Joint report

Overview of climatological mapping procedures

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Hungarian Meteorological Service

January 2011
### DELIVERABLE SUMMARY

#### PROJECT INFORMATION

<table>
<thead>
<tr>
<th>Project acronym:</th>
<th>DMCSEE</th>
</tr>
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<tr>
<td>Project title:</td>
<td>Drought Management Centre for South East Europe</td>
</tr>
<tr>
<td>Contract number:</td>
<td>SEE/A/091/2.2/X</td>
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<tr>
<td>Starting date:</td>
<td>1. 4. 2009</td>
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<td>Ending date:</td>
<td>31. 3. 2012</td>
</tr>
<tr>
<td>Project WEB site address:</td>
<td><a href="http://www.dmcsee.eu">http://www.dmcsee.eu</a></td>
</tr>
<tr>
<td>Lead partner organisation:</td>
<td>Environmental Agency of the Republic of Slovenia</td>
</tr>
<tr>
<td>Name of representative:</td>
<td>dr. Silvo Žlebir, director</td>
</tr>
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</tr>
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#### DELIVERABLE INFORMATION

<table>
<thead>
<tr>
<th>Title of the deliverable:</th>
<th>Overview of climatological mapping procedures</th>
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<tbody>
<tr>
<td>WP/activity related to the deliverable:</td>
<td>WP3, Activity 3.1.3</td>
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<td>Type (internal or restricted or public):</td>
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<tr>
<td>Location (if relevant):</td>
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<td>WP leader:</td>
<td>OMSZ</td>
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<td>OMSZ</td>
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<tr>
<td>Participating partner(s):</td>
<td>OMSZ, VITUKI, NIMH, AUA, GEORAMA, DHMZ, RHMS, HI-M, HMS, INEUM</td>
</tr>
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<td>Telephone number:</td>
<td>+36 13464727</td>
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</tbody>
</table>

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ABSTRACT

In Work Package 3 of DMCSEE project a mapping system as a precondition for the establishment of a common methodology for drought assessment has to be developed. The aim of the Act 3.1 is the preparation of climate data and maps. Outcomes of this Act 3.1 are three overviews about climatological databases (Act 3.1.1), procedures used for data quality and homogenisation (Act 3.1.2) and mapping procedures (Act 3.1.3).
In recent overview status of mapping procedures in partner institutes is described. We present the regular and state-of-art mapping techniques, capacities for interpolating of climatological and agrometeorological parameters, different interpolation methods.

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1. INTRODUCTION

One of the most important aims of DMCSEE project is mapping of drought. When somebody wants to interpolate drought indices he need:

- good quality time series of various climate parameters
- reliable interpolation methods

In this overview different interpolation techniques applied by DMCSEE project partners are presented.

To facilitate the work of partners a questionnaire was prepared. It was fulfilled by those partners who are climate data holders or use operationally climate data of other data holders. These partners are the national meteorological services and the hungarian VITUKI. This overview is based on their work. These partners are the following:

- Environmental Agency of Slovenia, Slovenia (EARS)
- Hungarian Meteorological Service, Hungary (OMSZ)
- Environmental and Water Management Institute, Hungary (VITUKI)
- National Institute of Meteorology and Hydrology, Bulgaria (NIMH)
- Agricultural University of Athens and Hellenic National Meteorological Service, Greece (AUA-HNMS)
- Meteorological and Hydrological Service, Croatia (DHMZ)
- Republic Hydrometeorological Service of Serbia, Serbia (RHMSS)
- Hydrometeorological Institute of Montenegro, Montenegro (HI-M)
- Hydrometeorological Service, Republic of Macedonia (HMS)
- Institute for Energy, Water and Environment, Albania (INEUM)

In the overview we tried to give a detailed description about the status of mapping procedures in partner institutes. However if anyone has questions about different parts of the overview, the following contact persons can answer them:
Contact persons:

<table>
<thead>
<tr>
<th>Institute</th>
<th>Country</th>
<th>Name(s)</th>
<th>E-mail(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARS</td>
<td>Slovenia</td>
<td>Gregor Gregorič Mojca Dolinar Gregor Vertačnik</td>
<td><a href="mailto:Gregor.gregoric@gov.si">Gregor.gregoric@gov.si</a></td>
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<td>Hungary</td>
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</tr>
<tr>
<td>HNMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DHMZ</td>
<td>Croatia</td>
<td></td>
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</tr>
<tr>
<td>RHMSS</td>
<td>Serbia</td>
<td>Tatjana Savić Predrag Petrović</td>
<td><a href="mailto:tatjana.savic@hidmet.gov.rs">tatjana.savic@hidmet.gov.rs</a> <a href="mailto:predrag.petrovic@hidmet.gov.rs">predrag.petrovic@hidmet.gov.rs</a></td>
</tr>
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<td>Montenegro</td>
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</tr>
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</table>
2. DESCRIPTION OF REGULAR CLIMATOLOGICAL AND AGROMETEOROLOGICAL MAPS

2.1 Existing partner obligation for operational production of climatological and agrometeorological subregional/countrywide/regional (international) maps

Experience in the interpolation:
No experience: HMS, INEUM.

Interpolated elements:
EARS: Temperature, precipitation, sunshine duration, wind, evapotranspiration, snow cover, some climate indices.
OMSZ: Temperature, precipitation, wind, some climate indices.
VITUKI: Temperature, precipitation.
NIMH: Temperature, precipitation, soil water content.
AUA-HNMS: Meteorological and agrometeorological elements.
DHMZ: Air temperature and precipitation amounts.
RHMS: Deviation of mean air temperature, precipitation as percentage of average, percentiles of mean air temperature and precipitation, Standardized Precipitation Index (SPI), departure from average of number of days with extreme temperature above or below certain thresholds, etc..
HI-M: Temperature and precipitation.

Users:
EARS: Government (legislation), hydrology, agronomy and energy sector, scientists from different sectors.
OMSZ: Government, industry, energy sector, scientists.
VITUKI: Public.
NIMH: End users of NIMH web page, decision makers, government.
DHMZ: Public, water and energy sector, tourism etc.
RHMS: Area of business, scientific institutions and government bodies.
HI-M: Public, projects.

Form of the output:
EARS: Pictures of maps (*.jpg), vector files (*.shp), grids (100 m, 1 km) (ArcASCII).
OMSZ: Pictures of maps (*.jpg), vector files (*.shp), grids (0.5').
VITUKI: Maps.
NIMH: Maps and grids.
AUA-HNMS: Maps and grids.
DHMZ: Electronic and hard copy as well.
RHMSS: Maps.
HI-M: Tabular forms and maps.

Type of distribution:
EARS: Web, e-mail and DVD distribution, planned web-based mapping service.
OMSZ: Web, e-mail.
VITUKI: Web.
NIMH: Web, printed paper.
AUA-HNMS: E-mail and printed paper.
DHMZ: Web, e-mail, fax, printed paper.
RHMSS: Regular RHMSS climatological and agrometeorological bulletins. Bulletins and other are disseminated via web, e-mail, fax and by post.
HI-M: E-mail, printed paper and web.

Frequency of publication:
OMSZ: Monthly, seasonally and yearly for precipitation and temperature on web.
VITUKI: Daily.
NIMH: Monthly.
AUA-HNMS: Monthly.
DHMZ: Monthly.
RHMSS: Weekly, in ten-days, monthly, seasonally and yearly.
HI-M: Monthly (web).

Method of preparation:
EARS: Semi-automatic, automatic is in preparation.
VITUKI: Semi-automatic.
NIMH: Manual and partly automatic.
DHMZ: Automatic and manual.
RHMSS: Partly automatic.
HI-M: automatic.
2.2 Description of method/tools/software used to produce operational products

Applied methods:

EARS: Geostatistical methods (residual kriging, ordinary kriging) in combination with simple mathematical and physical models.
OMSZ: MISH, spline, kriging.
VITUKI: IDW.
NIMH: Mainly kriging.
AUA-HNMS: Kriging.
DHMZ: Kriging and others.
RHMSS: Mainly kriging.
HI-M: Mostly kriging, then minimum curvature and inverse distance weighted.

