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Relationship between atmospheric rivers and aerosol atmospheric rivers in the Iberian Peninsula

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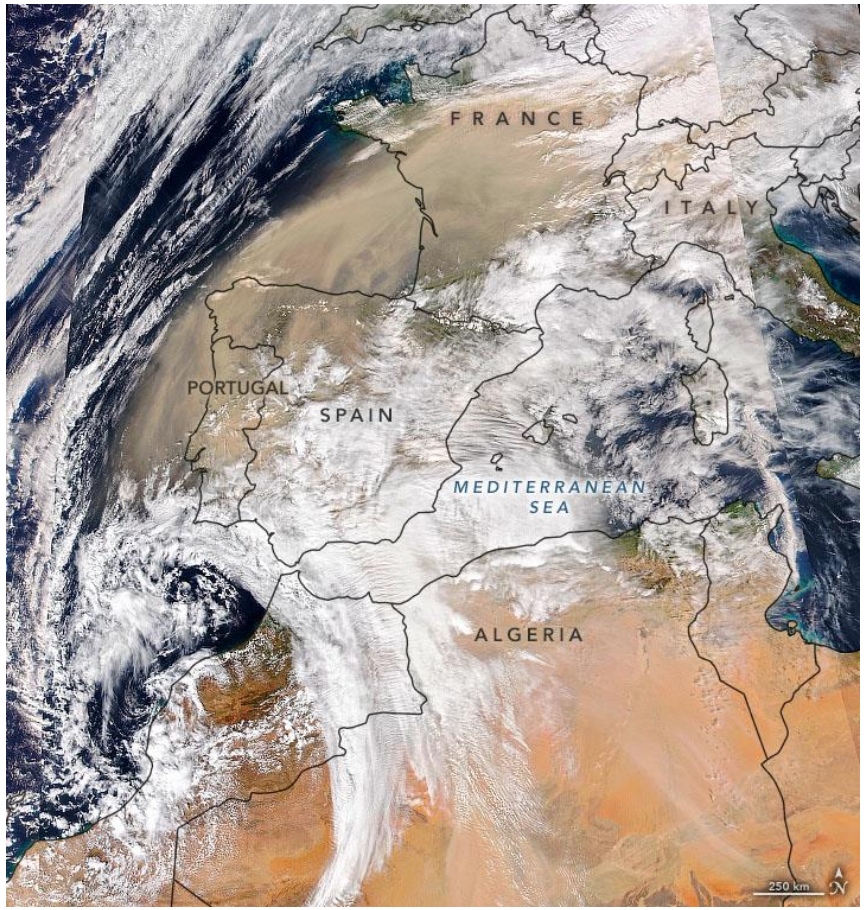
Motivation

- Recently, the water vapour atmospheric river (AR) concept was applied to aerosols
- **Aerosol Atmospheric Rivers (AARs) ->** long, narrow, and transient regions of intense aerosol mass transport
- The Iberian Peninsula is regularly affected by ARs, but there is a lack of regional studies on the impact of AARs
- Aerosols play a significant role in the climate system
- **Goal:** characterise the AARs that affect the Iberian Peninsula and better understand their relationship with ARs



AR carrying Saharan dust on 15 March 2022
(Credit: NASA, NOAA-20 - VIIRS)

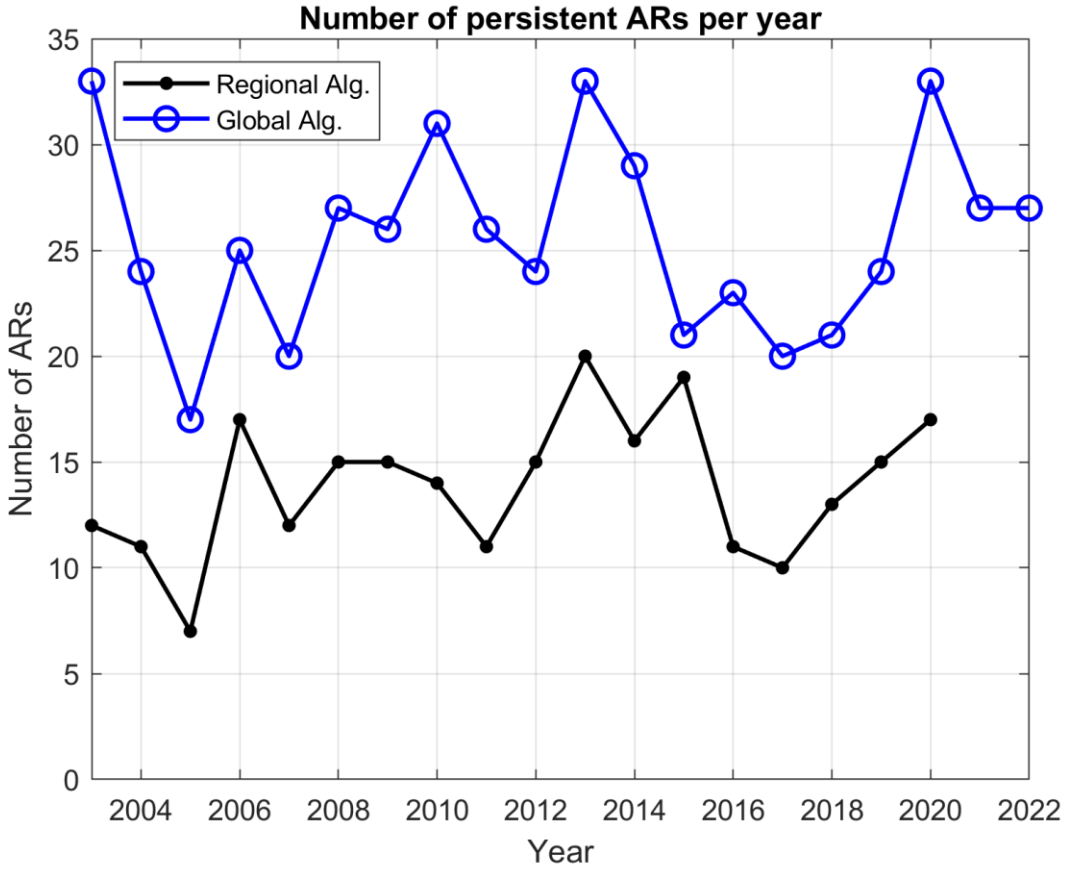
AR Identification

- **Data:** Integrated water Vapor Transport (IVT) from MERRA-2 reanalysis
- **Time Period:** 2003-2022
- **Algorithm:** Guan & Waliser (2015) -> global algorithm
- **Algorithm Criteria:**
  - 85th percentile at each grid cell and for each month (based on 3-month window)
  - fixed IVT lower limit of 100 kg m^{-1} s^{-1}
  - minimum poleward transport of 50 kg m^{-1} s^{-1}
  - coherence in IVT direction and consistency between object mean IVT direction and overall orientation (45º)
  - length > 2000 km
  - length/width ratio > 2

AAR Identification

- **Data:** Integrated Aerosol Transport (IAT) from MERRA-2 reanalysis
- **Time Period:** 2003-2022
- **Algorithm:** Guan & Waliser (2015), modified by Chakraborty et al. (2021, 2022)
- **Algorithm Criteria:**
  - 85th percentile at each grid cell and for each month (based on 3-month window)
  - ~~fixed IVT lower limit of 100 kg m^{-1} s^{-1}~~
  - ~~minimum poleward transport of 50 kg m^{-1} s^{-1}~~
  - coherence in IAT direction and consistency between object mean IAT direction and overall orientation (45º)
  - length > 2000 km
  - length/width ratio > 2
- **Aerosol Types:** dust (DU), sea salt (SS), sulphate (SU), organic carbon (OC), and black carbon (BC)

Global vs Regional Algorithm



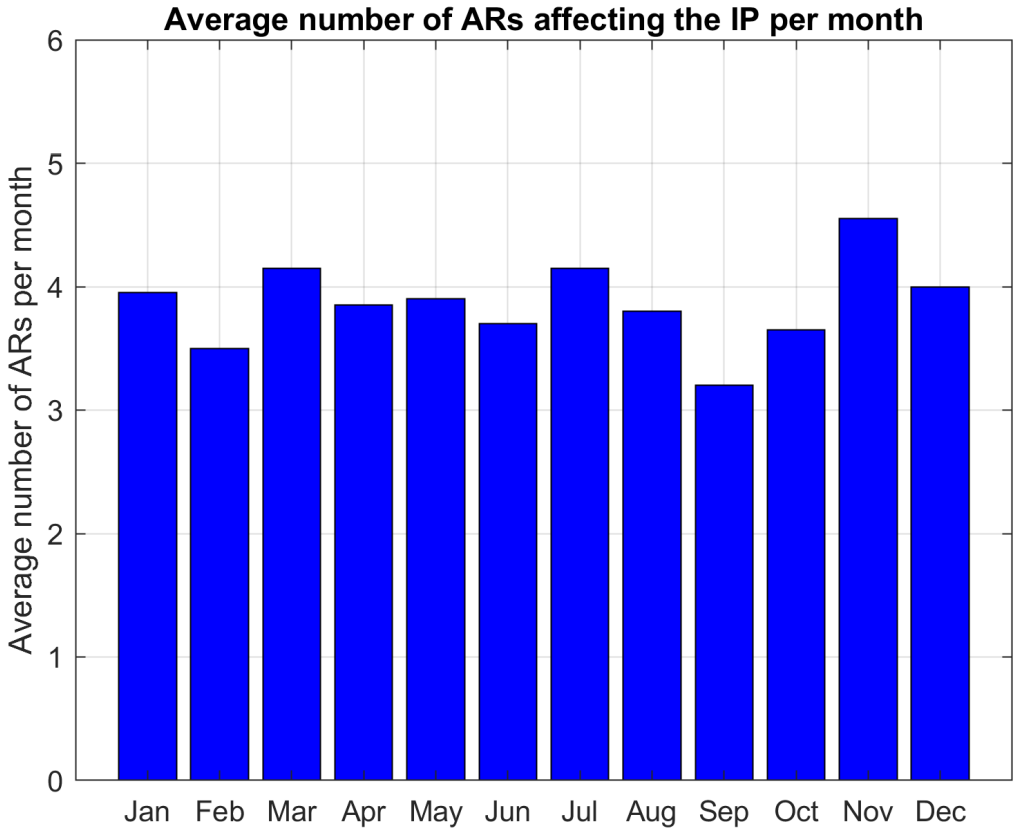
- Comparison with an algorithm developed specifically to the Iberian Peninsula (originally published by Ramos et al. (2015))
- Regional algorithm applied to ERA5

