EUREC4A/ATOMIC flight planning

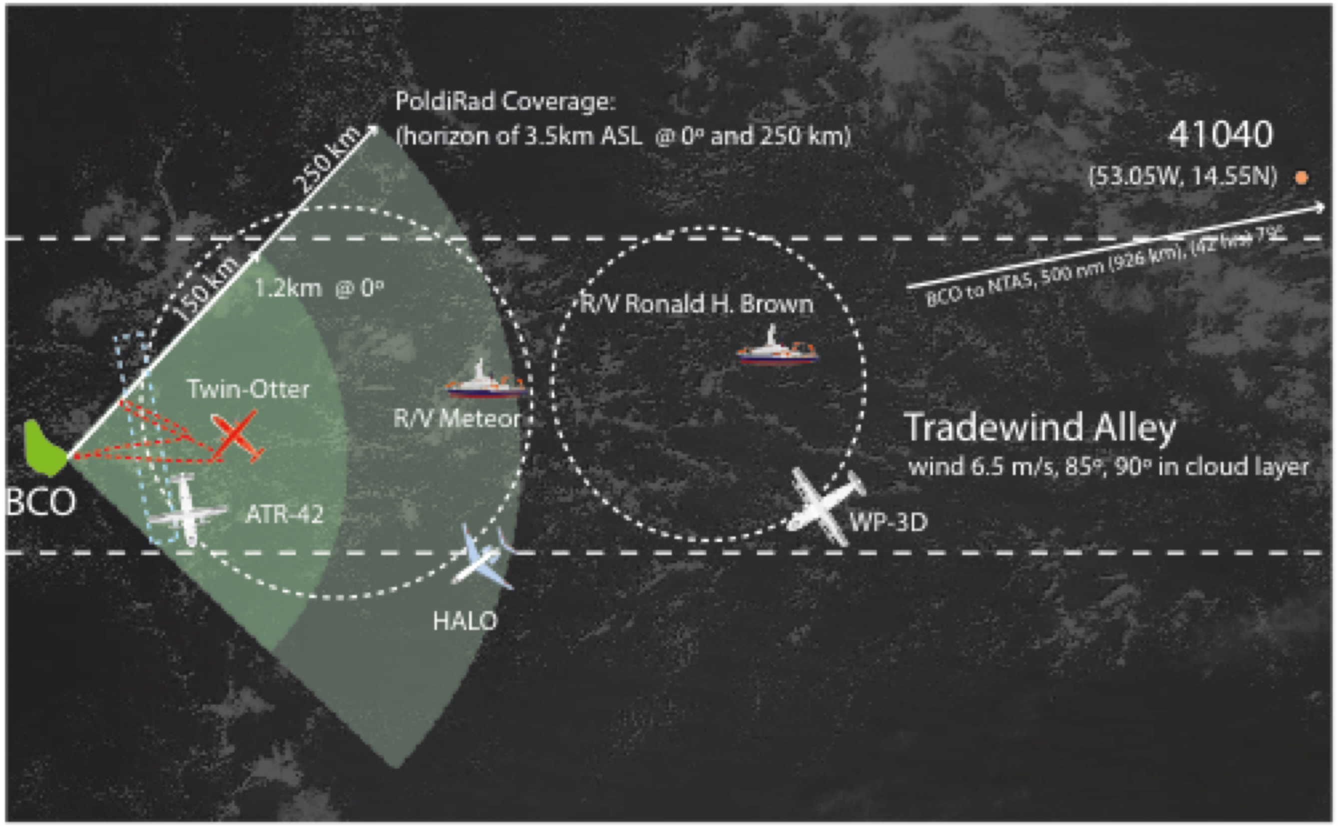
The flight planning group

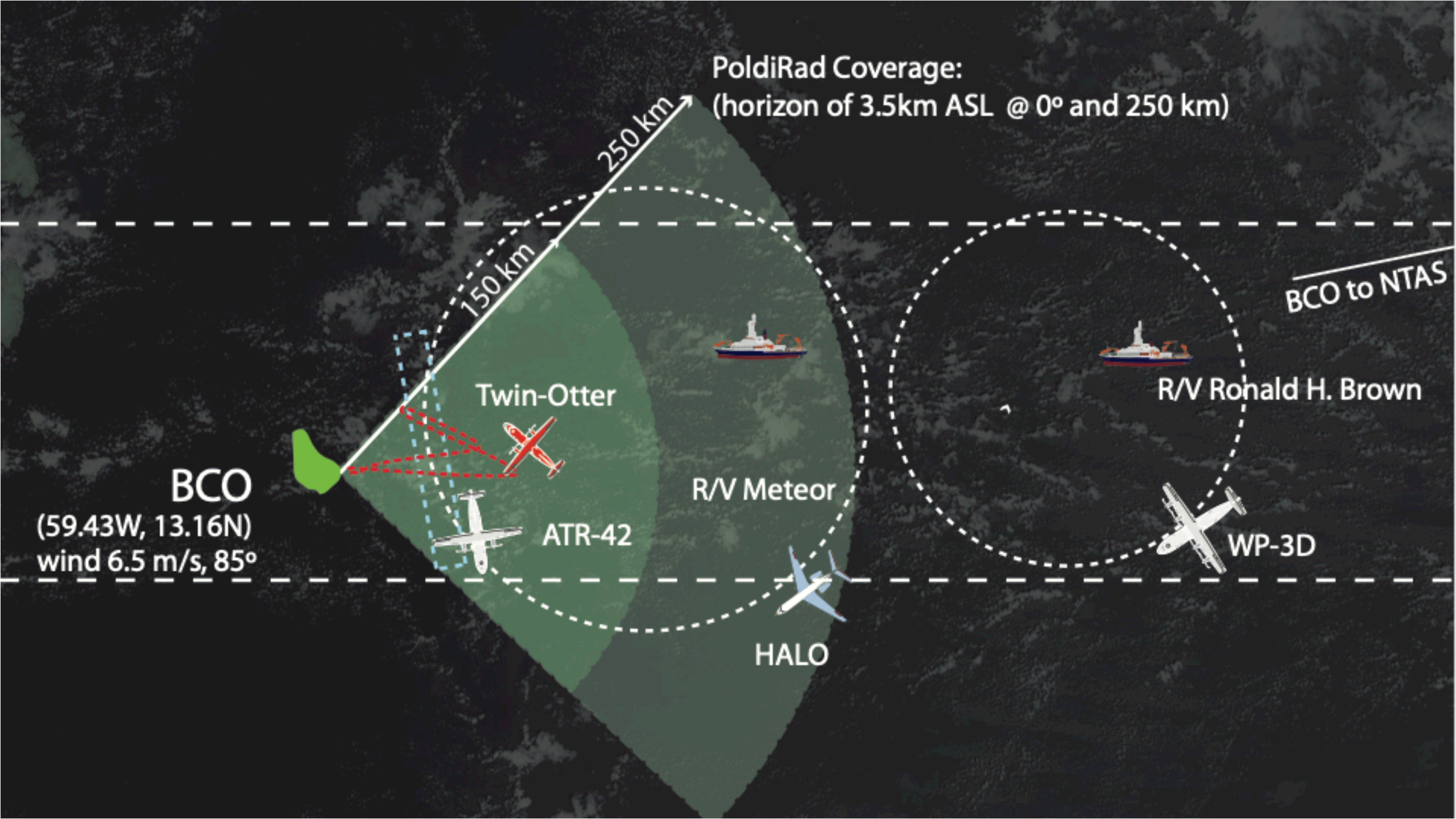
1. Flight planning

Things to discuss
- Flight schedules (early, daytime, late flights)
- Which aircraft can/will do which schedule
- Coordinated aircraft pattern, e.g., super curtain, overflights with other platforms.
- Flight plans (pattern, duration, flight level)
- Forecast products (if any?) for planning.
- Need for a big (3x) circle?

Things we cannot yet discuss
- Flight days
- Night flights
- Operation areas

Desired outcome
- Detailed flight plans (modulo unknowables)
- Understanding of benefits of coincidence
- Calibration needs




PoldiRad Coverage:
(horizon of 3.5km ASL @ 0º and 250 km)
250 km
150 km
BCO to NTAS
Twin-Otter
R/V Ronald H. Brown
BCO
(59.43W, 13.16N)
wind 6.5 m/s, 85º
R/V Meteor
ATR-42
WP-3D
HALO

