Coupled Long-term Wave Simulations Based on Regional Earth System Model over the Mediterranean Sea

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Outline

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- Model Domain & Configuration
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Motivation

- The aim of this study is investigating the adding value of the air-sea interaction produced by atmosphere-ocean-wave coupling in climate simulations.

- To investigate the capturing ability of the coupled model in generating the general charactheristics of the wave climatology and wave conditions in extreme weather across the Mediterranean Basin.

RegESM Design

- Model components merged with ESMF/NUOPC
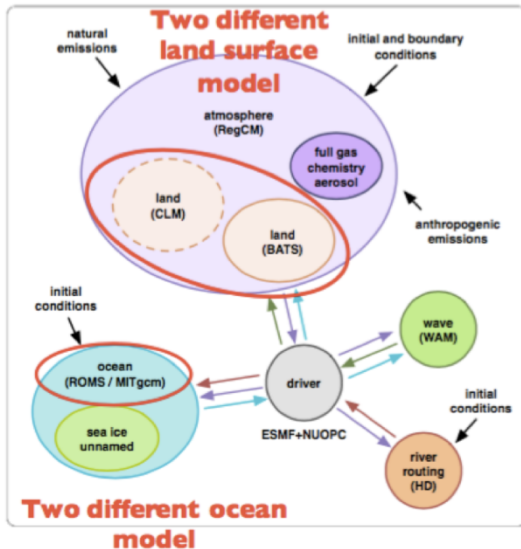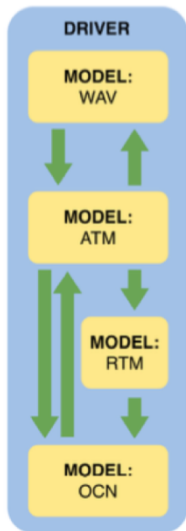
ATM:
ICTP's RegCM 4.4 / 4.5

OCN:
Rutgers Univ.
ROMS (r737)
MITgcm (63s / 64s)

WAV:
ECMWF's WAM
4.5.3 MPI

RTM:
Max Planck's HD
(1.0.2 modified)
Special thanks to
Prof. Stefan Hagemann

Following combination of model components can be used: 2 component: ATM-OCN, ATM-WAV, 3 component: ATM-OCN-RTM, 4 component: ATM-OCN-WAV-RTM
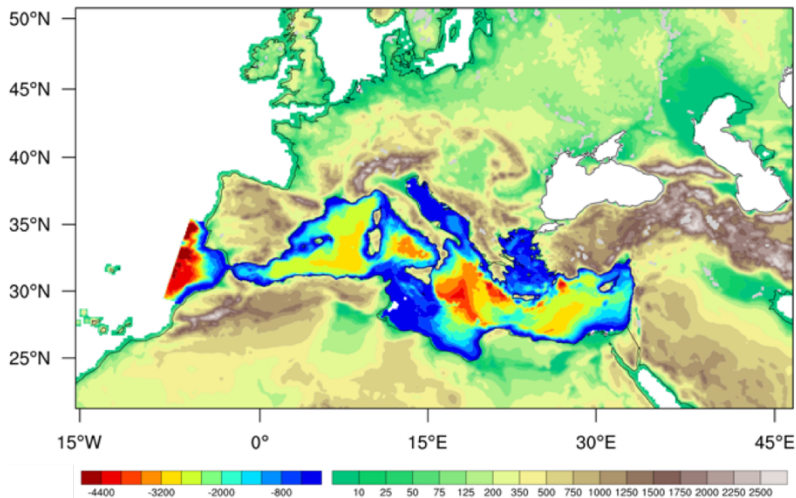
Model Domain & Configuration

Atmosphere: RegCM 4.6.0 (12 km)
Ocean: ROMS revision 809 (1/12º ~9km)
Wave: WAM Cycle-4 (4.5.3-MPI) (0.125º

- Closed boundary in Atlantic used as a bufferzone
- Model has been forced with ERA-Interim reanalysis for the 1979-2012 period.
- The coupling timestep is 1hour and exchanged variables among the models are;
  - **ATM-OCN:** windstress, surface air pressure, short wave radiation, net heat and fresh water flux (E-P)
  - **OCN-ATM:** sea surface temperature
  - **ATM-WAV:** wind
  - **WAV-ATM:** roughness length


Model Domain: Med-CORDEX

Precipitation, 2m Temperature and Sea Surface Temperature

- Precipitation distribution over the Mediterranean Sea is well represented with RegESM.

