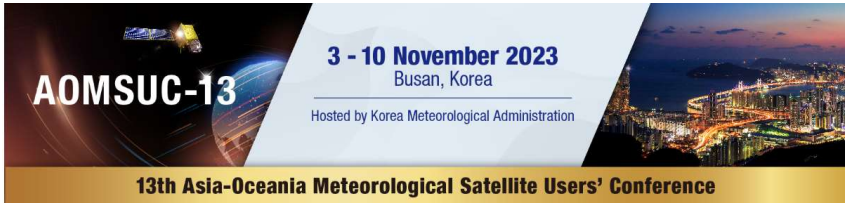

MODIS LST: A tool to generate high resolution temperature dataset in Iran

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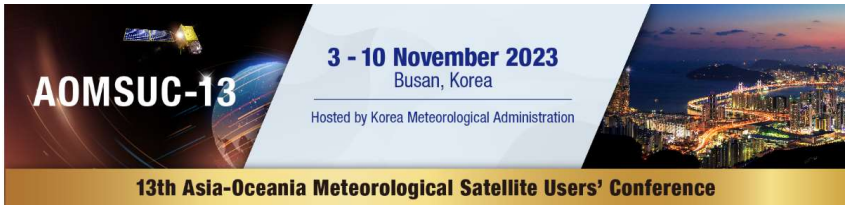
RESEARCH INSTITUTE OF METEOROLOGICAL AND ATMOSPHERIC SCIENCE (RIMAS)

IRAN



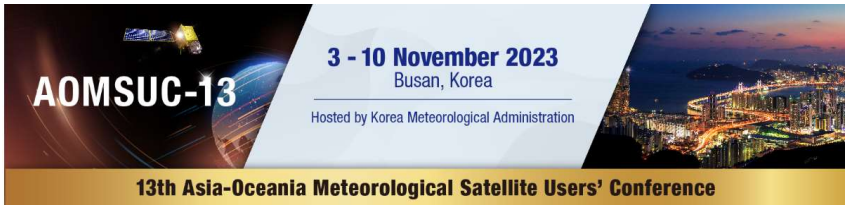
Outlines

Introduction
- Climate of Iran
- Importance of grided temperature database
- Temperature Laps Rate (TLR)
- MODIS

