

# **The Orographic Rain Index (ORI)**

**Stan Kidder & Steve Miller**

**CIRA**

**OCONUS Proving Ground Meeting**

*Hawaii, July 2010*

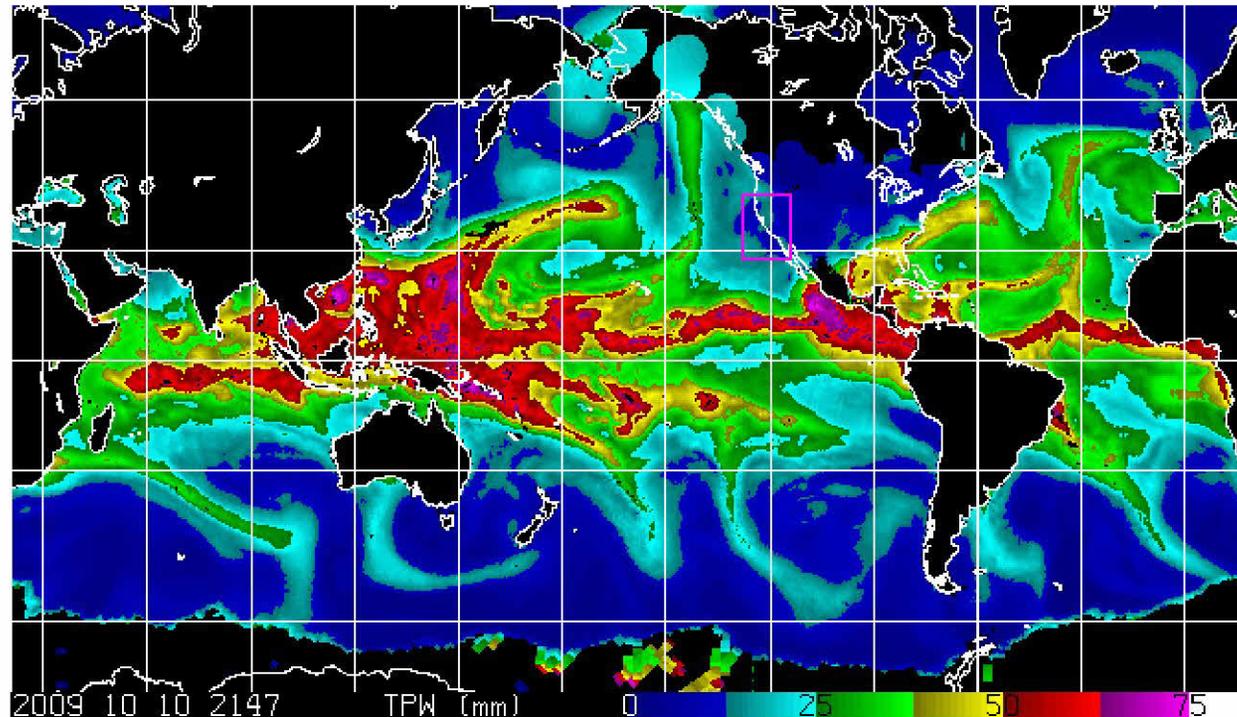
# How Did It Start?

1. Allen White gave a seminar at Colorado State
2. Dave Reynolds (MIC at Monterey) was asking for ideas about how to predict rain on burn areas.
3. Our Blended TPW became operational at OSDPD.



# Blended Total Precipitable Water

October 2009



# The Algorithm

$$\text{ORI} = \text{TPW} * \mathbf{V} \bullet \nabla H$$

H = USGS GTOPO30 terrain height (30 second resolution)

V = GFS 850 hPa wind vector at product time (30 minute resolution)

TPW = Blended TPW advected to product time using time and space interpolated GFS 850 hPa winds

# The Algorithm

$$\text{ORI} = \text{TPW} * \mathbf{V} \cdot \nabla H$$

↑  
moisture

↑  
“lift”

(an estimate of terrain-  
induced vertical motion)

Units = mm \* m/s or equivalently,  
but less heuristically, kg/m/s

Where  $\mathbf{V} \cdot \nabla H$  is less than zero, ORI is  
set to zero.

# The Algorithm

$$\text{ORI} = \text{TPW} * \mathbf{V} \bullet \nabla H$$

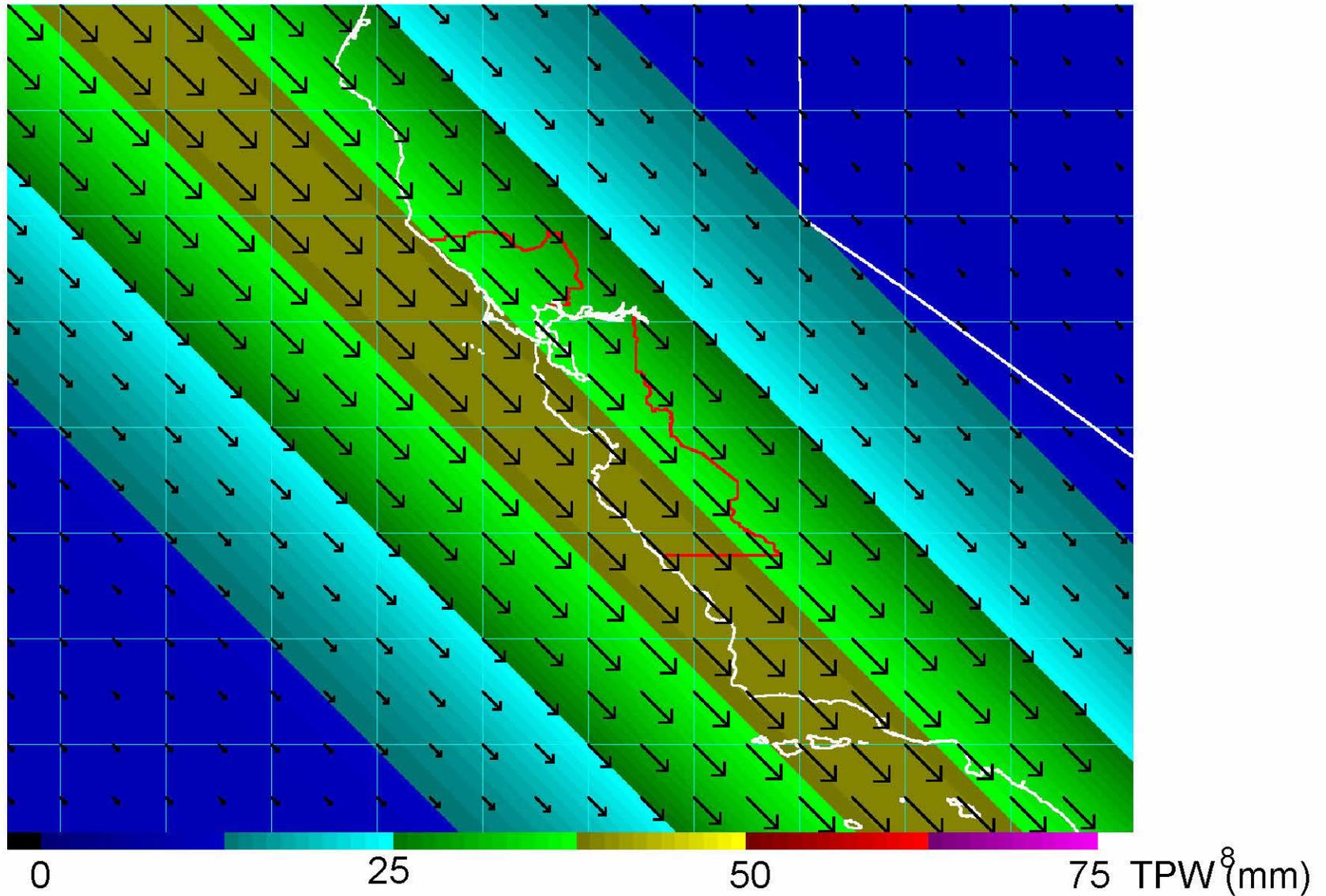
Note that the “upslope flow” used at ESRL is essentially  $\mathbf{V} \bullet \nabla H / |\nabla H|$

