Update on Assessment of Overnight Maximum in Convective Intensity during the Darwin-14 Flight Campaign

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The Problem of Overnight Convective Maximum

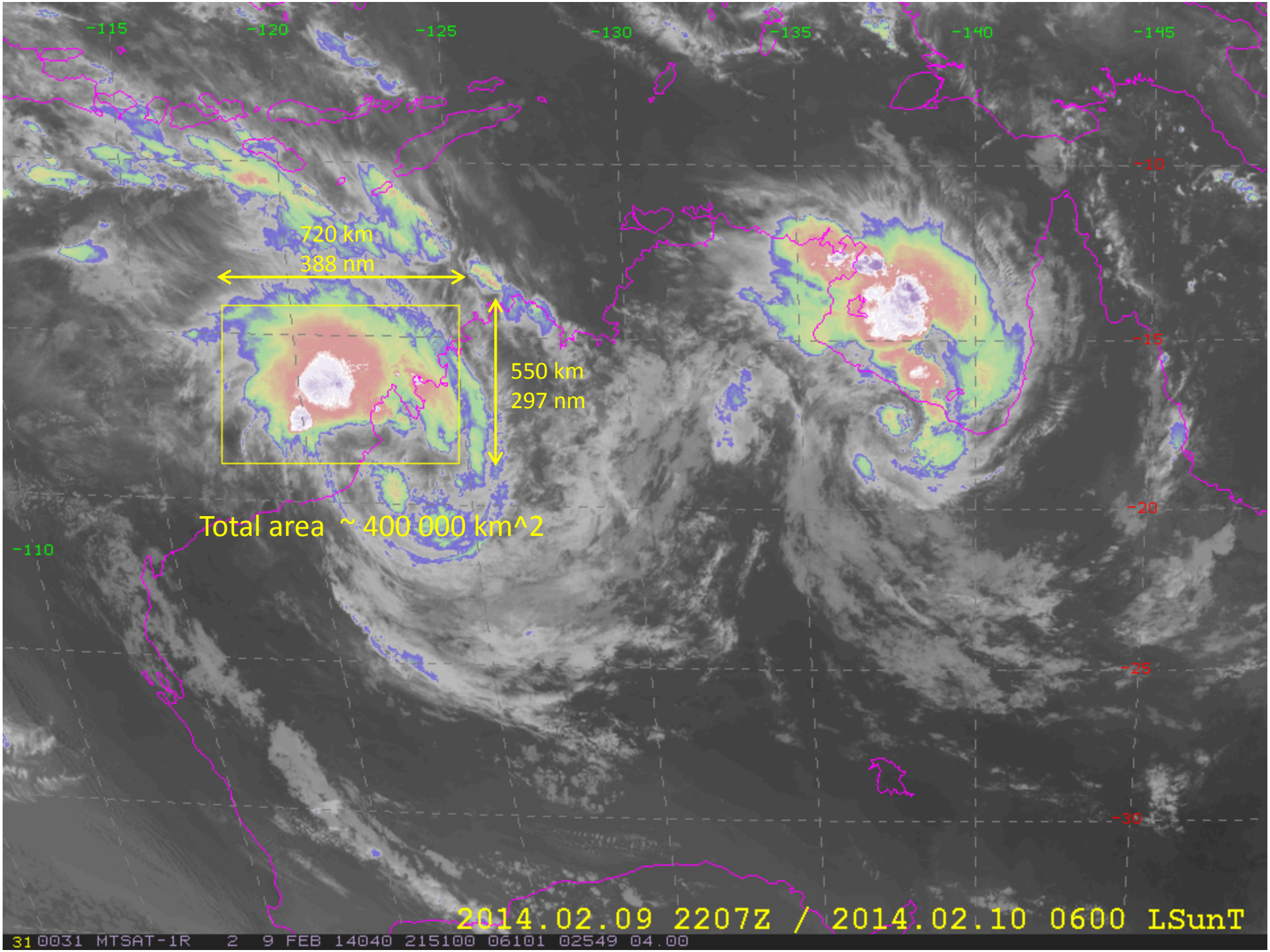
- In 2006, the Australian Bureau of Meteorology advised us that flights in Darwin would need to be as early in the day as possible, due to overnight maximum in convective activity

