Diffraction Model Comparisons

using the

ITU-R 3K1 Correspondence Group Database

Ken Craig, Mike Willis,
Nick Thomas, Sarah Callaghan

Rutherford Appleton Laboratory
UK

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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

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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.

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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

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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

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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

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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

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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

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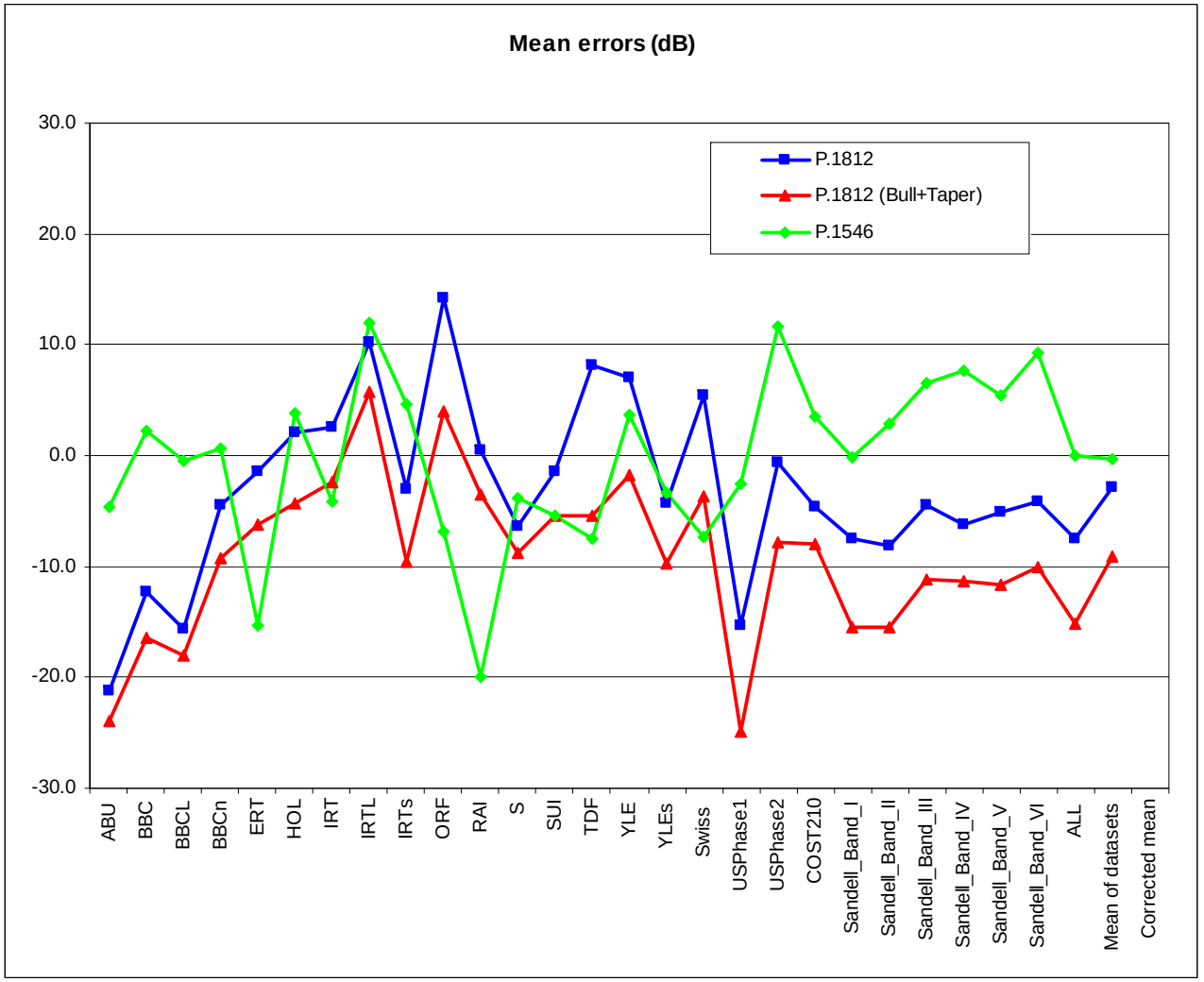
3-Edge/Bull/P.1546



