Results from the CONCIRTO campaign at the Maïdo Observatory

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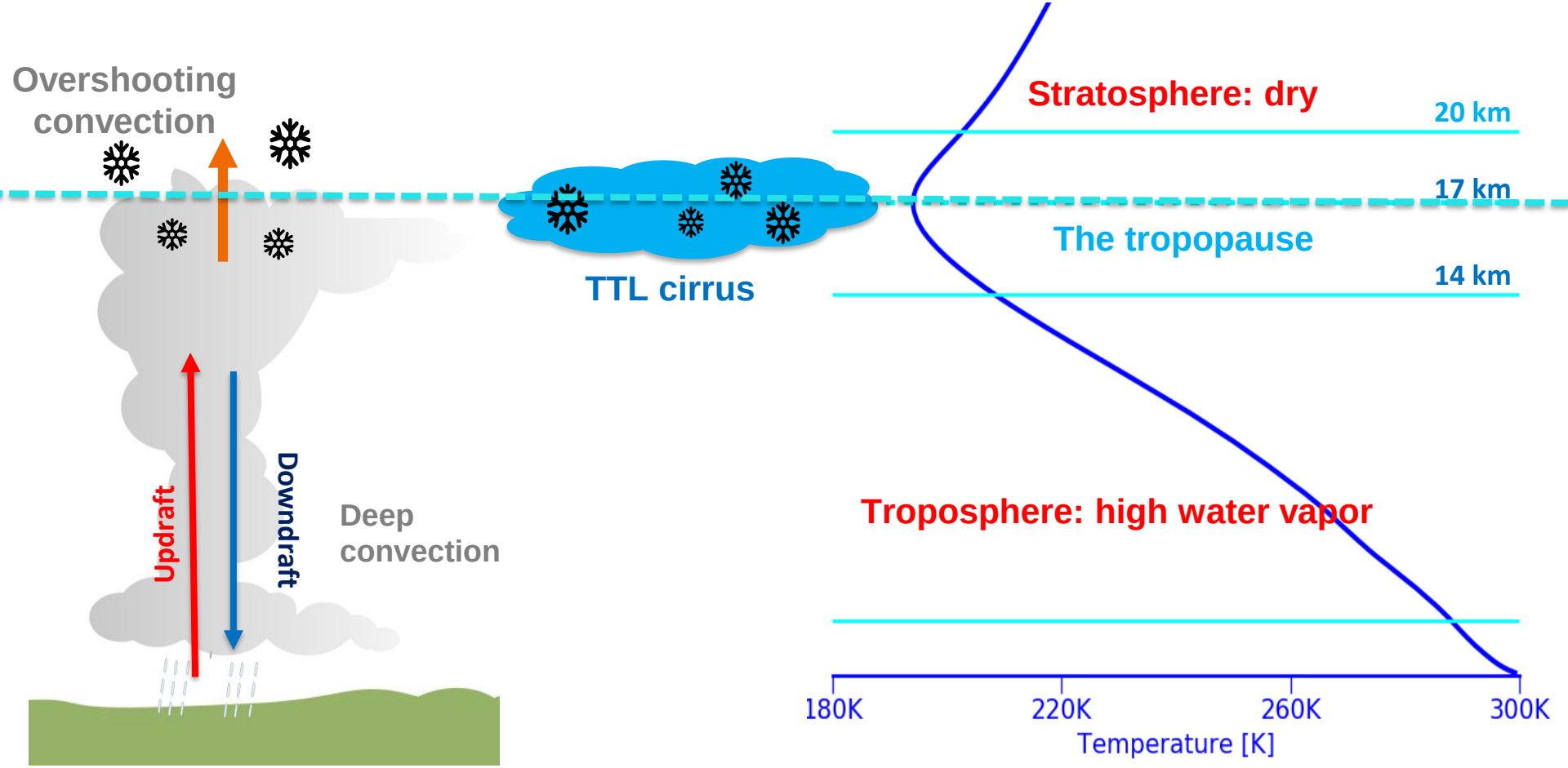
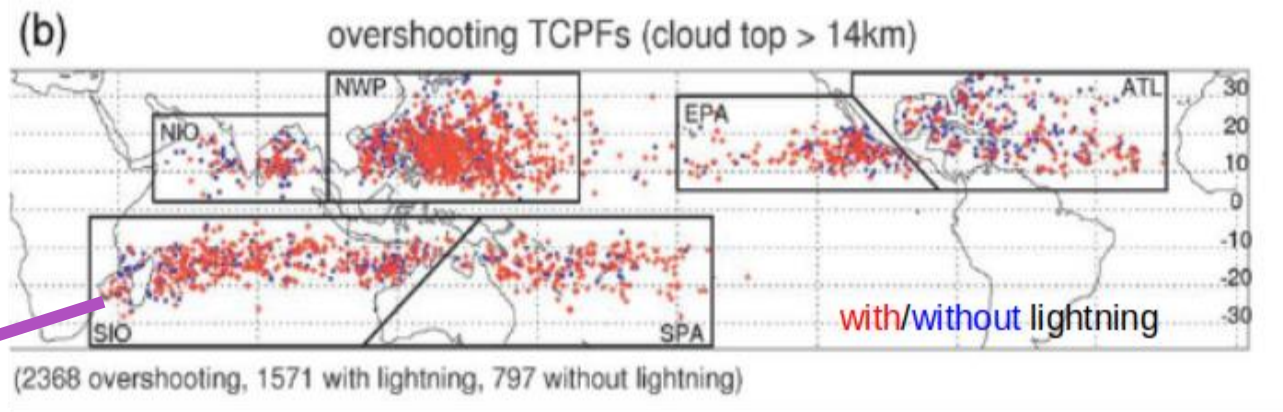
The Tropical Tropopause Layer (TTL, 14-20km)



