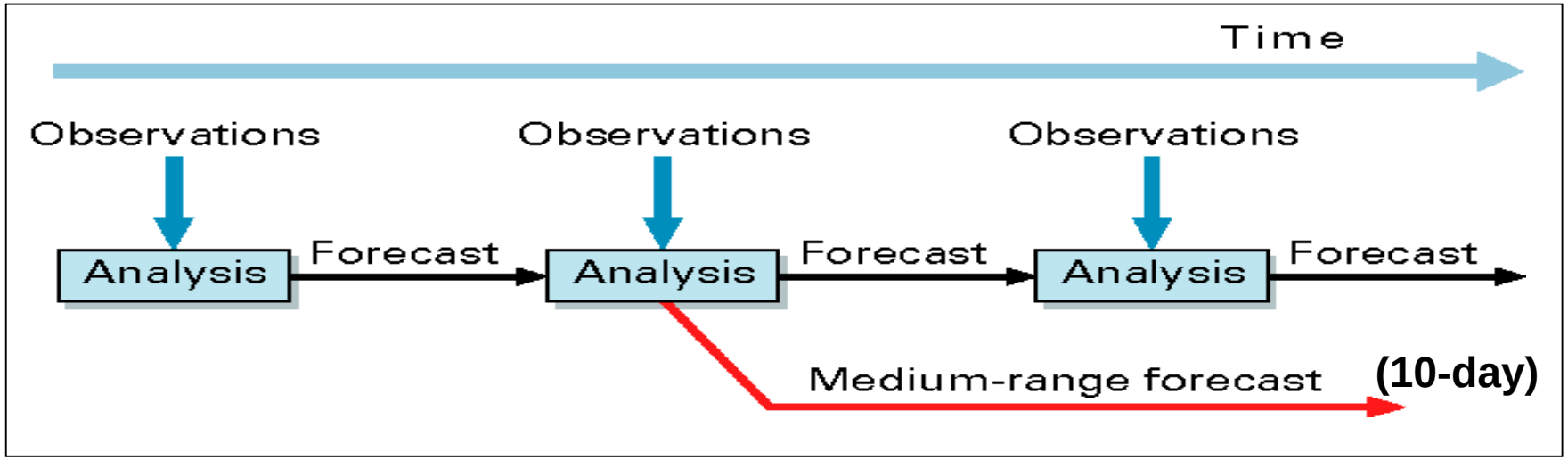
IGARSS, Valencia, Spain, 24 July 2018

SMOS data assimilation for Numerical Weather Prediction (NWP)

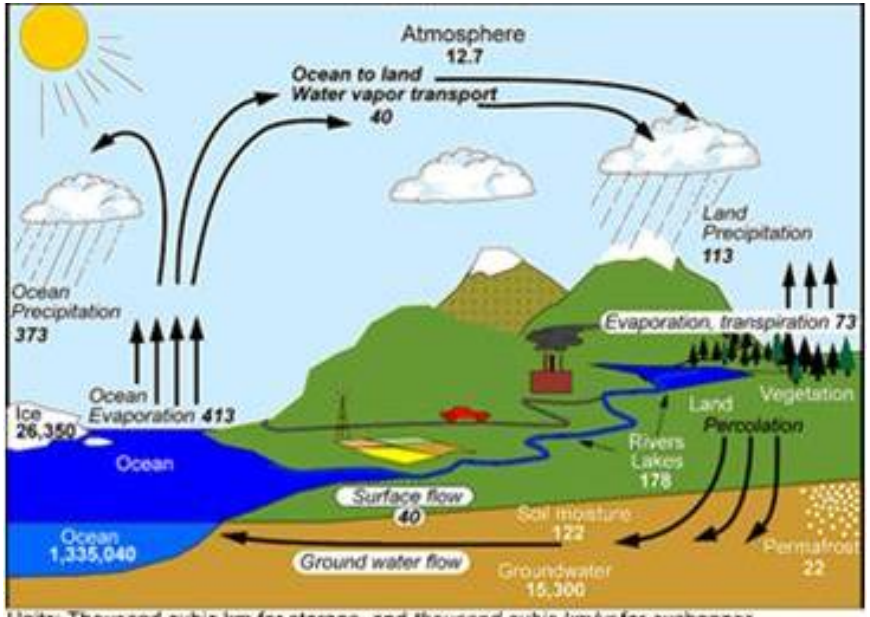
Patricia de Rosnay

Thanks to: Nemesio Rodríguez-Fernández, Joaquín Muñoz-Sabater, Clément Albergel, David Fairbairn, Phil Browne, Heather Lawrence, Lars Isaksen, Steve English, Filip Aires, Catherine Prigent, Matthias Drusch, Yann Kerr and Susanne Mecklenburg

ECMWF Integrated Forecasting System (IFS)

