BJERKNES CENTRE for Climate Research

Ready-to-use setup for high-frequent EnKF assimilation with NorESM2

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Introduction & first results

DA implementations for NorCPM

Offline (NorESM1,NorESM2)

- *Stop & restart*
  NorESM and DA seperate executables running sequent.
- *Disk-based communication* between model and DA via modifying full restart files
- *Components: ocn[12], ice[1] ,lnd[1]*
- *DA freq.:* monthly (slow model init. & read/write of full restarts)

Semi-online (NorESM2)

NEW

- *Pause & resume (hack)*
  NorESM and DA separate executables running in parallel
- *Disk-based communication* via reading/writing «reduced» restart files
- *Components: ocn, lnd,(ice,atm)*
- *DA freq.:* (sub-)daily, monthly

Results on next slides!

Online (NorESM2/2.5/3)

COMING SOON

- *Pause & resume (NCAR)*
  DA fully integrated part of NorESM and runs in same job
- *MPI-based communication* between model and DA
- *Components: ocn, lnd, ice, atm*
- *DA freq.:* (sub-)daily, monthly

Daily ocean data assimilation with NorESM2 *(preliminary results)*

Test using daily assim. of satellite SSTs and monthly assim. of T/S profiles

- Three 10-member ensembles with NorESM2-LM
  - FREE (no assimilation)
  - MONTHLY (monthly SST + monthly T/S)
  - DAILY (daily SST + monthly T/S)

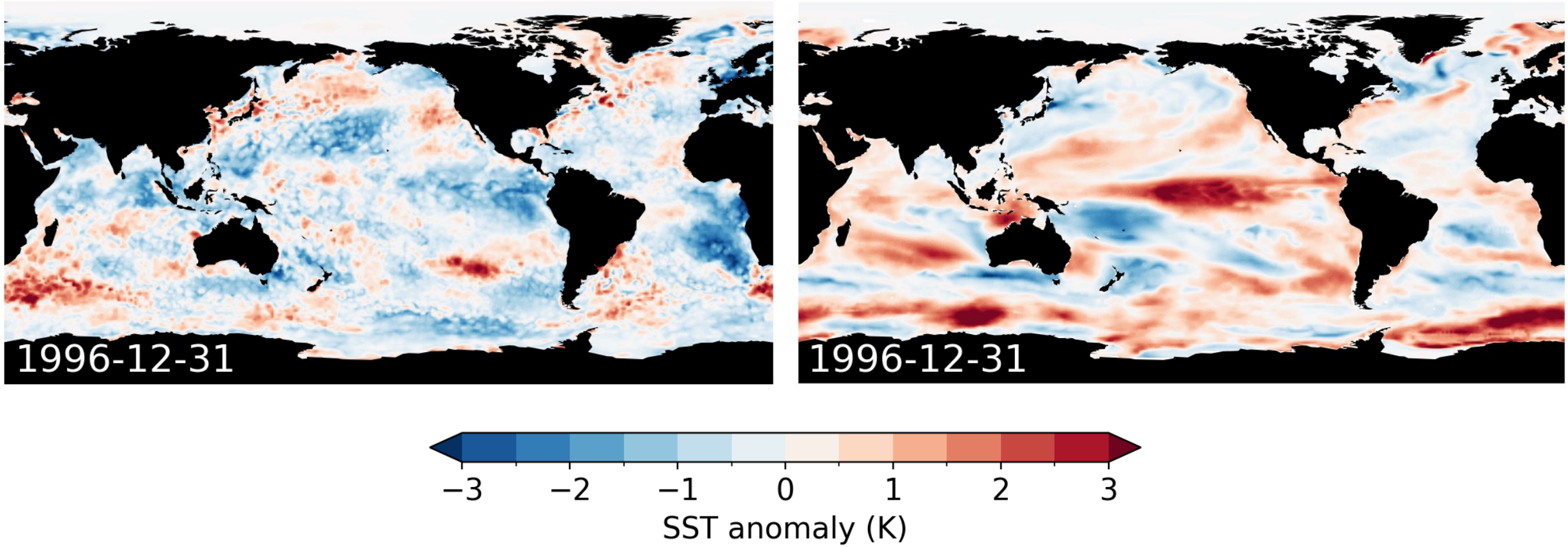
- 1996-2003 coverage (will only show results from first year)

- EnKF anomaly assimilation with 1980-2010 reference period

Assimilation of daily SST and monthly T/S observations – obs vs free run

OISST

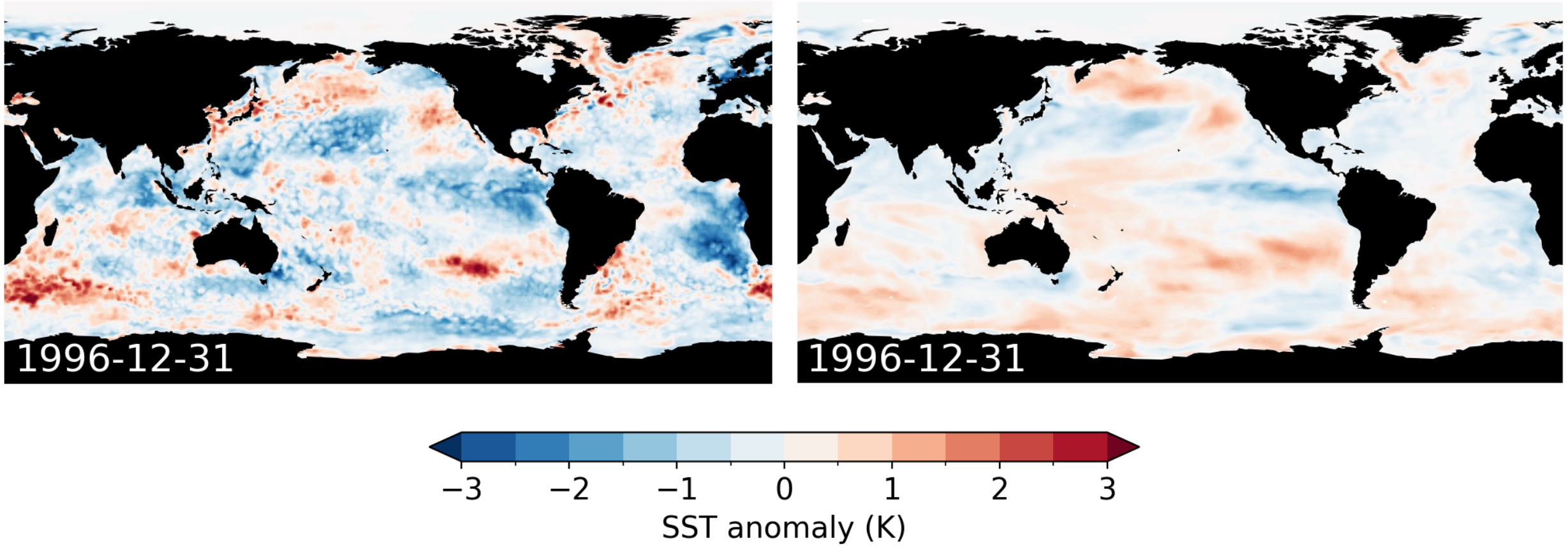
FREE (member 1)



Assimilation of daily SST and monthly T/S observations – obs vs monthly assimilation

OISST

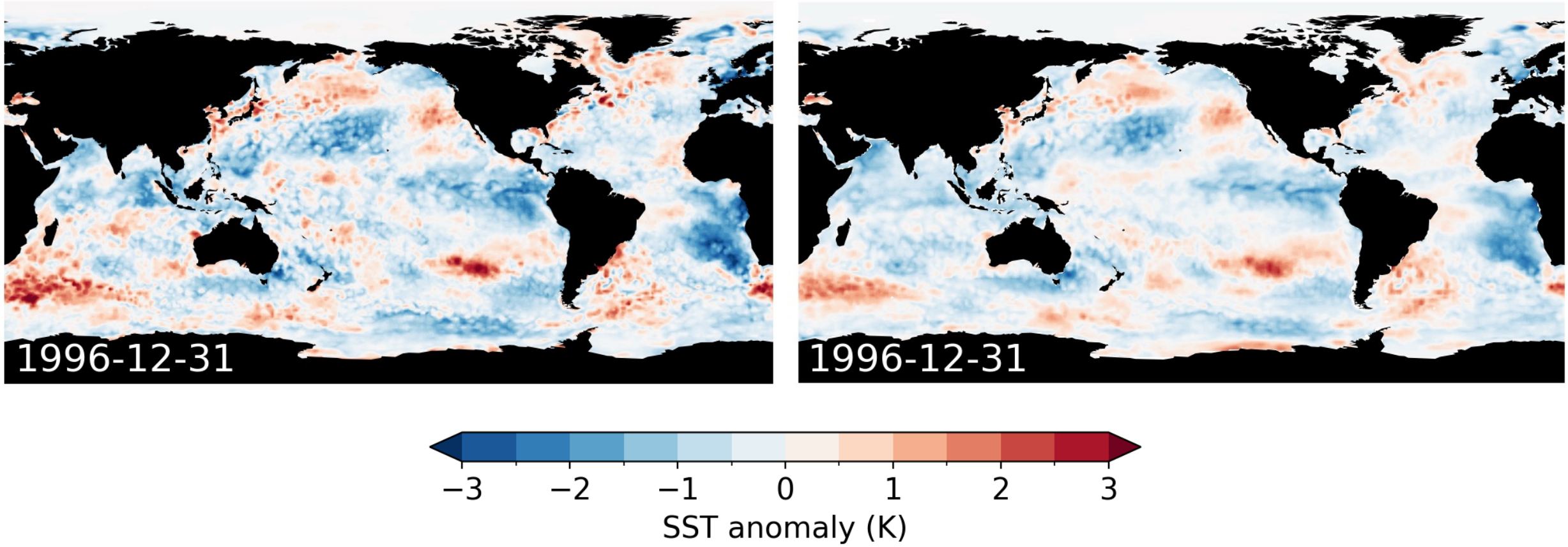
MONTHLY (ensemble mean)



