On the automated detection of the rotational center for the characterization of Mediterranean cyclones

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EMS Annual Meeting

MEDICANES

DEFINITION OF MEDICANES

Mediterranean cyclones showing tropical-like characteristics during their mature phase are characterized by: **ring-shaped closed cyclonic circulation with strong near-surface wind field**; **quasi-calm cloud free eye in its center**; **spiraling heavy rain bands around the center**; possible deep warm core (WC) of diabatic origin, deep convection (DC) in proximity of the center (Panegrossi et al., 2023).

OBJECTIVES

- sea surface wind field characterization through the definition of a Rotational Center (RC) and Radius of Maximum Wind (RMW), similarly to tropical cyclones (Rogers and Reasor, 2013);
- highlight the differences in terms of surface wind field between the development and the tropical-like phase;
- analyse the behaviour of RMW in the presence of WC.

DATASET

- **Sea surface wind speed and direction** → OSI SAF product from ASCAT on board Metop satellites
- **Mean Sea Level Pressure (MSLP)** → hourly estimates by ERA5 reanalysis
- **Brightness Temperature (TB)** → AMSU-A/B/MHS passive microwave radiometer on board Metop satellites

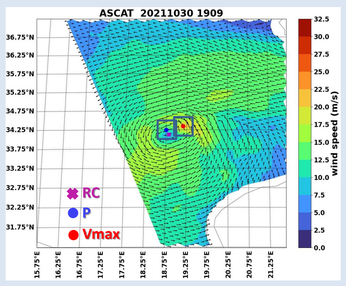
Medicane	Duration	Useful overpasses
Rolf	20111105-09	2
Qendresa	20141106-09	2
Trixie	20161028-31	6
Zorbas	20170927-29	4
Numa	20171115-19	5
Ianos	20200916-19	3
Apollo	20211026-31	9
Blas	20211107-15	10
Juliette	20230227-20230303	5
Daniel	20230905-10	3

10 Medicanes occurred **from 2011 to 2023** are analysed according to the ASCAT useful overpasses' avaibility.

METHODOLOGY

❑ **Medicane Rotational Center Automated Detection (MeRCAD):**

- minimum of ERA5 MSLP = P; maximum of ASCAT wind speed = Vmax;
- identification of two boxes of 0.5° surrounding P and Vmax;
- computation of the wind speed standard deviation in a 2x2 pixel moving window inside each box;
- selection of the ASCAT pixel closest to P where the standard deviation belongs to the 90th percentile and wind speed < 12 m/s for each box;
- between the two pixels thus detected, the RC corresponds to the pixel with the minimum wind speed.



❑ **RMW computation:** as the distance between the band of the maximum winds and RC.

CONCLUSIONS

- **RMW decreases as the medicane intensifies** (as wind speed and MSLP gradient increase, or the minimum MSLP decreases); **MeRCAD RMW analysis can be used as proxy of medicanes intensification**;
- generally, the distance between P and RC decreases as RMW decreases and during the mature phase;
- in most cases WC center falls within the RMW, even if at larger distances from the RC with respect to P.

FUTURE DEVELOPMENTS

- data provided by the Wind Radar (WindRAD) onboard of Feng Yun FY-3E satellite series will be used;
- comparison with cyclone center based on Cloud Top Height (CTH) field;
- ARCHER will be applied to all medicane cases.

ACKNOWLEDGMENTS

This work is part of the ESA project "Earth Observations as a cornerstone to the understanding and prediction of tropical-like cyclone risk in the Mediterranean (MEDICANES)".

