GHHIN FORUM
in Hong Kong,
Dec 17-20, 2018

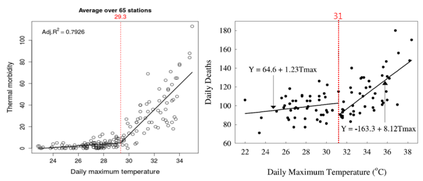
The Korean Heat-Health Warning System (HHWS) on a National and an Urban Scale

Changbum CHO, Miloslav BELORID, Ji-Sun LEE, Misun KANG, Britta JÄNICKE, Kyu Rang KIM
National Institute of Meteorological Sciences / Korea Meteorological Administration, South Korea

책임운영기관
국립기상과학원
National Institute of Meteorological Sciences

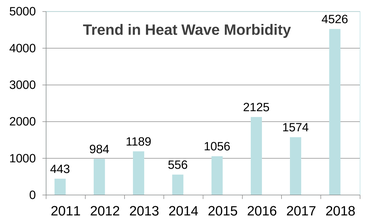
1 Introduction

Heat wave is becoming one of serious natural disasters in KOREA. Morbidity starts to increase when Tmax goes over 29.3 degree Celsius. In mortality, even though it isn't clearly separated, it goes up when Tmax exceeds 31.0 degree Celsius. In 2018, people in Korea had been under the new historical hazardous heat wave. Caused of heat-related illness, total 48 people were died and 4,526 patients had visited to Emergency Medical Service and it is noticeable three historical events are recorded after 2010 among the upper 5 events in the past 100 year.



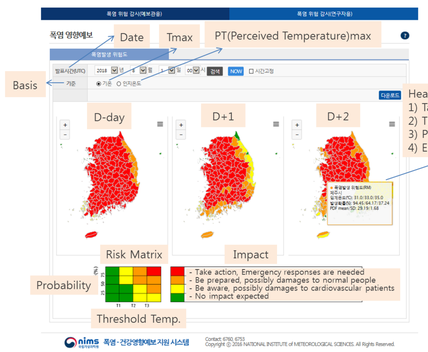
Rank	Tmax ≥33℃	
	Year	No. of days
1	2018	31.4
2	1994	29.7
3	2016	22.4
4	2012	18.2
5	1990	17.0

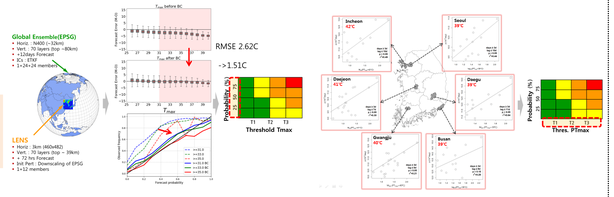
Top 5 Heat Wave Events



2 National Scale Heat Health Warning System

✓ Heat wave Impact forecasting system base on Limited area EPS (HILEPS)
- provides an option Tmax view and PTmax view
- not only provides a colored risk map up to three lead-days, but also, makes user to recognize a target province, threshold temperatures at the province, probability for each range of temperature, and ensemble PDF mean/spread making a color map.
- adopts risk matrix: Y axis means a probability of system and x axis means the threshold temperatures

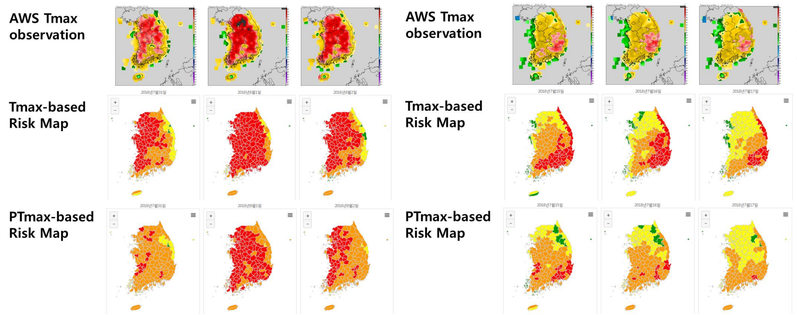




	2017	2018
Numerical model	UM(Unified Model) LENS(Local Ensemble System) v10.1	
Dynamic core	EG (ENDGame)	
Model domain	Horizontal 3.0 X 3.0km (with 460 X 482 grids), vertically 70 layer (up to 100 hPa) covering Korea	
Timestep / Forecast time	75 sec / 72hrs (up to 3 days)	
Ensemble members	1+12+12(time-lag)	1+12
Prognostic variables	Daily Tmax	Daily Tmax, Perceived Tmax
Probabilistic forecast	Basic probability (portion of members predicting event)	Normal PDF
Bias-correction	None	Decaying averaging
Final products	①Grid-Point Probability → ②Areal Probability → ③Areal Risk Maps	①Grid-Point Probability → ②Grid-Point Risk maps → ③Areal Risk Maps
Service Areas(Provinces)	165 provinces (Metropolitan, si, gun) covering South Korea	

