Assessment of Climate Data Uncertainty over the Nam Co Region

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Introduction

The overall objective of this study, within the DFG Priority Program 1372: "Tibetan Plateau: Formation – Climate - Ecosystems (TiP)", is to understand the driving forces controlling the hydrological system dynamic of the Tibetan Plateau in the context of a likely changing climate and monsoon dynamic.

The glacier-fed lake Nam Co (30°N/90°E, 4718 m a.s.l., 2000 km²) showed a noticeable increase which indicates that the Nam Co basin (10.800 km²), located at the northern foot of the Nyainqentanglha Mountains in the southern central part of the Tibetan Plateau, is experiencing remarkable changes in the hydrological dynamics.

Those changes need to be quantified by simulating or modelling the underlying hydrological processes and components, whereas one of the major challenges in the widely ungauged region is the lack of suitable and reliable climate data to drive hydrological models.

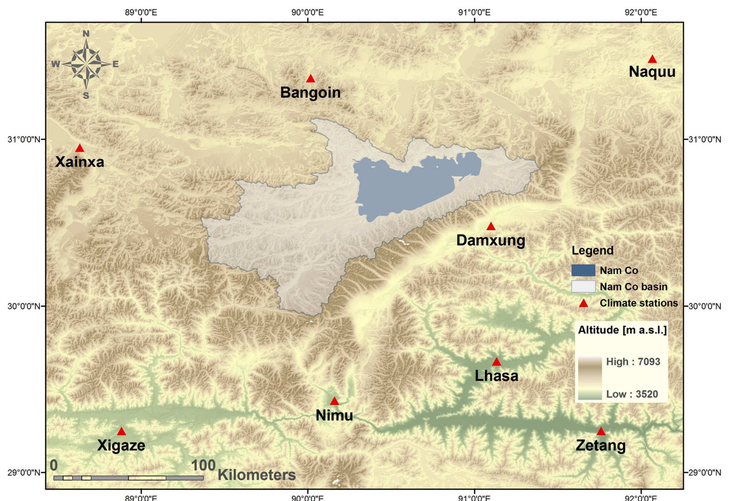

Figure 1: Location of long term meteorological in-situ measurements

Due to the severely limited data availability hydrological modelling applications of the Nam Co basin rely mostly on coarse global and regional gridded climate data sets.

Since the single data sets were derived using different input sources such as ground observation, satellite estimates and climate model simulations, differences in quality and quantity can be expected.

The differences need to be examined in order to identify the quantitative uncertainty and to evaluate the suitability of gridded climate data as driving forces for distributed hydrological modelling of the Nam Co basin.

This study compares temperature and precipitation time series of gridded climate data sets among each other and against corresponding ground-based observation data over an area with the extent of 29.5° N, 89° E – 31.5° N, 91.5 E° including the Nam Co catchment.

Climate Data Analysis

Analysis of long term meteorological in-situ measurements

- **Temperature and precipitation analysis (Tab. 1)**
  - ➢ High spatial variability → mean annual temperature and precipitation (1981-2004) ranges from 0°C to 9°C and 360mm to 540mm respectively
  - ➢ North of the Nyainqentanglha Mountains are colder and drier conditions
  - ➢ Large daily and seasonal variability
- **Mann-Kendall trend test for 1981-2004 (Tab. 1)**
  - ➢ Annual temperature: increasing trend for all stations (primarily in winter)
  - ➢ Annual precipitation: increasing trend for stations in the eastern and southern part (particularly in summer), stations in the western show no significant trend

Table 1: Annual average and Mann-Kendall trend test results for temperature and precipitation measurements surrounding the Nam Co basin for the time period1981-2004

