REAL-TIME SURVEY MANAGEMENT

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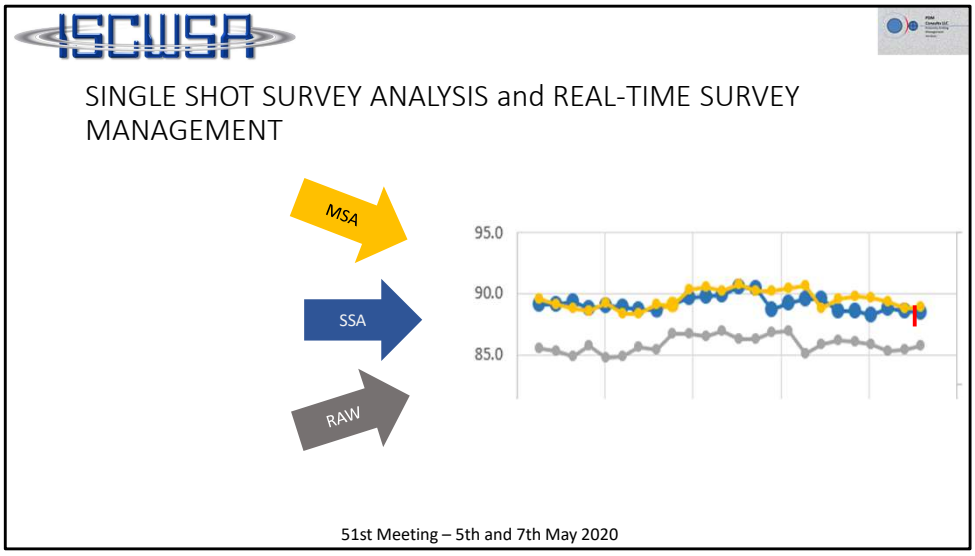
Proximity Drilling Management LLC

51st Meeting – 5th and 7th May 2020

HELLO EVERYONE !! IF YOU HAVE BEEN AROUND THIS GROUP MORE THAN 20 YEARS YOU PROBABLY KNOW ME. IF NOT, PLEASE ASK SOMEONE WHO HAS.

LET'S TAKE A LOOK AT MAGNETIC SURVEY CORRECTIONS WITH AN EYE TO REAL-TIME ANALYSIS FORWELLBORE QUALITY AND COLLISION RISK MITIGATION.

THIS WORK CAME ABOUT FROM ASSISTANCE TO A CLIENT WITH A NEED FOR HORIZONTAL EASTERLY SURVEY ACCURACY I HOPE YOU WILL UNDERSTAND THAT THE METHOD MAY HAVE BROADER APPLICATIONS.



THESE MWD SURVEYS WERE CORRECTED ONE BY ONE FOR DRILLSTRING INTERFERENCE AND COMPARED WITH AN END-OF-JOB MSA ANALYSIS WITH THE HELP OF DATA AND MSA PROVIDED BY INNOVA LLC**.**

THE CORRECTION METHOD WE USED ENABLES IN-SITU DRILLSTRING AND CROSS-AXIS INTERFERENCE ESTIMATES. . . . AND IT PROVIDES ACCURATE SURVEY CORRECTIONS WITHOUT NEEDING ACCURATE TOTAL REFERENCE FIELD AND DIP VALUES.

WHY DO WE NEED A NEW METHOD FOR SINGLE SHOT SURVEY CORRECTIONS?

WELLPLANS AND WHILE-DRILLING ANTI-COLLISION SCANS DEPEND ON PRE-JOB ESTIMATES OF DRILLSTRING INTERFERENCE THAT ARE UNRELIABLE AT BEST. SIMPLY PUT, IT IS DIFFICULT TO GET A RELIABLE ESTIMATE OF DSI PRIOR TO RUNNING IN HOLE.

AS WELL AS SIGNIFICANT ERRORS IN SURVEY CORRECTIONS CAN BE INTRODUCED BY INACCURATE OR VARIABLE REFERENCE FIELD VALUES THAT MAY OCCUR DUE TO GEOMAGNETIC ACTIVITY DURING DRILLING OPERATIONS . . .

MEANWHILE, REFERENCE DECLINATION AND DIURNAL VARIATIONS CONTINUE TO LIMIT OVERALL MAGNETIC SURVEY ACCURACY.

some Single Shot MWD survey “real-time” questions

“The first survey out of the shoe with this bha does not agree with the gyro survey at the shoe. DD wants to know “what is the problem?”

“It looks like we have a “hot” survey. DD wants to know “what is the problem?”

“Our last few surveys are “all over the place”. DD wants to know “what is the problem?

“We need to kick off as soon as possible out of the shoe. DD is asking “When can we get a good survey?”

51st Meeting – 5th and 7th May 2020

THERE IS A NIGHTMARE SCENARIO IN THESE QUESTIONS. CONSIDER THE SITUATION OF AN MWD HAND WITH A HOT SURVEY.

EVEN WITH THE ATTENTION THAT HAS RECENTLY BEEN GIVEN TO “STOP WORK” AUTHORITY, ROP STILL SEEMS TO “RULE” IN MUCH OF THE DRILLING WORLD.

ONCE DRILLING IS UNDERWAY AND IF ROP “RULES”, SURVEY MANAGEMENT MAY SUFFER. WHEN THAT HAPPENS AND DRILLING GOES “OFF THE PLAN”, **THE AC REPORT MAY NO LONGER BE VALID.**

AT WHAT POINT DOES A CONCIENTIOUS MWD HAND OR COORDINGATOR CALL OUT “STOP WORK”???

MY OPINION, WE CAN PROVIDE USEFUL ANALYSIS TOOLS TO MWD COORDINATORS TO ASSIST KNOWLEDGE BASED DECISIONS.

I HAVE SOME PRETTY STRESSFUL FIRST-HAND STORIES TO GO WITH THIS COMMENT AS I AM SURE OTHERS HERE HAVE AS WELL. THEY WILL HAVE TO WAIT FOR NOW.

(IN PARTICULAR, TOP-HOLE SLOT RECOVERIES WHERE “BAD” OFFSET WELLBORE SURVEYS HAVE BEEN DISCOVERED LATE IN PLANNING. NEED I SAY MORE?) MOVING ON . . .

Precise Wellbore Location or Collision Risk?

Staying “on the plan” is essential to maintain collision risk estimates

Real-time survey management is needed to maintain downhole collision risk estimates

Maybe we should call this “collision risk management”!!

Does the increased “value” of a smooth wellbore justify the costs of better survey practices for overall risk management?

