Climate Change

C3S Energy Webinar
GLOBAL CLIMATE INDICATORS

23rd April 2024

Tools for climate data processing: temporal downscaling, exclusion layers and spatial aggregation

Stefano Campostrini
Inside Climate Service

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

ICS Inside Climate Service

Climate Change

Tools for climate data processing

Tool	Purpose
Temporal interpolation	To **interpolate** datasets from 3h to 1h temporal resolution.
Exclusion area composition	To **mask** all the areas that the user may want to exclude from their data processing pipelines.
Spatial aggregation	To compute the **mean value of gridded data over specific regions** defined in shapefiles.

Climate Change

Temporal Interpolation

Temporal Interpolation

TEMPERATURE

WIND SPEED

Interpolation with **spline**

- 3 days of data
- **Spline interpolation**
- Keeping only the day in the middle of the time-window
- Iterating over days

GLOBAL HORIZONTAL IRRADIANCE

Interpolation using **diurnal cycle information***

- Interpolation of the **"clearness index"**
- Re-conversion to irradiance keeping daily profile

***developed by **ARMINES** (Association pour la Recherche et le Développement des Méthodes et Processus Industriels)

PROGRAMME OF THE EUROPEAN UNION

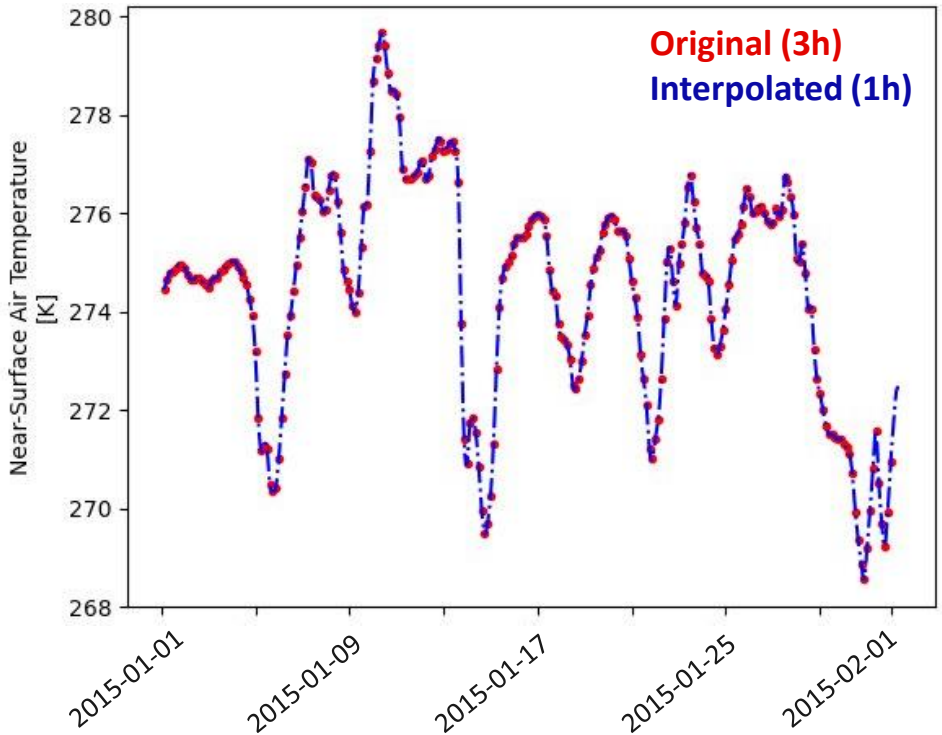
opernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Climate Change

Temporal Interpolation

Example of Air Temperature temporal interpolation for a selected grid point



Interpolation with **spline**

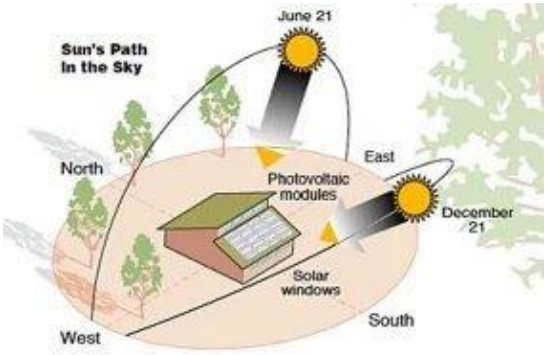
Downscaling of solar irradiance

Linear interpolation is not effective due to strong **daily cycle***

Instead, what is linearly interpolated is the **"clearness index"**,
a detrended indicator linked to atmosphere transmissivity

