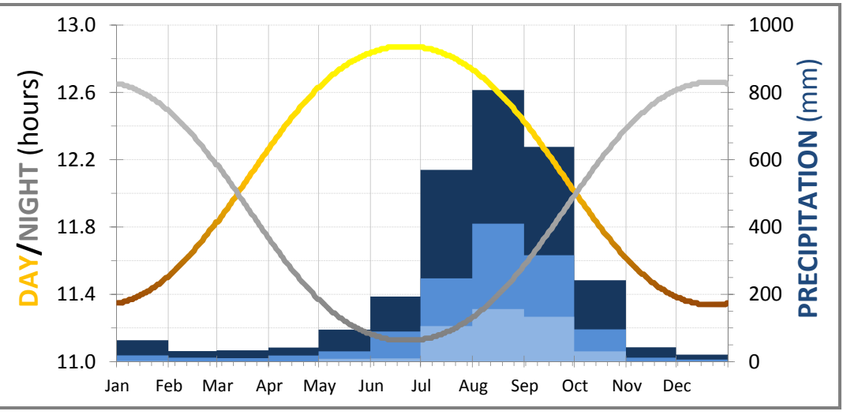
FIG 1. SENEGAL seasonal and diurnal variation in daily temperatures (°C) by location. Plots illustrate average daily maximum and minimum temperatures for the years 1994 through 2015 (bold lines), bounded by the daily mean plus and minus daily standard deviation (fine dashed lines).

Daily temperatures are affected by sunlight and precipitation (FIG 1a). Daily temperatures are lowest during winter month (fewer hours of daylight), increase in the spring and peak in the summer before mansoon. Dry periods occur from fall to early summer and have large diurnal temperature fluctuations (maximum versus minimum) than periods during the monsoon season. Diurnal temperature variation declines with the onset of the monsoon and again increases at the end of monsoon as dry conditions return.

Data source: NOAA NCDC. Prepared on Wednesday, March 22, 2017 by Wayne H. Thompson - M.S., Agronomist/Soil Scientist

FIG 1a. Day/Night (hours) and precipitation (mm).

Daylight (yellow line) and night time hours (gray line) illustrate seasonal changes in hours of sunlight and darkness for this latitude (left axis). The range of monthly precipitation (blue) is shown as bar charts, 22-year average maximum, mean and minimum monthly precipitation accumulations (mm, right axis).



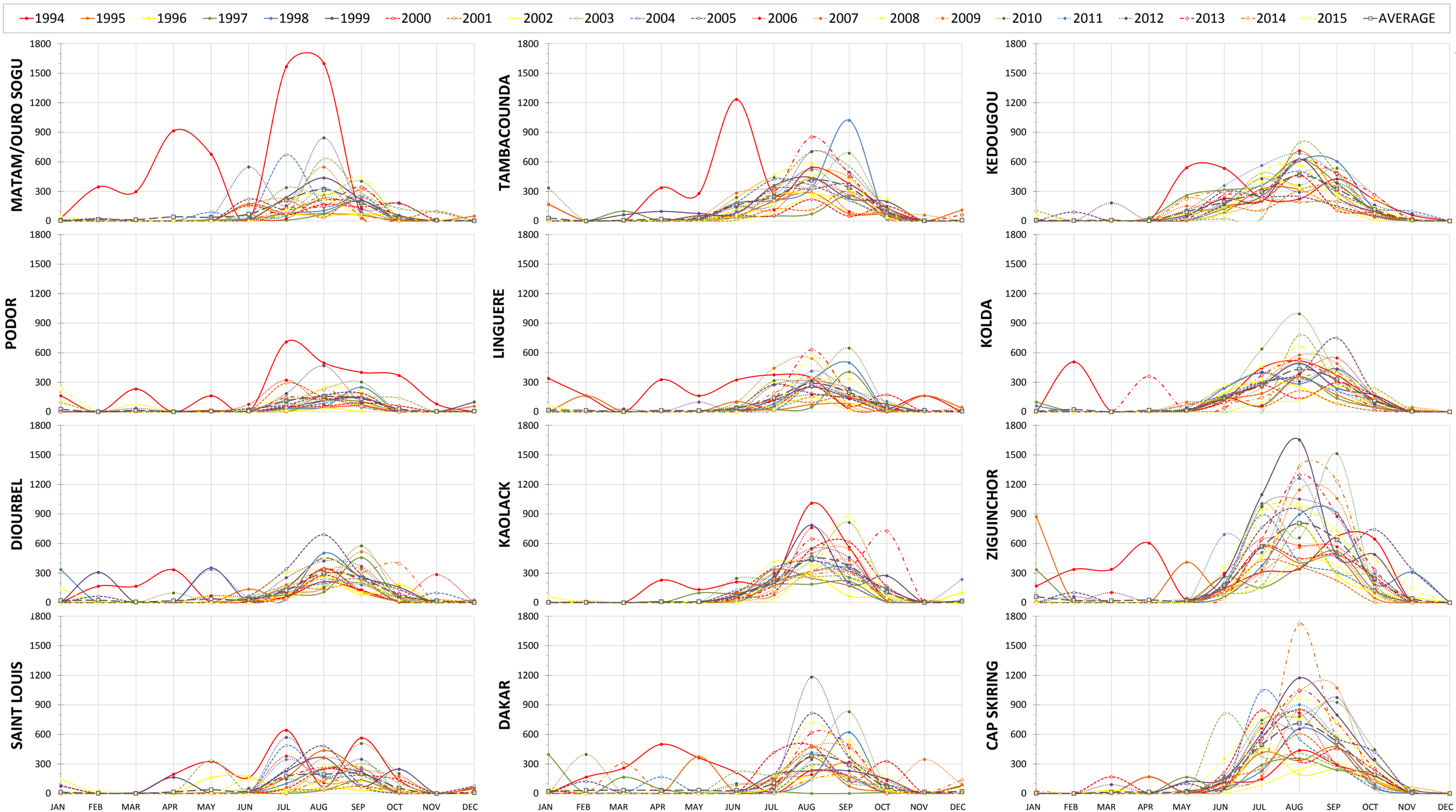


FIG 2. SENEGAL monthly precipitation (mm) by location and year. Precipitation records cited for this summary meet NOAA/WHO quality control standards.

