NOC MARINE AUTONOMY & TECHNOLOGY SHOWCASE

National
Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

noc.ac.uk/matshowcase

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Prof Russ Wynn

Chief Scientist Marine Autonomous and Robotic Systems MARS NOC

Session Chair Marine Autonomous Systems (MAS) Update

Lunch

55 Minute Break

Alberto Naveiro-Garabato

University of Southampton

Introduction to the NERC-EPSRC NEXUSS Centre for Doctoral Training

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

STEATITE

noc.ac.uk/matshowcase

NEXUSS

Next Generation Unmanned Systems Science

NERC / EPSRC Centre for Doctoral Training in the
Smart and Autonomous Observation for the Environmental Sciences

Prof. Alberto Naveira Garabato (Director)
Ocean and Earth Science, University of Southampton

nexuss@southampton.ac.uk

NERC SCIENCE OF THE ENVIRONMENT

NEXUSS

EPSRC Engineering and Physical Sciences Research Council

NEXUSS – The Vision

To develop, deliver and disseminate the world's first environmental science doctoral training programme founded around highly experiential, industry-engaging *Grand Challenge* events.

NERC SCIENCE OF THE ENVIRONMENT

EPSRC Engineering and Physical Sciences Research Council

NEXUSS – Aims

To transform UK environmental science by embedding the application of Smart and Autonomous Observation Systems (SAOS) across the research and business landscape. Specifically…

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To transform UK environmental science by embedding the application of Smart and Autonomous Observation Systems (SAOS) across the research and business landscape. Specifically…

- Developing and sharing *an international best practice template for training* future generations of environmental scientists

- Delivering *a cohort of technology-aware leaders* who will take forward SAOS approaches in science, industry and government

- Stimulating *high-calibre SAOS technology transfer* to environmental disciplines

The NEXUSS Partnership

An established alliance of 6 leading science and engineering universities and research organisations that:

- are in the vanguard of the UK research and training excellence in the development and environmental application of SAOS

UNIVERSITY OF Southampton

HERIOT WATT UNIVERSITY

UEA University of East Anglia

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

SCOTTISH ASSOCIATION for MARINE SCIENCE

The NEXUSS Partnership

An established alliance of 6 leading science and engineering universities and research organisations that:

- undertake world-leading, multidisciplinary science across the NERC remit, underpinned by a sustained stream of SAOS experiments across all of Earth's environments that is unrivalled in the UK

University of Southampton

Heriot Watt University

UEA University of East Anglia

British Antarctic Survey
Natural Environment Research Council

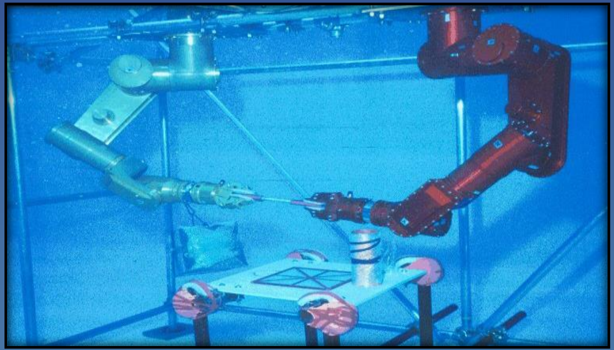
National Oceanography Centre
Natural Environment Research Council

Scottish Association for Marine Science

The NEXUSS Partnership

An established alliance of 6 leading science and engineering universities and research organisations that:

- include the UK's foremost SAOS engineers and physical scientists, with access to some of the world's best SAOS facilities



University of Southampton · Heriot Watt University · UEA University of East Anglia · British Antarctic Survey, Natural Environment Research Council · National Oceanography Centre, Natural Environment Research Council · Scottish Association for Marine Science

The NEXUSS Partnership

An established alliance of 6 leading science and engineering universities and research organisations that:

- represent the UK focus of development and application of SAOS approaches in marine science

University of Southampton

Heriot Watt University

UEA University of East Anglia

British Antarctic Survey
Natural Environment Research Council

National Oceanography Centre
Natural Environment Research Council

Scottish Association for Marine Science

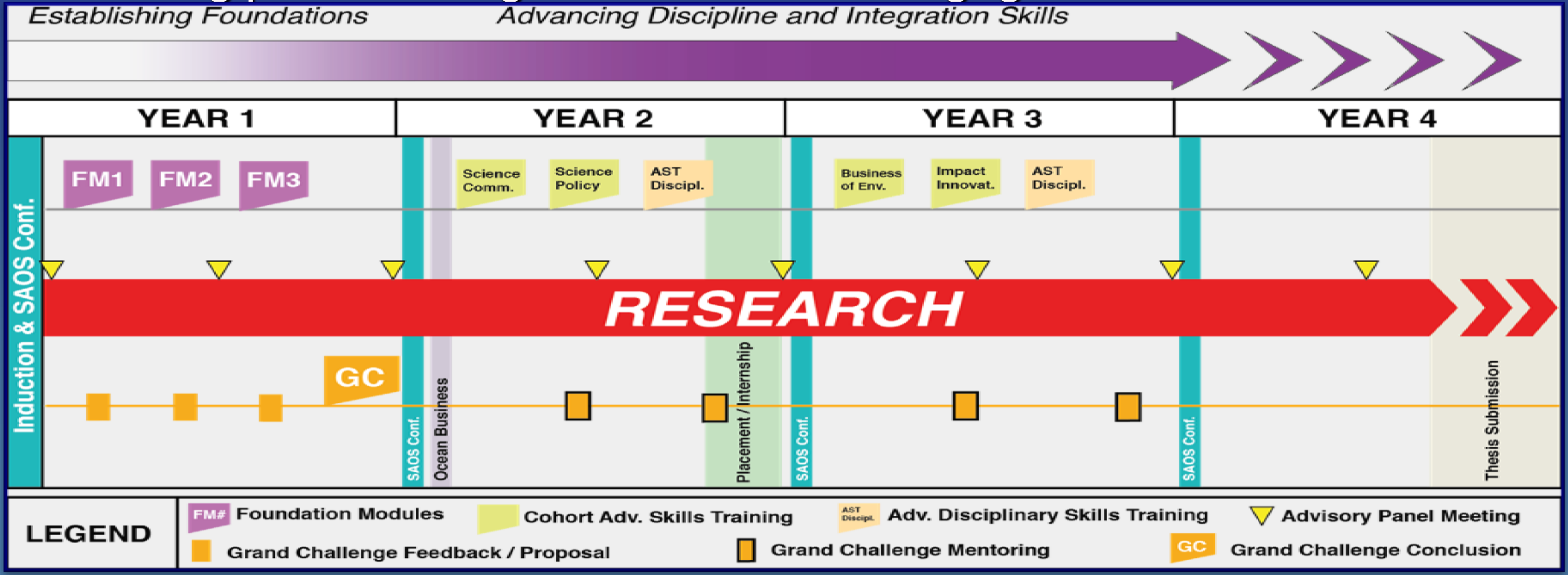
The NEXUSS Training Mission

To develop a cohort of world-class environmental scientists with a wide multidisciplinary bandwidth and high-calibre SAOS technological skills by:

- *Recruiting the best*
- Designing a *personalised training programme* of research and professional skills that prioritises the student's development experience
- *Engaging the stakeholder community* fully in building the training programme to ensure that it is bespoke and aligned with the community's needs

The NEXUSS Student Experience

Training programme a combination of 16 weeks high-quality training (cohort-based foundation elements and personalised advanced activities), with strong peer learning and stakeholder engagement.



The 1st NEXUSS Grand Challenge

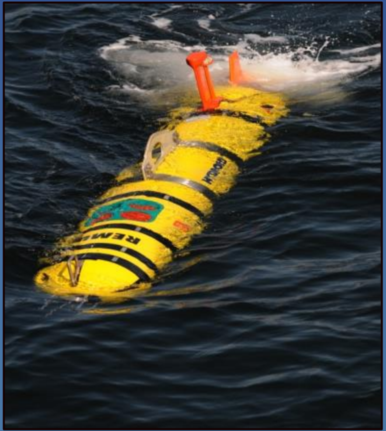
Challenge
- Locate possible ruptured sub-sea pipeline
- Assess pollution risk to air, land and sea

Training
- All NEXUSS Year 1 modules
- Challenges facing Oil and Gas sector

Resources
Fixed budget for:
- Hydrodynamic model
- AUV / Glider
- RPA
- Student-designed and fabricated sensors
- Mission control vehicle
- Command and control base
- Tech support

HOST

Scot - MRF
The Scottish Marine Robotics Facility



SPONSOR

bp

NEXUSS Training Outputs

- *A new breed of environmental scientist*

  – *more aware* of the cutting-edge technologies that will transform the field;

  – *more versatile* in applying and developing these technologies;

  – *more capable* of communicating across disciplinary barriers and extracting value from science.

- *A cultural change in environmental science*

  – addressing environmental problems with *bespoke SAOS approaches*

NEXUSS in numbers

- NEXUSS supported by NERC / EPSRC in October 2015
- NERC / EPSRC investment of £2.5M in >30 (3.75 year-long) PhD studentships
- Centre's initial lifetime of 6 years, with 3 starting cohorts
- First cohort started in October 2016
- Ambition to double number of studentships and extend Centre's lifetime by >2 years – by leveraging resources from Core, Associate and Stakeholder Partners

NERC SCIENCE OF THE ENVIRONMENT

EPSRC Engineering and Physical Sciences Research Council

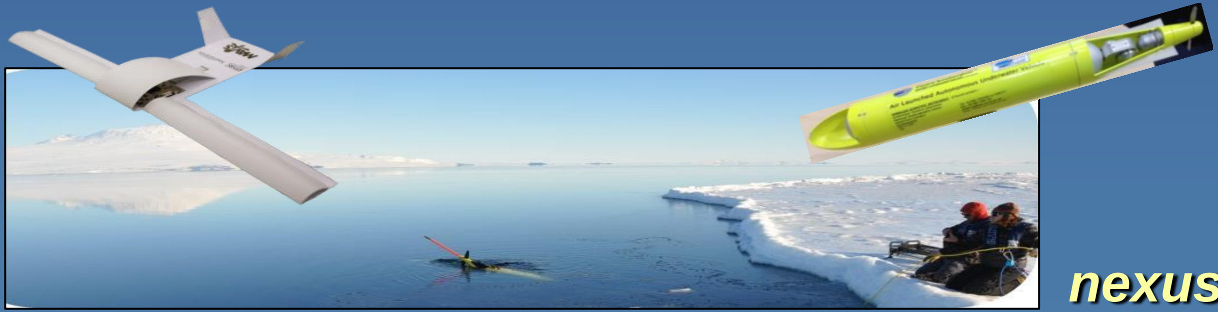
NEXUSS – Active Projects

- *Lab-on-chip sensors for environment, fisheries and aquaculture science* **(NOC, UoS, Cefas)**
- *Animal-borne sensors for studying foraging and habitat use of marine predators in the Southern Ocean* **(St. Andrews, SAMS)**
- *Multi-vehicle swarm behaviours for monitoring of rapidly evolving ocean phenomena* **(NOC, UoS)**
- *Can underwater gliders quantify ocean mixing in the West Antarctic?* **(BAS, UoS, Teledyne)**
- *Autonomous carbon system observations from gliders* **(UEA, NOC, Cefas)**
- *Sounds in the sea: how can we listen from ocean gliders?* **(UEA, SAMS, Cefas)**
- *Real-time reporting of ecosystem metrics from acoustic sensors on gliders* **(BAS, UEA)**
- *Quantifying the spatio-temporal variability of phytoplankton productivity from mobile autonomous platforms* **(SAMS, UEA)**
- *Cold-water coral habitats in submarine canyons* **(NOC, UEA, Cefas)**
- *Developing AUV strategies and technologies for the monitoring of benthic impacts in Marine Protected Areas* **(SAMS, HWU, Edinburgh)**
- *Terrain-following UAVs for sampling of boundary layer turbulent fluxes* **(UoS, NOC, HWU)**

NEXUSS – Call for Partners

We invite partners to participate in NEXUSS in a number of ways:

- Design of / involvement in student projects
- Hosting of flexible secondment of NEXUSS students
- Membership of NEXUSS Advisory Board to assist in steering proposed research
- Sponsorship of students, projects and *Grand Challenge* events
- Use of facilities or equipment
- Design and / or delivery of training events



NEXUSS

nexuss@southampton.ac.uk

Thomas Lowndes

NEXUSS NOC

NEXUSS Partner Presentations


Multivehicle swarm behaviours for monitoring rapidly evolving ocean phenomena
MAT Showcase 2016
Thomas Lowndes

What is a swarm?

4 Parameters of a swarm [1]

- **Scalable and not restricted to a maximum number of members**
- **Consists of mostly homogeneous members**
- **Significantly improve performance**
- **Each member has local and limited sensing and communication**

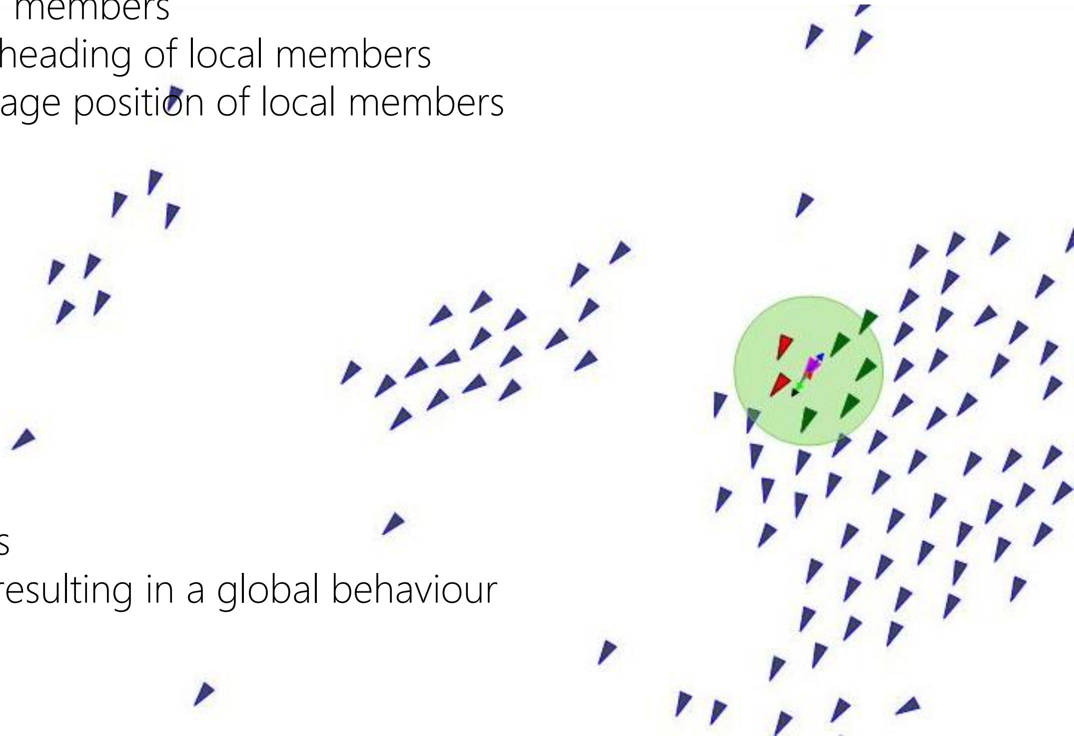
Why now?

Advancements in technology mean AUVs can be made smaller and cheaper

Robotic Swarms

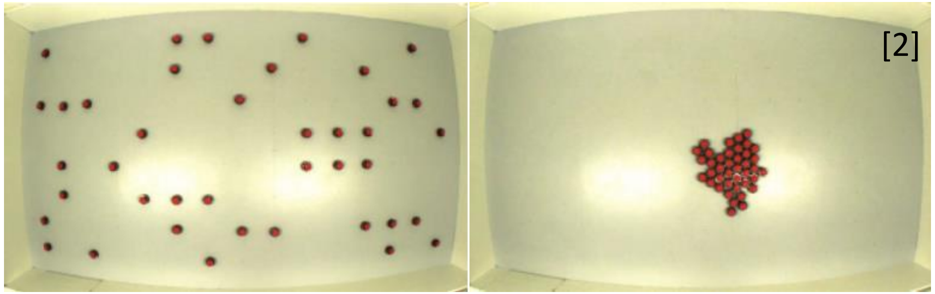
Craig Reynolds - Flocks, Herds and Schools: A Distributed Behavioural Model (1987)

- Separation – Avoid crowding local members
- Alignment – Align to the average heading of local members
- Cohesion – Move toward the average position of local members



Members of the swarm are homogeneous
Each member only has local perceptions resulting in a global behaviour

Robotic Swarms



Rapidly Evolving Ocean Phenomena

Plankton Blooms

- Karenia Brevis release toxins causing massive fish die-offs
- Blooms dying off leads to large proportions of the watercolumn being low in oxygen

Oil Spills

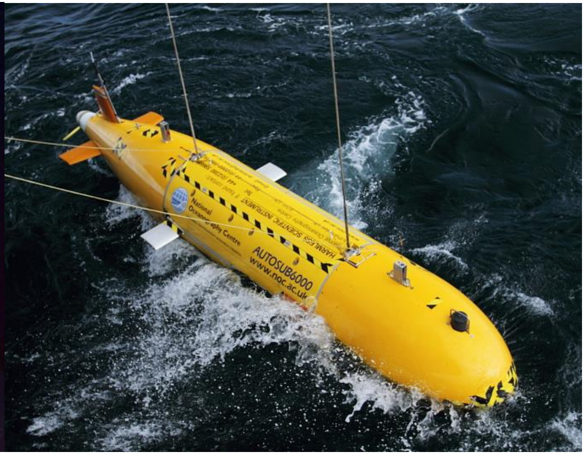
- Affect marine mammals through loss of habitat, toxicity, ecological changes etc.

Why swarms?

Gliders

Autosub LR

Autosub 6000

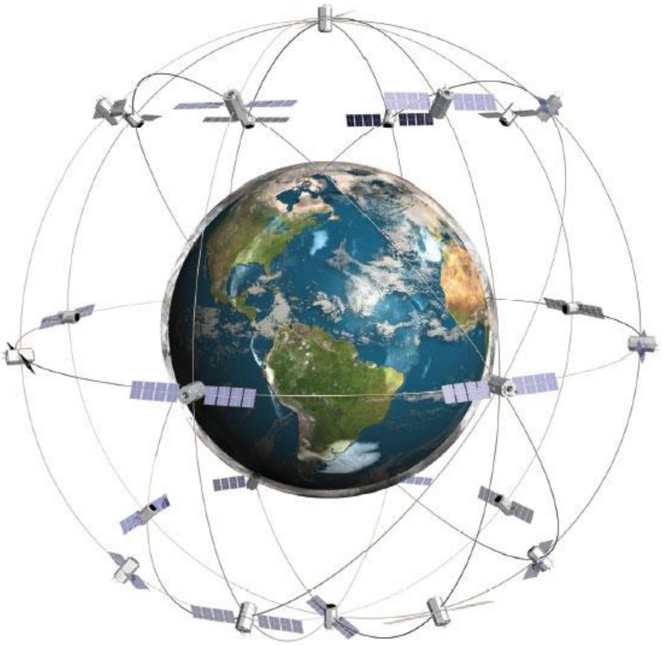


A rapidly evolving ocean feature requires:

- A large sampling area with a high sampling rate
- A rapid response

Constraints & Limitations

- Attenuation of electromagnetic signals e.g. GPS, WiFi
- Acoustic communication suffers from:
  - Low bandwidth
  - High latency
  - Severe packet loss
- Dynamic ocean environment
- Endurance order of days



Benefits

- Robust, distributed system
- Energy load distribution
  - 32% longer missions [4]
- 'Intelligent' approach
- Rapid response
  - UAV / USV Launch
- Low cost
  - Similar sensor suite


Thank you for listening
Any questions?
MAT Showcase 2016
Thomas Lowndes

Bibliography

[1] Osterloh, C., Meyer, B., Amory, A., Pionteck, T., & Maehle, E. (2012).
MONSUN II - Towards Autonomous Underwater Swarms for Environmental Monitoring.
IROS2012 - Workshop on Robotics for Environmental Monitoring.

[2] Gauci, M., Chen, J., Li, W., Dodd, T. J., & Gross, R. (2014).
Self-organized aggregation without computation.
International Journal of Robotics Research, *33*(8), 1145 – 1161.

[3] Tuci, E., Gross, R., Trianni, V., Mondada, F., Bonani, M., Dorigo, M. (2005)
Cooperation through self-assembling in multi-robot systems
ACM Transactions on Autonomous and Adaptive Systems, 1(2), 115 – 150.

[4] Ammory, A., Tosik, T., Maehle, E. (2014)
A load balancing behaviour for underwater robot swarms to increase mission time and fault tolerance
IEEE 28th International Parallel & Distributed Processing Symposium Workshops

Ryan Scott

NEXUSS BAS

NEXUSS Partner Presentations

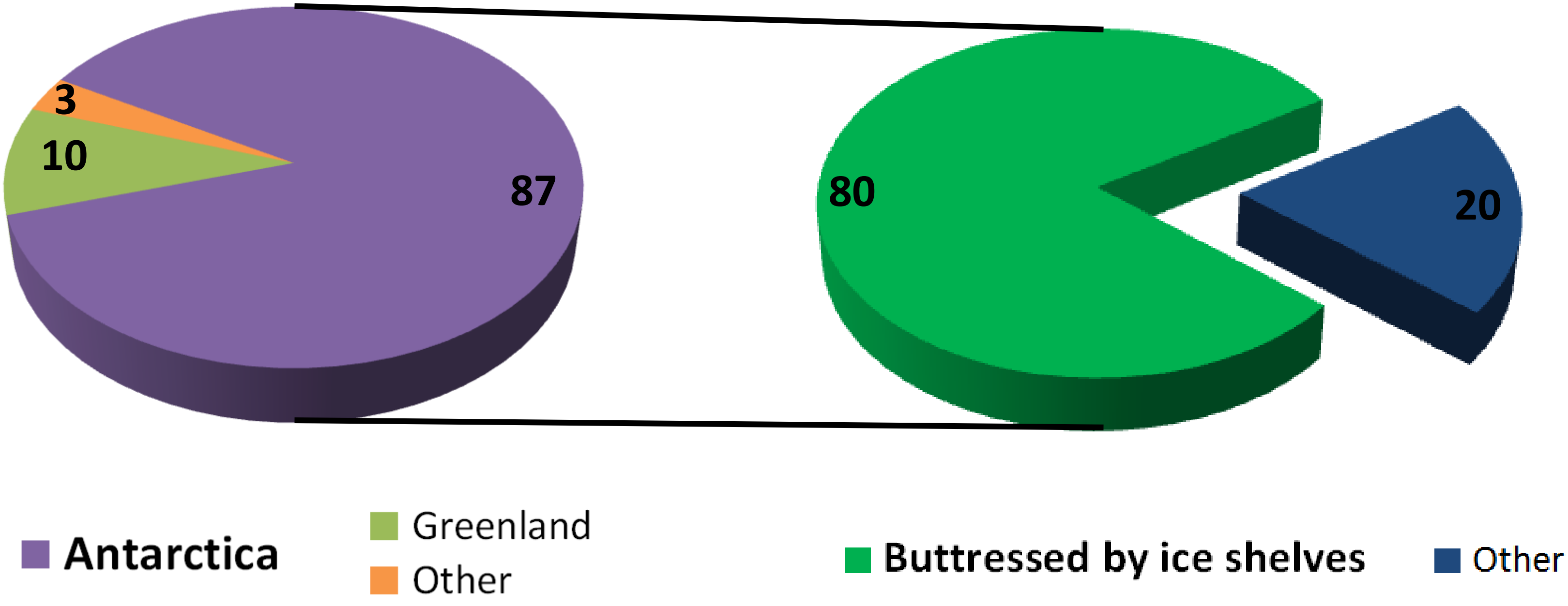
CAN UNDERWATER GLIDERS QUANTIFY HORIZONTAL MIXING IN THE WEST ANTARCTIC?

RYAN SCOTT
(BRITISH ANTARCTIC SURVEY)

WHAT AM I GOING TO COVER?

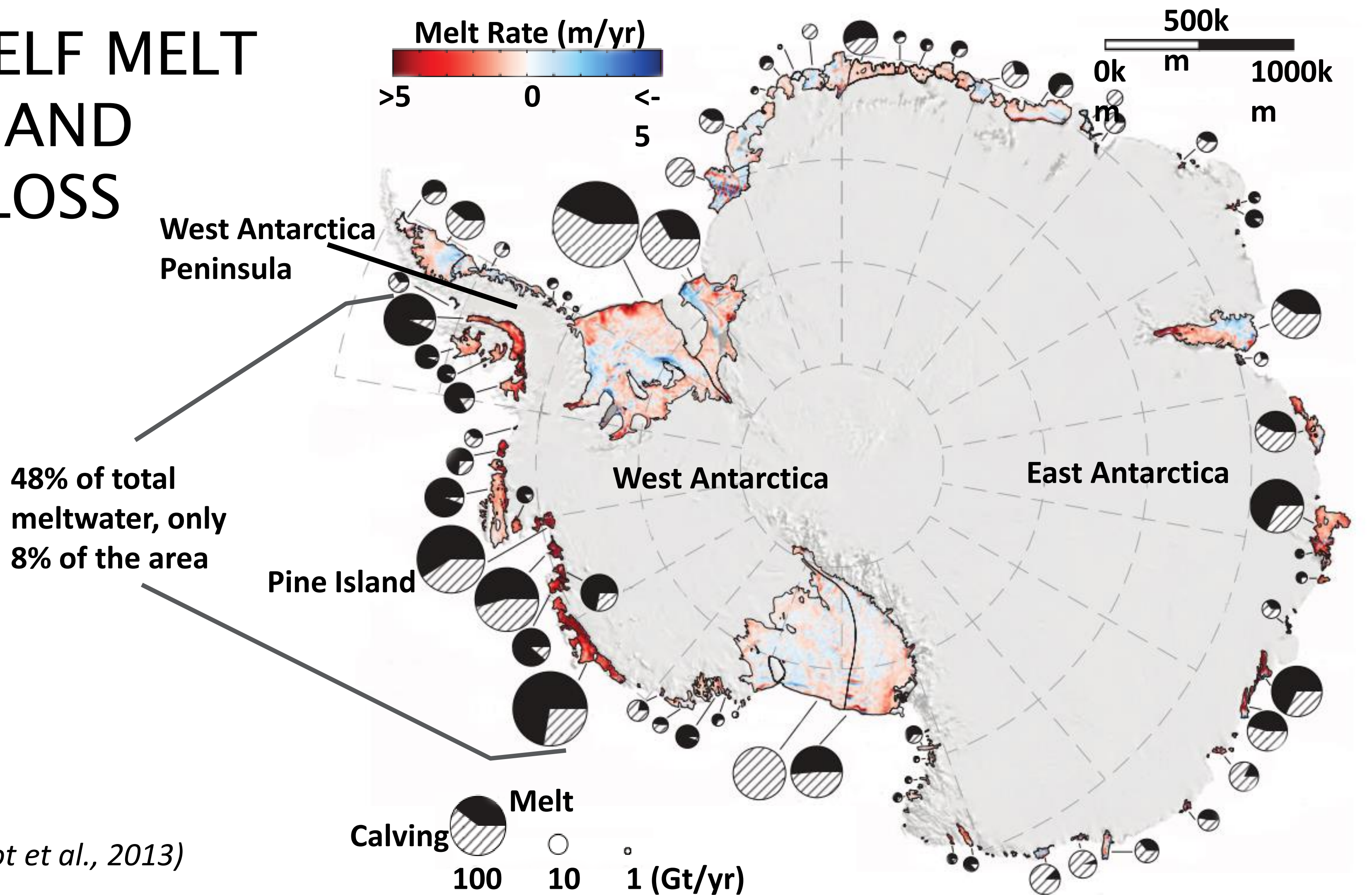
- Importance of melting
- Melting mechanisms
- Project aims
- Example plot

WHY IS MELTING IN ANTARCTICA IMPORTANT?



