Sensitivity study of two Mediterranean tropical-like storms

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Introduction

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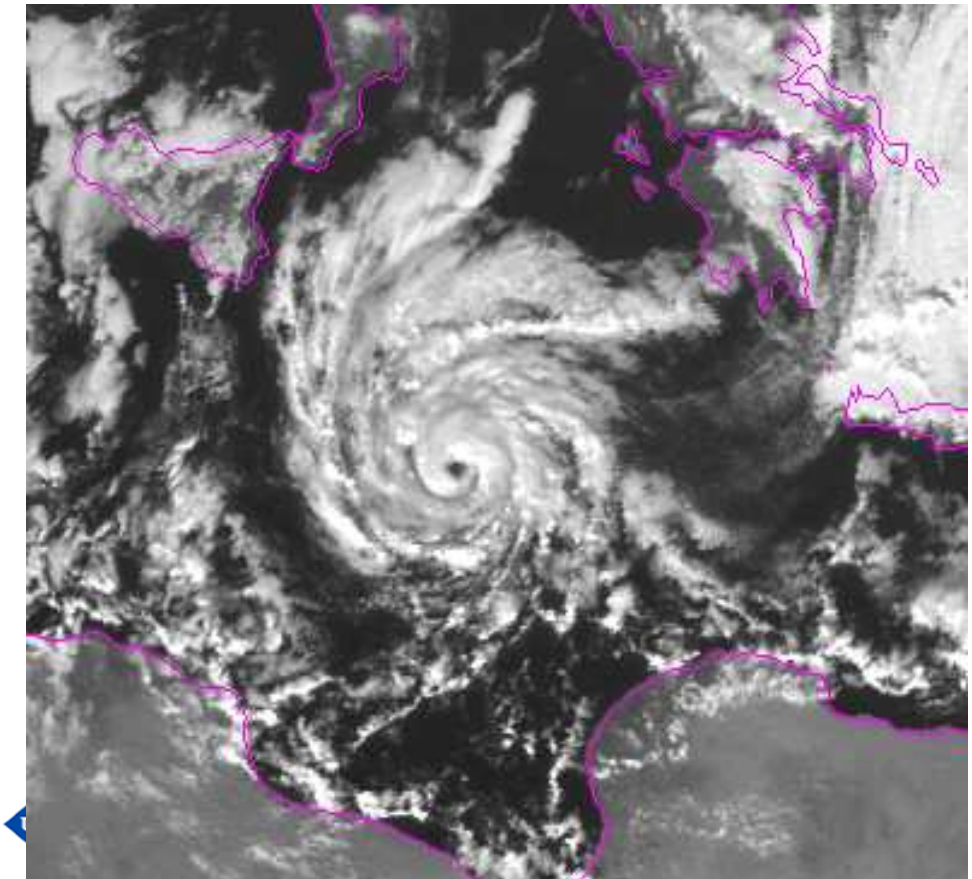

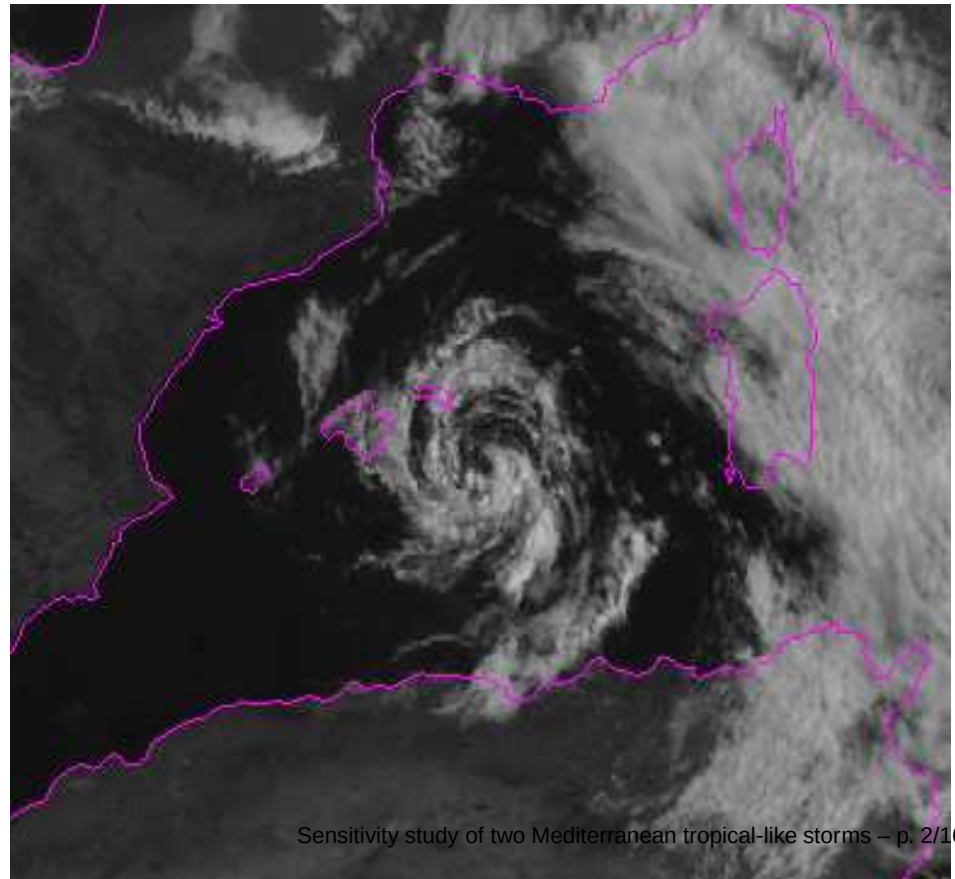

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- Factor separation
- Factor separation results
- Conclusions

Introduction

Description of a ’medicane’

- ’Satellite’ evidences

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Description of a ’medicane’

- ’Satellite’ evidences
  - Rounded cloud structure with a clear eye-like center
  - High instability
  - Strong vorticity

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Description of a ’medicane’

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NVIS-950116

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NVIS-030527

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Description of a ’medicane’

- Synoptic environment

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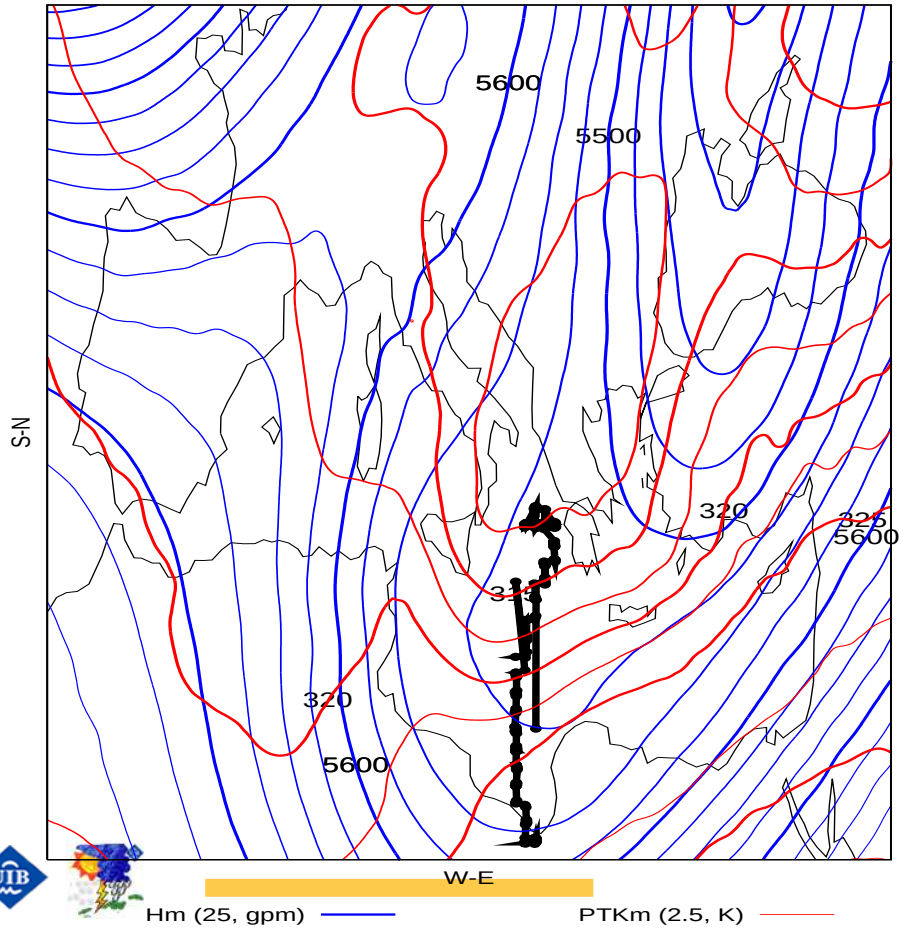
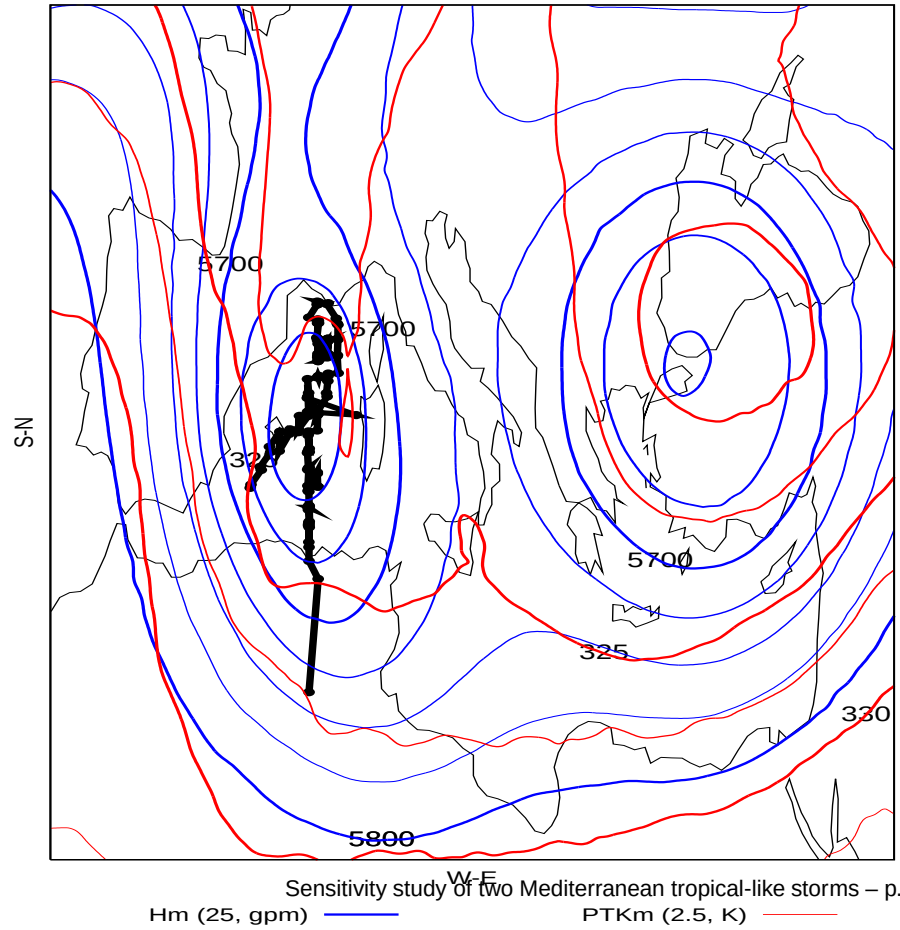
Description of a 'medicane'

- Synoptic environment
  - Upper level low ($\overline{H}_{500}$ & $\overline{PTK}_{300}$)





