

Weather Forecasting in Virtual Reality

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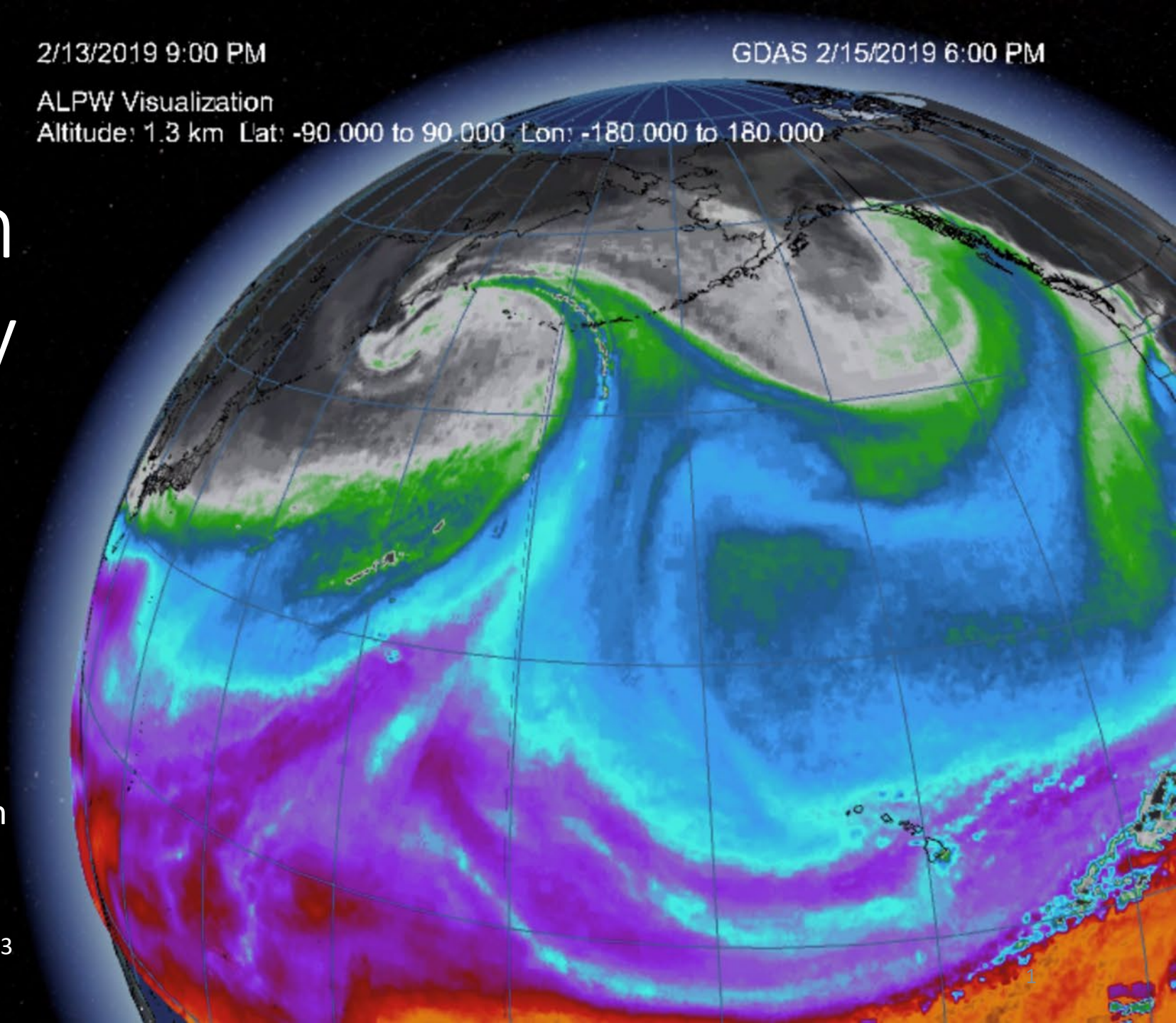
University of Maryland Institute for
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2/13/2019 9:00 PM

