SEKF Surface data assimilation experiments with cy40 AROME-SURFEX model

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ORSZÁGOS METEOROLÓGIAI SZOLGÁLAT

Motivation

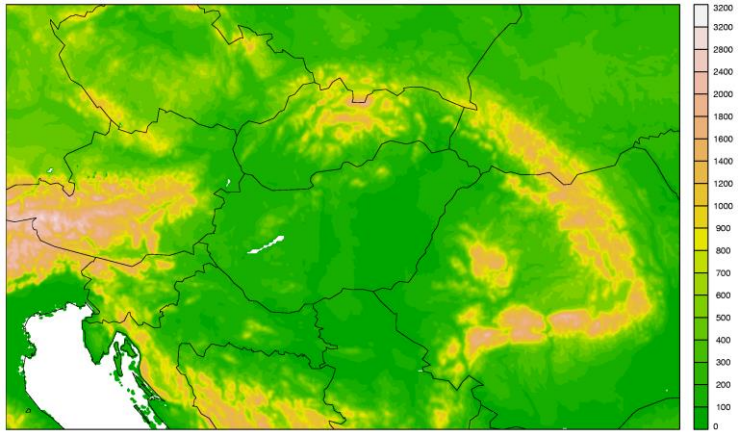
- Operational surface assimilation, CANARI OI-MAIN is very fast, but a lot of times inaccurate
- OMSZ strategy: use more reliable surface assim. (e.g. (S)EKF)

- Cy40t1 SODA was implemented but not tested

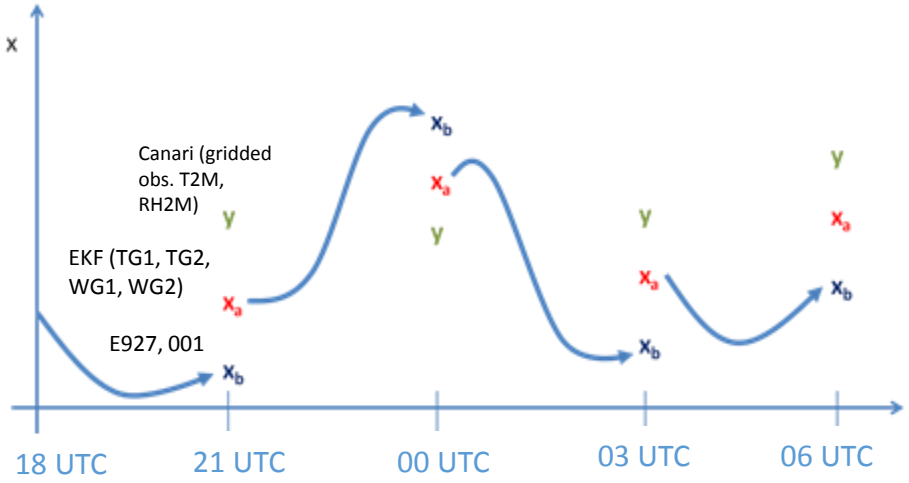
- Past: Surfex offline run (stand-alone versions 6.0 and 7.3) and (S)EKF assimilation of satellite data (SWI and LAI) were used in GEOLAND2 and IMAGINES project
- Experiences with VARASSIM code (similar to SODA) and ISBA-A-gs (prognostic LAI)

- Last half year: Development of SEKF scripts and SMS environment, performing 2 case studies

- ***Operational*** **Arome-Hungary**: 2.5 x 2.5 km horizontal resolution, 490 x 310 points, 60 vertical levels, cy40t1 with Surfex V7.3
- Data assimilation:
  - Assim window: 3 h
  - ***3D-VAR*** (Synop, Temp, Amdar, GNSS ZTD, Slovenian Mode-S)
  - Surface analysis: ***OI-MAIN***



- ***Experimental setup***: ***AROME + 3D-VAR+ SEKF***
- SEKF: CANARI gridded observation T2M and RH2M used => produce surface analysis (TG1, TG2, WG1 and WG2)
  - Forcings: inline fullpos from 9 m
  - Surfex: 4 tiles, 1 patch
    - ISBA: 3 layers, Canopy
    - B matrix: fixed



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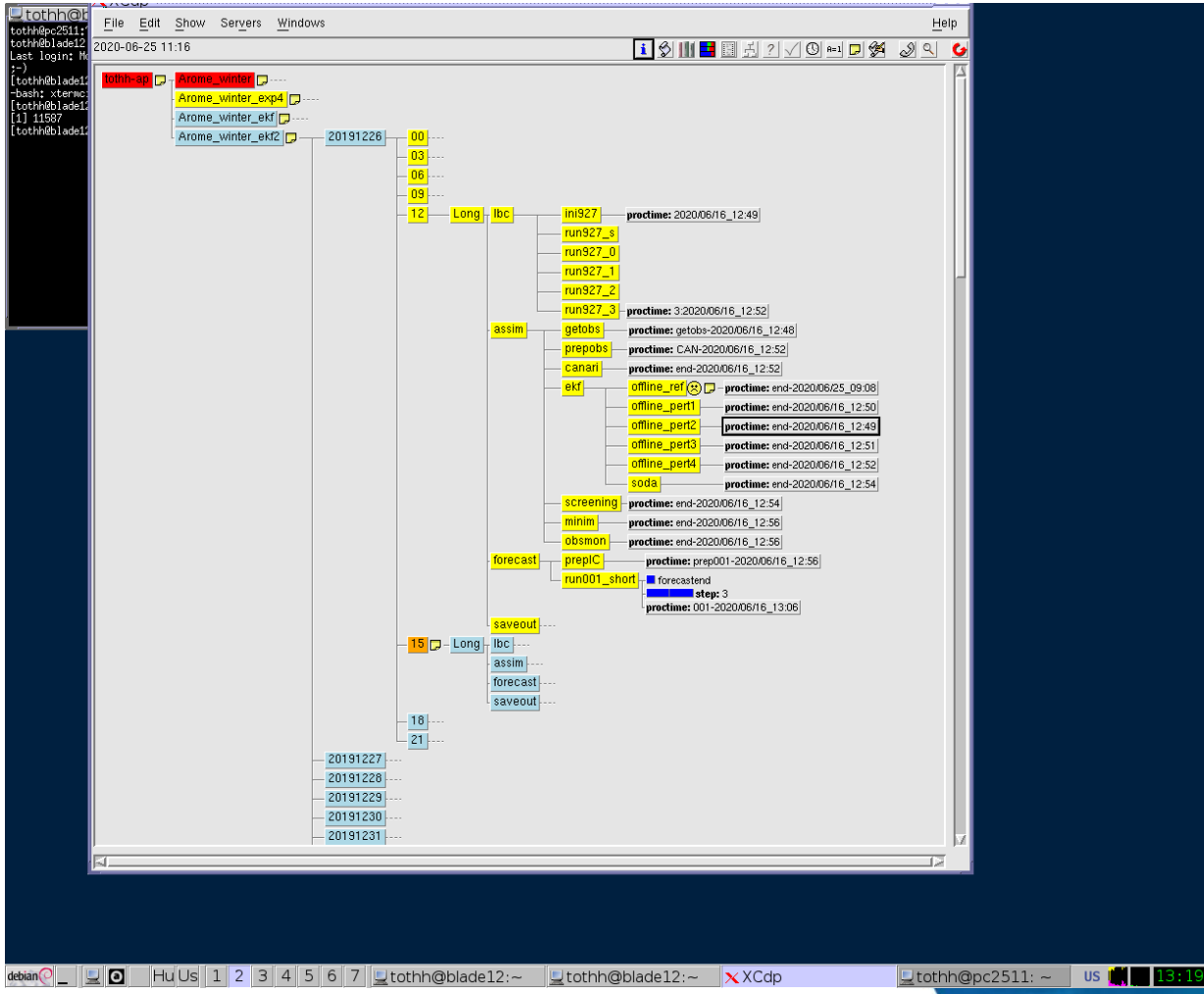
- $x_a = x_b + K\,(y - \mathcal{H}x_b)$
- where $\mathbf{K} = \mathbf{BH^T}\left(\mathbf{HBH^T} + \mathbf{R}\right)$

- **H** is linearized because the nonlinear operator is linearized around the background field (Taylor series):
- $$\mathbf{H} = \begin{matrix} \frac{\partial T2M}{\partial TG1} & \frac{\partial T2M}{\partial TG2} & \frac{\partial T2M}{\partial WG1} & \frac{\partial T2M}{\partial WG2} \\ \frac{\partial HU2M}{\partial TG1} & \frac{\partial HU2M}{\partial TG2} & \frac{\partial HU2M}{\partial WG1} & \frac{\partial HU2M}{\partial WG2} \end{matrix}$$

H members of the so-called. Jacobian elements. Generating the members in practice: we run the SURFEX model from t-1 to t0 n + 1 times, where n is the number of control variables. That is, in this case 5 times (4 controls + reference)



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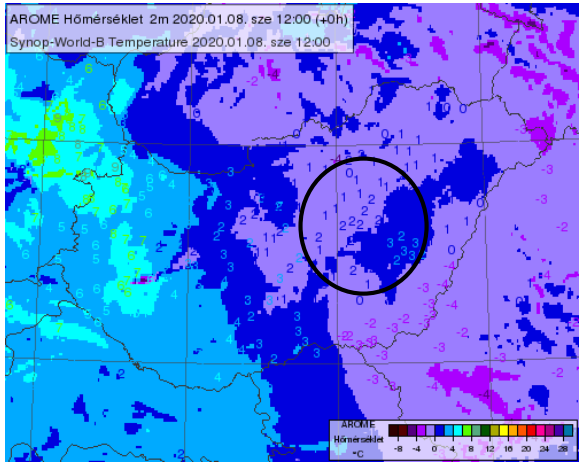
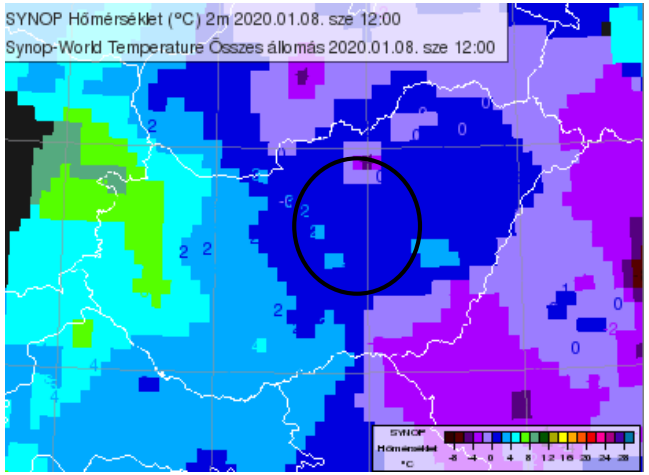
1. Case study: 8th January, 2020 12 UTC run