Stations	Longitude (E)	Latitude (N)	Altitude (m)	Temperature (1981-2004)				Precipitation (1981-2004)			
				Annual mean (°C)	Mann-Kendall trend test *			Annual mean (mm)	Mann-Kendall trend test *		
					Year	Nov.-Apr.	May-Oct.		Year	Nov.-Apr.	May-Oct.
Zetang	91.76	29.25	3552	8.9	+	+	no	464	+	+	+
Lhasa	91.13	29.67	3650	8.5	+	+	+	455	+	no	+
Nimu	90.16	29.43	3809	7.0	+	+	no	408	+	no	+
Xigaze	88.88	29.25	3837	6.9	+	+	no	476	no	no	no
Damxung	91.10	30.48	4200	1.8	+	+	no	541	+	no	+
Xainxa	88.63	30.95	4670	0.6	+	+	no	356	no	+	no
Bangoin	90.02	31.37	4701	-0.1	+	+	+	372	no	no	no
Naquu	92.07	31.48	4508	-0.6	+	+	no	482	+	+	+

* **no** = no significant trend; **+** / **+** = significant increasing trend with p=80%/**95%**

Comparison of global and regional gridded climate data

- **Mean temperature of ECHAM5 & CRU (1981-2004) (Fig. 2)**
  - ➢ good agreement in absolute magnitude, spatial pattern and seasonality
- **Mean precipitation of ECHAM5, CRU and APHRODITE (1981-2004) (Fig. 3)**
  - ➢ High disparity between ECHAM5, CRU and APHRODITE in precipitation amount, spatial distribution and inner annual variability
  - ➢ ECHAM5 shows much more precipitation, particularly in dry winter season
  - ➢ APHRODITE shows up to 60% less average rainfall amounts
  - ➢ ECHAM5 & CRU show similar pattern with a decrease from southwest to northeast, APHRODITE exhibits reverse decrease from southeast to northwest corresponding to Monsoon direction
- **Mean Precipitation of APHRODITE and TRMM (1999-2007) (Fig. 4)**
  - ➢ reasonably good accordance in magnitude, spatial pattern and seasonality
- **Mann-Kendall trend test for 1981-2004**
  - ➢ Temperature: ECHAM5 (lowly significant) & CRU (highly significant) increasing trend, particularly in winter period (Fig. 5)
  - ➢ Precipitation: ECHAM5 → no significant trend, CRU and APHRODITE→ highly significant increasing trend in the southern and eastern part in the Monsoon season (Fig. 6)

Table 2: Global and regional gridded climate data products

Data set	Space	Time period	Time step	Cimate variable	Reference
COSMO-CLM ECHAM5	0.5°	1960-2000 scenarios 2001-2080	daily	temperature, precipitation	Ahrens and Dobler 2008
CRU TS3.0	0.5°	1901-2006 scenarios 2007-2100	monthly	temperature, precipitation	Mitchell and Jones 2005
APHRODITE V1003R1	0.5°, 0.25°	1951-2007	daily	precipitation	Yatagai et al. 2009
TRMM 3B43	0.25°	1999-2008	monthly	precipitation	Huffmann et al. 2007