GDAS 2/15/2019 6:00 PM

ALPW Visualization

Altitude: 1.3 km Lat: -90.000 to 90.000 Lon: -180.000 to 180.000



Weather Forecasting in Virtual Reality

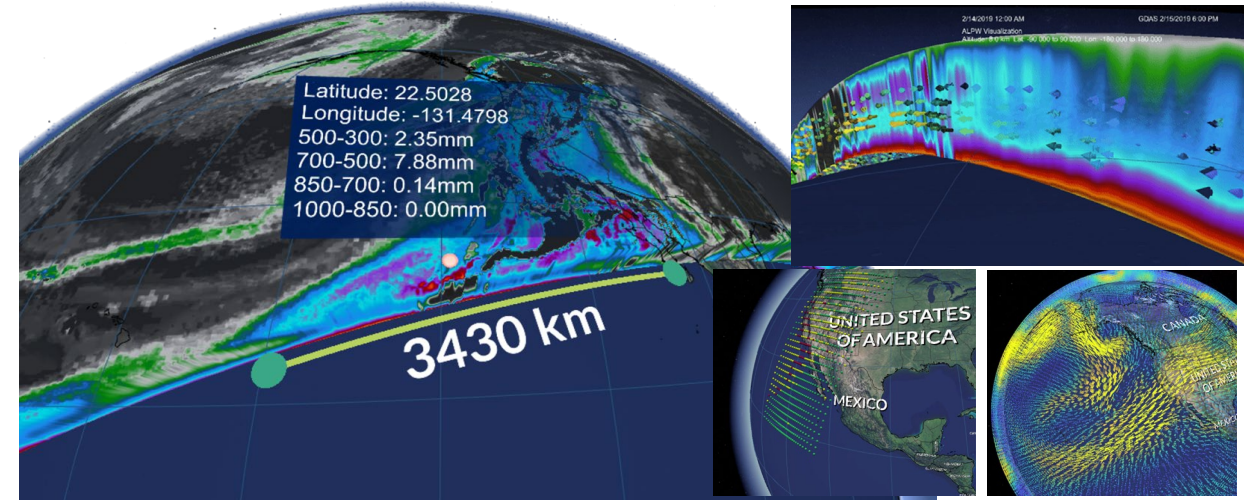
PI: Scott Rudlosky, NOAA/NESDIS/STAR

Objectives

- Identify scenarios where satellite products with enhanced vertical resolution help address specific forecast challenges
- Develop a series of VR demonstrations to gather forecaster feedback on the applicability of satellite products under various operational conditions
- Advise on future vertical resolution requirements for 3-D satellite data in anticipation of future NWS forecaster needs

Approach

- Begin building a research group focused on future integration of NESDIS satellite products into NWS operations
- Collaborate with NWS forecasters and VR experts at UMD, NASA/GSFC, and UCAR/COMET to demonstrate the value of 3-D satellite information in the warning and forecast process
- Integrate UMD students and recent graduates to provide novel perspectives and the latest technology



Narrated fly through available at <https://youtu.be/wgo8RHTTrHc>

Key Milestones

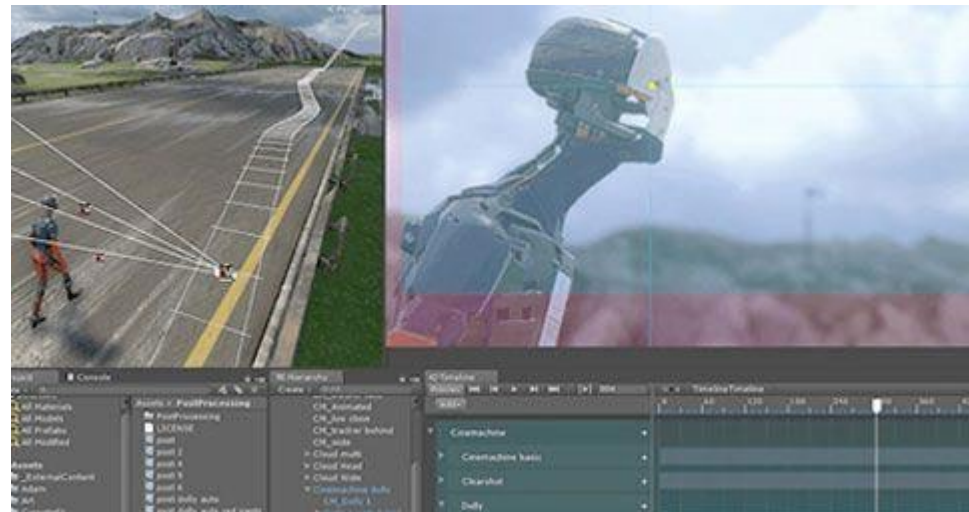
- Acquire and install hardware and software solutions (Dec 2018)
- Assemble and formalize VR/AR Team (Feb 2019)
- Define scenarios where VR/AR adds value (May 2019)
- Develop and evaluate demonstration cases (Jul/Aug 2019)
- Report on new 3-D satellite requirements (Sep 2019)
 - *User feedback required before formal recommendations*

Virtual Reality System

- OCULUS Rift
 - Headset with 6 DoF
 - Two 6 DoF Hand controllers
- Designed in Unity software
- Visualization Techniques
 - 2D texture mapping
 - 3D Volume Construction
 - Layered 2D Data used to Interpolate continuous volume field
 - Calculated during runtime
 - Volume Rendering
 - 3D Meshed Volume Surface
 - Volumetric Raymarching
 - Vector Field Simulation