- There is no clear sign for the precipitation over land.

- Using RegESM improves SST representation of the Med. Sea.

- 2m temperature occurence probability is captured well with RegESM.
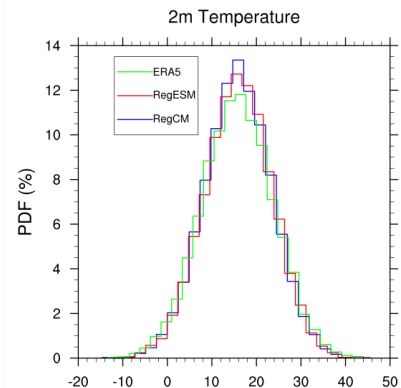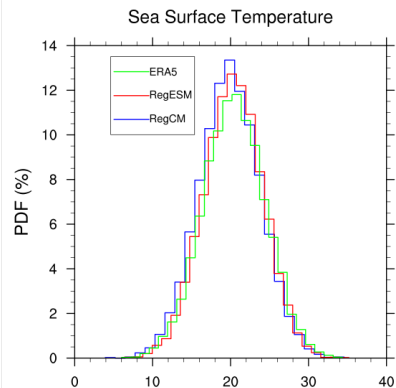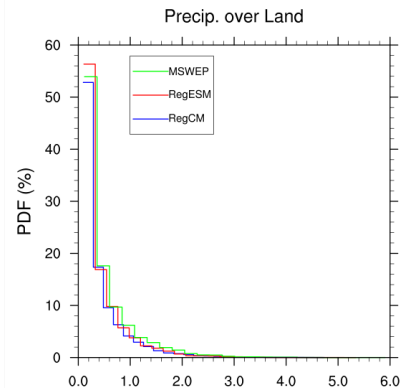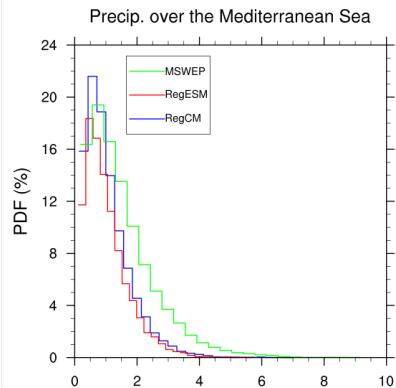
Wind

- Both standalone RegCM and RegESM overestimates wind speed with respect to ERA5.

- RegESM improves wind speed representation over the Med. Sea with respect to RegCM in some seasons.

- Both model captures the Etesian winds over the Aegean Region during summer.
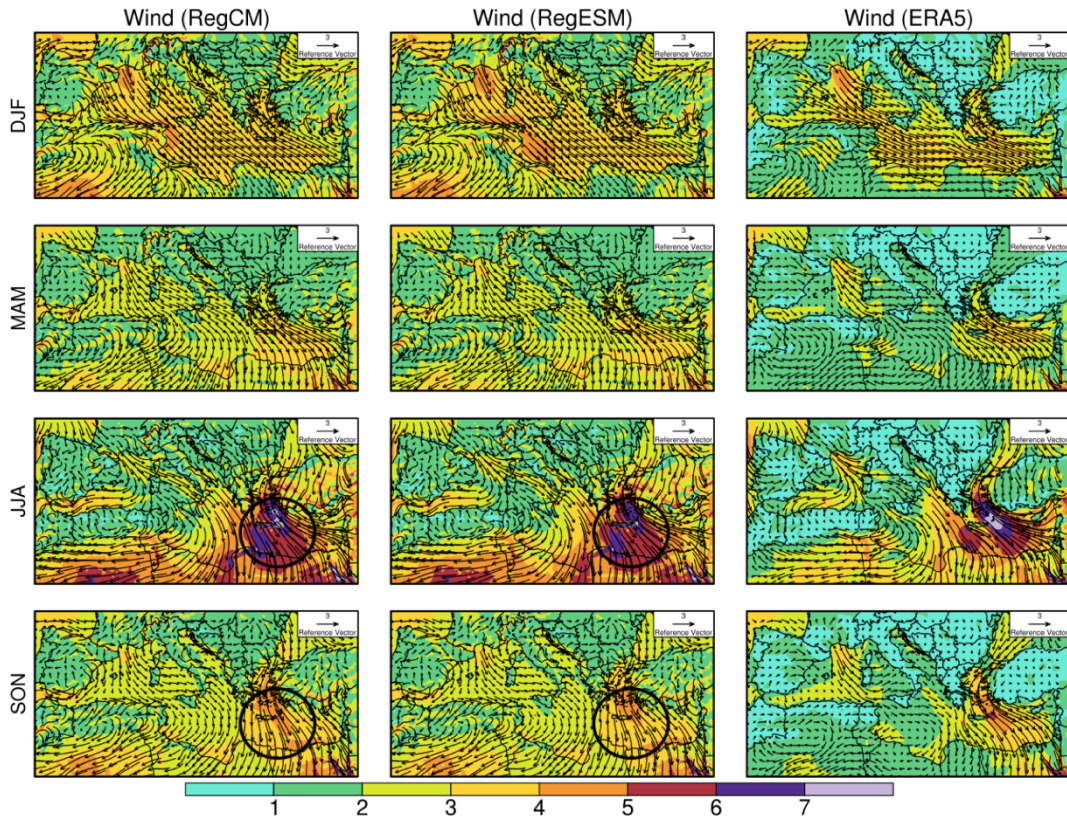
Significant Wave Height

