Recent developments in Noah-MP, its public repository, and initial results from the new WRF-CTSM coupled model.

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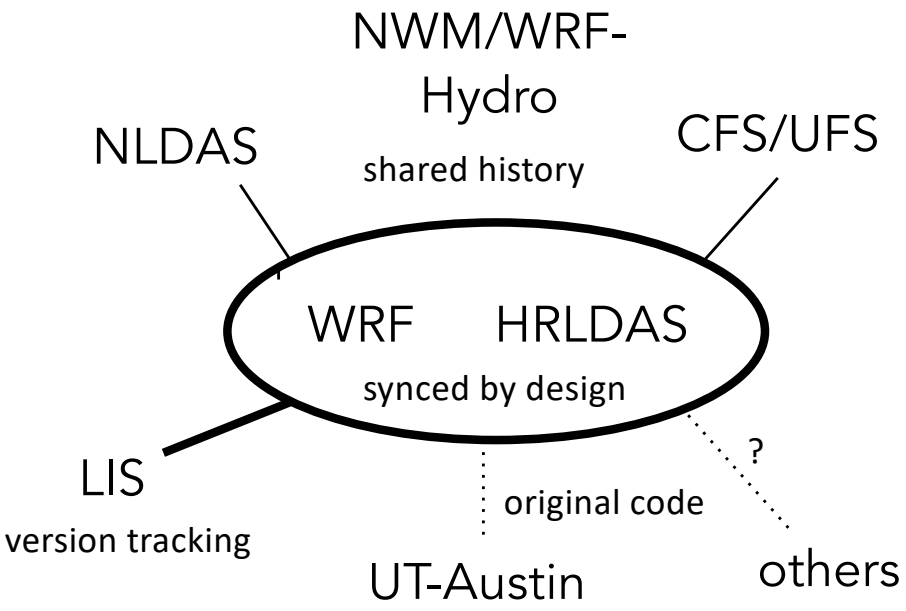
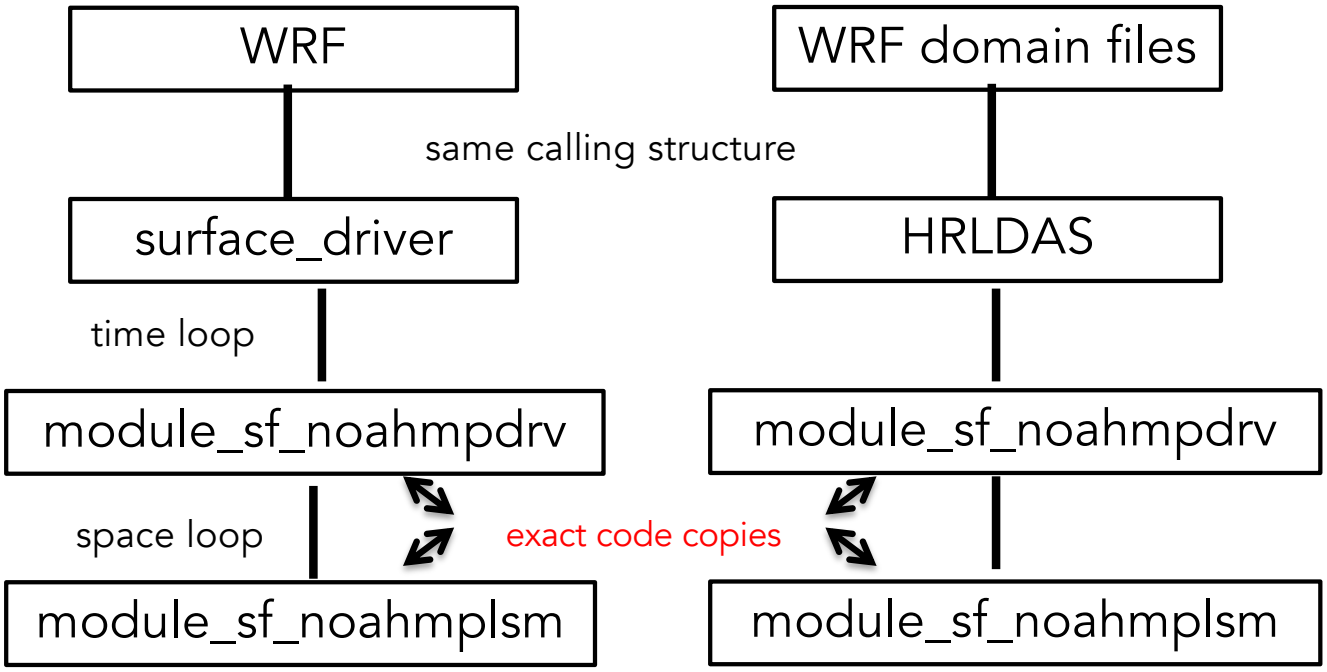
WRF/MPAS Users workshop, 9 June 2020.