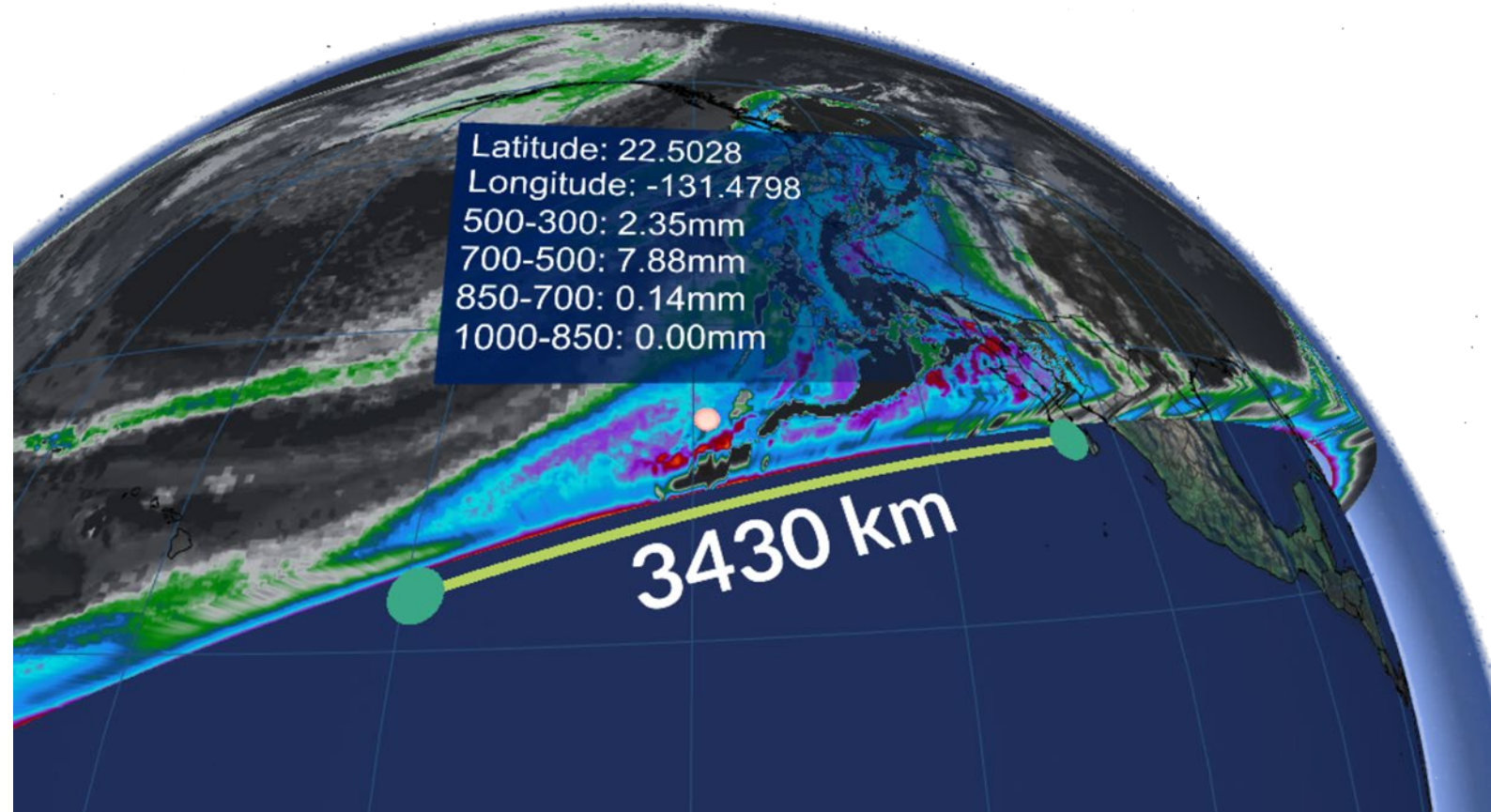


Unity Screen Capture



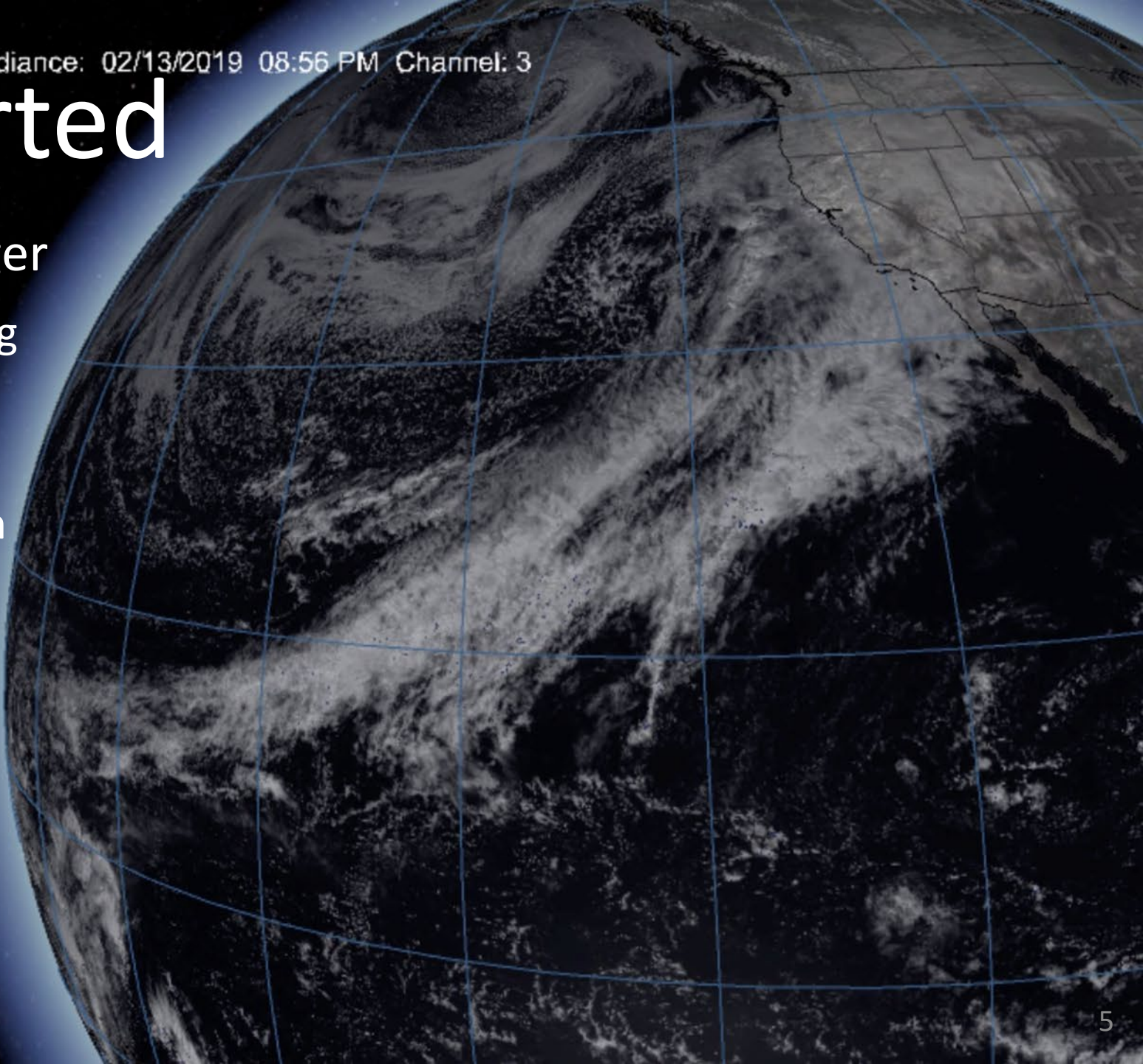
User Interaction

- Data Sampling Tools
 - Point sampling
 - Cross sections
 - Distance ruler
 - Adjustable thresholding
 - Text displays
- Navigation
 - Zoom
 - Rotation
 - Fly In (surface mode)
 - Loop Time Control



