HW3

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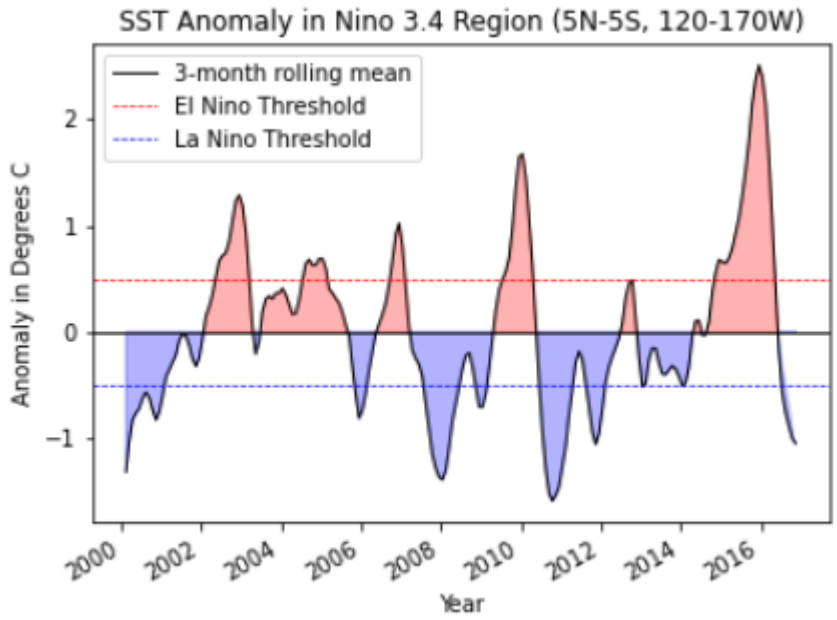
1 Niño 3.4 index

1.1 [5 points] Compute monthly climatology for SST from Niño 3.4 region, and subtract climatology from SST time series to obtain anomalies.

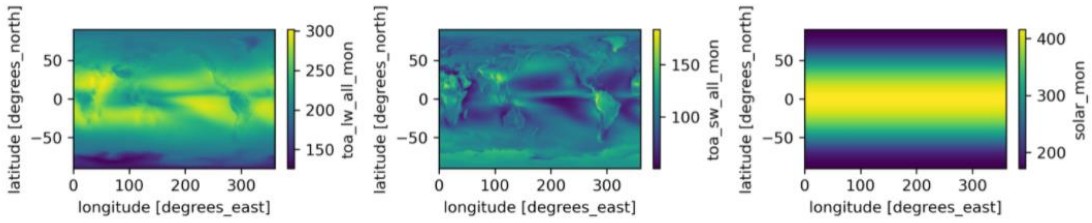
```
# Group data by month
group_data = ds.sst.sel(time=slice('2000','2020'),lat=slice(-5, 5), lon=slice(-170, -120)).groupby('time.month')#每个月group
group_data

# Apply mean to grouped data, and then compute the anomaly
sst_anom = group_data - group_data.mean(dim='time')#减去平均值得到每个月的异常值
sst_anom
```

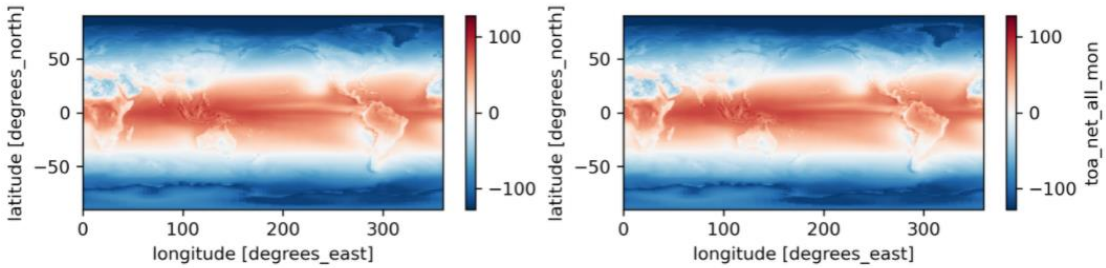
1.2 [5 points] Visualize the computed Niño 3.4.



