ON THE ECMWF RE-ANALYSIS OF THE MAP SOP

Christian Keil* and Carla Cardinali
European Centre for Medium-Range Weather Forecasts, Reading, UK

1. Introduction

In meteorology an analysis represents an accurate image of the true state of the atmosphere at a given time. The analysis not only provides the initial condition for numerical weather forecasts, but it can be useful as a comprehensive diagnostic of the atmosphere or be used to check the quality of new observations.

The Mesoscale Alpine Programme (MAP) Special Observing Period (SOP) took place from 7 September to 15 November 1999 and involved a large number of additional upper-air soundings and instrumented flights, along with an exeptional concentration of surface measurements (Bougeault et al., 2001). Using the ECMWF 12-hour 4D-Var global assimilation system, the MAP Re-Analysis will provide the most accurate reference of the atmosphere in terms of resolution and number of observations used over Europe (with respect to other existing systems, e.g. ERA-15, ERA-40, NCEP-Re-Analysis).

The objectives of the MAP Re-Analysis are to:

- produce a comprehensive set of analyses describing the state of the atmosphere for the 70-day period of MAP SOP in autumn 1999.
- Create a formatted archive of the additional MAP observations.
- Foster European and international research by making the observations and the analyses archive widely available.
- Perform validation and diagnostic studies.
- Indicate the benefit of the use of additional observations through data impact studies.

* *Corresponding author address:* Christian Keil, ECMWF, Shinfield Park, Reading, RG2 9AX, United Kingdom; e-mail: c.keil@ecmwf.int

In the following, recent changes of the ECMWF Integrated Forecasting System (IFS) are briefly described (Section 2) and the additional MAP observations are listed (Section 3). Section 4 provides an overview of the products and first results are presented in Section 5.

2. ECMWF Model System

Over the last years, considerable improvement in the accuracy of forecasts from global numerical weather prediction systems has been achieved. Since autumn 1999, when the MAP field experiment took place, there have been substantial modifications in the IFS (Simmons and Hollingsworth, 2002). The main model changes between the IFS operational in 1999 (cycle 21r2; o-suite) and the current version (cycle 24r3) used for the MAP Re-Analysis (denoted MAP-suite henceforth) are briefly summarized. During the SOP on 12 Oct 1999, the number of vertical levels increased from 50 to 60, a new orography and associated subgrid orographic fields were introduced, and changes occured in the cloud and convection schemes (Gregory et al., 2000). In 2000, other major changes involved an increase of the horizontal resolution to approximately 40 km (T511 spherical-harmonic representation), a revised treatment of the land surface scheme and a new parameterization of the long wave radiation. In the assimilation system, the 6-hour window 4D-Var has been extended to 12-hour and the inner-loop resolution increased from T63 to T159. Recently, a new shortwave radiation transfer model and new bias correction for satellite observations were included in the IFS.

3. MAP Observations

The supplemetary conventional data comprise roughly 3000 additional surface stations, an enhanced radiosonde network with some stations reporting every three hours, more than a dozen windprofilers and flight data from 8 research aircrafts. Some dropsondes were also released, measuring wind and temperature profiles. After the acquisition of these observations from the MAP Data Centre (MDC) in Zürich, the data has been formatted and archived in BUFR code at ECMWF.

4. Products

The basic analysed variables will include not only the conventional meteorological wind, temperature and humidity fields, but also model products currently available in the ERA-40 Re-Analysis.

The parameters of the MAP Re-Analysis will be archived with a horizontal resolution of T511 for upper air fields, and a reduced Gaussian Grid with approximately uniform 40 km spacing for surface und other grid-point fields. Upper air data (see Table 1) will be saved at each of the 60 "full" model levels and at 23 pressure levels. Additionally, a subset of upper air parameters will be archived on fifteen isentropic surfaces as well as on the $PV = \pm 2$ surface (for details see ERA-40 Archive Plan, 2000). Surface and single level parameters produced by the analysis are given in Table 2.

Extra fields from the physical parameterisations accumulated over three hour intervals are post-processed for 12 hour forecasts both at 00 and 12 UTC. The parameters used to validate clear sky radiation, to support trajectory stud-

Table 1. Upper air parameters on model (ml) and pressure levels (pl) analysed three hourly.

Parameter	ml	pl	Code	Units
surface geopotential	x		129	m^2s^{-2}
geopotential		x	129	m^2s^{-2}
temperature	x	x	130	K
specific humidity	x	x	133	$kg\ kg^{-1}$
vertical velocity	x	x	135	$Pa\ s^{-1}$
vorticity	x	x	138	s^{-1}
log surface pressure	x		152	Pa
divergence	x	x	155	s^{-1}
relative humidity		x	157	%
cloud liquid water c.	x		246	$kg\ kg^{-1}$
cloud ice water cont.	x		247	$kg\ kg^{-1}$
cloud cover	x		248	$(0-1)$

Table 2. Surface and single level parameters analysed three hourly.