- Problem:
  - for safety reasons, it was decided that flights were to be initially conducted in daytime hours only
  - Earliest takeoff ~5:30 am, in-cloud ~6:00-7:00 am.
  - During Darwin-14, it was our subjective impression during the flight program was that clouds were definitely in the decay-stage for many of the flights

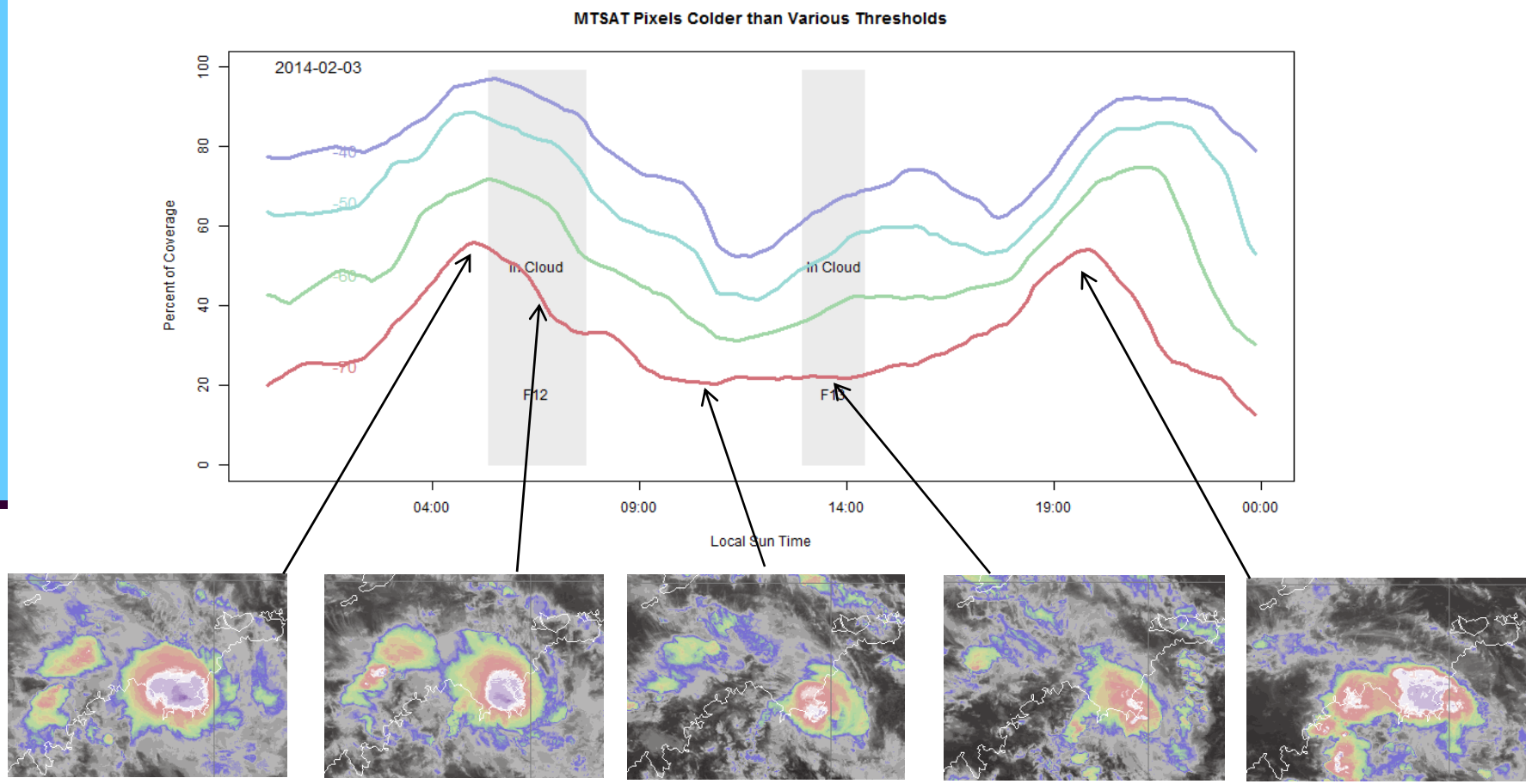
- Questions:
  - Was this subjective impression valid, and how late were we? (easy)
  - How does this affect our statistics? (difficult)

