On developing robust Dynamic Electronic Navigational data Production and Delivery systems.

(Canadian perspective, lessons learned, so far …)

Canadian Hydrographic Service

TWCWG4 Busan, South Korea

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Descriptive Adjectives: Challenging, Complex, Multi-Initiative, Multi-Year, Multi-Departmental, Industry Partners, International Oversight/Engagement, Collaborative, Team Building, Developmental, **Commitment**

Environment and Climate Change Canada

Environnement et Changement climatique Canada

Fisheries and Oceans Canada

Pêches et Océans Canada

CONCEPTS

The Need for Coupled Atmosphere-Ice-Ocean Prediction

CONCEPTS

Davidson et al., SCOR, 2013

Environment Canada requires ice-ocean forecasts and information services for:

- Improved weather and wave prediction
  - Timescales from days to seasons
  - Sea ice, tropical cyclones, surface interactions
  - Initialization of seasonal forecasts
- Sea ice prediction
  - Improved automated analyses and forecasts
  - Dangerous high pressure areas
- Emergency response
  - Comprehensive trajectory modelling capacity
  - E.g. dispersion of pollutants
- Collaboration with other GoC departments
  - Fisheries and Oceans, Coast Guard
  - National Defense

Coupled Operational Environmental PredicTion Systems

CONCEPTS

- Environment and Climate Change Canada
- Dept of Fisheries and Oceans Canada
- Department of National Defense
- Mercator Ocean (NEMO)
- Canadian Hydrographic Service (Dyn E-nav)

Ocean Foresting in Canada: Stream 2: 24/7 support – CONCEPTS efforts

GIOPS: ¼ °, DA, operational since Aug 2015; two versions: 30-day ensemble, 10-day deterministic coupled to weather

Great Lakes: 2 km, coupled to weather, since 2014

Gulf of St Lawrence: 5 km, coupled to weather, since June 2011; in process of being updating to 2km-500m

CIOPS-west: 1/36°, spectral nudging, operational by end of 2018

RIOPS: 1/12°, DA, operational by end of 2018; will replace existing system based on spectral nudging towards GIOPS, mainly used for short-term sea-ice forecasting

CIOPS-east: 1/36°, under development

Development Initiatives:

- World Class Tanker Safety (WCTS, 2014-17)
  - Port Modeling Proof of Concept
- Oceans Protection Plan (OPP, 2017-22)
  - Concept to Operational (Drift Prediction and Dynamic E-nav)

OPP

"…Make navigation safer by providing <u>modern hydrography</u> and charting in key areas of high traffic commercial ports and waterways, dynamic products, and …"

- 4 Streams
  - Ports
  - Near Shore Bathymetry
  - **Dynamic Hydrographic Products (DHP)**
  - Arctic

Dynamic Hydrographic Products (DHP)

Model Results and Station Observations, Predictions + Forecasts to Dynamic E-navigation, Science and Public Clients

Expanding Coupled Operational Environmental PredicTion Systems (CONCEPTS) DFO-ECCC-DnD

- ECCC nested Weather Prediction Systems: Global (GDPS) - Regional (RDPS) - High Resolution (HRDPS)
  Provide Environmental Surface Forcing for Ocean Models
- ECCC – DFO supported nested Ice Ocean Prediction Systems: Global (GIOPS) – Regional (RIOPS) – Coastal (CIOPS) – Port (POPS, missing, last part of the chain, started as WCTSS goal)
- POPS: OPP OESD-CHS Solution Development --- OPP Drift Prediction and Nearshore Modeling (DPNM) and E-nav HPC on GPSC (2-5000 core, multi-slot cluster machines)
- CHS IHO International Standard E-nav File Extraction/Production S111 (currents), S104 (waterlevels)
  Modeled (extraction from all relevant scales, from RIOPS, CIOPS, POPS) plus Observed, Predicted, Forecasts at obs. stns (CHS IWLS)
- POPS solution and E-nav File Delivery Systems:
  - Navigation: Caris-Primar Cloud distribution?
  - Science/Public: Navigator tool

OPP NEMO vs FVCOM

- Nucleus for European Modeling of the Ocean (NEMO)
- Finite Volume Community Model (FVCOM)

Main Objectives

- Evaluate the performance and efficiency of the two models
- Questions:

  1) How well do NEMO and FVCOM perform **for near-shore, high-resolution OPP applications?**

     Drift prediction and E-navigation

  2) How do the model results compare to what we currently use for operations?

