The Seventh ROWG was held at the Exploratorium Museum in San Francisco on March 4-5 2014. There were 43 attendees, although 42 registered, the largest ROWG meeting to date. Representatives from Australia, Canada, Taiwan, USA, Portugal and Turkey were present. Note that the presentations will be posted on the IOOS HF radar web page (http://www.ioos.noaa.gov/hfradar/) and on the ROWG web page (http://www.rowg.org ; membership login required).

The following notes are a compilation of a number of attendees' written meeting notes. Hence, they are somewhat terse. However, the reader may inquire of Jack Harlan (jack.harlan@noaa.gov) if there is a specific topic that needs clarification.

Day 1 Morning

IOOS and Global HF Radar Update – Jack Harlan

HFR currents are an operational data type for weather service
HFR data is going to AWIPS (Forecasters get info through this console, they are located at each WFO although only coastal WFO's will have access to HFR data)
HFR data is going to NCEP
Investigation pending on the negative impact of offshore wind farms on HF radar
$5M total HFR budget; nearly all to O&M with ~500K to servers, meetings, small projects
Beta APMs via AIS purchase funded by IOOS for FY14

130 radars in the US run by 30 institutions
40 government/private entities use the data

BOEM may fund study in FY15 on the effects of offshore wind turbines on HFR and study ways to mitigate them

USCG may not be using HFR data for SAROPS in every USCG sector; must keep communicating with them so they know they can use it. Unsure if the SAROPS training is making it into the USCG school. Possibly poor continuity of this information due to turnover in USCG staff.

GEO: 35 countries with HF radars

Best Practices in O&M – Tom Cook

Tom highlighted the wiki that has been set up to allow HFR community members to contribute their knowledge. Just go to rowg.org (see URL above) to get a login to allow you to edit the wiki. This has the potential to be a living document allowing continual updates. Needs e.g., a WERA section, use of SeaSonde spectrum analyzer, site locating. Best practices are guidelines, suggestions, First steps in QA. Wiki includes configs info, tuning, and APM info.

wiki: http://hfrnet.ucsd.edu/bestpractices
user: rowg2014, pass: R0wg2014 or create your own account (that is a capital R followed by the number zero)

Eventually move to rowg.org or ioos.noaa.gov/hfradar?

Feel free to send stuff to Tom and he can add it to the wiki if needed
IOOS manual for real time oceanographic data quality control flags will go on wiki

IOOS Network Performance Metric – Lisa Hazard

Lisa showed how the new metric is computed and options for displaying that would incorporate existing regional tools were discussed. The method also captures reporting time delay, but mostly to capture gross outages. (Note that data arriving within 25 hrs will still make it to total vectors). Point of the metric is to help managers diagnose system health, issues, and where money needs to go. Jack needs to know when a site goes down and why ... need a clearing house of sorts or a google doc. He will send an email stating when this is a requirement.

Data Quality Control - Hugh Roarty

Hugh described some of the procedures that are used within MARACOOS (http://maracoos.org/) for data QC. There was some discussion of QARTOD which Jack is not in favor of pursuing at this time due to the expense and time required. (Edit: Recent, post-ROWG discussions with QARTOD chairs indicate that QARTOD is not fully ready for non-point measurements. Within the next year, QARTOD may have a better handle on if/when they could engage discussions on HF radar data.) Some ROWG attendees suggest a better idea is to start with putting it on the wiki.

Several tools presented, see presentation
Drifter comparisons in support of SAROPS: released 1000 particles in a random flight model, computed centroid and compared that centroid with drifter tracks
O'Donnell, Ullman paper describes this method, Hugh will upload code to GitHub site

Flags are inserted for SeaSonde 7 overland and outside max current parameters

MARACOOS :
uses a radial database with one page to show site status
techs do weekly site inspection of 17 checks (how much can be automated)
plot 24 hr mean and variance to check on radial data
they also compare ideal and measured patterns
look at total coverage and total means, monthly and daily

Don Barrick: ITU, based in Geneva, is constructing a database to get an overview of which sites have good quality control on an international scale
Jack Harlan would like site outage information in near real-time. MARACOOS can share access to regional site inspection Google doc so he has this information for the Mid-Atlantic.

CO-OPS HF Radar Tidal Prediction Product – Greg Dusek

Greg demo'd the new product and distributed information as to how to access the data. Potential new regions where the product might be created were discussed. CO-OPS uses tidal constituent analysis (least squares harmonic analysis with 37 constituents) to do forecasting of flows, incorporating HF data model forecasts validated with HFR observations.

