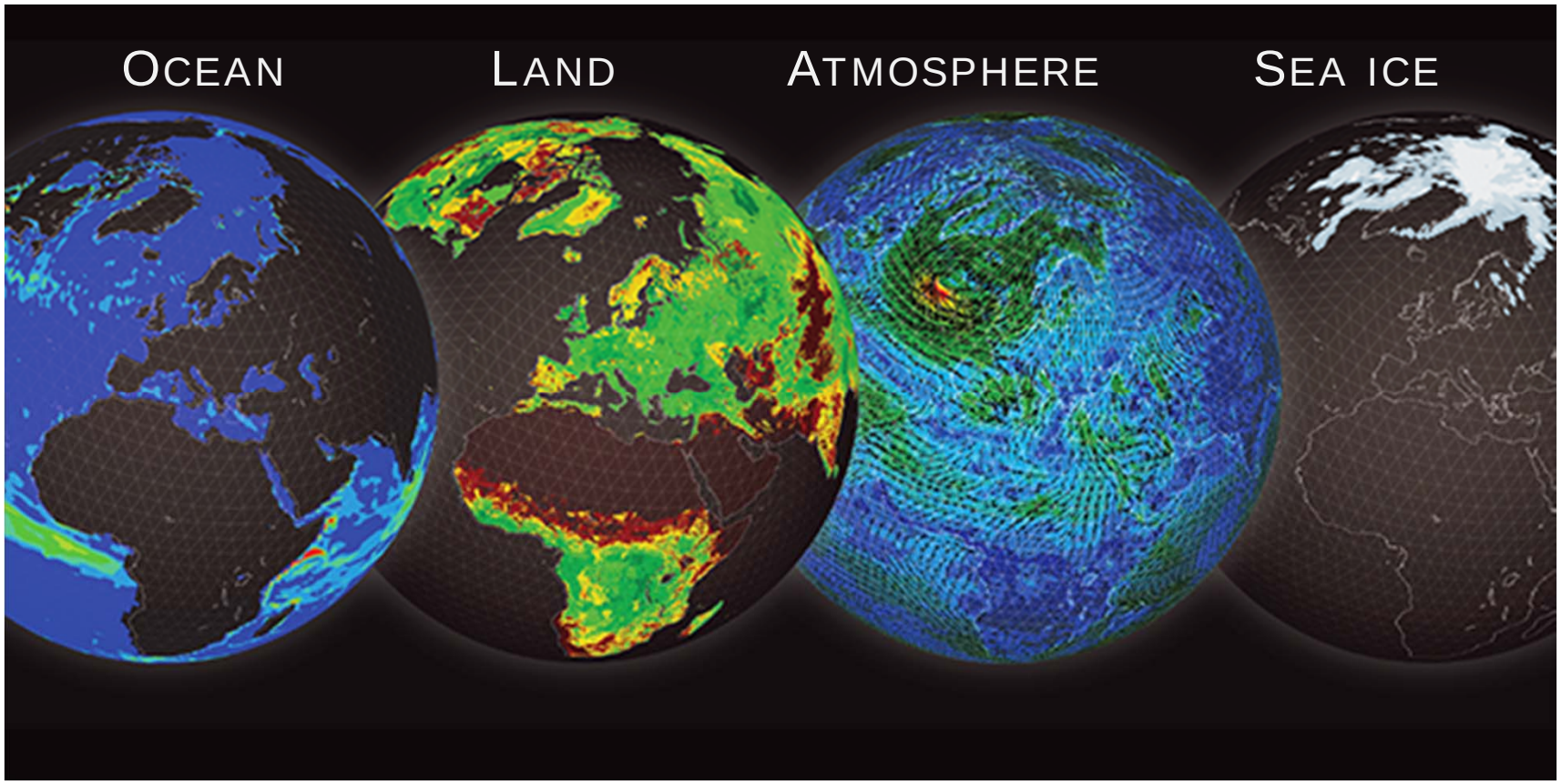
ISWG, Montreal, 15-17 July 2019

ECMWF land surface status

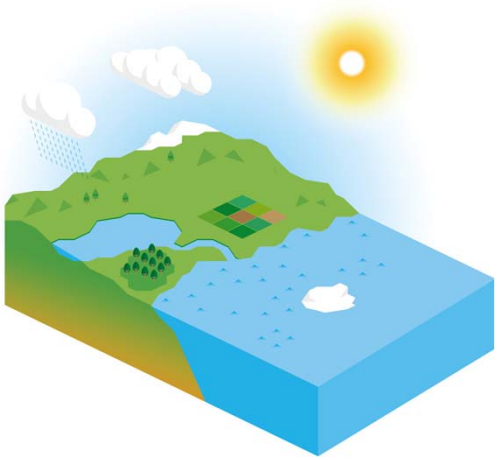
Patricia de Rosnay and Gianpaolo Balsamo

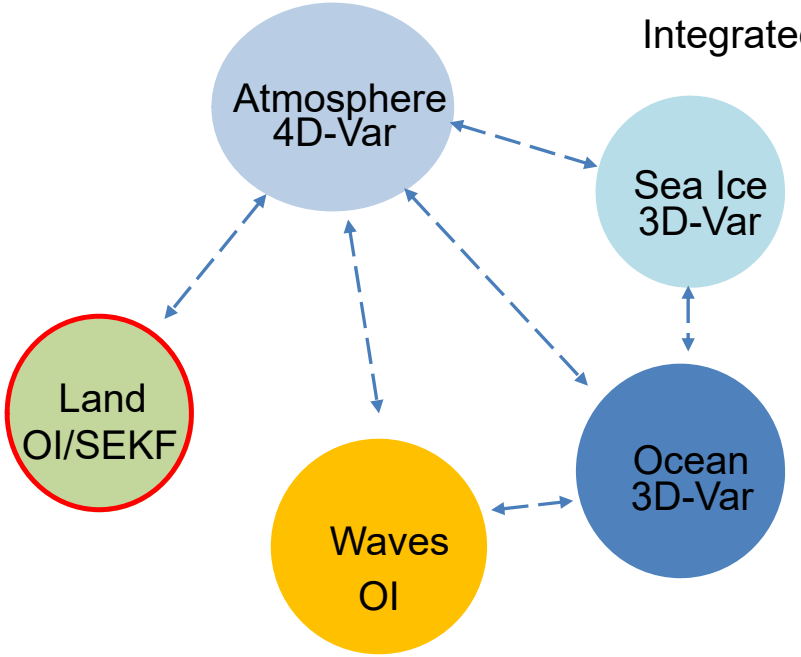
Thanks to the ECMWF coupled assimilation and coupled processes teams and many others

