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Co-location and validation of PAZ observations with polarimetric weather radars

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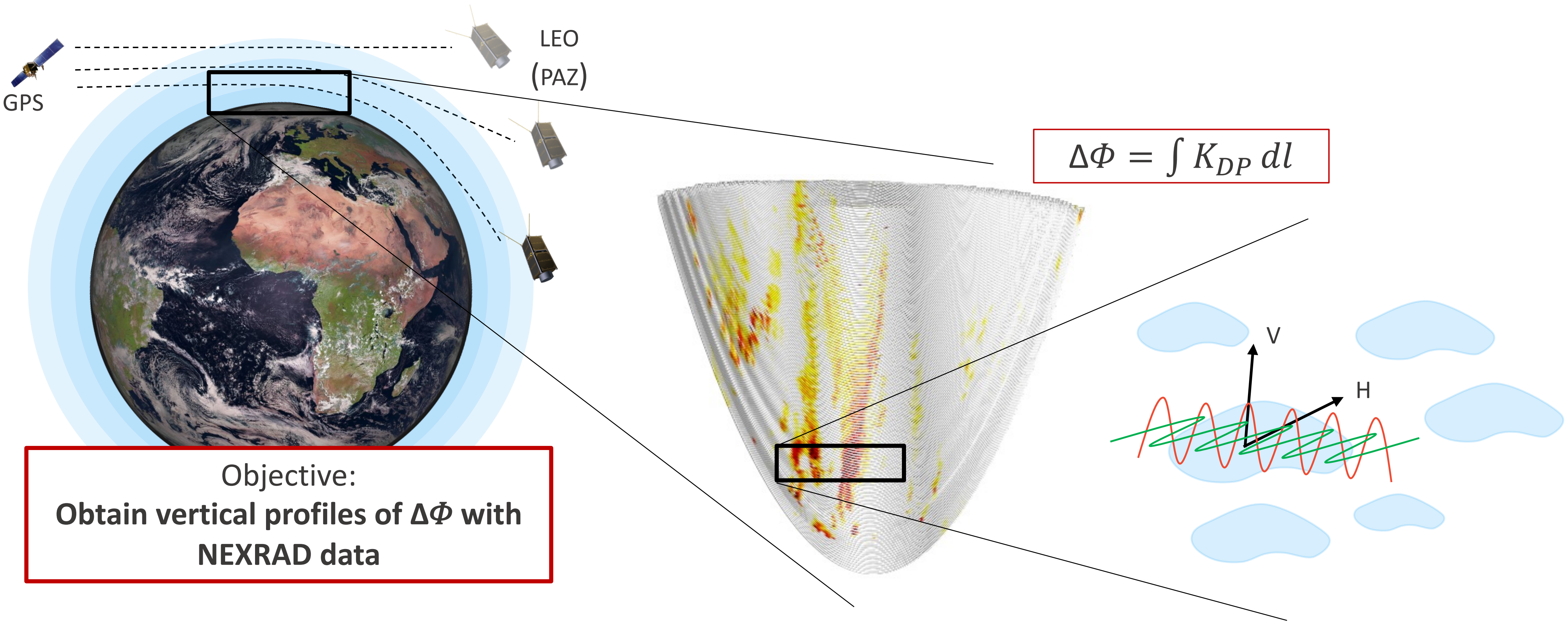
Polarimetric-RO

For horizontally oriented hydrometeors: $\Delta\Phi = \Phi_H - \Phi_V > 0$



$$\Delta\Phi = \int K_{DP}\, dl$$

Objective:
Obtain vertical profiles of $\Delta\Phi$ with NEXRAD data

NEXRAD

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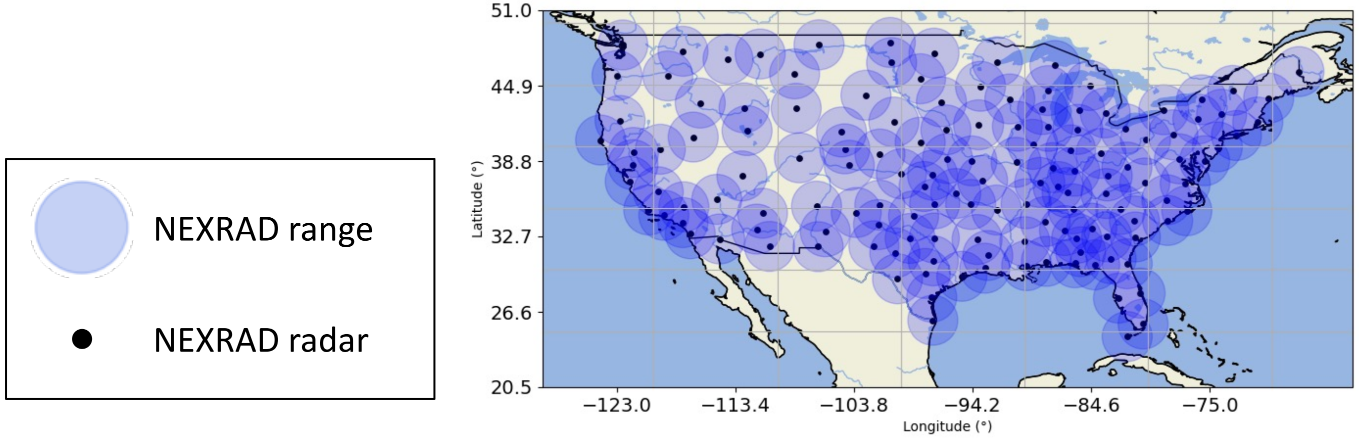
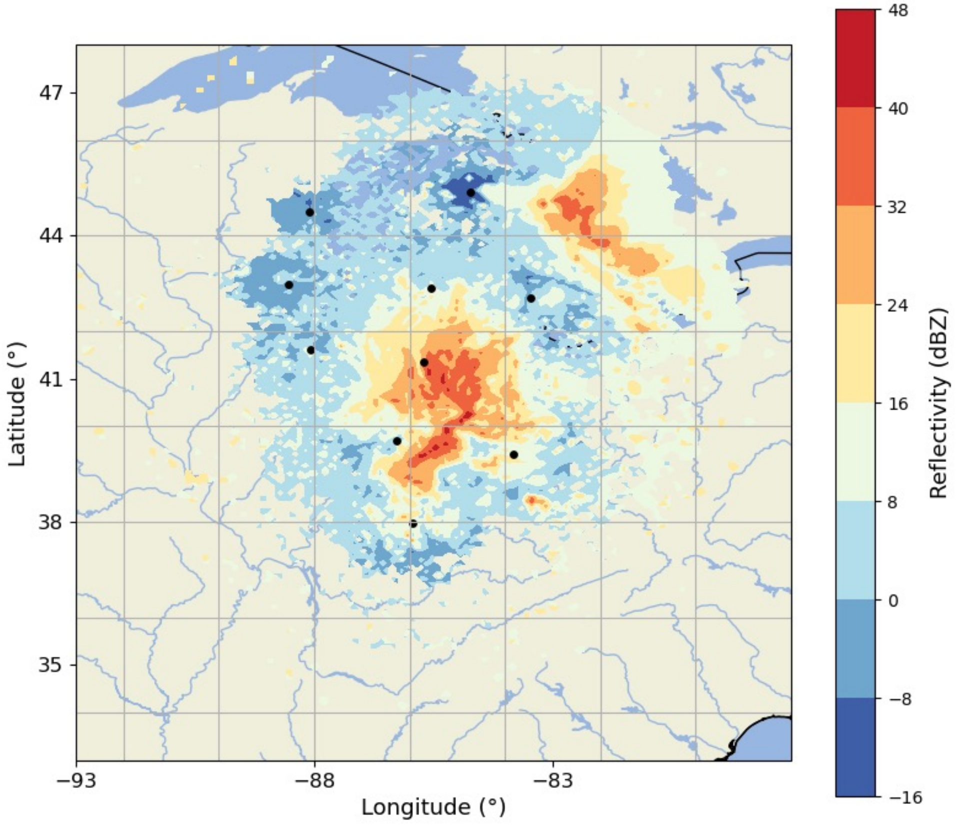
- NEXRAD radars provide reliable ground-based measurements, which can serve as ground truth data for assessing the accuracy and performance of the PRO technique.
- NEXRAD radars offer high spatial resolution and broad coverage over the US territory.
- NEXRAD radars have dual-polarization capabilities, providing variables that can be compared to the differential phase shift obtained with PAZ.





