Un ejemplo de added-value en simulaciones de clima mediante modelos regionales (RCMs): medicanes (mediterranean tropical-like cyclones) a partir de simulaciones de la iniciativa internacional CORDEX

Enrique Sánchez Sánchez
Facultad de Ciencias Ambientales y Bioquímica
Universidad de Castilla-La Mancha (UCLM)
Toledo
España

Instituto de Ciencias Ambientales de Castilla-La Mancha

momac

UCLM

Grupo MOMAC

Miguel Ángel Gaertner
Enrique Sánchez, Marta Domínguez, Raquel Romera, Victoria Gil, Clemente Gallardo[(1)]
+
Mario Marcello Miglietta[(2)]

[(1)]University of Castilla-La Mancha (Toledo, Spain)
[(2)]CNR-ISAC (Lecce, Italy)

Gracias a los grupos de EURO-CORDEX y Med-CORDEX

Instituto de Ciencias Ambientales de Castilla-La Mancha

momac

UCLM

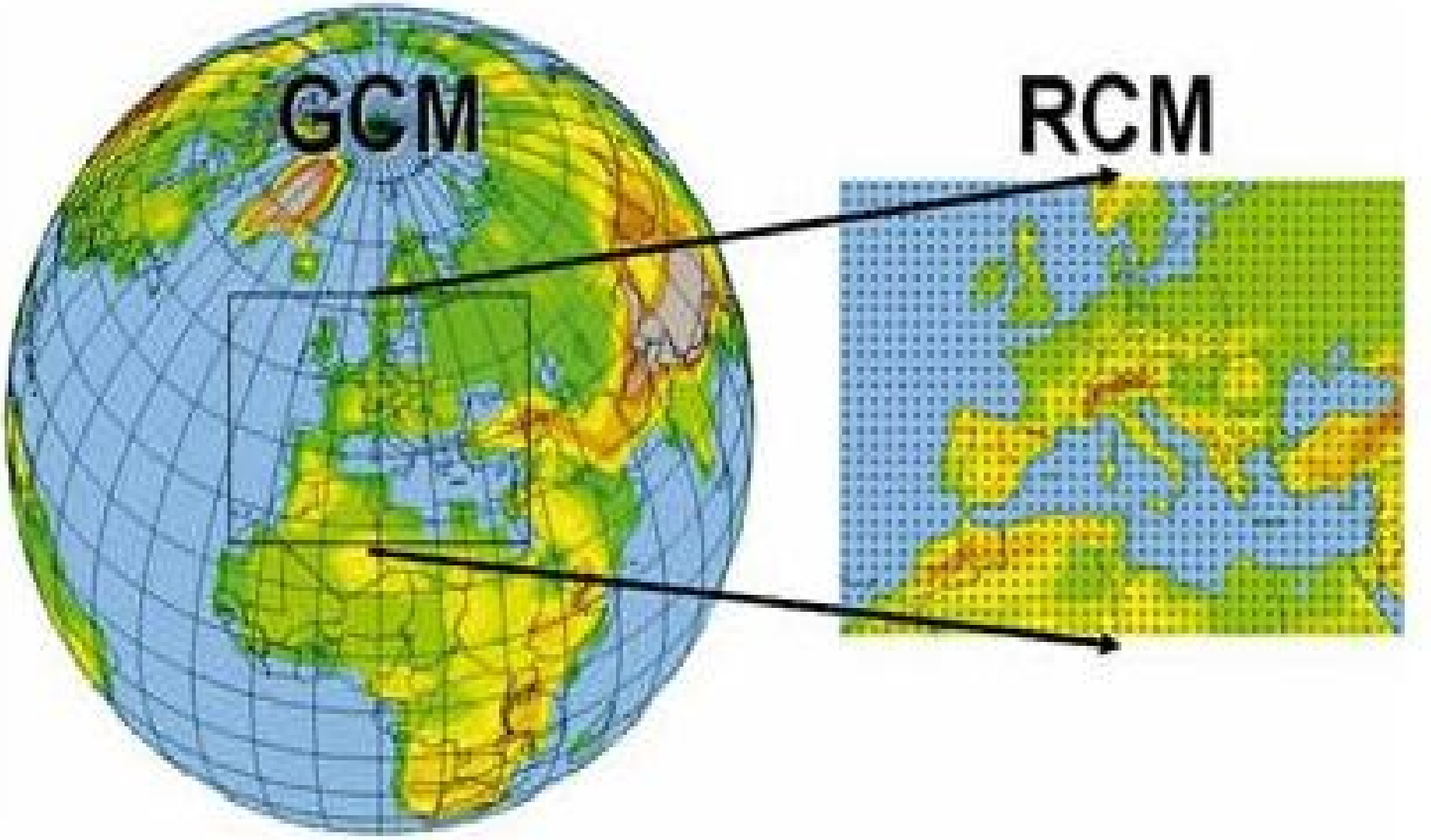
Objetivos generales del estudio

Analizar la capacidad de los modelos regionales de clima para simular tropical-like cyclones (TLCs, también llamados medicanes) sobre el mar Mediterráneo

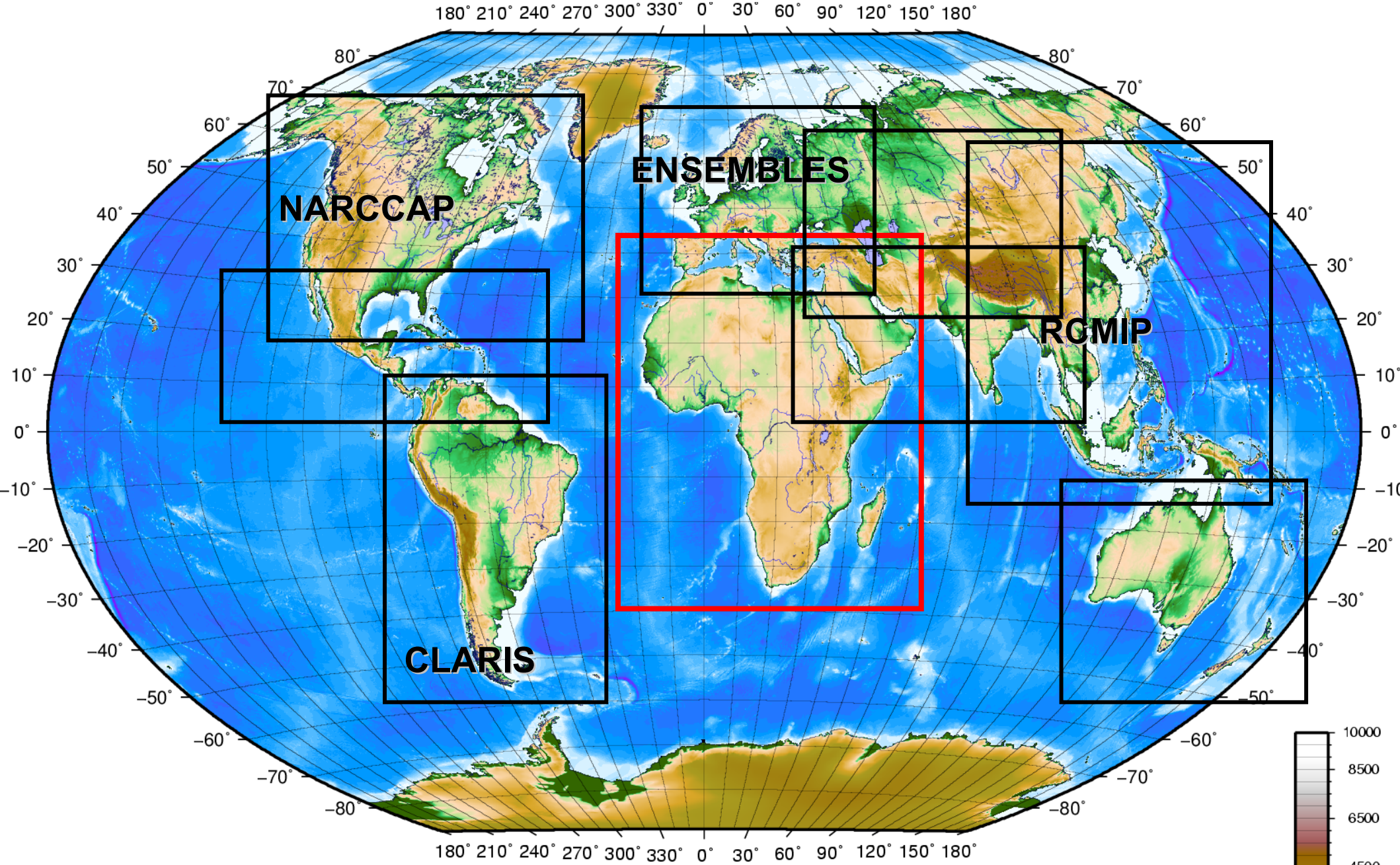
Analizar el impacto de modelos acoplados oceáno-atmósfera y de la alta resolución en la descripción de los TLCs

(Gaertner et al. (2016), Simulation of medicanes over the Mediterranean Sea in a regional climate model ensemble:impact of ocean-atmosphere coupling and increased resolution, *Clim. Dyn*., under review)

