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Ensemble surface MESCAN analysis

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1) Introduction

Within the UERRA project a 2D surface re-analysis have been performed at 5.5km grid space over Europe, aiming to provide added value for Essential Climate Variables (ECV) such as accumulated precipitation and 2m temperature and humidity, compared to the global atmospheric re-analysis. An additional important aspect, especially for the end-user perspective, is the benefit of using uncertainties estimates for the surface analysis products. Uncertainties can be estimated with an ensemble of analysis made with different options or "tuning" (statistics error), perturbed observations and backgrounds. The MESCAN-ENS has been based on perturbed observations, two different backgrounds from two physics packages (Ridal et al. (2016) UERRA report D2.5) and two observations networks. In this report, the MESCAN-SURFEX analysis system is described in Section 2. Section 3 investigates several options for the choice of the members for the ensemble. The 5-year simulations of 2m-temperature and precipitation uncertainties are presented in Section 4, followed in Section 5 by some preliminary results of the MESCAN-SURFEX-ENS ensemble. Discussions and some limitations will be discussed in Section 6.

2) The analysis system: MESCAN-SURFEX

The system used to provide the ECVs and other surface variables at 5.5km such as soil moisture at several levels, surface evaporation, snow depth, has two distinct components:

- MESCAN, a surface analysis system based on an Optimal Interpolation (OI) algorithm described by Soci et al. (2013, EURO4M report D2.6) for the screen level analysis 2m temperature (T2m) and relative humidity (RH2m). The 24h-total accumulated precipitation analysis used in the UERRA project has been developed and implemented in MESCAN during the EURO4M project by Soci et al. (2016).

- SURFEX (Masson et al, 2013) is a land surface platform. SURFEX is driven by atmospheric forcing at 5.5km of T2m, RH2m and 24h-precipitation analyzed by MESCAN and by radiative fluxes and wind. The radiative fluxes and wind are downscaled at 5.5km from the 3DVar re-analysis done at 11km by SMHI with the HARMONIE system and the ALADIN model.

a) MESCAN characteristics for the 2m-temperature and relative humidity analysis:

The structure function used in MESCAN for the near surface variables (Fig: 1), 2m-temperature (T2m) and relative humidity RH2m has the following expression :

$$Cor_{Surf}(r,d_p,d_z)=0.5\left[e^{-\frac{r}{L}}+\left(1+\frac{2r}{L}\right)e^{-2\frac{r}{L}}\right]F_p(d_p)F_z(d_z)$$

r is the distance between two points on the same horizontal surface, $F_p(d_p)$, and $F_z(d_z)$ are empirical linear functions to take into account respectively the land-sea mask difference d_p and the difference of height, d_z, between two locations. These functions vary from 1, for $d_p = d_z = 0$, to 0.5 for $d_p=1$ and $d_z \geq 500$m, respectively (Häggmark et al. (2002)). L is the characteristic horizontal scale set at 190Km.

The observation standard deviation error, σ_o, is set to 0.2 for RH2m and for T2m a dependency to the measured temperature is used, as it is in MESAN (Häggmark et al. (2002))

with T_{ref}=270K. It is a way to take into account the lower accuracy of the instrument with cold temperature.

$$\sigma_o = \begin{cases} 1.5+0.1\cdot(T_{ref}-T_{2m})+0.15\cdot[(T_{ref}-10)-T_{2m})], & T_{2m}<260 \\ 1.5+0.1\cdot(T_{ref}-T_{2m}), & (T_{ref}-10)\leq T_{2m}<T_{ref} \\ 1.5, & T_{2m}\geq T_{ref} \end{cases}$$

The background standard deviation error, σ_b, is set to 0.3 for RH2m and for T2m the value is higher during winter Nov, Dec, Jan, Feb with 8K and lower for June and July with 5K, the rest of the year the value is set to 7K, this season dependency of σ_b could be justified by the fact that model errors are higher during winter due to the stable boundary layer, fog and/or snow cover.

b) MESCAN 24h-precipitation analysis:

For precipitation, the background error spatial correlation function (Fig: 1) is expressed as follow with L=35km :

$$Cor_{RR}(r)=\left(1+\frac{r}{L}\right)^{-\frac{r}{L}}$$

The observation standard deviation error, σ_o, is set to 5mm and the background standard deviation error σ_b, to 13mm (default value used in SAFRAN).

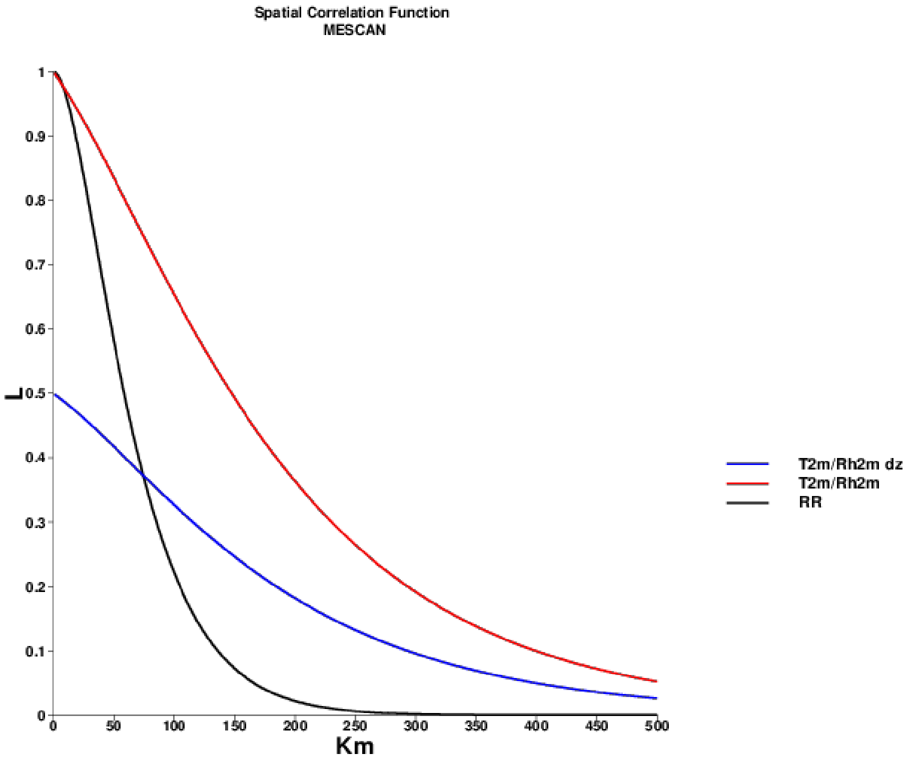

Fig 1: Horizontal background error spatial correlation function used in MESCAN: for (i) precipitation (black line), (ii) T2m and RH2m if the difference of elevation between the model and the observation is zero (red line), (iii) T2m and RH2m if the difference of elevation between the model and the observation is 500m (blue line).

3) Ensemble of surface re-analysis

Although the surface re-analysis will cover the 1961-2015 period, uncertainties will be estimated only for the 2006-2010 period, mainly due to computational resources and a limited project lifetime. The number of the ensemble members has been fixed to 8 for T2m and RH2m and 6 for precipitation analysis.

The uncertainties in a surface re-analysis system come from all the components of the system: observation, background and the analysis algorithm (tuning, etc.).

For estimating the background uncertainties, we have used two backgrounds from two 3DVar re-analysis at 11Km (from SMHI) with 2 physics packages (Ridal et al. (2016), UERRA report D2.5). The background fields have been downscaled at 5.5km. A dynamical downscaling has been also performed at 5.5km by running the ALADIN model at 5.5km. It was shown that, especially for precipitation, fine scale information was generated while integrating the forecast model (Soci et al. 2016). Some of the ensemble members use perturbed observations but only for T2m and RH2m not for the precipitation analysis.

The quality of the surface analysis is strongly dependent in time and space on the observations network density and on the background field especially where observations are sparse. For climate studies, 2m-temperature or precipitation trends are often used to characterize the climate change. In this respect, an estimate of the impact of the density network on the re-analysis could probably be very useful for the "end user".

The number of available observations on the ECMWF MARS archive system for the 1961-2015 period for screen level variables is shown in Fig 2. Two jumps occur around 1967 and 2000 and can potentially initiate a misleading interpretation of the trend in the re-analysis product. Another aspect is the spatial variability in some regions where almost no data are available (Fig: 3a and b) for the entire period. In such regions the uncertainties can only be estimated with different or perturbed background.

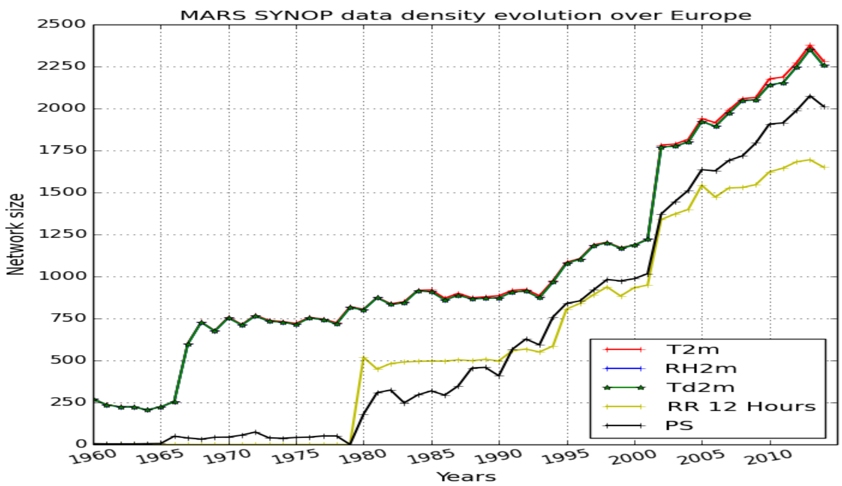

Fig 2: Number of observation available at ECMWF

Looking at the surface observation network in the 1960s (Fig: 3a and 3b), it can be noticed that it is extremely sparse and disparate over Europe. The observation spatial coverage is not homogeneous, and generally we can see that western, most of Central Europe, and

Scandinavian regions are characterized by a high observations density, particularly for precipitation, whereas, in the South and eastern Europe precipitation network are very sparse or even do not exist in North Africa.

