




UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI
SCIENZE DELLA TERRA "ARDITO DESIO"


Mauro GIUDICI
Measurement of oceanographic and
hydrological quantities
*Physics of the Hydrosphere and the
Cryosphere*

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Water level gauges

- Point level detection (usually conductive)
 - Hydrometric rod (stadia idrometrica)





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Water level gauges

- Ultrasonic gauges for non-contact level sensing
 - High frequency (20 kHz to 200 kHz) acoustic waves
 - Correction factors to account for the changing speed of sound due to moisture, temperature, and pressure variation.
 - Turbulence, foam, steam also affect the ultrasonic sensor's response
 - Proper mounting of the transducer is required to ensure the best response to reflected sound

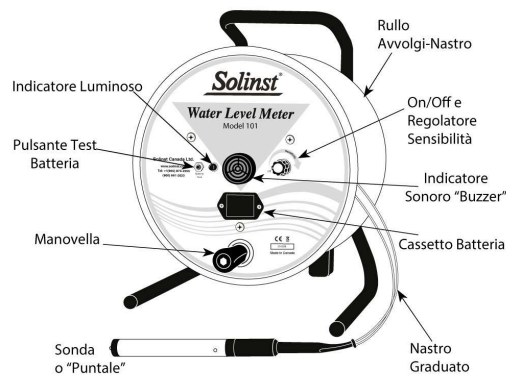


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Water level gauges

- Phreatimeter



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Water level gauges

- Phreatimeter
 - Piezometer vs well

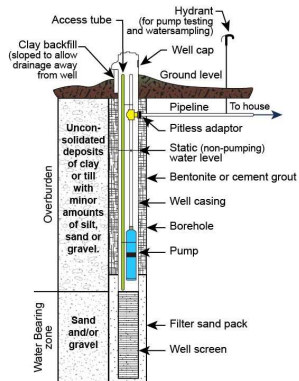


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Water level gauges

- Phreatimeter
 - Water well



<https://www.epa.gov/privatewells/learn-about-private-water-wells>

https://agriculture.canada.ca/sites/default/files/legacy/resources/prod/img/water-eau/wells_grndwtr_fig1-eng.jpg

https://www.paparelliscreens.com/files/thumbs/chi_siamo/qualita/x370/qualita.jpg

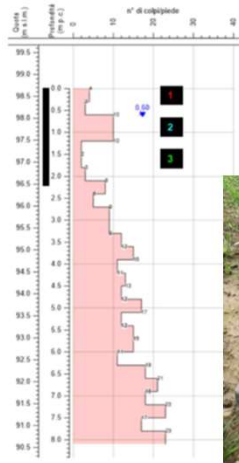


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Water level gauges

- CPT - Cone penetration test



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Water level gauges

- Hydrostatic pressure sensors

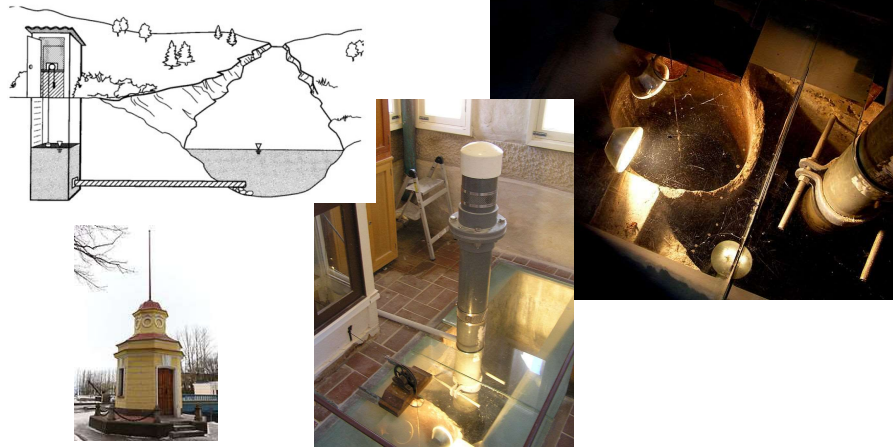


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Water level gauges

- Stilling wells for tide monitoring



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Wave buoys

- Moored buoys range from 1.5 m to 12 m in diameter
- Drifting buoys are smaller, with \varnothing of 30 cm to 40 cm
- Weather buoys measure:
 - air temperature above the ocean surface,
 - wind speed (steady and gusting),
 - barometric pressure, and wind direction,
 - water temperature (usually at a depth of 3 m for fixed buoys), wave height, and dominant wave period.

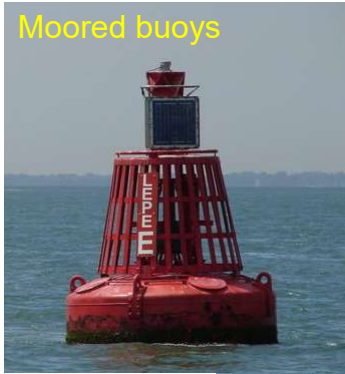


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Wave buoys

Moored buoys



Weather buoys



Drifting buoys



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Correntometric measurements

- Lagrangian measurements:
 - Drifters
- Eulerian measurements:
 - Mechanical current meters (propellers);
 - Acoustic Doppler Current Profiler (ADCP) measures the water current velocities over a depth range using the Doppler effect of sound waves scattered back from particles within the water column;
 - Electromagnetic induction: ions in seawater move with the ocean currents in the Earth's magnetic field and Faraday's law of induction permits to evaluate the variability of the averaged horizontal flow by measuring the induced electric currents;
 - Tilt current meters.



