ALADIN flat-rate stay report

Testing of new diagnostic fields: precipitation type in cy43t2 in ALARO.

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Ljubljana 19.08.2019-13.09.2019

My task was to test and evaluate new diagnostic fields within ALARO model version cy43t2, the main focus was on precipitation type, the other two: top of convective clouds and altitude of wet bulb temperature isotherm.

1. Precipitation type in ALARO

Precipitation type computation was prepared by Yann Seity and Ingrid Dombrowski-Etchevers (Meteo France), it is based on wet bulb temperature and amount and their ratio of snow, rain, ice and graupel/hail precipitation. The formula for diagnostic freezing drizzle is based on **Quéno et al, 2018**. Ingrid Dombrowski-Etchevers is working on an article "New algorithms for two forecasted products of weather: visibilities and precipitation type" for the Weather and Forecasting which will be more detailed.
Precipitation type in one point over a time period can be defined as most frequent type and/or most severe type in that period.

The code was already part of the Météo-France operational branch. Radmila Brožkova phased it in the local branch at CHMI, precipitation type modifications touch routines which had already been modified locally due to implementation of the visibility, mean radiant temperature, etc. This pack was compiled in Ljubljana and later in Krakow and used for evaluation within ALARO.

To get the precipitation type in the output few parameters have to be set in namelist NAMPHY and NAMDPRECIPS:

```
&NAMPHY
  LDPRECIPS=.T.,
  LDPRECIPS2=.T.,
  NDPRECPERIOD=3600,
  NDPRECPERIOD2=10800,
/
&NAMDPRECIPS
 RDHAIL1=0.5,
 RDHAIL2=1,
 RPRECSEUIL=0.0003,
/
```

The new fields are computed during the model integration and are:

PRECIP.TYPE – type of precipitation most frequent in selected first time period
PRECIP.TYPESEV - type of precipitation most dangerous in selected first time period
PRECIP.TYPE2 – type of precipitation most frequent in selected second time period
PRECIP.TYPESEV2 - type of precipitation most dangerous in selected second time period

The two time periods are defined via **NDPRECPERIOD** and **NDPRECPERIOD2,** their default values are accordingly 3600 and 900 seconds for first and second time period.

Various tuning parameters are set in the NAMDPRECIPS namelist, variables are further discussed later.

Precipitation type field contains 16 different types of fall:
0 – No rain
1 – Rain
3 – Freezing rain
5 – Dry snow
6 – Wet snow
7 – Rain snow mixture
8 – Ice pellets
9 – Graupel/small hail
10 – Hail
11 - Drizzle
12 – Freezing drizzle
193 – Moist snowsleet
201 – Intermittent rain
205 – Intermittent dry snow
206 – Intermittent wet snow
207 – Intermittent rain snow mixture
213 – Intermittent moist snow/sleet

It should be mentioned that the precipitation type field is written to the file (packing) as a real value therefore, values corresponding to the type of precipitation may slightly differ from the integer numbers listed above.
If the length of precipitation occurrence is between 1/12 and 5/6 of the time period is type called **intermittent**. If precipitation takes less than 1/12 it's set to 0 for all precipitation type except **hail**. At the figure 1 are presented plots of sum of precipitation for selected hour, diagnostic hail and fields of precipitation, most frequent and most dangerous. Precipitation 'rain' is called 'drizzle' when fluid rain is lower than 1mm/hour and higher than minimum total precipitation which is determined by variable **RPRECSEUIL -** minimum precipitation of snow, rain and graupel; set for all precipitation types. Default value of minimum precipitation is **$3 \cdot 10^{-5}$ mm/s** (equals **0.1 mm/hour**).
I am used to plot precipitation amounts only above 0.5 mm/hour, so I put RPRECSEUIL value to 0.00015, in order to obtain same area on the maps for precipitation and its type.

&NAMDPRECIPS RPRECSEUIL=0.00015,! minimum precipitation 0.5mm/hour

Another way to get the same area of precipitation type and precipitation is to add mask to precipitation type field. At figure 2 is presented precipitation type for different range of sum of precipitation.

In the field PRECIP.TYPESEV, which presents most severe precipitation type in selected time period the order is as following (from most dangerous):

1. Freezing rain
2. Freezing drizzle
3. Hail
4. Moist snow/sleet
5. Wet snow
6. Dry snow
7. Graupel
8. Ice pellets
9. Rain and snow mixture
10. Rain
11. Drizzle

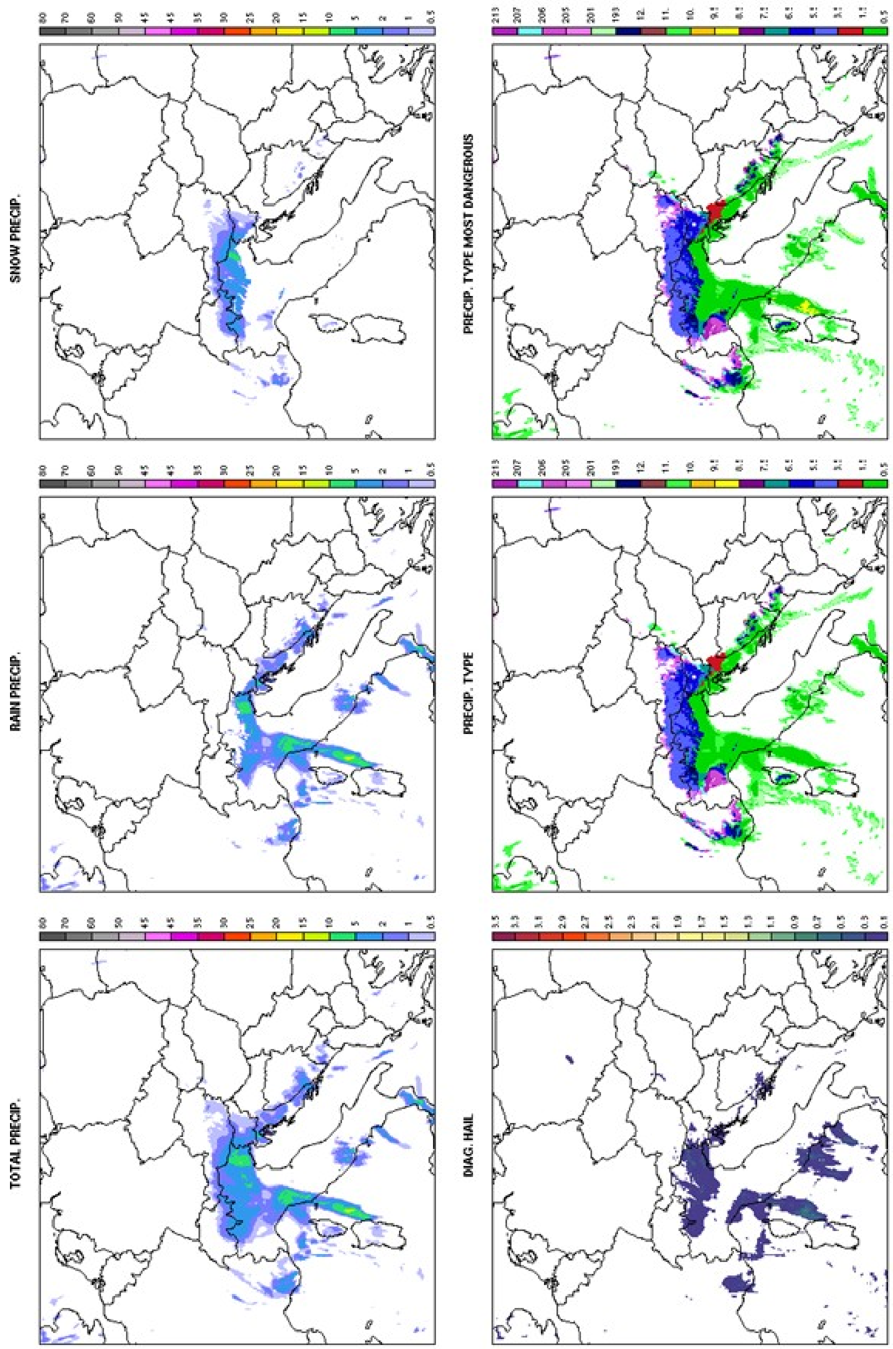


Figure 1. Precipitation type (most frequent, most severe in 1h period) and 1-hour precipitation amounts (total, rain, snow, diagnostic graupel) at 30.01.2014 20:00 UTC.

