POLITECNICO MILANO 1863
DIPARTIMENTO DI ELETTRONICA INFORMAZIONE E BIOINGEGNERIA
esa European Space Agency Agence spatiale européenne
U.R.S.I.

ITALSAT Ka, Q and V band Cross Polar Discrimination statistics measured in Pomezia, Italy

E. Regonesi, A. Martellucci, C. Riva, L. Luini,

Outline

- Introduction
- Cross Polar Discrimination
- Dataset
- Italsat XPD statistics at Ka, Q and V bands
- Conclusions

Introduction

- Dual polarization transmission is a sound technique to maximize the channel capacity of Satellite Communication (SatCom) systems, through the reuse of frequency
- The presence of raindrops and ice particles in the atmosphere may cause a variation in the polarization of received signals
- Reliable experiments to investigate this variation in received polarization are hard to be set up. ITALSAT campaign (1992-2000), mainly based in Italy, included depolarization analysis among its objectives

Cross Polar Discrimination

- This contribution presents the Cross Polar Discrimination (XPD) statistics, conditioned to CPA (rain excess attenuation) of the selected dataset
- XPD is the main parameter used to describe depolarization, defined from the electric field transfer equation through a medium

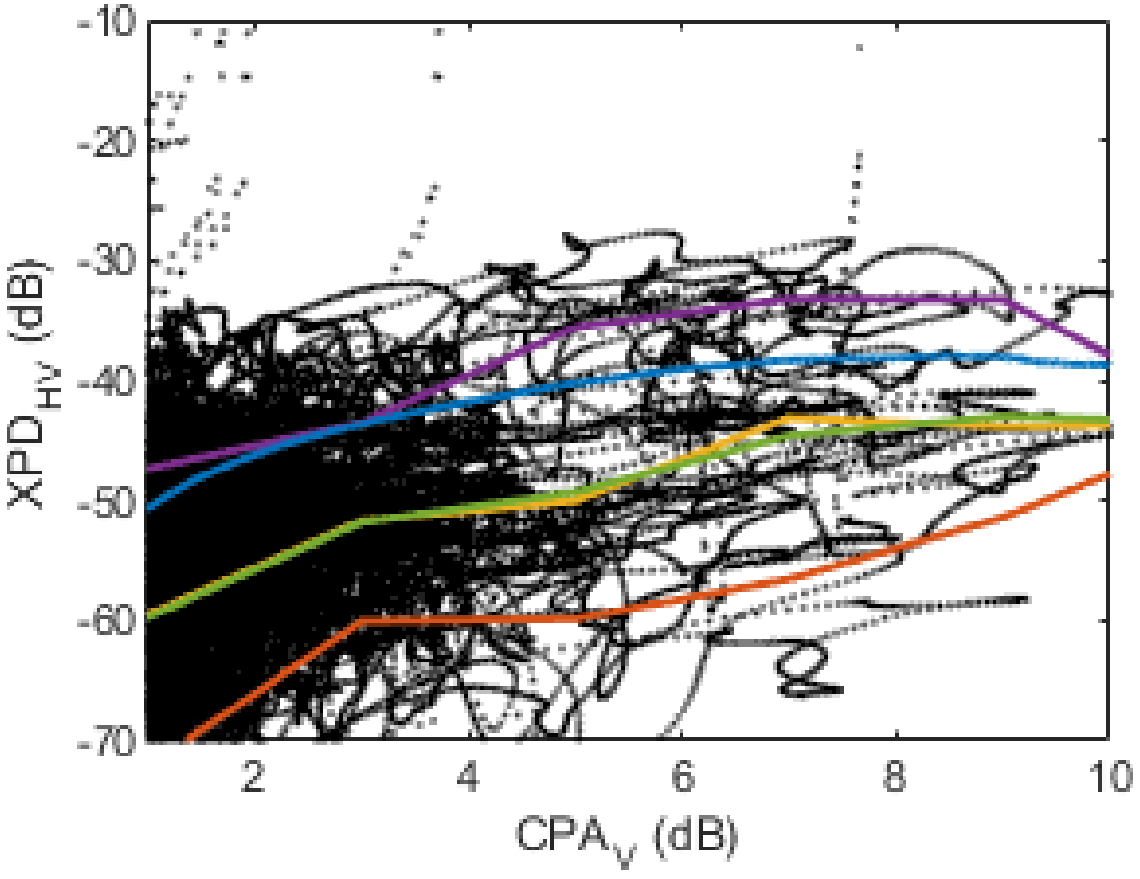
$$\begin{bmatrix} E_{out,1} \\ E_{out,2} \end{bmatrix} = \begin{bmatrix} T_{11} & T_{12} \\ T_{21} & T_{22} \end{bmatrix} \cdot \begin{bmatrix} E_{in,1} \\ E_{in,2} \end{bmatrix}$$

