Science & Technology Facilities Council

Diffraction Model Comparisons

using the

ITU-R 3K1 Correspondence Group Database

Ken Craig, Mike Willis,

Nick Thomas, Sarah Callaghan

Rutherford Appleton Laboratory

UK

ISART 2008, 3 June 2008

Data

- Used "cleaned" 3K1 Correspondence Group measurement database as described in preceeding presentation
- The subset of data used in this model testing used 26 datasets
  - 15 EBU, 2 US, ABU, Swiss, COST210, 6 Sandell
- 5316 links/data files accepted as defined by the data flags:
  - IsValid = 1
  - IsWorstMonth = 0
  - IsTopHeightInGroup = 1
  - InputsValid = 1
  - IsLongTerm = 0 and 1

Science & Technology Facilities Council

Models

- P.1546-3
- P.1812 as published (3-edge diffraction model)
- P.1812, but using the Bullington diffraction model (including the empirical, path length dependent, correction term and the line-of-sight taper, as described in Document CGD-05)
- P.1812, but using 3 variations of the US FCC PTP diffraction model that incorporates corrections for rounded obstacles. This model is described below.
- P.1812, but using the long path distance correction to the Bullington method given in 3K1 Correspondence Group Document CGD-16.

PTP Model

- H K Wong, 2002: “Field Strength Prediction in Irregular Terrain–the PTP Model”
  - 1998 FCC Notice of Proposed Rulemaking for FM service
  - Blends knife-edge and smooth-Earth diffraction losses in a way that takes account of the terrain roughness

- PTP Edge Loss = $J(v) + R \times (S(v) - J(v))$
  - v and $J(v)$ are as defined in P.1812
  - $S(v) = \max(21.66 + 27.35v, 0)$
  - $R = 75/(\Delta H + 75)$
  - ΔH is 90% of standard deviation of the terrain heights about the line of least squares fit to all available points within 10km of the edge

  - Here, three different assumptions have been made about the edges to which to apply the knife-edge/smooth-Earth blend

Metrics

- In the “raw”, unfiltered datasets, the probability density functions of the model-minus-measured path loss errors were often non-Gaussian (sometimes bimodal)
  - Implies that mean and standard deviation are not adequate as metrics

Science & Technology Facilities Council

Normality tests on raw data

- Different statistical tests give different (and often contradictory) results

- Table shows "normality" test on statistics of difference between P.1812 model and unfiltered measurements

Dataset	Points	Kstest	Lilliefors	Jarque-Bera	Chi-square
BBC	70	Y	Y	Y	N
BBCL	68	Y	Y	Y	Y
BBCn	274	Y	N	N	N
ERT	31	Y	N	Y	Y
HOL	73	Y	Y	N	Y
IRT	600	Y	N	N	Y
IRTL	156	Y	N	N	N
IRTs	63	Y	Y	Y	Y
ORF	497	Y	N	N	Y
RAI	87	Y	Y	Y	Y
S	107	Y	Y	N	Y
SUI	1247	Y	N	N	Y
Swiss	435	Y	N	N	N
TDF	72	Y	N	Y	Y
USPhase1	13639	N	N	N	N
USPhase2	11092	N	N	N	N
YLE	100	Y	Y	Y	Y
YLEs	51	Y	N	Y	N

Metrics

- However, the “cleaned”, filtered datasets are generally consistent with a Gaussian distribution (Doc 3K/30, this ITU-R meeting)
  - So can limit our metrics to mean and standard deviation