Where We were

- The Noah-MP land model exists in multiple systems
  - NWM/WRF-Hydro
  - WRF
  - CFS/UFS
  - NLDAS
  - HRLDAS
  - LIS
  - UT-Austin
  - others?



Why Did We Get Here – HRLDAS



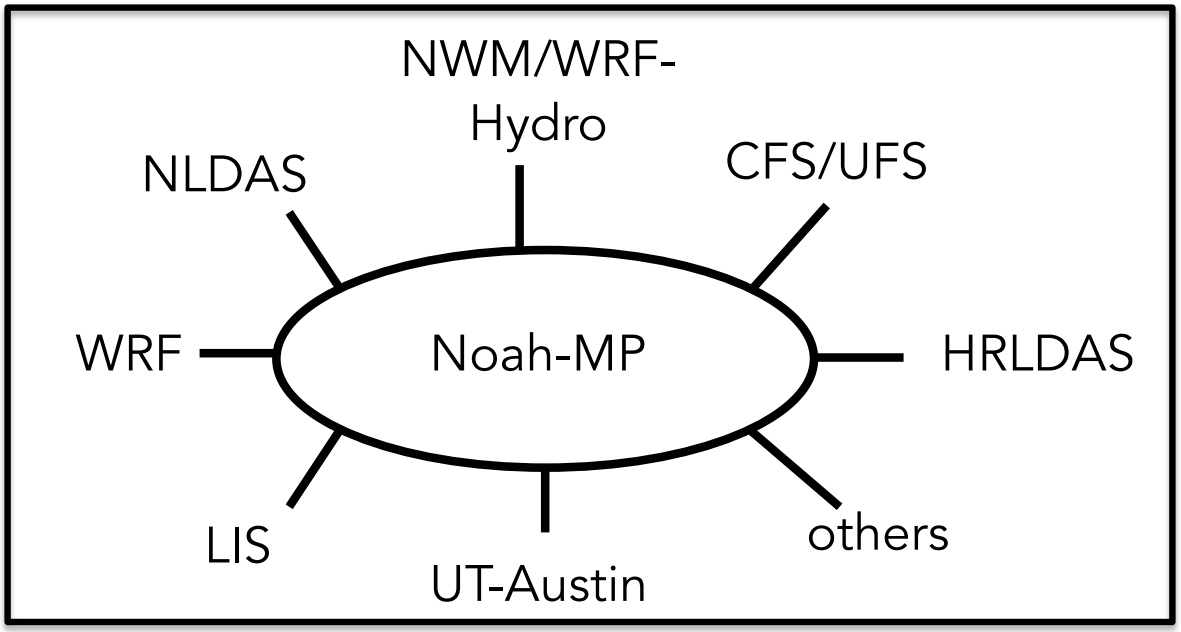
- Advantage: Any development in WRF or HRLDAS transfers directly to the other system
- Disadvantages: ties single column model tightly into 2D structure of WRF

Why Did We Get Here – HRLDAS/WRF-Hydro

- HRLDAS became the core of WRF-Hydro and eventually the National Water Model
- Maintained a synced HRLDAS/WRF and WRF-Hydro for a few years
- Eventually as the systems evolved, this became unsustainable and undesirable
- This was likely because too much of both systems was being maintained
- All we really need is a synced Noah-MP model

How Do We Move Forward?

