



HydrOffice



Finding Fliers:

New Techniques and Metrics

Matt Wilson ¹, Giuseppe Masetti ², Brian Calder ²

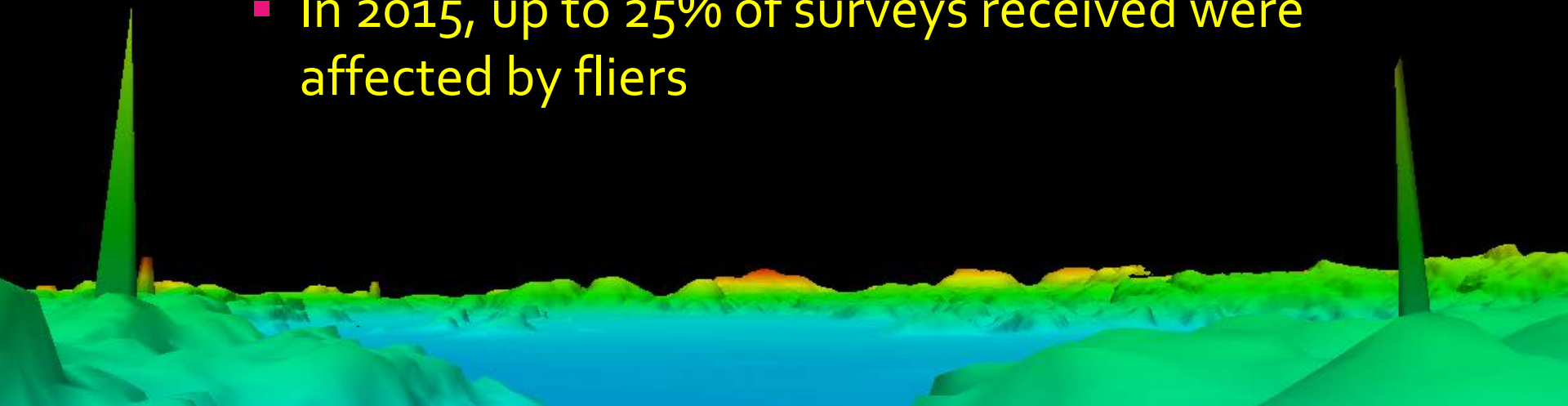


¹ NOAA Office of Coast Survey
² Center for Coastal and Ocean Mapping
and Joint Hydrographic Center



Finding Fliers: Introduction

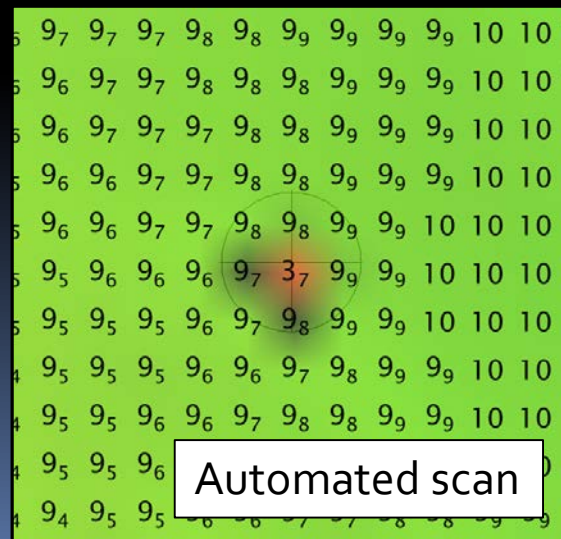
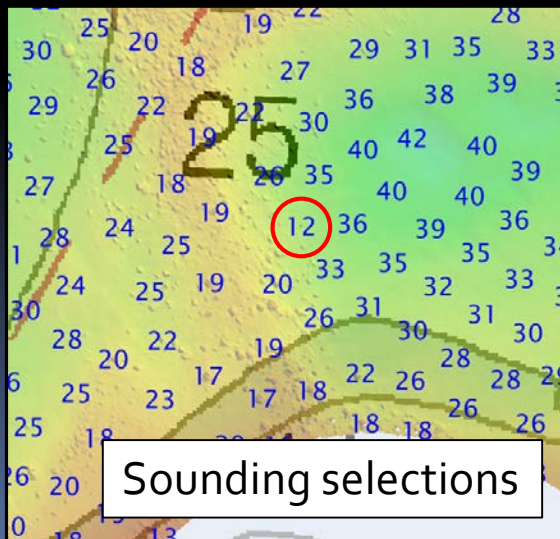
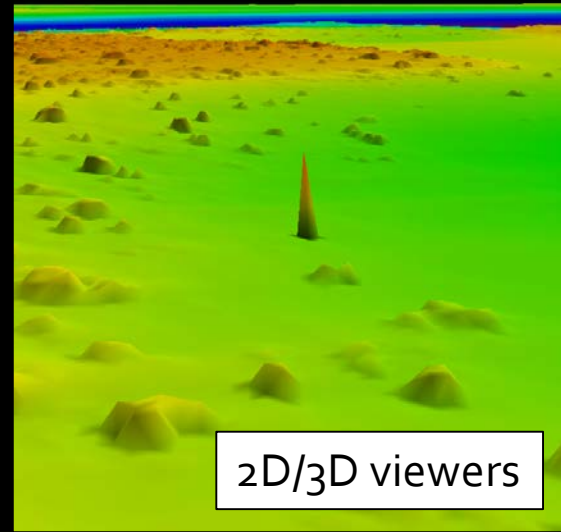
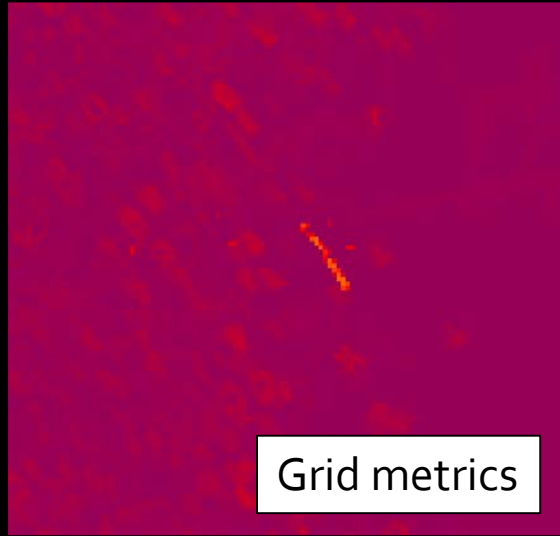
- Anomalous grid data, a.k.a. “fliers”
 - Inaccurate portrayal of seafloor
 - Require high time and effort to resolve
 - Lineage of original field submission compromised
- Manual detection methods lacking?
 - In 2015, up to 25% of surveys received were affected by fliers



