

IGP Aircraft campaign report

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Overall:

- Overall the IGP aircraft campaign was hugely successful. All 70 science hours were flown. All major science targets were hit. The team worked well together. The aircraft worked well and in general the instrumentation worked well.
- There were 17 flights during the IGP, including 2 short test flights, 1 re-position back to Akureyri and 3 days when we did 2 flights on one day with a refuel at Constable Point, Greenland.
- Overall there were 12 days with science flying, spread over about 21 days of possible science flying. The campaign started 1 day late and finished a day or so early when we finished our hours.
- Summing over all the science flights, we flew:
 - 505 minutes in the surface layer (435 minutes in Cold Air Outbreak conditions & 235 mins over or near sea ice)
 - 325 minutes in the boundary layer (140 in CAO, 185 in orographic flows)
 - 11 long BL cross-sections (made up of between 4-11 profiles)
 - with a further 12 short BL cross-sections (2-3 profiles)
- All the flights carried out their sortie briefs as planned, except M300 where the planned low-level work was not viable due to poor visibility.
- Most data on flight 302 were lost due to a disc writing error.
- Three flights were cancelled due to poor working conditions either in the target area or at Akureyri (which was subject to frequent snow showers in the first week or so); note this number of cancellations is usual in weather-focused campaigns and subsequent flights generally made up for them.

Aircraft:

- Generally the Twin Otter performed as expected. The pilots and operations team were great: patient, helpful and ready to do science. The pilots did their absolute best to execute our plans. It was a pleasure to work with the whole aircraft team.
- Flights of the duration necessary for our plans were possible and using Constable Point to refuel worked out well. The use of a hangar for the first 10 days or so seemed to be very useful. We only had to chemically de-ice the aircraft twice I believe.
- We had two pilots for the campaign and I have no doubt that this was a good decision. It enabled us to use Constable Point to refuel on 3 separate occasions; to coordinate with the Research Vessel on 3 occasions; and to execute two fairly complicated orographic flow flight plans.
- Having two pilots also allows more *effective* time on task for two reasons: (i) the second pilot can carry out 'non-critical tasks' such as fuel checks, re-calculations of off-task time and communications; and (ii) they can carry out rolling fuel checks based on actual weather reports. Both of these activities enable efficiencies that amount to more time on task in the target area, e.g. at low-level, perhaps 10-20 minutes per flight.
- However flying with two pilots does limit the number of seats available to mission scientists on the research flights. This is a concern for two reasons: (i) it limits training opportunities and the ability to gain experience of aircraft-based research; and (ii) it means not having a mission scientist in the cockpit. A scientist up front is particularly useful on flights over sea ice or when there are in-flight decisions to be made, so this did present a challenge, but one we tried to work around.
- Note these seating limitations are inherent to the Twin Otter (there is no mission scientist jump seat in the cockpit). So if two pilots are required by the flight plan and/or safety concerns, then that is the situation.

The customs problem:

- The success of the aircraft campaign was endangered by the MASIN instruments being stuck in customs in Chile on their way back from the Antarctic during January and February 2018.
- This is not the place to go into the details of what went wrong, but it goes without saying that this was a very stressful and time-consuming episode for everyone concerned. A lot of people at BAS and at the UK embassy ended up becoming involved and we are extremely grateful for their efforts. I am assuming that lessons are being learned.
- A project like the IGP with a coordinated field campaign and international multi-agency funding and participants cannot be re-scheduled. Consequently these sort of logistics problems could be fatal for such projects.

MASIN Instruments:

- The MASIN instrument fit generally functioned well, but we did have a few issues, as listed below.
- On 292: The turbulence probe was iced up on the first science flight, meaning no high-frequency winds.
- On 293 & 294: the front-facing video camera did not record after about 90 minutes.
- On 297: The slow temperature sensor didn't work after the first 90 minutes or so of the flight. Note this also affected the onboard display of many variables. The fast response T and humicap T were ok though.
- On 302: unfortunately almost all MASIN data seems to have been lost on flight 302, due to some sort of file writing error. Clearly this is disappointing, but at least it was an Akureyri-CP flight so relatively short. The CAPS probe is recorded separately and that data is ok, so it could be useable as GPS/IMU data are available to geo-locate.
- The thin wire on the BAT probe often seemed to go, but the thicker wire was ok, meaning high-frequency temperatures were always measured.