  3) What computer resources are required to run each model?

"model performance" refers to the model's ability to reproduce 1)in-situ and remote sensing observations and 2)any behaviour/dynamics that can be inferred from observations (ie. drifter statistics and oil spill simulations). It is evaluated separately from the model efficiency and the model's ability to meet OPP application requirements.

Model Setup

NEMO (Regular Grid, Nested Solutions)

5:1

Most Challenging Case: Saint John NB.

- 8 to 15 m tides, strong tidal flows
- strong river input, strong baroclinic flows
- shallow, depth + time limited port access

FVCOM (Adaptive Variable Scales Tin grid)

Low-Res (48 m – 14 km)

High-Res (17 m – 48 km)

Comparisons, Intra-Models and to Observation

Solution development and fitting: 1) Implement ocean BCs and environmental forcing.
2) Adjust model tunable parameters to best match observations by comparisons to Obs

Shallow, depth limited, large 8 m tides, strong river input, strongly baroclinic, near worst case conditions.

Comparisons, Intra-Models and to Observation

Solution development and fitting: 1) Implement ocean BCs and environmental forcing.
2) Adjust model tunable parameters to best match observations by comparisons to Obs

Important input Saint John River flow

Shallow, depth limited, large 8 m tides, strong river input, strongly baroclinic, near worst case conditions.

Drifters, obs vs modeled

Tide gauges (WL) and ADCPs (Currents)

Velocity Profiles

Water properties (T,S,r) obs (CTDs) vs model

Summary

1) How well do NEMO and FVCOM perform for near-shore, high-resolution OPP applications?

- Both models were able to provide reasonable simulations of Saint John Harbour and had comparable quantitative scores.
- Both models showed respective strengths and weakness, and had technical issues that can be corrected.

2) How do the model results compare to what we currently use for operations?

- Both models outperformed existing operational products for currents and drift.

3) What computer resources are required to run each model?

- Both models met the operational benchmark.
- There is an additional cost of running NEMO that may present an issue for e-nav applications.

Results:
Model Cost Efficiency

Computational cost is important for research and development and on-going e-nav operations; less so for operational emergency response.

Key points

- Both models meet the predefined operational benchmark (48 hour simulation in 30 mins).
- FVCOM has less computational costs (runs twice as fast 1/3 the resources).
- FVCOM can achieve ~20 m resolution within the defined operational requirement.
- Both models able to spin-up tides in 1-2 simulated days.

	NEMO (100 m)	FVCOM (Low Res)	FVCOM (High Res)
# of cores and run-time for operational requirement	31 slots 29m,7s	8 slots 19m,28s	32 slots 20m,35s

Considerations

- Both models would benefit from optimization.
- Preliminary results suggest use of AGRIF in NEMO considerably reduces cost.

Final Decision: Pragmatic

- FVCOM not presently supported under existing ECCC robust operational 24/7 supercomputer Environmental Prediction Environment.
- To partner/collaborate with ECCC under existing CONCEPTS structure and deploy solutions to ECCC Ops, port solutions (POPS) must be NEMO.
- NEMO costs more in CPU, additional nesting complexity, but provides best likelihood for robust operational service delivery

POPS Development and Support

<u>Objective: To develop and operationalize:</u>

- 6 OPP POPS model solutions (Vancouver, Fraser River, Kitimat-Prince Rupert, 100m St. Lawrence Seaway, Saint John NB, Canso)
- Dynamic file extraction applications for S111, S104 from both model outputs and observational (IWLS) databases

CHS needs to participate/develop High Power Computer (HPC) operational solutions within ECCC-DFO CONCEPTS

1. Develop solution and integration plans with existing systems
   - Provide for: In-transit, Approach and Port S111, S104 file solutions
   - Extract from RIOPS, CIOPS, POPS, WebTide and IWLS
   - Tiled delivery hi-res bathymetry S102 and dynamic data S111, S104 …
2. Develop and acquire necessary HPC Resources
3. Develop netcdf and IWLS to S111 and S104 extraction codes (Python)
4. Operational POPS and extraction codes in ECCC robust env.
5. QC E-navigation Outputs (Sxxx)
6. Product delivery systems: navigational, others
7. Support dynamic E-nav viewers development

