# Climate Smart Restoration on the Central Coast, Climate Analogs

Methods and Results   Sam Veloz, Climate Adaptation Group Director

## Introduction

A major challenge with communicating potential climate change impacts to general audiences is that many people have difficulty understanding how projected changes in temperature and precipitation affect the climate they are accustomed to and their lives in general. Climate analogs are an alternative tool that can be used to communicate potential climate change impacts by comparing locations with similar climates to illustrate changes that models project.

The approach works by comparing the future climate at a location of interest to the historic climate of all locations (Figure 1). We identify the location with the most similar historic climate (analog site) to the future climate at the location of interest. The location can then be used to provide context for what climate change might be like at the location of interest. We can use this tool when planning climate smart restoration to evaluate the types of vegetation that are dominant at the analog sites to consider adjusting restoration pallets. We could also consider looking at analog sites to collect seeds for restoration projects.

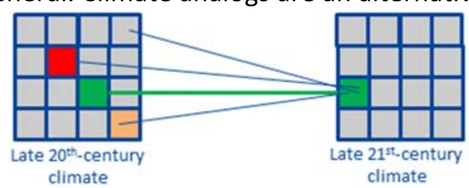



*Figure 1. Illustration of how climate analogs are identified. We compare two maps, where each pixel (grey boxes) contain values of historic climate or modeled future climate. We then evaluate the similarity in climate to one location of interest in the future map (green box) to all of the locations in the historic map. Some locations will have very different climate (red, orange pixels) but one pixel will have the most similar climate to the location of interest (green pixels). This location is the closest climate analog.*

## Methods

### Stream data

We identified closest climate analog sites and climate similarity maps for the Gonzales Ranch restoration project on the Pajaro River. Since the restoration site is a riparian restoration, we limited our comparisons to map pixels that overlap with riparian areas. We created a 270 m buffer around all rivers in the California Streams geodatabase (CA_Streams_2, ftp://ftp.dfg.ca.gov/GIS/California_Streams/CA_Streams.zip). We selected the 270 m buffer as this is the cell resolution of the climate data we used for the analysis (see below).

### Climate and Hydrology Data

We used downscaled climate and hydrology data from the Basin Characterization Model (http://climate.calcommons.org/dataset/2014-CA-BCM). We extracted monthly values of eight climate and hydrology variables from thirty year averages for the historic period (1981-2010) and three future thrity year periods (2010 – 2039, 2040-2069, 2070-2099). The variables we included in the analysis were actual evapotranspiration, climatic water deficit, potential evapotranspiration, recharge, runoff, minimum temperature and maximum temperature. We extracted future climate and hydrology data from four future climate models selected from an ensemble of 18 models(Figure 2). These models included a hot and dry model (MIROC_esm_rcp85), two hot and wet models (IPSL_cm5a_lr_RCP85), a warm model with no change in precipitation (CCSM_4_RCP85).

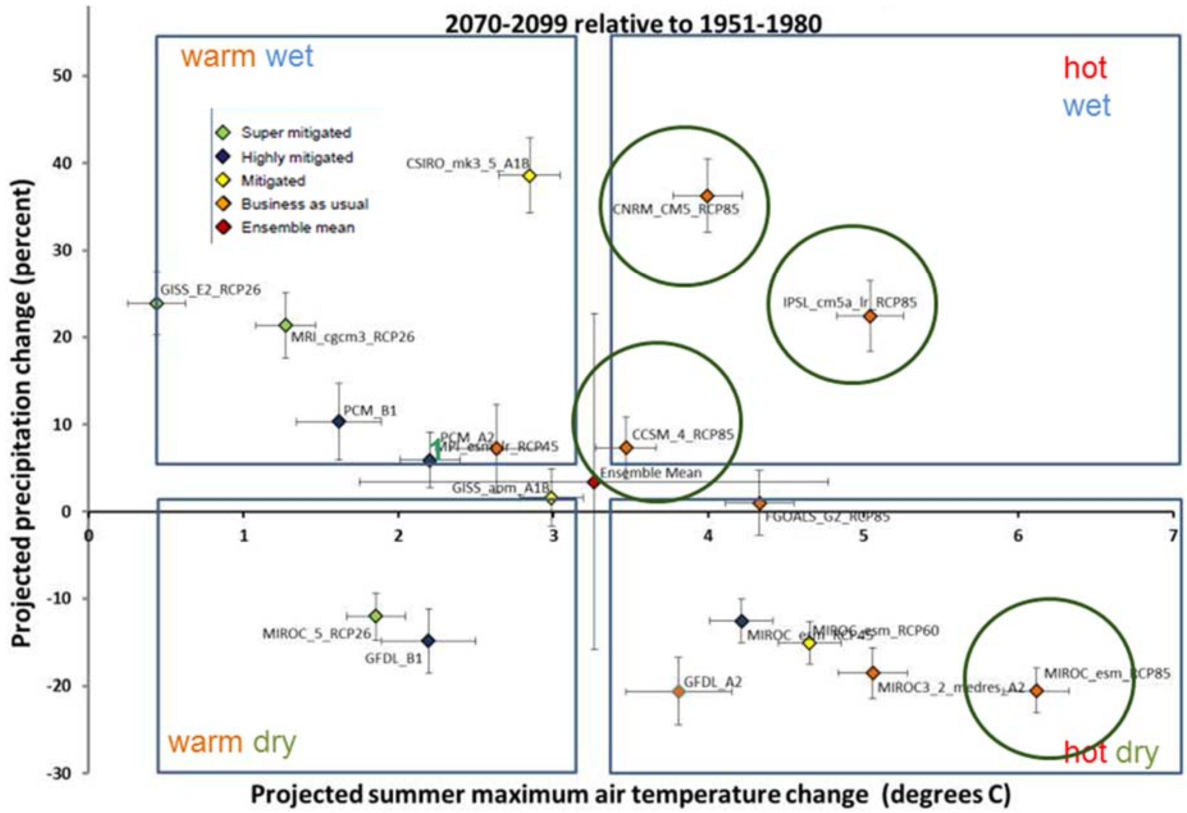



*Figure 2. Projected changes in annual precipitation and summer maximum monthly temperature from 18 climate futures. Each point indicates the Bay Area wide average projections for a particular climate model and emission scenario combination. The error bars indicate the spatial variation in the climate variables across the Bay Area (± 1 standard deviation). The colors of the points indicate the emission scenario from low emissions (Highly mitigated) to high emissions (business as usual). The green circles indicate the models that were selected for the climate analog analysis.*

## Climate analog analysis

Following methods applied previously (Veloz et al. 2012) we search for climatic analogs for the 21$^{st}$-century projections for the Gonzales Ranch restoration cite by calculating the climatic similarity between the future climate projected for the restoration cite grid cell and all grid cells from the California wide historical observational dataset of late 20$^{th}$-century climates. We use the standardized Euclidean distance (SED) as the measure of climatic dissimilarity, calculated as:

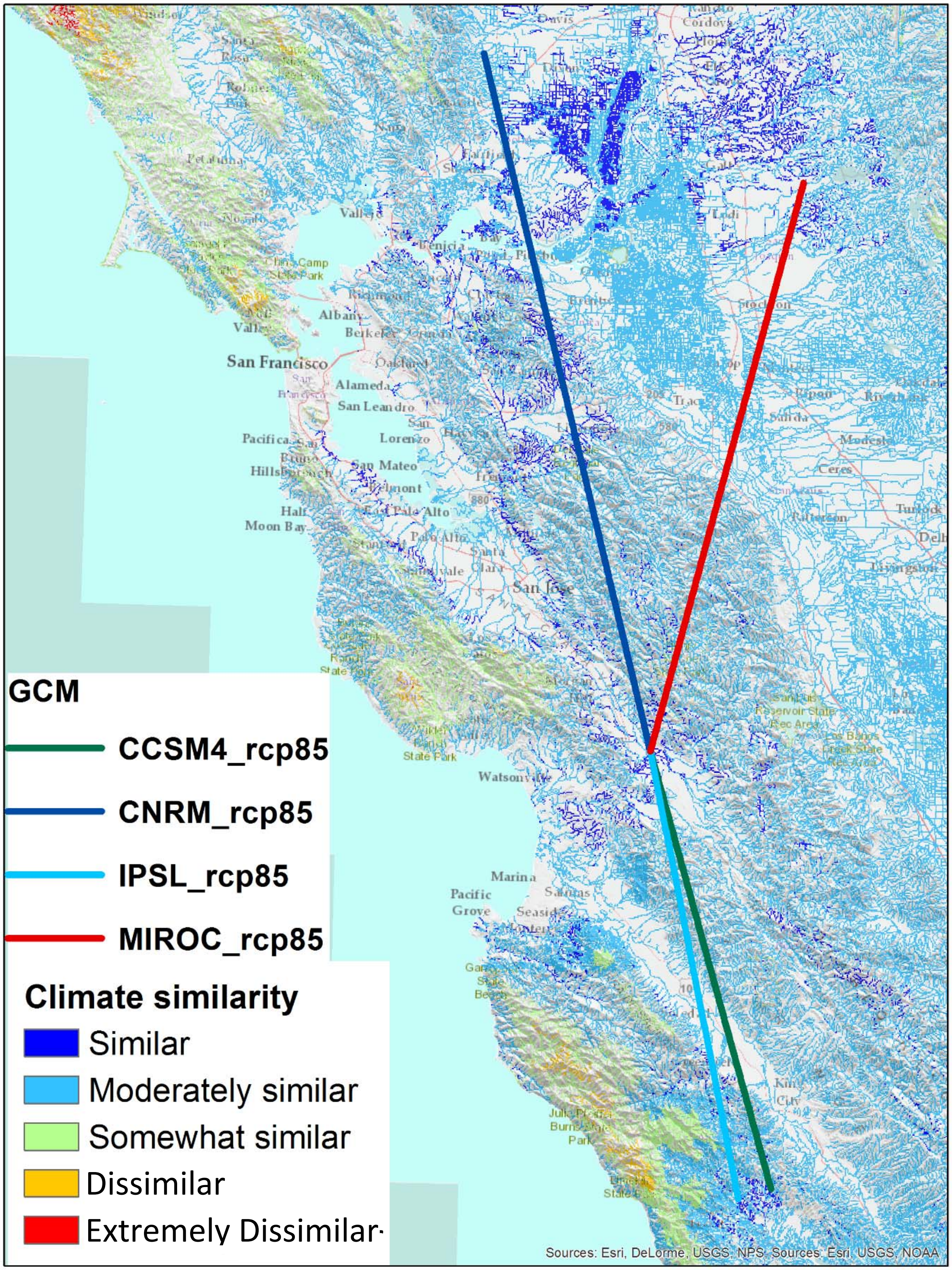
$$SED_{ij} = \sqrt{\sum_{k=1}^{n} \frac{(b_{ki} - a_{kj})^2}{s_{kj}^2}}$$

where $n$ is the number of climate variables included in the analysis (here, $n$=96 (8 variables x 12 months), $a$ is the mean of climate variable $k$ from the late 20$^{th}$-century California dataset at grid cell $j$, $b$ is the mean climate for the future climate projection at grid cell $i$,(restoration site) and $s_{kj}$ is the standard deviation of interannual variability of climate variable *k* in the historic climate projections. The SED thus summarizes climate changes across multiple climate dimensions. Standardizing by the interannual climate variability of each variable has two advantages: it places all climate variables on a common scale, and also it upweights climatic trends that are large relative to local historical interannual variability. The minimum SED (smallest dissimilarity) discovered between a given grid cell in the future climate projections and the set of all grid cells in the late $20^{th}$-century climate dataset thus identifies the closest contemporary analog for the restoration site.