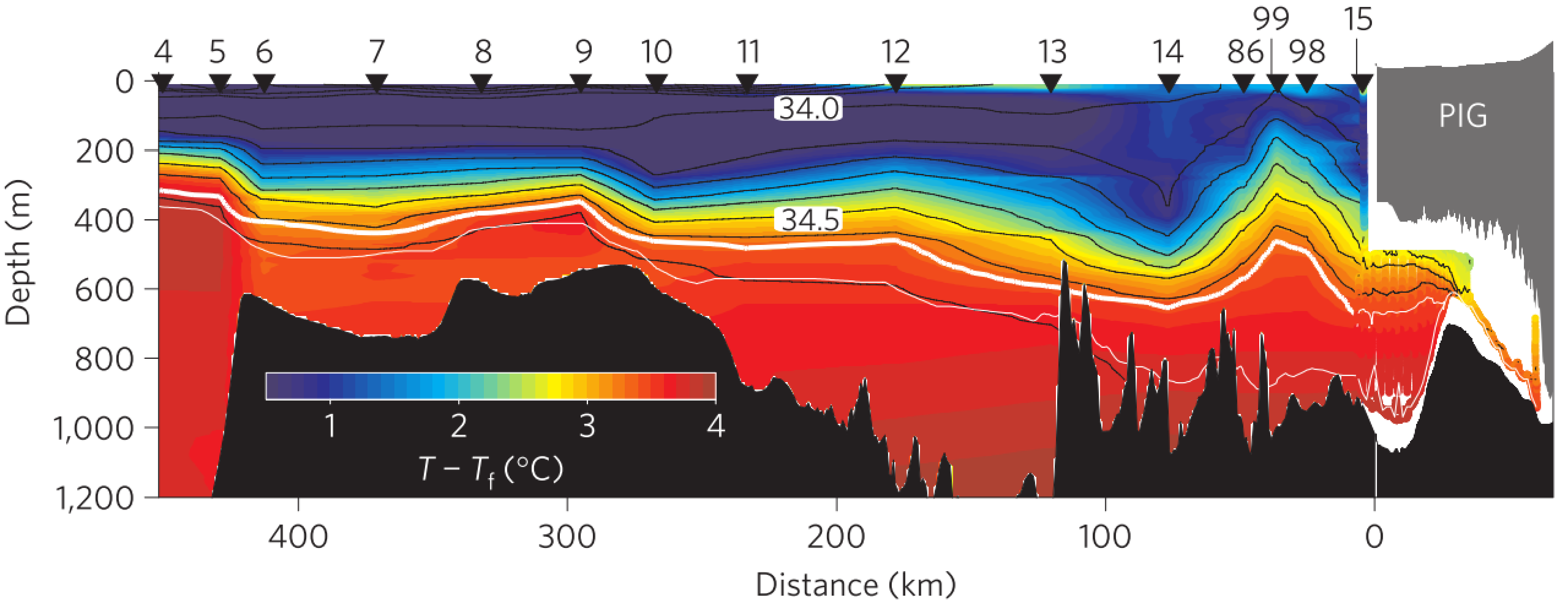
(After Pritchard et al., 2012)

ICE SHELF MELT RATES AND MASS LOSS



(After Rignot et al., 2013)

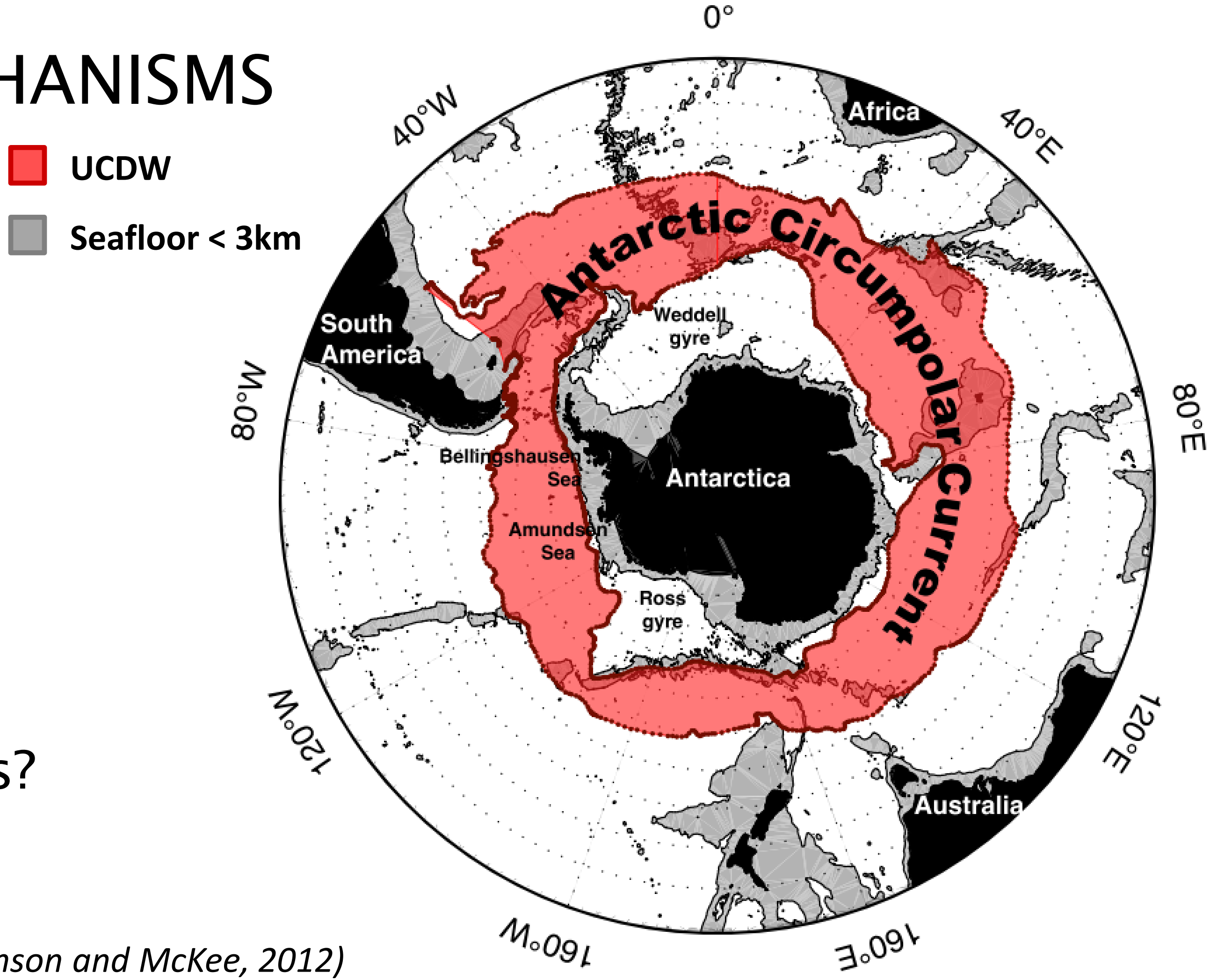
PINE ISLAND MELTING MECHANISMS



(Jacobs et al., 2011)

OCEANIC MECHANISMS

- Eddies?
- Canyons?
- Upwelling?
- Episodic events?



(Martinson and McKee, 2012)

MY PROJECT

- Can underwater gliders quantify horizontal mixing in the west Antarctic?

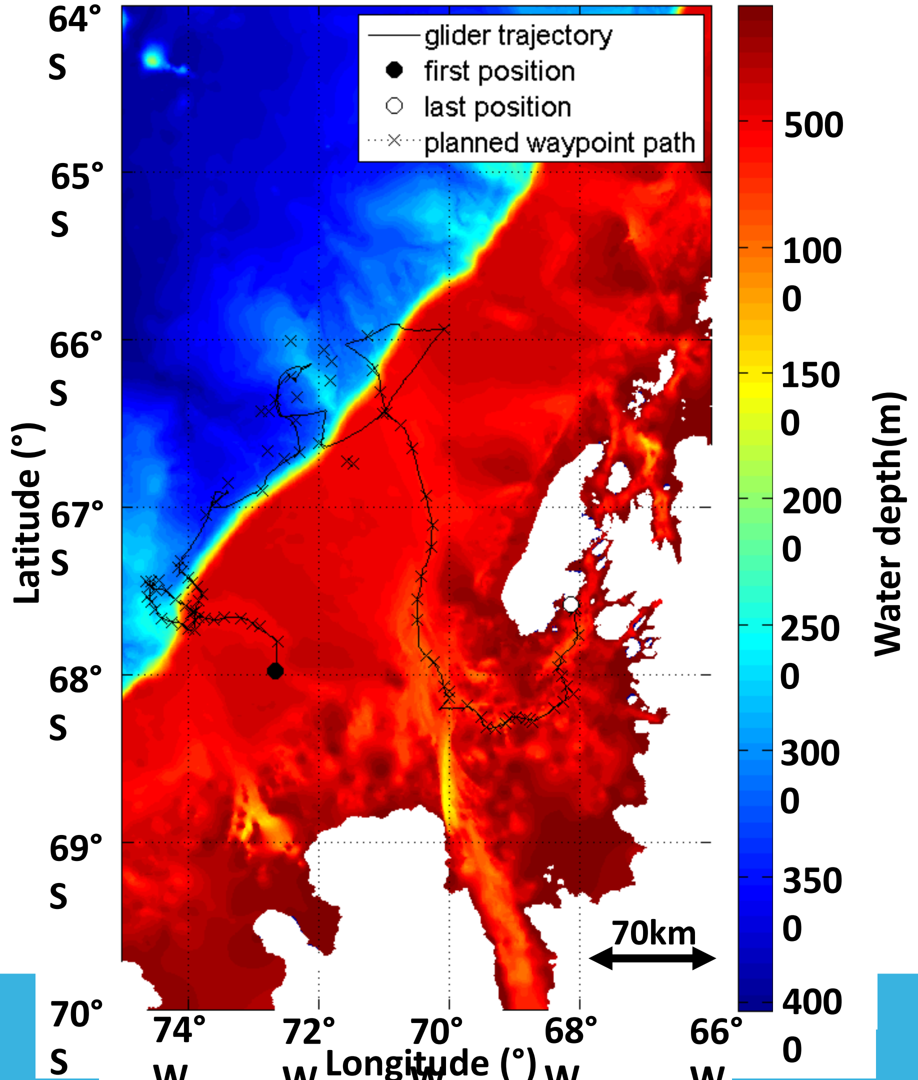
AIMS

1. How and where eddies generate temperature–salinity variance

2. Analyse the dissipation of temperature variance

3. Synthesize data to quantify horizontal mixing and heat fluxes

2015 GLIDER DATA



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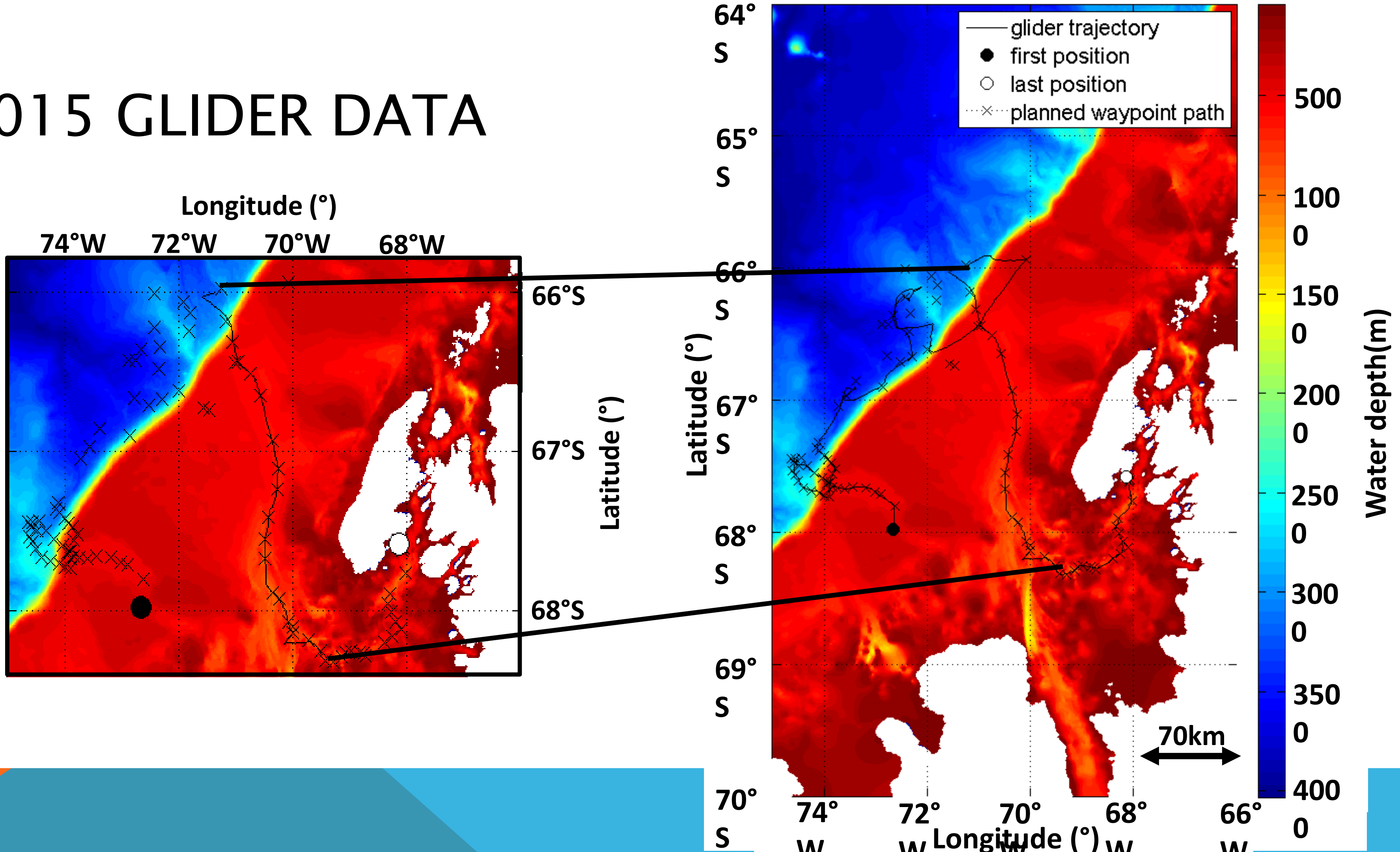
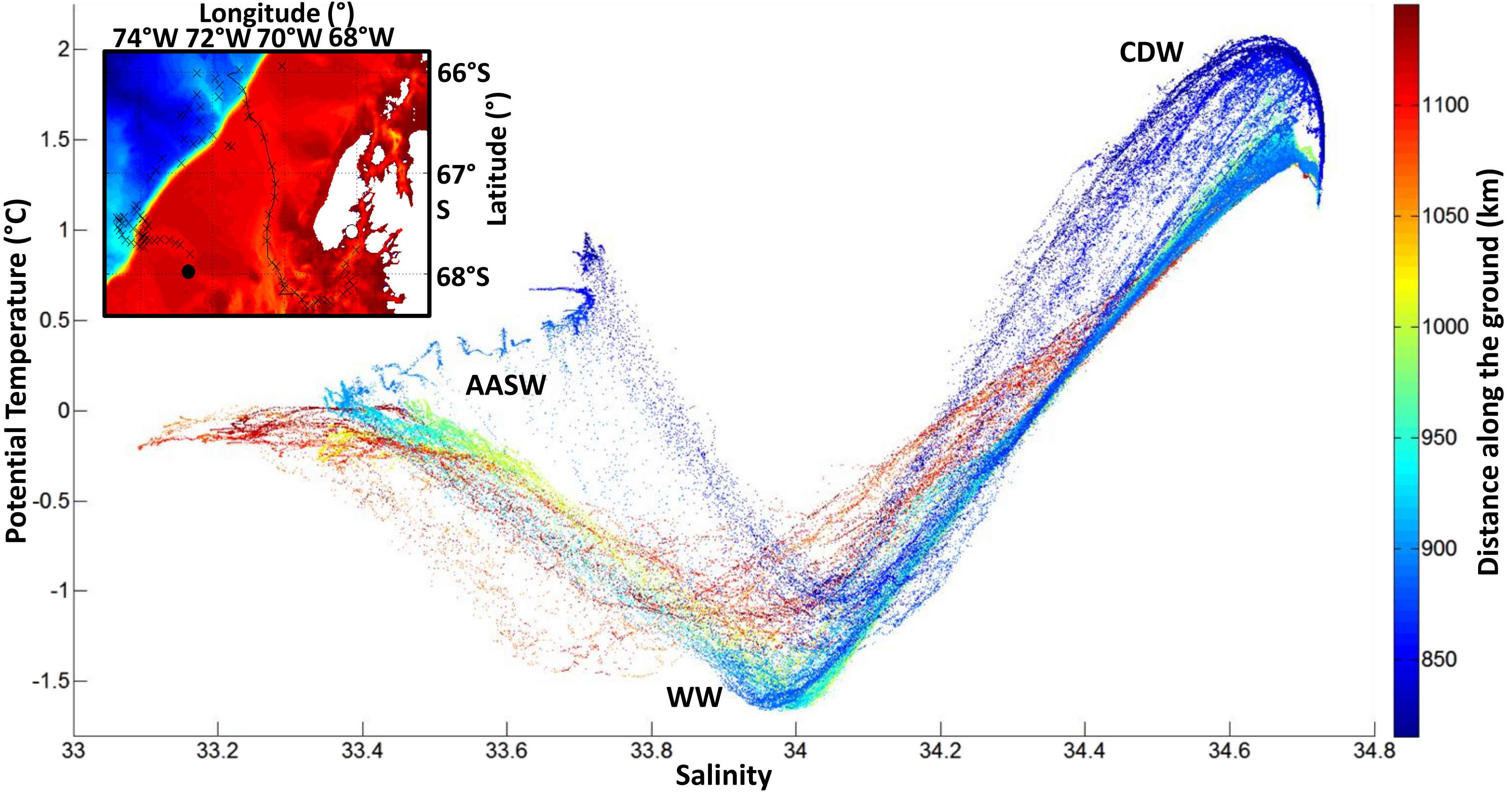


POTENTIAL TEMPERATURE VS SALINITY PLOTS

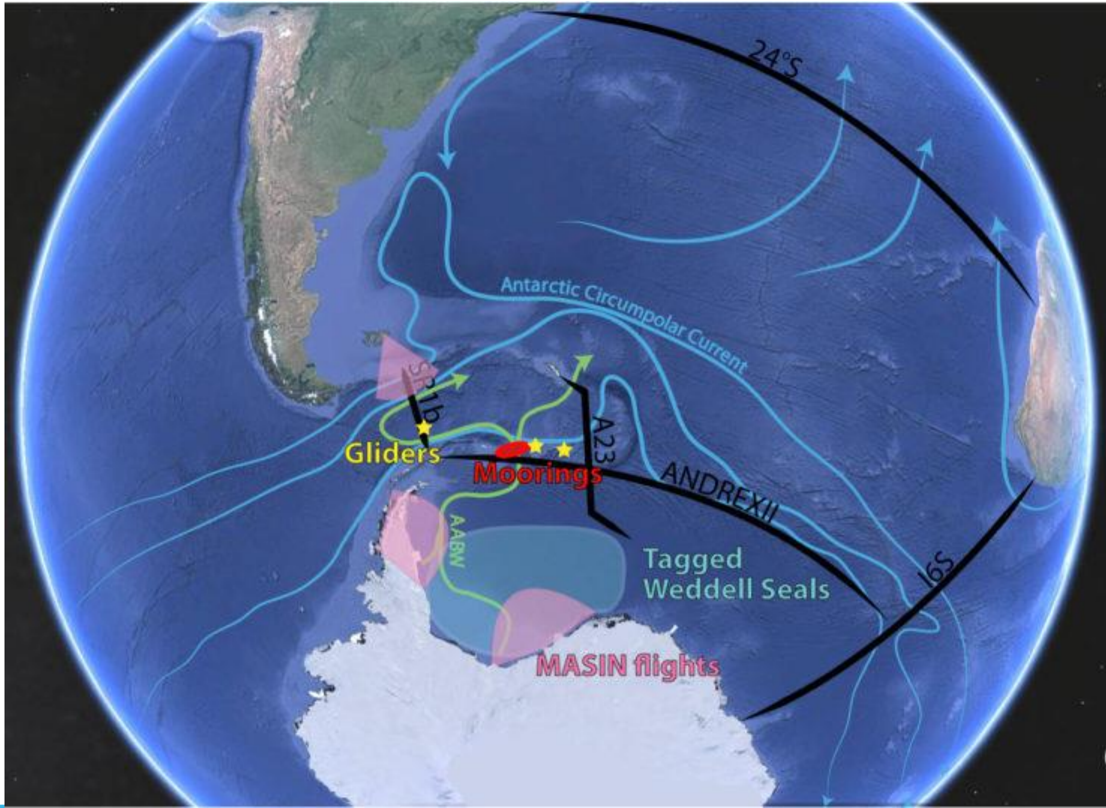


THANKS FOR LISTENING…

ANY QUESTIONS?

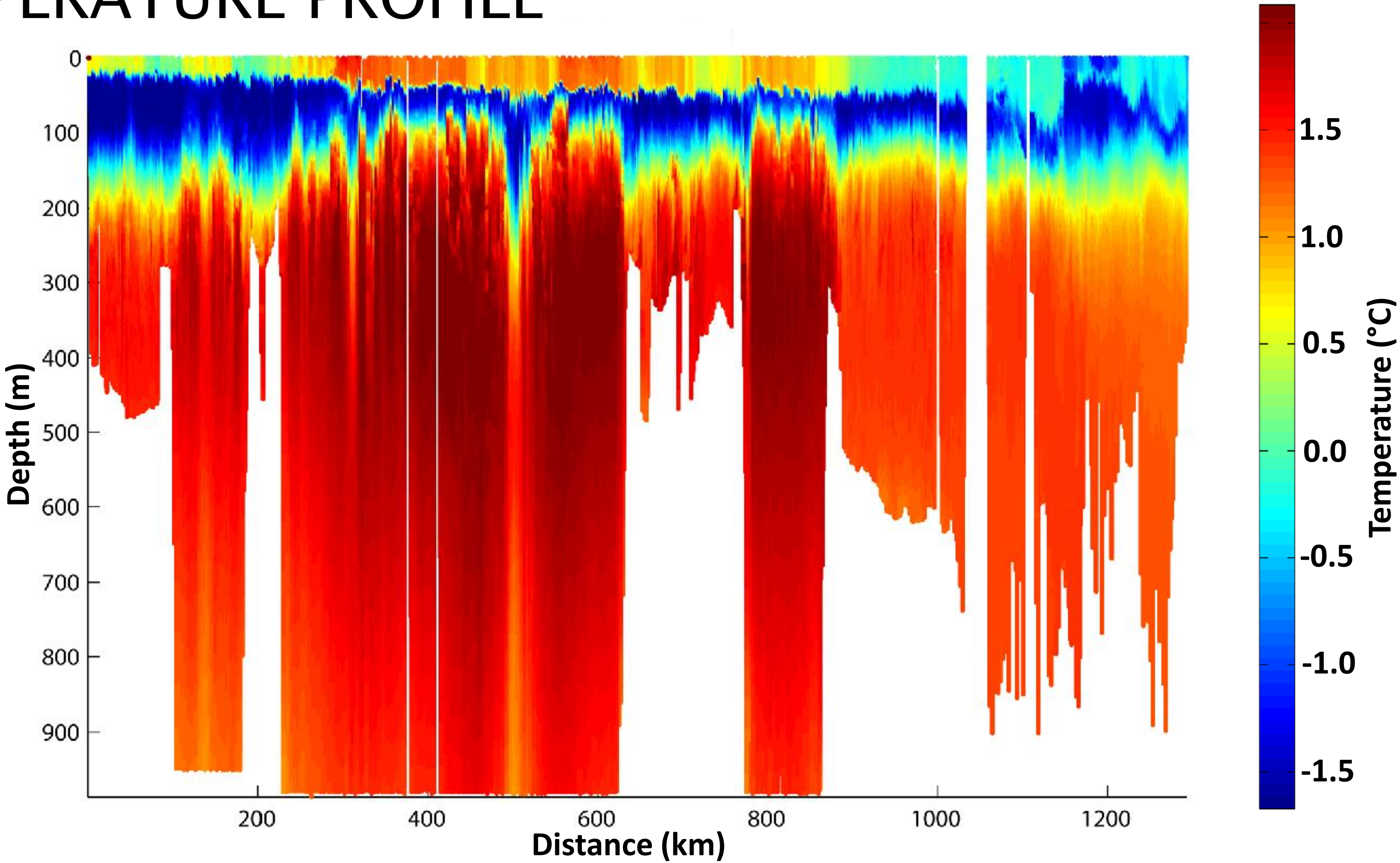
FIELDWORK

ORCHESTRA
OCEAN • CLIMATE • CARBON



(BAS, 2016)

TEMPERATURE PROFILE



Pierre Cauchy

NEXUSS UEA

NEXUSS Partner Presentations

Sounds in the sea

How can we listen from ocean gliders?

