ALADIN flat-rate stay report

Testing of new diagnostic fields: convective pack in cy43t2 and visibility in ALARO.

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My task was to run ALARO model version cy43t2 and add new diagnostic fields, convective and visibility fields.

To run ALARO integration within cy43t2 export version some changes were needed: adaptation of the namelist and due to problems with GRIB_API we had to comment #define FAGRIB2 lines in faigra.F90 and fasgra.F90.

1. Visibility diagnostic in ALARO

1.1 Computation in AROCLDIA routine

Computation was prepared by Yann Seity and Ingrid Dombrowski-Etchevers (Meteo France), it is based on Kunkel type formulations with separate clouds and precipitations (similar as it was done by Sami Niemala for AROME in 2014) [1]. Visibility is calculated separately due to hydrometeors (precipitation) and clouds (fog) at specific height above the ground, usually this is set to the height of the lowest model level.

Below are presented equations for calculation of VISICLD and VISIHYDRO, the first visibility depends on cloud liquid and ice water, the second one on rain, snow and graupel. Coefficients used in these equations can be adopted (COEFFEXTA, COEFFEXTB).

1. $VISICLD=-\ln(0.05)/(0.013+\beta_{CLD}+\beta_{ICE})$

$\beta_{CLD}=144.7\cdot C^{0.88}$ (C = cloud liquid water content [g/m^3])
$\beta_{ICE}=163.9\cdot C^{1.0}$ (C = cloud ice water content [g/m^3])

2. $VISIHYDRO=-\ln(0.05)/(0.013+\beta_{RAIN}+\beta_{SNOW}+\beta_{GRAUPEL})$

$\beta_{RAIN}=2.5\cdot C^{0.75}$ (C = rain content [g/m^3])
$\beta_{SNOW}=10.4\cdot C^{0.78}$ (C = snow content [g/m^3])
$\beta_{GRAUPEL}=2.4\cdot C^{0.78}$ (C = graupel content [g/m^3])

New fields computed in AROCLDIA are:

VISICLD - Visibility due to clouds (to cloud water and cloud ice) in km
VISIHYDRO - Visibility due to hydrometeors (rain and snow and graupel) in km
MXCLWC - Cloud Water Liquid Content on HVISI

Maximum possible value for field VISICLD and VISIHYDRO is set to 20 km, values of visibility are calculated at each time step of the model. Then, in CPXFU and related routines, a minimum hourly (for AROME) and minimum three hourly (for ARPEGE) values are calculated. Time length for visibility fields are controlled by the namelist parameters NVISIPERIOD and NVISIPERIOD2 in SUXFU (two time lengths can be requested in a same run).
The field PMXCLWC contains maximum of cloud liquid water content (CLWC), it is added by author as an output for verification purposes.

The following parameters can be set in the namelist:

HVISI in NAMPHY2 – height in meters at which visibility is calculated

COEFFEXTA in NAMPARAR – coefficients used to calculate visibility due to cloud condensates
COEFFEXTB in NAMPARAR - coefficients used to calculate visibility due to hydrometeors

NVISIPERIOD and NVISIPERIOD2 in SUXFU - time step in seconds for which is calculated minimum visibility and maximum cloud water liquid content (default values: NVISIPERIOD=3600, NVISIPERIOD2=900).

If HVISI is below lowest vertical model level, the visibility is defined at the height of the lowest vertical level. If HVISI is higher, values used in computation are interpolated from the model level above and below to HVISI height above the model orography.

1.2 Implementation of visibility diagnostics for ALARO

Firstly, visibility code from Ingrid's pack was re-phased into local CY43T2_bf.09 as a local research version. The two visibilities, VISICLD (due to clouds/fog) and VISIHYDRO (decrease of the visibility by the precipitations) are coded in AROCLDIA, called by APLPAR (physics Arpege) or APL_AROME (physics Arome). To compute visibility with ALARO physics some adaptation were needed in the APLPAR: positions of the calculation of air density (PRHO) and of the call of AROCLDIA routine were changed. Fields PQSRES and PQRRES (resolved snow and rain) which are not used in ALARO were changed to PS and PRR (snow and rain). For the time being values of graupel are set to zero. (As this is only testing version this was not done in a clean way.)

1.3 Validation

Various tests were performed
- to study the influence of HVISI and coefficients defined in namelist

- to study the impact if cloud water and cloud ice used in radiation or from microphysics are used

1.4 Results

First simulations were done with the Ingrid’s settings (case 1). Obtained values are reasonable, 2D visibility due to precipitation (Fig.1) and clouds (Fig. 3) are visualized on Figures 2 and 4.