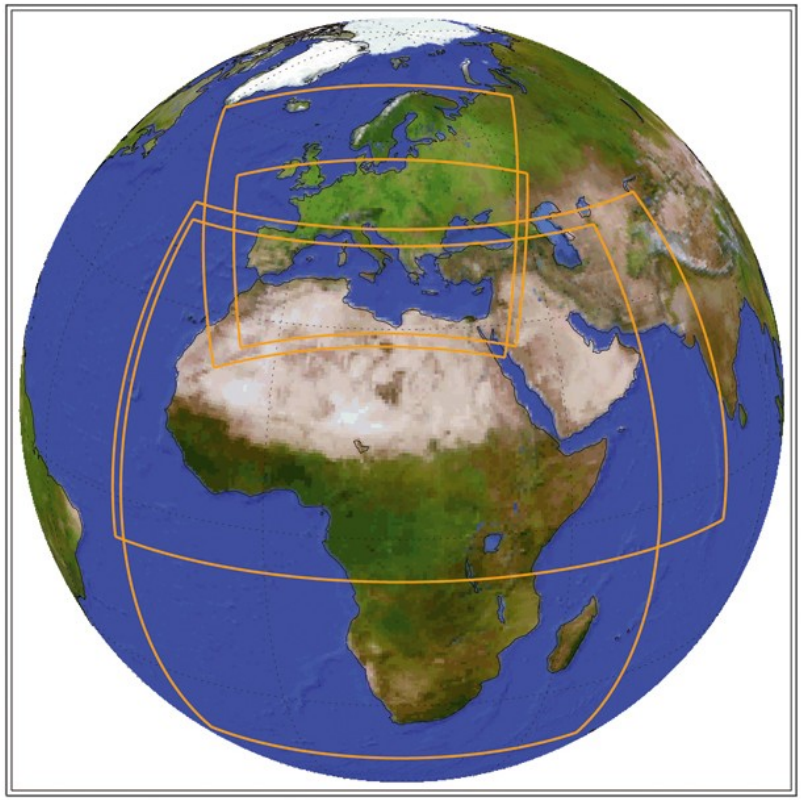
Modelos regionales de clima: RCMs

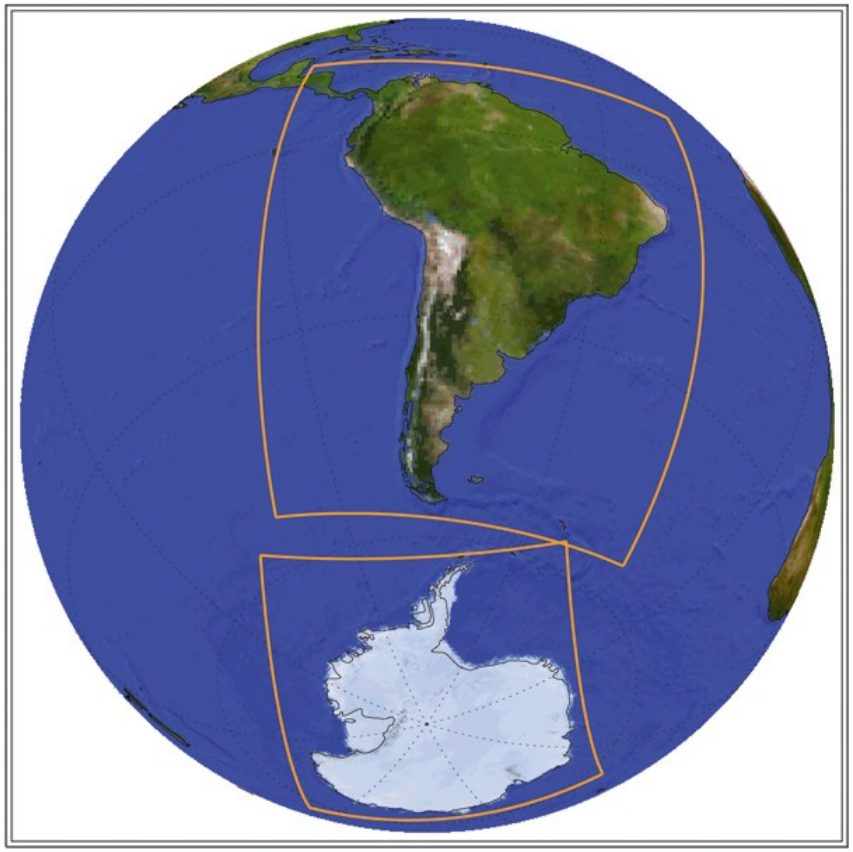


Ejercicios regionales con RCMs previos a CORDEX



Dominios CORDEX (iniciativa WCRP)





Principales características de los TLCs

- Dificultades para obtener una base de observaciones climatológica:

• Pequeño tamaño (radio típico de 150 km o menos): reanálisis demasiado grande para detectarlos

• Infrecuente (menos de 2 TLCs por año; valor específico dependiente del método de detección)

• Localizados sobre el mar: pocas observaciones directas

Principales características de los TLCs

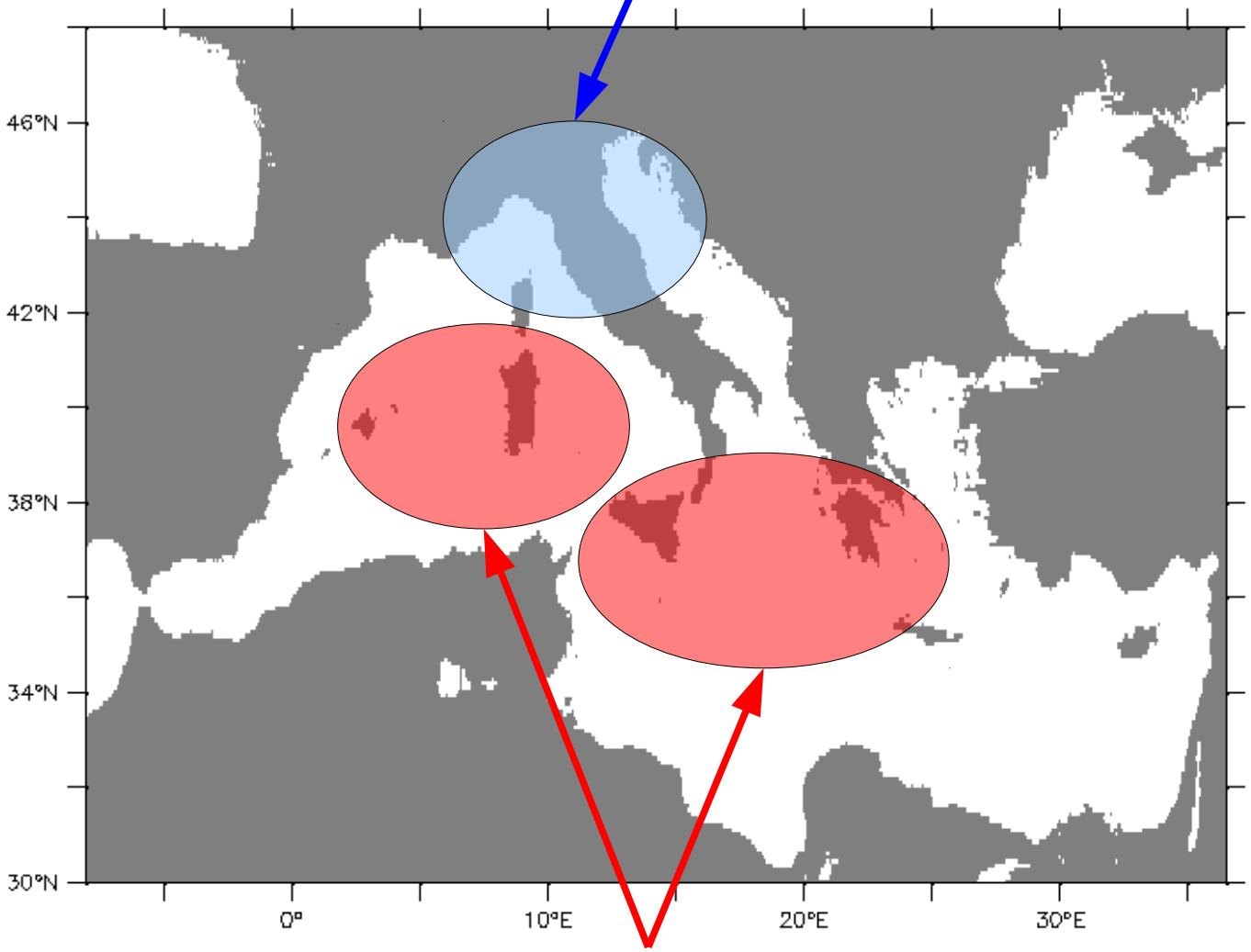
- Método más usual de detección: satélite (base de datos de la Universidad de las Islas Baleares, UIB; Tous and Romero, 2012): http://meteo.uib.cat/medicanes/

- Distribución geográfica: la densidad máxima de su recorrido está desplazada hacia el sur respecto a las más habituales bajas baroclínicas

- Mecanismo de generación: transición tropical desde una baja cut-off baroclínica

Observed characteristics of TLCs

Most frequent location areas of intense baroclinic cyclones



Most frequent location areas of tropical-like cyclones

Do the observed TLCs have tropical structure?

- Detection and analysis method: combined satellite and modelling (Miglietta et al., 2013)

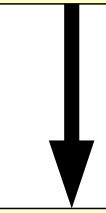
- Detection by satellite and dynamical downscaling of ERA-Interim reanalysis with a very high resolution model (7,5 km)

- Analysis of cyclone structure: cyclone phase-space method of Hart (2003), which offers an objective way for determining if a cyclone has extratropical or tropical characteristics

Reference

Miglietta, M. M., Laviola, S., Malvaldi, A., Conte, D., Levizzani, V., & Price, C. (2013). Analysis of tropical-like cyclones over the Mediterranean Sea through a combined modeling and satellite approach. Geophysical Research Letters, 40(10), 2400-2405.

