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Towards understanding aerosol transport with a Doppler lidar

Ewan O'Connor

ACTRiS

برنامج الإمارات لبحوث علوم الاستمطار
UAE Research Program for Rain Enhancement Science

Aerosol transport - Doppler lidar

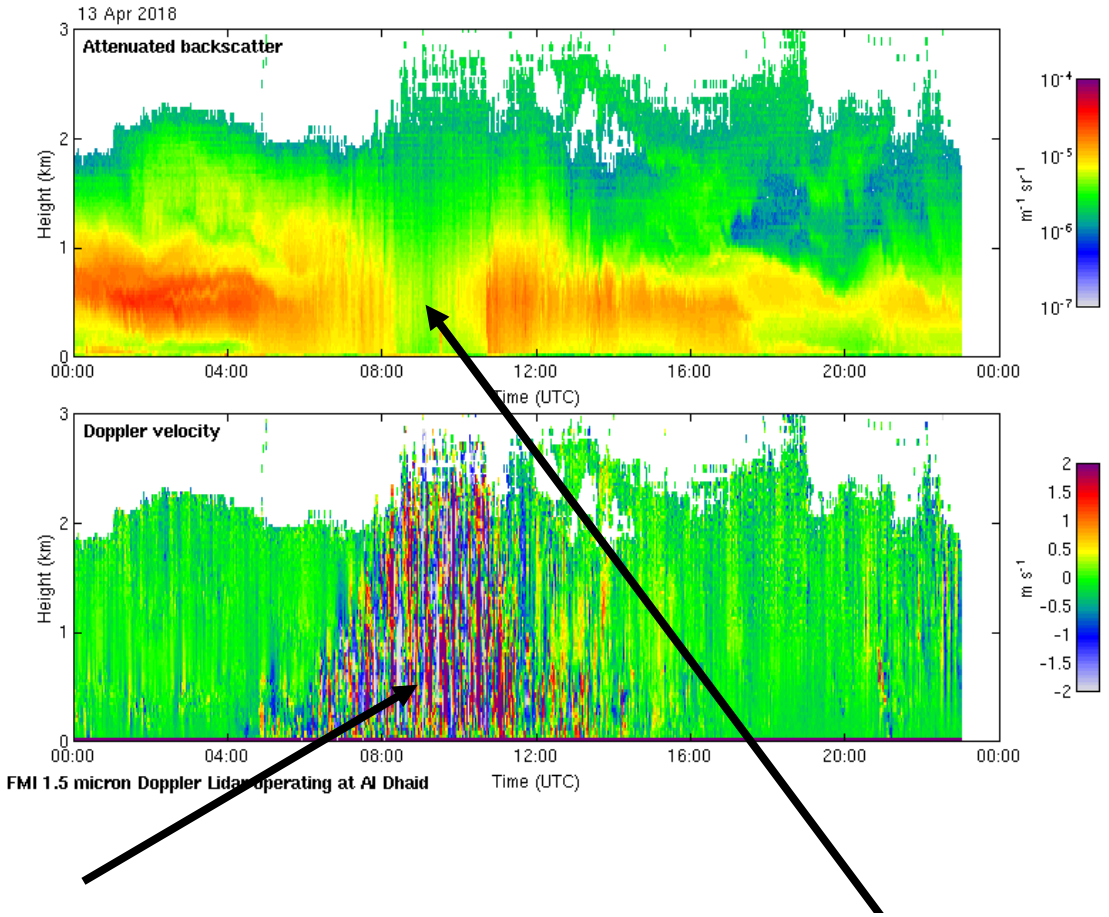
- Doppler lidar
  - Boundary layer dynamics
  - Combine turbulence and wind
    - Boundary layer classification
    - Turbulent source

  - Aerosol transport
    - Vertical – fluxes
    - Horizontal - advection
    - Combination – e.g. low-level-jets

Vertical transport

- Flux from surface
  - ‘Normal’ Aerosol (<< 1µm)
    - Generated in-situ – NPF and growth
  - Larger aerosol - Aeolian transport
    - Saltation or suspension
    - Scales with u^3 above friction velocity u*
- Flux to surface
  - Sedimentation or deposition

Convective Boundary layer



Turbulent, well-mixed

Dilution in concentration

Vertical fluxes

- Campaigns during ACTRIS
  - Tower-based in-situ aerosol fluxes
  - Lidar-based fluxes

  - $F_a = \overline{m'w'}$

Vertical fluxes

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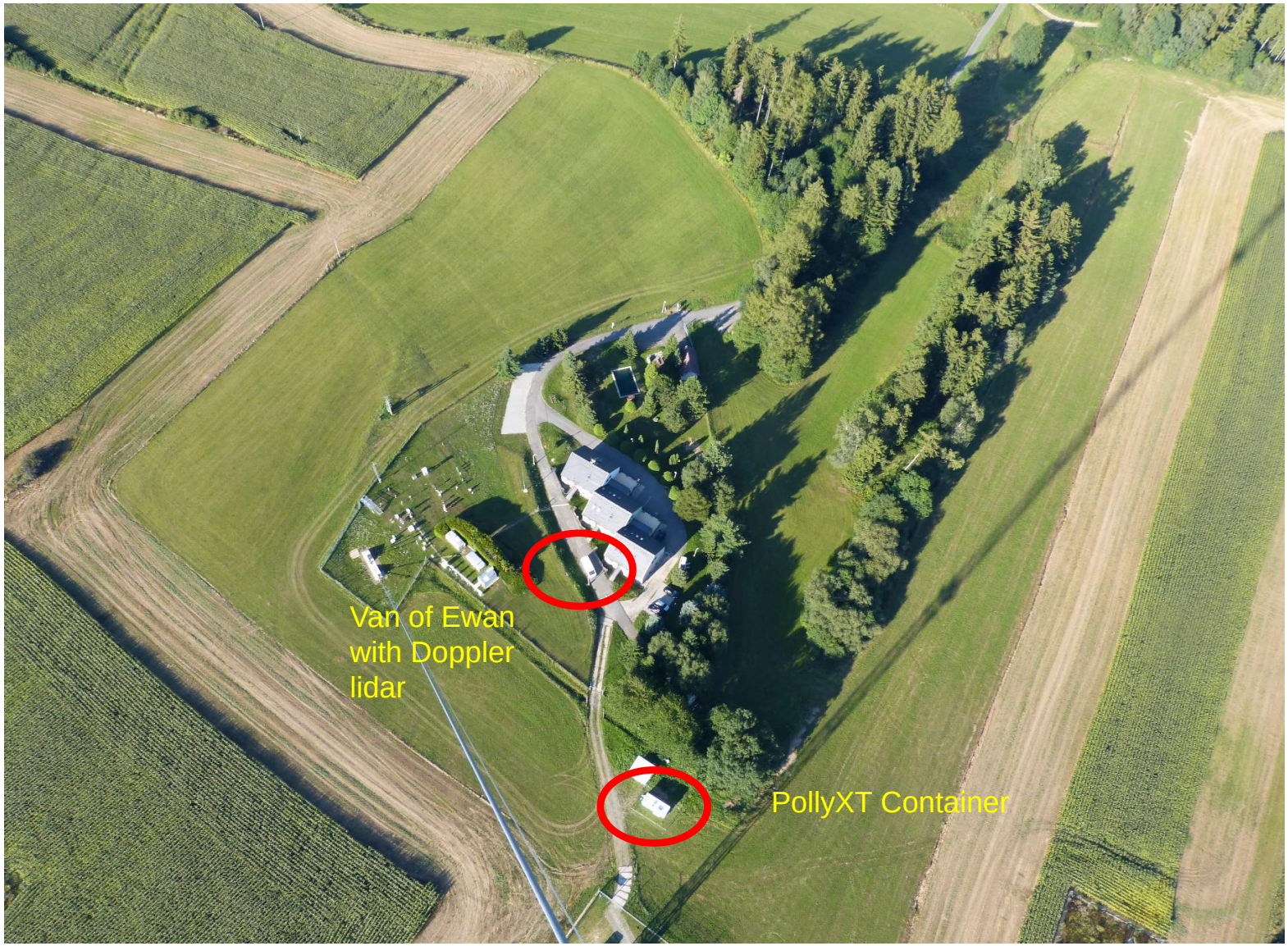
- $F_a = \overline{m'w'}$

