A STUDY OF RAPIDLY DEVELOPING LOW CLOUD CEILINGS IN A STABLE ATMOSPHERE AT THE FLORIDA SPACEPORT

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Project Objectives

- Formulate a database of days with rapidly-developing ceilings below 2438 m (8000 ft)
- Identify the onset and dissipation times
- Document the atmospheric regimes favoring the rapid, stable cloud formation

Data and Period of Record

- Cape Canaveral, FL morning rawinsondes
- Hourly surface observations across central Florida
- Archived visible satellite imagery every 30 minutes
- Daytime events only beginning at 1100 UTC
- Cool-season months of November to March, 1993 to 2003 (11 total cool seasons)

Methodology

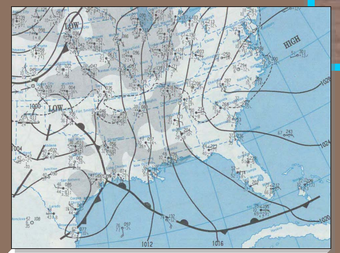
- Develop code to identify inversions (≥ 1°C) in the Cape Canaveral, FL morning rawinsonde in the lowest 8000 ft
  - Recorded the highest inversion in that layer
  - Recorded the height & strength of inversion, and mean wind & RH in layer beneath inversion
- Write code to examine hourly observations at the Shuttle Landing Facility and other central FL stations
  - Identify all ceilings (BKN/OVC) with heights below 8000 ft
  - 0600 to 2300 UTC (focusing on daytime hours)
  - Eliminate days with obvious fog-burn-off, widespread clouds/precipitation
  - Record days with possible ceiling formation
- Formulate a database of possible low ceiling development days
  - Combine days with possible ceiling formations and low-level inversions
  - Look for days with high mean RH below inversion
  - Identified 68 days with possible low ceiling formation
- Examine visible satellite imagery for the 68 possible days
  - Confirm whether each day had development or advection
  - Identified 20 cases with rapid ceiling formation

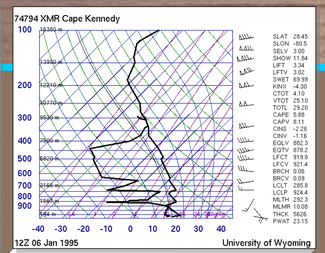
Space Shuttle Flight Rules for Ceilings/Visibility

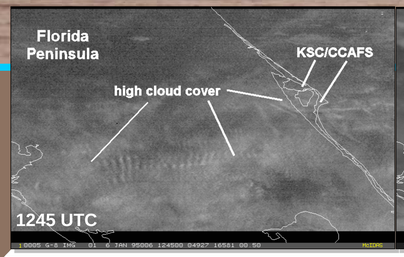
Table 1. Space Shuttle Flight Rules for cloud ceiling heights and visibility restrictions pertaining to various landing scenarios and locations (NASA/JSC 2004).

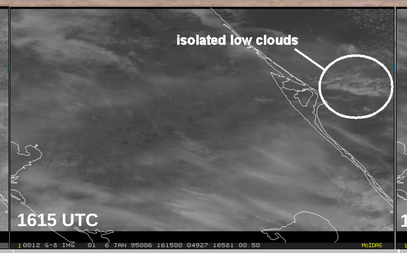
Ceiling / Visibility (kft)/(sm)			Redundant Microwave Landing System (MLS)	Single-String MLS	No MLS
KSC, EDW, NOR, Abort Once Around, Daily Primary Landing Site (PLS) Selection (all sites)	Concrete	Day		≥10/7	
		Night	≥8/5	NO-GO	
	Lakebed	Day	(Wx RECON Required)		≥10/7
		Night		≥15/7	NO-GO
Return To Launch Site (RTLS), Trans-oceanic Abort Landing (TAL)	Concrete	Day	≥5/4 RTLS ≥5/5 TAL	≥10/7	
		Night	(Wx RECON Required)	NO-GO	
Augmented Contingency Landing Site / East Coast Abort Landing / Emergency Landing Site			0/0		≥8/5
Predeorbit: One Auxiliary Power Unit (APU) failed OR Attempt two APU's procedure				≥10/7	

