

A satellite image of Earth showing a large, swirling storm system over the Pacific Ocean. The storm has a distinct eye and is surrounded by dense, white clouds. The surrounding ocean is a deep blue, and the landmasses of North and South America are visible on the right side of the frame. The text is overlaid on the top portion of the image.

Satellite Applications and User Needs at the Weather Prediction Center

NOAA Precipitation Workshop

Precipitation Estimation from LEO Satellites: Retrieval and Applications
Center for Hydrometeorology and Remote Sensing at the University of California at Irvine

March 2nd, 2023

Andrew Orrison

NOAA/NWS/NCEP/Weather Prediction Center

Rainfall-Focused Forecasters at WPC



Senior Branch Forecasters (SBF)

The SBF is the Shift Leader/Manager

3 shifts/day: 6am-3pm, 130pm-1030pm, 9pm-6am

- Marc Chenard (QPF/ERO program lead)
- Bob Oravec
- Brian Hurley
- David Roth
- Zack Taylor (split WWD/QPF)
- Frank Pereira (split WWD/QPF)
- Tony Fracasso (WWD program lead)
- Mike Schichtel (Medium Range program lead)

QPF/ERO Forecasters

2 shifts/day: 8am-5pm, 8pm-5am

- Rich Bann
- Amy Campbell
- Joseph Wegman
- - vacant -

MetWatch Forecasters

3 shifts/day in warm season;
2 shifts/day in cool season

- William Churchill
- Andrew Orrison (MetWatch program lead)
- Ashton Robinson Cook
- Rich Otto
- Gregg Gallina

SBFs manage the operations floor and internal/external collaboration, many media interviews, and tropical duties

Medium Range forecasters handle QPF Days 4-7, and ERO Days 4-5, among many other duties



WEATHER PREDICTION CENTER

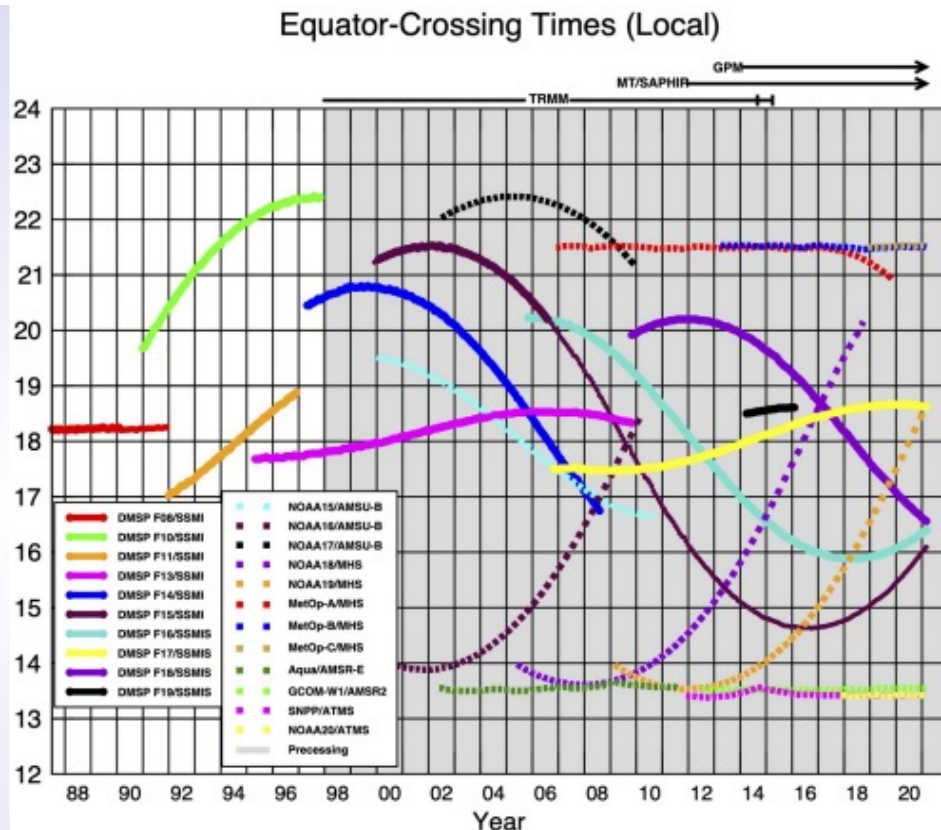
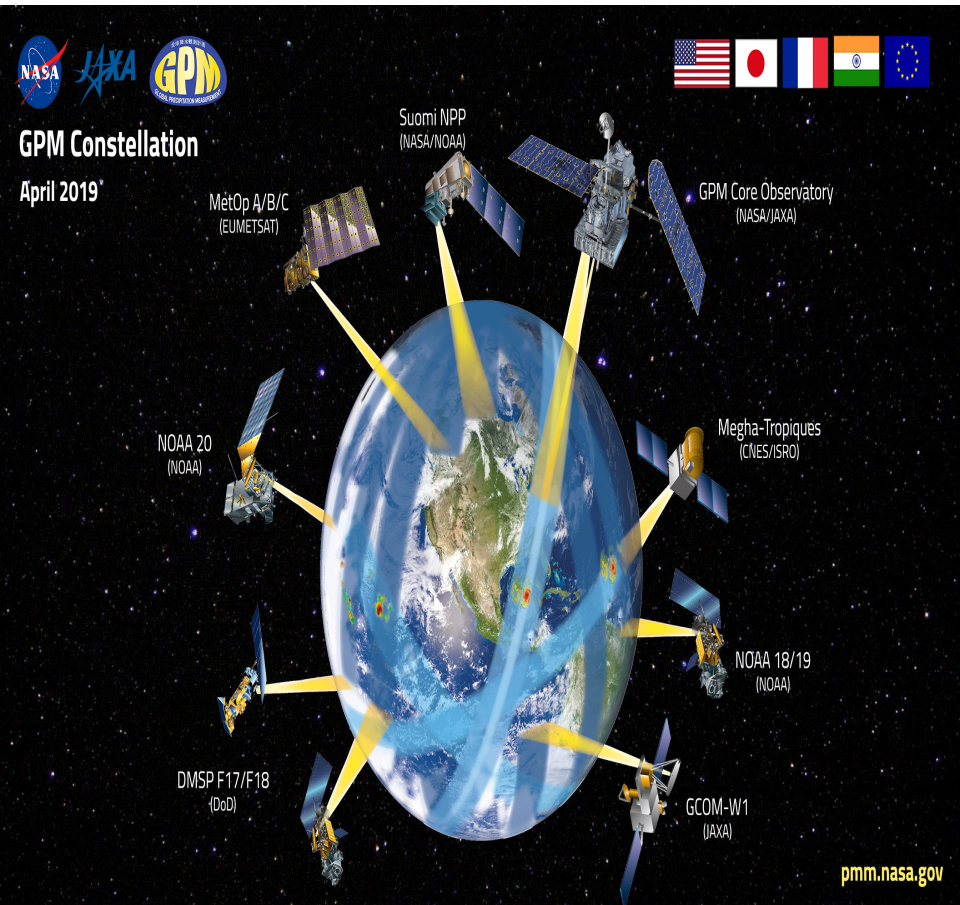
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

WPC Rainfall Program Overview and Updates
Updated February 2023

Evaluation of Satellite Data is Critical to Operations

- Includes assessment of GEO and LEO satellite data sets:
 - GOES ABI (G16/G18) data sets and L2 products can provide great insight into real-time CONUS threats of heavy rainfall by providing information on the key parameters of moisture, lift/forcing, and instability.
 - Passive microwave datasets provided by our constellation of polar-orbiters can play a key role in OCONUS threats and CONUS threats by providing a deep layer account of the moisture and temperature profiles, and thus providing information PWs, rain rates, and instability.
 - Model ingest and assimilation of polar datasets are extremely important to NWP performance.
 - NOAA's Geostationary Extended Observations (GeoXO) satellite system planned to be launched in the early 2030s in conjunction with a sustainable GPM Constellation Network will critical to the success of future real-time heavy rainfall prediction.

