



"Environmental Stress Factors, an index, and its prediction for a month ahead"

ECMWF, June 14th 2007.

"Environmental Stress Factors, an index, and its prediction for a month ahead" Bernd Becker

- Met Office Heat stress forecasts
- Monthly Forecast system
- Environmental Stress Index (Moran et al.)
- Future development and opportunities

Heat stress:

- Kills chickens
- Reduces milk production
- Reduces efficiency

Predictions can deliver a strategic benefit allowing to plan against adverse effects.

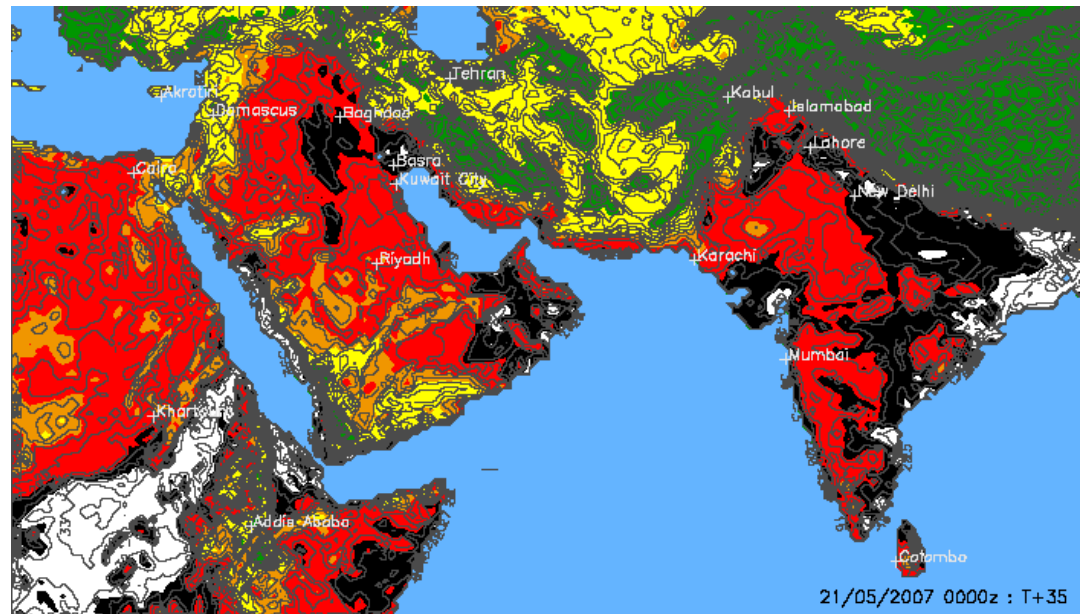
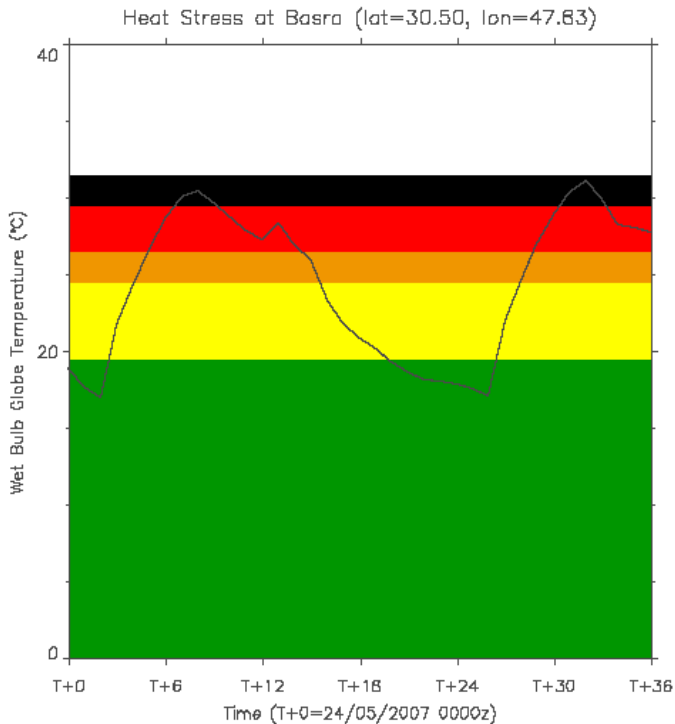


Heat stress products from the Met Office



- 0 -36 hrs deterministic:
Crisis Area Model (17 km resolution)
- Contact: Mike.Hobson@metoffice.gov.uk
- <http://da0600/heatstress/heatstress.html>

White	32°C and above
Black	30°C – 31°C
Red	27°C – 29°C
Amber	25°C – 26°C
Yellow	20°C – 24°C
Green	19°C and below

