Institute of Space Sciences

EXCELENCIA MARÍA DE MAEZTU

IEEC Institut d'Estudis Espacials de Catalunya

A Multi-center exercise on the sensitivity of PAZ GNSS Polarimetric RO for NWP modeling

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Table of contents

Scope and objectives

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The objectives of this activity are:

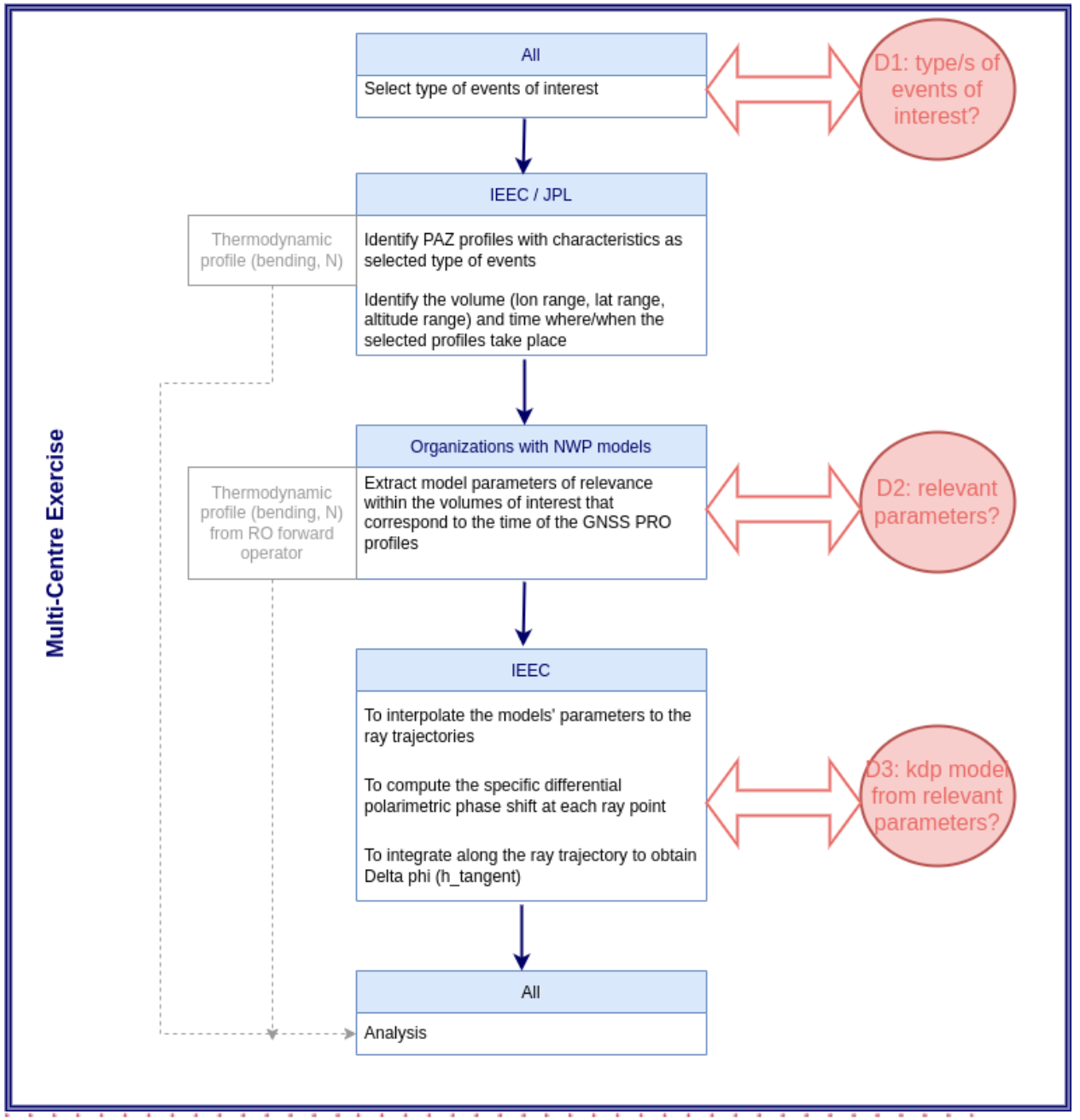
- To compare simulated GNSS PRO observables, generated with models from different centers and different microphysics schemes, against actual PAZ GNSS PRO observables → Can the models reproduce the main features of the actual data?
- To assess whether different models/schemes result in different GNSS PRO observables, and whether these differences are larger than the measurement uncertainty → insight on future methods to assimilate the PRO profile alongside other conventional (non-polarimetric) RO data.
- To examine the utility of PAZ GNSS PRO observations for model validation and diagnosis.