Embracing an Earth System approach



Embracing an Earth System approach

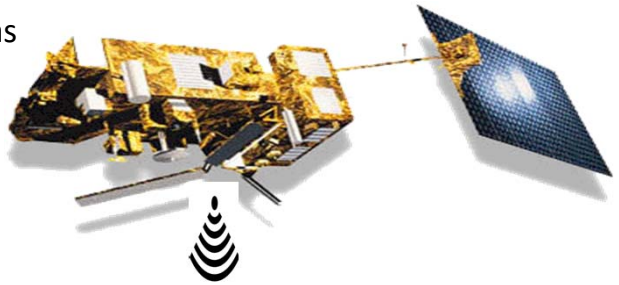




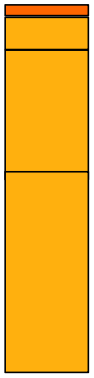
- Consistency of the infrastructure and coupling approaches across the different components
- Modularity to account for the different components in coupled assimilation

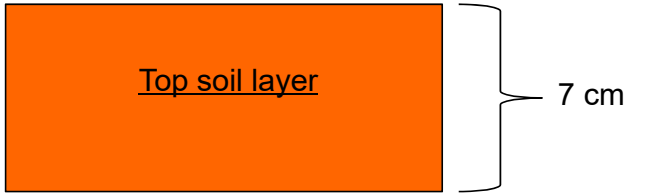
Increased soil model vertical resolution to improve use of satellite data

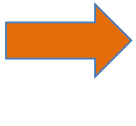
An enhanced soil vertical layer in H-TESSEL is motivated by land data assimilation as it shown to better correlate with satellite products of soil moisture.

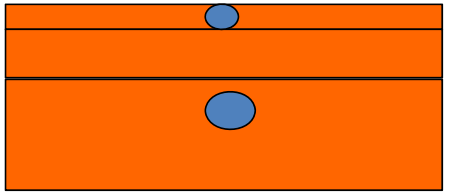


4-layers:
 # 0-7 cm
7-28 cm
28-100 cm
100-289 cm

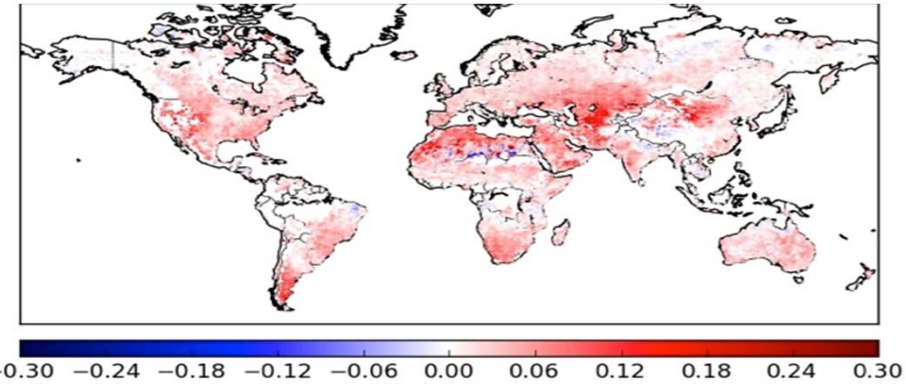








9-layers:
 # 0-1 cm
 # 1-3 cm
 # 3-7 cm
7-15 cm
15-25 cm
25-50 cm
50-100 cm
100-200 cm
200-300 cm



Comparison with ESA-CCI soil moisture remote sensing (multi-sensor) product.(1988-2014). A finer soil model improves the correlation with measured satellite soil moisture

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

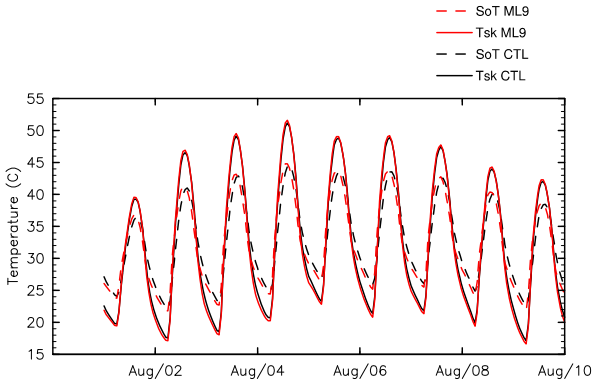
Thanks to Clément Albergel

See Dorigo et al. (2017 RSE)

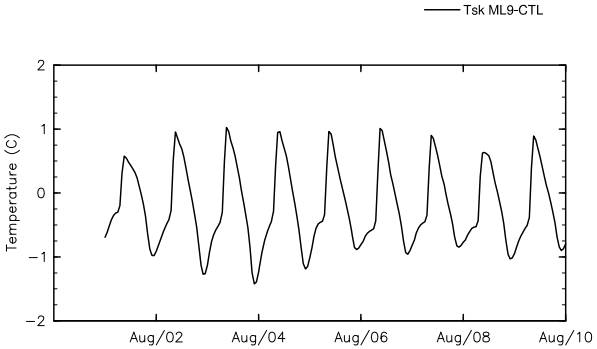
Impact of the soil model vertical resolution: heatwaves severity

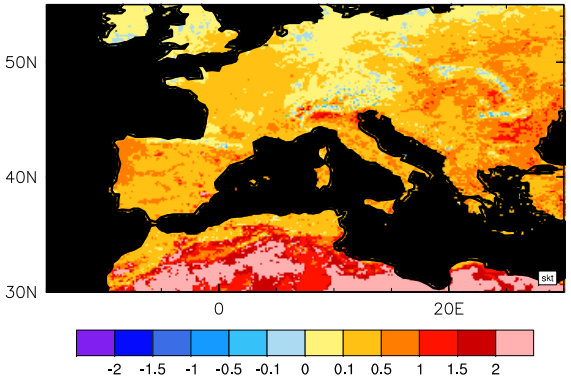
During summer 2017 the effect of multi-layer is examined for European heatwave, here shown for Cordoba (Spain) where temperatures went above 40º Celsius on the 6th of August 2017

ECMWF Land model ML9 & ML4 (offline)



Differenc ML9-ML4 soil mod (offline)





