National Aeronautics and Space Administration

NASA WATER INSIGHT PROJECT

NLDAS-3 Drought Monitoring Workshop April 10, 2025

Workshop Agenda

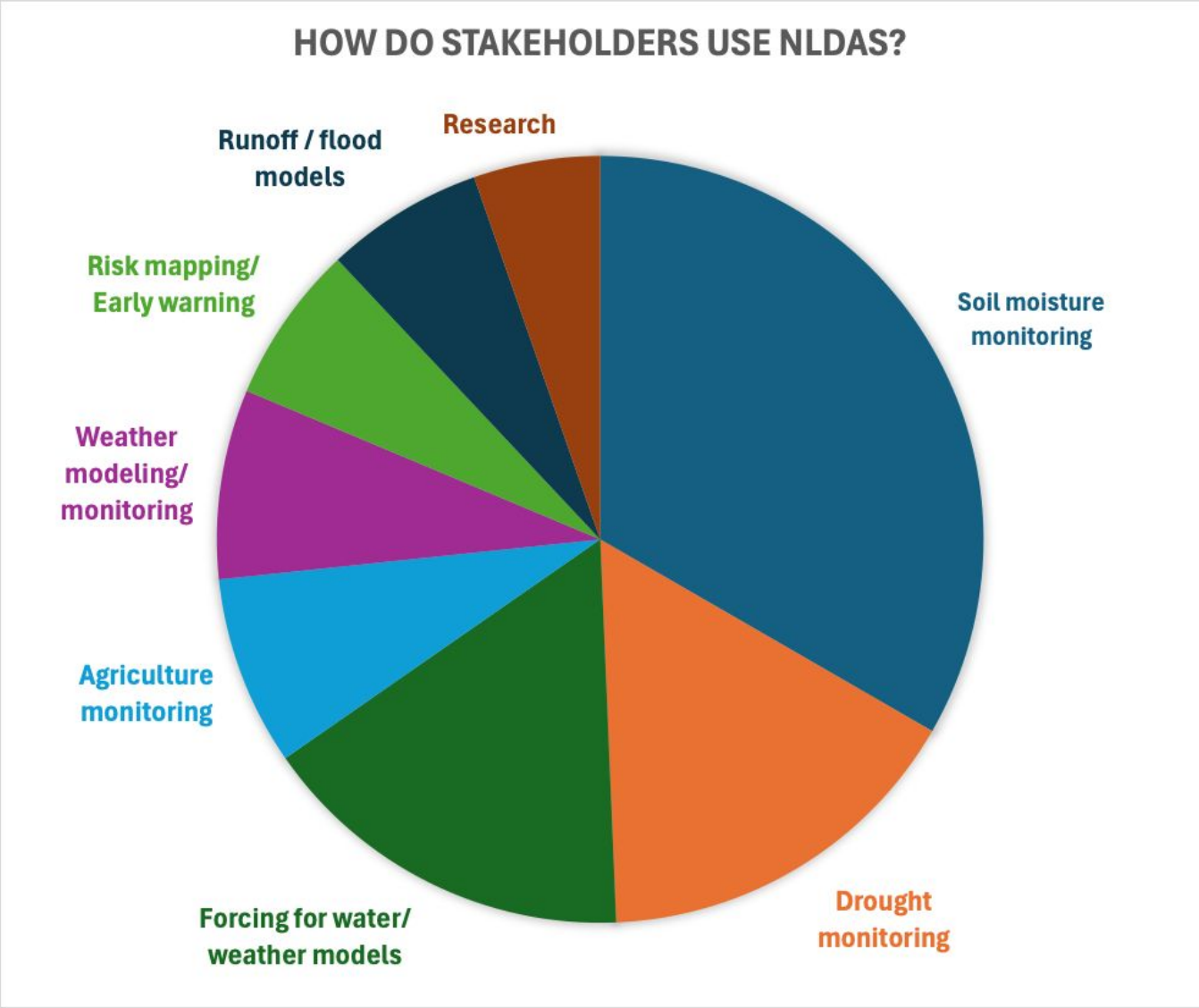
2:00	**Welcome Remarks**	Chris Hain, NASA MSFC Karen St. Germain, NASA HQ Veva Deheza, NOAA NIDIS Mark Svoboda, UNL/NDMC
2:10	**NLDAS-3 Updates**	Sujay Kumar, NASA GSFC
2:30	**Examples of NLDAS-3 Applications**	Jonathan Case, ENSCO/MSFC Brian Fuchs, UNL/NDMC Mike Hobbins, CIRES/NOAA
3:15	**Break**	
3:20	**Data Access, Analysis, Feedback**	Sid Chaudhary, UAH/MSFC
3:30	**Needs and Capabilities - Breakout Discussions** 1 - Meteorology/ Model Forcings/ DA 2- Applications/ Downstream Products	Kim Locke, SAIC/GSFC Fadji Maina, UMBC/GSFC Kristen Whitney, UMD/GSFC David Mocko, SAIC/GSFC Ryan Wade, UAH/MSFC Molly Woloszyn, CIRES/NOAA NIDIS
4:20	**Wrap Up Discussion & Next Steps**	Chris Hain, NASA MSFC

What’s New in NLDAS-3

Dr. Sujay Kumar

NASA Goddard Space Flight Center

Summary of Stakeholder Feedback



Specific NLDAS Uses from Previous Workshops

- Drought and flood operations
- Wildfire risk and prescribed burn planning
- NWP model data input
- Climatologies/Anomalies
- Generating refET for EDDI
- Runoff/soil saturation for flood and landslide risk
- Forcing for snow models
- Building ML/DL models
- Watershed modeling

Previous Feedback on Priority Needs

High-priority Model Improvements:

- Decreased output latency
- Better forcing data quality
- Finer spatial resolution
- Assimilation of observational data
- Expanding the model spatial domain
- Atmospheric forcing datasets back to 1980, for historical context
- Easier data access
- Choice of output formats
- Consistent datasets

Requests for Derived Products and Applications:

- Soil moisture percentiles and outlooks
- Drought percentiles, indices, and forecasts
- ET and PET products
- Soil hydrologic conductivity
- Modeled ET and runoff
- GIS-enabled data
- Weekly change maps
- Model uncertainty information

Requests for Derived Products and Applications

From Today's Workshop Registration Responses:

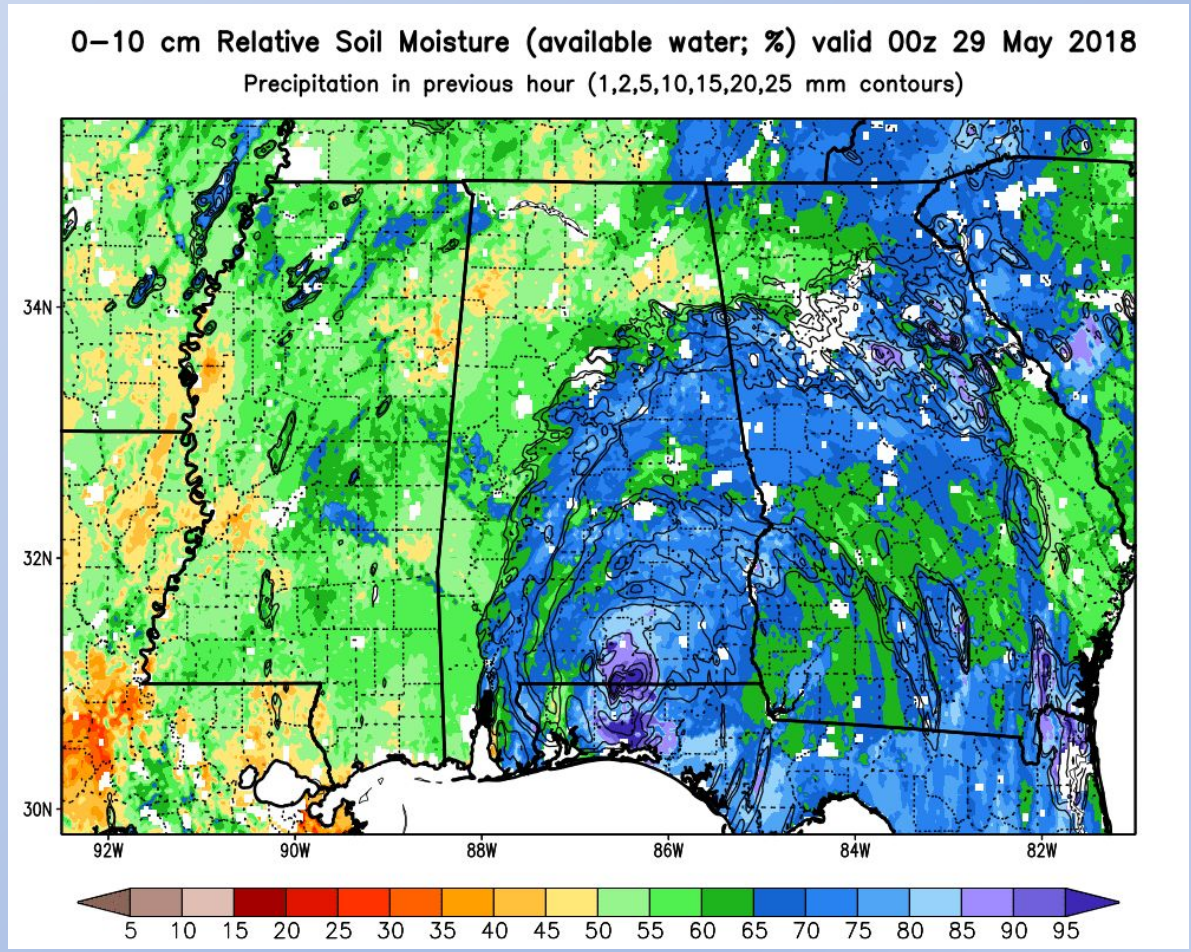
- Reference evapotranspiration (Penman-Monteith PET), actual evapotranspiration, EDDI, SPEI
- FAO56 PET (we currently rely on GridMET)
- Soil moisture percentiles - crop yields
- Climatology and percentiles
- Experimental forecast products; derived fields
- Enhance accuracy of U.S. Drought Monitor and as inputs into our other operational combined drought indicators
- Flash drought detection
- River and flood modeling

Near Real-time NLDAS-3 Product System

What do stakeholders need?

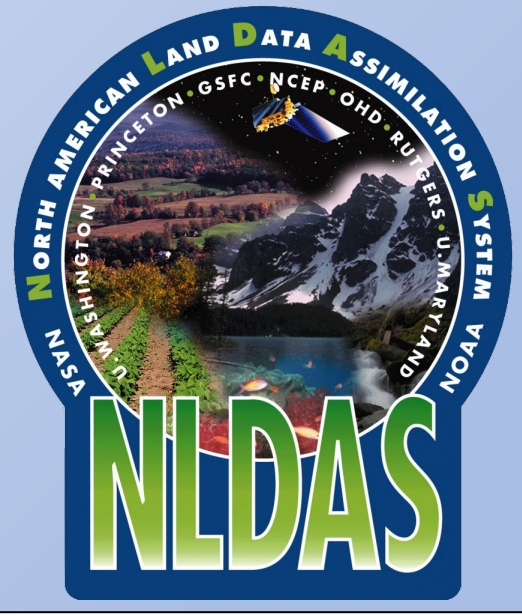
- User-centric design of the product system
- Low latency
- Easy to use formats
- Integration into decision-support systems
- Derived products
- Essential Agricultural Variables (proposed by NASA Acres/Harvest)
- **What else?**

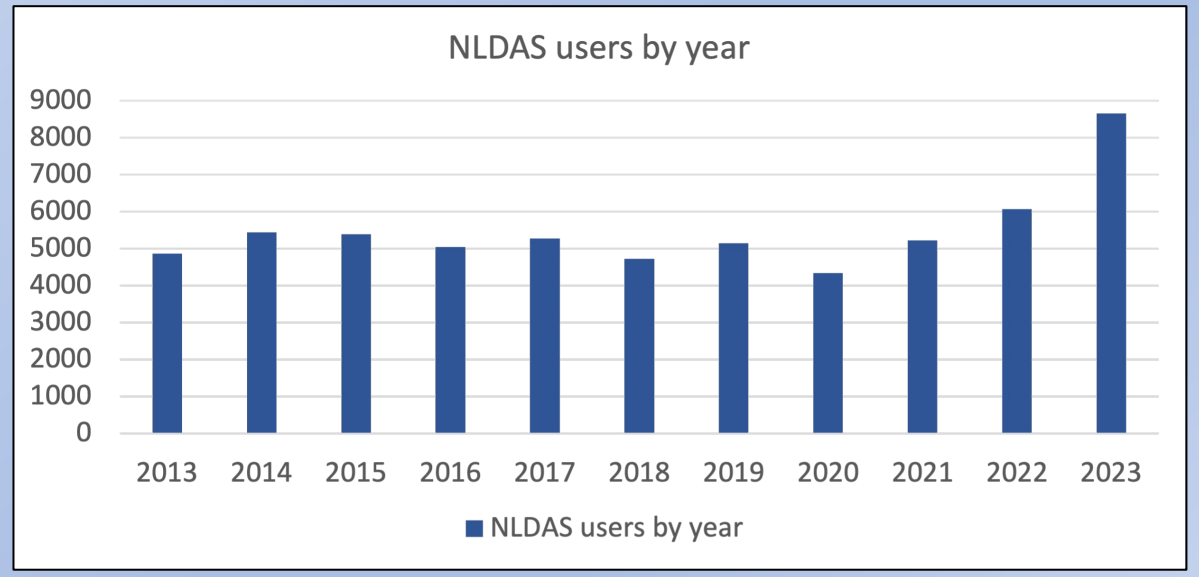
We have collected and started to integrate stakeholder feedback into the product system.



North American Land Data Assimilation System (NLDAS)

- NLDAS is a widely used land modeling environment, operational at NOAA.
- The number of unique users of NLDAS-2 data just from the NASA GES DISC has grown to over ~8,500 per year – plus users who get data from NOAA.
- Used by numerous different stakeholders and science groups:
  - UNL/NDMC/drought.gov/state-level agencies
  - NOAA/NWS, NOAA/CPC, NOAA/PSL (EDDI)
  - GRACE-DA, OpenET, WWAO, WLDAS, QuickDRI
  - USGS, EPA, FEMA, CUAHSI, USDA
  - NASA SPoRT and their stakeholders
  - State-level climate offices, Private enterprises

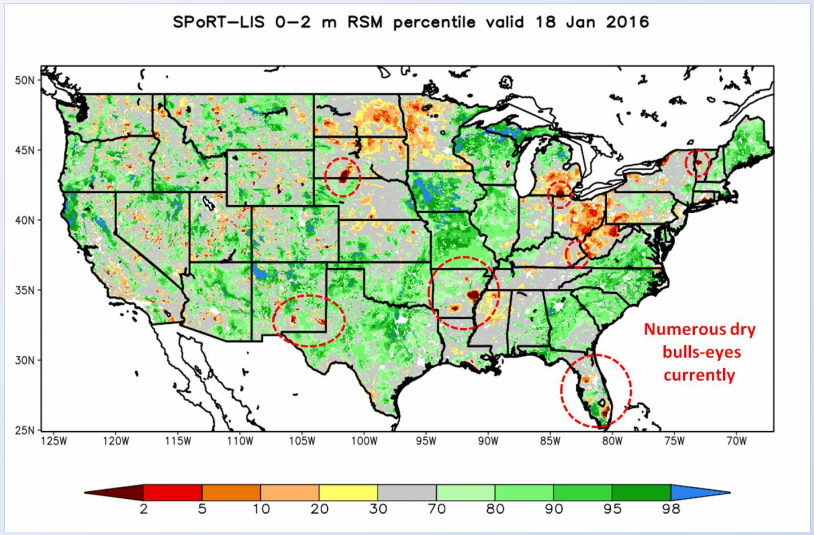




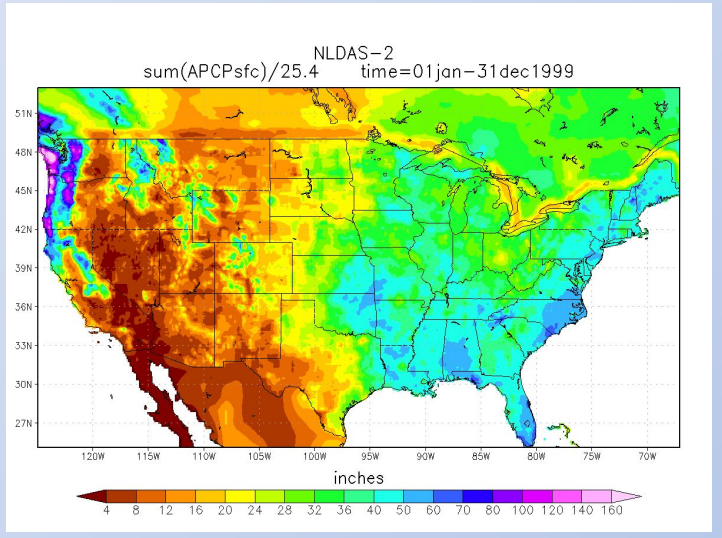
Enhancing NLDAS for the Future

- **Put the "DA" into NLDAS** – adding data assimilation capabilities to take advantage of unique NASA observations, allowing us to resolve the combined natural and human impacts on the water and energy cycle.
- **Build on previous joint efforts with NOAA**, with these priorities:
  - Use a modern land-surface model (including groundwater, prognostic phenology), and a modern river routing model (including streamflow, river depth, floodplains, etc.)
  - Reduce the ~4-day latency of current NLDAS-2 and enable forecasting capabilities
  - Make NLDAS "North American" (including AK, HI, and PR) and include Central America
  - Improve the quality of NLDAS forcing data
  - Move to a finer spatial scale of the datasets
- Transition to stakeholders via NASA SPoRT.