Parameter	Code	Units
sea surface temperature	34	K
sea ice fraction	31	$(0-1)$
surface geopotential	129	m^2s^{-2}
total column water	136	$kg\ m^{-2}$
total column water vapour	137	$kg\ m^{-2}$
soil temperature level 1	139	K
soil temperature level 2	170	K
soil temperature level 3	183	K
soil temperature level 4	236	K
soil moisture (4 levels)	39-42	m^3m^{-3}
Charnock parameter	148	
mean sea level pressure	151	Pa
stand. deviation orography	160	m
anisotropy of orography	161	m
angle of subgrid-scale oro.	162	m
slope of subgrid-scale oro.	163	m
total cloud cover	164	$(0-1)$
10 m eastward wind comp.	165	ms^{-1}
10 m northward wind comp.	166	ms^{-1}
2 metre temperature	167	K
2 metre dewpoint	168	K
downward surface solar radiation (accum.)	169	$Wm^{-2}s$
land/sea mask	172	$(0, 1)$
surface roughness	173	m
albedo (climate)	174	
downward surface thermal radiation (accum.)	175	$Wm^{-2}s$
low cloud cover	186	$(0-1)$
medium cloud cover	187	$(0-1)$
high cloud cover	188	$(0-1)$
latitudinal component of gravity wave stress (accum.)	195	$Nm^{-2}s$
meridional component of gravity wave stress (accum.)	196	$Nm^{-2}s$
gravity wave dissipation	197	$Wm^{-2}s$
skin reservoir content	198	m of water
runoff (accum.)	205	m of water
log. surface roughness length (m) for heat	234	
skin temperature	235	K
low vegetation cover	27	$(0-1)$
high vegetation cover	28	$(0-1)$
low vegetation type	29	*index*
high vegetation type	30	*index*
snow temperature	238	K
snow albedo	32	
snow density	33	
snow evaporation (accum.)	44	m
snow melt (accum.)	45	m
sea ice temperature (4 layers)	35-38	K

Table 3. Extra fields accumulated from the physical parameterisations archived at full model levels.

Parameter	Code	Units
Short wave radiative tendency	100	K
Long wave radiative tendency	101	K
Clear sky short wave rad. ten.	102	K
Clear sky long wave rad. ten.	103	K
u tendency	112	ms^{-1}
v tendency	113	ms^{-1}
T tendency	110	K
q tendency	111	kg/kg

Table 4. Extra fields accumulated from the physical parameterisations saved at half model levels.

Parameter	Code	Units
Updraught mass flux	104	$kg\ m^{-2}$
Downdraught mass flux	105	$kg\ m^{-2}$
Updraught detrainment rate	106	$kg\ m^{-2}$
Downdraught detrain. rate	107	$kg\ m^{-2}$
Total precipitation profile	108	$kg\ m^{-2}$
Turbulent diff. coeff. for heat	109	m^2

ies and to investigate the net tendencies from parameterised processes, are listed in Tables 3 and 4.

5. Example: Precipitation in the Po Catchment

While the data acquisation of the MAP observations is currently underway (March 2002), some experiments are carried out with the MAP-suite for selected episodes during the SOP. In these experiments, the additional MAP observations, which have already been transmitted via the GTS, are blacklisted.

For these cases, preliminary comparisons between the MAP-suite and the operational suite (used during the SOP) show a considerable improvement. Here we focus on daily precipitation (i.e. 24 hour accumulations from 06 UTC onwards) in the Southern Alpine Region, comparable with the catchment of the river Po (extending from 7° E to 12° E and 45° N to 46.5° N). Figure 1 shows the time series of daily precipitation averaged over the Po catchment area (66.000 km^2) for the high resolution precipitation analysis, the o-suite and the MAP-suite, respectively. Precipitation observations are taken from high resolution (25 km) analyses of Alpine

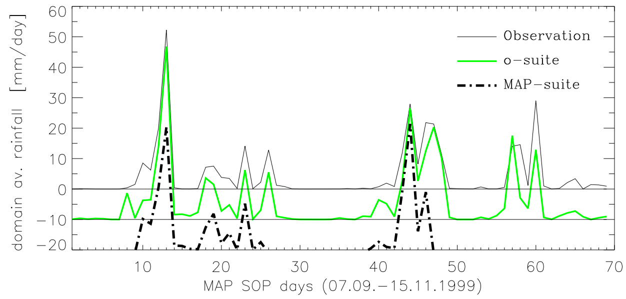

Fig. 1. Time series of daily precipitation averaged over the Po catchment in the Southern Alpine Region. IFS forecasts are shifted down by 10 mm/day (o-suite) and by 20 mm/day (MAP-suite) on the plot.