Evaluation of Satellite Data is Critical to Operations



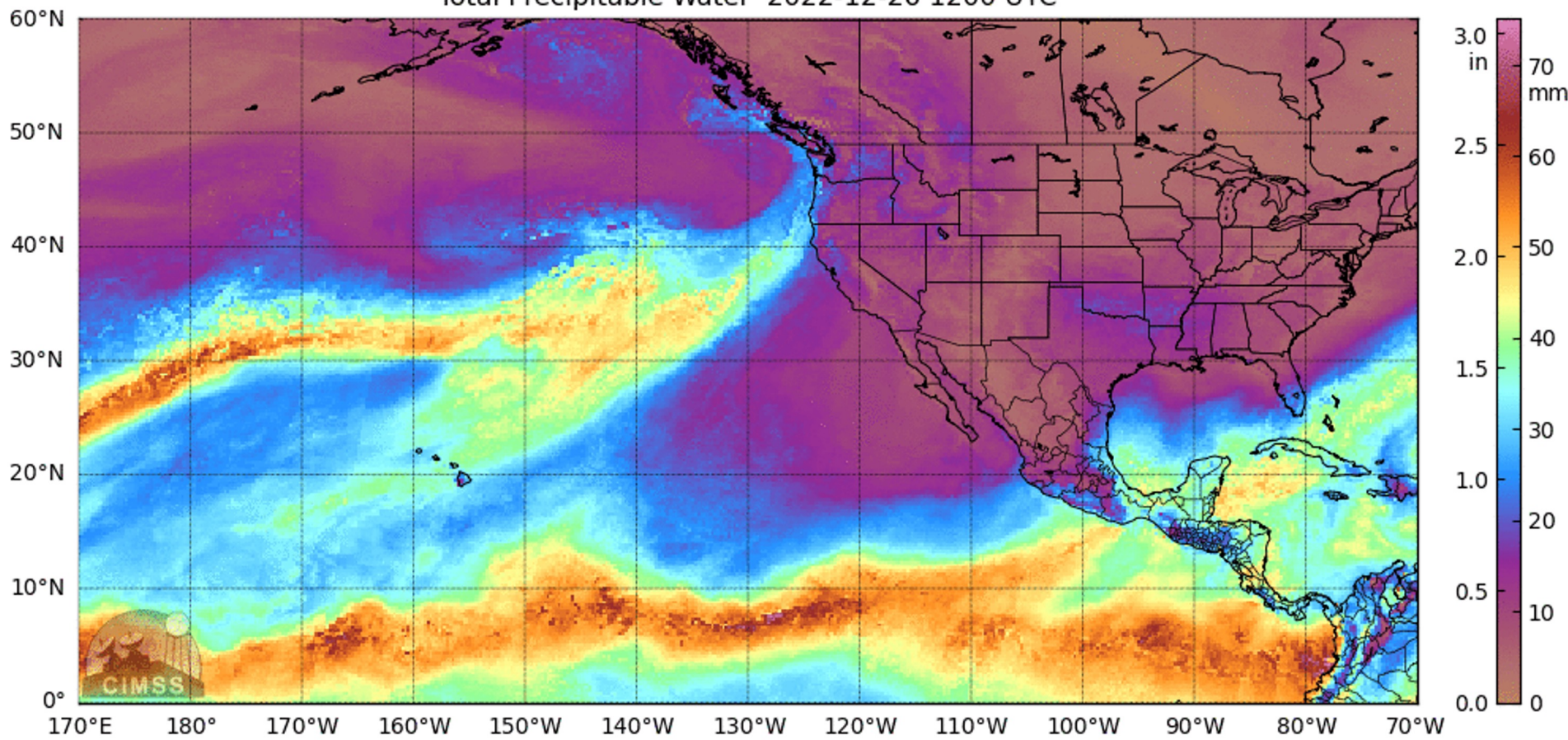
Ascending passes (F08 descending); satellites depicted above graph process throughout the day.
 Image by Eric Nelkin (SSAI), 21 April 2021, NASA/Goddard Space Flight Center, Greenbelt, MD.

**The GPM Constellation of LEO Satellites
Is Very Important to Heavy Precipitation Analysis
and Forecasting of High-Impact Seasonal Events!!**

**Do You Remember Christmas 2022 through Mid-
January 2023 in California?**

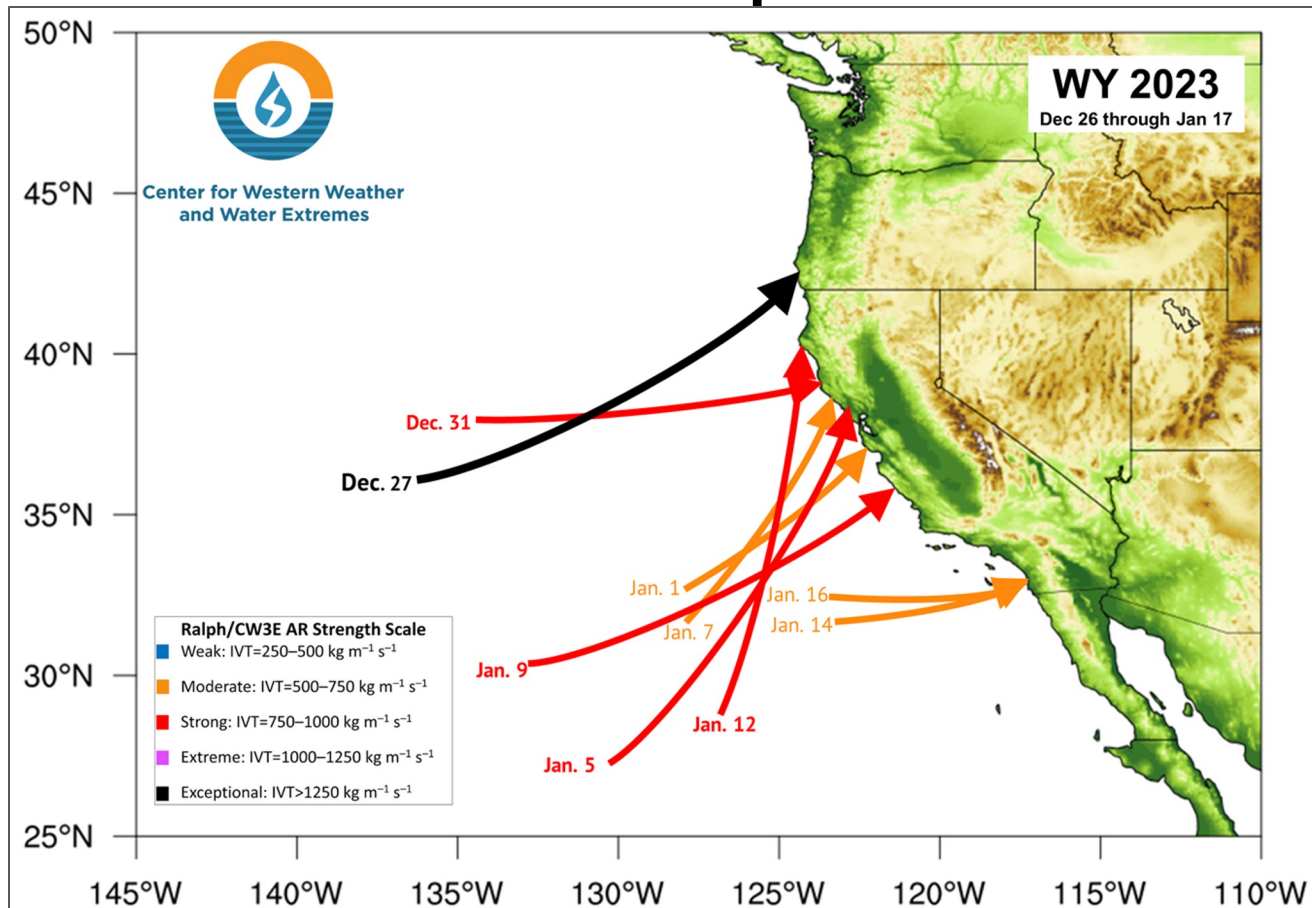
Christmas 2022 through Mid-January 2023 East Pacific ARs (as seen by MIMIC-2 TPW analyses)

