Recent developments on soil moisture assimilation at COMET

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2 EUMETSAT fellowship

Outline

- Objectives of the EUMETSAT fellowship
- Data Product description
- Transformed soil moisture: selected methods
- Data quality control
- What's new in KENDA code
- Next future steps

EUMETSAT FELLOWSHIP
Objectives

H-SAF ASCAT product

COMET NWP system

KENDA-LETKF algorithm

Use of

satellite soil moisture data

into an

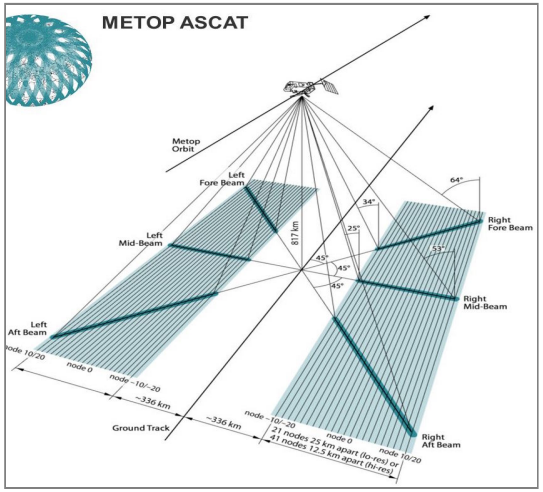
high-resolution short range forecasting model

with an

ensemble based data assimilation system

- ✓ *Influence of low level atmospheric variables*
- ✓ *Direct soil moisture analysis*

H-SAF ASCAT Soil moisture



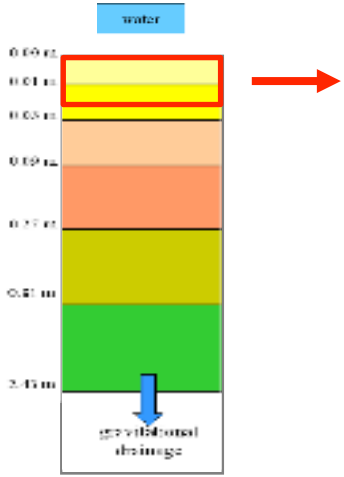
ASCAT soil moisture Data provided by EUMETSAT within the H-SAF project, one of the 8 EUMETSAT SAFs, lead by the Italian Air Force Met Service

- frequency: 5.3 GHz (microwave C-band)
- VV polarization
- Able to provide a triplet of backscattering coefficients for each swath
- 25 km resolution

*From backscattering coefficient measurements it is possible to retrieve the **soil moisture content** in the first **2 cm below the soil** by mean of **microwave technique** thanks to the high sensitivity of microwaves to the water content in the soil surface layer (for microwave frequencies in the C-band (< 10 GHz) the addition of liquid water to the soil strongly increases the soil dielectric constant, and so the backscattering coefficients)*

Transformed SOIL MOISTURE

- H-SAF ASCAT derived Soil Moisture: **degree of saturation** (%) in the first 2 cm
- COSMO TERRA_ML model soil moisture: **liquid water content** (m H2O) in the various model layers



layer structure of the hydrological part of the COSMO TERRA_ML soil model

To compare observed and model values the model values are transformed (to have quantities independent from the thickness of the layers) in **volumetric water content** (m^3/m^3) in the first 2 cm

