Basics on NorESM model output

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Directories storing model output

1. Run directory: (on Fram/Betzy)
   `/cluster/work/users/<username>/noresm/cases/$CASE`

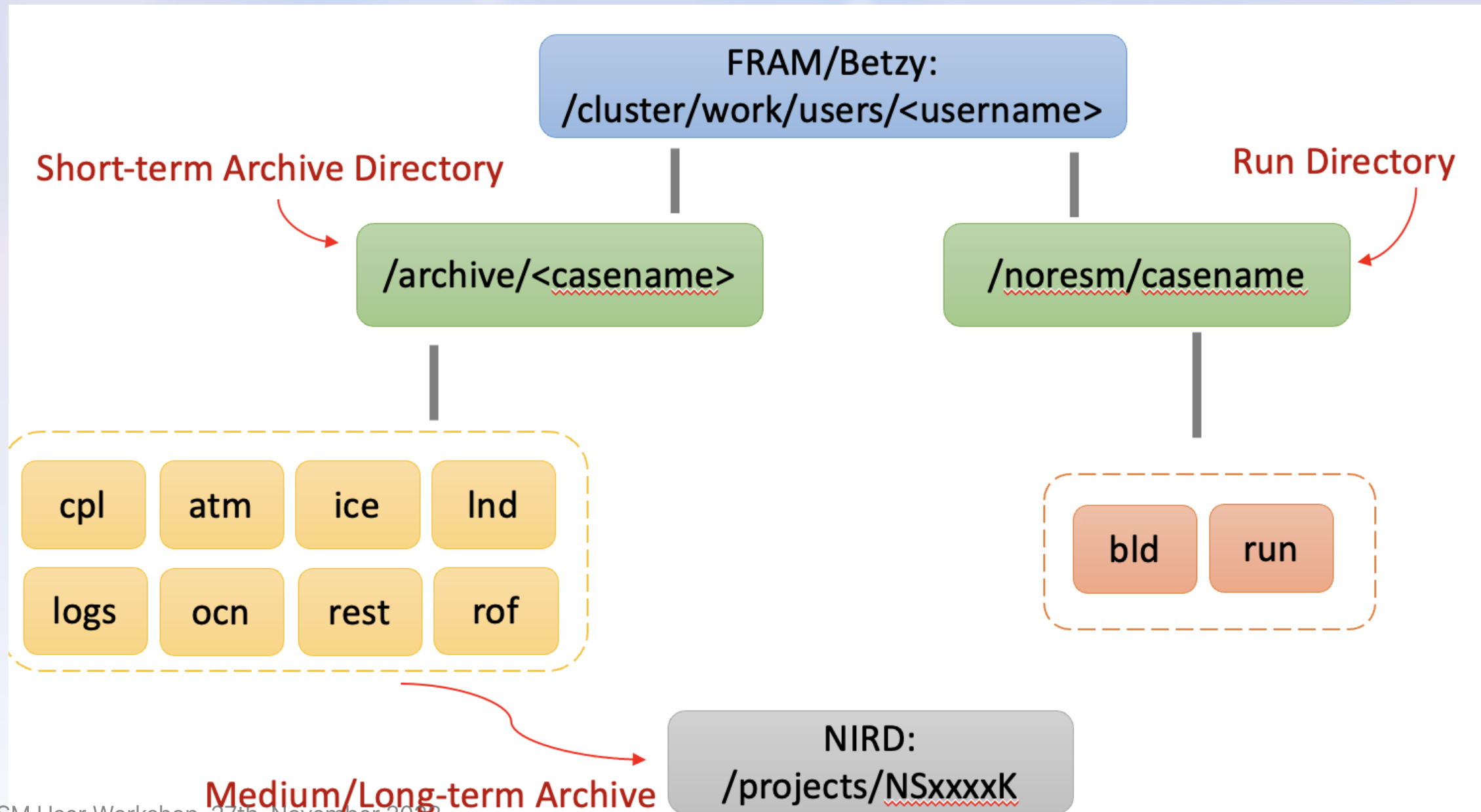2. Short-term archive: (on Fram/Betzy)
   `/cluster/work/users/<username>/archive/cases/$CASE`

   NOTE, files older than 21 days might be automatic deleted (see Fram/Betzy documentation)

3. Medium/Long-term archive: should archive the data to the NIRD project areas, e.g., `/projects/NS2345K` for INES project.

