Expanding GeoCAT's Climatology Resources to Support the Transition from NCL to Python

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Vermont State University, NSF NCAR
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NCL to Python

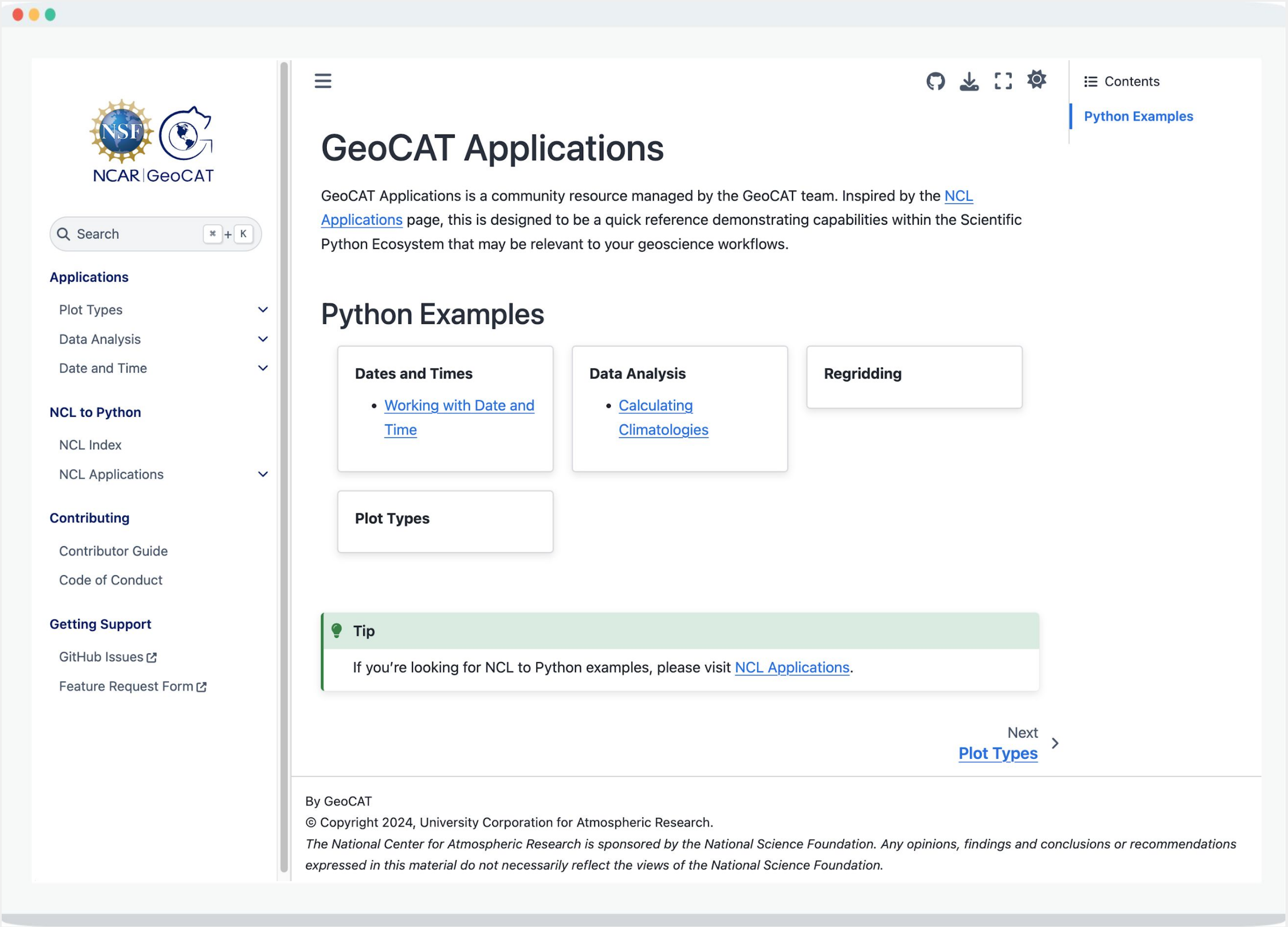
NCL
NCAR Command Language

GeoCAT

- COMP
- EXAMPLES
- VIZ
- DATAFILES
- WRF-PYTHON
- APPLICATIONS

GeoCAT Applications

- Inspired by the NCL applications page
- Designed to be a quick reference demonstrating capabilities within the scientific Python ecosystem
- Comprised of two main sections



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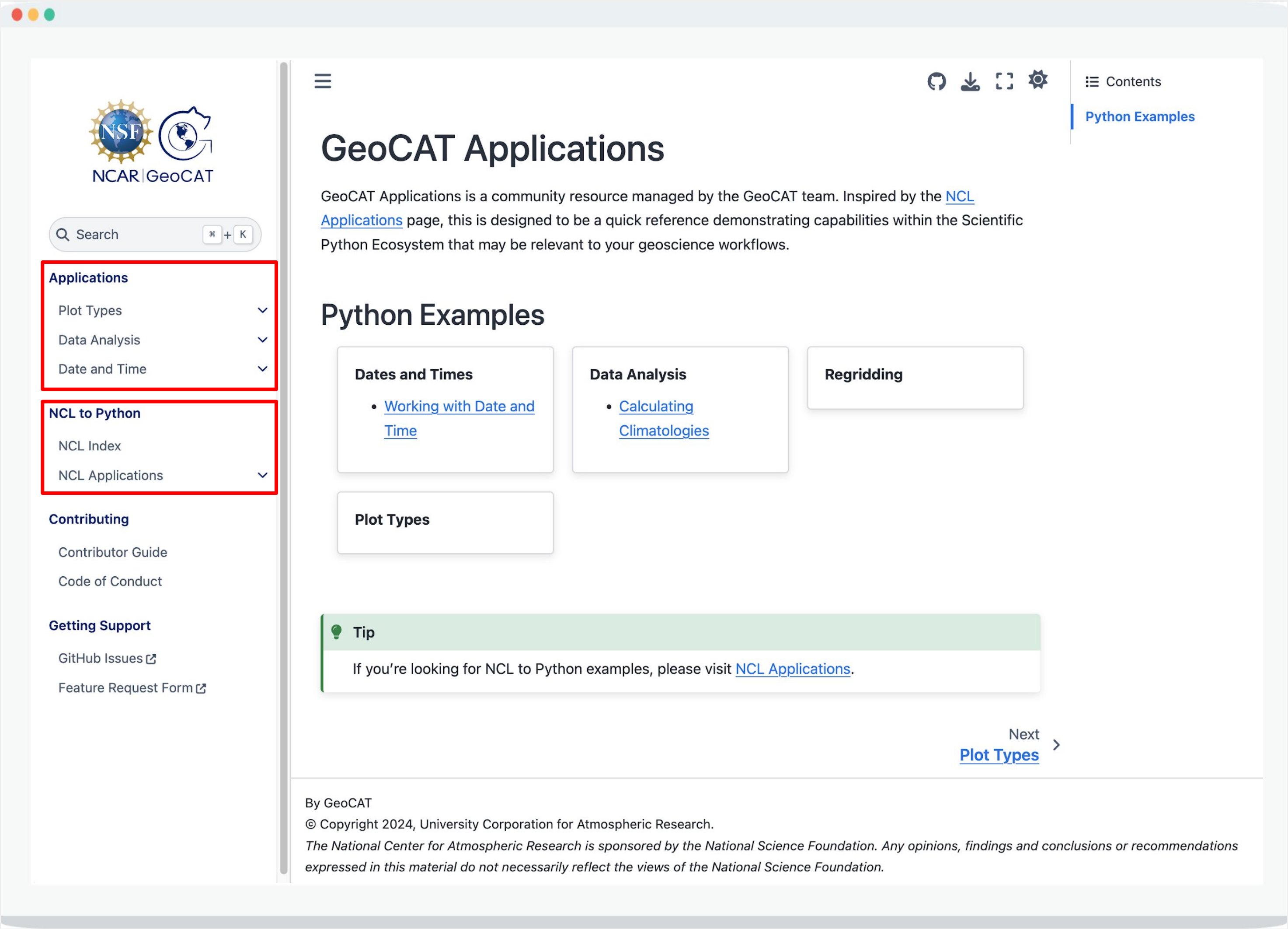

