SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Projection of Evapotranspiration from Regional Climate Models: Challenges

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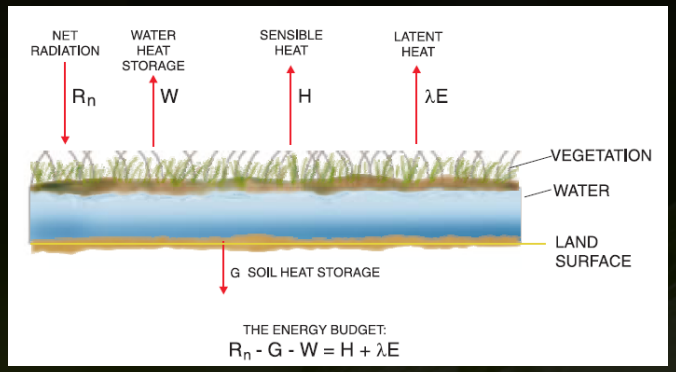
sfwmd.gov

Motivation

- Next to Precipitation, ET is perhaps the most important hydrologic variable in the Water Budget
- How ET may change in the context of climate change is not very clear
- Most Climate Change studies assume a simple ET model based on temperature only
- Regional Climate Models produce variables needed to compute ET

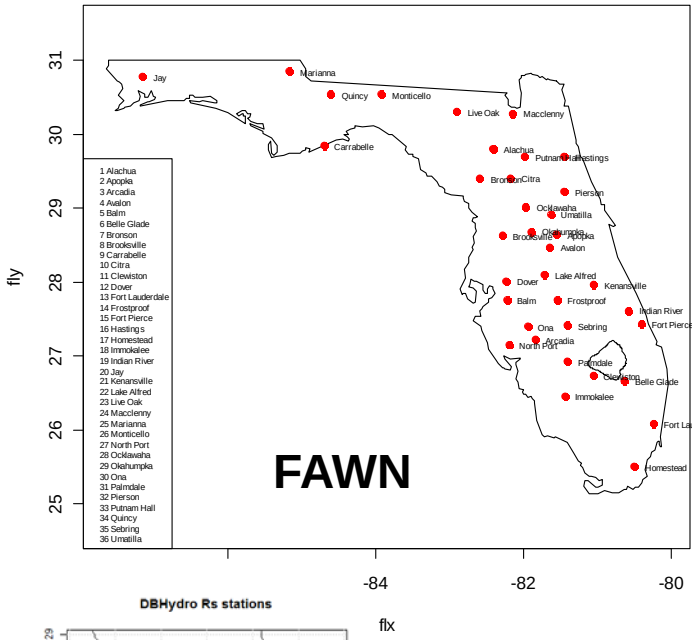
Evapotranspiration derived from NARCCAP Model Data



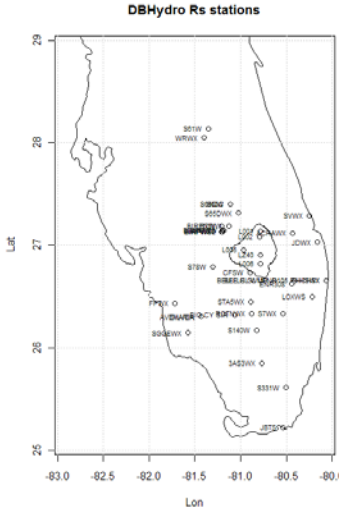
- Penman-Monteith Equation (FAO-56)
- Data used: Tmax, Tmin, Tave, Solar Radiation, Pressure, Wind, Min and Max Relative Humidity

Net solar Vapor pres. deficit

$$ET = \frac{1}{\lambda} \frac{\Delta(R_n - G) + \rho c_p (e_s - e_d) \frac{1}{r_a}}{\Delta + \gamma(1 + \frac{r_c}{r_a})}$$