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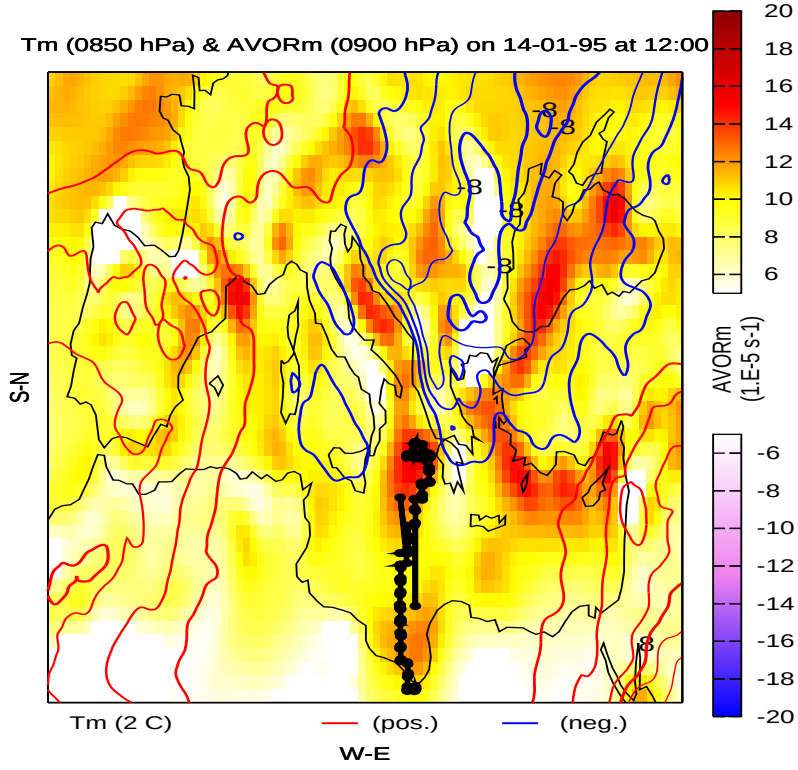
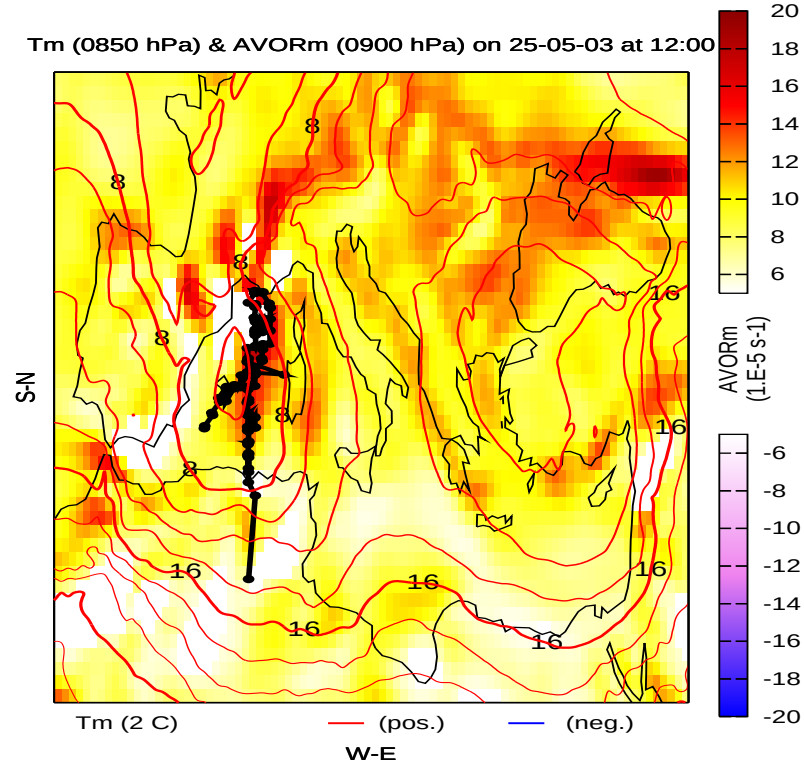
Description of a 'medicane'

- Synoptic environment
  - Strong thermal gradients and vorticity ($\overline{T}_{850}$ & $\overline{AVOR}_{900}$)





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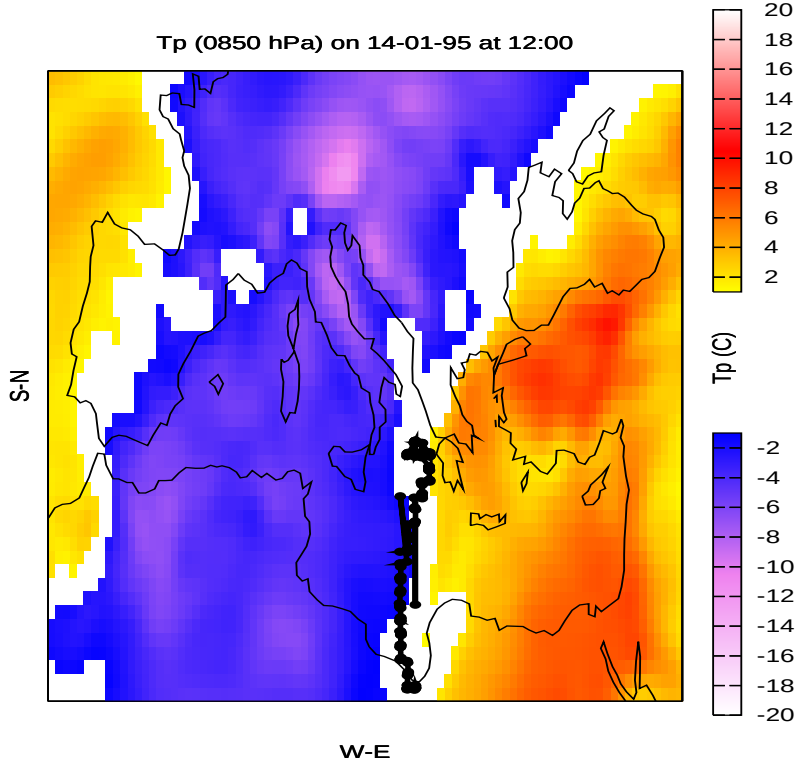
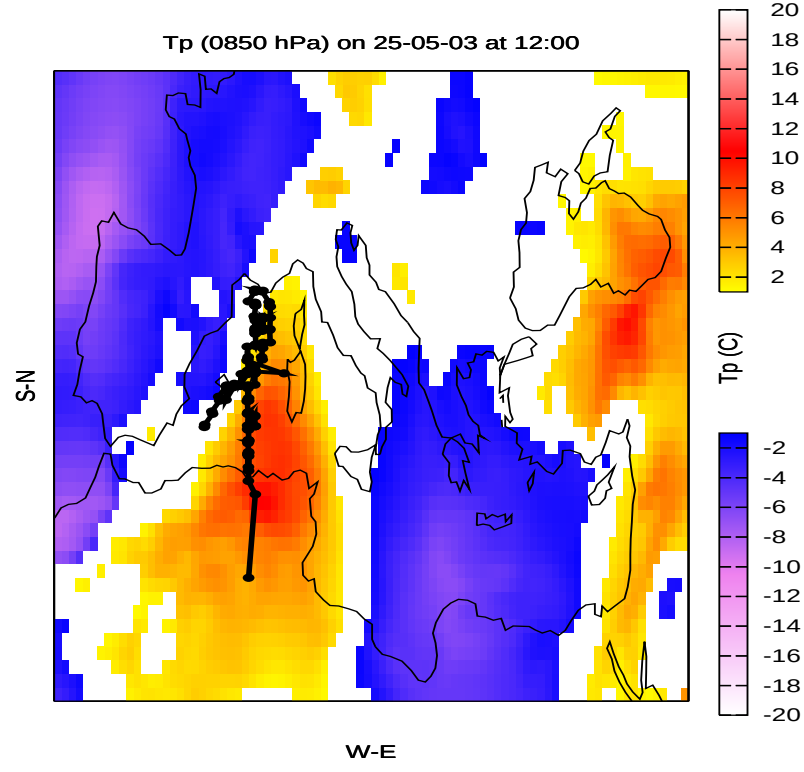
Description of a ’medicane’

- Synoptic environment
  - Significant initial thermal anomaly (Tp_{850})





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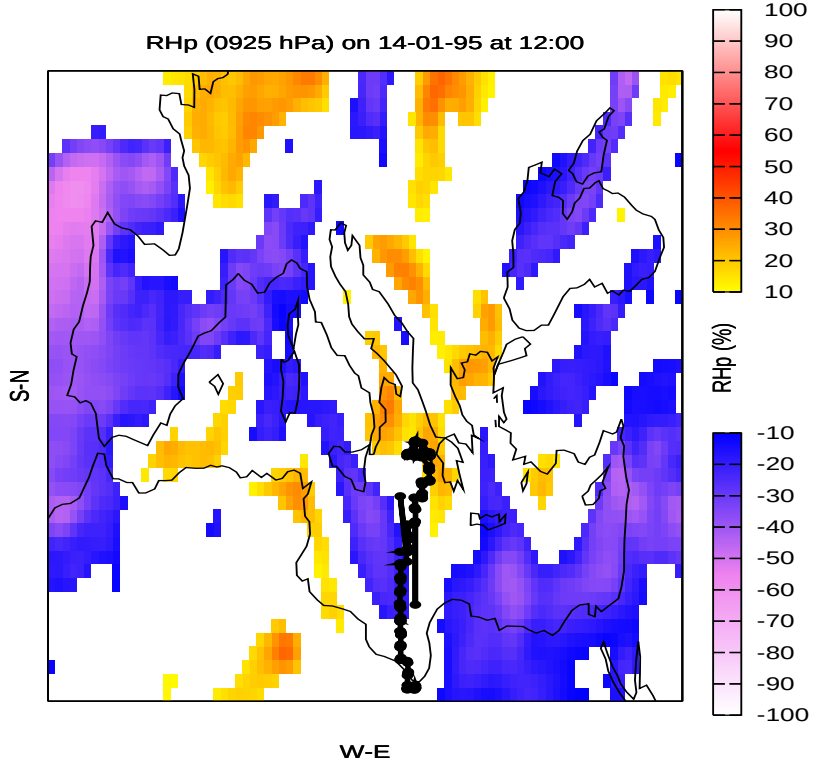
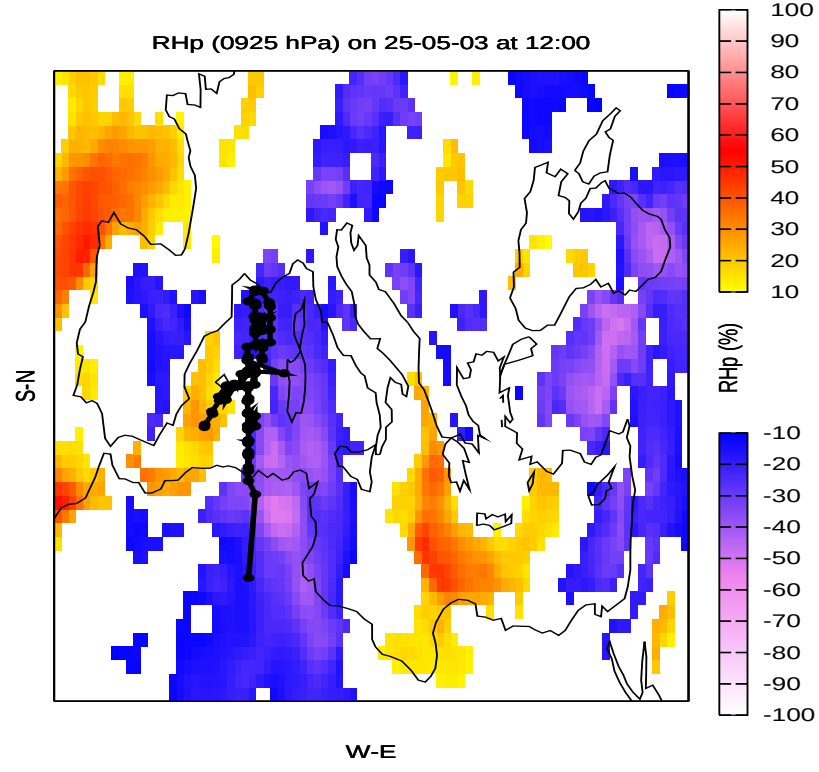
Description of a 'medicane'

- Synoptic environment
  - Absence of high amounts of humidity (RHp_{925})





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Main characteristics of a ’medicane’

- Tropical like structure in the Mediterranean environment

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Main characteristics of a ’medicane’

- Tropical like structure in the Mediterranean environment
- Merge of convective and baroclinic mechanisms
- ’Medicane’ evolution due to instability as a combination of SST and upper level cold low
- ’Medicane’ evolution may be affected by Mediterranean basin features: Small Sea, high surrounding orography, hot and dry air from North Africa plateau, ...