Calculating the day of the week

July						
Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Calculating the day of the week

Grab and Go

```python
import cftime

day = 4
month = 6
year = 2024

dow = cftime.datetime(
    year, month, day, calendar='proleptic_gregorian', has_year_zero=True
).strftime("%w")
print(dow)
```

```
2
```

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```
2
```

Year 0

Python

January						
Su	Mo	Tu	We	Th	Fr	Sa
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February						
Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29				

NCL

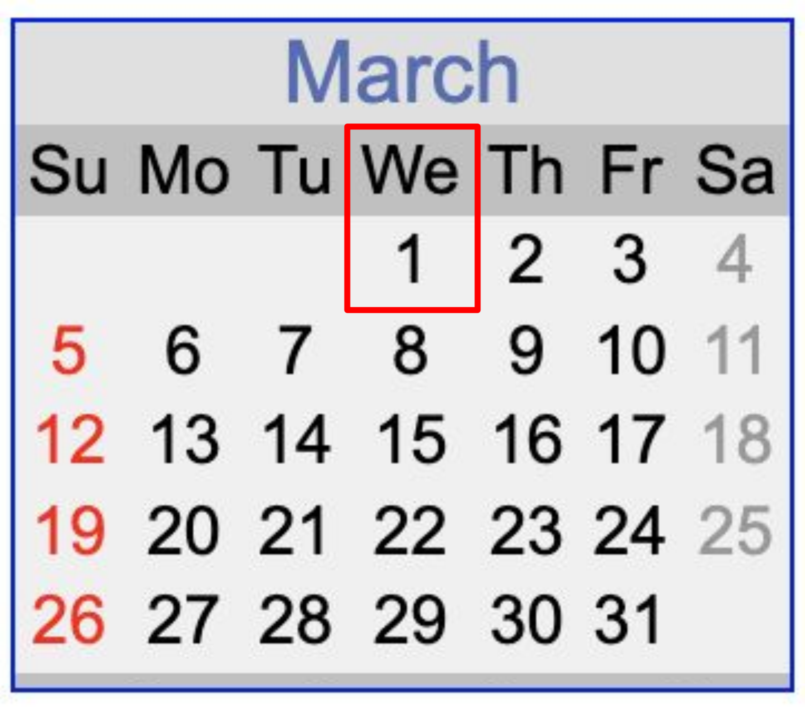
January						
Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February						
Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29			

Day of the Week