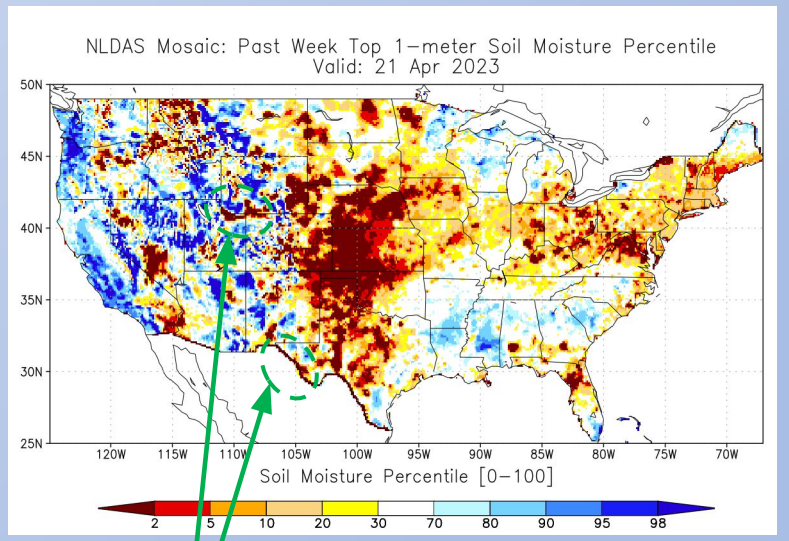
Resolving Stakeholders' Issues



Recurring/persistent dry bulls-eyes in precipitation and soil moisture from QC issues in the daily gauge analysis.



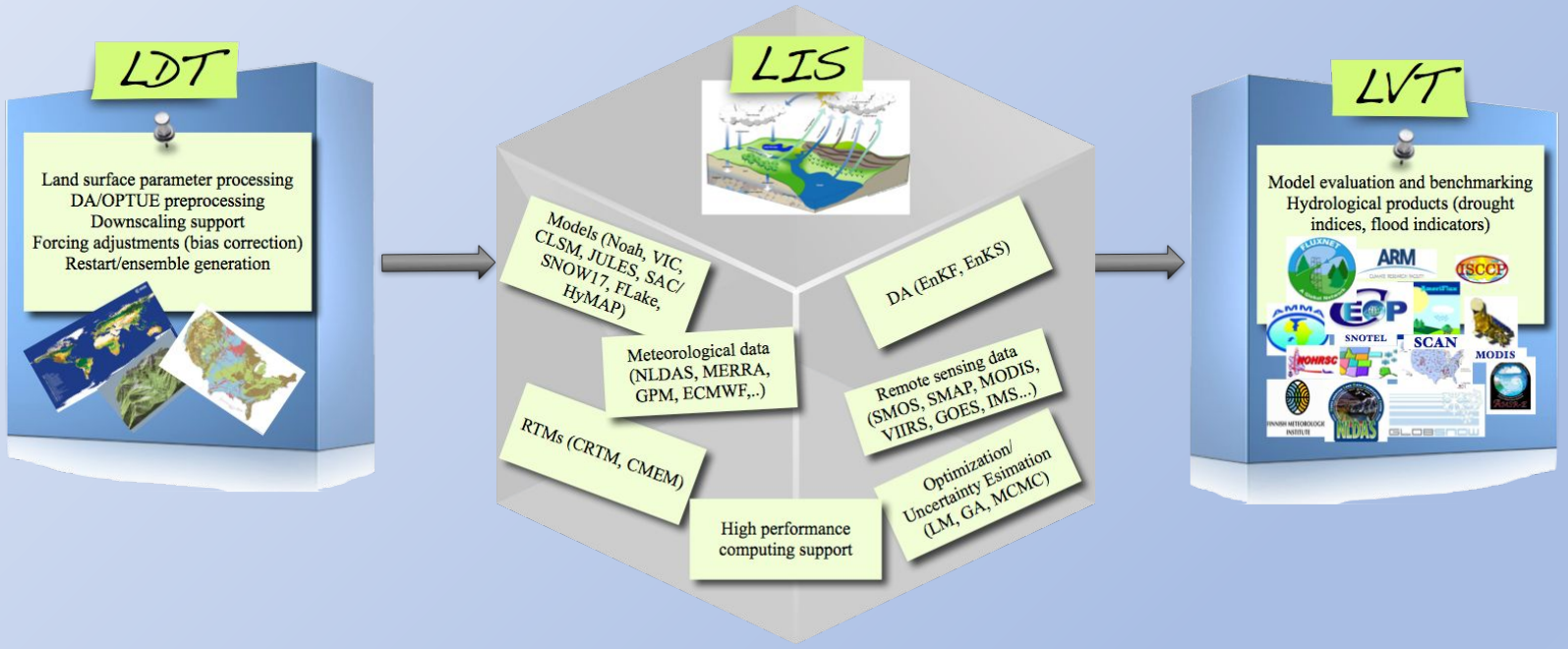
Cross-border (U.S.-Canada) precipitation issues related to the blending scheme between different input products.



Change in interpolation scheme in January 2012 affected soil moisture climatologies (esp. in intermountain West and along U.S.-Mexico border).

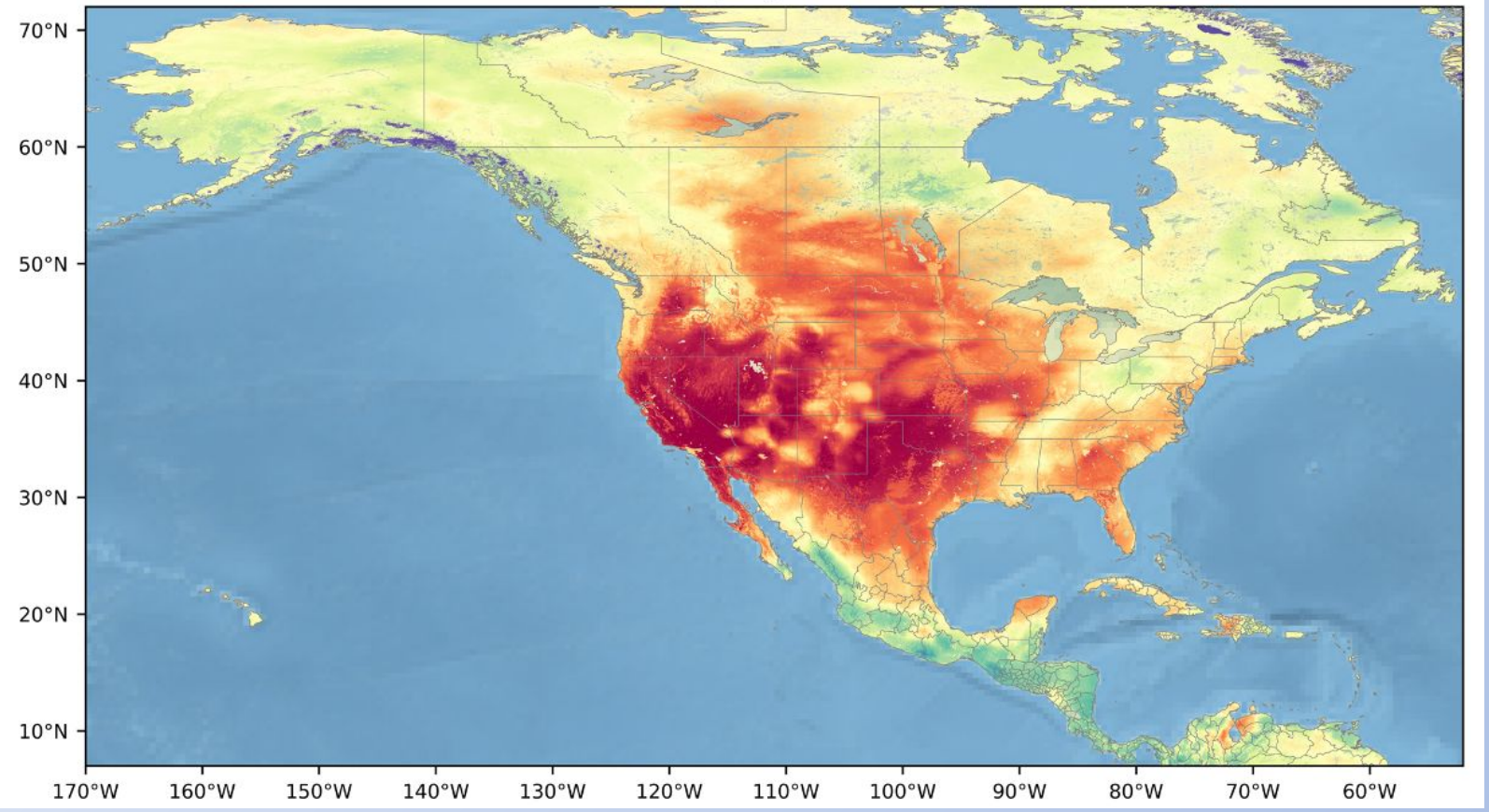
There are many downstream and value-added data products that rely on the quality of NLDAS forcing and model outputs.

Use NASA's LIS software for multi-variate data assimilation in modern LSM



- Use NASA's Land Information System (LIS) software framework.
- Assimilate remotely-sensed products (soil moisture, snow, TWS, vegetation).
- Use a modern state-of-the-art land-surface model (LSM) – Noah-MP.
- Use a modern state-of-the-art river routing model – HyMAP.
- Websites: https://lis.gsfc.nasa.gov/ https://github.com/NASA-LIS/LISF

NLDAS-3 vs. -2 Domain and Grid Spacing



NLDAS-3

Grid spacing: 1.0-km
Grid: 11,700 x 6,500 points
Domain: 7.0 – 72.0 North
-169.0 – -52.0 West
Land points: 27,245,580

NLDAS-2

Grid spacing: 12.5-km
Grid: 464 x 224 points
Domain: CONUS (25-53 North)
Land points: 76,088

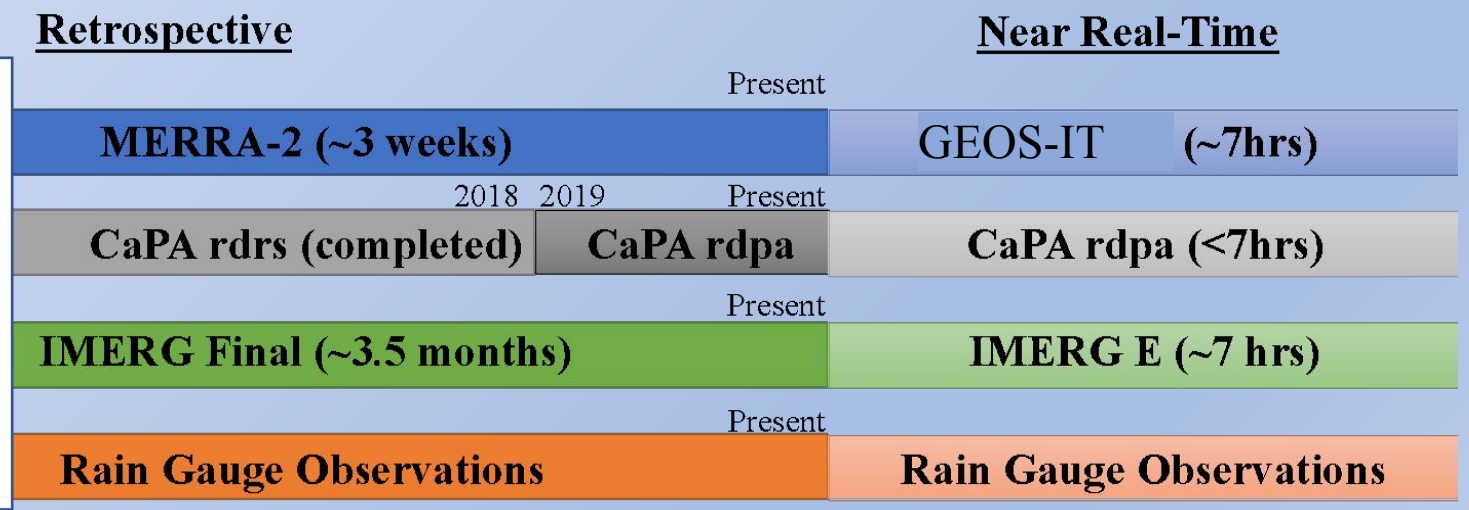
The huge increase in the number of land points for NLDAS-3, combined with the ensembles needed for DA, will require significant computational resources.

A NASA Data-driven Meteorological Forcing in Retrospective and Real Time

Precipitation Products	Latency	Spatial Resolution	Temporal Resolution
IMERG Final (IMERG-F)	~3.5 months	0.1°	30 min
IMERG Early (IMERG-E)	~ 4 hours	0.1°	30 min
MERRA-2	Third week of the following month	0.5°*0.625°	hourly
GEOS-IT	~7 hours	0.5°*0.625°	hourly
CaPA (RDRS for retrospective and RDPA for near real-time)	<7 hours	10 km	24-hourly

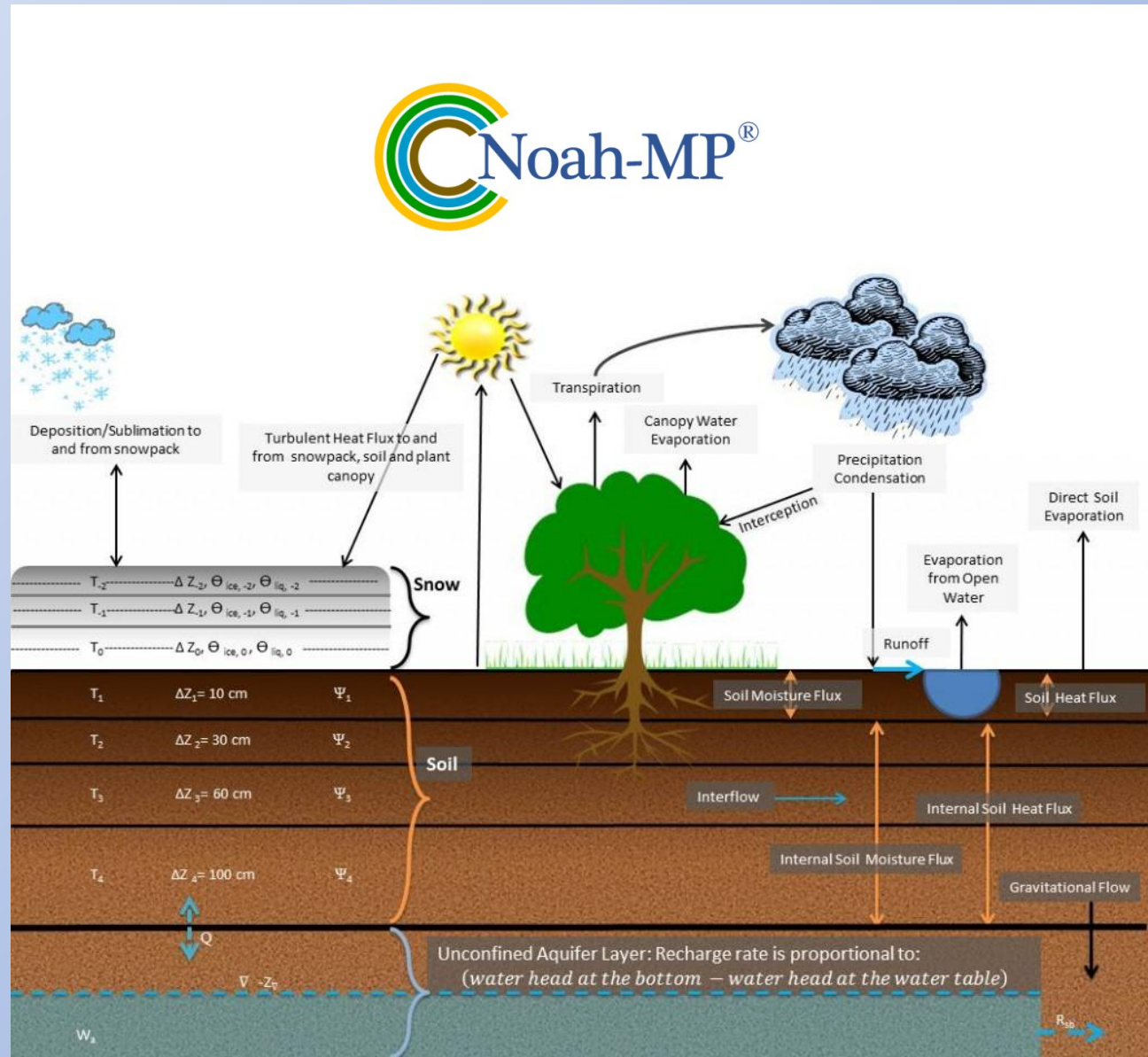
We are considering two products:

1) "Full DA" product: Starting ~2000, which is when many remotely-sensed DA products and IMERG begin
2) "Open Loop" product: Starting ~1980, with no data assimilation



Data Assimilation and Modeling

- Noah-MP LSM (managed by NCAR) is used in several other systems (NWM, WRF, UFS, etc.).
- Contains advanced physics, including 3-layer snow physics, etc. For NLDAS-3, we will use options for groundwater and for prognostic phenology.
- Assimilated data products:
  - Soil moisture (SMAP, AMSR-E, etc.)
  - Snow (Optical, passive microwave, ML)
  - MODIS/VIIRS 4-day LAI
  - GRACE/GRACE-FO TWS
  - SWOT (river height into HyMAP river routing model – in development)
  - Future: NISAR, other upcoming missions



Late and Early “full DA” NLDAS-3 Products

Final NLDAS-3 product (“Late Look”)

