Assessing the Impact of Potential Climate Changes on Surface Meteorological and Solar Energy Flux Parameters Relevant to Energy Usage and Efficiency

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Project Objectives

Objectives:

- Provide baseline analysis and and uncertainty assessment for the current state of:
  1. the building climate zone estimates and climate design conditions from GCM control model runs (i.e., AMIP) using MERRA and surface measurements (derived from temperature and precipitation); evaluate downscaled meteorological parameters as needed
  2. the surface solar radiation fluxes GCM control model runs (AMIP) using satellite based estimates of solar resource (e.g., GEWEX SRB and CERES) and surface measurements

- Provide an assessment and data sets of the building climate zones and solar resource derived using GCM runs (CMIP5) from various climate change scenarios to the present day.
  1. Assess observed shifts and changes in terms of the current climate uncertainties and variability for both quantities.
  2. Develop these climate scenario based products in formats commonly used by industry professionals for further use and assessment.
  3. Also, provide these data sets for use by other interested participants and web based tools to access derived parameters.

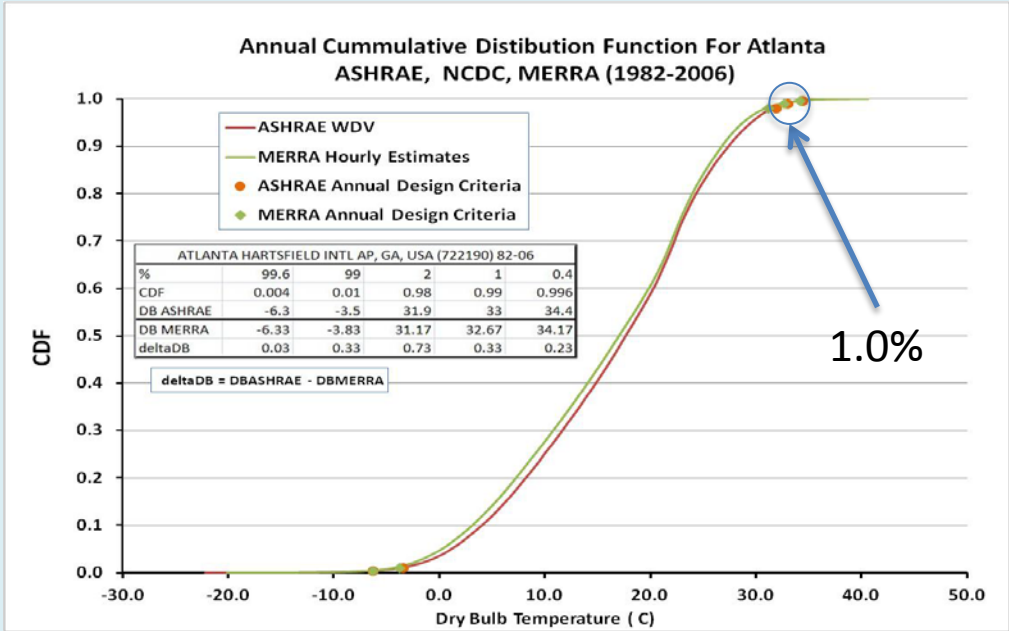
NCA Progress

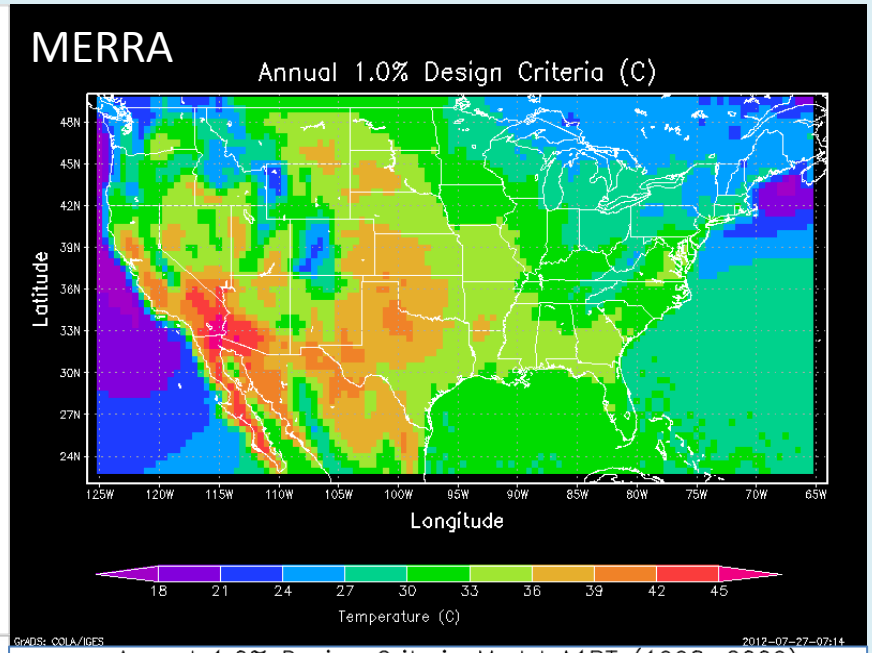
- **Assessing 30 year baseline of Building Design Related Parameters From MERRA and Satellite Surface Radiation**
  - *i. Derived Building Climate Design Conditions from 30-year MERRA hourly surface parameters*
    - Include estimates of extremes called "Dry Bulb Design Criteria"
    - Validated against ASHRAE surface measurements;
    - **Published paper in ASHRAE Transactions**
  - *ii. Derived Building Climate Zone Types from MERRA the daily averaged temperatures, daily max/min temperatures and precipitation to the ½ ° x ½ ° degree resolution.*
    - Validated data products against surface sites.
    - Assessed the variability of the zones in past 30 years
    - **Draft paper being finalized**
  - *iii. Derived Surface Solar Irradiance amounts and variability from GEWEX SRB/CERES EBAF and MERRA*
    - Validated against US based surface measurements
    - Assessed variability within 30 years
- **Assess Application of Climate Design, Climate Zone and Solar Irradiance with AMIP/CMIP5 output**
  - *i. Evaluated base state to MERRA, Satellite Data Products and Surface Observations*
  - *ii. Evaluated changes of 3 future decades to present*