Then, the interpolated index is reconverted to irradiance, keeping the proper daily profile

Limitation: assumes stable weather inside each of the original timesteps

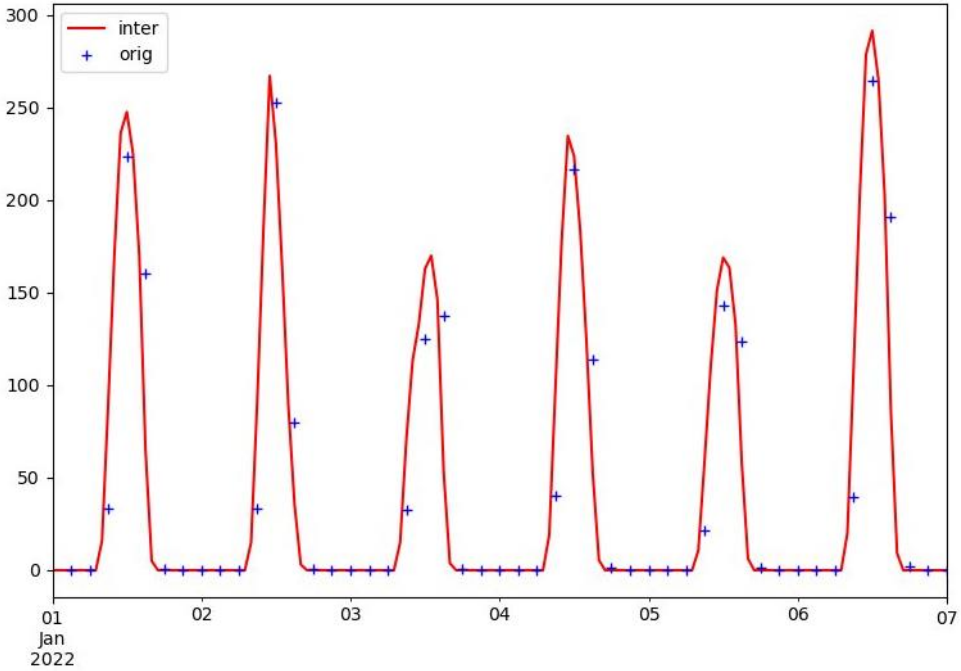


*Downscaled profile should be slightly shifted to the left

Climate Change

Temporal Interpolation

Example of temporal interpolation for Global Horizontal Irradiance



Interpolation using **diurnal cycle information**

Temporal Interpolation

Climate Change

```
>>> import c3s_utilities as c3su
>>> import xarray as xr
>>> ds = xr.open_dataset('example.nc')
>>> ds_interpolated = c3su.interpolate_ghi(ds, target_tres='1H')
```

PROGRAMME OF THE EUROPEAN UNION
opernicus Europe's eyes on Earth
IMPLEMENTED BY ECMWF

Climate Change

Exclusion Areas

Exclusion Areas: areas in which it's not possible to build wind/solar/hydro power plants

1. Protected Areas
2. Polar Areas
3. Urban areas
4. Water and continent areas
5. High slope areas
6. High elevation areas
   (elevation greater than 2000 m above sea level)
7. Distance to shore areas
8. Combination of restricted areas:
   - For wind generation modelling
   - For PV generation modelling

Examples of exclusion areas

PROGRAMME OF THE EUROPEAN UNION

opernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Combination of Exclusion Areas

Each grid point has a value:

1 → exclusion
0 → inclusion

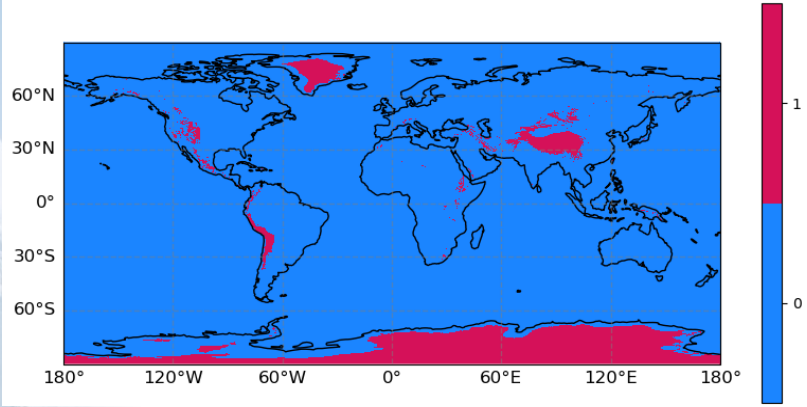
Combination with “or”

