Use of Meteorological data sets at European level for input to the PESERA Grid Model

Prepared by:
Robert J A Jones
Mirco Grimm &
Luca Montanarella

European Soil Bureau
Soil & Waste Unit
JRC Ispra

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PESEERA
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Joint Research Centre
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Objectives
This document analyses some problems associated with the use of meteorological data sets prepared for use at European level for environmental assessments. The data – rainfall, temperature, radiation and evapotranspiration – were prepared at 1km x 1km resolution for input to the PESERA grid model for estimating soil loss by erosion. Soil (CEC, 1985) and land use (CORINE) data have also been prepared at the same resolution.

Methodology
A database of daily weather data has been compiled at 50km x 50km resolution by the MARS Project (Vossen & Meyer-Roux, 1995) for crop yield forecasting using CGMS. The details of the interpolation procedures adopted, to generate the 50km x 50km data from measurements made at meteorological stations, are described in detail by van der Goot (1997).

The 50km x 50km meteorological data (daily averages and totals) were interpolated as monthly averages (total rainfall and evapotranspiration, number of rain-days, mean temperatures and standard deviations of these parameters) at 1km using an inverse-spline function and making the final calculations using ARC/INFO (Daroussin, unpublished 2002). This is essentially a mathematical approach not taking into account other environmental factors, such as altitude, aspect and distance from the sea, likely to affect the parameter being interpolated.

Results and Milestones
The primary data are the 50km x 50km MARS meteorological data and a 1km DEM for Europe.

Rainfall
Rainfall is influenced, to a varying degree, by aspect, altitude, distance from sea and prevailing wind direction. However, in preparing rainfall data at European level for input to PESERA, it was not possible to include some or all of these factors into the interpolation process. This is because developing the necessary algorithms to incorporate other environmental factors would require access to a significant number of measurements from recording stations throughout Europe. The amount of station data actually available to the project was not sufficient for computing the necessary algorithms.

The 1km rainfall data are the result of a purely mathematical interpolation. Figure 1 showing the rainfall distribution for the European area for which crop yields are forecast using CGMS. In broad terms, the pattern accords with reality but the distribution is crude and thus some areas are misrepresented. In principle, rainfall varies greatly within 50km x 50km grid cells in some regions, e.g. north-west Europe, the Alps and western Iberia, such that assigning a single rainfall total as being representative of a 50km grid cell leads to serious errors for many parts of that cell.

The interpolated rainfall data, using the inverse-spline function, is shown in Figure 2. In general, the pattern relates to that in Figure 1.
Figure 1 Average annual precipitation (mm) for MARS 50km x 50km grid cells

Figure 2 Average annual precipitation (mm) at 1km resolution interpolated from MARS 50km gridded data
For reasons of verifying the accuracy of the interpolated MARS rainfall data for use in PESERA, a study was implemented to compare these data with other rainfall data available for Europe. However, because of the poor availability of other more detailed meteorological data (many data exist but access is restricted by the national meteorological services), a comparison for the whole of Europe is not possible at this time.

![Image of rainfall maps](image_url)

**Figure 3.** Average annual precipitation (mm) from the MARS grid (50km x 50km) compared with the same data interpolated at 1km resolution, for Italy.

**Comparison of national records with MARS data**

Therefore the MARS data were compared with other meteorological data for Italy that were available to the project (Rusco, pers. comm.). Firstly, Figure 3 shows the average annual precipitation in the period 1975 to 1995 from the MARS database, with a pixel size of 50km x 50km, compared to 1km interpolated data from the same database. Secondly, for comparison with the 1km interpolated MARS rainfall data, average monthly precipitation was computed from measurements made at 366 meteorological stations distributed throughout Italy (Figure 4), for the period 1931-1960. Finally for detailed comparison, the average annual rainfall for these meteorological stations were first interpolated at a resolution of 5km x 5km, using nearest neighbour analysis (Figure 5). A correction for altitude, latitude or distance from the sea was not included. Since differences in the order of magnitude were of interest, the comparison was thought to be valid despite the different recording periods.
Meteo Stations [366] recording precipitation in Italy

Meteo Stations [47] recording precipitation for MARS in Italy

**Figure 4. Meteorological Stations recording precipitation in Italy.**

**Discussion**

Figure 5 shows that there are significant differences in Liguria and the upper Po Valley, Le Marche and Calabria between the MARS 50km data, interpolated to a 1km grid, and the national data, from the 366 stations in Italy, interpolated to 5km.

These differences are summarised in Figure 6. This subtracts the average annual precipitation of the MARS grid data from the data in Italy, at 5km. Resolution. The red colours show the areas where the annual precipitation from the MARS grid data is less than the interpolated values for the national stations, whereas the blue colours show the areas where the MARS data are overestimates. It is clear that the data based on the MARS grid data mostly underestimate precipitation in the mountainous areas (e.g Alps and Apennines).

The 1km interpolated rainfall data for UK are compared with the long-term distribution of rainfall, produced by the Meteorological Office, Bracknell (UK) from its national recording network, in Figure 7.
Figure 5. Average annual rainfall from national network compared to MARS 50km data interpolated to 1km, for Italy.