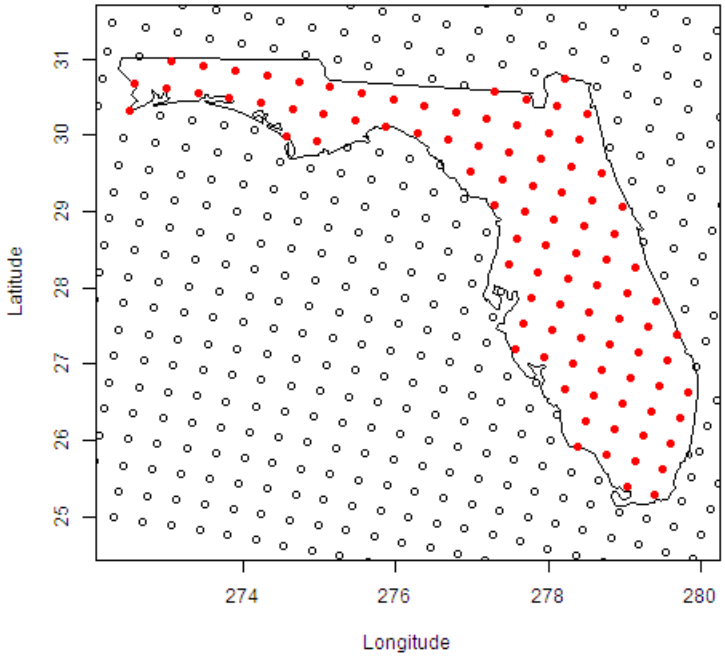


FAWN



SFWMD

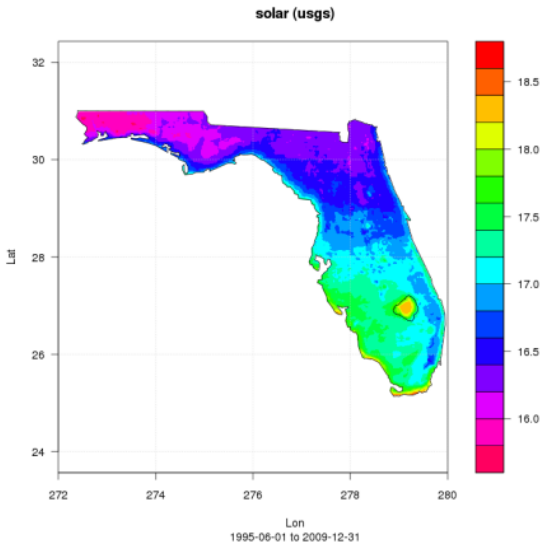
USGS

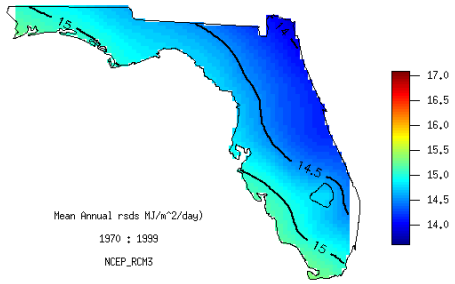


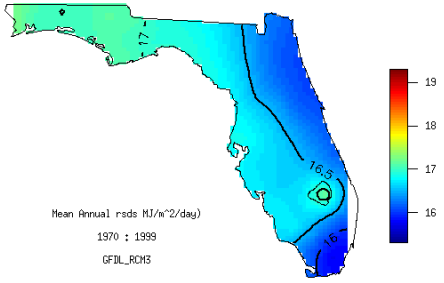
RCM grid points

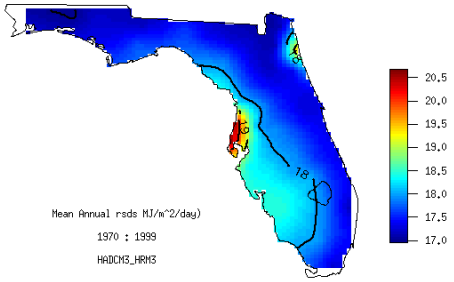
Data

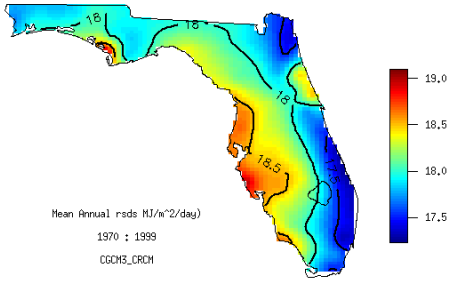
Solar Radiation

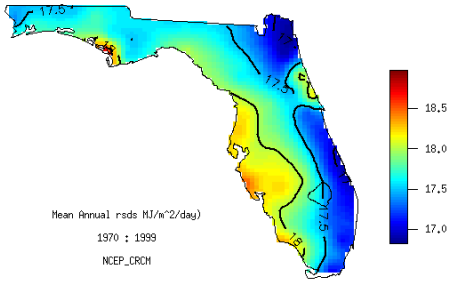


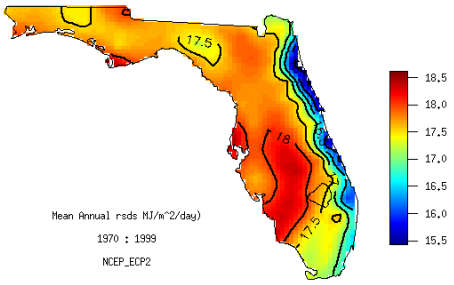


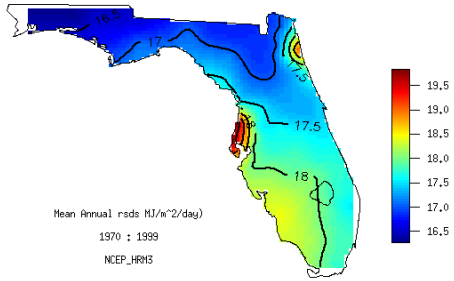




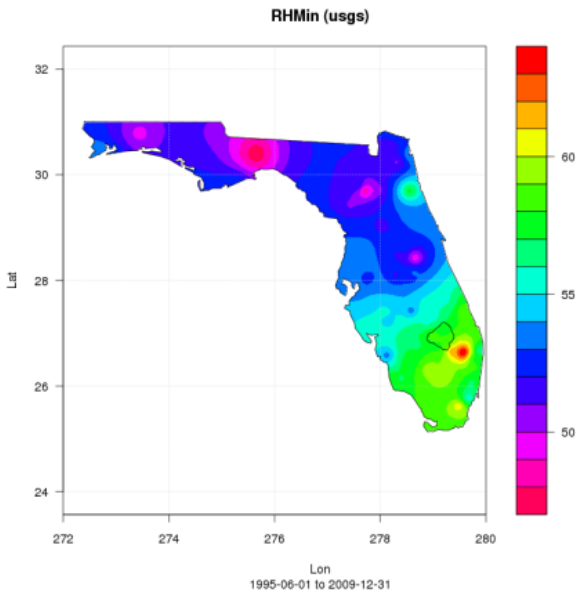


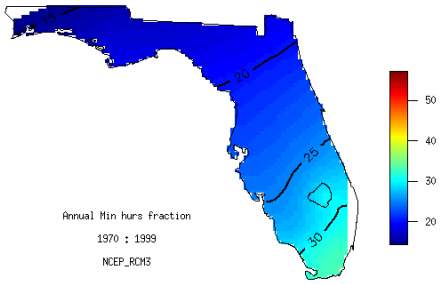


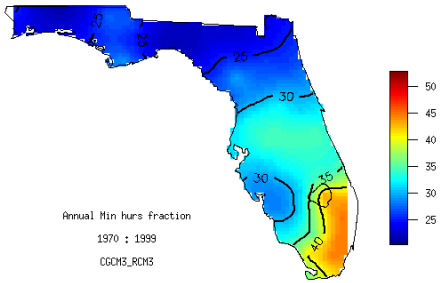


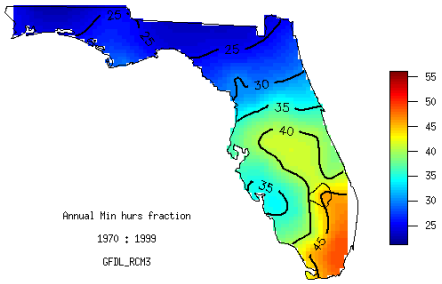


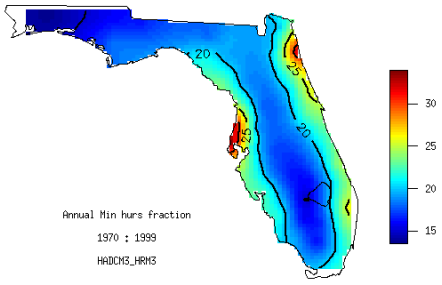
Relative Humidity-Minimum

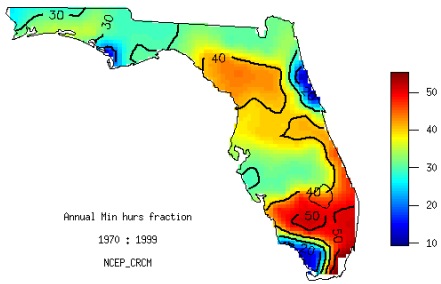


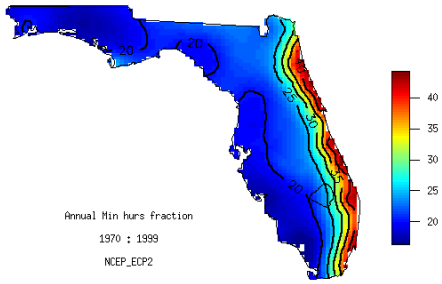


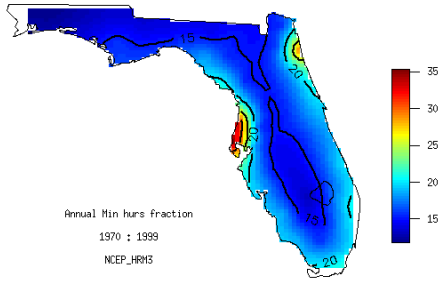




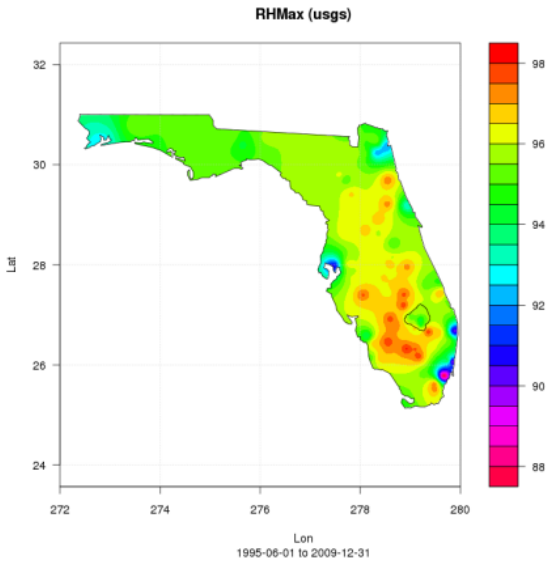


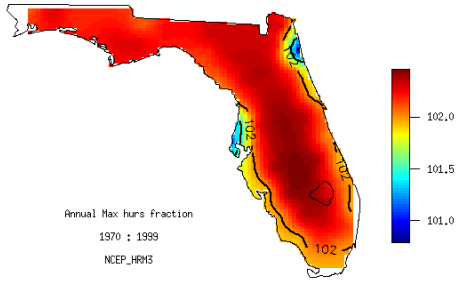


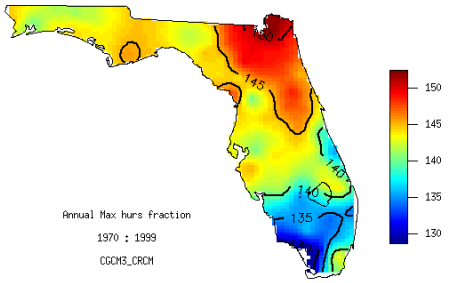


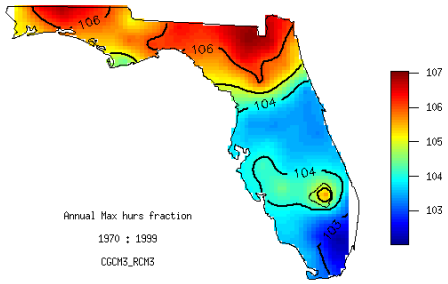


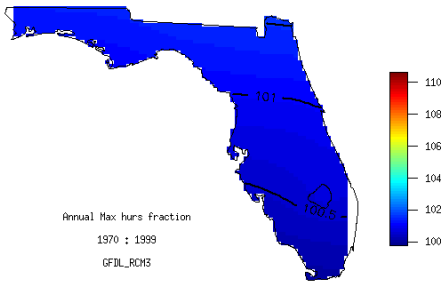
