ASHRAE VIRTUAL WINTER CONFERENCE

February 9-11, 2021

Seminar ? - Updating ASHRAE's IWEC2 weather files to reflect changes in the climate over the past decade

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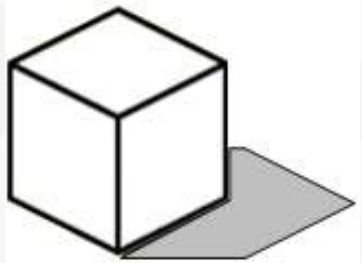
How the sausage is made: past, present, and future adventures in determining climate zones



Learning Objectives

1. Understand the presentation of trends in Chapter 14 of Handbook – Fundamentals and Standard 169.
2. Understand the value and limitations of ASHRAE climate zones to design.
3. **Examine the value of IWEC2 files and their possible evolution.**
4. Understand how recent trends due to climate change will begin to affect design and design guidance.

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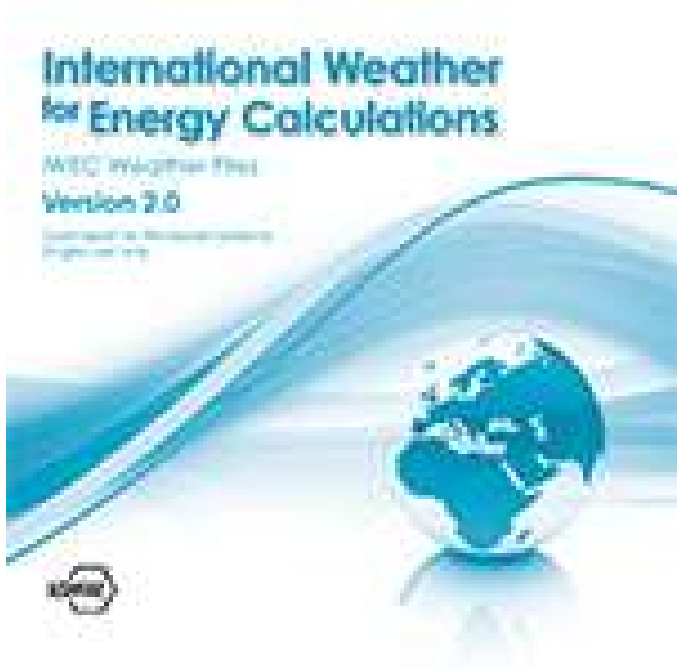
Outline/Agenda

1. **Description of ASHRAE's IWEC2 weather files**
2. **How much climate change has occurred in IWEC2 locations over the past 11 years?**
3. **Revisiting the "typical year" methodology to capture observed trends in the climate**
4. **Incorporating new sources of weather data such as satellite-derived solar radiation and reanalysis data**
5. **Current status in updating the IWEC2s to IWEC3s**

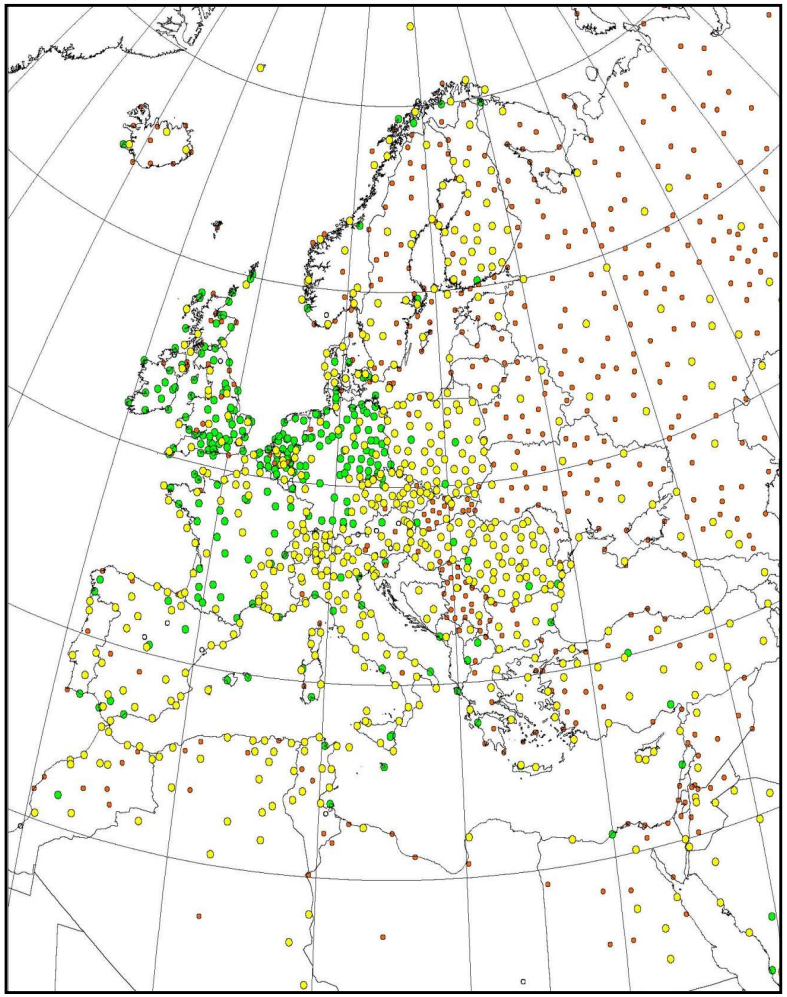
Description of ASHRAE's IWEC2 weather files



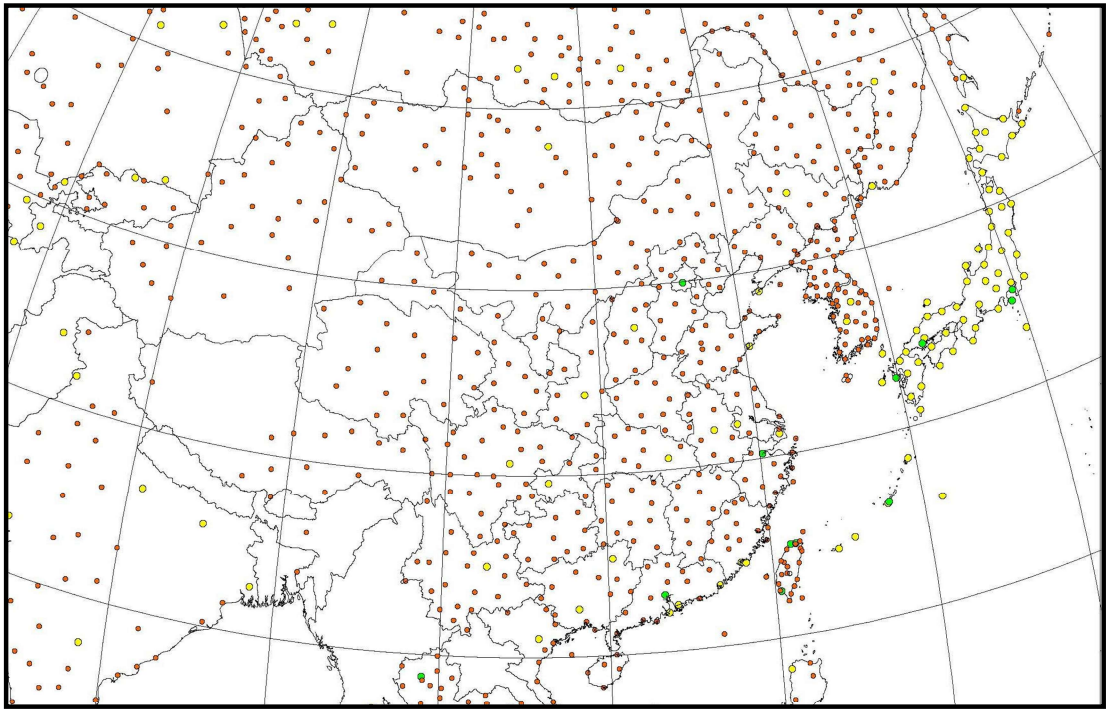
- Created in 2010 through ASHRAE RP-1477, submitted as an URP by Huang.
- Covers 3,012 International locations covering the entire world except for the US and Canada.
- Based on weather station data archived in the Integrated Surface Database (ISD).
- Period of record going back as far as 30 years to 1984 through 2009, and at least 10 years.
- Solar radiation calculated using several empirical solar models.
- Coverage excellent for Europe, Japan, and South Korea; good for Russia, China, East Asia, South Asia, and Australia; moderate in a few areas but poor for the rest of Latin America and Africa.

