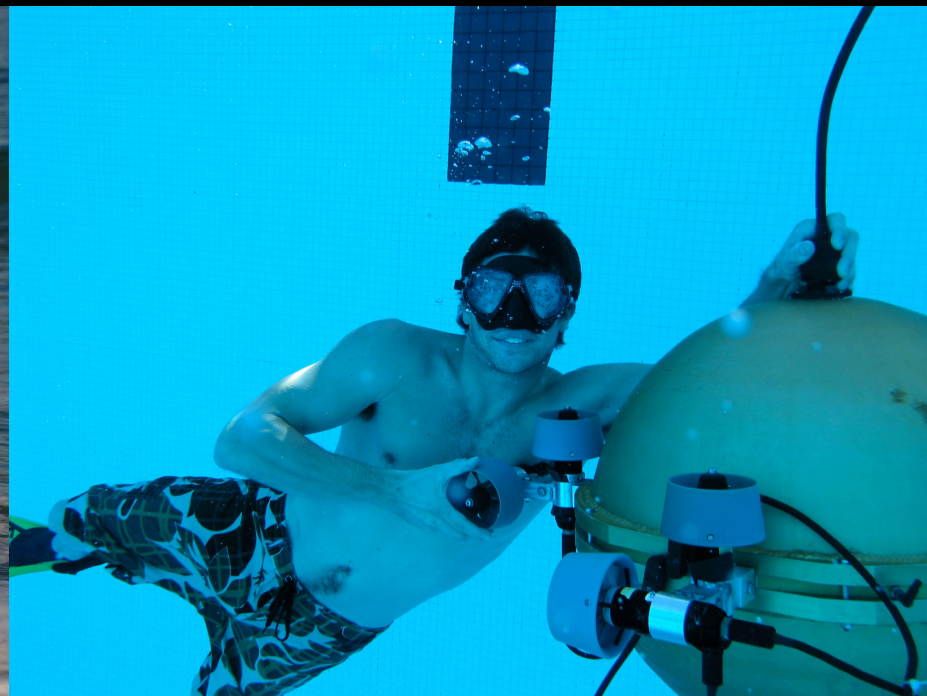


MRRSS

Marine Robotics Research Summer School

AUV Data Analysis



MRRSS – 2016

Ryan N. Smith

Topics

- Data Types
- Data Format
- On Board/Off Board
- Data Transmission
- Time Delays
- Use in Deliberation
- Modeling

Data Types

- Point measurement
 - Data at a single point in space and time
 - Rapid collection
 - Small storage size
- Range measurement
 - Data covering a large spatial region
 - Dense dataset
 - Large storage size

Data Formats

- ASCII text
 - CSV
 - Fixed-width
- Binary
- Images
- Video
- Point Cloud

[illegible]

Bag File (ROS)

```
chu-chu@play: ~ x /home/chu-ch... x chu-chu@play: ~ x chu-chu@play... x chu-chu@play: ~ x chu-chu@play: ~ x chu-chu@play: ~ x chu-chu@play... x chu-chu@play... x
chu-chu@play:~/catkin_ws/src/rpg_monocular_pose_estimator/monocular_pose_estimator$ rostopic hz /camera/image_raw
subscribed to [/camera/image_raw]
average rate: 29.899
  min: 0.027s max: 0.040s std dev: 0.00237s window: 29
average rate: 29.940
  min: 0.027s max: 0.040s std dev: 0.00219s window: 59
average rate: 29.968
  min: 0.027s max: 0.042s std dev: 0.00273s window: 89
average rate: 29.976
  min: 0.027s max: 0.042s std dev: 0.00271s window: 119
average rate: 29.992
  min: 0.027s max: 0.042s std dev: 0.00274s window: 148
^Caverage rate: 29.960
  min: 0.026s max: 0.042s std dev: 0.00289s window: 166
chu-chu@play:~/catkin_ws/src/rpg_monocular_pose_estimator/monocular_pose_estimator$ rostopic hz /monocular_pose_estimator/image_with_detections
subscribed to [/monocular_pose_estimator/image_with_detections]
average rate: 0.259
  min: 0.736s max: 6.986s std dev: 3.12526s window: 3
no new messages
no new messages
average rate: 0.303
  min: 0.736s max: 6.986s std dev: 2.67027s window: 4
no new messages
no new messages
no new messages
no new messages
no new messages
no new messages
average rate: 0.338
  min: 0.097s max: 7.303s std dev: 3.03129s window: 7
no new messages
no new messages
no new messages
no new messages
no new messages
no new messages
average rate: 0.290
  min: 0.097s max: 7.303s std dev: 3.05029s window: 8
```