Co-located observations

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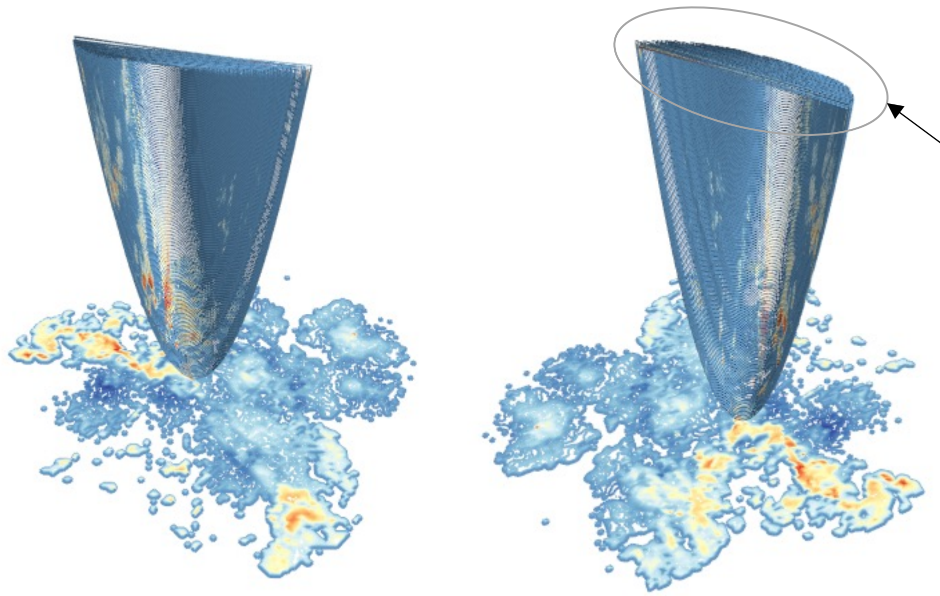
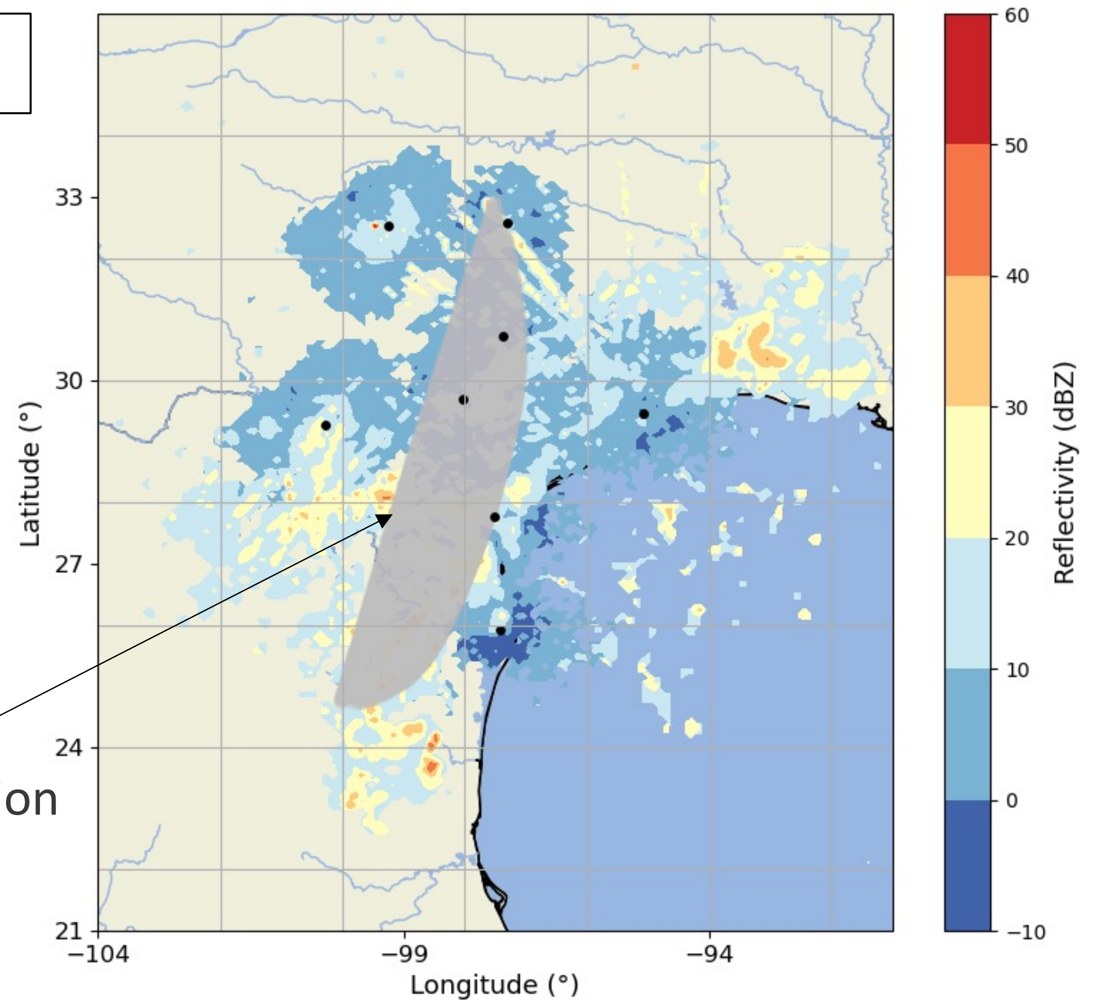
- NEXRAD Level II dataset
- Time difference < 8 minutes
- Minimum distance between radar and PRO < 250 km
- Total of ~3200 observations