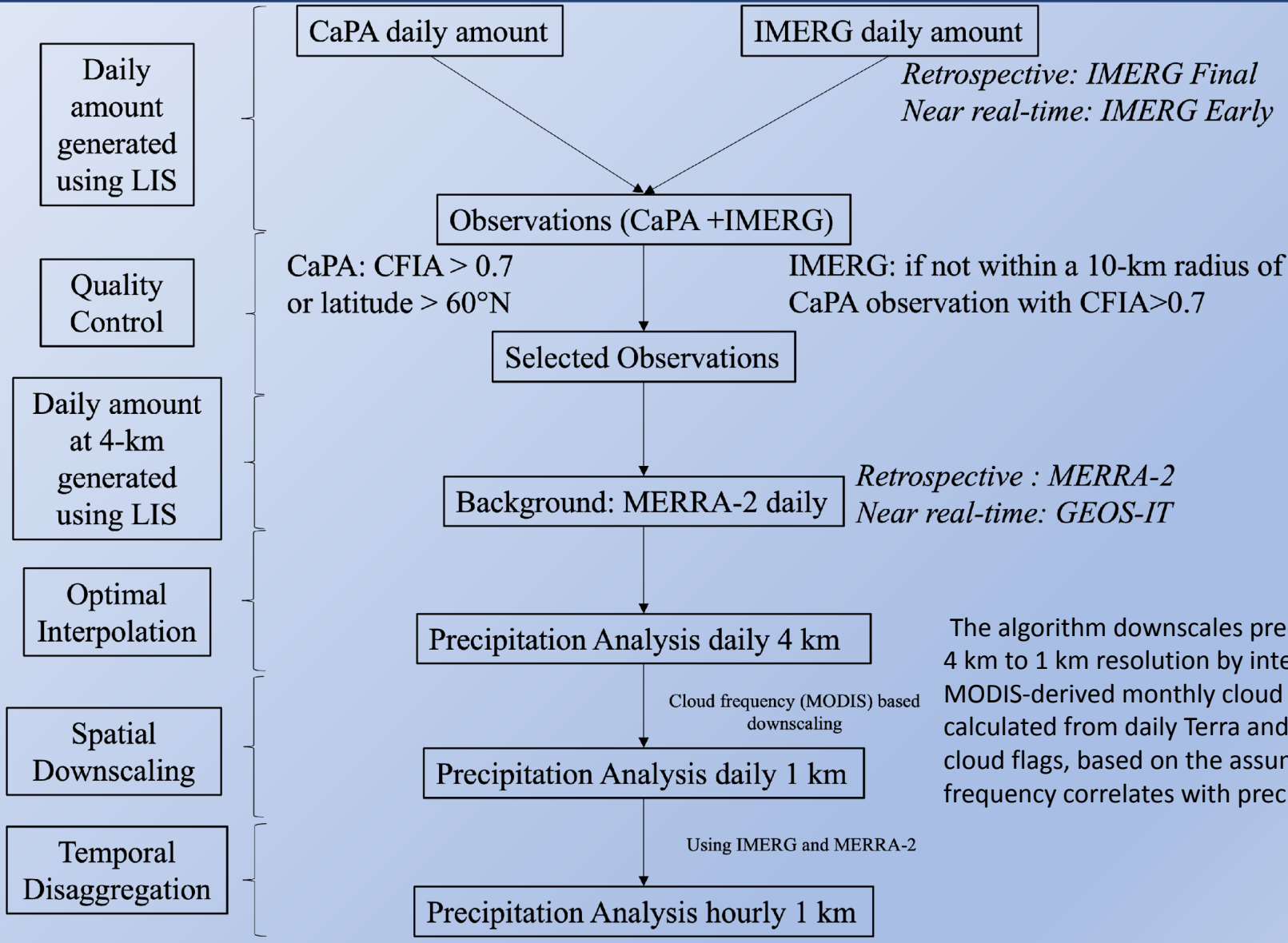
- MERRA-2 surface meteorology and background for precipitation analysis (product has ~3 weeks latency)
- IMERG Final (product has ~3.5 months latency)
- GRACE/GRACE-FO TWS assimilation (product has ~3-4 months latency)
- Soil moisture, snow, vegetation DA
- Serves as “best possible” analysis for most accurate quantification of all key water cycle components
- Will be produced for the full period of record

Near real-time NLDAS-3 product (“Early Look”)

- Latency of about ~7 hours (1x per day)
- NASA’s GEOS-IT surface meteorology and background for precipitation analysis
- IMERG Early
- Near real-time DA for soil moisture, snow, vegetation
- When the Final product is updated, the Early run will restart from the latest available Final states, and continue to real-time (planning for monthly update)
- Will be provided for the gap between the late-look and near-time period.

What goes into NLDAS-3 meteorology (precipitation)?

NLDAS-3 uses advanced optimal interpolation techniques to blend well-known and widely used meteorological forcing: **NASA's MERRA-2 and IMERG** and ECCC Canada's CaPA

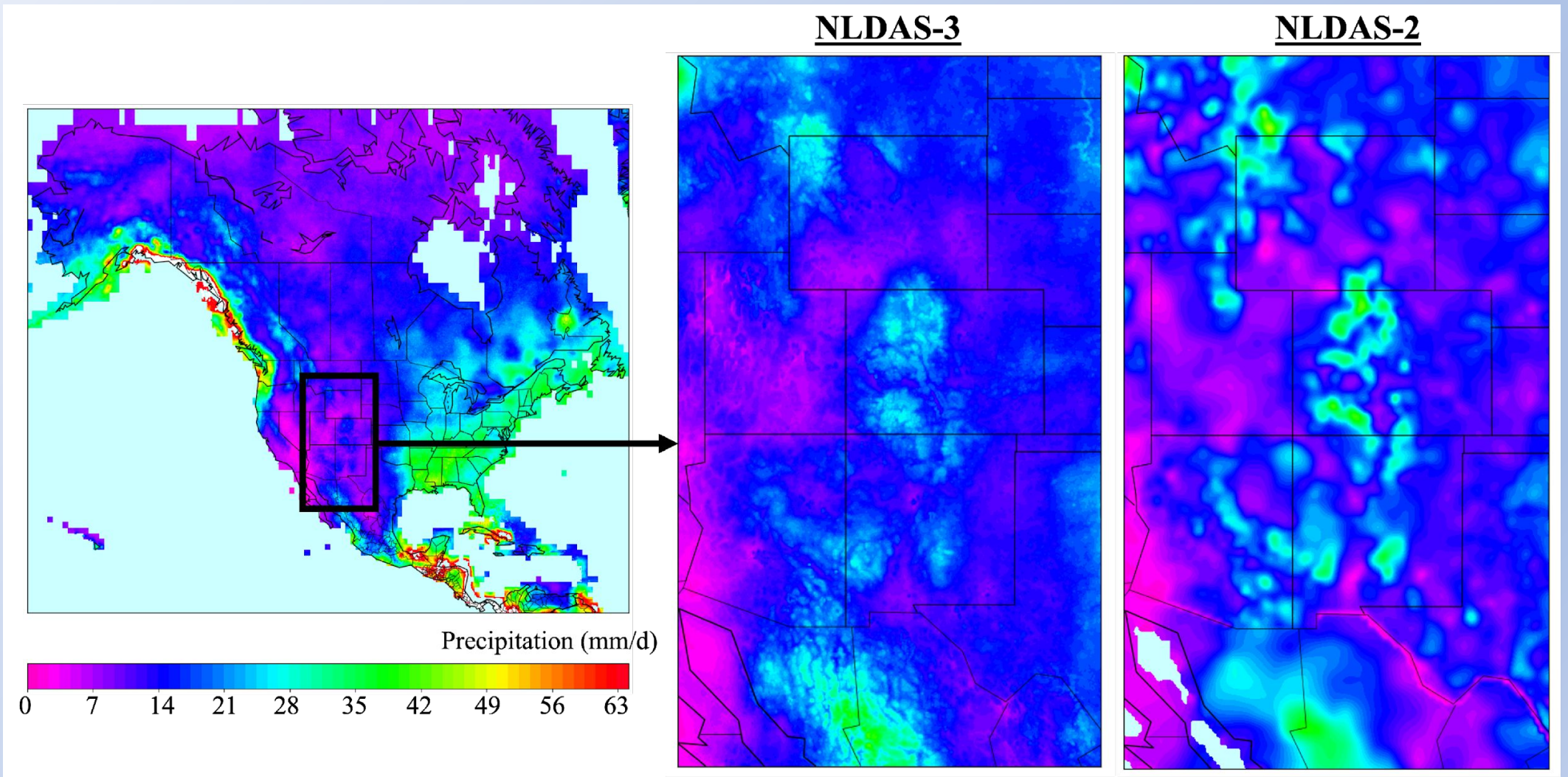


The algorithm downscales precipitation data from 4 km to 1 km resolution by integrating MODIS-derived monthly cloud cover frequency, calculated from daily Terra and Aqua satellite cloud flags, based on the assumption that cloud frequency correlates with precipitation patterns.

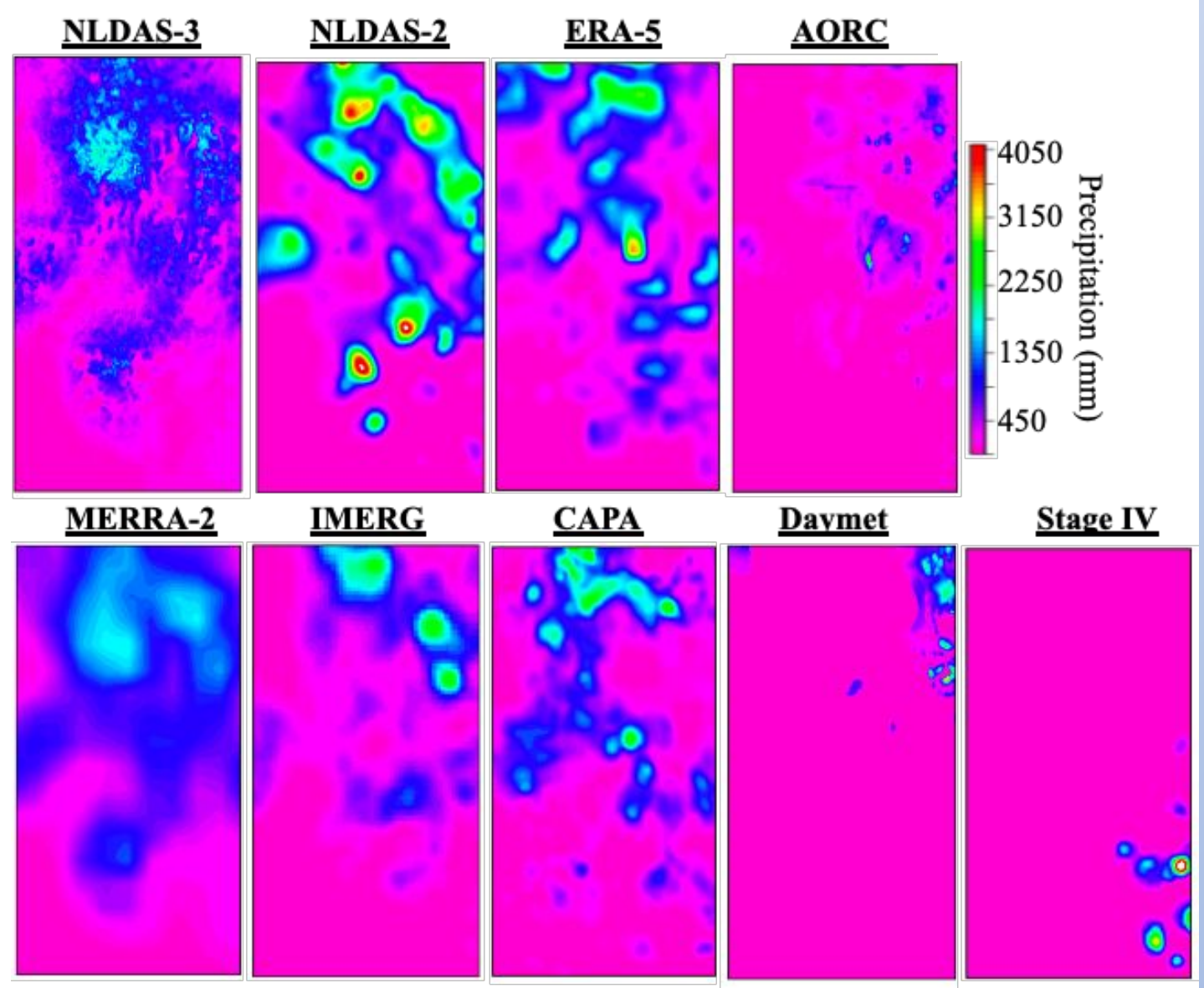
NLDAS-3 provides surface meteorology at 1-km resolution

NLDAS-3 provides surface meteorology over North & Central America

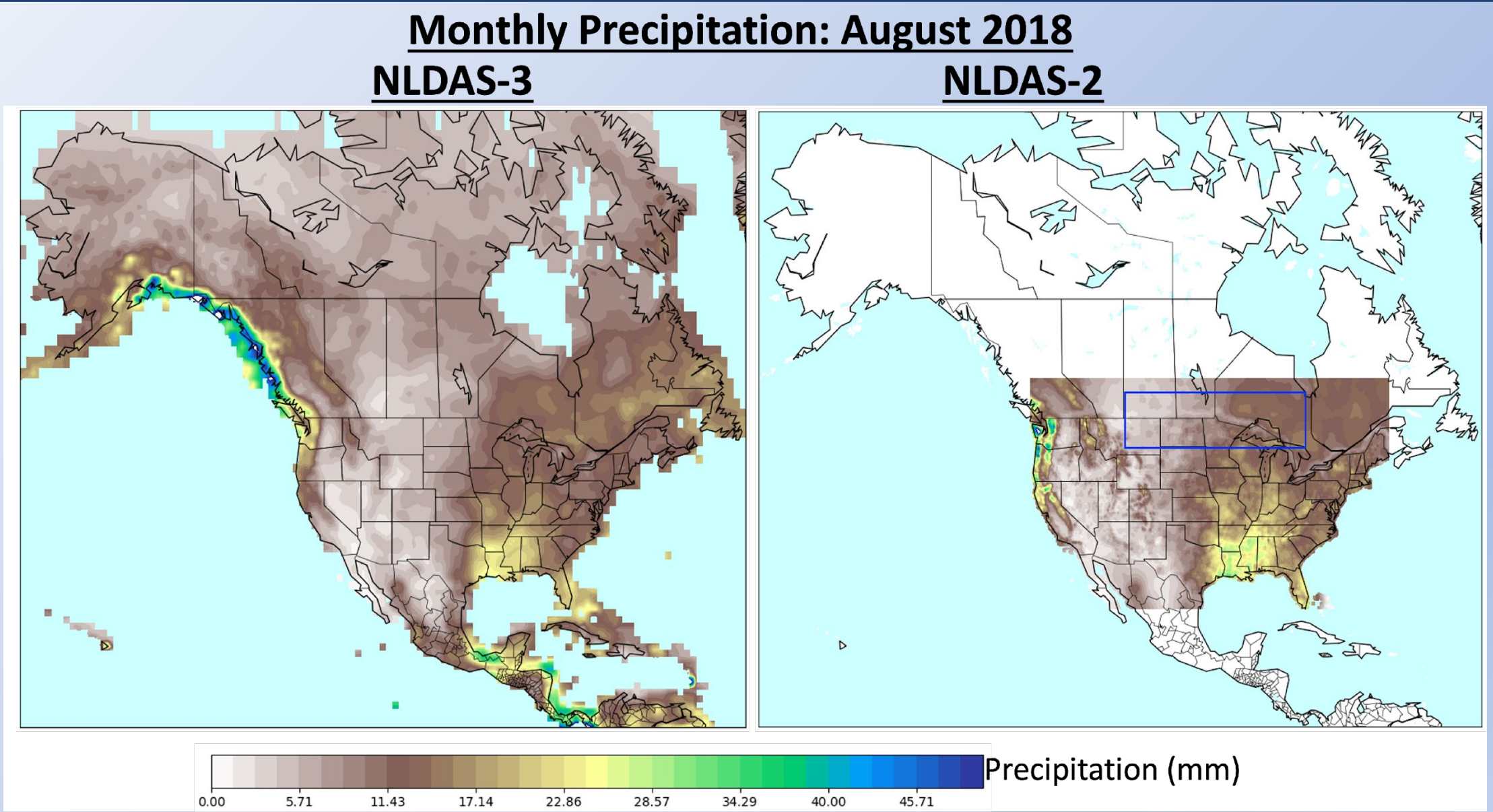
NLDAS-3 provides surface meteorology ar 1-km resolution (higher than NLDAS-2)