The monsoon season typically begins in JUL, reaches a maximum in AUG to SEP, and tapers to nil by NOV. The dry season extends from OCT or NOV through JUN. Nearly every year in multiple regions, sporadic inundations greater than 200 mm produce flash floods, take lives and cause severe infrastructure and environmental damage.

Data source: NOAA NCDC. Prepared on Saturday, February 25, 2017 by Wayne H. Thompson - M.S., Agronomist/Soil Scientist

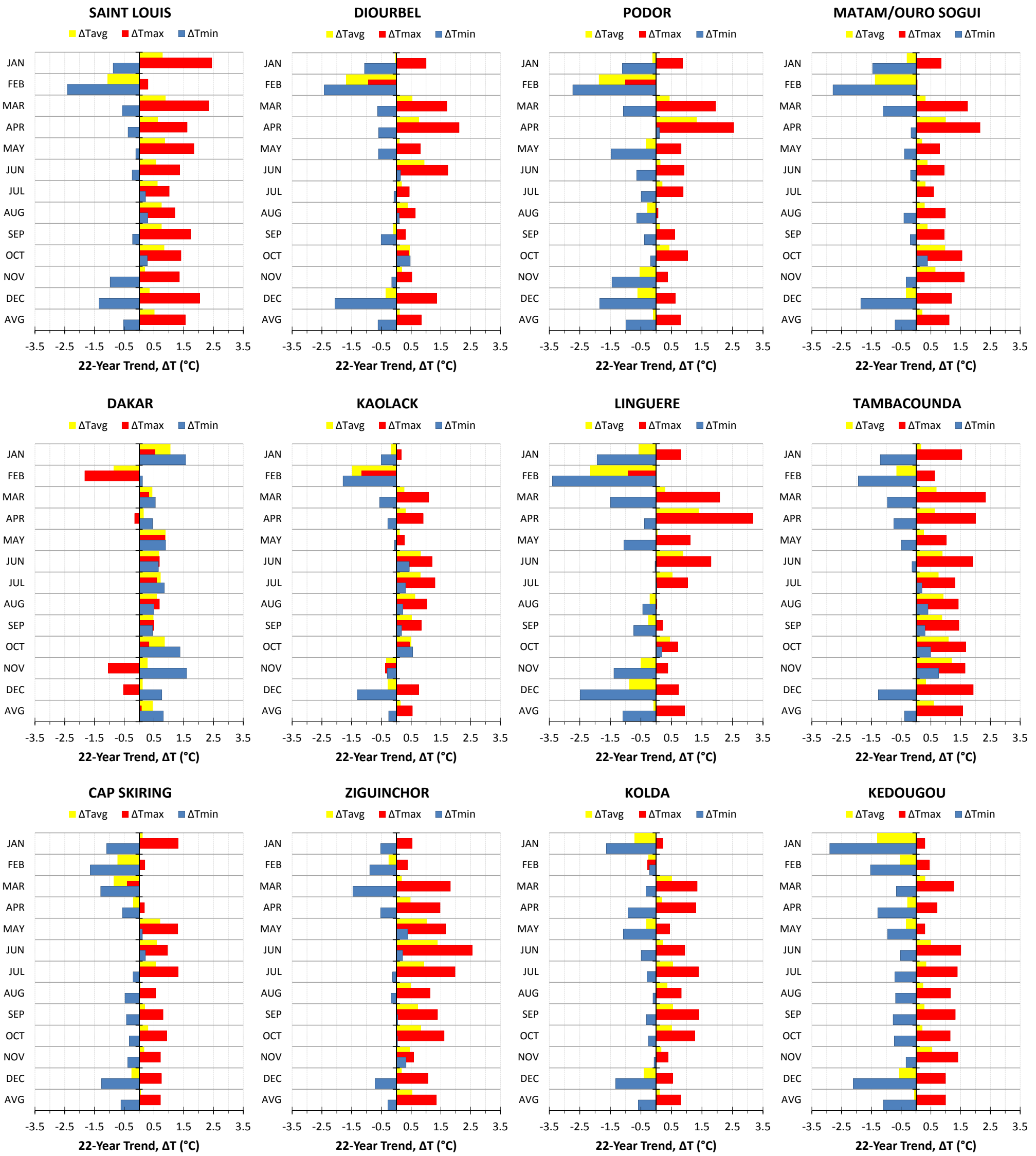
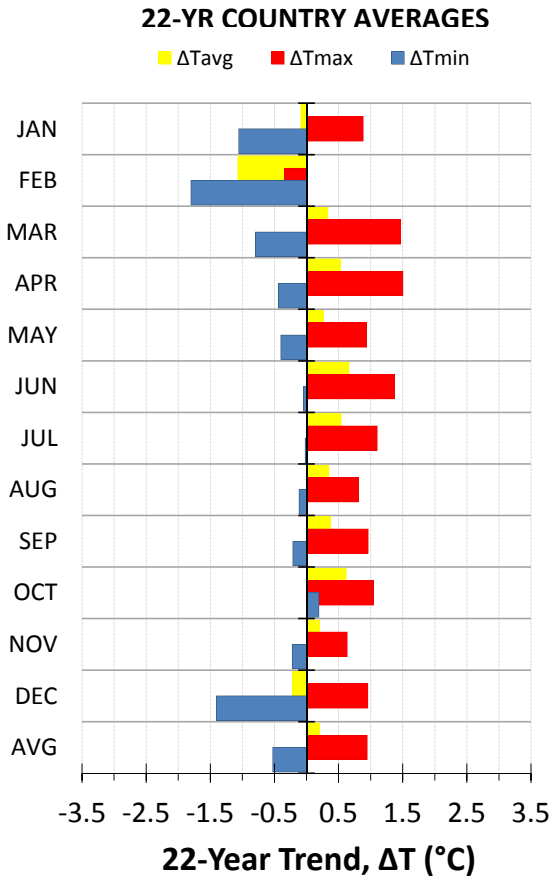


FIG 3. SENEGAL daily temperature change (°C).