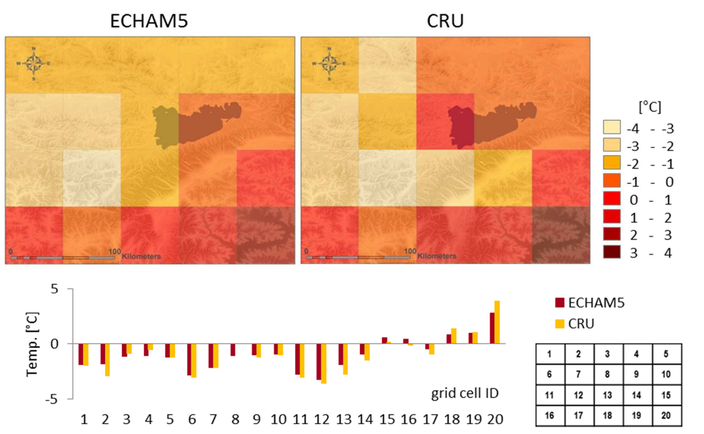

Figure 2 : Mean temperature of ECHAM5 and CRU for 1981-2004

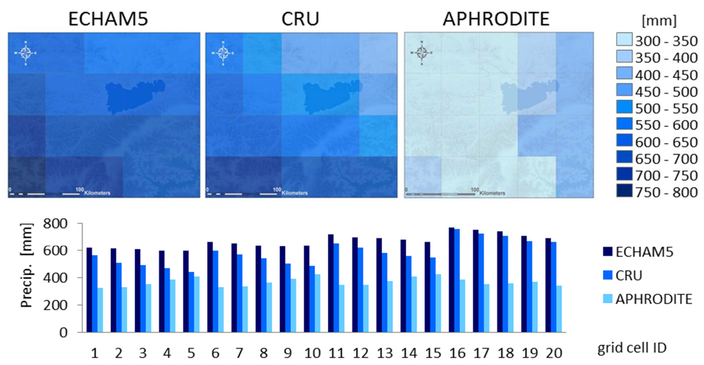

Figure 3: Mean precipitation of ECHAM5, CRU and APHRODITE for 1981–2004

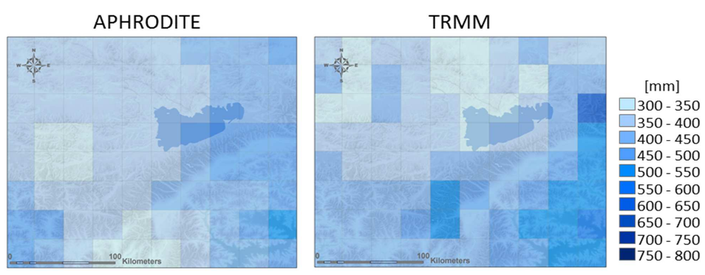

Figure 4: Mean precipitation of APHRODITE and TRMM for 1999-2007

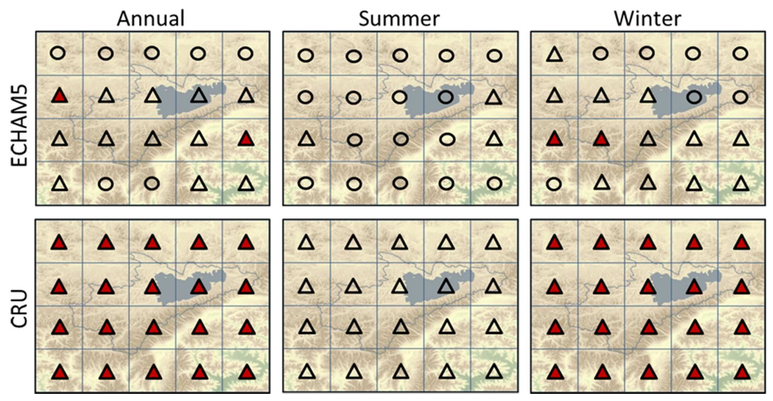

Figure 5: Mann-Kendall trend test results for annual, summer and winter temperature of ECHAM5 (top) and CRU (bottom) for the period 1981-2004
(△/▲ = significant increasing trend with p=80%/**95%**; ○= no significant trend)