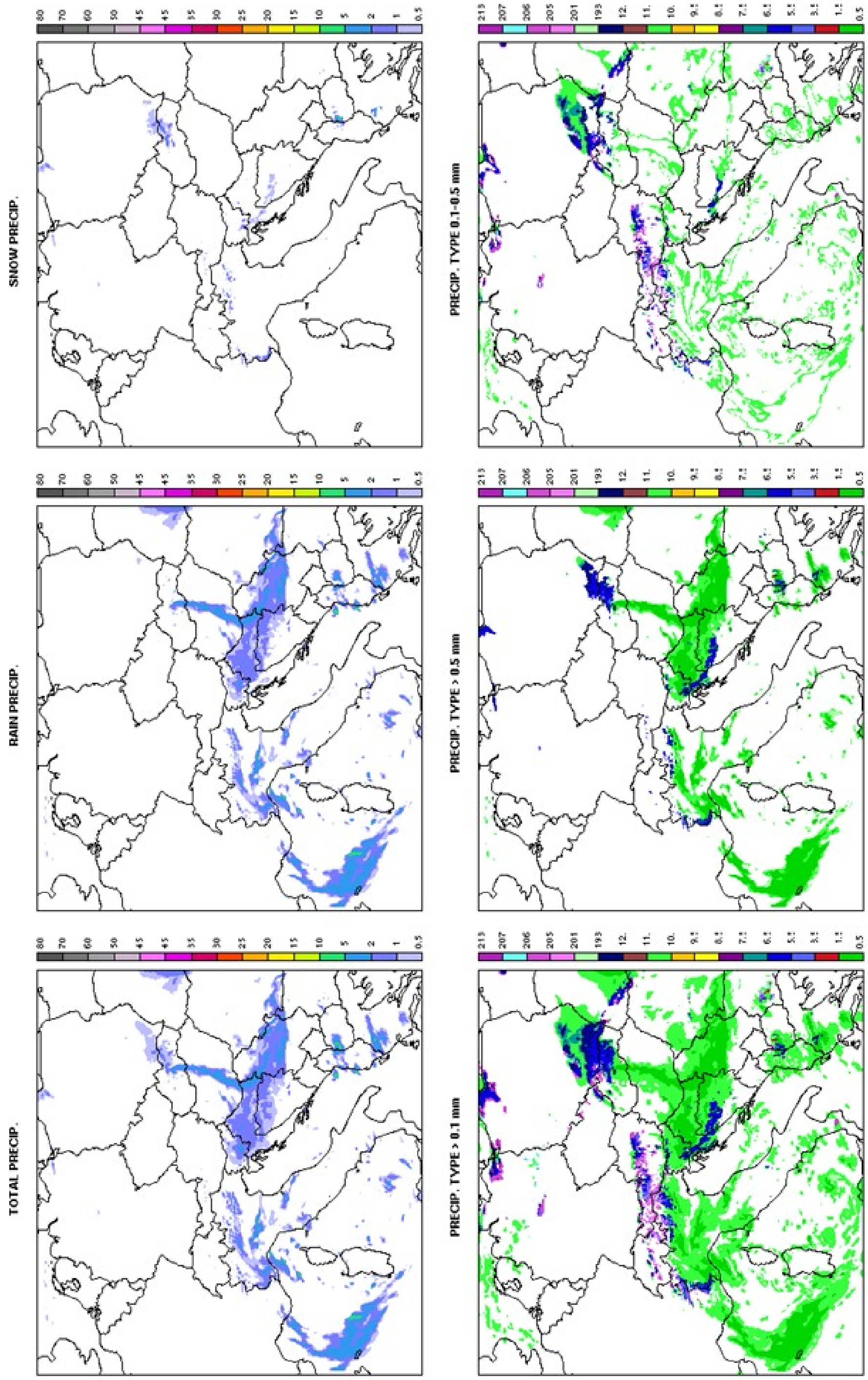
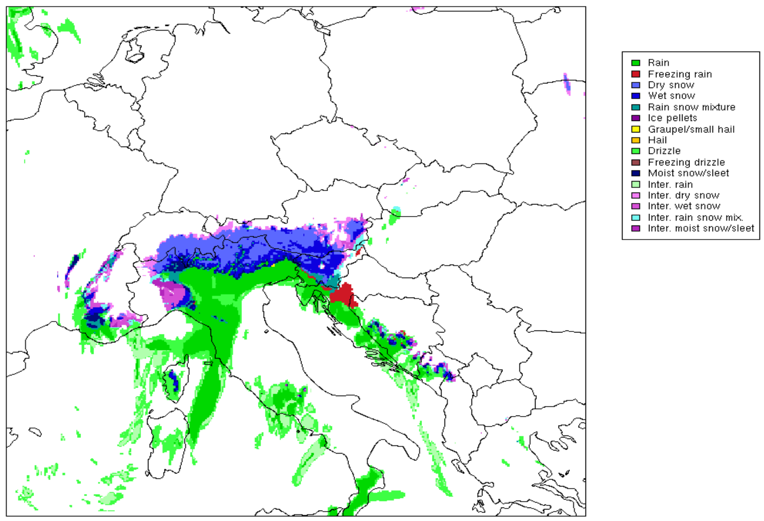


Figure 2. Precipitation type (most frequent in 1h period) where 1h precipitation are >0.1 mm/h, >0.5 mm/h, between 0.1 and 0.5 mm/h and 1-hour precipitation amounts (total, rain, snow) at 12.04.2019 01:00 UTC.