Description of ASHRAE's IWEC2 weather files

IWEC2 locations in Europe

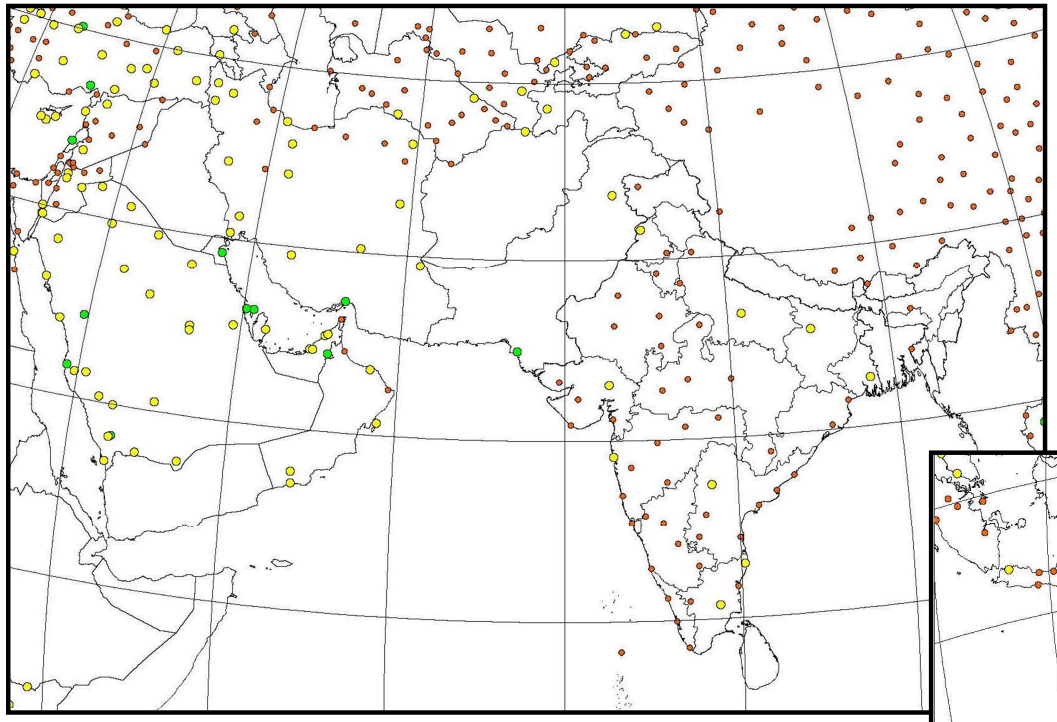


IWEC2 locations in East Asia

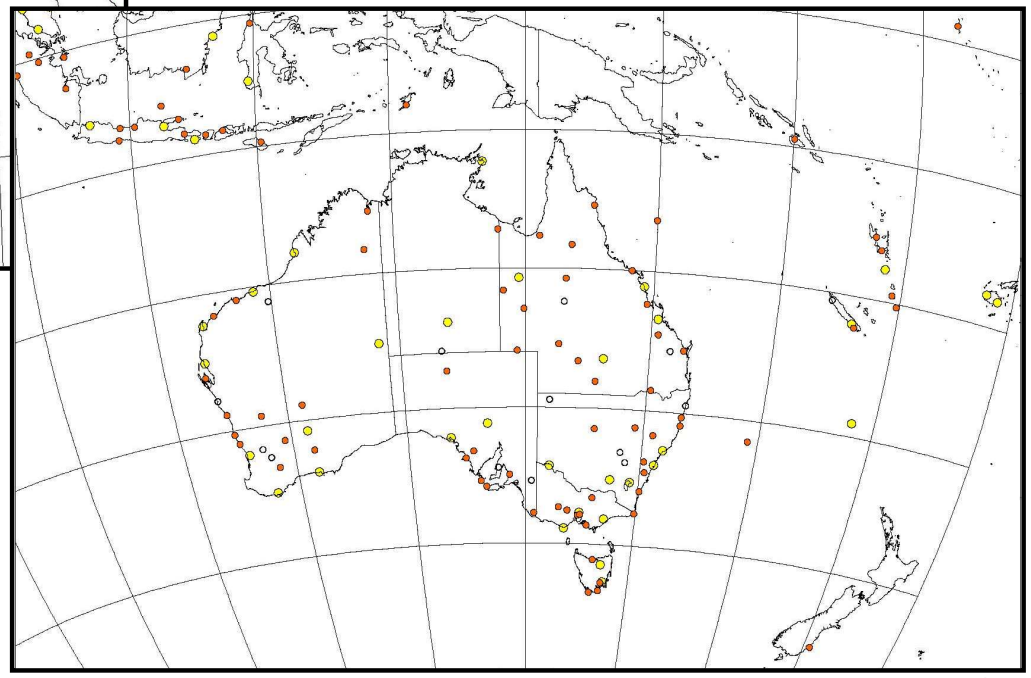


Description of ASHRAE's IWEC2 weather files

IWEC2 locations in South Asia

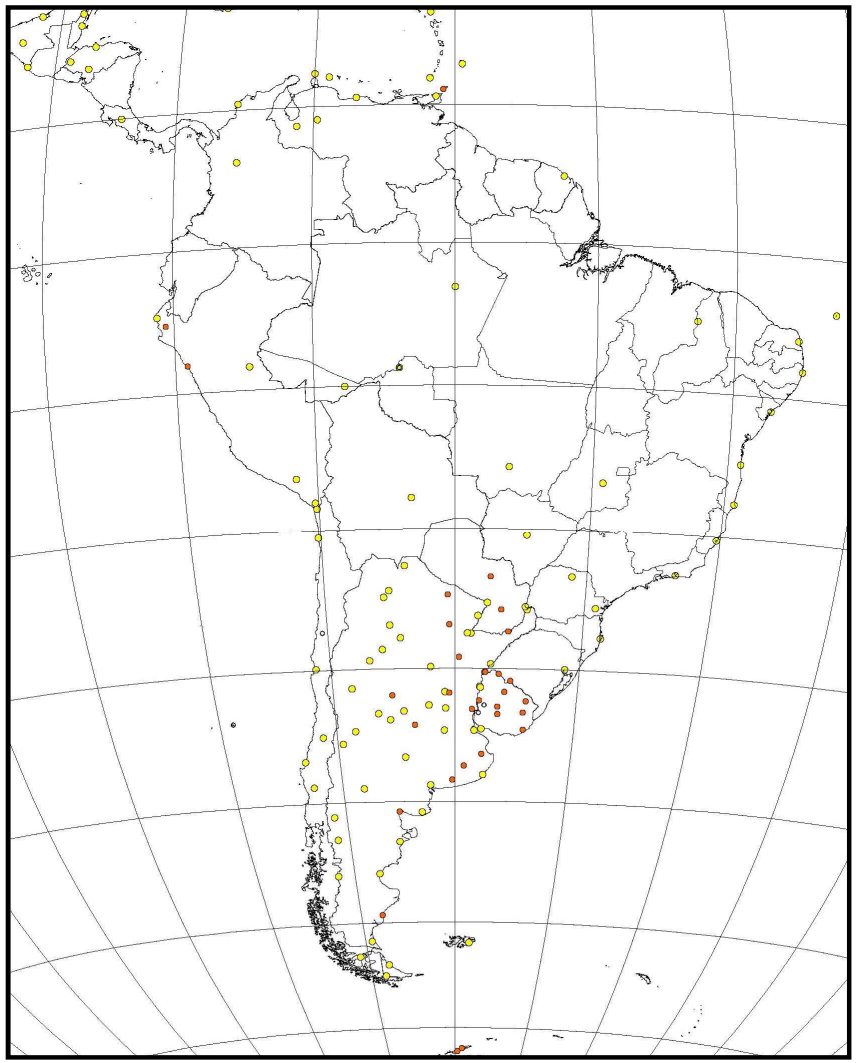


IWEC2 locations in Australia

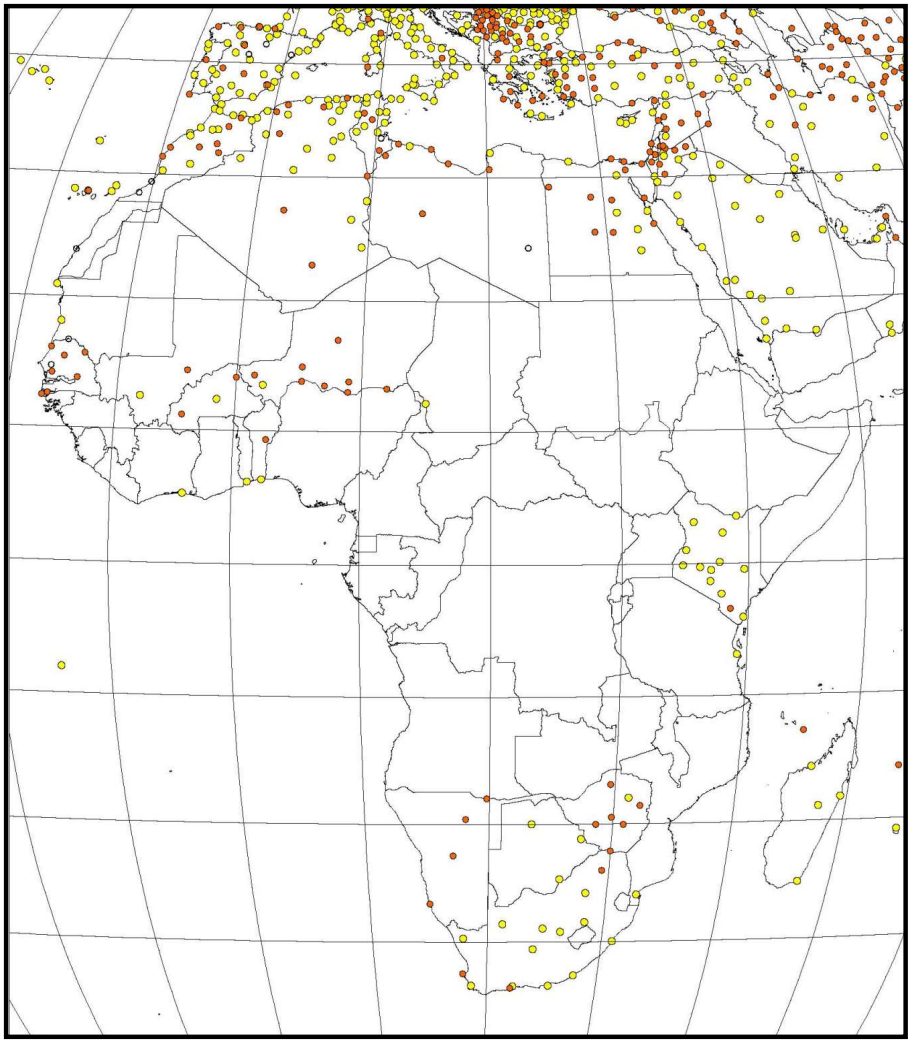


Description of ASHRAE's IWEC2 weather files

IWEC2 locations in South America

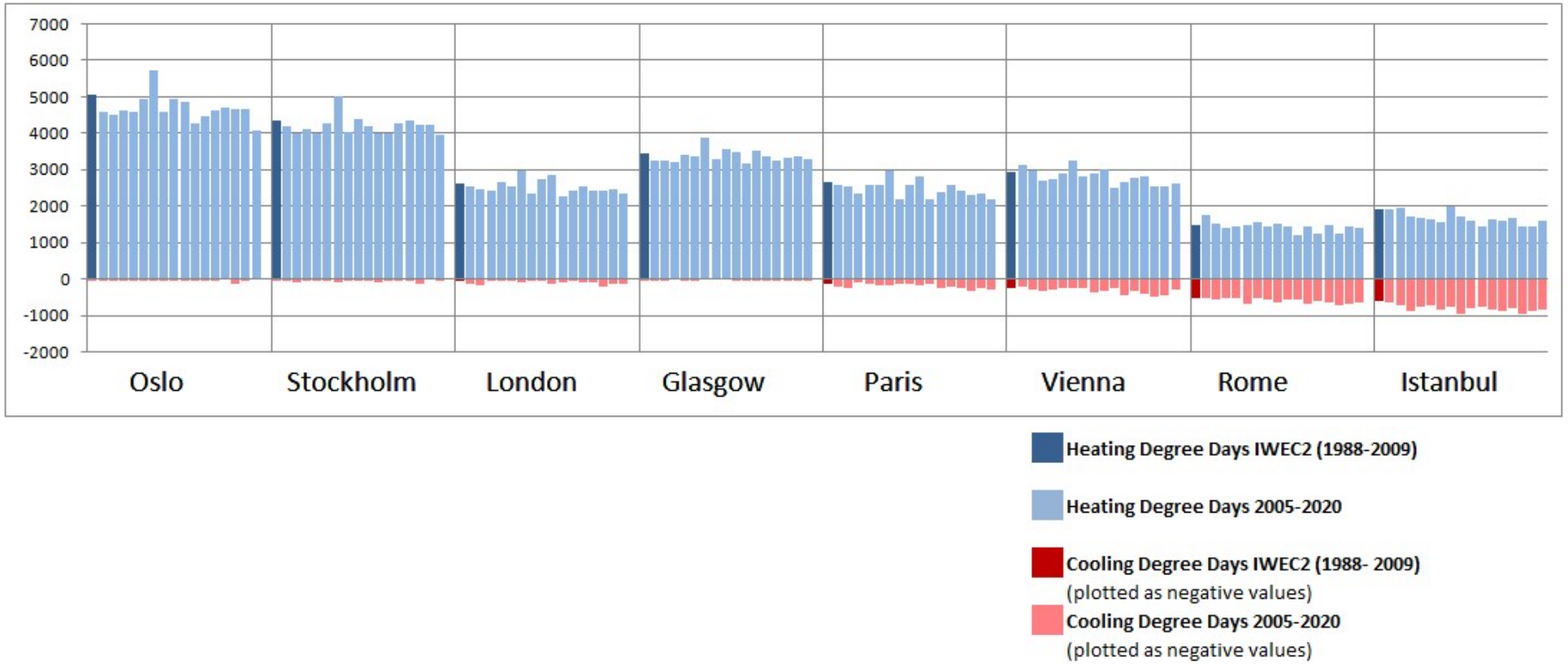


IWEC2 locations in Africa



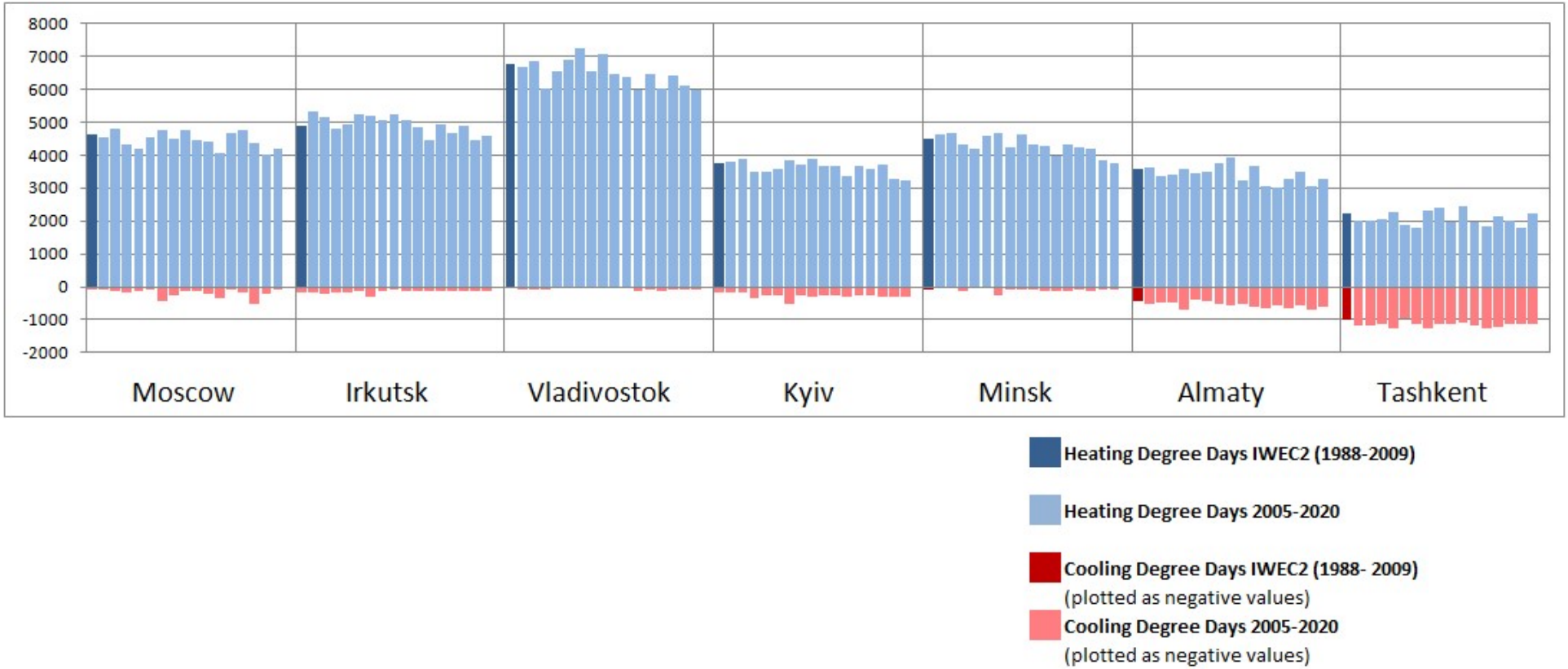
How much climate change has occurred in IWEC2 locations over the past 11 years?

