

Chinese lockdown as aerosol reduction experiment

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ABSTRACT

The lockdown of large parts of chinese economy beginning in late January 2020 lead to significant regional changes of aerosol loads, which suggests a reduction of backscatter and consequently a regional warming in the following months. Using local data and a numerical experiment with a limited area model, we have examined how strong this response may have been. The observed (local and re-analysis) observations point to a warming of less than 1.0° , the simulations to a warming of about 0.5° . These numbers are uncertain, because of large-scale natural variability and an ad-hoc choice of aerosol optical depth anomaly in the simulation. Thus, the result was, in short, that there was actually a weak warming of a few tenth of degrees, while noteworthy changes in circulation or in precipitation were not detected.

More specifically, we found

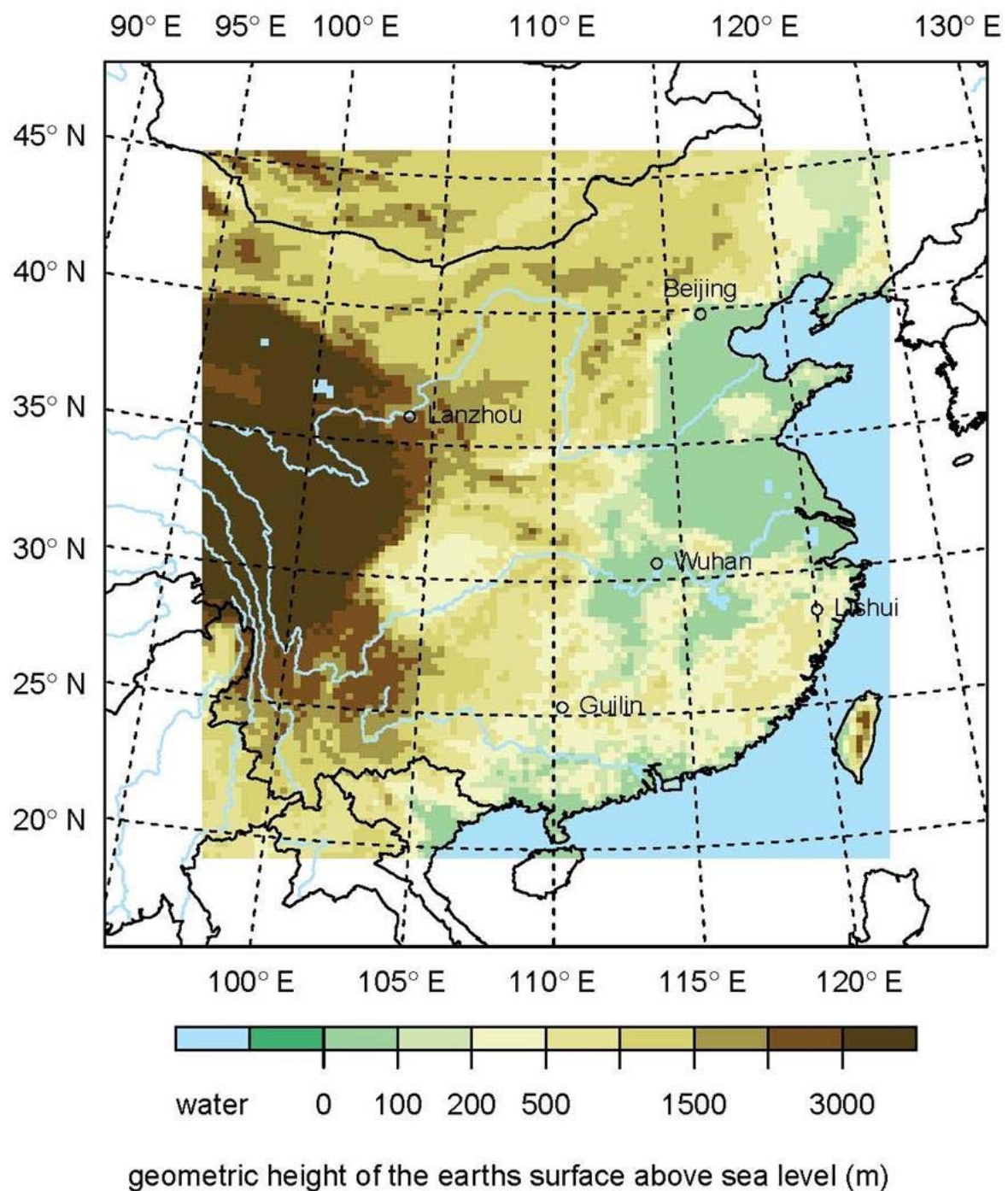
- at selected central China stations temperature were found to be higher than in previous 2 years. This warming goes with a marked **diurnal** signal. Maximum warming in the early afternoon (06 UTC), weakest at night (18 UTC)
- This may be related to a **general warming** of large swaths of Asia (including Siberia, which is not related to local aerosol forcing. Indeed, also the stations outside the immediate strong lockdown are showing a albeit weaker warming. Thus, the difference 2020 minus 2919/2018 may overestimate the effect.
- The ad-hoc numerical experiment indicates that the change caused by the overall reduction of the atmospheric optical depth does not lead to phases of larger deviations of local time series in the simulations. Instead, the simulations with reduced aerosol load show more a mere locally increased temperature. This may indicate that the aerosol effect is mostly local thermodynamic.

