



# Comparative Analysis of Temperature Inversions and Influences of Aerosols and Radiation using ARM data in Shouxian and SGP



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## Introduction

Low-level atmospheric temperature inversions frequently occurred at middle and high latitudes. They influence the depth of vertical mixing in the boundary layer, surface radiation balance, cloud formation, and aerosol transport. In 2008, the ARM Mobile Facility (AMF) was deployed in China, and acquired high temporal and spatial resolution radiosonde data at Shouxian for nearly eight months. We are analyzing the measurements of atmospheric profiles, aerosol and radiation in Shouxian and SGP to obtain the statistical characteristics and monthly variation of temperature inversions, aerosols and radiation at these two sites.

## Data Used in the Study

ARM radiosonde, aerosol condensation, radiation and cloud base height data obtained in Shouxian and SGP, from May to December in 2008, are used in this study. These include:

- Radiosonde data from Balloon-Borne Sounding System
- Aerosol condensation data from CPC and OPC
- Radiation data from SKYRAD and GNRAD
- Cloud base height data from Vaisala Ceilometer

## Statistical Analysis of Shouxian and SGP Temperature Inversions

Clear-sky Inversion Freq.: 63.83%

Shouxian inversion freq: 37.26%(307/824) Clear-sky frequency: 58.37%(481/824)

time (LT)	clear	inversion	percent	<50m	50-100m	100-200m	200-500m	500-1000m	1000-2000m	2000-3000m	3000-4000m				
02:00	103	91	88.35%	73	0	2	3	4	5	3	1				
08:00	116	91	78.45%	49	12	11	6	3	5	4	1				
14:00	150	63	42.00%	0	0	2	7	11	31	9	3				
20:00	102	62	60.78%	31	0	1	2	7	13	6	2				
				165/307 53.75%				69/307 22.48%				76/307 24.76%			

0-100m, 02:00 and 08:00 (LT), inversion percent under clear sky: 70.9% and 52.6%

Clear-sky Inversion/clear freq: 76.11%

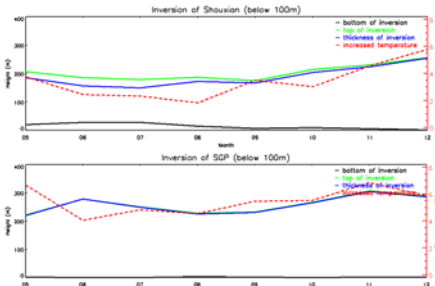
SGP inversion freq: 55.64%(513/922) clear-sky frequency: 73.10%(674/922)

time (LT)	clear	inversion	percent	<50m	50-100m	100-200m	200-500m	500-1000m	1000-2000m	2000-3000m	3000-4000m				
00:00	161	154	95.65%	131	0	2	4	8	5	3	1				
06:00	154	151	98.05%	130	0	4	7	7	3	0	0				
12:00	179	111	62.01%	1	0	1	22	40	32	9	6				
18:00	180	97	53.89%	22	0	2	3	23	31	16	0				
				284/513 55.36%				123/513 23.98%				99/513 19.30%			

0-100m, 00:00 and 06:00 (LT), inversion percent under clear sky: 81.4% and 84.4%

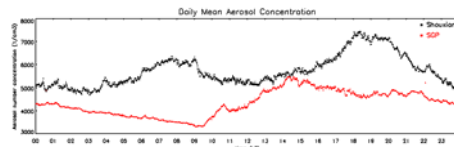
- The Shouxian inversions frequency is 37.26%, almost 20% less than that of SGP, and under clear sky, Shouxian inversions percent is 63.83%, 12% less than that of SGP.
- More than half of inversion layers occurred in Shouxian and SGP are near-surface inversions.
- At night and in early morning, more near-surface inversions occurred in SGP, due presumably to stronger radiation cooling.

