EUMETSAT
H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

The stand-alone surface analysis and ASCAT SM bias correction

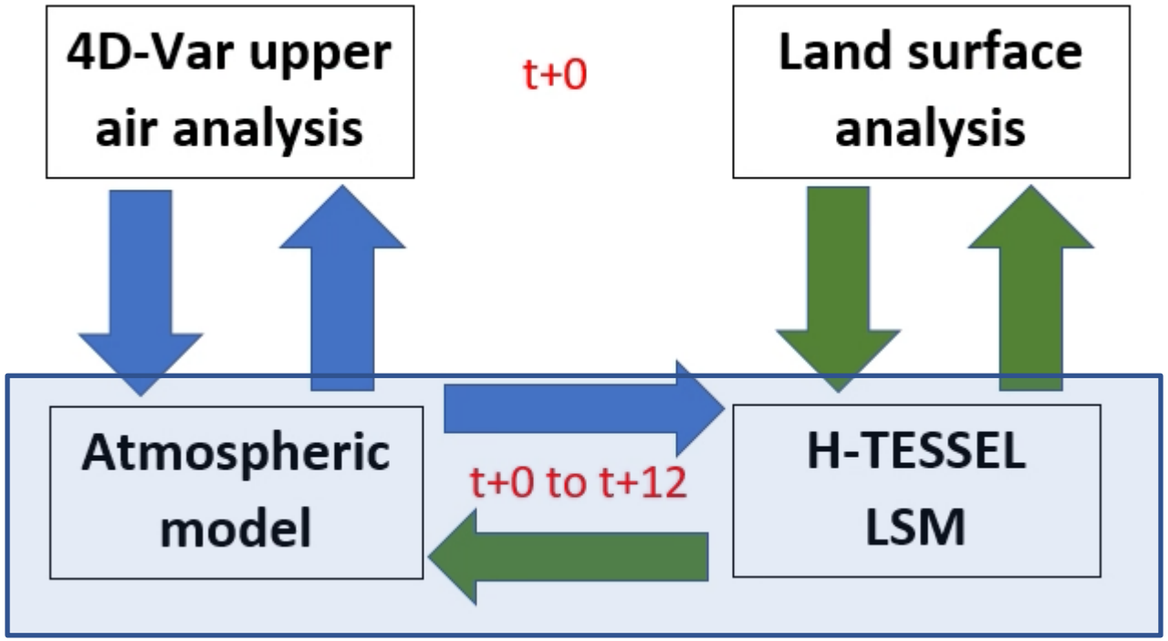
UKMO meeting, December 2020

David Fairbairn, Patricia de Rosnay, Phil Browne

EUMETSAT
H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

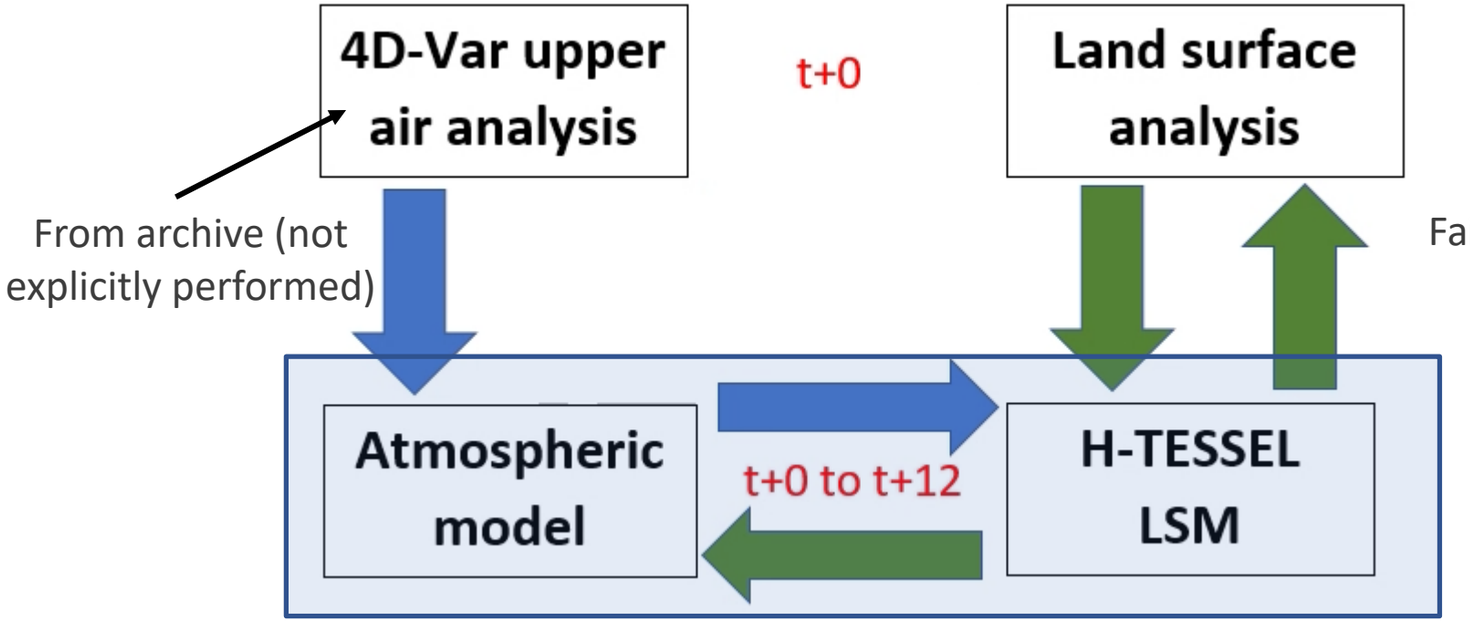
The stand-alone surface analysis (SSA)

WCDA system at ECMWF



- Analyses performed independently at the start of each 12-hour assimilation window
