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Memorie della

Long Duration Balloon flights development

(Italian Space Agency)

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Abstract. Stratospheric balloons are rapidly becoming the vehicle of choice for near space investigations and earth observations by a variety of science disciplines. With the ever increasing research into climatic change, earth observations, near space research and commercial component testing, instruments suspended from stratospheric balloons offer the science team a unique, stable and reusable platform that can circle the Earth in the polar region or equatorial zone for thirty days or more. The Italian Space Agency (ASI) in collaboration with Andoya Rocket Range (Andenes, Norway) has opened access in the far northern latitudes above 78 N from Longyearbyen, Svalbard. In 2006 the first Italian UltraLite Long Duration Balloon was launched from Baia Terra Nova, Mario Zuchelli station in Antarctica and now ASI is setting up for the their first equatorial stratospheric launch from their satellite receiving station and rocket launch site in Malindi, Kenya. For the equatorial missions we have analysed the statistical properties of trajectories considering the biennial oscillation and the seasonal effects of the stratospheric winds. Maintaining these launch sites offer the science community 3 point world coverage for heavy lift balloons as well as the rapidly deployed Ultra-light payloads and TM systems ASI developed to use for test platforms, micro experiments, as well as a comprehensive student pilot program. This paper discusses the development of the launch facilities and international LDB development.

Key words. Long Duration Ballooning, Svalbard, Stratospheric Research, Greenland

1. Introduction

Starting with a conversation between 3 colleagues (Peterzn - ISTAR, Masi - U of Rome LS, and Romeo - INGV (National Institute of Geophysics and Volcanology), Rome) in 1998 during a NASA Long Duration Balloon Campaign in Antarctica, the idea of developing a Northern Hemisphere balloon launch facility was born. The idea was simple...find a location that was similar in latitude to the NSF/NASA facility in Antarctica, maintain a trajectory that the balloon/payload would pass over unpopulated areas, be certain the termination and recovery can be performed in a

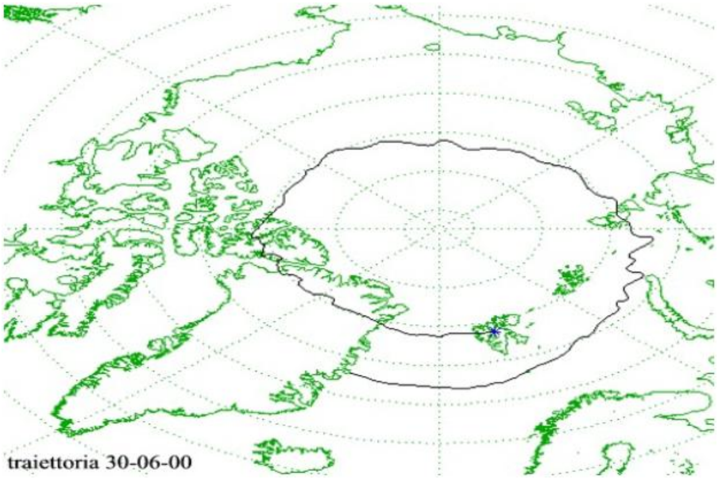

Fig. 1. Andrea Cardillo and Ivano Musso (ISTI - Pisa) provided trajectory profile estimates prior to the beginning of the 2003 campaign (Cardillo et al. 2003; Musso et al. 2003, 2004). Although the sounding balloons did not remain aloft long enough to prove a full circumpolar trajectory, the 6 sounding balloons launched in 2003 gave confirming proof the possibility existed.

safe area that has the infrastructure to support the recovery efforts. The initial investigations pinpointed Svalbard, Norway as the logical choice with the Greenland Ice Sheet as the recovery zone. Between 1998 and 2001 the idea of a balloon launch facility was presented to the Italian Space Agency (ASI) by Dr. Silvia Masi from the University of Rome La Sapienza. ASI then contracted ISTAR in 2002 to develop and manage the Long Duration Balloon Program. ISTAR, along with Dr. Masi made contact with Andoya Rocket Range on Andenes Island, Norway to share in the development of what has become the Nobile / Amundsen Stratospheric Balloon Center - Svalbard

2. Launch Locations

SVALBARD - Although Svalbard was chosen as the potential launch location, it was only a theory that the stratospheric winds would support a trajectory that would take a balloon launched from Svalbard around the polar region and back over the Greenland Ice Sheet for termination and recovery. During June of 2003, ISTAR supported by ASI travelled to Longyearbyen, Svalbard to perform a series of sounding balloon launched to prove concept of launching from 78^o north. The sounding balloons launches of 2003 carried a 4 kilogram package consisting of a ARGOS transmitter powered by lithium batteries. During this initial season, Andoya Rocket Range (ARR) supported the campaign by providing local support, helium and inflation manifold. ISTAR provided the launch equipment and managed the launch operations. Antonio Leonardi (ASI) was the third member of the 2003 launch team.