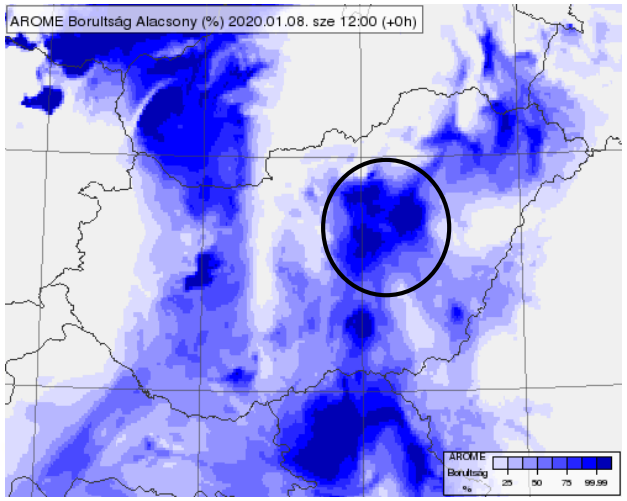
OPER analysis T2M



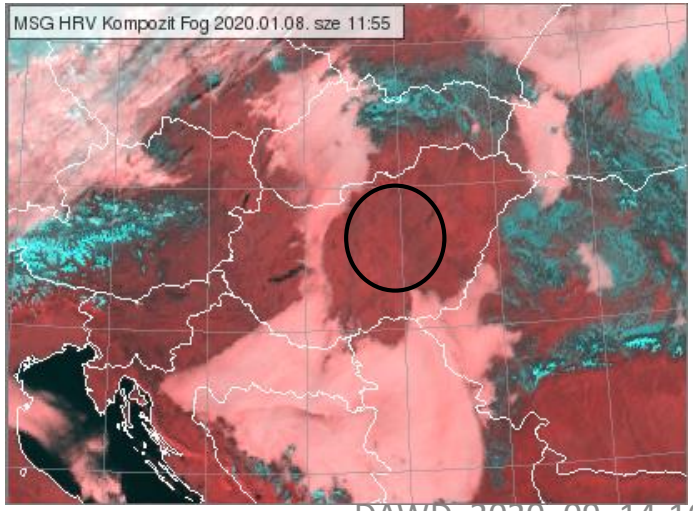
SYNOP



OPER analysis low level cloudiness



MSG Fog



False low level cloudiness analysis => bad (colder) T2M anal. and forecast

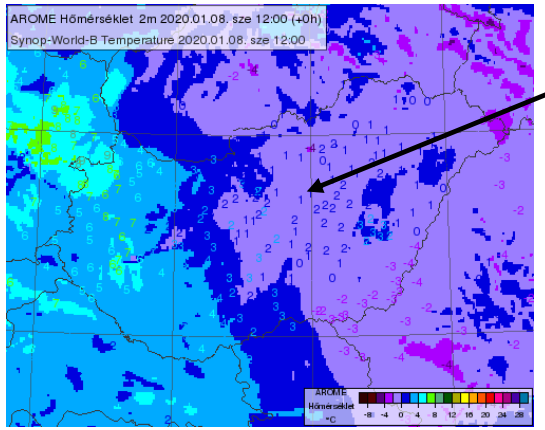
The surface is probably **too wet!**

SEKF exp.: spinup from 26th Dec. 2019

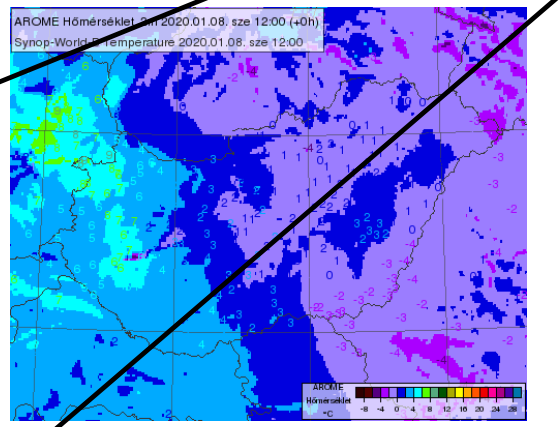
- Assim run: 26th Dec 2019 – 08th Jan. 2020 with 3 hours cycle
- Obs.: CANARI T2M and RH2M
- Control variables: WG1,WG2,TG1,TG2

SEKF also produced the wrong low level cloud. and T2M

EKF



OPER



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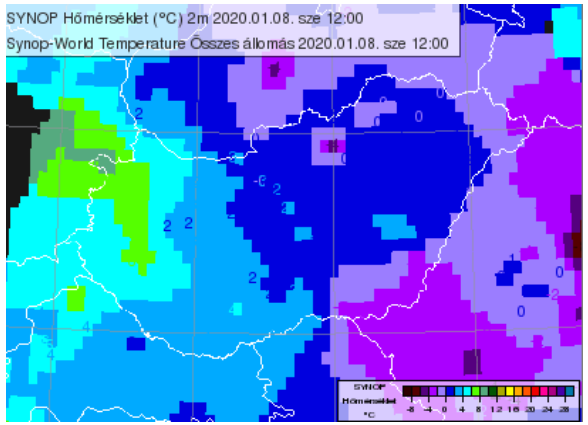
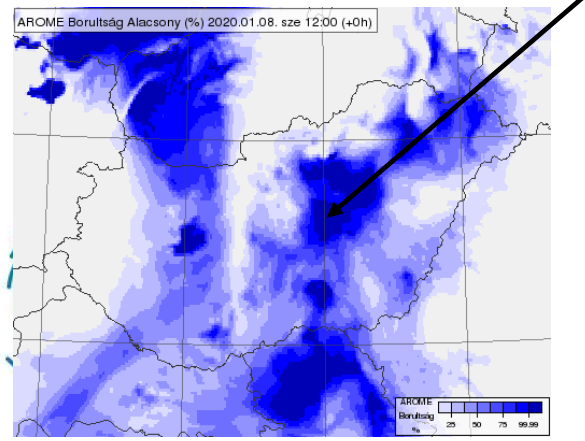
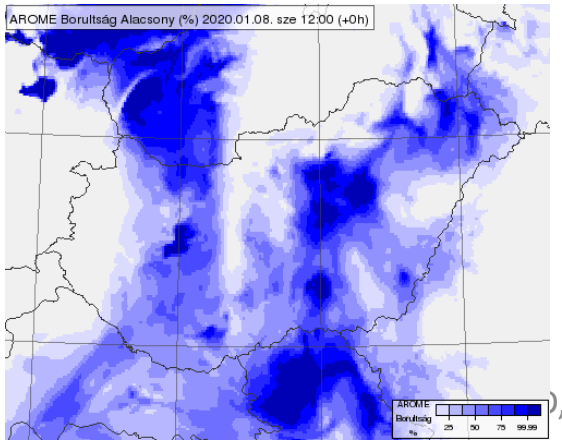
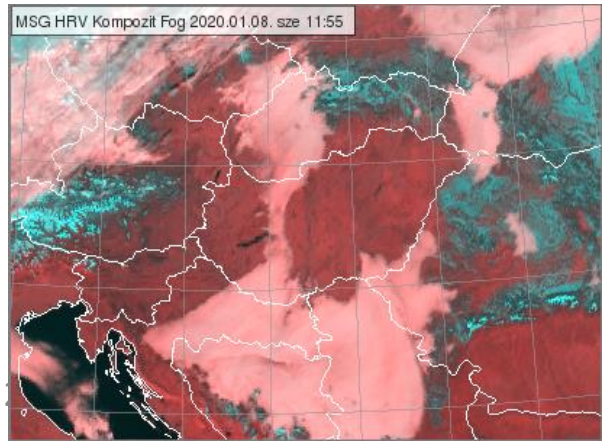
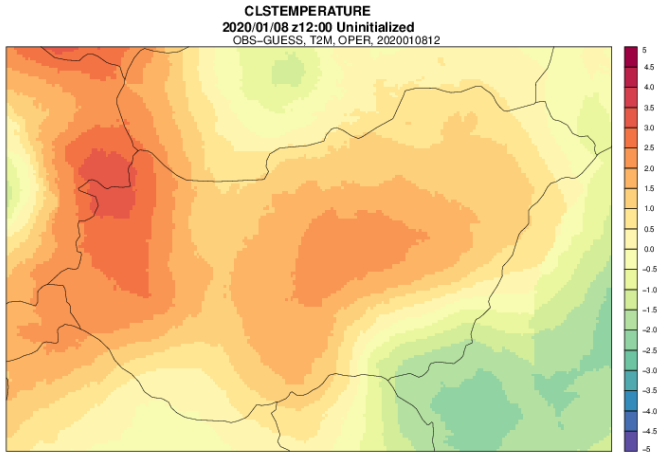








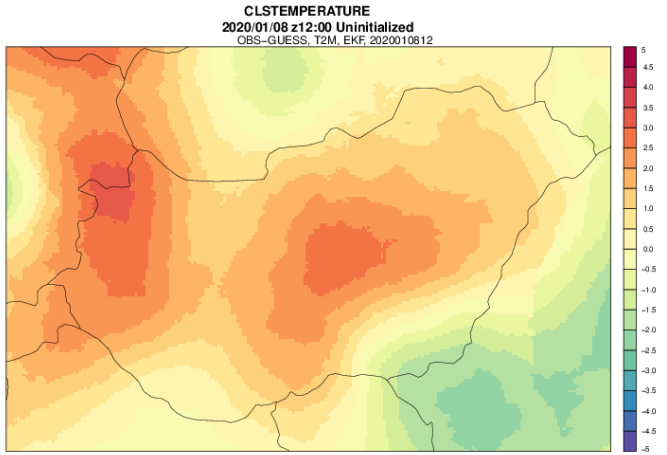
OBS-GUESS, OI-MAIN, T2M



5

-5

OBS-GUESS, SEKF, T2M



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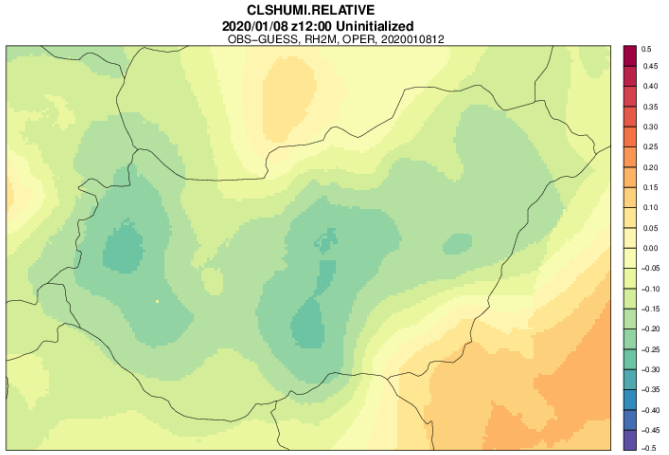
-5