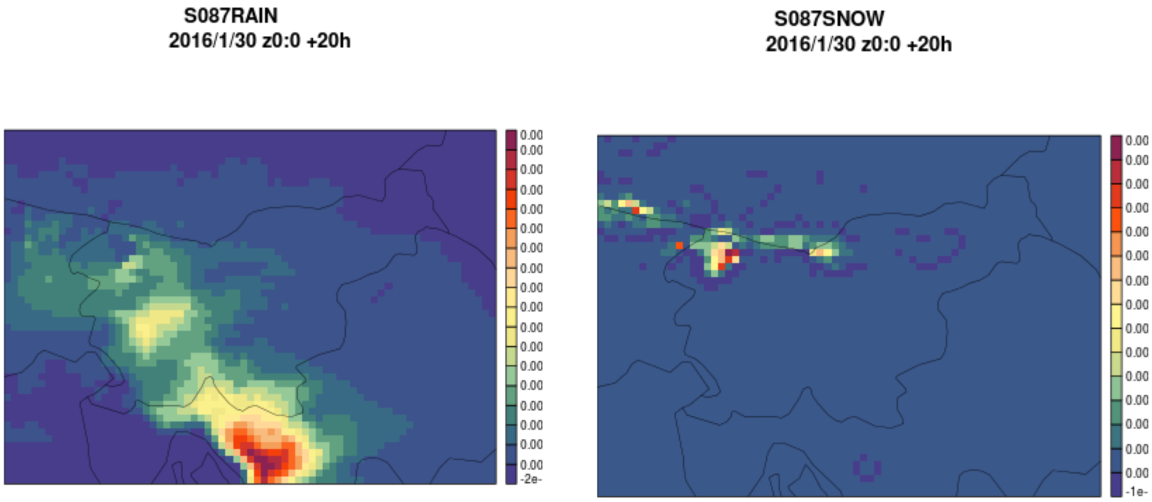

Figure 1. Rain (left) and snow (right) for lowest vertical level at 20:00 UTC 2016/01/30.

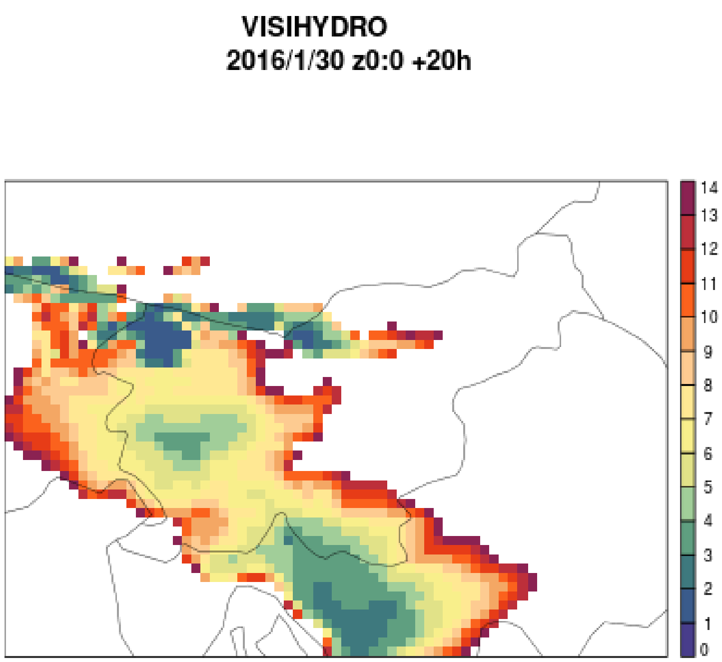

Figure 2. Visibility due to hydrometeors at the height of lowest model level (HVISI=5) at 20:00 UTC 2016/01/30.

