Tracing Air Parcel Trajectories Using No-Lift-Balloons. A Brief Report Including a Light Wind Flight over Complex Terrain During MAP 99 IOP

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There are two classes of Free Lift Balloons (FLB):

I. Constant Volume Balloons (CVB)

II. No Lift Balloons (NLB)

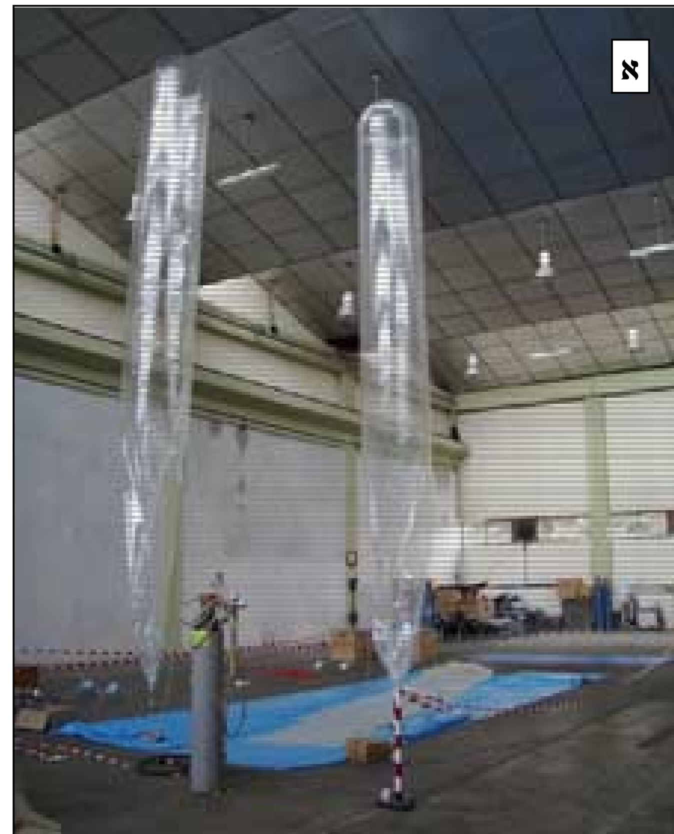
I. Constant Volume Balloon (CVB)

- Tailored with sheets of materials characterized by low elasticity and low permeability (Polyester, Polyethylene).
- Super-pressurized with gas lighter than air (H_2 ,He).
- Almost-constant effective density.
- Tendency to remain in a prefixed isopycnic layer.
- Rugged and almost impermeable to filling gasses commonly used.

Partially filled CVB in standby

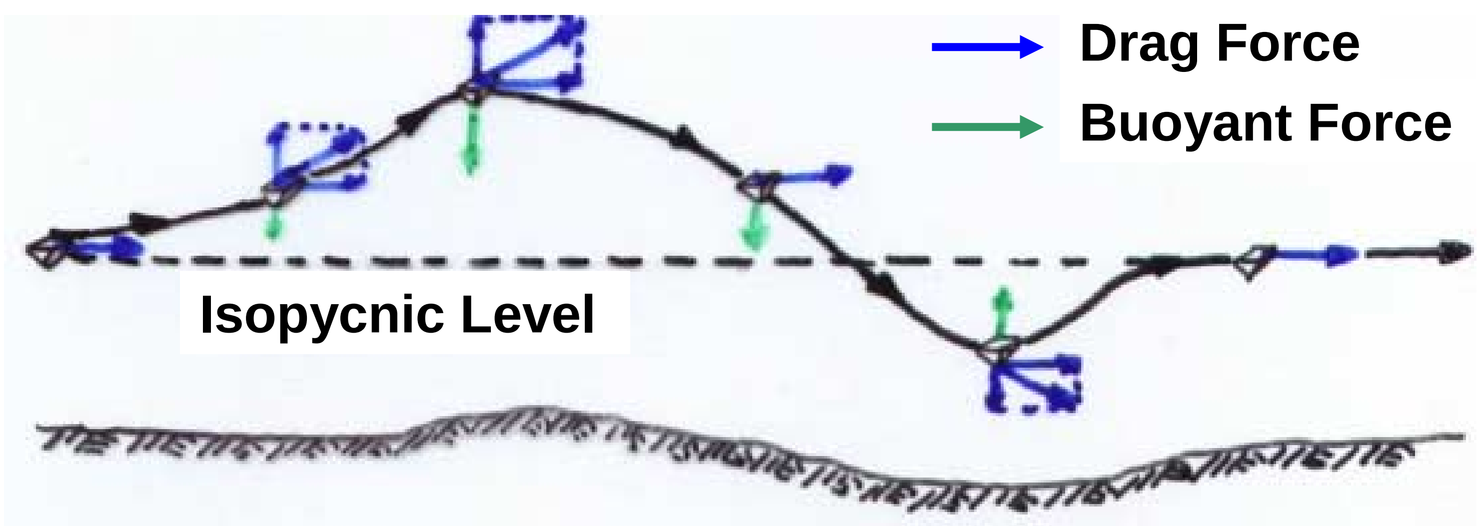
Swiss-madeTetroon
(V=1.1 m^3)

French-made Cylinder
(h=7 m, Ø=0.7 m)



CVB Motion

- Horizontal motion driven by the drag force exerted by the horizontal wind.
- Vertical motion driven by the drag force exerted by the vertical wind component and the buoyant force developed outside the equilibrium layer.



Applicability of CVB

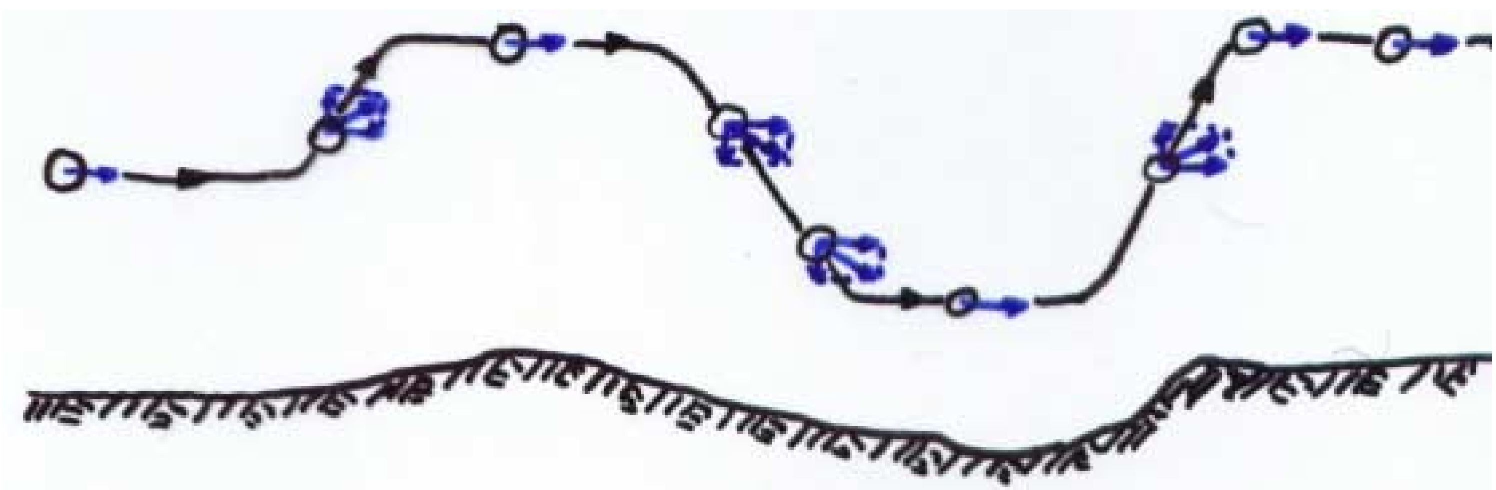
- Characterizes the thermodynamic and dynamic structure of a shallow atmospheric layer surrounding the equilibrium level, along the flying trajectory.
- The tendency to remain in the equilibrium flying level invalidates the CVB to be a true Lagrangian tracer of air parcel trajectories.