2 Earth's energy budget

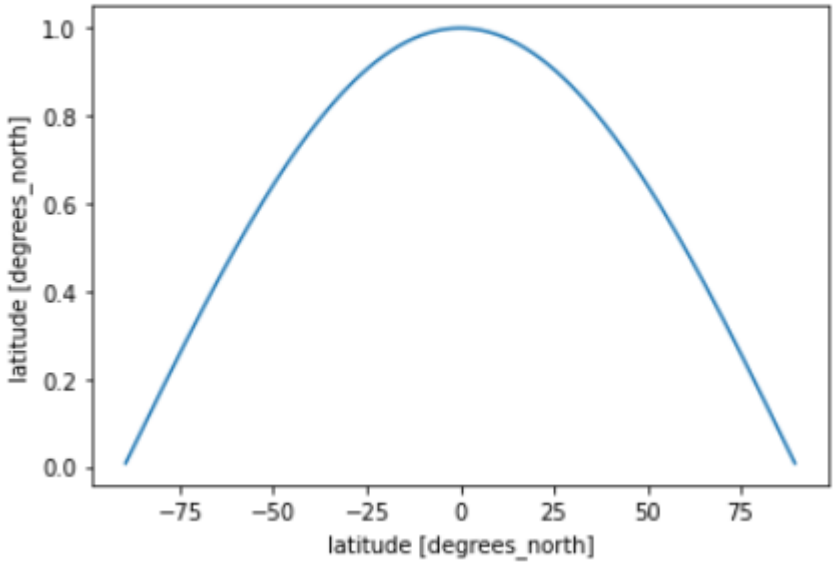
2.1 [5 points] Make a 2D plot of the time-mean TOA longwave, shortwave, and solar radiation for all-sky conditions. Add up the three variables above and verify (visually) that they are equivalent to the TOA net flux.





2.2 [10 points] Calculate and verify that the TOA incoming solar, outgoing longwave, and outgoing shortwave approximately match up with the cartoon above.
[Hint: Consider calculating the area of each grid]

```
[<matplotlib.lines.Line2D at 0x20d971a3280>]
```



```
print('TOA incoming solar:')
ds.solar_mon.weighted(weights).mean()
```

```
TOA incoming solar:
xarray.DataArray 'solar_mon'
array(340.28326598)
► Coordinates: (0)
► Attributes: (0)
```

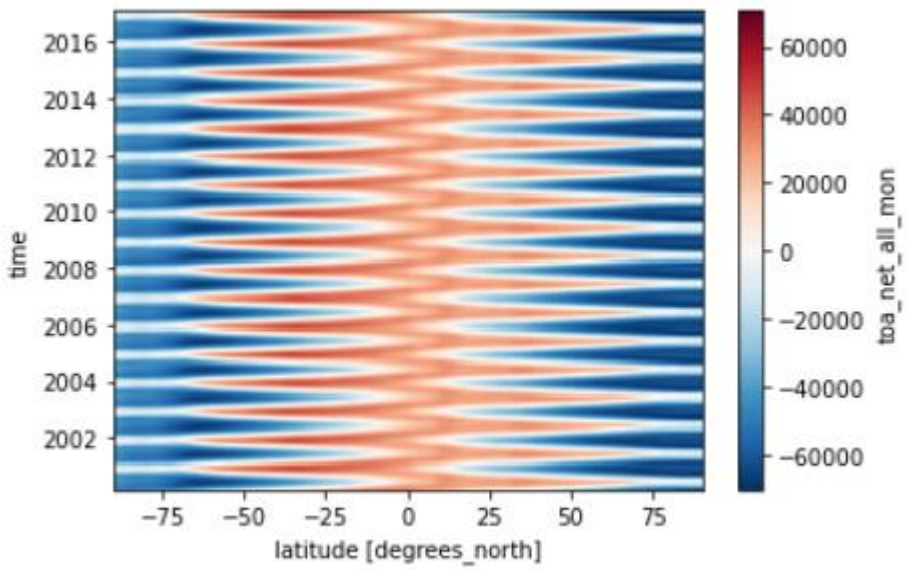
```
print('outgoing longwave:')
ds.toa_lw_all_mon.weighted(weights).mean()
```

```
outgoing longwave:
xarray.DataArray 'toa_lw_all_mon'
array(240.26693375)
► Coordinates: (0)
► Attributes: (0)
```