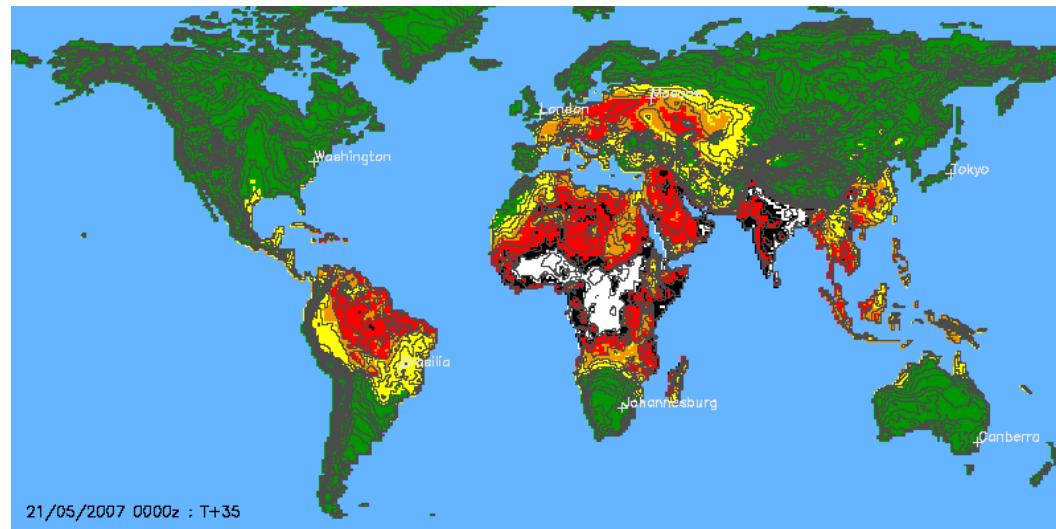
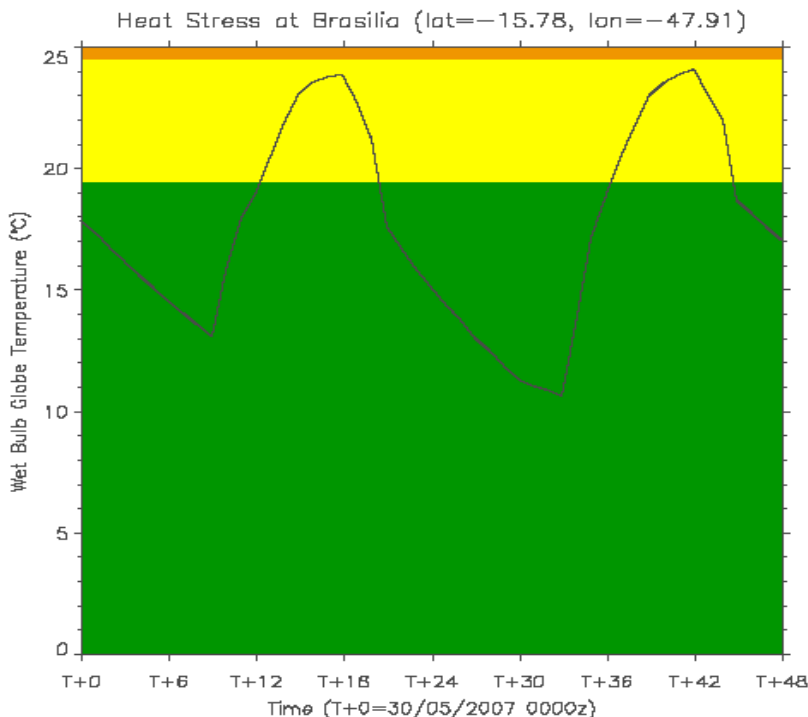


Heat stress products from the Met Office



- 0 – 5 days deterministic:
Global Unified Model (60 km resolution)
- Contact: Mike.Hobson@metoffice.gov.uk
- <http://da0600/heatstress/heatstress.html>

White	32°C and above
Black	30°C – 31°C
Red	27°C – 29°C
Amber	25°C – 26°C
Yellow	20°C – 24°C
Green	19°C and below



Heat stress products from the Met Office

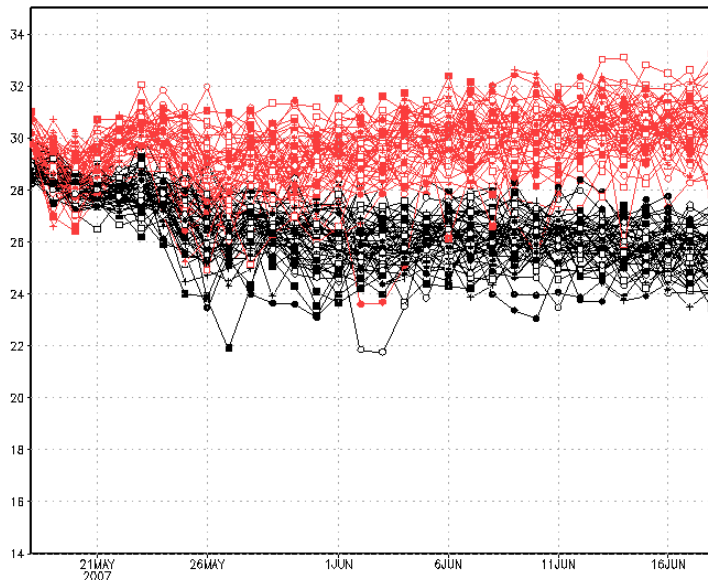


- 0 – 32 days: Monthly component of Ensemble Forecasts for Monthly and Seasonal Time scale (FORMOST)

