APRIL 2018

ANTICIPATING CRISES DUE TO EXTREME HEAT IN PAKISTAN:

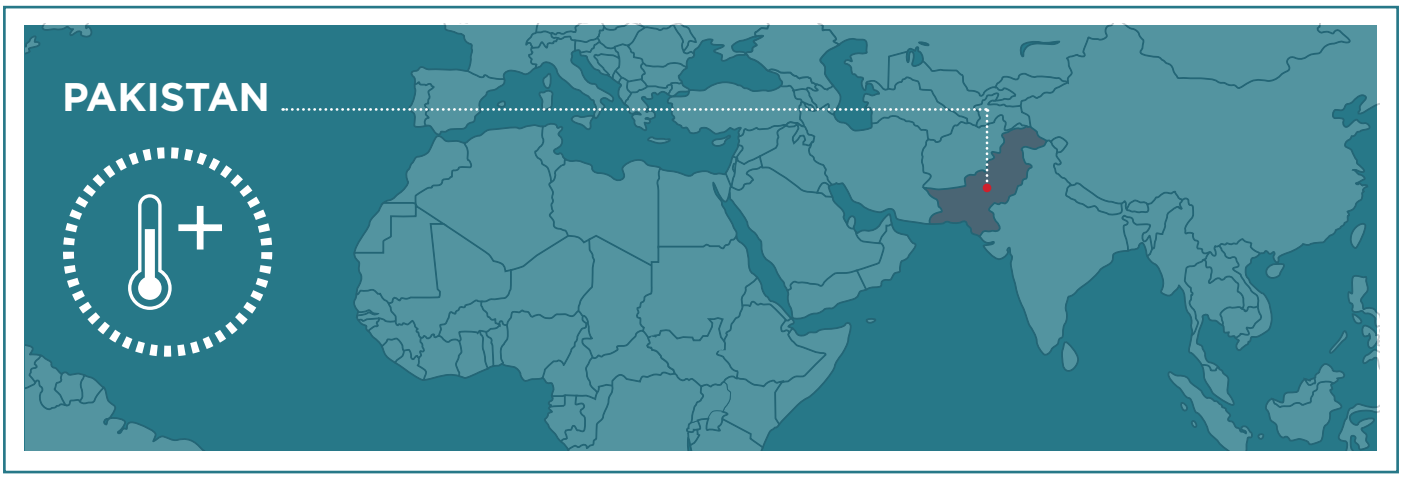
USING WEATHER FORECASTS EFFECTIVELY

LSE NERC SCIENCE OF THE ENVIRONMENT

This document sets out the best sources of useful information to look at when considering anticipatory humanitarian action in advance of extreme heat in Pakistan. It has been produced by Dr Erica Thompson of LSE's Centre for the Analysis of Time Series (funded by the Natural Environment Research Council) in partnership with the Start Network.

Executive Summary

- **Forecast information should signal the possibility of extreme heat 7-10 days before the event. This gives time to raise an anticipatory alert, perhaps conditioning activation on forecast confirmation around 5 days in advance of the event or on an official alert being issued by the government.**
- **Humanitarian impacts of extreme heat are not only dependent on the highest temperatures measured by a thermometer. Where high temperatures continue overnight and for several days, or where humidity levels are also high, these factors reduce people's ability to cope with the heat.**
- **Published Heat Action Plans *(eg Karachi, Ahmedabad)* provide useful reference points for assessing the impact of different forecast events. Coastal/humid regions are likely to suffer greater impacts at lower temperatures than inland/drier regions, due to the additional effect of humidity.**
- **Any reputable national or commercial forecast *(Pakistan Meteorological Department, UK Met Office, Accuweather, etc)* will give good basic information for the next three days and an indication of possible changes developing over the next week.**
- **Where extreme heat appears to be developing, more detailed forecasts can be found up to about 8-10 days in advance. The best easily-accessible forecasts are the PMD maps of *daily maximum* and *minimum* temperatures. 11-day *city-level forecasts* are also available from *PMD* and from the Japanese Meteorological Agency. These show the likely duration of the event.**
- **There are no reliable detailed forecasts beyond about 10 days lead time. Experimental seasonal forecasts may give a tentative indication of increased or decreased likelihood of extreme heat over the coming months. *Measurements of soil moisture* can help assess the likely impact of extreme heat if it were to occur.**
- **During a declared heatwave event, the most reliable short-term (3-day) forecasts will be those issued by the PMD (*alert page for Karachi* already live).**



