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Thematic Priority: Global Change and Ecosystems

D5.23 Detailed comparison of extremes in daily station observations and in gridded daily data

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the Consortium (including the Commission Services)	

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ENSEMBLES D5.23

The tasks listed towards ENSEMBLES WP5.4 (see http://www.knmi.nl/samenw/ensembles_rt5/wp54.html) include the need for an assessment of the extremes in the observed daily dataset and its gridded derivative.

The observational dataset has been created under WP5.1 (Haylock *et al*., 2008). See also

http://www.knmi.nl/samenw/ensembles_rt5/wp51.html).

The analyses undertaken and documented here (towards Deliverable D5.23) include:

1. Evaluation of the gridded observed dataset (E-Obs) with respect to the effects of gridding on the extreme values of temperature and precipitation (as compared to those of individual station series)

2. Assessment of the extreme values and their trends in temperature and precipitation seen in the gridded observed data

The assessment of the effects of gridding on observed extreme values centres on the degree to which daily extremes are moderated by the inevitable averaging processes that occur when station observations are interpolated to individual grid points. Added to this, are the potential effects of the lack of temporal continuity of the numbers of observing points which have a bearing on the interpolated value for each grid point through time. Observational station density (both spatial and temporal) varies considerably over the ENSEMBLES domain. This makes the job of interpolation to fixed grid-points, for the period 1951-2006, a difficult one from the homogeneity perspective even if all observed series are homogeneous. Some basic evaluations of the gridded observed dataset have been undertaken (Haylock *et a*l.., 2008 at http://eca.knmi.nl/download/ensembles/Haylock_et_al_2008.pdf, Ensembles Deliverable 5.18).

More extensive evaluations, with a particular focus on the likely homogeneity of the observing-station and gridded-observed datasets, have been undertaken by Hofstra *et al*., (2009).

Fig. 1 provides a guide as to the spatial and temporal density of the input observations entering the gridding procedure. The focus here is daily minimum temperature (Tn) so the equivalent map for precipitation would differ slightly. There is a general trend towards shorter records being available, for gridding purposes, when moving east from the western coasts. It is also worth noting that it is more common to see records that end before the year 2000, particularly in regions to the north of the Black Sea.

The variability of both spatial and temporal observing-station density, compounded by the natural variability which is imparted to the local climate, by physical relief and other geographical aspects, makes the accurate interpolation of climate characteristics to a grid, a large undertaking. However, the interpolation of climate to a regular grid is a pre-requisite to the objective assessment of the ability of climate models to simulate real climate.

The more systematic assessment of the gridded product, by Hofstra *et al*. (2009), provides useful and necessary guidance to those wishing to make use of the gridded-observed products, as a means of assessing the performance of climate models. The potential user of the gridded products should not be overly influenced by the rather widespread occurrence of probable inhomogeneities in the grids (particularly those for temperature). It is likely that many of the flagged inhomogeneities are relatively minor and thus not greatly detrimental to the RCM assessment in terms of the RCM ability to reproduce realistic climate extremes and their trends. However, the user should be familiar with the possible effects of inhomogeneous gridded series on the calculation of climate extremes and their trends.

The production of (interpolated) regular grids, even without the possible complications of inghomogeneity, has the tendency to moderate the extremes seen in individual observed series, when compared to the extremes shown at the various grid points. The magnitude of this effect has been tested by reference to observed and grid-box series.

The effects of interpolation on extreme values

The possible effects of interpolation on extreme values have been tested, with the focus on station series within an area of relatively low spatial (station) density and relatively homogeneous elevation. The regions chosen were around Kiev and Lubny in the Ukraine (50.4N, 30.5E and 50.0N, 33.0E). The grid resolution used for this work is 0.5° x 0.5°. If the station spatial density is low, it is possible to look at the extreme values in nearby grid-boxes that are largely or totally determined by the interpolations from the target station (*e.g*. Lubny). In addition, if relief is relatively uniform, any comparison is free of the complexities of the effects of elevation on temperature and precipitation. Extreme values (for a range of extremes) were compared between the Kiev and Lubny series with those from nearby grid-boxes, for a selection of temperature and precipitation variables. For example, Figs. 2a (DJF) and 2b (JJA) show the comparison between the extreme seasonal values (as time-series) from the Lubny station series and those from the nearest grid-point in the gridded daily series. The variables/extreme percentiles examined here are: Tn_95, Tx_95, Tg_95, RR_95, Tn_05, Tx_05 and Tg_05 (see Table 1 for their definitions). As expected, the precipitation extremes (RR_95) show the greatest divergence between observed and gridded extremes. The differences are greater for summer than winter due to the more sporadic nature of convective rainfall (convection being the prominent mechanism for rainfall in summer in the Ukraine).

The other variables/percentiles show a close agreement in the examples shown. This is also the case for other examples not shown. In addition, the moderating effect on extremes, through gridding, is greatest for the more extreme extremes. This is particularly so for precipitation (see also Haylock *et al*., 2008). This limited investigation suggests that whilst extreme values are moderated by the gridding operation, the degree of moderation is not high for the $95^{th}/05^{th}$ percentiles. From this, we conclude that it is a reasonable test to compare extremes and their trends in gridded observed daily data with their modelled (ERA-40 driven RCM) counterparts for $95^{th}/05^{th}$ percentiles (see later WP5.4 output in D5.31

Table 1. The variables/percentiles used for the assessment of the effects of gridding on extreme values of temperature and precipitation

Variable/percentile	**Definition of variable/percentile**
Tx_95	95th percentile value of Tmax in each of the conventional three-month seasons
Tn_95	95th percentile value of Tmin in each of the conventional three-month seasons
Tg_95	95th percentile value of Tmean in each of the conventional three-month seasons
RR_95	95th percentile value of Precip. in each of the conventional three-month seasons
Tx_05	05th percentile value of Tmax in each of the conventional three-month seasons
Tn_05	05th percentile value of Tmin in each of the conventional three-month seasons
Tg_05	05th percentile value of Tmean in each of the conventional three-month seasons

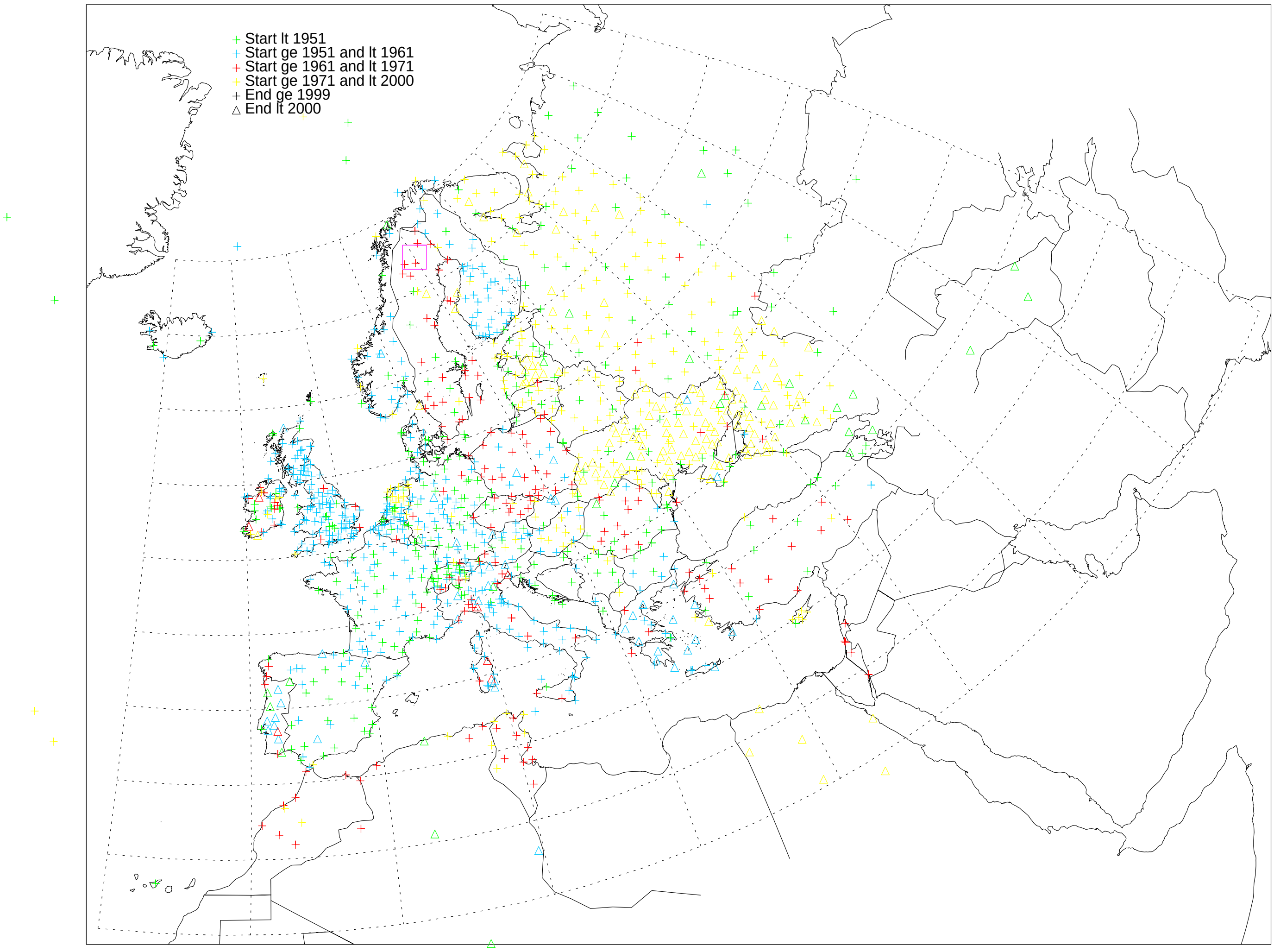

Fig. 1. The location of all observed series that have been used in the creation of the gridded observed Tn grids. The coloured symbols (station markers) indicate the approximate period of data availability for each station. The red box in Northern Sweden is the one referred to later in Fig. 3b.