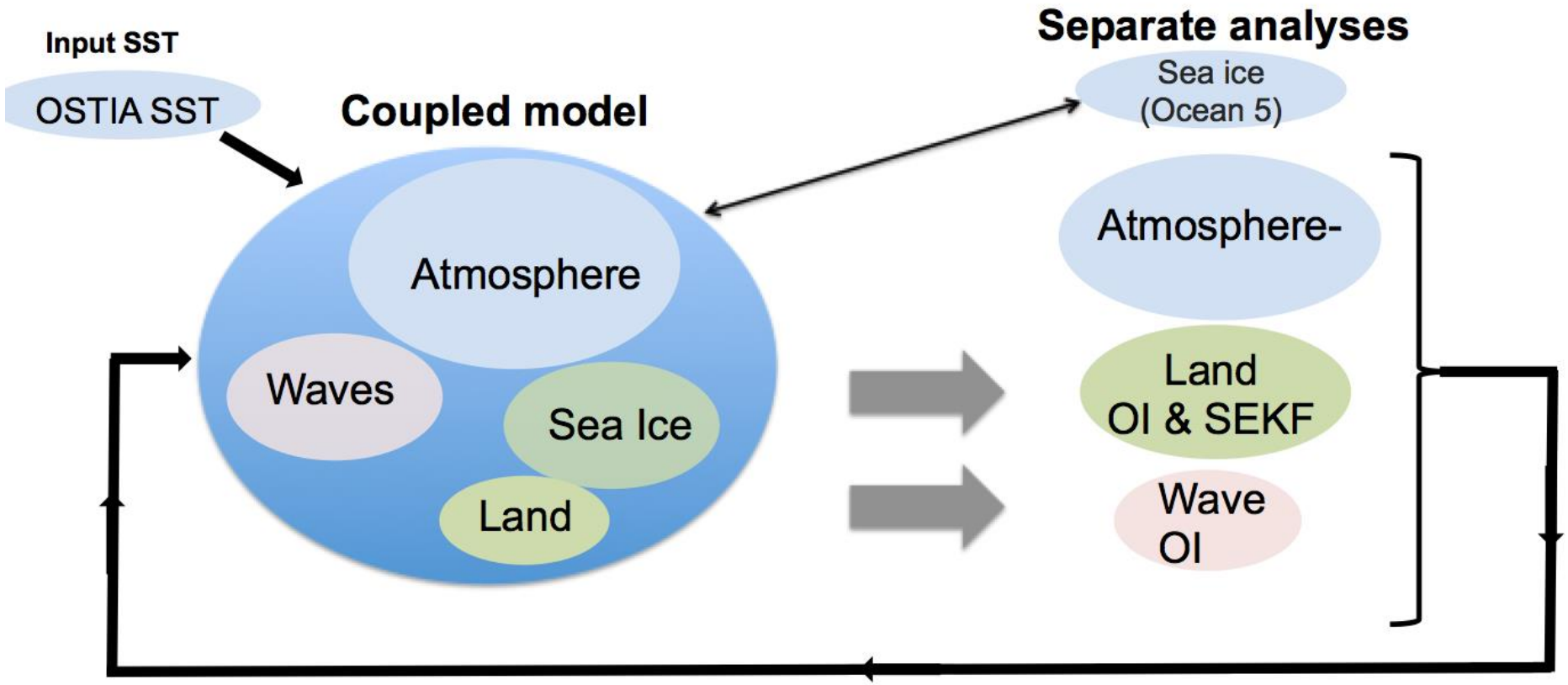


- **Coupled land-atmosphere Forecast Model**
- **Data Assimilation: atmosphere (4D-Var), land (SEKF,OI), ocean (3D-Var)**



Current operational NWP system at ECMWF

weakly coupled land-atmosphere-wave and sea ice assimilation



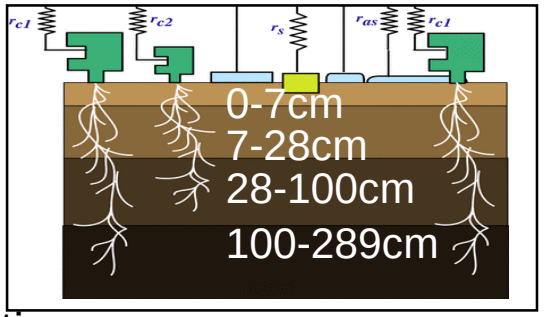
→ **Importance of the interface observations for consistent initialisation of coupled land-atmosphere forecasts**

→ **SMOS observations highly relevant for coupled assimilation**

ECMWF Soil Analysis submitted for IFS 46r1 (2019)

Ensemble Data Assimilation (EDA)

NWP Forecast Coupled Land-Atmosphere



Land initial conditions

Jacobians

T2m, RH2m

& soil moisture

Background

Soil Analysis (SEKF)

SM1, SM2, SM3

σ_{O_T2M}= 1K $\sigma_{b\_}$ = 0.01m3/m3 σ_{SMOS_NN}= 0.02+3ε

σ_{O_RH2M}= 4% σ_{ASCAT}= 0.05m3/m3

In situ Observations

T_2m RH_2m

Screen level analysis (2D-OI)

