A Cloud- and Precipitation Classification for MC3E
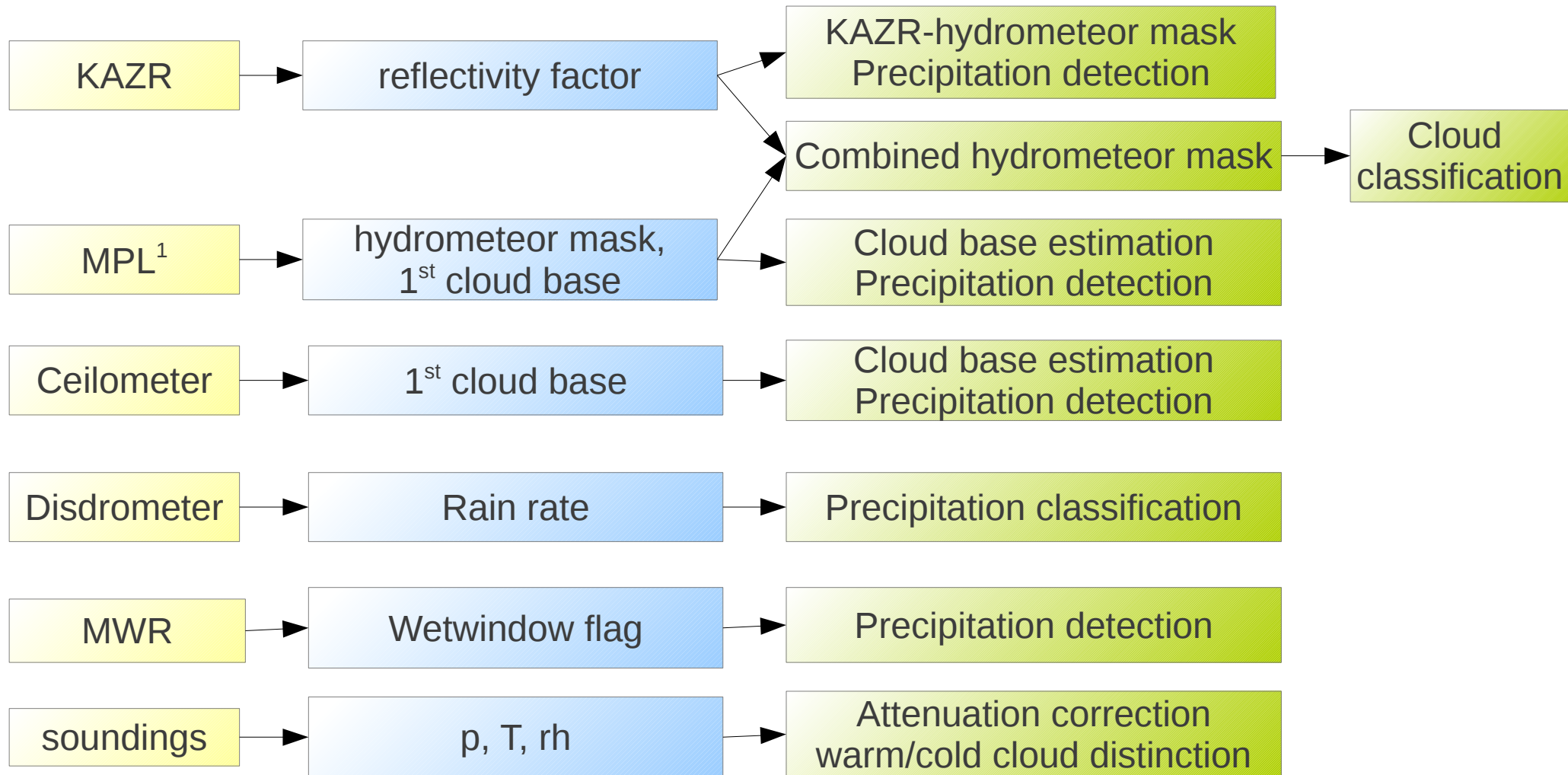
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Outline

- Input Data

- Methodology

  - KAZR data processing

  - Insect filtering

  - Cloud Classification

  - Precipitation Classification

- Data availability and Outlook

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MC3E Input Data

KAZR	reflectivity factor	KAZR-hydrometeor mask Precipitation detection
		Combined hydrometeor mask → Cloud classification
MPL[1]	hydrometeor mask, 1st cloud base	Cloud base estimation Precipitation detection
Ceilometer	1st cloud base	Cloud base estimation Precipitation detection
Disdrometer	Rain rate	Precipitation classification
MWR	Wetwindow flag	Precipitation detection
soundings	p, T, rh	Attenuation correction warm/cold cloud distinction

[1] sgp30smplcmask1zwangC1*

→ Data availability: April 22 – June 6, 2011

→ Regridding of all data to same time x height grid

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KAZR data processing

1. **Masking**

   - Mask 1: Filter noise based on copol-signal-to-noise ratio (Hildebrand, J. Appl. Meteorol., 1974)