Total Precipitable Water 2022-12-26 1200 UTC

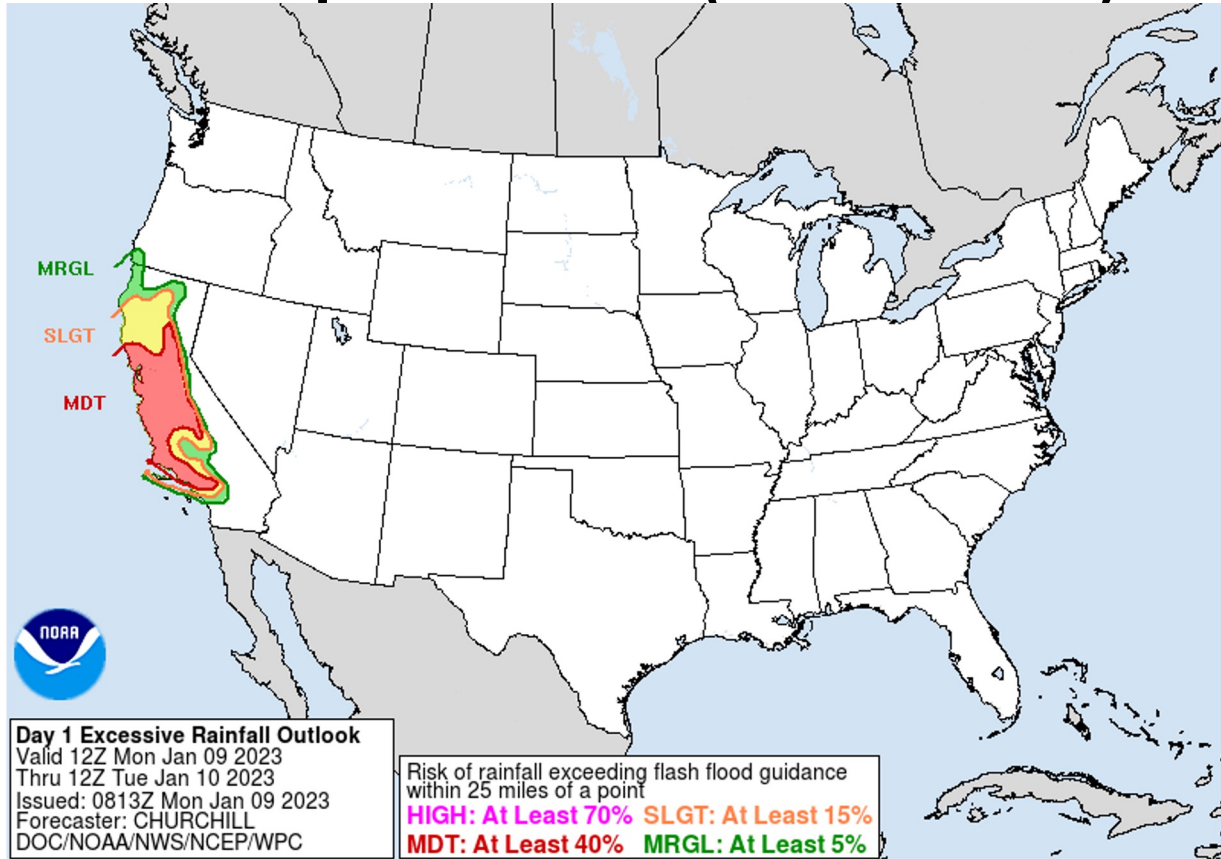


Christmas 2022 through Mid-January 2023

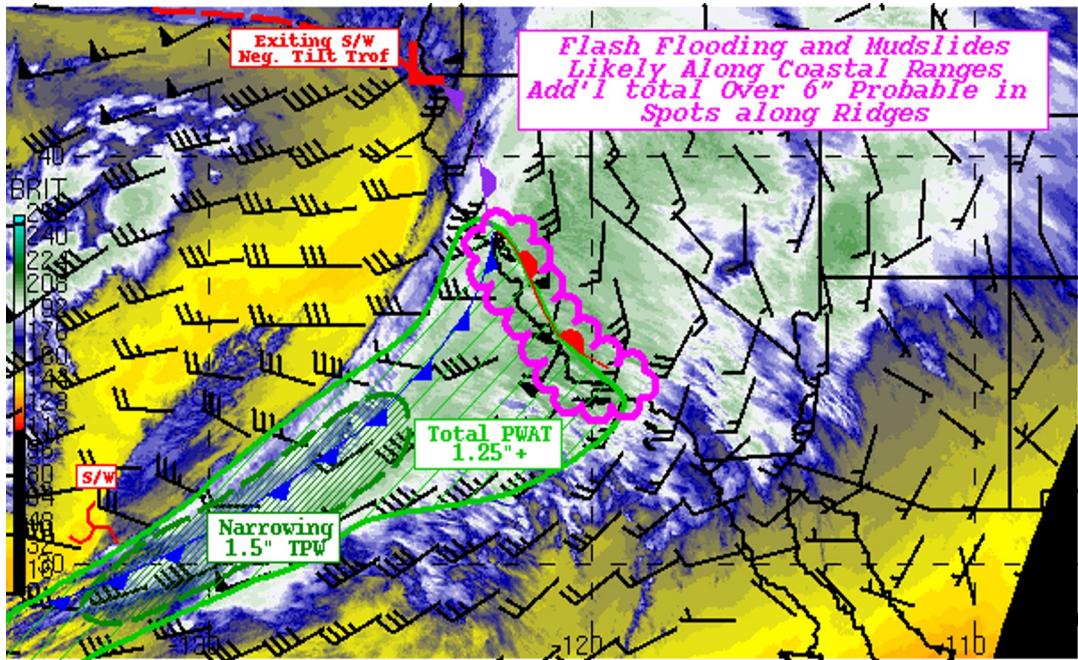
East Pacific Atmospheric Rivers



Day 1 WPC Excessive Rainfall Outlook For Strong Atmospheric River (Jan 9th/10th)



Mesoscale Precipitation Discussion #32 (issued at 8:23 AM PST) - Depicting Likely Flash Flooding and Mudslides



230109/1616 GOES18 CH10 WV 7.3
RAP32 850 MB WINDS 230109/1400f000
WPC MPD #0032

Mesoscale Precipitation Discussion 0032
NWS Weather Prediction Center College Park MD
1123 AM EST Mon Jan 09 2023

Areas affected...Central Coastal to western Transverse Ranges of California...

Concerning...Heavy rainfall...Flash flooding likely

Valid 091630Z - 100230Z

SUMMARY...Core of Strong to Very Strong AR coming ashore. Flash flooding is likely within burn scars given hourly rates up to 1-1.25"/hr in Central CA Coastal range and additional totals of 6-8". Plume will start moving south after 21z and increase exposure to Transverse Ranges with 3-5" totals possible through 03z.