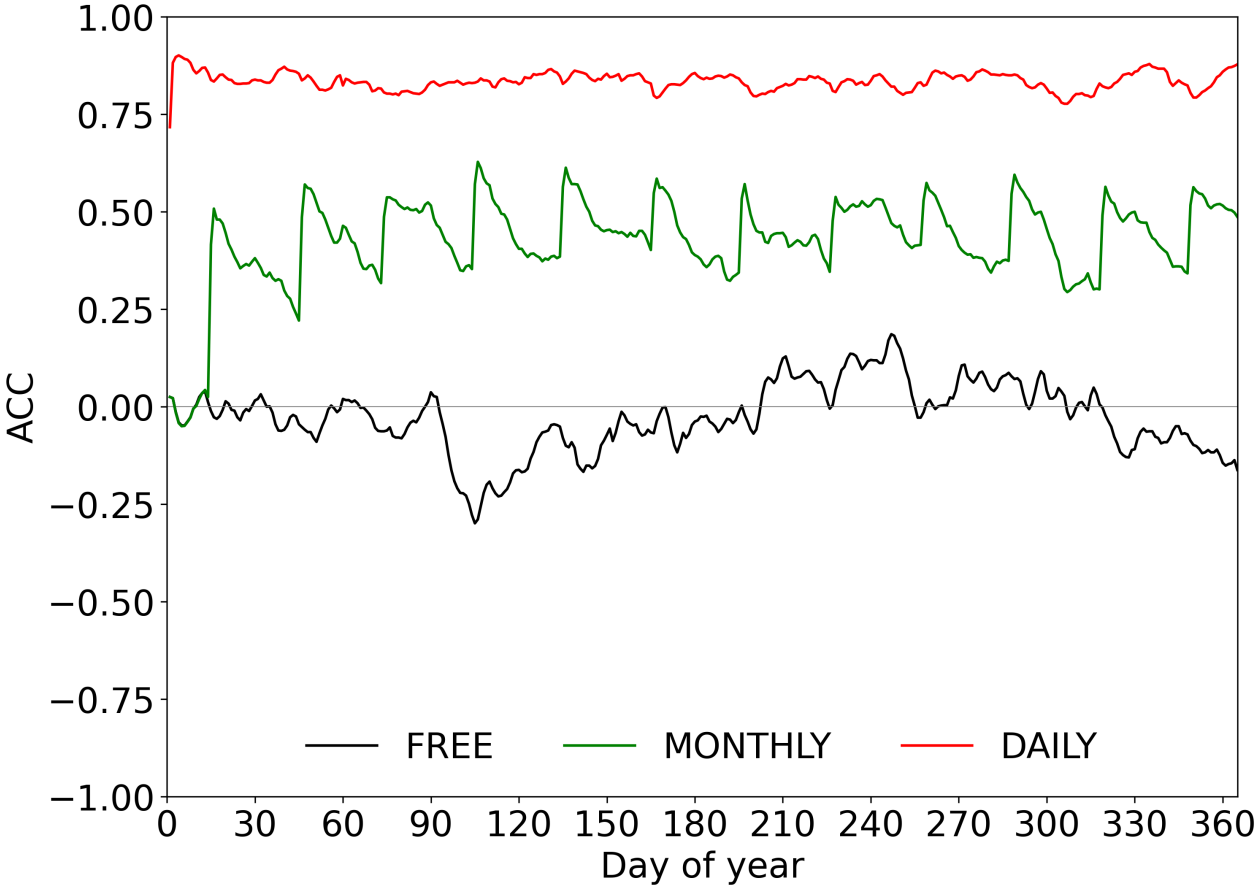
Assimilation of daily SST and monthly T/S observations – obs vs daily assimilation

OISST

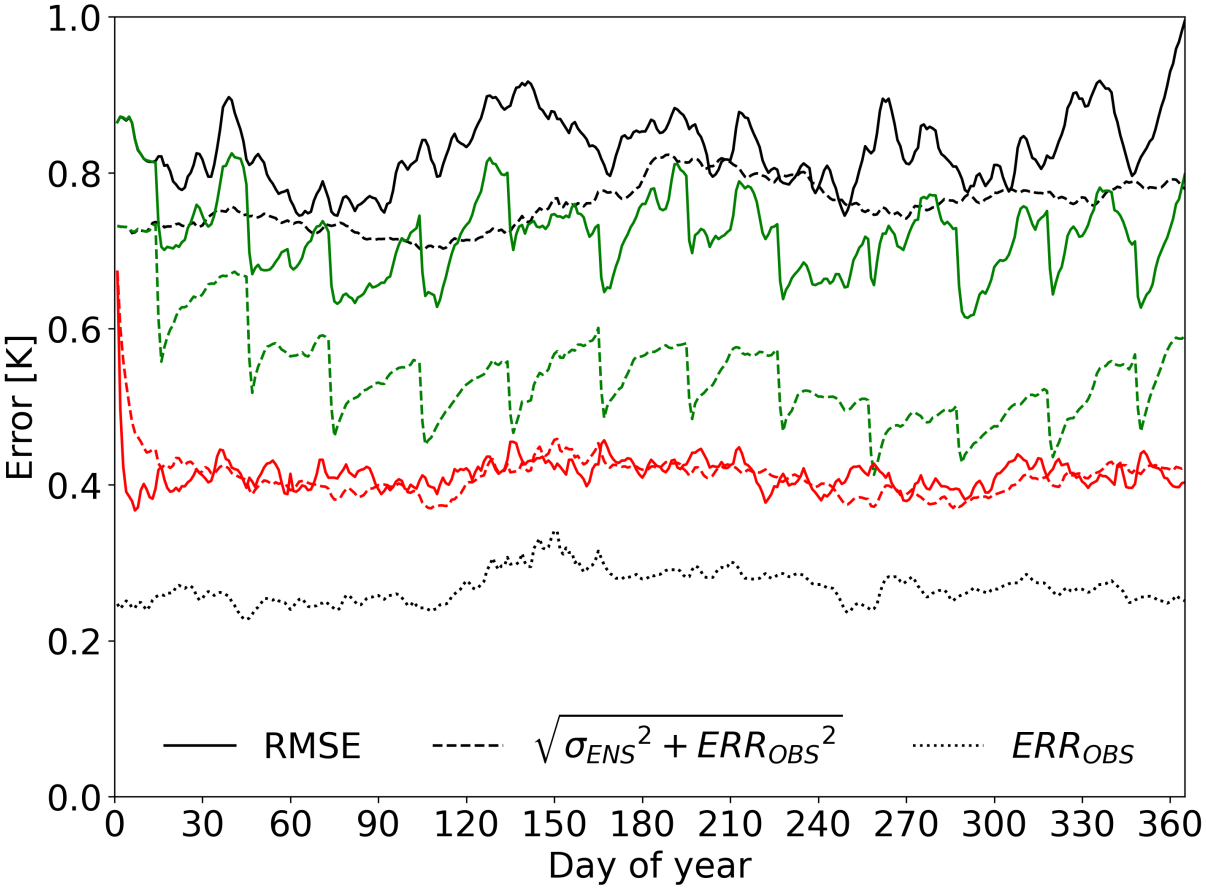
DAILY (ensemble mean)



Assimilation of daily SST and monthly T/S observations – global statistics (spatial averages)