Motivation

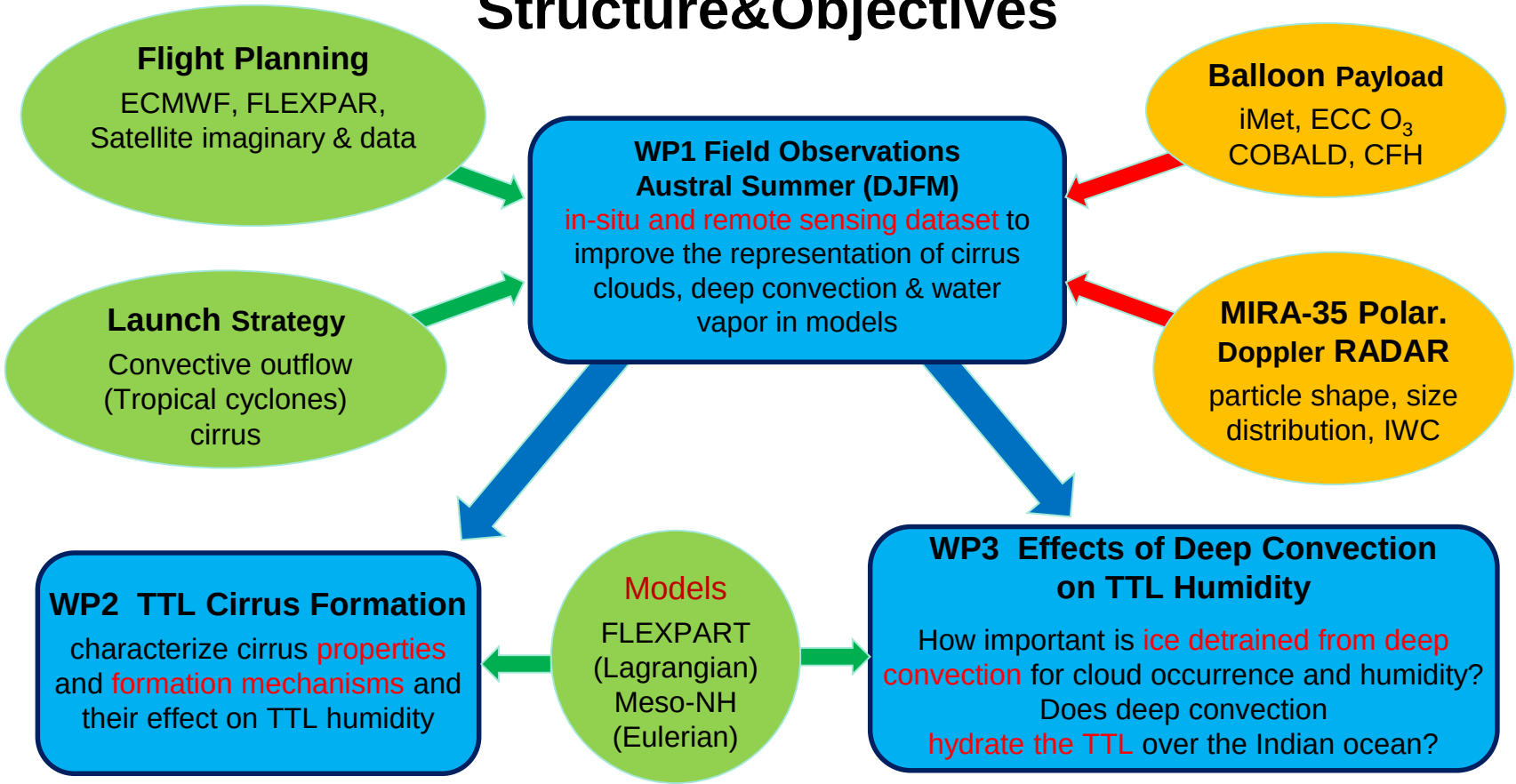


The SWIO is the 3rd most TC active basin

11-year TRMM data Tao and Jiang, 2013 J. Climate:
Global distribution of tropical cyclones with overshooting tops > 14 km
Indian Ocean, 60% of cirrus occurrence (austral summer).

- UTLS composition (H_2O, O_3, aerosols) plays an important role on Earth's climate system
- Southern Hemisphere Tropics: poorly sampled region
- Maïdo Observatory on Réunion Island:
  - ❖ infrastructure for remote sensing and in-situ measurements
  - ❖ one of the largest observatory in the SH tropics

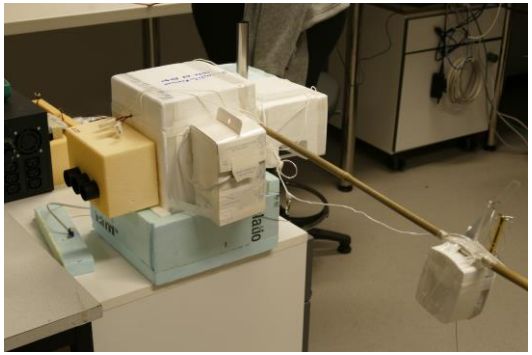
CONCIRTO: CONvection, CIRrus and tropical Tropopause layer over the Indian Ocean
Structure&Objectives



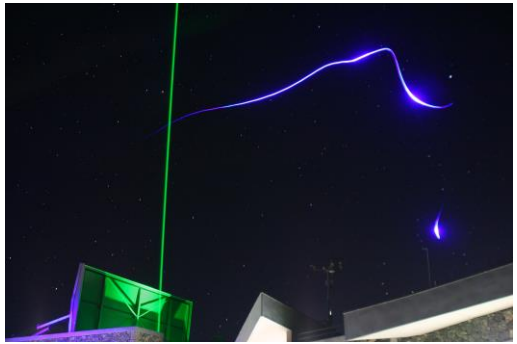
Instruments

Balloons

Daytime (~noon local time)
RS92/RS41/M10

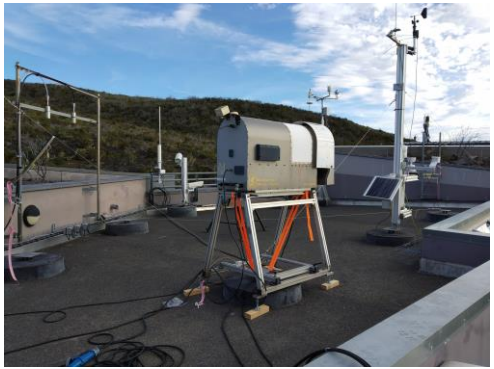


Nightime CFH/COBALD/ECC O3/Imet + M10



Lidars
(H2O/O3/Aerosols)

MIRA-35 Cloud radar (U. Leeds)