ΔT = average change in daily temperature (°C) over a 22-year period, from 1994 through 2015. Trends were estimated using the slope of temperature change over time × 22 years for each of the twelve locations (see FIG 3a). Positive trends (+) indicate elevating temperatures. Negative trends (-) indicate lowering temperatures. Monthly average temperatures are presented. Tmax (red) = daily maximum temperature; Tmin (blue) = daily minimum temperature; Tavg (yellow) = daily temperature ([Tmax+Tmin]÷2).

Analysis revealed numerical trends of rising maximum daily temperatures (AVG ΔTmax = 0.9°C), and falling average daily minimum temperatures (AVG ΔTmin = -0.5°C). The dynamics of changing air temperature points to an increasing magnitude in diurnal daily temperatures, i.e., the difference between daily minimum and daily maximum temperature is increasing (refer to ΔTdiff, FIG 3a). This trend is most apparent among inland locations at higher elevations, notably KEDOUGOU. An exception to SENEGAL's changing temperatures is on the DAKAR peninsula where the trend is reversed, where the trend of Tmin remained positive for all months, and Tmax decreased during the winter months (NOV, DEC and FEB); ΔT trends for this location closely parallel reported changes in Atlantic Ocean surface water temperature dynamics for this region.



Data source: NOAA NCDC. Prepared on Sunday, February 26, 2017 by Wayne H. Thompson - M.S., Agronomist/Soil Scientist

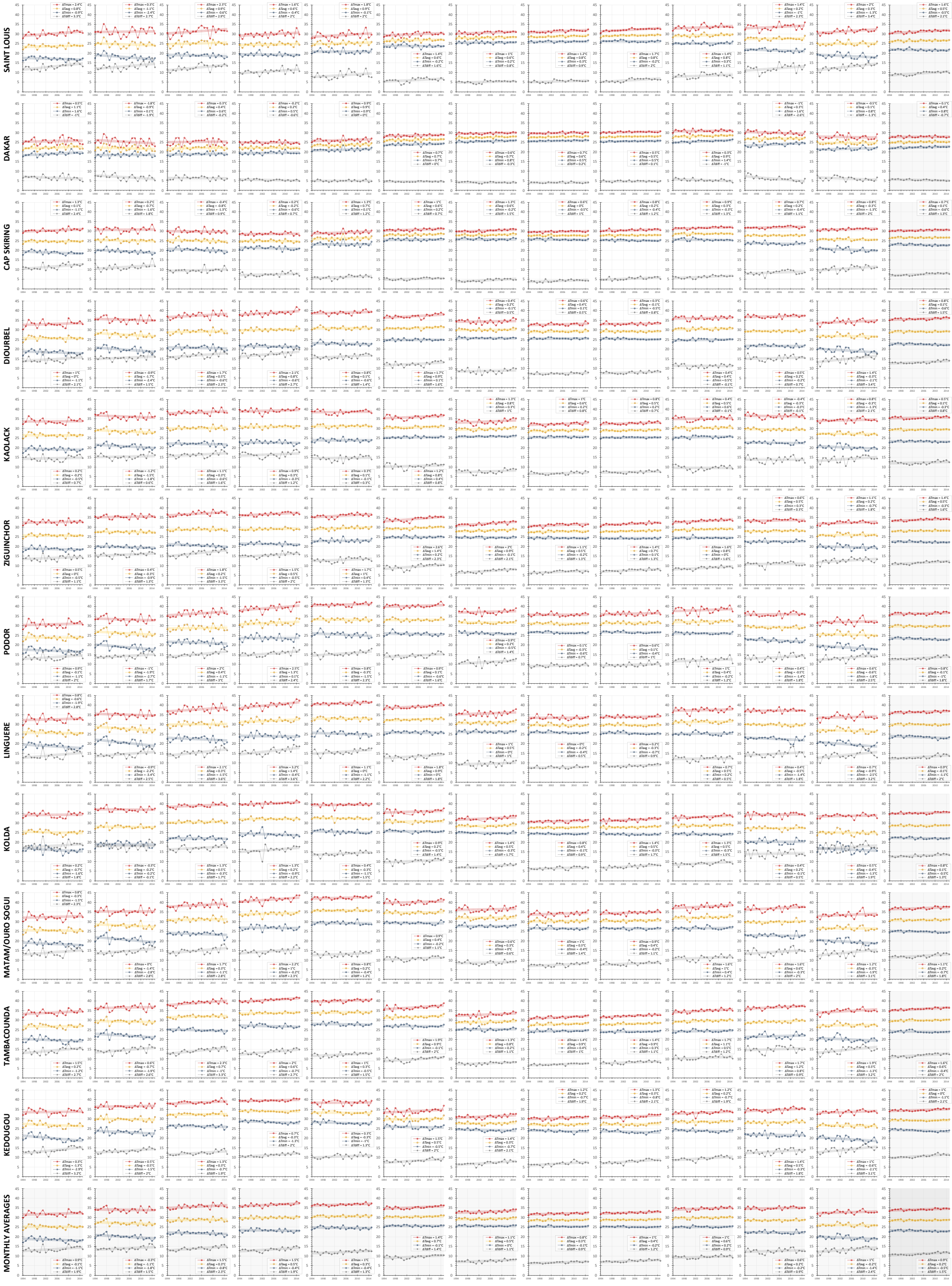


FIG 3a. Senegal's changing daily temperatures (°C). Variations in daily temperatures and trends of temperature change (ΔT) over time.