Tropical characteristics



Vertical structure - Cyclone phase space analysis (Hart, 2003) (see http://moe.met.fsu.edu/cyclonephase/ for examples)

3 PARAMETERS:

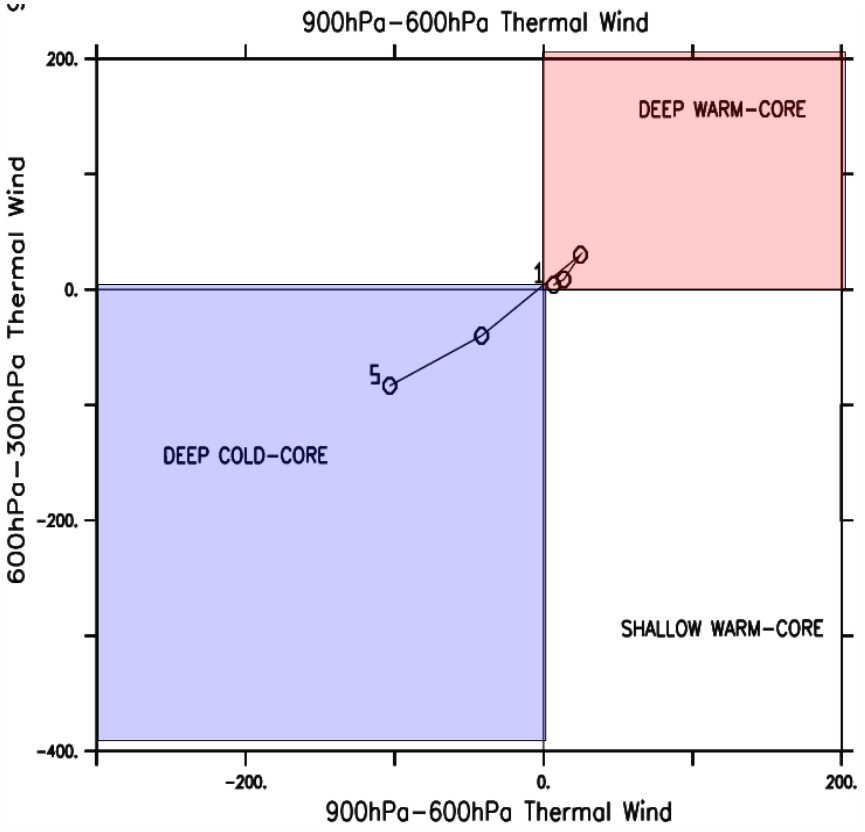
- Thermal symmetry (frontal/non-frontal structure)
- Lower troposphere thermal wind (cold/warm core)
- Upper troposphere thermal wind (cold/warm core)

Tropical cyclones are thermally symmetric lows with a full-tropospheric warm core

Do the TLCs have tropical structure?

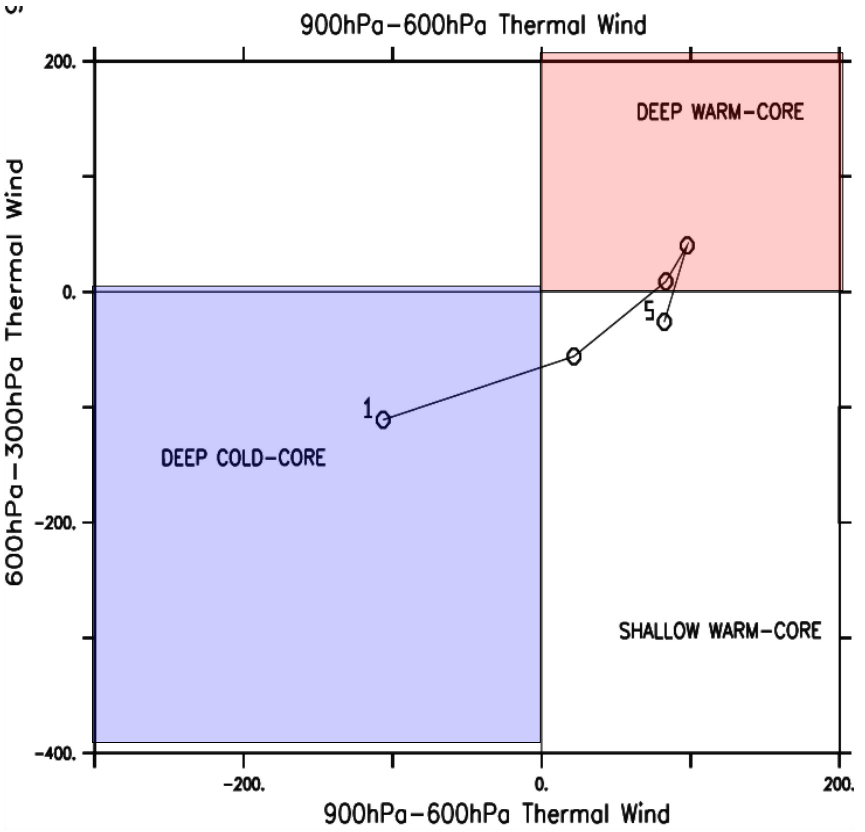
- **Other evidence: ECWMF operational analysis: higher resolution in recent years (from 2006: 0.22º)**

Upper cold | warm core



Lower cold | warm core

October 2007 medicane



Lower cold | warm core

November 2011 medicane

0.22º resolution analysis

Do the observed TLCs have tropical structure?

- Criteria for selection of TLCs (Miglietta et al., 2013): cyclones reaching fully tropical characteristics at some time of its evolution

• Frequency: about 1 per year

• Intensity: moderate intensity (17-25 m/s), about 0.5 per year; high intensity (25-33 m/s), about 0.5 per year

• Most TLCs show tropical characteristics during one day or less. Main exception: November 2011 TLC shows a deep warm core during nearly 3 days.

Mediterranean tropical-like cyclones reach indeed a fully tropical structure, though it's generally short-lived.

Aim and data

- Analyse the impact of high-resolution and atmosphere-ocean coupling on the simulation of tropical-like cyclones over the Mediterranean Sea with RCMs

    - Resolution: high resolution simulations should improve the representation of small-size cyclones

    - Air-sea interaction: for tropical cyclones, this interaction could reduce its intensity (lower SSTs through mixing)

- Simulations:
    - Pairs of higher and lower resolution climate simulations from EURO-CORDEX and Med-CORDEX

    - Pairs of uncoupled and coupled runs from Med-CORDEX

    - Evaluation runs (nested in reanalysis)

A recent “medicane” example

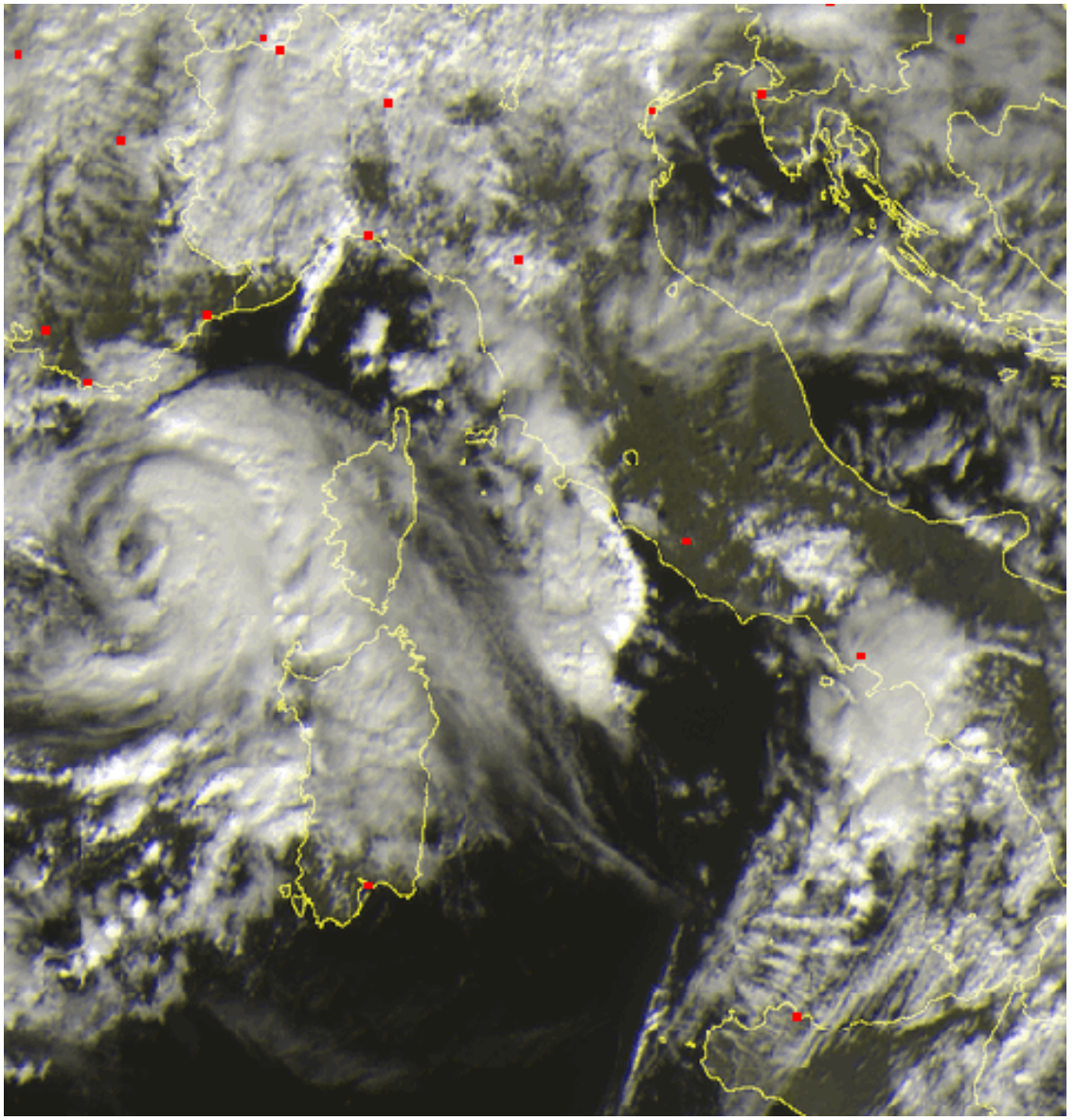
Observations (SE France):