Pierre Cauchy[1]

K. J. Heywood[1], B. Y. Queste[1], N. D. Merchant[2], D. Risch[3]

[1] COAS - University of East Anglia, [2] CEFAS, [3] SAMS

MAT showcase – NOC – 17th November 2016

Sounds in the sea

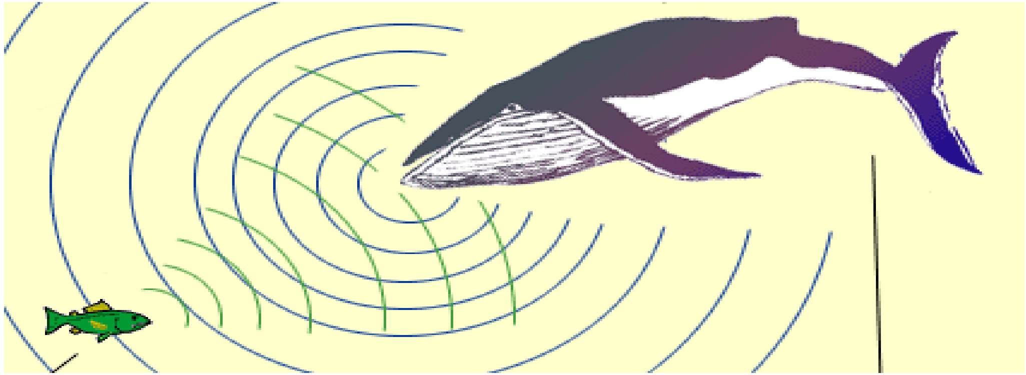
Propagation in seawater

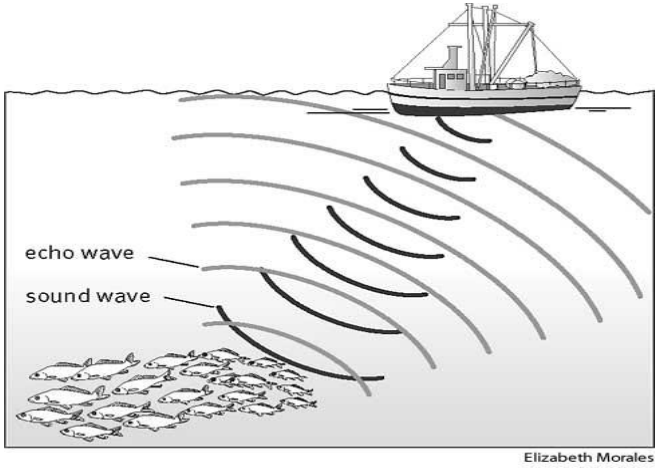
Light → ~10s of meters   Sound → ~100s of kilometers

Acoustics provides the best means of communication, navigation and imaging

Active acoustics

Modification of the signal ↔ Information about the **environment**





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Active acoustics

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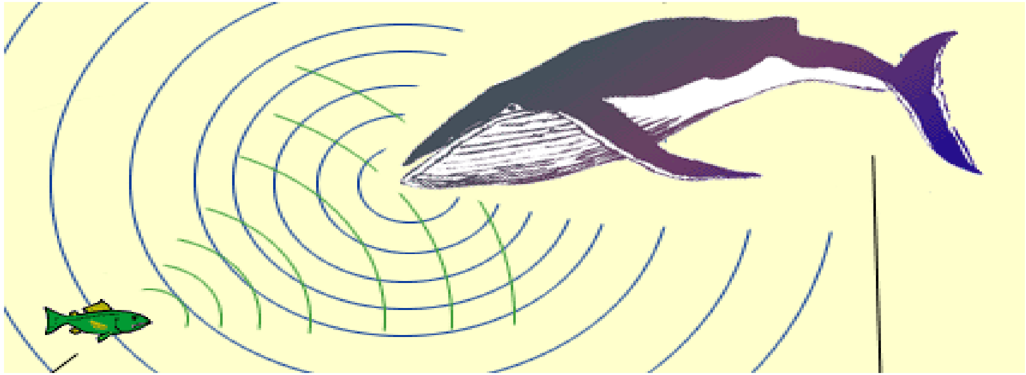
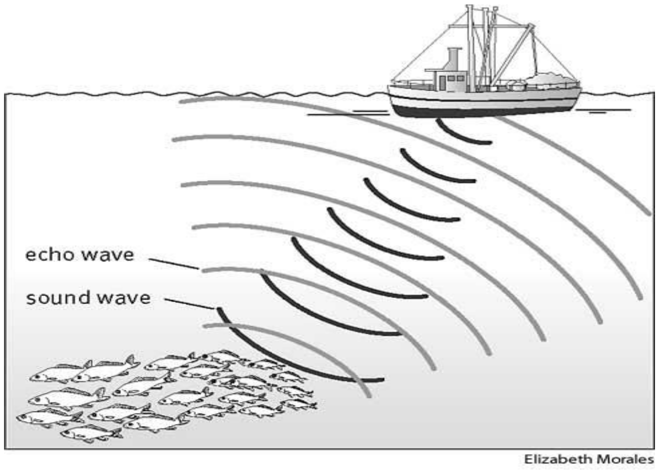
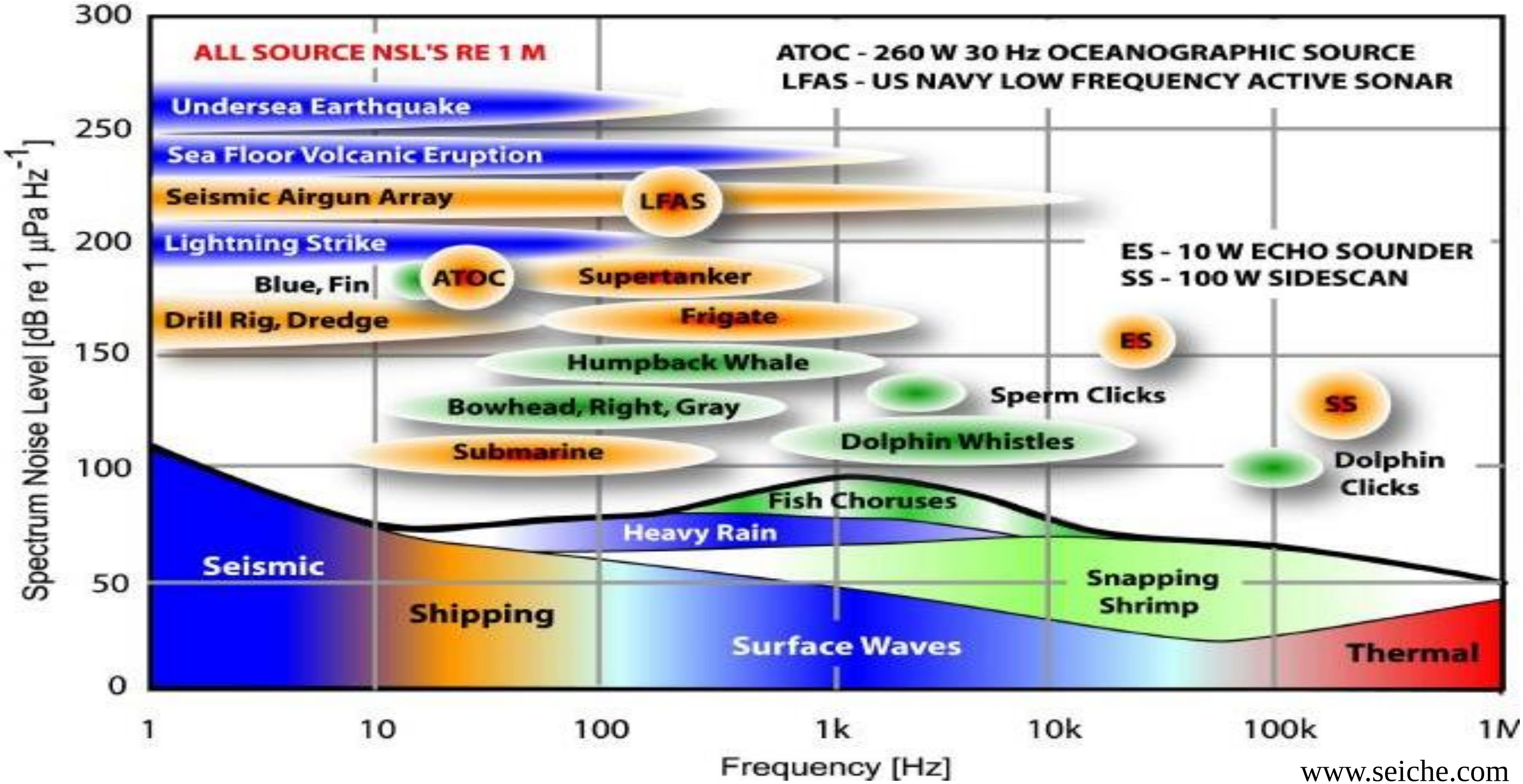
Passive acoustics

Signal ↔ Information about the **source**





Sounds in the sea — Ambient and localized noise sources



www.seiche.com

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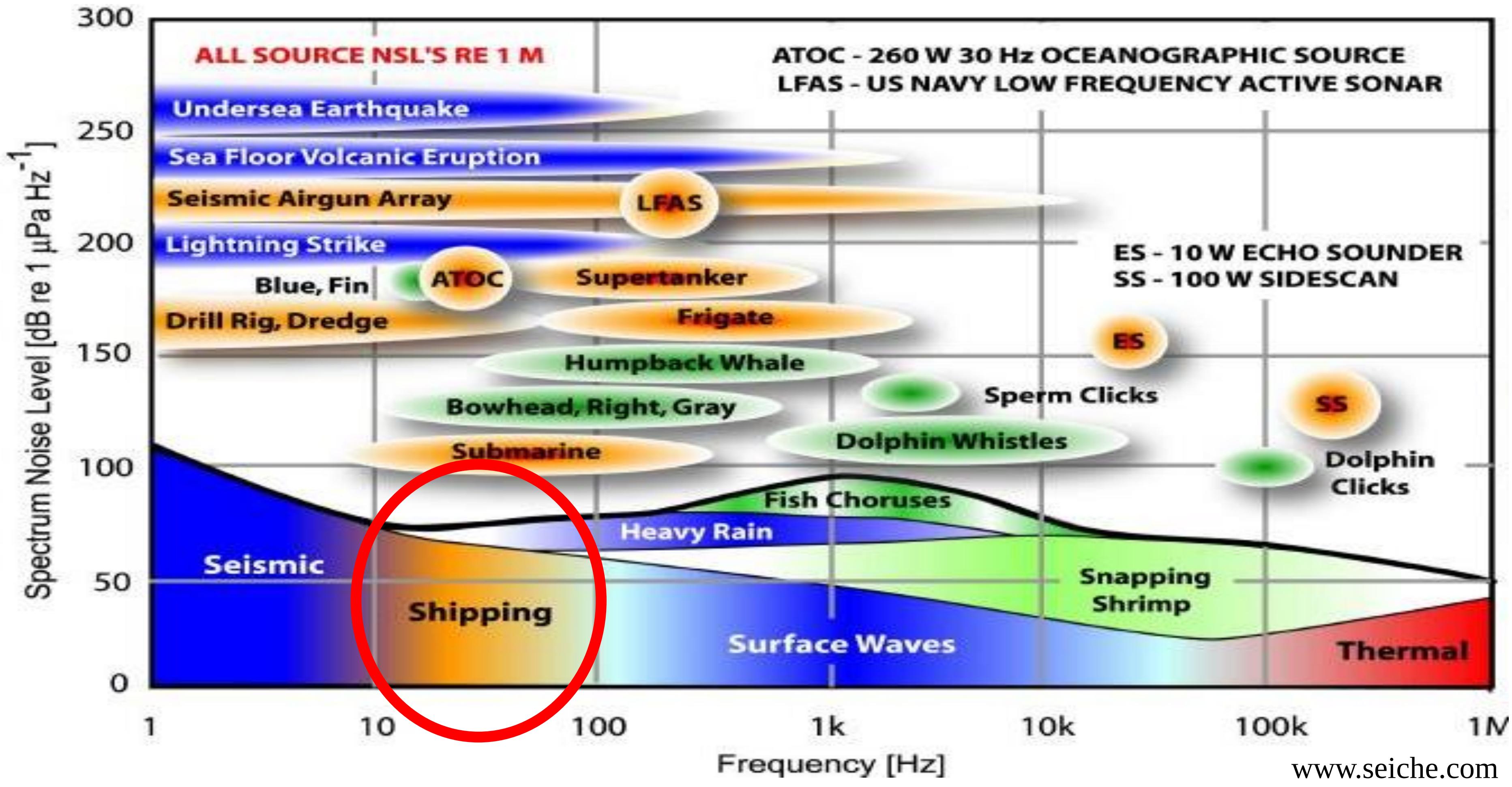

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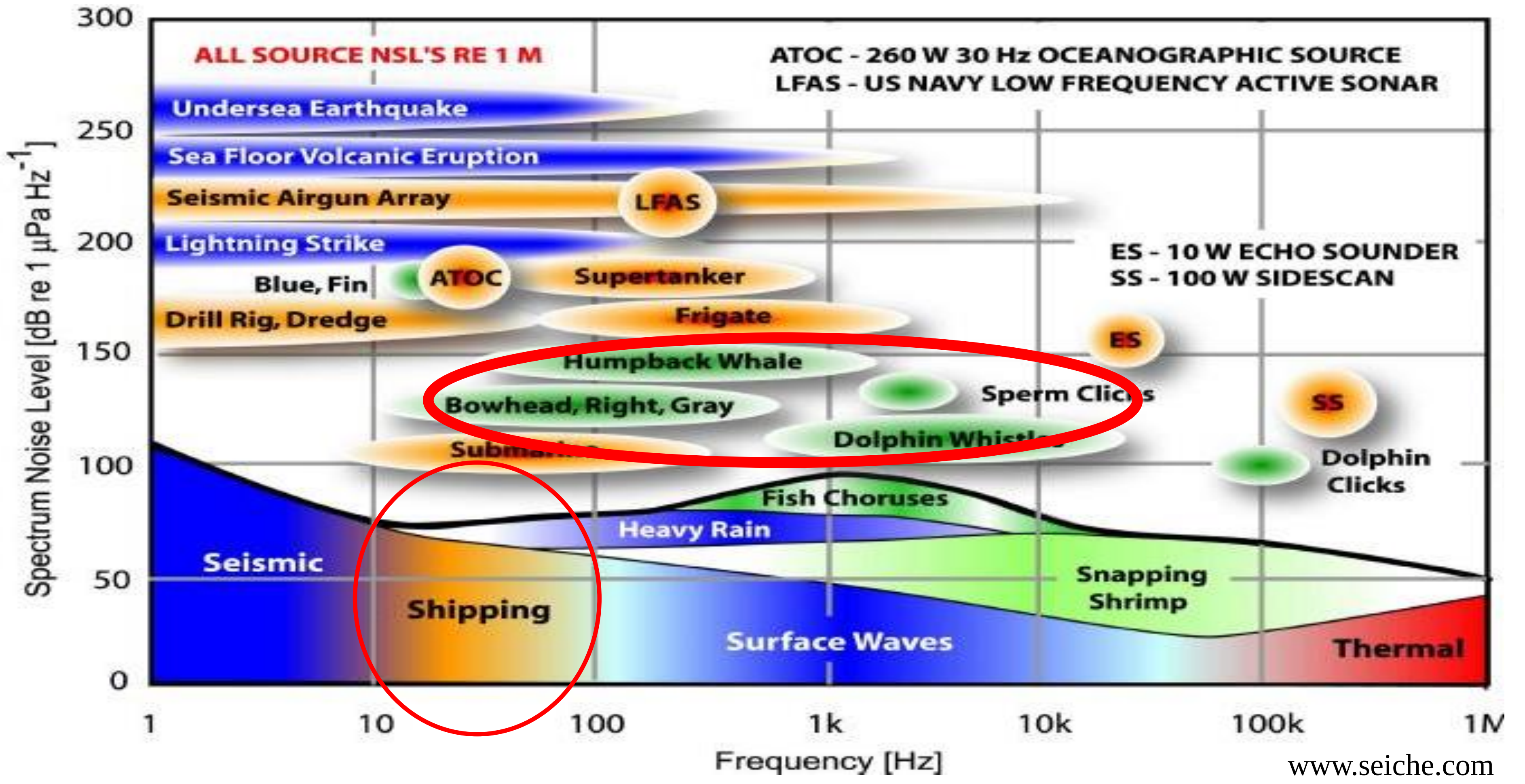

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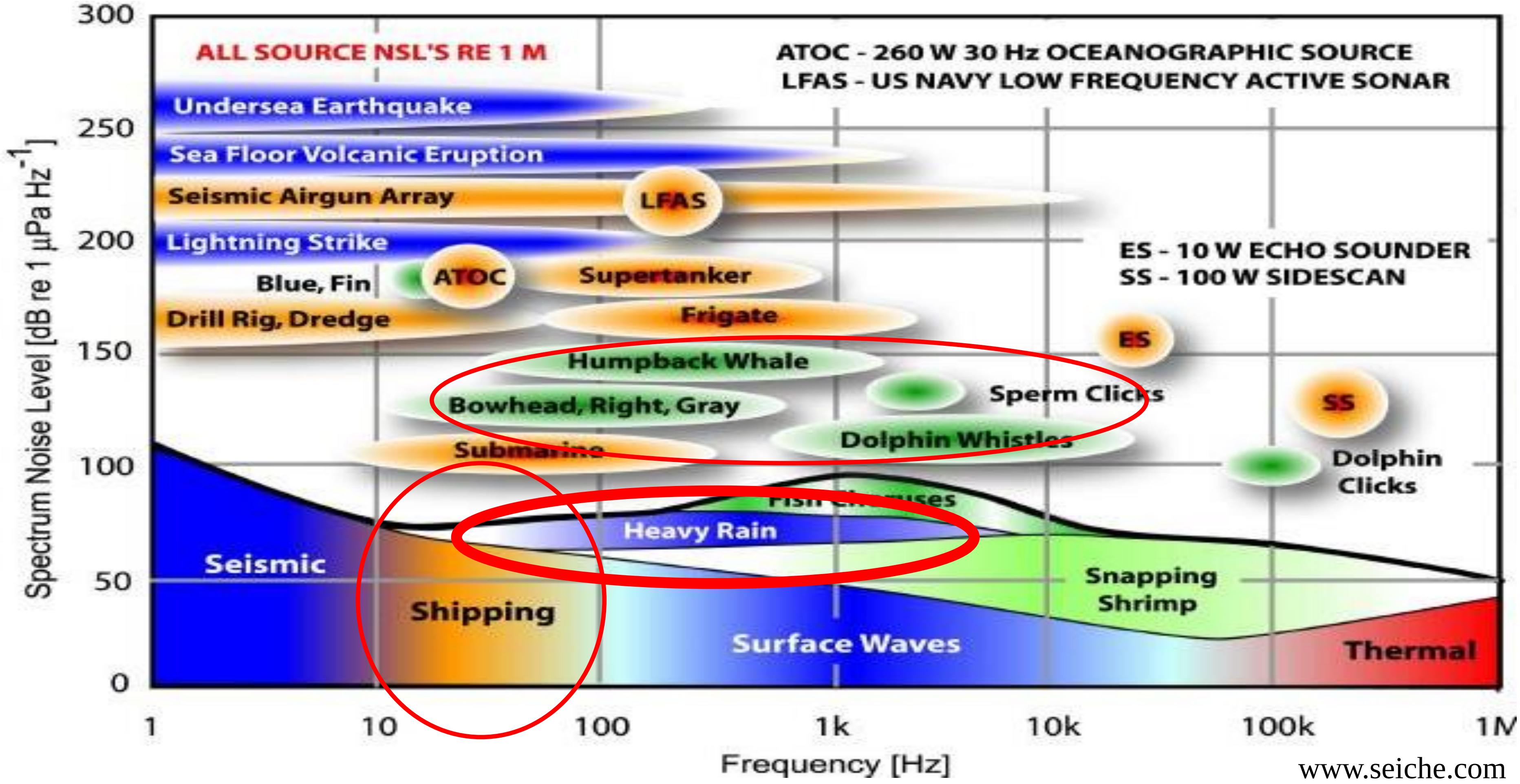

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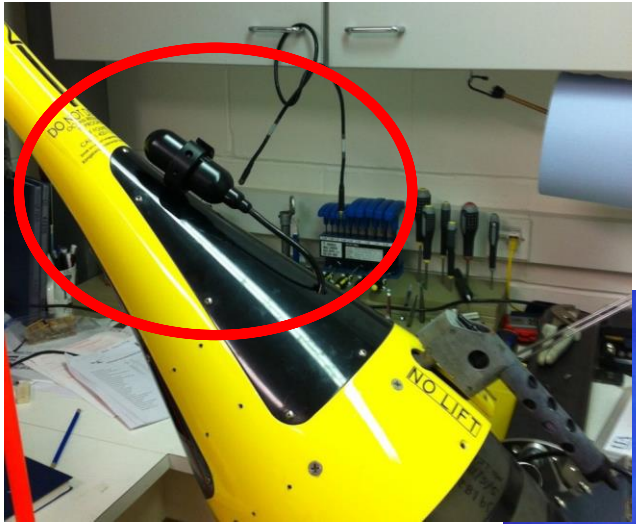
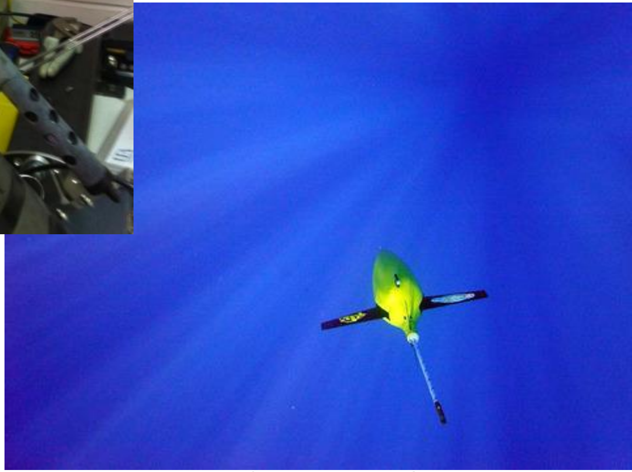
Sounds in the sea — Available datasets



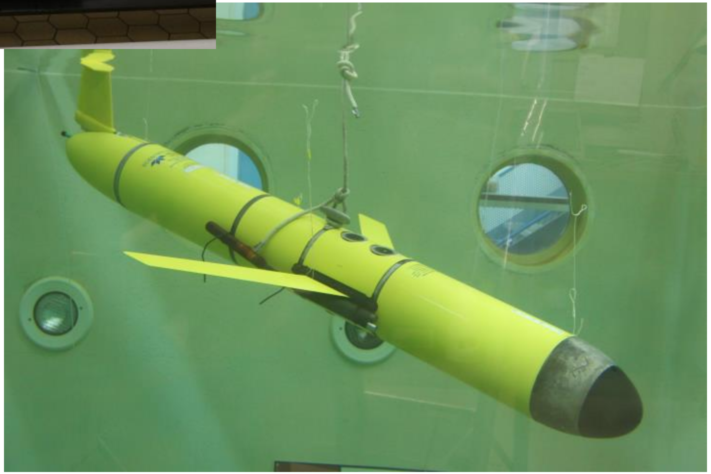


Hydrophone & Kongsberg Seaglider™

MED-REP14 COAS-UEA, CMRE

GALWAY COAS-UEA, Kongsberg

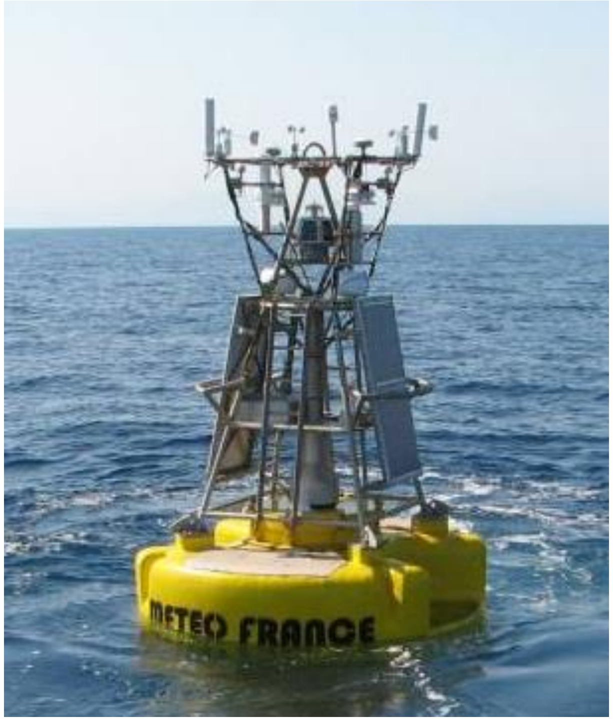
Sounds in the sea — Available datasets



Acousonde™ & Slocum™ glider

MED-REP13	LOCEAN, CMRE
MOOSE	LOCEAN

Sounds in the sea — Wind Observation Trough Ambient No



Meteofrance weather buoy

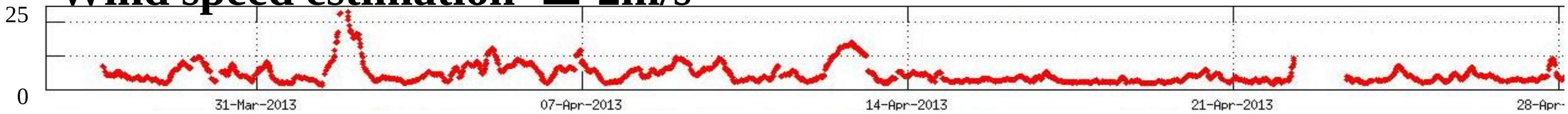
Weather buoy

Real time surface weather sensors

Wind speed

Sounds in the sea — Wind information co-located with glide

Wind speed estimation ± 2m/s



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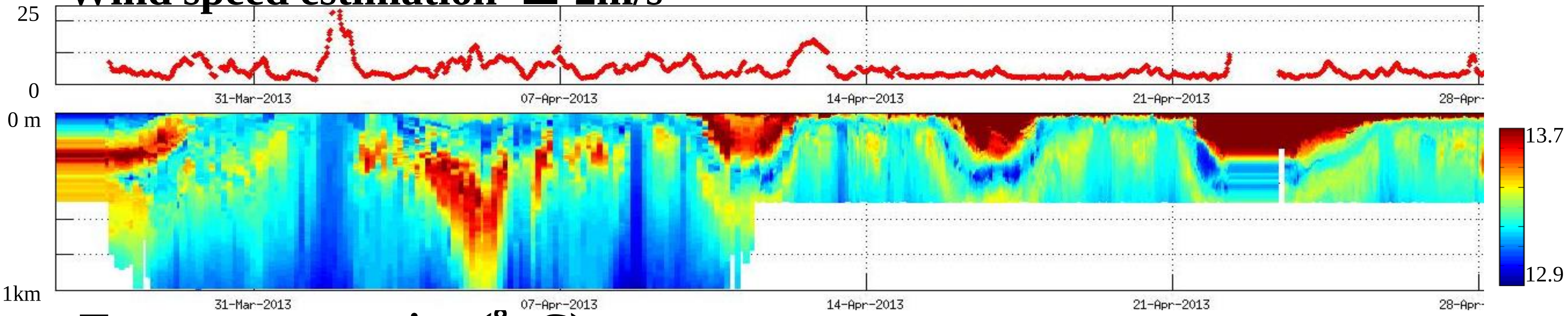

