Distributed Land in the SPCESM

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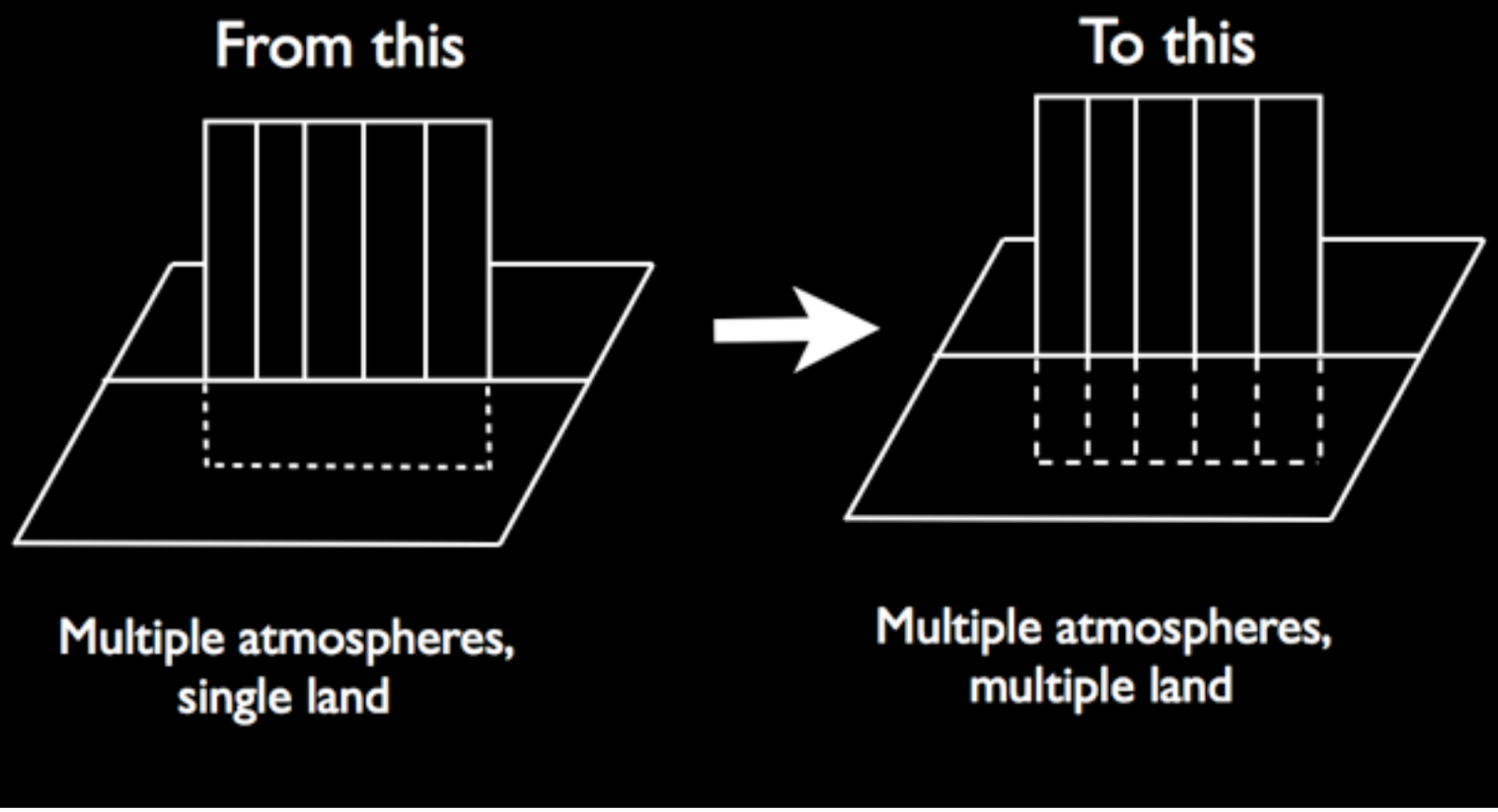
Superparameterized CESM (SP-CESM)



Multi-Instance Functionality in the CESM

- CESM1.1 includes new capability to run multiple component instances under one model executable
- **Caveat:** if N multiple instances of any one active component is used then N multiple instances of **ALL** active components are required
- Primary motivation: Ability to run an ensemble kalman filter for data assimilation and parameter estimation.
- Also provides ability to run a set of experiments within a single CESM executable (each instance can have a different namelist)

Multiple Component Instances in the SPCESM

- Extend multi-instance capability to couple each cloud-resolving model (CRM) column with a unique land grid cell
  - **Trick in env_mach_pes.xml:** Set NINST_ATM=NINST_LND (= # of CRMS) but set NINST_ATM_LAYOUT to "sequential" instead of "concurrent"
- One instance of CAM running, but the coupler will think there are as many instances as cloud columns per grid cell