- Coupling provided by first guess forecasts between assimilation cycles
- WCDA also implemented at Meteo-France, UK Met Office, Environment Canada etc…

Stand-alone surface analysis (SSA)



- Atmospheric analysis forced from an archived experiment
- Coupled forecast model between cycles but no feedback to atmospheric analysis
- SSA is in-between WCDA and offline land DA in terms of coupling/computational cost

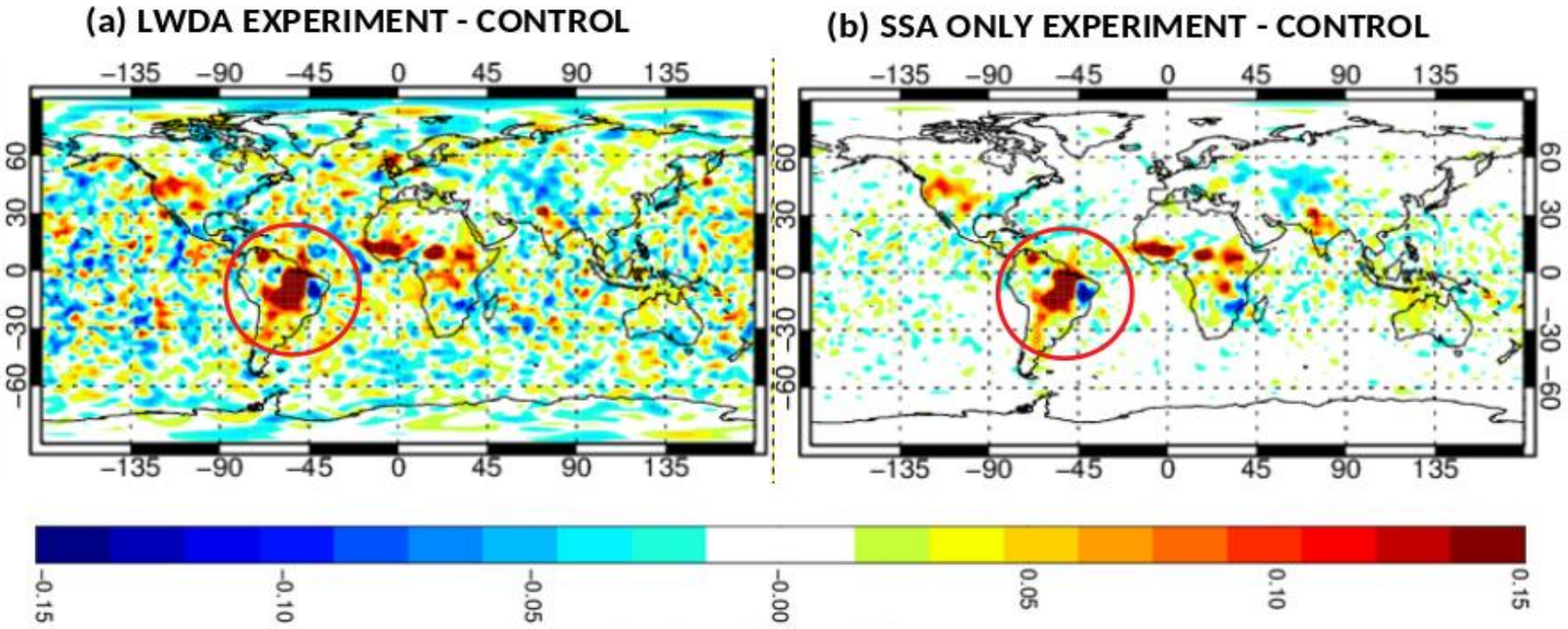
EUMETSAT
H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