Temperature section (° C)

Air sea interactions

Wind forcing

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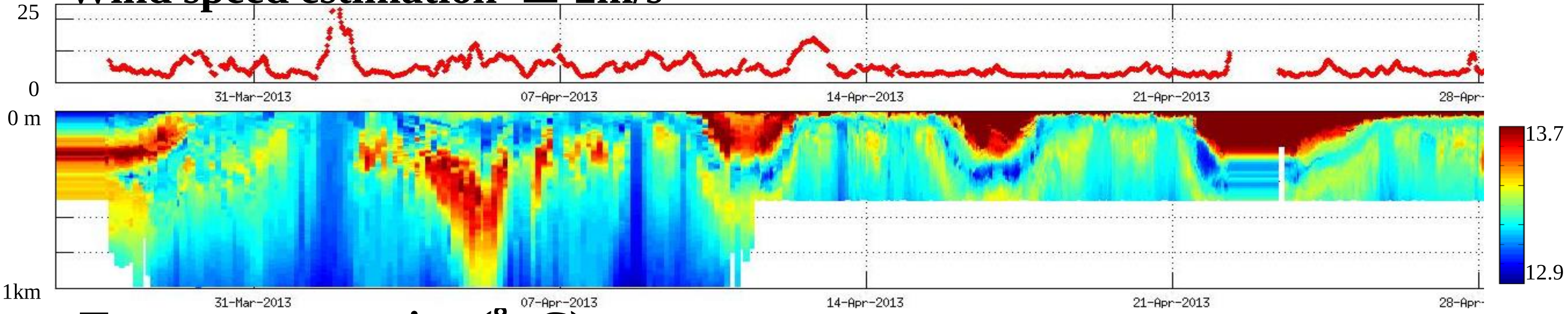


Temperature section (˚ C)

Air sea interactions

Wind forcing

Contextual information

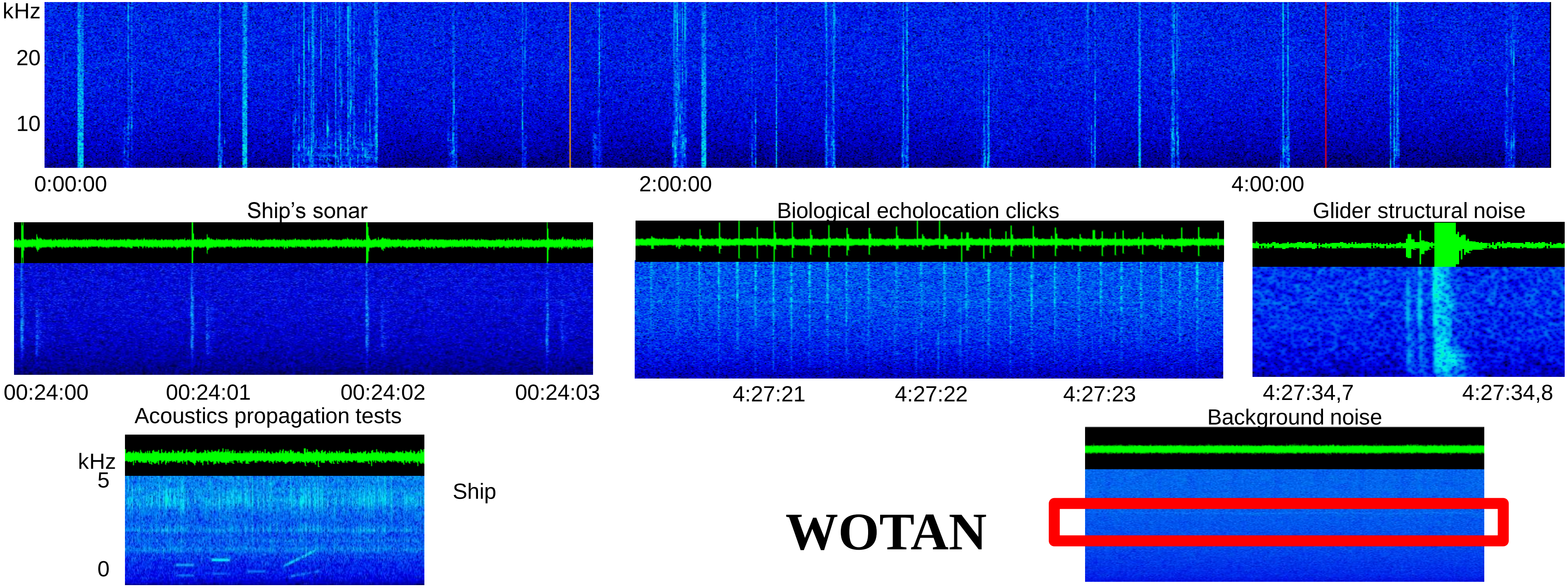
Sound velocity profiles

Area mapping

Sounds in the sea — How can we listen from ocean gliders?

Unwanted noise filtering

- Glider generated noises (pump, altimeter, engine...)
- Biological noises (whistles, clicks)
- Anthropic noises (ships, sonars...)



Sounds in the sea — Future datasets

Future deployments

WOTAN

Surface weather measurements

Various weather conditions

Rain !

Marine mammals monitoring

Visual survey

Bioacoustics knowledge

Anthropogenic noise

Repeated measurements

Sounds in the sea — Future datasets

Thanks

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How can we listen from ocean gliders?

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MAT showcase – NOC – 17th November 2016

Luca Possenti

NEXUSS UEA

NEXUSS Partner Presentations

Luca Possenti (University of East Anglia)

Autonomous carbon system observations from gliders (AUTOCARB)

NEXUSS supervisory team:
Jan Kaiser & Bastien Queste (UEA)
Liam Fernand (Cefas)
Matt Mowlem & Socratis Loucaides (NOC)

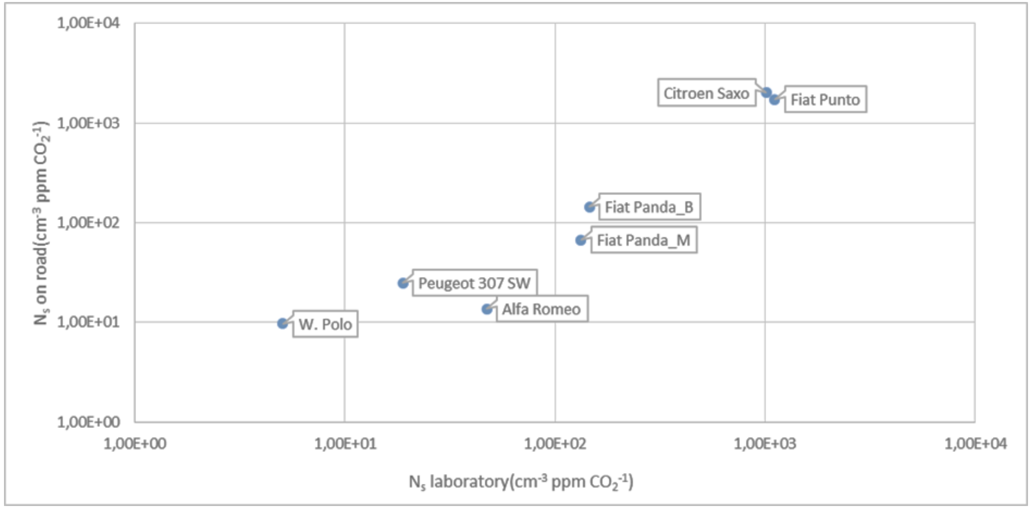
University of East Anglia

Cefas

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Background

- Bsc in Environmental sciences, Milano Bicocca University
  Thesis: Evaluation of the Carbon Footprint of Environmental Science department
- Master in Environmental and Land Sciences and Technology, Milano Bicocca University
  Thesis: Real time analysis of vehicles emissions measured on road and in the laboratory (with JRC of Ispra and Innovhub)



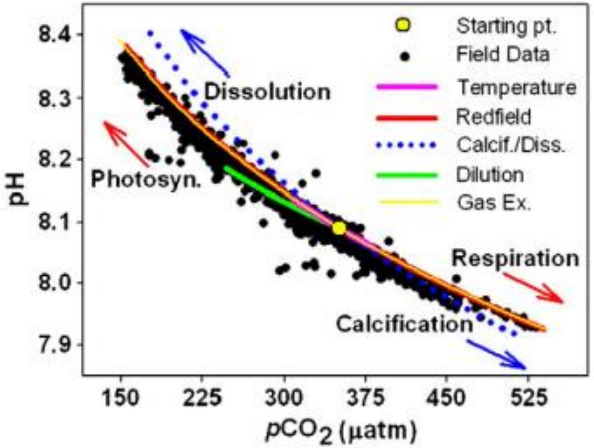
General problem

- pH / $p(CO_2)$ sensors problem with drift, accuracy and response time.
- No sensor to measure on a glider Total alkalinity (AT) and the total dissolved carbon (Σ(DIC))
- Only a small amount of the Ocean has been characterised.

Need a sensor to quantify the ocean acidification and Carbon system

The sensor needs:

- stability
- accuracy
- precision
- low power consumption
- minimise the effects of biofouling

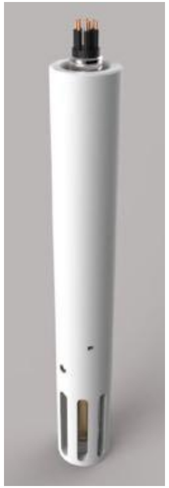


Cullison Gray et al. 2011

My project

What will I be doing?

- Lab work to test the sensor pH and pCO_2, in the future we hope to tackle A_T and Σ(DIC)
- Work at Cefas and NOC (OTE Group)
- Deploy the sensors on Gliders in the North Sea
- Move forward from prototype to mature technology
- Modelling of the data collected



New pH sensor of Fluidion:

- Resolution time of 1 s
- resolution 0.001
- light weight

Andrew Lock

NEXUSS UOS

NEXUSS Partner Presentations

UNIVERSITY OF Southampton

Terrain Following UAVs for Sampling of Boundary Layer Turbulent Fluxes

Andrew Lock
a.lock@soton.ac.uk
Faculty of Engineering and the Environment
17th November 2016

Southampton UAVs

UNIVERSITY OF Southampton

- 2Seas20 / SPOTTER

Southampton UAVs

UNIVERSITY OF Southampton

- SULSA – Southampton University Laser Sintered Aircraft

Boundary Layer Turbulent Fluxes

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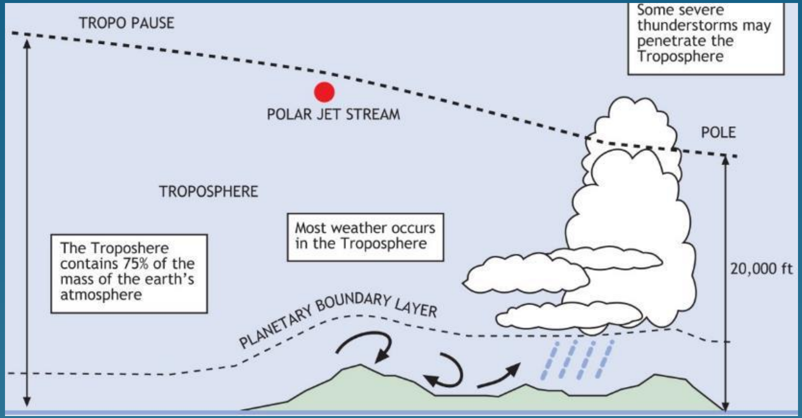
- Boundary layer – the interface between the atmosphere and the Earth's surface
- Highly turbulent
- Turbulent fluxes – transport of energy, chemicals, moisture, etc.
- Characterising turbulent fluxes can allow understanding of larger scale processes



Measurement Tools

University of Southampton

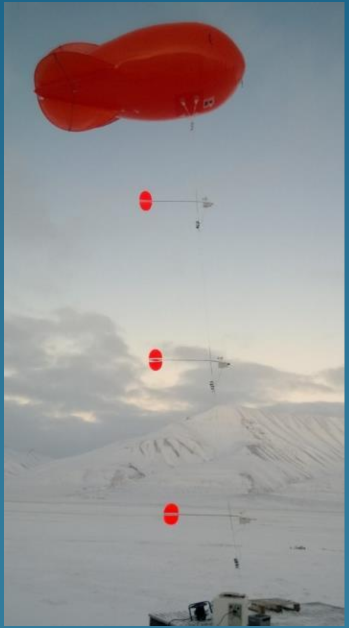
Automatic Weather Station

BL Profile Mast

Sonic Anemometer

SODAR

Balloonsonde/ Tethersonde



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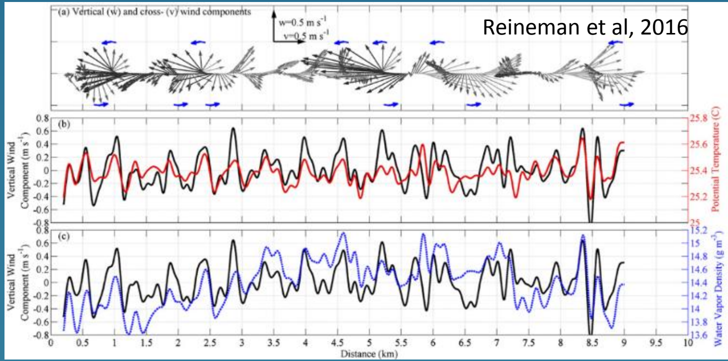
UAVs for Boundary Layer Science

- Captures the spatial evolution of turbulent fluxes
- Differentiates from advection
- Need for better performance at low altitudes (<10 m)


bas.ac.uk/


http://ciresblogs.colorado.edu/



Reineman et al, 2016

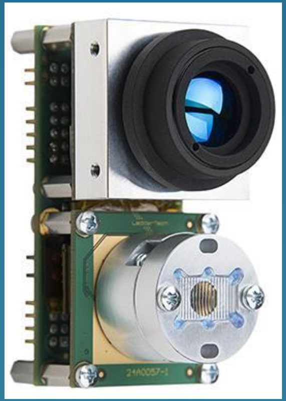

unmanned-aerial.com

Thomas et al, 2012

Terrain Following Challenges

UNIVERSITY OF Southampton

- Challenging surfaces
- Turbulence
- Temperature inversions
- Turbulence probe requirements



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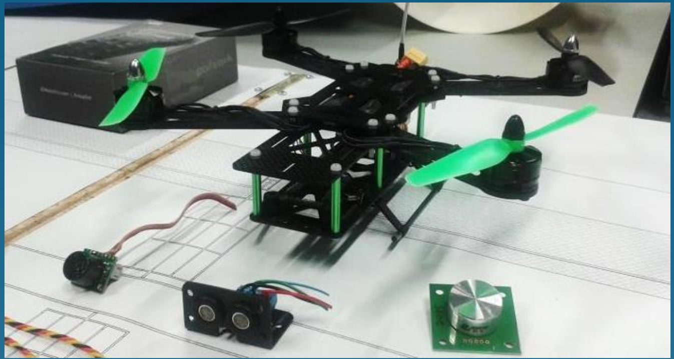
Approach

- Begin with multirotor
- Gain experience with sensors and control
- Develop a test platform for sensors

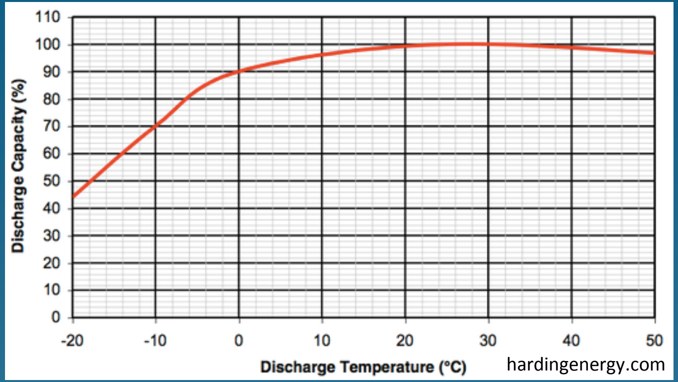


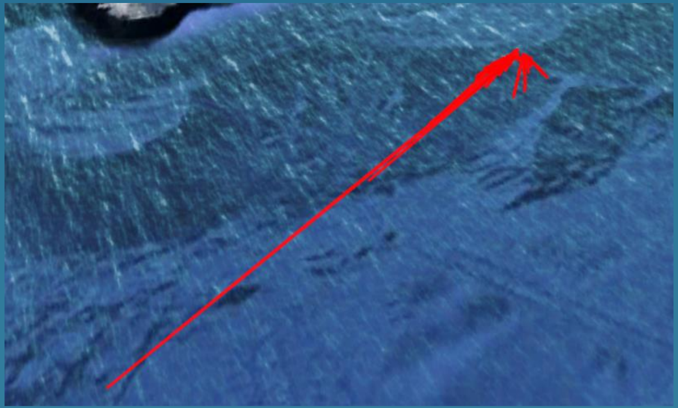
- Move on to fixed wing aircraft
- Testbed followed by purpose-built aircraft

Design and Operational Challenges

UNIVERSITY OF Southampton

- Endurance requirements – challenging to meet with an electric aircraft, particularly at low temperatures
- Performance in turbulent air
- Turbulence probe requirements
- Navigation – GPS and magnetometers less reliable in polar regions
- Practical considerations





Thank you

Andrew Lock
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Faculty of Engineering and the Environment
17th November 2016

Andras Sobester

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NEXUSS Partner Presentations

Oceanography and Polar Science through Agile Robotic Systems

Andras Sobester & Eleanor Frajka-Williams

University of Southampton,

Faculty of Engineering and the Environment and Faculty of Natural and Environmental Sciences

Observational challenges for Oceanography

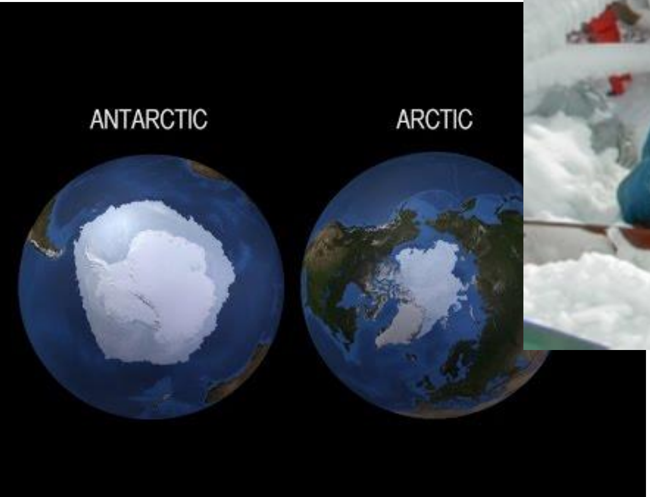
- Oceanic processes vary spatially and temporally.
- Difficult observational conditions.
- Traditional methods are expensive. (£30-50k/day for a big ship.)
- Challenges for autonomous platforms: must withstand high pressures, salty water, biological growth, and typically must surface to transmit data

We'll discuss a couple science problems, proposed and funded technological solutions (particularly for deploying instruments in remote regions) and new ideas for platform development.

Polar observations are particularly challenging

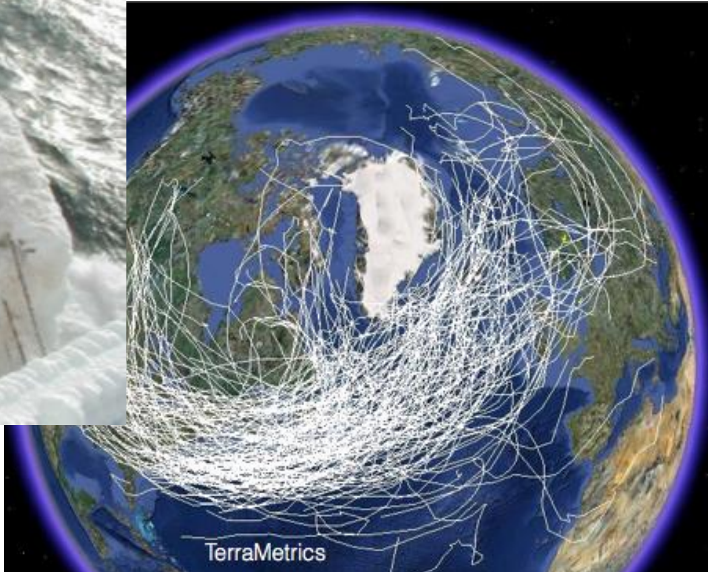
Observational challenge: Inhospitable region, small spatial scales of variability, and both seasonal and interannual variability.
Ice & weather present challenges, and regions are remote (expensive to access)

Polar ice caps



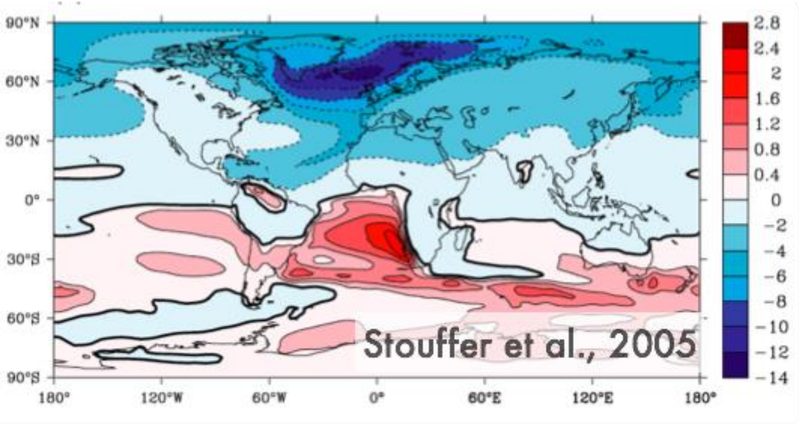
Observations in the Labrador Sea

Storm tracks



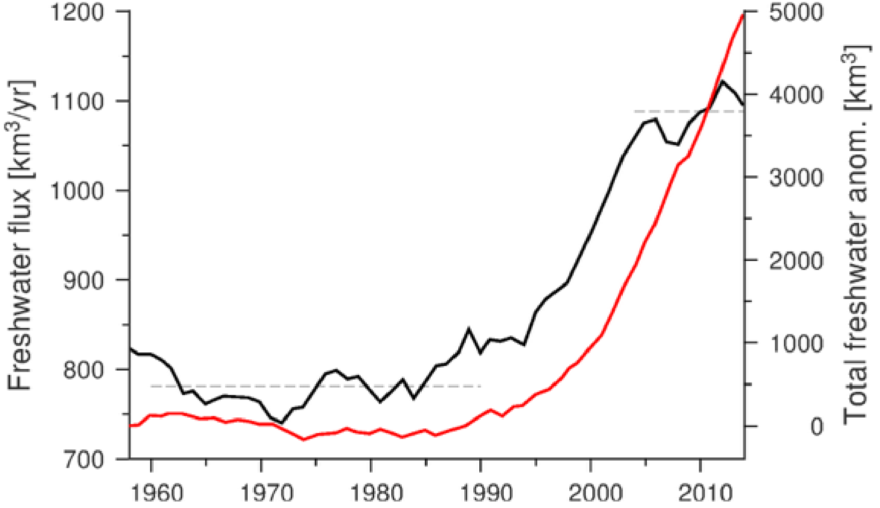
Freshwater dispersal in the high-latitudes

- **Scientific problem:** High-latitudes freshwater input may shut down the MOC. Greenland is melting, and the Arctic is storing freshwater and may release it. How does the freshwater escape boundary currents to influence convection?



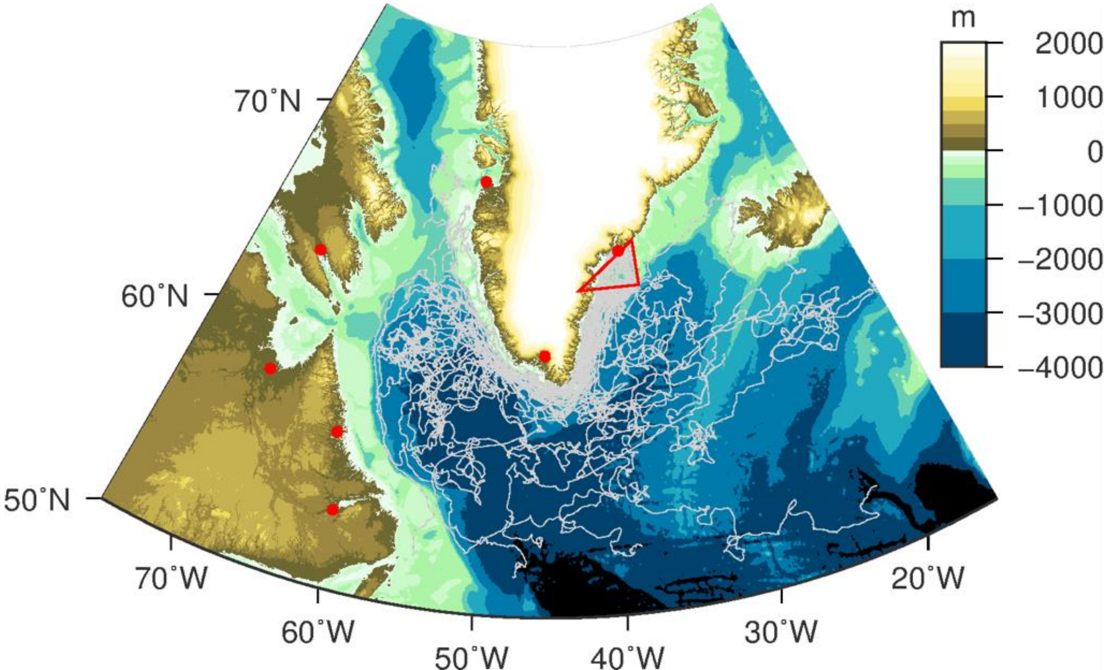
Temperature anomaly 100 years after MOC shutdown, in a coupled climate model.