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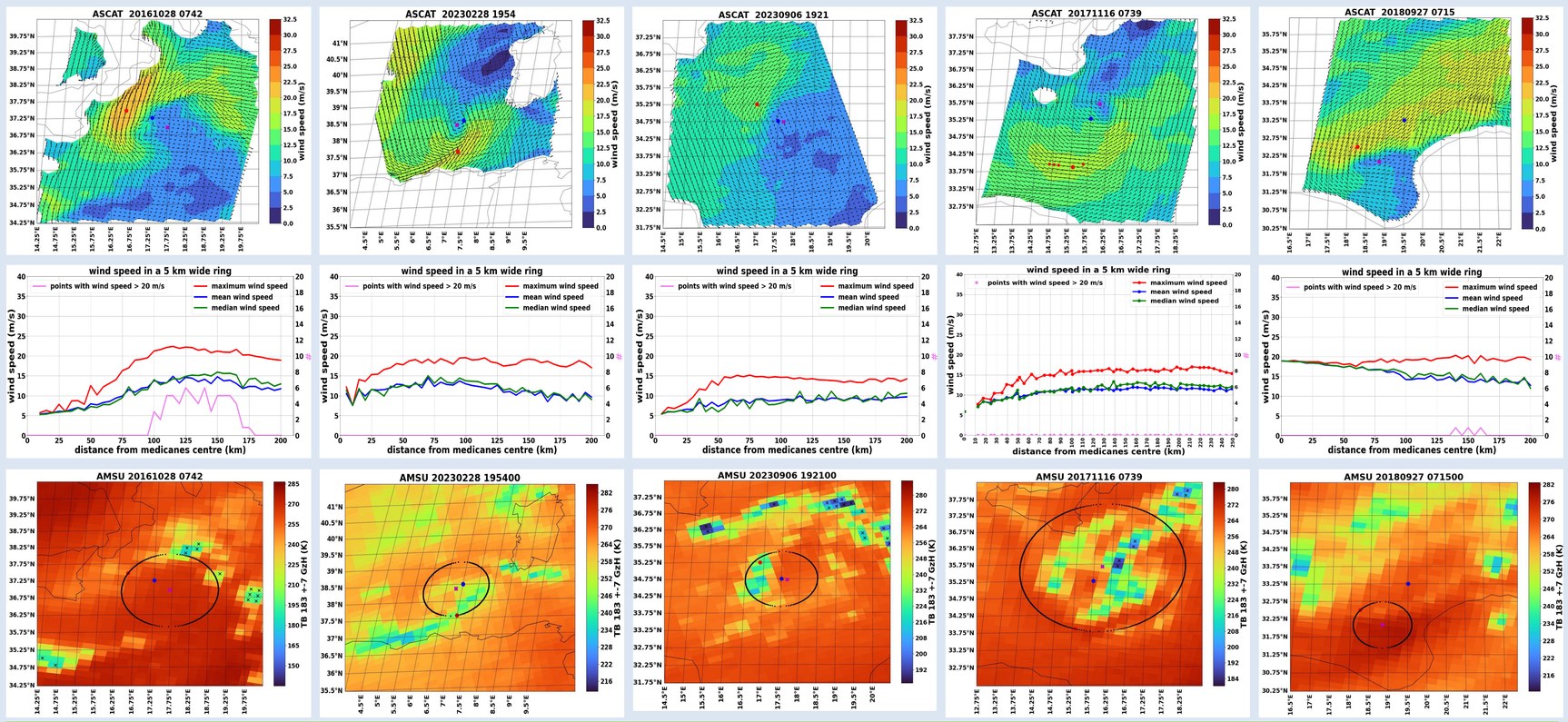
RESULTS