II. No Lift Balloon (NLB)

- The original carrying platforms are aerological balloons.
- The rubber skin has high elasticity index.
- The light filling gas (H_2, He) can expand and contract following the ambient pressure changes.
- The effective density changes adiabatically.
- Once the system is balanced at launching level, it will remain free of buoyant positive or negative lift at any altitude, in an atmosphere having an adiabatic lapse rate.

NLB Motion

- NLB horizontal motion is driven by the drag force exerted by the horizontal wind.
- NLB vertical motion is driven by the drag force exerted by the vertical component of the wind vector. ***No buoyant forces are present***.
- NLB are true Quasi-Lagrangian air parcel tracers that can characterize the dynamic and thermodynamic structure of the atmosphere along a particular air parcel trajectory.



A Serious Problem!!

- Thin rubber or neoprene sheets used in aerological balloons are extremely permeable to light filling gasses commonly used (H_2, He).
- Loss of filling gas by diffusion causes a loss of buoyancy that disrupt the free lift balance.
- If the loss of buoyancy is not compensated, the NLB system will plunge down at increasing rate.

Compensation of loss of buoyancy due to filling gas leakage

- Longhetto used a mixture of two gasses:

  H_2 lighter than air.

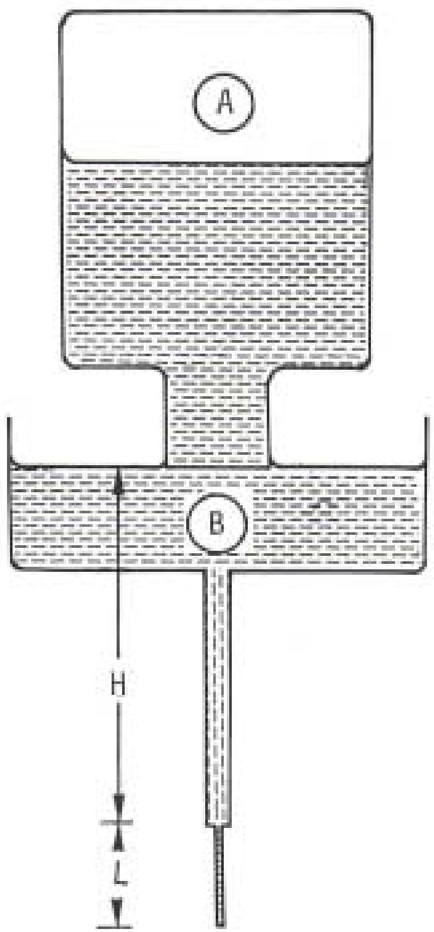
  CO_2 denser than air
- For a proper mixture ratio, the simultaneous leakage of both gasses keeps the system balanced for a reasonable time.
- The mixture is only slightly lighter than air, greatly reducing the capability to carry a useful payload.
- The method suits short time flight up to optical tracking range.

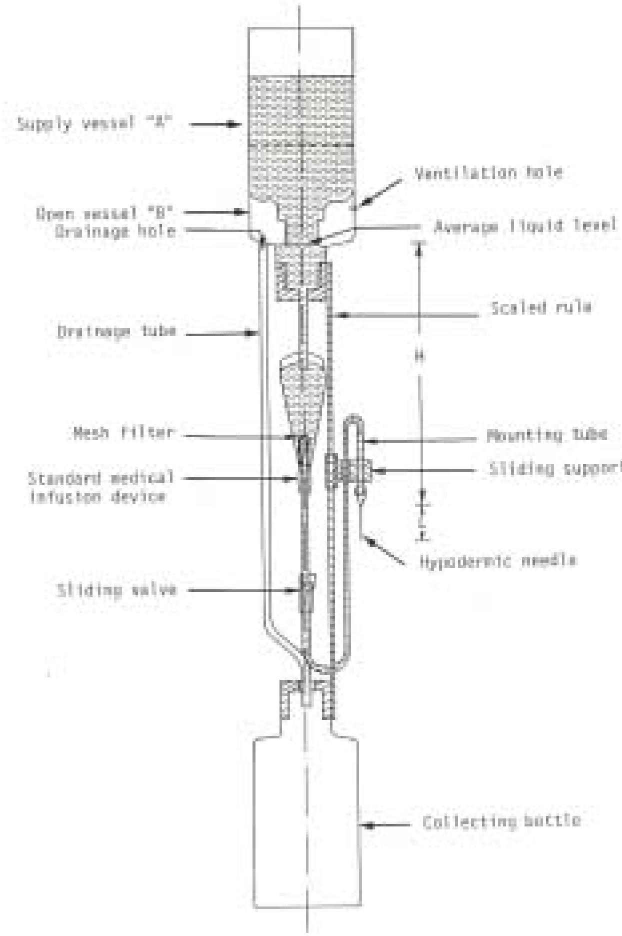
Compensating the loss of buoyancy using a dripping device

Terliuc developed a dripping device that:

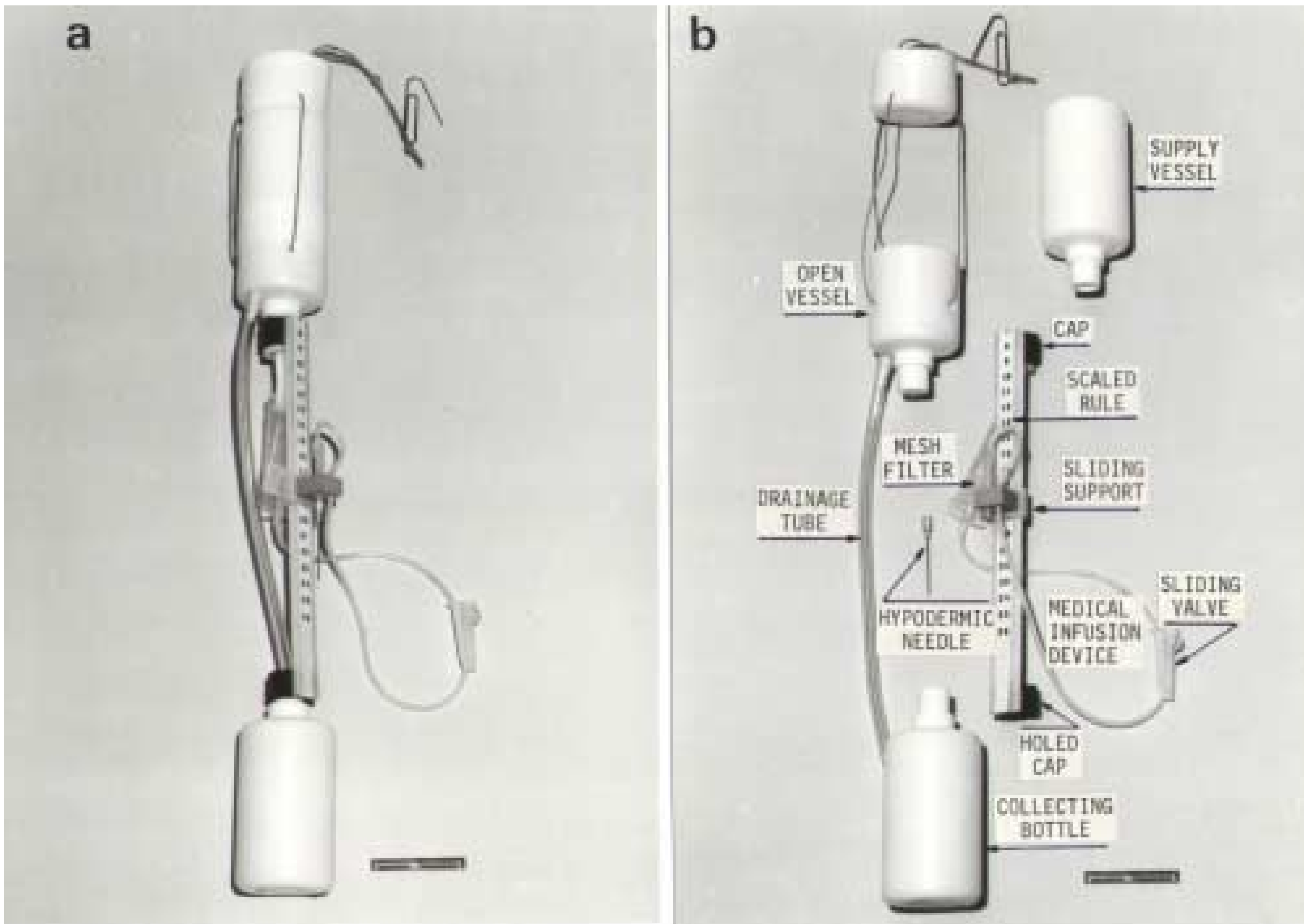
- Provides a constant-rate loss of ballast, at constant temperature.
- The compensation rate can be fitted to the buoyancy loss rate of a specific balloon.
- Using the appropriate liquid, the temperature dependence of the compensation rate is fitted to the temperature regime of the loss of buoyancy.
- The device is cheep an can be easily manufactured.

The dripping compensation device developed by Terliuc

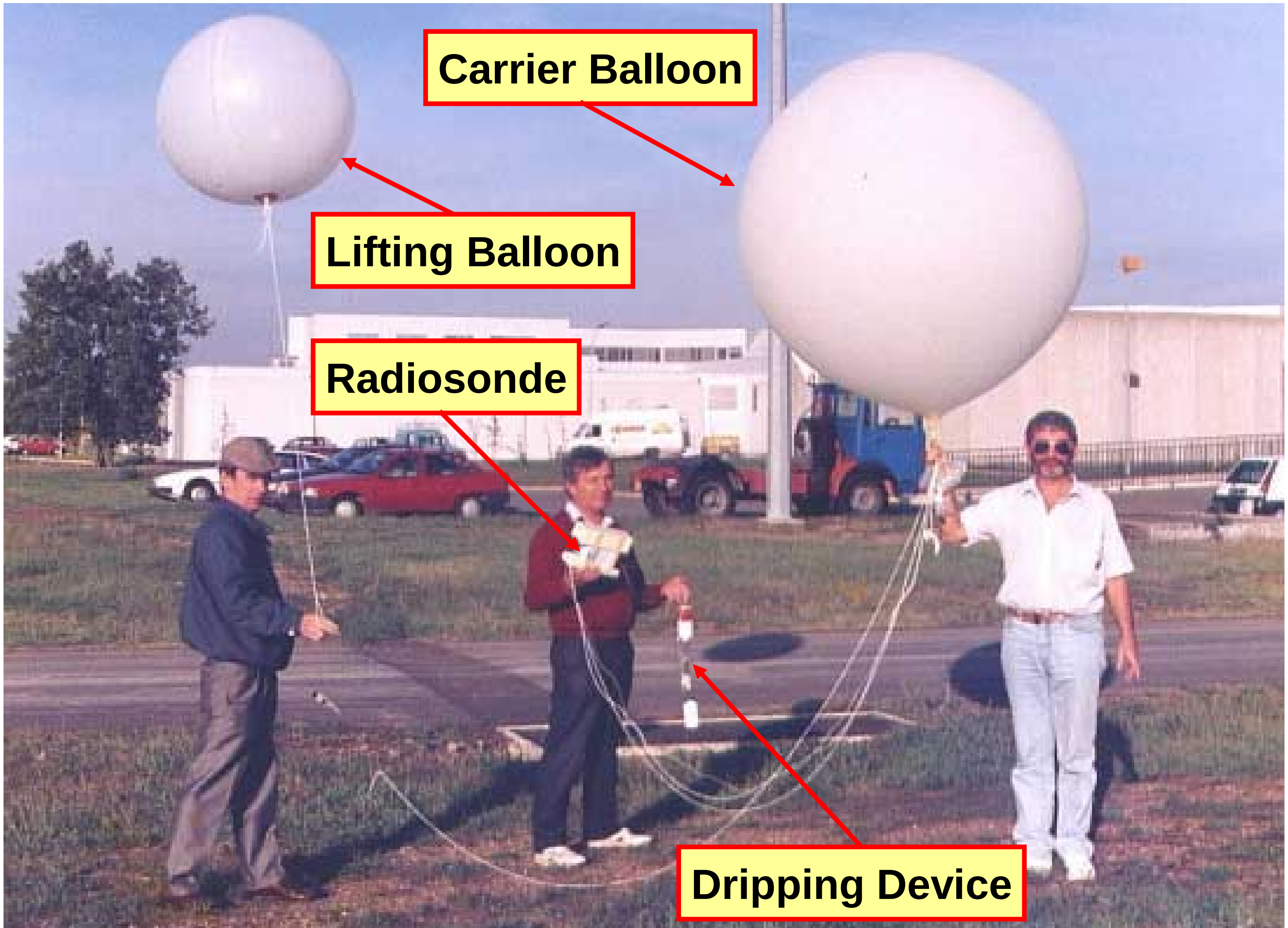




The dripping compensation device



The whole NLB system (after Terliuc) at Meteo-France – Toulouse (1991)