Kdp calculation

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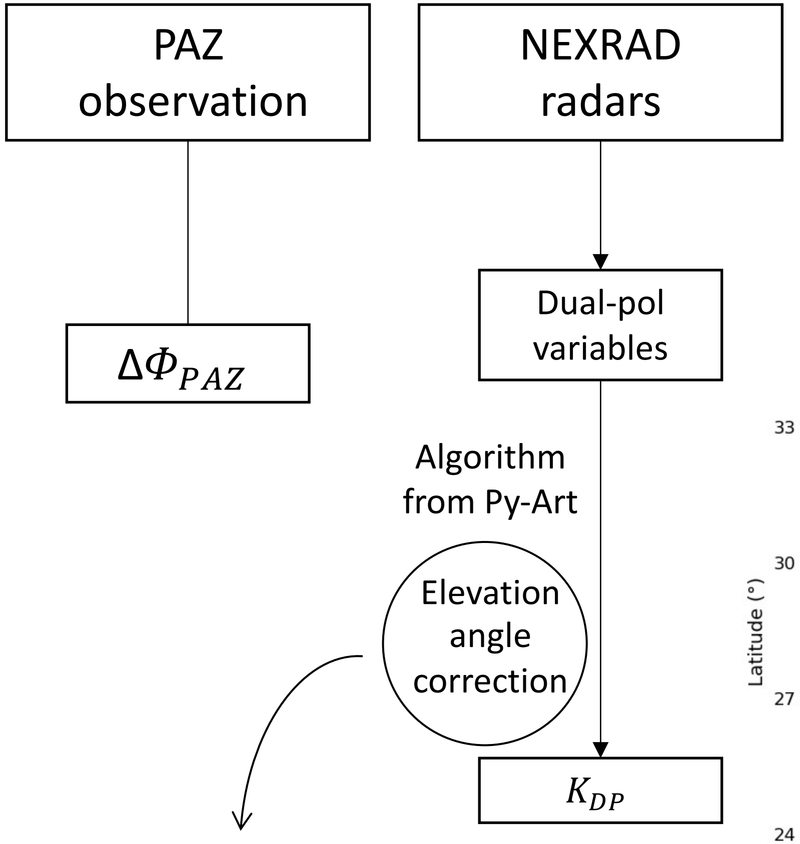
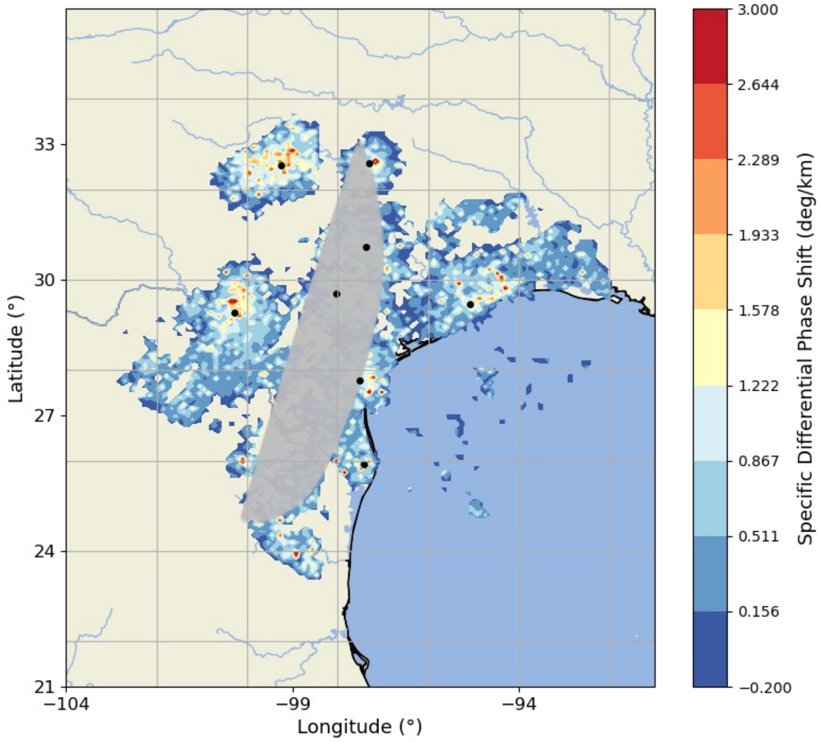
- Radar data treatment with **Py-Art**
- Calculation of Kdp based on the method developed by Vulpiani (Vulpiani et al. 2012, Vulpiani et al. 2015)
  - Four step process to estimate K_{DP}
    - K_{DP} is estimated through computing the finite difference over the raw Ψ_{DP} field over a moving window of user-defined size
    - Validity of the K_{DP} values are compared to a set of defined thresholds
    - Ψ_{DP} is reconstructed from the processed K_{DP} field
    - final K_{DP} estimate is obtained from the reconstructed Ψ_{DP} field through using finite differencing once more



$$K_{DP}(0) \approx \frac{K_{DP}(\theta)}{cos^2(\theta)}$$

$$\Delta\Phi = \int K_{DP}\, dl$$



Kdp calculation

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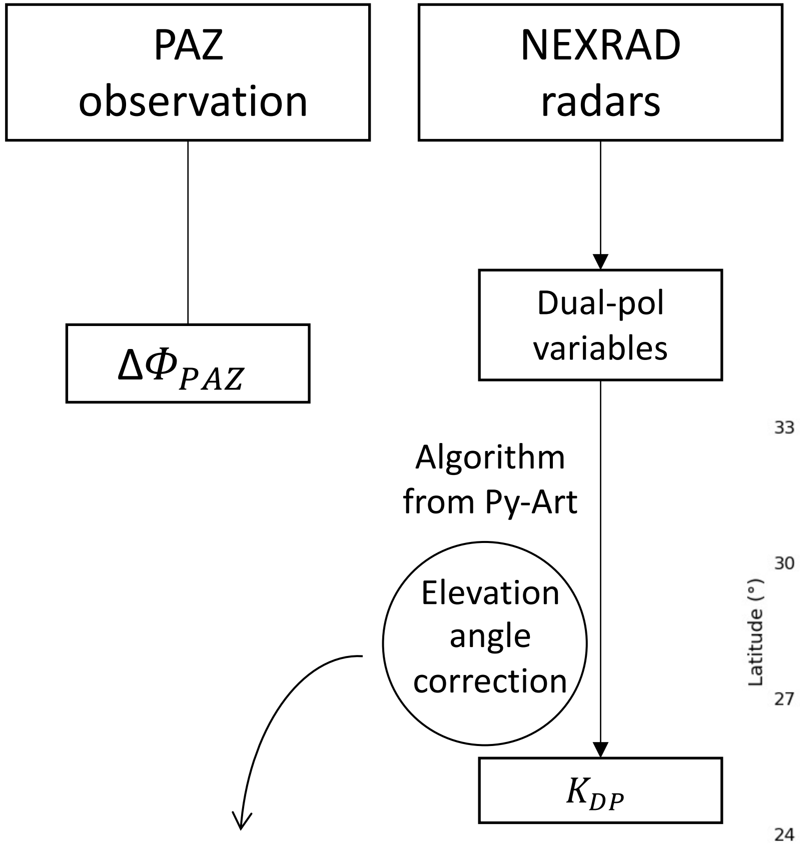
- Calculation of K_{DP} based on the method developed by Vulpiani (Vulpiani et al. 2012, Vulpiani et al. 2015)