# Simulation



# NW Flow

Max Wind = 30 m/s  
MAX TPW = 40 mm

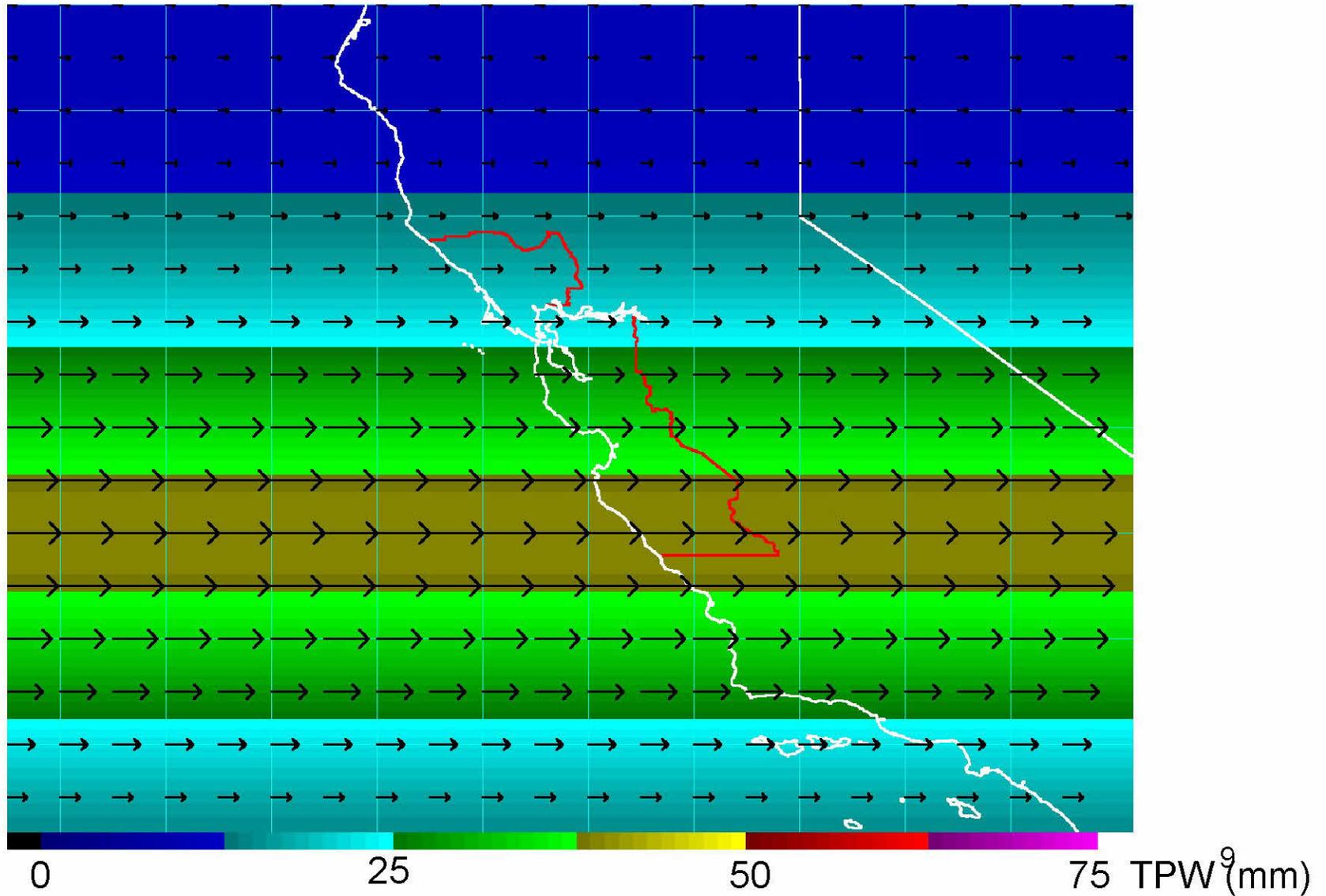




# W Flow

Max Wind = 30 m/s

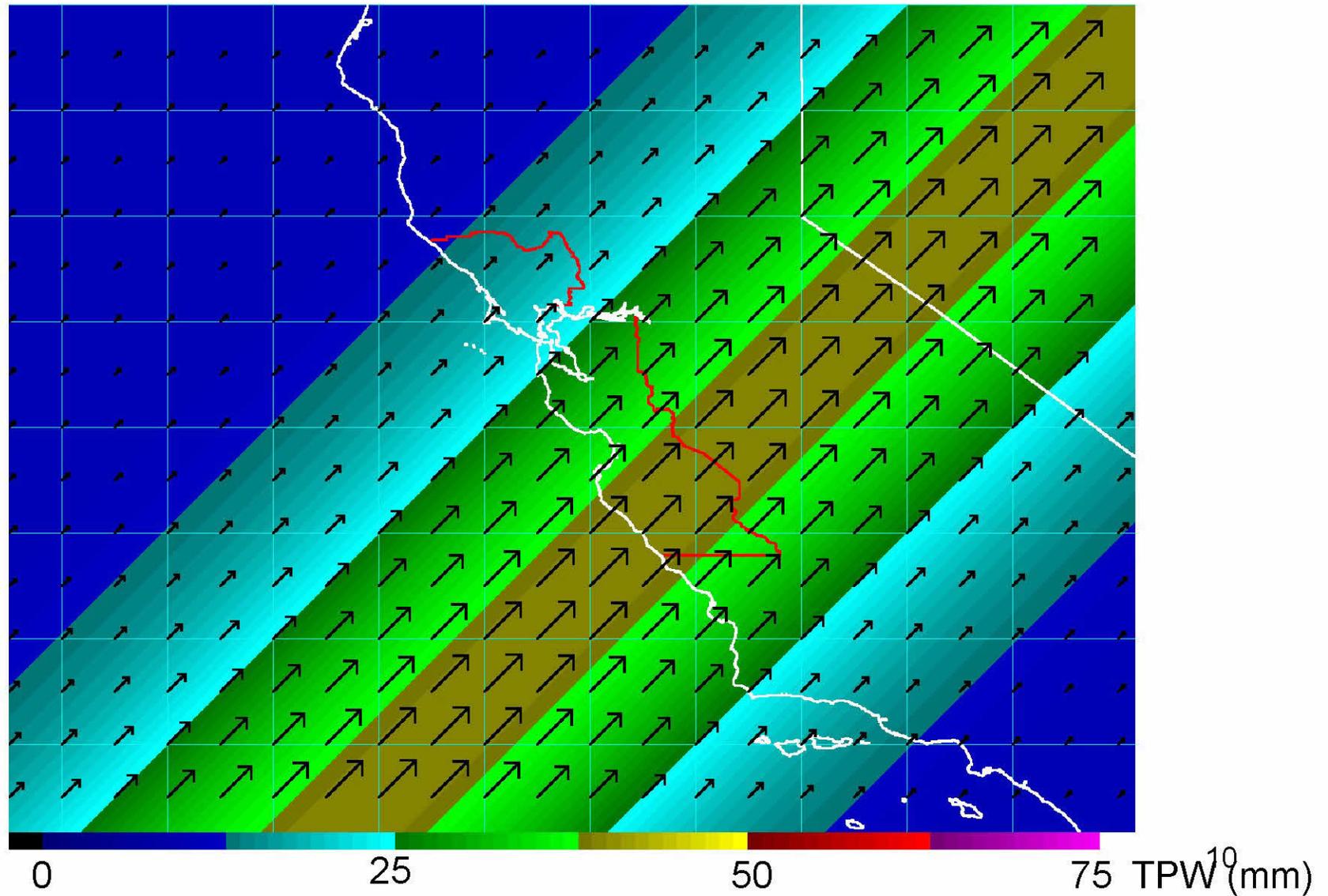
MAX TPW = 40 mm





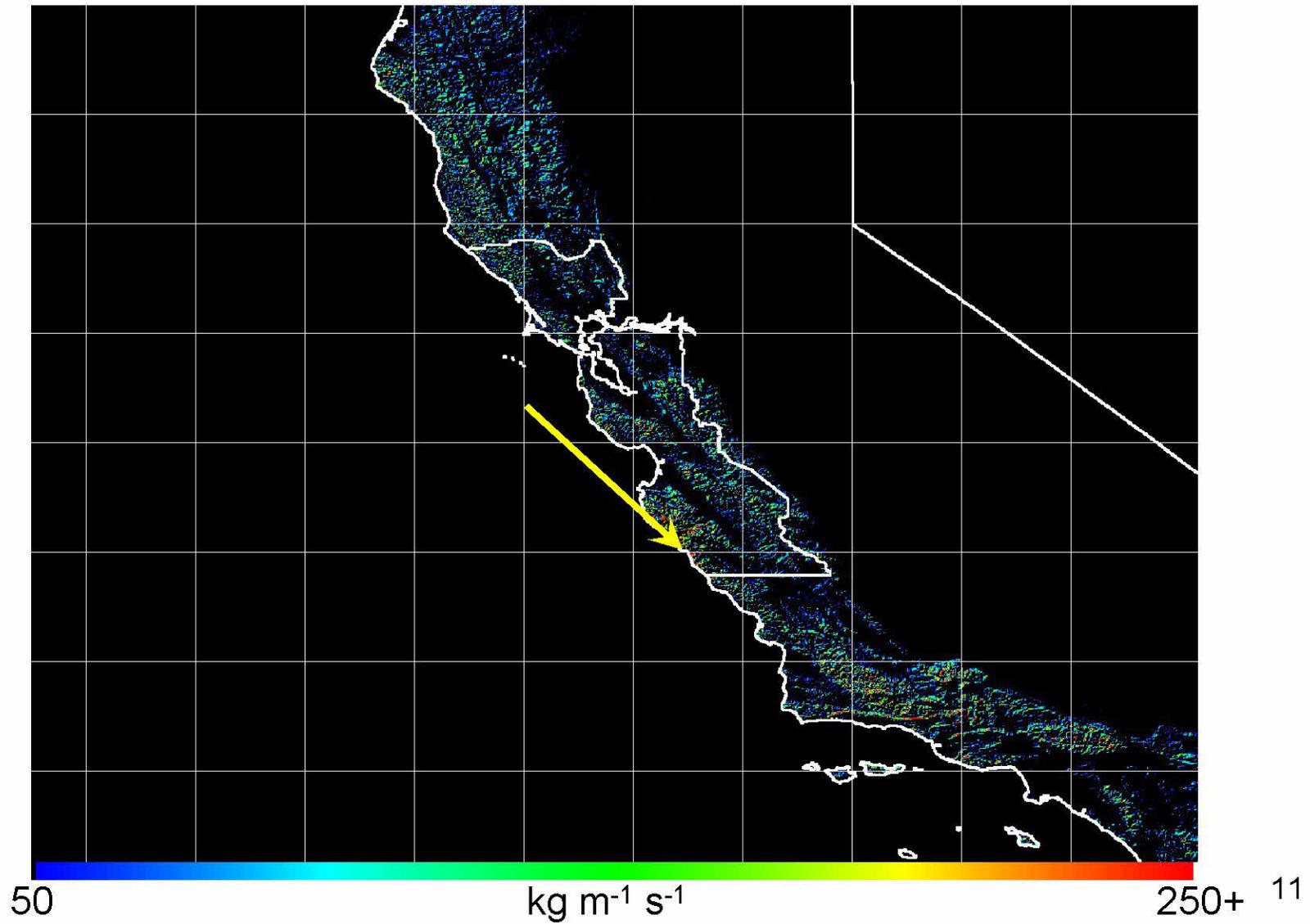
# SW Flow

Max Wind = 30 m/s  
MAX TPW = 40 mm



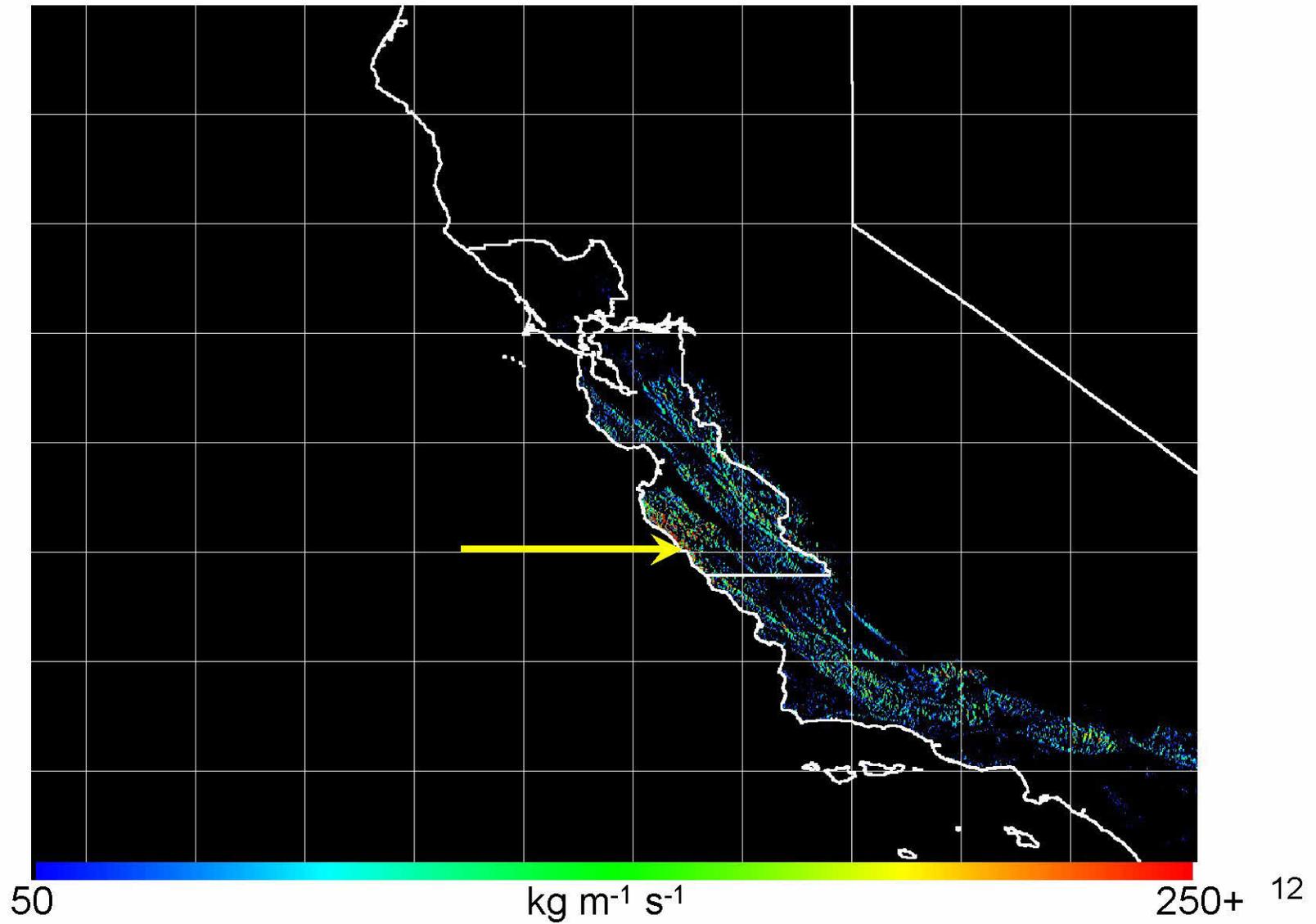