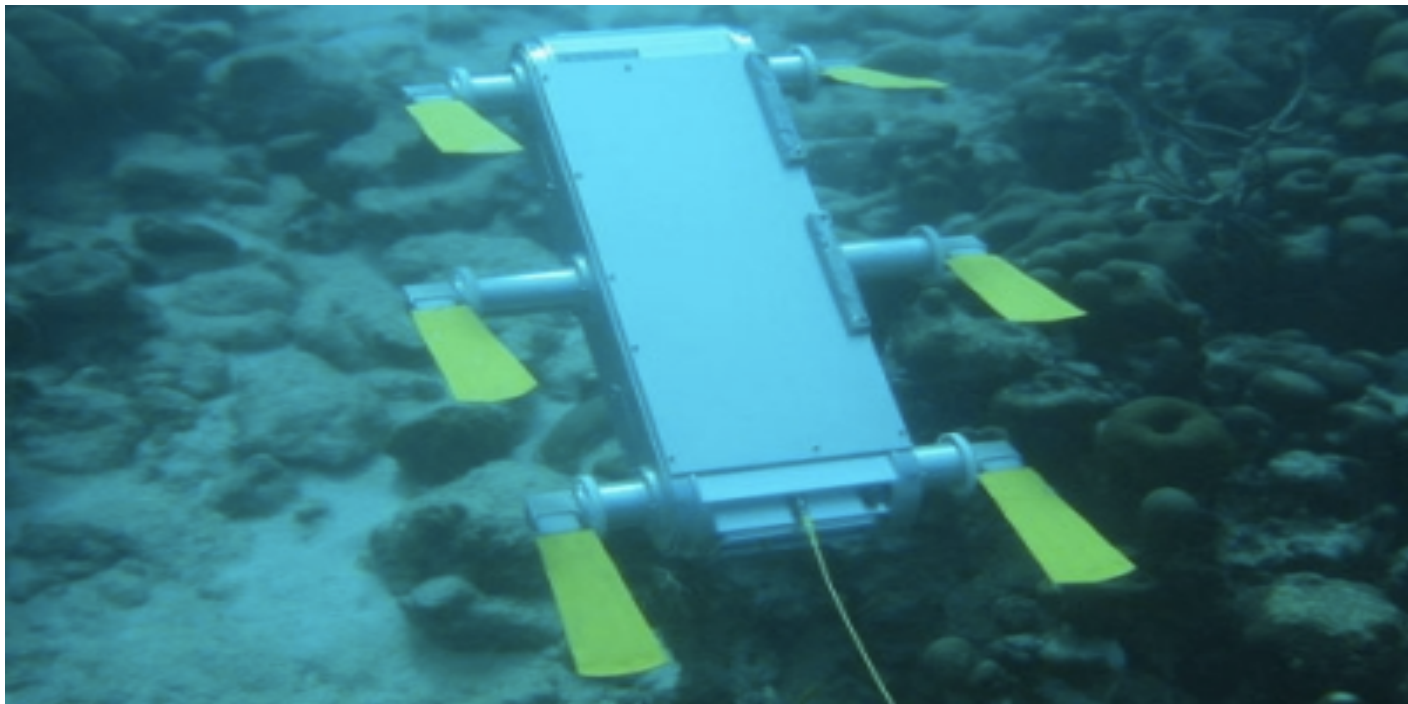

Marine Robotics Summer School

[illegible][illegible]