Freshwater melt from Greenland is increasing (since a 1960-1990 typical value), with accumulated freshwater release equal to that of the GSA by 2025 (Bamber et al., 2012)



Freshwater dispersal in the high-latitudes

- **Scientific problem:** High-latitudes freshwater dispersal
- **Observational challenge:** Rough seas, small areas, long timescales
- **Technological solution:** Low cost, lightweight surface drifters to map the surface currents



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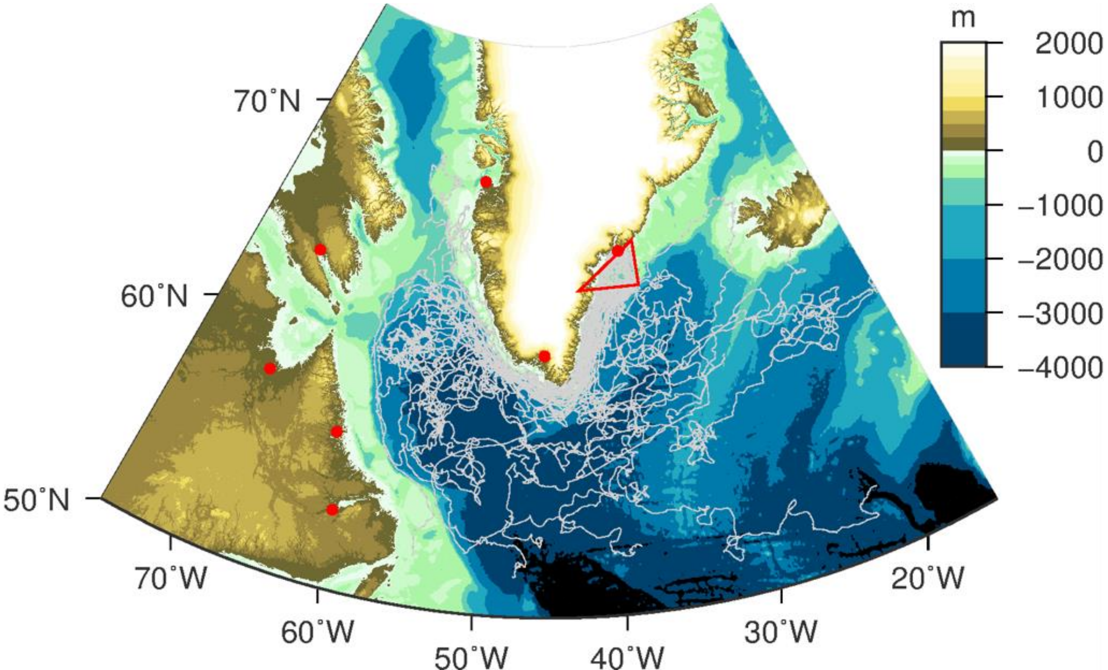
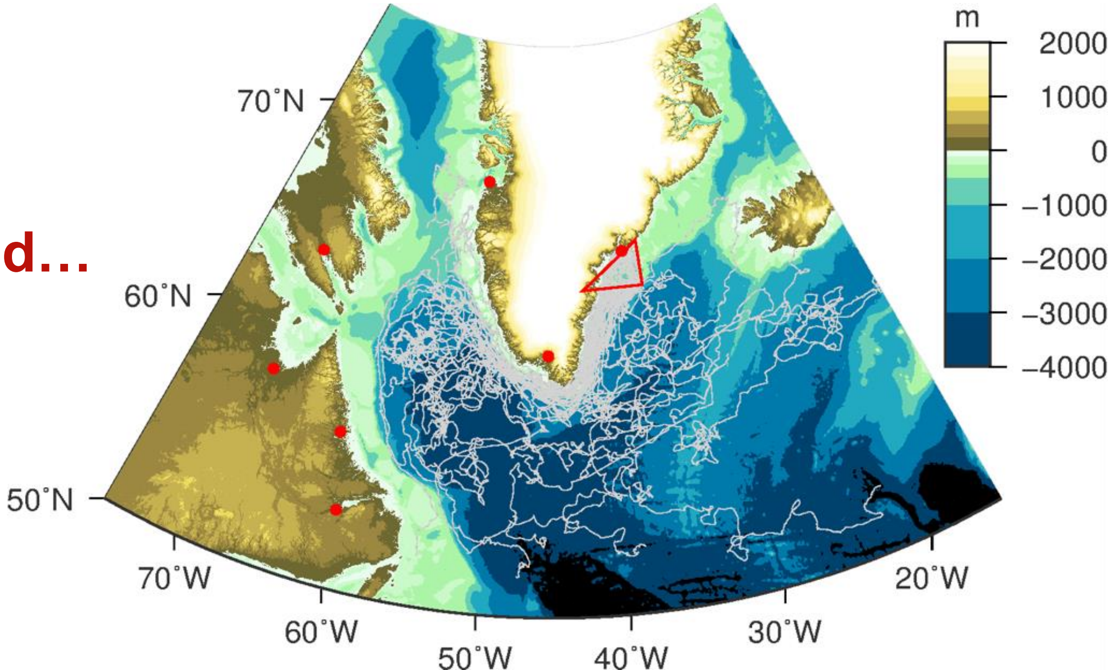


Freshwater dispersal in the high-latitudes

- **Scientific problem:** High-latitudes freshwater dispersal
- **Observational challenge:** Rough seas, small areas, long timescales
- **Technological solution:** Low cost, lightweight surface drifters to map the surface currents

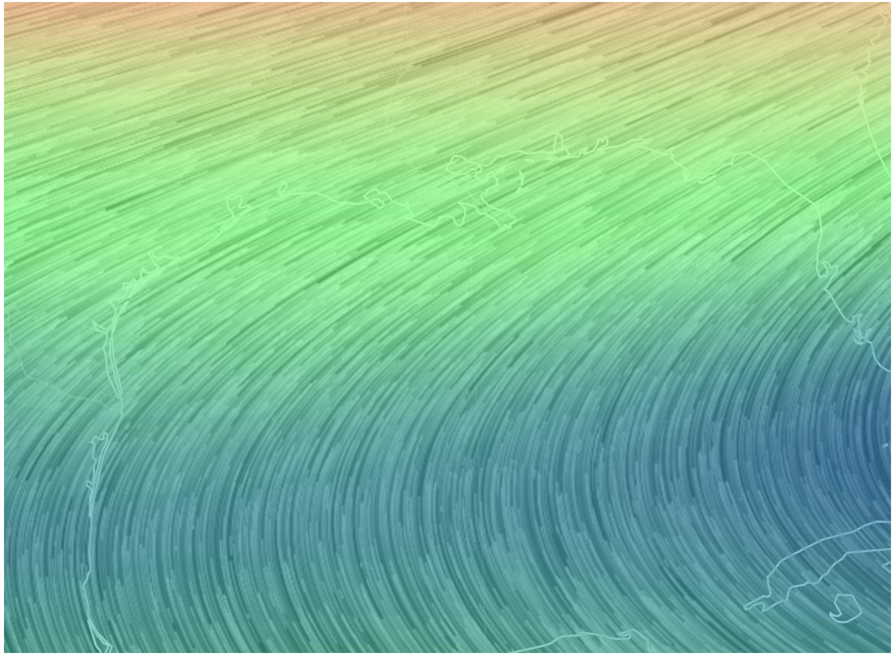
Drifter deployment is still expensive if a ship is needed…



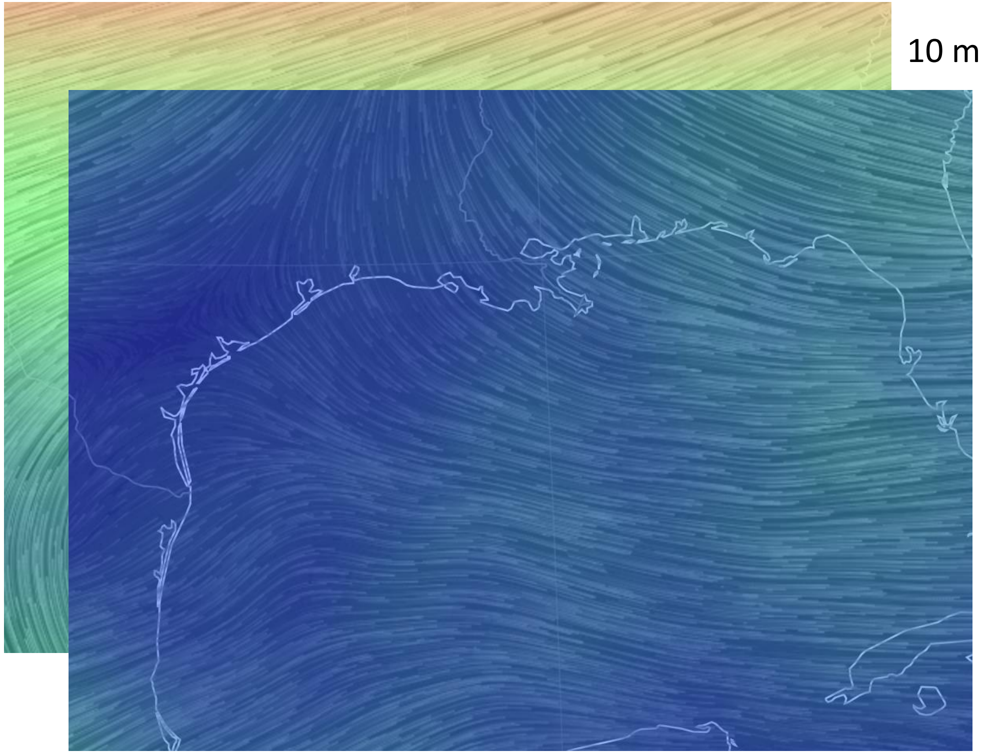
Disruptive ideas
- innovative range extension methods

- How to cut the costs of tracking ocean currents (or oil slicks)?

Fresh Ways of Targeting and Employing Robotic Systems (NERC-funded)



10 mbar



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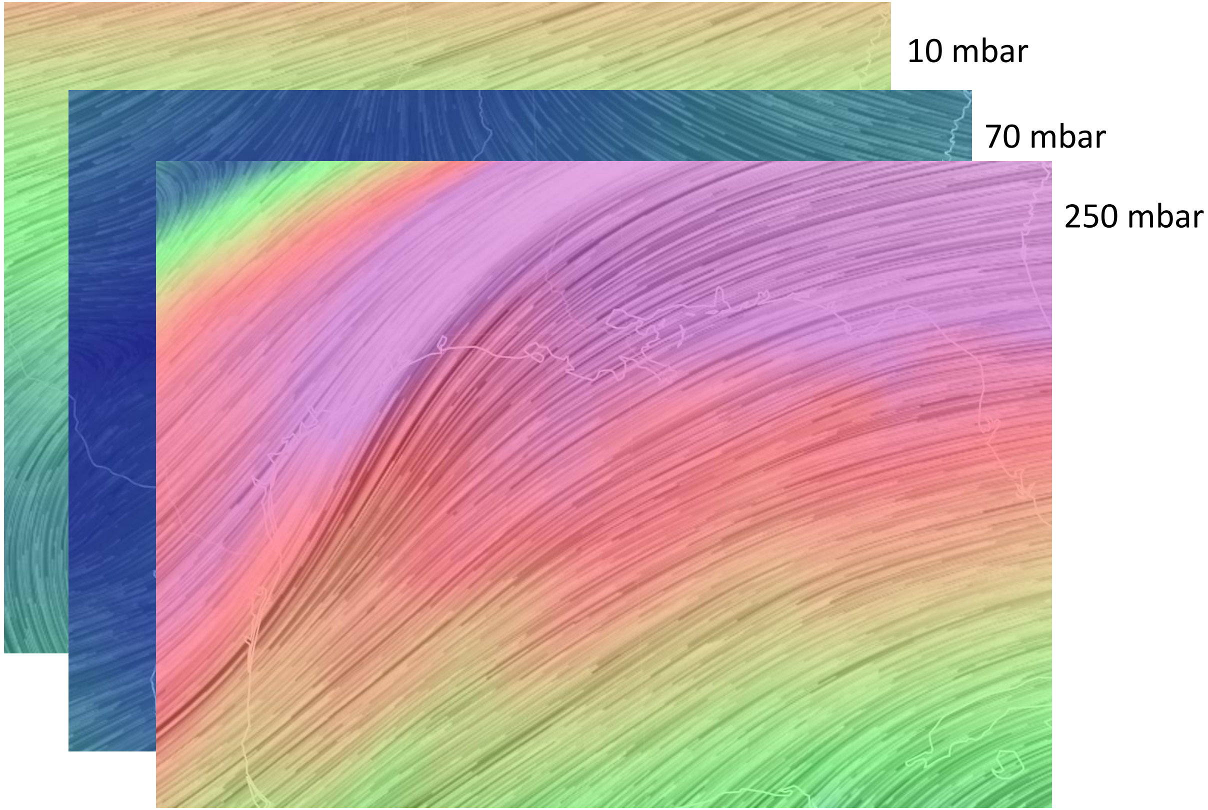
70 mbar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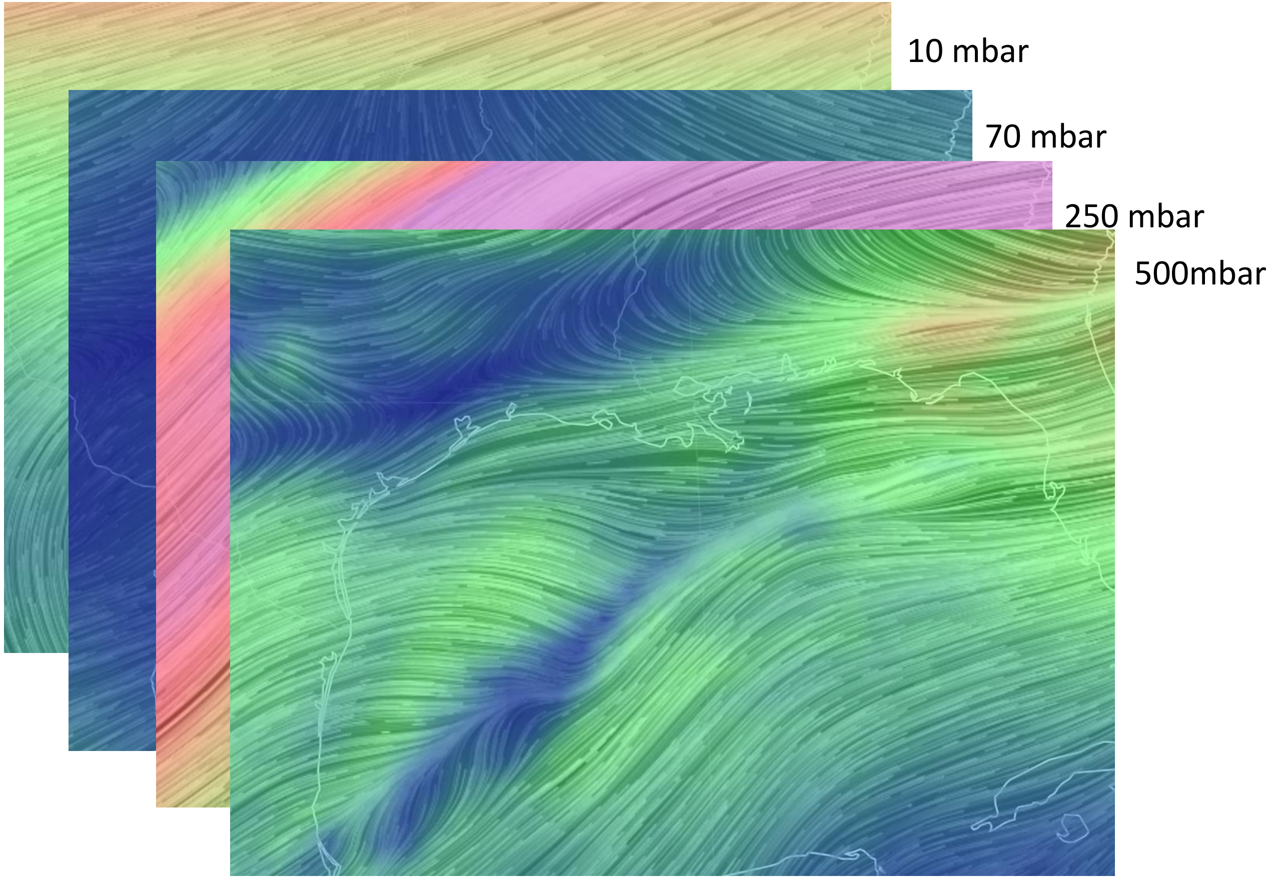
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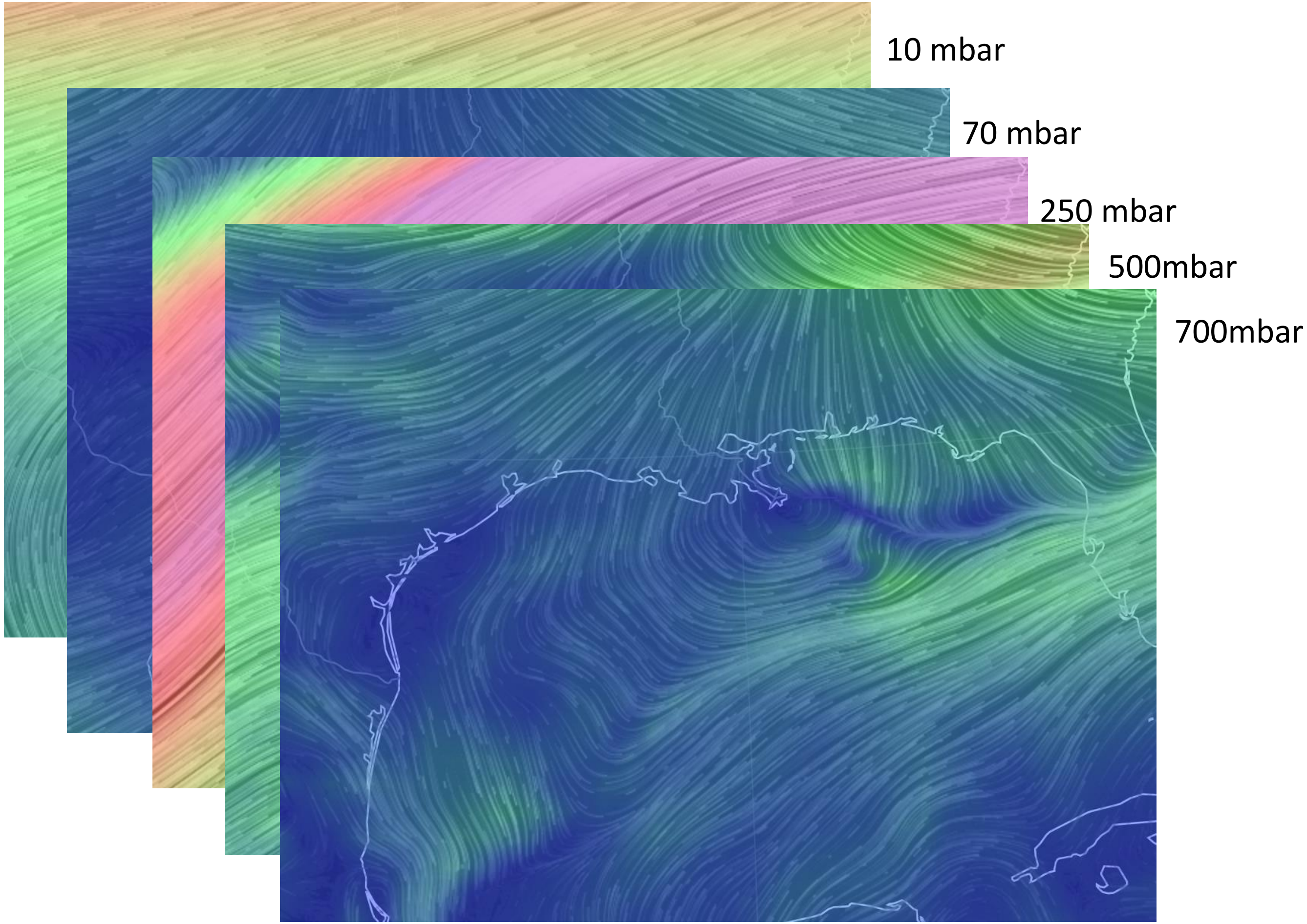