+

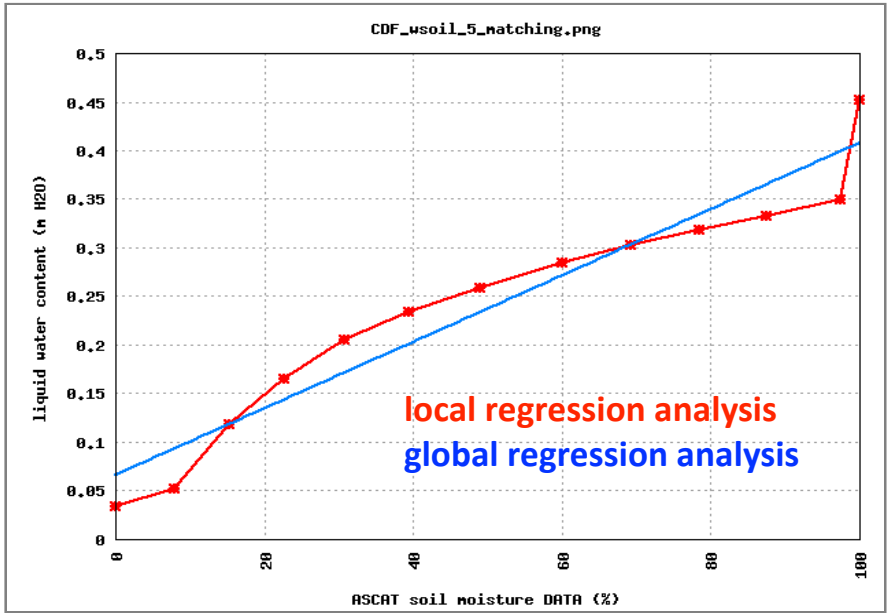
NEED TO RESCALE THE SATELLITE OBS TO THE MODEL VALUES

- CDF matching method
- Normalization methods

CDF matching

ECWMF approach

To scale the ASCAT derived soil moisture to the model climatology so that the cumulative distribution functions (CDF) of satellite and model soil moisture match.



This method doesn't allow deriving "correct" soil moisture. Rather it removes differences between satellite observations and model data by ensuring statistical consistency.

- **Linear regression analysis of ASCAT data plotted against model data**

  2 options investigated:
  - total regression analysis
  - local regression analysis

$$\omega_{obs} = max\left(0, a + b\frac{\theta_{obs}}{100}\right)$$

b slope, a intercept

Normalization Method

UKMO approach

$$\omega_{obs} = \omega_{ADP} + \frac{\theta_{obs}}{100}(\omega_{PV} - \omega_{ADP})$$

$$\omega_{obs} = \omega_{ADP} + \frac{\theta_{obs}}{100}\left(\frac{\omega_{PV} + \omega_{FC}}{2} - \omega_{ADP}\right)$$

soil type	**1** ice	**2** rock	**3** sand	**4** sandy loam	**5** loam	**6** loamy clay	**7** clay	**8** peat
volume of voids w_{PV} [1]	-	-	0.364	0.445	0.455	0.475	0.507	0.863
field capacity w_{FC} [1]	-	-	0.196	0.260	0.340	0.370	0.463	0.763
permanent wilting point w_{PWP} [1]	-	-	0.042	0.100	0.110	0.185	0.257	0.265
air dryness point w_{ADP} [1]	-	-	0.012	0.030	0.035	0.060	0.065	0.098

Evaluation of Results

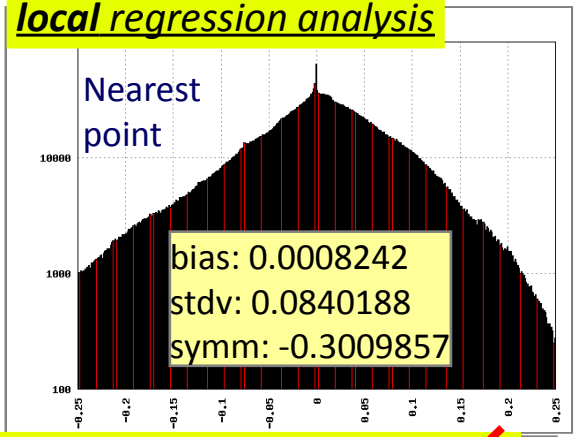
Observation Increment Statistics

- 1 year time series of ASCAT and model SM data
  (january 2015 - january 2016)
- model data from **COMET-LETKF** system
  (10 km grid spacing)
- difference between the obs value and
  its model equivalent value (ensemble mean)
- **FGAT**
- **2 methods for space interpolation**:
  - nearest grid point
  - average on the 9 nearest grid points