- **Mean IVT of global alg.:** 362.2 kg m^{-1} s^{-1}
- **Threshold of regional alg.:** 418 kg m^{-1} s^{-1}

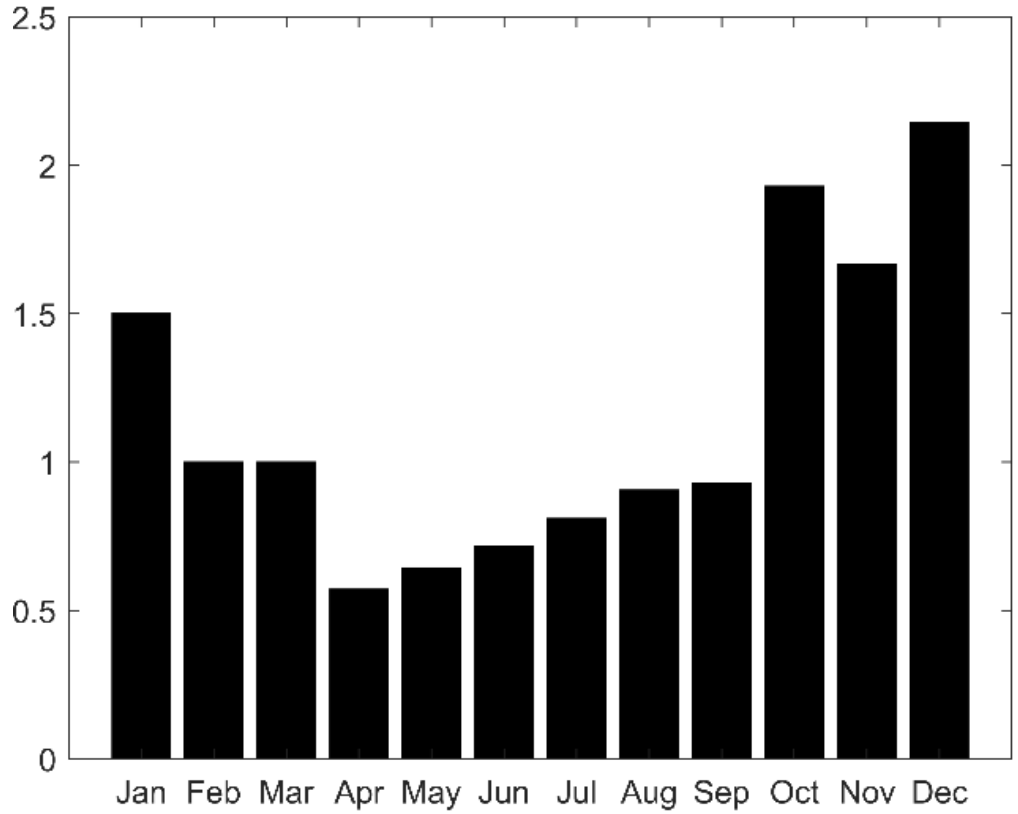
- Global algorithm is more permissive

Global vs Regional Algorithm

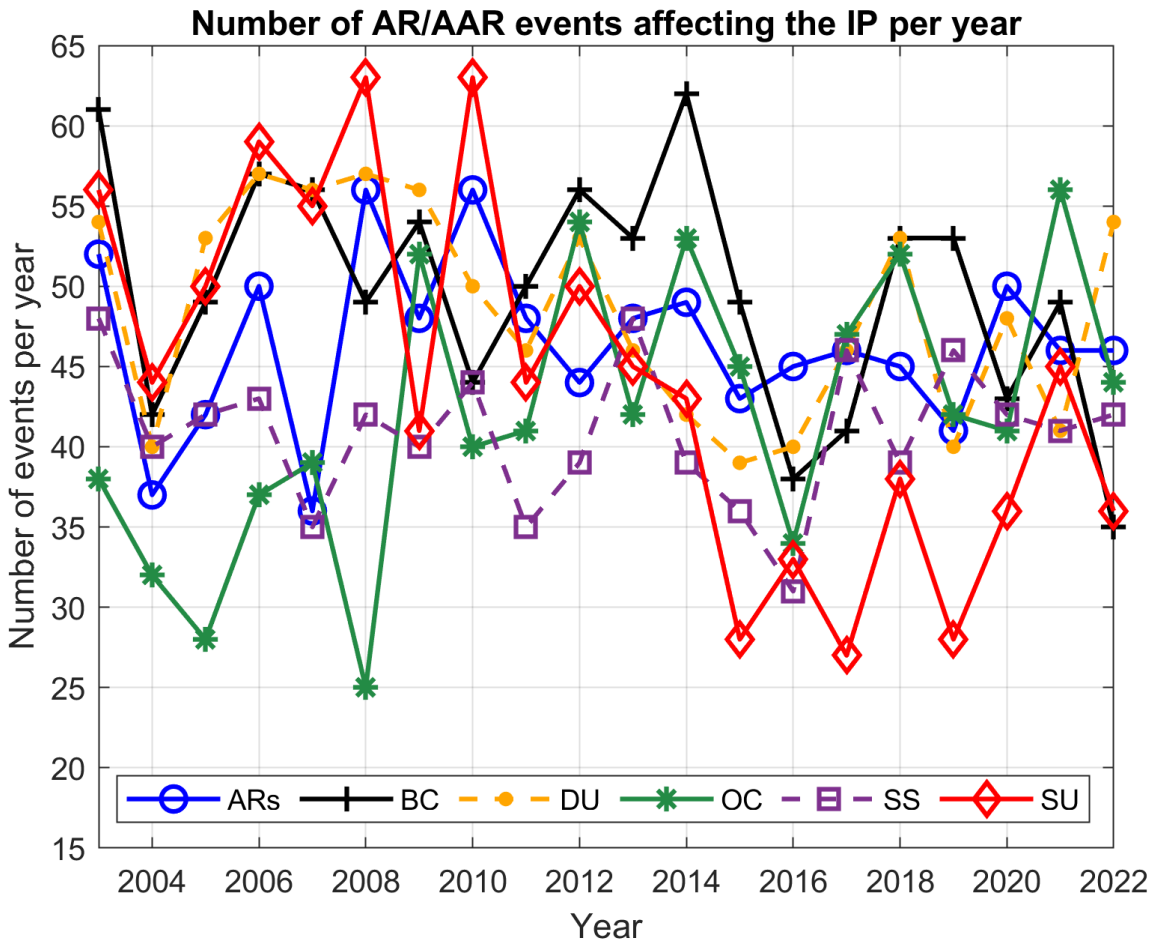
Global



Regional



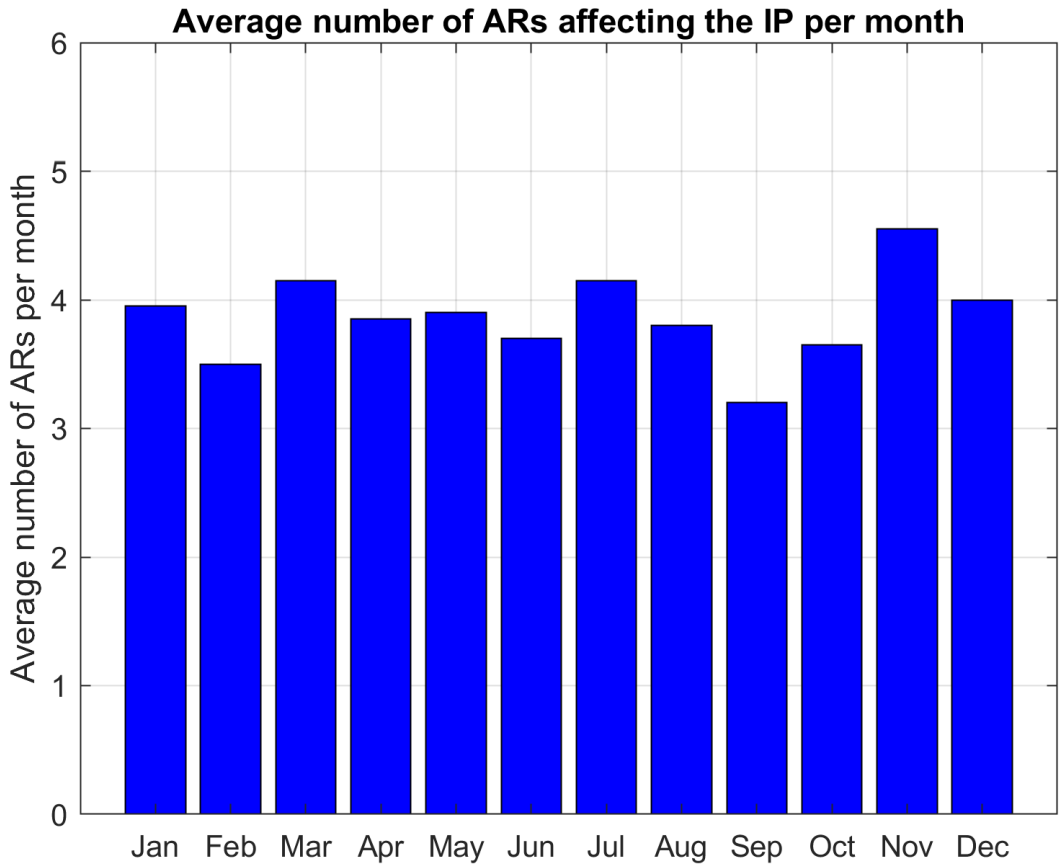
Aerosol Atmospheric Rivers



- **Average per year:**
- **(water vapour) ARs:** 46.4 per year
- **Black Carbon (BC):** 49.7 per year
- **Dust (DU):** 48.6 per year
- **Organic Carbon (OC):** 42.1 per year
- **Sea Salt (SS):** 40.9 per year
- **Sulphate (SU):** 44.2 per year