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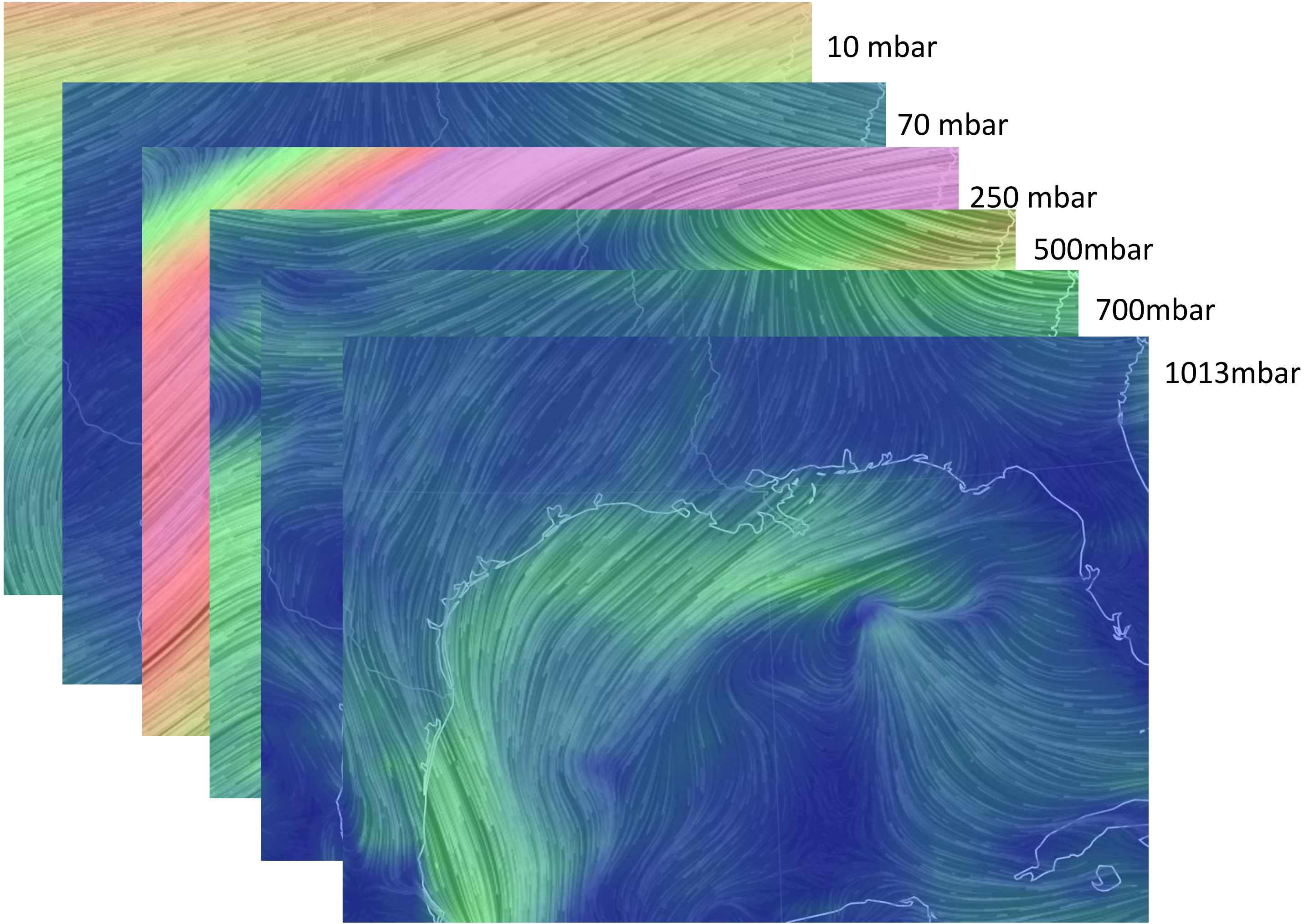
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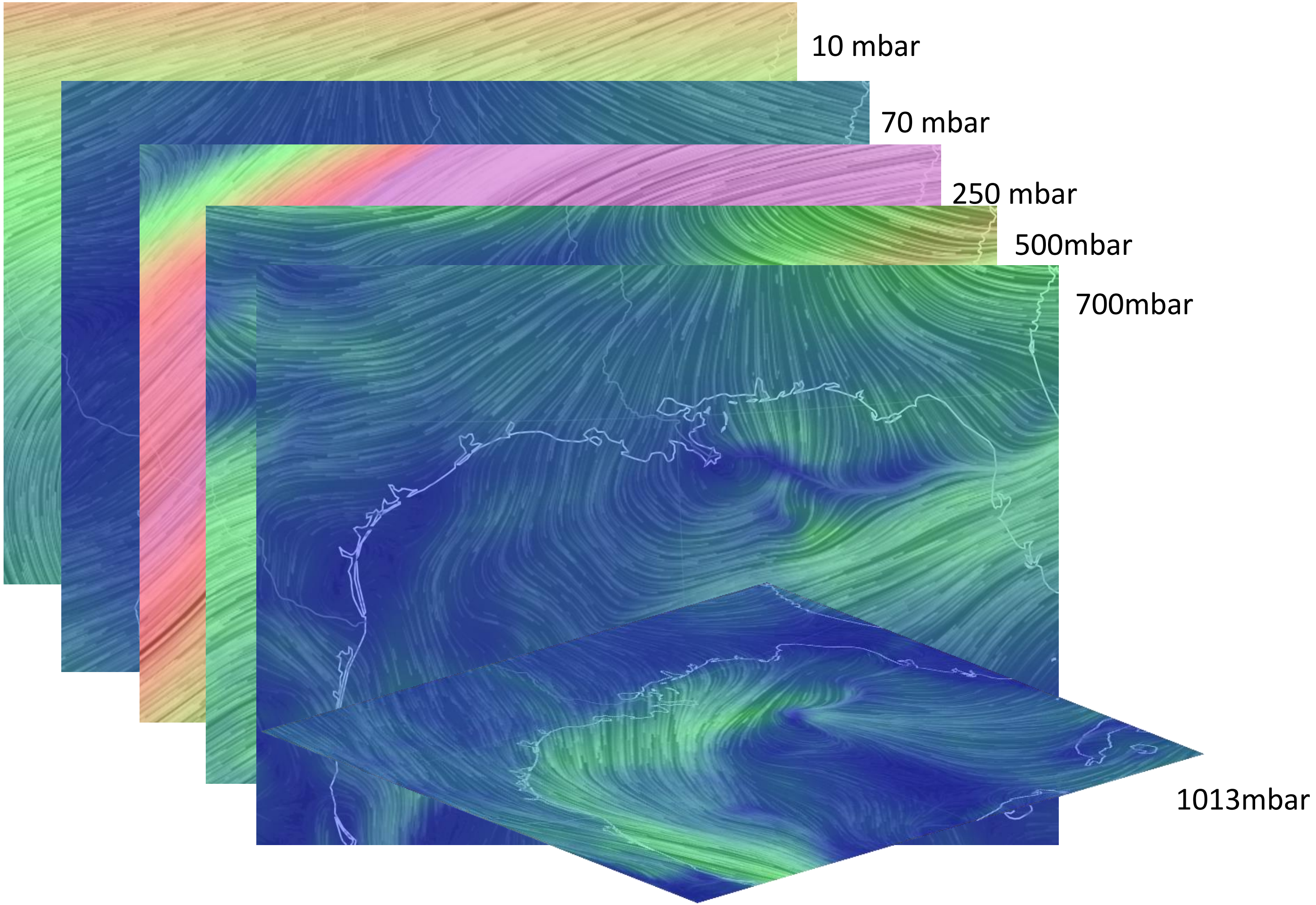
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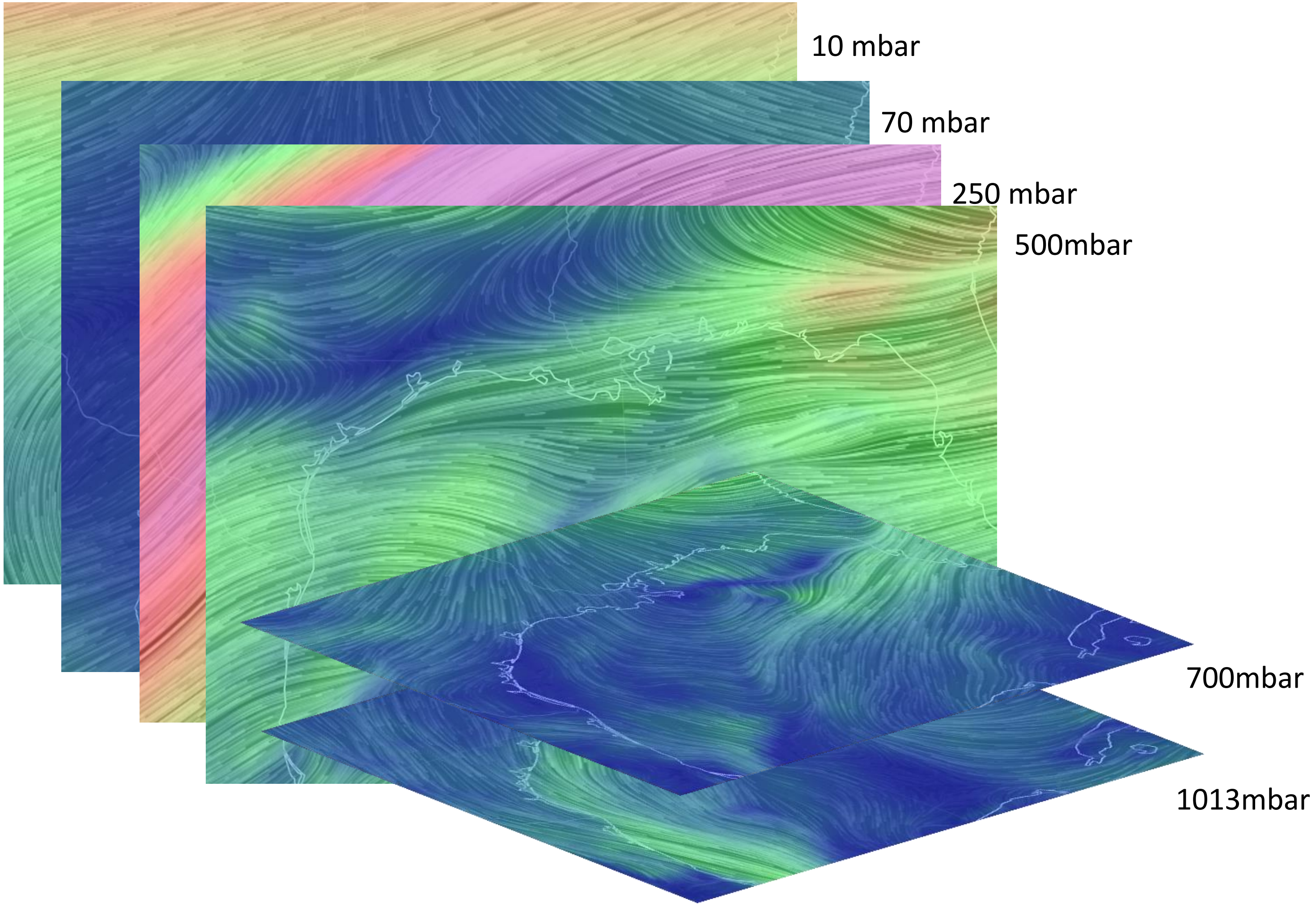
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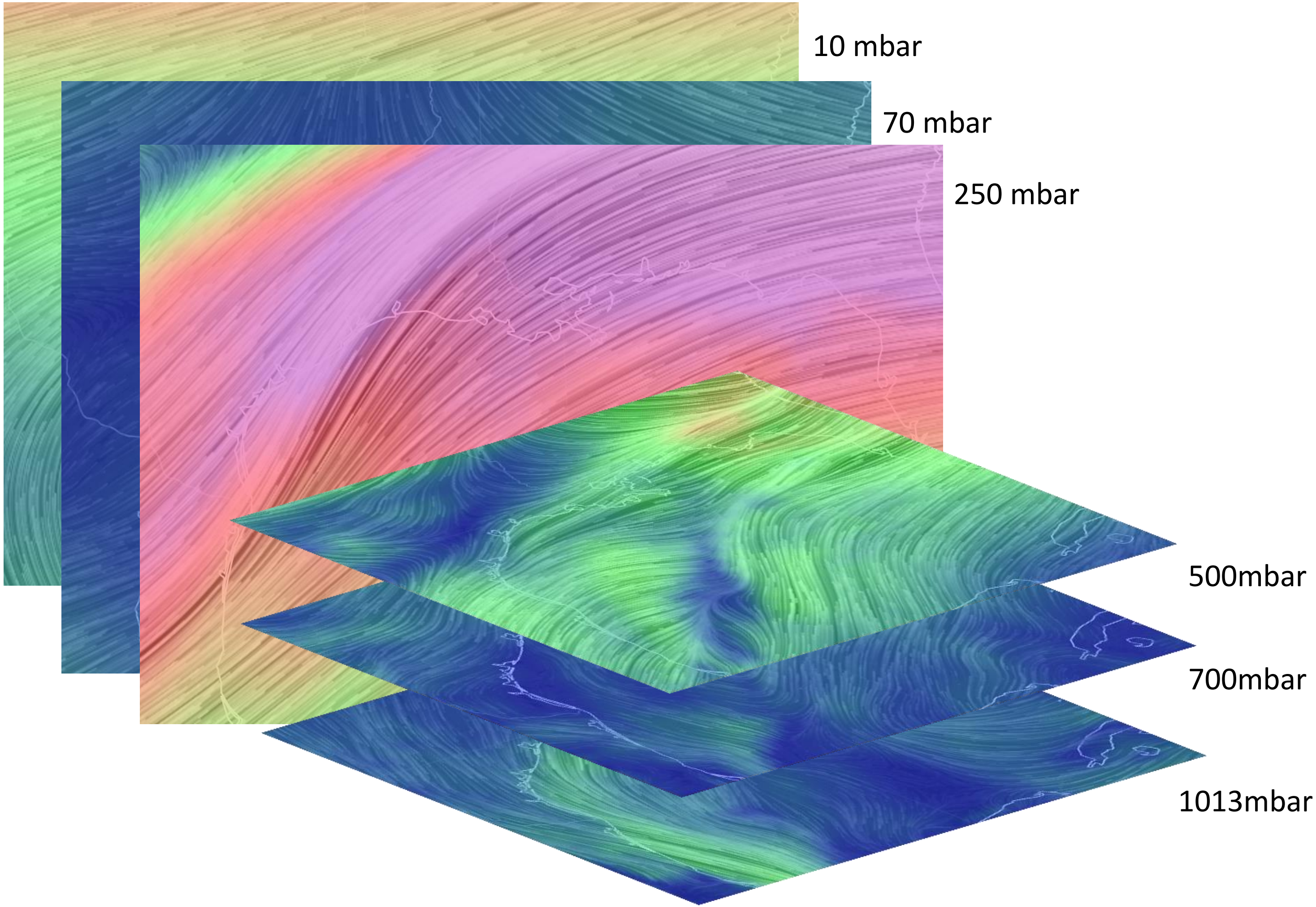
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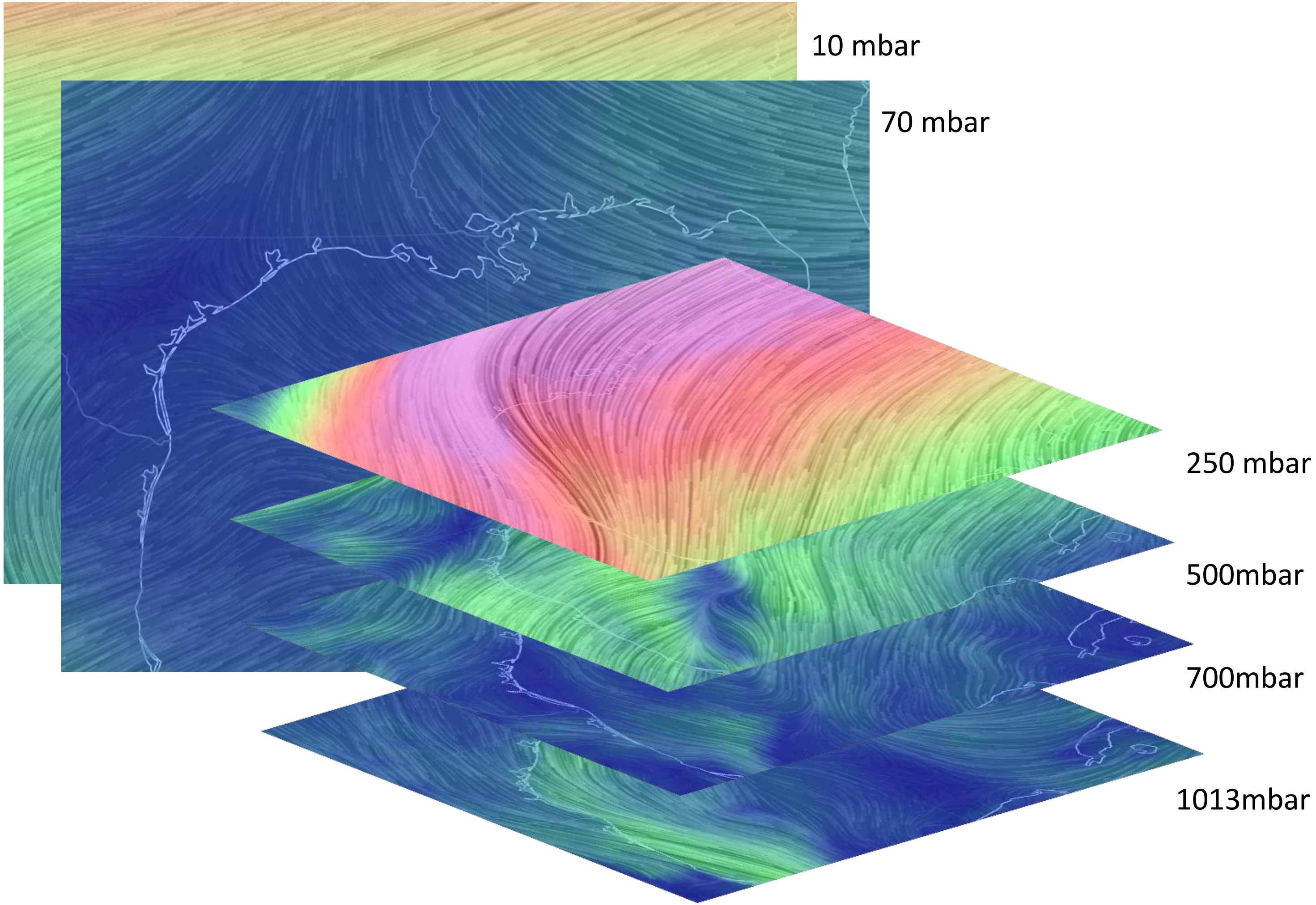

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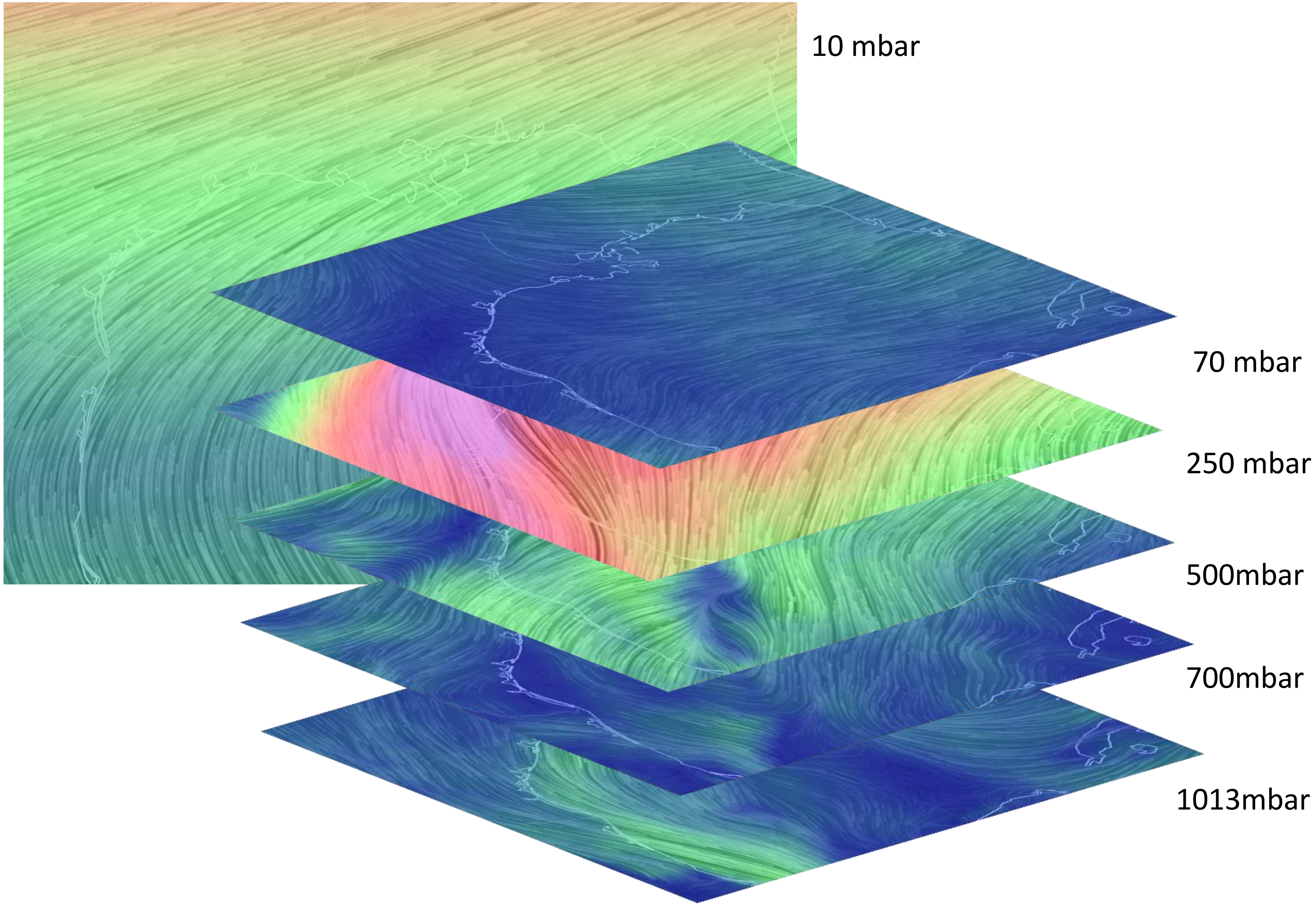
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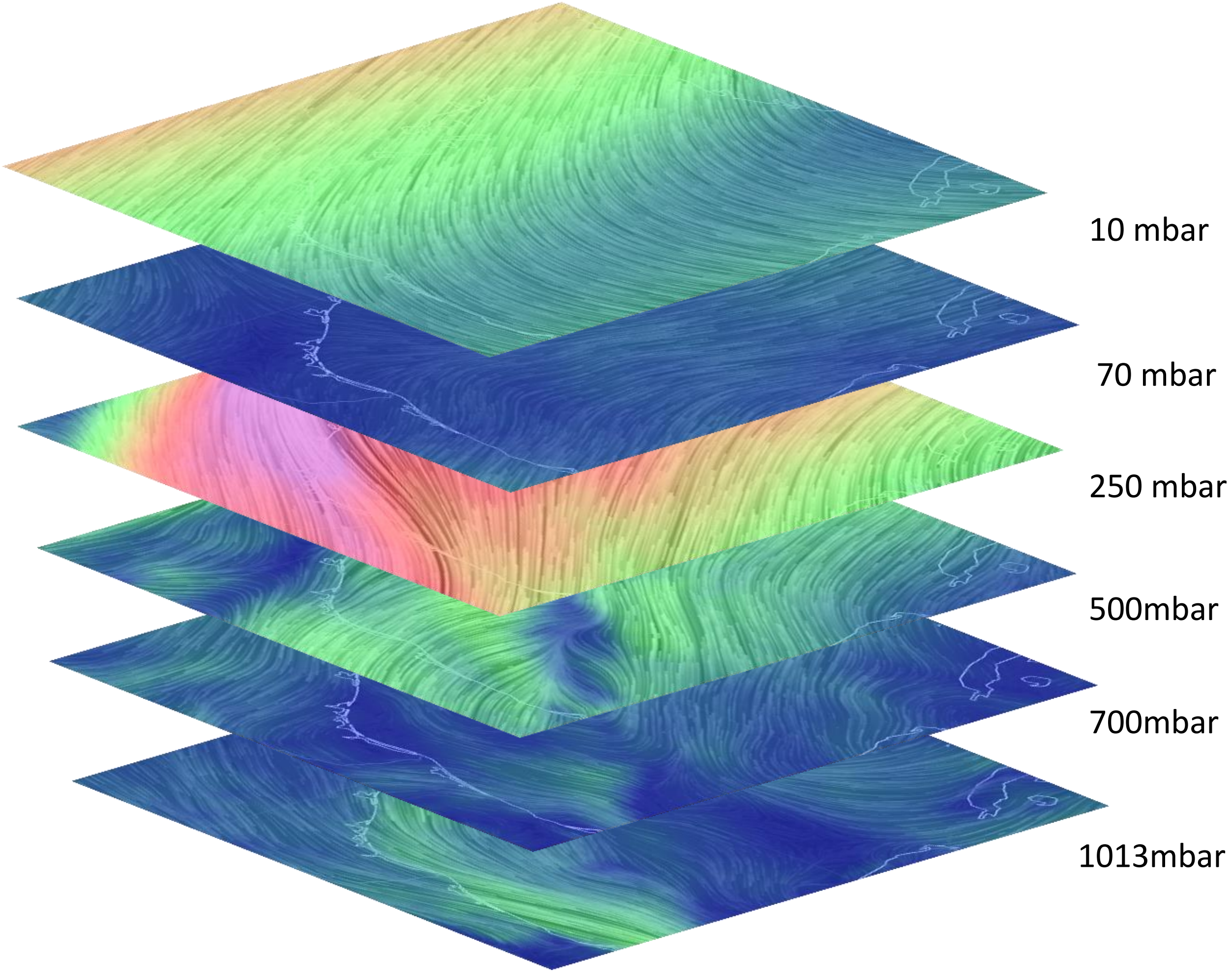
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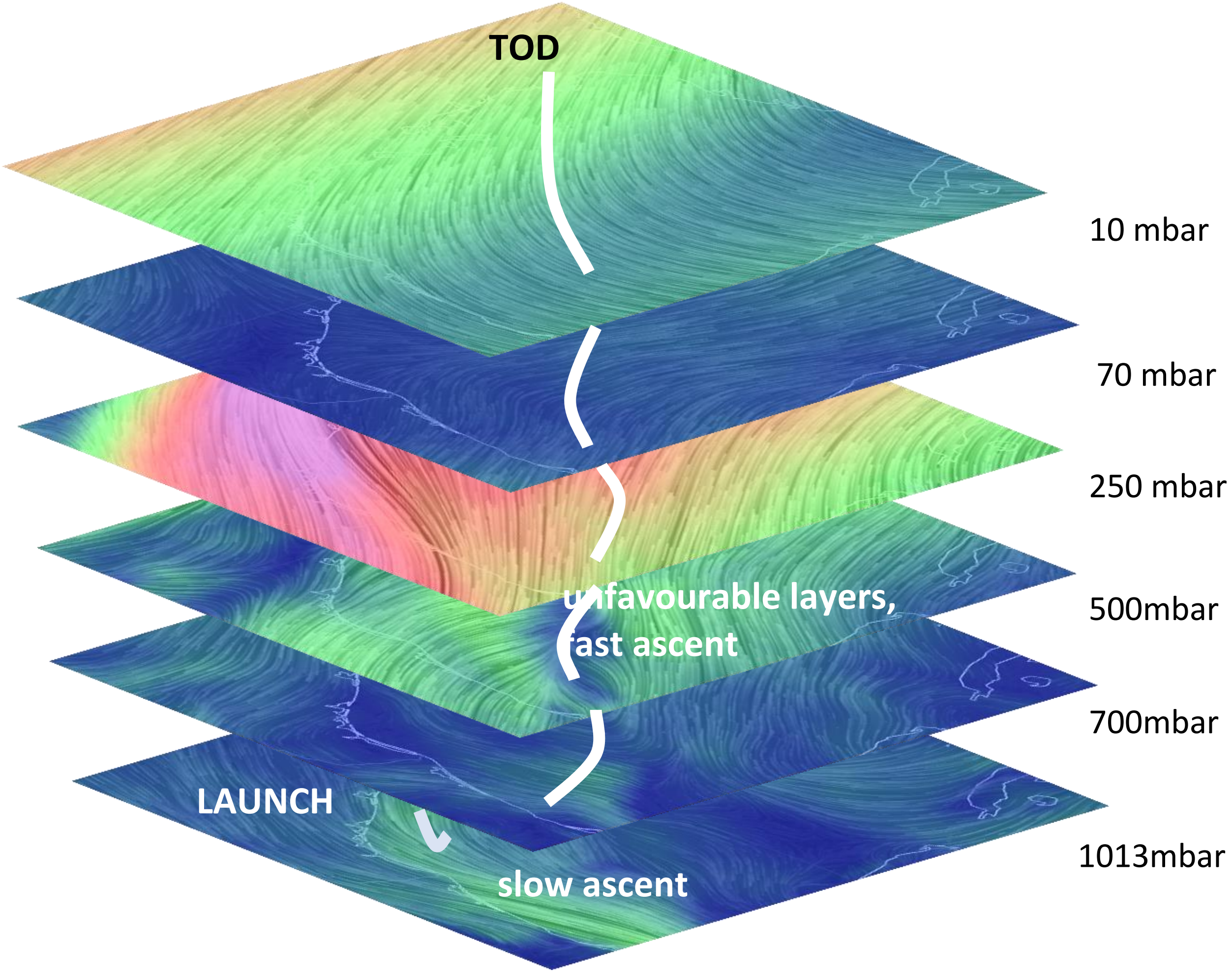
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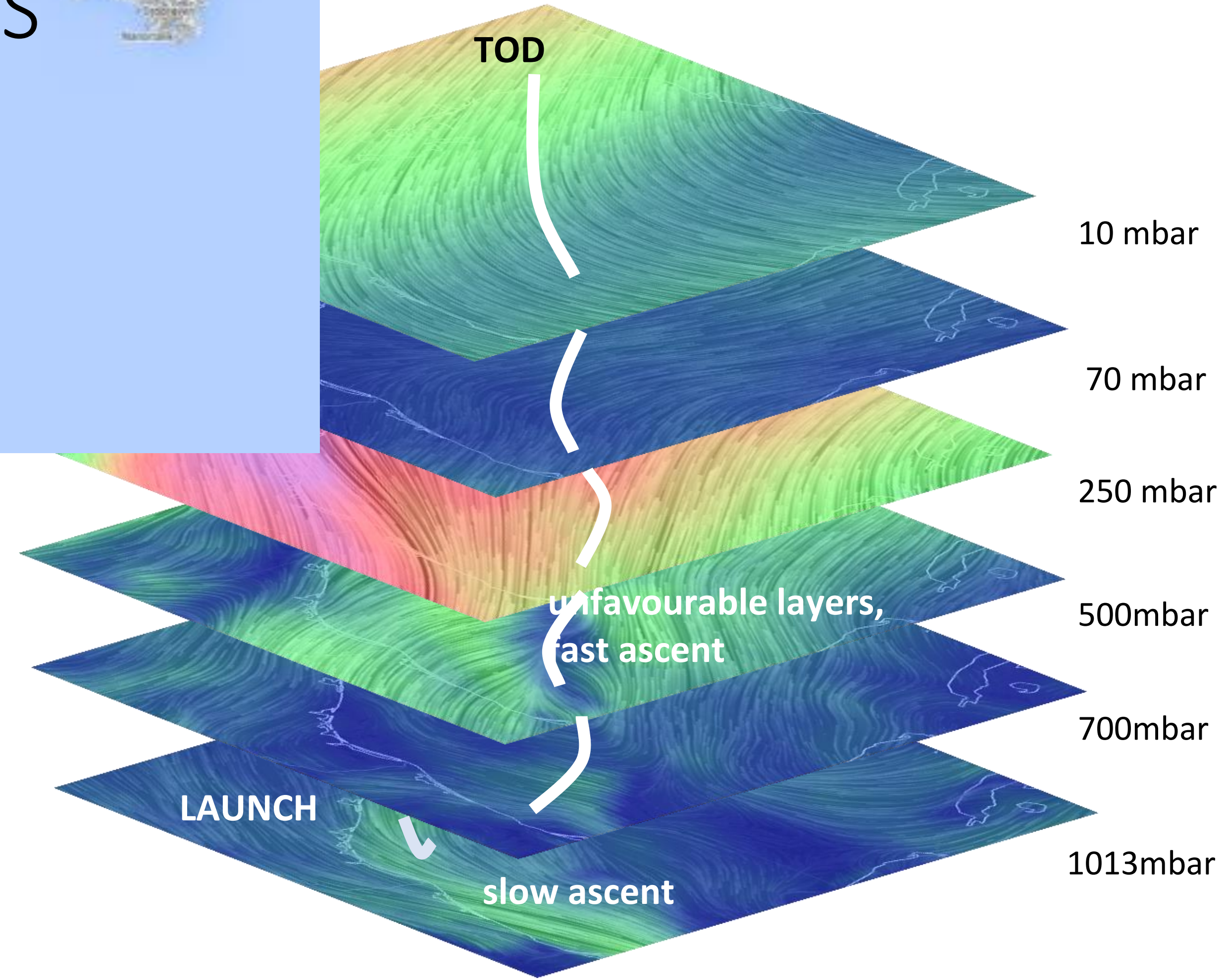
unfavourable layers,
fast ascent
500mbar
700mbar
LAUNCH
1013mbar
slow ascent

FreshWATERS



FreshWATERS

Potential:

- Rapid deployment (<24 hours) from a fixed point weather station
- Potential for one balloon can carry multiple (compact) ocean drifters
- “Smart” navigation using near-real time weather forecasts to optimize flight altitude
- Enables multi-season deployment

- Reduced cost, reduced risk

Oceans and ice

- **Scientific problem:** High-latitudes, icy regions (e.g., polynyas), ocean-ice interactions are sites of dense water formation. Ice melt contributes to sea level rise, freshening of the North Atlantic, but the role of the oceans in melting is unclear.