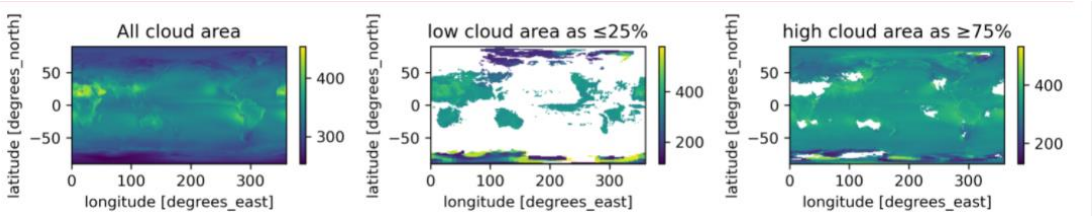
```
print('outgoing shortwave:')
ds.toa_sw_all_mon.weighted(weights).mean()
```

```
outgoing shortwave:
xarray.DataArray 'toa_sw_all_mon'
array(99.13805277)
► Coordinates: (0)
► Attributes: (0)
```

2.3 [5 points] Calculate and plot the total amount of net radiation in each 1-degree latitude band. Label with correct units.



2.4 [5 points] Calculate and plot composites of time-mean outgoing shortwave and longwave radiation for low and high cloud area regions. Here we define low cloud area as ≤25% and high cloud area as ≥75%. Your results should be 2D maps.



2.5 [5 points] Calculate the global mean values of shortwave and longwave radiation, composited in high and low cloud regions. What is the overall effect of clouds on shortwave and longwave radiation

```
toa_lw_all_mon_lt25=ds.where(ds.cldarea_total_daynight_mon<25).toa_lw_all_mon.mean()
print(toa_lw_all_mon_lt25)
toa_sw_all_mon_lt25=ds.where(ds.cldarea_total_daynight_mon<25).toa_sw_all_mon.mean()
print(toa_sw_all_mon_lt25)

toa_lw_all_mon_gt75=ds.where(ds.cldarea_total_daynight_mon>75).toa_lw_all_mon.mean()
print(toa_lw_all_mon_gt75)
toa_sw_all_mon_gt75=ds.where(ds.cldarea_total_daynight_mon>75).toa_sw_all_mon.mean()
print(toa_sw_all_mon_gt75)
```

```
<xarray.DataArray 'toa_lw_all_mon' ()>
array(247.33109, dtype=float32)
<xarray.DataArray 'toa_sw_all_mon' ()>
array(97.11116, dtype=float32)
<xarray.DataArray 'toa_lw_all_mon' ()>
array(215.39049, dtype=float32)
<xarray.DataArray 'toa_sw_all_mon' ()>
array(111.765945, dtype=float32)
```

3 Explore a netCDF dataset

- **Data from:**

The second Modern-Era Retrospective analysis for Research and Applications

MERRA-2 tavgU_2d_glc_Nx: 2d,diurnal,Time-Averaged,Single-Level,Assimilation,Land Ice Surface Diagnostics V5.12.4 (M2TUNXGLC)

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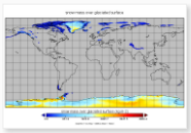

View Full-size Image

M2TUNXGLC (or tavgU_2d_glc_Nx) is a 2-dimensional monthly diurnal means data collection in Modern-Era Retrospective analysis for Research and Applications version 2 (MERRA-2). This collection consists of assimilated land ice surface diagnostics at the single levels, such as fractional area of glaciated surface snow cover, snow mass over glaciated surface, snow depth over glaciated surface, and total snow mass residual due to densification. This data collection is the monthly mean of data fields for each 3-hour and time-stamped at the central time starting from 01:30 UTC, e.g.: 01:30, 04:30, ... , 22:30 UTC.