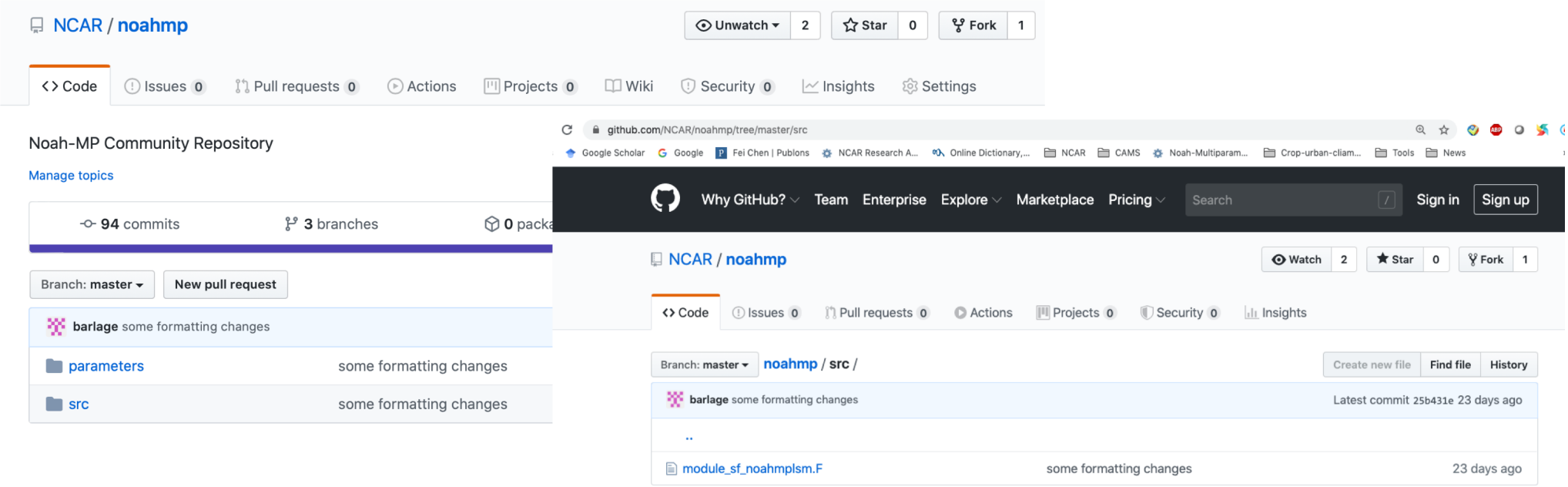
- A single source repository for Noah-MP code
- All models access the code from the same location



- WRF v4.1 (released in April): added NWM changes
- NWM v2.1 (to be released this year): adding WRF changes
- Noah-MP code will be unified again!

New Noah-MP Repository

- Available at https://github.com/NCAR/noahmp
- Contains physics modules (/src) and parameter tables (/parameters)
- Linked to via git submodules



How Do We Move Forward?