Relative Humidity-Maximum

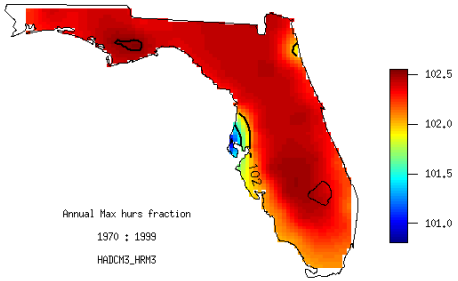


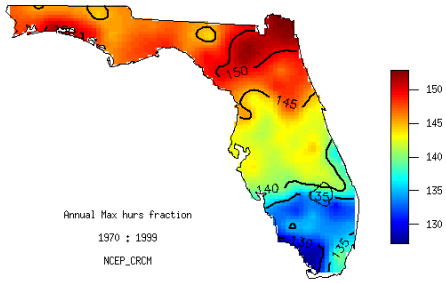


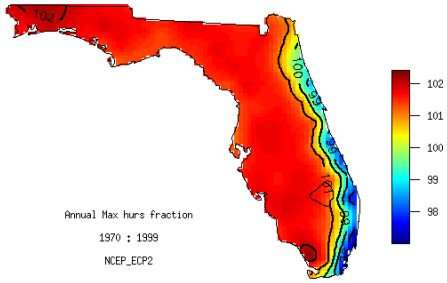




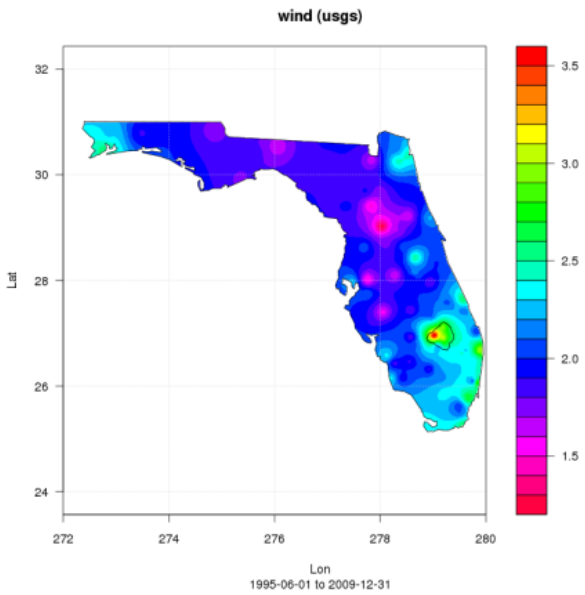


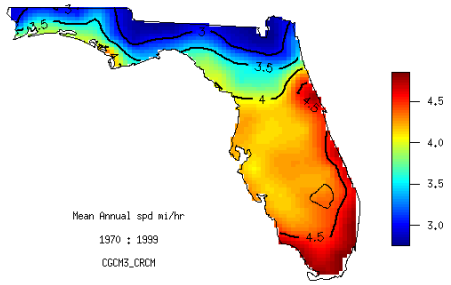


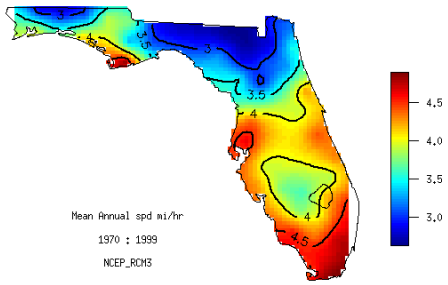


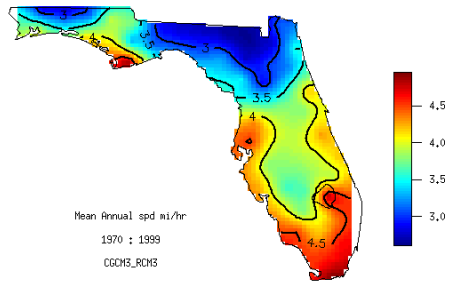


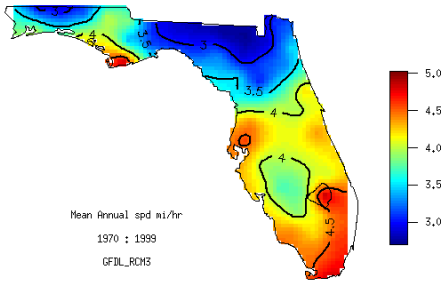
Wind Speed

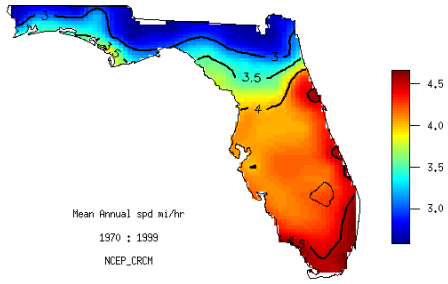


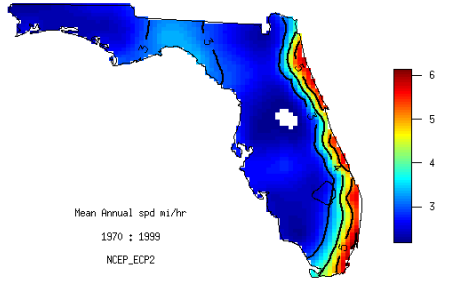




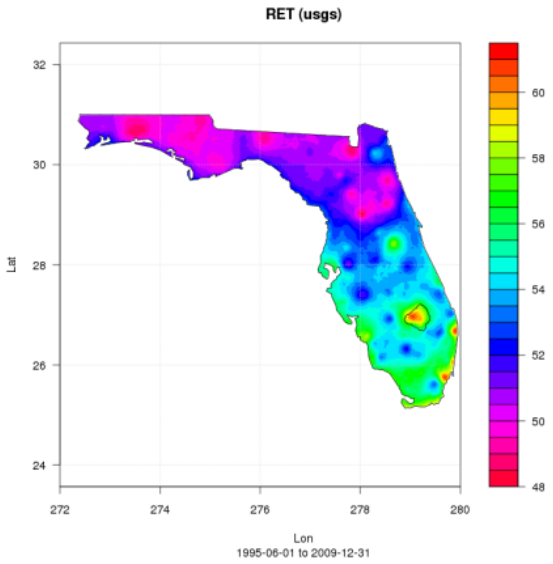


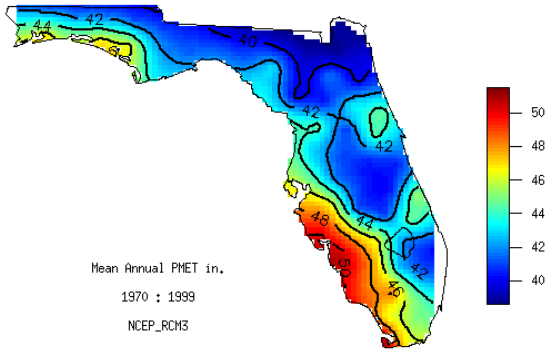


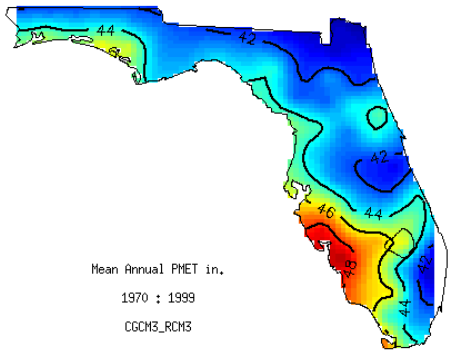


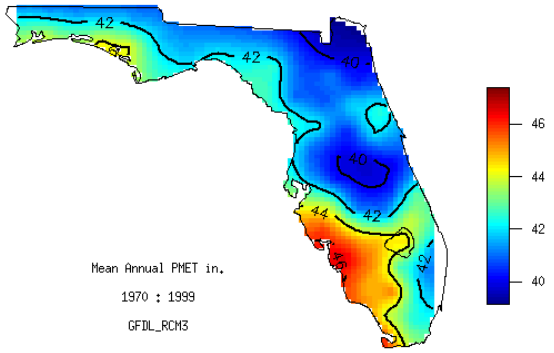


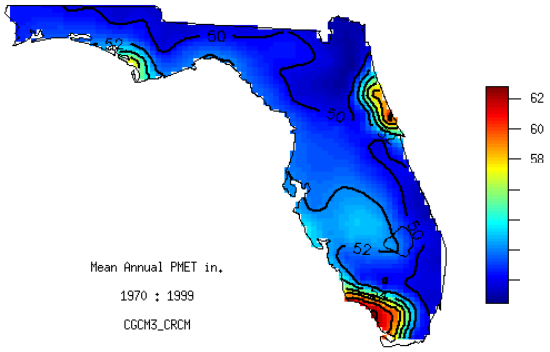
Reference ET

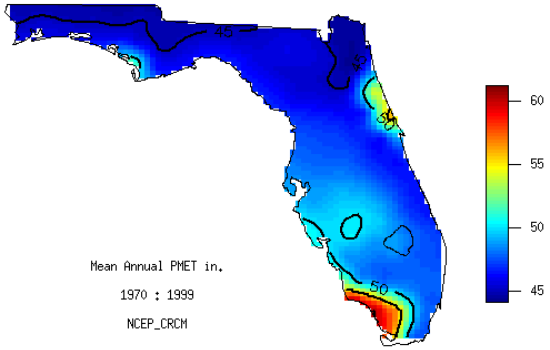


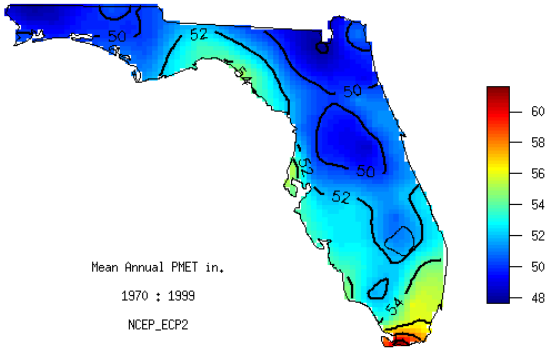




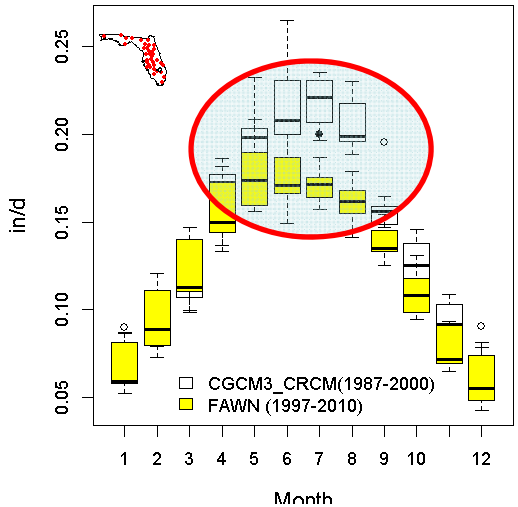


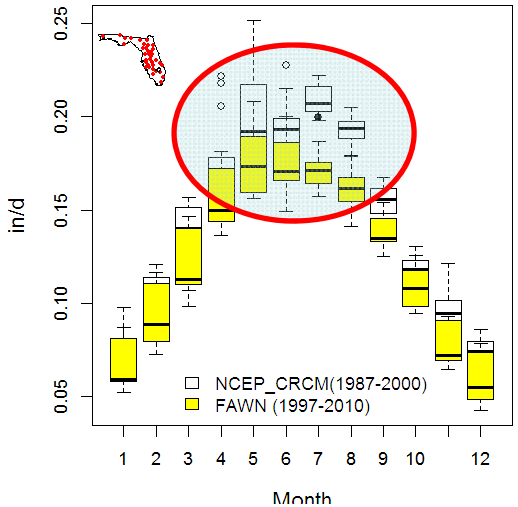


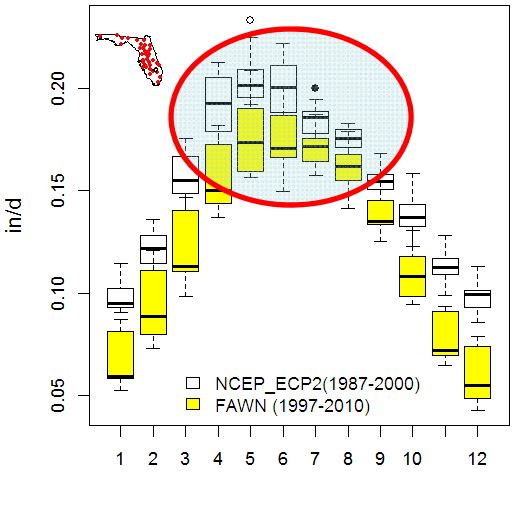


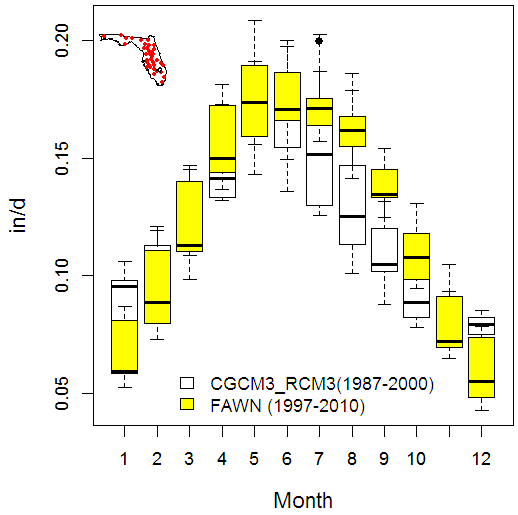


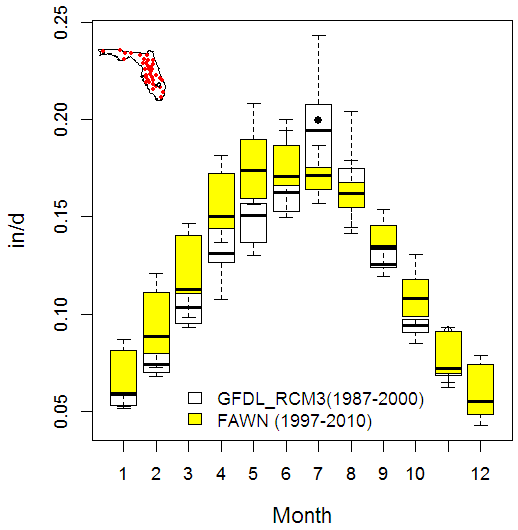
Seasonal Patterns – Issues with summer months