The final mask is the **union** of all the combined exclusion areas

Exclusion area A	V	Exclusion area B	=	Combined mask
1	or	1	=	1
0	or	1	=	1
1	or	0	=	1
0	or	0	=	0

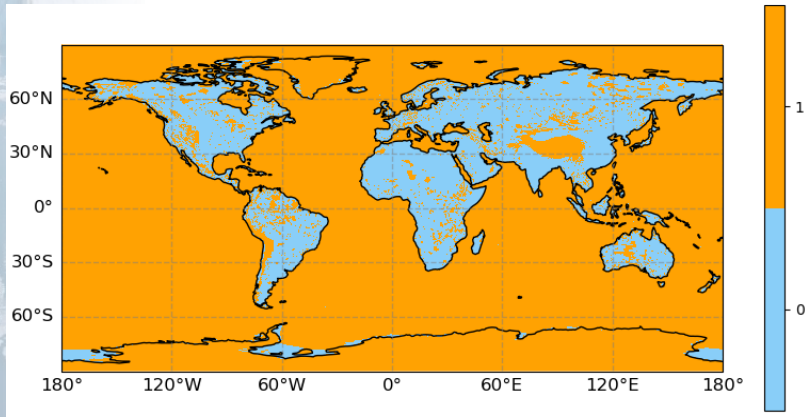
Climate Change

Exclusion Areas



Examples of masks for exclusion areas

High elevation areas (> 2000 m)



