

Removing the 2-step Coldstart in UFS-S2S-model

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Current UFS-S2S-model run procedure

Step 1: Run a 1 hour 'cold start' from Initial Conditions (ICs) using a sequential run sequence

Step 2: Using the coupler restart file from (1), start the coupled model using the same ICs (for Atm,Ocn and Ice) in a concurrent run sequence

For the following discussion these will be labeled "Cold1" and "Cold2"

Cold2 in this case is NOT a 'warm start' since it is using the same ICs as Cold1

Why is the two step Coldstart Procedure Used?

- Ocean is running at slow coupling timestep concurrently with ATM and ICE.
- Ocean needs valid fields at the first coupling timestep.
 - Our ICs do not come from a coupled system so we must do something to provide those initial fields and fluxes
- Valid in this context means several things:
 - Non-zero
 - 'Consistent' between ATM-OCN-ICE. Lacking coupled model ICs, the best we can do is to have the model start up in a consistent state for all components.

Problems with the Existing Two-Step Coldstart

- The current Cold1 results in fields of 0.0 being sent to OCN at first coupling timestep of Cold2.
- A 2-step procedure is required for any run start-up, either in Regression Test (RT) system or workflow
 - complexity should only be tolerated when it accomplishes some purpose
- Not User Friendly
 - it is already a source of misunderstanding and confusion from non-EMC users
 - a clean run procedure is critical as we move towards public release of UFS-S2S-model and merging the ufs-weather and ufs-s2s repos

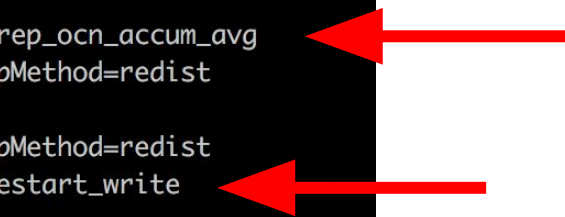
Wait! What do you mean Cold1 is sending 0.0?

Cold1 Run Sequence

- Accumulated fields are zero'd at the end of med_phases_prep_ocn_accum_avg
- The restart file is written after the accum_avg in the restart_write phase
- This means that the accumulation fields in the mediator restart from Cold1 are zero; averaging them at the start of the Cold2 produces 0.0 for the first export to the OCN
- NOTE: This was also what the NEMS mediator was doing

```
# CMEPS cold run sequence

runSeq:
@1800
@450
  MED med_phases_prep_atm
  MED -> ATM :remapMethod=redist
  ATM
  ATM -> MED :remapMethod=redist
  MED med_phases_prep_ice
  MED -> ICE :remapMethod=redist
  ICE
  ICE -> MED :remapMethod=redist
  MED med_fraction_set
  MED med_phases_prep_ocn_map
  MED med_phases_prep_ocn_merge
  MED med_phases_prep_ocn_accum_fast
@
  MED med_phases_prep_ocn_accum_avg
  MED -> OCN :remapMethod=redist
  OCN
  OCN -> MED :remapMethod=redist
  MED med_phases_restart_write
@
::
```




Fixing the Cold1 Run Sequence

Fixed Cold1 Run Sequence

- In CMEPS, the phases can be easily reordered
- Inserting the restart_write prior to accum_avg means the coupler restart file will have non-zero values for the accumulation fields
- The first step of the Cold2 run sequence is to average the accumulation fields so this will provide correctly averaged accumulations the first time OCN runs in Cold2

```
# CMEPS cold run sequence

runSeq:
  @1800
  @450
    MED med_phases_prep_atm
    MED -> ATM :remapMethod=redist
    ATM
    ATM -> MED :remapMethod=redist
    MED med_phases_prep_ice
    MED -> ICE :remapMethod=redist
    ICE
    ICE -> MED :remapMethod=redist
    MED med_fraction_set
    MED med_phases_prep_ocn_map
    MED med_phases_prep_ocn_merge
    MED med_phases_prep_ocn_accum_fast
  @
  MED med_phases_restart_write
  MED med_phases_prep_ocn_accum_avg
  MED -> OCN :remapMethod=redist
  OCN
  OCN -> MED :remapMethod=redist
@
::
```




