WECAN Project Manager Report

General Data notes

Ambient temperatures: three measurements were available during WECAN, a fast response unheated ATF1 and two anti-iced heated, ATH1 and ATH2. The latter two agree to within 0.2 degrees throughout the entire project. The fast response ATF1 is generally in very good agreement with the heated sensor but diverges slightly more at the beginning of flight, usually in the first hour. The differences between ATF and ATH during the first 45-60 minutes of the flight are on the order of 0.2-0.4 degrees whereas for the rest of the flights are usually less than 0.1 degree. Users of the data are advised to be aware that ATF and ATH may differ during ascent and descents and when crossing rapid temperature gradients. This is due to the faster response of ATF1, which can detect rapid temperature change earlier than the ATHx.

The ATF sensor experienced a step change during RF04, likely in response to a small object or ice impact on the Pt wire of the sensor. This caused ~0.4 degree change that persisted through RF04 and RF05. The sensor was replaced with a spare for RF06. Subsequent calibration of the original ATF1 will allow removing the offset in Rf04 and RF05 more precisely. The relative response of ATF1 after the event on RF04 during RF04 and RF05 appears consistent.

ATH1 was accidentally only logged at 10 Hz, instead of the usual 100 Hz. This will have minimal impact on the 1 Hz data, but the high rate data should only use ATH2 or ATF1, which were both sampled correctly at 100 Hz. RTX is set to RTH2 and ATX is set to ATH2 for the entire project.

As of March 2019, calibrations of ATF1 are preliminary for RF05 through RF19 due to the temporary unavailability of the calibration facility. ATF1 data will be updated once the sensors are re-calibrated. No significant change in the value is expected.

Dew point measurements: three measurements are available for WECAN: chilled mirror DPT and DPB and the calculated DP_UVH from the Lyman-Alpha hygrometer. The chilled mirror sensors performed within their specifications, however the DPT frequently exhibited ringing that is likely related to the inability of the internal temperature controller to lock on the dewpoint temperature quickly enough. DPB is used as the reference dewpoint. Both chilled mirror sensors sometimes exhibit overshooting after altitude changes, due to the thermal inertia of the mirror. The overshooting is evident in the form of a rounded, sloping ramp-up, followed by settling, ringing signal. It is recommended to use the DP_UVH or a Picarro water vapor measurement during and immediately following climbs and descents.

UV Hygrometer mixing ratio, MR_UVH: data reported in ppmv of water vapor. Values were derived by fitting the UV hygrometer absorption signal and cell temperature and pressure to the calibrated Aerodyne water vapor mixing ratio for all flights except RF10 for which the Picarro mixing ratio was used. For every flight, approximately the first 30 minutes after takeoff have been removed as it took that long for the signal to stabilize. In some flights portions of the data have been removed due to noise spiking. This was most common in the pressure data, in which case the impact was usually minor, but sometimes occurred in the absorption signal as well. In either case, artifacts could be seen in the derived mixing ratio data.

Vertical wind: the calculation of the vertical wind (WIC) is currently undergoing improvements. The current calculation contains imperfection that sometimes results in slight slope and offset in the WIC over the course of the flight. The physical parameters related to this artifact are the decrease of the aircraft weight caused by the fuel burn and the resulting change of the angle of attack to pitch relationship. The RAF is working on improving the WIC algorithm and the trend and offset in the WIC will be corrected in a future data release.

Radiometric temperatures: The Wintronics KT19.85 sensors that measure radiometric surface temperature (RSTB, RSTB1) and radiometric sky temperature (RSTT) are specified to provide

measurements over a range of -50 to +50 C. In WE-CAN, surface temperatures sometimes exceeded +50 C (typically during the afternoons in southern Idaho, eastern Oregon, and northern Nevada). Comparison with satellite infrared brightness temperatures from GOES-16 confirms these conditions. As well, radiometric sky temperatures in clear, low humidity conditions often drop below -50 C. In these events, the variables RSTB, RSTB1, and RSTT do not provide useful measurements.