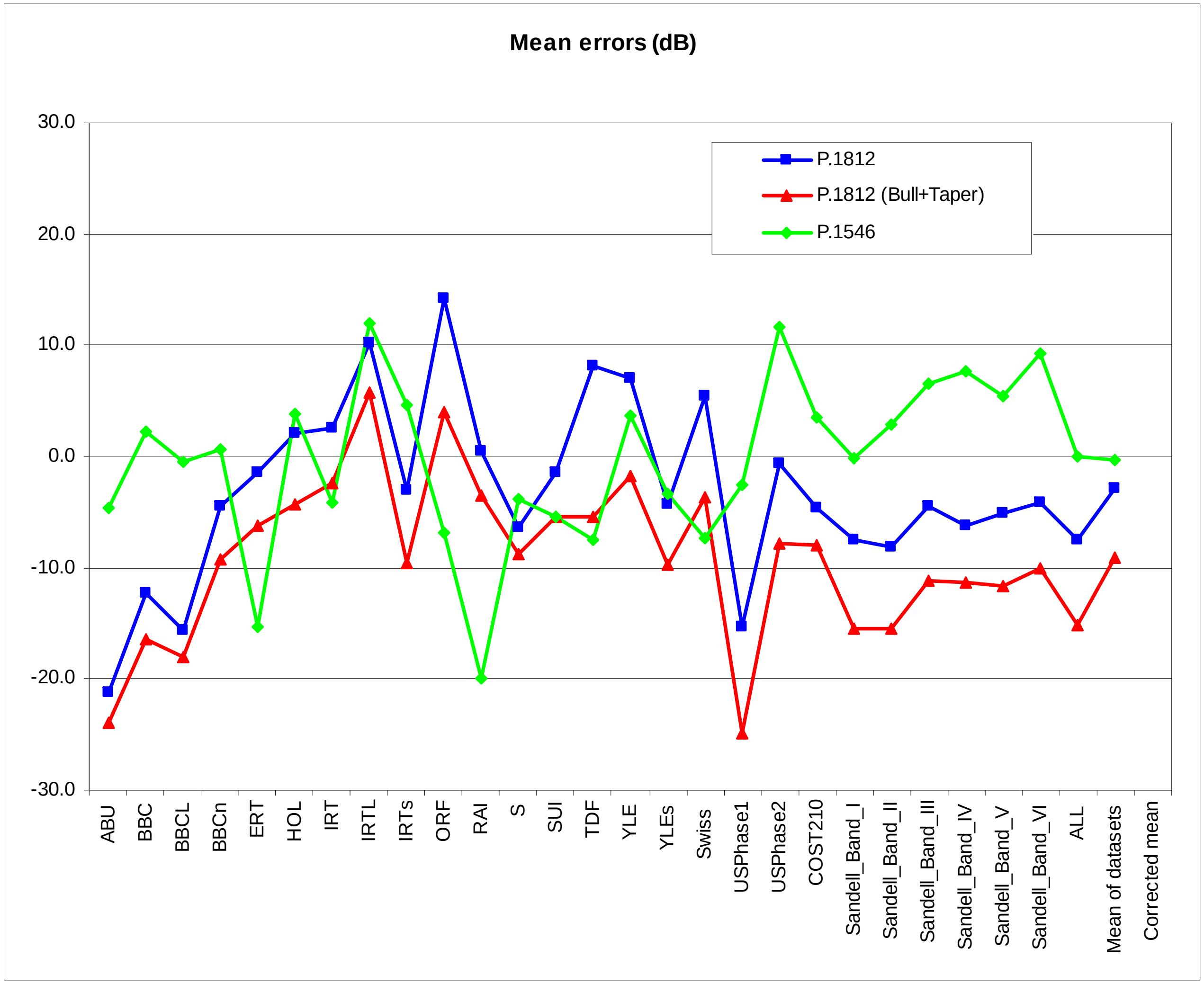
- Calculated mean and SD of each of the 26 datasets for all 7 models

