

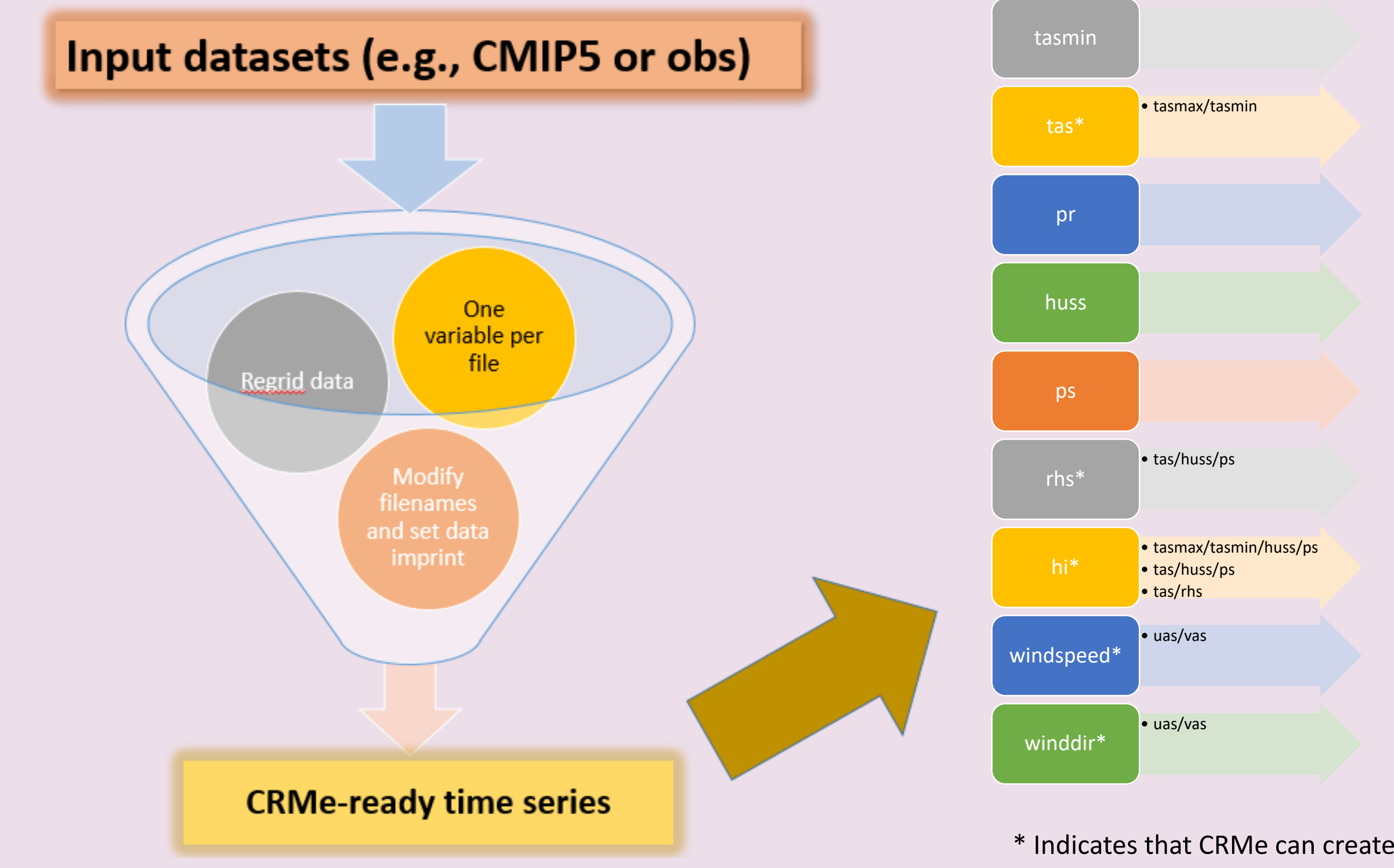
Access, evaluation, analysis and translation of complex climate data in efficient, transparent and reproducible ways / for specialized and interdisciplinary science, for applications, and for communication and education.

