Malta Summer School 2018 Operational Oceanography for Blue Growth



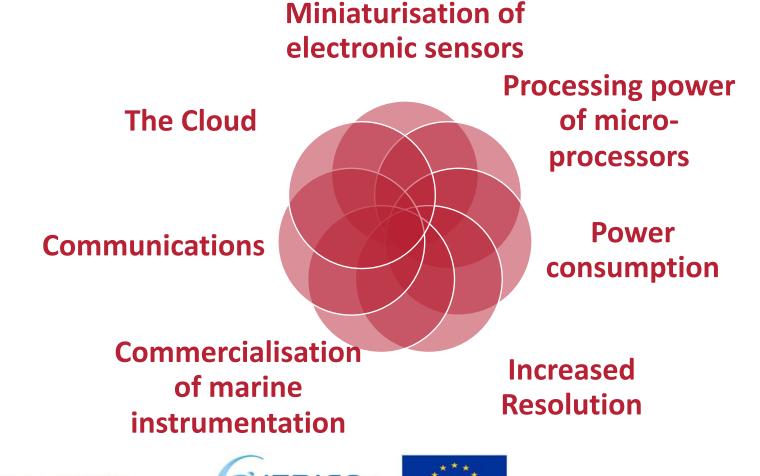


Digital Age in Operational Oceanography the cloud and consumer technology

Graham Worley Bangor University (thanks to David Mills)



Drivers for the development of Digital Operational Oceanography







Miniaturisation of sensors



Processing power of micro-processors

MOS 6502 1980s 0.430 MIPS at 1.000 MHz



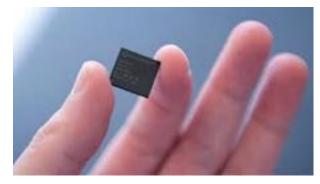


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Qualcomm Snapdragon 800 2010s (based on ARM Cortex A57) ~14,000DMIPS at 2.8GHz



🕑 LG





Power consumption of micro-processors

Intel Pentium Pro 1990s 541MIPS 50 Watts



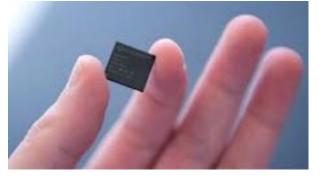
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Qualcomm Snapdragon 800 2010s (based on ARM Cortex A57) 3-4 Watts

SOC







Resolution

SeaBat T50-P / 7125 512beams 0.5x1 degree 300Gbytes of data a day <0.5m grid





72.06 74.00 -76.09 76.00 42.00 84100







Communications

1990s Telephone Modem 9600 bits/s



5-12Mbits/s

2010s





2400bits/s

X25 Leased Line 2400 – 2048k bit/s



Malta Summer School 2018 Operational Oceanography for Blue Growth 400kbit/s FleetOne

JERICOext



100Mbit/s to 10Gbit/s



Cloud Computing



Software As A Service (SAaS) Pre-installed ready-to-use software:

- Microsoft Office 365
- Adobe Creative Cloud

Combines storage, computing and software as one service

Infrastructure As A Service (IAaS) Public cloud: On-demand Pay as You Go Storage – massively scalable Compute – 1 to thousands of cores **Automation Scalability** Orchestration











Cloud Computing – Lightweight scalability

+

Compute

Glacier

Database RDS

No more heavy machines....point and click deployment...





Malta Summer School 2018 **Operational Oceanography for Blue Growth**











C f Ahttps://console.aws.amazon.com/console/home?region=us-east-1

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Learn more

Tag Editor

C Other bookmarks

Cloud Computing – Storage

- Scale 1byte to infinity
- Cost 360 USD per Tbyte per annum
- Accessibility
- Security / Encryption
- Programmability S3 Application Programming Interface











Cloud Computing – Data Delivery

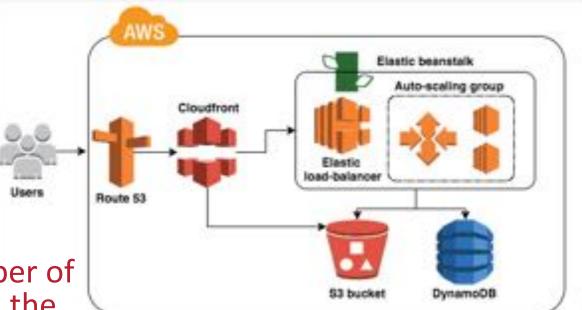
AWS Elastic beanstalk

- Orchestration
- Auto-scaling
- Fault-tolerant
- Geo-localised



- Can serve any number of people anywhere in the world.
- No longer constrained by power of one or two servers in the laboratory.