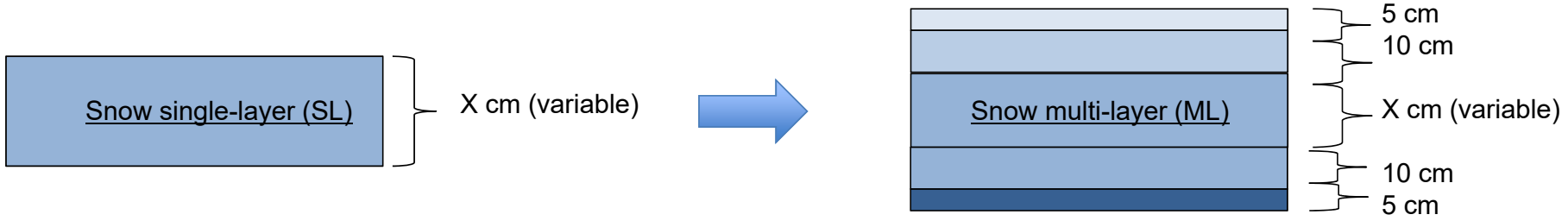
Differences in the maximum skin temperature ML9-ML4

enhanced soil vertical discretisation is increasing the amplitude the diurnal cycle. Extremes heatwave are up to 1 K hotter

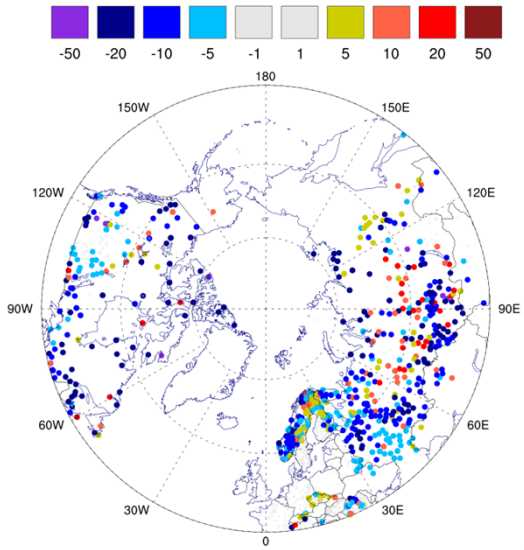
Thanks to Gabriele Arduini

Increased snow model vertical resolution: impact in cold regions climate

Increased vertical discretization of the H-TESSEL snowpack (**up to 5 layers**) permits a better physical processes representation

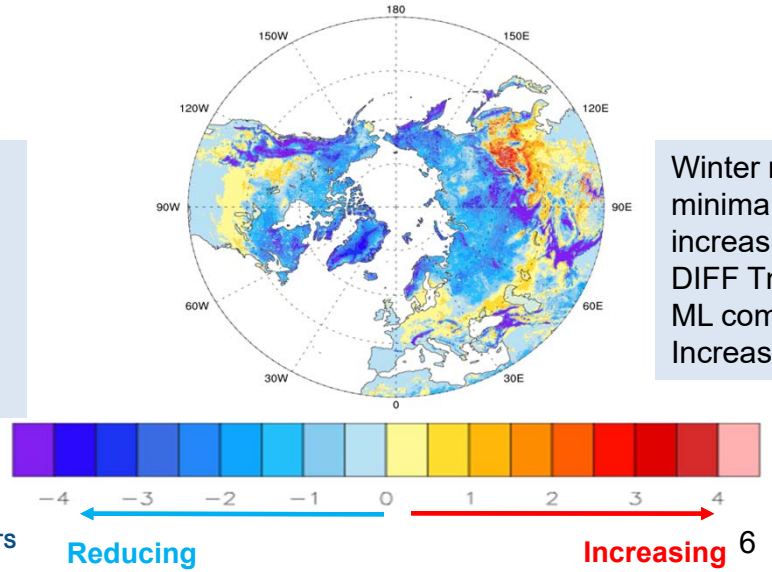


Difference ML- SL in Snow depth RMSE winter (DJF)



An improved snow depth (ML – SL) evaluated with in-situ SYNOP snow depth. RMSE of 0.19m (0.23m) in ML (SL).
This is 17% RMSE error reduction in snow depth.

Difference ML - SL in T_{skin} minimum winter (DJF)



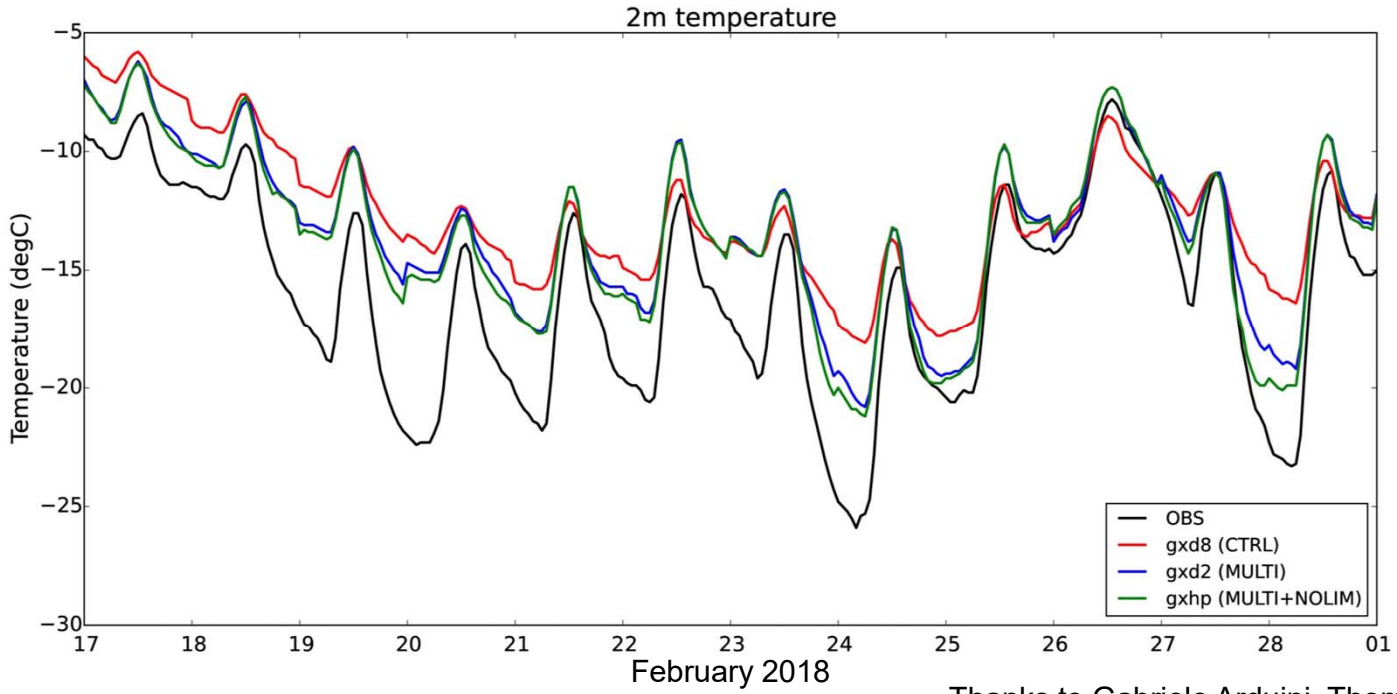
Winter reduction of the 2m minima temperatures with increasing diurnal-cycle. DIFF Tmin 2-4 K colder in ML compared to SL snow. Increased variability

