



# Atmospheric Rivers Rivers in the Sky

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Blue Waters Users Symposium  
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## BLUE WATERS

NCAR is sponsored by the National Science Foundation



# Model Simulations

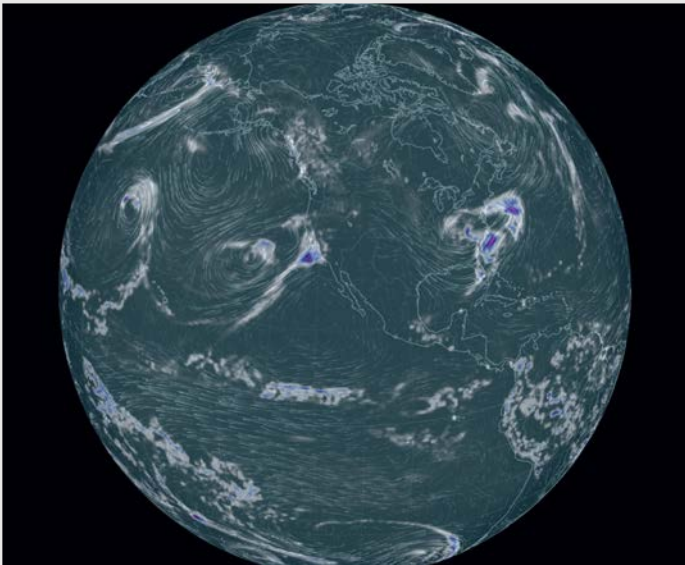
## Progress on Blue Waters

- **0.25°atmos/land –only** (30 years)
  - 0.36M node-hours for one simulation – total **~4.3M**
  - 4 present day
  - 8 future scenarios (RCP8.5)
- **Fully-coupled 0.5° atmos/land - 1° ocn/ice**
  - 1 Pre-industrial control
  - 3 20<sup>th</sup> Century
  - 3 future RCP2.6
  - 3 future RCP4.5
  - 3 future RCP6.0
  - 3 future RCP8.5
- **Fully-coupled 0.25° atmos/land - 1° ocn/ice**
  - 1-1.8M node-hours for one simulation – total **~17M**
  - 1 Pre-industrial control
  - 2 climate sensitivity
  - 3 20<sup>th</sup> Century
  - 3 future RCP2.6
  - 3 future RCP8.5 } **complete within 2-3 months**
- **Fully-coupled 0.25° atmos/land – 0.1° ocn/ice**
  - 3.23M node hours for one simulation – total **~13M**
  - 1 Pre-industrial control
  - 1 20<sup>th</sup> Century
  - 1 future RCP8.5

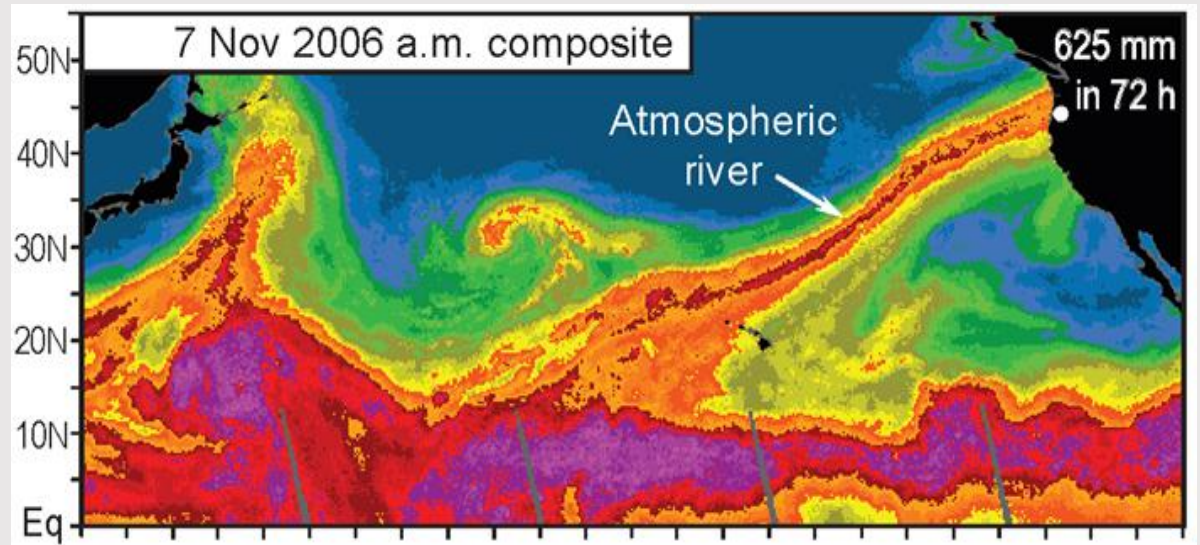
node-hours

# What is an Atmospheric River?

## Observations



EarthWind map, 3-hr precip overlaid on 850mb winds



Ralph et al. 2011 (NOAA HMT program)

20 times as much water as the Mississippi River.