$ACC = pattern\ correlation\ (area\ weighted)$

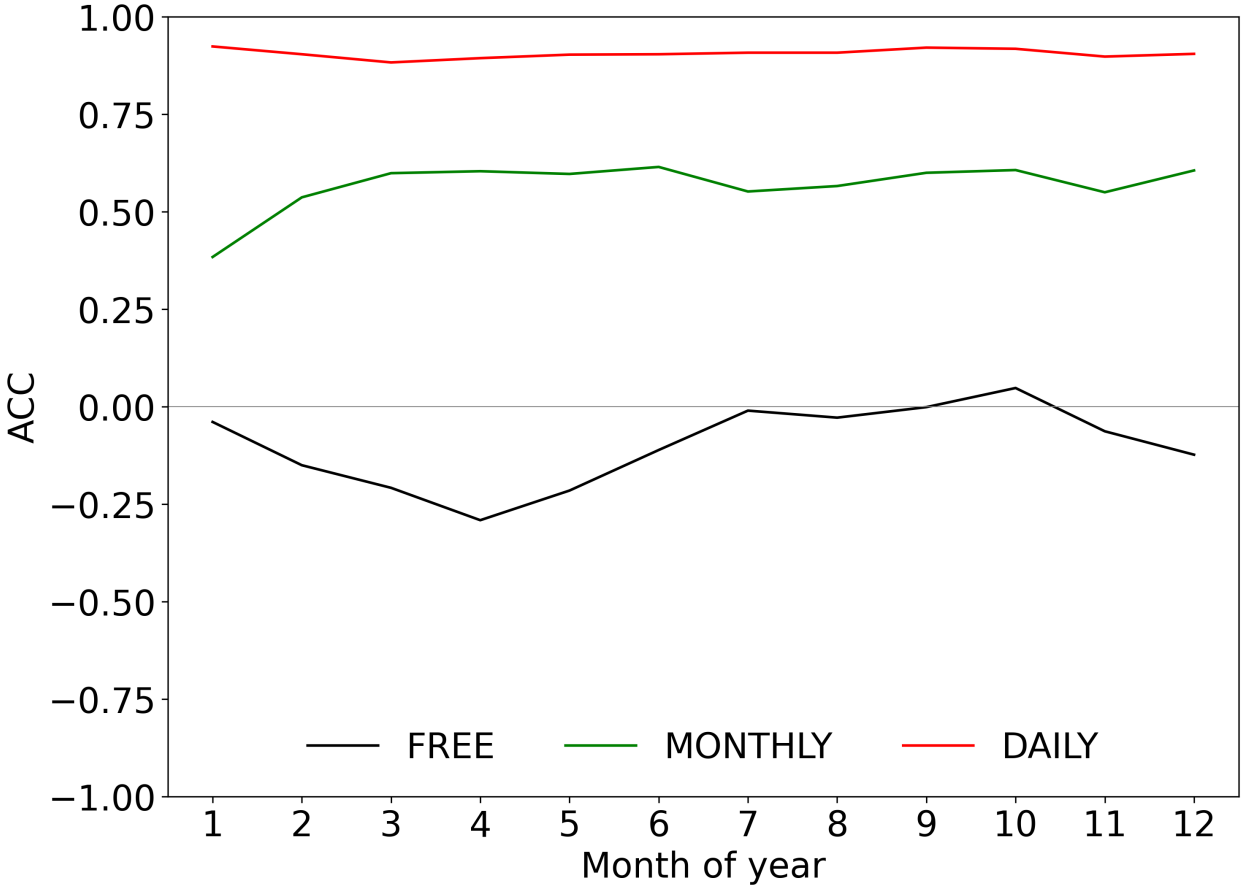


$RMSE = root\ mean\ square\ deviation\ (area\ weighted)$

$\mathrm{ERR}_{OBS} = observation\ error (area\ weighted)$

$\sigma_{ENS} = ensemble\ spread\ (area\ weighted)$

Assimilation of daily SST and monthly T/S observations – global statistics (spatial averages)



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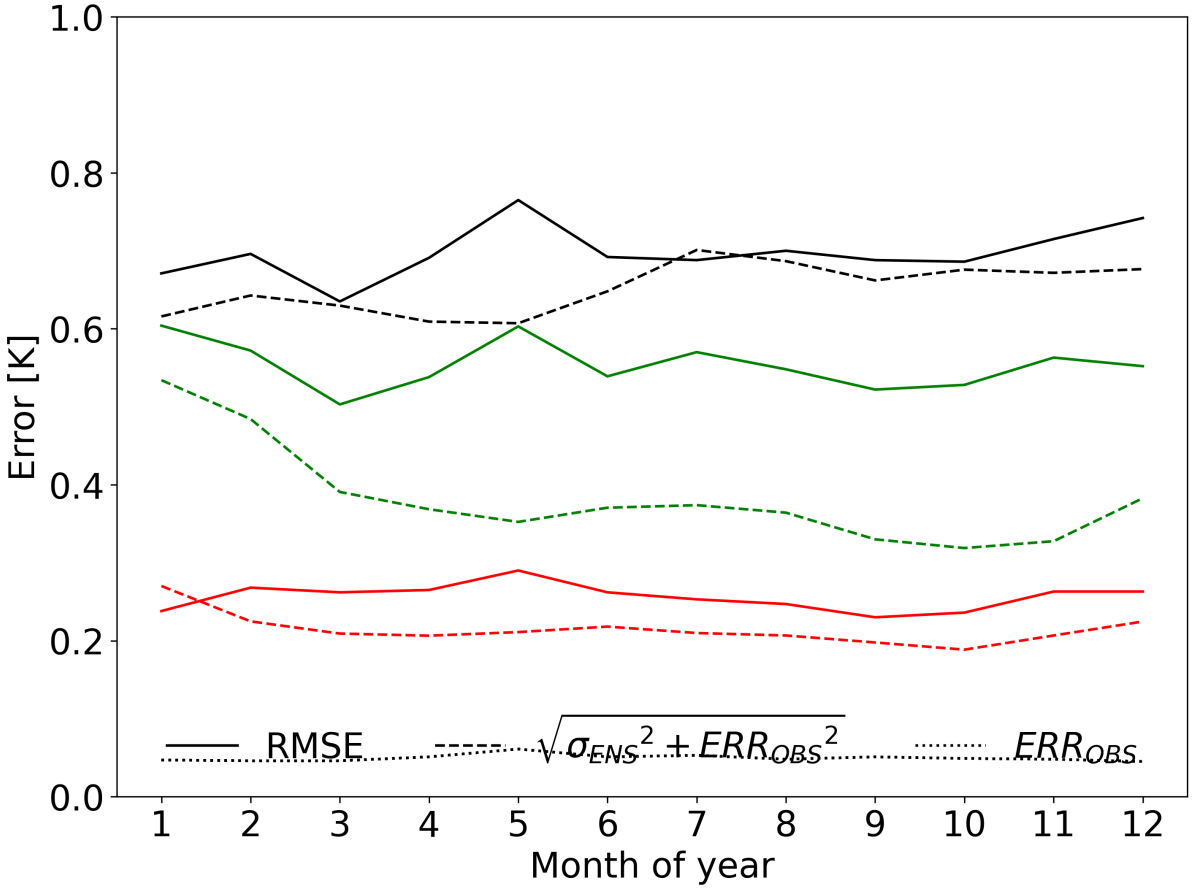