DEFINING EXTREME HEAT

Many different definitions of "extreme heat" and "heatwave" exist, which make it hard to compare studies with each other. Daytime maximum temperatures are the most strongly linked to humanitarian impact, especially where they are extended over consecutive days and where they are more unusual for the area in question.

THE HUMANITARIAN IMPACT ALSO DEPENDS ON OTHER PHYSICAL FACTORS SUCH AS:

- **High night-time temperatures** are strongly linked to increased death rates, but if the temperature drops overnight this offers cooling opportunities
- **High humidity** and **low wind speed** each make it harder to stay cool by evaporation
- **Low soil moisture** increases the impact of extreme heat, especially in rural areas.
- Large urban areas of concrete and metal contribute to an **urban heat island effect** which gets hotter during the day and retains more heat at night.

THE HEATWAVE IN KARACHI IN JUNE 2015 WAS EXACERBATED BY ALL OF THESE FACTORS.

KARACHI NOW HAS A HEATWAVE MANAGEMENT PLAN WHICH SPECIFIES TEMPERATURE LEVELS FOR ADVISORY, WARNING & EMERGENCY STATES.

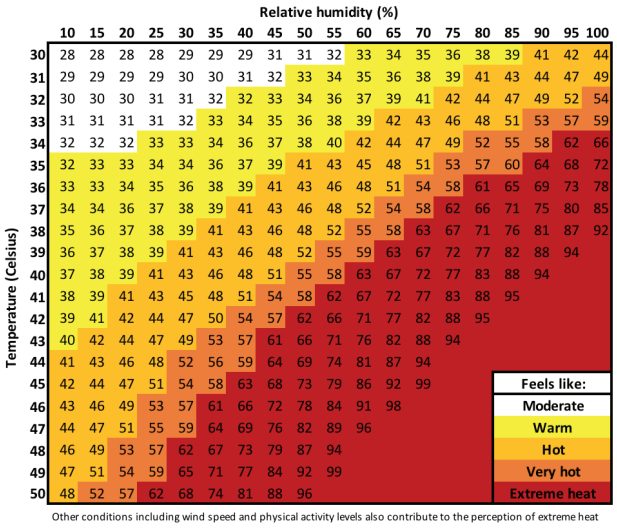
TYPE OF ALERT	CRITERIA
HEATWAVE EMERGENCY	≥42°C FORECAST AND **MINIMUM** TEMPERATURE ≥30°C FOR 2 OR MORE DAYS When there are significant levels of heat related illness & even mortality there must be the declaration of a Heatwave Emergency & a rapid response regardless of specific weather criteria
HOT DAY WARNING	FORECAST ≥42°C
HOT DAY ADVISORY	FORECAST 40°C - 41.9°C

1 **Thresholds for warnings in Karachi Heat Management Plan, suitable for use to assess the impact of forecast temperatures in coastal & humid areas** (Sindh & Balochistan coastal regions).

AHMEDABAD IN GUJARAT (INLAND, AND MORE COMPARABLE IN CLIMATE TO INLAND PAKISTAN REGIONS) USES ALERT THRESHOLDS DEFINED IN THE AHMEDABAD HEAT ACTION PLAN 2018

TYPE OF ALERT	TEMP. THRESHOLD °C
EXTREME HEAT ALERT DAY	≥45°C
HEAT ALERT DAY	43.1°C - 44.9°C
HOT DAY ADVISORY	41.1°C - 43°C

2 **Thresholds for warnings in Ahmedabad Heat Action Plan, suitable for use to assess the impact of forecast temperatures in drier inland regions of Sindh, eastern Balochistan, and southern Punjab.**