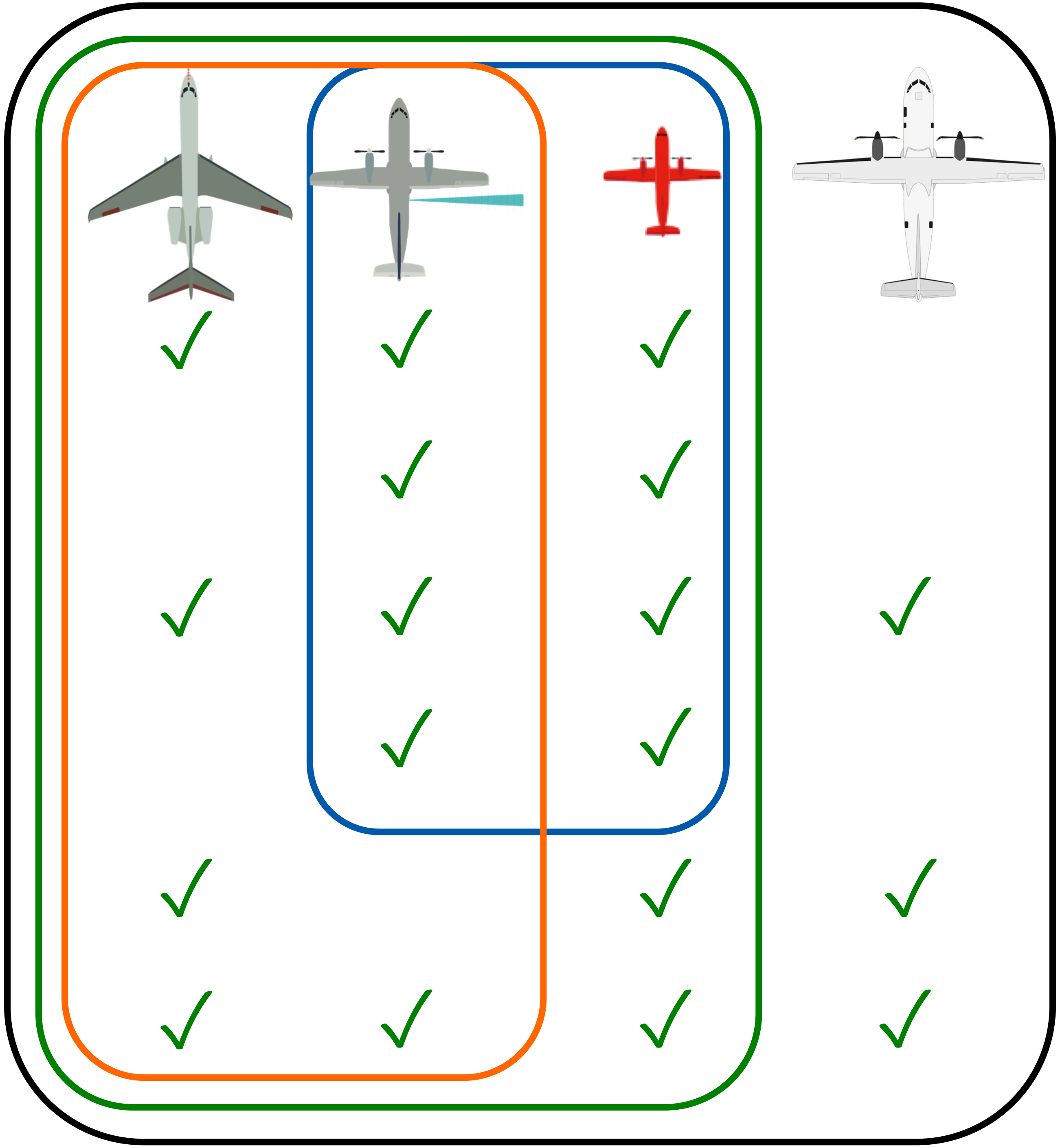
Scientific Objectives

Benefits of coincidence

Scientific Objectives

Benefits of coincidence

- **Mass flux (cloud base to detrainment)**
  → "Common area" for HALO/ATR/TO (HAT)
- **Boundary layer turbulence**
  → ATR/TO same track, different levels
- **Diurnal cycle (statistics)**
  → Shifted HAT schedules + W-P3 night flights
- **Warm rain processes**
  → TO at different levels, coordinated with ATR radar/lidar (following or offset)
- **Mesoscale organization / Cold pools**
  → Leg along BCO-NTAS / super-curtain
- **Calibration / Validation**
  → "Super curtain" after take-off



Instrument Needs

Calibration and Validation

- **Validate VELOX SST (HALO and SHIPS)**
  - Fly straight legs (5-10 min) at different altitudes over same position to test influence of atmosphere between instrument and sea surface (once)
  - Collocate with sea surface measurements from buoy and/or ships
- **Calibrate SMART, Velox and BARCARDI (HALO)**
  - Radiation rectangle with clear sky above (once)
  - Boresight calibration (once)
- **Cloud radar calibration and sensitivity intercomparison (ALL)**
  - Calibration roll maneuvers (end of each flight)
  - Circle with known sea level wind speed e.g. bouy or W-P3D (once)
  - Overflights with HALO/ATR over shipborne cloud radars (during super-curtains / HALO excursions)
- **Insitu - Insitu intercomparisons (during super-curtains after take-off) (ATR/TO)**

Scientific Objectives

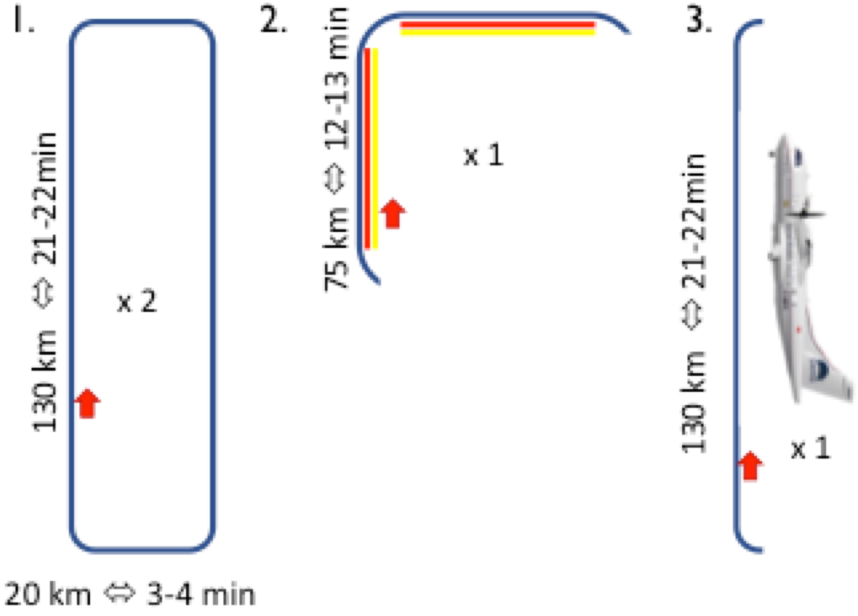
HALO specific

No.	aim	how?	who?
1	Provide context; how representative are the circles at their location; spatial variability of water vapor in free troposphere	Long legs (e.g. upstream), over moisture gradients to buoy and/or ships	WALES
2	Daylight measurements (for visible instruments)	Fly as much during daylight as possible	SpecMacs
3	Testing retrievals of SpecMacs	ATR HALO collocation with ATR in HALO's shadow	SpecMacs
4	Characterization of the large scale cloud structure (cloud fraction, cloud size distribution, degree of clustering) with respect to VELOX, specMACS, HAMP	MODIS and AVHRR collocation in the afternoon	SMART/Velox/ HAMP
5	Validation of SST measurements	Flying at different altitudes to test influence of atmosphere between instrument and sea surface; Collocated sea surface measurements from buoy and/or ships	Velox
6	Calibrate SMART and Velox	Fly calibration pattern	SMART/Velox
7	Assessment of satellite derived LWP and rain	GPM underflights	HAMP
8	Instrument assessment	Comparison flight with P3; comparison with ship measurements	
9	Development of rain from shallow convection	Check for precipitating clouds; adjust flight pattern if needed; gradient legs	HAMP
10	Radar comparison (HAMP, BCO, Poldirad, Ships)	BCO overpasses (possibly best before landing)	HAMP/Poldirad
		Flying above cirrus that is upstream of BCO	HAMP/Ships
11	Testing BACARDI	Flying above below and through cirrus	BACARDI
12	Representativeness of different cloud masks from airborne and spaceborne instruments	All flight pattern ok, access to satellite images	SMART
13	Water vapor distribution between clouds	Low approach (ca. 5 km for 15-20 min) to Barbados	WALES

Flight plans

Platform priorities (recap)

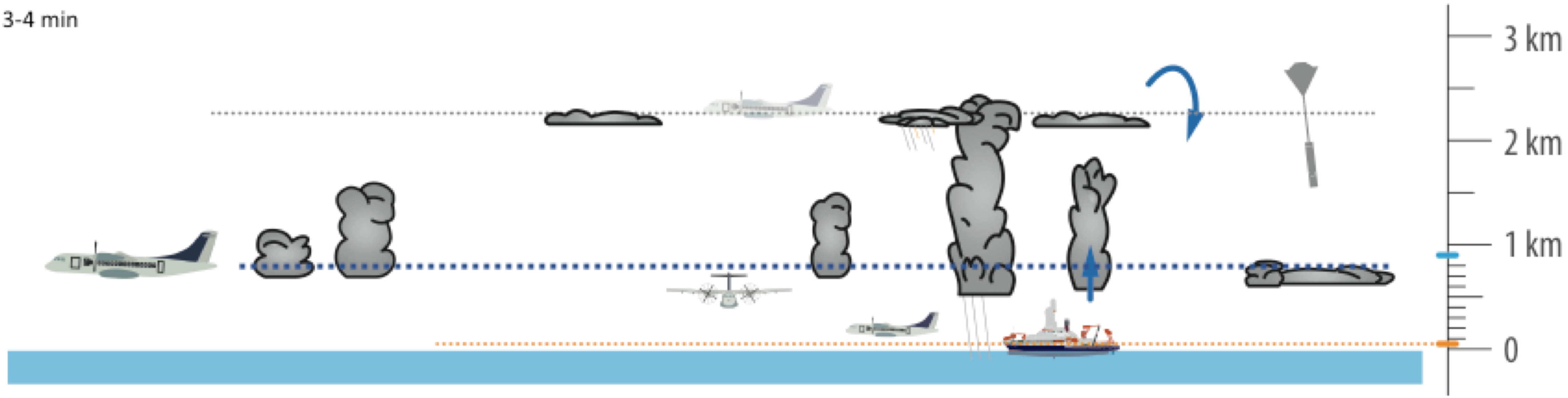
ATR-42 flight plans



1. **Cloud base rectangles just above cloud base — how to determine this flight level?**
2. **Wind parallel and perpendicular legs at 350 (FL11) m and 500 m (FL16) in sub-cloud layer**
3. Stratiform cloud layer legs at 2.5 km (FL82) with possible roll