   - Mask 2: 5x5 box, keep data at central pixel if >12 surrounding pixel have data
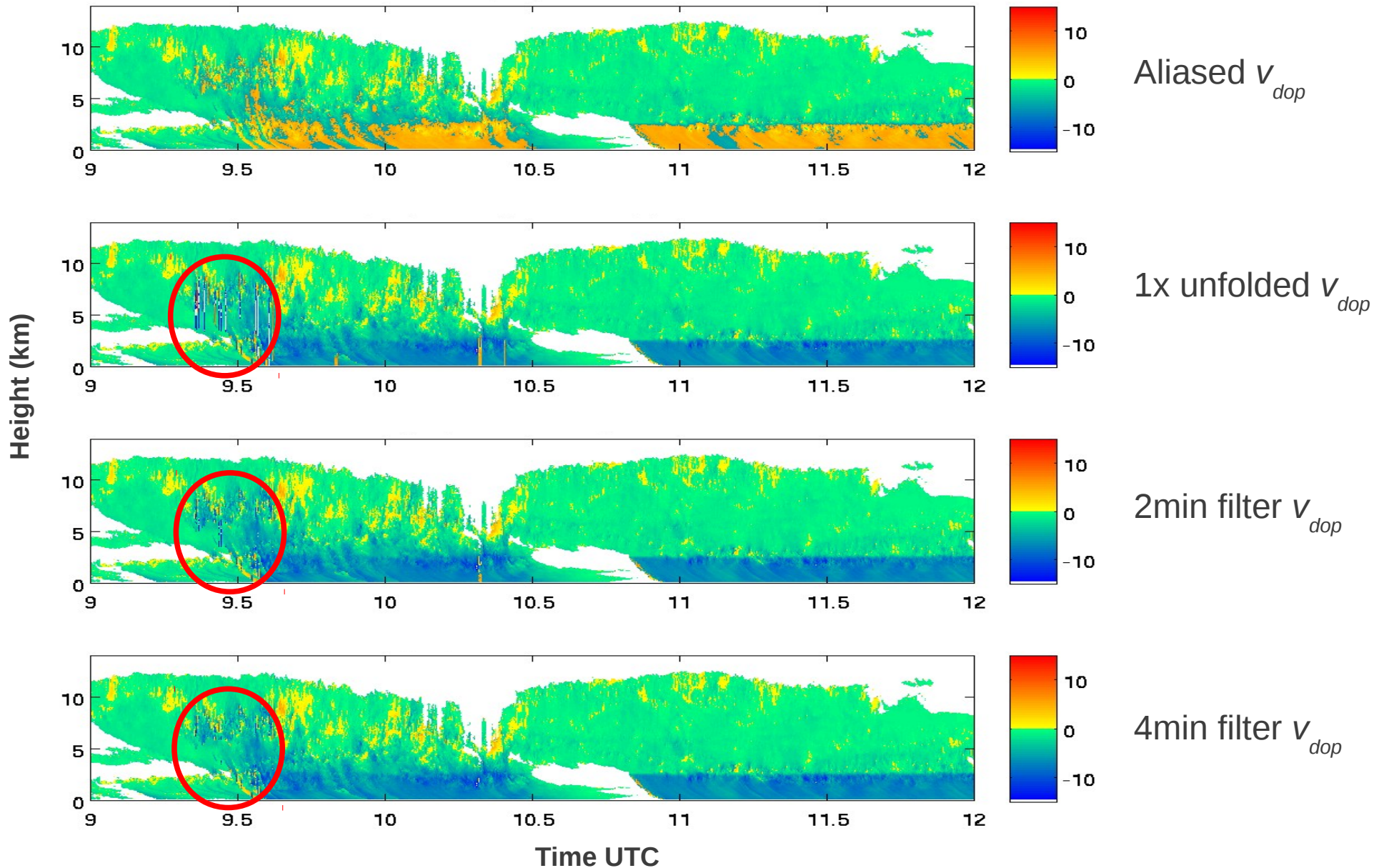
2. **Correct measured reflectivity for two-way attenuation by atmospheric gases**

   - correction for absorption by water vapor and atmospheric oxygen (Liebe, 1985)

   - Use atmospheric sounding for profile of p, T, humidity

3. **Doppler velocity v_{dop} de-aliasing**

   - Profile-by-profile, top-down correction, assumption: v_{dop} at cloud-top **not** aliased

   - Nyquist velocity: 5.9634 m/s

   - $v_{dop\_cor} = v_{dop} \pm 2 \cdot$ Nyquist velocity

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KAZR Doppler velocity de-aliasing – Example 20110424

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Ground Clutter (Insect) Filtering

1. Detect Precipitation at ground (disdrometer)
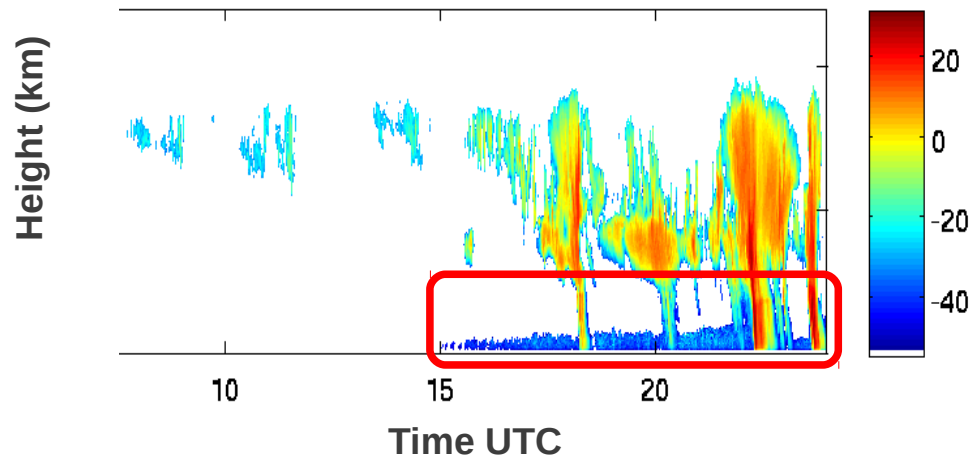2. For profiles for which **no** precipitation was detected, check criteria:

- **KAZR first hydrometeor base < MPL- or ceilometer first hydrometeor base ?**
- **Mean' LDR > -15 dB?**
- **Mean' abs(Doppler velocity) < 2.5 m/s?**
- **Mean' reflectivity < -15 dBZ ?**

(Mean' : average from ground to first MPL or ceilometer hydrometeor base)

3. Criteria fulfilled = ground clutter → remove
4. Adjustment of criteria if no MPL and ceilometer data are available
5. Problem: Boundary layer clouds embedded in insect layer

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Ground Clutter (Insect) Filtering – Example 20110426

KAZR reflectivity (dBZ)

KAZR LDR (dB)

Insect-filtered KAZR reflectivity (dBZ)