2. Tests of precipitation types – freezing rain

Most dangerous types, which are also difficult to forecast are **freezing rain** and **hail** or **graupel.** The period 30.01.2014 and 3.02.2014, when severe freezing rain event occurred in Slovenia and surroundings, was selected for testing. For these days numerical weather forecast has been made. Figure 3 present example plots with forecasted freezing rain (red color).

a) precipitation type most frequent



b) precipitation type most dangerous

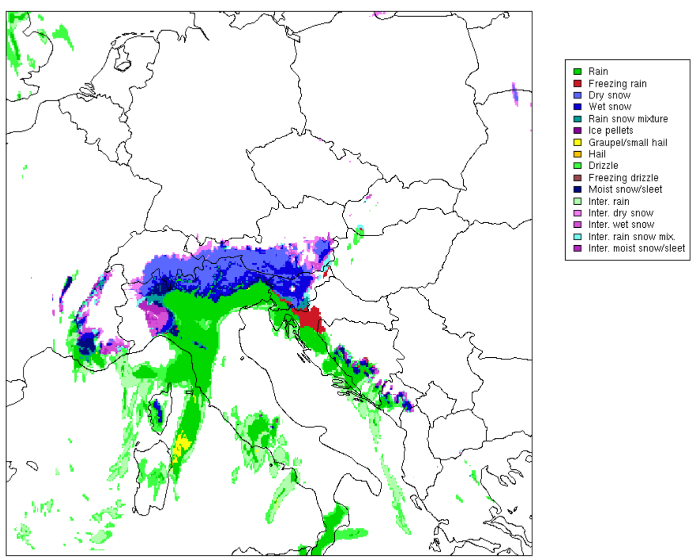


Figure 3. Precipitation type most frequent (a) and most dangerous (b) on 30.01.2014 20:00 UTC.

Additionally, three days with freezing rain in Poland were determined based on observations in synoptic stations:

- 2018-12-01
- 2018-12-02
- 2018-12-07

This atmospheric phenomenon in SYNOP is marked with numbers 56, 57, 66, 67 and 79. During all three days 6-hour sum of precipitation were between 0.1-3mm/6 hours.

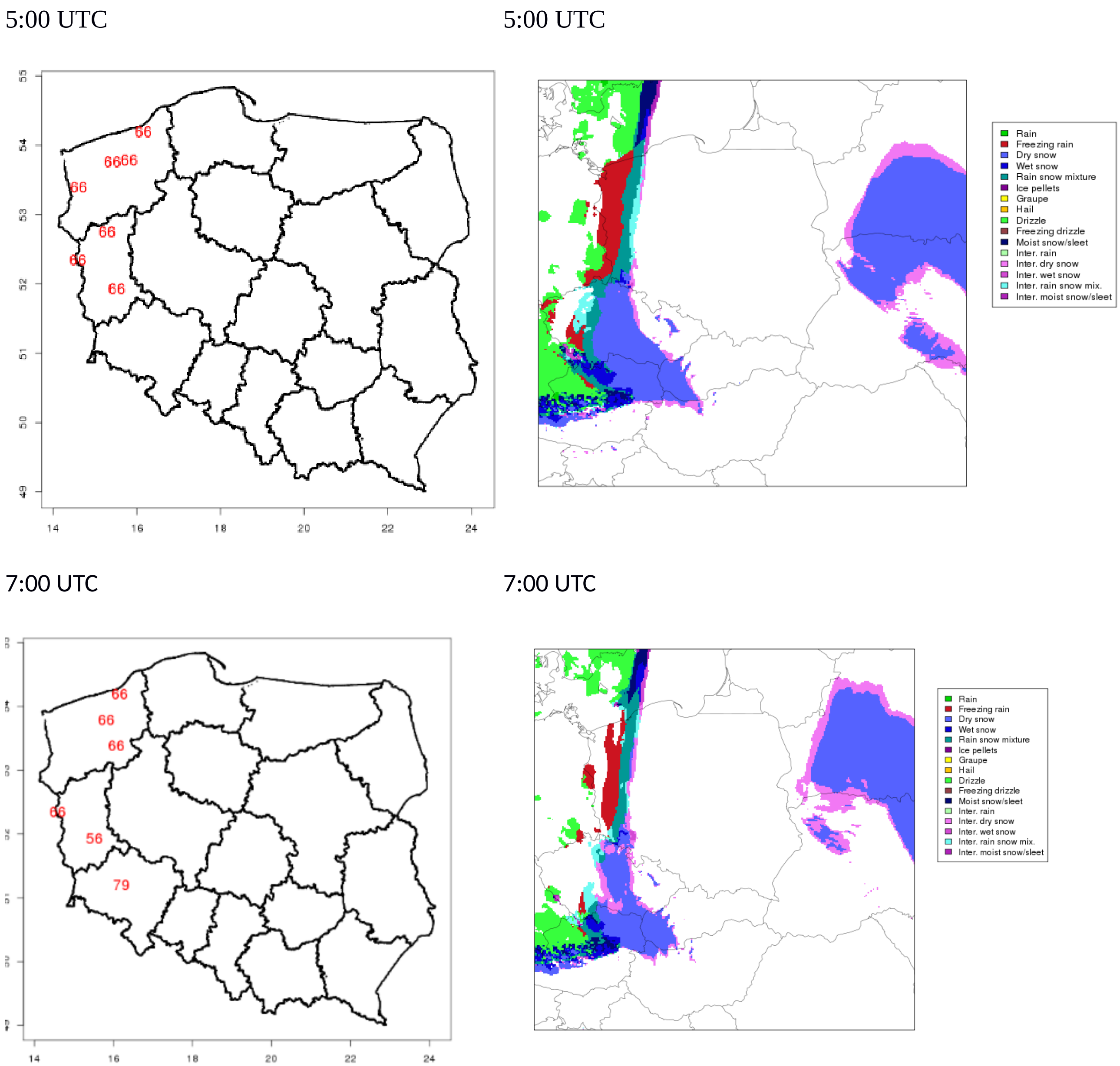
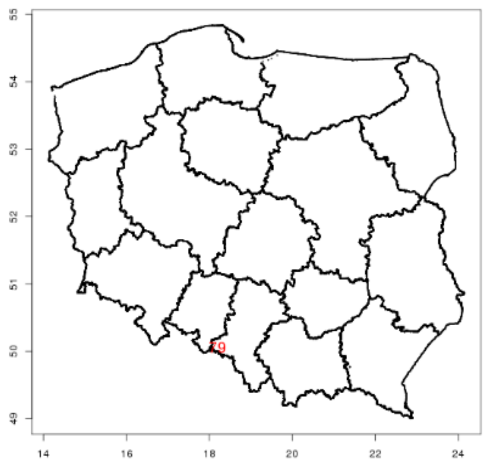


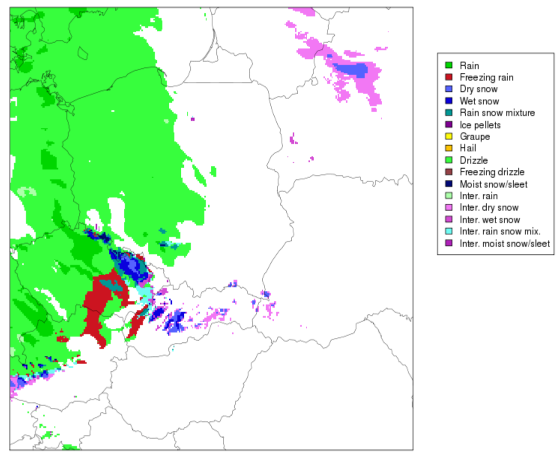
Figure 4. Predicted type of precipitation (right) and locations of observed freezing rain on 1.12.2018.

For day 1.12.2018 (Figure 4) predicted type of precipitation agrees with the observations, prediction of freezing rain in the west part of Poland fit to observation. For day 2.12.2018 (Figure 5), area of predicted freezing rain was significantly smaller than observed. On the most of the Poland predicted precipitation type was drizzle (bright green) which is consistent with measured precipitation amounts.