- Standalone WAM overestimates the significant wave height (swh) in some seasons, especially over the Eastern Med.

- Significant Wave Height Climatology is well represented with coupled model
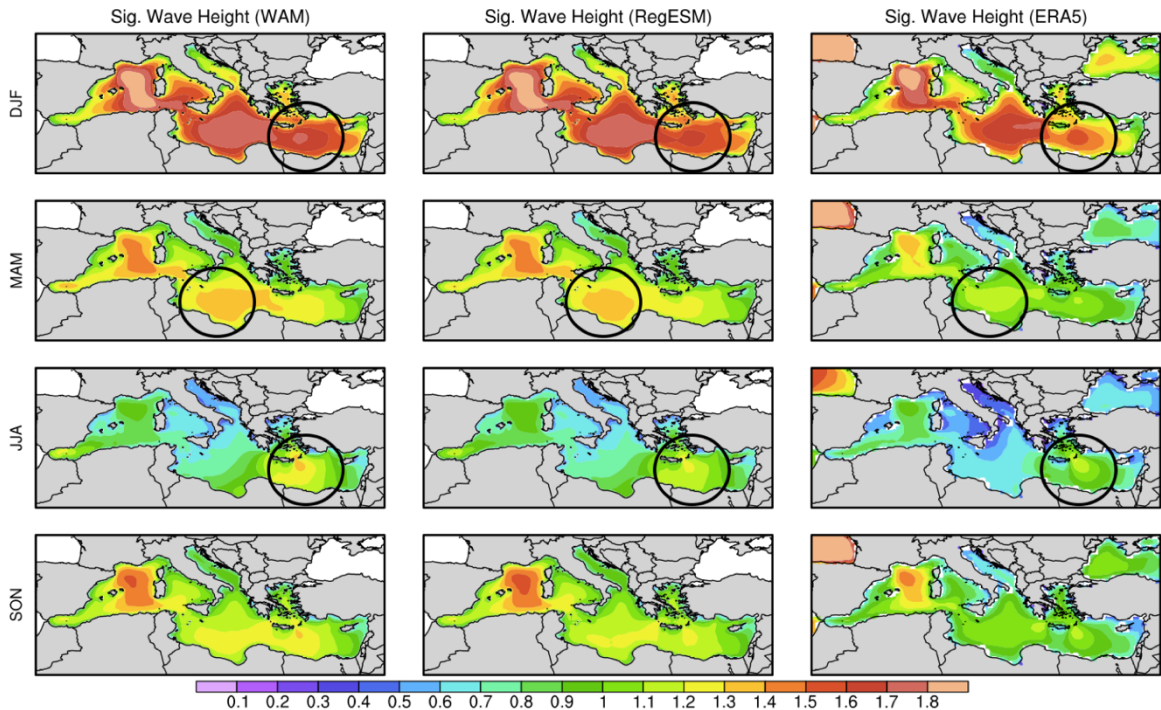
Average of Extreme Significant Wave Heights & Wind Speeds during the Winter Season

- RegESM improves extreme wind speed representation.

- Extreme Significant Wave Height is well represented with RegESM compare to WAM.