Data presented in each chart represents monthly average daily maximum (Tmax), minimum (Tmin), average (Tavg), and difference between daily maximum and minimum temperatures (Tdiff) for the years 1994 through 2015. A trend line of annual average daily temperature versus time for each month and location is used to highlight the trend of ΔT over the period of 22 years. The slope of each trend line was used to calculate the average change in daily temperature [ΔT = slope × time] for daily Tmax, Tavg, Tmin, and Tdiff (refer to chart legends for trend values). Averages by month and by location are summarized in the bottom row and right column, respectively.

Analysis of climate data provided by the NOAA National Climate Data Center (NCDC) revealed increasing daily maximum temperatures, decreasing daily minimum temperatures, minor changes in daily average temperatures, and increasing diurnal variations, or differences between daily maximum and daily minimum temperatures.

Daily Tavg was calculated with the equation (Tavg = [Tmin + Tmax] ÷ 2). We assumed daily Tmin data to be accurately represented by the lowest recorded daily temperature between the hours 12:00 AM and 9:00 AM, and daily Tmax by the highest recorded daily temperature between the hours of 9:00 AM and 12:00 AM. The average daily temperature was estimated only when both Tmin and Tmax were measured for a given day, and only days with "complete" data, as described, were included in the analysis. A graphical summary of monthly average daily temperature trends is provided in FIG 3.

Data source: NOAA NCDC. Prepared on Sunday, February 26, 2017 by Wayne H. Thompson - M.S., Agronomist/Soil Scientist

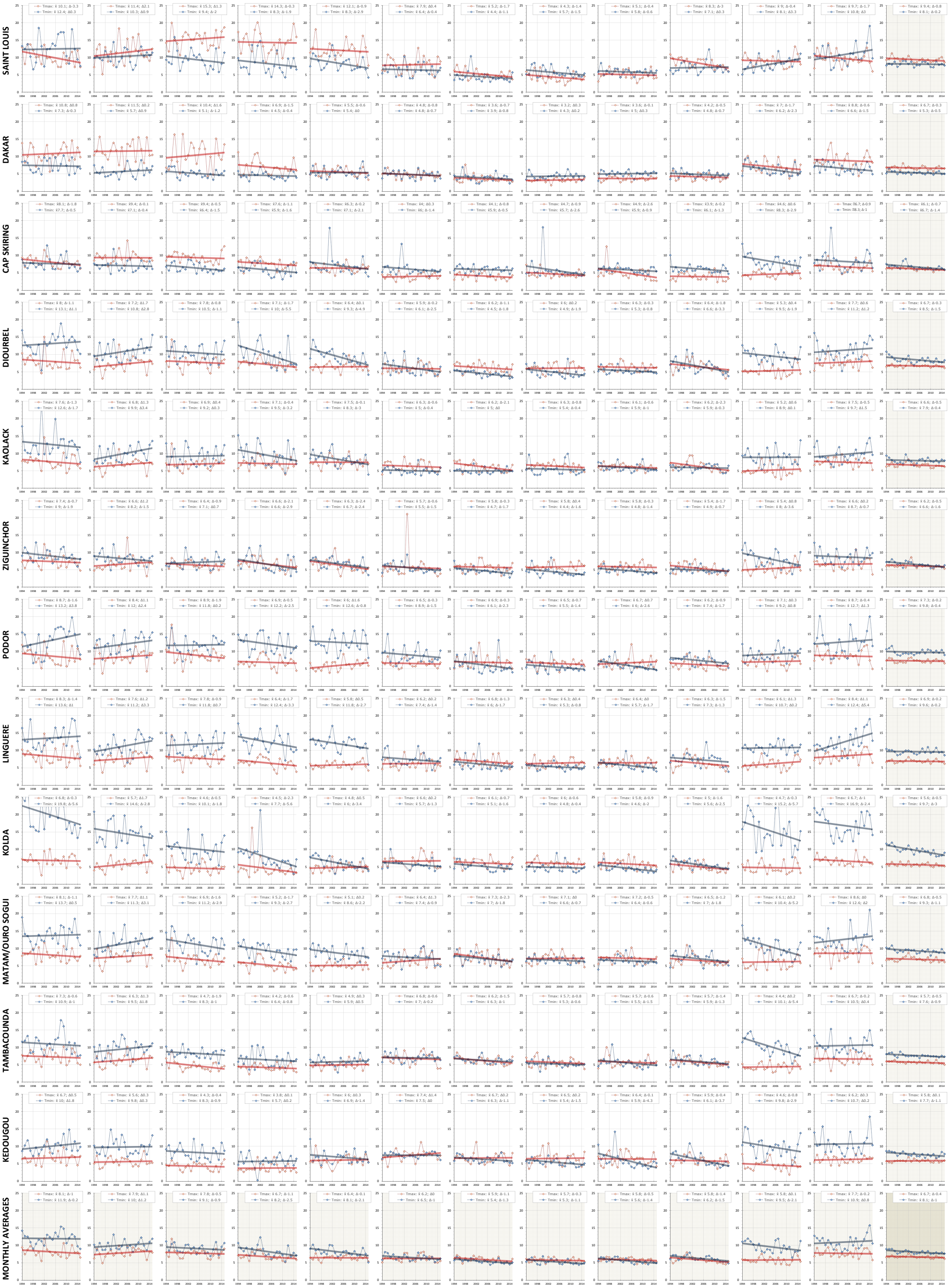


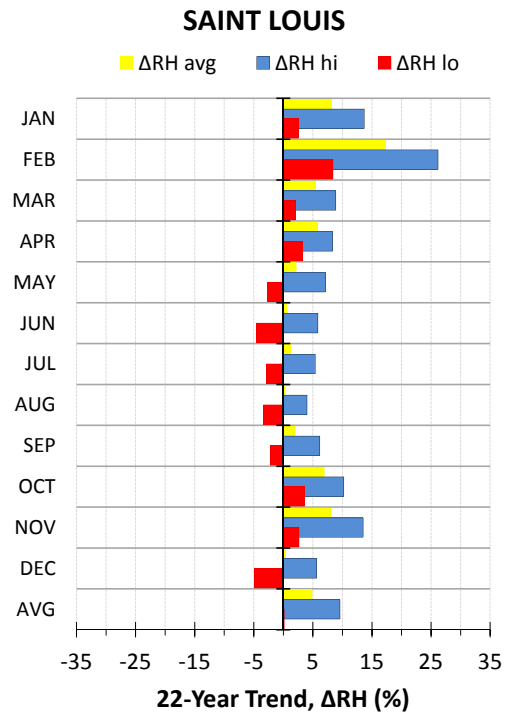
FIG 3b. SENEGAL changing temporal variability (ΔCV%). Year to year variation in daily temperatures by month and location, 1994 to 2015.