Sustained winds: 100 km/h

Gusts: 150 km/h

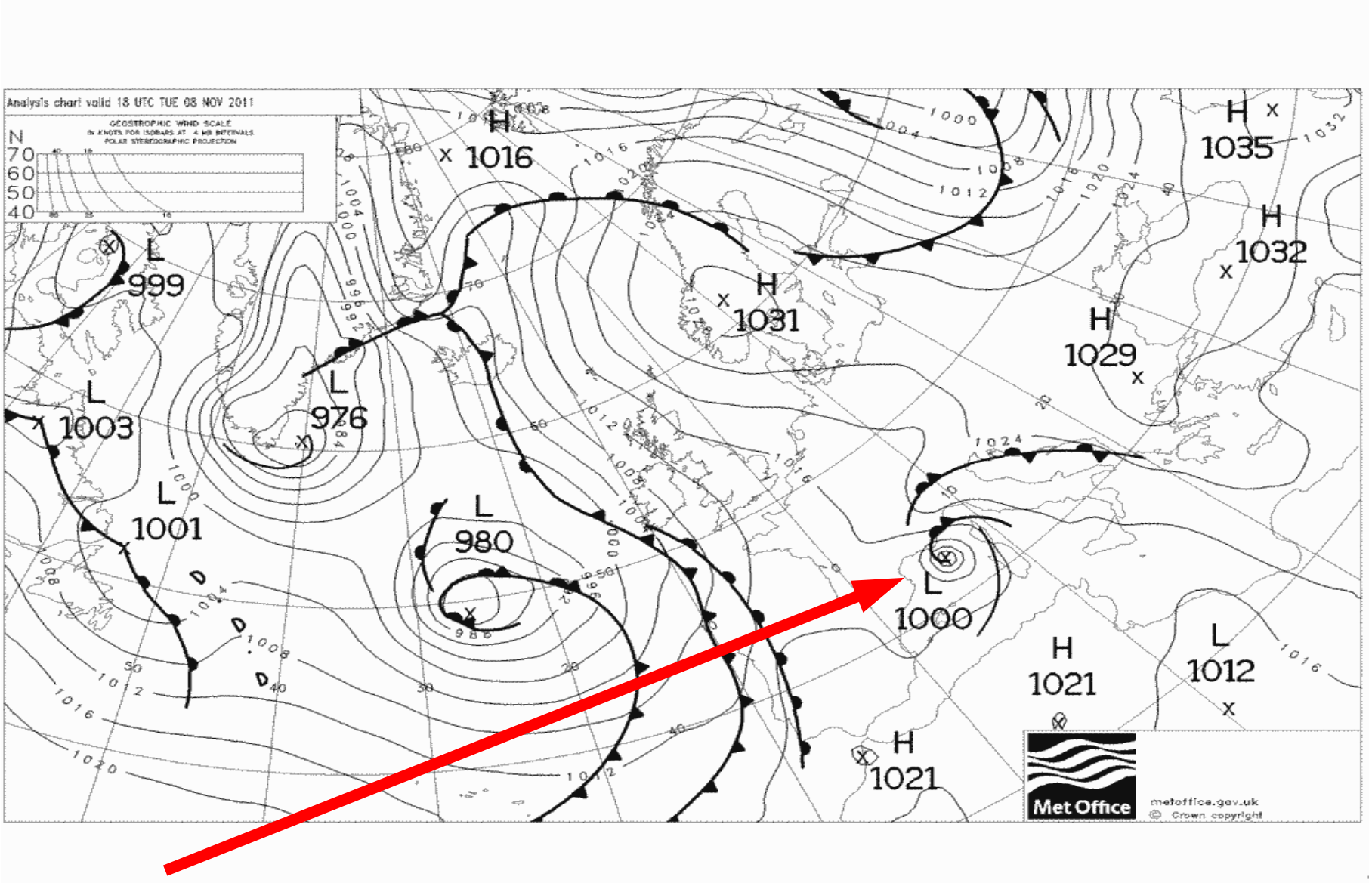
24-h precipitation: 135 mm

Classified as Tropical Storm by NOAA



Visible satellite image – 8/11/2011 (11h15')

A recent “medicane” example



Met-Office Analysis – 8/11/2011 (18h)

Method

- Cyclone detection and tracking: sea level pressure minima (Picornell et al., 2001)

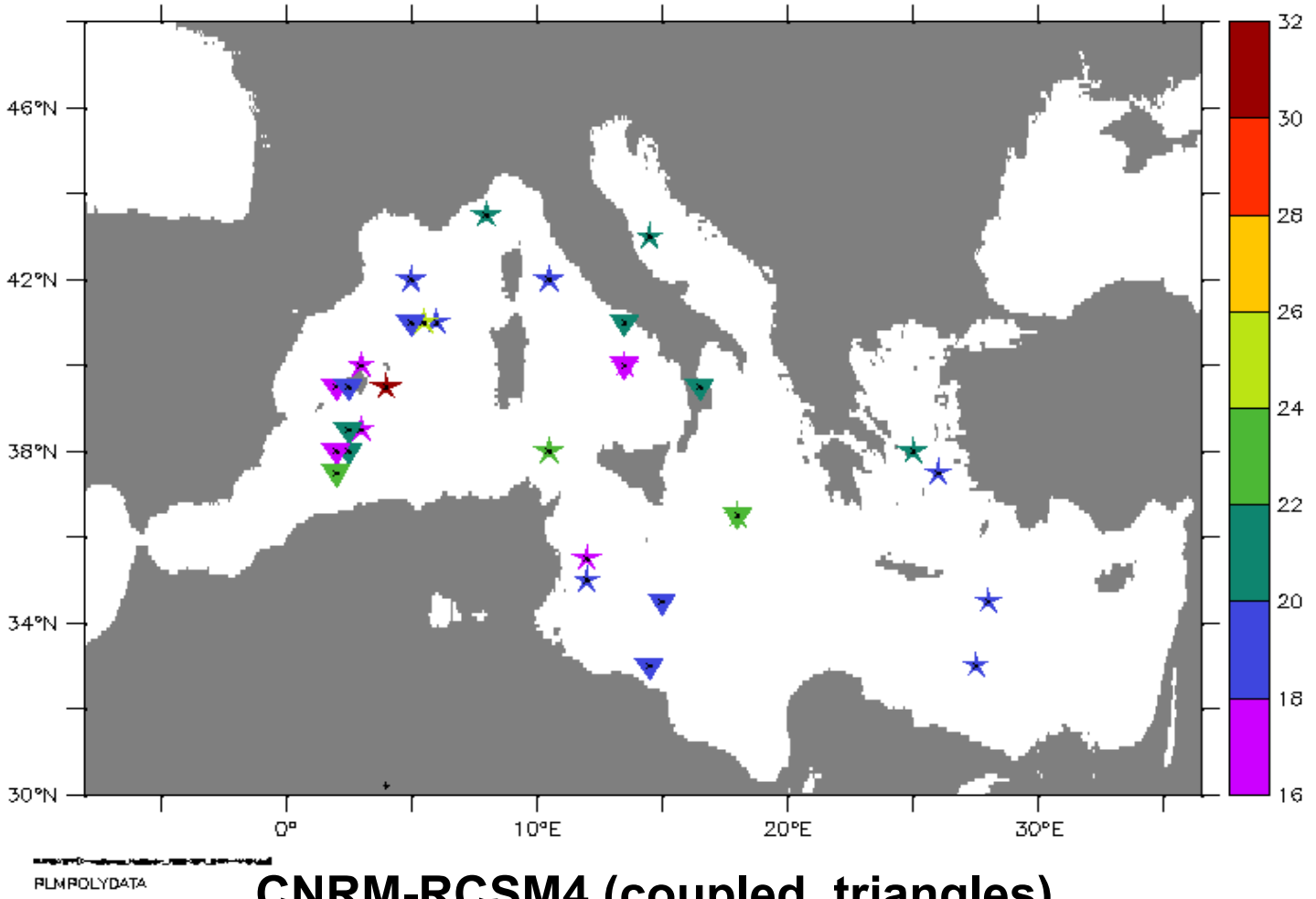
- Intensity threshold: 17,5 m/s (tropical storm intensity)

- Analysis months: August-January

- Vertical structure of most intense cyclones: cyclone phase space method of Hart (2003)

- Criteria for selecting medicanes: cyclones reaching fully tropical characteristics at some time of its evolution (thresholds derived from Miglietta et al., 2013)