# NW Flow (CA Regional)



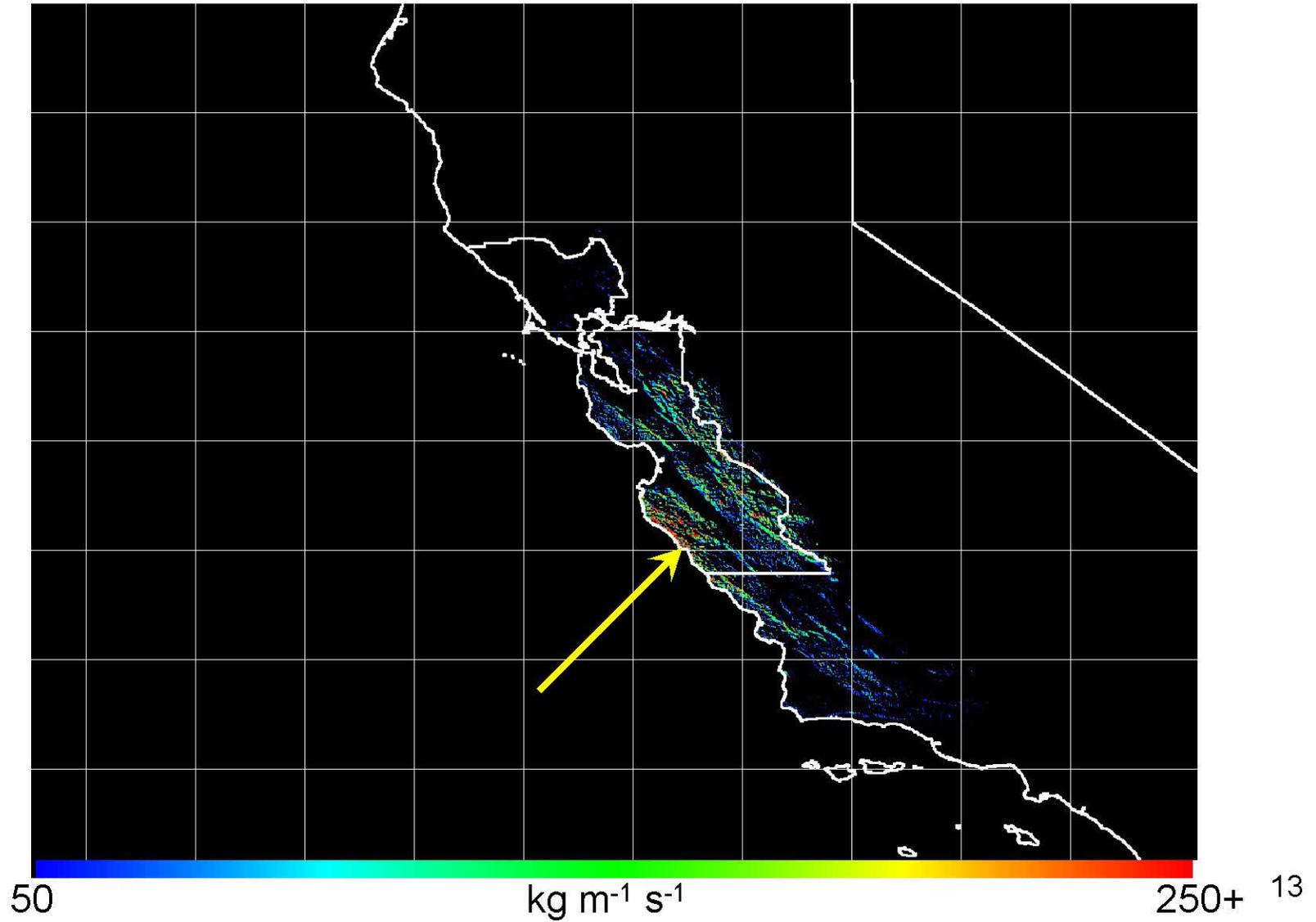


# W Flow (CA Regional)



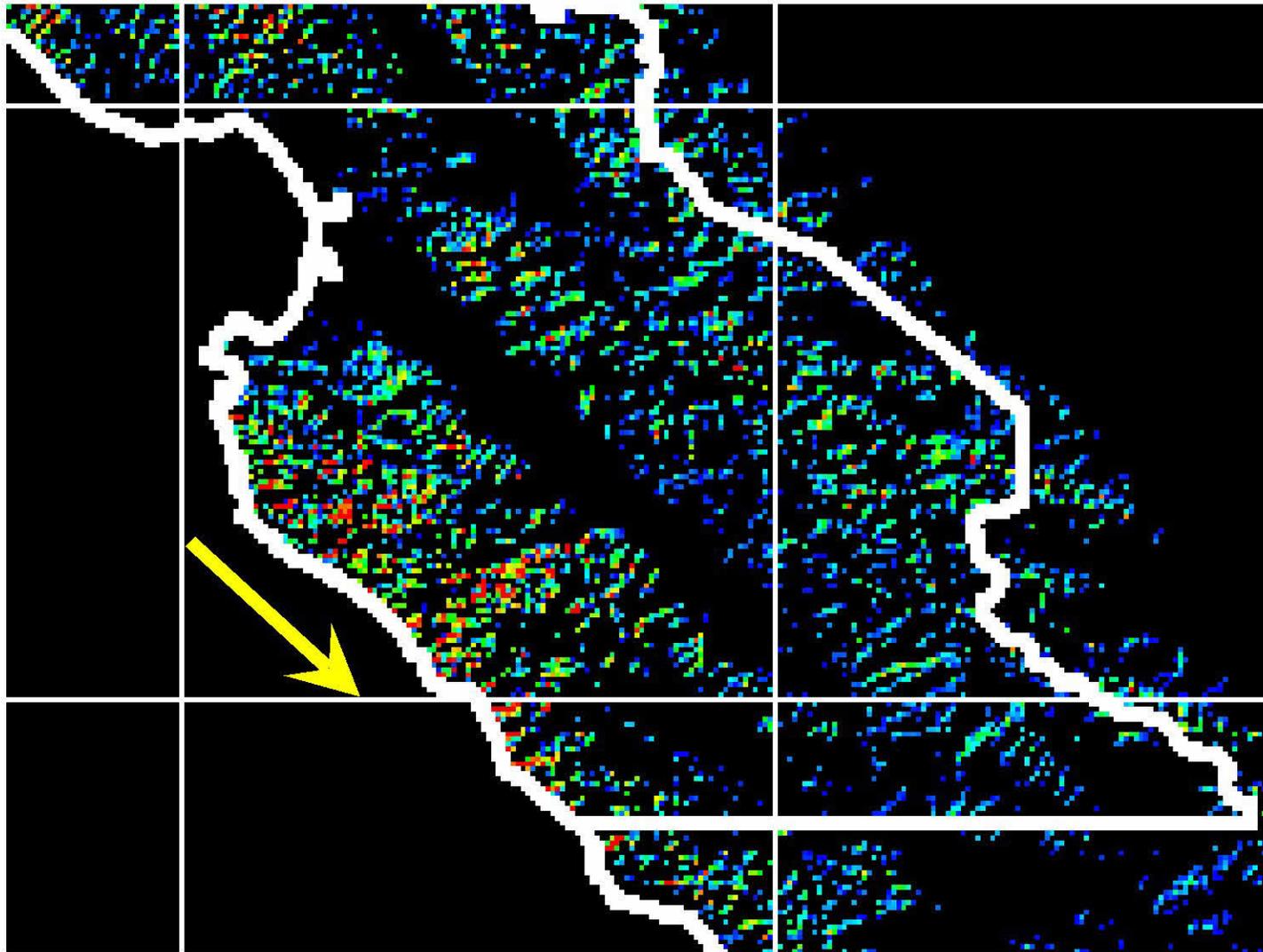


# SW Flow (CA Regional)



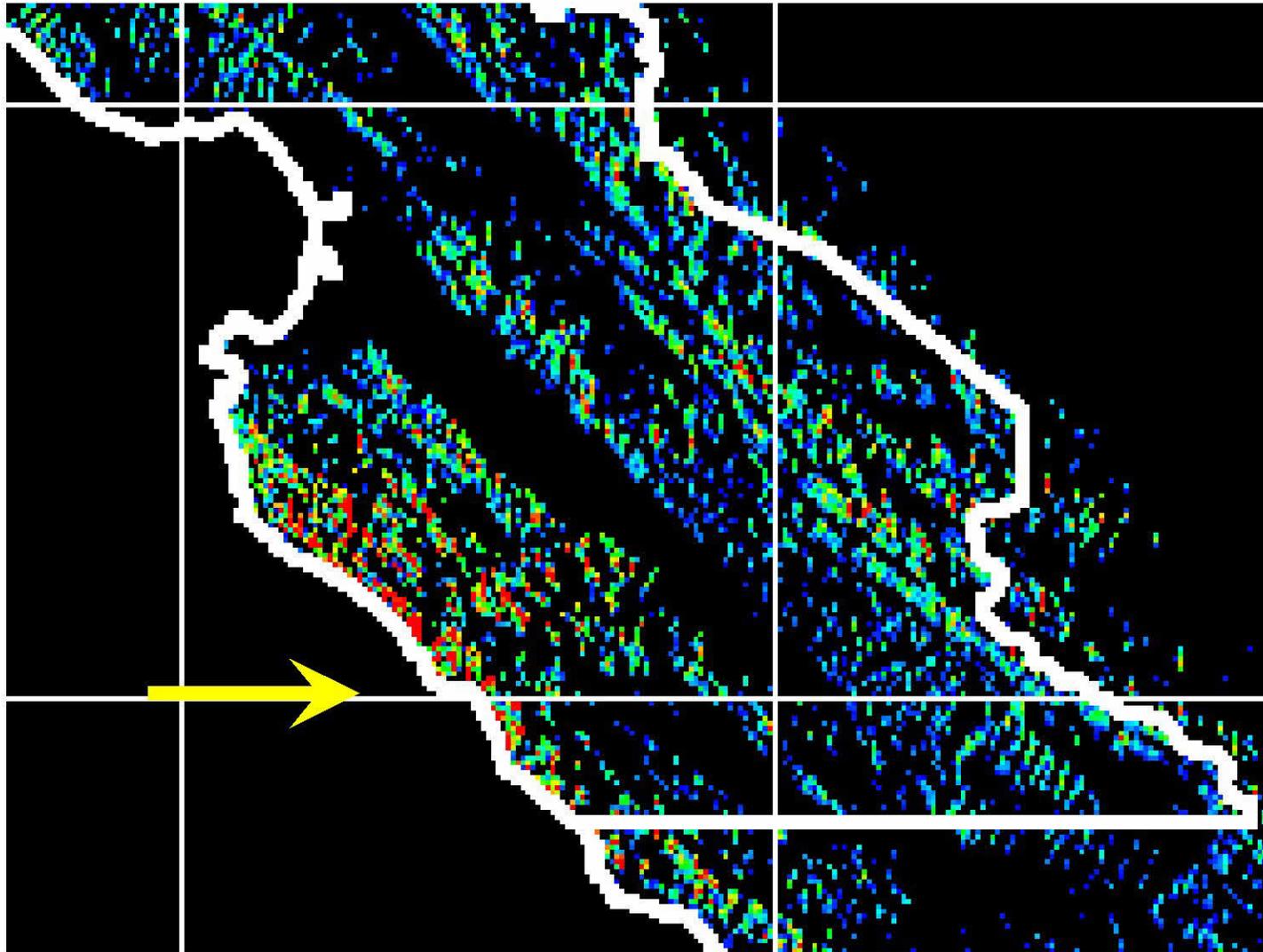


# NW Flow (MRY County)



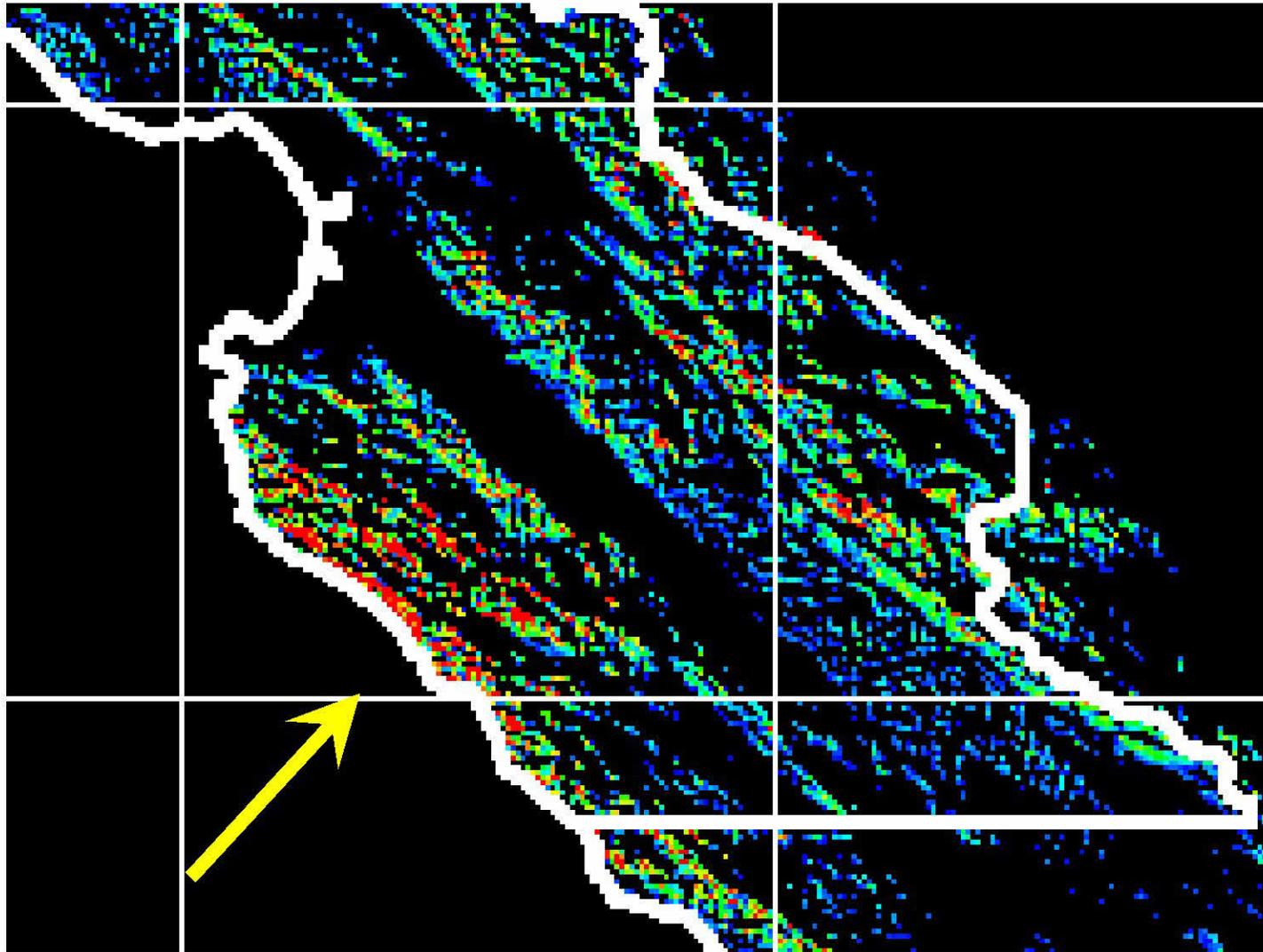


# W Flow (MRY County)





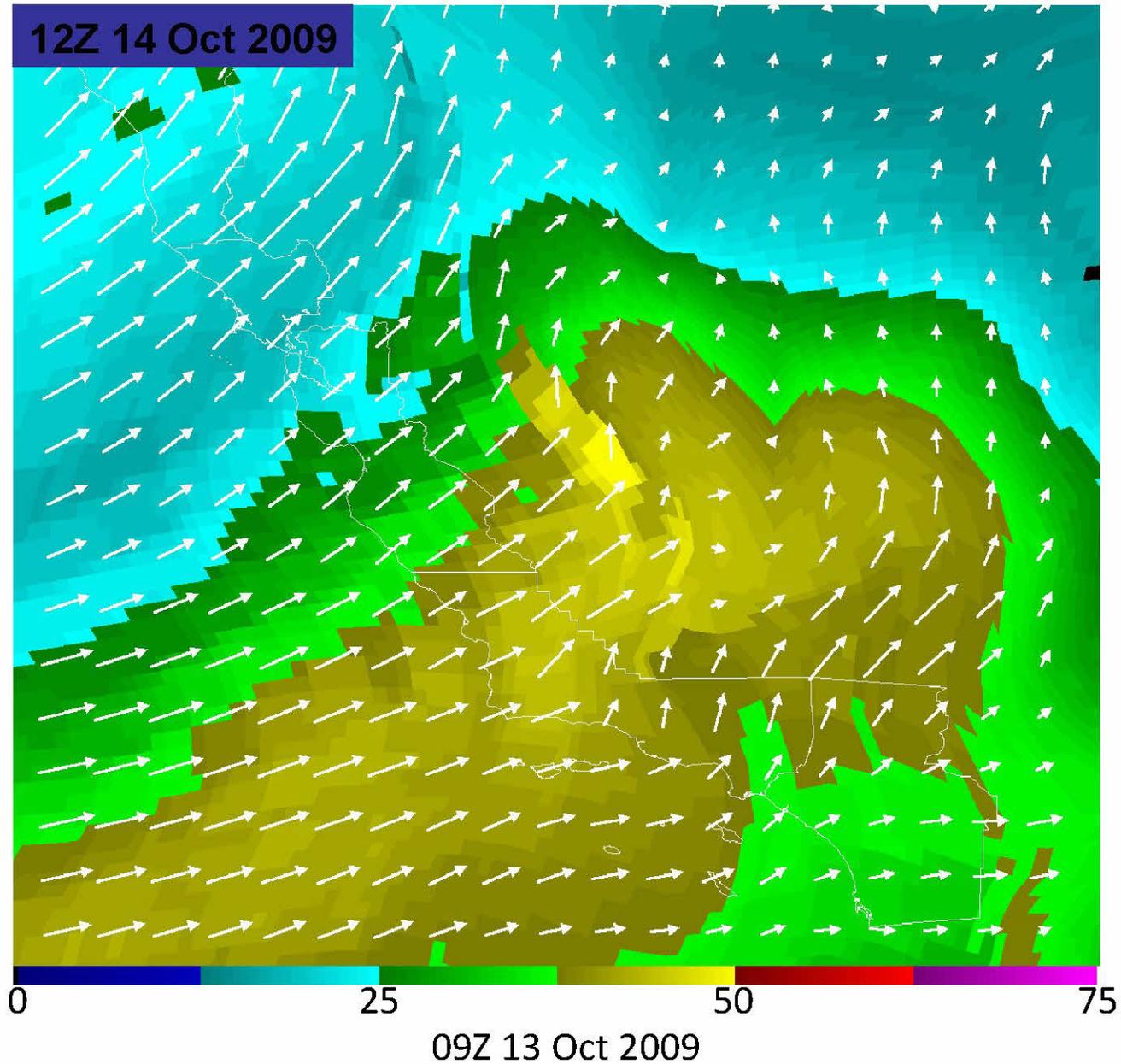
# SW Flow (MRY County)