Difference between annual precipitation at the MARS grid points and the precipitation interpolated (at 5km) from the Meteo stations (for the same grid points)

MARS mostly underestimates precipitation especially in mountain areas

Figure 6. Comparison of differences between annual precipitation interpolated from the MARS grid with precipitation interpolated at 5km intervals from national station data.
There are some large discrepancies; for example in the Snowdonia area of north Wales (see within the red square, left), the long-term average annual rainfall (AAR) totals >2000mm, whereas the 1km interpolated data show a total of only 620-825mm. For the area further north (red square, right), the long-term AAR is >1600mm where the interpolated data show values between 825 and 1030mm. This difference is less than for Snowdonia but is still large.

Figure 7. Long-term average annual rainfall from national recording stations in UK compared with average annual precipitation interpolated at 1km from the MARS grid.

Another study on the MARS meteorological data (Jutta Thielen, IES, JRC Ispra) drew similar conclusions. The source data were: (a) the MARS data on 50km x 50km grid; (b) GCCP data from the DWD. GCCP gives only monthly, annual or seasonal totals for this period.

Figure 6 shows Thielen’s results from subtracting the rainfall totals for the period March 1994 until March 1995. The resolution is 1degree (ca. 100km x 80km). The two data sets have been brought into the same projection and then the values subtracted.

As was clear from the comparison of MARS data with the 366 Italian meteorological stations (1931 – 1960), Thielen’s comparison shows that the MARS data set gives much lower rainfall totals for the Alps than the GCCP data set.
Figure 8 Comparison of rainfall data from MARS with those from GCCP

Conclusion

The MARS data generally underestimate rainfall in the mountainous areas and in other areas where there is considerable variation in rainfall over small distances. This tendency in the MARS data to underestimate rainfall in these areas is understandable when considering that the emphasis on the original site selection, for recording rainfall, was based on the need to characterise the climate of agricultural areas. This led to less accurate results when the MARS interpolation routines were applied in mountainous regions.

Since the MARS 50km rainfall data, interpolated to 1km, are a primary input to the PESERA grid model, the estimated sediment losses predicted for some areas, such as those described above, will be much less accurate that elsewhere.

Temperature

Temperature data are used for input to the vegetation module of PESERA. The MARS 50km data are the primary source for temperature as well as rainfall data at European level. The interpolation procedure (to 1km), based on the inverse-spline function similar to that used for rainfall, was also adopted for temperature, except that, in addition, a correction for altitude was applied.

There is a strong relationship between altitude and temperature – the adiabatic lapse rate equating to approximately 6 deg C decline in temperature for every 1000m rise in
altitude. This relationship was built into the interpolation process of all the temperature parameters, using a 1km altitude data set for Europe. The results are shown in Figure 9 and the pattern of temperatures appears to be a more accurate representation than Figure 2 is for rainfall.

**Comparison of national data with MARS data**

Mean temperatures for January and July, from long-term Meteorological Office (UK) data sets, are shown in Figure 10, alongside the corresponding interpolated 1km MARS data. Throughout the UK, interpolated average temperatures compare favourably with the long-term national averages.

![Figure 9 Mean annual temperature (deg C) interpolated at 1km from MARS 50km grid data with correction for altitude](image)

**Conclusion**

Because the comparison between national and interpolated data for the UK is favourable, the accuracy of the temperature data for use in PESERA is confirmed.

**Evapotranspiration**

Evapotranspiration data were interpolated using the same procedure as for rainfall, hence no correction for altitude, aspect or distance from the sea. The results of interpolating these data at 1km are shown in Figure 11.
Figure 10 Mean temperatures (deg C) for January & July, interpolated & national data, UK
The results are not encouraging with little differentiation between high and low land in UK, with respect to total evapotranspiration, and clearly this is not correct.

![Figure 11](image.png)

**Figure 11  Mean annual evapotranspiration (mm) interpolated at 1km from MARS data.**

**Comparison of national data with MARS data**

The comparison between national and interpolated evapotranspiration data is portrayed for UK in Figure 12. The UK data were computed for the period 1961-75 by Jones and Thomasson (1985). There are significant difference in amounts of evapotranspiration, measured or calculated nationally, compared with the interpolated data for Europe.

**Conclusion**

There is a close relationship between temperature and evapotranspiration so the interpolation procedure could be improved in future by including the correction for altitude.
General conclusion

The 1km meteorological data have proved useful for testing the estimation of sediment loss, in the whole of Europe, by the PESERA Grid Model. However, the interpolation procedure adopted needs to be improved significantly for rainfall and evapotranspiration. An altitude correction based on the adiabatic lapse rate, incorporated in the interpolation procedure for temperature gave much more accurate results than the procedure adopted for rainfall and evapotranspiration.

It is important to stress that the estimates of soil loss from running the PESERA Grid model on the current meteorological data sets will be in error for areas where the interpolated (1km from 50km) rainfall deviates significantly from more detailed national measurements (see Figure 5 & 7).

References

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