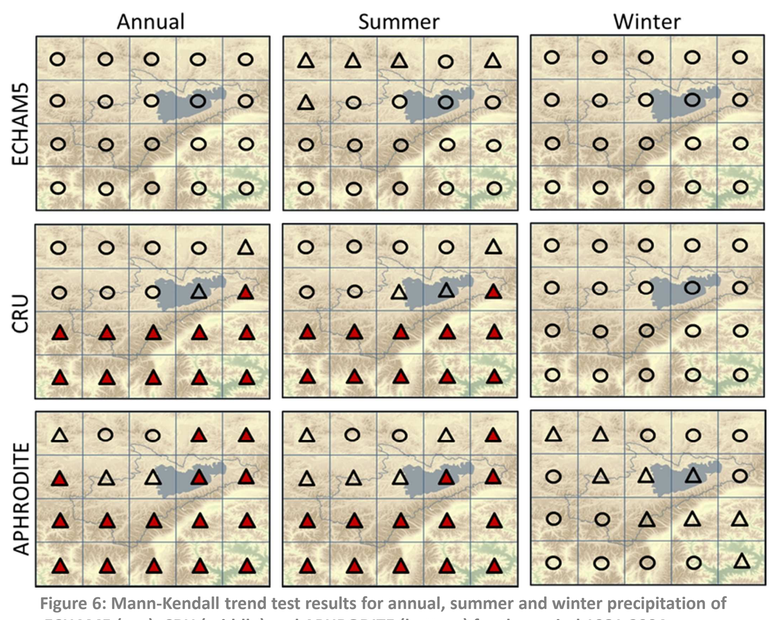

Figure 6: Mann-Kendall trend test results for annual, summer and winter precipitation of ECHAM5 (top), CRU (middle) and APHRODITE (bottom) for the period 1981-2004
(△/▲ = significant increasing trend with p=80%/**95%**; ○= no significant trend)

Comparison of gridded data sets against observation data

- **Correlation of mean seasonal temperature for 1981 to 2004 (Tab. 3)**
  - ➢ ECHAM5 and CRU reproduce measured annual cycle of temperature with a correlation coefficient of nearly 1.0
- **Correlation of mean seasonal precipitation for 1981 to 2004 (Tab. 3)**
  - ➢ ECHAM5, CRU and APHRODITE represent the inner annual variations associated with the Monsoon
  - ➢ APHRODITE shows the highest and ECHAM5 the lowest correlation values
- **Mann-Kendall trend test results**
  - ➢ Temperature: all stations and corresponding grid cell data of CRU show highly significant increase, while ECHAM5 shows a less accordance with no trends in some cells and significant and highly significant increasing trend in other cells as well
  - ➢ Precipitation: ECHAM5 shows no significant trend → in accordance with stations in north-western part, but in disagreement with the increasing trend in the eastern and southern part
  - ➢ CRU and APHRODITE reproduce the positive tendency in the East and South

Table 3: Correlation analysis of mean seasonal temperature and precipitation between station data and corresponding gridded climate data for 1981-2004

r^2 mean monthly temperature	Zetang	Lhasa	Nimu	Xigaze	Damxung	Xainxa	Bangoin	Naquu
ECHAM5	0.98	0.98	0.99	0.98	0.98	0.98	0.97	0.98
CRU	0.99	0.99	0.99	0.99	1.0	1.0	1.0	1.0
r^2 mean monthly precipitation	Zetang	Lhasa	Nimu	Xigaze	Damxung	Xainxa	Bangoin	Naquu
ECHAM5	0.95	0.99	0.98	0.96	0.94	0.96	0.83	0.91
CRU	0.93	0.99	0.98	0.96	0.97	0.97	0.90	0.94
APHRODITE	1.0	1.0	0.99	1.0	1.0	1.0	0.98	0.99

Conclusions and Outlook

To evaluate the input data uncertainty in the Nam Co region and most importantly, to assess the spatial and temporal deviations between various data sets, a comprehensive data evaluation of temperature and precipitation time series was carried out.

The comparison of individual data sets showed some reasonable agreement, but also substantial differences as well as large deviations in the magnitude, the spatial pattern and the seasonality.

Due to the coarse resolution of the gridded data and the sparse availability of ground data, which are mainly located in lower elevations, the comparison between gridded and station data was strongly limited.

Since it is hard to determine the reliability and plausibility of several data products for modelling applications, sensitivity and uncertainty analyses of climate input data along with ensemble modeling strategies are required to quantify the impact of data uncertainty on the model response.

This study, however, emphasizes the importance of future research efforts in terms of the development of regional data sets with finer resolution to overcome the poor data situation over the Tibetan Plateau.

Such high resolution is needed for a sufficient representation of regional orographic patterns and effects as well as to reduce the model's uncertainty attributed to climate input data.

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