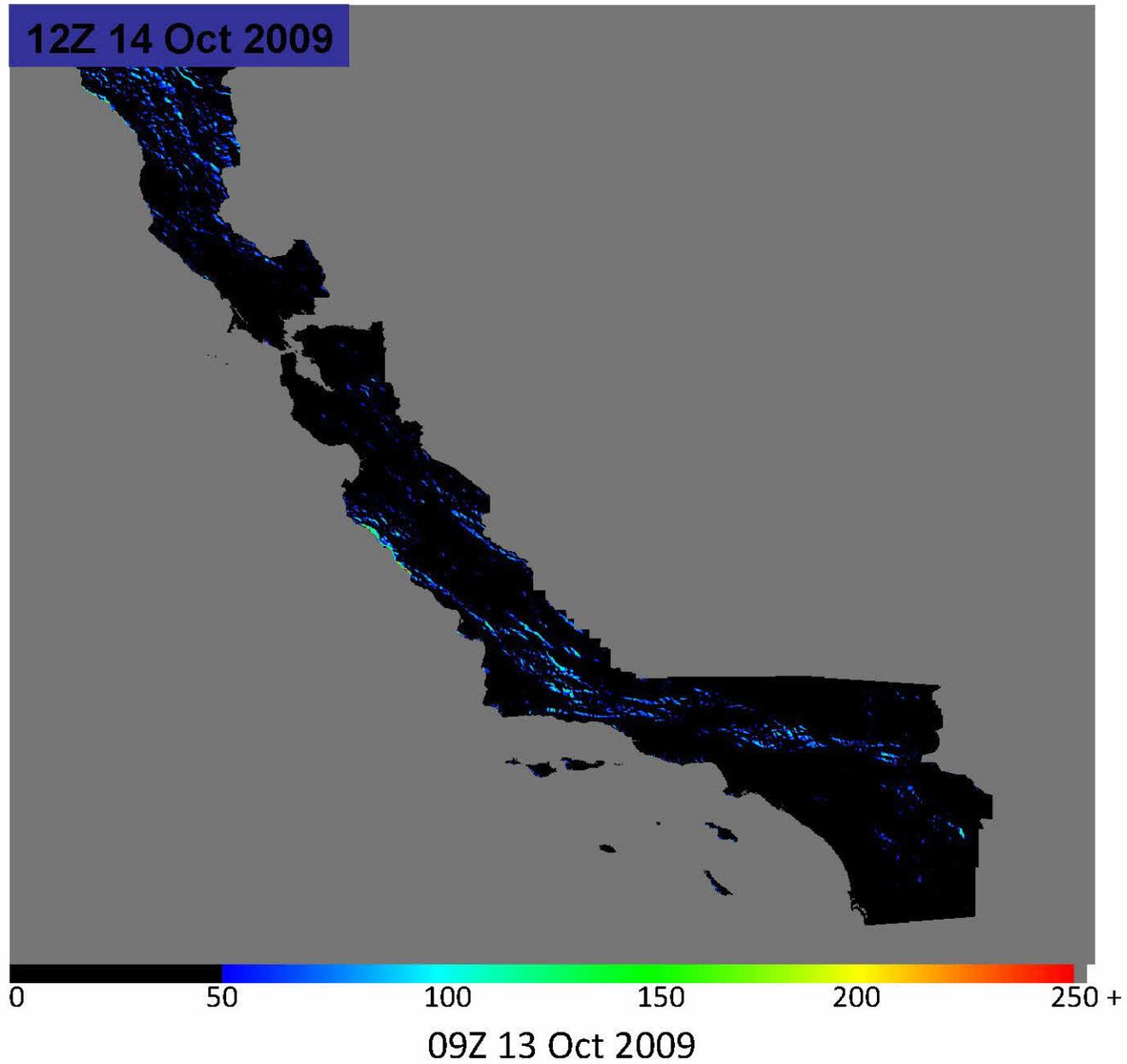
# October 2009 Case



# Blended TPW (mm) and 850 hPa GFS Winds

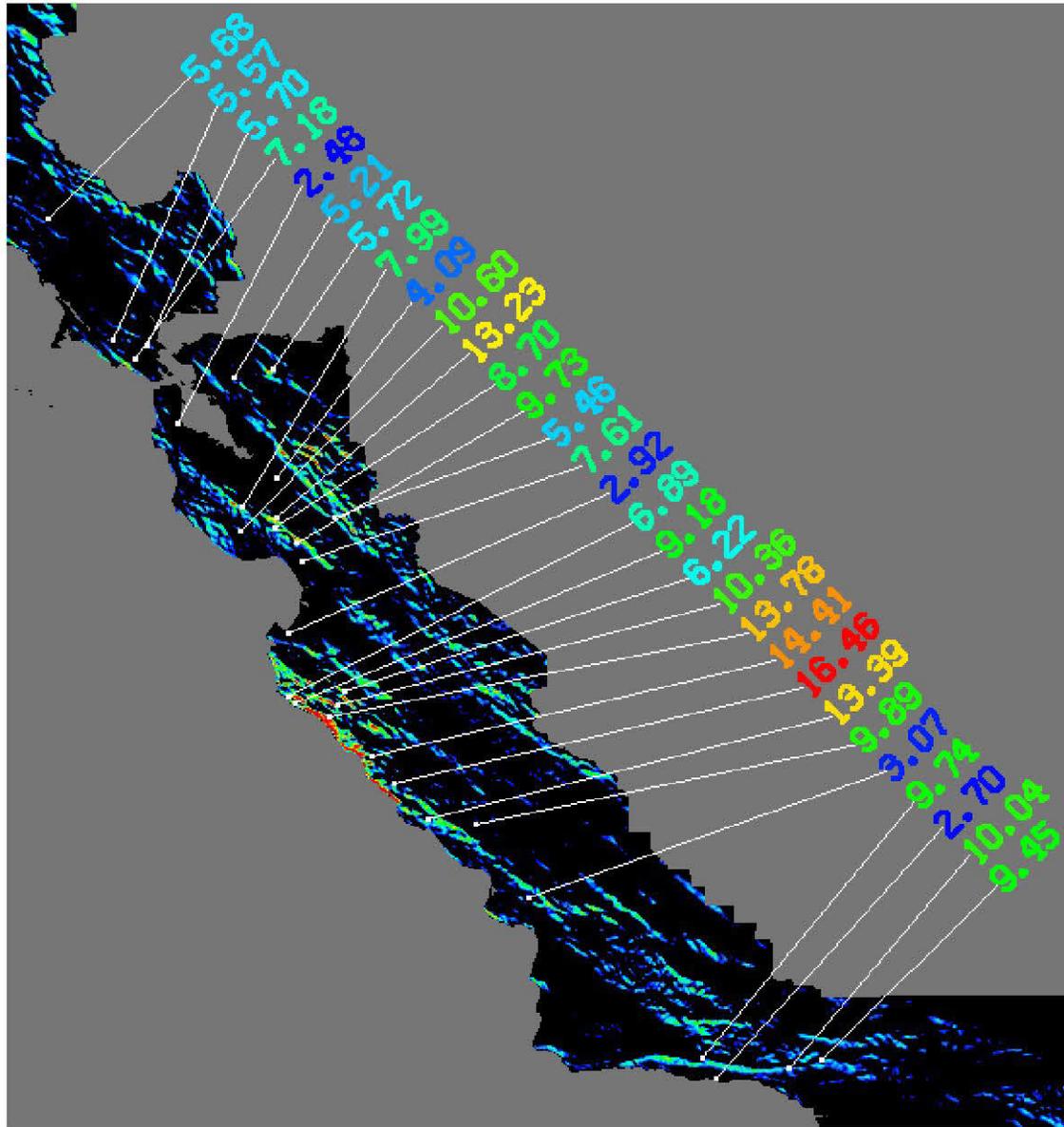


# ORI (mm \* m/s)





# Observed Precip (in.) 06Z Tue 13 Oct – 15Z Wed 14 Oct



ORI “hot spots” correlated with heaviest rain regions

# NCEP/HPC Usage of ORI

SATELLITE PRECIPITATION ESTIMATES..DATE/TIME 10/13/09 1836ZSATELLITE ANALYSIS BRANCH/NESDIS---NPPU---TEL.301-763-8678LATEST DATA USED: GOES-11 1800Z KUSSELSON BLENDED TPW PRODUCTS THRU 1616Z; DMSP SSMI/S:1520-1615ZNOAA AMSU:1325Z.

LOCATION...EXT W NEVADA...N AND C CALIFORNIA...SW OREGON....  
ATTN WFOS...VEF...REV...HNX...LOX...MFR...STO...MTR...EKA...  
ATTN RFCS...NWRFC...CNRFC....

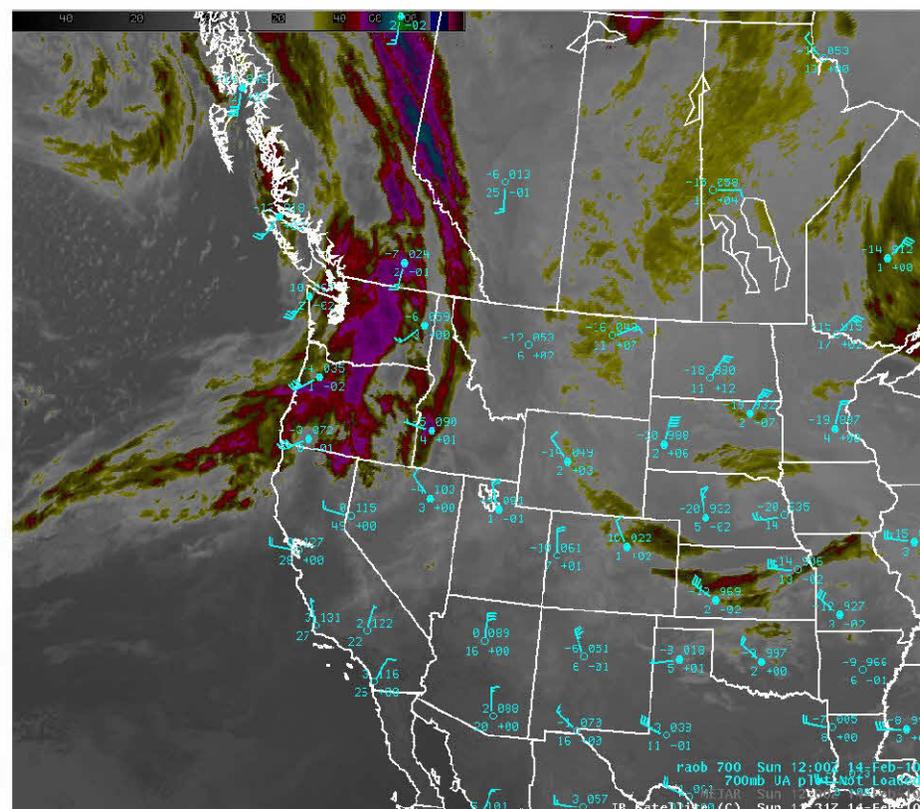
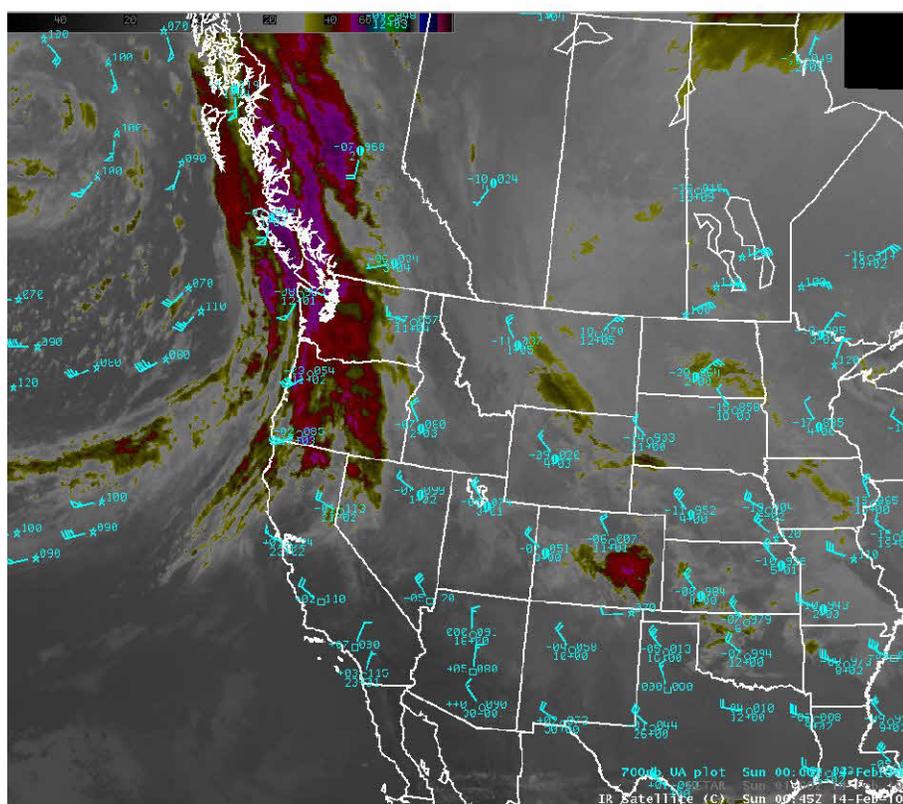
**EVENT...OROGRAPHIC INDEX POINTS TOWARD MONTEREY COUNTY AND BIG SUR AREA....SATELLITE ANALYSIS AND TRENDS...EXPERIMENTAL CIRA/COLORADO ST UNIV OROGRAPHIC INDEX THAT INCORPORATES LATEST BLENDED TOTAL PRECIP WATER WITH 850MB WINDS WAS SHOWING BEST POTENTIAL OROGRAPHICS IN MONTEREY COUNTY AND SPECIFICALLY CENTRAL AND SOUTH NEAR BIG SUR.** THIS IN LINE WITH SHORT WAVE GOING NEGATIVE TILT FROM OFF OREGON COAST AT 43N/129W TO 37N/128W THAT ALONG WITH JET WILL HELP ENHANCE FRONTAL PRECIP FROM SFOBAY TO MRY BAY AND POINTS SOUTH INTO CENTRAL CA COAST. FURTHER EAST THIS SHOULD TRANSLATE HIGHEST RAIN AMOUNTS INTO CENTRAL AND N SIERRAS NEXT FEW HRS.