MM5 simulations

General characteristics

- MM5 v3.7 (ECMWF analyses & BUFR observations)
- 2 domains (15 i 5 km) i 23 vertical levels
- moisture scheme: graupel(reisner2)
- cumulus: Kain-Fritsch, ∅
- Planetary Boundary Layer: Blackadar
- Radiation scheme: cloud

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  - Domain 1: 150 x 120 centered at 37.0N, 17.0E
  - Domain 2: 223 x 121

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- 950116 case
  - Domain 1: 150 x 120 centered at 37.0N, 17.0E
  - Domain 2: 223 x 121
- 030527 case
  - Domain 1: 150 x 150 centered at 39.0N, 3.0E
  - Domain 2: 181 x 127

MM5 simulations

Control simulation results

- ’Medicane’ properly simulated: small dimensions vortex, similar trajectory

MM5 simulations

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PSEALVLC-950116

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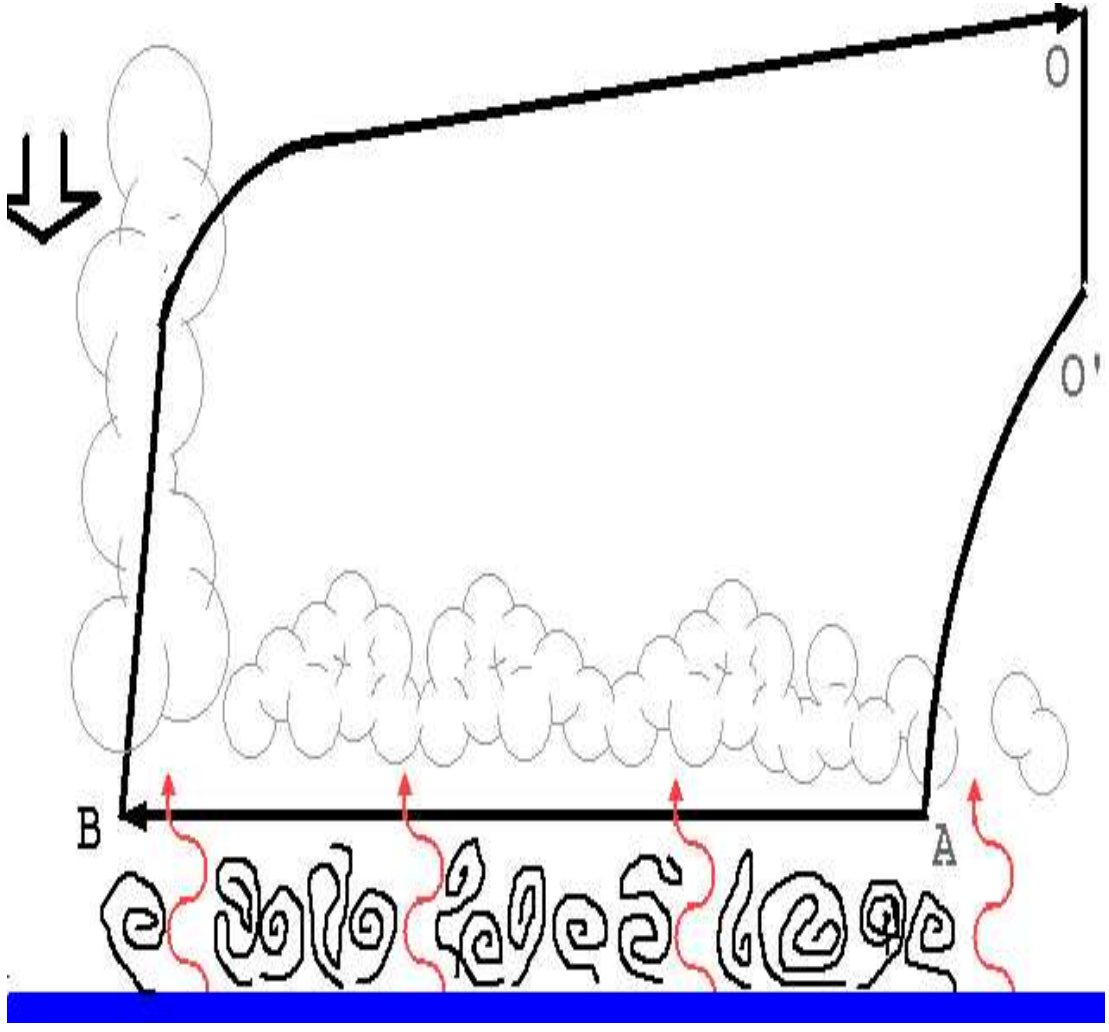
PSEALVLC-030527

Structure of a Tropical storm



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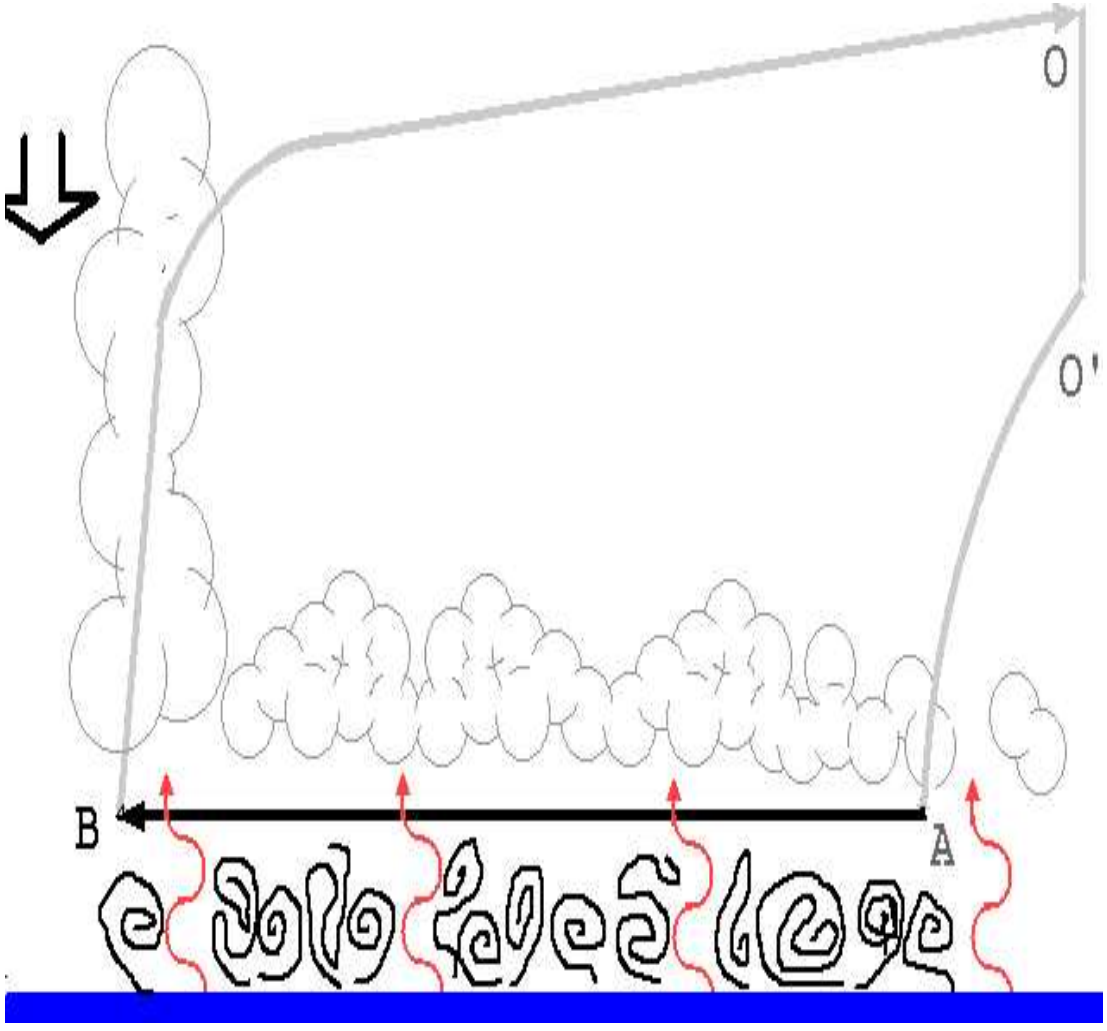
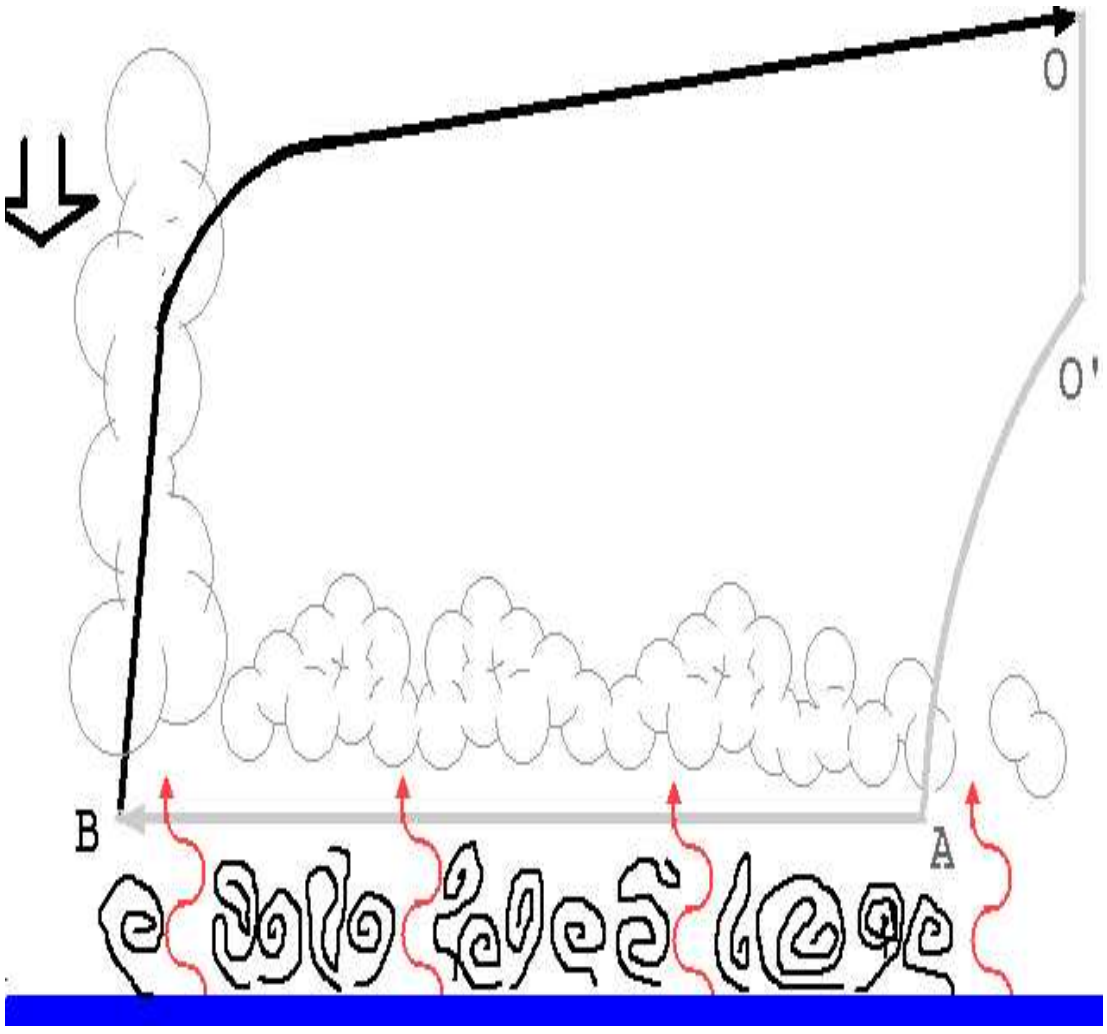