Temporal resolution of the elements:

EARS: Temperature, precipitation and evapotranspiration monthly, other elements long term.
OMSZ: Daily, monthly, long term.
VITUKI: Daily.
NIMH: Monthly, seasonal, annual and it depends on the request.
AUA-HNMS: Monthly.
DHMZ: Monthly, seasonal and annual.
RHMSS: Monthly, seasonal, annual.
HI-M: Mostly monthly, seasonal, annual and long term.

Density of the input station network (number of stations/1000 km²):

<table>
<thead>
<tr>
<th></th>
<th>EARS</th>
<th>OMSZ</th>
<th>VITUKI*</th>
<th>NIMH**</th>
<th>AUA-HNMS</th>
<th>DHMZ</th>
<th>RHMSS</th>
<th>HI-M***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>Precipitation</td>
<td>10</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>10</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>Sunshine duration</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wind</td>
<td>1.5</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
<td>-</td>
</tr>
<tr>
<td>Snow cover</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Network operated by the Hungarian Meteorological Service (OMSZ).
** Depends on meteorological parameter.
*** Sufficient coverage along the coastal area, valleys of the river Moraca and Zeta, northeastern part and outmost northern parts of Montenegro. Insufficient data coverage in northwestern parts of the State mostly due to the problems with data quality.
**Applied input data:**

**EARS:** DEM 25 m or 100 m, derived topographical variables: relative altitude to the nearest orographic barrier in different direction, basin index, distance to the sea, Corine land Cover, Radar measurements, satellite measurements, long term gridded climatologies.

**OMSZ:** In case of MISH: DEM (0.5’), other topographic values, (for wind speed: roughness, elevation of wind measurement), different gridded statistics of long term data series, radar and satellite data, weather forecast.

**VITUKI:** DEM.

**NIMH:** DEM in some maps.

**AUA-HNMS:** DEM, distance to the sea, land cover, latitude, longitude, altitude.

**DHMZ:** DEM, other topographic values, distance to the sea, land cover, other meteorological parameters.

**RHMS:** None.

**HI-M:** None.

**Spatial resolution of the output map:**

**EARS:** 100 m and 1 km.

**OMSZ:** 0.5’.

**VITUKI:** 0.1 degree.

**NIMH:** Depends, sometimes down 1 x 1 km.

**AUA-HNMS:** 1000*826.

**DHMZ:** 1 km.

**RHMS:** 1 km approximately.

**HI-M:** 1:25000 for climate visualization and 1:100 000 for the river Moraca basin.

**Softwares for calculation:**

**EARS:** Gstat (stand alone), R.

**OMSZ:** Own developed softwares in Fortran and C.

**VITUKI:** Own developed softwares.

**NIMH:** Surfer, ArcView, ArcGIS.

**AUA-HNMS:** Surfer 9.

**DHMZ:** Internal softwares.

**RHMS:** Golden Software Surface Mapping System.

**HI-M:** Surfer.
Softwares for visualization:

**EARS**: ArcGIS 9.3, Saga GIS.
**OMSZ**: ArcView, ArcGIS, Saga, Surfer.
**VITUKI**: ArcGIS 9.3.
**NIMH**: Surfer, ArcView, ArcGIS.
**AUA-HNMS**: Surfer 9.
**DHMZ**: ECMWF compatible.
**RHMS**: Golden Software Surface Mapping System.
**HI-M**: Surfer.
3. DESCRIPTION OF THE STATE-OF-ART MAPPING PROCEDURES IN PARTNERS’ INSTITUTIONS

3.1 Capacities for mapping of climatological and agrometeorological parameters different to those applied for operational maps

Interpolated elements:

**EARS**: Precipitation, Temperature, Snow cover, Sunshine duration, Evapotranspiration, Wind, Some climate and drought indexes (SPI is currently being put to operation).