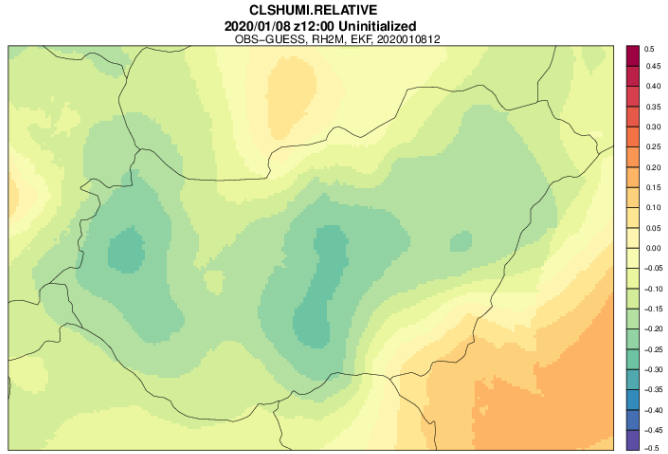
OBS-GUESS, OI-MAIN, RH2M



0.5

-0.5

OBS-GUESS, SEKF, RH2M



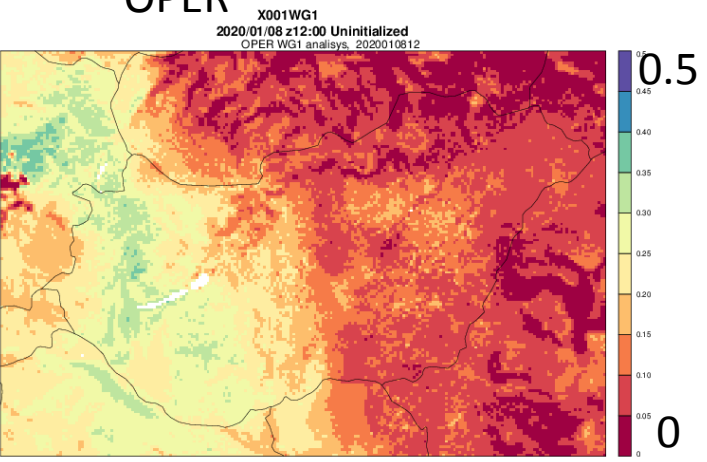
0.5

-0.5

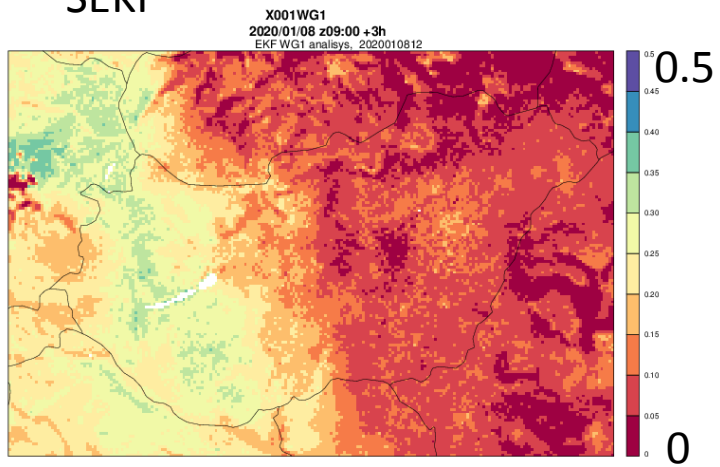
Similar obs-guess pattern appeared in both experiments.

WG1

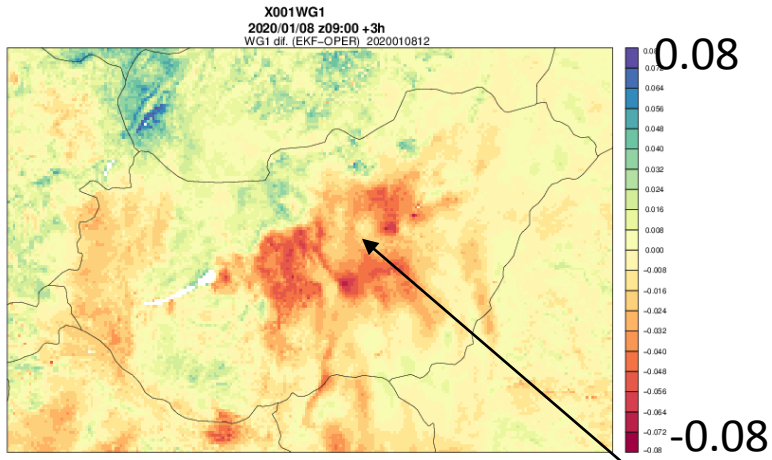
OPER



SEKF

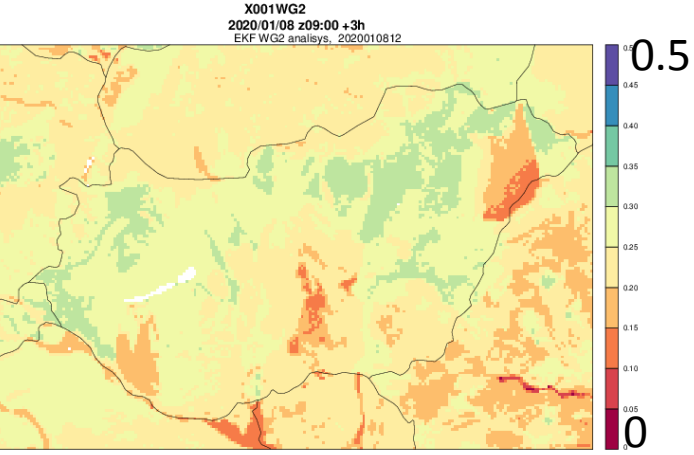


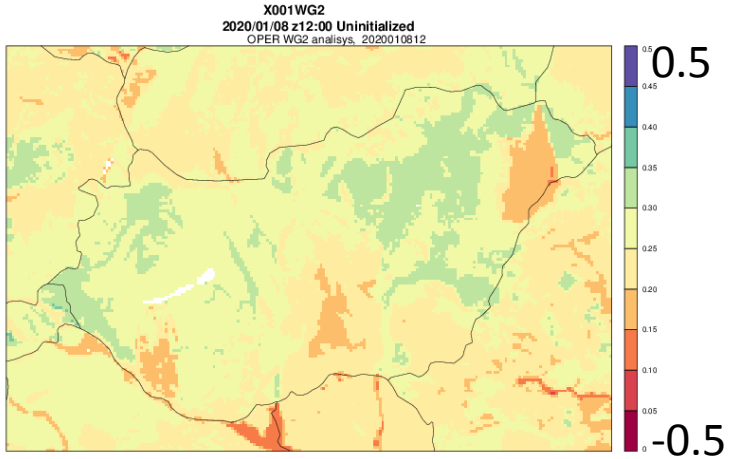
(SEKF-OPER)

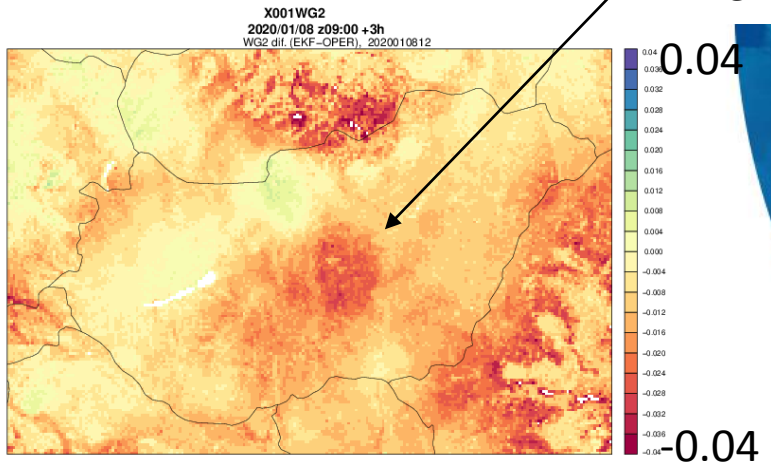


SEKF is drier for both variables, which is expected

WG2





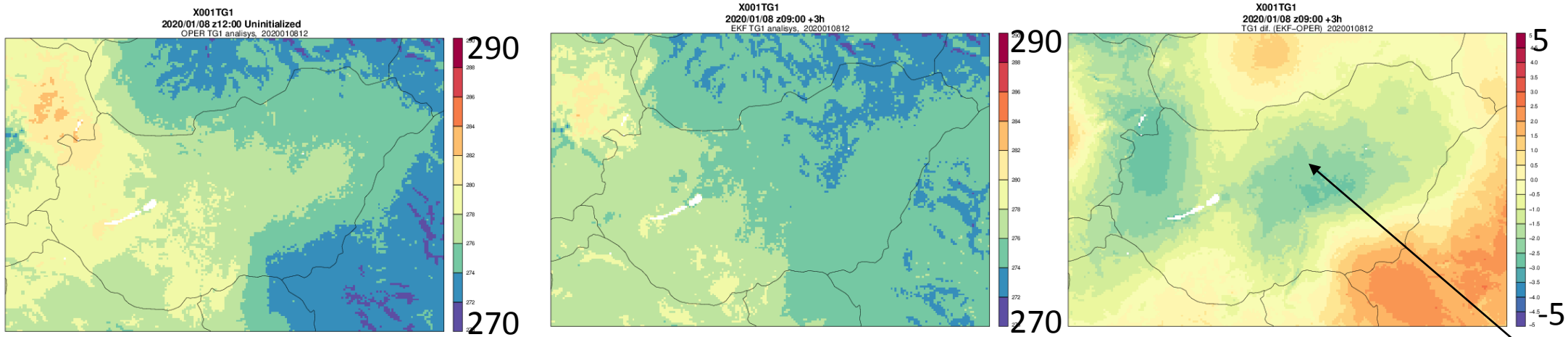


TG1

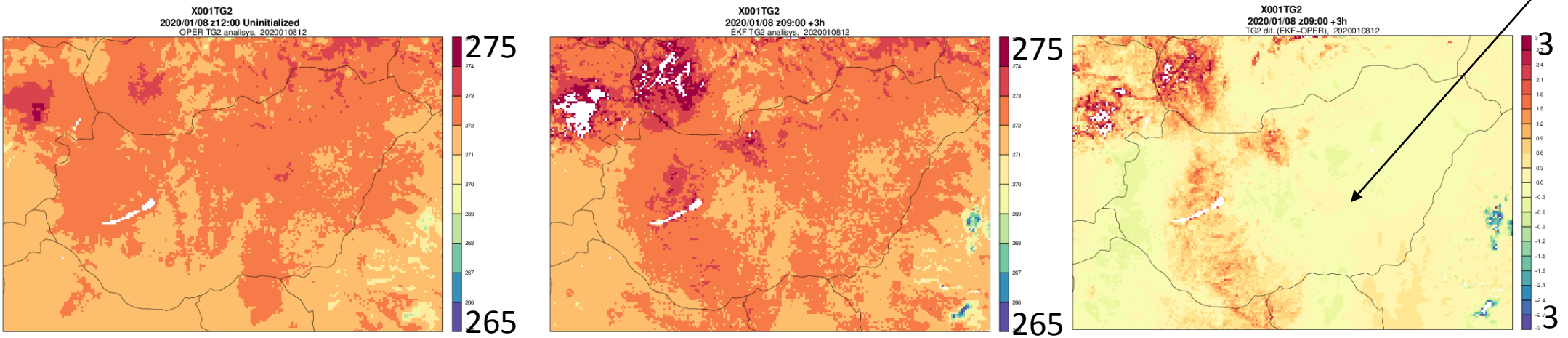
OPER

SEKF

(SEKF-OPER)