- $F_a = \frac{\bar{m}}{\bar{\beta}} \overline{\beta' w'},$

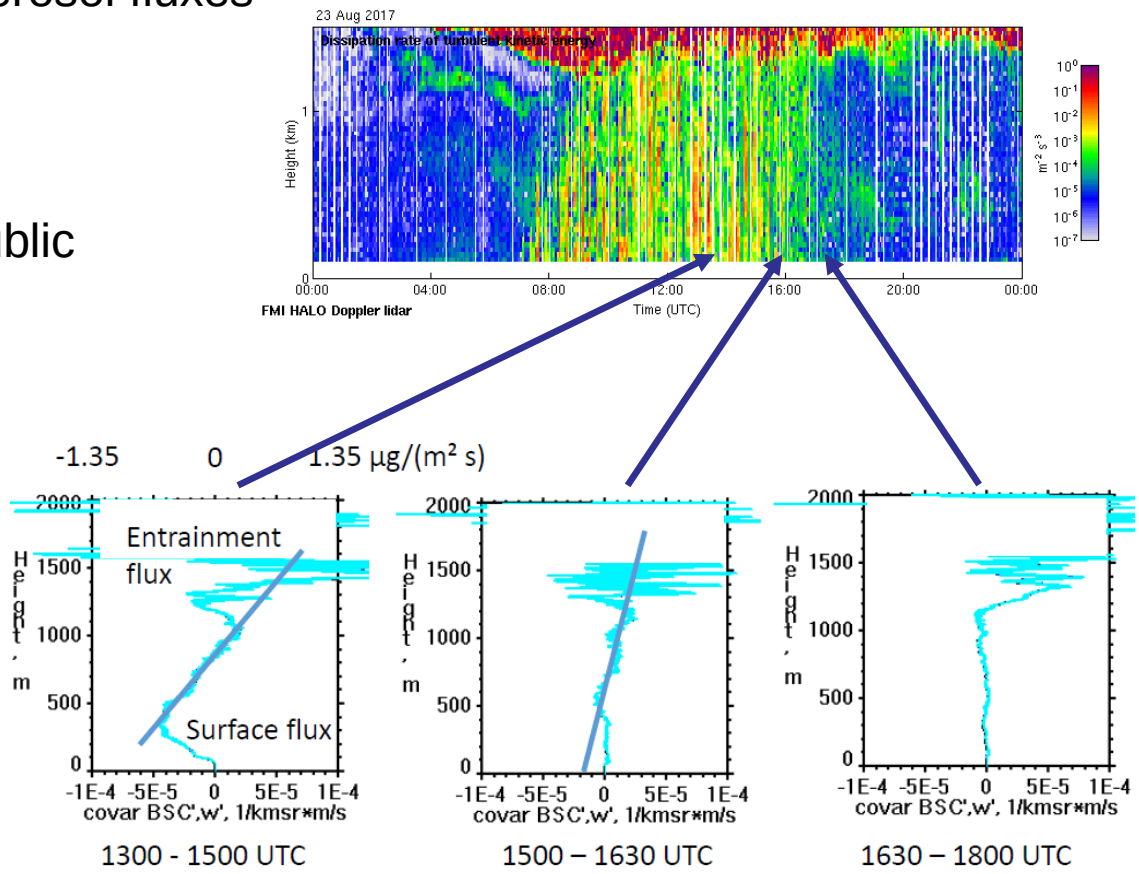
Assuming $\frac{\beta'}{\bar{\beta}} = \frac{m'}{\bar{m}}$ (Engelmann et al., 2008)

Košetice - view from tower top



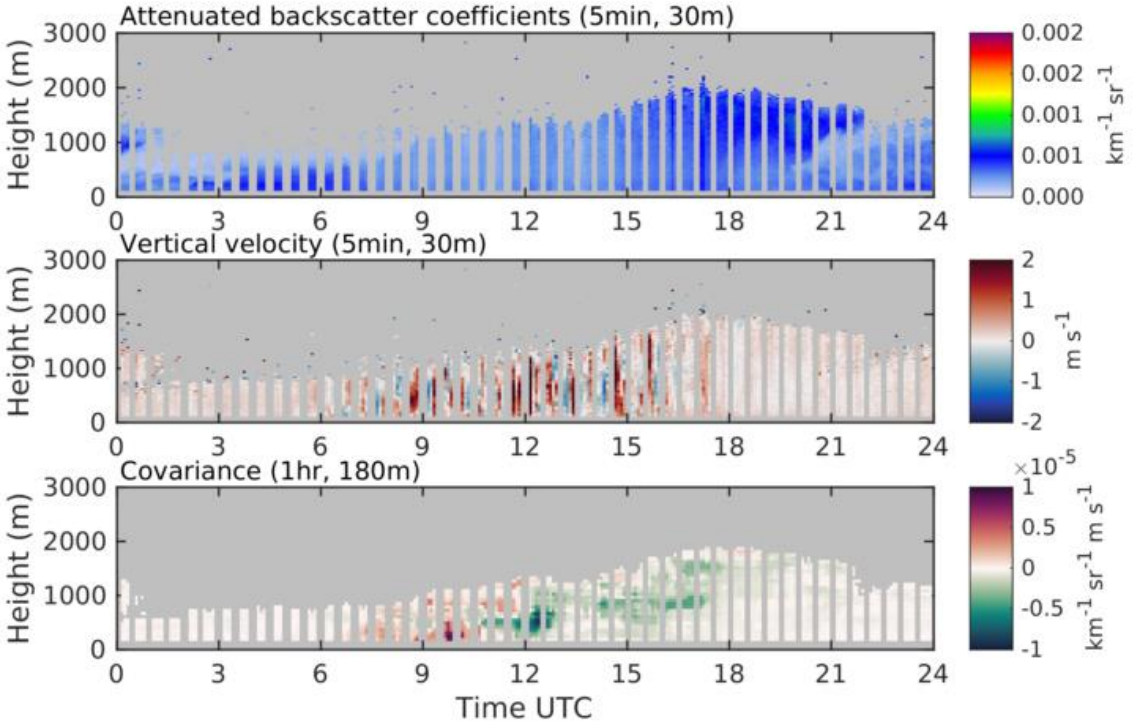
Vertical fluxes

- Campaigns during ACTRIS
  - Tower-based in-situ aerosol fluxes
  - Lidar-based fluxes
  - Košetice, Czech Republic

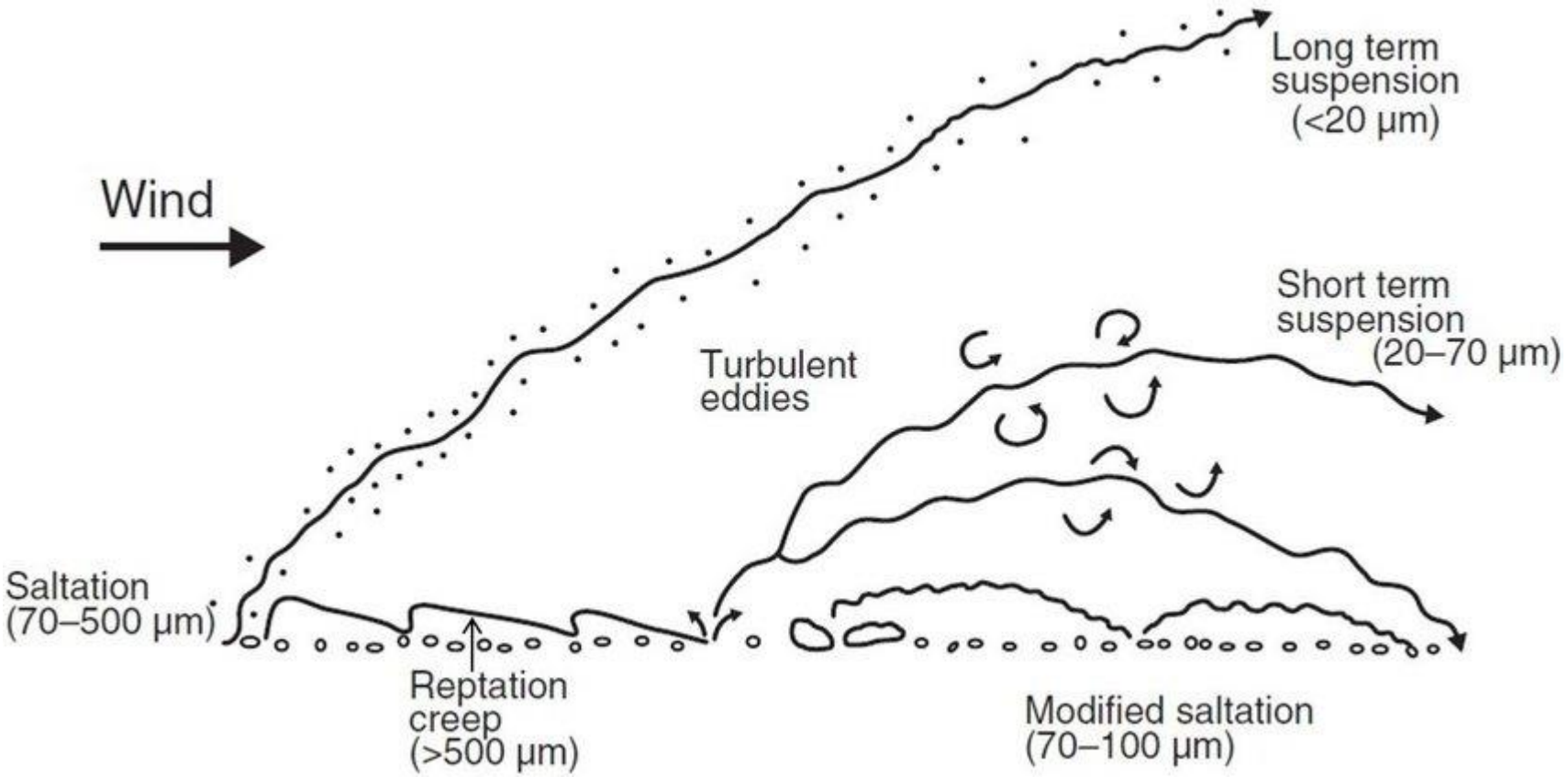


Vertical fluxes

- Campaigns during ACTRIS
  - Tower-based in-situ aerosol fluxes
  - Lidar-based fluxes
  - Hyytiälä, Finland