### 1. Overview

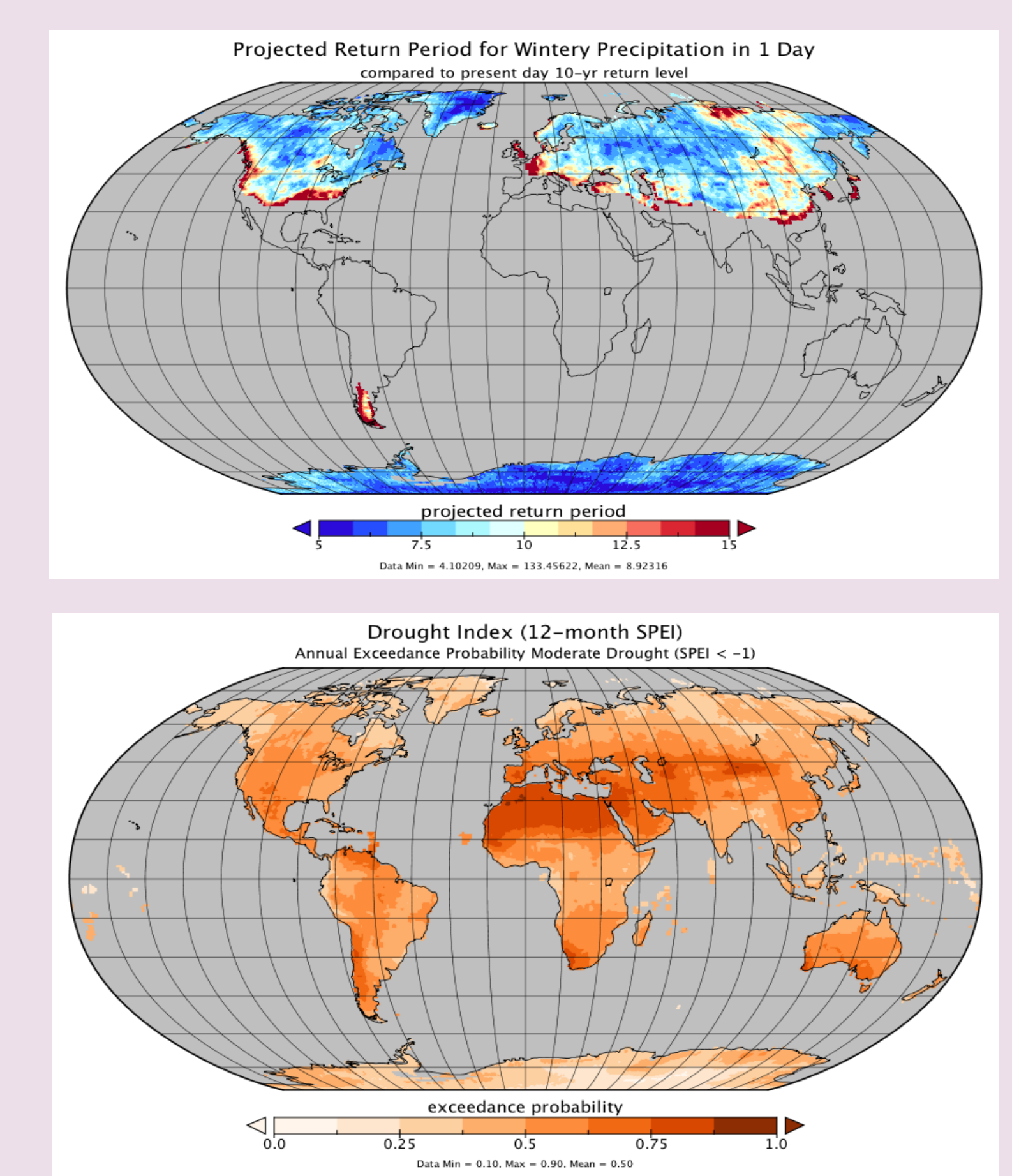
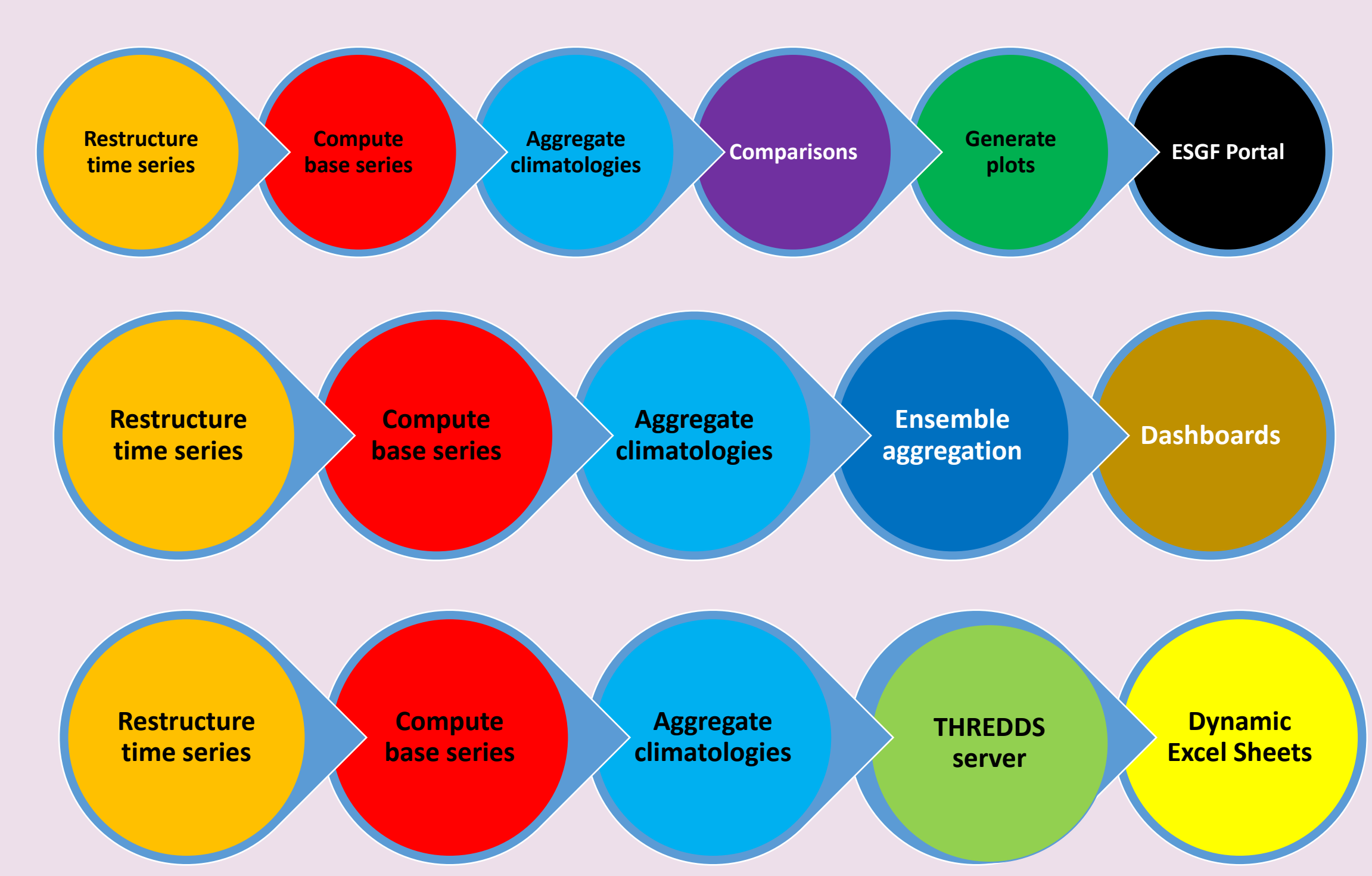
The Climate Risk Management engine (CRMe) is an NCL-based code set (with capability to integrate R packages) used to process and analyze large climate data sets (daily or monthly) from a variety of different sources (observations, model output) and on any horizontal resolution (global, regional, local).