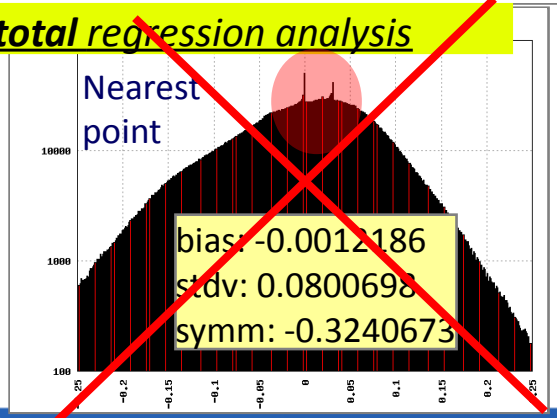
Because of the assumption of no bias and gaussianity, their distribution in terms of bias and symmetry will be analyzed

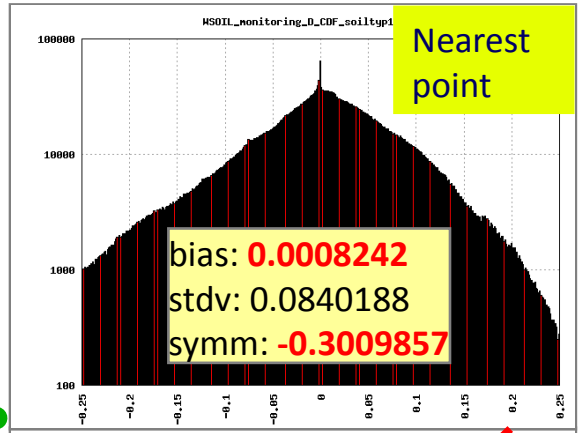
Evaluation of results (CDF)

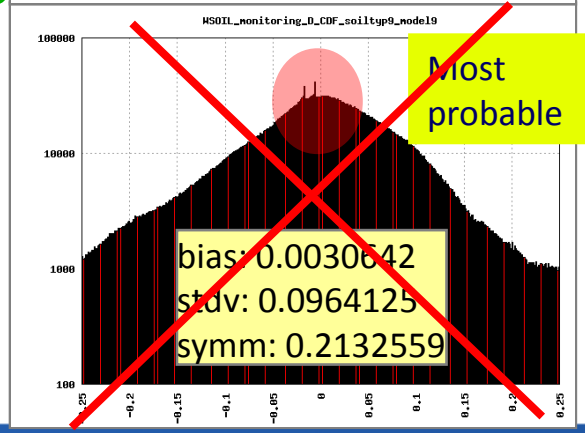
***local** regression analysis*



***total** regression analysis*





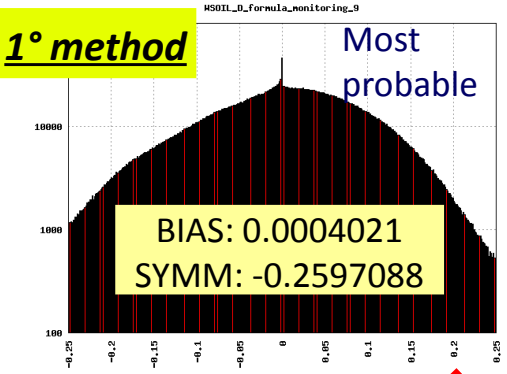


FINAL CHOICE:
Local regression
+
Nearest point soil type

Evaluation of results (Normalization Method)