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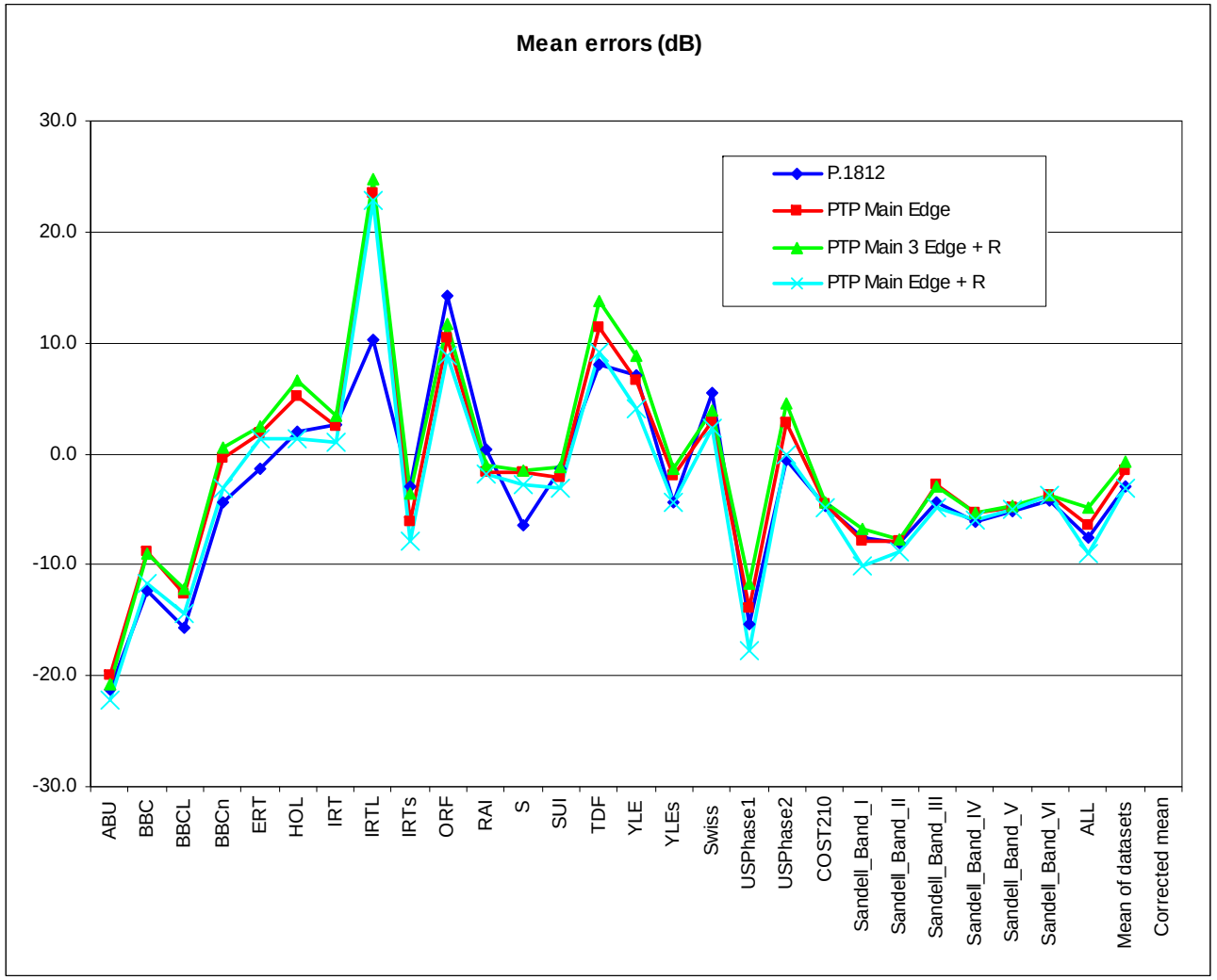
PTP + Variations