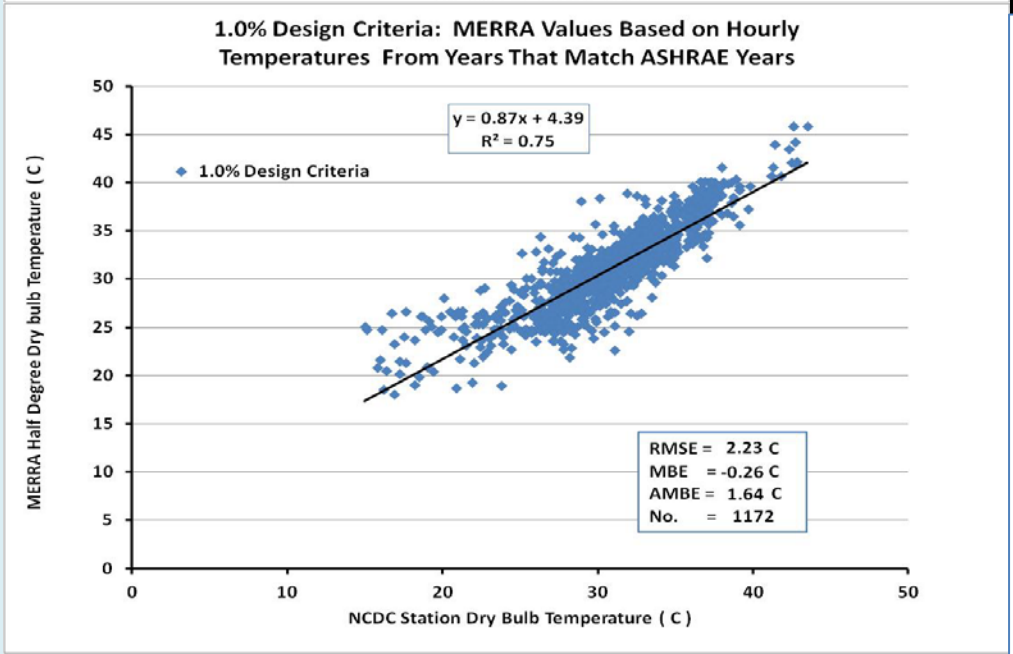
ASHRAE Annual Climate Design Conditions

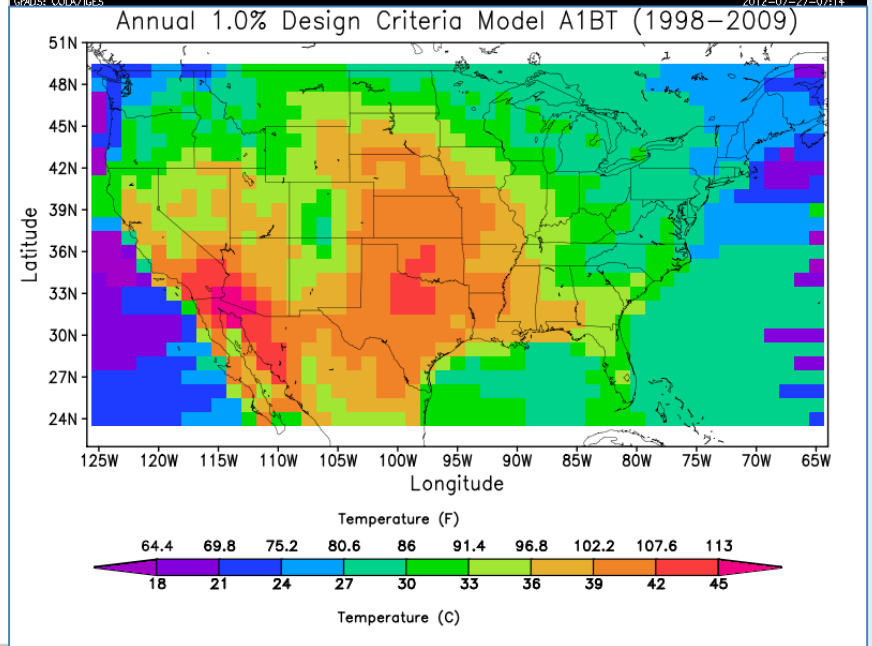
Used for designing and specification of building heating/cooling systems

I. ASHRAE Climatic Design Conditions





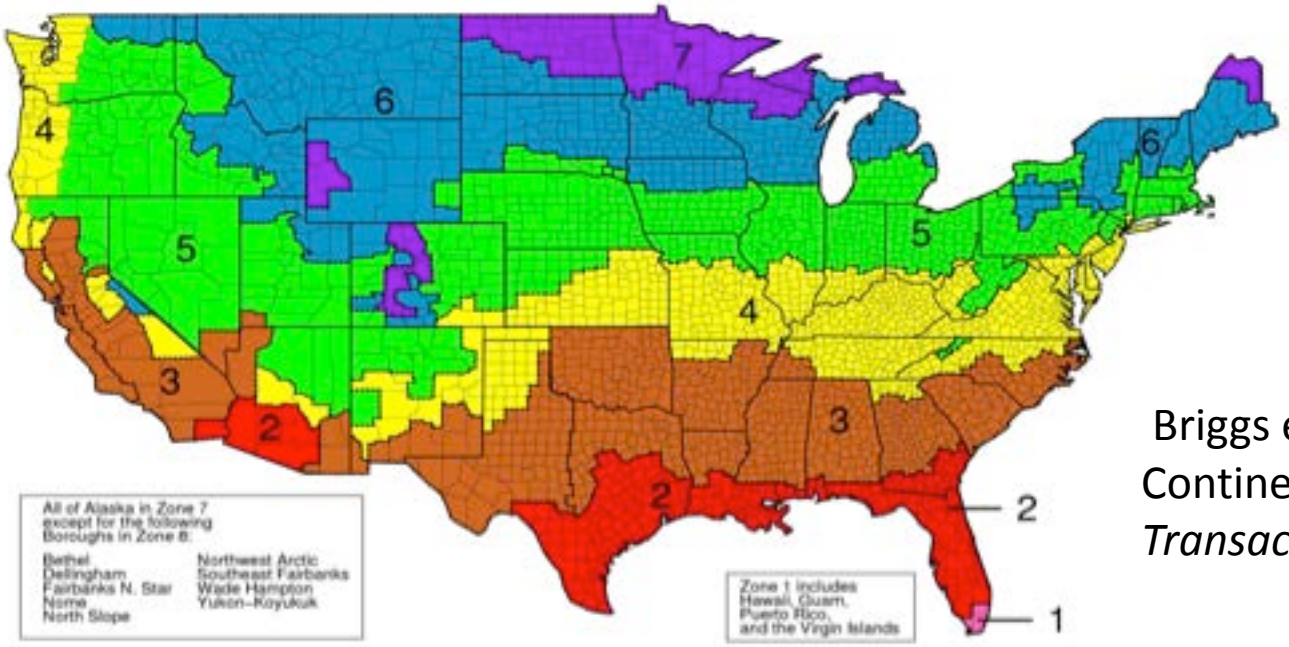




DOE/ASHRAE Building Climate Zone Types

Climate zone types determine building codes for building materials, insulation, HVAC, etc.

Current Climate Zones Maps



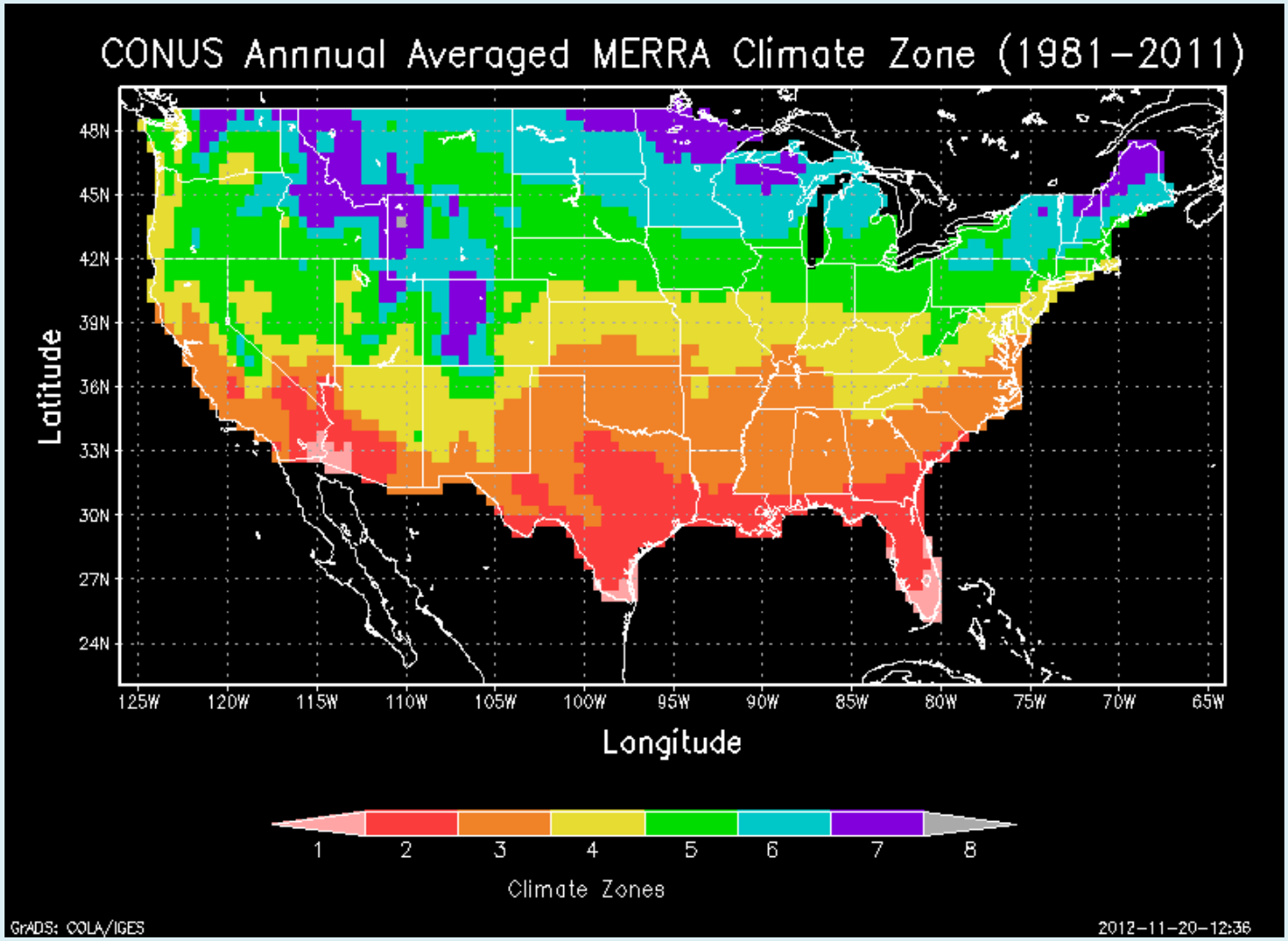
Briggs et al., 2002 of the Continental US (*ASHRAE Transactions*)