Scope and objectives

- This is work under progress, discussed with several organizations (ICE/CSIC-IEEC, JPL, ECMWF, UCSD/SIO, JMA, NOAA, JCSDA, U. of Virginia, GSFC, Spire, PlanetIQ)

- This talk shows preliminary results using models from a few centers only, open to others.

- Experiment designed to minimize work to be done at the centers. See original plans on the right:



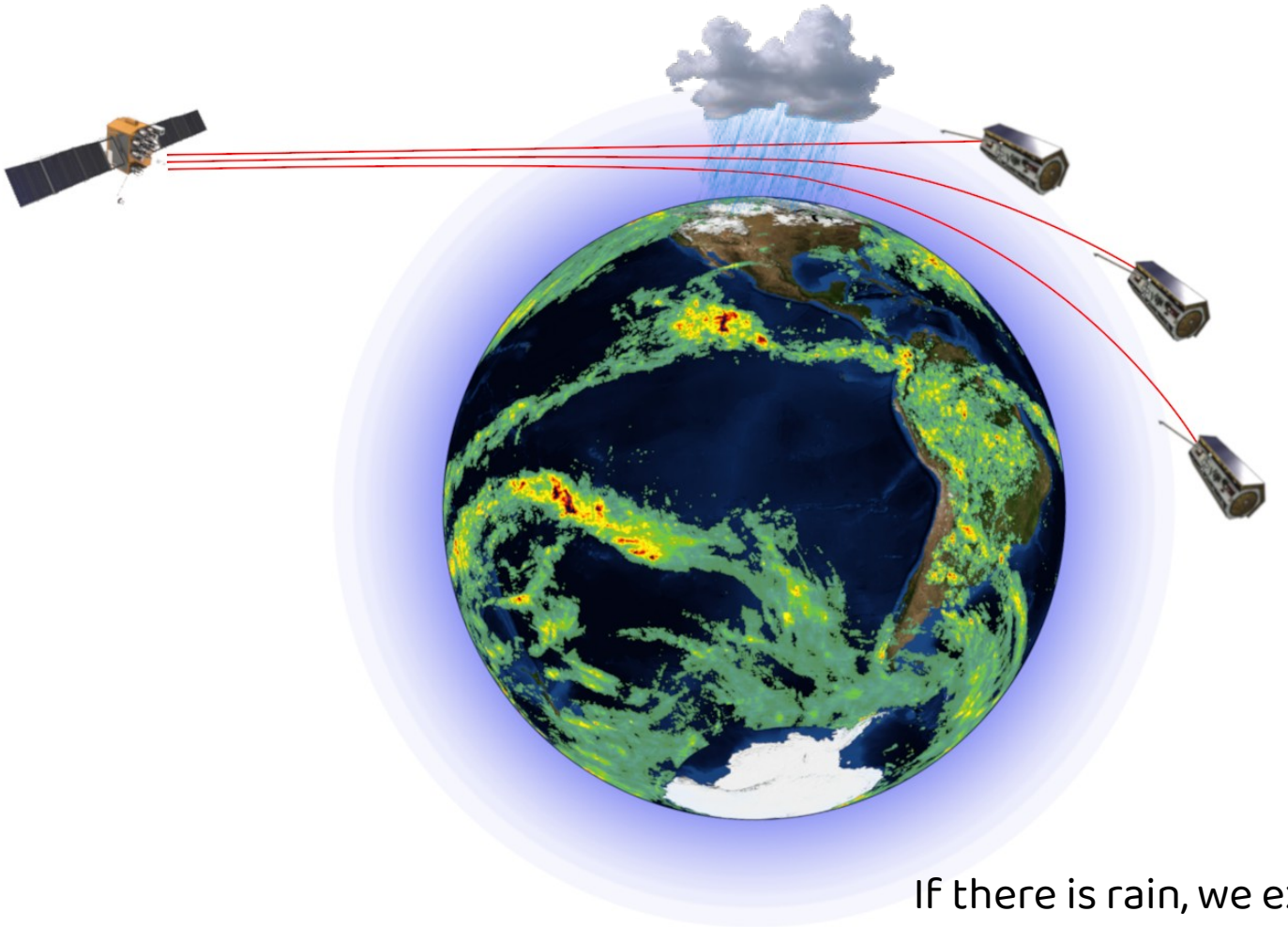
Scope and objectives

- After discussion with the different centers, the study now focuses on:
  - **Tropical Cyclones** (PAZ cases identified, co-location time+3D boxes listed)
  - **Atmospheric Rivers** (PAZ cases identified, co-location time+3D boxes listed)
  - **Mesoscale Convective Systems** (PAZ cases identification under progress)