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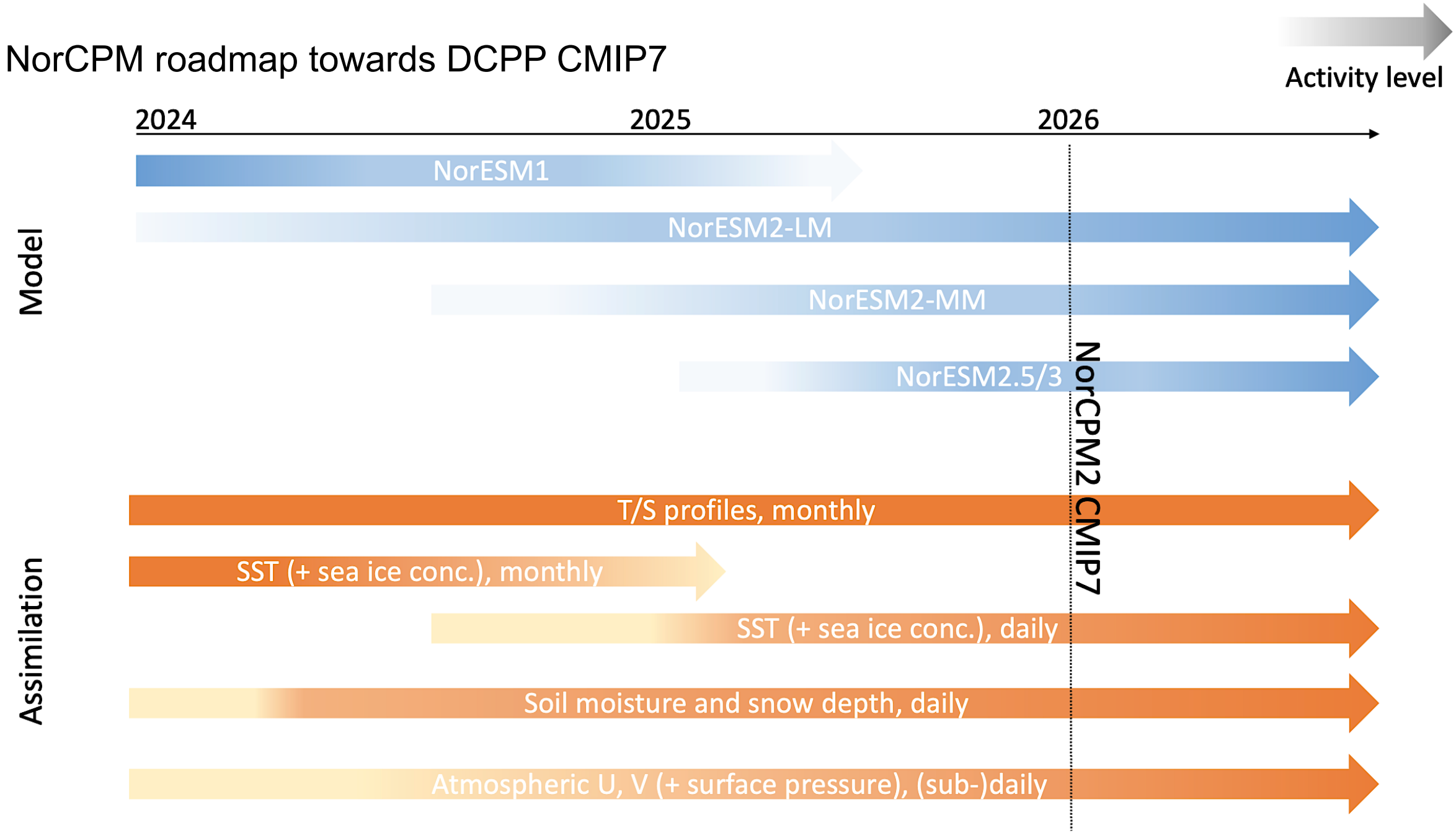
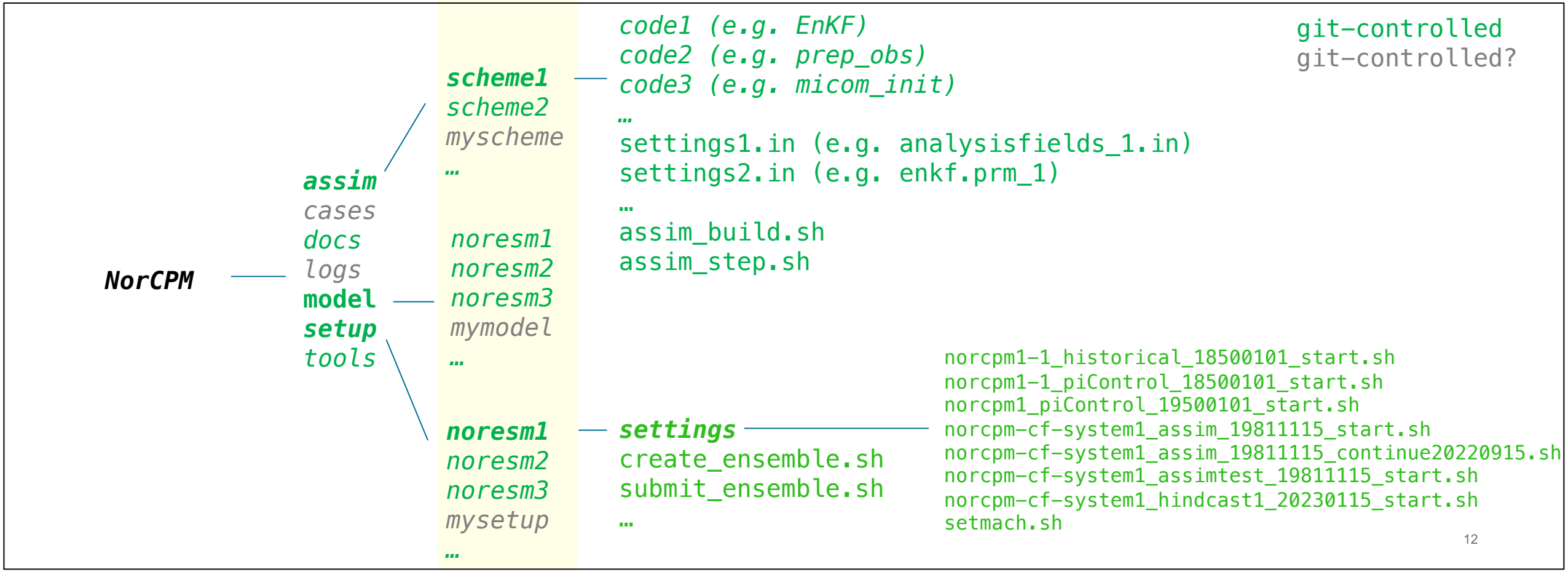

NorCPM roadmap towards DCPP CMIP7
Activity level
2024
2025
2026
Model
NorESM1
NorESM2-LM
NorESM2-MM
NorESM2.5/3
NorCPM2 CMIP7
Assimilation
T/S profiles, monthly
SST (+ sea ice conc.), monthly
SST (+ sea ice conc.), daily
Soil moisture and snow depth, daily
Atmospheric U, V (+ surface pressure), (sub-)daily

User guide

NorCPM repository with revised structure https://github.com/NorESMhub/NorCPM

- supports **multiple ESM versions, *assimilation schemes* and *experiment setup environments***
- multiple users can contribute to the same repository without interfering with each other's work
- flexible, well-structured and organized; fully version controlled
- suitable for use with NorESM1, NorESM2 and later versions



Mini-tutorial for performing a daily assimilation experiment using NorESM2-LM

Install NorCPM in the nn9039k project space

```
mkdir -p /cluster/projects/nn9039k/people/$USER
cd /cluster/projects/nn9039k/people/$USER
git clone https://github.com/NorESMhub/NorCPM.git NorCPM
```

Install NorESM2

```
cd /cluster/projects/nn9039k/people/$USER/NorCPM/setup/noresm2
./install_noresm2.sh
```

Set up a NorESM2-LM assimilation test experiment with 10 members

```
./create_ensemble.sh settings/noresm2-lm_odaday_10mem_19960101pgchiu.sh
```

Submit experiment

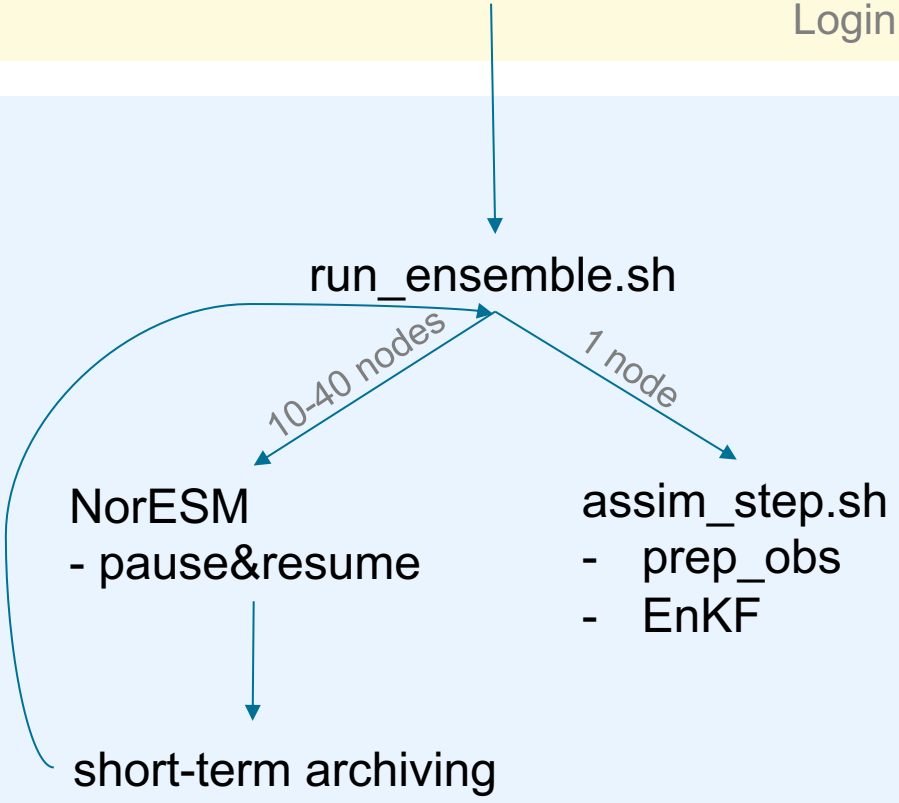
```
./submit_ensemble.sh settings/noresm2-lm_odaday_10mem_19960101pgchiu.sh
```

Workflow

1

create_ensemble.sh <settings file>
submit_ensemble.sh <settings file>

Login node



Batch system
(compute nodes)

2

compress_ensemble.sh <settings file>

Login node

4 nodes

noresm2nc4mpi

Batch system
(compute nodes)

3

Transfer of output to NIRD

Login node

Customizing NorESM2 (cpu settings, source code, diagnostic output)

`NorCPM/setup/noresm2/user_mods` contains NorESM2 customization folders

```
noresm2-lm_128pes
noresm2-lm_640pes
noresm2-lm_clmda_128pes
noresm2-lmesm_128pes
```