AB: Isothermic expansion

- Increase of energy from sea surface heat and moist fluxes
- SST sensitivity

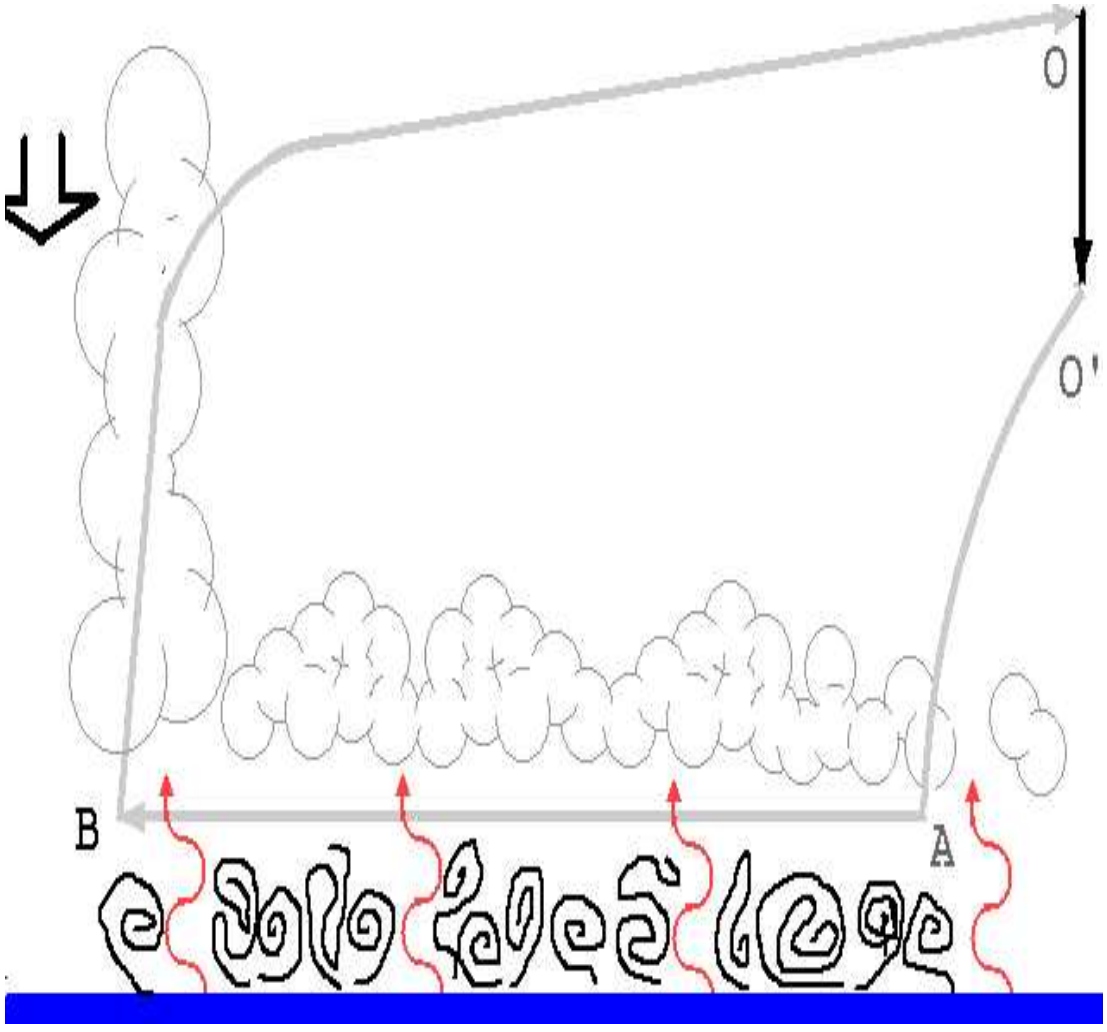
Structure of a Tropical storm



BO: Adiabatic expansion

- Adiabatic expansion of air
- Conservation of angular momentum

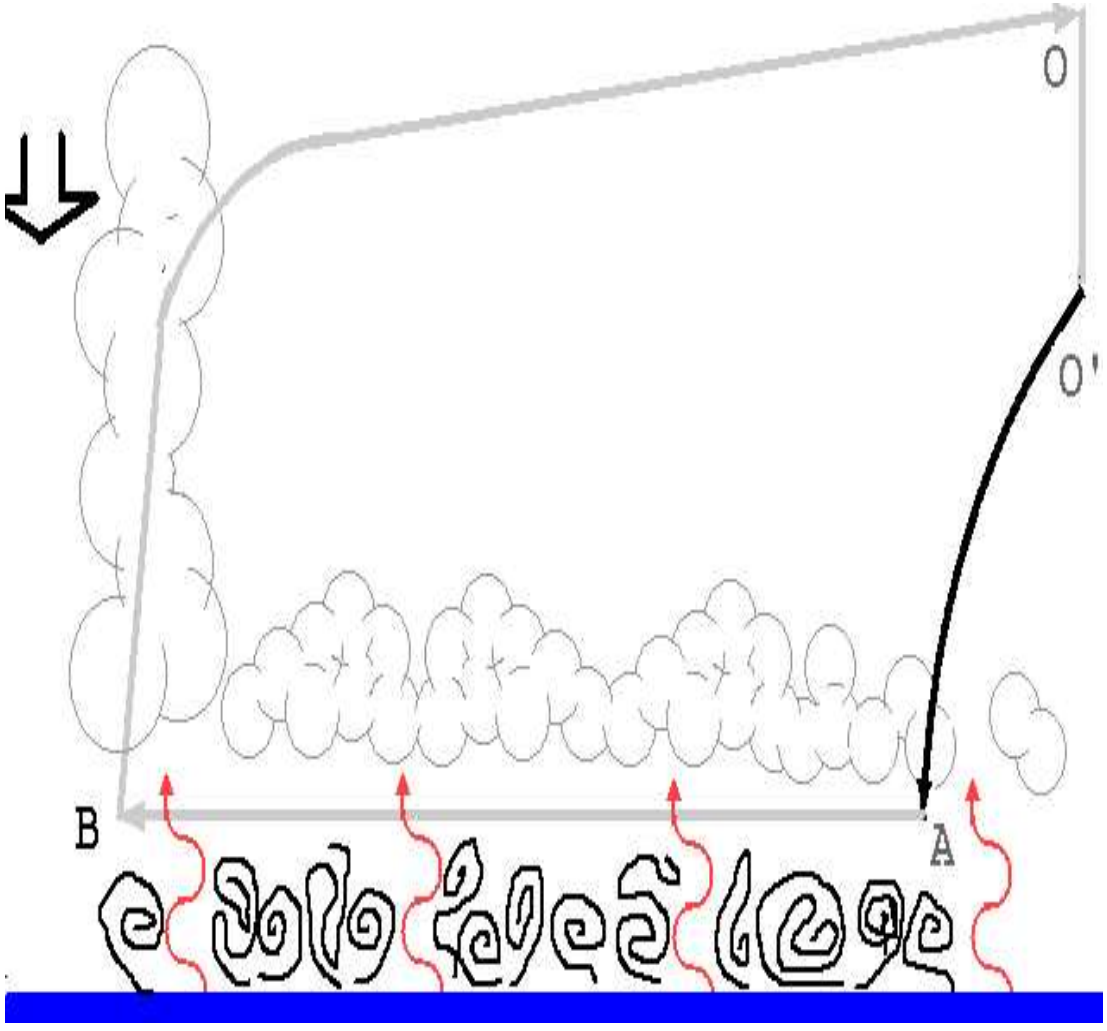
Structure of a Tropical storm



OO': Isothermic compression

- Radiative cooling
- Sensitivity to upper-level temperature

Structure of a Tropical storm



O'A: Compression

- Conservation of angular momentum

Factor separation

Description of factors

- f_1: LHFsea

Factor separation

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- f_1: LHFsea
  - Suppression of the Latent Heat Flux from the Sea
  - Effect on the energy source of the storm

Factor separation

Description of factors

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- f_2: SSHF

Factor separation

Description of factors

- f_1: LHFsea
- f_2: SSHF
  - Suppression of the Surface Sensible Heat Flux
  - Effect on the boundary layer: mixing efficiency, heat and moist transport

Factor separation

Description of factors

- f_1: LHFsea
- f_2: SSHF
- f_3: PVU

Factor separation

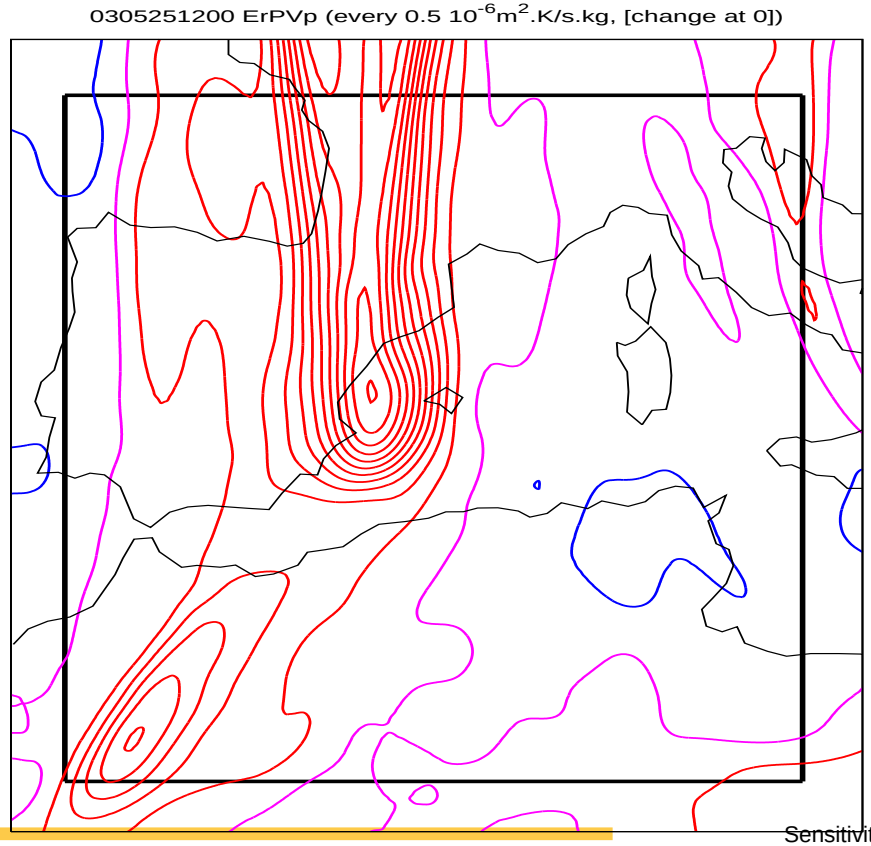
Description of factors

- f_1: LHFsea
- f_2: SSHF
- f_3: PVU
  - Modification of the Upper level cold low
  - 10% Decrease of almost all the ErPV upper level positive anomaly (until 500 hPa) of ECMWF analyses
  - Effect on the vertical instability and efficiency of the storm

Factor separation

Description of factors

- f_1: LHFsea
- f_2: SSHF
- f_3: PVU



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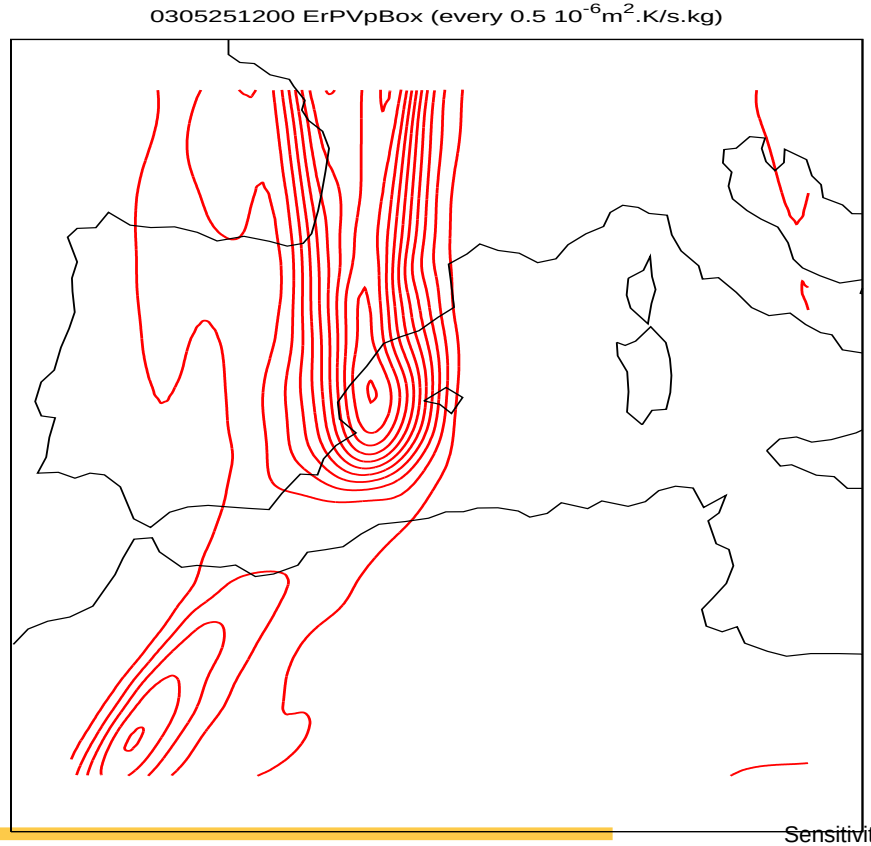

