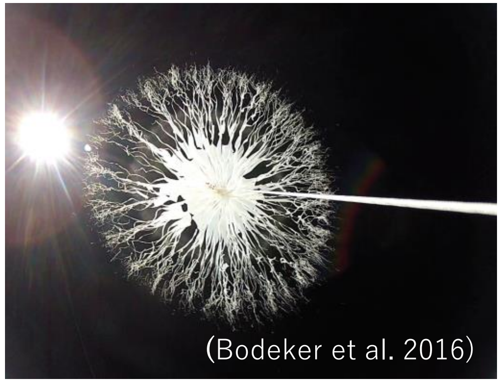

High altitude attainment study progress (C7)

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(*)IPET-OSDE: WMO CBS (Commission for Basic Systems) Inter-Programme Expert Team on Observing System Design and Evolution

GRUAN ICM-14, La Reunion Island, 28 Nov.-2 Dec. 2022

Task: Justification for high ascent attainment (for balloon soundings at GRUAN and other sites)

- Main Contact: TT Radiosondes, IPET-OSDE (since ICM-11)
- Milestone: Publication in the peer reviewed literature or a technical report

- Higher than 10 hPa level, 5 hPa level. . . (compared to 30 hPa)
- Criteria to include not only climate monitoring, but also: NWP impact; seasonal predictability; importance of monitoring LS winds; radiative transfer calculations; satellite validation; climatology, etc. [The "user needs"!]

- Notes:
  - Very important & very difficult task, as we have to provide the appropriate message to various different stakeholders
  - Your expert inputs (and strong support/encouragement) are essential to complete this task!

- **Progress since ICM-13:**
  - **Started to draft a paper manuscript (contact MF if you would like to take a look)**
  - **Realized that we need at least one figure for each section – Need your help!**

Contents of the manuscript

1. Introduction

2. Technical issues for balloon sounding

3. Climate monitoring
4. Satellite validation
5. Radiative transfer calculations

6. Impacts on numerical weather forecast & Sub-seasonal to seasonal predictability

7. Summary and Conclusions

1. Introduction (. . . drafted)

- Role of balloon-borne radiosondes for upper air observations

- Height attainment requirements for . . .
  - GUAN (GCOS, 2002, 2010)
  - GBON (WMO, 2021)
  - GRUAN (GCOS, No. 112, 2007) [Table 1 (next slide) for the burst altitude statistics]

- "All the above requirements for height attainment for balloon-borne radiosonde soundings were provided without explicit scientific justification nor technical guidance." . . . as a justification of the paper manuscript

[Provided by Tony Reale]

GRUAN Ascent Heights Jan 2018 to March 2020

[Need updates]

	Launches	20 hPa (26km)	10 hPa (31km)	5hPa (36km)
Counts	23102	14542 (63%)	7565 (33%)	420 (2%)
All Polar (90-60)	7107	3681 (52%)	1559 (22%)	60 (1%)
All Mid-Lat (60-30)	10961	6975 (64%)	3769 (34%)	294 (3%)
All Tropic	3332	2758 (82%)	1460 (44%)	66 (2%)
Winter Polar	1169	489 (42%)	296 (25%)	18 (2%)
Winter Mid-Lat	1968	1125 (57%)	716 (36%)	93 (5%)
Summer Polar	1337	757 (57%)	126 (9%)	2 (<1%)
Summer Mid-Lat	2262	1542 (68%)	700 (31%)	36 (2%)
All NZ	1680	1111 (66%)	766 (46%)	0
Summer NZ	322	303 (94%)	222 (69%)	0
Winter NZ	327	304 (92%)	214 (65%)	0

Winter: Oct 2018 to March 2019 Summer: April 2019 to Sept 2019

*NZ: 10/1/2017 to 10/1/2018, 87% do not reach 20 hPa; *Invercargill 350g to 700g; Lauder 1500g*

(Note: At Lauder, NZ, 1/4 of the launches are FPH that are valved to open at 15 hPa (28 km))