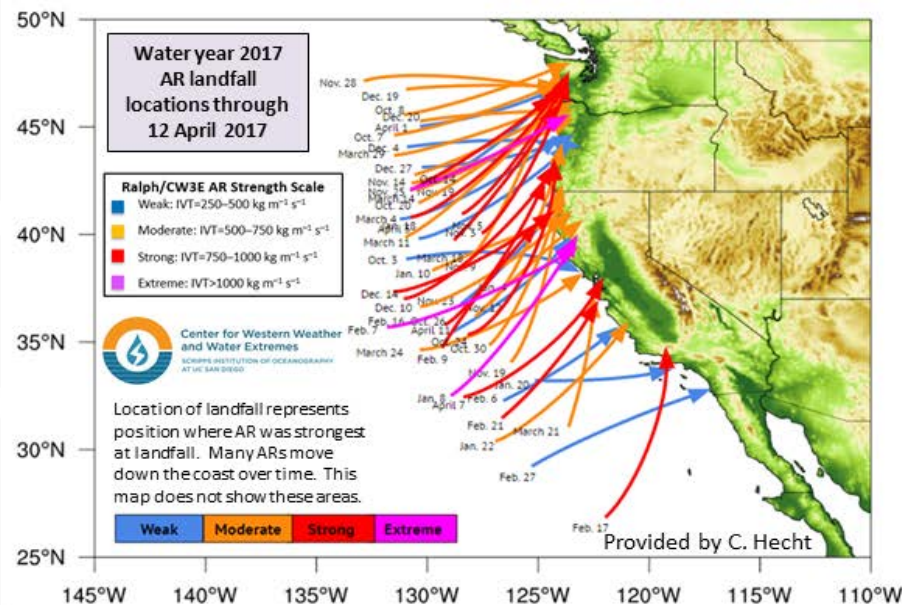
# The Record Breaking Water Year 2017

A major contributor to the anomalous precipitation over California has been the numerous landfalls of atmospheric rivers over the U.S. West Coast

49 Atmospheric Rivers have made landfall over the West Coast thus far during the 2017 water year (1 Oct. – 12 April 2017), which is much greater than normal

Of the 49 total atmospheric rivers that made landfall this year, 1/3 have been “strong” or “extreme” based on the AR strength scale.

AR Strength	AR Count*
Weak	12
Moderate	21
Strong	13
Extreme	3



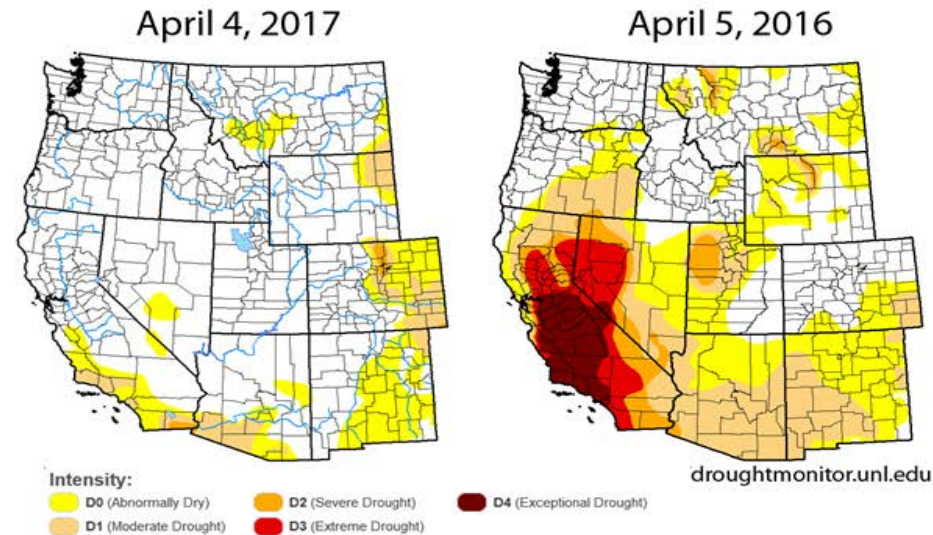
Center for Western Weather  
and Water Extremes

SCRIPPS INSTITUTION OF OCEANOGRAPHY  
AT UC SAN DIEGO

By F.M. Ralph, D. Pierce, C. Hecht, M. Dettinger, D. Cayan

*Experimental*

# The Record Breaking Water Year 2017



**The high levels of precipitation during the current water year have led to a significant reduction in the region's drought**

**One year ago much of California was in exceptional drought (brown areas). As of early April 2017, this has mostly ameliorated, with only residual pockets of moderate drought in the southern coastal region between Santa Barbara and Orange counties, and in Imperial county**