Cloud Computing – Compute Resource Supercomputing - HPC in the cloud for modelling



1 to many traditional virtual machines

Custom machine images (AMIs)

CfnCluster – AWS CloudFormation Cluster



15 billion forecast per day via AWS



AWS EC2 Powers NETFLIX



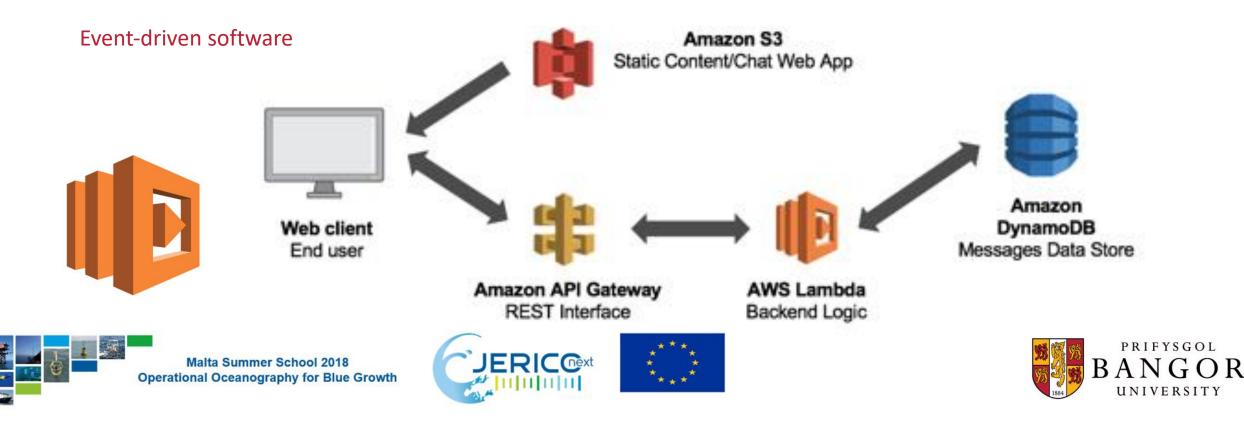




Cloud Computing – Compute Resource Functional Computing - Lambda Functions

Virtual Machines – High idle-time

Lambda functions – No idle-time charging



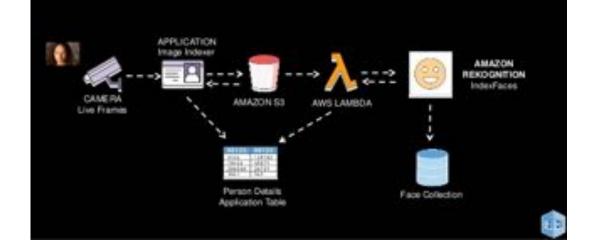
Cloud Computing – Compute Resource Analytical Computing

Tailored software services powered by virtual machines and lambda functions

Machine Learning – On-demand regression analysis on a massive scale

Tnext





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Face Recognition - Use Cases Indexing Faces into a Collection

> **Re-purpose face recognition services for feature detection?**

- Detection of fronts
- Wave / Surface current analysis
- Beach morphology



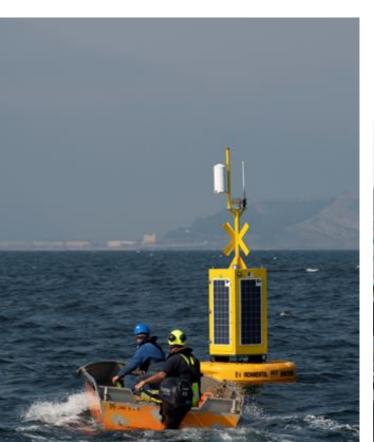
Cloud Computing – In summary

Great for prototyping and production workloads Delete when done









Relocatable OSIL Fulmar Buoy 4G and Iridium Coms Multi-parameter









• 6km North-east of Llandudno



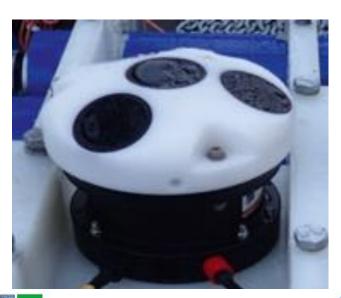
©Google Inc

Poulton-le Fylde

Blackpool

Sub-Surface Instrumentation

- Nortek AWAC
- Campbell Scientific Turbidity Sensor
- Teledyne Acoustic Modem





Surface Instrumentation

- RBR Maestro CTD (conductivity, temperature, depth, chlorophyll,
- Teledyne Acoustic Modem
- 3G Modem
- Rockblock Iridium Modem
- AirMar Wind Vane







