# Unusual Atmospheric-River-like structures coming from Africa induce extreme precipitation over western Mediterranean Sea

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# BACKGROUND

Source: NOAA



g/cm<sup>4</sup>

### **Atmospheric rivers**

- Long (at least 2.000 km), shallow (1-2.5 km in height) and narrow (300-500 km in width) plumes with high water vapor contents.
- Transport of atmospheric water vapor from subtropics to the midlatitudes
- They are relevant in water supply in several regions and can lead to flooding or drought

## BACKGROUND

### On 16-18th December 2016 a devastating flood affected the Southeast of the Iberian Peninsula

Estimated economic losses overpassed 70 millions of euros

Location	Precip. (I/m²)
Beniarrés (Alicante	) 404
Pinet (Valencia)	329.2
Agres (Alicante)	286.6
Aeropuerto (Murcia	a) 227.2
Cartagena (Murcia)	) 221.2

Source:https://noticias.eltiempo.es/imagenes-lluvias-torrenciales-e-inu ndaciones-levante/ https://www.tiempo.com/ram/300272/episodio-de-precipitaciones-del-16al-19-de-diciembre-de-2016-en-la-region-de-murcia/



## BACKGROUND

### On 16-18th December 2016

Total precipitable water from NESDIS (National Environmental Satellite Data an Information Service) showed long filaments over the Mediterránean Sea.

#### ARE THESE METEOROLOGICAL PHENOMENON SIMILAR TO ATMOSPHERIC RIVERS?



# DATA

### ERA5

- ECMWF reanalysis
- Data available from 1979
- ~30 km spatial resolution
- Hourly temporal resolution
- Assessed variables:
  - Total column water vapor
  - Integrated water vapor
  - SLP, 850 hPa winds and Z500
  - Precipitation

### SPAIN02

- Gridded observational database
- Data available from 1951 to 2015
- ~10 km spatial resolution
- Daily precipitation
- Encompasses the peninsular Spain

# AR DETECTION

A longitudinal **cross-section over the Mediterranean Iberian coastline** is preselected and we track a long plume from a grid-point inland to along the Mediterranean based on:

- Relaxed requirements for **length and width**: 1000 km and 500km
- Absolute values for **IWV and IVT**: 15 mm and 200 kg/ms (85th percentile)
- Temporal requirement: at least 18 h of persistence
- **Strong IVTx** to guarantee eastern flux approaching to the IP

# IVT CHARACTERISTICS

With this approach, **163 Med-ARs objects** were found (structures following the requirements) corresponding to **43 Med-AR events** (Med-AR objects persisting 18h at least)



IVT is higher over the western Mediterranean Sea overpassing 300 kg/ms which is 100 kg/ms higher than the mean.

During these events, there are also **positive anomalies of IVT** over northern Africa (Algeria, Lybia and Tunisia).

Lorente-Plazas et al., 2020

# SYNOPTIC AND MESO-SCALE CHARACTERISTICS

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The **SLP increases over north-east Europe**, with anomalies larger than 4 hPa.

These changes in SLP promote the increase of **easterly winds** reaching the eastern Iberia.

Med-AR events are characterized by **a trough over eastern Iberia** injecting warm air with a cutoff cyclone with a cold core over Algeria coast.

#### Larger geopotential heights over

**northern Europe** with positive anomalies overpassing 60 m and less intense negative anomalies over Algeria. Lorente-Plazas et al., 2020

# HYDROLOGICAL IMPACTS



Larger values of precipitation (<25 mm/day) and **positive anomalies over eastern IP** during the Med-AR's events.

Extreme precipitation induced by complex orographic features.

Lorente-Plazas et al., 2020

# HYDROLOGICAL IMPACTS

- MED-AR are **more frequent in the transitional seasons** with a peak in October, meanwhile they are scarce in summer
- There is not evidence of more IVT more precipitation or larger area affected
- Correlation with precipitation increases (up to 0.9) when IVT component perpendicular to the topography (IVTx)



## SCHEMATIC SUMMARY OF AR vs MED-AR



Lorente-Plazas et al., 2020

## CONCLUSIONS

- AR-like structures over the western Mediterranean **are scarce**, with a frequency close to a one per year. Med-ARs **can induce precipitation larger than 400 mm** which is more than 40% of the annual precipitation in some of the affected locations.
- These events are related to extreme precipitation enhanced by the orographic features over the Iberian Mediterranean coastline. The direction of these plumes when hitting the coastline could be more relevant than the intensity of the IVT to produce high precipitations.
- Med-ARs are associated to **a trough over Iberia with colder air mass** over northwestern Africa and warmer air mass over northern Europe. SLP pattern induces an increase of easterly winds over the western Mediterranean and, favours the penetration of a warmer from Africa to the Mediterranean Sea through Libya.
- Although Med-ARs and standard ARs share some geometric and meteorological features there are some differences that show that **they may be a different phenomenon**.

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