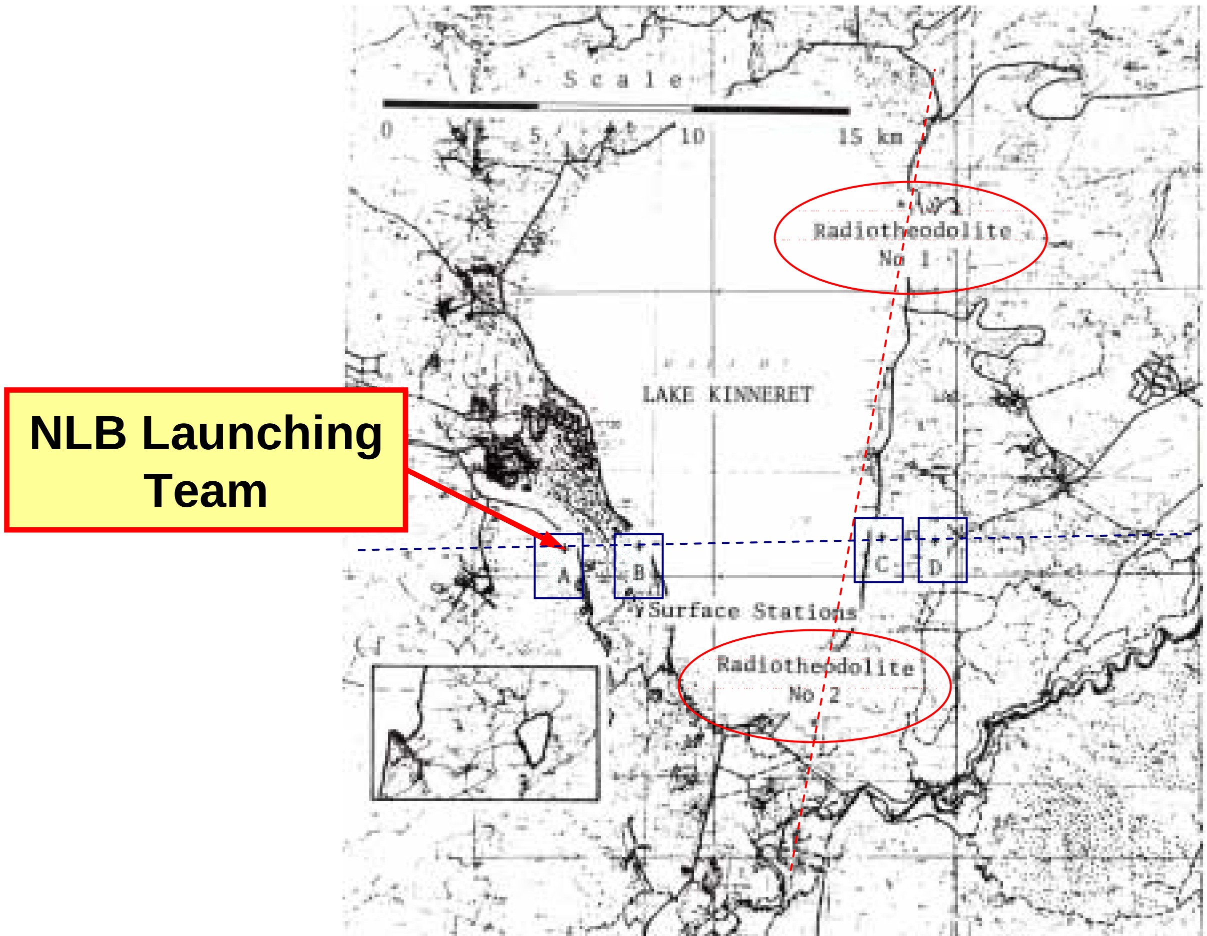


Applications of NLB

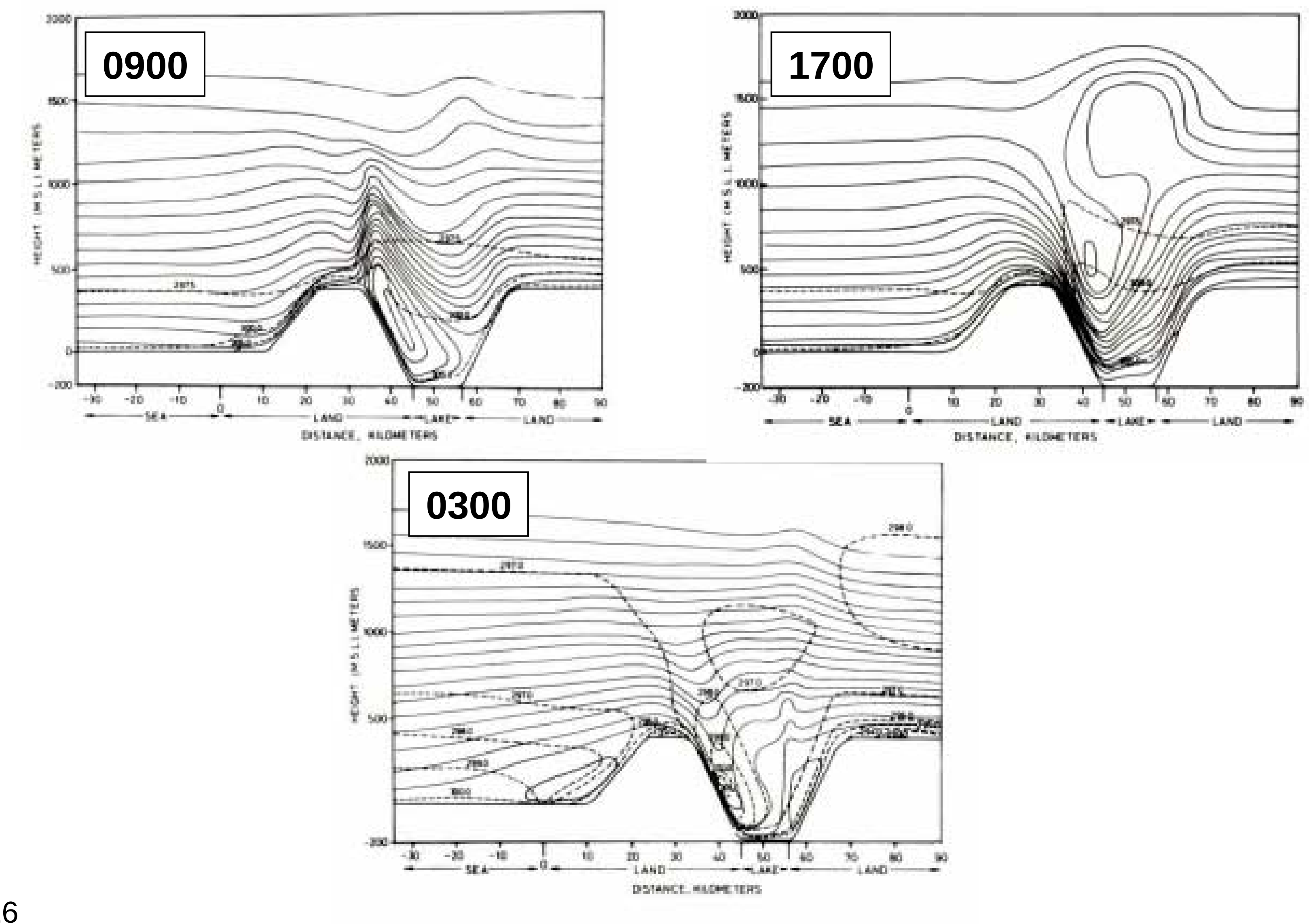
1. Circulation Model ⇔ Balloon Behavior assessment.
2. Light wind flow over complex terrain under lake-breeze regime.

