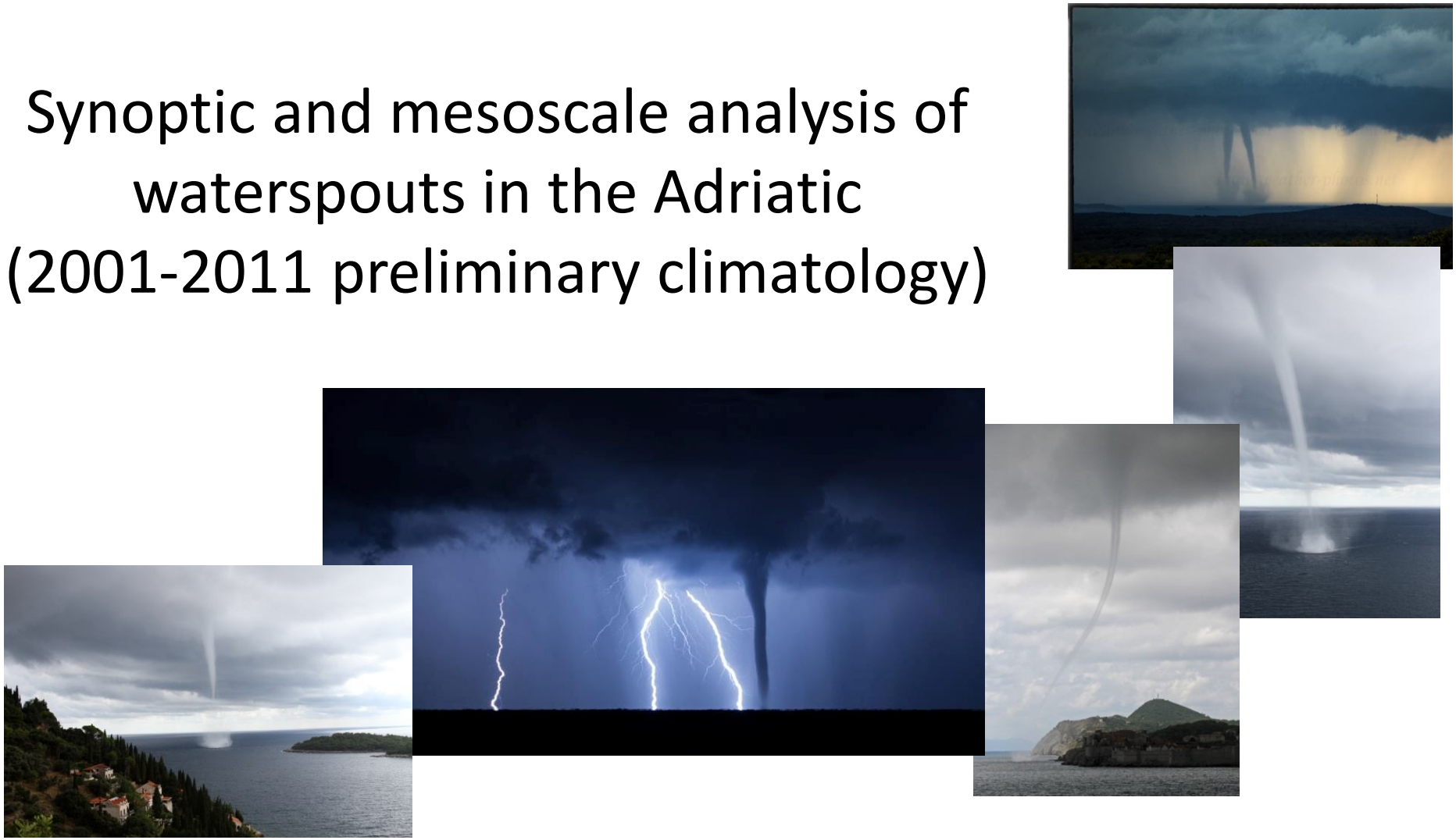
Synoptic and mesoscale analysis of waterspouts in the Adriatic (2001-2011 preliminary climatology)



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Challenges in meteorology 3: Extreme weather and impact on society

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Introduction

- Very complex coastline topography → differential heating (land/sea) → local convergence → convection → conditions for waterspout development