Wind (RegCM-ERA5)

Wind (RegESM-ERA5)

Significant Wave Height (WAM-ERA5)

Significant Wave Height (RegESM-ERA5)
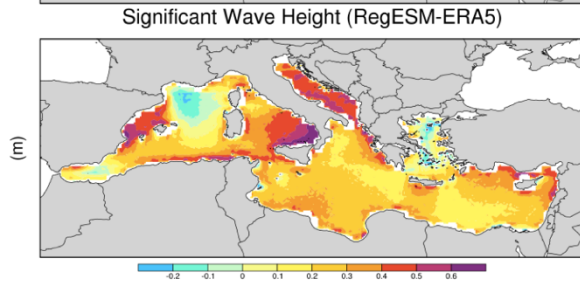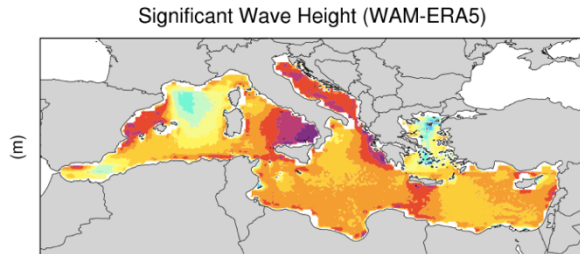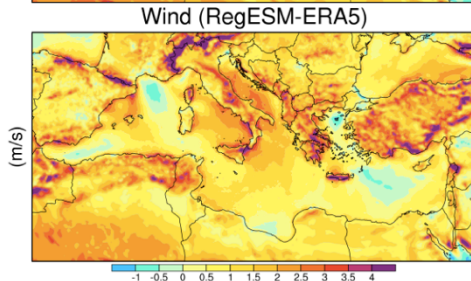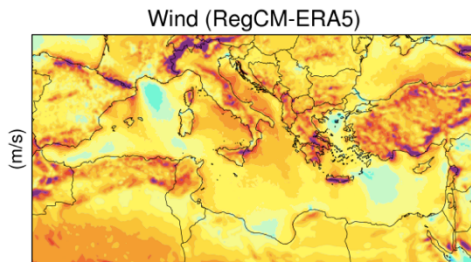
- Standalone WAM overestimates the extreme significant wave heights especially over the central and eastern Mediterranean during Winter.

Point-based comparison of SWH

- RegESM produces less bias for swh.

- Both standalone WAM and RegESM over-estimates swh by the end of August but RegESM improves the magnitudes compare to WAM.