Location and intensity of coupled and uncoupled runs



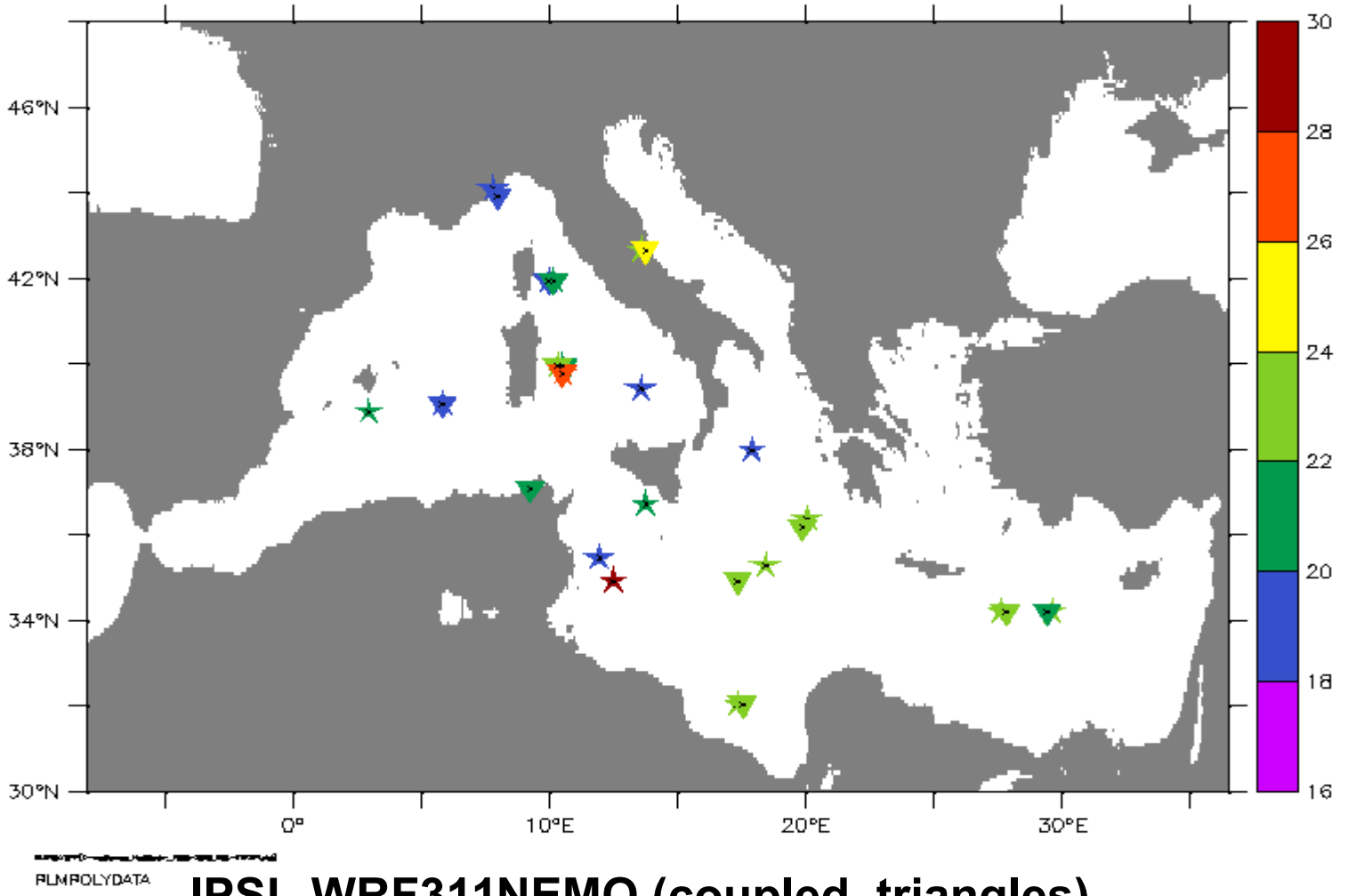
Intensity (wind, m/s)

CNRM-RCSM4 (coupled, triangles)
CNRM-ALADIN (uncoupled, stars)
(50 km resolution)

Frequency:
Coupled: 0.41/year
Uncoupled: 0.59/year

High intensity frequency:
Coupled: 0
Uncoupled: 0,06/year

Location and intensity of coupled and uncoupled runs

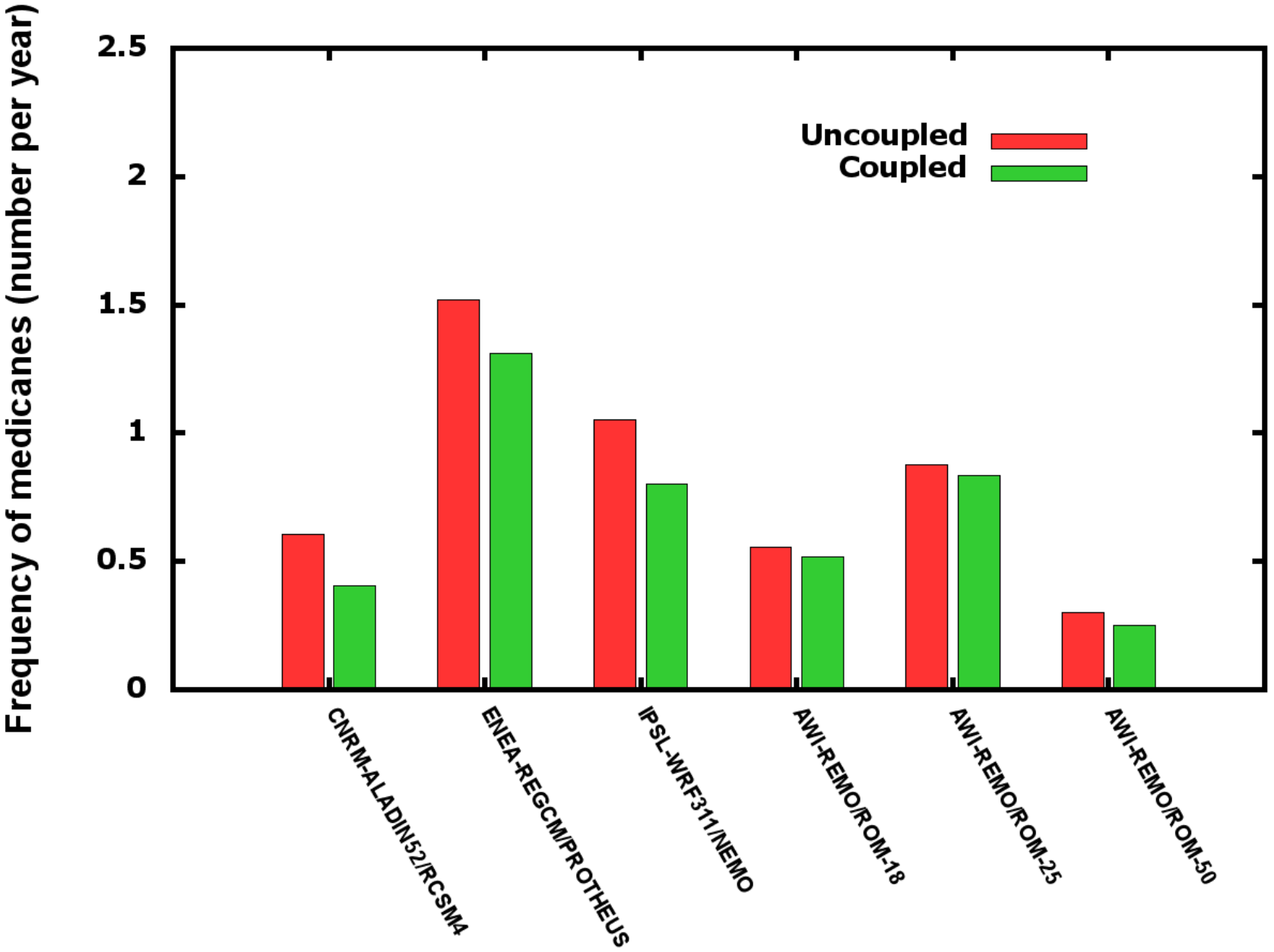


IPSL-WRF311NEMO (coupled, triangles)
IPSL-WRF311 (uncoupled, stars)
(20 km resolution)

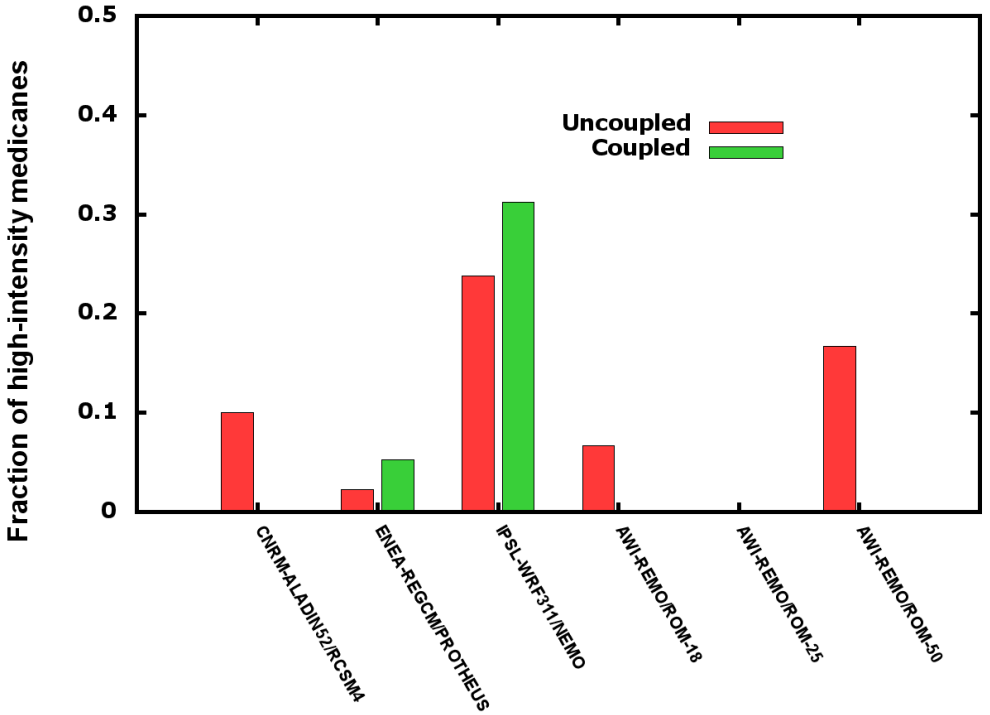
Frequency:
Coupled: 0.7/year
Uncoupled: 0.95/year