Characteristics of Briggs buildings climate zones			
Zone #	**Climate Zone Name and Type**	**Zone #**	**Climate Zone Name and Type**
1A	Very Hot – Humid	4C	Mixed – Marine
1B	Very Hot – Dry	5A	Cool – Humid
2A	Hot – Humid	5B	Cool – Dry
2B	Hot – Dry	5C	Cool – Marine
3A	Warm – Humid	6A	Cold – Humid
3B	Warm – Dry	6B	Cold – Dry
3C	Warm – Marine	7	Very Cold
4A	Mixed – Humid	8	Subarctic
4B	Mixed – Dry		

Key Parameters:

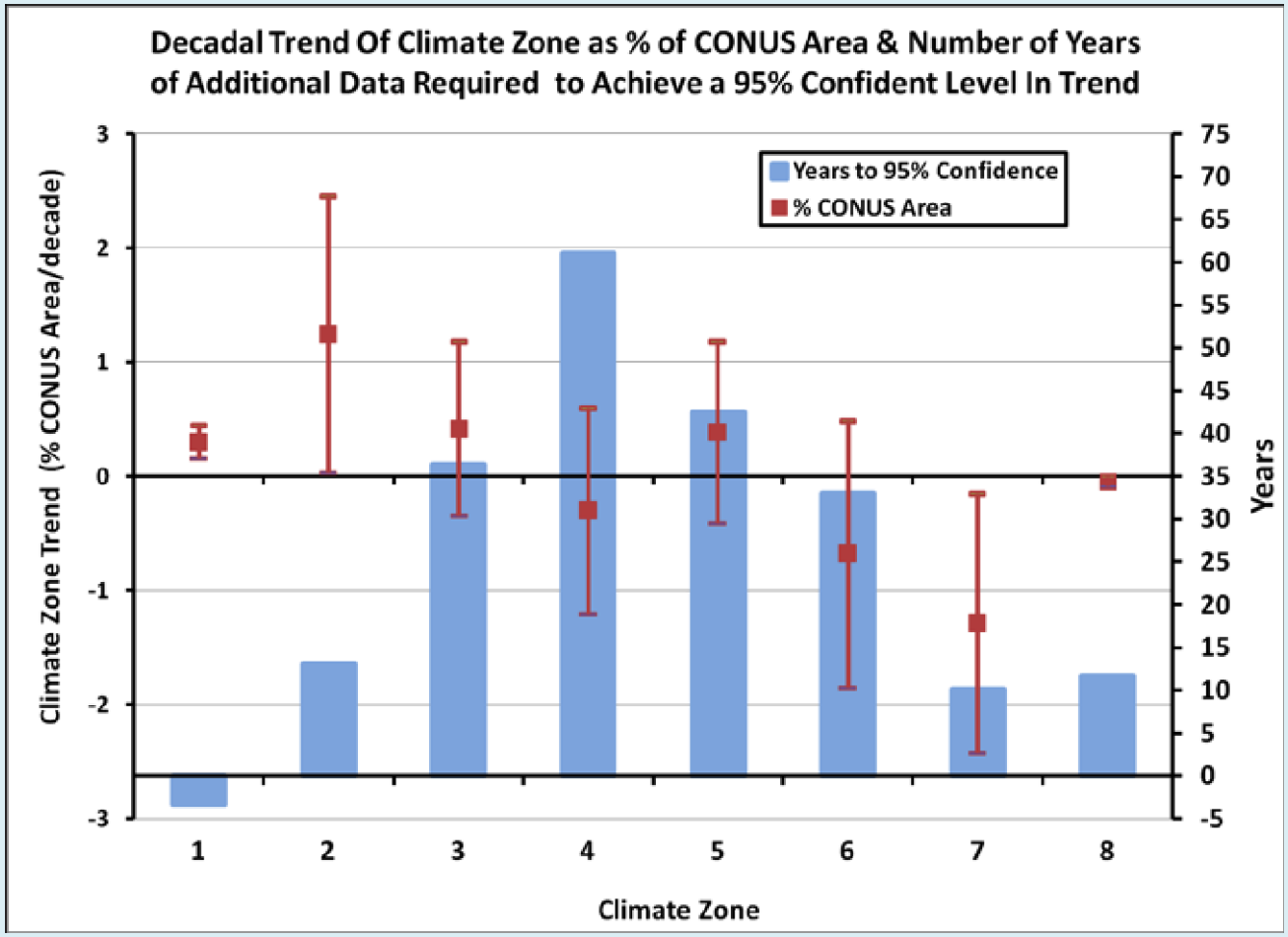
- Heating/Cooling Degree days using Max/Min daily temperatures
- Annual precipitation

MERRA Based 30 Year Climate Zones for CONUS



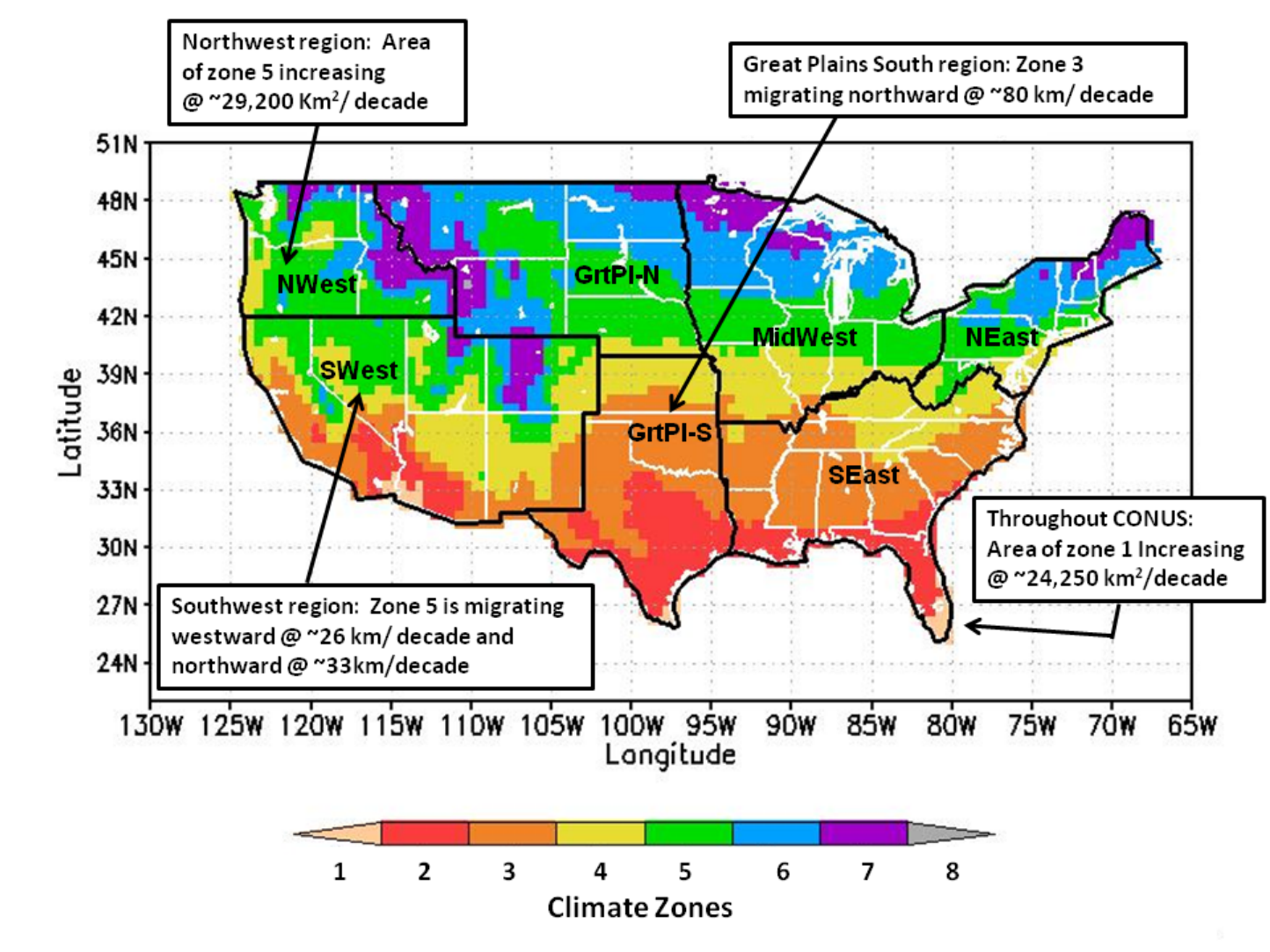
Statistical Significance?