Satellite imagery analysis method

- perform an objective analysis of the MTSAT IR imagery
- draw a box around the cloud of interest, and follow the cloud evolution from midnight sun time to midnight the next day
- Characterize the ‘intensity’ of the convection in terms of the amount of high cloud
  - Area of cloud colder than -40, -50, -60, -80, -90 C
- Shows results in terms of local solar time (GMT with one hour/15 degrees longitude adjustment, center of box)
- Sunrise was ~05:45 am solar time


-115
-120
-125
-130
-135
-140
-145
-10
-15
-20
-25
-30
-110
720 km
388 nm
550 km
297 nm
Total area ~ 400 000 km^2
2014.02.09 2207Z / 2014.02.10 0600 LSunT
31 0031 MTSAT-1R 2 9 FEB 14040 215100 06101 02549 04.00

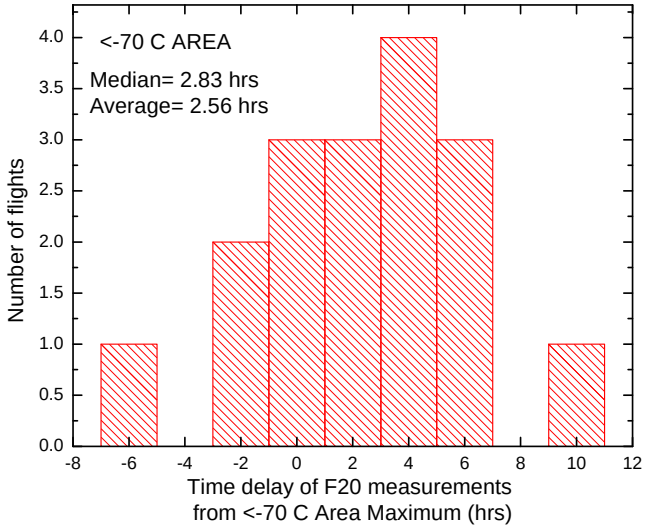
Example 2: Two flights same day in tropical low at different periods of intensity cycle

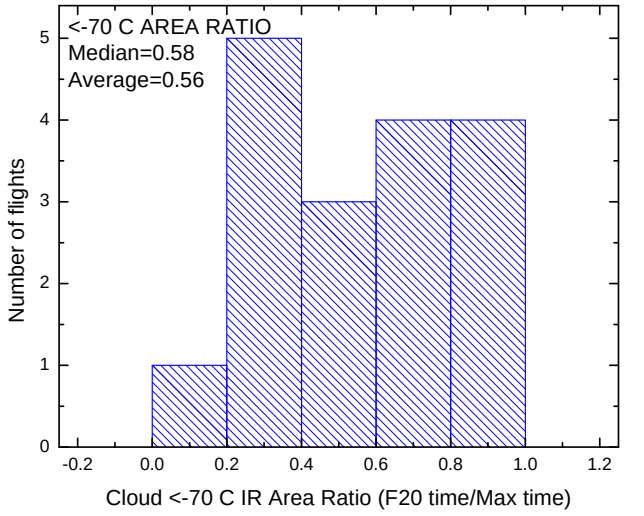


Overall results, all Darwin-14 flights
Cloud Area at -70 C (complete)

