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D64 – EGU2020-8858

ADCP with onboard GPS for streamflow velocity measurement usable for physical models calibration

EDF DTG R&D

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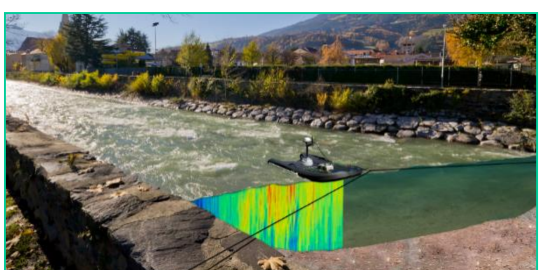

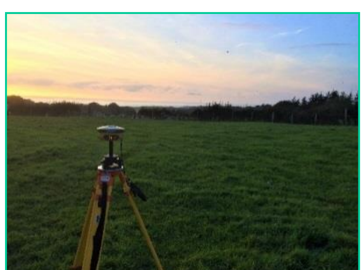

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Why using ADCP to get velocity measurements ?

Hydro sedimentary modelling

- Sediments blocked in reservoirs & loss of storage capacity,
- Difficulties to ensure sedimentary or ecological continuity,
- Siltation of nuclear plant cold springs …

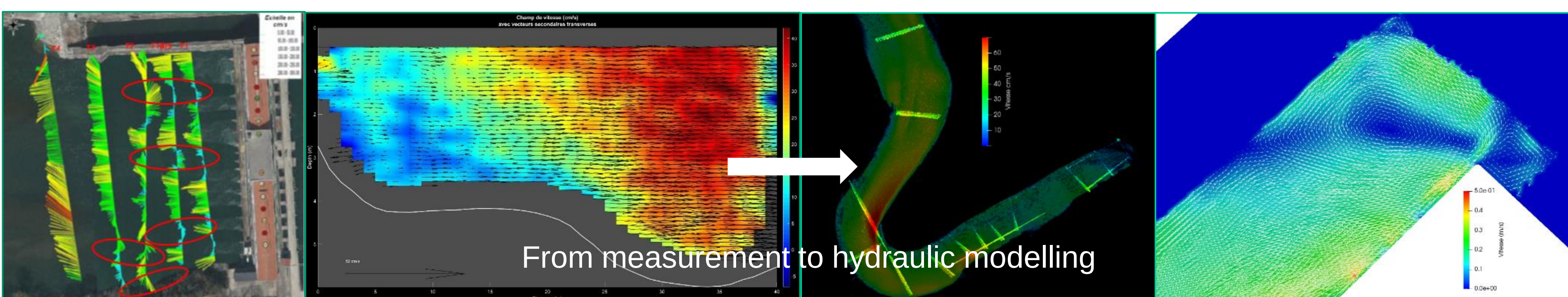
Hydraulic modelling

- Bank erosion downstream of a dam,
- Flow problems through grids,
- Clogging problems (fry, jellyfish…) of nuclear plant cold springs …

Spatial mapping of velocities

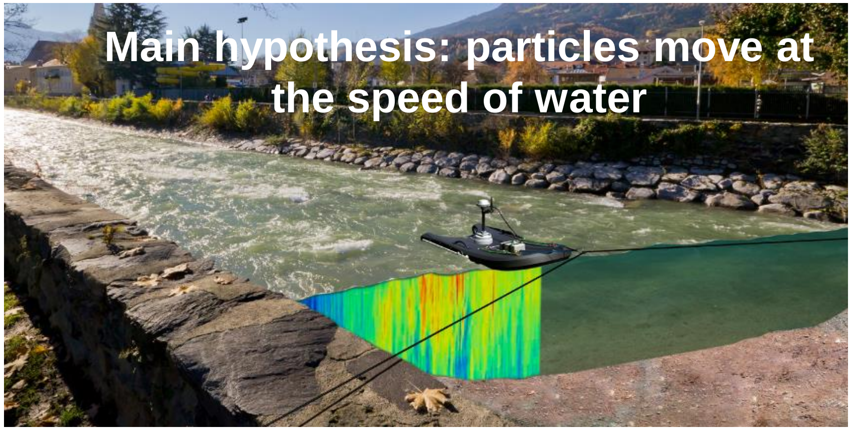
- Marine or fluvial tidal wave,
- Spatial mapping of velocities for sizing of structures (dike, dam…).

1/ Map, model and reproduce the behaviour of rivers or facilities
2/ With specific conditions applied to the model, understand the evolution of flow, sediments, or fish paths…
3/ Find solutions to meet environmental, producing and safety challenges



How to get velocity measurements ?

- **ADCP measurement (Acoustic Doppler Current Profiler)**
  - Velocity profiler working with Doppler effect (double Doppler effect),
  - Measuring velocity and depth under the device.

