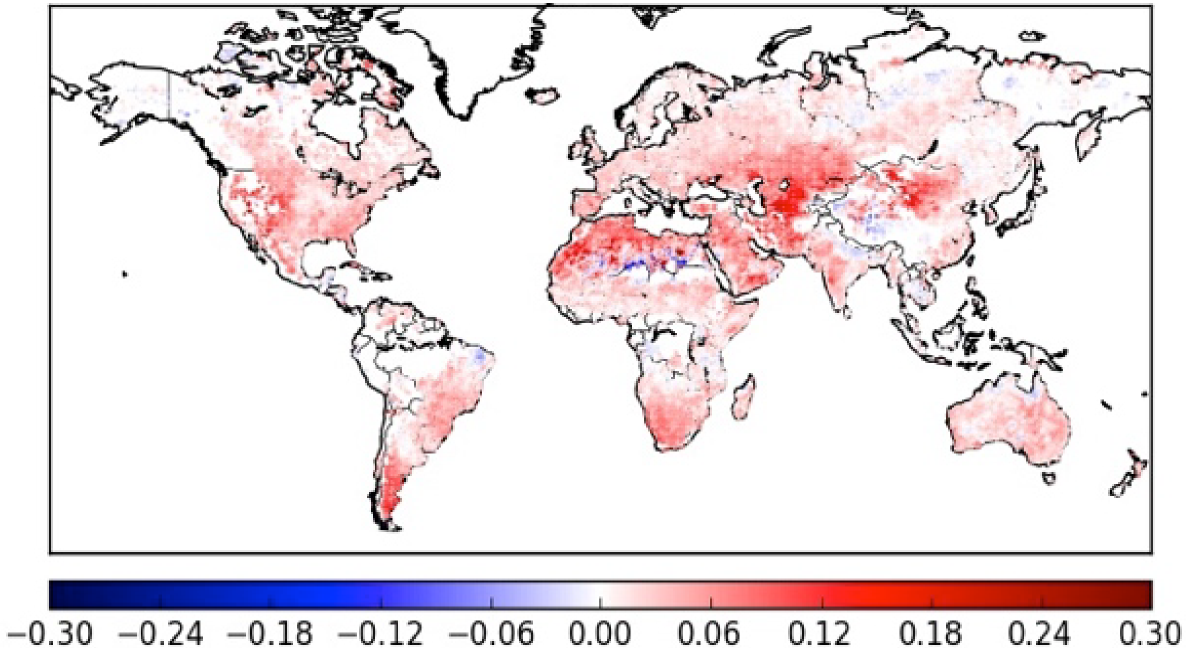


ESA-CCI soil moisture to validate soil vertical resolution

Tests to investigate possible H-TESSEL soil resolution increase:

H-TESSEL top soil layer 0-7cm replaced by 3 layers 0-1cm, 1-3cm, 3-7cm

Impact on Anomaly Correlation with ESA-CCI satellite soil moisture



Globally Improved match to satellite soil moisture (shown is ΔACC calculate on 1-month running mean)