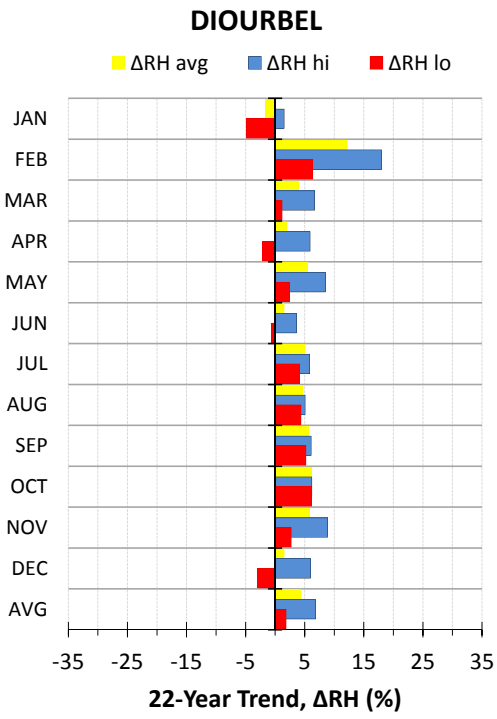
Daily maximum and minimum temperature data (FIG 3a) was de-trended by calculating a coefficient of variation (CV%) for each month from 1994 through 2015. Chart legends indicate: i) the overall monthly average CV% for both daily maximum and daily minimum temperatures; and ii) the relative change (Δ) in variability over 22 years. Positive Δ values indicate increasing monthly variability in daily temperatures while negative Δ values indicate decreasing variation.

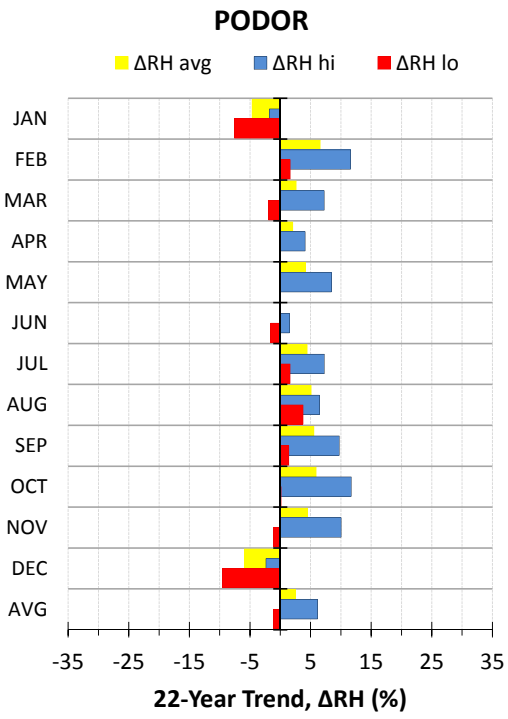
CV% was calculated with the equation: (CV% = [STANDARD DEVIATION ÷ MEAN] × 100) where the monthly standard deviation of daily temperature is divided into the monthly average daily temperature for daily maximum and minimum temperatures.

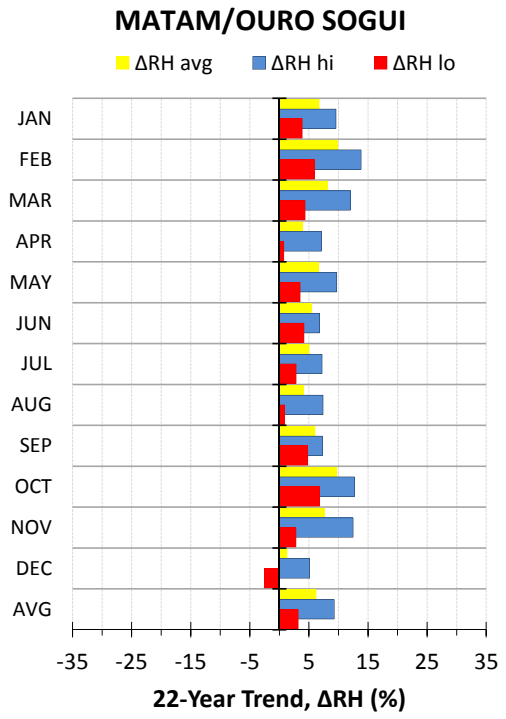
In contrast to increasing diurnal variation in Senegal's daily temperatures (Tdiff, FIG 3a), data analysis reveals a decreasing trend in temporal variability for daily temperature (ΔCV% for Tmax of -0.4% and ΔCV% for Tmin of -1.0%). Three exceptions to this trend occur with FEB Tmax and Tmin with increasing ΔCV% of 1.1% and 1.2%, respectively, and increasing ΔCV% for DEC Tmin of 0.8%. Monthly temporal variation in daily temperatures is highest during the dry periods from NOV through MAR. Overall, average temporal variability of daily minimum temperature is greater than that of daily maximum temperature for all locations, except for two coastal locations, Dakar and Cap Skiring.