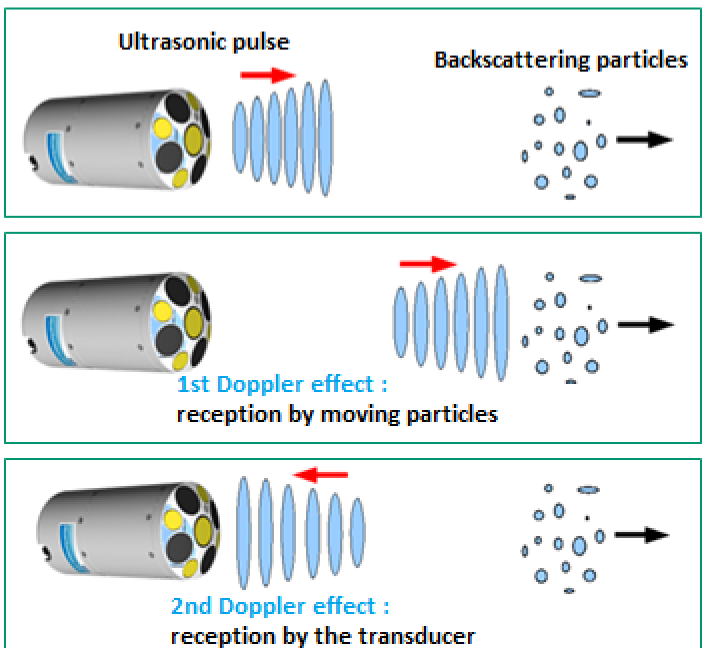


$$V = \frac{c\Delta F}{2F_0 \cos(A)}$$

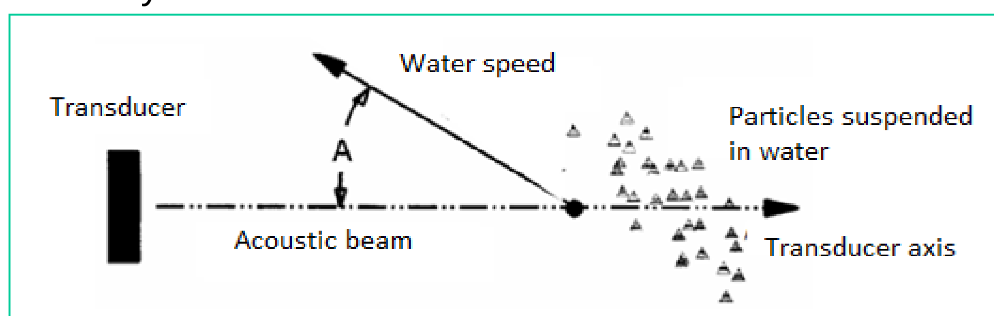
Win River II

River Surveyor

Qrev

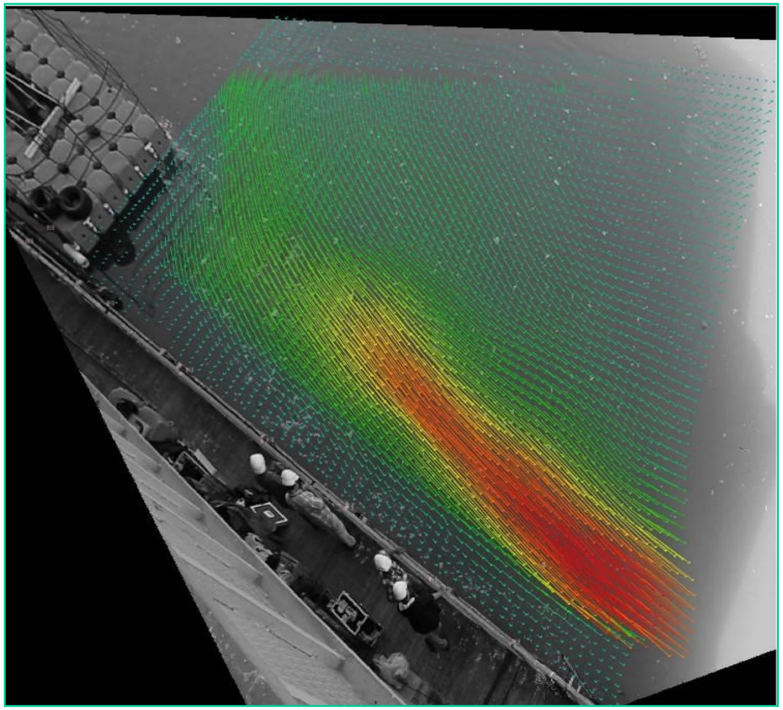


- $\Delta F = F_1 - F_0$
- F_0 : frequency of the signal emitted by the transducer
- F_1 : frequency of the signal received by the transducer
- c : wave speed (depending on water temperature and salinity) ⇨ importance of temperature measurement and stability



Additional measurements : $V_{surface}$

- **LSPIV measurement (Large Scale Particle Image Velocimetry)**
  - Surface velocity measurement : complementary to ADCP,
  - Non-intrusive measurement (fixed camera, aerial drone),
  - May require injection of tracers (corn chips…).



Fudaa-LSPIV

- **SVR measurement (Surface Velocity Radar)**
  - Surface velocity measurement,
  - Non-intrusive measurement (mainly from bridges).