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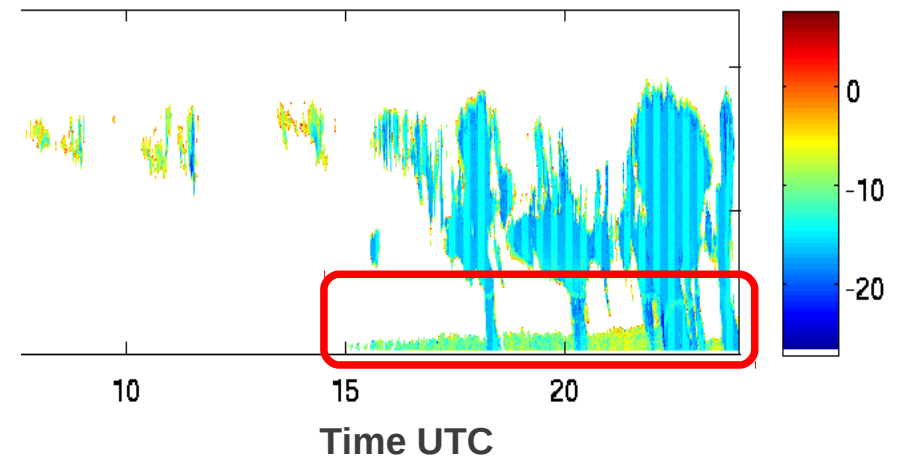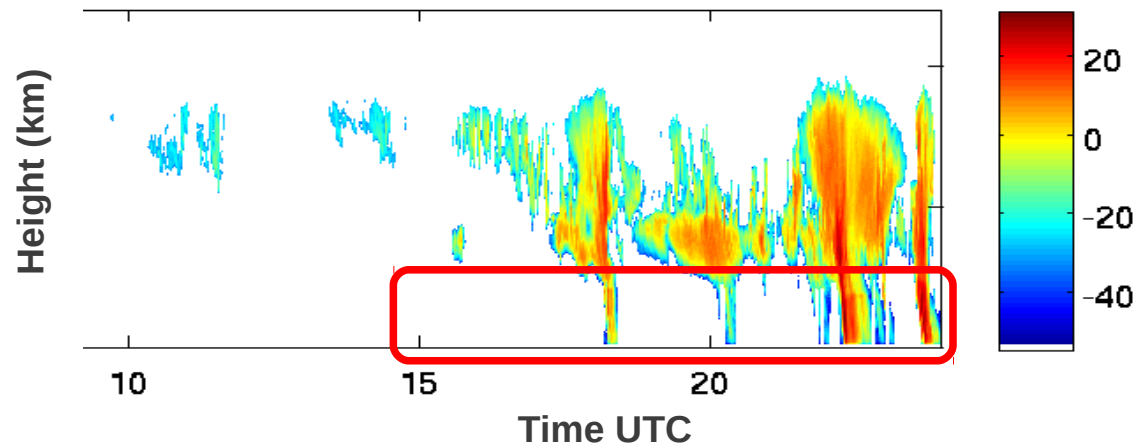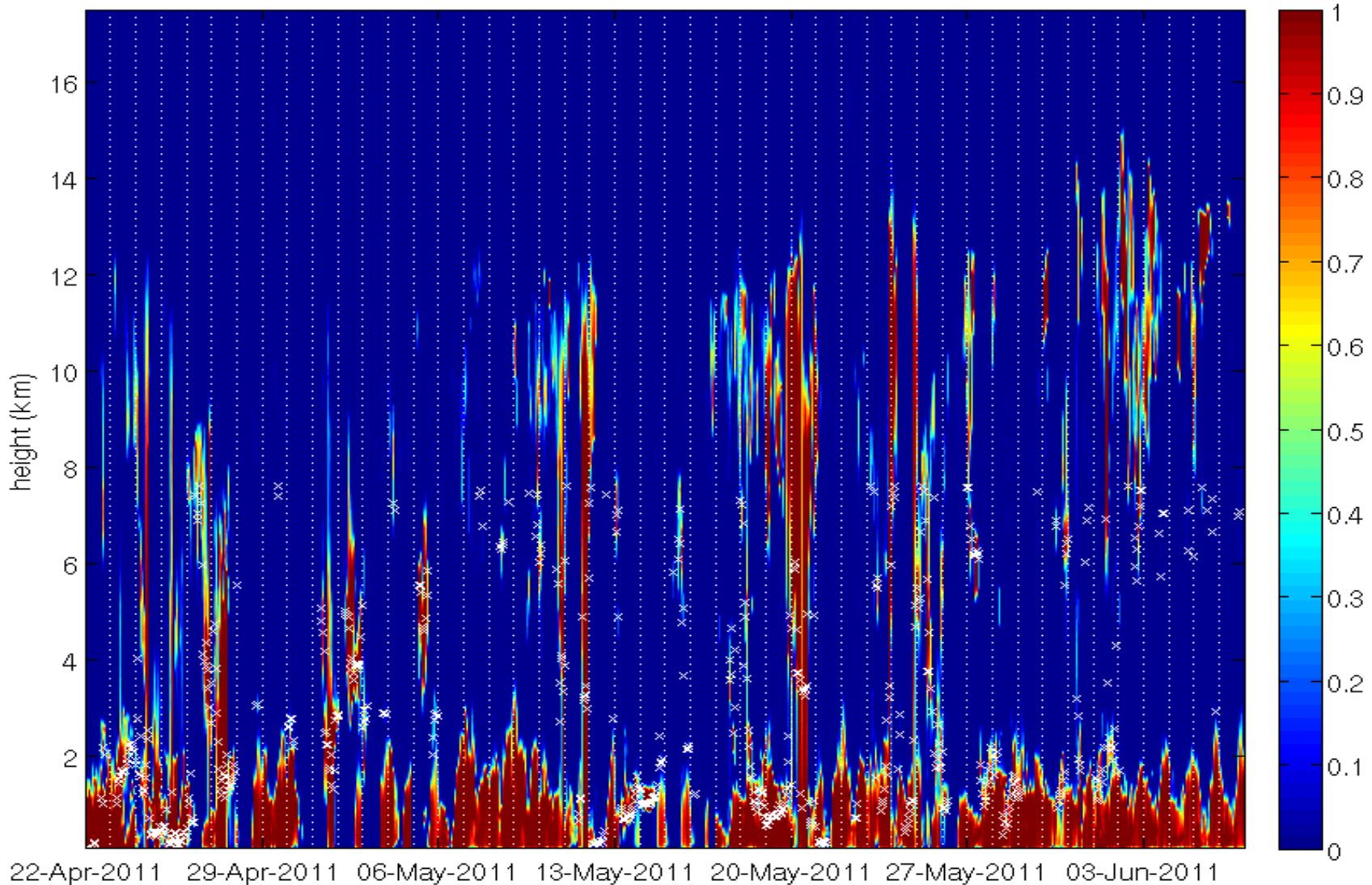
Ground Clutter (Insect) Filtering - before insect filtering