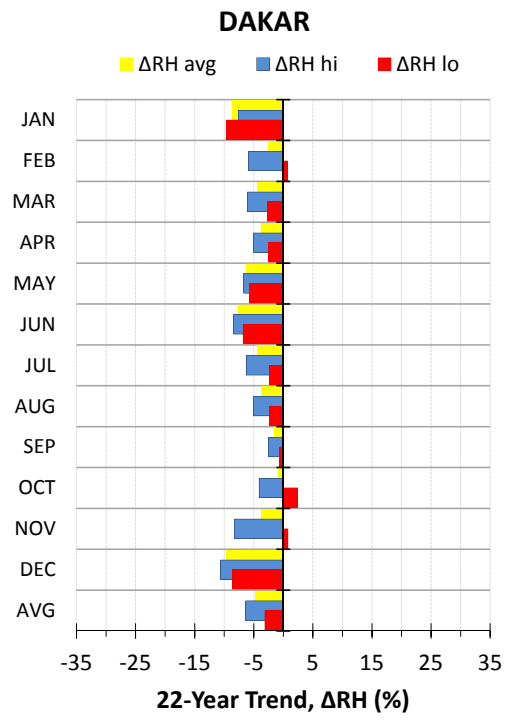
Data source: NOAA NCDC. Prepared on Saturday, February 25, 2017 by Wayne H. Thompson - M.S., Agronomist/Soil Scientist