Legend: ✖ RC ✖ DC ★ WC ● P ● Vmax

DEVELOPMENT

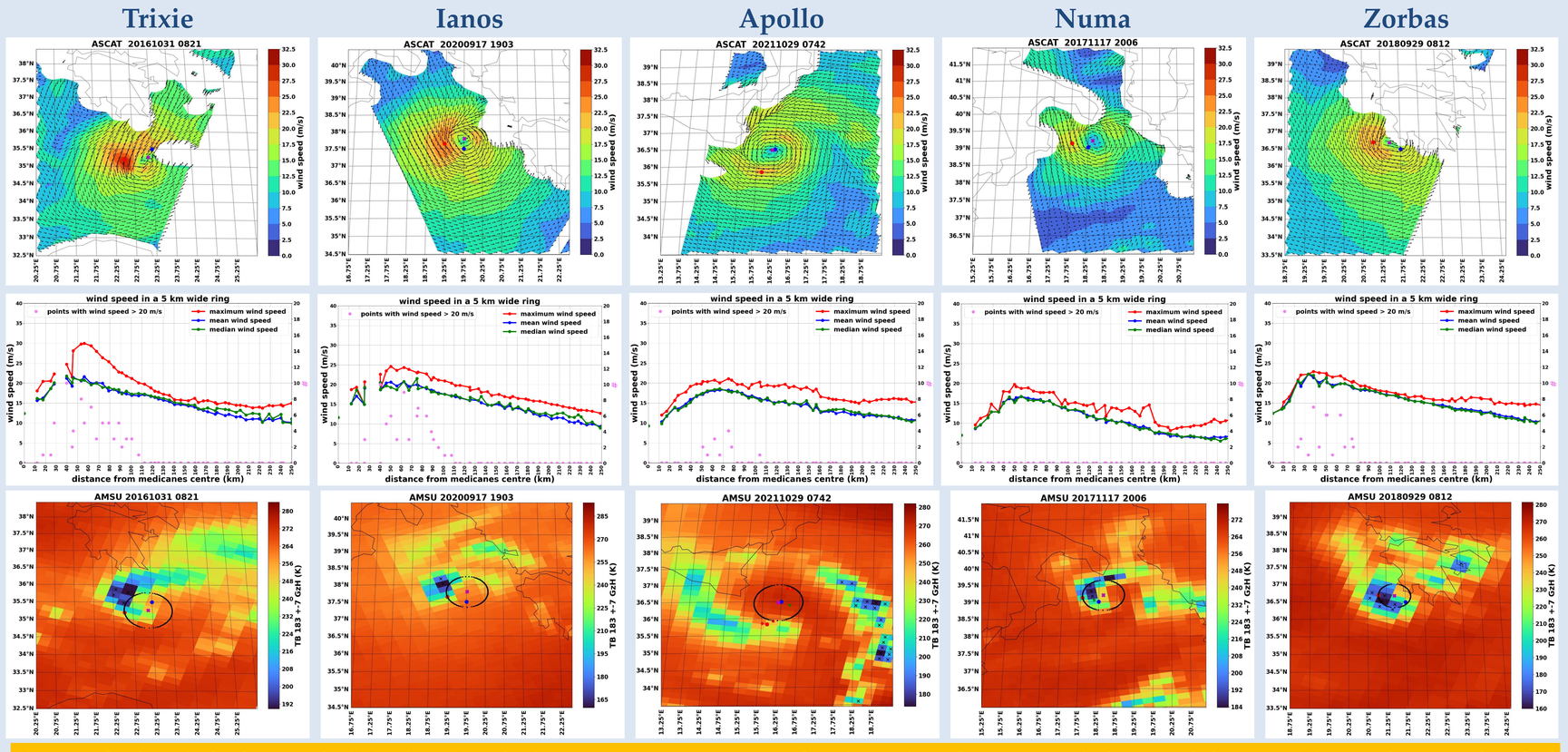
Trixie | Juliette | Daniel | Numa | Zorbas



A wide area of calm winds near the center exists rather than an <<eye>>, so it is more difficult to identify the RC • The cyclonic vortex structure of strong winds is not present at this stage • Distance between band of maximum winds and RC is higher than in mature phase (ellipse) • Wind speed is lower than in mature phase • Trends of maximum, mean and median wind speed show almost a plateau.