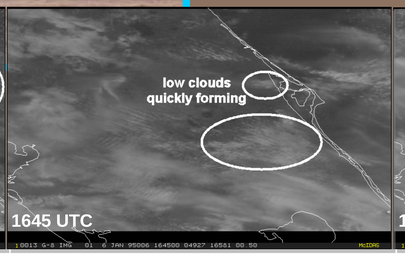
6 JAN 1995 Event

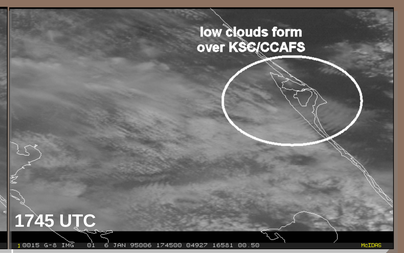










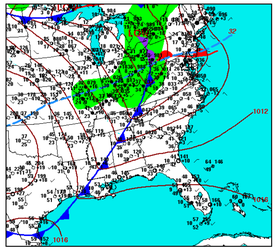


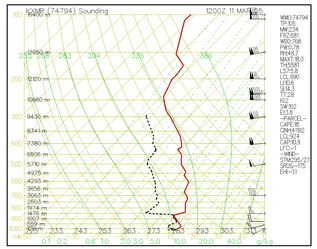
Previous Work

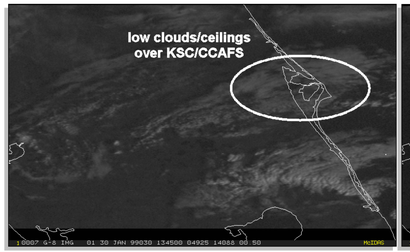
- Considered daytime only events
- Used high resolution 1 km visible satellite imagery
- Identified the atmospheric regimes favoring the rapid, stable cloud formation
  - 85% of events had veering wind profile
  - Mean inversion strength 4.0 ºC
  - Average onset time 1403 UTC (0903 EST)

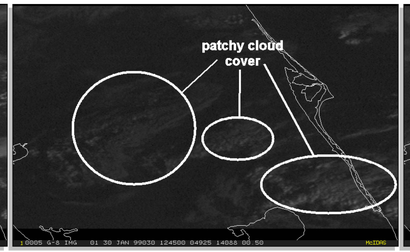
Definitions

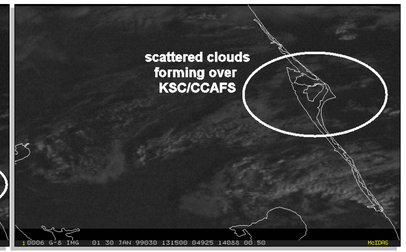
- Rapid development
  - Cloud ceiling forms in less than 90 minutes
- "Event days"
  - Low ceiling violations at Kennedy Space Center (KSC) Shuttle Landing Facility (SLF)
  - Rapid development occurred as confirmed by examination of infrared satellite imagery
- "Non-Event days"
  - Low ceiling violations at SLF
  - Rapid development did NOT occur
  - Low ceilings resulted other mechanisms besides rapid development

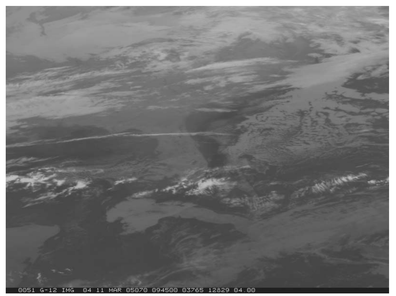


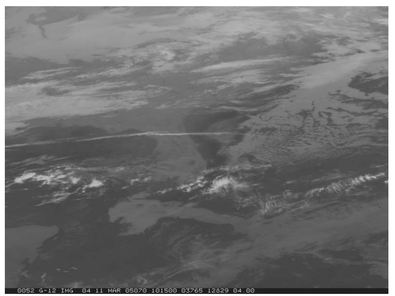


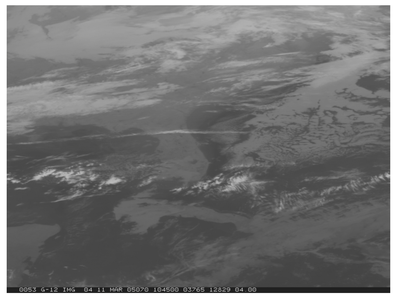


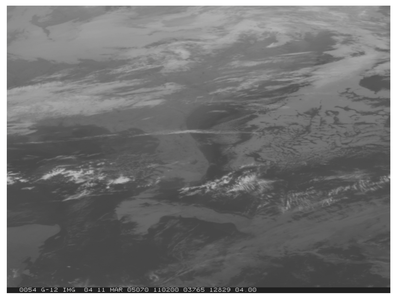












Summary of Parameters for Events/Non-Events

Parameter	Event Days	Non-Event Days
# of days w/ backing winds negligible shear	3 days (15%)	40 days (83%)
# of days w/ veering winds	17 days (85%)	8 days (17%)
Mean inversion height	1219 m	1378 m
Mean inversion strength	4.0°C	3.4°C
Mean RH below inversion	87%	80%

Future Work

- Expand database period of record
  - Include nocturnal events
  - Include years before 1993
- Determine forecast skill of veering/backing wind profile
  - Examine all cool-season days that meet pre-defined criteria
  - Find how many days had rapid ceiling development w/ veering winds
- Develop statistical forecast model from identified criteria
- Examine predictability of ceiling cessation times