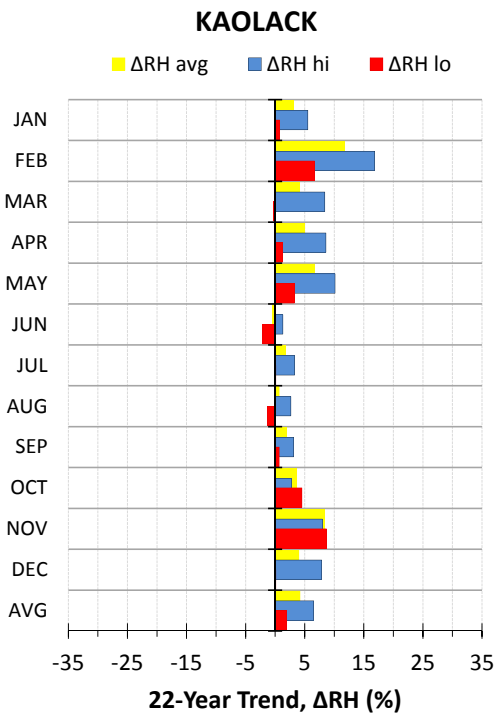


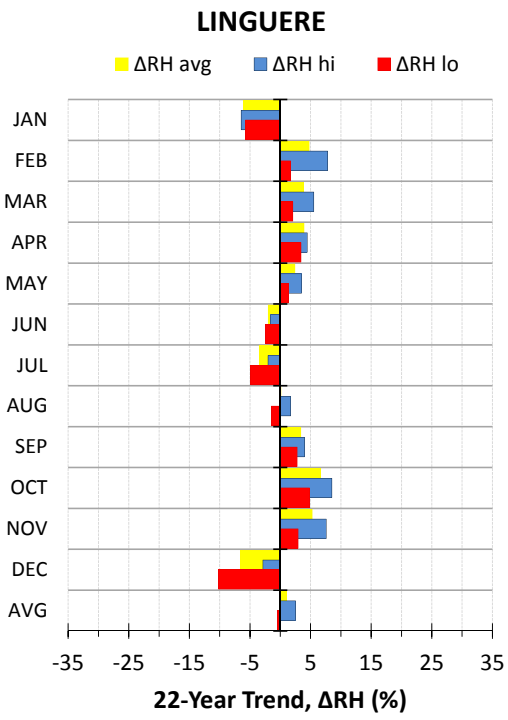


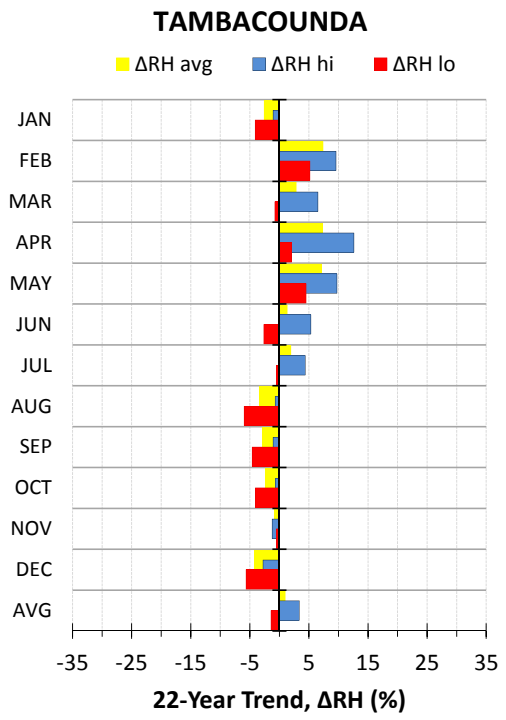


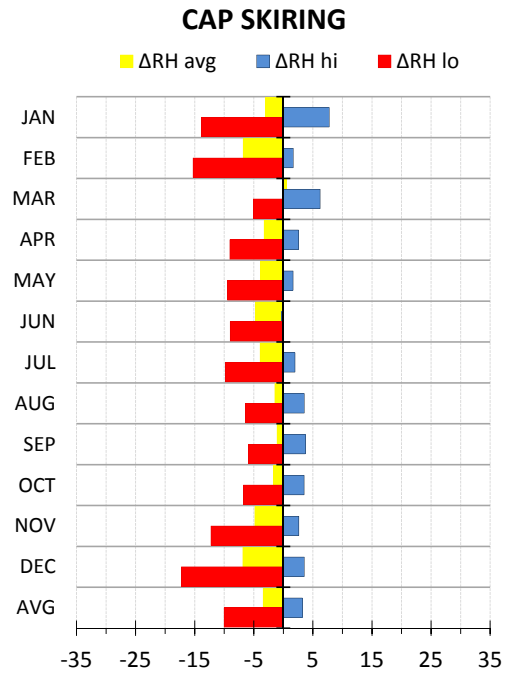


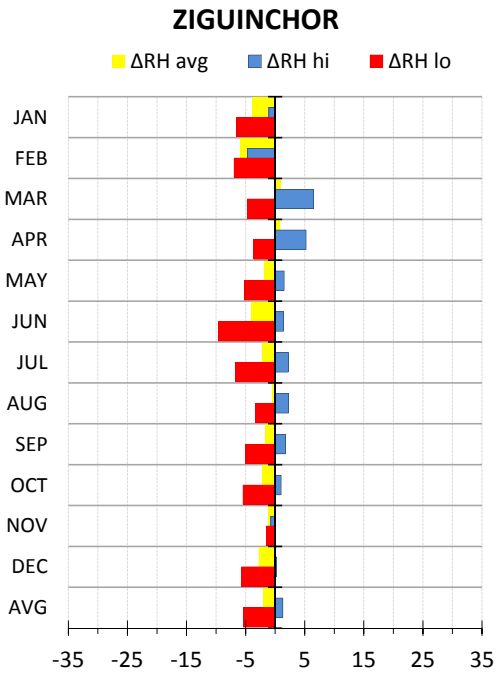


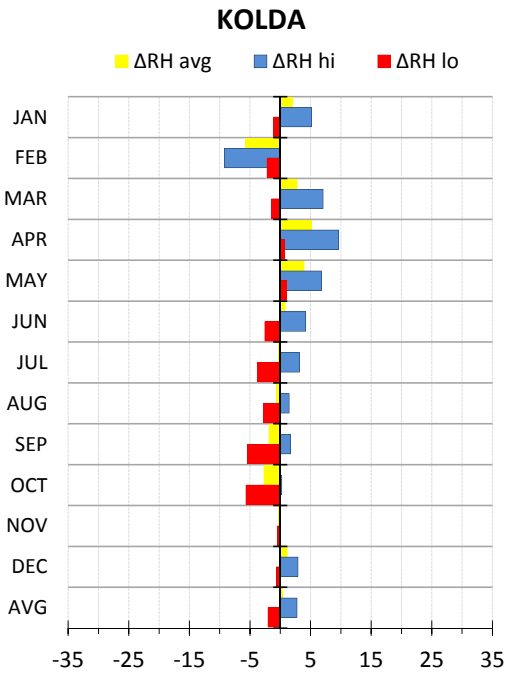












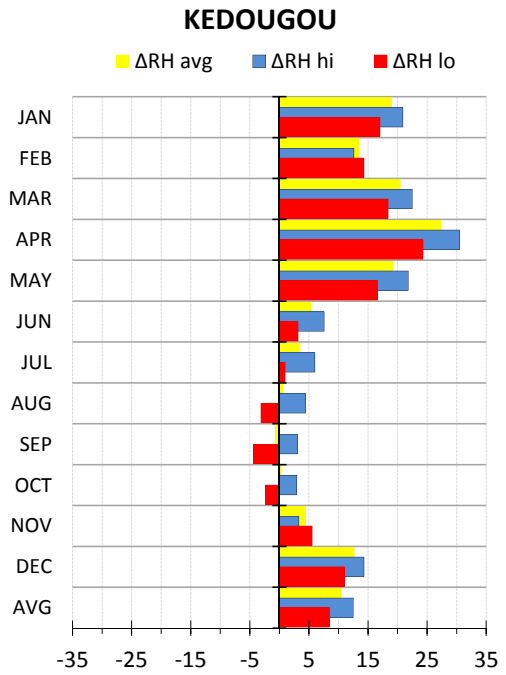
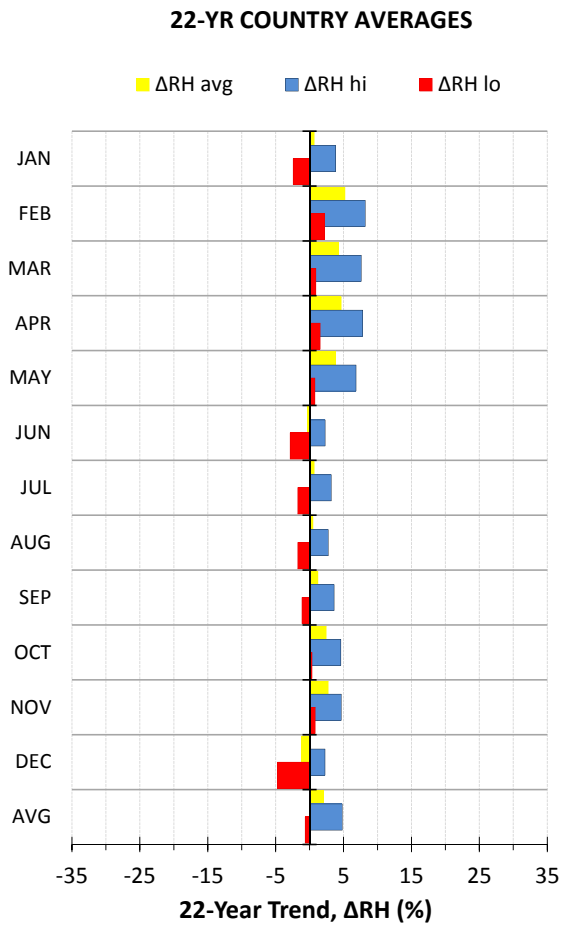


FIG 4. Changes in SENEGAL Relative Humidity (%), 1994 to 2015.

ΔRH (%) = average change in daily relative humidity over a 22-year period, from 1994 through 2015. Trends were calculated using the slope of relative humidity over time × 22 years for each location (FIG 4a). Positive trends (+) indicate rising relative humidity. Negative trends (-) indicate lowering relative humidity. ΔRH lo (red) = daytime low relative humidity; *source:* lowest recorded relative humidity measured between the hours 9:01 AM and 12:00 AM. ΔRH hi (blue) = night time high relative humidity, %; *source:* the highest relative humidity measured between the hours 12:00 AM and 9:00 AM. ΔRH avg (yellow) = average daily relative humidity ([(RH hi) + (RH lo)] ÷ 2). *NOTE:* Urbanization effects and potential effects due to changes in instrumentation technologies or potential changes in individual station microclimate are not considered in the presented estimates.