2. Technical issues for balloon soundings [and how to solve them] (. . . drafted)

- Balloon size versus burst altitude
  - limitation of rubber balloon technology (Why we cannot say we should aim at 1 hPa or 0.1 hPa?) (cf. Kinoshita et al., JTECH, 2022 (reaching 40 km by using 3000 g balloon for a 40 g radiosonde))
  - cost issue (by showing cost estimates???)
- Some important notes:
  - Early burst issues – at nighttime tropical tropopause / in winter polar lower stratosphere (cf. the kerosene treatment / double balloon technique)
  - Issues in automatic radiosonde launchers?: Now they have capabilities for 800/1000 g balloons; but issues may arise when surface winds are too strong.
  - The biases in pressure-sensor measurements & the low biases of GNSS height measurements
  - We should make some practical suggestions on “how” to increase the average burst altitude (not only “why”) – perhaps also in the Conclusions section.
- Other important aspects?

3. Climate monitoring [at 30-5 hPa / 25-37 km]

- Good examples (studies) on this? ***A good figure or two on this?*** The followings are some examples (Please suggest me more!):

- Temperature:
  - Homogenized satellite data products versus homogenized radiosonde data products (e.g.,Maycock et al., 2018; Philipona et al., 2020) ; GNSS RO temperature versus radiosonde temperature (e.g., Steiner et al., 2020 (?))
  - (See also SPARC Temperature activity: https://www.sparc-climate.org/activities/temperature-changes/)

- Winds in the stratosphere:
  - The QBO disruptions (2015/16 & 2019/20; e.g., Anstey et al., 2021) – and the role of QBO in climate
  - (Issues in extratropical stratospheric winds?)
  - Satellite instrument Aeolus (August 2018) observes global wind profiles to 30 km (https://earth.esa.int/eogateway/missions/aeolus)

- Water vapor and ozone in the stratosphere:
  - Aura MLS (v4 to v5) versus FPH/CFH (Hurst et al., 2022)
  - O3S-DQA (ozonesonde data homogenization) & SPARC LOTUS (https://www.sparc-climate.org/activities/ozone-trends/)

4. Satellite validation (. . . inputs needed!)

- GSICS (Global Space-based Inter-Calibration System, https://gsics.wmo.int/)
  - higher ascent radiosondes are collocated with satellite (hyperspectral IR, etc. (GNSS RO when available))
  - Key references:
- NPROVS (STAR / SMCD / OPDB - NOAA Products Validation System, https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/)

- GNSS RO validation: "Depending on the accuracy of the sonde measurements at these heights (30-5 hPa / 25-37 km), there will be great benefits in cross-validation with GNSS-RO temperature retrievals (e.g., evaluating the effect of ionospheric residual error). It's always hard to find stratospheric data good enough for that." (Comments by Chi O. Ao @NASA/JPL)
- The GNSS RO temperature issues presented at ICM-13 . . . Different retrieval products show differences (By Noersomadi at BRIN/LAPAN)

- Aura MLS water vapor (v4 to v5) vs. FPH/CFH (Hurst et al., 2022)
- How about ozone? (e.g., the use of ozonesonde data to homogenize satellite ozone data sets by Davis et al., 2016)

- Aeolus validation status?

- ***A good figure or two on this?***

5. Radiative transfer calculations [including GSICS need] (. . . inputs needed!)

- Context:
  - Validation of climate models and weather forecast models
  - Validation of satellite data processing / satellite sensor monitoring [GSICS]
  - Validation of ground-based remote sensing data processing
  - Others?

- Show some examples . . .
  - Impact on line-by-line radiative transfer calculations [Lori A. Borg / Nico Cimini]

- ***A good figure or two on this?***

6. Impacts on numerical weather forecast & Sub-seasonal to seasonal predictability

- There were substantial inputs and discussions on this aspect (from Met Office and JMA colleagues; also some info from NCEP colleagues).
- There was a comment that we GRUAN should focus primarily on climate; but, WG asked us to include the NWP aspect as well. – Perhaps, we will try to make this section short and concise?

- (Ask for inputs also from SPARC researchers on the role of stratosphere on predictability?)

