Implementation Plan
Adriatic Target Area

I Observational Strategy
II Modelling and Data Assimilation Strategy

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Adriatic TA - characteristics:

The area includes:
- Regions in north-eastern Italy (Trentino, Alta Adige, Veneto, Friuli)
- Slovenia
- Croatia

- Mediterranean and Alpine-Mediterranean climate
- Complex terrain triggering heavy storms,
- Small to medium scale catchments prone to flash floods in association to debris flows
- Special topography and hydrogeological conditions (steep slopes, karstic environments)
- Droughts, heat waves, forest fires
- Dense water formation - NAdDW and SAdDW
- Importance of the Adriatic Sea for Mediterranean circulation and viceversa
### Observational strategy

<table>
<thead>
<tr>
<th>Year</th>
<th>SOP 1 (June-Sept)</th>
<th>SOP 2 (Sept-Dec)</th>
<th>SOP 3 (Feb-June)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dense monitoring of hydrologic processes, heavy rainfall, flash floods</td>
<td>- ocean preconditioning phase in the Adriatic Sea to control generation and spreading of the newly formed dense water in the two targeted areas</td>
<td>- dense water formation and ocean convection - strong cyclogenesis connected with severe local winds (Bora and Jugo)</td>
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<td>3</td>
<td>SOP 1.1</td>
<td>SOP 1.2</td>
<td>SOP 2.1</td>
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<tr>
<td>4</td>
<td>SOP 1.3</td>
<td>SOP 2.2</td>
<td>SOP 2.3</td>
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**SOP 1**
- Dense monitoring of hydrologic processes, heavy rainfall, flash floods

**SOP 2**
- Ocean preconditioning phase in the Adriatic Sea to control generation and spreading of the newly formed dense water in the two targeted areas

**SOP 3**
- Dense water formation and ocean convection
- Strong cyclogenesis connected with severe local winds (Bora and Jugo)
The NEI Observatory covers the north-east part of Italy, which is subject to severe flash flood events. Topography of the Observatory: includes two major river systems:

- **Adige**, 11,900 km²
- **Tagliamento**, 3,000 km².

**Altitude:**
100 – 4,000 m a.s.l. for the Adige.
Lower altitudes for the Tagliamento.

The region exhibits a typical Alpine-Mediterranean hydrological regime:
- affected by snowmelt,
- two runoff peaks:
  - one in June (due to snowmelt)
  - one in the Autumn (due to rain events).
## WHO?

<table>
<thead>
<tr>
<th>Organization</th>
<th>Location</th>
<th>Focus</th>
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<tbody>
<tr>
<td>University of Padova</td>
<td>Padova</td>
<td>Flood and flash flood risk analysis, hydrological modelling, radar hydrology</td>
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<tr>
<td>ISIG (Istituto Sociologia Internazionale Gorizia)</td>
<td>Gorizia</td>
<td>Social perception of risk</td>
</tr>
<tr>
<td>CNR (National Research Council)</td>
<td>Padova</td>
<td>Geomorphic processes triggered by flash floods; post event surveys, regional hydrology</td>
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<tr>
<td>ARPAV</td>
<td>Mestre</td>
<td>Regional hydrological center</td>
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<tr>
<td>OSMER</td>
<td>Cervignano (Friuli)</td>
<td>Regional meteorological center</td>
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<tr>
<td>MeteoTrentino</td>
<td>Trento</td>
<td>Regional meteorological center</td>
</tr>
<tr>
<td>Dipartimento Protezione Civile (Trento e Bolzano)</td>
<td>Trento and Bolzano</td>
<td>Civil Protection</td>
</tr>
<tr>
<td>Ufficio Idrografico Bolzano</td>
<td>Bolzano</td>
<td>Regional hydro-meteorological center</td>
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</tbody>
</table>
THE ENVIRONMENT: RAINFALL REGIME

Mean annual precipitation (1971-1990)
Strong gradients of precipitation
The TA covers part of the dry core of the Alps (mean annual precipitation around 500 mm) as well as the much wetter eastern Alpine chain (mean annual precipitation > 3000 mm).