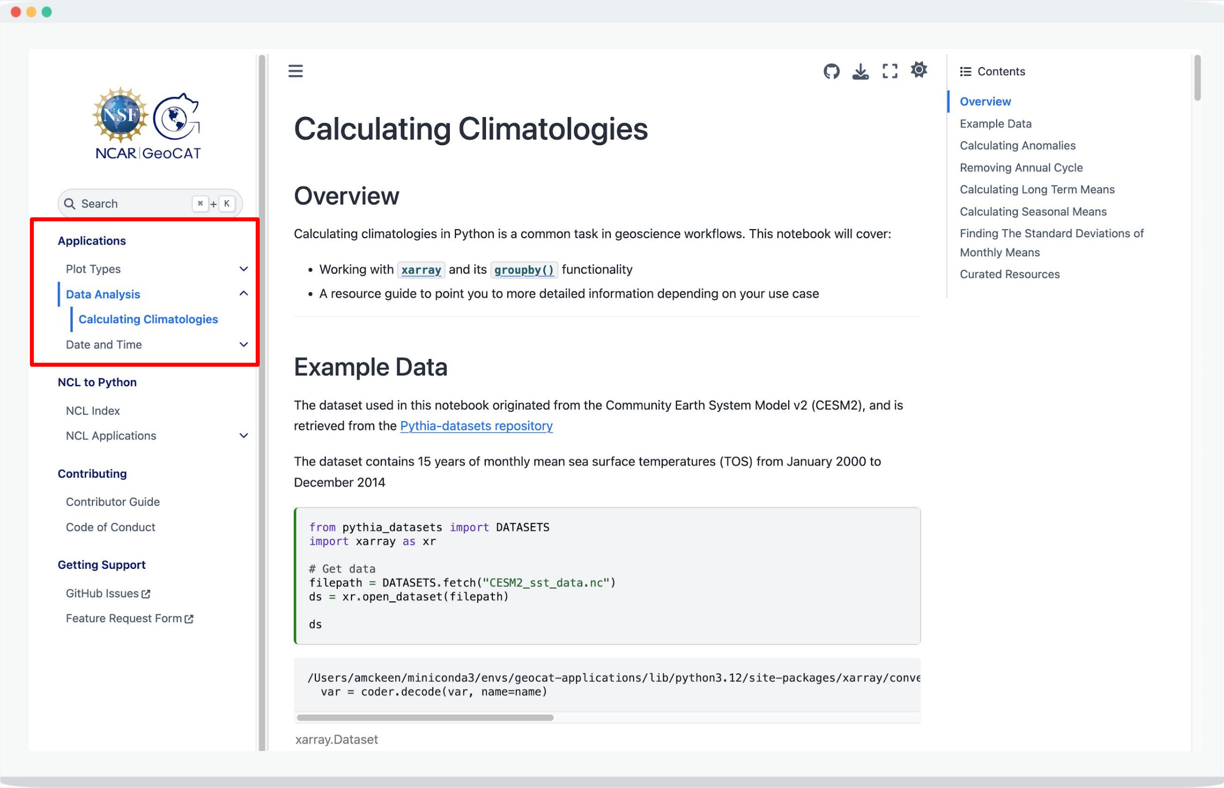
Year 0

Python & NCL

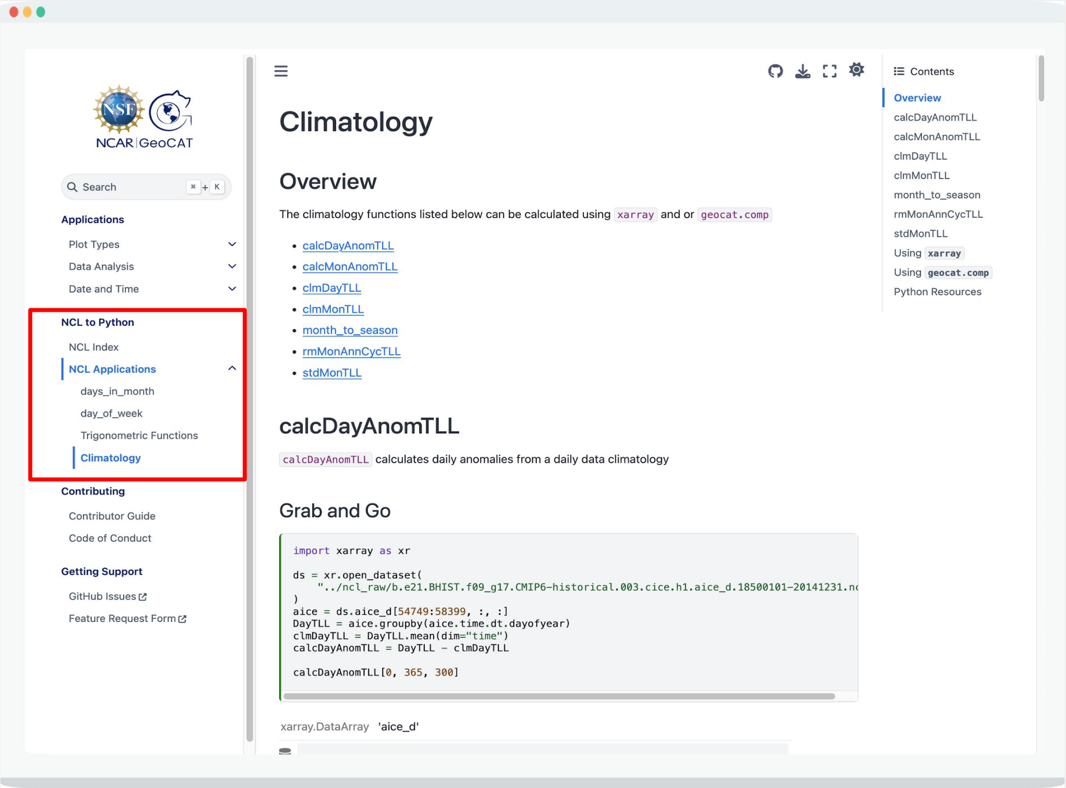


GeoCAT Applications

Applications



NCL to Python



GeoCAT Applications

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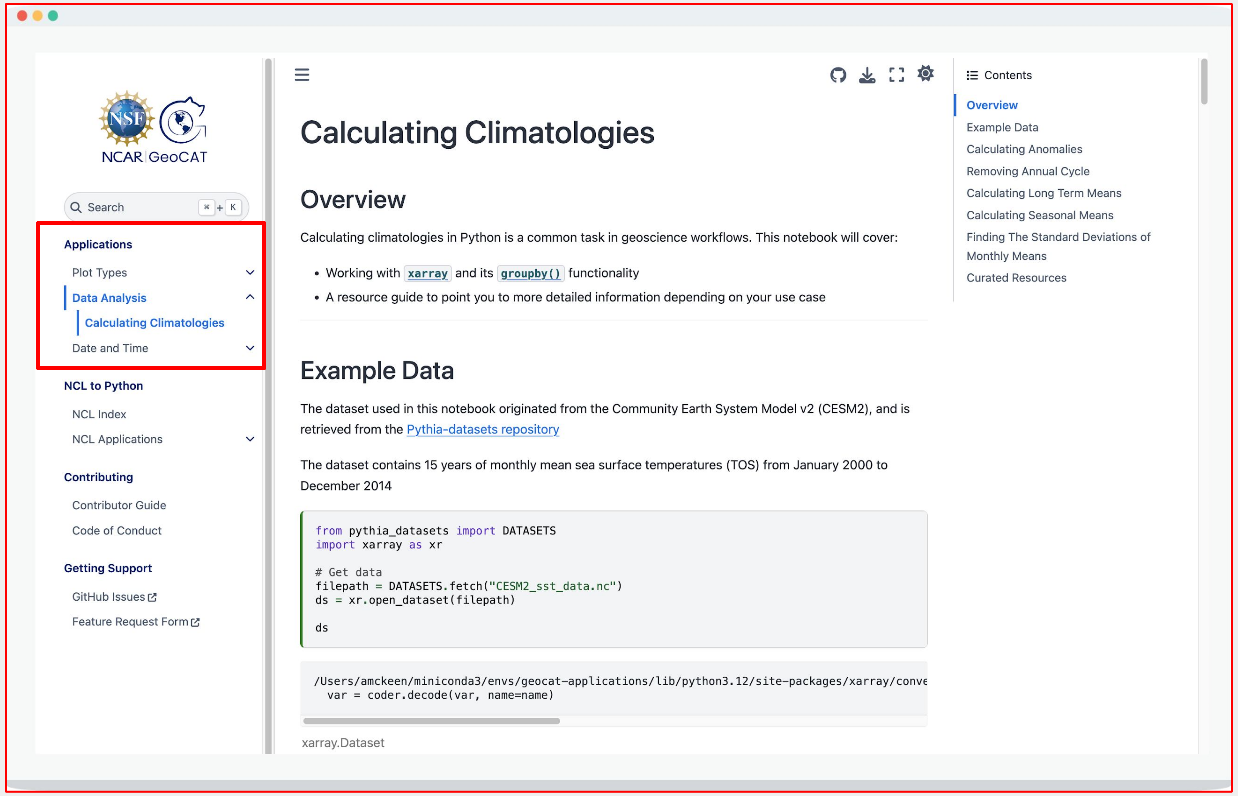

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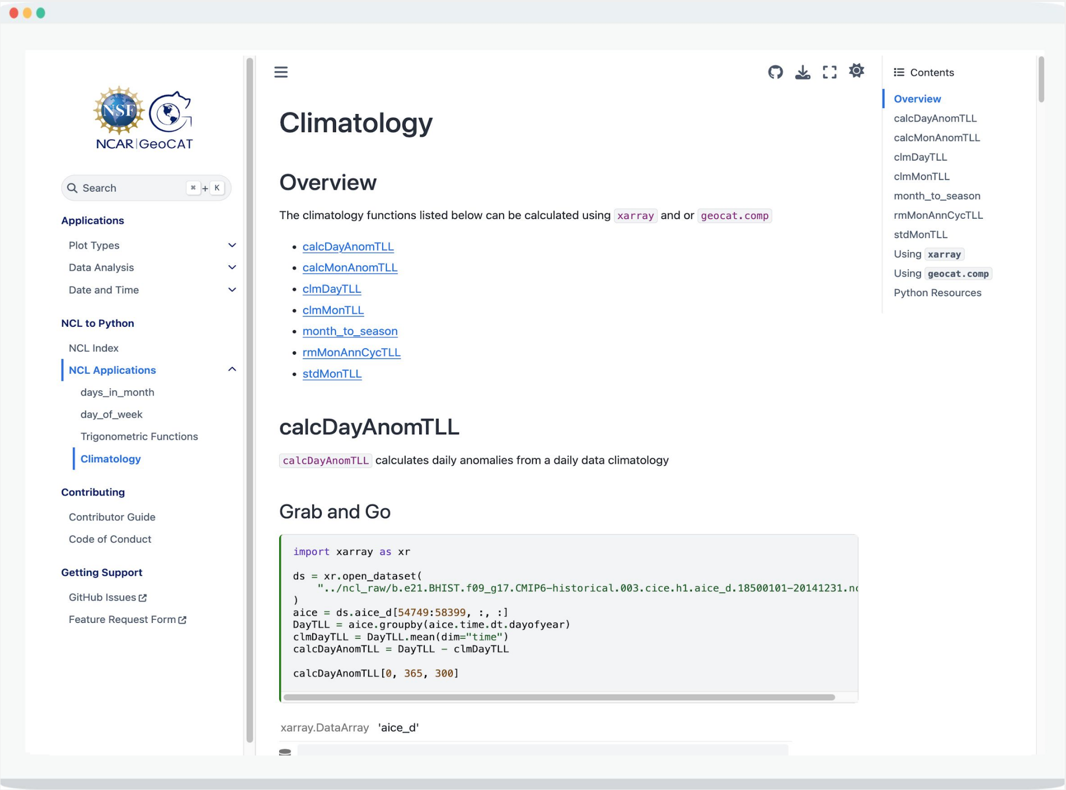

