An Estimation of Human-Error Contributions to Historical Ionospheric Data

- Ground-based radar sounders are used to characterize the dynamics and chemistry of Earth’s ionosphere.
- Manual analyses of older/analog (pre-digital age) radar ionograms to derive ionospheric characteristics was a tedious procedure and susceptible to human error.
- In this study, a team of ionospheric researchers hand-scaled radar ionograms repeatedly, providing multiple estimates of the same ionospheric parameters. This was done to estimate the amount of human variability in the hand-scaling process.
- The resulting variability was then added & subtracted from the mean parameter values and used to drive physics models that use the ionospheric parameters as input. This was done to estimate downstream impacts on physics modeling.

**RESULTS:** The variability due to human-scaling of radar ionograms can be very significant!

Long-term (months/years) modeling results showed a low sensitivity to human-related errors, but short-term term analyses (hours/days) showed very different results when small errors were applied to the input parameters.

### Variability of the foF2 ionospheric parameter; from 10 ionograms; each ionogram was hand-scaled 20 times.

![Variability of foF2](image)

- **Maximum foF2** from all participants
- **Average foF2** from all participants
- **Minimum foF2** from all participants
- **Mean of foF2** with **STDEV**
- **Error from Overestimating**
- **Error from Underestimating**
- **Error from STDEV from MEAN**

### Modeling results with no error imposed on the parameters, and with ± errors imposed; short-term analysis.

![Modeling results](image)

- **Height of Ionospheric Max Electron Density**
- **Neutral Wind speeds**
- **Ionosphere Peak Electron Density**

The circles are ground truth observations.