Notes:

- Two (4.5 hr) flights per day
- Top-down patterns to minimize sea-spray influence on sensors
- Horizontal lidar and radar remote sensing for cloud-base cloud amount



Twin-Otter flight plans

1. Detrainment layer

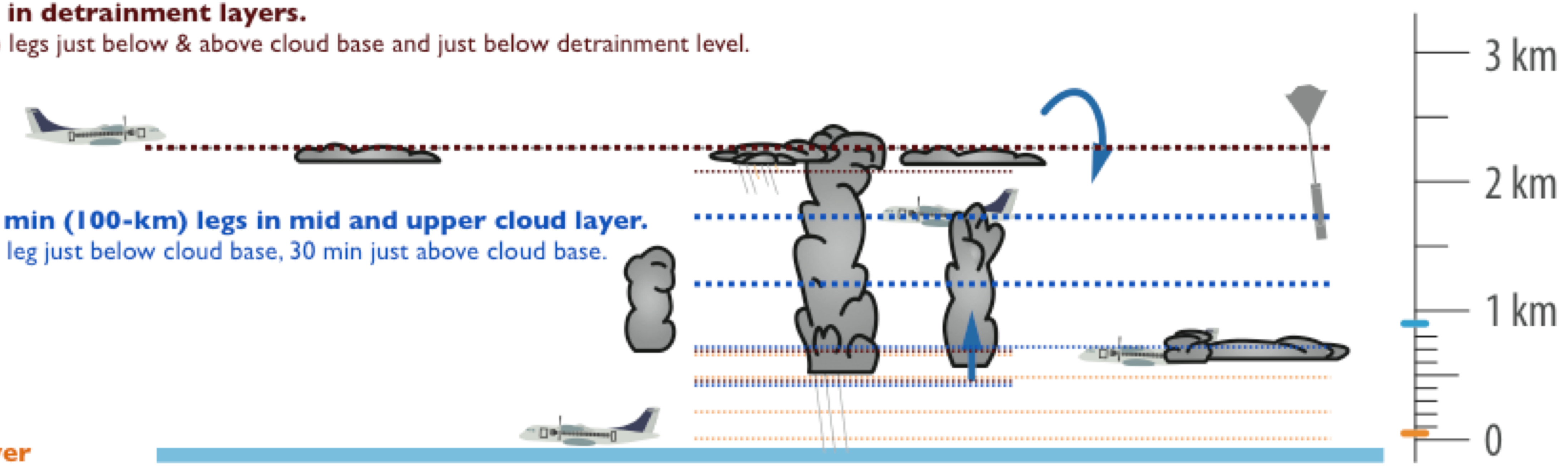
a. 150 min legs in detrainment layers.

b. 15 min (50-km) legs just below & above cloud base and just below detrainment level.

2. Cloud layer

a. repeated 30 min (100-km) legs in mid and upper cloud layer.

a. 15 min (50-km) leg just below cloud base, 30 min just above cloud base.



3. Sub-cloud layer

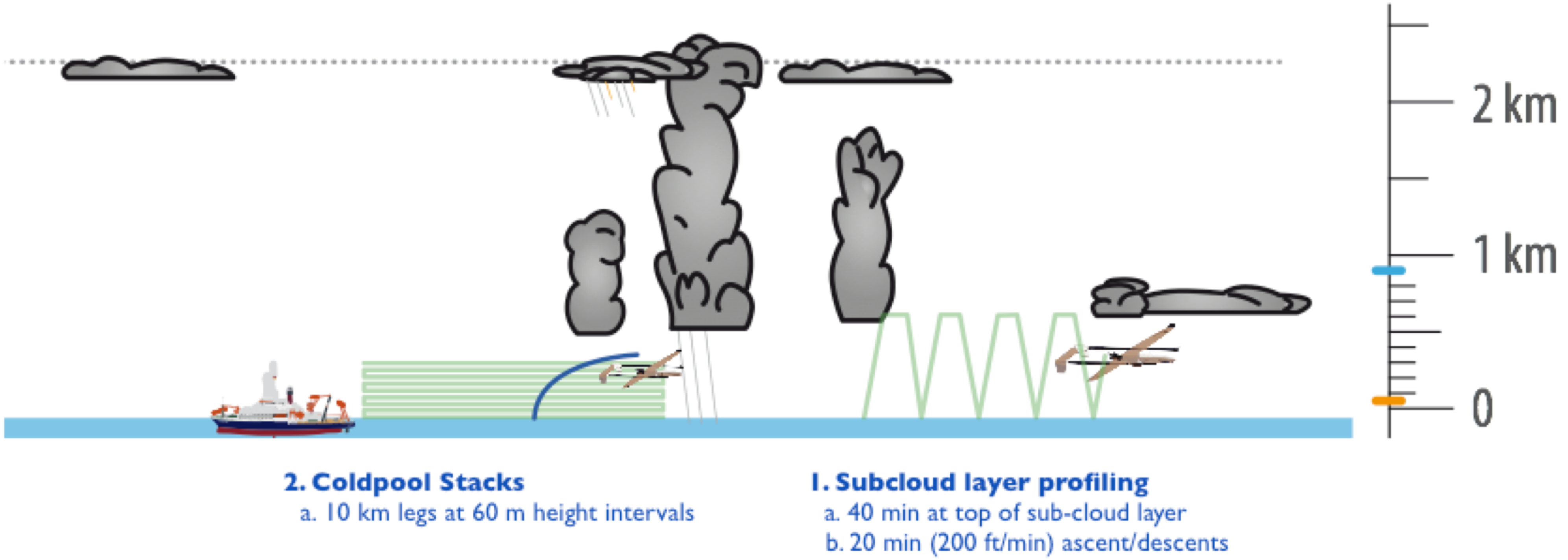
a. 15 min (50-km) leg just above cloud base.

b. 30 min (100-km) legs just above cloud base, at lowest safe flight level and midway through the sub cloud layer.

Notes:

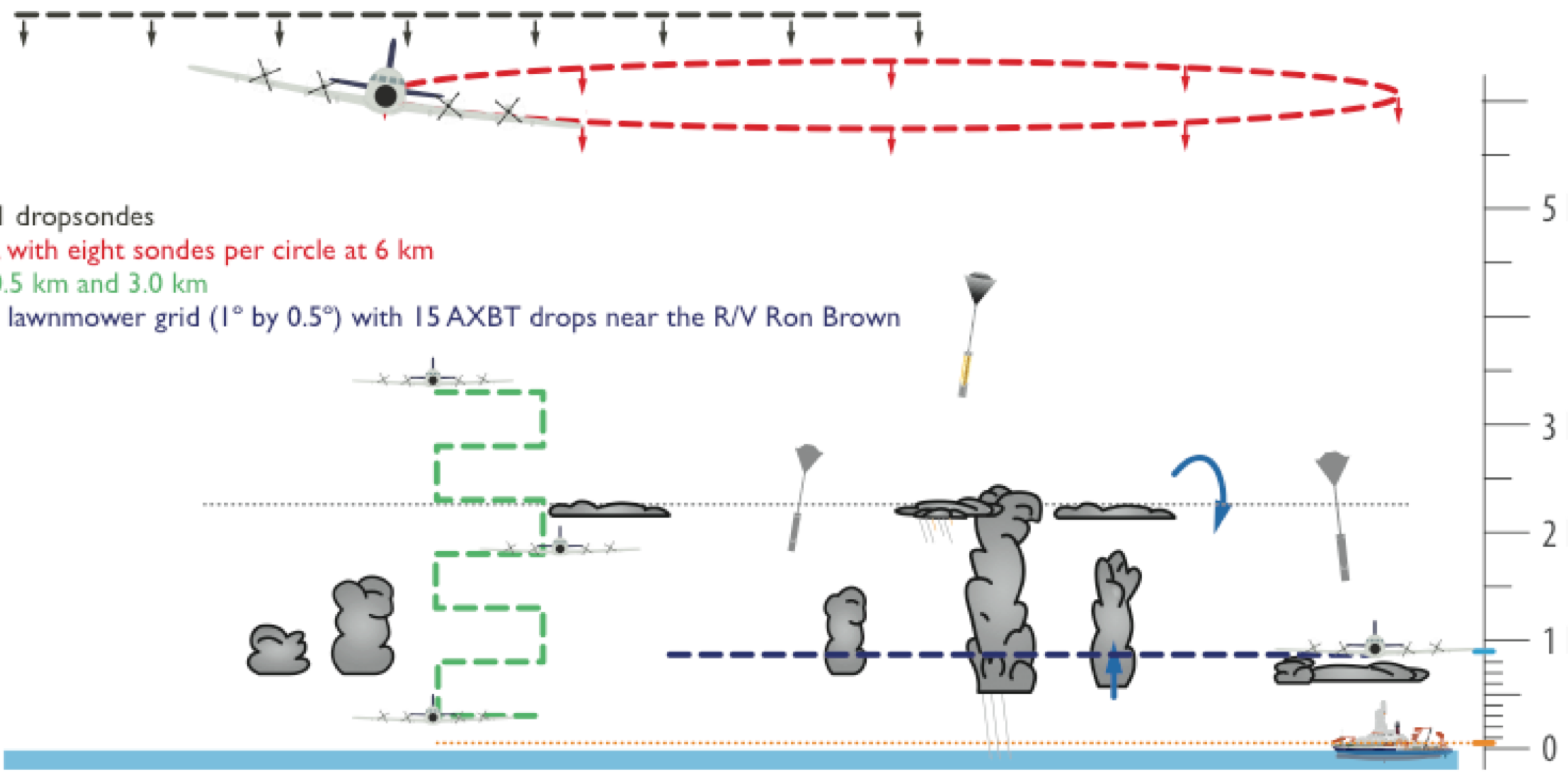
- Each flight concentrates on one pattern, with two (3 and 4hr) flights a day.
- Most flights will use the ferry to target to make a sounding.
- All patterns provide cloud base sampling.
- Most patterns will try to optimize cloud penetrations while maintaining rough course (non-random sampling).