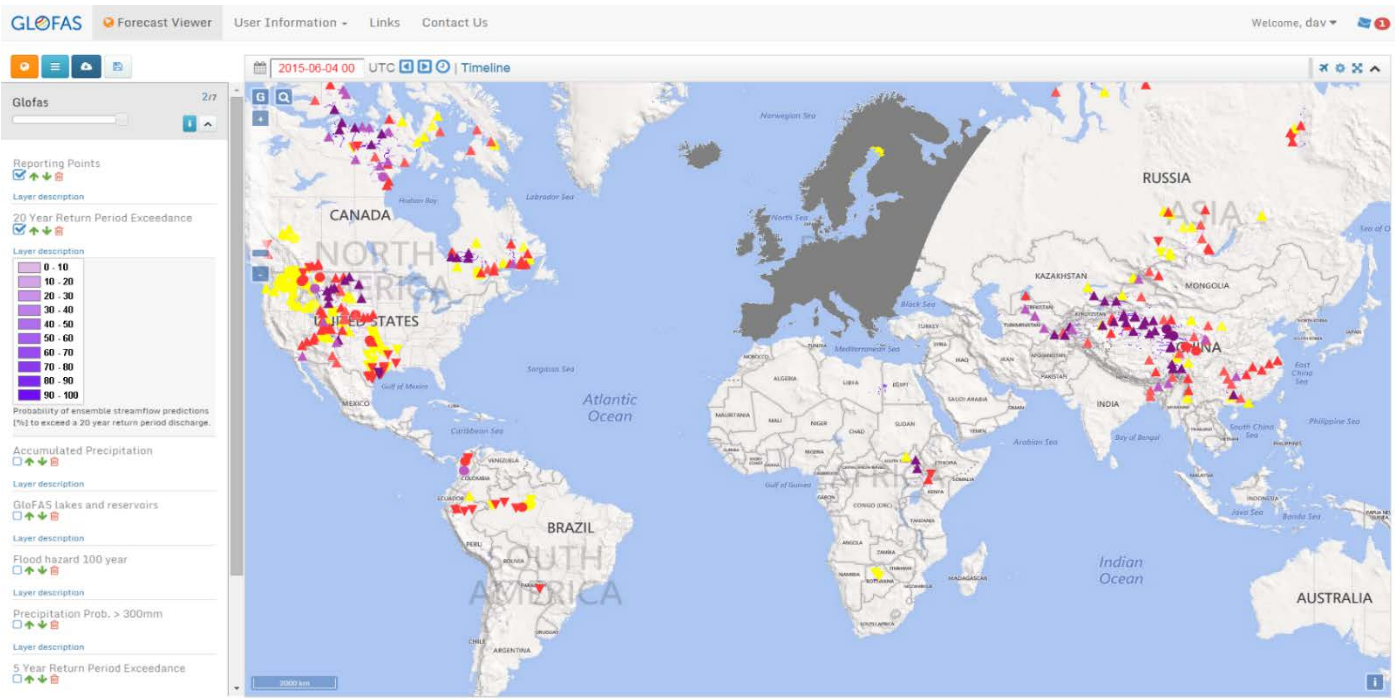
Anomaly correlation (1988-2014) measured with ESA-CCI soil moisture remote sensing (multi-sensor) product.

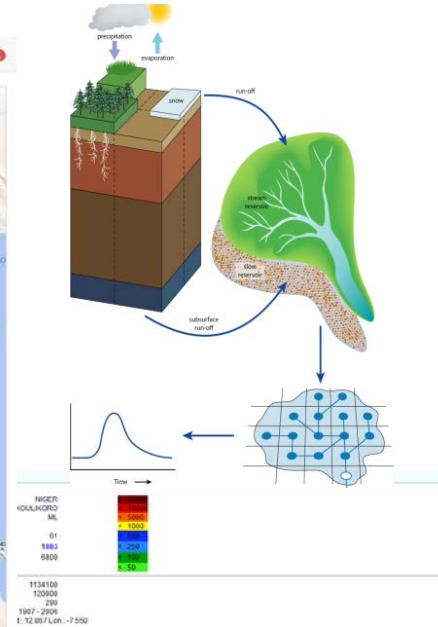
→ Provides a global validation of the usefulness of increase soil vertical resolution

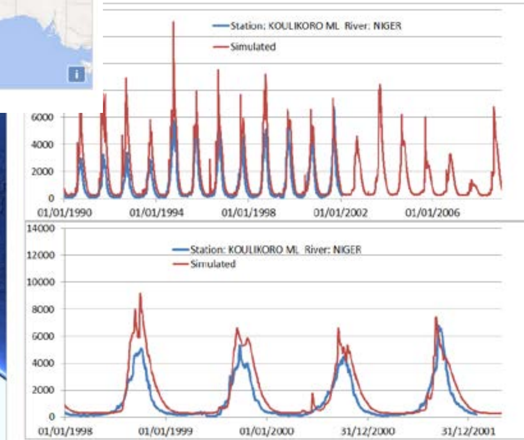
The Global Flood Awareness System

www.globalfloods.eu

florian.pappenberger@ecmwf.int







Output from global ECMWF NWP land-surface forecast is fed into a routing model (Simplified LISFLOOD (JRC)) to produce flood forecasts – benefiting from all the improvements in the ECMWF Integrated Forecasting System (model and assimilation)!

ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

ERA-5Land plans

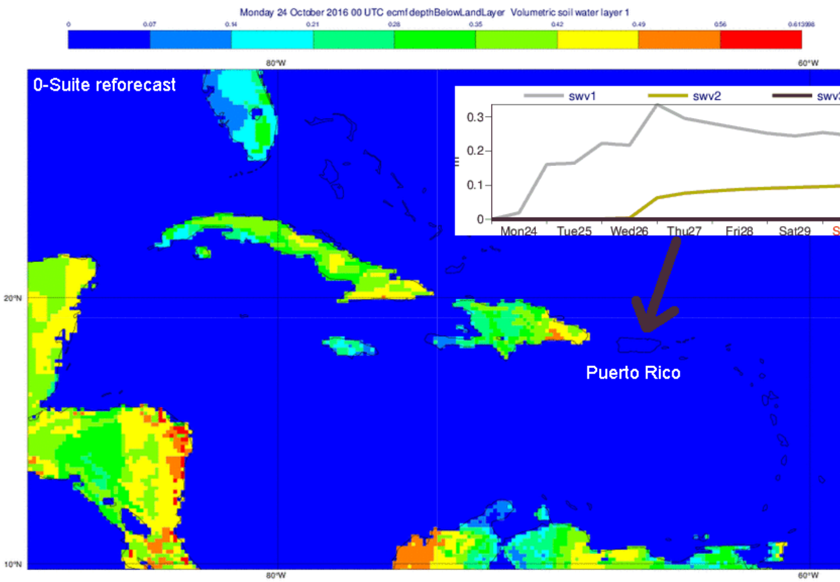
- High-resolution land component forced by ERA5 atmospheric reanalysis
  - Running in a stand-alone suite, decoupled from the atmosphere (lower computational cost)
  - Resolution will follow ECMWF operational system (TCo1279 → approx. 9 km)
  - Extended archive of variables compared to ERA-Interim
  - Monthly means and ensemble spread will be included
  - Higher resolution of land fields very useful for commercial applications too→ C3S end-user
  - Expected start of production by the Q1-Q2 2017 (ERA-5L lags behind the ERA5 production)

- Some characteristics
  - Atmospheric forcing from ERA5
  - T, Q and P fields corrected from orography height difference (lapse-rate correction)
  - Surface fields uncertainty estimated from 10-ensemble members run at TCo639 resolution
  - Currently no assimilation implemented

- Current & future developments
  - Precipitation & lapse-rate corrections
  - Post-processing of carbon fluxes with BFAS
  - More realistic ensemble spread through additional perturbations
  - Possible increase to 10 soil layers (from the current 4 layers)

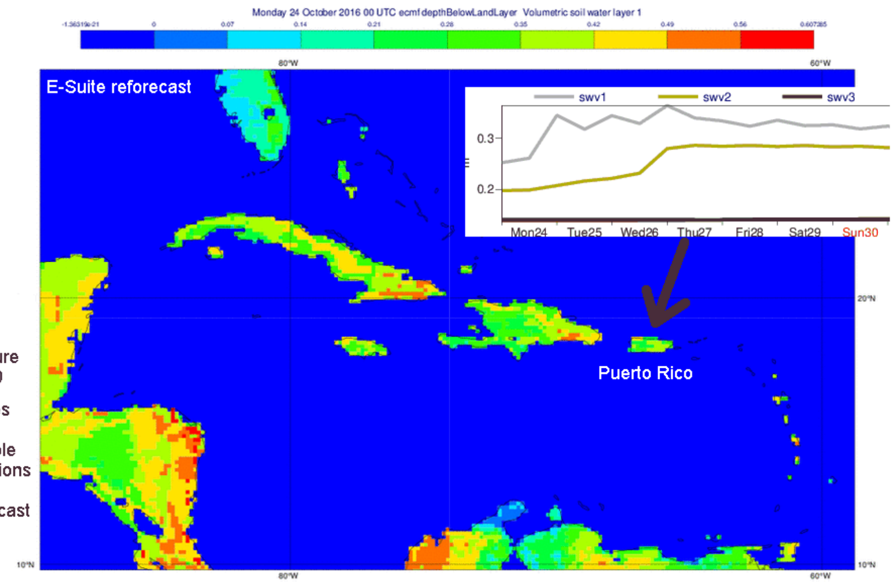
ERA-5Land: a case for HRES

Why High-resolution land ? A case for Puerto Rico from daily-report



Maps show level 1 Soil Moisture at T+0

Profiles show example evolutions from a reforecast



Summary

Land reanalyses at ECMWF are necessary to provide appropriate initial conditions to reforecasts

The quality of meteorological forcing combined with model advances have made them added-value products (e.g. conservation, hydrological consistency, verification effort).