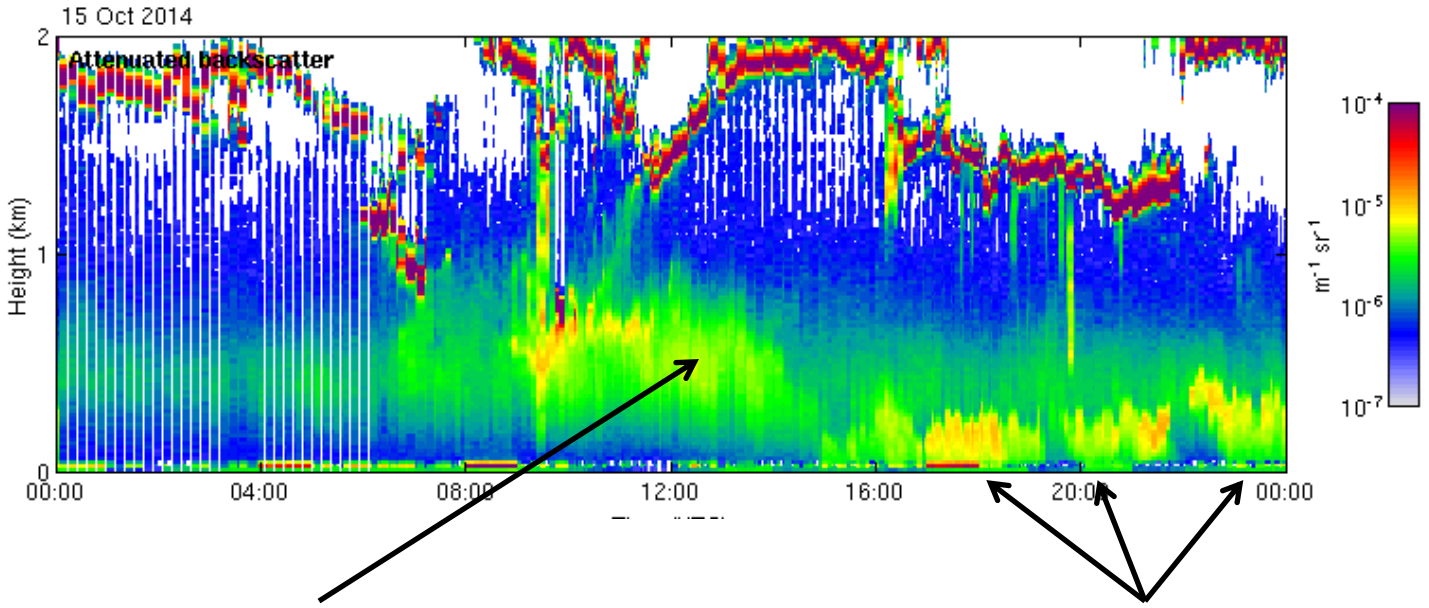
Saltation process



Nickling and McKenna Neuman (2009)

Re-suspended ash/dust

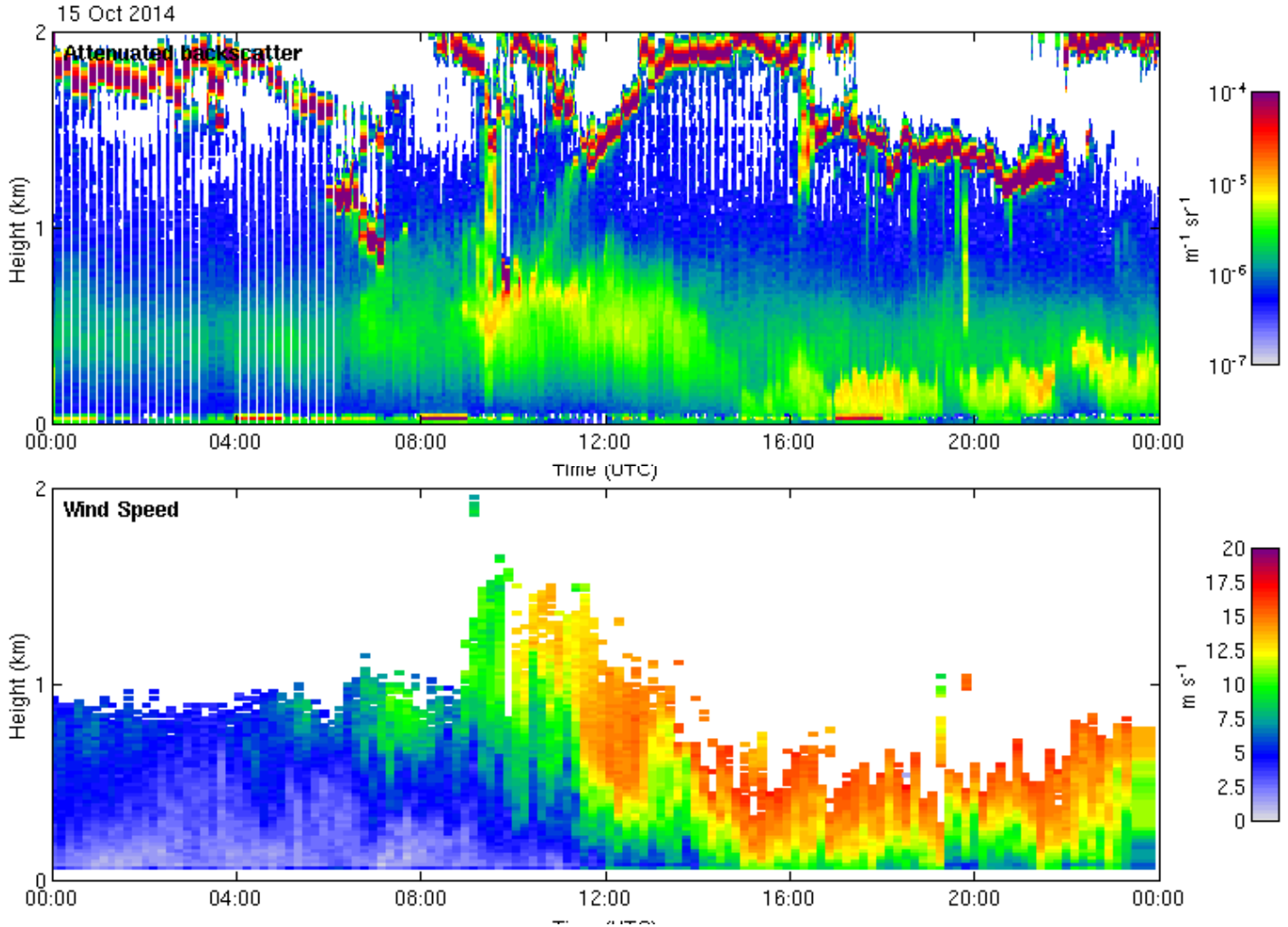
Re-suspended ash/dust: NCAS DL at Hatun



Elevated dust

Local dust being lofted

Re-suspended ash/dust: NCAS DL at Hatun



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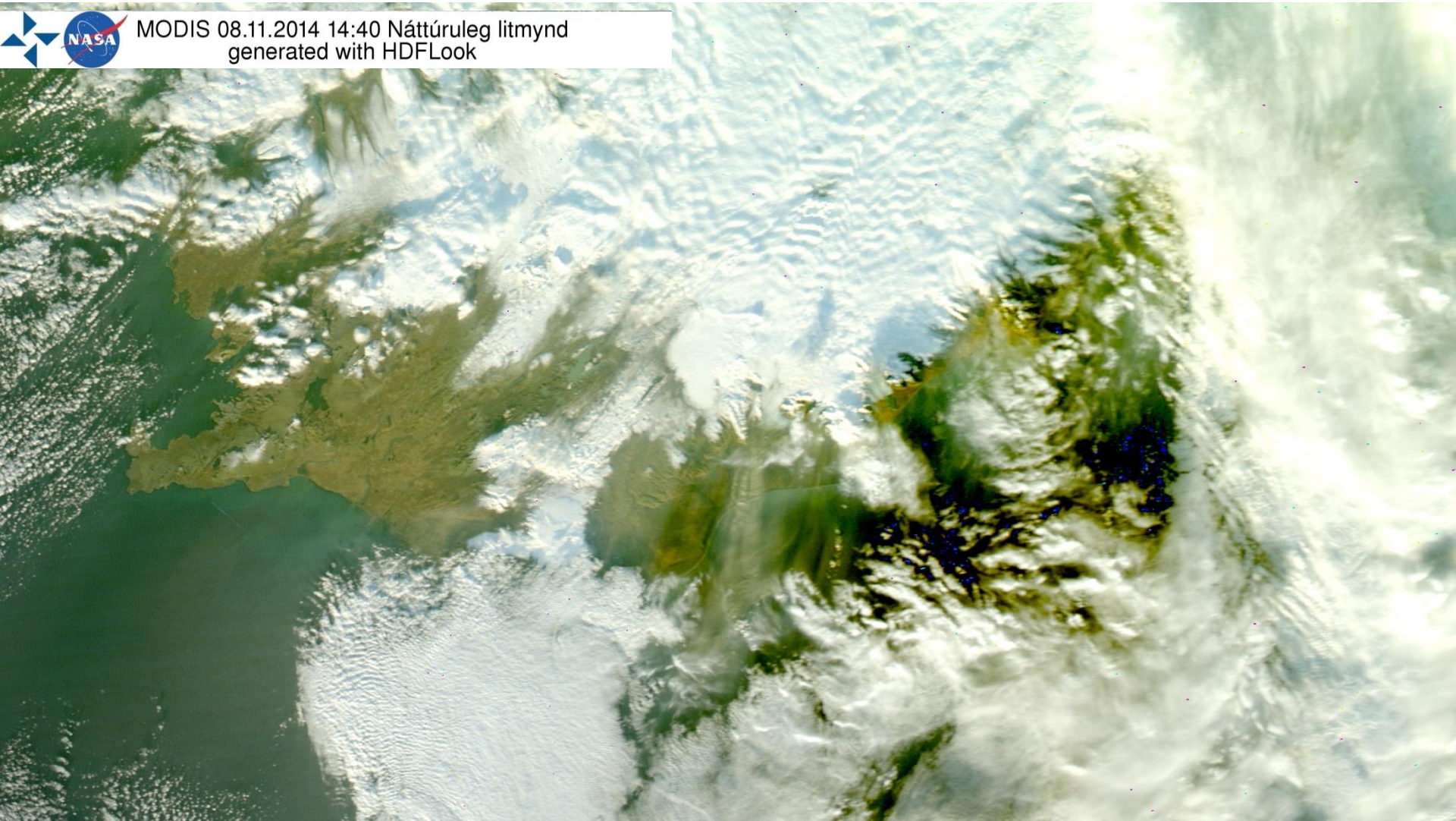
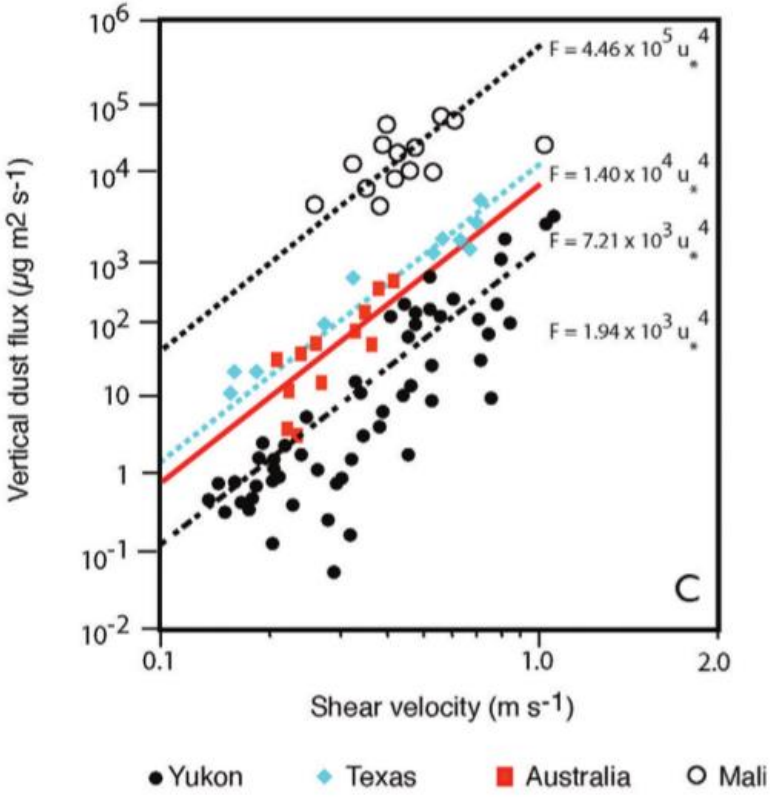
Re-suspended ash/dust: Iceland