BOREAL flight plans (or other drones)



- L-shape curtain with 50 km legs on each side at four altitudes (40, 80, 200, 500 m.asl) to focus on structure of sub-cloud layer.
- Profile to 2500m.asl, curtain flight with 75 km legs perpendicular to wind at 5 or 6 altitudes for cold pool characterization.

WP-3D flight plans

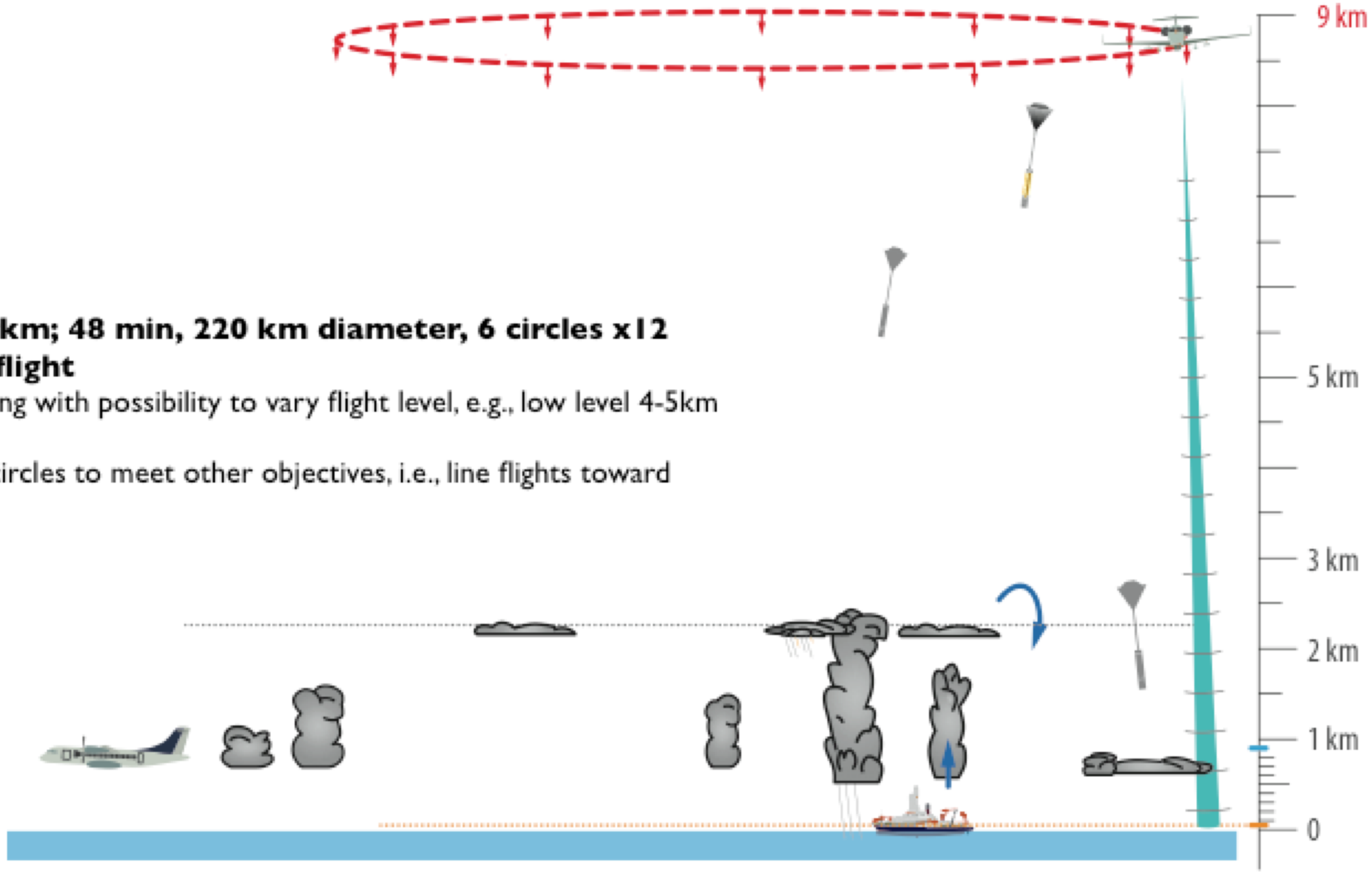


- Long ferries at 6 km with 11 dropsondes
- Two 1.5° circles, and ferries, with eight sondes per circle at 6 km
- Stepped profiling between 0.5 km and 3.0 km
- Long cloud based legs along lawnmower grid (1° by 0.5°) with 15 AXBT drops near the R/V Ron Brown

Notes:

- WP-3D may fly night flights
- Intends to combine all patterns in each flight
- Orientation of lawnmower patterns open, as is range of stepped profiles

HALO flight plans



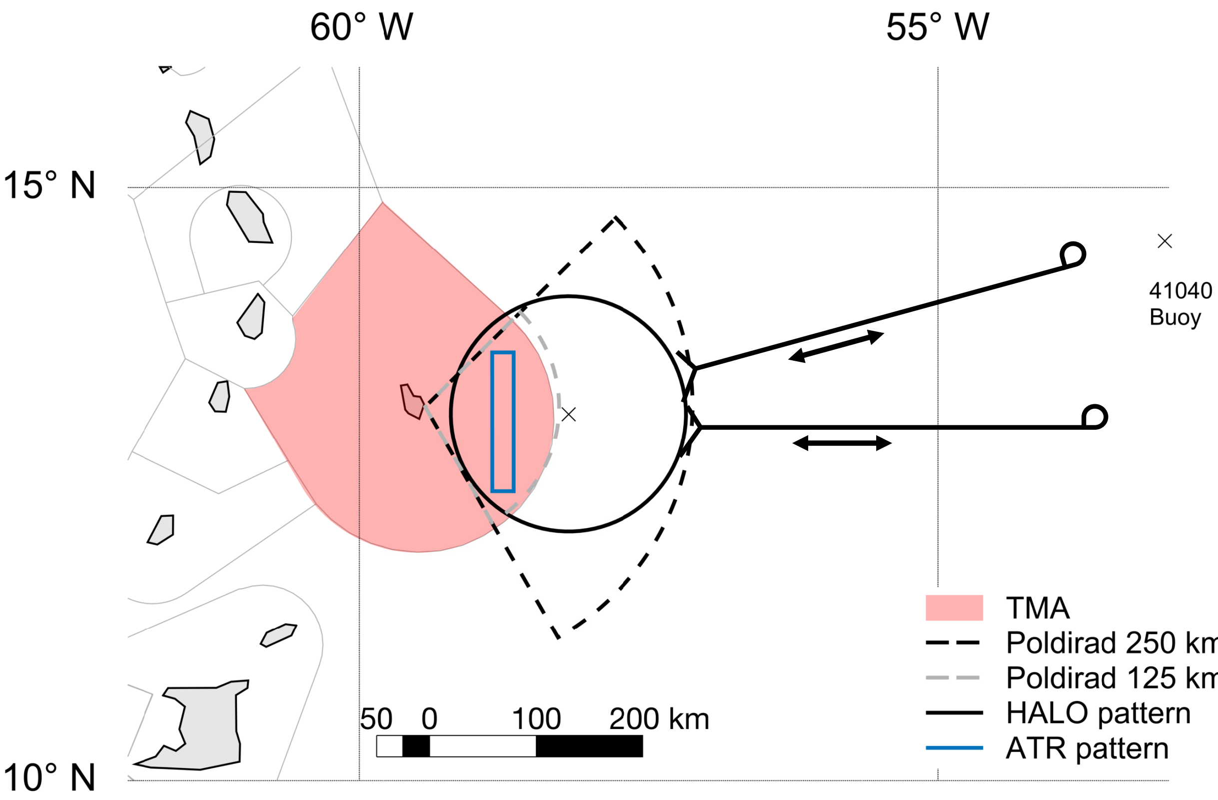
- **Circles, presently planned for 9km; 48 min, 220 km diameter, 6 circles x12 sondes, yielding 72 sondes per flight**
- Two additional circles for remote sensing with possibility to vary flight level, e.g., low level 4-5km circle for better radar/lidar sensitivity
- Possible substitution of non-sounding circles to meet other objectives, i.e., line flights toward buoy or satellite overpass.

Notes:

- For a wind-speed of 8 m/s, in 8 h the air moves across the diameter of a circle (230 km)
- Area of a 110 km radius circle 38 000 km2; 8 circles with a 7 km field of view map out the same area. Hence HALO's downward looking imagers can map out the area of a circle in the course of a flight.