DISCUSSION...GOES-W WV suite depicts strong negative tilt trof swinging to almost E-W just north of 40N while the next amplifying shortwave at the base is starting to show baroclinic leaf development west of 130W north of 30N. The spacing between is along the south side of a 130kt 250mb jet streak with very strong vorticity gradient and some weak short-wave ridging crossing the central CA coastline. This is generally coincident with the warm front that has started to surge ashore across Santa Cruz/Santa Lucia Range and through SBP. This is allowing for strong WAA and moisture surge through the coastal terrain along a 50-60kt jet per VWP from DAX to VBP and RAP analysis. **CIRA LPW shows nose of .6-.7" sfc-850mb and .3-.4" 850-700mb moisture intersecting the coast. This has resulted in record total PWAT values at OAK and VBG this morning with 1.3" and 1.25" and generally running slight below greatest moisture values for this part of the month. Combined with the strong deep flow, IVT values are over 800 kg/m/s occasionally ticking to 1000 kg/m/s.** As such, rainfall rates in the orthogonal intersection across the Santa Lucia Range have been observed as high as 1.25", with average values in the .75", resulting in mudslides and rockfalls reported even into the Diablo range and .5-.75" in the Santa Cruz Range as well. Given the distance upstream of the height-falls approaching shortwave, there is going to be very limited southward push of the core of the AR through 21z resulting in additional 6-8" totals by 00z and likely continued considerable flash flooding conditions.

After 21z, the shortwave will approach, this is already starting to show signs of severing the subtropical connection to the deeper moisture source and narrowing the plume of 1.5" TPW seen well upstream. Less unidirectional flow will reduce winds slightly but maintain 750-850 IVT values toward 00-03z as the cold front/AR plume round Cape Conception. This will rapidly increase favorable orientation to the Santa Ynez, Sierra Madre and into the downstream Transverse Ranges in Ventura and Los Angeles county. While winds/moisture will decrease, the slope of orographic ascent should increase slightly and slightly reduced rates of .5-.75" will be expected between 00-03z in favored terrain, totaling to 3-5" by 03z (with more to come after). Soil conditions are slightly better further south given some time to recover over the past few days with 0-40cm relative soil saturation ratios ranging from 60-75% versus near full saturation further north. As such, flash flooding and mudslides, remain possible, but should be a bit less in magnitude and coverage relative to further north.

Gallina

Christmas 2022 through Mid-January 2023

East Pacific Atmospheric Rivers

Selected Precip Totals

(from December 26, 2022 to January 17, 2023; asterisks indicated CoCoRaHS totals through 4 AM PT Jan 17.)

- 47.74" *3mi SSE Honeydew, CA
- 35.39" *4mi N Boulder Creek, CA
- 33.11" *6mi W Cazadero, CA
- 29.54" *4mi E Nevada City, CA
- 18.33" Oakland, CA (23d record)
- 17.64" Downtown San Francisco, CA
- 15.28" SFO Int'l Airport, CA (23d record)
- 14.01" Redding, CA
- 11.97" Downtown Sacramento, CA
- 10.99" Santa Barbara, CA
- 10.79" Stockton, CA (23d record)



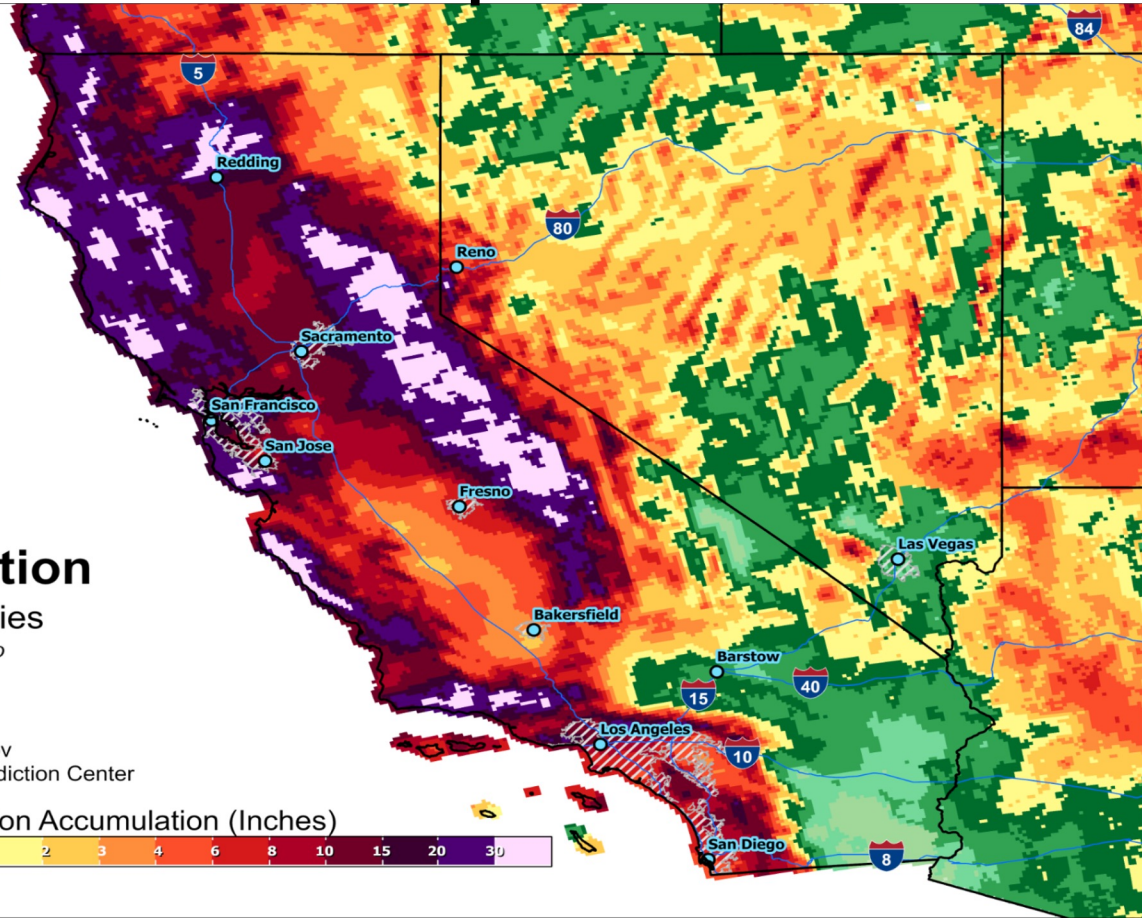
Total Precipitation

Atmospheric River Series

4 AM PST December 26, 2022 to
4 AM PST January 17, 2023

NWS Stage IV Precip Analysis
Gridded Analysis: water.weather.gov
Image made by NWS Weather Prediction Center

Precipitation Accumulation (Inches)



Christmas 2022 through Mid-January 2023

East Pacific Atmospheric Rivers

Selected Snowfall Totals

(from December 26, 2022 to January 17, 2023; asterisks indicated CoCoRaHS totals through 4 AM PT Jan 17)

240"	Mammoth Mountain, CA
181.7"	Donner Pass (CSSL), CA
155"	Tahoe Donner, CA
106.1"	*Tahoma, CA
101"	*Mono City, CA
88.0"	Tahoe City, CA
16.7"	Reno, NV