Degree Days from 2005 through 2020 for European Locations



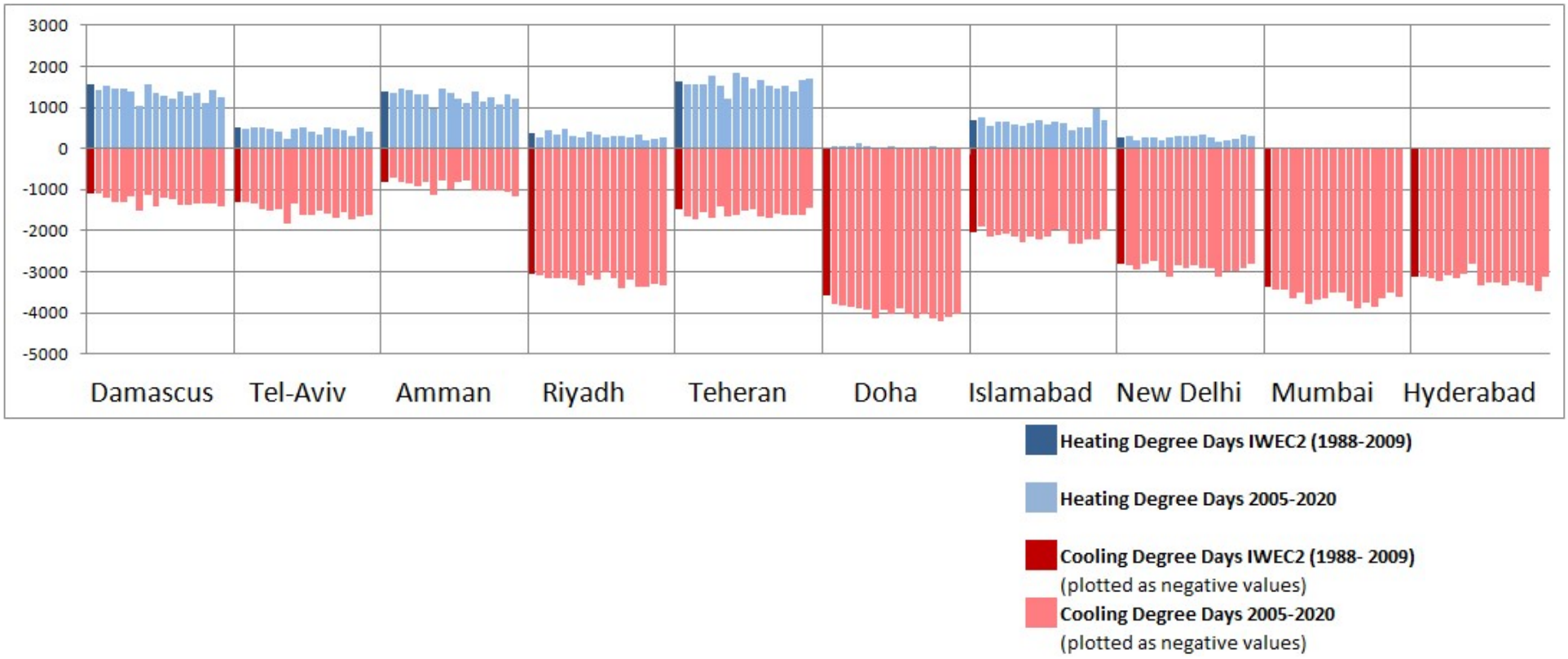
How much climate change has occurred in IWEC2 locations over the past 11 years?

Degree Days from 2005 through 2020 for Former Soviet Union Locations



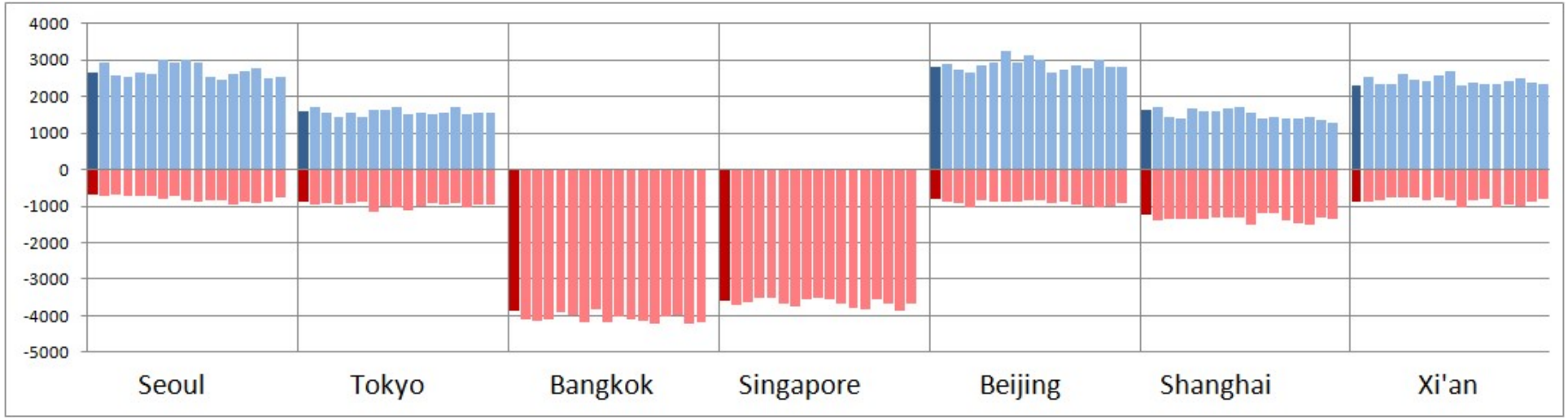
How much climate change has occurred in IWEC2 locations over the past 11 years?

Degree Days from 2005 through 2020 for Middle East and South Asia Locations



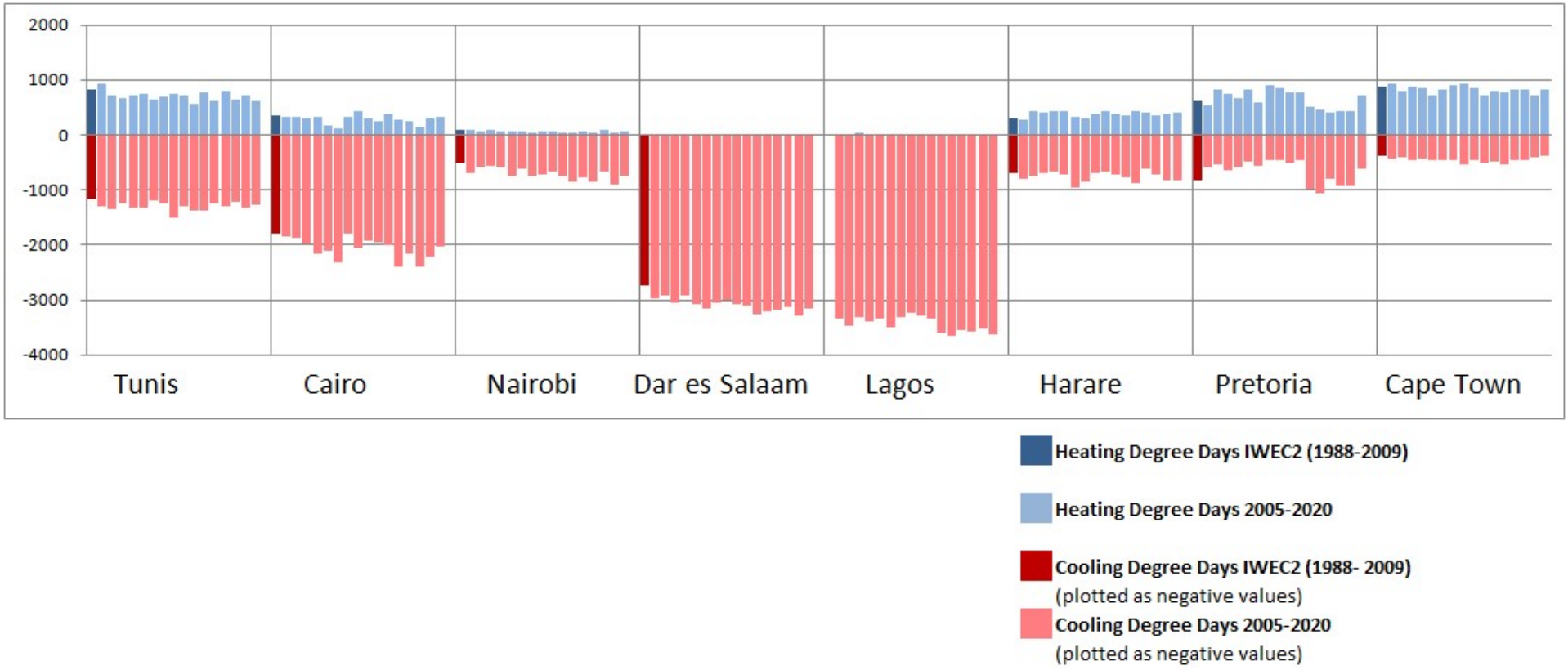
How much climate change has occurred in IWEC2 locations over the past 11 years?