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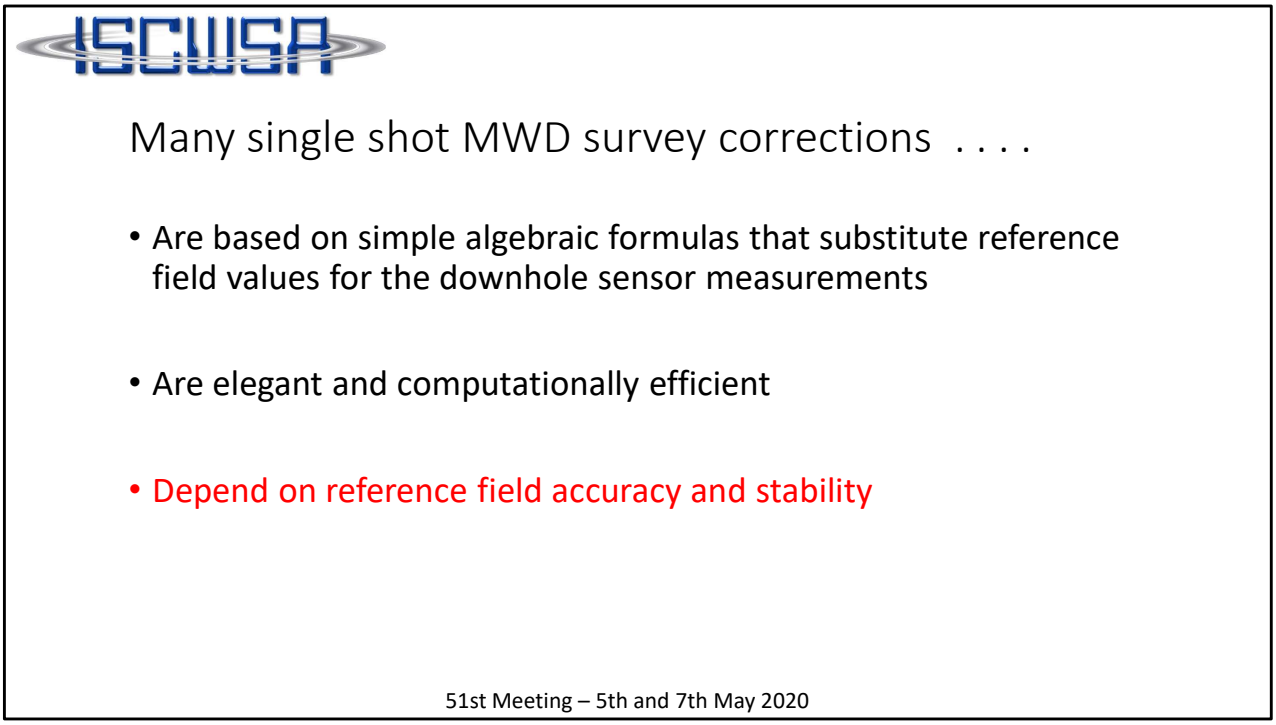
TODAY, OFFSET WELLBORE SURVEYS WITH MSA CORRECTIONS COMPRISE BEST PRACTICES FOR ANTI-COLLISION SCANS DURING WELLPLANNING.

IT IS SOMETIMES FORGOTTEN THAT ANTI-COLLISION SCANS ARE ONLY AS GOOD AS THE WHILE-DRILLING ACTIVE WELLBORE LOCATION.

HOW OFTEN SHOULD THE REAL-TIME WELLBORE LOCATION AND FORWARD PLAN BE UPDATED WITH A FULL MSA REPORT?

WELLBORE QUALITY HAS BEEN DISCUSSED GENERALLY IN SEVERAL RECENT TRADE JOURNAL ARTICLES AND BY ANGUS TUESDAY AS REGARDING TORTUOSITY.

IS IT NOW THE TIME FOR A FOCUS ON REAL-TIME SURVEY MANAGEMENT TO REDUCE SURVEY UNCERTAINTY WHILE DRILLING?



MANY IMPLEMENTATIONS OF THE ORIGINAL RUSSELL BROTHERS SHORT COLLAR CORRECTION METHOD HAVE BEEN PATENTED OR IMPLEMENED SINCE THE EARLY '90'S. AS FAR AS I KNOW, ALL OF THEM IN SOME WAY RELY ON PRIOR KNOWLEDGE OF THE REFERENCE FIELD STRENGTH AND / OR DIP.

WE WILL SHOW THAT INACCURATE REFERENCE VALUES MAY SIGNIFICANTLY AFFECT THE ACCURACY OF TYPICAL SHORT COLLAR CORRECTIONS. THERE MAY BE PROPRIETARY WORK AROUNDS TO MITIGATE THIS PROBLEM BUT ARE THEY ALWAYS APPLIED CORRECTLY DURING OPERATIONS?

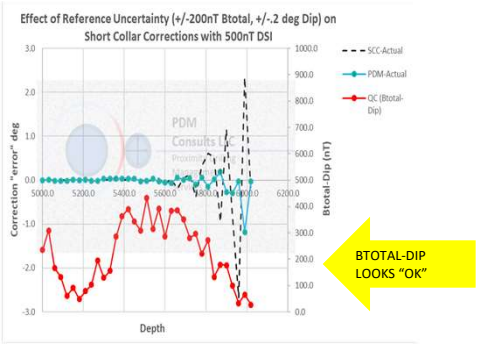
THE NEW METHOD IS SINGLE SHOT-BASED AND DOES NOT REQUIRE ACCURATE REFERENCE FIELD VALUES. . . . AND A REAL TIME-IN-HOLE DSI ESTIMATE IS AVAILABLE AT EACH SHOT.

THE METHOD HAS POTENTIAL FOR ACCURATE SURVEYS SHORTLY OUT OF A CASING SHOE OR WINDOW WITH REDUCED NMDC REQUIREMENTS

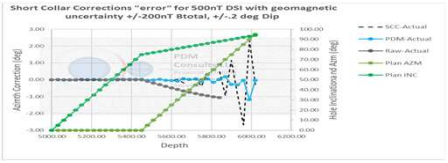
SURVEY ACCURACY AT HORIZONTAL EASTERLY IS DEMONSTRATED WITH SURVEYS AND MSA ANALYSIS PROVIDED BY INNOVA LLC.

Example: the effects of (random) reference field uncertainty

- Simple short collar corrections can do more harm than good when drilling near e/w horizontal without a very accurate and stable reference field



- build and turn to horizontal 90E for synthetic data calculations



51st Meeting – 5th and 7th May 2020

THIS SYNTHETIC EXAMPLE SHOWS HOW A DIURNAL OR MODERATELY ACTIVE REFERENCE FIELD CHANGES AFFECT CONVENTIONAL SINGLE SHOT DSI CORRECTIONS FOR A SIMPLE WELLBORE.