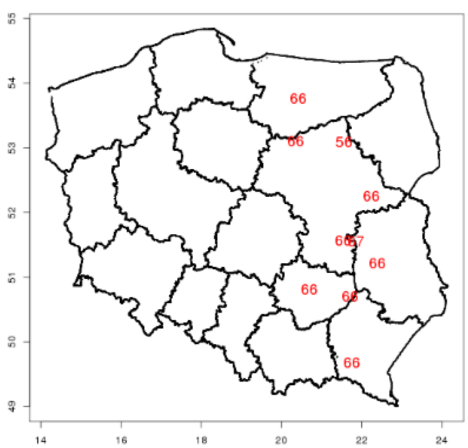
18:00 UTC



18:00 UTC



22:00 UTC



22:00 UTC

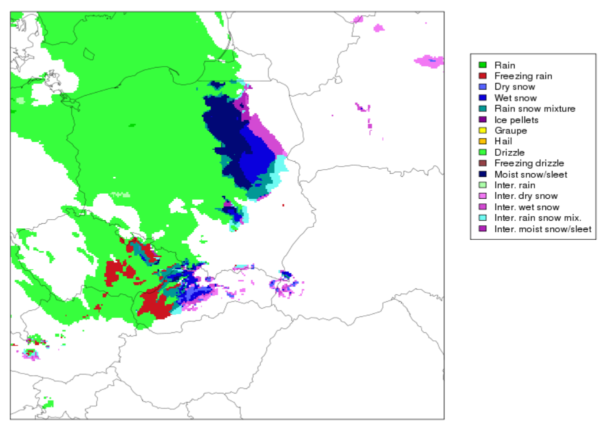
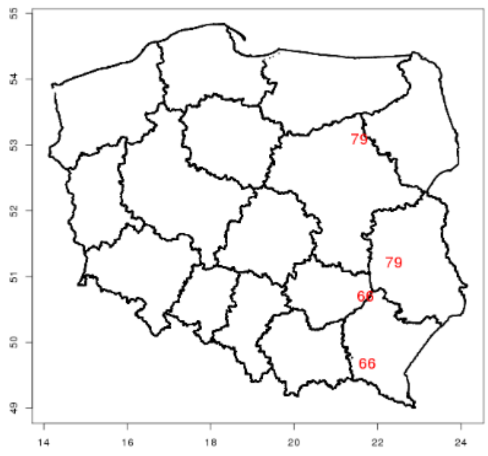
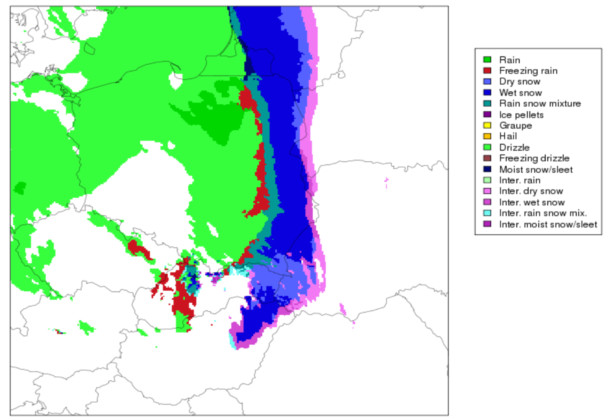


Figure 5. Predicted type of precipitation (right) and locations of observed freezing rain (left) on 2.12.2018.

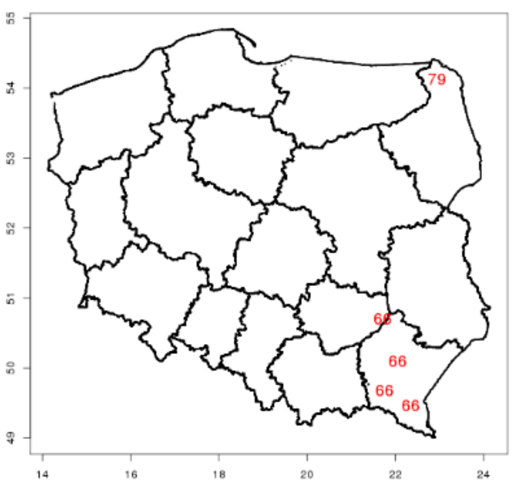
For day 7.12.2018 (Figure 6) model ALARO properly predicted occurred freezing rain, on the plots we can also notice that drizzle (bright green) was predicted for the dominant region of Poland.

5:00 UTC *5:00 UTC*





7:00 UTC *7:00 UTC*



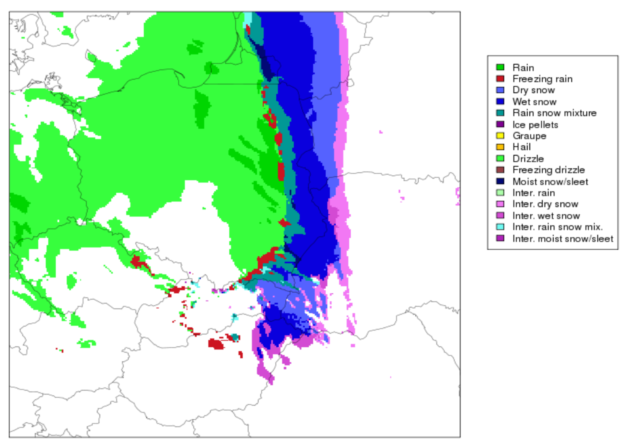


Figure 6. Predicted type of precipitation (right) and locations of observed freezing rain (left) on 7.12.2018

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3. Diagnostic graupel in ALARO model:

Computation of graupel and hail is different in AROME and ALARO microphysics, in AROME prognostic graupel and diagnostic hail is available in AROME, while in ALARO only diagnostic graupel which includes also hail. This field is calculated in the forecast when adding:
&NAMXFU
LXXDIAGH=.TRUE.,

The precipitation types hail and graupel in ALARO are defined based on the diagnostic graupel. Points in which the value of diagnostic graupel is between **RDHAIL1** and **RDHAIL2** are set to graupel or small hail. For points where value is bigger than **RDHAIL2** are set to hail. Default values of these variables are set to 8 and 16, accordingly. For model AROME these values (8 and 16) has been obtained by a statistical study of small/medium/large hail observations derived from polarimetric radar products compared with model hail diagnostic. For ALARO, a simple method, should be evaluated in the future:
&NAMDPRECIPS
RDHAIL1=0.5,
RDHAIL2=1,

During the period between 26.07.2019 and 02.08.2019 was observed hail and graupel in Slovenia. For this period has been made forecast to get maximum value and distribution of diagnostic hail for different ranges of values. Tests pointed out that maximum value is 3.6, which occluded only 3 times in this period. Figure 4 presents histogram of maximum value and histogram of mean value of diagnostic hail for values bigger than 0.1 and 0.01.