Total Snowfall

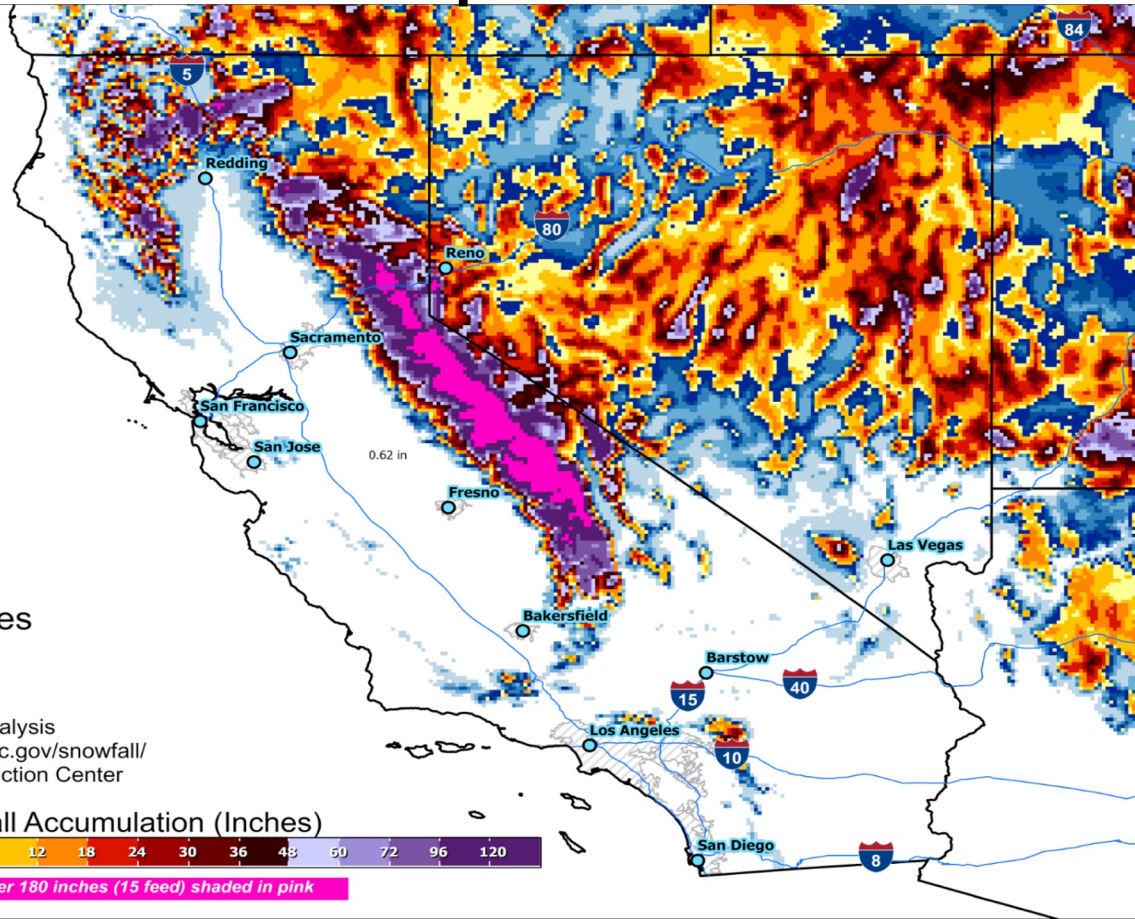
Atmospheric River Series

4 AM PST December 26, 2022 to
4 AM PST January 17, 2023

NOHRSC Snowfall Accumulation Analysis
Gridded Analysis: <https://www.nohrsc.gov/snowfall/>
Image made by NWS Weather Prediction Center



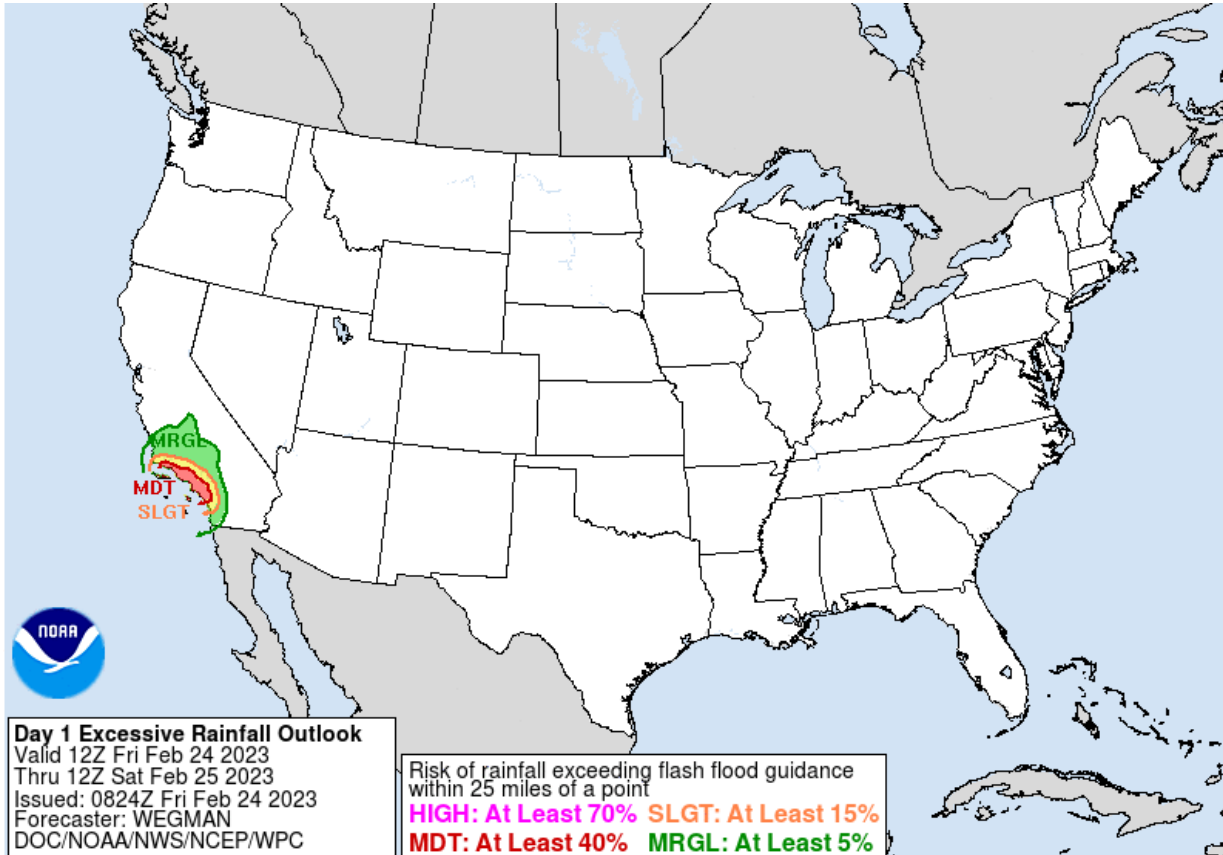
Totals over 180 inches (15 feet) shaded in pink