T_2m RH_2m

$\sigma^{o}_{T2m} = 2K$ $\sigma^{o}_{RH2m} = 10\%$

ASCAT SM
SMOS SM

SMOS EC Neural network

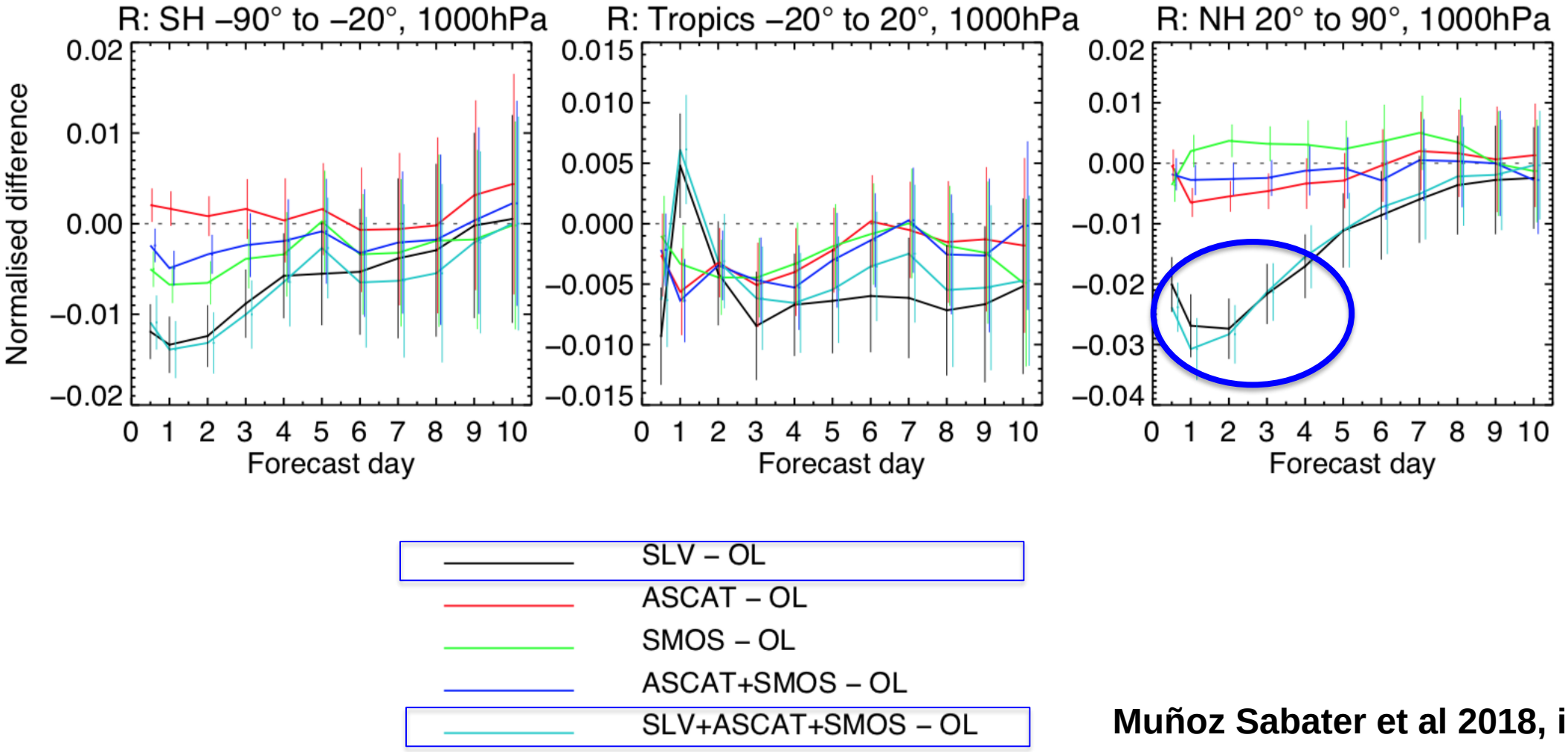
SMOS TB

Satellite

L-band assimilation in ECMWF IFS

SMOS TB assimilation

Atmospheric forecasts evaluation for MJJAS 2013



Muñoz Sabater et al 2018, in prep

SMOS neural network assimilation in H-TESSEL

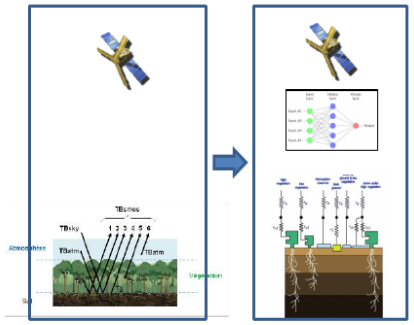
SMOS neural network soil moisture data assimilation

N. Rodríguez-Fernández (1), P. De Rosnay (2), C. Albergel (2), F. Aires (4), C. Prigent (4)
P. Richaume (1), Y. Kerr (1), M. Drusch (5)

Creating a new SMOS soil moisture dataset specific for the data assimilation experiment

Instead of computing the complex radiation transfer trough the biosphere why not linking directly the best remote sensing observations to the best NWP models ?
Prigent & Aires 2006, JGR; Prigent, Aires, et al. 2005, JGR

- **One interesting application will be efficient Data Assimilation.** The retrieved datasets are similar to the model fields, by construction, but they are driven by the remote sensing input data *Aires, Prigent, Rossow 2005, JGR*



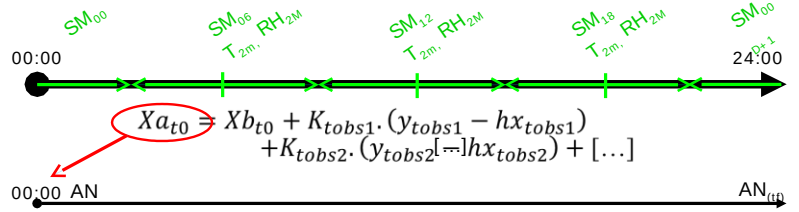
- Neural network SM can be produced **in near-real-time** and **with associated errors**
Rodriguez-Fernandez, Muñoz-Sabater et al. (in prep)

The ECMWF surface-only Land Data Assimilation System

Offline surface model (HTESSEL, *Balsamo et al. 2009*) forced by ERA-Interim reanalysis

Soil moisture analysis : T2m, RH2m, ASCAT SM, SMOS NN SM

Simplified EKF equation. The analysis state is applied at the beginning of the assimilation window