http://www.bbc.co.uk/weather/ukweather/monthly_outlook.shtml

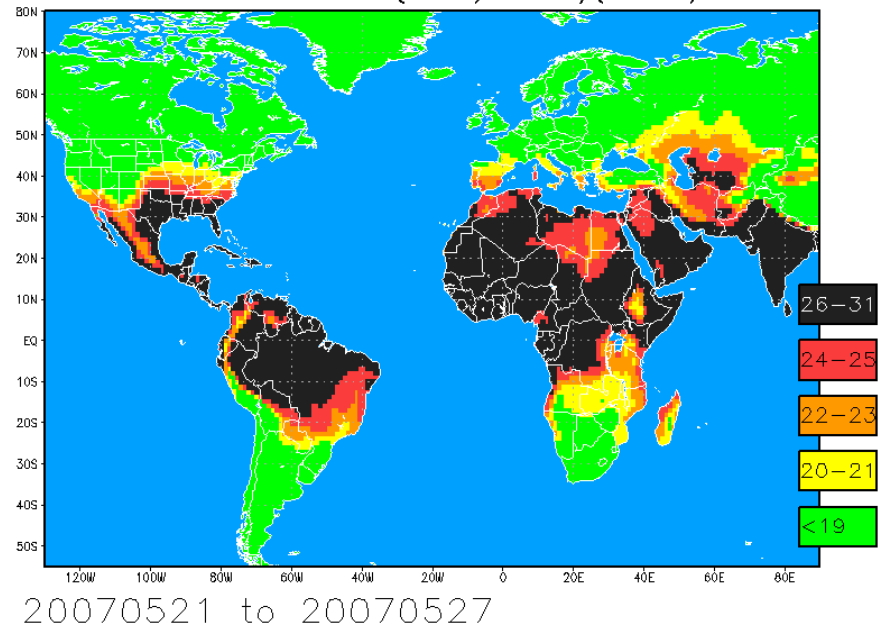
Contact: Phil.Dominy@metoffice.gov.uk

$$\text{Heat Stress, WBGT=ESI(1)} = 0.62 \text{ TA} - 0.007 \text{ RH} + 0.002 \text{ SR} + 0.0043 (\text{TA RH}) - 0.078 / (0.1 + \text{SR})$$



Tmax
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Stress Index



Coupled ocean-atmosphere model:

- ❑ Oceanic component: with a zonal resolution of 1.4 degrees and 29 vertical levels
- ❑ Atmospheric component: ECMWF IFS at T159L62 (ca 110 km) resolution

Hindcast statistics:

- ❑ 5-member ensemble integrated over 32 days during the past 12 years
- ❑ Representing a **60-member ensemble**.

Forecast statistics:

- ❑ a **51-member ensemble** is integrated for 32 days
- ❑ Running every week

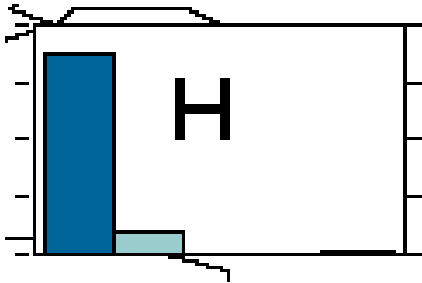
Methodology:



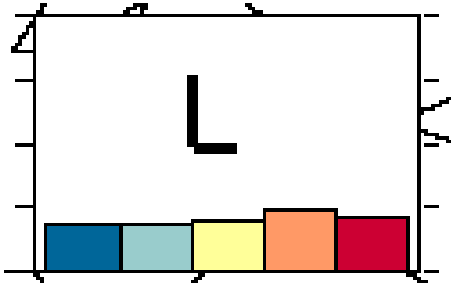
- Run Hindcast: 5 members * 12 years (Model climatology)
- Run Forecast: 51 times with slight initial perturbations
- Average data to 7/14 day calendar weeks at each grid point
- Rank order Hindcast results and divide into quintiles
- Count forecast members in each quintile
- Overlay with observed (“Truth”) quintiles
- Interpolate to customer location

Philosophy: Quintiles (generic)

Well Below – Below – Normal - Above - Well Above



Ideal forecast quintile histogram.
Little spread, high confidence.



More typical distribution, in
particular at longer lead times.

Coarse model resolution (110 km) , 7 (14) day averages.

Temperature, Precipitation, Wind etc.

In particular:

Environmental Stress index: $F(t, rh, ssr)$

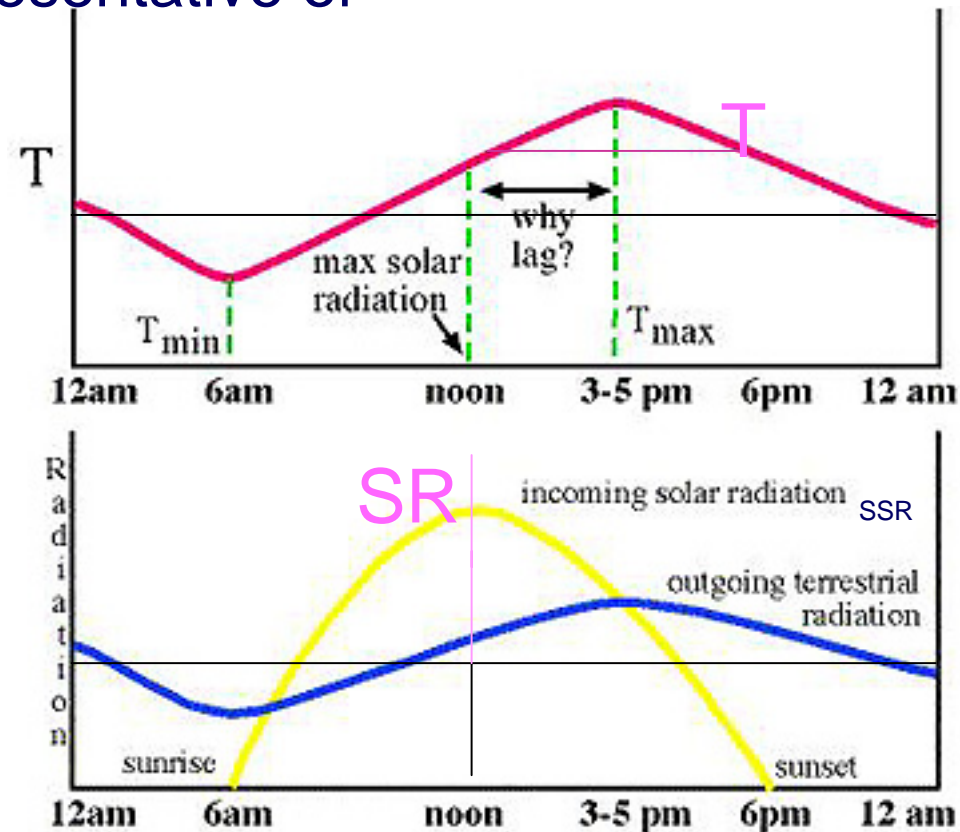


- **ESI and WBGT describe the same phenomenon**
- **For planning on longer timescale:**
- **ESI: = $0.62 * T - 0.007 * RH + 0.002 * SR + 0.0043 * (T * RH) - 0.078 / (0.1 + SR)$ (Moran et al. 2004)**
- **Important assumption: Model grid point weekly averages represent sub grid/ time scale variability.**
- **The causes of variability in the model and in reality are the same.**

ESI for daily/weekly averages: Assumptions



- $ESI = 0.62 * T - 0.007 * RH + 0.002 * SR + 0.0043 * (T * RH) - 0.078 / (0.1 + SR)$ (Moran 2004)
- To derive ESI values representative of daytime working hours:
- $T = (T_{mean} + T_{max}) / 2$.
- $SR = SSR * 3$.
- $RH = \min(100., f(q,t)|_{1000hPa})$
- T is most important

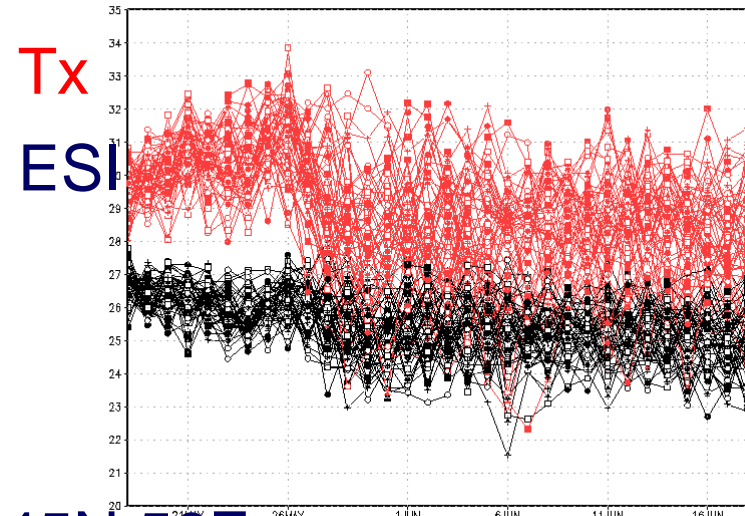


Plumes of ESI

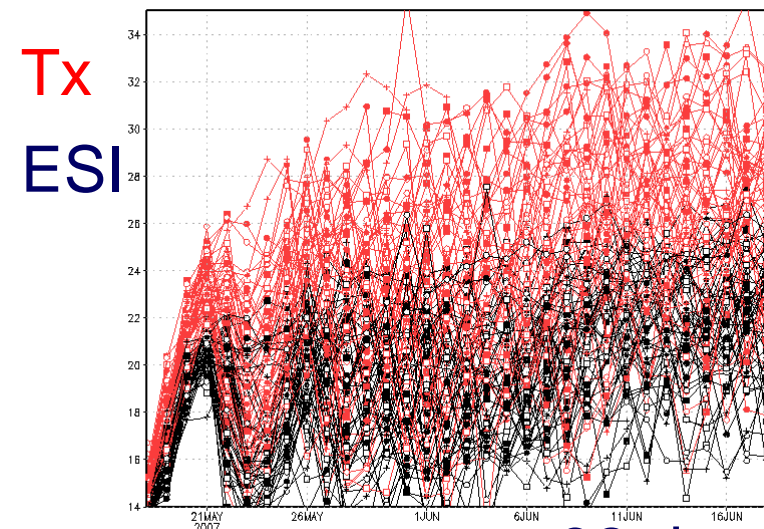


- Tx: red, ESI: black
 - Uncertainty increases with lead time
 - Regime changes are highlighted
 - Predictability changes with location
-
- What opportunities?
 - Average working weeks
 - Express in quintiles