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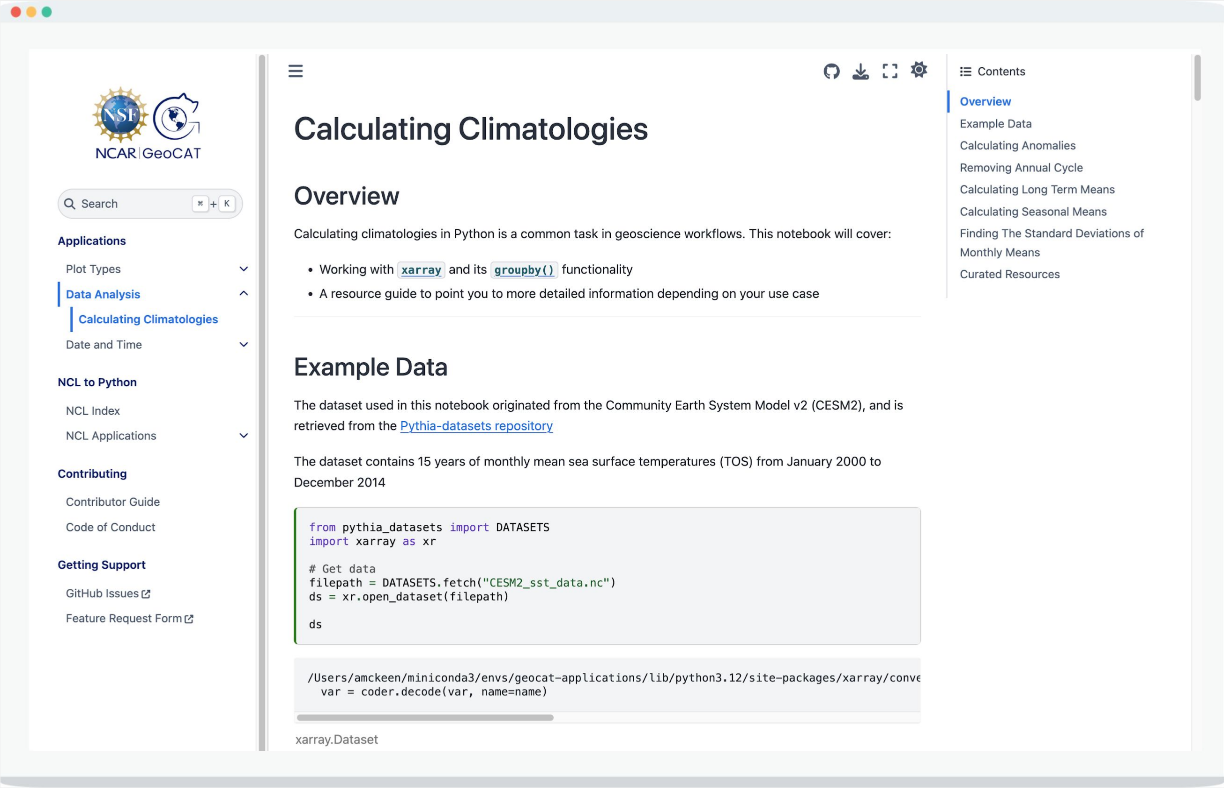

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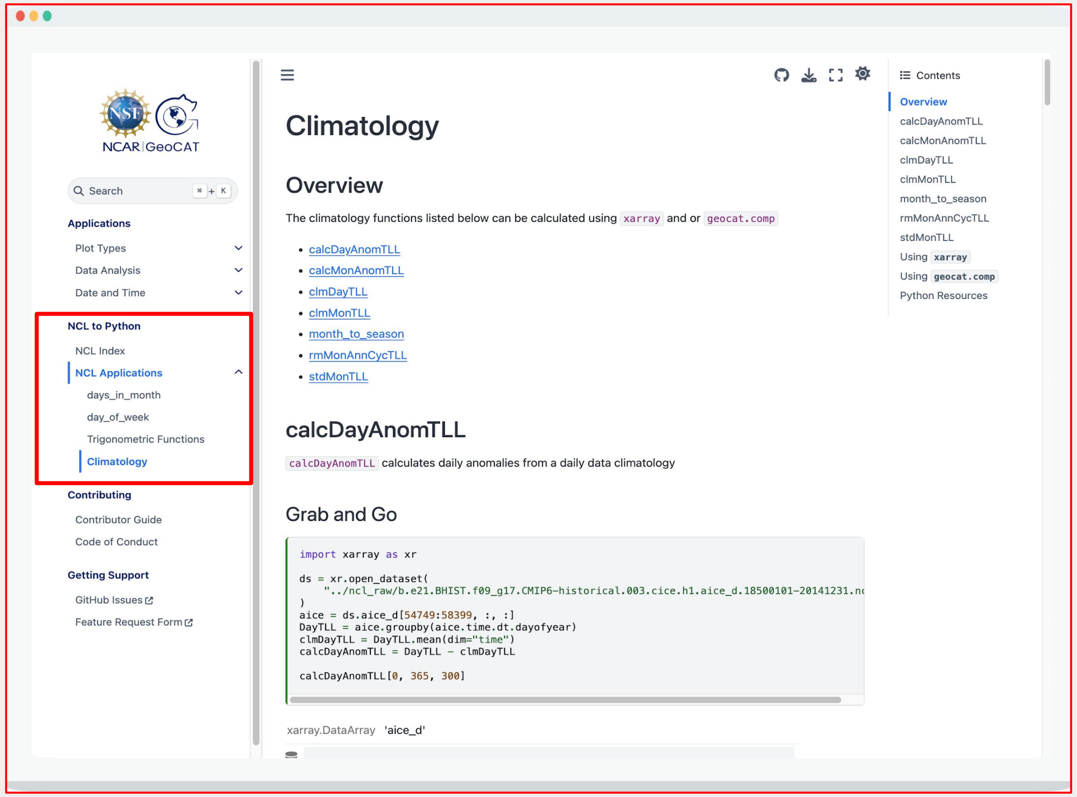
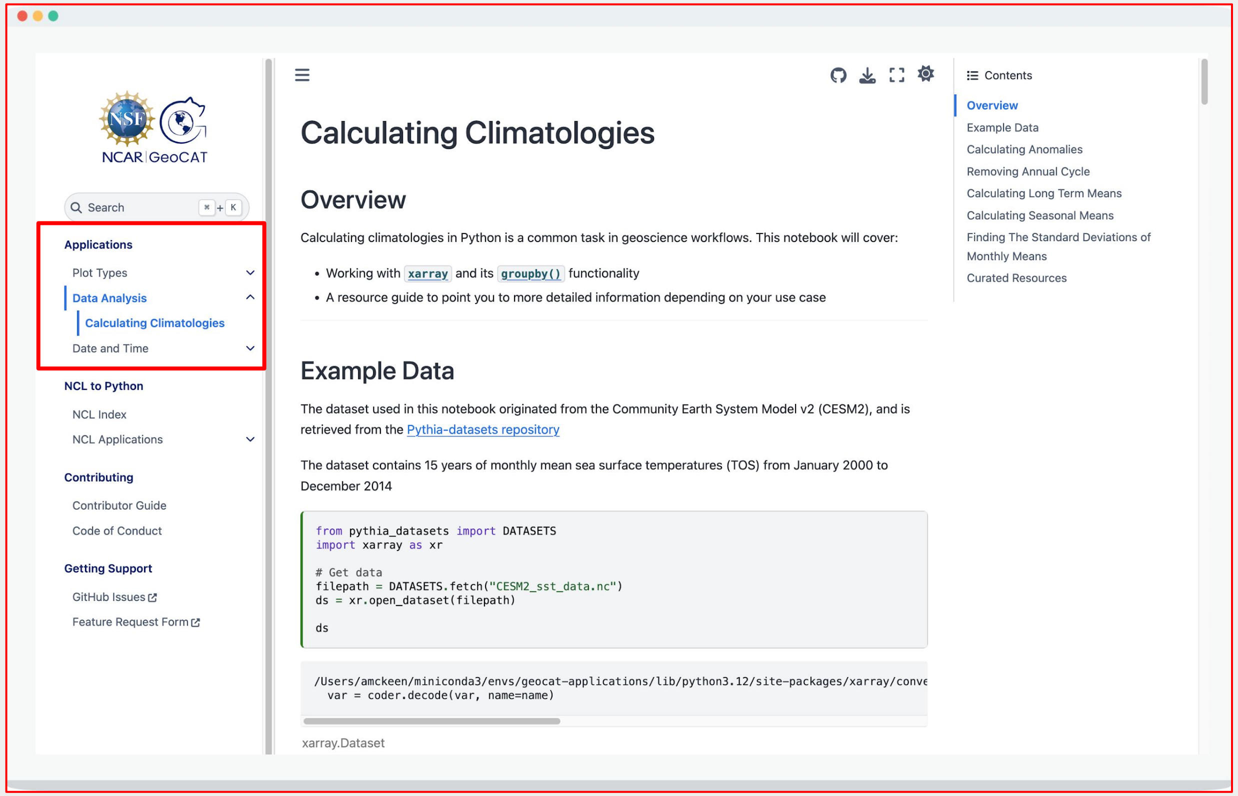


Calculating Climatologies

Applications



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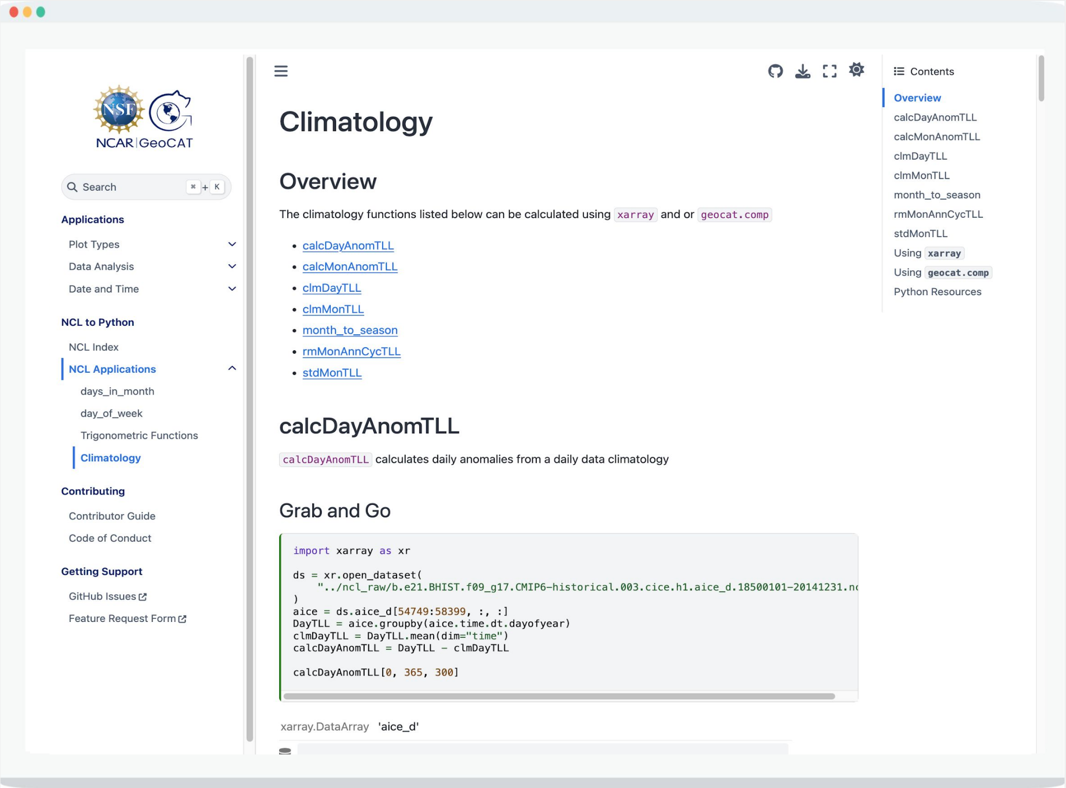
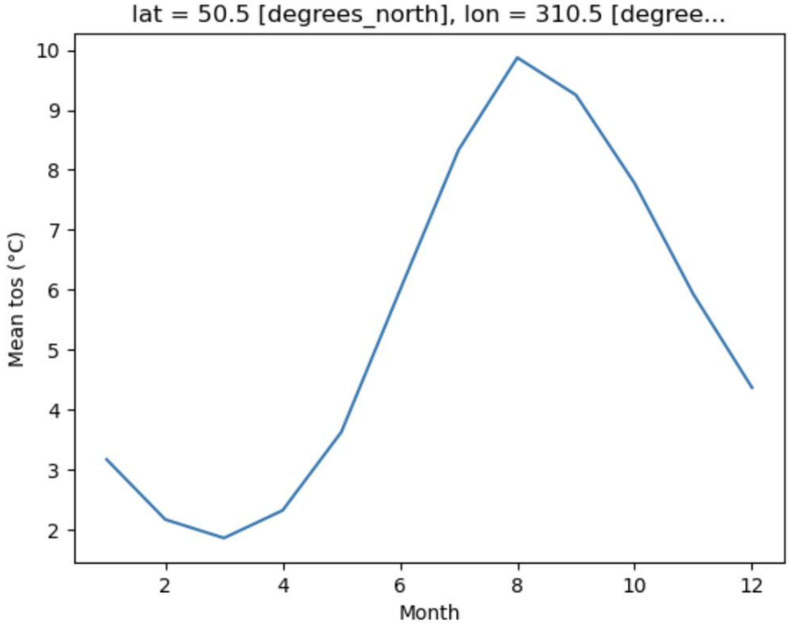


Calculating Long Term Means