# February 2010 Case



# ORI Case Study

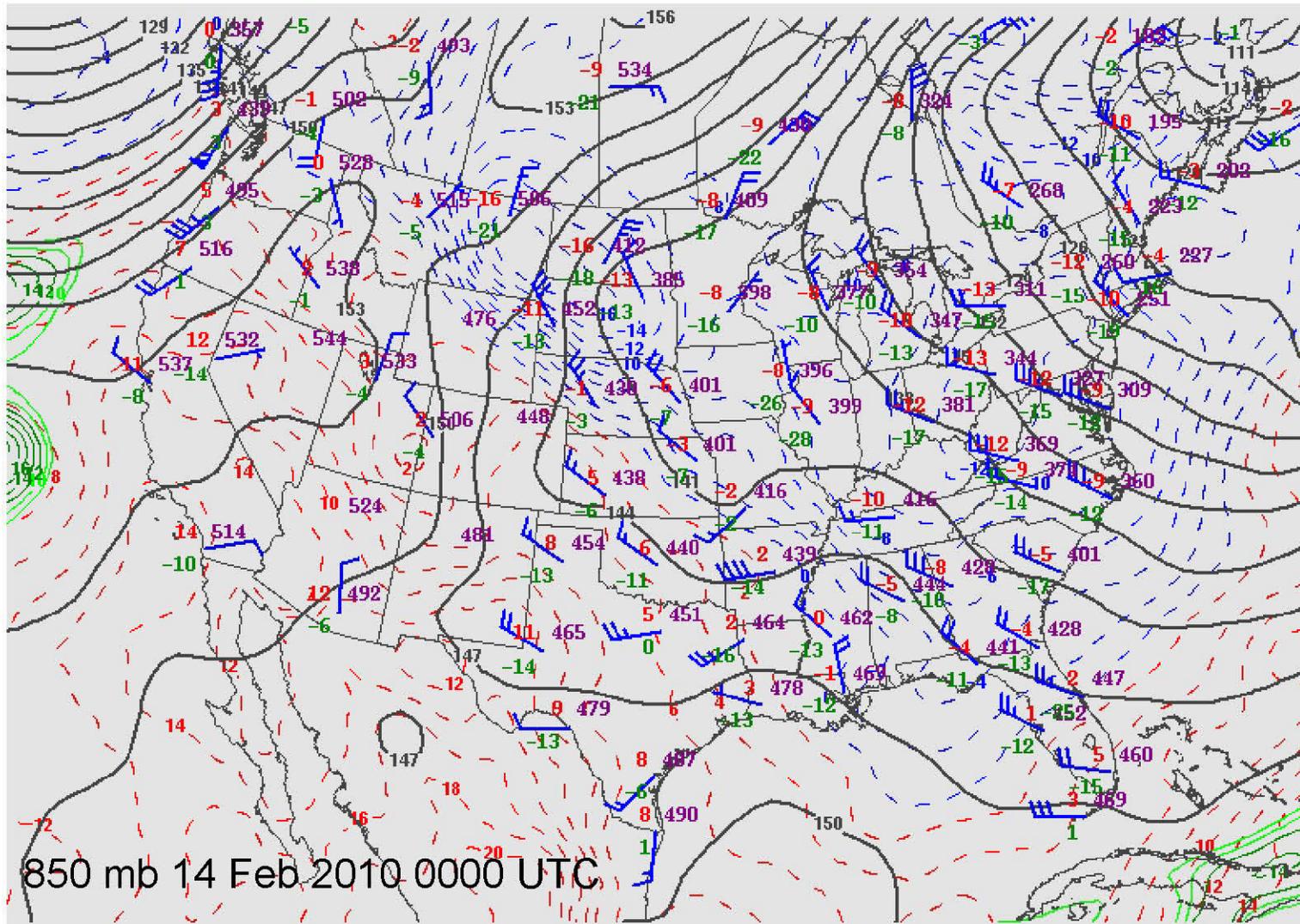
## Seattle, 14 February 2010



IR image with 700 mb plot for 0000 UTC (left) and 1200 UTC (right) on 14 February 2010

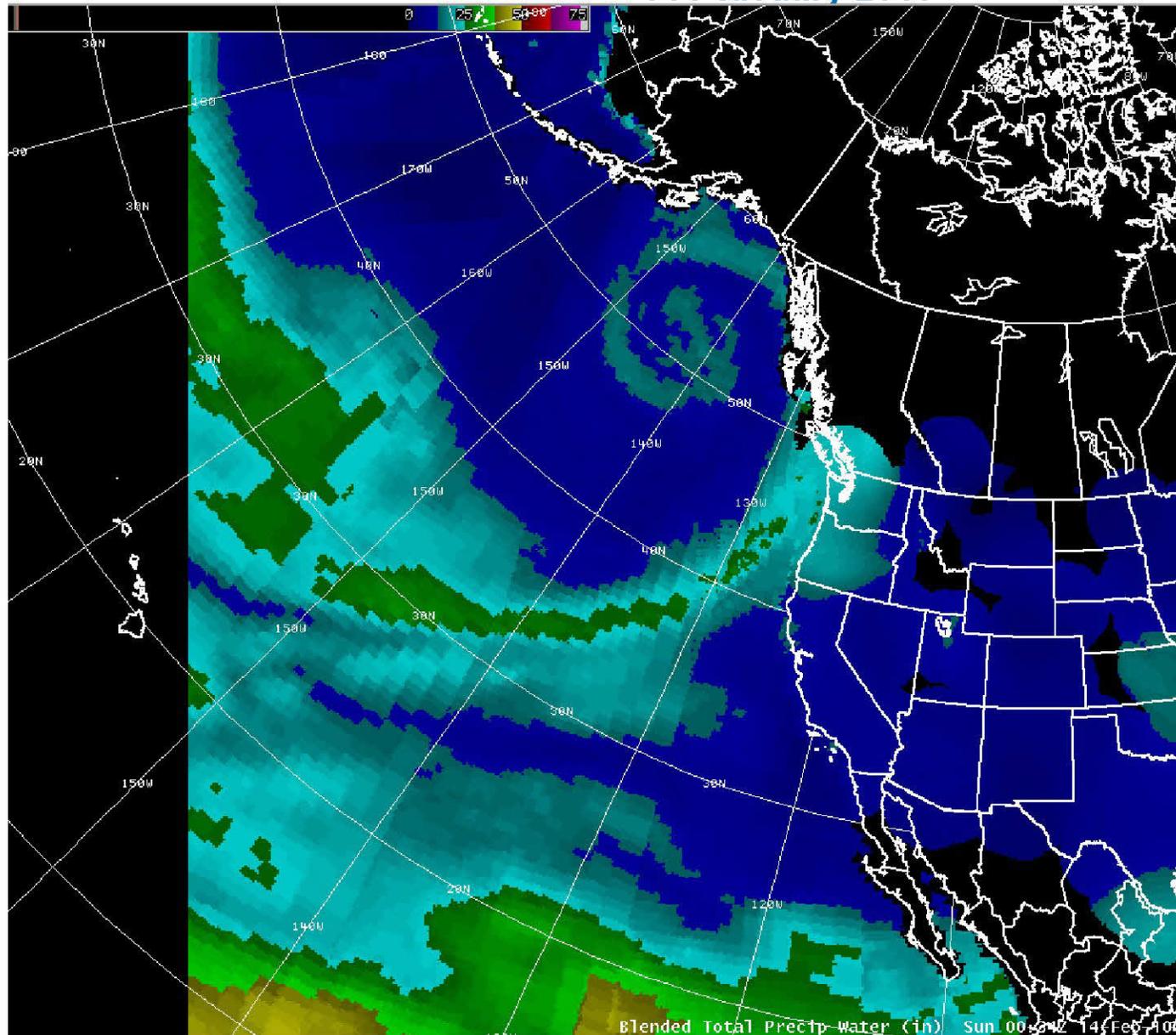
# ORI Case Study

14 February 2010



# ORI Case Study

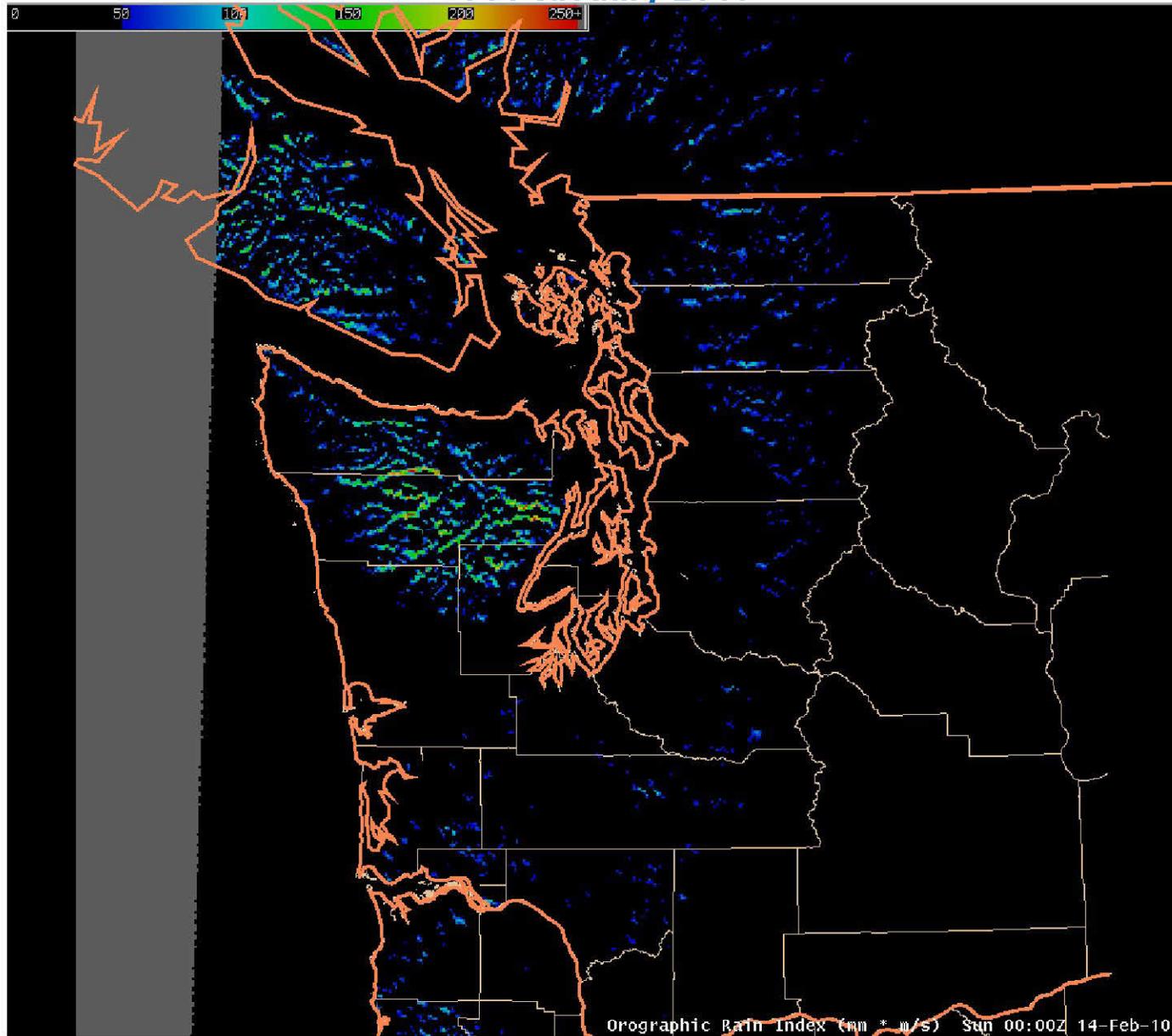
14 February 2010



CIRA Total Precipitable Water (TPW) image on 14 February from 0000 through 1800 UTC. Depicted is the plume of moisture from Washington all the way back to Hawaii.

# ORI Case Study

14 February 2010





# On-line ORI Product Description

[Click here for on-line ORI product description](#)

- Goal: the Web product description is being used as a training tool
- Includes detailed examples using AWIPS screen captures.



## Proving Ground Product Categories

*Each application demonstrated maps to at least one of the following Proving Ground categories:*

- **Category 1:** AWG Baseline (■ = variant)
- **Category 2:** AWG Option 2 (■ = variant)
- **Category 3:** GOES-R3 Product
- **Category 4:** Integrated Product
- **Category 5:** Decision Aid



CIRA Proving Ground Product Name	Satellite	Category
GeoColor Imagery	GOES/MODIS/DMSP	 
True Color Imagery	MODIS	 
Low-Cloud/Fog Imagery	GOES	  
Cirrus Enhancement Imagery	MODIS	
<b>Orographic Rain Index</b>	POES/GOES/GFS	 
Marine Stratus Cloud Climatology	GOES	
Blowing Dust Detection (split-window)	GOES	  
Blowing Dust (blue-light-absorption)	MODIS	 
Cloud/Snow Discriminator (binary)	MODIS	 
Cloud Layers & Snow Cover (multi-layer)	MODIS	 
Cloud / Snow Discriminator (3-color)	GOES	  
Volcanic Ash (PCI)	GOES	  
Volcanic Ash (blue-light-absorption)	MODIS	 
Land Surface Temperature	GOES	
Vegetation (NDVI)	MODIS	
SPC Hail Probability	GOES/RUC	  
Synthetic NSSL WRF Imagery	NSSL WRF-ARW	
NHC Lightning-based TC Intensification	Grnd-based lightning network/ GFS/GOES	   
MSG-based Air Mass Product	MSG	 
MSG-based Dust Product	MSG	  
Super Rapid Scan Imagery	GOES	