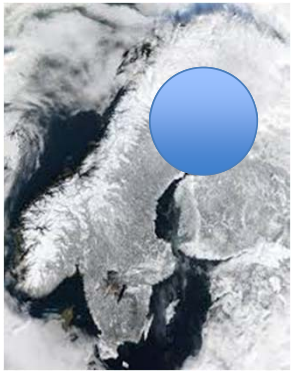
Thanks to Gabriele Arduini, Jonny Day, Linus Magnusson

Impact of snow model vertical resolution increase on near surface temperature

Increased vertical discretization of the snowpack (**up to 5 layers**) permits a better 2-m forecast: here hourly day-2 forecasts are shown for 24-hour to 47-hour ahead, concatenated to form a continuous time-series

T2m Observations, T2m forecast (current snow, SL), T2m forecast (ML)





In clear-sky the MULTI-layer snow scheme is capable to produce stronger winter inversions improving observation match.

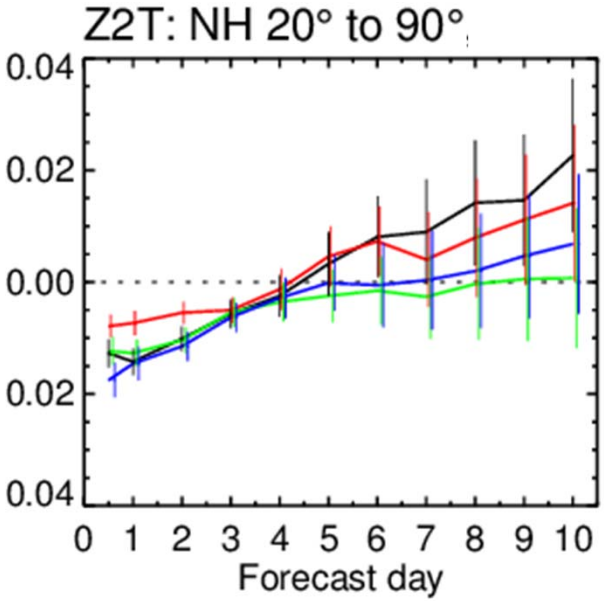
The increased variability in the diurnal cycle is beneficial for ensemble forecasting.

Thanks to Gabriele Arduini, Thomas Haiden, Irina Sandu & USURF Team

Snow data assimilation OSEs

Winter 2014-2015 (December to April) - Assess the impact of the snow observing system

Expts	SYNOP	National Data	IMS snow cover
0- OL (no snow data assimilation)			
1- Snow DA: SYNOP+IMS	✓		✓
2- Snow DA: SYNOP+Nat (all in situ)	✓	✓	
3- Snow DA SYNOP+Nat+IMS (all)	✓	✓	✓



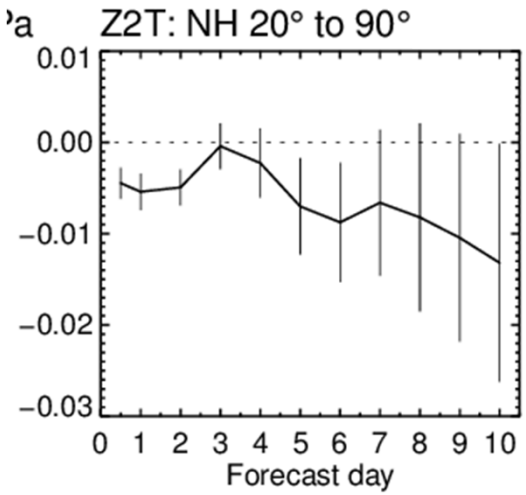
Impact on T2m Forecasts:
Normalized RMSE for T2m FC difference compared to the reference (OL)

SYNOP+IMS (1-0)
SYNOP+Nat (2-0)
SYNOP+Nat+IMS (3-0) -> oper

Best T2m Forecast when all observations, combining in situ and IMS, are assimilated.

Impact of IMS snow cover assimilation (case 3-2)

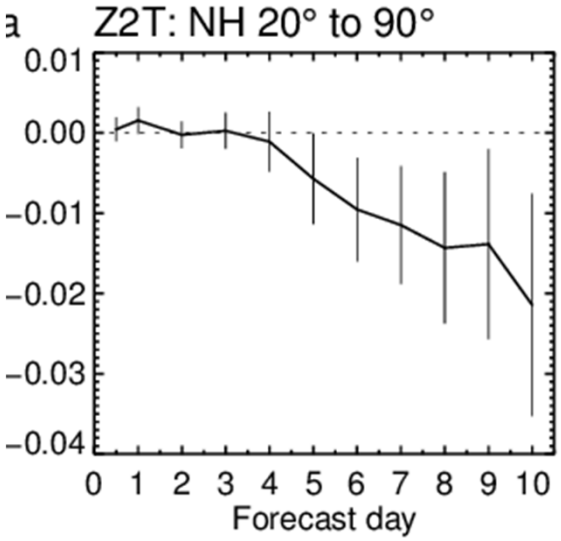
Wednesday:
More on IMS DA impact



All data assimilated (Synop+Nat+IMS)
compared to all in situ data assimilated (SYNOP+Nat)
-> Further T2m forecasts error reduction,
significant at short range

Impact of National data (case 3-1)

All data assimilated (SYNOP+Nat+IMS)
compared to SYNOP+IMS assimilation
-> Further T2m forecasts error reduction at medium range



Contribution & complementarities of each observation types to improve T2m forecasts at short and medium ranges