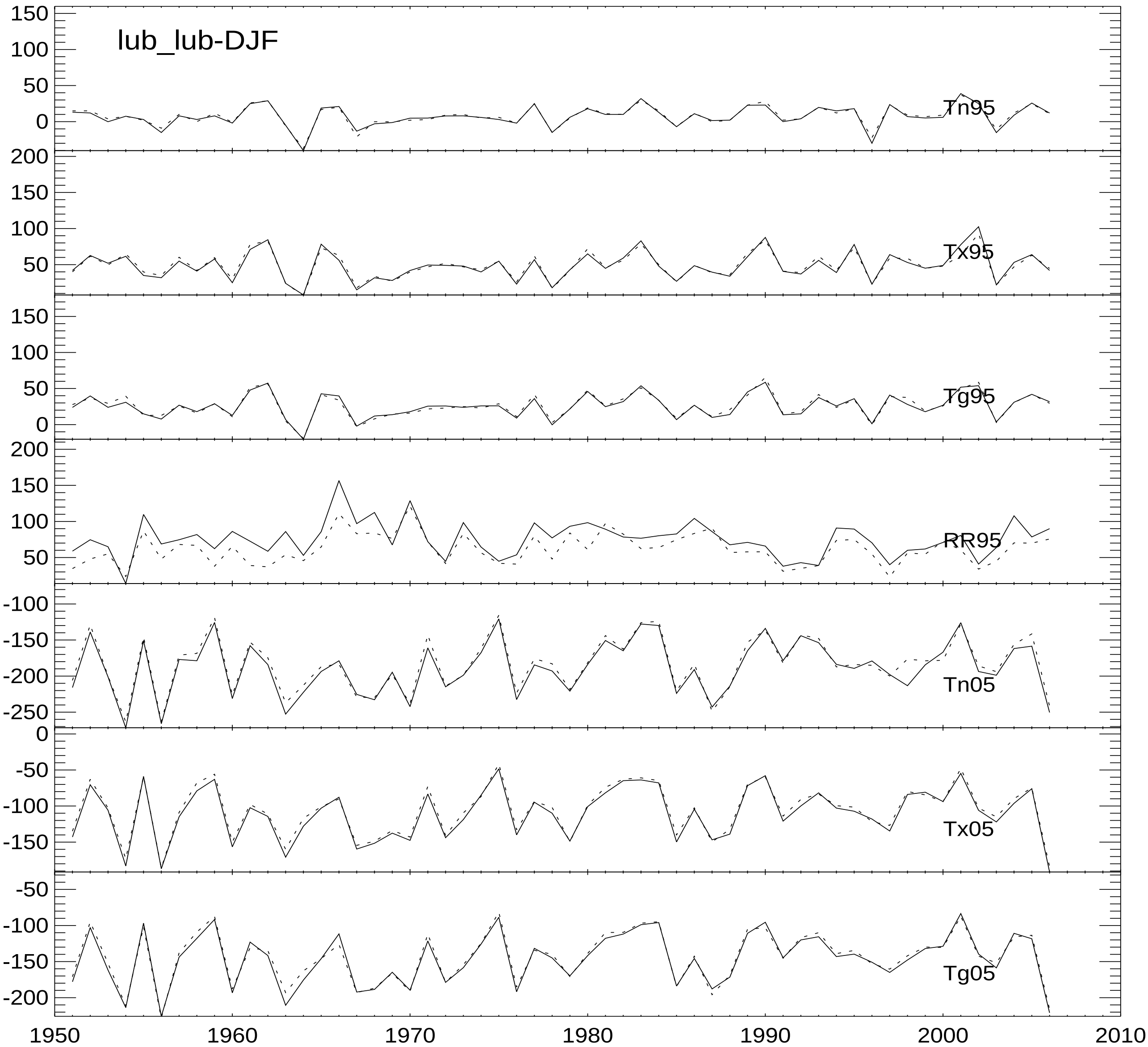

Fig. 2a. The winter seasonal (DJF) extreme time-series for Lubny and its nearest grid-point neighbour. The station series is marked by the solid line. Precipitation (RR) extremes are expressed in percentage terms – with respect to their 1961-90 normals. Otherwise, y-axis values are expressed in °C*10.

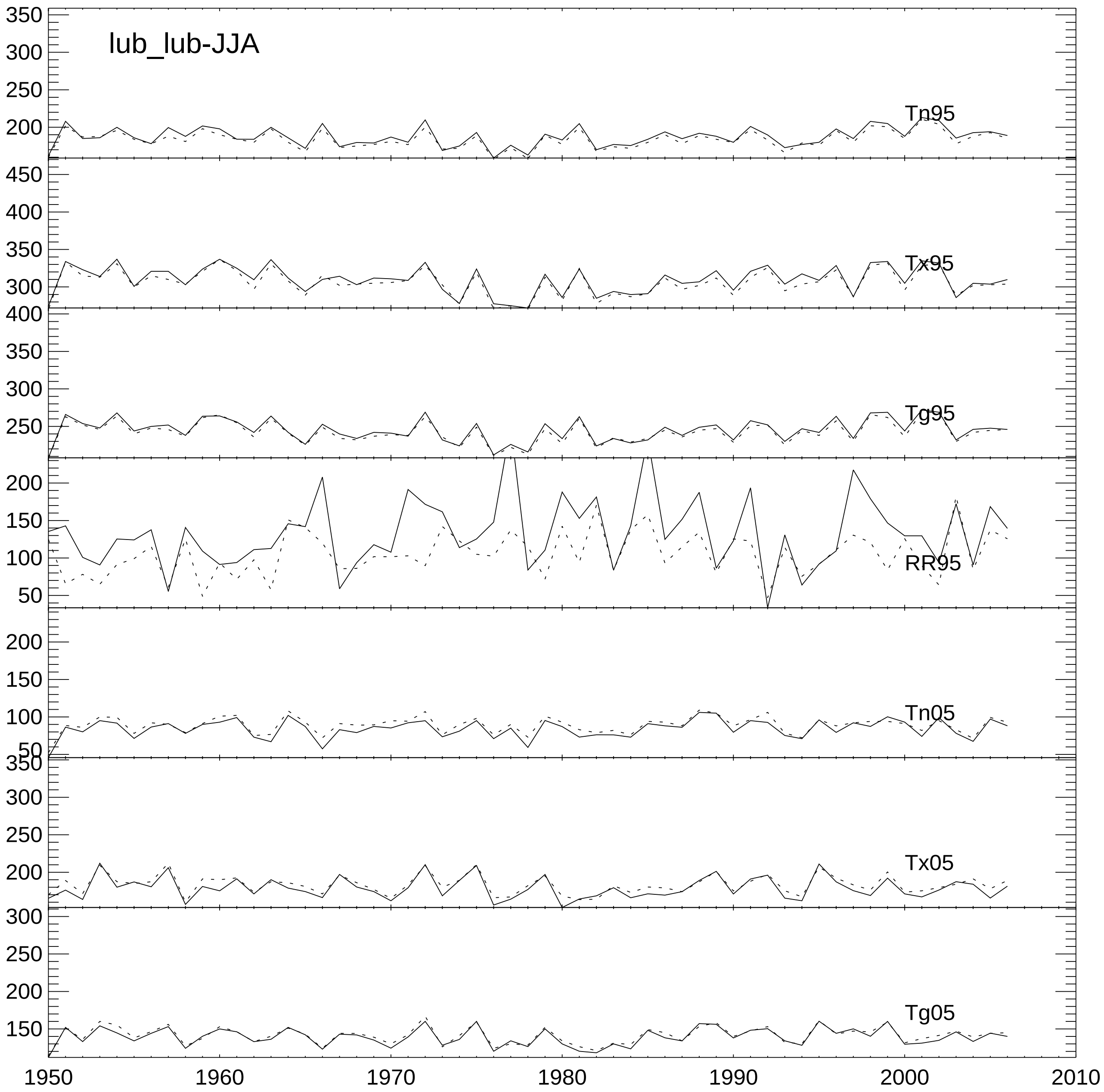

Fig. 2b. The summer seasonal (JJA) extreme time-series for Lubny and its nearest grid-point neighbour. The station series is marked by the solid line. Precipitation (RR) extremes are expressed in percentage terms – with respect to their 1961-90 normals. Otherwise, y-axis values are expressed in °C*10.