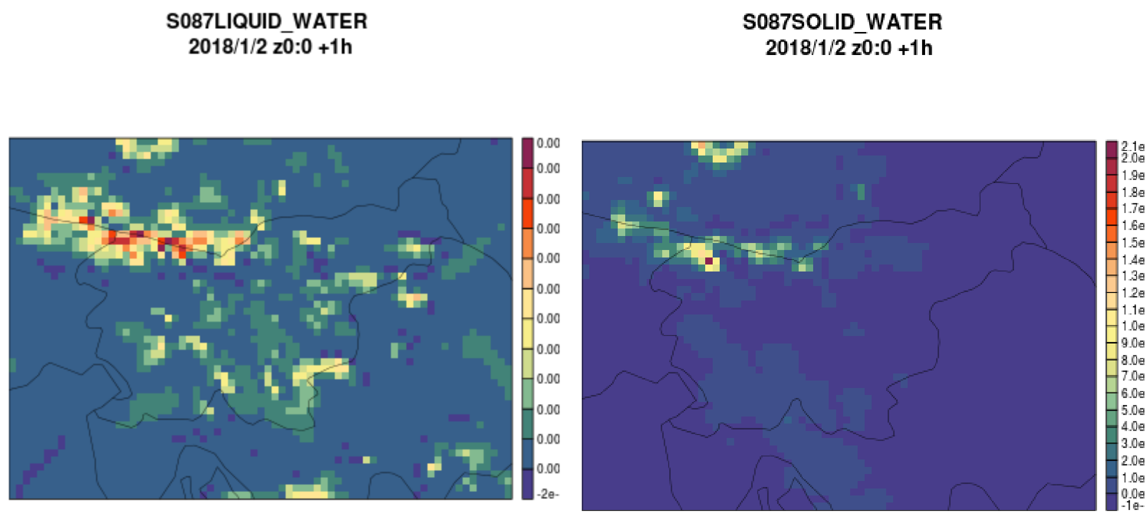

Figure 3. Cloud liquid water (left) and solid water (right) for lowest vertical model level at 01:00 UTC 2018/01/02.

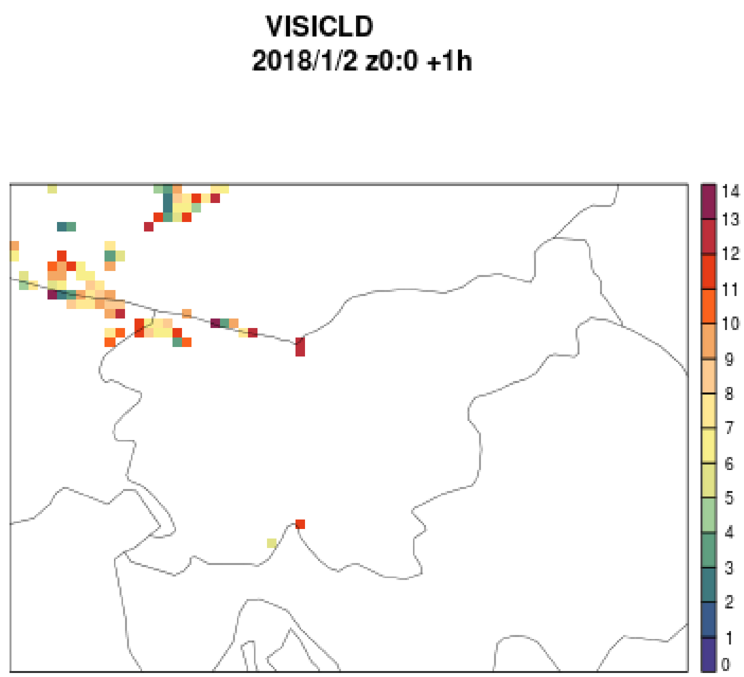

Figure 4. Visibility due to clouds at the height of lowest model level (HVISI=5) at 1:00 UTC 2018/01/02.

1.4.1 Verification of visibility fields

To validate results of visibility I run forecast for Slovenian operational domain ALARO 4 km x 4 km for period 1-15.01.2018, 24-hours forecast. Results of forecast were compared with measurements from automatic and SYNOP stations. Looking at results for fields **VISICLD** and **VISIHYDRO** I suggest that this fields should be probably combined. In some cases low visibility is caused by fall of rain and/or snow but there are also some cases when it is due to fog. For this chosen period low visibility is probably mainly caused by precipitations.

On the figures 5-7, values of observed/measured visibility and the two visibilities, VISICLD (f_cld) and VISIHYDRO (f_hydro) are presented for 3 Slovenian stations. Conditions for low visibility are often complex, so to predict visibility it is necessary to compare visibility due to precipitation and due to fog and (probably) use lower one. In further validation, observed precipitation should be also used to get cleaner comparison.