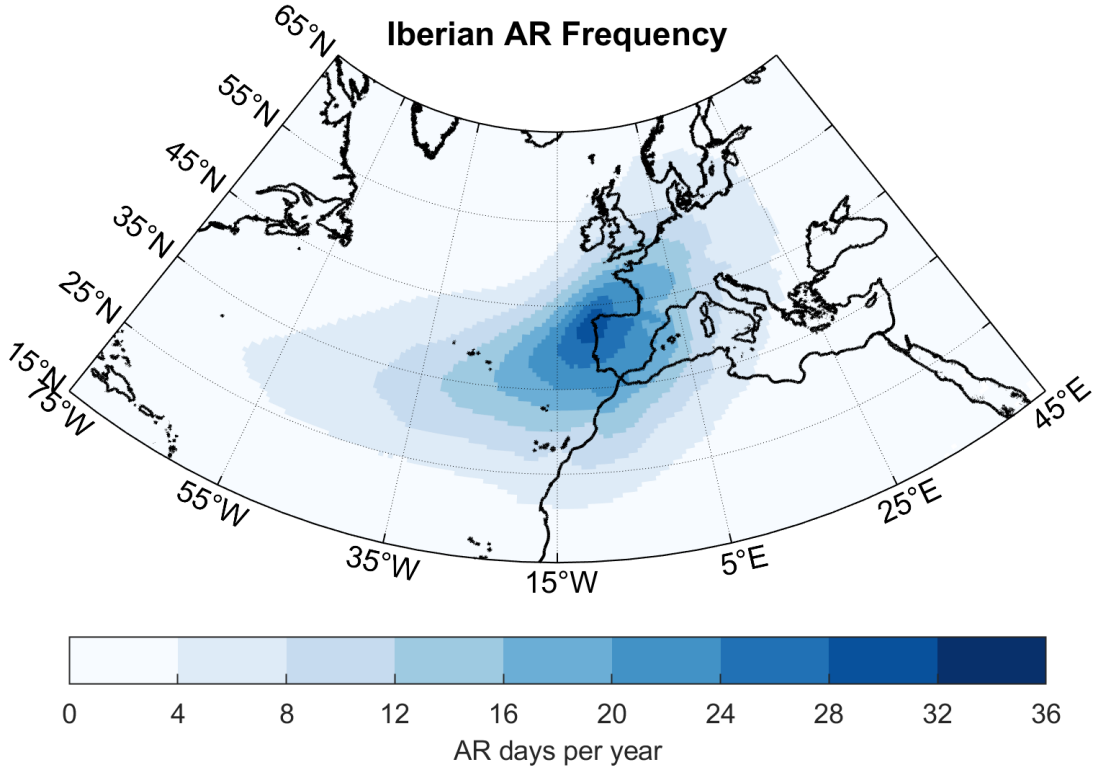
- Two ARs/AARs were considered distinct events only if they were separated by more than 1 day

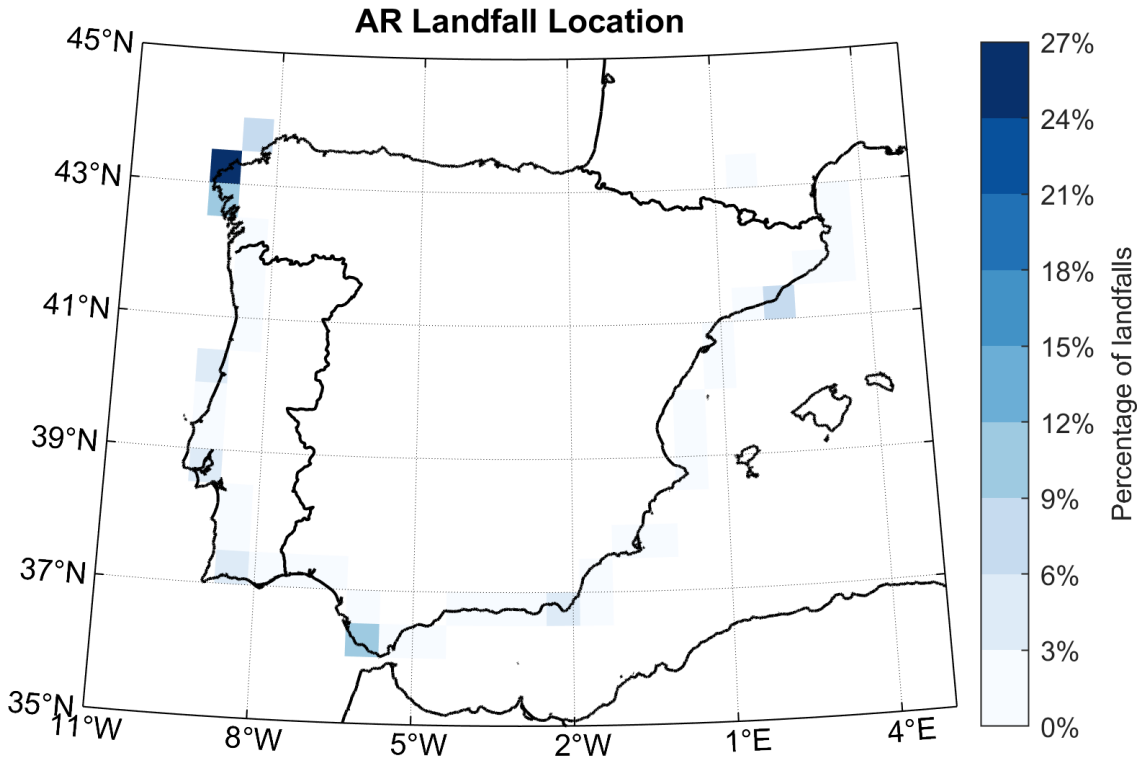
Iberian ARs



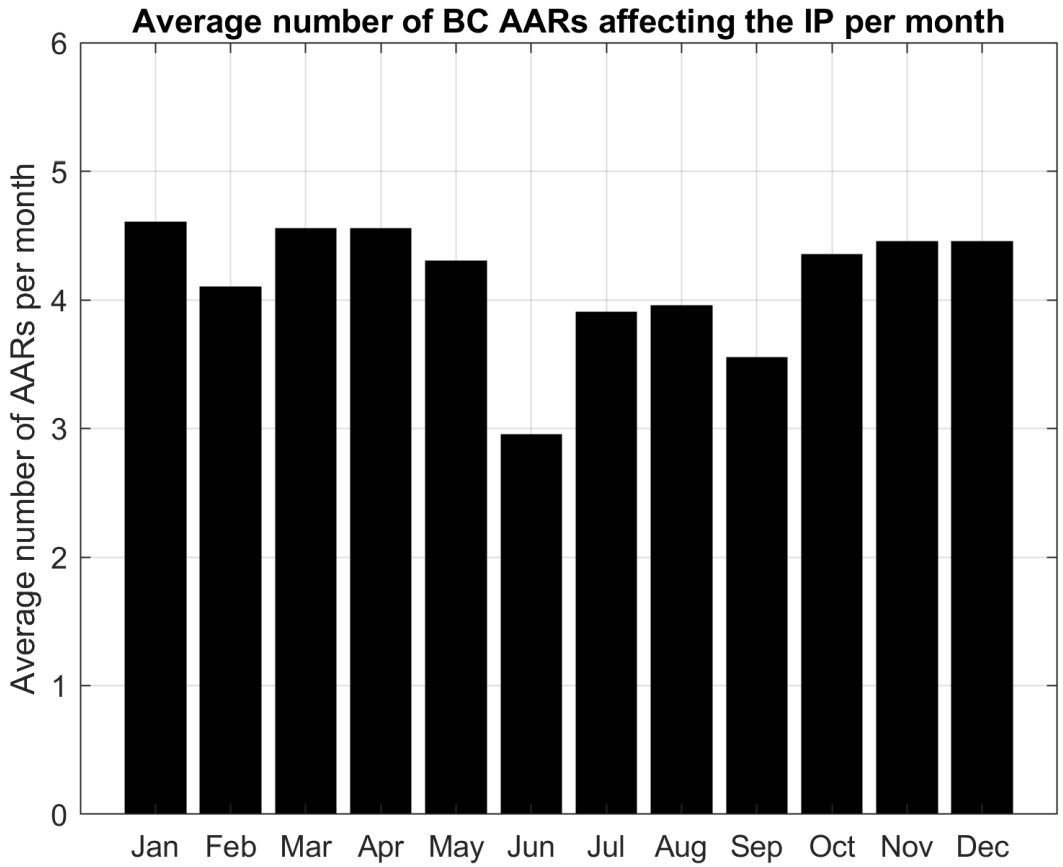
- **Average:** 46.4 per year
- **Maximum:** 56 per year
- **Minimum:** 36 per year
- **Mean IVT:** 362.2 kg m^{-1} s^{-1}
- **Median length:** 5414.5 km
- **Median width:** 638.6 km
- **Median duration:** 21 hours
- **Median length/width ratio:** 8.5