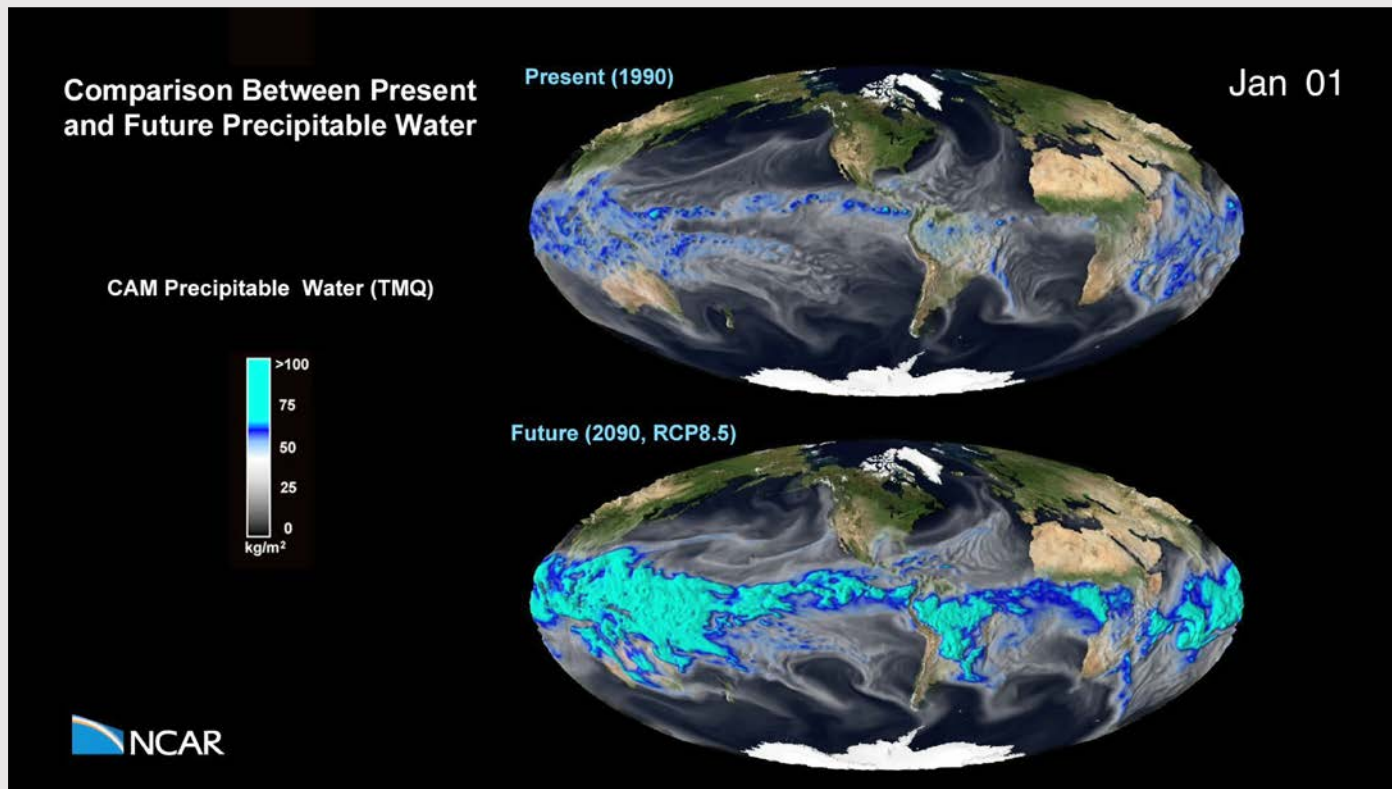


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# What is an Atmospheric River?

## CESM Representation



# Atmospheric River Definition

Relative threshold technique (Zhu and Newell (1998 *Mon. Wea. Review*))

$$|Q_{\text{threshold}}| \geq |Q_{\text{mean}}| + 0.3 ( |Q_{\text{max}} - Q_{\text{mean}}| )$$

U.S. West Coast (35-52N)

Wind speed threshold = 10 m/s

Wind direction = from the southwest

United Kingdom (49-60N)

Wind speed threshold = 25 m/s

Wind direction = easterly component

Iberian Peninsula (35-49N)