CHS - DHP: Developmental and Test Operational E-nav Ports Ocean Prediction Systems (POPS) + Ground Truth Observational Data (CHS and Verified Client) 1

DPNM and E-nav High Power Computing (HPC) Resources

GPSC: 22 core slots, 2100 cores, DPNM (1500) and E-nav (600)

- Reach balanced agreement on use with DPNM to support/achieve:
  - Scientific development and validation of Port Prediction Systems (POPS): **DPNM HPC**
  - POPS model development towards Operations (CPOP ECCC prep): **E-nav HPC**
  - CHS IHO S111 and S104 file extraction (RIOPS, CIOPS, POPS and CHS IWLS: obs, pred, forecasts) **E-nav HPC**
  - Interim operational POPS hosting/staging for later deployment to ECCC: **E-nav HPC**
- E-nav HPC on GPSC designed to host all 6 POPs 'best effort' FVCOM solutions.
  - NEMO POPs need ~ 3 times + cores for same resolution.
  - Under ECCC Ops, to act as staging Area for Dev. to Ops Deployment in ECCC.
  - Staging should require similar or greater cores, need to re-examine solution scheduling

Larger Scale Model Inputs/Results

POPS Scheduling

Complex Operational Structures, Planning

Observational data Water levels + currents

CHS Grid Based Products (3 usages)

- S-101 – ENC
- S-102 – Bathymetric surface
- S-104 – Water level
- S-111 – Currents

Proposed Cell Definitions Using 3 Usages Only

-WGS84 (EPSG :4326), HDF5 (.h5 / .bag)

Level	Resolution	Coverage	
2	0.001° ≈ 100m	1° X 1° ≈ 100km	All Canada
5	0.0001° ≈ 10m	0.1° X 0.1° ≈ 10km	Near Shore – Less than 50m deep
6	0.00002° ≈ 2m	0.02° X 0.02° ≈ 2km	Maintained areas + coverage ENC CA5

S-102 « Data as Service » Pilot Project

S-102 – WCS capability

-Vancouver Harbour in image below using QGIS, WCS shown is from Teledyne CARIS

Webtide S111&S104 data threaded production on gpsc<2,4> using python2.7 multiprocessing module

L2 (~100km x ~100km) & L5 (~10km x ~10km) tiles bounding boxes W-Coast with WebTide ne_pac4 grid points.

Webtide S111&S104 data threaded production on gpsc<2,4> using python2.7 multiprocessing module

S111&S104 data produced with WebTide grid points located inside S102 tiles.

one S102 tile with WebTide grid points => one S111 HDF5 file written by one thread.
=> one S104 HDF5 file written by one thread.

S104: 3642 L5 tiles + 31 L6 tiles(Hfx. harb.) => 3673 tiles => 3673 S104 HDF5 files

S111: 1016 L2 tiles + 1389 L5 tiles + 31 L6 tiles(Hfx. harb) => 2436 S111 HDF5 files

54 hours(6 in the past, 48 in future) of tidal predictions at 15mins intervals.

DataCodingFmt type 3 with S111 IHO data file spec version 1.0.0 used also for S104.

HDF5 dual compound type data => S111 velocity(knots) and direction(nav. angle)
=> S104 water level and time trend

File size limit ??? Still 10 Meg?

Webtide S111&S104 data threaded production on gpsc<2,4> using python2.7 multiprocessing module