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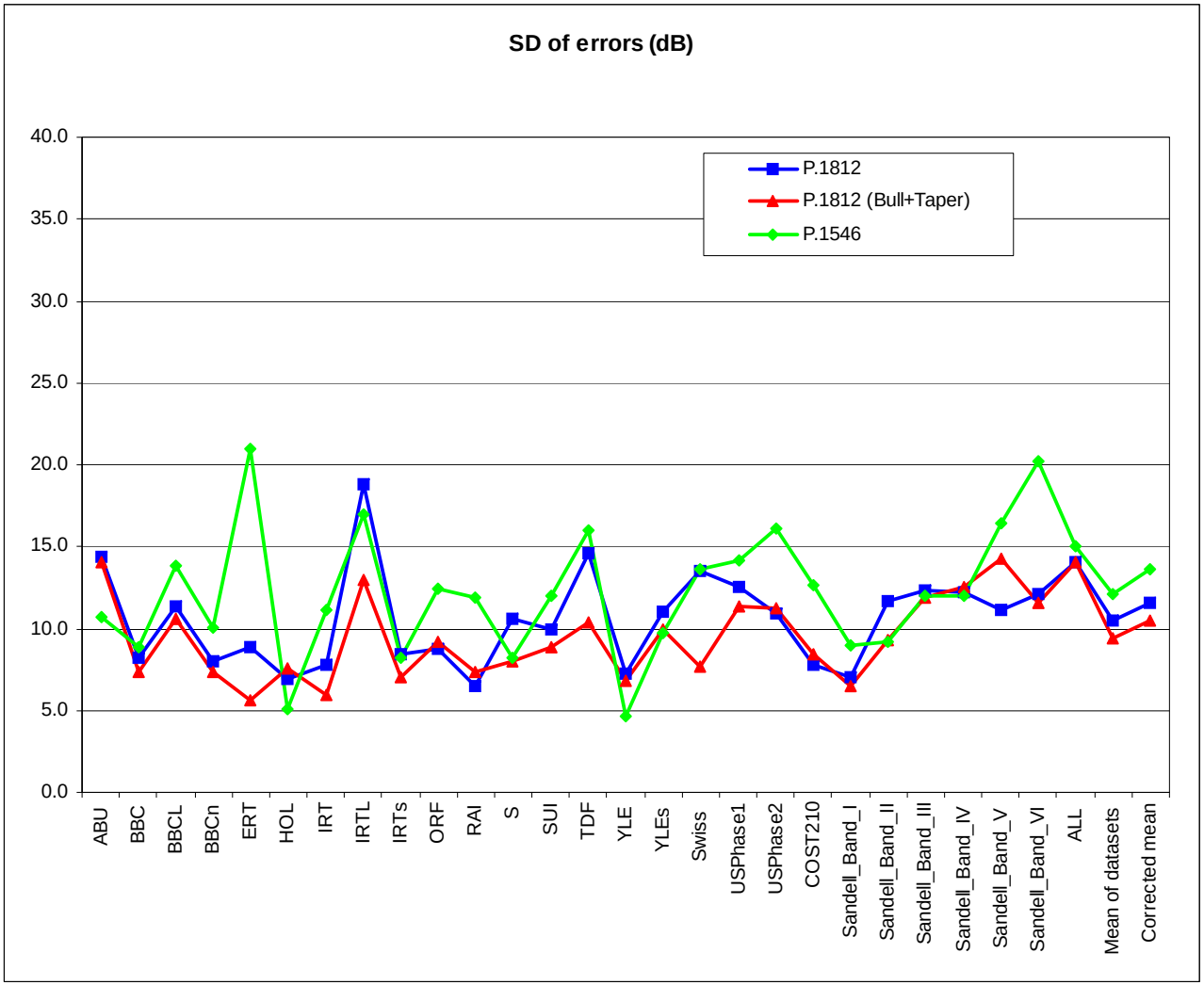
3-Edge/Bull/P.1546