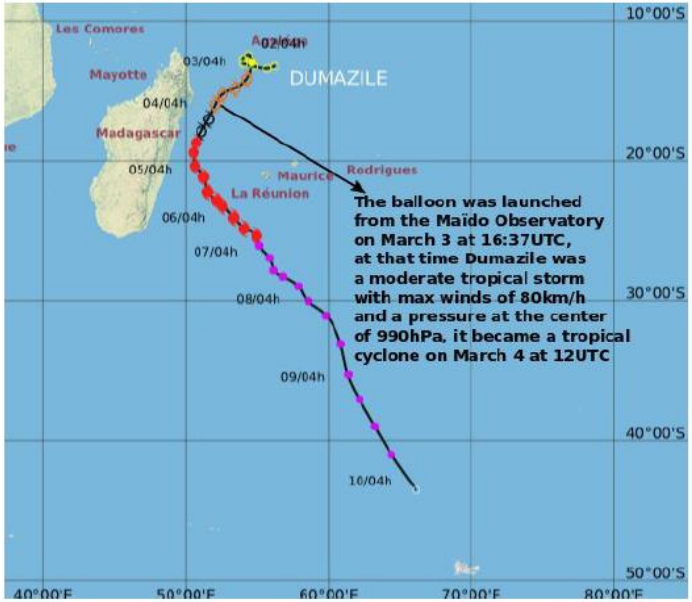
MW Radiometer (U. Leeds)

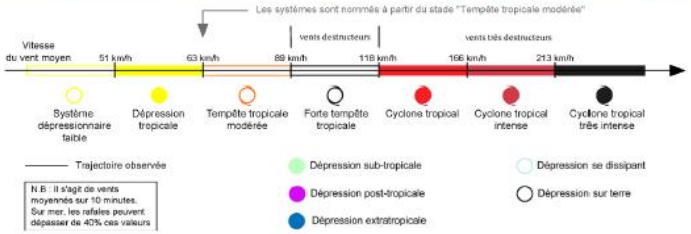
Flight overview

Launch Time (UT)	Identifier	Classification	Remarks
2018-03-03 16:37	LM018	cyclonic convective outflow	TC Dumazile
2018-03-17 15:43	LM019	cyclonic convection	TC Eliakim
2019-01-11 17:55	LM020	in-situ cirrus formation	in-situ cirrus at tropopause
2019-01-24 17:04	LM021	convection over sea	cirrus with water cloud below
2019-01-31 18:41	LM022	in-situ formation over sea & land	subsequent evaporation
2019-02-08 18:51	LM023	cyclonic convective outflow	TC Gelena – early formation mixed phase cloud & cirrus
2019-02-28 17:35	LM024	in-situ formation over sea & land	cirrus at tropopause
2019-03-01 17:00	LM025	in-situ formation over sea & land	UT cirrus
2020-03-06 18:40	LM026	Convection over sea/cirrus	Cirrus at 15km
2020-03-12 16:34	LM027	Cyclonic convective outflow	TC Herold

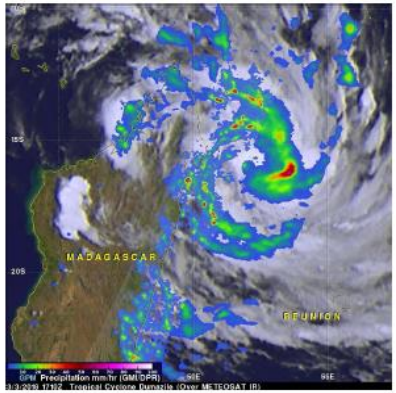
Some flight results: cyclonic outflow, TS Dumazile

