

Chapter 10

Climate Stations

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Abstract Data from the climate stations was on the one hand used as an input source for the temporal and spatial interpolation of meteorological data by the model *AtmoStations* (see Chaps. 1.5, 1.6, and 1.7) and on the other hand to validate the results of the component *Rivernetnetwork* (Chap. 2.3.1) and the models *Snow* (Chap. 2.4.1) and *AtmoMM5* (Chap. 2.5.1). Data from all available climate stations (totalling 377) were obtained from the respective German and Austrian national meteorological agencies for the modelling period between 1960 and 2004. The analysis of the source data showed differences in the measurement procedures over time (change to automated data collection) and between the two national agencies (time of measurement and measurement units). However, these differences are taken into account in the model *AtmoStations* as much as possible, so that the degree of inhomogeneity in the data is kept as low as possible. The individual stations cover different time periods. Only a quarter of the stations (approx. 100) have a complete record for the modelling period. Therefore, the number of stations per time increment available for spatial interpolation varies considerably. The altitude of the climate stations varies from 96 m above sea level (Mannheim) to 3,105 m above sea level (Sonnblick). The analysis of the altitude distribution of the climate stations shows that the vast majority of stations are below 1,000 m above sea level. However, station density approximately corresponds to the area-altitude distribution of the catchment area.

Keywords GLOWA-Danube • Upper Danube • Meteorological observations • Station data • *AtmoStations*

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10.1 Introduction

Almost all DANUBIA model components require values at ground level for meteorological parameters at high temporal and spatial resolution. Such data is already generated at 1 km² resolution and at hourly intervals either via the mesoscale atmosphere model *MM5* or by interpolation of observed time series. The measurement data from climate stations form the basis for the temporal and spatial interpolation of the meteorological parameters with the model *AtmoStations* and are used to validate the results of the DANUBIA component *Rivernetwork* (Chap. 29) and the models *Snow* (Chap. 30) and *AtmoMM5* (Chap. 32).

In order to rely on a network of measurement stations with good coverage and of guaranteed data quality, homogeneity and continuity, data from all available stations of the German Weather Service (Deutscher Wetterdienst=DWD), the national meteorological service of the Federal Republic of Germany and the Central Institution for Meteorology and Geodynamics (Zentralanstalt für Meteorologie und Geodynamik=ZAMG) and the national meteorological and geophysical service of the Federal Republic of Austria were obtained for the Upper Danube catchment area and its surroundings. For the modelling period from 1960 to 2004, there were a total of 377 weather stations available for the region in question, of which 280 were German and 97 were Austrian. For the region within Switzerland, there was discharge data at the boundary gauges and climatologies for various meteorological parameters. Thus, there was no need for a costly acquisition of data.

10.2 Data Processing

The DWD data come from climate stations with up to three daily observations and from the main synoptic-climatological network (hourly measurements, enhanced with climatological data). The data obtained from the ZAMG include ground-level observations of meteorological parameters that are captured at conventional climate stations with manual measurements and at semiautomated weather stations. Table 10.1 presents the parameters for which data was captured at these stations.

On April 1, 2001, the method for capturing climatological data at the DWD was converted. New automatic data acquisition meant that additional data for calculating daily values could be utilized. One main aspect of the change in data management at the DWD was the shift in scheduled weather measurements from 7:30, 14:30 and 21:30 CET to 7:00, 14:00 and 19:00 CET. The actual observation time is 10 min prior to the reference time. This shift took effect at first for the main synoptic-climatological automated network. The new times were also adopted with the subsequent automation of the secondary climate and precipitation network (www.dwd.de). This change entailed only a minor shift in the time points for the temporal interpolation of the parameter with the model *AtmoStations*. However, the change entailed a significant change in the mean values (Gattermayr 2001). The model *AtmoStations* did not use the mean values from the weather stations, but instead calculated these from the interpolated values.

Table 10.1 Parameters of weather stations with time-scheduled measurement or measurement duration

Parameter	DWD	ZAMG
Air temperature (2 m above ground)	(1)	(2)
Air humidity (2 m above ground)	(1)	(2)
Wind direction and force	(1)	(2)
Visibility	(1)	(2)
Soil condition	(1)	(2)
Cloud coverage	(1)	(2)
Precipitation amount	(3)	(4)
Type of precipitation	(3)	(4)
Air pressure	(1) (5)	(2)
Cloud density and weather events	(1)	(2)
Snow depth, type of snow cover	7:30 CET	7:00 LMT
Depth of fresh snow	(6)	(6)
Snow water equivalent	7:30 CET	
Precipitation total	(8)	(9)
Mean air temperature	(10)	(11)
Mean air humidity	(10)	(10)
Mean wind force	(10)	(10)
Mean cloud coverage	(10)	(10)
Mean air pressure	(10)	(10)
Information on fallen precipitation, condensation/sublimation and weather events	(12)	
Sunshine duration	(12)	(12)
Maximum gust of wind	(12)	(12) (15)
Maximum air temperature	(13)	(16)
Minimum air temperature	(13)	(16)
Minimum ground temperature	(14)	(17)
Global radiation		(12)