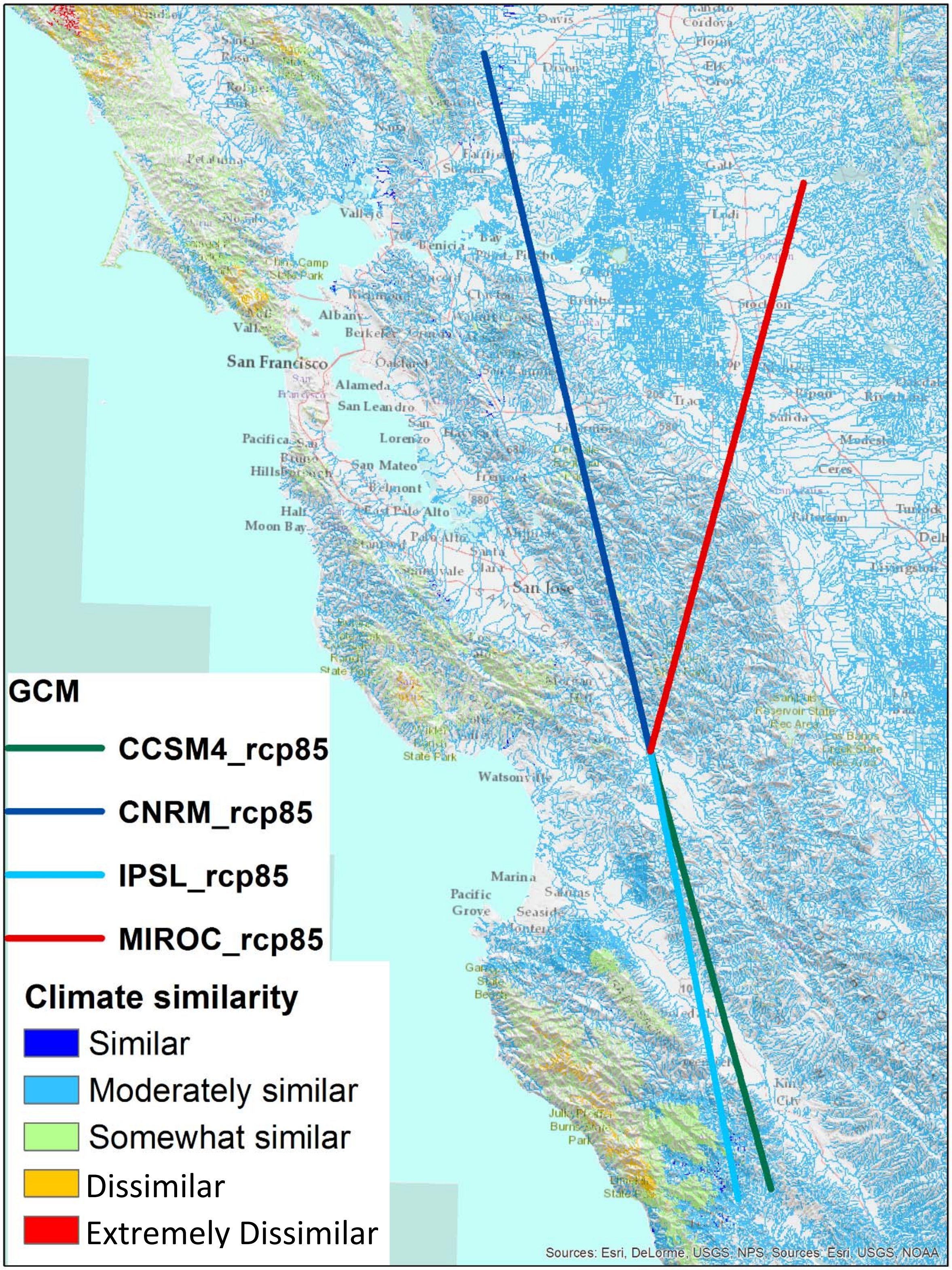
## Results

The following maps show the climate similarity between the future modeled climate at the Gonzales Ranch restoration site and the climate across California and the closest analog sites for each of the four climate models. Climate similarity is mapped with cool colors indicating more similar climate and warm colors greater climatic dissimilarity. The lines in each figure connect the closest climate analog to the Gonzales Ranch site.