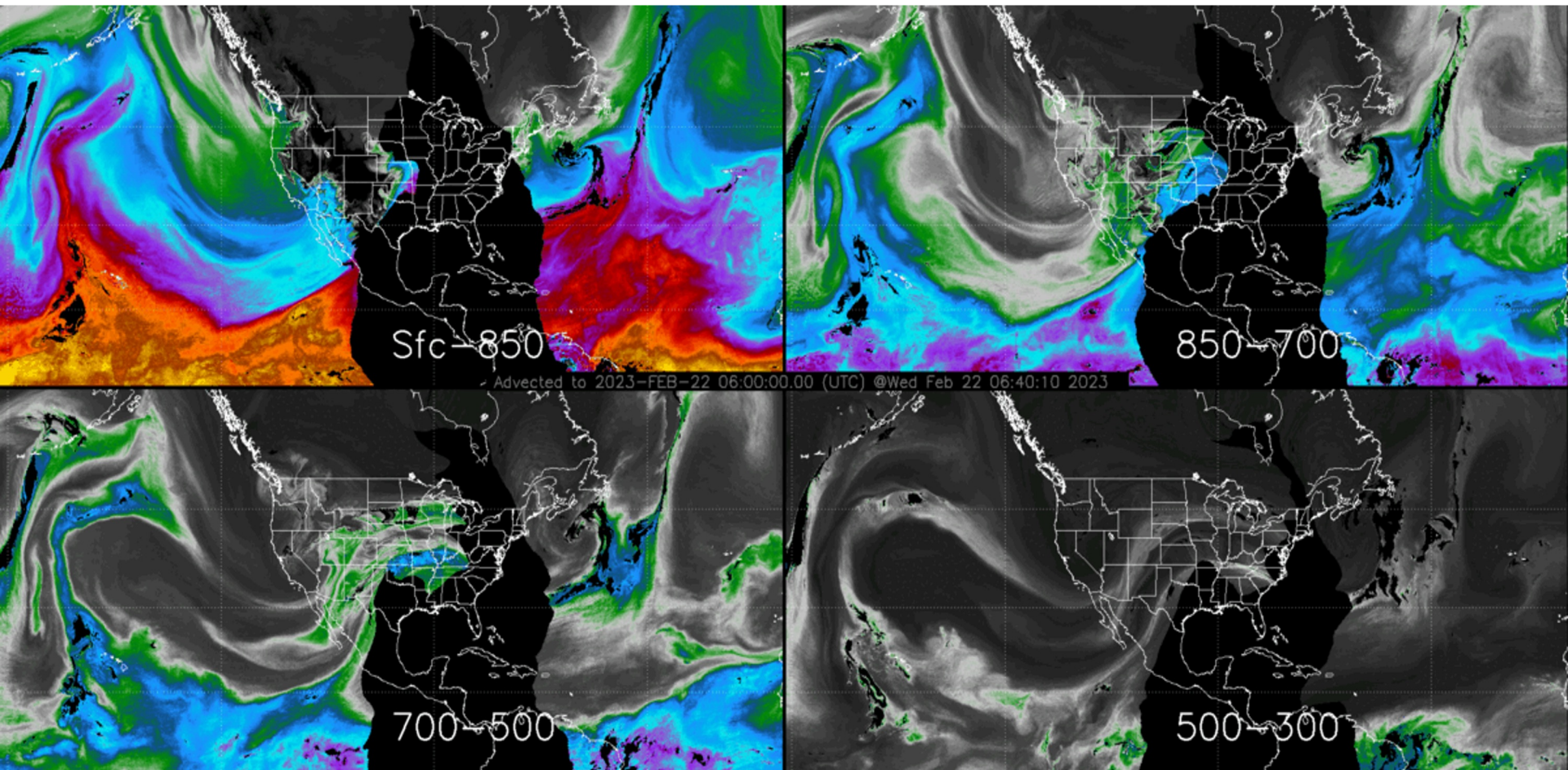
A Network of LEO-Influenced Datasets Used by WPC for Heavy Precipitation Analysis

**(A Look at the February 24th-25th, 2023
High-Impact Precipitation Event in California)**

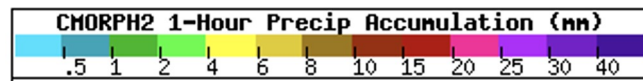
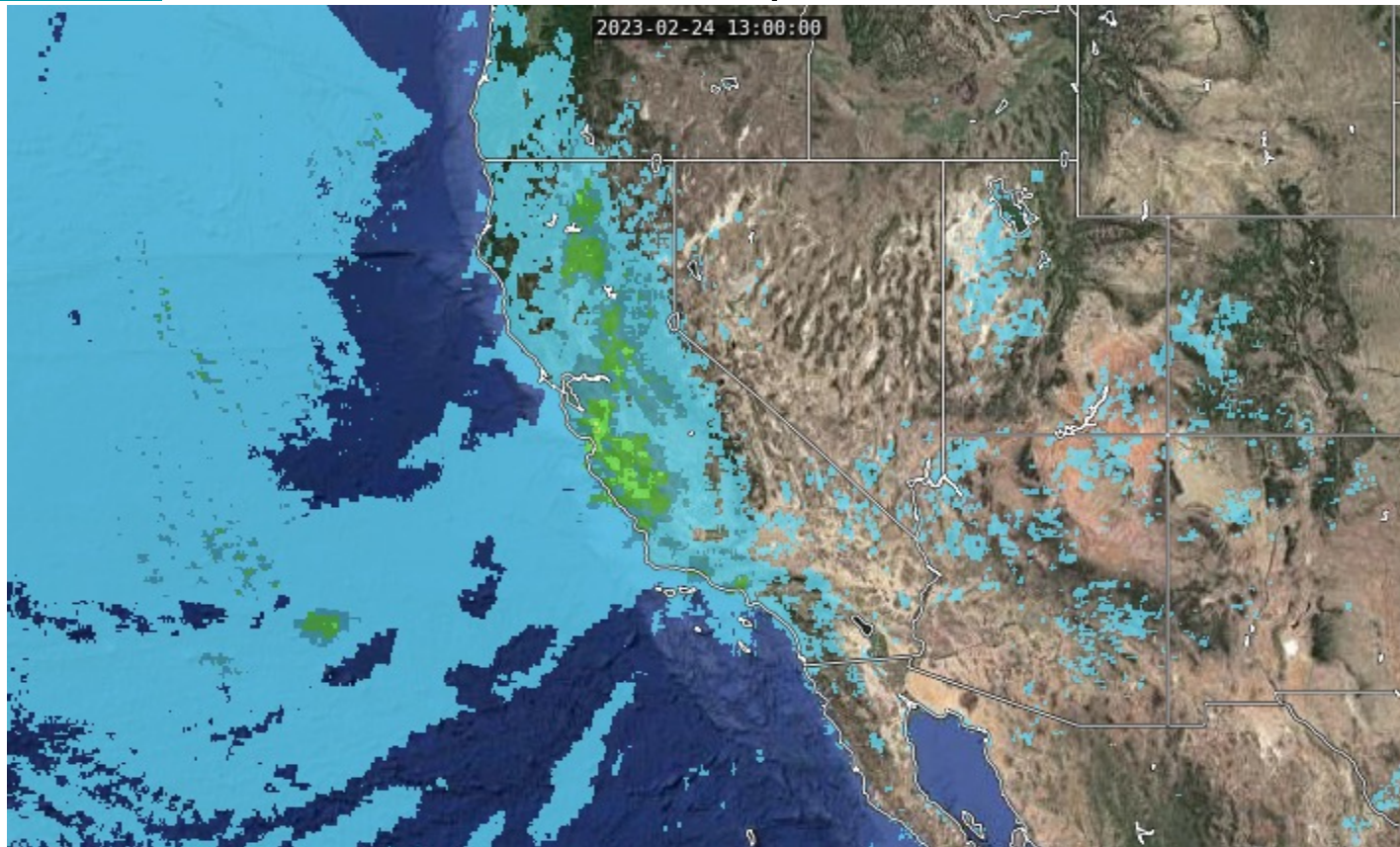
Day 1 WPC Excessive Rainfall Outlook For Feb 24th/25th – SoCal Moderate Risk



