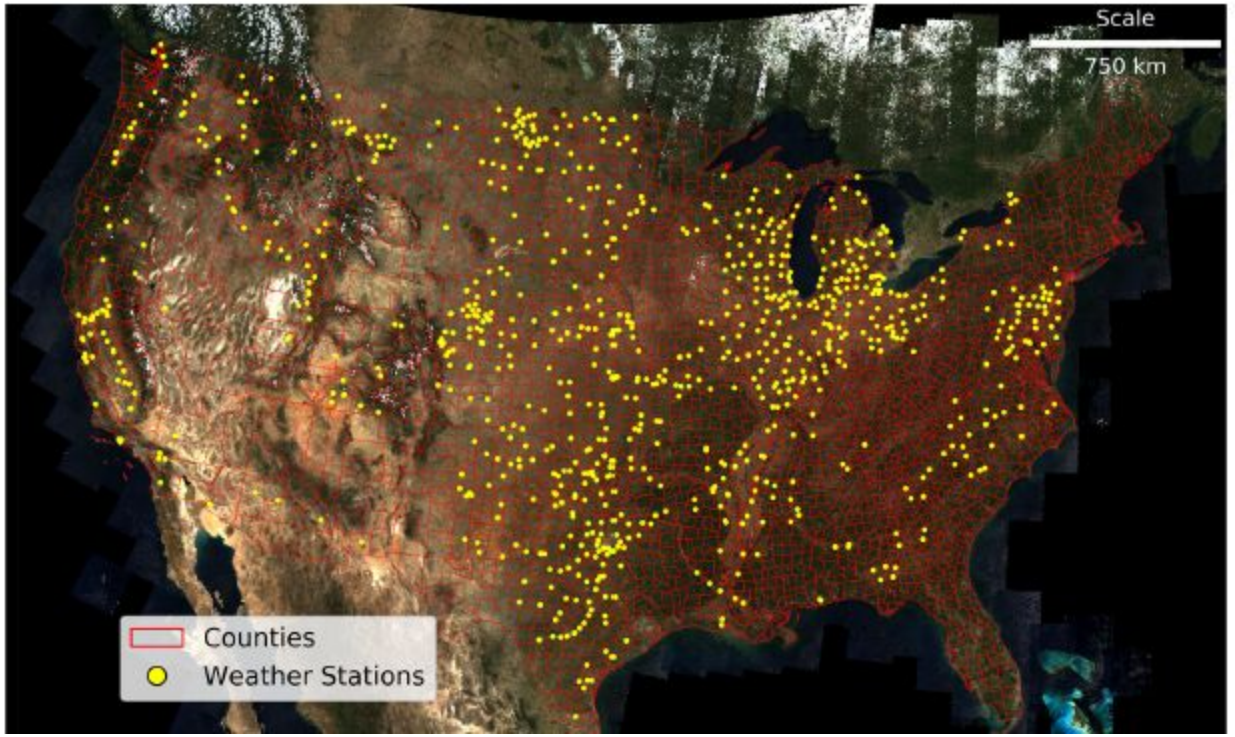
Special Topics in Applications (AIL861)
Artificial Intelligence for Earth Observation
Lecture 18

Instructor: Sudipan Saha



Locations of weather stations in United States

Source: Evaluation of Near-Surface Air Temperature From Reanalysis Over the United States and Ukraine : Application to Winter Wheat Yield Forecasting

Reanalysis Data

- ✔ The availability of observations depends on the coverage, in space and time, of global observing systems. Despite this wealth of data, the coverage is not complete and data quality may vary with time.

- ✔ Data interpolation, or other processing, can bring observations into a uniform shape. Purely mathematical interpolation can do this, but does sub-optimally, as it is unphysical.

- ✔ In reanalysis, physical models are used to provide the extra information, resulting in a physically consistent description.

Reanalysis Data

- ✔ Generally, the models used for reanalysis are meteorological numerical weather prediction (NWP) models. NWP employs a set of equations that describe the flow of fluids.

- ✔ They assimilate available observations and ensure that the numerical solution differs as little as possible from the observations where these are present, and offers physically consistent values for data sparse regions.

Reanalysis Datasets

- ✔ Limited range of rather widely used reanalysis datasets available.
- ✔ While most reanalyses cover the global atmosphere, there are also reanalyses for the oceans and for the land surfaces.
- ✔ Three major reanalysis projects: the European ERA project, the US NCEP/NCAR project, and the Japanese JRA project.

ERA5

- ✔ European atmospheric reanalysis.
- ✔ Produced by the European Centre for Medium-range Weather Forecasts (ECMWF).
- ✔ The data cover the Earth on a 30 km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80km.