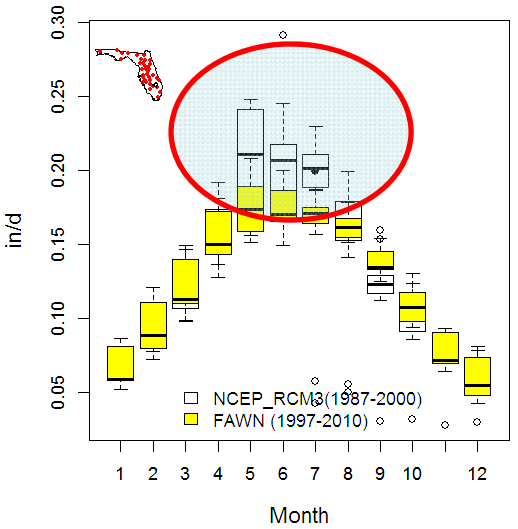




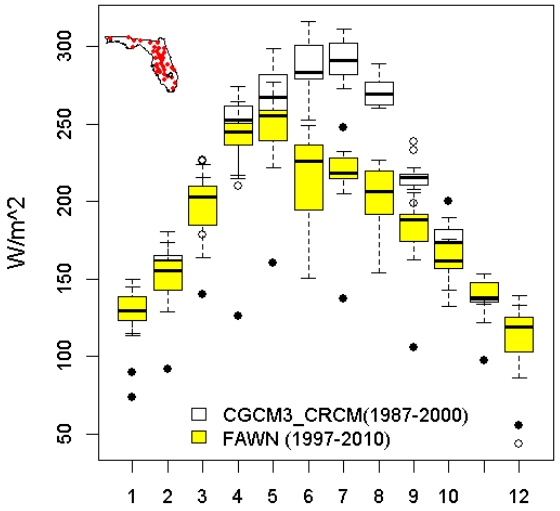


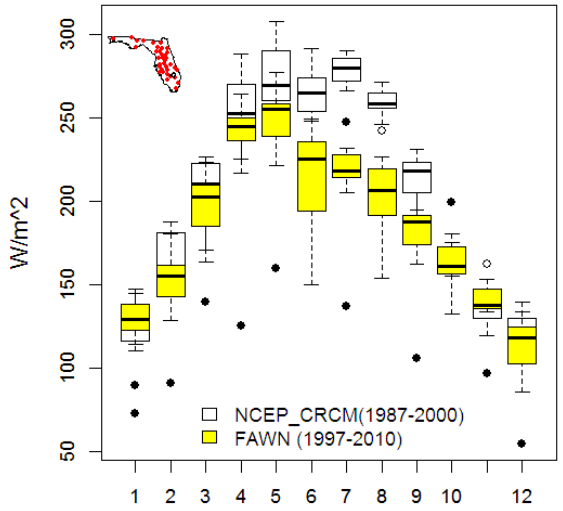


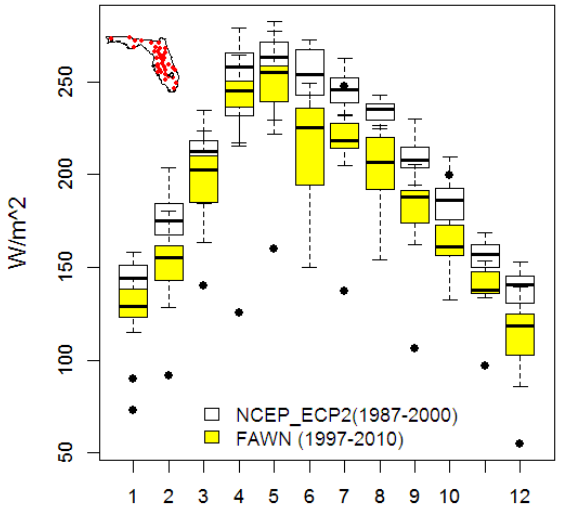


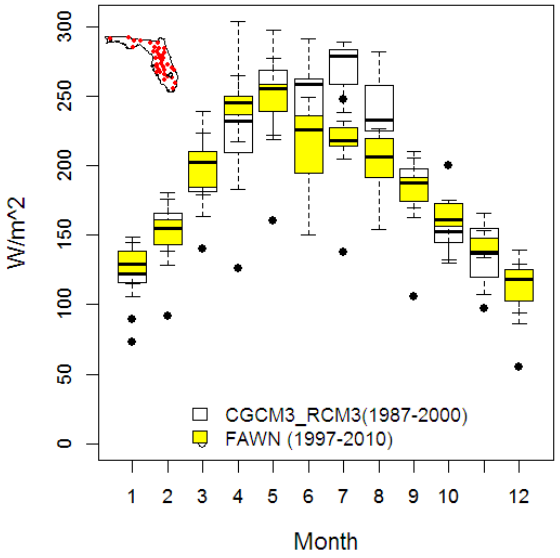


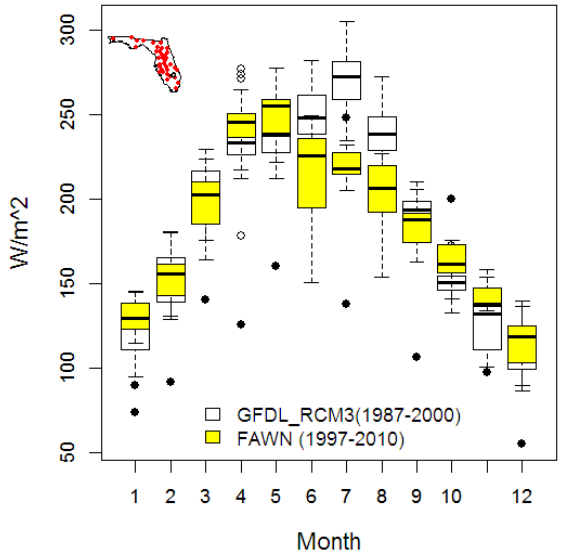
Seasonality – Solar Radiation

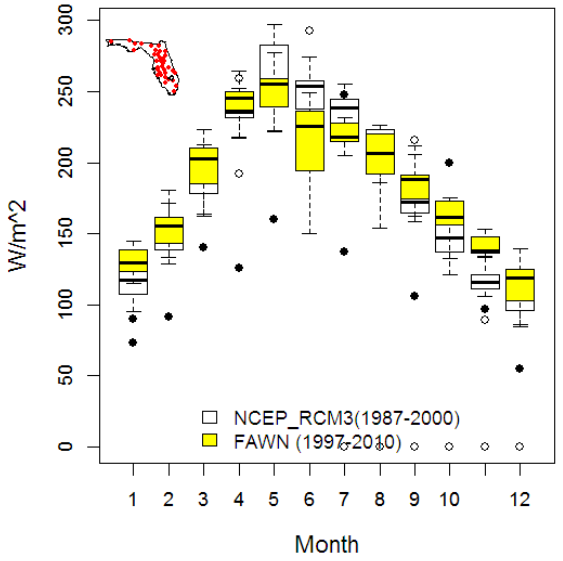




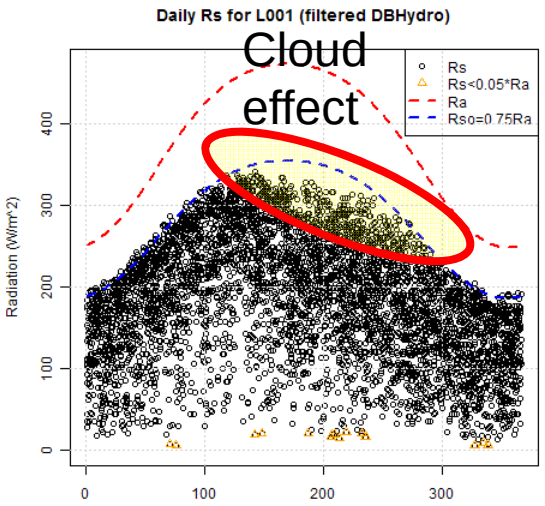


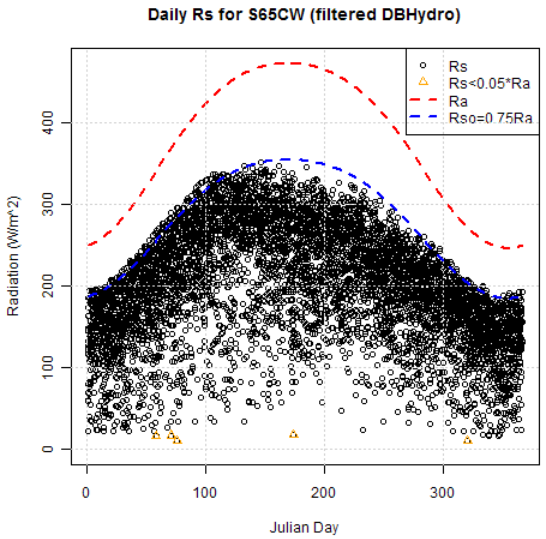