Material and methods
- Study area
- Data
- Methodology

Results

Main Findings

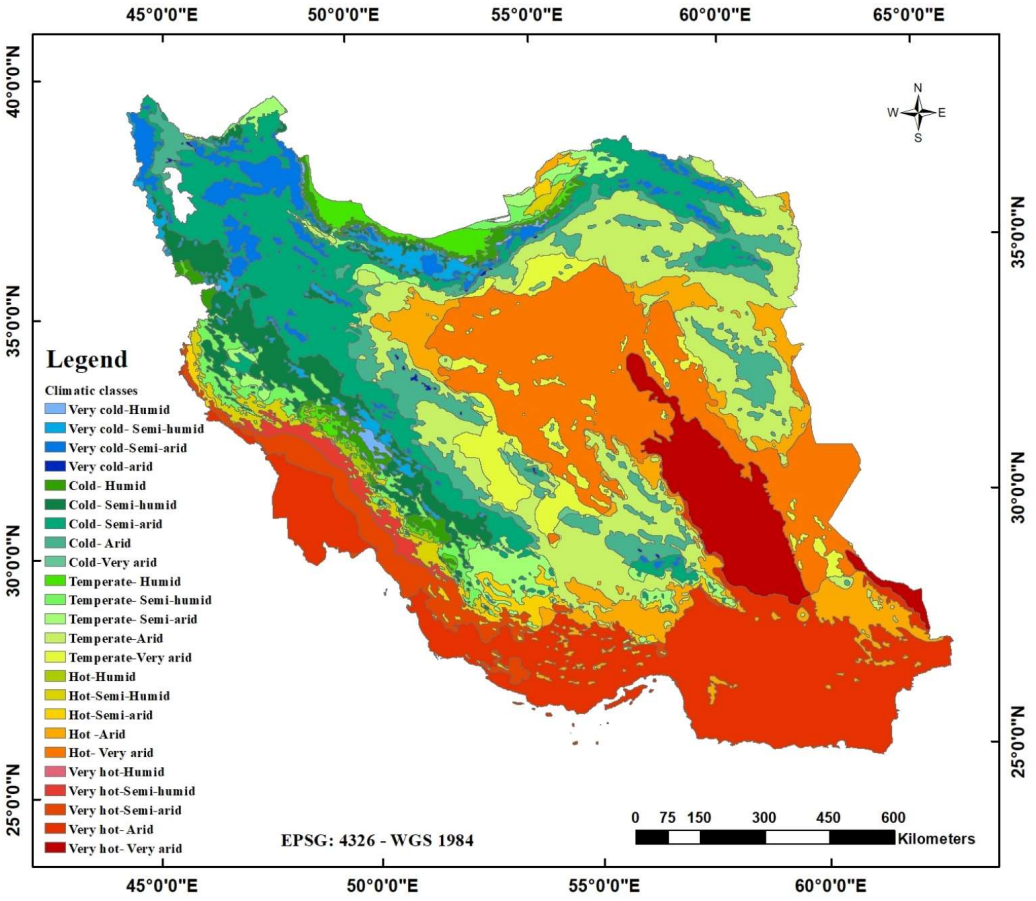


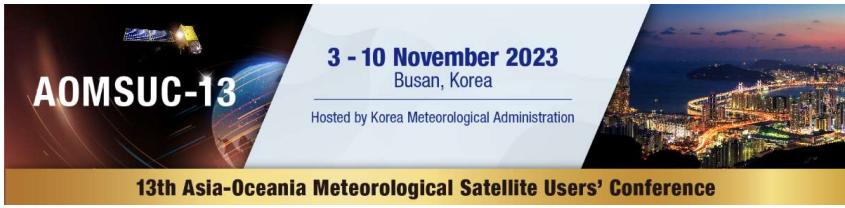
Climate of Iran

Precipitation: 15mm to 2113 mm/year with most of the area with 200mm/year

Temperature: 17 -18 degree centigrade

Evaporation: ~2100 mm/year





Importance of grided temperature database

It is an important climate factor in several sectors:

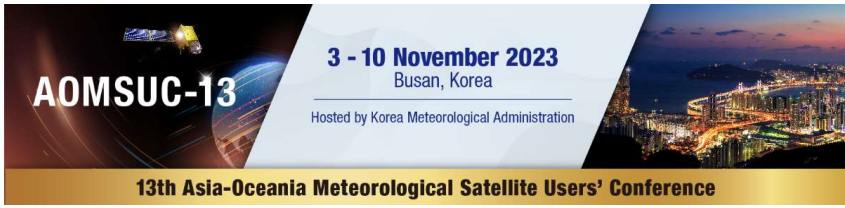
- Agriculture
- Water resources
- Environmental resources
- Climate …

Stational data

- Spatial and temporal discontinuity of data
- Usability in for example hydrological and climatological modeling contains limitations

Grided data

- Spatially continues
- Suited for modeling purposes



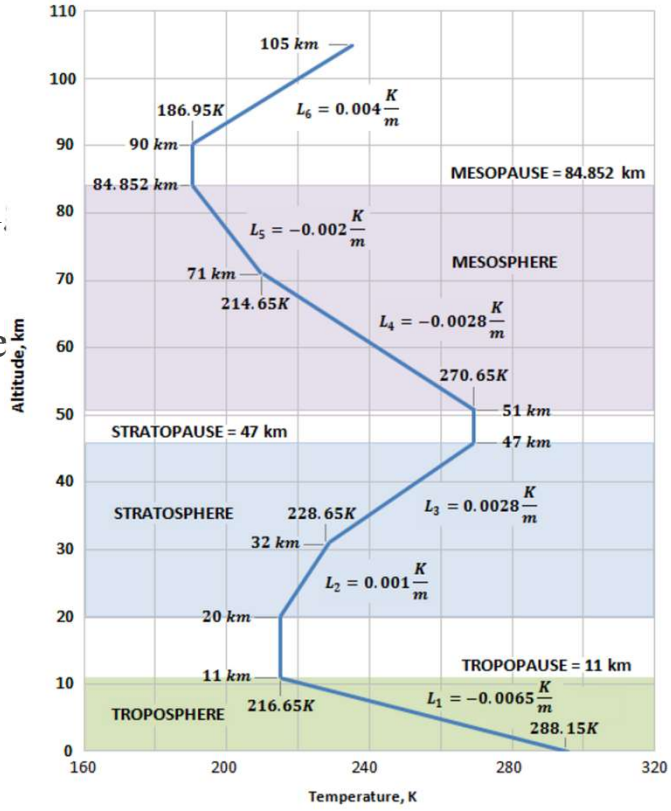
Temperature Laps Rate (TLR)

Higher elevation: lower temperature

TLR is a good tool for spatial interpolation of temperature

Low number of stations and unsuitable distribution of them: bi uncertainty in calculated TLR

Satellite data is a good approach to estimate spatially continue TLRs



Moderate-resolution Imagi
Spectroradiometer (MODIS)

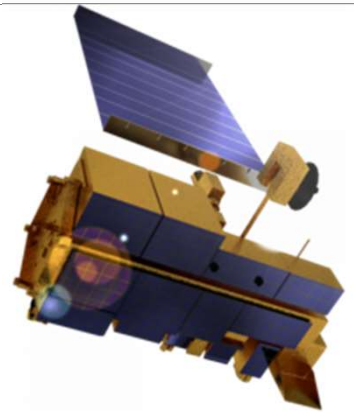
Satellite-based sensor used for earth and climate measurements

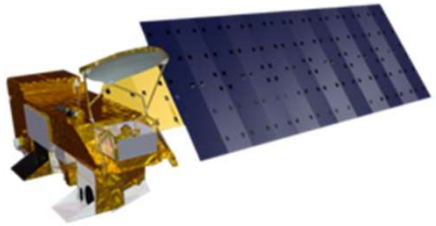
Terra (EOS AM) satellite, launched by NASA in 1999

Aqua (EOS PM) satellite, launched in 2002

Obtaining data in 36 spectral bands with wavelengths ranging from 0.4 to 14.385 μm