TG2



SEKF is colder / neutral for both variables

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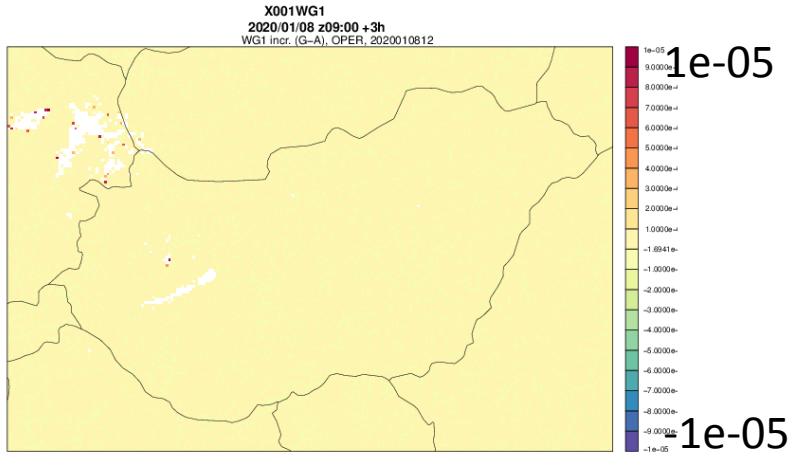
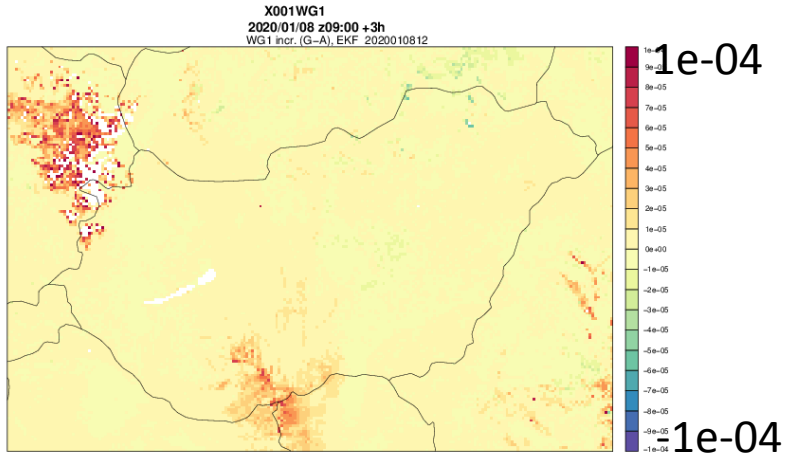
Analysis increments

WG1

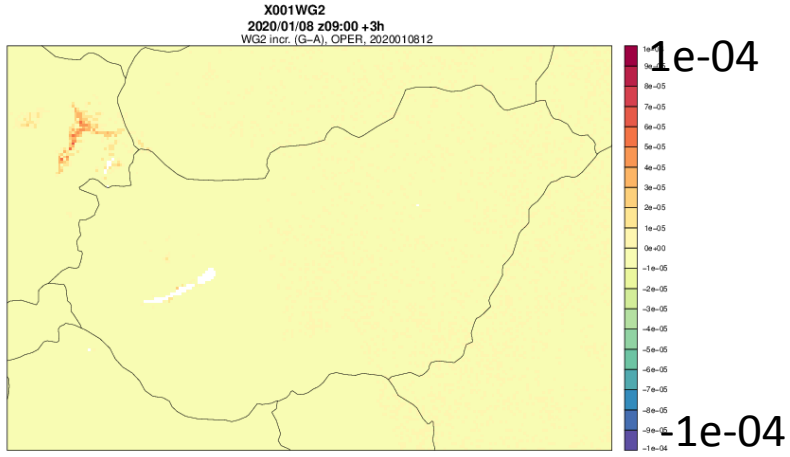
OPER, G-A

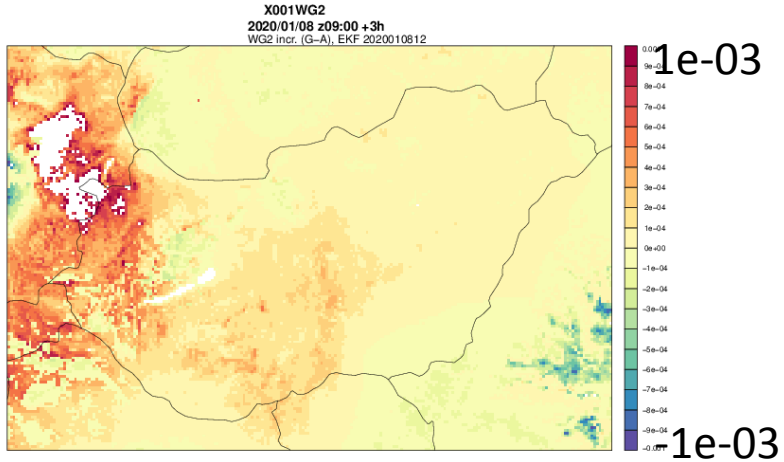


SEKF, G-A



WG2

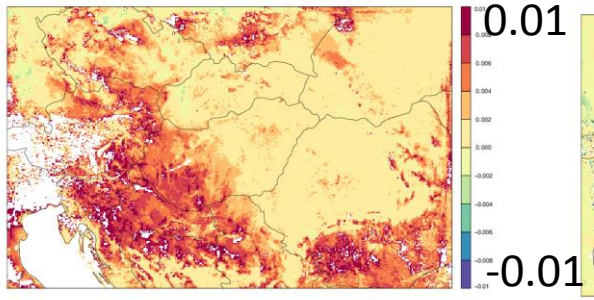




No increments of WG1 and WG2 for OI-MAIN, small increments for SEKF

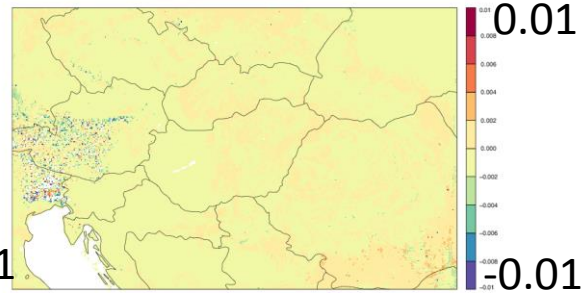
Jacobian elements

dT2M/dTG1



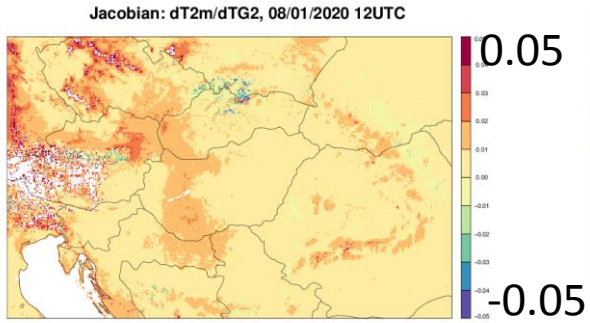
Incr. soil TG1 => incr. T2m

dRH2M/dTG1



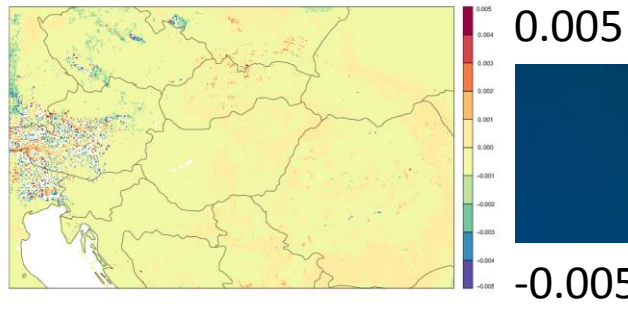
Incr. soil TG1 => decr. RH2m

dT2M/dTG2



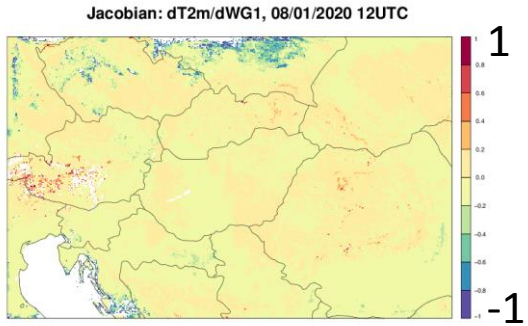
Incr. soil TG2 => incr. T2m (effect is larger, than TG1)

dRH2M/dTG1



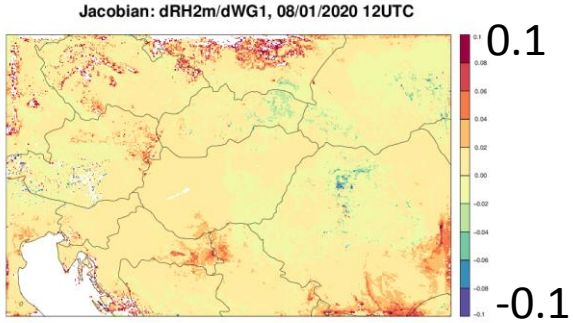
Incr. soil TG2 => decr. RH2m

dT2M/dWG1



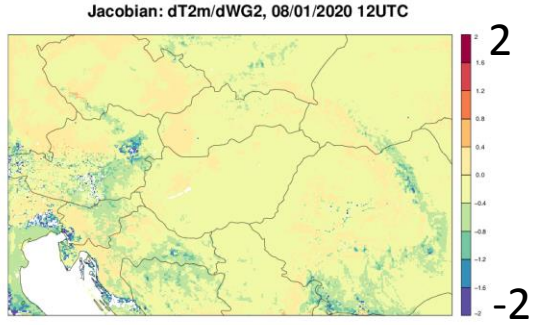
Incr. soil WG1 => decr. T2m

dRH2M/dWG1



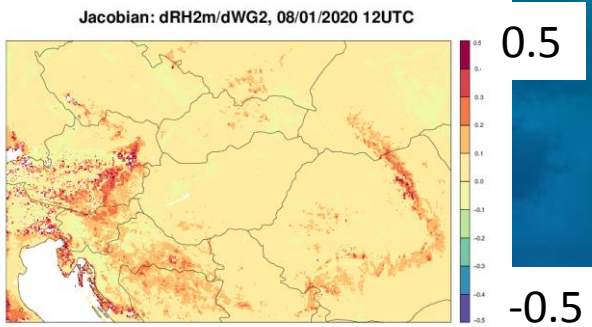
Incr. soil WG1 => incr. RH2m

dT2M/dWG2



Incr. soil WG2 => decr. T2m (effect is smaller then WG1)

