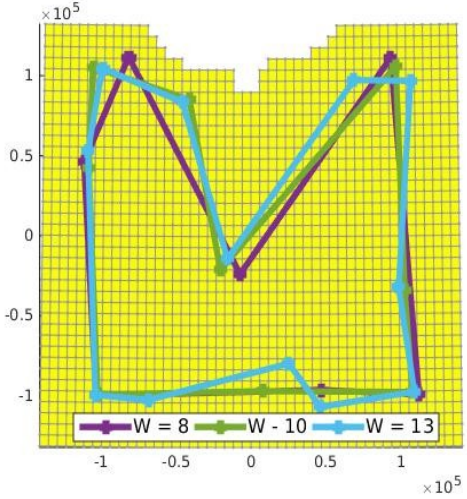
BRIDGES

BRINGING TOGETHER RESEARCH AND INDUSTRY FOR THE DEVELOPMENT OF GLIDER ENVIRONMENTAL SERVICES

γ-planner

A mission designing tool for optimal area coverage using fleets of underwater gliders



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Outline

1. **Introduction**
    a) Gliders and their applications
    b) Mission planning challenges
2. **γ-planner**
    a) Targets and purpose of the tool
    b) Problem formulation
    c) Graphic User Interface (GUI)
3. **Results**
    a) Case 1: Cyprus waters concept exploratory mission comparison
    b) Case 2: Cyprus-Crete actual mission comparison
4. **Conclusions and Future work**

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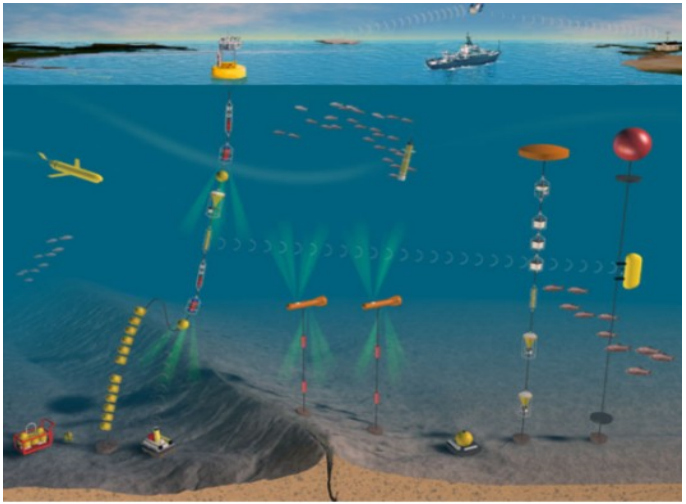
Gliders and their applications

- **Advantages of gliders**
  - Low logistics due to their longevity in the water
  - Low costs in comparison to other sampling instruments
  - Ability to use a wide variety of sensors

- **Applications**
  - Commercial services/projects
  - Oil and gas
  - Sea mining
  - Archeology
  - Operational data assimilation forecasting models
  - Environmental studies



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Coverage missions

- Why are they useful?
  - High efficiency for every mission
  - The best method to derive a general picture of an area of interest when having no prior knowledge

What is the problem with planning a mission?

- Coverage based missions targets
  - Optimally well distributed sampling locations
  - Mission time constraints
  - Use of all observation tools to their full potential

