WORLD METEOROLOGICAL

ORGANIZATION

Innovation in Hydrometry – from ideas to operation

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#### Back to the future of stream gauging

When innovating stream gauging techniques are historic techniques revisited





#### Jérôme LE COZ

Irstea, Hydrology-Hydraulics, Lyon-Villeurbanne, France





# Darwinism in hydrometric instrumentation?

#### The current-meter evolution







*Woltmann (1790)* Graëff (1883)



#### Albert Ott (1885)

Price AA Pygmy (USGS)



SEBA F1



#### *Ott Nautilus* (electromagnetic)



SonTek Flowtracker (hydroacoustic)



*Ott ADC* (hydroacoustic)

#### Has the daily life of field hydrologists much changed in 100 years?



From Alexandre Hauet (EDF-DTG)

#### Floats / Surface velocimetry



Leonardo Da Vinci (ca 1500) L'Hôte (1990), Biswas (1970)





Floats used by Leonardo (a) and Mariotte in 1686 (b)

Di Fidio & Gandolfi (2011)





LSPIV applied to a crowd-sourced drone video

Le Coz et al. (2016)

#### Image orthorectification





Graphical image orthorectification for stream gauging

Bureau (1910)

Image orthorectification using Fudaa-LSPIV software

Le Coz et al. (2014)

#### Pitot tubes

*Hydrotachymètre* Ritter (1892)



Technicians using a Pitot-Darcy tube

Darcy and Bazin (1865)

Darcy's Pitot tube design (1858)

Brown (2003)





Pressure-Operated Electronic Meter POEM (NIWA, New Zealand) Smart (1991), Magirl et al. (2009) <sup>6</sup>

#### **Rising floats / bubbles**



Rising float (empty iron sphere)

Bureau (1910)



#### Nozzle on bed

#### Hydrometric pendulum (inter-comparison exercise in the Po River, 1716–1721!!)









Guglielmini (1690)

Storz (2016)

Flood gaugings in Ethiopia 8

#### Velocity head rods



(1944)

# Wilm and Storey



Drost (1963)





Transparent velocity head rod Pike et al. (2016)

Fonstad et al. (2005)

# Taking more and more distance from the river?

In-situ streamflow measurements and stations remain absolutely necessary to the establishment of reliable streamflow series



# Taking more and more distance from the river?

How to **combine** satellite remote sensing with in-situ measurements and hydrodynamical modelling?



Monitoring and management of freshwater resources has long depended upon on-the-ground measurements. Satellite remote sensing has brought new complementing capabilities. In this final of three debates, *Science* invited arguments about the appropriate roles for, and balance between, each approach.

Famiglietti et al. (2015) versus Fekele et al. (2015), Science

# Taking more and more distance from the river?

- Future SWOT satellite will provide river stage, slope and width
- Slope-area models could be applied to satellite data with limited numbers of stream gauging data

4e-05

3e-05

2e-05

1e-05

0e+00







Traditional twin-gauge station to cope with variable backwater

Madeira at Fazenda, Brazil

Bayesian stage-fall-discharge model (Mansanarez et al. 2016)

# Does the 'stage-coach' effect hold for hydrometry?

Before a technical invention becomes accepted as an innovation, old protocols are applied to new techniques (Jacques Perriault)

# Thank you for your attention!







The first train carriages were shaped like stage-coaches and compatibility was ensured