Iberian ARs


Iberian AR Frequency
65°N
55°N
45°N
35°N
25°N
15°N
75°W
55°W
35°W
15°W
5°E
25°E
45°E
0
4
8
12
16
20
24
28
32
36
AR days per year

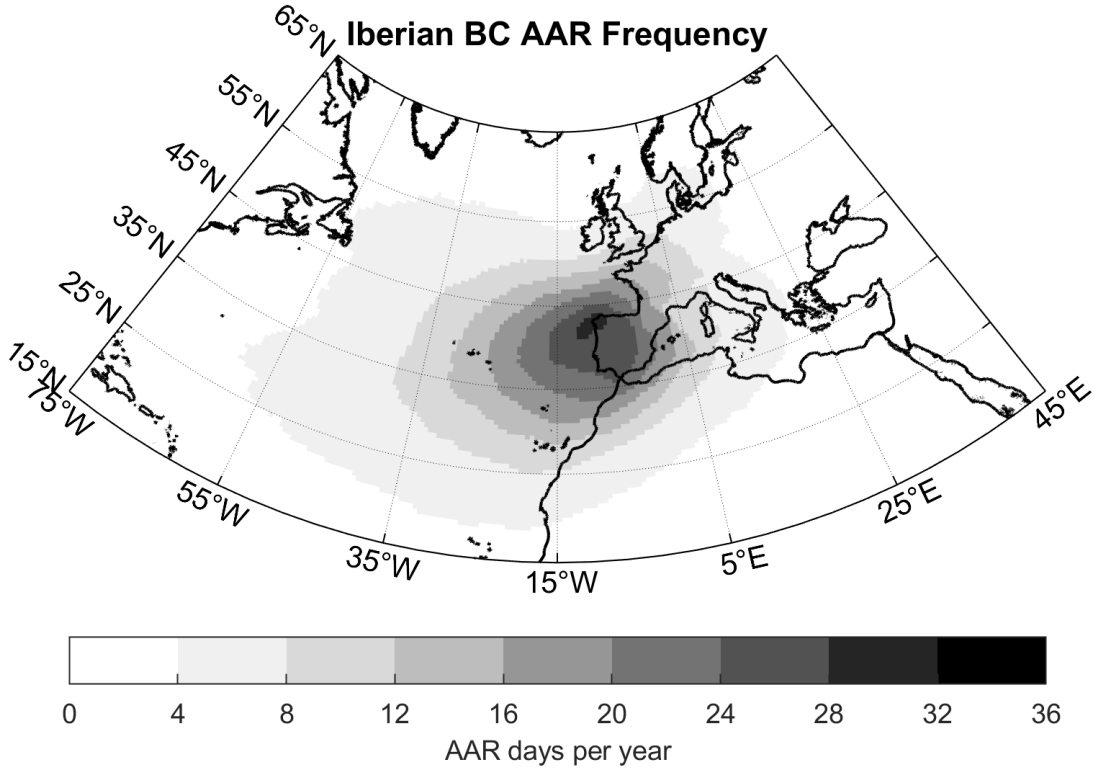

AR Landfall Location
45°N
43°N
41°N
39°N
37°N
35°N
11°W
8°W
5°W
2°W
1°E
4°E
27%
24%
21%
18%
15%
12%
9%
6%
3%
0%
Percentage of landfalls

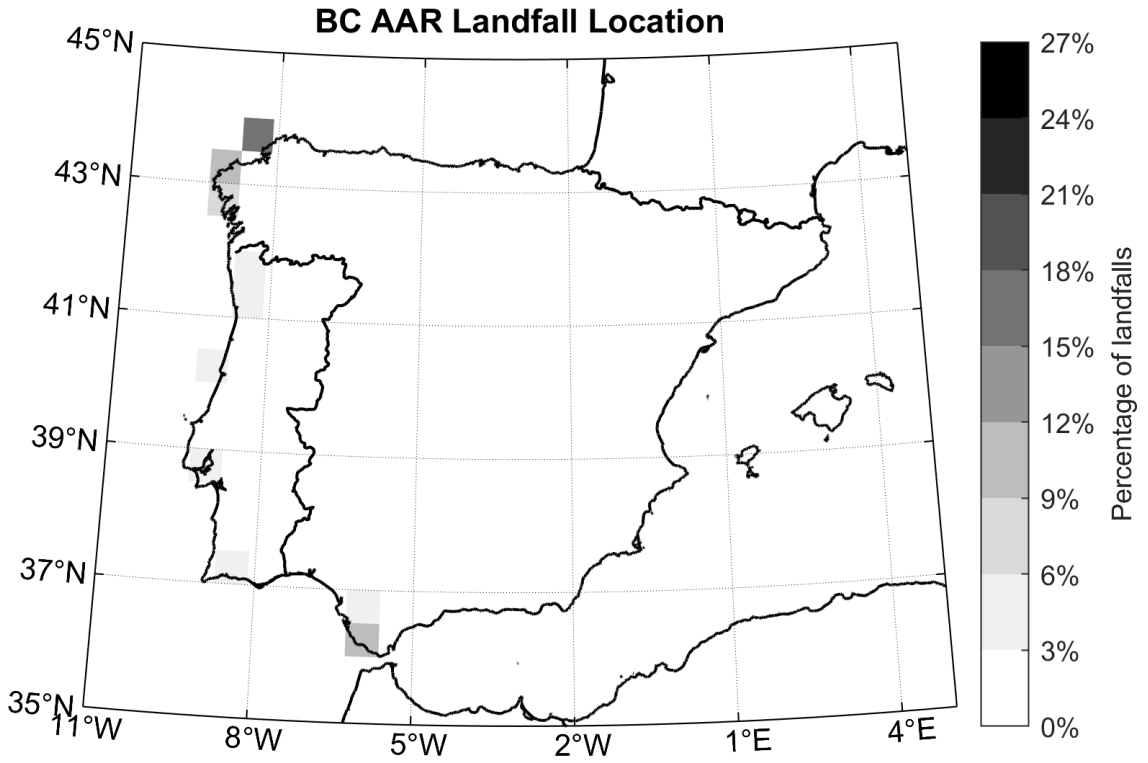
Black Carbon AARs



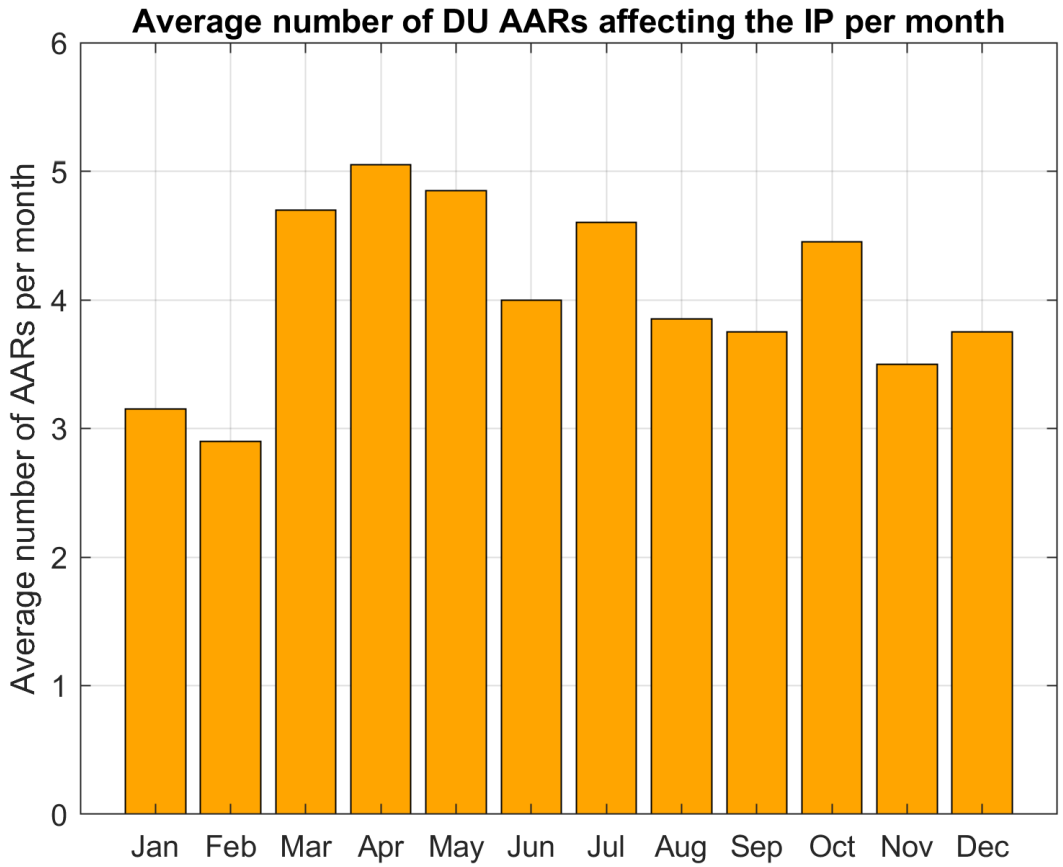
- **Average:** 49.7 per year
- **Maximum:** 62 per year
- **Minimum:** 35 per year
- **Mean IAT:** 1.14 x 10^{-5} kg m^{-1} s^{-1}
- **Median length:** 4924.9 km
- **Median width:** 712.1 km
- **Median duration:** 21 hours
- **Median length/width ratio:** 7.1