Noah-MP repository:

https://github.com/NCAR/noahmp

Example dependent repositories

HRLDAS repository:
https://github.com/NCAR/hrldas

WRF-Hydro/NWM repository:
https://github.com/NCAR/wrf_hydro_nwm_public

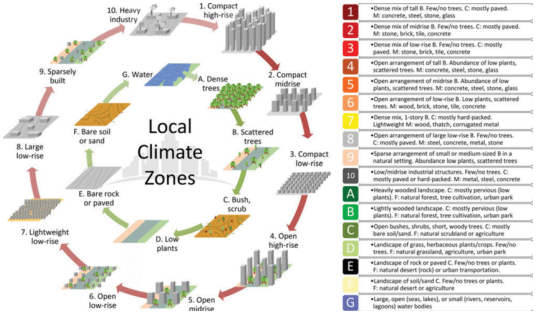
WRF repository:

https://github.com/wrf-model/WRF

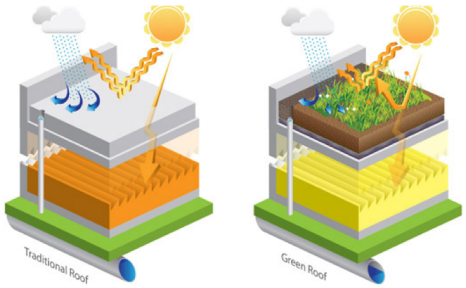
WRF-Urban and WRF-Crop Model Updates
to be released in 2021

WRF-Urban:

- Rooftop Photovoltaic Panels (RPVP) coupled to BEP/BEM
- Green roofs coupled to BEP/BEM
- BEP and BEM: Reduce memory footprint
- Accommodate local climate Zone (LCZ) data

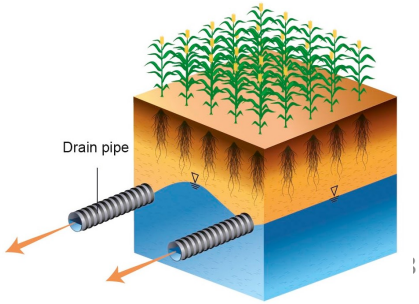


Green Roofs



WRF-Crop:

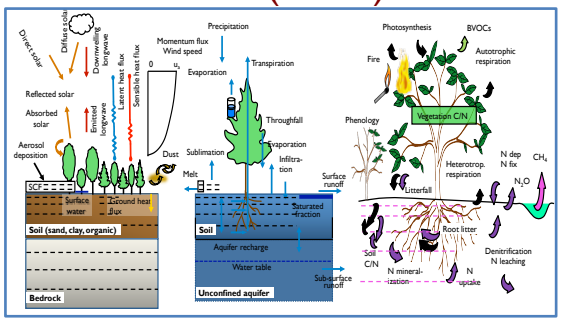
- Dynamic irrigation model
- Dynamic crop rooting depth
- Tile-drainage model



The Community Terrestrial System Model (CTSM)

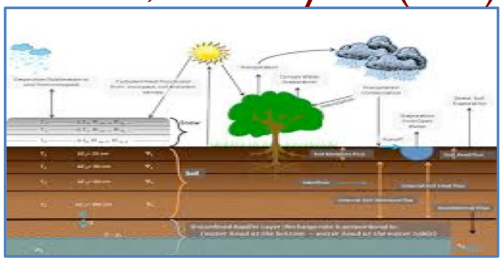
A unified model for research and prediction in climate, weather, water, and ecosystems

CLM (CGD)



CTSM

Noah-MP, WRF-Hydro (RAL)



CTSM (unification) benefits:

- extend leadership in community modeling
- reverse trends of model proliferation
- more efficient use of NCAR and community model development resources
- improve science through multiple hypothesis testing, accelerate land model R2O

CTSM software improvement goals:

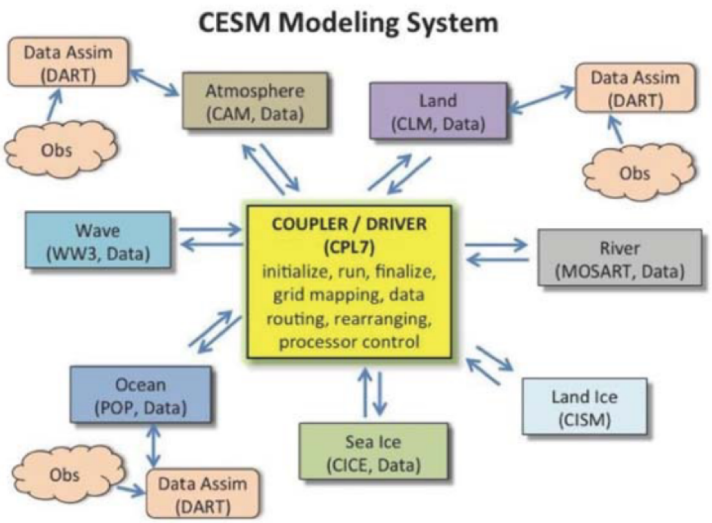
- reduce accumulated technical debt
- modularity; alternative hypotheses
- hierarchy of complexity (climate, NWP, water, and ecology applications)
- flexibility of multi-scale modeling

CTSM configurations

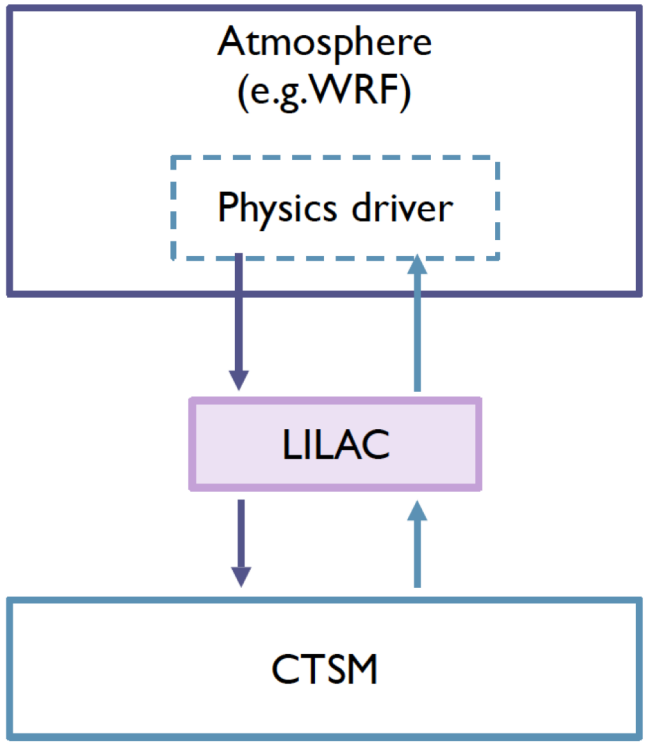
- Climate and weather applications share same physics (currently physics version 5)
- Configurations (default, mixing and matching possible, emphasis on flexibility)
  - CTSM5(NWP) – emphasis on speed; single dominant landunit, single dominant PFT, 5 soil layers, 5 snow layers, plant hydraulics off, prescribed vegetation state, reduced canopy flux iterations
  - CTSM5(CLMSP) – full subgrid complexity, PHS on, prescribed vegetation state, land-cover change
  - CTSM5(CLMBGC-crop) – as CLMSP, but with prognostic biogeochemistry and global crop model, land-cover and land-use change
  - CTSM5(FATES) – experimental; as CLMBGC with full ecosystem demography model
  - CTSM5(HP) – hydrologic prediction; TBD

WRF-CTSM coupling through LILAC (Light-weight Infrastructure for Land-Atmosphere Coupling)