one tile, one file, one thread in action on one gpsc2 node

(2 sockets: 12 cores/socket, 24 phy. cores, 2 threads/core, using all 48 threads)

```
~
top - 14:53:49 up 11 min,  0 users,  load average: 109.82, 84.76, 40.65
Tasks: 143 total,  26 running, 101 sleeping,   0 stopped,  16 zombie
%Cpu0  : 29.8 us, 26.0 sy,  0.0 ni, 41.1 id,  2.4 wa,  0.0 hi,  0.7 si,  0.0 st
%Cpu1  : 29.5 us, 24.0 sy,  0.0 ni, 43.8 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu2  : 28.9 us, 23.8 sy,  0.0 ni, 44.6 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu3  : 28.1 us, 23.5 sy,  0.0 ni, 45.0 id,  3.3 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu4  : 28.0 us, 23.7 sy,  0.0 ni, 46.3 id,  2.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu5  : 26.0 us, 23.2 sy,  0.0 ni, 48.4 id,  2.4 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu6  : 27.3 us, 21.5 sy,  0.0 ni, 48.1 id,  3.1 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu7  : 24.5 us, 23.5 sy,  0.0 ni, 49.7 id,  2.4 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu8  : 28.7 us, 22.0 sy,  0.0 ni, 46.7 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu9  : 30.8 us, 19.7 sy,  0.0 ni, 46.8 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu10 : 24.0 us, 24.7 sy,  0.0 ni, 48.0 id,  3.4 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu11 : 24.7 us, 23.4 sy,  0.0 ni, 49.8 id,  2.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu12 : 26.6 us, 23.3 sy,  0.0 ni, 47.2 id,  3.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu13 : 24.9 us, 22.9 sy,  0.0 ni, 49.1 id,  3.1 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu14 : 29.0 us, 21.9 sy,  0.0 ni, 46.5 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu15 : 24.4 us, 24.1 sy,  0.0 ni, 48.8 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu16 : 28.2 us, 22.4 sy,  0.0 ni, 46.6 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu17 : 24.0 us, 24.3 sy,  0.0 ni, 49.0 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu18 : 26.5 us, 26.8 sy,  0.0 ni, 44.4 id,  2.3 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu19 : 24.7 us, 24.4 sy,  0.0 ni, 47.8 id,  3.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu20 : 27.9 us, 23.5 sy,  0.0 ni, 46.3 id,  2.4 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu21 : 28.9 us, 22.4 sy,  0.0 ni, 45.9 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu22 : 27.6 us, 23.9 sy,  0.0 ni, 45.8 id,  2.7 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu23 : 25.3 us, 22.3 sy,  0.0 ni, 50.0 id,  2.4 wa,  0.0 hi,  0.0 si,  0.0 st
KiB Mem : 73728000 total, 67407288 free,  5974408 used,   346304 buff/cache
KiB Swap:  4194300 total,  4194300 free,        0 used. 67407288 avail Mem

   PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
   669 gme042    20   0 2122748 878944   9908 D  18.7  1.2   0:41.25 S100ProductsMai
   700 gme042    20   0 2122748 878944   9908 D  15.0  1.2   0:43.27 S100ProductsMai
   688 gme042    20   0 2122748 878944   9908 D  14.0  1.2   0:42.59 S100ProductsMai
   691 gme042    20   0 2122748 878944   9908 R  14.0  1.2   0:43.10 S100ProductsMai
   636 gme042    20   0 2122748 878944   9908 D  13.3  1.2   0:42.83 S100ProductsMai
   693 gme042    20   0 2122748 878944   9908 D  13.0  1.2   0:42.18 S100ProductsMai
   698 gme042    20   0 2122748 878944   9908 D  13.0  1.2   0:43.15 S100ProductsMai
   643 gme042    20   0 2122748 878944   9908 D  12.7  1.2   0:41.54 S100ProductsMai
   685 gme042    20   0 2122748 878944   9908 D  12.7  1.2   0:41.56 S100ProductsMai
   686 gme042    20   0 2122748 878944   9908 D  12.7  1.2   0:42.86 S100ProductsMai
   702 gme042    20   0 2122748 878944   9908 D  12.7  1.2   0:42.62 S100ProductsMai
   703 gme042    20   0 2122748 878944   9908 R  12.7  1.2   0:42.85 S100ProductsMai
   705 gme042    20   0 2122748 878944   9908 D  12.7  1.2   0:43.16 S100ProductsMai
   626 gme042    20   0 2122748 878944   9908 R  12.3  1.2   0:43.61 S100ProductsMai
   652 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:42.92 S100ProductsMai
   655 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:42.43 S100ProductsMai
   690 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:42.90 S100ProductsMai
   692 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:42.59 S100ProductsMai
   694 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:43.06 S100ProductsMai
   695 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:42.63 S100ProductsMai
   701 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:43.24 S100ProductsMai
   704 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:43.14 S100ProductsMai
   708 gme042    20   0 2122748 878944   9908 D  12.3  1.2   0:42.78 S100ProductsMai
```

3673 S104 files:

gpsc4 => ~35mins

gpsc2 => ~30mins

2436 S111 files:

gpsc4 => ~19mins

gpsc2 => ~22mins

- ***Fairly easy to implement with S102 tiles bounding boxes***
- ***No third party module***
- ***But one drawback:***

  => memory duplication.