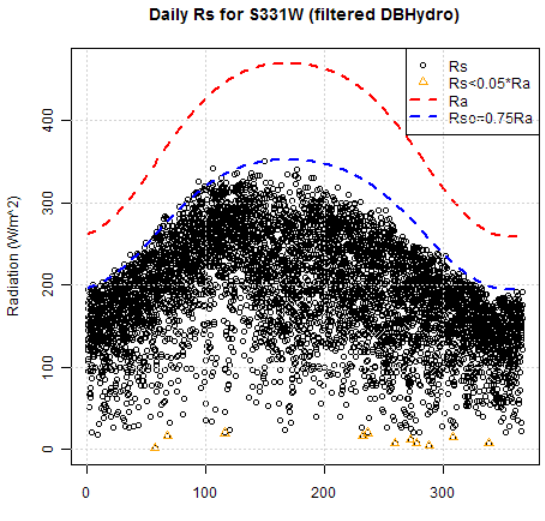


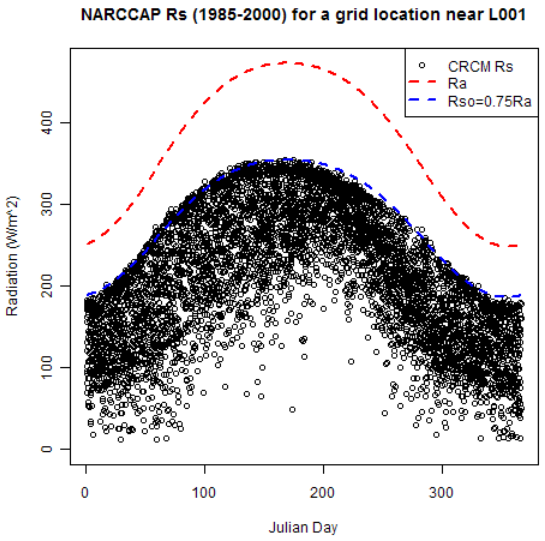


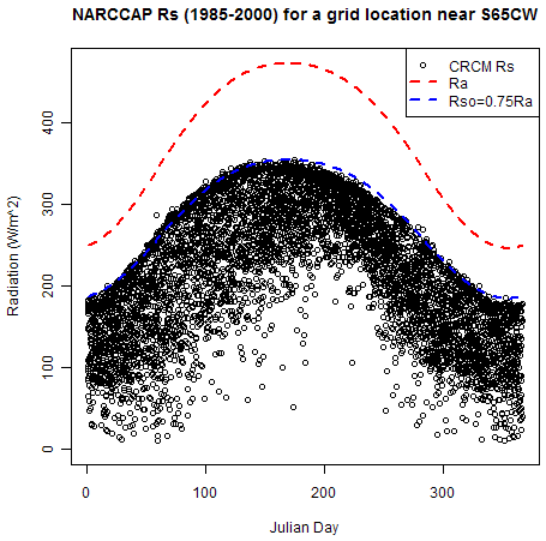
SFWMD observations versus NARCCAP

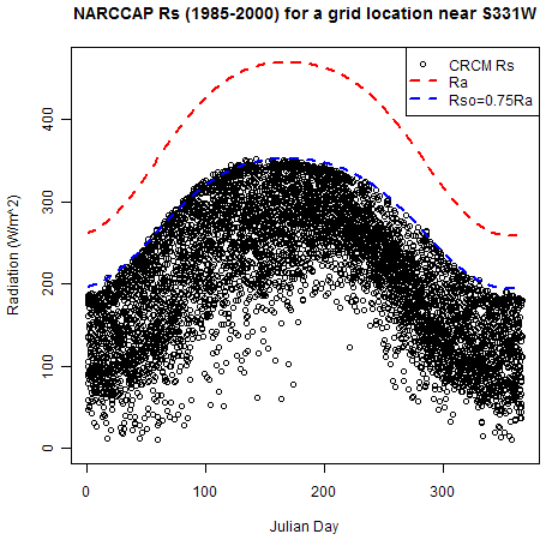




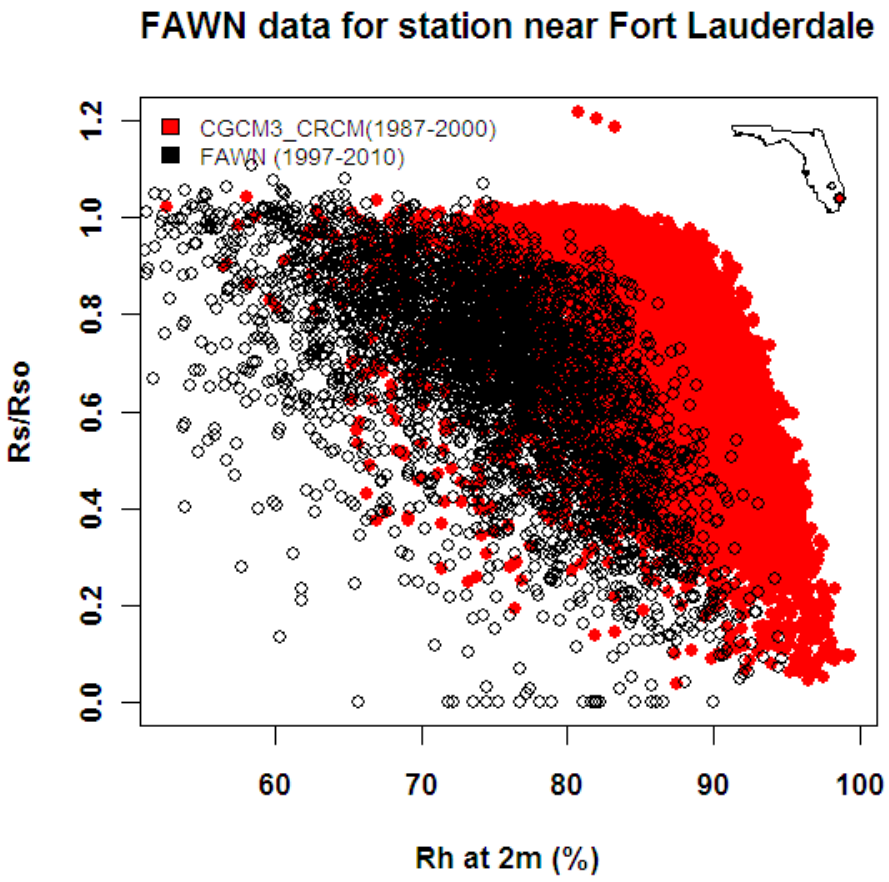


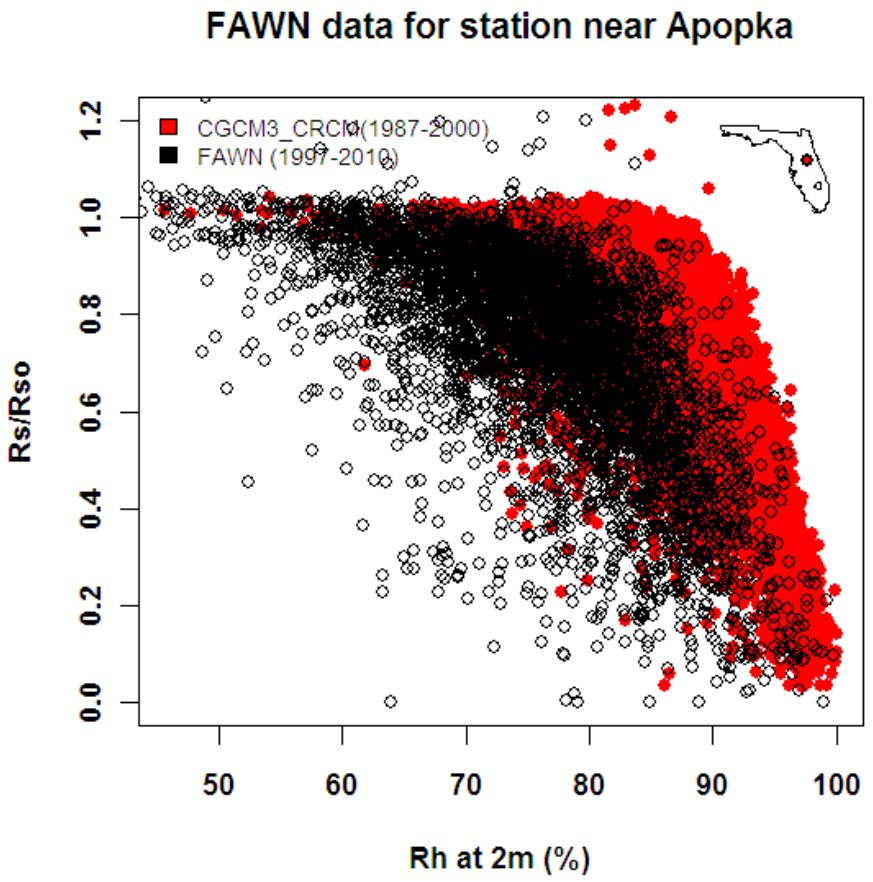






Solar Radiation vs. Relative Humidity

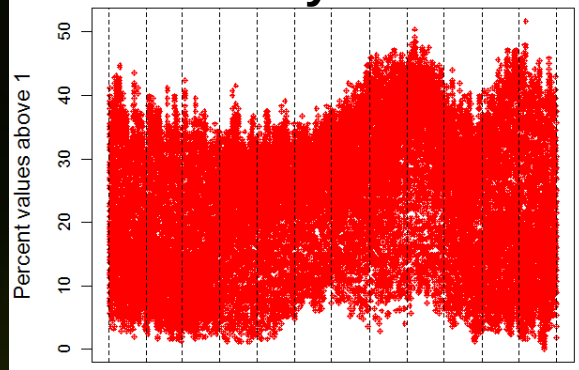




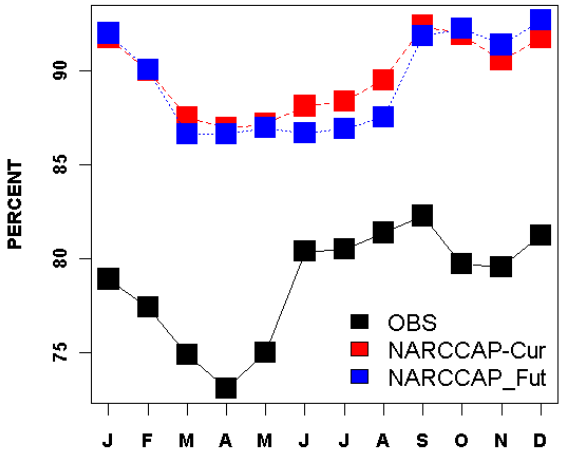
Joint Variable Spatial Downscaling?