- Major challenge: different field variables used by different models/centers.

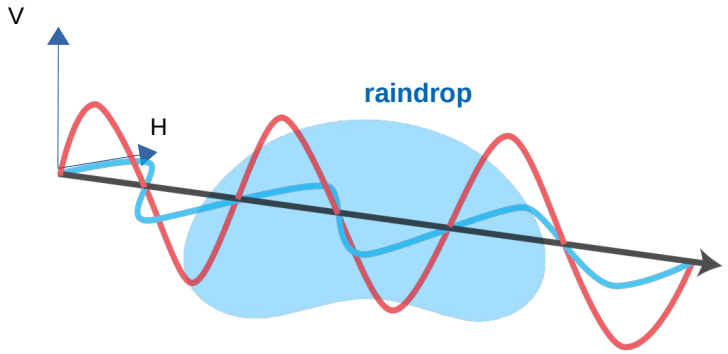
Preliminary results using ERA-5

Polarimetric RO



Polarimetric RO

Minor hardware modification to receive H and V linear polarizations, instead of RHCP



$$\phi_H - \phi_V > 0$$

If there is rain, we expect to see larger excess phases in the H than in V

Preliminary results using ERA-5

Data used

ERA-5 hourly data on pressure levels

Data variables

- Pressure levels
- Geopotential (m^2s^{-2})
- Temperature, specific humidity, relative humidity

- Specific rain water content (kg kg^{-1})
- Specific snow water content (kg kg^{-1})
- Specific cloud liquid water content (kg kg^{-1})
- Specific cloud ice water content (kg kg^{-1})

3D grid-box

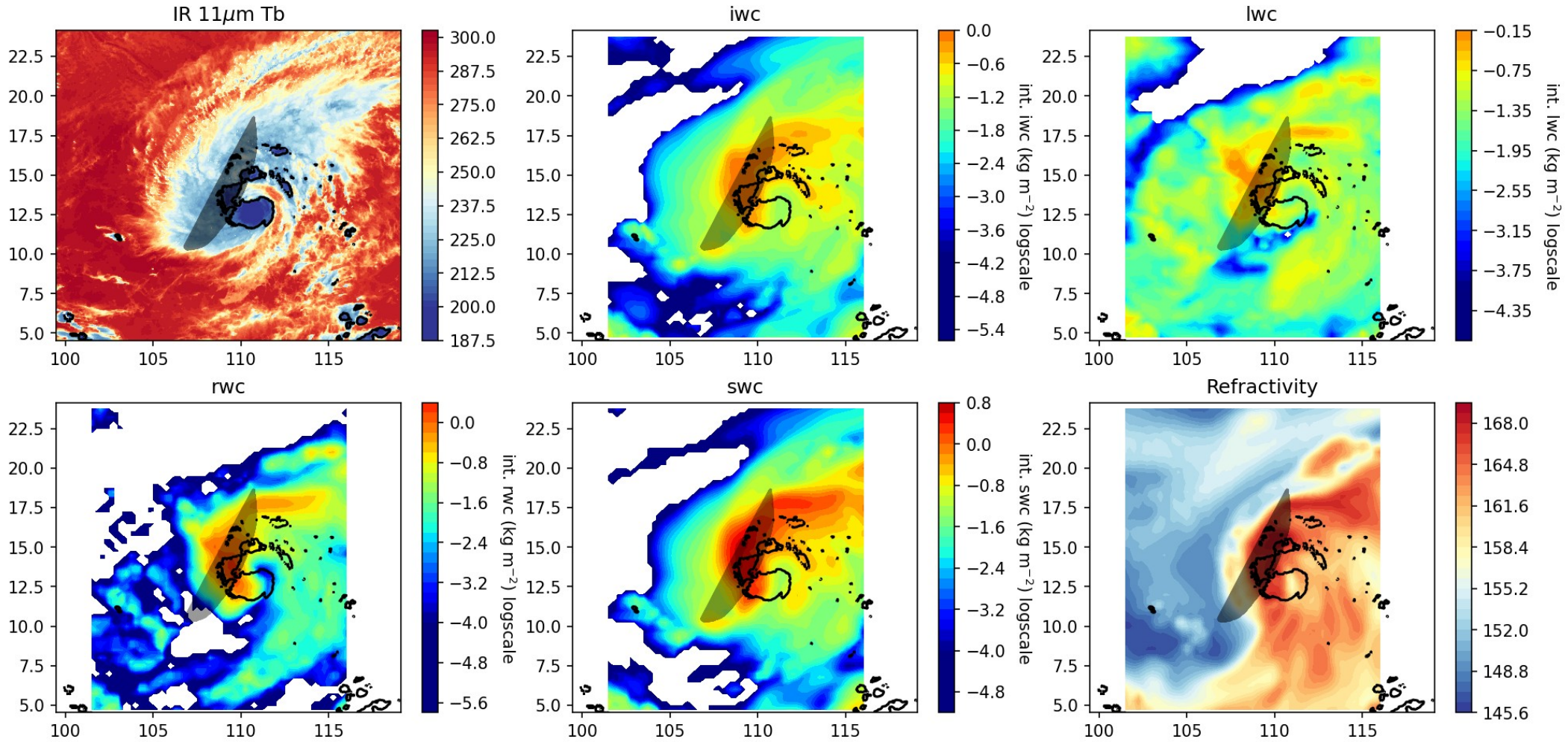
Height (km)