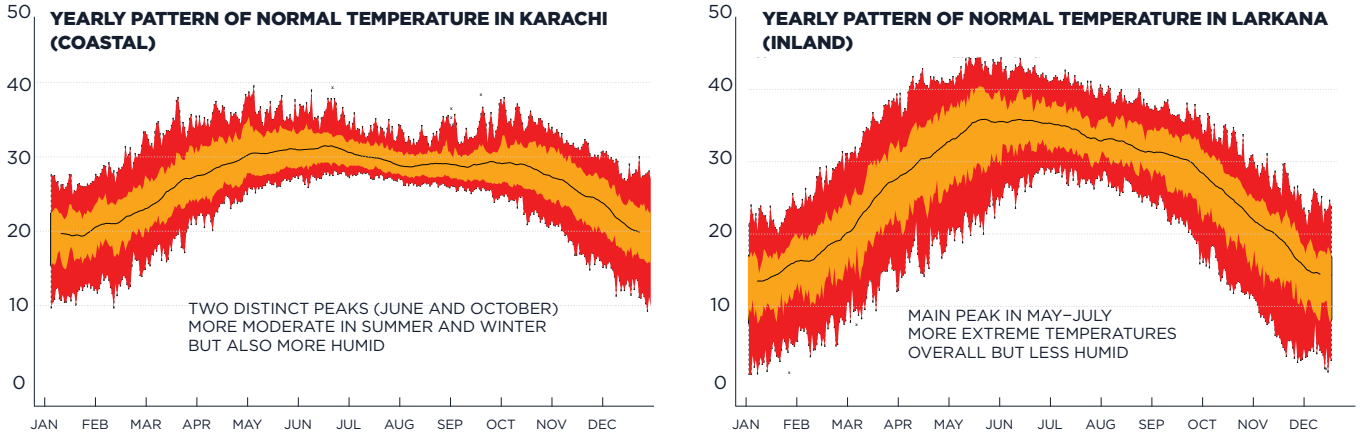


Other conditions including wind speed and physical activity levels also contribute to the perception of extreme heat

3 **This Heat Index takes into account both temperature and relative humidity levels to give a "feels like" temperature in these conditions. Calculated using *NOAA published formula*, with colour shading chosen to approximately match alert criteria above. Note that there is no single accepted "Heat Index" and different providers may use different formulas.**

Date	Location	T	RH	Heat index
20/06/10	Dera Ismail Khan	47	45	76
20/06/15	Karachi	45	50	73
21/06/15	Turbat	49	40	73
20/04/17	Jacobabad	48	36	67
22/05/13	Lahore	46	27	57
17/06/14	Sialkot	43	40	57
29/06/10	Multan	42	40	54
27/06/10	Multan	50	15	52

4 **Examples of temperature (T) and relative humidity (RH) measurements used to determine a Heat Index ("feels like" temperature) for some historical extreme heat events in Pakistan. Relative humidity forecasts for the next ten days can be found in the city-level forecasts as shown on page 4. Relative humidity often goes down as temperature goes up."**



5 **Yearly patterns of normal temperature based on 2010-2017, showing the difference between Karachi and Larkana regions. Black line shows the most common (median) temperature for the time of year, orange zone is the normal variation around that and red zone is a more extreme variation. Note that this is an average over a region, so individual weather stations** (especially in urban areas) **will record more extreme temperatures.**

In more hilly/mountainous regions, where normal temperatures are lower on average, a lower threshold may be appropriate as high temperatures are in themselves more unusual. A single threshold for hilly regions would not make sense because altitudes and therefore normal temperatures vary greatly. *Normal monthly mean and maximum temperatures for a few cities are available for comparison.*

Of course, the potential impact also depends on many human factors such as working patterns, religious observance, power availability, populations engaged in outdoor manual labour, access to cooling spaces, community vulnerability and access to medical care. These should be taken into account in the preparation of an alert note.