Degree Days from 2005 through 2020 for East and Southeast Asia Locations



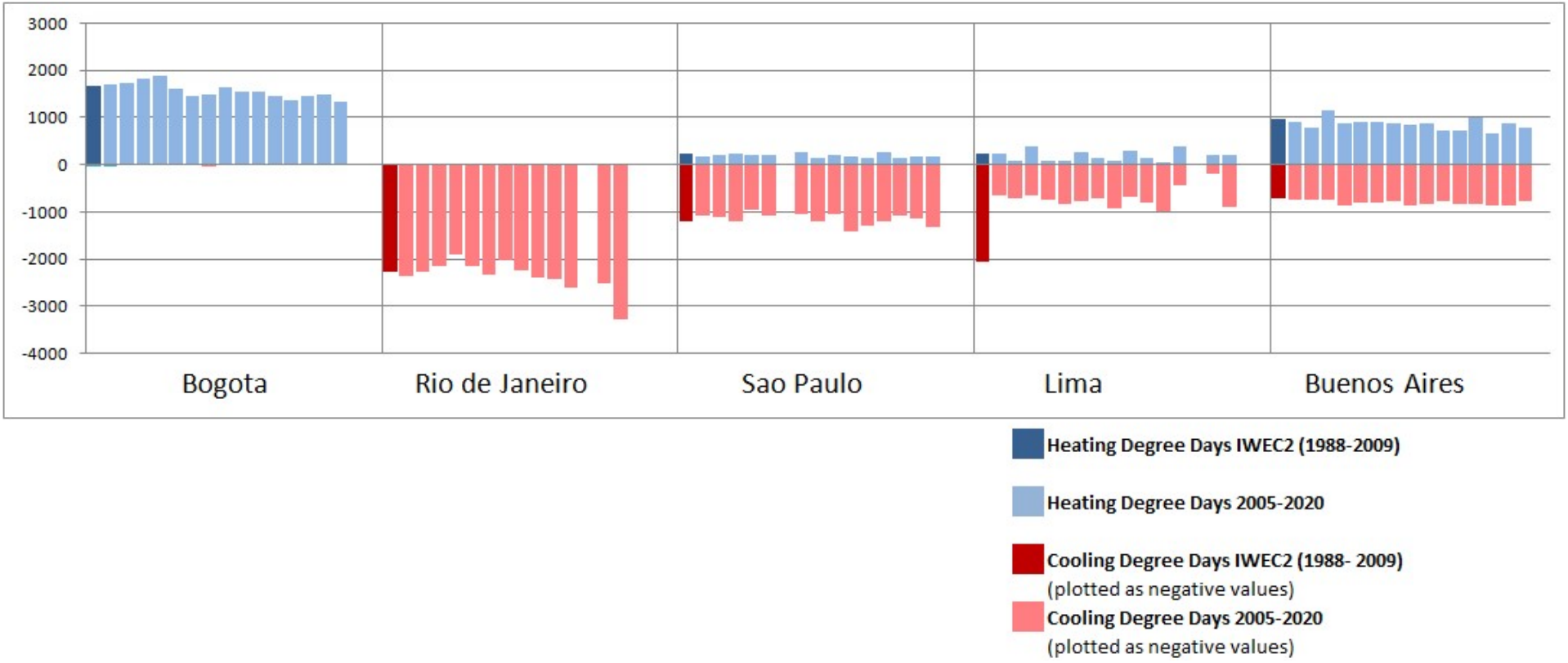
How much climate change has occurred in IWEC2 locations over the past 11 years?

Degree Days from 2005 through 2020 for African Locations



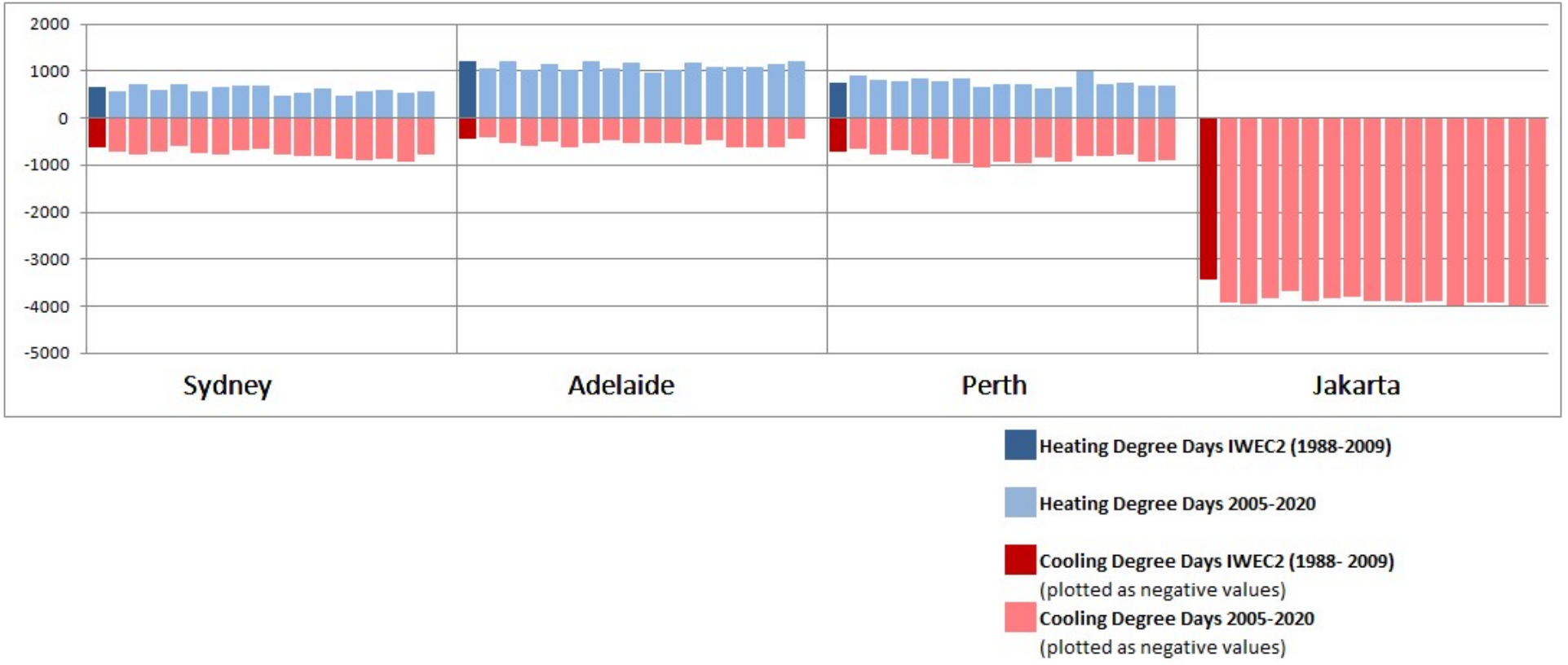
How much climate change has occurred in IWEC2 locations over the past 11 years?

Degree Days from 2005 through 2020 for South American Locations



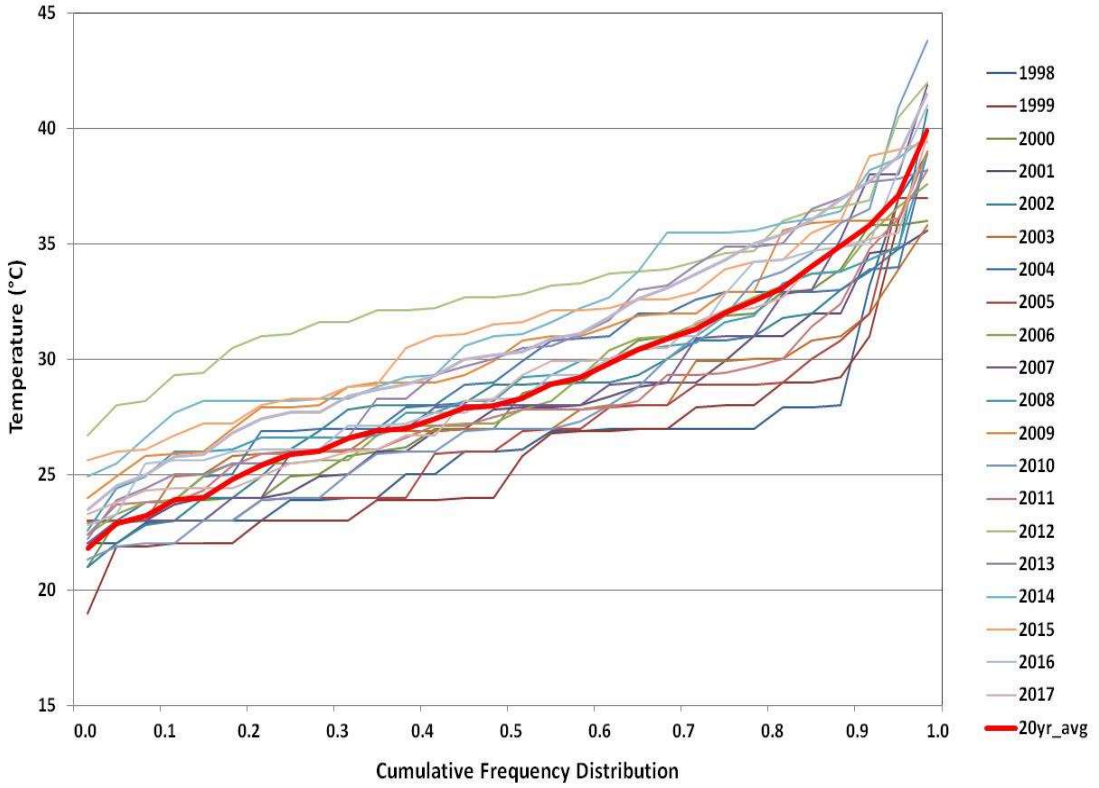
How much climate change has occurred in IWEC2 locations over the past 11 years?

Degree Days from 2005 through 2020 for Oceania Locations



Revisiting the Typical Year Methodology

- The **Finkelstein-Shafer (FS)** statistic is the absolute area enclosed between the Cumulative Frequency Distribution (CFD) of a climate parameter for each month and the long-term CFD for the same month over all years.
- The weighted sum of the FS statistic for all the parameter is the Cumulative FS (CFS) for that month.
- The month with the smallest CFS is considered the "typical month".



Sept daily max dry-bulb temperatures in Fullerton 1998-2017

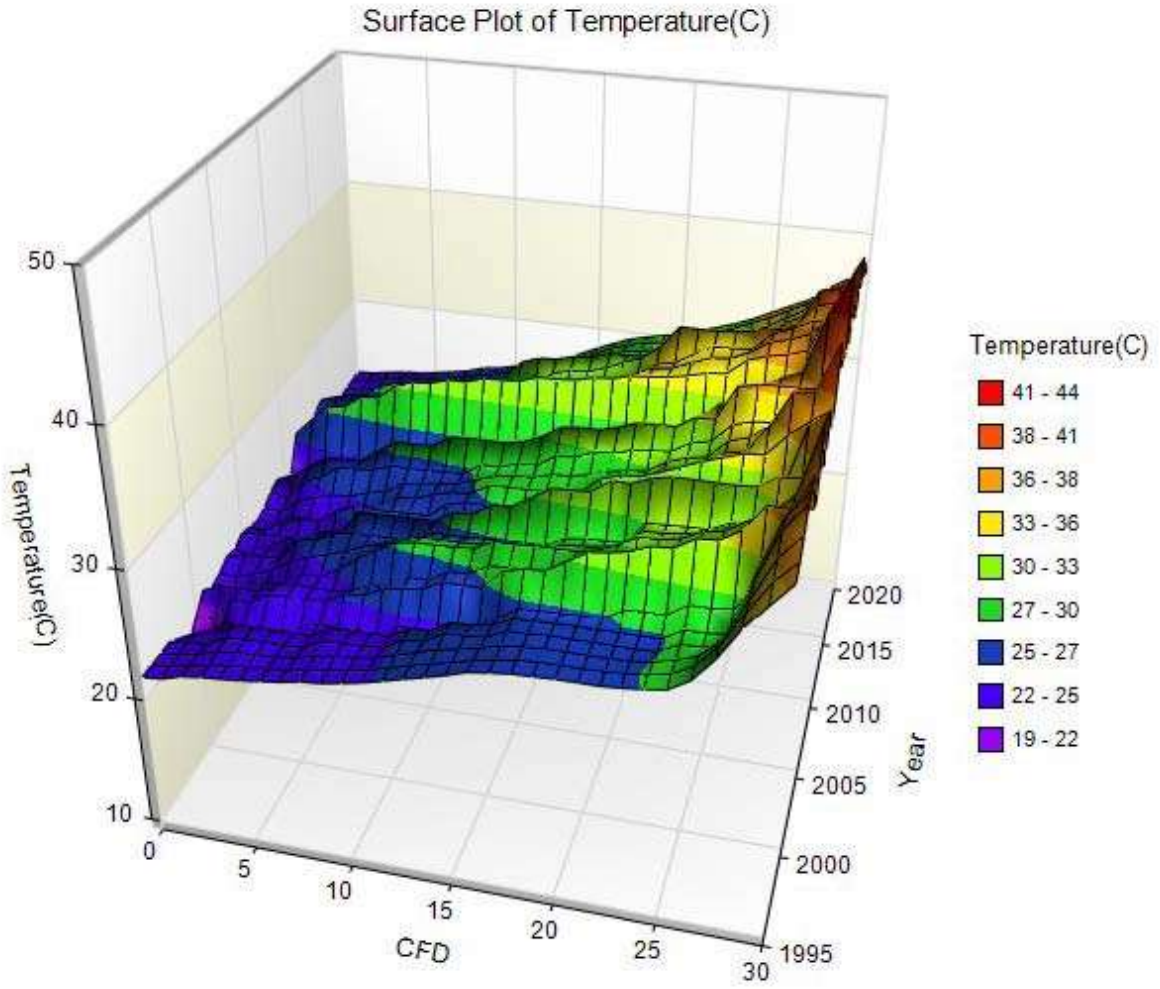
Revisiting the Typical Year Methodology

What are the limitations in the current “typical year” methodology?