You can convert the units of this parameter to kg m^{-3} by multiplying by the density (=P/RT, where P is pressure, T is the absolute temperature and R is the specific gas constant)

RWC(h), SWC(h), CLWC(h), CIWC(h) (kg m^{-3})

Methodology

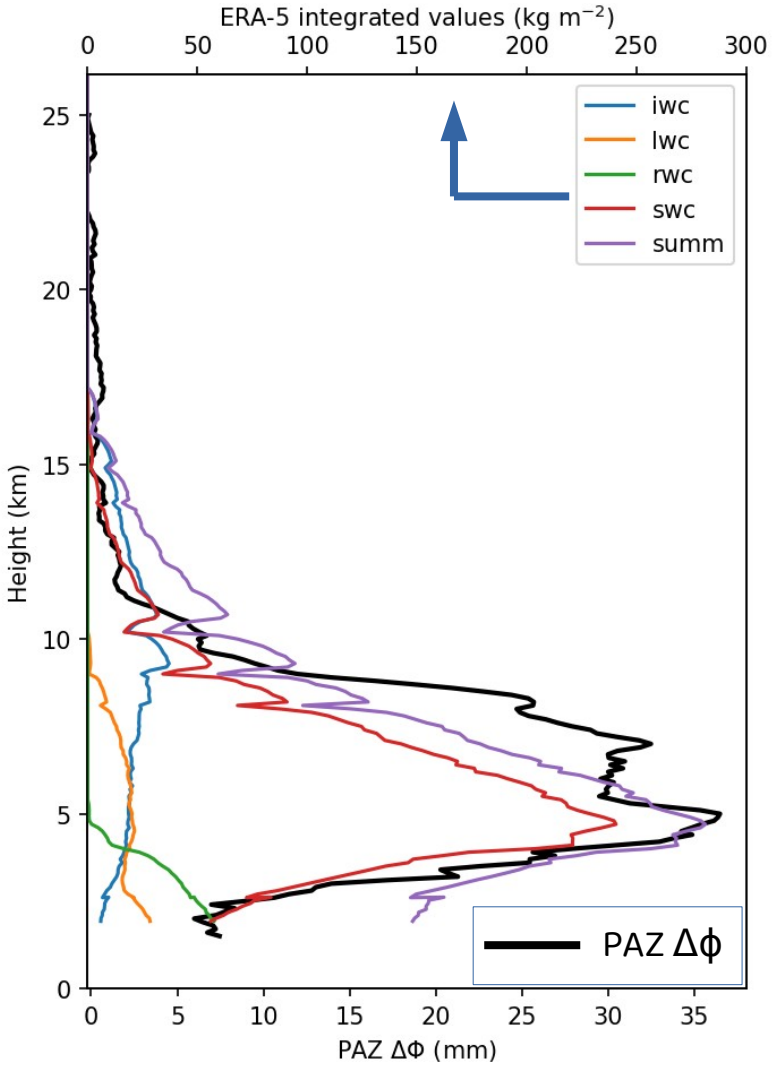
Interpolation of ERA-5 3D fields into RO plane