ERA5-Land

DATA DESCRIPTION	
Data type	Gridded
Projection	Regular latitude-longitude grid
Horizontal coverage	Global
Horizontal resolution	0.1° x 0.1°; Native resolution is 9 km.
Vertical coverage	From 2 m above the surface level, to a soil depth of 289 cm.
Vertical resolution	4 levels of the ECMWF surface model: Layer 1: 0 -7cm, Layer 2: 7 -28cm, Layer 3: 28-100cm, Layer 4: 100-289cm Some parameters are defined at 2 m over the surface.
Temporal coverage	January 1950 to present
Temporal resolution	Hourly
File format	GRIB
Update frequency	Monthly with a delay of about three months relatively to actual date.

Source: https://cds.climate.copernicus.eu/

ERA5 - GEE

- ✔ Available in Google Earth Engine, called ERA5 DAILY (https://developers.google.com/earth-engine/datasets/catalog/ECMWF_ERA5_DAILY).

- ✔ ERA5 DAILY provides aggregated values for each day for seven ERA5 climate reanalysis parameters: 2m air temperature, 2m dewpoint temperature, total precipitation, mean sea level pressure, surface pressure, 10m u-component of wind and 10m v-component of wind.

ERA – Two Questions

How can we serve ERA?

How can ERA serve us?

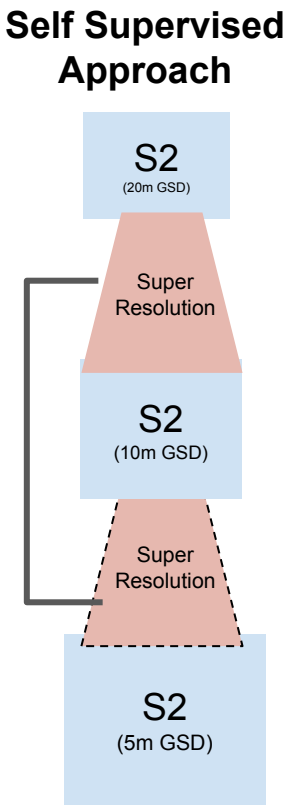
Creating High Resolution ERA5

- ✔ ERA5 resolution – hard to meet requirement of meteorological applications in complex-terrain areas due to their coarse spatial resolution and large uncertainties.

- ✔ Two steps:
  First, the ERA5 precipitation is corrected by the high-resolution simulation at the coarse spatial resolution.
  Second, the corrected data is downscaled using a convolution neural network (CNN) based model at daily scale.

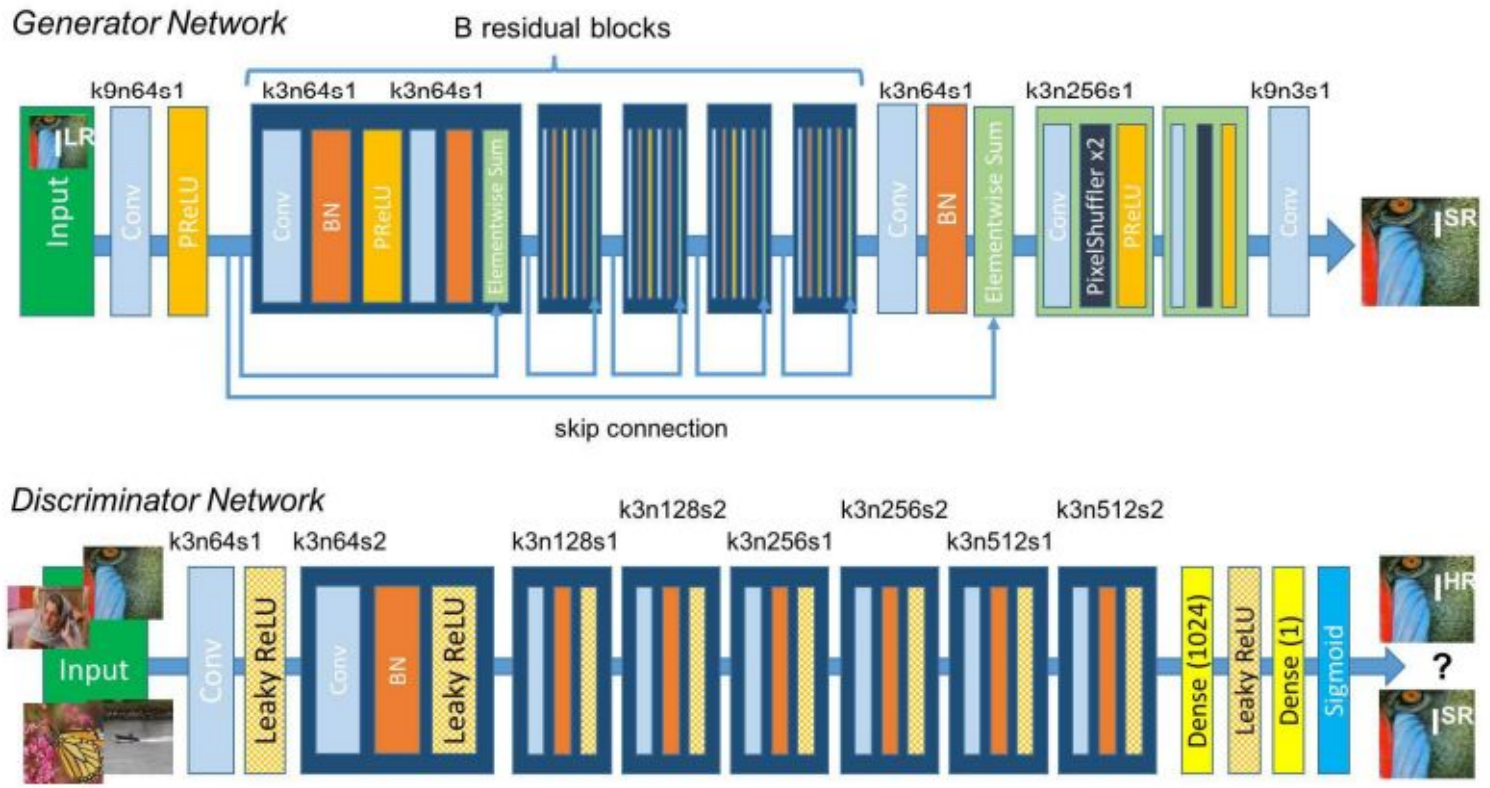
A downscaling approach for constructing high-resolution precipitation dataset over the Tibetan Plateau from ERA5 reanalysis