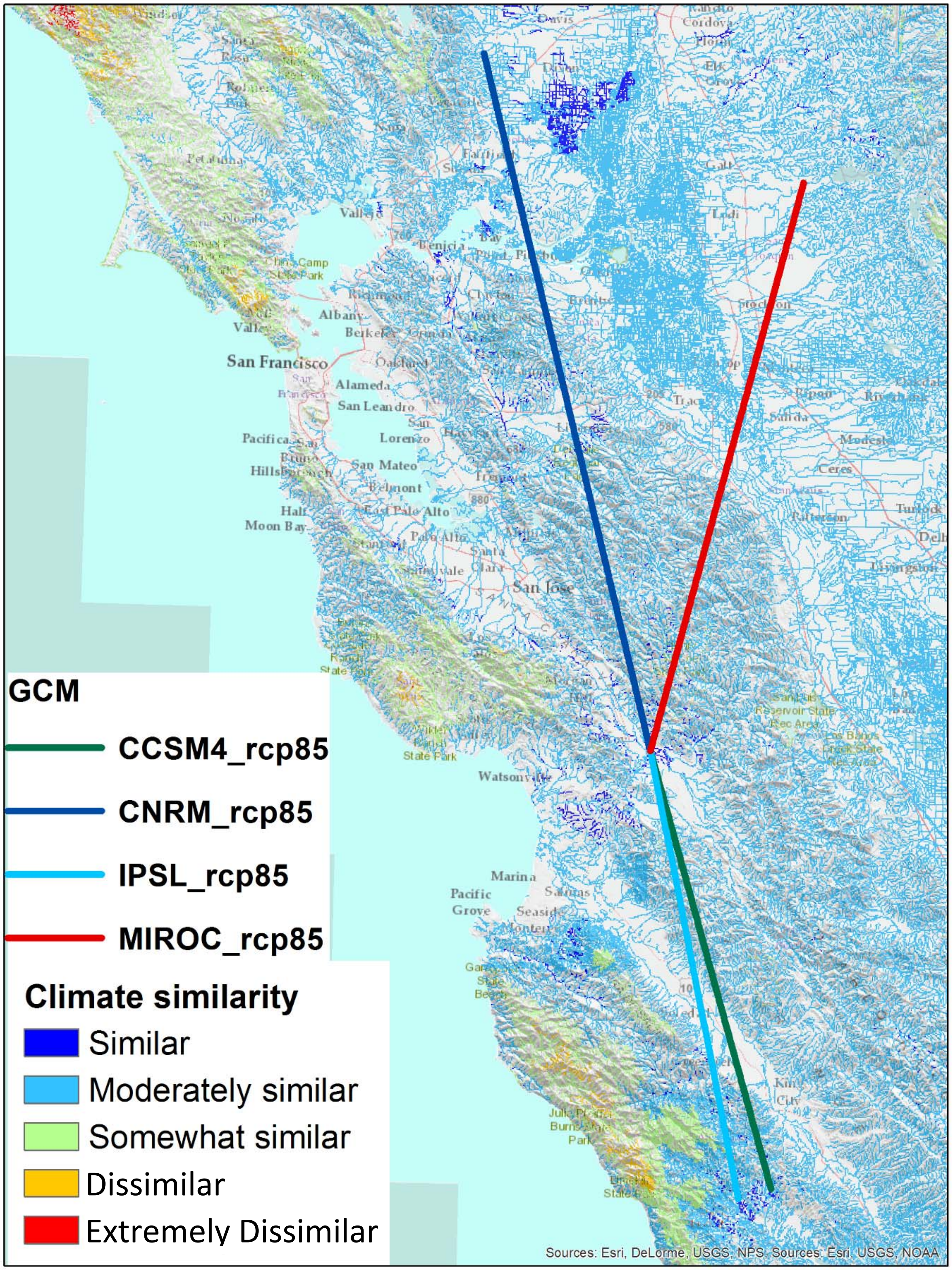
2010 – 2039 CCSM4



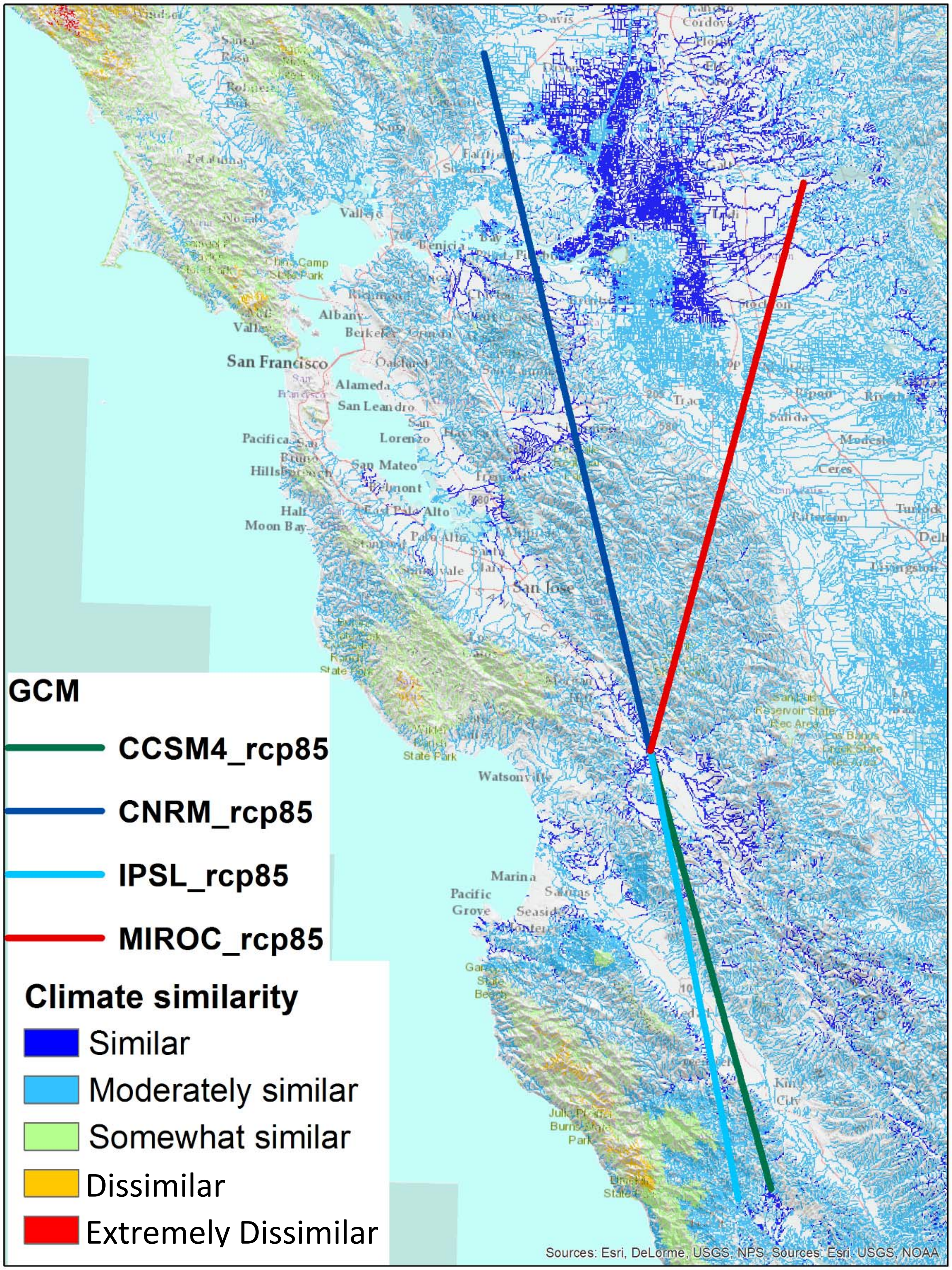
## 2010 - 2039 CNRM



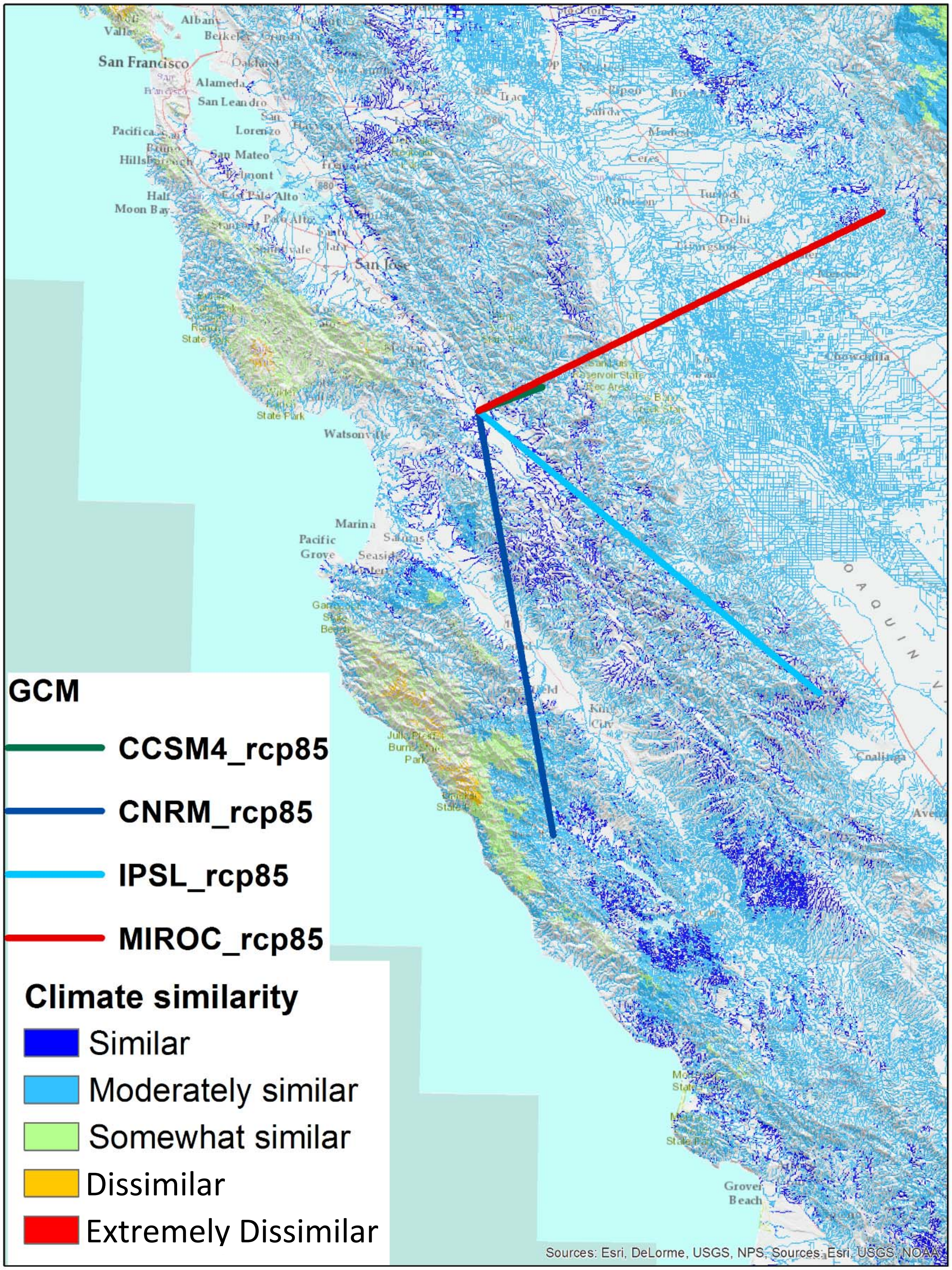
