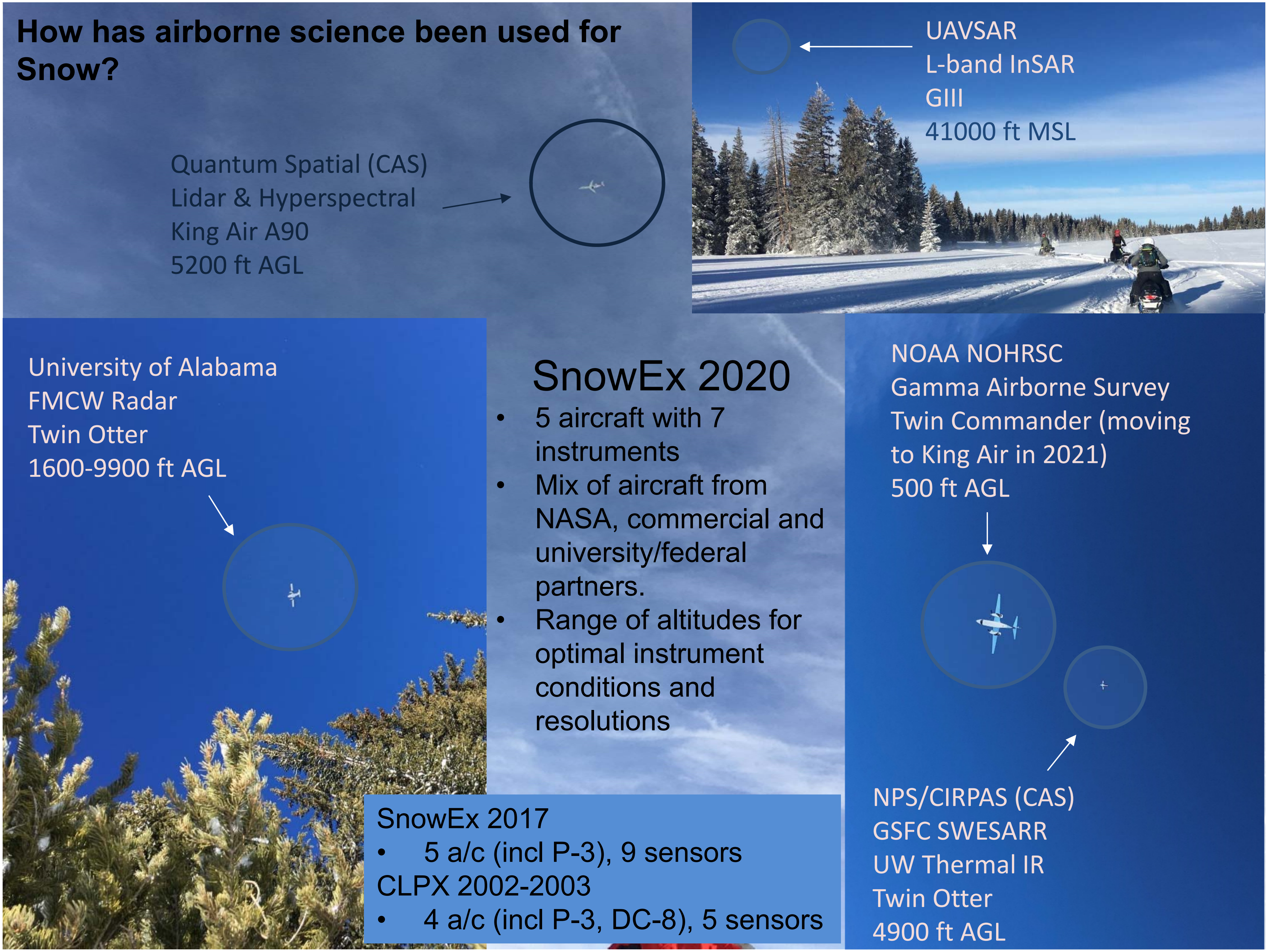
# Airborne Observations of Snow

## How has airborne science been used for Snow?

1. Satellite mission concept development:
    - Technology development
    - Calibration and validation
    - Algorithm development
2. Operational snow surveys:
    - NOAA NOHRSC, Gamma Airborne Surveys, 1980 – Present
    - Airborne Snow Observatory (ASO, lidar/hyperspectral), 2013 – Present
3. Local to regional science studies (mainly lidar, stereophotogrammetry)
    - Snow depth spatial variability in various landscape
    - Repeatability of snow patterns

## Value of airborne science for Snow?

- Large, complete spatial coverage (vs ground observations)
- Bridges gap between point ground observations and satellite data→ high spatial resolution
- Helps address scaling & model validation questions
- Efficient way to demonstrate constellation approach (multiple observations from different instruments/frequencies)


How has airborne science been used for Snow?
Quantum Spatial (CAS)
Lidar & Hyperspectral
King Air A90
5200 ft AGL
UAVSAR
L-band InSAR
GIII
41000 ft MSL
University of Alabama
FMCW Radar
Twin Otter
1600-9900 ft AGL
SnowEx 2020
• 5 aircraft with 7 instruments
• Mix of aircraft from NASA, commercial and university/federal partners.
• Range of altitudes for optimal instrument conditions and resolutions
NOAA NOHRSC
Gamma Airborne Survey
Twin Commander (moving to King Air in 2021)
500 ft AGL
SnowEx 2017
• 5 a/c (incl P-3), 9 sensors
CLPX 2002-2003
• 4 a/c (incl P-3, DC-8), 5 sensors
NPS/CIRPAS (CAS)
GSFC SWESARR
UW Thermal IR
Twin Otter
4900 ft AGL

# Future of Airborne Snow Observations

## Lessons Learned

- Limitations on availability, flexibility, instrument accommodation on NASA aircraft
  - Multiple last-minute schedule changes due to other commitments/maintenance impacted science
  - Limited flexibility and availability of smaller NASA aircraft (Twin Otter, Pilatus PC-12)
  - NASA lidar capabilities do not match snow needs. Airborne lidar will be critical for future snow (and Earth Science) campaigns.
- Onerous requirements for non-NASA aircraft (e.g. Medical clearance, Part 135, NAVAIR)
  - New requirements should be relayed to instrument operators 6 months before they are implemented
  - Grace period for signed contracts

## Future airborne science needs

- Multiple instruments for coincident observations (through multiple aircraft or large aircraft)
  - Optical, microwave, lidar to efficiently demonstrate constellation approach
  - Multiple frequencies (e.g. L-band, S-band, X/Ku-band) to test multi-frequency retrieval scheme
- Time series approach: critical to assess how snow changes over time → availability, cost
- Autonomous observations: easier use of small UAVs to provide flexibility

## Need for large payload, prolonged duration aircraft

- Flying larger/multiple instruments (P-3 more useful than DC-8 for snow)
- Long-endurance aircraft to cover large areas efficiently and/or base further away
- Test/demonstrate scaling up for space
- Continuing need for smaller aircraft option for collecting multiple observations