```
from pythia_datasets import DATASETS
import xarray as xr
import matplotlib.pyplot as plt

# Get data
filepath = DATASETS.fetch("CESM2_sst_data.nc")
ds = xr.open_dataset(filepath)

# Calculate long term mean
tos_monthly = ds.tos.groupby(ds.time.dt.month)
tos_clim = tos_monthly.mean(dim="time")

tos_clim
```

Visualization

```
# Plot an example location of the calculated long term means
tos_clim.sel(lon=310, lat=50, method="nearest").plot()
plt.ylabel("Mean tos (°C)")
plt.xlabel("Month")
```



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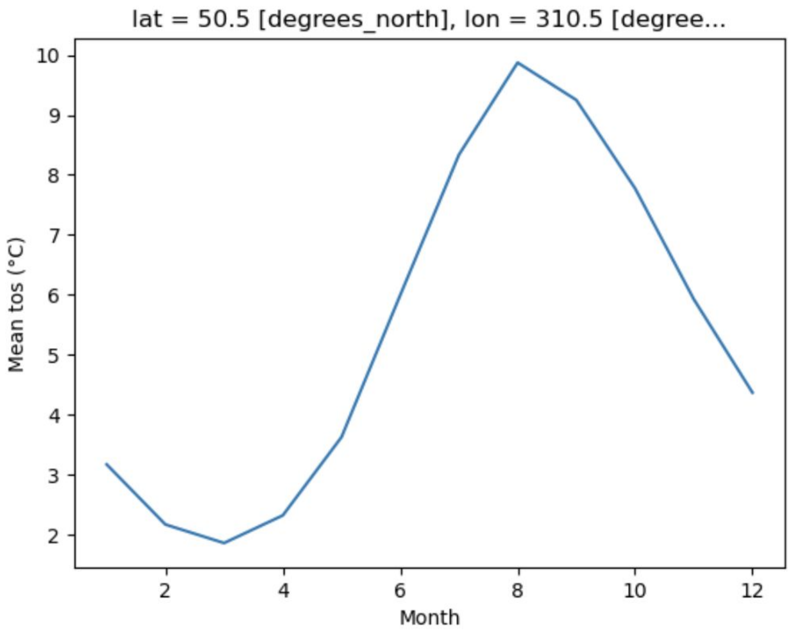

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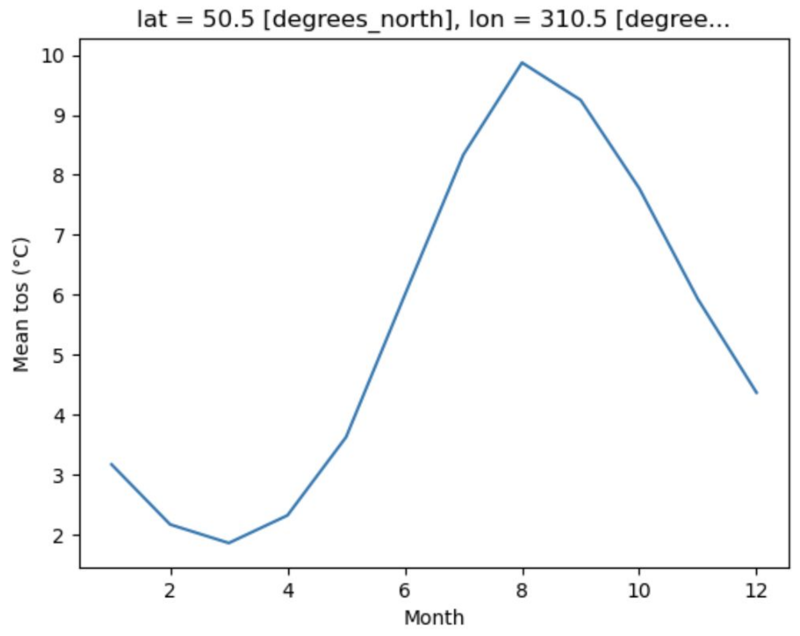

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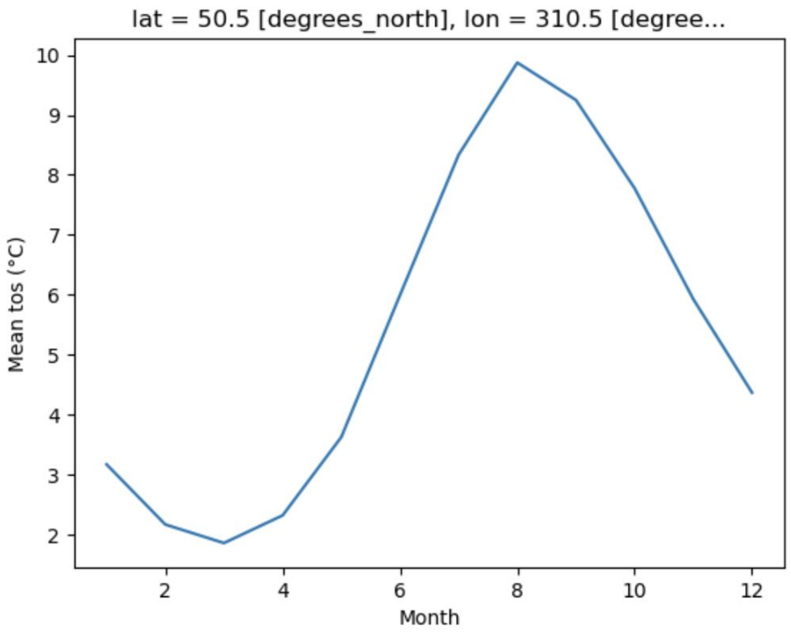

Quick Reference Materials

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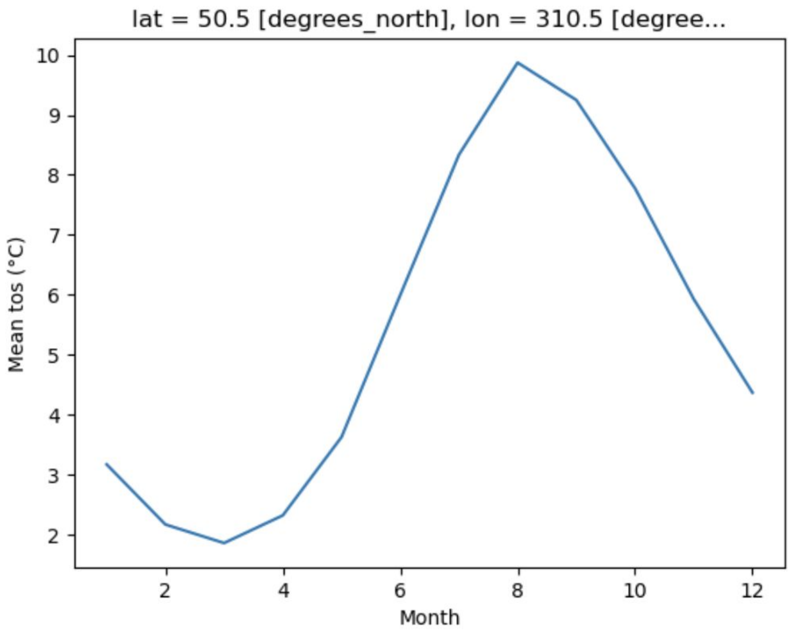


Curated Resources

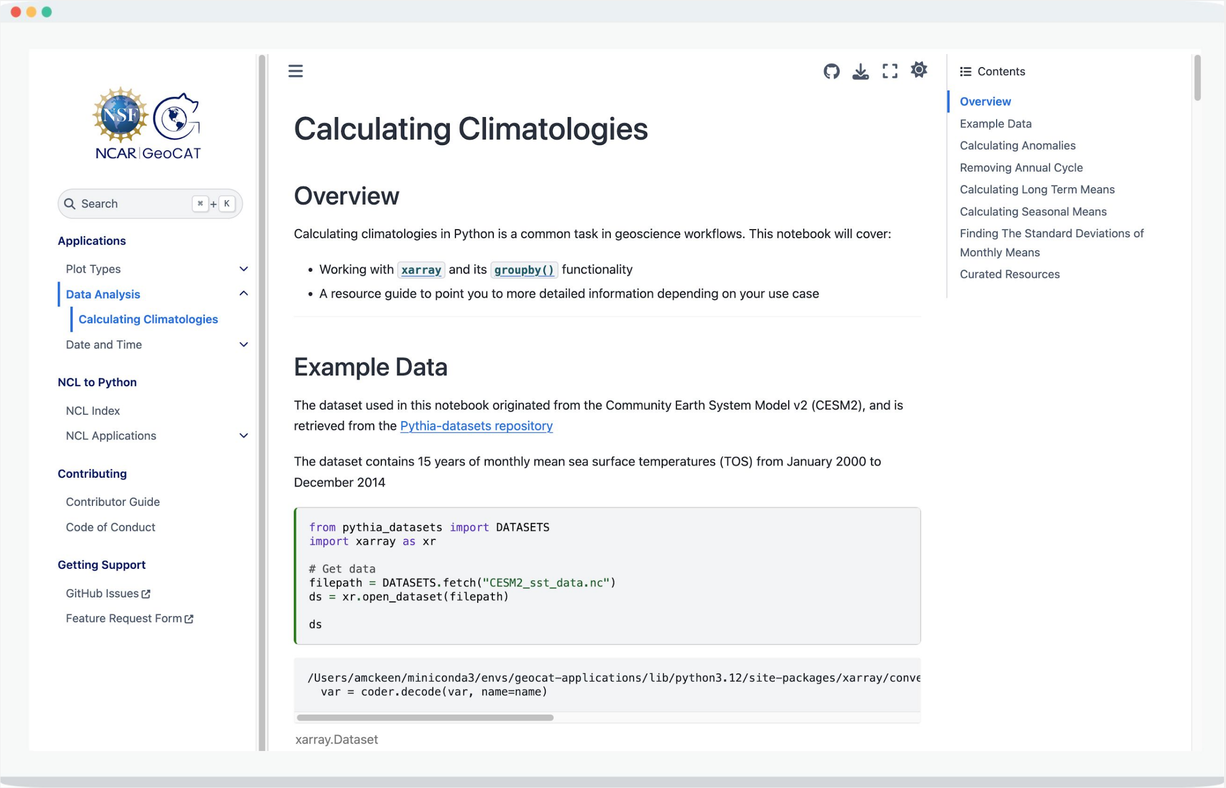
To learn more about calculating climatologies in Python, we suggest:

- This Climatematch Academy notebook on xarray Data Analysis and Climatology
- This Project Pythia Foundations tutorial on Computations and Masks with xarray
- The xarray user guide on working with time series data

Previous
Data Analysis

Next
Dates and Times

Applications