## 2010 – 2039 IPSL



## 2010 – 2039 MIROC



## 2040 – 2069 CCSM



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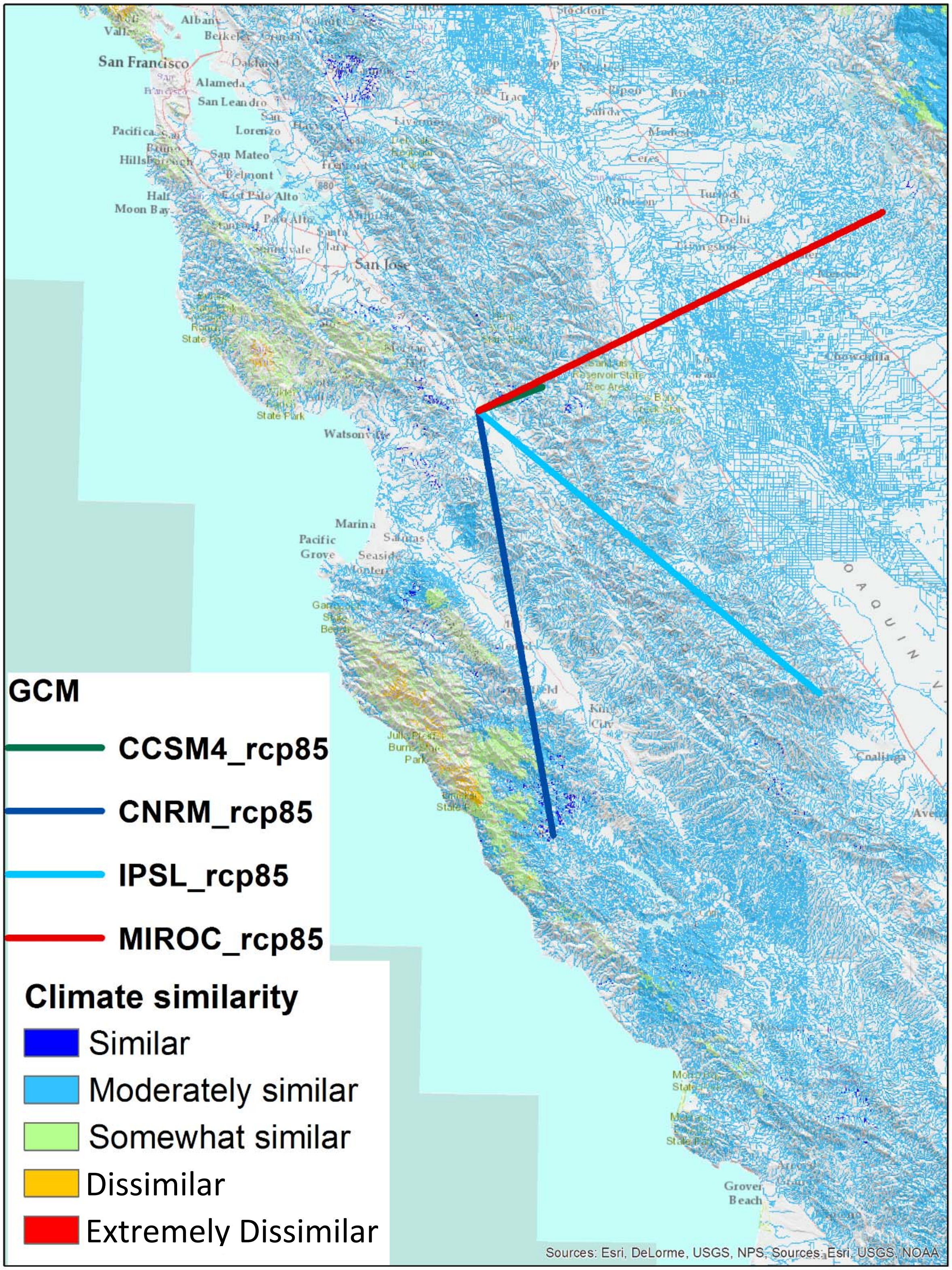