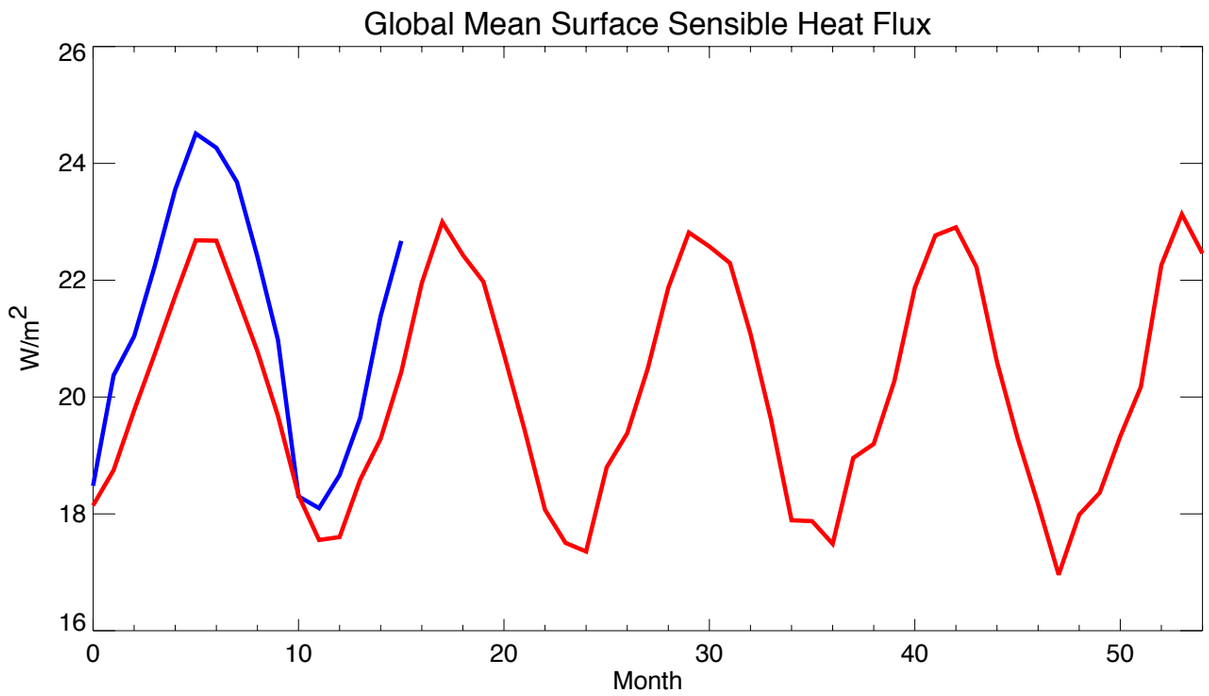
Software Engineering

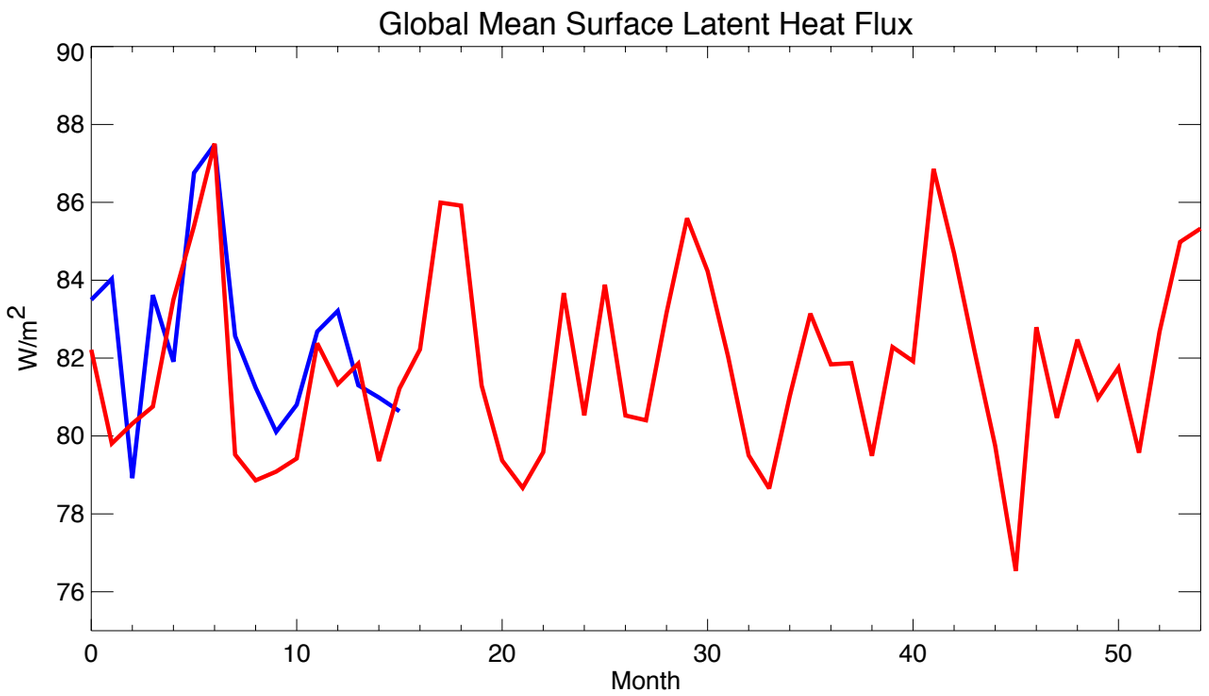
- Add **inst_index** component to coupler variables: sensible and latent heat fluxes, albedos, surface upward longwave flux, etc.
  - cam_in%shf(ncols) becomes cam_in%shf(ncols,inst_index) in coupler code
  - cam_in%shf(ncols) becomes cam_in%shf(ncols,crm_nx) in CAM code
    - Do this **everywhere** they are found!!!

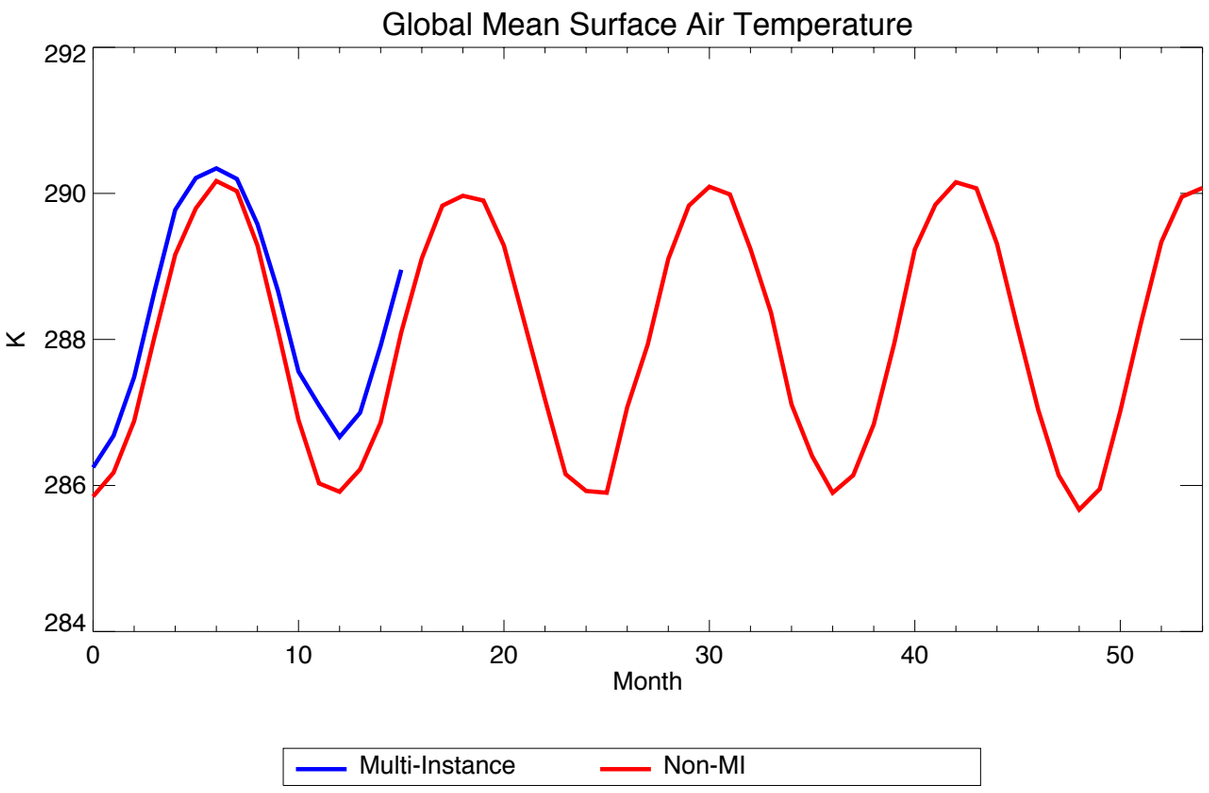
Software Engineering (2)

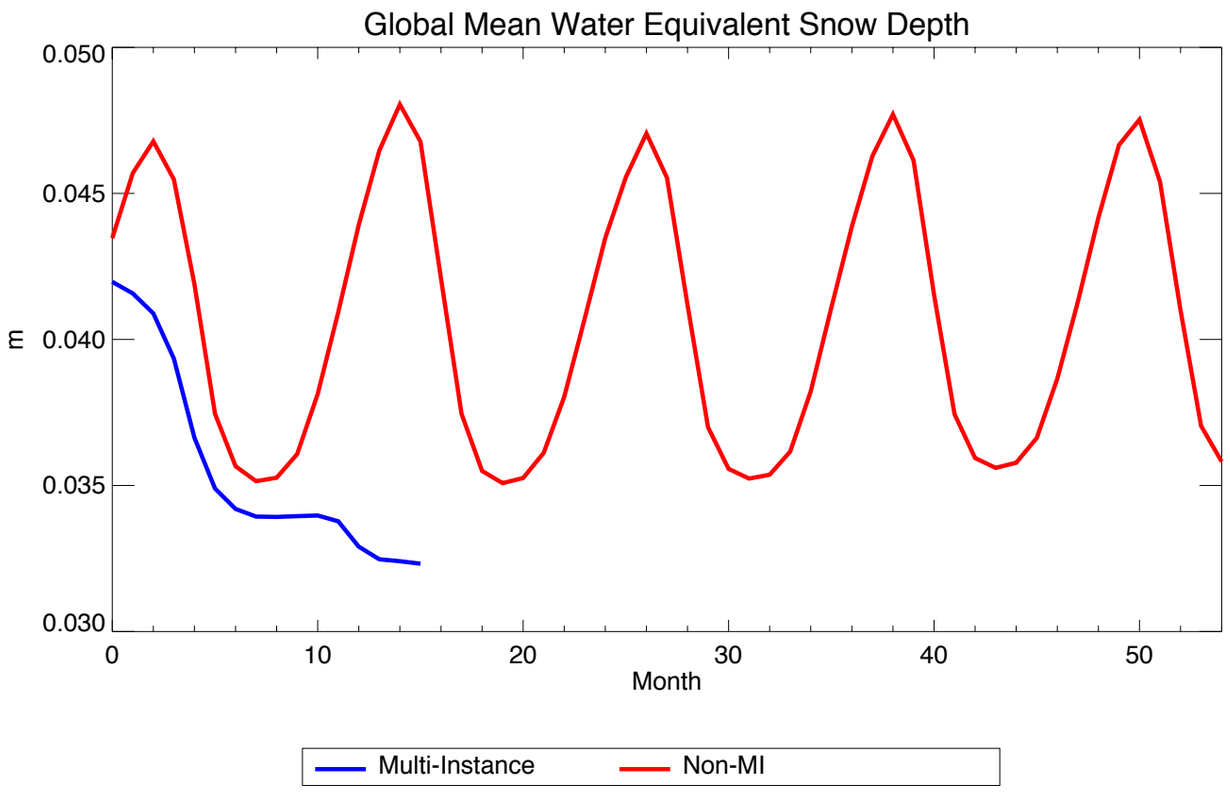
- Pass CRM-level variables through coupler to CLM:
  - Lowest layer: T, U, V, q, z, rho, theta
  - Rain and snow
  - Radiation: surface downward LW, sfc net SW, etc.
- **Turn the CRM-level v winds back on!**