- Not rare phenomena in the Mediterranean → in last two decades quite a number of publications → detailed analysis and climatological background for some areas (Gaya et al., 2001, Giaiotti et al., 2007, Sioutas and Keul, 2007)

- More detailed analysis of waterspout events in eastern Adriatic → cases accompanied by strong storms and caused great damage (Ivančan Picek and Jurčec, 2005, Ivančan Picek and sur., 1995)

- Renko et al. (2012) tested forecast method for 19 events that occurred in the Eastern Adriatic basin in 2010

- Detailed analysis which would include long time series of data has not been made so far

Data and methods

- Information and data were collected from

1) Weather stations
2) Climate reports
3) Articles and reports on the damages caused by waterspouts
4) Few reports from local residents and meteorological enthusiasts

- Based on this → waterspouts are not rare phenomena but most of them were not recorded

5) Survey “You saw the waterspout/tornado? Report to us!” was launched in spring 2011

Data and methods

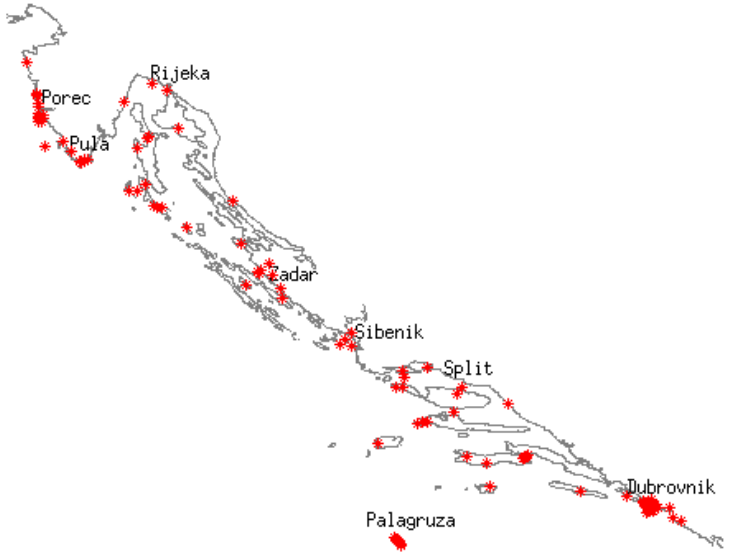
- Thermodynamic environment – radiosonde data were obtained via (http://weather.uwyo.edu/upperair/europe.html) – data from Zadar and Udine were used

- Four instability indices KI (measure of thunderstorm potential), TT (static stability and moisture), SWEAT (potential for severe weather) and CAPE (amount of energy available to accelerate parcel verticaly) were analyzed

- Presence of lightning activity provided by the LLS – Local Lightning System (part of LINET)

- Synoptic charts (surface pressure field and 500 hPa topography charts) available at 00, 06, 12, 18 UTC were analyzed

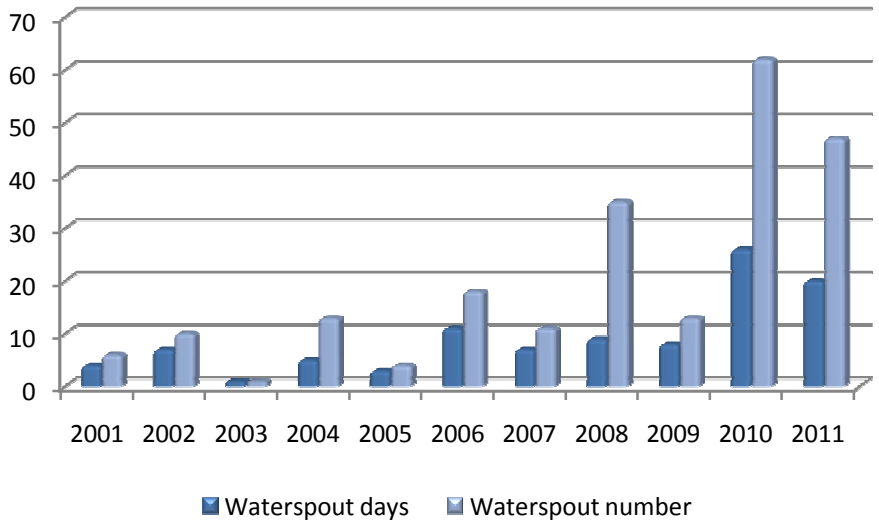
Spatial distribution



- In eleven-year period (2001-2011) 220 waterspouts were recorded
- Locations are determined subjectively (accuracy depends on the assessment of the observer)
- Events are distributed rather evenly along the coast