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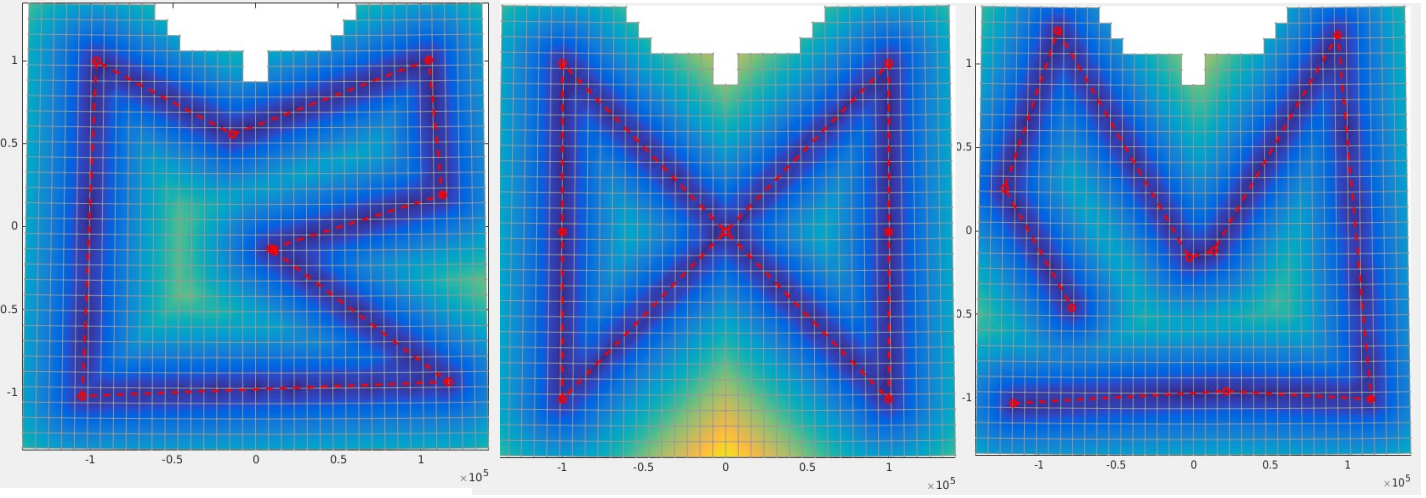
Planning a mission

- Which mission offers the best coverage?
- Same mission length/time for all cases



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What can γ-planner offer?

- Coverage based optimization
  - Provide a near optimal mission plan subject to user constraints
- Variety of missions according to user requirements
  - Closed trajectories
  - User defined collection/deployment points
  - Mission length adjustment
- Multiple gliders and option to add buoys
- Paths planned based on waypoints instead of angles
  - Offers flexibility compared to equidistant waypoint approach
  - Increased computational cost depending on mission
- 1st phase as required in BRIDGES guidelines
  - Exploratory missions, i.e no currents taken into consideration

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Geometric objective function

- Problem formulation
  - Set of sampling points s = {s_1,s_2, … , s_M}
  - Set of non-sampling points g = {g_1,g_2, … , g_N}

- Coverage function is defined based on the distance of the sampling and non-sampling points, i.e

$$C = \Sigma_i^N min(\underline{d}(g_i, s))$$

- Constraints used
  - Mission time/length constraints

$$\max(\Sigma_{i=1}^{M-1} \underline{d}(s_i^j, s_{i+1}^j)) - m_l = 0$$

  - Mission optimization constraints
    - Well separated paths between multiple gliders
    - Path of every glider without nodes

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γ-planner GUI

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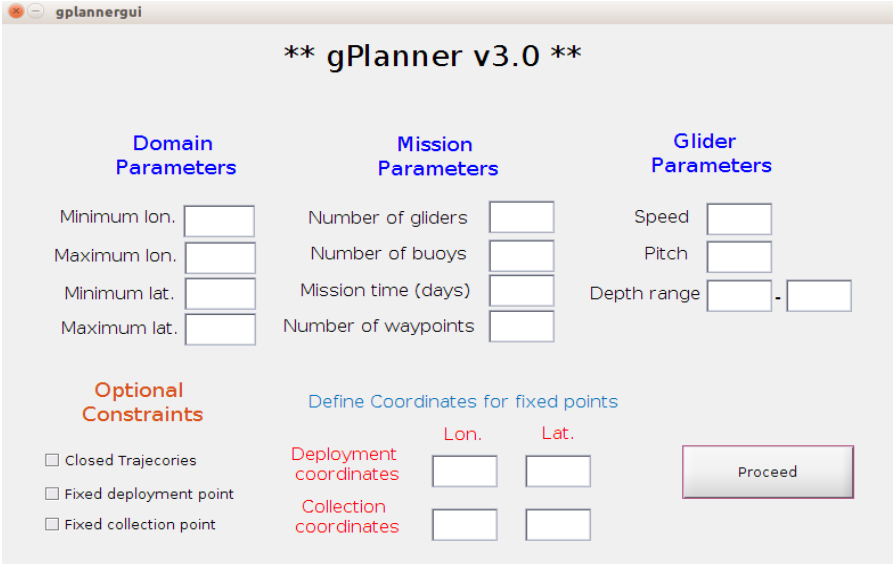
User Inputs

Parameters

- Domain
- Mission
- Glider

Constraints

- Closed Trajectories
- Fixed deployment and/or collection point.



