R Code – NASA Space Apps Challenge Hackathon Oct 2025

> library(ncdf4)

> test\_file <- "/Users/gaellemuller-greven/Downloads/GLDAS\_CLSM10\_3H.A20150101.2100.021.nc4"

> test\_nc <- nc\_open(test\_file)

> print(test\_nc)

File /Users/gaellemuller-greven/Downloads/GLDAS\_CLSM10\_3H.A20150101.2100.021.nc4 (NC\_FORMAT\_NETCDF4):

39 variables (excluding dimension variables):

double time\_bnds[bnds,time] (Chunking: [2,1])

float Swnet\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_net\_downward\_shortwave\_flux

long\_name: Net short wave radiation flux

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 758.048889160156

float Lwnet\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_net\_downward\_longwave\_flux

long\_name: Net long-wave radiation flux

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -294.523773193359

vmax: 33.784008026123

float Qle\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_upward\_latent\_heat\_flux

long\_name: Latent heat net flux

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -37.7972221374512

vmax: 728.135070800781

float Qh\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_upward\_sensible\_heat\_flux

long\_name: Sensible heat net flux

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -349.447418212891

vmax: 478.533813476562

float Qg\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: downward\_heat\_flux\_in\_soil

long\_name: Heat flux

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -115.819801330566

vmax: 139.293380737305

float Snowf\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: snowfall\_flux

long\_name: Snow precipitation rate

units: kg m-2 s-1

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 0.00107227999251336

float Rainf\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: rainfall\_flux

long\_name: Rain precipitation rate

units: kg m-2 s-1

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 0.00239599961787462

float Evap\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: water\_evaporation\_flux

long\_name: Evapotranspiration

units: kg m-2 s-1

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -4.73383879580069e-05

vmax: 0.000295209843898192

float Qs\_acc[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_runoff\_amount

long\_name: Storm surface runoff

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 21.8256092071533

float Qsb\_acc[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: subsurface\_runoff\_amount

long\_name: Baseflow-groundwater runoff

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 0.325224697589874

float Qsm\_acc[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_snow\_melt\_amount

long\_name: Snow melt

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 9.26264190673828

float SnowT\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: temperature\_in\_surface\_snow

long\_name: Snow Surface temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 212.862289428711

vmax: 317.568603515625

float AvgSurfT\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_temperature

long\_name: Average Surface Skin temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 212.905319213867

vmax: 310.550415039062

float Albedo\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_albedo

long\_name: Albedo

units: %

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 6.87705278396606

vmax: 58.413990020752

float SWE\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_snow\_amount

long\_name: Snow depth water equivalent

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 538.419616699219

float SnowDepth\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_snow\_thickness

long\_name: Snow depth

units: m

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 2.02367758750916

float SoilMoist\_S\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_moisture\_content

long\_name: Surface Soil moisture

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0.00961640011519194

vmax: 9

float SoilMoist\_RZ\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_moisture\_content

long\_name: Root Zone Soil moisture

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 32.689395904541

vmax: 464.431182861328

float SoilMoist\_P\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_moisture\_content

long\_name: Profile Soil moisture

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 111.558280944824

vmax: 3653.5048828125

float SoilTMP0\_10cm\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_temperature

long\_name: Soil temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 236.249481201172

vmax: 310.162200927734

float SoilTMP10\_29cm\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_temperature

long\_name: Soil temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 236.691146850586

vmax: 313.601379394531

float SoilTMP29\_68cm\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_temperature

long\_name: Soil temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 237.727432250977

vmax: 311.388122558594

float SoilTMP68\_144cm\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_temperature

long\_name: Soil temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 239.776504516602

vmax: 309.4404296875

float SoilTMP144\_295cm\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_temperature

long\_name: Soil temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 242.946395874023

vmax: 311.311614990234

float SoilTMP295\_1295cm\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: soil\_temperature

long\_name: Soil temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 248.193237304688

vmax: 311.063171386719

float ECanop\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: evaporation\_flux\_from\_canopy

long\_name: Canopy water evaporation

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -37.7972221374512

vmax: 148.142776489258

float TVeg\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: transpiration\_flux\_from\_veg

long\_name: Transpiration

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -0.0143461041152477

vmax: 572.920349121094

float ESoil\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: evaporation\_flux\_from\_soil

long\_name: Direct Evaporation from Bare Soil

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: -0.0135433161631227

vmax: 332.572967529297

float CanopInt\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: canopy\_water\_amount

long\_name: Plant canopy surface water

units: kg m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 0.919391870498657