MOTIVATION / CHALLENGE

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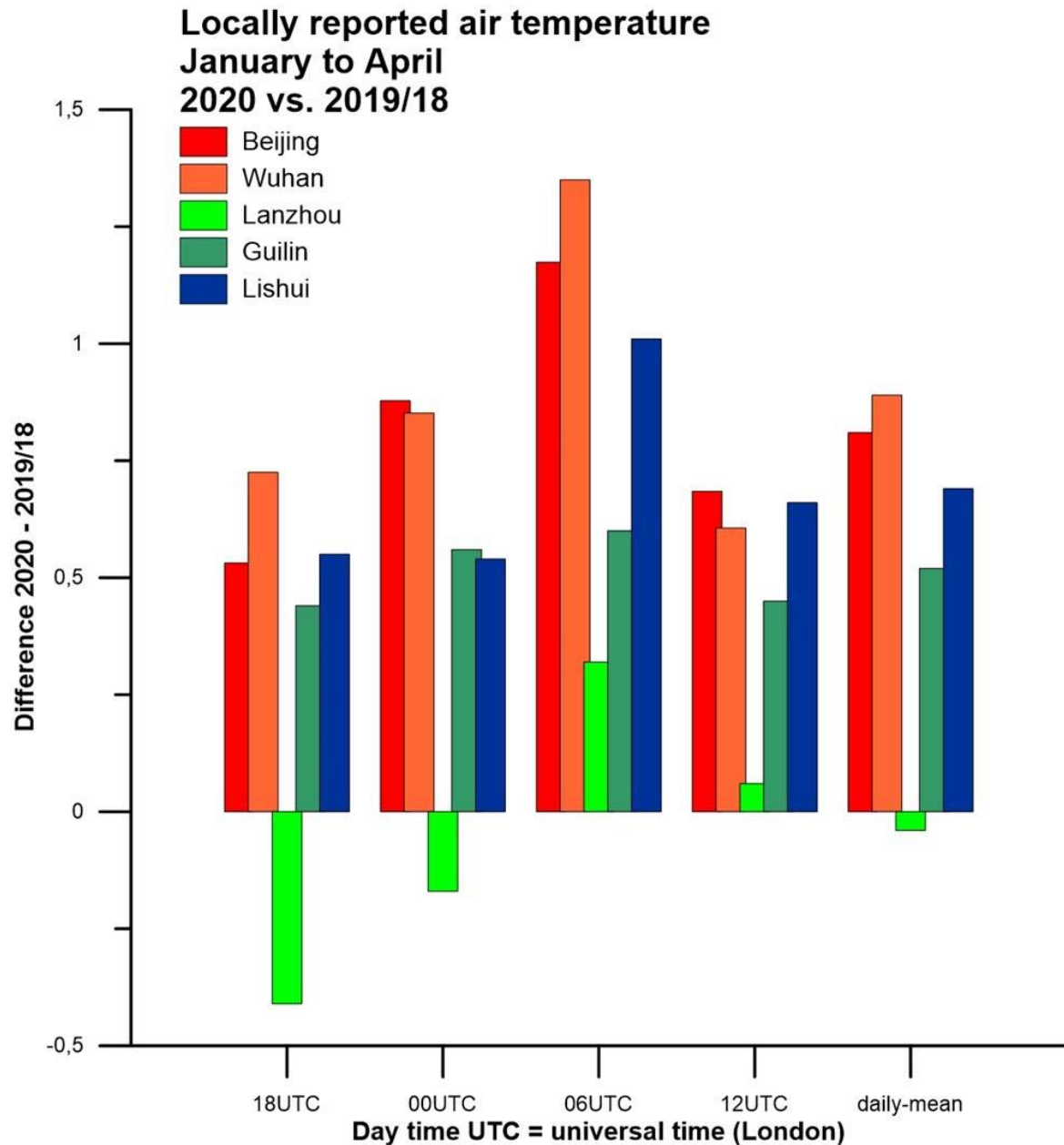