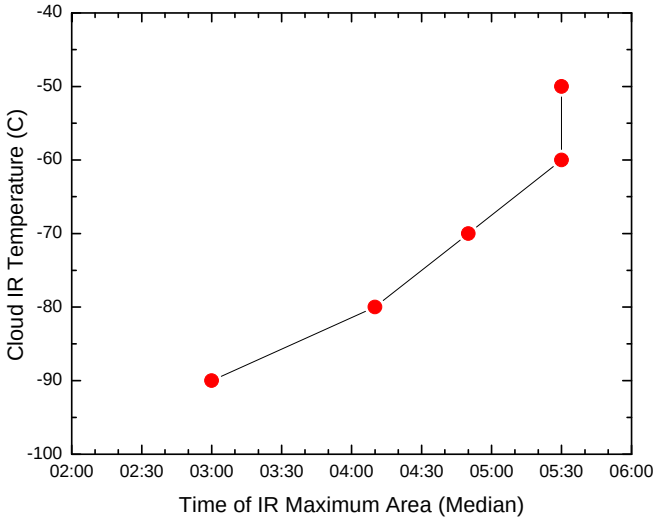
UTC Date	Flt#	Takeoff-landing locations	Time of Max. high cloud LST	Time of midpt of F20 flight LST	Flt time – Max time	Deep cloud area ratio Flt-time/Max-time
16-Jan-14	2	DRW-BME	1:20	7:13	5.9	0.51
17-Jan-14	3	BME-DRW	1:10	11:43	10.6	0.03
18-Jan-14	4	DRW-DRW	3:50	7:51	4.0	0.24
23-Jan-14	6	DRW-DRW	1:50	6:18	4.5	0.74
24-Jan-14	7	DRW-DRW	2:20	5:46	3.4	0.27
27-Jan-14	8	DRW-DRW	8:40	6:44	-1.9	0.64
28-Jan-14	9	DRW-DRW	4:00	7:19	3.3	0.35
29-Jan-14	10	DRW-GOV	6:20	6:58	0.6	0.89
2-Feb-14	12	DRW-DRW	4:50	6:43	1.9	0.69
3-Feb-14	13	DRW-DRW	19:30	13:40	-5.8	0.34
4-Feb-14	14	GOV-GOV	7:10	7:16	0.1	0.53
5-Feb-14	15	GOV-GOV	7:30	10:00	2.5	0.71
7-Feb-14	16	DRW-BME	6:40	7:08	0.5	0.94
8-Feb-14	18	DRW-DRW	0:00	6:31	6.5	0.42
9-Feb-14	19	DRW-BME	0:30	6:53	6.4	0.58
17-Feb-14	22	DRW-DRW	9:20	7:42	-1.6	0.96
18-Feb-14	23	DRW-DRW	4:40	7:32	2.9	0.20

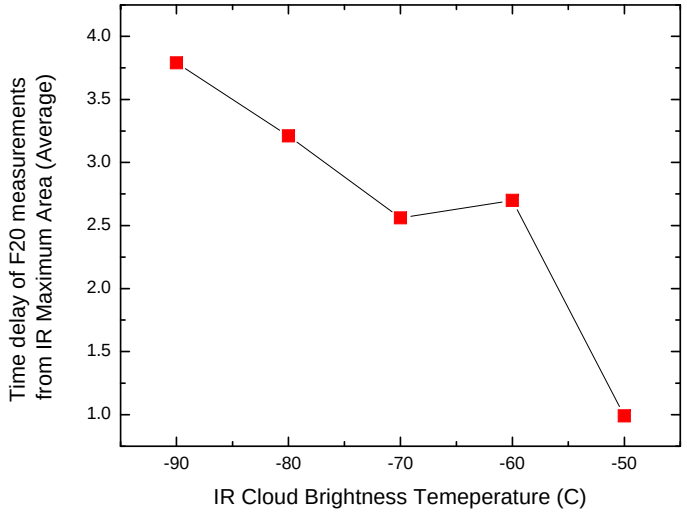
Yellow boxes: new since Paris





Other Cloud temperature areas





Conclusions (p1 of 2)

- For the 17 flights analyzed, F20 flights were in every case but 2 after the convective maximum peak (<-70 C) for the cloud (median 2.8 hours after maximum)
- Location of high-IWC regions in cloud was correlated to region of cold cloud (needs more work to confirm to what degree)
- Median Area of cold cloud (<-70 C) at flight time 58% of cloud at always lower than at cloud peak intensity.

