SMOS PM meeting 21-04-15

- Operational work for CY41R2
- Data assimilation experiments
- Progress on the T_B processor for the Neural Network

ECMWF

Operational work for CY41R2 - Summary

☑ Scientific contribution:

- Introduced mixed-layer lake temperature in the SMOS observation operator,
- Created structure to introduce a 3D background error in the soil moisture analysis as a function of soil texture and soil depth,
- Different incidence angles for operational monitoring and assimilation allowed with ODB interface,
    - Optional arguments in general GETDB group of functions introduced,
    - SQL queries for SMOS rewritten compatible with new arguments
- Feedback to ODB to monitor ”bias corrected first-guess”,

☑ Technical contribution

- New structure to use SMOS data assimilation in operations, compatible with structure and time operational constraints.
    - New python definition file with new presatsekf task
    - New 'SMOS' python class in dictionary of computing resources

+ code maintenance and bug-fixing !!

Lake implementation in the forward operator

- Introduction of mixed-layer lake temperature, iced lake temperature and lake ice depth variables in SMOS structure in IFS and in the observations operator:

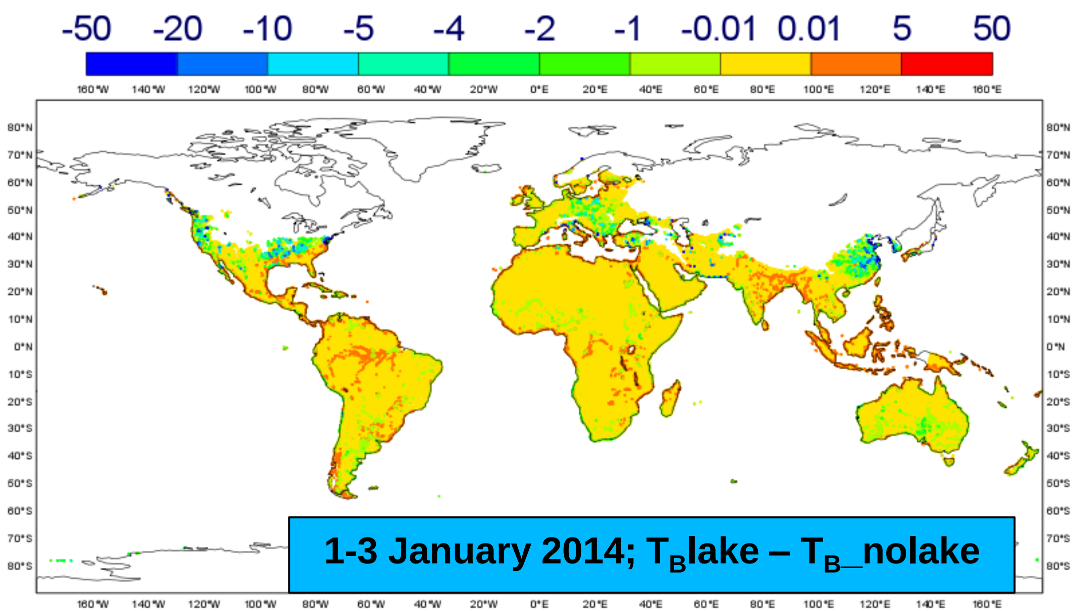
```
DO JL=DIMS%KIDIA,DIMS%KFDIA
        YL_SMOS_PHYS(JL)%TLK = PSURF%PSP_SL (JL,YSP_SL%YLMLT%MP9)
        …
        …
ENDDO
```

→ **For water tile, effective temperature is mixed-layer lake temperature instead of skin temperature,**

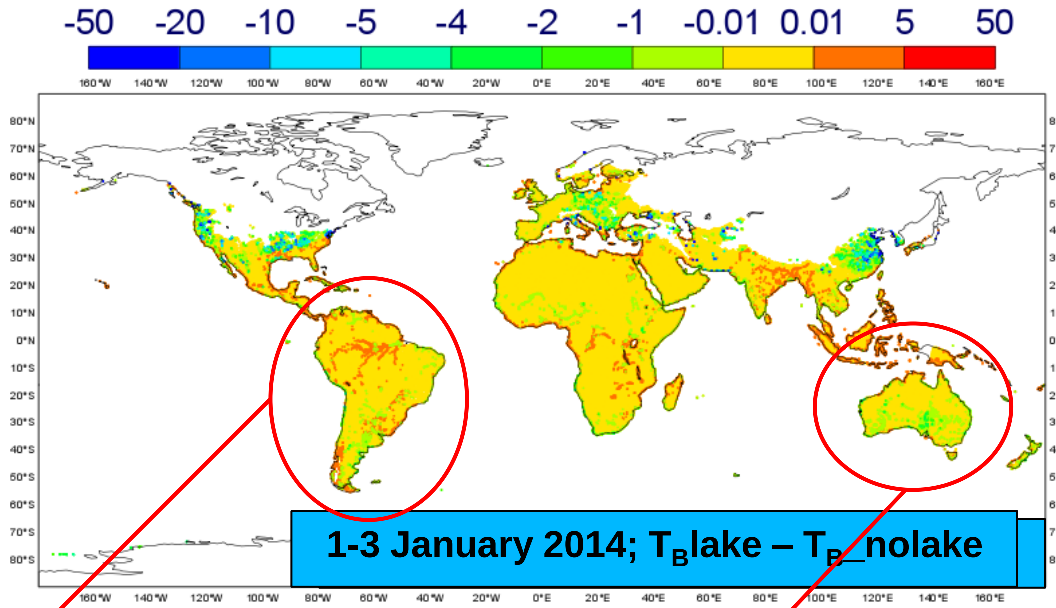
→ **If ice_depth > 0, the effective temperature is ice lake temperature instead of skin temperature (*)**

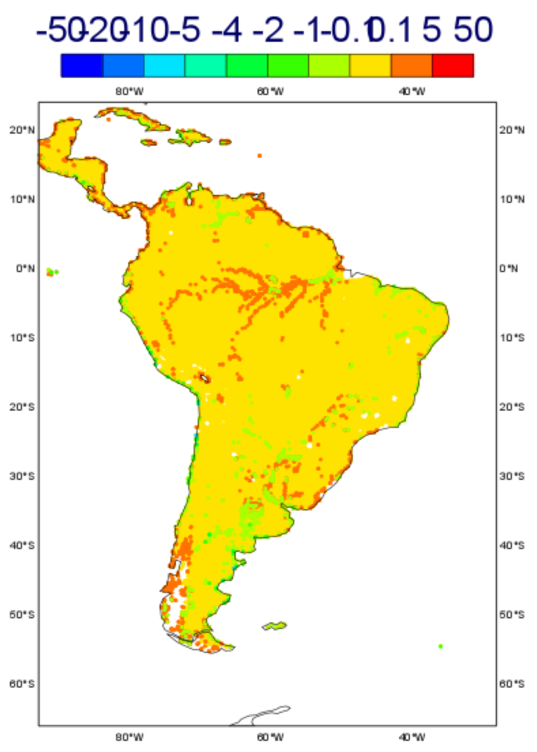
→ 3-days global coverage

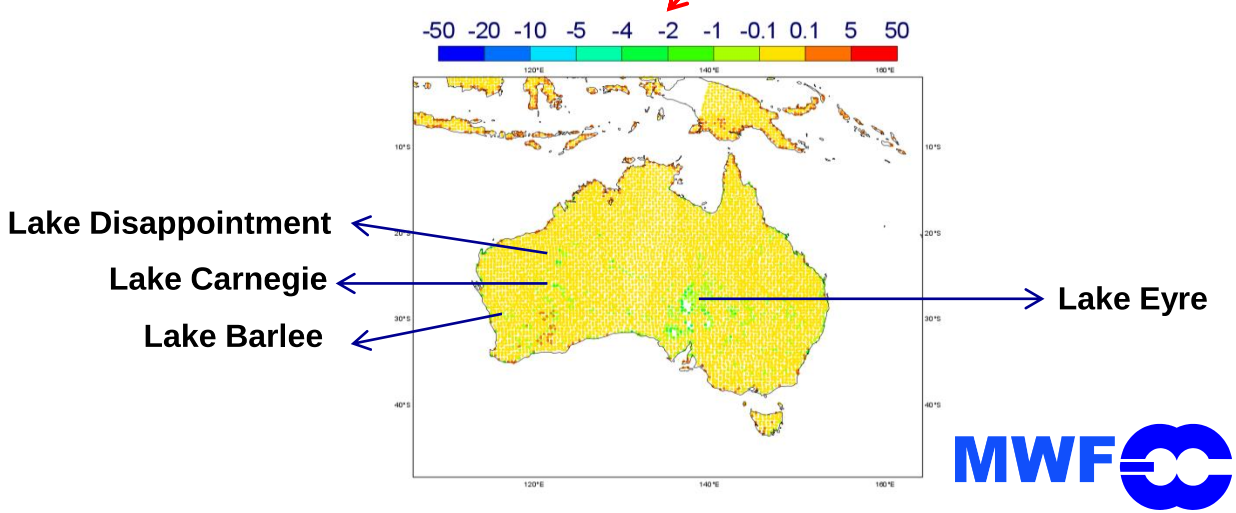
→ Only active observations (no CDF matching and SEKF filters yet!)