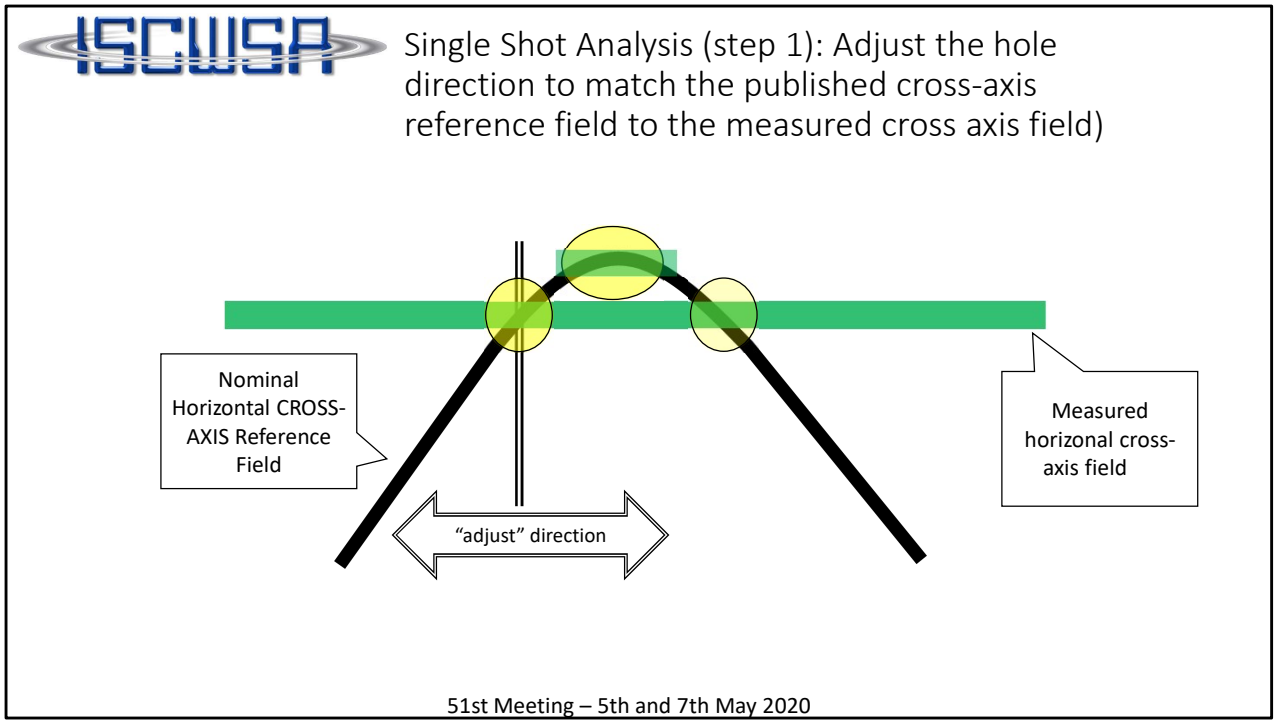
THE BTOTAL-DIP PARAMETER BELOW MANY QC LIMITS AS THE HOLE TURNS TO THE EAST. IT IS IMPORTANT TO BE CAREFUL WITH ONE-SIZE-FITS-ALL QC PARAMETERS!!

BY THE WAY, WITH NO DSI RAW SURVEY VALUES ARE "ACCURATE" WITHIN ERRORS ARE DUE TO CHANGES IN MAGNETIC DECLINATION. **THE HORIZONTAL E-W PROBLEM LIES WITH THE NEED TO CORRECT FOR DSI !!**

UNFORTUNATLY IT IS NOT EASY TO ENSURE NO DSI OTHER THAN MORE SPACING, OR HWDC AND MOTOR DEMAGNETIZING.

SO WHAT CAN BE DONE TO ENSURE ACCURATE SURVEY CORRECTIONS SHORT OF DECLINATION UNCERTAINTY?

End of introduction.



A COMPASS NEEDLE "ALIGNS" WITH THE LOCAL MAGNETIC FIELD WITHOUT "KNOWING" THE REFERENCE FIELD OR DIP VALUES.

THIS METHOD COMPUTES THE DIRECTION FOR WHICH THE REFERENCE MAGNETIC FIELD MOST CLOSELY MATCHES THE MEASURED CROSS-AXIS MAGNETIC FIELD. **(POINT OUT MWD SENSOR NOISE BAND AND REFERENCE OFFSET UNCERTAINTY**) AS IF WE WERE PHYSICALLY "TWISTING" A COMPASS NEEDLE.

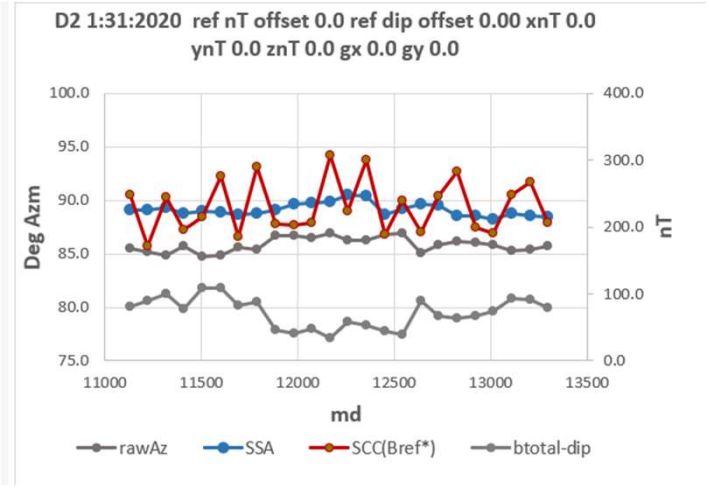
THE METHOD IS ESSENTIALLY INDEPENDENT OF REFERENCE FIELD VALUES OTHER THAN DECLINATION BECAUSE ONLY THE **NORMALIZED** HORIZONTAL FIELD DIRECTION IS USED TO DETERMINE THE HOLE DIRECTION. In effect we do not know the "torque" necessary to align our metaphorical compass needle.

YOU CAN SEE THAT THE SENSITIVITY OF THE METHOD IS SOMEWHAT LIMITED BY SENSOR NOISE WHEN VERY CLOSE TO THE "TOP" OF THE REFERENCE FIELD CURVE AT 90 AZIMUTH. AT HIGH LATITUDES DRILLING HORIZONTAL EAST THIS TURNS OUT TO BE ON THE ORDER OF +/- 2 DEGREES FOR TYPICAL SENSOR NOISE AND GEOMAGNETIC VARIATIONS. NOT BAD GIVEN THE CIRCUMSTANCES.

WE ALSO NEED A "SEARCH" ALGORITHM THAT CAN CHOOSE THE "CORRECT" AZIMUTH FROM TWO OPTIONS WHEN DRILLING NEAR E-W.

Surveys courtesy of Innova LLC

- Drilling horizonal easterly with Nominal Reference Values
- Single shot correction shows significant scatter



51st Meeting – 5th and 7th May 2020

MANY THANKS AGAIN TO JAY MCLELLAND AND DANIEL WESSEL OF INNOVA LLC FOR THIS DATA AND USE OF THEIR MSA ALGORITHM . THERE IS NOTHING LIKE REAL DATA TO VALIDATE METHODS THAT LOOK GREAT IN THEORY. WE SPENT A LOT OF TIME IN EARLY DAYS TRYING TO SIMULATE MWD SURVEYS BY CONVERTING MAGNETIC OBSERVATORY DATA TO A ;;POSSIBLE WELLPATH AND TOOLFACE ORIENTATION AND ADDING NOISE TO THE RESULTING SENSOR VALUES. THE PROBLEM IS HOW TO REALISTICALLY CHARACTERISE SENSOR OFFSETS AND TOOLFACE NOISE..