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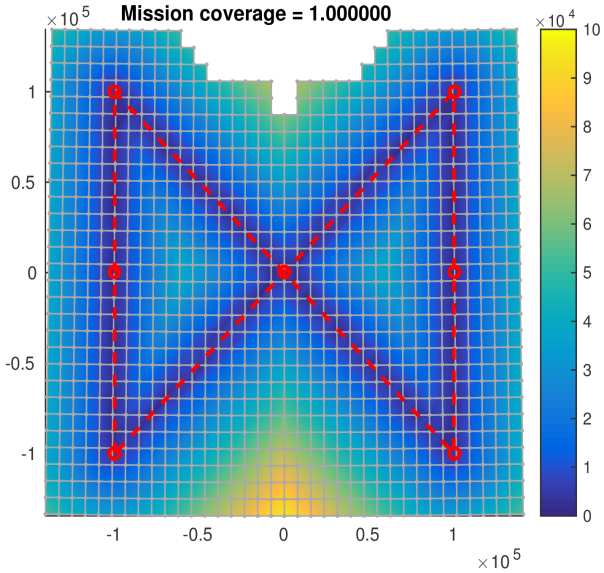
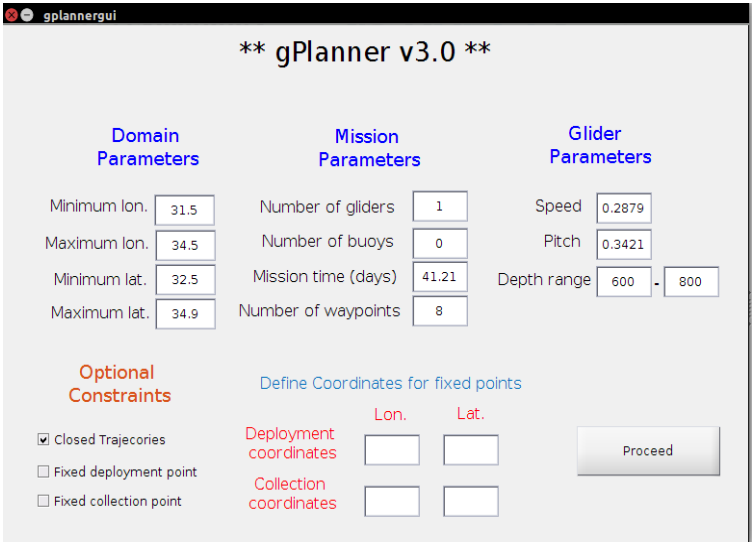
1st case: Cyprus waters exploratory mission

Coverage evaluation of "butterfly" mission using 8 waypoints



γ-planner GUI input

- 8 waypoints
- Closed trajectories



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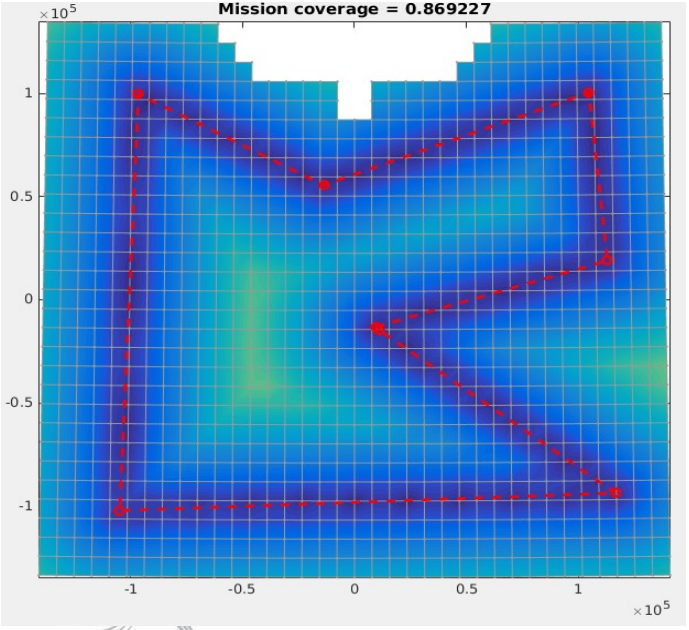
1st case: Cyprus waters exploratory mission

