SPACE-O Workshop on using Water Quality Forecasting in Decision Making
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Early Warning System (EWS)

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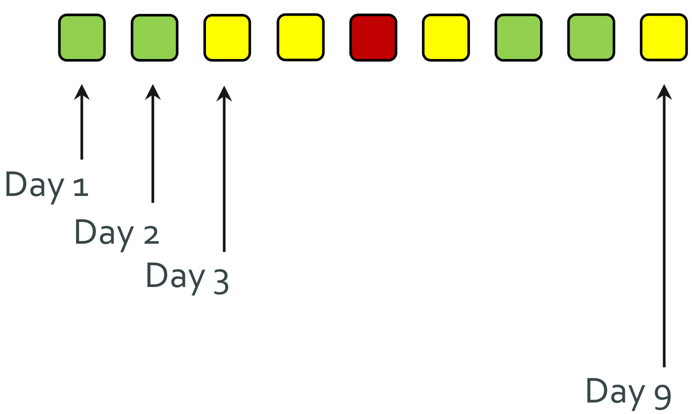
Early Warning System - EWS

The EWS ***aims*** to

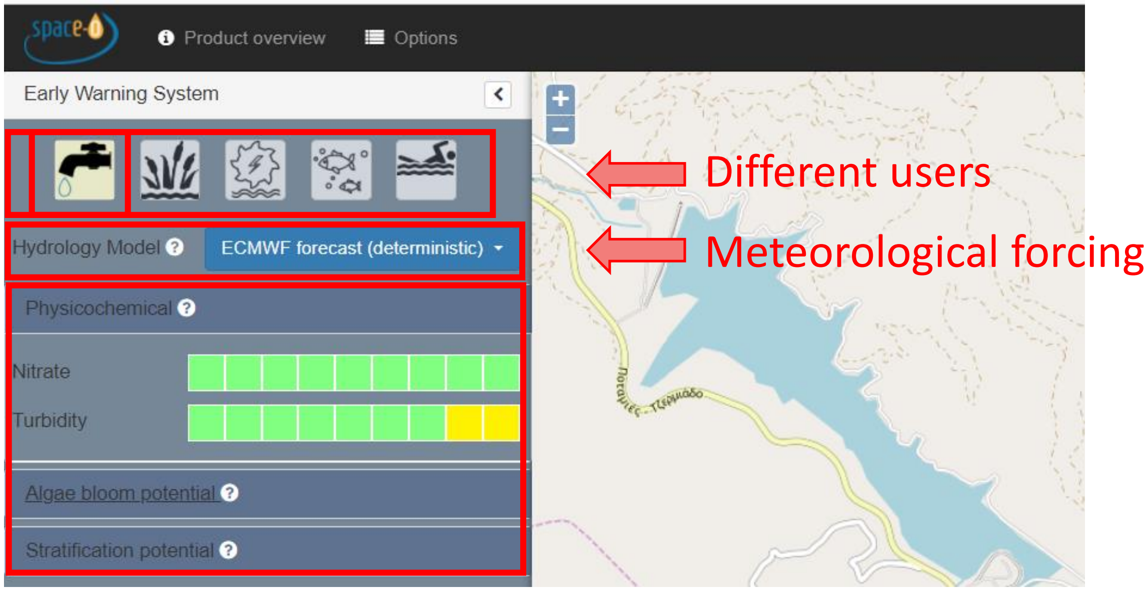
- interpret forecasts in readily comprehensible warnings that can be coupled with specific action plans
- enhance the resilience and the adaptive capacity of water reservoir managers and water utility operators
- mitigate of the impact of potentially harmful algae blooms

Keep it simple

Use color scales



Early Warning System - EWS



Three types of early warnings are issued

Physicochemical parameters

- NO_3
- Turbidity

Algal bloom potential

- Chlorophyll-a
- Cyanobacteria biovolume
- Evenness index
- Bloom intensification index

Stratification and mixing

- Thermocline depth
- Schmidt stability
- Wedderburn and lake numbers

Physicochemical parameters

Nitrate concentrations

- Nitrate concentrations are tested against the maximum allowable concentration of **50 mg/l** according to the Drinking Water Directive (Council Directive 98/83/EC) on the quality of water intended for human consumption

🟩 NO_3 remains below 25 mg/l

🟨 NO_3 exceeds 25 mg/l, but still remains below the maximum allowable concentration of the DWD

🟥 NO_3 surpasses the maximum allowable concentration of the DWD

Turbidity

- Early warnings resonate with the operational standards of the downstream water treatment utilities
- Maximum workable turbidity – MWT:
  - Turbidity levels that could impede the function of the WTP
  - e.g. past-period data for the Simbirizzi WTP in Mulargia indicate that the WTP can cope with raw water turbidities as high as 108 NTU

🟩 Turbidity remains below the 75% of the MWT limit

🟨 Turbidity exceeds 75% of the MWT, but is still lower than the MWT limit

🟥 Turbidity exceeds the MWT limit

Algal bloom potential (1)