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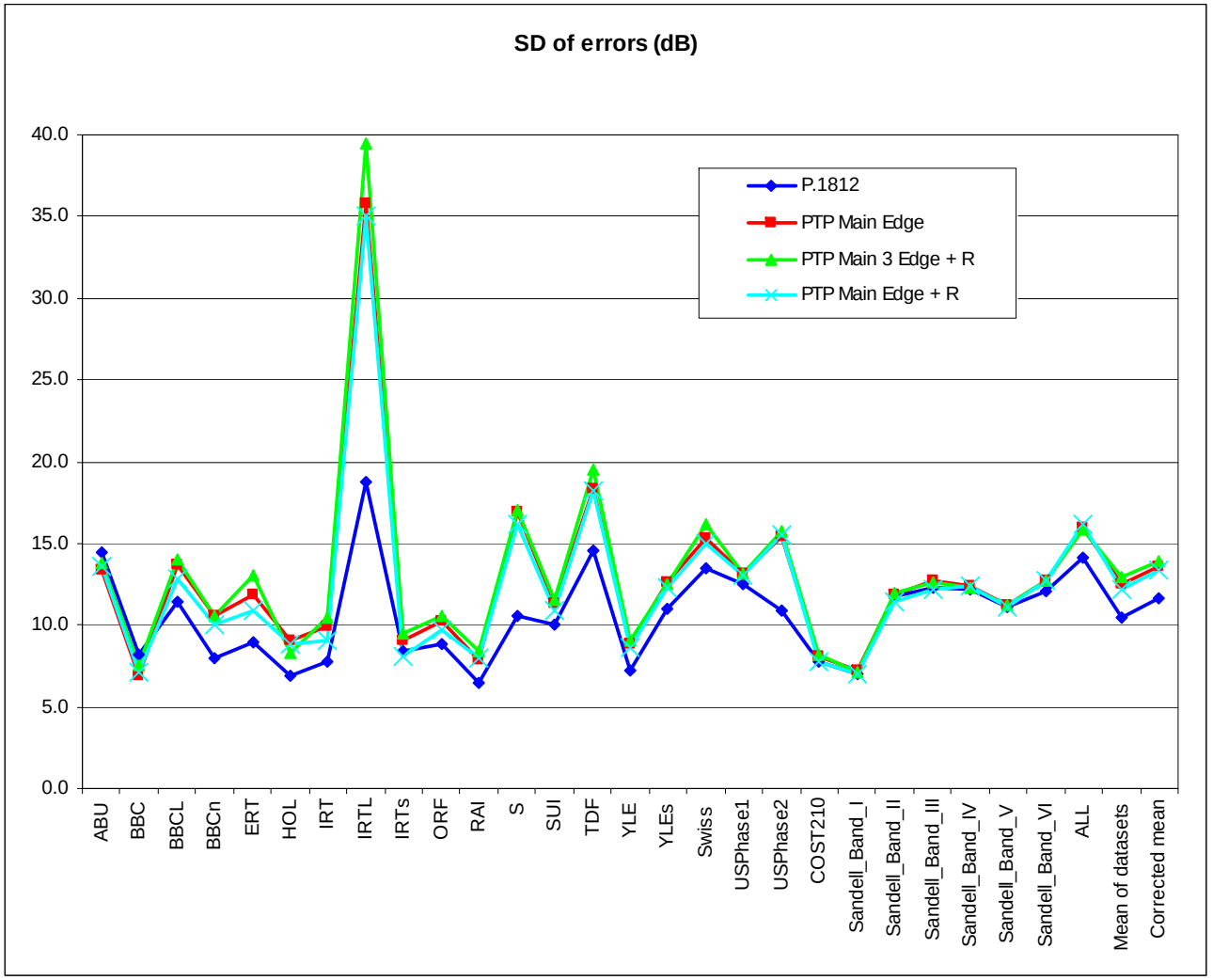
PTP + Variations



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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

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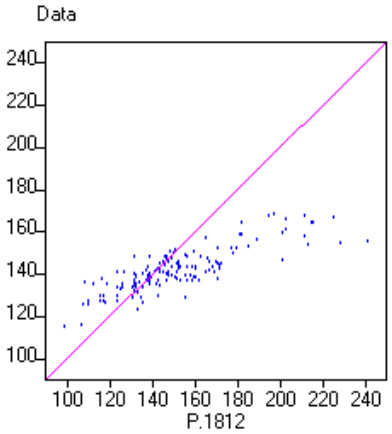
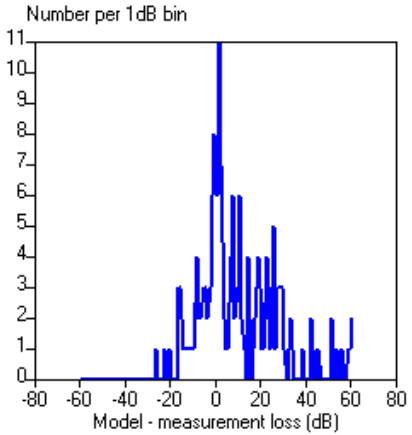
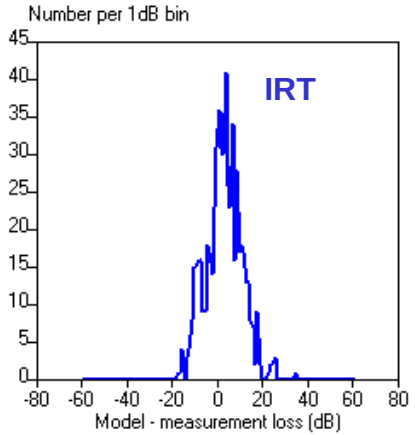
Two examples