Lake implementation in the forward operator



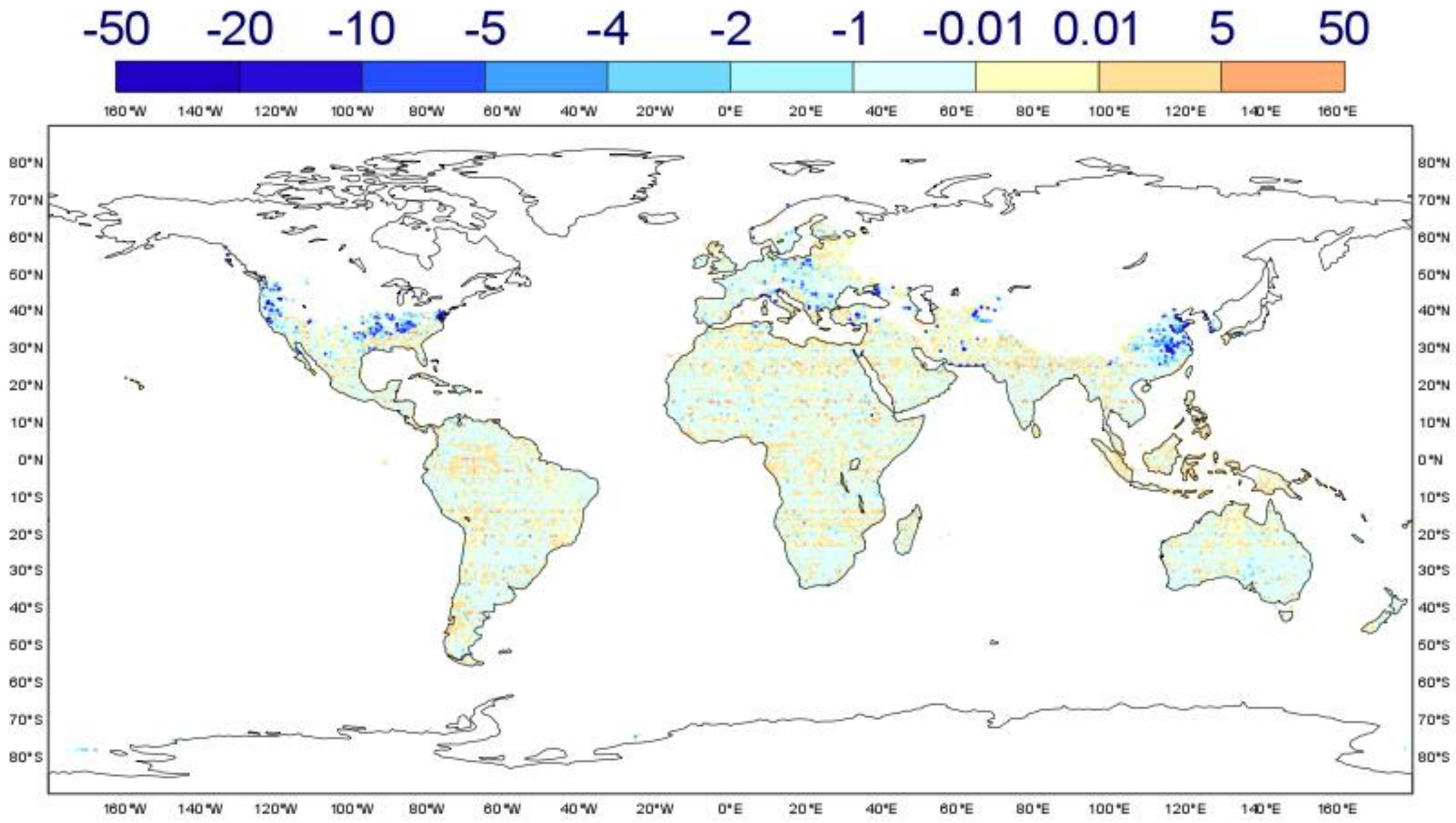




MWF

Lake implementation in the forward operator

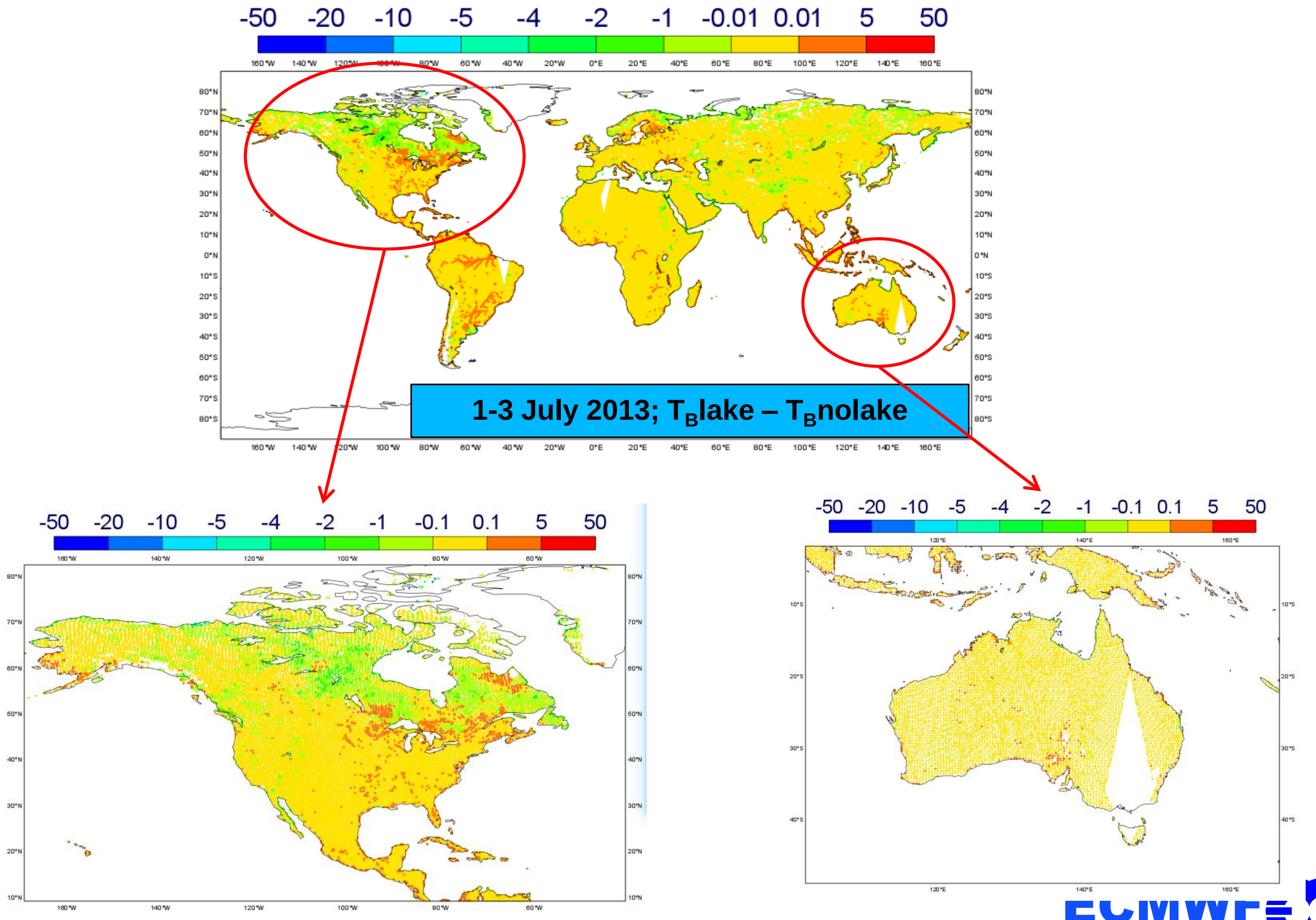
1-3 January 2014; $(T_B\text{lake} - T_{B\_}\text{nolake})_{XX}$ - $(T_B\text{lake} - T_{B\_}\text{nolake})_{YY}$



→ **Difference lake/no_lake is stronger in YY polarisation**

ECMWF

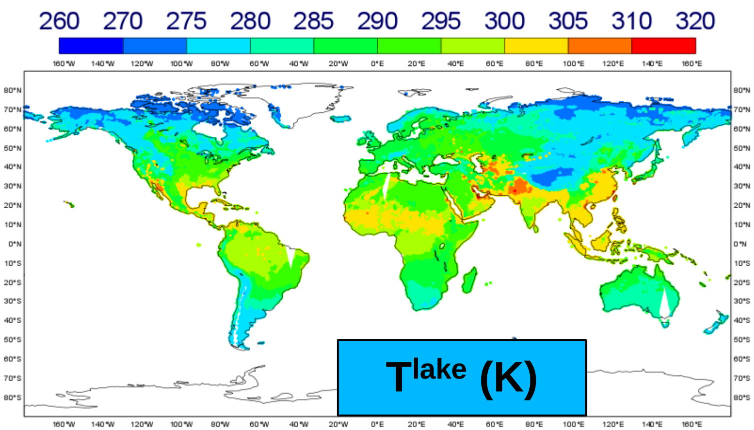
Lake implementation in the forward operator

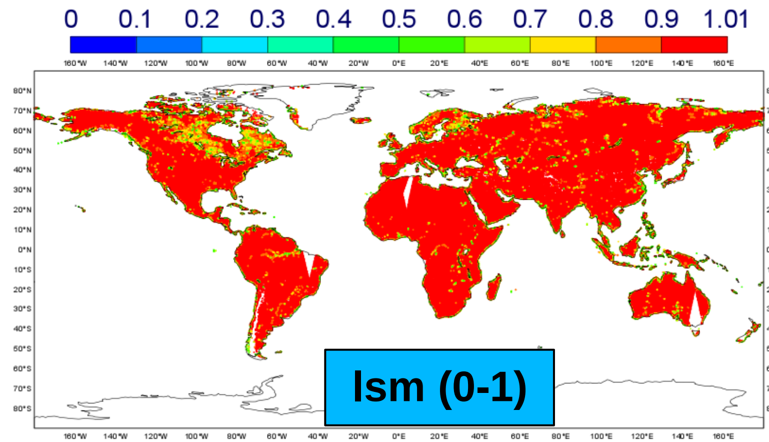


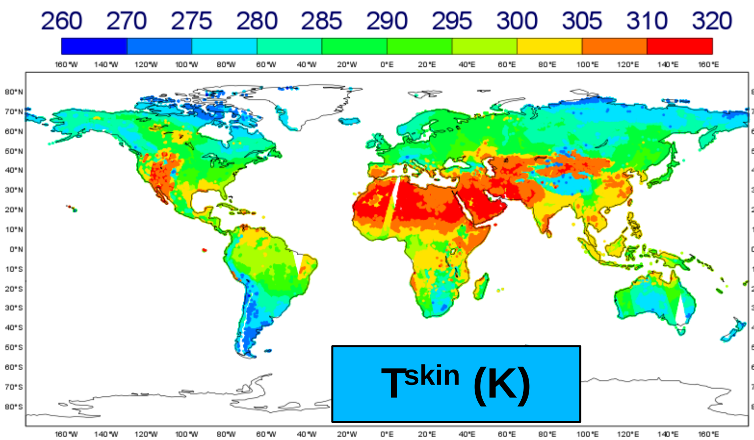
ECMWF

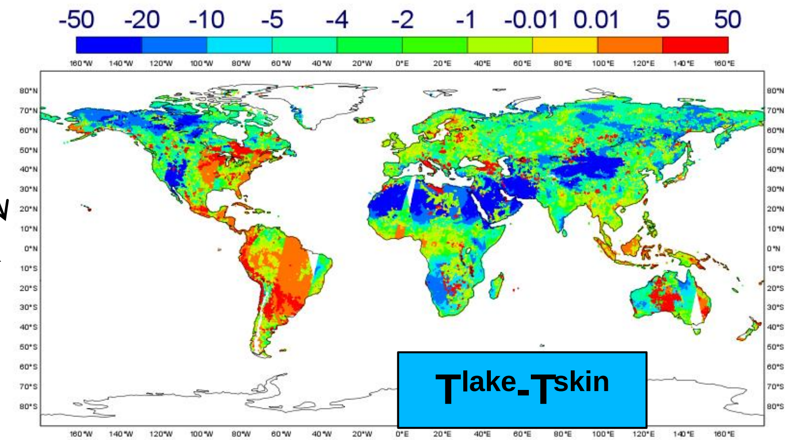
Lake implementation in the forward operator

Validation: $T_B^{lake}-T_B^{no\_lake}$ α $(1-lsm)x(T^{lake}-T^{skin})$







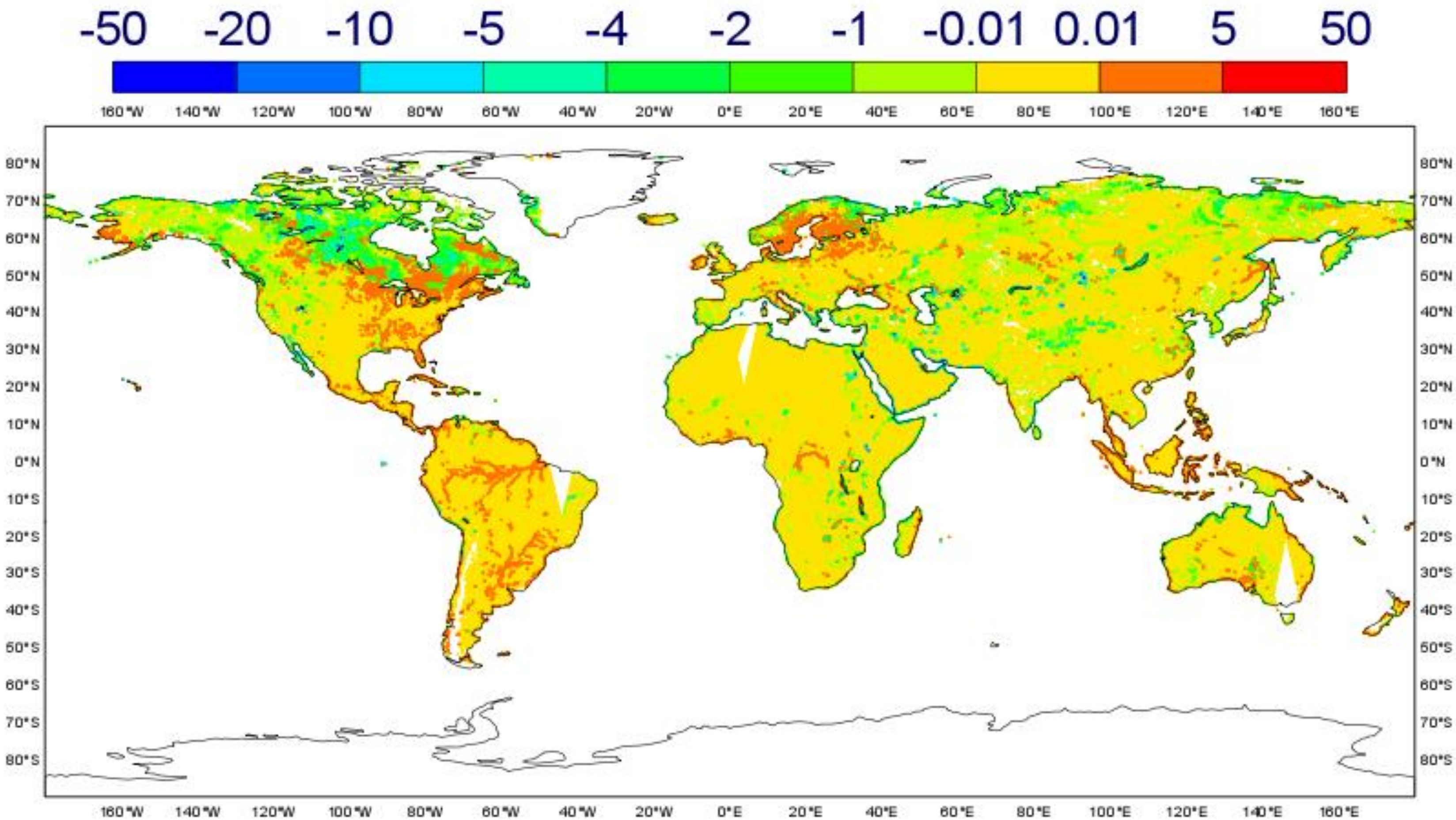


ECMWF

Lake implementation in the forward operator

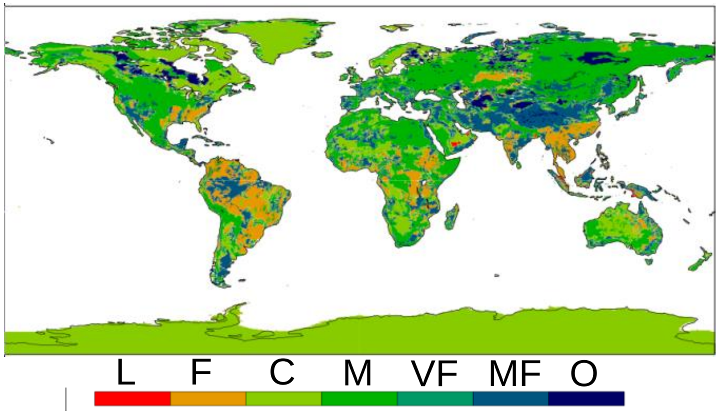
1-3 July 2014;

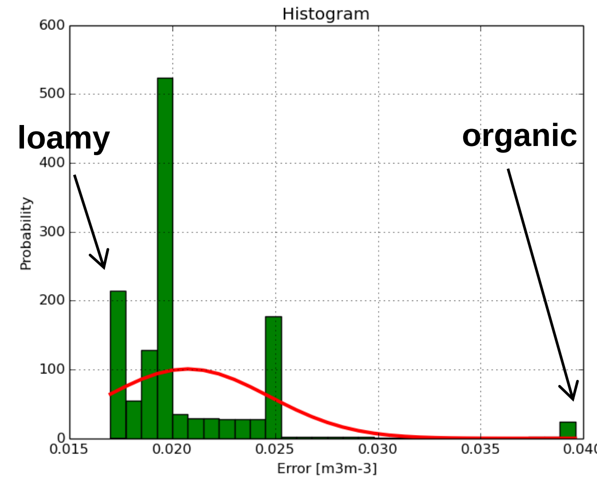
$$T_B^{lake} - T_B^{no\_lake} \;\alpha\; (1-lsm) x (T^{lake} - T^{soil\_l1})$$

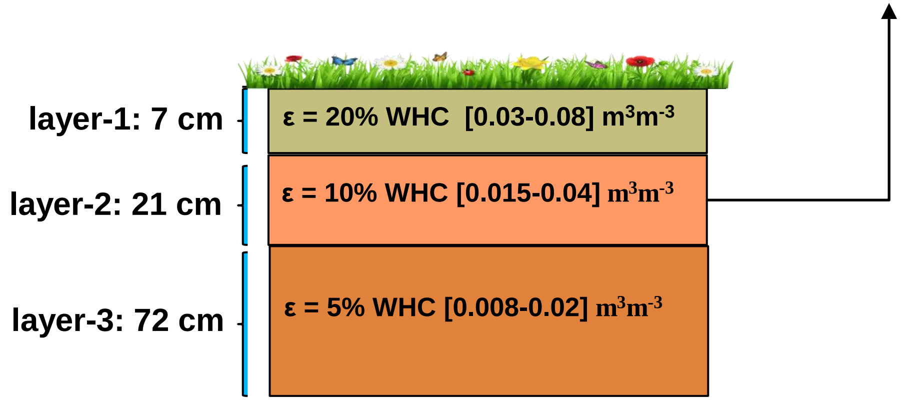


3D-error structure for sm background error & obs errors

Water holding capacity = *f*(soil texture)