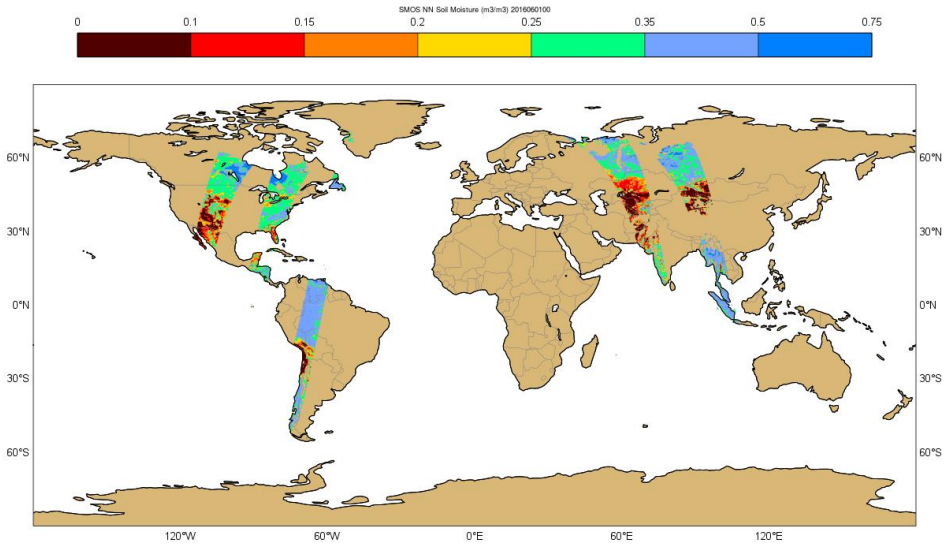


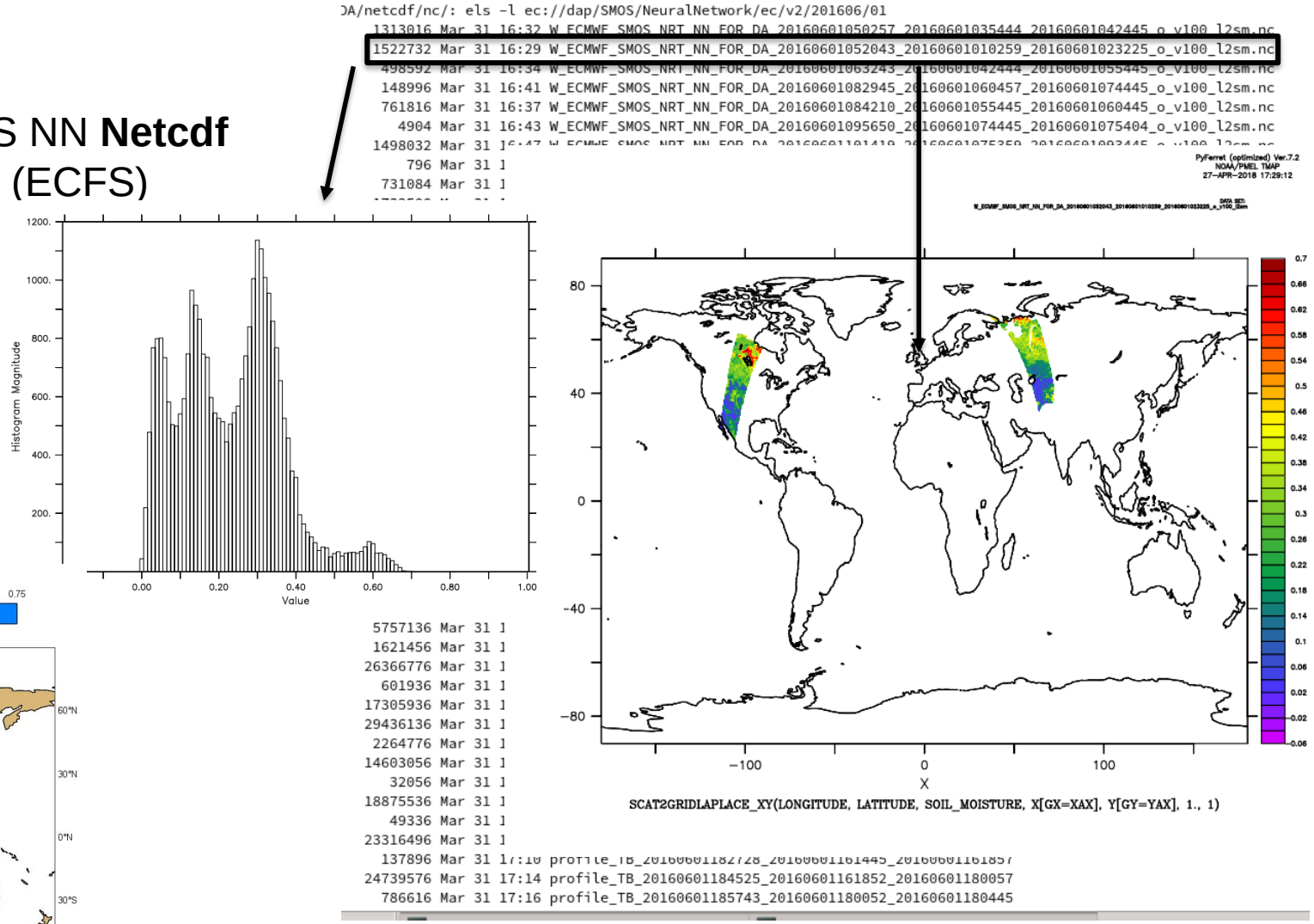
Poster on Wednesday morning, WEP1.PR.10 poster area R (10:10-11:10)

2018: New SMOS neural network processor for data assimilation

Example on 01 June 2016:
- 27 NRT TB files received → 27 SMOS NN **Netcdf** files produced and archived at ECMWF (ECFS)

Preprocessing (NRT):
Regridding, conversion GRIB,
6-hours grib files,
[SSM, SSM error (ε), obs time, RFI proba, nb obs]
→ Suitable and ready to DA in IFS





SMOS neural network assimilation in the IFS: Numerical experiments

Best candidate SMOS and EDA-SEKF proposed for operational usage in IFS cycle 46r1:

- **CTRL**: current IFS 45r1 (Finite difference SEKF, uses T2m, RH2m, ASCAT SM)
- **SMOS_DA**: CTRL+SMOS NN DA (obs error =0.02+3*ε, RFI filter 20%)
- **EDA_SMOS_DA**: proposed for 46r1 (SMOS_DA + EDA_SEKF with 50 EDA members)

Two sets of experiments (standard for ECMWF future IFS cycle testing):

- Summer June-July-August 2017
- Winter December-January-February 2016-2017

Resolution testing for candidates 46r1: Tco399 (25 km)