CESM hub and spoke architecture

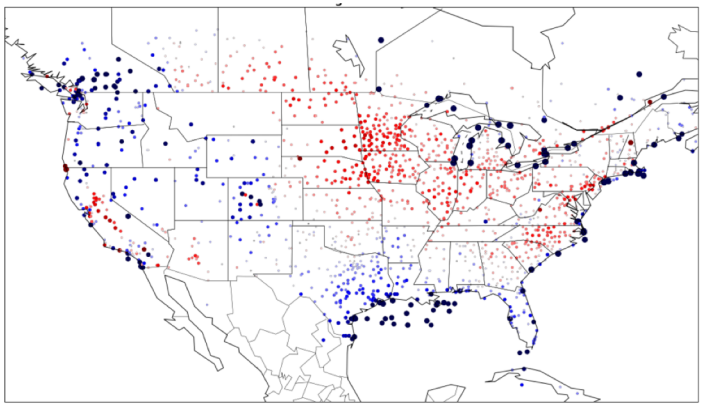


LILAC architecture



WRF/CTSM-NWP Test Simulations

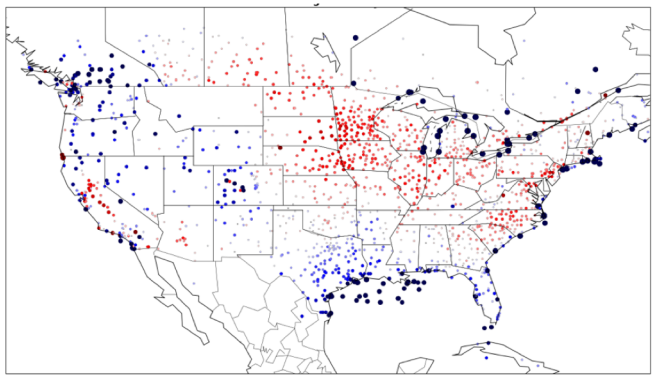
- Simulations compared
  1. WRF/Noah out of the box
  2. WRF/Noah-MP out of the box
  3. WRF/CTSM5(NWP) (5SL-3m, 1 landunit, no PHS)
- ~CONUS domain (27km, 200x140 lat-lon)
- 6 month: April- September, 2013
- IC/BC provided by ERA-I, no initial snow, no land DA
- 90 second time step
- 36 MPI tasks
- Wallclock comparison:
  - Noah: ~4h10m
  - Noah-MP: ~4h19m
  - CTSM5(NWP): ~5h20m (~+20%)



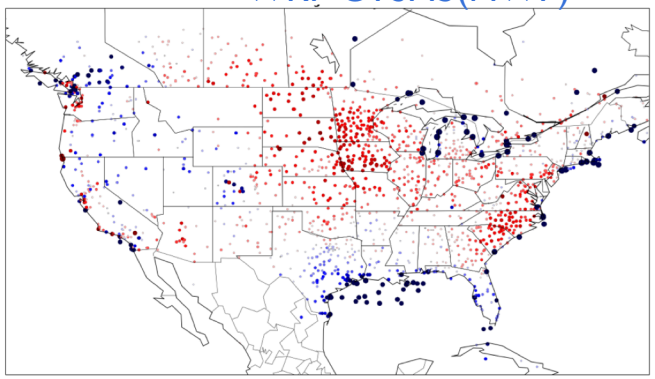
Preliminary results from WRF-CTSM5(NWP) test run

Tmax bias over US for July 2013

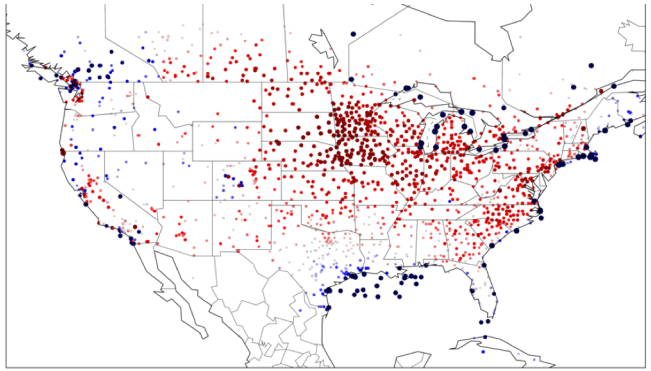
WRF-Noah

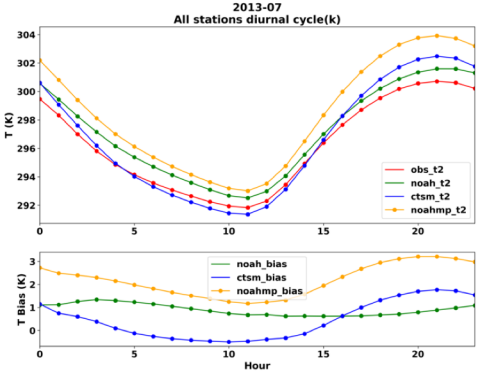


WRF-CTSM5(NWP)