- Calculated mean and SD of complete dataset with data combined in 3 ways

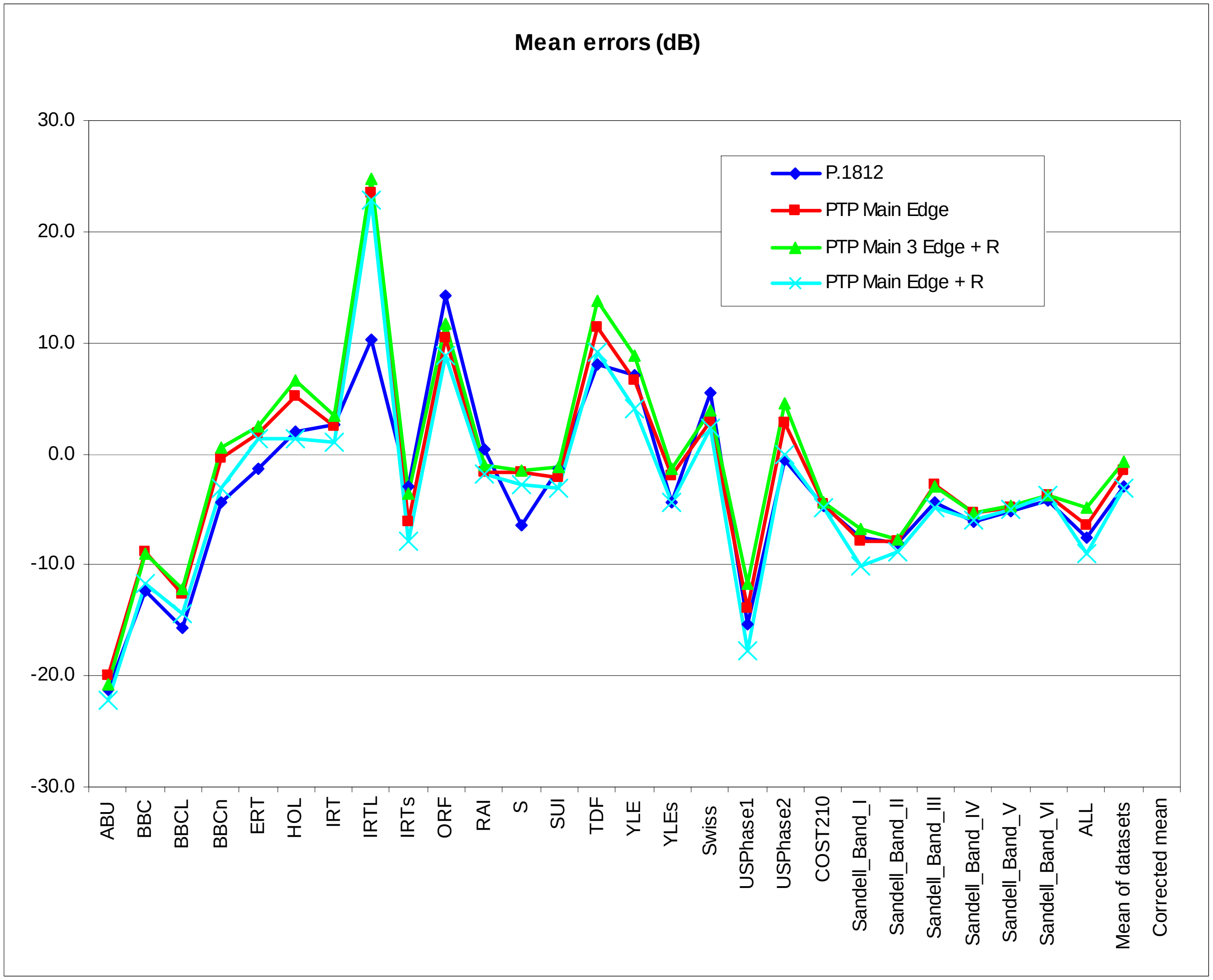
Metrics

- Three ways of combining the 19 individual datasets into one dataset were used
  - "ALL": all data points combined with equal weight, irrespective of data source. Assumes a single distribution
    - Appropriate if all data are equally good and unbiased
  - "Mean of datasets": "average" obtained by simply taking the mean of the individual dataset means and standard deviations
    - Gives equal weight to each dataset, rather than to each measurement
  - "Corrected mean" (standard deviation only): obtained by (a) "correcting" the individual measurement values by removing the mean error of each dataset and calculating the standard deviation of aggregated dataset
    - Corrects for measurement biases to first order