A One-step Coldstart using Ocean Lag at startup

- With ESMF, each component's ModelAdvance is from CurrTime => CurrTime + coupling_timestep
 - Internally, the component model takes as many timesteps as required to advance to this Time
- Using Ocean Lag, OCN does not advance at FIRST coupling timestep
- At the SECOND coupling timestep:
 - the currTime is set back to the StartTime
 - the OCN advances from currTime => currTime + 2*coupling_timestep
 - the OCN ModelAdvance ends at the same "Time" as 2 advances of a non-lagged run

Ocean Lag cont'd

- All subsequent coupling timesteps in the Cold2 run sequence occur normally
- No Ocean Lag is required for restarts from Cold2 (ie, true 'warm starts').
 - In the Cold2 run sequence, the accum_avg occurs first in the run sequence, using the (non-zero) accumulation fields written as the last step of the previous Cold2 run.

```
# CMEPS warm run sequence
runSeq::
@1800
MED med_phases_prep_ocn_accum_avg
MED -> OCN :remapMethod=redist
OCN
MED med_phases_history_write
@450
MED med_phases_prep_atm
MED med_phases_prep_ice
MED -> ATM :remapMethod=redist
MED -> ICE :remapMethod=redist
ATM
ICE
ATM -> MED :remapMethod=redist
ICE -> MED :remapMethod=redist
MED med_fraction_set
MED med_phases_prep_ocn_map
MED med_phases_prep_ocn_merge
MED med_phases_prep_ocn_accum_fast
MED med_phases_profile
@
OCN -> MED :remapMethod=redist
MED med_phases_restart_write
@
::
```



Testing One Step Coldstart vs Two Step Coldstart

- All runs used same ufs-s2s-model branch and same executable: [S2S branch](#) containing:
 - FV3@develop + Jun's fv3_cmepsIC branch.
 - This change is critical: it provides bottom layer values to ice at the first fast coupling timestep
 - MOM6 with small change to read configuration variable 'use_coldstart'
- Run 3 cases for 12 hours each:
 - Original Cold1 + Cold2
 - Fixed Cold1 + Cold2
 - Cold2 only (with Ocean Lag)
- Include instantaneous coupler history files written after each OCN run step

Results from the 3 Test Cases will show:

- 1.** The current Cold2 run is getting fields of "0.0" for ocean import on the first coupling time step.
- 2.** The Cold1 run sequence can be fixed (page 6) to send non-zero fields to the ocean on the first coupling time step of the Cold2 run
- 3.** Using a one-step Coldstart creates nearly identical fields for SST after 12 hours of integration compared to the two-step Coldstart
- 4.** The one-step Coldstart can provide consistent initial fields to the coupled model at startup