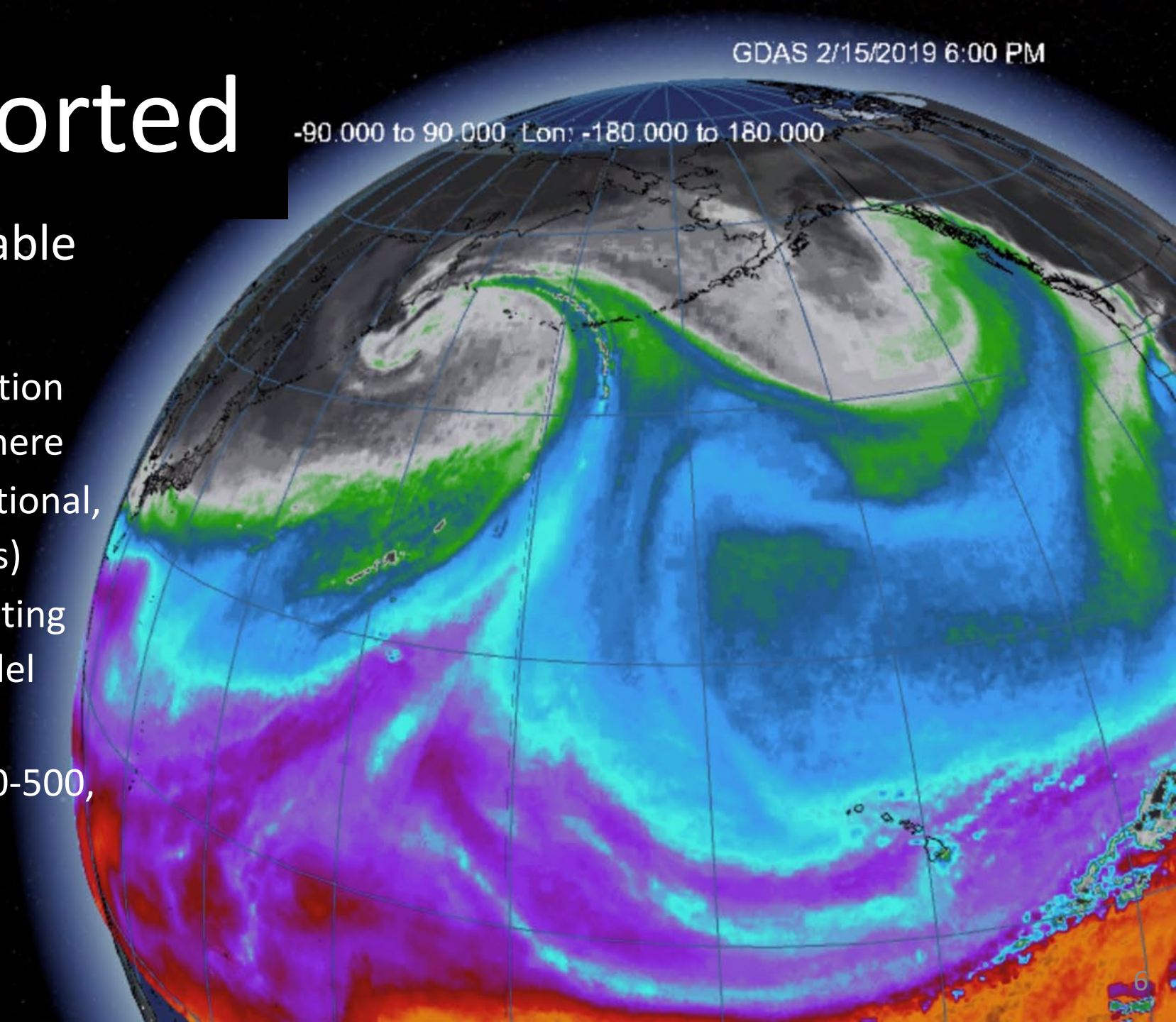
Datasets Imported

- GOES Advanced Baseline Imager
 - Geostationary satellite providing full-hemisphere multi-channel imagery every 10 minutes
 - GOES ABI products include both L1b radiance and baseline L2 derived products
 - CH 3 – 860 nm - veggie
 - CH 9 – 6.9 μm – mid level tropospheric water vapor
 - Cloud-top height
 - Derived motion winds



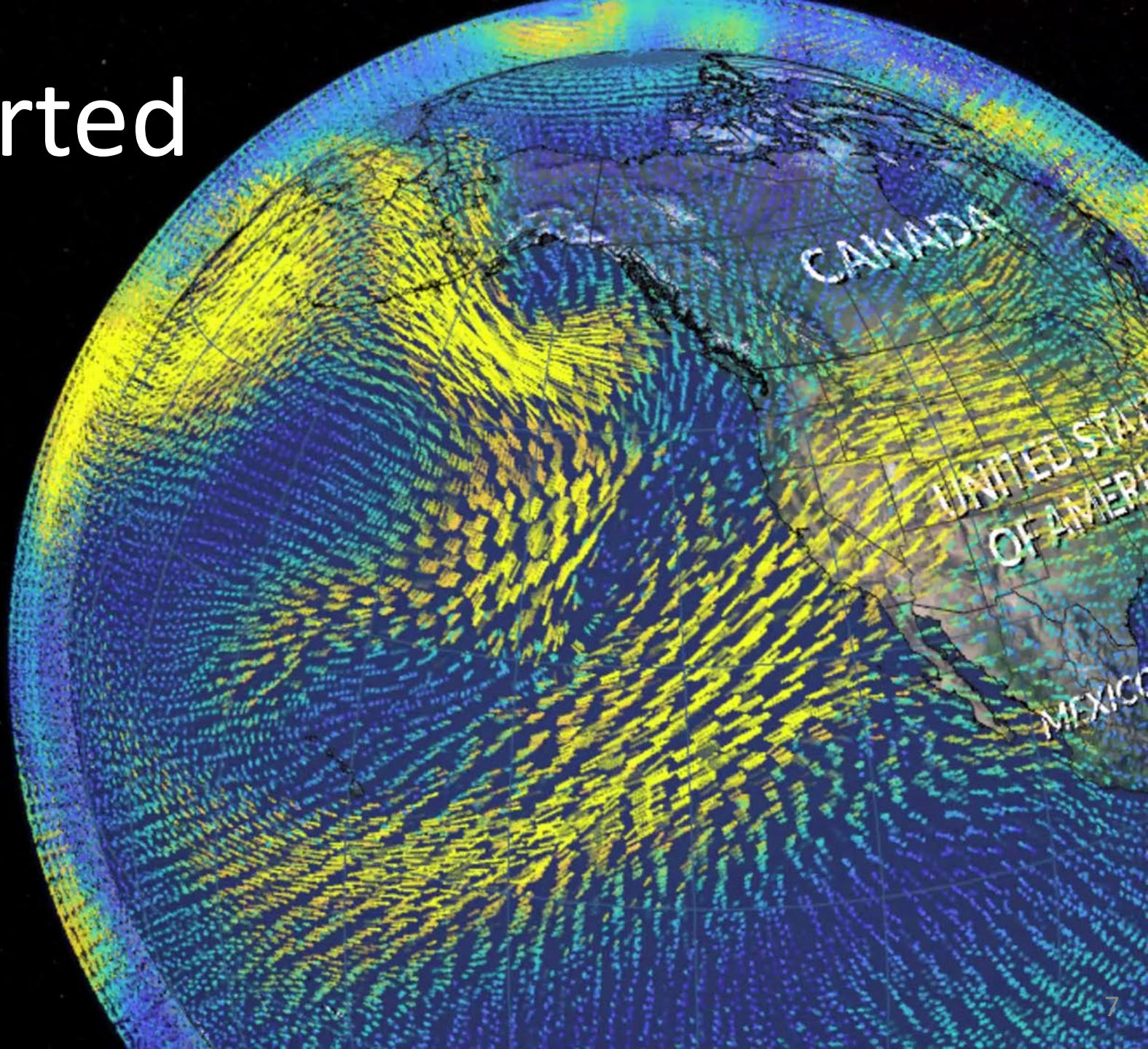
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- Advected Layered Precipitable Water (ALPW)
 - Estimates the vertical distribution of water vapor in the atmosphere
 - Produced by CIRA (non-operational, but used by some NWS offices)
 - Derived from 7 low-earth orbiting sounding satellites, using model winds to propagate moisture.
 - 4 layers: sfc-850, 850-700, 700-500, 500-300mb
 - 3 hourly, 16 km grid