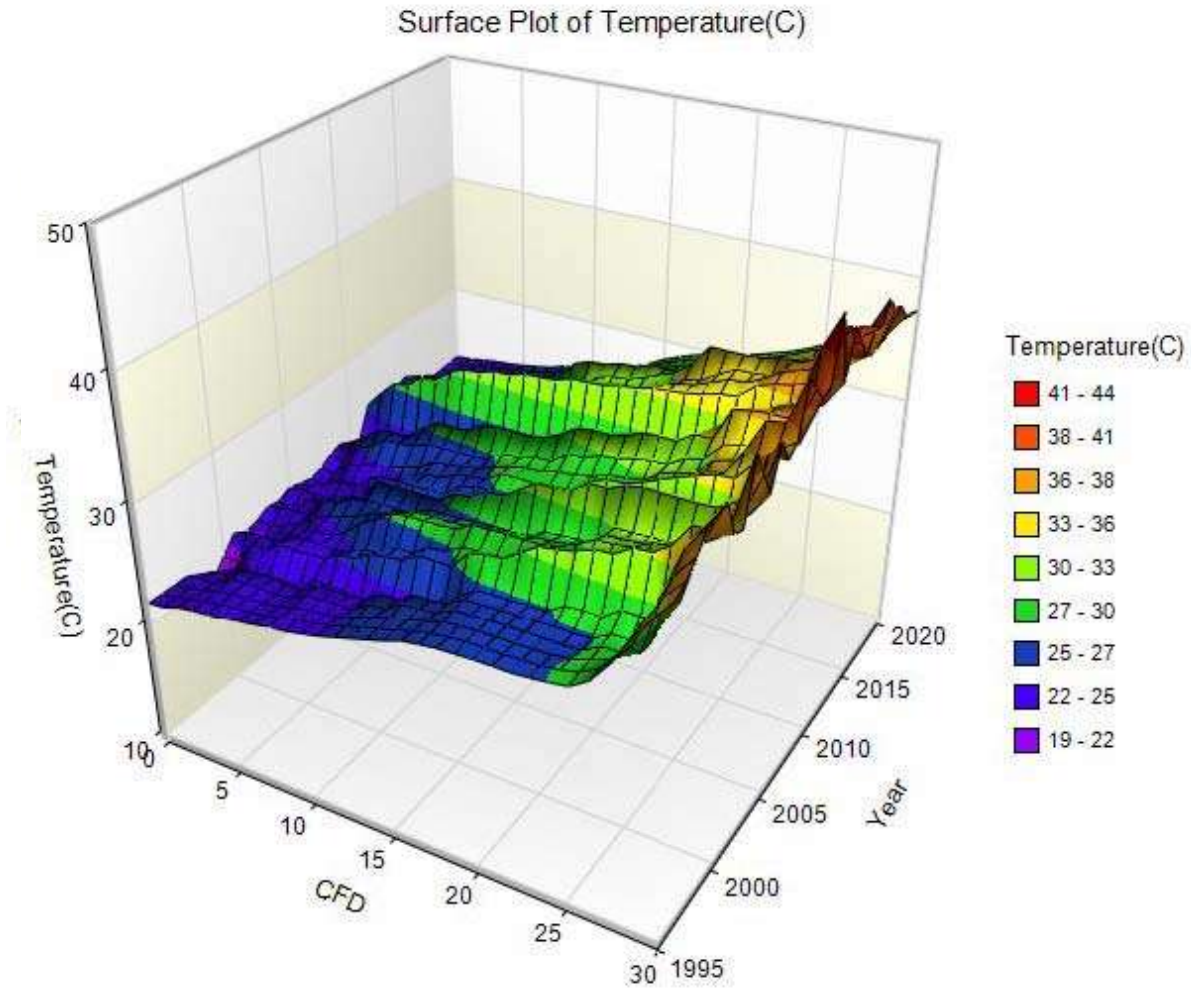
- Good representation of past weather.
- Assumes that the climate is long-term steady-state.
- Ahistorical, i.e., doesn’t consider time as an independent variable.

Revisiting the Typical Year Methodology

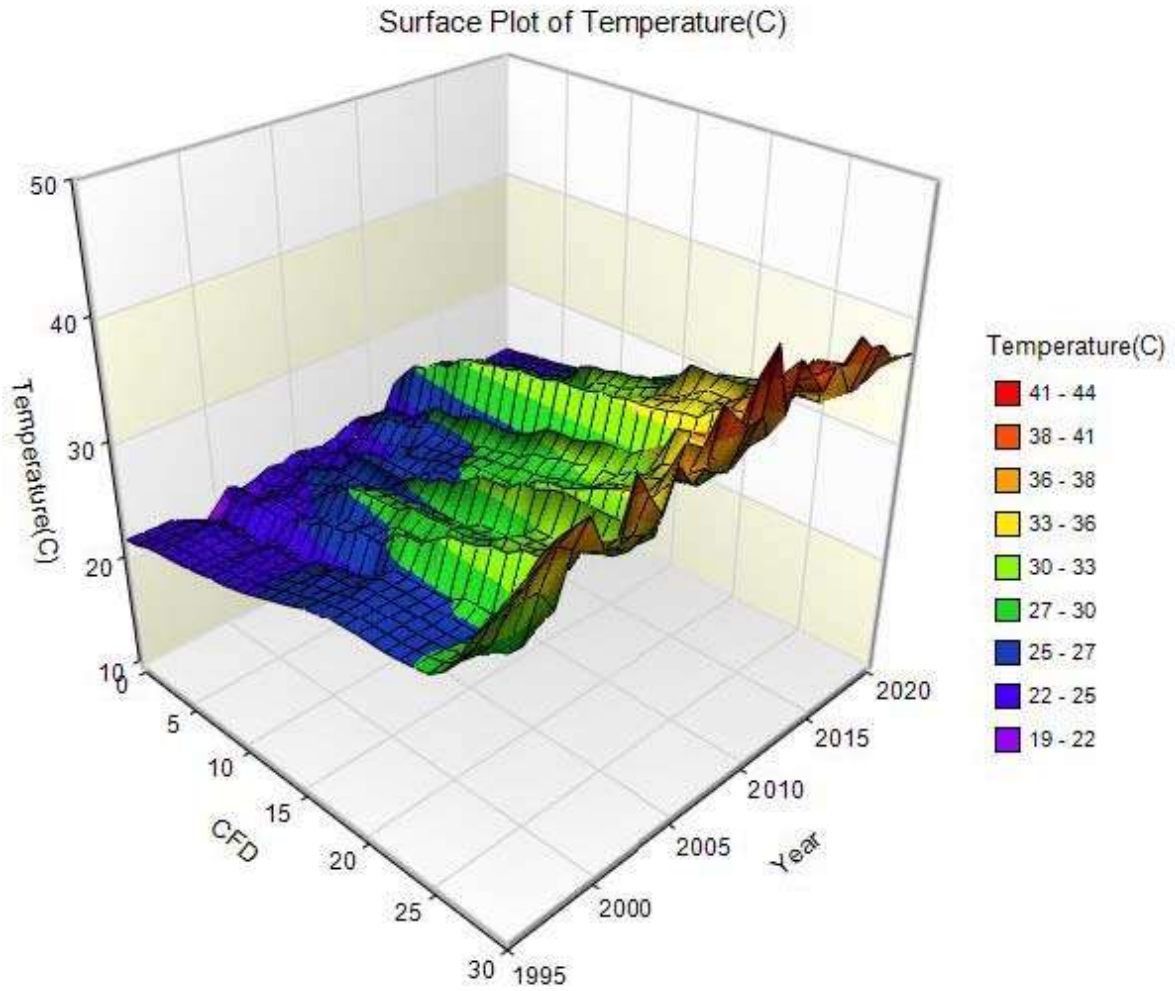
Is it possible to incorporate trends in the data ?