Each customization folder countains

- env_mach_pes.xml: specifies pes/cpu settings
- SourceMods: customized source code should be placed there
- user_nl_*: user namelists used to customize diagnostic output

Can create new customization folder and point to it in experiment settings file (next slides)

Settings file – experiment and job settings

```
# experiment settings
: ${EXPERIMENT:=noresm2-lm_odaday_10mem} # case prefix, not including _YYYYMMDD_memXX
suffix
: ${MEMBER1:=1} # first member
: ${ENSSIZE:=10} # number of members
: ${COMPSET:=NHISTfrc2} # need to switch compset at start of 2015
: ${USER_MODS_DIR:=$SETUPROOT/user_mods/noresm2-lm_128pes}
: ${RES:=f19_tn14}
: ${START_DATE:=1996-01-01} # YYYY-MM-DD

# job settings
: ${STOP_OPTION:=nyears} # units for run length specification STOP_N
: ${STOP_N:=1} # run continuesly for this length
: ${RESTART:=7} # restart this many times
: ${WALLTIME:='96:00:00'}
: ${ACCOUNT:=nn9039k}
: ${MAX_PARALLEL_STARCHIVE:=30}
```

Settings file – initialisation option 1: guessed reference case names

```
# initialisation settings – ref. cases guessed from REF_CASE_PREFIX, REF_CASE_SUFFIX_MEMBER1
: ${RUN_TYPE:=branch}
: ${REF_CASE_PREFIX:=noresm_ctl_19700101_19700101}
: ${REF_CASE_SUFFIX_MEMBER1:=_mem01}
: ${REF_PATH_LOCAL:=$INPUTDATA/ccsm4_init/$REF_CASE_PREFIX}
: ${REF_DATE:=$START_DATE}
```

- reference case names guessed from REF_CASE_PREFIX and REF_CASE_SUFFIX_MEMBER1
- number of references cases >= ENSSIZE
- RUN_TYPE can be either “branch” or “hybrid”
- available ref dates for NorESM2-LM: 1975, 1985, 1996, 2015

Settings file – initialisation option 2: explicitely specified reference case names

```
# initialisation settings
: ${RUN_TYPE:=hybrid}
: ${REF_CASE_LIST:='noresm_ctl_19700101_19700101_mem01 noresm_ctl_19700101_19700101_mem02
noresm_ctl_19700101_19700101_mem03 noresm_ctl_19700101_19700101_mem04
noresm_ctl_19700101_19700101_mem05 noresm_ctl_19700101_19700101_mem06
noresm_ctl_19700101_19700101_mem07 noresm_ctl_19700101_19700101_mem08
noresm_ctl_19700101_19700101_mem09 noresm_ctl_19700101_19700101_mem10'}
: ${REF_PATH_LOCAL:=/cluster/work/users/$USER/restarts}
: ${REF_DATE:=$START_DATE}
: ${ADD_PERTURBATION:=1} # only for RUN_TYPE=hybrid
```

- reference case names specified with REF_CASE_LIST
- reference cases cycled if their number is < ENSSIZE
- ADD_PERTURBATION=1 adds atmospheric perturbation if RUN_TYPE=1

Settings file – initialisation option 3: single reference case, multiple reference dates

```
# initialisation settings
: ${RUN_TYPE:=hybrid}
: ${REF_CASE:=N1850frc2_f09_tn14_20191113}
: ${REF_PATH_LOCAL:=$INPUTDATA/ccsm4_init/$REF_CASE}
: ${REF_DATE_LIST:='1500-01-01 1505-01-01 1510-01-01 1515-01-01'}
: ${ADD_PERTURBATION:=1} # only for RUN_TYPE=hybrid
```

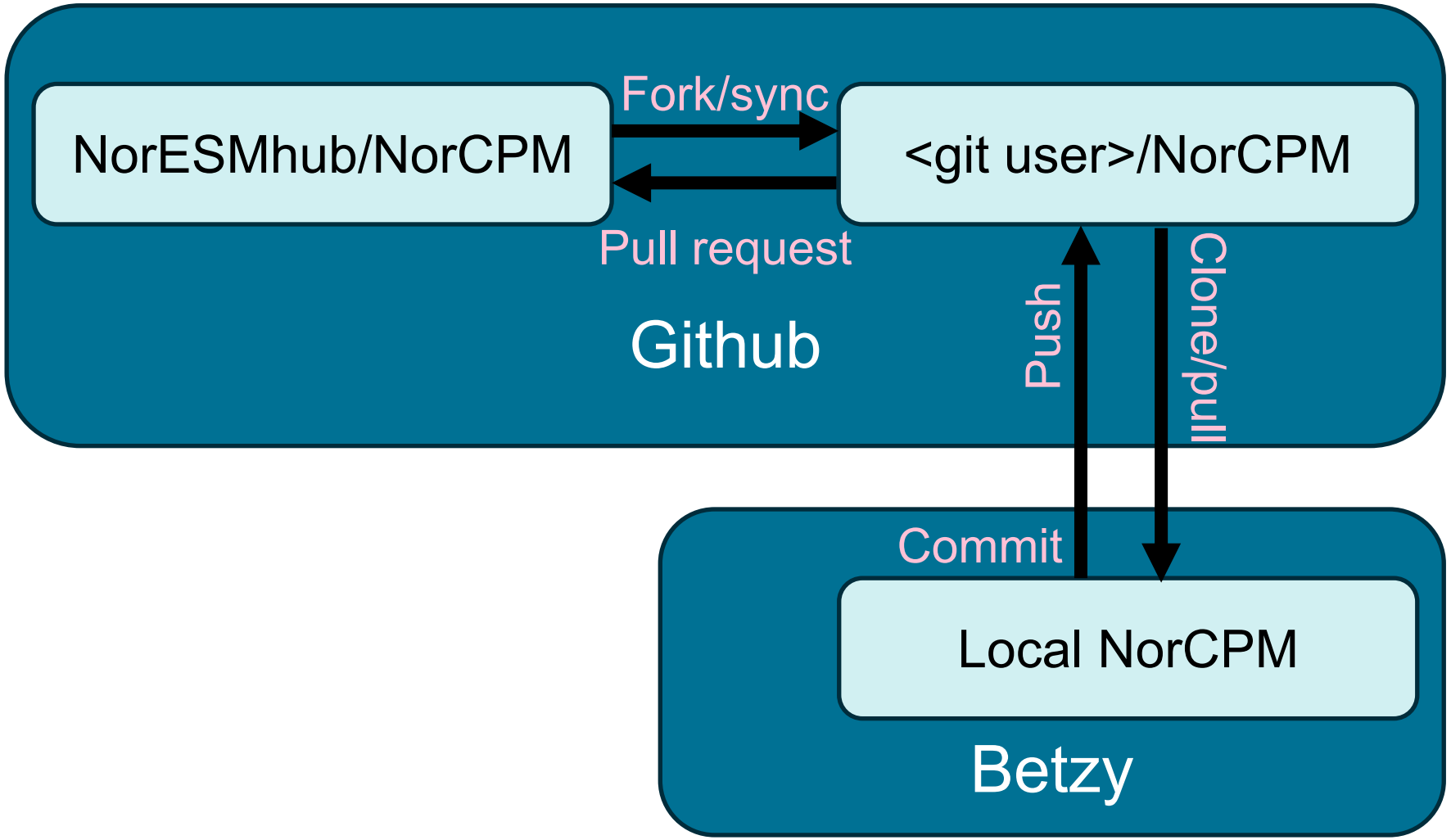
- reference case specified with REF_CASE or REF_CASE_LIST
- references dates specified with REF_DATE_LIST
- references dates cycled if number of dates < ENSSIZE
- RUN_TYPE must be “hybrid”

Settings file – assimilation

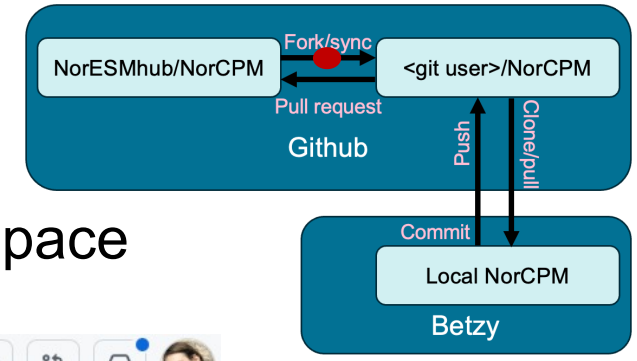
```
# assimilation settings
: ${ASSIMROOT:=$SETUPROOT/../../assim/enkf_noresm2_oda}
: ${MEAN_MOD_DIR:=$INPUTDATA_ASSIM/enkf/$RES/NorESM2-LM-CMIP6}
: ${NTASKS_DA:=128}
: ${NTASKS_ENKF:=108}
: ${OCNGRIDFILE:=$INPUTDATA/ocn/blom/grid/grid_tnx1v4_20170622.nc}
: ${OBSLIST:='TEM SAL SST'}
: ${PRODUCERLIST:='EN422 EN422 NOAA'}
: ${FREQUENCYLIST:='MONTH MONTH DAY'}
: ${REF_PERIODLIST:='1980-2010 1980-2010 1980-2010'}
: ${COMBINE_ASSIM:='0 0 1'}
```

