SUMMER TIME NORTHERN ITALY OUTBREAKS, DESCRIPTION OF "ADRIATIC SLOT" CIRCULATION DYNAMICS AND THEIR ROLE IN CONVECTIVE TRIGGER AND INITIATION OF MISO AND MESOCYCLONS. 3D RENDERING OF "ADRIATIC CORKSCREW" CIRCULATION.

Angelo Bertozzi[1], Pierluigi Randi[2]

[1]*SMS- Meteocenter, via Einstein 8 Faenza , Italy, angelo.bertozzi@meteocenter.it*
[2]*SMS- Meteocenter, via Einstein 8 Faenza , Italy, pierluigi.randi@meteocenter.it*

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I. INTRODUCTION

The cold air outbreaks behaviour in northern Mediterranean are strongly influenced by complex orography profile. Alps, Apennines and Balcanic mountains chain drive the evolution of the outbreaks in various reproducible pattern of circulation. In this work we analyze the circulation pattern created in Po valley and northern (and sometimes central) Adriatic sea slot by southeastward and southward moving outbreaks during summer time.

II. PRESENTATION OF RESEARCH

The entrance in northern Mediterranean basin of a south-moving outbreaks generally force the accumulation of cold air in northern side of all Italian Alps and in eastern side of Dinaric Alps while the Po Valley boundary layer remains initially untouched.

This situation obviously drives the formation of a relative pressure minimum in Po Valley and strong potential temperature gradient between northern Adriatic boundary layer and the Balcanic boundary layer.

When the cold front ahead the outbreak reaches the "Bora doors" the coldest air laying eastward the Dinaric Alps is forced to enter in Adriatic basin, often with strong to severe downslope windstorm in Croatian and Trieste gulf coasts.

The entrance of Bora Winds in northern Adriatic exasperates the directional low level shear and frequently causing mesofrontogenesys.

The Bora wind acts as disruptor of the Adriatic and Po Valley planet boundary layer with multiple cold air pools which tend to merge during the evolution of the outbreak.

These dynamics are responsible for the creations of many low level convergence zones at different stage of development. When these convergence areas (usually associated to dry lines) come to "collide" themselves or merge together, we usually assist to formation of strong discontinuities of the boundary layer (sometimes with misocyclons formation) before the merging giving rises to mesofrontogenesis.

Strong directional low level shear starts from the eastern side of adriatic coasts; strong drirectional shear in small vertical space often sets up critical levels (usually between 3000 to 4000 m above MSL) which breaks the vertical propagation of orographic waves in Dinaric Alps, favoring downslope windstorms.

The air mass entering in the northern adriatic slot with elevated turbolent kinetic energy and during the evolution of the outbreak, the maximum values of turbolent kinetic energy tends to concentrate nearby the Italian Adriatic coast.

When the air mass involved in downslope windstorms approaches the western coast, the increased friction offered by the thicker and more structured terrestrial PBL and by increased surface roughness rapidly slows the westward surface winds, making possible hydraulic jumps. Some hydraulic jumps may occur in cold pools merging areas and in early stage of outbreak evolution, when Dinaric Alps orographic wave breaking is not present.

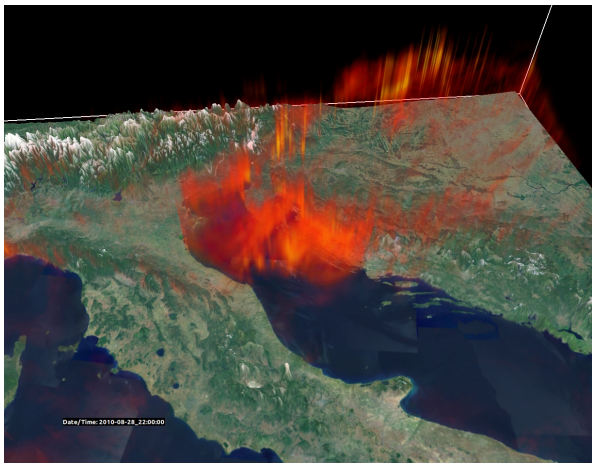


FIG. 1: TKE Bora distribution windstorm, subsequent to southeastward moving outbreak. 3 cold pools tend to merge together.

When massive hydraulic jumps starting near the western coast (the typical case) we have sudden triggering and rapid development of extensive convection; the consequence of this explosive nearshore and offshore convection on western side of Adriatic is the forcing to horizontal divergence in low level zonal jet and in middle troposphere.

Increased divergence in turns encourages the tendency to low level winds who approaching west coast to "jump" vertically.

This kind of clockwise vertical circulation is been "closed" (or partly closed) more southeasterly by squall lines downdrafts and weak (but more extended) gravity waves in low level jet

Finally, in this pattern of circulation a huge rotor shear which looks like a corkscrew will take place over

Adriatic sea and moves southeastward in southward outbreaks and eastward in southeastward outbreaks.

When the corkscrew "rotor shear" becomes large and occupies the entire northern Adriatic basin or the central one, severe thunderstorms are very likely to occur.

The coupling of low level wind shear conditions and the highly irregular structure of Adriatic PBL is favorable for misocyclonic phenomena with nearshore waterspout or some weak tornadoes and hailstorms.