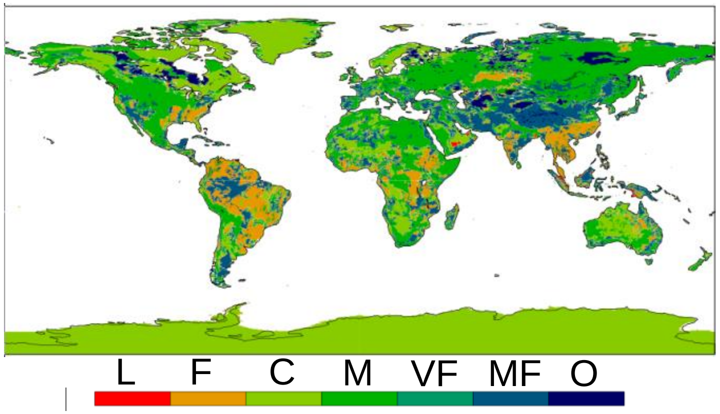


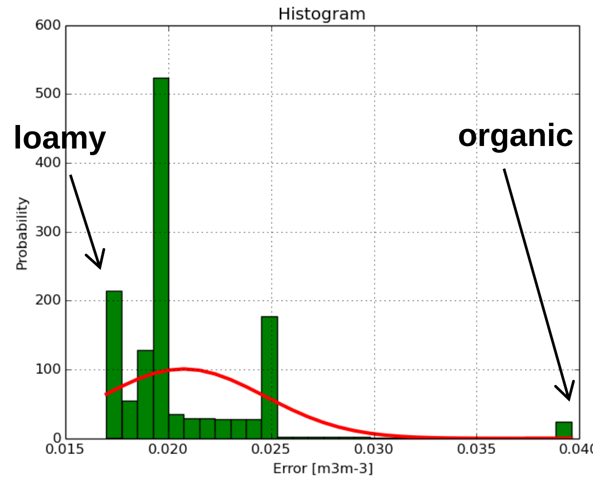




3D-error structure for sm background error & obs errors

Water holding capacity = *f*(soil texture)





layer-1: 7 cm — **ε = 20% WHC [0.03-0.08] m^3m^{-3}**

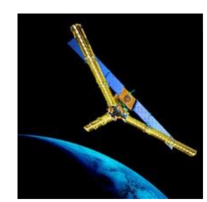
layer-2: 21 cm — **ε = 10% WHC [0.015-0.04] m^3m^{-3}**

layer-3: 72 cm — **ε = 5% WHC [0.008-0.02] m^3m^{-3}**

Conventional data

$\sigma(T_{2M})$= 1 K; $\sigma(RH_{2M})$= 4%;

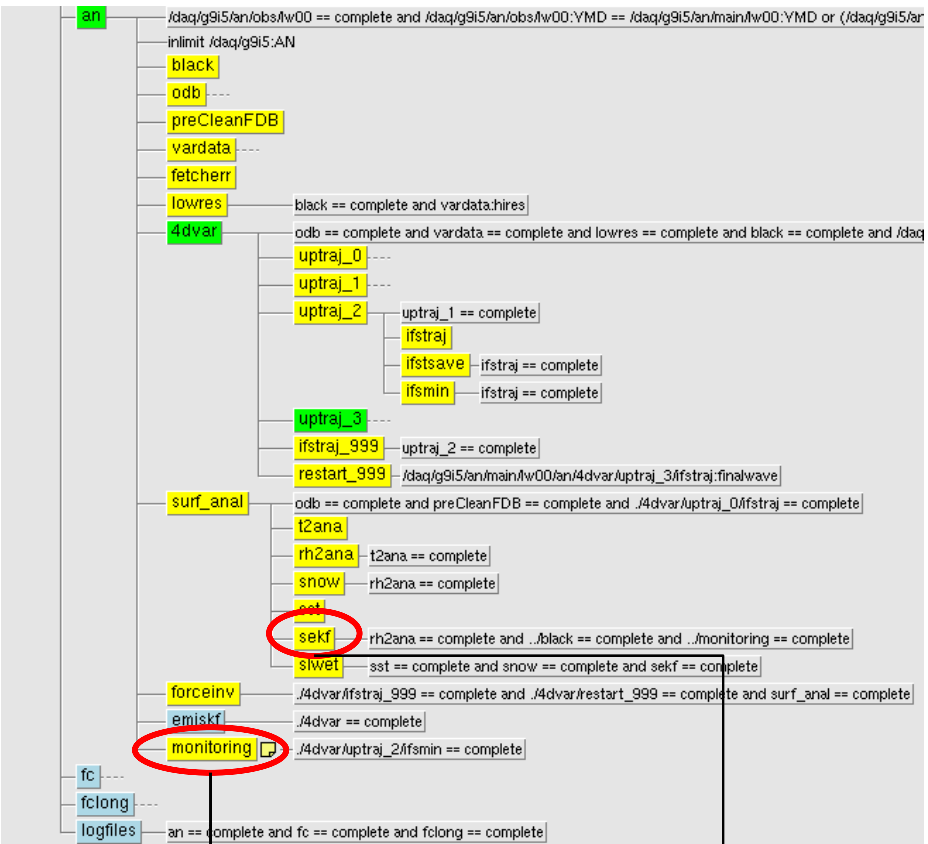
$\sigma(SM)$= 0.05 m^3m^{-3}



$\sigma(T_B)$= 6 + p·x·rad_acc

Operational assimilation; technical implementation

Research configuration

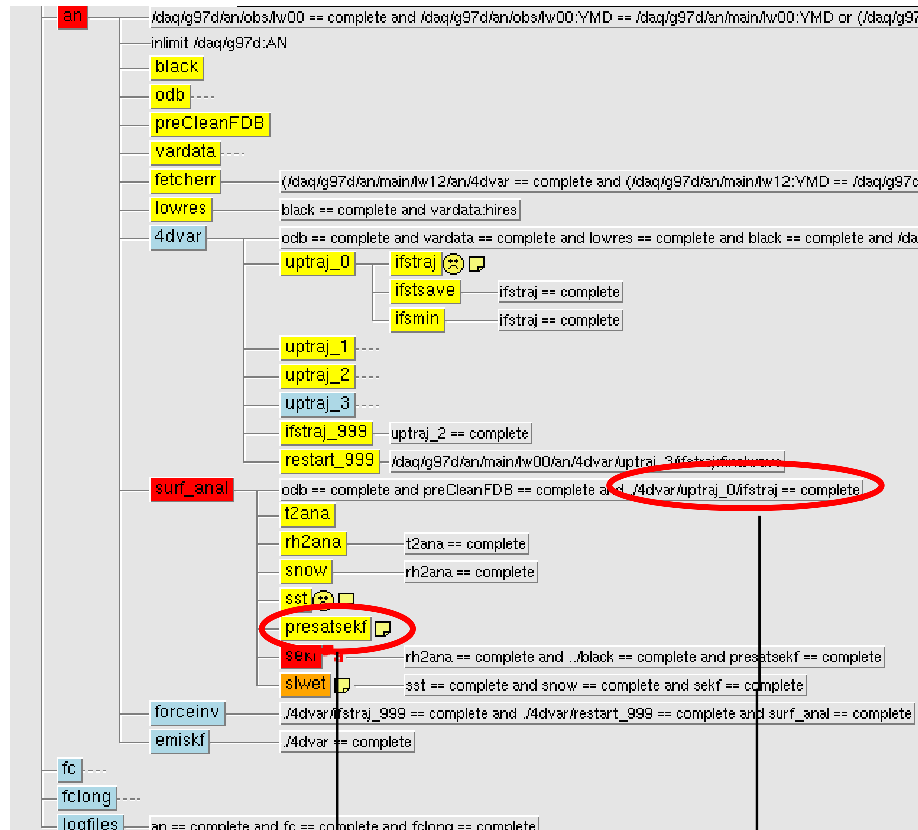


- CMEM simulations
- First-guess computation
- Observational Data Base filled

Monitoring (passive data)

SMOS assimilation & soil moisture analysis→ Need to wait for the CMEM simulations

Operational configuration (first version)



- CMEM simulations
- First-guess computation
- Observational Data Base filled

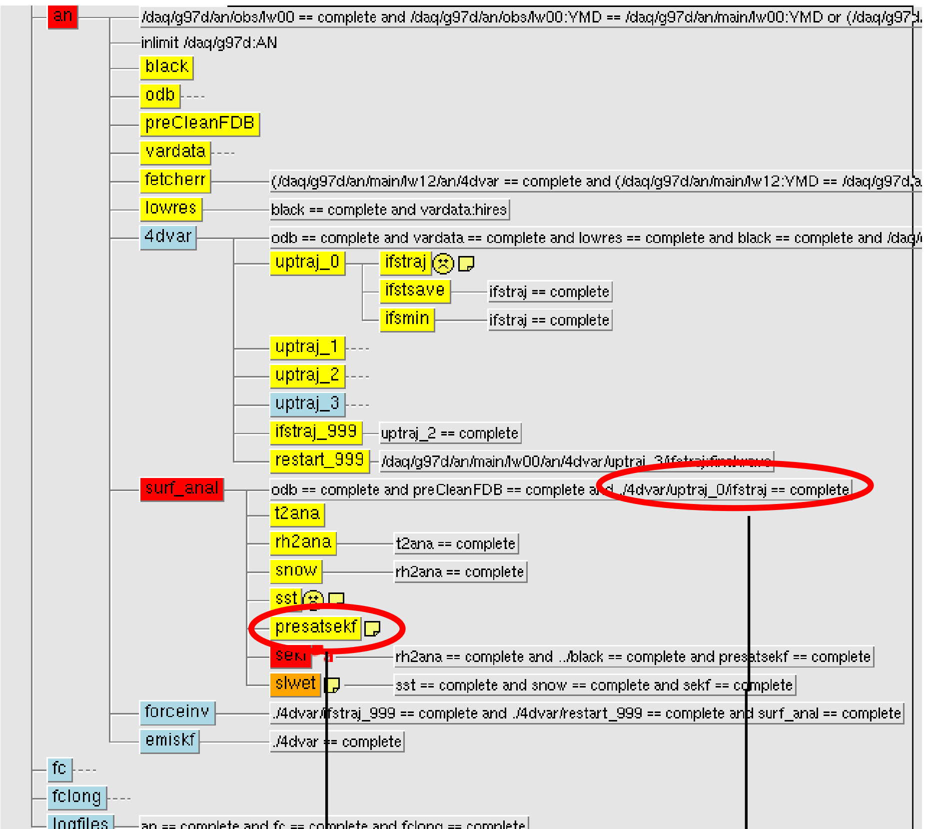
Monitoring (active)

It doesn't delay the surface analysis.

ECMWF

Operational assimilation; technical implementation

Operational configuration (first version)

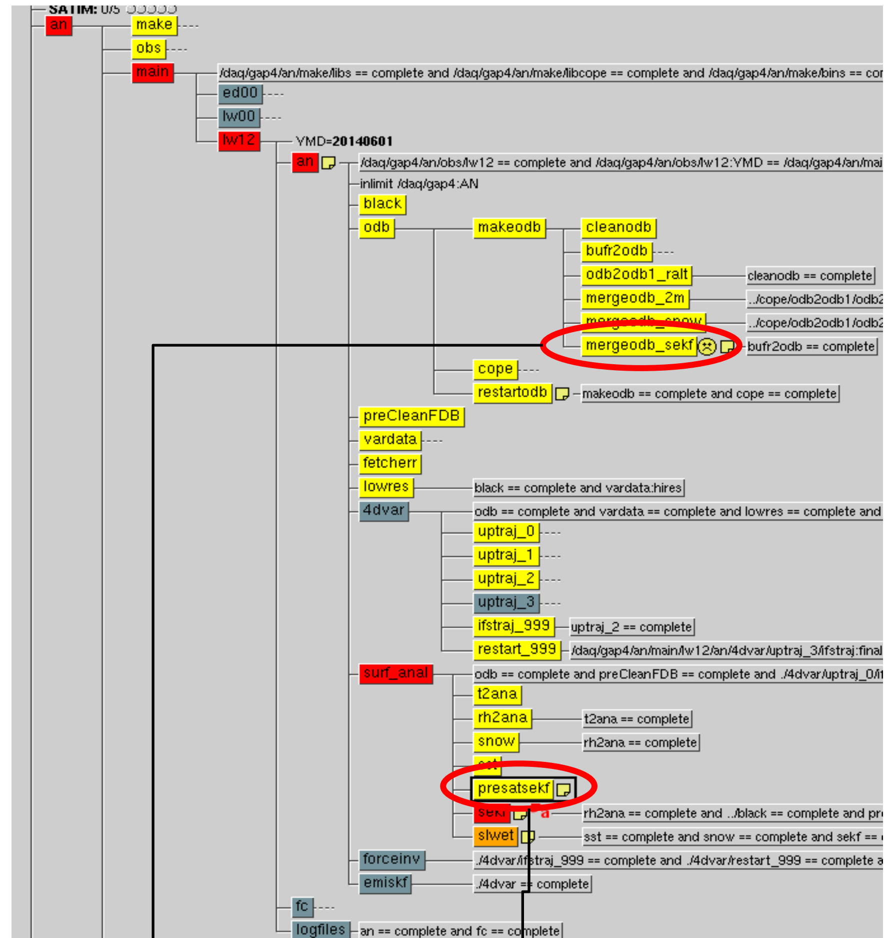


- CMEM simulations
- First-guess computation
- Operational Data Base filled

Monitoring (active)

It doesn't delay the surface analysis.

Operational configuration (second version)



It merges all satellite databases for soil moisture analysis.