Multi-layer forward emission

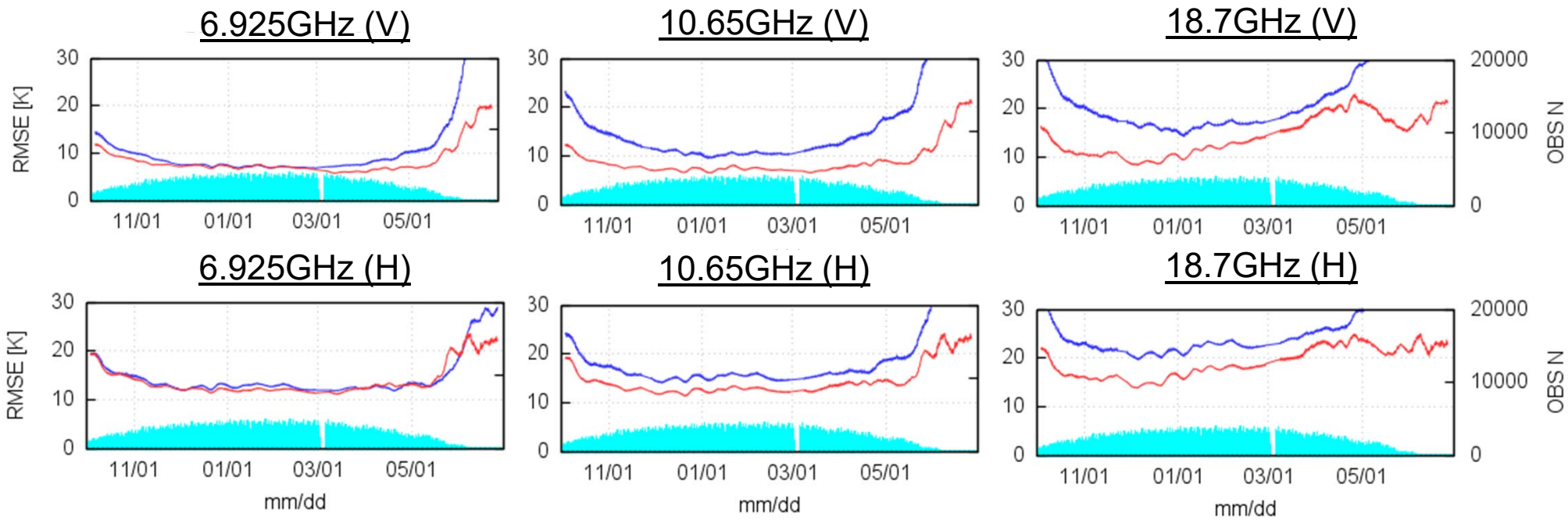
Towards coupling through the observation operator

HTESSEL-ML5:HUT-M
HTESSEL-SL1:HUT-S

Single vs Multi-layer snow pack (H-TESSEL) & emission (CMEM/HUT)

STDV of TB(OBS) – TB(CMEM)
snow-covered area [Global] (w/o glacier)
1 Oct 2017 – 30 Jun 2018

Wednesday:
Presentation by
Yoichi Hirahara

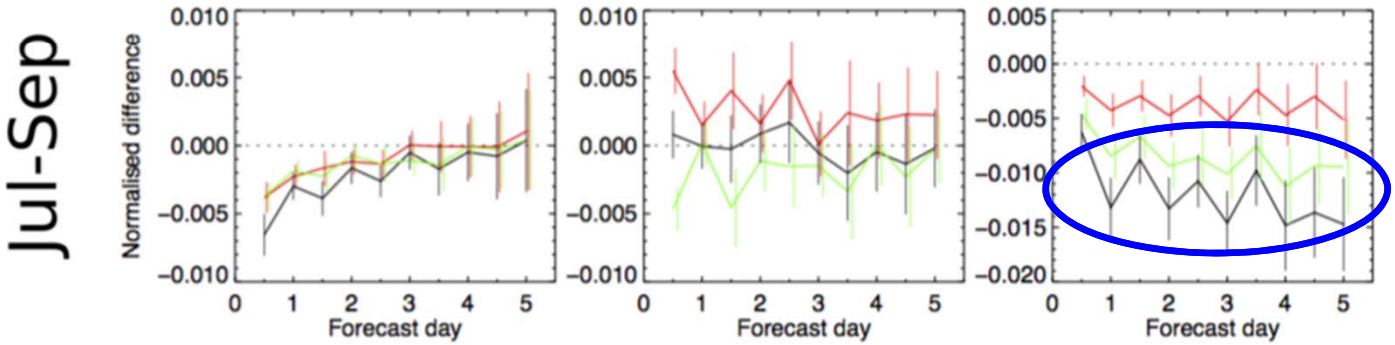


ECMWF

SMOS Neural Network (NN) Soil Moisture assimilation in H-TESSEL

NN trained on offline H-TESSEL runs forced by ERA-Interim

Impact on two-meter air temperature forecasts (JAS 2012)
(Reference H-TESSEL with no assimilation: Open Loop 'OL')



SMOS+SYNOP -OL
SMOS only-OL
SYNOP only-OL

- Offline soil DA research tool (24h DA window, uncoupled model, uncoupled atmosphere, B)
- No screen level, soil temp & snow analysis
- Uses of ERA-Interim Screen analysis as inpu 'SYNOP'
- Stand-alone atmospheric forecasts

→ Proof of concept of SMOS NN assimilation for NWP initialisation

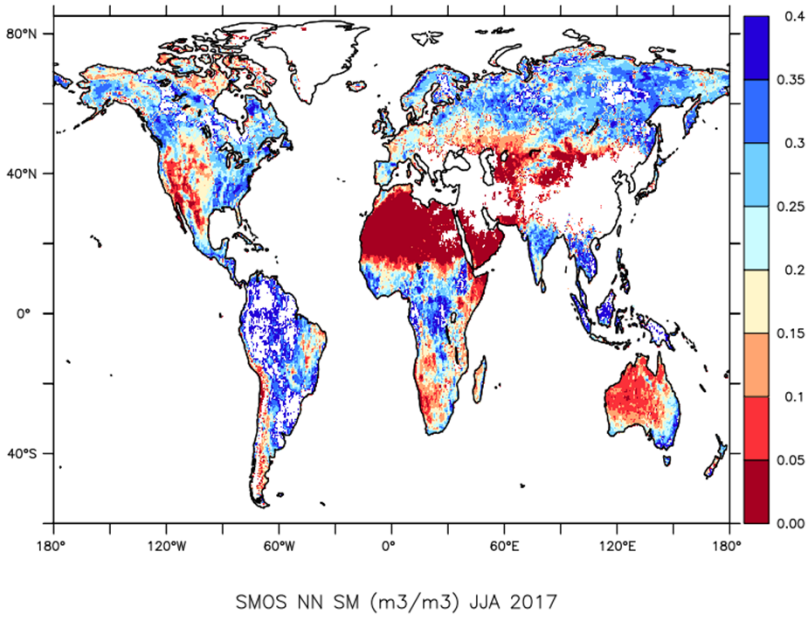
Rodriguez-Fernandez et al, Remote Sensing, 2019