location of used meteorological stations and region covered by the limited area model

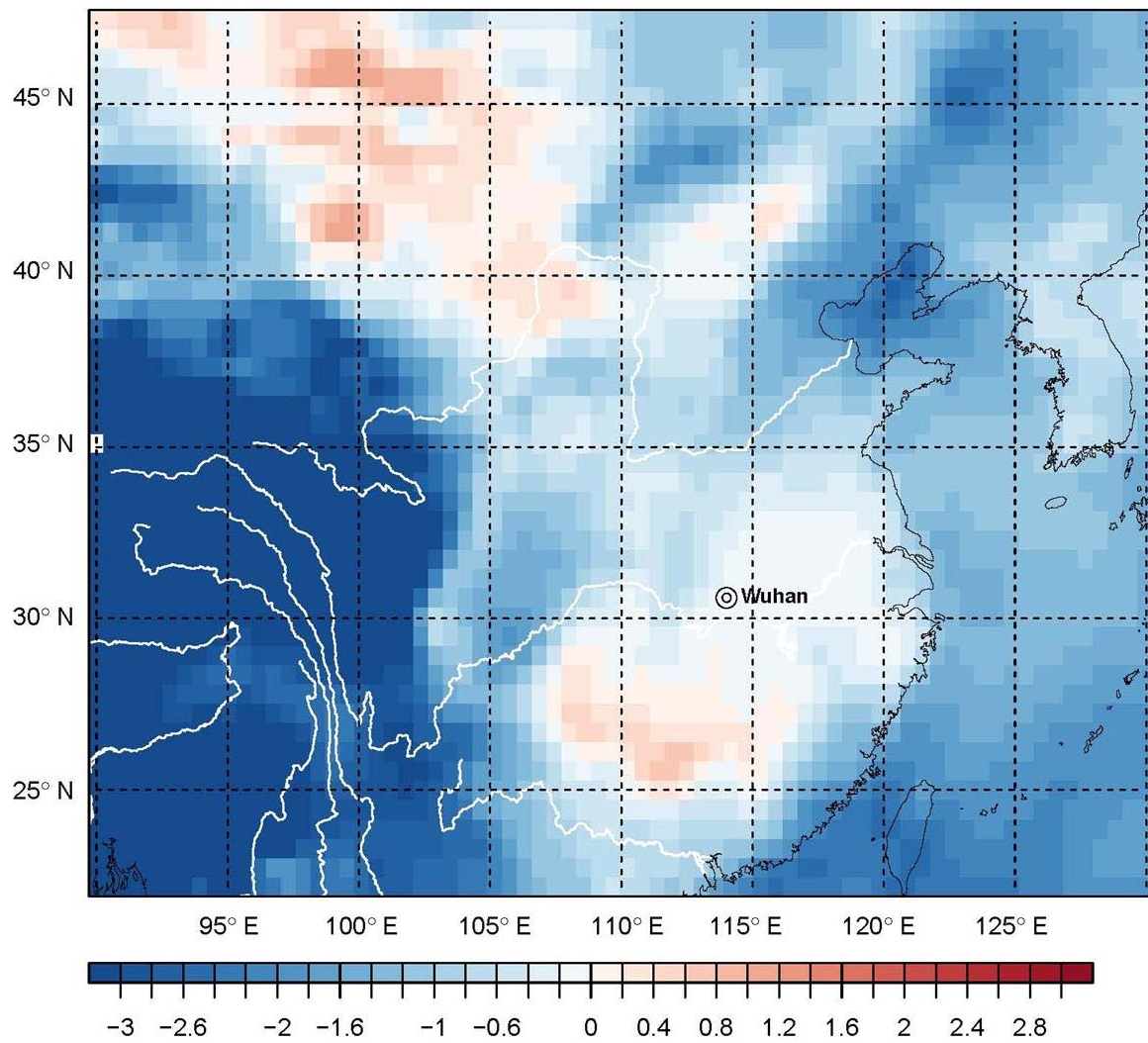
OBSERVATIONAL EVIDENCE

A problem with determining the change from observed data is that there happen large changes of the aerosol optical depth with a significant decrease since about 2010. Therefore, we examine the difference between the JFMA-period in 2020 and in 2019/18.

A number of locations were chosen (see map), with Wuhan and Beijing in the center of the lockdown, a unaffected remote station in the far west, Lanzhou, and two stations in the south, Guilin and Lishui.



The relative warming shows a marked diurnal cycle, with maxima at local early afternoon. The effect amounts to about 0.7K at Wuhan and Beijing, is weaker in the southern stations and absent in the far west.