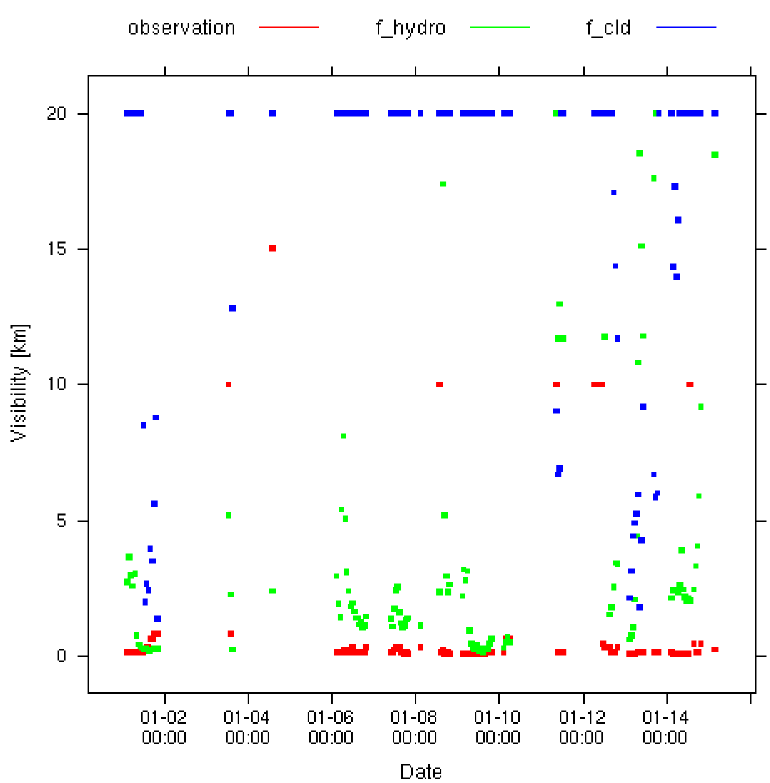

Figure 5. Timeline graph of visibility for SYNOP station KREDARICA (ID. 14008)

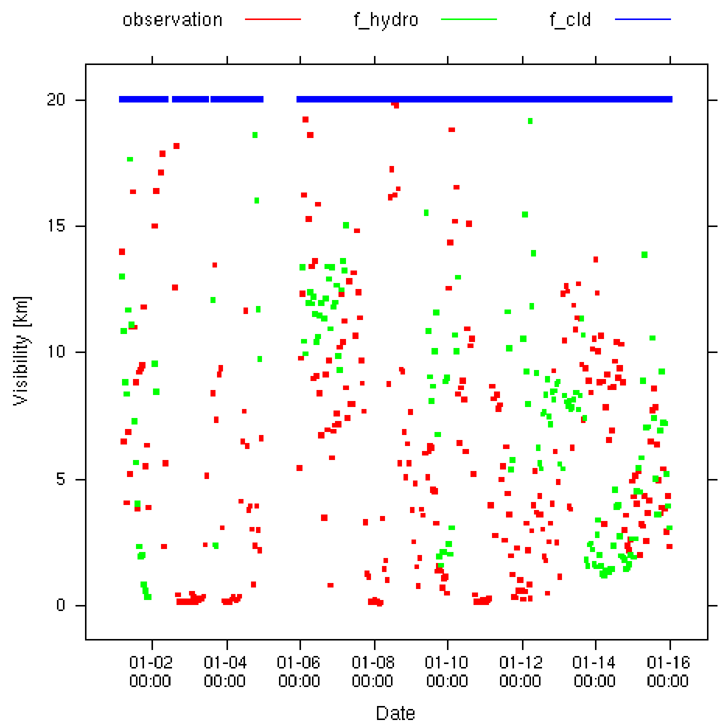

Figure 6. Timeline graph of visibility for automatic station ČRNOMELJ – DOBLIČE (ID. M33)

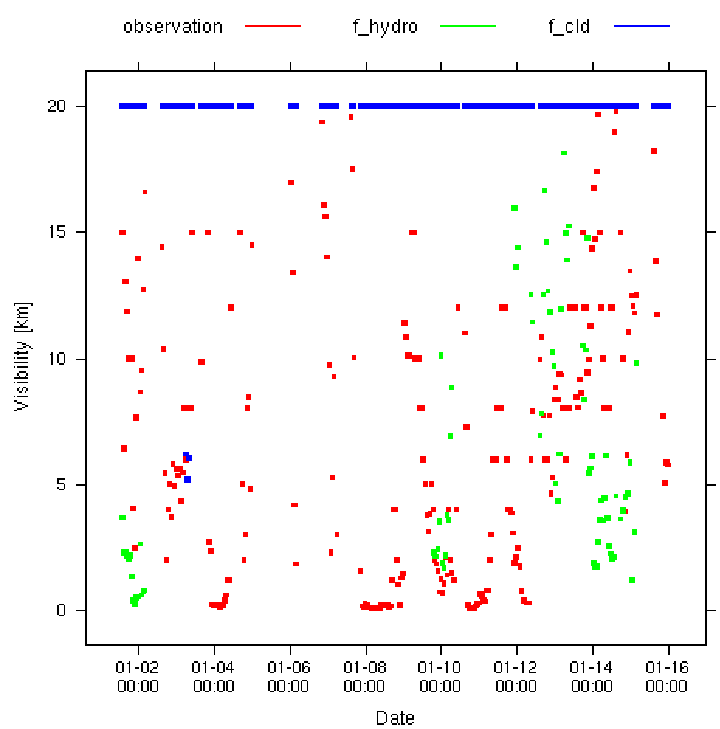

Figure 7. Timeline graph of visibility for SYNOP station CERKLJE – LETALISCE (ID. 14122)