- Used statistical technique of Weatherhead et al (1998) as modified by Hinkelman et al (2009) considers the autocorrelation as part of the time series.
- Determines confidence inteval and estimates # of years until 90% probability is obtained.



MERRA Climate Zones & Variability

Region 2 (7) is In(de)creasing by about 1.2% per decade; change won't be significant to 90% probability unless maintained another 10 years



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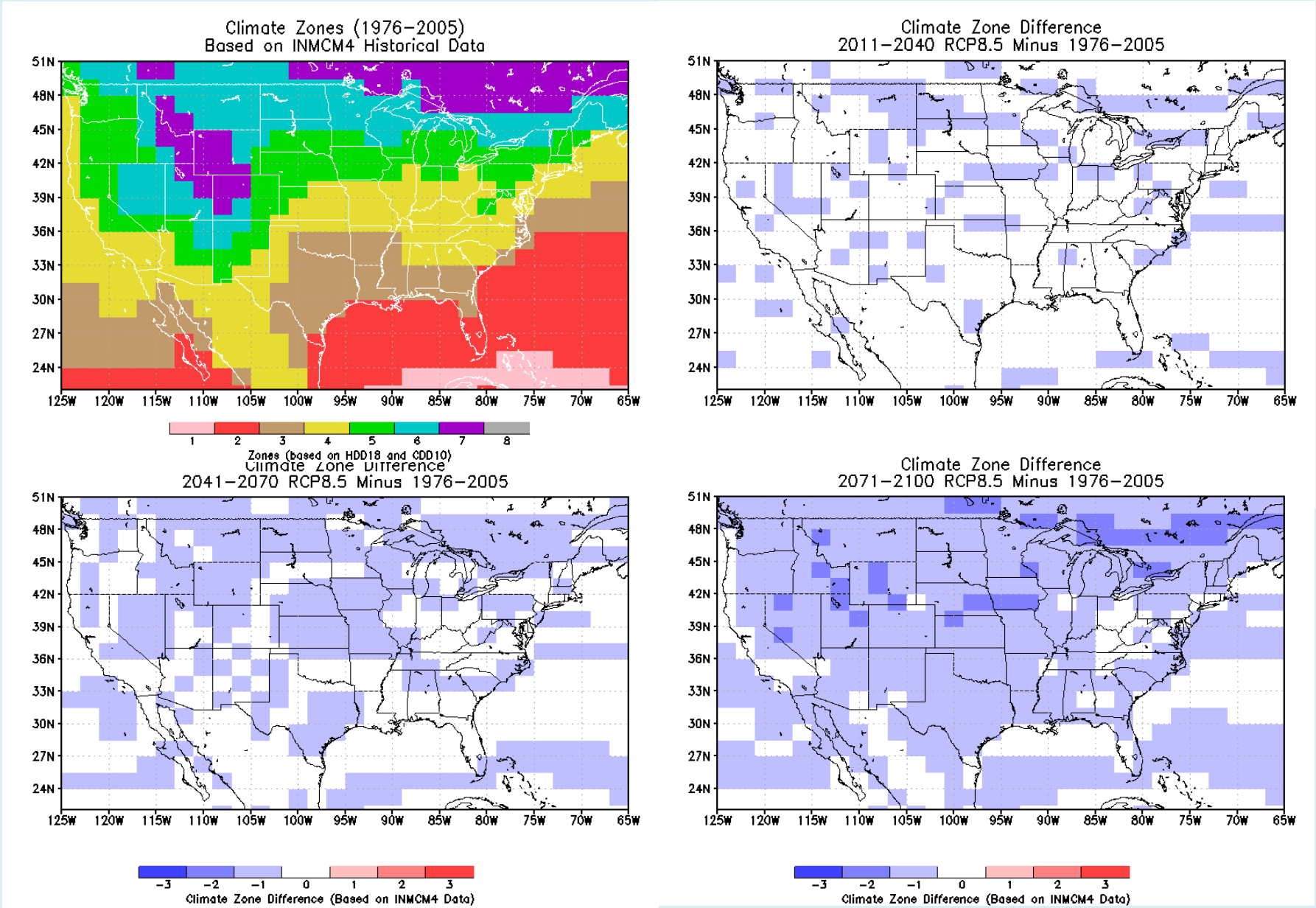
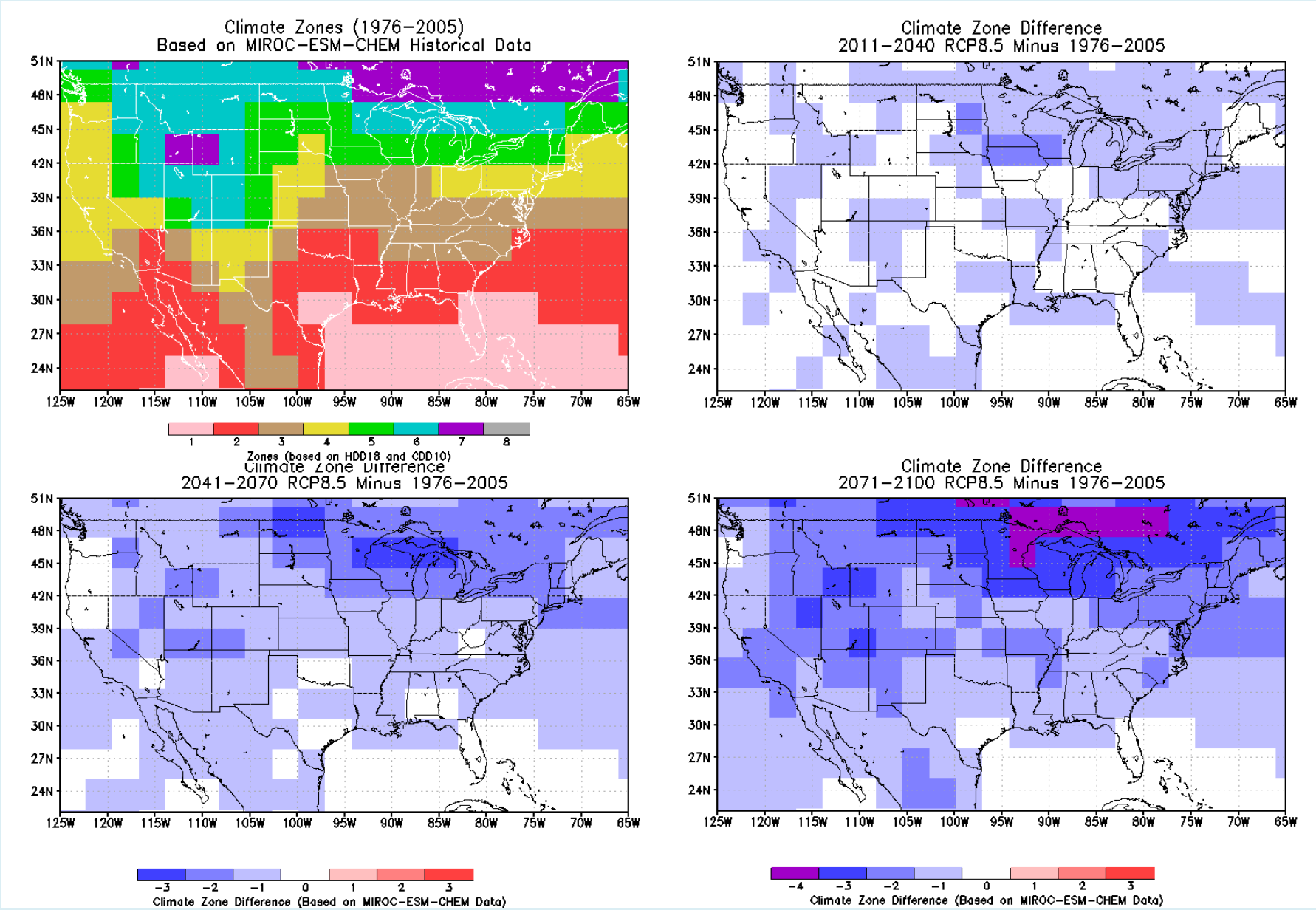
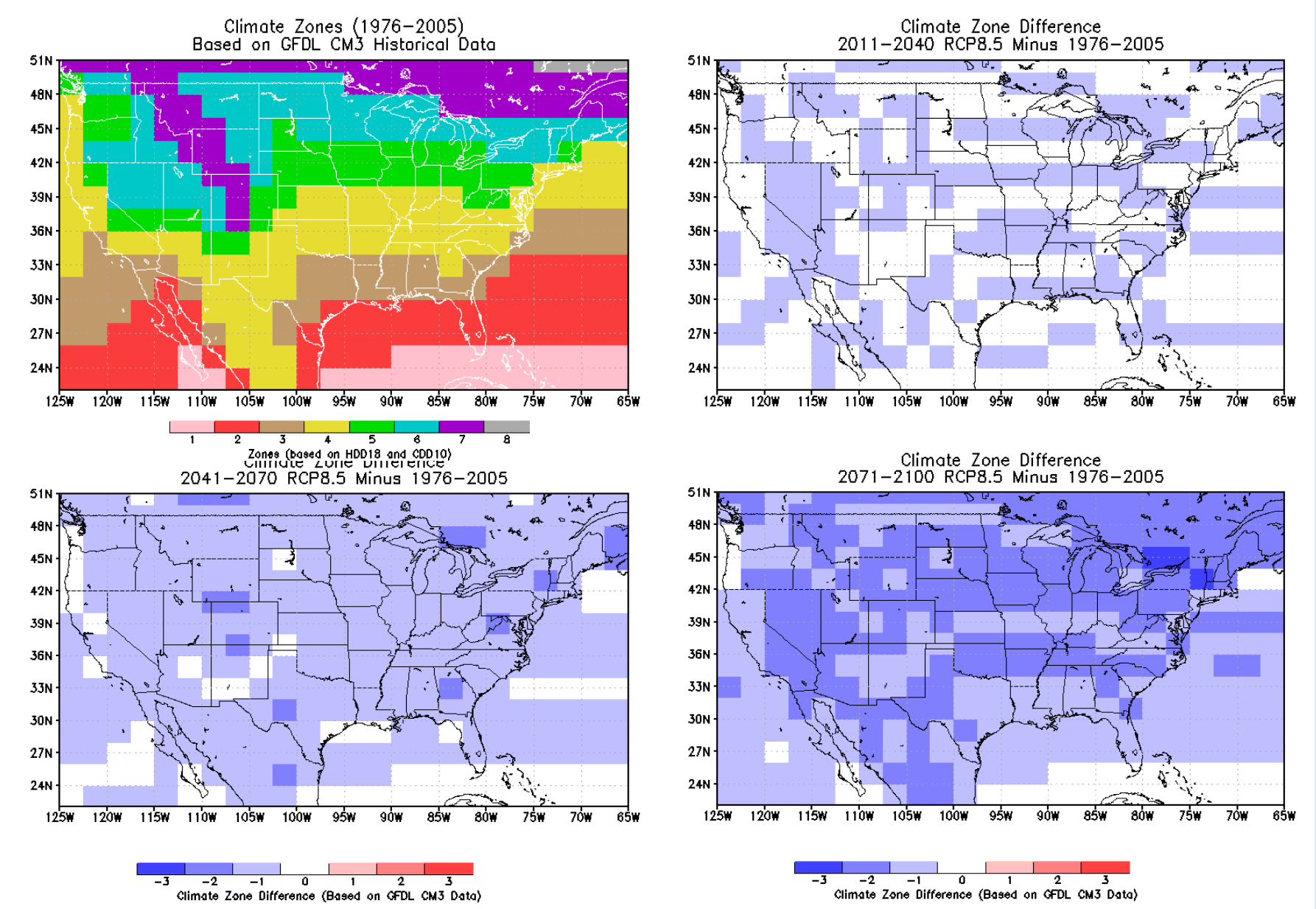
INM CM 4: 2011-2040 (RCP8.5) minus 1976-2005 (1.5 x 2.0 Degree Grid)