It runs just after mergeodb_sekf, and complete before end of first traj, thus not increasing the time critical path

Technical implementation -- runtime

Model trajectories

```
main/an/4dvar/uptraj_0/ifstraj.1:## INFO Runtime                : 965 seconds
main/an/4dvar/uptraj_1/ifstraj.1:## INFO Runtime                : 382 seconds
main/an/4dvar/uptraj_2/ifstraj.1:## INFO Runtime                : 408 seconds
main/an/4dvar/uptraj_3/ifstraj.1:## INFO Runtime                : 664 seconds
```

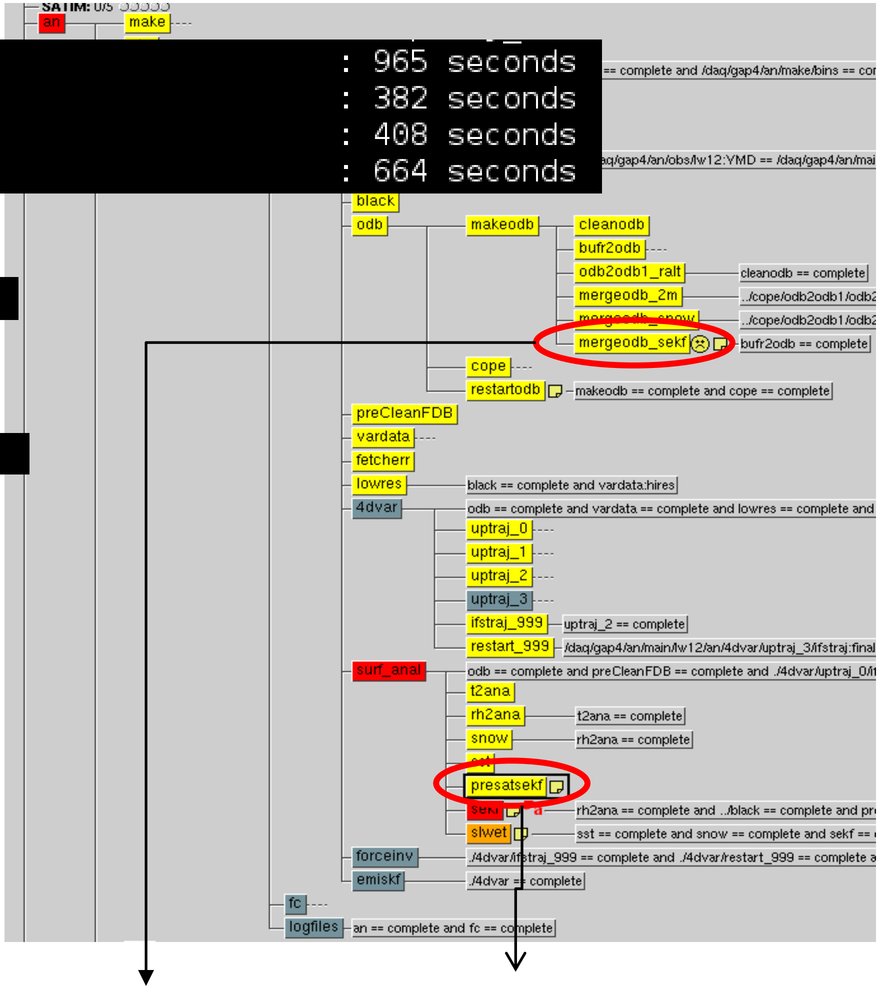
Monitoring

```
## INFO Runtime                : 501 seconds
```

Presatsekf

```
## INFO Runtime                : 613 seconds
```

Latest developments reduces runtime



It merges all satellite databases for soil moisture analysis.

It runs just after mergeodb_sekf, and complete before end of first traj, thus not increasing the time critical path

Technical points of the implementation

Monitoring configuration	(New) Assimilation configuration
fg computed in monitoring task	fg computed in presatsekf task
$WDIR = 'an'	$WDIR = 'surf_anal'
Produces $WDIR/monitor/ • merged ECMA for monitoring is created here • ODB environment variables and $dbdir are set up here	No new directory is created because • No mergeodb is necessary as it is previously done for the sekf. • However, $dbdir, ODB env variables and $FSFAMILY need to be changed to read the right ECMA in the right place.
No feedback to ODB for bias correction	Feedback to ODB for bias corr is done in SEKF
	Crash if running at the same time that ifsmin • It can be safely run after uptraj_2/ifsmin but it will delay the last trajectory. • New vardir_presatsekf created to run ifstraj where the simplified first traj should be run and doesn't clash with ifstraj and ifsmin of 4dvar.
SMOS is safely removed from big ODB through a sms variable	New sms variable has to be created that removes SMOS from big ODB, as it is not part of upper-air analysis
The switch LMONITORING controls the monitoring configuration at script level	The switch LPRESATSEKF controls the presatsekf config for assimilation
Both are compatible and can be run at the same time → future passive monitoring data	

Technical points of the implementation

- The key to merge several individual ODB via ifstraj_0 and to compute the closest observations to the model grid is to set the variable **ODB_MERGEODB_DIRECT=1** → CALL getenv('ODB_MERGEODB_DIRECT', clenv), which then set **ienv=1,** then allows a call to **SHUFFLE_ODB,** and finally to **grid_nearest** via **UPDATE_OBSD**. The variable **LDTRANSFORM=.TRUE.** does the conversion from degrees to radians.

- So, how and where to set **ODB_MERGEODB_DIRECT=1?**→ All is set in the ifsvar script, in the first trajectory. This script is general for many tasks, so one has to be careful how to set it up and under which circumstances.

- Another important variable set in ifsvar is **ODB_CCMA_CREATE_DIRECT**. If set to zero means that one is not working with the CCMA, as in the SMOS case because is not part of the upper-air atmospheric analysis.

TASK	ODB_MERGEODB_ DIRECT before ifstraj	mergeodb	ODB_CCMA_ CREATE_DIRECT	mergeodb_done_ ECMA
IFSTRAJ_0	1	Yes, big ECMA	-	Produced after ifstraj_0 in $WDIR
MONITORING	1	Yes, only SMOS (in the future other passive data too)	0	Produced after ifstraj_0 call, in $WDIR/monitor
PRESATSEKF (1)	1	No need, already done in mergeodb_sekf	0	Produced after ifstraj_0 in $WDIR

- NOTE: To run **presatsekf** and process SMOS observations, **mergeodb_done_ECMA** must not exist in $WDIR/an, otherwise **ODB_MERGEODB_DIRECT** will be set to 0! After ifstraj_0, **mergeodb_done_ECMA** is created, but then the trick is to search for **mergeodb_done_ECMA** in $WDIR/sekf/, which is not created yet, so **ODB_MERGEODB_DIRECT** still 1. Even if **ODB_MERGEODB_DIRECT=0**, then presatsekf will run but without SMOS processing. If it is re-run again, then it will work, because bufr2odb_smos is rerun too, and this removes the **mergeodb_done_ECMA** file in $WDIR.

Technical issues

- ☑ SMOS data was not fetched for the Early Delivery stream and thus it would not influence directly the medium-range forecast.
- ☑ Very difficult bug in ASCAT code detected, which prevented joint assimilation of ASCAT and SMOS → it happened only under very particular circumstances
- ☑ Last model trajectory (after presatsekf) produced unrealistic values in the Jo table for all SCATT group data.
- ☑ Experiment in 2012 cannot be initialized from operational using 41R1 branch (only the EDA). Start them from e-suite 0058. Then, on 20120620 it has to be turned to operations (0001).
- ☑ Verify database is built up since cy41r1 in parallel. If verify for 00 and 12 UTC run at the same time, crash columns and the experiment failed --> Solved at script level,
- ☑ The new technical structure reopened the merged database for sekf, which caused break of link between header and body tables in ODB for ECMA.scatt,
- ☑ Second version of operational structure tested and working. However, there is not bit-identical to a control assimilation experiment.
- ☑ Problems found in CY41R1 when trying to run with only satellite data.
- ☑ Recent ODB bug found in the e-suite, which makes the 'monitoring' job to fail.

….

- *The IFS code is becoming very complex. SMOS structure does not follow the usual path of other satellites and constant maintenance is needed. However, current projects (OOPS, COPE) will make life easier in the future.*
- *CRAY traceback (in my opinion) is less informative than IBM.*

SMOS PM meeting 21-04-15

- Operational work for CY41R2
- **Data assimilation experiments**
- Progress on the T_B processor for the Neural Network

ECMWF

Fine-tunning experiments - Summary

- Assimilation of SLV and SMOS T_B alone or in combination → Several background and observation error configurations were tested:
  - Background error **B**:
    - Propagated within two assimilation cycles,
    - Depending on the soil texture,
    - Depending on the depth of the soil layer and soil texture.
  - Observation error for SMOS TB:
    - Direct insertion approach,
    - Doubling the observation error (radiometric accuracy)

- Main conclusions:
  - 1- Compared to an open-loop, analysing soil moisture is very beneficial for atmospheric scores
  - 2- The assimilation of SMOS data had a positive impact on soil moisture averaged over all the US in-situ stations. However screen-level variables added very little.
  - 3- Introducing soil texture information in the background error and doubling the SMOS observations error, decreased the bias and increased the correlation coefficient with in-situ data, respectively.

ECMWF

Fine-tunning expts for operational configuration

- To fine-tune the use of SMOS data in the assimilation system, the previous conclusions led to the following new experiments:
  - Assimilation of SMOS data doubling observation error and **B** matrix depending on soil texture and depth,
  - As the previous experiment but halving the first-guess check,
  - Assimilation of SMOS data doubling observation error and **B** matrix depending only on soil texture,

- Main conclusions:
  - Combining a 3D structure with soil texture information in the **B** matrix and doubling the error of SMOS observations is the most beneficial for both the unbiased RMSD and the correlation coefficient.
  - The fg_check of 10 K can be very restrictive, especially in areas with strong variability of T_B. Therefore, if a single value has to be used, better to leave it as it is now, i.e., 20 K. fg_check plays important role in surface scores, therefore recommended to implement a variable fg_check as a function of the location.

- 1.5 months (instead of 1-month) expts (15 Sept - 31 Oct 2012) → validation data available!

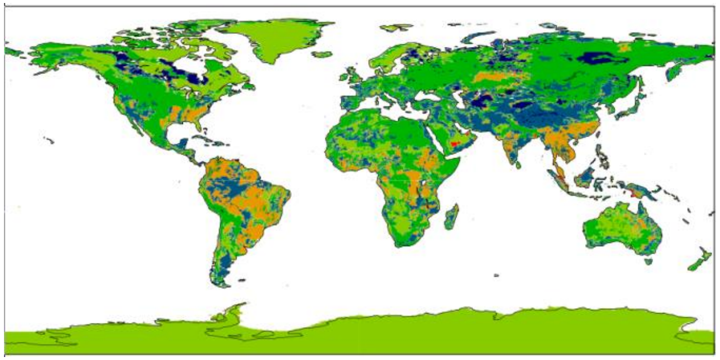
- *Configuration as in operational. What are the main changes compared to the previous expts?*
  - Resolution: TL639, and global scale,
  - Cycle 41r1 (previous in 40r1),
  - ASCAT assimilation turned on,
  - $\sigma(T^{2m})$ = 1 K (2 K), $\sigma(RH^{2m})$= 4% (10%),
  - Surface lake temperature introduced,
  - 3D-structure for background error introduced (also in previous expts),

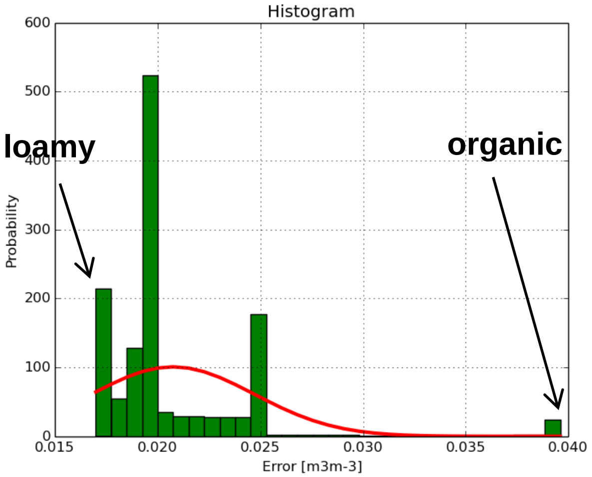
- *What is yet missing?*
  - New version 6.20 → improved use of flags for RFI detection,
  - New CDF matching coefficients

ECMWF

Fine-tunning expts for operational config

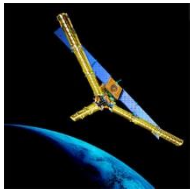
Water holding capacity = *f*(soil texture)





☑ Experiments:

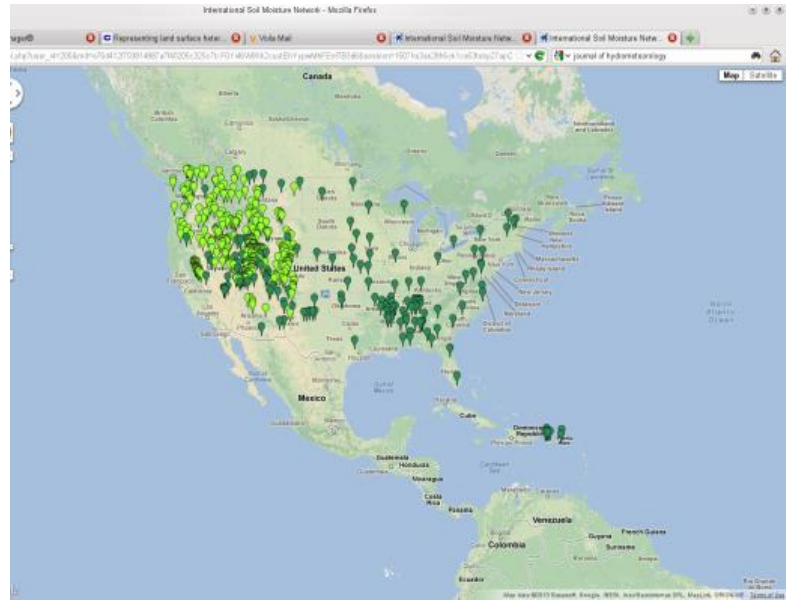
CTRL: SLV + ASCAT: $\sigma(T_{2M})$= 1 K; $\sigma(RH_{2M})$= 4%; $\sigma(SM_{ASCAT})$= 0.05 m^3m^{-3}

	SLV + SMOS R1-B1 + ASCAT	SLV + SMOS R1-B2 + ASCAT	SLV + SMOS R2-B2 + ASCAT
layer-1: 7 cm	ε = 20% WHC [0.03-0.08] m^3m^{-3}	ε = 10% WHC [0.015-0.04] m^3m^{-3}	ε = 10% WHC [0.015-0.04] m^3m^{-3}
layer-2: 21 cm	ε = 10% WHC [0.015-0.04] m^3m^{-3}	ε = 5% WHC [0.008-0.02] m^3m^{-3}	ε = 5% WHC [0.008-0.02] m^3m^{-3}
layer-3: 72 cm	ε = 5% WHC [0.008-0.02] m^3m^{-3}	ε = 5% WHC [0.008-0.02] m^3m^{-3}	ε = 5% WHC [0.008-0.02] m^3m^{-3}
	$\sigma(T_B)$= 6 + rad_acc ~ [8.5-10] K	$\sigma(T_B)$= 6 + rad_acc ~ [8.5-10] K	$\sigma(T_B)$= 6 + 3xrad_acc ~ [13.5-18] K

ECMWF

Soil moisture validation

- Soil moisture analyses and forecasts are validated against in-situ data (“truth”)



SCAN & USCRN

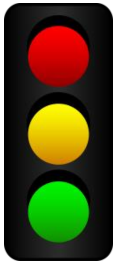
- The forecast skill of atmospheric variables is compared against a control experiment (using own analyses as reference),

Soil moisture validation

USCRN	Bias	RMSD	UnRMSD	R	Ano_R	N
CTRL	-0.105	0.117	0.032	0.815	0.580	42
R1+B1	-0.094	0.113	0.041	0.788	0.571	42
R1+B2	-0.098	0.114	0.037	0.814	0.610	42
R2+B2	-0.104	0.117	0.034	0.811	0.559	42

SCAN	Bias	RMSD	UnRMSD	R	Ano_R	N
CTRL	-0.059	0.098	0.035	0.774	0.555	36
R1+B1	-0.048	0.096	0.037	0.787	0.553	36
R1+B2	-0.053	0.098	0.035	0.786	0.577	36
R2+B2	-0.058	0.098	0.035	0.764	0.550	36

REMEDHUS	Bias	RMSD	UnRMSD	R	Ano_R	N
CTRL	-0.122	0.136	0.051	0.792	0.671	19
R1+B1	-0.076	0.115	0.071	0.783	0.663	19
R1+B2	-0.096	0.121	0.062	0.782	0.677	19
R2+B2	-0.101	0.123	0.059	0.808	0.671	19



→ Worst than control.