<u>Extremes in the observed grids</u>

Having shown the potential of the gridded observed database, with regard to its ability to show realistic extreme values at specific grid-points, it was then possible to calculate the trends in these extreme values. Given that the gridded observed database covers the period 1950-2006, the whole period was used for the generation of seasonal trends in Tx_95, Tx_05, Tn_95, Tn_05 and RR_95. These were mapped, with the grid resolution being retained at 0.5 x 0.5°. For further background regarding the measurement of trends in extreme temperatures and precipitation, for regions having significant overlap with the ENSEMBLES study area, see Moberg and Jones, (2006) and Moberg *et al.*, (2006).

Figs. 3a and 3b show the decadal trends for Tx_95 and Tn_05. The decadal trends are derived via the slope of a linear regression fit for the periods specified. As a simple means of assessing the veracity of the trend maps we compare them with trends in seasonal mean values of Tx and Tn derived from the CRU TS3.0 dataset (an updated version of Mitchell and Jones, 2005). We are not looking for strong agreement (as one map will be for extremes and the other for changes in the mean), but we use the CRU TS3.0 dataset as a gross check of the trend maps, particularly for regions where there are very strong gradients or calculated trends.

Fig. 3b shows an area (for Tn_05, centred approximately on 67° N, 20° E) of cooling, particularly for the autumn and winter seasons. Note that it is possible for trends to go "off-scale" in the maps – as in this case where the largest (central) negative trend appears white. When compared to the CRUTS 3.0 trends in Tn_05 (see Fig. 4), there is no indication of the significant cooling trend. Fig.1 shows that the input station density is not high and that most of the station series present in this region begin after 1960. This apparent anomaly in the daily observed grids (as seen in the trends in Tn_05) is probably an extreme illustration of how the spatial and temporal variability of input station density, compounded by the relative proximity of coastal and mountainous terrain, can adversely affect the interpolation/gridding process. These kinds of effects could be reduced by the avoidance of the early parts of the observed grids where possible. It is advisable in this case to use the observed grids from 1961. Indeed, when the periods are changed to 1961-2006 for the above comparison (see Figs. 5 and 6), there is no longer any notable contradiction between the Tn_05 trends seen in the daily observed grids and the trends in mean temperature seen in CRUTS 3.0.

Other possible indications of problems in gridded-observed trends include:

1. The negative winter and autumn trends in Tn_05 evident over parts of central and eastern Turkey – see Fig. 5

2. The positive spring trends in Tn_05 over Finland, the Baltic States and nearby Russia/Ukraine – see Fig. 5

The negative trends (in Tn_05) apparent over Turkey (in the gridded observed-trend maps) have been investigated. Two of the input-station data series from Eastern Turkey have been extracted and their Tn_05 seasonal time-series produced. The figures (Figs 7 and 8) show the Tn_05 seasonal time-series for Trabzan (41°N, 39.7°E, 38m) and Erzurum (39.9°N, 41.2°E, 1758m). There is a slight negative trend evident in all except the summer series for Trabzan. There is a more obvious downward trend evident from the series for Erzurum – particularly the autumn, winter and spring series. There is also evidence of a step-jump for this station around 1987/88. This potentially indicates an inhomogeneity of some kind. Whilst this investigation is far from comprehensive, it suggests that there are real decreases in Tn_05 values in the input-station series for this region which are being reflected in the gridded series. Whether or not these trends are real or are artefacts due to the inhomogeneity of the input-station series is not clear.

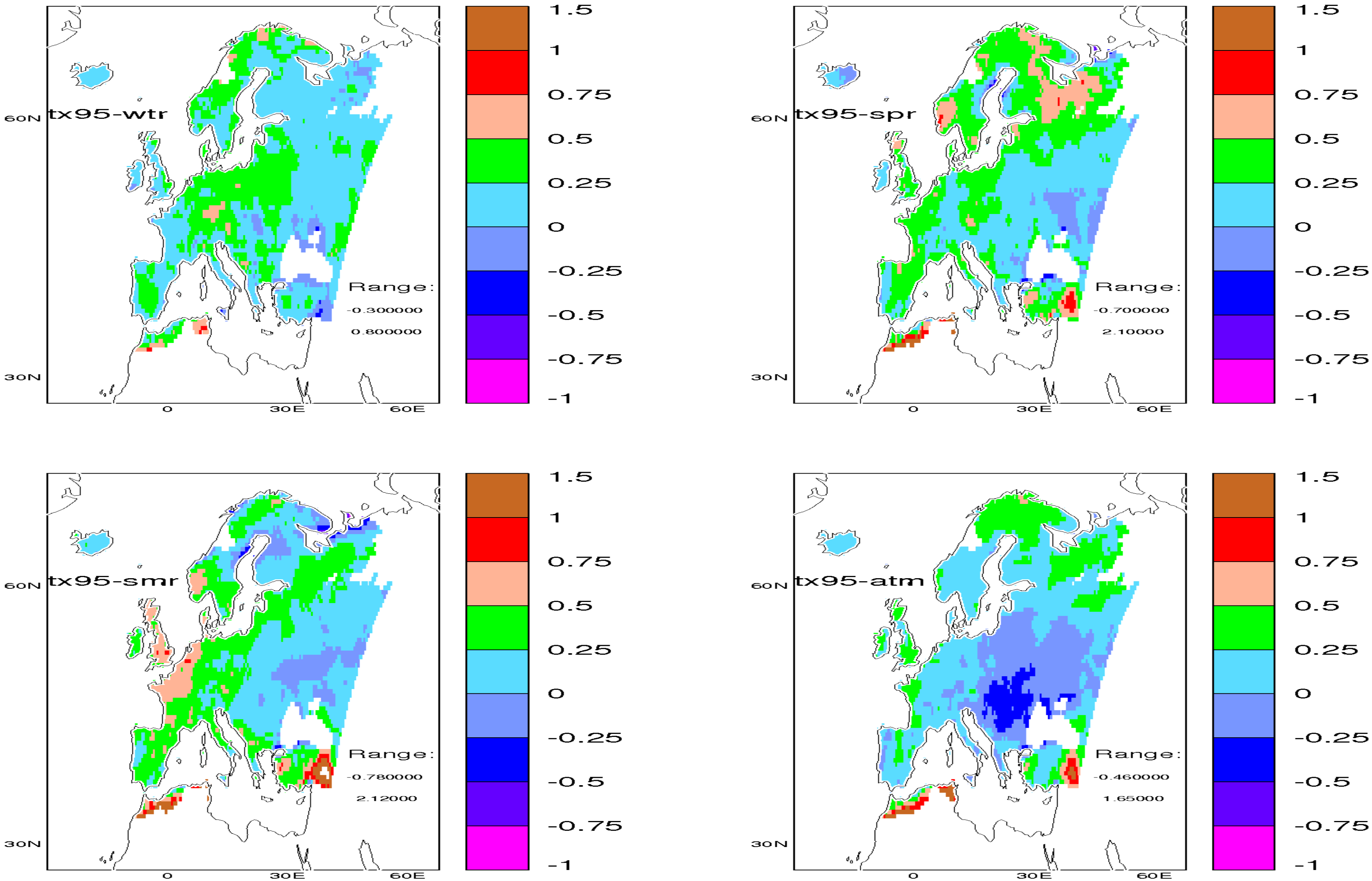

Fig. 3a. Decadal trends (deg. C) in 0.5° x 0.5° gridded observed Tx_95 – for the period 1950-2006