- Several areas stand out (western coast of Istria, surroundings of Zadar, Šibenik, Split and Dubrovnik and the area around island Palagruža)

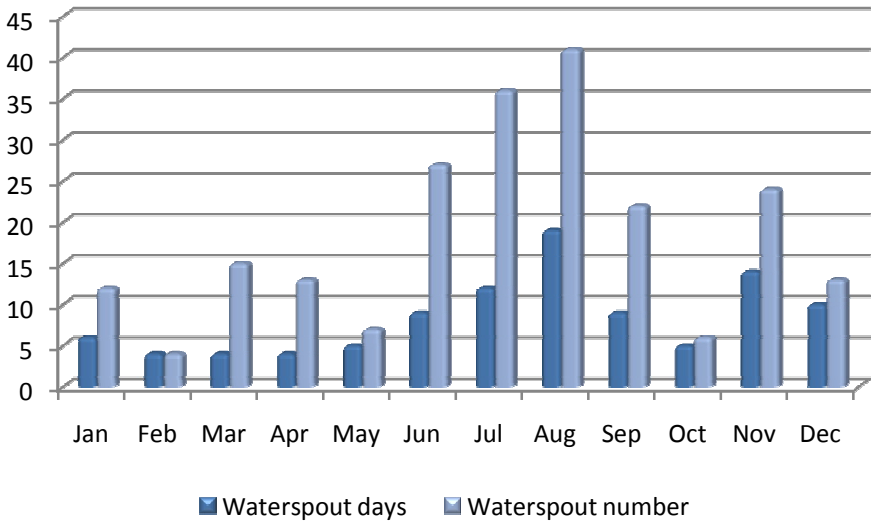
Temporal distribution



- Number of waterspouts as well as waterspout days were analyzed
- Waterspout day – the day in which at least one waterspout was observed within 24 hours
- This is preliminary climatology (different data colection during the years)

- The trend of an increasing number of waterspouts is clearly seen
- Sudden increase is not a result of any meterological phenomena but rather of a better access to information via survey

Temporal distribution

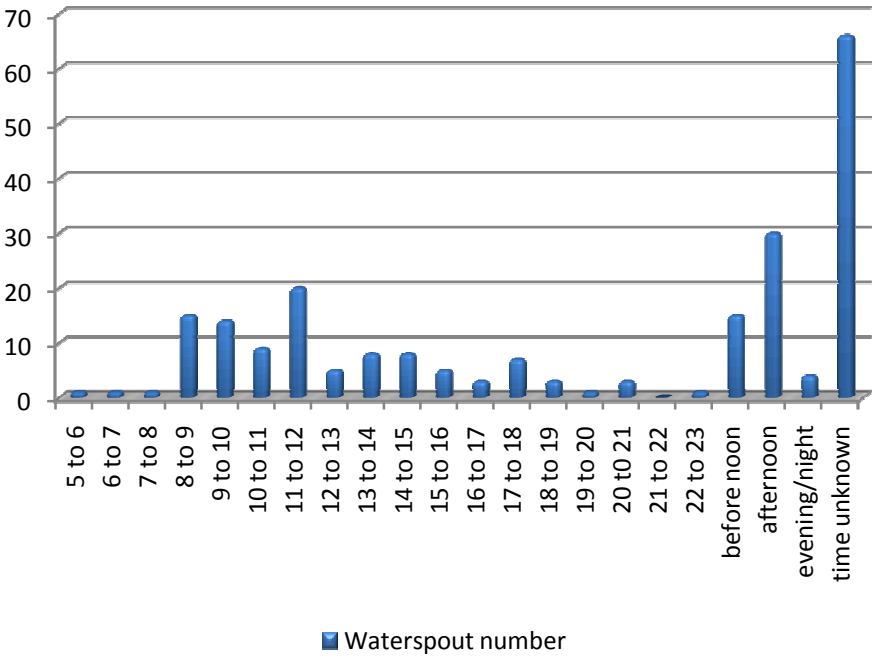


- Waterspouts can occur in all seasons but a peak is in summer amounting 104 waterspouts in 40 waterspout days (June, July, August)