During the 2003 season, it was hoped that a more significant payload system would be developed that would include an IRIDIUM based telemetry system (TM), terminate commands, and support capabilities of a small science instrument. For the 2004 season, ASI funded INGV to develop such a TM platform. ISTAR along with support from the University of Rome LS, INGV and ARR returned to Svalbard to test the newly developed PEGASO (Polar Explorer for Geomagnetics And other Scientific Observations) TM platform. In addition to the new telemetry, ISTAR had been specified a new balloon to be built by Aerostar (formerly Raven Industry) that would be called

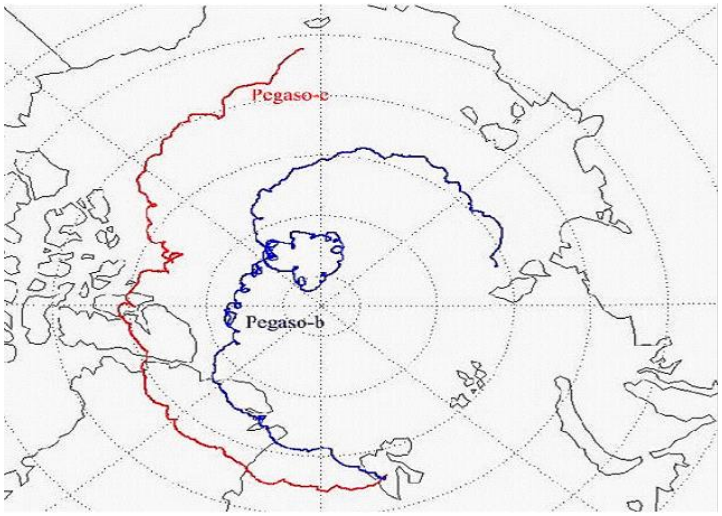

Fig. 2. Trajectories of the 2, 2005 balloon flights from Svalbard, Norway. Both flights were terminated and not recovered as overflight permission from Russia had not been received. Flight "b" was launched June 29th, 2005, flight "c" on the 4th of July 2005.

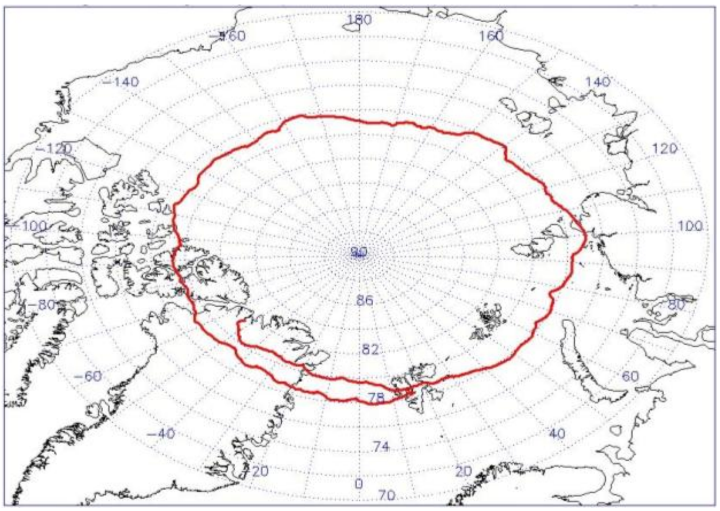

Fig. 3. Complete circumpolar trajectory of a balloon launched from Svalbard. Launched on the 12th of June, the flight lasted 17 days (417 hours 33 minutes) and was then terminated over the northern Greenland Ice Sheet, where the payload impacted.

a TrailBlazer for the Ultralight LDB campaigns. The idea was to have a relatively small 9258 m balloon that could carry at least 25 kilo to an altitude of 36 kilometers and be durable enough to circumnavigate the northern hemisphere for at least 40 days. This was the first season of using the TrailBlazer balloons that included a telemetry system, terminate as