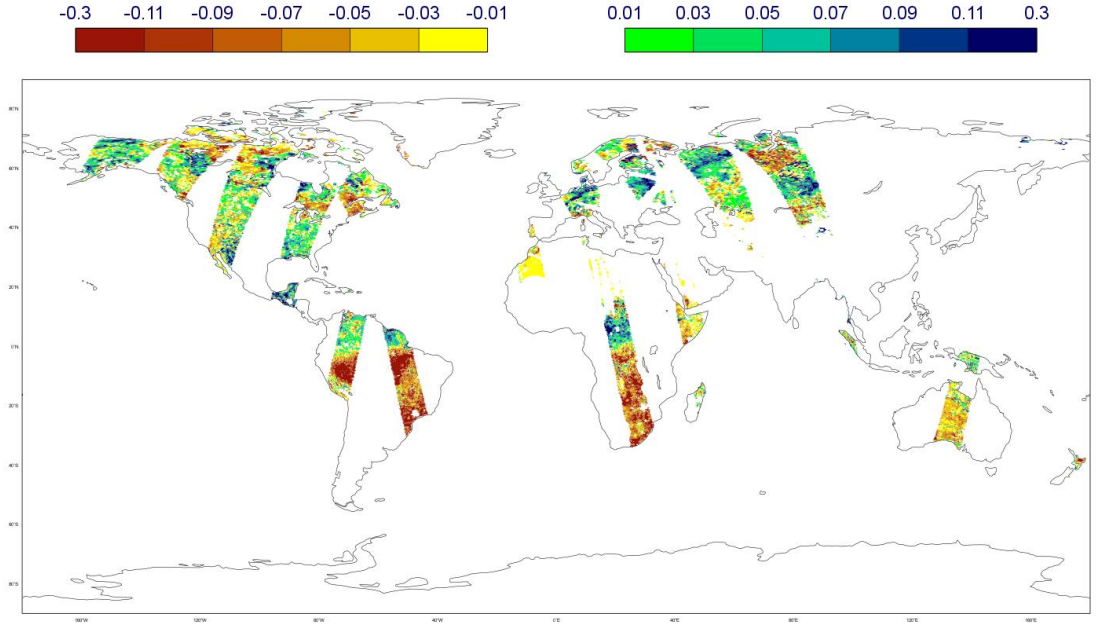
New soil analysis: EDA SEKF and SMOS NN DA

Reduction of the SEKF CPU cost by a factor ~3.6

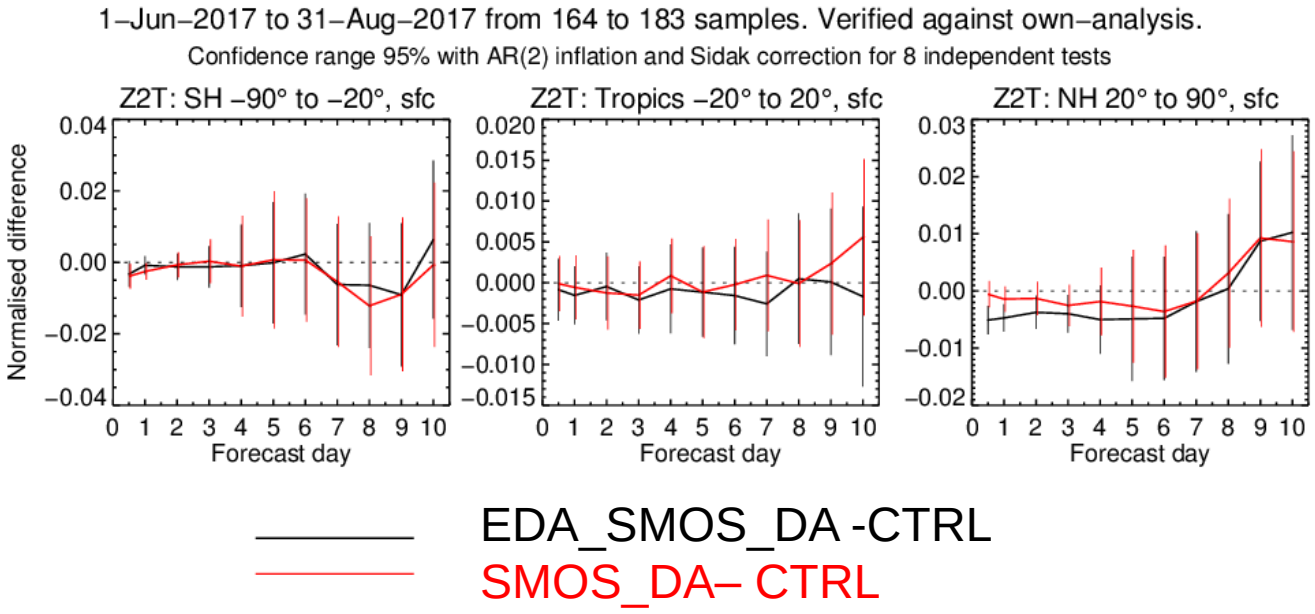
Technical work for 46r1

- Use the EDA to compute the SEKF Jacobian
- SMOS neural network soil moisture assimilation
- CPU reduction from EDA_SEKF, cost neutral for SMOS

	NPES*THREADS	45r1	46r1
Tco 1279	300*9	1580	435
TCo399	54*6	815	235



SMOS innovation (obs-model)
01 August 2017 (m3/m3)