NLDAS-3 Provides Surface Meteorology at 1-km Resolution

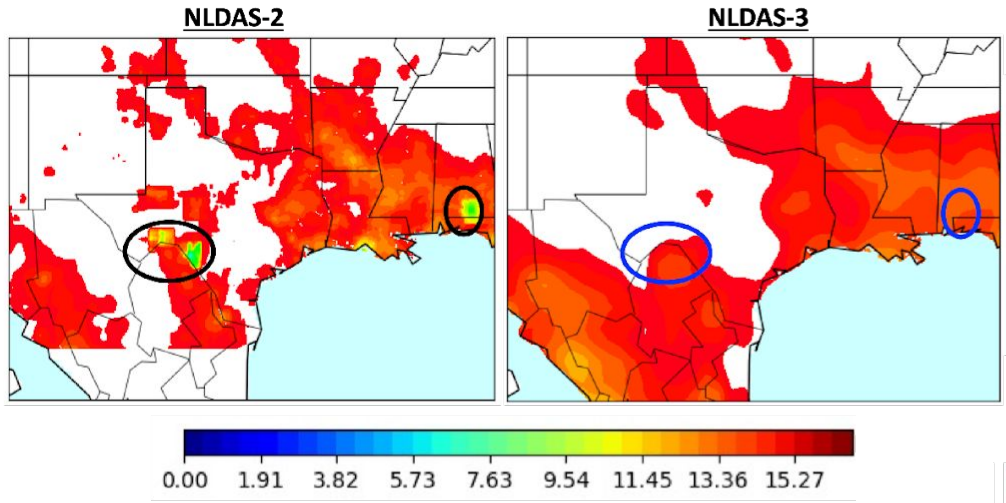


NLDAS-3 Overcomes NLDAS-2 Border Issues



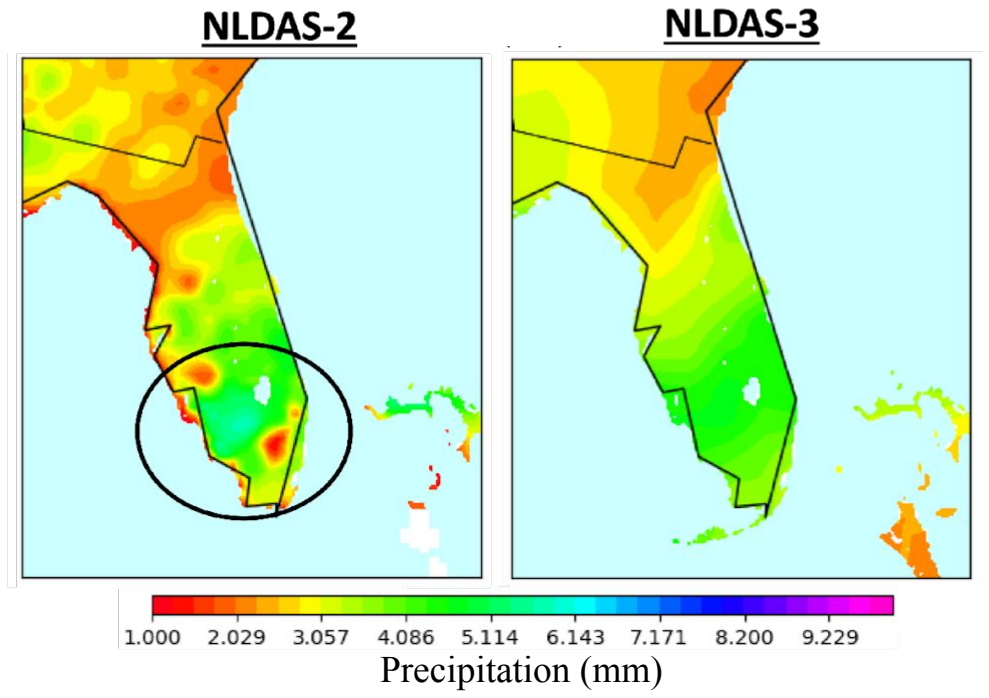
NLDAS-3 does not induce local high and low precipitation values

Abnormally localized wet conditions

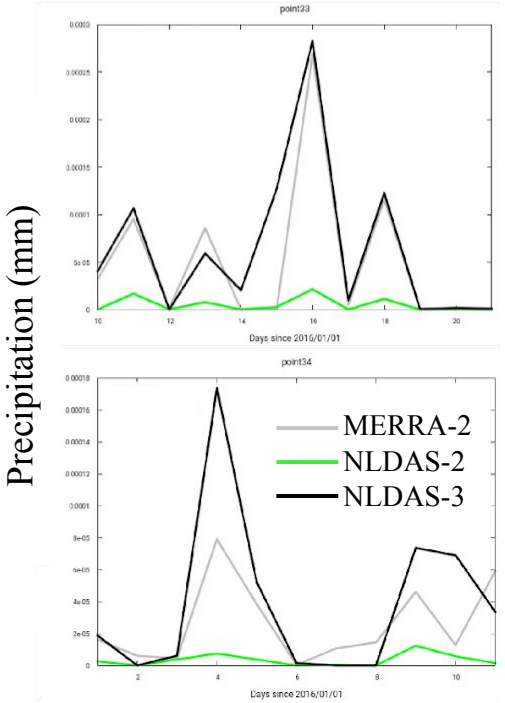


Unrealistically high precipitation in small localized regions in Texas and the Southeast U.S. for August 2008 in NLDAS-2, which is not the case for NLDAS-3

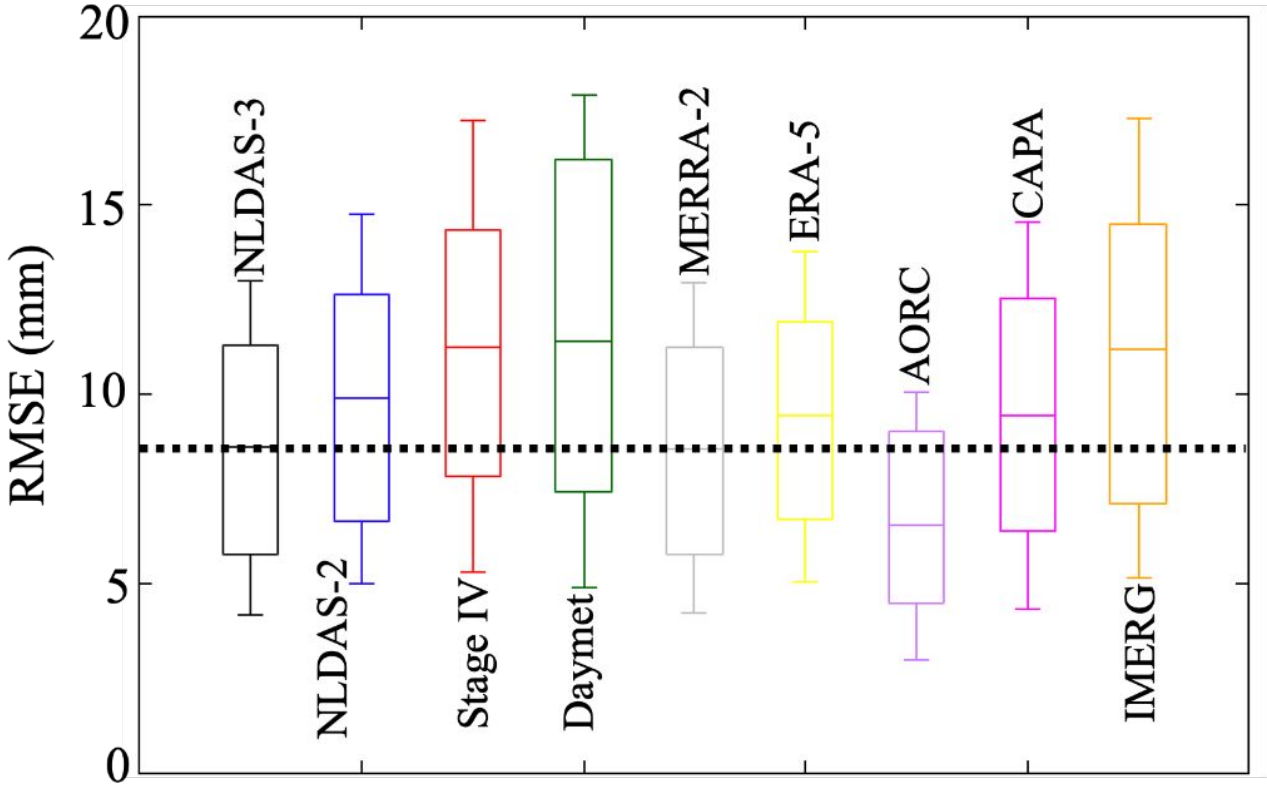
Abnormally localized dry conditions

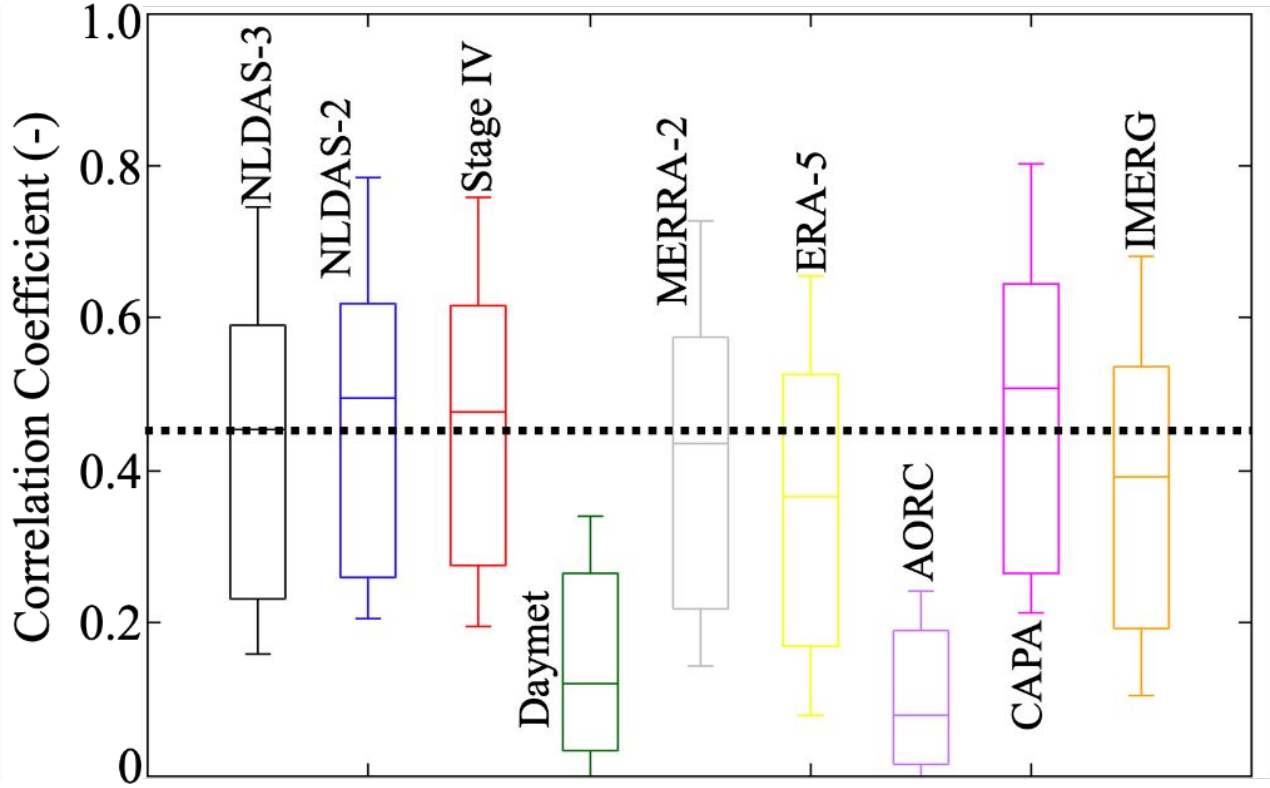


NLDAS-2 is dry over Florida in January 2016



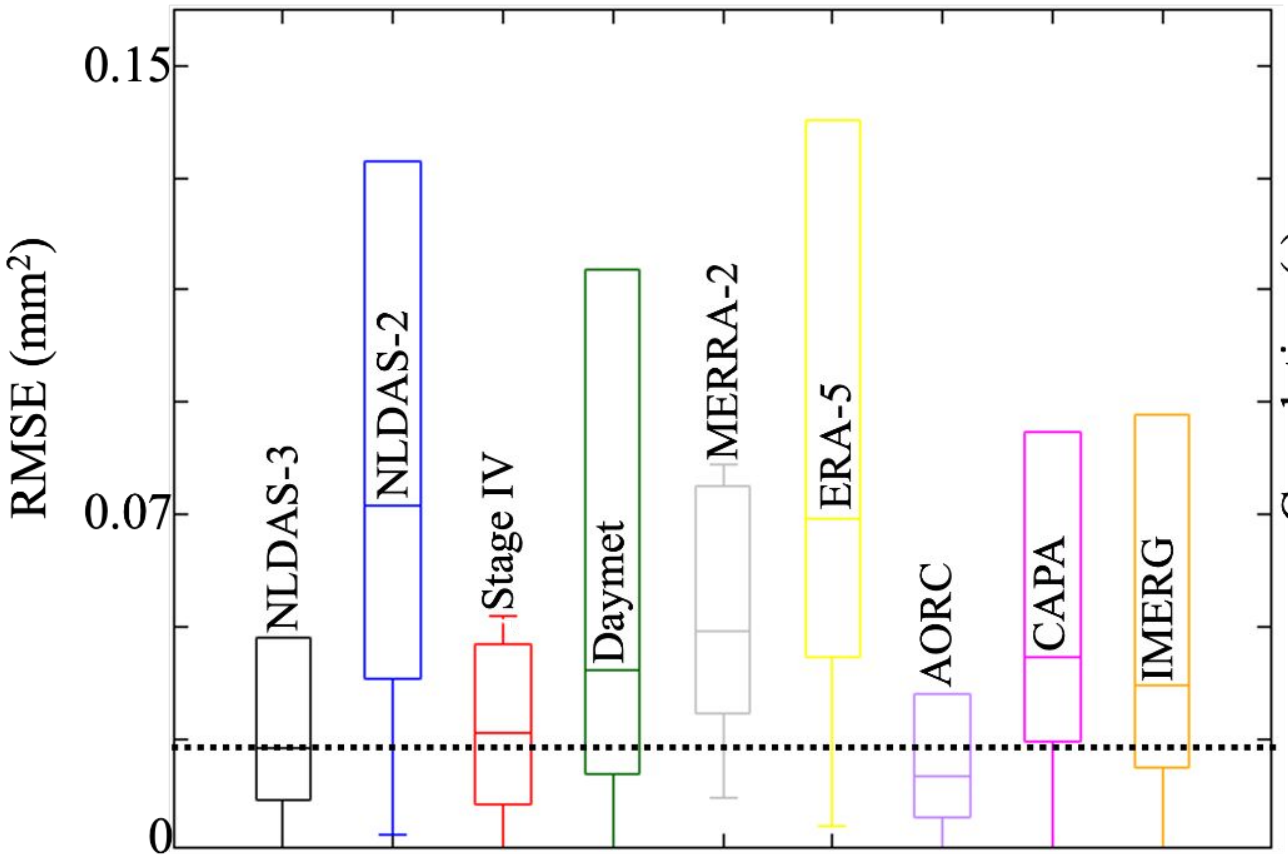
NLDAS-3 precipitation evaluation (vs ground obs)

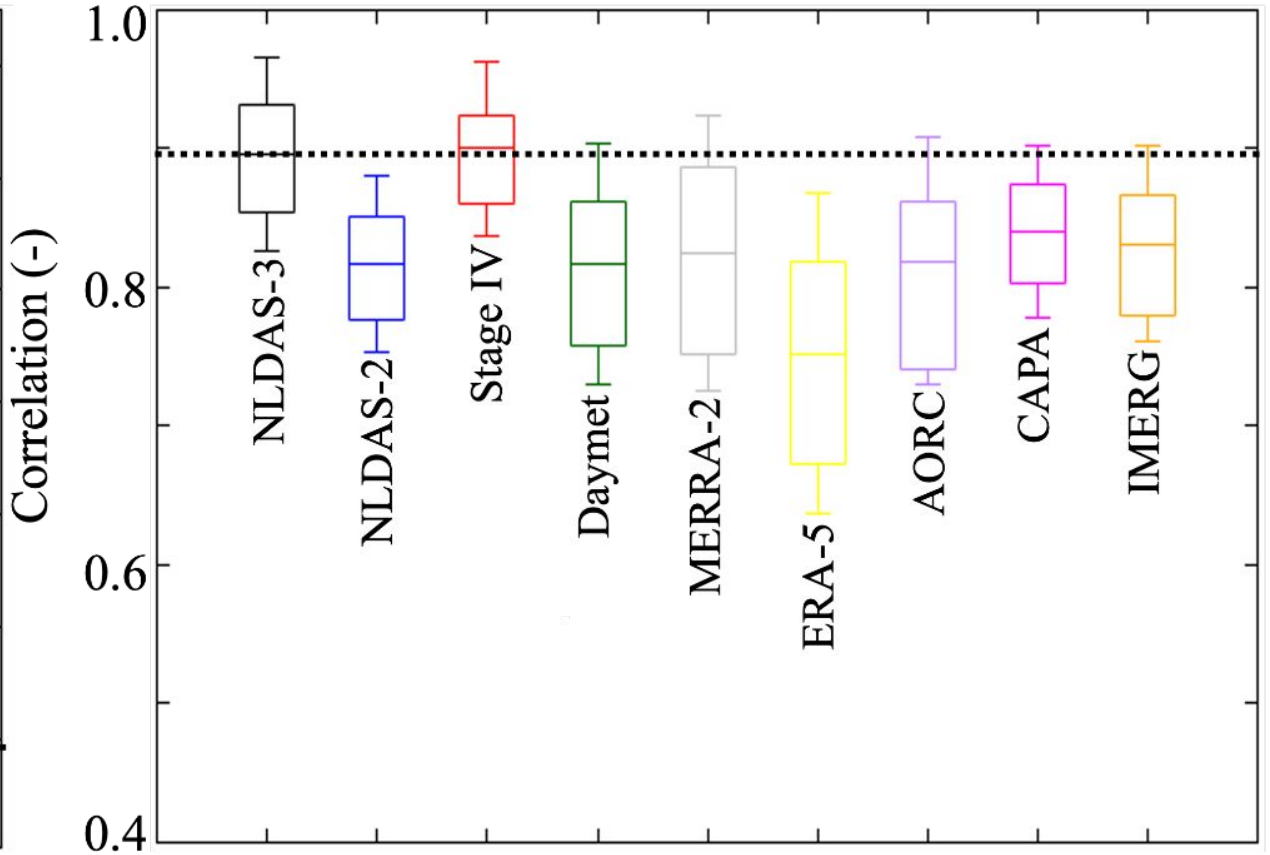




- AORC outperforms other products by ingesting ground observations.
- NLDAS-3 performs better than NLDAS-2 but slightly below MERRA-2.