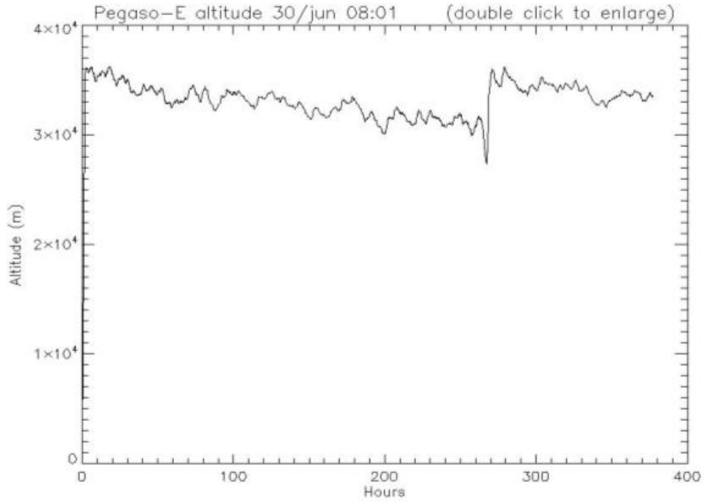

Fig. 4. 2006 PEGASO - Time vs. Altitude

well as ballasting. The successful single flight launched from Longyearbyen, Svalbard during the 2004 season lasted 39 days and was later recovered in Alaska.

Following the success of the 2004 season, ISTAR returned in 2005 with the same support team from the University of Rome LS, ARR and INGV to perform two launches using the TrailBlazer balloons. The launches both were terminated early before there was an opportunity for recovery as overflight of Russian territory had not been received. However, the PEGASO TM package and a magnetometer designed and built by INGV were flown on these balloons. This marked the first scientific experiment flown on a TrailBlazer balloon.

Returning after a successful campaign in Antarctica launching the first LDB experiment from Baia Terra Nova, the ”team” launched the first TrailBlazer balloon from Longyearbyen that completed a circumpolar trajectory (Peterzen et al. 2003, 2005). Again the PEGASO TM platform was used though the 2006 season in both Baia Terra Nova (February 2006) and again in Svalbard. However, investigations into an alternative TM platform has begun with the reasoning being that INGV was not in the business to produce TM platforms. ISTAR and the University of Rome LS (Peterzen / Masi) contacted ELTA in France who had successfully developed a small Iridium based TM system for CNES. This same platform was then ordered from ELTA to be used on future Ultralight LDB campaigns.

Unfortunately the 2007 Svalbard summer and the winter (Arctic SWIFT) campaigns were canceled due unavailability of the ELTA TM systems.

Another milestone for the 2006 Svalbard campaign was the inclusion of a student program whereby a University of Norway - Tromso student mounted a small Gamma Ray experiment onboard the PEGASO platform.

In 2007 ISTAR again requested ASI to buy a balloon that would double the payload capability yet still fall within the range of launch operations using the simple launch spool designed and built by ISTAR and the University of Rome LS.

Using one of the new 32,000 m3 balloons, the DUSTER experiment was launched from Svalbard in 2008 on the 21st of June. The new balloon performed very well and was terminated on the 24th of June 100 kilometers east of Thule Air Base in northern Greenland. The

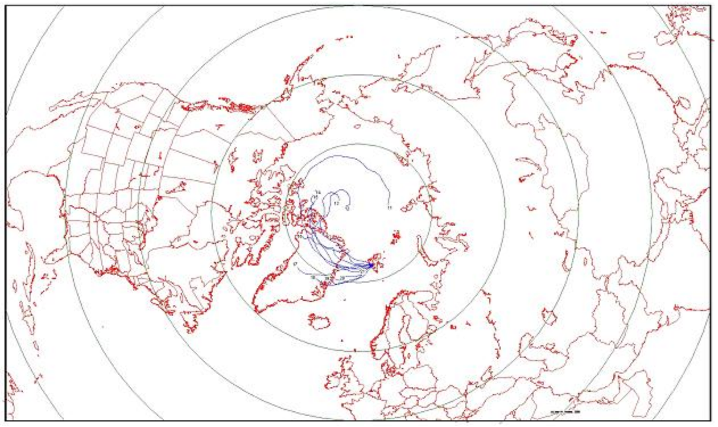

Fig. 5. Flight predictions for the DUSTER experiment. John Hobbie, meteorologist, produced these trajectory predictions. Each line represents a launch prediction at noon Z each day during a 10 day period.