Hence, to account for the effect of observation density while estimating uncertainties in surface reanalyses, we have generated a low density or “degraded” observation network with a uniform spatial coverage for the three parameters (T2m/RH2m/RR24) over the 2006-2010 5-year period.

Note that the low-density observation network is a sub-network of the reference one, and is generated as following: first a 2 degrees latitude/longitude regular grid (see Fig: 5) was defined in order to sample observations from the high-density network (reference observation network), and for each single grid box one site was randomly selected from the existing sample points. In this way, a low-density observation network with homogeneous spatial coverage was designed. Fig 6 (bottom panel) depicts the pattern for low density network for the surface parameters. Note that on average in the low-density network, the number of observations per day varies from 831 at 6-hour interval for T2m/RH2m, and 474 for daily precipitation.

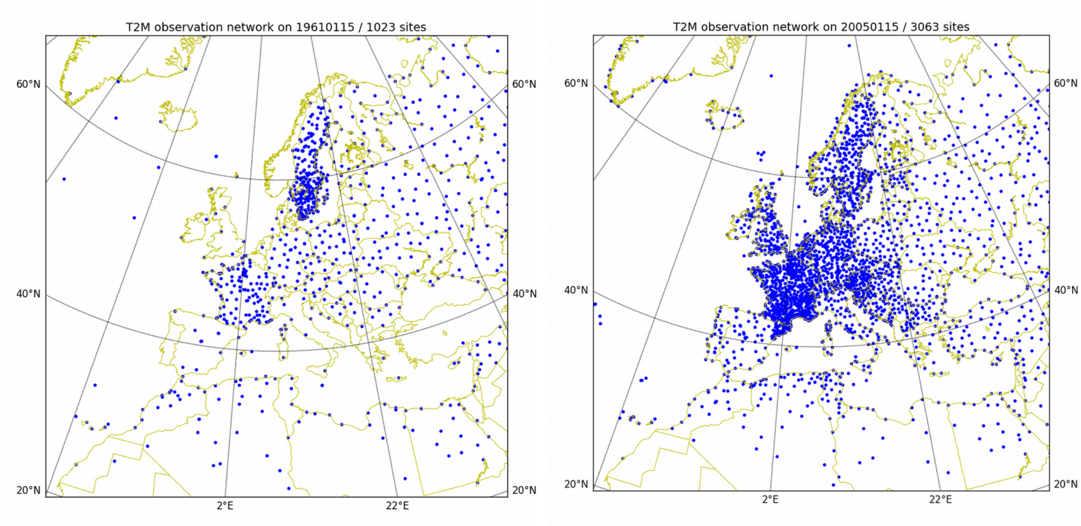

Fig 3a: T2m observation available. Left: 15th Jan 1961. Right: 15th Jan 2005

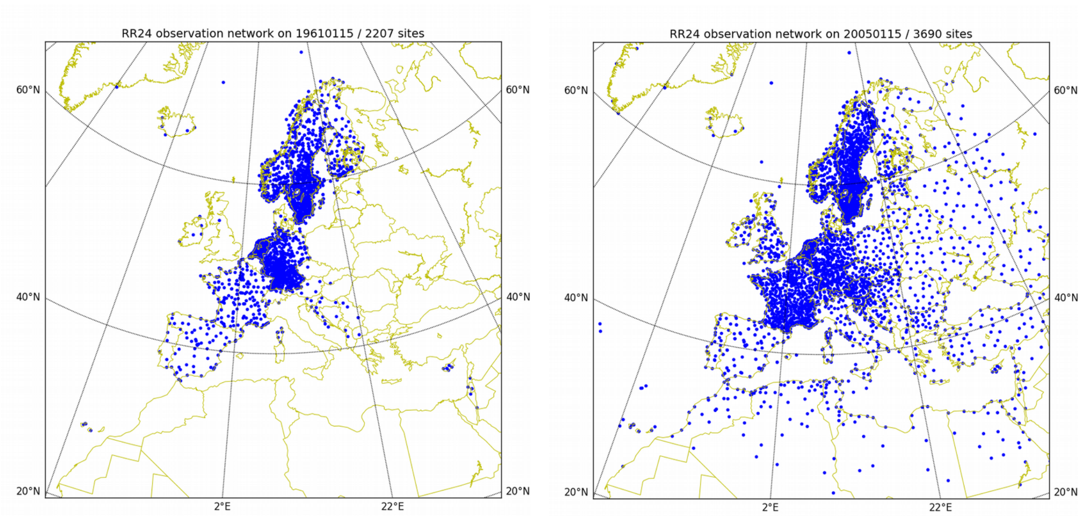

Fig 3b: 24h precipitation observation available. Left: 15th Jan 1961. Right: 15th Jan 2005

The impact of the observation network on the MESCAN analysis is shown in Fig: 7. As expected, the impact is mostly located where the change of the density is significant: France, Alps, Scandinavia.

Over the mountainous regions (Alps, Scandinavia), a high density network have more impact (up to 4K for the T2m and more than 100mm for precipitation) especially due to the MESCAN fine scale re-analysis resolution (5.5km). For the Eastern part of Europe or in North Africa the impact is lower or nil.

From those results, two important conclusions can be drawn for the design of the ensemble:

- the impact of the density network is more important in mountainous regions due to the fine scale and local effect, so some members should use the low-density network

- an ensemble based only on perturbed observations is probably not relevant for the users, since there's almost no variability in some regions like North Africa or Eastern Europe.

Subsequently, this low-density observation network is used for some members in the surface reanalyses in order to increase the sampling error of the ensemble of reanalyses.

Figure 4 shows the monthly variation of the observation number in the high and low-density networks for T2m/Rh2m and 24h precipitations for the 5-years period. The number of observations in low-density network is more or less stable over the whole time period. In contrast, the observation number in the high-density network shows a gradually increase and decrease respectively for T2m/Rh2m and 24h precipitation.

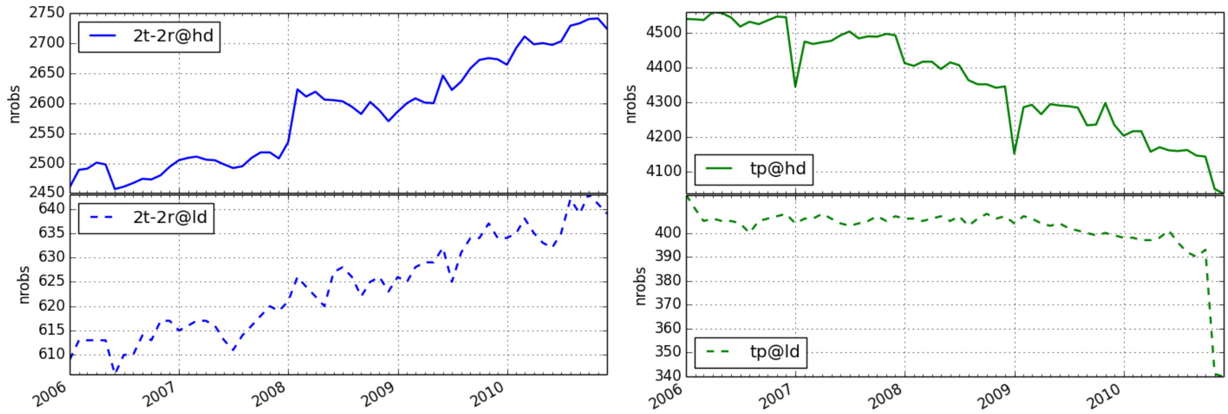

Fig 4: Monthly observation number in high and low-density networks of T2m/Rh2m and RR24 over the 5-years period. Left T2m/Rh2m. Right: RR24. Top: High-density. Bottom: low-density

To build the ensemble system for the T2m/RH2m analysis, several combinations between perturbed observations and several background at 5.5km were performed: ALADIN forecast at 5.5km, background down-scaled at 5.5km from 11km and two observations network. The impact of the physics (Fig: 8) used in the forecast model (background) is nicely complementary to the impact of the observations network as shown in Fig: 7. For the precipitation analysis, several backgrounds are mandatory to estimate uncertainties especially over North Africa and Turkey. It is also important for the screen level analysis (T2m, RH2m) for the Eastern part of Europe with sparse observation and errors related to the snow cover.