1) Cold1 results in 0.0 fields for Cold2 at the first advance

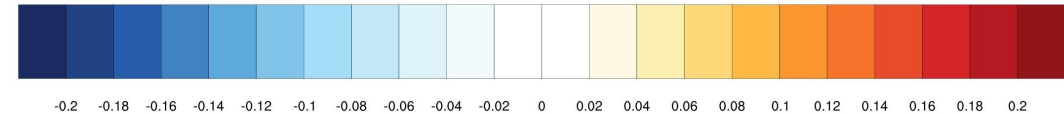
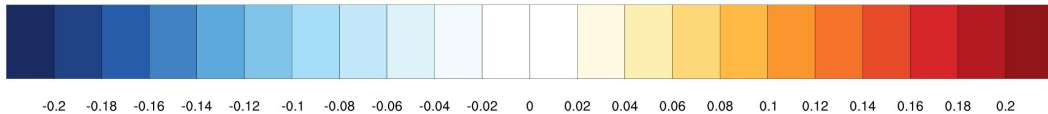
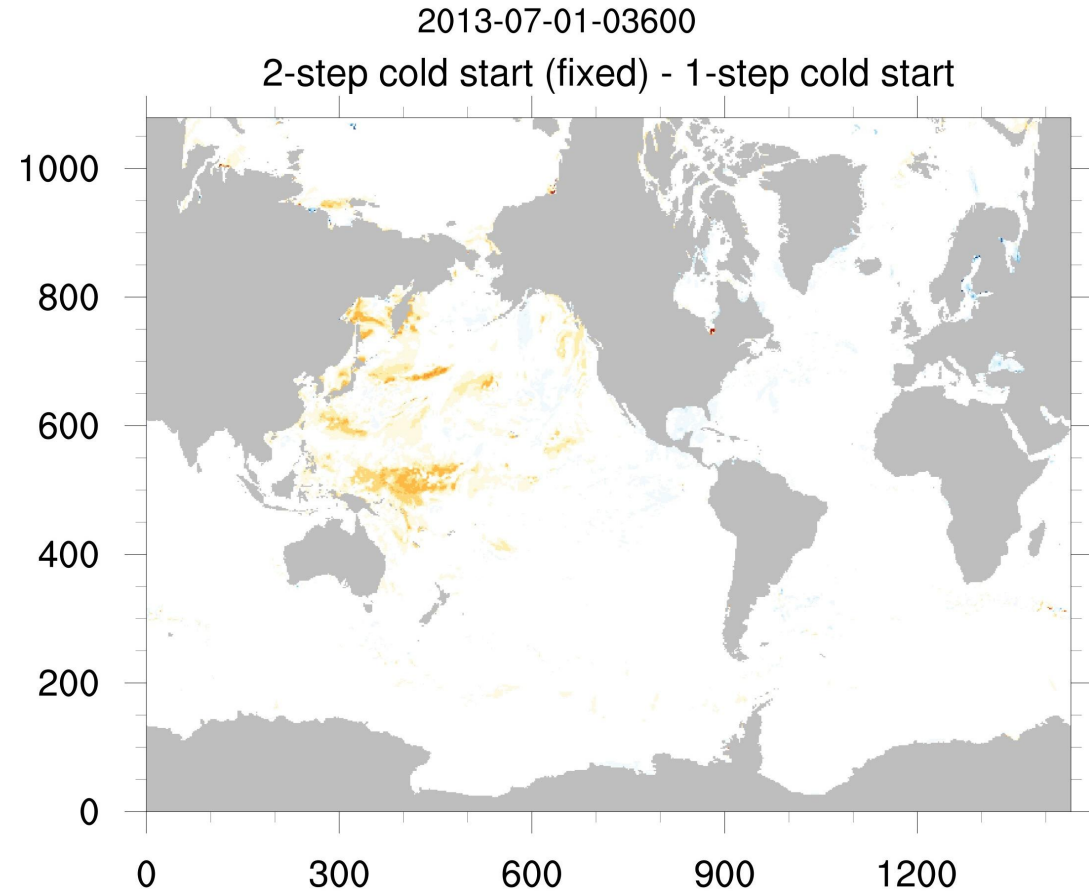
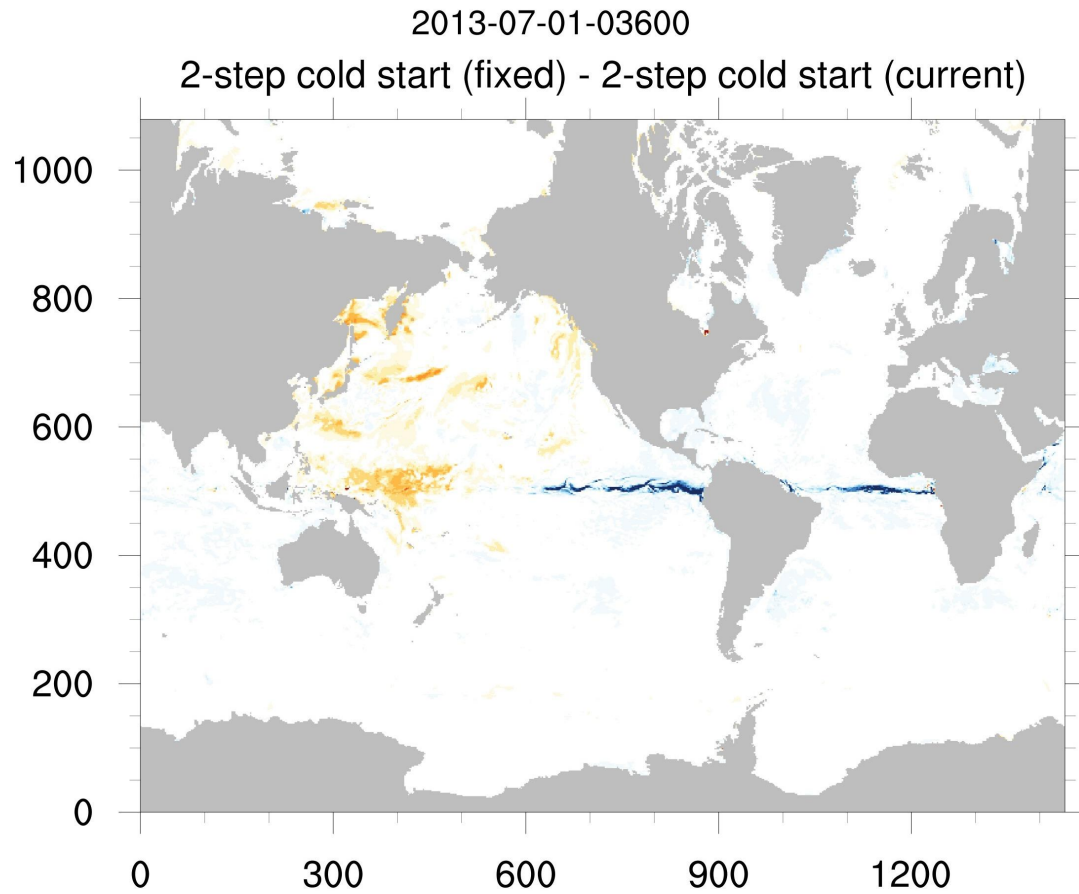
```
PET320 MOM6 - Initialize-Data-Dependency SATISFIED!!!
PET320 MOM_cap:(ModelSetRunClock) Restart_n = 840
PET320 MOM_cap:(ModelSetRunClock) Restart_option = nhours
PET320 MOM_cap:(ModelSetRunClock) Restart_ymd = -999
PET320 MOM_cap:(ModelSetRunClock) Restart alarm is Created and Set
PET320 MOM_cap:(ModelSetRunClock) Create Stop alarm
PET320 Stop Alarm will ring at : 2013-07-01T12:00:00
PET320 (MOM_cap:ModelAdvance)----->Advancing OCN from: 2013 7 1 0 0 0 0 ← First OCN Advance
PET320 -----> to: 2013 7 1 0 30 0 0
PET320 (MOM_cap:ModelAdvance):IS: cpl_scalars no data
PET320 (MOM_cap:ModelAdvance):IS: inst_pres_height_surface 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_evap_rate 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_fprec_rate 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_fresh_water_to_ocean_rate 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_merid_moment_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_lw_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_ir_dif_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_ir_dir_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_vis_dif_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_vis_dir_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_prec_rate 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_salt_rate 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_sensi_heat_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_zonal_moment_flx 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: net_heat_flx_to_ocn 0.000000 0.000000 0.000000 12960
```