HALO flight plans

- **Circles** at 9 km, 48 min, 110 km radius, 6 circles x 12 sondes simultaneously with flights of ATR and Twin Otter
- **Excursion** during refueling: long leg along Tradewind Alley
    - Provide context for circles (wind shear)
    - Aerosol layers transported from Africa
    - Predictable for ships for intercomparison
    - Dropsondes
- **Approach to TBPB**: at around 5 km for approximately 20 minutes for high resolution radar/lidar measurements
- Some **BCO overpasses** upon return
- **Calibration** patterns for SMART, VELOX, HAMP (once in beginning of campaign)



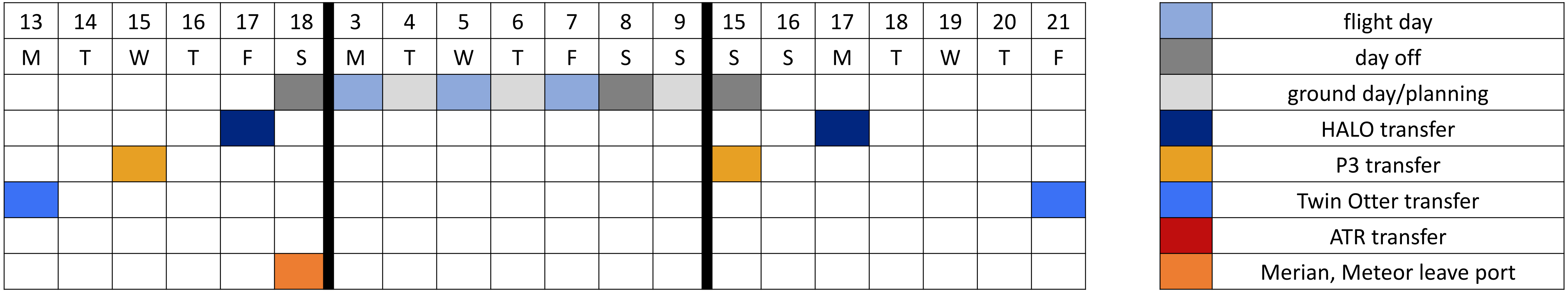
Flight schedules

Temporal coordination

Flights schedules

Temporal coordination

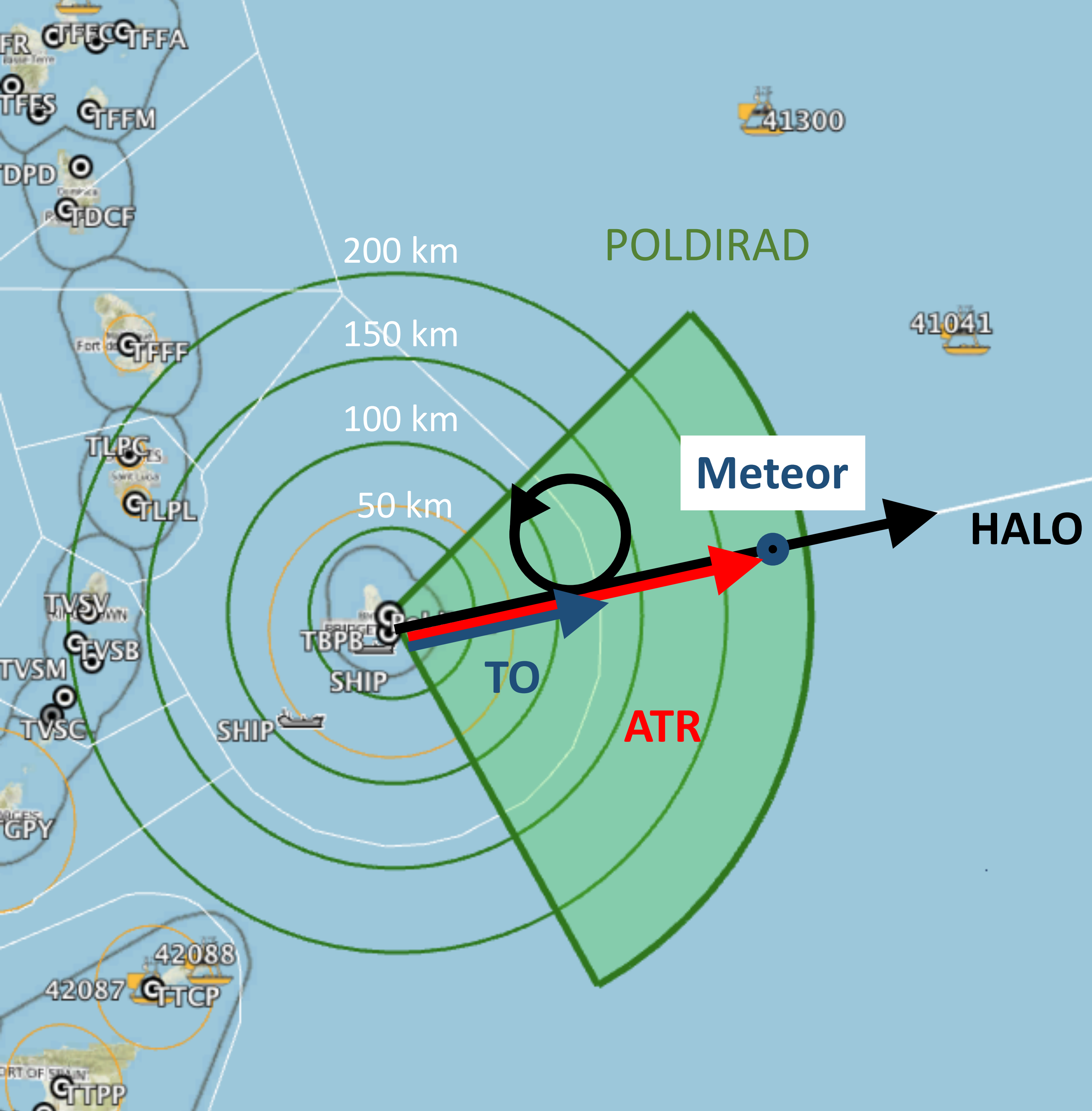
- Three different take-off times for HALO, ATR, Twin Otter:
  - 04, 08, 12 LT
  - Possibly: Mondays 08 LT, Wednesdays 12 LT, Fridays 04 LT (has to be cleared with Barbados airport)
  - Ideally, we could schedule the flights to coincide with satellite overpasses
- TO more focus on daytime flights, but could also do nighttime (but no subcloud layer flights)
- For diurnal cycle measurements it could be interesting to leave earlier than 08 LT (e. g. 06 LT); but it takes time for the aircraft to reach the area and for the instruments to be operational
- W-P3D might do one week of nighttime flights with take-off around 20 LT



Flight patterns

Spatial coordination

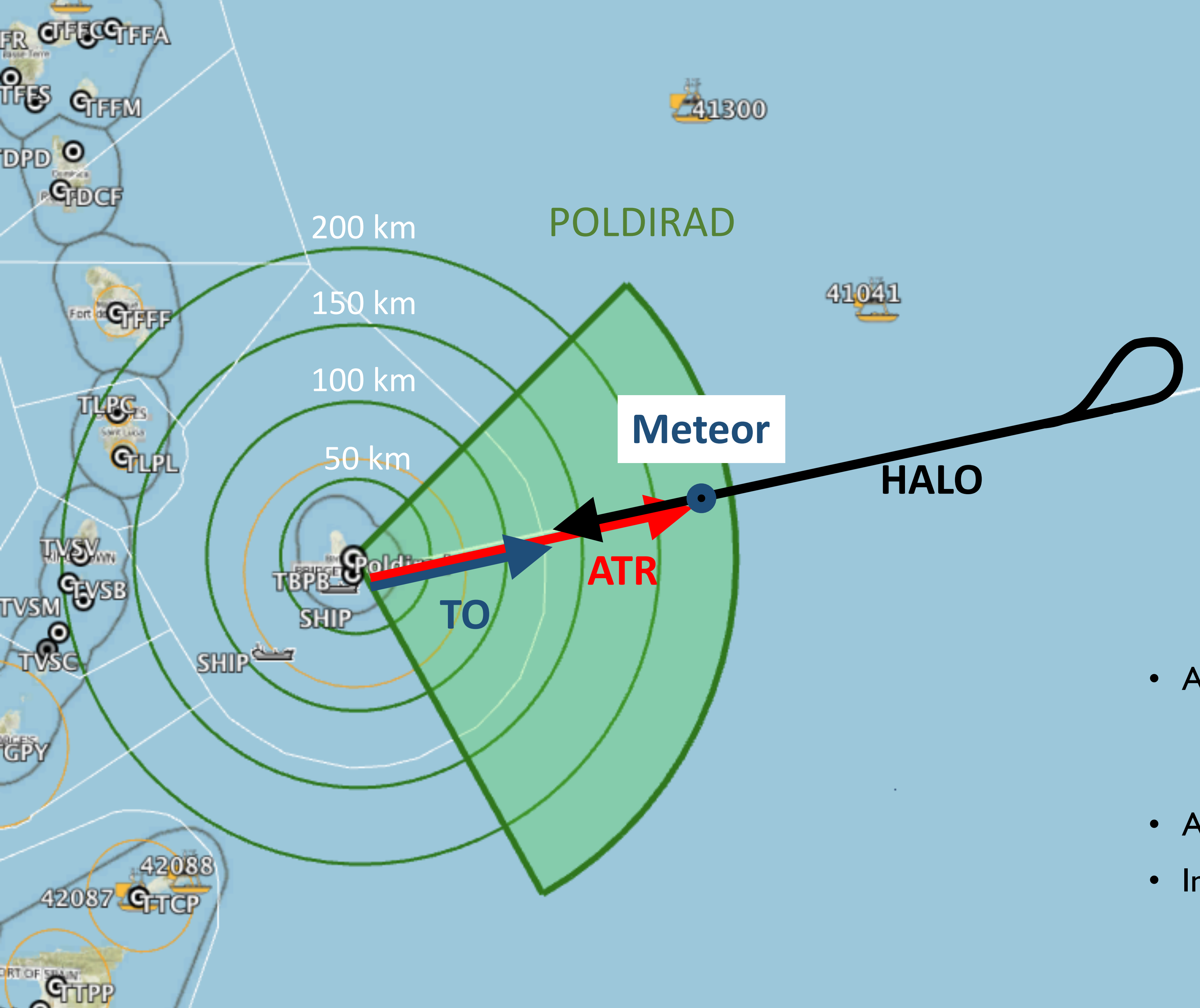
Flight patterns
Spatial coordination



Super Curtain (V1)