(POINT OUT SINGLE SHOT V SHORT COLLAR CORRECTION NOISE) AS EXPECTED, BUT STILL WORTH NOTING AGAIN, THERE IS A SIGNIFICANT SINGLE SHOT UNCERTAINTY INTRODUCED BY THE CONVENTIONAL SHORT COLLAR CORRECTION USED HERE.

(POINT TO BTOTAL-DIP PLOT) IN THIS EXAMPLE NOTE THAT THE BTOTAL DIP OFFSET IS WELL BELOW COMMON QC THRESHOLDS. THIS CAN BE A WORRY WHEN USING OVERLY SIMPLE QC PARAMETERS AND CONVENTIONAL SINGLE SHOT CORRECTION METHODS.

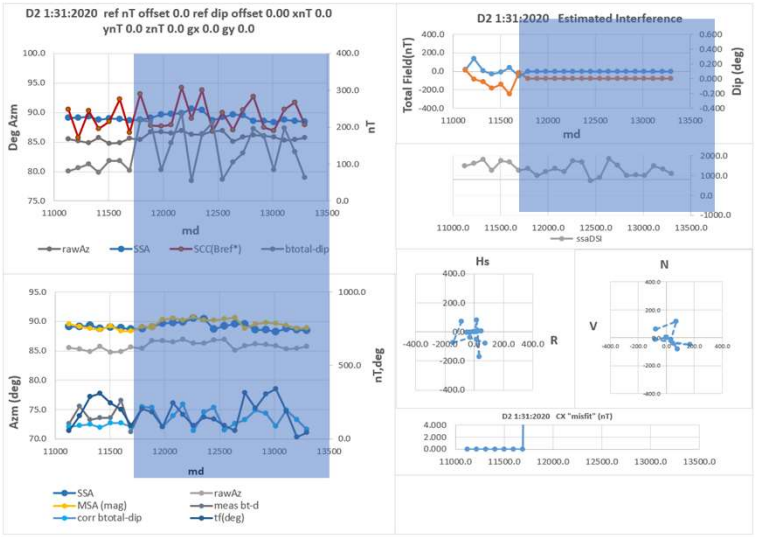
Single shot analysis "while drilling"

- SSA (real-time single shot analysis) shows good correlation with post-job MSA results

SSA v SCC

- Survey data and multi-station analysis courtesy of INNOVA LLC

SSA v MSA



51st Meeting – 5th and 7th May 2020

THIS IS A **"REAL-TIME" CORRECTION METHOD** FOR A STAND-ALONE MWD COMPUTER AT THE RIG SITE OR IN AN OPS CENTER ENVIRONMENT. **(POINT TO FIRST FEW SHOTS TO EMPHASIZE).**

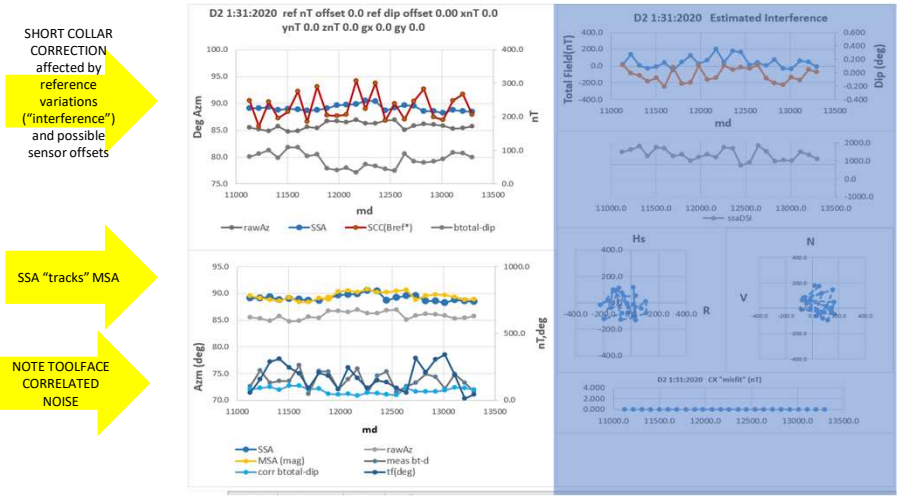
LET'S IMAGINE THIS PROCESS BY LOOKING AT THE FIRST FEW SURVEYS OF OUR INNOVA-PROVIDED DATA SET AS IF IT WERE JUST OUT OF A SHOE. (OF COURSE, IN THIS SITUATION THE MSA RESULTS WOULD NOT YET BE AVAILABLE.)

THINKING BACK ON ONE OF THE POSSIBLE "QUESTIONS" FROM AN MWD COORDINATOR, WE WOULD SEE THE EFFECT OF THE SHOE AS A DECREASING DSI ESTIMATE **(POINT TO DSI GRAPH)** AT EACH SHOT. WE HAVE NOT HAD AN OPPORTUNITY TO "TEST" HOW SOON OUT OF THE SHOE SURVEYS MIGHT BE SUFFICIENTLY CORRECTED. MY OPIMISTIC GUESS IS QUITE A BIT SOONER THAN WITH EXISTING CORRECTION METHODS. **ONCE CLEAR OF THE SHOE, THIS IN-HOLE ESTIMATE OF DRILLSTRING INTERFERENCE** GIVES AN EARLY VALIDATION OF PRE-JOB WELL-PLANNING DSI ASSUMPTIONS!

I BELIEVE THERE WAS SOME DISCUSSION OF DSI ESTIMATES AT THE LAST ISCWSA MEETING. IT IS AN IMPORTANT SUBJECT AS IT IMPACTS E.O.U. CALCULATIONS FOR OFFSET WELLBORE SURVEYS AND THE AS-DRILLED DOWNHOLE E.O.U. ESTIMATES.

PRE-RUN MOTOR MAGNETIC CHECKS ARE ALWAYS RECOMMENDED, BUT ARE THEY ALWAYS CARRIED OUT AND REPORTED CORRECTLY? THERE ARE LOTS OF ANECDOTES OF MOTORS COMING OUT OF HOLE "HOT" AFTER A PRE-RUN OR SHOP CHECK.