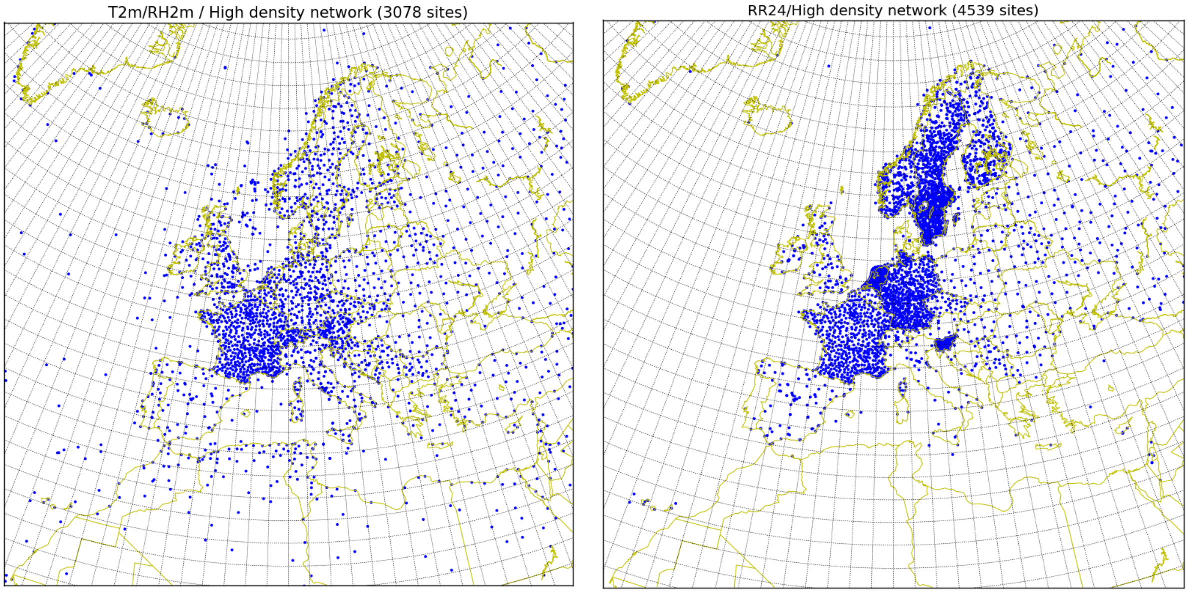

Fig 5: High density network. Left T2m/RH2m. Right: 24h precipitation

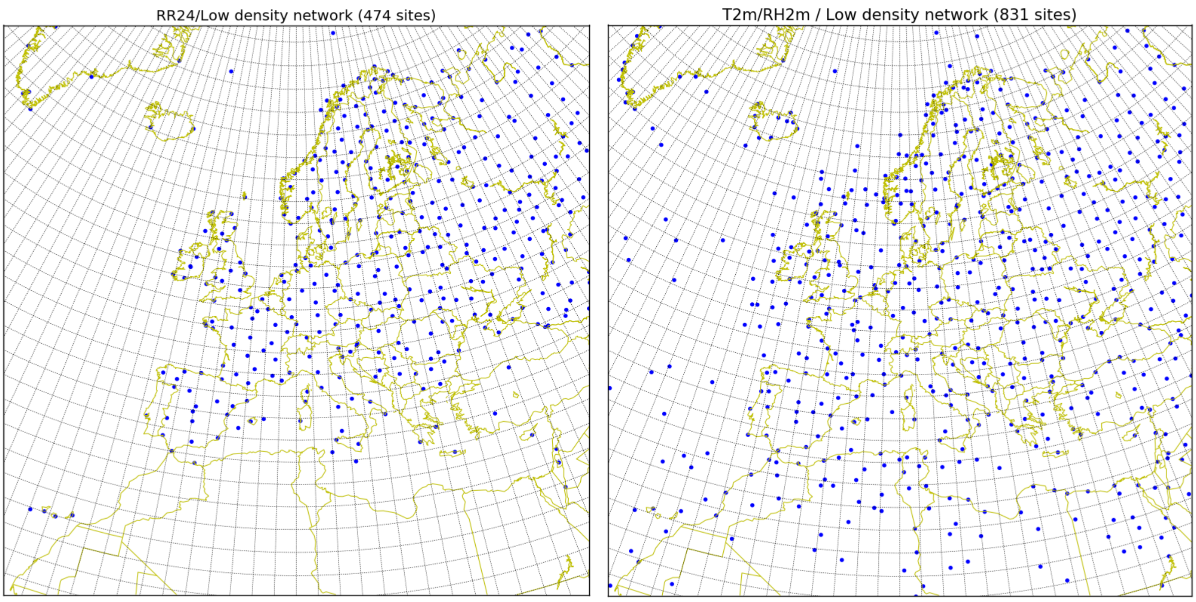

Fig 6: Low density network Left T2m/RH2m Right: 24h precipitation (6 UTC to 6 UTC)

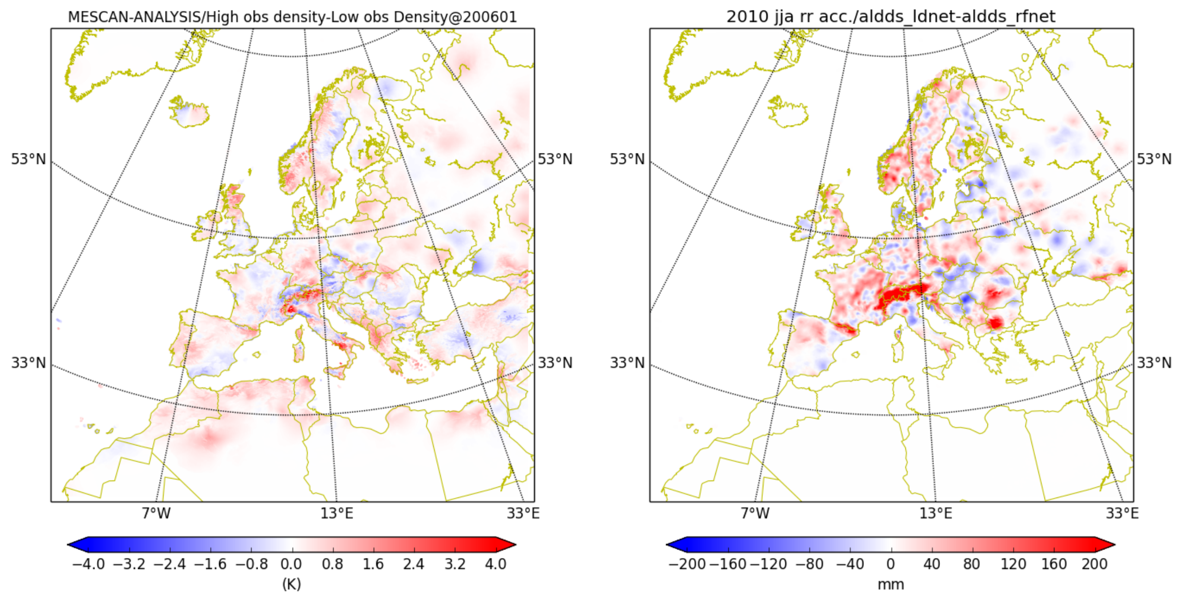

Fig 7: Impact of the low-density network on (i) January 2006 monthly mean temperature (left panel), and (ii) JJA 2010 accumulated precipitation (right panel).

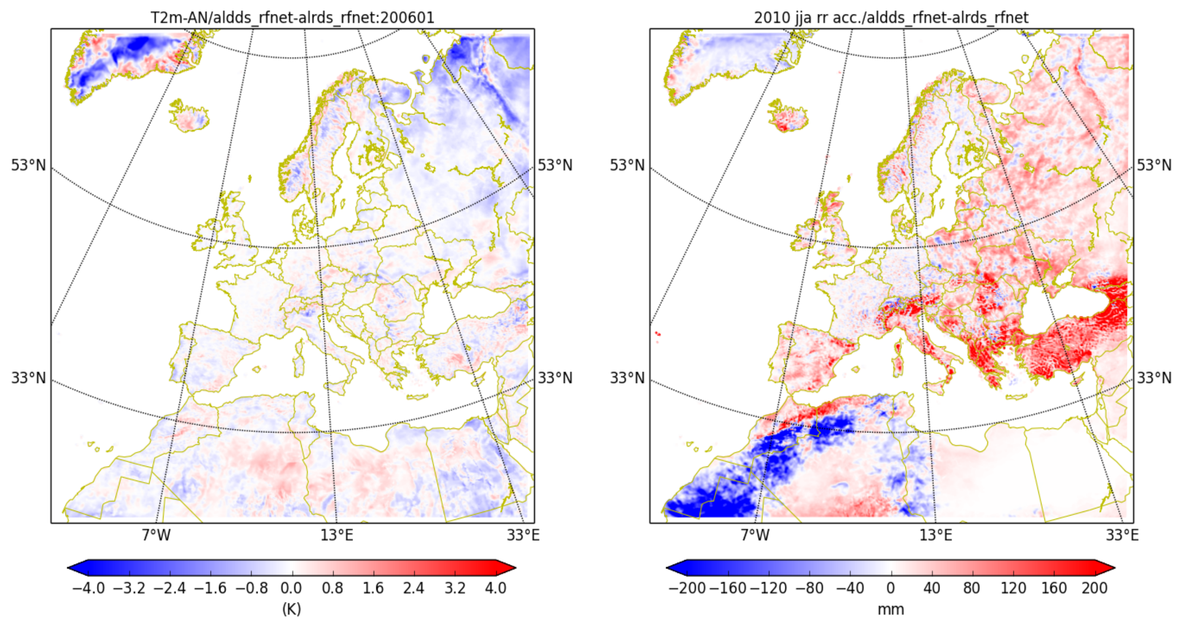

Fig 8: Impact of the physics (background) on (i) January 2006 monthly mean temperature (left panel), and (ii) JJA 2010 accumulated precipitation (right panel).

<u>Setup for the MESCAN-ENS T2m and RH2m analysis:</u>

Two types of ensemble with 8 members for months January and June 2006 and 2010 were evaluated. One ensemble named (Ens-8-OP) was based only on perturbed observation for the 8 members and use the same static downscaled ALADIN-HARMONIE background. The second ensemble Ens-8-UE uses 4 members with perturbed observations and 4 members based on the two backgrounds provided by SMHI with 2 physics (ALADIN and ALARO) and two observation networks with low and high densities.

One possible evaluation of the ensemble of the T2m re-analyses is to use their associated rank histograms. Fig: 9 shows the rank histogram for both ensembles over Europe for June 2006. The Ens-8-OP system generated with one background and 8 data sets of perturbed observations (Fig: 9 left) have a rather flat one, with may be an overpopulation of the middle ranks which may indicate a little excess of variability in the ensemble. The Ens-8-UE (Fig 9 right) have clearly a U-shaped rank histogram, which commonly indicates a lack of variability in the ensemble. Nevertheless, the evaluation with the rank histogram is limited, the observations are used in the analysis and in the rank histogram computation, so it is just a statistical way to evaluate the ensemble where observations are available.