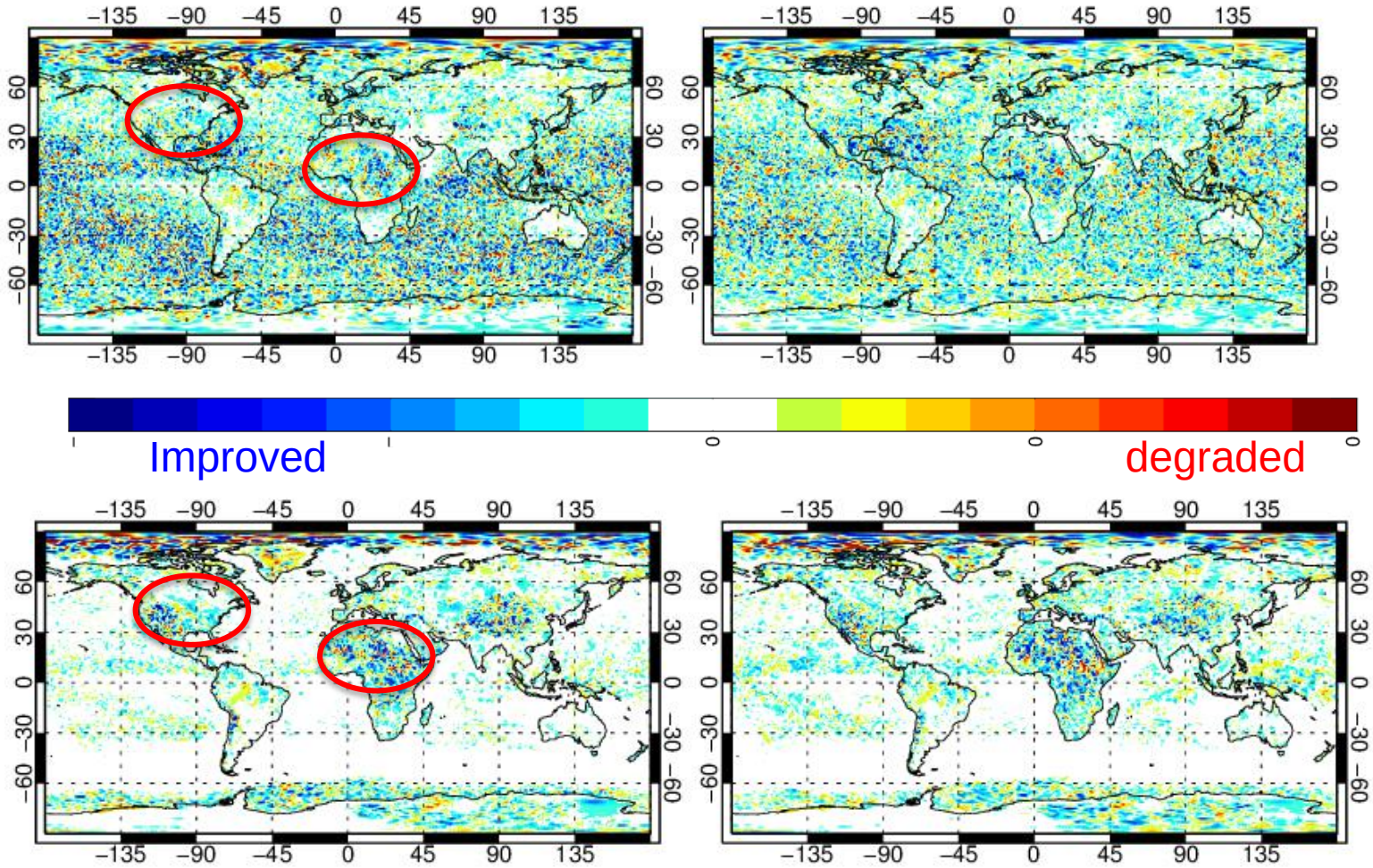


Atmospheric impact (T2m) compared to CTRL

SMOS neural network data assimilation: forecast impact

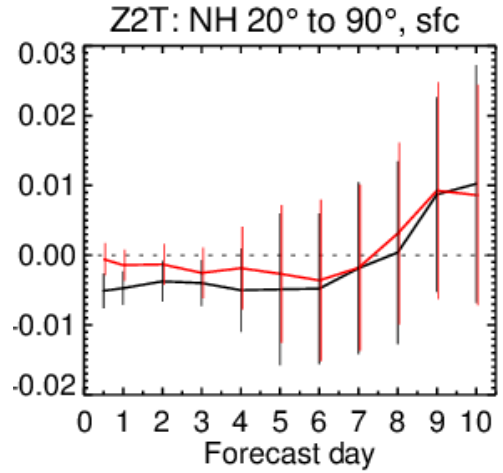
T+12

T+24

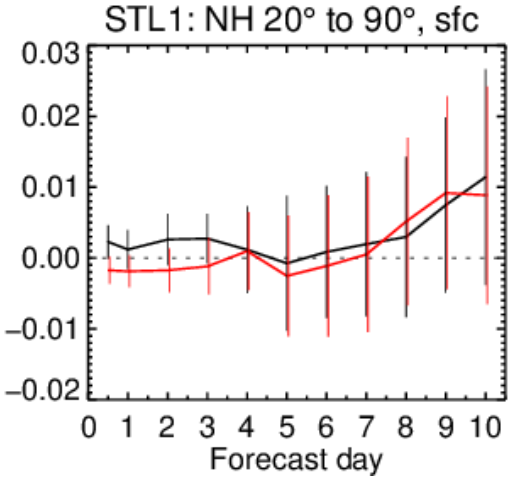


Normalised RMSE [SMOS_DA – CTRL]