Black Carbon AARs



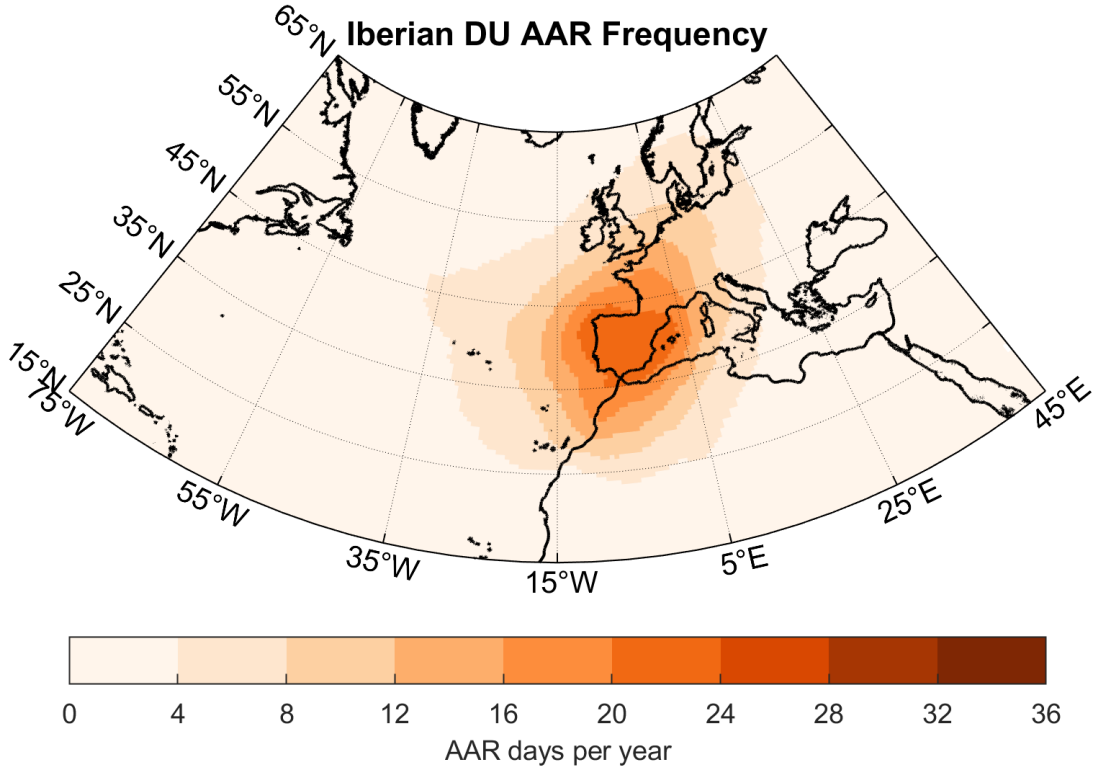


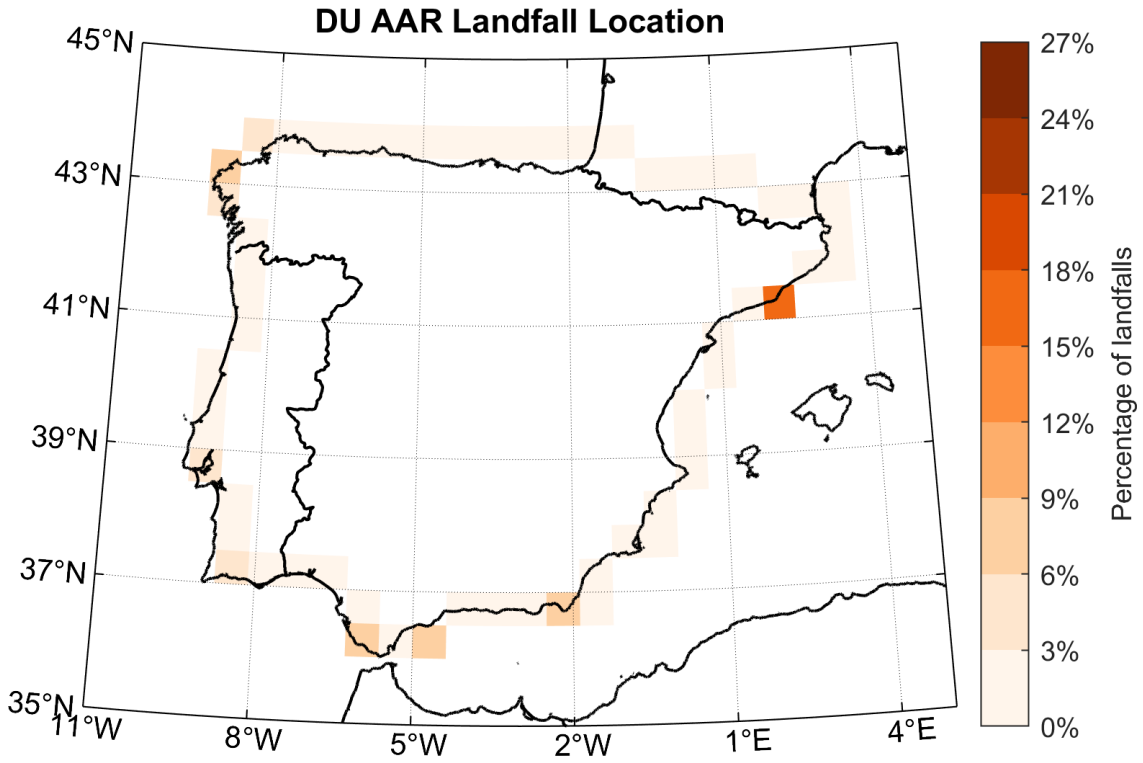
Dust AARs



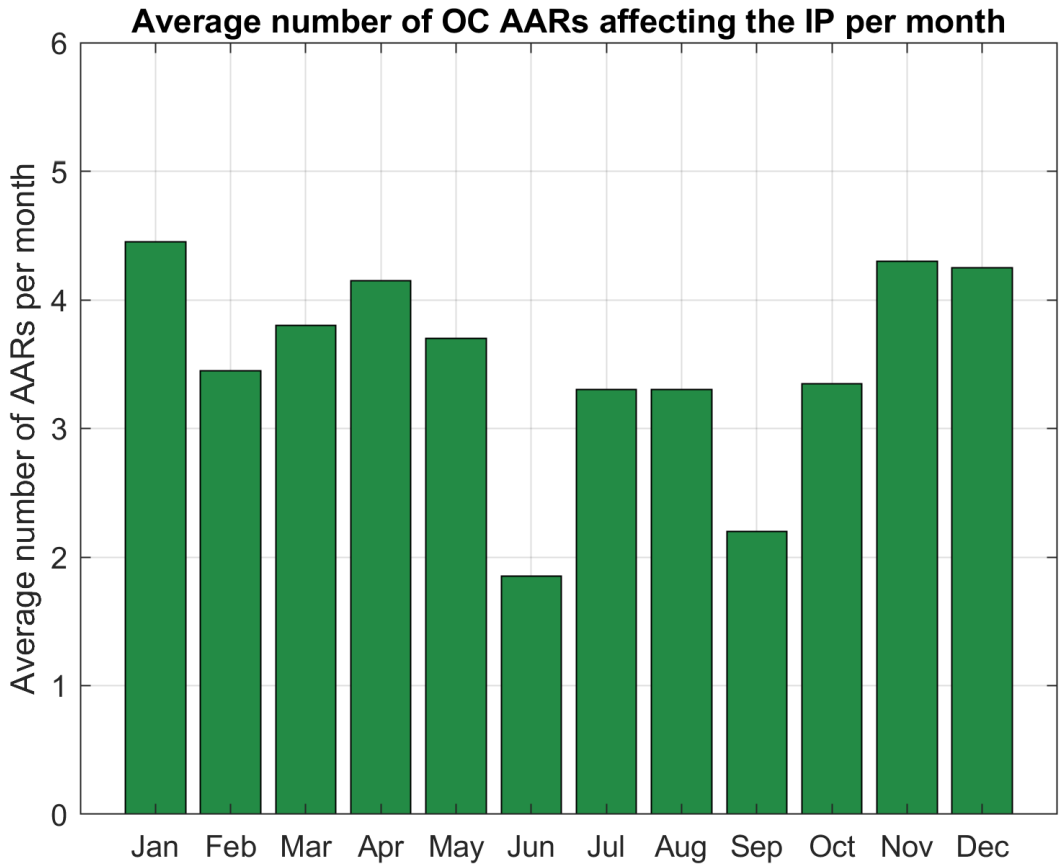
- **Average:** 48.6 per year
- **Maximum:** 57 per year
- **Minimum:** 39 per year
- **Mean IAT:** 271 x 10^{-5} kg m^{-1} s^{-1}
- **Median length:** 4319.1 km
- **Median width:** 661.8 km
- **Median duration:** 21 hours
- **Median length/width ratio:** 6.7

Dust AARs


Iberian DU AAR Frequency
65°N
55°N
45°N
35°N
25°N
15°N
75°W
55°W
35°W
15°W
5°E
25°E
45°E
0
4
8
12
16
20
24
28
32
36
AAR days per year