Preliminary Results

Integration of ERA-5 fields along RO rays

- Qualitatively, $\Delta\phi$ agrees well with the integrated SWC along the rays
- Order of magnitude of integrated WC values agrees with study using Cloudsat (*ACPD, under review*)
- Next step: to convert the WC fields into K_{dp}
  - Point by point (more or less complex)
  - Integrated quantities → directly to $\Delta\phi$



Preliminary Results

Integration of ERA-5 fields along RO rays

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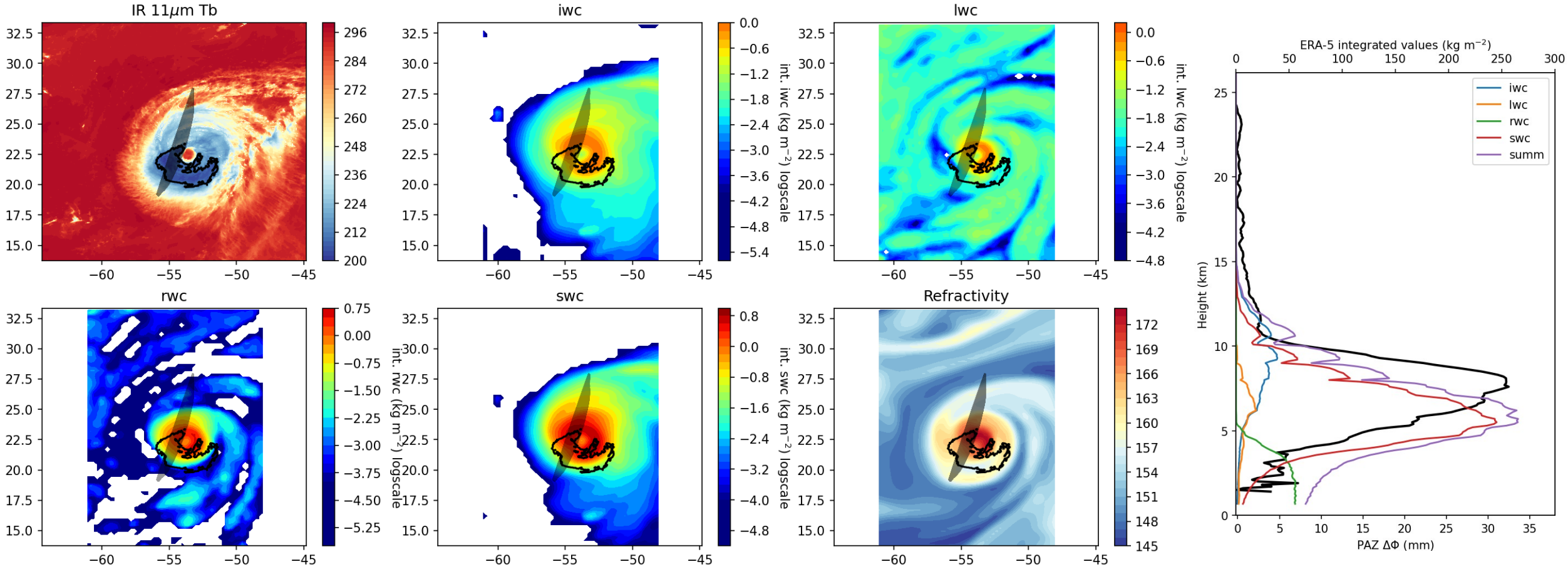
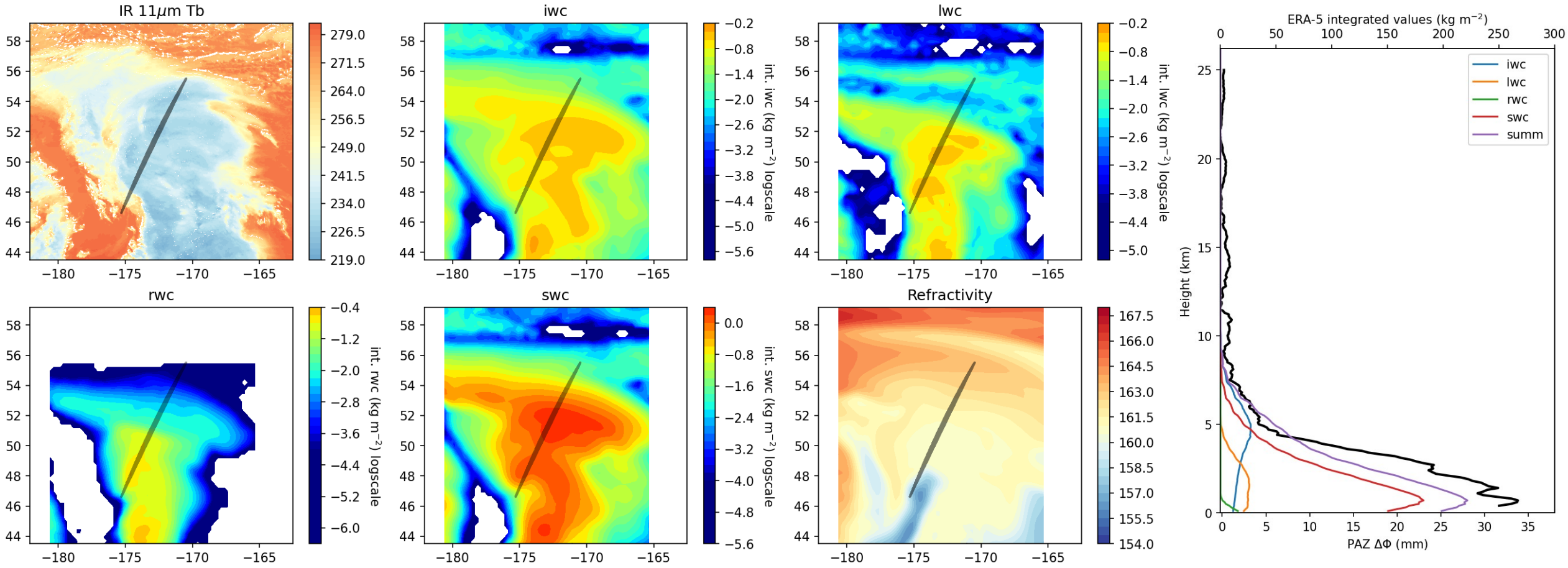
Example of Tropical Cyclone



