**A stress-test of heat health warning systems and actions plans under future climate change scenarios**

# Abstract

Heat waves can cause a significant increase in morbidity and mortality in vulnerable populations.1,2 In response, many national and regional administrations have developed their own heat health warning systems and action plans designed to minimise extreme heat exposure of the most vulnerable.3,4

Heat waves, however reasonably defined, are expected to increase in frequency and duration over the next century under all viable future climate change scenarios.5 This casts a special focus on how action plans are designed and equipped to handle heat waves in the next century. It is thus incumbent on those in the climate and health research communities to scrutinise the limits and tolerance levels of such plans, and to understand how prepared we will need to be for future heat waves.

In our analysis, we will ‘stress-test’ a representative selection of warning system and action plans. By using a future global climate projections of the 21st century in conjunction with thresholds explicit in identified warning systems, we will assess the number of times actions plans will need to be implemented, as well as how exposure to alert days are projected to change by using population projections.

This study will provide a quantitative framework on the requirements of future action, in terms of financial and human cost. The aim of the study is to judge the feasibility of such action plans under projected climate change.

# Example work

Using the Ahmedabad Heat Action Plan6, warning thresholds are obtained

(table 1).

|  |  |  |
| --- | --- | --- |
| **Yellow alert** | Hot Day Advisory | 41.1-43°C |
| **Orange alert** | Heat Alert Day | 43.1-44.9°C |
| **Red alert** | Extreme Heat Alert Day | ≥45°C |

Table 1: Ahmedabad Heat Action Plan warning thresholds based on daily maximum temperatures

Using the KNMI Climate Explorer, projections for daily Tmax in 2046-2065 and 2081-2100 were obtained for the Ahmedabad grid square using CSIRO Mk3 Climate System Model under the A2 scenario.7

Figure 1 and Figure 2 show the daily Tmax values, demonstrating the greater frequency of red, orange, and yellow alerts.

../../../../../output/plot2.pdf

Figure 1. Ahmedabad alert days 2046-2065

../../../../../output/plot3.pdf

Figure 2. Ahmedabad alert days 2081-2100

The statistics of the alert days under the A2 scenario are shown in Table 2:

|  |  |  |
| --- | --- | --- |
| Alert level | Percentage of alert days 2046-2065 | Percentage of alert days 2081-2100 |
| **No alert** | 89.4 | 83.1 |
| **Yellow alert** | 7.0 | 9.1 |
| **Orange alert** | 2.6 | 5.0 |
| **Red alert** | 0.9 | 2.7 |

Table 2. Statistics of alert days in Ahmedabad, 2046-2065, 2081-2100 under A2 scenario.

Using Gridded Population of the World, from the Socioeconomic Data and Applications Centre (SEDAC) for population estimates of the year 2000, and population projections consistent with climate change scenarios8, we will analyse the change in exposure of Ahmedabad’s population (not done yet).

Under this framework, we have a quantitative analysis of the frequency of the alert days, as well as the population exposed.

# References

1 Basu R. High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. *Environ Heal* 2009; **8**: 40.

2 Ye X, Wolff R, Yu W, Vaneckova P, Pan X, Tong S. Ambient temperature and morbidity: a review of epidemiological evidence. *Environ Health Perspect* 2012; **120**: 19–28.

3 Lowe D, Ebi KL, Forsberg B. Heatwave early warning systems and adaptation advice to reduce human health consequences of heatwaves. *Int J Environ Res Public Health* 2011; **8**: 4623–48.

4 Lowe R, García-Díez M, Ballester J, *et al.* Evaluation of an early-warning system for heat wave-related mortality in Europe: Implications for sub-seasonal to seasonal forecasting and climate services. *Int J Environ Res Public Health* 2016; **13**. DOI:10.3390/ijerph13020206.

5 Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia VB and PMM (eds. . Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. *CEUR Workshop Proc* 2015; **1542**: 33–6.

6 Azhar GS, Mavalankar D, Nori-Sarma A, *et al.* Ahmedabad Heat Action Plan 2017. *PLoS One* 2014; **9**. DOI:10.1371/journal.pone.0091831.

7 Gordon HB, Rotstayn LD, McGregor JL, Dix MR, Kowalczyk, O’Farrell SP, Waterman LJ, HirstAC, Wilson SG, Collier MA, Watterson IG ET. The CSIRO Mk3 climate system model. *Asoendale CSIRO Atmos Res Tech Pap* 2002; : 130.

8 Jones B, Neill BCO, Hegre H, *et al.* Spatially explicit global population scenarios consistent with the Shared Socioeconomic Pathways. *Environ Res Lett* 2016; **11**.