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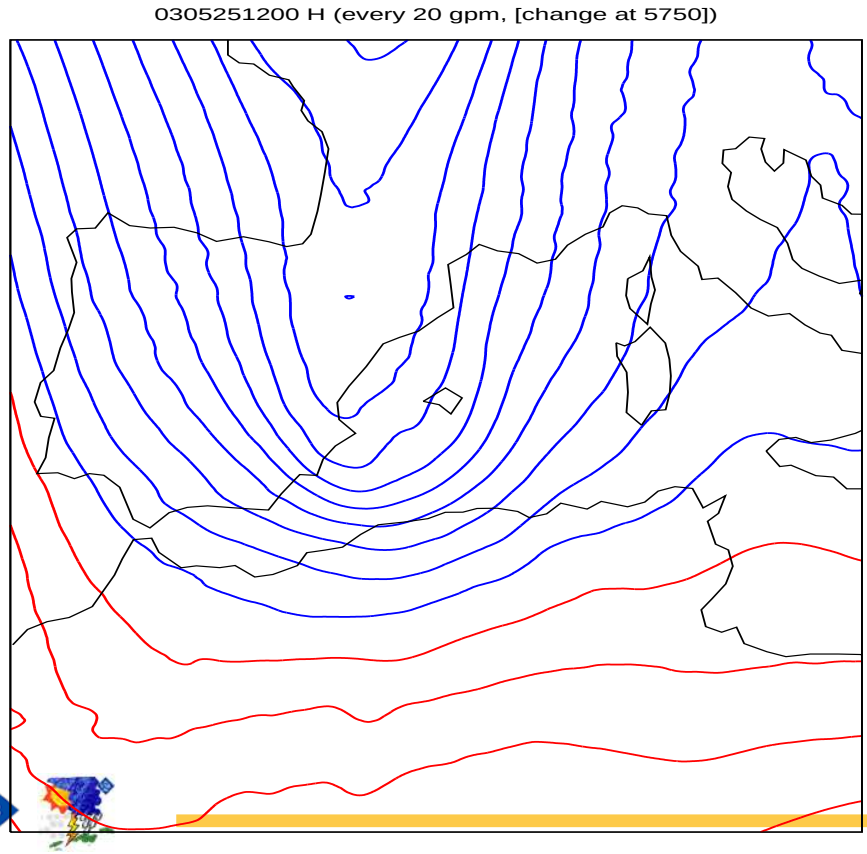

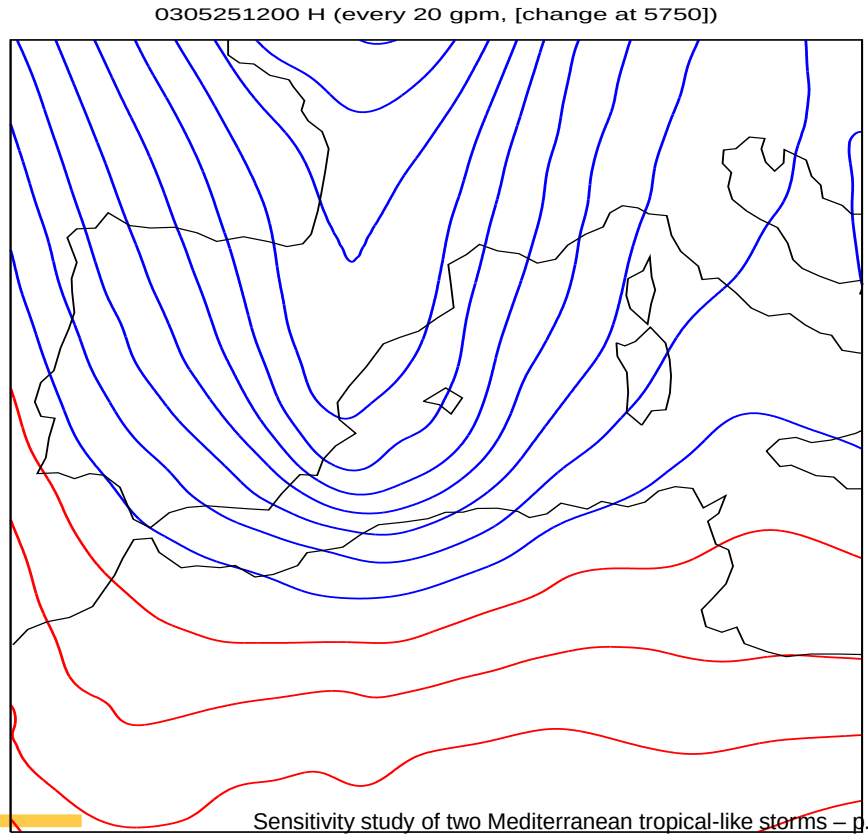

Factor separation

Description of factors

- f_1: LHFsea
- f_2: SSHF
- f_3: PVU
- f_4: SST

Factor separation

Description of factors

- f_1: LHFsea
- f_2: SSHF
- f_3: PVU
- f_4: SST
  - Modification of the Sea Surface Temperature
  - $5° K$ Decrease of the SST of ECMWF analyses
  - Effect on the energy source of the storm

Factor separation

Simulations

- Study of the factors $\{i, j, ...n\}$ on forecasted field f

Factor separation

Simulations

- s_0: Control simulation (f_{1234})

Factor separation

Simulations

- s_0: Control simulation (f_{1234})
- s_1: Simulation without LHFsea (f_{234})

Factor separation

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- s_0: Control simulation (f_{1234})
- s_1: Simulation without LHFsea (f_{234})
- s_2: Simulation without SSHF (f_{134})

Factor separation

Simulations

- s_0: Control simulation (f_{1234})
- s_1: Simulation without LHFsea (f_{234})
- s_2: Simulation without SSHF (f_{134})
- s_3: Simulation -10% UPV (f_{124})

Factor separation

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- s_0: Control simulation (f_{1234})
- s_1: Simulation without LHFsea (f_{234})
- s_2: Simulation without SSHF (f_{134})
- s_3: Simulation -10% UPV (f_{124})
- s_4: Simulation SST -5°K (f_{123})

Factor separation

Simulations

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- s_1: Simulation without LHFsea (f_{234})
- s_2: Simulation without SSHF (f_{134})
- s_3: Simulation -10% UPV (f_{124})
- s_4: Simulation SST -5°K (f_{123})
- s_{12}: Simulation without LHFsea & SSHF (f_{34})

Factor separation

Simulations

- s_0: Control simulation (f_{1234})
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- s_4: Simulation SST -5°K (f_{123})
- s_{12}: Simulation without LHFsea & SSHF (f_{34})
- s_{124}: Simulation without LHFsea, SSHF & SST -5°K (f_3)
- s_{1234}: Simulation without LHFsea, SSHF, -10% UPV & SST -5°K (f_0)

Factor separation

Effects

- Forecasted field f
  - Central Sea level pressure
  - Maximal radial-averaged horizontal wind speed

Factor separation

Effects

- Forecasted field f
  - Central Sea level pressure
  - Maximal radial-averaged horizontal wind speed
  - $f_i = e_i + f_0$
  - $f_{ij} = e_{ij} + e_1 + e_2 + e_0$
  - $f_{ijk} = e_{ijk} + e_{ij} + e_{ik} + e_{jk} + e_i + e_j + e_k + e_0$

Factor separation

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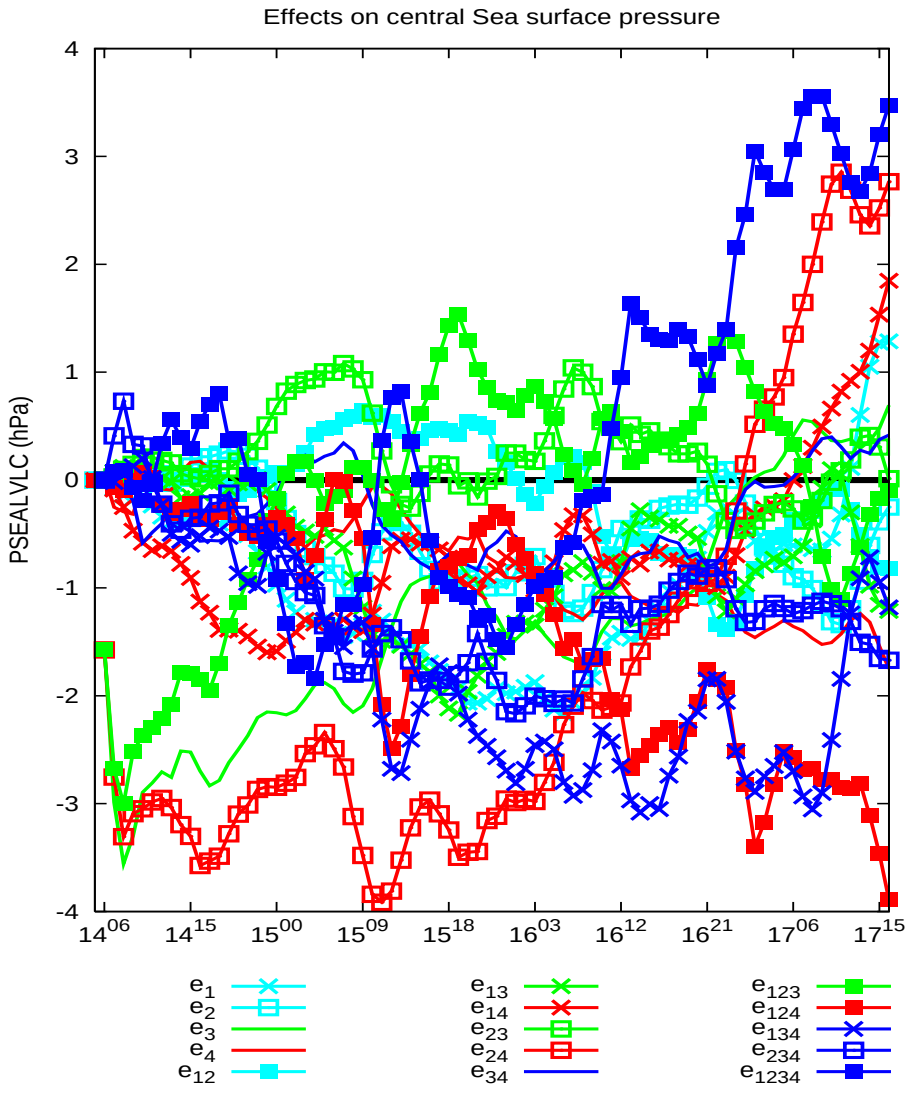
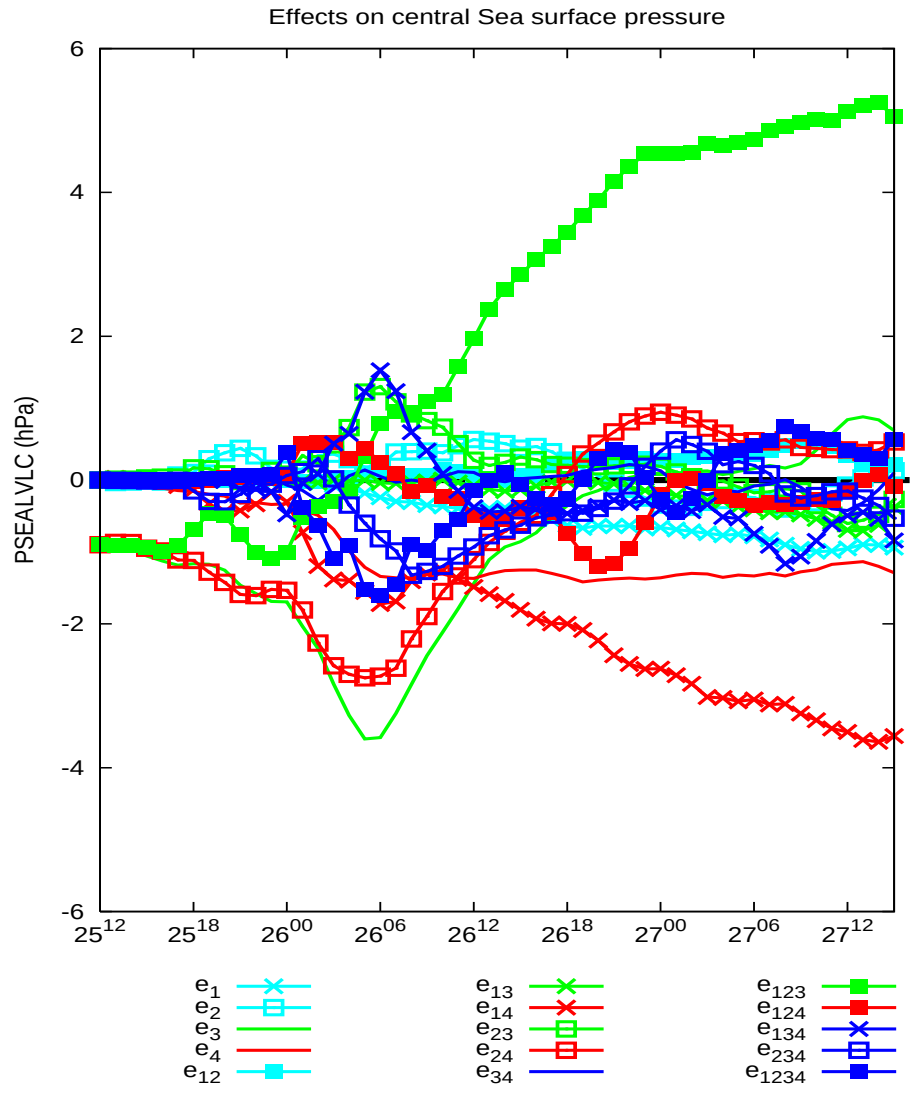
- Effect e
  - $e_i = f_i - f_0 \equiv s_{jkl} - s_{ijkl}$
  - $e_{ij} = f_{ij} - (f_i + f_j) + f_0 \equiv s_{kl} - (s_{jkl} - s_{ilk}) + s_{ijkl}$
  - $e_{ijk} = f_{ijk} - (f_{ij} + f_{ik} + f_{jk}) + (f_i + f_j + f_k) - f_0 \equiv$ $s_l - (s_{kl} + s_{jl} + s_{il}) + (s_{jkl} + s_{ikl} + s_{ijl}) - s_{ijkl}$
  - $e_{ijkl} \equiv s_0 - (s_l + s_k + s_j + s_i) + (s_{kl} + s_{jl} + s_{jk} + s_{il} + s_{ik} + s_{ij}) - (s_{jkl} + s_{ikl} + s_{ijl} + s_{ijk}) + s_{ijkl}$