- Shortly after take-off (each flight day)
- Along BCO-NTAS to common area
- HALO goes first and gains altitude
- ATR and TO follow to common area
- Including ships if on BCO-NTAS line

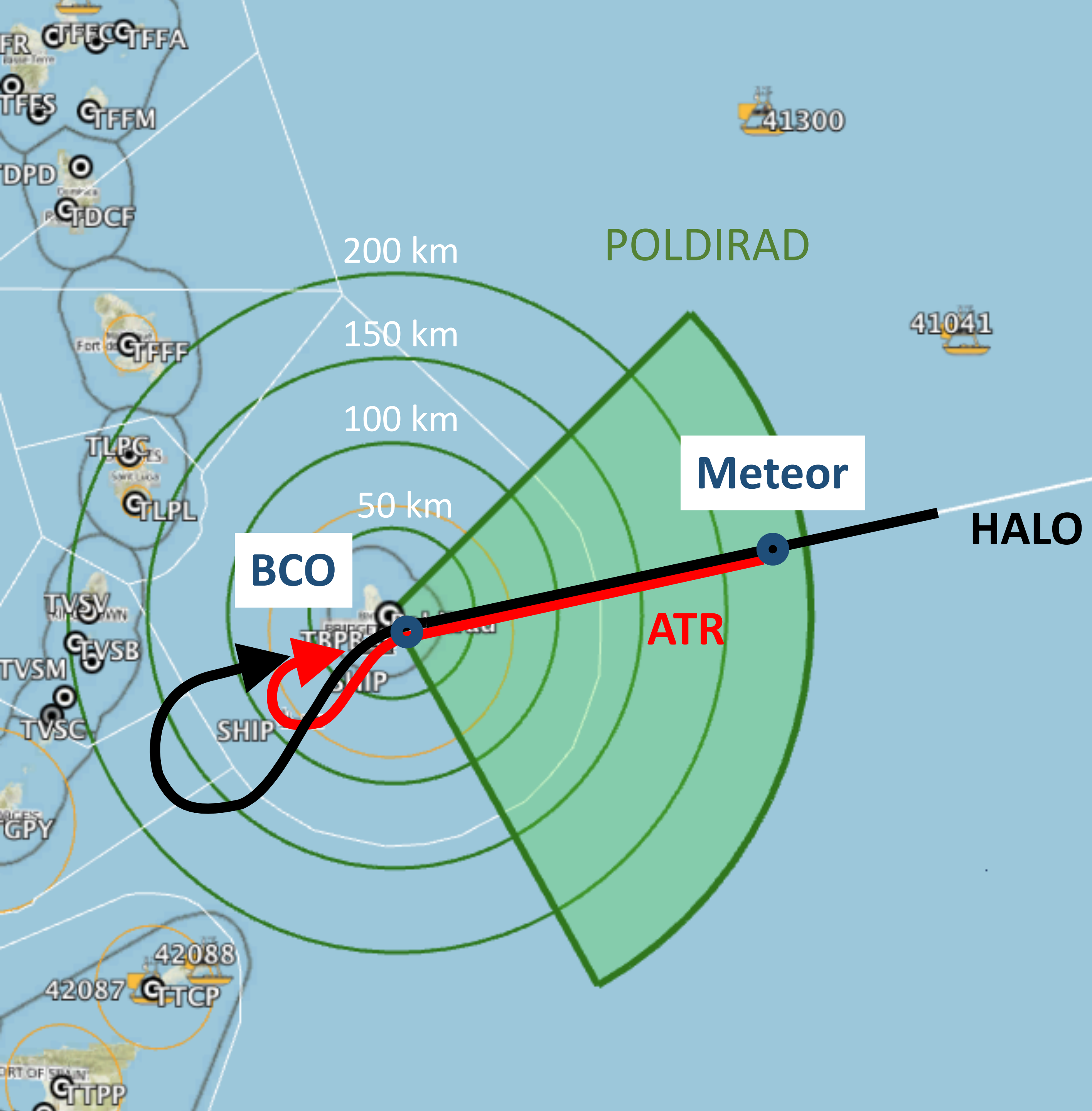
Flight patterns
Spatial coordination



Super Curtain (V2)

- After take-off or after refueling
  - If HALO take-off (has to be) earlier
  - Or as HALO excursion pattern
- As kick-off for operation in common area
- Including ships if on BCO-NTAS line

Flight patterns
Spatial coordination

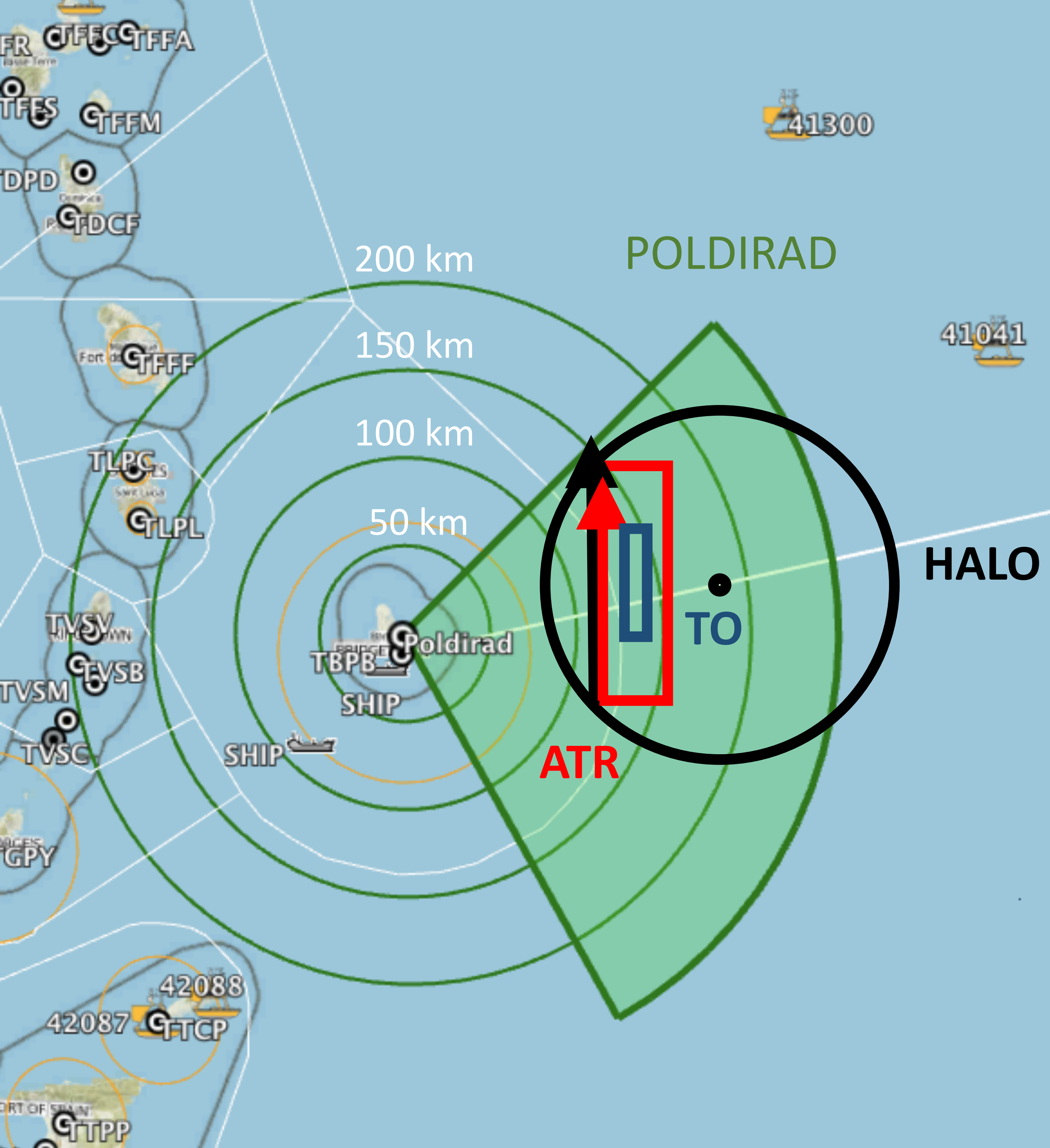


BCO Overpass

- End of day (2-3x during campaign)
- Along NTAS-BCO line
- Upstream measurements for upcoming BCO night measurements
- High resolution radar/lidar measurements