→ Equal than control

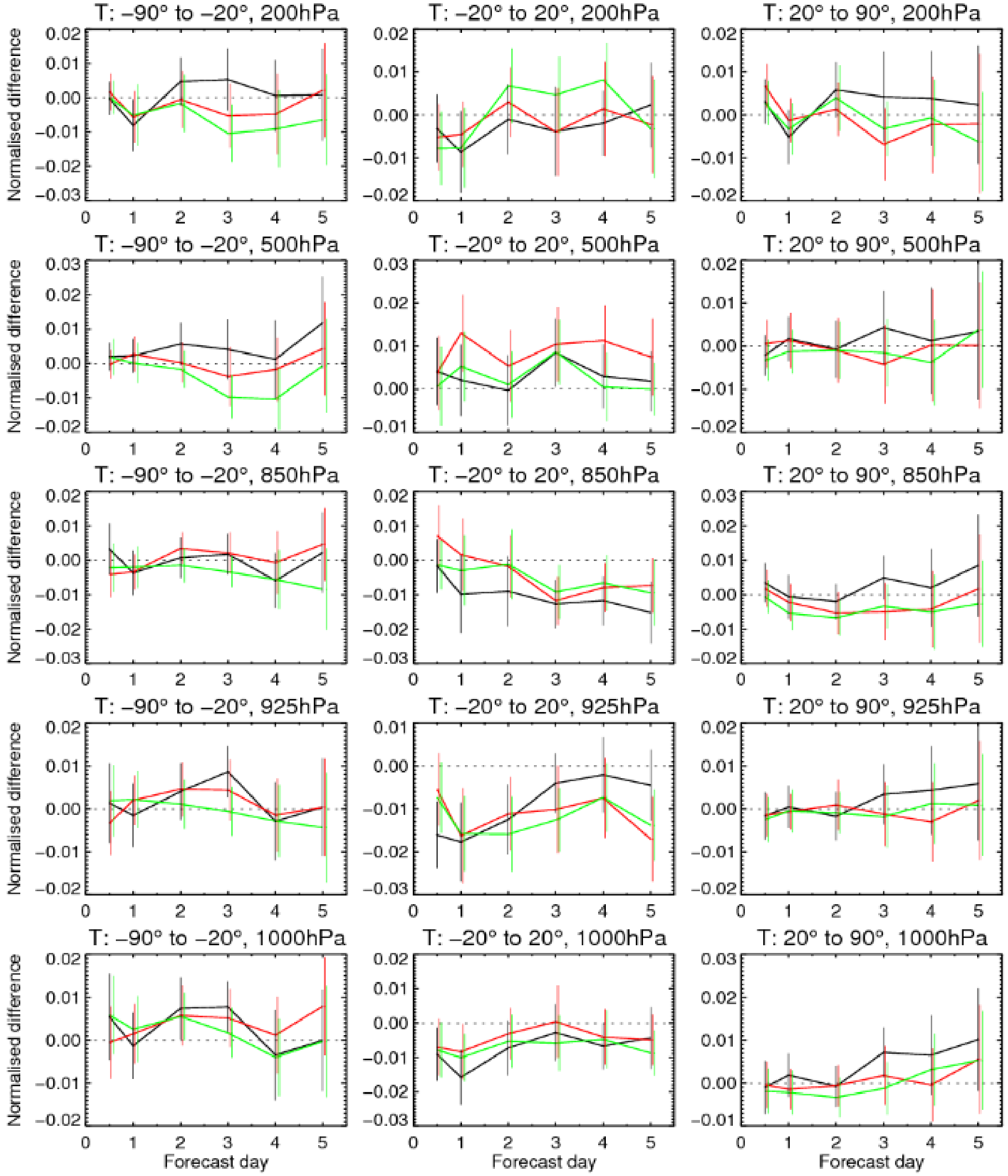
→ Better than control.

$[Bias]=[RMSD]=[UnRMSD]=m^3m^{-3}$

Lowest median

ECMWF

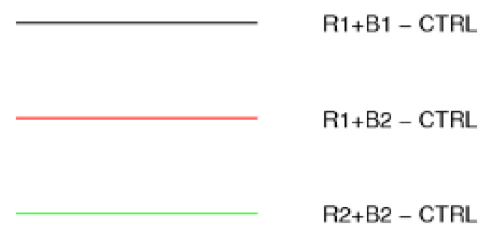
Forecast scores air temperature - RMSE



<u>Normalized RMS forecast error</u>

NMRS>0 → expt increases error

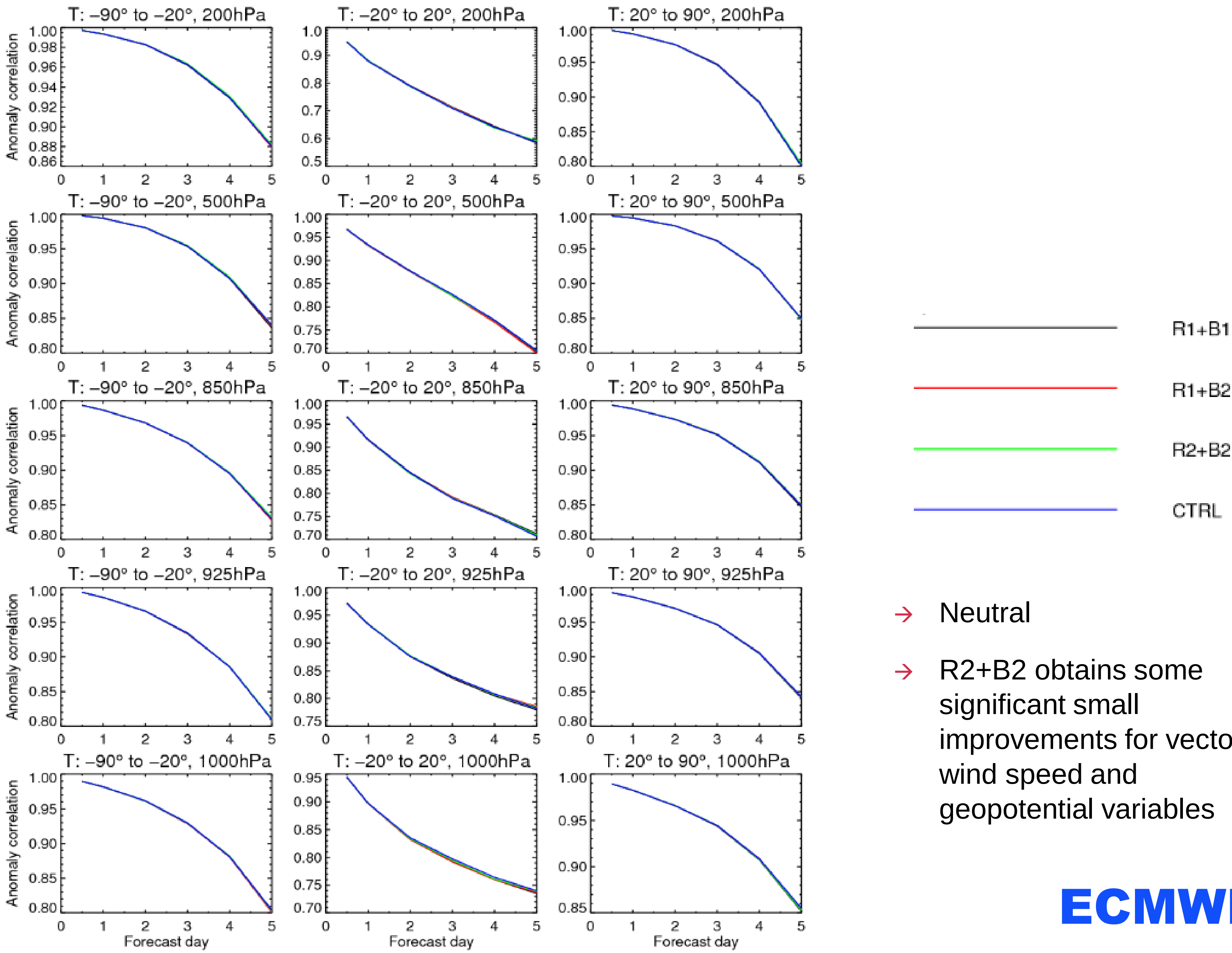
NMRS<0 → expt decreases errorc



- → Neutral
- → For air humidity, some significant improvement, around 1% fro R2+B2 config.

ECMWF

Forecast scores air temperature – Anom Correlation

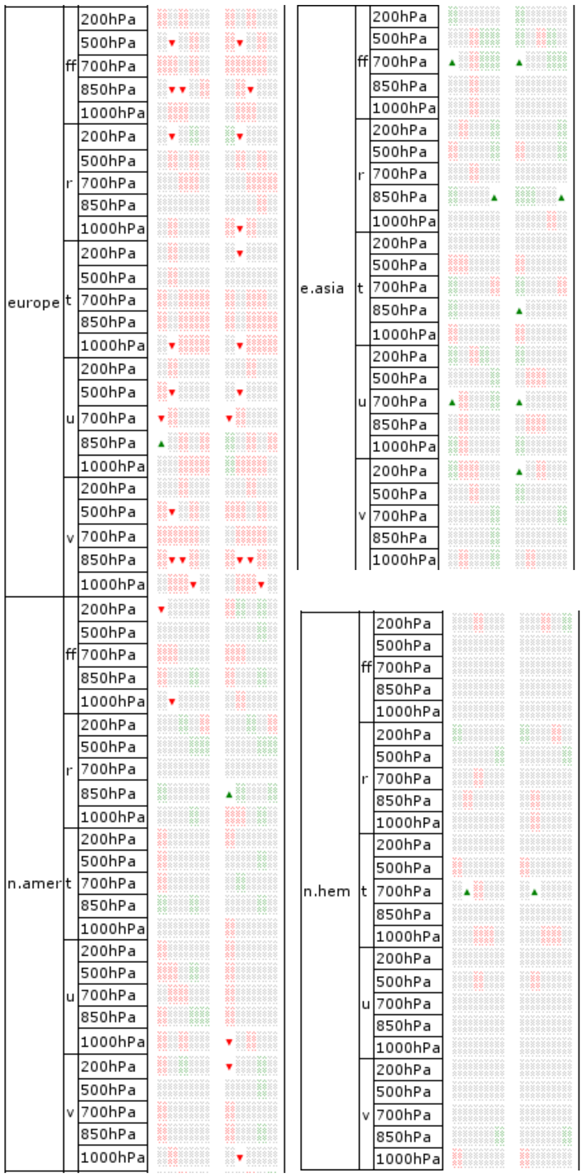


- Neutral
- R2+B2 obtains some significant small improvements for vector wind speed and geopotential variables