1.4.2 Verification of different coefficients

Next validation step was to check the influence of HVISI and coefficients defined in namelist on visibility values. Using two different coefficient values COEFFEXTA, COEFFEXTB and HVISI tests have been carried out. Values which were used are presented below in CASE 1 and CASE 2 (used by Ingrid in her tests). The period for testing results of forecast was selected between 1-st and 7-th January 2018. In these two cases only the first value of COEFFEXTA and COEFFEXTB differ, their values have significant impact on calculation VISICLD.

Comparing two different values of coefficients, we can see that RMSE and BIAS of visibility for VISIHYDRO field is almost the same (fig. 9). Differences are visible for field VISICLD, BIAS and RMSE are lower for constants in CASE 2 (fig. 8). Change of height at which visibility is calculated does not have a significant impact on the results of visibility, difference is too small.

CASE 1:

```
&NAMPHY2
HVISI=5.0,

&NAMPARAR
COEFFEXTA(1,2)=144.7,2.5,163.9,10.4,2.4,
COEFFEXTB(1,2)=0.88,0.75,1.0,0.78,0.78,
```

CASE 2:

```
&NAMPHY2
HVISI=10.0,

&NAMPARAR
COEFFEXTA(1,2)=18.77,2.5,163.9,10.4,2.4,
COEFFEXTB(1,2)=0.33,0.75,1.0,0.78,0.78,
```

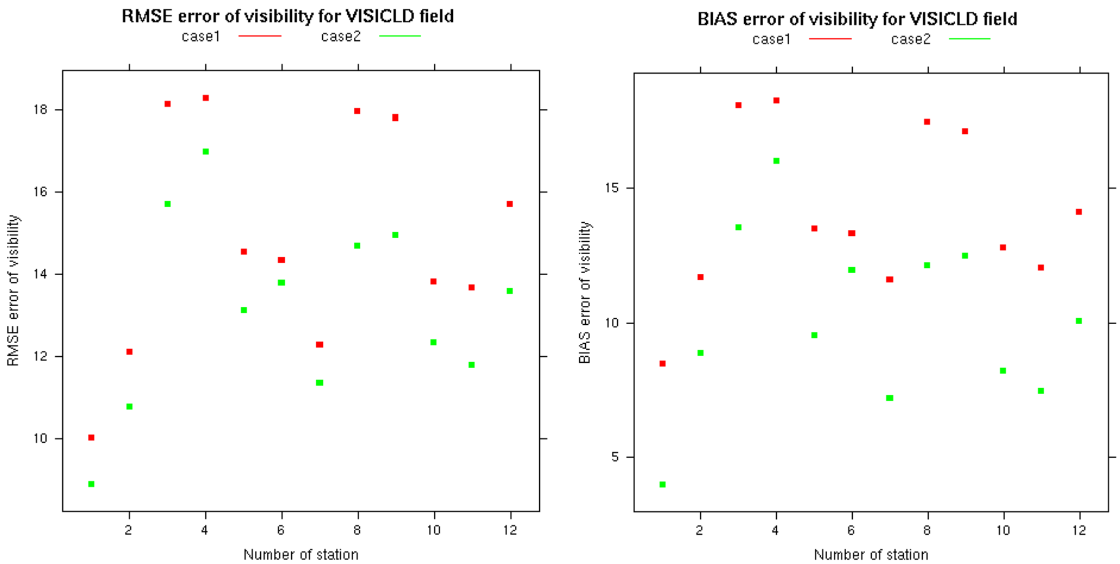

Figure 8. Comparison of RMSE (left) and BIAS (right) of visibility VISICLD for two sets of constants for 12 stations for the period of 7 days.