✓ For T, 31, 33, 35 degree Celsius are fixed in x axis.
✓ For PT, the first threshold temperature varies with provinces. The second and third thresholds are equivalent PT of air temperature 33 and 35 degree Celsius, respectively.

✓ Comparison result with AWS Tmax observation from July 15 to July 17 and from July 31 to August 2 in 2018
- Tmax-based risk map has a similar pattern with AWS Tmax observation
- PTmax-based risk map shows their own unique and looks like to be underestimated comparing to AWS. However, it is noticeable PT-based risk map showed red or orange signals on coastal areas even below 30 degree Celsius, while Tmax-based Risk map showed yellow or green signals on the same areas.



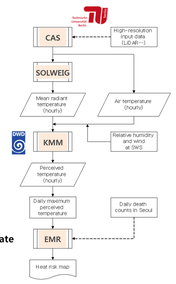
* Red color indicates that temperature was above 30 degree Celsius and dark red color indicates above 35 degree Celsius in AWS observation images (upper).

☞ **visit 'Development of impact-based forecasting system for heat waves in Korea integrated with LENS' (M.Belorid)**

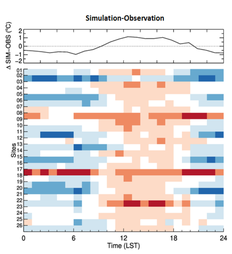
3 Urban Scale Heat Health Warning System

✓ Urban scale HHWS (BioCAS)
- climatological urban heat environment analyzing system for Seoul
- BioCAS's temperature forecast capability is higher than NWP model and comparable with an operational forecast
  * BioCAS results with Tmax observation data for 13days at 26 stations in 2015 under the heat wave conditions of Tmax>30℃ and WS<2m/s shows RMSE 1.44 degree Celsius.
- provides an option Tmax view and PTmax view
- provides Tmax and PTmax distribution in a heat wave day, and an elevation of Excess Mortality Rate (EMR)
- provides zoom-in and zoom-out function covering whole Seoul metropolitan divided into 25 Districts (gu) & 425 Neighborhoods (dong) with 10m x 10m horizontal resolution

Step 1. Calculation of climatological temperature deviation (TD)
Step 2. Calculation of Tmrt (Mean Radiant Temperature)
Step 3. Calculation of PT base on T, Tmrt, RH, WS
Step 4. Calculation of Excess Mortality Rate

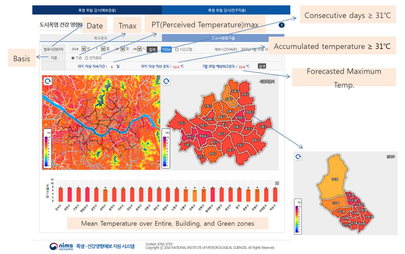


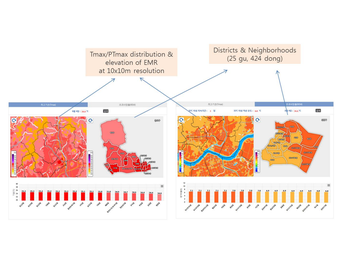
	2017	2018
Numerical model for climate data	MetPhoMod	
	for getting hourly temperature (in this study)	
Model domain	MR: 200km X 200km , 2000m resolution (with 100 X 100 grids) SR: 50km X 40km , 10m resolution (with 5000 X 4000 grids) One-way nesting MR → SR	
Model physics	Air pressure non-hydrostatic, κ-ε turbulence closure, full radiation and soil physics, wind advection, no clouds, no border dampening, no spatial filtering	
Analyzed period	Jun to Sep during 2000 ~ 2016	
Initial conditions	No wind, Vertically constant virtual potential temperature 20℃, Vertical constant mixing ratio 0.4g/kg	
Numerical model for forecasting data	Tmax : MOS	Tmax : MOS PTmax: UM LENS v10.1, KMM v2015
Numerical model for TMRT	-	SOLWEIG v2013a
Prognostic variables	Daily Tmax, CAS_TA_REM	Daily Tmax, Perceived Tmax CAS_TA_REM, CAS_PT_REM
Target Areas(Provinces)	424 dong, 25 gu in Seoul	