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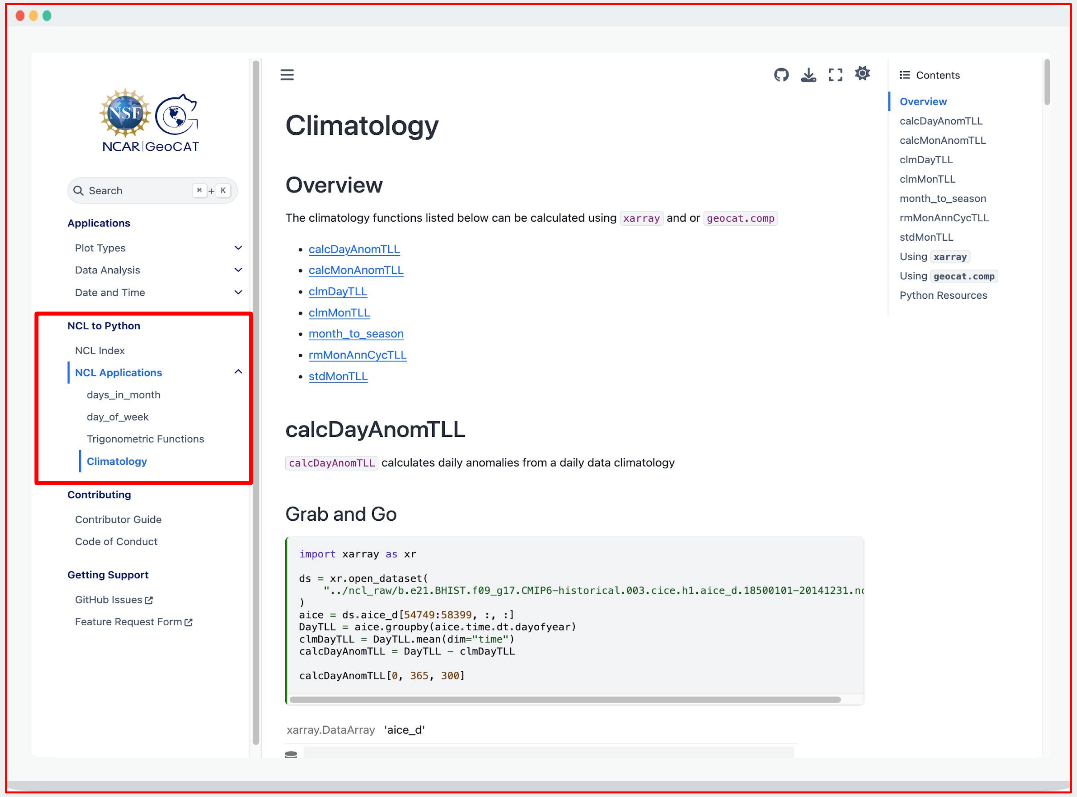

Climatology

calcDayAnomTLL	Calculates daily anomalies from a daily data climatology.
calcMonAnomTLL	Calculates monthly anomalies by subtracting the long term mean from each point (time,lat,lon version)
clmDayTLL	Calculates long term daily means (daily climatology) from daily data.
clmMonTLL	Calculates long term monthly means (monthly climatology) from monthly data: (time,lat,lon) version
month_to_season	Computes a user-specified three-month seasonal mean (DJF, JFM, FMA, MAM, AMJ, MJJ, JJA, JAS, ASO, SON, OND, NDJ).
rmMonAnnCycTLL	Removes the annual cycle from "monthly" data.
stdMonTLL	Calculates standard deviations of monthly means.

NCL Index

NCL Function	Description
calcDayAnomTLL	Calculates daily anomalies from a daily data climatology
calcMonAnomTLL	Calculates monthly anomalies by subtracting the long term mean from each point
clmDayTLL	Calculates long term daily means (daily climatology) from daily data
clmMonTLL	Calculates long term monthly means (monthly climatology) from monthly data
month_to_season	Computes a user-specified three-month seasonal mean
rmMonAnnCycTLL	Removes the annual cycle from monthly data
stdMonTLL	Calculates standard deviations of monthly means

clmDayTLL

`clmDayTLL` calculates long term daily means (daily climatology) from daily data

Grab and Go