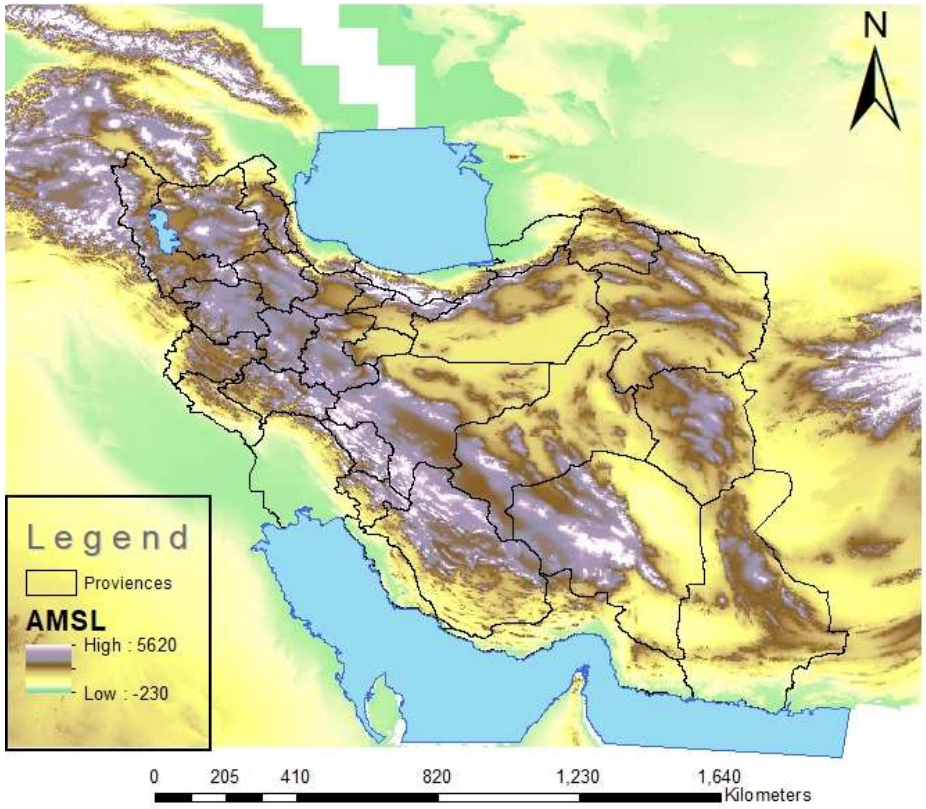
spatial resolution of 250 m, 500 m, and 1 km

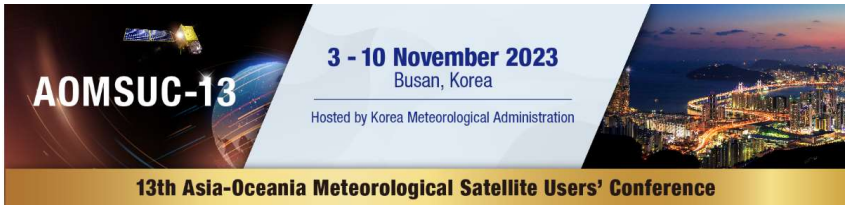




Study area

- South West of Asia
- Area: 1648195 Km2
- 25N to 45N and 44E to 63E
- Almost 24 different climatic regions
- Mostly arid and semi-arid
- East and center: Uncomplicated, low height and relatively uniform views
- West: Elevated and with various views





Data

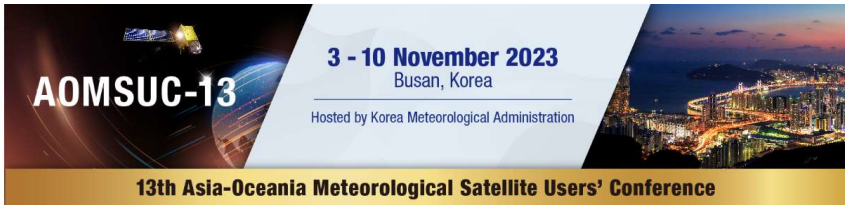
Observations:

- QC temperature data of 317 stations (1980-2021)

Satellite data:

- Averages daily Terra and Aqua Land Surface Temperature (LST) with 1km spatial resolution