γ-planner 8 waypoints optimization (41 days mission)

- 13.1% increased coverage



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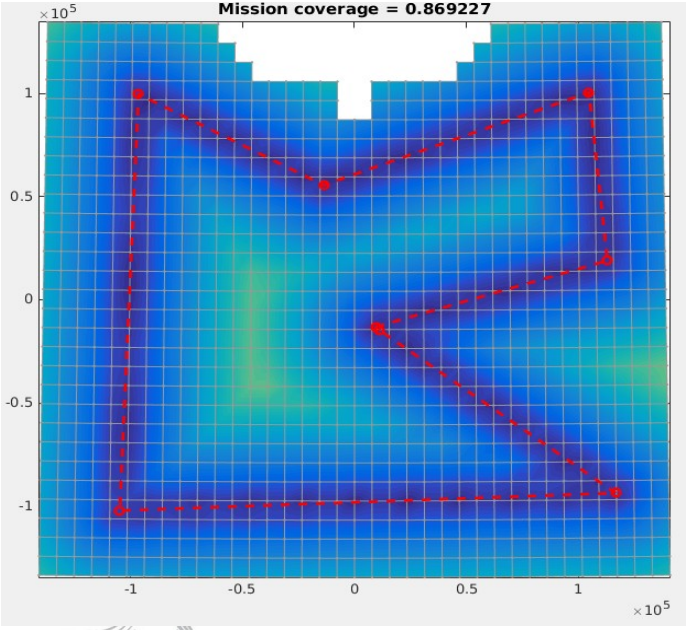

γ-planner 3 gliders and 3 buoys optimization (8 days)

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1st case: Cyprus waters exploratory mission

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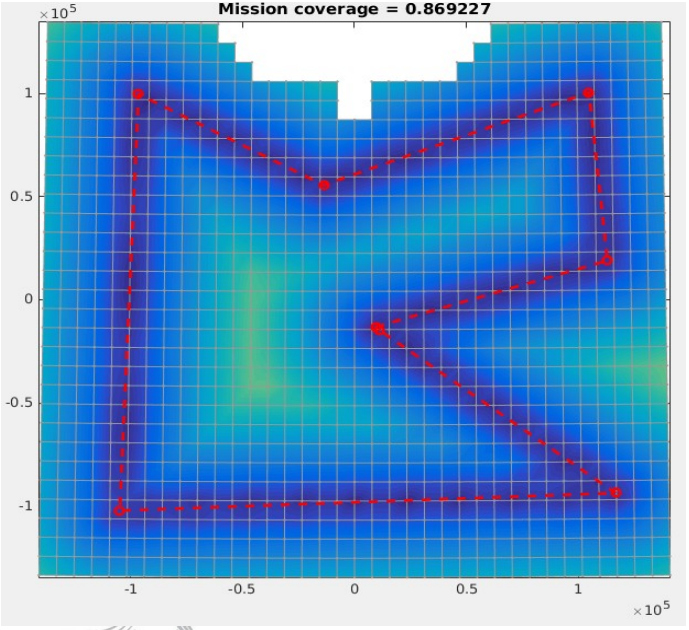
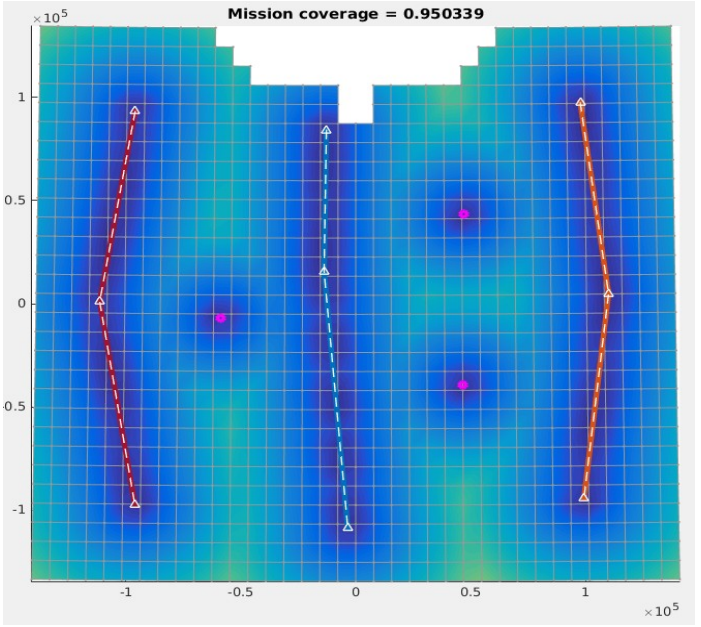