Juazeiro

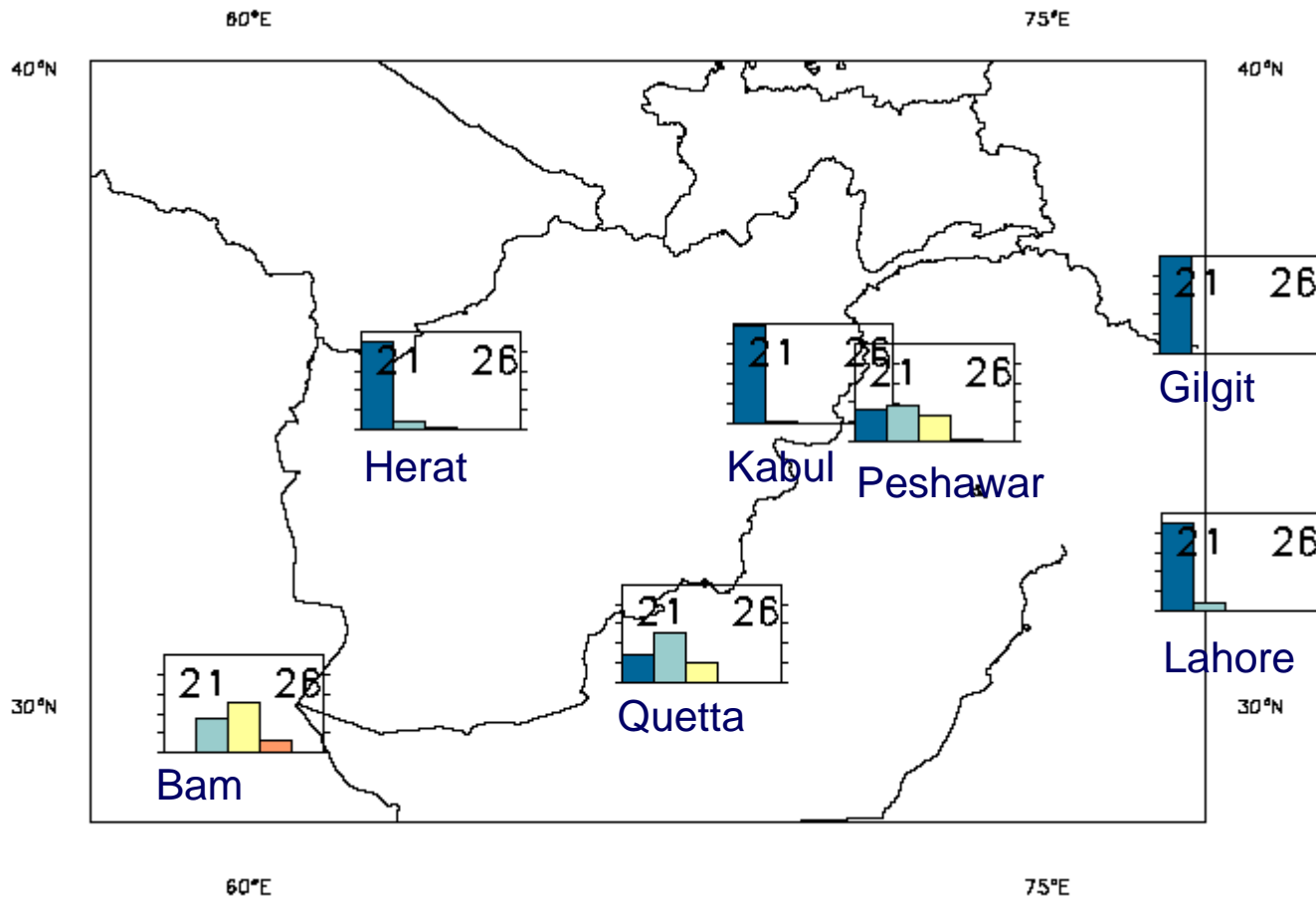


45N 56E



32 days 2

ESI histograms on maps



Forecast from 20070517 for 20070604 to 20070617

Heat wave duration and risk: maps.



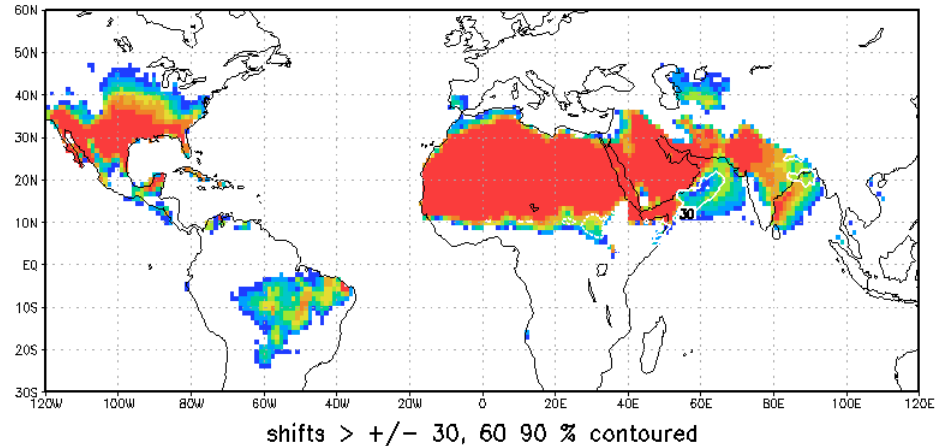
count occurrences and duration:

$T_x > 30C$, $T_n > 15C$, $T_x > 30C$

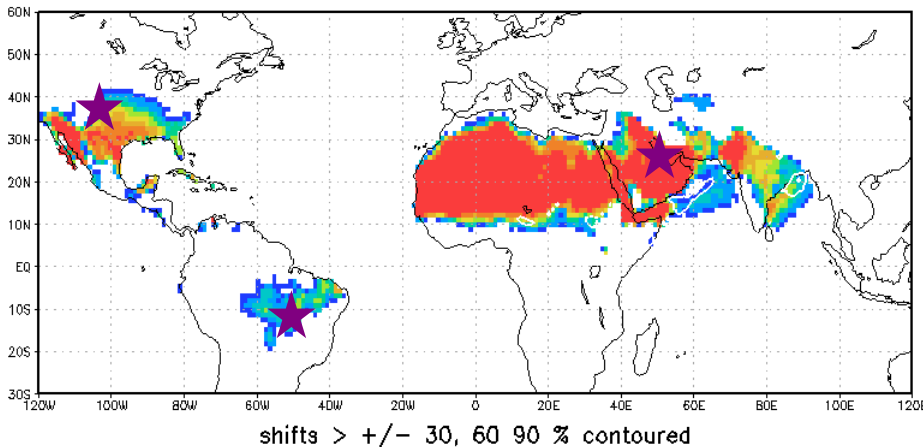
colour: expected risk (climatology)