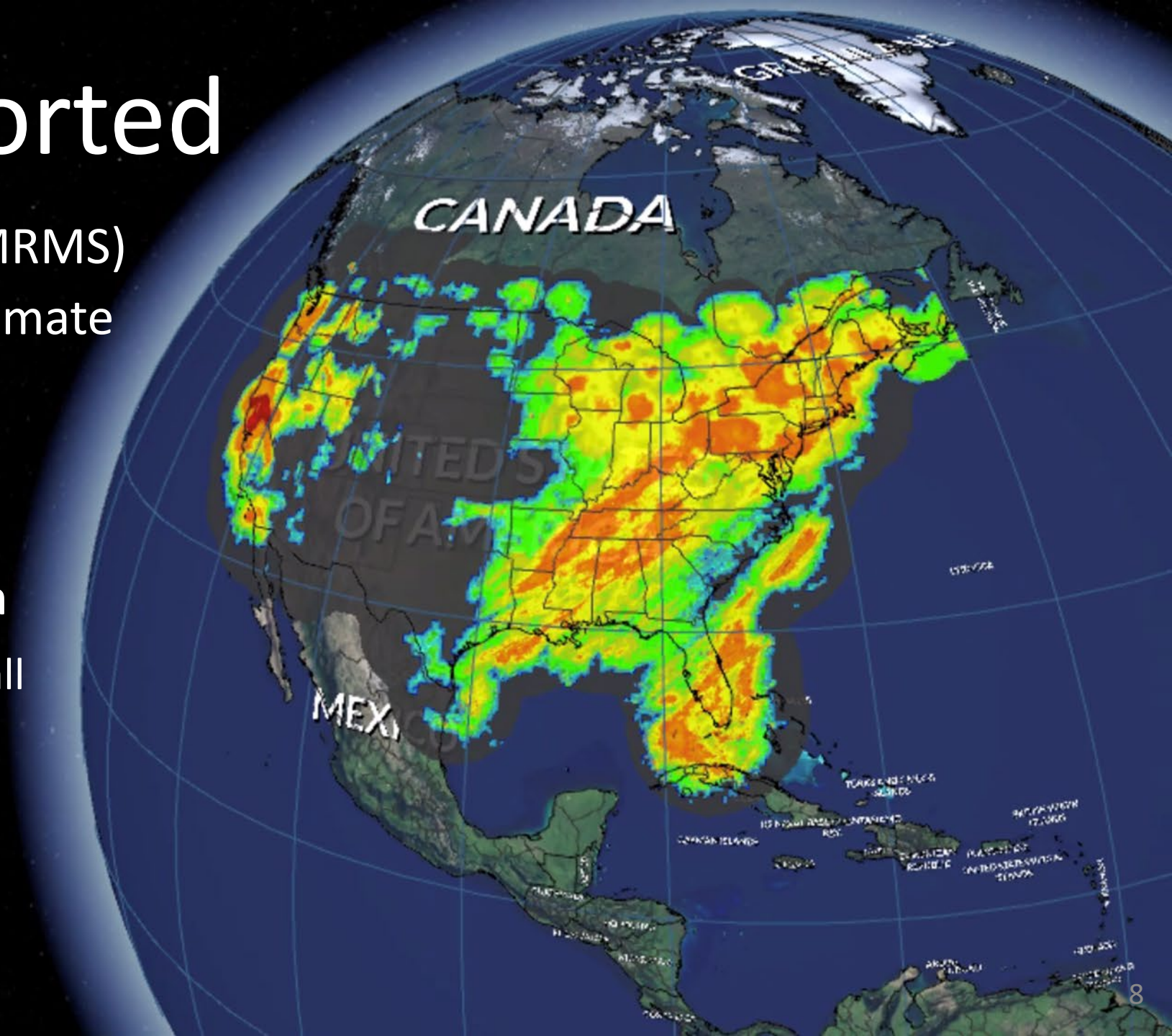
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- Global Data Assimilation System (GDAS)
 - Model-estimated wind vectors
 - (north-south, east-west)
 - 1×1 degree, 24 pressure levels
 - Can reveal total moisture flux when paired with precipitable water products



Datasets Imported

- Multi-radar multi-sensor (MRMS) gauge corrected rainfall estimate
 - 1 hrly Rain Rate (mm/hr)
 - Accumulation (mm) since 00:00z Feb 12, 2019
- Snowfall Rate Accumulation
 - Interpolated satellite snowfall rate estimates from microwave sounders
 - Improved coverage over mountains where radars experience beam blockage