Wind speed threshold = 15 m/s

Wind direction = easterly component

Q = total column

precipitable water

Mean = zonal mean

Max = zonal maximum

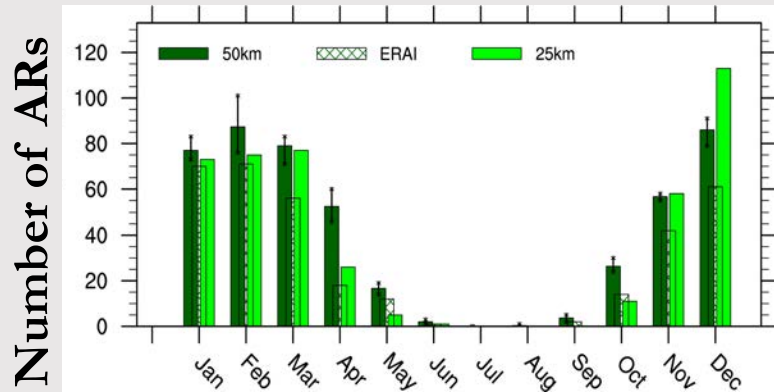
Shape thresholds

$dy/dx \geq 2$

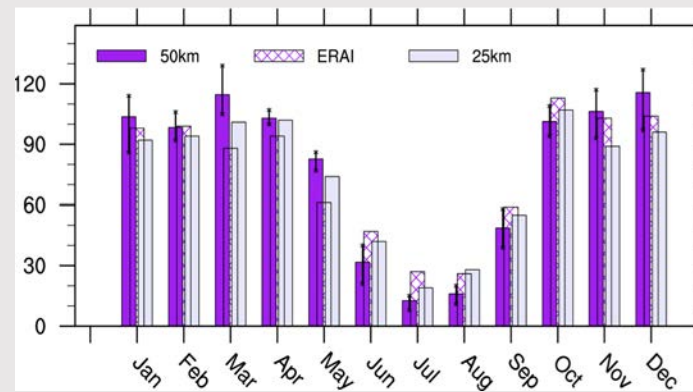
dy minimum = 200km

# Atmospheric River Climatology

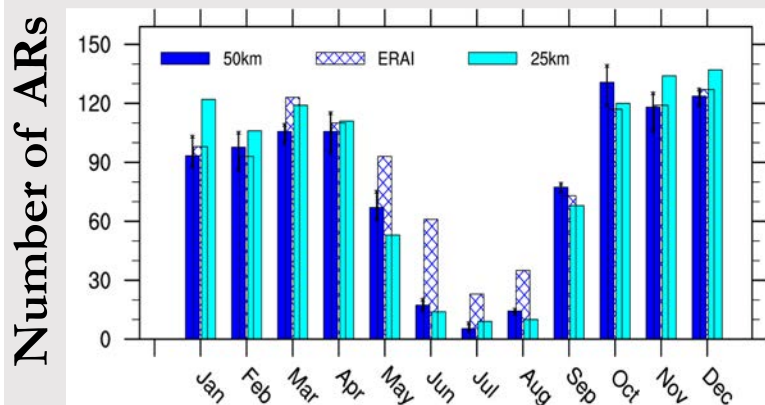
## California



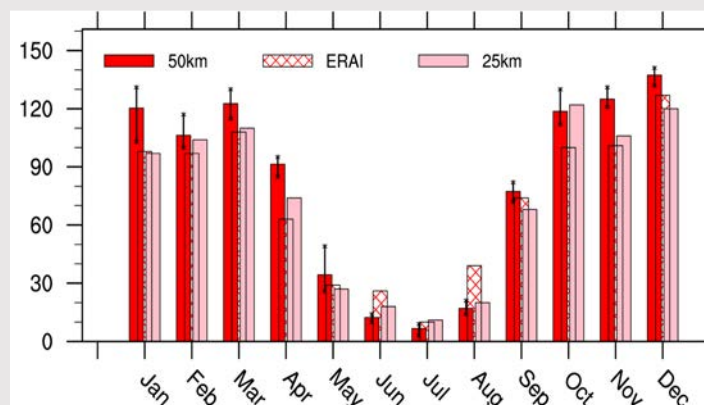
## Iberian Peninsula



## Pacific Northwest



## UK



One-degree ocean/sea-ice

- Half-degree atm/lnl
- Quarter-degree atm/lnl

Dark color = 50 km (half-deg)  
Coupled Ensemble Suite

Light color = 25 km (quarter-deg)  
Single Run

Hash-filled = ERA-I  
Reanalysis

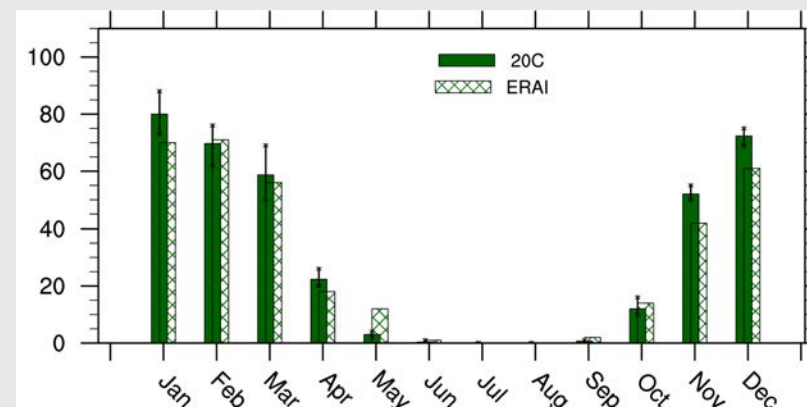
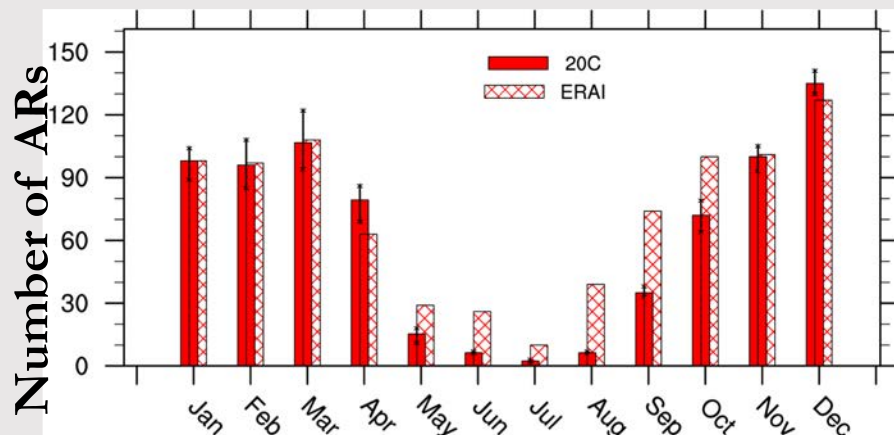
# Atmospheric River Future Change

Atmos/land only  
Quarter-degree

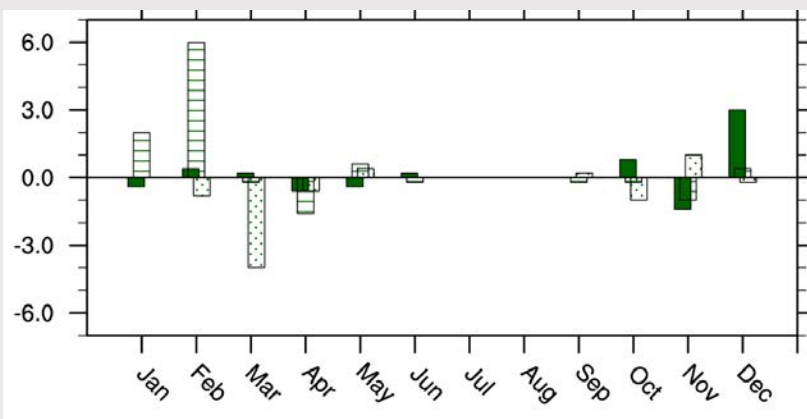
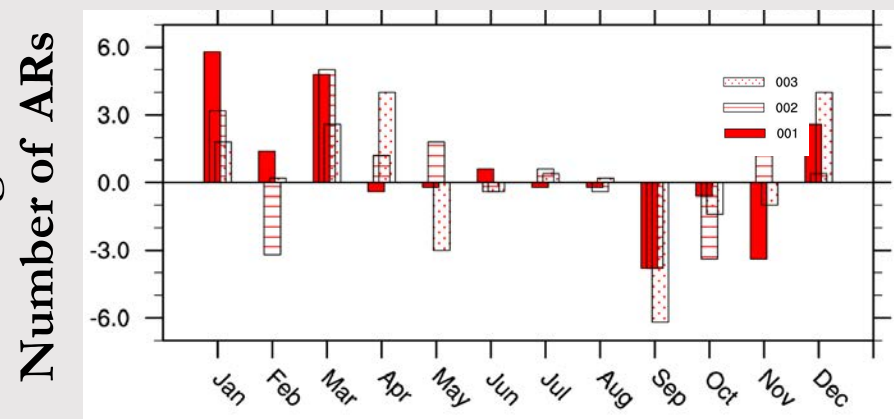
UK