float ACond\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: aerodynamic\_conductance

long\_name: Aerodynamic conductance

units: m s-1

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0.000391673675039783

vmax: 1.0559948682785

float TWS\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: terrestrial\_water\_storage

long\_name: Terrestrial water storage

units: mm

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 111.558288574219

vmax: 3653.50512695312

float Wind\_f\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: wind\_speed

long\_name: Wind speed

units: m s-1

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0.0222315080463886

vmax: 14.997784614563

float Rainf\_f\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: precipitation\_flux

long\_name: Total precipitation rate

units: kg m-2 s-1

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 0.00239599961787462

float Tair\_f\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: air\_temperature

long\_name: Temperature

units: K

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 220.533096313477

vmax: 309.749694824219

float Qair\_f\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: specific\_humidity

long\_name: Specific humidity

units: kg kg-1

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 1.86427878361428e-05

vmax: 0.0235061105340719

float Psurf\_f\_inst[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_air\_pressure

long\_name: Pressure

units: Pa

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 51677.8203125

vmax: 103443.71875

float SWdown\_f\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_downwelling\_shortwave\_flux\_in\_air

long\_name: Downward short-wave radiation flux

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 0

vmax: 860.654541015625

float LWdown\_f\_tavg[lon,lat,time] (Chunking: [360,150,1]) (Compression: shuffle,level 4)

standard\_name: surface\_downwelling\_longwave\_flux\_in\_air

long\_name: Downward long-wave radiation flux

units: W m-2

\_FillValue: -9999

missing\_value: -9999

cell\_methods: time: mean

vmin: 89.4814987182617

vmax: 499.689239501953

4 dimensions:

time Size:1 \*\*\* is unlimited \*\*\*

standard\_name: time

long\_name: time

bounds: time\_bnds

units: minutes since 2000-01-01 03:00:00

calendar: standard

axis: T

bnds Size:2 (no dimvar)

lon Size:360

standard\_name: longitude

long\_name: longitude

units: degrees\_east

axis: X

lat Size:150

standard\_name: latitude

long\_name: latitude

units: degrees\_north

axis: Y

19 global attributes:

CDI: Climate Data Interface version 1.9.8 (https://mpimet.mpg.de/cdi)

Conventions: CF-1.6

history: created on date: 2020-01-16T03:56:04.664

source: CLSM\_F2.5 forced with GDAS-AGRMET-GPCPv13rA1

institution: NASA GSFC

missing\_value: -9999

tavg definision:: past 3-hour average

acc definision:: past 3-hour accumulation

inst definision:: instantaneous

title: GLDAS2.1 LIS land surface model output

references: Rodell\_etal\_BAMS\_2004, Kumar\_etal\_EMS\_2006, Peters-Lidard\_etal\_ISSE\_2007

conventions: CF-1.6

comment: website: https://ldas.gsfc.nasa.gov/gldas, https://lis.gsfc.nasa.gov/

MAP\_PROJECTION: EQUIDISTANT CYLINDRICAL

SOUTH\_WEST\_CORNER\_LAT: -59.5

SOUTH\_WEST\_CORNER\_LON: -179.5

DX: 1

DY: 1

CDO: Climate Data Operators version 1.9.8 (https://mpimet.mpg.de/cdo)

# get the time data for the data

> v1 <- test\_nc$var[[1]]

> data1 <- ncvar\_get(test\_nc, v1)

> str(data1)

num [1:2(1d)] 7890660 7890840

> data1

[1] 7890660 7890840

# Either copy-paste the number above into ChatGPT using this prompt:

# “What date and time is this value (7890840) if the units are "minutes since Jan 1, 2000 at 3AM"? Please output the value as DATETIME readable by R.”

# Or ask ChatGPT to create the R code to convert this number while the R script is running, so we can automatically collect the time data while collecting the other data

# Example: get snow surface temperature (13th var in the test\_nc data structure) for Mandan, ND.

> v13 <- test\_nc$var[[13]]

# view v13 structure

> str(v13)

List of 22

$ id :List of 5

..$ id : num 15

..$ group\_index: num -1

..$ group\_id : int 65536

..$ list\_index : num 13

..$ isdimvar : logi FALSE

..- attr(\*, "class")= chr "ncid4"

$ name : chr "SnowT\_tavg"

$ ndims : int 3

$ natts : int 8

$ size : int [1:3] 360 150 1

$ dimids : int [1:3] 2 3 0

$ prec : chr "float"

$ units : chr "K"

$ longname : chr "Snow Surface temperature"