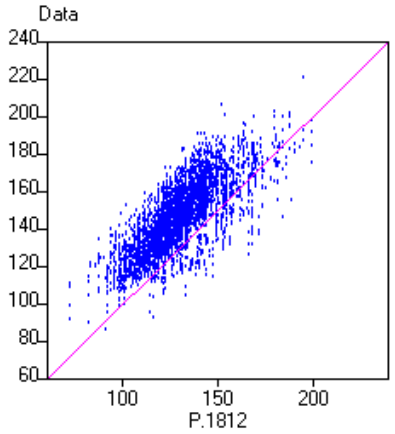
IRTL: model over-prediction; high SD => calibration issue?

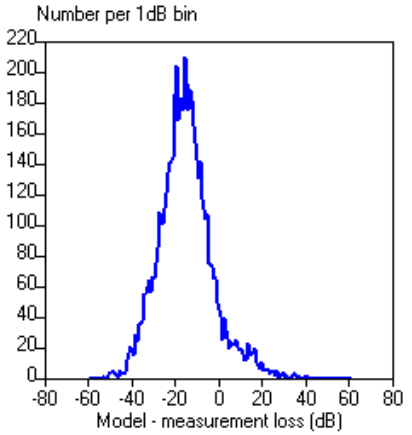


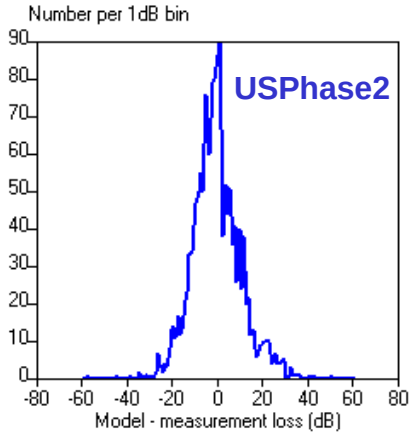




USPhase1: model under-prediction; low SD => missing clutter







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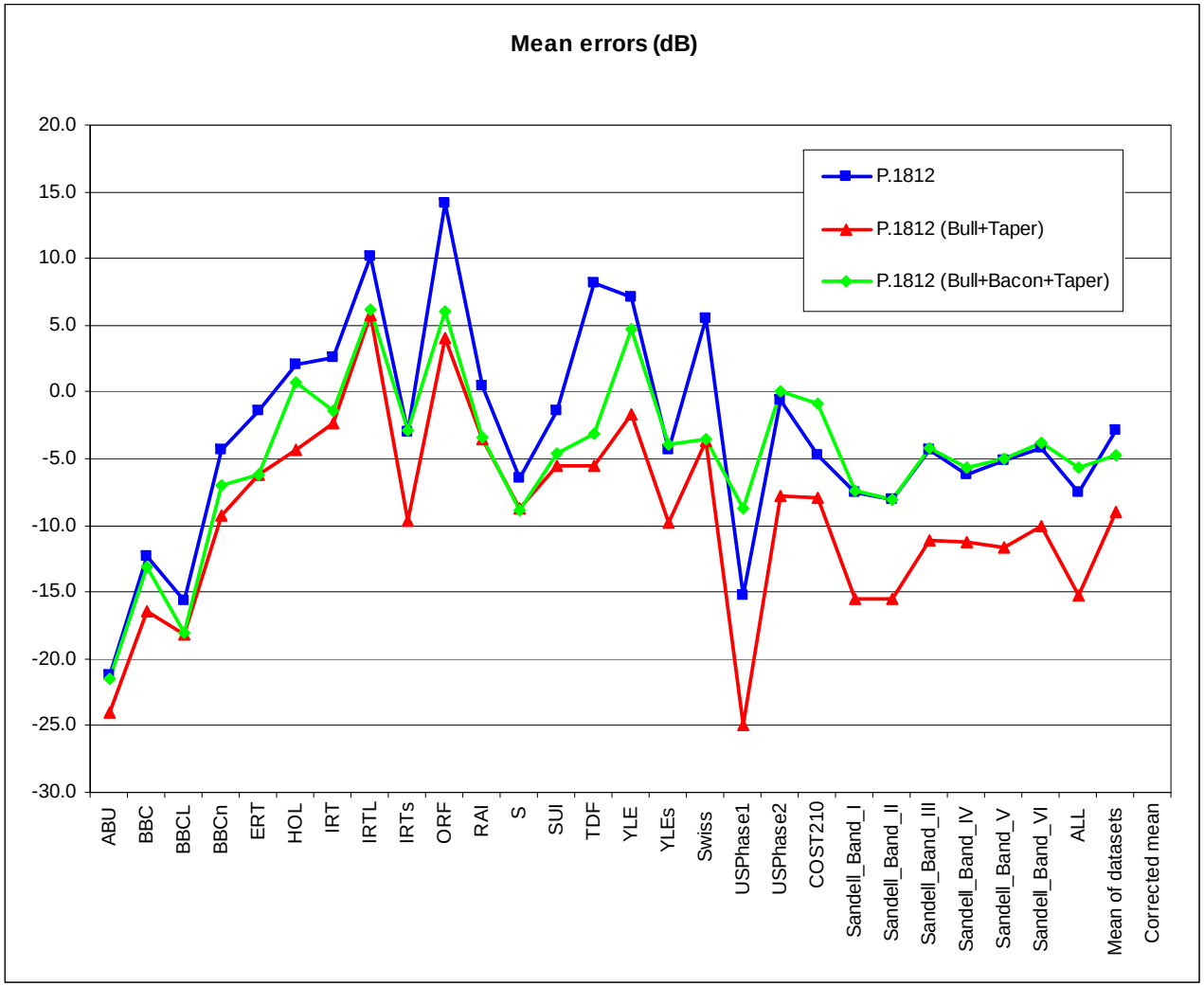
3-Edge/Bull/CGD-16