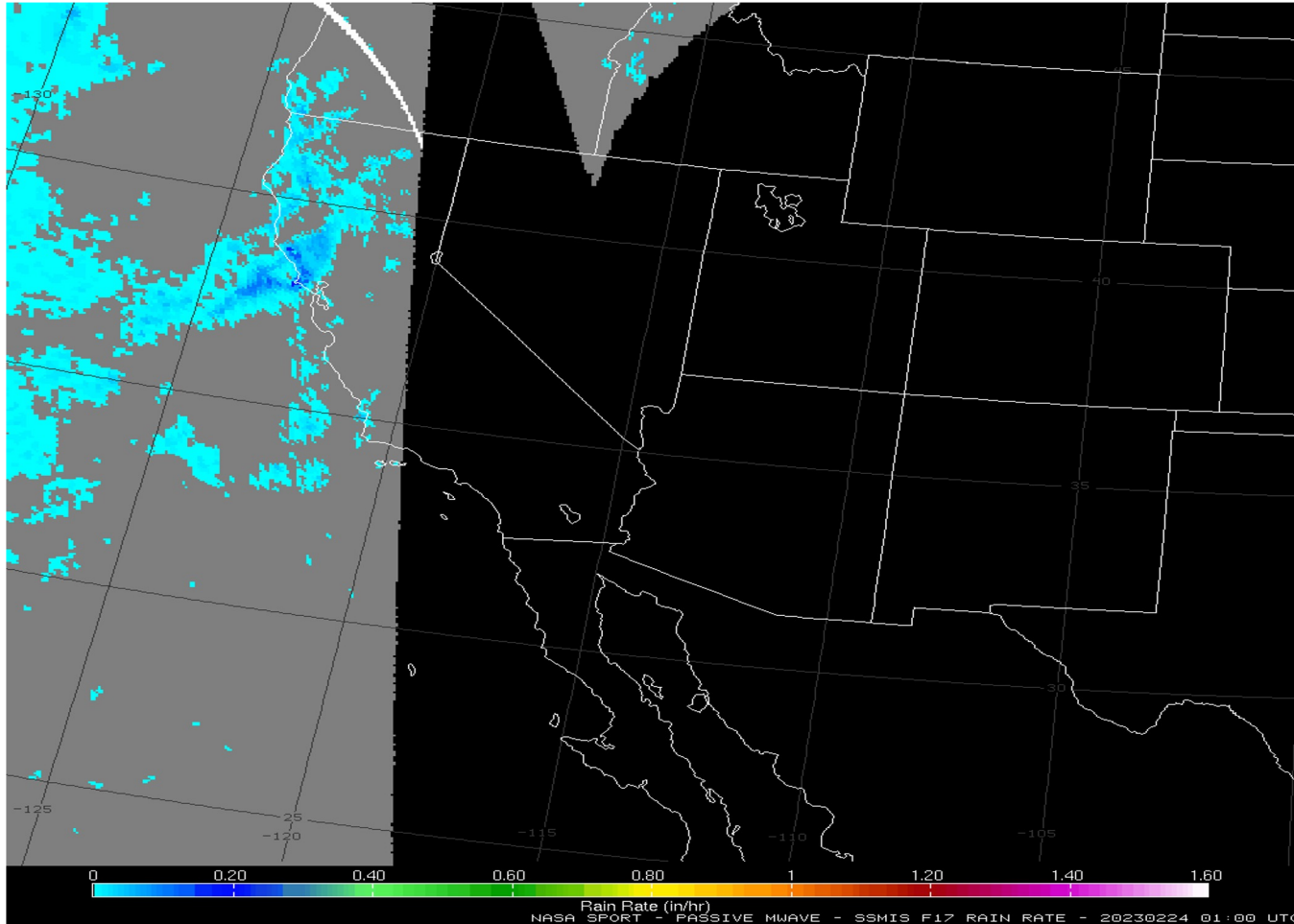
Multi-day CIRA Advected Layered Precipitable Water (ALPW) Loop (06Z/February 22nd to 09Z/February 25th)



CMORPH2 Real Earth Web Viewer (12Z/Feb 24th to 12Z Feb 25th)

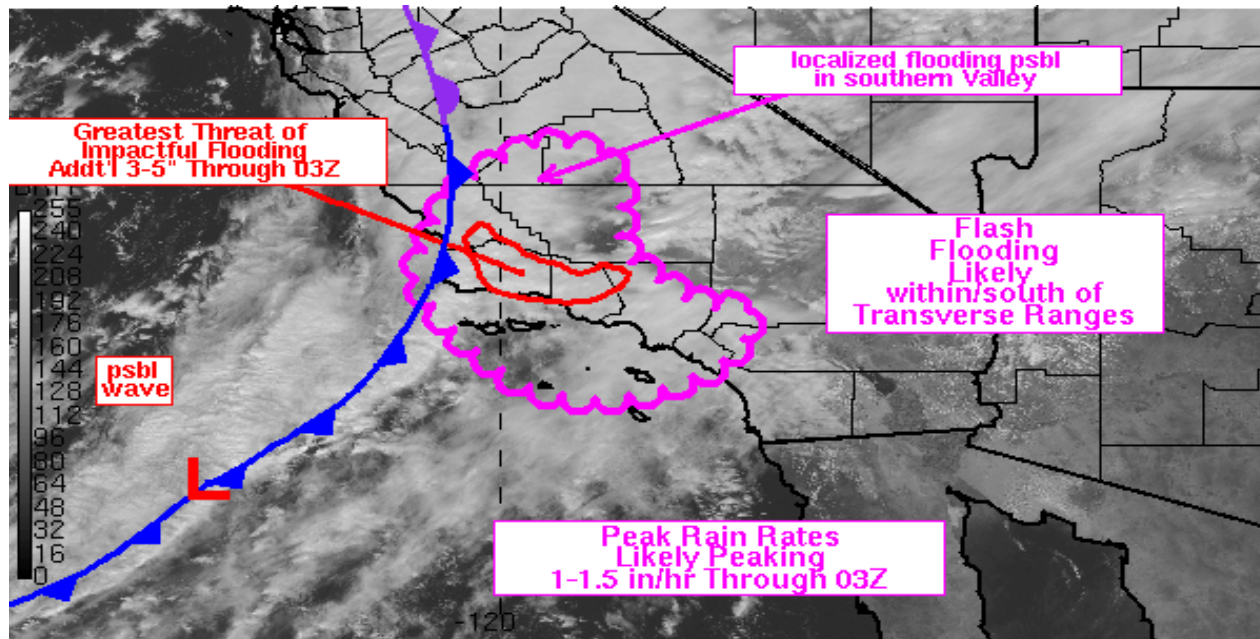


GPM PMW Rainfall Rates [\(NASA SPoRT\)](#)