$ group\_index : int 1

$ chunksizes : int [1:3] 360 150 1

$ storage : int 2

$ shuffle : int 1

$ compression : int 4

$ dims : list()

$ dim :List of 3

..$ :List of 10

.. ..$ name : chr "lon"

.. ..$ len : int 360

.. ..$ unlim : logi FALSE

.. ..$ group\_index : int 1

.. ..$ group\_id : int 65536

.. ..$ id : int 2

.. ..$ dimvarid :List of 5

.. .. ..$ id : int 2

.. .. ..$ group\_index: int 1

.. .. ..$ group\_id : int 65536

.. .. ..$ list\_index : num -1

.. .. ..$ isdimvar : logi TRUE

.. .. ..- attr(\*, "class")= chr "ncid4"

.. ..$ units : chr "degrees\_east"

.. ..$ vals : num [1:360(1d)] -180 -178 -178 -176 -176 ...

.. ..$ create\_dimvar: logi TRUE

.. ..- attr(\*, "class")= chr "ncdim4"

..$ :List of 10

.. ..$ name : chr "lat"

.. ..$ len : int 150

.. ..$ unlim : logi FALSE

.. ..$ group\_index : int 1

.. ..$ group\_id : int 65536

.. ..$ id : int 3

.. ..$ dimvarid :List of 5

.. .. ..$ id : int 3

.. .. ..$ group\_index: int 1

.. .. ..$ group\_id : int 65536

.. .. ..$ list\_index : num -1

.. .. ..$ isdimvar : logi TRUE

.. .. ..- attr(\*, "class")= chr "ncid4"

.. ..$ units : chr "degrees\_north"

.. ..$ vals : num [1:150(1d)] -59.5 -58.5 -57.5 -56.5 -55.5 -54.5 -53.5 -52.5 -51.5 -50.5 ...

.. ..$ create\_dimvar: logi TRUE

.. ..- attr(\*, "class")= chr "ncdim4"

..$ :List of 11

.. ..$ name : chr "time"

.. ..$ len : int 1

.. ..$ unlim : logi TRUE

.. ..$ group\_index : int 1

.. ..$ group\_id : int 65536

.. ..$ id : int 0

.. ..$ dimvarid :List of 5

.. .. ..$ id : int 0

.. .. ..$ group\_index: int 1

.. .. ..$ group\_id : int 65536

.. .. ..$ list\_index : num -1

.. .. ..$ isdimvar : logi TRUE

.. .. ..- attr(\*, "class")= chr "ncid4"

.. ..$ units : chr "minutes since 2000-01-01 03:00:00"

.. ..$ calendar : chr "standard"

.. ..$ vals : num [1(1d)] 7890840

.. ..$ create\_dimvar: logi TRUE

.. ..- attr(\*, "class")= chr "ncdim4"

$ varsize : int [1:3] 360 150 1

$ unlim : logi TRUE

$ make\_missing\_value: logi TRUE

$ missval : num -9999

$ hasAddOffset : logi FALSE

$ hasScaleFact : logi FALSE

- attr(\*, "class")= chr "ncvar4"

# get data from test\_nc data structure from variable v13

> data13 <- ncvar\_get(test\_nc, v13)

# view the structure of data13 (2D array of temps in Kelvin units)

> str(data13)

num [1:360, 1:150] NA NA NA NA NA NA NA NA NA NA ...

> head(data13[,1:3]) # view first three columns 1:3 and first 6 rows (from head() function)

[,1] [,2] [,3]

[1,] NA NA NA

[2,] NA NA NA

[3,] NA NA NA

[4,] NA NA NA

[5,] NA NA NA

[6,] NA NA NA

# get dimensions of array… notice 360 degrees LON (-180E to +180E) and 150 degrees LAT (-60N to 90N)

> dim(data13)

[1] 360 150

# get snow surface temp for Mandan, ND …

# located at (46N, 100W) or as NASA prefers, (46N, -100E)

# to convert to array (150 columns [LAT], 360 rows [LON])

# (lat and lon are switched in the array)

# to get [LAT, ] for array do: 150 – (90 – *lat*) + 1 … where *lat* is 46

# to get [ ,LON] for array do: ABS(-180 – (*lon*)) … where *lon* is -100

> data13[80,106]

[1] 270.8056 # 270.8 degrees K = -2.35C or 27.8F

# may want to consider testing whether output of above returns a value, and if it doesn’t, get the mean of surrounding areas. For example:

> mean(data13[78:82,104:108], na.rm = TRUE)

[1] 270.6113

… more R code here