HydrOffice: QC Tools

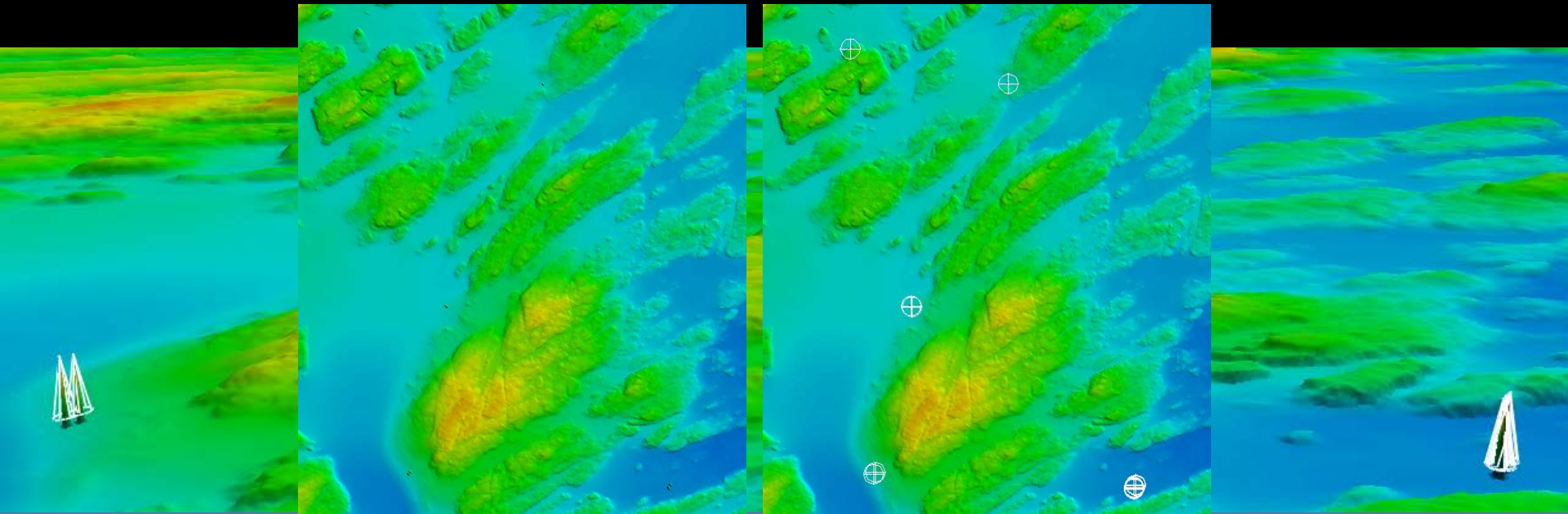
- A suite of applications
 - Targets common hydrographic office challenges
- Prioritize review where intervention needed
 - Rather than spreading effort equally across all data
- Developed in HydrOffice
 - Open source research software environment
- Recent increase in data quality and timeliness
 - Attributed in-part to adoption of QC Tools
- “Flier Finder”, a component part of QC Tools
 - Algorithms to identify potential fliers