Polynyas are localised ice-free regions, surrounded by ice

Ice makes travel by sea slow (and costly)

Oceans and ice

- **Scientific problem:** High-latitudes, icy regions (e.g., polynyas), ocean-ice interactions are sites of dense water formation. Ice melt contributes to sea level rise, freshening of the North Atlantic, but the role of the oceans in melting is unclear.

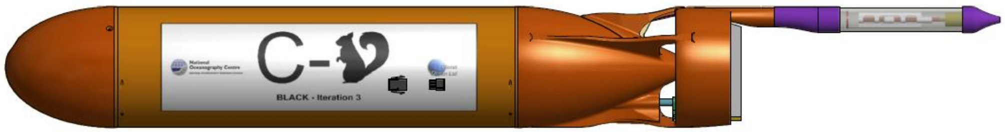
Ice can be dangerous

Oceans and ice

- **Scientific problem:** Icy regions are important to global circulation
- **Observational challenge:** Hard to get to, hard to work in

Technological solution: AUV

However, delivery is still expensive if a ship is needed...



ALTERNATIVE:

ecoSUB-µ – low cost, low mass, AUV

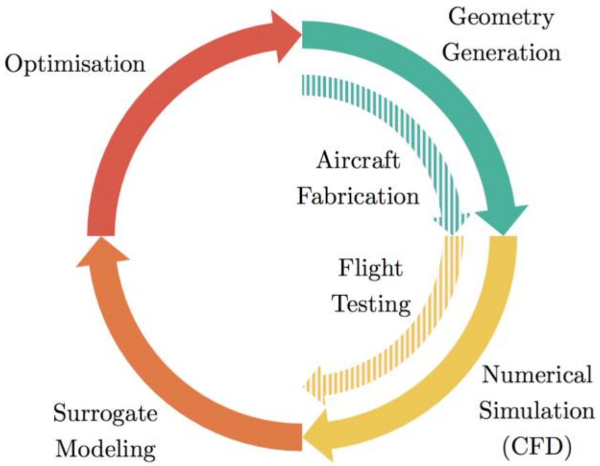
Oceans and ice

- **Scientific problem:** Icy regions are important to global circulation
- **Observational challenge:** Hard to get to, hard to work in

Technological solution: Unmanned aerial deployment of sensors (AUV) in exciting areas

Oceanography and Polar Science through Agile Robotic Systems (OPSARS) – Pilot study funded through Southampton Marine and Maritime Institute

Disruptive ideas
- agile
platform development



Disruptive ideas
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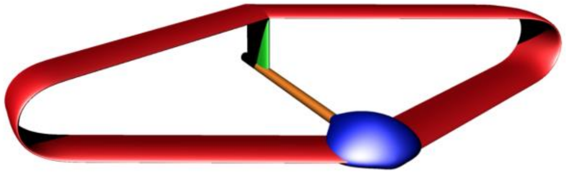
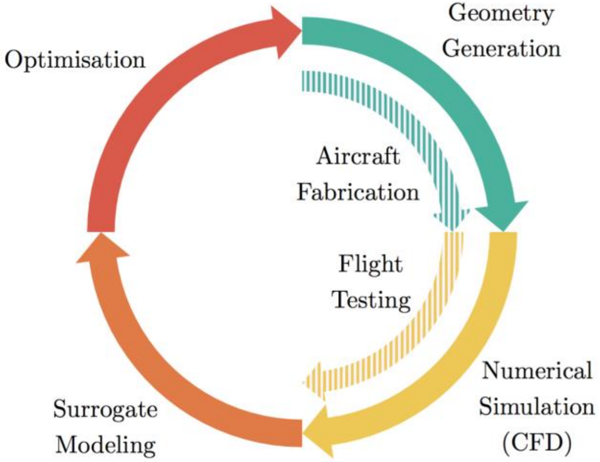
platform development





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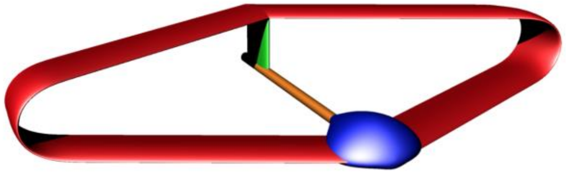

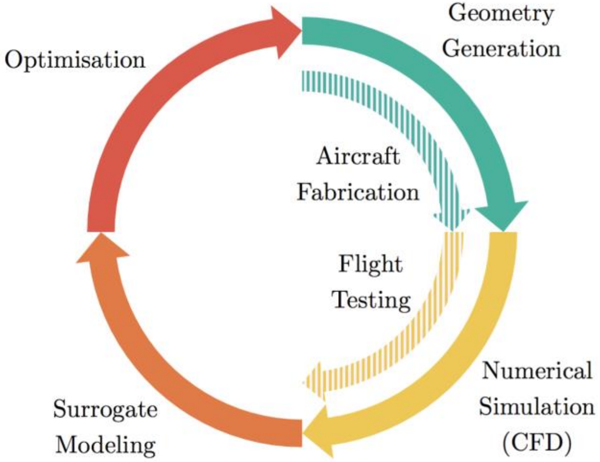

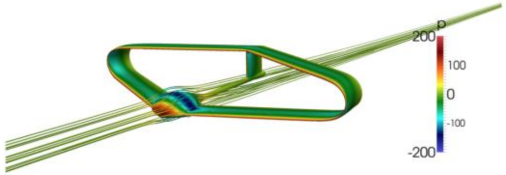

Disruptive ideas
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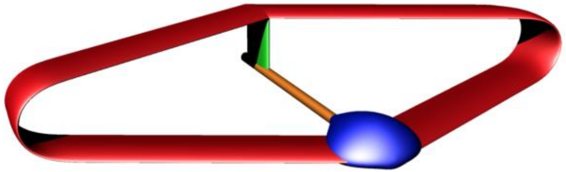

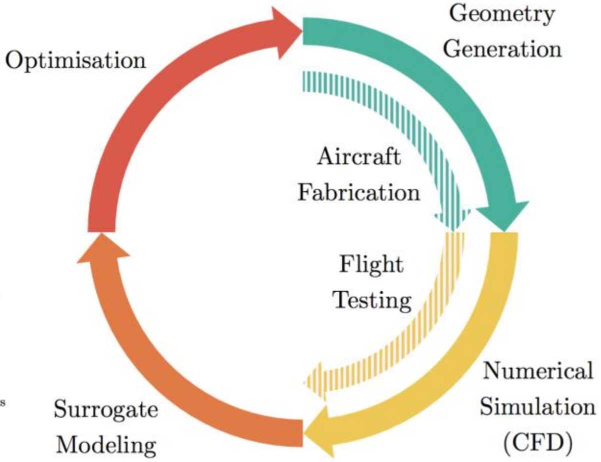

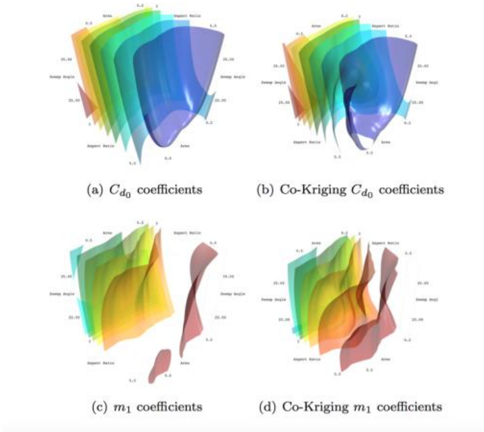

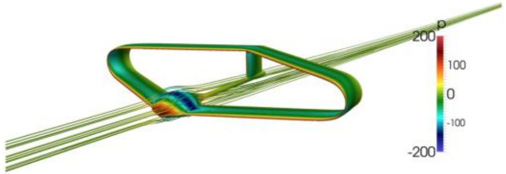

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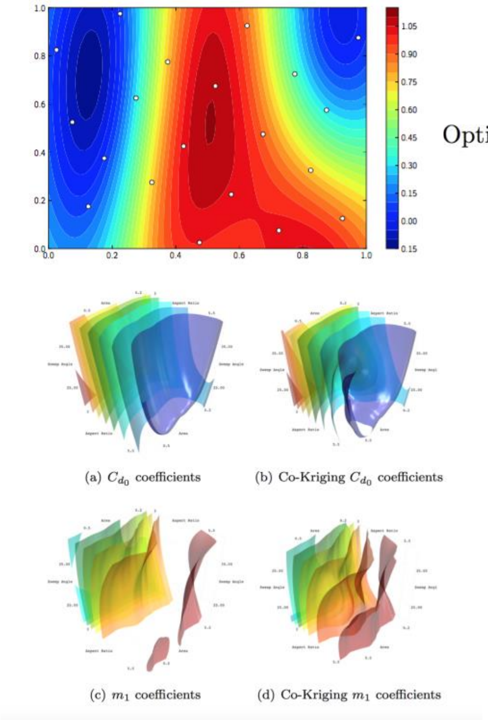
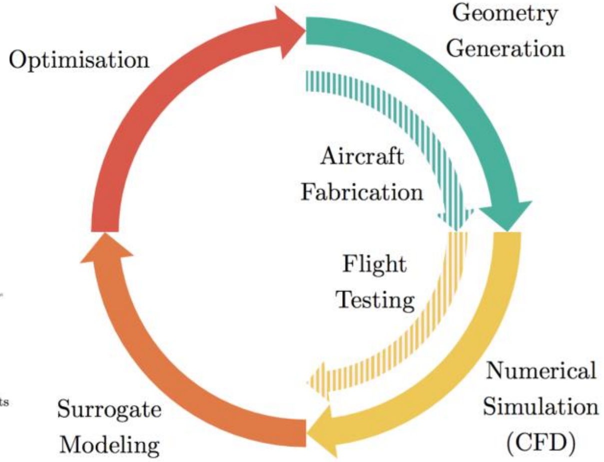
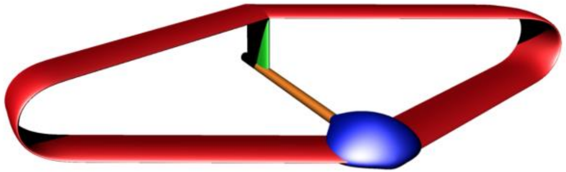
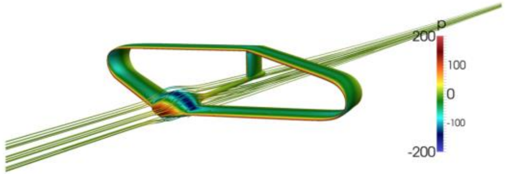
platform development









Disruptive ideas
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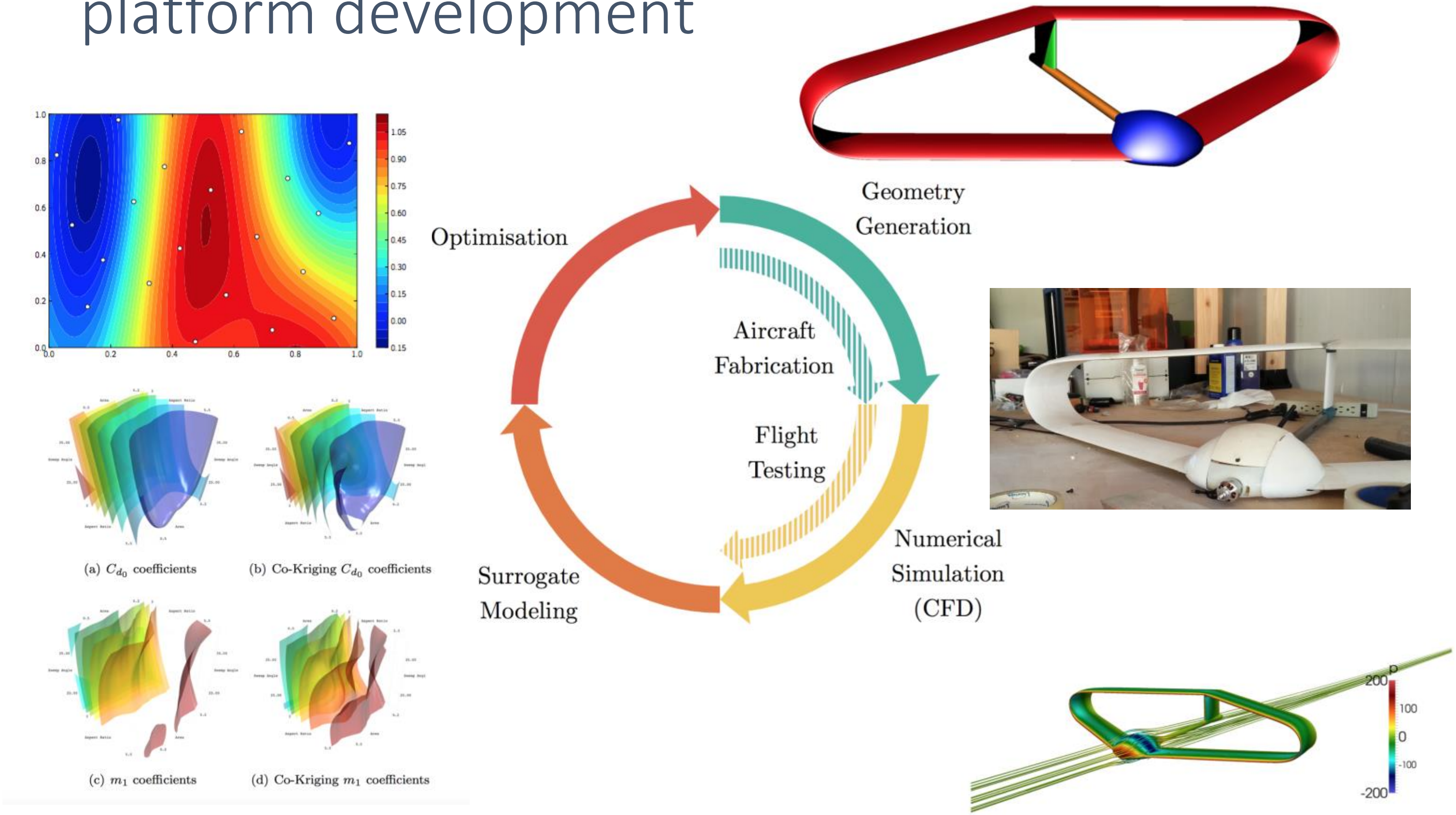

Disruptive ideas
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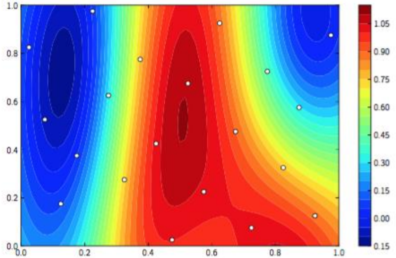
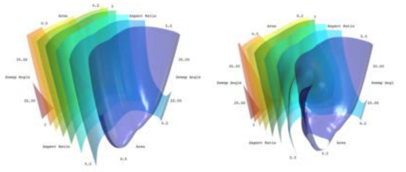
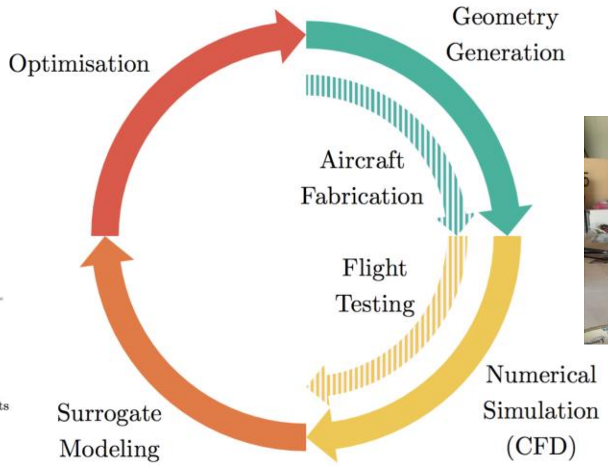
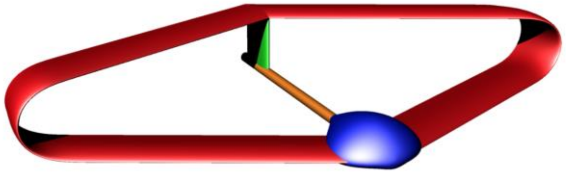


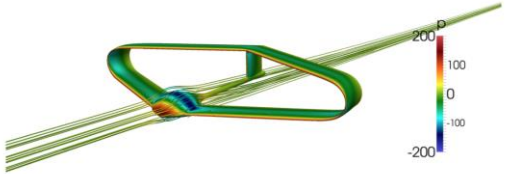


(a) C_{d_0} coefficients (b) Co-Kriging C_{d_0} coefficients

(c) m_1 coefficients (d) Co-Kriging m_1 coefficients







Afternoon Refreshments

30 Minute Break

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

Prof Matt Mowlem

OTE Group Head NOC

Introduction to the Sensors Capital Programme

Dr David Smeed

NOC

Science enabled by gliders: penguin ecology, hurricane prediction, ocean dead zones and other highlights from the EGO conference

Science enabled by gliders: penguin ecology, hurricane prediction, ocean dead zones and other highlights from the EGO conference

David Smeed
National Oceanography Centre, UK

Acknowledgement

Thank you to all the presenters from the EGO conference for permission to use their material in this presentation

http://www.ego-network.org

Outline

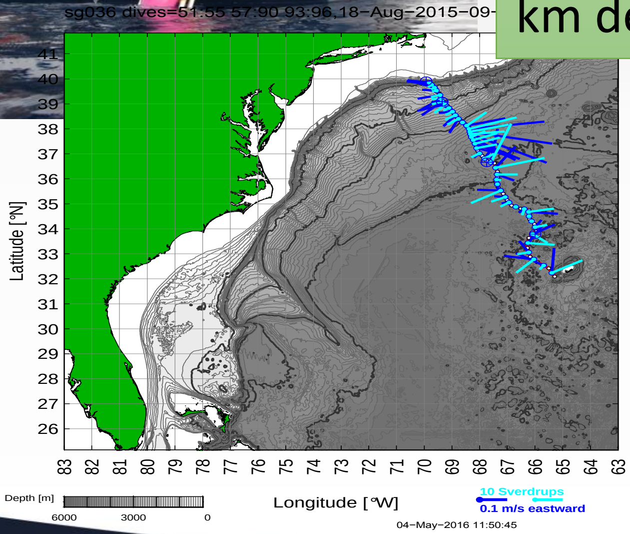
- The EGO network
- 7Th EGO conference on autonomous ocean gliders and their application
  - New developments in glider and sensor technology
  - Micro-scale to meso-scale physical processes observed with underwater gliders
  - Gliders in polar oceans: science and technological challenges
  - Observing biogeochemical processes with autonomous vehicles
  - Sampling strategies for single vehicles and networks
  - Glider operations: piloting, infrastructure, data management and legal issues
- Gliders in the Global Ocean Observing System
  - The Ocean Gliders steering team

The EGO network

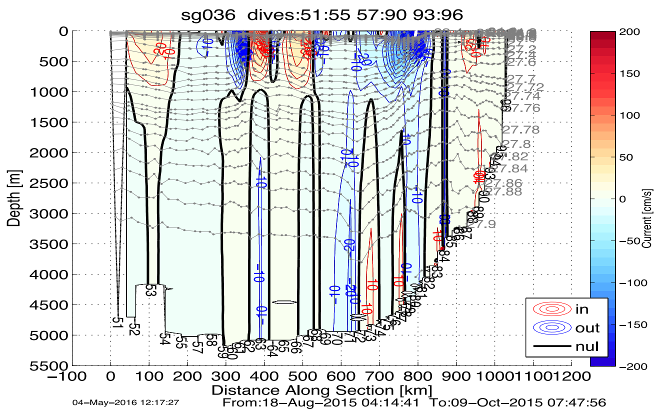
- Started as informal collaboration between European glider users
- Subsequently supported by two EU programs: EU-COST action and GROOM FP7 project
- Now a global network of scientists and engineers
- 150 attendees at the conference

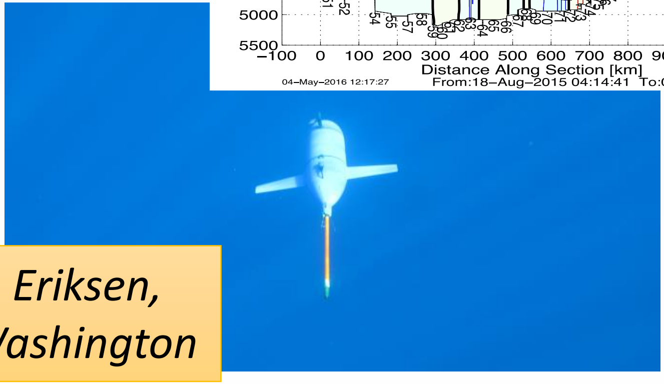
http://www.ego-network.org

New developments in glider and sensor technology – DeepGlider



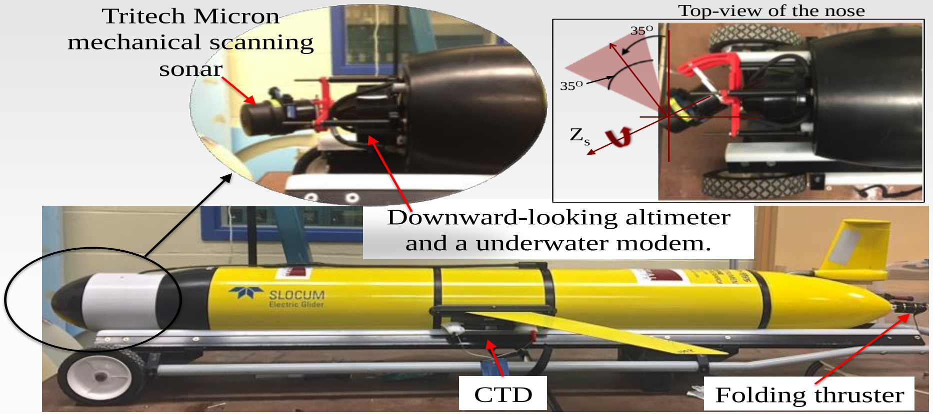
18 month / 10,000 km missions of continuous dives to 6 km depth @ 0.25 m/s



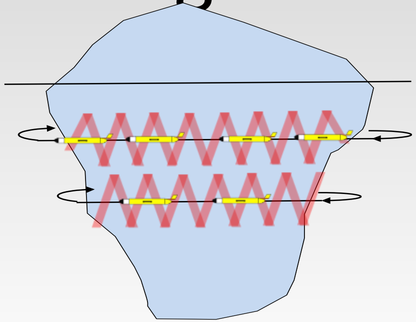


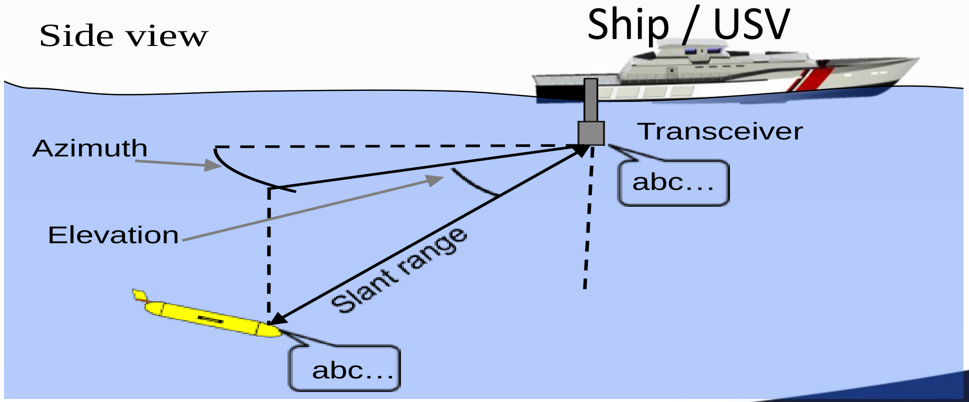
Charlie Eriksen, Univ Washington

New developments in glider and sensor technology - Surface vehicle assisted navigation