Preliminary Results

Integration of ERA-5 fields along RO rays

Example of Atmospheric River



Preliminary Results

Correlation of Δϕ with integrated wc quantities

- Correlation coefficient between Δϕ and integrated WC for one year of data (2018)

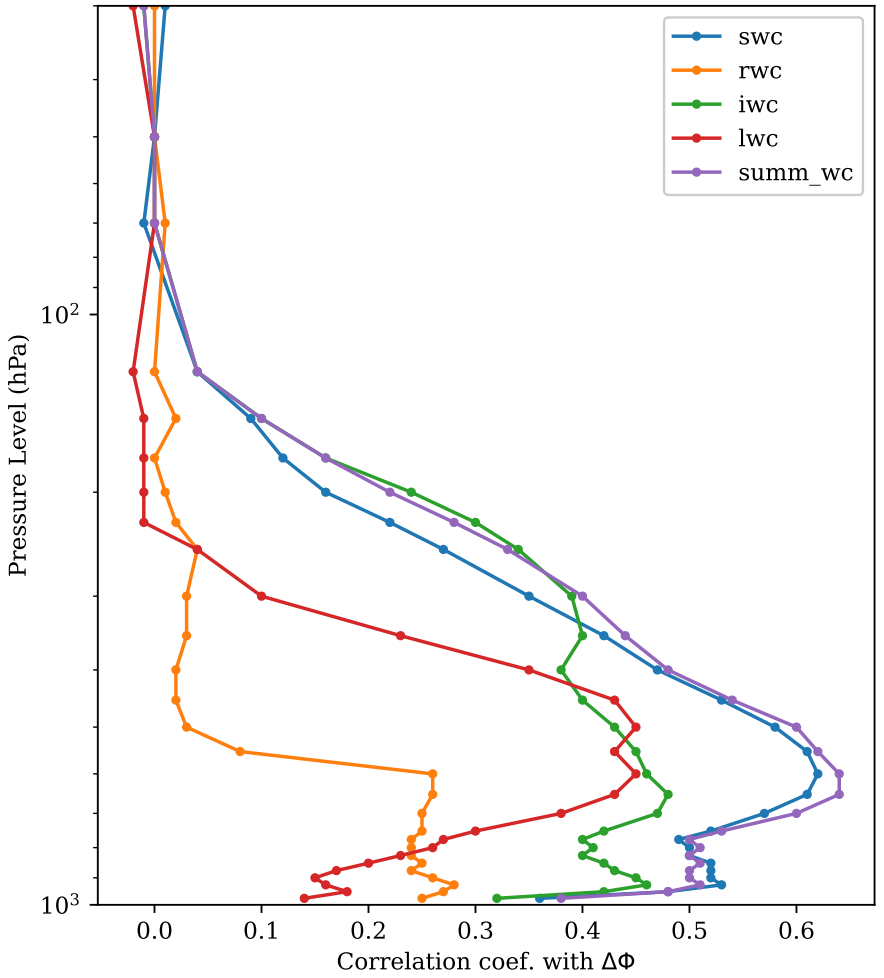
- **Largest correlation is for SWC**
- At **higher heights**, correlation is **higher with IWC**

- When accounting for all WC species (summ), correlation slightly increases

- Correlation **maximizes around 500-600 hPa** (~4.5/6 km in the Tropics, ~4/5.5 km in the mid-latitiudes)

- For some cases there is a misplacement of the convective cells
  - completely wrong simulated profile
  - or a difference in the Δϕ peak height

Statistical results



Initial tests using JMA's model

Data used

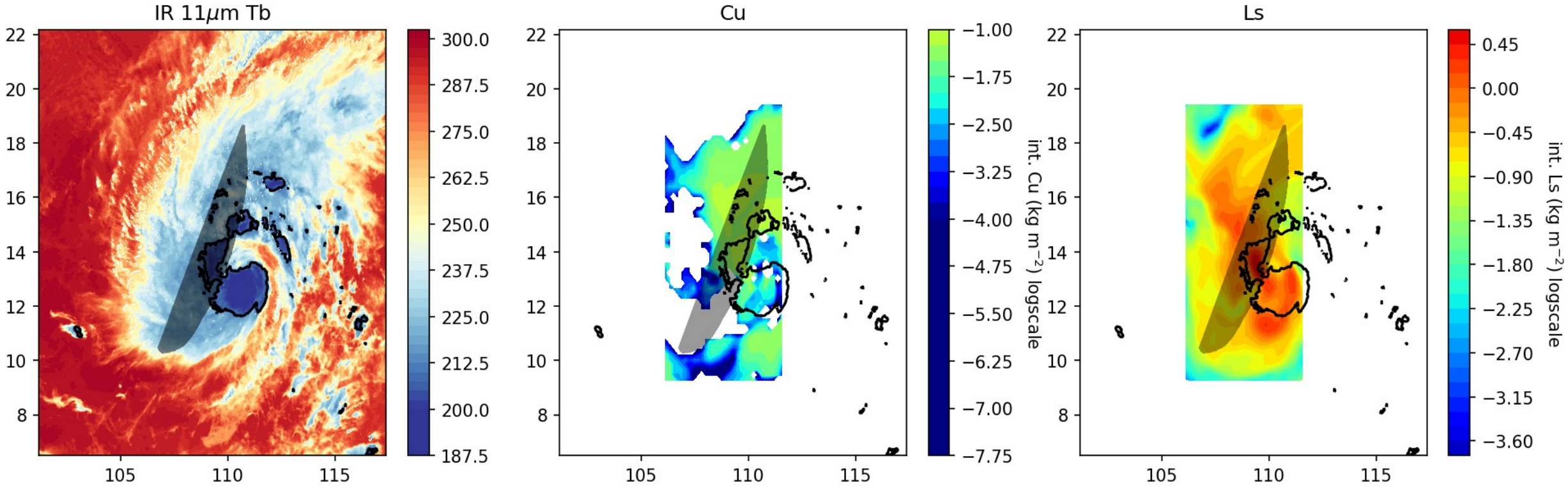
JMA hourly data on pressure levels

- Similar procedure as with ERA-5
- Only two mixing ratio parameters Cu and Ls
  (Cu: cloud water mixing ration attributable to convection scheme;
  Ls: cloud water mixing ration attributable to large-scale condensation scheme)