rain-gauge observations embracing roughly 5000 rain-gauges (Frei and Häller, 2000). Peak values are found for IOP2b (19/20 Sept 1999; day 13 in Fig. 1), when 27 individual stations reported rainfall amounts exceeding 200 mm in 48 hours. The operational forecast is well performing, capturing the majority of the events recording more than 10 mm/day area averaged precipitation. However, the amount of rainfall is slightly overestimated. The two episodes covered by the MAP-suite show a better agreement than the o-suite with respect to the high resolution precipitation analysis (e.g. day 10, 18 and 40 in Fig. 1).

For IOP2b, the spatial distribution of daily accumulated precipitation is depicted for the high resolution analysis, the o-suite and the MAP-suite in Figures 2, 3 and 4, respectively. Peak values exceeding 100 mm at many gridpoints were recorded in the Lago Maggiore Area, in the Dolomites and Carnic Alps in northeastern Italy (Fig. 2). Whereas the operational suite with 60 km grid-spacing is only able to predict the general distribution of the precipitation, the MAP-suite with 40 km horizontal resolution can also spot some locations of the heavy precipitation (values larger than 75 mm/day, Fig. 4). The events timing is well represented in both suites. The MAP-suite also predicts a 'dry' area in the lee of the Alps Maritime, which the high resolution analysis shows. Anyhow, because of the different resolution used for the plots representation, these results must be taken only as a preliminary assessment of the MAP-suite.

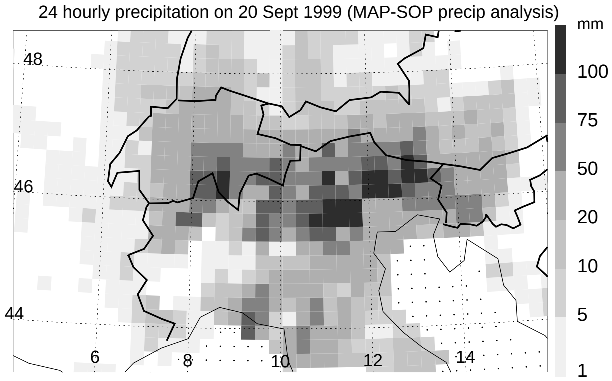

Fig. 2. Alpine 25 km high-resolution analysis from rain-gauge observations on 20 Sept 1999 (IOP 2b).

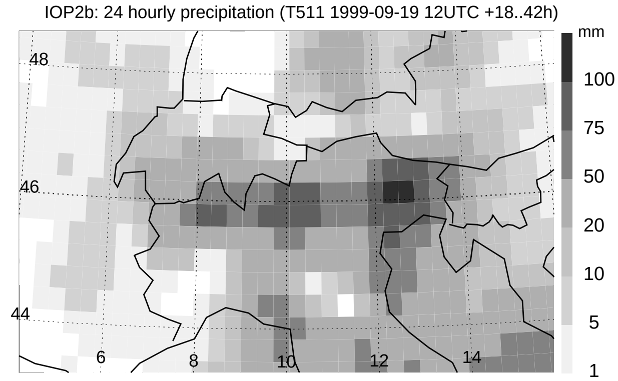

Fig. 4. 24-hour rainfall from the MAP-suite on 20 Sept 1999.

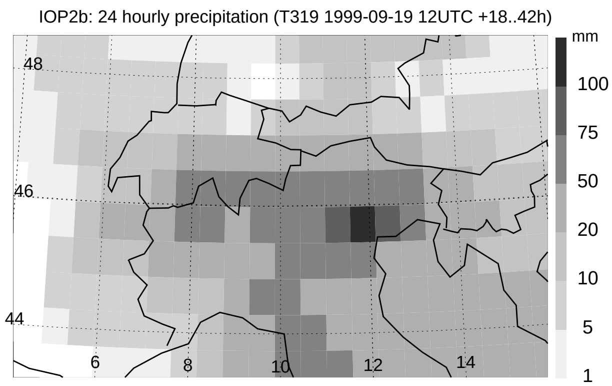

Fig. 3. 24-hour rainfall from the operational suite on 20 Sept 1999.

6. Conclusions

The investigations of the temporal and spatial mesoscale precipitation distribution exhibit an improvement when the MAP-suite is used. However, such a visual intercomparison can only give a first glimpse on the expected quality of the new MAP Re-Analysis.

At the time of writing, preparatory work is still ongoing paving the way towards the MAP Re-Analysis performance.

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