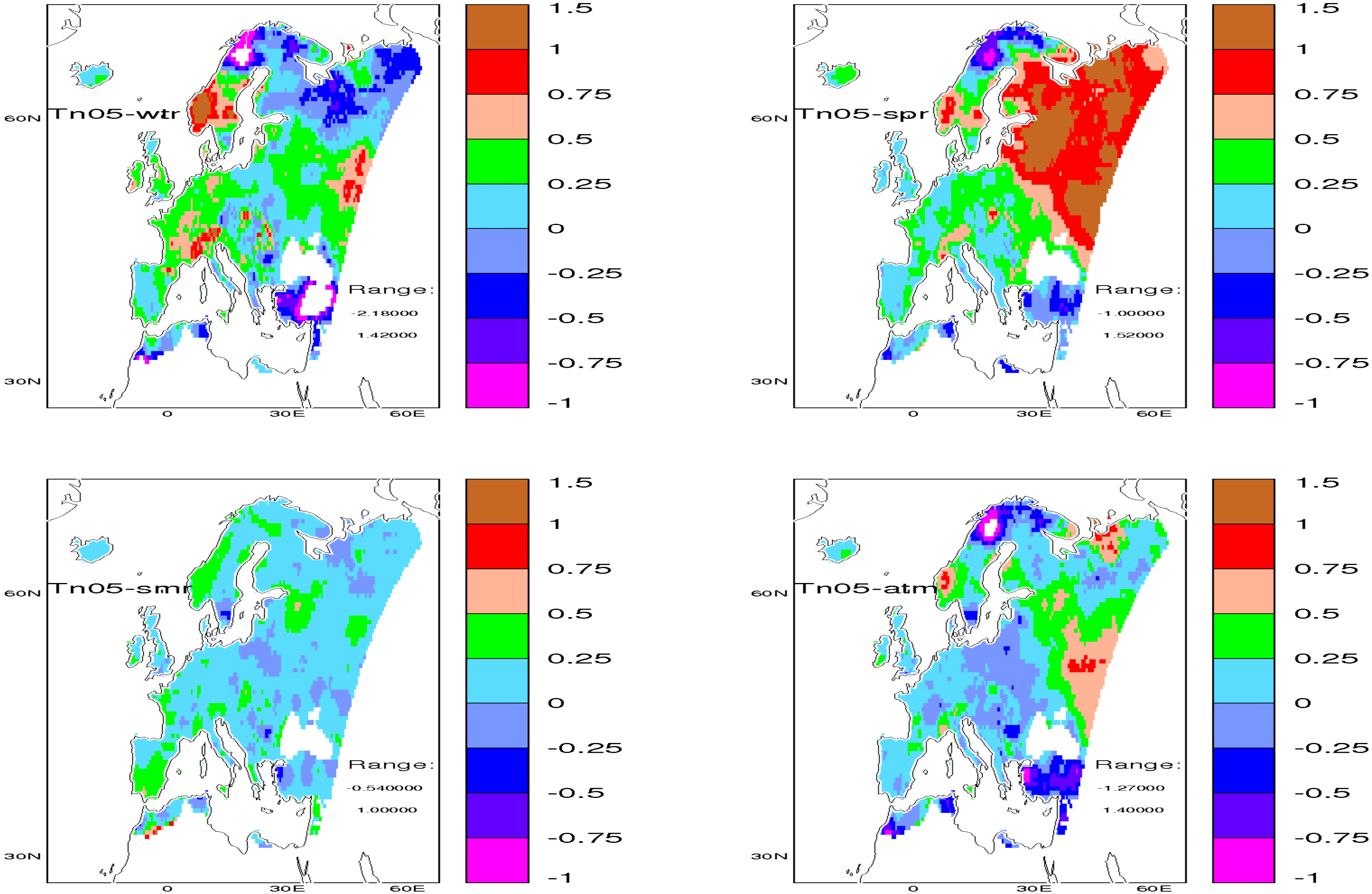

Fig. 3b. Decadal trends (deg. C) in 0.5° x 0.5° gridded observed Tn_05 – for the period 1950-2006

The question over the positive spring-trends in Tn_05 for the region including Finland/Baltic States and adjoining areas has also been examined in a similar way to that for Turkey. This investigation has also used spot checks on extreme value series for a few station series only. The Tn_05 seasonal trends for Minsk (53.9N, 27.5E, 222m) and Sortavala (61.7N, 30.7E, 19m) are shown in Figs. 9 & 10. Positive trends in Tn_05 are evident, for the spring season in particular, in both figures. On checking the available input-station data for Finland it is evident that many series end around the year 2000. In the light of this, the input-station density is not as high after 2000, than before 2000, so the gridded observed dataset may not be as reliable after 2000. By comparing the trends in observed daily extremes with trends in the CRU TS3.0 monthly grids, trends in extremes are being compared with trends in monthly average values. A lack of corroboration here does not necessarily negate the possibility of positive trends in extremes in the spring season.

From the three documented checks into possible problems with extreme series, which may be the result of inhomogeneities or other problems inherent to the interpolation/gridding of the observed station-series, a rather complex impression emerges. Many could have resulted from the use of non-homogeneous daily temperature and precipitation data, but the Project did not have the necessary resources to assess and correct all station series for homogeneity problems. Outliers were flagged, checked and adjusted if necessary but adjustments for site moves, instrument changes and issues with changes to observation times were not accounted for (see Haylock *et al*., 2008).

It is clearly evident that the interpolation/gridding process has caused problems when the whole period of the observed dataset is used for extreme/extreme trend determination (Scandinavia and Turkey). However, there is reasonable evidence to suggest that the spring trends in Tn_05, as seen in the region close to the Baltic States are not erroneous. With the shortening of the trend period to match the period when the observational station database is at its strongest (with respect to station density), the trends in extreme values appear to be quite reliable.

A further illustration of the effects of uneven temporal density of (input) observations is seen when decadal trends in RR_95 (precipitation) are mapped for the period 1951-2006. Fig.11. shows that a large part of the north-eastern section of the ENSEMBLES domain is not showing any trends. This is due to the application of minimum presence criteria that are imposed for the determination of trends using linear regression. That is, it is necessary to ensure that the series used in the regression have sufficient representation particularly at the ends so that spurious trends are not generated. For example, in the determination of trends for the period 1951-2006, the minimum requirement was for there to be at least 16-years of data in each of the sub-periods 1951-68, 1969-87 and 1988-2006. However, if the criteria are relaxed slightly, the trends appear once again as in Fig. 12. Note that the trend period in Fig. 12.is different and covers the period 1961-2006. The reappearance of the missing trends is due to the relaxation of the minimum presence criteria towards the end of the period and has no connection with the changed starting points.

Figures 12 – 14 show the trends in RR_95, Tx_95 and Tn_05 for the shorter period 1961-2002. When these were produced, the intention was to have trends for a period to match that of the ERA-40 RCM output (see http://www.ensembles-eu.org/deliverables.html Deliverable 5.31) for comparison. The findings (above) regarding the question of the strongly positive spring-trends, in the region of Finland/Baltic States and adjoining areas, indicate that a trend period 1961-2000 would be more reliable than the longer 1961-2006 or even 1961-2002 periods.

Conclusions

Trends of the extreme measures, calculated from the gridded data for the period 1961-2000, have been shown to be reliable compared to other observational datasets. Outside of this period, reductions in coverage in some parts of Europe can impart strong influences on trends calculated over longer periods. Reductions in coverage appear to be a stronger impediment to developing large gridded datasets than extensive inhomogeneity in the daily temperature and precipitation observations. As the correction of the latter is costly and labour intensive, the resources would be better spent in digitizing and gaining improved station densities for the period before 1961.

Most of the European region, in all four seasons (Figure 12), shows an increase in RR_95 - particularly in the northern part. Reductions in RR_95 are mainly confined to the Mediterranean and Black Sea regions. Tx_95 and Tn_05 have increased (Figures 13 and 14) over much of Europe in all seasons except autumn. Increases are strongest in the northern half of Europe.