(Schwarb et al., 2001)
THE ENVIRONMENT:
EXTREME RAINFALL REGIME

Impact of orography on rainfall quantiles

In Friuli (eastern part of the Observatory) 24 hr rainfall quantiles ~ 500 mm. In the Upper adige river basin (western part of the Observatory) 24 hr rainfall quantiles ~ 200 mm

Quantile Maps for Friuli

D=24 hr  T=100 yr  D= 1 hr
HEAVY RAINFALL AND FLASH FLOOD TYPOLOGY

Upper Adige river basin:
small space-time scales (duration 1-6 hours; 5-50 km²)
Usually these events trigger shallow landslides and debris flows.

Upper Tagliamento river basin:
larger space-time scale (duration 3-12 hours; 50-300 km²)
Usually these events trigger diffuse geomorphic effects as well as large liquid discharges.
Three C-band, Doppler radar,
The Fossalon radar has dual-polarization capability.

The region is well monitored by a dense network of raingauges and streamgauges.
FLASH FLOOD MONITORING STRATEGY - 2
Post event field surveys.

After each significant flash flood event, a field survey is executed to gather information on flow type process, peak discharges and peak timing. Post event surveys are co-organised with local Agencies.

Specific efforts:
- survey of geomorphic effects. New observation technologies: e.g. LIDAR and Ladar-based surveying.
- Development of survey of social - human behaviour observations
Supersite: Rio Vauz catchment

- Surface: 1.9 km²
- Max altitude: 3152 m a.s.l.
- Min altitude: 1835 m a.s.l.
- Mean slope: 30.3 %

- Steep slopes in the upper part
- Valley in the bottom with main stream

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STUDY AREA

Mean annual precipitation: 1160 mm/year, 40% as snow.
STUDY AREA:
Nested observation structure: 0.1 - 100 km²
Supersite

Main science questions:

i) is it possible to clearly identify non-linear and threshold behaviours in the soil moisture-runoff relation? Is there the same soil moisture threshold controlling both surface and subsurface runoff response?

ii) Does the overall catchment topography, in terms of percentage of riparian versus hillslope area, have significant influence on runoff generation?

iii) What is the spatial organization and the temporal persistence of soil moisture spatial patterns in wet and relatively dry conditions? Is there a connection between hillslope spatial distribution of water content and triggering of transient lateral subsurface flow?

iv) What is the influence of antecedent wetness condition and of rainfall event size on runoff depth?
Three experimental hillslopes:

- Piramide
- Emme
- Vallecola

STUDY AREA

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METHODOLOGY

Two portable instruments for spot soil moisture measurements:

Theta Probe (Delta-T Devices Ltd.): estimates soil moisture by measuring impedance, which depends on dielectric constant of soil ($\varepsilon$), related to water content.
Sampling depth: 0-6 cm
2) **TDR 300** (Spectrum Technologies Inc.): works on Time Domain Reflectometry. Electric signal is reflected when it reaches the interface rod tip-soil; frequency of return signal is proportional to water content. Sampling depth: 0-12 and 0-20 cm (two interchangeable rods)
Publications


Operational meteorological observation systems

Existing meteorological observation networks will form the backbone of the observation strategy:
- Surface data (air temperature, wind, humidity, pressure, precipitation, etc.)
- Radio sounding data
- Rain gauge data
- Radar data (15 minutes, reflectivity and velocity data)
- Additional measurements by sonic anemometer would be available (Geophysical Institute, University of Zagreb)

Radar network in Croatia (three radars on the coast are not installed yet)

Lightning networks - ATDnet, ZEUS, LINET
Observational strategy

**Needs:**

- Simultaneous measurements of atmospheric and oceanic parameters to deduce the heat, water and momentum fluxes between them.

- Extensive dataset of surface winds, temperature and humidity combining in-situ measurements (buoys, weather stations), and airborne and spaceborne remote sensor measurements (SAR, QuikSCAT, lidar), as well as wind profilers and aircrafts to identify the upper-level features (mountain waves, wave-breaking, critical levels, turbulence, etc) contributing to low-level wind reinforcement and vertical profiles of temperature, humidity and pressure to analyze the role of stability in the low-level wind dynamics.