Pulls data from Scripps
Removes grid points with low data return

Some questions...
1) Does hourly averaging affect results? In Tampa Bay test (with ADCP) hourly averages caused only ~1-2 cm/s difference in results compared to results using 6 minute data.
2) Missing data effects? What is threshold where we lose too much information? Testing with a Chesapeake Bay site found that 87% can be removed (randomly) and cause only a 5 cm/s error compared with the full set of data, having data points for 95% of the time. If you have chunks of data missing,which is more likely the case, or are consistently missing data on one part of a tidal cycle, then a higher threshold is needed. NOAA chose 40% data availability as their initial cutoff threshold.
3) Is it worthwhile to report at grid points located in more non-tidal areas because the tidal prediction is not giving much information to the user? Still looking at this question…

Right now the processing flags locations with data density $< 50\%$, GDOP > 0.7 or major axis residual variance $> 50\%$

Looking ahead, next analyses will focus on
 -adding non-tidal predictions
 -comparisons with numerical models
 -adding more harmonic constituents
 -website scaling for appearance on different devices (Note: this is now complete and will be live by mid-May)

NOAA deployed 60 ADCPs in 2012/2013; the data are available at cmist.noaa.gov

Day 1 Afternoon

Radial Velocity QC & Outlier Removal

Much of the radial velocity QC is done at the radar itself with Doppler spectra thresholding that ensures a retrievable velocity.

Don Barrick noted that Codar includes, in the radial files, two calculations that indicate data quality: temporal uncertainty and spatial uncertainty. Kip Laws' work, performed several years ago, showed the value of temporal uncertainty. However, Codar encourages the HFR

community to use these parameters to investigate their use as radial velocity QC and outlier removals. SeaSonde software can use a median filter, creates filtered radials.

Also mentioned by various attendees:
- the least squares technique used for total vector computation essentially filters radials.
- Median filter probably better than mean for outlier removal
- Interpolation across azimuth
  These last two techniques could be done in succession, separately, in a QC process.
- Radials from totals as a check on quality (this is also an existing Codar tool and it outputs a separate file (.edt?) and is also in HFRProgs (yes?)
- there was some discussion of where the radial QC needs to happen, site or nationally.

John Largier mentioned that Chris Halle did some important work that could be used in a wider area than the California coast where it was focused. Lots of interest in following up to see if it can be revisited. Hugh Roarty (Rutgers) has been in contact with Chris for more details on how to use the scripts.

Jack Harlan has Kip Laws' reports on work with CODAR's spatial and temporal uncertainties. The fall 2013 CODAR newsletter has an article on the surface current vector uncertainties.

SeaSonde Combine software includes a feature that produce (back-calculate) a radial map from a total map (output is a TDT file)

Two distinct categories must have different approaches: outlier removal for real-time and outlier removal for reprocessed data

It's good to identify outliers in order to remove them from files, but also important to try to identify the source of outliers (such as first order or pattern). Correct a problem with FOL or APM and you remove outliers by removing the source of errors.

Each site is unique so outlier removal must be developed by operators for their sites, not by the national network. Depends on if operators have time for this. Would be good to have tools to use to make development easier such as the Halle Matlab toolbox but this needs further work/documentation.

Take home point: what tools do we need to do QC and vet radial data?

Are the QC tools for real time data different than reprocessed?
Develop a tool box for operators to use because most don't have time to perform the vetting process

Codar calculates a radErr: the fit difference between the original radial and the back calculated radial

First Order Limits

- Noted that one size does not fit all sites
- May need to have multiple settings within a single site

Anthony Kirincich gave an impromptu presentation on his algorithm that detects first order limits using an image processing technique on the Doppler cross spectra. This could be implemented more widely relatively easily. Uses dynamic first order line settings using marker controlled watershed segmenting, which are matlab image processing tools, to determine first order region then runs music on the result. There is a crucial smoothing length scale that needs to be tuned. He runs this operationally

Matlab image processing tools used to set first order lines.
Reads the actual binary file though, does not import an image.
Uses an edge detection tool -- Marker Controlled Watershed Segmentation
Removes top 10% and drops out values under a threshold
Some tunable parameters - signal to noise ratio, maximum velocity, smoothing is a critical parameter
Routines work with HFR-Progs

Also mentioned was the bearing map tool that is available as part of SeaSonde software

FOL can be difficult in strong currents, high waves and high radar frequency
FOL can be simple for low currents, low waves and low radar frequrncy

Anthony's method is dynamic, more so the current CODAR method?