combined KAZR and MPL hourly hydrometeor fraction
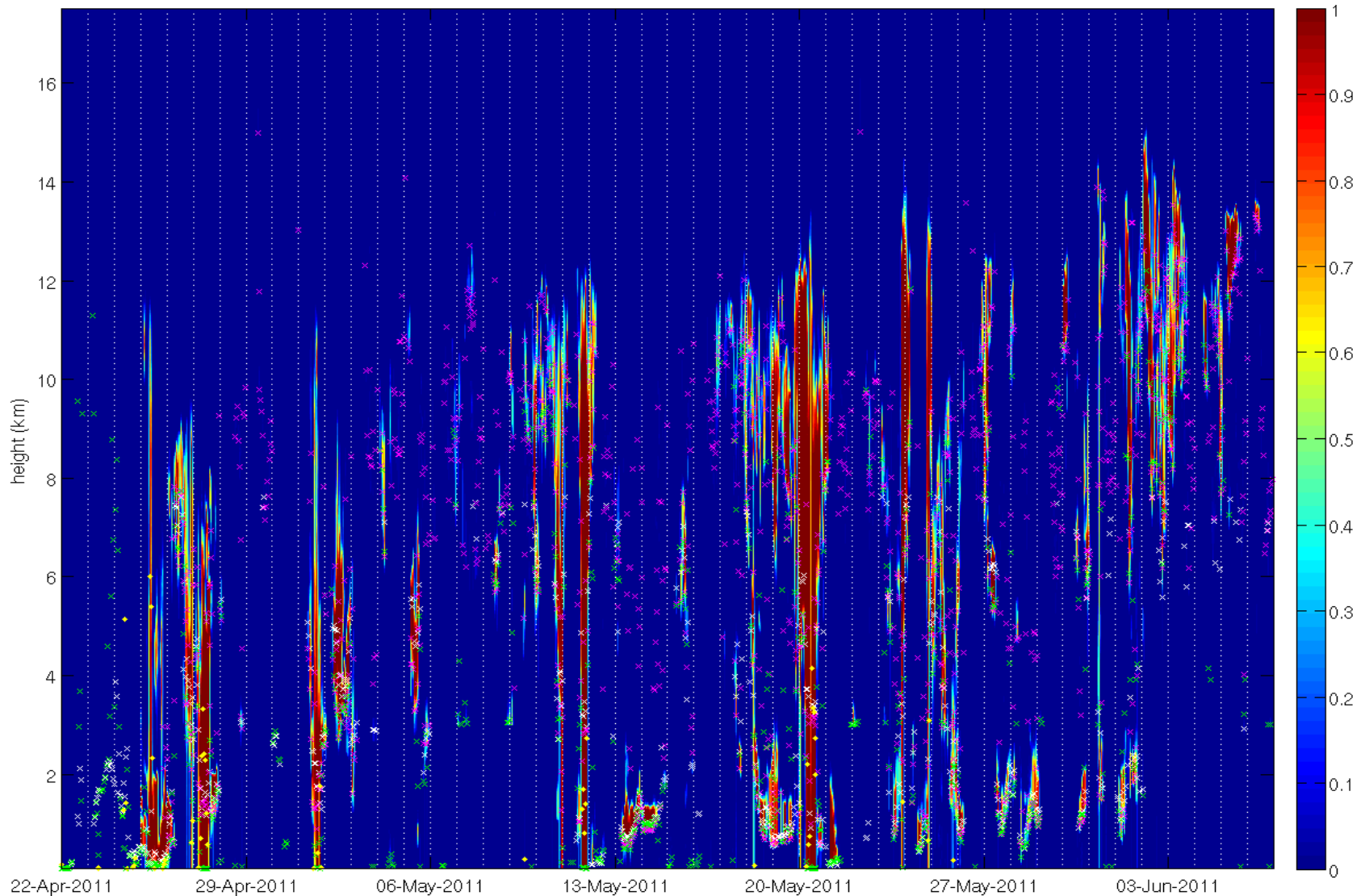and ceilometer hourly first cloud base   (white x = ceilo first base)

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Ground Clutter (Insect) Filtering - after insect filtering

combined KAZR and MPL hourly hydrometeor fraction
and ceilometer hourly first cloud base   (white x = ceilo first base)

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Cloud Classification

- Create MPL and KAZR hydrometeor mask composite

- 4 types of clouds classified (following Kollias, 2007):

    cirrus, mid-level clouds (alto), boundary layer clouds, deep convective clouds

- Clouds are only classified, if no precipitation detected by disdrometer (rainrate <= 0.01mm/h)

- If disdrometer detects rain, precipitation type identified instead:

    – warm/cold rain: cold rain = strati/conv/inconclusive

Cloud types detection criteria:

1. Deep convective clouds

   cloud bases < 2 km, cloud tops > 3 km, cloud thickness > 1.5 km, rainrate <= 0.01 mm/h

2. BL clouds

   cloud bases < 2 km, cloud tops < 3 km, cloud thickness <1.5 km, rainrate <= 0.01 mm/h
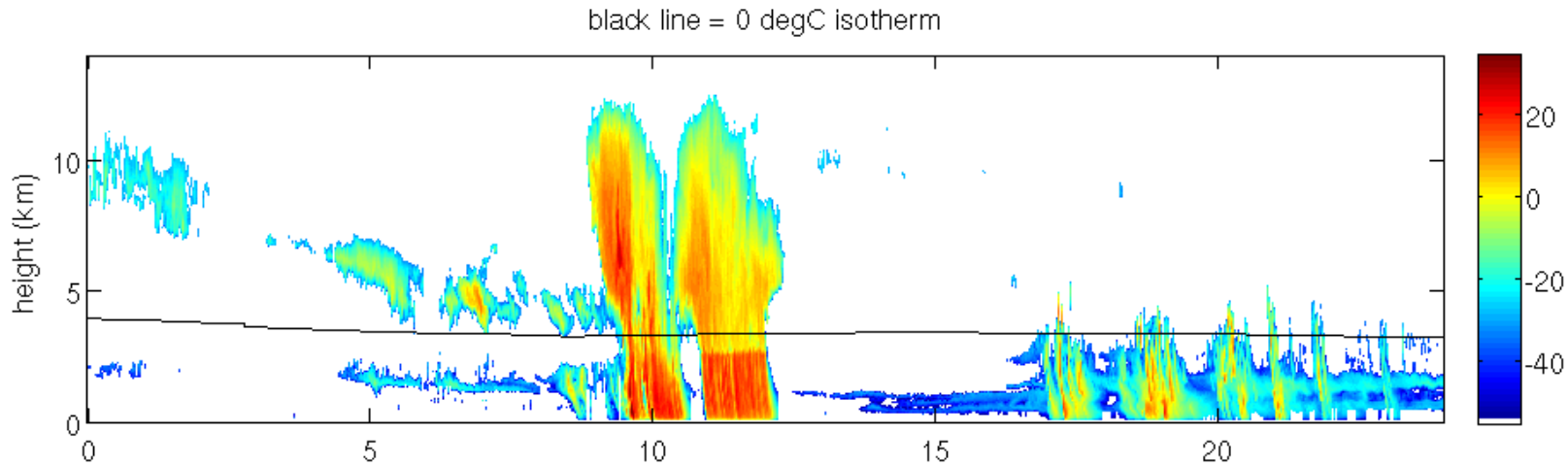
3. Mid-level clouds (alto)

   cloud bases at 2-6 km, rainrate <= 0.01 mm/h

4. Cirrus
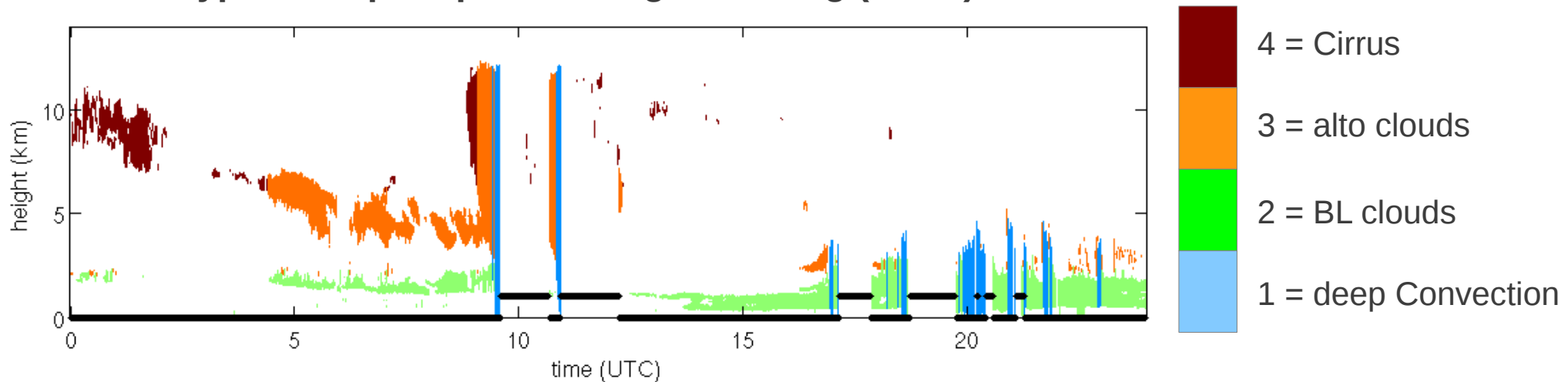
   cloud base > 6 km

Cloud Classification – Example 20110424

KAZR reflectivity (dBZ)