```
import xarray as xr

ds = xr.open_dataset(
    "../ncl_raw/b.e21.BHIST.f09_g17.CMIP6-historical.003.cice.h1.aice_d.18500101-20141231.nc"
)
aice = ds.aice_d[54749:58399, :, :]
DayTLL = aice.groupby(aice.time.dt.dayofyear)
clmDayTLL = DayTLL.mean(dim="time")

clmDayTLL[0, 365, 300]
```

xarray.DataArray 'aice_d'

```
array(0.40314254, dtype=float32)
```

```
; clmDayTLL
; Adapted from https://www.ncl.ucar.edu/Document/Functions/Contributed/clmDayTLL.shtml
f = addfile("b.e21.BHIST.f09_g17.CMIP6-historical.003.cice.h1.aice_d.18500101-20141231.nc", "r")
time = f->time(54749:58398)
TIME = cd_calendar(time,0)
year = toint(TIME(:,0))
month = toint(TIME(:,1))
day = toint(TIME(:,2))
ddd = day_of_year(year, month, day)
yyyyddd = year*1000+ddd
aice = f->aice_d(54749:58398,:,:)
aiceClmDay = clmDayTLL(aice, yyyyddd) ; aiceClmDay = 0.4031426
print(aiceClmDay(0,365,300))
```

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print(aiceClmDay(0,365,300))
```

month_to_season

`month_to_season` computes a user-specified three-month seasonal mean (DJF, JFM, FMA, MAM, AMJ, MJJ, JJA, JAS, ASO, SON, OND, NDJ)

`xarray` may not be sufficient to calculate custom seasonal means. If you need to work with custom seasons, we suggest using `geocat.comp.climatologies.month_to_season`

Grab and Go

```
import xarray as xr
import geocat.comp as gc

ds = xr.open_dataset(
    "../ncl_raw/b.e21.BHIST.f09_g17.CMIP6-historical.003.cice.h.aice.185001-201412.nc"
)
aice = ds.aice[1799:1919, :, :]
mon_to_season = gc.climatologies.month_to_season(aice, "ASO")

mon_to_season[0, 365, 300]
```

xarray.DataArray 'aice'

```
array(4.9227783e-06, dtype=float32)
```

```
; month_to_season
; Adapted from https://www.ncl.ucar.edu/Document/Functions/Contributed/calcDayAnomTLL.shtml
f = addfile("b.e21.BHIST.f09_g17.CMIP6-historical.003.cice.h.aice.185001-201412.nc", "r")
aice = f->aice(1799:1918,:,:)
aiceSeason = month_to_season(aice, "ASO") ; aiceSeason = 4.922778e-06
print(aiceSeason(0,365,300))
```

Comparison

```
rmMonAnnCycTLL:
        python:         0.09780758619308472
        ncl:            0.09780759

calcMonAnomTLL:
        python:         0.09780758619308472
        ncl:            0.09780759

clmDayTLL:
        python:         0.4031425416469574
        ncl:            0.4031426

clmMonTLL:
        python:         0.126130610704422
        ncl:            0.1261306

stdMonTLL:
        python:         0.10731684416532516
        ncl:            0.1073168

month_to_season:
        python:         4.9227783165406436e-06
        ncl:            4.922778e-06

calcDayAnomTLL:
        python:         0.21562078595161438
        ncl:            0.2156208
```

Differences

```
for c in ncl_results.keys() & results.keys():
    print(f"{c}:")
    print(f"\t{results[c] - ncl_results[c]}")
```

```
rmMonAnnCycTLL:
        -3.806915283011136e-09
calcMonAnomTLL:
        -3.806915283011136e-09
clmDayTLL:
        -5.835304262014063e-08
clmMonTLL:
        1.0704421987695056e-08
stdMonTLL:
        4.416532516093863e-08
month_to_season:
        3.165406432182791e-13
calcDayAnomTLL:
        -1.404838562146793e-08
```

Climatology Receipt

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        3.165406432182791e-13
calcDayAnomTLL:
        -1.404838562146793e-08
```

Conclusion

Thank you to my mentors:
Anissa Zacharias & Katelyn FitzGerald

Thank you the GeoCAT team & the SIParCS program!

Questions?

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GeoCAT
Applications

Expanding GeoCAT's Climatology Resources to Support the Transition from NCL to Python

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