Results Factor separation

Central pressure at Sea surface level





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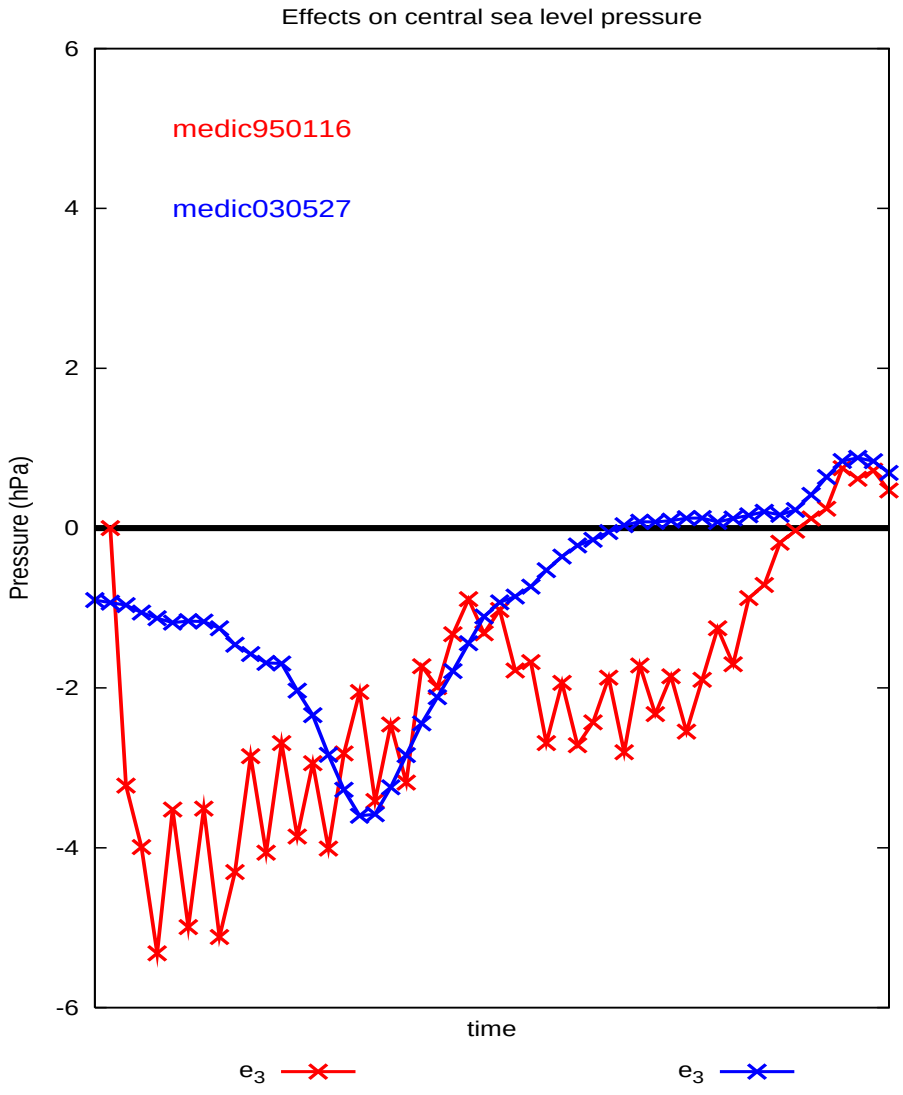