Flier Detection Methods



Flier Finder: Overview

- Scans depth nodes for shoal or deep “spikes”
 - Flags written to S-57 file to guide the review
- Five algorithms; some require a search height
 - Customized to find specific types of fliers



Flier Finder: Algorithm #1

- Laplacian Operator
 - Measure of curvature at each node
 - Values $\geq 4 \times$ search height are flagged

3 meter search height

9	9	9	9
9	8	9	6
9	9	3	9
9	9	9	9

0	1	0	3
1	4	10	9
0	7	24	9
0	0	6	0

Flier Finder: Algorithm #2

- Gaussian Curvature
 - Measure of concavity at each node
 - Values ≥ 6 are flagged

$K = \frac{(g_{xx} \times g_{yy} - g_{xy} \times g_{yx})}{(1 + g_x^2 + g_y^2)^2}$				0	0	0	0	Independent of search height g_x
				-1	0	-1	-0.09	
9	9	9	9	0	-2.3	0	-0.14	g_{xy}
				-2.5	0	20	0	g_y
				0	-9	0	-36	
9	9	9	9	0	0	-3	0	g_{yx}
				0	0.5	0	1.5	g_{yy}
				0	0	6	0	

Flier Finder: Algorithm #3

- Adjacent Nodes
 - Ratio of # height exceedances with # of neighbors
 - Values ≥ 0.8 are flagged

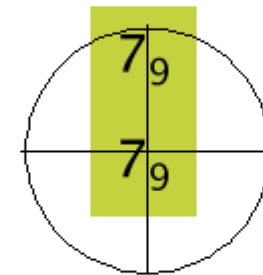
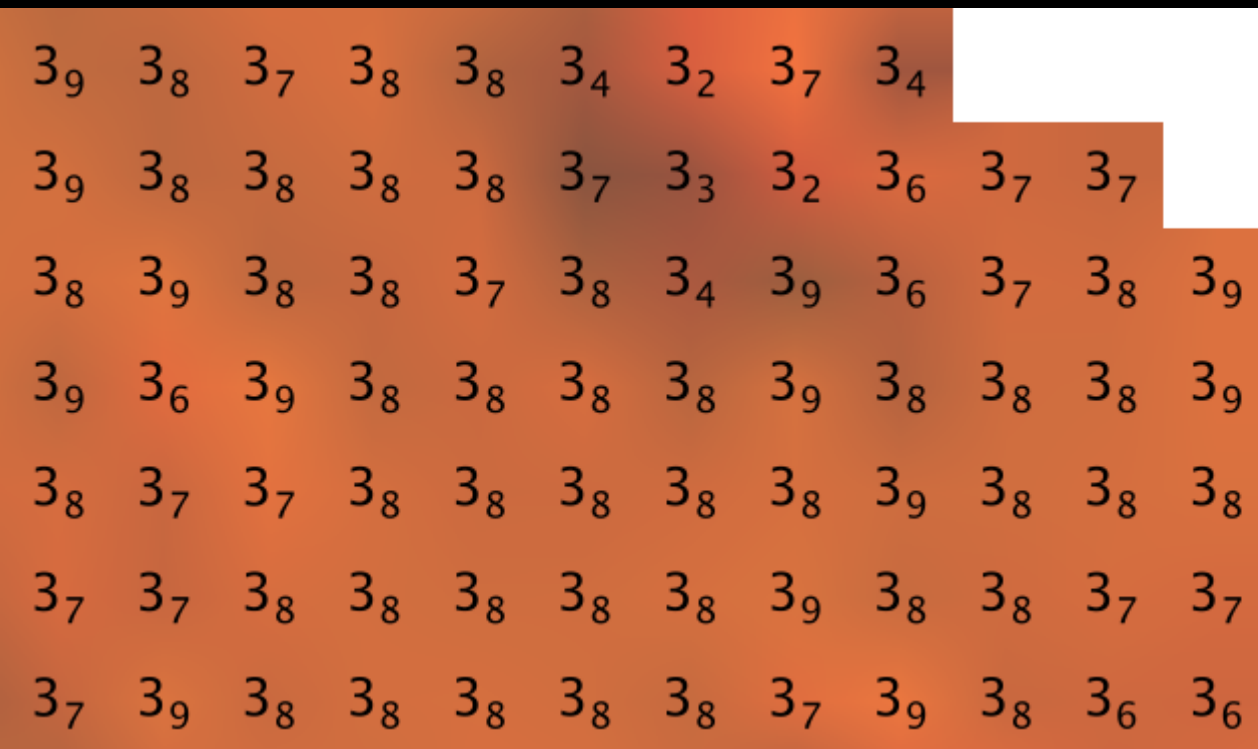
3 meter search height