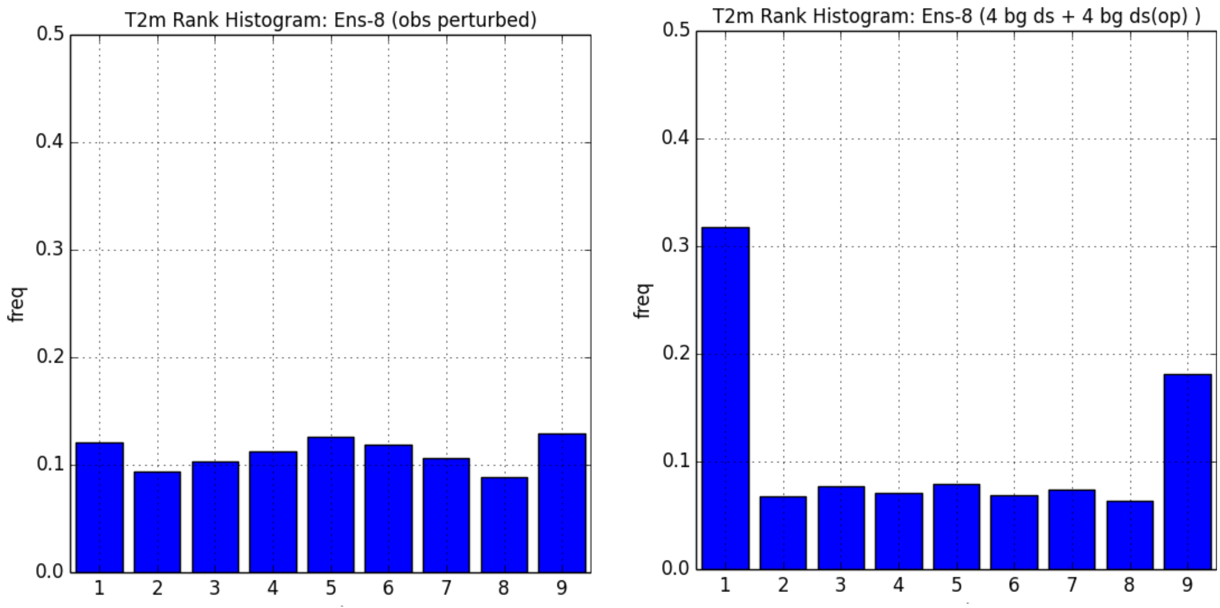

Fig 9: Rank Histogram for T2m. June 2006. Left: Ens-8-OP. Right: Ens-8-UE

For example, figure 10 shows the standard deviation for an ensemble of 4 members with the perturbed observation (left) and an ensemble of 4 members with two backgrounds and two network density (middle) for the 15th January 2006 at 12UTC. The pattern of the standard deviation is significantly different between both ensembles, the perturbed observation method is probably relevant to estimate the uncertainties due the observation measurement but generates some circles in some regions with sparse observations (North Africa, Greenland, East Europe) due to the correlations functions and the correlation length, nevertheless this weakness can be reduced by increasing the correlation length but it does not really solve the problem. In Fig: 10 (middle), the standard deviation is really high in Greenland and in Northern part of Scandinavia, it is a well-known deficiency in Numerical Weather Predication models or in GCM (Holtslag et al. 2013) in winter with stable boundary layer in presence of snow.

However, the two maps are complementary, so by using 4 members with perturbed observations and 4 with 2 backgrounds and two observations network, this ensemble of 8 members, ENS-8-UE, is probably a “rather good” compromise to estimate the uncertainties for T2m and RH2m analysis, which are important for end users applications (Fig: 10 right).

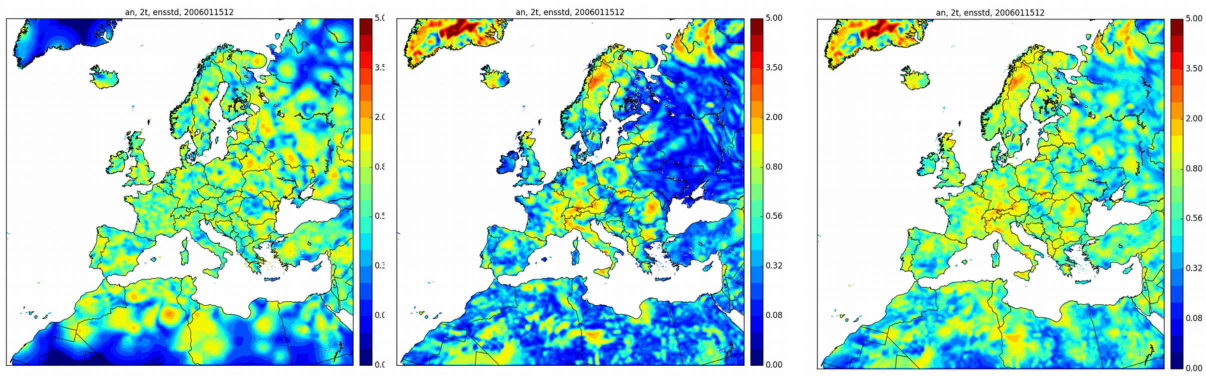

Fig 10. T2m standard deviation for the 15th January 2006 at 12UTC. Left : 4 members perturbed observations. Middle: 4 members 2 backgrounds and two networks. Right: the combined ensemble ENS-8-UE.

Setup for the MESCAN-ENS precipitation analysis:

The precipitation is one of the most important variable together with 2m-temperature for climate study, water management, and to drive surface and hydrological model. The need of an estimation of the uncertainties is probably stronger than for the 2m-temperature for several reasons: frequency of extreme rainfall, flash flood, drought period, etc. For the ensemble precipitation, the perturbed observation method was not used for mainly two reasons: the precipitation field is not a Gaussian variable and the observation network (Fig: 3) is too inhomogeneous in space and time. Eastern part of Europe and North Africa have almost no observation data available. Therefore, 3 backgrounds combined with two types of observation network (Fig 5 and Fig 6), so finally 6 members will be used. The 3 backgrounds at 5.5km are obtained by two “static” downscaling (interpolation) and from a full integration of the ALADIN forecast at 5.5km grid spacing:

- static downscaling of 4 successive 6h forecast from the 3DVAR HARMONIE-ALADIN re-analysis at 11km.
- static downscaling of 4 successive 6h forecast from the 3DVAR HARMONIE-ALARO re-analysis at 11km.
- 4 successive 6h forecast with the ALADIN model at 5.5km initialized with a downscaled analysis at 5.5km from the 3DVAR HARMONIE-ALADIN re-analysis at 11km. The lateral boundary condition are also from the 3DVAR HARMONIE-ALADIN re-analysis at 11km.

The background generated with ALADIN at 5.5km is very useful to obtain a finer scale structure for the precipitation as shown by Soci et al (2016) with a spectral analysis and a slightly better rank histogram with only 4 members from 2 downscaled background and two observation networks (Fig 11). Nevertheless, the ensemble is still under dispersive.

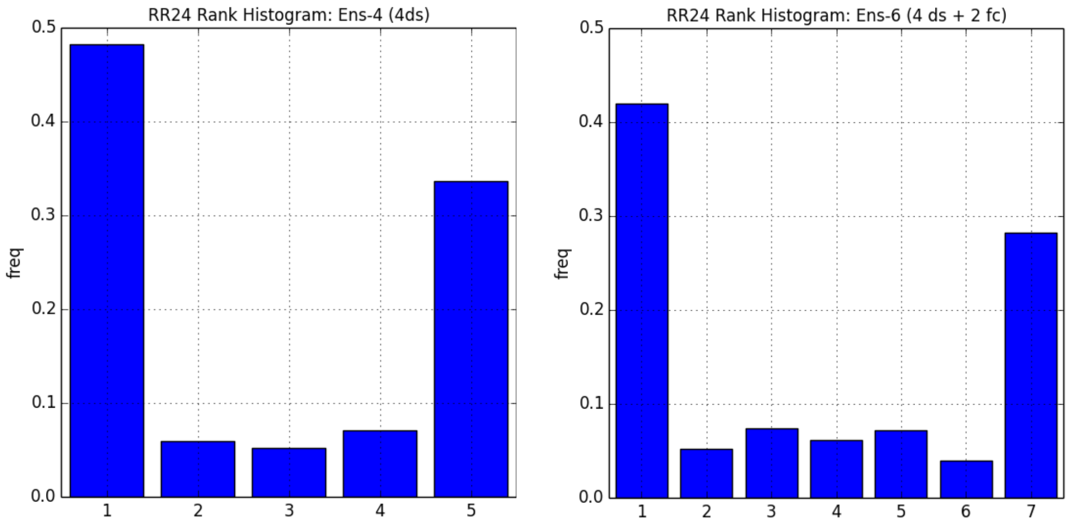

Fig 11: Rank histogram for the 24h precipitation analysis January 2006. Left: ensemble with only 4 members. Right: Ensemble with 6 members (two additional members from ALADIN at 5.5km)

4) 5 years results for the T2m/RH2m and precipitation uncertainties

Figure 13 shows the time evolution of the monthly mean temperature difference between each member and the mean of the ensemble for 4 sub domains over Europe (Fig: 12). The four sub-domains have been selected to illustrate the differences in the uncertainties between areas along the season. The full lines are for the 4 members with perturbed observations and the 4 dashed lines for the 2 backgrounds with the two density networks. The gray area is defined as 2 times*standard deviation of the ensemble.