γ-planner 3 gliders and 3 buoys optimization (8 days)

- 5% increased coverage
- 80% mission time reduction



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Case 2: Cyprus-Crete actual mission comparison

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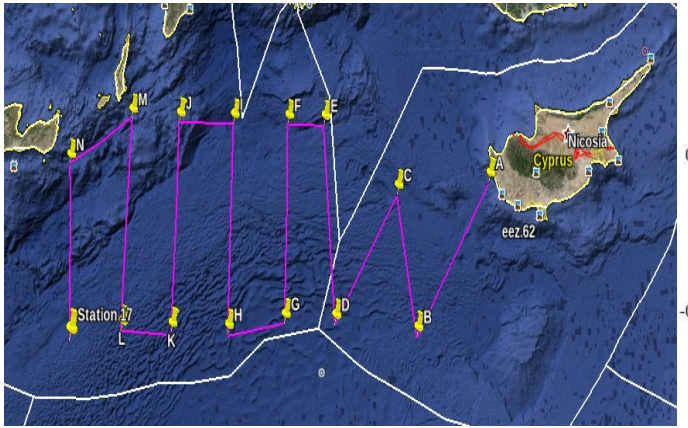
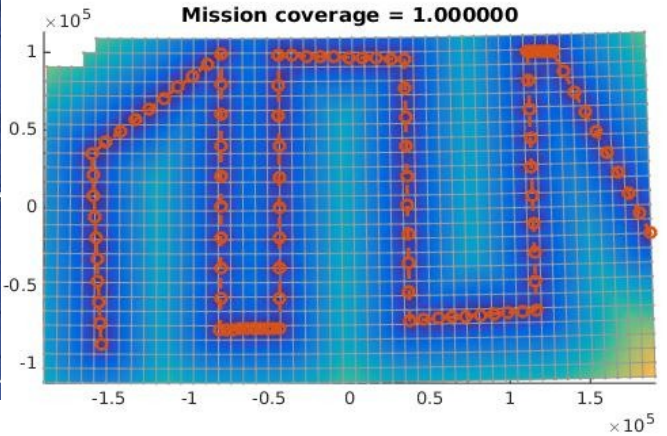
Initial exploratory glider mission

- Cyprus to Crete
- Truncated section to increase coverage

Coverage evaluation

- Mission constraints
  - Fixed deployment and collection points
  - Original mission time/length