Suspension process

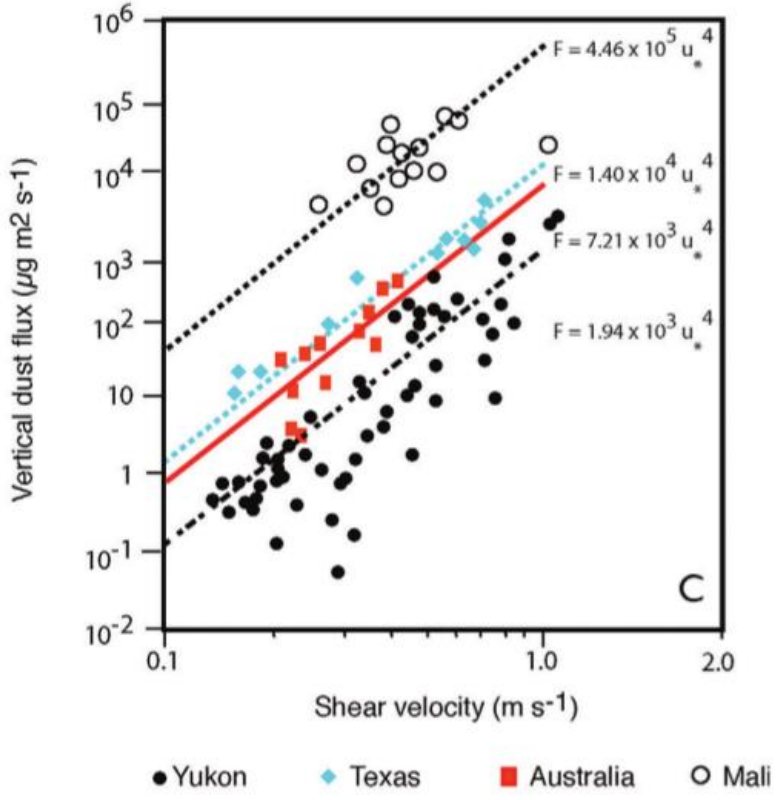


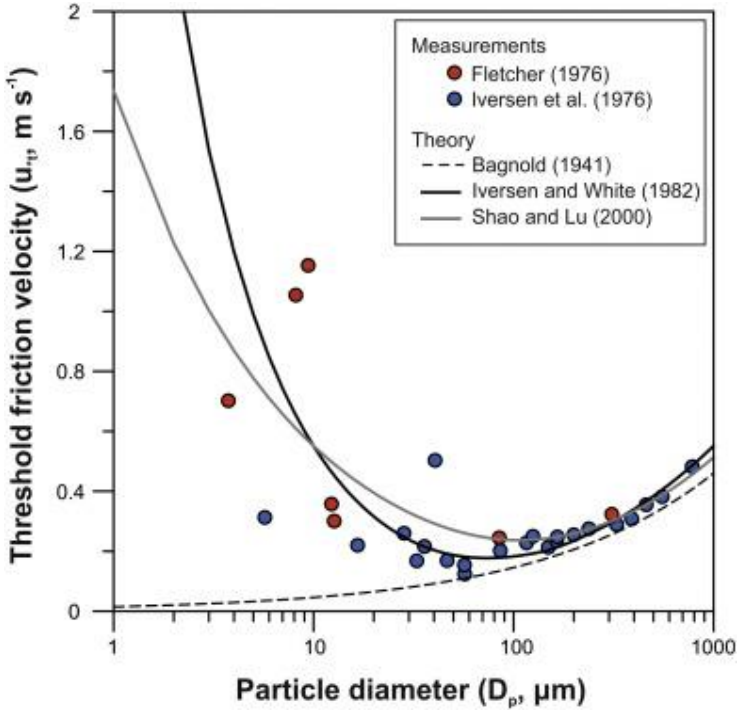
Flux ~ u^3

but prefactor?

Nickling WG, McTainsh GH, and Leys JF (1999)

Suspension process





Nickling WG, McTainsh GH, and Leys JF (1999)

OASIS measurement campaign, UAE

Hannele Korhonen[1], Jutta Kesti[1], John Backman[1], Timo Anttila[1], Heikki Lihavainen[1,3], Antti-Pekka Hyvärinen[1], Mika Komppula[4], Maria Filioglou[4], Xiaoxia Shang[4], Farah Abdi[5] and Siddharth Tampi[6]

[1]FMI, Helsinki, Finland; [2]Univ. of Reading, UK ; [3]SIOS, Longyearbyen, Svalbard; [4]FMI, Kuopio, Finland; [5]United Arab Emirates University, Al Ain, UAE; [6]National Center for Meteorology, Abu Dhabi, UAE