MERRA-2 is the latest version of global atmospheric reanalysis for the satellite era produced by NASA Global Modeling and Assimilation Office (GMAO) using the Goddard Earth Observing System Model (GEOS) version 5.12.4. The dataset c ...more

Data Access

Online Archive

Earthdata Search

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Product Summary | Data Citation | Documentation | References

Shortname:	M2TUNXGLC
Longname:	MERRA-2 tavgU_2d_glc_Nx: 2d,diurnal,Time-Averaged,Single-Level,Assimilation,Land Ice Surface Diagnostics V5.12.4
DOI:	10.5067/7VUPQC736SWX
Version:	5.12.4
Format:	netCDF
Spatial Coverage:	-180.0,-90.0,180.0,90.0
Temporal Coverage:	1980-01-01 to 2021-10-01
File Size:	3.9 MB per file
Data Resolution	
Spatial:	0.5 ° x 0.625 °
Temporal:	1 month

- **Data processing**

```
ds = xr.open_mfdataset('data/MERRA2*.nc4',combine = 'by_coords', concat_dim="time")#https://
ds.to_netcdf('MERRA2_combined.nc')
```

```
ds
```

xarray.Dataset

► Dimensions: (**time**: 864, **lat**: 361, **lon**: 576)

▼ Coordinates:

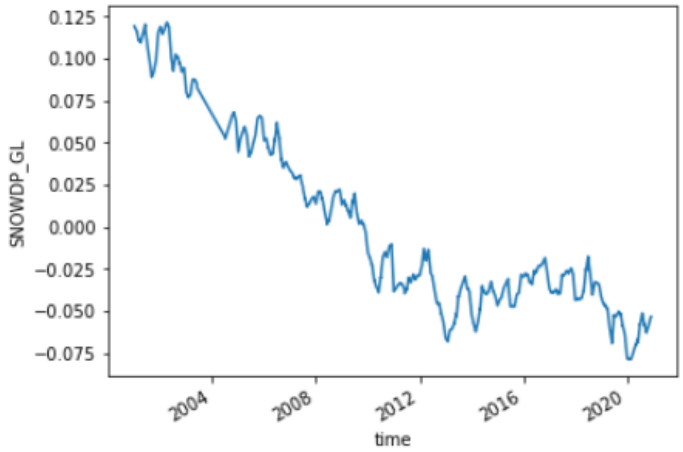
lat	(lat)	float64	-90.0 -89.5 -89.0 ... 89.5 90.0
lon	(lon)	float64	-180.0 -179.4 ... 178.8 179.4
time	(time)	datetime64[ns]	2001-01-01T01:30:00 ... 2010-12-...

▼ Data variables:

WESNSC	(time, lat, lon)	float32	dask.array<chunksize=(8, 361, 576), meta=np.n...
RUNOFF	(time, lat, lon)	float32	dask.array<chunksize=(8, 361, 576), meta=np.n...
SNOMAS_GL	(time, lat, lon)	float32	dask.array<chunksize=(8, 361, 576), meta=np.n...
WESNEXT	(time, lat, lon)	float32	dask.array<chunksize=(8, 361, 576), meta=np.n...
SNOWDP_GL	(time, lat, lon)	float32	dask.array<chunksize=(8, 361, 576), meta=np.n...
ASNOW_GL	(time, lat, lon)	float32	dask.array<chunksize=(8, 361, 576), meta=np.n...
SNICEALB	(time, lat, lon)	float32	dask.array<chunksize=(8, 361, 576), meta=np.n...

► Attributes: (32)

3.1 [5 points] Plot a time series of a certain variable with monthly seasonal cycle removed.



3.2 [5 points] Make at least 5 different plots using the dataset.