Learjet Participation in SEAC$^4$RS

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SPEC                                                 NCAR
SEAC4RS Science Meeting - 29 April 2013 - Boulder, CO
<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Takeoff Weight</td>
<td>15,000 lbs</td>
</tr>
<tr>
<td>Maximum Certificated Ceiling</td>
<td>45,000 ft</td>
</tr>
<tr>
<td>Time to Climb Sea Level to 35,000 ft at Max T.O. Weight @ ISA</td>
<td>16 min</td>
</tr>
<tr>
<td>Maximum Duration (to fuel exhaustion)</td>
<td>3 hr</td>
</tr>
<tr>
<td>Maximum Airspeed</td>
<td>0.82 Mach (306 KIAS)</td>
</tr>
<tr>
<td>Number of Seats excluding pilots</td>
<td>4</td>
</tr>
<tr>
<td>Electrical Capability</td>
<td>(2) 400 A Generators @ 28.8 VDC = 23 KW Research Power = 7.2 KW distributed as 6.2 KW @ 110 VAC 60 Hz 1.0 KW @ 28 VDC</td>
</tr>
<tr>
<td>Equipment List</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>----------------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Temperature</td>
<td>Rosemount Model 102 &amp; 510BH</td>
</tr>
<tr>
<td>Altitude</td>
<td>Royal Air FAA RVSM Certification</td>
</tr>
<tr>
<td>Airspeed</td>
<td>Royal Air FAA RVSM Certification</td>
</tr>
<tr>
<td>Dew Point Temperature</td>
<td>EdgeTech Chilled Mirror C-137</td>
</tr>
<tr>
<td>Cloud Liquid Water/Total Water (2)</td>
<td>Sky Tech Nevzorov LWC/TWC</td>
</tr>
<tr>
<td>Icing Rate</td>
<td>Rosemount Icing Rod 871LM5</td>
</tr>
<tr>
<td>Aircraft Position</td>
<td>Aventech AIMMS-20 Dual GPS</td>
</tr>
<tr>
<td>Aircraft Heading</td>
<td>Learjet Sperry Directional Gyro</td>
</tr>
<tr>
<td>Horizontal Wind</td>
<td>Aventech AIMMS - 20</td>
</tr>
<tr>
<td>Vertical Wind</td>
<td>Aventech AIMMS - 20</td>
</tr>
<tr>
<td>2D-S (Stereo) Optical Array Spectrometer</td>
<td>SPEC Model OAP 2D-S</td>
</tr>
<tr>
<td>Fast Cloud Droplet Probe (FCDP)</td>
<td>SPEC Model FCDP-100</td>
</tr>
<tr>
<td>Fast Forward Scattering Spectrometer Probe (FFSSP)</td>
<td>SPEC Model FFSSP-100</td>
</tr>
<tr>
<td>High Volume Precipitation Spectrometer (HVPS)</td>
<td>SPEC Version-3 HVPS</td>
</tr>
<tr>
<td>Combination FCDP, 10 and 50 μm 2D-S, V 2.5 CPI</td>
<td>SPEC Hawkeye</td>
</tr>
<tr>
<td>Passive Cavity Aerosol Spectrometer (PCASP)</td>
<td>PMS</td>
</tr>
<tr>
<td>Nucleation Mode Aerosol Size Spectrometer (NMASS)</td>
<td>DU</td>
</tr>
<tr>
<td>CCN Counter</td>
<td>DMT CCN-100</td>
</tr>
</tbody>
</table>
Measurements In Convection

- Learn to Collect Air Motion, State Parameter, Aerosol and CCN Measurements at Cloud Base.
- Climb Rapidly with Ascending Updraft and Collect Microphysical Data from Cloud Base to -37°C.
- Suite of Cloud Particle Probes Measure Size Distribution from 1 μm to several cm.
- Cloud Particle Imager (CPI) used to Distinguish Water Drops and Ice Particles in Growing Cumulus, and to Automatically Identify Ice Particle Habit in Anvils and Cirrus.
2D-S Images in a Decaying ICE-T Turret @ -24°C Appear to be All Ice (Rosemount icing Probe Indicates no SLWC)

CPI Images at Same Time Show Low Concentration of Supercooled Drops
Examples of CPI Images in Mixed-Phase at -17 C
CPI Images in Mixed-Phase Automatically Separated into:

Water                 and                 Ice

7/12/2011 183140-- 183140 <-------->200microns crystal eq 1 and focus gt 2

7/12/2011 183140-- 183149 <-------->200microns crystal eq 15 and focus gt 2
Particle Size Distributions from Various Probes

Time: 183138 to 183150
Flight date: 2011-07-12
Using CPI Automatic Image Recognition to Generate FFSSP, 2D-S, HVPS Water and Ice Size Distributions in Mixed-Phase

**Water**
- CPI Water Drops = 4354
- Conc = 24 /cc
- LWC = 0.13 g/m³
- Reff = 14 μm
- Z = -17 dBz

**ICE**
- CPI Ice Particles = 440
- 2D-S Ice Conc = 182 /L
- IWC = 0.27 g/m³
- Reff = 146 μm
- Z = 13 dBz

Time: 183138 to 183150
Flight date: 2011-07-12
Example of Measurements In SPartICus Cirrus and Anvils

205-215 K

N = 151 L⁻¹  IWC = 7 mg m⁻³

Cirrus Particles (>50 μm) Classified by Habit
- Number
- Area
- Mass

215-225 K

N = 79 L⁻¹  IWC = 11 mg m⁻³

Cirrus Particles (>50 μm) Classified by Habit
- Number
- Area
- Mass

225-235 K

N = 64 L⁻¹  IWC = 23 mg m⁻³

Cirrus Particles (>50 μm) Classified by Habit
- Number
- Area
- Mass
Example of Aerosol Activation: WB-57 in MACPEX Anvil

- O$_3$
- CO
- 4 nm
- 8 nm

2D-S Particle Size (μm)

Time (UTC):
- 18:48
- 19:56
- 21:04
- 22:12
- 23:20

Particle Concentration (L$^{-1}$)
Example of CPI Images in Smoke

CPI Smoke Images Collected in Wyoming by the NSF/NCAR C-130
Measurements in Pyrocumulus?
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SUMMARY

- Learjet capable of rapid (6,000 fpm @ Sea Level) climb to measure aerosol and CCN at cloud base, then ascend with a convective updraft and document the development of cloud drop and ice particle formation.

- State-of-the-art cloud particle probes will collect ice particle size and shape data in Cirrus and Anvils.

- PCASP and NMASS will document new aerosol nucleation in Anvils.

- Collect CPI images of smoke from forest fires.

- First-time measurements in Pyrocumulus?