RESULTS FROM LAST TIME

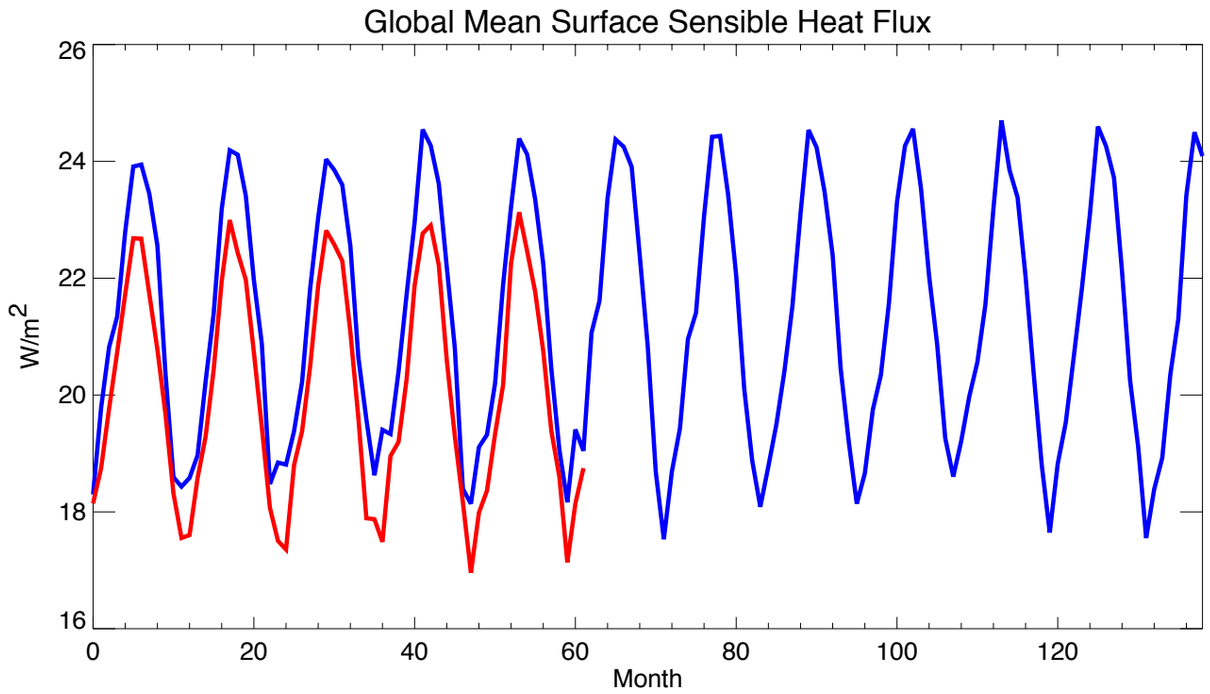


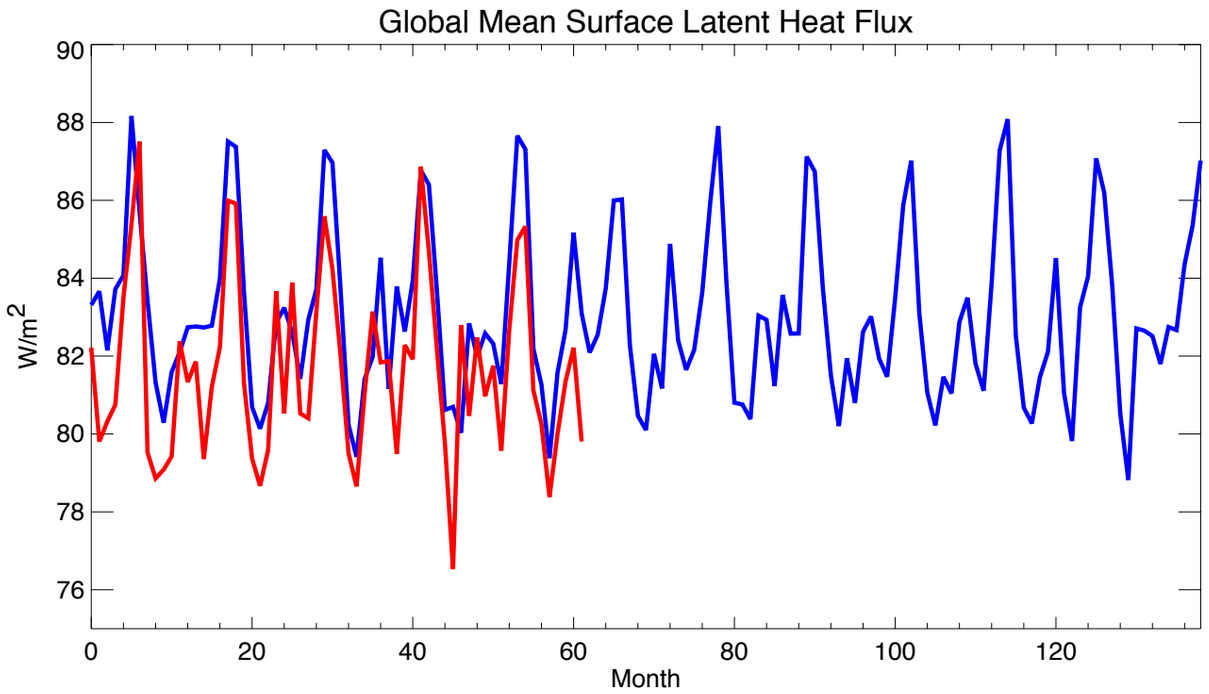


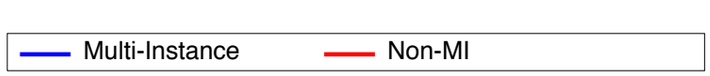


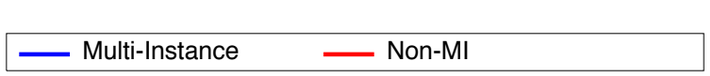


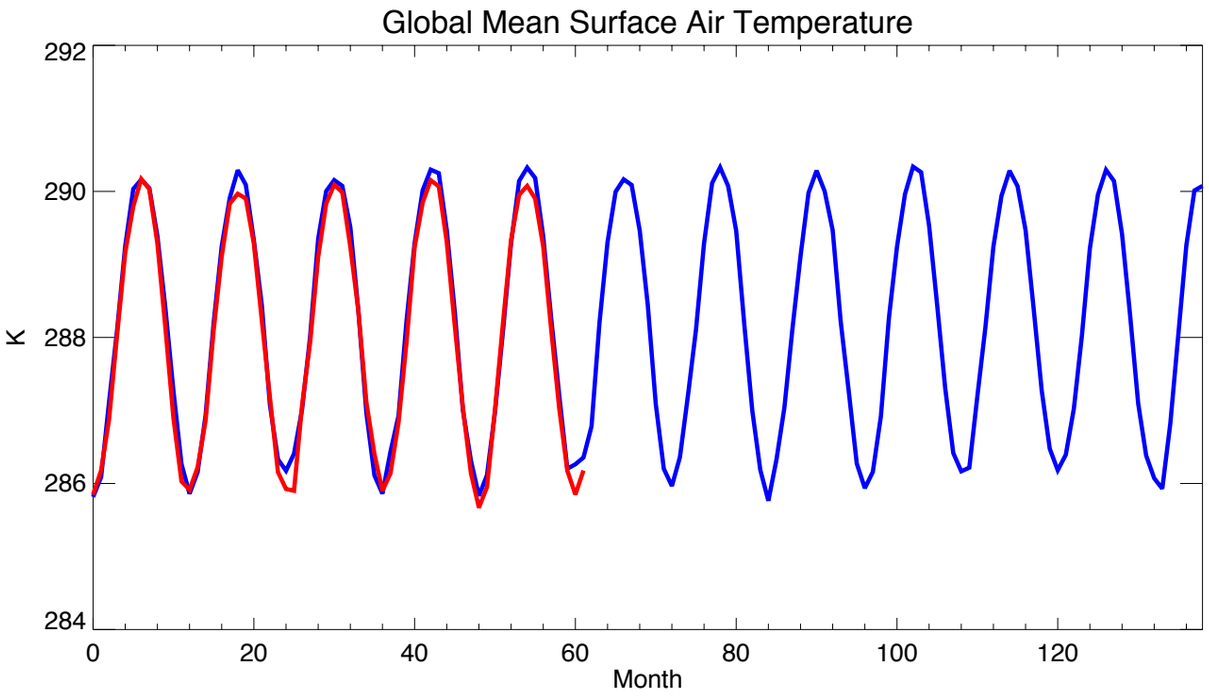
NEW RESULTS

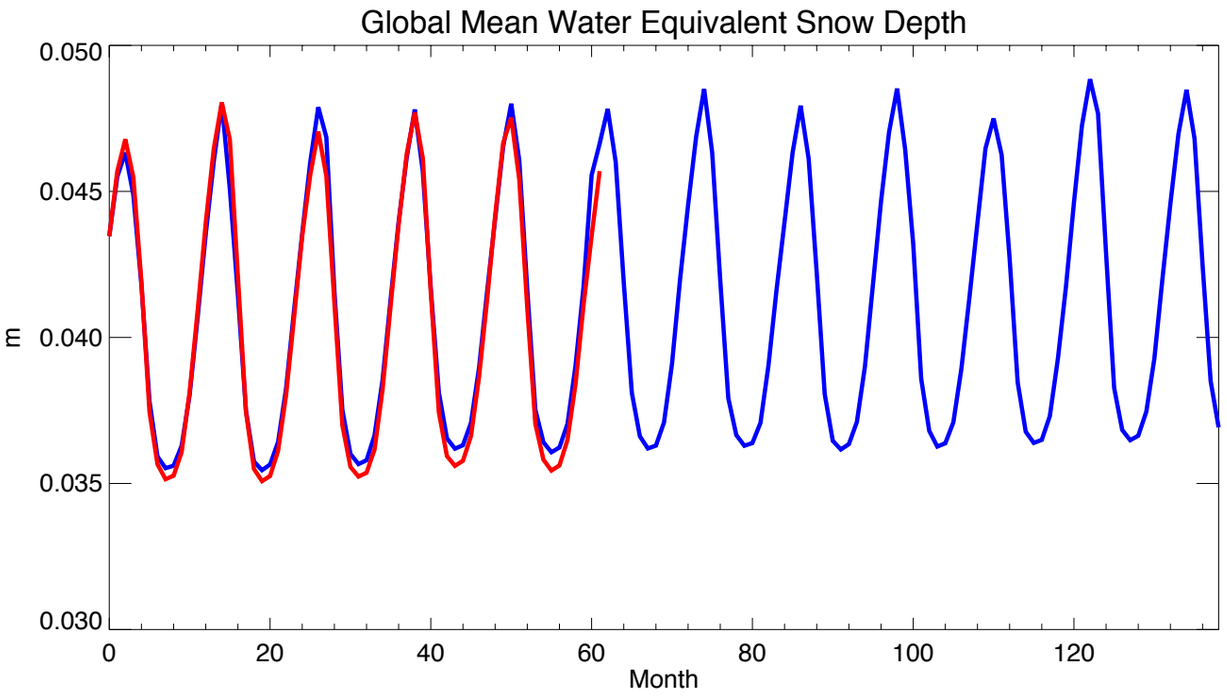

Global Mean Surface Sensible Heat Flux
W/m2
Month
26
24
22
20
18
16
0
20
40
60
80
100
120

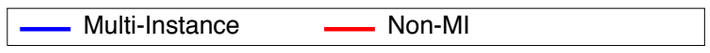