$$\delta_{ij} = \frac{T_{ij}}{T_{jj}} \quad (i,j = 1,2; i \neq j) \qquad \mathrm{XPD}_{ij} = 20 \log_{10} \delta_{ij}$$

Dataset

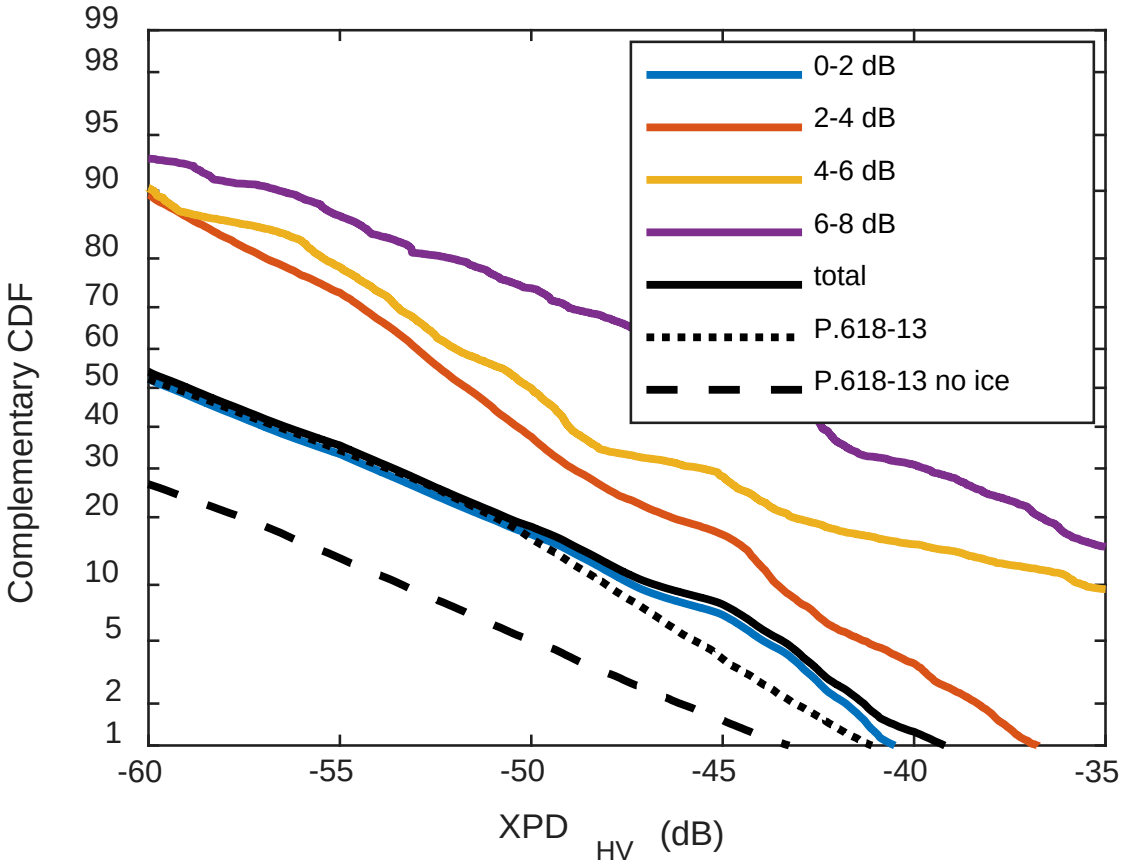
- ITALSAT geostationary satellite (13° E) beacons were transmitted at Ka, Q and V bands:
  - Vertical linear polarization at 18.7 GHz (tilt=0°)
  - Right-handed circular polarization at 39.6 GHz
  - Vertical/horizontal switched linear polarization at 49.5 GHz (tilt=20°)
- 70 significant XPD events were collected in Pomezia (Italy) from ITALSAT beacon data (elevation angle: 41.8°. Antenna diameter: 3.5 m)
- Data were processed by applying clear sky effect removal and XPD level-based noise reduction