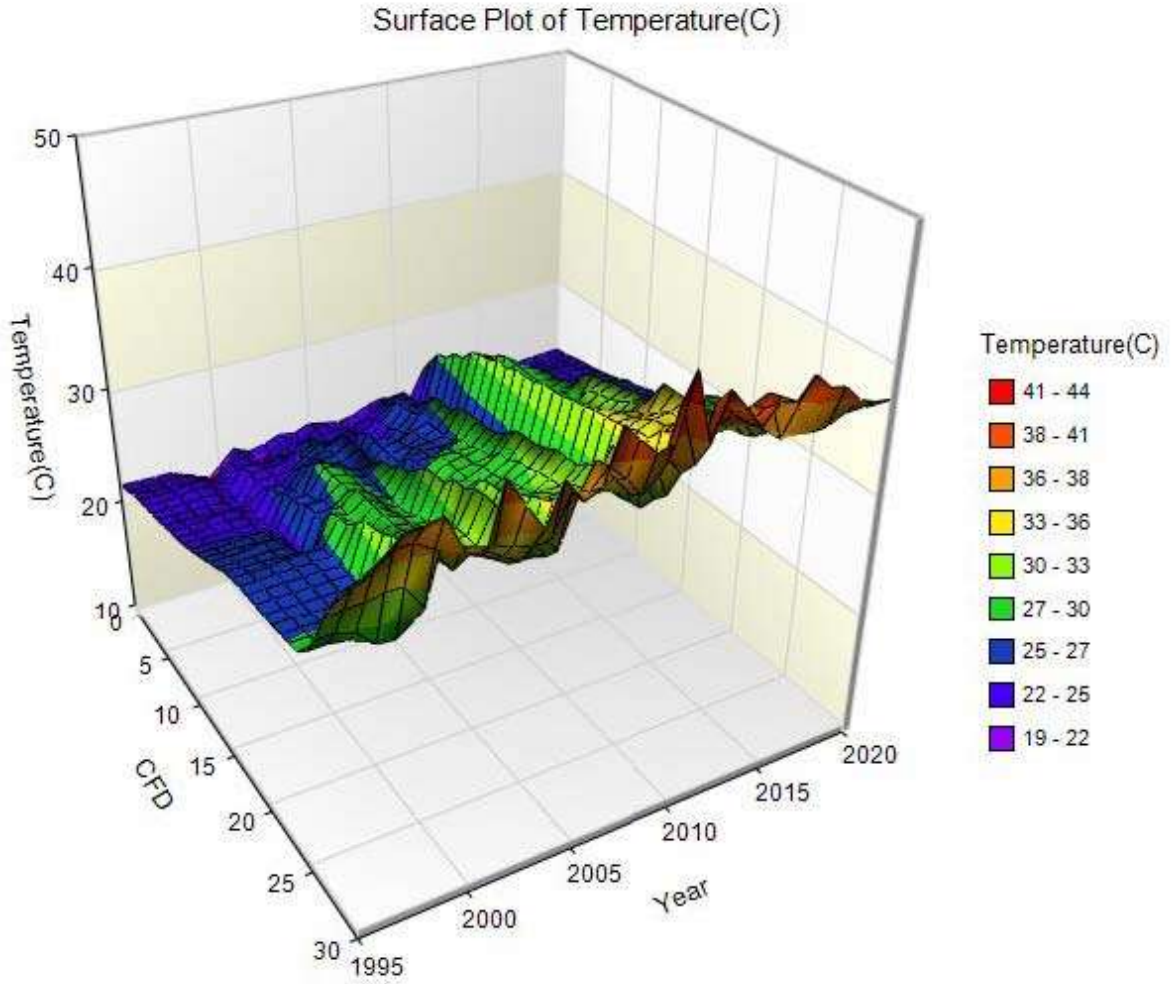
Revisiting the Typical Year Methodology



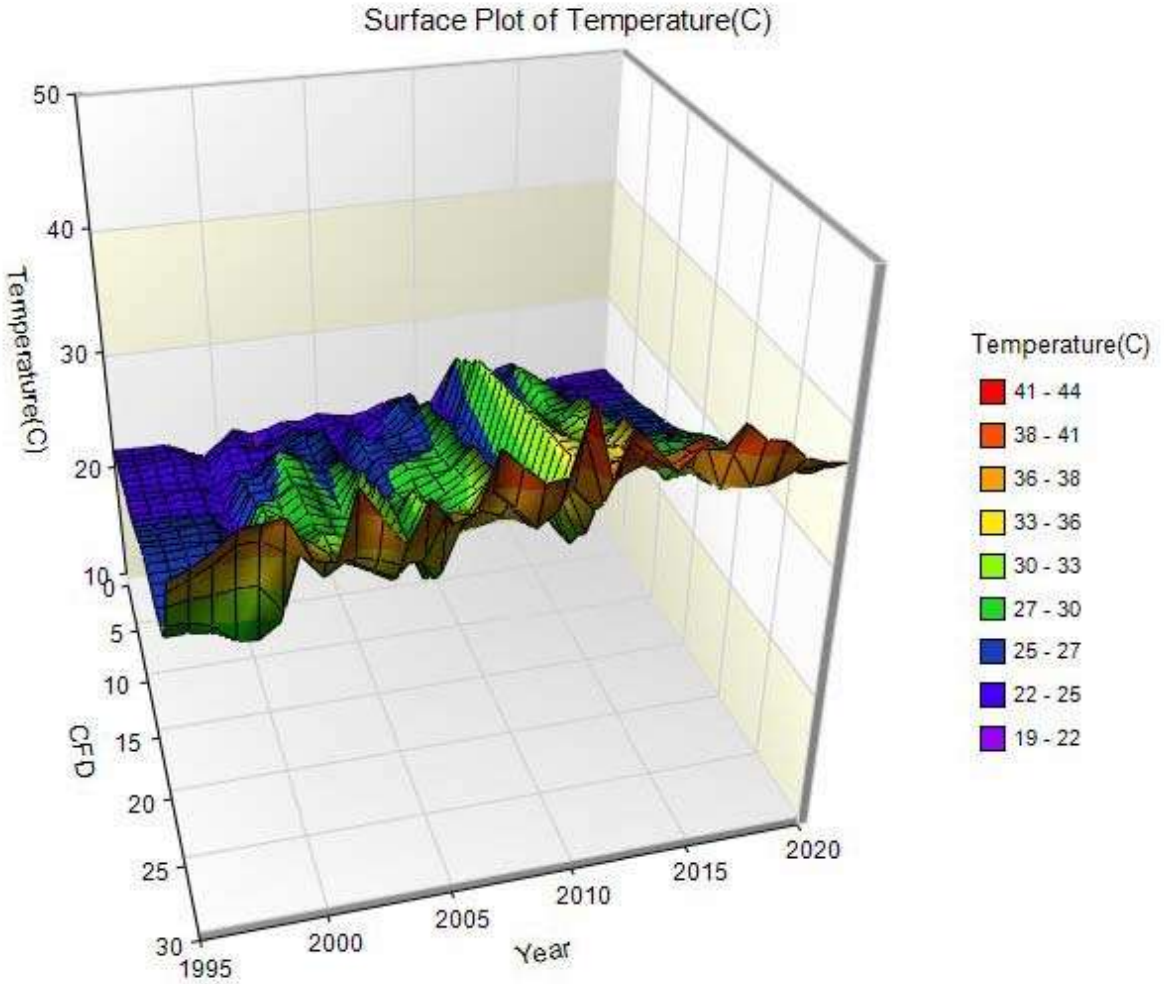
Revisiting the Typical Year Methodology



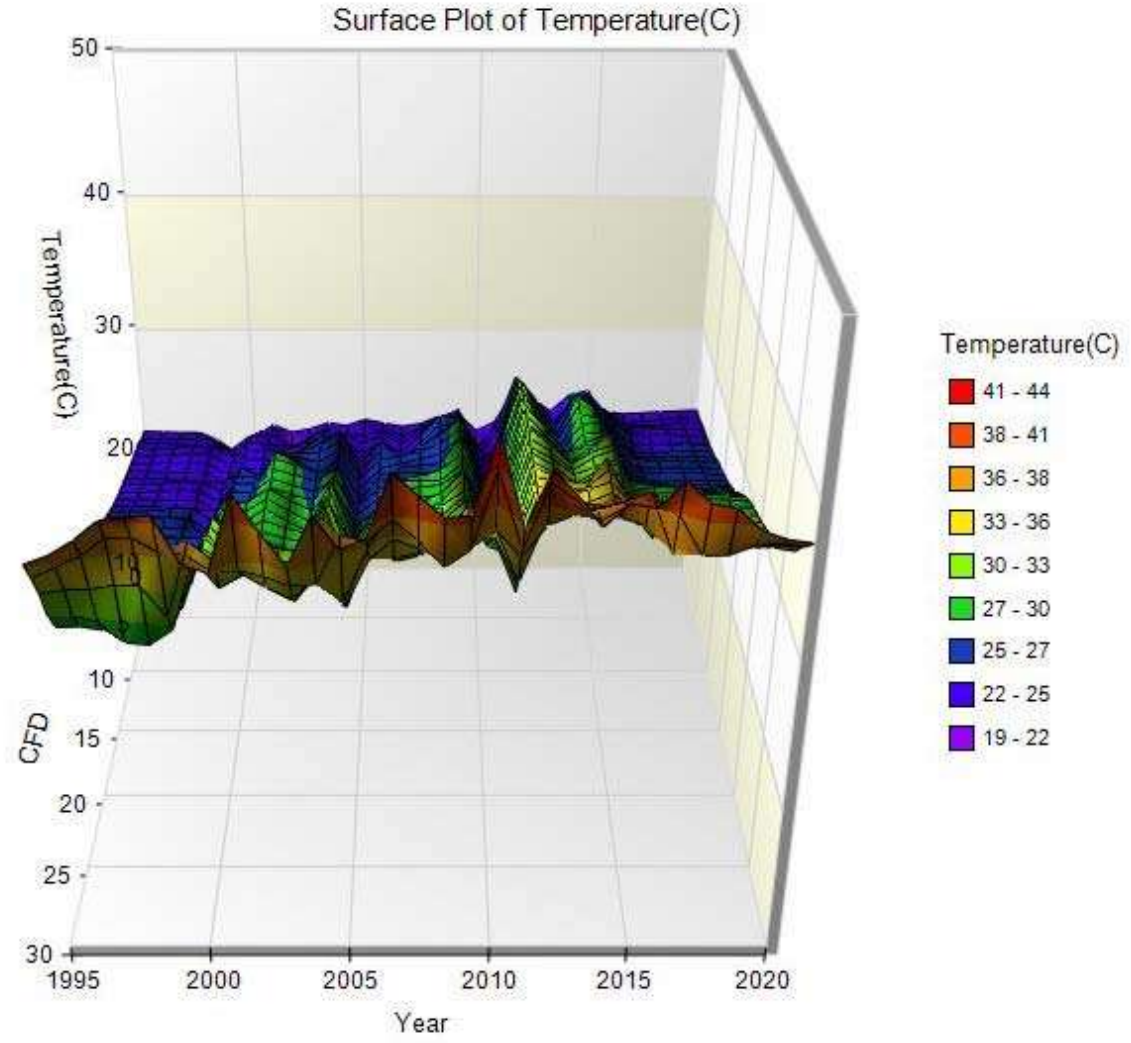
Revisiting the Typical Year Methodology



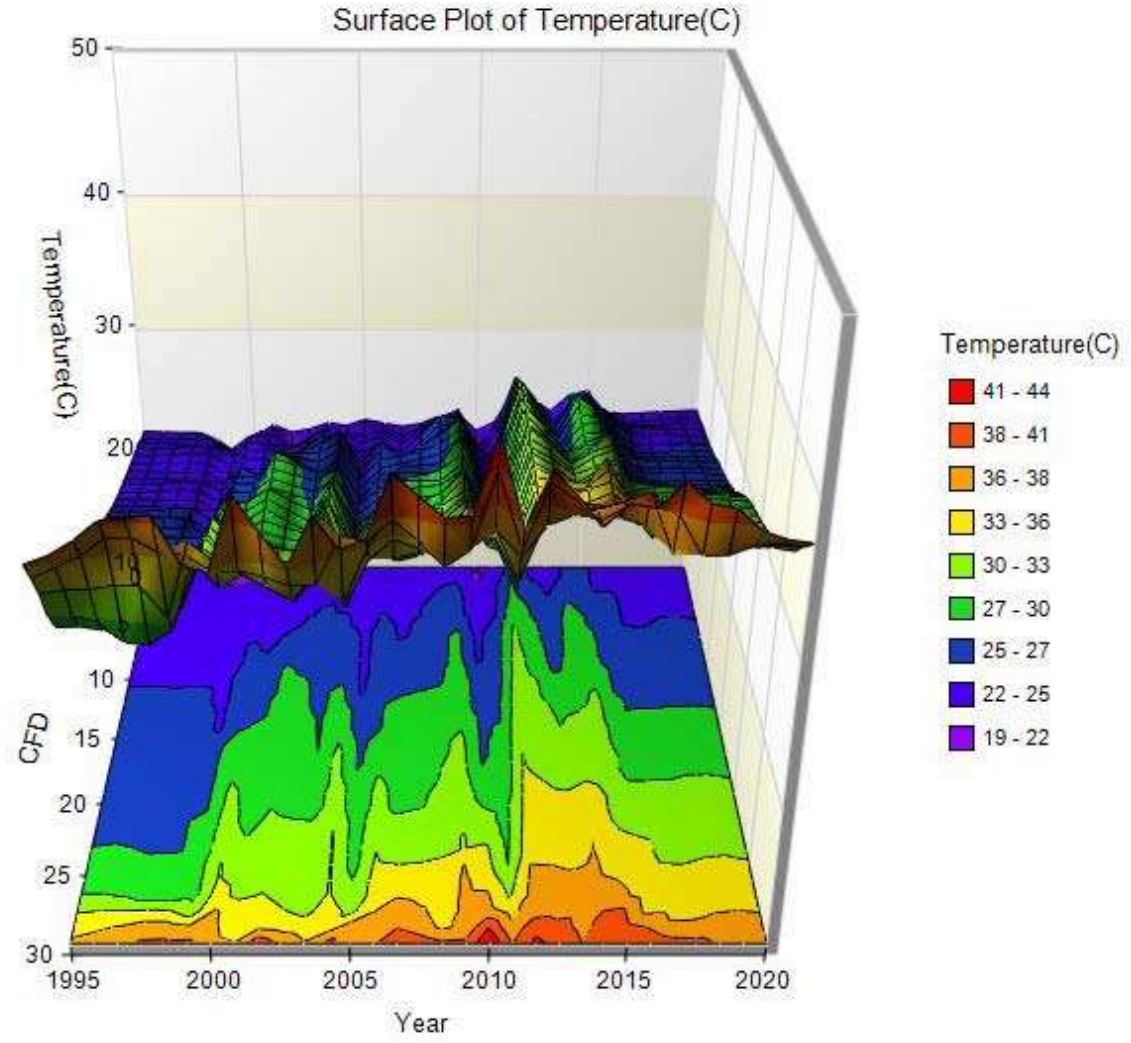
Revisiting the Typical Year Methodology



Revisiting the Typical Year Methodology



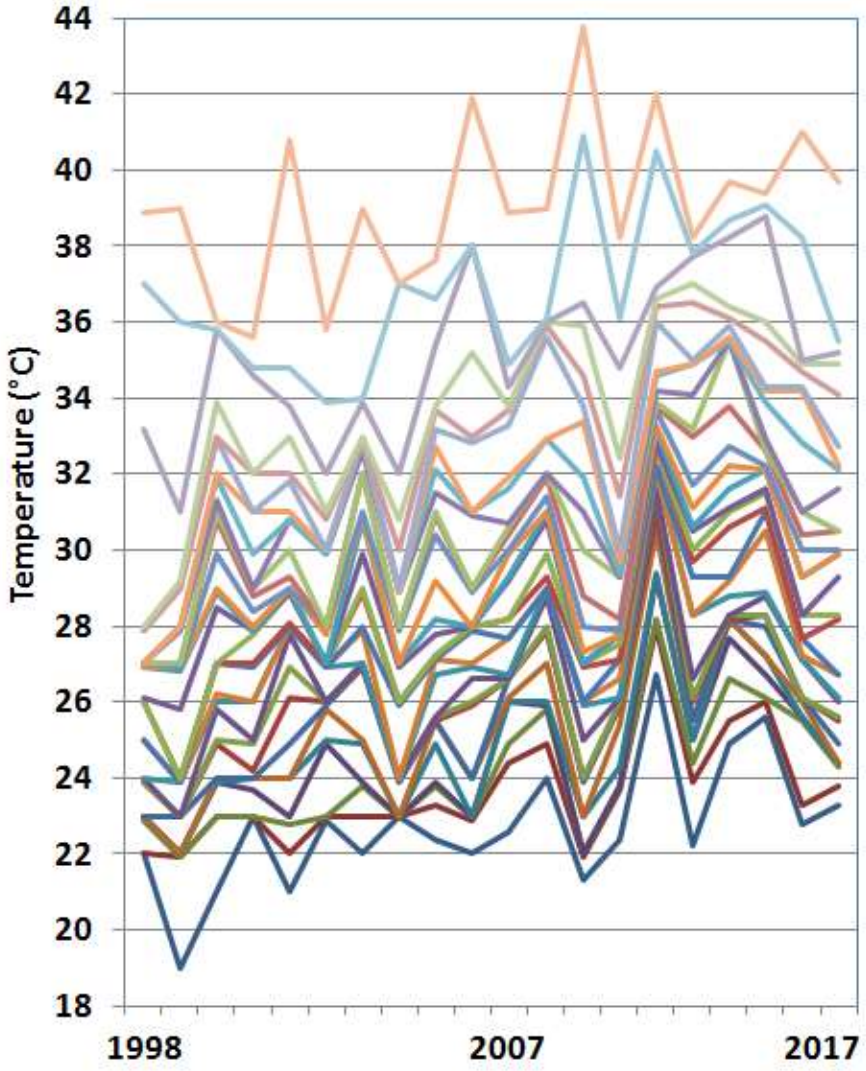
Revisiting the Typical Year Methodology

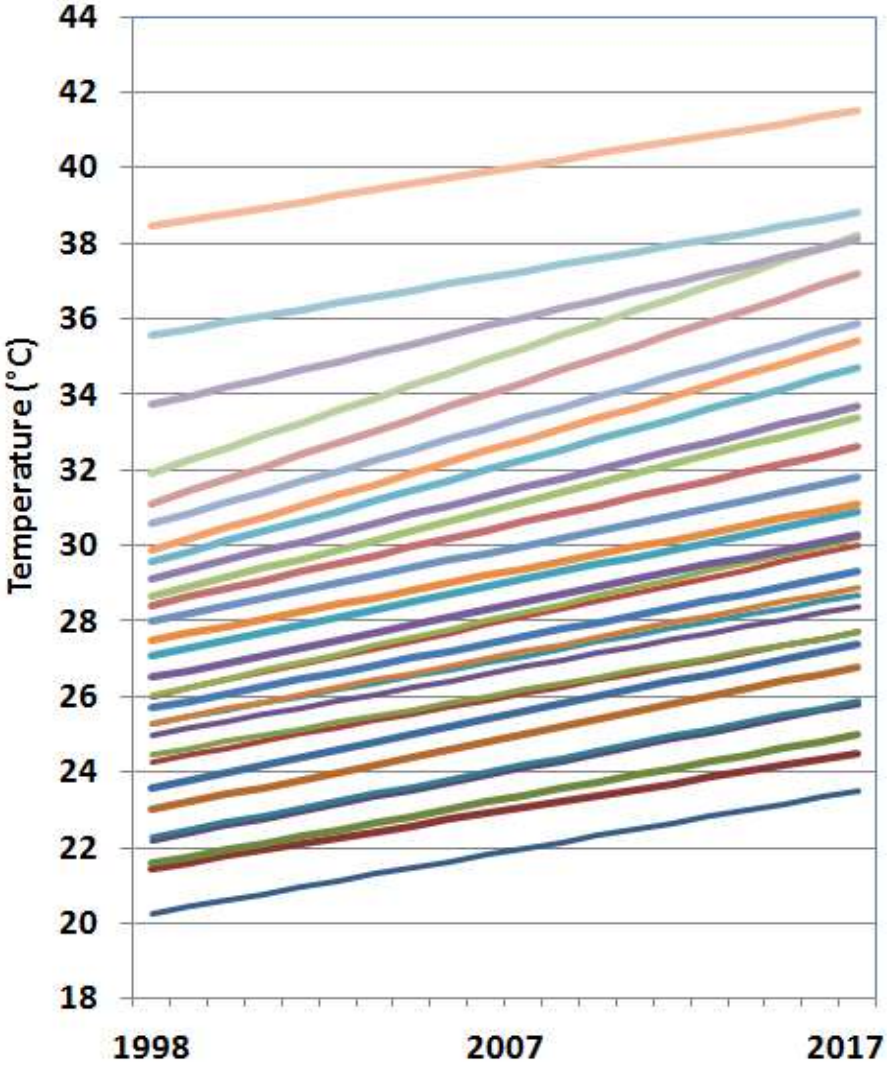


Revisiting the Typical Year Methodology

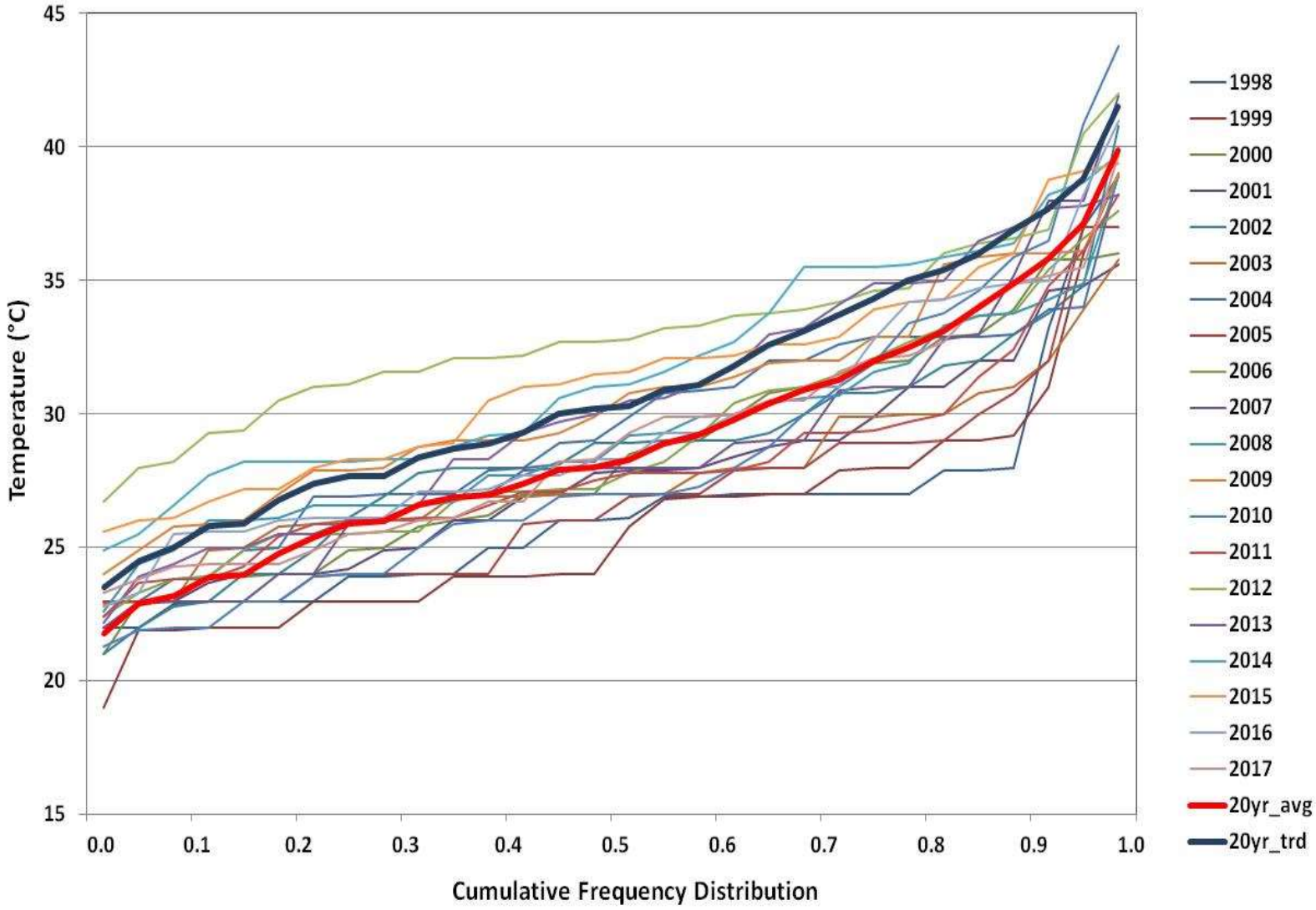
CFD	20yrs	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0.033	21.8	22.0	19.0	21.0	23.0	21.0	22.9	22.0	23.0	22.4	22.0	22.6	24.0	21.3	22.4	26.7	22.2	24.9	25.6	22.8	23.3
0.067	22.9	22.0	21.9	23.0	23.0	22.0	23.0	23.0	23.0	23.3	22.9	24.4	24.9	21.9	23.7	28.0	23.9	25.5	26.0	23.3	23.8
0.100	23.2	22.9	21.9	23.0	23.0	22.8	23.0	23.8	23.0	23.8	23.0	24.9	25.8	22.0	23.8	28.2	24.4	26.6	26.1	25.5	24.3
0.133	23.9	23.0	22.0	23.9	23.7	23.0	24.9	23.9	23.0	23.9	23.0	26.0	25.9	22.0	23.8	29.3	25.0	27.7	26.7	25.6	24.4
0.167	24.0	23.0	22.0	23.9	24.0	24.0	25.0	24.9	23.0	24.9	23.0	26.0	26.0	23.0	24.3	29.4	25.0	28.2	27.2	25.6	24.4
0.200	24.8	23.0	22.0	24.0	24.0	24.0	25.8	25.0	23.0	25.5	24.0	26.1	27.0	23.0	25.4	30.5	25.5	28.2	27.2	26.0	24.4
0.233	25.4	23.0	23.0	24.0	24.0	24.9	25.9	26.9	23.9	25.5	24.0	26.6	27.9	23.9	25.9	31.0	25.5	28.2	28.0	26.1	24.9
0.267	25.9	23.9	23.0	24.9	24.2	26.1	26.0	26.9	24.0	25.5	25.9	26.6	27.9	24.0	25.9	31.1	26.0	28.2	28.3	26.1	25.5
0.300	26.0	23.9	23.0	25.0	24.9	26.9	26.0	27.0	24.0	25.6	26.0	26.6	28.0	24.0	26.0	31.6	26.1	28.3	28.3	26.1	25.6
0.333	26.6	24.0	23.0	25.8	25.0	27.8	26.0	27.0	24.0	25.6	26.6	26.6	28.8	25.0	26.1	31.6	26.6	28.3	28.8	27.1	26.0
0.367	26.9	24.0	23.9	26.0	26.0	28.0	26.9	27.0	24.0	26.7	26.9	26.7	29.0	25.9	26.1	32.1	28.3	28.8	28.9	27.1	26.1
0.400	27.0	25.0	23.9	26.2	26.0	28.0	26.9	27.9	24.0	27.1	27.0	27.7	29.0	26.0	26.6	32.1	28.3	29.2	30.5	27.2	26.7