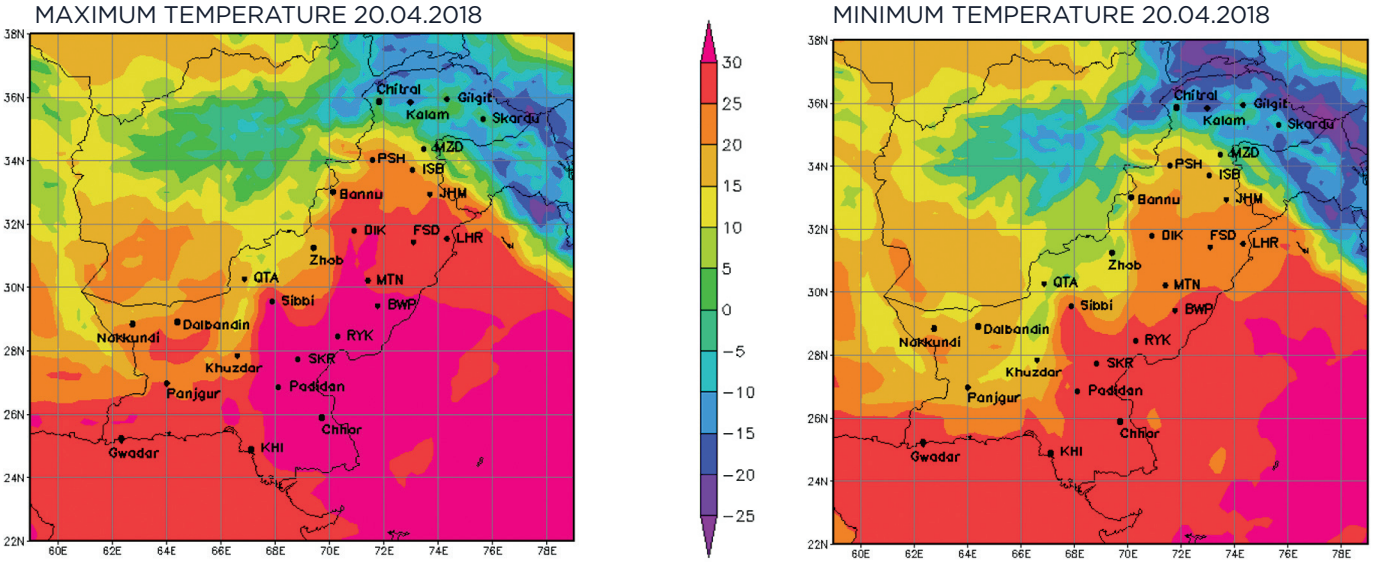
WHAT FORECASTS ARE AVAILABLE IN PAKISTAN?

SHORT-TERM (UP TO 3 DAYS)

Pakistan Meteorological Department (PMD) have access to better model runs than most commercial providers. Up to 3 days this is likely to be the most accurate forecast for local detail and the PMD will issue advisories based on their forecast during a declared heatwave event.

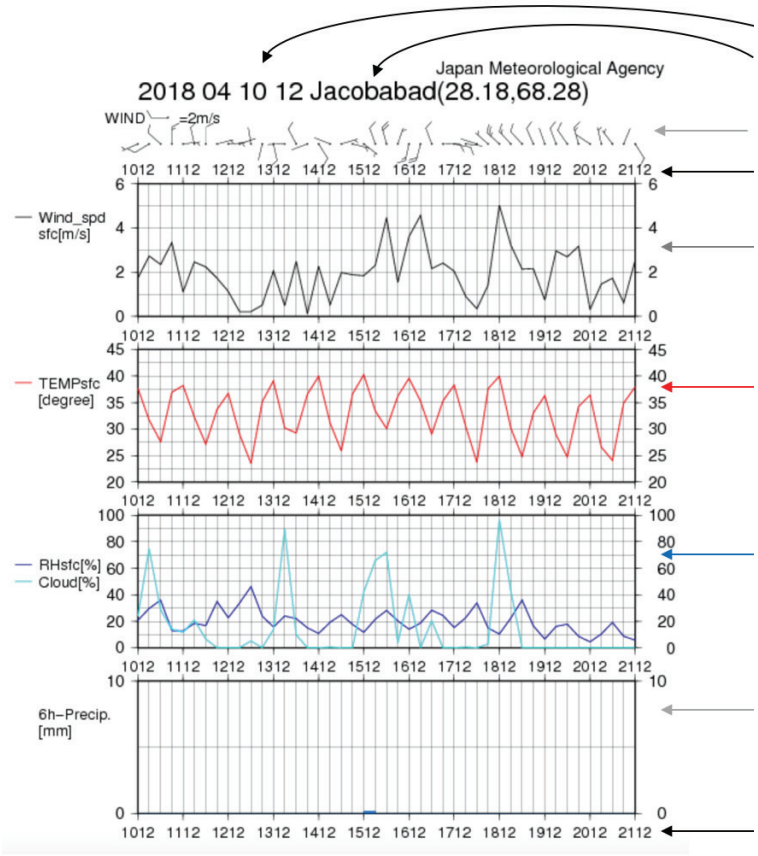
MEDIUM-TERM (UP TO 8-10 DAYS)