1. Circulation Model ⬄ Balloon Behavior reciprocal assessment

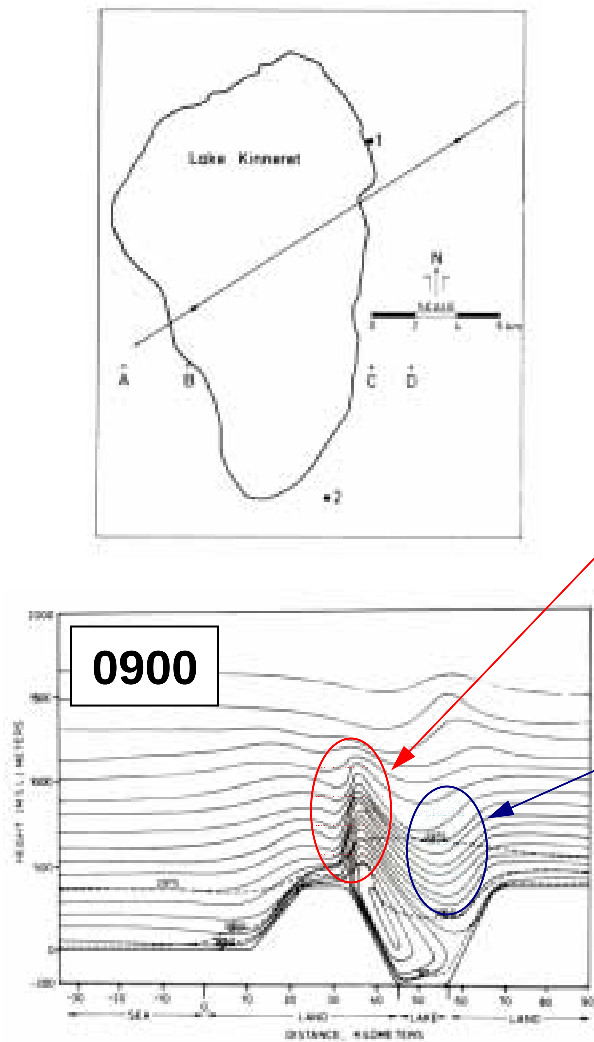
A field study in the Lake Kinneret area (Summer 1981)

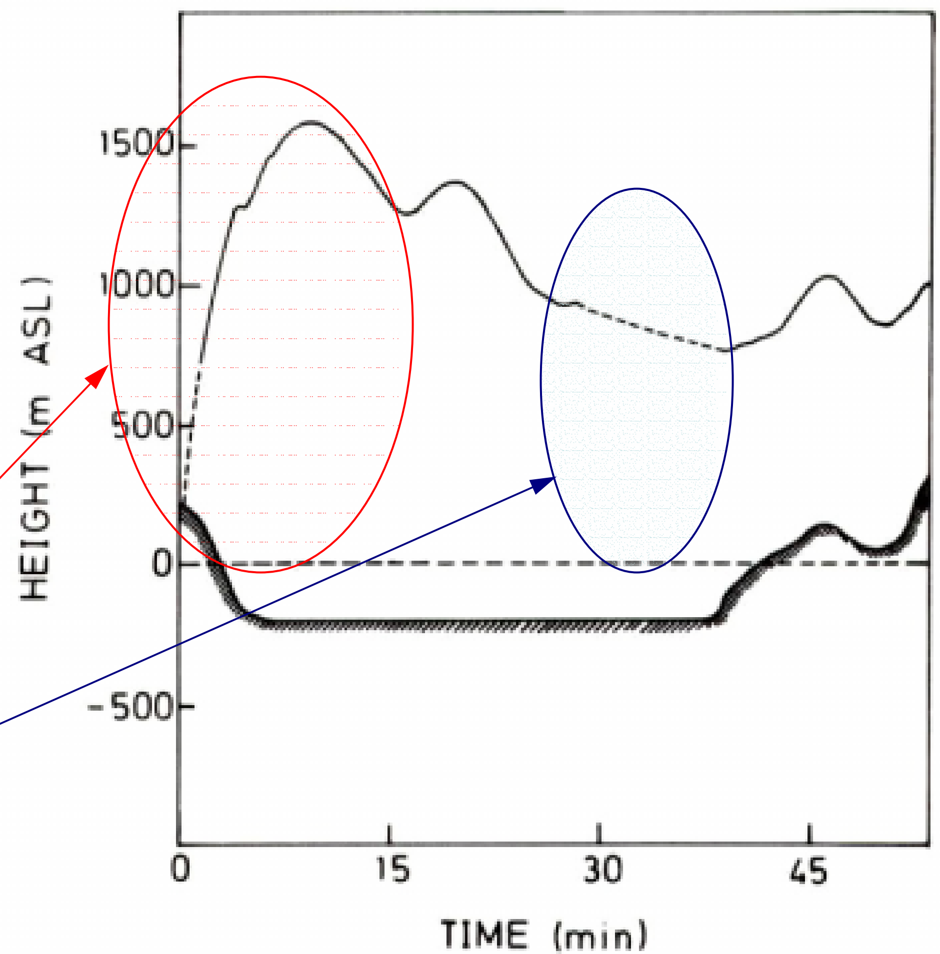


Results of Mesoscale Model simulations of the flow pattern involving: Mediterrenean Sea Breeze, Lake Kinneret Breeze and Mountain-Valley Wind (Doron & Neumann, 1977).