0.433	27.4	25.0	23.9	27.0	26.9	28.0	26.9	28.0	25.9	27.1	27.9	27.7	29.0	26.0	27.1	32.2	29.3	29.3	31.0	27.7	26.7
0.467	27.9	26.0	24.0	27.0	27.0	28.1	27.0	28.9	26.0	27.2	28.0	28.2	29.3	26.9	27.1	32.7	29.7	30.6	31.1	27.7	28.2
0.500	28.0	26.0	24.0	27.0	27.8	28.9	27.0	29.0	26.0	27.2	28.0	28.2	29.9	27.0	27.5	32.7	30.0	31.0	31.5	28.3	28.3
0.533	28.3	26.1	25.8	28.5	27.9	28.9	27.0	29.9	26.9	27.8	28.0	29.2	30.8	27.0	27.8	32.8	30.5	31.1	31.6	28.3	29.3
0.567	28.9	26.9	26.8	28.9	27.9	29.0	27.0	30.8	27.0	28.2	28.0	29.3	31.0	27.0	27.8	33.2	30.6	31.6	32.1	29.3	29.9
0.600	29.2	26.9	26.9	29.0	28.0	29.0	27.8	30.9	27.0	29.2	28.0	29.9	31.0	27.3	27.8	33.3	31.1	32.2	32.1	29.3	29.9
0.633	29.8	27.0	26.9	29.9	28.4	29.0	28.0	31.0	27.9	30.4	28.9	30.0	31.4	28.0	27.9	33.7	31.7	32.7	32.2	30.0	30.0
0.667	30.4	27.0	27.0	30.8	28.8	29.3	28.0	32.0	28.0	30.9	29.0	30.4	31.9	28.8	28.2	33.8	33.0	33.8	32.6	30.4	30.5
0.700	30.9	27.0	27.0	31.0	29.0	30.0	28.0	32.0	28.0	31.0	29.0	30.6	32.0	30.0	29.3	33.9	33.2	35.5	32.6	31.0	30.5
0.733	31.3	27.0	27.9	31.3	29.0	30.8	29.9	32.6	28.9	31.5	30.9	30.7	32.0	31.0	29.3	34.2	34.1	35.5	32.9	31.0	31.6
0.767	32.0	27.0	28.0	31.9	29.9	30.8	29.9	32.9	28.9	32.1	31.0	31.6	32.9	31.9	29.4	34.6	34.9	35.5	33.9	32.8	32.1
0.800	32.5	27.0	28.0	32.0	31.0	31.0	30.0	32.9	28.9	32.7	31.0	31.9	32.9	33.4	29.7	34.7	34.9	35.6	34.2	34.2	32.2
0.833	33.1	27.9	29.0	32.9	31.0	31.8	30.0	32.9	29.0	33.2	32.8	33.3	35.6	33.8	30.0	36.0	35.0	35.9	34.3	34.3	32.7
0.867	34.0	27.9	29.0	33.0	32.0	32.0	30.8	32.9	30.0	33.7	33.0	33.7	35.9	34.6	31.4	36.4	36.5	36.1	35.5	34.7	34.1
0.900	34.9	28.0	29.2	33.9	32.0	33.0	31.0	33.0	30.8	33.8	35.2	33.8	36.0	35.9	32.4	36.6	37.0	36.4	36.0	34.9	34.9
0.933	35.8	33.2	31.0	35.8	34.6	33.8	32.0	33.9	32.0	35.4	38.0	34.3	36.0	36.5	34.8	36.9	37.7	38.2	38.8	35.0	35.2
0.967	37.1	37.0	36.0	35.8	34.8	34.8	33.9	34.0	37.0	36.6	38.0	34.9	36.1	40.9	36.1	40.5	37.8	38.7	39.1	38.2	35.5
1.000	39.9	38.9	39.0	36.0	35.6	40.8	35.8	39.0	37.0	37.6	41.9	38.9	39.0	43.8	38.2	42.0	38.2	39.7	39.4	41.0	39.7