Flight patterns

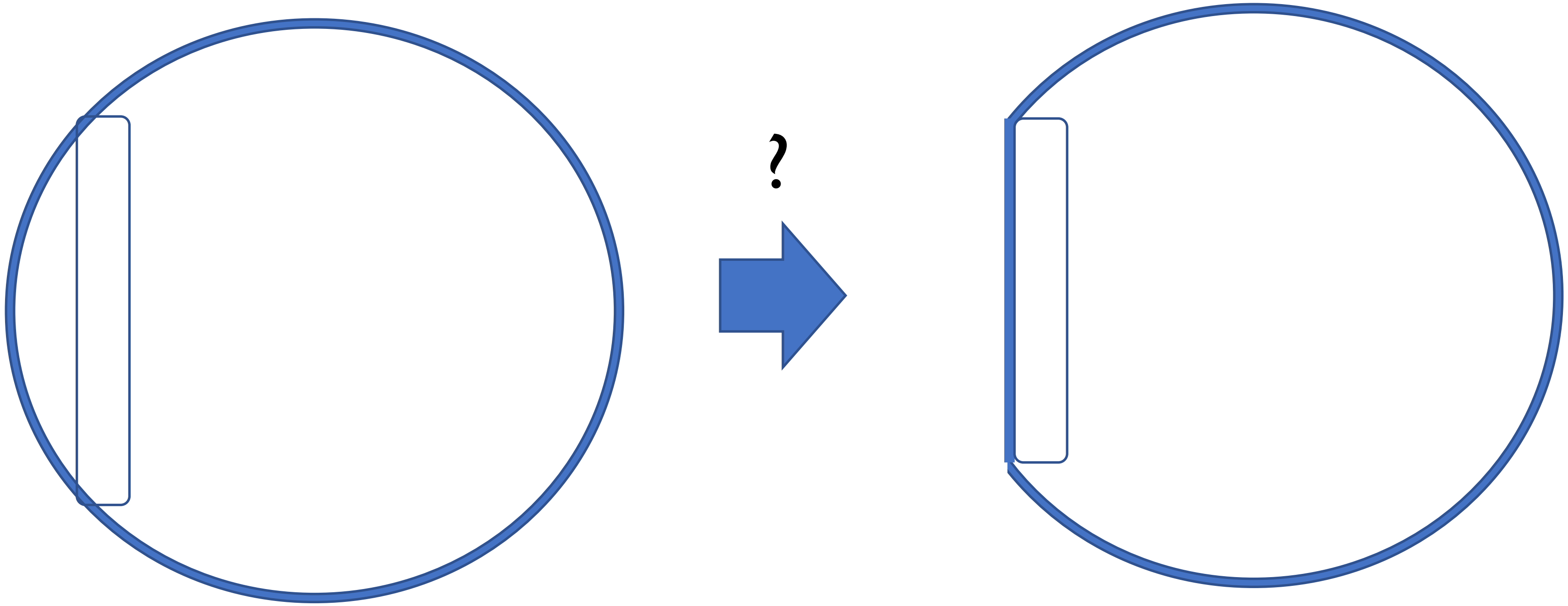
Spatial coordination



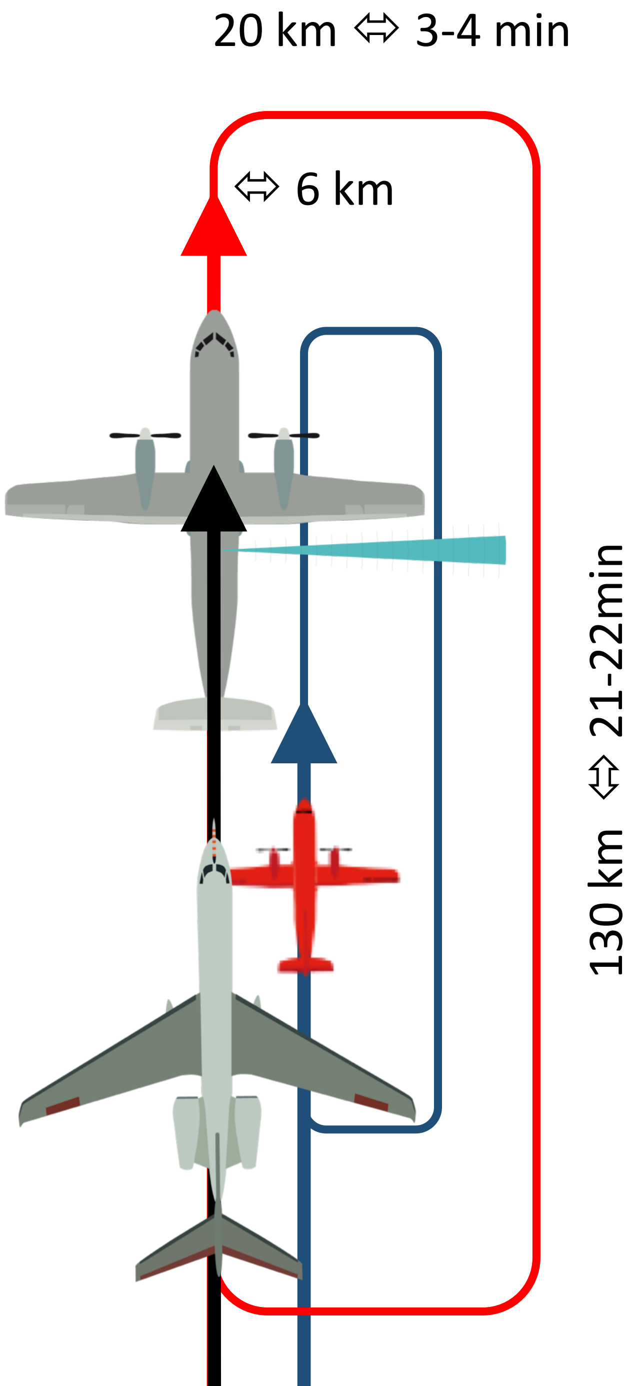
Common area

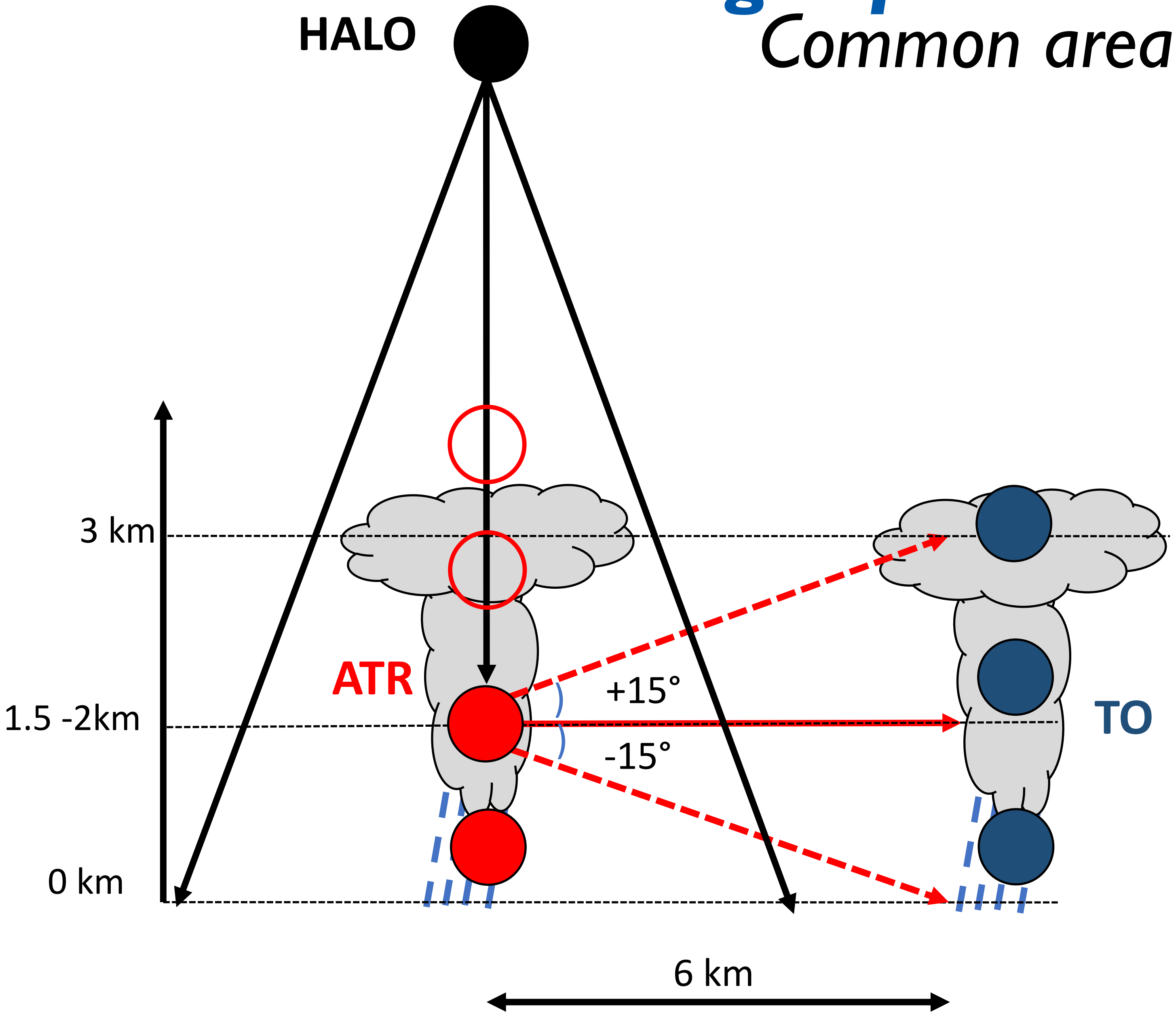
- Core pattern (massflux / closure studies)
- On all flight days (AM + PM flights)
- Close tandem of HALO / ATR
- Twin Otter will join as often as possible
- <u>Key request</u>: flattened HALO circle