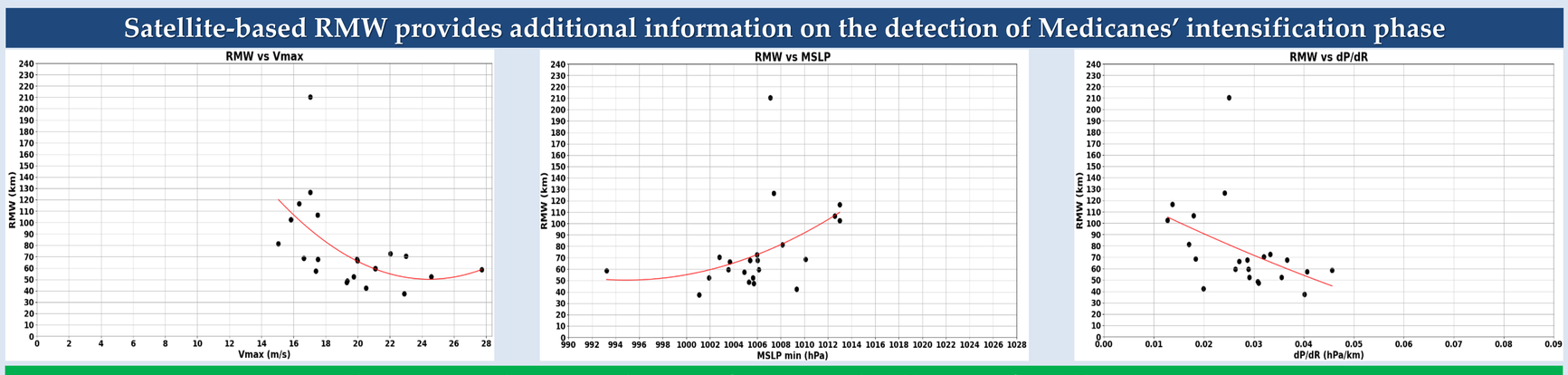
MATURE PHASE

Trixie | Ianos | Apollo | Numa | Zorbas



An eye of calm winds close to the RC exist • A cyclonic vortex structure appears forming a ring of strongest winds around the eye • Distance between band of maximum winds and RC (RMW) is shorter than in development phase (ellipse) • Wind speed is greater than in development phase • Trends of maximum, mean and median wind speed show a peak located in correspondence with the band of maximum winds followed by a decreasing trend with distance • WC due to diabatic heating (with deep convection in proximity of the center) may occur at distances shorter than the RMW.

Satellite-based RMW provides additional information on the detection of Medicanes' intensification phase



Comparison between the use of ERA5 and WC center for RC estimation

TRIXIE			
P-RC (km)	RMW (km)	WC-RC (km)	DATE TIME
30.44	134.5	41.5	2016-10-28 19:40
38.57	191.9	-	2016-10-28 20:26
26.15	91.0	-	2016-10-30 08:25
40.91	79.5	-	2016-10-30 09:19
28.5	52.5	-	2016-10-31 08:59

IANOS			
P-RC (km)	RMW (km)	WC-RC (km)	DATE TIME
40.5	72.5	-	2020-09-16 08:13
19.5	68.5	36.6	2020-09-16 20:19
32.3	52.5	84.8	2020-09-17 19:11

NUMA			
P-RC (km)	RMW (km)	WC-RC (km)	DATE TIME
52.2	211.7	-	2017-11-16 08:19
64.7	126.5	-	2017-11-16 09:14
17.0	48.8	-	2017-11-17 19:17
24.5	49.8	26.6	2017-11-17 20:13
8.7	47.5	-	2017-11-18 09:18

ZORBAS			
P-RC (km)	RMW (km)	WC-RC (km)	DATE TIME
143.1	67.5	-	2018-09-27 07:53
20.7	70.5	77.5	2018-09-27 20:14
32.7	37.5	-	2018-09-29 08:52

ROLF			
P-RC (km)	RMW (km)	WC-RC (km)	DATE TIME
17.7	82.8	55.6	2011-11-06 09:20
57.6	90.8	86.0	2011-11-08 10:18
18.3	55.9	-	2011-11-08 19:58

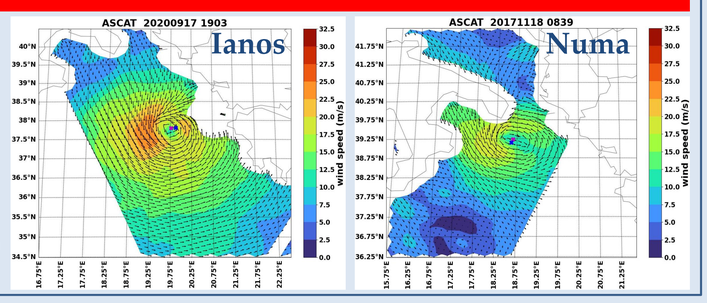
APOLLO			
P-RC (km)	RMW (km)	WC-RC (km)	DATE TIME
69.8	106.7	-	2021-10-27 08:13
38.1	102.5	-	2021-10-27 19:32
37.3	116.5	-	2021-10-27 20:20
36.6	68.5	-	2021-10-28 18:42
7.9	59.5	29.1	2021-10-29 08:20
9.2	62.9	-	2021-10-29 09:12
12.1	57.5	-	2021-10-29 19:39
15.7	69.4	-	2021-10-29 20:31
14.8	39.7	-	2021-10-30 19:18

development phase
mature phase

In most cases the WC center is located at shorter distances than RMW, even if at larger distances from RC with respect to P. Generally, the distance between P and RC decreases as RMW decreases and during mature phase.

ARCHER vs MeRCAD

The Automated Rotational Center Hurricane Eye Retrieval (ARCHER) algorithm, developed by the TC group at CIMSS/University of Wisconsin-Madison, is widely used for the correct identification of a TC's center of rotation (Wimmers and Welden, 2016). In this study it is applied to medicanes for the first time. A very good agreement between MeRCAD and ARCHER position of the RC for Ianos and Numa occurs.



✖ MeRCAD
✖ ARCHER