2) Cold1 can be fixed to not send 0.0 fields

```
PET320 MOM6 - Initialize-Data-Dependency SATISFIED!!!
PET320 MOM_cap:(ModelSetRunClock) Restart_n = 840
PET320 MOM_cap:(ModelSetRunClock) Restart_option = nhours
PET320 MOM_cap:(ModelSetRunClock) Restart_ymd = -999
PET320 MOM_cap:(ModelSetRunClock) Restart alarm is Created and Set
PET320 MOM_cap:(ModelSetRunClock) Create Stop alarm
PET320 Stop Alarm will ring at : 2013-07-01T12:00:00
PET320 (MOM_cap:ModelAdvance)----->Advancing OCN from: 2013 7 1 0 0 0 0
PET320 -----> to: 2013 7 1 0 30 0 0
PET320 (MOM_cap:ModelAdvance):IS: cpl_scalars no data
PET320 (MOM_cap:ModelAdvance):IS: inst_pres_height_surface 0.000000 100612.0 0.8569605E+09 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_evap_rate-0.3110095E-04 0.000000 -0.7478987E-02 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_fprec_rate 0.000000 0.1248357E-04 0.1599360E-02 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_fresh_water_to_ocean_rate-0.1397692E-02 0.2266772E-12 -1.830169 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_merid_moment_flux-0.1203466 0.2190484 10.86190 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_lw_flux -82.99661 0.000000 -20782.06 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_ir_dif_flux 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_ir_dir_flux 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_vis_dif_flux 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_net_sw_vis_dir_flux 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_prec_rate 0.000000 0.000000 0.000000 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_salt_rate-0.5590619E-05 0.8344722E-15-0.7345417E-02 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_sensi_heat_flux -181.5108 0.000000 -44937.27 12960
PET320 (MOM_cap:ModelAdvance):IS: mean_zonal_moment_flux-0.7081625E-01 0.2037039 132.1076 12960
PET320 (MOM_cap:ModelAdvance):IS: net_heat_flux_to_ocn -26.85005 0.000000 -22224.01 12960
```