- CRMe provides:
- **Consistent data provenance** preserves metadata from source data
  - **Structured metadata schema with controlled vocabulary**
  - **Support for "Big Data"**-sized problems (e.g., 100+ years of half degree global data, or 60+ years of quarter degree global data)
  - **Support data delivery** to portals, customized viewers, and other applications such as Microsoft Excel and Open Climate GIS.

### 2. Data Preparation



### 3. Example CRMe Workflows



Projected change in 10-y return period for wintery precipitation in 2035

Projected annual exceedance probability of moderate drought in 2036 (12-month SPEI < -1)

### 4. Discrete, efficient workflows

Through thoughtful discretization of computational tasks, CRMe supports highly efficient processing workflows that are flexible enough to be run on a desktop, a server, or a supercomputer.

- Key steps include:
- **Preprocess, subset, and regrid** input datasets (daily or monthly)
  - **Standardize data** into CF-compliant netCDF
  - **Restructure daily data** to enable very efficient computations
  - **Calculate base series** of various sector- and application-oriented indices at the monthly, seasonal, annual, and decadal time frames
  - **Aggregate base series data** into climatological period statistics.

CRMe can take ~10 TB of CMIP5 data and compute hundreds of complex indices with a turnaround time of a few days.

CRMe employs workflow parallelization by dataset, so scores of climate model datasets can be run simultaneously over multiple climate periods. These capabilities, coupled with the CRMe Viewer, provide powerful new ways to browse and compare large sets of climate data in past and future climates.

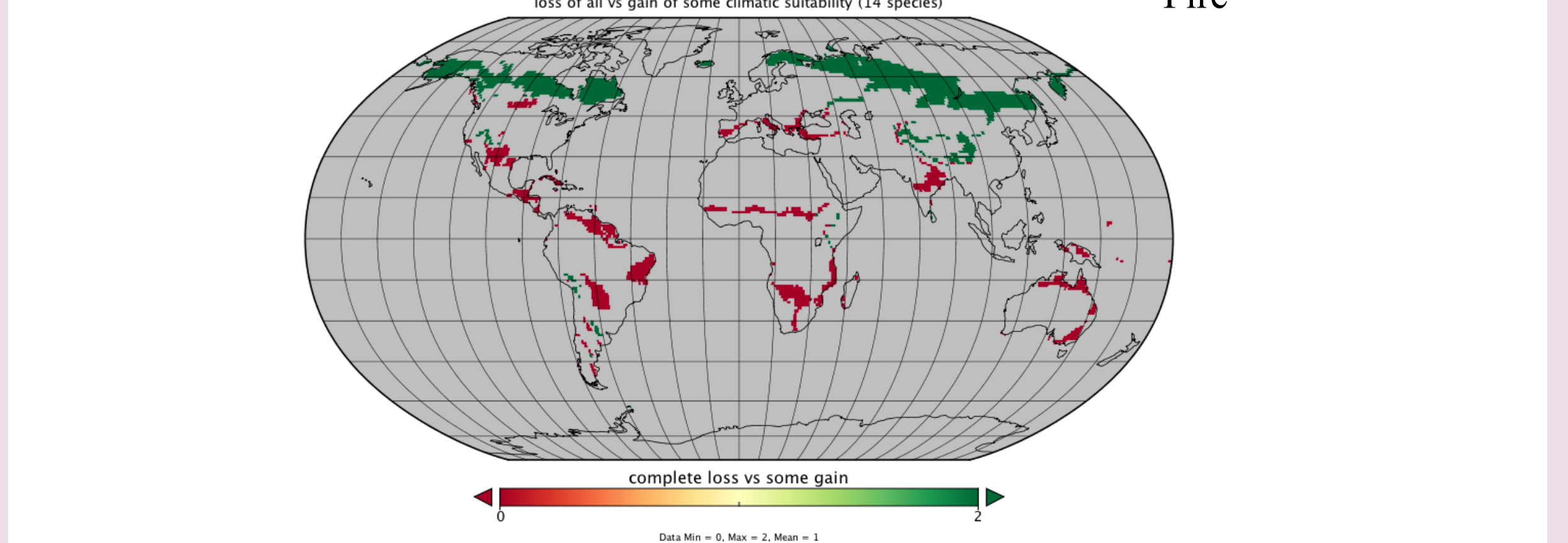


### 5. Sector Indices: Extensibility

Diverse application-oriented practitioners have data needs that cannot be fully satisfied using existing indices. Through coordination with experts and practitioners from various industry sectors, new indices have been developed to assess climate risks specific to each sector.