NLDAS-3 precipitation evaluation (extended triple collocation)





The extended triple collocation shows that NLDAS-3 has lower RMSE and higher correlation coefficient than the other products

1-km Surface Meteorology

The other surface meteorological variables are also downscaled to 1-km:

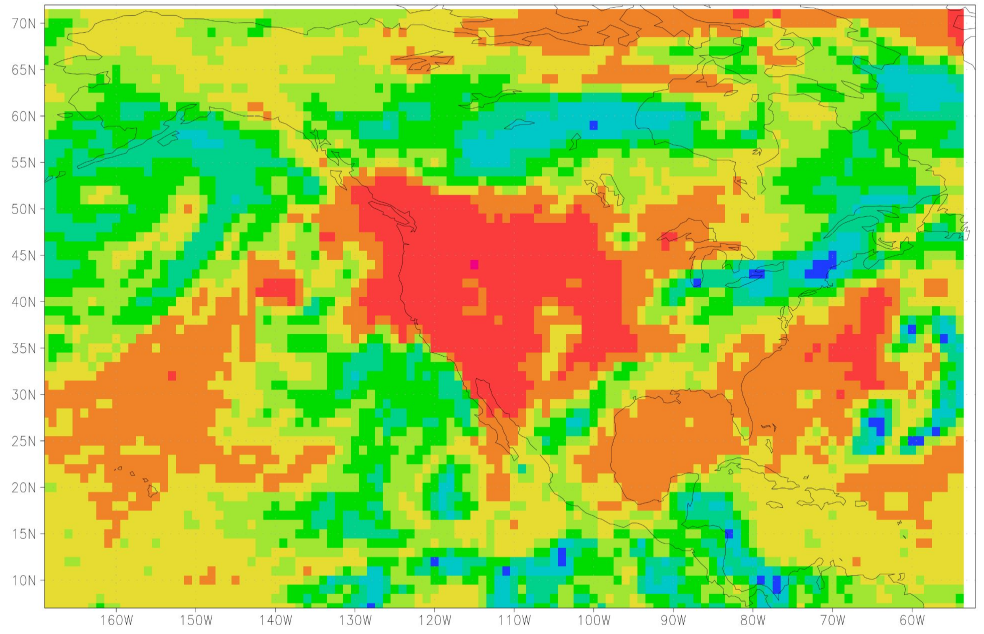
- Surface **temperature**, **moisture**, & **pressure** adjusted via a dynamic (local, hourly) lapse rate method (Whitney et al. submitted).
- **Winds** adjusted via MicroMet (uses topographic slope, curvature, azimuth).
- **Shortwave down** using CERES/POWER data → downscaled via slope-aspect correction from 1-km topography.
- **Longwave down** using CERES/POWER data → downscaled via a dynamic (local, hourly) lapse rate method (similar to surface temperature, moisture, pressure).

Downscaling of CERES Downwelling Shortwave Radiation

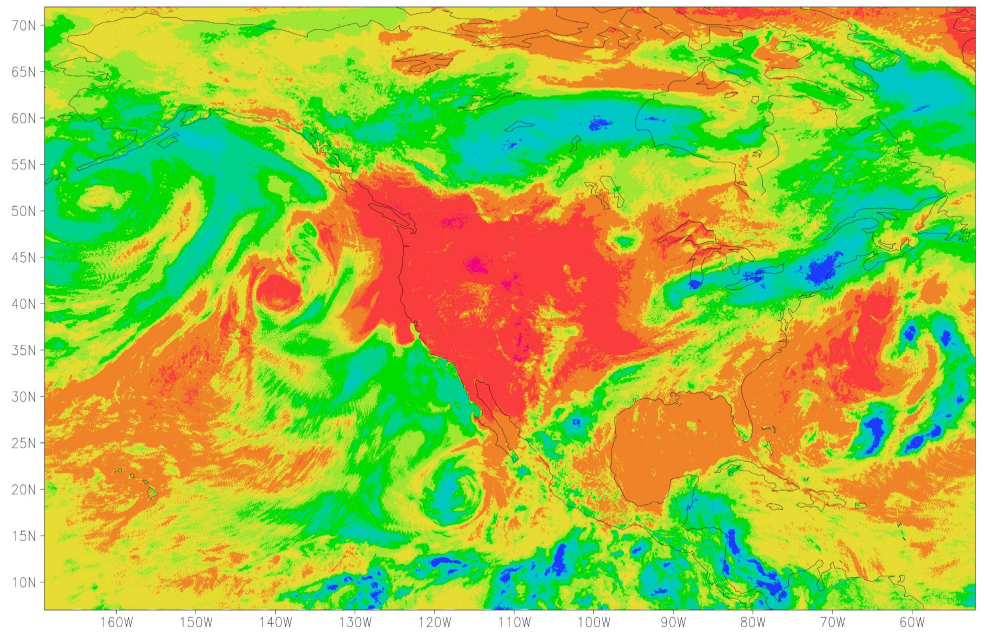
Current NASA POWER products from CERES/GEO imagers provide hourly radiative flux estimates at coarser resolutions than the proposed NLDAS-3 framework.

To address this, **we developed an ML-based method** to downscale 1° CERES fluxes to 4-km using the original 4-km resolution of GOES for NLDAS-3.

Original CERES 1°



Downscaled CERES at 4-km



NLDAS-2 to NLDAS-3

Attribute	NLDAS-2	NLDAS-3
Spatial coverage	CONUS (25-53 North / 125-67 West)	North America including Alaska, Hawaii, Puerto Rico, and Central America (7-72 North / 169-52 West)
Spatial resolution	12.5-km	1.0-km
Latency	~4 days	~7 hours
Precipitation	CPC daily 12.5-km analysis over CONUS	Assimilation using gauges, IMERG, CaPA, with MERRA-2/GEOS-IT as background
Surface meteorology	NARR with constant lapse-rate adjustment	MERRA-2/GEOS-IT/CERES with advanced downscaling
Land surface models	4 (Noah, VIC, Mosaic, SAC)	1 (Noah-MP)
Data assimilation	None	Assimilation of remotely-sensed data sets of soil moisture, leaf area index, snow, terrestrial water storage, etc.
Forecasting	None	Up to 2 week hydromet/hydrologic forecasts

NLDAS-3 Variables and Data Access

Energy fluxes and states	Latent heat flux, sensible heat flux, ground heat flux
Surface state variables	Snow water equivalent, snow depth, snow cover, skin temperature, albedo, evapotranspiration, potential evapotranspiration, vapor pressure deficit, leaf area index
Carbon variables	Gross primary production, net primary production
Soil and subsurface state hydrologic variables	Soil moisture, terrestrial water storage, groundwater storage, water table depth, surface runoff, subsurface runoff, streamflow

- Data in **netCDF-4 format, accessible from the cloud** for analysis without downloading large datasets.
- Spatial, regional, and variable **subsetting tools** for targeted data downloads.
- Cloud-optimized GeoTIFF and GIS collections of **selected variables based on stakeholder needs**.

NLDAS-3 Data Timeline

Product	Variables	Production Estimate
NLDAS-3 Surface meteorology (hourly; Jan 2001 to present)	Precipitation, SW/LW down at the surface, 2-m T/q, 10-m winds	**Beta version available now**
NLDAS-3 Open Loop (no surface data assimilation)	Soil moisture/temps, snow, surface fluxes, groundwater, LAI, streamflow	**Late summer 2025**
NLDAS-3 Full DA (multivariate surface data assimilation)	Same as Open Loop	**Late fall 2025**
NLDAS-3 Forecasting	Soil moisture, hydrometeorology	**2026**

For updates on NLDAS-3 data availability: https://ldas.gsfc.nasa.gov/nldas/v3

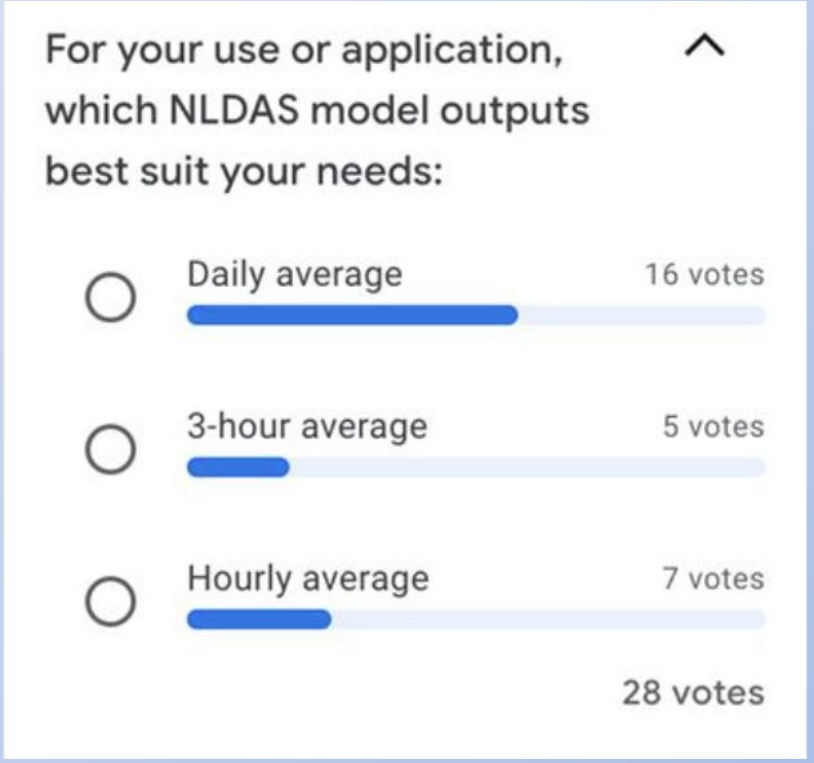
Precipitation data now on the SMCE/AWS has a known issue with mask / interpolation along coastlines. We have a solution, but it will be a couple of weeks before the corrected data is available: NLDAS-3 Forcing README

NLDAS-3 Data Temporal Resolution

- We are considering providing NLDAS-3 model output data (from both the Noah-MP LSM and the HyMAP river routing model) at **daily-average** temporal resolution only.
- NLDAS-3 surface meteorology and precipitation will still be provided **hourly** (to drive the models): precipitation, SW/LW downward radiation, winds, surface pressure, 2-m air temperature/humidity.
- Reasoning:
  a. Reduces data storage by a factor of $1/24^{th}$ due to smaller file sizes;
  b. Significant improvement in model simulation speed by writing data only once, minimizing I/O wall-clock time.
- A discussion on this topic is already ongoing on the NLDAS-3 GitHub: https://github.com/NASAWaterInsight/NLDAS-3/discussions

NLDAS-3 Data Temporal Resolution Poll

Workshop Participant Poll:



Example Applications:
Historic, Real-time, and Forecasts

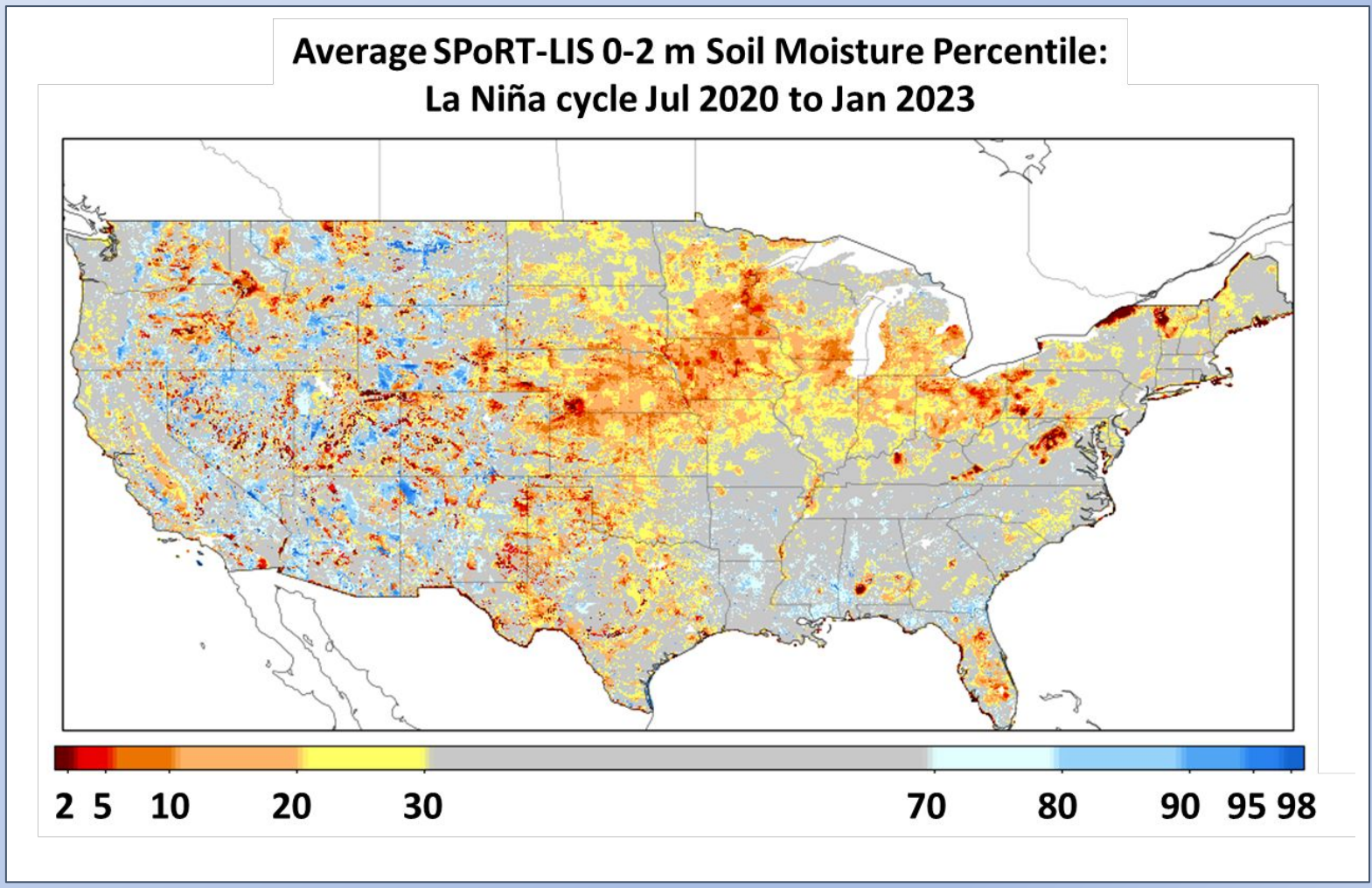
Jonathan Case

With Christopher Hain, Andrew White, Rob Junod,
Vikalp Mishra, and Mitchell Dodson

NASA Marshall Space Flight Center

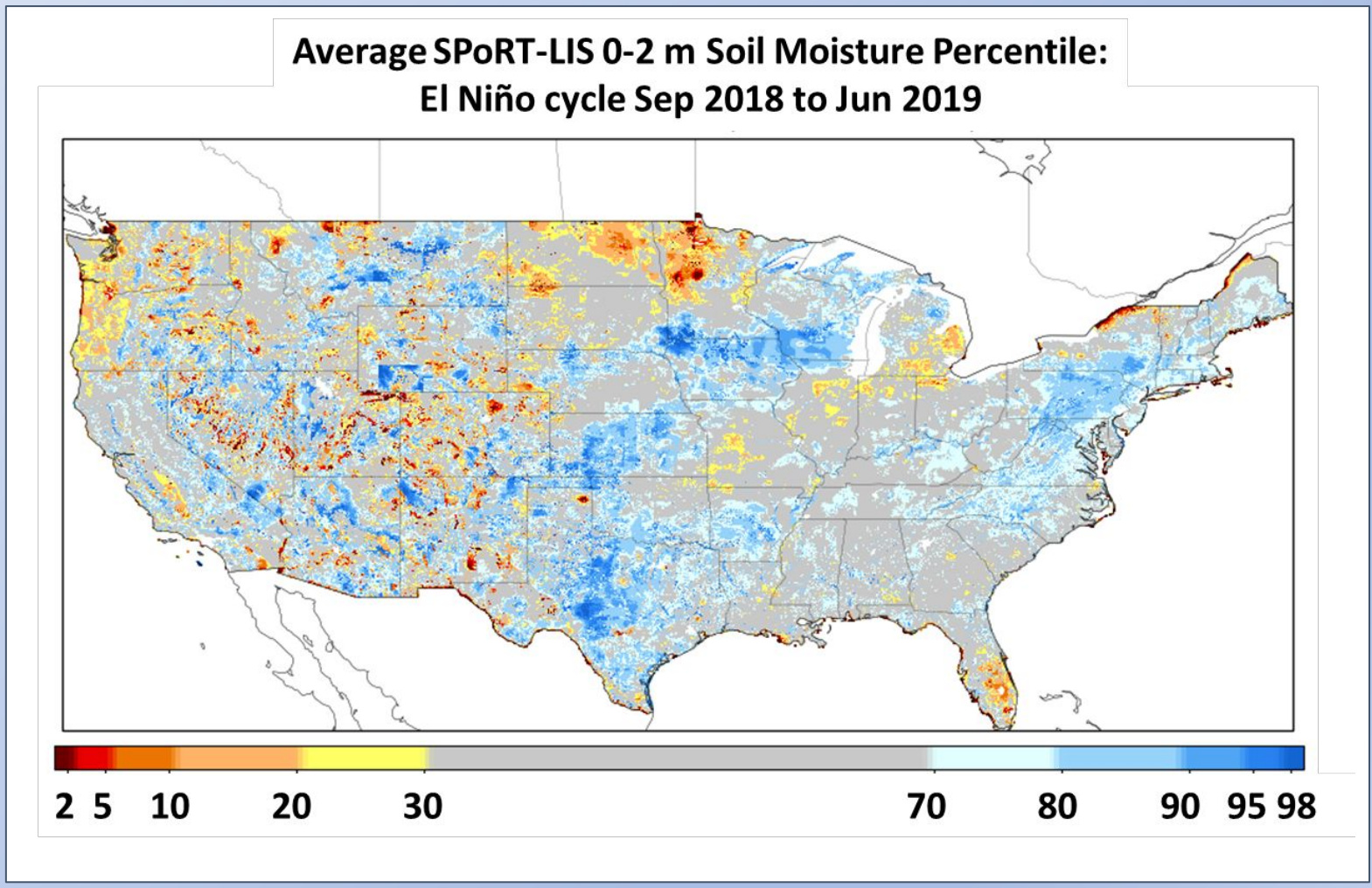
Historic Soil Moisture Percentiles

- Examine mean soil moisture percentiles during El Niño and La Niña episodes
- Most recent La Niña and El Niño periods shown at right using SPoRT-LIS daily percentiles, averaged between mid-points of months experiencing at least 0.5° C anomaly in Ocean Niño Index (ONI)