- Input parameters
  - **Number of iterations**
  - **Window size**
  - **Filtration of Ψ_{DP}**
    - Censor it where ρ_{HV} is lower than 0.65
    - Unravel angles when strong discontinuities are detected
    - Remove very short sequences of valid data
    - Apply a median filter on every profile



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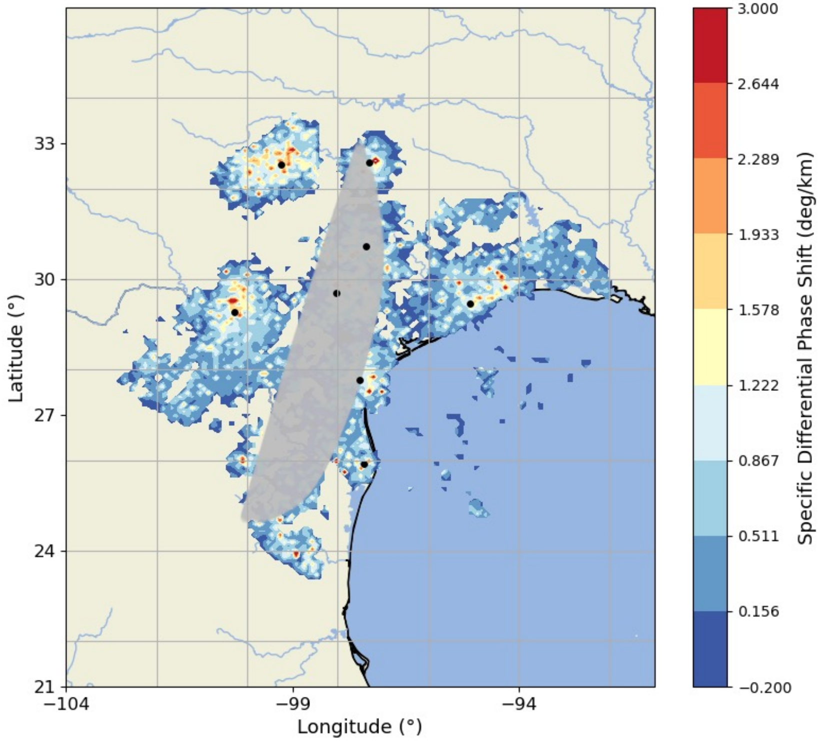

$\Delta\Phi$ calculation

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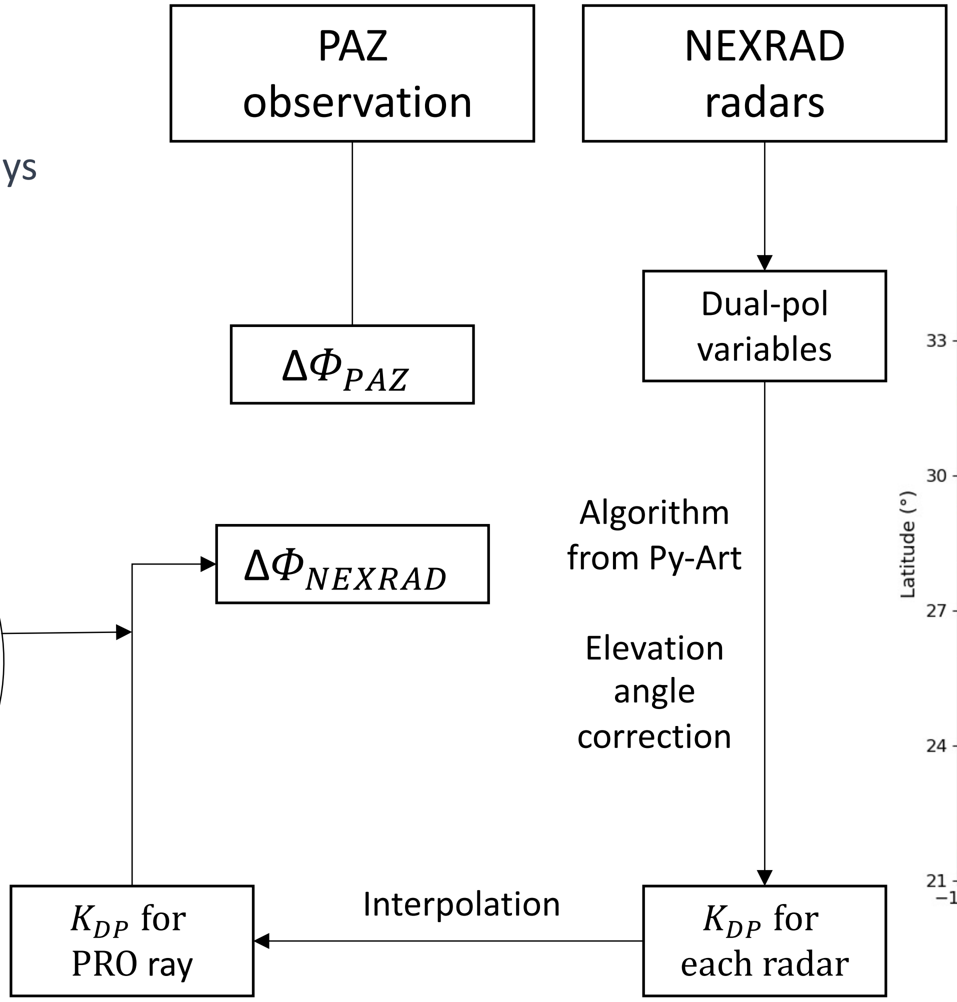
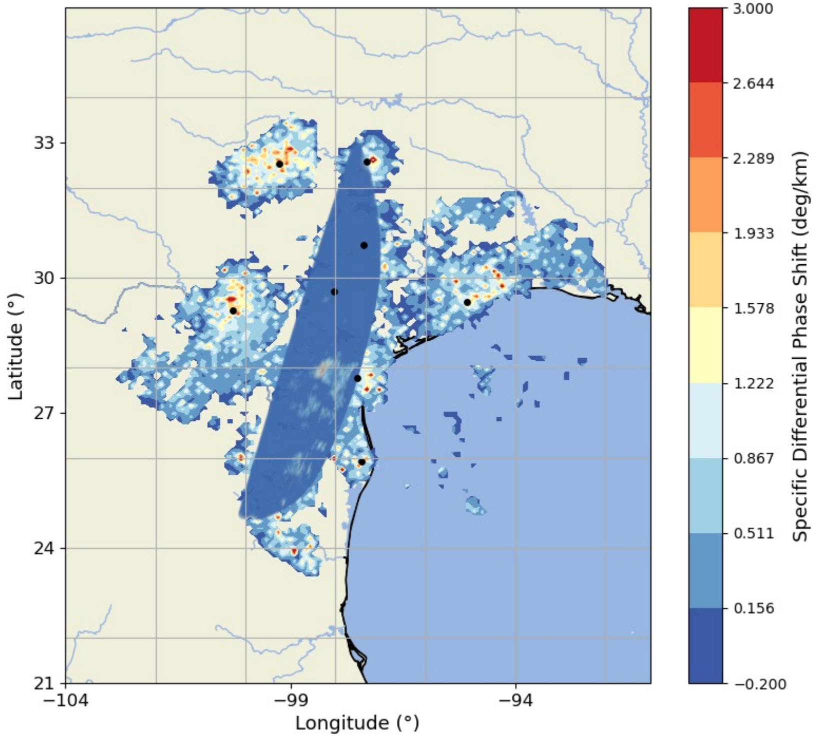
- **Interpolation** of K_{DP} into the PRO rays
- **Integration** of K_{DP} for each PRO ray