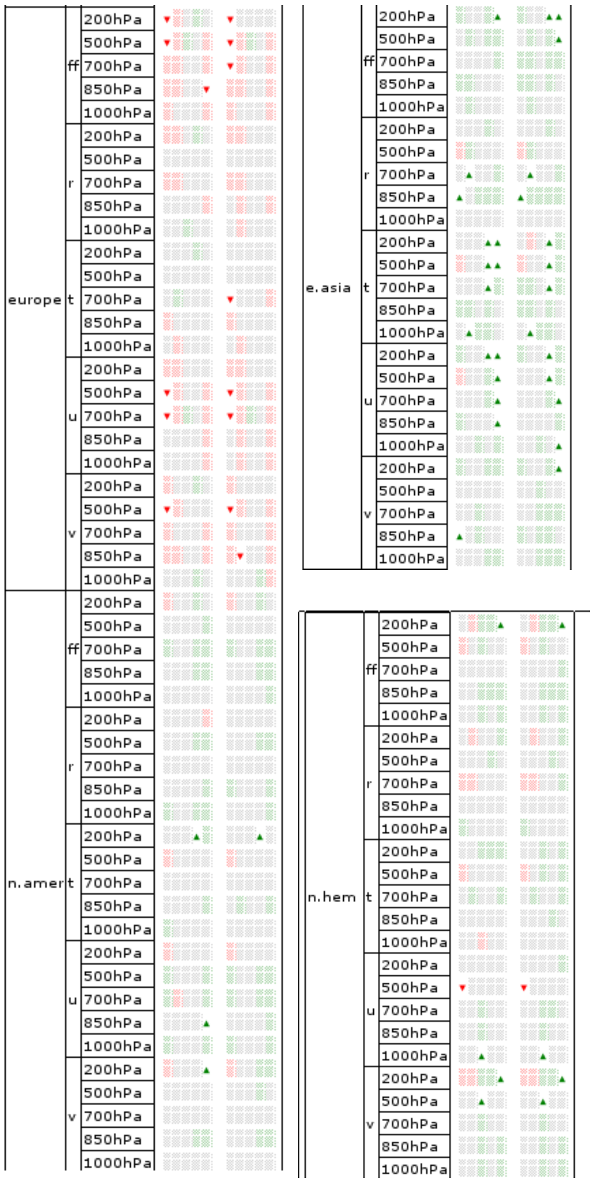
ECMWF

Forecast scores – North Hemisphere

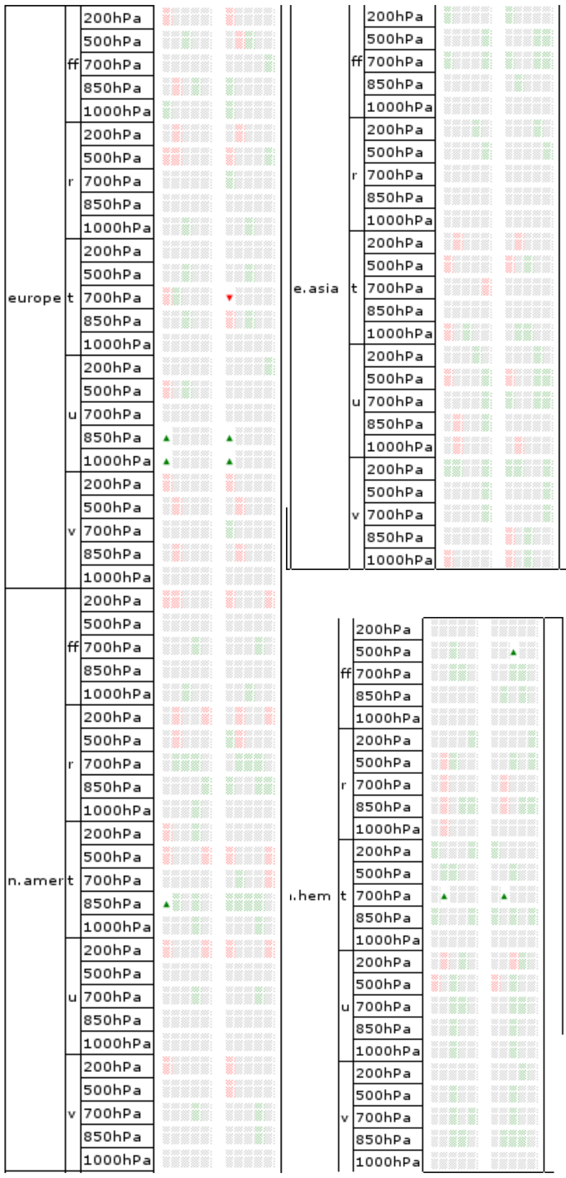
SLV + ASCAT + SMOS R1-B1



SLV + ASCAT + SMOS R1-B2

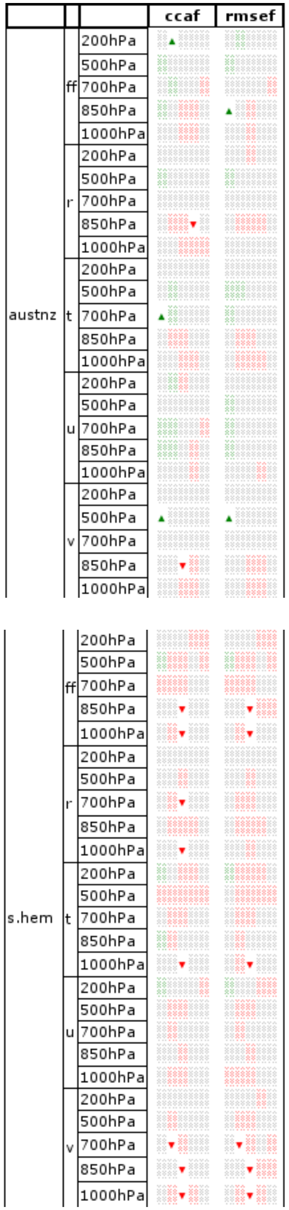


SLV + ASCAT + SMOS R2-B2

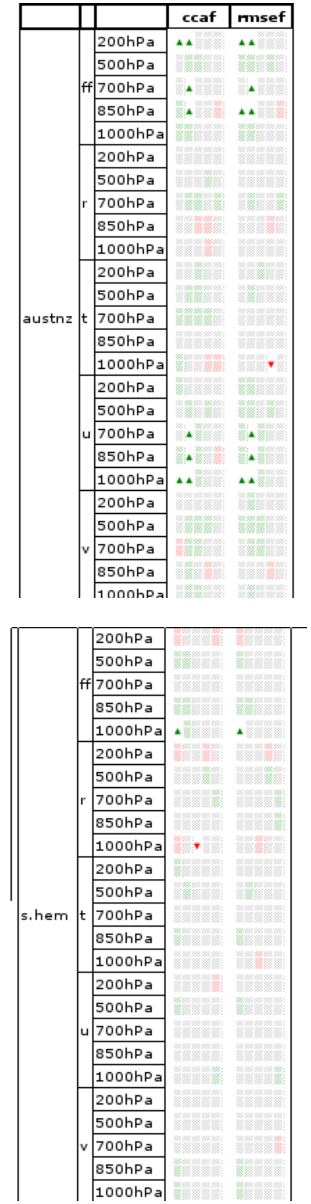


Forecast scores – South Hemisphere

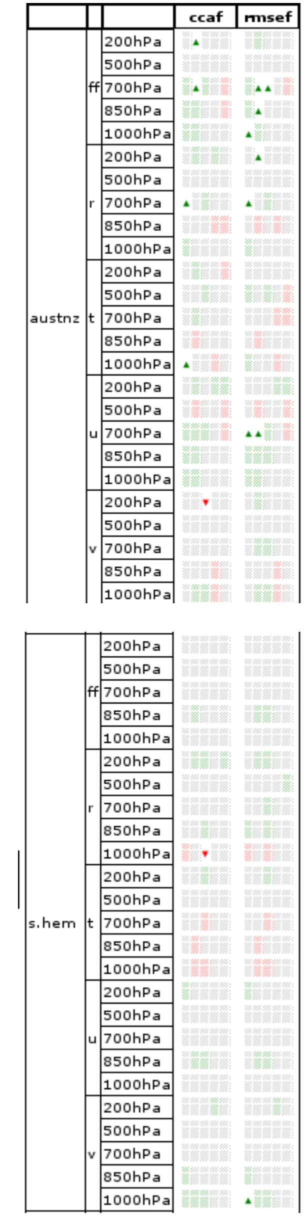
SLV + ASCAT + SMOS R1-B1



SLV + ASCAT + SMOS R1-B2



SLV + ASCAT + SMOS R2-B2



Last set of experiments (SLV – ASCAT – SMOS)

☑ Long experiments status:

☑ Last teleconference decisions:

- Long-term experiments SMOS configuration: SMOS R2-B2
- Period: 2012 (or 2014) and 2013 MJJAS

☑ Configuration:

- These experiments use cycle 41r1 with new SMOS implementations (lake temperature and 3D structure for the soil and new operational structure for SMOS Data Assimilation),
- Period: MJJAS 2012 and 2013, because reprocessed data are available. 2014 reprocessed data were not available at the date of these experiments.
- Global scale experiments,
- New flags for SMOS,
- AF-FOV for SMOS data,
- Last CDF-matching coefficient parameters used for ASCAT and SMOS,
- Resolution is T511 (closer to SMOS observations and faster),
- Full observational system,
- New observation errors for the conventional data: sigma(T2m)= 1 K, sigma(RH2m)=4%
- ASCAT observation error: sigma(soil_moisture_ASCAT)=0.05 m3/m-3
- SMOS observation error: sigma(TB_SMOS)=6+3*rad_acc.
- Background error: variable as a function of soil texture and depth: sigma(top level)=10% WHC, sigma(2nd_layer)=5% WHC, sigma(3rd_layer)=5% WHC

Last set of experiments (SLV – ASCAT – SMOS)

- Long experiments status:
  - Last teleconference decisions:
    - Long-term experiments SMOS configuration: SMOS R2-B2
    - Period: 2012 (or 2014) and 2013 MJJAS

SLV (T^{2m}, RH^{2m})	ASCAT SM	SMOS TB	Description
-	-	-	**open-loop 2012**: open-loop, no soil moisture analysis
√	-	-	**CTRL-2012**: assimilation of only SLV
-	√	-	**ASCAT-2012**: assimilation of only ASCAT SM observations
-	-	√	**SMOS-2012**: assimilation of only SMOS TB observations
-	√	√	**ASCAT+SMOS-2012**: assimilation of ASCAT SM and SMOS TB observations
√	√	√	**SLV+ASCAT+SMOS-2012:** assimilation of SLV, ASCAT SM and SMOS TB observations
-	-	-	**open-loop 2013:** open-loop, no soil moisture analysis
√	-	-	**CTRL-2013**: assimilation of only SLV
-	√	-	**ASCAT-2013**: assimilation of only ASCAT SM observations
-	-	√	**SMOS-2013**: assimilation of only SMOS TB observations
-	√	√	**ASCAT+SMOS-2013**: assimilation of ASCAT SM and SMOS TB observations
√	√	√	**SLV+ASCAT+SMOS-2013:** assimilation of SLV, ASCAT SM and SMOS TB observations

Last set of experiments (SLV – ASCAT – SMOS)

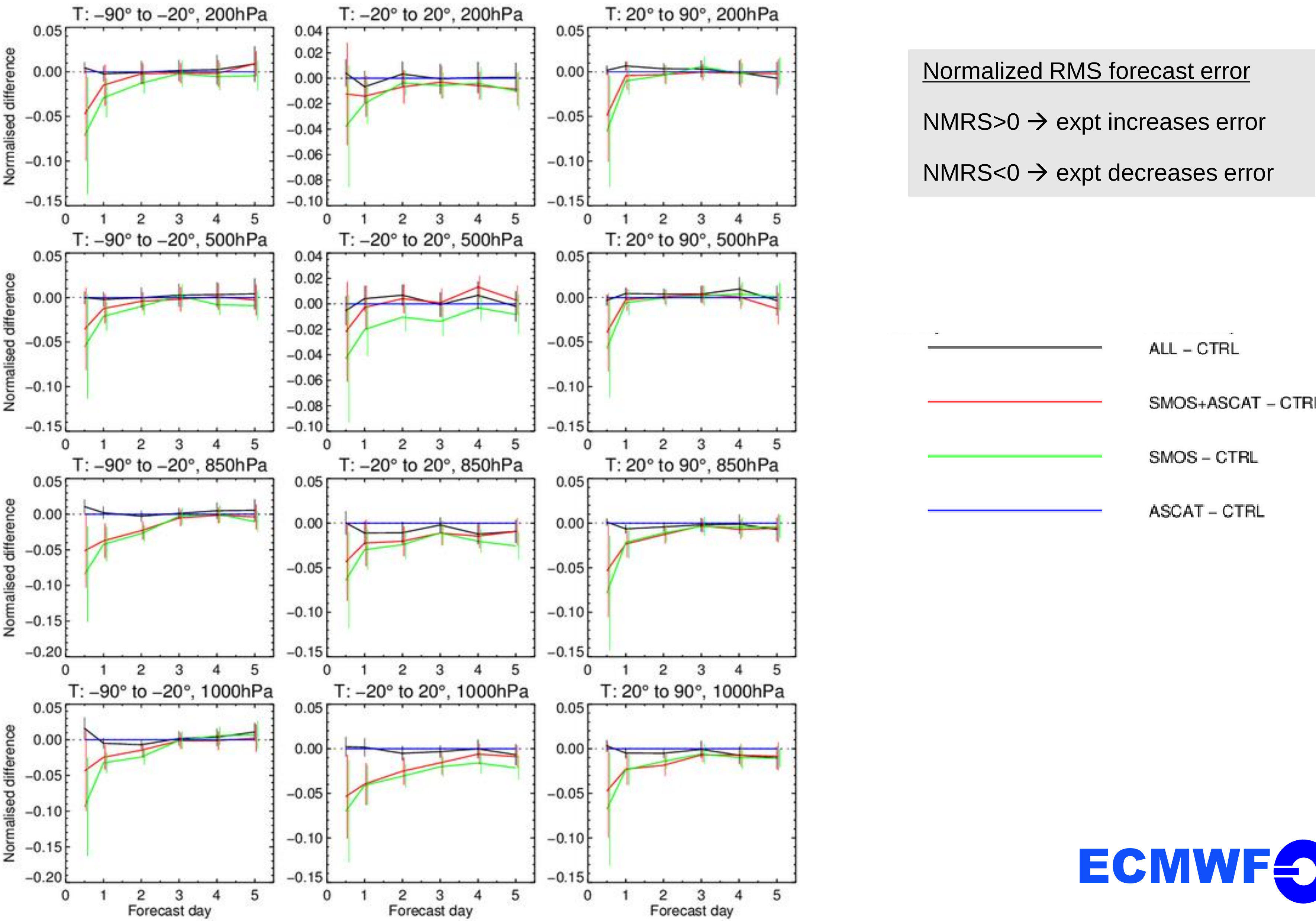
- Long experiments status:
  - Last teleconference decisions:
    - Long-term experiments SMOS configuration: SMOS R2-B2
    - Period: 2012 (or 2014) and 2013 MJJAS

SLV (T^{2m}, RH^{2m})	ASCAT SM	SMOS TB	Description
-	-	-	**open-loop 2012**: open-loop, no soil moisture analysis
√	-	-	**CTRL-2012**: assimilation of only SLV
-	√	-	**ASCAT-2012**: assimilation of only ASCAT SM observations
-	-	√	**SMOS-2012**: assimilation of only SMOS TB observations
-	√	√	**ASCAT+SMOS-2012**: assimilation of ASCAT SM and SMOS TB observations
√	√	√	**SLV+ASCAT+SMOS-2012:** assimilation of SLV, ASCAT SM and SMOS TB observations
-	-	-	**open-loop 2013:** open-loop, no soil moisture analysis
√	-	-	**CTRL-2013**: assimilation of only SLV
-	√	-	**ASCAT-2013**: assimilation of only ASCAT SM observations
-	-	√	**SMOS-2013**: assimilation of only SMOS TB observations
-	√	√	**ASCAT+SMOS-2013**: assimilation of ASCAT SM and SMOS TB observations
√	√	√	**SLV+ASCAT+SMOS-2013:** assimilation of SLV, ASCAT SM and SMOS TB observations

O S A J J M

Preliminary scores – May 2013

1–May–2013 to 31–May–2013 from 27 to 31 samples. Confidence range 95%. Verified against own–analysis.