Relative Humidity

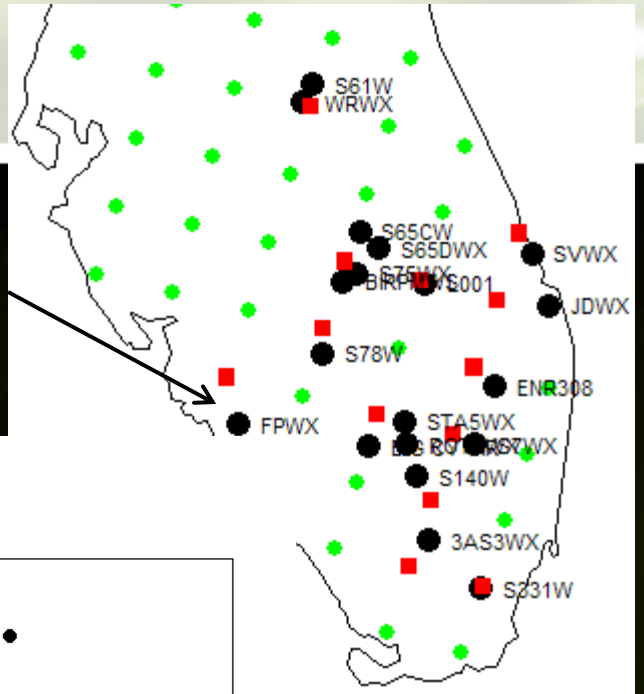
Too many values > 1



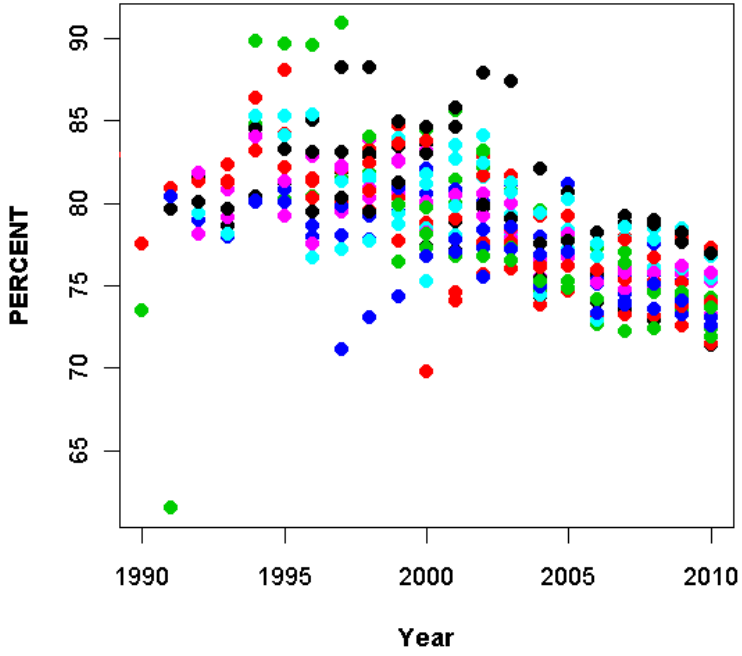
Seasonal Pattern



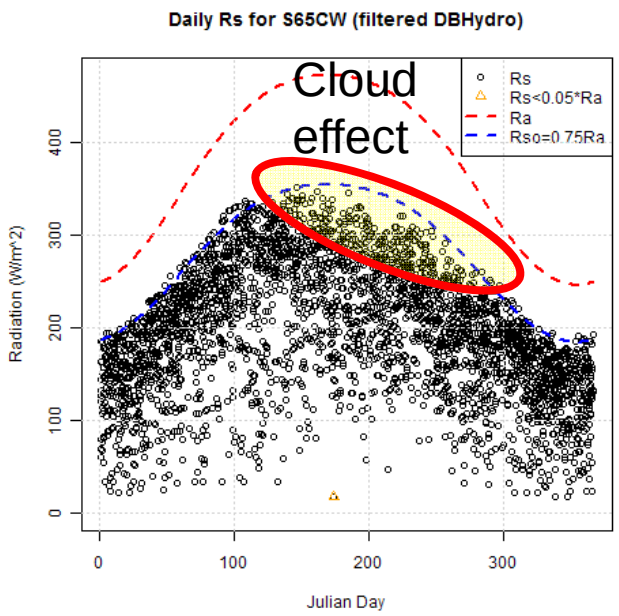
SFWMD Observation Stations

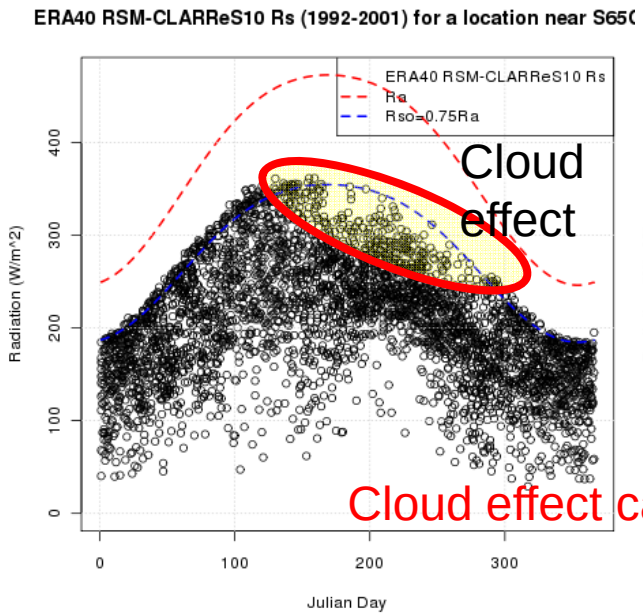


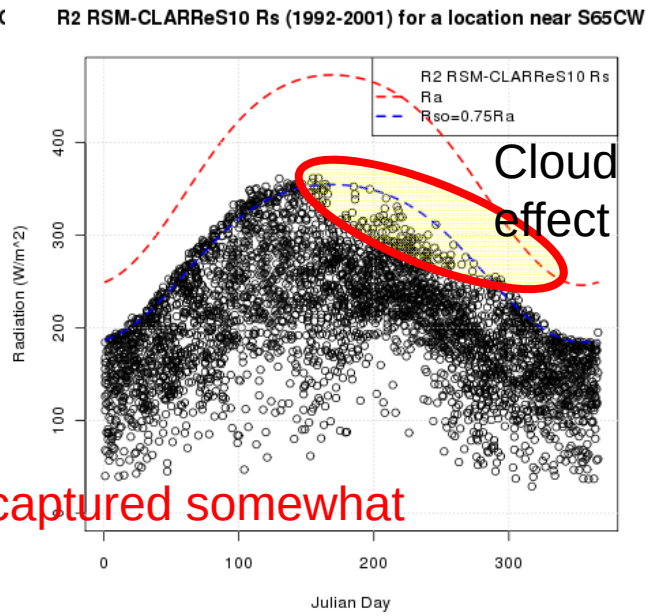
Observations: Is this trend real?