Global Mean Surface Latent Heat Flux
W/m2
Month
90
88
86
84
82
80
78
76
0
20
40
60
80
100
120

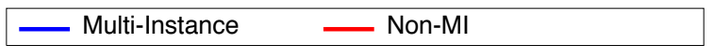

Multi-Instance
Non-MI


Multi-Instance
Non-MI

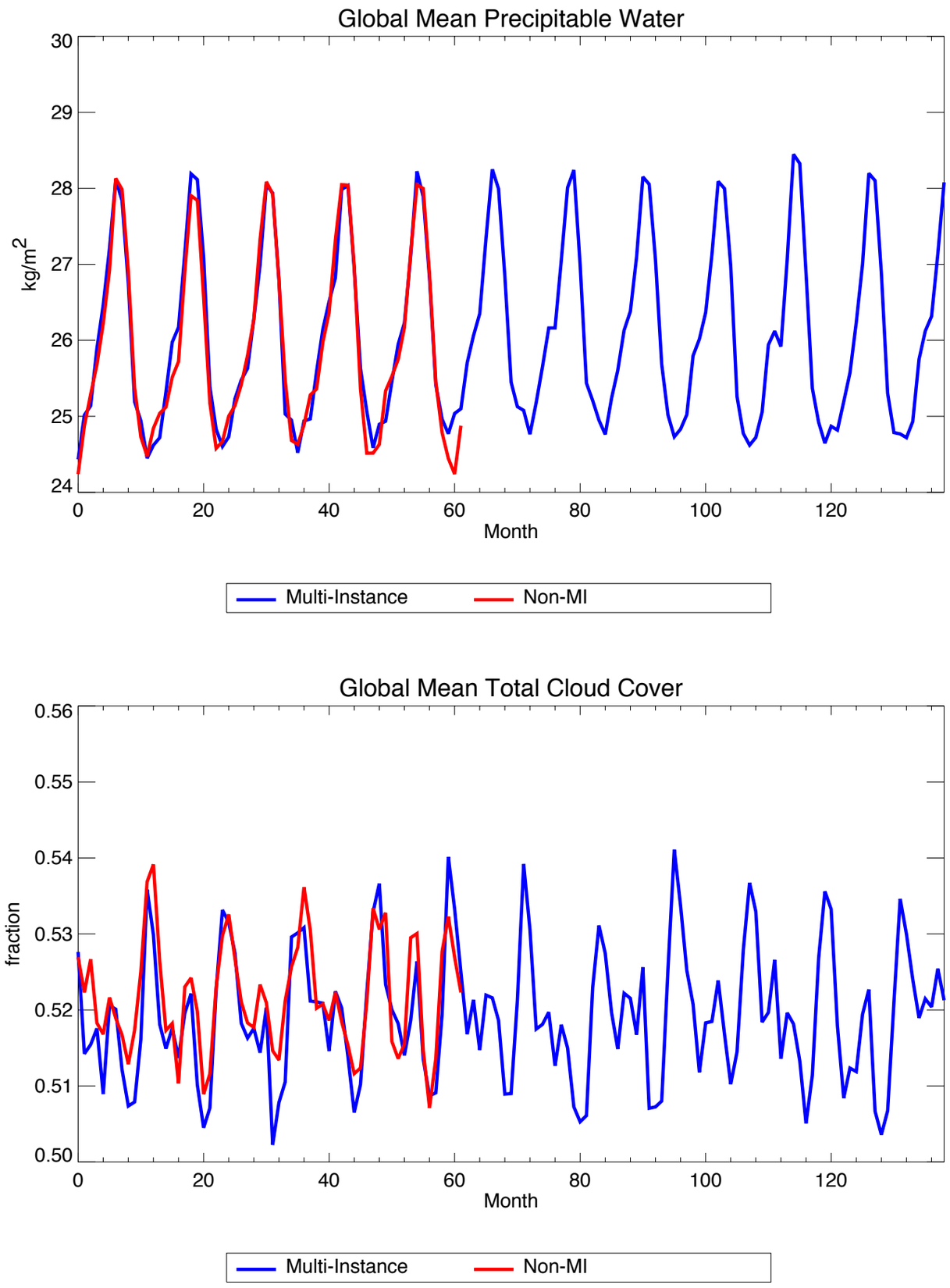

Global Mean Surface Air Temperature
K
Month
292
290
288
286
284
0
20
40
60
80
100
120

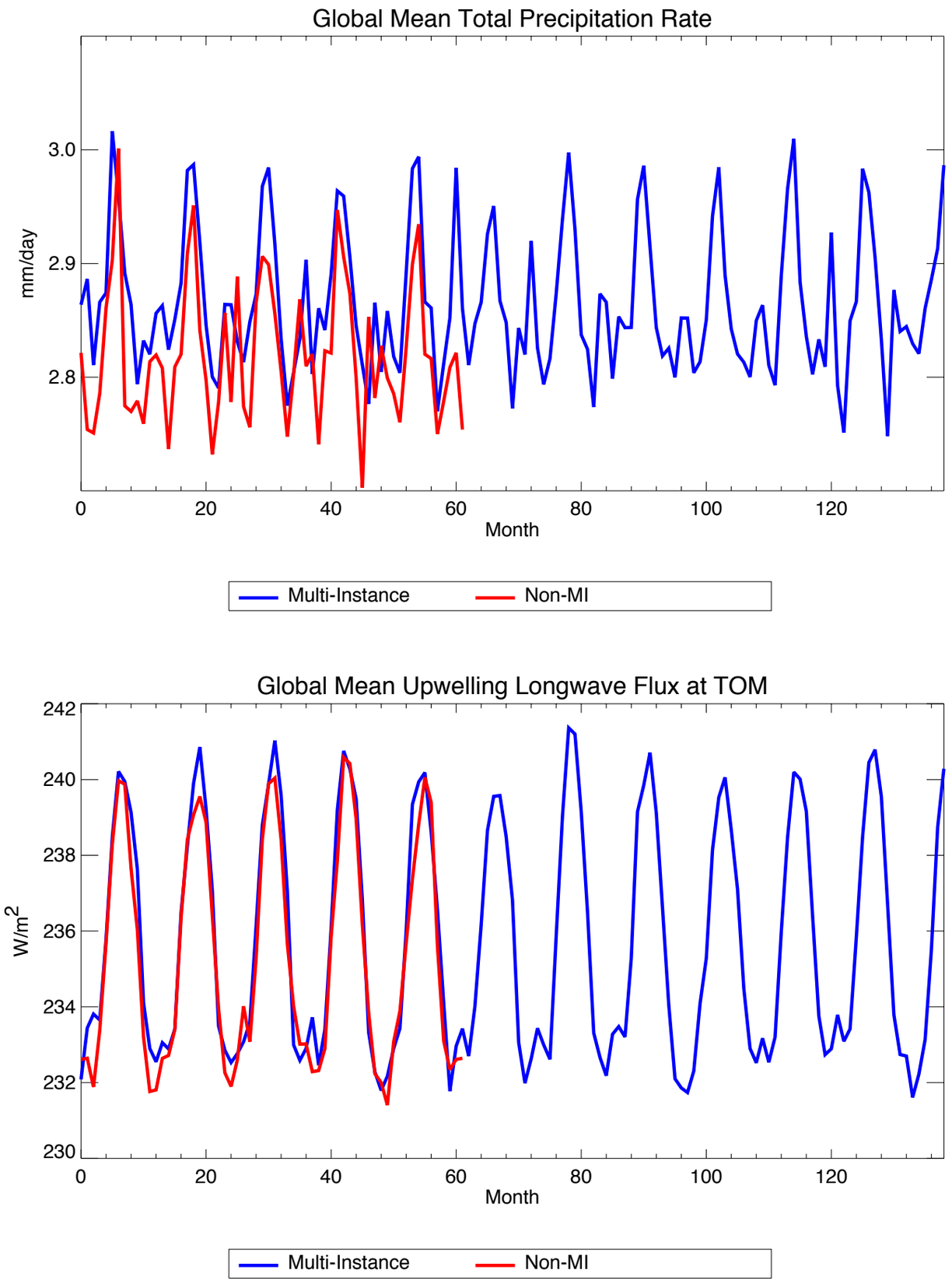

Global Mean Water Equivalent Snow Depth
m
Month
0.050
0.045
0.040
0.035
0.030
0
20
40
60
80
100
120