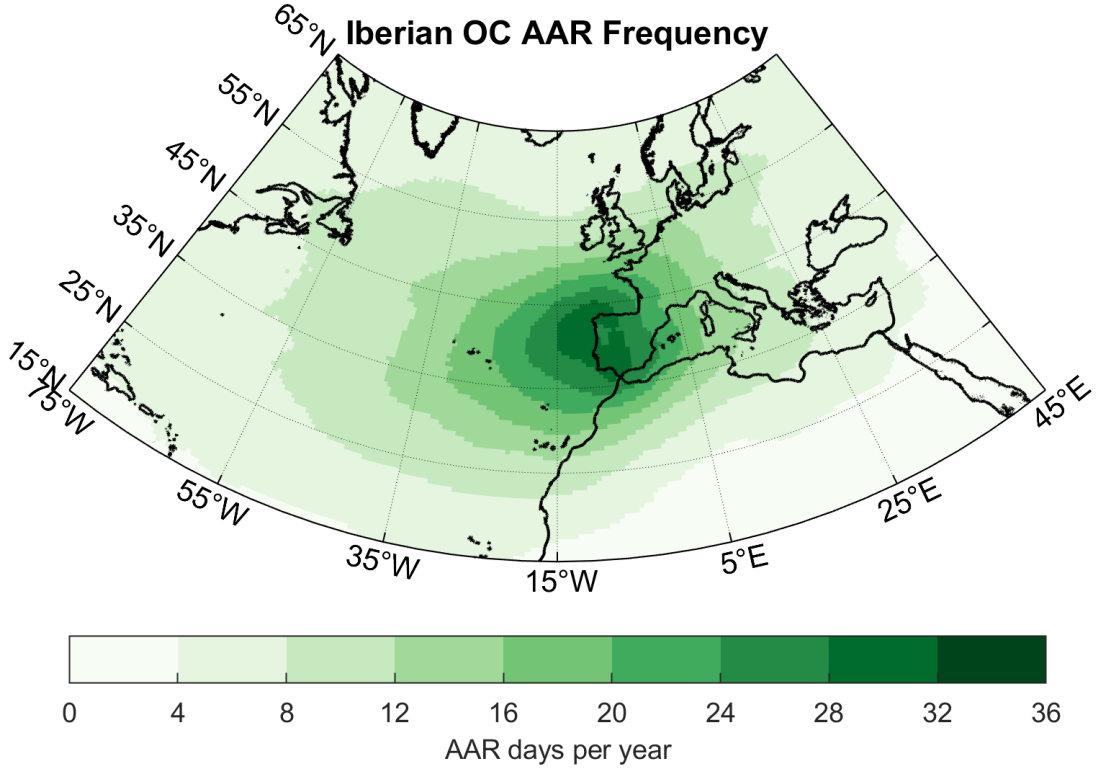

DU AAR Landfall Location
45°N
43°N
41°N
39°N
37°N
35°N
11°W
8°W
5°W
2°W
1°E
4°E
27%
24%
21%
18%
15%
12%
9%
6%
3%
0%
Percentage of landfalls

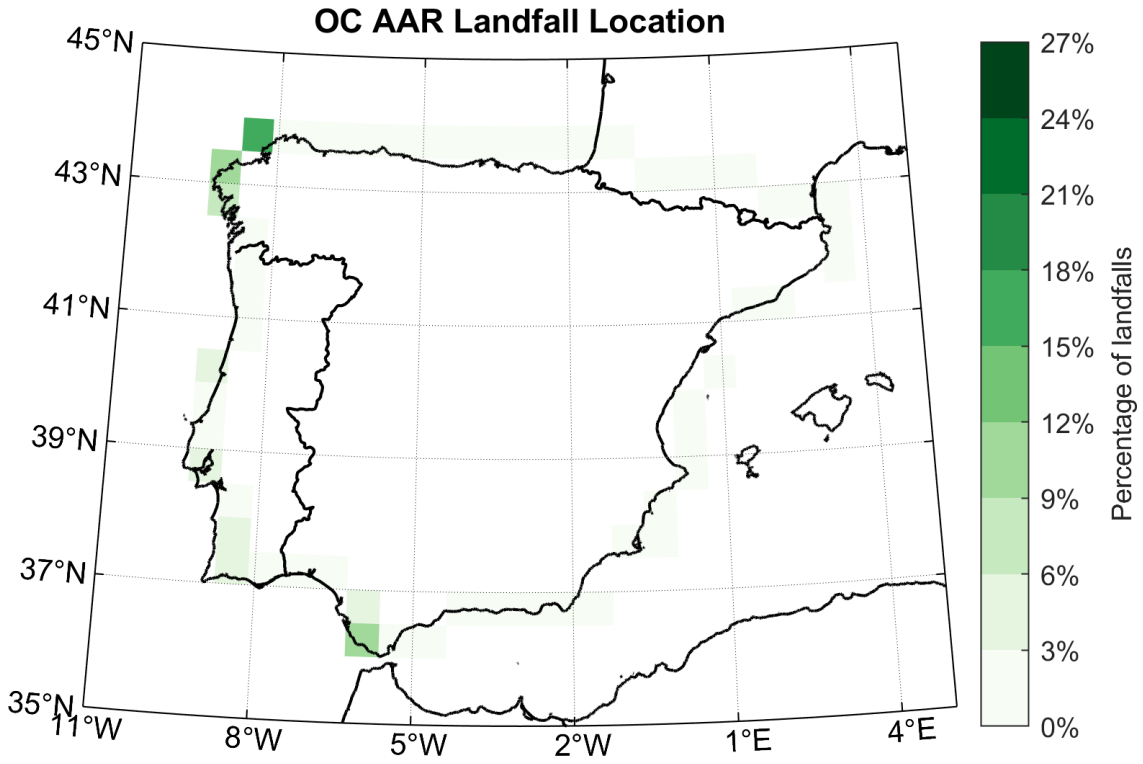
Organic Carbon AARs



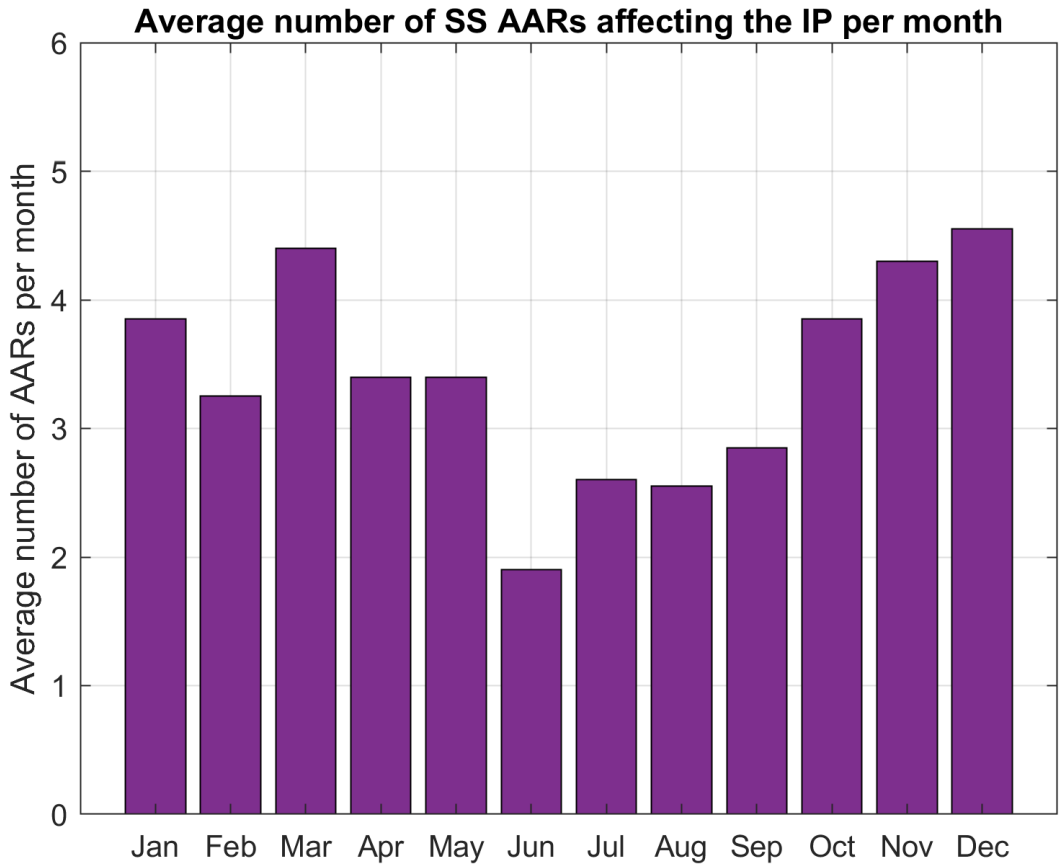
- **Average:** 42.1 per year
- **Maximum:** 56 per year
- **Minimum:** 25 per year
- **Mean IAT:** 7.01 x 10^{-5} kg m^{-1} s^{-1}
- **Median length:** 6354.5 km
- **Median width:** 874.3 km
- **Median duration:** 21 hours
- **Median length/width ratio:** 7.1