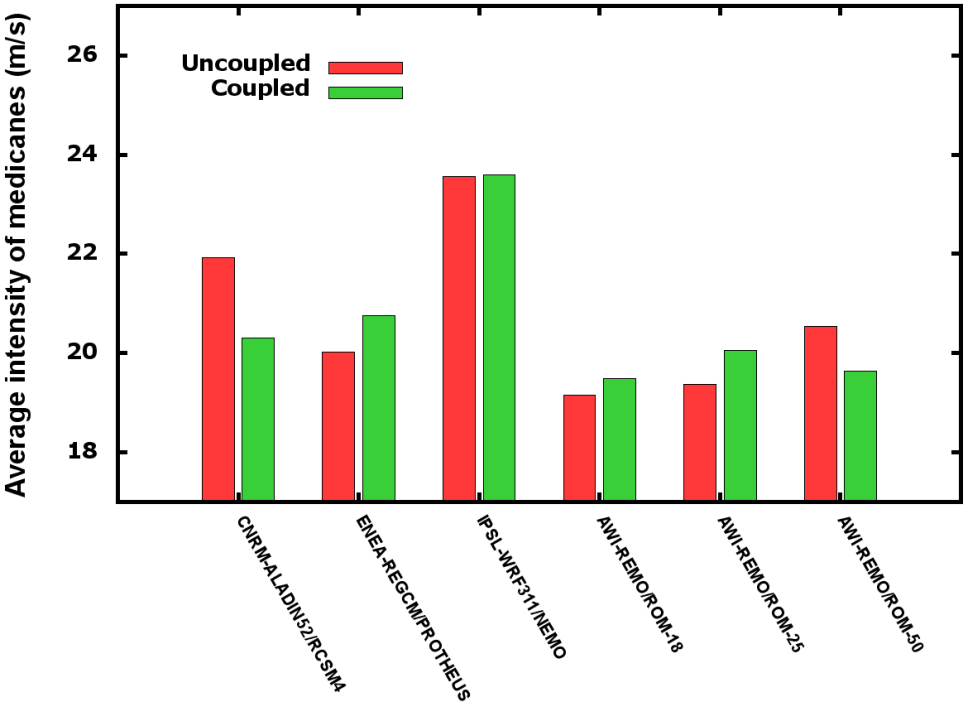
High intensity frequency:
Coupled: 0.07/year
Uncoupled: 0.11/year

Location and intensity of coupled and uncoupled runs



Location and intensity of coupled and uncoupled runs

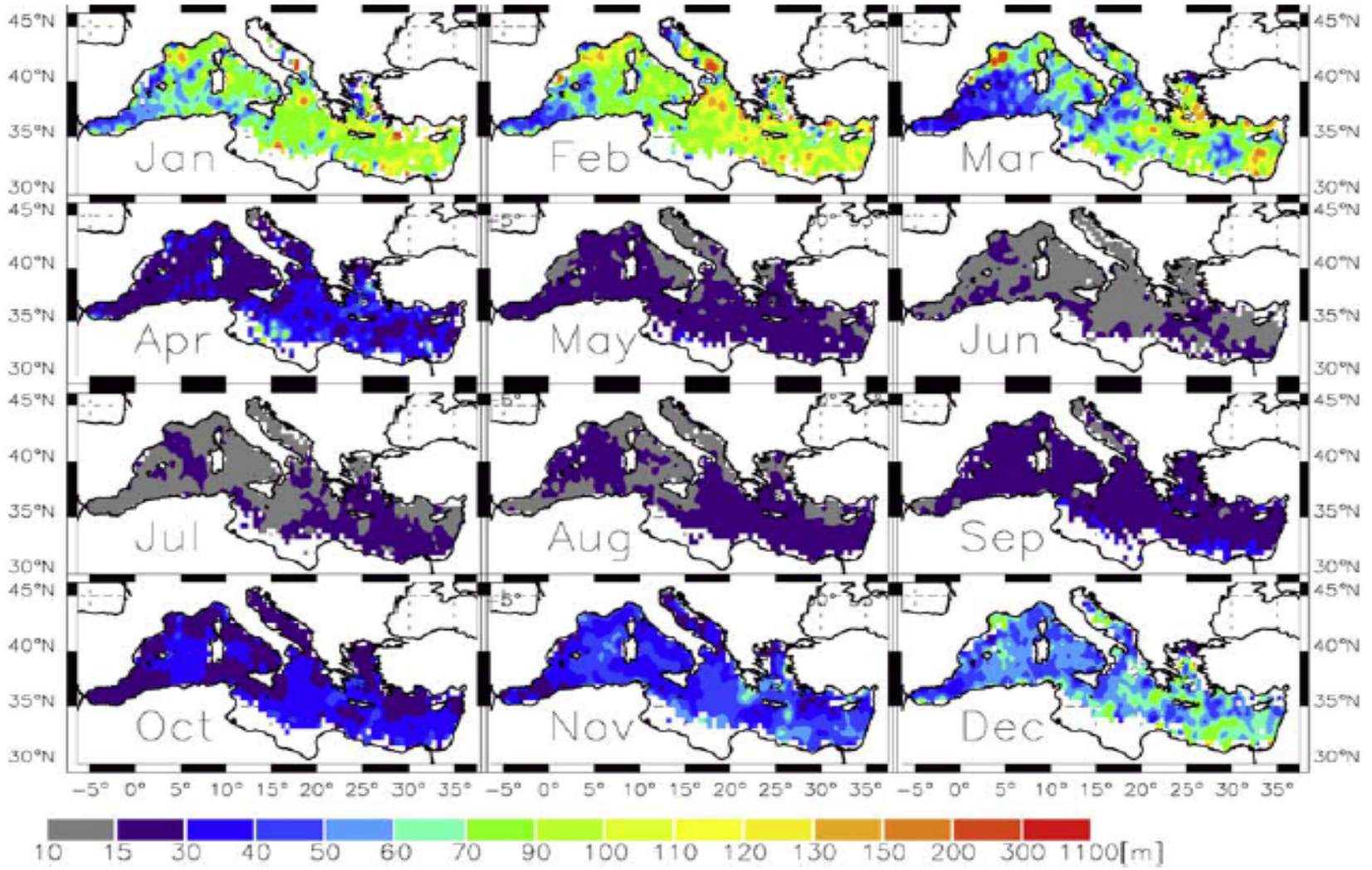




Possible factors influencing the air-sea coupling

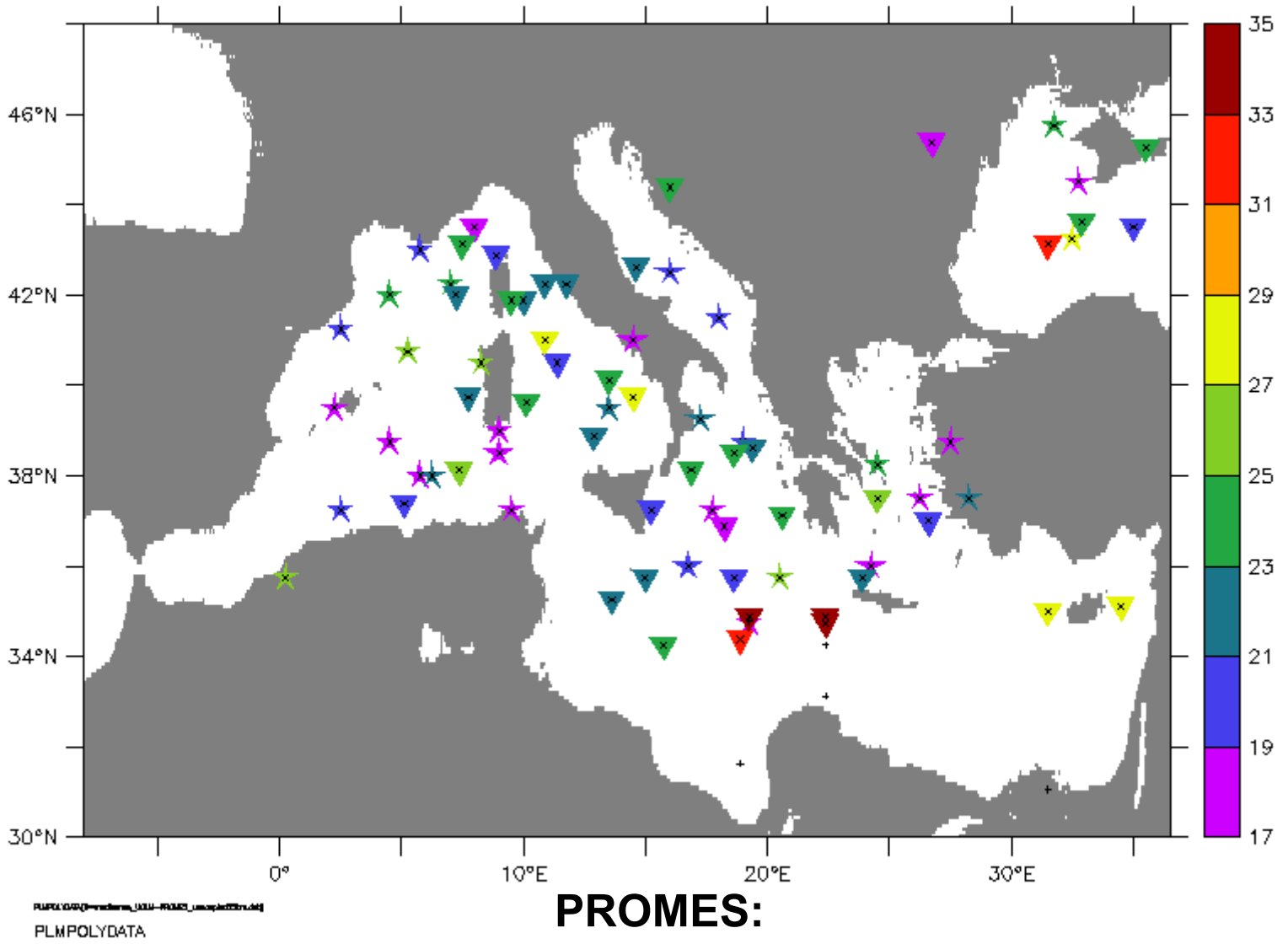
- SST

- Mixed layer depth: strong SST cooling if MLD low, no SST cooling if MLD high



Mediterranean mixed layer depth (d'Ortenzio et al., 2005)