XPD at Ka band



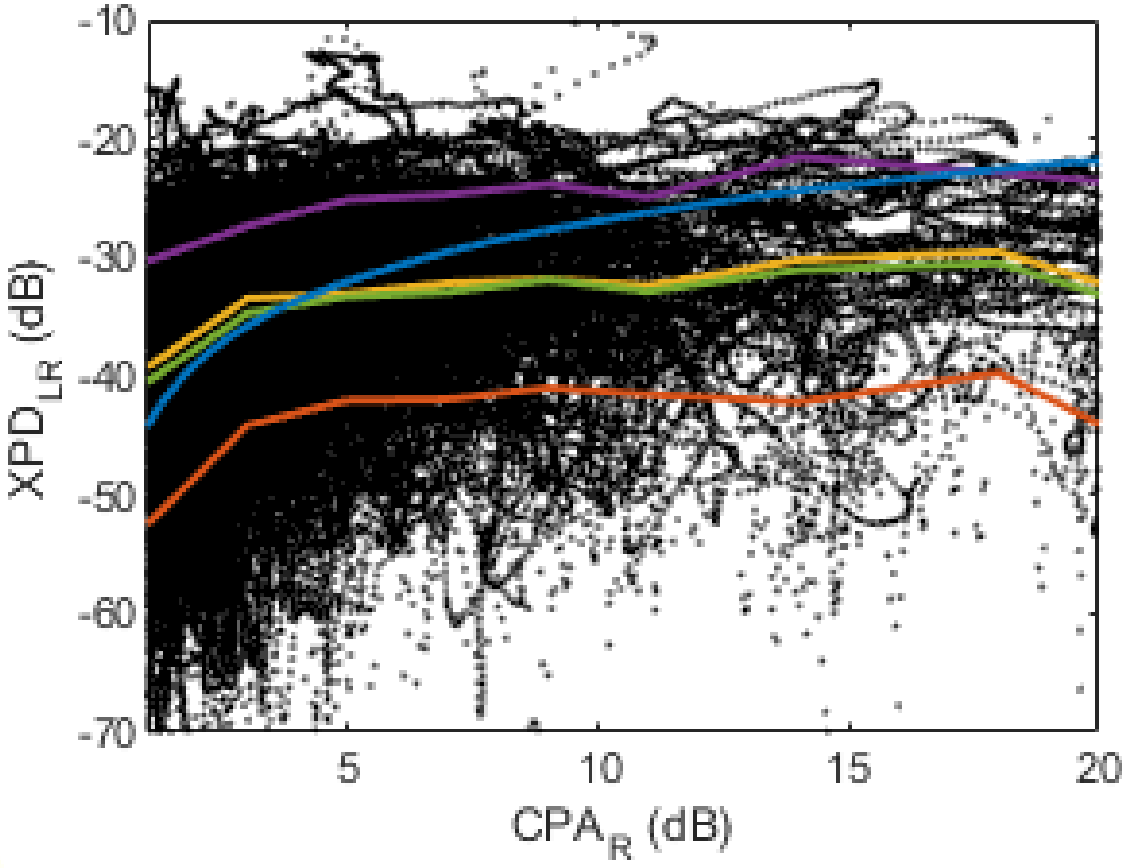
- The majority of points lays in the region:
  CPA < 5 dB ∩ XPD < -30 dB
- Points beyond CPA = 10 dB are not statistically significant
- ITU-R P.618 XPD prediction (cyan) represents the 90% percentile (purple) for CPAs lower than 5 dB, and between 50% and 90% percentiles for CPA above 5 dB
- A relevant number of samples has XPD close to -40 dB and very low CPA, meaning a significant effect of ice depolarization with no rain