Obvious links between velocity and discharge measurements (tools, devices, softwares)…

A few differences …

Q *discharge*

- **Mainly « organized » flow on cross sections**
- **6 transects required and averaged**
- **Q conservative, navigation accuracy « not very important »**
- **GPS used if bad bottomtrack signal (moving bed, algae…)**
  - HDOP < 4
  - DGPS (quality 2) acceptable
  - Number of satellites > 5

GPS	
Latitude (degrés)	43° 4' 18.65"
Longitude (degrés)	0° 36' 23.84"
Altitude (m)	[illegible]
Nb Satellites	4
Qualité GPS	2
Age GPS	49.00
T	164 027
HDOP (GPS)	10.20
Course GPS/Suivi ...	3.3
Dist. Suivi de Fon...	[illegible]
Mag. corr. Suivi F...	1.04
Dir. corr. Suivi Fon...	139.7
UTM (m)	694 856.75
UTM (m)	4 771 573.46

Tableau GPS 1 - TRDI

Latitude	43° 8.001019' N	
Longitude	1° 36.028890' E	
Nombre invalide	0	
Nombre de Sats.	23	
Changement de Sats.	31	
Altitude	264.6	[m]
Ecart d'Altitude	1.8	[m]
HDOP	0.6	
Ecart HDOP	0.1	
Laps de temps	1.0	[s]
Statut DGPS	DGPS	
DGPS Date de la Corr.	2.9	[s]
DGPS ID Stn	123	

- **Optional compass (except if moving bed)**

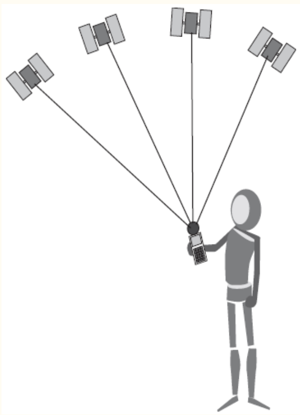
V *velocity*

- **Mainly « disorganized » flow**
- **1 transect may be enough, if not several averaged transects**
- **Local velocity field (magnitude and orientation) and good navigation accuracy required**
- **GPS used if bad bottomtrack signal and for geolocation (GGA & VTG)**
  - HDOP < 0.8
  - DGPS sometimes not sufficient, RTK (quality 3) required
  - Number of satellites> 12
- **Some additional softwares**
  - VMT (velocity representation), Hypack (navigation and bathymetry), QGis (cartography)
- **In marine environment, salinity profile required**
- **Calibrated compass and magnetic declination (if GPS used for velocity computation)**

GPS « World » (GNSS*) important…

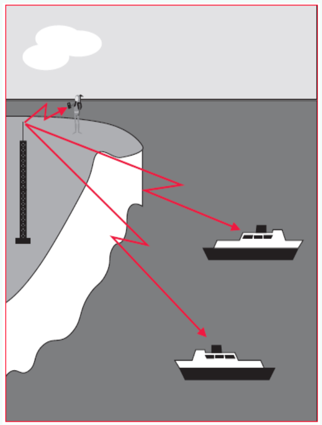
Geolocation must be as precise as possible!

Quality : Medium
Precision : ~10m



GPS
[Global Positioning System]

Qualité : Good
Precision : ~ 1- 3m



DGPS
[Differential Global Positioning System]

Qualité : Excellent
Precision : ~ 1- 10 cm

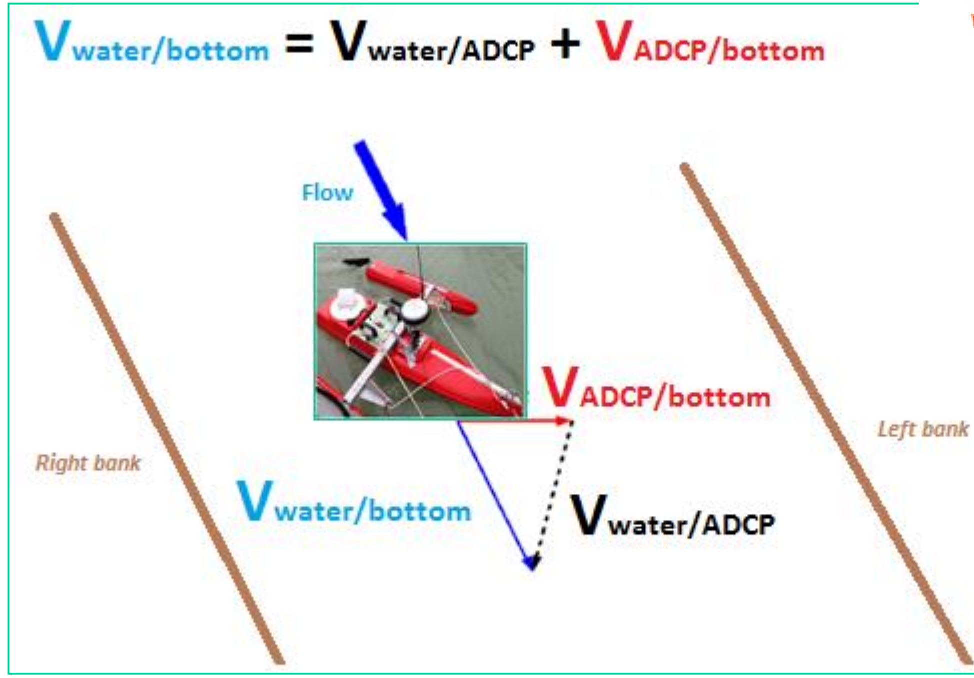
RTK (base < 10km)
[Real Time Kinematic]

- Existing satellite systems (GPS, GLONASS, BEIDOU, Galileo) must be complemented with **performance enhancements system that deliver real-time corrections to improve accuracy**

- Ground reference stations continuously measure the error and send a correction signal to users :
- With GSM connexion, it is called RTK « Network »
- With a reference installed by the user before each measurement, it is called RTK « classical ».