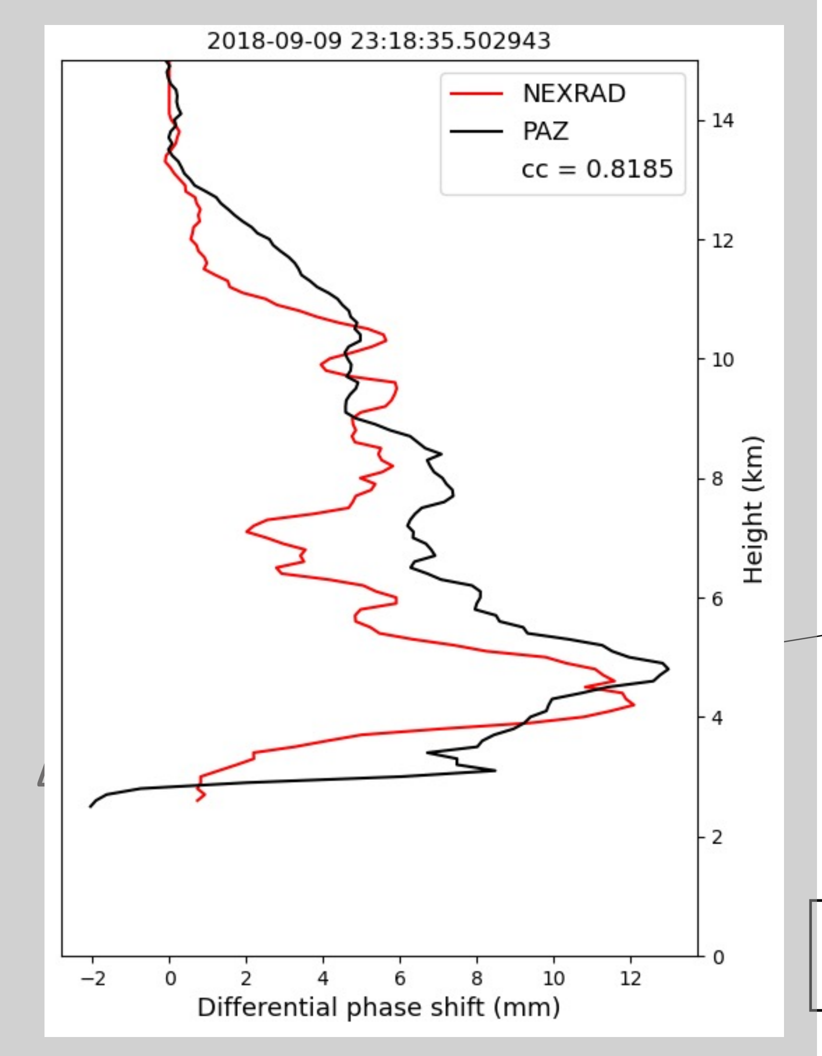
$$\Delta\Phi = \int K_{DP}\, dl$$

$$\Delta\Phi \text{ (mm, L band)} = \Delta\Phi \text{ (degrees, S band)} \cdot \frac{\lambda_S}{\lambda_L} \cdot \frac{\lambda_L}{360}$$



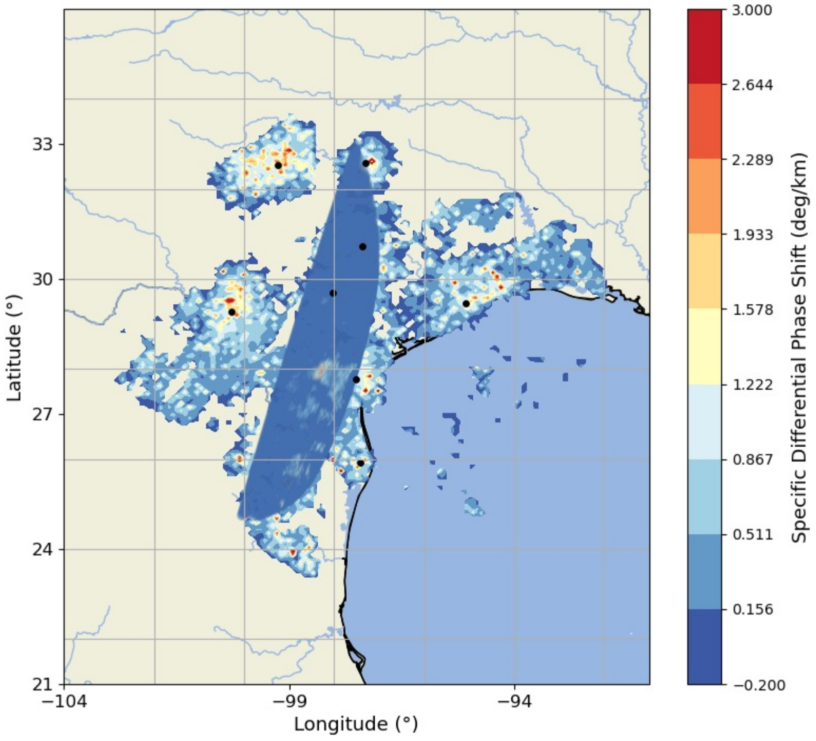


$\Delta\Phi$ calculation



PAZ observation → $\Delta\Phi_{PAZ}$

NEXRAD radars → Dual-pol variables → (Algorithm from Py-Art; Elevation angle correction) → K_{DP} for each radar → Interpolation → K_{DP} for PRO ray → $\Delta\Phi_{NEXRAD}$