Single shot analysis compared with MSA at TD



51st Meeting – 5th and 7th May 2020

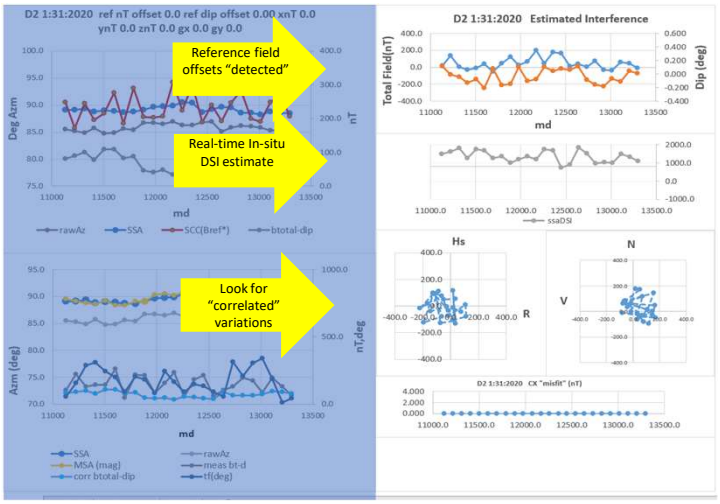
LOOKING MORE CLOSELY AT THE OVERALL RESULTS FOR THIS SECTION, **(POINT TO SHORT COLLAR RESULTS)** CLEARLY THE CONVENTIONAL SHORT COLLAR CORRECTION WE ARE USING HERE INTRODUCES SURVEY UNCERTAINTY FOR THE RAW SURVEY DATA AND REFERENCE FIELD VALUES AS PROVIDED BY INNOVA.

MANY SHORT COLLAR CORRECCTIONS ARE NOT RELIABLE IF THERE IS SOME UNCERTAINTY IN THE PUBLISHED REFERENCE FIELD OR MODERATE GEOMAGNETIC ACTIVITY WHILE DRILLING. HOW MANY LEGACY SURVEY FILES SUFFER THIS LEVEL OF INACCURACY EVEN AT LOWER INCLINATIONS? (PRESUMEABLY THE RESTRICTION TO AVOID E/W IS ALWAYS IN PLACE AND RESPECTED BUT REALLY??)

NOTE THE SOLID AGREEMENT BETWEEN THE NEW SINGLE SHOT METHOD AND POST JOB MSA RESULTS.

ANOTHER ASPECT OF THIS METHOD IS APPARENT ON THIS "DASHBOARD" DISPLAY. **(POINT TO TOOLFACE VARIATIONS LOWER LEFT)** SIGNIFICANT TOOLFACE RELATED "INTERFERENCE" SHOWS UP IN THE DATA AND IS "CLEANED" UP BY THE NEW ANALYSIS. THIS INTERFERENCE IS PROBABLY CAUSED BY SENSOR OFFSETS OR AN NMDC HOTSPOT.

Single shot analysis for interference detection



51st Meeting – 5th and 7th May 2020

THIS DATA SET ALSO DEMONSTRATES THAT **(POINT TO TOTAL FIELD AND DIP PLOTS)** THE METHOD DETECTS A FAIRLY CONSTANT REFERENCE FIELD OFFSET OF 100 NT IN FIELD STENGTH AND .1 DEG DIP IN THIS DATA SET. TO SOME DEGREE, AN IN-HOLE IFR MEASURE OF BTOTAL AND DIP, BUT NOT DECLINATION!

REAL-TIME MONITORING OF THE "APPARENT" REFERENCE FIELD MAY BE USEFUL TO AVOID "FALSE ALARMS" OF OFFSET WELLBORE INTERFERENCE. **(POINT TO THE DSI PLOT)**

IF THE BTOTAL AND DIP INTERFERENCE REMAIN RELATIVELY CONSTANT AND WE OBSERVE A SIGNIFICANT CHANGE IN DSI, THIS WOULD BE IN INDICATION OF POSSIBLE OFFSET WELLBORE INTERFERENCE AND COLLISION RISK.

THE RELATIVELY SMALL DSI VARIATIONS HERE ARE LIKELY DUE TO THE AXIALLY ALIGNED COMPONENT OF GEOMAGNETIC VARIATIONS WHILE DRILLING THIS SECTION.

FINALLY, THIS BHA EXHIBITS A DRILLSTRING INTERFERENCE OF ABOUT 1400 NT IN-SITU. IS THIS AN INDICATION OF A HOT MOTOR OR UNPLANNED NMDC SPACING?

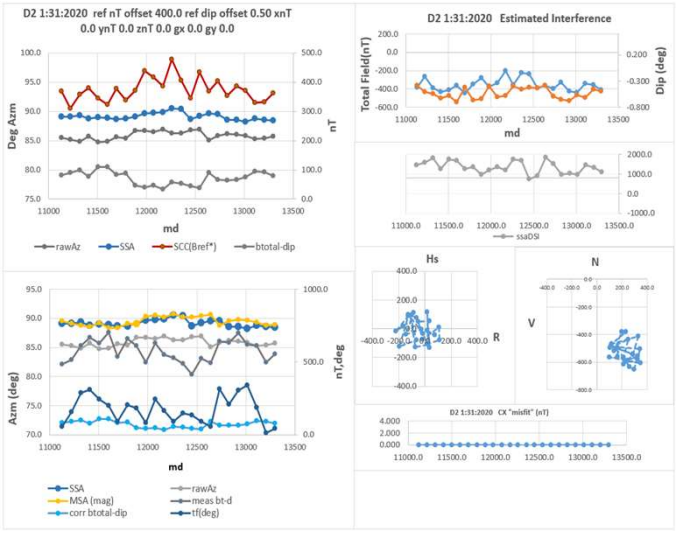
HOW MUCH CAN BIT-SENSOR SPACING BE SHORTENED WITH THIS METHOD? IT WILL BE RELATIVELY STRAIGHTFORWARD TO DEMONSTRATE WITH SYNTHETIC DATA. TO BE DETERMINED.

A SINGLE SHOT ANALYSIS THAT IS INDEPENDENT OF REFERENCE FIELD OR DIP OFFSETS !

Reference field is deliberately offset to simulate uncertainty

SCC v SSC

SSC and MSA still "tracking"



51st Meeting – 5th and 7th May 2020

TO DEMONSTRATE THAT **SURVEYS THAT ARE CORRECTED BY THIS METHOD ARE NOT SIGNIFICANTLY AFFECTED BY GEOMAGNETIC ACTIVITY OR REFERENCE FIELD OFFSETS OTHER THAN DECLINATION UNCERTAINTY**, WE USED A DELIBERATELY INACCURATE REFERENCE FIELD. (**POINT TO COMPARISON (POINT TO SSC AND MSA "TRACKING")**

IT IS IMPORTANT TO NOTE AGAIN THAT CONVENTIONAL SHORT COLLAR CORRECTIONS CAN RESULT IN WORSE THAN NO CORRECTION AT ALL EVEN UNDER TYPICAL GEOMAGNETIC CONDITIONS. (**POINT TO SHORT COLLAR CORRECTION OFFSET)**

BECAUSE THIS METHOD IS RELATIVELY INDEPENDENT OF REFERENCE FIELD VALUES OTHER THAN DECLINATION, IT MAY BE PARTICULARLY USEFUL IN FRONTIER OR OFFSHORE OPERATIONS WHERE IT MAY BE DIFFICULT OR COSTLY TO OBTAIN IFR QUALITY ACCURATE REFERENCE FIELD VALUES.