CA

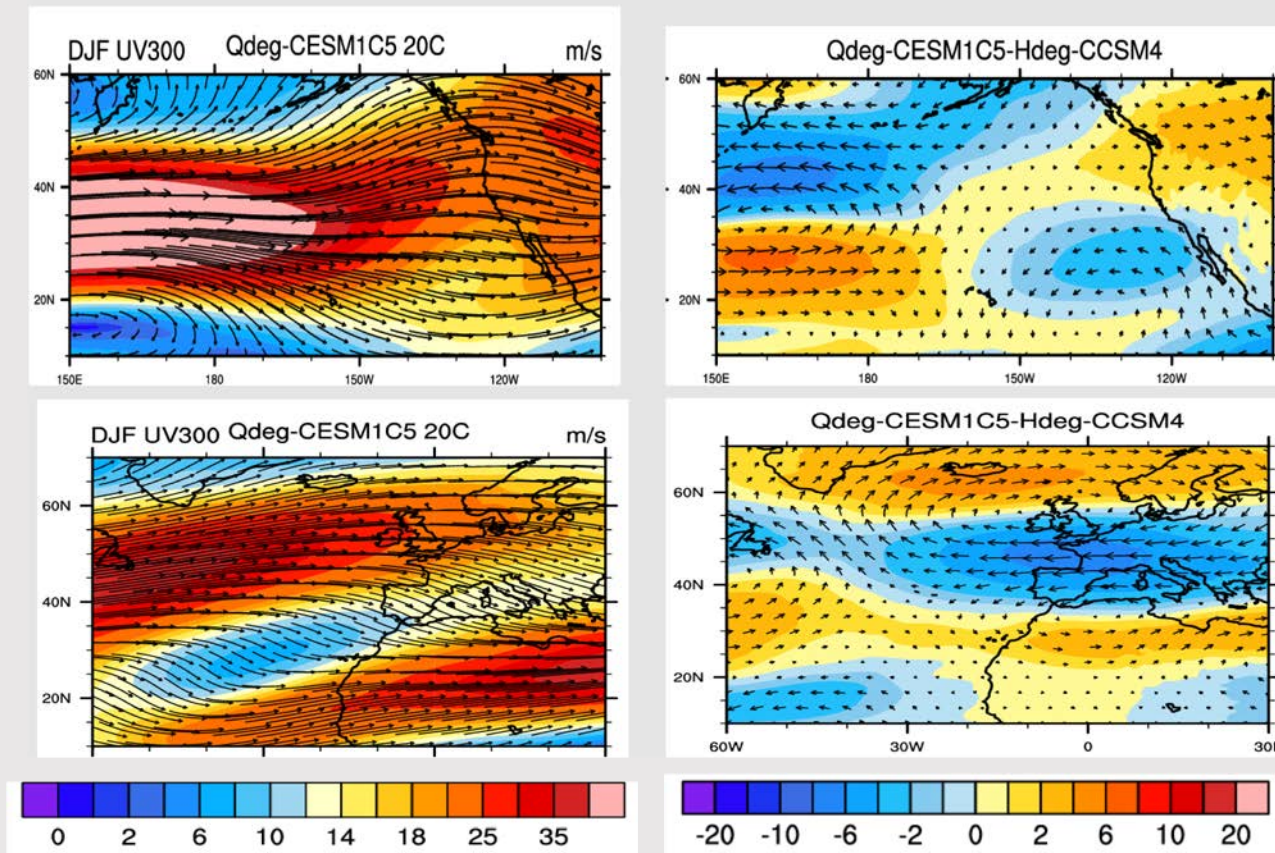
Climatological



Change in



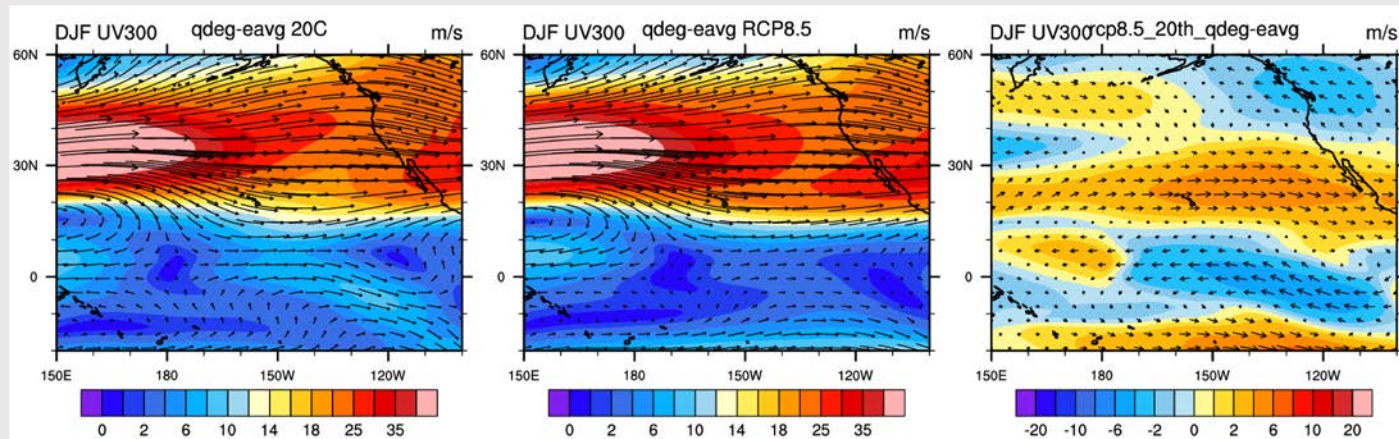
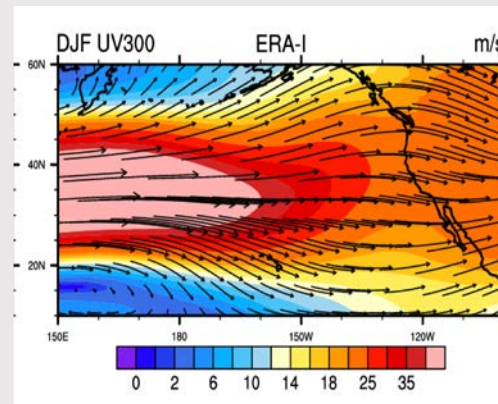
# Changes in Wind due to Resolution