## Monthly Change of Near-surface Inversions in Shouxian and SGP (05/2008-12/2008)



- The mean bottom, top, thickness and temperature increase of Shouxian near-surface inversion layers are 14.8m, 204.5m, 189.6m and 3.4°C, and those of SGP are 1.9m, 259.4m, 257.5m and 5.5 °C. Intensity of SGP near-surface inversions is stronger than that of Shouxian.
- Near-surface inversions has obvious seasonal changes at Shouxian. In the summer, intensity of inversions is the weakest, and bottom of inversions uplift from surface.
- Almost all of near-surface inversions are surface-based inversion at SGP, and its seasonal change is not obvious.

## Aerosol Concentration under Different Low-atmospheric Stable Conditions



- Mean aerosol concentration of Shouxian and SGP are 5732/cm<sup>3</sup> and 4341/cm<sup>3</sup> respectively, from July to December, 2008.
- During night time, Shouxian aerosol concentration is far greater than that of SGP.

	mean	No inversion	Inversion	Clear no inversion	Cloud no inversion	0-100m	100-1000m	1000-3000m
SGP	4305	3712	4614	4306	3356	4752	5107	4245
Shouxian	6787	6448	7506	6678	6192	7681	5639	7814

- Mean aerosol concentration of Shouxian and SGP during radiosonde observations are 6787/cm<sup>3</sup> and 4305/cm<sup>3</sup> respectively.
- Under clear sky, the occurrence of inversions led to increases of aerosol concentration by 12.4% (Shouxian) and 7.2% (SGP). Near-surface inversions incurred higher aerosol concentration, 15.0% at Shouxian, 10.4% at SGP.
- Inversions occurred above 1km increased aerosol concentration by 17% at Shouxian, but it decreased by 1.4% in SGP.
- At night and in the morning, the presence of near-surface inversions, aerosol concentrations increased by 23.8% and 50.8% at Shouxian and SGP respectively.

## Radiation in Shouxian and SGP under Different Low-atmospheric Stable Conditions

	mean	No inversion	Inversion	Clear no inversion	Cloud no inversion	0-100m	100-1000m	1000-3000m
SGP Upwelling Long-wave	402.2	424.7	384.9	473.1	393.7	374.1	378.3	429.4
SGP Downwelling Long-wave	344.7	379.5	318.1	391.1	372.0	319.7	295.8	344.3
Shouxian Upwelling Long	402.9	423.4	376.0	437.4	416.8	353.8	389.7	410.9
Shouxian Downwelling Long	352.7	384.0	311.2	363.7	393.5	297.1	319.9	330.8

- Under clear sky, when inversions occurred, up-welling, down-welling and net up-welling long-wave radiation **decreased** by near 15% in Shouxian, and by 18.6% in SGP.
- At night (inversions formation), most inversions occurred near surface, up-welling and down-welling **decreased** by 11.2% and 15.7%, and net up-welling long-wave radiation **increased** by 22.1% in Shouxian. At SGP site, up-welling and down-welling **decreased** by 6.0% and 8.9%, and net up-welling long-wave radiation **increased** by 15.0%.
- In the morning (inversion development and dissipation), most inversions also occurred near surface, Shouxian up-welling and down-welling long-wave radiation **decreased** by 15.5% and 22.3%, net upwelling long-wave radiation **increased** by 39.5%. In SGP, up-welling long-wave radiation and down-welling long-wave radiation **increased** by 4.0% and 13.2%, net up-welling long-wave radiation **decreased** by 22.8%.

## Summary

Shouxian and SGP are located in different continents of similar climate, but different atmospheric conditions. This study analyzed the statistical characteristics of inversions, its effect on, and interactions with, aerosols and the relationship between long-wave radiation and inversions in Shouxian and SGP. The results are as following: (1) Shouxian inversions frequency is less than that of SGP, and more than half inversions occurred near surface at both sites. (2) Shouxian mean aerosol concentration is much higher than that of SGP, and the occurrence of inversions increase aerosol concentration at the two sites, but higher inversions have little impact on SGP aerosols. (3) The development of near surface inversions have a close relationship with net up-welling long-wave radiation.

## Future Work

- Using 1-D coupled atmospheric boundary layer (ABL) and radiation-transfer model to simulate the interaction between aerosols, radiation and inversions, and the evolution of inversions and general boundary conditions in Shouxian and SGP.

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