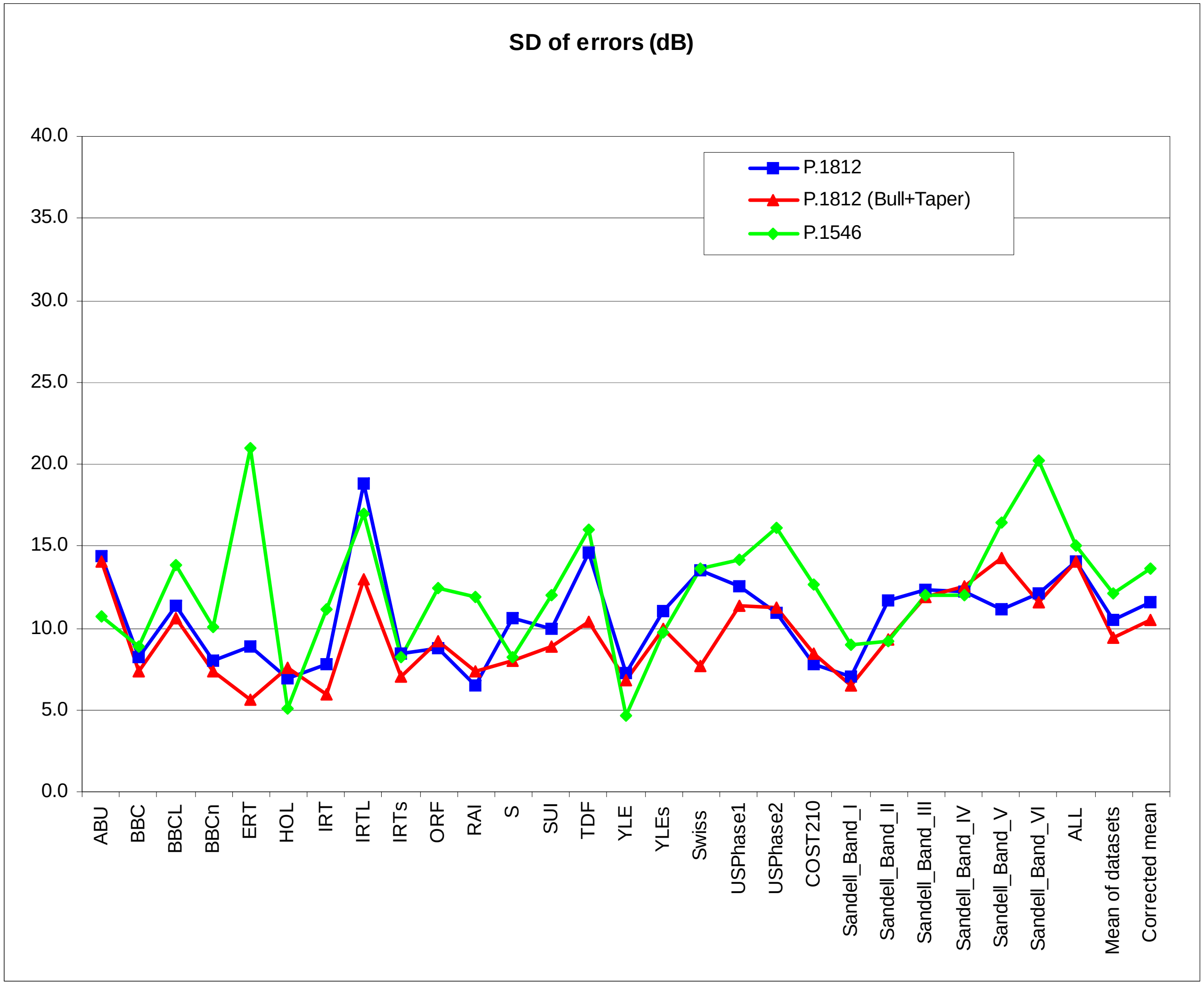
3-Edge/Bull/P.1546



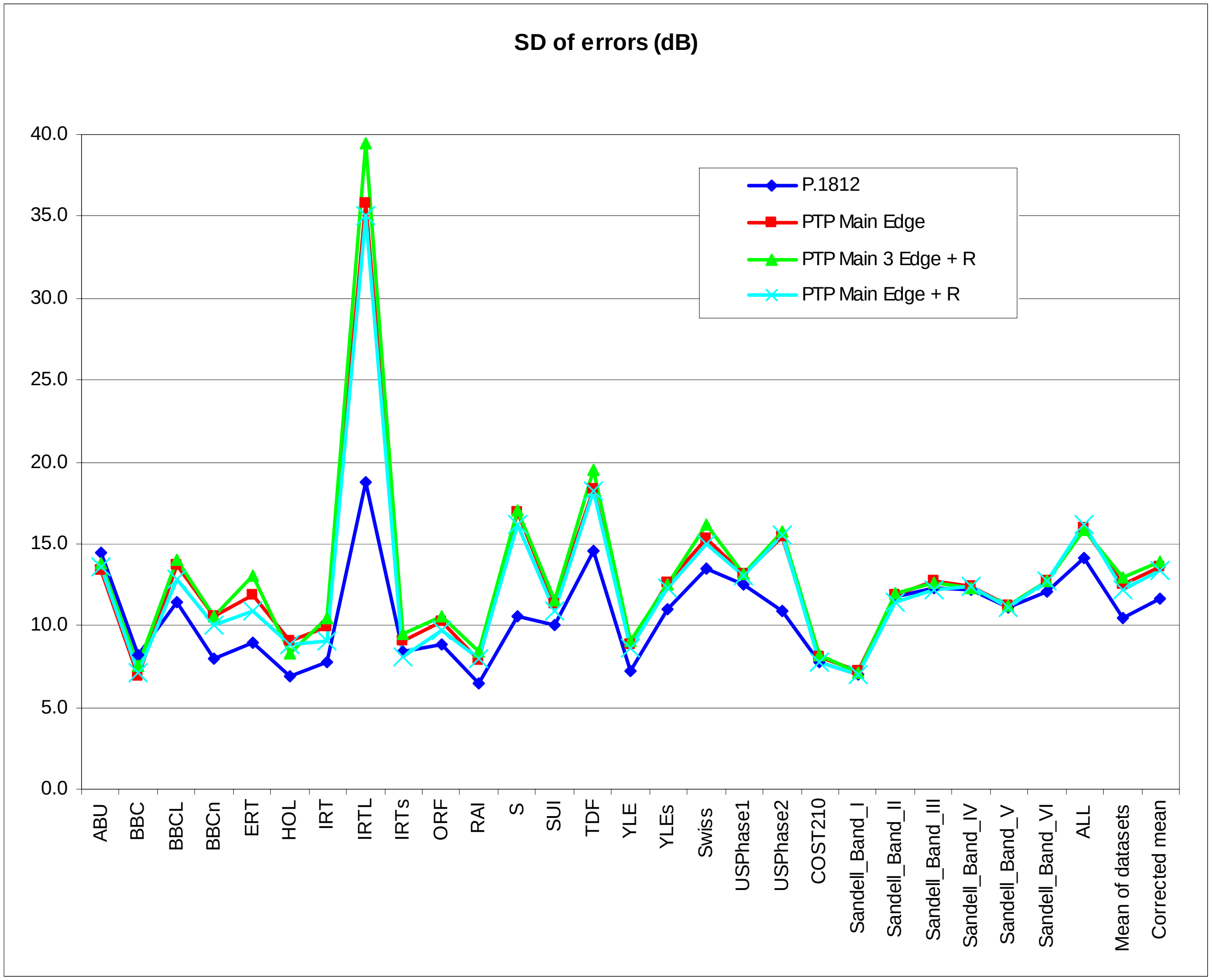
PTP + Variations



3-Edge/Bull/P.1546



PTP + Variations



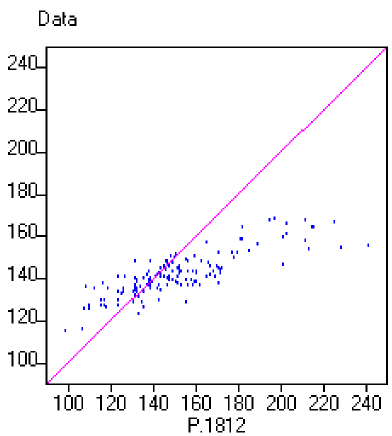
Points to Note

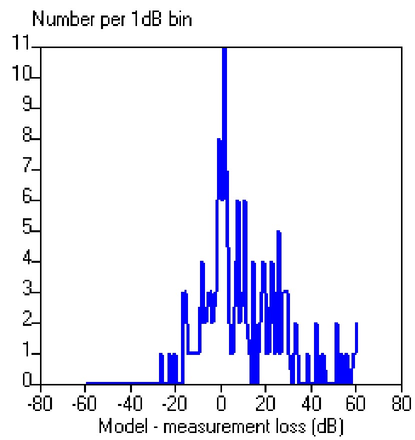
- Mean errors vary greatly from dataset to dataset (cf. CGD-05)
  - Dataset-to-dataset variation in mean error is greater than model-to-model variation !
  - But all terrain-based diffraction models show the same trends/biases
  - So, conclude that variations are probably due to measurement biases