XPD at Ka band



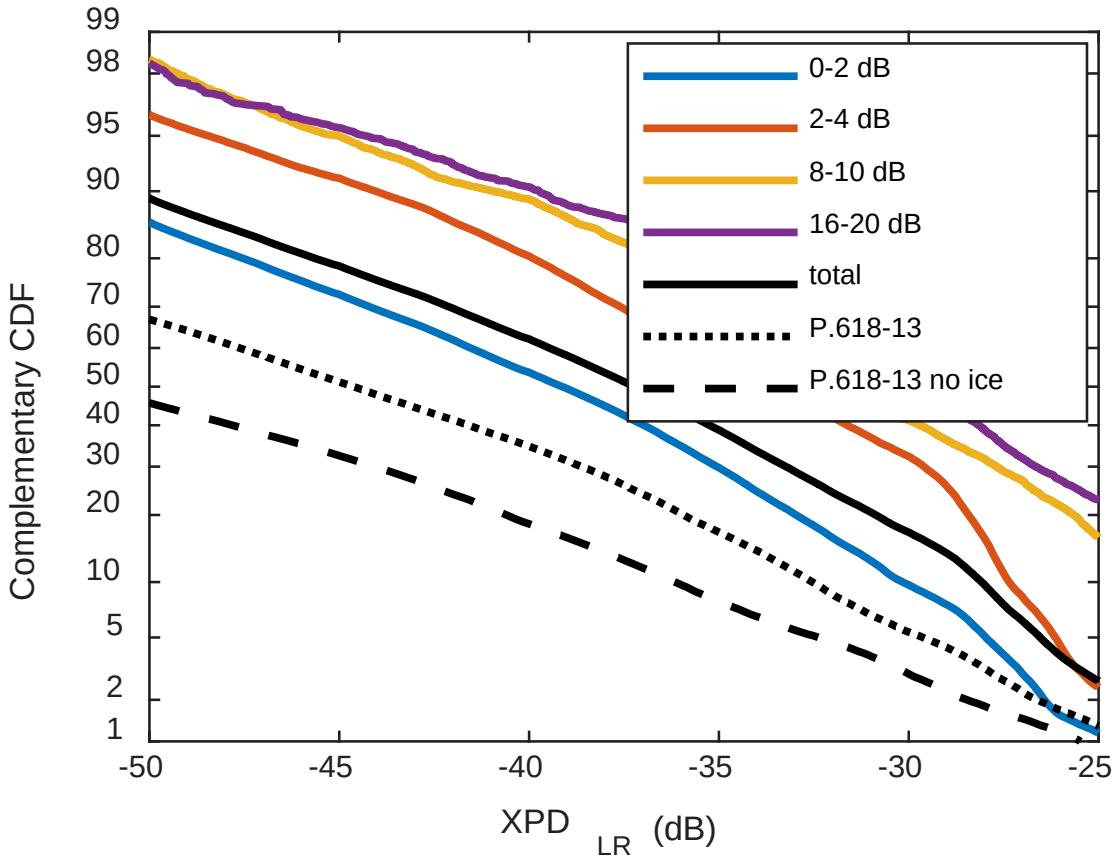
- Irregular pattern at high CPA-conditioning values is due to the low fraction of data represented
- Fair accordance up to -50 dB of XPD between empirical CCDF and prediction of ITU-R P.618-13
- The few dB underestimation of ITU-R prediction may be ascribed to ice depolarization