Multi-Instance
Non-MI


Multi-Instance
Non-MI

NEW RESULTS


Global Mean Precipitable Water
kg/m2
Month
Multi-Instance
Non-MI


Global Mean Total Precipitation Rate
mm/day
Month
Multi-Instance
Non-MI

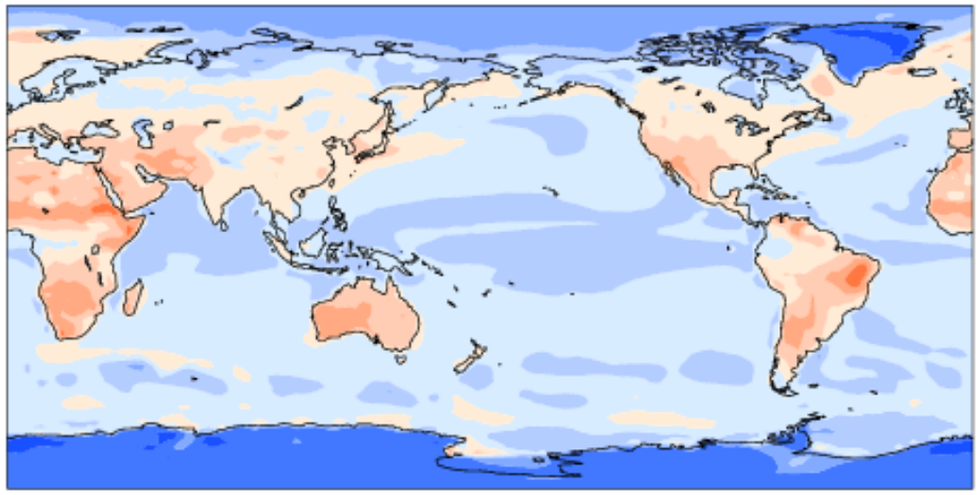
Global Mean Total Cloud Cover
fraction
Month
Multi-Instance
Non-MI

Global Mean Upwelling Longwave Flux at TOM
W/m2
Month
Multi-Instance
Non-MI

Sensible Heat Flux

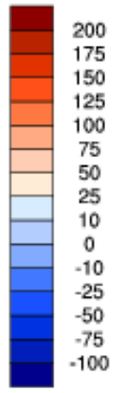
SPCAM_multi_instance (yrs 2-11)

Surf sensible heat mean= 21.31 W/m^2



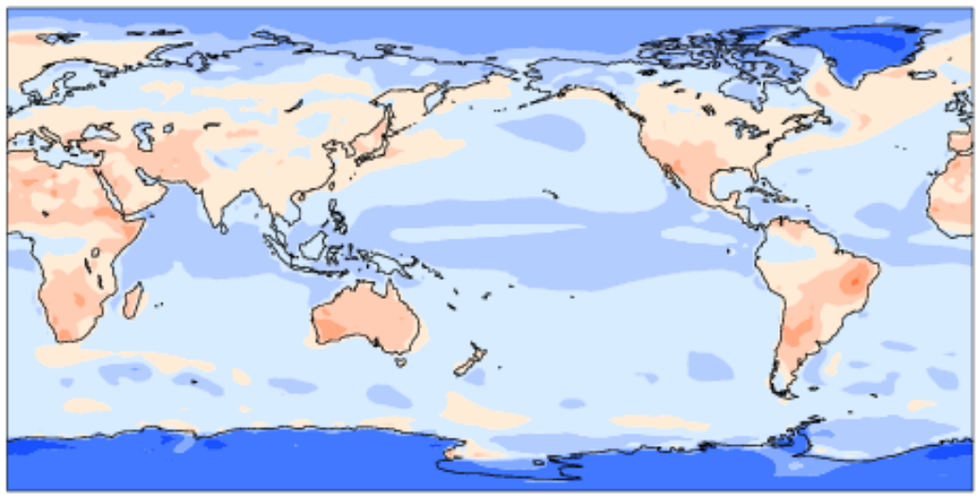
ANN

Min = -30.07 Max = 115.88

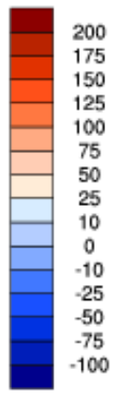


SPCAM_cntl (yrs 1-5)

Surf sensible heat mean= 20.13 W/m^2

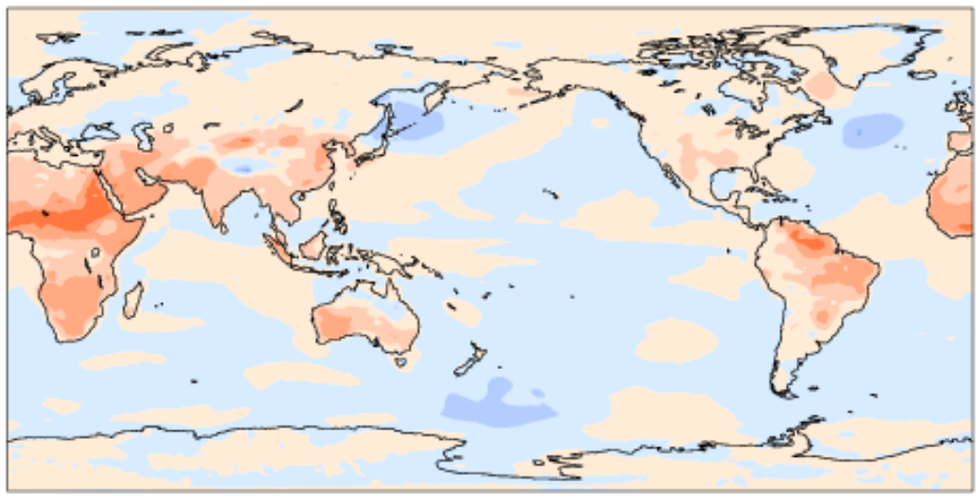


Min = -30.41 Max = 104.75

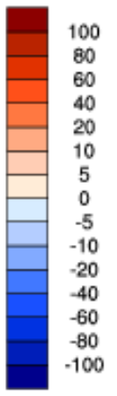


SPCAM_multi_instance - SPCAM_cntl

mean = 1.18 rmse = 4.61 W/m^2



Min = -11.92 Max = 37.91



Surface Temperature

SPCAM_multi_instance (yrs 2-11)

Surf Temp (radiative) mean= 288.20 K

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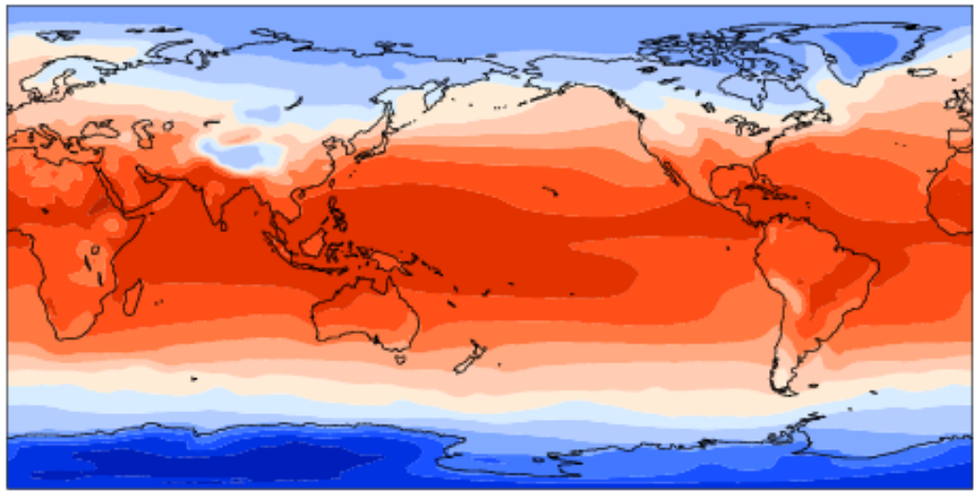
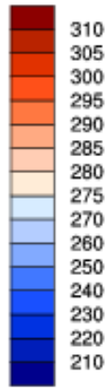
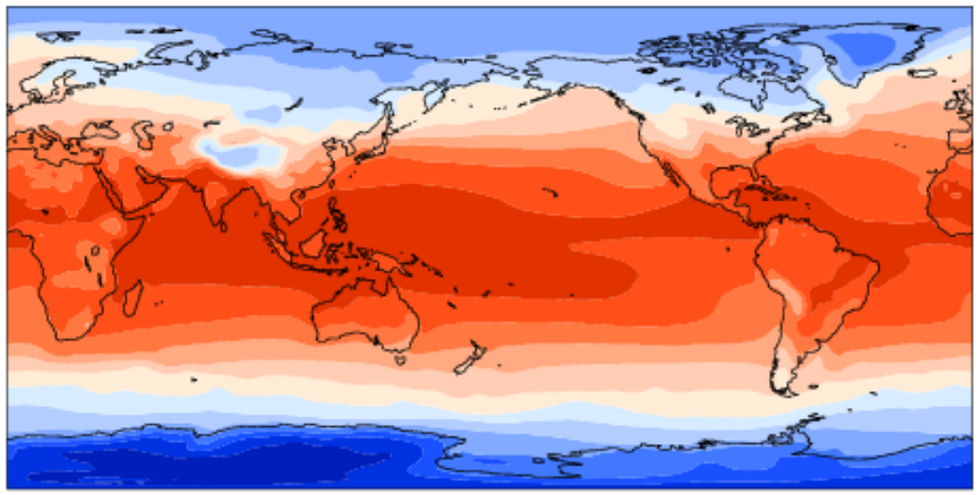