Analysis in terms of window size

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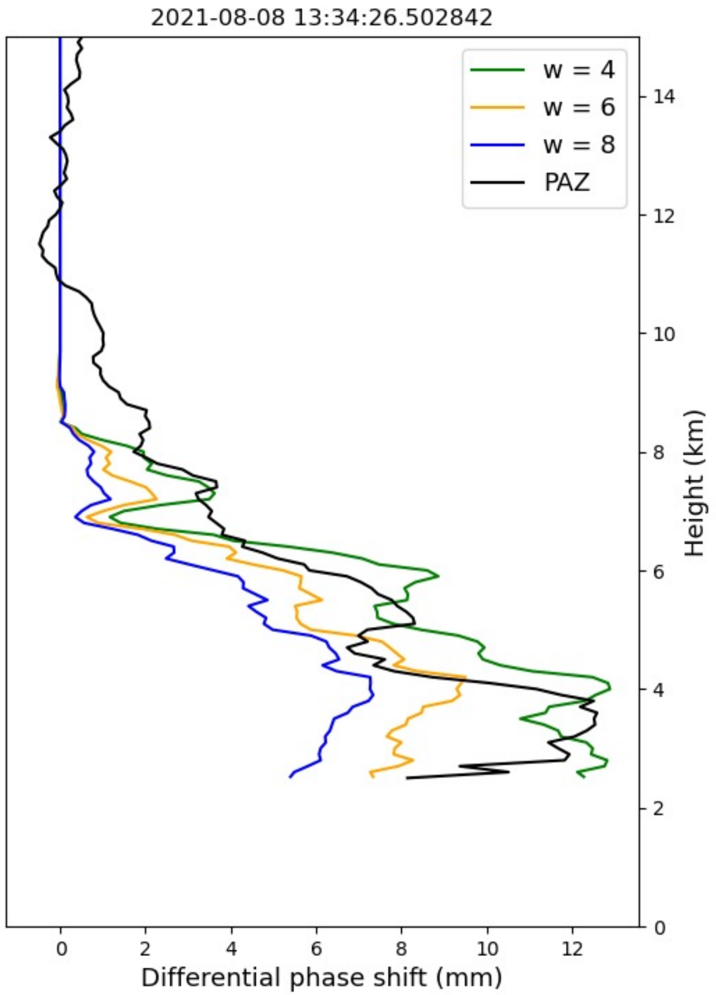
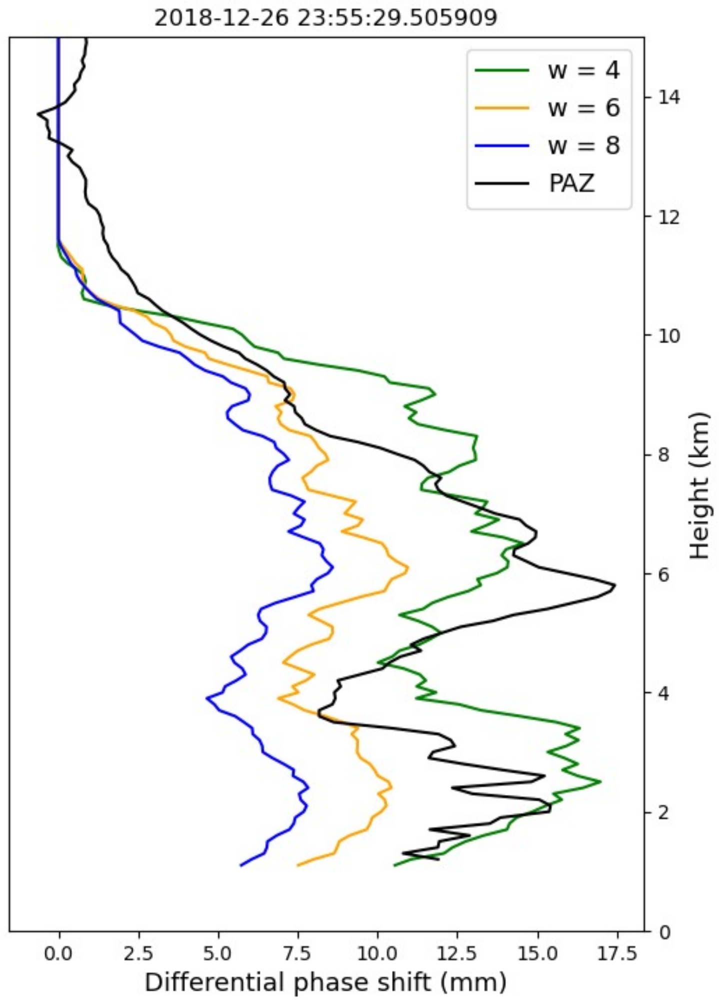
- **Window size: represents the smoothing used for computing K_{DP}**
- The size of the moving window and the magnitude of $\Delta\Phi$ are inversely proportional
- Most of the peaks are represented with all window sizes
- Esentially what changes is the module