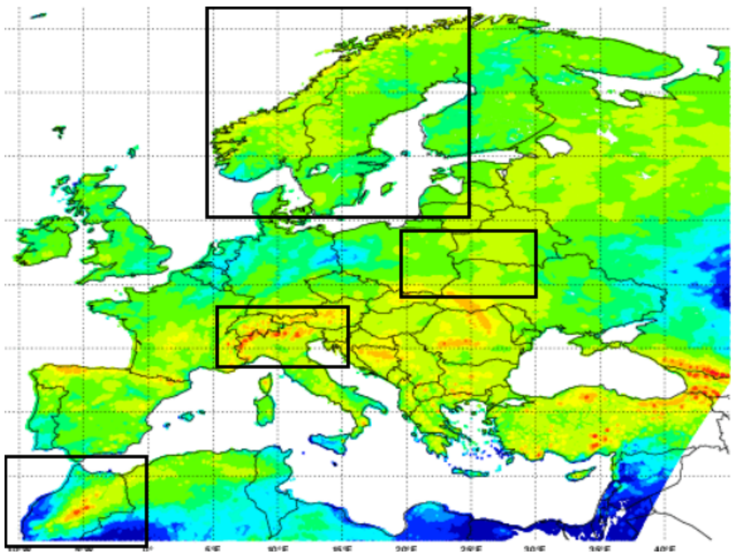

Fig 12. Atlas [-11.7E; 29N] [-0.3E;36N]. Alps [5.35W; 42.82N] [16.W;48N].

Scandinavia [5W; 55N] [25W;72N]. East Europe [20W; 48.5] [30W;54.2N].

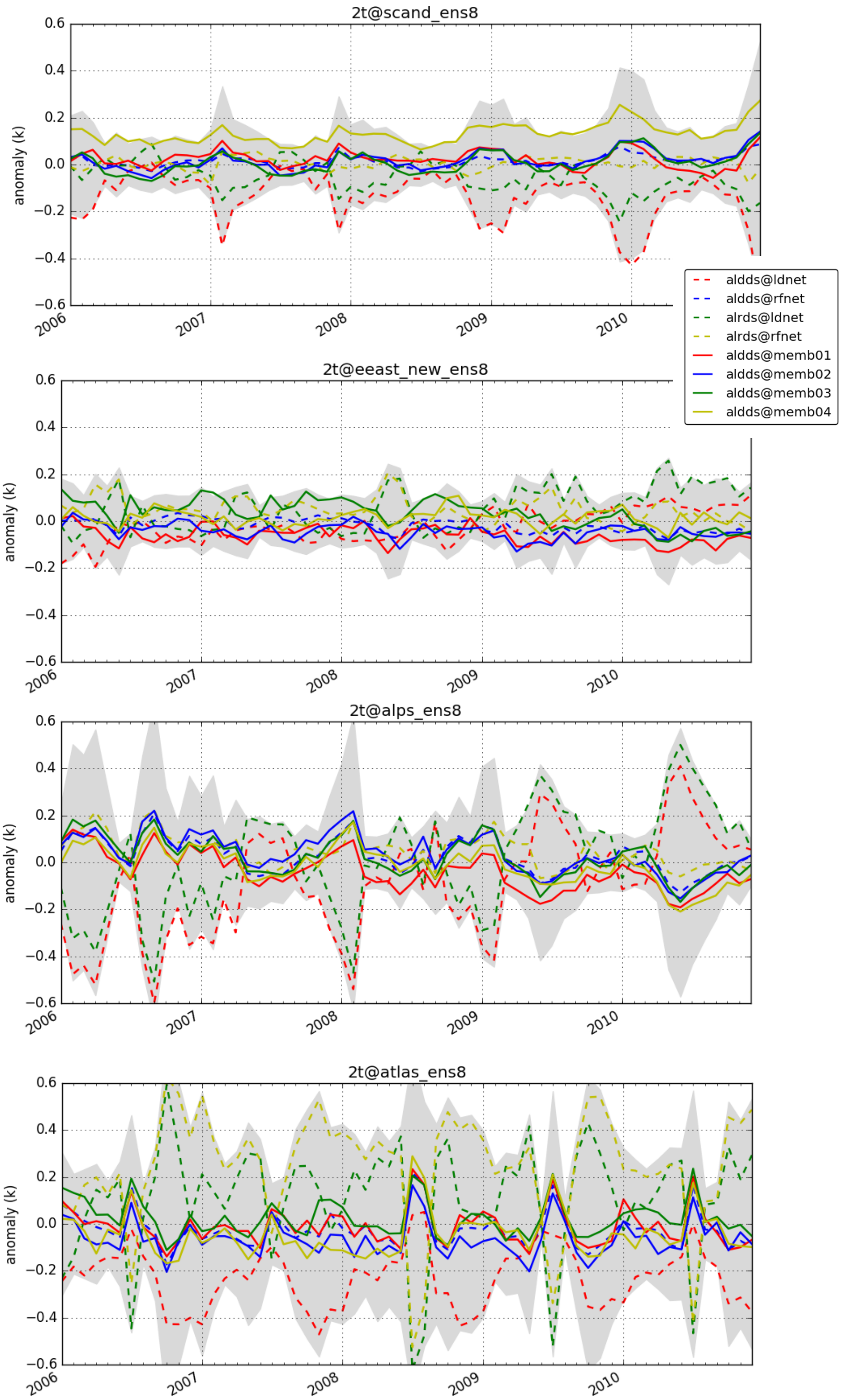

Fig 13: Time evolution of the anomaly of the monthly mean T2m for each member versus the ensemble mean. From the top to the bottom: Scandinavia, East Europe, Alps and Atlas.

Depending on the area and the season the variability or the "uncertainties" can be very different with a rather constant value of uncertainties around 0.1°C along the 5 years for the Eastern part of Europe and more "uncertainties" over the Atlas or the Alps. An interesting question to be addressed is from which methods or members the spread comes from?

- For the Eastern part of Europe all the members have almost the same behavior. In fact, the observation network is dense enough to limit the impact of the two different backgrounds. In addition, the differences of the two observations networks are rather small (Fig 5 and 6) and the topography in this region is flat.
- For Scandinavia, there is more spread during the winter period due mainly to the two backgrounds with the low-density network (dashed-green and dashed-red line). The forecast error is increased during the winter due to the stable boundary layer, snow cover and low clouds, and with the low density network the analysis depends even more of the background. The evolution of the network density along the 50-year period (Fig 3) is an important information for the user.
- For the Alps, the uncertainties are higher compared to Scandinavia and the maximum is not only during the winter period, the last two summers have a spread of about 0.4°C probably linked with a larger variability of the weather phenomena during summer with more rain and clouds.
- For the Atlas region, the uncertainties are rather constant, there is no season dependency and again, due to the sparse observations the variability comes from the two backgrounds.

In Fig 14, the monthly accumulated precipitations are showed for the same 4 sub-domains used previously for the T2m. The gray area is defined with the mean of the ensemble and + or – 2*times standard deviation. For all the sub areas, the variability or the spread is larger during the summer period with a less extent in Scandinavia. The convective activity in summer and the small scale of the precipitation are not really well captured by the forecast model even at 5.5km and by the observation network, especially over the Alps and the Atlas. The three members based on the full observation network (dashed line) have less variability, especially over the Alps, in summer compared to the analysis done with low density network (full line). It is a logical result: the analysis with more observations is less dependent on the background. The use of different backgrounds (3 for this ensemble) is really necessary to estimate the uncertainties for the precipitation analysis especially over mountainous areas and regions with sparse observations.

Over the Atlas regions, the impact of the density network is completely negligible (Fig: 14) only the 3 members from the 3 background generate variability, in addition the MESCAN analysis done with the downscaled ALARO (blue line) physics is significantly different for the last 3 summers from the ALADIN physics. Over the Alps, MESCAN analysis with ALARO background have less precipitation and the impact of the density network (same color but full line and dashed line) is smaller.

Figure 15 shows the ensemble mean of the monthly mean precipitation for June-July-August (JJA) for the 5-year period (left column) and the associated standard deviation (right column). The standard deviation (STD) is very high, above 50mm/month, in some mountainous regions such as the Alps or the Atlas where the observations are not dense enough to describe the small scale of a convective event and to reduce the impact of the different backgrounds.