→ WC_Cu(h), WC_Ls(h)
(kg m^{-3})

Methodology

Interpolation of JMA fields into RO plane



Preliminary Results

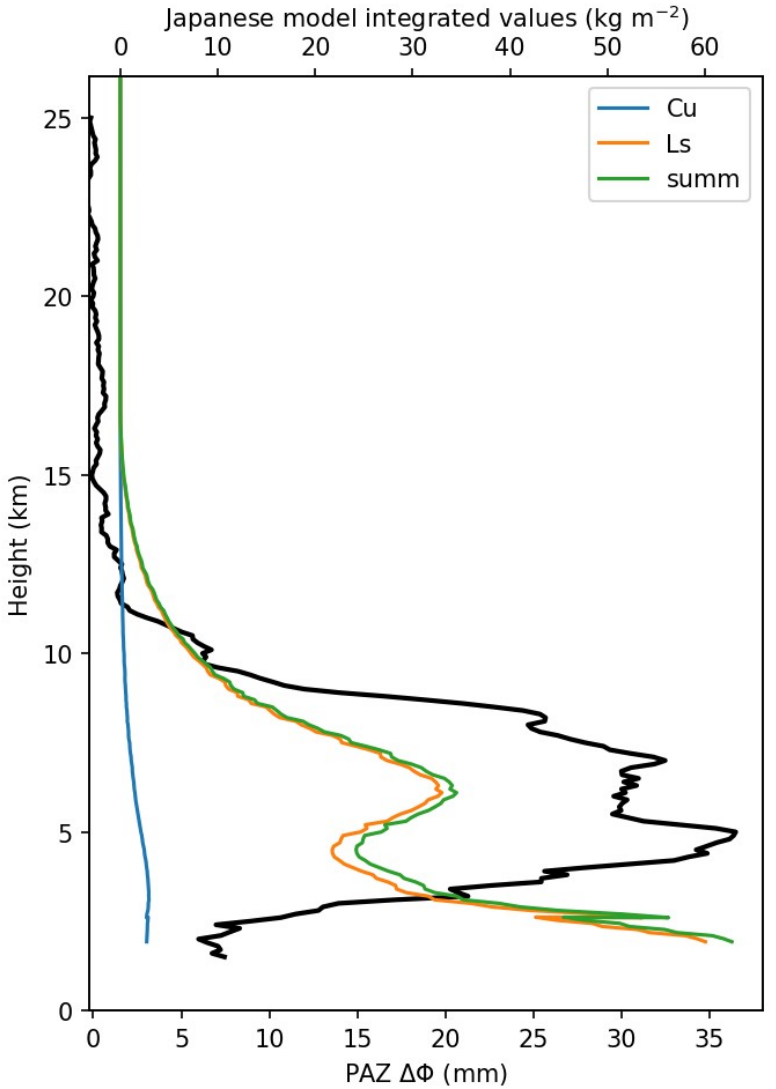
Integration of JMA fields along RO rays

- JMA approach to hydrometeor is more challenging for this exercise.
- Only two 3D field quantities available

- Rest of hydrometeors projected to surface variables (more difficult for us to model the integrated hydrometeors along the GNSS PRO ray trajectory).

- As a consequence, integrated quantities are smaller.

- **Lesson learned**: forward modeling GNSS PRO profiles can be easier or more difficult depending on model's schemes. Not always possible to compare across different models.



Summary

- Exercise ongoing to assess the potential usefulness of GNSS PRO for model diagnosis and validation, and to prospect ways to assimilate these new observables.
- Preliminary results shown from a couple of models, more to come.

Some conclusions after looking at these couple of models:

- The summation of along-track integrated ice/rain/snow water contents correlated well with GNSS PRO observable (ERA-5).
- Maximum correlation occurs between 500-600 hPa (ERA-5).
- One of the main challenges will be to compare equivalent quantities, as different models provide different outputs.
- GNSS PRO modelling can be more challenging under certain model schemes.

Thank you

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