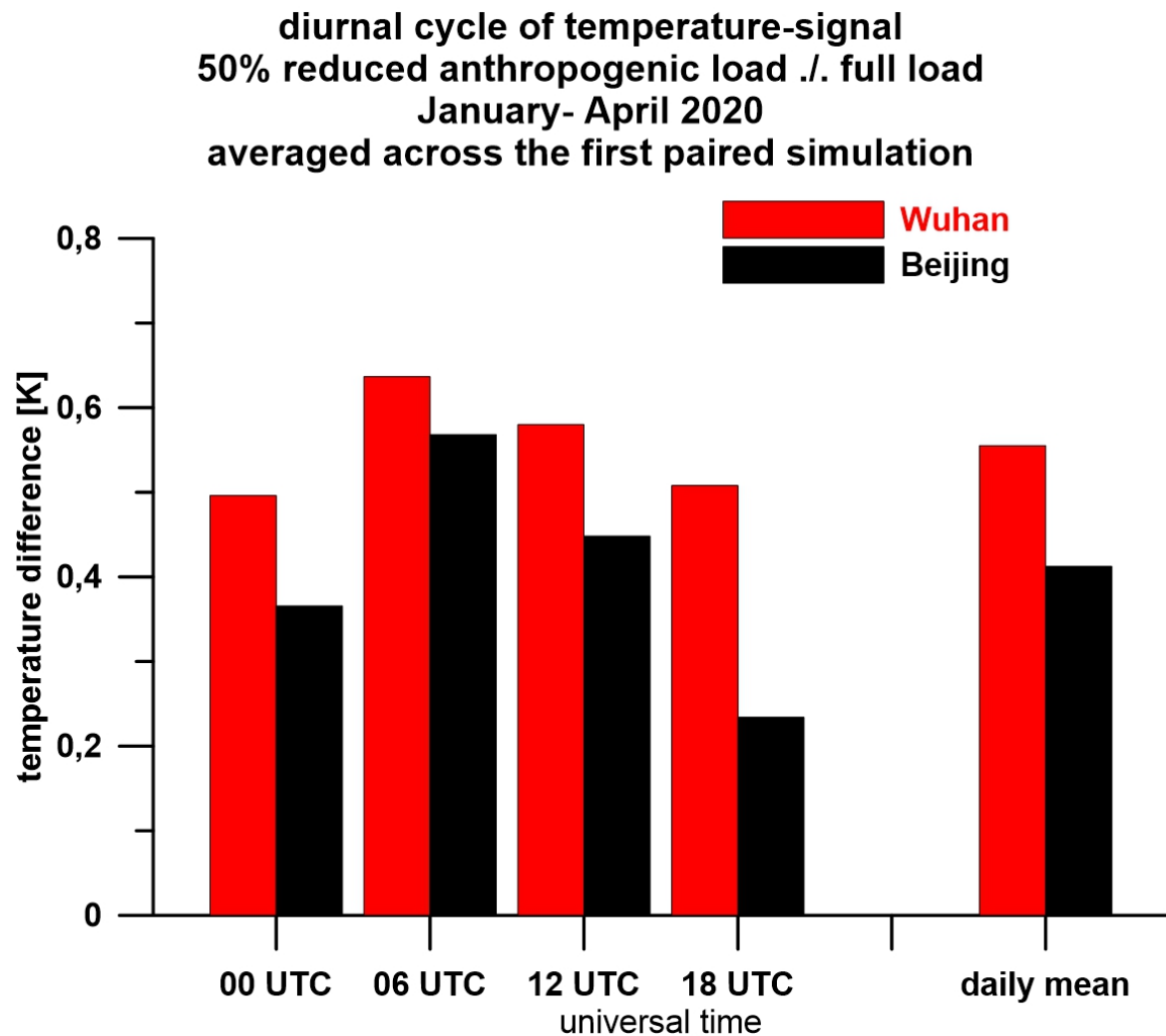


Differences of 2020 and 1990-2019 daily mean temperatures according to the JRA55 analysis - relative to the same difference in Wuhan.
 Thus, in the surrounding area of Wuhan the warming of 2020 is larger than in more remote areas, indicating that the local warming in Wuhan is not due to regional synoptic processes.