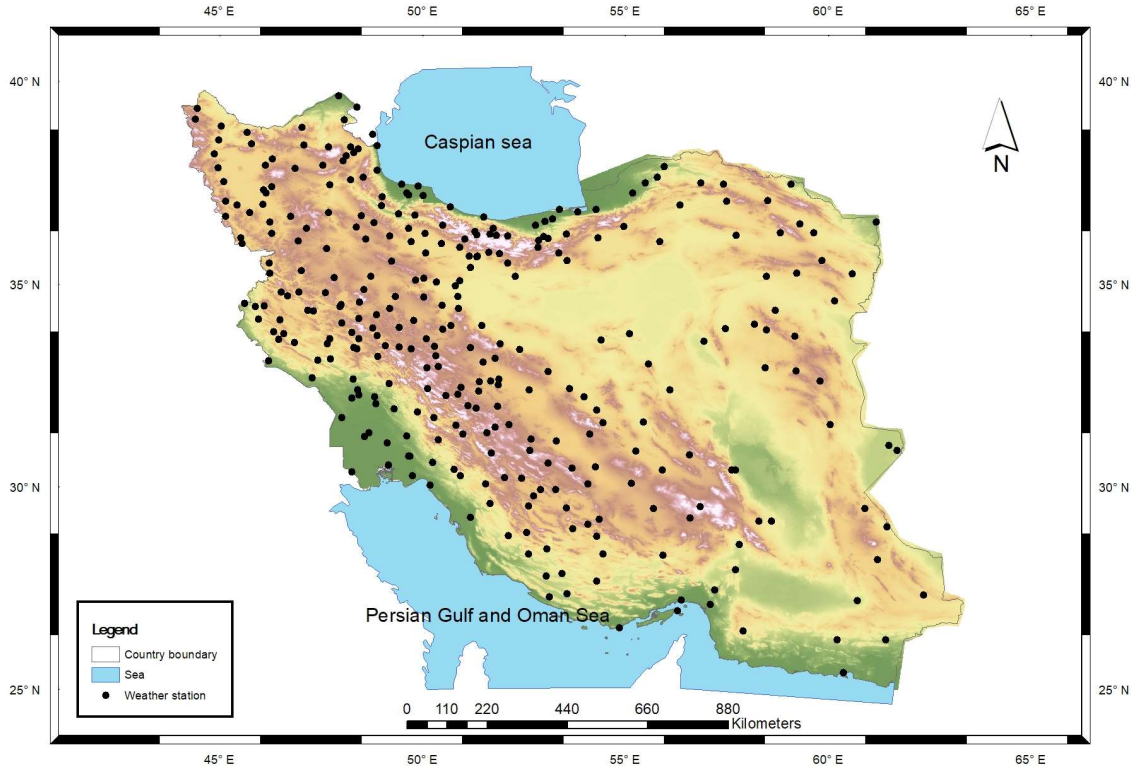
Reanalysis temperature data from 3 database: ERA5, CFS and MERRA2

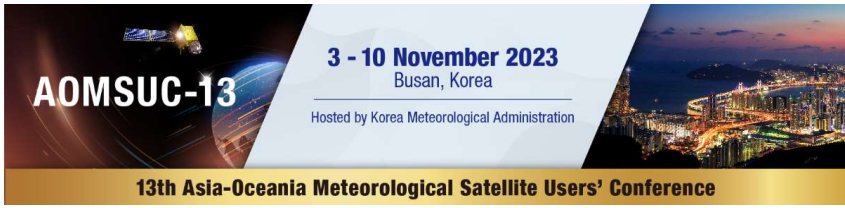


Data

Reanalysis Database	Source	Spatial resolution
ERA5	Herbach et.al. (2021)	0.25 by 0.25 degree
CFSR/CFS.v2	Saha et.al. (2010) Saha et.al. (2014)	0.3125 by 0.3125 degree for CFSR/ 0.25 by 0.25 for CFS.v2
MERRA2	Gelaro et.al. (2017)	0.625 by 0.5 degree

Data


45° E
50° E
55° E
60° E
65° E
40° N
35° N
30° N
25° N
Caspian sea
Persian Gulf and Oman Sea
N
Legend
Country boundary
Sea
Weather station
0 110 220 440 660 880
Kilometers



Method

Obtain monthly TLR maps using MODIS LST and DEM data

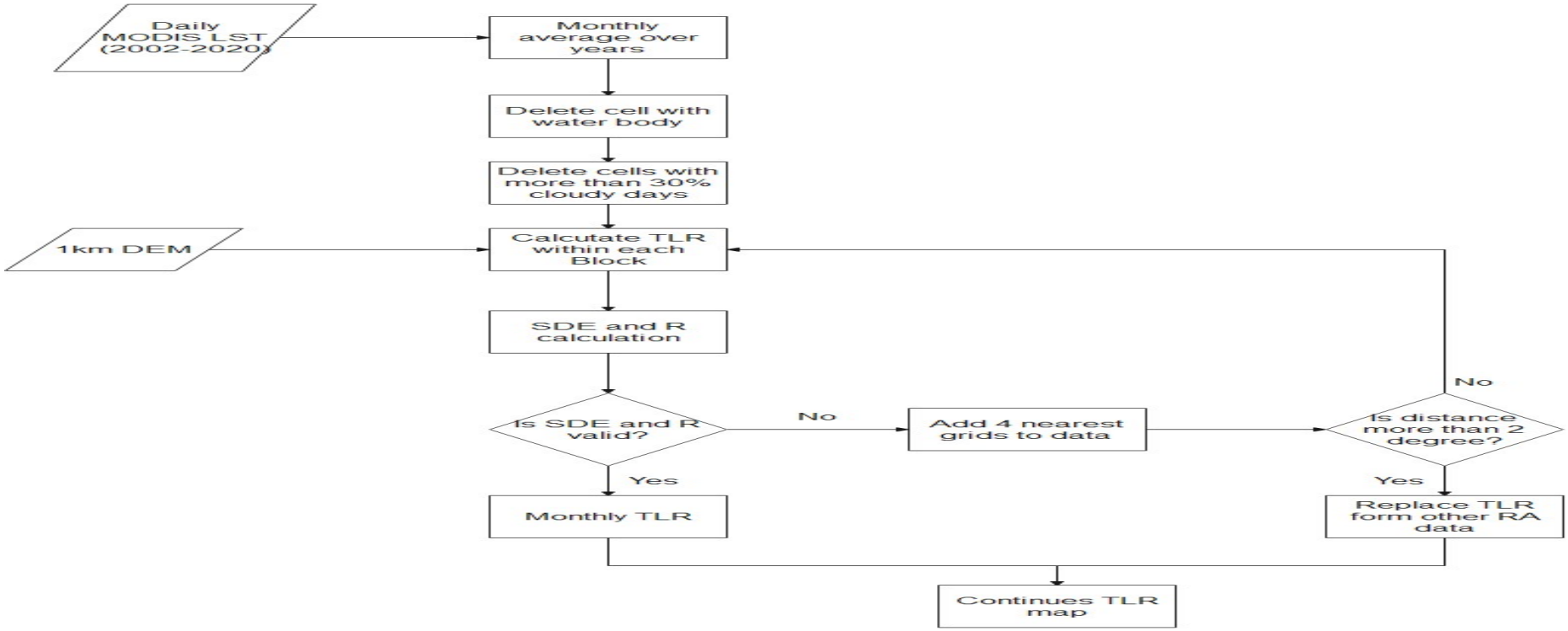
- TLR should not be more than 0.015 degree centigrade in meter
- Relationship between elevation and temperature should be significant
  - A threshold for Standard division of elevation (SDE) by trial and error
  - Correlation coefficient (R) should be significant