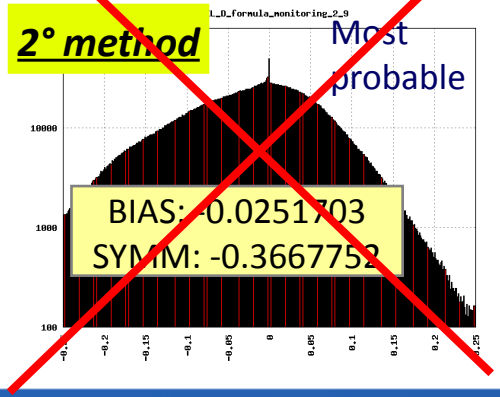
1° method

Most probable

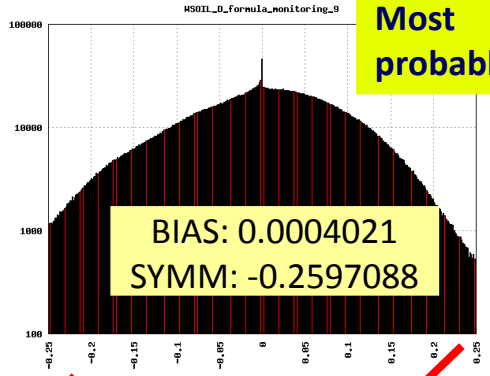


2° method

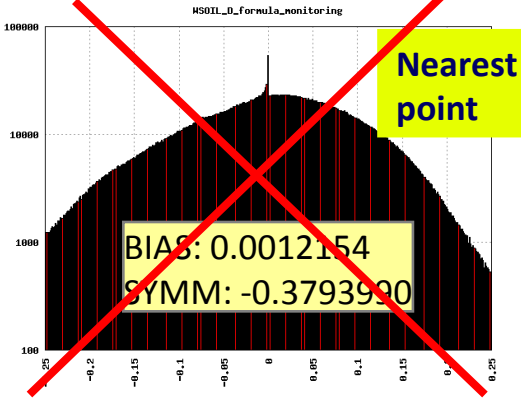
Most probable



Most probable



Nearest point



FINAL CHOICE:
1st method
+
Most probable soil type

Soil Moisture Assimilation
Data quality control

Soil moisture cannot be estimated if the fraction of dense vegetation, open water, snow/frozen soils, mountains, sand dunes and/or wetlands dominates the scatterometer footprint

H-SAF ASCAT soil moisture data are rejected if:

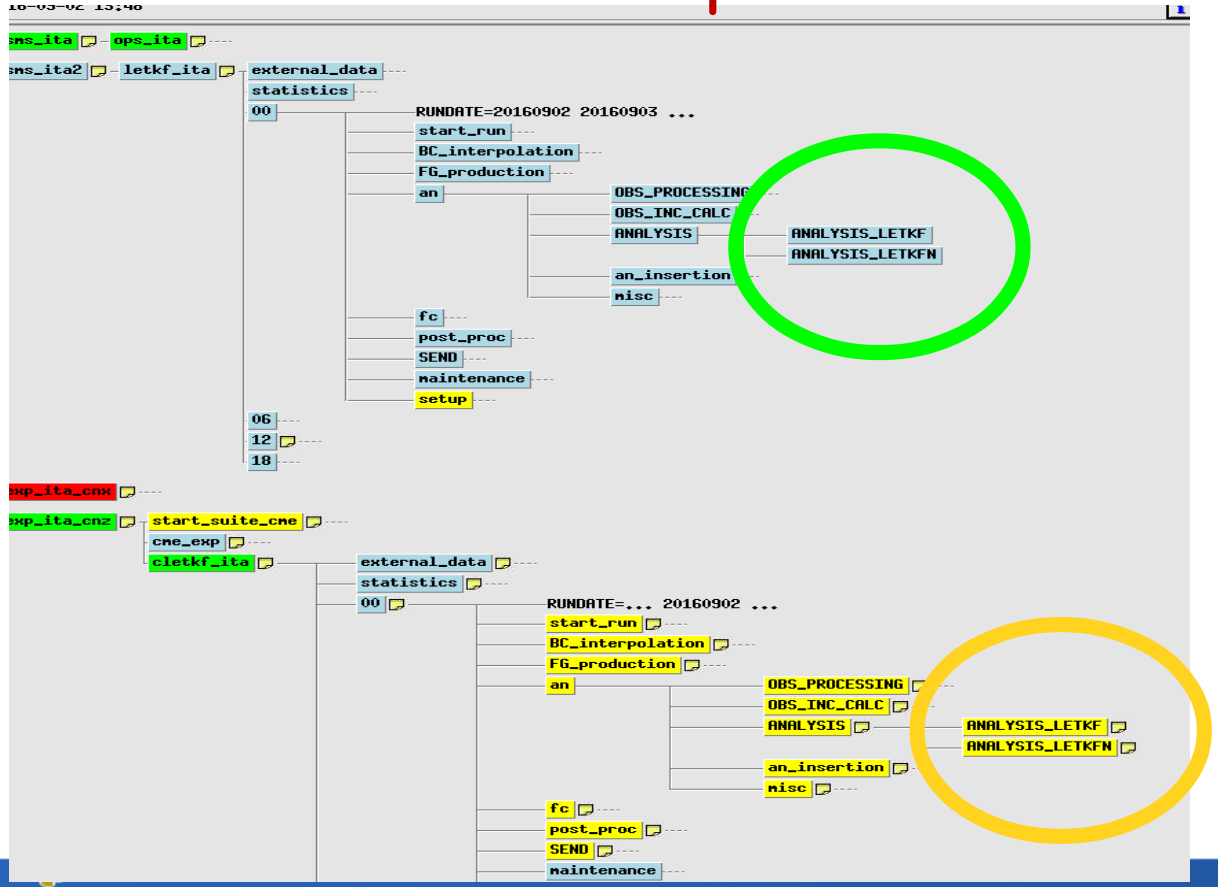
- *snow:* the analysed snow amount is greater than 0.05 kg/m^2 **(**not active**)**
- Sea point (check land sea mask)
- *frost:* the 2m Temperature analysis is below 275.15 K **(**not active**)**
- *wetlands:* the inundation and wetland amount has a value greater than 15%
- *mountains:* the topographic complexity has a value greater than 20%
- *ASCAT estimated error:* greater than 8% (ECMWF value, UKMO uses 7%)
  This check rejects ASCAT data from regions with dense vegetation and sand dunes
- "Cross number cell number" UKMO checks (implemented but not active)
- Soil type =1 or 2 (ice and rock)
- "processing flag"≠ 0 (quality of retrieval **??**)