** GNSS: Global Navigation Satellite System*

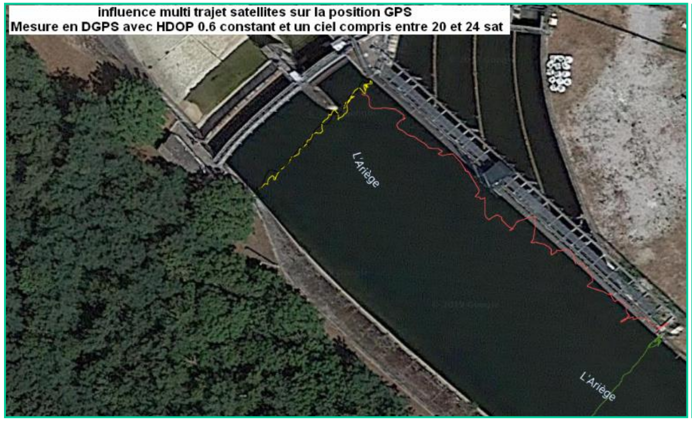
Why using ADCP with onboard GPS ?

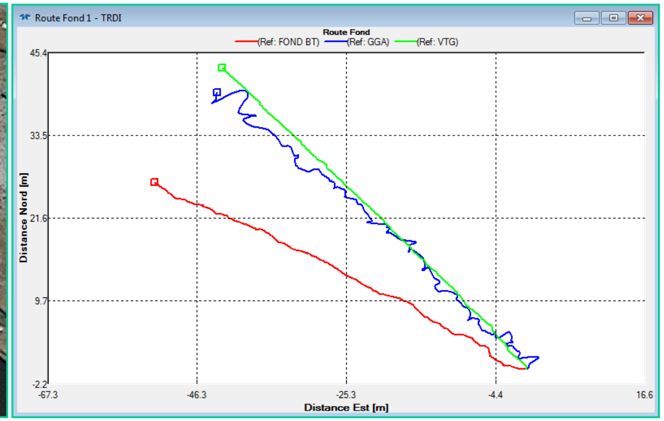


$V_{\text{ADCP/bottom}}$ **:** computed with GPS or Bottom Track (BT) reference $V_{\text{water/ADCP}}$ **:** measured by the ADCP $V_{\text{water/bottom}}$ **:** computed with $V_{\text{ADCP/bottom}}$ and $V_{\text{water/ADCP}}$

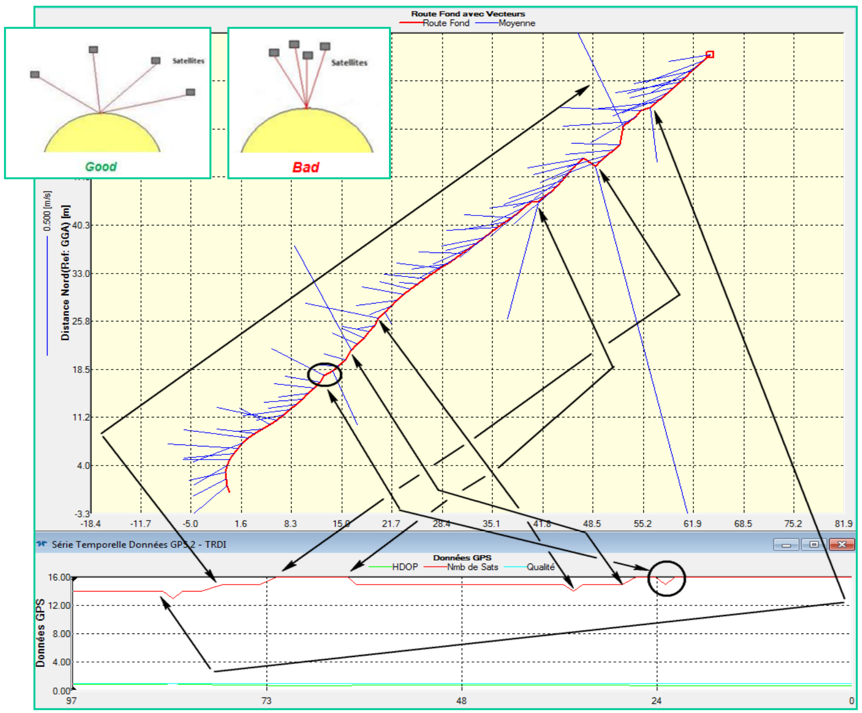
- GPS is used to geolocalize each velocity measurement : accuracy required to properly localize the measured velocity fields.
- If GPS reference is selected (instead of Bottom Track reference), the GPS is used to compute $V_{\text{ADCP/bottom}}$: accuracy required to compute properly the final wanted value of $V_{\text{water/bottom}}$, in this case a calibrated compass and the magnetic declination are needed.