9	9	9	9
9	8	9	6
9	9	3	9
9	9	9	9

0.33	0.2	0.4	0.33
0.2	1	0.38	1
0.2	0.25	1	0.4
0	0.2	0.2	0.33

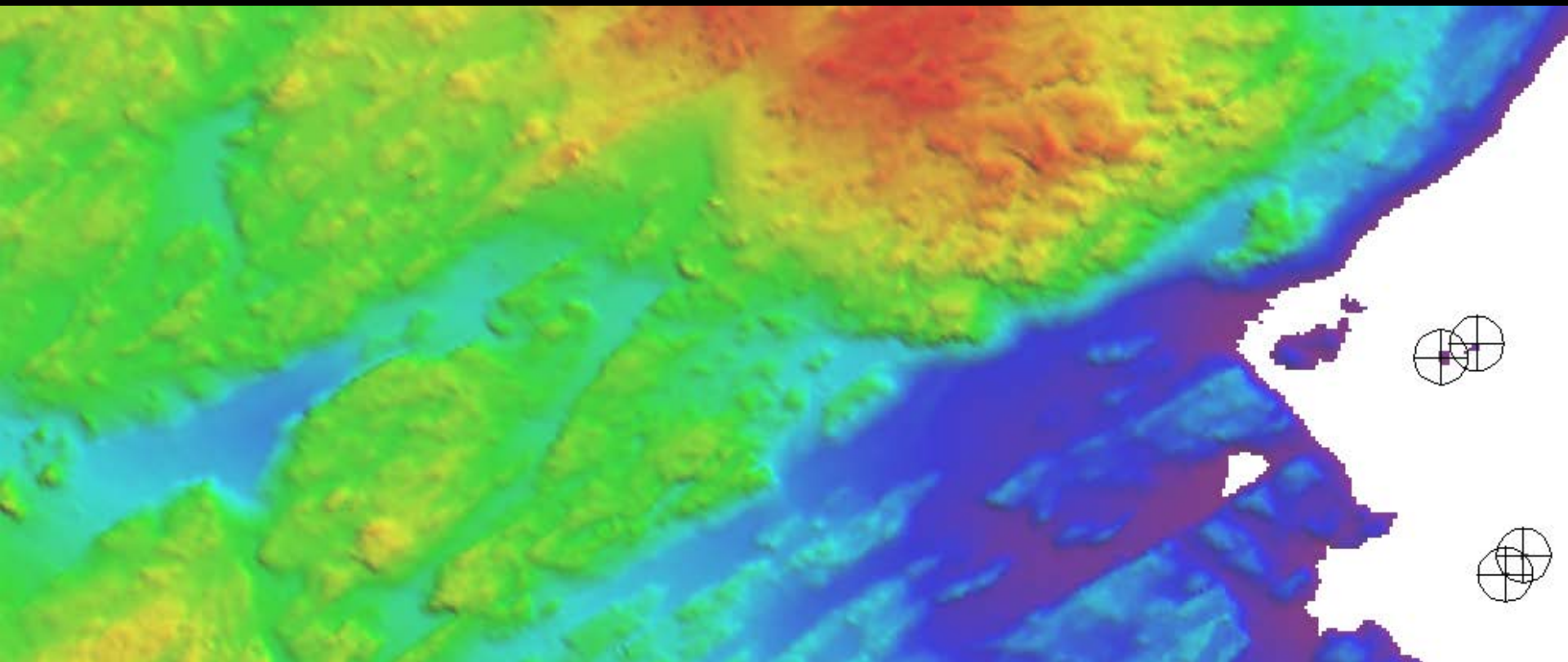
Flier Finder: Algorithm #4

- Edge Slivers
 - Detects nodes disconnected from grid, with depth discrepancy



Flier Finder: Algorithm #5

- Isolated Nodes
 - Flags any nodes far detached from grid



Flier Search Height

- A subjective input
 - Too sensitive yields excessive “false positives”
 - Too coarse may miss fliers
- Standardized search height needed
 - Output easily repeatable
 - Ease acceptance procedures
- Auto-search height from grid depth median
 - Variability (NMAD¹) adjustment
 - Roughness (STD GC²) adjustment

¹ Normalized Median of Absolute Deviation

² Standard deviation of Gaussian Curvature

Auto-search height estimate

Depth Median	< 20	20 - 40	40 - 80	80 - 160	> 160				
Base Height	1	2	4	6	8				
Normalized Median of Absolute Deviation	# of increases								
> 0.2	0								
0.2 - 0.1	1								
< 0.1	2								
Standard Deviation of Gaussian Curvature	# of increases								
< 0.01	0								
0.01 - 0.10	1								
> 0.10	2								
Advance base height along the scale below by the total # of increases									
Final Height	1	2	4	6	8	10	12	14	16