NWP research with SSA

Impact on atmos forecasts

EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

- Validation of 48 hour 850 hPa temperature forecasts against operational analysis when doubling SLV observation errors in WCDA and SSA relative to control.
- Most significant degradation in WCDA dRMSE (plot a) captured by SSA (plot b).
- Impacts have been captured by SSA for snow changes as well (not shown)



Fairbairn, David, Patricia de Rosnay, and Philip A. Browne. "The New Stand-Alone Surface Analysis at ECMWF: Implications for Land–Atmosphere DA Coupling." *Journal of Hydrometeorology* 20, no. 10 (2019): 2023-2042.

EUMETSAT
H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

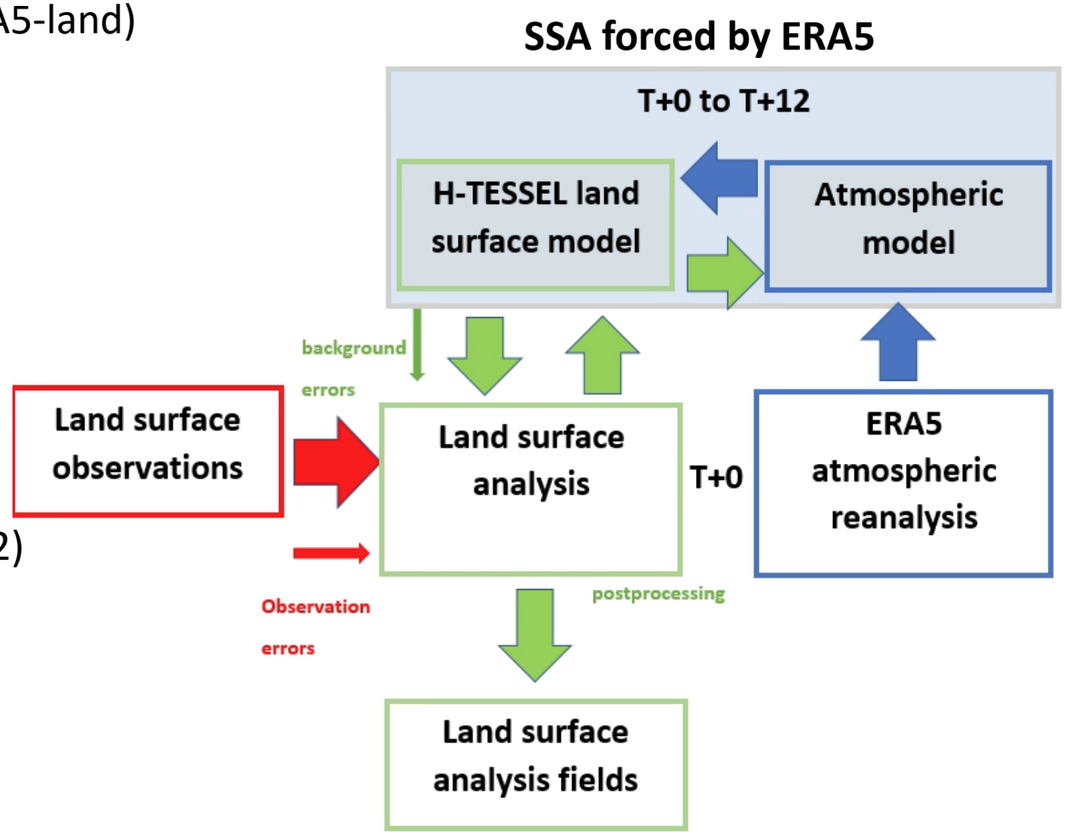
Land reanalyses with SSA

- There are currently 3 options for land reanalyses at ECMWF:

1. Offline surface model forced by atmospheric reanalysis (e.g. ERA5-land)
   - ☺ Allows enhanced surface model/resolution
   - ☹ No land-atmosphere coupling and no land DA

2. Offline soil moisture DA (e.g. H SAF soil moisture data records)
   - ☺ As (1), but offline soil moisture analysis included

3. Stand-alone surface analysis (SSA, Fairbairn *et al*., 2019)
   - ☺ Full land DA system in IFS (soil moisture, snow, etc…)
   - ☺ Coupled land-atmosphere model
   - ☹ Significantly more computationally expensive than (1) and (2)



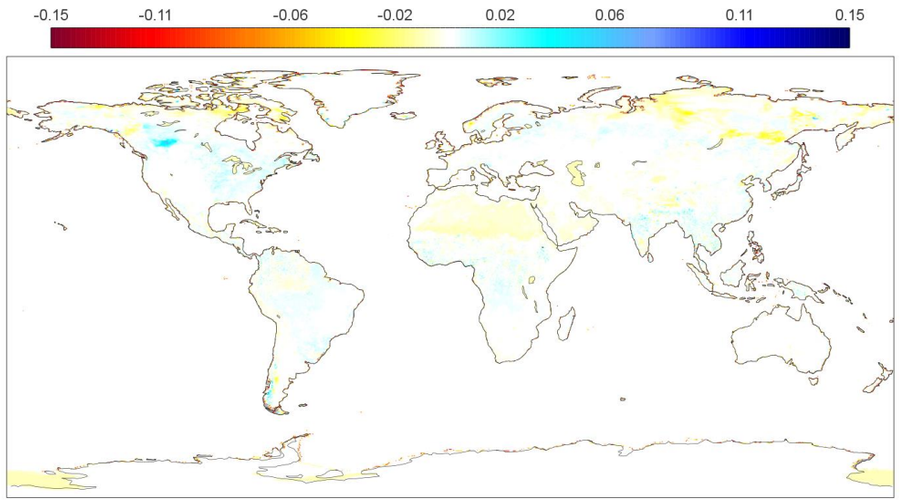
D. Fairbairn, P. de Ronsay, and P. Browne, "The new stand-alone surface analysis at ECMWF: Implications for land-atmosphere DA coupling," *J. Hydrometeor*, 2019. https://doi.org/10.1175/JHM-D-19-0074.1