Errors due to GPS quality…

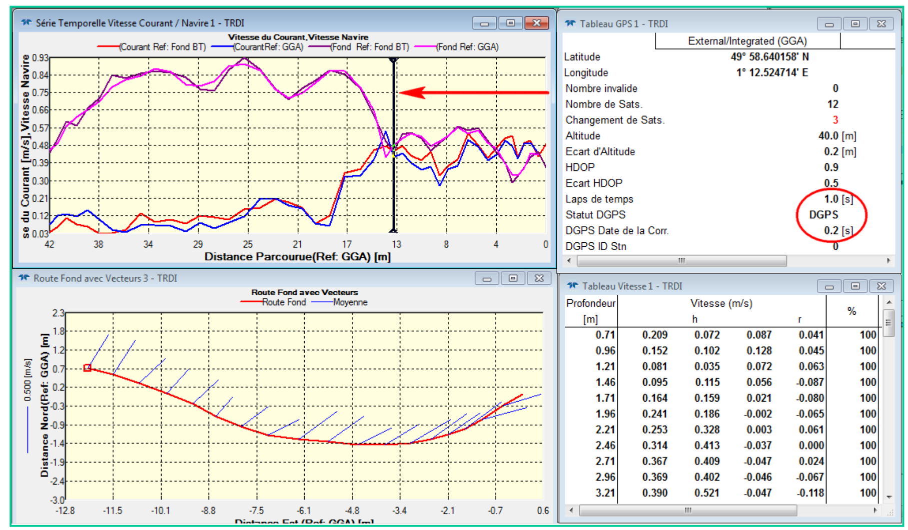




1/ « multipaths » errors : when GPS signal is reflected by objects like tall buildings before it reaches the receiver



2/ Changes in satellite sky can have direct influence on accuracy of measured flow velocities (in GPS and DGPS quality)

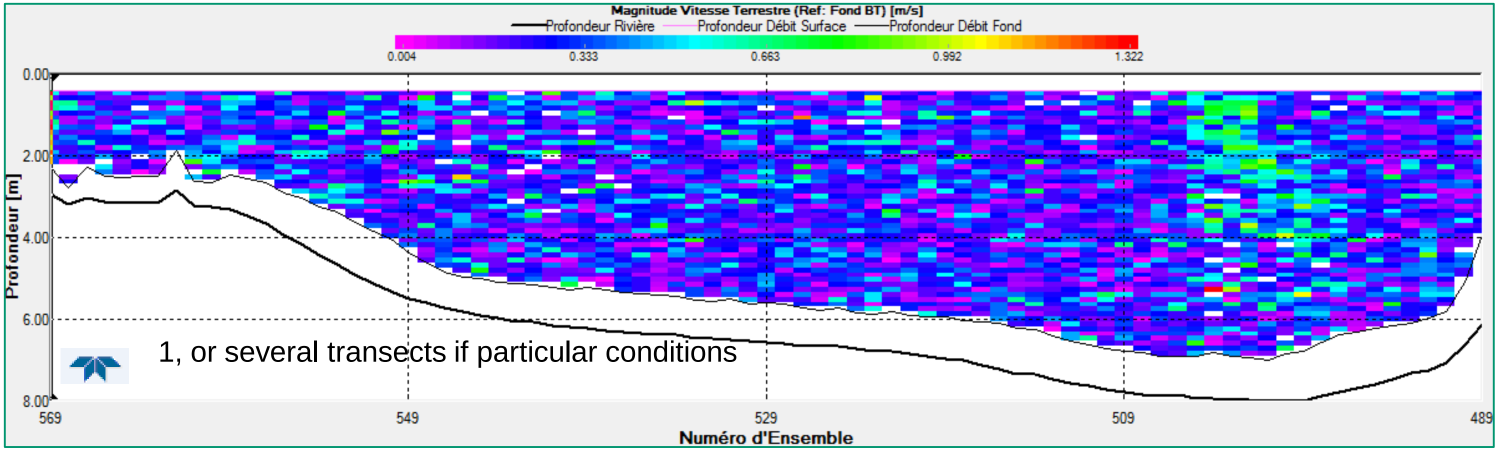


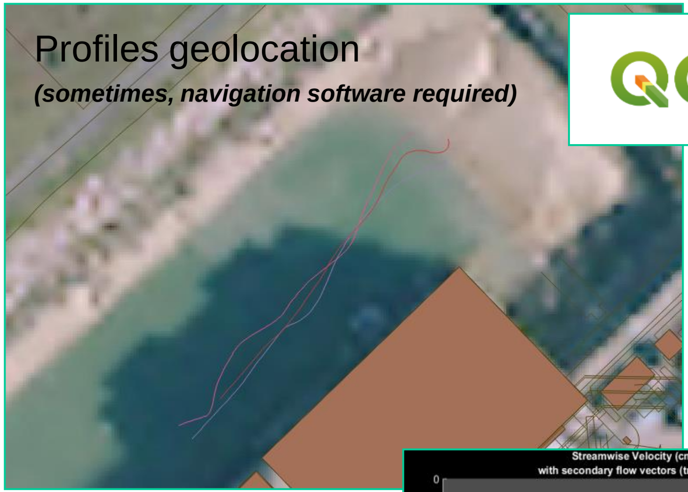
3/ Changes in GPS status (GPS, DGPS, RTK) during measurement can have consequences on quality of the measured velocities.