WRF-NoahMP





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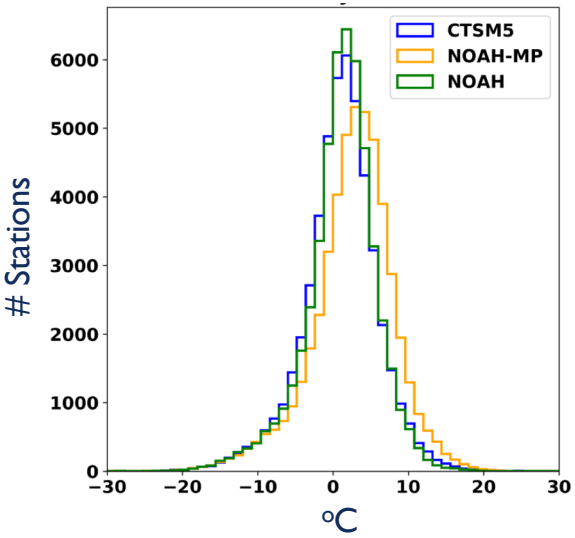
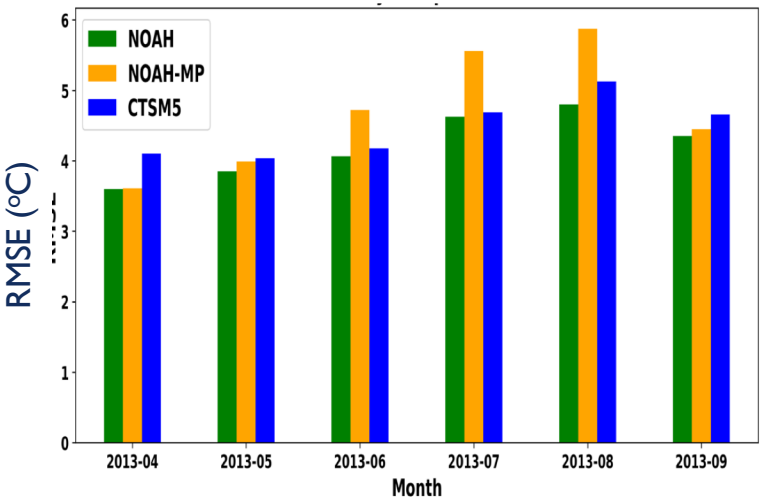
Note: WRF-CTSM5(NWP) ~20% more expensive than WRF-Noah

Preliminary results from WRF-CTSM5(NWP) test run

Daily Tmax bias
July 2013



Daily Temperature RMSE



Simulated surface air temperature from three LSMs are largely similar, with strengths and weaknesses seen for each model

Plan to release WRF-CTSM in 2021 with limited unsupported

WRF 'feature branch' with CTSM, coupled with LILAC, to be released to friendly users by end of June

- Runs on Cheyenne, no guarantees about other systems
- Experimental release: use at own risk
- Includes documentation about how to get the code, and how to build, configure, initialize, and execute runs
- Out-of-box support for CONUS 27km grid
- Capability to define new grids (we can help)
- Feedback from friendly users welcome and encouraged
- Targeting a full release with April 2021 WRF update

- Note: Fei has run WRF-CTSM5(NWP) CONUS, so …
- More details at https://github.com/escomp/ctsm

Questions?