Downscale reanalysis data from their original spatial resolutions to 0.0083 KM

$$T_{DS} = T_{org} - [Z_{DS} - Z_{org}]TLR$$

Compare downscaled data with observed data using RMSE, MAE and NS

Method-TLR computation



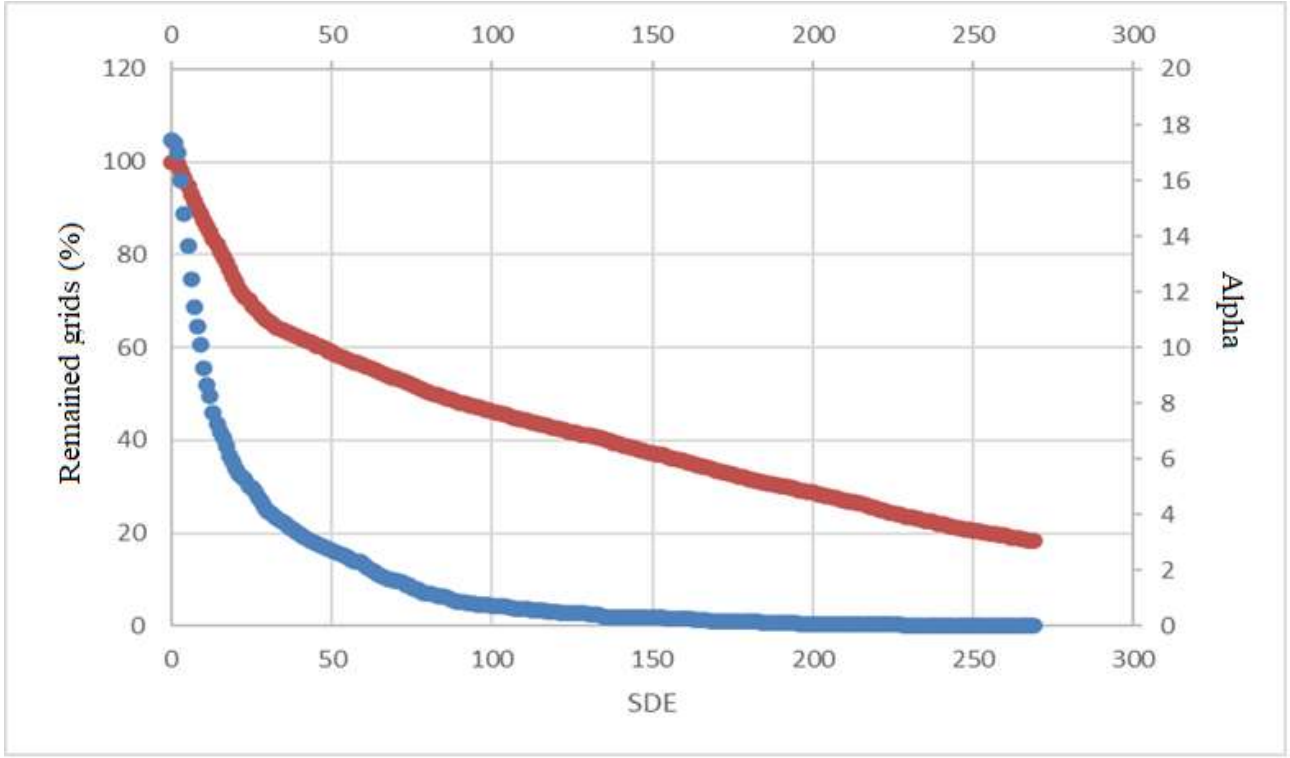
Results

Standard division of elevation (SDE) threshold: 66m

Correlation coefficient (R) should be significant

Blue: Alpha

Red: Remained grids (%)