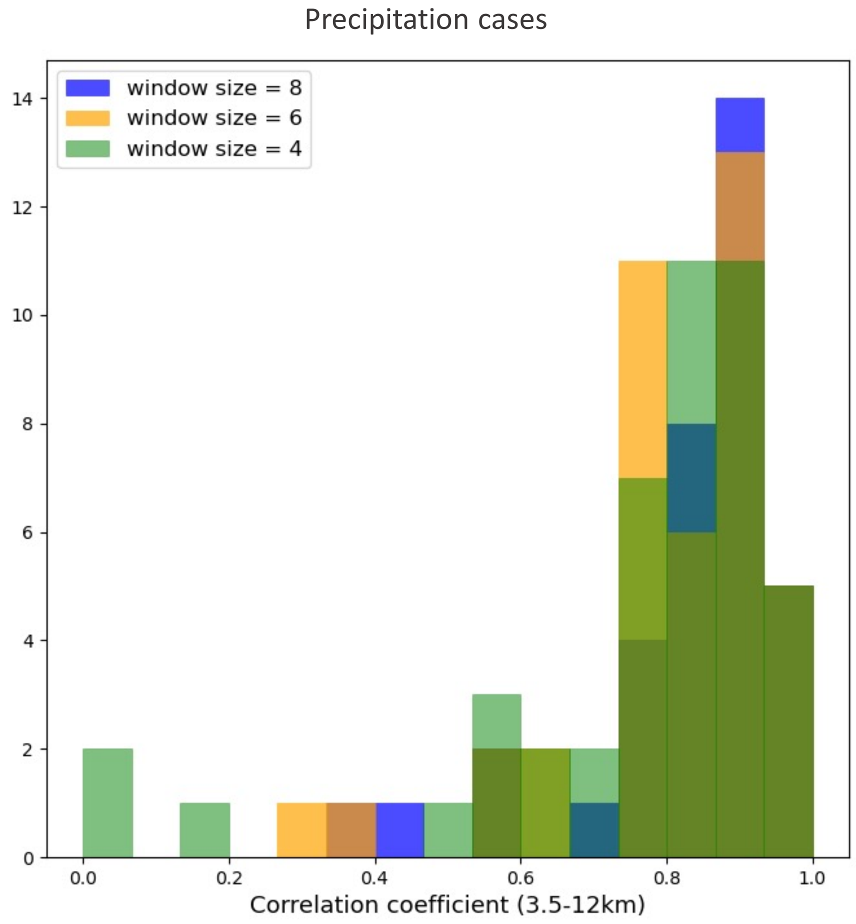


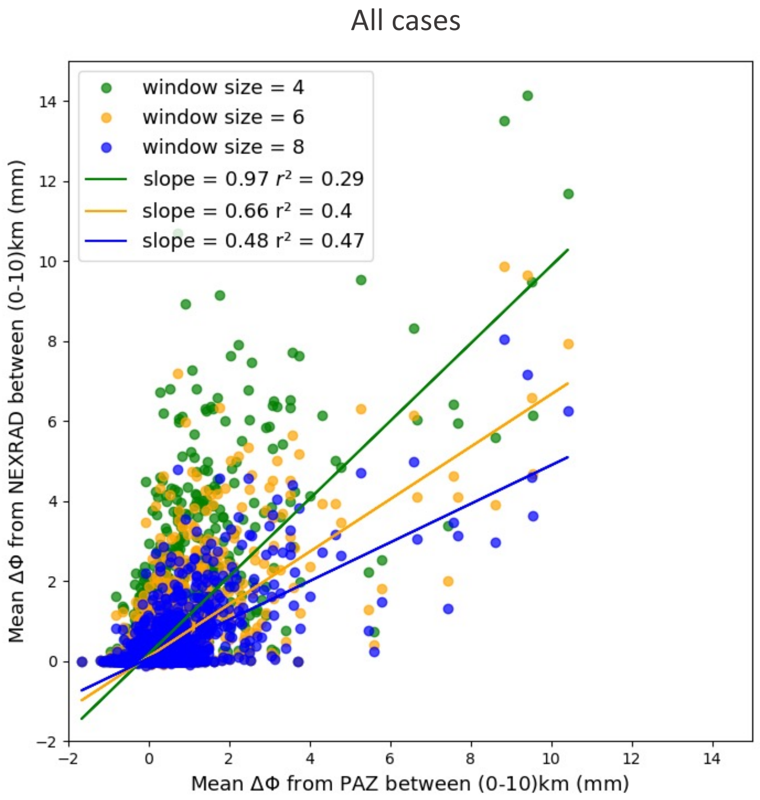


Analysis in terms of window size

Observations considered as precipitation cases:

- >60% of PRO's area covered by radars
- Mean $\Delta\Phi$ between 0-10km: Dphi010 > 1.5 mm





Vertical profiles $\Delta\Phi$

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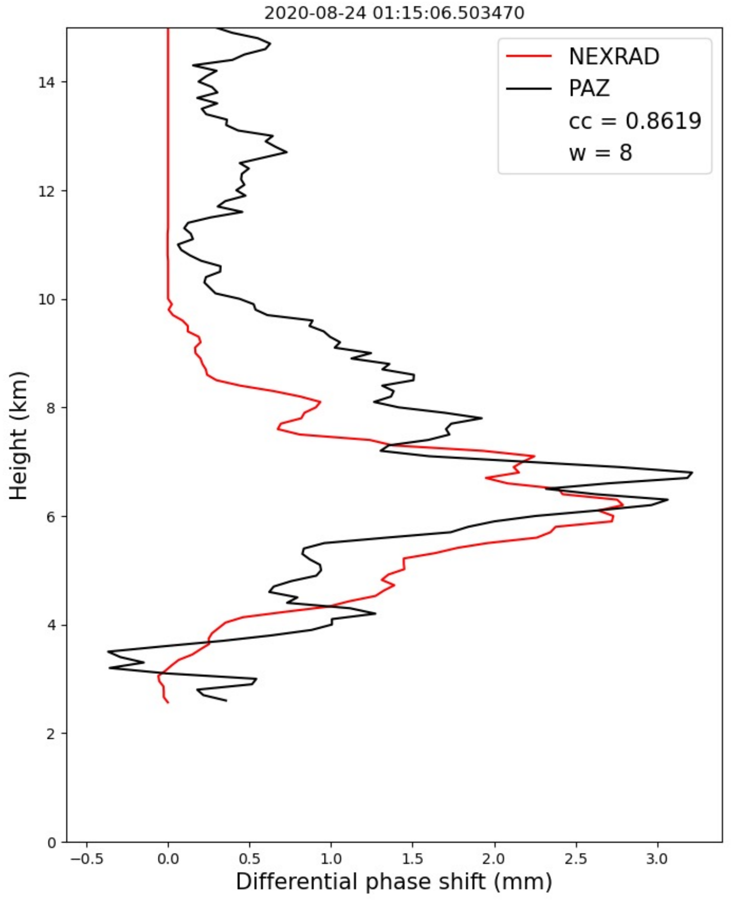
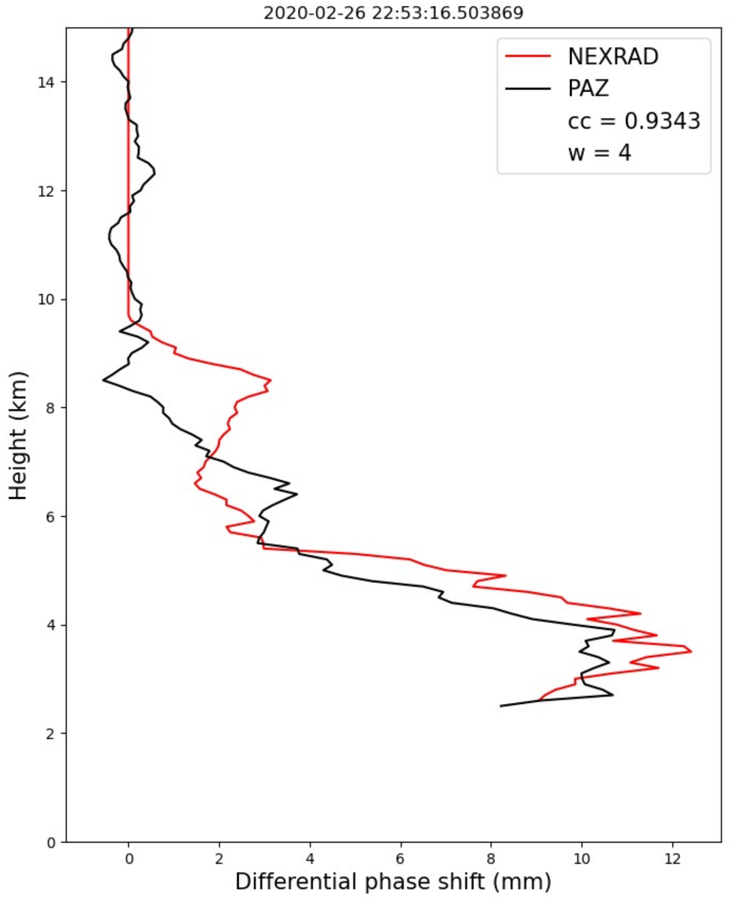
- General good agreement between profiles
- NEXRAD and PAZ have similar comprehension of the observable $\Delta\Phi$
- The peaks of maximum $\Delta\Phi$ exhibit remarkably close values and occur at nearly identical heights
- Better agreement for those observation with peaks at lower altitudes
- For larger $\Delta\Phi$ best fit with smaller window sizes and vice-versa.