Min = 213.74 Max = 306.80

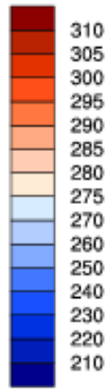


SPCAM_cntl (yrs 1-5)

Surf Temp (radiative) mean= 288.07 K

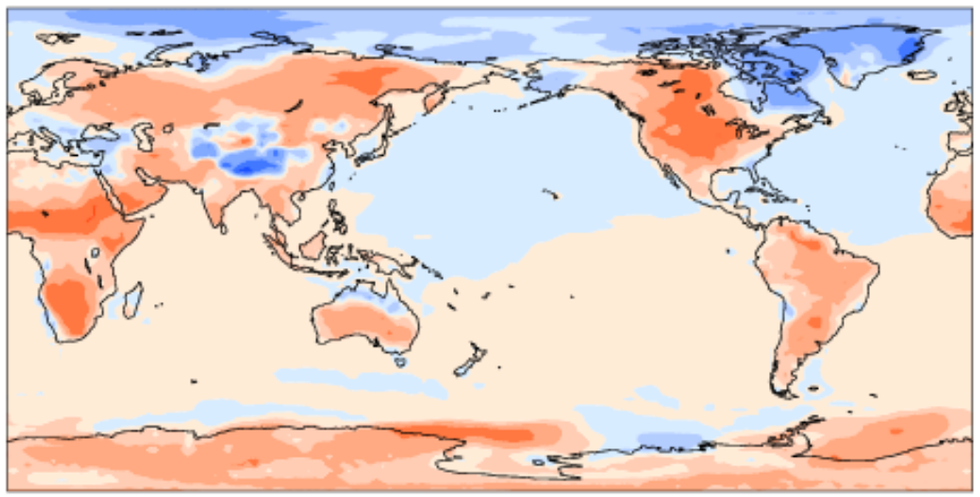


Min = 212.75 Max = 304.76

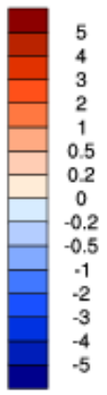


SPCAM_multi_instance - SPCAM_cntl

mean = 0.13 rmse = 0.37 K



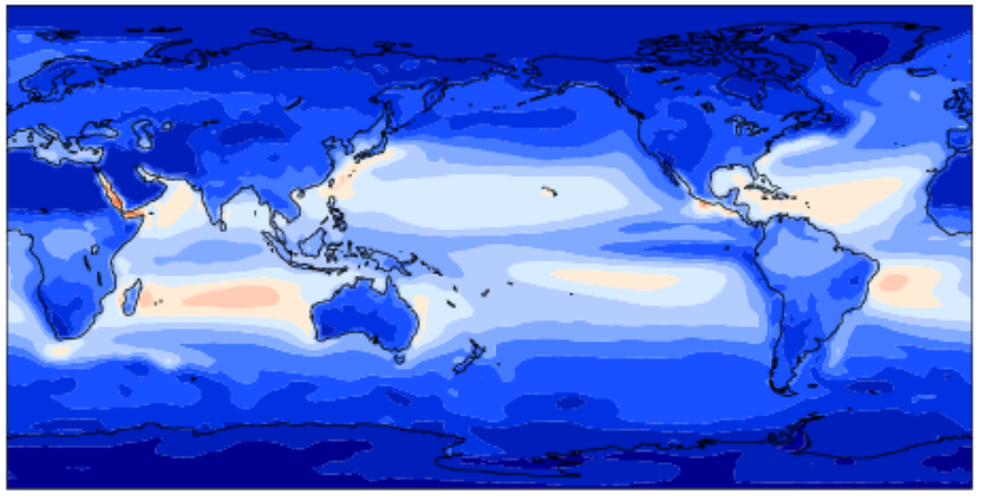
Min = -2.90 Max = 2.21



Latent Heat Flux

SPCAM_multi_instance (yrs 2-11)

Surf latent heat flux mean= 84.05 W/m^2



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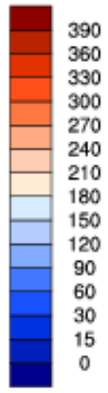
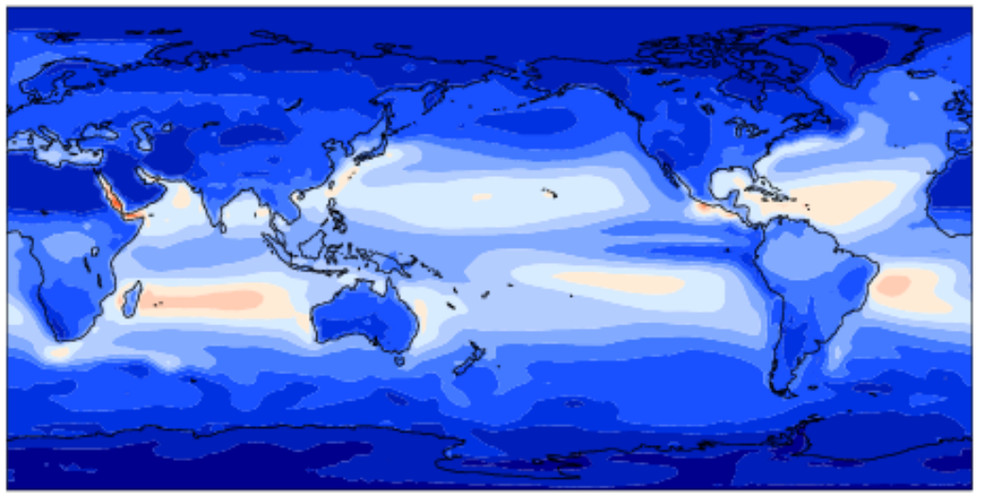
Min = -3.07 Max = 320.60

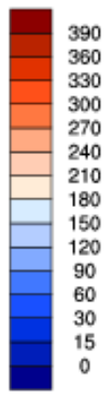


SPCAM_cntl (yrs 1-5)