# Data Access

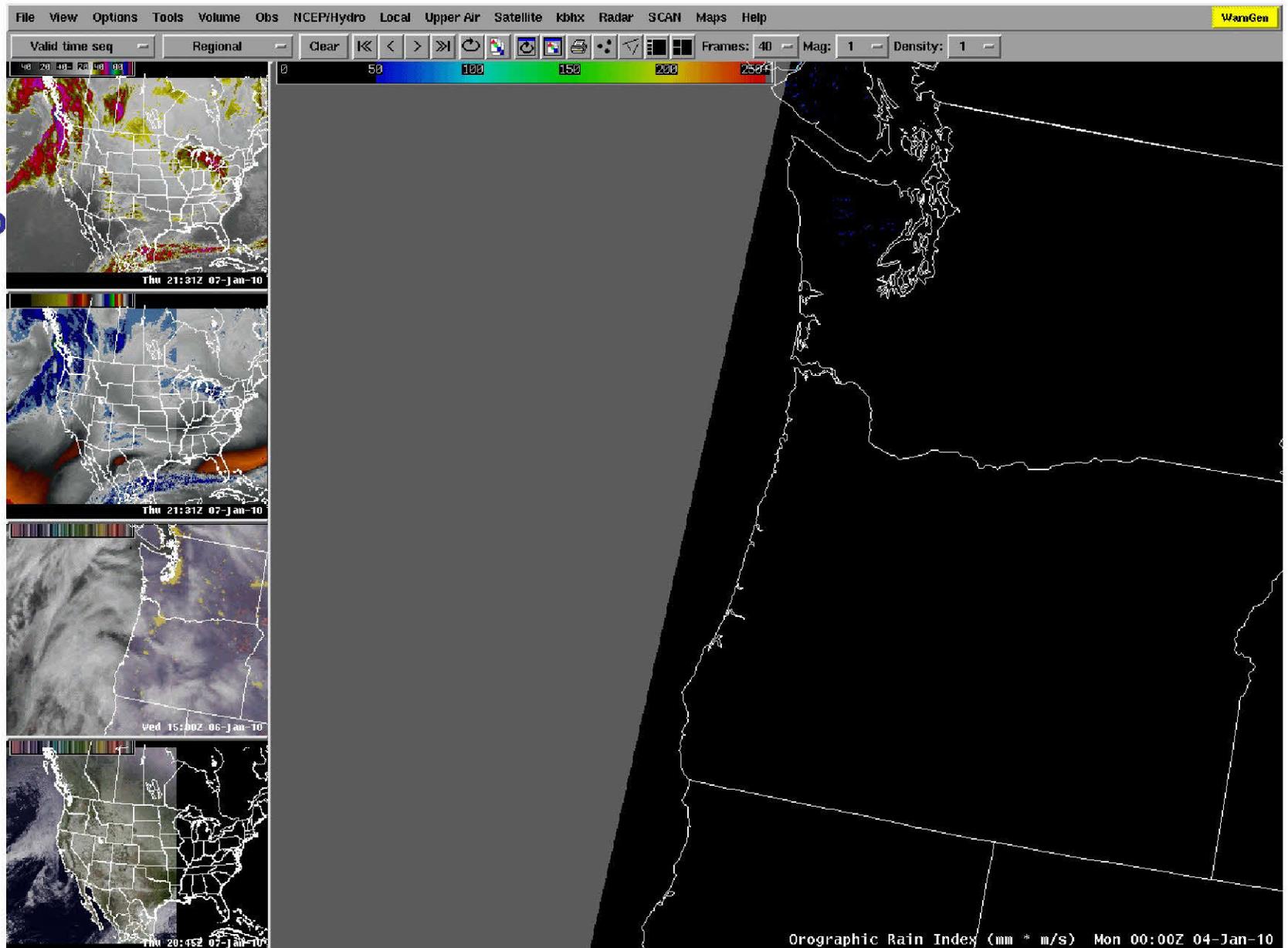
- In Western Region, data area available in AWIPS
- Other users can access data via the Web:
  - <http://products.cira.colostate.edu/ORI>