Cloud Types and precipitation at ground flag (black)

4 = Cirrus

3 = alto clouds

2 = BL clouds
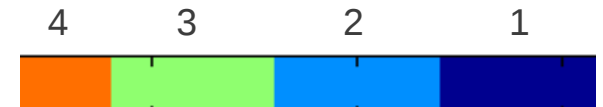
1 = deep Convection

Time resolution of cloud type classification: 30s (profile-by-profile)
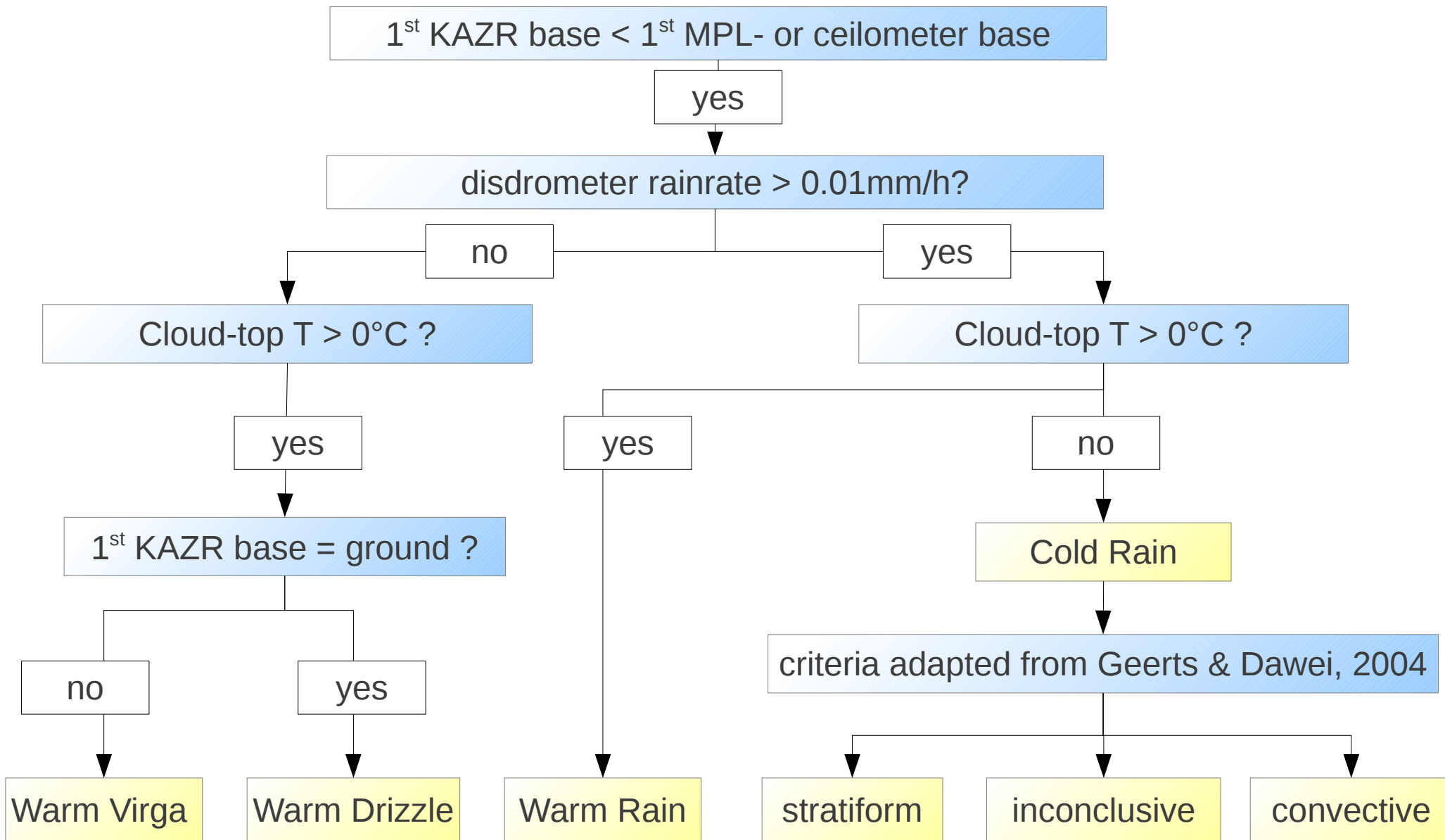
Cloud Classification – MC3E times series