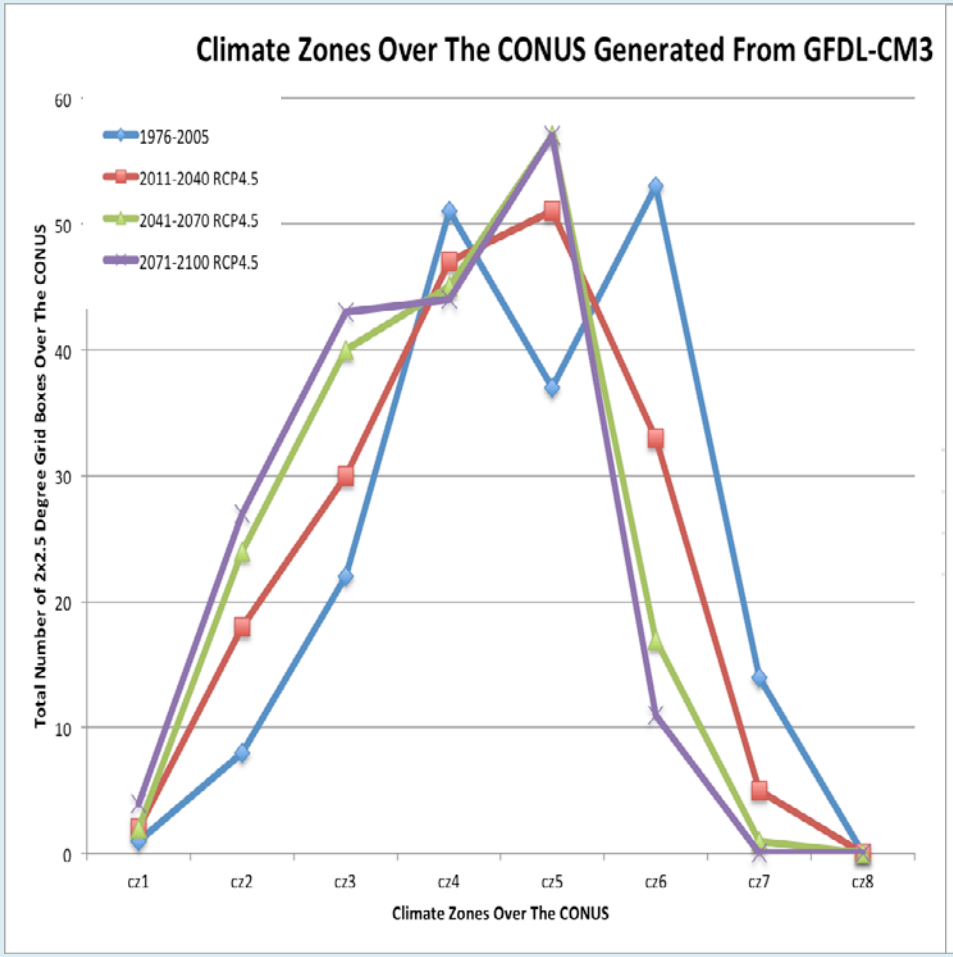
MICROC-ESM-CHEM: 2011-2040 (RCP8.5) minus 1976-2005 (2.8125 x 2.8125 Degree Grid)

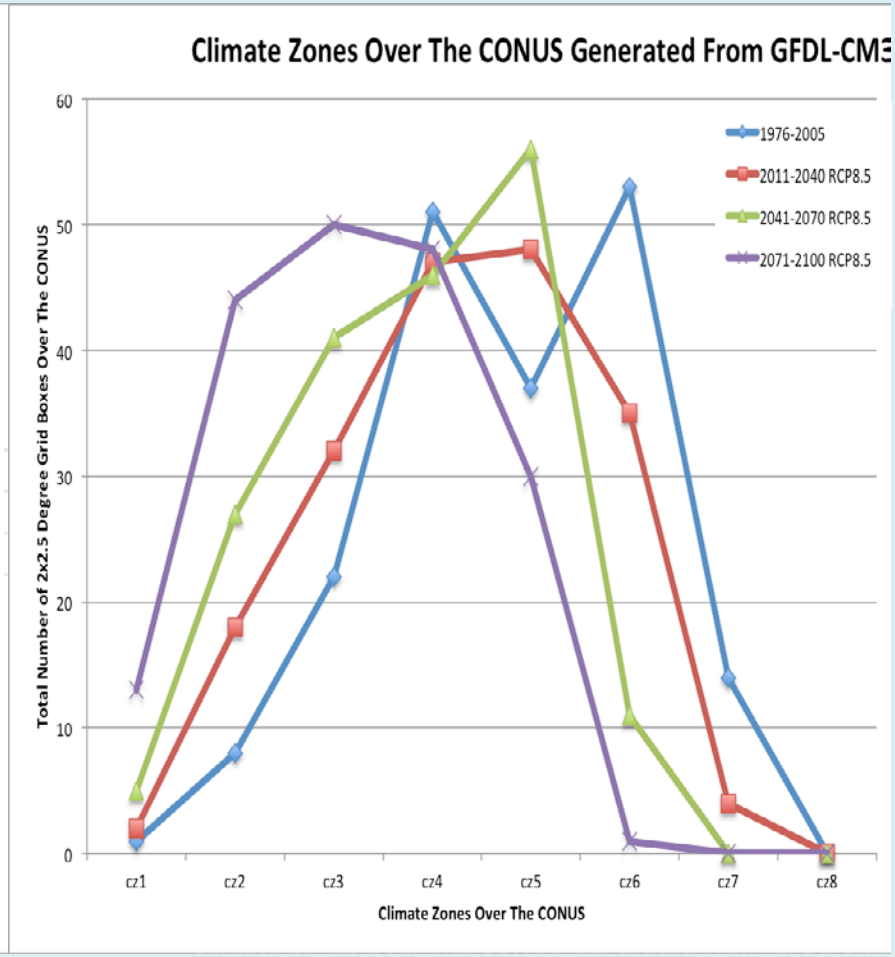


GFDL-CM3: 2011-2040 (RCP8.5) minus 1976-2005 (2.0 x 2.5 Degree Grid)