Archiving of lower level data types e.g. spectra, range series

Jack Harlan noted that NODC is working on a plan with Scripps and IOOS Program Office to include all needed levels of data and metadata for archiving at NODC. Although there was some dissent, the consensus about lower level data was that range series files are the most needed of the data types lower than radial velocities. The challenge that remains is determining which metadata are needed. For example, it was largely agreed that a list of the history of the antenna pattern measurements made at a site would be needed, as well as config files for SeaSonde systems.
There was some consensus by the group that range series were the "raw" files to archive at NODC
Range files represent the most useful raw form of the data
Don Barrick: at the range series level, no irreversible steps have been taken
Plenty of discussion on what metadata to include, but no final consensus here
It is possible to save everything because the metadata does not take up much disk space

A guide that summarizes the particular bits of information necessary to reprocess a data set was suggested. This would involves operator participation so would require consensus and coordination.

If a future user reprocesses based on saved RadialConfigs, then they may potentially repeat the same mistakes that were made in realtime processing.

Important metadata must include what? patterns, site logs, diagnostic files, radial configs,   …

-We would need to tell NODC the mechanics and logistics of how it would be done
-Totals are going into the archive by the end of FY 2014
-Best practices indicates CrossSpectra, NODC and IOOS want totals, radials, and 'most raw' (ie range)
-Bill suggests using the report scripts to document changes
-Debate about what to archive and what level of processing
-Summary: range files, meta data, versioning of config files **add to best practices**, include diagnostics, also include the logs folder (need to add this to archivalist?)
-Jack to do a webinar
-Teresa has a template for tracking site issues

HFR Progs status & code sharing/software repository

HFR Progs is still available at:
https://cencalarchive.org/~cocmpmb/COCMP-wiki/index.php/HFR_Progs_download_page

Hopefully, everyone who is using it and has discovered bugs or developed improvements will push those improvements back to the community (which the software license requires us to do!). Many tools (and companies) have been built by software developers to enable this, one example of which is github.com. Brian Emery has posted HFRprogs along with some extensions to the toolbox and some of Teresa's code at: https://github.com/rowg

This site could act as a central location for combining, documenting and enabling improvements to HFR progs. Improvements that are needed include:
   - parallel processing of radials to totals
   - built in tests to enable new development without breaking old features
   - better integration of optimal interpolation methods

Brian Emery (UCSB) has set up an account on GitHub, now includes
HFR-Progs
RADAR_GUIS
miscellaneous scripts (rsync, scripts for working with antenna patterns, etc)
read_cs.m is in hfrp_additions
Brian is also looking at "puppet" software that would be useful for managing large networks of sites, e.g. would have easy ways to install a file on every site or pull preferences from each site, he will share information later
Paul Lethaby (Australia) - Icinga also has network management tools

Site Communications

This was a fairly short discussion but it was noted that Iridium has been asked to devise a backup method

CLS Iridium solution?

Hank Statscewich (UAlaska): Alaska uses satellite communications

Jamie Davis (USM): USM uses GlobalSat for buoy data

Scripps: Hughsnet direct dish $50/month + $500 install

Wireless bridge devices - Ubiquiti, Engenius (5 GHz better than 2.5 and 900(MHz?) has more bandwidth)

Jim Pettigrew (SFSU): had Ethernet extenders on a DSL line, Surflink solved his slow speed problems, runs now without extenders $60/month

Brian Emery (UCSB): satellite cable $50/month

Ed Romero (UCSB): uses Chrome Remote Desktop to screen share

Rutgers looking into iridium for redundant (backup) comms, will get a quote

Lots of users of satellite internet

Cellular theoretically robust

Rutgers going to try to bridge 6 hr power loss gaps

Discussion of wireless methods for remote connections (UCSB has done a lot of this)

Frequencies that are out there are 900 MHz, 2.4 GHz and 5 GHz for wireless communications

Cradle point router is a good option for site communication, dual wan inputs

Satellite is ~ $50 per month

Exede/viasat is a good option, 11 GB per month

Need to replace the equipment every three years

Ideas for offline studies

Don Barrick brought up some ideas for offline research:
- o APM smoothing when APMs are severely distorted
- o MUSIC parameters and effects
- o Improvements to the temporal quality for use by modelers

In any case, studies should have access to *in situ* data and possibly range files for extra processing. Drifters best for comparison data.

Errors in the radial data in the context of circulation model input were mentioned.