Forecasts and flight planning:

- By the time the aircraft campaign started, the forecast products provided by our Project Partners (the Met Office and the Icelandic Met Office) were working well and were easily available via websites or ftp sites. But it took about 6 weeks to reach this point. The 3 week lead in to the Research Vessel's leg 1 was insufficient to sort out technical problems associated with transferring data and providing suitable charts. We were working with new forecast products (Harmonie IGB; MetUM 2.2 for IGP domain), new plotting domains and in the case of the Met Office a relatively new set of plotting software and troubleshooting problems took time. By the start of the aircraft campaign all problems had been sorted out, which is to the great credit of our project partners.
- The cold-air outbreak (and surface sensible heat flux) probability maps were really helpful for medium-term flight planning and also for coordinating with the ship. These were based on the ECMWF ensemble predictions system and set up by Lukas Papritz and Harald Sodemann (UiB).
- The scripts set up by the UEA team to transfer charts to the ftp site (and then on to the Research Vessel), to email charts, and to convert graphics files into kml files all worked well.
- Flight planning generally worked well. At the start we had a sizeable team doing flight planning (6-8 people) which was useful and allowed us to write sortie briefs that were of high quality. It also meant flight planning was not impacted by people being absent on a flight.
- My impression was everyone was 'busy and content' even at the start of the campaign when we had a lot of people in attendance (up to about 10 at one point). There was a lot to do, partly because we were also coordinating with the research vessel and this took time.
- The ability to flight plan over the top of our forecast products was really valuable. People used either Google Earth (with charts converted to kml files); or Matlab code that Andy had written. Both seemed to work well. Sea-ice fields as kml were useful for planning too.
- In terms of aircraft operations the critical diagnostics were 'cloud base height', 'cloud amount' and 'precipitation', while geo-referenced tiffs from NEODAAS were also critical for go/no go decisions on the morning of flights.

Logistics:

- Overall Akureyri was a good operations base. The airport is very close to the town. The airport staff (Isavia) were really helpful. Renting apartments was a good decision and worked well. However the weather was challenging in the first week or so and did lead to a couple of cancelled flights and one use of the alternate in Reykjavik.
- The hire of a room at the University for flight planning, etc, was absolutely the right decision and worth the cost (£1500 for 4 weeks). Bringing a few computers monitors was a good decision, similarly power bars, cables, etc. With hindsight we should have brought more than one printer.
- Overall we had 20 people taking part in the campaign. The BAS team were 2 pilots, operations manager, mechanic, instrument engineer and 2 mission scientists, one of whom was on every flight as task specialist. The other 13 people were mission scientists, flight planners and wise heads; 2 did the whole campaign and the others covered a week or two (see Table in appendix). Overall I think we had about the right amount of people, but a couple did miss out on a flight.
- Putting together the IGP flight campaign booklet was worth while.

Coordination with the R/V Alliance:

- Coordination with the R/V Alliance generally worked well. Emails at least daily between the aircraft and ship's teams kept each abreast of the others' plans and allowed careful planning of some coordinated activities.
- We carried out 3 research flights in the vicinity of the ship, and from these we will be able to compare atmospheric observations, provide spatial context to the ship's observations and coordinate sets of coupled atmosphere-ocean observations.
- In another couple of flights the ship was upstream and acted as an upstream sounding station.

IGP flight campaign summary

Date	Flt. No.	Flight time	Mission Scientists	Science aims	Location and flight pattern	Radiosondes
Tue 27/2/18	290 291	2 h 30 (2.5 h)	Russ, Tom Russ, Alex	Test flights	A-A, N of Iceland, including low level legs	12, 18, 21 UTC
Wed 08 UTC 28/2/18	292	4h 10 (6.7h)	Andy, Tom, Denis	CAO development	A-A, 66.5-69.5 N Sawtooth and limited low-level	00, 03, 06, 09, 12, 15, 18, 21
Thur 1/3/18	293 294	3h 35 5h 7 (15.3h)	Ian, Tom,	CAO, fluxes & ship coord.	A-CP-A, 67-70N Sawtooth, 2 BL stacks & low-level near the ship	00, 03, 06, 09, 12, 15, 18, 21
2/3/18					<i>A-A – cancelled</i>	00, 06, 09, 12, 15,
3/3/18					<i>rest</i>	00, 12
Sun 4/3/18	295	6 h (21.3h)	Annick, Alex	CAO, fluxes & ship coord.	A-Rey – BL stack & sawtooth near the ship	00, 06, 09, 12, 15, 18
Mon 5/3/18	296	1 h (22.3h)	Annick, Alex		Rey-A - Transit	06, 09, 12, 18
Tue 6/3/18	297	5 h 40 (28.0h)	Andy, Alex	CAO, fluxes & ship coord.	A-A – BL stack & sawtooth near the ship	00, 06, 09, 12, 15, 18
7/3/18					<i>A-A – cancelled</i>	00, 06, 12, 18
Thu 8/3/18	298 299	3h 30 6h (37.5 h)	Lukas, Tom	Sea-ice fluxes and dynamics	A-CP-A – low-level across MIZ & jet, then parallel to Greenland coast	00 (Akureyri)
Fri 9/3/18	300	4h 45 (43 h)	Denis, Kjersti, Alex	Sea-ice fluxes	A-A – sawtooths across MIZ (<i>low-levels not viable</i>)	(Akureyri)
10/3/18				<i>Sea-ice fluxes</i>	<i>A-A – cancelled; low cloud</i>	00, 06, 12
11/3/18					<i>Rest day</i>	12
Mon 12/3/18	301	6h 10 (49.1 h)	Ian, Tom	Lee side fluxes, waves & wakes	A-A – legs on ridge and on leeside (stack) across and along wind + profile	00, 12
13/3/18					<i>No flight</i>	0, 12
Wed 14/3/18	302 303	3h 5h 40 (57:50)	Andy, Alex	Fluxes over the MIZ	A-CP-A – 500-1000 ft across MIZ at 69-70N; 4 legs at 100 ft across MIZ	0, 12
15/3/18					<i>No flight</i>	0, 12
Fri 16/3/18	304	1h 45 (59:35)	Alexandra Kent, Tom	Husavik box pattern	A-A – racetrack 4000 to 1000 ft & missed approach	0, 12, 15, 18, 21
17/3/18					<i>No flight</i>	00, 03, 06, 09, 12, 15, 18
Sun 18/3/18	305	6 h 05 (65:40)	Kent, Alex	Buoy and leg across CAO	A-A – low-level across CAO at MSA, past the buoy & downstream of ship	00, 06, 09, 12, 15, 18
Mon 19/3/18	306	4 h 30 (70:10)	Andy, Tom	Lee side fluxes during foehn	A-A – leg & sawtooth on ridge; legs downstream across and along wind & a cross-wind sawtooth	00, 12