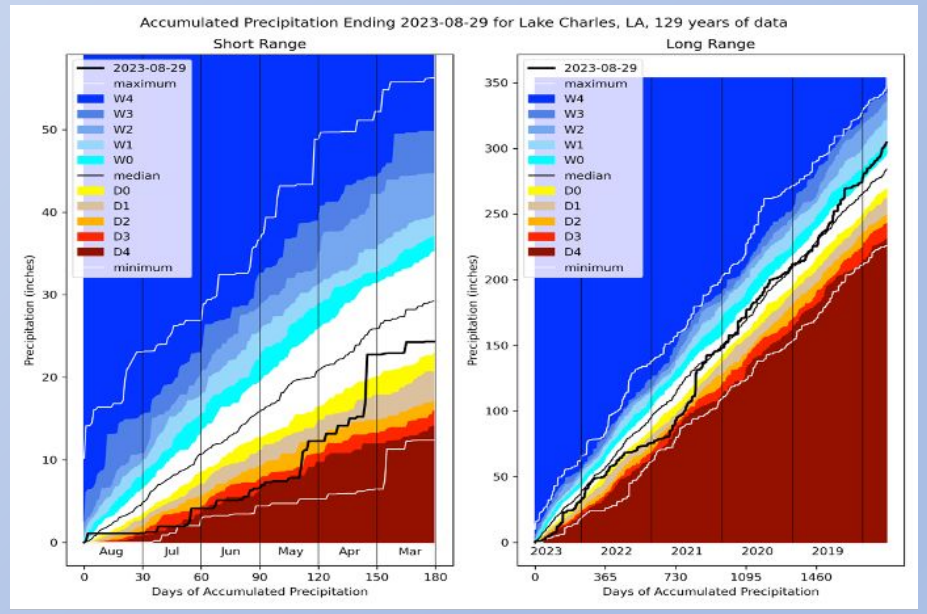
Historic Soil Moisture Percentiles

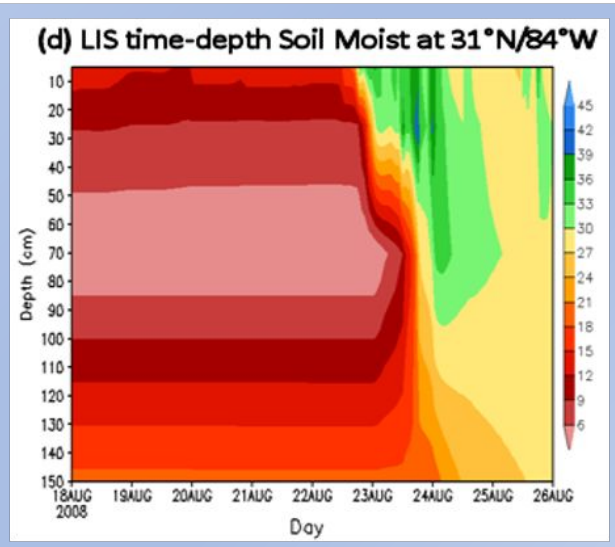
- Examine mean soil moisture percentiles during El Niño and La Niña episodes
- Most recent La Niña and El Niño periods shown at right using SPoRT-LIS daily percentiles, averaged between mid-points of months experiencing at least 0.5° C anomaly in Ocean Niño Index (ONI)



Enhanced Product Ideas for NLDAS-3 Analyses

- Soil Moisture Volatility Index (SMVI) for identifying regions experiencing flash drought conditions based on soil moisture deficits
- Composite/Blended Drought Indicators such as those at https://ndmcblends.unl.edu/Home.aspx
- Dr. Nielsen-Gammon's "Precipitation Fingerprint Plots", derived from NLDAS-3 forcing (upper-right)
- Layered data formats (cloud-optimized geoTIFFs)
- Interactive capabilities to query areas of interest
- County- and HUC-basin masking for bulk stats
- Time-depth cross sections at select locations, or averaged over masked regions (example, bottom-right)
- Soil moisture associated with lightning-initiated wildfires

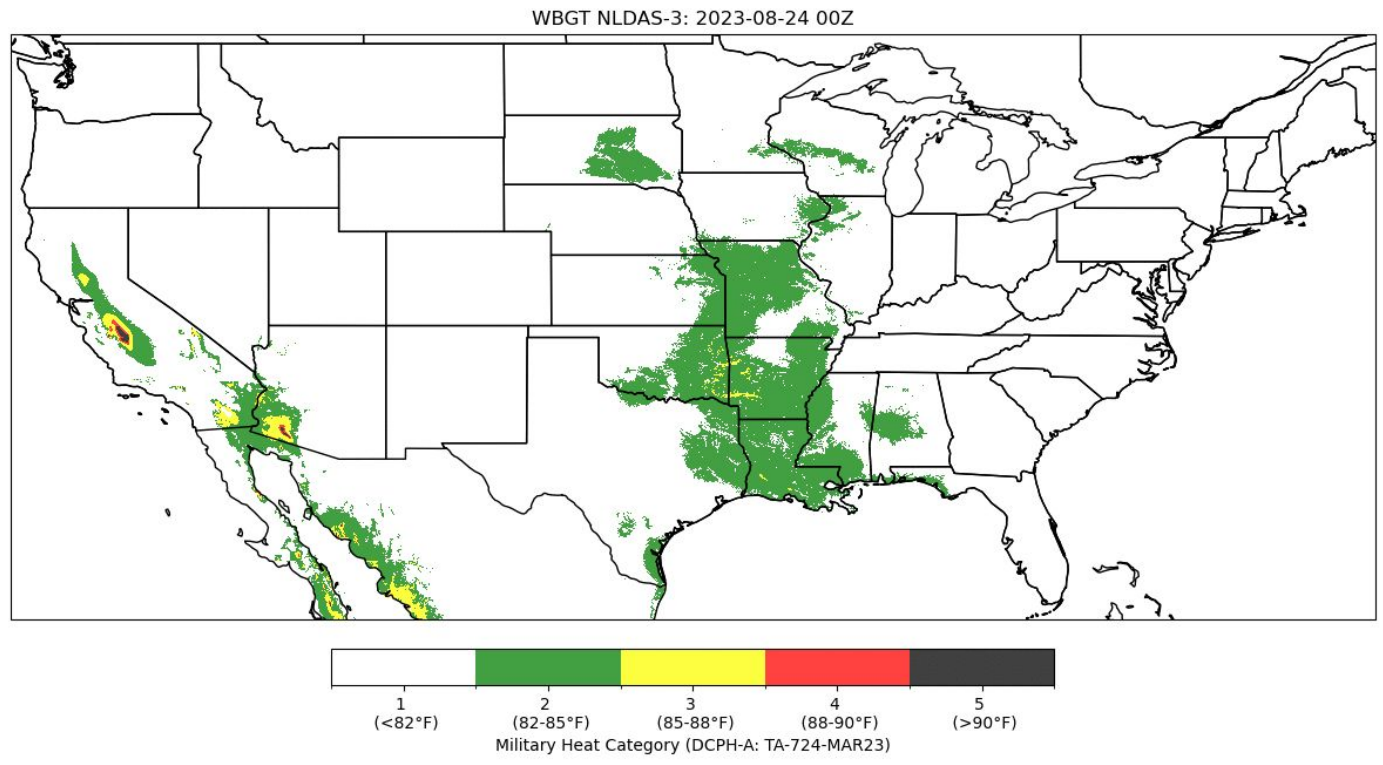




Heat Tool Using NLDAS-3 Forcing

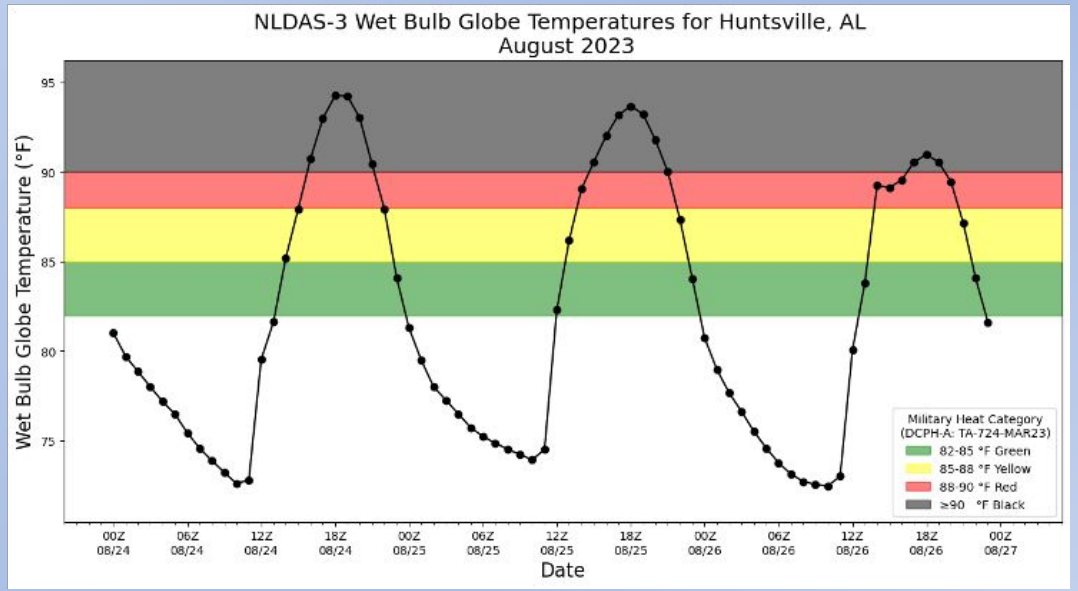
Wet Bulb Globe Temperature (WBGT) Example for August 24-26th 2023

- Hourly WBGT based on NLDAS-3 forcing dataset
- Calculation based on Liljegren et al., 2008
- WBGT heat criteria based on military guidelines (TB MED 507)



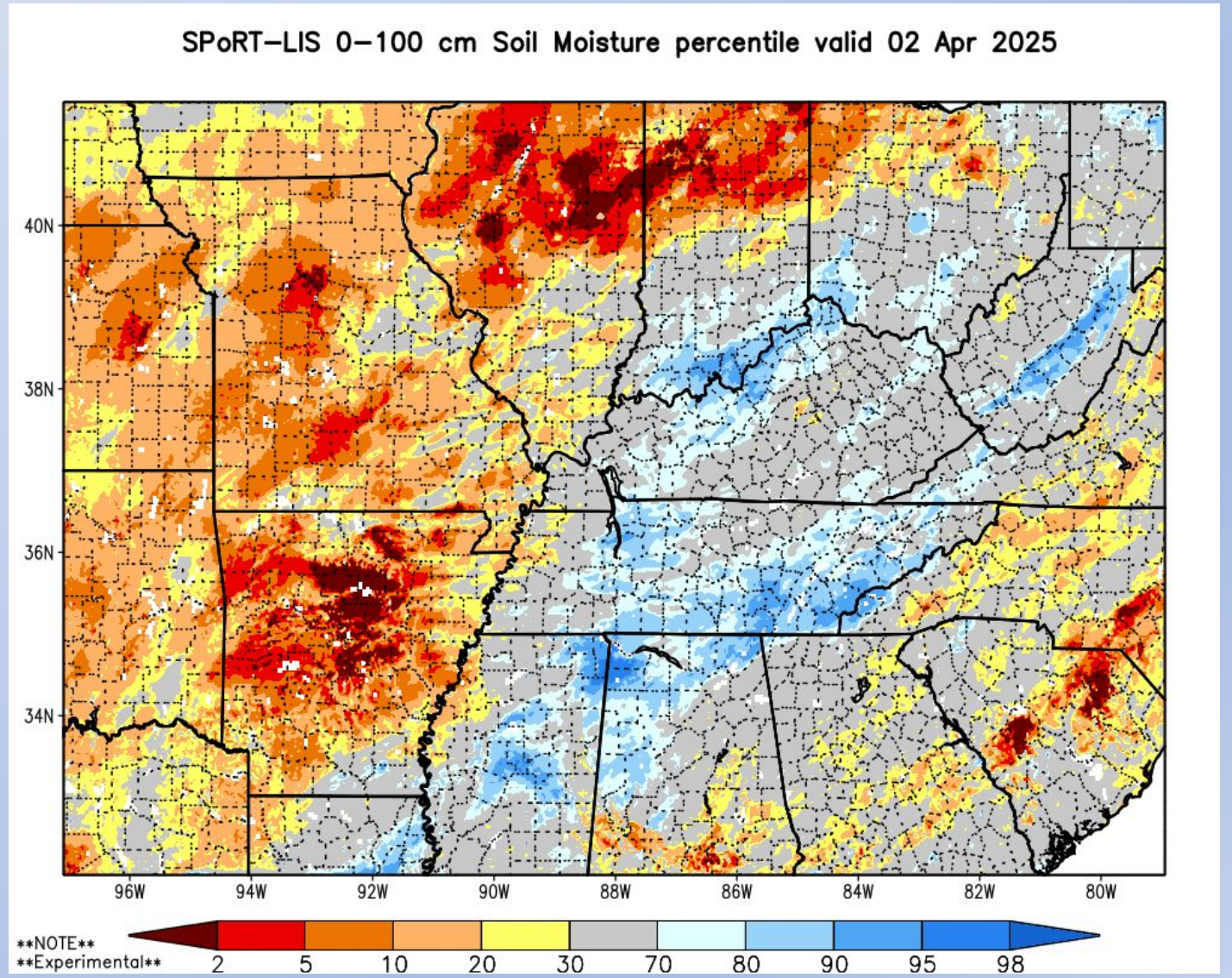
Heat Cat	WBGT Index, °F	Easy Work		Moderate Work		Heavy Work		Very Heavy Work	
		Work (min)	Water Intake qt/hr	Work/Rest (min)	Water Intake qt/hr	Work/Rest (min)	Water Intake qt/hr	Work/Rest (min)	Water Intake qt/hr
1	78° - 81.9°	NL	½	NL	¾	40/20	¾	20/40	1
2	82° - 84.9°	NL	½	NL	¾	30/30	1	15/45	1
3	85° - 87.9°	NL	¾	NL	¾	30/30	1	10/50	1
4	88° - 89.9°	NL	¾	50/10	¾	20/40	1	10/50	1
5	> 90°	NL	1	20/40	1	15/45	1	10/50	1

Source: DCPH-A: TA-724-MAR23



Forecast Soil Moisture Percentiles

- SPoRT currently generates 14-day forecast soil moisture percentiles, driven by GFS forecast precip
- For NLDAS-3 forecasts, we envision:
  - 14-30 day forecasts, bridging gap from short-term forecasting to S2S
  - Deterministic and ensemble outputs
- Forecast ensemble proposal:
  - Daily spread of forecast LSM solutions, forced by all GEFS members
  - Probabilities of soil moisture or other variables falling below or exceeding threshold percentiles
  - Soil Moisture Volatility Index for flash drought prediction



The National Drought Mitigation Center's Use of NLDAS: Data and Needs

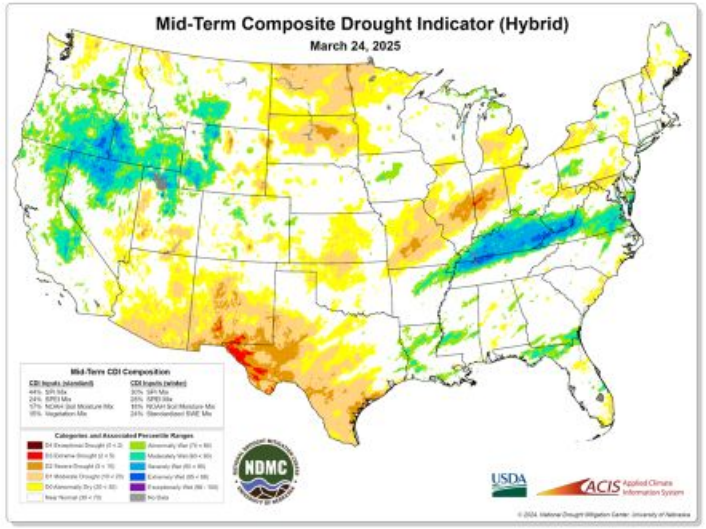
Brian Fuchs
&
Dr. Mark Svoboda

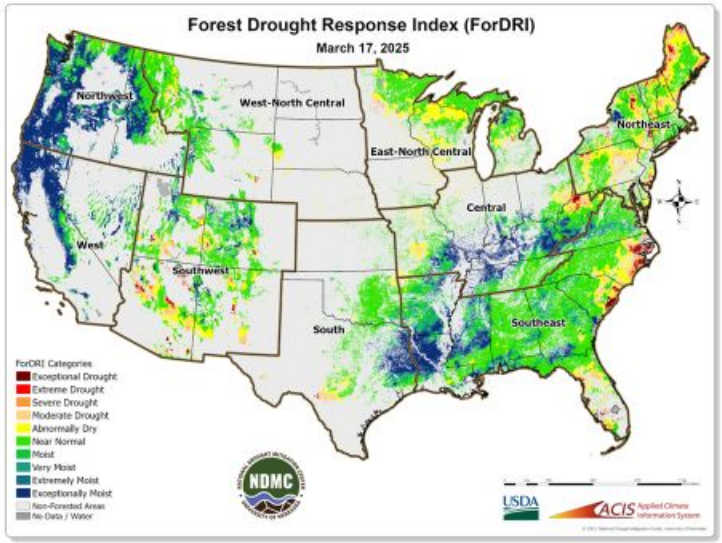
NATIONAL DROUGHT MITIGATION CENTER
UNIVERSITY OF NEBRASKA

NLDAS-3 Stakeholders Workshop
April 10, 2025

Current uses of NLDAS data:

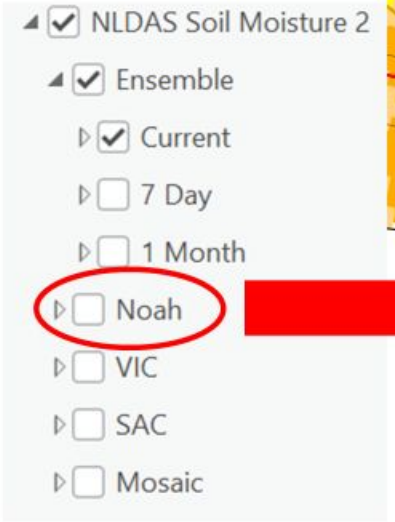
- Legacy “blends” of short- and long-term drought products
  - https://ndmcblends.unl.edu/Legacy.aspx
- New NDMC Composite Drought Indicators (CDI’s)
  - https://ndmcblends.unl.edu/Home.aspx
    - Flash drought CDI
    - Short-term CDI
    - Mid-term CDI
    - Long-term CDI
- NDMC’s Quick Drought Response Index (QuickDRI)
  - https://quickdri.unl.edu/Home.aspx
- NDMC’s Forest Drought Response Index (ForDRI)
  - https://fordri.unl.edu/
- Radiation and Humidity values are used in the GridMET processing of PET which we are utilizing in various products and calculations

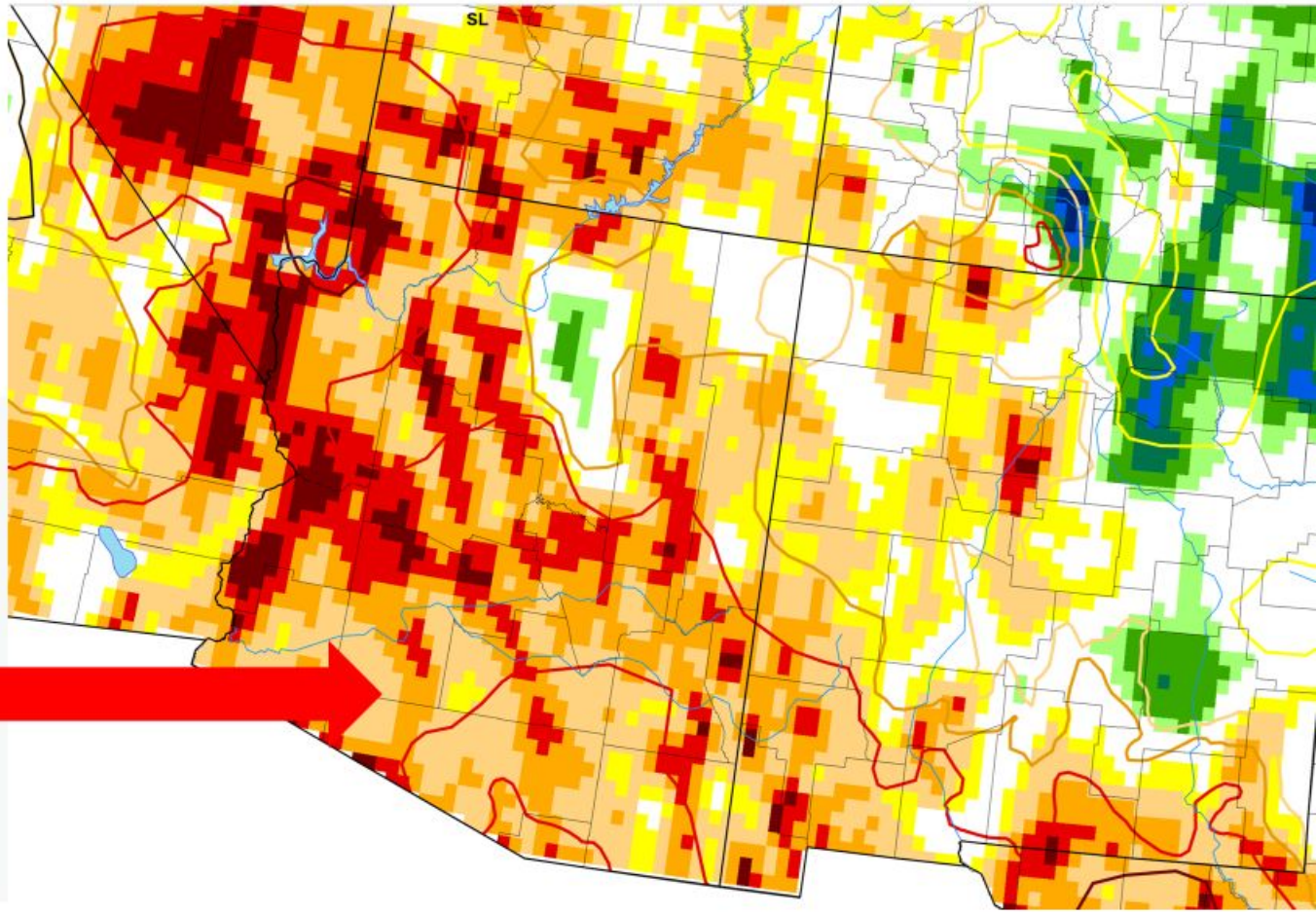




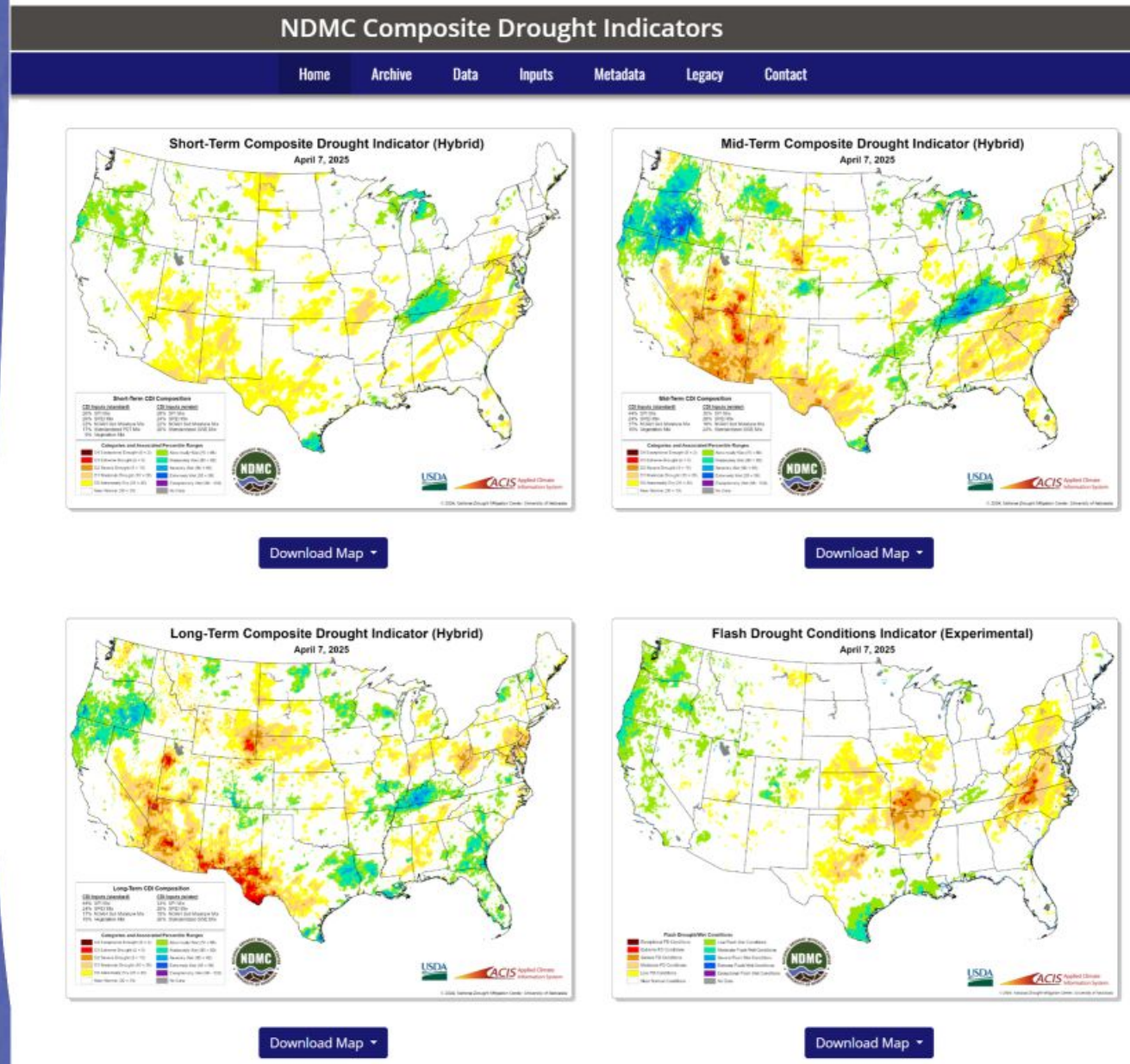
Current uses of NLDAS data:

- The United States Drought Monitor (https://droughtmonitor.unl.edu/) Authors utilize all the NLDAS soil moisture products in the weekly operational production of the USDM map. The Authors use the current, 7-day, and 1-month values for
  - NOAH
  - VIC
  - SAC
  - Mosaic
  - Ensemble





Composite Drought Indicators using NLDAS-3



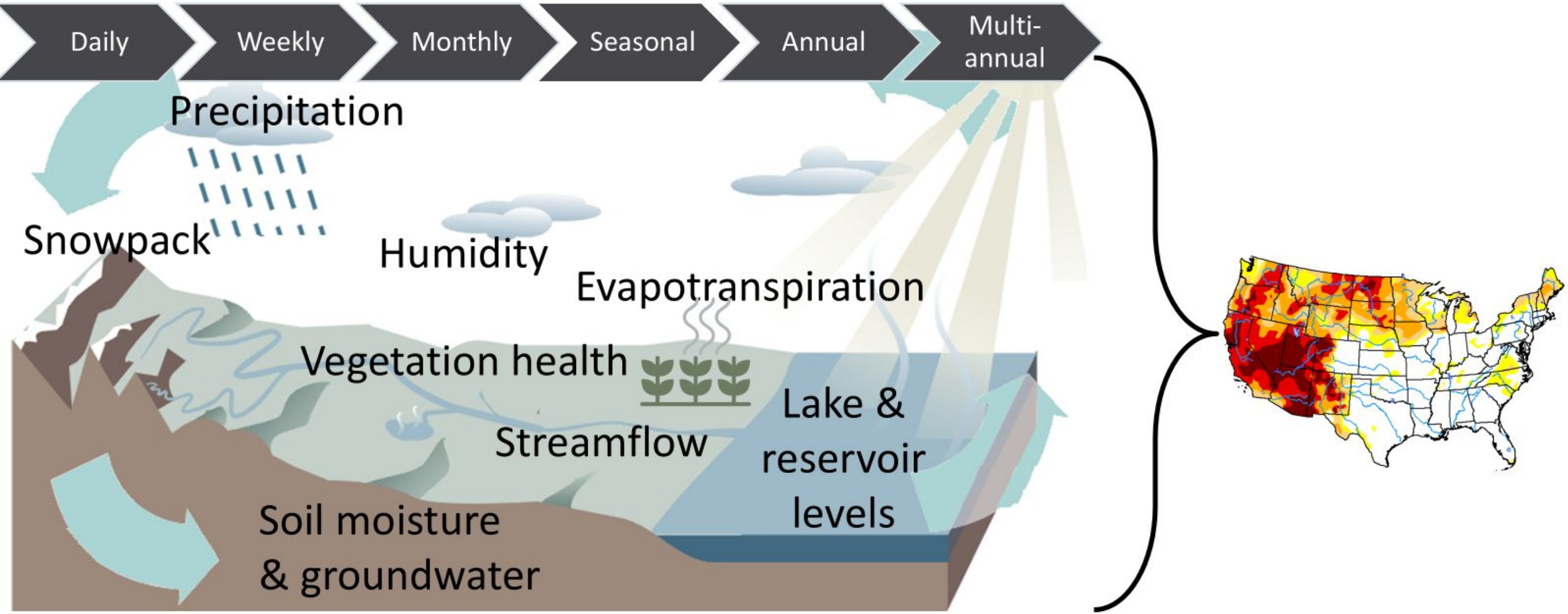
- Will integrate NLDAS-3 into the Machine Learning processes to incorporate new variables
- Investigate how new variables in NLDAS-3 can enhance current CDI's especially for Flash Drought

Needs going forward…….

- Continued support and dissemination of current products.
  - Full Period of Record
  - API/Data services availability
- A longer period of record (POR); back to 1948 similar to what GLDAS provides if possible.
- Vegetation greenness going back to 1948 for vegetation anomalies.
- Surface and baseflow runoff affecting adjacent grid cells (if this is not already being done) including the streamflow amount for affected cells.
- 1-week prediction of values using NCEP model data (HREF/SREF/NAM) for variables provided currently where it is possible.

New uses going forward in NLDAS-3….

- Incorporating the data for Alaska, Hawaii, Puerto Rico into the weekly USDM production.
- Using the North and Central America data in the NDMC CDI work.
- Provide daily values (sum/max/min/mean) where applicable.
- Transition all soil moisture uses to Noah-MP in NLDAS-3
  - Incorporating into NDMC's suite of CDI's
  - Other NDMC operational tools
  - US Drought Monitor production
- We will investigate other variables due to improved latency (especially precipitation)
- Are there plans for GLDAS effort?



The USDM incorporates multiple types of data & multiple timescales

NLDAS-3 will provide consistent and near real-time data for water resource monitoring

Table 2: List of expected Noah-MP LSM output variables from HydroGlobe.

Variable	Short Name	Units
Surface net downward shortwave flux	SWnet_tavg	W m^{-2}
Surface net downward longwave flux	LWnet_tavg	W m^{-2}
Surface upward latent heat flux	Qle_tavg	W m^{-2}
Surface upward sensible heat flux	Qh_tavg	W m^{-2}
Downward heat flux in soil	Qg_tavg	W m^{-2}
Snowfall rate (frozen)	Snowf_tavg	kg m^{-2} s^{-1}
Rainfall rate (liquid)	Rainf_tavg	kg m^{-2} s^{-1}
Total evapotranspiration	Evap_tavg	kg m^{-2} s^{-1}
Surface runoff amount	Qs_tavg	kg m^{-2} s^{-1}
Subsurface runoff amount	Qsb_tavg	kg m^{-2} s^{-1}
Surface temperature	AvgSurfT_tavg	K
Daily minimum surface temperature	AvgSurfT_tavg_min	K
Daily maximum surface temperature	AvgSurfT_tavg_max	K
Liquid water content of surface snow	SWE_tavg	kg m^{-2}
Snow depth	SnowDepth_tavg	m
Soil moisture - 4 layers [0-10cm; 10-40cm; 40-100cm; 100-200cm]	SoilMoist_tavg	m^3 m^{-3}
Soil temperature - 4 layers [0-10cm; 10-40cm; 40-100cm; 100-200cm]	SoilTemp_tavg	K
Potential evapotranspiration	PotEvap_tavg	kg m^{-2} s^{-1}
Vapor pressure deficit	VPD_tavg	Pa
Vegetation transpiration	TVeg_tavg	kg m^{-2} s^{-1}
Bare soil evaporation	ESoil_tavg	kg m^{-2} s^{-1}
Total canopy water storage	CanopInt_tavg	kg m^{-2}
Water table depth	WaterTableD_tavg	m
Terrestrial water storage	TWS_tavg	mm
Groundwater storage	GWS_tavg	mm
Surface snow area fraction	Snowcover_tavg	[-]
Gross primary production	GPP_tavg	g m^{-2} s^{-1}
Net primary productivity	NPP_tavg	g m^{-2} s^{-1}
Net ecosystem exchange	NEE_tavg	g m^{-2} s^{-1}
Leaf area index	LAI_tavg	[-]

Variable	Short Name	Units
Streamflow	Streamflow_tavg	m^3 s^{-1}
River depth	RiverDepth_tavg	m
Flooded fraction	FloodedFrac_tavg	[-]
Surface water elevation	SurfElev_tavg	m
Surface water storage	SWS_tavg	mm

Thank You!
Questions?

DROUGHT.UNL.EDU e | ndmc@unl.edu /NationalDroughtMitigationCenter @droughtcenter

Brian Fuchs
bfuchs2@unl.edu

Using NLDAS drivers in drought monitoring: the Evaporative Demand Drought Index (EDDI)

Mike Hobbins

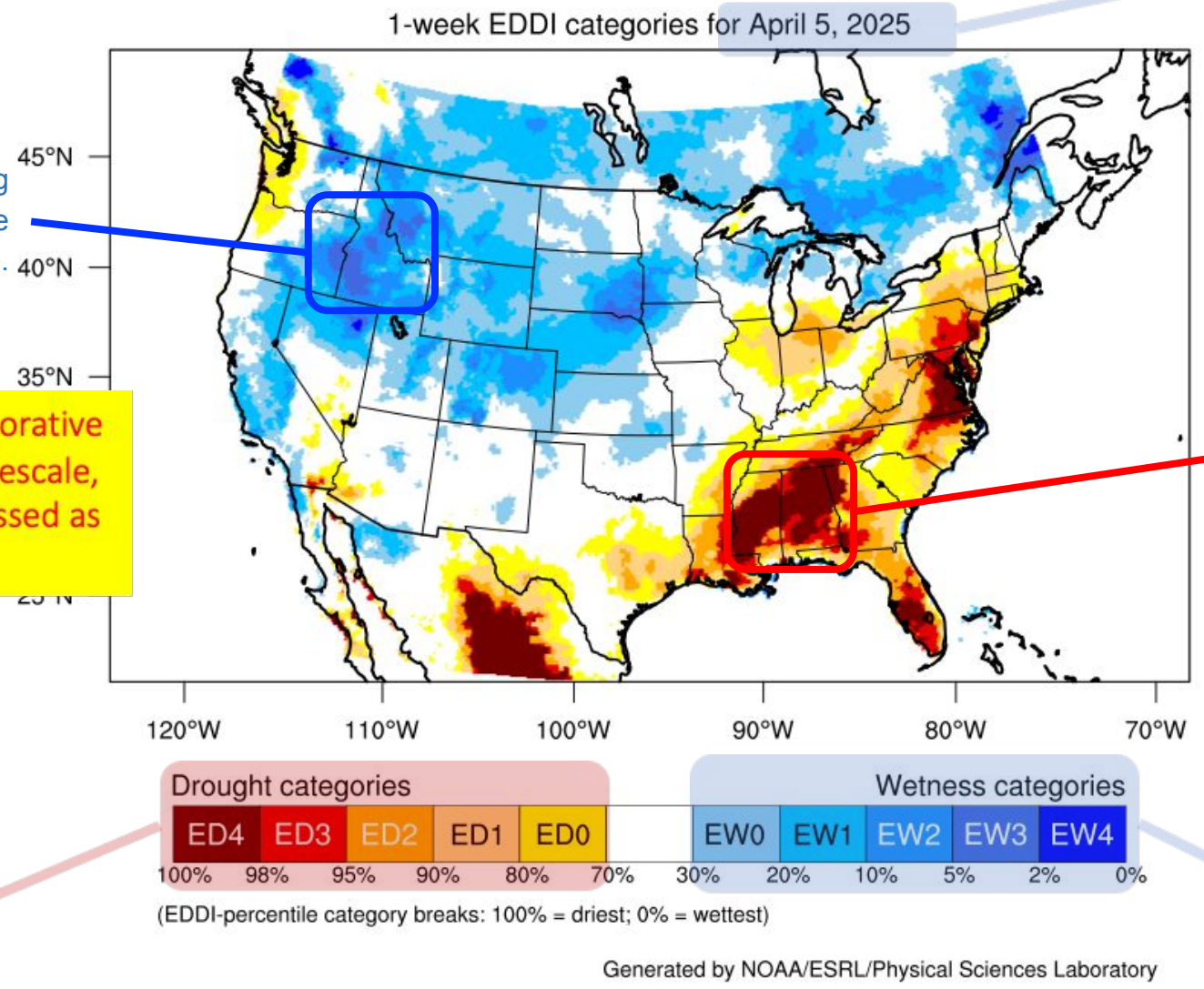
University of Colorado-Cooperative Institute for Research in Environmental Sciences
(at NOAA-Physical Sciences Laboratory)

Cooperative Institute for Research in Environmental Sciences
University of Colorado **Boulder**

NLDAS-3 Drought Monitoring Workshop, April 10, 2025

What is EDDI (currently)?