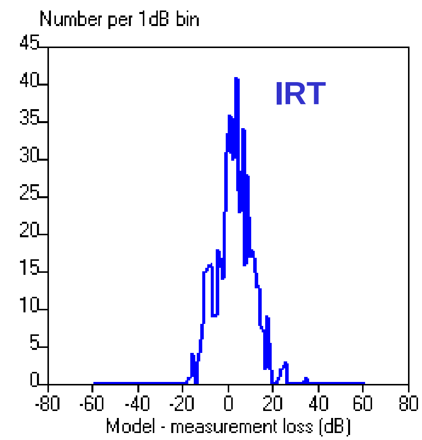
- Conclusions are supported by
  - Standard deviations
  - Scatter plots
  - Histograms of prediction errors

Two examples

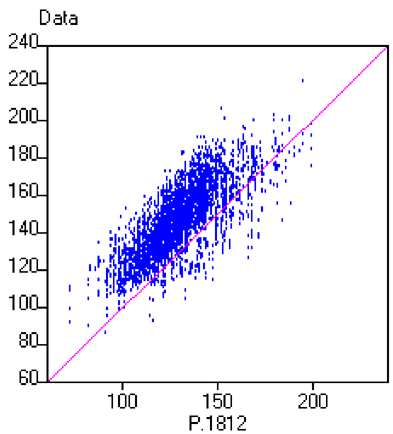
IRTL: model over-prediction; high SD => calibration issue?

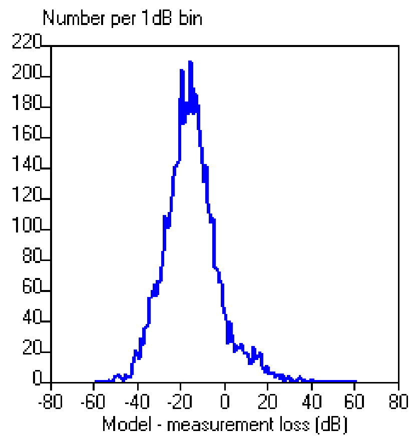


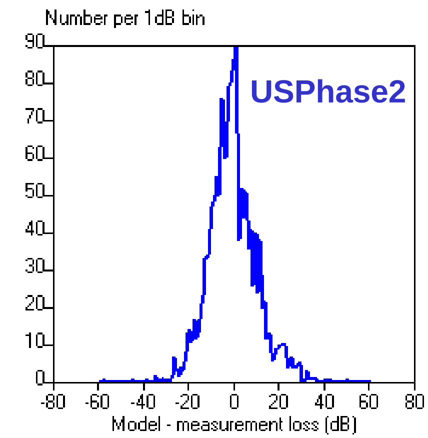




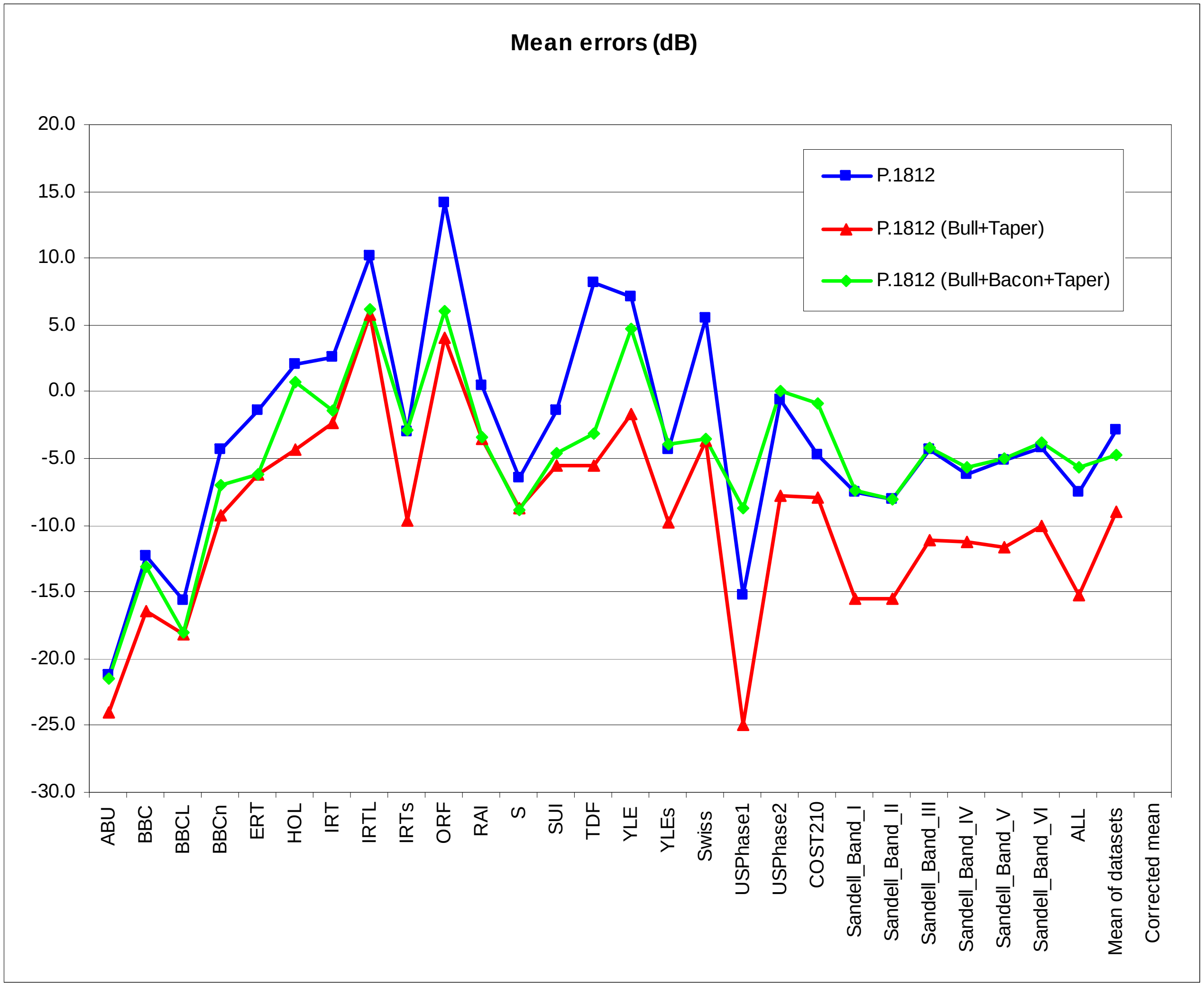
USPhase1: model under-prediction; low SD => missing clutter