GGA *: positionning information, disturbed by «multipaths»*

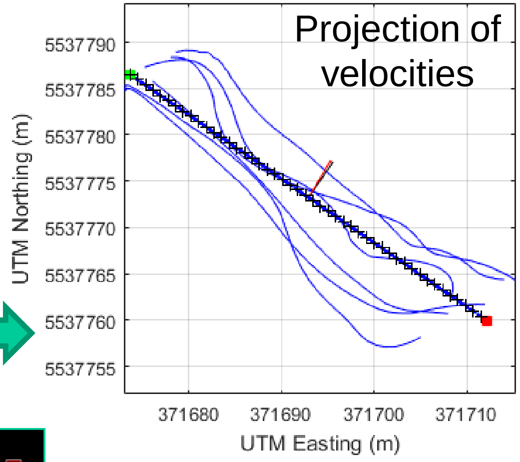
VTG *: velocity information, disturbed by satellites sky changes*

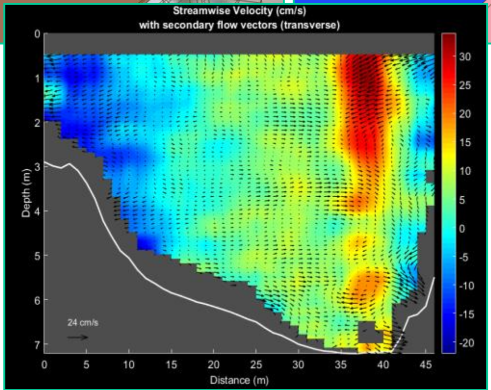
Some results of a field campaign

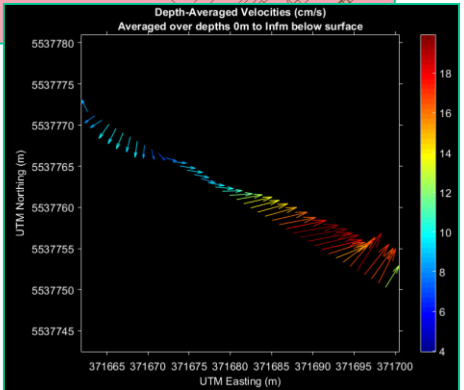




QGIS







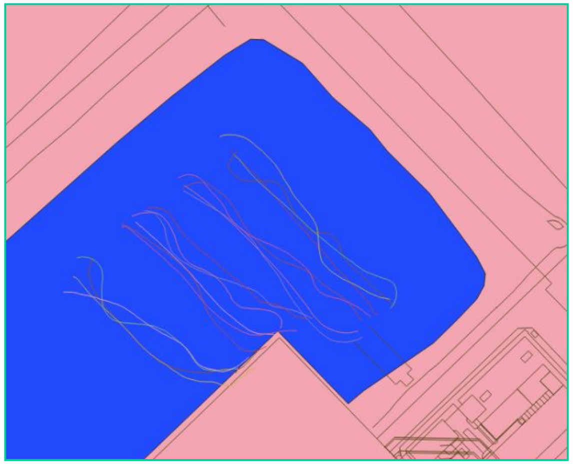
USGS
science for a changing world
Velocity Mapping Toolbox

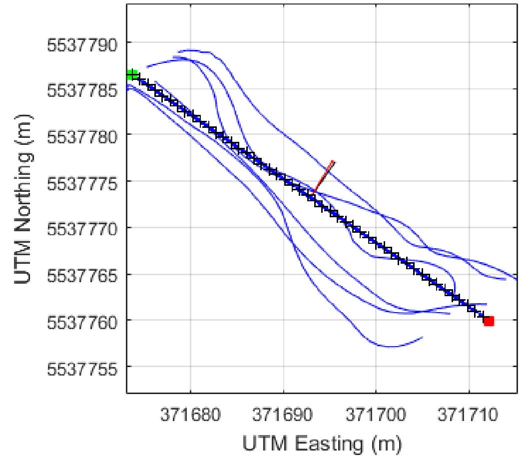
Work with VMT software …

USGS science for a changing world
Velocity Mapping Toolbox

Required data with VMT :
Several transects on the same cross section
ADCP TRDI or SonTek
GPS positioning