ECMWF

SMOS Neural Network (NN) Soil Moisture assimilation in the IFS

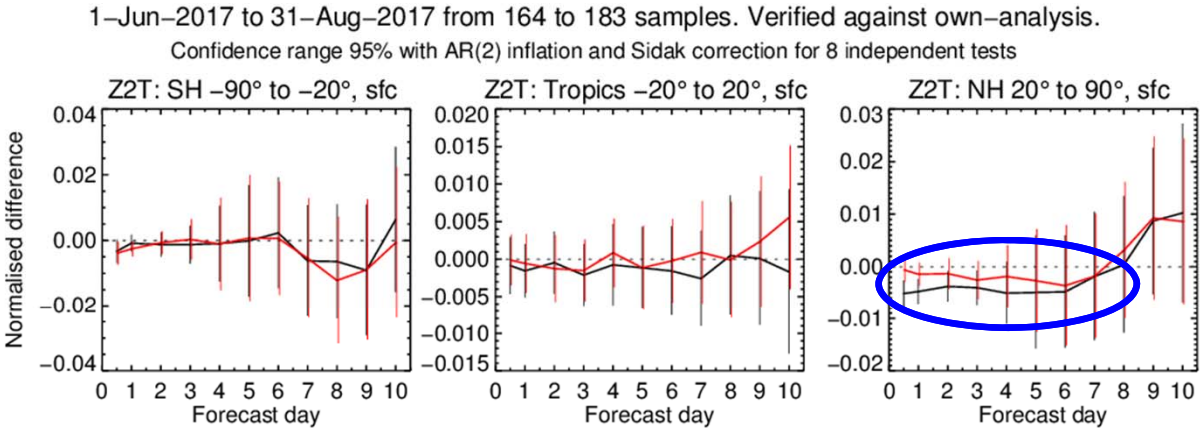
EC SMOS: NN trained on operational IFS

Implemented in the IFS with the new EDA-SEKF soil analysis



SMOS NN SM (m3/m3) JJA 2017

Atmospheric impact (T2m)



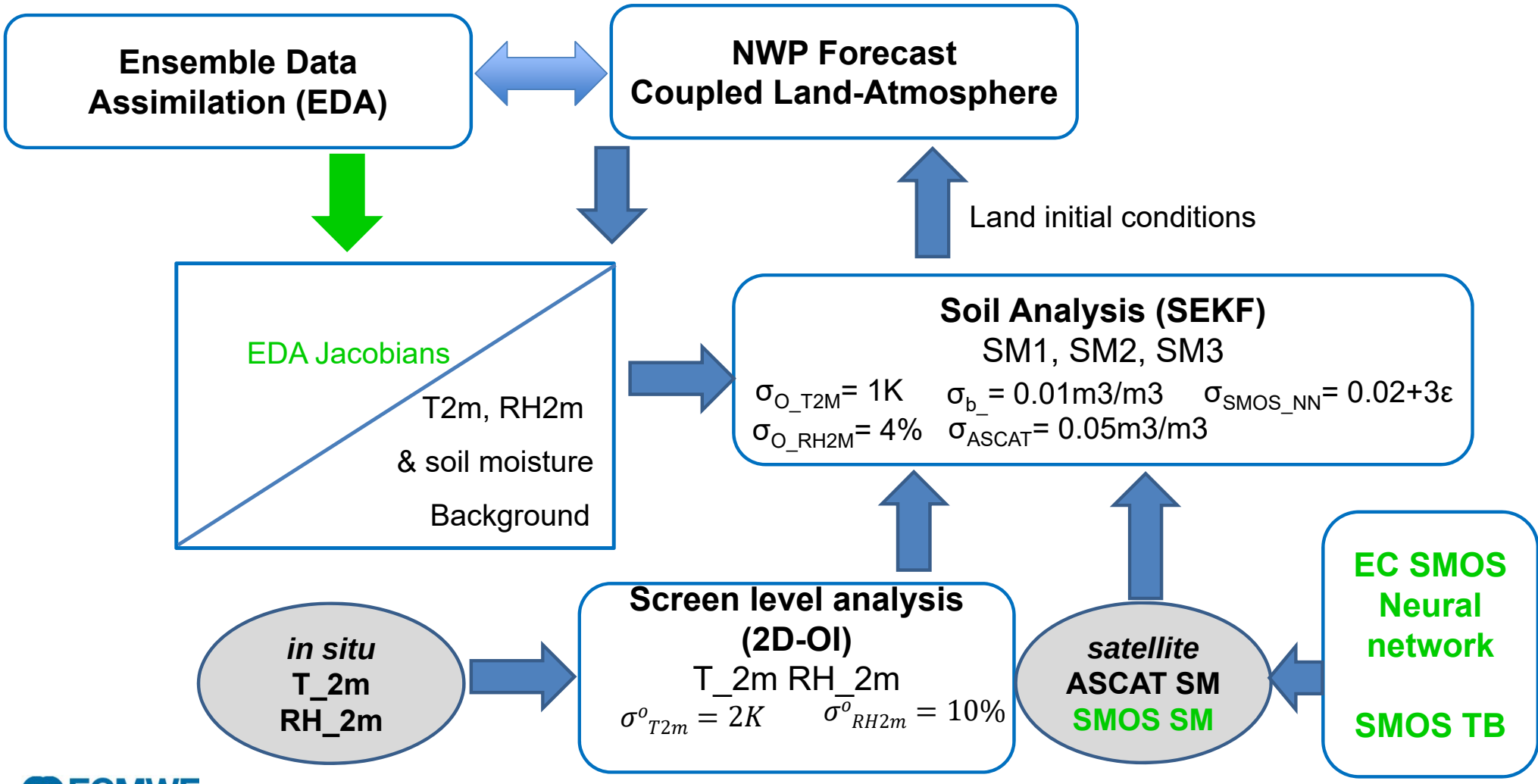
EDA&SMOS - CTRL

SMOS – CTRL

(CTRL: IFS cycle 45r1)