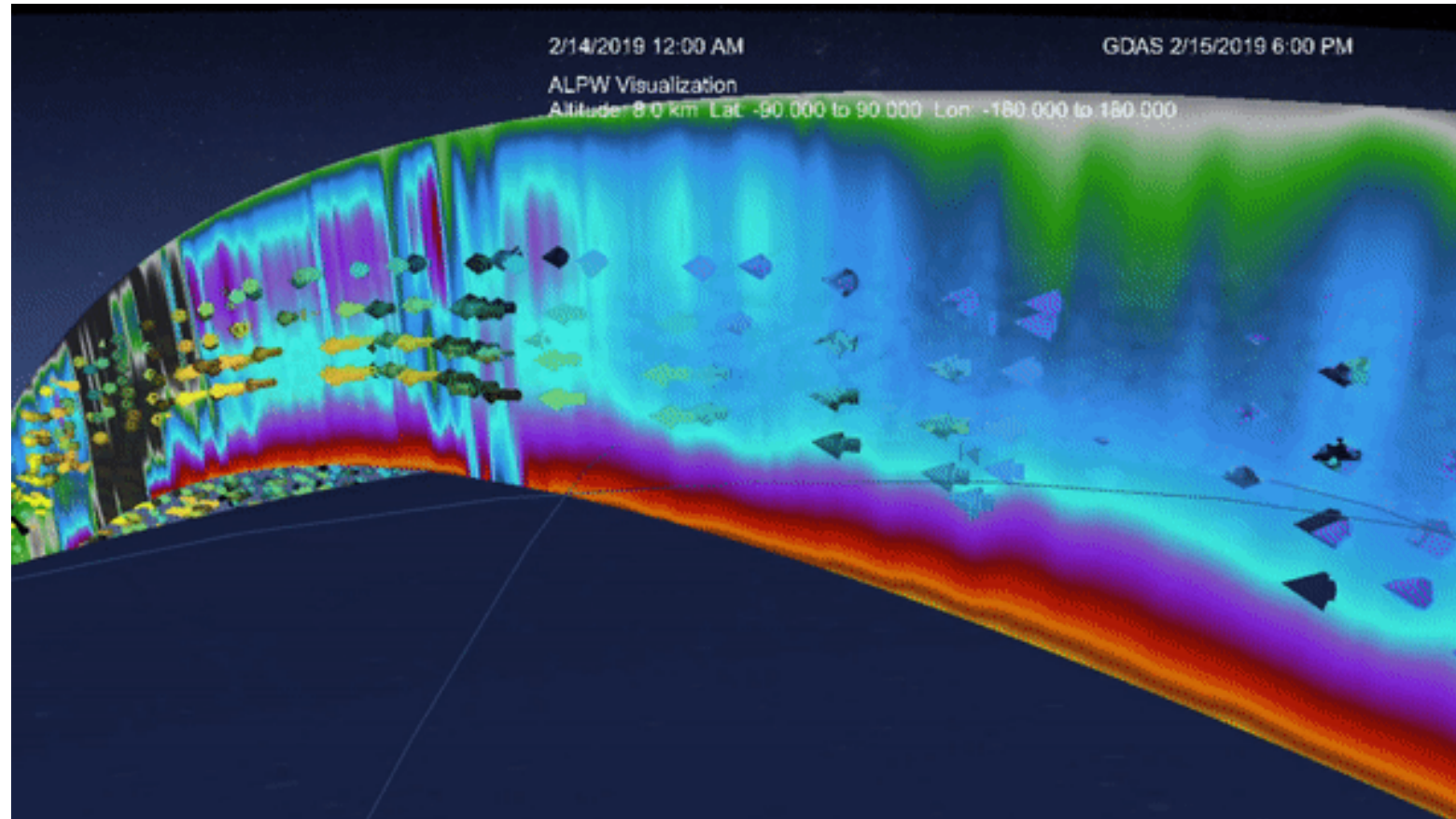
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- Soil Moisture Operational Products System (SMOPS)
 - 6 hrly, 0.25 x 0.25 degree grid
 - Soil moisture for top 1-5 cm soil
- NOAA Unique Combined Atmospheric Processing System (NUCAPS)
 - Derived from JPSS CrIS/ATMS
 - Vertical profile of temperature and water vapor content
 - Estimates vertical stability
 - 0.5° latitude, 2° longitude