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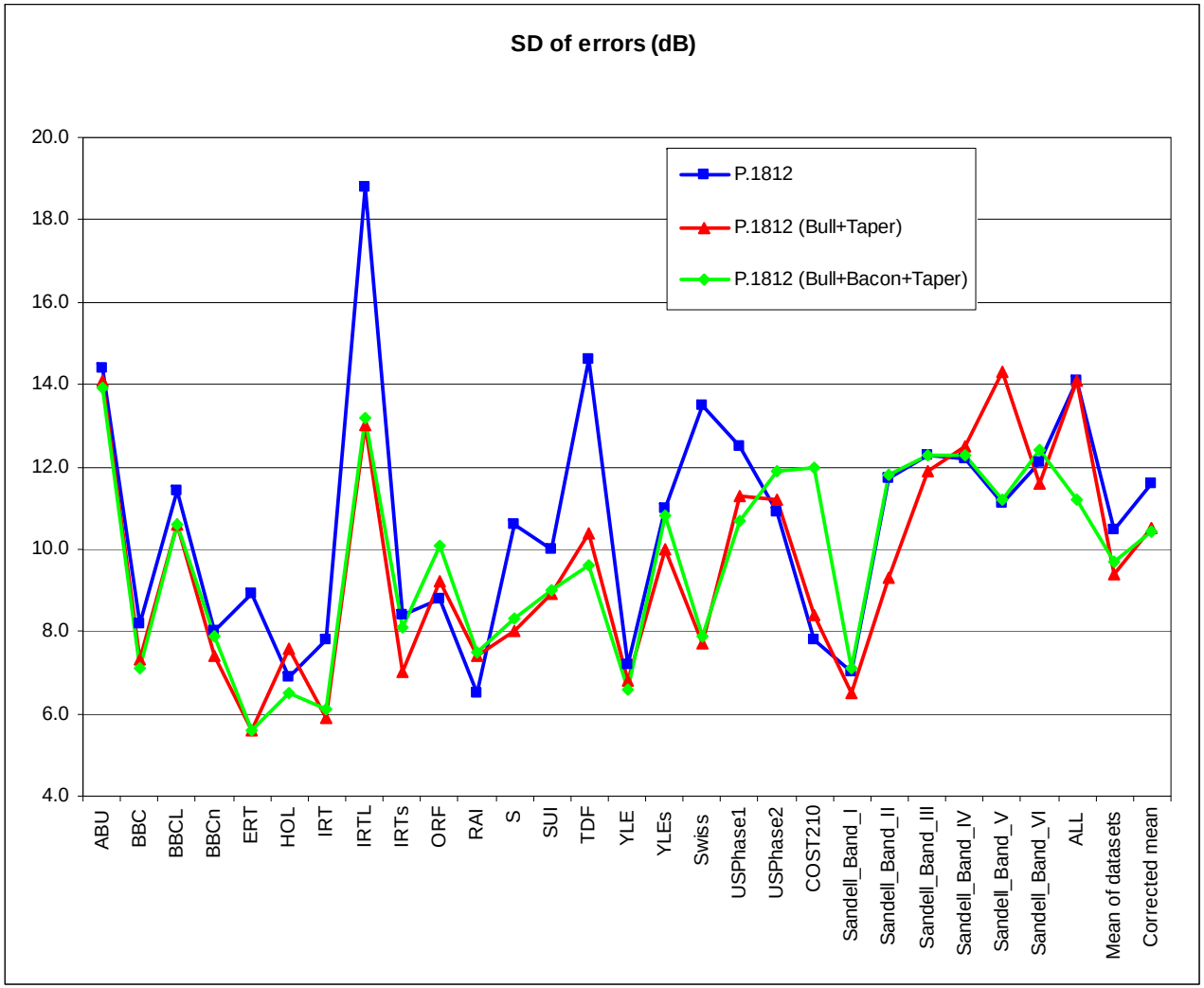
3-Edge/Bull/CGD-16