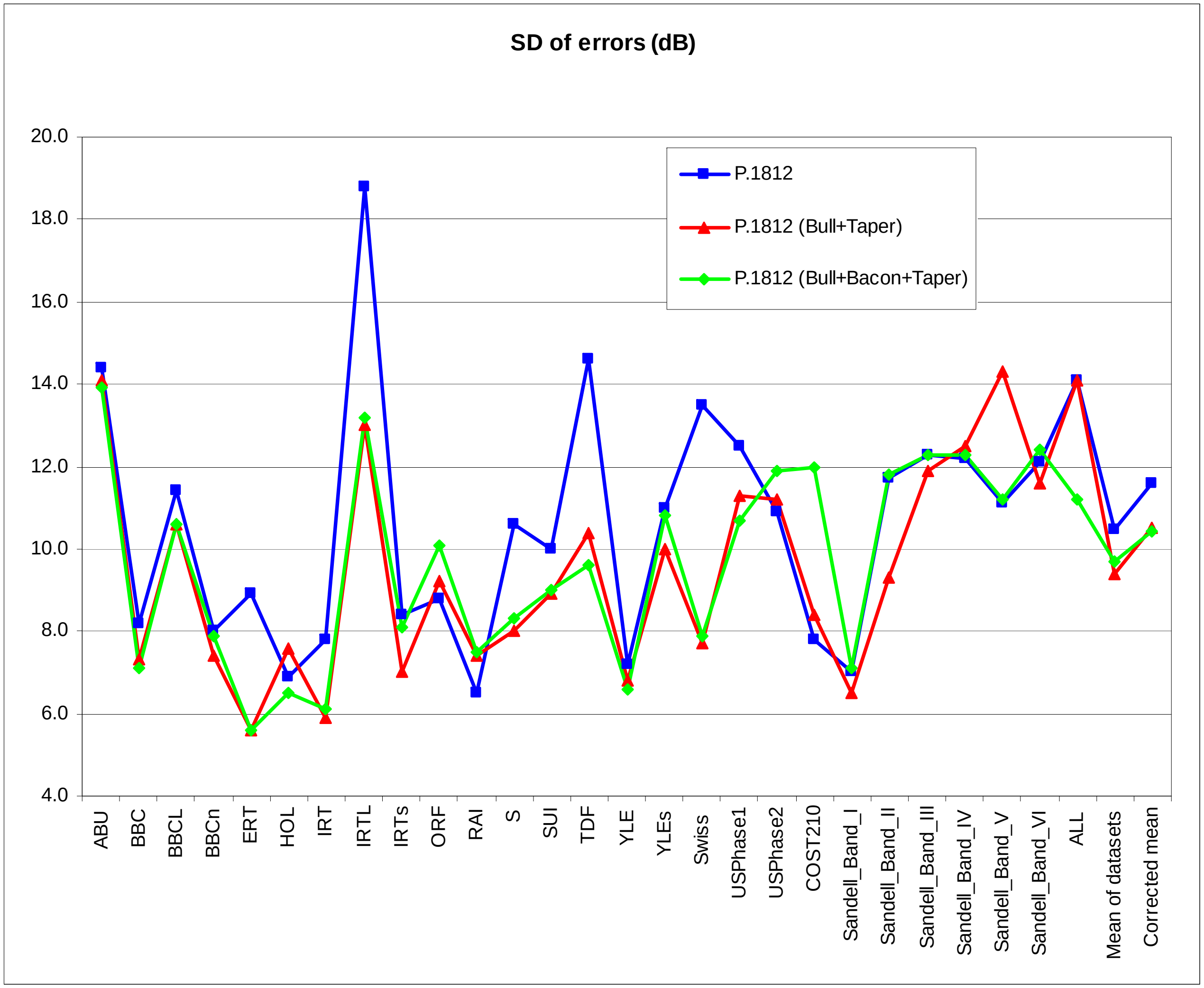




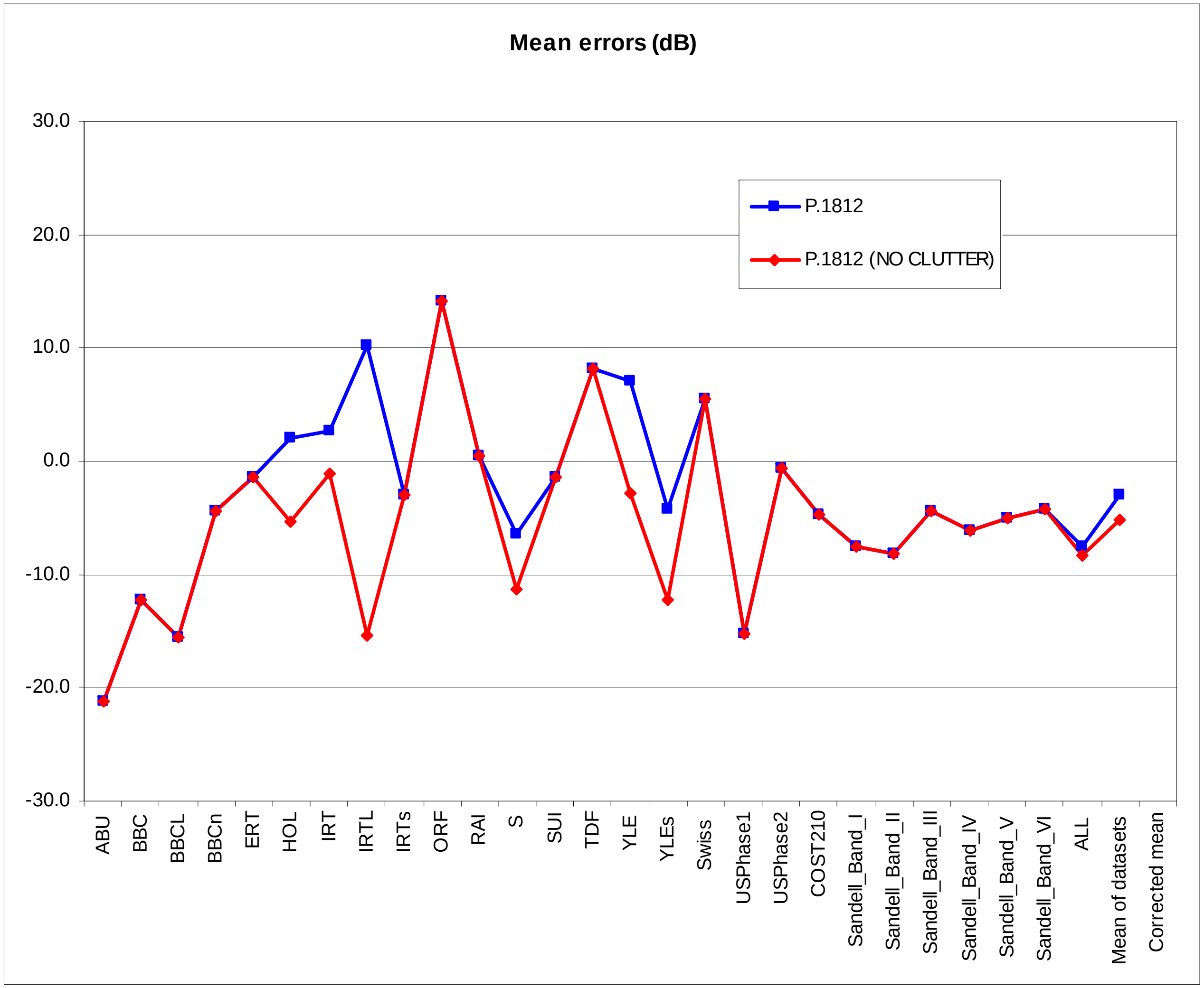
3-Edge/Bull/CGD-16



3-Edge/Bull/CGD-16

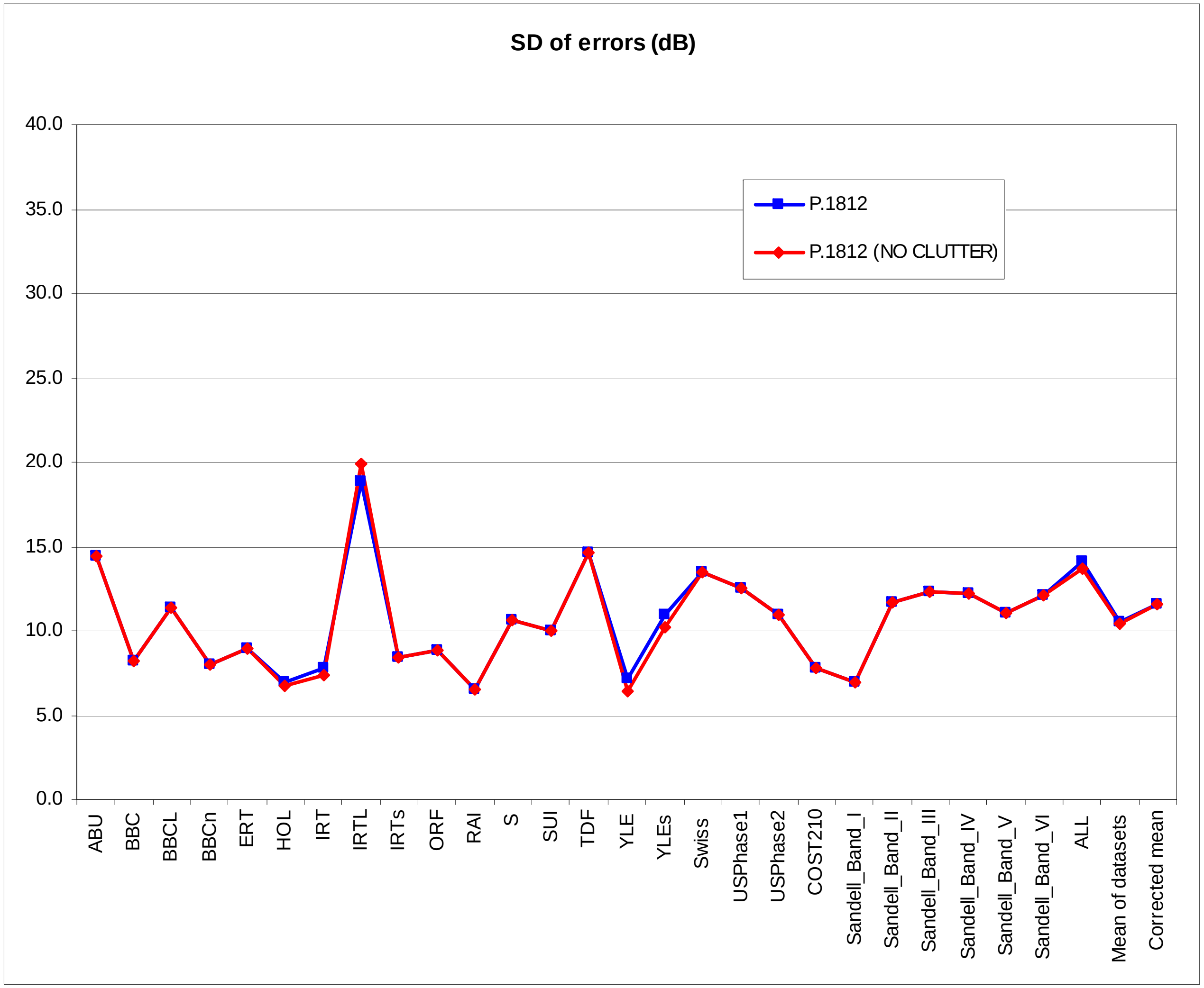


Clutter



Mean errors (dB)
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
P.1812
P.1812 (NO CLUTTER)
ABU
BBC
BBCL
BBCn
ERT
HOL
IRT
IRTL
IRTs
ORF
RAI
S
SUI
TDF
YLE
YLEs
Swiss
USPhase1
USPhase2
COST210
Sandell_Band_I
Sandell_Band_II
Sandell_Band_III
Sandell_Band_IV
Sandell_Band_V
Sandell_Band_VI
ALL
Mean of datasets
Corrected mean

Clutter



SD of errors (dB)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
P.1812
P.1812 (NO CLUTTER)
ABU
BBC
BBCL
BBCn
ERT
HOL
IRT
IRTL
IRTs
ORF
RAI
S
SUI
TDF
YLE
YLEs
Swiss
USPhase1
USPhase2
COST210
Sandell_Band_I
Sandell_Band_II
Sandell_Band_III
Sandell_Band_IV
Sandell_Band_V
Sandell_Band_VI
ALL
Mean of datasets
Corrected mean

Conclusions 1

- Can’t make best choice decision on mean errors
  - Well-known fact, and most “practical” models have empirical corrections
  - But Bullington generally underpredicts 3-edge and both underpredict P.1546
- All PTP model variations give similar results
  - Smooth-Earth corrections don’t make much difference on these datasets
- Standard deviations similar across datasets
  - SD is a better metric than mean
  - SD of Bullington is generally less than 3-edge and P.1546

Conclusions 2

- Long- path distance correction model of Document CGD-16
  - Overall mean errors similar to 3-edge and smaller than Bullington
  - Overall SD is better than either 3-edge or Bullington
- Clutter
  - Including clutter in the models does increase the loss ☺
  - But it increases the SD of the error ☹
  - Too few datasets have clutter information for firm conclusions
- Recommendation
  - On the basis of these model-measurement comparisons, the CGD-16 model should be used