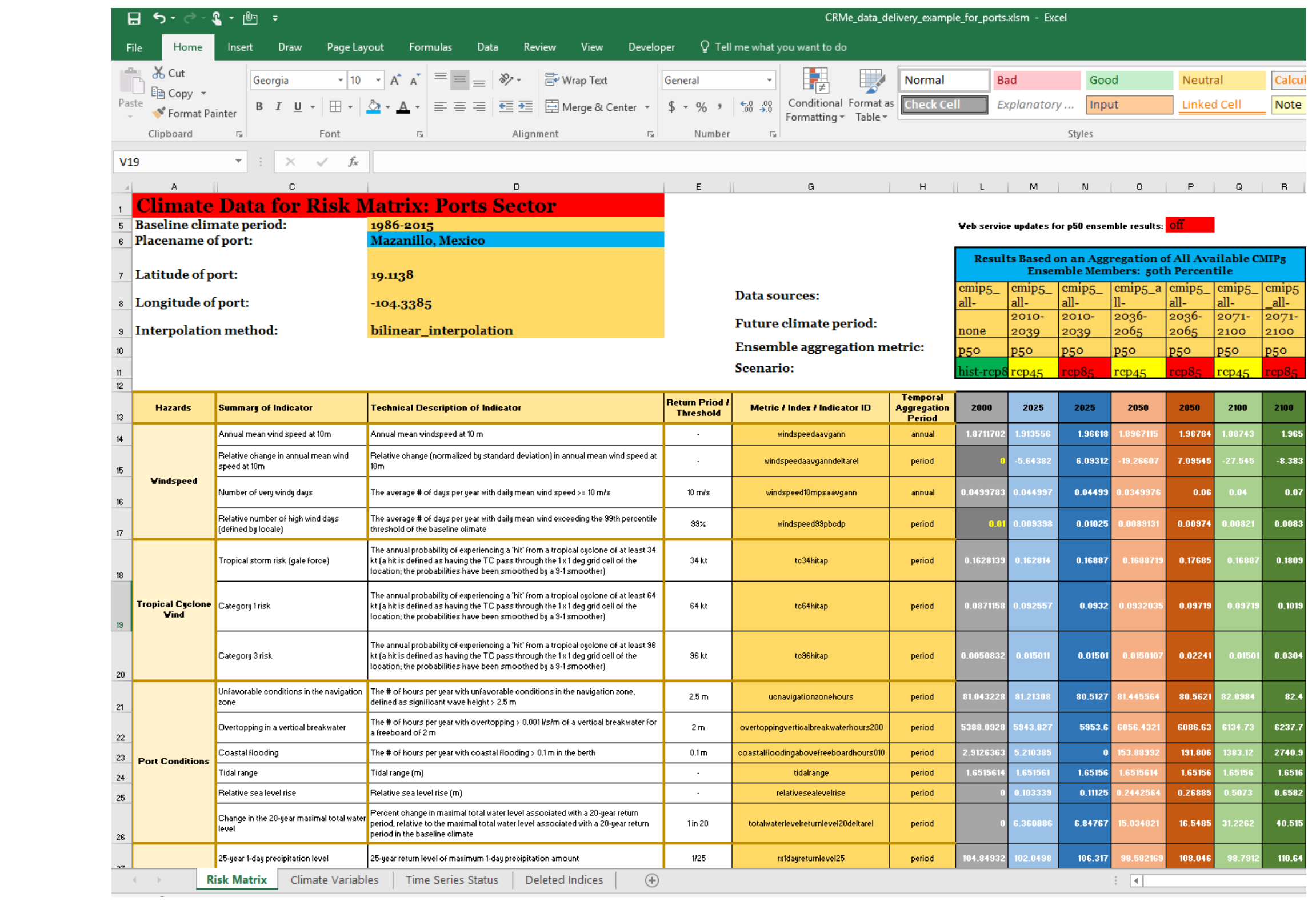
- Forestry**
  - Forest fire
  - Shift in geographic range
  - Droughts
  - Floods
  - Extreme winds
  - Heat/cold stress
  - Snowfall
- Ports & Water Transport**
  - Tropical cyclones
  - River levels
  - Storm surge / waves
  - Wind
  - Floods
  - Heat/cold hazards/costs
- Insurance**
  - Tropical cyclones
  - Extratropical cyclones
  - River floods
  - Flash floods
  - Storm surge
  - Heat/cold waves
  - Drought
  - Fire



Summary of change in climate suitability for 14 species of plantation tree species for a 30-year future climate period centered on 2085. Areas in red show a complete loss of climate suitability. Areas in green show a gain of suitability for 2 or more tree species.

### 6. Tailored Data Delivery

In order to be usable, climate data needs to be delivered to end-users in forms that they can work with. Recently, a new data delivery modality was developed to deliver climate data directly from an NCAR-based server to users' Excel spreadsheets. This allows users to dynamically download detailed climate information for a specific location (e.g., user-provided lat/lon coordinates).



Example of an Excel spreadsheet using the CRMe Web Data Service.

The CRMe Web Data Service delivers discrete pieces of climate information, called *climatons*, at the rate of 18 per second. A climaton can be a time-aggregated value of a variable (e.g., mean monthly temperature in Jan) or a period index value (e.g., change in 10-year return period of 5-day rainfall). Users can select whether to use the nearest grid point, bilinear interpolation, or country-aggregated results.

### 7. Projects using CRMe

**National Predictions & Projections Project (NCPP)** - evaluation of downscaling methods, supported QED workshop in 2013

**World Bank** – CRMe has recently been used to provide the data that will populate the next generation Climate Change Knowledge Portal

**UAE AGEDI** – CRMe was used to provide data for an interactive “climate inspector” tool

**A major international development bank** – CRMe has recently been used to provide data for climate risk screening tools, adding 100+ new sector-oriented indices

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