Surf latent heat flux mean= 82.84 W/m^2

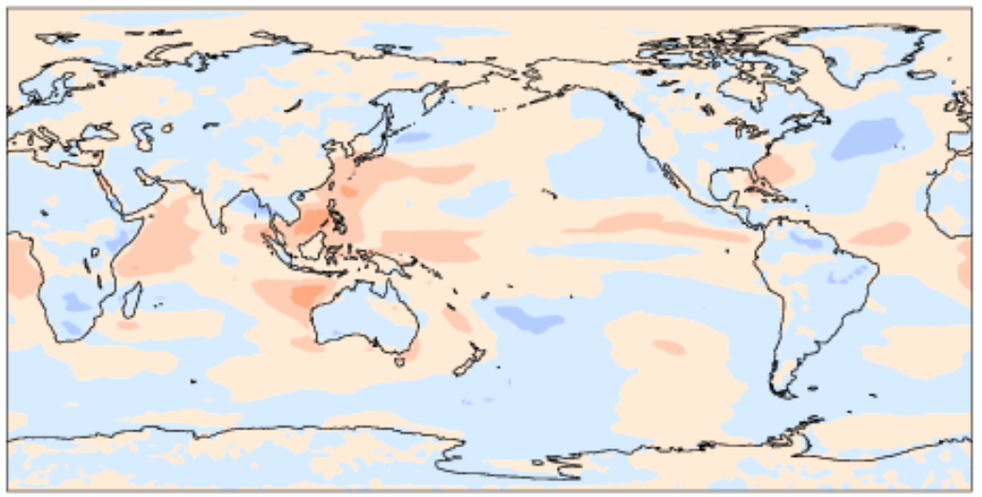


Min = -1.82 Max = 320.25

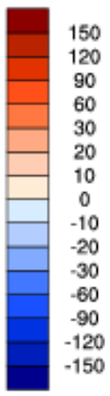


SPCAM_multi_instance - SPCAM_cntl

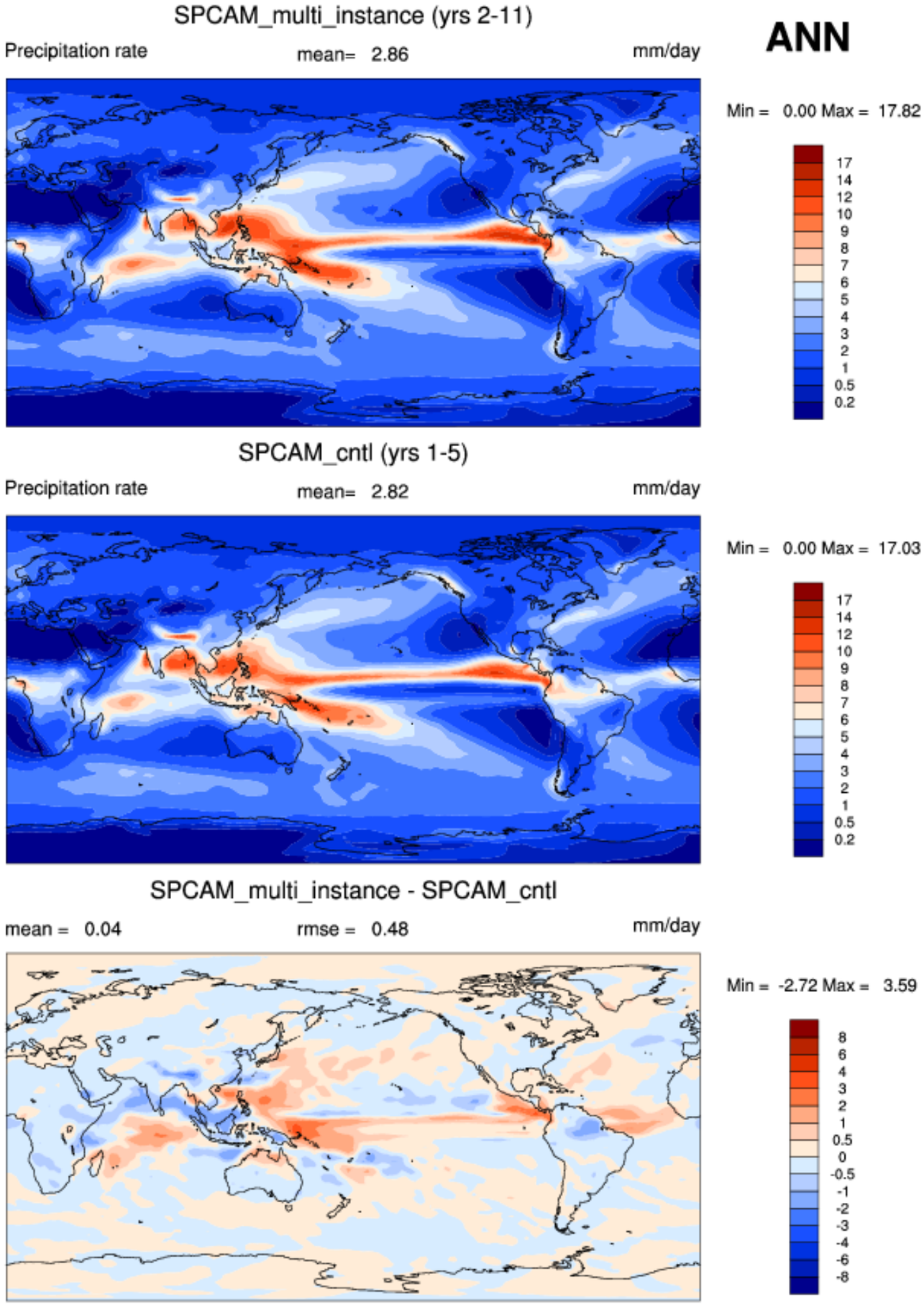
mean = 1.21 rmse = 5.91 W/m^2



Min = -26.19 Max = 28.32

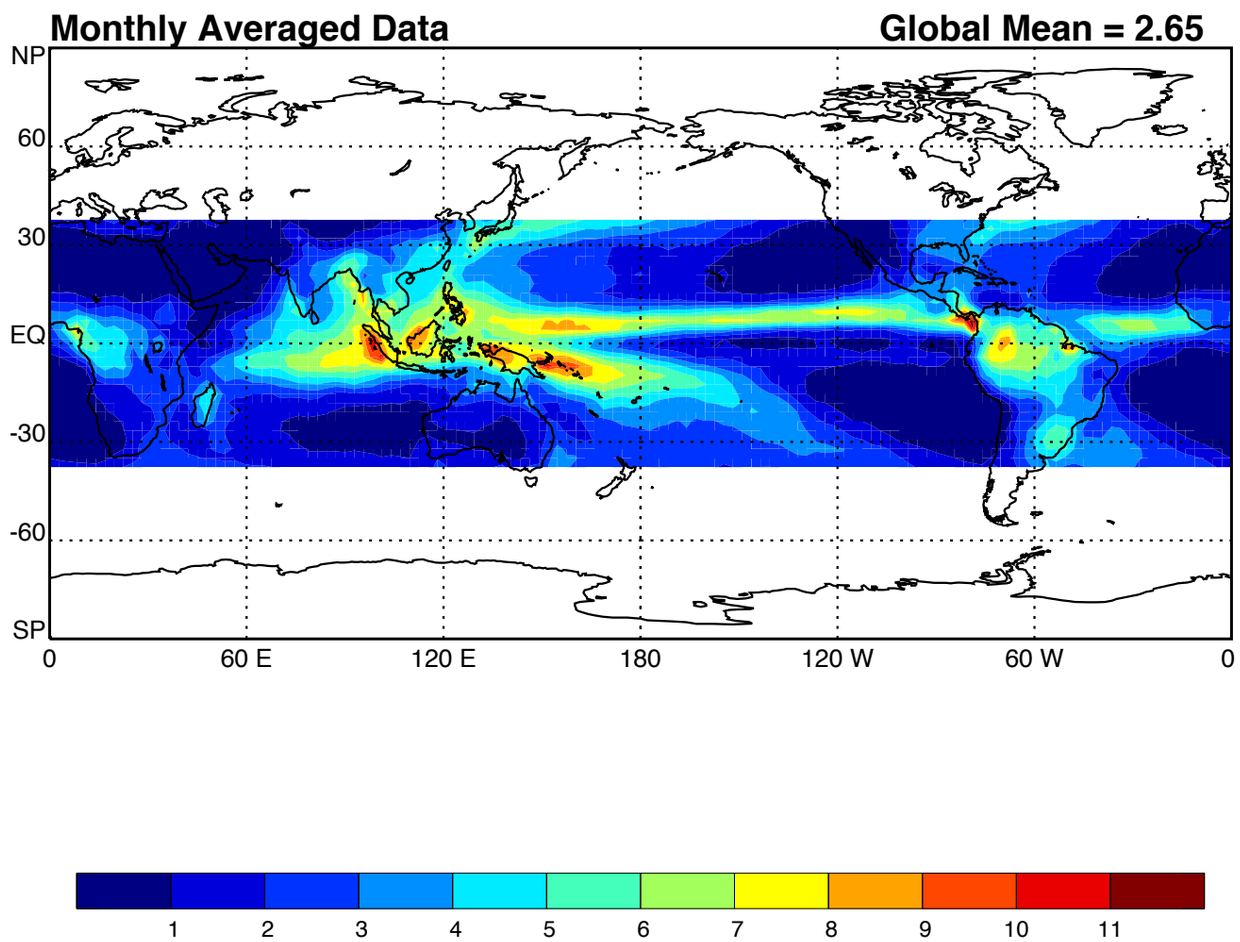


Precipitation Rate



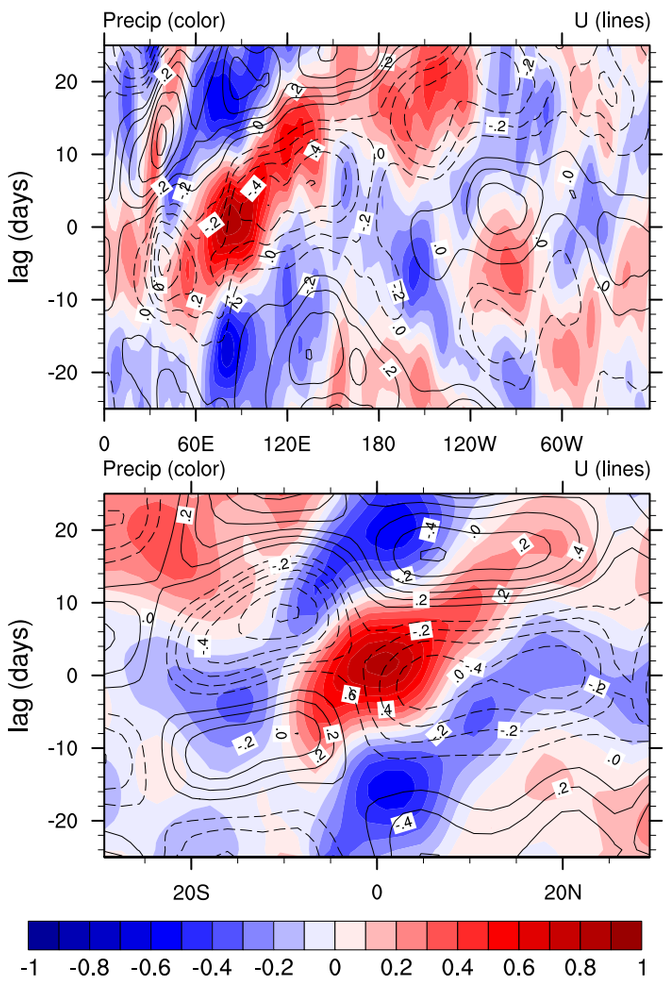
TRMM Precipitation Rate (Annual Mean)

