Lidar observations of PBL dynamics in the Arctic

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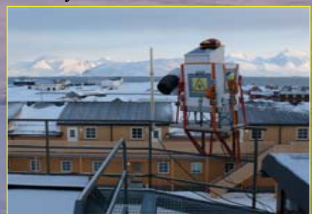
There is no region on Earth where the climate is changing faster than in the Arctic. A proper characterization of the Polar Boundary Layer processes, affecting the exchange of momentum, heat, moisture and chemical species between the surface and the free troposphere, is needed for a better understanding which forcings drive the changes going on in these region. Research interest in this polar region is notably increasing at the moment, with many stations engaged in different activities in the Arctic. Among these, Ny Alesund (79N, 12E), Svalbard Norway, represents a unique site where a large international cooperation allows the deployment of an ample set of instruments for monitoring a large number of key parameters of the arctic system.



In the frame work of the Climate Change Tower – Integrated Project (CCT-IP), an instrumented meteo tower (32 m) has been deployed in Ny Alesund. A small-sized, portable and automated micro-LIDAR (LIght Detection And Ranging), MULID, has been installed at the AWI Koldewey station and has provided high resolution profiles of the aerosol vertical distribution and optical properties since March 2010 .

Admunsen-Nobile Climate Change Tower (CCT)

1 K&Z CNR 1 Net radiometer	[33 m]
2 radiometer (CM11 and CGR4) for up- rad	[25 m]
4 Young propeller anemometers	[34m ,10m, 5m and 3m]
4 HMP45 Thermo-hygrometers	[34m ,10m, 5m and 3m]
1 Gill Solent sonic anemometer	[6.5 m]
1 Kh-20 fast Hygrometer	[6.5 m]
1 flux plate at the interface soil-snow	[surface]
2 PT100 for the snow temperature profile	[17.5 cm, 7.5 cm]
1 IR120 infrared sensor for snow skin temperature	[5m]
1 SR50 sonic range sensor for the snow height	[5m]

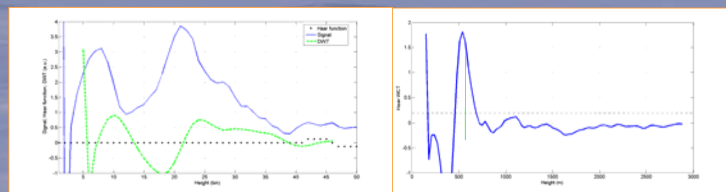
Tethered balloon [Miss Piggy] and Radiosounding

AWIPEV Arctic Research Base

Balloon-borne sensors record temperature, humidity, wind and air pressure, as well as ozone-profiles.

LASER	Nd –YAG diode pulsed: Pulse energy 35 μJ (532nm) ν = 1 kHz
TELESCOPE	Cassegrain diam. 200mm
DETECTOR	PMT 532nm // and PMT 532 nm ⊥
ACQUISITION	Embedded Devices: Analog and Photon Counting
THERMAL STRUCTURE	Temperature operative range: -40 / +40 °C
OPERATION	Unattended - USB Interface

micro-Lidar [MULID] and Discrete Wavelet Transform (DWT) method



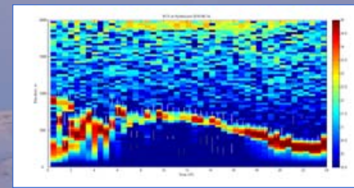
The height of the PBL is detected using the gradient method. Under the assumption that the aerosol is well mixed within the Planetary Boundary Layer, its top is detected as the strongest variation of the aerosol backscatter cross section (i.e. the inflection points of the Range-Corrected Signal, RCS). We employed the Discrete Wavelet Transform (DWT) method, which uses the convolution of the signal with a finite-size step function (Haar wavelet) to determine the inflection points of the RCS. The convolution peaks represent the top of aerosol layers, and the less elevated peak that overpasses a threshold is chosen as the PBL top, which is reasonable under most conditions. The method is well described in Brooks 2003. As an alternative, the maxima of the numerical gradient could be employed, but this approach is less robust than the wavelet, since it is based on numerical differentiation instead of integration.

Batcharova and Gryning Model

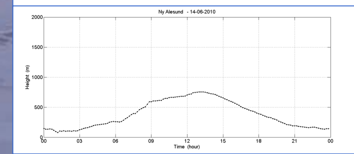
The parameterization proposed by Batcharova and Gryning, 1994 was used to determine the MLH during the summer. The model is a zero order model depending on surface turbulent fluxes and the potential temperature gradient in the free atmosphere.

Results

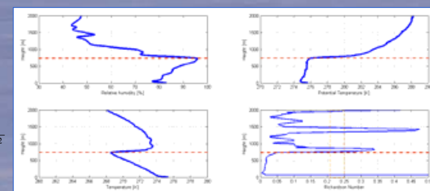
Range Corrected Signal at 532 nm (parallel polarization). Gray and white bars represent the top of aerosol stratification and hence the PBL height with the relative indetermination.



Batcharova and Gryning model uses as input the surface turbulence data obtained by the Gill Solent sonic anemometer. Results computed with the model are in good agreement with Lidar wavelet method.



Validation with RS92 (Vaisala DigiCORAIII)
Launch time 12.00 UT



Richardson number

$$R_{ib}(z) = \frac{g(z-z_0)}{\vartheta(z)} \frac{[\vartheta(z)-\vartheta(z_0)]}{[u(z)-u(z_0)]^2+[v(z)-v(z_0)]^2}$$

$R_{ib} > R_{ibc}$ with $R_{ibc} = [0.21-0.25]$

Campaign 2011-2012

A tethered balloon will be launched with one meteorological sonde to profile the atmospheric parameters up to 1000 m every 4 hours. The profiling should be performed at the NDSC observatory where also the MULID is located.

Bibliografia

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