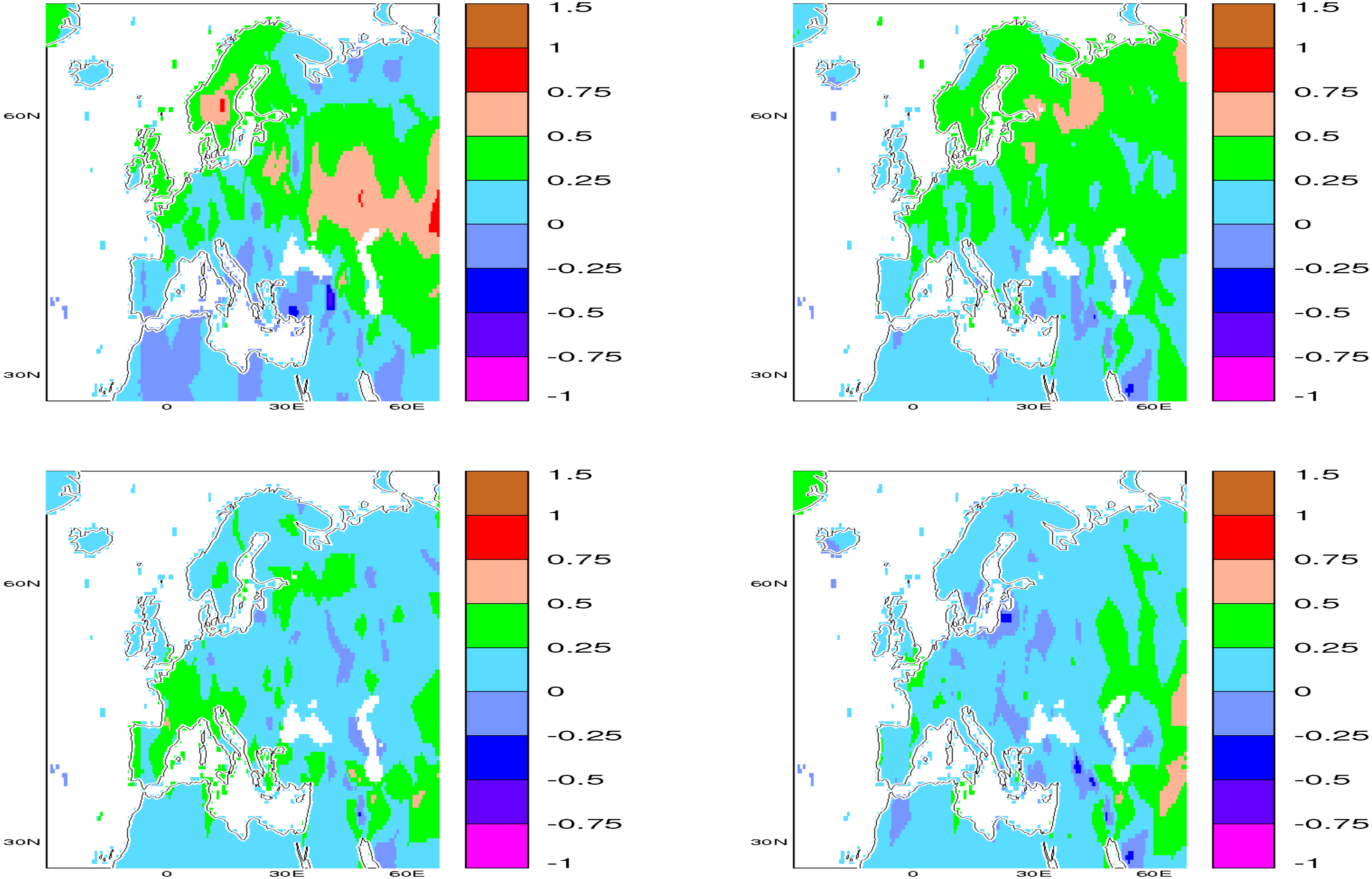

Fig. 4. Decadal trends in (deg. C) in Tn in the 0.5° x 0.5° CRUTS 3.0 Tn grid – for the period 1950-2006

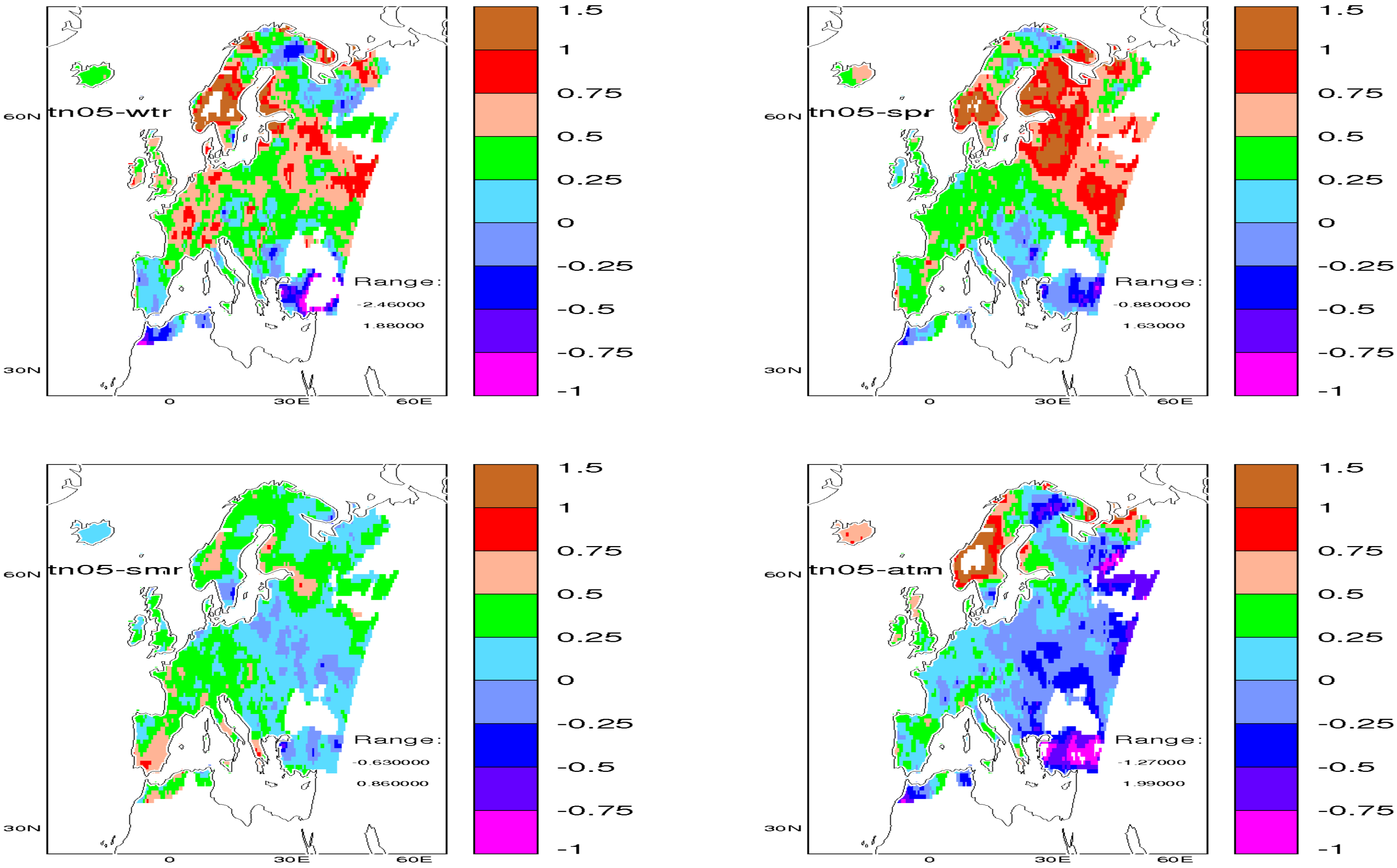

Fig. 5. Decadal trends (deg. C) in 0.5° x 0.5° gridded observed Tn_05 – for the period 1961-2006