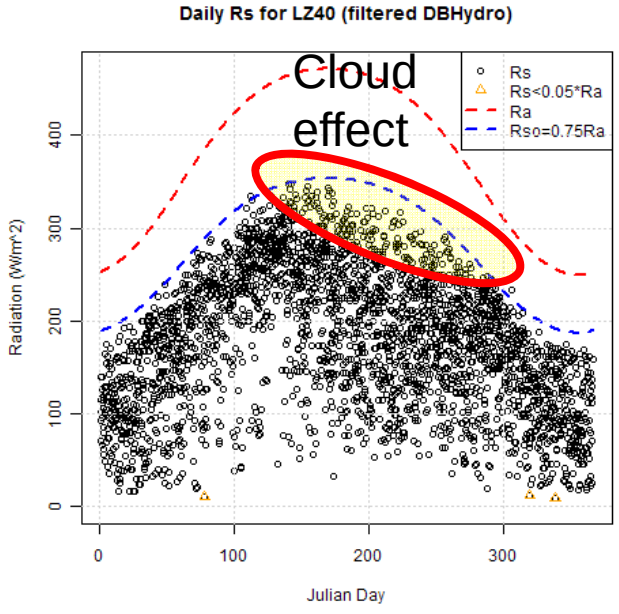
Solar Radiation (W/m^2) Comparison

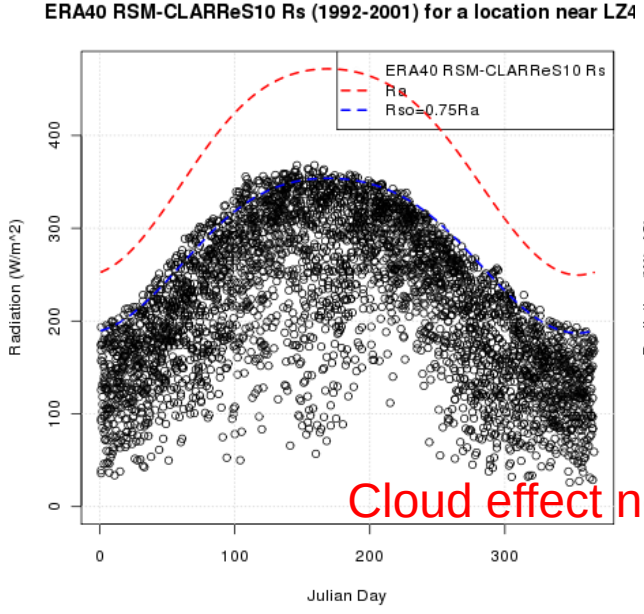


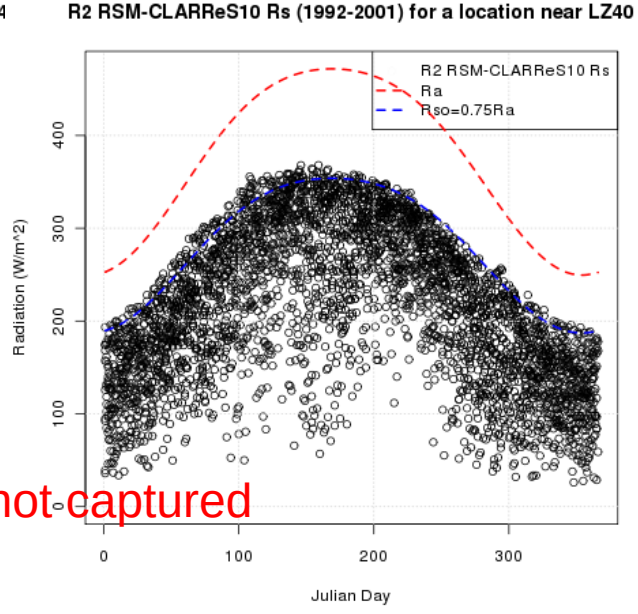




Cloud effect captured somewhat



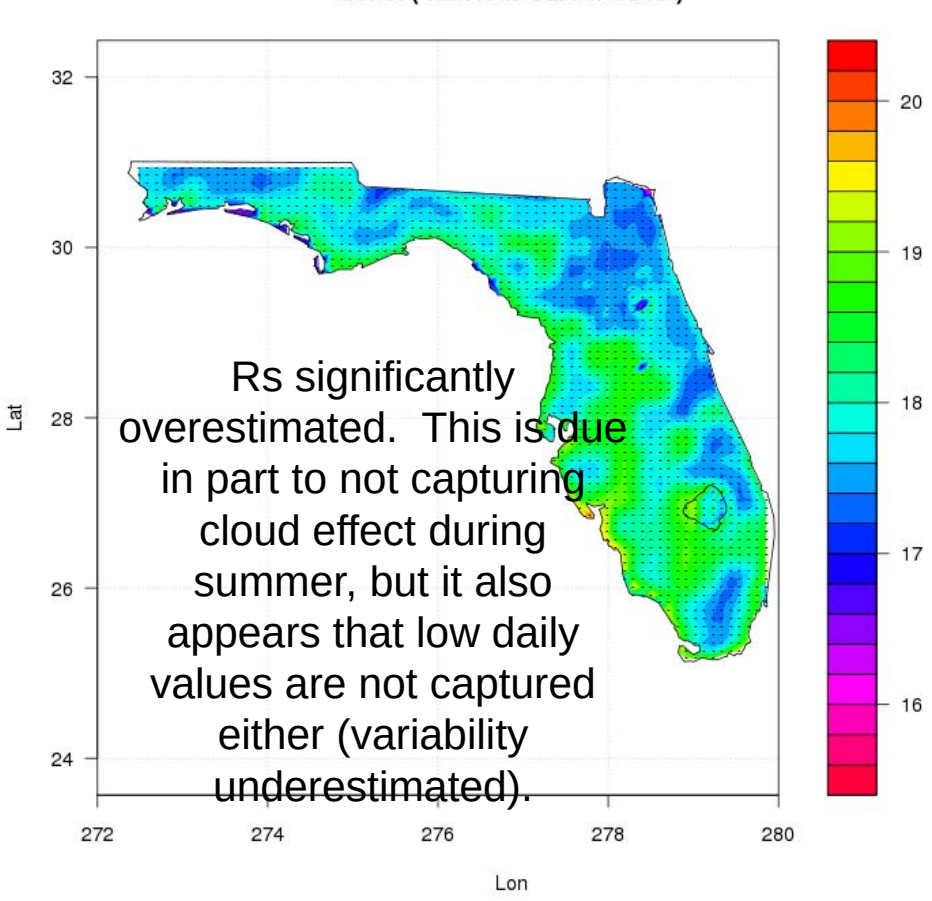




Cloud effect not captured

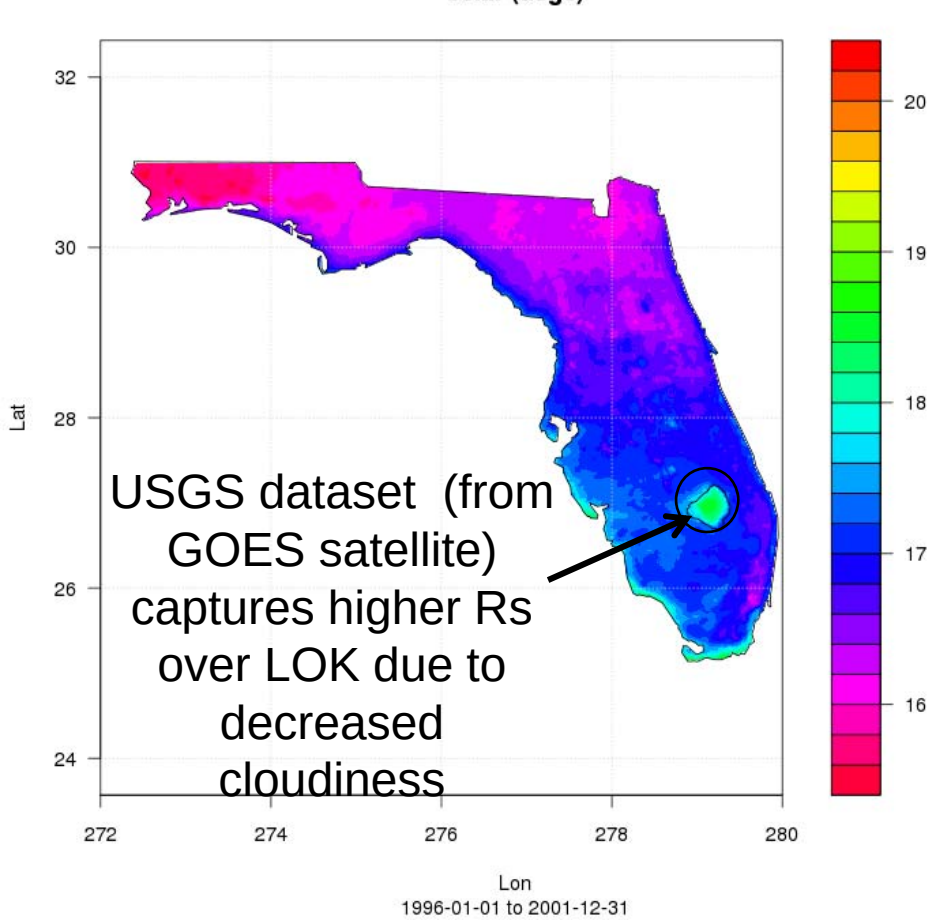
Average Annual Rs (MJ/m²/d) Comparison

R2 RSM-CLARRES10
Rs (1996-2001)



Rs significantly overestimated. This is due in part to not capturing cloud effect during summer, but it also appears that low daily values are not captured either (variability underestimated).

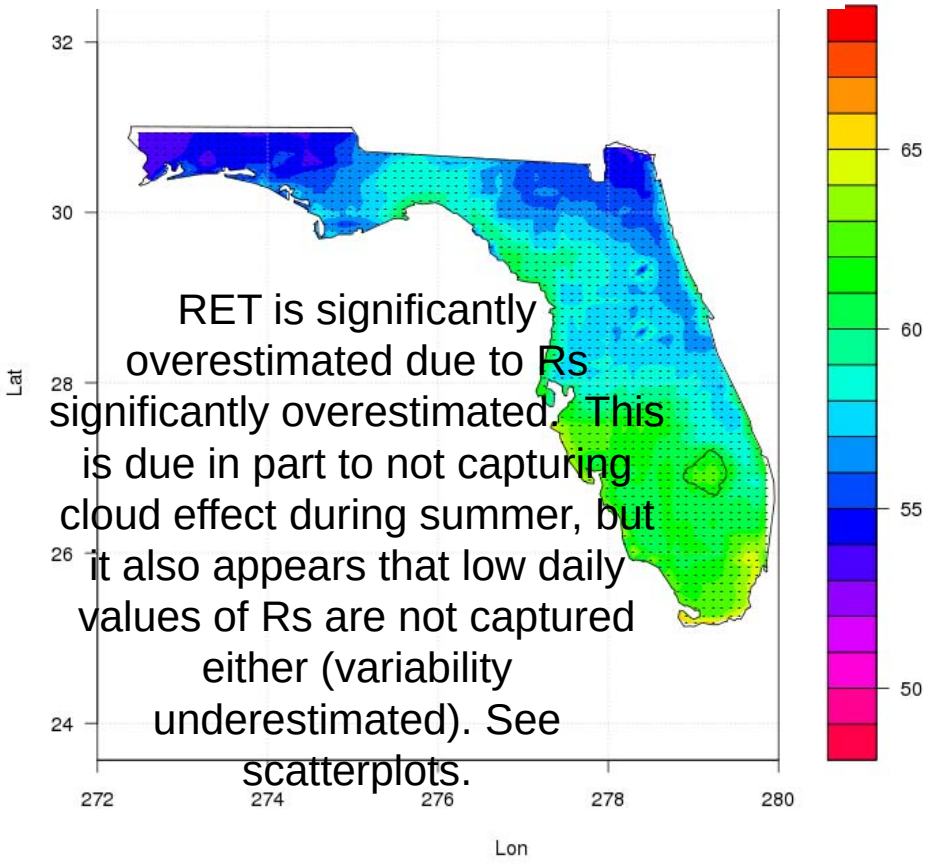
USGS
Rs (1996-2001)



USGS dataset (from GOES satellite) captures higher Rs over LOK due to decreased cloudiness

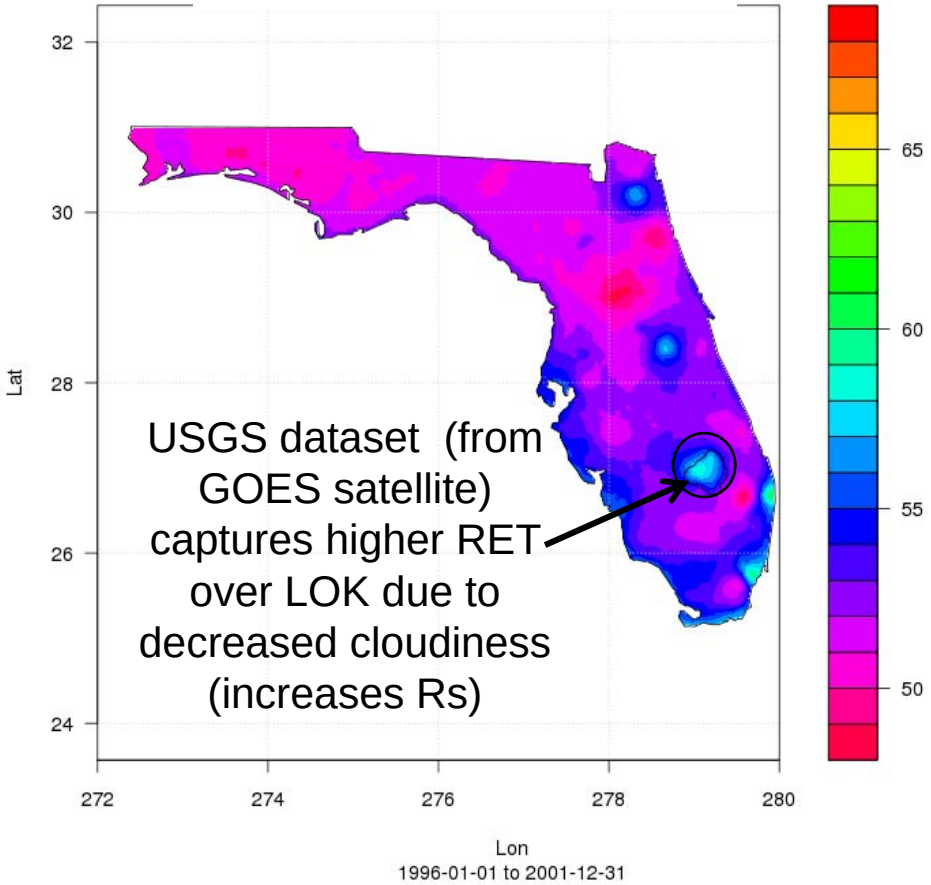
Average Annual Reference Grass ET (in) Comparison

ERA40 RSM-CLARRES10
RET(1996-2001)