XPD at Q band



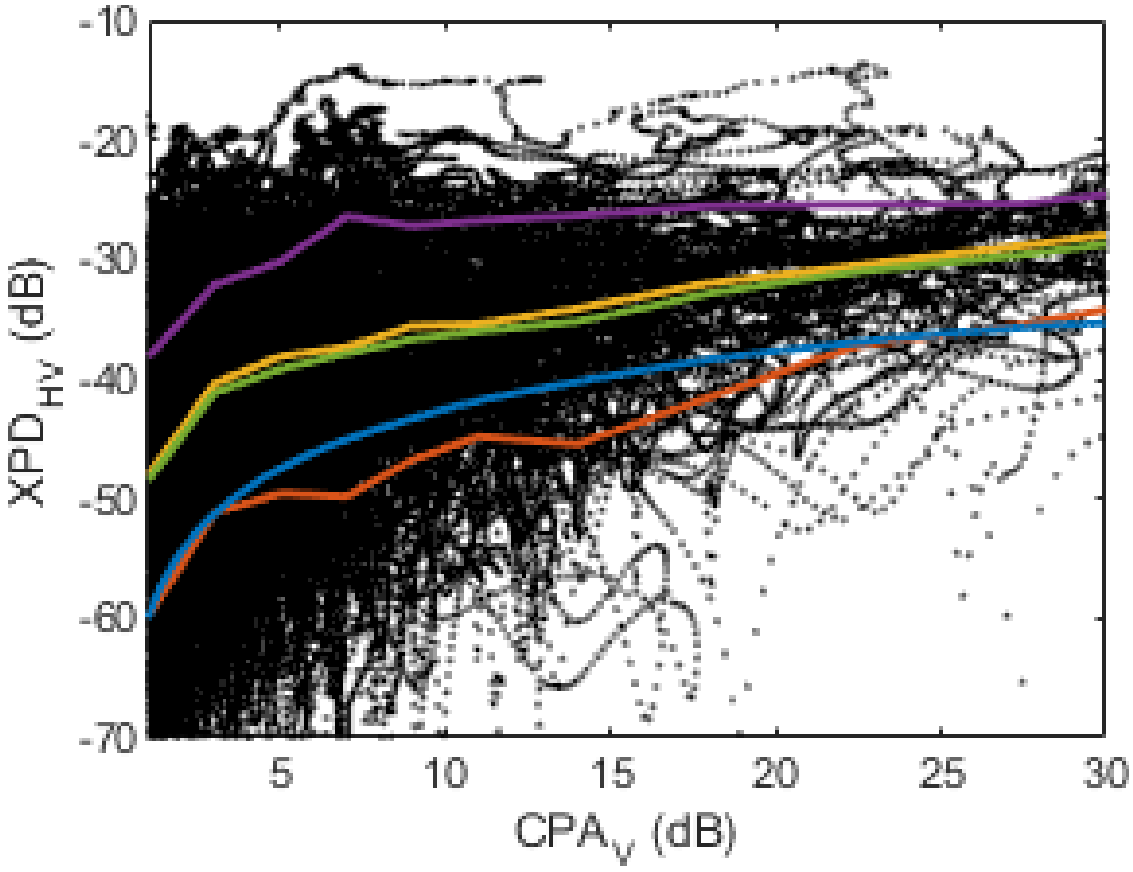
- Values of XPD are pretty high, being XPD of circularly polarized signals not sensitive to canting angles
- The ITU-R predicted XPD (cyan) represents the 50% percentile for CPA lower than 5 dB, shifting towards the 90% percentile at high excess attenuations
- This may indicate an overestimation of XPD in presence of strong attenuation, due to a different microstructure of precipitations or a combination of ice and rain