Near surface air temperature

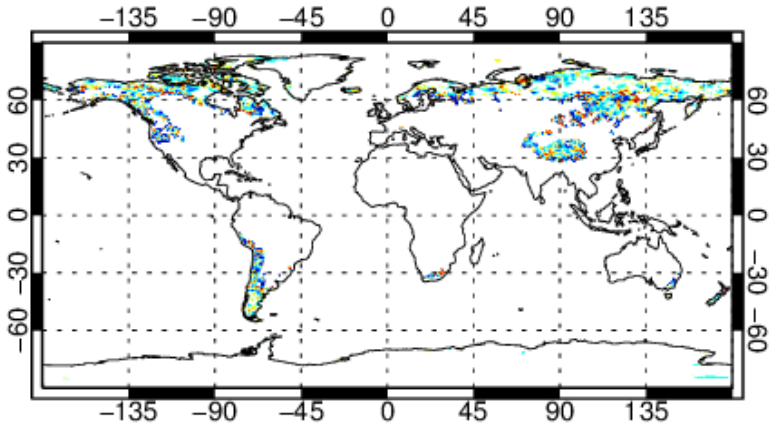


Soil temperature

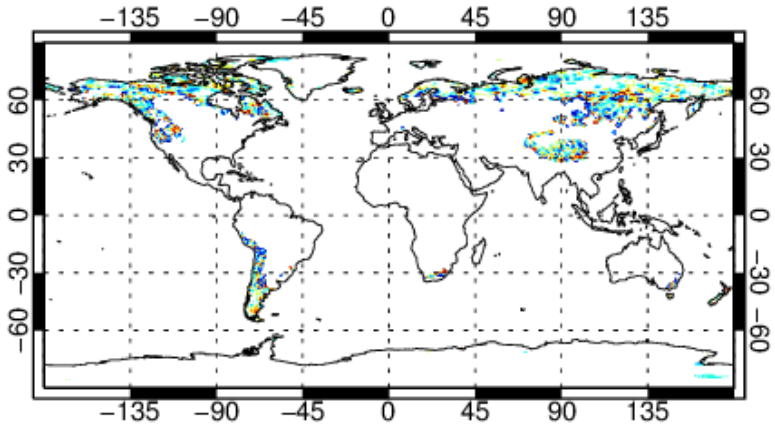


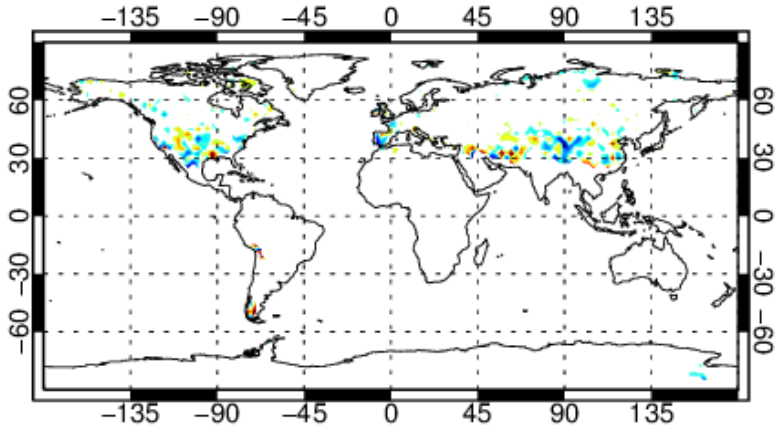
SMOS neural network data assimilation: forecast impact

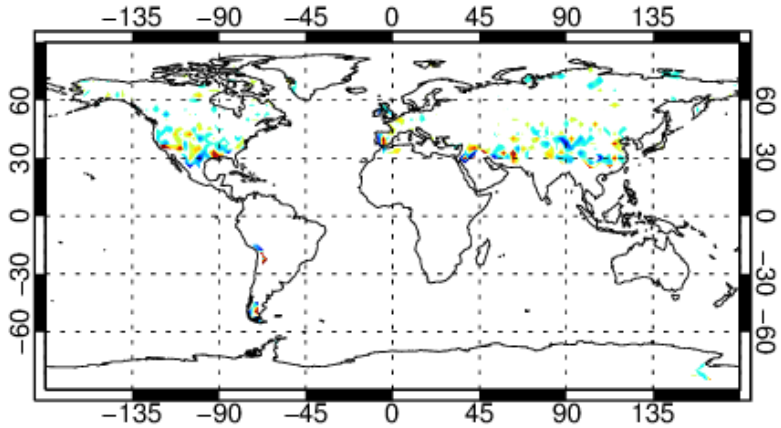
T+12



T+24



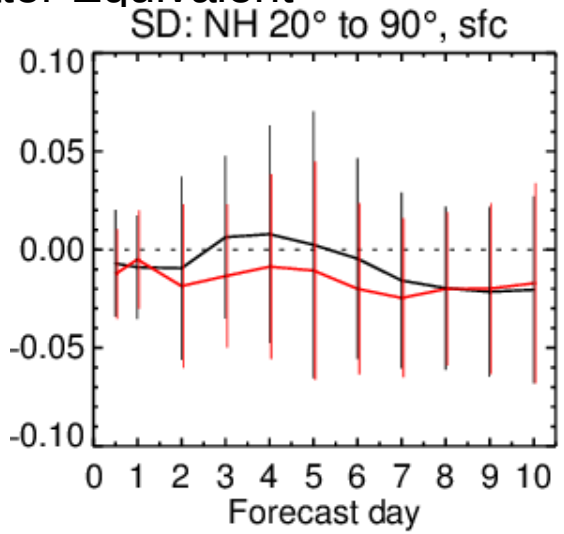




Normalised RMSE [EDA_SMOS_DA – CTRL] (winter)