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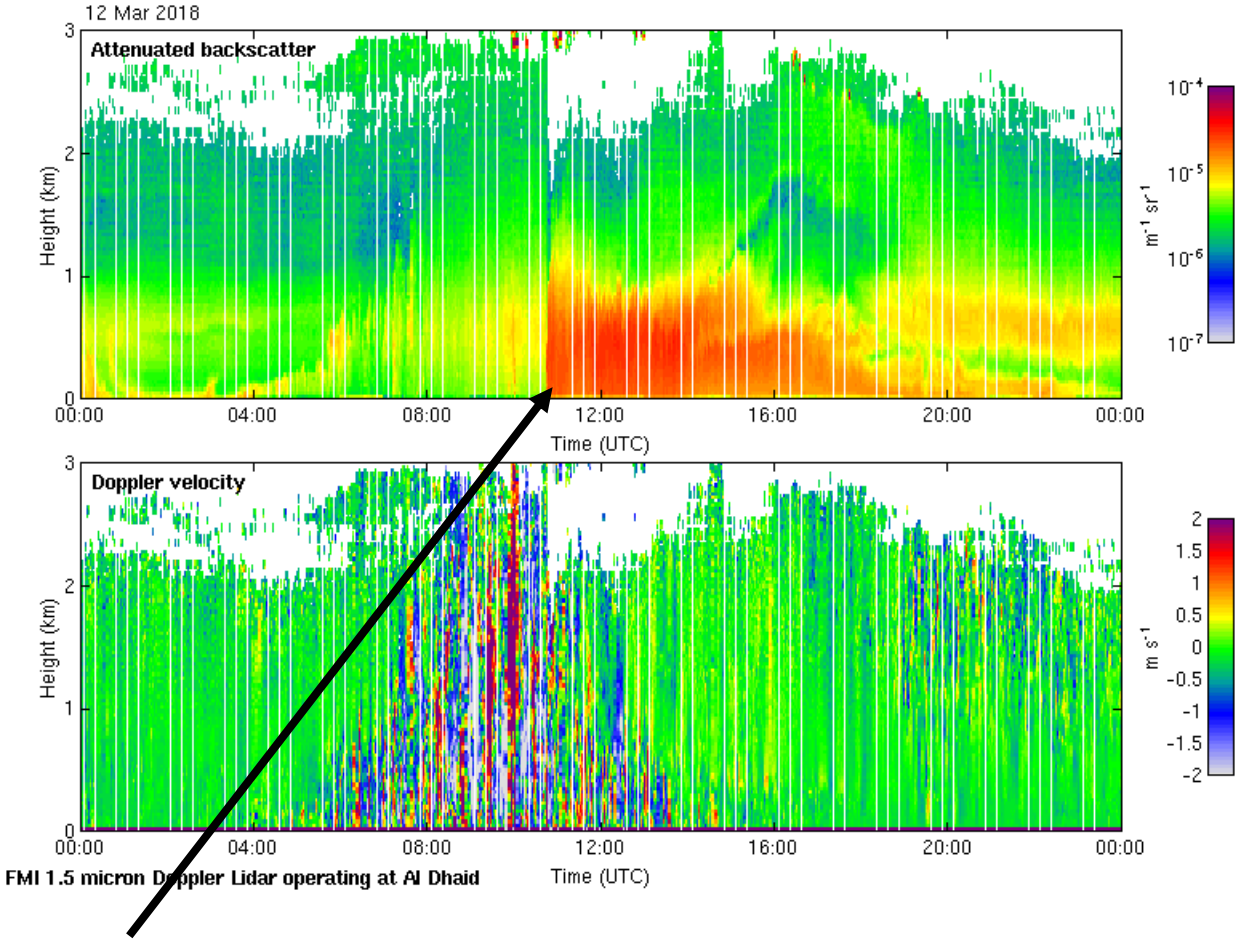
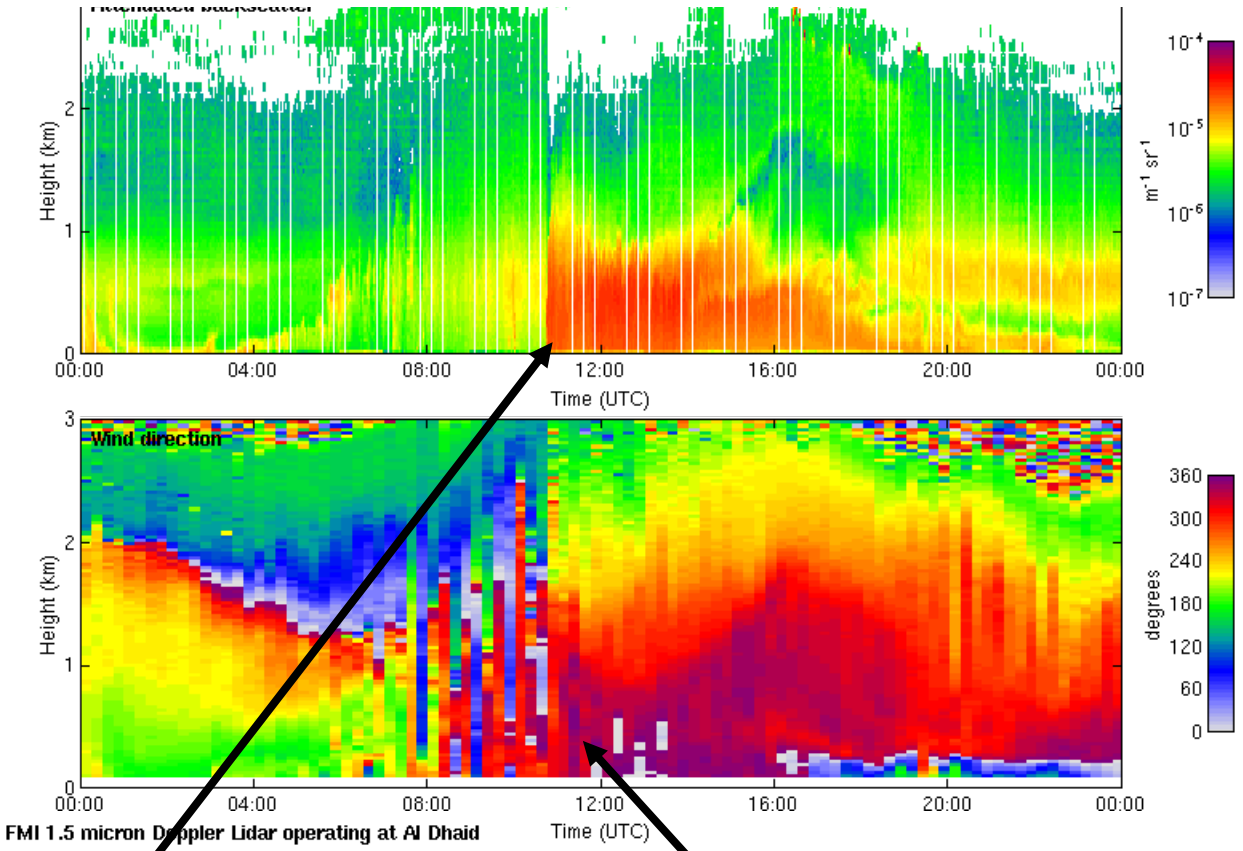
Strong winds at surface