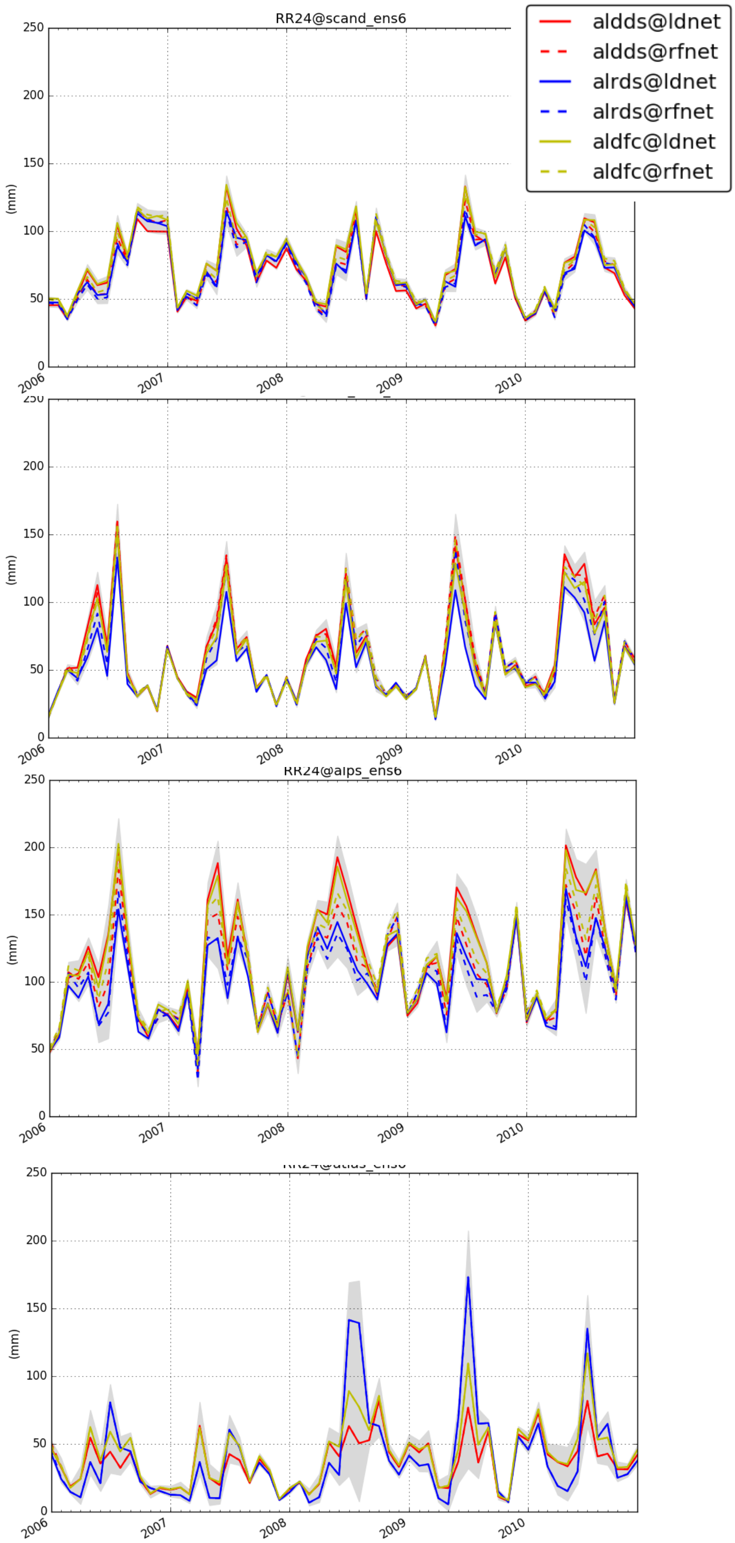

Fig 14: Monthly accumulated precipitation on 4 sub-domains defined in Fig: 12. The full line is for the analysis done with the high-density network and the dashed line for the low-density network. Red line: Downscaled ALADIN model. Blue line: Downscaled ALARO model. Gold: ALADIN forecast at 5.5km.

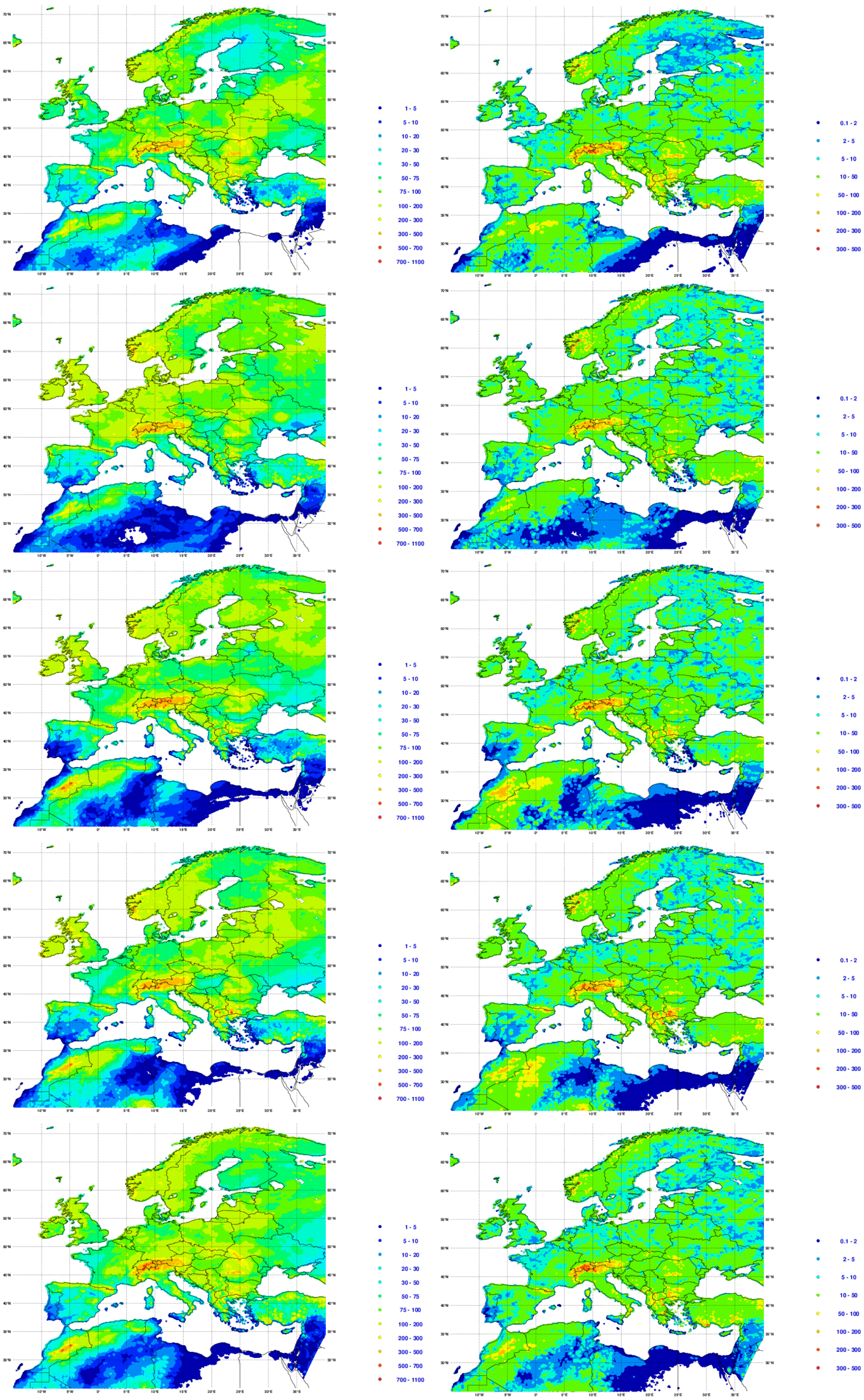

Fig 15: Ensemble mean of the monthly mean precipitation for June-July-August (JJA) for the 5-year period (left column) and the associated standard deviation (right column). From top to bottom 2006, 2007, 2008, 2009 and 2010.

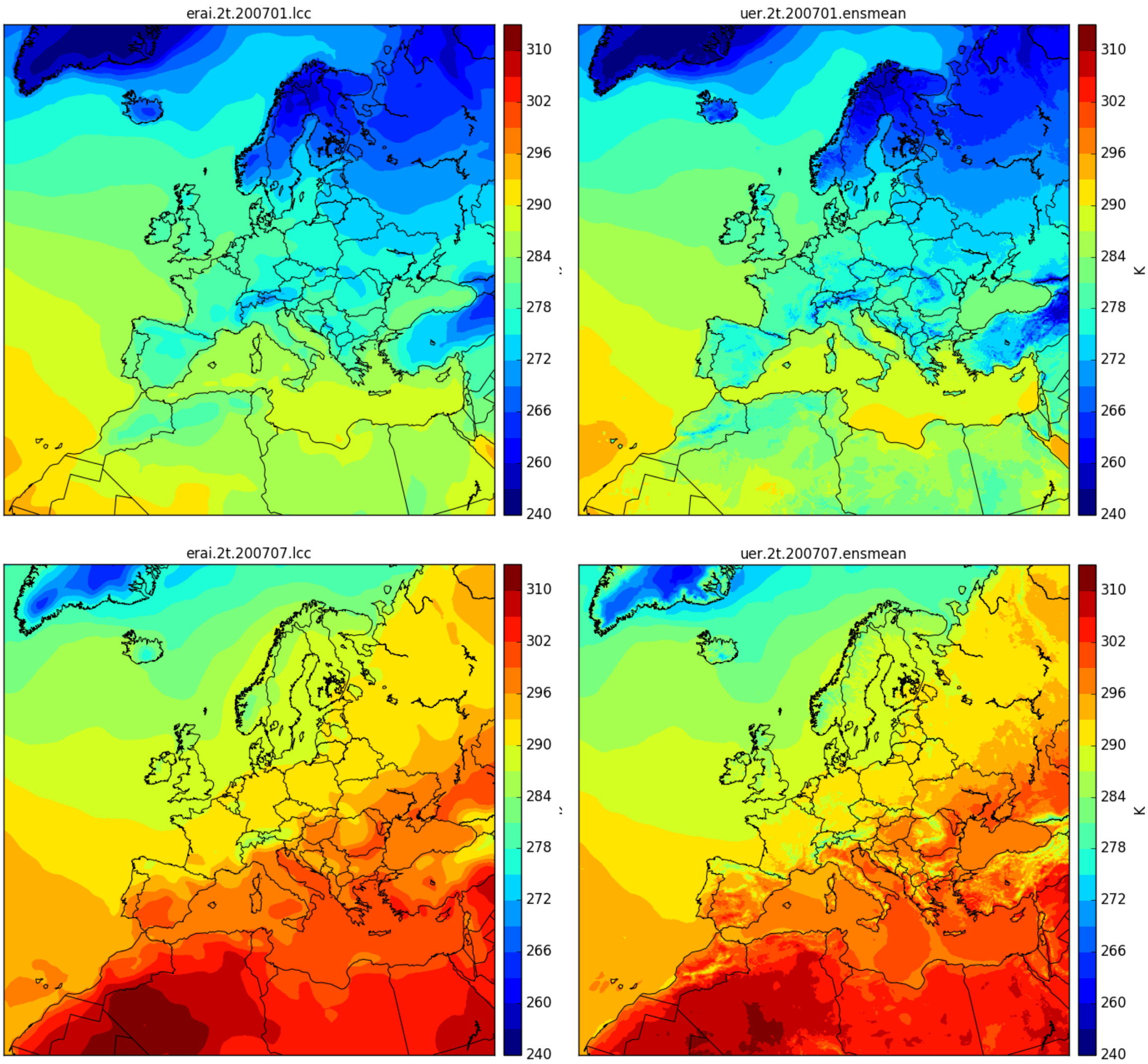

Fig 16: Monthly mean temperature. Top: January 2007. Bottom: July 2007. Left: ERA-Interim. Right: MESCAN-Ensemble

The monthly mean temperature of the mean ensemble gives more fine scale information compared to ERA-Interim, as expected due to the horizontal resolution of the surface analysis and the use of more observations (Fig: 16).