IGP flight details

Date	Flt. No.	Flight time	Science aims	Sawtooth BL cross-sections	SL flux legs (mins)	BL flux legs (mins)
Tue 27/2/18	290 291	2 h 30 (2.5 h)	Test flights			
Wed 08 UTC 28/2/18	292	4h 10 (6.7h)	CAO development	4x3 profiles 2x2 profiles	(20)	
Thur 1/3/18	293 294	3h 35 5h 7 (15.3h)	CAO, fluxes & ship coord.	1x8 profile 1x4 profile	30 30	60
2/3/18						
3/3/18						
Sun 4/3/18	295	6 h (21.3h)	CAO, fluxes & ship coord.	2x2 profile	20	40
Mon 5/3/18	296	1 h (22.3h)				
Tue 6/3/18	297	5 h 40 (28.0h)	CAO, fluxes & ship coord.	1x8 profile 1x2 profile	20	40
7/3/18						
Thu 8/3/18	298 299	3h 30 6h (37.5 h)	Sea-ice fluxes and dynamics	3x6 profile	45 90	
Fri 9/3/18	300	4h 45 (43 h)	Sea-ice fluxes	1x6 profile 2x2-3 profile		
10/3/18			<i>Sea-ice fluxes</i>			
11/3/18						
Mon 12/3/18	301	6h 10 (49.1 h)	Lee side fluxes, waves & wakes		50	85
13/3/18						
Wed 14/3/18	302 303	3h 5h 40 (57:50)	Fluxes over the MIZ	1x11 profile	100	
15/3/18						
Fri 16/3/18	304	1h 45 (59:35)	Husavik box pattern			
17/3/18						
Sun 18/3/18	305	6 h 05 (65:40)	Buoy and leg across CAO	1x2 profile 1x4 profile	80	
Mon 19/3/18	306	4 h 30 (70:10)	Lee side fluxes during foehn	1x6 profile 1x4 profile	20	100
TOTAL	17	70:10		11 long cross-sections 12 short cross-sections	505	325

Note: SL flux legs were minimum safe altitude (over the ocean) so 50-150 ft; the BL flux legs are those below 5000 ft, but excluding the SL legs.

IGP aircraft campaign participants

Name	Institution	Campaign role	arrival	depart
Ian Renfrew	UEA	Co-lead + planning + ship liaison	23-Feb	22-Mar
Andy Elvidge	UEA	Planning + MO Forecasts	23-Feb	22-Mar
Tom Lachlan-Cope	BAS	Co-lead, planning, task specialist	22-Feb	22-Mar
Alex Weiss	BAS	CoI, planning, task specialist	22-Feb	22-Mar
Russ Ladkin	BAS	Instrument Scientist	22-Feb	22-Mar
Vicky Auld	BAS	Pilot	22-Feb	22-Mar
Jon Bowland	BAS	Lead Pilot	22-Feb	22-Mar
Steve Patterson	BAS	Mechanic	22-Feb	22-Mar
Daniel Beeden	BAS	Operations manager	22-Feb	16-Mar
Annick Terpstra	UEA/Bergen	Ship liaison + planning	25-Feb	13-Mar
Denis Sergeev	UEA	planning, data analysis	25-Feb	12-Mar
Kent Moore	Toronto	PP + Planning	15-Mar	20-Mar
Nina Petersen	IMO	IMO Forecast, local advice	03-Mar	06-Mar
Haraldur Olafsson	IMO	Local advice, orographic flows	03-Mar	06-Mar
Lukas Papritz	Bergen	Planning + ECMWF EPS	25-Feb	13-Mar
Harald Sodemann	Bergen	Isotope PP	23-Feb	09-Mar
Alexandra Touzeau	Bergen	Isotope Scientist	07-Mar	23-Mar
Heidi Golid	Bergen	MSc student - isotopes	07-Mar	14-Mar
Thomas Spengler	Bergen	PP + Planning	23-Feb	04-Mar
Kjersti Konstali	Bergen	MSc student - dynamics	28-Feb	14-Mar