Daytime Dynamo Rocket Investigation

Daytime wind profile measurement with a lithium trail release

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Joint Japanese-U.S. Rocket Experiments
A long history of fruitful collaborations

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<th>Experiment</th>
<th>Launch site</th>
<th>Year</th>
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<td>SEEK-1</td>
<td>Uchinoura, Japan</td>
<td>1996</td>
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<td>SEEK-2</td>
<td>Uchinoura, Japan</td>
<td>2002</td>
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<tr>
<td>WIND-1</td>
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<td>DELTA-2</td>
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<tr>
<td>Dynamo-1</td>
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<td>WIND-2</td>
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<td>Test Flight</td>
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<td>EVEX</td>
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<tr>
<td>Dynamo-2</td>
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<td>Moonlight</td>
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<td>C-REX</td>
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Lithium at twilight in a recent Japanese experiment
(August 2007)
Daytime lithium release experiments

The bright narrow-band emissions at 670.7 nm produced by lithium make it possible to track the chemical optically, even when viewed against the bright daytime background.

Several groups carried out such experiments:

- In the U.S.
  - launches from Wallops Flight Facility
  - narrow band filter camera deployed on high-altitude aircraft
  - effective field of view only 5 degrees

- In India (collaboration between U.K. and India)
  - Rees et al. (1972, 1976)
  - launches from Thumba
  - raster scanning photometer with narrow-band filter

- In Australia
  - Hind and Lloyd (1973, 1974)
  - launches from Woomera
  - raster scanning photometer with narrow-band filter
Daytime neutral wind measurements

Trail is from Lithium chemical release from Wallops as part of ALADDIN campaign in 1974 (Philbrick, 1974).
Measurement by Hind
Measurement by Rees

P154  9 Feb. 75, 0554 morning twilight TMA trail release
P155  9 Feb. 75, 1105 lithium trail release
P156  19 Feb. 75, 1415 lithium trail release
P157  19 Feb. 75, 1902 evening twilight TMA trail release
Chemical components

Mixture of thermite and lithium, small pellets of uniform size, usually approximately 8 to 1 ratio (thermite:lithium)

Thermite mixtures used in earlier experiments include:

- Iron oxide
- Cupric oxide
- Titanium boride
Set up for the burn test in Vac

- Thermocouples
  - 45-degree pitch
  - 20mm pitch, 39 ch

- Thermocouple for exhaust tube

- Equipment of SAD

- Sand for the hot product quench

- Fixed on the test bench

- Sideways
• LES-R

• Normal VTR High speed camera

• Ignition delay: 0.7s, Duration: 1.5 sx

• X From the video data
• After the test

• Exterior, no change

• Inner tube was melted

• Reaction Products

• Flange was eroded by the hot products
Canister design used on the flight

A total of 125 g of lithium per canister
Two canisters per trail
Three trails
Optical tracking of the releases requires

Narrow-band 2 nm optical filter centered at 671 nm

Telecentric optics for lens system with 40 deg horizontal field of view

Camera system Nikon D90 with factory IR filter removed

Requirements include

  Aircraft to reduce effect of aerosol scattering

  Angle mapping within field of view, using star field calibration, e.g.

  Aircraft position from GPS

  Aircraft orientation from IMU (roll, pitch, and heading information)
NASA King Air used as camera platform for observations
B-200 King Air: Daytime Dynamo Sounding Rocket Photo Support

• The B-200 supported the Terrier-Orion Pfaff Daytime Dynamo mission between 6/24 and 7/4.
• The aircraft was configured with four cameras to record chemical releases in flight, as previously conducted in January 2013.
Narrow-band (2-nm) lithium filter observation of lithium trails from aircraft at 1434 UT (1034 LT) – 1/30 sec exposure
Aircraft flight path

~250 km
Original plan for triangulation: Combine data from a range of azimuths at different times to produce a solution for the profile of horizontal winds.
…but within a few minutes, sections of the trail had already passed outside the field of view (~40 deg of the lithium-filter cameras on the aircraft.
Aircraft image sequence (1 image every 5 sec cadence)
Plan B: Locate the top of the trail in images taken every 5 sec as trails are released.

Use radar track to identify altitude for that point

Assume altitudes of trail features are constant and track in time
Radar track position for trail immediately after first release starts gives an initial pointing direction for the camera(s).

Aircraft IMU data gives relative changes in camera pointing for each consecutive image/ aircraft GPS gives camera lat/long
Daytime Lithium Wind Profile

Wallops Island, Virginia, 10:31 LT, July 4, 2013