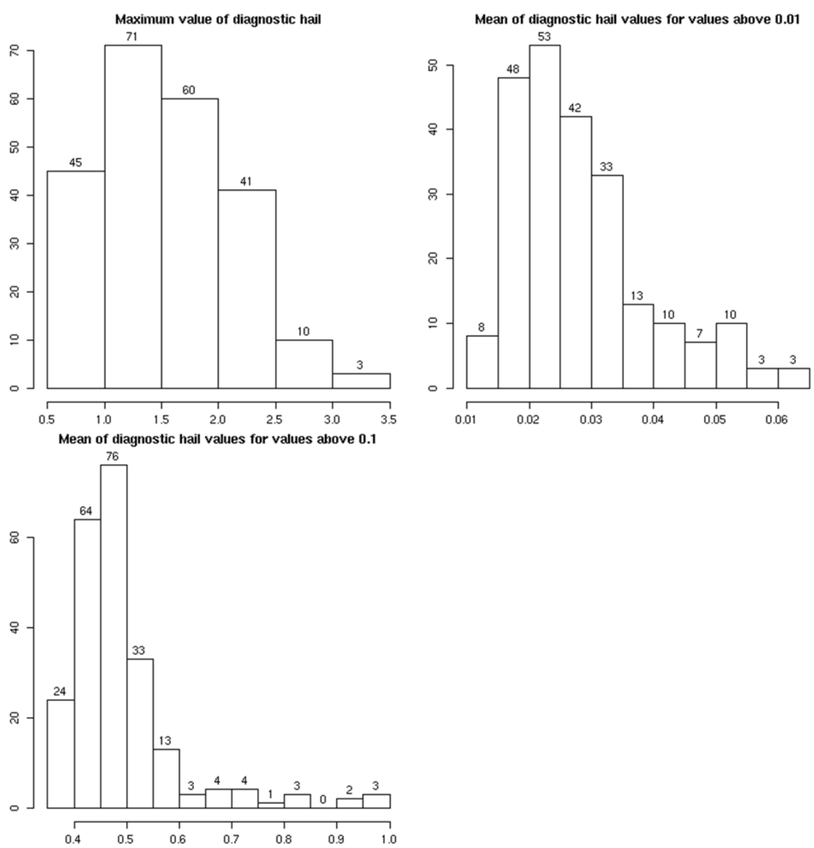


Figure 7. Histogram of diagnostic graupel for period 26.07-2.08.2019 for Slovenian ALARO domain.

Based on presented results and tests of different configurations we have decided that reasonable values for graupel or small hail are between 0.5 and 1, and for hail values bigger than 1. Figure 8 presents sum of precipitation, precipitation types due to most frequent and most dangerous and diagnostic hail field. Small hail or drizzle is marked by yellow color, and hail by orange color (circles on the plots presents location of forecasted hail and graupel).

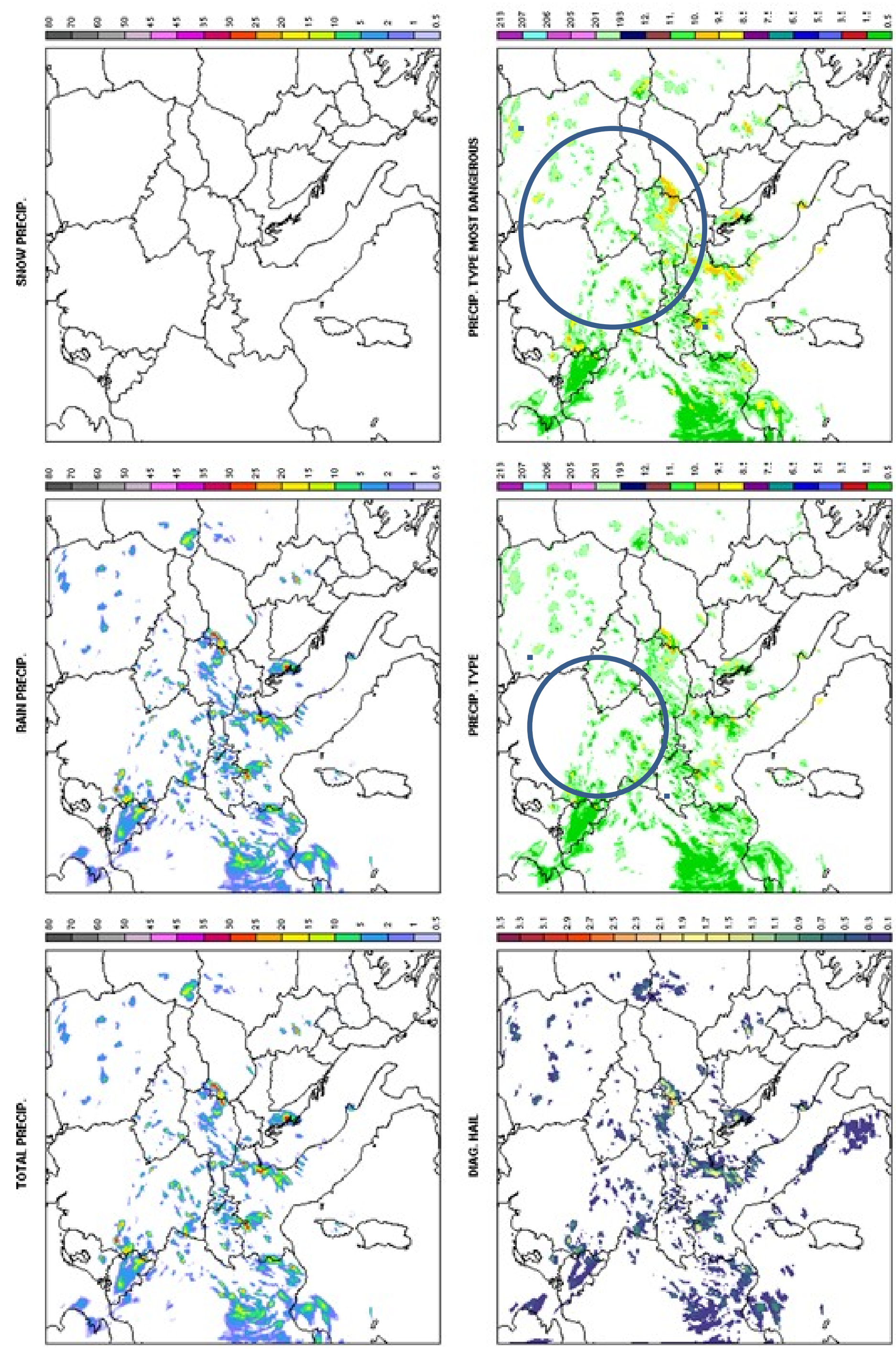


Figure 8. Precipitation type, diagnostic hail and 1-hour sum of precipitation at 27.07.2019 17:00 UTC.

4. Precipitation types- visualization

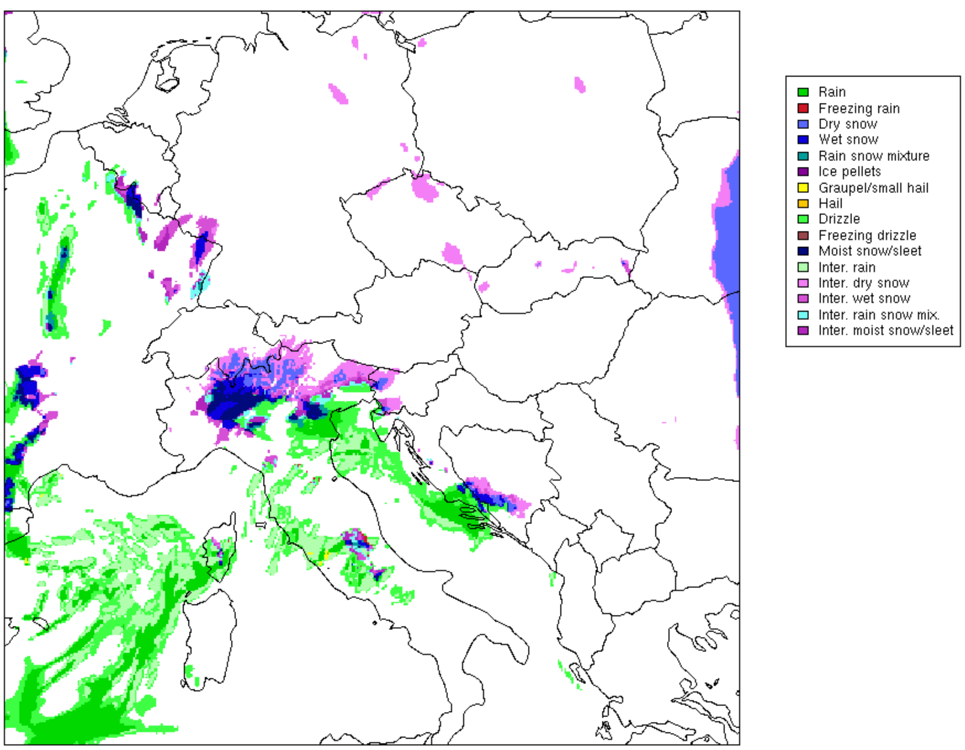
Precipitation type can be presented in two different ways:

- dependent from time of occurrence (rain or intermittent rain) of the phenomenon and sum of precipitation (rain or drizzle) - 16 types
- dependent from types of precipitation – 9 types

1. Rain
2. Freezing rain
3. Dry snow
4. Wet snow
5. Rain snow mixture
6. Ice pellets
7. Graupel/small hail
8. Hail
9. Drizzle
10. Moist snow/sleet

Below are presented two types of plots: using 16 types and 10 types:

a) 16 types of precipitation



b) 10 types of precipitation

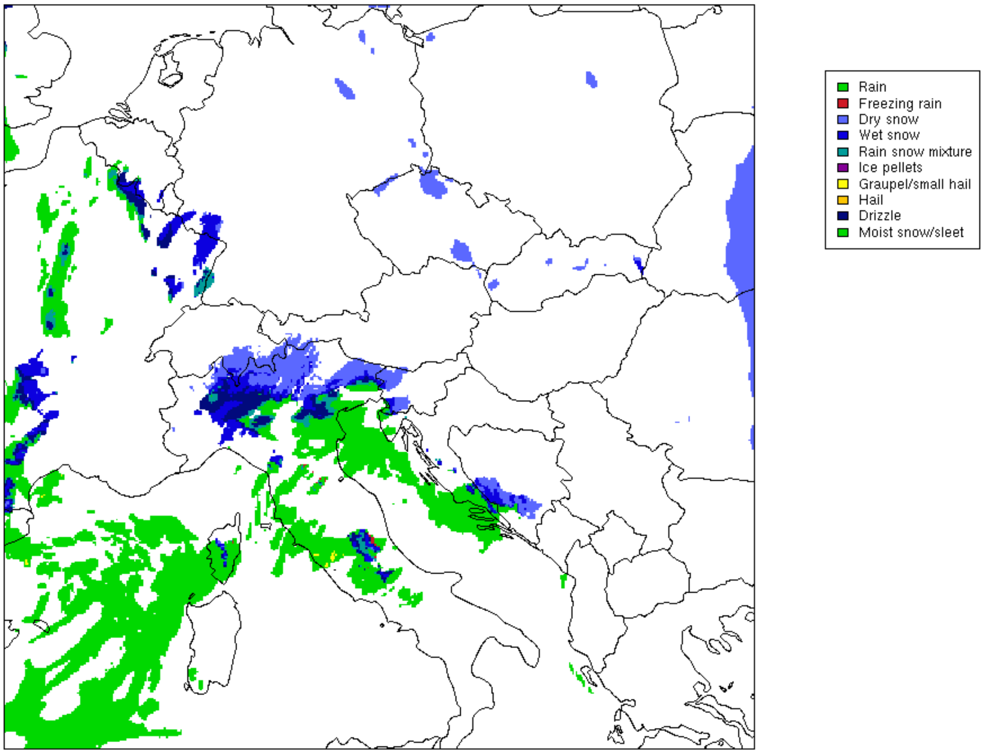


Figure 9. Precipitation type at 2014-01-30 01:00 UTC with 16 and 10 classes.

5. Additional fields

A short overview of additional fields which are available in cy43t2 was done during the stay in Ljubljana.

Altitude of wet bulb temp. isotherm 0°C : calculated from surface [m a. s. l.]	SURFISOTPW0.MALT	PF file
Altitude of wet bulb temp. isotherm 1°C : calculated from surface [m a. s. l.]	SURFISOTPW1.MALT	PF file
Altitude of wet bulb temp. isotherm 1.5°C : calculated from surface [m a. s. l.]	SURFISOTPW2.MALT	PF file
Ventilation Index :	CLPVEIND.MOD.XFU	ICMSH file

U-Total Stress	:	SURFTENS.TOTA.ZO	PF file
V-Total Stress	:	SURFTENS.TOTA.ME	PF file
Surface direct normal irradiation:	:	SURFDIR NORM IRR	ICMSH file
Surface global normal irradiation	:	SURFGLB NORM IRR	ICMSH file
Mean radiant temperature	:	LSMEAN.RAD.TEMP	ICMSH file
Top of convective clouds	:	CLPTOPCONV.MOD.X	PF file

Fields **Surface direct normal irradiation** and **Surface global normal irradiation** are by default saved in ICMSH files.

To get fields **Mean radiant temperature** and **Ventilation Index** you have to add in namelist:

```
&NAMXFU
LXVEIN=.TRUE.        !   ‘CLSVENTNEUTRE.U'
LXMRT=.TRUE.         !    LSMEAN.RAD.TEMP
```

To get fields of **Altitude of wet bulb isotherm of 0ºC, 1ºC and 1.5ºC** and **Total Stress components** you have to add in namelist:

```
&NAMFPC
CFP2DF(1)='SURFISOTPW0.MALT'
CFP2DF(2)='SURFISOTPW1.MALT'
CFP2DF(3)='SURFISOTPW2.MALT'
CFPCFU(1)='SURFTENS.TOTA.ZO'
CFPCFU(2)='SURFTENS.TOTA.ME'
```

Altitude of wet bulb isotherm is calculated by routine **PPWETPOINT**.

To get field pressure at the top of convective clouds you have to add in the namelist

```
&NAMPHY
LPTOPC=.T.,
```

```
&NAMFPC
CFPXFU(1)='CLPTOPCONV.MOD.XFU'
```

To separate top of convective clouds from surface pressure we used field **SURFPRESSION,** if the difference between these two fields is lower than 3hPa their values are set to 0. On Figure 10 is presented original field and modified using field of surface pressure.