dRH2M/dWG2



Incr. soil WG2 => incr. RH2m

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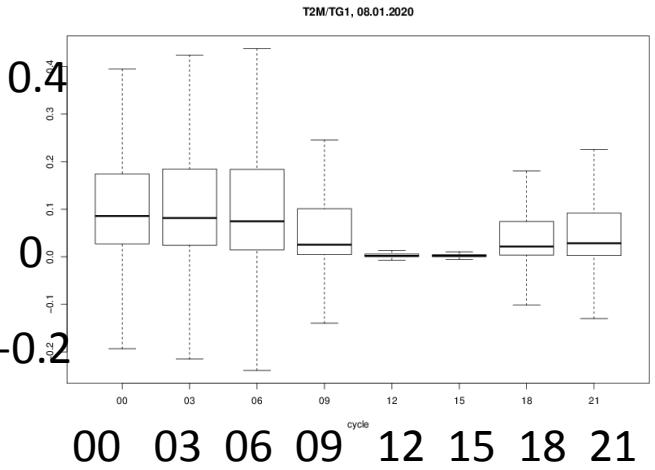
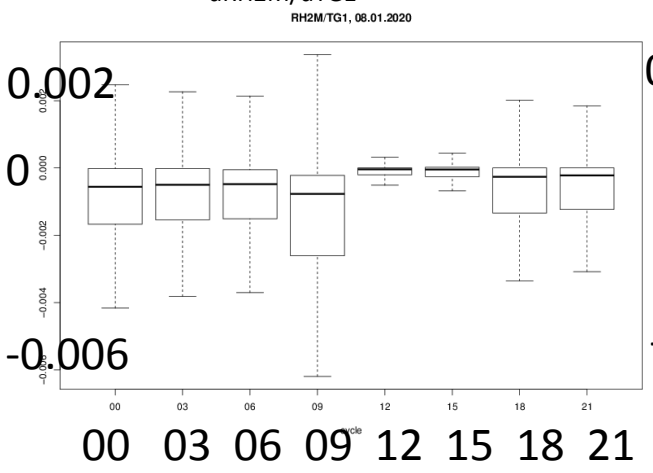
Jacobians seems OK, except in the mountain regions (very noisy)

Jacobian box-plots for 08.01.2020 (all points in the whole domain)

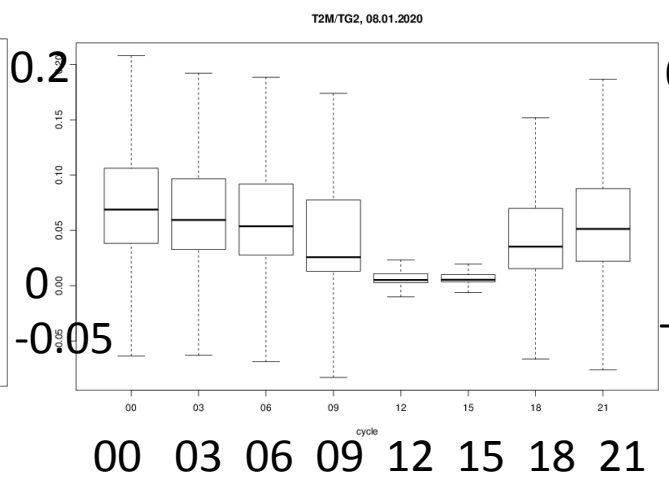
dT2M/dTG1



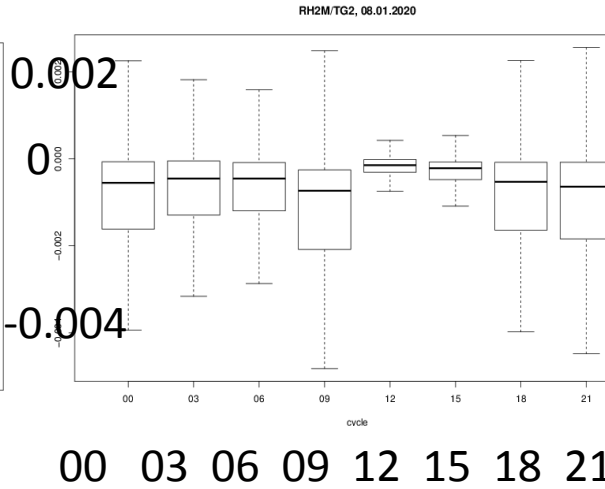
dRH2M/dTG1



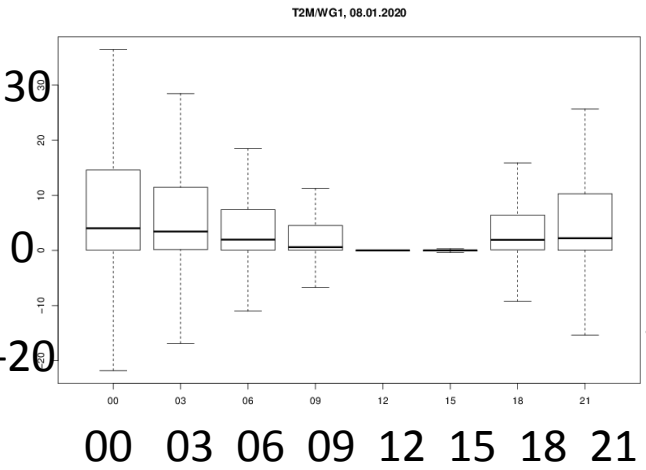
dT2M/dTG2



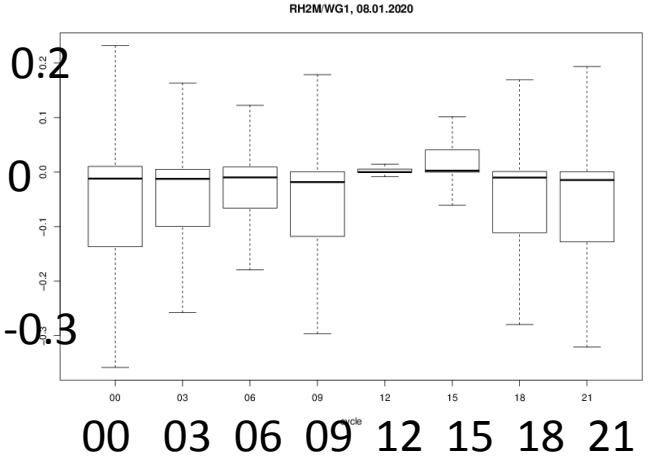
dTRH2M/dTG2



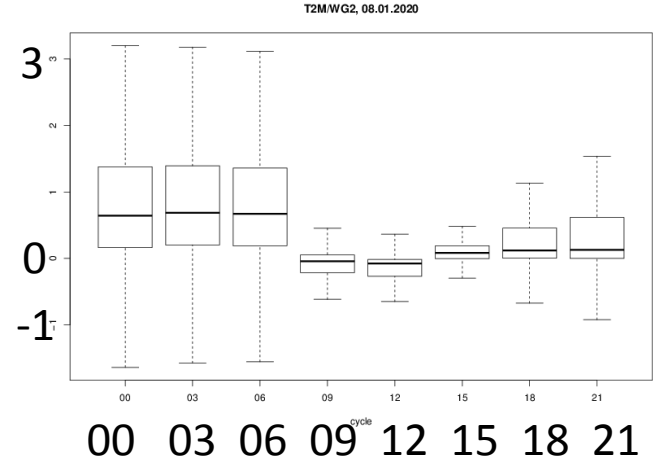
dT2M/dWG1



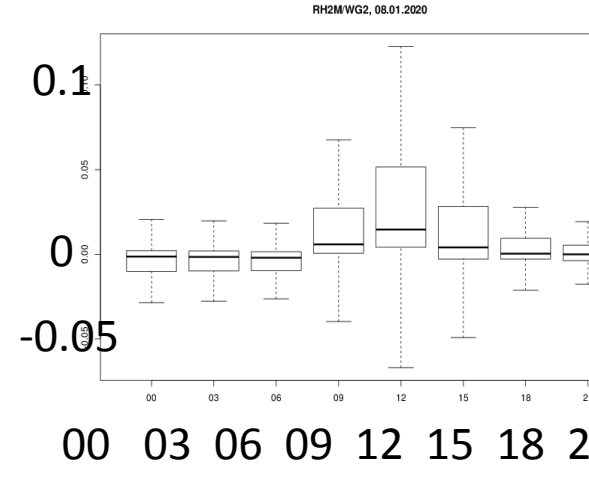
dRH2M/dWG1



dT2M/dWG2



dRH2M/dWG2

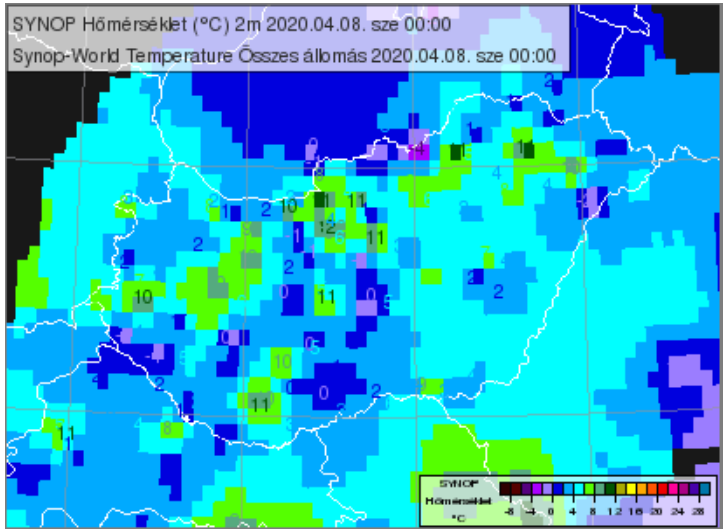


SZOLGÁLAT

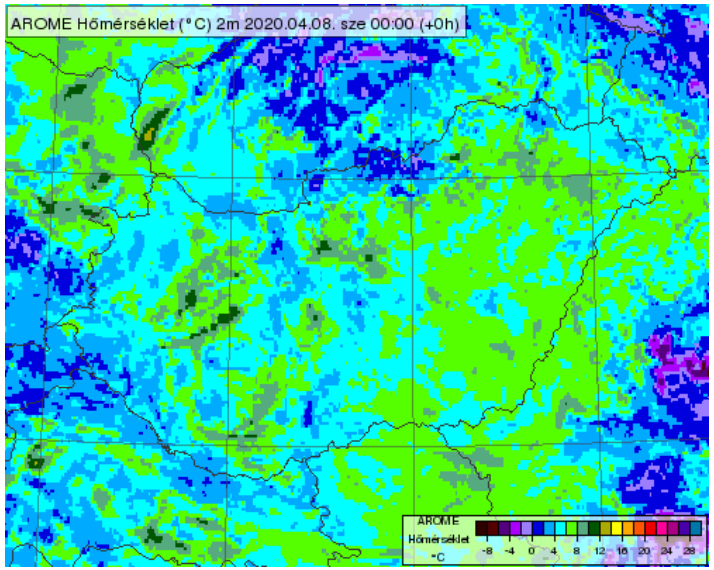
=> Small Jacobians during daylights (except for RH2M/WG2) => almost no effect on 2m elements