1/ Import of GPS tracks



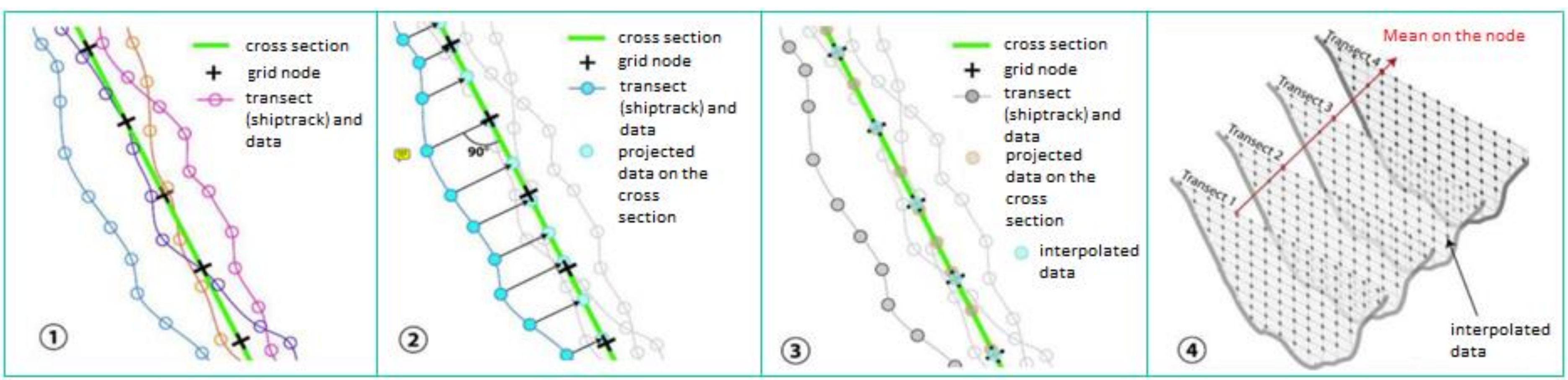


2/ Calculation of a rectilinear average transect from GPS tracks (least squared)

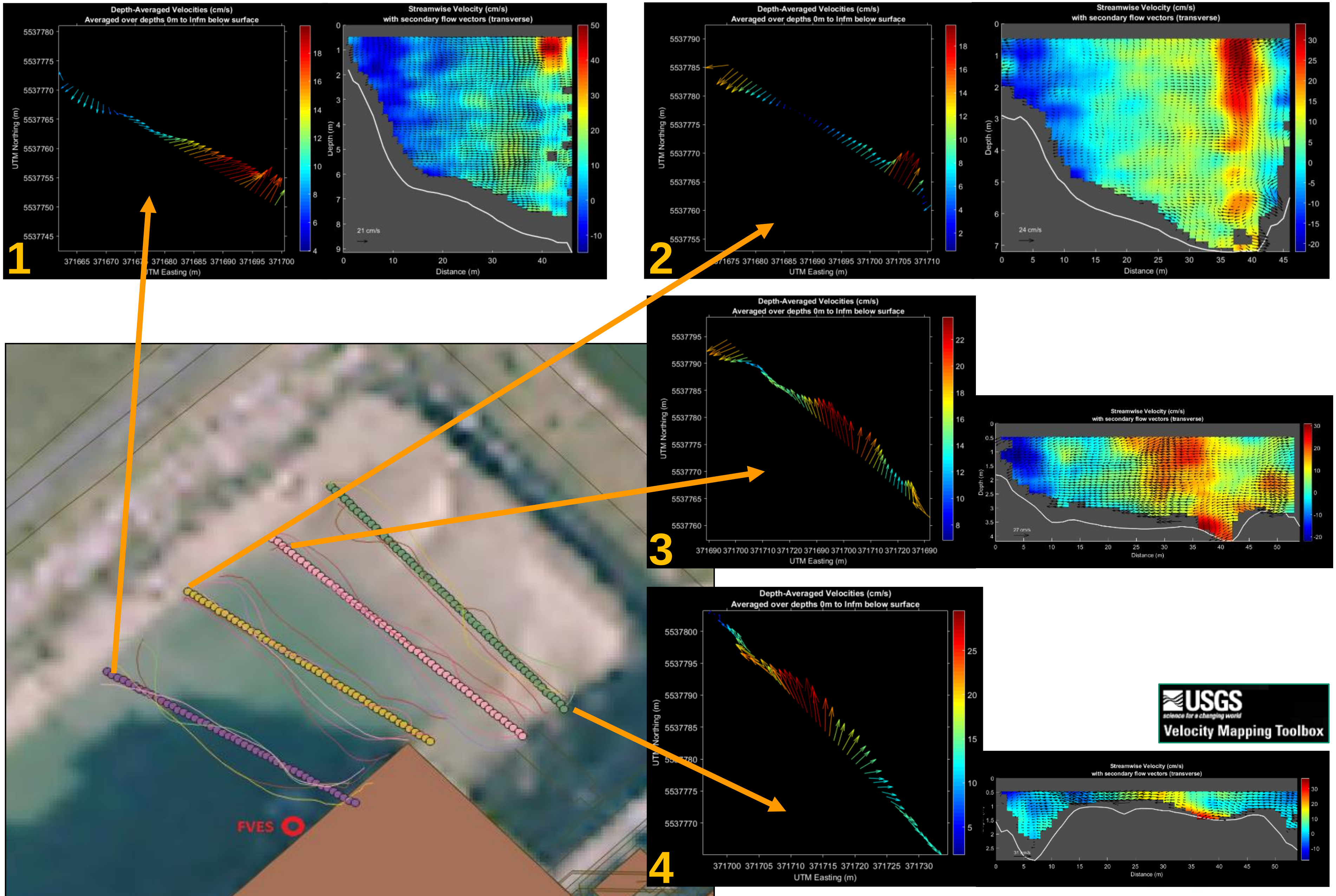
3/ Definition of a regular calculation grid on the average transect

4/ Projection of velocity measurements of each transect on the average profile

Different possible projections :
Zero Net Cross Stream Discharge Definition (ZSD) -> for turns
Rozovskii Definition (ROZ) -> for confluence or asymmetrical factory configuration