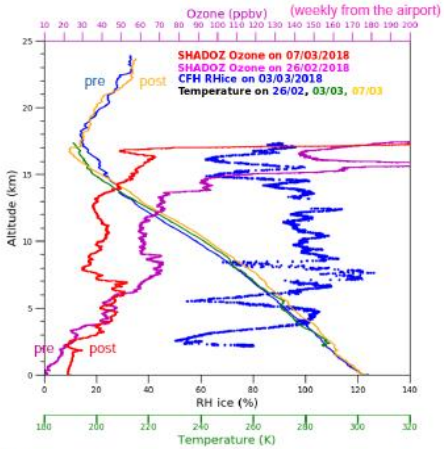
Storm Track



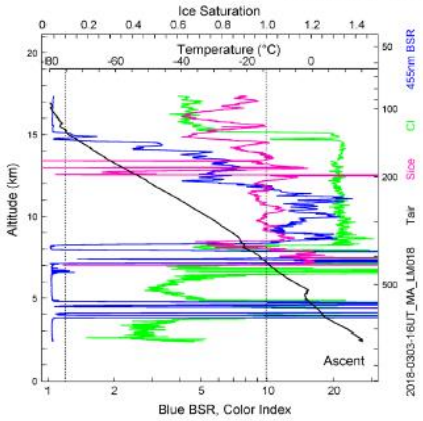


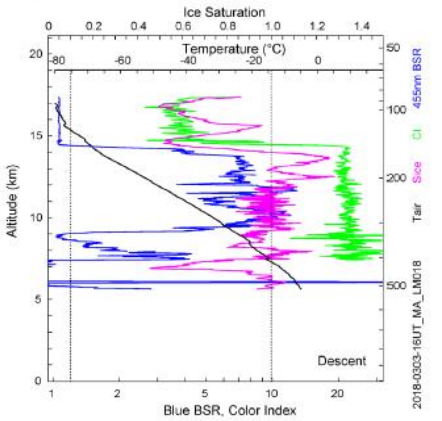
GPM Satellite Radar





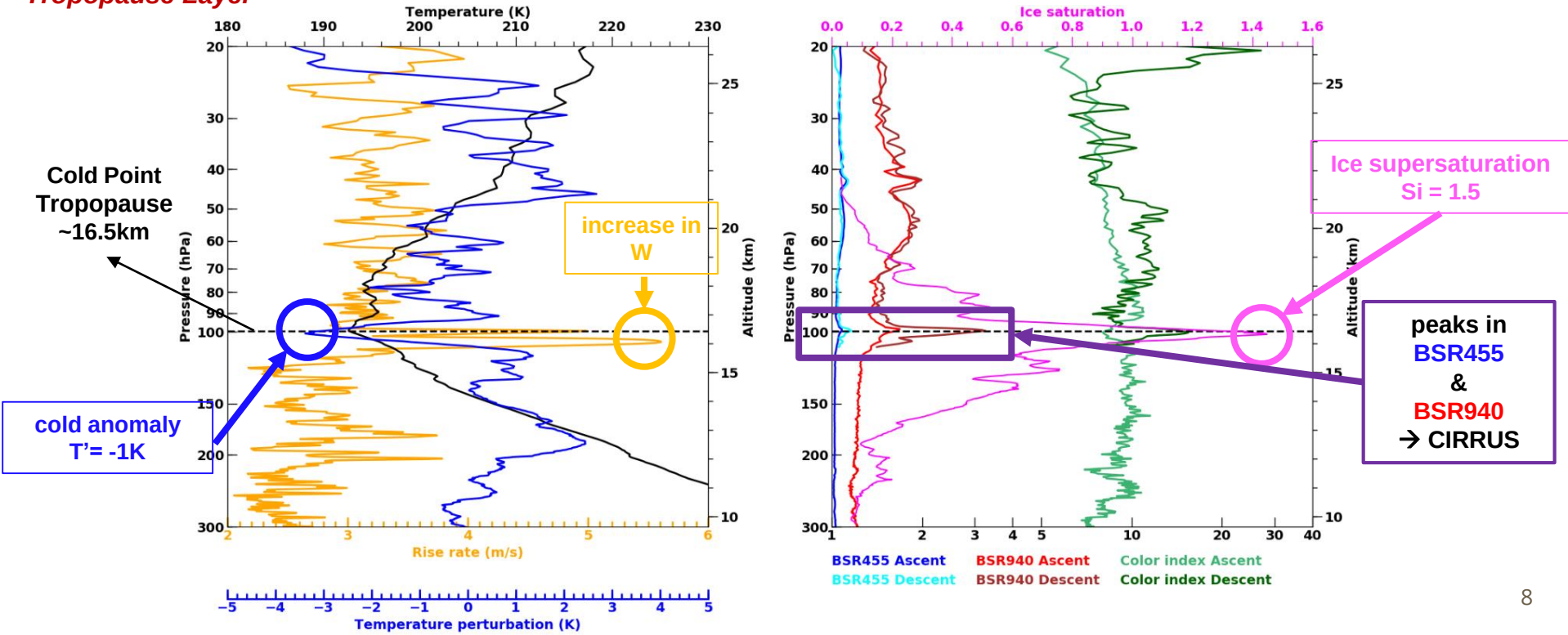
Balloon Sounding





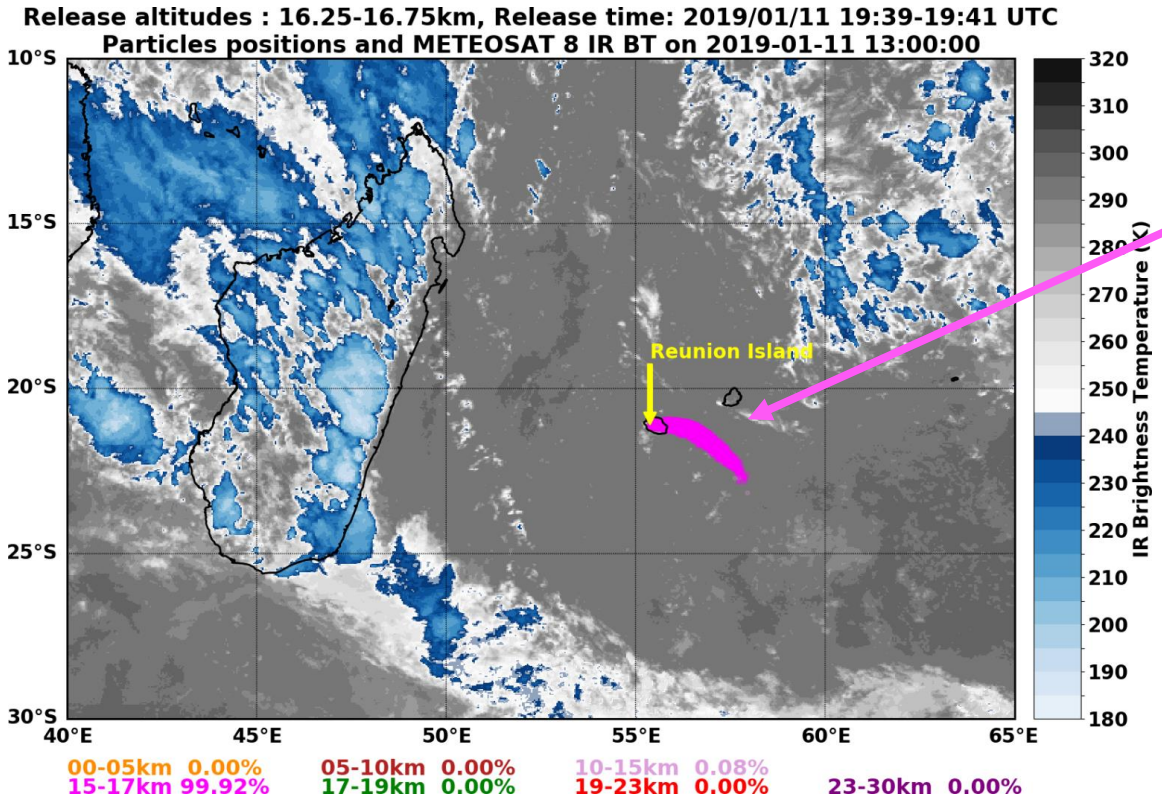
The case of 11 January 2019: Tropopause Cirrus over Réunion Island

Reinares Martínez et al., 2020, GRL, under review, "Unprecedented Observations of a Nascent in Situ Cirrus in the Tropical Tropopause Layer"



The origin of the air masses is consistent with in situ cirrus formation

FLEXPART Lagrangian backtrajectories for airmass at the tropopause **5 hours before the cirrus observation**



The observed airmass remained within 15-17 km over the ocean

No convection up to 1 day before launch IN SITU TTL CIRRUS FORMATION

Cirrus properties/formation mechanism

COBALD observations (blue and red BSR), CFH ice saturation + Mie optical & microphysical modelling = Microphysical estimates