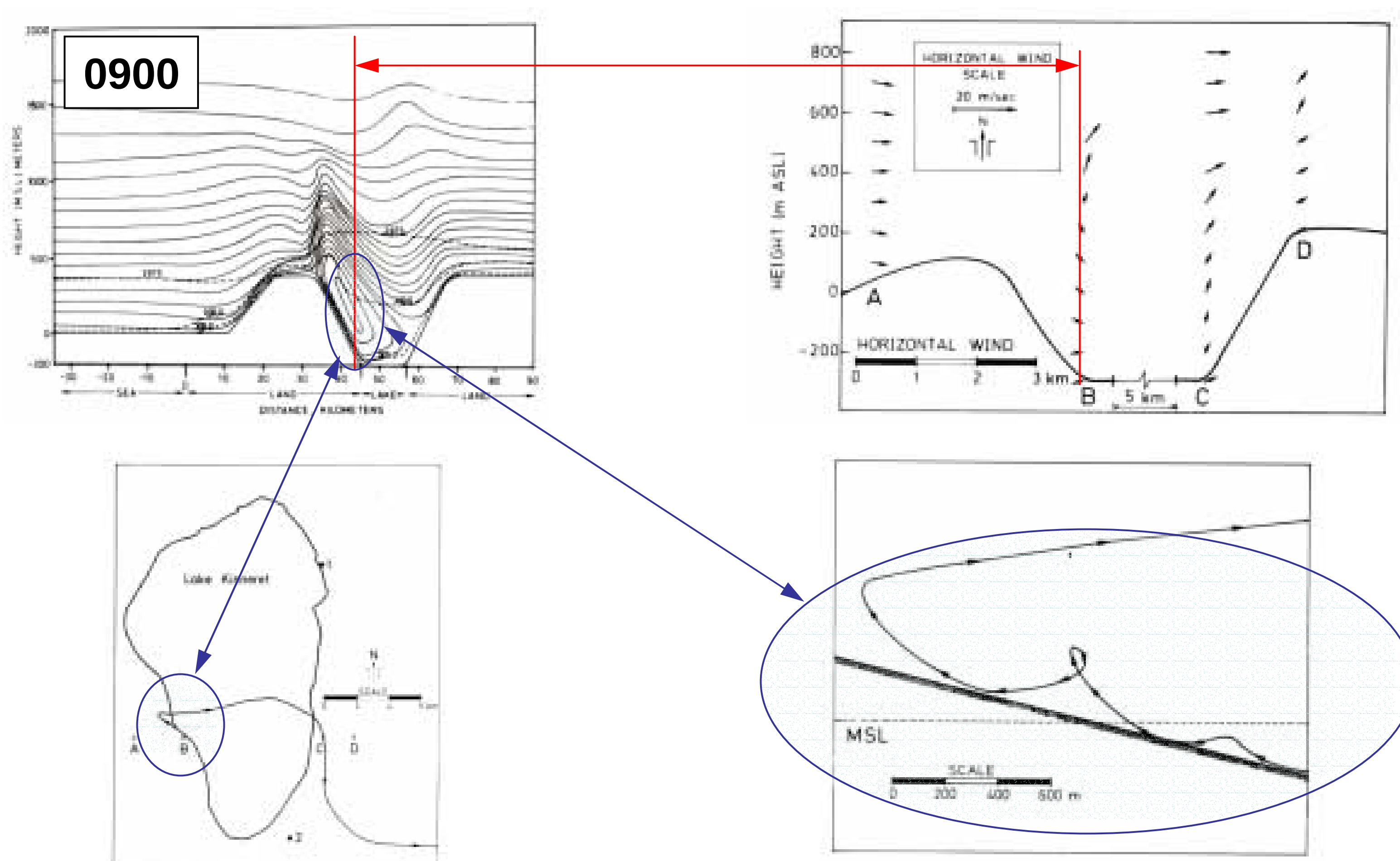


Flow pattern at 07/07/81, 08:00 LT

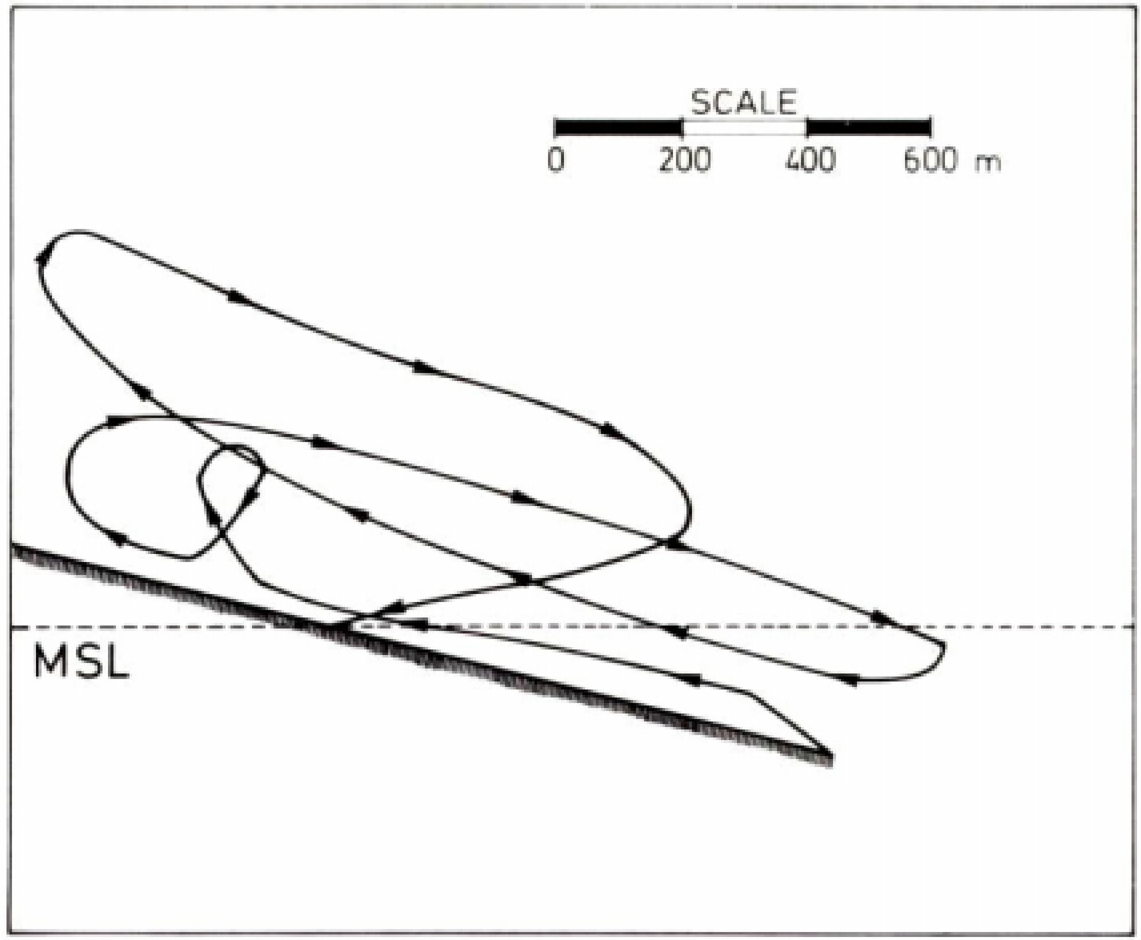




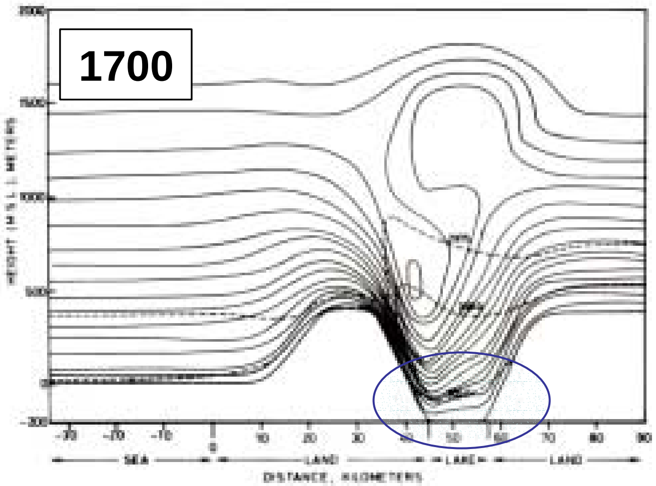
Flow pattern at 12/07/81, 09:00 LT

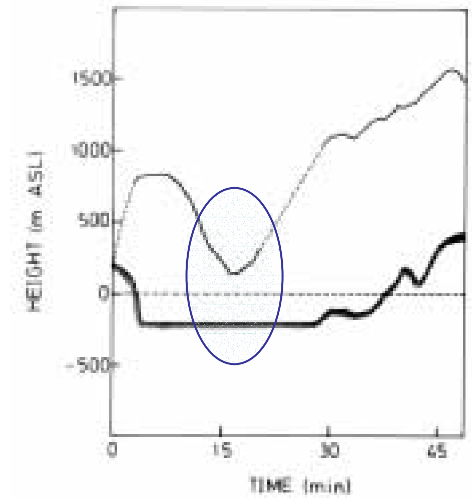


Flow pattern at 12/07/81, 11:00 LT



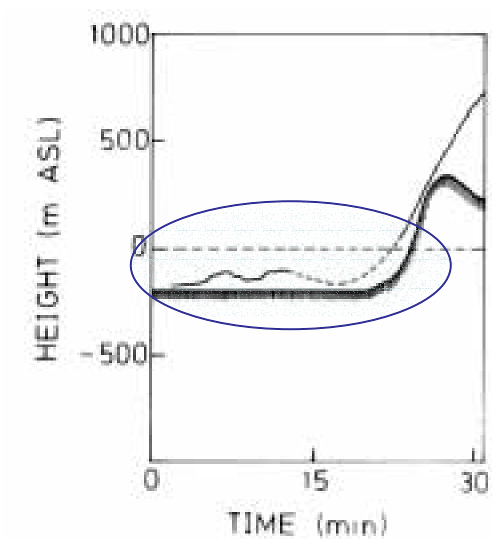
Flow pattern at 12/07/81, afternoon

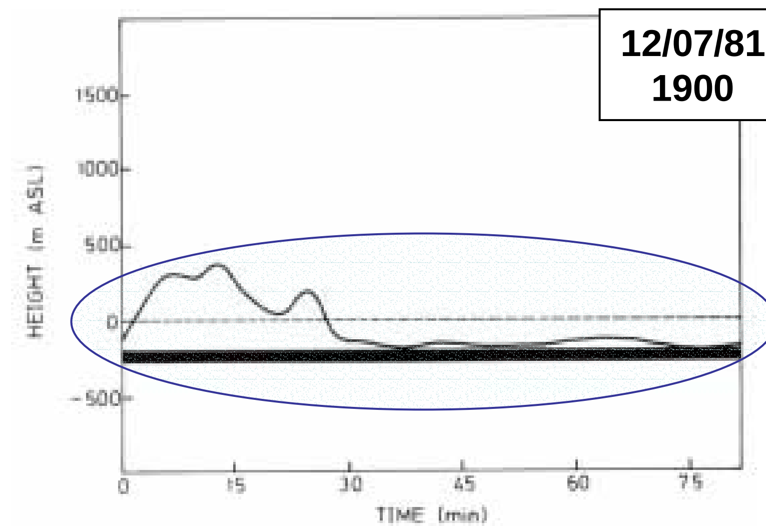




07/07/81
1300

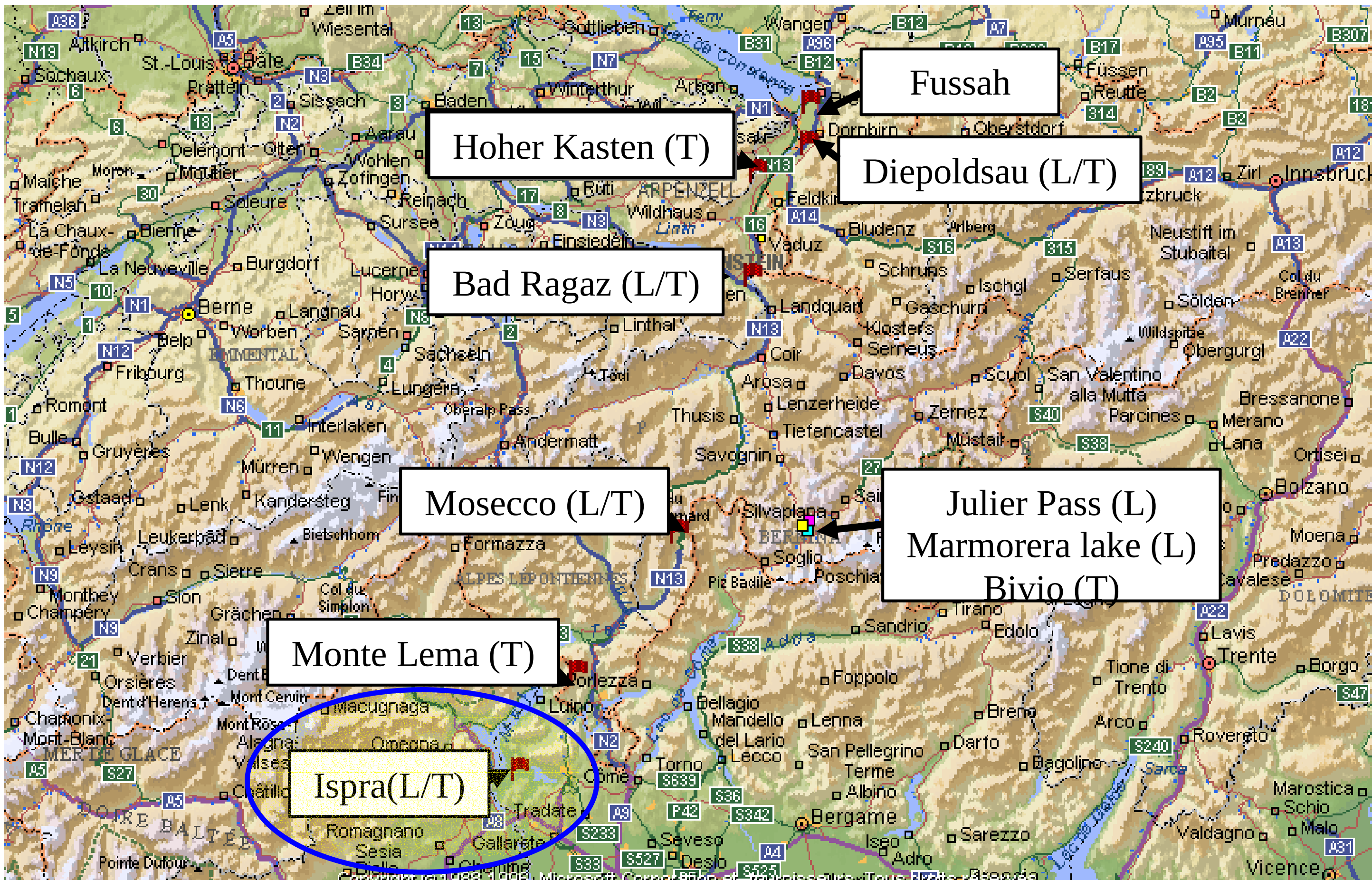
12/07/81
1530





2. Light wind flow over complex terrain under lake-breeze regime.

Mesoscale Alpine Program (MAP)-1999



A new approach to a simplified NLB technique: Partially inflated Tetroon

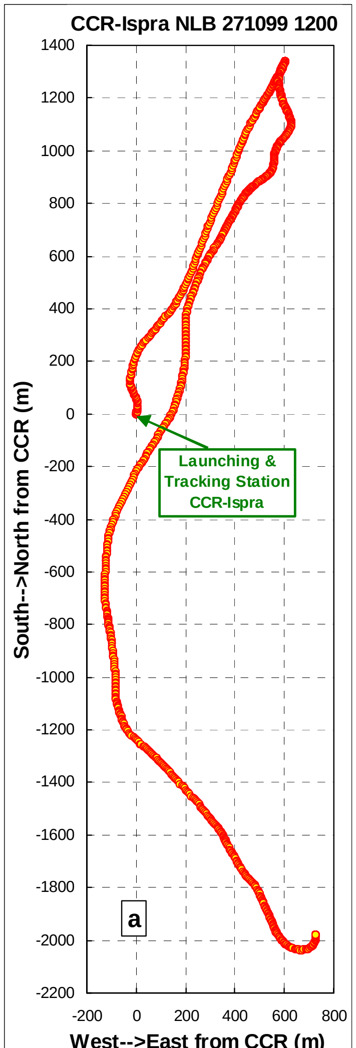
☺ **IN FAVOR**

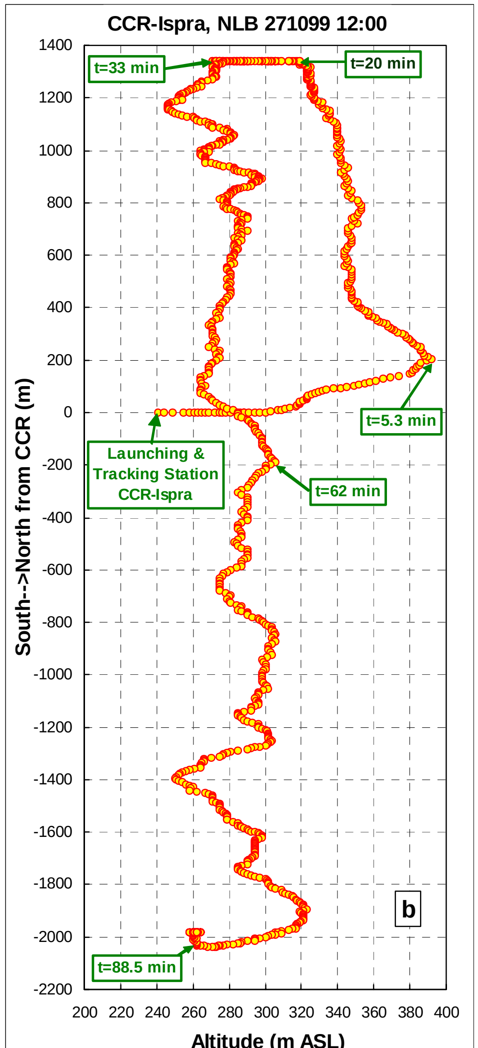