contours: predicted anomaly

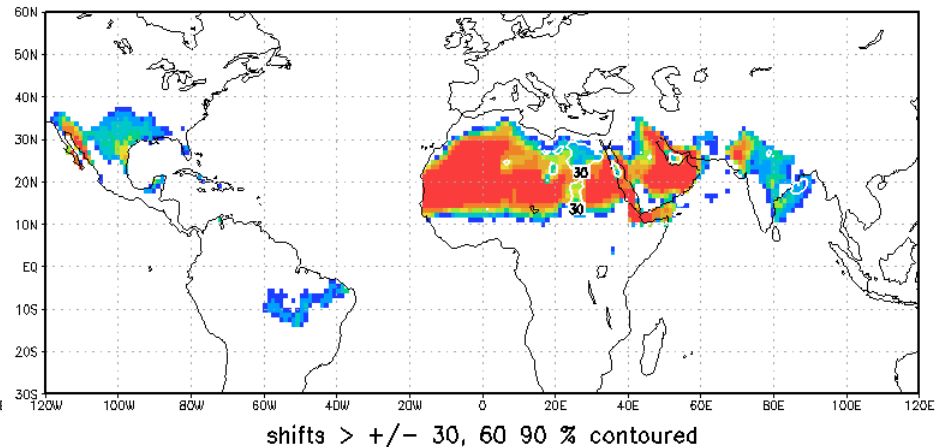
d-3 heat waves from 20070517 to 20070618



d-7 heat waves from 20070517 to 20070618



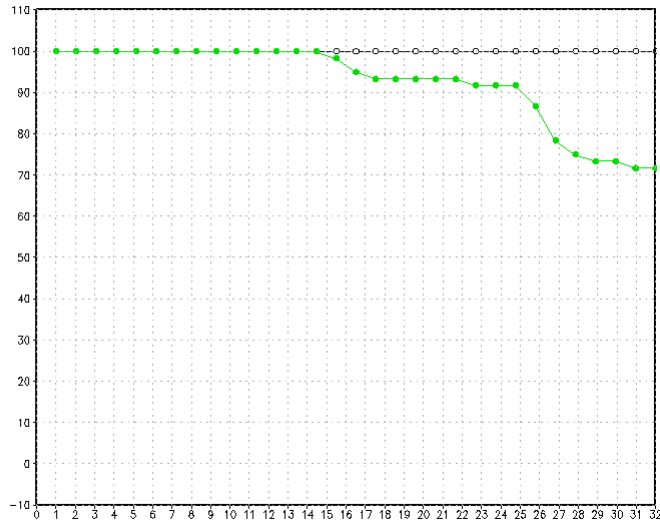
d-15 heat waves from 20070517 to 20070618



Heat Wave duration and risk: local.



Basra



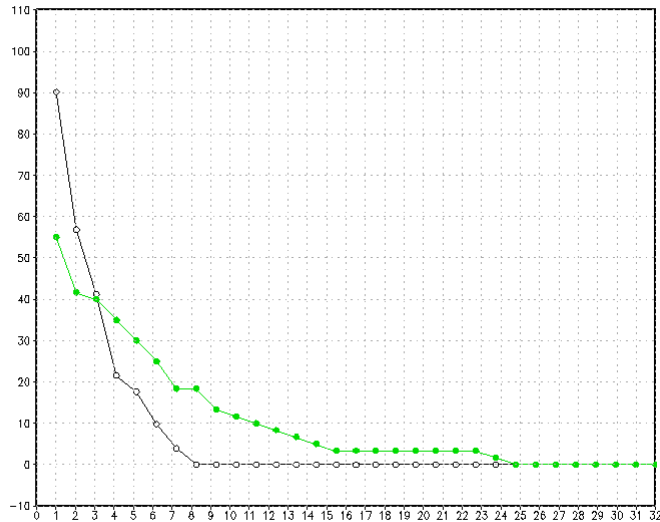
- Predicted change with respect to expectation:
- Hotter Basra
- Brazil: Increased risk of shorter heat waves
Reduced risk of medium range heat waves
- Risk for Heat Wave in North America doubled

Duration

Forecast

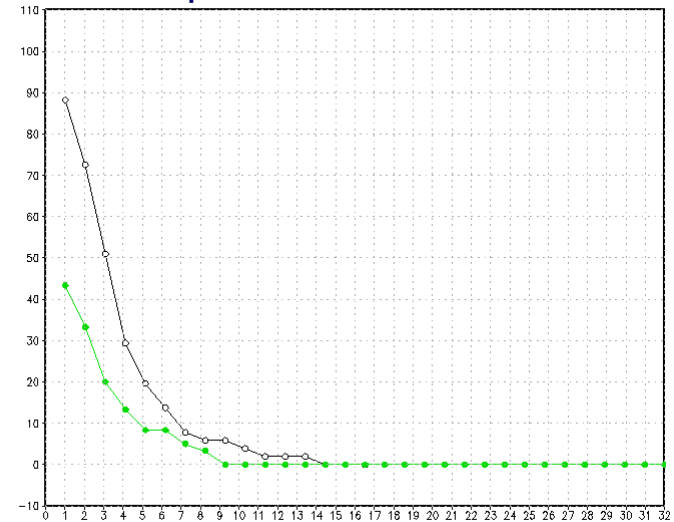
Climatology

Juazeiro



32 days

Minneapolis



32 days

The Met Office provides seamless Heat Stress forecasts to MOD customers:

- 0 – 768 hrs: Monthly component of Ensemble Forecasts for Monthly and Seasonal Time range
- 0 – 120 hrs deterministic: Global Unified Model
- 0 – 36 hrs deterministic: Crisis Area Local Model

The ESI allows to derive Heat Stress products from forecast models directly:

- Local plumes
- Histograms on maps
- Backed up by high resolution Heat stress products from short range deterministic forecasts

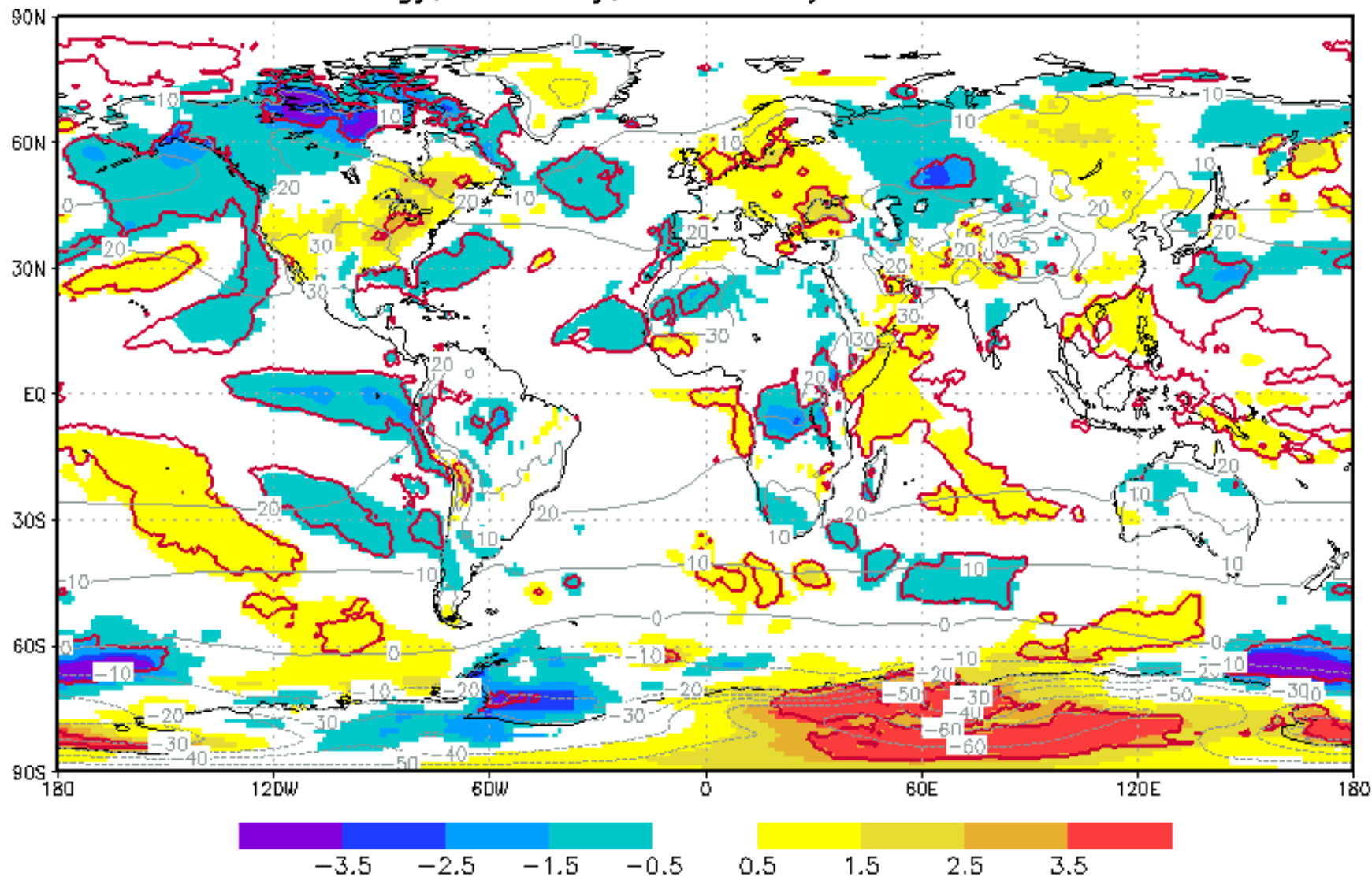
Local Heat wave duration and risk prediction shows:

- Local extent of area prone to heat wave conditions
- Historical context of predictions in probabilistic terms
- An opportunity to extend into other threshold based decision tools

Product: global Temperature anomalies



20070607 tmean 20070611 to 20070709
Climatology, Anomaly, Probability > 60 % dark red



Environmental Stress index:



$$ESI = 0.62 * T - 0.007 * RH + 0.002 * SR + 0.0043 * T * RH - 0.078 / (0.1 + SR)$$

Const:

98%

RelH

10%

31 C

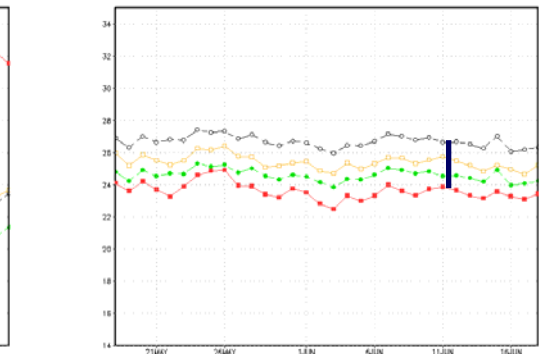
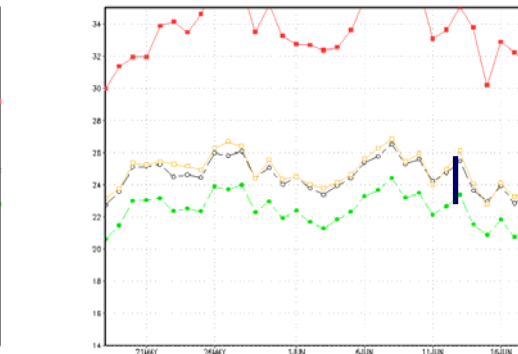
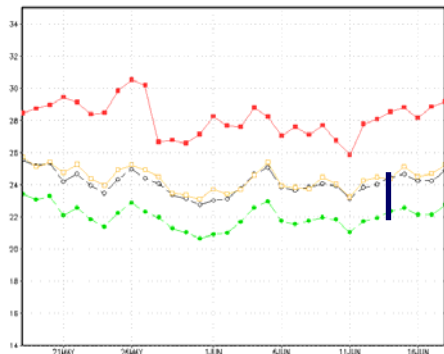
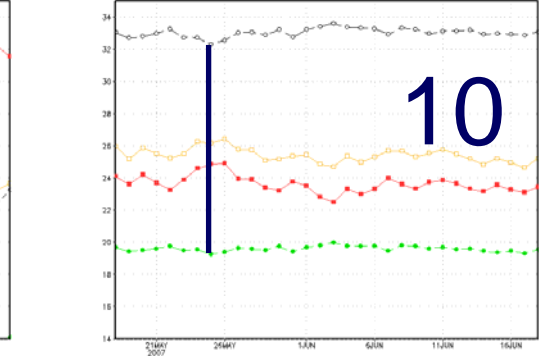
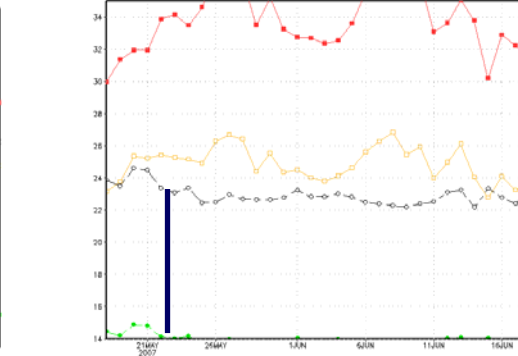
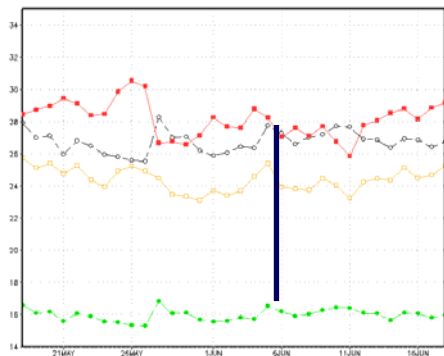
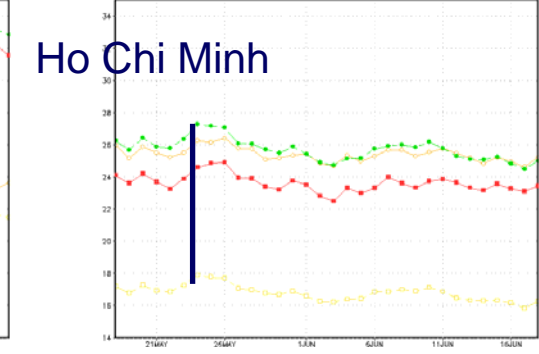
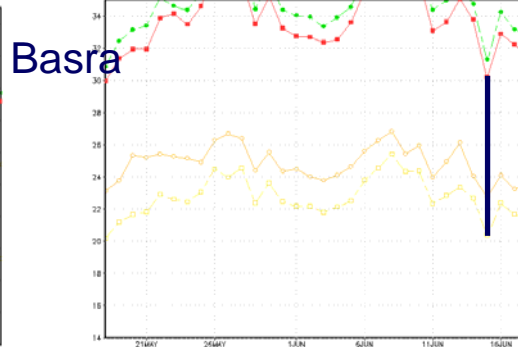
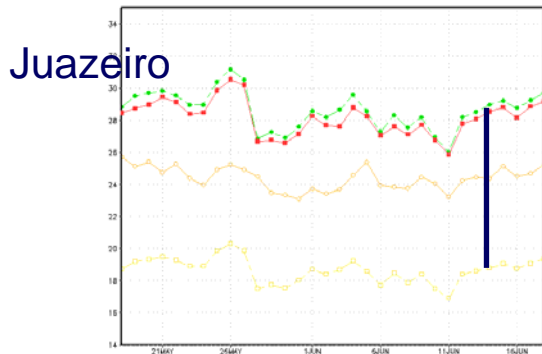
Temp.

18 C

1100

SSR

50 W



10

34

10

ESI

TMAX

14

2