Canadian Hydrographic Service

CVDCW

- Spatially Continuous Vertical Separation Surfaces (HyVSEPs) for all CHS vertical control practices (move from station to spatial referencing systems)
- **Linkage between MWL Ocean model reference and Navigational Chart Datum (CD)**
- **Provide depths for modeling on MWL or geodetic ref. and convert ocean model output to DHP CD reference using CVD grids and techniques for adjustment**

HyVSEP's Layer Model

Methods:

- High Res. Adaptive TIN Working Grids
  ~80m coastal resolution
- Observational and modeled input data
- Grid interpolation/smoothing tools:
  - Laplace 'heat-transfer' interpolator/extrapolator
  - Finite Element Smoother
- Boundary condition tools
  - Pseudo stations
  - Control shoreline
  - Blend zones
  - Warp fit

Robin, C. et al (2016), Hydrographic Vertical Separation Surfaces (HyVSEPs) for the Tidal Waters of Canada, Marine Geodesy, vol. 39, No. 2, pp 195-222

CVDCW Elements

Idealized Solution

+ Station Observations = (Warping)

<u>Operational CD HyVSEP</u>

CVDCW Web tool

HyVSEP data delivery

- Select extents of desired surface and surface reference
- Data download:
  - ascii point cloud
  - other file formats
- Based on existing Matlab based functionality

OPP Rust out

Pêches et Océans Canada | Fisheries and Oceans Canada

Operational standardization:

Achieve a common national level of service for data accuracy, quality and reliability:

- All gauges will receive the CHS newly standardized data collection electronics package (data-logger, supporting electronics and power systems, and redundant communication systems), running standardized data collection and transmission programming.
- Wherever technically feasible all gauges will be equipped with and run a standardized set a navigational sensors (3 sensor per gauge, 1 radar and 2 density compensating submersible pressure sensors)
- All gauges will provide data in near real time to the new mirrored nationalized data base structure being developed under the CHS-IMTS Water Level System Renewal (WLSR) project.
- All gauge data will pass through the same primary, automated and secondary, manual quality control procedures.

Physical Infrastructure Re-conditioning:

Renewal and standardization of physical infrastructure: stilling wells, gauge support huts and boxes to conform to accepted environmentally effective regional models.

Water Level System Renewal (WLSR) Project:

New national centralized water level and current database structures: predictions, observations, forecasts, added value products, station metadata and linkages to operational ocean model outputs. Associated: data collection; automated primary and secondary manual QC; forecasting and data delivery applications (webpages, cloud apps, IHO international file formats S104, S111)

Canadian Gauging Environments

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Pacific: warm summer mediterranean to oceanic, 3-8 m tides, exposed rocky coasts, large waves, generally ice free, high risk shipping, tsunami risk

Canadian Arctic: arctic to temperate, winter + year-round ice, sensitive environments, high risk shipping
Western 0.5-3 m tides,
Eastern, Hudson's bay, Foxe Basin 3-8 m
Hudson St., Ungava Bay 3-18 m

1 Tuktoyaktuk
2 Iqaluit
3 Nain
4 Various arctic

200,000+ km coast
- 1200+ gauge stns
- 500+ gps links
- 90+ permanent stns

tides.gc.ca

Langara Island 9
Bonilla Island 10
Vancouver 11
Tofino 12

5 St. Lawrence
6 Rimouski
7 Baie Ste Cath
8 Bedford Inst
Great Lakes

St Lawrence river + Great Lakes: temperate, estuarine, fresh water, storm surge, winter ice, high shipping traffic, high risk shipping

Atlantic + Labrador: temperate to sub-Arctic, 1.5-18 m tides, large waves, storm surge, winter ice, tsunami risk, high shipping transit, high risk shipping

Rustout

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Standardized Supporting Electronics:

- BackPlanes, loggers, sensors, communications … Several versions on same theme

Regions building systems for installation

Original Pacific Model

National 20X20 STD and STD E-nav Sensors

1. Sutron 8310 Datalogger
2. Pacific backplane and support electronics
3. Radar sensors: stilling well (through air, wire guided), arm mount (through air)
4. Density Compensated Submersible Pressure (DCSP) sensors with customizations
5. Comms (at least 2): Ipcell, radio, GOES, landline