Atmospheric River Case Study

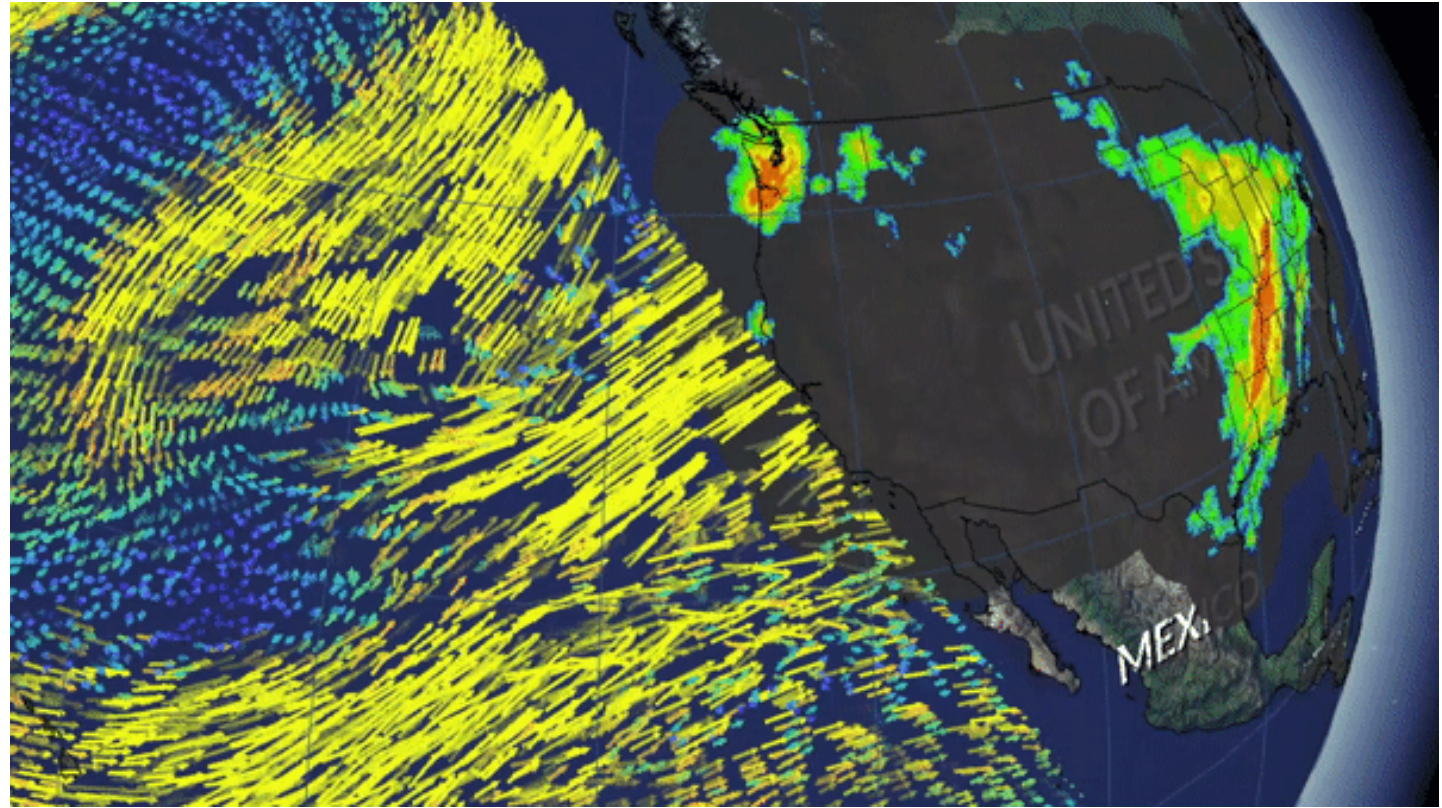
- Corridor of moisture stretching thousands of km from tropics to west coast of North America
- Atmospheric Rivers are associated with intense precipitation events associated with flooding and landslides
- AR occurred on 12-16 February 2019
- Vertically stacked winds advect moisture over 4000 kilometers



Note: Unsteady screen capture results from the VR headset needing to be worn during video creation, have obtained a “mannequin” to steady future training videos

Atmospheric River Case Study

- Winds perpendicular to orography drive moist air upward over terrain
- Exceptionally high accumulated rainfall driven by this exceptional combination of atmospheric conditions
- Produced more than a foot of snow in Redding, CA
- 10.1 inches of rain at Palomar Observatory, wettest day ever recorded
- Palm Springs had 3.68 inches, third heaviest 24-hour rainfall ever recorded
- Numerous reports of washed-out and flooded roads and highways



Atmospheric River Fly Through

<https://youtu.be/wgo8RHTTrHc>

Continued Work

- Pursue additional funding to maximize impact (likely multi-source)
- Build another video highlighting different datasets and tools/features
- Perform formal user testing to gather forecaster feedback
- Incorporate more datasets (e.g., dropsondes) and develop new case studies (e.g., Hurricane Dorian)
- Develop real time capability for future operational use (explore reading directly from NWS AWIPS* feeds)
- Investigate potential as a user training tool (provides a means for easily packaging and sharing training simulations)

**Advanced Weather Interactive Processing System (AWIPS) is the primary NWS forecasting software to examine satellite, radar, model, and ground observations (exclusively a 2D tool with no 3D rendering i.e., vertical scale/relations are unresolved)*

Summary

- Developed a versatile VR program to ingest and display various Earth science / satellite datasets
- New VR system allows users to view data in its native 3D format
- Implemented tools that provide both qualitative and quantitative analysis
- Continue working to understand the spatial and temporal resolution needed from satellites to meet future forecaster needs and fully exploit future analysis capabilities