# Future Jet Changes: East Pacific

Wind speed and Direction  
300mb  
DJF average

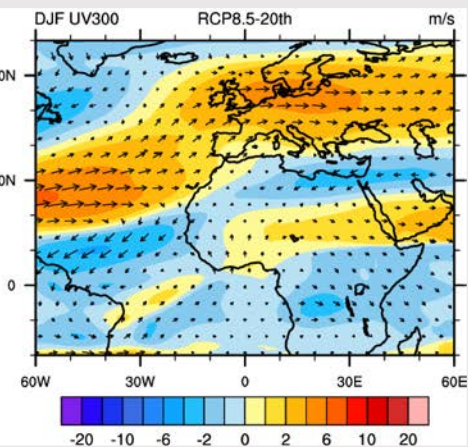
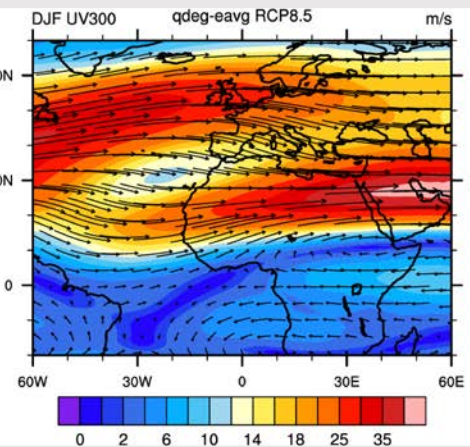
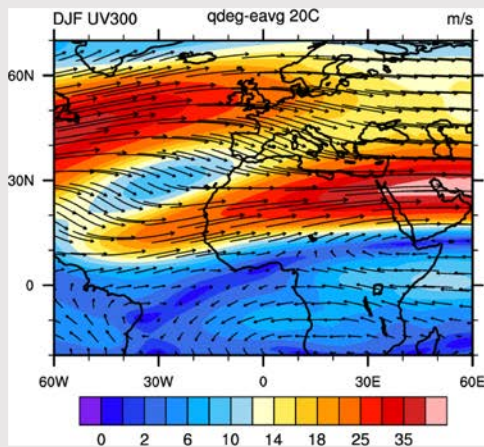
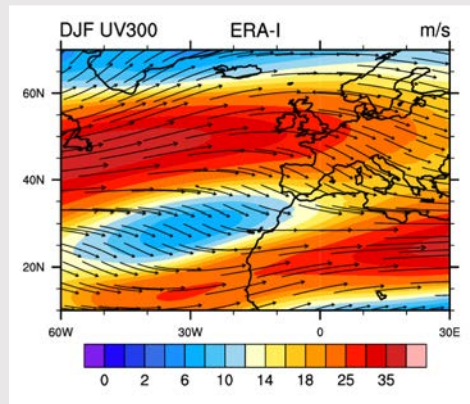
Atmos/land only  
Quarter-degree



# Future Jet Changes: East Atlantic

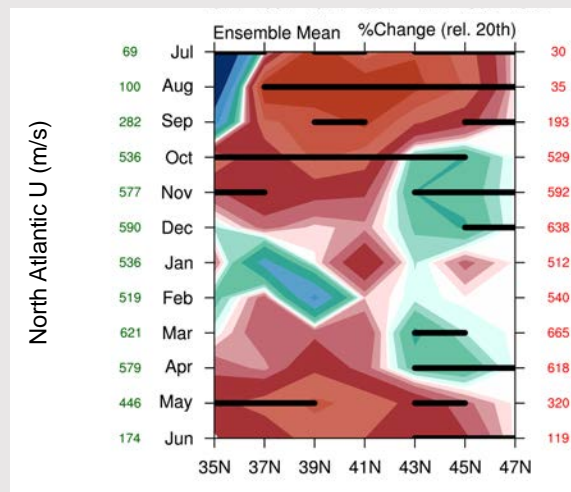
Wind speed and Direction  
300mb  
DJF average

Atmos/land only  
Quarter-degree

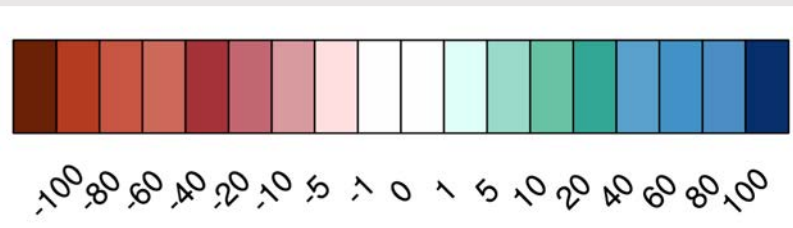
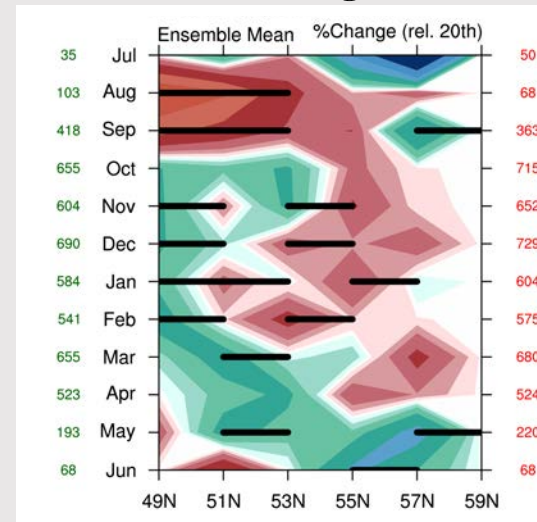