Location and intensity of low and high resolution runs



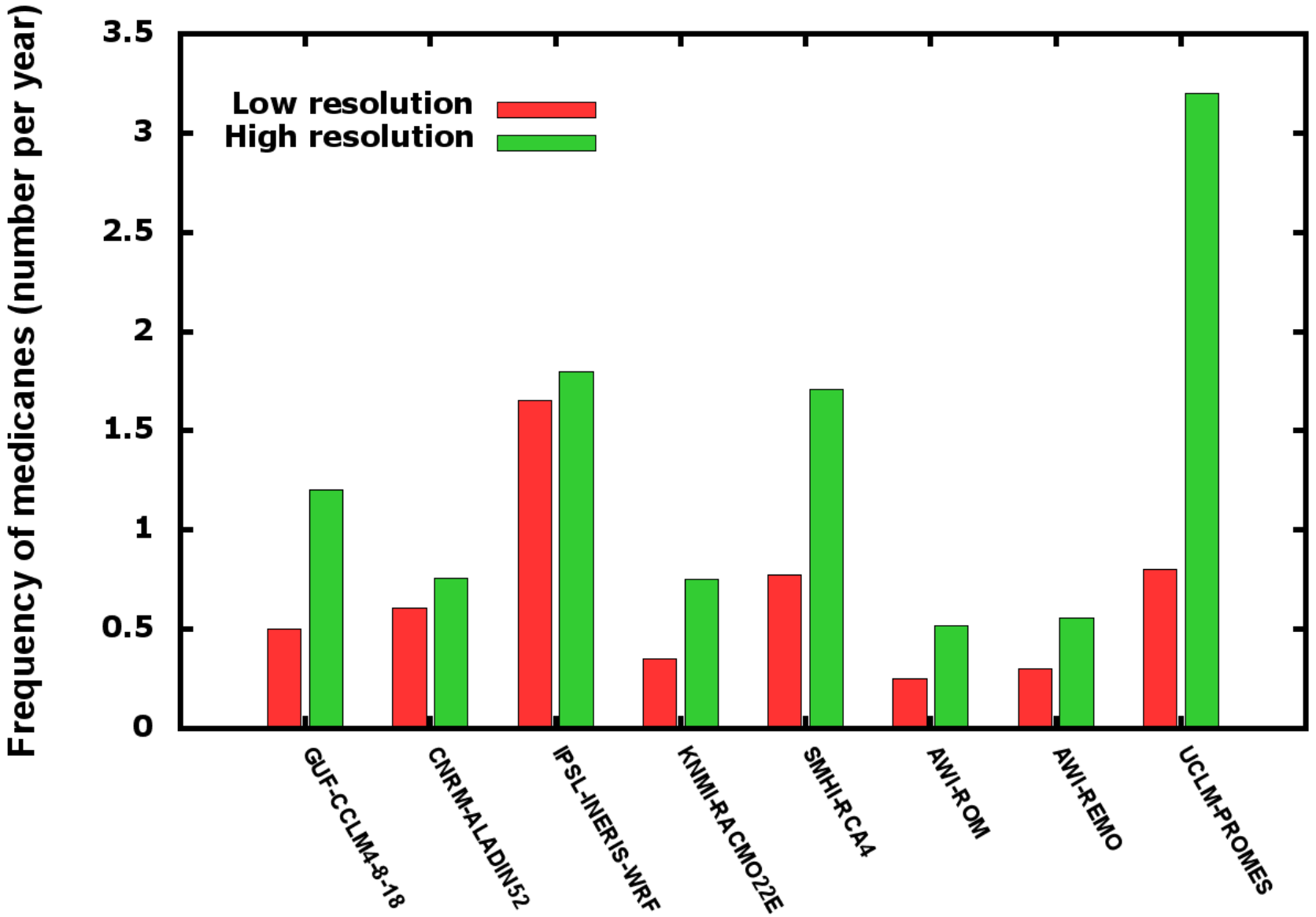
Intensity (wind, m/s)

PROMES:
High resolution: 12.5km, triangles
Low resolution: 25 km, stars

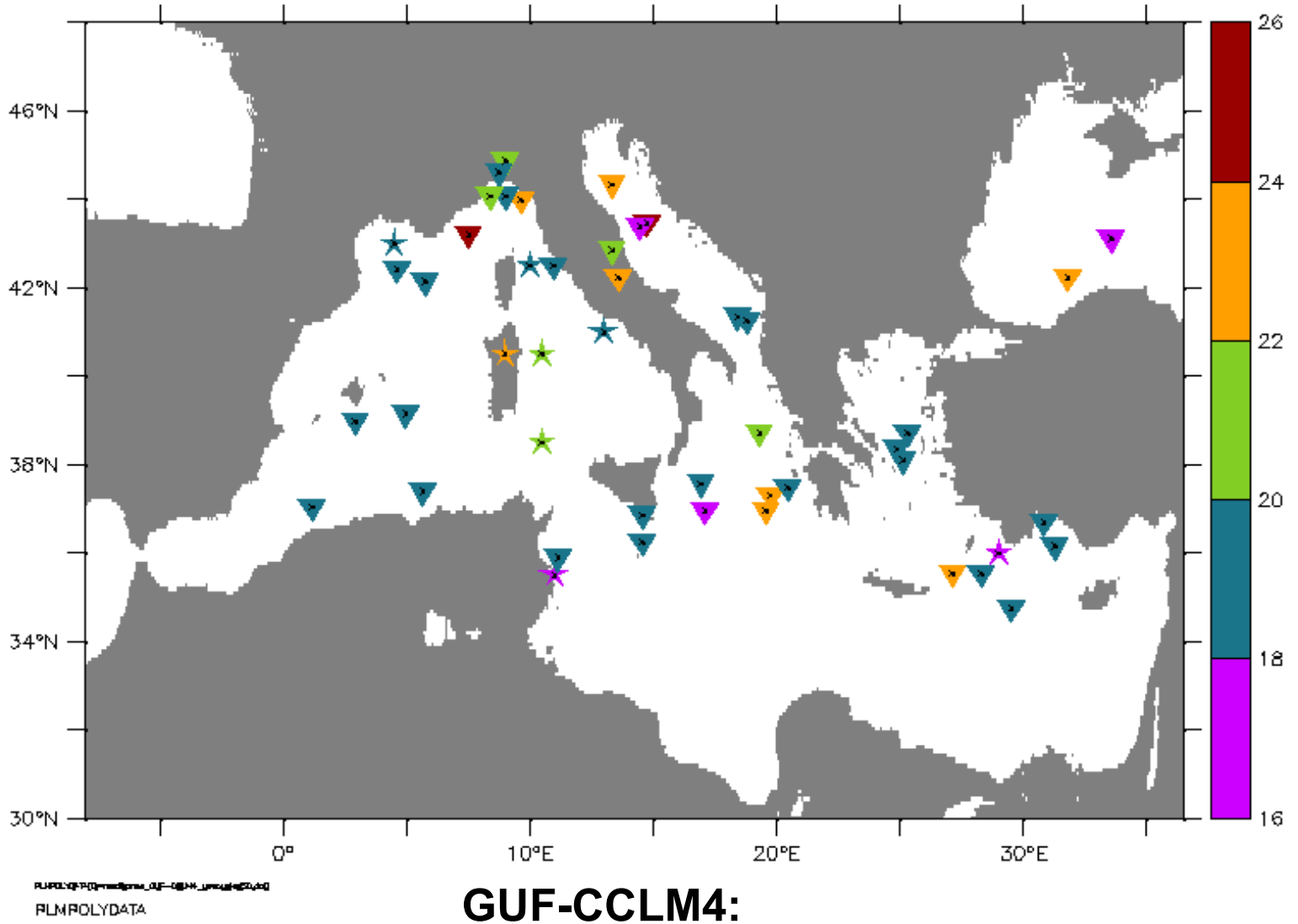
Frequency:
High res.: 1.9/year
Low res.: 1.5/year