de Rosnay et al, in prep, 2019

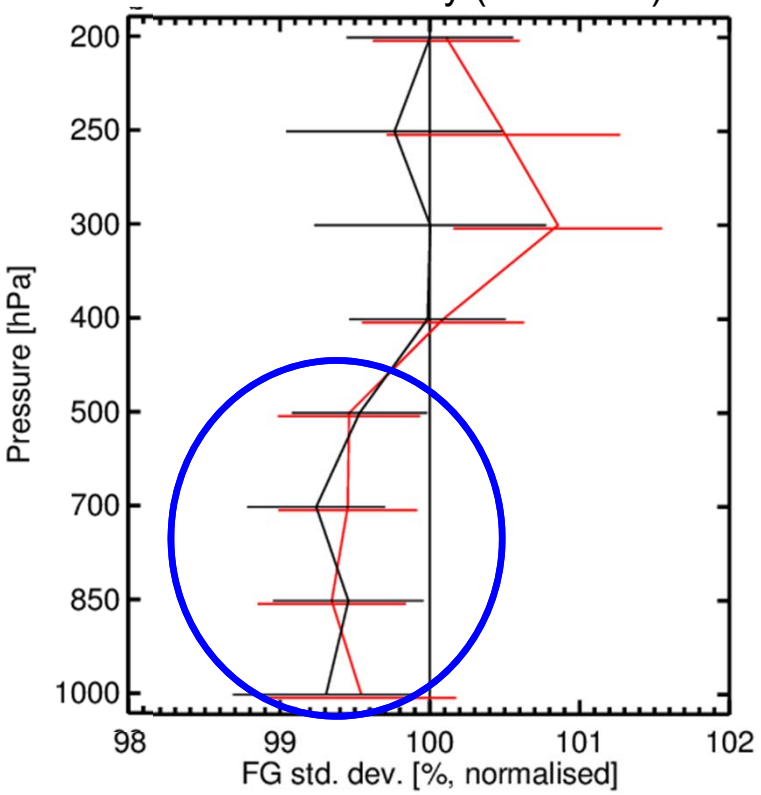
IFS implementation 46r1 (oper 11 June 2019): EDA-SEKF and SMOS NN



de Rosnay et al, in prep, 2019

IFS impact (EDA-SEKF and SMOS neural network)

Aircraft humidity (JJA 2017)

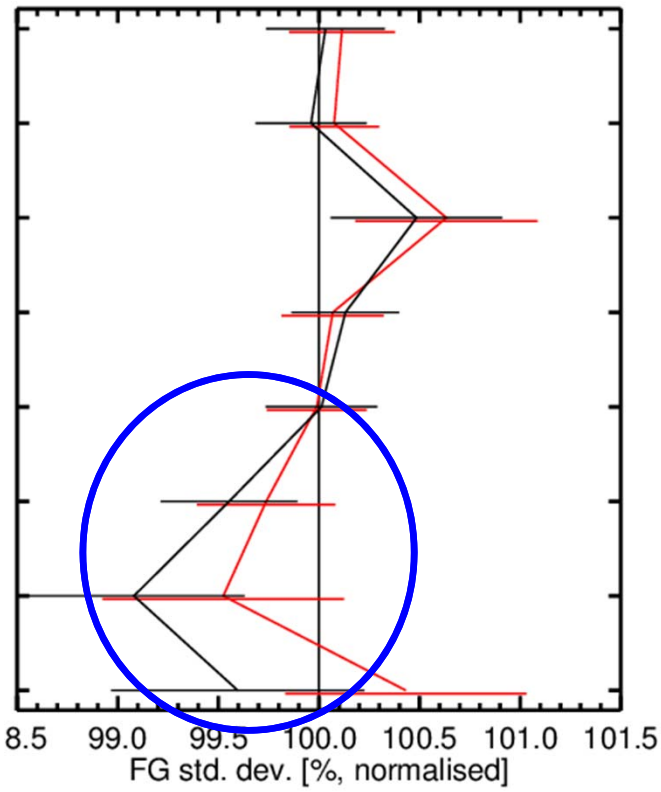


SMOS impact

EDASEKF+SMOS impact

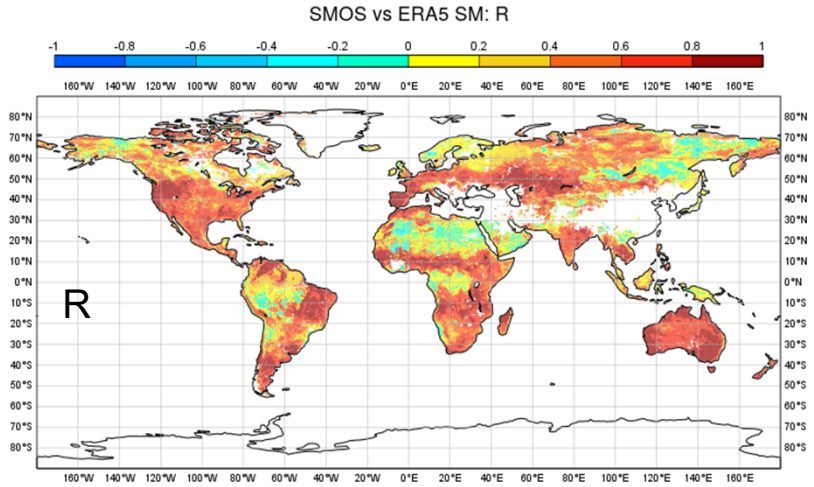
Improved fit
low troposphere

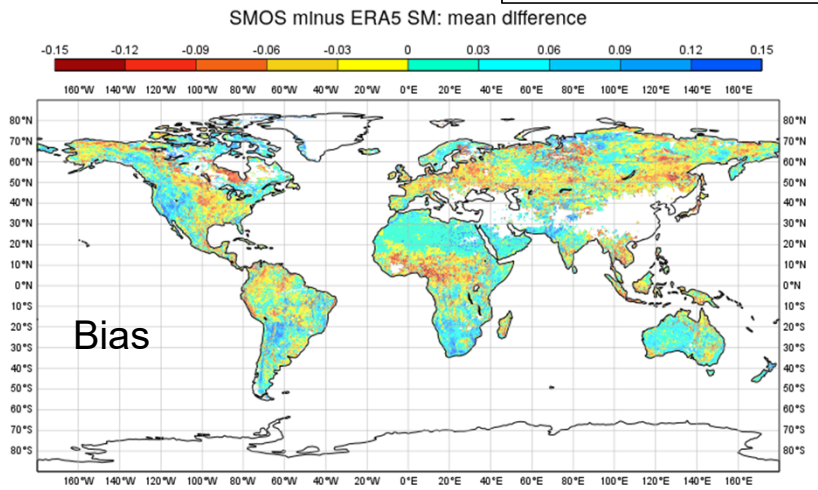
Aircraft temperature (JJA 2017)