# Future AR Changes

North Atlantic  
Iberian Peninsula



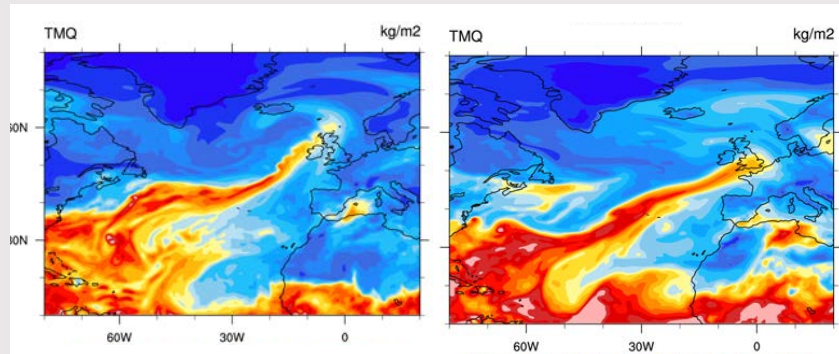
North Atlantic  
United Kingdom



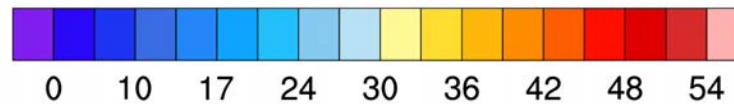
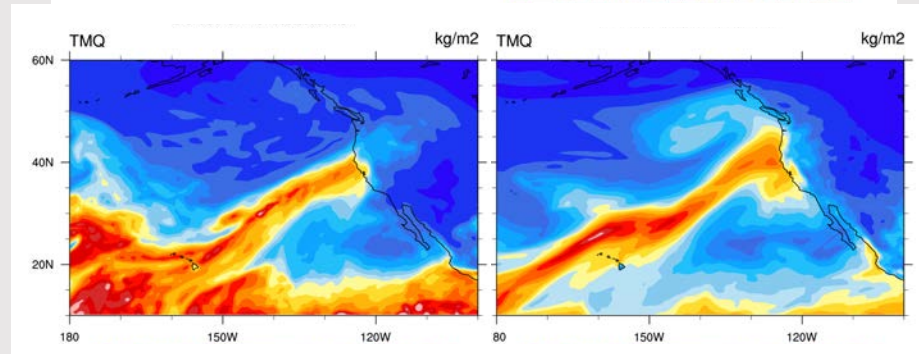
# Impact of tenth-degree Ocean

## Integrated Atmospheric Moisture

Atlantic Basin



Pacific Basin



kg/m<sup>2</sup>

# Summary

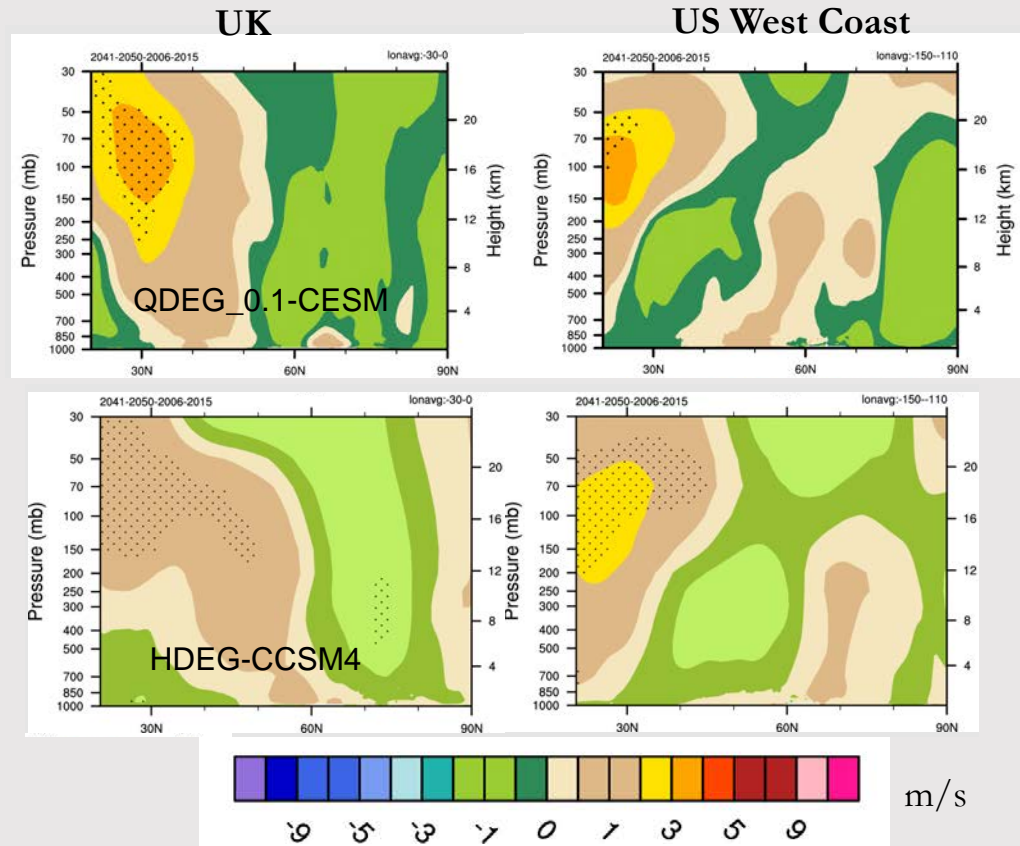
- AR location and strength has been tied to atmospheric jets
  - Those making landfall on the U.S. West Coast and Iberian Peninsula track the subtropical jet
  - Those making landfall in the U.K. track both the subtropical and eddy-driven jets
- Using a higher resolution atmosphere improves the representation and statistics of ARs
  - Due to improvements in position and strength of the atmospheric jets
- The largest changes in number of ARs occurs in their active season
- In DJF, the active season for ARs, we anticipate a decrease in landfalling ARs in the PNW and an increase in CA, the UK, and Iberian Peninsula due to changes in the atmospheric jets.