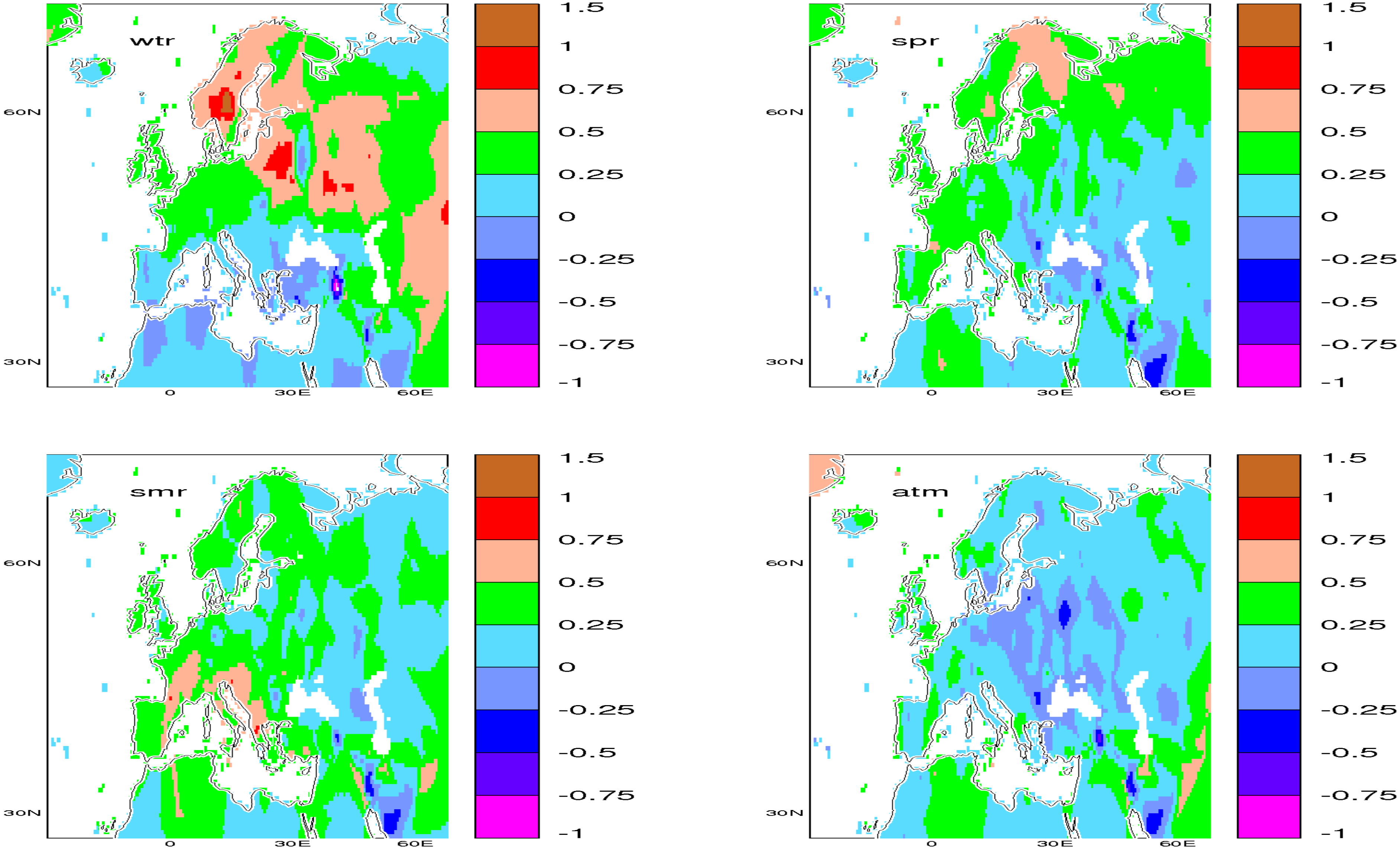

Fig. 6. Decadal trends (deg. C) in Tn in the 0.5° x 0.5° CRUTS 3.0 Tn grid – for the period 1961-2006

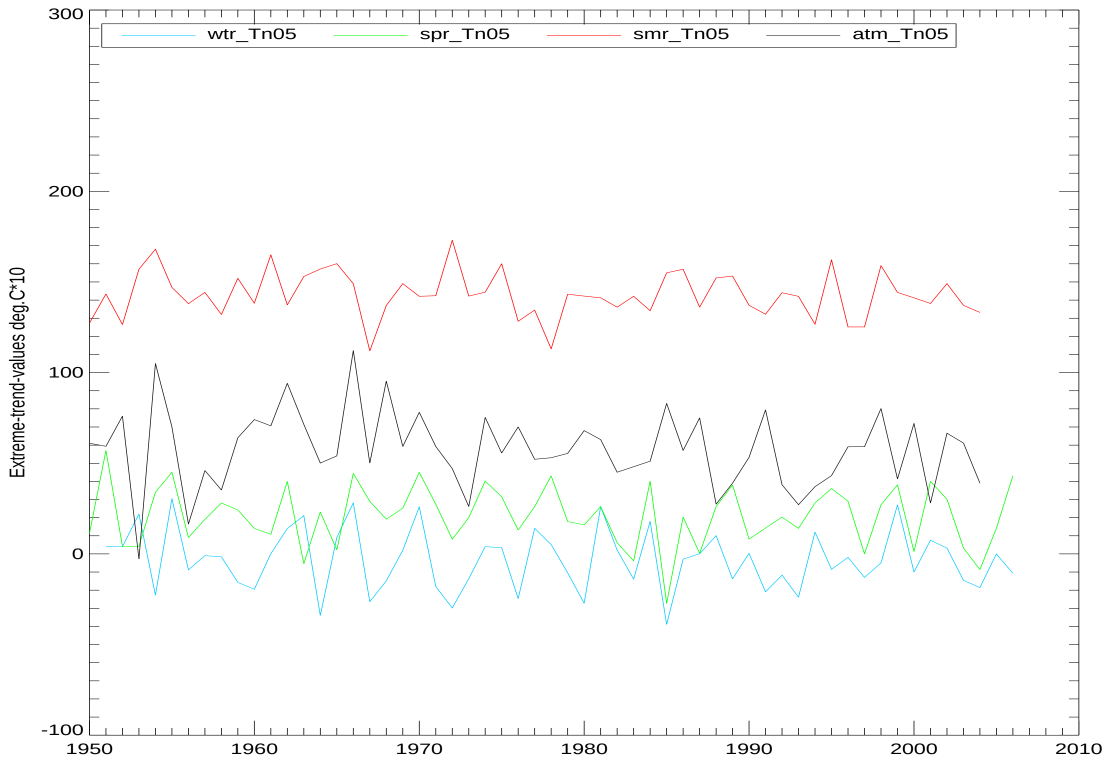

Fig. 7. Tn_05 seasonal time-series for Trabzon (Turkey)

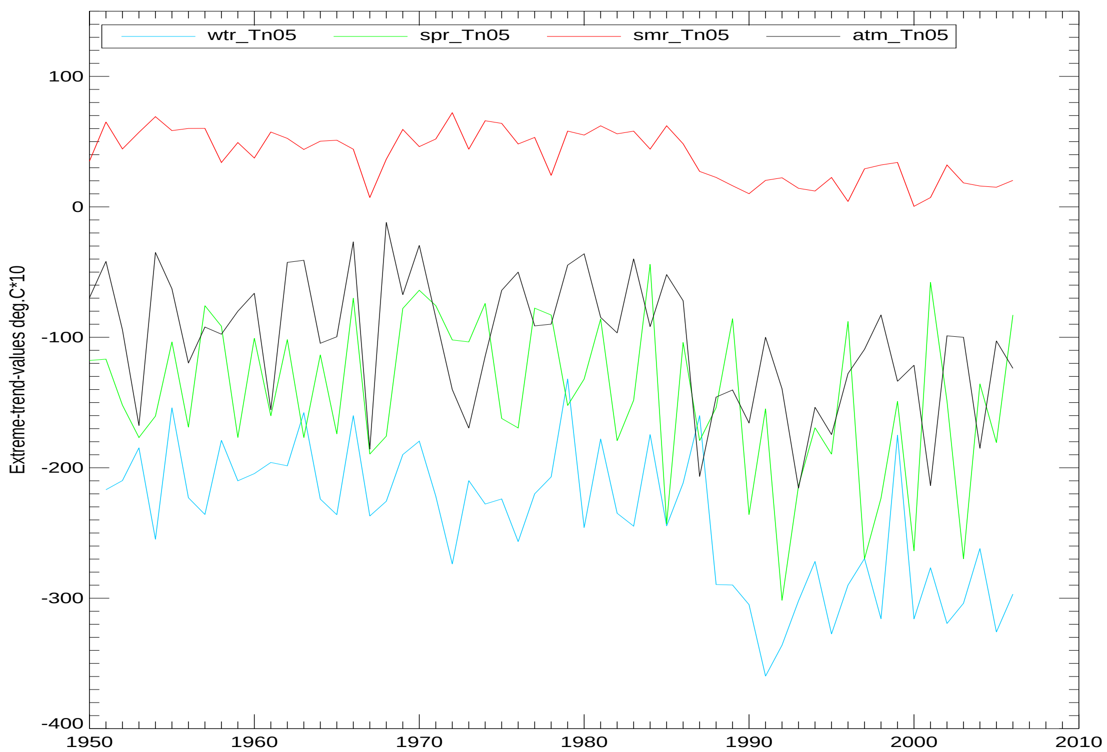

Fig. 8. Tn_05 seasonal time-series for Erzurum (Turkey)