5) Setup and some results for the MESCAN-SURFEX-ENS system:

The MESCAN-SURFEX-ENS system at 5.5km will provide uncertainties for surface and soil variables such as surface and deep soil temperature (14 layers), soil moisture, snow cover, snow height, surface fluxes, etc. SURFEX is used in an offline mode driven by radiative fluxes, T2m, RH2m, wind, precipitation and surface pressure. To estimate the uncertainties, we use 8 members of the MESCAN-ENS T2m/RH2m analysis, the 6 members of the MESCAN-ENS precipitation analysis combined with two types of downscaled of radiative forcing from ALADIN and ALARO. The 8 members are defined below:

Forcing used for SURFEX		M1	M2	M3	M4	M5	M6	M7	M8
Wind, PS, Radiative fluxes		DSB ALD	DSB ALR	DSB ALD	DSB ALR	DSB ALD	DSB ALD	DSB ALD	DSB ALD
T2m/Rh2m MESCAN	**Background**	DSB ALD	DSB ALR	DSB ALD	DSB ALR	DSB ALD	DSB ALD	DSB ALD	DSB ALD
	Obs	HD	HD	LD	LD	HDPert1	HDPert2	HDPert3	HDPert4
24h-precipitation MESCAN	**Background**	DSB ALD	DSB ALR	DSB ALD	DSB ALR	DSB ALD	DSB ALD	ALD5	ALD5
	Obs	HD	HD	LD	LD	HD	HD	HD	LD

DSB/ALD: Downscaled background (interpolation) from HARMONIE/ALADIN at 11km

DSB/ALR: Downscaled background (interpolation) from HARMONIE/ALARO at 11km

ALD5: background from the ALADIN model at 5.5km

LD, HD: respectively Low Density and High Density network used in the MESCAN analysis

HDPert: Perturbed observation with the HD network (4 members)

Finally, the MESCAN-SURFEX-ENS is based on several forcing from several backgrounds, observation network and perturbed observation to estimate the uncertainties. The SURFEX model components are the same for all the members, in the future it would be also interesting to use several advanced options, available in the SURFEX system, to estimate the surface model error. Due to the computer time and the storage space, we have limited the number of member at 8, although in terms of statistics, it would better to have all the possible combinations given by the 3 backgrounds, two types of network and perturbed observations. The SURFEX configuration used for the MESCAN-SURFEX-ENS is based on the diffusion scheme with 14 layers in the soil and the snow scheme is ISBA-ES (Boone et al. 2000).

Several surface variables and surface fluxes are available on the MARS archive from the MESCAN-SURFEX-ENS such as soil moisture, snow depth, latent and sensible heat fluxes etc. (list in appendix A).

Figure 17 shows the ensemble mean of snow depth for the 1st March of 2006, 2007, 2008, 2009 and 2010 at the European scale at 5.5km. The spatial snow depth can vary significantly from one year to another such as 2006 and 2008. The comparison against several observation sites such as Sodankÿla in Finland or Col de Porte in the Alps can be done to evaluate independently this product.

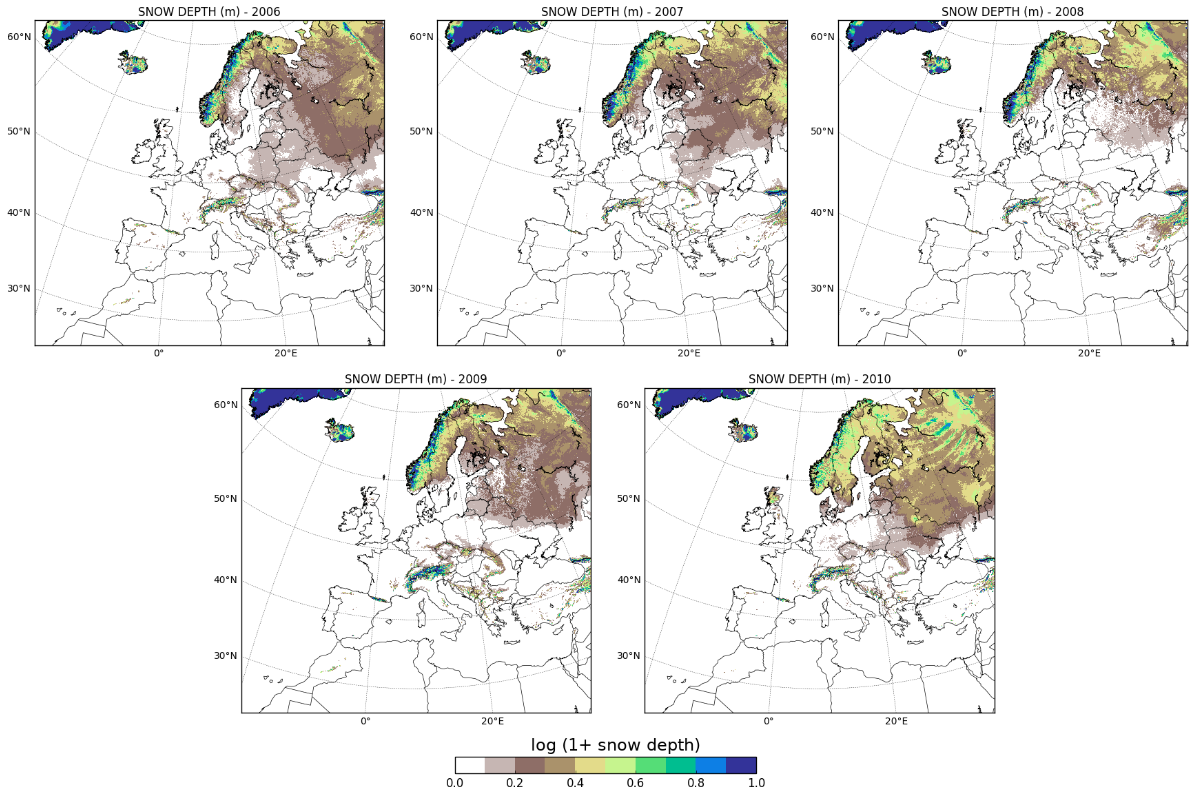

Fig 17: Ensemble mean of the snow depth valid for the 1st March 2006, 2007, 2008, 2009 and 2010.

Figure 18 shows the ensemble snow depth at Sodankyla (Top) and Col de Porte (Bottom). Unfortunately, the MESCAN-SURFEX-ENS has a tendency to underestimate the snow depth for these two stations, probably due to the underestimation of the precipitation in the solid phase in the MESCAN analysis. The snow depth observations, not used in the analysis, are very useful to validate independently the MESCAN-SURFEX. The spread can be significantly different between two winters e.g. winter 2009 vs winter 2007 with a similar amount of snow. At the Col de Porte, the snow depth underestimation is less at least for the two last winters. These results are in agreement with the EURO4M product done with a previous version of MESCAN-SURFEX (M. Coustau et al. 2014) and still improves the snow depth obtained by SURFEX driven by ERA-interim as shown by (Coustau et al., 2014) (Fig: 19).

Nevertheless, the climatology of the snow depth is well captured by MESCAN-SURFEX-ENS at least for these two stations. The poor results at Col de Porte for the first winter (2006) is due to the initialization of the snow pack the 1st January 2006.

Figure 20 is an example of the spread obtained for the surface latent and sensible heat flux at Sodankÿla, the overestimation of the latent heat flux already shown by Coustau et al. (2014) (Fig 9 p16, EUROM D2.11 report) still exists for all the members and explains the underestimation of the sensible heat flux. Nevertheless, the MESCAN-SURFEX-ENS surface fluxes are slightly better than the ERA-I-SURFEX product, at least for this station. More validation will be done by WP3 in the UERRA project.

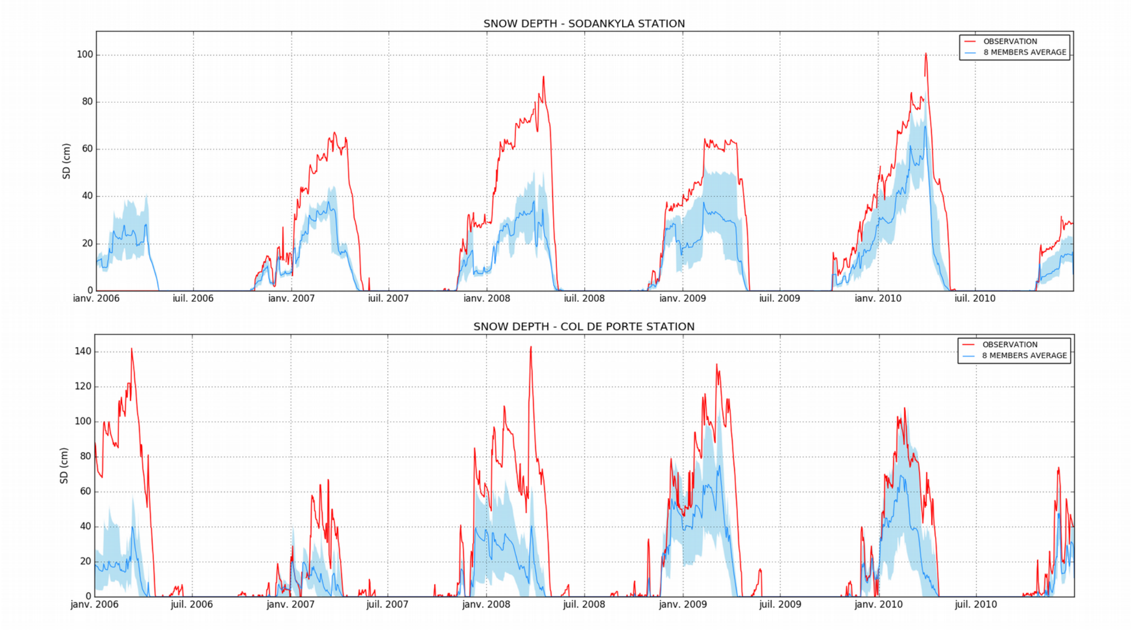

Fig 18: Sodankÿla (Top) and Col de Porte (Alps) snow depth. Red: observations not used in the MESCAN-SURFEX-ENS. Blue area: defined by the extreme value of the 8 members. Blue line: mean of the ensemble.