Day 2 Morning

Improving Baseline Variance through Radial Metrics - Tony DePaolo

Tony covered the extensive testing that the Scripps CORDC group has done with the direction of arrival (DOA) parameters that can be embedded in SeaSonde output files. Using a similar analysis done by Lipa, et al (2006) investigating baseline data consistency, CORDC used signal to noise ratio (SNR) from the monopole antenna and the "signal power" metric to filter out

inconsistent radial vectors on the three baselines of their San Diego SeaSonde system. The idea being that in a uniform directional flow, removal of radial vectors that are pointing the opposite direction and are of a magnitude much outside the mean is a good practice. The effect of the filtering reduced the baseline variance in many cases, at the expense of minor reduction in coverage. Tony advocated that even if you don't want to remove inconsistent radials, each radial velocity could be flagged using the DOA metrics, and vectors with less that optimal metrics can at least be weighted less in the computation of system total vectors.

After the filtering process, there were still inconsistent radial velocity vectors that got past the metric thresholds. When looking at these remaining inconsistent vectors, they generally had larger "DOA width" metrics, and seemed to come from the dual angle path through the MUSIC algorithm. This might indicate using the "DOA width" metric to better the filtering process, as well as tuning the system to use more single angle solutions rather than dual angle solutions. This can be done by setting the input MUSIC parameters (Eigenvalue ratio, etc.) accordingly.

-Used 45 days of data to do baseline comparisons
-Thinks flagging data is a good idea, can plot them and also weight based on the flags in the totals

The extensive study optimized for the minimum variance of all radials from 2 sites in a box around the baseline, using different thresholds and values of many parameters. Variance seems to be driven by large outliers, and this analysis is effective at removing them

Take home: Metrics can be used to remove outliers, at a cost of reduced coverage
DOA width will be investigated, more work to look at dual angle solutions
Would like to see a quality indicator come out of this

Signal Power seems to be the best indicator of quality, along with Doppler cell SNR on channel 3
Others are not used at this point because study of every combination of the 6 metrics

Weigh the radials by quality flag when combining radials into totals

The six metrics they examined were
1. DOA max
2. Width of the DOA function
3. Signal power
4. SNR on channel 1
5. SNR on channel 2
6. SNR on channel 3

SNR changes throughout the day; need to make the algorithm adaptive

Can weight poor or suspect quality vectors less in the total vector processing
Recommend using signal power and Doppler cell signal to noise ratio metrics
Tested all combinations of metric parameters and using those two metrics were best

In ppt slides, histograms display all the radial velocities for an hour and filtering scheme pairs are "OR" tests not "AND" tests
Don Barrick comment: Once signal to noise is above a certain threshold, shouldn't make much difference in results.
Variability in the Bragg peak itself as a Gaussian variable is a culprit in overall variance.
In terms of flagging vectors, Tony has a quality number ranging from -3 to 3 that can be plotted on a color coded map.

APMs via Unmanned Aerial Vehicles - Ed Romero

It's probably fair to say that Ed's video and demonstration stole the show! Using UAVs could make APMs significantly easier, cheaper and safer. A handout listing everything used to construct and fly the plane is available. Comparisons of conventional patterns vs AUV measured patterns are very similar. Don indicated that sea surface 'filter's the signal such that the measurements should be similar when the range between the site and the source is large (many wavelenths from the site).

UAV for $1,000 30 km range
Copper tape for the ground plane can be found on mcmaster carr
They used a 22' antenna
The signal source needs 10 mW and can last for 40-60 minutes in the air
Payload is currently 5.6 pounds with a maximum of 8 pounds
Need ~20 feet for UAV antenna clearance on takeoff and maximum wind speed is around 10 mph
Fly at 18 mph
Typically ~150 feet or less and up to 200-300 feet, but not as comfortable flying above this height
They have only performed APMs for 13 MHz so far
If the ground plane is smaller you need a larger antenna
Need COA certificate of authorization from FAA to be official
Batteries are not protected
Part 15
It's the density of the payload that matters, wrap the payload in Styrofoam container to reduce density, then you can fly wherever you want
Signal source has 25 millihertz resolution and there is some Doppler drift over a half hour
Using filter right now for 13MHz
Set site to transmit 50 Hz above the center frequency (similar to site setup for CODAR "supertransponder")

Cables, Connectors and Tool Suggestions - Cyril Johnson

Cyril demonstrated specific tools and techniques for RG-8 and RG-59 cables and their connectors; techniques that he has learned from decades of experience.
Cyril's notes:

Installing cables and forgetting about them probably not the best strategy in the long run. In the harsh environments that most of the HF radar installations are in, cables can deteriorate. Some means of testing and a maintenance schedule is suggested. A handout was available listing cables, connectors, and tools used by the UCSB group.