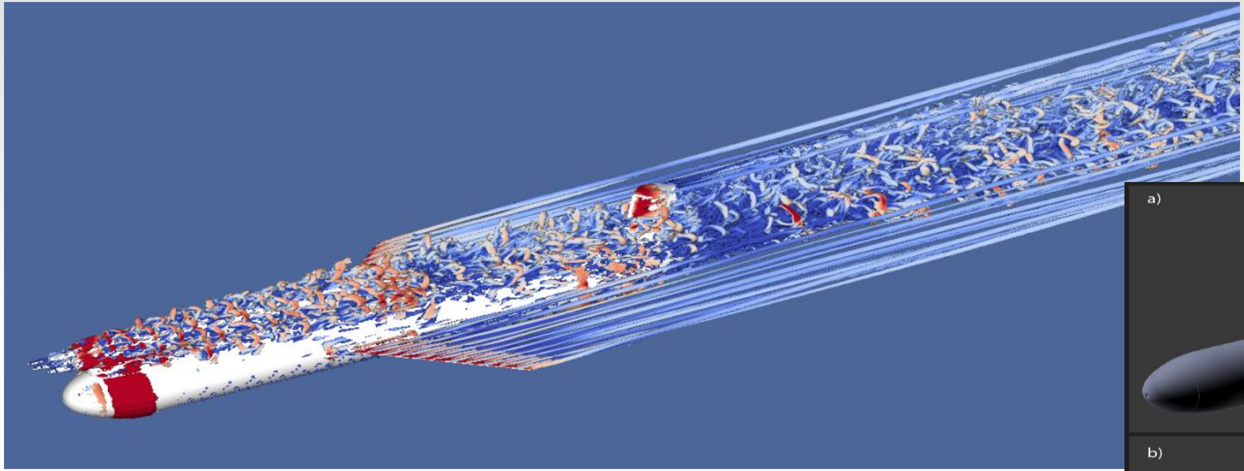
Objective:
To map and monitor icebergs



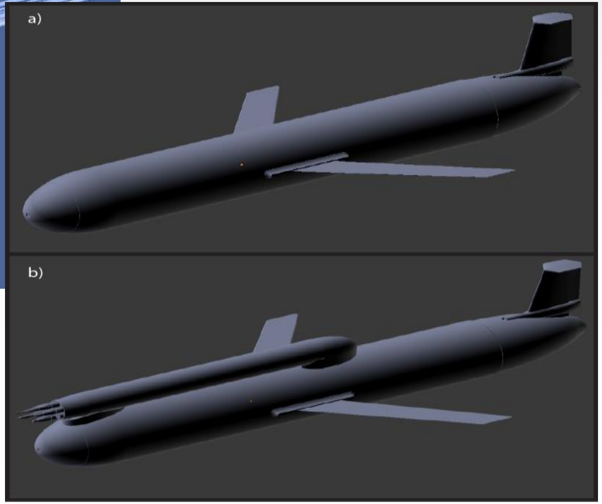


Mingxi Zhou, Brad deYoung
Ralf Bachmayer
Memorial University, Canada

New developments in glider and sensor technology – Modelling flow around gliders



Ben Moat, NOC

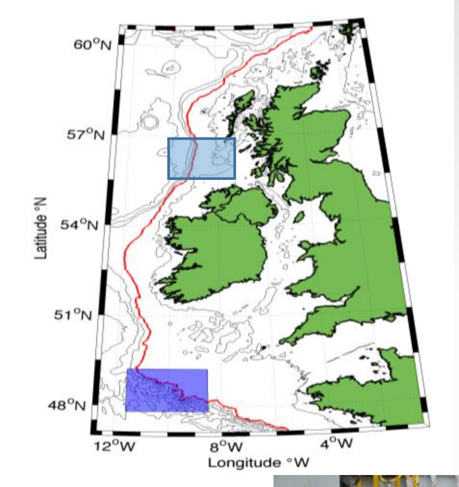


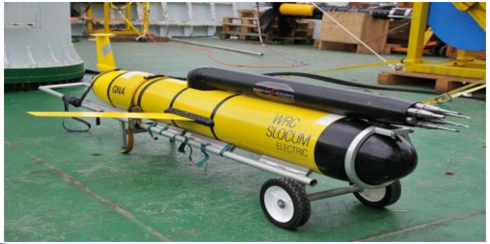
CFD simulations used to determine distortion of flow around glider and the impact upon sensor measurements

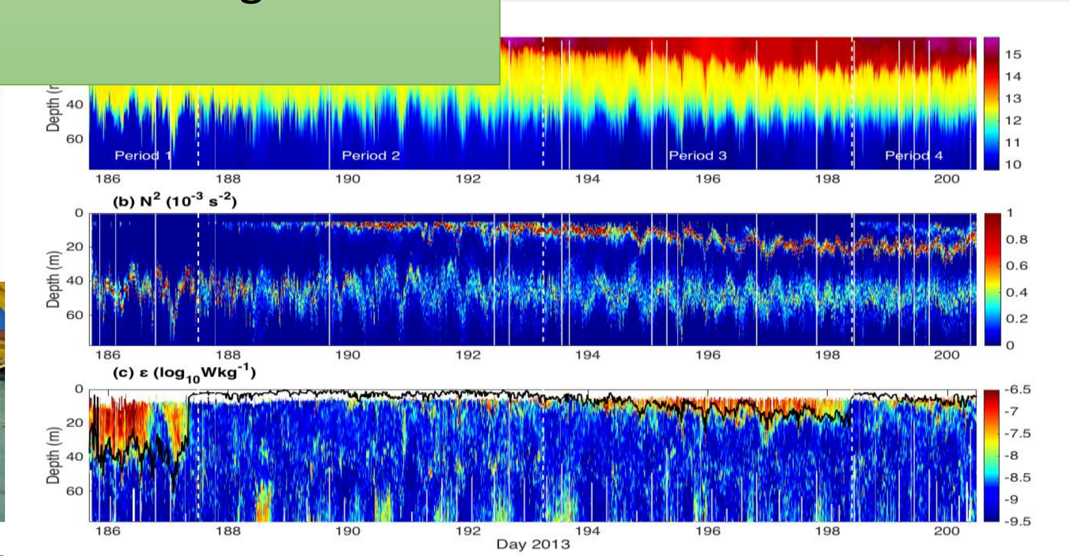
Micro-scale to meso-scale physical processes observed with underwater gliders - Ocean microstructure glider

Measuring turbulence down to scales of 1cm to understand mixing in the ocean

Matthew Palmer, NOC

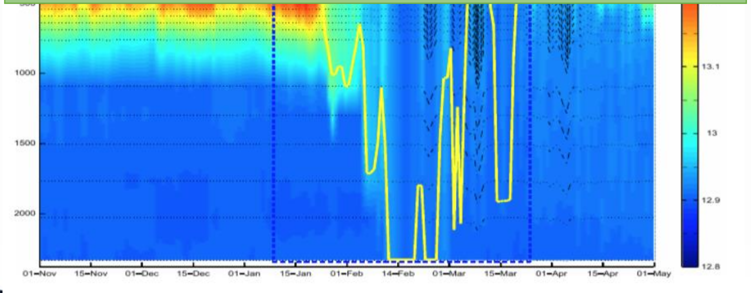


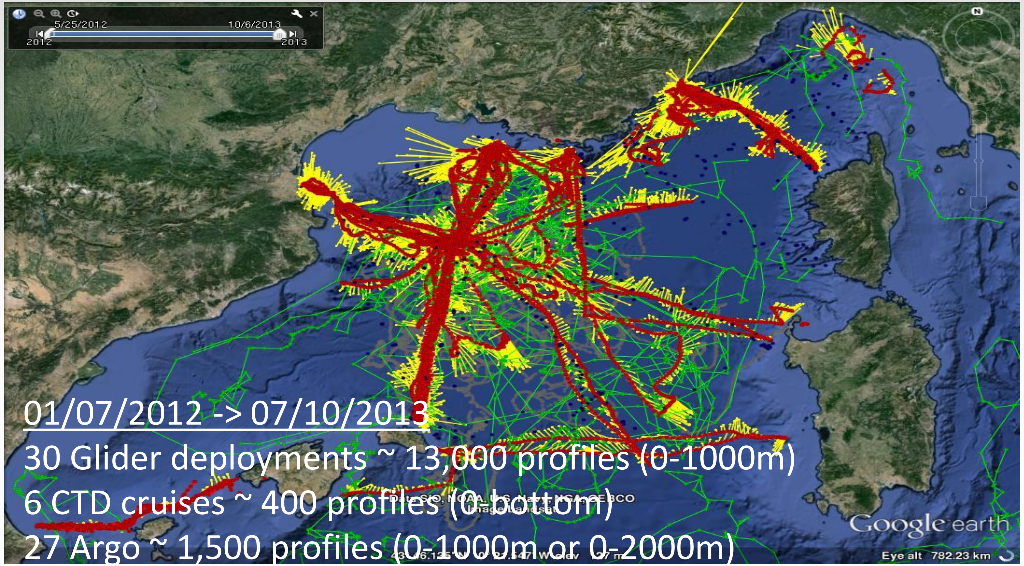




Micro-scale to meso-scale physical processes observed with underwater gliders - Deep convection events

Sustained glider measurements in combination with other platforms reveals details and long term variability of intermittent but climatically important deep convection





01/07/2012 -> 07/10/2013

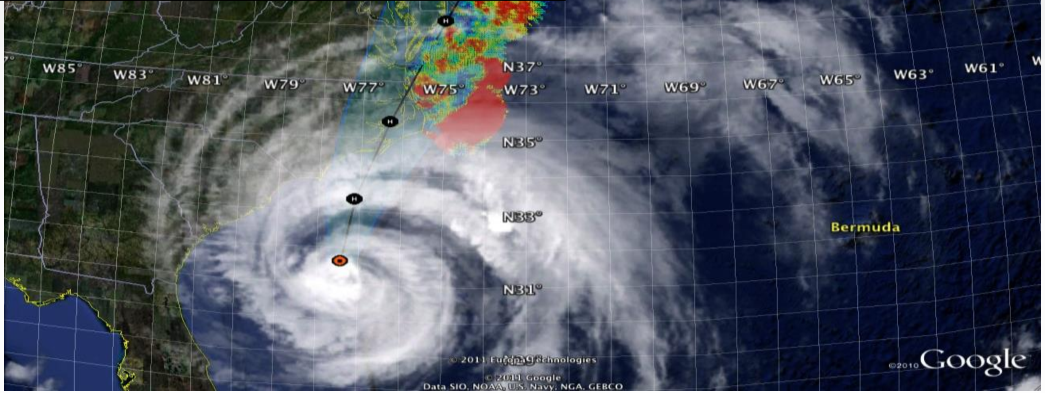
30 Glider deployments ~ 13,000 profiles (0-1000m)

6 CTD cruises ~ 400 profiles (0-bottom)

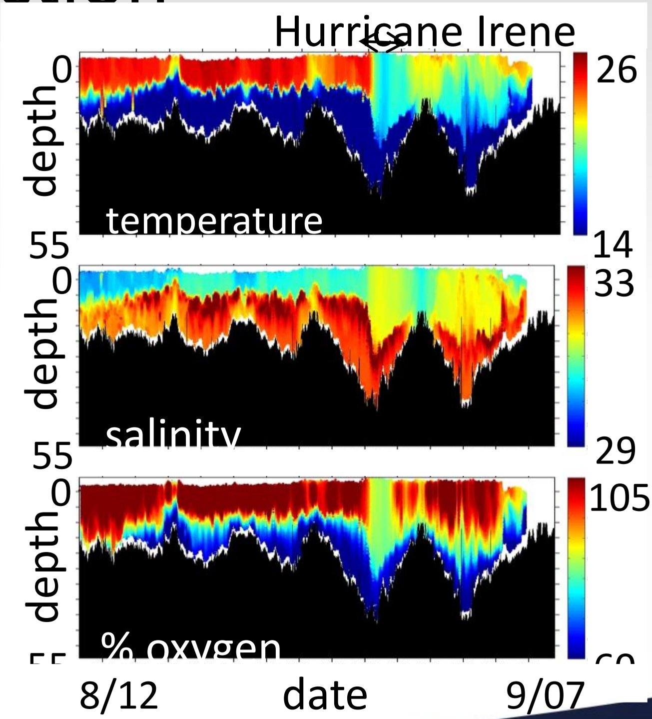
27 Argo ~ 1,500 profiles (0-1000m or 0-2000m)

Pierre Testor, Félix Margirier, UPMC, France

Micro-scale to meso-scale physical processes observed with underwater gliders
-- Hurricane prediction



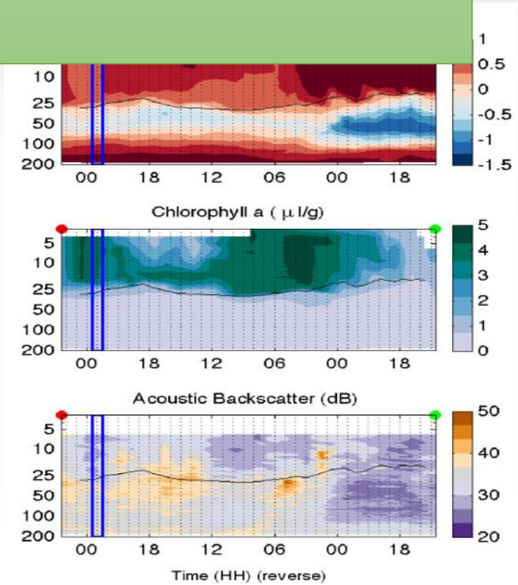
Scott Glenn,
Rutgers University

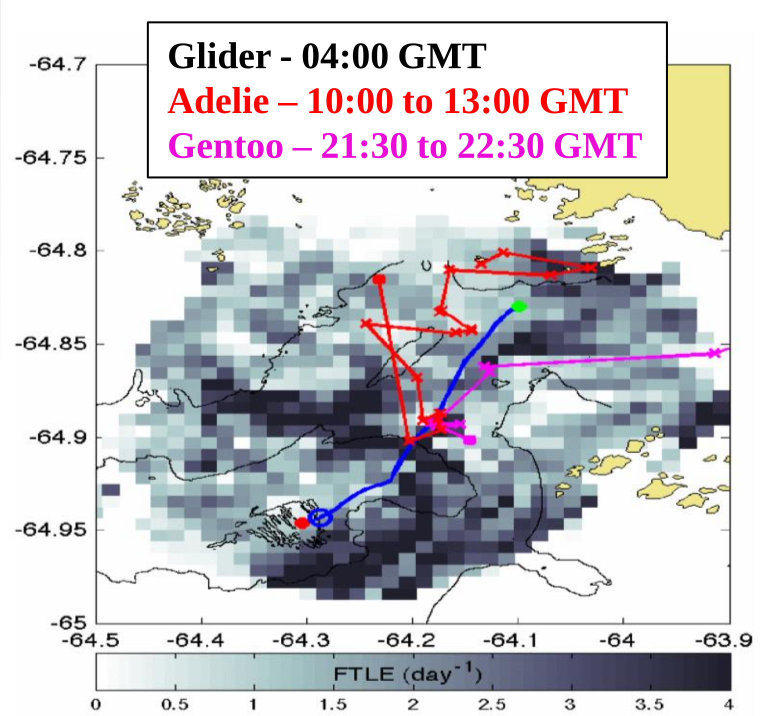


Observing in hostile environments to improve the prediction of hurricanes intensity

Gliders in polar oceans: science and technological challenges – Penguin ecology

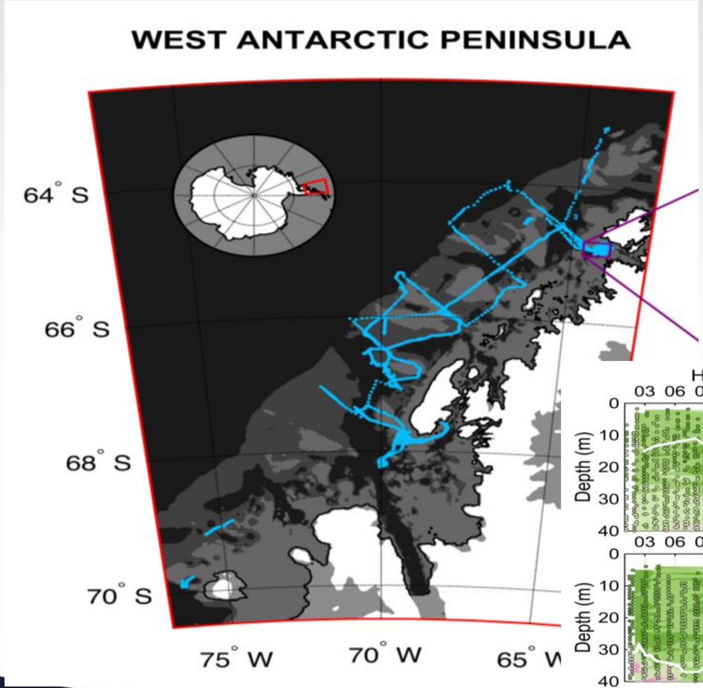
Tidal convergence zones concentrate phytoplankton, aggregate schools of krill and influence the behavior of penguins



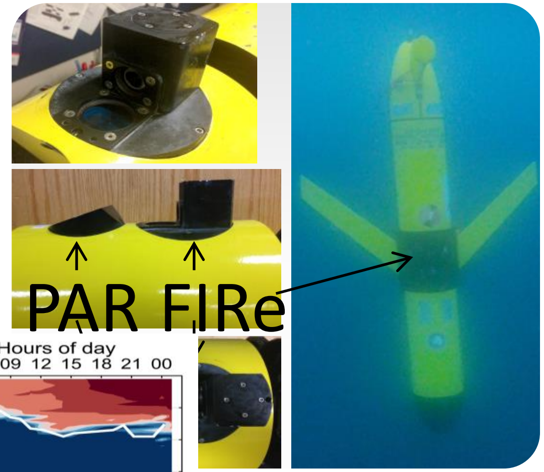


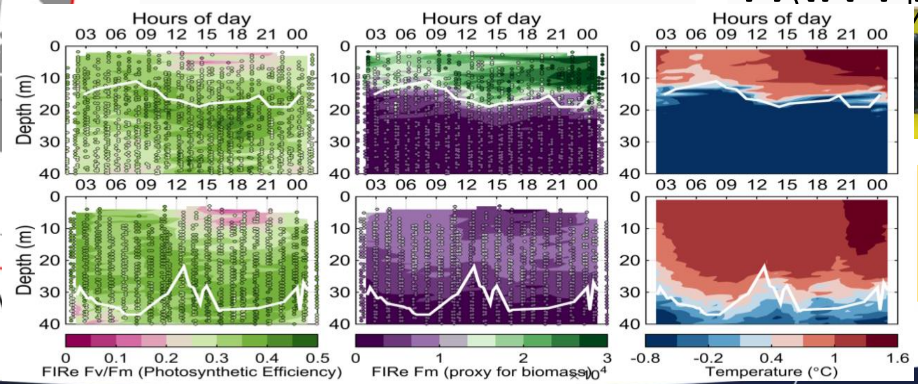
Josh Kohut,
Rutgers University

Observing biogeochemical processes with autonomous vehicles – Coupled physical and phytoplankton dynamics



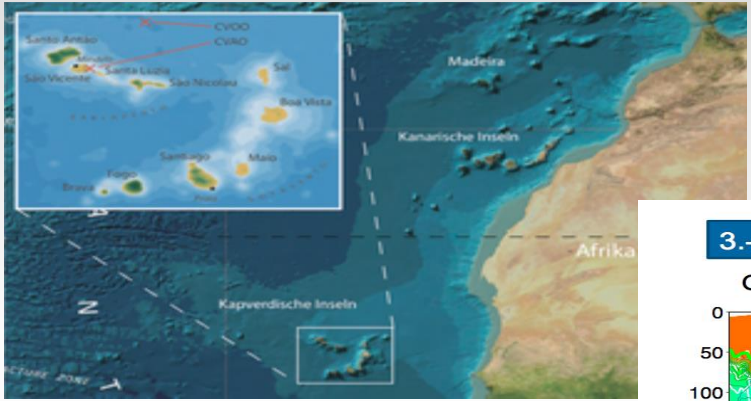
Fluorescence **I**nduction and **Re**laxation (**FIRe**) sensor on a glider maps phytoplankton physiological responses to physical forcing



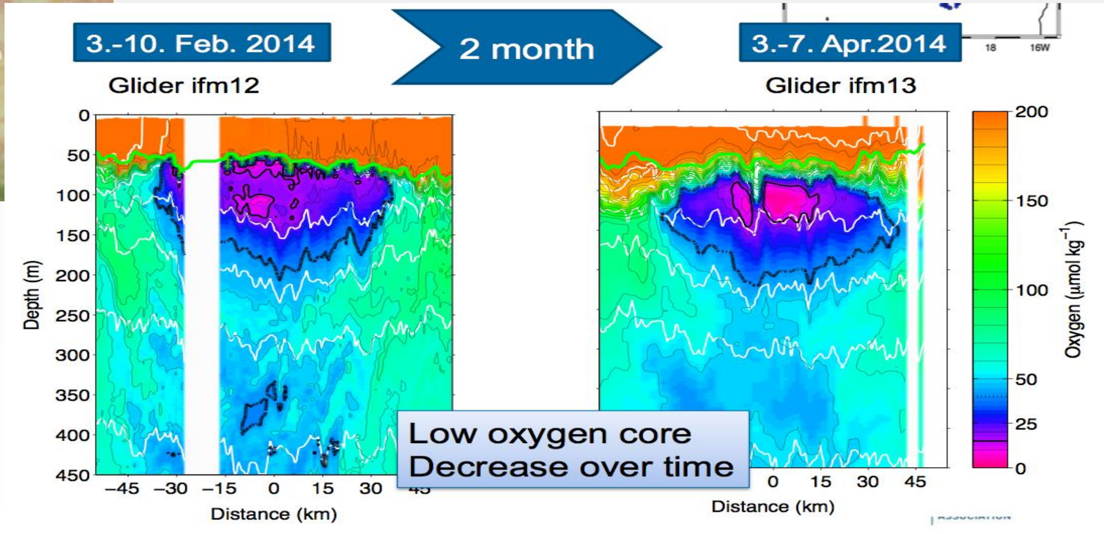


Filipa Carvalho, Rutgers university

Observing biogeochemical processes with autonomous vehicles – Ocean ‘dead zones’

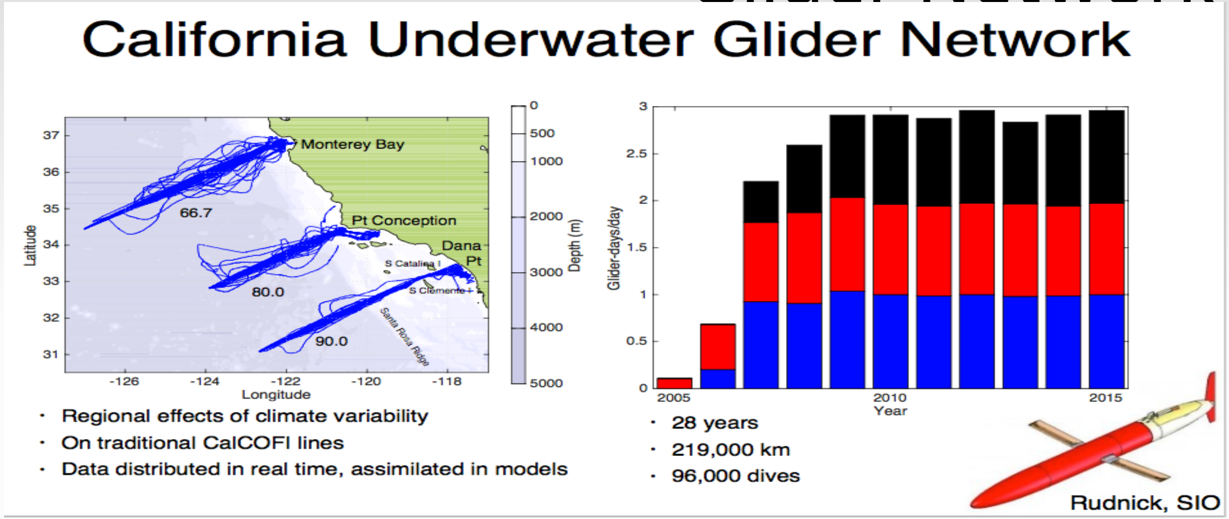


Oxygen depleted eddies and nitrate cycling in the tropical Atlantic

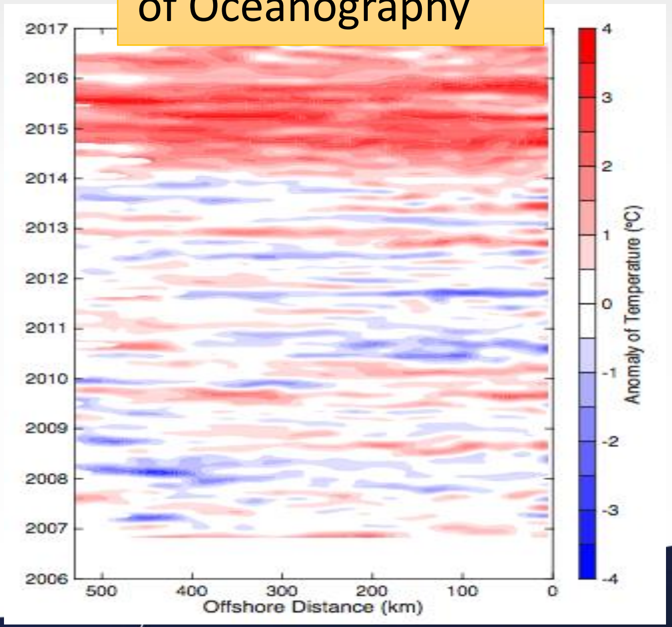


Johannes Karstensen, GEOMAR

The role of gliders in the Global Ocean Observing System - The California Underwater Glider Network



Daniel Rudnick, Scripps institution of Oceanography



10 years of continuous occupation allows identification of Climate anomalies, e.g. 2014-2015 warming, and 2015-2016 El Niño

Summary

- Novel science often involves multiple platforms
- Gliders enable:
  - New sampling strategies that compliment other platforms
  - Capability to monitor in hostile environments
  - Efficient platform for many sensors
- International coordination and adoption of common standards will enable gliders to make important contribution to regional and global observing systems

www.ego-network.org

Dr Maaten Furlong

NOC

Accessing the MARS Fleet

Prof Russ Wynn & Dr Maaten Furlong

NOC

NERC MAS Capital Programme: Introduction and Opportunities

Prof Russ Wynn

NOC

Close and Thank You