Throughout the project there is a consistent high bias in RSTB compared to RSTB1, both of which measure radiometric surface temperature from Wintronics KT19.85 sensors. The average difference varies from about 0.2 to 1.0 C, which is slightly higher than the specified measurement uncertainty of 0.5 to 0.7 C. The bias shows a slight positive correlation with the sensor housing temperature, though the correlation is not sufficiently convincing to attribute the bias to sensor heating. Comparison with satellite infrared brightness temperatures confirms that both sensors are providing realistic estimates of radiometric surface temperature.

UHSAS: the instrument generally ran well during WE-CAN, but there were two (unrelated) problems throughout the project. One of these was frequent periods of laser instability, usually just one to a few seconds, but occasionally longer. The instability caused spurious particle counts in the small-diameter bins, and it was necessary to discard the first ten bins for the project. The effective minimum diameter is therefore 80 nm. At times the noise extended into higher diameter bins, and the data have been blanked for these events. Despite this discarding and blanking, and in order to avoid excessive discarding of valid data, some noise counts have been left in the histograms in cases where they have an insignificant effect on total concentration, but may lead to a high bias in the CONCU-CONCU100 difference.

The other problem was saturation effects caused by the extreme particle concentrations found in smoke plumes, where counts were simply too high for what is by design a single-particle instrument. Very high count rates lead to coincidence of particles in the detection volume as well as saturation effects in the pulse processing electronics. The result is undercounting of particles, incorrect sizing of two or more coincident particles, and distortion of the histogram. In an attempt to counter these effects, the sample flow was reduced by a factor of five after RF03, and restored to its normal value for RF17-19. While the lower flow reduced saturation effects, it could not eliminate them, and came at the cost of greater sample flow fluctuations making the concentration measurements very noisy. At times there is apparent severe ringing in the true flow that is not reflected in the measured flow. Although data are still reported at 1 Hz, time averaging of ten or more seconds is recommended, and large fluctuations of a few seconds period should not be interpreted as spatial structure in the aerosol field. The reduced flow also introduced a delay in the sample measurement, so the data for those flights have been shifted ahead by 2 seconds based on comparisons with PCASP.

In addition to the flow reduction, a statistical coincidence correction has been applied to all UHSAS concentrations. This extends the range over which observed total concentrations are close to true values, but it is limited and still underestimates the highest concentrations encountered.

PCASP: the instrument generally ran well during WE-CAN, with no failures. However, the probe had difficulty with the extreme particle concentrations found in smoke plumes, where count rates were simply too high for what is by design a single-particle instrument. Very high count rates lead to coincidence of particles in the detection volume along with saturation effects in the pulse processing electronics. This causes undercounting of particles, incorrect sizing of two or more coincident particles, and distortion of the histogram. A statistical coincidence correction has been applied to PCASP concentrations, extending the range over which observed total concentrations are close to true values, but it is limited and still underestimates the highest concentrations encountered.

The Picarro G2401-m CO2, CO, CH4 & H2O data has a time resolution of 2 seconds.

The Aerodyne miniQCL CO, N2O & H2O has a time resolution of 1 second.

The forward color camera and downward monochrome camera operated normally for all flights except RF02 (early shutdown), RF07 (early shutdown), and RF15 (late start). See the individual flight QC sheets for these flights.

Flight Specific Data notes

RF01
07/24/2018
No specific issues identified for this flight.

RF02
07/26/2018
Recording for both forward and downward looking cameras failed at 20:50. No images or movie past this point. Started normally on takeoff at 20:19. No other specific issues identified for this flight.

RF03
07/30/2018
Dynamic pressure measurements were affected by a cloud penetration and icing event at 20:41:25. All three QC measurements were offline from 20:47:59 to 20:50:10. All dependent variables, including TAS and resulting cloud probe concentrations, are unavailable. The radome dynamic pressure, QCR, was completely offline from 20:45:45 to 21:19:30. Fast temperature measurement, ATF1, was affected by the icing event and should not be used from 20:41:25 to 21:19:30. Avionics data are Ok during all of these periods.
The angle of attack, AKRD is unavailable from 20:47:46 to 20:50:42 due to the blockage of the ADIFR radome differential pressure lines. Wind data are not available during this period.