**OMSZ**: Temperature, precipitation, wind, some climate indices, sunshine duration, SPI, relative humidity.

**NIMH**: Temperature, precipitation, soil water content, etc.

**AUA-HNMS**: Precipitation, temperature, topography and land cover.

**DHMZ**: Air temperature and precipitation amounts.

**RHMSS**: Analyses of some other parameters which are under the significant influence of elevation, such as: average air temperature, average potential evapotranspiration, average precipitation amount, etc.

**HI-M**: Temperature and precipitation.

Aim of the interpolation:

**EARS**: Research, case studies of extreme events, climate analysis, regular publication of climatological maps.

**OMSZ**: Research, case studies of extreme events, climate analysis.

**NIMH**: Research, case studies of extreme events.

**AUA-HNMS**: Research, case studies of extreme events.

**DHMZ**: Research and applications.

**RHMSS**: Research, long term planning.

**HI-M**: Research, case studies of extreme events.

Form of the output:

**EARS**: Grids; they maintain a grid database. Maps are prepared as second step.

**OMSZ**: Pictures of maps, grids.

**NIMH**: Maps and grids.

**AUA-HNMS**: Maps and grids.

**DHMZ**: Maps and grids.

**RHMSS**: Maps.

**HI-M**: Maps.
3.2 Description of method/tools/software used to produce state-of-art products

**Applied methods:**

**EARS:** Geostatistical methods (residual kriging, ordinary kriging) in combination with simple mathematical and physical models.

**OMSZ:** MISH.

**NIMH:** Mainly kriging.

**AUA-HNMS:** Kriging.

**DHMZ:** Kriging and others.

**RHMSS:** Mainly kriging.

**HI-M:** Mostly kriging, then minimum curvature and inverse distance weighted.

**Temporal resolution of the elements:**

**EARS:** All from hourly to long term.

**OMSZ:** Daily to long term means.

**NIMH:** Monthly, seasonal, annual, long term.

**AUA-HNMS:** Monthly.

**DHMZ:** Monthly, seasonal and annual.

**RHMSS:** Monthly, seasonal, annual, long term.

**HI-M:** Monthly, seasonal, annual, long term.

**Density of the input station network (number of stations/1000 km$^2$):**

<table>
<thead>
<tr>
<th></th>
<th>EARS</th>
<th>OMSZ</th>
<th>NIMH*</th>
<th>AUA-HNMS</th>
<th>DHMZ</th>
<th>RHMSS**</th>
<th>HI-M***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Precipitation</td>
<td>10</td>
<td>6</td>
<td>-</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>-</td>
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<tr>
<td>Sunshine duration</td>
<td>3</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Wind</td>
<td>1.5</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Snow cover</td>
<td>10</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<td>Relative humidity</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Air pressure</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Depends, sometimes up to 300 stations, but also less than 100 stations.

** Available data are included. As a role, only data from climatological stations are used.

*** Sufficient coverage along the coastal area, valleys of the river Moraca and Zeta, northeastern part and outmost northern parts of Montenegro. Insufficient data coverage in northwestern parts of the State mostly due to the problems with data quality.
Applied input data:

**EARS:** DEM, derived topographical variables: relative altitude to the nearest orographic barrier in different direction, basin index, distance to the sea, Corine land cover, radar measurements, satellite measurements, long term gridded climatologies.

**OMSZ:** DEM, other topographic values, for wind speed: roughness, elevation of wind measurement, different gridded statistics of long term data series, radar and satellite data, weather forecasts.

**VITUKI:** DEM.

**NIMH:** DEM.

**AUA-HNMS:** DEM (1:50000 and 1:5000), distance to the sea, land cover, latitude, longitude, altitude.

**DHMZ:** DEM, other topographic values, distance to the sea, land cover, other meteorological parameters.

**RHMSS:** DEM (0.5 km).

**HI-M:** None.

**Resolution of DEM:**

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<tr>
<td>EARS</td>
<td>25-100 m</td>
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<tr>
<td>OMSZ</td>
<td>90 m</td>
</tr>
<tr>
<td>VITUKI</td>
<td>-</td>
</tr>
<tr>
<td>NIMH</td>
<td>1000 m</td>
</tr>
<tr>
<td>AUA-HNMS</td>
<td>1:50000 and 1:5000</td>
</tr>
<tr>
<td>DHMZ</td>
<td>1000 m</td>
</tr>
<tr>
<td>RHMSS</td>
<td>0.5 km</td>
</tr>
<tr>
<td>HI-M</td>
<td>-</td>
</tr>
</tbody>
</table>