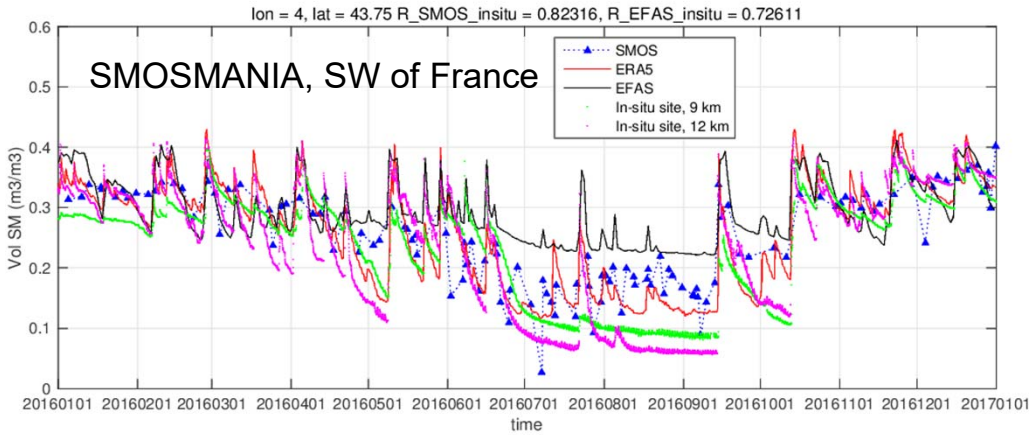


ECMWF SMOS Neural Network soil moisture compared to ERA5 in 2016

NN trained on operational IFS





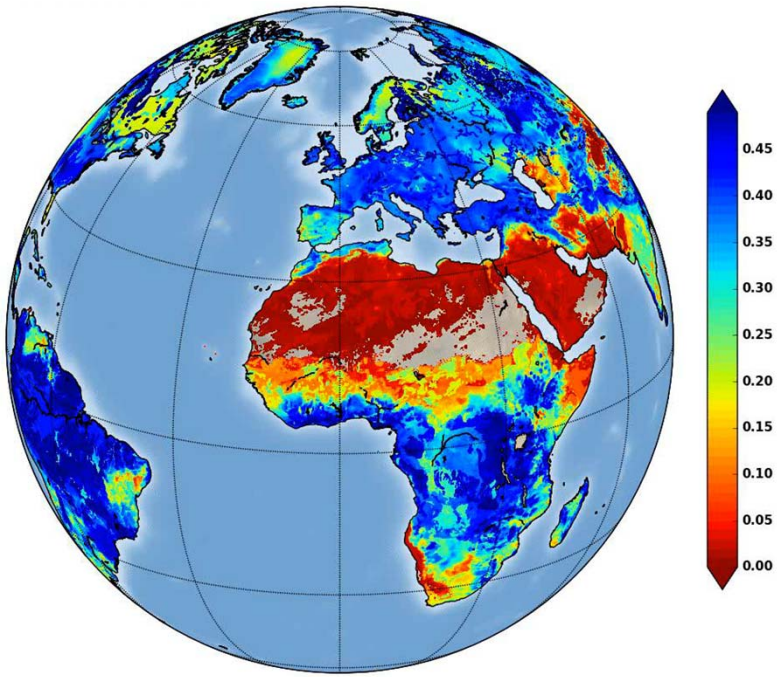


Comparison with the European Flood Alert System (EFAS) soil moisture

Lawrence et al. ECMWF/ESA report 2019

ERA5 reanalysis replaces ERA-Interim from 2019

ERA5, two operational land products:



Land of ERA5: 31km with coupled land-atm. data assimilation

ERA5-Land: 10km without land data assimilation

	ERA-Int	Era-Int/Land	ERA5	ERA5-Land
Period covered	Jan 1979 – NRT(*)	Jan 1979 – Dec 2010	Jan 1979 - NRT	Jan 1979 - NRT
Spatial resolution	~79km / 60 levels	79 km	~32 km / 137 levels	~9 km
Model version	IFS (+TESSEL)	HTESSEL cy36r4	IFS (+HTESSEL)	HTESSEL cy43r1
LDAS	cy31r1	NO	cy41r2	NO
Output frequency	6-hourly Analysis fields	6-hourly Analysis fields	Hourly (three-hourly for the ensemble)	Hourly (three-hourly for the ensemble)

Hersbach et al., in prep 2019

Summary and outlook

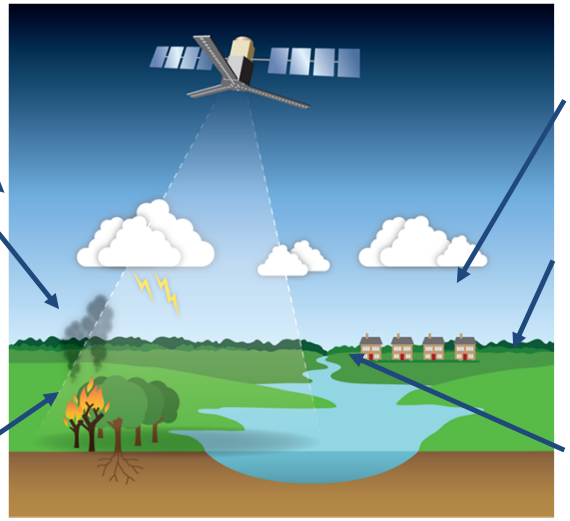
- Earth system approach → Coupling land-atmosphere-hydrology-ocean for NWP and reanalysis
- Multilayer model and DA, land surface mapping, SMOS NN DA, EDA-SEKF, ……
- The CO2 Human Emission EU-funded Project will drive forward requirements for a global km-scale Monitoring System (Gianpaolo Balsamo's talk tomorrow)

FIRE

Identify dry lightning ignition potential

Modulation of fire emissions

SMOS biomass load → fuel for burning



FLOOD

SMOS, ERA5, EFAS benchmarking

EFAS (Europe) & GloFAS (global) flood forecast systems initialisation

Flood forecasts and the role of soil moisture excess

Copernicus Emergency and Management Service(CEMS)

Satellite inspired hydrology in an uncertain future: an H SAF and HEPEX workshop

Expand all Collapse all

ECMWF | Reading | 25-28 November 2019

https://www.ecmwf.int/en/learning/workshops/satellite-inspired-hydrology-for-an-uncertain-future

ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

9th EARSeL workshop on Land Ice and Snow

Remote Sensing of the Cryosphere: Monitor what is vanishing

03 - 05 February 2020, Bern, Switzerland

Call for Papers

You are cordially invited to attend the 9th Workshop on Remote Sensing of Land Ice and Snow of the European Association of Remote Sensing Laboratories (EARSeL), which will be held at the Institute of Geography, University of Bern, Switzerland, from **03 - 05 February 2020**.

Bern – capital of Switzerland and UNESCO world heritage

http://www.earsel.org/SIG/Snow-Ice/workshop/call.php