Declination Uncertainty

QUIET (<.3d)

DISTURBED (>.3d)

VERY DISTURBED (>1d)

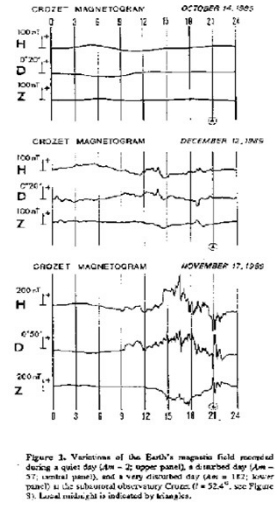


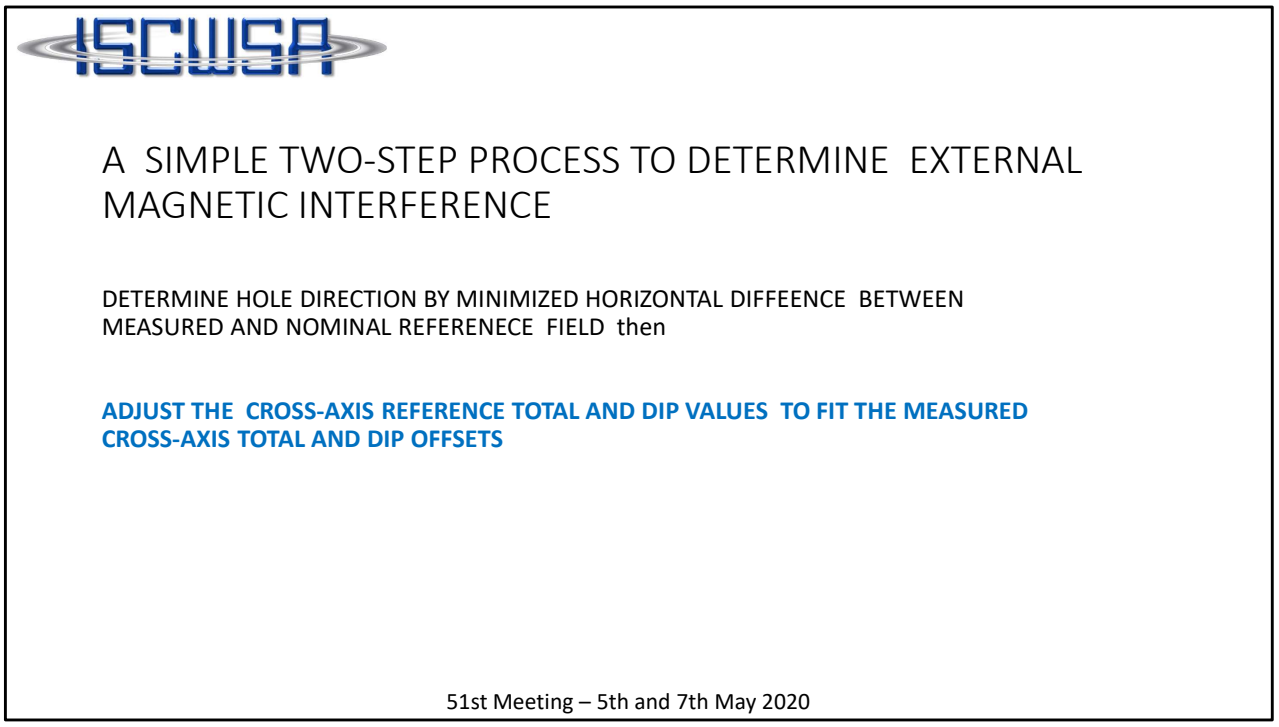
Figure 1. Variations of the Earth's magnetic field recorded during a quiet day (Am = 2; upper panel), a disturbed day (Am = 57; central panel), and a very disturbed day (Am = 182; lower panel) at the subauroral observatory Crozet (I = 52.4°; see Figure 9). Local midnight is indicated by triangles.

WALLACE CAMPBELL, AN INTRODUCTION TO QUIET DAY GEOMAGNETIC FIELDS, PURE AND APPLIED GEOPHYSICS 131, SEPT 1989

51st Meeting – 5th and 7th May 2020

SKIP DUE TO TIME LIMIT BUT OTHERWISE NOTE THAT WALLY DID A LOT OF WORK IN THIS AREA TO STATISTICALLY CHARACTERIZE DECLINATION CHANGES. MIGHT BE USEFUL TODAY WITH AI ALGORITHMS.

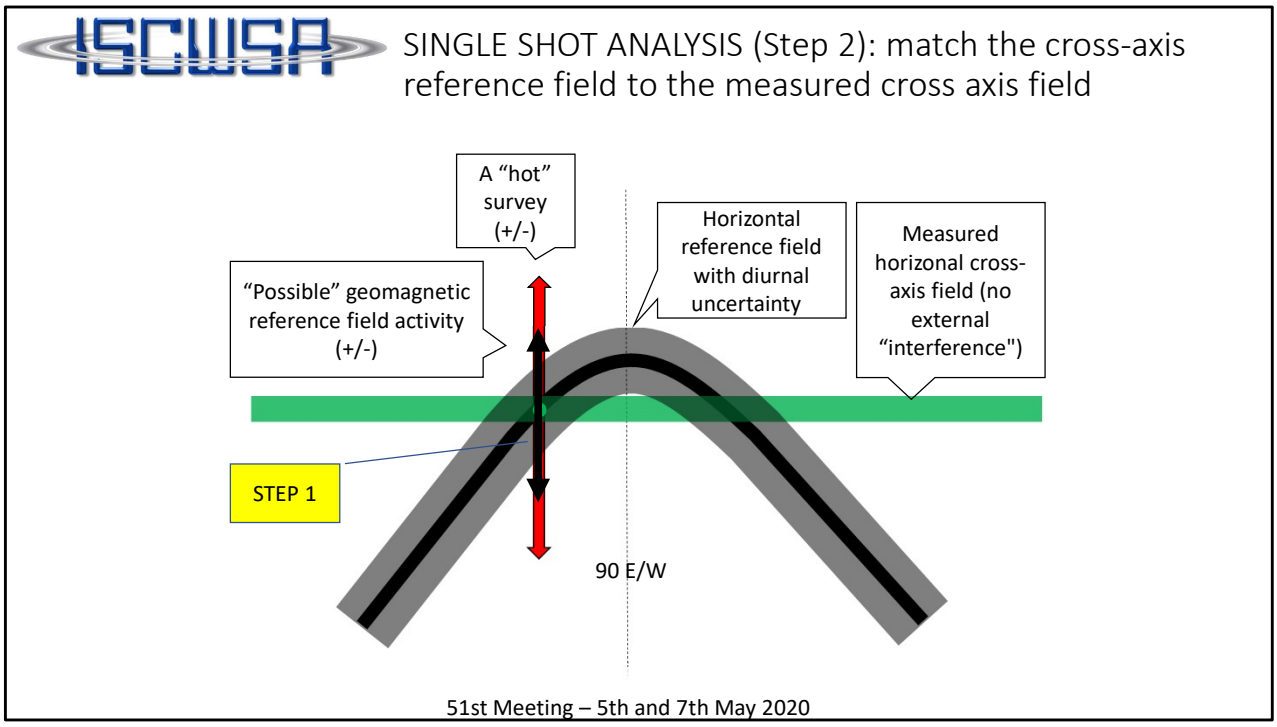
OPTIONAL HERE DEPENDING ON TIME



ESTIMATING THE INTERFERENCE THAT MAY BE ASSOCIATED WITH OFFSET WELLBORES IS ANOTHER FEATURE OF THIS METHOD

FIRST STEP, THE HOLE DIRECTION IS DETERMINED BY THE BEST FIT OF **THE NORMALISED VALUES OF MEASURED AND REFERENCE CROSS AXIS FIELDS.**