**Spatial resolution of the output map:**

**EARS:** 100 m and 1 km.

**OMSZ:** 0.5'.

**VITUKI:** 0.1 degree.

**NIMH:** Depends, sometimes down 1 x 1 km.

**AUA-HNMS:** 1000*826.

**DHMZ:** 1 km.

**RHMSS:** ~1 km.

**HI-M:** 1:25000 for climate visualization while others depends on customers demands.
Softwares for calculation:

EARS: Gstat (stand alone), R.
OMSZ: Own developed softwares in Fortran (MISH).
VITUKI: Own developed softwares.
NIMH: Surfer, ArcView, ArcGIS.
DHMZ: Internal softwares.
RHMS: Golden Software Surface Mapping System.
HI-M: Surfer.

Softwares for visualization:

EARS: ArcGIS 9.3, Saga GIS.
OMSZ: ArcView, ArcGIS, Saga, Surfer.
VITUKI: ArcGIS 9.3.
NIMH: Surfer, ArcView, ArcGIS.
DHMZ: ECMWF compatible.
RHMS: Golden Software Surface Mapping System.
4. REMARKS ON THE APPLIED METHODS (BOTH OPERATIONAL AND STATE-OF-ART PROCEDURES)

**Experiences on applied methods:**

**EARS:** The results are satisfying. Problems occur by interpolation of elements on daily or smaller temporal scale.

**OMSZ:** MISH is satisfying, there are problems with spline and kriging but they are used only for those elements which the MISH isn’t modelled yet.

**NIMH:** Good experience.

**AUA-HNMS:** Very experienced.

**DHMZ:** Good.

**RHMS:** Used interpolation and mapping procedures enable only quite coarse spatial analyses.

**HI-M:** Kriging is the most suitable, but it is always compares with other two mentioned methods.

**Evaluation of methods:**

**EARS:** Operationally cross-validation. If possible also comparison with other elements or results.

**OMSZ:** In automatic procedures: no, in manual procedures: yes.

**VITUKI:** Yes.

**NIMH:** Not yet.

**AUA-HNMS:** Yes.

**DHMZ:** Yes.

**RHMS:** Objective evaluation: no.

**HI-M:** No.

**Control of suspicious data:**

**EARS:** Always.

**OMSZ:** In automatic procedures: no, in manual procedures: yes.

**VITUKI:** Yes.

**NIMH:** Yes.

**AUA-HNMS:** Yes.

**DHMZ:** Yes.

**RHMS:** Procedures do not comprise detecting outliers.

**HI-M:** Yes.
Inquiry for other methods:

EARS: For daily scale.
OMSZ: No, they try to develop MISH.
VITUKI: Yes.
NIMH: Yes.
AUA-HNMS: Yes.
DHMZ: Yes.
RHMS: Yes.
HI-M: Yes.
5. REQUEST FOR PERSONAL TRAINING

EARS: No.
OMSZ: No.
NIMH: Yes.
AUA-HNMS: No.
DHMZ: No.
RHMS: Yes.
HI-M: Yes.
HMS: Yes.
INEUM: Yes.
6. CONCLUSIONS

According to the content of questionnaires most of the partners have different techniques and softwares for interpolating climatological and agrometeorological parameters. Only HMS and INEUM don’t have experiences in this field. They and some other partner institutions require personal training to acquire the principles of interpolation and study the accessible techniques and softwares.

The main meteorological and agrometeorological parameters (temperature, precipitation, sunshine duration, wind, SPI, etc) are well mapped in the region. The most common applied interpolation methods are the different types of kriging. Both operational and state-of-art mapping products are generated on various time scales from daily to long term means.

The final aim of application adequate interpolation methods in the DMCSEE project is to make regional maps of drought indices. The presented possibilities shows that this aim will be realizable in the frame of the project.