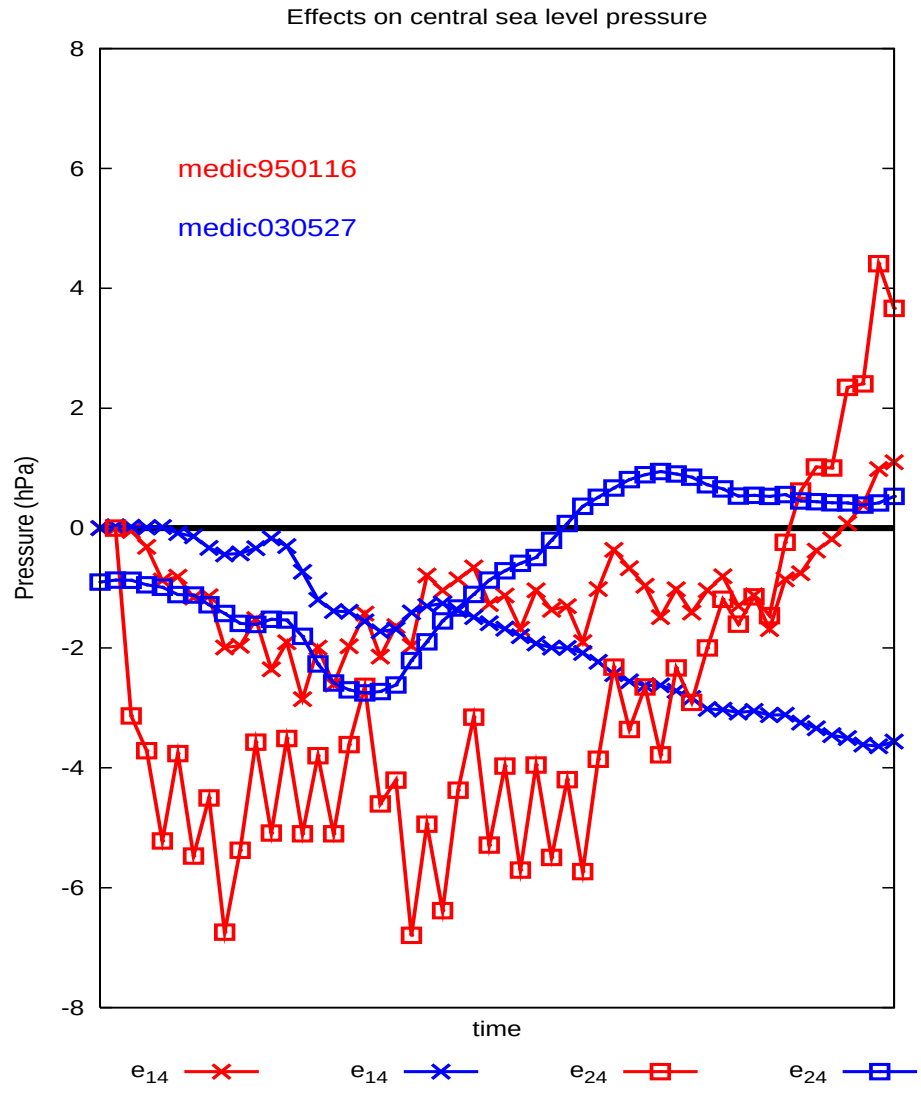

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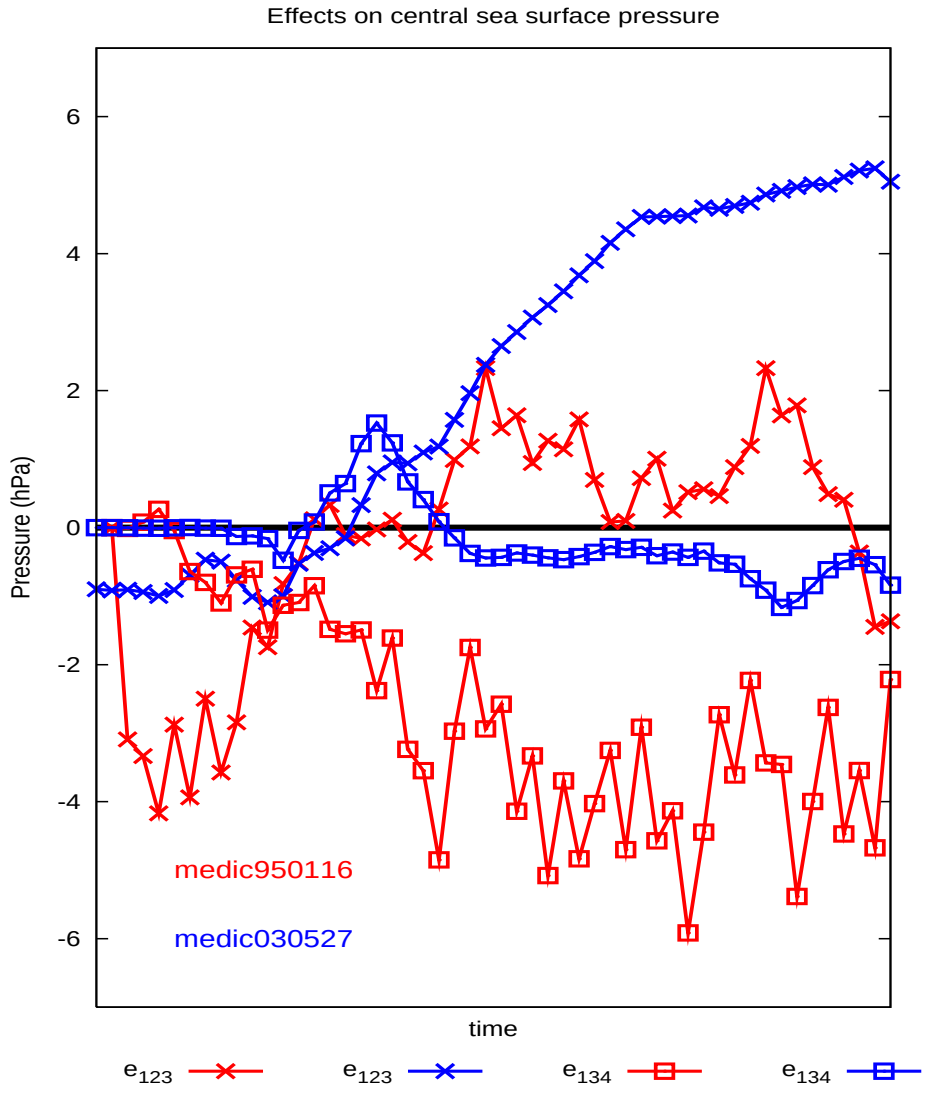
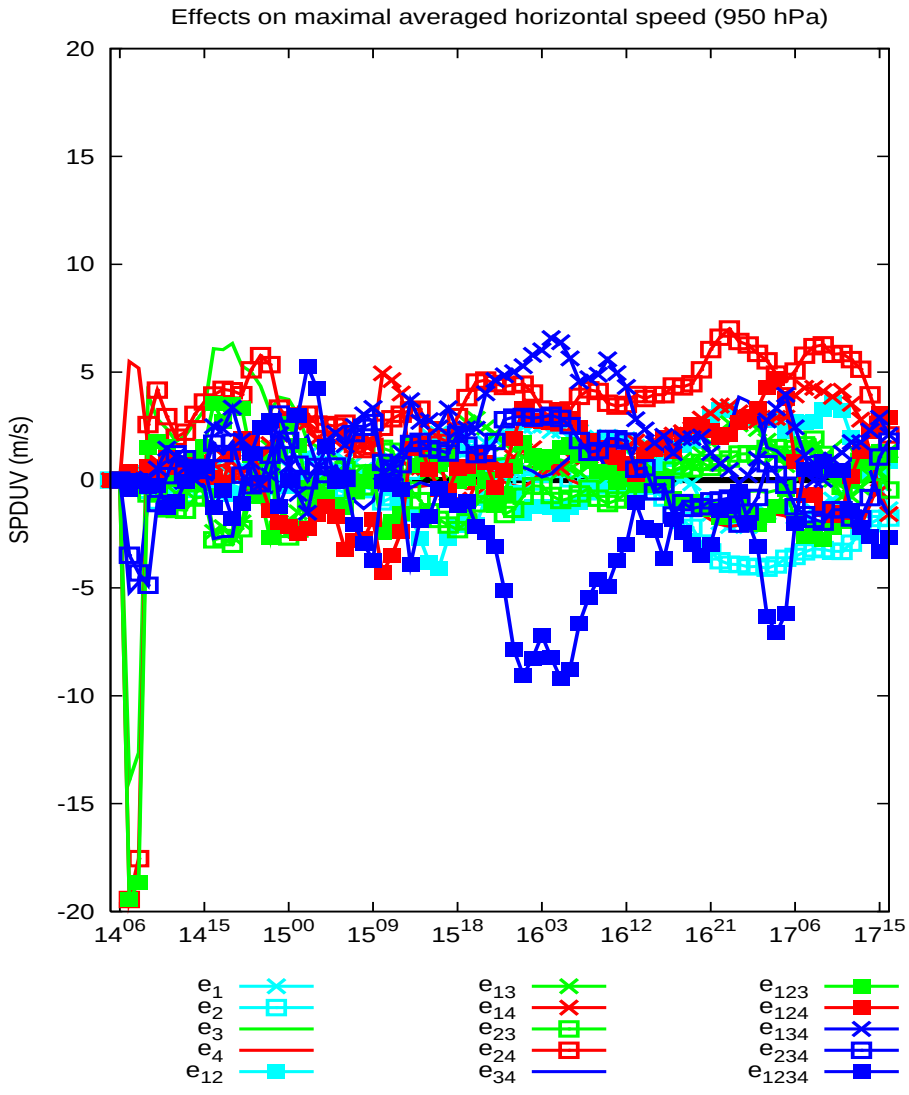
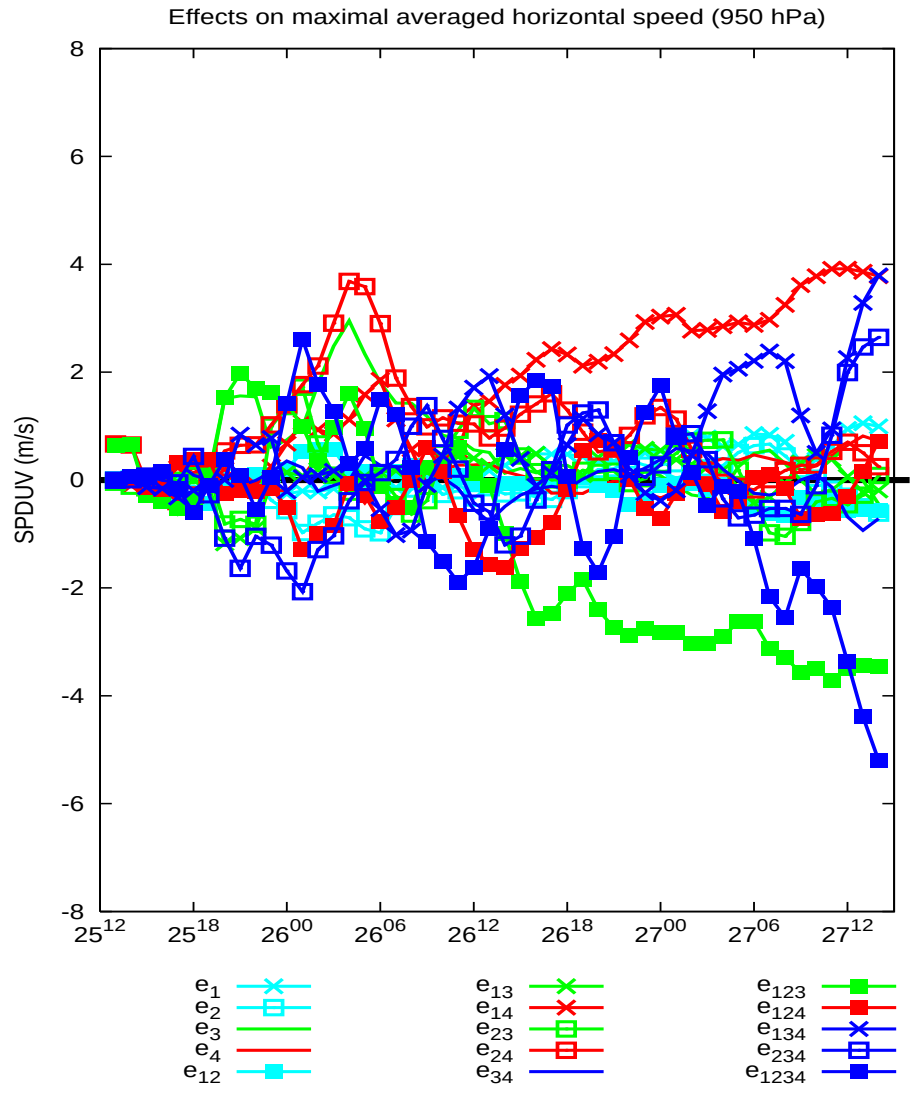


Results Factor separation

Maximal radial average speed at 950 hPa





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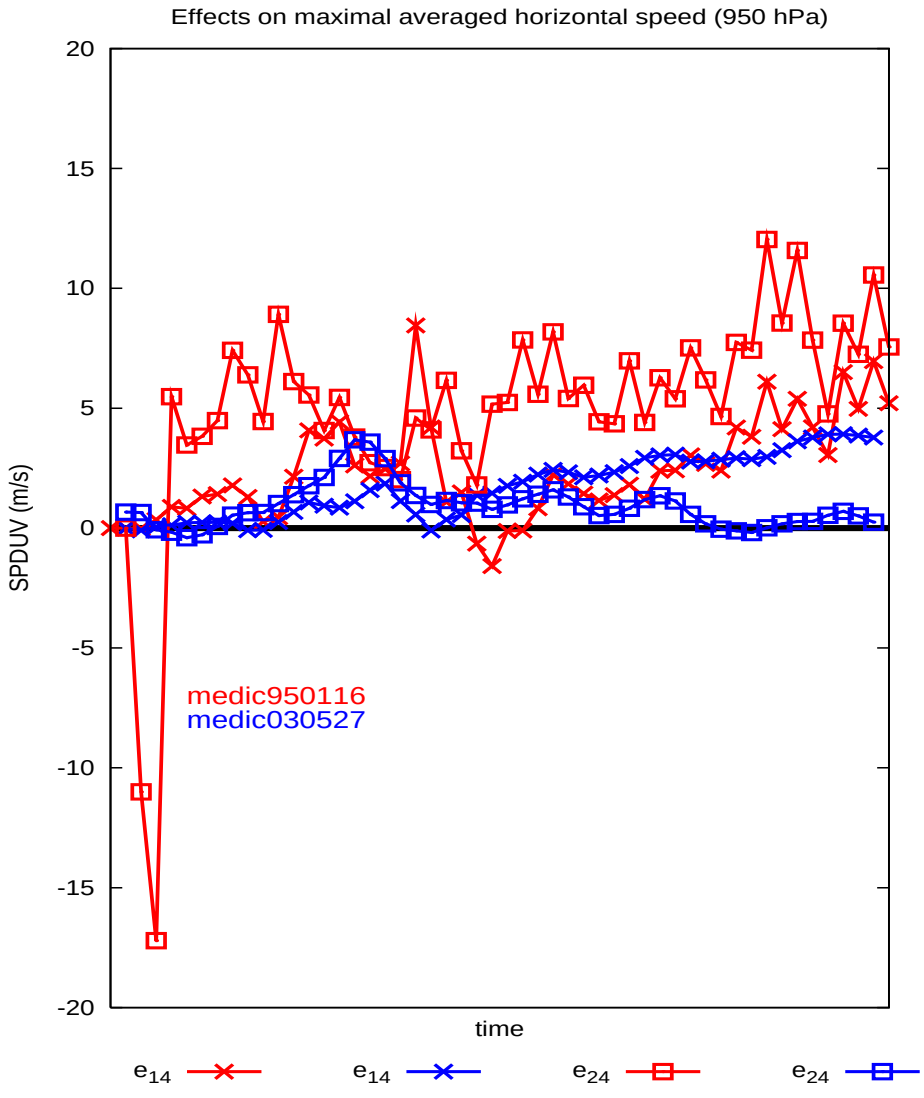