MC3E non-precipitating cloud types; 1 = deepConv, 2 = low BL clouds, 3 = Alto clouds, 4 = Ci
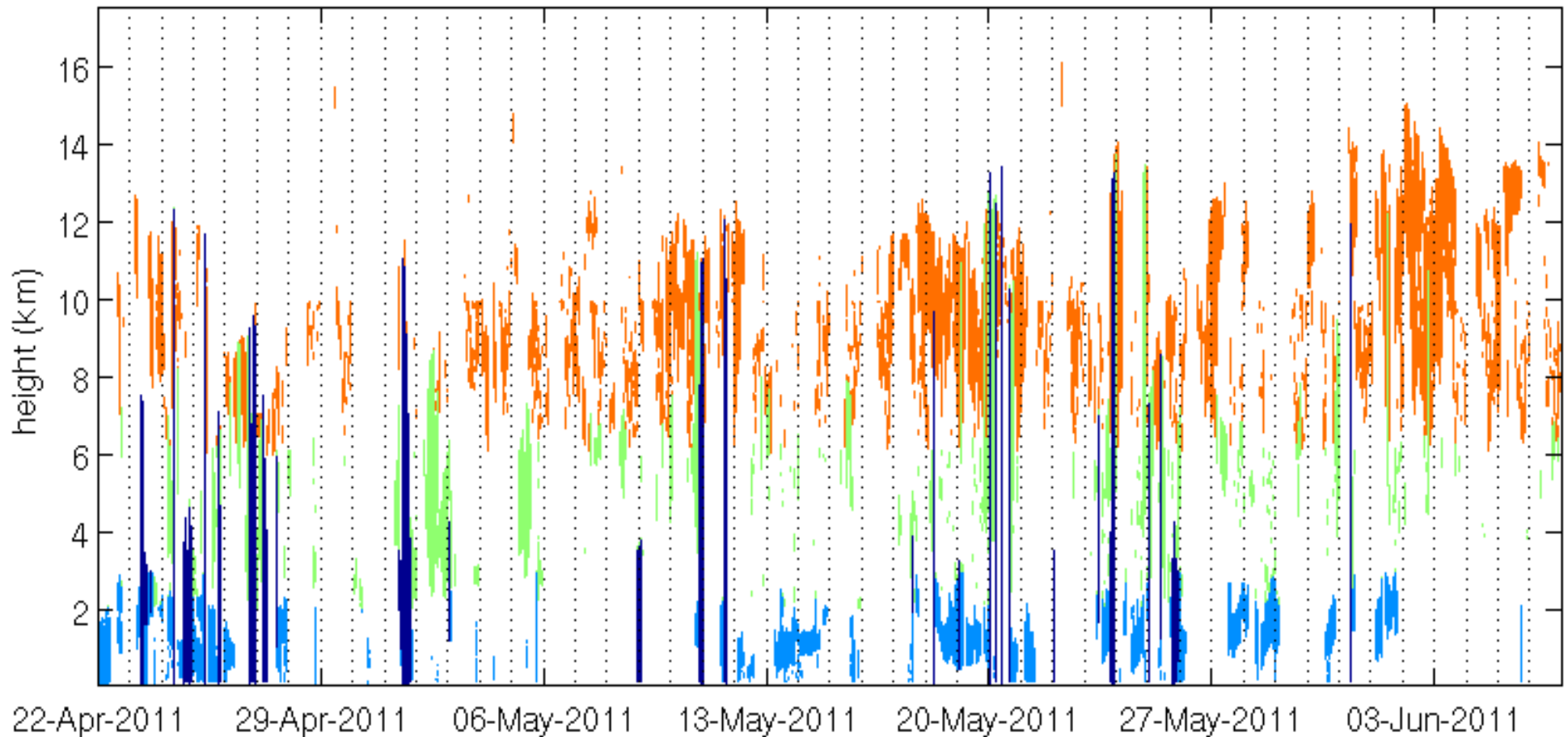
- Hourly cloud fraction of each cloud type per pixel (0-1)
- Hourly occurence of each cloud type (0-1)
- Hourly mean bases and tops of each cloud type (up to 4 layers)

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Precipitation Classification

Not classified: virga from cirrus/alto clouds/deep convection, drizzle from cold clouds

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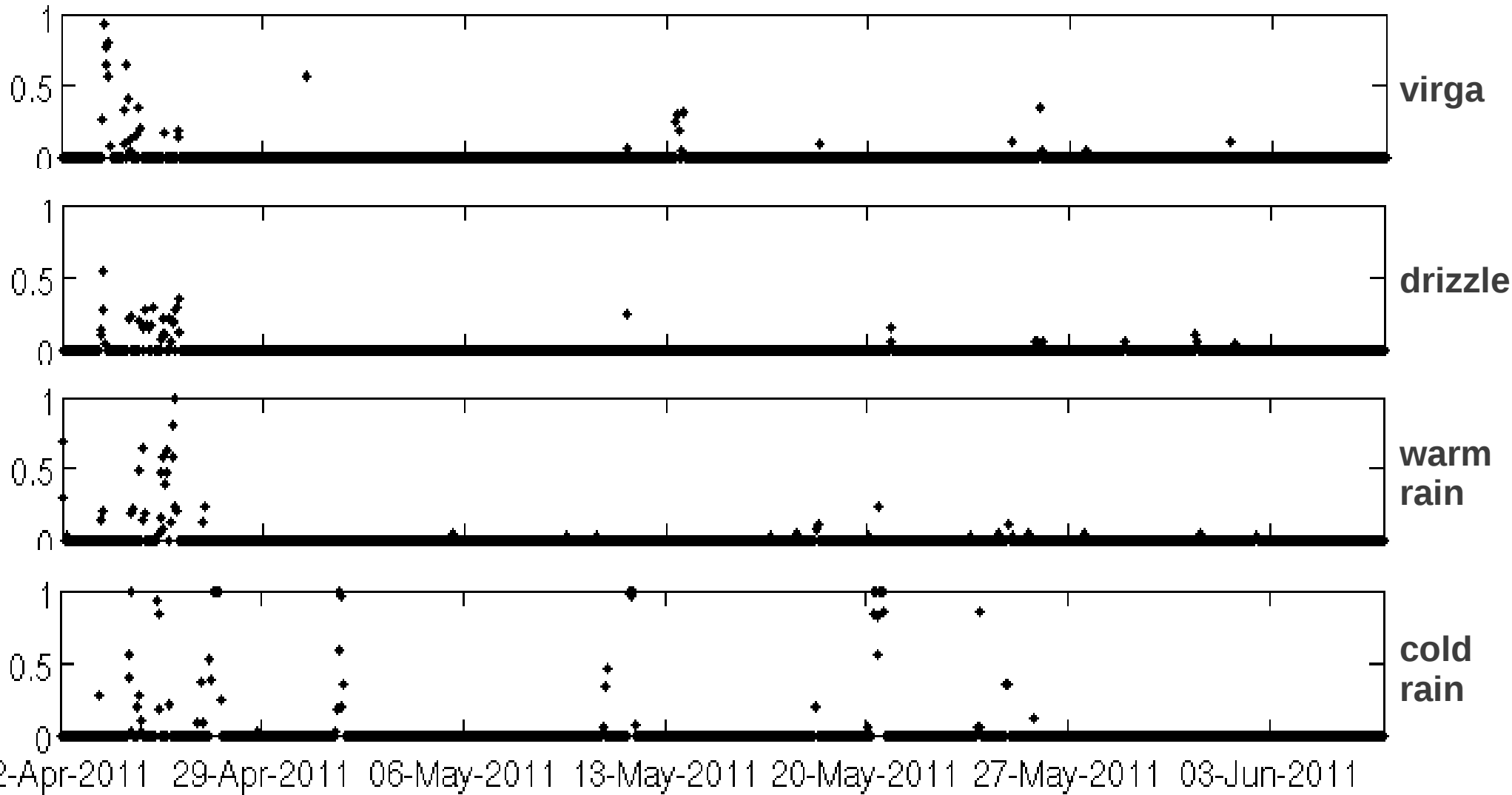# Precipitation Classification – Example 20110424