Trends of rising maximum daily temperatures (FIGS 3 and FIG 3a) combined with decreases in daytime relative humidity (AVG ΔRH lo = -0.7%) signal conditions with increasing evaporative water loss and increasing rates of evapotranspiration. Decreasing night time temperatures combined with elevating average night time relative humidity (AVG ΔRH hi = 4.8%) alter night respiration of plants and enhance activity of both beneficial and pathogenic microorganisms. As with changing air temperatures, the trend of changing relative humidity is most apparent at low elevation coastal locations (CAP SKIRING AND ZIGUINCHOR), versus the opposite trend for inland locations at higher elevations, (KEDOUGOU).



Data source: NOAA NCDC. Prepared on Saturday, February 25, 2017 by Wayne H. Thompson - M.S., Agronomist/Soil Scientist

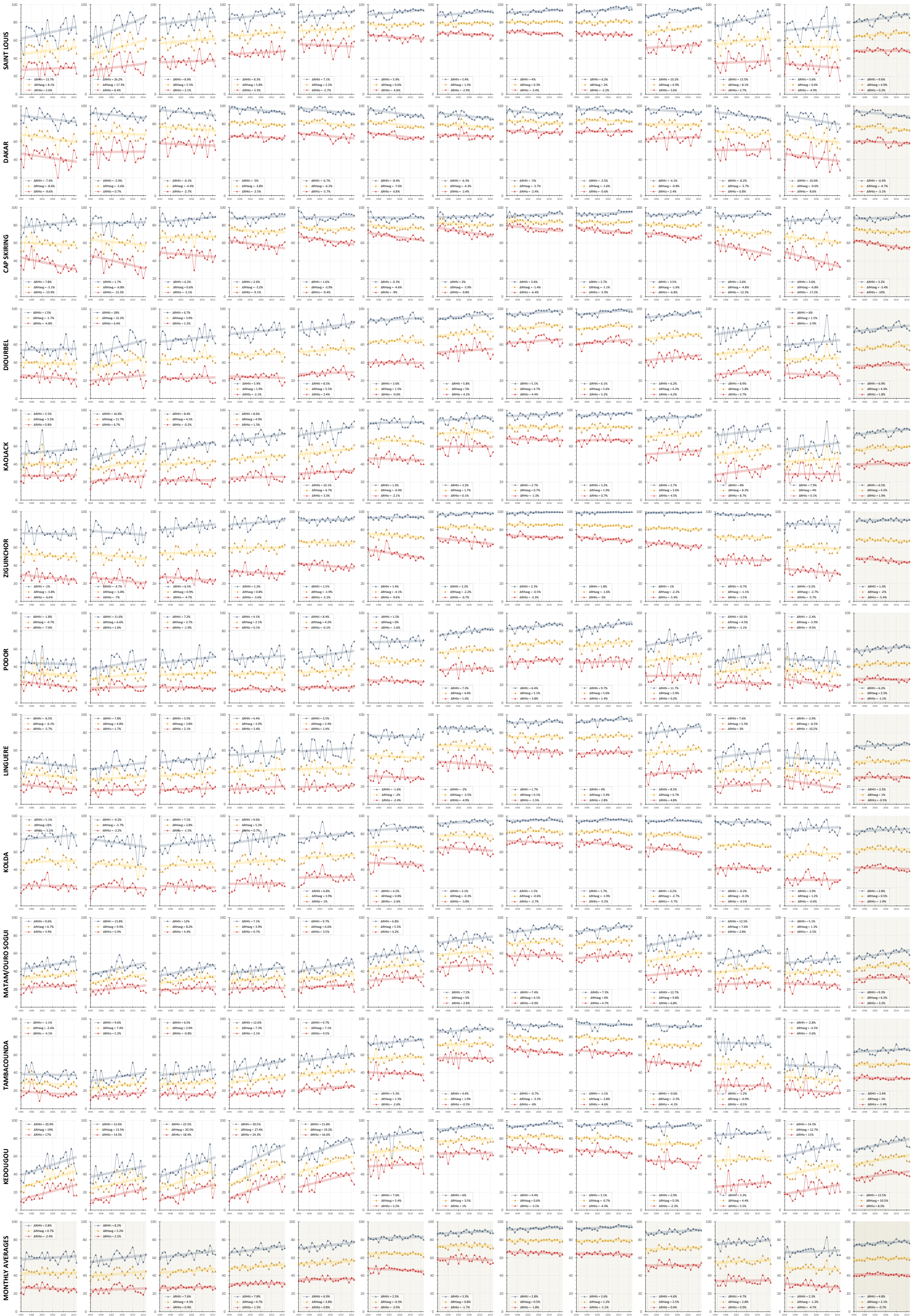


FIG 4a. SENEGAL changes in daily relative humidity, (%).

Data presented in each chart represents monthly averages of daily low, average and daily high relative humidity for the years 1994 through 2015. A trend line for annual average relative humidity versus time for each month and location is used to highlight the trend of ΔRH over 22 years. The slope of each trend line was used to calculate the average change in relative humidity [ΔRH = slope × time] for low (ΔRH lo), average (ΔRH avg), and high (ΔRH hi) daily relative humidity conditions.

Analysis of climate data provided by the NOAA National Climate Data Center (NCDC) reveals dynamic variations in daily relative humidity with 22-year trends indicating numerous changes in daily low and high relative humidity (ΔRH). The data provides evidence of significant trends of increasing daily low and decreasing high relative humidity.

Data source: NOAA NCDC. Prepared on Saturday, February 25, 2017 by Wayne H. Thompson - M.S., Agronomist/Soil Scientist