Case study: 8th April, 2020 00 UTC run (long-life AC) (spinup from 26th Marc. 2020)

SYNOP T2M

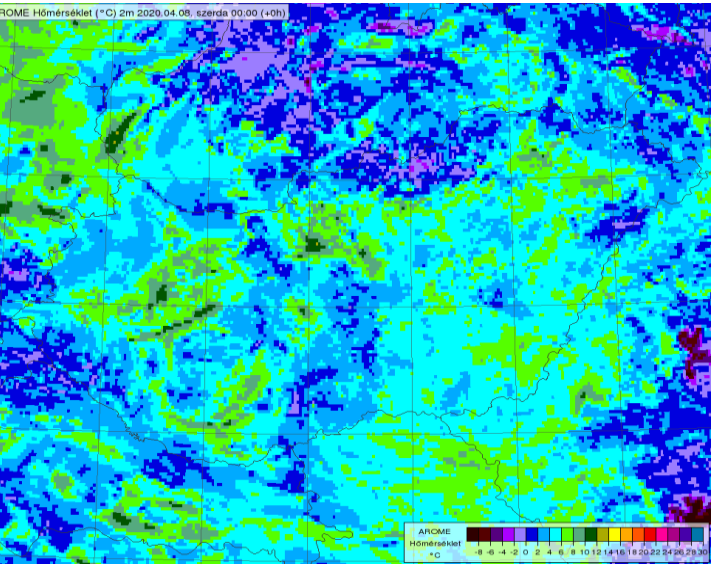


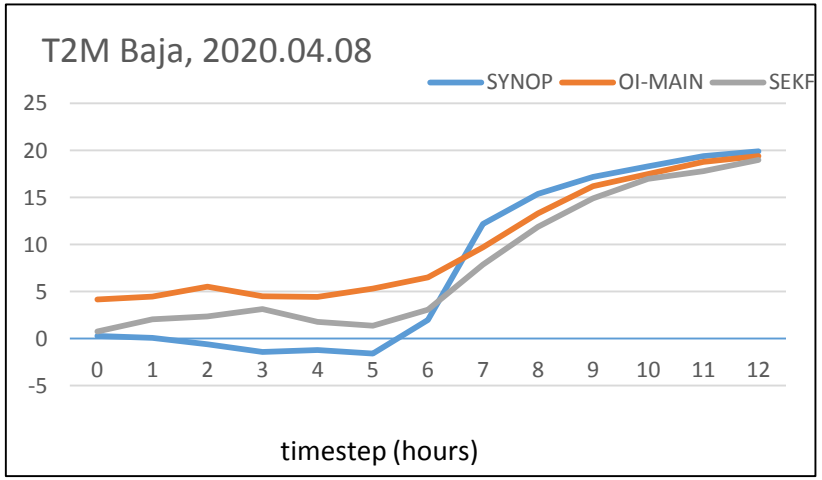
OI-MAIN T2M analysis



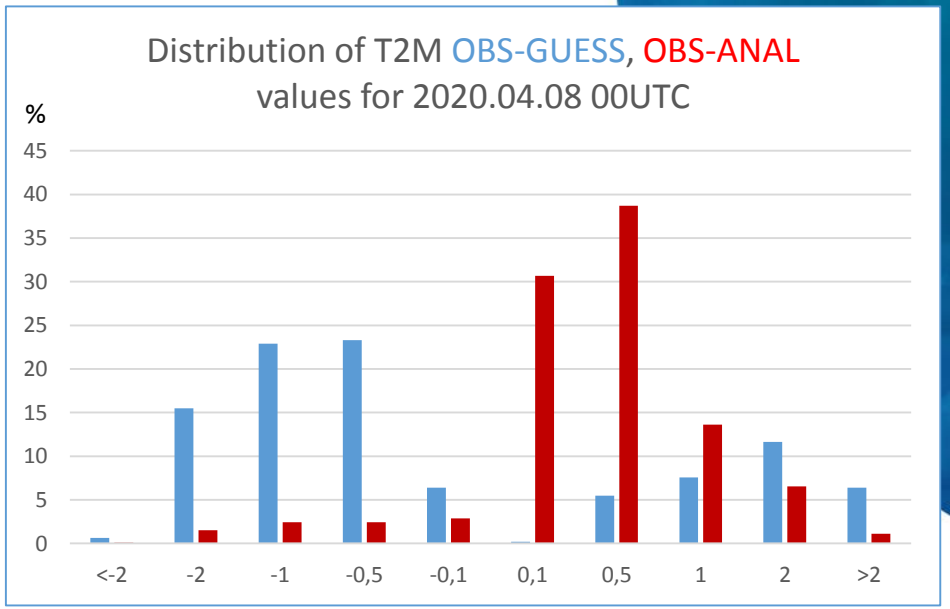
Typical AROME problem: TMIN is usually overestimated and TMAX is underestimated in these kinds of anticyclonic cases