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Ocean vertical profilers

- CTD (Conductivity-temperature-depth) sondes
 - Cluster of sensors which measure conductivity, temperature, and pressure;
 - Other sensors to measure chemical or biological parameters (e.g., dissolved oxygen and chlorophyll fluorescence) may be added to the cluster;
 - Sensors commonly scan at a rate of 24 Hz;
 - Depth is derived from measurement of hydrostatic pressure, and salinity from electrical conductivity;
 - Sensors are arranged inside a metal (Titanium housings allow sampling to depths > 10,000 m) or resin housing.

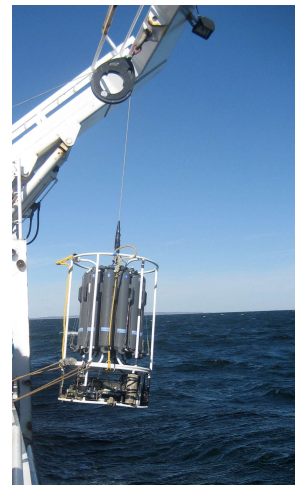


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Ocean vertical profilers

- CTD (Conductivity-temperature-depth) sondes
 - *Downcast* to a determined depth or to a few meters above the ocean floor, generally at a rate of about 0.5 m s^{-1} .
 - During *upcast* the rosette is stopped to collect water samples using attached bottles at depths based on the water column profile.



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Ocean vertical profilers

- CTD (Conductivity-temperature-depth) sondes
- NANSEN (Fridtjof Nansen, 1894) & NISKIN (Shale Niskin, 1966) bottles (w/reversing thermometer).



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Bathymetry

- Early techniques used heavy ropes or cables lowered over a ship's side
- Sonar (SOund Navigation And Ranging) - 1 kHz to 30 kHz
[Hearable sound from 20 Hz to 20 kHz]
 - Military and civil (fishery) applications
- Multibeam echosounder



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Autonomous Underwater Vehicle (AUV)

- Applications
 - Commercial: mapping seafloor for design of subsea infrastructure; pipeline inspection.
 - Research.
 - Illegal drug traffic.
 - Air crash investigations.
 - Military applications (UUV).



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Autonomous Underwater Vehicle (AUV)

- Applications
- Sensors:
 - compasses, depth sensors, sidescan and other sonars, magnetometers, thermistors and conductivity probes, biological sensors (e.g., fluorometers i.e. Chlorophyll sensors), turbidity sensors, and chemical sensors (pH, dissolved oxygen).
- Positioning:
 - Dead reckoning (navigazione stimata)
 - Long (LBL), Short (SBL) and UltraShort (USBL) BaseLine acoustic positioning system; SBL & USBL require the presence of a supporting ship.



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Autonomous Underwater Vehicle (AUV)

- Applications
- Sensors
- Positioning
- Propulsion:
 - Electrical engine connected with propeller or thruster.

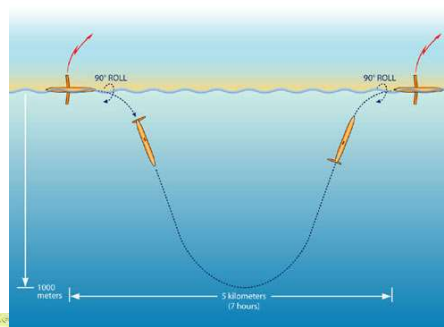


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Autonomous Underwater Vehicle (AUV)

- Applications
- Sensors
- Positioning
- Propulsion:
 - Electrical engine w/ thruster
 - Underwater glider



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Autonomous Underwater Vehicle (AUV)

- Applications
 - Sensors
 - Positioning
 - Propulsion:
 - Electrical engine w/ thruster
 - Underwater glider
 - Wave glider
- <https://youtu.be/77Wg1MFsLpQ>

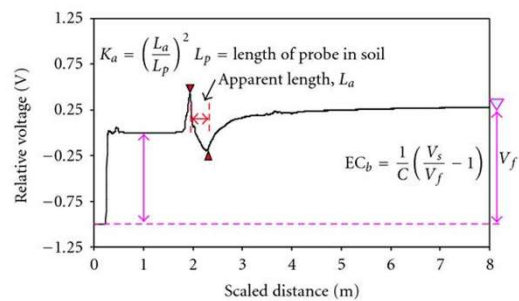


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Soil water content

- Gravimetric
- Resistive probes
- Capacitive gauges
 - TDR
 - FDR



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Soil water content

- Gravimetric
- Resistive probes
- Capacitive gauges
- Neutron probes
 - Fast neutrons emitted from a radioactive source ($^{241}\text{Am}/^9\text{Be}$) slow down when collide with particles with the same mass as a neutron (i.e., protons, H^+). H_2O is the main source of H in most soils \Rightarrow density of "thermalized" (slowed) neutrons formed around the probe \propto the volume fraction of water present in the soil.
- NMR

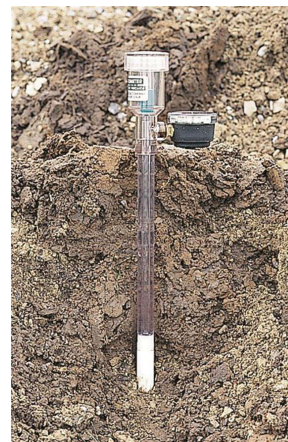
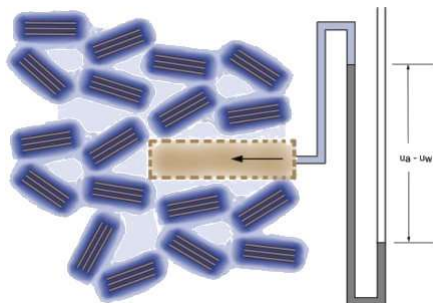


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Suction

- Tensiometer



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