- Time of Maximum in IR areas is earliest for cold CT temperatures and latest for warmest (from 03:00 < -90 C to 05:30 < -50 C). Time shift was roughly 45 minutes for every 10 C.

- F20 measurements times varied from average of 3.8 hours after -90 C maximum to 1.0 after -50 C maximum.

Conclusions

- Still Insufficient information at this point to conclude if F20 TWCs are biased low because measured after peak time. For the one case we have with 2 flights on the same cloud (Flights 12/13):
  - No clear indication of differences in TWC averages or peaks values;

- For F12/13, there is a strong indication of longer high-IWC zones for the flight closer to the time of maximum intensity (F12)
  - nearly double the run length in high-IWC.
  - May be important conclusion for Appendix D/P work

- In spite of lack of clear conclusion on TWC bias, this work is very important as documentation of the flight measurements, and is part of the contextual description of the database.
  - Should be repeated for the Cayenne flights

Further ideas and way forward

- Look for evidence in existing data for any link between TWC levels and cloud IR top temperature (started)
- Investigate TWC changes during flights where IR BT decaying with time
- Look at when lightning strike maximize relative to cloud lifecycle (too much lightning not workable and not relevant to Appendix D)
- Investigate alternative parameters for assessing peak cloud intensity, e.g….
    - Ratio of IR areas of (e.g. -80/-40) rather than individual temperatures
- For Cayenne, suggest we look for other opportunities to fly 2 flights in one cloud system at different life stages (e.g. Tropical Storm)

Final note

- It takes several hours to arrive at a cloud after the decision to fly is made. Lifetimes of clouds are such that timing the flight to arrive on the cloud at peak intensity, based on data available several hours before, is extremely unlikely.
- Need to take risks to initiate flights to arrive at a promising cloud area at a favoured time (e.g. for Darwin in 2014 this was before 5 am solar time).
- For Cayenne, similar early morning maximum expected for oceanic cloud
- Tropical lows appear to be more persistent than typical regular MCSs, and are a good potential target for future flights (climatology ??)