SEKF T2M



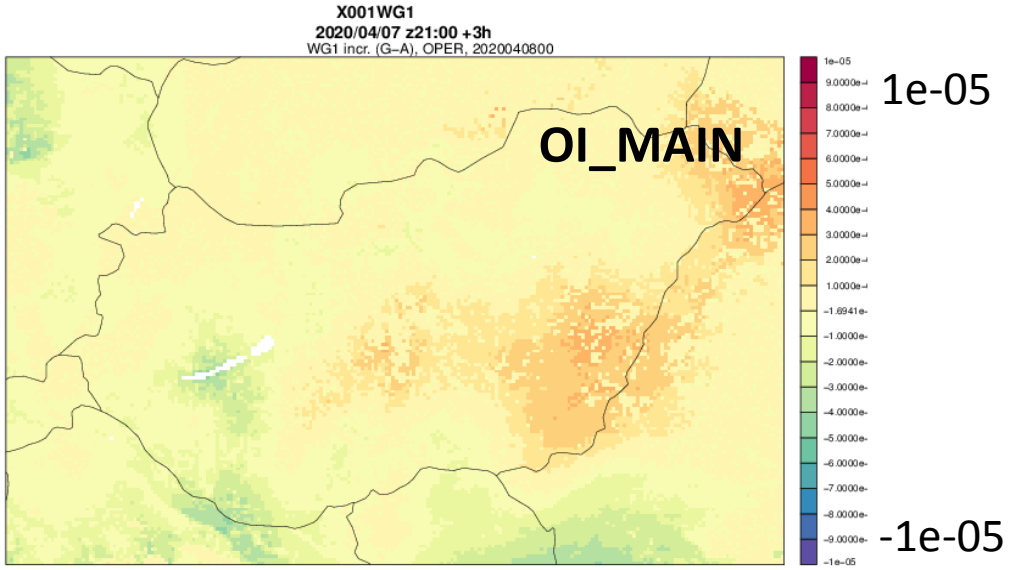


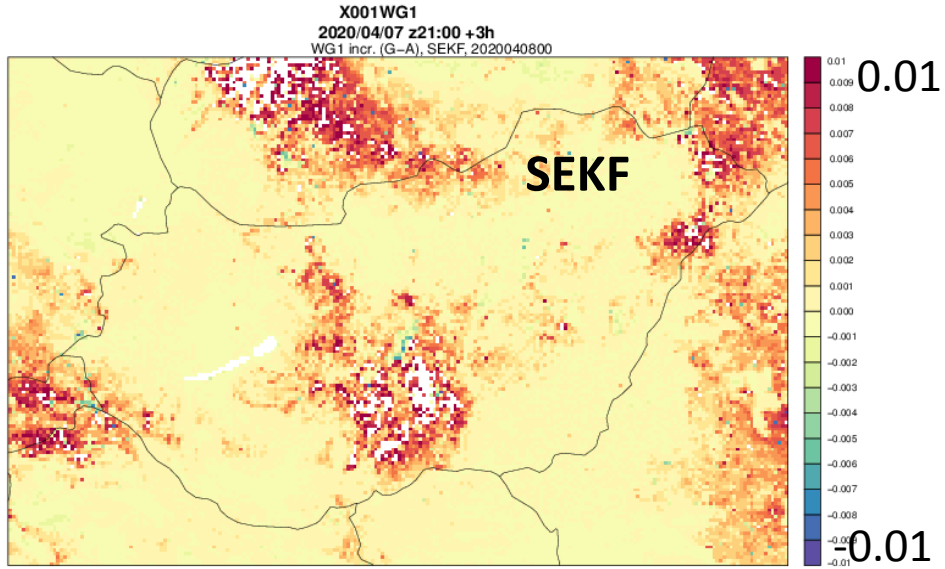
DAWD, 2020. 09. 14-16



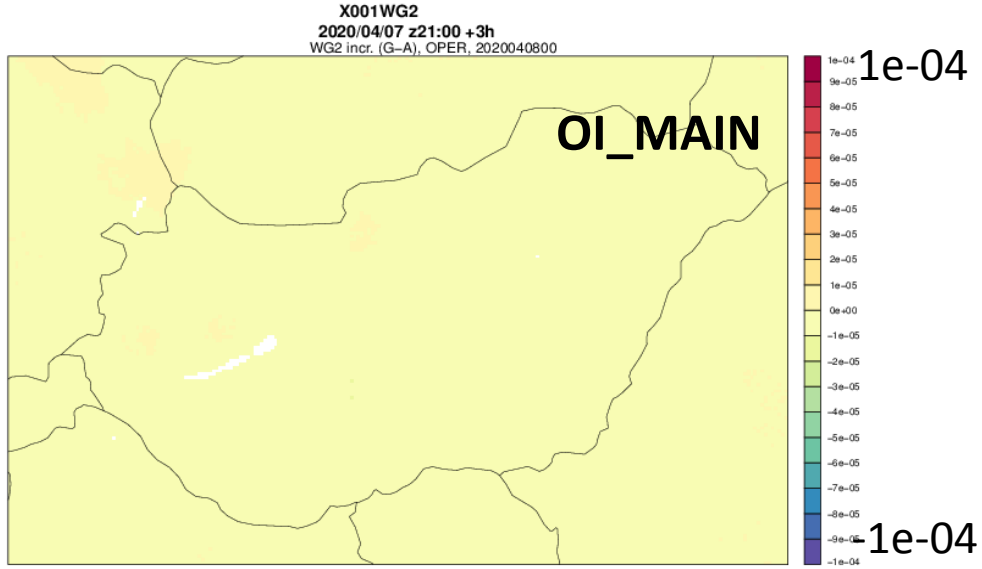
Analysis increments

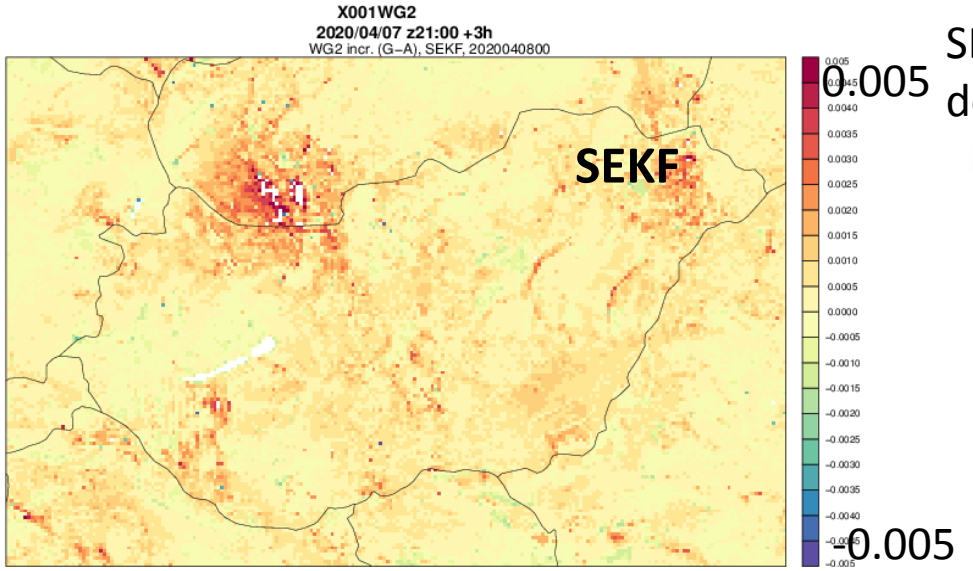
WG1





WG2

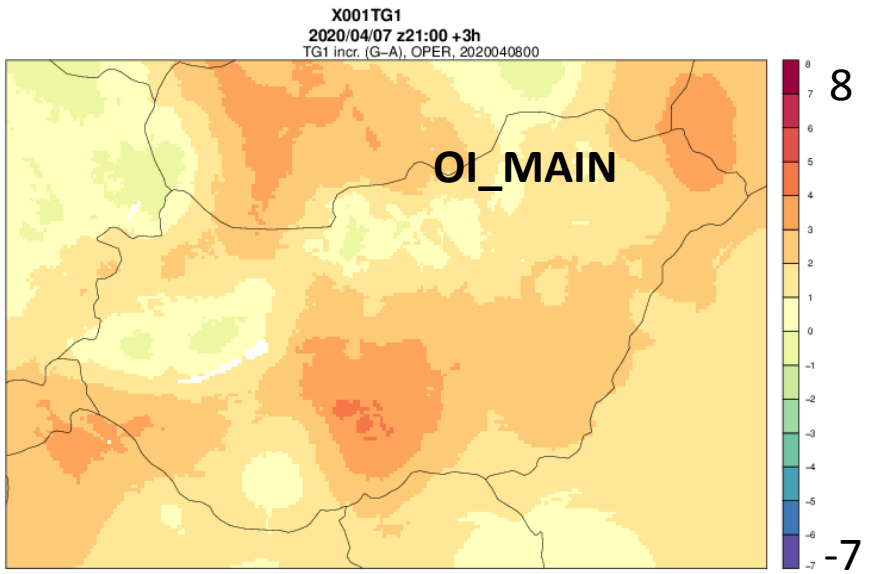


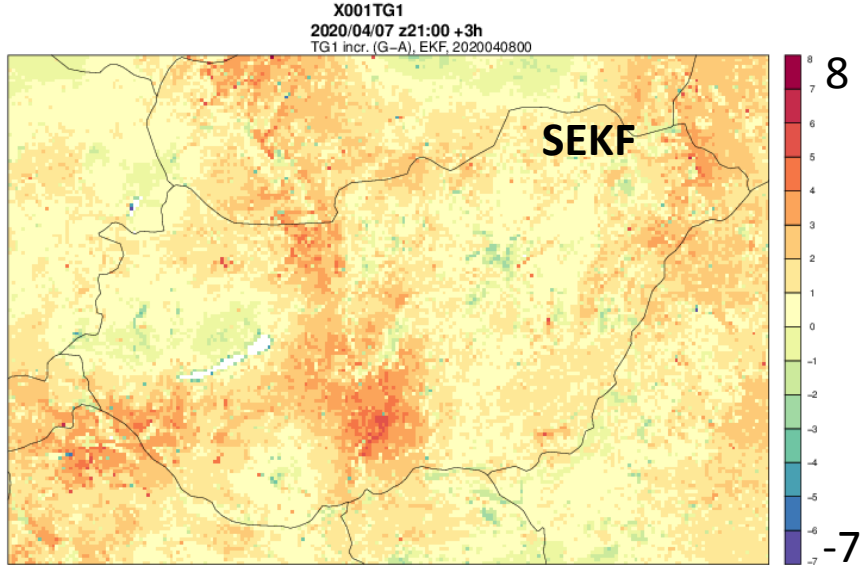


OI-MAIN gives a much smaller increment (several orders of magnitude) than SEKF, no incr. at deeper levels

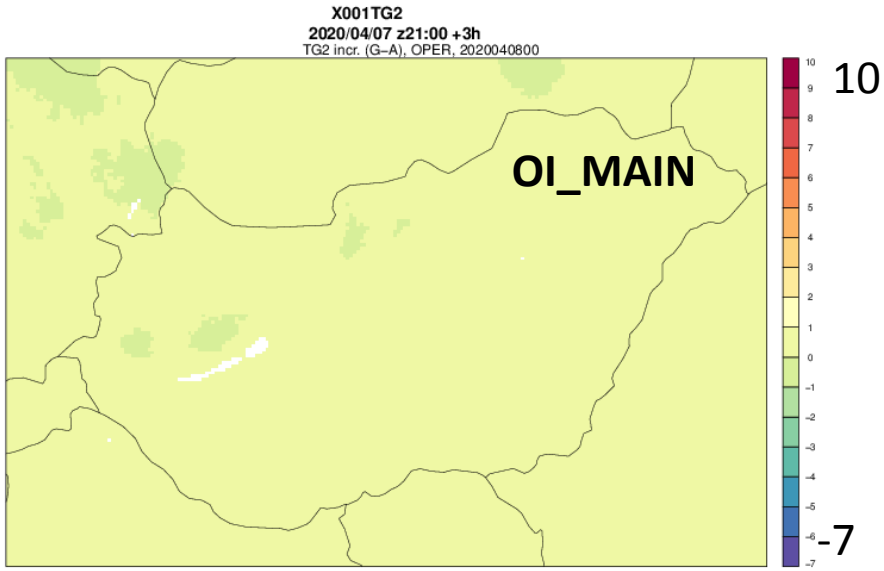
Analysis increments

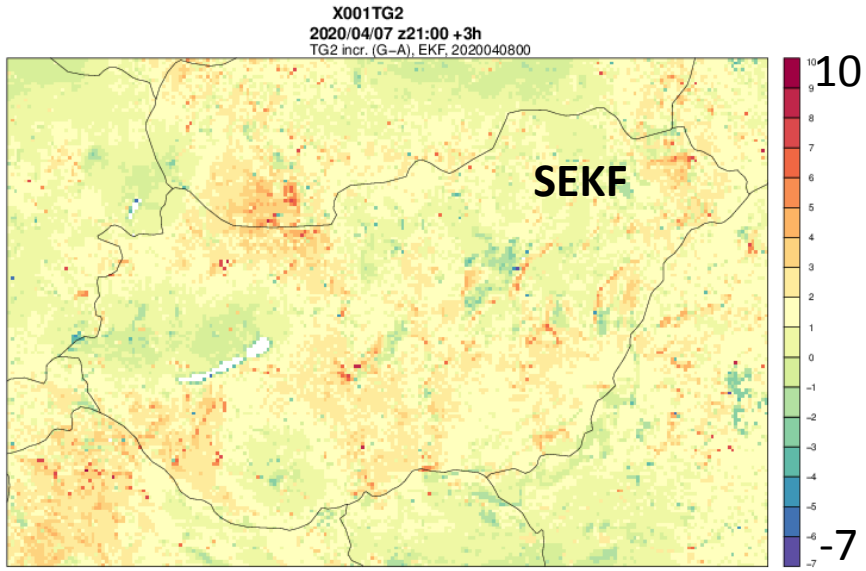
TG1





TG2

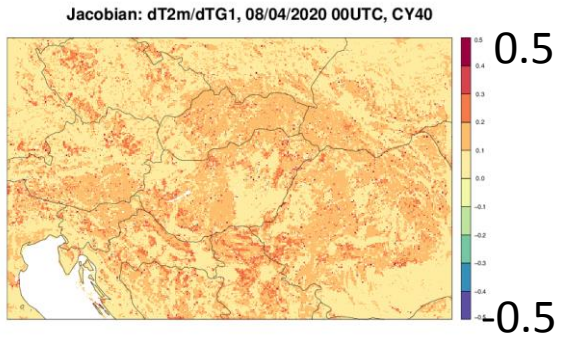




OI-MAIN gives a smaller increment than SEKF, 0 at deeper levels. SEKF is very noisy