Chlorophyll-a (Chlf-a) concentration

- Proxy for the overall abundance of algal species
- Chlf-a vs. good/moderate (G/M) boundary value and the critical bloom density (CBD) limit for Mediterranean lake types
  - G/M and CBD as reported by Mischke et al. (2012) – WISER report on sampling, analysis and counting standards for phytoplankton in lakes

- (green) Chlf-a is below the G/M boundary value for Mediterranean lake types (i.e. 5.1 μg/l)
- (yellow) Chlf-a exceeds the G/M boundary but does not surpass the CBD limit (i.e. 7.7 μg/l)
- (red) Chlf-a surpasses the CBD limit of 7.7 μg/l

Cyanobacteria biovolume

- Cyanobacteria populations vs. low and medium risk levels reported by the World Health Organization
  - Low risk = 20,000 cyanobacteria cells/ml
  - Medium risk = 100,000 cyanobacteria cells/ml

- (green) Cyanobacteria biovolume does not exceed the low risk threshold reported by the WHO
- (yellow) Cyanobacteria biovolume exceeds the low risk threshold reported by the WHO
- (red) Cyanobacteria biovolume surpasses the medium risk threshold reported by the WHO

Algal bloom potential (2)

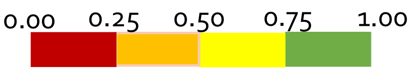
Evenness Index

- Estimate of the diversity of algal species calculated from the Shannon diversity index:

$$J' = \frac{H'}{H'_{\max}}$$

where $$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

Presence of a dominant species



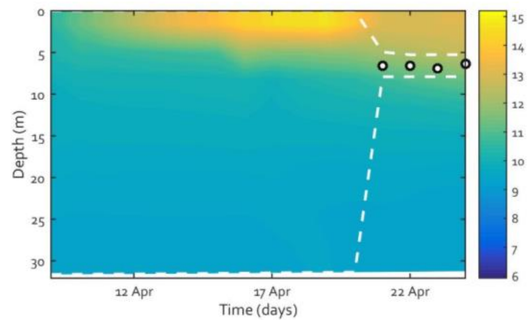
Even distribution of algal populations

Bloom intensification index

- Relative change in cyanobacteria cell density

- (green) The dissipation of the bloom is likely, i.e. the relative decline of cyanobacteria is greater than 25%.
- (yellow) No drastic change is anticipated, i.e. cyanobacteria will not increase or decrease by more than 25%.
- (red) A further evolution of the bloom is likely, i.e. cyanobacteria will increase by more than 25%.

Stratification and mixing



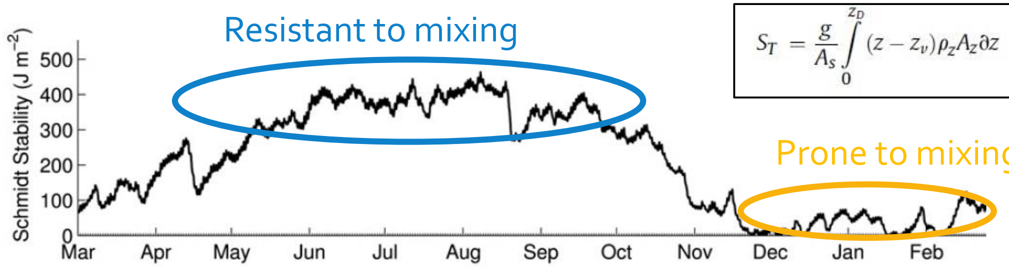
Thermocline depth

Depth of the maximum temperature gradient

- Estimate of the width of the mixed surface layer

Schmidt stability, S_T

- Resistance to mechanical mixing due to the potential energy inherent in the stratification of the water column



$$S_T = \frac{g}{A_s}\int_0^{z_D}(z - z_v)\rho_z A_z \partial z$$

Wedderburn number, *W*

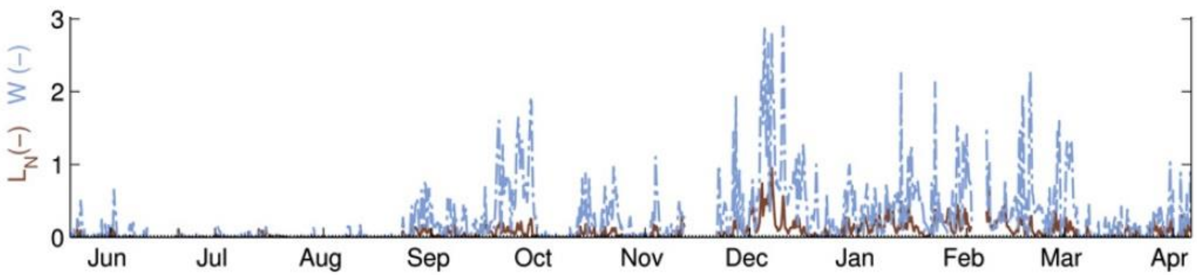
- Potential wind-induced upwelling events in lakes
- *W*<1 , upwelling events are likely to occur

$$W = \frac{g' z_e^2}{u_*^2 L_s}$$

Lake number, L_N

- Internal mixing due to wind forcing
- Low values = increased vertical mixing

$$L_N = \frac{S_T(z_e + z_h)}{2\rho_h u_*^2 A_s^{1/2} z_v}$$



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