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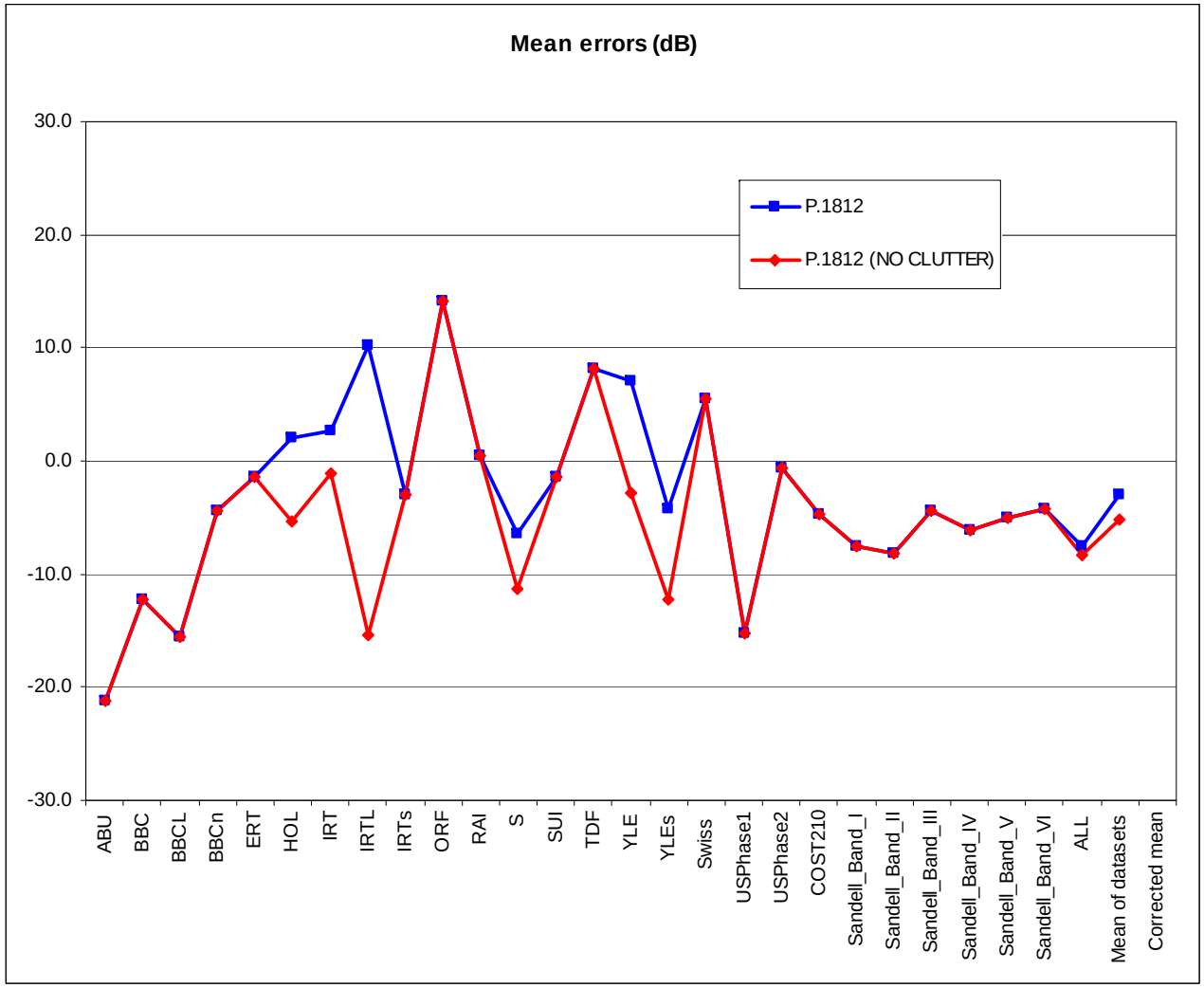
Clutter