# Backup Slides

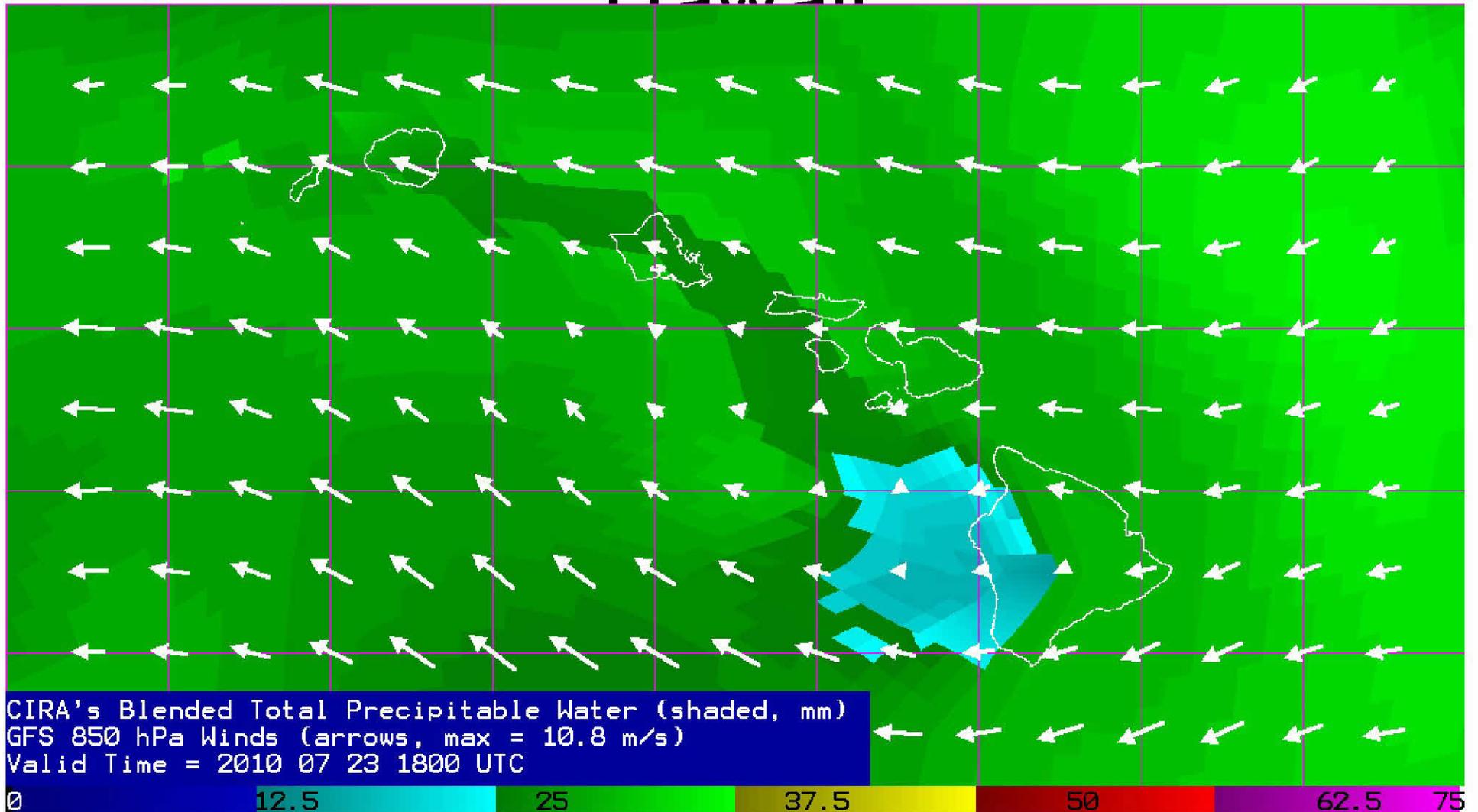
# ORI in AWIPS



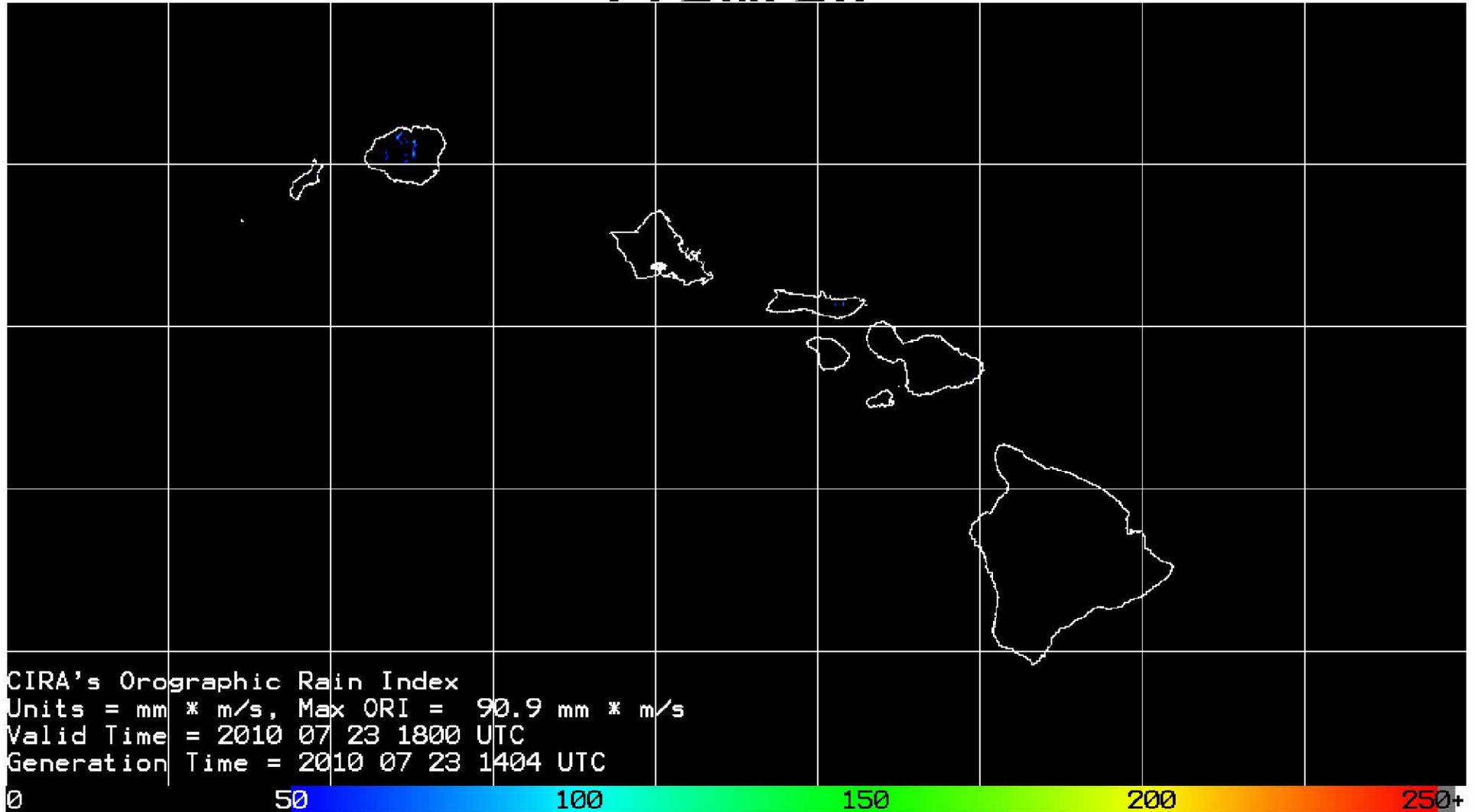
ORI  
being  
sent to  
WRH



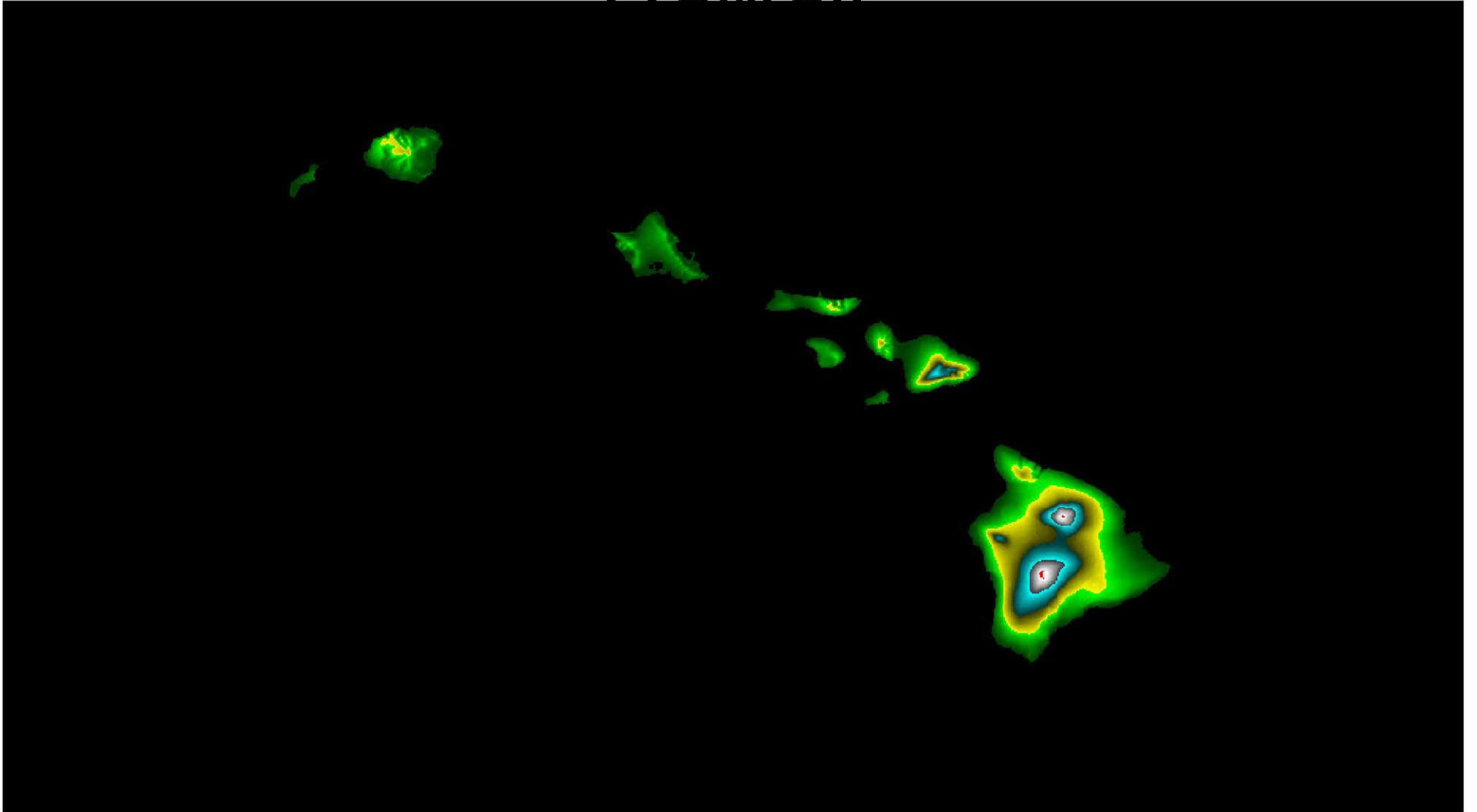
# Hawaii



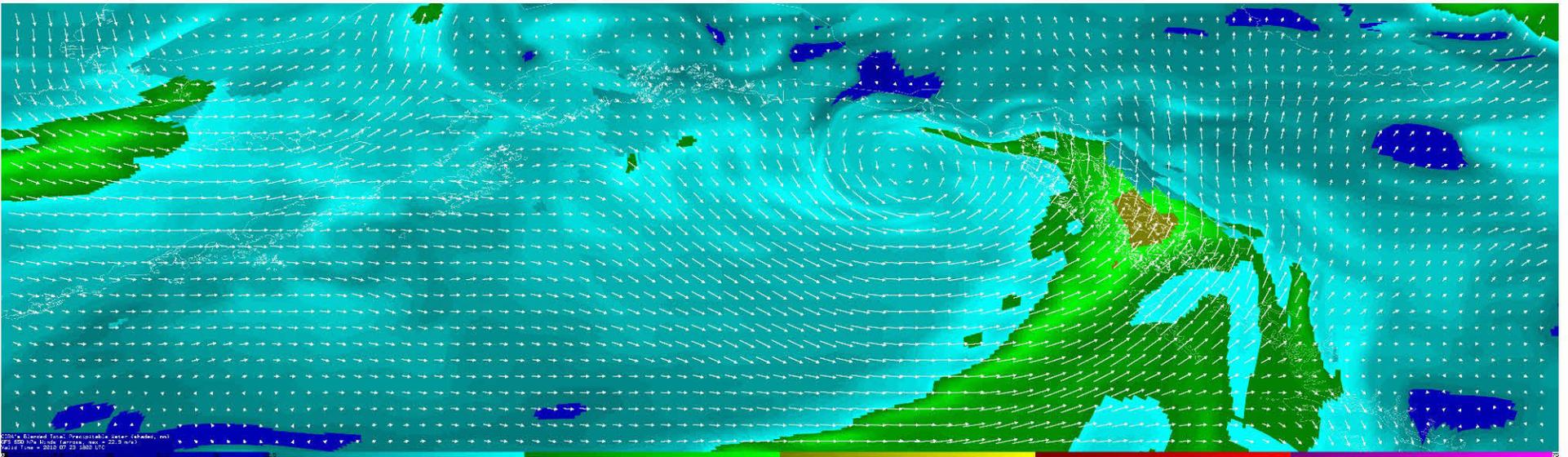
# Hawaii



# Hawaii



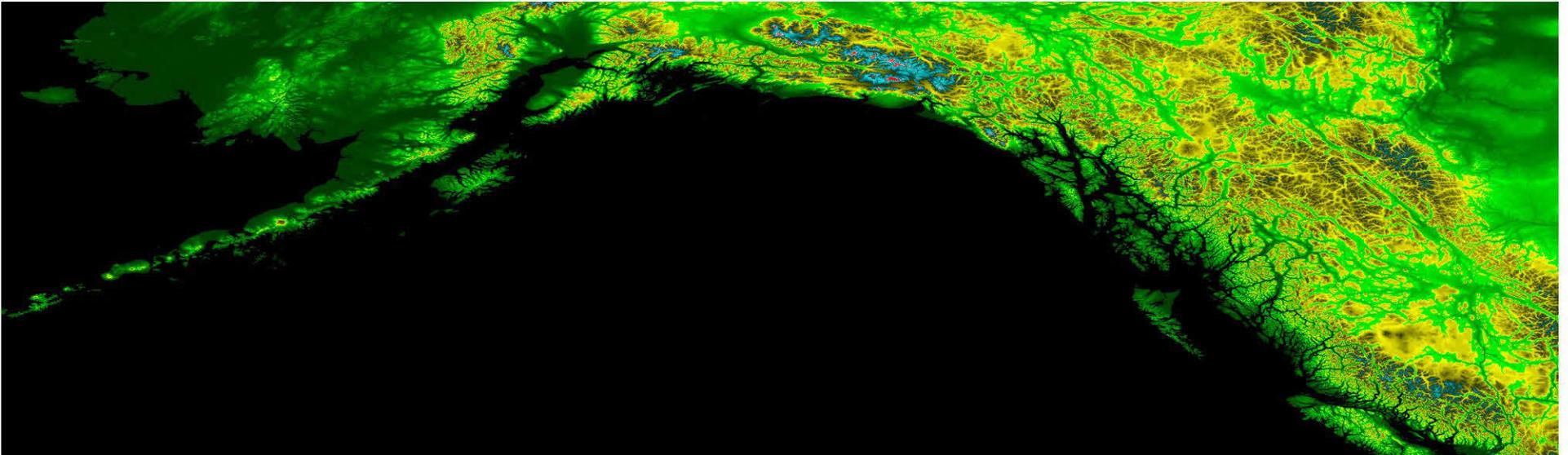
# Alaska



# Alaska



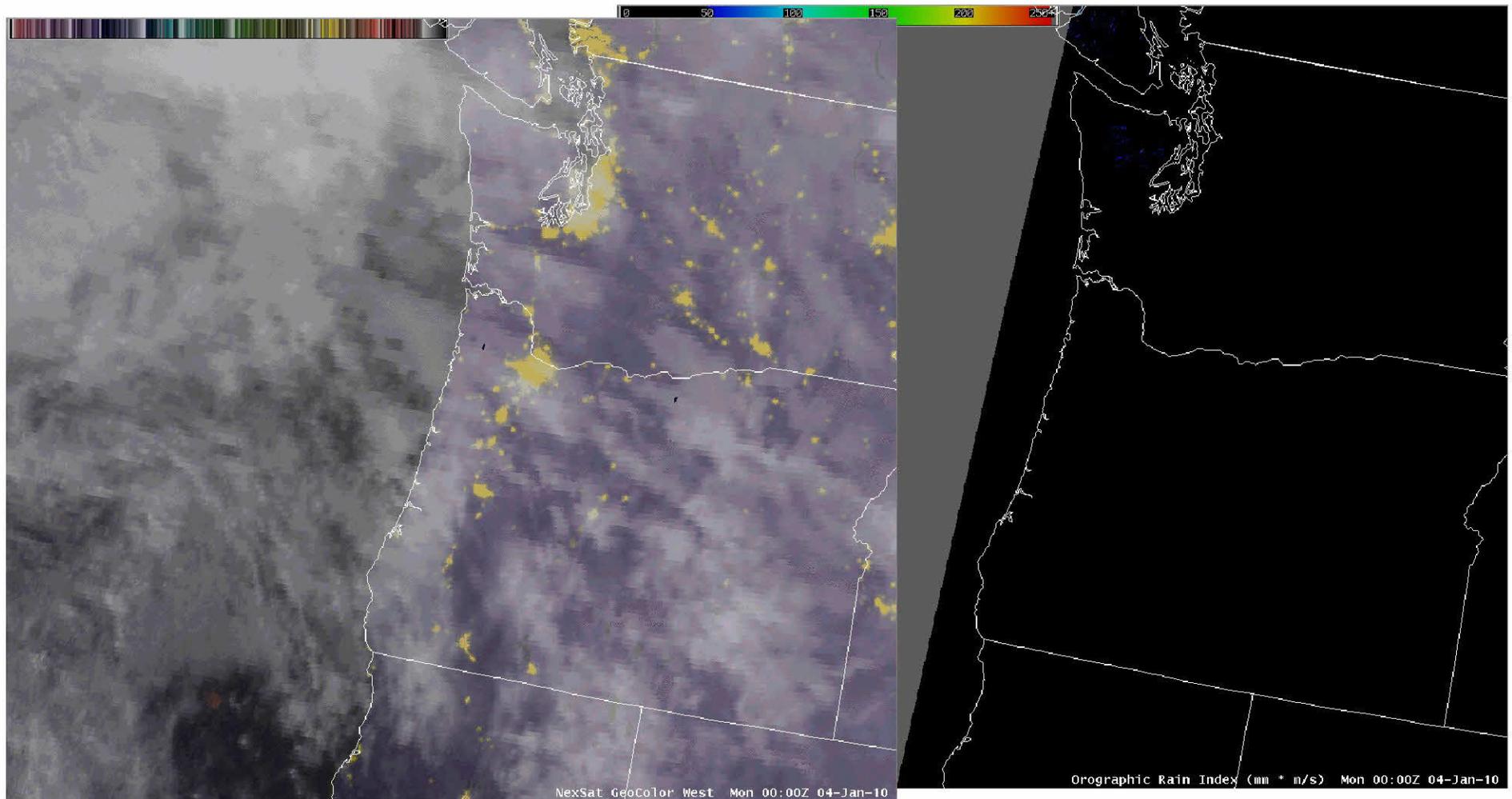
# Alaska





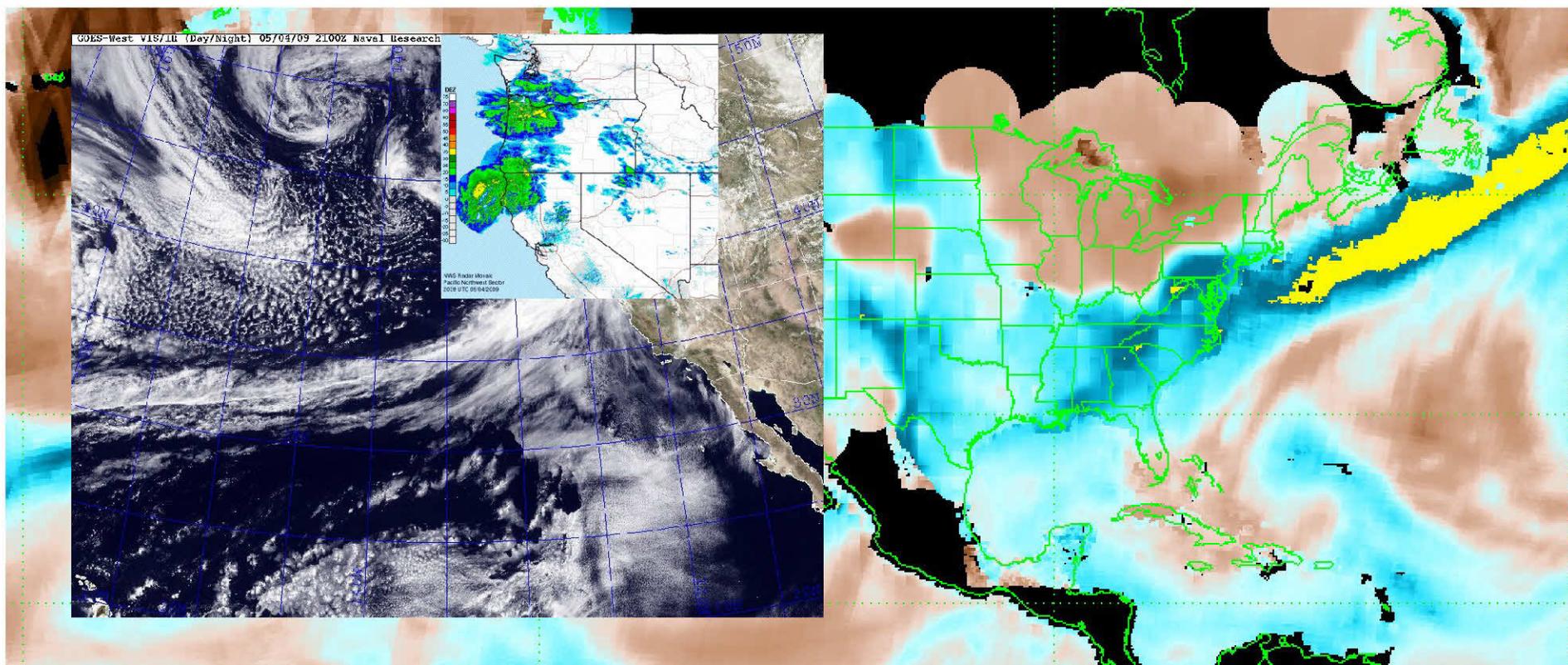
# ORI – GeoColor- Comparison

4 Jan 2010 00Z 48 hour loop





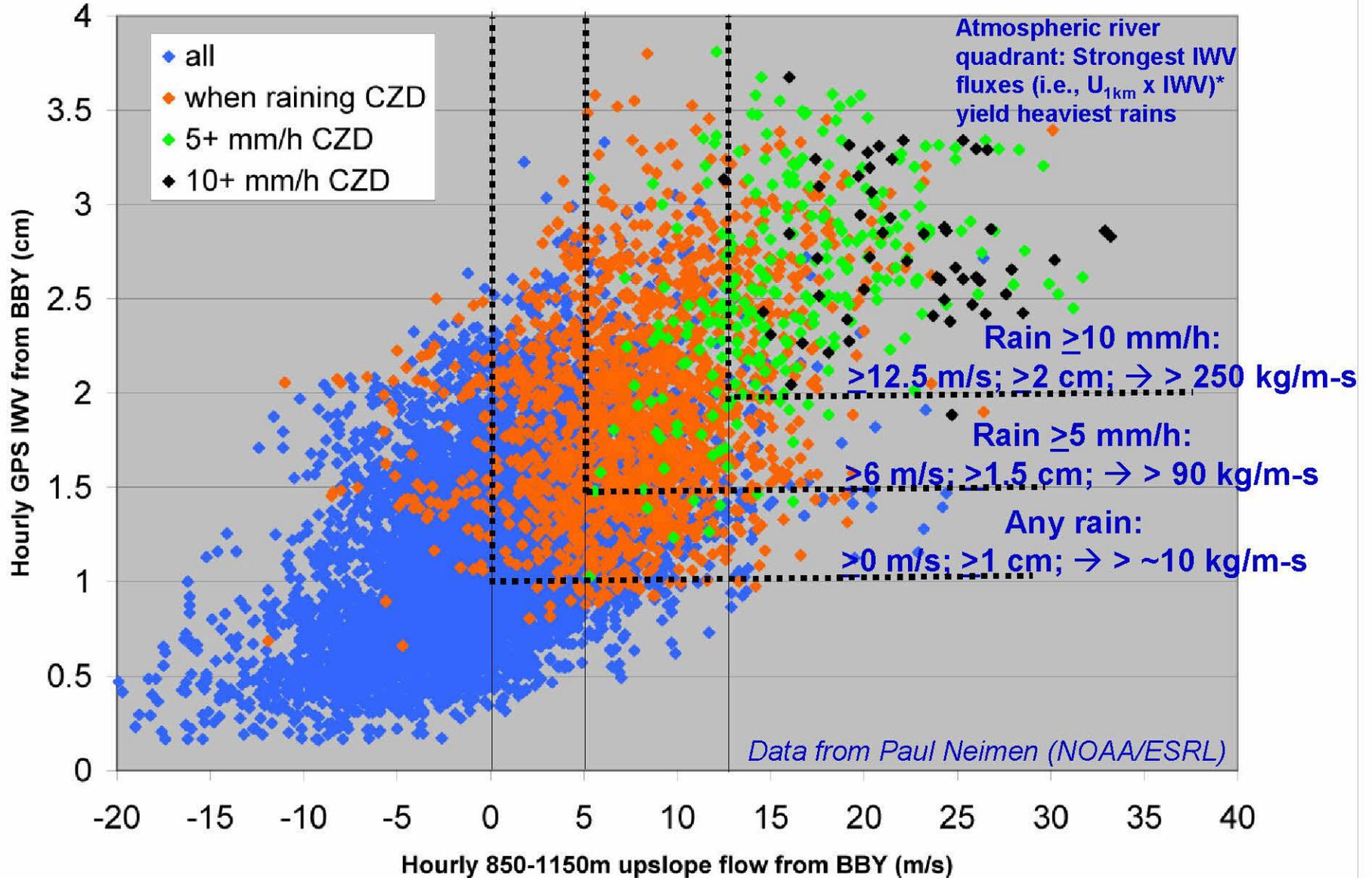
# Land-Falling Atmospheric Rivers

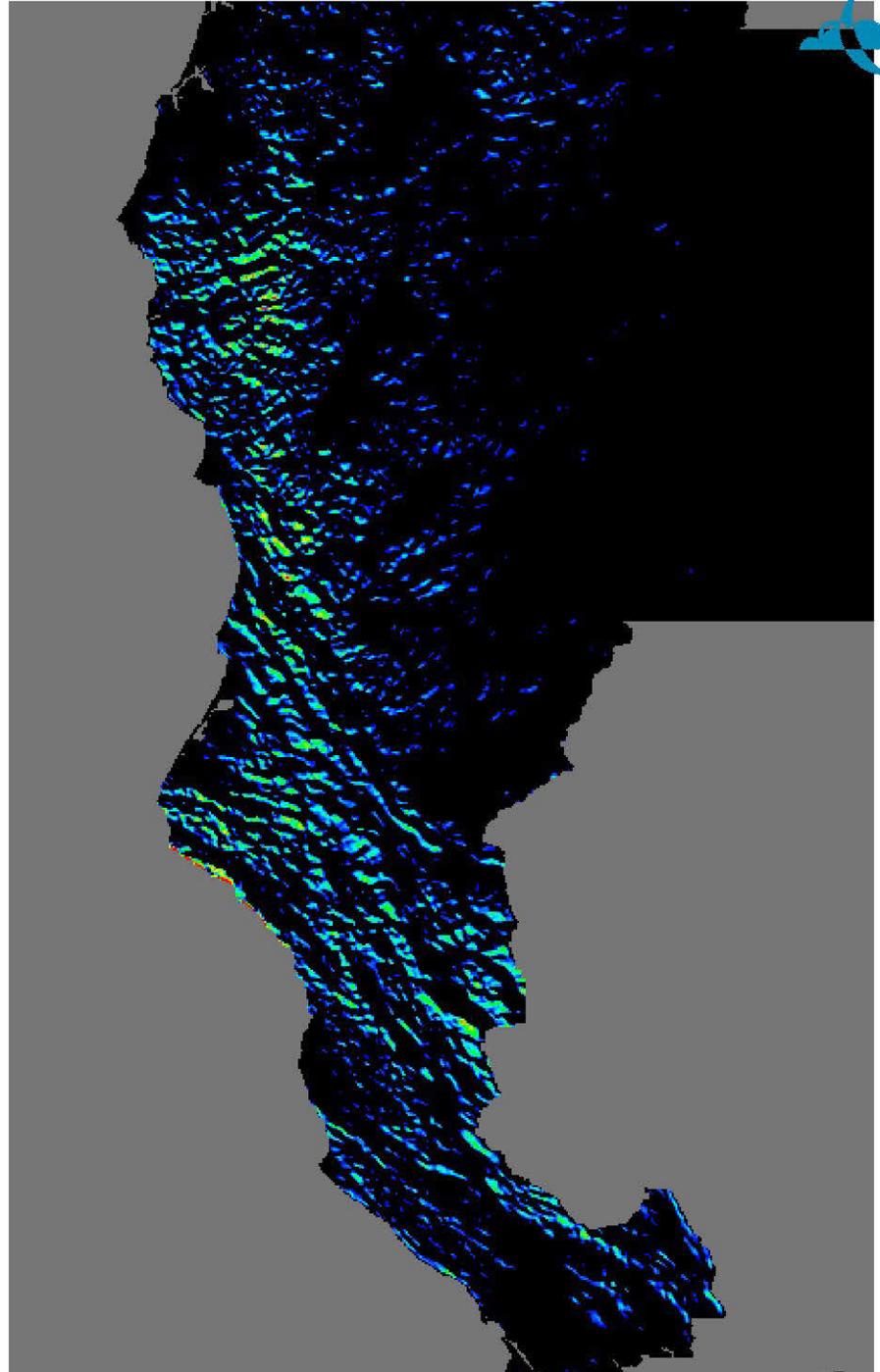
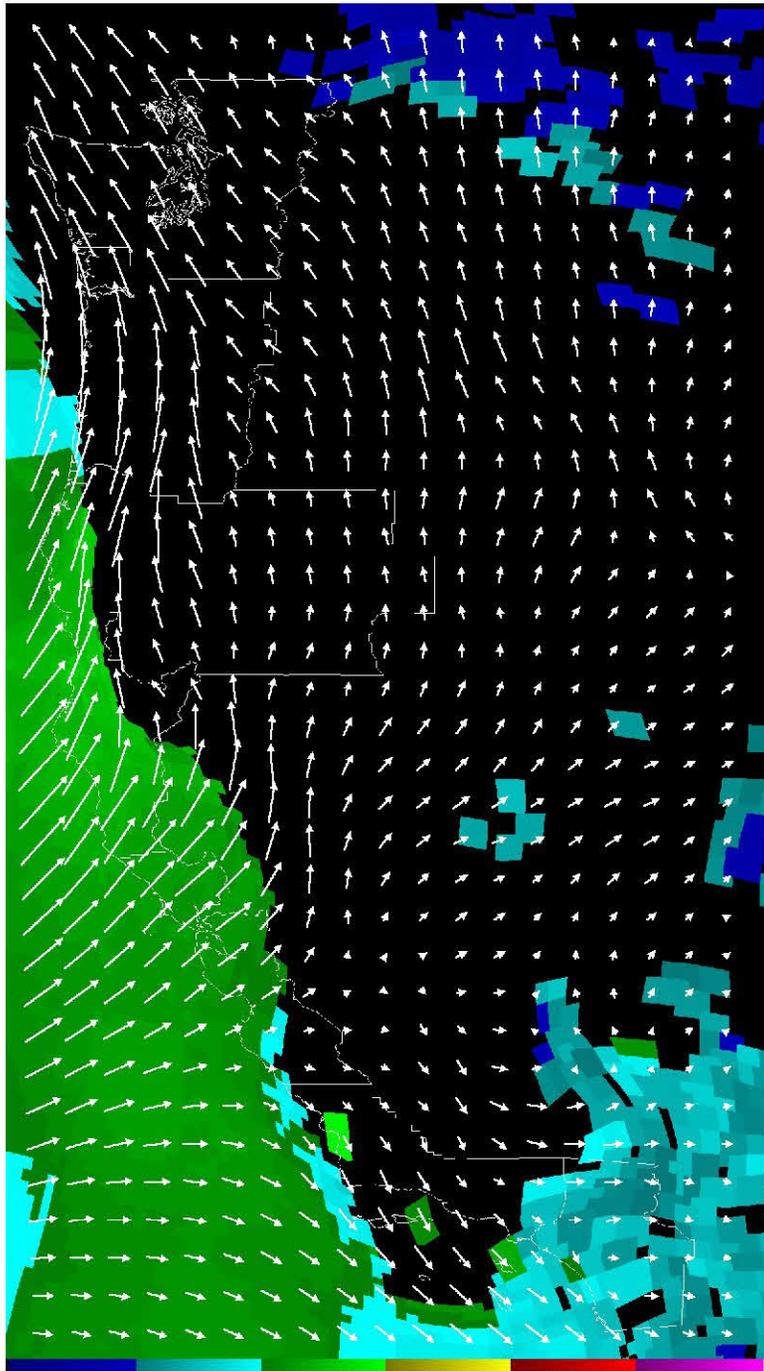


→ Significant wintertime concern for Pacific coastal ranges in terms of flooding and debris flows (e.g., American River basin, burn scar areas).



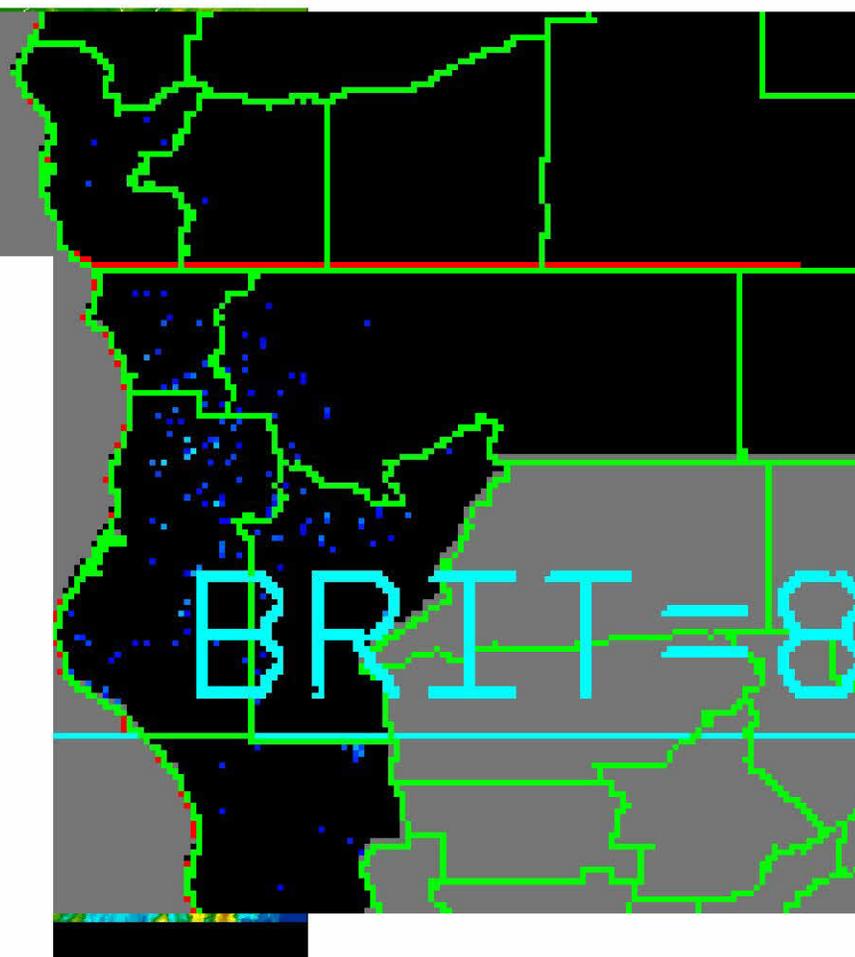
# TPW “Upslope Flow”







# Operational Usage of ORI



ZCZC NFDSPENES ALL  
SPENES  
CAZ000-ORZ000-

.  
SATELLITE PRECIPITATION ESTIMATES...DATE/TIME 02/15/09 0152Z  
SATELLITE ANALYSIS BRANCH/NESDIS---NPPU---TEL.301-763-8678  
LATEST DATA USED: GOES-11 0145Z KUSSELSON  
NOAA AMSU:2111Z/2350Z NASA AMSR-E:2135Z

.  
LOCATION...N CALIFORNIA...SW OREGON...

.  
ATTN WFOS...MFR...STO...MTR...EKA...  
ATTN RFCS...NWRFC...CNRFC...

.  
EVENT...OCCLUSION LIFTING NNE AND BEST MOISTURE ADVECTION HEADING  
TOWARD  
N CA AND SW OREGON...

.  
SATELLITE ANALYSIS AND TRENDS...SURFACE AND UPPER LOW SETTLING INTO  
40N/131W WITH OCCLUSION LIFTING NNE THE PAST FEW HRS OFFSHORE OR-CA  
BORDER COAST NEAR 41N/127.5W. ENERGY COMING AROUND LOW AND APPROACHING  
130W WILL HELP FURTHER DEVELOP A WAVE ON FRONT JUST SOUTH OF OCCLUSION  
TO ALLOW FOR SURGE OF MOISTURE AND PRECIP INTO NORTHERN CA SOUTH OF  
CAPE MENDOCINO. BUT FOR FIRST HALF OF THE NIGHT WARM OCCLUSION WILL BE  