Developer guide

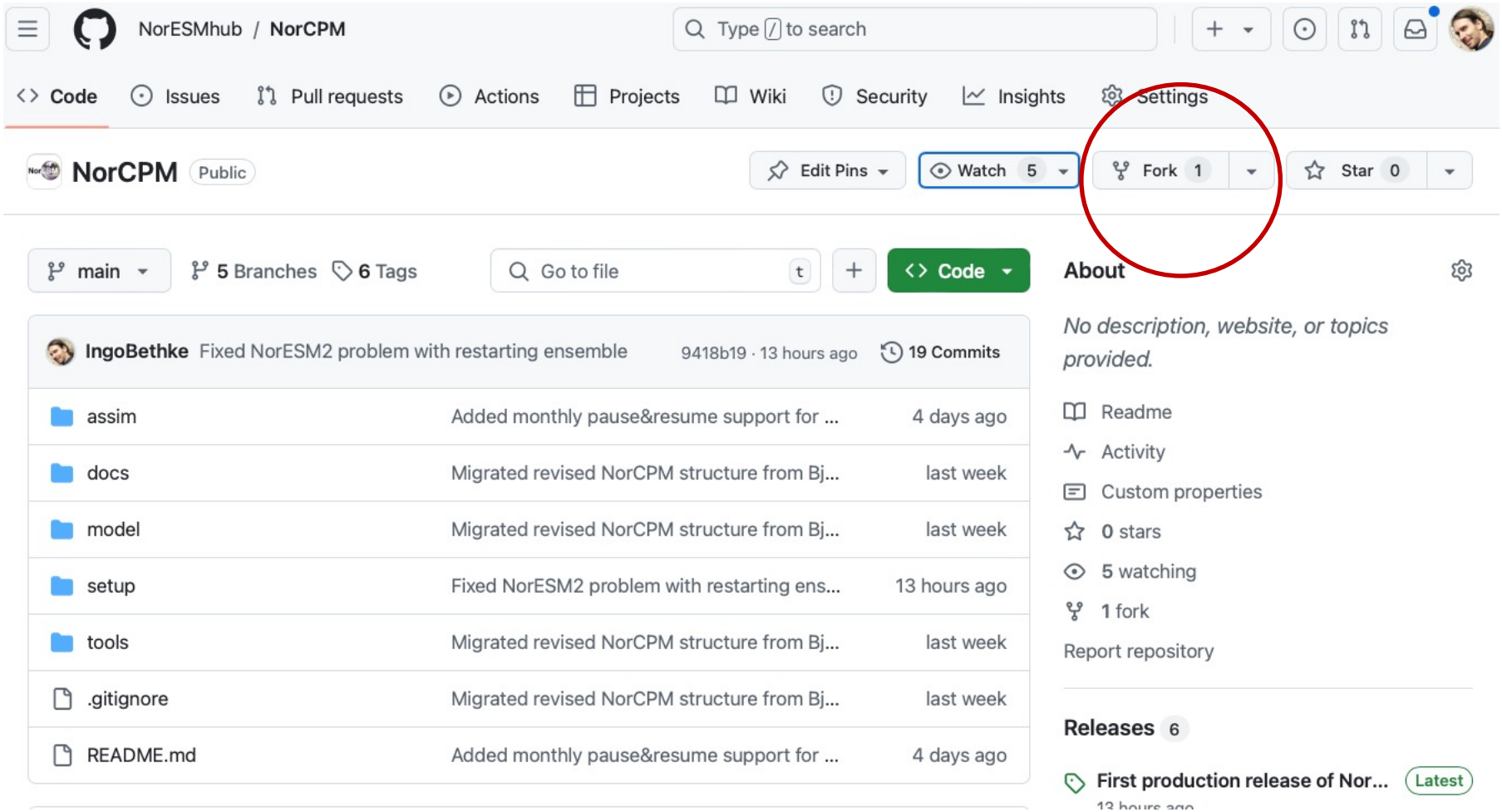
How to contribute to developing NorESMhub/NorCPM



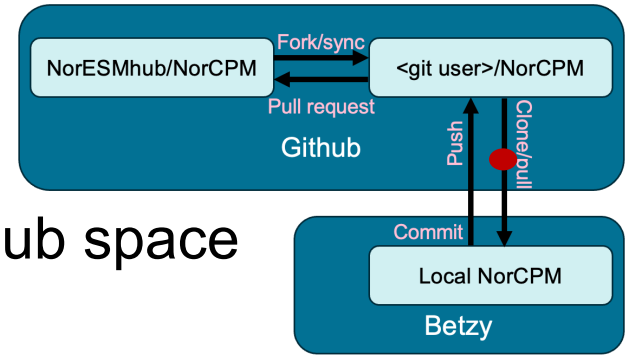
How to contribute to developing NorESMhub/NorCPM



- Step 1: create fork NorESMhub/NorCPM in your personal github space



How to contribute to developing NorESMhub/NorCPM



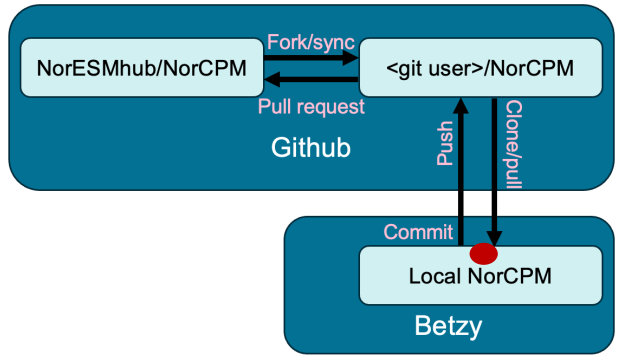
- Step 2: log on to Betzy and clone NorCPM from your personal github space

```
mkdir –p /cluster/projects/nn9039k/people/$USER
cd /cluster/projects/nn9039k/people/$USER
git clone ssh://git@github.com/<my github user>/NorCPM.git NorCPM
```

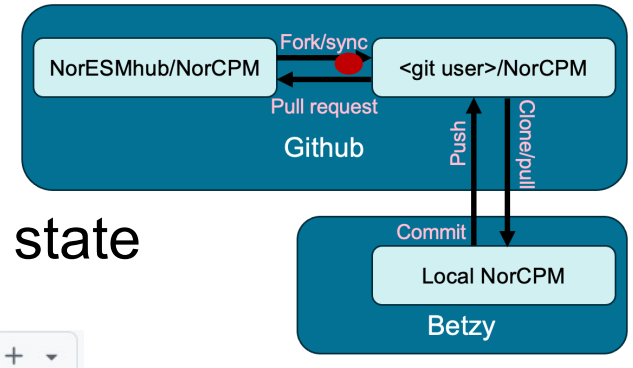
IMPORTANT: Before using ”ssh://git@github.com” form Betzy, create a public ssh-key on Betzy and upload the key to your github profile.