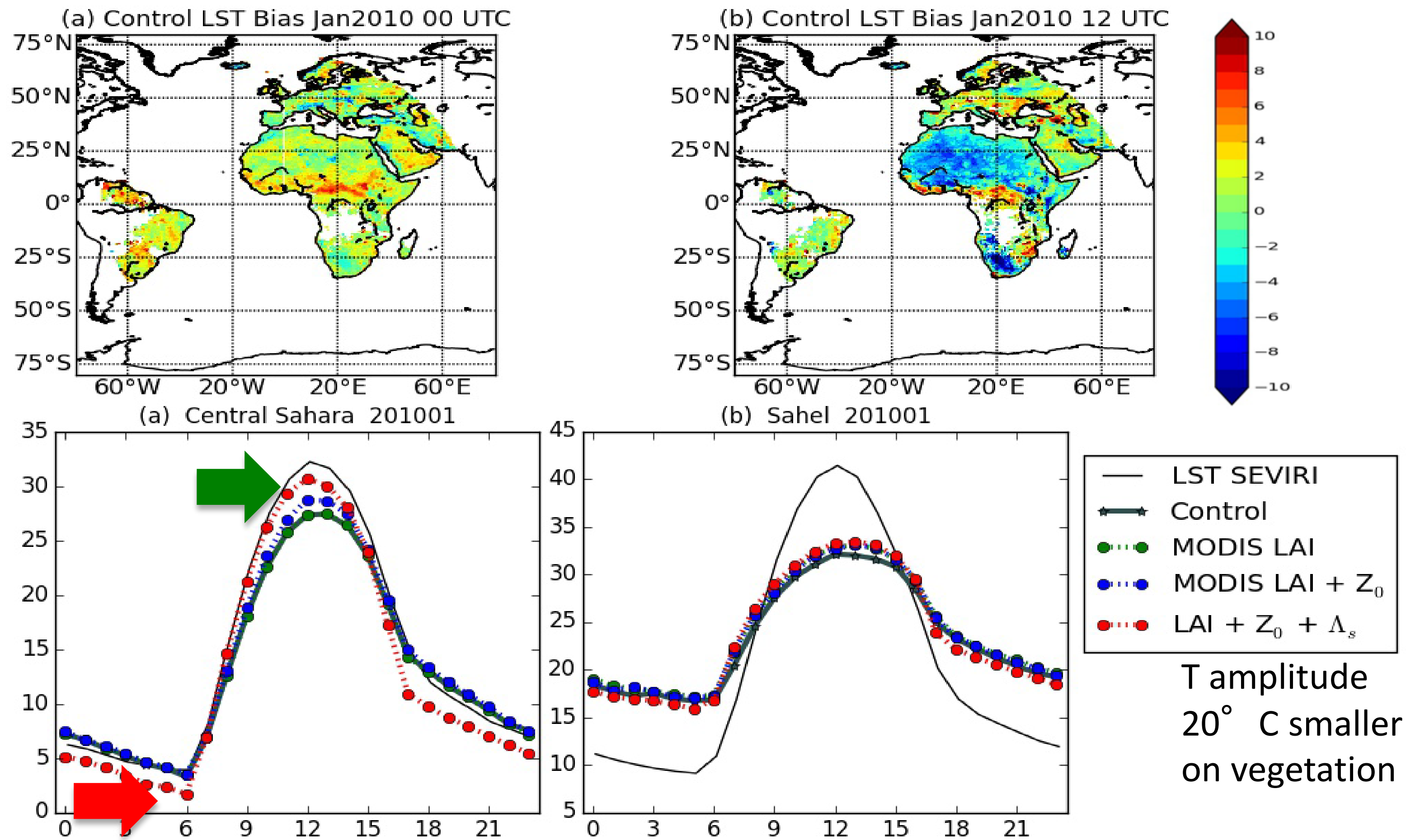
The extension to further processes shall enhance the monitoring capacity (e.g. in ERA-5 there are lakes)

Land reanalyses (such as ERA-Interim/Land and ERA5-Land) do not yet include stand-alone land data assimilation system and work to include this component will be beneficial to constrain modelling errors and enhance the consistency with the NRT-LDAS

Land dedicated reanalyses foreseen in future ERA products will probably still include forced-mode integration as they are water-conserving and can provide useful guidance on trends and further information for model error characterisation.