GFDL-CM3: Climate Zone Number Changes for RCP 4.5 and 8.5

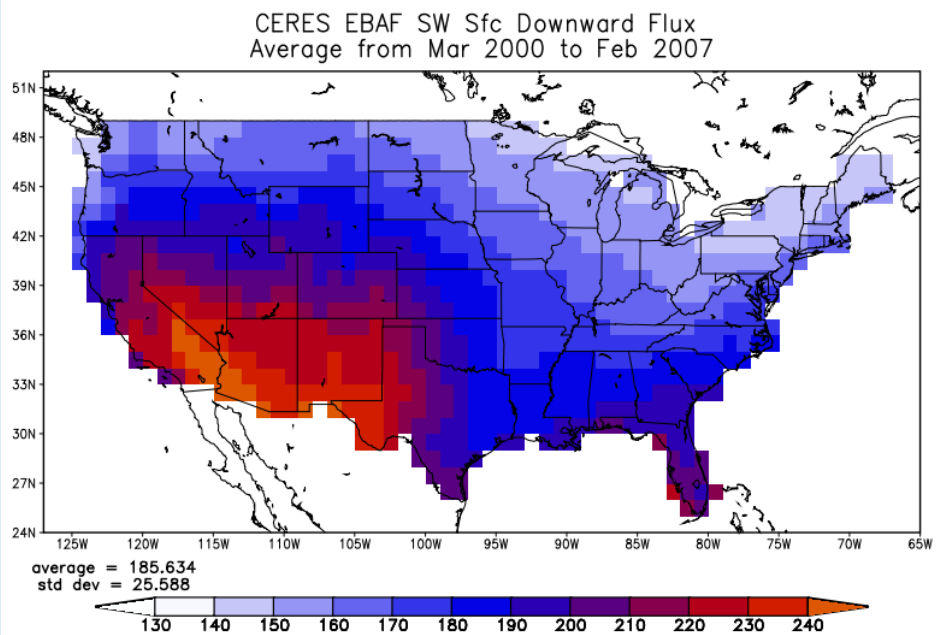


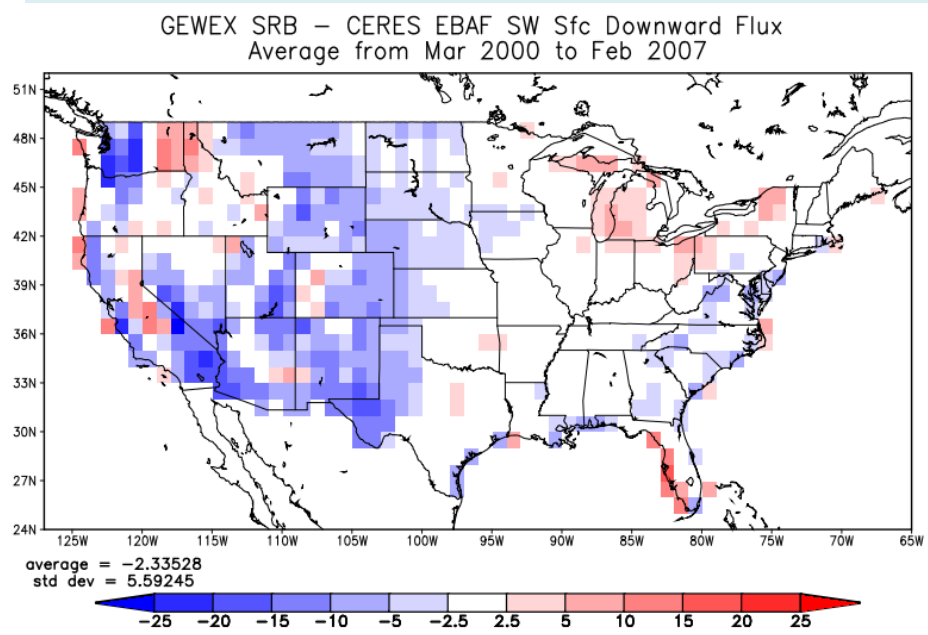


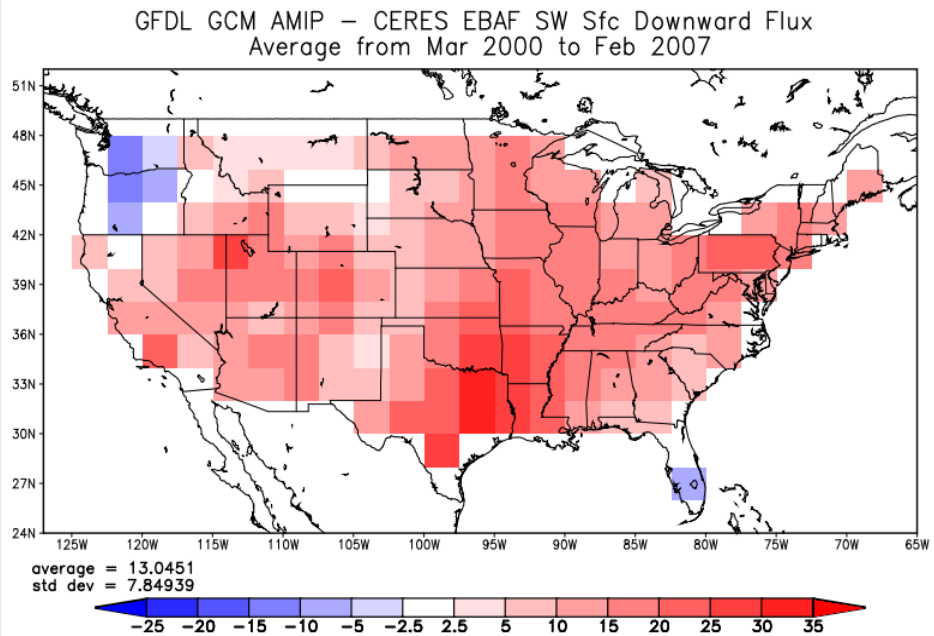
Solar Irradiance

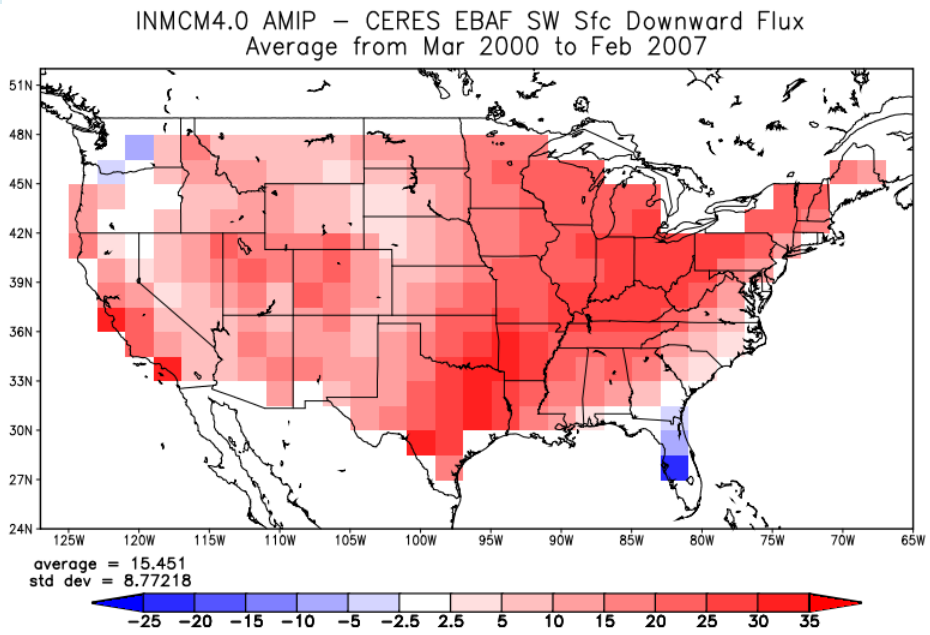
Solar energy systems ranging from standalone power generation to building integrated systems