THEN THE NORMALIZING CONSTRAINT IS REMOVED TO **DETERMINE THE ACTUAL CROSS AXIS INTERFERENCE AND GEOMAGNETIC OFFSET RELATIVE TO THE PUBLISHED REFERENCE FIELD.**



WITH THE HOLE DIRECTION KNOWN FROM THE NORMALIZED CROSS AXIS FIELD VALUES IN STEP 1 WE CAN ADJUST THE "INSTANTANEOUS" REFERENCE FIELD BTOTAL AND DIP TO GET A BEST FIT IN THE CROSS-AXIS PLANE. **THE RESULTING BTOTAL AND DIP OFFSETS ARE DUE GEOMAGNETIC VARIATIONS ABOUT THE AVERAGE REFERENCE FIELD, LOCAL GEOLOGY, OR OFFSET WELLBORE INTERFERENCE**. DEVIATIONS DEVIATION OF REFERENCE FIELD VALUES FROM THE PREVIOUS "MEAN" ARE DUE TO LOCAL GEOLOGY OR OFFSET WELLBORE INTERFERENCE. OF COURSE IT TAKES A FEW SHOTS TO ESTIMATE A MEAN. (NOTHING IS PERFECT!!)

THE ADJUSTED CROSS AXIS REFERENCE AND MEASURED FIELD VALUES ARE RESOLVED TO HIGHSIDE AND RIGHT COMPONENTS TO DETERMINE THE NET HIGHSIDE AND RIGHT "INTERFERENCE", THE COMPONENTS OF THE RED AND BLACK ARROWS IN THE HS AND RIGHT DIRECTIONS.

KEEP IN MIND, THE METHOD **DOES NOT** CORRECT FOR THE LARGE VALUES OF CROSS-AXIS INTERFERENCE THAT ARE SHOW HERE ONLY TO ILLUSTRATE.

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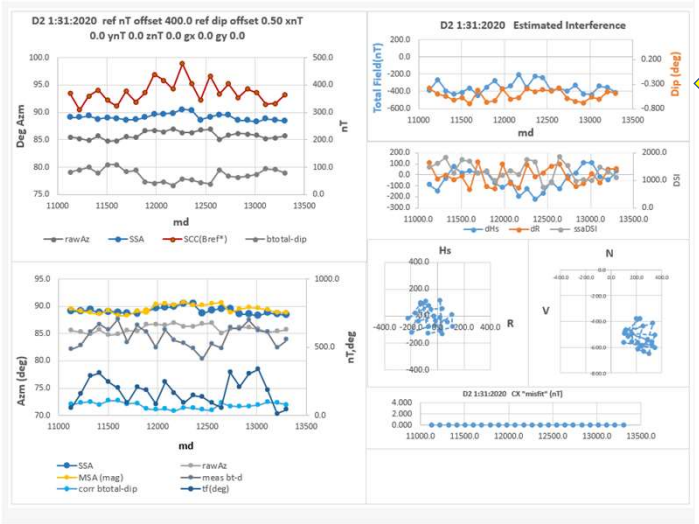
A close approach warning?



Keep an eye on interference and check geomagnetic monitors to avoid false alarms

51st Meeting – 5th and 7th May 2020

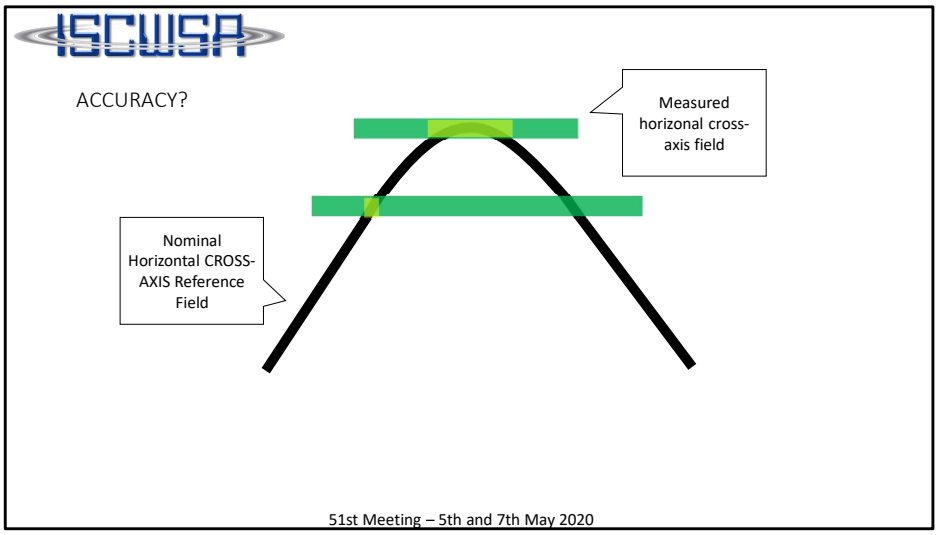
THE METHOD CAN PROVIDE A PRELIMINARY INDICATION OF OFFSET WELLBORE INTERFERENCE AND ENABLE FOLLOWUP LOCATION OF THE OFFSET WELLBORE BY MEANS OF PASSIVE MAGNETIC RANGING.

THE INTERFERENCE COMPONENTS SEEN HERE **(YELLOW ARROW)** ARE DUE TO VARIATIONS IN THE REFEENCE FIELD. **AN OFFSET WELLBORE WOULD BE INDICATED BY "CORRELATED" INTERFERENCE COMPONENTS.**

AN UNEXPECTED LEVEL OF INTERFERENCE RELATIVE TO PREVIOUS SHOTS CALLS FIRST FOR A QUICK CHECK OF THE NEAREST GEOMAGNETIC OBSERVATORY TO DETERMINE IF THE INTERFERENCE IS DUE PRIMARILY TO GEOMAGNETIC ACTIVITY OR A POSSIBLE APPROACH TO AN OFFSET WELLBORE.

MY EXPERIENCE WITH PASSIVE MAGNETIC RANGING INDICATES THAT FOR LOW ANGLE-NEAR PARALLEL APPROACHES TO OFFSET WELLBORES, WE HAVE AN OPPORTUNITY TO DETECT AND AVOID UNWANTED PROXIMITY.

DISCUSS LATER IF WE HAVE TIME!!