Revisiting the Typical Year Methodology





Revisiting the Typical Year Methodology



Revisiting the Typical Year Methodology

How has this modification been received ?

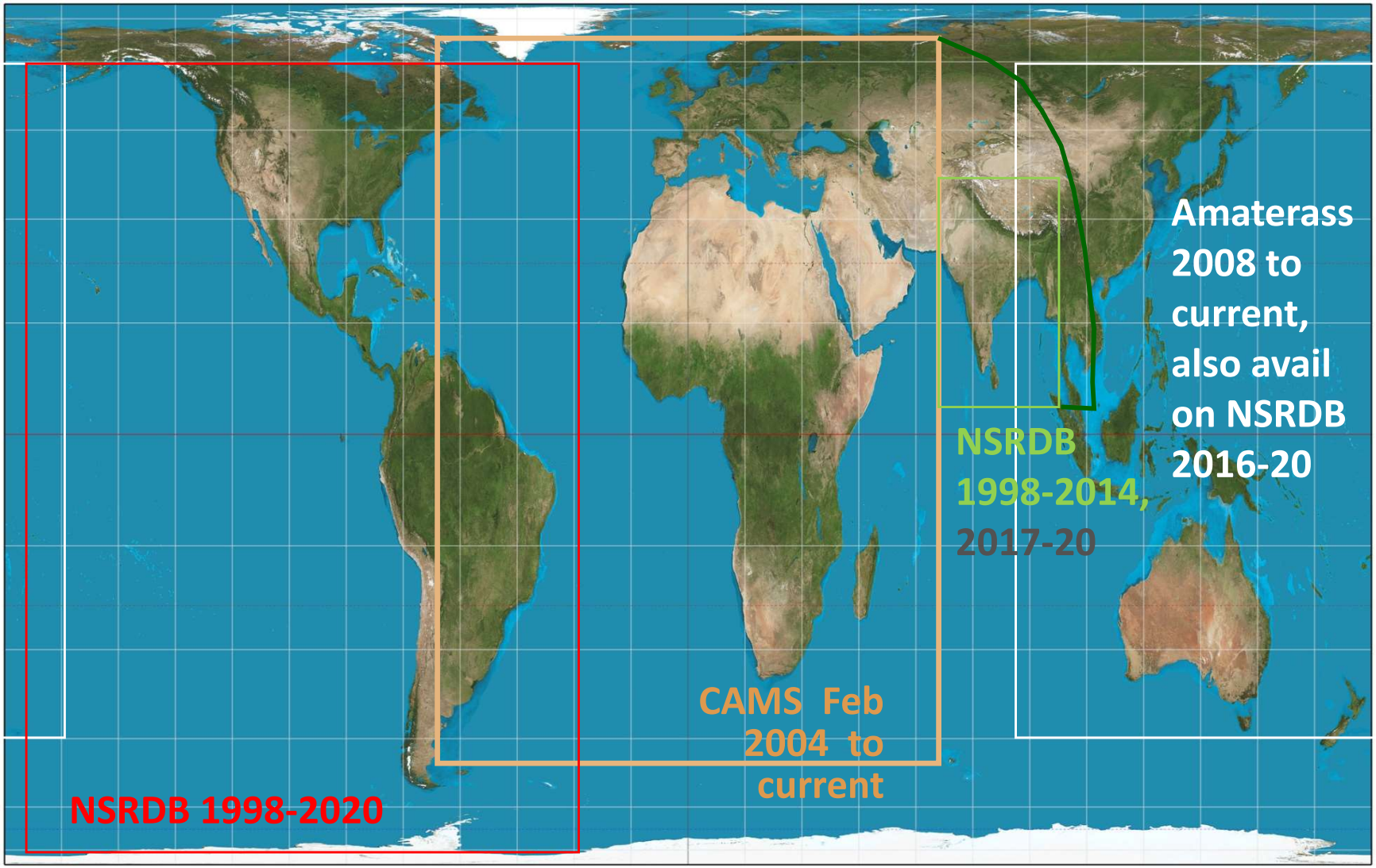
- **“The change is too drastic”**
- **“Trends are meaningless”**

Proposed Solution :

- **Create two sets of “typical year” files**
- **Use the “standard” typical year files as the baseline for evaluating existing projects.**
- **Use the “trended” typical year files as the baseline for evaluating proposed projects.**

Incorporating new sources of weather data in updating the IWEC2 to IWEC3

Satellite-derived solar radiation now available for practically anywhere around the world



Incorporating new sources of weather data in updating the IWEC2 to IWEC3

Reanalysis data are now available for anywhere and any time for data filling

Fig. 1. Measured and original MERRA2 Dry Bulb Temperatures in Jumla Nepal WMO 444240 Jan 2014

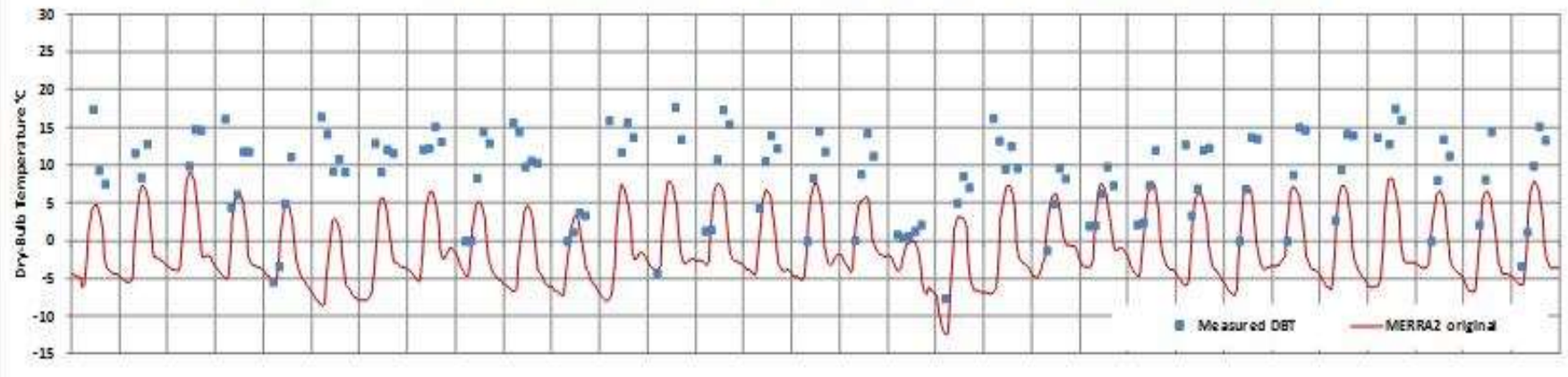
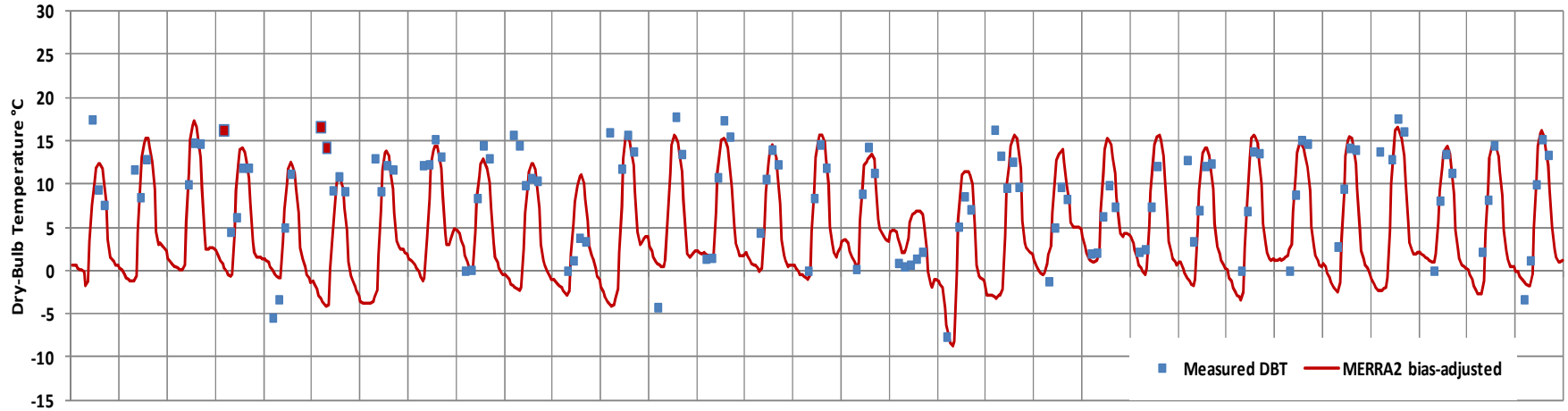


Fig. 3 Measured and MERRA2 bias-adjusted Dry Bulb Temperatures in Jumla Nepal WMO 444240 Jan 2014



Current status of updating the IWEC2s to IWEC3s

- Identified 2160 locations in Europe and former Soviet Union
- Identified 2308 locations in Asia, Africa, South America, and Oceania
- Meteorological data are all ready, but still lacking solar data for earlier years in East Asia and all years in the polar regions
- Created trial set of files for 1000 locations in Europe with complete satellite-derived solar
- Since both meteorological and solar data were already complete and available, created a set of TMY4s for the US that have been sent to NREL for evaluation.
- Still refining software and evaluating results of the time-trended typical years
- Expected timeline for first complete set of IWEC3s in 3-6 months

Questions and Comments?

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