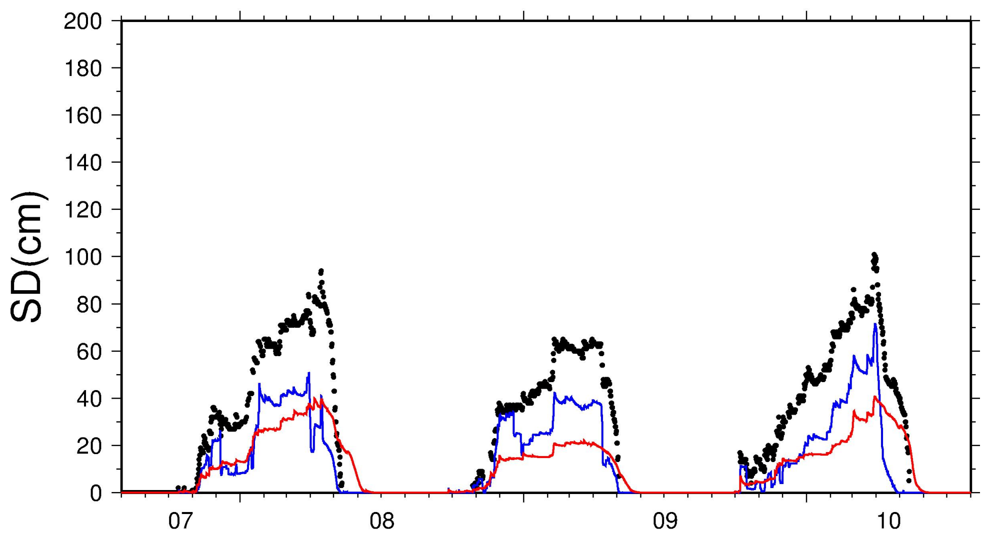

Fig 19: time series of snow depth (in cm) at the Sodankÿla station during the period 2007-2010. The black dots represent the observations, the blue curve represents the simulation made by SURFEX driven by MESCAN and the red curve represents the simulation made by SURFEX driven by ERA-Interim. (From M. Coustau et al. 2014).

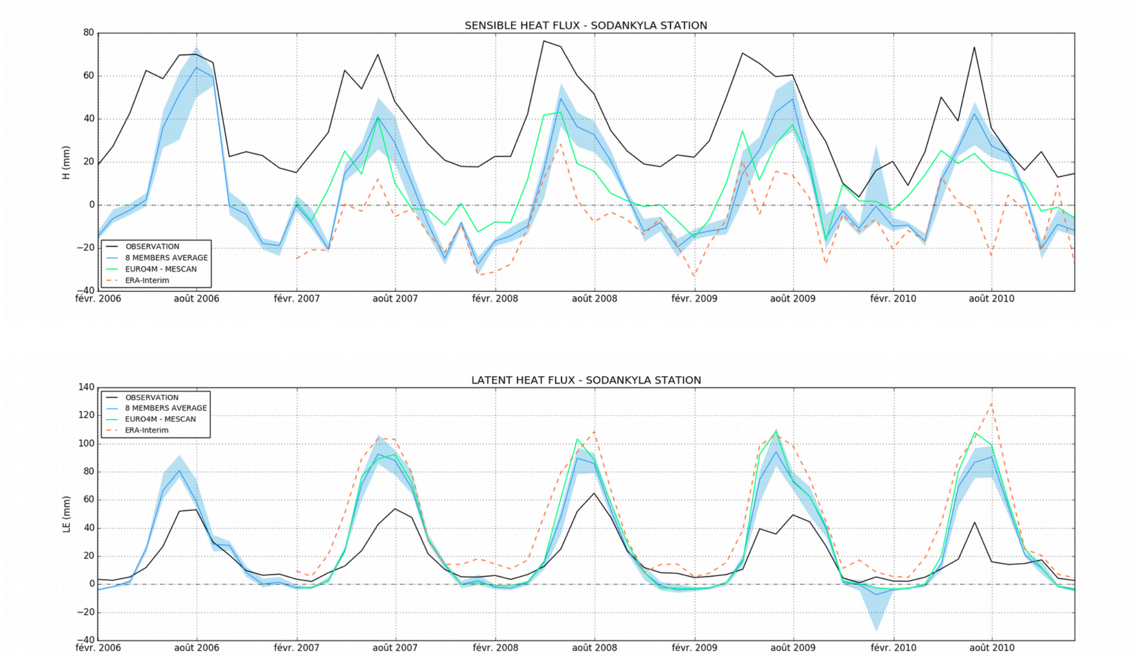

Figure 20: time series of sensible heat flux (top) and latent heat flux (bottom) at Sodankÿla. Black line: observations. Blue area: defined by the extreme value of the 8 members. Blue line: mean of the ensemble. Green line: EURO4M-MESCAN-SURFEX (Coustau et al. 2014). Red dashed line: ERA-I-SURFEX.

6) Conclusions and remarks

This report describes how the MESCAN-SURFEX-ENS was created and shows some preliminary results. Since the beginning of the project (2014) it was decided to generate only an ensemble of forcing data such as precipitation, T2m, Hu2m, radiation and wind to drive the SURFEX platform. Finally, an ensemble of 8 members of forcing was designed based on:

1. an ensemble of precipitation analysis with 6 members
2. an ensemble of T2m/RH2m analysis with 8 members
3. 2 types of radiative fluxes, wind and surface pressure from 2 physics packages: ARPEGE-ALADIN and ALARO

Recently, Lafaysse et al. (2017) show the impact of a multi-physical ensemble for the snow modelling. This multi-physical approach, not only for the snow scheme, could probably improve significantly the spread of the MESCAN-SURFEX-ENS based only of an ensemble of forcing. Nevertheless, the spatial and temporal variability of the standard deviation (or uncertainties) of the ensemble can already give to the users some useful information even if the ensemble is under dispersive.

The authors recommend to the “users” of the MESCAN-SURFEX-ENS to use this ensemble ONLY for the uncertainties information and do not consider the mean ensemble as a reference analysis to evaluate the reference production done for the 50 years. In fact, the MESCAN analysis was re-tuned after the ensemble production and before the 50-year production to improve the precipitation analysis for small precipitation amount and to improve the T2m analysis over mountain. It was not possible to re-run the ensemble for the 5 years but the impact of the modification done in MESCAN was evaluated for one summer and one winter and the results show that the spread is the same and the impact is only on the mean ensemble over mountain area.

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First, a special thought for our colleague who passed away on the 7th April 2017 following a mountain accident in the Pyrenees: Françoise Taillefer, always happy to help us with any scientific and technical aspect related to the surface analysis and SURFEX.

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Appendix:

Final parameter list for MESCAN-SURFEX available on MARS (ECMWF)

MESCAN-SURFEX: (lfpw, oper) for type=an

UERRA GRIB2				
Parameter	Unit	paramId	shortName	Time
Accumulated total precipitation	kg m-2	228228	tp	Only available at 6h (24h accumulated from 6 to 6)
2m relative humidity	%	260242	2r	0, 6, 12, 18
10m wind speed	m s-1	207	10si	0, 6, 12, 18
10m wind direction	degree true	260260	10wdir	0, 6, 12, 18
2m temperature	K	167	2t	0, 6, 12, 18
Land cover (1=land,0=sea)	(0-1)	172	lsm	constant
Orography (surface geopotential height)	m	228002	orog	constant

MESCAN-SURFEX: (lfpw, oper) for type=fc

UERRA GRIB2				
Parameter	Unit	paramId	shortName	Time
Surface pressure	Pa	134	Sp	av. at 6h step
Accumulated total precipitation	kg m-2	228228	tp	av. at 6h step
2m relative humidity	%	260242	2r	av. at 6h step
2m temperature	K	167	2t	av. at 6h step
10m wind speed	m s^{-1}	207	10si	av. at 6h step
10m wind direction	degree true	260260	10wdir	av. at 6h step

Direct short-wave radiation flux at the surface	J m^{-2}	260264	tidirswrf	av. at 6h step
Net long-wave radiation flux at the surface	J m^{-2}	177	str	av .at 1h step
Net short-wave radiation flux at the surface	J m^{-2}	176	ssr	av. at 1h step
Surface solar radiation downwards	J m^{-2}	169	ssrd	av. at 1h step
Surface thermal radiation downwards	J m^{-2}	175	strd	av. at 1h step
Surface runoff	kg m^{-2}	174008	sro	av. at 1h step
Albedo	%	260509	al	av. at 1h step
Surface latent heat flux	J m^{-2}	147	slhf	av. at 1h step
Surface sensible heat flux	J m^{-2}	146	sshf	av. at 1h step
Skin temperature	K	235	skt	av. at 1h step
Water equ. of acc. snow depth	kg m^{-2}	228141	sd	av. at 1h step
Acc. total snowfall	kg m^{-2}	228144	sf	av. at 1h step
Snow density	kg m^{-3}	33	rsn	av. at 1h step
Snow depth	m	3066	sde	av. at 1h step
Soil temperature on 14 levels	K	260360	sot	av.at 1h step
Volumetric total soil water on 14 levels	m3 m^{-3}	260199	vsw	av.at 1h step
Liquid non-frozen	m3 m^{-3}	260210	liqvsm	av.at 1h step

volumetric soil moisture on 14 levels				
Soil heat flux	J m^{-2}	260364	sohf	av.at 1h step
surface roughness	m	173	sr	av.at 1h step
Volumetric wilting point	m3 m^{-3}	260200	vwiltm	constant
Volumetric field capacity	m3 m^{-3}	260211	voltso	constant