Rapid increase in aerosol

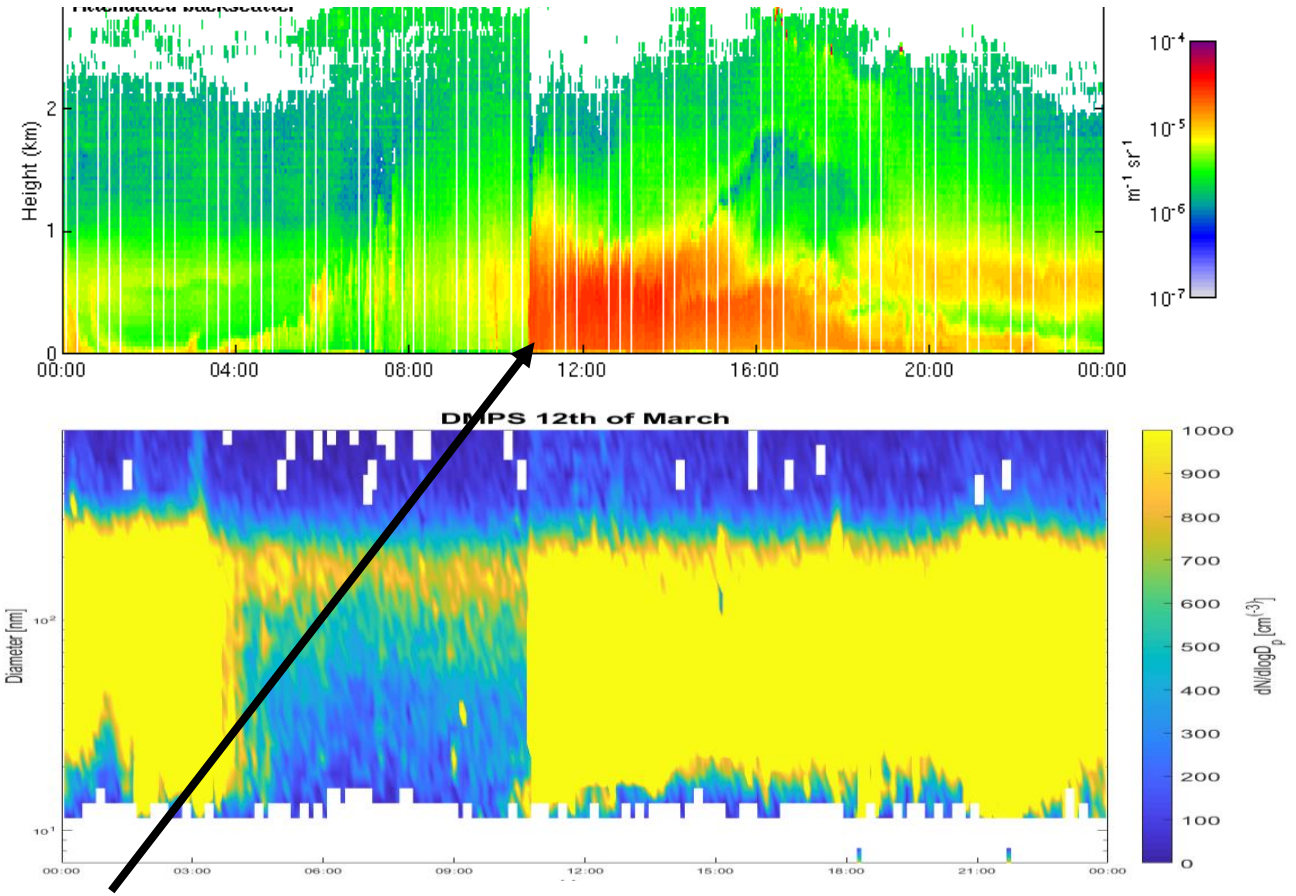
Strong winds at surface



Rapid increase in aerosol

Change in wind direction

Strong winds at surface



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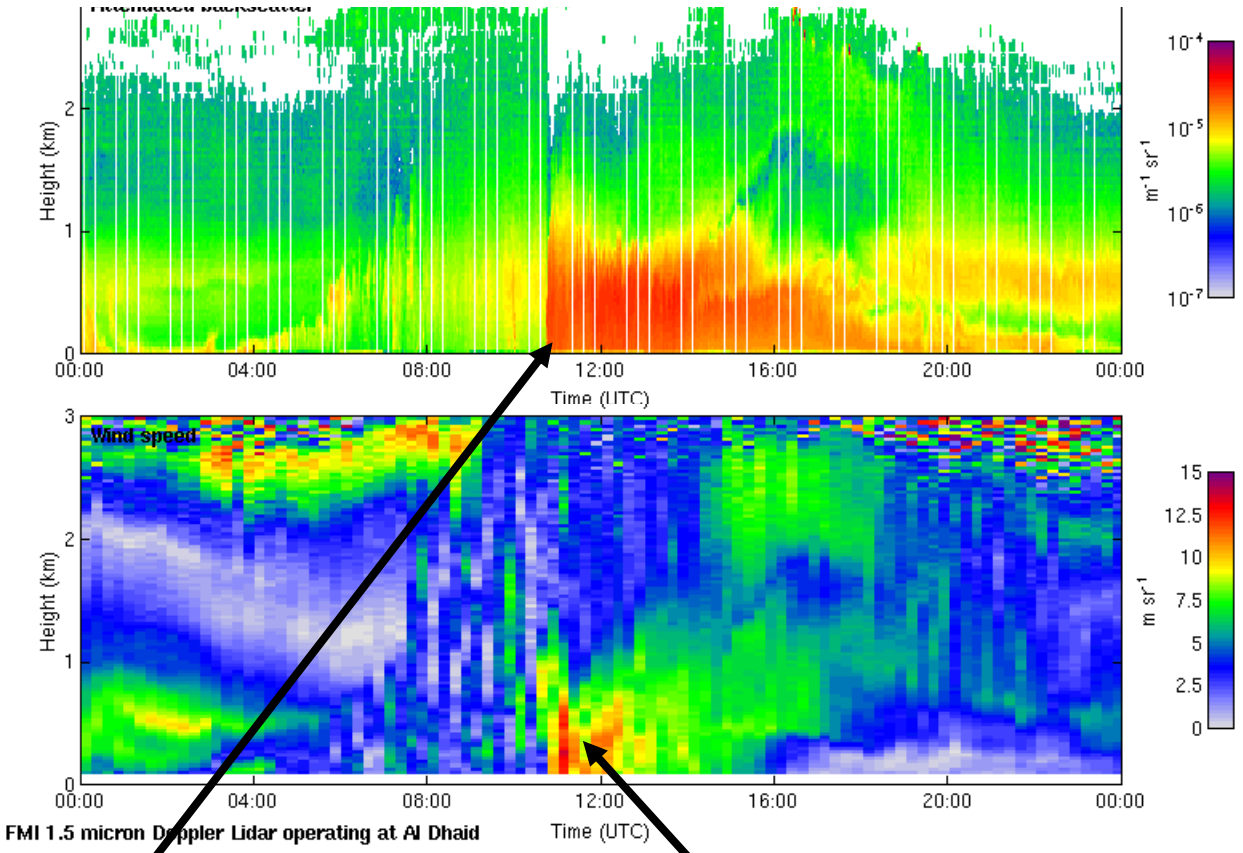
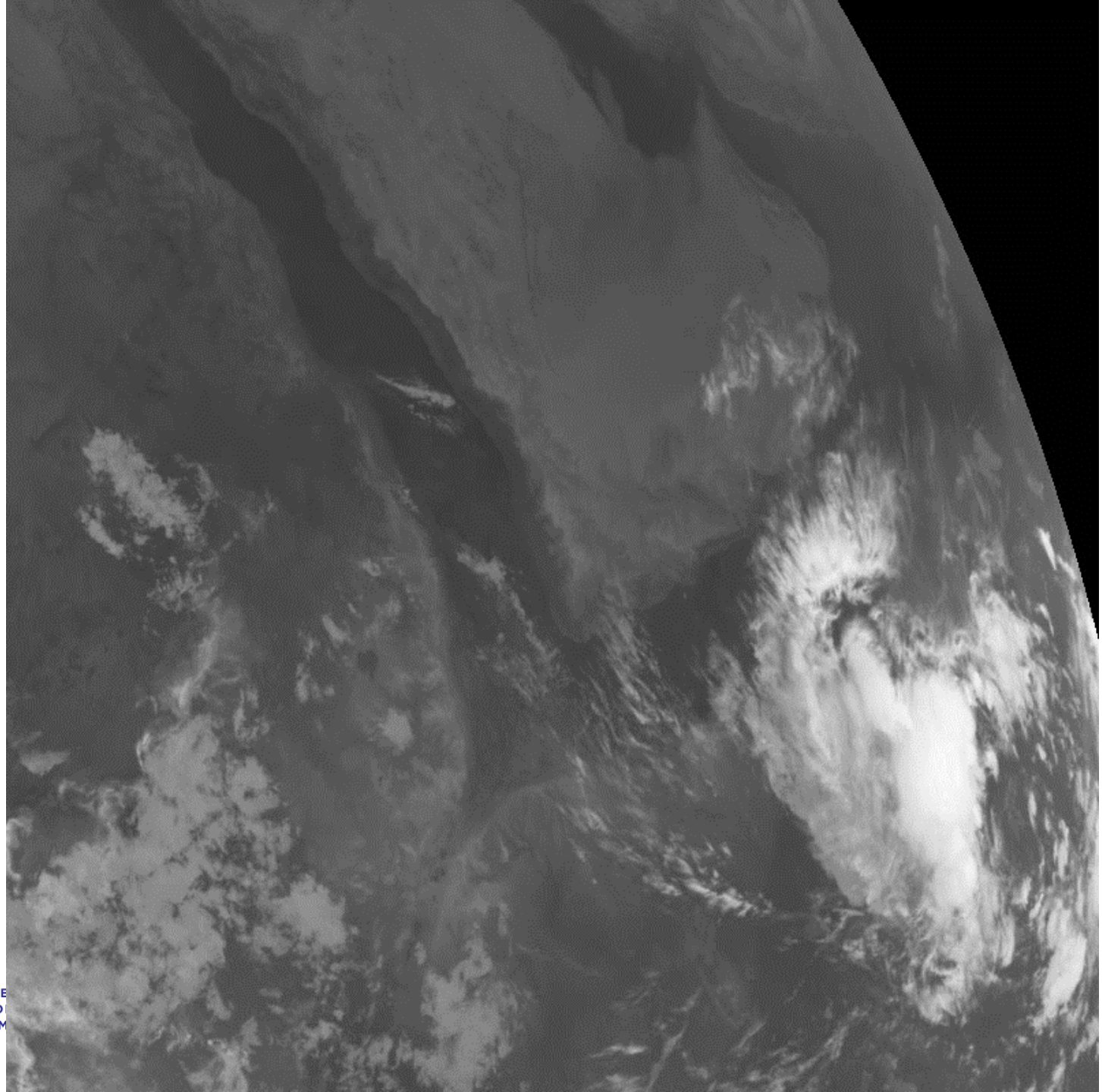


Rapid increase in aerosol

Increase in wind speed

Synoptic scale – Haboob

Example from aircraft



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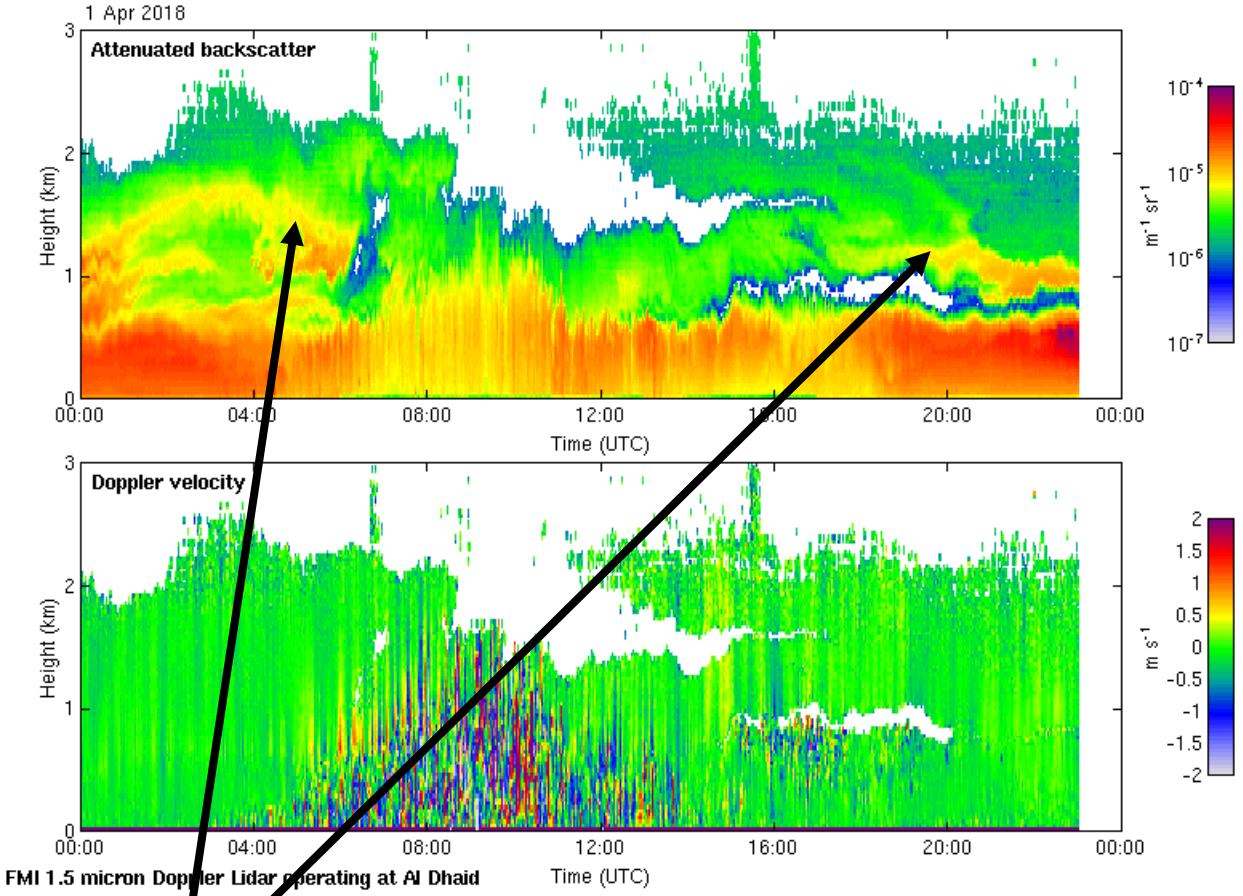
Outlook