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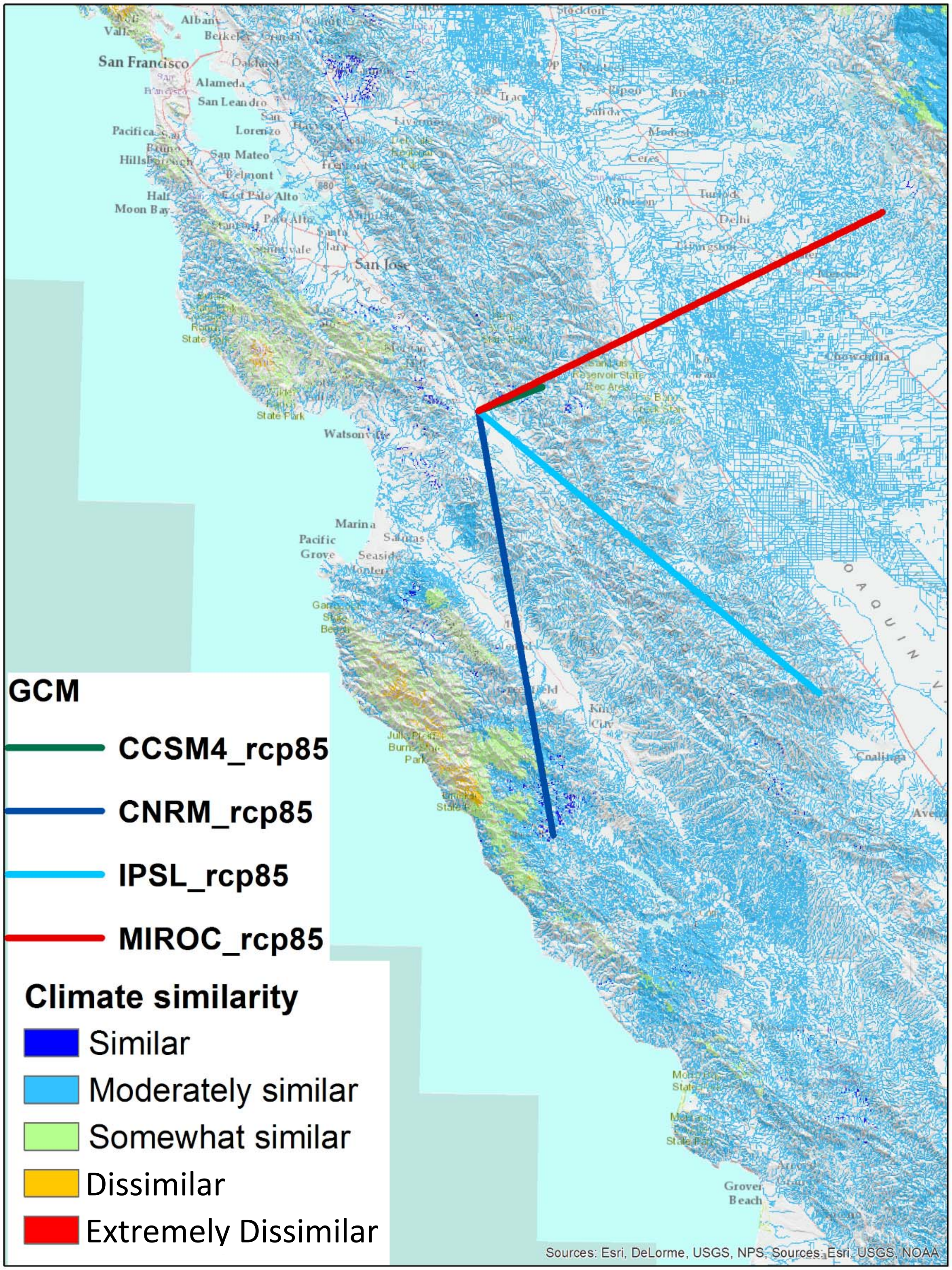
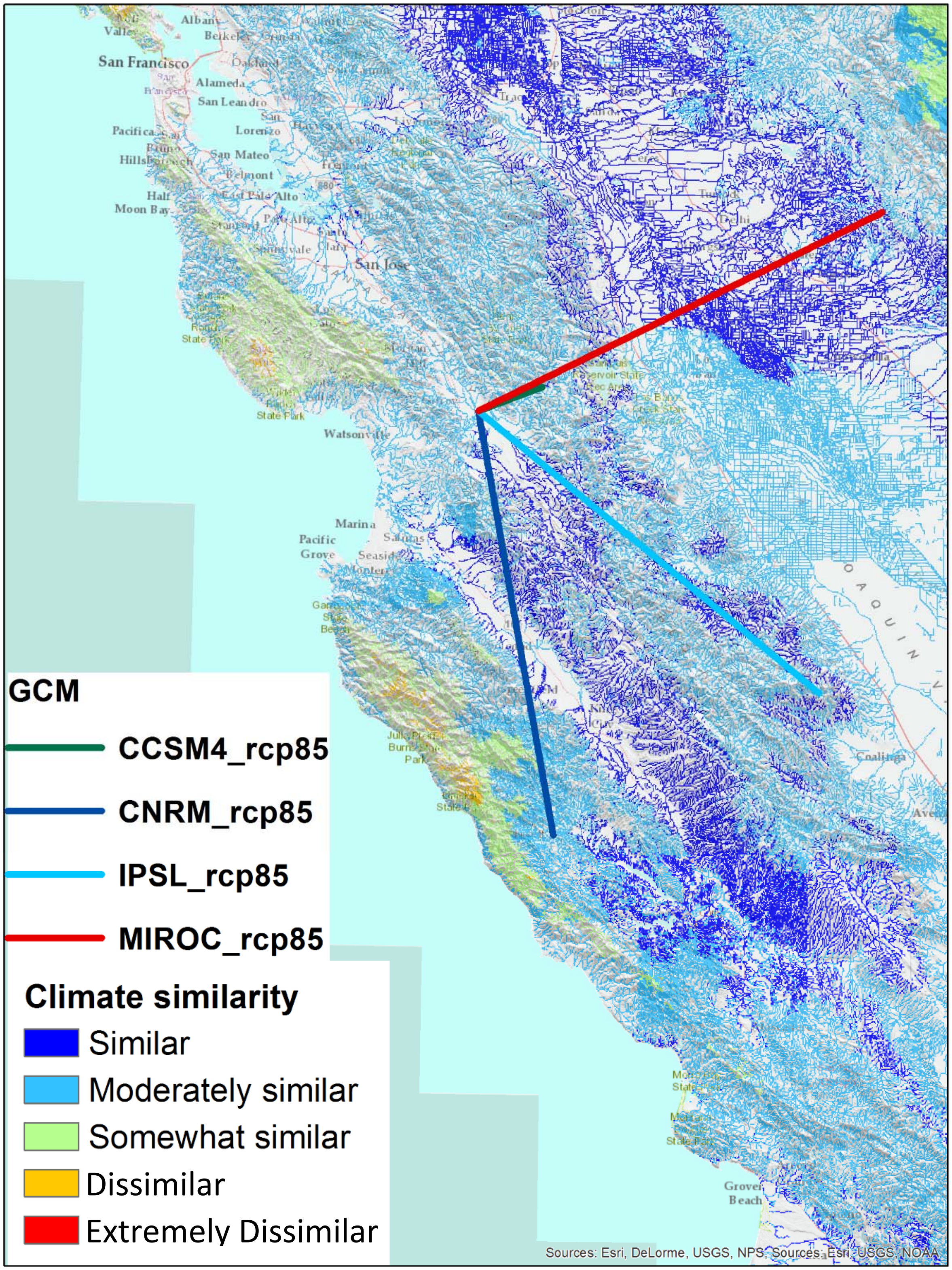
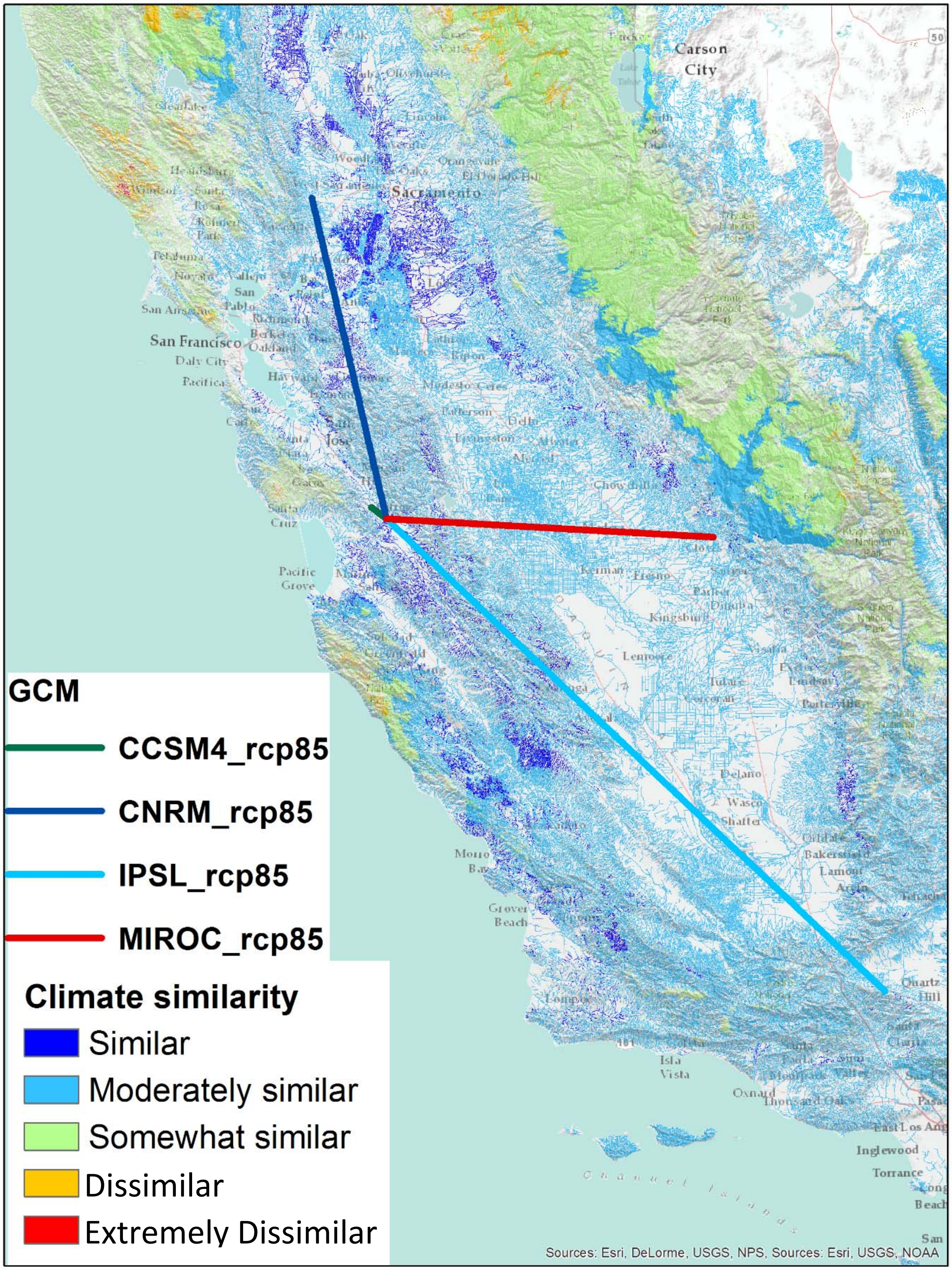