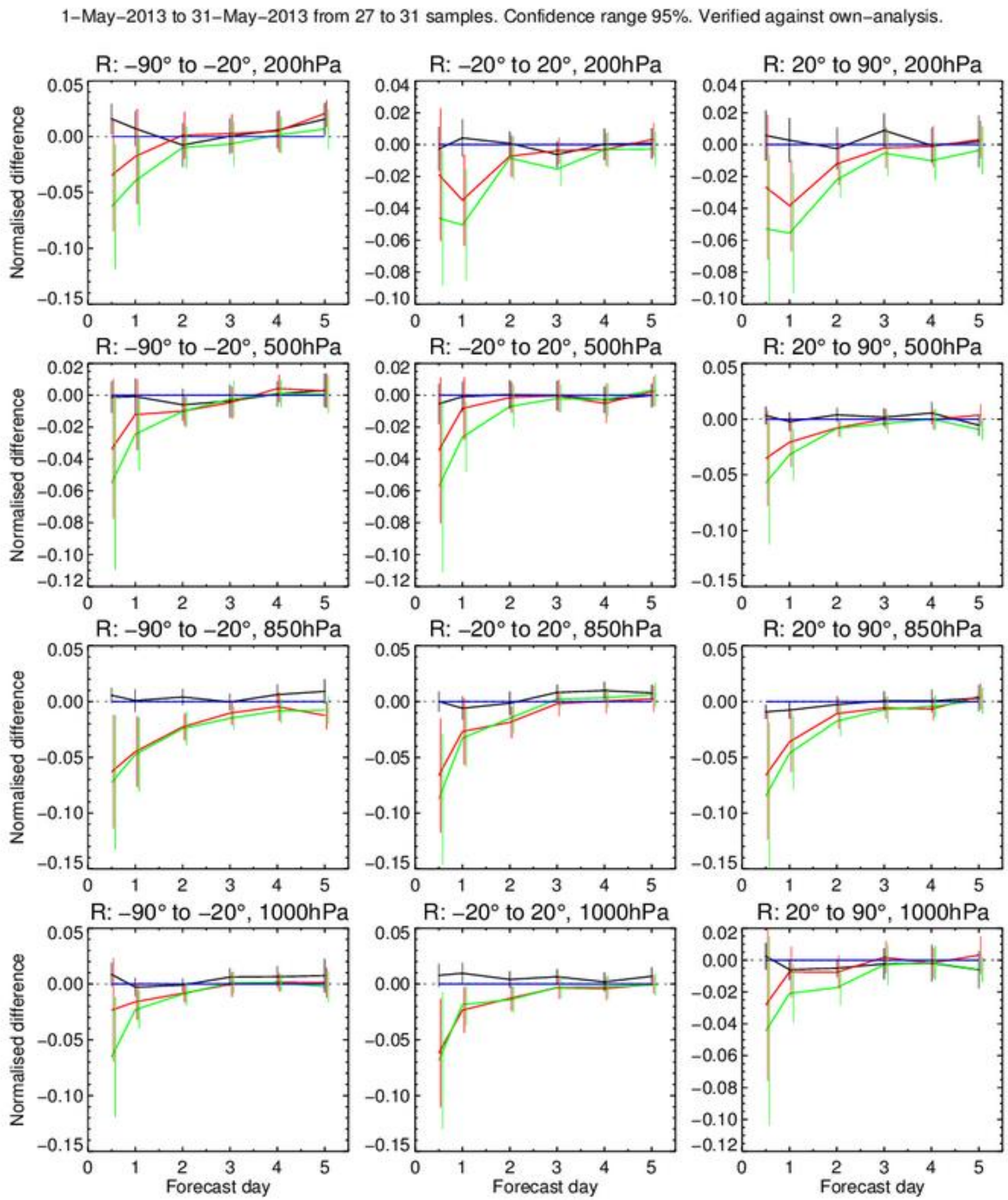
<u>Normalized RMS forecast error</u>

NMRS>0 → expt increases error

NMRS<0 → expt decreases error

ECMWF

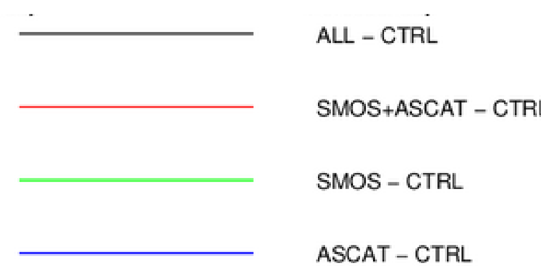
Preliminary scores – May 2013



<u>Normalized RMS forecast error</u>

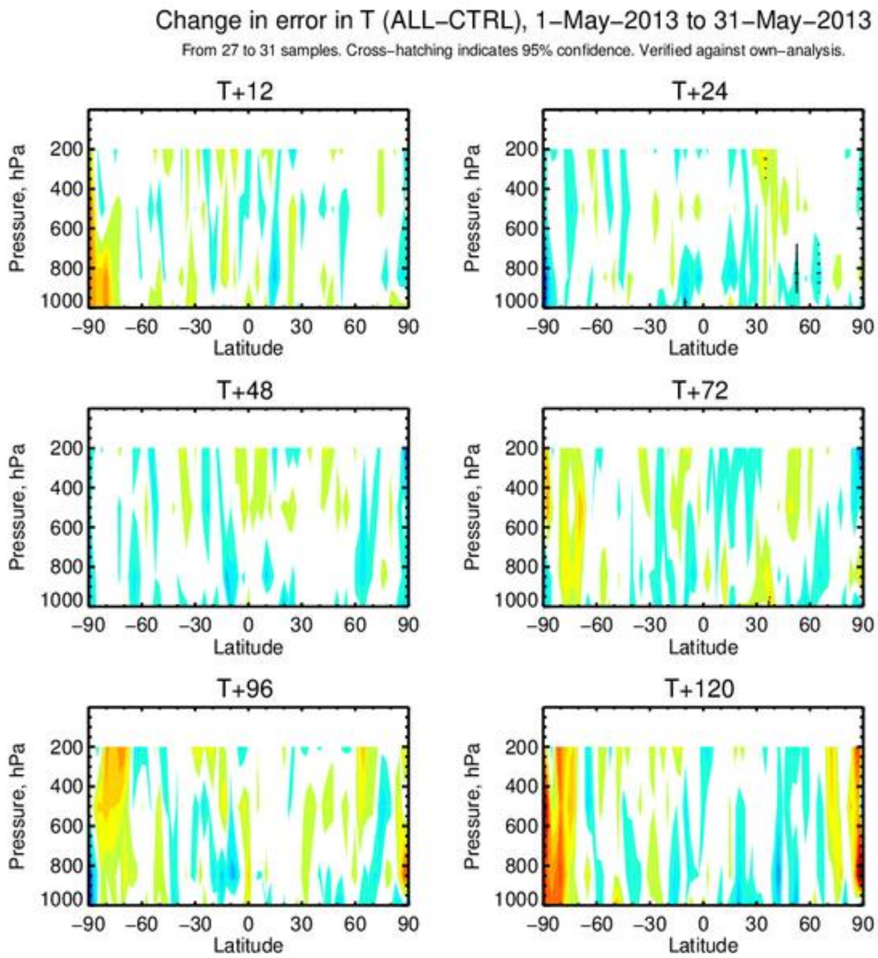
NMRS>0 → expt increases error

NMRS<0 → expt decreases error

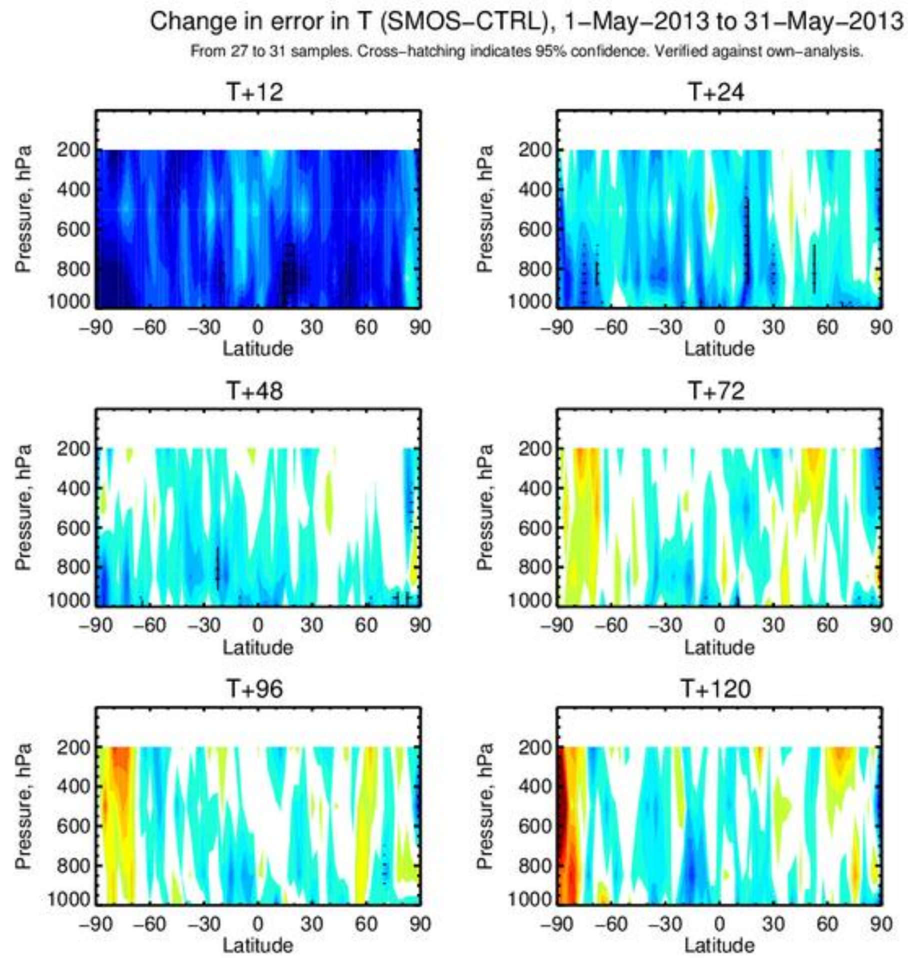


ECMWF

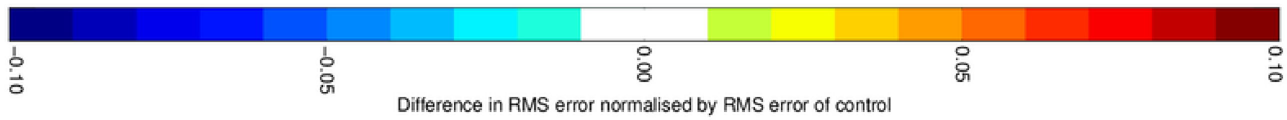
Preliminary scores – May 2013



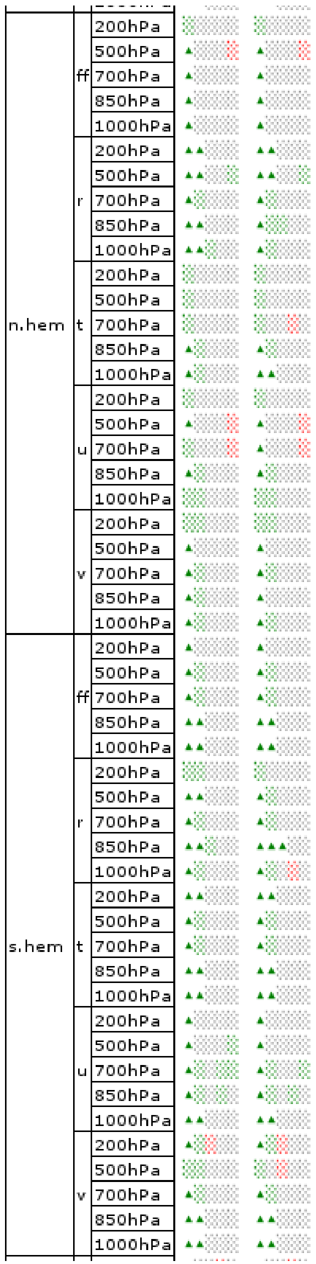
ALL – CTRL



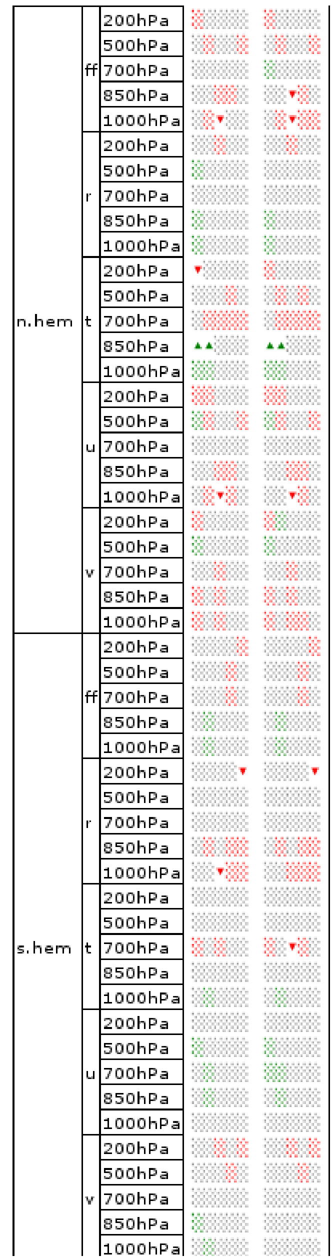
SMOS – CTRL



Preliminary scores – May 2013



SMOS – CTRL



ALL – CTRL

ECMWF

SMOS PM meeting 21-04-15

- Operational work for CY41R2

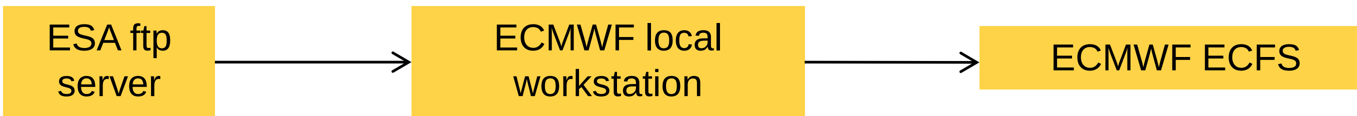
- Data assimilation experiments

- **Progress on the T_B processor for the Neural Network**

ECMWF

SM NRT with Neural Network

- Data from the 2nd reprocessing will be used to train the NN (better quality and better RFI flagging) →
  - Big volume of data (~15 Tby!),
  - Downloading on-going

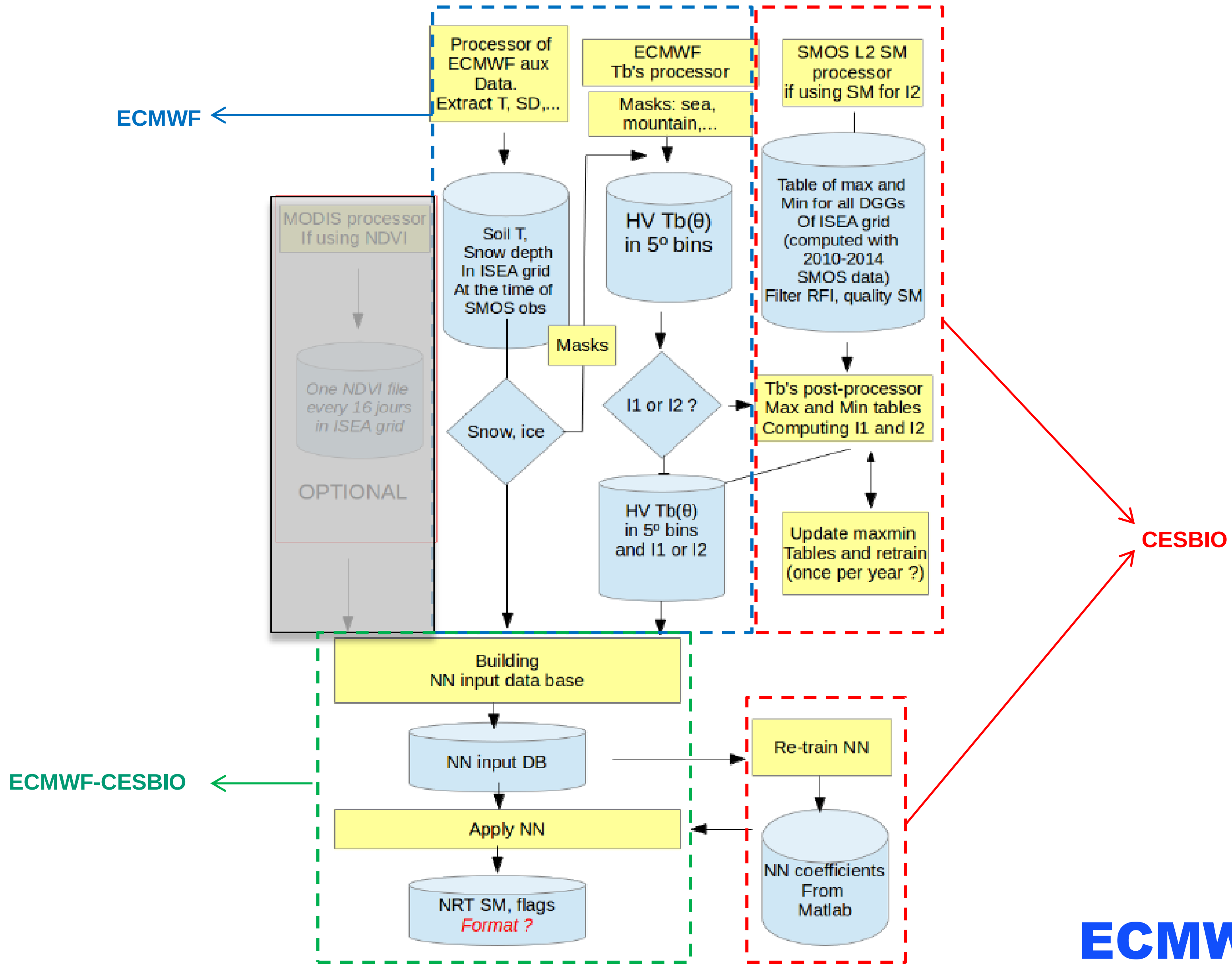


  - Reprocessing by operations is not needed!