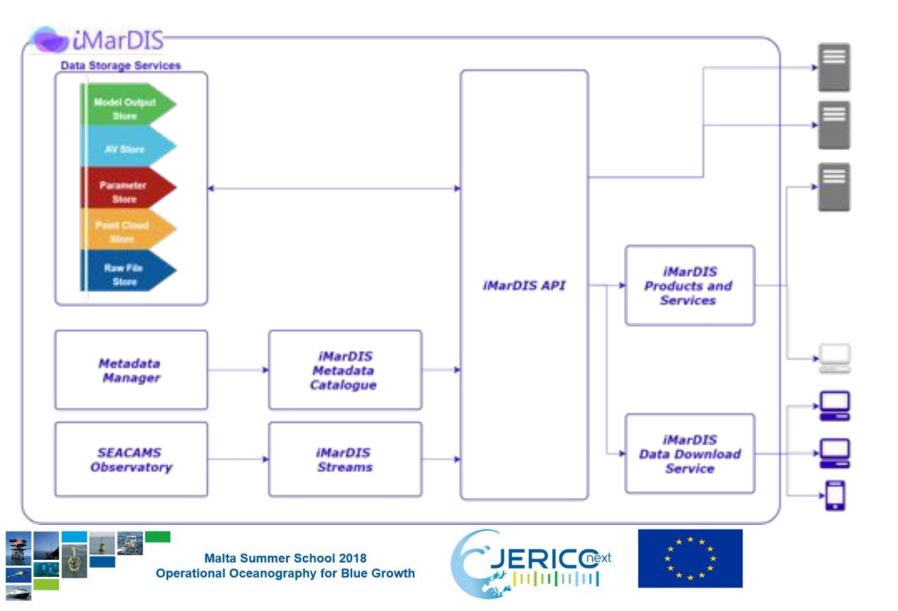


Campbell CR6 Logger



- Assembles data frames
- Delivers to Amazon Web Services via 3G / Iridium
- IoT Internet of Things?





iMarDIS
Integrated Marine
Data and
Information System
Cloud-based
infrastructure to
handle and share
marine data



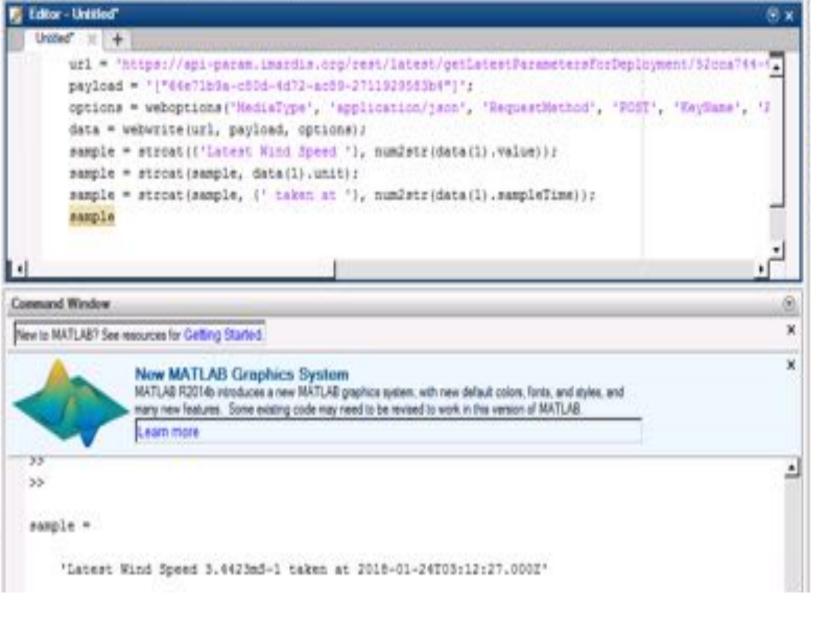
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Similar Deployment – CEFAS SmartBuoy

SmartBuoy – Near surface instruments



Multichannel logger - CTD, OBS, 02

Flurometers: Applied Oceanography - Mills



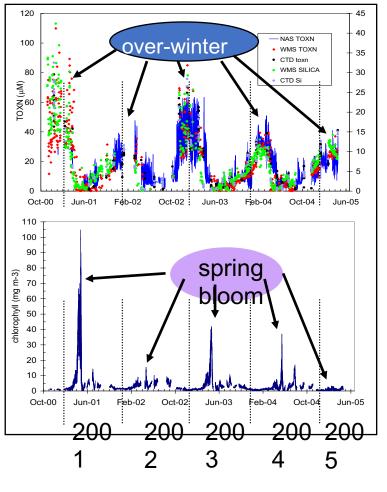
In situ nitrate analyser

Water sample











Intelligent Sensors

- Sensors with micro processors
- Internet of Things
- File their own data Sensor Web Enablement SensorML describes the sensor and the data enables IoT data deposit
- Many standards JSON over REST will eventually dominate









Passive sampling devices **Thicles – Surface / Sub-Surface**

Advantages

- Operate in adverse conditions
- High spatial and temporal resolution
- Cost efficiency (?)