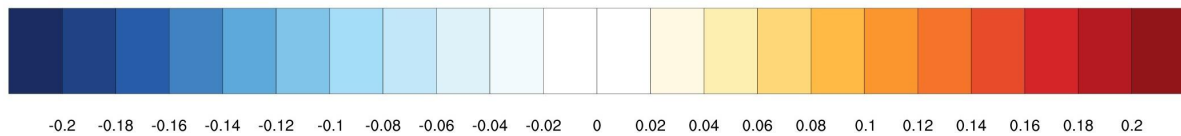
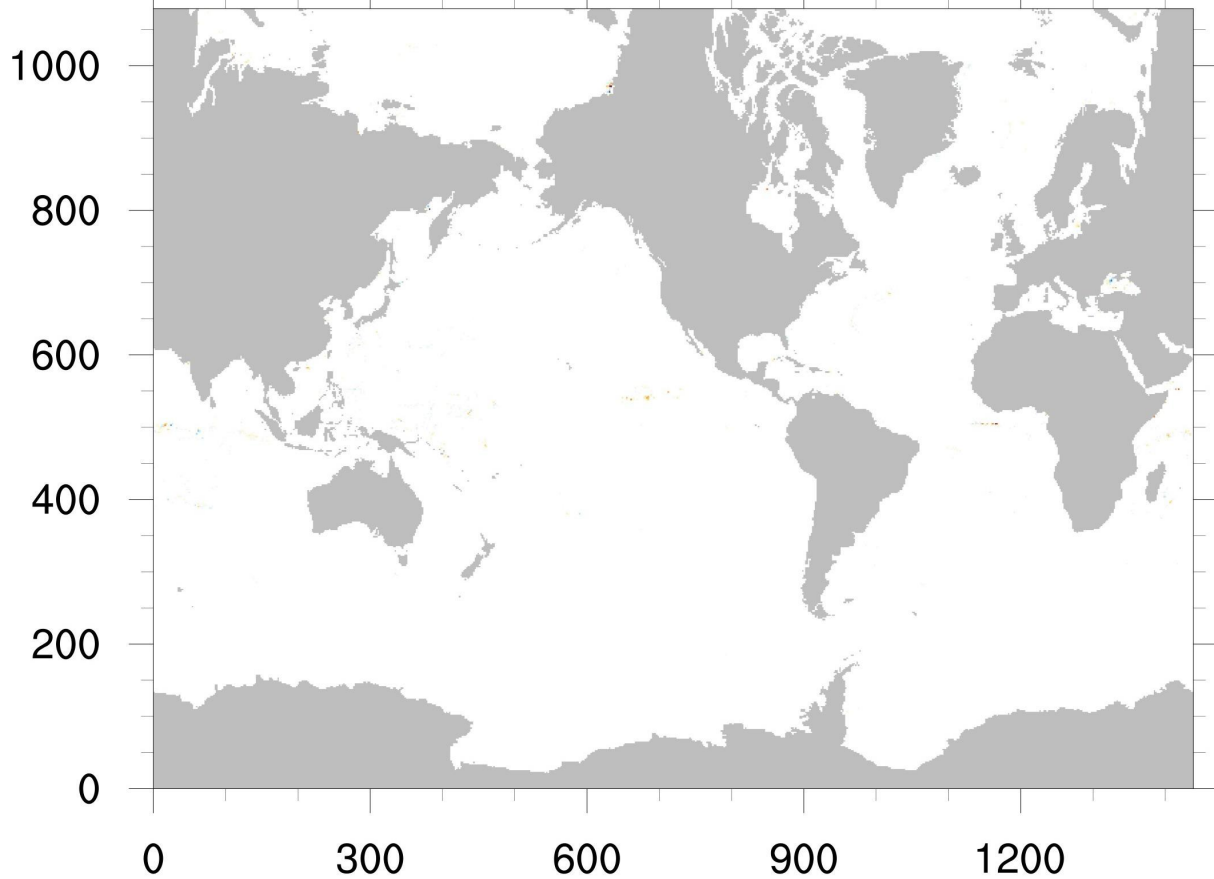
← First OCN Advance