How to contribute to developing NorESMhub/NorCPM

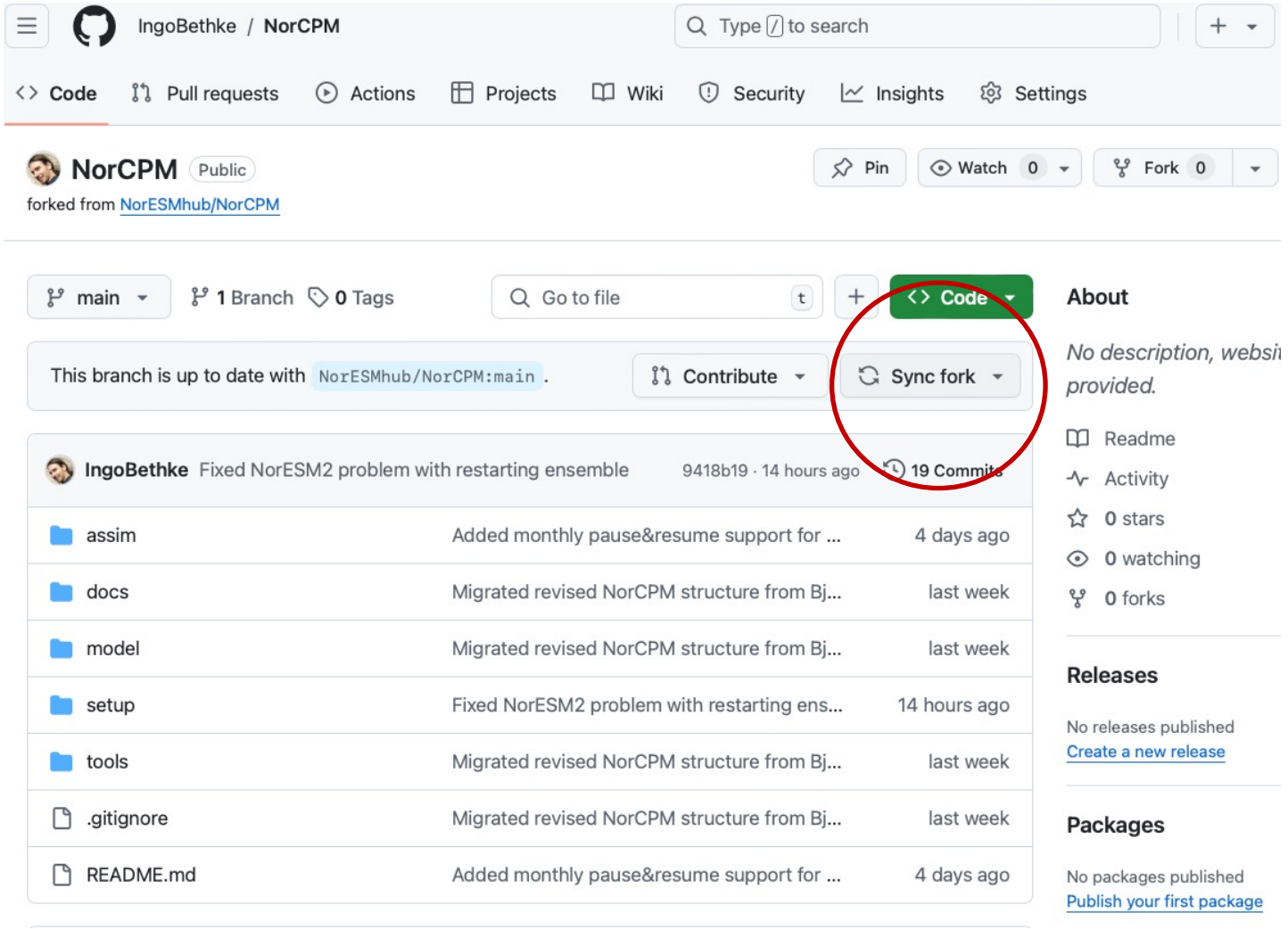
- Step 3: apply changes to your local NorCPM clone on Betzy



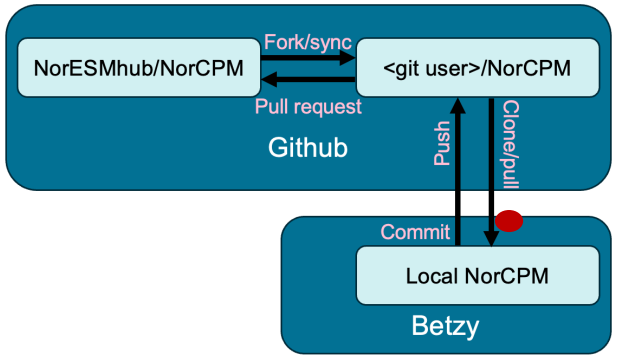
How to contribute to developing NorESMhub/NorCPM



- Step 4: synchronize your fork with the latest NorESMhub/NorCPM state



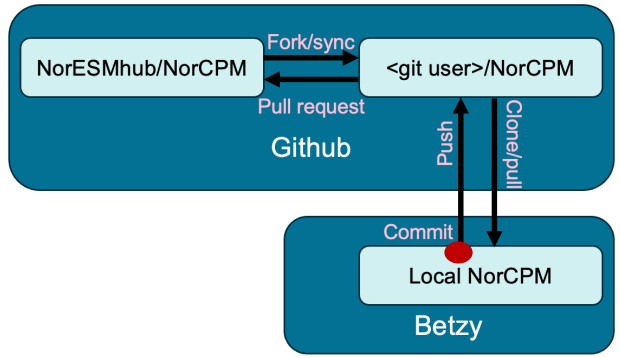
How to contribute to developing NorESMhub/NorCPM



- Step 5: synchronize your local NorCPM clone with your github fork

```
git pull
```

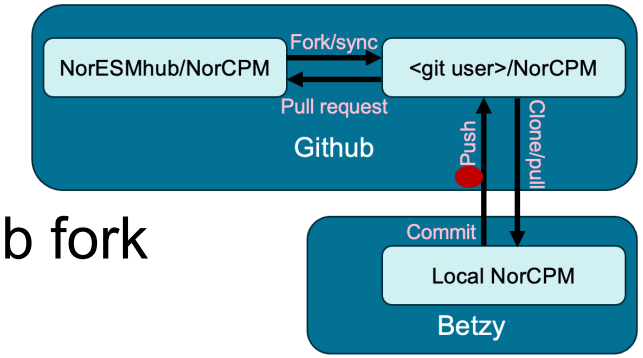
How to contribute to developing NorESMhub/NorCPM



- Step 6: commit your changes to your local NorCPM clone

```
git add .
git status
git commit –m 'my commit message'
```

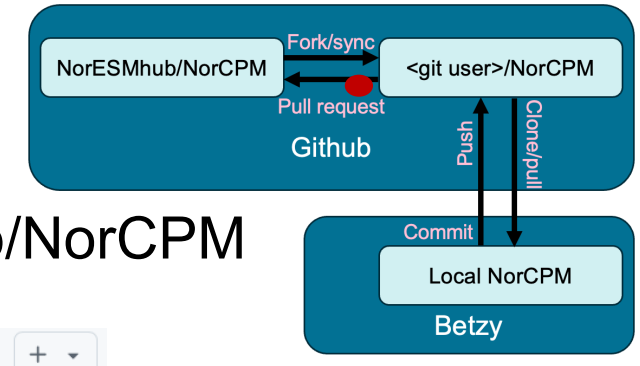
How to contribute to developing NorESMhub/NorCPM



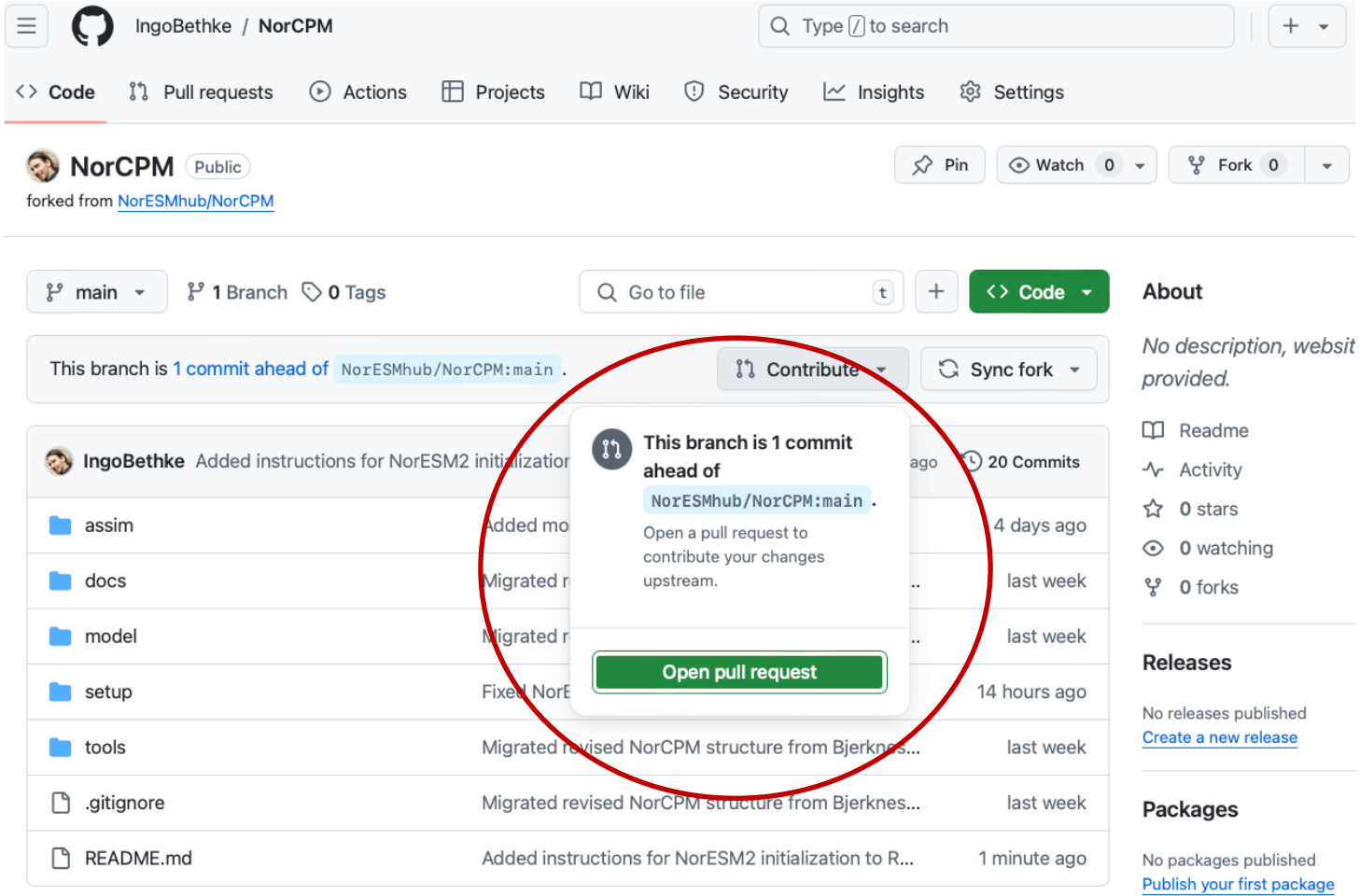
- Step 8: push changes from your local NorCPM clone to your github fork

```
git push
```