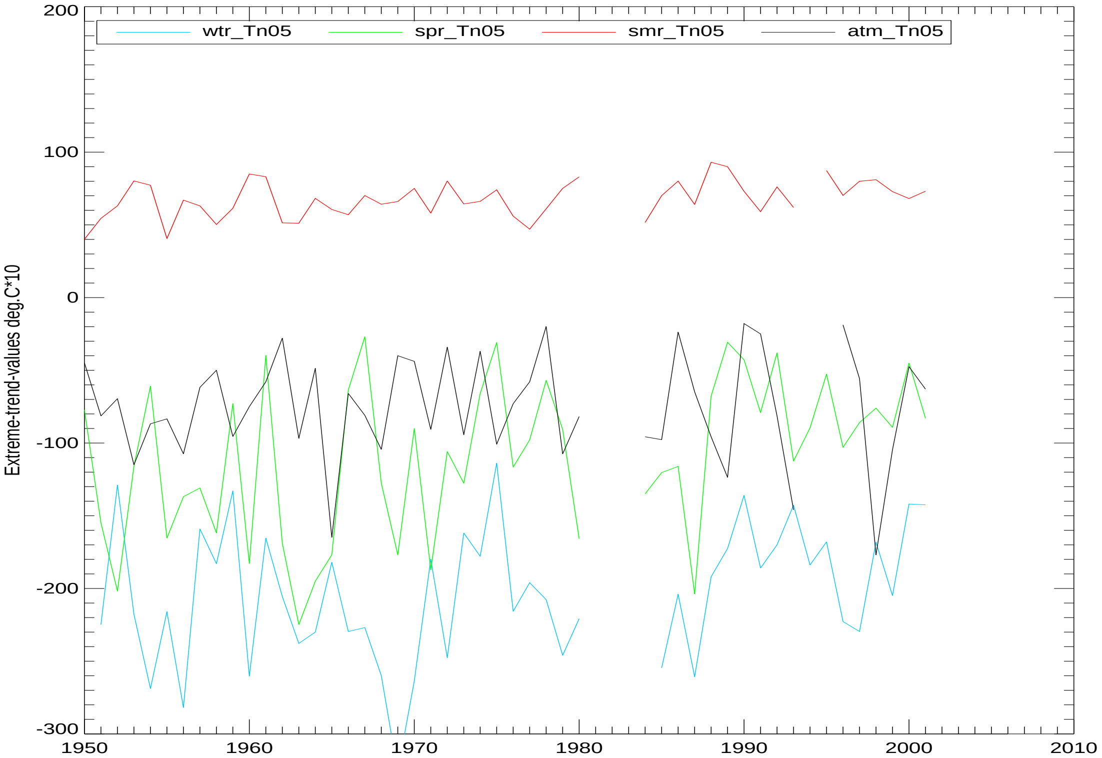

Fig. 9. Tn_05 seasonal time-series for Minsk (Belarus)

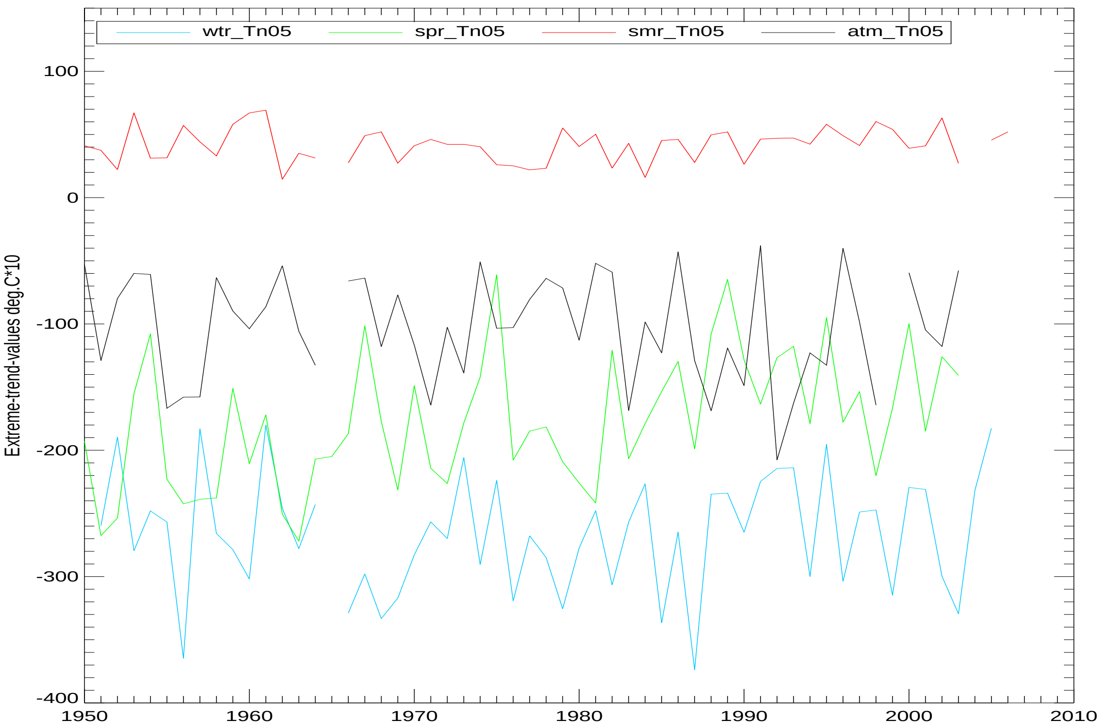

Fig. 10. Tn_05 seasonal time-series for Sortavala (Russia)

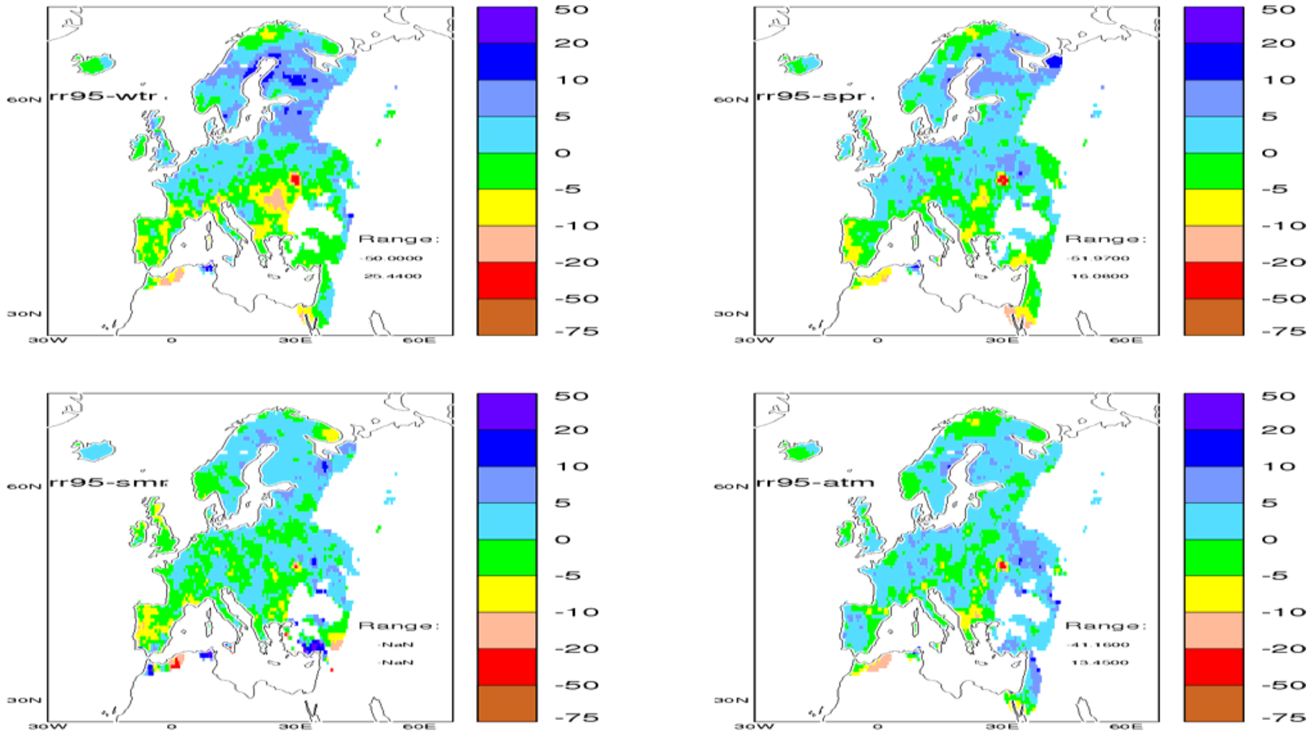

Fig. 11. Decadal trends (expressed as a % of 1961-90 normals) in 0.5° x 0.5° gridded observed RR_95 – for the period 1951-2006