Impact of land DA

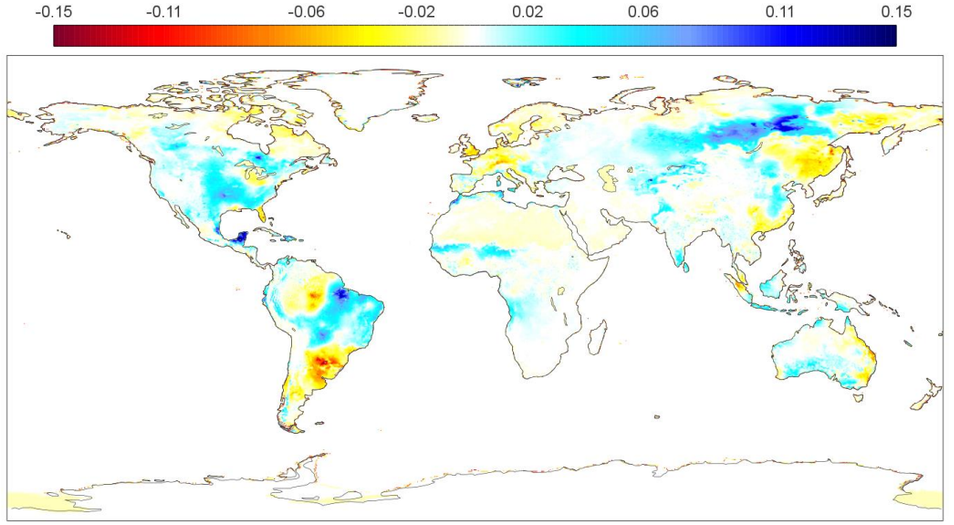
Experiment type	Configuration (47r1, Tco399)
Exp1	IFS with no land DA
Exp2	Offline surface model forced by Exp2
Exp3	IFS with land DA
Exp4	Offline surface model forced by Exp3
Exp5	SSA forced by exp3

Differences in soil moisture layer 3 (m3/m3) after 3 months cycling (30/9/2019):

Exp1 – Exp2



Exp3 – Exp4



Exp5 – Exp3

Bit-identical

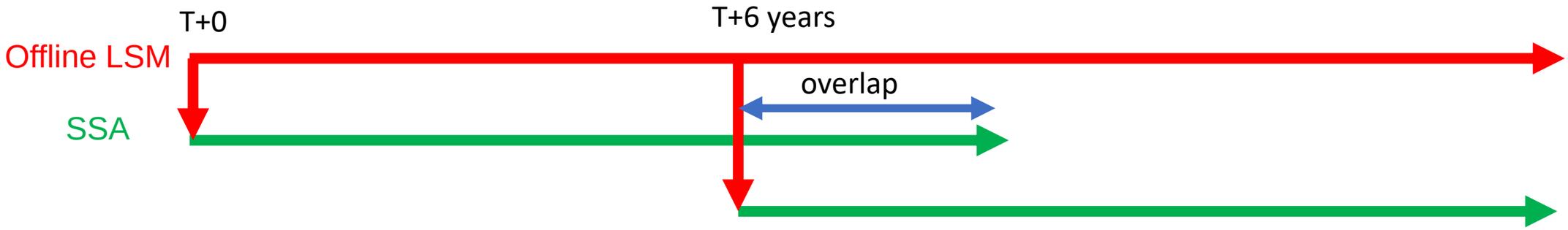
How to run affordable SSA reanalyses

EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

- Expected SSA speed at Tco 399 (25 km res) for cycle 48r1:

Reanalysis length	Time taken (approx.)
1 year	3 weeks
10 years	6 months

- Land surface reanalyses (e.g. ERA5-land, reforecasts): 30 years in approx 6 months computing time
- Proposed solution (cc Gianpaolo Balsamo, Gabriele Arduini): Run offline surface model and use it to initialize overlapping SSA streams.
- Essential that overlap accounts for memory of land surface fields – at least one year is needed



EUMETSAT
H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

ASCAT SM bias correction

CDF matching bias correction

EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

- SEKF method assumes observations are unbiased with respect to model climatology – designed to correct random errors rather than systematic errors;
- ECMWF employs a linear CDF matching (Scipal et al., 2008): first two moments of the observation CDF are rescaled to match the model equivalent
  - Slope *B* and intercept *A* calculated from standard deviations and means of model *x* and observations *y* over climatological period (typically 5 years or more):

$$B = \frac{\sigma_x}{\sigma_y}$$

$$A = \bar{x} - B\bar{y},$$

- Rescaled scatterometer observations ($\hat{y}$):

$$\hat{y} = A + B.y$$

- Seasonal CDF matching employed using 3-month moving average (Draper et al., (2009); Barbu et al., (2014))

- By design, CDF matching converts units of ASCAT from soil wetness index to volumetric.