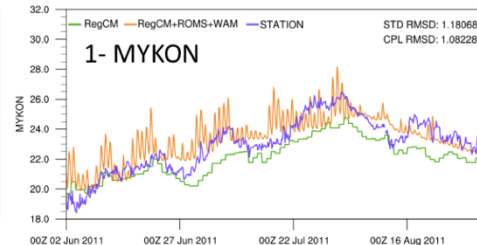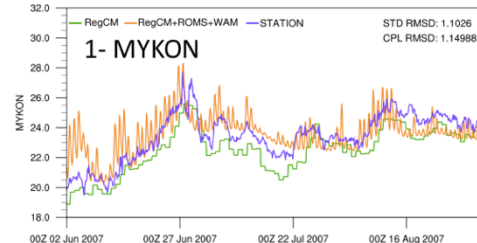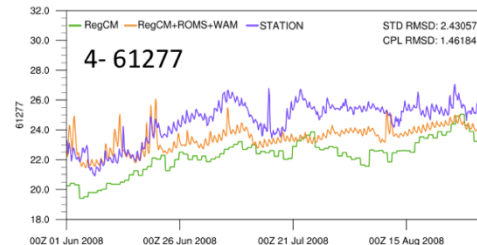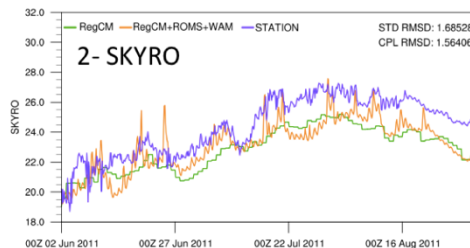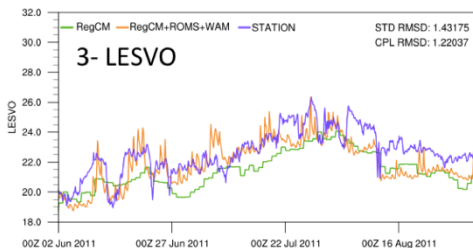- MYOCEAN data has been used as an observation.
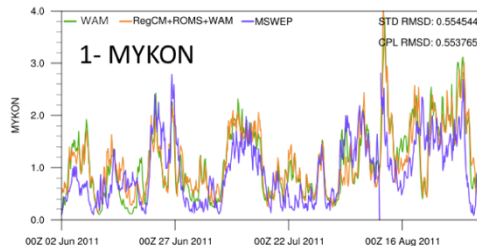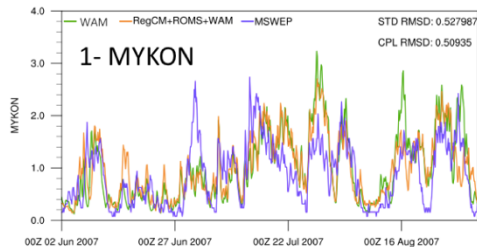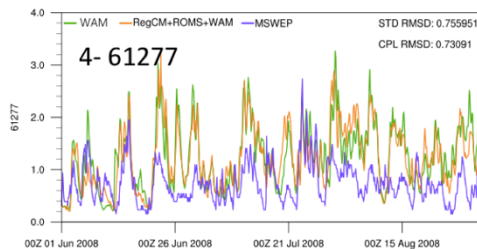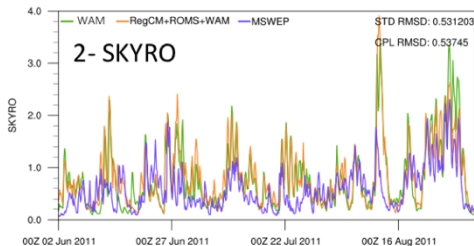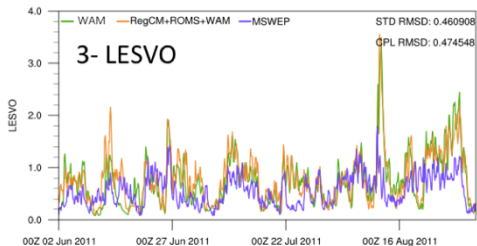
Point-based comparison of SST

- Both simulations are able to provide sst distributions.

- RegESM produces less bias for SST variable.

- Standalone RegCM underestimates SST values for the Summer season.

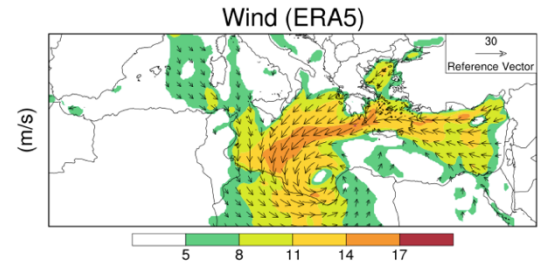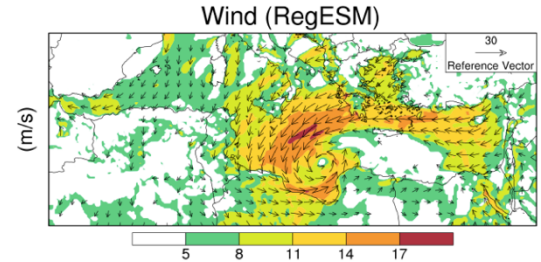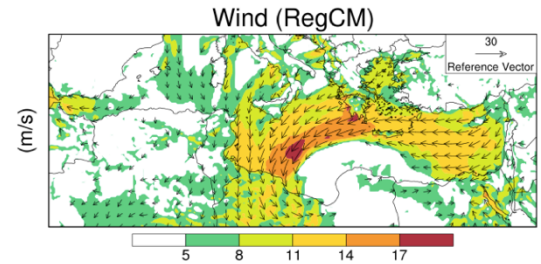- MYOCEAN data has been used as an observation.

A snapshot of a medicane event on 1st February 2006 to test the capturing ability of the coupled model (RegESM)

- Storm symmetry, wind speed and direction are well captured and better represented by RegESM compare to RegCM.