CONSUS Solar Irradiance (Mar 2000 – Feb 2007)

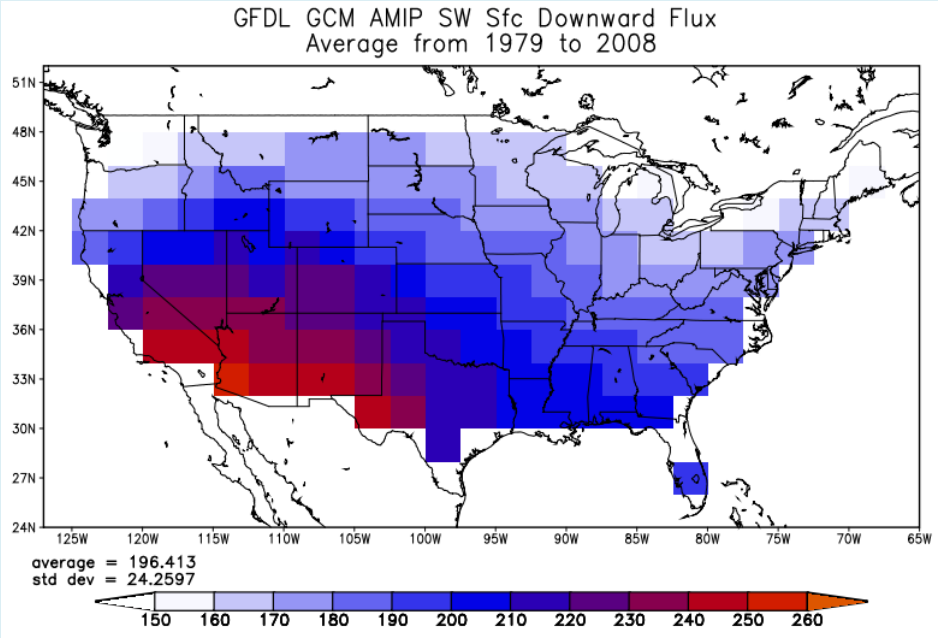


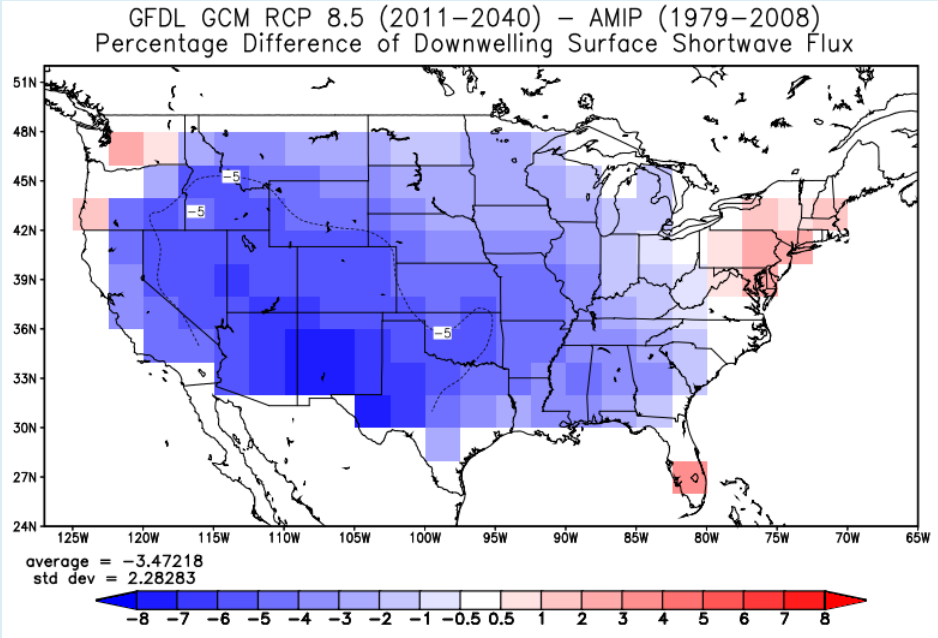


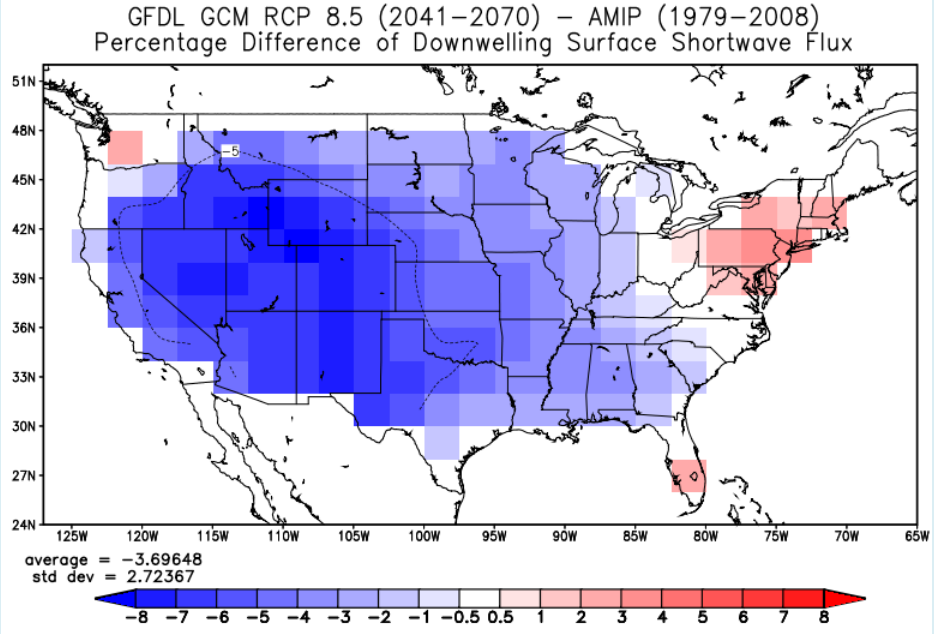


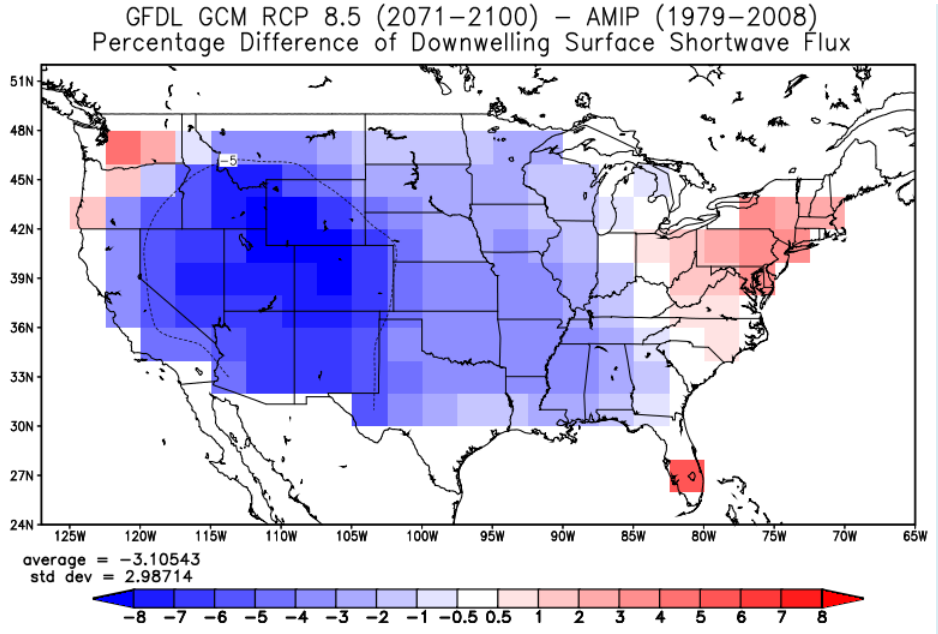


GDFL CONUS Solar Irradiance Changes

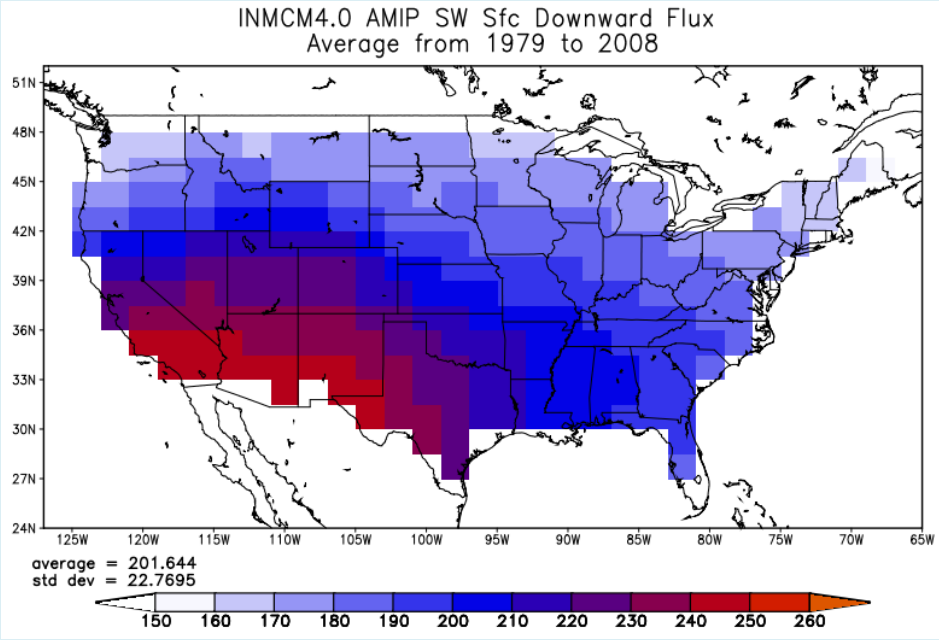


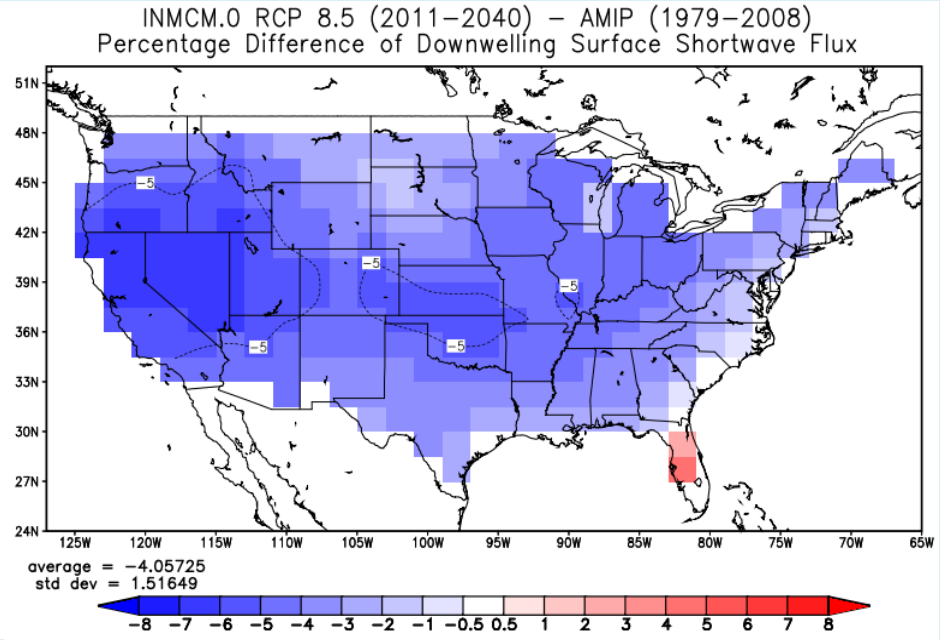


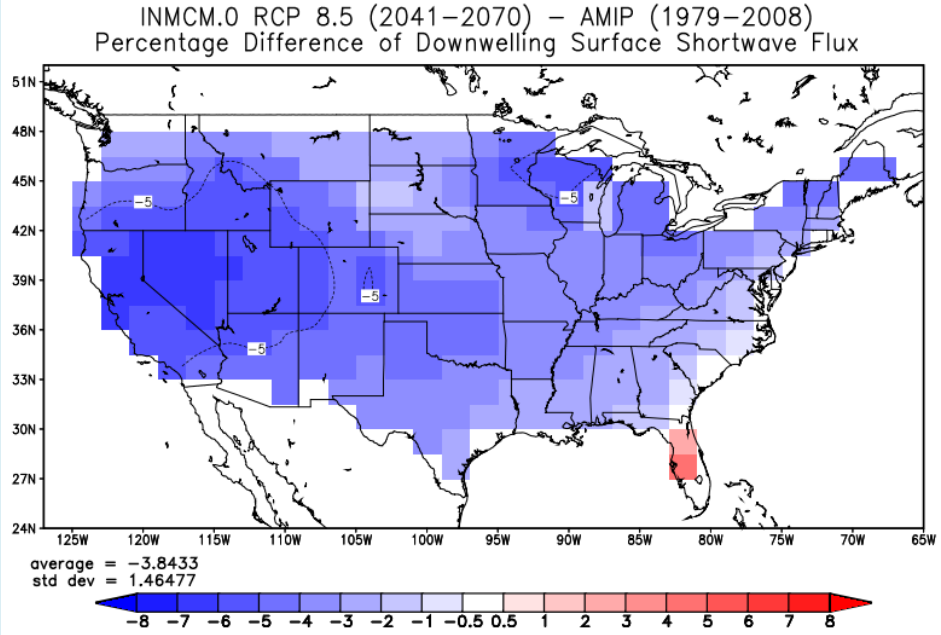


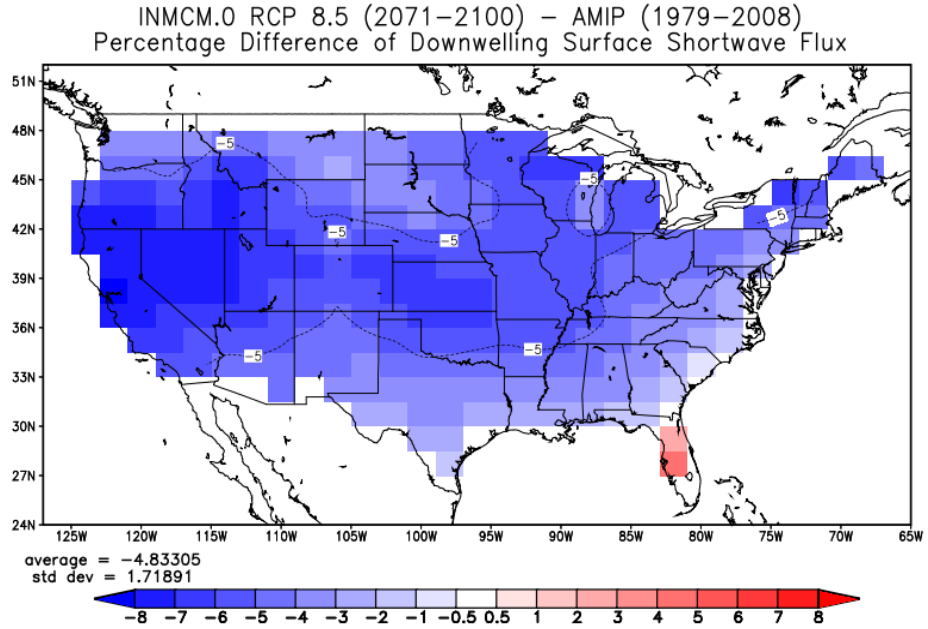


INM CM4 CONUS Solar Irradiance Changes









NCA Energy Related Planned Activities

- **ASHRAE Climatic Design Conditions**
  - ***i. Paper in ASHRAE Transactions on results***
  - *ii. Demonstrated implementation of analysis of climate model run output (GEOS GCM Fortuna_2_0 run), using models with 3-hourly data attempt first assessment for dry bulb temperature parameters*
- **DOE/ASHRAE Climate Zones**
  - ***i. Work with ASHRAE to publish climate zones from MERRA in next Handbook Edition (circulated in US and worldwide to more than 40,000 members)***
  - *ii. Complete assessment of sensitivity of zones from CMIP5 outputs for range of model simulations including ensemble statistics (assess need for bias correction)*
  - *iii. Submit paper on MERRA climate zone variability relative to surface observations and CMIP5 model output*
  - *iv. Improve web site capability for users to see climate zone and variability for any location on globe, including CMIP5 climate zone changes*
- **Solar Irradiance Assessment**
  - i. Assessed surface solar irradiance and variability using long-term NASA/GEWEX SRB, CERES EBAF 2.7 in comparison to MERRA and GEOS GCM run.
  - ii. Complete assessment surface solar irradiance sensitivity to CMIP5 model outputs including ensemble statistics
  - iii. Submit paper on solar variability and potential impact (assess bias correction)
  - **iv. Plan to report results to ongoing IEA Solar Knowledge Resource Assessment task**