Up to 8 days lead time, daily maximum and minimum temperatures derived from the (publicly-available) GFS model are presented by PMD on the website *here*:



6 **Spatial map of forecast maximum and minimum temperatures, available via** *PMD web page*.

11-day city-level forecasts are also available from a Japanese model, accessed via the PMD web page *here*. This should give a reasonable indication of trends at each of the available cities and the likely duration of the event, although in the second half of this forecast period we do not expect the forecast to be accurate in detail.



FORECAST ISSUED (1200 on 10th April 2018)

CITY & LOCATION (latitude, longitude)

WIND DIRECTION (unlikely to be important)

FORECAST TIME (1200 on 10th, 1200 on 11th etc)

FORECAST WIND SPEED
Lower = more heat impact (not very important)

FORECAST TEMPERATURE
Look at daytime & nighttime levels.
May not match perfectly with other forecasts.
Look at trends as well as absolute values.

FORECAST HUMIDITY
Higher = more heat impact (moderately important)

FORECAST PRECIPITATION
May give indication of respite from heat

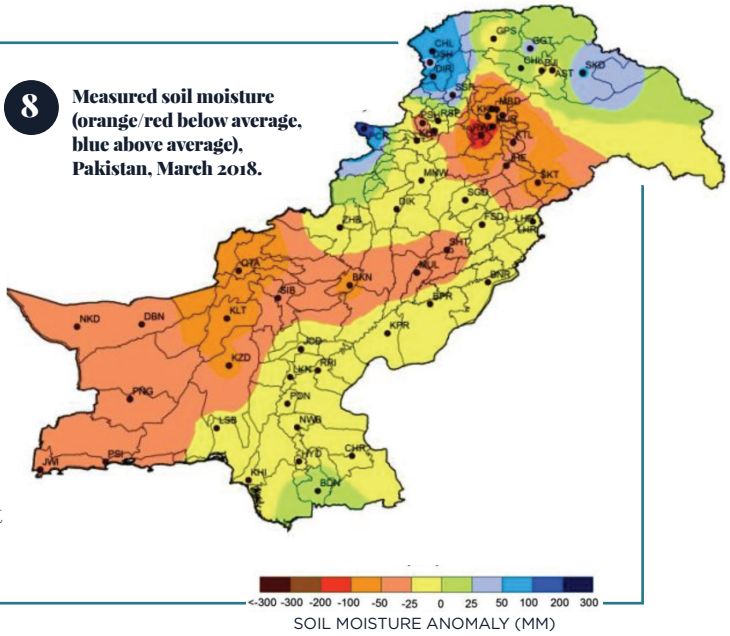
FORECAST TIME (1200 on 10th, 1200 on 11th etc)
Times are stated in UTC (note PKT = UTC+5)

7 City-level forecast provided by JMA, available via *PMD web page*.

LONG-TERM (BEYOND 8-10 DAYS)

There are no reliable detailed forecasts beyond about 10 days lead time, so on longer timescales the main humanitarian actions would be general seasonal preparedness. There may be contributory information which can help to assess the likely impact of extreme heat if it were to occur. For example, there is ongoing *monitoring of soil moisture levels*.