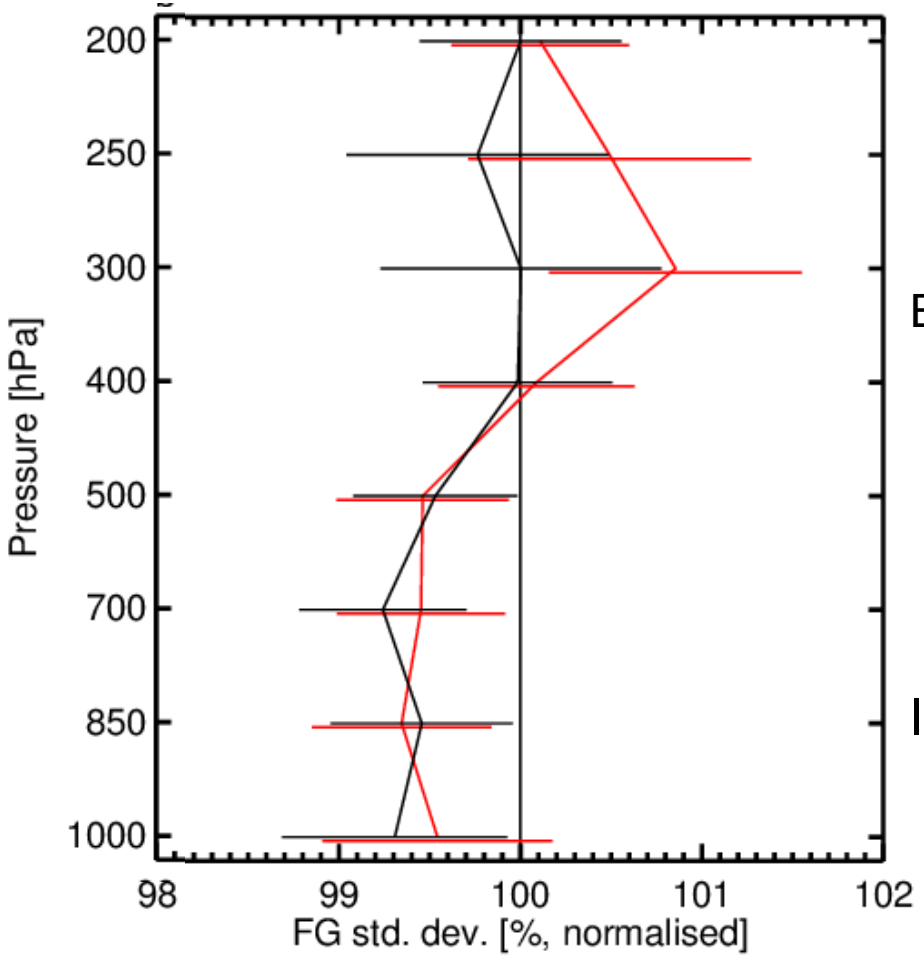
Normalised RMSE [SMOS_DA – CTRL] (summer)

Snow Water Equivalent



SMOS neural network data assimilation:
Fit between IFS first guess and independent observations (obs-model)

Aircraft humidity (JJA 2017)

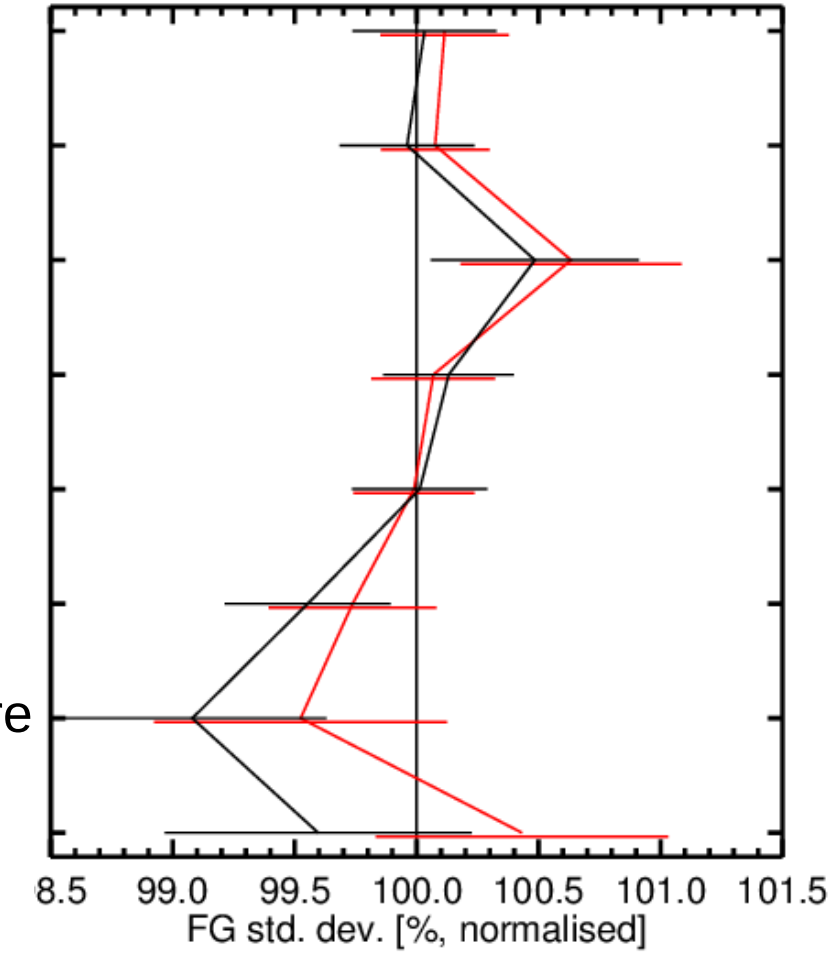


EDA_SMOS_DA minus CTRL

SMOS_DA minus CTRL

Improved fit in low troposphere

Aircraft temperature (JJA 2017)



Evaluation of surface and root zone soil moisture against in situ data

More than 300 stations in US and Europe (SCAN, USCRN, SNOTEL and SMOSMANIA)

Experiment	R		Ranom		uRMSD		Bias	
	surface	root Zone	Surface	root zone	surface	root zone	surface	root zone
CTRL (oper)	0.617	0.65	0.518	0.428	0.052	0.031	0.06	0.058
SMOS DA (oper+SMOS DA)	0.609	0.667	0.507	0.443	0.052	0.030	0.058	0.052
SMOS+EDA (oper+SMOS+EDA)	0.623	0.64	0.521	0.421	0.051	0.029	0.055	0.052

SMOS Neural Network assimilation in the IFS combined with the EDA SEKF
→ Small impact, but on a slight improvement side in soil moisture

SMOS contribution to improve root zone soil moisture (systematic on all four networks)

Summary and perspectives

- Current: SMOS neural network SM assimilation in review for operational NWP
- Next: Assessment of SMOS NN soil moisture assimilation for consistent NWP and flood forecasting systems

The Global Flood Awareness System

opernicus
The European Earth Observation Programme

www.globalfloods.eu