EcoMapper Log File

```
Latitude;Longitude;Time;Date;Number of Sats;GPS Speed (Kn);GPS
True Heading;GPS Magnetic Variation;HDOP;C Magnetic Heading;C
True Heading;Pitch Angle;Roll Angle;C Inside Temp (c);DFS Depth
(m);DTB Height (m);Total Water Column (m);Batt Percent;Power
Watts;Watt-Hours;Batt Volts;Batt Ampers;Batt State;Time to
Empty;Current Step;Dist To Next (m);Next Speed (kn);Vehicle Speed
(kn);Motor Speed CMD;Next Heading;Next Long;Next Lat;Next Depth
(m);Depth Goal (m);Vehicle State;Error State;Distance to Track
(m);Fin Pitch R;Fin Pitch L;Pitch Goal;Fin Yaw T;Fin Yaw B;Yaw
Goal;Fin Roll;DVL-Depth (m);DVL -Altitude (m);DVL -Water Column
(m);DVL-FixType;DVL-FixQuality;DVL-Temperature;Conductivity
(mmhos/cm);Temperature (c);Salinity (ppt);Sound Speed (m/s);Date
m/d/y ;Time hh:mm:ss;Temp C;SpCond mS/cm;Sal ppt;Depth
feet;pH;pH mV;Turbid+ NTU;Chl ug/L;BGA-PC cells/mL;ODOsat %;ODO
mg/L;Battery volts;
37.290932;-
107.844191;10:14:04.55;6/21/2016;11;0.074;123.91;9.46915788676373
;0.83;26.3;38.6;3.01;-4;19.1;.01;1.77;1.78;91;20;550.8;16.1;-
1.2;D;1822.4;0;2.978;2;0.02;128;200.27;-
107.84420266;37.29090638;0;0;1;N;2.524606;76;76;11;250;250;158.56
77;0;9999.99;1.80;1.927;2;9;18.3;0;18.2000007629395;0.1;1476.7940
1;06/21/16;10:11:20;17.53;0.203;0.10;-7.438;8.25;-71.7;4.2;-2.0;-
3103;86.3;8.25;12.5;
37.2909311666667;-
107.844192;10:14:05.55;6/21/2016;11;0.063;123.91;9.46915788676373
;0.83;26;38.29;2.91;-4;19.1;.01;1.77;1.78;91;20;550.8;16.1;-
1.2;D;1822.4;0;3.031;2;0.02;128;199.9;-
107.84420266;37.29090638;0;0;1;N;2.558844;74;74;11;250;250;158.75
82;0;9999.99;1.80;1.927;2;9;18.2;0;18.2999992370605;0.1;1477.1161
7;06/21/16;10:11:21;17.53;0.203;0.10;-7.442;8.26;-72.7;4.6;-1.2;-
```


Image File



On-Board vs. Off-Board

- Data transmission
- Time delays
- Use on deliberation
- Modeling

Data Transmission

Types:

- Acoustic
- Satellite
- Wi-Fi/Radio

Limitations:

- Distance
- Bandwidth/Transmission speed
- **Cost**

Time Delays

Acoustic

- ▣ up to 80 kbits per second

■ Satellite

- ▣ ~10 Megabits per second

■ Wi-Fi/Radio

- ▣ ~1 Gigabits per second

Time Delays

Limitations:

- Acoustic
 - 2 km
- Wi-Fi/Radio
 - Line of sight
 - 20 km

Use in Deliberation

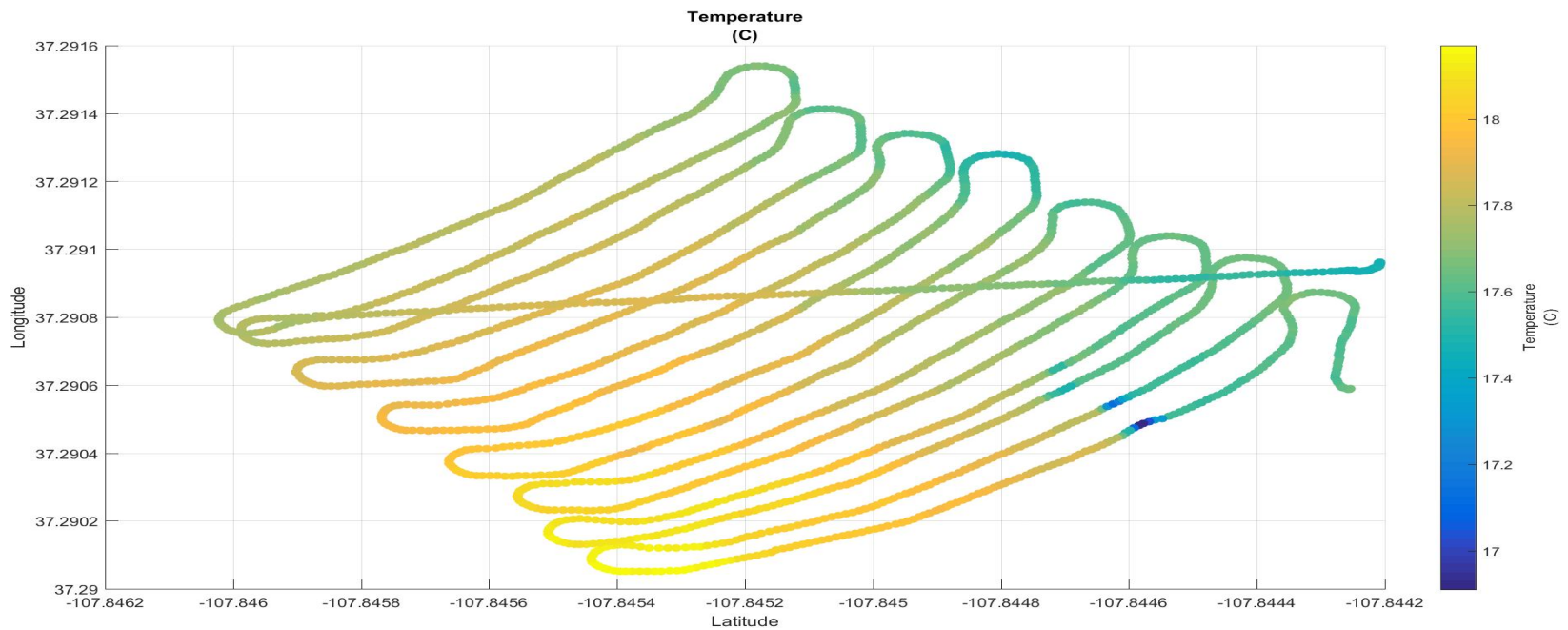
Data processing

- On Board