Organic Carbon AARs



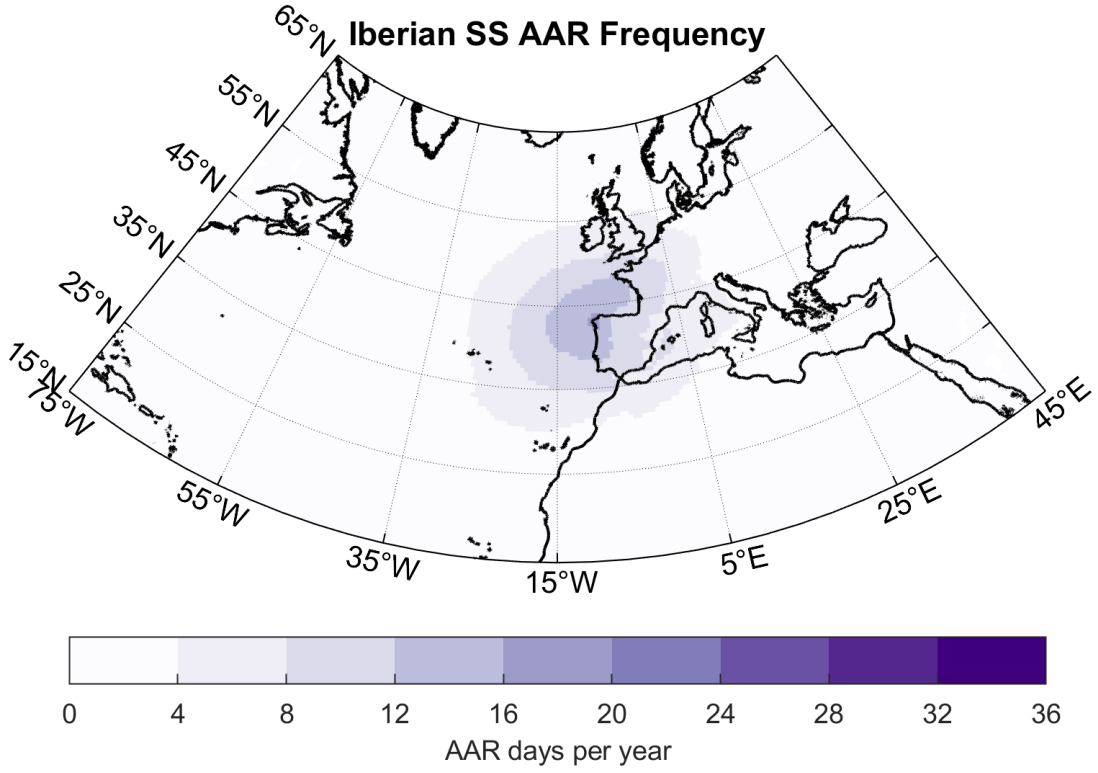


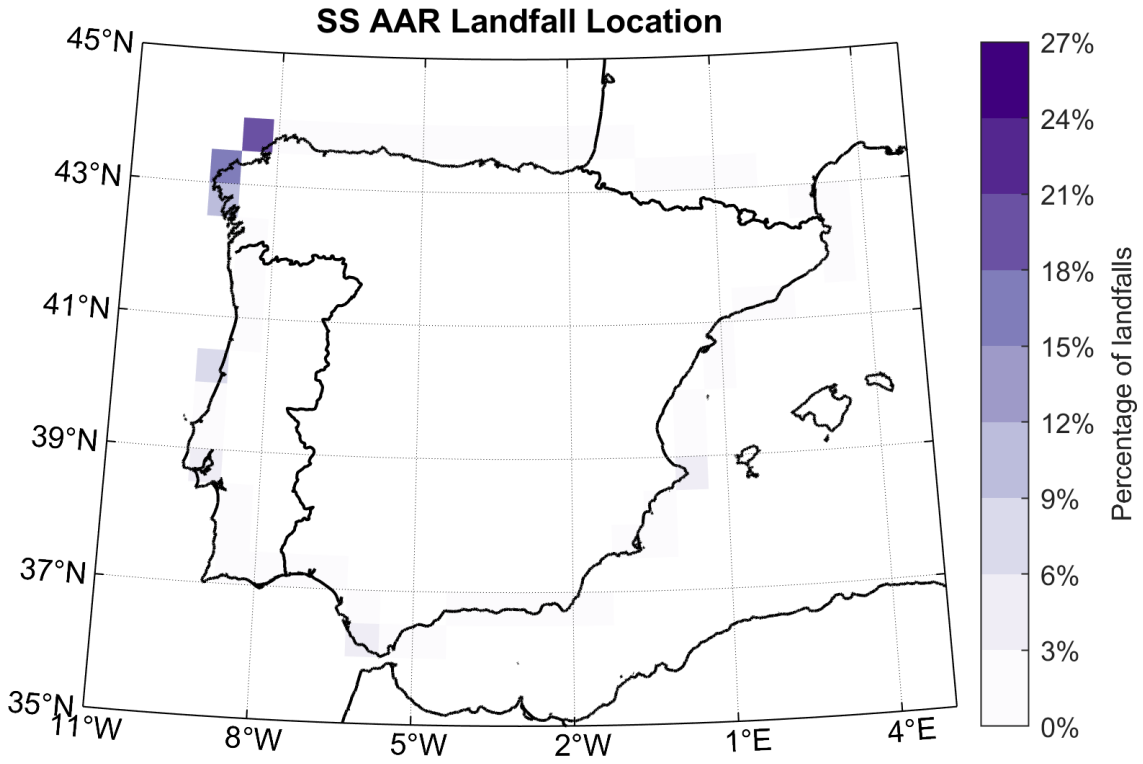
Sea Salt AARs



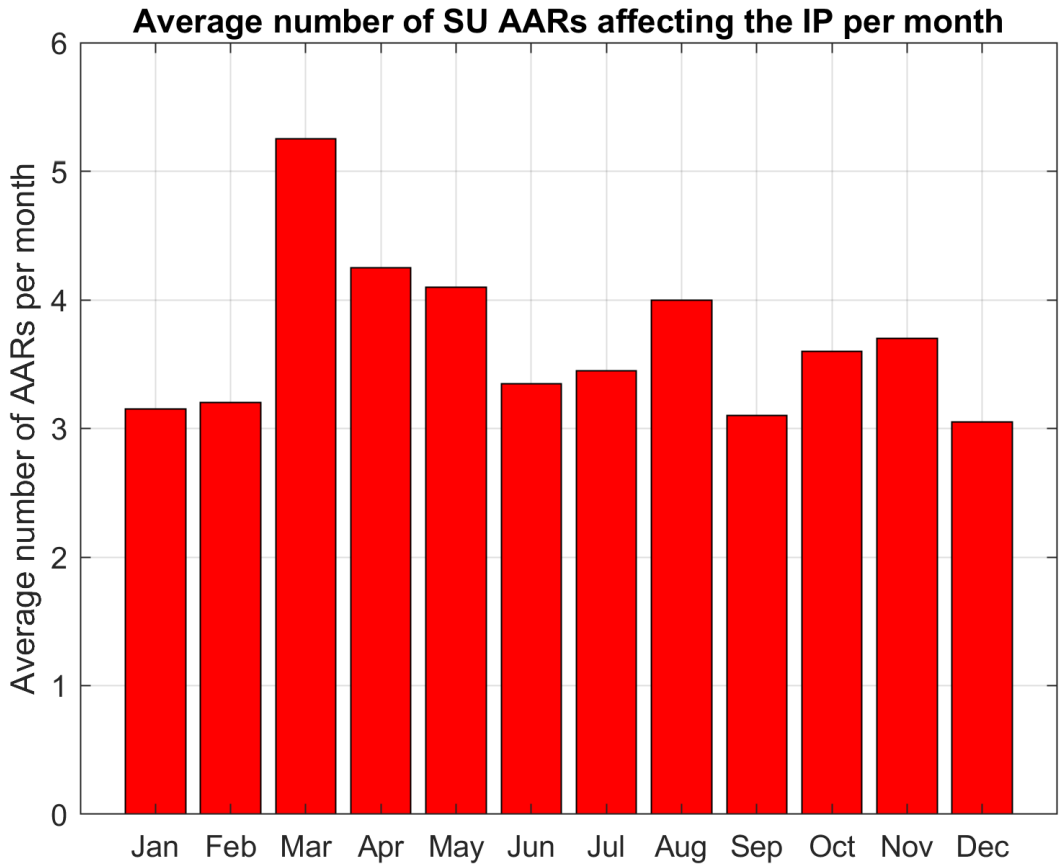
- **Average:** 40.9 per year
- **Maximum:** 48 per year
- **Minimum:** 31 per year
- **Mean IAT:** 98.6 x 10^{-5} kg m^{-1} s^{-1}
- **Median length:** 3720.2 km
- **Median width:** 781.5 km
- **Median duration:** 15 hours
- **Median length/width ratio:** 5.2