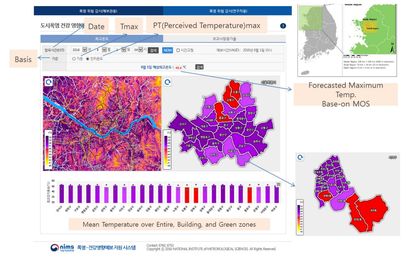


Name	No	MB (℃)	RMSE (℃)	MAE (℃)
Gangnam	1	-0.22	1.40	1.20
Seocho	2	-1.96	2.27	2.05
Gangdong	3	0.66	1.10	0.80
Songpa	4	0.39	1.27	0.97
Gangseo	5	-0.83	1.71	1.41
Yangcheon	6	-0.35	1.21	0.96
Dobong	7	0.45	1.03	0.77
Nowon	8	1.66	2.12	1.78
Dongdaemun	9	0.47	1.14	0.84
Jungrang	10	0.09	1.16	0.94
KMA	11	-0.78	1.75	1.43
Mapo	12	0.37	1.08	0.88
Seodaemun	13	-0.71	1.35	1.08
Gwangjin	14	0.15	1.19	0.92
Seongbuk	15	-0.94	1.66	1.40
Yongsan	16	-0.26	1.09	0.90
Eunpyeong	17	-2.21	2.50	2.26
Geumcheon	18	0.13	1.23	0.99
Hangang	19	-0.42	1.46	1.20
Junggu	20	-1.23	2.16	1.83
Seongdong	21	0.25	1.11	0.89
Bukhansan	22	0.52	1.94	1.63
Guro	23	0.14	1.13	0.82
Gangbuk	24	0.26	1.00	0.77
Gwanak	25	0.05	1.18	0.94
Yeongdeungpo	26	-0.38	1.28	1.05
Average		**-0.01**	**1.44**	**1.18**

- In calculation of Excess Mortality rate (EMR), the human heat stress are considered into the function of magnitude and consecutive day of heat wave.
- the system automatically calls daily observed or forecasted maximum temperature from the other KMA system. as well as automatically provides consecutive days and accumulated temperature above 31 degree Celsius after calculation.
- also, user can put their own values reflecting to a virtual heat wave scenario.







☞ **visit 'Heat-stress and health impact assessment of building scale by land cover based on BioCAS-PT' (Ji-Sun LEE)**

4 Summary

✓ NIMS/KMA has developed National scale HHWS named as HILEPS and Urban scale HHWS named as BioCASs.
- pros and cons, and summarized specifications are as follows:

	National Scale	Urban Scale
Name of System	HILEPS	BioCAS
Component models	UM LENS, KMM	MetPhoMod, SOLWEIG, CAS, KMM, EMR
Model domain	Horizontal 3.0kmx3.0km (460x482grids) Vertically 70 layers	Horizontal 10mx10m (4,000x5,000 grids)
Interval / lead day	2 times/day, 3 days	2 times/day, D-day at 04LST, D+1 at 16LST
Approaching Algorithm	Deterministic + Stochastic(PP) (EPS-based numerical simulation)	Stochastic (Climatological TD under heat wave & its impact on mortality)
Prognostic variable	Tmax, PTmax	Tmax, PTmax, EMR
Final product	Heat Wave Risk Map	Tmax & PTmax distribution map, elevation of EMR (%) map
Service area	165 provinces covering S. Korea	424 dong, 25 gu in Seoul city
Strengths	providing a higher reliability via bias correction & user friendly information	providing EMR considering heat stress magnitude and consecutive day Highly resolved domain and quick result
Weaknesses	not providing EMR	not considering a heat exchange with water body, limited (implicit) consideration of anthropogenic heat production

Acknowledgments This work was funded by the Korea Meteorological Administration Research and Development Program "Research and Development for KMA Weather, Climate and Earth system Services- Advanced Research on Biometeorology" under Grant (KMA2018-00621).