Superresolution (in general)



Superresolution (in general)

SRResNet further adds discriminator to the architecture.



[Ledig, Christian, et al. "Photo-realistic single image super-resolution using a generative adversarial network." Proceedings of the IEEE conference on computer vision and pattern recognition. 2017.

ERA for Better Understanding of Different Phenomena

Abstract—Heavy rainfall has been known as one of the factors inducing hydrometeorological hazards over the Megacity Jakarta. However, research on changes in rainfall extremes (REs) is somehow very limited in the region. This study will investigate annual and seasonal of REs and how it varies with different topography. We used daily rainfall record at nine observational sites (1975-2016) and reanalysis data of ERA INTERIM (1979-2016). The result shows that the severest rainfall (maximum of consecutive 5-day rainfall/RX5day and 99th percentile/R99p) has strong positive trends particularly at Kemayoran (coastal site) although the increased trends are also found at any other stations over the inland and mountainous areas. The analysis of seasonal trends demonstrates that significant increasing trends only occur in the wet (Dec-Feb) and transitional season (Mar-May, Sep-Nov) over Kemayoran (the coastal station) while a positive trend is observed in all seasons over Citeko (the mountain site). Compared to the wet season, in

Annual Changes in Rainfall Extremes over the Megacity Jakarta, 2020

A global drought monitoring system and dataset based on ERA5 reanalysis: A focus on crop-growing regions

Sergio M. Vicente-Serrano, Fernando Domínguez-Castro, Fergus Reig, Miquel Tomas-Burguera, Dhais Peña-Angulo, Borja Latorre, Santiago Beguería, Isabel Rabanaque ... See all authors

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Dataset

Dataset is available at https://global-drought-crops.csic.es/

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Abstract

Drought monitoring systems are real-time information systems focused on drought severity data. They are useful for determining the drought onset and development and defining the spatial extent of drought at any time. Effective drought monitoring requires databases with high spatial and temporal resolution and large spatial and temporal coverage. Recent reanalysis datasets meet these requirements and offer an excellent alternative to observational data. In addition, reanalysis data allow better quantification of some variables that affect drought severity and are more seldom observed. This study

ERA5 data to train ML models

ERA5 data, though not exactly historical in true sense, can serve as a starting point to train ML models.

Let's read from "Analysis of Copernicus' ERA5 Climate Reanalysis Data as a Replacement for Weather Station Temperature Measurements in Machine Learning Models for Olive Phenology Phase Prediction":

"The timing of phenological stages and phases is known to be highly correlated with temperature which is therefore an essential component for building phenological models. Satellite data and, particularly, Copernicus' ERA5 climate reanalysis data are easily available. Weather stations, on the other hand, provide scattered temperature data, with fragmentary spatial coverage and accessibility, as such being scarcely efficacious as unique source of information for the implementation of predictive models. **However, as ERA5 reanalysis data are not real temperature measurements but reanalysis products, it is necessary to verify whether these data can be used as a replacement for weather station temperature measurements. The aims of this study were: (i) to assess the validity of ERA5 data as a substitute for weather station temperature measurements**,"