Sea Salt AARs



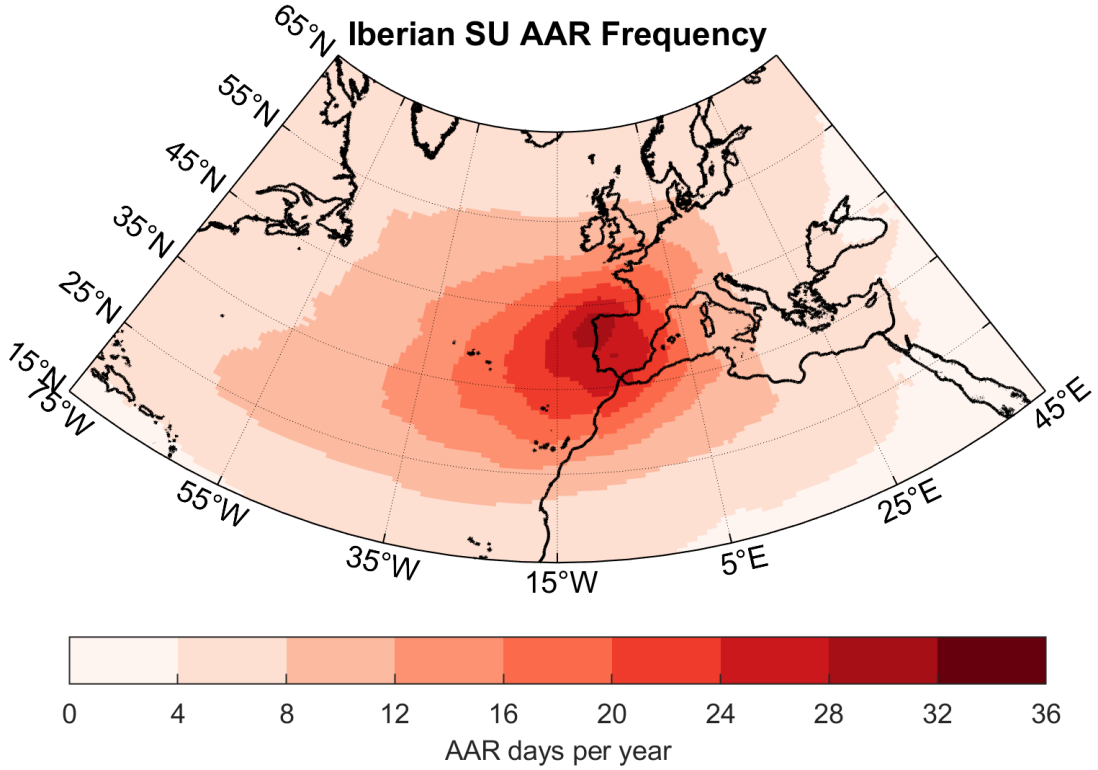


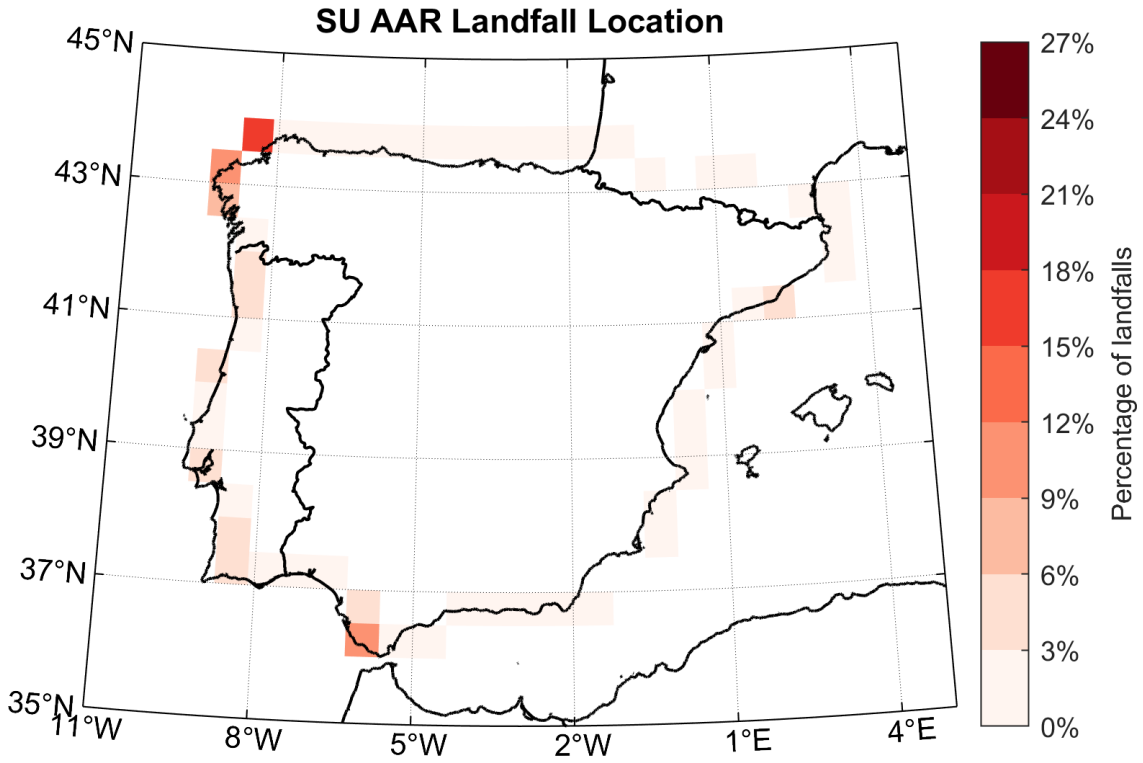
Sulphate AARs



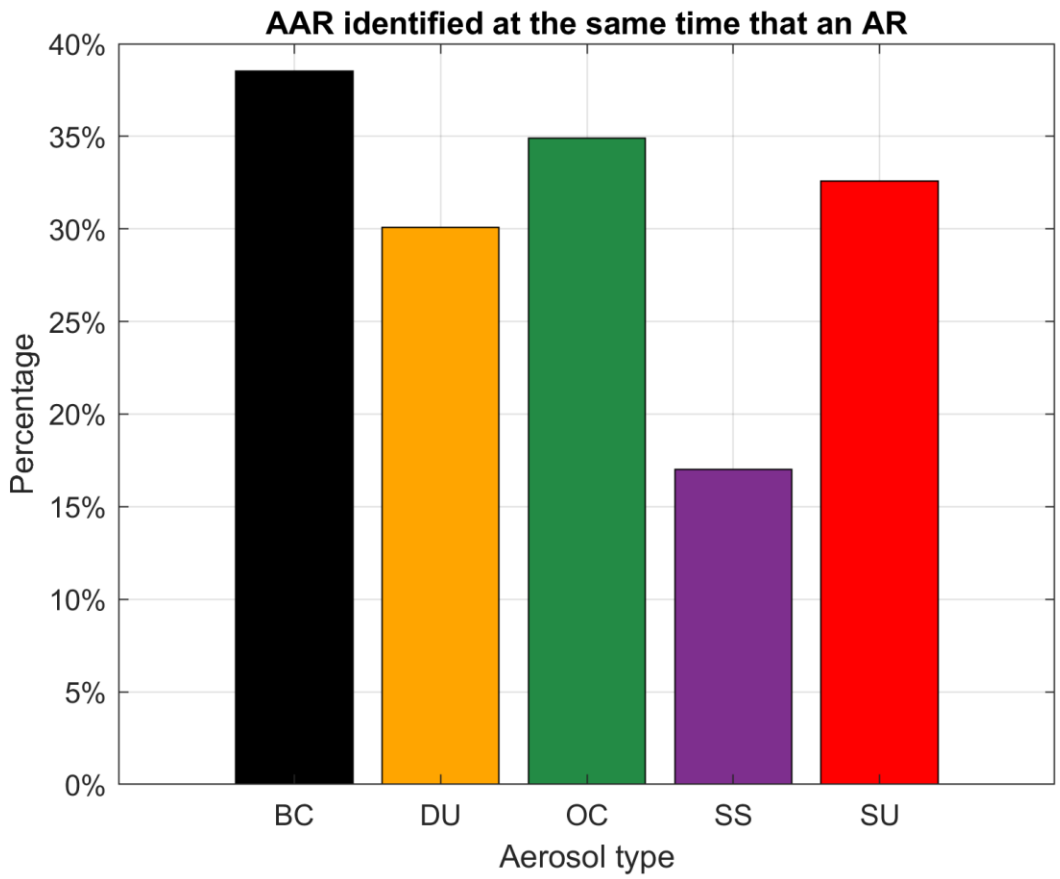
- **Average:** 44.2 per year
- **Maximum:** 63 per year
- **Minimum:** 27 per year
- **Mean IAT:** 7.65 x 10^{-5} kg m^{-1} s^{-1}
- **Median length:** 5778.7 km
- **Median width:** 798.5 km
- **Median duration:** 18 hours
- **Median length/width ratio:** 6.6

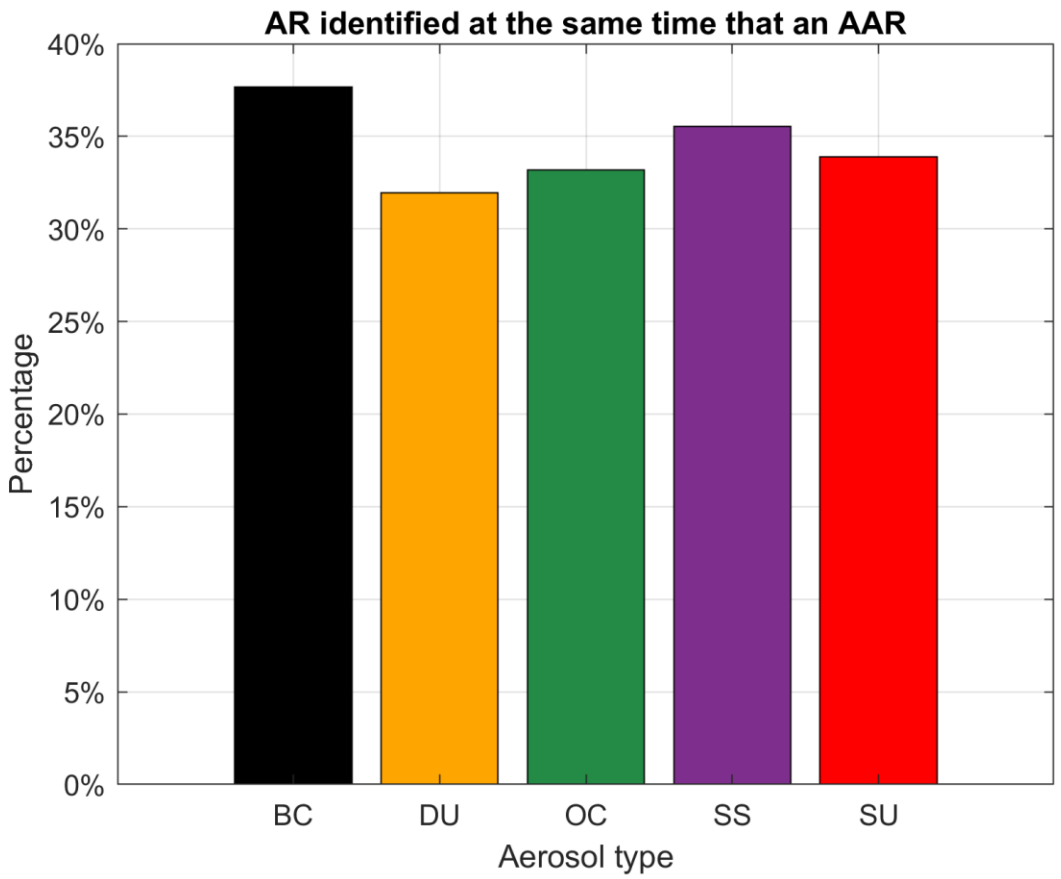
Sulphate AARs





Co-occurrence of ARs/AARs





- The percentage corresponds to the fraction of time steps for which an AR/AAR was detected at the same time

Outlook

- A global AR detection algorithm was applied to identify AARs affecting the Iberian Peninsula
- An average of 40-50 AARs per year were identified for 5 different aerosol species
- ARs and AARs in the Iberian Peninsula co-occur ~1/3 of the time

- **Future work:** Understand and quantify the impact of the presence of aerosols within ARs

Acknowledgments

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