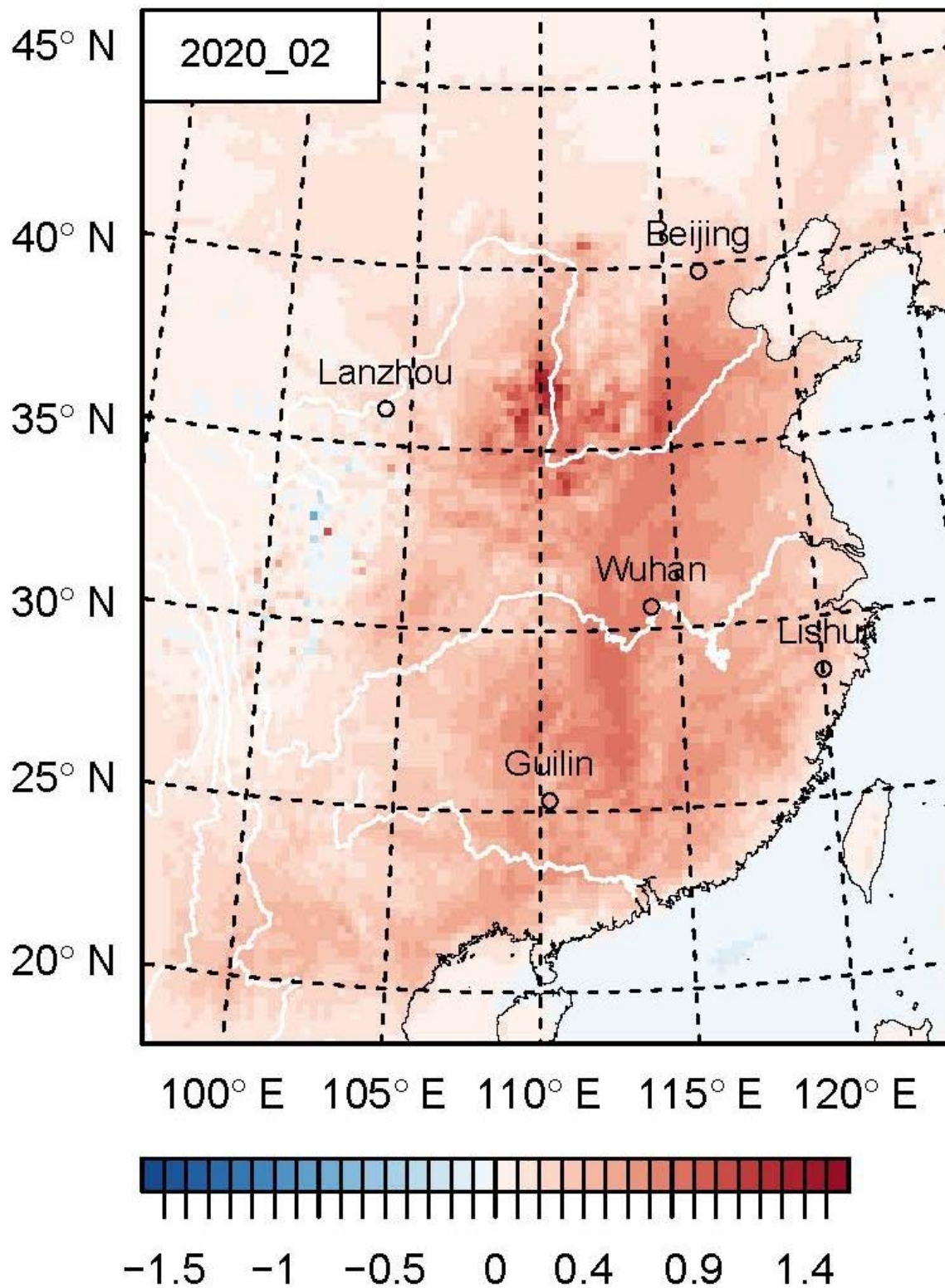
MODELLING

To further estimate the expected climatic response to an increased aerosol optical depth due to the lockdown an ensemble of simulations covering China extending across January to April 2020 was done.

The model is COSMO._CLM with a horizontal grid of about 0.22° , with lateral forcing given by JRA55. The radiation scheme uses the aerosol optical depth, single scattering albedo and asymmetry factor given by the MAC-v2 climatology. Three pairs of simulations were done, one with the anthropogenic load given in 2019 (control) and one with the anthropogenic load everywhere reduced by 50%. This is thought to be a rough estimate of the changed conditions in 2020 due to the lockdown



The effect causes in Beijing and Wuhan a mean increase of temperature of 0.5K



Ensemble-mean for February 2020 representing the effect of a 50% reduction of anthropogenic AOD in all of China. Spatially, the whole central and southern part of China is affected by an increase of temperature.

These effects repeat in all three pairs of simulations.

CONCLUSION

- At selected central China stations temperature were found to be higher than in previous 2 years. This warming goes with a marked **diurnal** signal. Maximum warming in the early afternoon (06 UTC), weakest at night (18 UTC)
- This may be related to a **general warming** of large swaths of Northern Asia which is not related to local aerosol forcing. Indeed, also the stations outside the immediate strong lockdown are showing an albeit weaker warming. Thus, the difference 2020 minus 2019/2018 may overestimate the lockdown effect.
- The ad-hoc **numerical experiment** with an overall 50%-reduction of anthropogenic aerosol load results in an overall warming is of the order of half a degree with maxima at about noon time, and minima during night.
- The numerical experiment indicates that the reduction of the atmospheric optical depth does not lead to phases of larger deviations of local time series in the simulations has hardly an effect on synoptic dynamics, and the temperature increase is a local effect, albeit everywhere.