Archive structure of model output

History File Naming Conventions

- All history output files are written in NetCDF-3 format, and automatically converted to compressed NetCDF-4 format (with tool `noresm2netcdf4`)
- Output of each component store seperately as `<component>/hist`, e.g, `atm/hist` `ocn/hist`, etc. Restart files are stored under `rest/hist`.

```
$ tree -L 2
.
├── archive.log.200921-151923
├── atm
│   └── hist
├── cpl
│   └── hist
├── esp
│   └── hist
├── ice
│   └── hist
├── lnd
│   └── hist
├── logs
│   ├── atm.log.781577.200921-144102.gz
│   ├── cesm.log.781577.200921-144102.gz
│   ├── cpl.log.781577.200921-144102.gz
│   ├── ice.log.781577.200921-144102.gz
│   ├── lnd.log.781577.200921-144102.gz
│   ├── ocn.log.781577.200921-144102.gz
│   └── rof.log.781577.200921-144102.gz
├── ocn
│   └── hist
├── rest
│   └── 0001-02-01-00000
├── rof
│   └── hist
```

Example history file names:

- `<compset name>_<resolution sname>_<opt_desc_string>_<component>.<frequency>_<date>.nc`
- N1850frc2_f19_tn14_Workshop2021.blom.hm.0001-01.nc
- N1850frc2_f19_tn14_Workshop2021.cam.h0.0001-01.nc

By default, `h0,hm` denotes that the time sampling frequency is monthly.

Other frequencies are saved under the h1, h2, etc.

Different time sampling frequencies have distinct tags in the file names.

A full list of the tags:

```
  - blom.hy    = blom yearly
  - blom.hbgcy = blom/bgc yearly
  - blom.hm    = blom monthly
  - blom.hbgcm = blom/bgc monthly
  - blom.hd    = blom daily
  - blom.hbgcd = blom/bgc daily
  - cice.h     = ice monthly
  - cice.h1    = ice daily
  - cam.h0     = cam monthly
  - cam.h1     = cam daily
  - cam.h2     = cam 6-hourly average
  - cam.h3     = cam 6-hourly instant
  - cam.h4     = cam 3-hourly average
  - cam.h5     = cam 3-hourly instant
  - clm2.h4    = clm yearly
  - clm2.h0    = clm monthly
  - clm2.h1    = clm daily
  - clm2.h2    = clm 3-hourly average
  - clm2.h3    = clm 3-hourly instant
```

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NorESM horizontal and vertical grid system

Horizontal grids

- NorESM2-LM (CAM) for CMIP6: 2x2 degree

- NorESM2-MM (CAM) for CMIP6: 2x2 degree

- NorESM1 (MICOM) for CMIP5: bipolar grid

- NorESM2-LM/MM (BLOM) for CMIP6: tripolar grid

CAM: 2x2 degree

```
$ ncdump -h NHIST_f19_tn14_20200909_test1.cam.h0.2000-06.nc
netcdf NHIST_f19_tn14_20200909_test1.cam.h0.2000-06 {
dimensions:
        lat = 96 ;
        lon = 144 ;
        zlon = 1 ;
        nbnd = 2 ;
        time = UNLIMITED ; // (1 currently)
        chars = 8 ;
        lev = 32 ;
        ilev = 33 ;
```

</div> <div> <img src="images/grid-horizontal.png" width="500px" alt="NorESM horizontal and vertical grid system"> </div> </div>

<div class="columns"> <div>

NorESM horizontal and vertical grid system

Horizontal grids

- NorESM2-LM (CAM) for CMIP6: 2x2 degree

- NorESM2-MM (CAM) for CMIP6: 2x2 degree

- NorESM1 (MICOM) for CMIP5: bipolar grid

- NorESM2-LM/MM (BLOM) for CMIP6: tripolar grid

CAM: 1x1 degree

```
$ ncdump -h NHISTfrc2_f09_tn14_20200718.cam.h0.2000-06.nc
netcdf NHISTfrc2_f09_tn14_20200718.cam.h0.2000-06 {
dimensions:
        lat = 192 ;
        lon = 288 ;
        zlon = 1 ;
        nbnd = 2 ;
        time = UNLIMITED ; // (1 currently)
        chars = 8 ;
        lev = 32 ;
        ilev = 33 ;
```