## 2040 – 2069 MIROC



## 2070 – 2099 CCSM4



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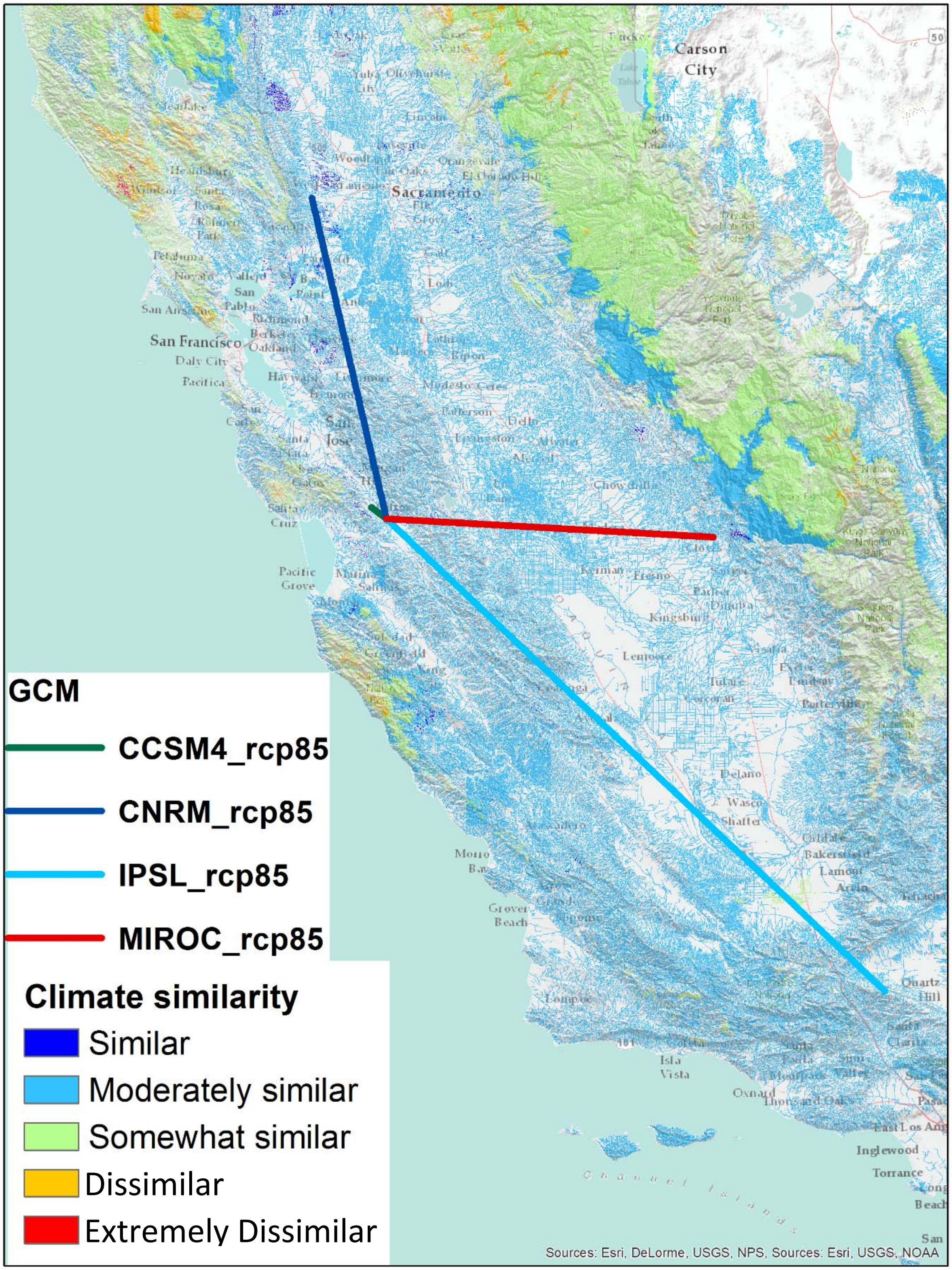
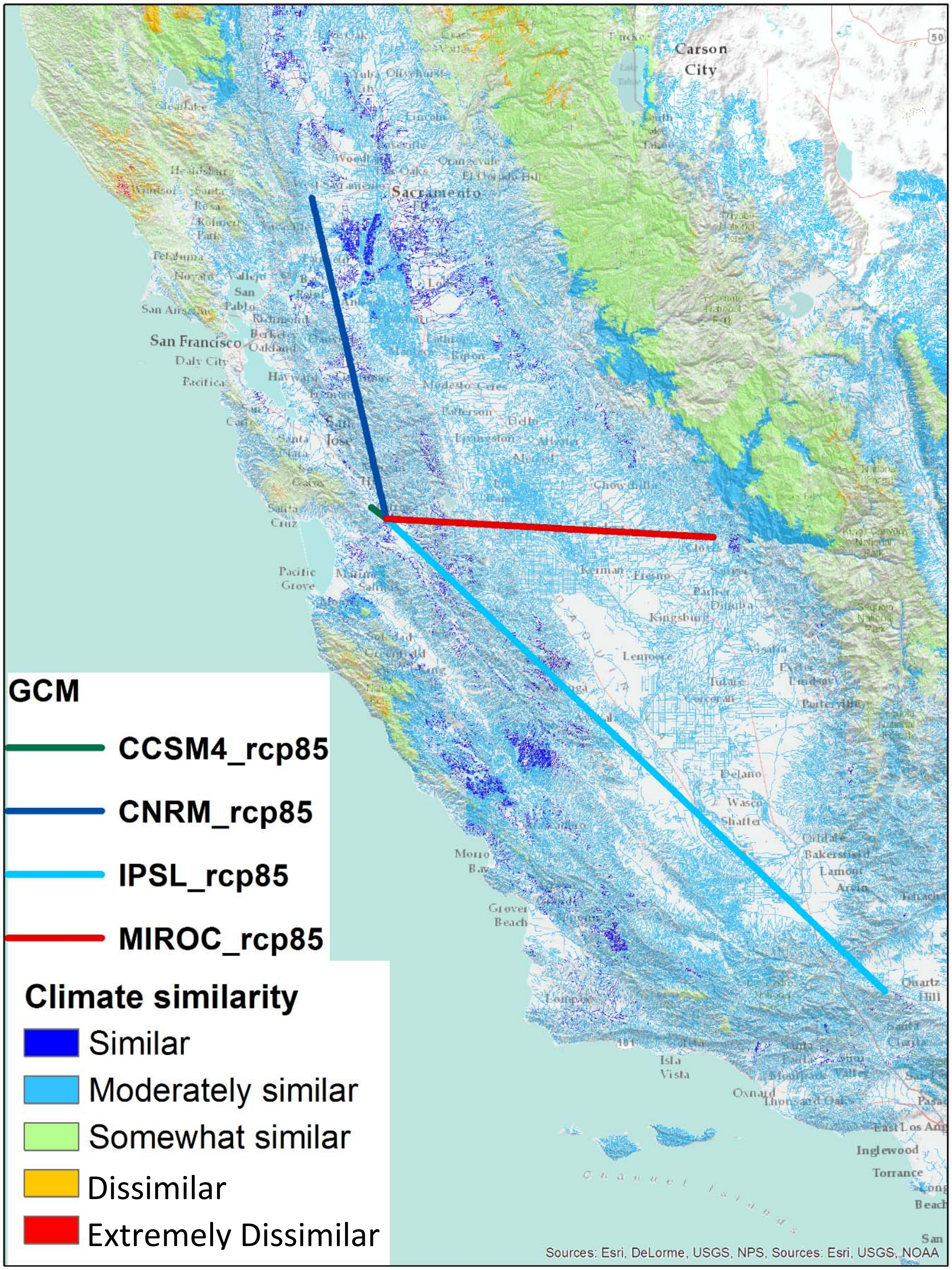
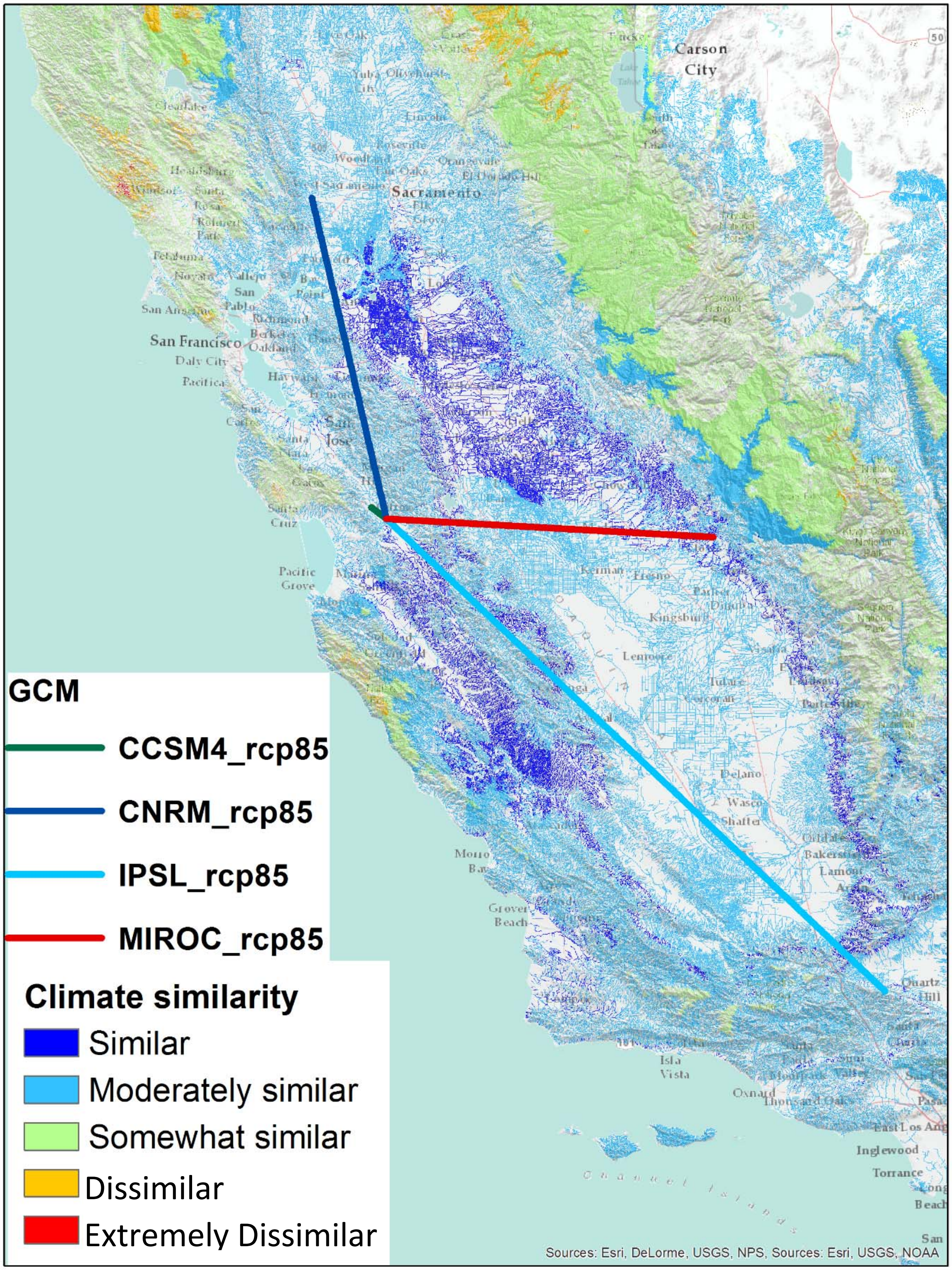


## 2070 – 2099 IPSL



## 2070 – 2099 MIROC



## References

Veloz, S., J. Williams, D. Lorenz, M. Notaro, S. Vavrus, and D. Vimont. 2012. Identifying climatic analogs for Wisconsin under 21st-century climate-change scenarios. Climatic Change 112:1037–1058.