3D Cloud Reconstructions

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Scan strategy used in 3D cloud reconstructions

Plan position indicator (PPI)

Cross wind range-height indicator (CWRHI)

Scan strategy used in 3D cloud reconstructions

**plan position indicator (PPI)**

**cross wind range-height indicator (CWRHI)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PPI</th>
<th>BLRHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation (°)</td>
<td>0: 3: 42</td>
<td>0: 45</td>
</tr>
<tr>
<td>Azimuth (°)</td>
<td>90 – 270</td>
<td>75: 2: 165</td>
</tr>
<tr>
<td>Time (min)</td>
<td>8</td>
<td>5.3</td>
</tr>
</tbody>
</table>

*Courtesy of Zuidema*

Small and thin clouds will be easily missed by old scanning cloud radar
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Impact of radar sensitivity

Radar sensitivity gives the greatest error in reconstructions

Fielding et al. (JGR, 2013)
Small and thin clouds will be easily missed by old scanning cloud radar

Impact of radar sensitivity

Radar sensitivity gives the greatest error in reconstructions

Fielding et al. (JGR, 2013)
Sensitivity of scanning cloud radars

Radar reflectivity (dBZ)

Effective radius (μm)

Liquid water content (g m⁻³)

new radar

missed!

at 2 km away from radar

new radar
Sensitivity of scanning cloud radars

Radar reflectivity (dBZ)

RACORO

new radar

at 2 km away from radar

missed!
Sensitivity of scanning cloud radars

Radar reflectivity (dBZ)

- New radar
- RACORO
- LASIC

Effective radius (\(\mu\text{m}\))

Liquid water content (g m\(^{-3}\))
Low wind speed conditions could potentially lead to a poor reconstruction

Fielding et al. (JGR, 2013)
Wind conditions during LASIC

At 500 m:
- Power 2 mode: 24%
- Surface: 8%

At 1 km:
- Power 2 mode: 0%

At surface:
- Power 2 mode: 15%
Wind conditions during LASIC

- At 500 m
  - Power 1 mode
  - 15%
  - 5%

- At 1 km
  - 15%
  - 5%

- At surface
  - 15%
  - 5%
Reconstructed cloud fields from LASIC

- Reconstructions rely on sufficiently good wind radar data

High-power mode

Low-power mode

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Novel 3D cloud retrieval (ENCORE)

- Combine scanning cloud radar and shortwave radiometer obs.
- Include 3D radiative transfer as a forward model
- Use the Iterative Ensemble Kalman Filter as an optimal estimation framework

State vector (what we retrieve)
- Total cloud droplet number concentration
- Cloud water content
- Cloud effective radius

Examples from the ARM Mobile Facility deployment at the Azores
Shallow cumulus at the Azores

Effective radius

Fielding et al. (JGR, 2014)
Radiation scheme incorporating 3D effects

• Speedy Algorithm for Radiative TrAnsfer through CloUd Sides (SPARTACUS; Hogan and Shonk, 2013)

• Variables needed for this fast scheme
  – cloud water content
  – cloud effective radius
  – cloud fraction
  – cloud inhomogeneity
  – overlap
  – Cloud-side length

Schäfer et al. (JGR, 2016)
Hogan et al. (JGR, 2016)
An example snapshot of 3D cloud effect

Difference in net cloud radiative effect at surface (with minus without 3D)

Summary

• Proper 3D cloud reconstructions allow us to characterize cloud populations for radiation schemes, and to track individual clouds for studying their life cycles.

• The current scanning cloud radar appears to have sufficient sensitivity to capture cumulus clouds (with 5 microns effective radius).

• We need to resolve the issue with wind radar profiler products.