Coupling and diurnal cycle: vegetation

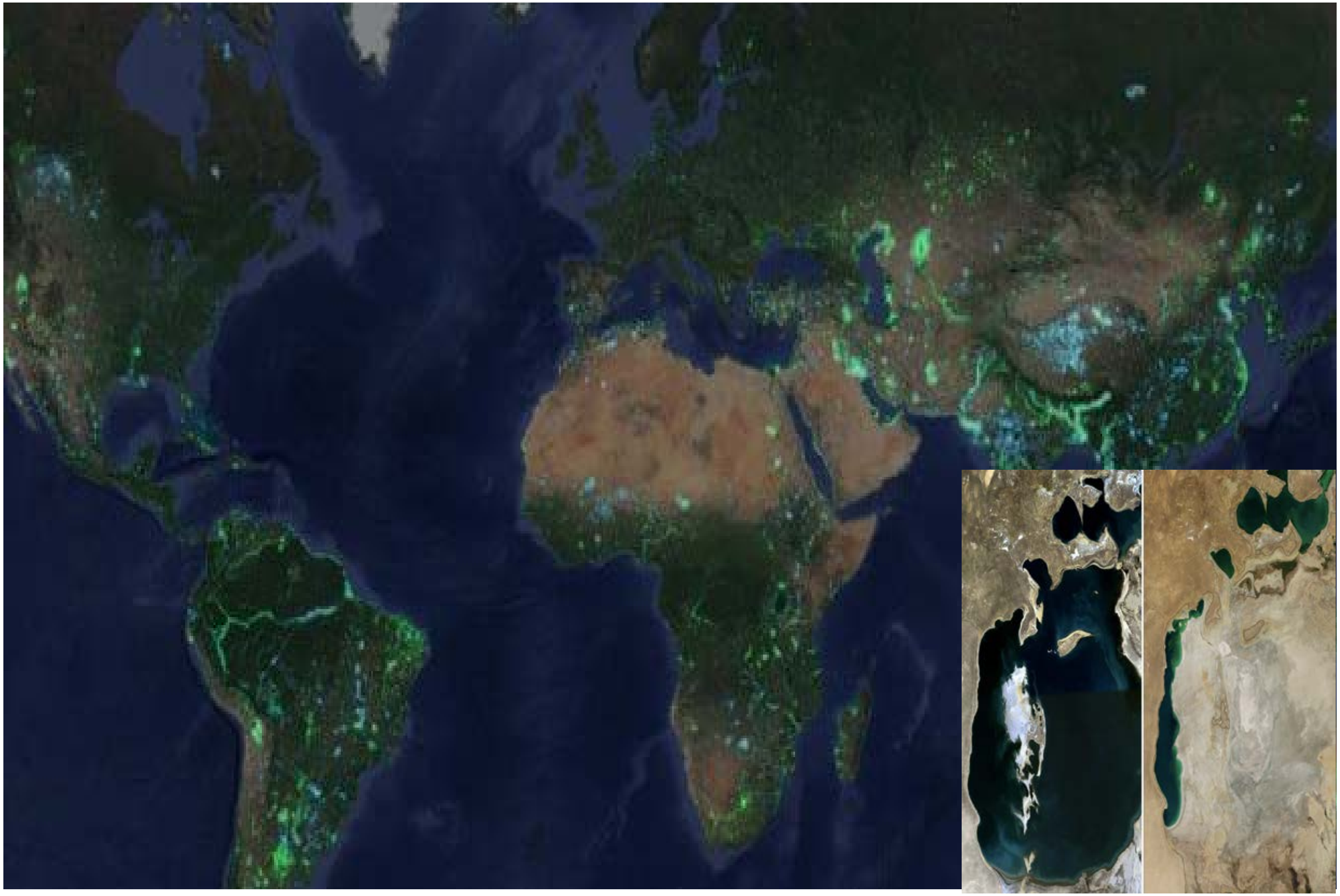
Trigo et al. (2015, JGR in rev.), Boussetta et al. (2015, RSE)



T amplitude 20° C smaller on vegetation

Findings of large biases in the diurnal temperature reposed on the use of MSG Skin Temperature. However with the current model version we are limited (both over bare soil and vegetation)

Inland water bodies dataset: a moving target?



http://aqua-monitor.appspot.com

- Lake Aral in 1989 and 2014 (source: NASA)

ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FOR

Urban cover uncertainties

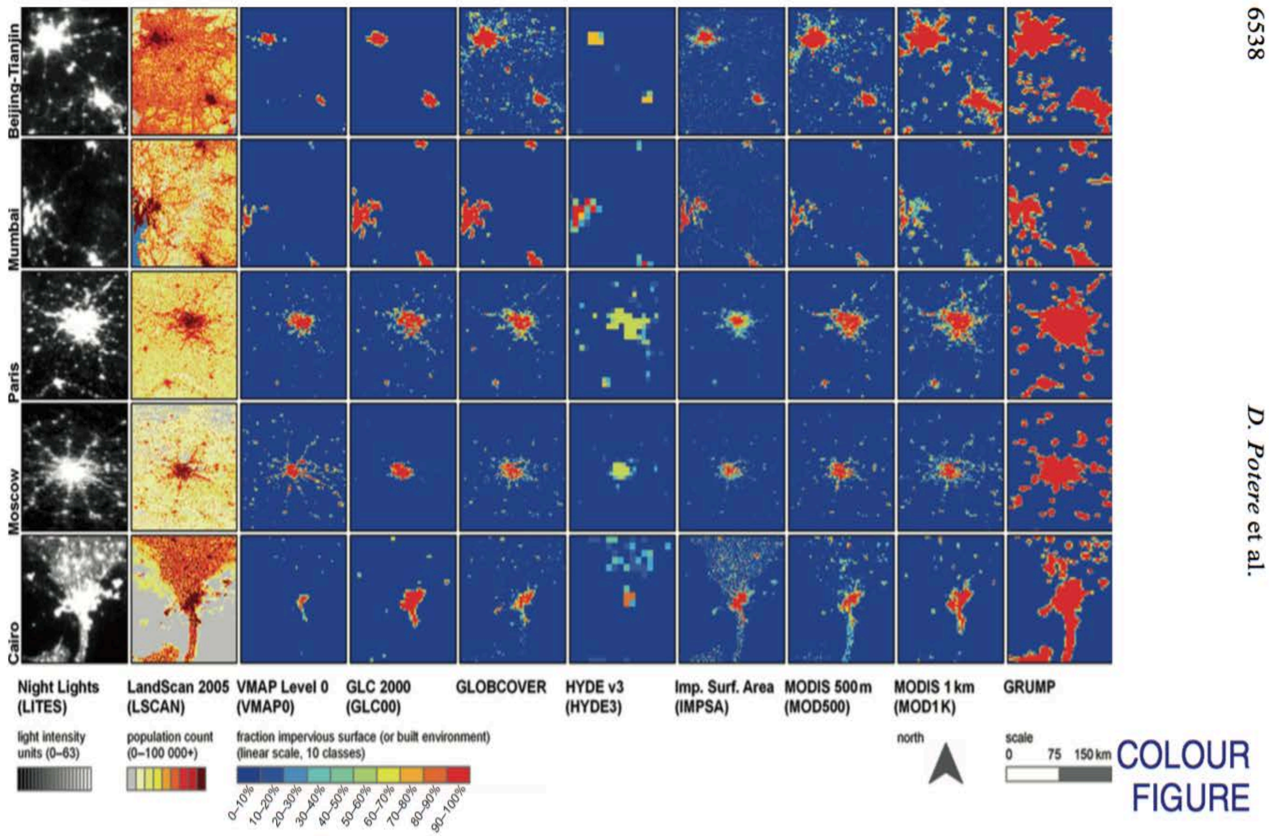


Figure 1. The eight global urban maps and two urban-related maps for Beijing-Tianjin, China (top row), Mumbai, India (second row), Paris, France (third row), Moscow, Russia (fourth row), and Cairo, Egypt (bottom row). LITES, LSCAN and IMPSA are at native 30 arc-second resolution, HYDE3 is at native 5 arc-minutes, and the remaining maps have been aggregated from 30 arc-seconds to 1.5 arc-minutes for display. This aggregation effectively converts their legends from binary (urban/rural) to continuous (percentage urban).

- Urban area dataset comparison on selected cities (Potere et al., 2009 IJRS) reveal large uncertainties and discrepancies

Thank you for your Attention!

Useful links:

ECMWF LDAS: https://software.ecmwf.int/wiki/display/LDAS/LDAS+Home
ECMWF SMOS: https://software.ecmwf.int/wiki/display/LDAS/SMOS
ECMWF CMEM: https://software.ecmwf.int/wiki/display/LDAS/CMEM

ECMWF Land Surface Observation monitoring:
https://software.ecmwf.int/wiki/display/LDAS/Land+Surface+Observations+monitoring