- Deep, variable, rough seafloor
 - High height (trend toward 16m)
- Shallow, flat seafloor
 - Low height (trend toward 1m)

Flier Finder interface

Flier finder v3


Parameters

Current flier heights[meter]:


Force flier heights[meter] to:


Checks

- #1: Laplacian Operator
- #2: Gaussian Curvature
- #3: Adjacent Cells
- #4: Edge Slivers
- #5: Isolated Nodes



Execution





Flier Finder Pros/Cons

- Evaluates all grid nodes for fliers
 - Flag anomalies not otherwise noticed
- Shallower, high-resolution bathy
 - Most effective
- “Steep and deep” bathy
 - Less effective due to high false-positives
- Adaptive search height to resolve issues
 - Current development geared toward variable resolution grid compatibility

Flier Metrics

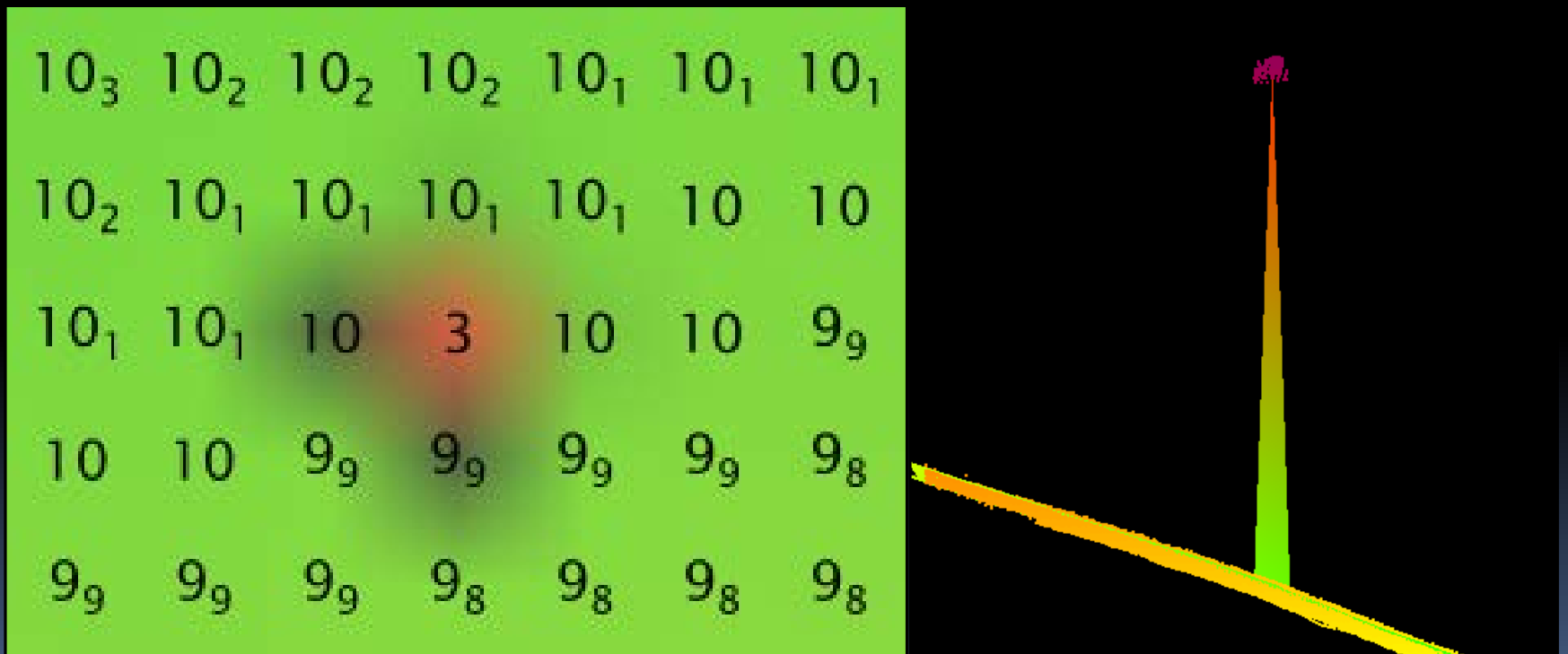
- Widespread adoption of Flier Finder
 - Needs to be evaluated objectively
- Established control grids with known fliers
 - Compare human and machine reviews
- Humans used only manual methods
 - Flags placed manually atop potential anomalies
- Only control grids and chart made available
 - Sounding data not available to verify anomalies
- Metrics examined: 7 humans vs 1 machine
 - Detection rates, time needed, years of experience

Control grids: Overview

- 2 grids from 2015
 - Covering approximately 22 square kilometers
- Acquired to object detection standards
 - 50 cm resolution in depths 0-22 meters
- Data as-submitted
 - Representative of actual data quality issues
- 42 verified fliers within 2 control grids
 - Composed of shoal, deep, and edge fliers