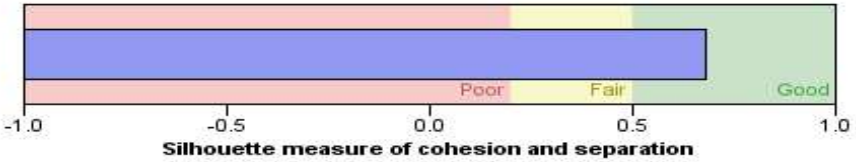
Elevation zoning

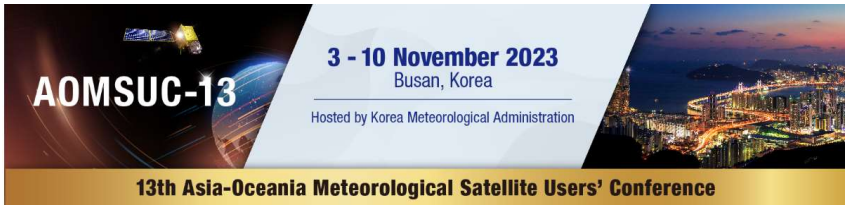
K-means and silhouette coefficient: 5 elevation clusters

Model Summary

Algorithm	TwoStep
Inputs	1
Clusters	5

Cluster Quality

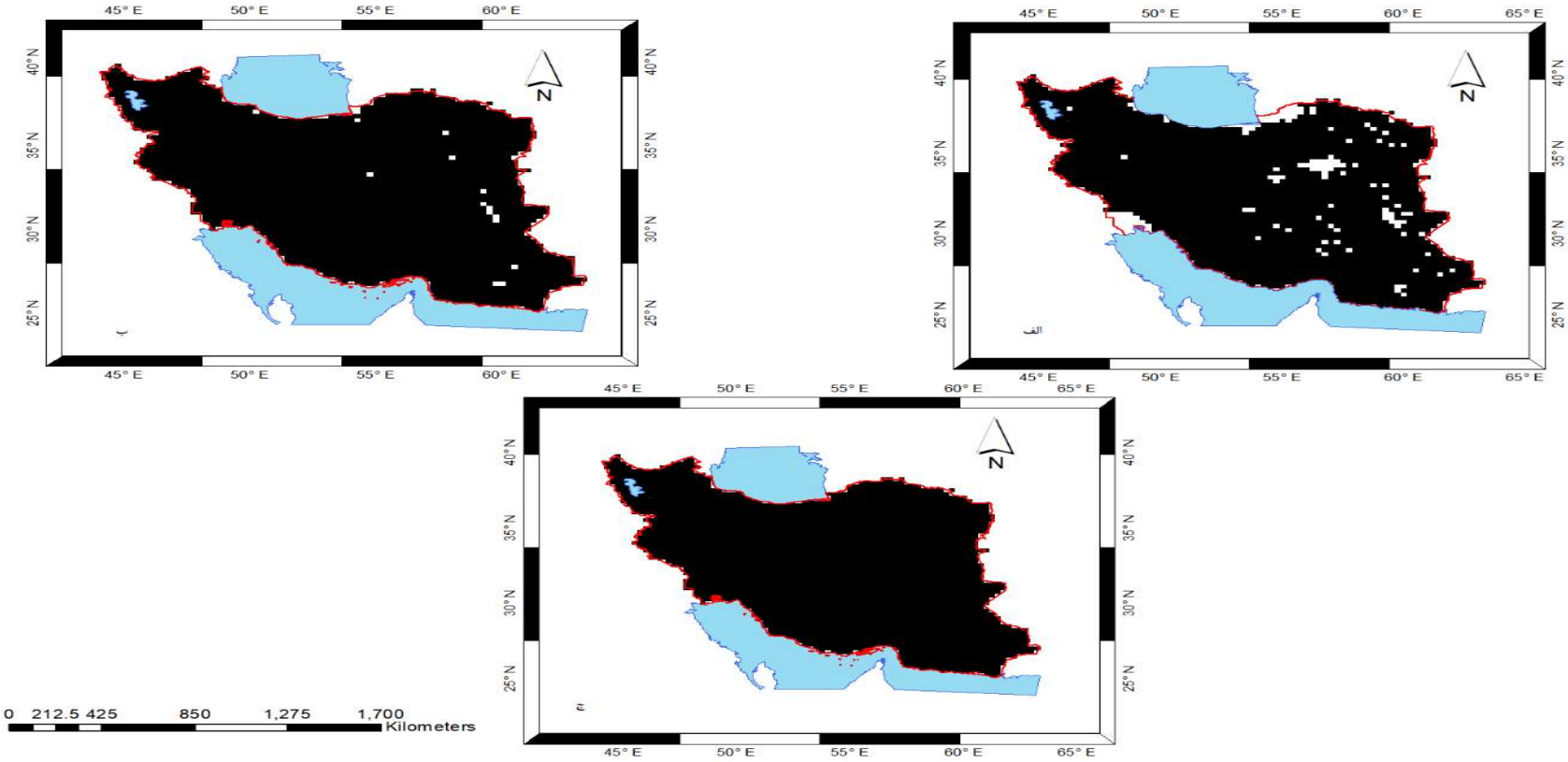




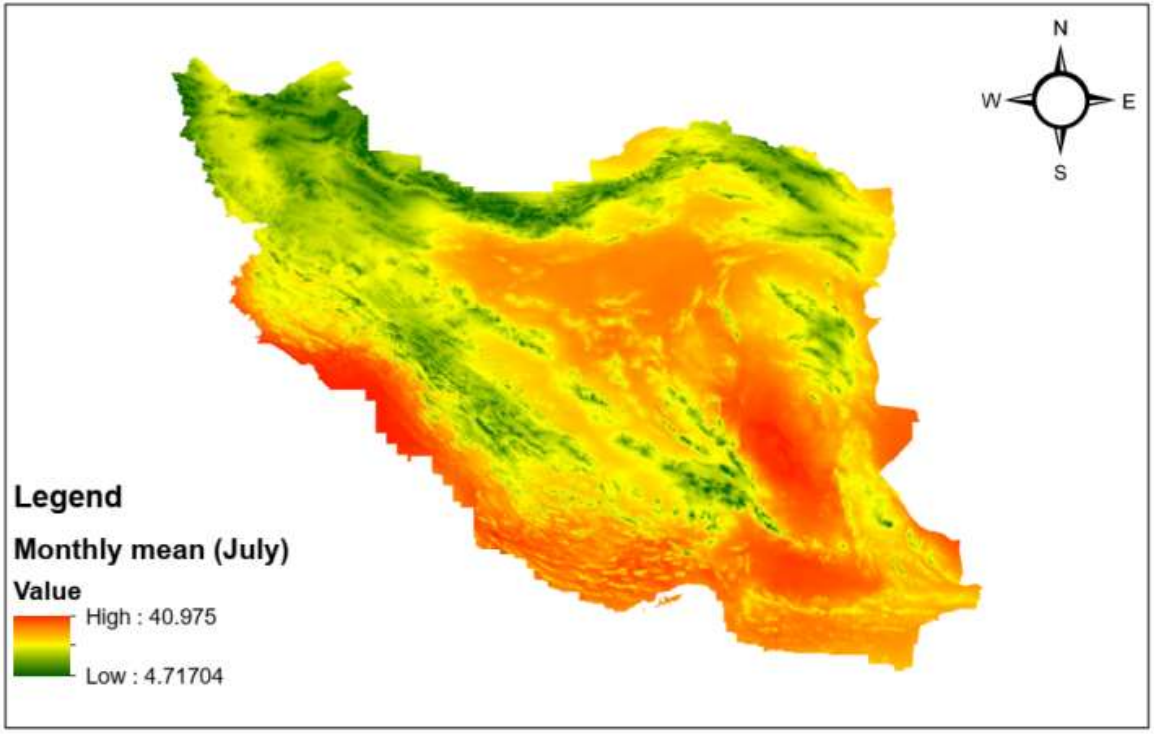
Elevation zoning

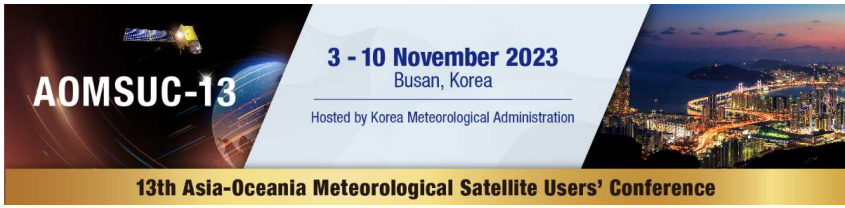
Elevation Class	AMSL	Number of Stations
Flat lands	103.95	59
Low lands	830.92	62
Moderately elevated	1349.85	101
Almost elevated	1748.48	70
Elevated lands	2268.26	25

TLR


45° E
50° E