# Future Jet Changes: Resolution Impacts

Future (2041-2050) minus Present Day (1980-2005): DJF wind speed

Fully-coupled  
Quarter-degree atm/lnd  
Tenth-degree ocean/ice  
Single simulation

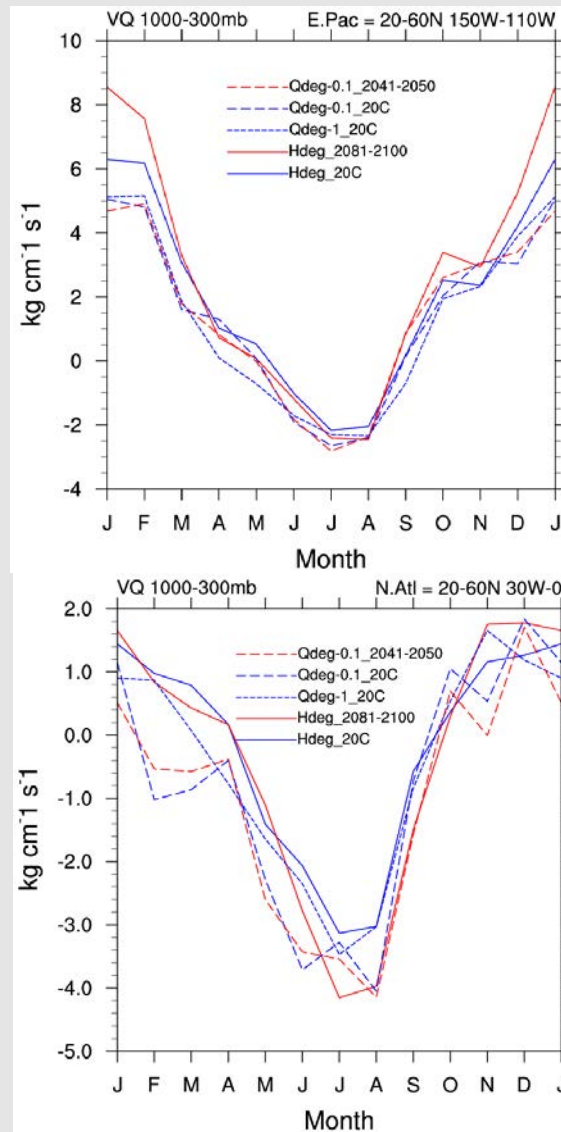
Fully-coupled  
Half-degree atm/lnd  
One-degree ocean/ice



Pacific Northwest:  
Decrease in wind speed  
Subtropics: Increase

UK/Iberian Peninsula:  
Only seeing increase of  
subtropical jet over the  
ocean

Structure of winds does  
not depend on  
resolution but the  
strength does.



## Meridional Water Transport

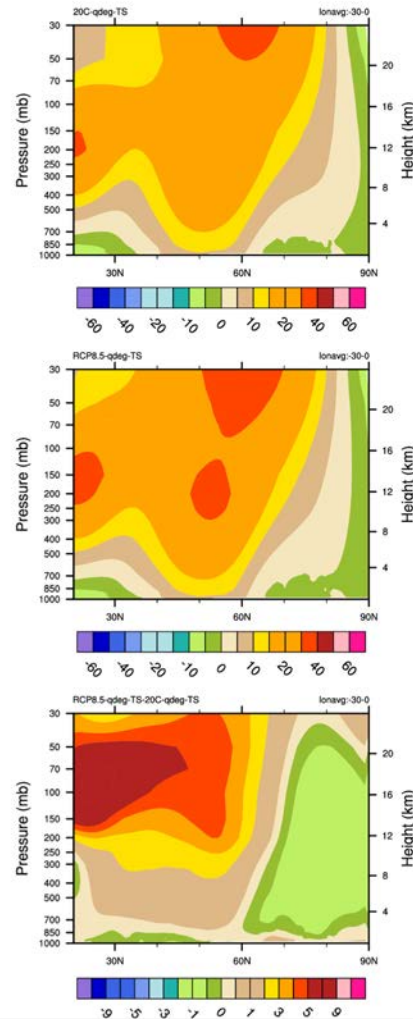
Column integrated meridional water transport appears to behave differently with an ultra high resolution ocean model (wide dashed lines, bottom left) for the North Atlantic during seasonal transition months. Heat transport (not shown) also exhibits this behavior. The presence of detailed ocean eddies and their impact on heat and water transports warrant further investigation.

Zonal wind is  
the driver for  
ARs tracking

Climate  
change for U  
area averaged  
over longs  
noted in title

Latitude x axis  
Height y axis

Qdeg-CAM5 DJF U m/s UK\_30W-0E



Qdeg-CAM5 DJF U m/s WestUS\_150W-110W