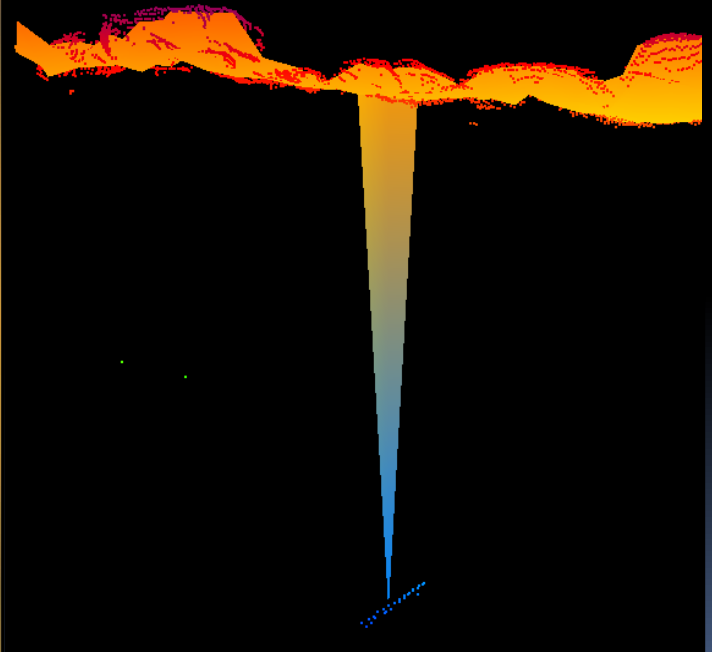
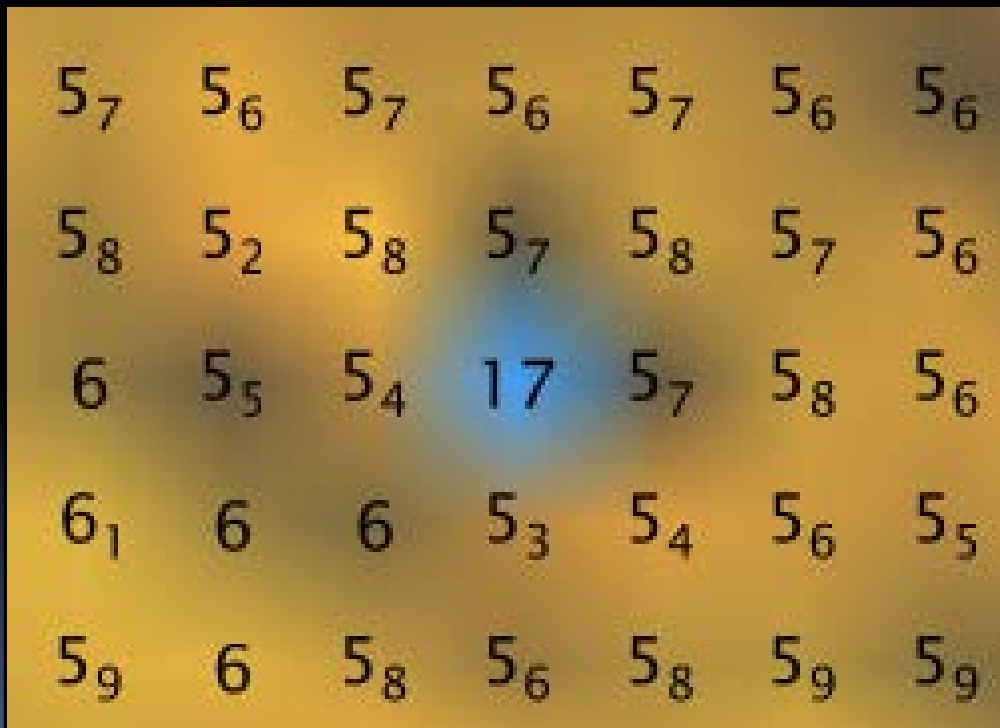
Control Grids: Shoal Fliers