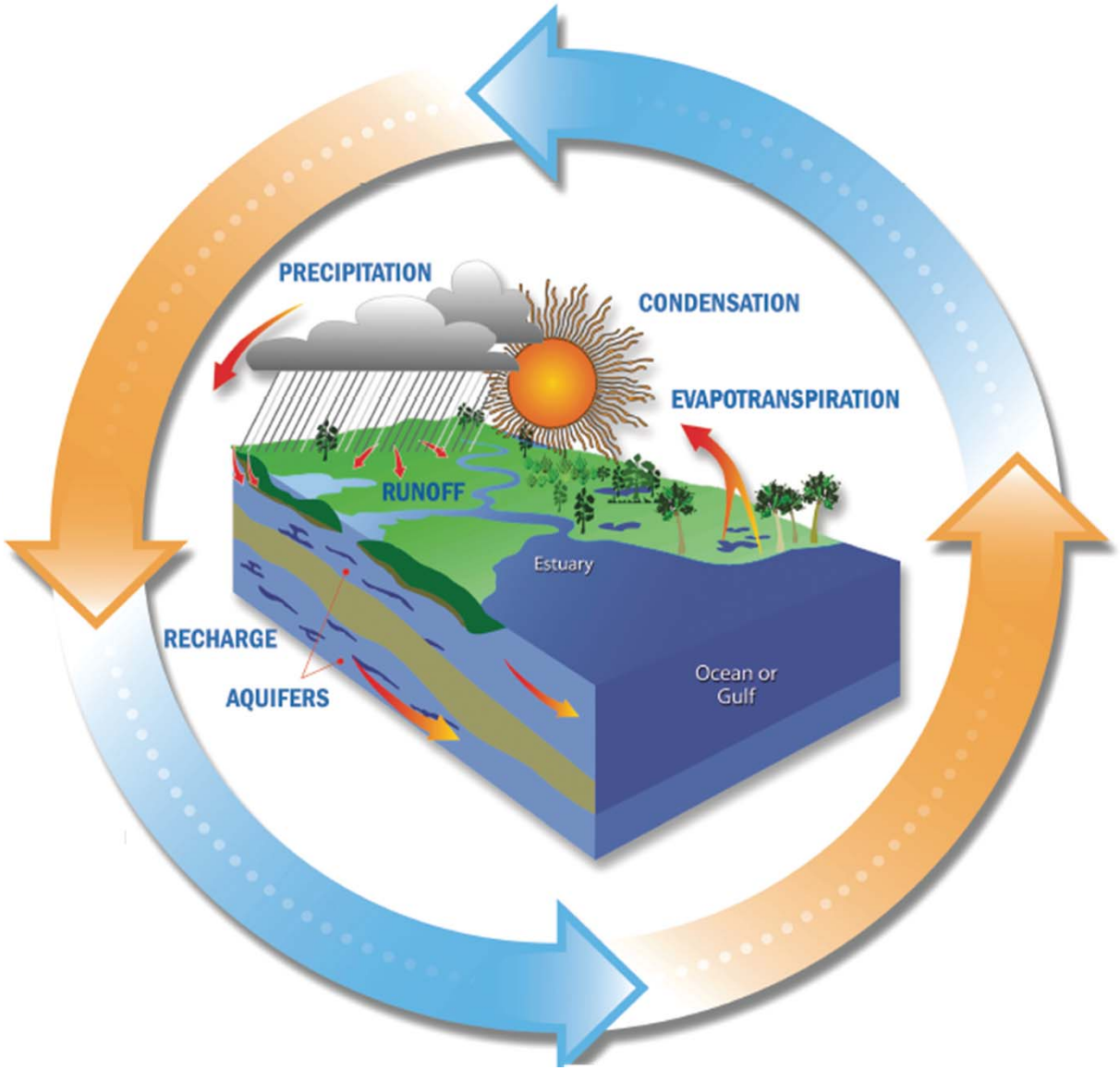
RET is significantly overestimated due to Rs significantly overestimated. This is due in part to not capturing cloud effect during summer, but it also appears that low daily values of Rs are not captured either (variability underestimated). See scatterplots.

USGS
RET (1996-2001)



USGS dataset (from GOES satellite) captures higher RET over LOK due to decreased cloudiness (increases Rs)

Questions?


PRECIPITATION
CONDENSATION
EVAPOTRANSPIRATION
RUNOFF
Estuary
RECHARGE
AQUIFERS
Ocean or
Gulf

Extra slides

Major findings by variable

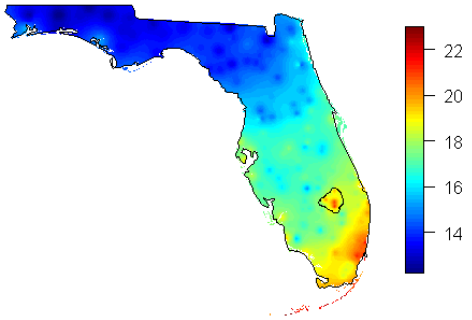
- Model topography compares favorably to PRISM
- Consistent significant overestimation of relative humidity (RH) seen in other models is not an issue here
- Solar radiation (Rs):
  - Cloud effect not captured at the great majority of stations in Central and Southern Florida with the exception of S65CW – Note: Will look at locations in Central & Northern Florida to see if cloud effect is better captured there.
  - Significantly overestimated across the state due to cloud effect not being captured, low values not captured (underestimation of variability).
  - Higher Rs over Lake Okeechobee (LOK) due to decreased cloudiness as seen in the USGS (GOES) dataset not very obvious in model.
- Precipitation (Precip):
  - ERA40 shows significant overestimation in the southwest mostly in summer (ASO). NDJ precipitation in the Panhandle underestimated.
  - Both models show decreased coastal precipitation in South Florida (especially R2) whereas PRISM and SFWMM rainfall grid show the opposite along the Lower East Coast (LEC) of South Florida. Unclear as to which is correct (model or observations). HESM staff believes that precipitation just along the coast may in fact be lower than farther inland; however, this is effect not expected to penetrate as far inland as seen in the model.
  - Both models show decreased precipitation over LOK due to atmospheric subsidence consistent with decreased cloudiness seen in the USGS (GOES satellite) dataset (but not captured in PRISM). Models are probably correct in this feature.
- Daily average temperature (Tave) is captured very well in both models.
- Daily maximum temperature (Tmax):
  - Both models significantly overestimate Tmax across the state especially from Feb-Oct.
  - In both models LOK and areas very close to the coast show lower Tmax than interior areas (not evident in PRISM or USGS). Models are probably correct.
- Daily minimum temperature (Tmin):
  - In general, Tmin is overestimated across the state, especially in northern Florida and in the Panhandle area.
  - In both models LOK and areas very close to the coast show higher Tmin than interior areas (higher Tmin over LOK not seen in PRISM or USGS). Models are probably correct.

Major findings by variable (Cont.)

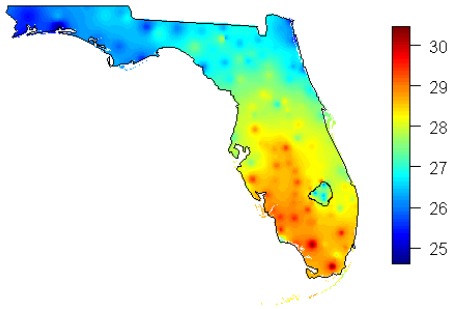
- Daily temperature range (DTR):
  - In both models simulated DTR is very spatially uniform . The exception is LOK and areas very close to the coast which show much lower values than interior areas (not evident in PRISM or USGS). Models are probably correct in this feature.
- Daily average dew point temperature (Tdew) is captured very well in both models.
- Daily maximum relative humidity (RHmax):
  - Both models significantly underestimate RHmax.
  - Both models show lower values of RHmax along the coast and over LOK, which are consistent with higher simulated values of Tmin in these areas compared to more interior areas (not evident in USGS). Models are probably correct in this feature.
- Daily minimum relative humidity (RHmin):
  - Both models significantly overestimate RHmin probably due to overestimating Tmax.
  - Both models show higher values of RHmin along the coast and over LOK, which are consistent with lower simulated values of Tmax in these areas compared to more interior areas (not evident in USGS). Models are probably correct in this feature.
- Will look at specific humidity in addition to RH and Tdew.
- Wind speed (Wind):
  - Both models show overestimation of wind speed especially in central areas of the Panhandle and along the LEC in South Florida.
  - Both models simulates higher values of wind speed along the coast and over LOK compared to interior areas (USGS only shows some higher wind speeds on the northwestern edge of LOK). Models are probably correct in this feature.
- Reference grass evapotranspiration (RET) – derived using FAO-56 Penman-Monteith equation (virtually equivalent to USACE standardized equation) and meteorological data from model output:
  - Both models significantly overestimate RET mainly due to overestimating Rs since cloud effect is not being captured.
  - Higher RET over Lake Okeechobee (LOK) due to decreased cloudiness (increased Rs) as seen in the USGS (GOES) dataset not very obvious in model.

Satellite Based USGS Dataset

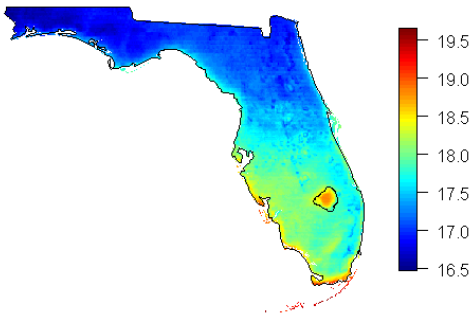
Daily Minimum Temperature



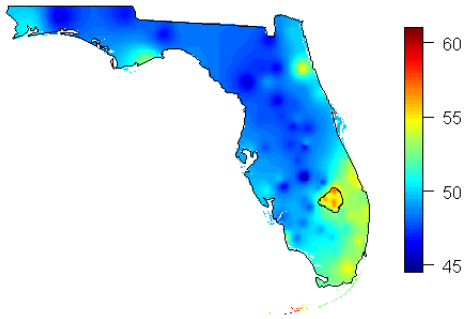
Daily Maximum Temperature



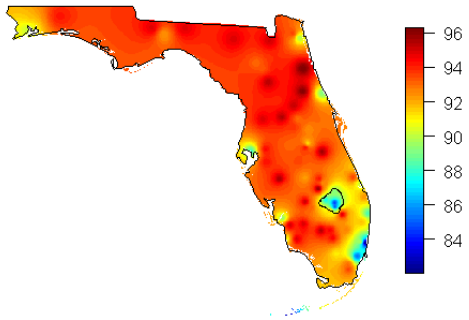
Solar Radiation



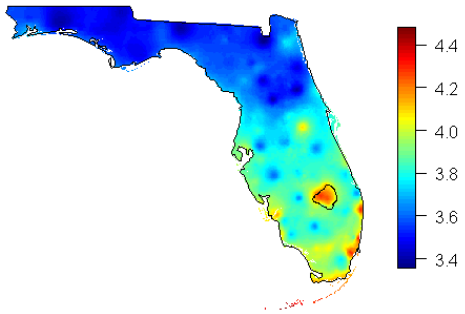
Daily Minimum Relative Humidity



Daily Maximum Relative Humidity



Reference ET



Incoming Solar Radiation at the Surface
District DBHydro stations (1992-2001)