CET Central European Time, *LMT* local mean time

1. Three scheduled measurements: 7:30, 14:30 and 21:30 CET until March 2001 and 6:50, 12:50 and 18:50 CET since April 2001
2. Three scheduled measurements: 7:00, 14:00 and 19:00 LMT
3. Three measurements: 21:30 on the previous day to 7:30, 7:30 to 14:30 and 14:30 to 21:30 CET until March 2001 and 18:50 on the previous day to 6:50, 6:50 to 12:50 and 12:50 to 18:50 CET since April 2001
4. Two measurements: 19:00 on the previous day to 7:00 and 7:00 to 19:00 LMT
5. Only at synoptic-climatological network stations
6. 7:30 on the previous day to 7:30 CET (since April 2001: 6:50 on the previous day to 6:50)
7. 7:00 on the previous day to 7:00 LMT
8. 7:30 to 7:30 CET on the following day (since April 2001: 6:50 to 6:50 on the following day)
9. 7:00 to 7:00 LMT on the following day
10. Daily from three scheduled measurements
11. $(\text{Max} + \text{min})/2$
12. Daily (between 00:00 and 24:00 legal time, at full-time stations UTC)
13. Until March 2001: 21:30 CET on the previous day to 21:30 CET (since April 2001; see 10)
14. Until March 2001: 21:30 CET on the previous day to 7:30 CET (since April 2001; see 10)
15. Additional information at the time of daily maximum
16. 19:00 on the previous day to 19:00 LMT
17. 19:00 on the previous day to 7:00 LMT

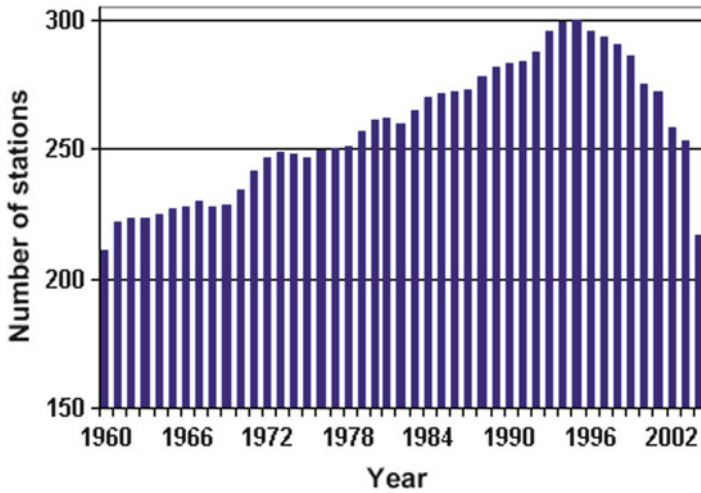


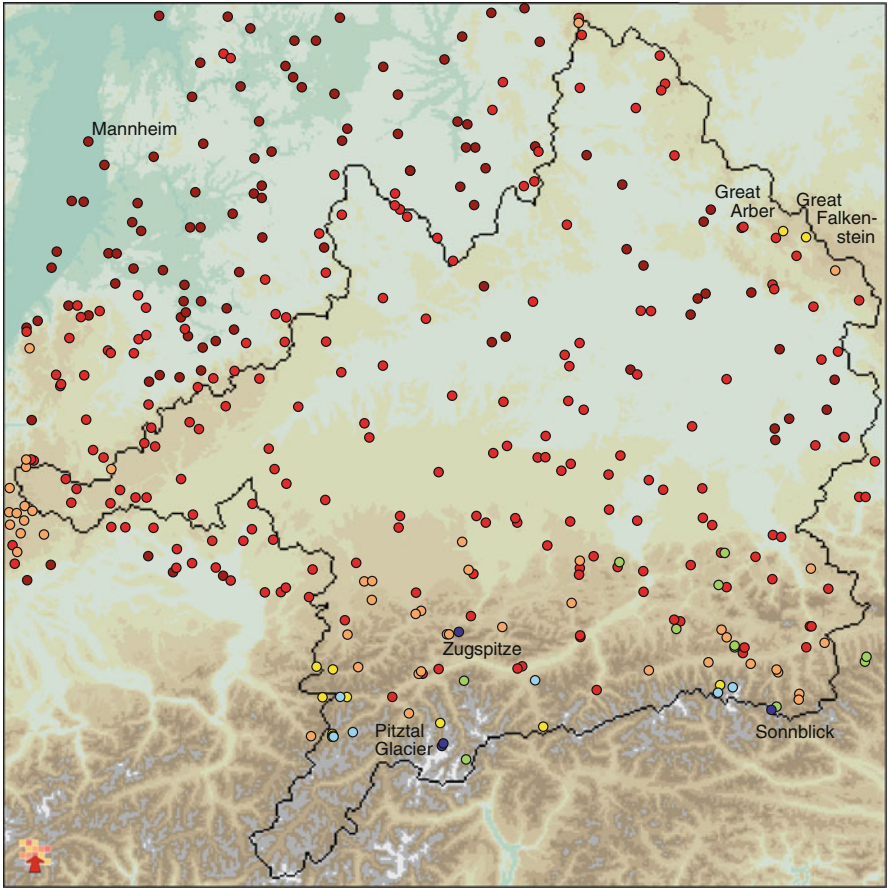
Fig. 10.1 Number of stations with daily measures per year

In addition to the change in measurement procedure during the study period, there is also the difference in the methods used by the DWD and ZAMG to be considered (e.g. different measurement times, timing according to CET or LMT or different units of the measurements). However, these differences are taken into account in the model *AtmoStations* as much as possible, so that the degree of inhomogeneity in the data is kept as low as possible.