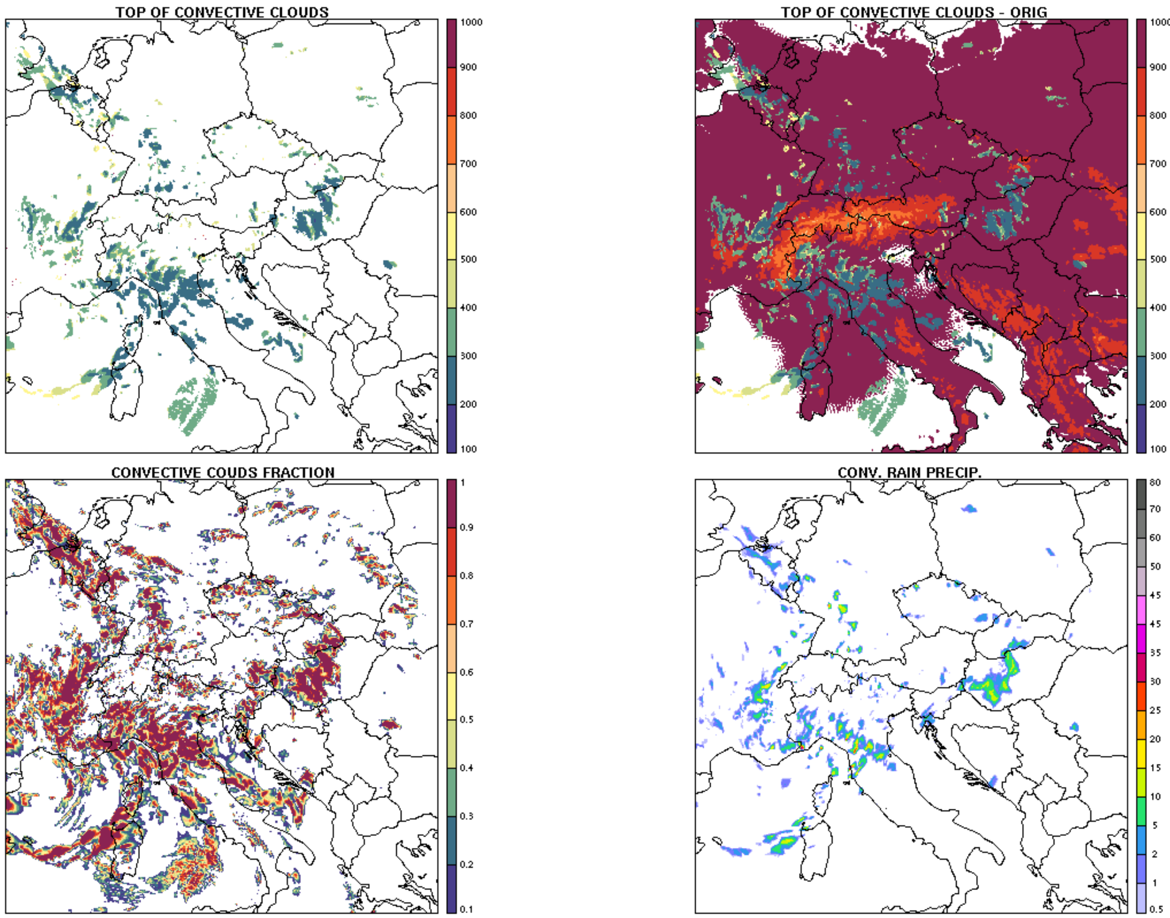


Figure 10. Plot of convective cloudiness, convective rain precipitation and height of top of convective clouds in hPa (original field top right, modified top left).

Comparison of the forecasted top of convective cloudiness with satellite imagery (you can explain from where is this product) is presented on Figure 11. It can be seen that predicted top of convective clouds have similar location and height.

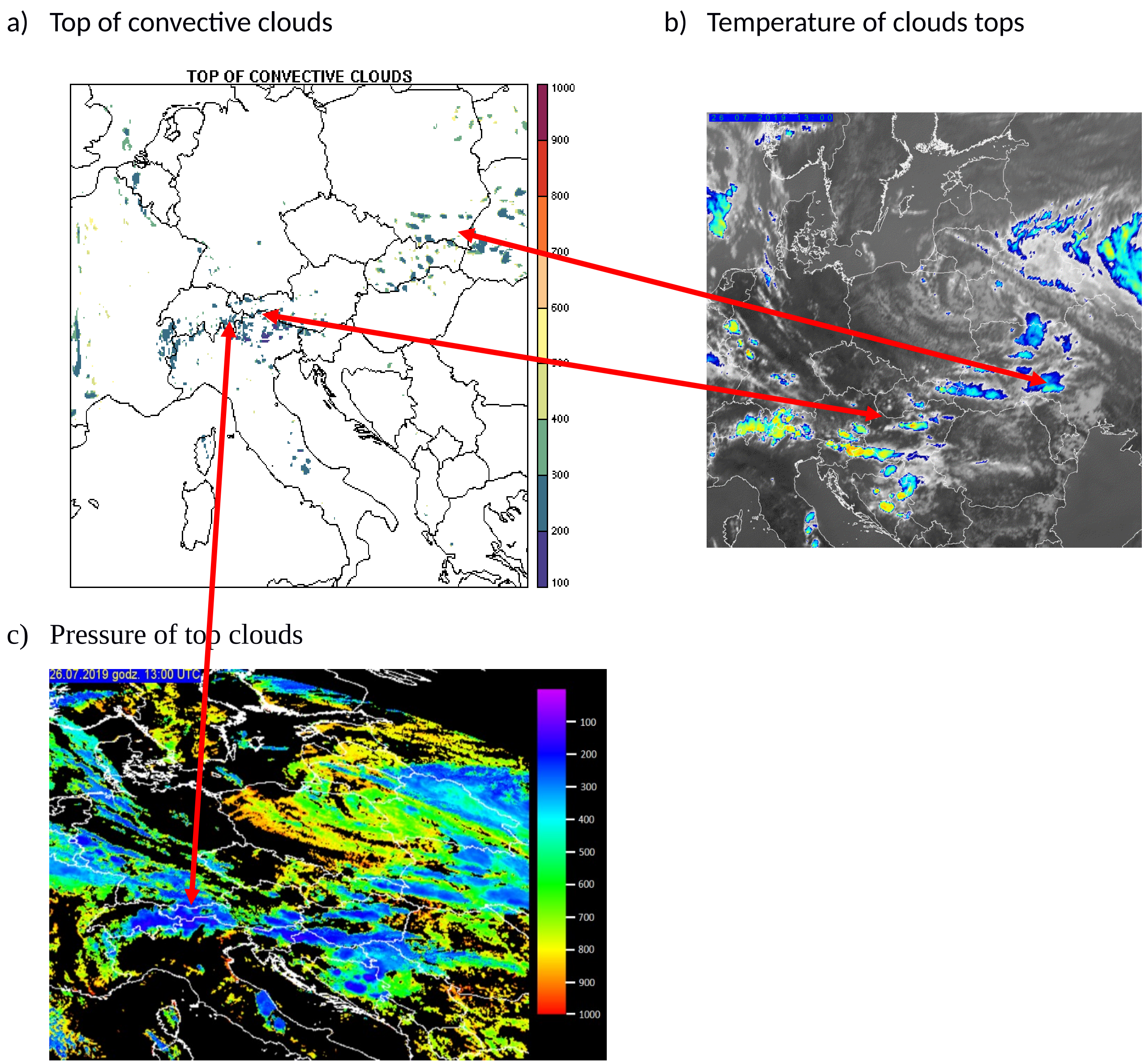
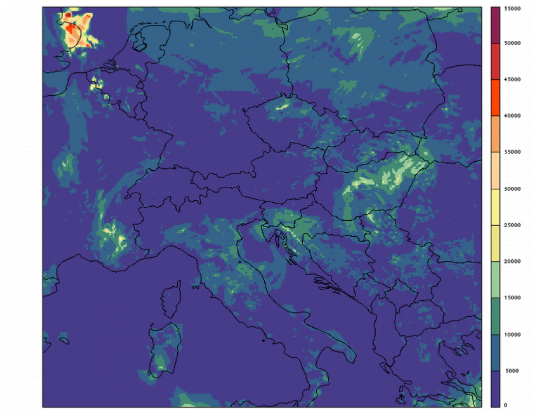


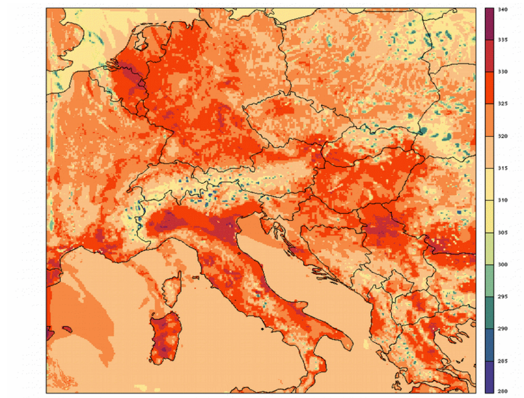
Figure 11. Comparison of field top of convective clouds with satellite data for period 26.07.2019 13:00 UTC.