 - 2-3 second delay
- Off Board
 - Days to weeks in some cases

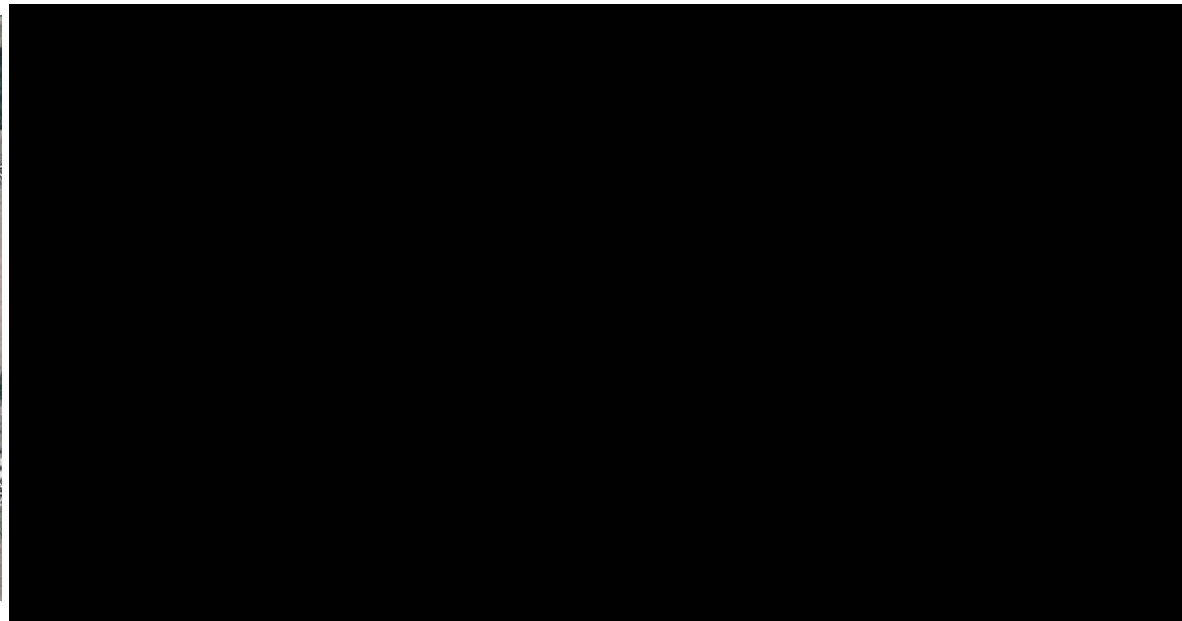
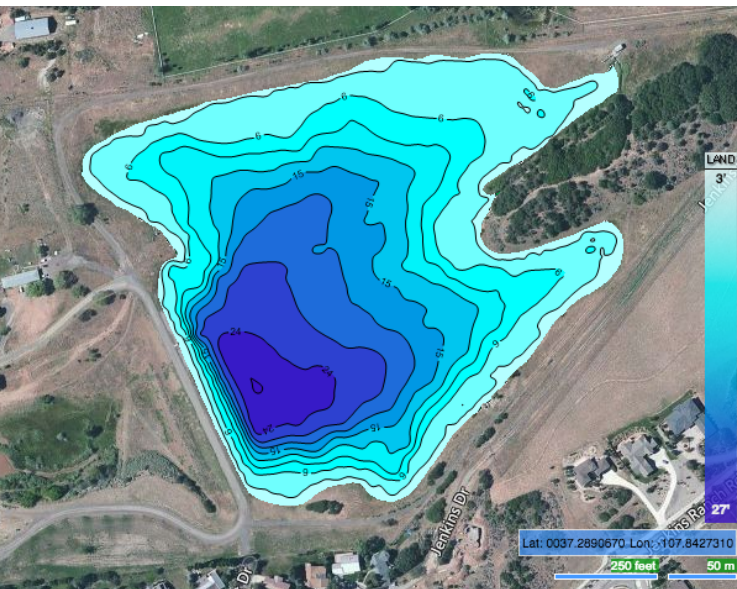
Data Processing

