A Comparison of Vertical Velocity PDFs in the Cloudy and Cloud-Free Atmosphere

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1. Motivation

Determine the distribution of vertical velocity perturbations to compare with

- velocity statistics from a range of remote sensing instruments
- assumptions commonly applied in global and regional scale models of the atmosphere

2. Data Summary

RACORO campaign 10Hz Cabin Data

59 flights were conducted over the ARM Southern Great Plains (SGP) site from January through June of 2009.

21 flights included cloudy data:

- 339 Flight Legs
- 125 Cloudy Flight Legs
  - 3.4 hours of cloud data
  - 15.2 hours of cloud-free data

Figure 1. Measurement probes mounted under the wing of the CIRPAS Twin Otter aircraft. (Photo from ARM)

3. Outline of Methods

Separate data into cloudy and cloud-free portions using cloud & aerosol spectrometer.

Use wavelet analysis to filter data.

Evaluate probability distribution functions of vertical velocity variance.

4. Cloudy Flight Case Studies

Two dates with moderately cloudy legs were selected:

- 4/19/09 – 19 legs in total, 9 legs with clouds
  - most cloudy legs were ~90% cloud
- 5/06/09 – 26 legs in total, 7 legs with clouds
  - cloudy legs varied from 13% to 98% cloud

Expected characteristics of PDFs are observed:

- Standard deviation is smallest above clouds and larger below cloud layer
- Skewness is positive in- / below cloud and negative out-of / above cloud

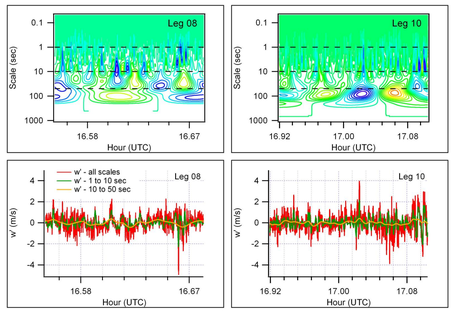

Figure 2. Sample w' scalograms and w' time series at three scales for two cloud layer legs during 4/19/09.

Figure 3. Sky images from the aircraft (at 1603 UTC) and TSI (at 1633 and 1655 UTC) on 4/19/09.

Figure 4. Sky images from the aircraft (at 1800 UTC) and TSI (at 1754 and 1802 UTC) on 5/6/09.

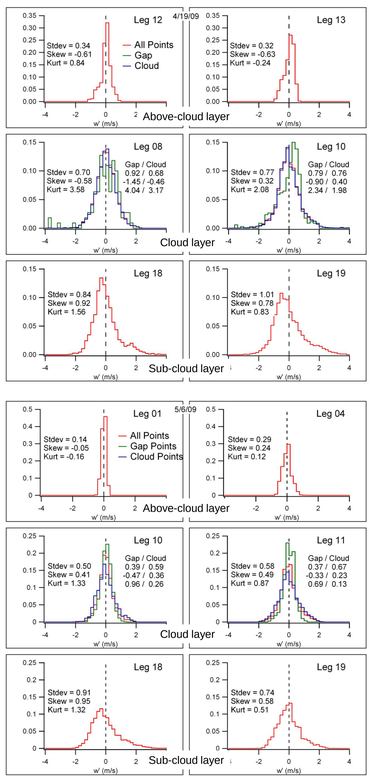

Figure 5. w' PDFs of all, cloud, and gap data for selected legs on 4/19/09 and 5/6/09.

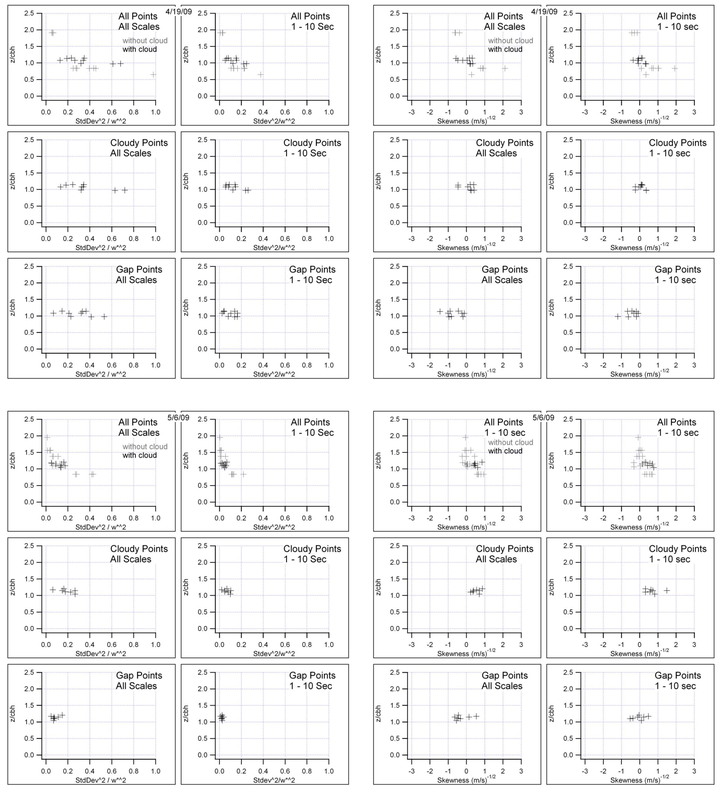

Figure 6. Normalized variance and skewness (at two scales) of w' PDFs from flight legs on 4/19/09 and 5/6/09.

5. Cloud-flight PDF Summary

- Standard deviation is largest for PDF of all points, and much smaller for gap/cloud PDFs
- Skewness tends to be positive in clouds
- Kurtosis is largest at All Scales

Distinct differences in statistics by cloud presence and by time scale.

Potential for bias in w' from ground-based remote sensing instruments associated with sampling interval.

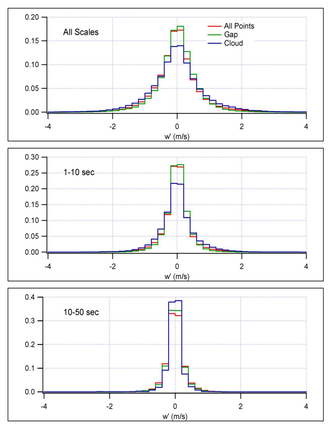

Figure 7. PDFs of w' for all, cloud gap, and in-cloud measurement points separated by time scales.

All Pts = 50 hrs
Gap Pts = 15.2 hrs
Cloud Pts = 3.4 hrs

Table 1. Summary of statistics for the PDFs shown in Figure 7.

		Std Dev.	Skewness	Kurtosis
All Scales	All	1.156	0.652	0.967
	Gap	0.184	-1.170	2.522
	Cloud	0.321	0.099	0.181
1-10 Sec	All	0.741	0.565	0.325
	Gap	0.103	-0.545	0.972
	Cloud	0.207	0.577	-0.035
10-50 Sec	All	0.438	0.053	0.027
	Gap	0.066	-0.280	-1.313
	Cloud	0.065	-0.167	-0.338

6. Acknowledgements

Haf Jonsson at the Naval Postgraduate School provided an early version of this dataset.

This work is supported under BER by the U.S. Department of Energy (DE-AC05-76RL01830) as part of the ASR program and as part of ARM.

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Flaherty_ASRPoster_2011.ppt | PNNL-SA-78719