Issues

Echosounder

Hydrophon

- Sensor calibration and validation
- Requires additional data/information from other sources (ships, moorings)
- Qualitative vs quantitative observations

Assessing the potential of autonomous submarine gliders for ecosystem monitoring across multiple trophic levels (plankton to cetaceans) and pollutants in shallow shelf seas. Suberg et al., 2014. https://doi.org/10.1016/j.mio.2014.06.002



Semi-Autonomous Vehicles - Airborne

Instrumented drones - LIDAR











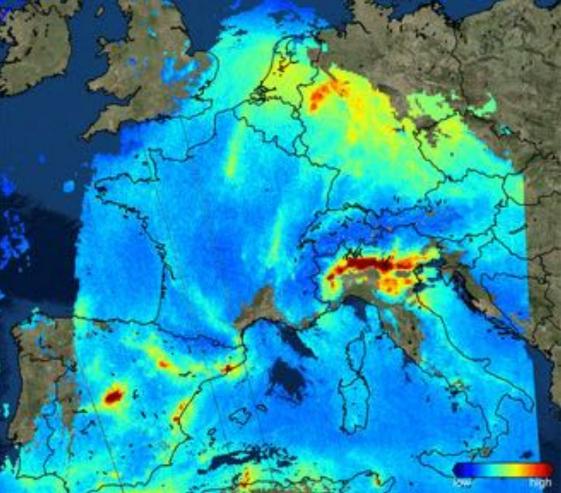


Remote Sensing

continual evolution















The Future

Ships are expensive













UK-IMON International Workshop on New Monitoring Technologies:



Themes

- Autonomous systems
- Conventional systems
- Sensors
- Other data acquisition systems



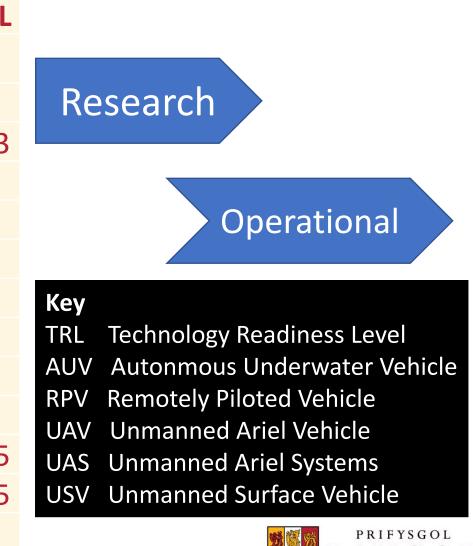


How can we reduce the cost of making observations ?



UK-IMON - Autonomous platforms ranking

Platform name	Score	TRL
AUV Class #1 (small / coastal / shore based)	15	5
AUV Class #2 (medium / shelf)	15.5	5
AUV / Hybrid / longrange	14.5	2/3
AUV Class #3 (large / deep)	13.5	5
Bio-mimetic fish		1
Crawlers / rovers / benthic	13.5	3
Buoyancy Gliders deep	18.5	5
Buoyancy Gliders shallow	18.5	5
RPAs / UAVs / UAS	17	5
Mammals (OR IN OTHERS ?)	17	5
USV #1 (Short duration)	16	4/5
USV #2 (long endurance)	19.5	4/5
Buoyancy floats	20	5
Surface Drifters	19	5



UNIVERSITY

Sensor/Platform	TRL
Lab on chip	
nitrate	3
phosphate	3
silicate	3
ammonium	2
iron/manganese	2
conductivity, temperature, oxygen	3-4
nucleic acid sensor	1-2
synthetic immuno sensor - proteins, small organics, small molecules	1
cytometry	1-2
рН	3
Total Alkalinity / DIC	2
Optode CO2	3
mass spectrometry	4
"Sniffer" methan, PAH/hydrocarbon, carbon dioxide	5
RAMAN	2
ESP/nucleic acid and protein sensor	4-5
Biotaguard (mussel valve opening and sponge)	4-5
acoustic recorders (hydrophone, passive, wide range)	5
automated flow cytometry (full size, in-line, data automation, different types)	5

Sensors



Lab on a chip



Data Sharing

- Open Data != Free Data
- Discovering data Metadata



• Beyond metadata – NoSQL Databases



- More to a dataset that a title, date and creator
- Beyond OGC JSON JavaScript Object Notation, RESTful web services









The Future

- Higher Resolutions
- Multi-parameter sensors (on a chip)
- Yet Faster Data
- Machine Learning Targeted sampling
- Citizen Science (e.g. beach morphology)
- Automated Model Optimisation / Validation









The Future

• Armchair Oceanography?????