Satellite image from https://worldview.earthdata.nasa.gov
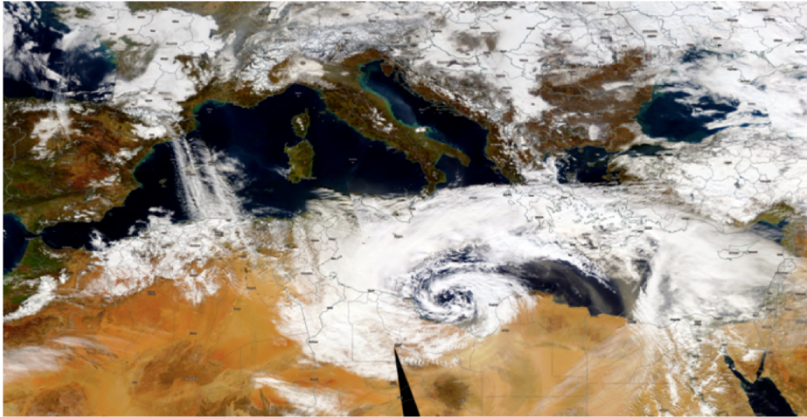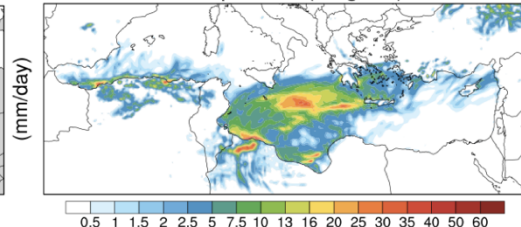
A snapshot of a medicane event on 1st February 2006 (18Z)

- Standalone WAM overestimates the significant wave height and doesn't capture the symmetry of the cyclone as well as RegESM.

- Significant Wave Height is well represented with RegESM.

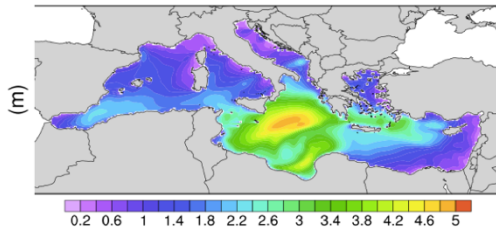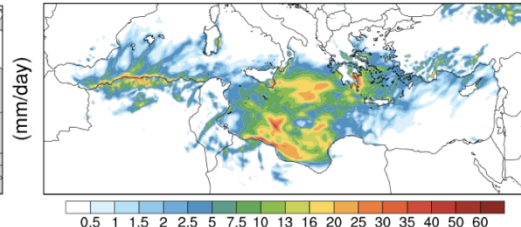- Precipitation amount and pattern is well represented with RegESM with respect to MSWEP observations.
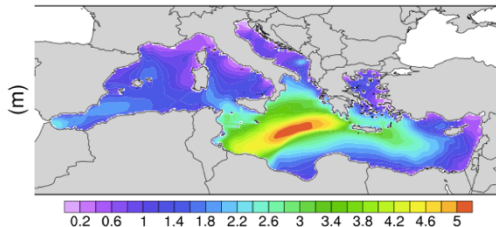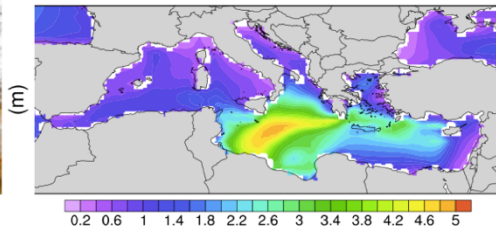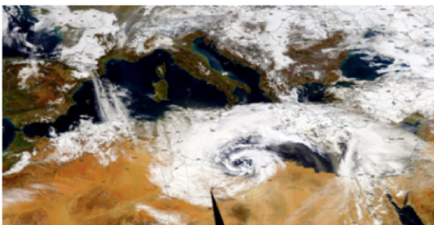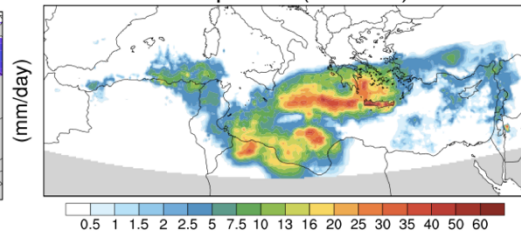
Conclusions

- Using RegESM improves on some standalone model limitations.

- Compare to standalone WAM simulations, RegESM represents significant wave heights more accurately in terms of magnitude and distribution.

- RegESM improves wind speed and direction representation especcialy for the extreme cases.

- The cyclonic distribution of wind and rainfall caused by medicane is captured well with RegESM.

Questions!

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