- Point Data
- Range Data
 - Visualization
 - Usability
 - Complexity

Data Visualization



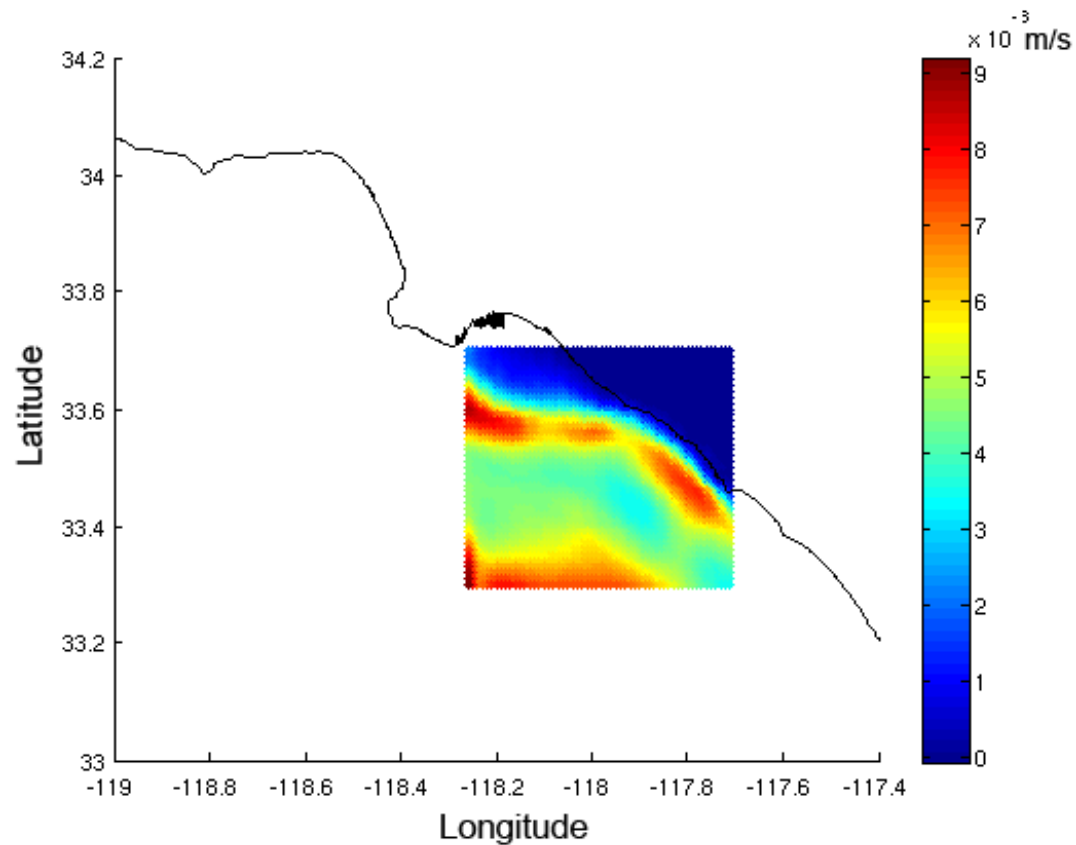
Final Products



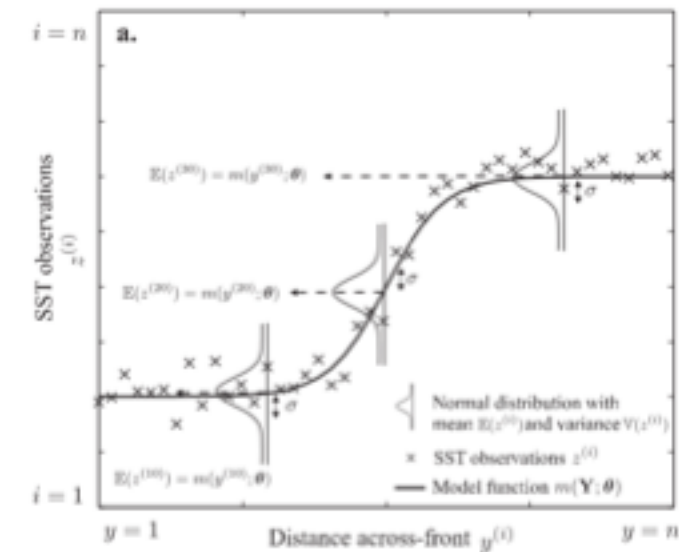
Modeling

- Use of data
- Inform future sampling
- Predict where to be and what to sample

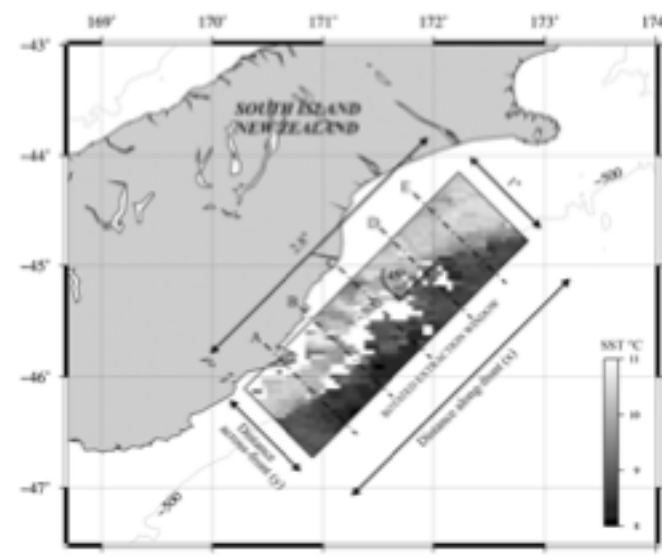
Modeling



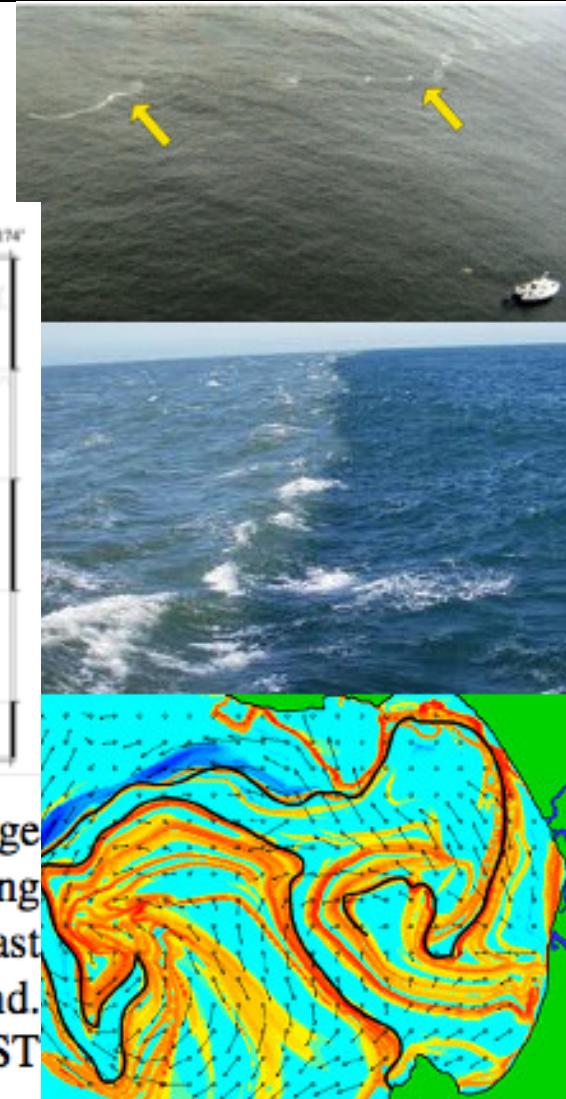
Modeling



(a) Theoretical model of an ocean front, assuming that each SST observation $z^{(i)}$ is drawn from a normal distribution. See [91] for details.



(b) A window of satellite image data aligned approximately along the Southland Front off the east coast of South Island, New Zealand. Image extracted from AVHRRSST data.



Exercise

Exercise:

Describe effective methods of processing and visualizing the following types of data:

- ❑ Vision
- ❑ GPS
- ❑ Water quality (%Chlorophyll, pH, ORP, Turbidity, etc.)
- ❑ Radio beacon
- ❑ Inertial Measurement Unit (IMU)
- ❑ Compass
- ❑ Gyro
- ❑ LiDAR (Light Distance And Ranging)
- ❑ Radar
- ❑ Doppler Velocity Log (DVL)
- ❑ Sonar
- ❑ Acoustic