55° E
60° E
65° E
40° N
35° N
30° N
25° N
N
0 212.5 425 850 1,275 1,700
Kilometers

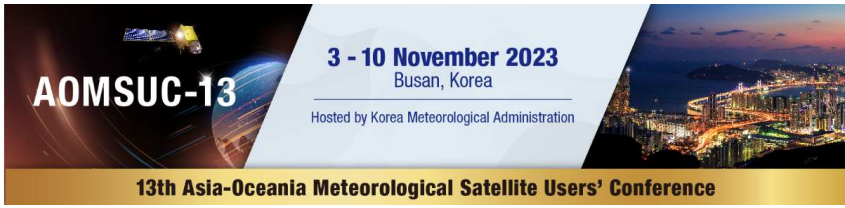
Sample Downscaled data





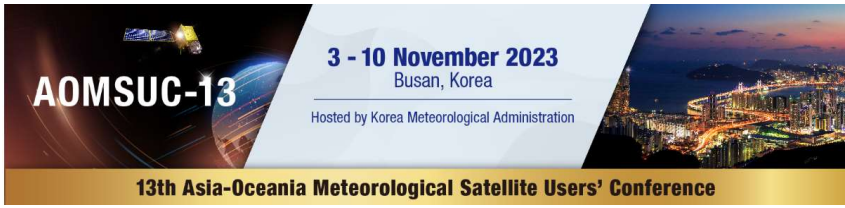
TLR

Climate Region	Min	Max	Range	Mean	Stdv
Cold and mountainites	-0.0145	0.0127	0.0271	-0.0042	0.0033
Moderate and dry	-0.015	0.0109	0.0259	-0.0034	0.0027
semi dry hot	-0.0083	0.0009	0.0092	-0.0032	0.0019
Semi-humid warm	-0.012	-0.0022	0.0098	-0.0066	0.0012
Caspian humid	-0.0113	0.0018	0.0131	-0.0024	0.0028
Very hot and dry	-0.0127	0.0140	0.0267	-0.0018	0.0026