ASCENT

r_M	N_{ice}	***IWC***
< 1μm	520 L^{-1}	0.4 μg m^{-3}

DESCENT

r_M	N_{ice}	***IWC***
~ 1μm	40 L^{-1}	1.3 μg m^{-3}

6 μm ***Growth computation***

Tropopause

Convectively generated Gravity wave induces cooling at the tropopause
T'= -1 K
w'= 0.5 m s^{-1}
Sice = 1.5

TWO HYPOTHESIS

1. Temperature tendency changes during the nucleation event may have truncated the process and limited the ice concentration.
2. The balloon sampled two different regions of the cirrus on the ascent and descent (small-scale structures inside TTL cirrus).

Airborne (balloon/aircraft) in-situ measurements of TTL/stratospheric composition

- The ice crystals present a mode radius of <1 µm, the optical depth of the cirrus is ~10^{-4}

This cirrus would be missed by current aircraft instruments or remote sensing systems

Need of in situ airborne measurements in remote tropical oceanic regions

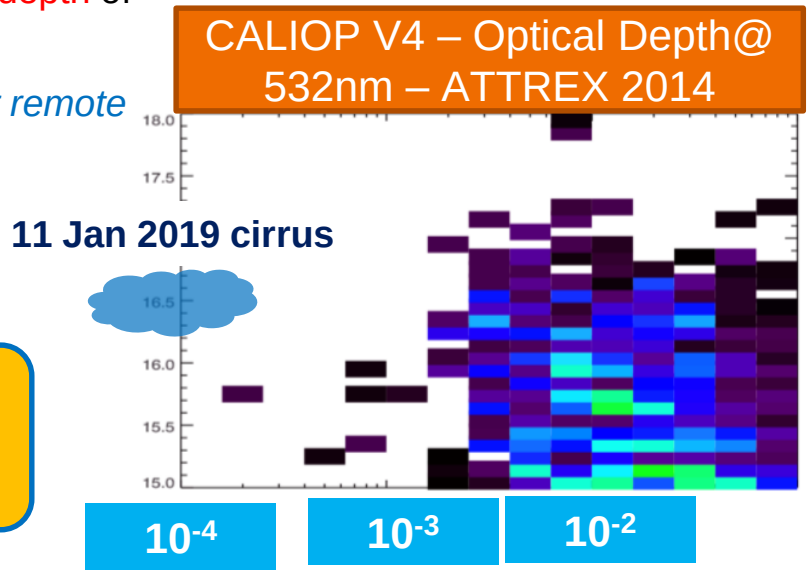


Figure courtesy of Melody Avery, adapted from Davis et al., 2010.

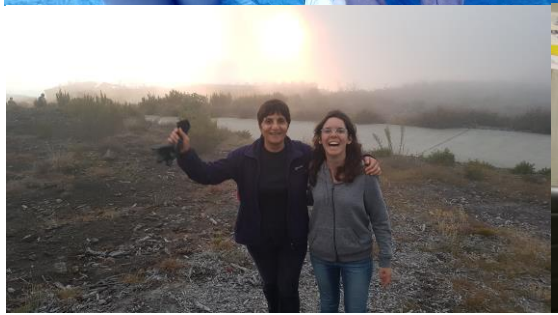
Lessons learned/Results from CONCIRTO

- **Balloon measurements are challenging in a convective environment (early balloon burst, contamination) but provide useful observations for modeling of deep convection/TCs and effects on TTL composition (TC Enawo/Gelena)**
- **2 cases of TTL cirrus from the intensive Jan-Feb 2019 campaign/ongoing cloud resolving modeling**
- **Data from RS92/RS41/M10/CFH & Lidar have been used for validation of the M10 GDP**
- **~2 months of cloud radar observation to be analyzed**
- **Microwave radiometer water vapor profiles will be used to test Raman water vapor lidar calibration with MWR.**

Need of TTL/stratospheric in situ airborne (balloon/aircraft) measurements in remote tropical oceanic regions

A big thanks to the CONCIRTO Team: Jerome, Susanne, Frank, Bert, Damien, Irene, Jean-Marc, Françoise, Neely, Allister, Emal, Freya…!




Lyanna, born on 23 Apr 2019

Thank you for your attention and see you (hopefully…) next year in Réunion Island !