Where soil moisture levels are below average for the time of year (orange and red colours), this may slightly exacerbate the impact of extreme heat. Where soil moisture levels are above average (blue colours), this may slightly reduce the impact of extreme heat, especially in rural areas.

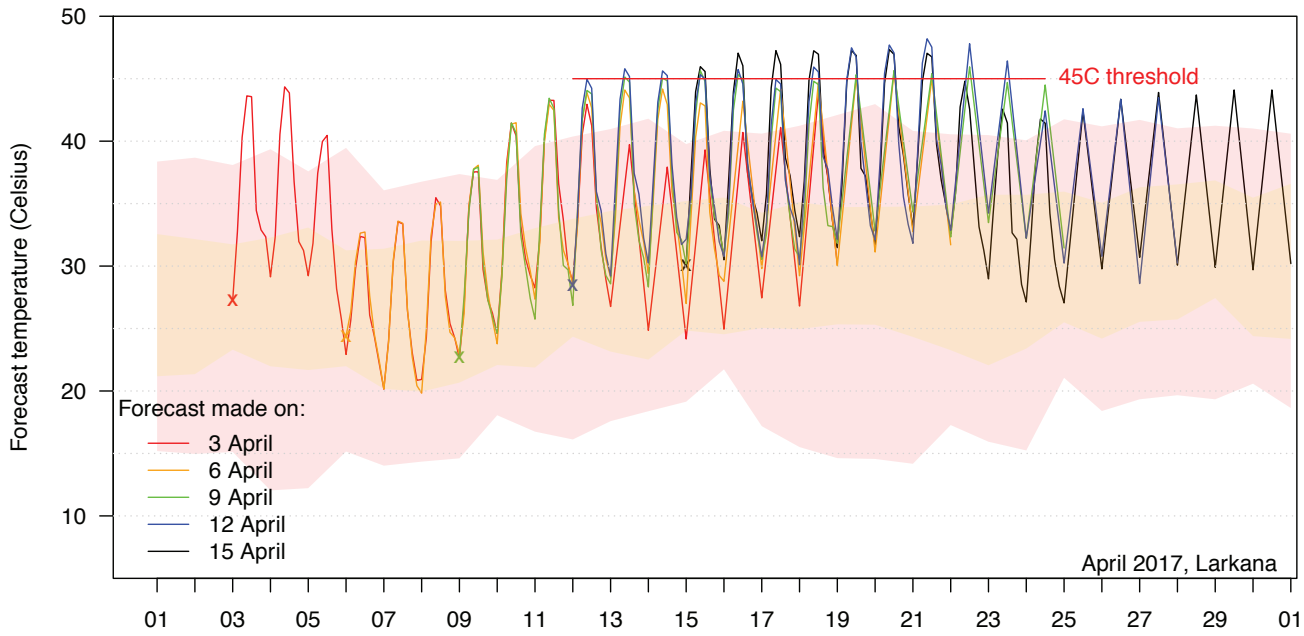


8 Measured soil moisture (orange/red below average, blue above average), Pakistan, March 2018.

Finally, so-called "experimental" seasonal forecasts are available. As of March 2018, these suggest that Pakistan is more likely to experience slightly warmer than usual temperatures during April/May/Jun and slightly cooler than usual temperatures during June/July/August, especially in coastal regions. However, these systems **have very low skill**, have a tendency to under-predict extremes, and of course a season may contain an extreme heat event and still end up being "cooler than usual". Seasonal forecasts are most appropriate for use when the question of interest includes the whole season (such as average rainfall amounts for reservoir replenishment) and least appropriate for forecasting single extreme events

Some commercial providers, such as AccuWeather, give detailed daily weather forecasts for several weeks; these are simply not supported by any scientific evidence of skill and should be ignored.

HOW RELIABLE ARE THE FORECASTS AT DIFFERENT LEAD TIMES?