A study of this circulation pattern was initially made by a Meteocenter operational limited area model (3DVAR WRF-ARW core solver, 7.5 km over all Europe and Mediterranean sea and 2.5 km nest over central Mediterranean).

The aim of the study was oriented to verify the impact of high vertical resolution (the operational model is configured with 25 vertical level under 850 hpa) in forecast skill for this kind of outbreaks and more generally in the dynamics involved in Bora winds oubreaks.

A reforecasting of 40 similar events was subsequently made with more elevated horizontal resolution model (0.9 km) for 3D flows rendering and for discriminate the conditions that drives to severe weather events

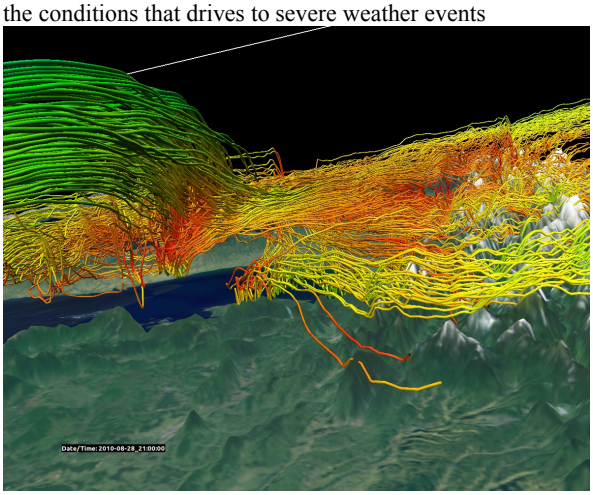
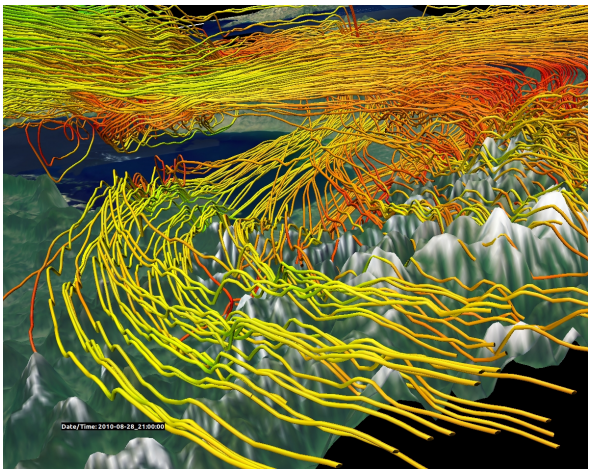


FIG. 2: 3D rendering of flow path over Carnic and Dinaric Alps with huge hydraulic jump (in western coast) and rotors shear over Adriatic basin.



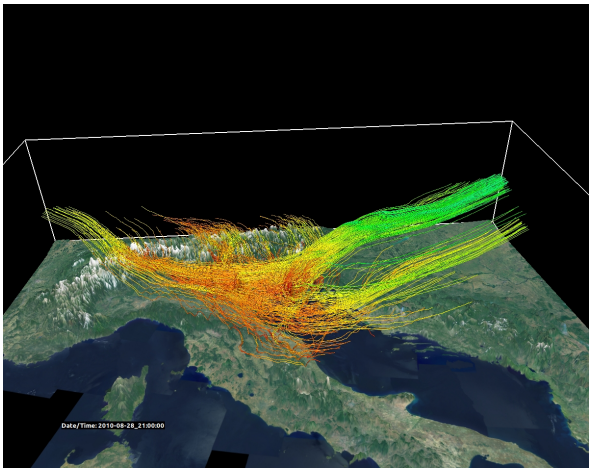


FIG. 3: 3D rendering of flow path over northern Italy; low level jet flux lines (selected streamlines enter in the domain from NW at 4500 m. Strong horizontal divergence over Adriatic sea with flux splitting. Large rotor is present in splitting zone

III. RESULTS AND CONCLUSIONS

Near to all the simulation of past outbreaks events made with operational and reforecasting model, the large rotor shear over Adriatic basin was simulated.

The most severe phenomena was associated to early development of the large Adriatic rotor shear after the outbreaks reach Dinaric Alps.

Early development of Adriatic rotor shear means frequently strong northerly or northwesterly low level jet, and consequent more elevated SWEAT and 0-3 km SREH.

During the slow moving oubreaks the hydraulic jumps tends to concentrate in middle Adriatic and the convection usually doesn't reach the Italian coast.

The forecast skill of the operational model appears good, especially in the window +24 / +48 hours; severe weather events was correctly depicted in 30 cases over 40, in 6 cases the model underestimate the severe weather events , in 3 cases we have overestimated simulated phenomena. In one case only the simulation showed no appreciable phenomena missing to depict them for exaggerated propagation of Alpine foehn in eastern Po Valley

The vertical resolution of the model appears to have more impact on the model skill than the horizontal resolution. None significant improvement of model skill noticeable over 2.2 km of horizontal resolution; otherwise a large number of vertical levels in lower troposphere give a better representation of mountain waves dynamics, critical layer generation and behaviour and wave trapping depiction, driving to best forecast skill.

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