THE METHOD DOES NOT CORRECT FOR “LARGE” VARIATIONS IN THE REFERENCE FIELD OR INTERFERENCE FROM OFFSET WELLBORE CASING. THIS IS A SUBJECT FOR DISCUSSION, BUT NO TIME HERE. WE ARE TRYING TO STAY WITH A “SIMPLE” SINGLE SHOT METHOD. HOWEVER, AS NEEDED, IT WOULD BE POSSIBLE TO “UPDATE” THE REFERENCE FIELD ESTIMATES AFTER SEVERAL QUIET SHOTS.

ACCURACY DEPENDS ON THE SENSITIVITY OF THE MATCHING METHOD AND OF COURSE MWD SENSOR NOISE RELATIVE TO THE HORIZONTAL FIELD. THIS IS INDICATED HERE BY THE WIDTH OF THE GREEN LINE

THE UNCERTAINTY IN THE METHOD IS GREATEST NEAR THE TOP OF THE CURVE AS MIGHT BE EXPECTED, E/W THE AZIMUTH ESTIMATE IS STILL UNCERTAIN +/- DECLINATION VARIATIONS.

IT LOOKS LIKE, BUT NEEDS VERIFICATION, THAT THE ONLY SOURCES OF AZM “ERROR” OTHER THAN LARGE OFFSET OR REFERENCE INTEFERENCE ARE SENSOR MISALIGNMENTS AND TOLERANCES SET BY THE NON-LINEAR FITTING METHOD.

SHORT OF MORE MSA COMPARISONS, IN HOLE ROLL CHECK DATA WITH A **SLICK** BHA WOULD PROVIDE A USEFUL VERIFICATION OF THESE COMMENTS.

Advantages for real-time survey management

1. Stable, less affected by reference error or geomagnetic activity (other than declination offset and changes)
2. Earliest possible accurate survey out of shoe. Accounts for significant axial interference from shoe.
3. Enables quick corrective survey checks after slides
4. Shorter bit-to-sensor spacing is enabled (axial magnetic sensor not used)
5. A possible collision warning for near-parallel approaches
6. (In-hole declination with a gyro check?)

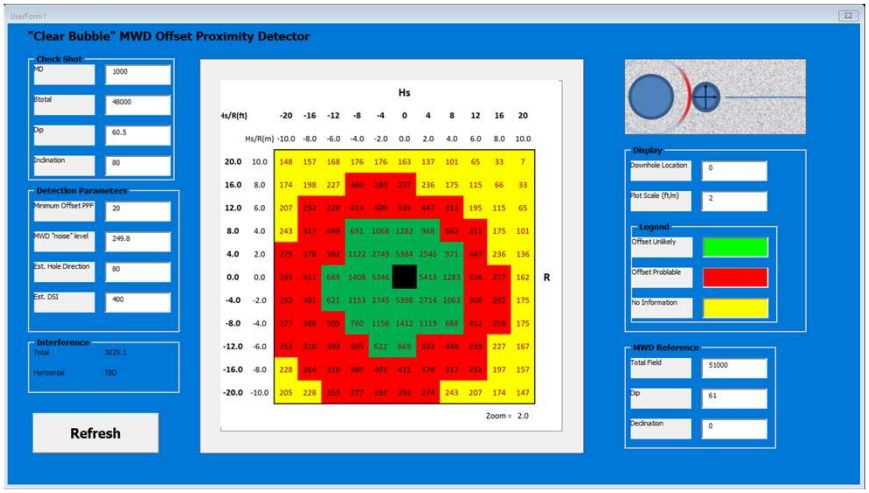
THIS IS AN OPEN SOURCED OPPORTUNITY FOR IMPROVED MWD SURVEY MANAGEMENT. COMMERCIAL BELLS AND WHISTLES AND USERFRIENDLY INTERFACES ARE WELL BEYOND MY CAPABILITIES.

IMAGINE A FUTURE OPS CENTER SCREEN THAT PROVIDES A REAL TIME TRACE OF CORRECTED SURVEYS, DSI, OFFSET INTERFERENCE AND GEOMAGNETIC FIELD ACTIVITY FROM NEAREST OBSERVATORY.

MANY SECOND TIER JOBS TOTAY DO NOT HAVE BENEFIT OF OPS CENTER LEVEL EXPERTISE AND DIRECT LINKS TO REAL TIME GEOMAGNETIC MONITORS. CALLOUT SUPPORT WOULD BE NEEDED.

THE SIMPLE METHOD THAT I DESCRIBED HERE MAY ENABLE QUICK RECOGNITION OF OFFSET INTERFENCE AND ELIMINATION OF FALSE ALARMS DUE TO GEOMAGNETIC ACTIVITY.

A BETTER “CLEAR BUBBLE”?



51st Meeting – 5th and 7th May 2020

IF TIME PERMITS . . . I HAD EXPECTED TO PRESENT THIS A FEW YEARS AGO BUT WAS NOT ABLE DUE TO PERSONAL CONFLICTS. THANKS ANYWAY ROSS AND JONATHAN FOR THE ACCEPTANCE. BRIEFLY, THE INTERFERENCE MARKER BTOTAL-DIP INTRODUCED TO THIS GROUP BY TORGEIR TORKILDSEN MANY YEARS AGO MAY HAVE A NEW LIFE

BECAUSE WE NOW HAVE AN IN-SITU ESIMATE OF THE REFERENCE FIELD WE CAN REFINE THE CALCULATION OF BTOTAL-DIP VALUES AS THEY ARE USED IN THE CLEAR BUBBLE DISPLAY. OLLI COKER WHO MIGHT STILL BE ATTENDING THESE MEETING FIRST PROPOSED THIS TO ME AS AN ANALOG OF ACOUSTIC COLLISION AVOIDANCE IN SUBMARINES.

BECAUSE WE NOW HAVE A BETTER WAY TO ESTIMATE INTERFERENCE THIS IS A GOOD TIME TO MENTION THE “CLEAR BUBBLE CONCEPT FOR EARLY WARNING OF OFFSET WELLS. THINK OF IT AS A “WHAT IT” DIAGRAM. “WHAT IF” THE INTERFERENCE IS DUE TO AN OFFSET CASING OF WEIGHT GREATER THAN A SPECIFIED WEIGHT? WHERE WOULD IT NOT BE POSSIBLE FOR THE CASING TO BE LOCATED? **(INDICATE WITH POINTER)**

GREEN MEANS IMPOSSIBLE FOR A CASING OF THIS WEIGHT OR GREATER TO BE CAUSE OF THE OBSERVED INTERFERENCE. RED MEANS THAT THE OBSERVICED INTERFERENCE IS LIKELY CAUSED BY A CASING STRING OF THIS WEIGHT OR GREATER. YELLOW MEANS NOISE LEVELS PREVENT DETERMINATION.

THIS IS A VERY SIMPLIFIED FORM OF INTEFERENCE DETECTION. IF THE PLAN-AHEAD REQUIRES DRILLING INTO THE RED AREA IT WOULD BE ADVISABLE TO PROCEED CAUTIOUSLY WITH CHECK SHOTS TO ENABLE PMR IF NEEDED.