Thank you, merci

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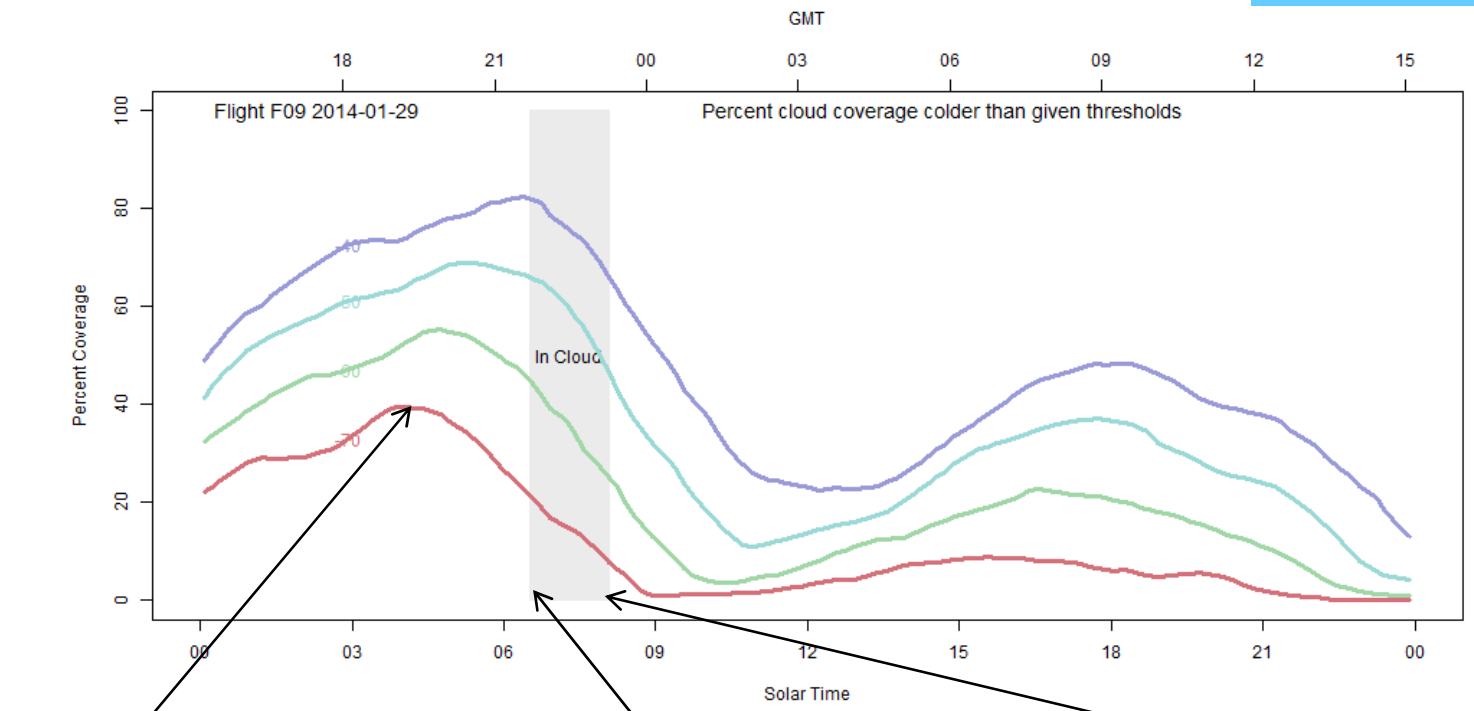
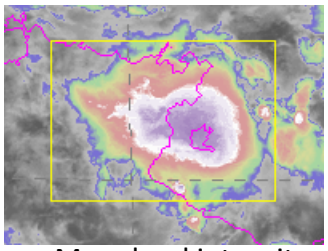
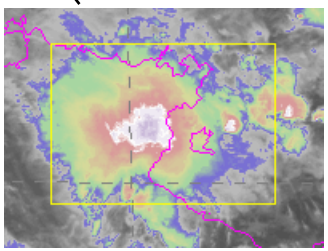
spare slides