2) Instantaneous SST differences from coupler history after 1 hour



2013-07-01-43200

2-step cold start - 1-step cold start

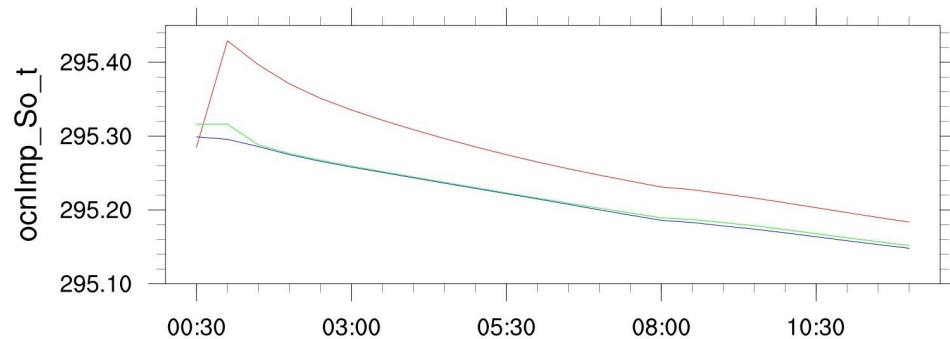
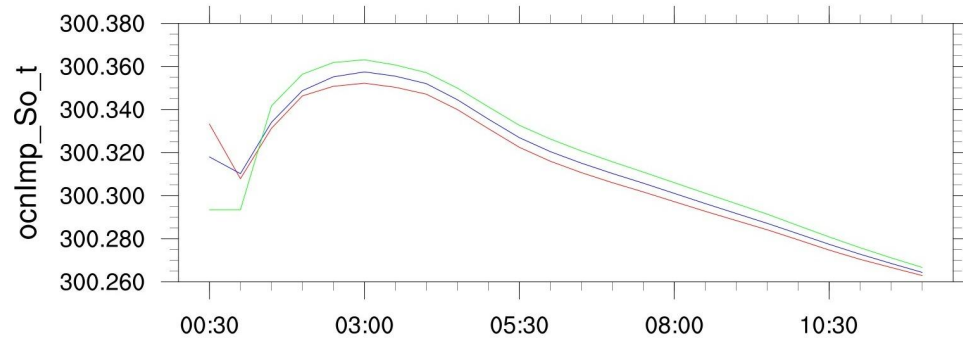
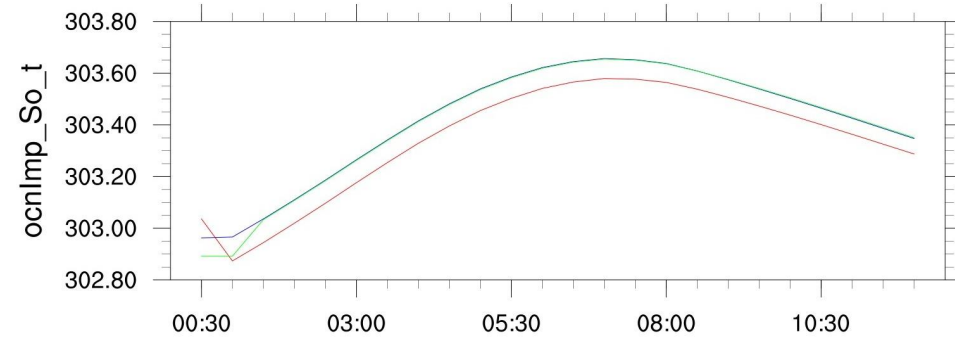


3) Instantaneous SST differences from coupler history after **12 hours:**

- Differences between two step Coldstart and one step Coldstart are nearly zero after **12 hours**
- What is the advantage of two steps if a one step produces the same result?

4) Single Point SST timeseries

- Three locations across Pacific at $\sim 1^{\circ}\text{S}$ illustrate the single step Coldstart evolves very similarly to the two step Coldstart
- The impact of using Ocean Lag at startup is short lived



- 2-step cold start (current)
- 2-step cold start (fixed)
- 1-step cold start

The similarity of the fixed two-step and the one step coldstart with Ocean Lag makes sense.

In both cases, the first OCN advance occurs using ATM/ICE fields averaged over the T=30min:1hour interval

Results of 3 Cases show:

- The current two-step Coldstart procedure is not working as intended
- The two-step Coldstart procedure could be fixed
- Using one-step Coldstart (Cold2 with Ocean Lag) for startup is simpler and produces nearly identical results after 12 hours

Conclusion:

- We should abandon the two step Coldstart and replace it with a one step Coldstart with Ocean Lag for startup.
- Ocean Lag is required only for startup. Restarts of the coupled model (Cold2=>Cold2) do not require Ocean Lag.