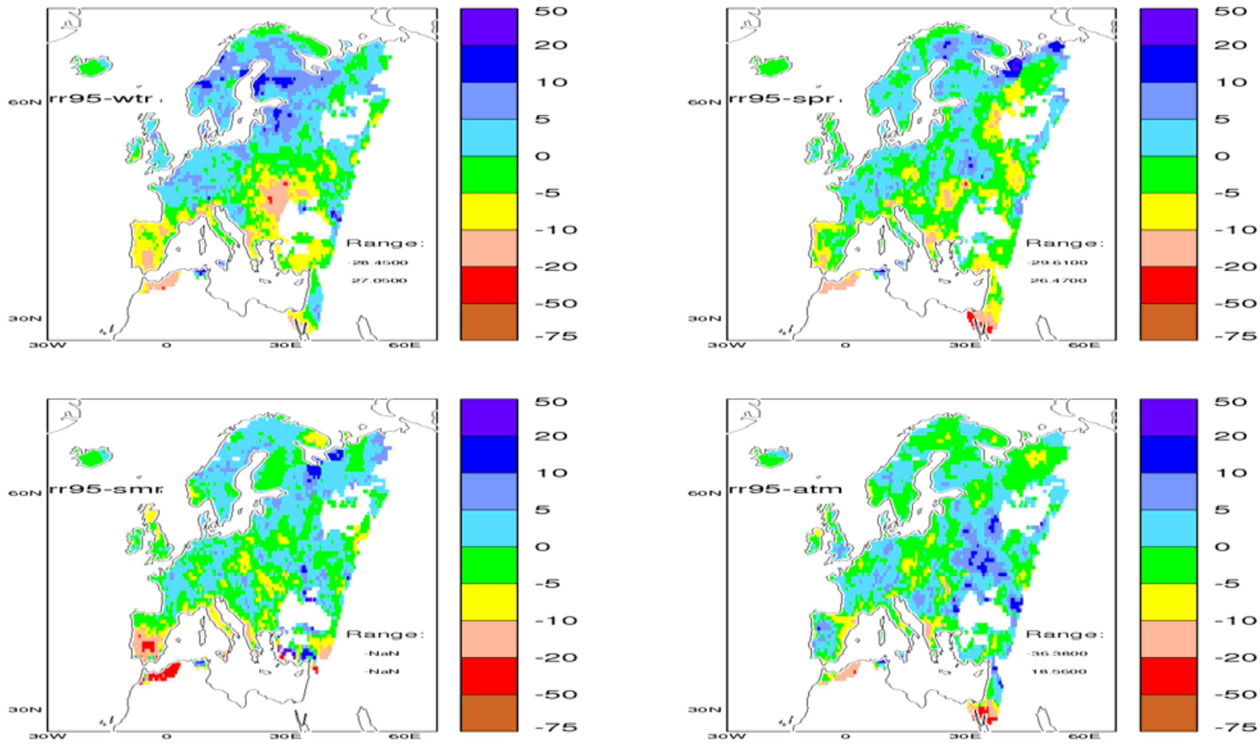

Fig. 12. Decadal trends (expressed as a % of 1961-90 normals) in 0.5° x 0.5° gridded observed RR_95 – for the period 1961-2002

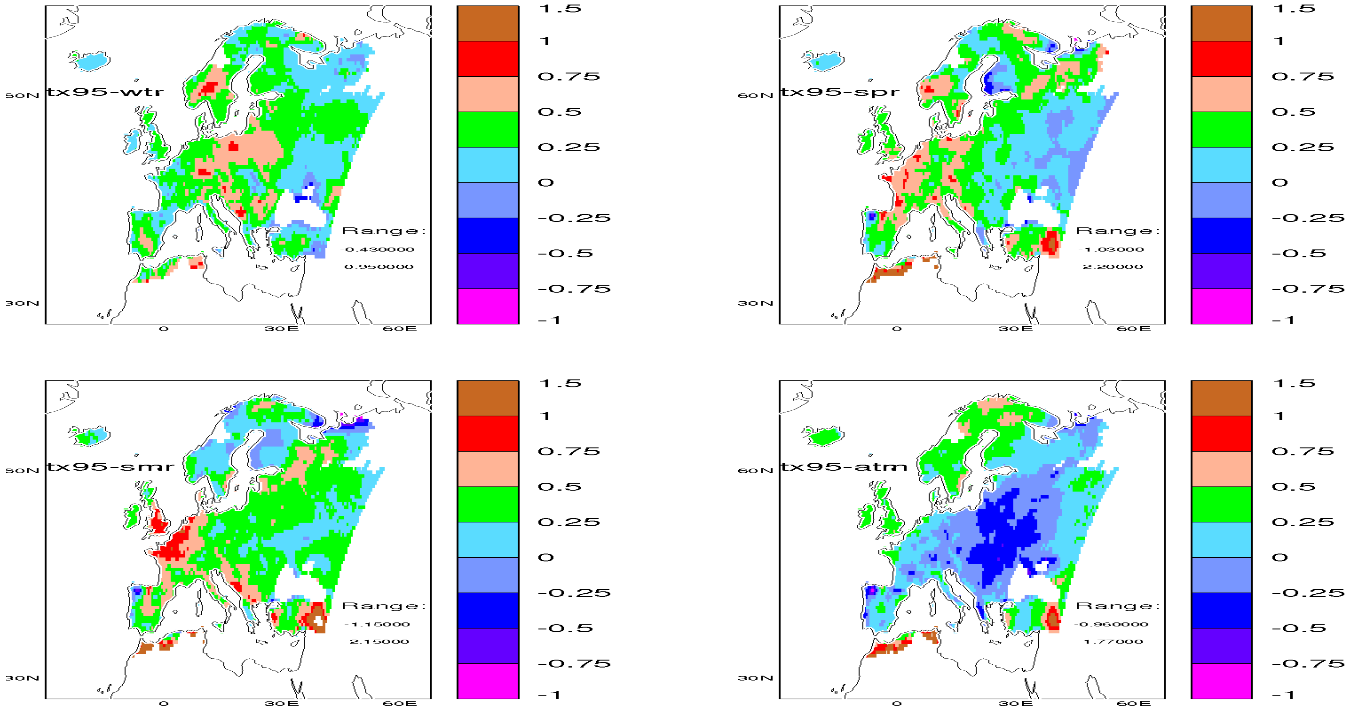

Fig. 13. Decadal trends in 0.5° x 0.5° gridded observed Tx_95 – for the period 1961-2002

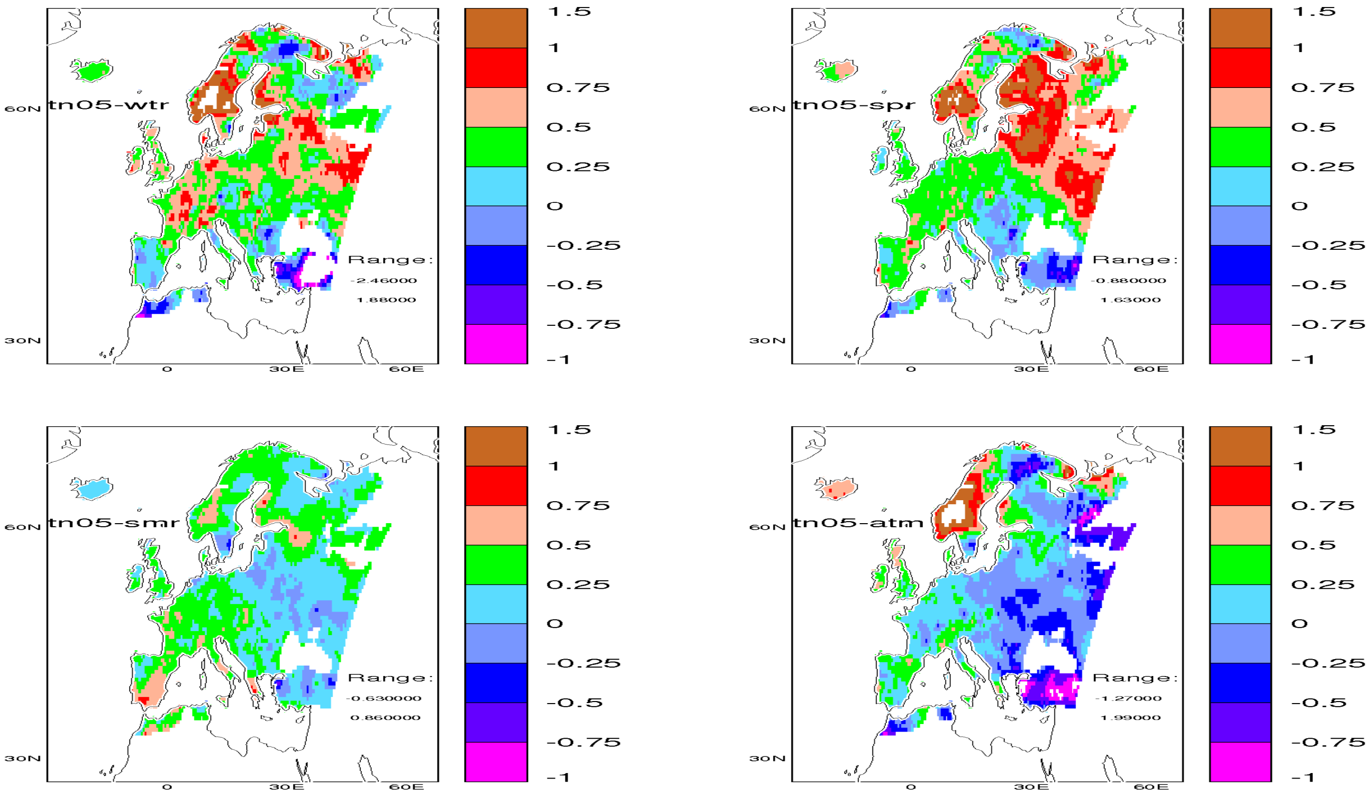

Fig. 14. Decadal trends in 0.5° x 0.5° gridded observed Tn_05 – for the period 1961-2002

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