Combined exclusion areas for PV generation modelling

PROGRAMME OF THE EUROPEAN UNION

opernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

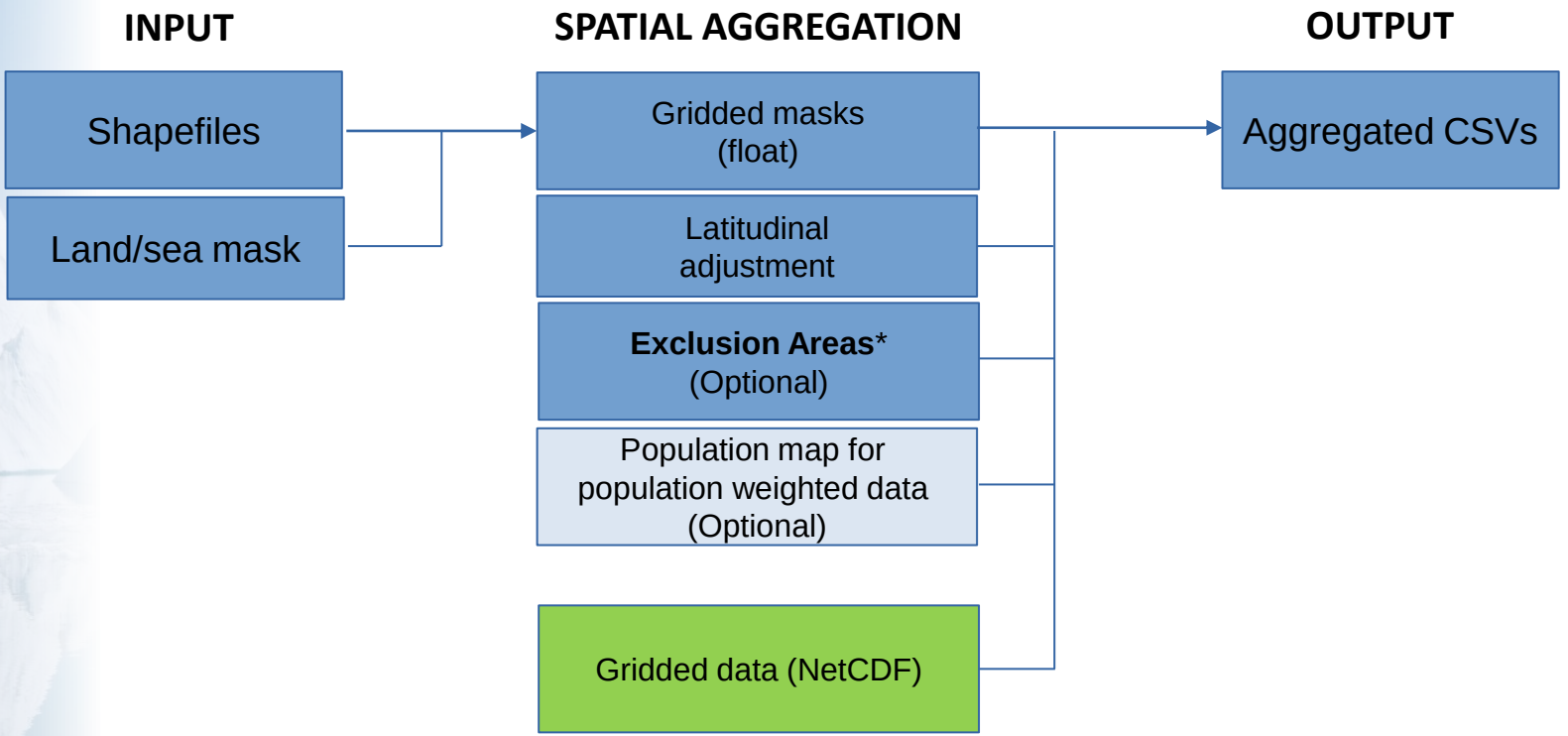
Exclusion Areas

Climate Change

```
>>> import c3s_utilities as c3su
>>> exca_ds = c3su.exclusion_areas_composition(['protected_areas', 'urban_areas'])
```