Conclusions

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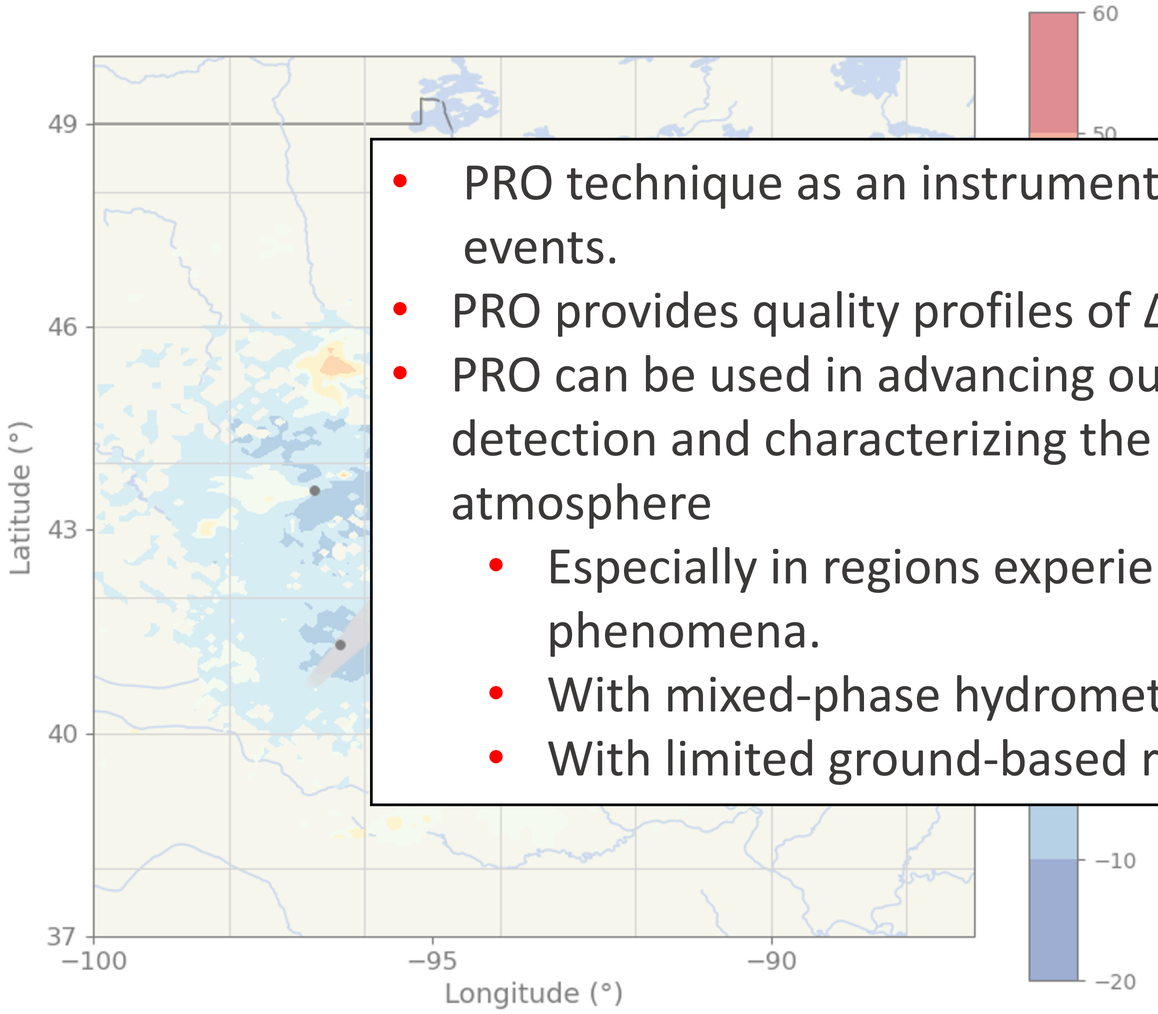

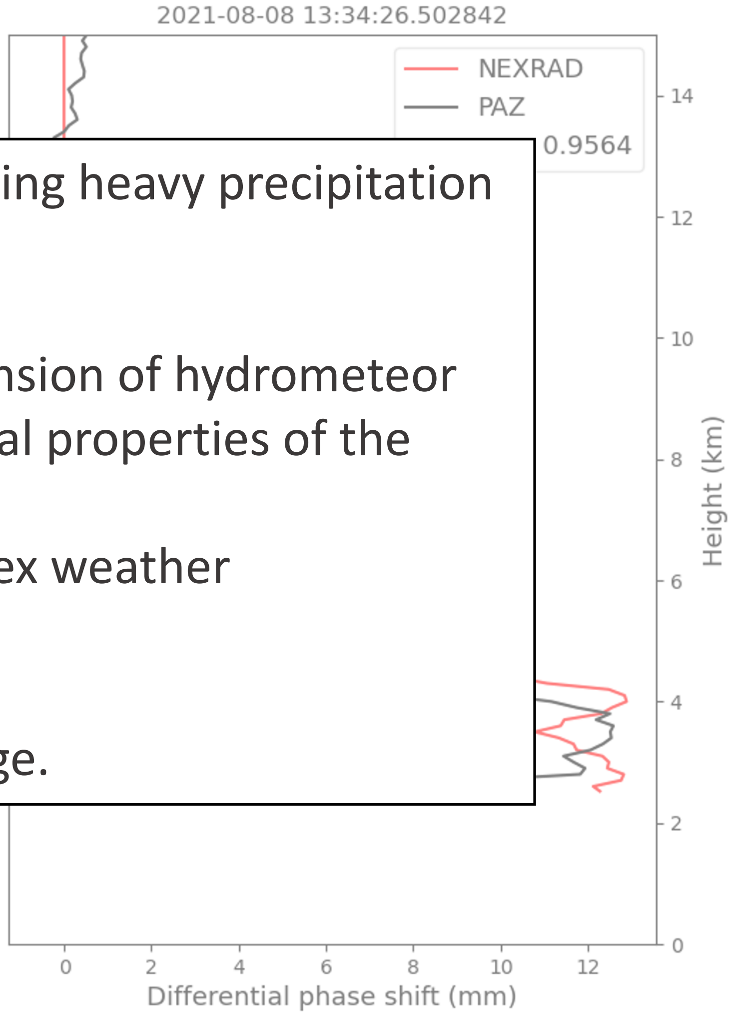

- PRO technique as an instrument for quantifying heavy precipitation events.
- PRO provides quality profiles of $\Delta\Phi$.
- PRO can be used in advancing our comprehension of hydrometeor detection and characterizing the microphysical properties of the atmosphere
    - Especially in regions experiencing complex weather phenomena.
    - With mixed-phase hydrometeors.
    - With limited ground-based radar coverage.

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Thank you!

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