If there is a mismatch in impedance between the transmit cable and antenna and the cable is shortened the SWR measured at the transmitter will be worse (bigger ratio). This is due to less loss in the reflected power return path from the antenna to the transmitter where the SWR is measured. The mismatch at the antenna has not changed and the loss through the cable to the antenna will be less, it will just "look" worse.

Other notes:

Problems with exposed cables lying in the sun or combinations of sun/shade,
Don Barrick: differential heat changes are a problem for phases, phased arrays
Tom Cook (USCD): foam center cables had a problem with heat in Miami
RG is a loose grouping and need to be specific to get the right one
Suggests cutting cables to length on site and terminating with proper tools and connectors
Crimp before solder is ok, but he does not recommend soldering, (not necessary, takes a lot of time) and just crimping seems fine (using the correct tool and connector for the cable, of course!)

Never solder then crimp
Hank uses pre pull tape installed conduit

Don: Try to do cable runs less than 500 ft, but if you have to, long cable runs are better than long setbacks from the water

UCSB's longest receive cable run <~500feet (~150m) Santa Cruz Island we used Belden 8214 (RG8U).

Teresa Updyke (ODU):1000 feet of HDPE conduit (1 1/2" black UV stabilized duct in black, spool size 66" drum x 42" wide 525#s) We could not order in lengths of less than 1000 foot but we were able to use it all at our 2 sites. We ordered Shurlock 1 1/2" watertight couplers but ended up not needing them since we were able to pull our entire length of rx cables (550 feet) by hand. Our entire order which included the spool of conduit, delivery and some extra money for the couplers, lubricant and a beveler came to $1325.
Contact information for our supplier:
Joe Lesnieski Contracting
283 Clarkstown Road, Mays Landing, NJ 08330
609 909 8888   jlesnieski@verizon.net

LMR 600 cable worked in malta for 350 m run
If you change the rcv cable length: need new APM

Antenna analyzer AIM 4170
CT50 Psiber cable tool
Time domain reflectometer

Don't kink the solid conductor

Jim Pettigrew (SFSU): Psiber CT-50 Cable Tool Multifunctional Cable Meter $279
Paul Lethaby (Australia): AEA Vector Impedance Analyzer

Update on the SF Bay HF Radar Currents App - Jim Pettigrew

Lots of users of the Bay Currents app; 5700 downloads in 42 countries.
Jim is Thesis advisor for SFSU Design and Industry student who is working on a display for use by Crissy Field kiters and windsurfers who are often rescued by the USCG as a result of misreading the tides and currents.
Working with CODAR to increase the temporal and spatial resolution; all 6 SF Bay sites are now gathering data at 1-degree, 200m resolution
Trying to get data into the TV broadcasts of the next America's Cup
30 minute output, 55 minute average for radial data; includes 6 hours prediction

Hosting on amazon web services for $60 per month
Streaklines which are shown at the Exploratorium are written java code, Brian Zelenke
US Army corps uses the App to help locate floating hazards to navigation in SF Bay

Marinexplore Demo - John Graybeal
        John came in from Silicon Valley to give an interesting demo on the leading edge in data mining of oceanographic data including HF radar data. Majority of active users currently on the site are interested laypeople
http://marinexplore.org/

Day 2 Afternoon

- There was an action item taken by Anthony Kirincich and Tony DePaolo to analyze the next steps needed for implementation of DOA metric as QC and possible error analysis for input to models. They will provide this to Jack within the next six months or so.

- Discussion of the next ROWG, tentatively Fall 2015 on the East Coast of the USA. Anthony Kirincich volunteered WHOI (https://www.whoi.edu/main/visitor-information) as the venue which has plenty of infrastructure for meetings of ROWG's size. Also, via email, Mike Muglia offered the new University of North Carolina Institute of Marine Sciences http://ims.unc.edu/ .

- Need to archive range, configs and diagnostics files

- Need to develop a reprocessing template, plan written by end of august

- Improving radial velocity, MUSIC metrics, DOA, areas to improve QC

1) improve the radial velocity measurements

2) assess the error and give it to the modellers

Don Barrick: Offshore wind turbines will cause interference in spectra (not as much of a problem for long range systems) There should be a software fix, trying to get $ from energy companies to develop a solution.

Scripps dealing with some interference issue, they've used SpectraAnalyzer but there is no documentation for this SeaSonde tool
Must turn off Tx to use. Would be best to record over 24 hours and analyze. However files are binary and nothing set up to view them so for now it is best to look at the data in realtime.

SCOOS setup has a map with stoplight colors, can click on a site for details, maintenance notes, etc. some notes can be designated as public or private (I couldn't find this interface - does someone have a link?)