AFFECTING AREA FROM FAR N MENDOCINO TO TEHAMA NORTH TO OREGON BORDER  
AND  
BEGINNING TO SEEP MORE INTO SW OREGON AS OCCLUSION LIFTS SLOWLY NORTH.  
EXPERIMENTAL OROGRAPHIC PRECIP INDEX SHOWING BEST MOISTURE TRANSPORT  
WITH OROGRAPHICS INTO HUMBOLDT COUNTY THRU 03Z WHICH COULD INCLUDE FAR  
N CENTRAL AND NW CA COUNTIES IN THE 03-06Z TIME PERIOD...AT SAME TIME  
FRONTAL BOUNDARY WITH NARROW MOIST PLUME CONTINUES SHIFTING EAST TO  
REST OF THE NORTHERN CA COAST. OVERLAYING 85H/70H WIND FLOW ON COMMA  
SHAPED ATMOSPHERIC RIVER MOISTURE PLUME SHOWS MOISTURE TRANSPORT/  
MOISTURE FLUX IMPROVING AND AIMED AT FAR N CA/EX SW OREGON NEXT FEW  
HRS...AND WILL LIKELY CONTINUE VERY GOOD THRU MOISTURE PLUME WITH FRONT  
AS IT APPROACHES REST OF N CA THIS EVENING AND TONIGHT.  
WILL CONTINUE TO MONITOR...ANALYSIS GRAPHIC ON HOME PAGE AT ADDRESS  
BELOW....



# An Orographic Rain Index (ORI)

- Uses the following data:
  - Multi-sensor blended Total Precipitable Water (TPW) product (Stan Kidder's satellite application)
  - GFS forecast fields (850 mb "steering" wind vectors)
  - 30-second resolution terrain database
- Procedure:
  - For a given forecast time, obtain the most recent TPW analysis
  - Using GFS data, trace back from each land pixel to the TPW analysis time to determine the value of land-falling TPW at the forecast time.
  - Compute the local gradient of the terrain, and determine the normal component of the GFS wind vector to this gradient (via the dot product)
  - Multiply the land-falling TPW by the quantity derived above
  - Calibrate the result using Paul Neiman's surface data (previous slide)
  - Create a graphic with colors corresponding to potential rain enhancement
  - Deliver graphics to WFO on AWIPS, via the Satellite Proving Ground project

(SMEs: Stan Kidder, Steve Miller)<sup>44</sup>