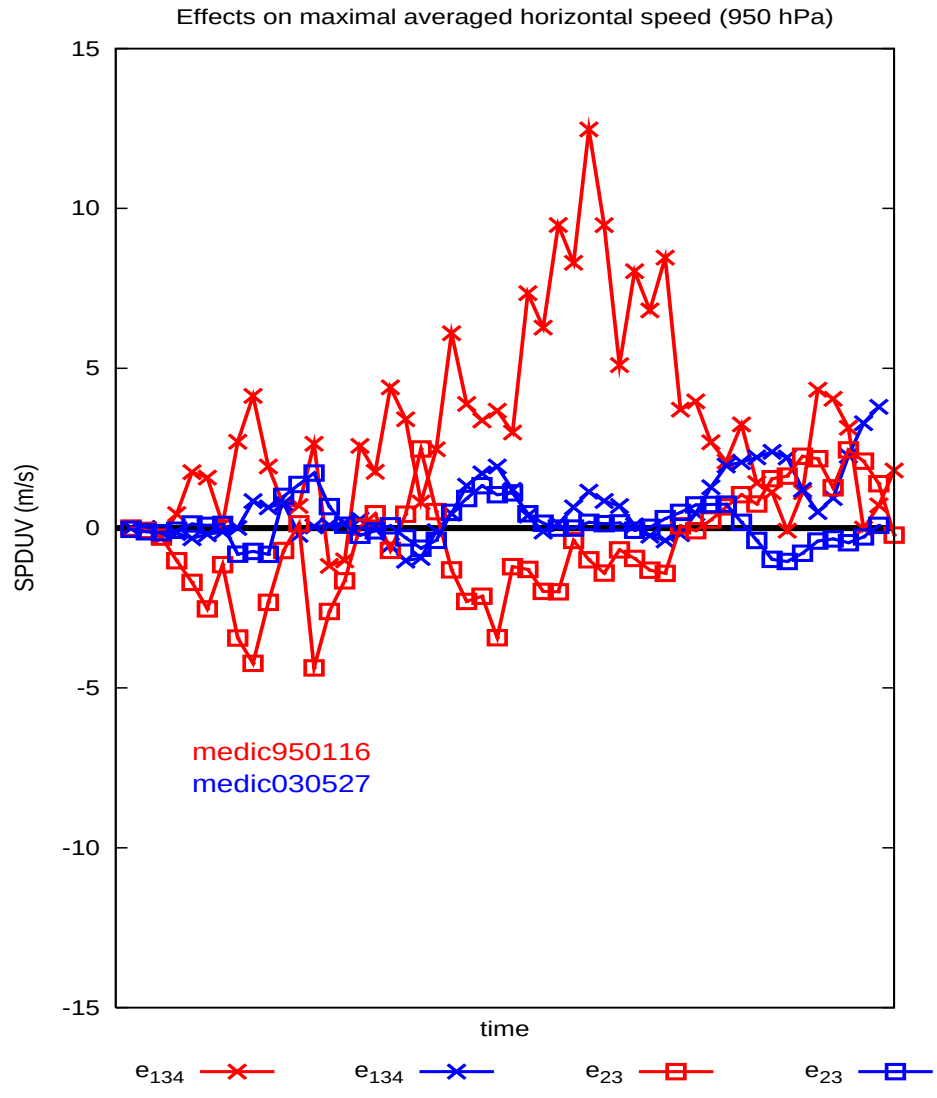

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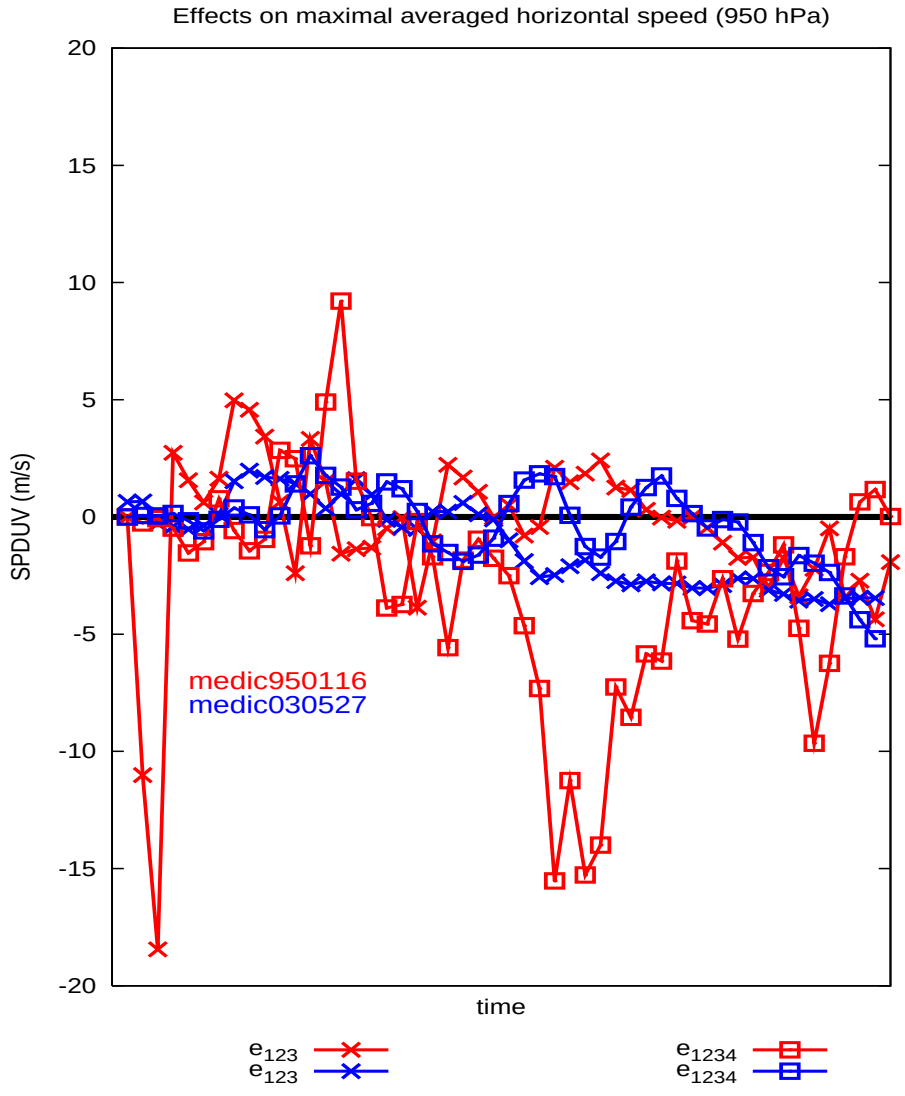
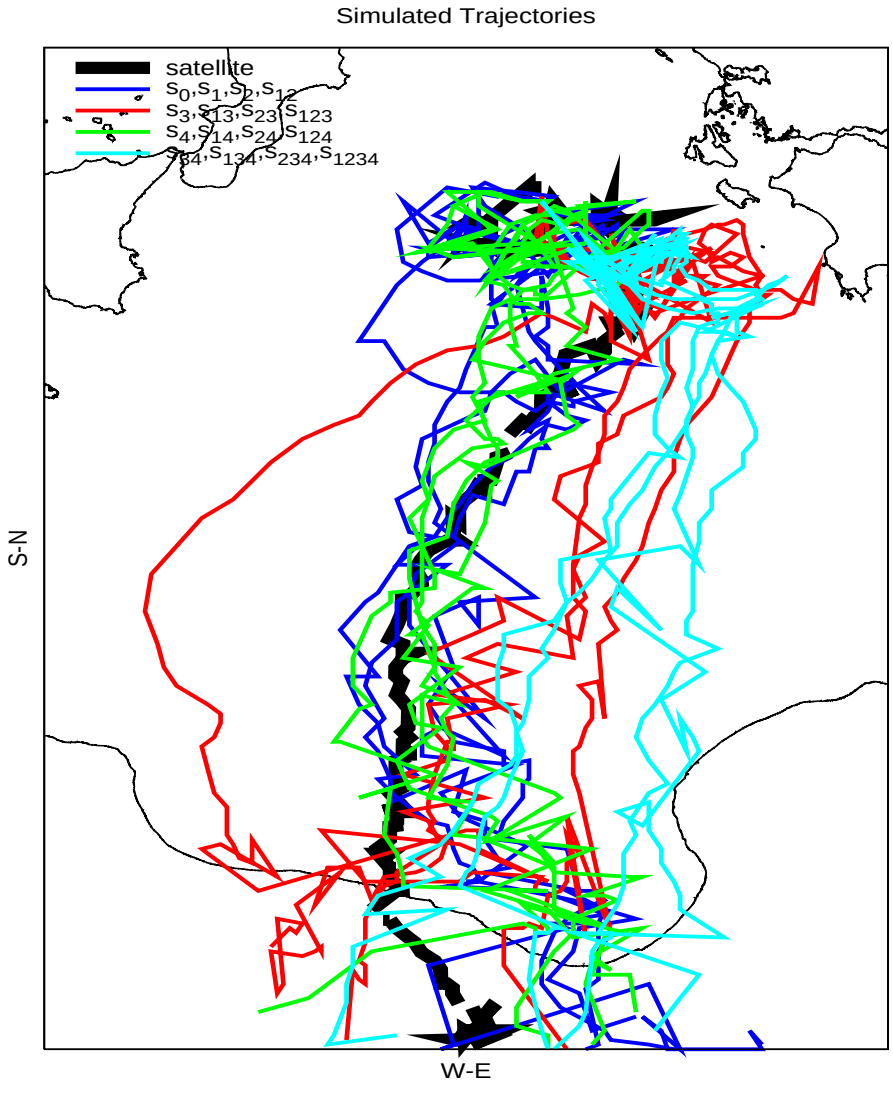
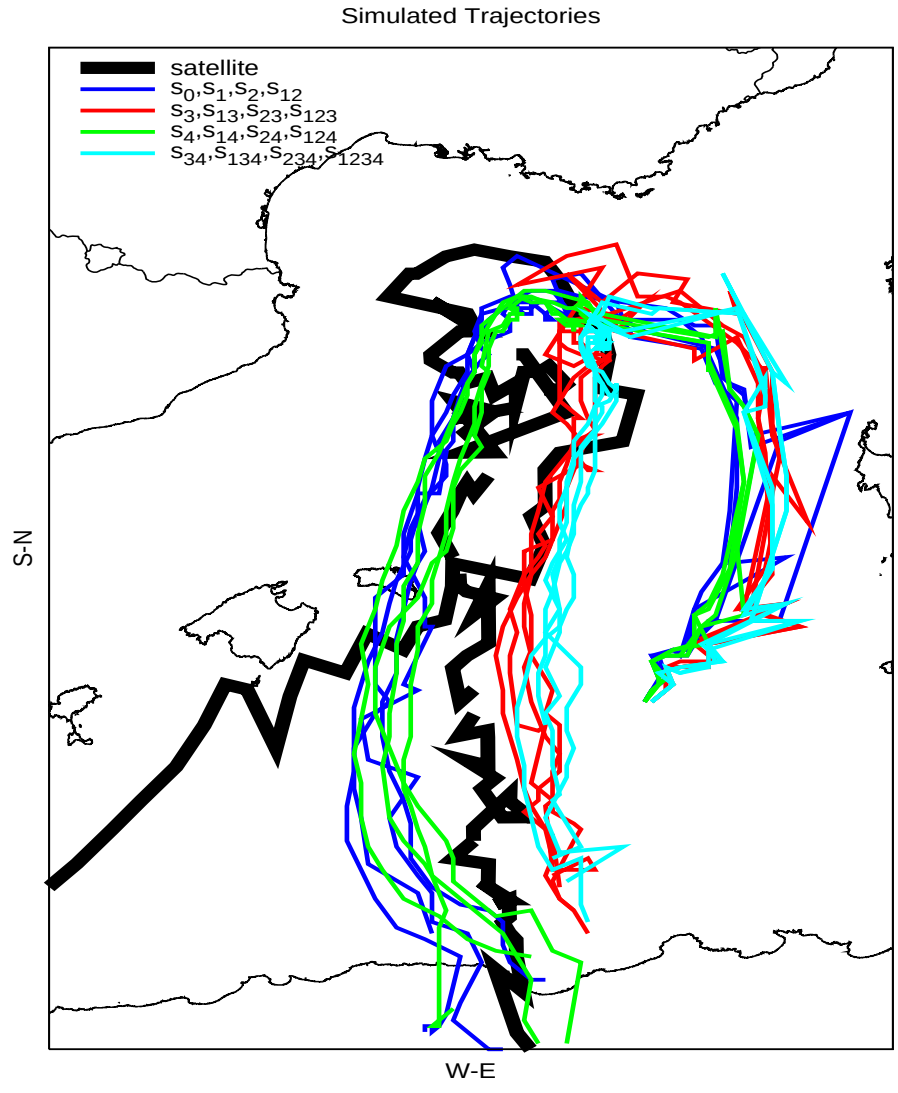


Results Factor separation

Trajectories





Conclusions

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- Medicanes do not show same major dependence
- Much more influence in synergies than individual effects
- Major dependencies related to Upper level PV anomalies and Sea Surface Temperature

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- Central Sea surface level pressure and maximal radial-averaged wind speed showed similar major effect dependencies with different behaviour
- Medicanes do not show same major dependence
- Much more influence in synergies than individual effects
- Major dependencies related to Upper level PV anomalies and Sea Surface Temperature
- Medicane trajectory high dependent on upper level PV anomalies

Conclusions

- MM5 simulations in good agreement with observed cases
- Both medicanes showed similar behaviour and effects dependencies, in different degree
- Central Sea surface level pressure and maximal radial-averaged wind speed showed similar major effect dependencies with different behaviour
- Medicanes do not show same major dependence
- Much more influence in synergies than individual effects
- Major dependencies related to Upper level PV anomalies and Sea Surface Temperature
- Medicane trajectory high dependent on upper level PV anomalies
- Deeper study need to be done to study each effect properly

Thank you for your attention !!