KAZR reflectivity (dBZ) with precipitation type flags:
Pink = virga, black = drizzle, red = warm rain,
blue = stratiform cold rain, green = convective cold rain
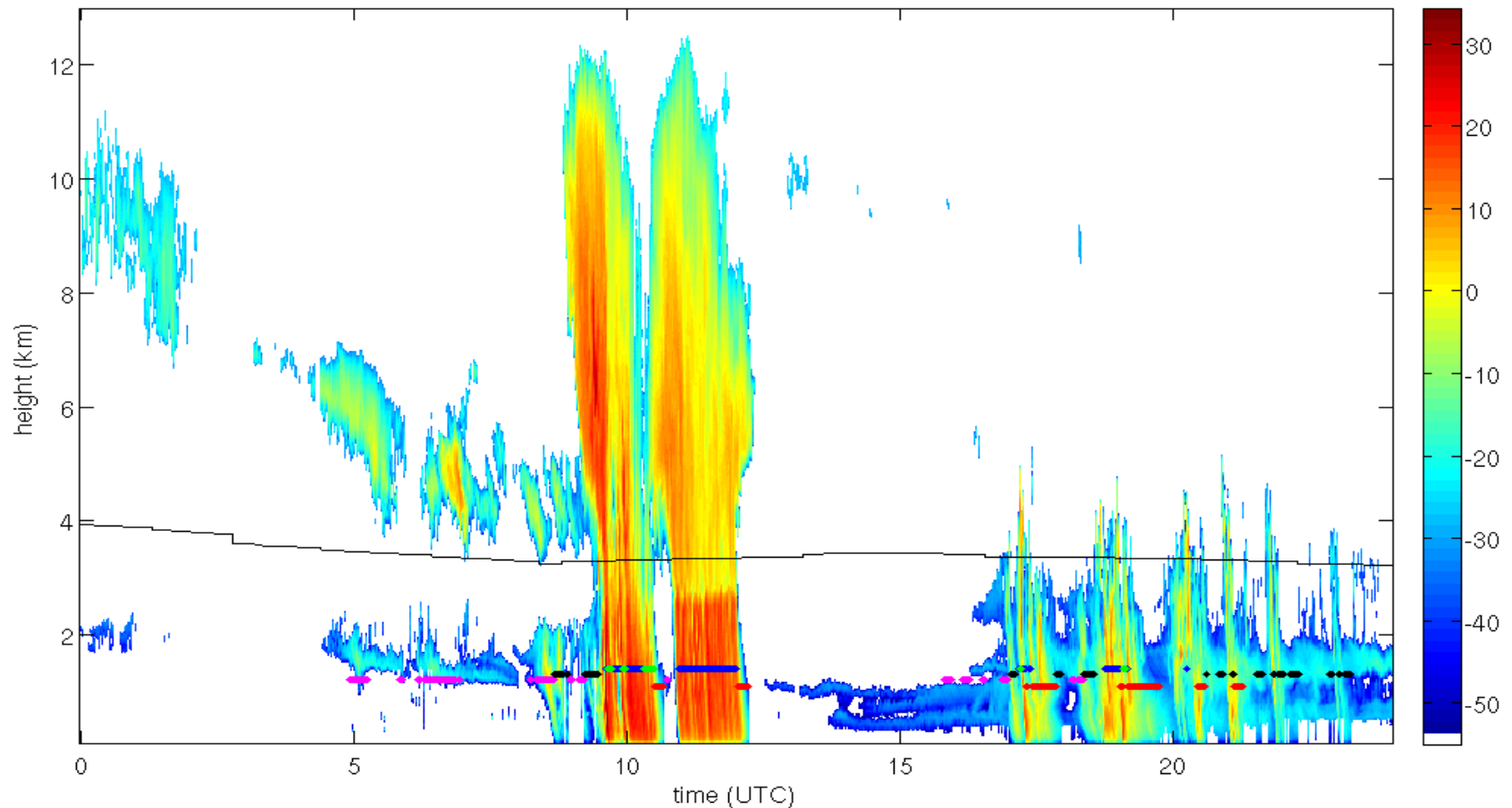
Time resolution of precipitation type classification: 30s (profile-by-profile)

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Precipitation Classification – MC3E

Hourly fractions of classified precipitation types

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Data availability and outlook

netcdf with the **hourly** values of MC3E timeseries variables

- Combined KAZR+MPL hydrometeor mask
- Cloud types + bases + tops
- Precipitation types (occurence per hour (0-1))
- ...

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Value-added product (VAP) generation for ARM SGP data ?

- Use ARSCL as input if available
- use 1hr-resolution ECMWF re-analysis data (sgpecmwfvarX1*) instead of soundings
- discriminate hydrometeor phase
- ...

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References

Geerts B. and Y. Dawei. *Classification and Characterization of Tropical Precipitation Based on High-Resolution Airborne Vertical Incidence Radar.* Part I: Classification, J. Appl. Meteorol., 43, 2004

Hildebrand, P. H., and R. S. Sekhon, *Objective determination of the noise level in Doppler spectra*, J. Appl. Meteorol., 13, 808, 1974.

Kollias, P. et al. *Cloud Climatology at the SGP and the layer structure, drizzle, and atmospheric modes of continental stratus*, JGR, 2007

Liebe, H.. *An updated model for millimeter wave propagation in moist air*, Radio Science , 20, 1069-1089, 1985
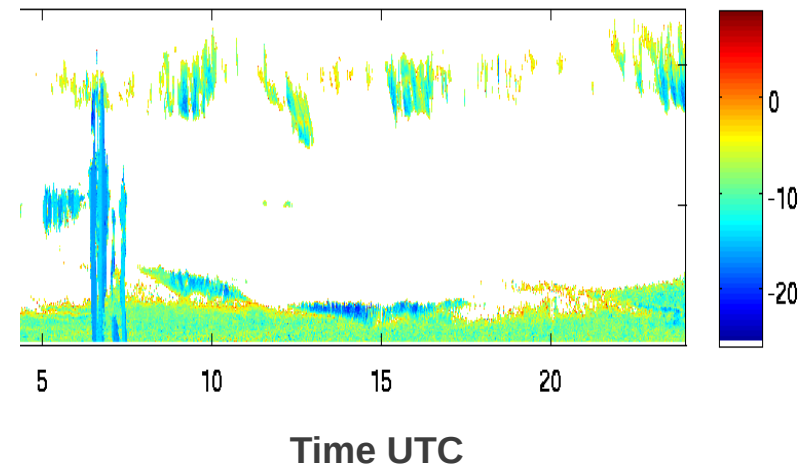
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Ground Clutter (Insect) Filtering – Example 20110518

BL clouds embedded in insect layer

KAZR reflectivity (dBZ)

KAZR LDR (dB)