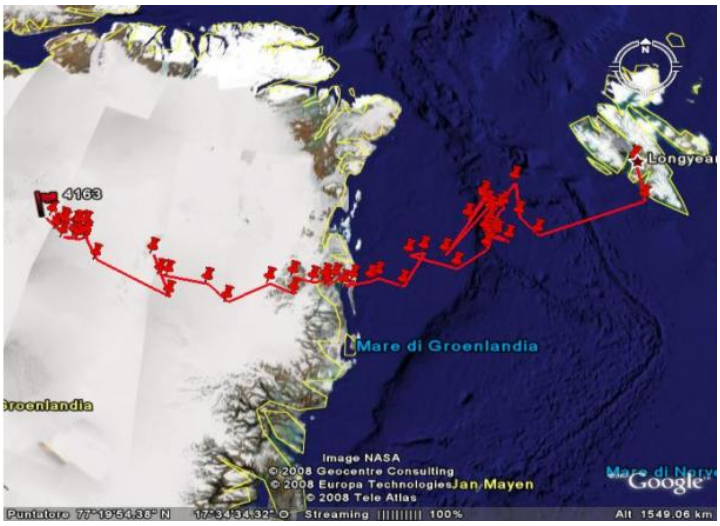

Fig. 6. Trajectory of the DUSTER balloon/payload.

payload was recovered on the 25th of June by Air Greenland helicopters based in Thule.

The 2008 season in Svalbard also worked as a training program for several Norwegian employees of ARR. The ARR team worked very well in their first LDB campaign and are now involved in the readiness of the launch equipment for the heavy lift campaigns for the 2009 season in Longyearbyen. In addition to the heavy lift payloads for 2009 (see e.g. Masi et al. (2005)), ARR will be supporting the 2008/09 winter Arctic SWIFT campaign planned for a late December, early January launch from Longyearbyen.

BAIA TERRA NOVA - In February of 2006 the first LDB flight was launched from Baia Terra Nova (BTN). The balloon was a TrailBlazer (9258 m) launched by ISTAR and University of Rome LS (S. Masi). Balloons up to the 32,000 m3 could easily be launched from

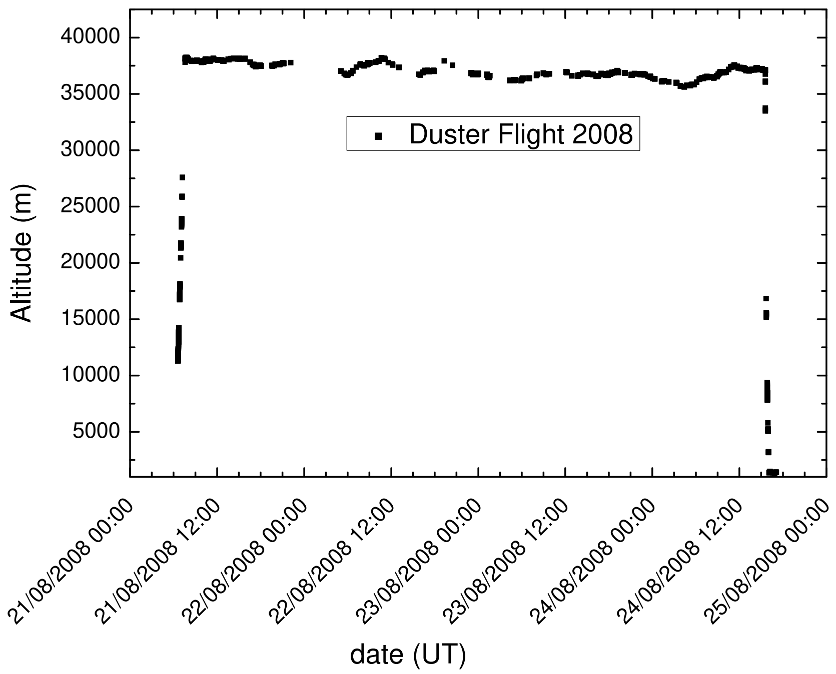

Fig. 7. Time vs. Altitude of DUSTER

BTN, heavy lift payloads may be difficult due to limited launch locations.

TROLL STATION Antarctica - Investigations are on-going into the possibilities of developing a launch facility at the Troll Station (Norway) in Antarctica. The "Blue-Ice" surface near Troll would be ideal for a the development of a launch pad due to such a solid, smooth surface.

MALINDI KENYA - In September of 2008, ISTAR again with the University of Rome LS plans to launch a TrailBlazer balloon from the Luigi Broglio Space Center at 2.99 S 40.196 W to investigate the stratospheric winds in preparation for future balloon campaigns.

3. Summary

With the development of N/A-SBC, the continued possibility of BTN and now the potential of Malindi, Kenya, Italy offers three distinct locations from both polar regions as well as an equatorial location.

The growth and renewed interest in Long Duration Ballooning in Italy is evident with the ASI funded research platforms such as OLIMPO, BOOMERanG, DUSTER and the continued ASI supported development of the LDB facilities.

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