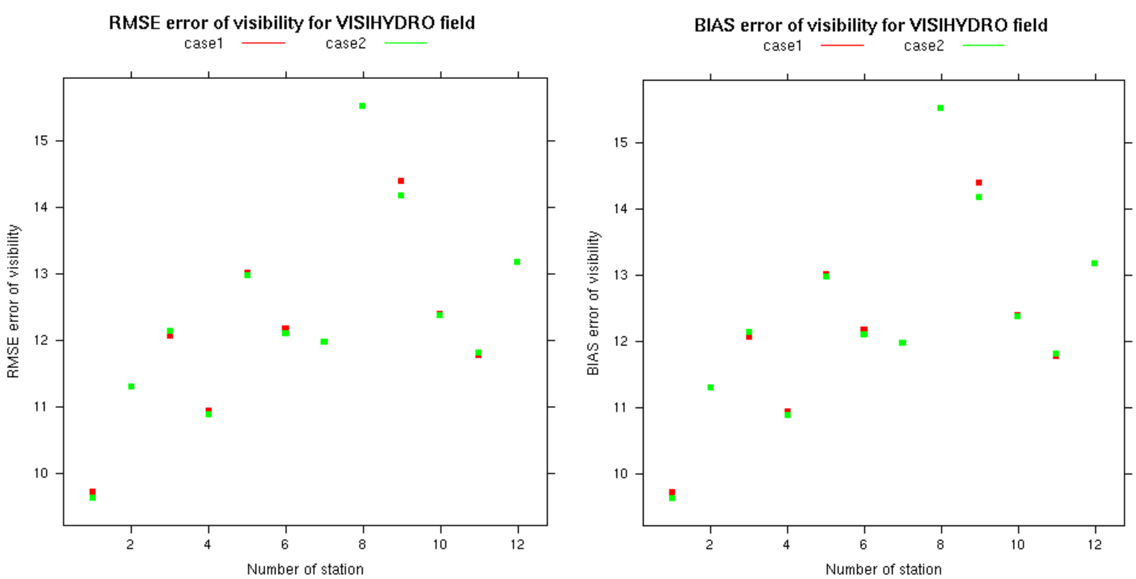

Figure 9. Comparison of RMSE (left) and BIAS (right) of visibility VISIHYDRO for two sets of constants for 12 stations for the period of 7 days.

1.4.3 Testing different cloud condensates

Test were performed with different fields of cloud condensates in visibility diagnostics, once those used in radiation(PQLI and PQICE) and once those from microphysics(PQI and PQL)

Results using different fields of cloud liquid and solid water in model are presented on figures 10 and 11. Difference between them are insignificant for field VISIHYDRO and VISICLD. Fields of liquid and solid water used in radiation scheme are smoother, fields of clouds for radiation can't be sharp.

CASE 1
! PQLI   : LIQUID WATER FOR RADIATION
! PQICE   : SOLID WATER FOR RADIATION

CASE 2
! PQI   : SOLID WATER (ICE)
! PQL   : LIQUID WATER

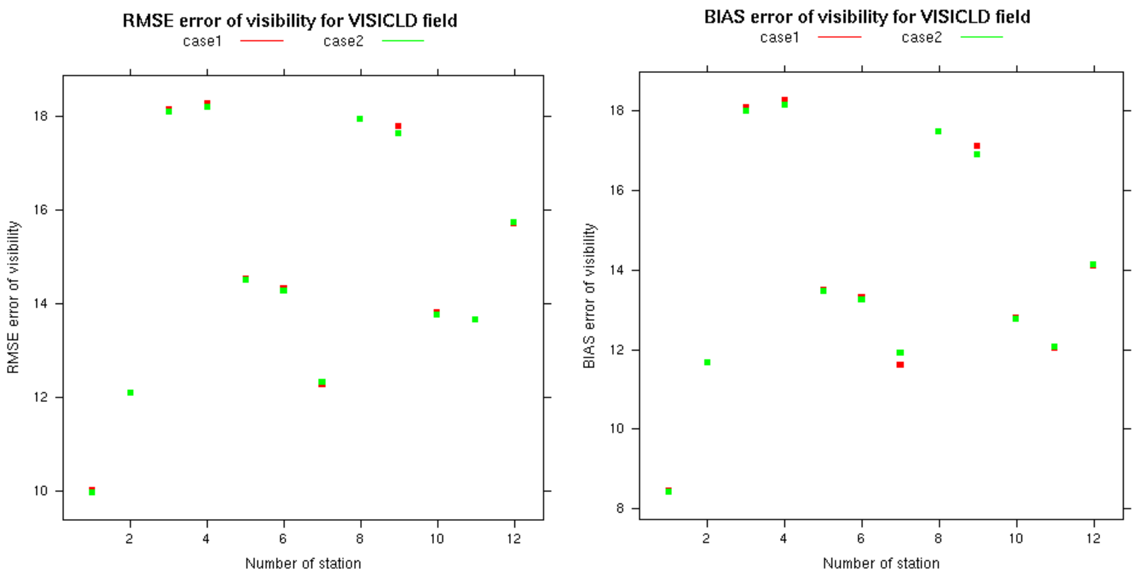

Figure 10. Comparison of RMSE (left) and BIAS (right) error of visibility for VISICLD field for two cases of fields.