- Specifications of the NRT SM NN:
  - Trade-off quality_product-swath_width → conservative approach is 3 angles and 2 polarisations → retrieval swath is 914 km,
  - Full swath retrieval still possible 1174 km at reasonable quality
    - One incidence angle and local normalization
    - Potential poor temporal correlations with L3SM at high latitudes
  - NDVI increases complexity of the processor and if *I2* is used, then no better performance,
    - MODIS NDVI MYI13C1 not in ECMWF archives
    - Development of acquisition stream and pre-processor
    - But NDVI important if less than 3 incidence angles.
  - Soil temperature included,

ECMWF

NRT processor



SM NRT with Neural Network

☑ What is done in a nutshell?:

- Master script to generate training database
  - retrieve data from archives,
  - compile fortran source,
  - manage time computations
  - archive and distribute files
  - clean memory
- “Raw” BUFR decoder developed in Fortran-90 (shorter latency than 6-h pre-processed BUFR),
- Profiles of T_B per ISEA node (T_B, rad. accuracy and geometry) constructed for input semi-orbit,
- Construction of T_B per ISEA node parallelised in MPI → Increase speed of processing,
- Breaks between snapshots computed through a break-hit table,
- Full pure-cross T_B profiles and radiometric accuracy profile generated through linear interpolation

☑ What is left to produce a training dataset?

- Rotation antenna (X,Y) → Earth (H,V)
- Binning in 5-degrees,
- ☑ Soil temperature interpolated at the location and time of the SMOS observations → best would be to use a part of the L2 pre-processor (IDEAS+)

ECMWF

SM NRT with Neural Network

☑ What is the objective of the ECMWF T_B processor?:

- Construct binned, HV full DGG profiles from XY observations

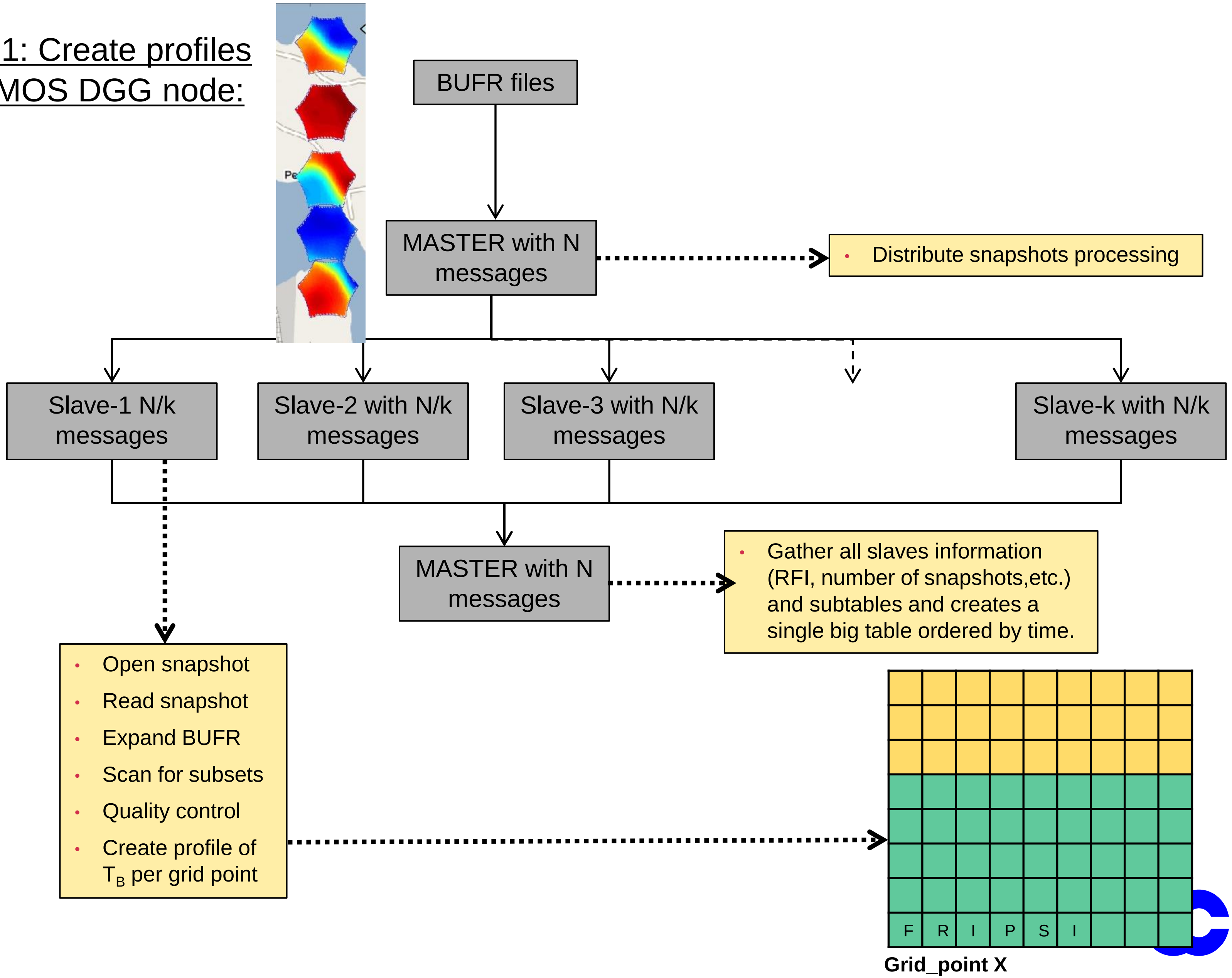
☑ Main steps

- Production of full profiles (T_B, geometry, flags, etc.) per SMOS DGG node,
- Detection of gaps in a sequence of snapshots,
- Interpolation of full T_B and accuracy profiles per consecutive segments,
- Rotation antenna (X,Y) → Earth (H,V)
- Binning and averaging
- Write output binary files and push them into a ftp (?)

ECMWF

NN - TB processor

☑ Step 1: Create profiles per SMOS DGG node:



NN - Gaps in a sequence ; break-hit table

- ☑ Gaps in a sequence of snapshots can be generated because:
  - Of the geometry near the swath border,
  - Local Oscillator CALibration event (it will miss 4 science snapshots every 10 minutes),
  - RFI detected will discard a snapshot,
- ☑ The best method to detect is through snapshot_id increments (by 2 every 5, otherwise 1) and snapshot time increments (1.2 s)

  → In BUFR, Snapshot time is composed of six INTEGER fields

Snap	Snp_inc	Pol-1	Pol	Sequence [snp_{-1} – snp]
1	1	3	0	[YX - XX]
2	1	0	0	[XX – XX*]
3	0	0	2	[XX* – XY]
4	2	2	1	[XY – YY]
5	1	1	1	[YY – YY*]
6	0	1	3	[YY* - YX]
7	1	3	0	[YX – XX]

Unique sequence of polarisations

[XX]	[XX/XY]	[YY]	[YY/YX]
[0]	[0/2]	[1]	[1/3]

NN - Interpolation table

- ☑ <u>Step 3:</u> Interpolation of full T_B and accuracy profiles in consecutive segments
  - ☑ Creation of interpolation tables
  - ☑ Much simpler in matlab (*IBTtmp(5,flgyy)=interp1(TStmp(flgxx),IBTtmp(5,flgxx),TStmp(flgyy));*

	[XX]	[XX/XY]	[YY]	[YY/YX]	[XX]	[XX/XY]
	1	**2**	**3**	**4**	**5**	**6**
TBxx	$TBxx_1$	$TBxx_2$			$TBxx_5$	$TBxx_6$
TByy			$TByy_3$	$TByy_4$		
Re(TBxy)		$Re(TBxy)_2$		$Re(TByx)_4$		$Re(TBxy)_6$
Im(TBxy)		$Im(TBxy)_2$		$Im(TByx)_4$		$Im(TBxy)_6$
RAxx	$RAxx_1$	$RAxx_2$			$RAxx_5$	$RAxx_6$
RAyy			$RAyy_3$	$RAyy_4$		
RAxy		$RAxy_2$		$RAyx_4$		$RAxy_6$
θ	θ_1	θ_1	θ_3	θ_3	θ_5	θ_5
α	α_1	α_1	α_3	α_3	α_5	α_5
TS	TS_1	TS_2	TS_3	TS_4	TS_5	TS_6

Observed

Not defined

Ascendent sorted

Main_program
- ...
- **SUB XY2HV**
  - **SUB interp_linear**
    - **FUNC vec_asc_test**
    - **SUB vec_bounds**

NN - Interpolation table - example

☑ Step 3: Interpolation of full T_B and accuracy profiles in consecutive segments

☑ Numerical example of interpolated profiles for test semi-orbit

	[XX]	[XX/XY]	[YY]	[YY/YX]	[XX]	[XX/XY]
	1	**2**	**3**	**4**	**5**	**6**
TBxx	247.8	251.8	249.1	246.4	243.7	240.2
TByy	261.6	252.3	243.1	233.8	234.0	234.5
Re(TBxy)	-3.47	**-4.99**	-6.50	**-8.02**	-7.47	**-6.36**
Im(TBxy)	4.79	**1.24**	-2.31	**-5.86**	-5.60	**-5.09**
RAxx	3.18	5.21	4.56	3.91	3.27	5.34
RAyy	-0.91	1.21	3.33	5.46	4.98	4.01
RAxy	4.39	**4.46**	4.52	**4.58**	4.58	4.58
θ	θ_1	θ_1	θ_3	θ_3	θ_5	θ_5
α	α_1	α_1	α_3	α_3	α_5	α_5
TS_diff	0	1	2	3	4	6

Main_program
...
└► **SUB XY2HV**
  └► **SUB interp_linear**
    ├► **FUNC vec_asc_test**
    └► **SUB vec_bounds**

Interpolate TBxx where there are pure YY records

Interpolate RAxx where there are pure YY records

ECMWF

NN - Interpolation table - example

- Step 3: Interpolation of full T_B and accuracy profiles in consecutive segments
  - Numerical example of interpolated profiles for test semi-orbit

	[XX]	[XX/XY]	[YY]	[YY/YX]	[XX]	[XX/XY]
	1	**2**	**3**	**4**	**5**	**6**
TBxx	247.8	251.8	249.1	246.4	243.7	240.2
TByy	261.6	252.3	243.1	233.8	234.0	234.5
Re(TBxy)	-3.47	**-4.99**	-6.50	**-8.02**	-7.47	**-6.36**
Im(TBxy)	4.79	**1.24**	-2.31	**-5.86**	-5.60	**-5.09**
RAxx	3.18	5.21	4.56	3.91	3.27	5.34
RAyy	-0.91	1.21	3.33	5.46	4.98	4.01
RAxy	4.39	**4.46**	4.52	**4.58**	4.58	4.58
θ	θ_1	θ_1	θ_3	θ_3	θ_5	θ_5
α	α_1	α_1	α_3	α_3	α_5	α_5
TS_diff	0	1	2	3	4	6

Main_program
...
└ SUB **XY2HV**
  └ SUB **interp_linear**
    ├ FUNC **vec_asc_test**
    └ SUB **vec_bounds**

Interpolate TByy where there are pure XX records

Interpolate RAyy where there are pure XX records

SM NRT with Neural Network

☑ <u>Step 4:</u> Rotation from the antenna reference to the Earth reference frame

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ A_4 \end{bmatrix} = \begin{bmatrix} \cos(\alpha)^2 & \sin(\alpha)^2 & sin(\alpha)\cos(\alpha) & 0 \\ \sin(\alpha)^2 & \cos(\alpha)^2 & -sin(\alpha)\cos(\alpha) & 0 \\ \sin(2\alpha) & -\sin(2\alpha) & \cos(2\alpha) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} T_B H \\ T_B V \\ ST_3 \\ ST_4 \end{bmatrix}$$

A_1= real($T_B XX$)

A_2= real(T_BYY)

A_3= 2 * real($T_B X$Y)

A_4= -2 * imag(T_BXY)

$\alpha = \text{Geometric} + \text{ Faraday angle}$

$A = MR_4(\alpha)\ T \rightarrow MR_4^{-1}(\alpha)\ A = MR_4(-\alpha)\ A = T$

SM NRT with Neural Network

☑ Caveats:

- Matlab code cannot directly be translated into Fortran code,
- Matlab uses lot of built-in functions (BLKDIAG, CELL, BITAND, DATESTR, DATENUM)
  - Lot of new functions need to be written
  - Use of external libraries
- BUFR is different from L1C

☑ Others:

- So far, 1400 lines of code (included subroutines and functions)
- First version of processor tested in CRAY (batch-job),
- Optimization will probably be necessary to avoid very long runtime. Profiling will be done with gnu compiler.

ECMWF