Atl 20X16 Box Option

C+A Variant

Pressure sensors, any environment

Density compensated pressure sensor buildup

1. Ott PLS-C
2. 7/8" Shaft Zinc Anode machined down to fit 2" well,
3. Copper anti-foul cover for Conductivity/temp sensors
4. Base adapter to move to ¼"NPT female end
5. 316-SS short nipple
6. ¼ NPT female to slip adapter (3/8") PVC
7. 3/8" male insert machined from ½"PVC pipe with grooves for finger cot and o-ring
8. Small Nitril finger cot
9. O-ring to provide compression seal
10. 1" PVC protective pipe end cap

<u>Objective:</u> Increase sensor reliability, maintenance interval and lifetime (2 - 3X)

- Zinc – extra anodic corrosion protection (pressure sensor body SS-316)
- Copper anti-foal to suppress marine growth around conductivity sensor
- Parts 4-10: establish physically protected silicon oil filled bladder, protection for pressure sensing element. Bladder is very thin nitril, flaccid oil fill, causes no pressure effect on pressure sensing element.

Legacy sensors

Pêches et Océans Canada
Fisheries and Oceans Canada

Nain Labrador:

Heated, insulated Multi-well laser tide gauge

1. 6” main well with laser
2. 2” secondary wells with vented pressure sensors
3. Heater well and heat trace
4. Tough Poly Shell

Heated, Insulated Multi-Well Construction:

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Laser Shroud Alignment Guide

Eliminates data spikes, laser can only see direct reflections from float

Legacy Dry Counter F + P

Pêches et Océans Canada | Fisheries and Oceans Canada

Pacific Dry Counter Weight Float and Pulley:

- robust, reliable, linear,
- can be accurate to ~ 1-2 mm
- relative BEI encoder, absolute encoder with high count per rev >1000 would be improvement (better prevent position loss on power failure)

Dry Counterweight Tide Gauge

Specifications:

1. Encoder shaft diameter = 3/8".
2. Starting Torque: 10. in-oz. (existing system is 2.5 in-oz gives excellent sensitivity near slack water).
3. Counter weight lead ball = 5. lb, may be adjusted for sensitivity.
4. Temperature range = -20. to +35. degrees Celsius.
5. Eccentricity error = +/- 0.03 mm
6. Linear error = +/- 0.1 mm
7. Float drum line capacity = 12.m + 5 spare grooves at each end of drum.
8. Counterweight line capacity = 3.5m + 5 spare grooves at each end of drum.
9. Circumference Ratio of float to counter weight = 6.
10. Float drum maximum diameter = 250. mm (space between equipment on bench).
11. Counter weight drum minimum diameter = 70.-80.mm (to avoid work hardening SS)
12. Maximum float or CW drum length ~ = 100.mm (ensures float clearance to well).

Dry Counter weight Notes:

1) Drum material: Aluminum.
2) Drum finish: Anodized.
3) Drum hard anodizing growth allowance = 0.0005" to 0.001".
4) Line selected: Surflon model C135T Nylon coated 1x7 Stainless Steel.
5) Drum groove width = 0.045" (1.15 mm)
6) Drum groove taper, each side = 0.005" (0.13 mm)
7) Drum groove guard width = 0.030" (0.77 mm)
8) Drum groove pitch = 0.085" (2.16 mm)
9) Drum line termination resists slippage.
10) Drums centered on shaft with keyless bushings.
11) Shafts and Encoders connect with spiral couplings.
12) Shaft diameter = 5/8" or ¾" to suit keyless bushings.
13) Keyless bushing inside diameter = 5/8", or ¾".

Physical Infrastructure Reconditioning

Pêches et Océans Canada | Fisheries and Oceans Canada

- Pacific Model: Standard building mounted over uninsulated polyethylene stilling wells with removable-cone orifices
- Atlantic Model: New Small Huts or Gauge Box (new versions will be fiberglass electrical enclosure, top image) mounted over insulated, heated polyethylene encased Multi-well
- Central and Arctic, Great Lakes Model: Standard gauge hut mounted over 36” steel well (great lakes international standard), heated in winter.
- Quebec Model(s): Gauge box or building connected to sensors in square steel wells in fresh water, new heated wells in salt water, single wells where available wharf space insufficient for larger well infrastructure.