For the period from 1960 to 2004, a total of over four million measurement days (data records) are available. The individual stations cover different time periods and also sometimes contain significant gaps in the data. Roughly a quarter of the stations (approx. 100) have a complete record for this period. Therefore, the number of stations per time increment available for spatial interpolation varies considerably. For the year 1960, data from 211 stations could be used for the model, whereas for the years 1994 and 1995, up to 300 stations were available (see Fig. 10.1).

10.3 Results

Map 10.1 shows the locations of the DWD and ZAMG climate stations within the study area. The station with the highest altitude is located in Austria on Sonnblick Mountain (3,105 m a.s.l.), and the second highest is in Germany on the Zugspitze (2,960 m a.s.l.); third highest is the device on the Pitztal Glacier at 2,850 m a.s.l. The two highest stations in the Bavarian Forest are on the Great Arber (1,437 m a.s.l.) and the Great Falkenstein (1,307 m a.s.l.). The lowest altitude measurements



Elevation [m a.s.l.]

0 15 30 45 60 km

- 0 - 400
- > 400 - 800
- > 800 - 1,200
- >1,200 - 1,600
- >1,600 - 2,000
- >2,000 - 2,400
- >2,400 - 2,800*
- > 2,800

* currently no station

Map 10.1 Climate stations (Data source: DWD, Deutscher Wetterdienst, ZAMG, Zentralanstalt für Meteorologie)

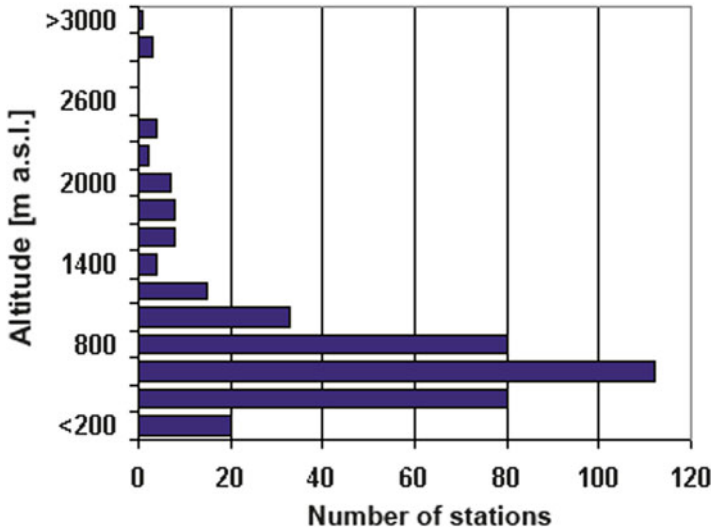


Fig. 10.2 Altitude distribution of the climate stations

are taken in Mannheim at 96 m a.s.l. It is noteworthy that at several Austrian stations, two symbols are directly adjacent or virtually on top of each other. In part, this situation derives from the fact that these stations are carried forward under a new designation if the type of station changes (e.g. as a result of automation). Another reason is that stations on private property must be relocated and supplied with a new number if the observer changes.

The altitude distribution of the climate stations indicates that above 1,000 m a.s.l. there are significantly fewer stations in operation than below 1,000 m a.s.l.. Half of the sites are below 533 m a.s.l. and 75 % lie below 785 m a.s.l. (see Fig. 10.2). Eight stations are located above 2,000 m a.s.l., of which seven are in Austria. However, station density approximately corresponds to the area-altitude distribution of the catchment area.

The high altitude and the strong small-scale variability in the Alpine region have an important impact on the climate and water supply in the Upper Danube catchment area. Relief enhances the thermal and dynamic processes in the atmosphere that can, for example, lead locally to more precipitation and hence can be very significant for the water supply. For the spatial interpretation and simulation of climatic state variables in regions with sharp relief patterns, there is therefore a need for a greater number of stations with regular high-quality data even at high sites and the most extreme locations of the study area. Unfortunately, at these sites logistical problems for the operation of the stations are often experienced. In addition to the measurements from the stations depicted on Map 10.1, data from climate stations at academic institutions were used to validate the model results. For example, the “Vernagtach Climate Station” (at Vernagtferner) in Ötztal at an altitude of 2,640 m a.s.l., which belongs to the Commission for Geodesy and Glaciology of the Bavarian

Academy of Sciences and Humanities, supplied year-round hourly data for all parameters listed in Table 10.1 except for cloud cover and visibility. Another station is located also in Ötztal on the Schwarzkögele Glacier (3,074 m a.s.l.), and there are several measurement sites on the glacier itself that are at 3,000 m a.s.l.

Reference

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