Mesoscale Precipitation Discussion #75

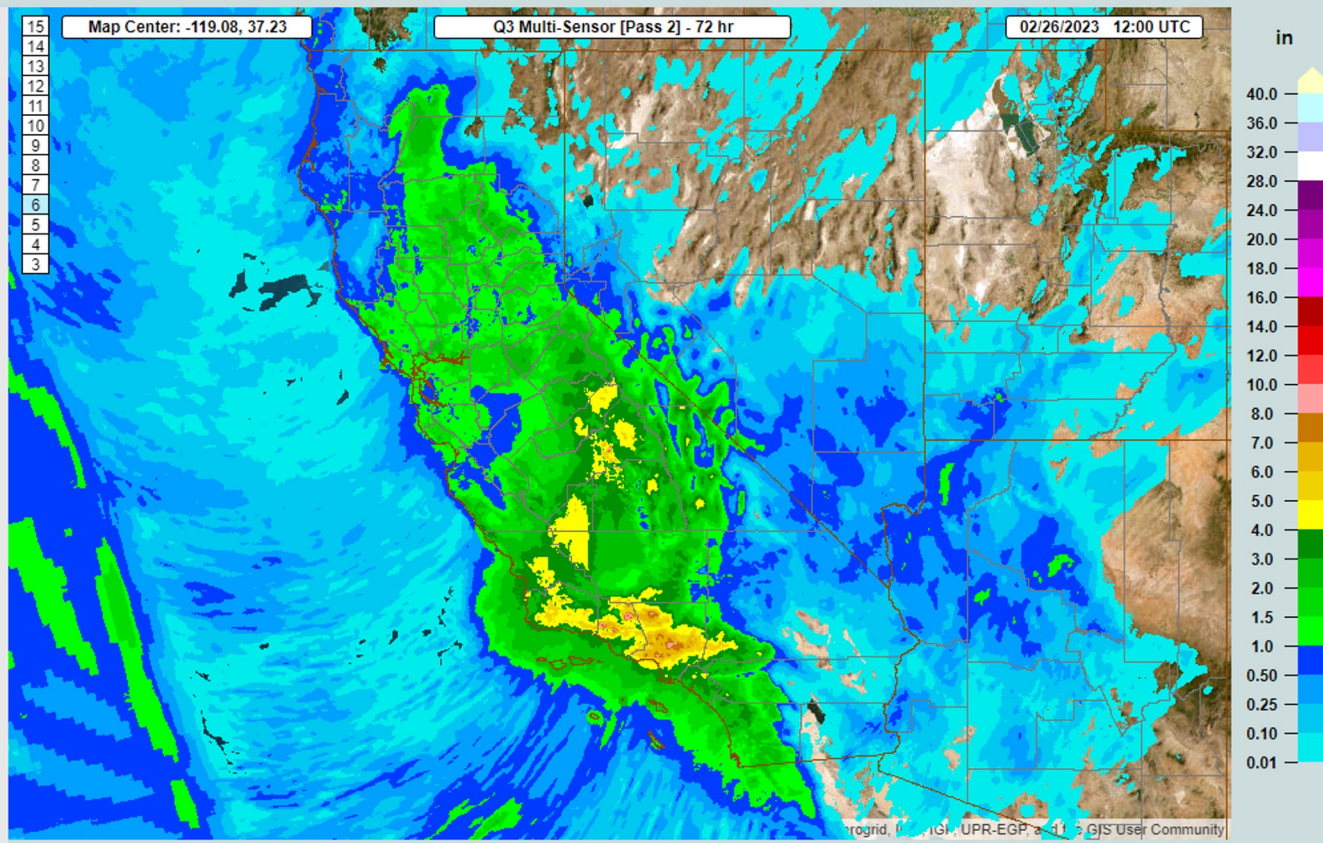
(issued at 12:12 PST) –Depicting Likely Flash Flooding



230224/2011 GOES18 CH02 VIS_0.64
WPC MPD #0075

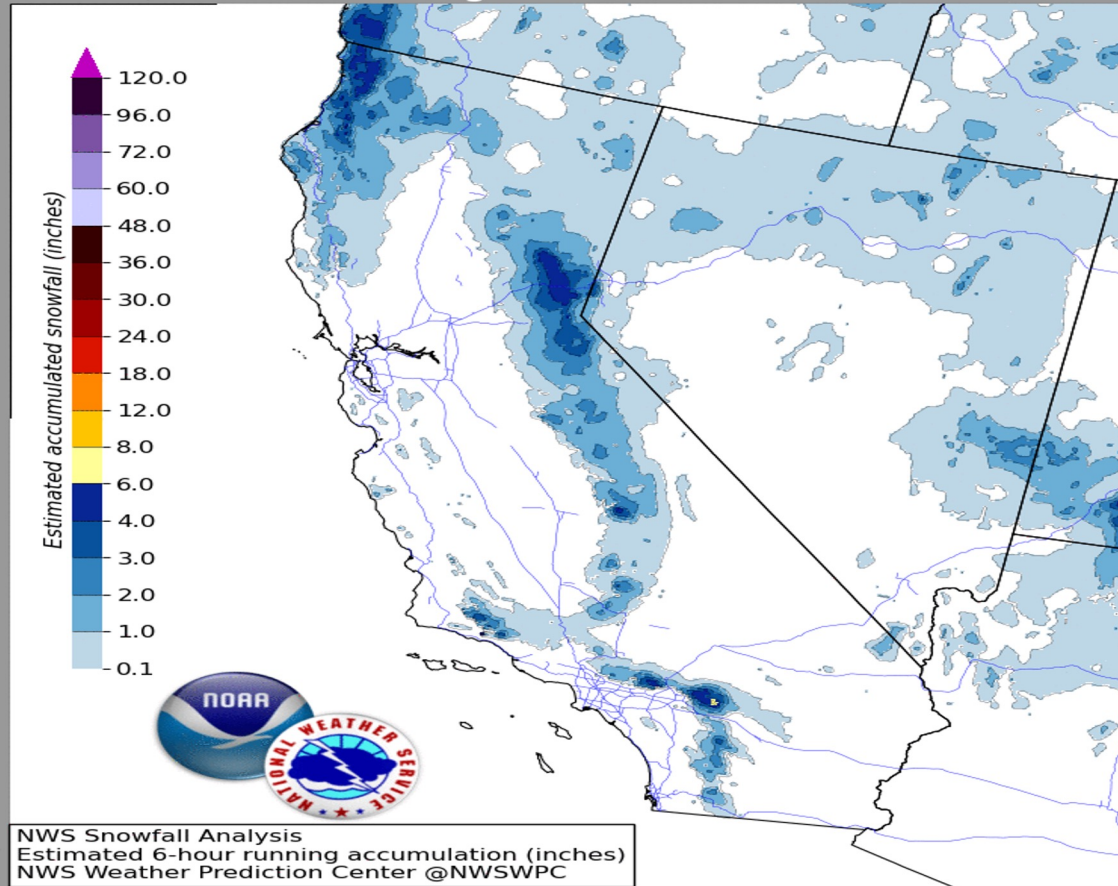
72 Hour Gauge-Corrected MRMS QPE (12Z/February 23rd to 12Z February 26th)

Operational Product Viewer



Several Feet of New Snowfall in Sierra Nevada and the Transverse Ranges of Southern California

6 hours ending 00 UTC, Feb. 24, 2023



General Satellite Data Latency Recommendations for Heavy Rainfall Nowcasting

Microwave data latency requirements for nowcasting heavy rainfall considerations...

In general, when it comes to nowcasting, data sets that arrive with a latency of greater than 6 hours have minimal value. However, it also depends on what other data might be available that could allow for an extrapolation of precipitation trends from a certain time reference point.


I would break down the benefits of improved latency to the end-user in the following way...

- 1. > 6-hour latency - would be of limited benefit, but in the absence of other remotely sensed data, it would still be worth looking at.**
- 2. 3 to 6-hour latency - would be of good benefit in conjunction with other remote sensing data (polar in conjunction with GEO satellites).**
- 3. 1 to 3-hour latency - would be very good and could help drive nowcast and short-range forecast products.**
- 4. < 1-hour latency - optimal/excellent end-user support with strong benefits to nowcast and short-range forecast products.**

So, shorter latency is ideal, and especially since most nowcasting products are produced with a T+6 hour window or less in mind.

General Comments and Thoughts

- The LEO constellation of satellites is critical for especially CONUS and OCONUS heavy precipitation analysis and can influence a large suite of forecast products.
- LEO satellites with their microwave imager and sounder instrumentation have long been shown to improve NWP performance through the data ingest and assimilation process! This coupled with a future global constellation of GEO hyperspectral sounders suggests an opportunity for substantial improvements in forecast skill of global and mesoscale models.
- Having a fully integrated GPM constellation of satellites by ideally integrating additional foreign satellite agency partners and their LEO plans would be helpful to mitigate concerns over data latency and spatial data gaps over specific geographically points of interest while facilitating the aforementioned improvements in NWP.
- The GPM constellation of satellites needs to be supported for the long term. As satellites over time age and reach end-of-mission status, suitable replacements with next generation sensors need to be considered and funded where possible.
- Data fusion concepts should continue to be explored and accommodated with respect to GEO and LEO satellite constellations where possible to provide moisture, instability, and precipitation rate information at smaller temporal and spatial scales. Using advective wind methodologies from a combination of NWP and GEO-based satellite-derived wind vectors (DMVs) are key to facilitating a near seamless depiction of satellite-derived products that forecasters use for their decision-making routines.



Thank you!!
Any Questions?