</div> <div> <img src="images/grid-horizontal.png" width="500px" alt="NorESM horizontal and vertical grid system"> </div> </div>

<div class="columns"> <div>

NorESM horizontal and vertical grid system

Horizontal grids

- NorESM2-LM (CAM) for CMIP6: 2x2 degree

- NorESM2-MM (CAM) for CMIP6: 2x2 degree

- NorESM1 (MICOM) for CMIP5: bipolar grid

- NorESM2-LM/MM (BLOM) for CMIP6: tripolar grid

BLOM: 1x1 degree (tripolar)

```
$ ncdump -h NHISTfrc2_f09_tn14_20200718.micom.hm.2000-06.nc
netcdf NHISTfrc2_f09_tn14_20200718.micom.hm.2000-06 {
dimensions:
        x = 360 ;
        y = 385 ;
        sigma = 53 ;
        depth = 70 ;
        region = 4 ;
        bounds = 2 ;
        slenmax = 50 ;
        time = UNLIMITED ; // (1 currently)
        section = 17 ;
        lat = 171 ;
```

</div> <div>

Horizontal Arakawa-C grid staggering of variables

<img src="images/grid2d_hv.png" width="500px" alt="Arakawa-C (https://xgcm.readthedocs.io/en/latest/grids.html)"> </div> </div>

NorESM horizontal and vertical grid system

Vertical grids

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- CAM: terrian-following sigma coordinate

- BLOM: isopycnic (potential density σ_2) coordinated vertical coordinate

```
float temp(time, sigma, y, x) ;
        temp:_FillValue = 9.96921e+36f ;
        temp:units = "degC" ;
        temp:long_name = "Temperature" ;
        temp:standard_name = "Ocean temperature" ;
        temp:coordinates = "plon plat" ;
        temp:cell_measures = "area: parea" ;

float templvl(time, depth, y, x) ;
        templvl:_FillValue = 9.96921e+36f ;
        templvl:units = "degC" ;
        templvl:long_name = "Temperature" ;
        templvl:standard_name = "Ocean temperature" ;
        templvl:coordinates = "plon plat" ;
        templvl:cell_measures = "area: parea" ;
```

<img src="images/blom-hybrid.png" width="500px" alt="BLOM sigma vertical coordinate"> </div> <div> <img src="images/grid-vertical.png" width="350px" alt="NorESM horizontal and vertical grid system"> </div> </div>

NorESM output time axis/variable

BLOM

The time coordinate variable in ocean model BLOM history represents the middle of the averaging period for variables that are averages.
No `time_bounds` for the `time` axis.

BLOM output

```
$ ncdump -t -v time N1850frc2_f19_tn14_Workshop2020.blom.hm.0001-01.nc |tail -4
data:

 time = "0001-01-17" ;
}
```

NorESM output time axis/variable

CAM

The time coordinate variable in atmospheric model CAM history and timeseries files represents the end of the averaging period for variables that are averages (inherited from CESM). Its `time_bnds` attribute of `time` axis gives over which period the field is averaged.

Example File: `N1850frc2_f19_tn14_Workshop2020.cam.h0.0001-01.nc`
When the time coordinate variable is translated, the time is 00Z Februray 1st 0001, even though the file holds averaged variables for January 0001.

CAM output

```
$ ncdump -t -v time N1850frc2_f19_tn14_Workshop2020.cam.h0.0001-01.nc |tail -5
                :time_period_freq = "month_1" ;
data:

 time = "0001-02-01" ;
}

$ ncdump -t -v time_bnds N1850frc2_f19_tn14_Workshop2020.cam.h0.0001-01.nc |tail -5
data:

 time_bnds =
  "0001-01-01", "0001-02-01" ;
}
```

The end!