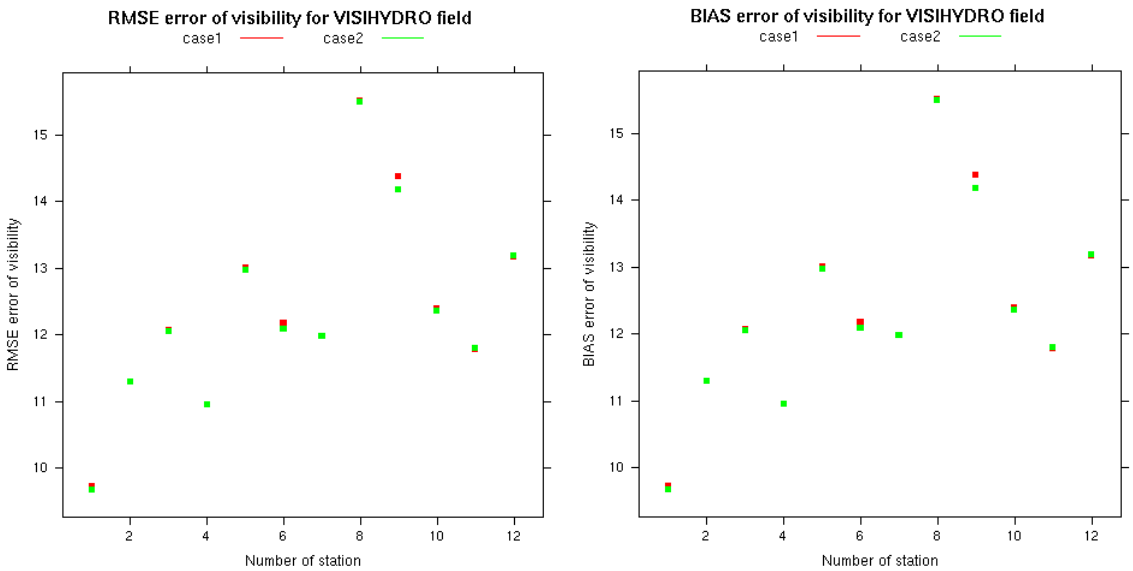

Figure 11. Comparison of RMSE (left) and BIAS (right) error of visibility for VISIHYDRO field for two cases of fields.

1.5 Discussion

Results of visibility due to hydrometeors and clouds have promising results, in most cases values were similar to observations. This method for visibility diagnostics needs more validation and tuning of coefficients inside ALARO. Also there is a question how visibility should be presented to the end-user, probably the minimum of both.

The visibility diagnostic will become fully available to all partners with CY46T1.

2. **Diagnostic convective fields in ALARO**

Pack with convective fields (authors Jure Cedilnik and Christoph Wittmann) has been implemented into cy43t2 export version and validated. The changes were done in the following files:

arpifs/setup/sucape.F90
arpifs/setup/suafn1.F90
arpifs/setup/suafn2.F90
arpifs/setup/suafn3.F90
arpifs/namelist/namfpc.nam.h
arpifs/namelist/namafn.nam.h
arpifs/pp_obs/pos.F90
arpifs/fullpos/endpos.F90
arpifs/fullpos/fpdiagflash.F90
arpifs/fullpos/fpsrh.F90
arpifs/fullpos/fpstrmm.F90
arpifs/fullpos/sufpc.F90
arpifs/fullpos/phymfpos.F90
arpifs/fullpos/fpshear.F90
arpifs/fullpos/vpos.F90
arpifs/fullpos/fpcica.F90
arpifs/module/yomfpc.F90
arpifs/module/yomcape.F90
arpifs/module/yomafn.F90

To get convective fields with the off-line Full-Pos it was necessary to add these fields into namelist and change CFPFMT='MODEL' NFPOS=2.
Also with settings CFPFMT='LELAM' NFPOS=1 is OK except for vertical temperature gradient.

Convective diagnostic fields are:

CFP2DF(1)='SURFFLASHDIAG'	! Flashes field	
CFP2DF(2)='SURFUSTORMMOTION'	! U-component of storm motion	unit [m/s]
CFP2DF(3)='SURFVSTORMMOTION'	! V-component of storm motion	unit [m/s]
CFP2DF(4)='SURFDEEPLAYERSHR',	! Deep Layer Shear, 0-6 km shear	unit [m/s]
CFP2DF(5)='SURFLOWLEVELSHR ',	! Low Level Shear, 0-1 km shear	unit [m/s]
CFP2DF(6)='SURFHELICITY ',	! Horizontal helicity [1], [2]	unit [m^2/s^2]
CFP3DF(1)='VERTTEMPGRAD	! vertical temperature gradient	unit: [deg. C/m]

Few fields are presented on figures 12-14.