An extreme heat event in April 2017 was the subject of Start Fund Alert 157. It was not activated due to concerns about timing: the event was already occurring when the alert was actually raised on 19th April, although it was forecast to continue. Forecasts indicated rising temperatures as early as 6th April, although at this point the actual temperature and duration of the event were very uncertain. Over that week, it could have been flagged for discussion, with a decision to be made on, say, the 12th. On the 12th, the new forecast would have continued to show extreme temperatures occurring around the 17th-23rd, giving time for anticipatory action with greater confidence.

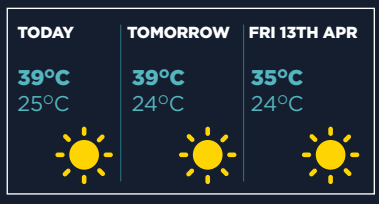
INFORMATION PORTALS

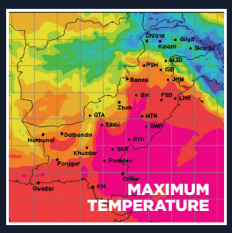
- **7-day forecast of maximum temperature in Pakistan:** *http://www.pmd.gov.pk/rnd/rndweb/rnd_new/hrm/gfs_12z_files/focusmaxtemp.html* Note that the temperature scales can vary, so you need to check each map individually and not just assume the same colour means the same thing everywhere.
- **City-level forecasts are available through PMD web pages here:** *http://www.pmd.gov.pk/PAK-Wx/3%20days%20city%20forecast.html*
- **Indian Meteorological Department publishes a Heatwave Bulletin and extended guidance:** *http://www.imd.gov.in/pages/heatwave.php* Forecasts are available for Indian states neighbouring Pakistan.
- **IRI Maprooms showing historical and forecast data for many weather variables:** *http://mbell.maproomdev.iri.columbia.edu/maproom/START/index.html* **All forecasts beyond 2 weeks are experimental and should be treated with caution.**

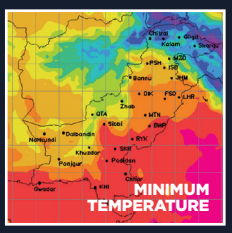
USING FORECASTS TO SUPPORT ANTICIPATORY ACTION

01 Look at your preferred weather forecast provider (eg Pakistan Meteorological Department, UK Met Office, AccuWeather) for the next 5-10 days in areas of interest.

Is there any sign of temperatures increasing to extreme levels? If so, check the "Feels like" temperature as well.







02 Look at daily maximum and minimum temperature forecast for the next 8 days on PMD website.

Do these also show extreme heat developing?
Where are the most affected areas and/or cities?

03 Consider raising an anticipatory alert. In addition to the humanitarian factors, useful contributory information could include:

- **Forecast maximum daytime and minimum night-time temperatures and the expected duration of the extreme heat;**
- **City-level detailed forecasts, where available;**
- **Note the current state of soil moisture, especially in rural areas;**
- **Note the humidity and wind speed forecasts in addition to temperature, where available** (see city-level forecasts)**;**
- **Has PMD or National Disaster Management Authority raised a warning?;**
- **Are there any warnings in neighbouring Indian regions** (see www.imd.gov.in)**?**

04 RAISE ANTICIPATORY ALERT BASED ON YOUR UNDERSTANDING OF THE HUMANITARIAN SITUATION AND ON WEATHER FORECAST INFORMATION AS ABOVE.

FURTHER READING

PMD Technical Report on Karachi Heatwave 2015. PMD, July 2015

Karachi Heatwave Management Plan. Karachi Commissioner Office, 2017.

Ahmedabad Heat Action Plan 2018. NRDC, 2018.

Defining and Predicting Heat Waves in Bangladesh
2017 study by IRI scientists looked at which types of heatwave conditions are most linked to death rates in Bangladesh, confirming that both maximum daytime temperatures and minimum night-time temperatures are important.

START FUND

IF YOU HAVE ADDITIONAL QUESTIONS, PLEASE CONTACT THE START FUND TEAM:
startfund@startnetwork.org