Flight patterns
Common area

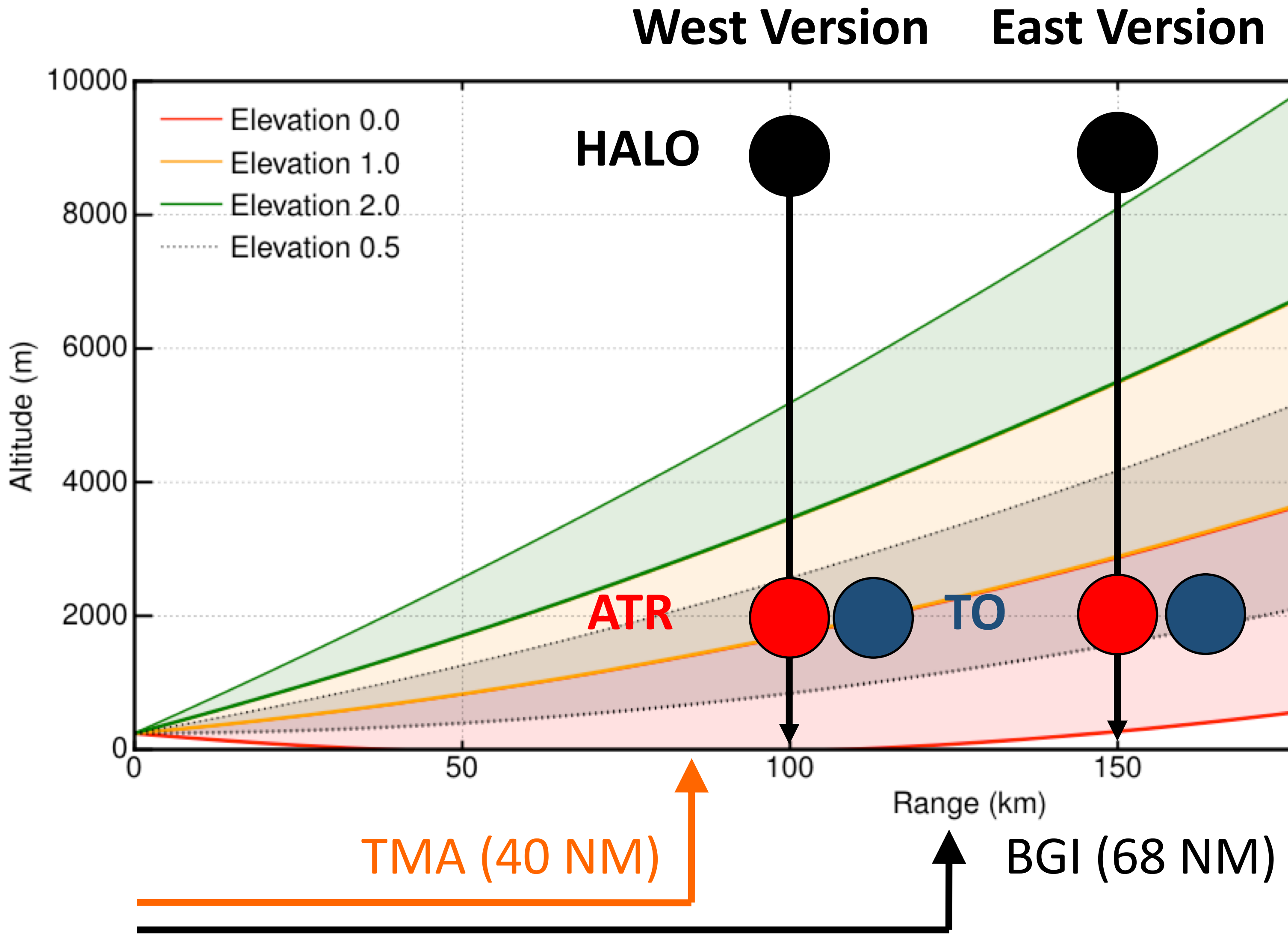


Flight patterns
Common area





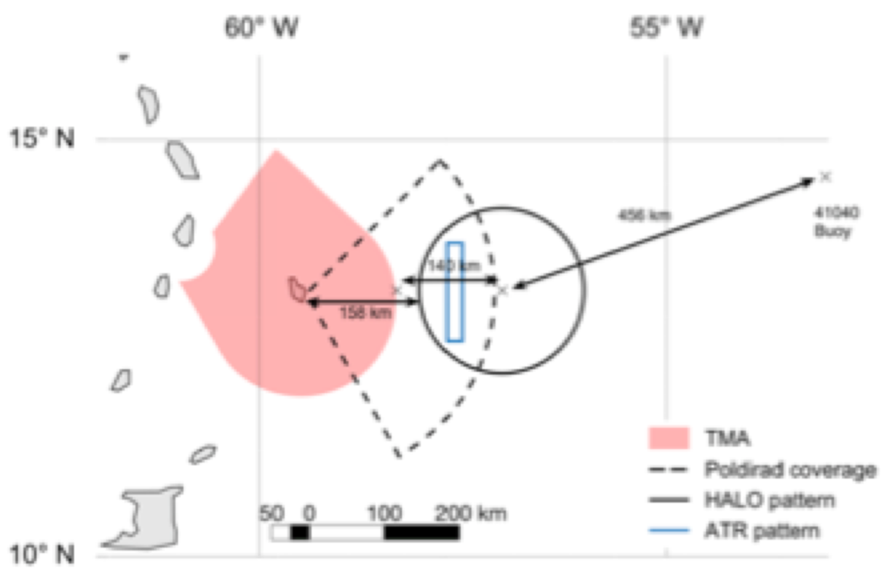
Flight patterns
Common area (POLDIRAD)

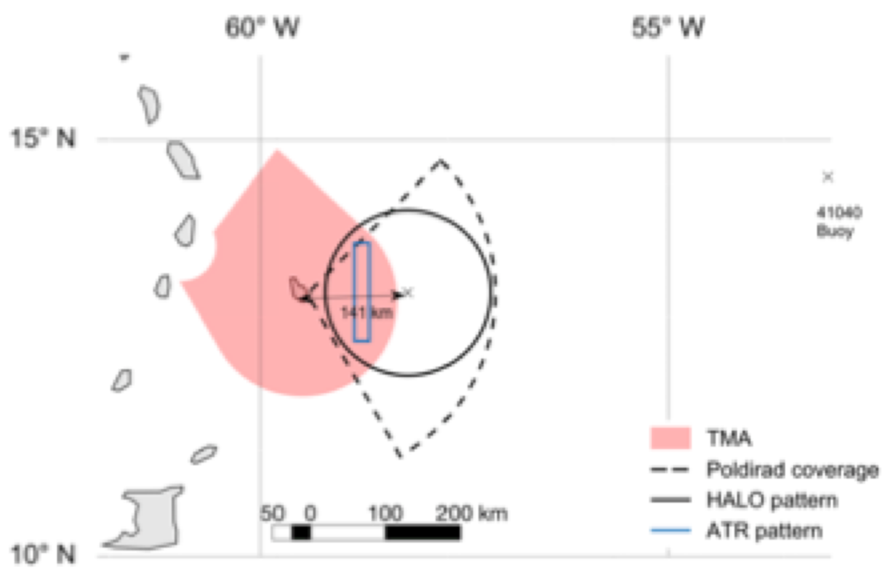


Open issues

Known unknowns

Airspace and Airport Limitations





- Plan to fly regular 'weekly' schedule, with three flights per week & staggered departure times.
- Airspace restrictions (2.5 km to 7.5 km) may influence where sondes can be launched.
- Work is planned for the runway, which could imply airport closures, and limits on landing and takeoff times.
- GAIA winter schedule (major airlines arrival & departures) may influence choice of flight days, take-off/landing times and refueling schedule.

	Sunrise (LT)	Sunset (LT)	Sunrise (UTC)	Sunset (UTC)
20. Jan 2020	0625	1753	1025	2153
20. Feb 2020	0619	1805	1019	2205

Aircraft limitations

Common area (closure studies) + Super curtain

- Possibility / restrictions for flying and dropping sondes inside the TMA
- Location, duration, specific plans for calibration patterns
- Refuel @ around 4 pm might be an issue – take-off at noon therefore not optimal
- TO is happy to fly with ATR42
  - could fly inside the ATR42's pattern

  → vertical separation at least 1000ft
- How does construction work on runways impact our plans?

Aircraft limitations

Night time flights (Diurnal cycle)

- ATR, TO: Interest / feasibility for night-time flights?
- TO: How far in advance will flight plans be fixed?
- W-P3D could fly nighttime (take off 8pm) – 3 flights for one week?
- TO and ATR42 could fly at night but with restriction in terms of lowest altitude (adv more stat during night / cons change in stat + logistic)

Open questions
Twin-Otter specific

Points to consider.

1. Include a profile except perhaps in the BL-focus flights. Time is a factor.
2. Divide flights into two categories of sampling and three vertical regions.
   Suggest we focus on one region per flight.
3. It may be possible to have two flights per day: e.g. first of 4 hrs and second 3 hrs.

Categories

1. Study of "single cloud": e.g. for flowers, but also for developing clouds in other regimes
2. Quasi-statistical flying, in more-or-less straight line, or along a curve (fish), but diverting to target clouds if necessary