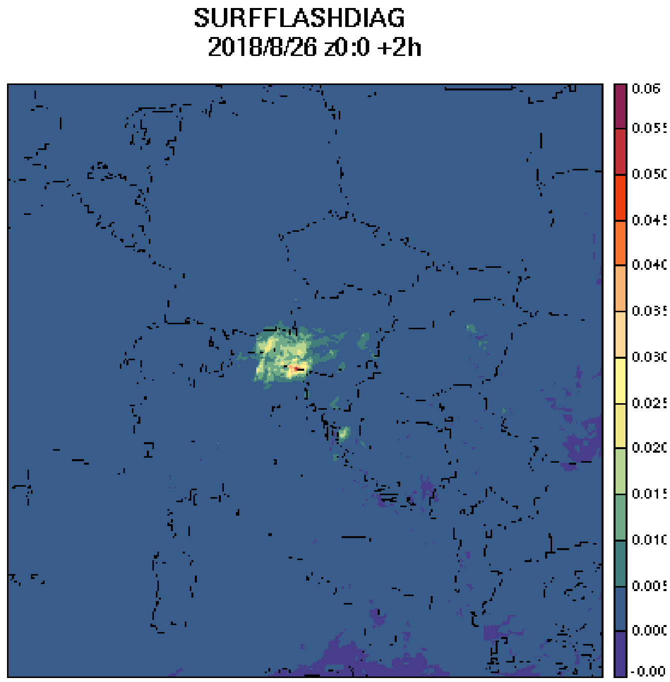

Figure 12. Map of flashes for date 2018/08/26 2:00 UTC.

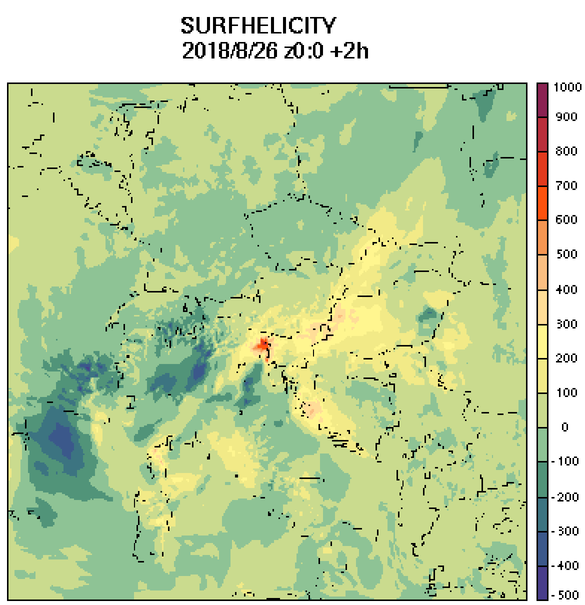

Figure 13. Map of helicity for date 2018/08/26 2:00 UTC.

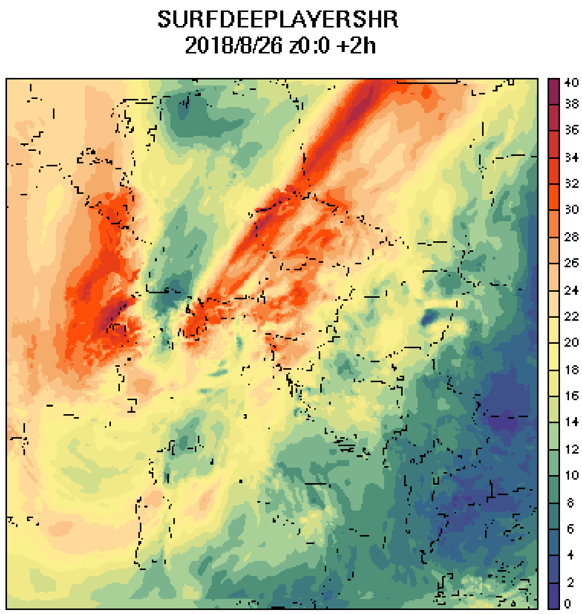

Figure 14. Map of deep layer shear for date 2018/08/26 2:00 UTC

Reference:

[1] http://www.meteo.fr/cic/meetings/2018/AMA/presentations/AMA_1402/13-%20presentation_AMAs2018_Visi.pdf
[2] https://library.wmo.int/pmb_ged/wmo_8_en-2012.pdf
[2] Christoph Wittman and Jure Cedilnik, 2015: Additional fullpos parameters for convection forecasting, http://www.rclace.eu/File/Physics/2015/fpconvection_docnote.txt
[3] http://tornado.sfsu.edu/geosciences/classes/m500/Shear_Helicity/Helicity.htm
[4] Synoptic-Dynamic Meteorology in Midlatitudes Howard B. Bluestein