CDF matching bias correction

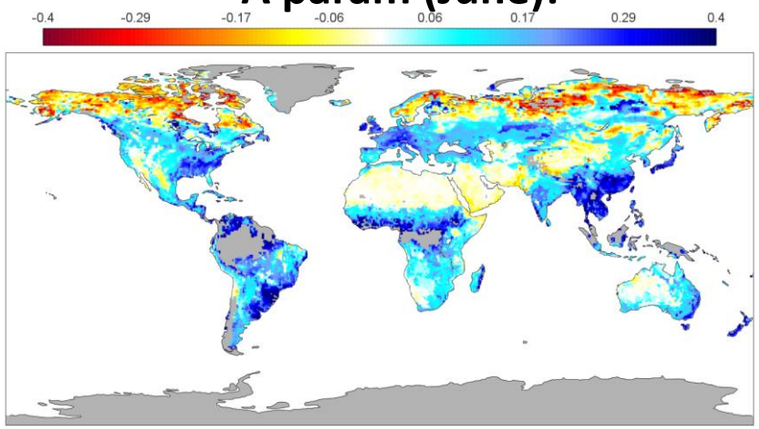
EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

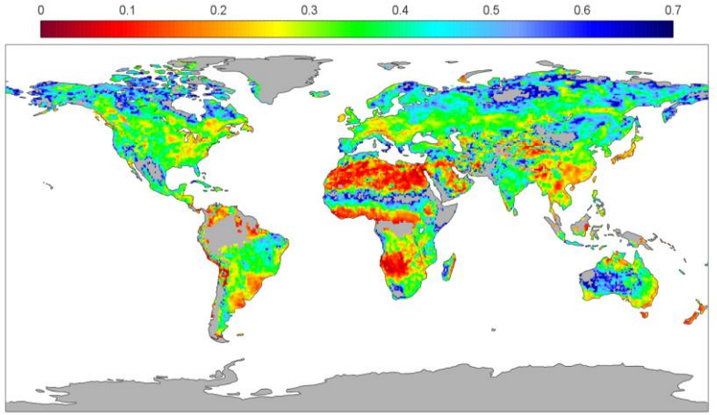
- CDF matching parameters in H141 based on ERA-Interim, ERS/SCAT (1992-1999) and ASCAT-A (2007-2009) data
- Recalibrated parameters using ERA5 and ASCAT-A/B data from 2009 to 2018

A param (June):

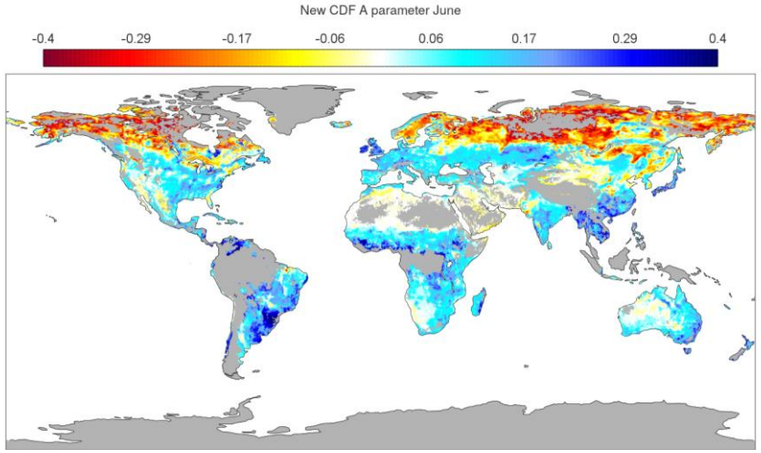
B param (June):

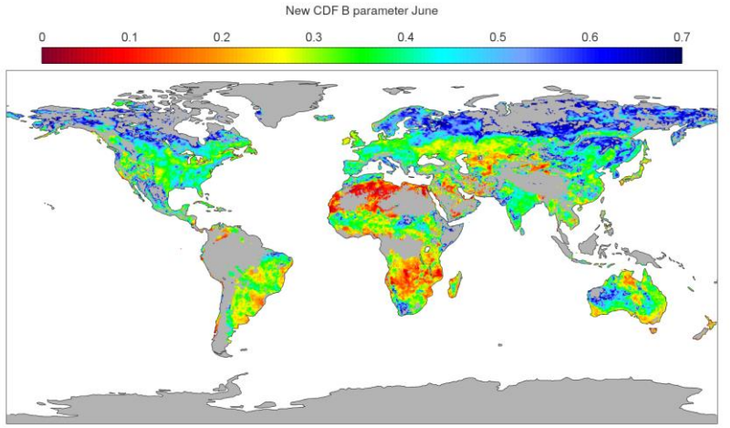
Current:





New:



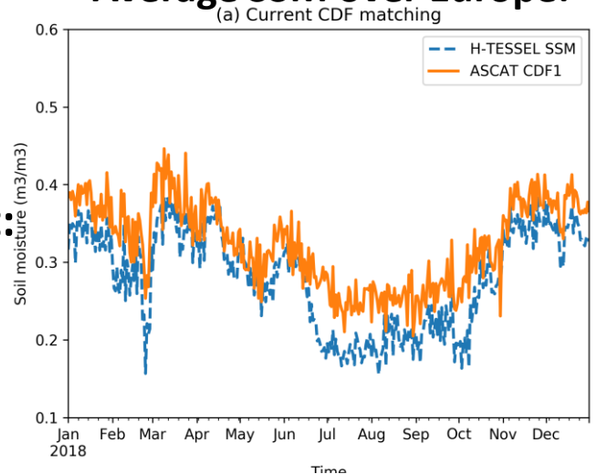


ASCAT soil moisture bias correction

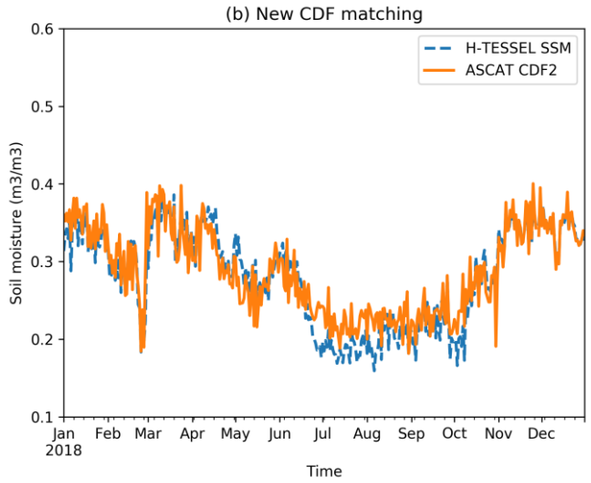
- Reduction in fg departures and low level RH2m mean forecast errors (evaluated over June-September 2020)
- Adaptive bias-correction to be explored in 2021

Average SSM over Europe:

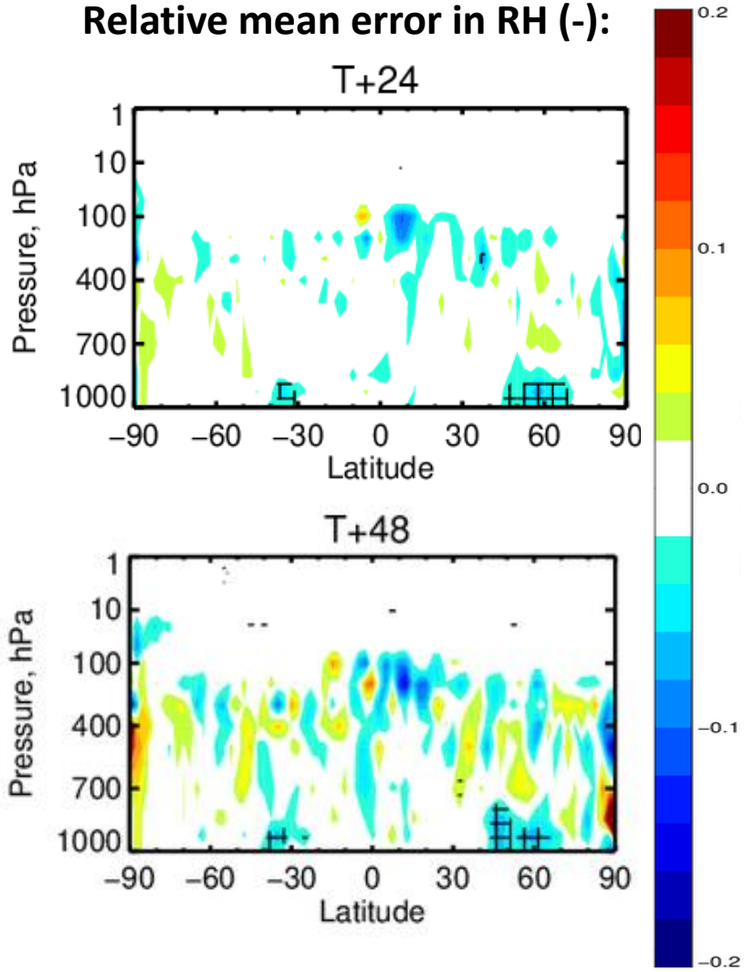
Current:



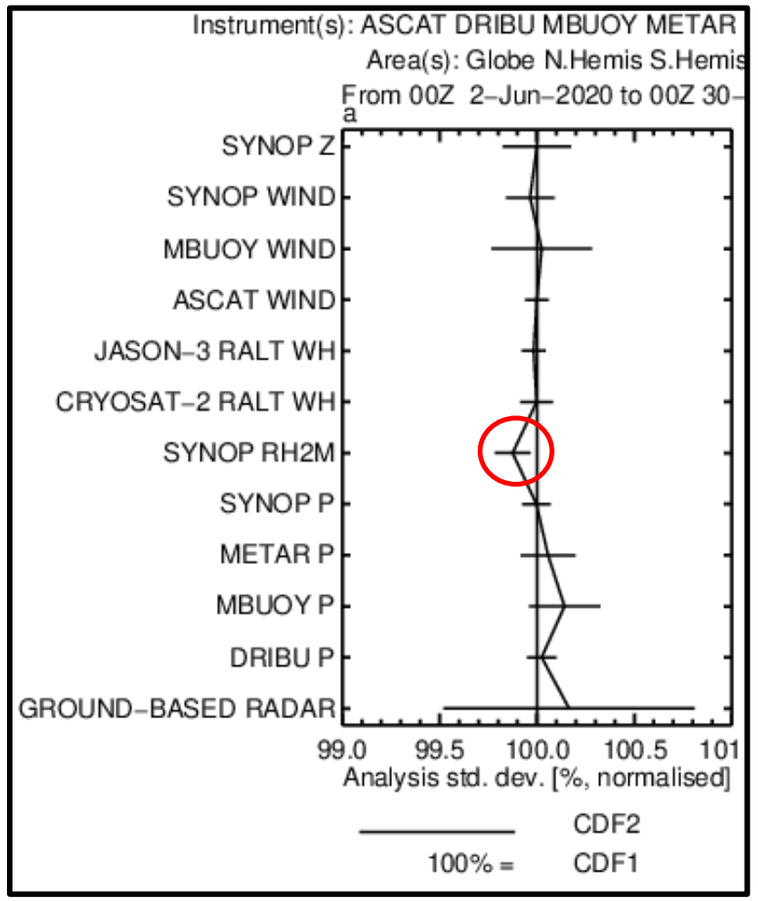
New:



Relative mean error in RH (-):



Obstat scores



Summary and other news

EUMETSAT H SAF
SUPPORT TO OPERATIONAL HYDROLOGY AND WATER MANAGEMENT

- SSA equivalent to WCDA but 4D-Var atmos analysis not explicitly performed
  - SSA much faster than WCDA
  - SSA lacks feedback to atmos analysis
- SSA shown to replicate impacts from major land surface changes in atmos forecast scores
- There are currently 3 options for land reanalyses at ECMWF:
  1. Offline land surface model (forced by atmos. Reanalysis): Enhanced model but no land DA
  2. Offline SM analysis: As (1) with offline SM analysis included
  3. SSA: Full land DA and coupled model but more expensive than (1) and (2)
- Method 3 is preferable, but needs efficiency improvements e.g. multiple streams
- ASCAT soil moisture CDF matching bias correction updated (validation in progress)
- Adaptive ASCAT SM bias correction will be explored using offline SM analysis (method 2 above)