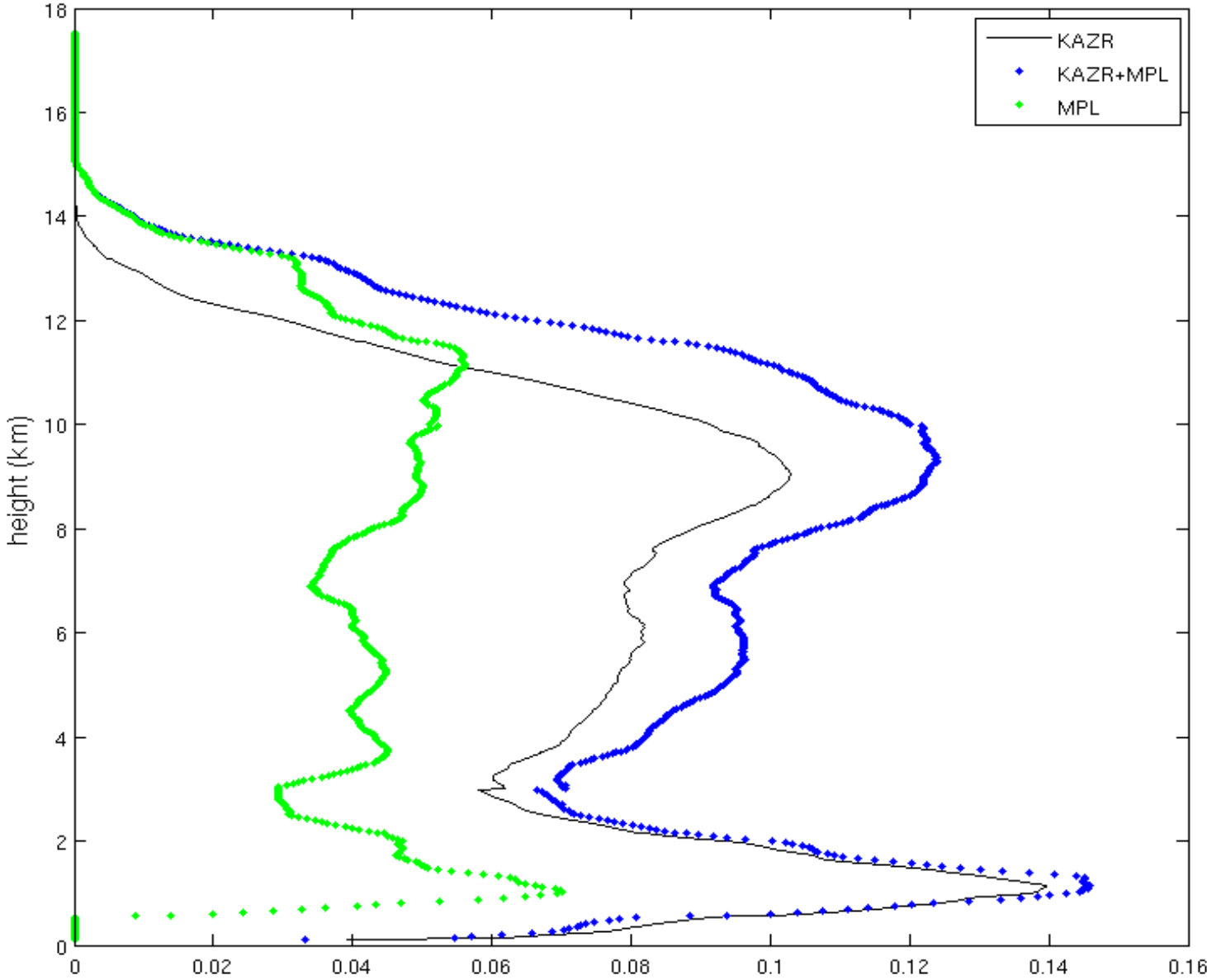Insect-filtered KAZR reflectivity (dBZ)

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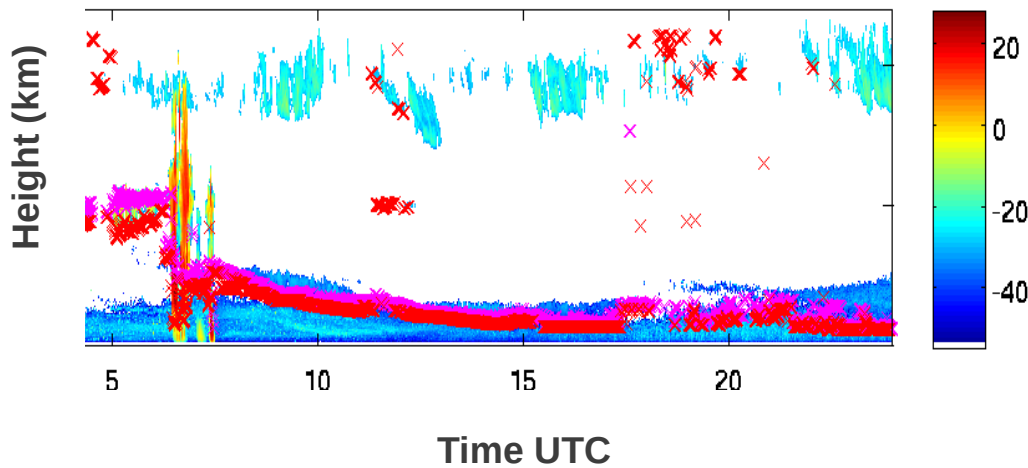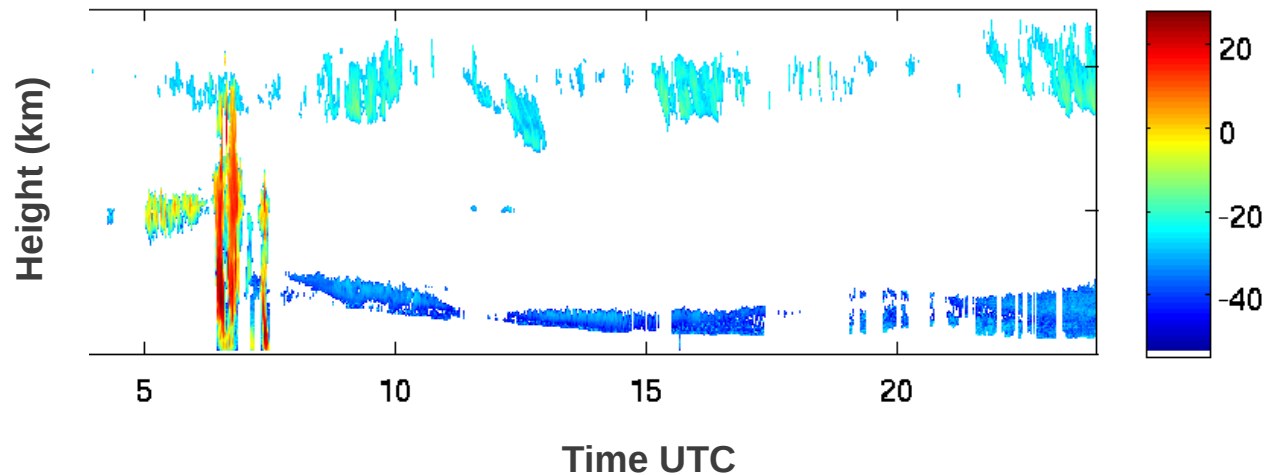
Mean profile of hydrometeor fractions (April 22- June 6, 2011)

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Precipitation Classification – criteria adapted from Geerts & Dawei, 2004

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