- Here, only the key points are summarized:
  - WMO Impact Studies Workshops have always been concerning this. The latest question is: "What is the changing impact of radiosonde data in the presence of changes in satellite data?"
  - There are tools: e.g., FSOI (Forecast Sensitivity of Observations Impact) at Met Office. (But, many said that it is not easy to show the impacts in a clear way due to the S/N issue.)
  - Radiosonde data are also useful to assess NWP/forecast models in radiance/TB space (not only as anchor observations to keep an NWP system (and its bias correction) healthy). (In competition with GNSS RO?)
  - Recent works found that the stratosphere is crucial in initialisation and in the skill from the seasonal forecast [through the North Atlantic Oscillation or Arctic Oscillation].
  - Regarding the forecast skill, high ascents in winter is much more important as stratosphere-troposphere dynamical coupling operates in winter. [By Bruce Ingleby]

7. Summary and Conclusions

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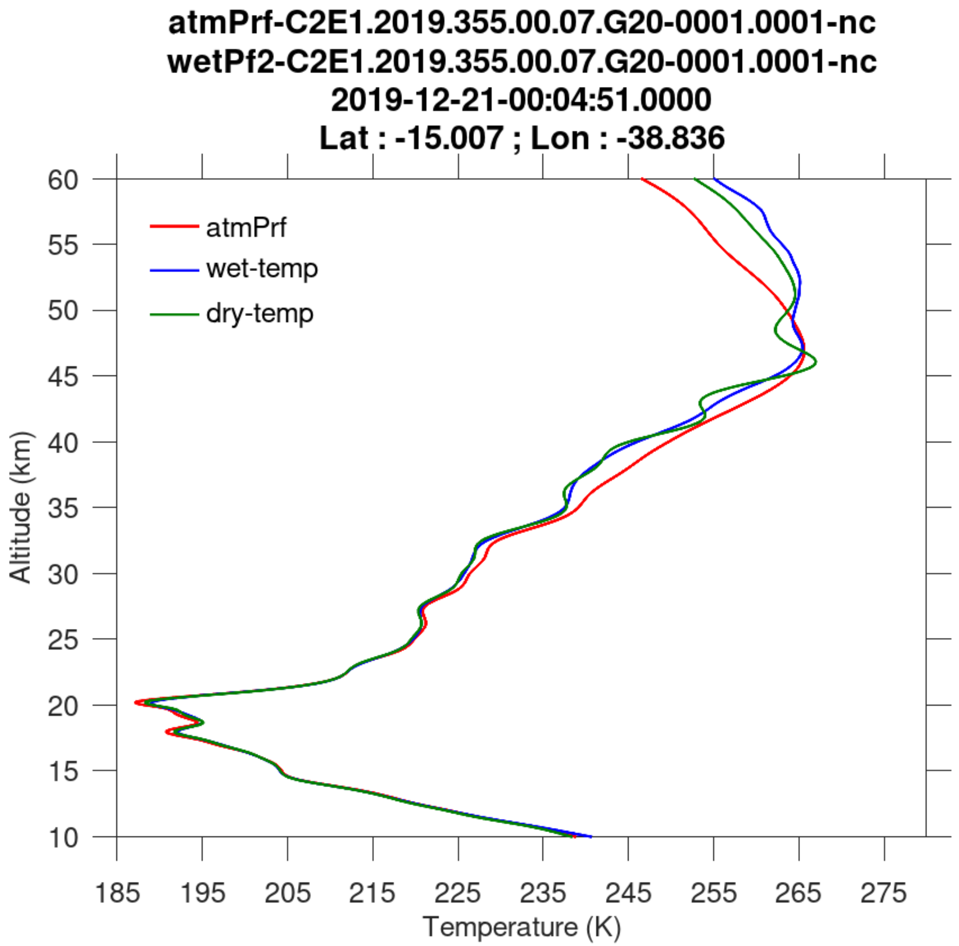
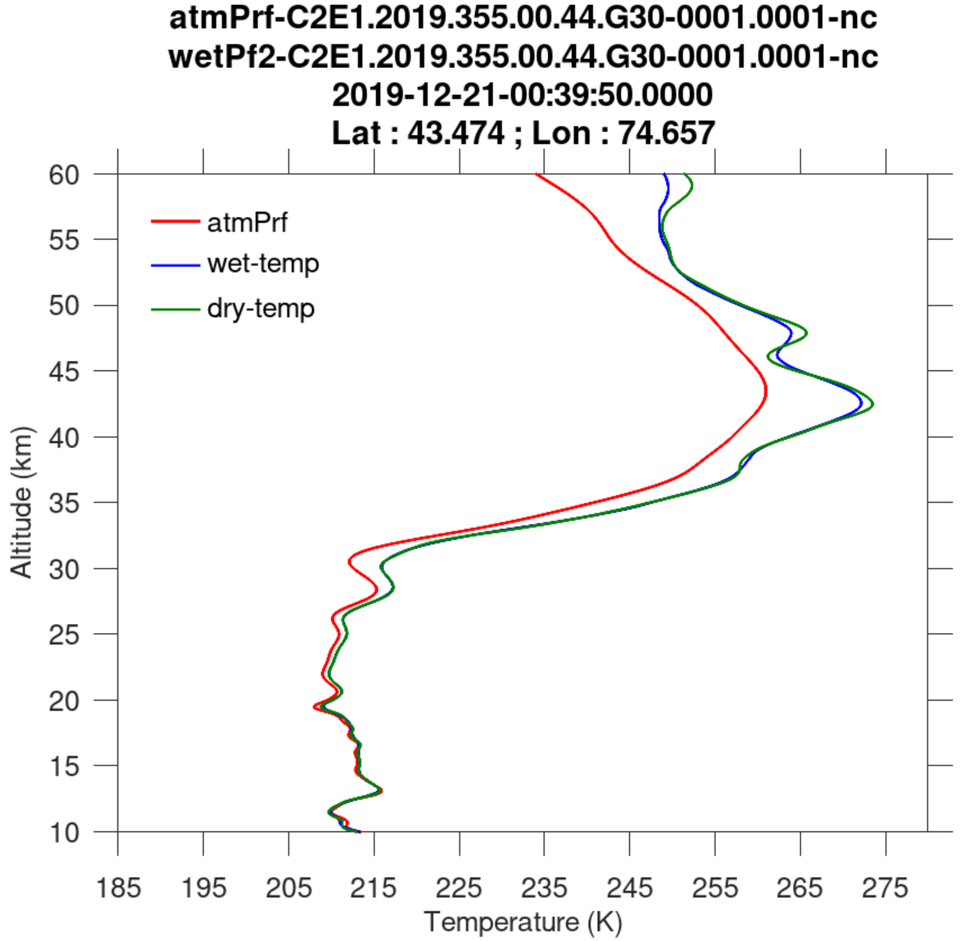
Need your help! (figs. & text) (items 3–5)