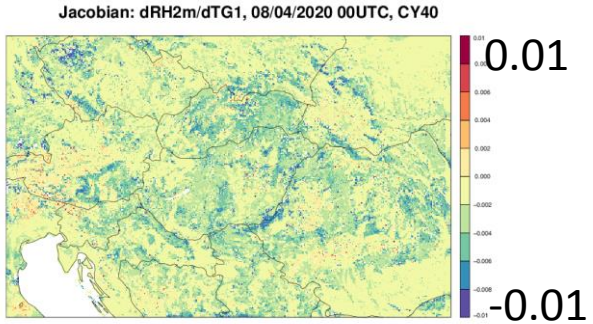
Jacobian elements

dT2M/dTG1



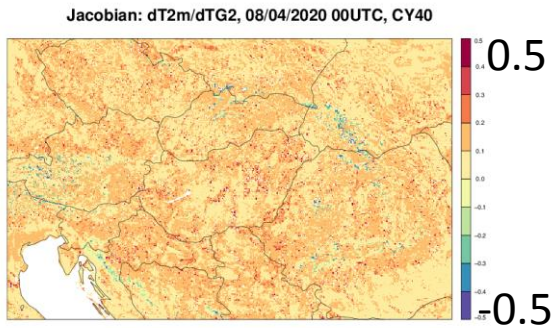
rising TG1 => rising T2m

dRH2M/dTG1



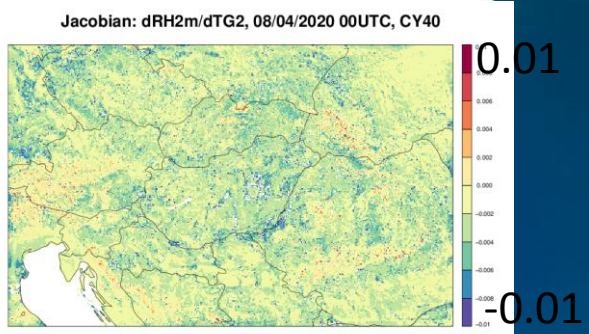
Rising TG1 => decreasing RH2m

dT2M/dTG2



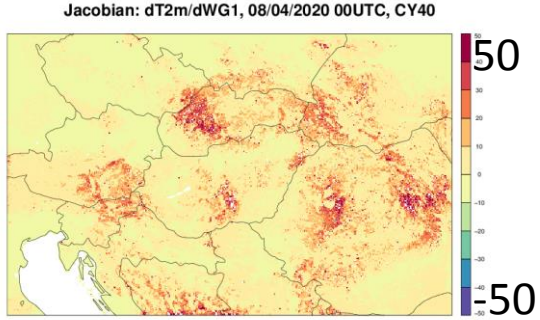
rising TG2 => rising T2m

dRH2M/dTG1



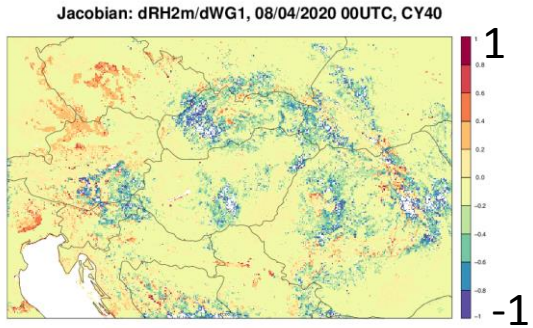
rising TG2 => decreasing RH2m

dT2M/dWG1



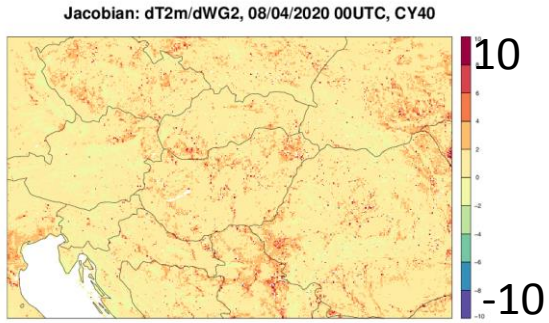
rising WG1 => decreasing T2m (big values)

dRH2M/dWG1



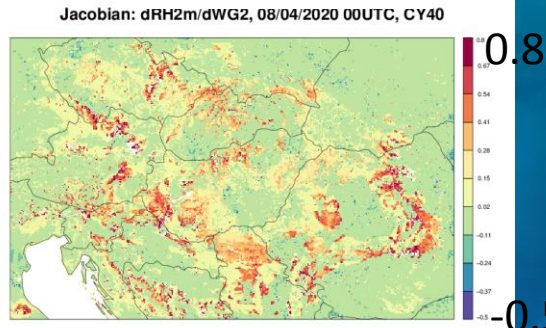
rising WG1 => not everywhere
rising RH2m (very noisy field)

dT2M/dWG2



rising WG2 => rising T2m
(?????)

dRH2M/dWG2



rising WG2 => rising RH2m

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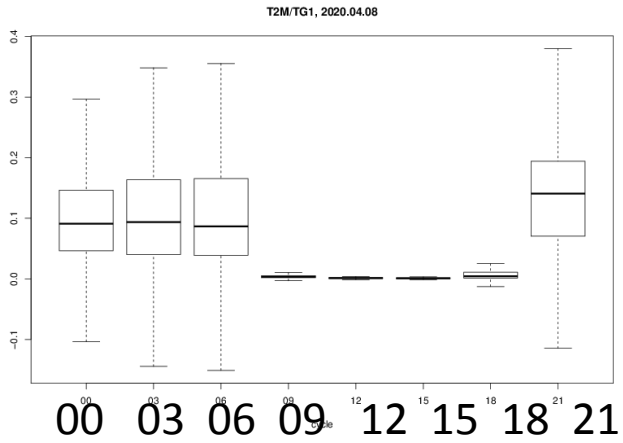
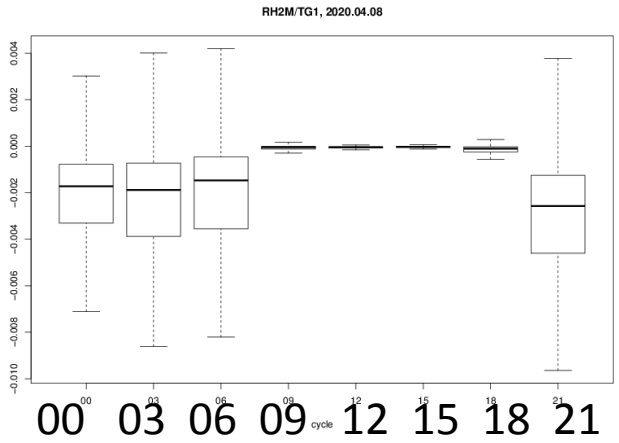
Very noisy Jacobi fields, some members are controversial, a lot of the so-called crazy Jacobians mainly for WG1 and WG2

Jacobian box-plots for 08.04.2020 (all points in the whole domain)

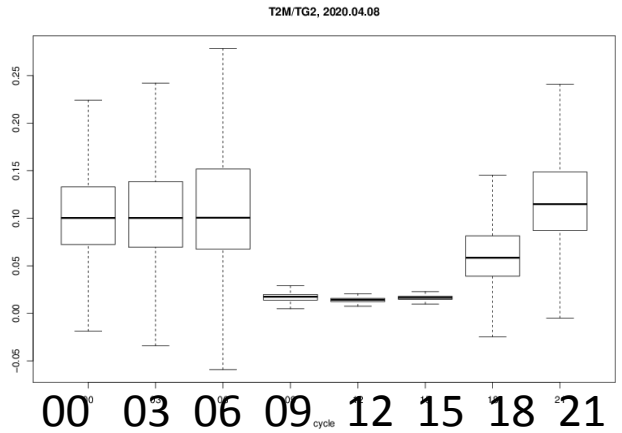
dT2M/dTG1



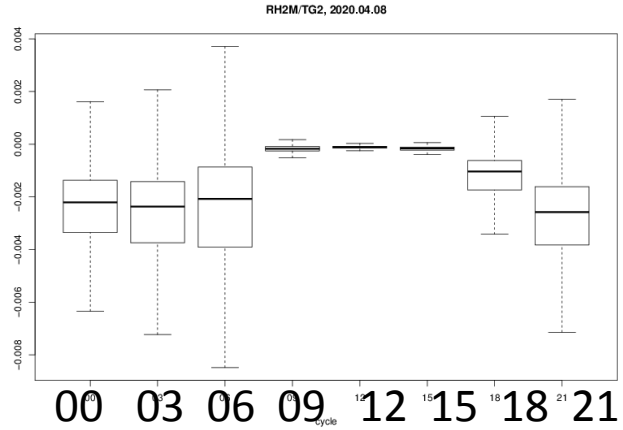
dRH2M/dTG1



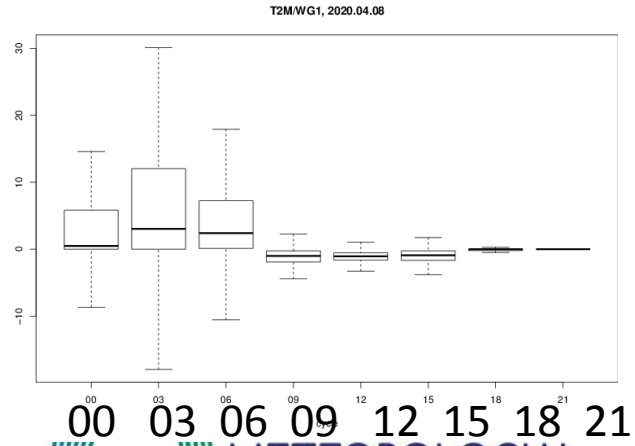
dT2M/dTG2



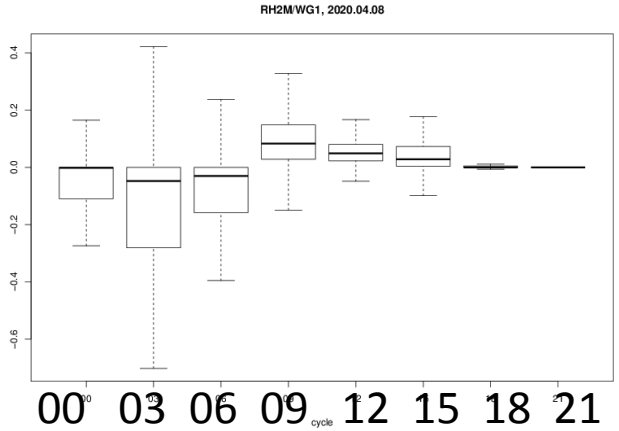
dTRH2M/dTG2



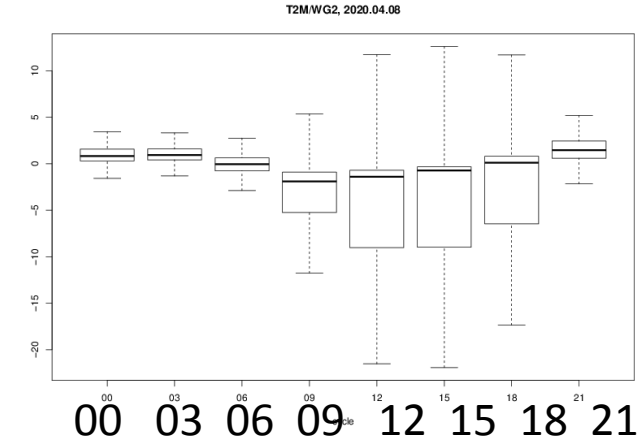
dT2M/dWG1



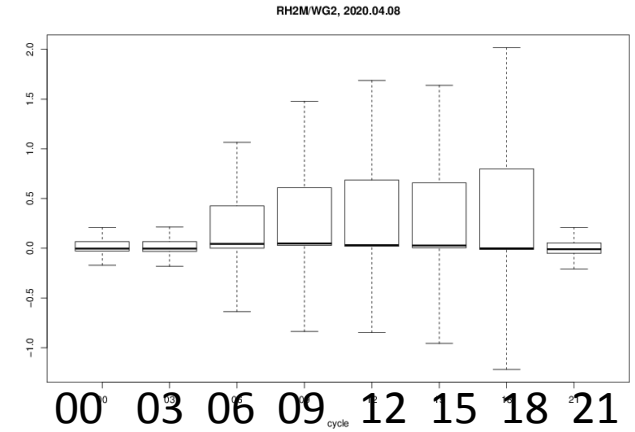
dRH2M/dWG1



dT2M/dWG2



dRH2M/dWG2



=> Small Jacobians during daylights (except for T2M/WG2 and RH2M/WG2) => almost no effect on 2m elements (similar results than in winter)

Future plans

Near future:

- cy43t2 AROME+Surfex (8.0) implementation, SODA validation
- Comparison with cy40t1 (winter and summer cases)
- Investigations of Jacobians in cy43 (linearity check, examining the negative/positive perturbation of Surfex runs, test with different perturbations (TPRT_M), **B** (XSIGMA_M) and **R** (YERROBS) constants)
- Introduction of SEKF into operational practice

Later:

- Testing of DIF-soil scheme with more layers, more control variables
- Using of Satellite observations (e.g. soil moisture)

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