mm/day

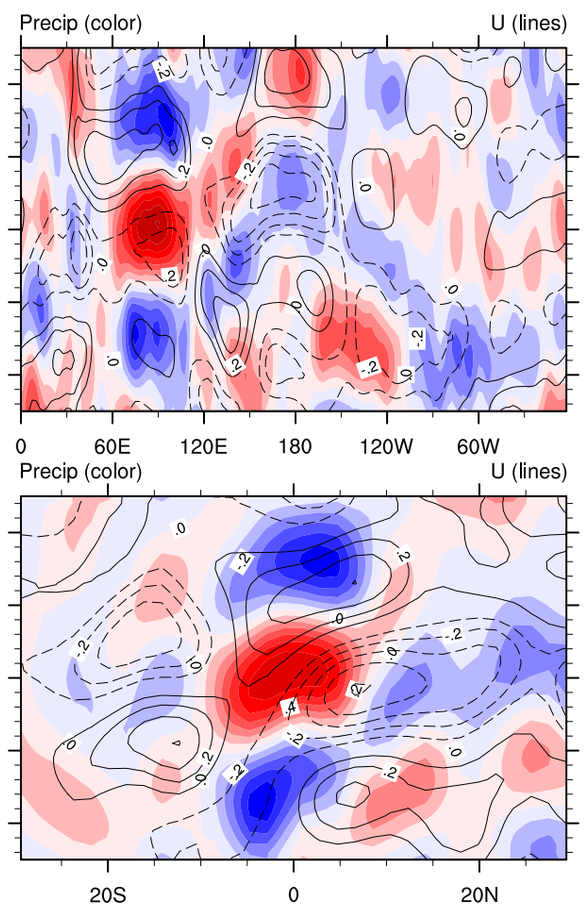


Lag-correlation, winter

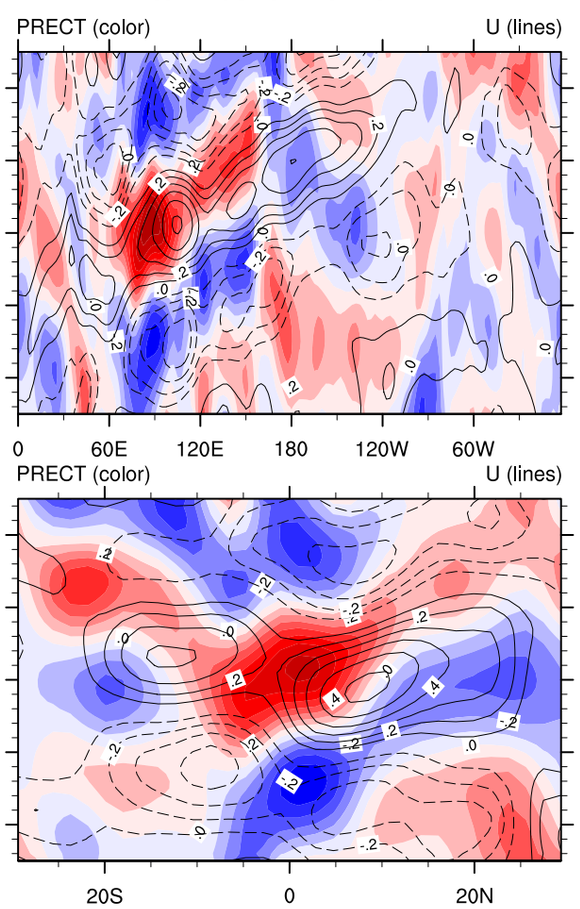
ctrl



with vcrm



multi-instance



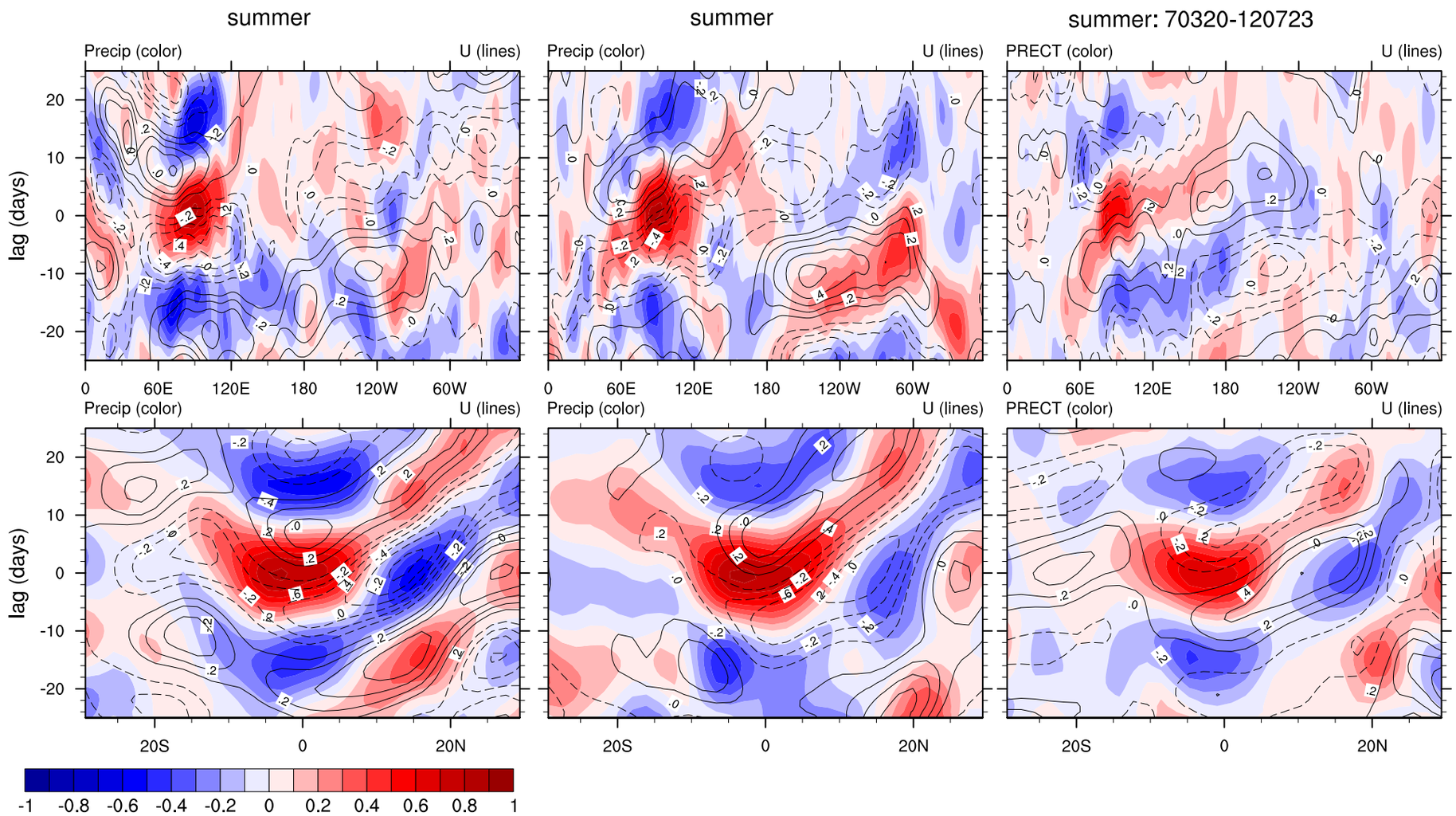
- ctrl is best, then MI

Lag-correlation, summer

ctrl

with vcrm

multi-instance



- vcrm is best, then maybe MI

Conclusions

- It works! And it looks like planet earth.
- Some interesting differences in the surface fluxes

Going Forward

- Explore spatial heterogeneity within the CRM framework
- Incorporate tracer (CO2, OCS, isotopes?) fluxes
- Run a fully-coupled simulation: How to handle enormous ocean history files for all instances