QC implemented outside KENDA (to be discussed)

- Ens.mean Observation Increments > 2.5 σ
  (σ estimated from 1 year statistics for each soyl type)

QC implemented inside KENDA

KENDA implementation at COMET



COMET-LETKF
Operational suite

KENDA@10km
real time test-suite
with w_so assimilation

Soil Moisture Assimilation

First implementation in KENDA code

New Features

(to be submitted)

- introduction of wso obs in fdbk files
- *e_o*= 2 x BUFR estimated error (suggested by P. De Rosnay ECMWF 1 ÷ 3 → to be estimated by Desroziers statistics after data assimilation cycle)
- ***w_so analysis***:

Wr_soil matrix (single level) computed only with soil moisture obs *(+ T2m,RH2m in progress)*

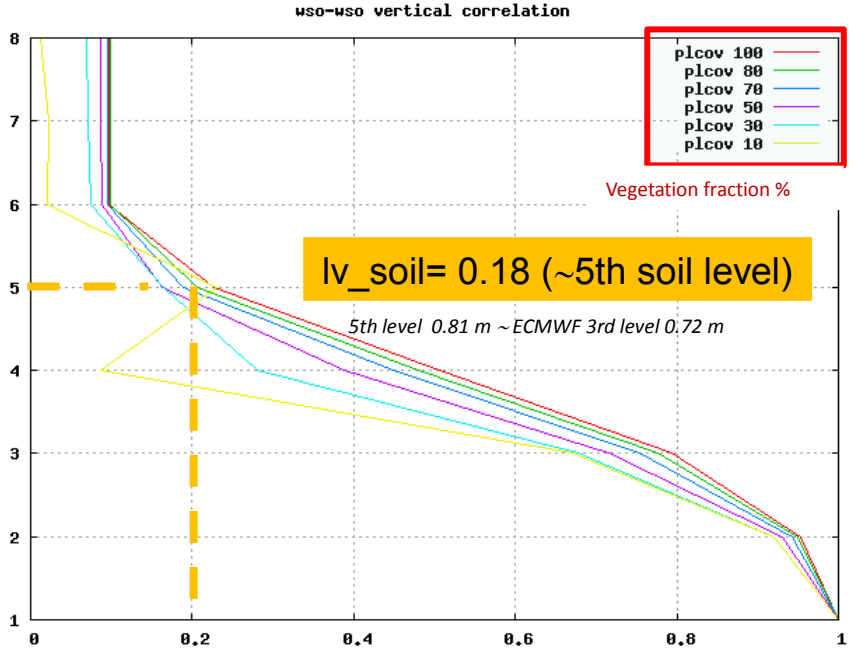
- **atm variables analysis**:

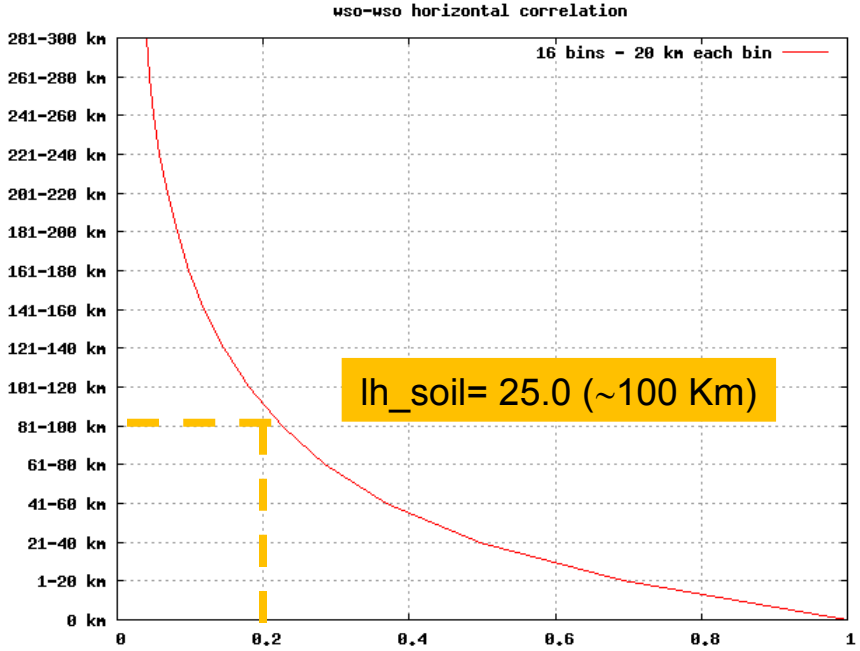
wso obs inluence *analysis of low level atm variable*

- Different localization scales for w_so obs

Soil Moisture Assimilation in KENDA settings

- ***w_so analysis***:





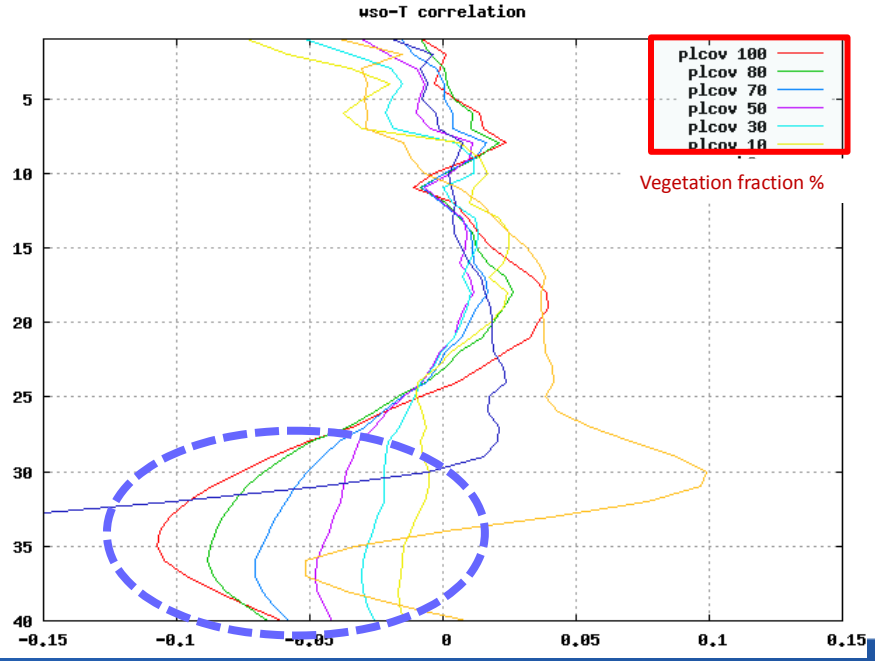
Soil Moisture Assimilation in KENDA settings

- ***atm variable analysis***:

lh_wso = lh_soil

lv_wso = UP TO LEVEL30
<< lv_surf = 0.18

2800 m, 750 hPa



Soil Moisture Assimilation
Next Future steps

- Evaluation of first results (CDF method)
- Test with normalization method
- Add T2m/RH2m obs in Wr_soil
- Influence of neighbourhood depending on soil type

Thanks for your attention!