- 6 shoal fliers (of the 42 verified)
 - 3 m (min) to 6 m (max) magnitude



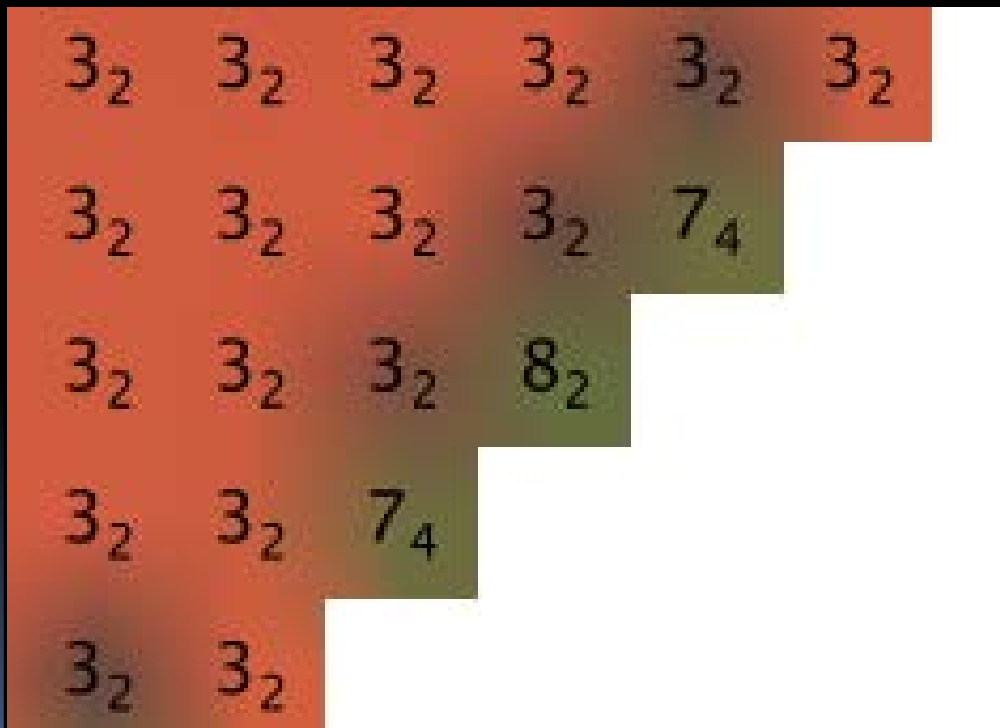
Control Grids: Deep Fliers

- 10 deep fliers (of the 42 verified)
 - 3 m (min) to 11 m (max) magnitude



Control Grids: Edge Fliers

- 16 edge fliers (of the 42 verified)
 - 1 m (min) to 16 m (max) magnitude



Results

	Flier Detection Rates			Time Needed	# of flags ³	% False positive ³
	Shoal	Deep	Edge			
Manual Detections ¹	45%	0%	26%	2.5 hours	224	84%
Automated Scan ²	83%	90%	85%	-	43	16%

¹ all values given as averages among 7 reviewers

² performed with auto-estimated search height and default algorithms

³ in "steep and deep" bathymetry, values for automated scanning may be much higher

- 12 fliers not found by any humans
 - All were detected by machine
- 4 fliers not found by machine
 - 3 were detected by at least one human

Machine: # of Flags Returned

	Flier Search Height (m)								
	1	2	4	6	8	10	12	14	16
Test Grid A	+2032%	+136%	*	-40%	-64%	-72%	-76%	-76%	-76%
Test Grid B	+933%	*	-56%	-83%	-89%	-89%	-89%	-94%	-94%

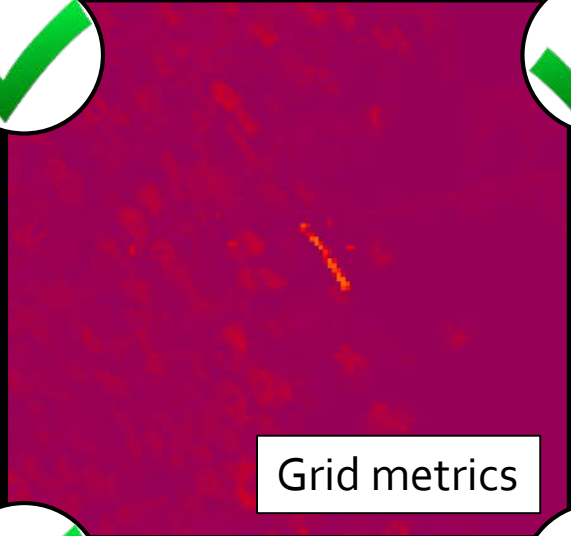
* 25 and 18 flags returned for Test Grids A and B, respectively, when ran with auto-estimated search heights and default algorithms

- Output sensitivity to flier search height
 - Potential for high false positives
- Auto-estimated search height
 - Valuable guidance

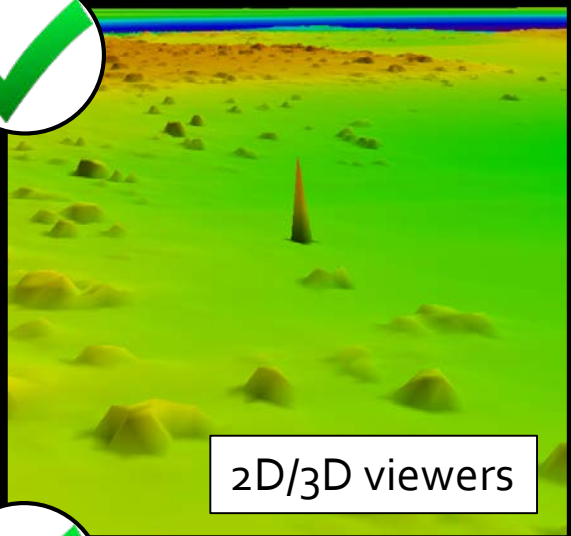
Discussion

- Effectiveness of manual review
 - No correlation found to years of experience
- High variation in manual review techniques
 - Suggests need for more standardized practices
- Manual flier detection
 - Much more difficult than commonly believed
- Flier Finder = direct flier detection
 - Very effective in certain types of bathymetry