For the draft, the template for Atmos. Meas. Tech. is currently being used. Any other, more appropriate journal to target?

- GNSS RO temperature retrievals are often considered as "bias free" in the UTLS
- However, there are differences in the data products above ~25 km due to the differences in the processing algorithms, e.g., treatments of the ionospheric effects, of the lower tropospheric humidity, etc.
- There are several processing centers, e.g., CDAAC, DMI, WEGC, GFZ
- (Note that reanalyses assimilate GNSS RO data as bending angle or refractive index, not temperature retrievals)
- Below are examples of comparisons among different COSMIC-2 data products from CDAAC





(Courtesy of Dr. Noersomadi at LAPAN, Indonesia)

Slide presented at ICM-13

In ICM-14 . . . Talks with some relevance

Session 6 - Science and Innovation-1 (09:00-10:45 RET – 05:00-06:45 UTC) (Presentations 15min+5min)			
6-2	09:20-09:40	The impact analysis of NWS migration to Vaisala RS41	Tony Reale
6-3	09:40-10:00	Sequential radiosonde launches and their use in satellite data calibration/validation	Bomin Sun
6-4	10:00-10:20	Options for radiosonde launches with EUMETSAT Metop and Metop-SG overpasses	Axel Von Engeln
6-5	10:20-10:40	Fine detailed fitting of observed IASI radiances to calculated ones using GRUAN sondes and radiative transfer modelling water vapor inhomogeneities within the satellite field of view.	Xavier Calbet

8-2	13:50-14:10	Direct validation of radiosonde data against radio occultation bending angles	Axel Von Engeln