Example 2: Monsoon MCS over Land, Flight 9, 29-Jan-14

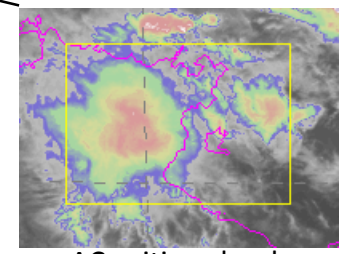




Max cloud intensity



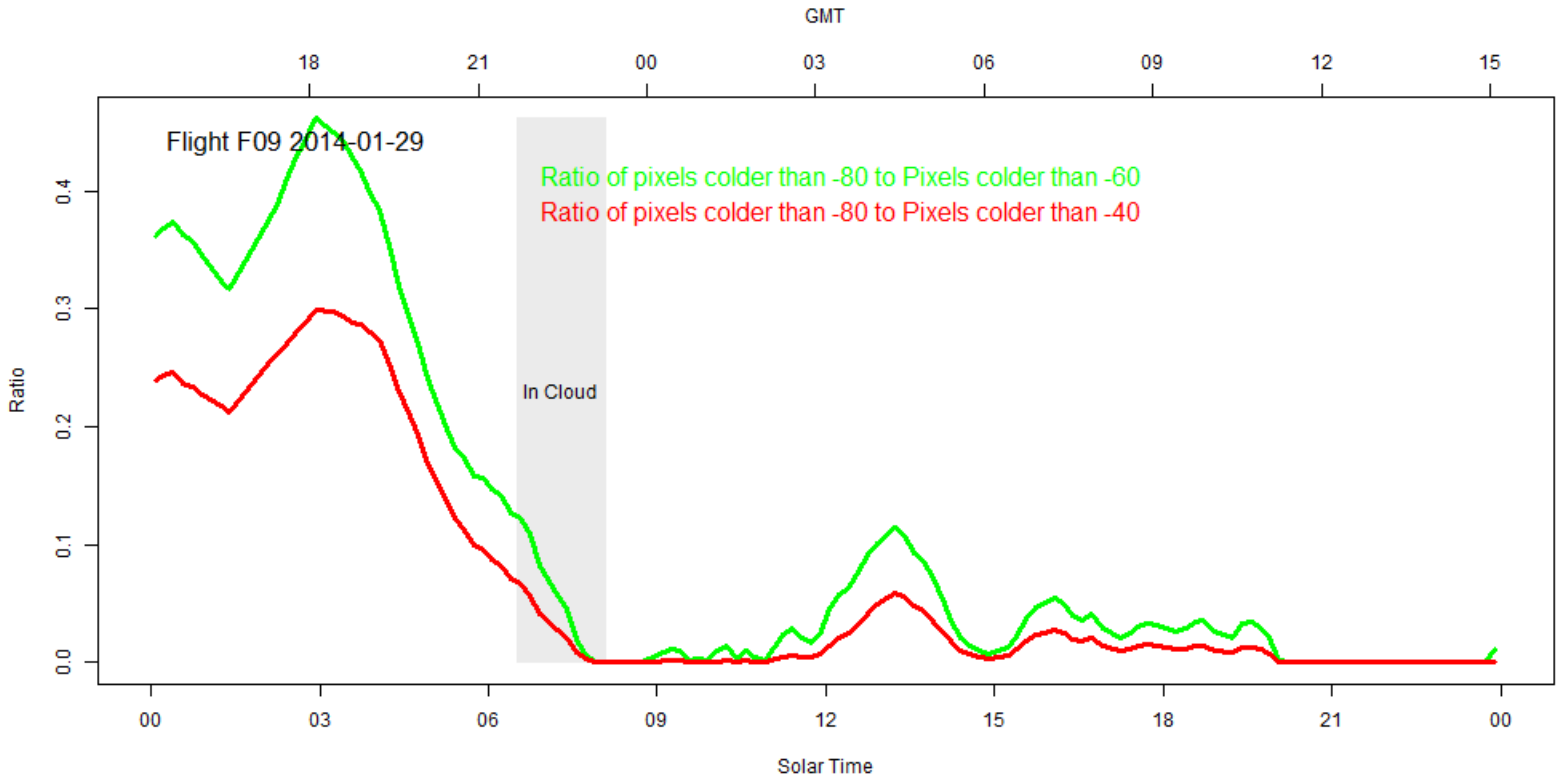
AC entering cloud



AC exiting cloud

Pixel values are extracted from within the yellow boxes for each image in 24 hours from solar midnight to solar midnight

Example 1: (cntd): Ratio of highest cloud to lower cloud



Example 1: Summary

- Fraction of cloud ‘enhanced’ area, as defined by Boeing as the cloud rising above the tropopause height , maximizes at ~3 am solar-time
- The amount of coldest cloud (<-70 C) maximizes at ~4 am solar-time
- We start watching this cloud in the weather office at ~1:30 am solar-time.
- Takeoff is at 06:10 solar-time, arrive at cloud ~06:50 solar time

- Measurements are made 3.2-4.8 hours after the maximum convective intensity

- ~5% of the cloud area (relative to -40 C) is ‘enhanced’ during the flight period, relative to ~30% at the period of max intensity
    - the implication is that the scale-size of HIWC areas may be much reduced relative to the period of peak intensity.