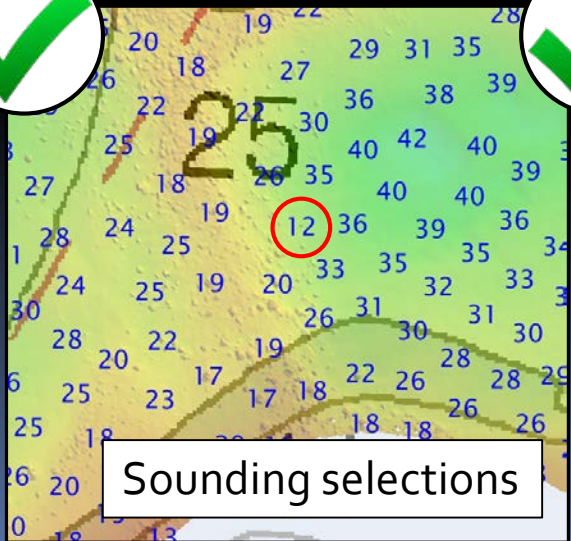
Flier Detection Scorecard



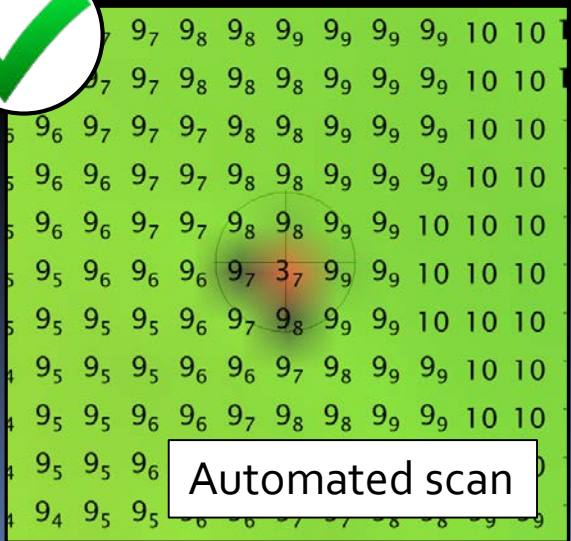
Grid metrics



2D/3D viewers



Sounding selections

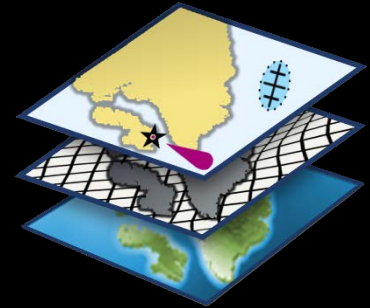


Automated scan

Conclusions

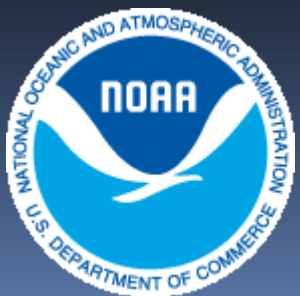
- Recent increase in data quality and timeliness
 - Attributed in-part to adoption of QC Tools
- Automated scanning
 - Might be critical in certain bathymetry
- Reduce fliers at the source?
 - Integrate algorithms directly into gridding process
- Shouldn't replace manual, qualitative review
 - Rather, automated bulk scanning is a supplement to manual review

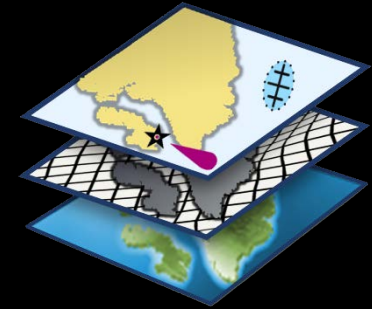
Acknowledgements



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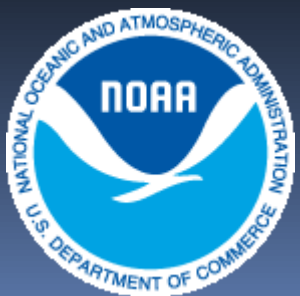
Also thanks to NOAA Coast Survey and UNH CCOM/JHC for supporting new products and innovation.





Questions

- For more information:
 - <https://www.hydrooffice.org/>
- Or send email to:
 - matthew.wilson@noaa.gov
 - gmasetti@ccom.unh.edu
 - brc@ccom.unh.edu



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