More diagnostic fields are presented on figure 12.

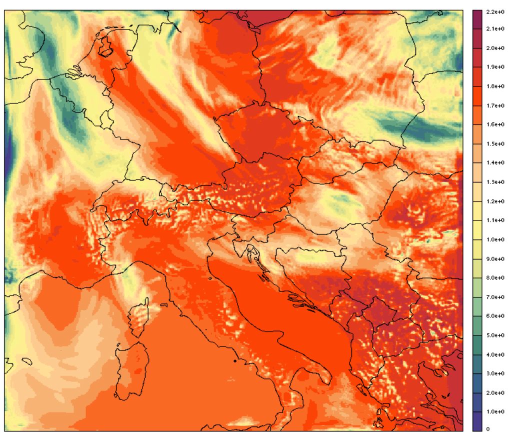
a) Ventilation index



b) Mean radiant temperature



c) Surface direct normal irradiation



d) Surface global normal irradiation

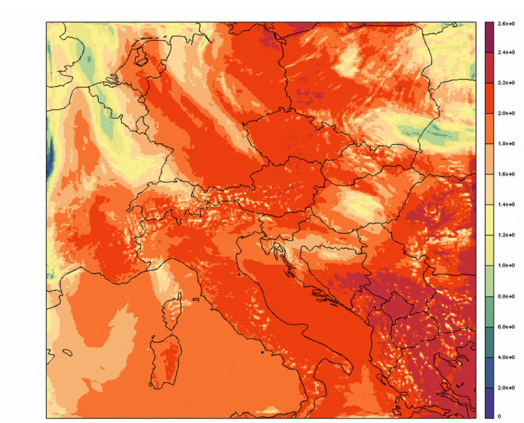


Figure 12. Few diagnostic fields valid for forecast 26.07.2019 12:00 UTC.

To separate **Altitude of wet bulb temp. isotherm 1°C** calculated from surface in units if m a.s.l. from terrain topography we used **SPECSURFGEOPOTEN** field**,** if the difference between these two fields is lower than 0 their values are set to -999. On Figure 13 below is presented original field and modified using field of terrain topography in units' meters above sea level (bottom left picture) and meters above ground level (bottom right picture). Values which are below 0 in plot are presented by white color.

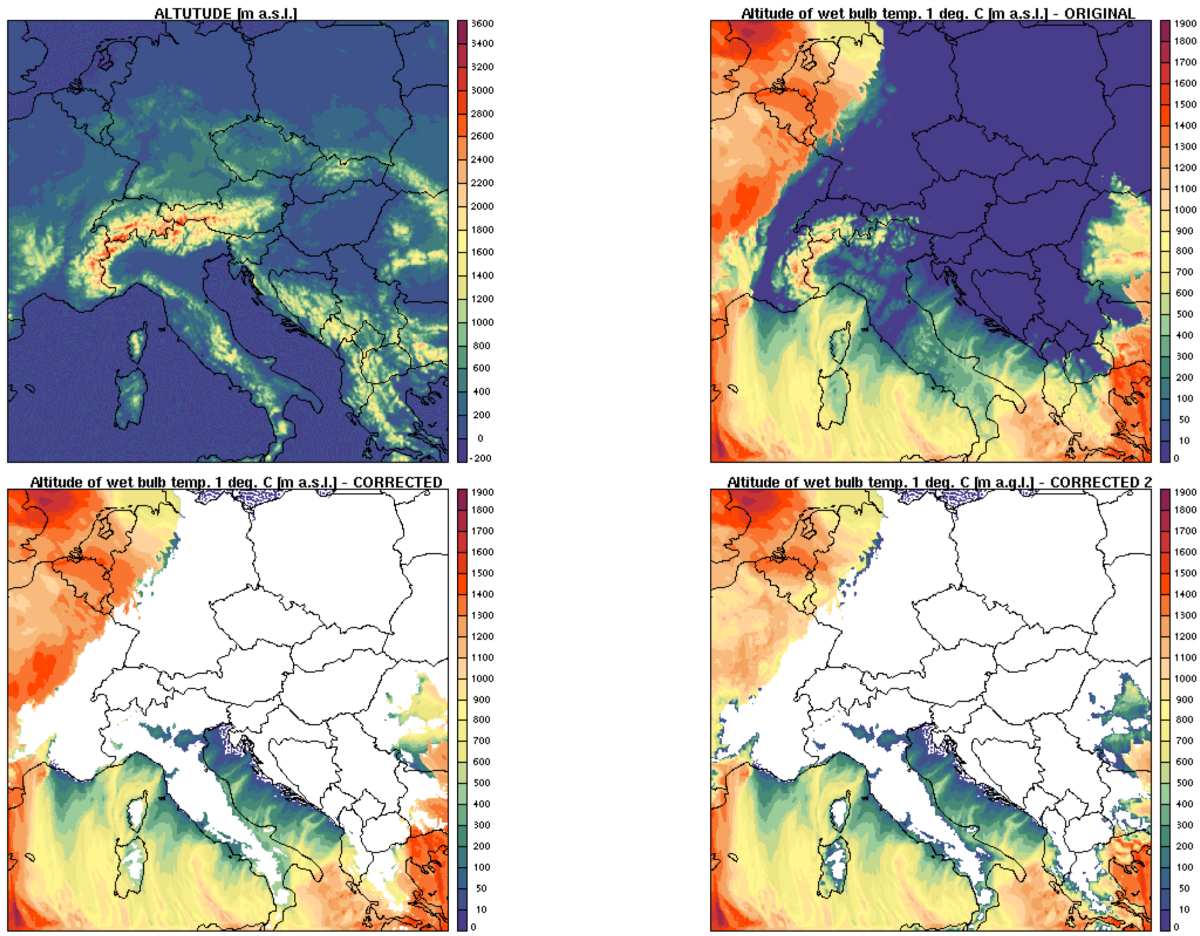


Figure 13. Plots of altitude of wet bulb temperature isotherm at 1 deg. C (original and modified) and terrain topography at 26.01.2019 1:00 UTC.

Reference

Quéno, L., Vionnet V., Cabot F., Vrécourt D. and Dombrowski-Etchevers I., Forecasting and modelling ice layer formation on the snowpack due to freezing precipitation in the Pyrenees. Cold Regions Science and Technology Volume 146 (2018), Pages 19-31