- Autumn season – sea temperature is still relatively high and frequency of cold advection form the higher latitudes is increasing

- Spring season has the least number of waterspout days, winter season has the least number of recorded waterspouts

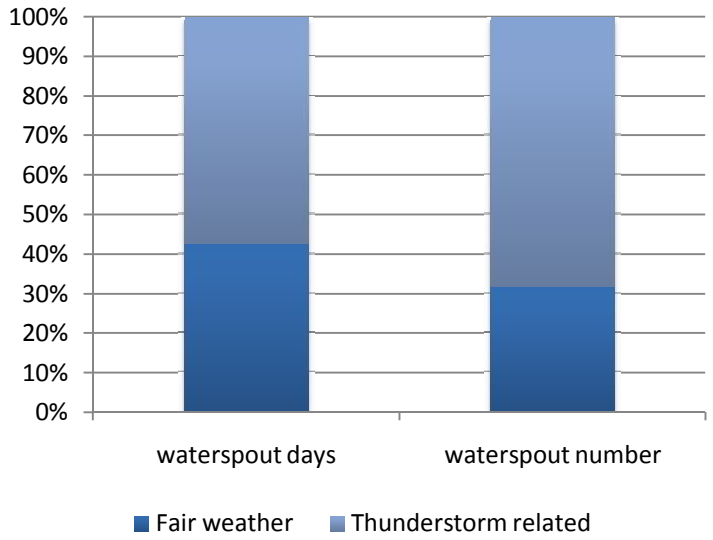
Temporal distribution

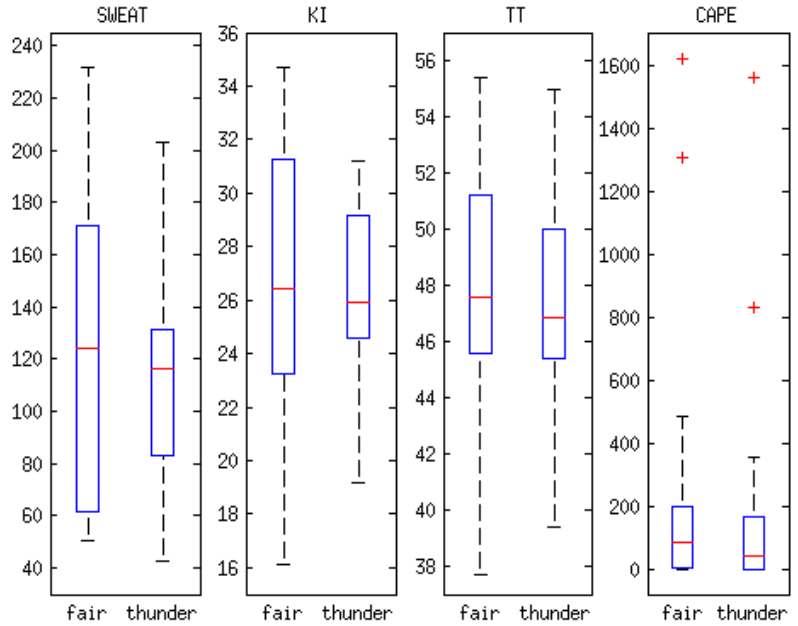


- Waterspouts were mainly observed during the daylight and in the evening
- According to the available data maximum is achieved in the morning (8 to 10 UTC) and in the afternoon (when diurnal heating reaches maximum)

- **Important to note!** A lot of data were obtained from public questionarre and data are incomplete (lack the exact time of waterspout occurence)