XPD at Q band



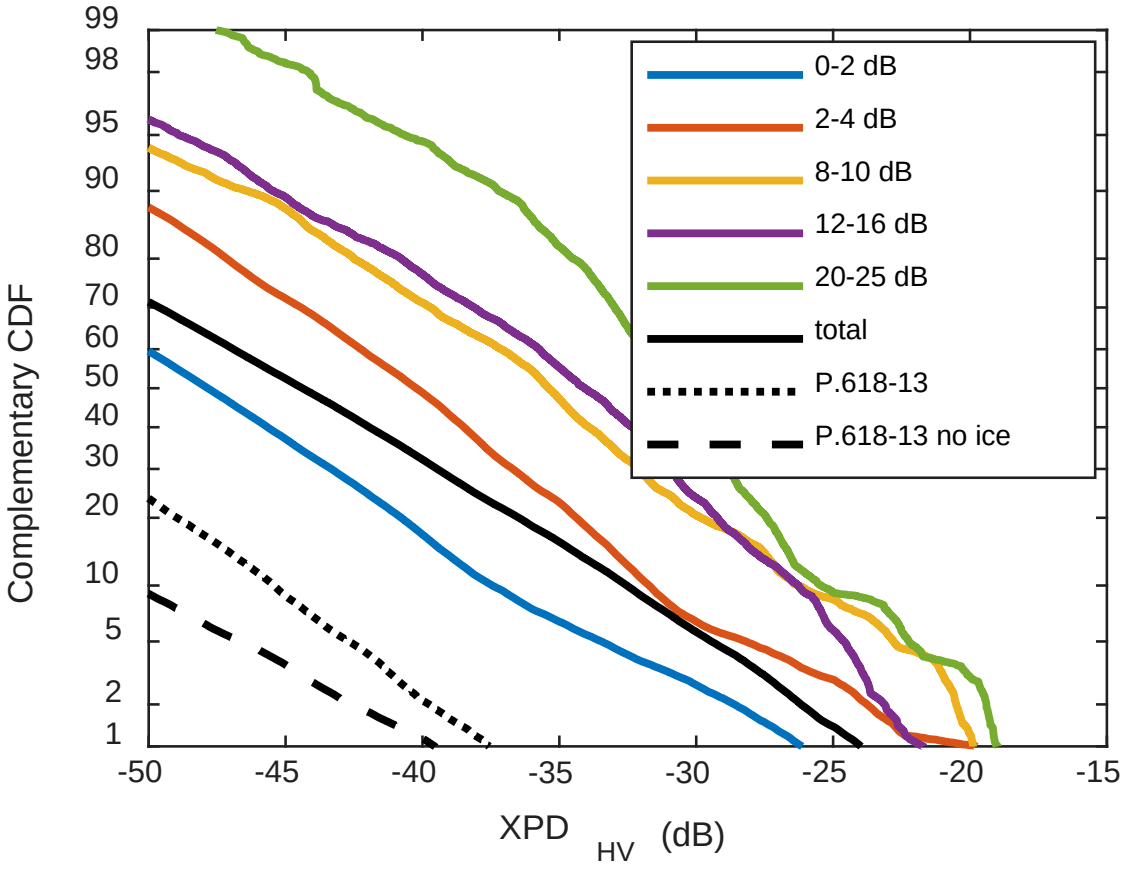
- CPA conditioning has been considered up to 20 dB
- It is noticeable a 5 dB mean underestimation of ITU-R predictions
- This may be ascribed to the effect of ice depolarization, since the predicted curve agrees or overestimates the median value of the data

XPD at V band



- Data lie mostly under 20 dB of XPD
- The ITU-R curve (cyan) agrees with lower fraction of data, approximatively between 10% (red) and 30% (green) percentiles
- This is in contrast with the Ka and Q band cases, pointing out a greater influence of ice also at high rain intensities

XPD at V band



- High CPA-conditioned curves influenced by the low fraction of data represented
- Lower CPA-conditioned curves may be described using a normal distribution
- Difference between measured and predicted CCDF of XPD increases up to 12 dB

Conclusion

- Analysis of the atmospheric depolarization for SatCom systems operating at Ka, Q and V bands using experimental data collected at the Pomezia station with the ITALSAT satellite
- Data processing of the quantities of interest (XPD and CPA)
- Comparison of measured XPD statistics and ITU-R P.618 model
- Varying level of agreement of XPD predictions to the measured data percentiles, depending on the frequency and the type of polarization
- Growing underestimation of the XPD CCDF by the predictions, with the frequency increase
- Gaussian model fits satisfactorily XPD CCDFs conditioned to CPA
- The presented statistics represent the basis for future XPD prediction models

Thank you!