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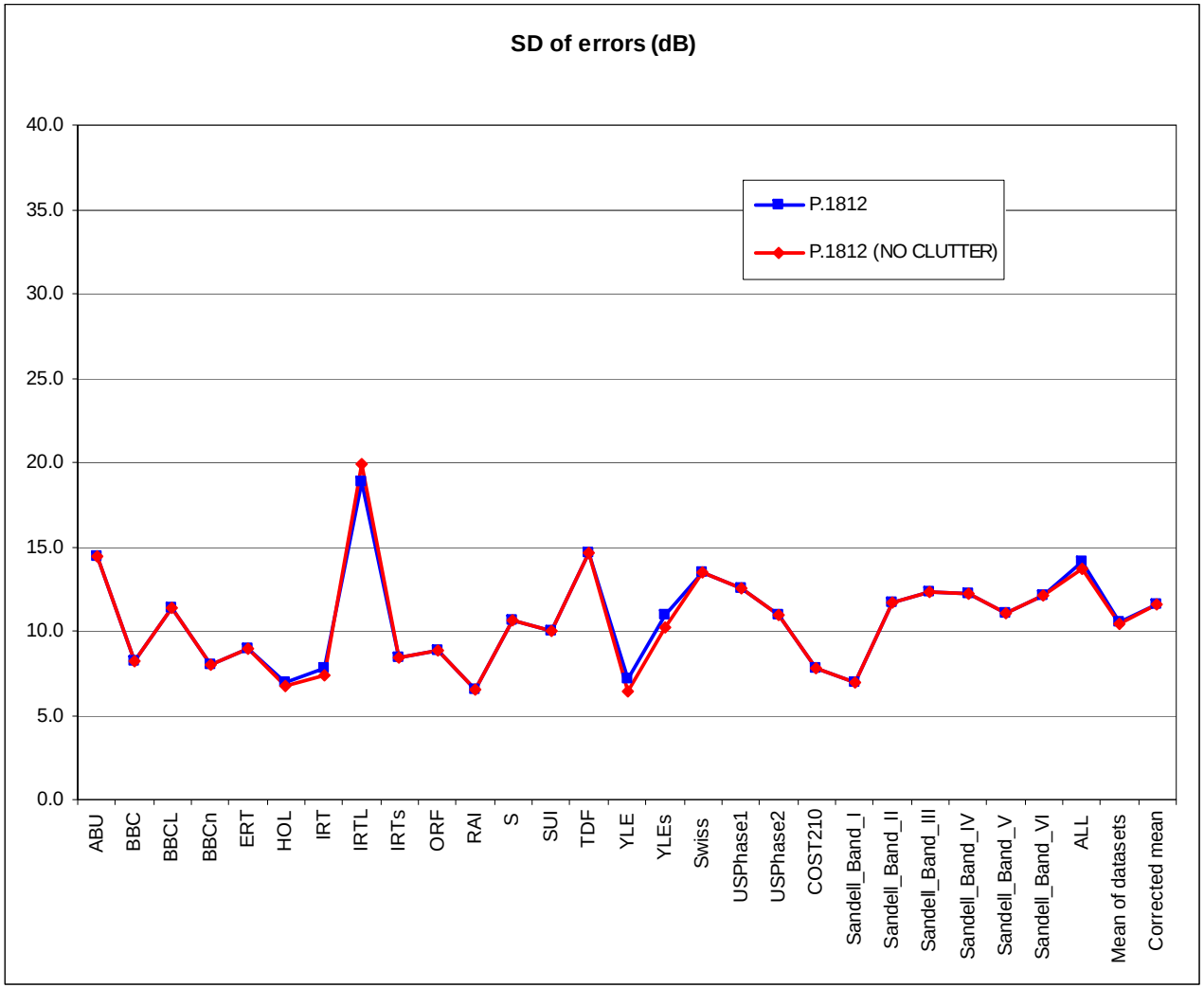
Clutter



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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

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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