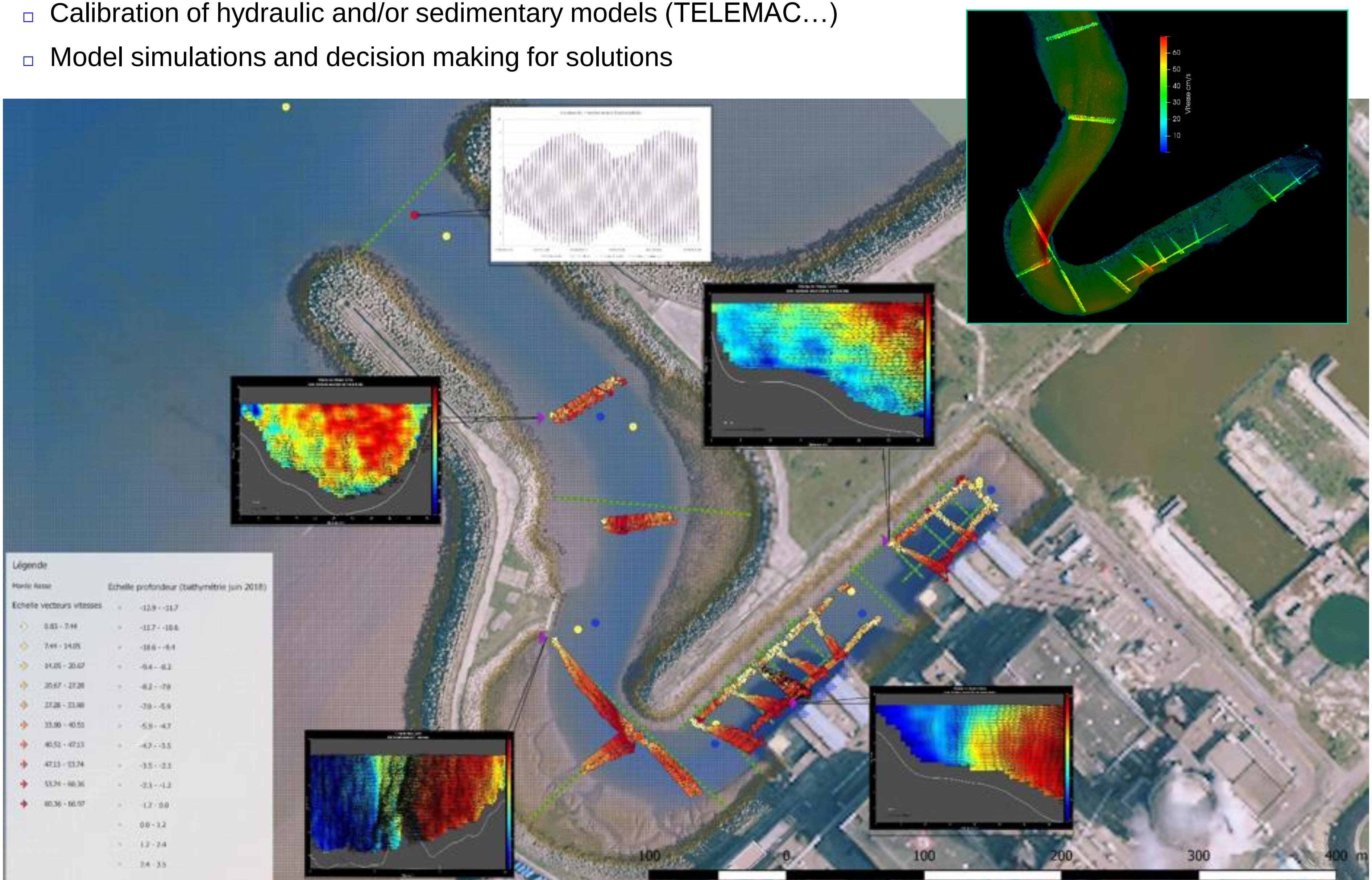


Some results from a measurement campaign…



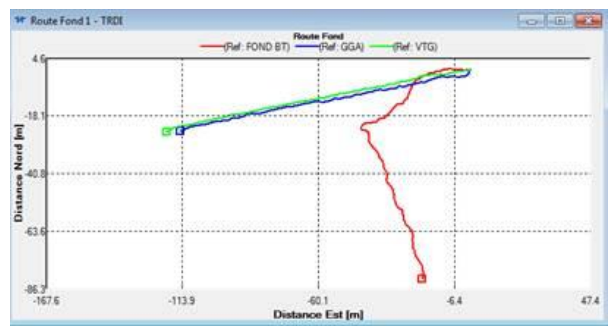
Data transmitted for modelling

- Measured data are provided to the modeller
- Calibration of hydraulic and/or sedimentary models (TELEMAC…)
- Model simulations and decision making for solutions



Technical problems still to be solved …

- Make connections more reliable
  - Radio, Bluetooth ? How increasing the field measurement range ?
  - Doppler communication - PC more robusts
- Software applications : standardization required
  - A lot of manipulations : HYPACK for navigation, QGIs for cartography, VMT for projection …
  - VMT software upgradeable to better answer the needs (recalculating GPS tracks ?)
  - Recovery of bottom velocities (side lobes, ambiguity) ?
- GPS : Complete, automatic and easy to use set (Sontek ?)
- General reflection about ADCP + GPS to improve data collection ?



The end … Thanks !