How to contribute to developing NorESMhub/NorCPM

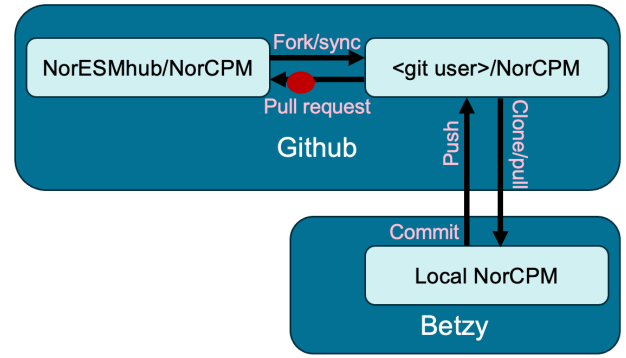


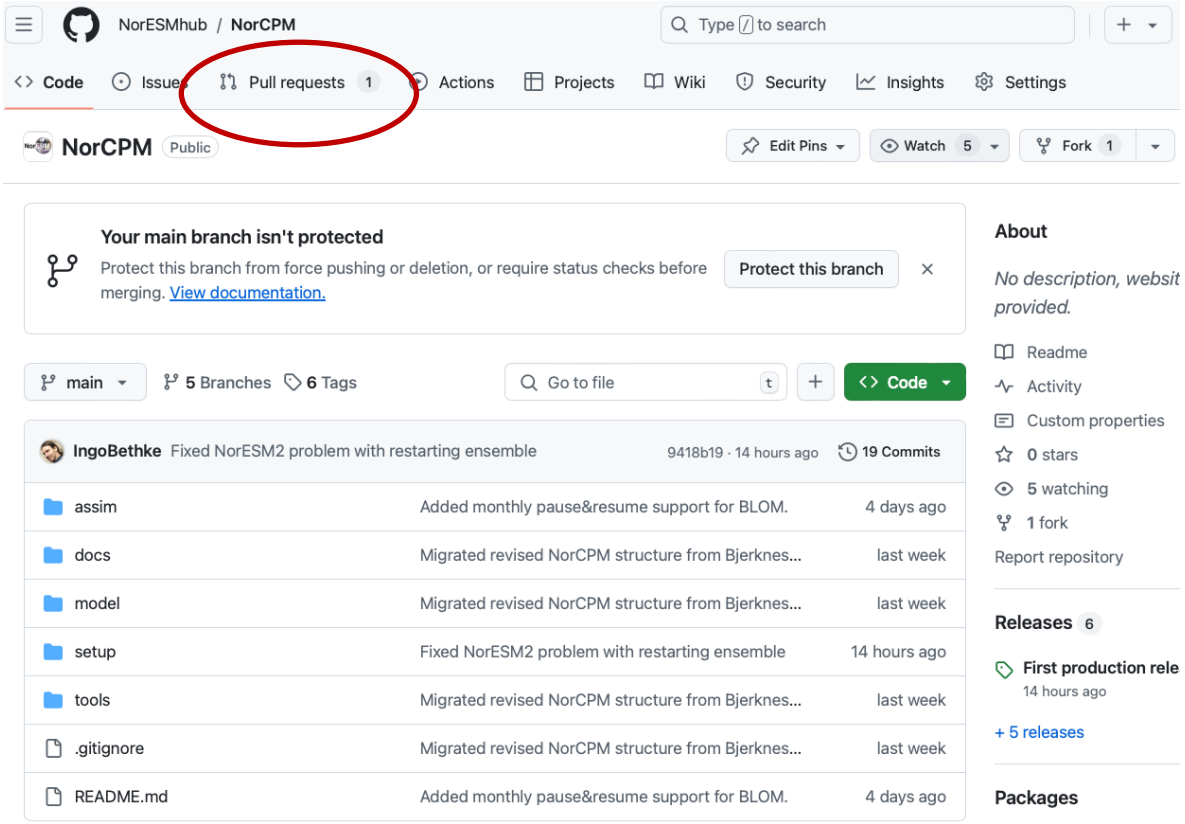
- Step 9: pull request for applying changes from fork to NorESMhub/NorCPM

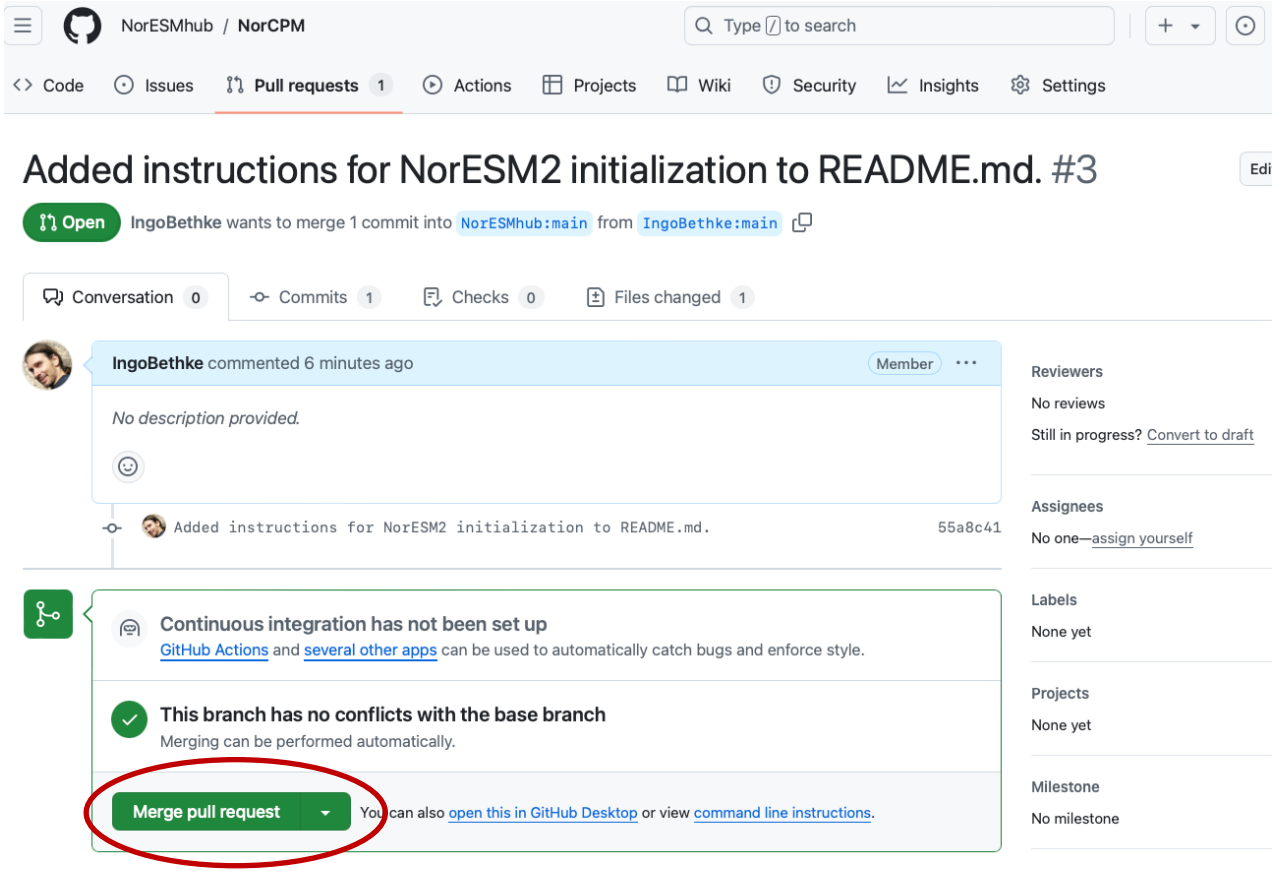


How to contribute to NorCPM

- Step 10: merge pull request (only for maintainers)







Status

- ready-to-use NorESM2 setup with daily SST assimilation and monthly T/S assimilation
- initial conditions available for 10 members for years 1975, 1985, 1996, 2015
- must switch from historical to scenario compset in 2015
- git-workflow for contributing new developments

Coming soon

- more restart members and restart dates for NorESM2-LM
- combined historical-scenario compset that allows running 1850-2100
- support for 1991-2020 reference period (in addition to 1980-2010)
- «full-online» assimilation setup developed by Ping-Gin