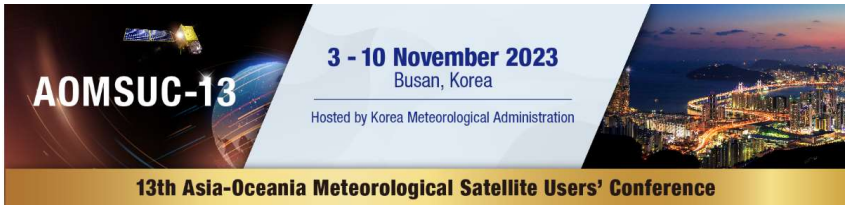
Downscaled grided data

Index									
NSE		MAE		R		RMSE			
DS data	Original data	DS data	Original data	DS data	Original data	DS data	Original data	RA Model	Elevation Class
0.88	0.84	1.98	2.43	0.99	0.99	2.27	2.70	ERA	Flat lands
0.86	0.83	2.35	2.64	0.98	0.98	2.74	3.02	CFS	
0.86	0.82	2.23	2.65	0.98	0.98	2.61	3.00	MERRA2	
0.87	0.82	2.59	3.25	0.99	0.99	2.88	3.51	ERA	Low lands
0.78	0.72	3.45	4.17	0.98	0.98	3.87	4.55	CFS	
0.83	0.76	3.01	3.87	0.98	0.98	3.37	4.19	MERRA2	
0.90	0.87	2.17	2.83	0.99	0.99	2.49	3.13	ERA	Moderately elevated
0.85	0.80	2.97	3.68	0.98	0.98	3.44	4.13	CFS	
0.89	0.85	2.45	3.10	0.98	0.98	2.88	3.49	MERRA2	
0.92	0.88	2.06	2.69	0.99	0.99	2.38	2.99	ERA	Almost elevated
0.88	0.84	2.77	3.36	0.98	0.98	3.25	3.82	CFS	
0.91	0.89	2.23	2.75	0.98	0.98	2.69	3.17	MERRA2	
0.87	0.84	2.54	3.06	0.99	0.99	2.92	3.42	ERA	Elevated lands
0.85	0.84	2.80	3.10	0.98	0.98	3.30	3.60	CFS	
0.89	0.89	2.26	2.52	0.98	0.98	2.70	2.93	MERRA2	



Downscaled grided data

Index										
NSE		MAE		R		RMSE				
DS data	Original data	DS data	Original data	DS data	Original data	DS data	Original data	RA Model	No. stations	Climate Region
0.94	0.91	1.82	2.41	0.99	0.99	2.09	2.67	ERA	71	Moderate and dry
0.87	0.81	2.86	3.54	0.98	0.98	3.28	3.95	CFS		
0.92	0.85	2.28	3.17	0.99	0.99	2.63	3.49	MERRA2		
0.91	0.86	2.19	3.05	0.99	0.99	2.49	3.29	ERA	22	Semi-humid warm
0.89	0.84	2.41	3.19	0.99	0.99	2.78	3.53	CFS		
0.90	0.85	2.26	2.79	0.99	0.99	2.58	3.09	MERRA2		
0.91	0.89	1.65	1.93	0.99	0.99	1.89	2.18	ERA	24	semi dry hot
0.86	0.80	2.04	2.35	0.98	0.98	2.39	2.68	CFS		
0.91	0.87	1.75	2.05	0.99	0.98	2.06	2.37	MERRA2		
0.87	0.83	2.09	2.54	0.98	0.98	2.46	2.88	ERA	25	Caspian humid
0.87	0.83	2.56	2.82	0.98	0.98	3.10	3.32	CFS		
0.86	0.80	2.32	2.74	0.97	0.97	2.83	3.21	MERRA2		
0.86	0.82	2.57	3.28	0.99	0.99	2.92	3.60	ERA	152	Cold and mountainites
0.83	0.79	3.12	3.71	0.98	0.98	3.60	4.18	CFS		
0.86	0.84	2.66	3.19	0.98	0.98	3.13	3.60	MERRA2		
0.92	0.92	1.94	2.13	0.99	0.99	2.22	2.40	ERA	23	Very hot and dry
0.84	0.78	3.16	3.75	0.98	0.98	3.57	4.13	CFS		
0.87	0.81	2.71	3.31	0.99	0.99	3.06	3.65	MERRA2		



Key Findings

Downscaling procedure applied in this study improved the spatial resolution of RA data to 1km

The produced 1km data set showed better performance in comparison with original data sets at all climate regions and elevation classes

ERA5 (both original and downscaled data) showed better performances

The highest improvement in precision was seen for MERRA2 and in low lands with 17% improvement and in moderate and dry climate region the improvement is 20%.