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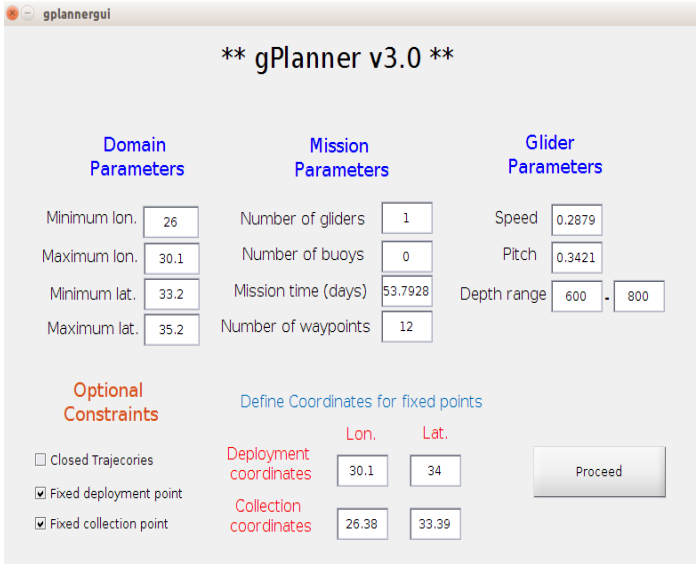
Case 2: Cyprus-Crete actual mission comparison

GUI inputs

- Collection/Deployment waypoints defined



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Case 2: Cyprus-Crete actual mission comparison

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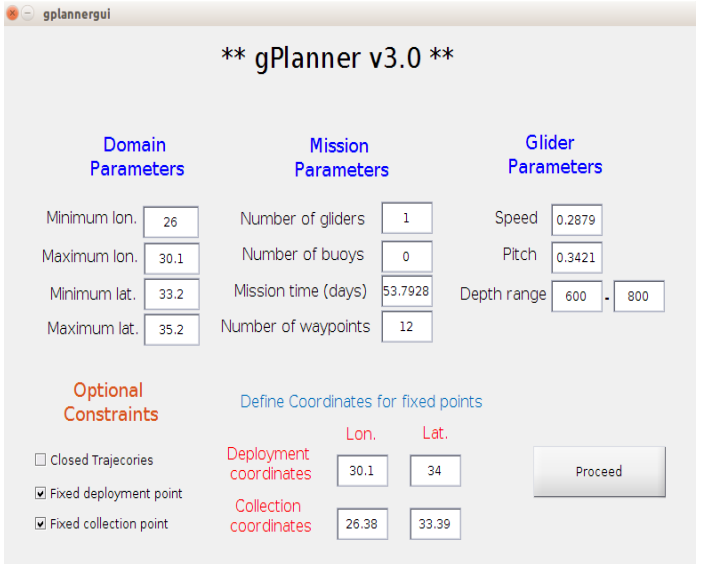
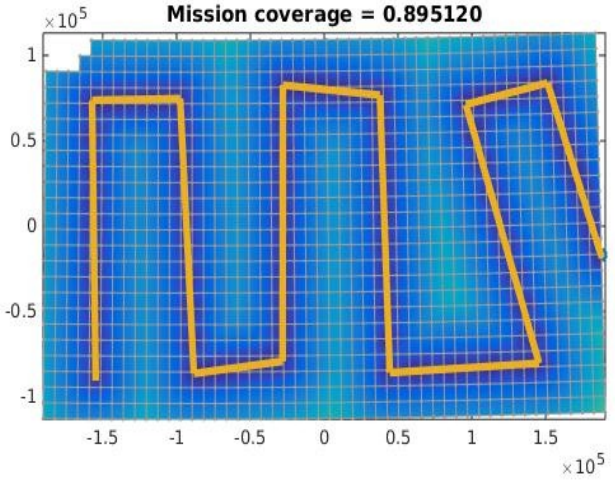
GUI inputs

- Collection/Deployment waypoints defined



γ-planner near optimal outcome

- Same number of waypoints
- Same mission time
- Increased coverage by 10.5%



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Conclusions

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Conclusions:

- Area coverage is one of the most important targets of a glider mission and has to be well-defined and optimized

- γ-planner
  - near optimal exploratory missions based on coverage
  - considering a wide variety of constraints
  - various observational instruments
  - reduce logistic costs
  - improve mission's efficiency
  - bring mission-planning closer to a wider spectrum of scientists

Future Work:

- Take ocean currents into consideration

- Develop an optimal coverage-based global observational network
  - Based on each country's equipment and EEZ

THANK YOU

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