- Need to build a data base (meteorology, hydrology, oceanology).
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Observational strategy

Enhanced existing observing system in the Adriatic TA

Enhanced current operational observing system

Special observing periods in the Adriatic TA (ships, aircraft, …)
Observational Strategy

**SOP/EOP**

- Heavy precipitation, severe local winds, flash floods

- Investigation of the water budget
  (boundary layer processes including measurements/reanalysis of precipitation $R$ and evaporation $E$ over the sea, and river runoff $R$)

- Investigation of the dense water formation rate
  (target areas for the CTD and XBT)

Concerning the Adriatic, a strategy has been elaborated concerning the monitoring of the dense water formation rate and of the characteristics ($T,S$) of dense water formed near the coast and in the open sea. This proposal is based first on monthly CTD at two sites in the region of Split at the scale of the LOP (and at higher frequency focusing events during SOP) and second on monthly to bi-monthly XBT(S) transects aboard ships of opportunity from Croatia to Italy (Split-Ancona and Dubrovnik-Bari).

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Observational strategy

Data base of transects: 40 years giving the opportunity to detect long-term trends and regime shifts

Research ship BIOS-II, Institute of Oceanography and Fishering

Air-sea interactions:
- Ship (atmospheric mast, CTD, XBT)
- Buoy (atmospheric parameters, aerosols)
- Local water budgets
- Boundary layer processes
- CTD mooring (MLD, DWF)
- ADCP in Otranto Strait

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Observational Strategy

- CTD will be coupled to measurements and calculations of evaporation during winter and summer Bora and Sirocco events

- XBT measurements will be performed to characterize the cascading of the North Adriatic dense water (NAdDW) to the deep South Adriatic Pit (the NAdDW formed during strong Bora events in the Northern Adriatic flows southward along the west Adriatic coast and crosses the section Split-Ancona few weeks after. Control of this process at this transect is very important while the Dubrovnik Bari transect allows to determine the water characteristics in the deep sea)

- ADCP measurements in Otranto Strait are essential to address the question of the interannual and decadal variability of the water exchange between the Ionian and Adriatic
**Observational Strategy**

**Available measurements:**
- Surface data (air temperature, wind, humidity, pressure, precipitation, etc.)
- Radio sounding data
- Rain - gauge data
- Radar data (15 minutes, reflectivity and velocity data)
- Ships (atmospheric mast, CTD, XBT)
- Buoys (atmospheric parameters, aerosols)
- XBT and CTD (sea vertical profiles, salinity, oxygen, nutrient)

**Needs and Plans:**
- Wind profilers
- Aircraft measurement
- Scintillometers (evaporation)
General needs

Coupled and non-coupled models of high resolution need to be developed in order:

- to study the cyclogenetic processes in the Mediterranean
- to study strong local winds, influenced by topography
- to ameliorate the parameterization of the air-sea interactions
- to make sensitivity experiments
- to evaluate forecasts
- to make scenarios
- to make high-resolution reanalyzes
Operational forecasting support – Adriatic TA

**ARPAGE** global hydrostatic, 10 km horizontal resolution, assimilation cycle – 6 h  
(METEO-France)

**ALADIN/HR** mesoscale hydrostatic model – 8 km horizontal resolution, assimilation cycle – 6 h;  
DADA dynamical adaptation of surface wind field at 2 km 10-year (1991 - 2000) dynamical  
downscaling the global data (ERA-40) with ALADIN/HR/DADA are available  
(DHMZ-Croatia)

**ALADIN/NH** non-hydrostatic version of the ALADIN model – 2 km horizontal resolution,  
assimilation cycle – 6 h;  
(DHMZ-Croatia)

**BOLAM??**
Research modeling support – Adriatic TA

**WRF** model – 1 km horizontal resolution

WRF is already operational at NOA and it will be used as the primary tool for very-high resolution modelling over the Aegean Sea and especially Crete.

In Croatia after the model comparison with the observed data, improvements in the turbulence parameterization scheme are planned. These improvements will address Monin-Obukhov length and mixing length scale for sloped coastal flows.

(UniZagreb)

**COAMPS** model (Coupled Ocean – Atmosphere Mesoscale Prediction System) – multiple nested grid domains, the finest grid having 333-m horizontal spacing.

COAMPS numerical simulations results are able to reconstruct the full three-dimensional structure and temporal evolution of the flow (lee wave, rotor, flow separation, etc.)

(DHMZ)
Thank you for your attention