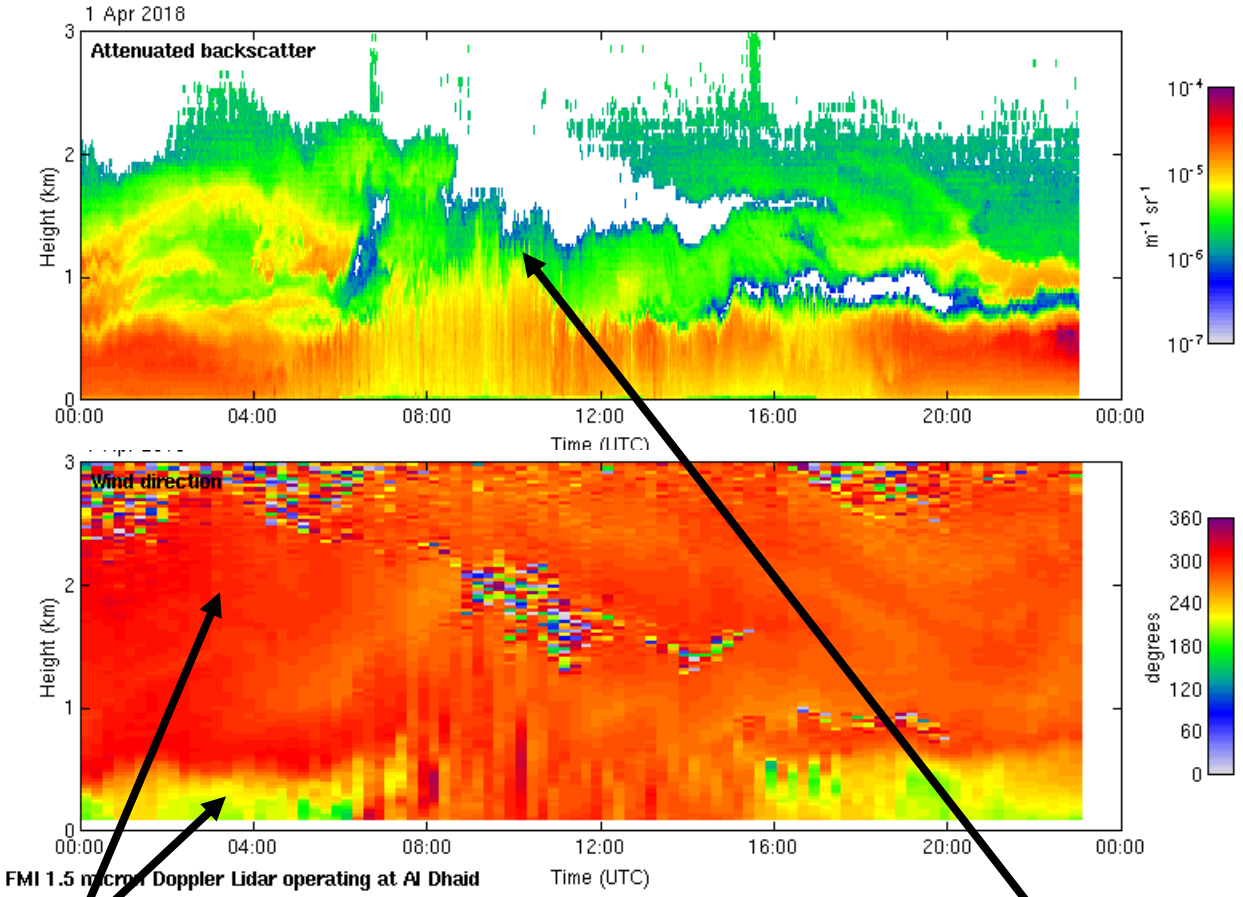
- Doppler lidar provides boundary layer dynamics
  - Investigate both vertical and horizontal transport terms
- Require transfer function to relate attenuated backscatter to mass
  - Need additional information
    - Colocated multiwavelength Raman lidar
    - In-situ tower or surface measurements
    - Sun photometer
- Evaluate and assist transport models

Elevated layers



Elevated and residual layers present

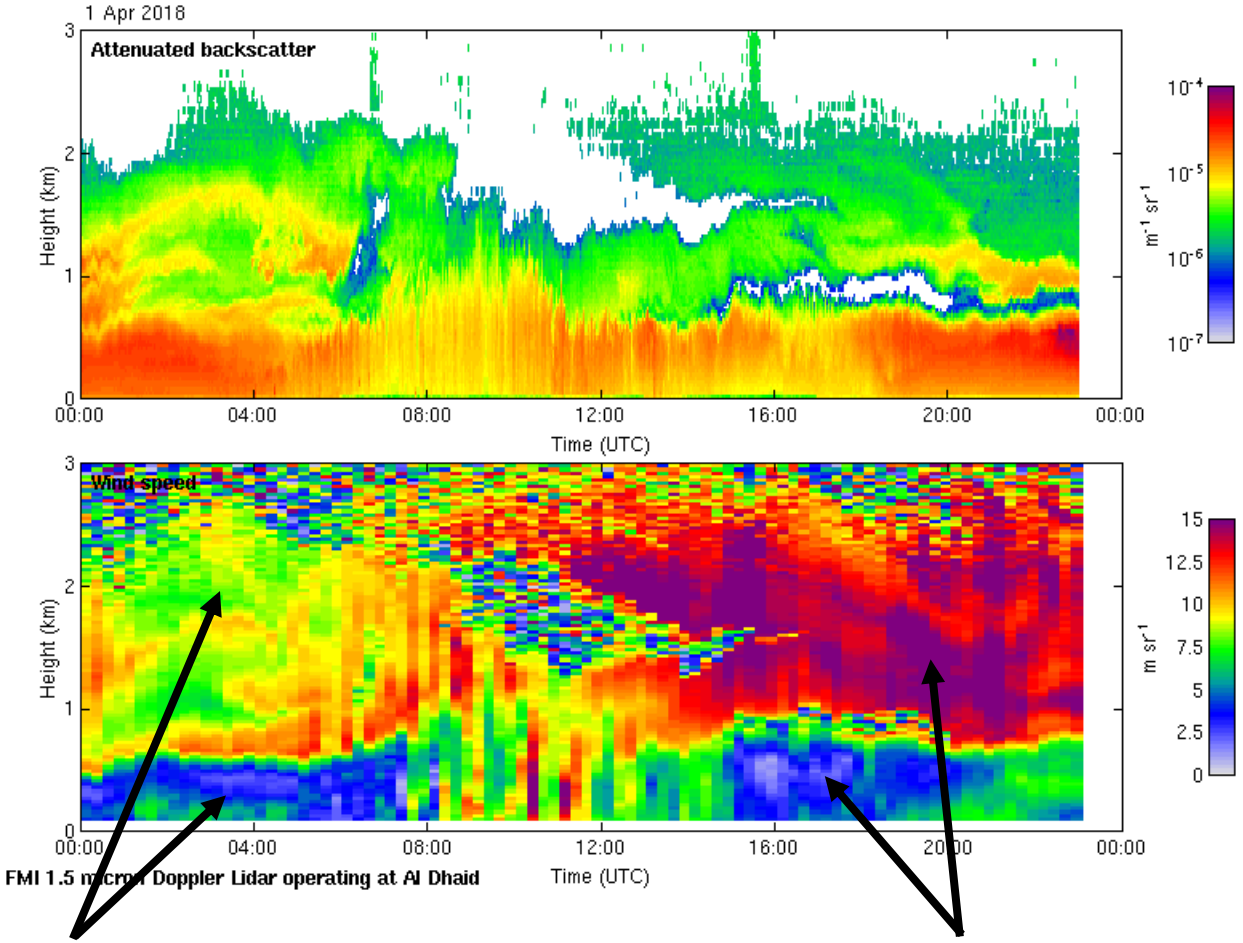
Elevated layers



Wind direction different

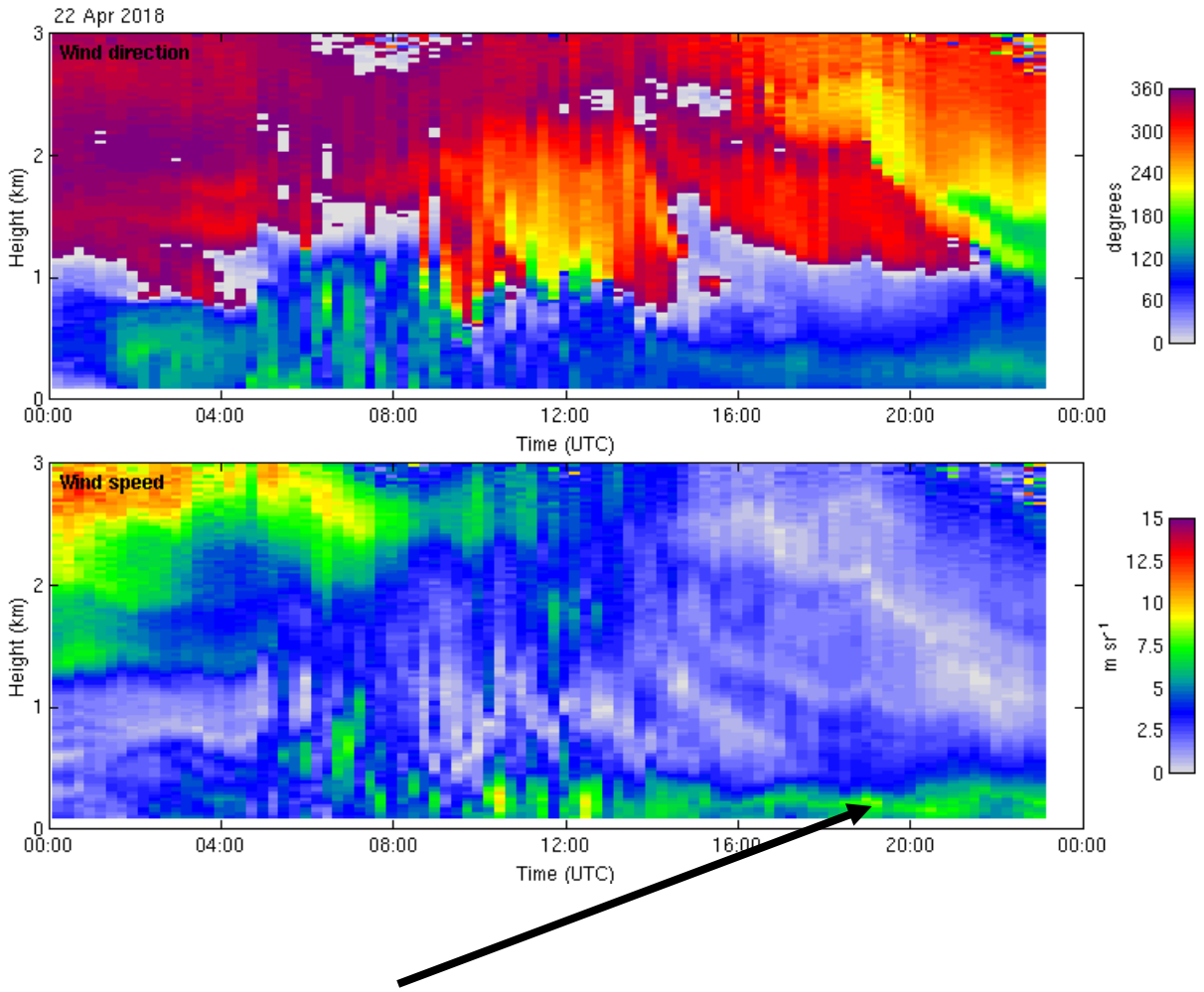
Mixed into boundary layer during the day