RF04
07/31/2018
ATF1, the fast temperature measurement, has experienced two step changes during the flight. This is thought to be due to a physical impact on the sensor platinum wire. The sensor can't be calibrated to accurately recover the absolute value and the ATF1 data have been removed from the dataset. However, the relative sensor response is believed to be unaffected. If relative high rate temperature data are desired for RF04, please contact RAF for a separate release of ATF1 for RF04.
DPT measurement appears to have experienced a +1 degree step change at 20:37 that lasted until 23:59. DPX (which is set to DPB) is unchanged and is recommended for use.
The average vertical wind, WIC, for the flight of -0.46 m/s and earlier sections of the flight as much as -0.7 m/s. The likely cause is a changed vertical differential pressure and angle of attack calibration, and the reason for this is being investigated.
Sample flow for the UHSAS was reduced from 50 vccm to 10 vccm before flight. This setting was retained through RF16.

RF05
08/02/2018
At 23:00, sideslip angle shows a step change from 0.66 deg to -0.87 deg. The cause is unknown.

RF06
08/03/2018
Data gap in multiple variables, including redundant static pressures, ADIFR and BDIFR from 21:02 to 21:05, with resulting loss of wind data for this time period. The redundant airspeed data also have a gap during this time period but the reference airspeed TASX (TASFR) is not affected.

RF07
08/06/2018
Digital cameras image recording started normally on takeoff at 19:56:48 but failed at 22:54:45. No images or movie past this time. No specific issues identified for this flight.

RF08
08/08/2018
Data gaps at 18:58-19:05 and 00:00-00:08 due to DSM319 freeze-ups; rebooting the DSM fixed the issue. Affected variables: QCF, ADIFR, BDIFR, DPB and dependent winds and redundant airspeeds.
Sideslip angle changes twice in this flight, at 20:45 and 23:53. This might be due to the trimming of the aircraft by the pilots, therefore if data changes are seen at these times be cognizant that change of the airplane configuration might be causing an artifact.
Noisy MR_UVH data, mainly in first half of flight. The fit is biased to the middle low altitude portion of the flight at the cost of a poorer fit in the high-altitude ferry at beginning and end. Times after 93000 seconds were removed. High rate UVH data are not available for this flight.

RF09
08/09/2018
No specific issues identified for this flight.

RF10
08/13/2018
DPT and DPB diverged by approximately 1 degree between 18:58: and 22:24. The reason is unclear. Recommend using UVH or Picarro humidity data during this period.
Radome icing occurred from 23:36:30 to 23:44:06. QCR data unavailable during the event; ADIFR is unaffected.
Aerodyne CO, N2O and H2O instrument was inoperative during RF10 due to a UPS failure during pre-flight.

RF11
08/15/2018
Data gap in pressure and dependent wind data from 00:08:00 to 00:12:45 due to a DSM 319 serial channels lock-up. Rebooting the DSM restored the functionality.

RF12
08/16/2018
No specific issues identified for this flight.

RF13
08/20/2018
No specific issues identified for this flight.

RF14
08/23/2018
Sideslip change from -0.8 deg to -0.2 deg and back, apparently associated with a wind direction change, between 22:30 and 01:20, presumably due to trimming of the aircraft in response to wind direction change. Angle of attack also changes during the same time period from 0.8 deg to 1.7 deg.
The vertical wind variable (WIC) has substantial drift from the beginning of the flight to its end, changing from -0.8 m/s to -0.2 ms. These values are unrealistic and the reason for this is being investigated. Short term changes in the WIC are believed to be real.

Unusably noisy MR_UVH data during low-altitude portion of flight, most of the data are missing. Data recovered to normal during ferry flight return.

RF15
08/26/2018
Data system was restarted between 21:47:20 and 21:54:00. There are no aircraft data available at all during this period.
Digital cameras were not recording at start of flight. No image or movies until 21:56:36. Recording was then normal until touchdown at 02:13:54.
Pressure sensor noise causes spikes of ~20% in the MR_UVH during much of flight.

RF16
08/28/2018
No specific issues identified for this flight.

RF17
09/06/2018
No usable MR_UVH data exist for this flight.
Sample flow reset to normal value of 50 vccm for this and remaining flights.

RF18
09/10/2018
No specific issues identified for this flight.

RF19
09/13/2018
No specific issues identified for this flight.