Lag of ~4 days, so this map was released on April 9, 2025.



ET_0 is unusually low, indicating wetter-than-normal surface conditions and atmosphere.

EDDI: the anomaly in evaporative demand at a specified timescale, for a given location, expressed as a percentile.

ET_0 is unusually high in the southeast, indicating drier-than-normal surface conditions and atmosphere.
ED4 (e.g., in MS) means that such dry conditions are expected only 2% of March 30 – April 5 periods.

Names, colors, and %ile breaks for EDDI drought categories reflect those of the US Drought Monitor.

Wetness and dryness categories mirror each other, so ED2 and EW2 have identical expected frequency.

What is EDDI (currently)?

AGRICULTURAL DROUGHT
- soil moisture
- grazing health
- ET

HYDROLOGIC DROUGHT
- streamflow
- snowfall

FIRE-RISK MONITORING
- weather
- fuel loads

ECOLOGICAL DROUGHT

What is EDDI (currently)?

EDDI is derived from 40+ years of daily reference ET, ET_0

Penman-Monteith reference *ET* (FAO-56):

$$ET_0 = \frac{0.408\Delta}{\Delta + \gamma\left(1 + C_d U_2\right)}\left(R_n - G\right)\frac{86400}{10^6} + \frac{\gamma \frac{C_n}{T}}{\Delta + \gamma\left(1 + C_d U_2\right)} U_2 \frac{\left(e_{sat} - e_a\right)}{10^3}$$

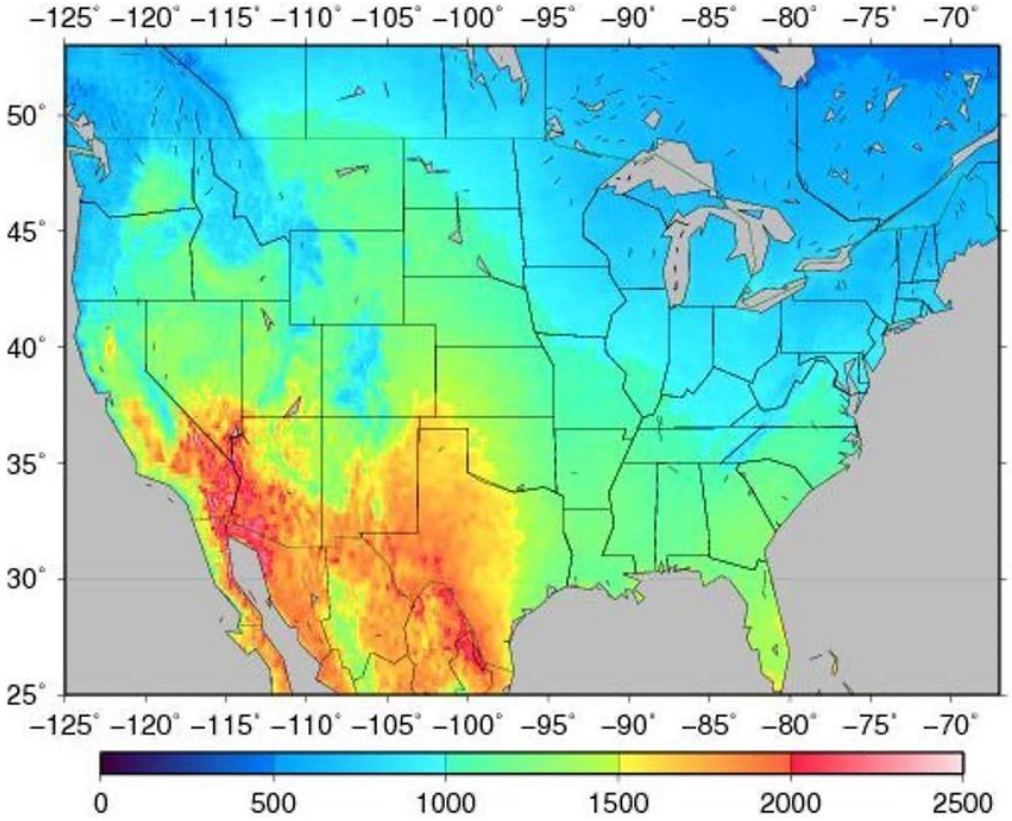
Drivers from NLDAS-2:

- temperature at 2 m
- specific humidity at surface
- downward SW at surface
- wind speed at 10 m

ET_0 dataset specifications:

- daily, Jan 1, 1979 – present
- latency ~ 5 days
- 0.125° lat x lon, CONUS+ (to 53°N)

Mean annual ET_0 (mm), 1981-2010

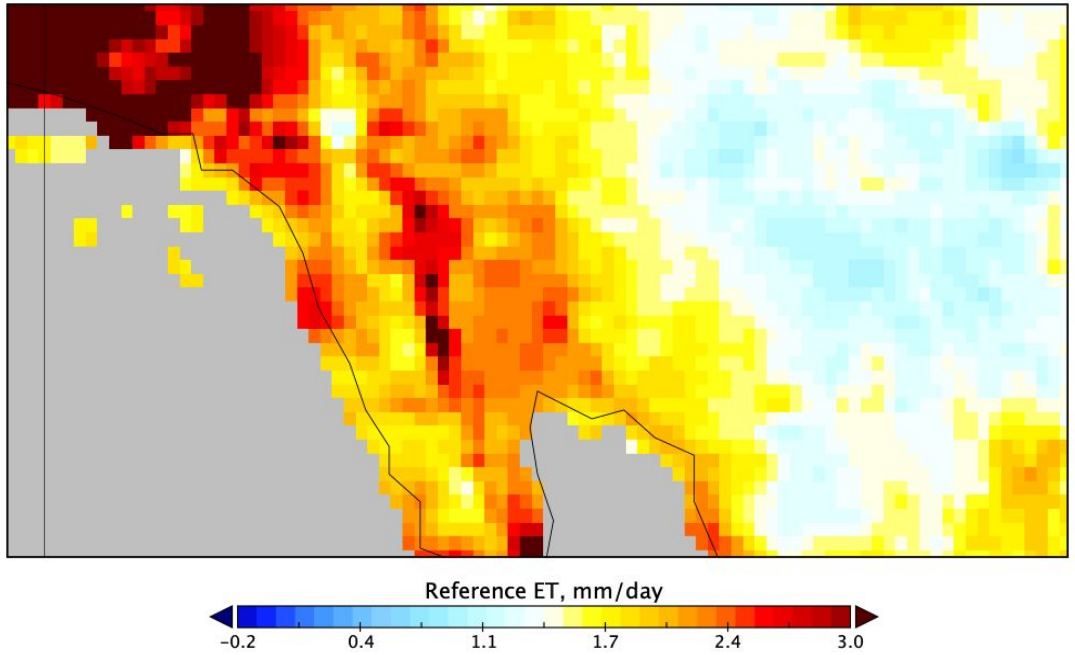


Extending EDDI

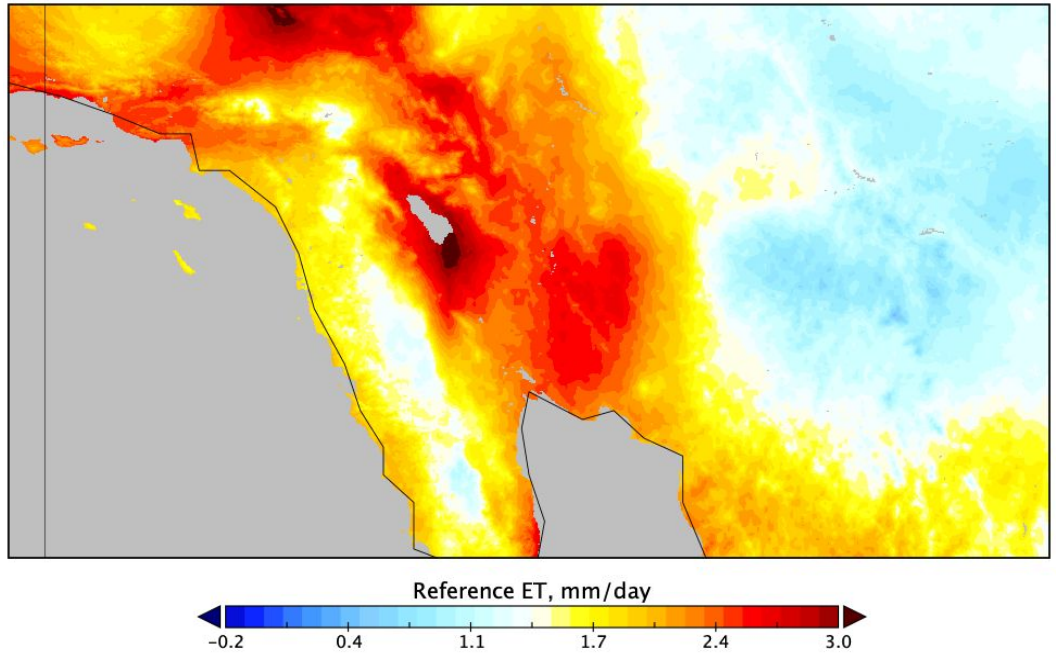
- Current operational constraints:
  - Latency - *~4 days*
  - Geographic extent - *25-53°N*
  - Trans-border issues - *US/Canada discontinuities*
- Stakeholders' un-met needs:
  - Lower latency - *wildfire management, operational drought monitoring, and flash-drought detection*
  - Higher spatial resolution - *ecological drought monitoring and analysis*
  - Larger spatial extent - *Canada, AK, HI, PR*

ET_0: NLDAS-3 vs. NLDAS-2

NLDAS-2



NLDAS-3



12-km resolution	1-km resolution
224 lat * 464 long	6500 lat * 11700 long
~100k cells	732 x NLDAS-2
Hourly drivers: 40.7 MB / day	Hourly drivers: 12.58 GB / day
ET_0: 1.8 MB / day	ET_0: 0.304 GB / day
1979 - present	2000 - present

- ~1.5 GB / day for drivers & ET_0 after trimming variables & converting hourly to daily
- 13.7 TB for 25 years of data

Challenges in moving EDDI to NLDAS-3?

- Verification
  - EDDI and ET_0 against NLDAS-2
- Data size
  - data format within NetCDFs?
    - floats or compressed?
  - pre-processing on NASA's servers
    - e.g., generating daily means from hourly data
  - downloading geographic chunks
- Period of record (full EDDI requires ~40 years)
  - use open-loop (non-DA) runs for longer POR?
  - ranks vs. percentiles for shorter POR?

Questions?

Cooperative Institute for Research in Environmental Sciences
University of Colorado **Boulder**

Data Access, Analysis, and Feedback

Dr. Sid Chaudhary

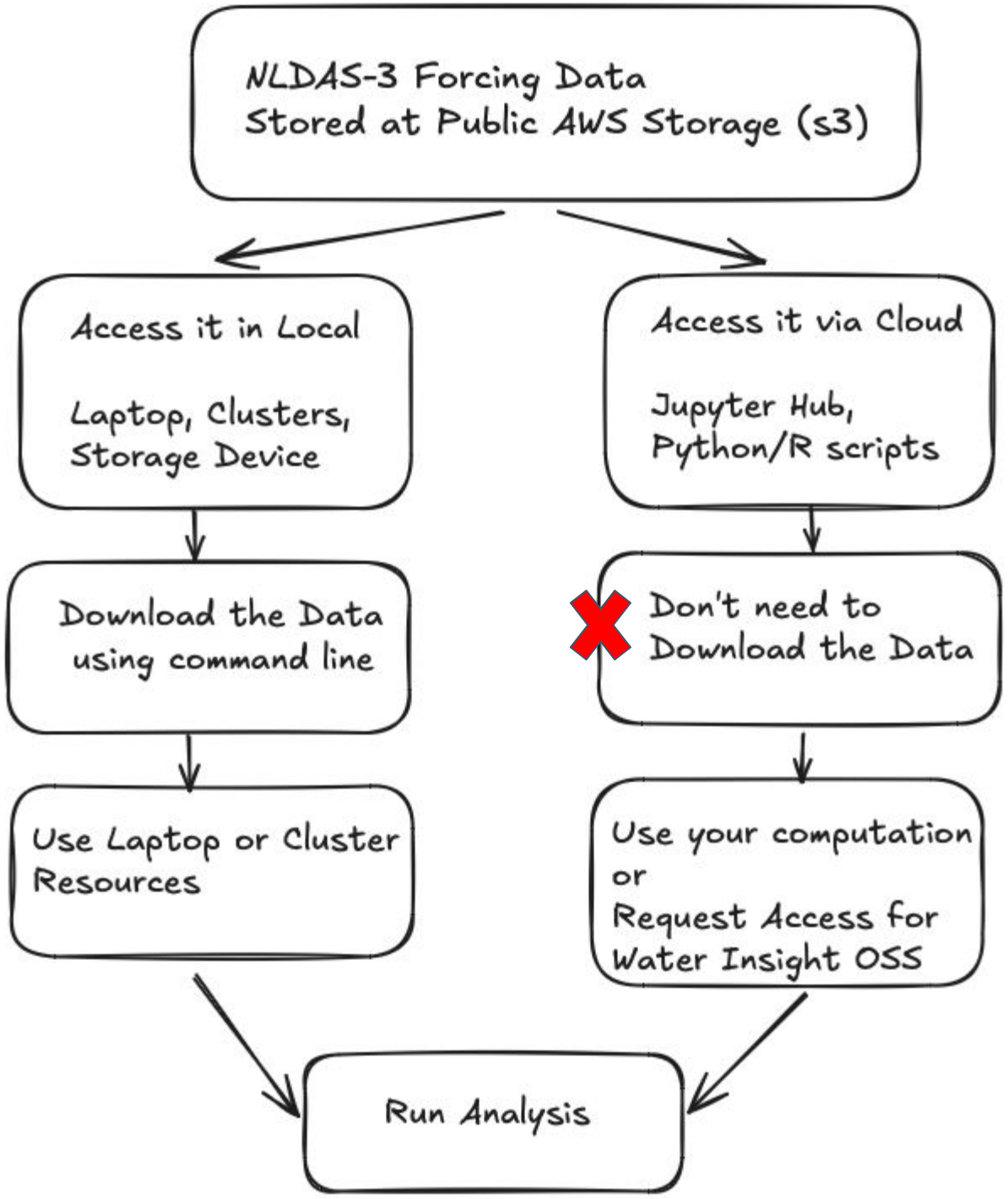
NASA Marshall Space Flight Center

https://github.com/NASAWaterInsight/NLDAS-3.git

develop NLDAS-3 / data_access /

siddharth0248 minor edits to access

Name
..
cloud_request_access_analysis.md
download_from_aws.md



develop NLDAS-3 / user_data_notebooks /

rra-na Updated comments + documentation

Name
..
1-read_aws_data.ipynb
2-create_timeseries.ipynb
3-temp_change_map.ipynb
4-clip_data.ipynb
use_case-hurricane_harvey.ipynb

https://bit.ly/nldas-3-hub

Needs and Capabilities - Breakouts

Ryan Wade

We will split into two breakout groups for more detailed Q&A, feedback and discussion on drought monitoring needs.

Meteorology/ Model Forcings/ Data Assimilation

Kim Locke, Fadji Maina, Kristen Whitney, David Mocko, Sujay Kumar, Melissa Wrzesien

Applications/ Downstream Products

Ryan Wade, Molly Woloszyn, Jonathan Case, Chris Hain, Brian Fuchs, Mike Hobbins, Jessica Erlingis

For a summary of participant feedback and discussions from the breakout sessions, please go to the link on the NASA NLDAS-3 webpage: https://ldas.gsfc.nasa.gov/nldas/v3

Wrap-up & Next Steps

Dr. Chris Hain

- Key takeaways from the breakout discussions
- Continue the conversation (provide feedback and ask/answer questions) at NASA Water Insight GitHub discussions page: https://github.com/NASAWaterInsight
- Get involved with the NLDAS-3 Drought Focus Group to co-develop new applications and use case examples (email Kim Locke: kim.a.locke@nasa.gov)
- We will send out workshop slides with a feedback summary and a brief survey for any additional questions and feedback

Thank you for participating!