Elevated layers

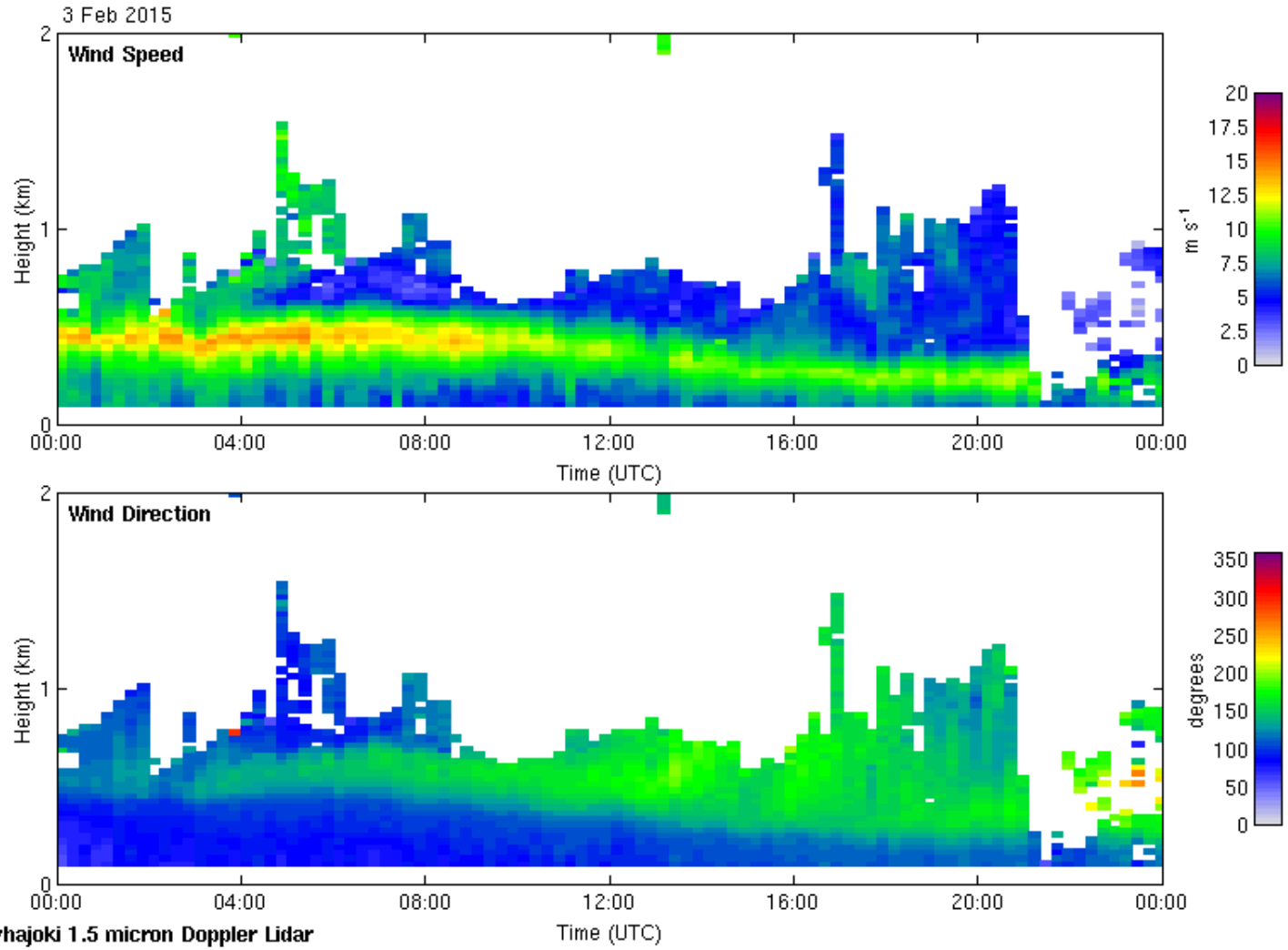


Wind speeds increase above

Low level jets



Increase in wind speed near surface



Pyhajoki 1.5 micron Doppler Lidar

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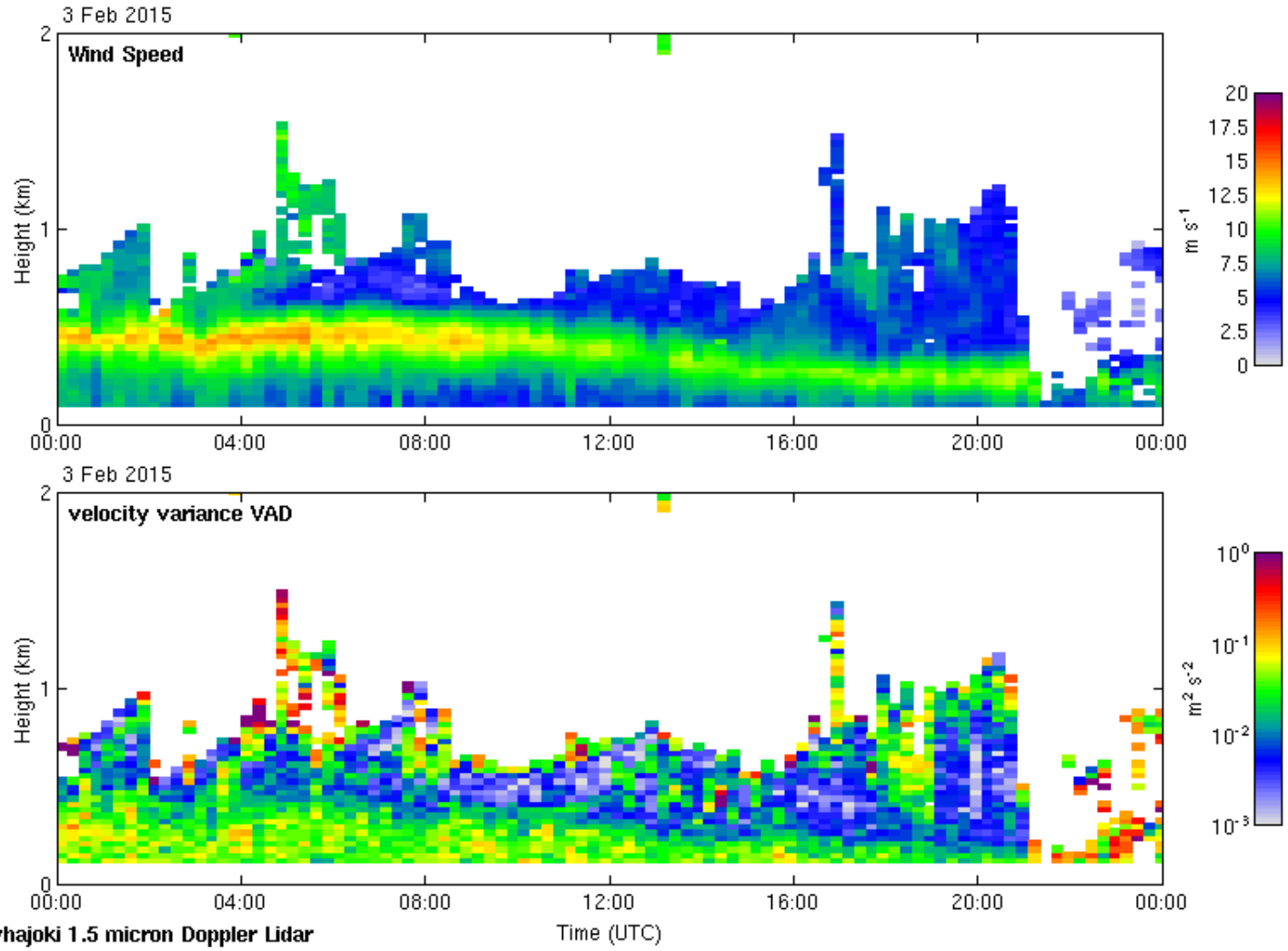

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