- ☺ Tailored with polyester (Hostophan™), the tetroon-based NLB is rugged and almost impermeable to light filling gasses.
- ☺ Almost transparent to solar radiation.
- ☺ Spare tuning of compensating device.
- ☺ Can be easily implemented.
- ☺ Can be kept in standby during relatively long time.

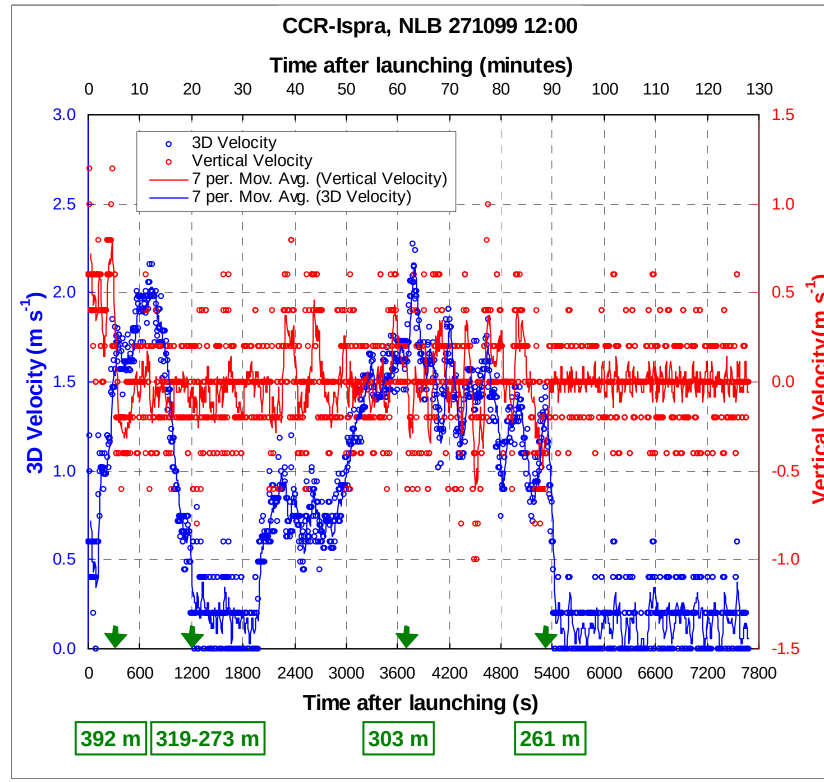
☹ **AGAINST**

- ☹ The expansion volume is limited, reducing the ceiling for NLB technique validity.
- ☹ The shape can not be predicted accurately.
- ☹ The stiff sheet may not respond smoothly to differential pressure changes.
- ☹ There will be some uncertainties when evaluating the drag coefficients

SMI tetroon, partialy inflated, launched from CCR Ispra at 27/10/99, 1200GMT







Conclusions

- No Lift Balloon are true Quasi-Lagrangian tracers of particular air parcels.
- The NLB based on aerological balloons have well defined shape, good response to differential pressure changes, unlimited ceiling, can carry big useful payload and can be parameterized with reasonable accuracy. Its preparation requires expert operators and is time consuming.
- The NLB based on tetroon made with stiff sheet is rugged, almost transparent and, therefore, insensible to solar radiation heating and easy to be prepared. Its ceiling and carrying capability are limited and the parameterization involves some unavoidable uncertainties.
- Both techniques provide valuable information that can not be acquired by other means and, therefore, are worth to be implemented in field experiments.
- The NLB based on tetroon can be easily adapted to be launched in emergency situations to trace pollutants trajectories in real time.