Lightning and thermodynamic activity





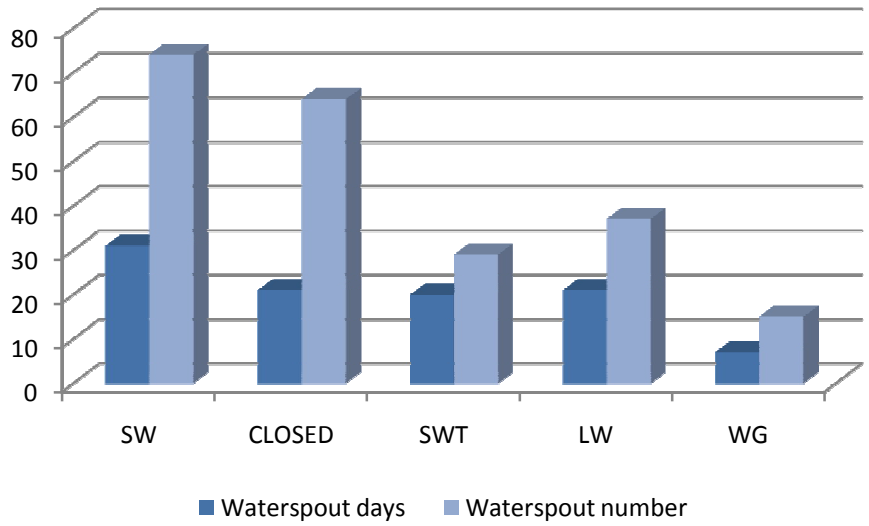
- Based on lightning presence/absence, waterspouts were divided into thunderstorm related and “fair” weather ones

- KI and TT meet the conditions for storm development

- Difference between median values are negligible, significant difference is visible in the dispersion of values

Instability indices	Adriatic sea	Sioutas, Keul
KI	26	30
TT	47	48
CAPE	70	50
SWEAT	118	140

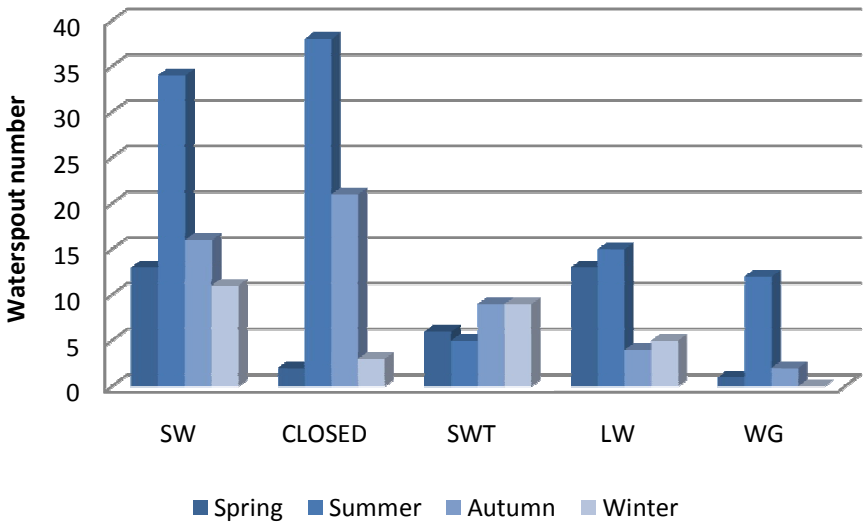
Synoptic environment



- The circulation flow at 500 hPa level and the position and orientation of trough and ridge axis in conjuction with surface features were analyzed
- Five synoptic types proved to be the most relevant: south west flow (SW), closed low (CLOSED), short-wave trough (SWT), long-wave trough (LW) and non-gradient pressure field (WG)

- Waterspouts occur most frequently when south westerly flow is present (33.7%)

Synoptic environment



- Largest number of waterspouts:
  Summer and autumn – CLOSED
  Winter and spring – SW
- Non-gradient pressure field - supportive for waterspout development mainly during the warmer part of the year
- Classification of weather types for Croatia (Poje, 1965) - non-gradient pressure field is the type of weather typical for the warm part of the year

Conslusions

- There were 220 waterspouts observed in 101 days in the period 2001-2011
- Waterspouts were evenly distributed along the coast
- Waterspouts were mostly develop in the summer months and in autumn
- Minimal activity was observed in spring
- 69% of waterspouts were thunderstorm related
- Instability indices KI and TT – meet the theoretical values considered to be supportive for the storm development
- Waterspouts occur most frequently when SW flow is present (33.7%), folowed by CLOSED (27.1%)

Thank you for your attention!