Pacific Model

Atlantic Model

Central and Arctic
Great lakes Model

Quebec Models

Databases, Pre-WLSR OPP Systems

Pêches et Océans Canada | Fisheries and Oceans Canada

National delivery systems

Regional data collection systems

Regional gauging solutions

OPP WLSR National Solution

Pêches et Océans Canada | Fisheries and Oceans Canada

Integrated Water Level System (iWLS) – High Level Diagram
Version: 1.0.1 (2016-12-07)

Cloud Implementation

National standardized gauging (inter-region maintenance support), data collection applications, database structures and supporting applications, simplified data delivery applications,

Currents

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- Historical data: Drift measures, S4 EM meters, ADCP data
  - Tidal analysis, current constituents, current predictions
- Real-time currents
  - Horizontal and Vertical ADCPs
    - Bottom mounted, Buoy mounted, Wharf mounted

Virtual Tide Gauge (VTG)

A VTG is a transfer function relating astronomic and atmospheric forcing to water level response at a defined Point of Interest (POI). It is based on an all-source Green's function formulation. The transfer function is trained over a 'short-term' set of observations through data assimilation (least-squares fittings). Once trained, given the spatial forcing functions the transfer function can be used to easily calculate and forecast water levels with significantly greater skill than standard tidal predictions. Once the transfer functions have been trained, VTG calculations for multiple stations can be done a simple PC.

Zhigang Xu
http://odylab.ocean.dal.ca/vtg/

Pressure and wind forcing

S100 As a Data Service

aws

OGC® Making location count.

TELEDYNE CARIS

PRIMAR

DEMONSTRATION SCENARIO – S-102 DATA AND THE POTENTIAL FOR e-NAVIGATION

Vancouver Harbour in Kongsberg S-102 Demonstrator

CHS bathymetry in CARIS Bathy DataBASE

S-102 datasets in CARIS cloud

S-102 datasets in PRIMAR Map Viewer

Link:
http://165.227.38.222/S111_viewer/index/

Vancouver Harbour S-102 Datasets in Kongsberg S-102 Demonstrator

TELEDYNE CARIS

PRIMAR

Model Solutions and Extracted Sxxx QC, comparison to data, Non-navigational Data Access.

The Ocean Navigator

The Ocean Navigator is a webserver software interface that enables visualization, analysis and verification for all aspects of the Operational Oceanography value chain from observations to end use. It is designed to be intuitive for first time users while as well as experienced oceanographers.

OCEAN NAVIGATOR
http://navigator.oceansdata.ca/

Navigator Components

Python

Plotting
Calculation
& Read
layers

DATA
OBS
Models

Interface
WEB / API

THREDDS

Java Script
JSON

OCEAN NAVIGATOR
http://navigator.oceansdata.ca/

Connects to modeling and observation data sources, Web-Interface, Data Viewing tools

S111 Web test viewer

Web viewer for S111 format files

- Testing S111 Extracted IHO format filew
- Web viewer, CHS + other HOs

http://165.227.38.222/S111_viewer/index/

Viewer Development Contracts

Source: https://s102.no/2018/08/21/operational-test-aboard-the-largest-cruise-ship-with-marine-pilots-from-nca/

On developing robust Dynamic Electronic Navigational data Production and Delivery systems.

(Canadian perspective, lessons learned, so far …)

Canadian Hydrographic Service

TWCWG4 Busan, South Korea

Phillip MacAulay

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Descriptive Adjectives: Challenging, Complex, Multi-Initiative, Multi-Year, Multi-Departmental, Industry Partners, International Oversight/Engagement, Collaborative, Team Building, Developmental, **Commitment**

Environment and Climate Change Canada

Environnement et Changement climatique Canada

Fisheries and Oceans Canada

Pêches et Océans Canada

CONCEPTS

Lessons Learned, so far …

- As per title adjectives
- Many parts to coordinate and work together
- Build teams and collaborations to succeed
- Rely on, and learn from, partners
- Much juggling, coordination, people skills required
- New line of business, new skills required
- International comparisons to establish best practice, share methods
- Still very much a work in progress, commitment and persistence required (unexpected speedbumps)
- Interesting, will change the face of hydrography

Parting Messages (from Louis Maltais)

As it matures Caris-Primar cloud solution could be used to by other HOs as a test cloud based delivery concept. Upload data and start distribution to stimulate PPU development and establish mariner buy-in.

What to do about cross-jurisdiction responsibility, i.e. Great lakes. Suggest common agreed capacity, comparisons heathy, but one solution as service.