High intensity frequency:
High res.: 0.55/year
Low res.: 0.25/year

Location and intensity of low and high resolution runs



Location and intensity of low and high resolution runs



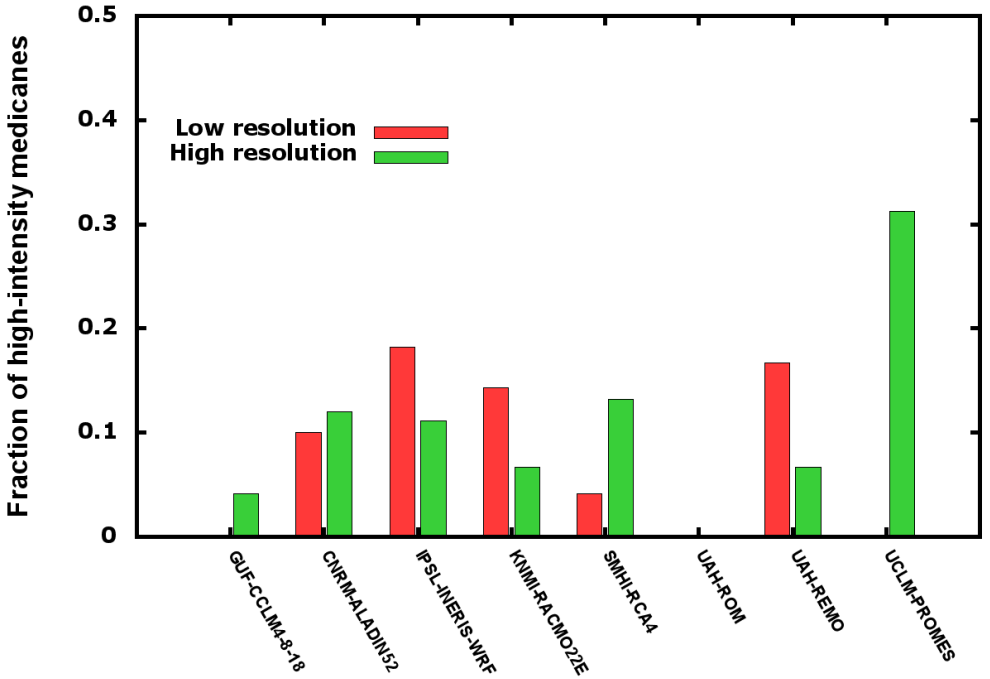
Intensity (wind, m/s)

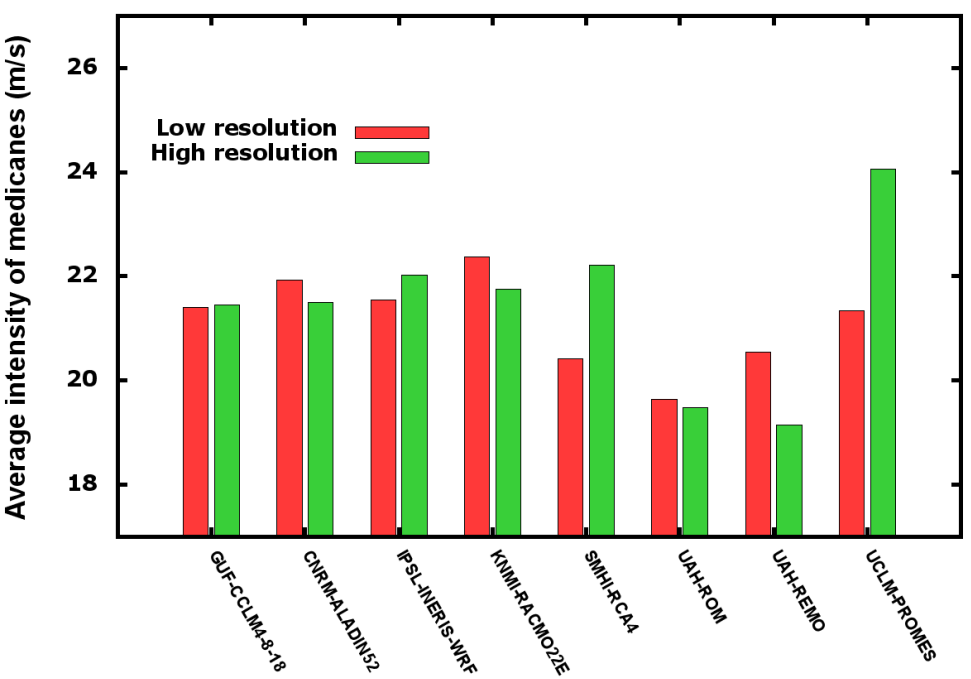
GUF-CCLM4:
High resolution: 10km, triangles
Low resolution: 50 km, stars

Frequency:
High res.: 1.95/year
Low res.: 0.45/year

High intensity frequency:
High res.: 0.05/year
Low res.: 0

Location and intensity of low and high resolution runs



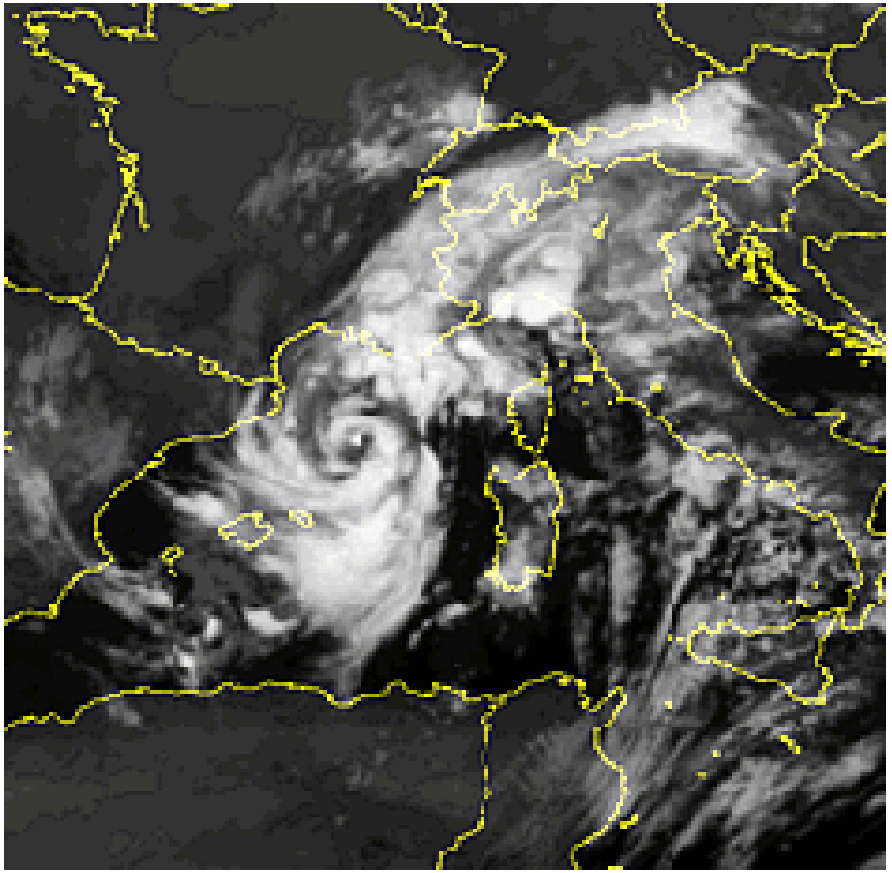


Final remarks

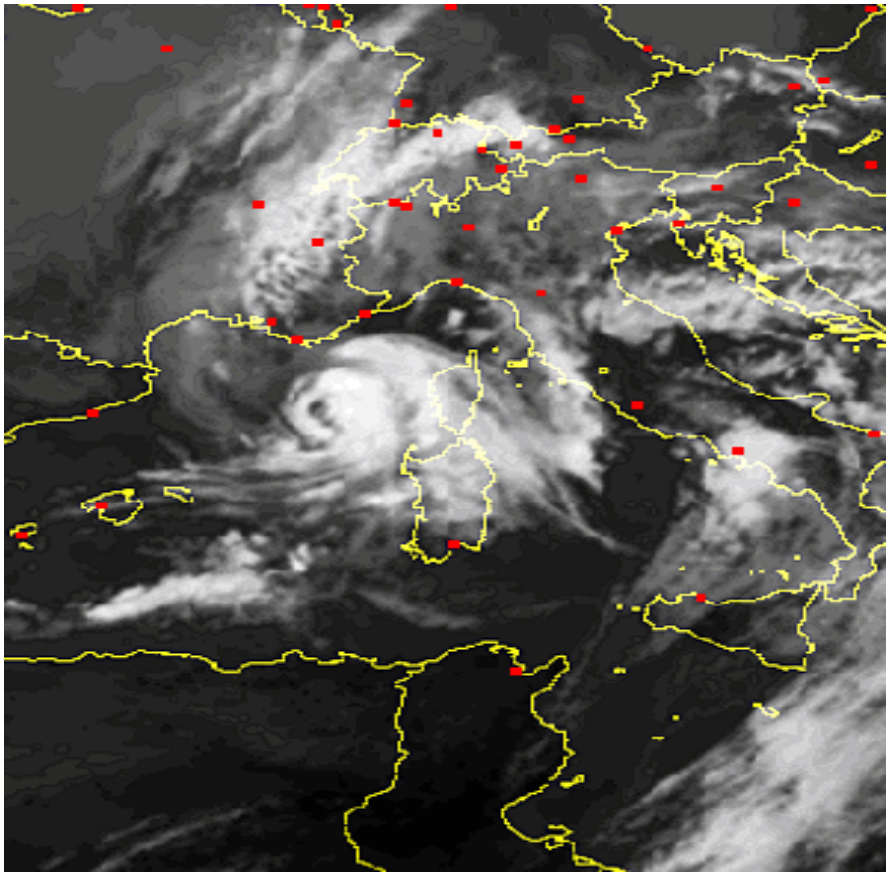
- **RCMs are able to simulate medicanes**
- **Most models underestimate the intensity of medicanes**
- **Location: RCMs capture displacement to the south in comparison to baroclinic cyclones**
- **High resolution impact: higher frequency**
- **Air-sea coupling impact: lower frequency in coupled simulations**

Acknowledgements: this work is being funded by the Spanish Economy and Competitivity Ministry, through grants CGL2010-18013 and CGL2013-47261-R

A recent “medicane” example



8/11/2011 (02h15')



8/11/2011 (11h15')

IR satellite image