Climate Change

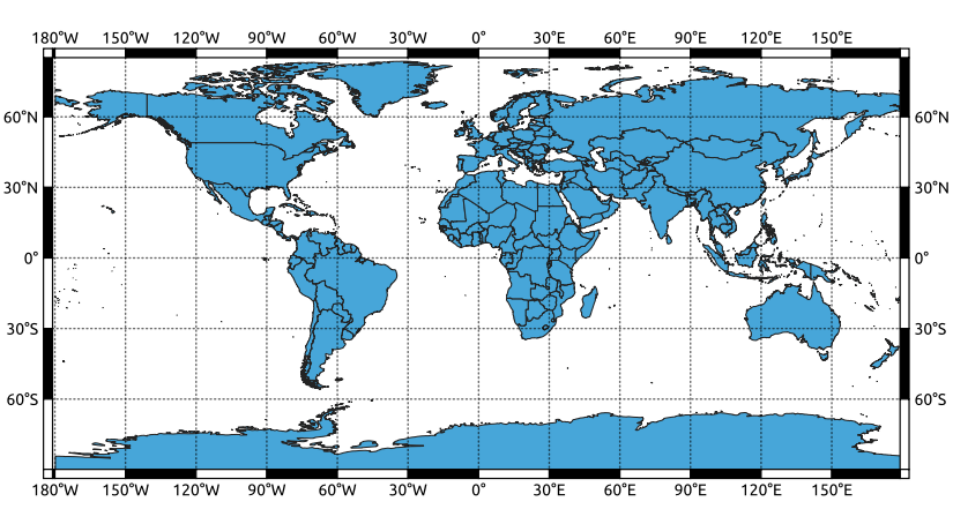
Spatial Aggregation



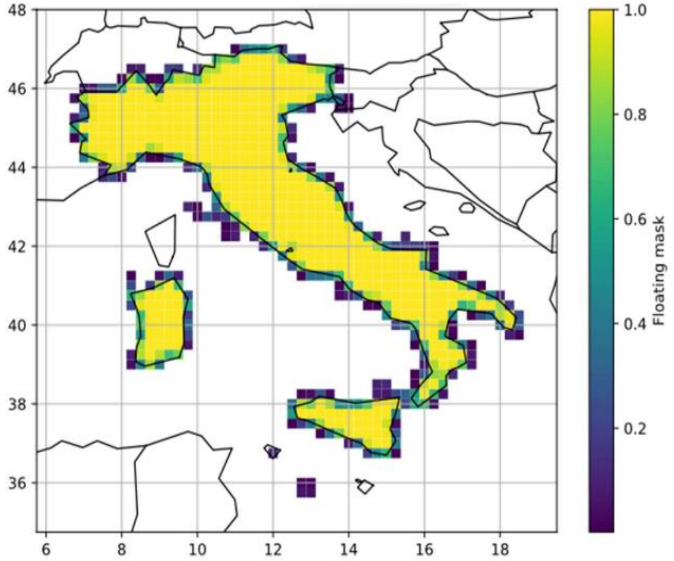
Climate Change

Spatial Aggregation

ADMIN 0 level global shape file



Floating point mask for the Italian ADMIN 0 administrative region



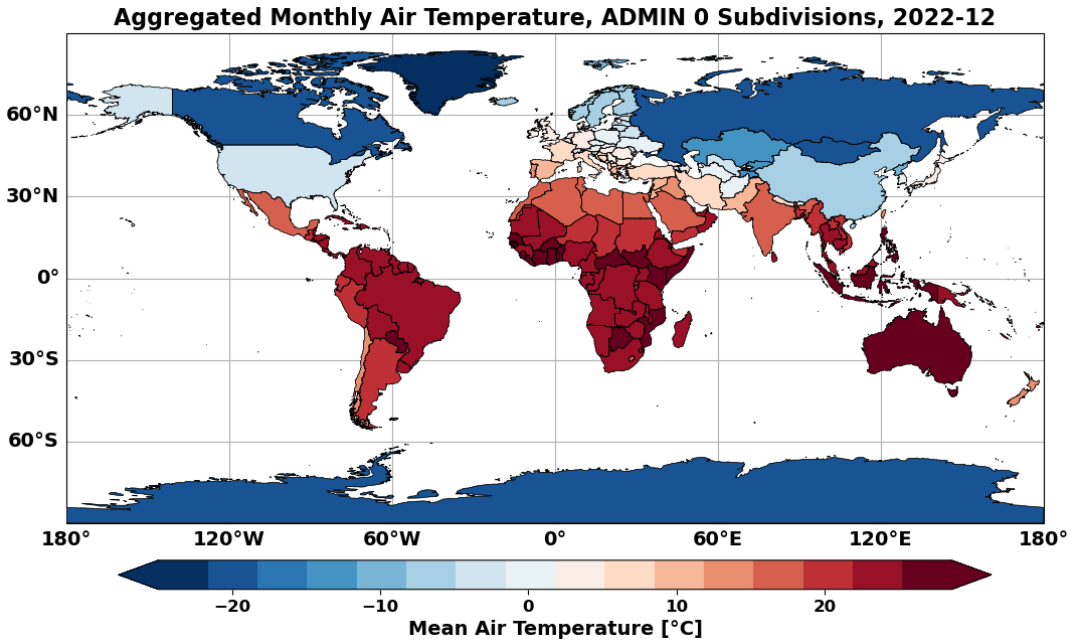
PROGRAMME OF THE EUROPEAN UNION

opernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Spatial Aggregation

Example of aggregated Air Temperature at monthly resolution over **ADMIN 0 regions** (= country level)



CSV with monthly values of ADMIN 0 Air Temperature [K]

```
53  Date,AD,AE,AF,AG,AI,AL,AM,AO,AQ,AR,AS,AT,AU,AW,AX,AZ,
54  2022-12-01,274.2640397616129,295.11365941935486,274.3
```

Spatial Aggregation

Climate Change

```
>>> import c3s_utilities as c3su
>>> import geopandas as gpd
>>> import xarray as xr
>>> data_ds = xr.open_dataset('example_data.nc')
>>> regions_df = gpd.read_file('example_regions.shp')
>>> exclusion_areas_ds = xr.open_dataset('example_exclusion_areas.nc')
>>> land_sea_mask_ds = xr.open_dataset('example_land_sea_mask.nc')
>>> aggregated_df = c3su.spatial_aggregation(data_ds, regions_df, exclusion_areas=exclusion_areas_ds,
land_sea_mask=land_sea_mask_ds, latitude_weights='auto')
```

PROGRAMME OF THE EUROPEAN UNION
opernicus Europe's eyes on Earth
IMPLEMENTED BY ECMWF