The THINICE Field Campaign: Interactions Between Arctic Cyclones, Clouds and Sea Ice

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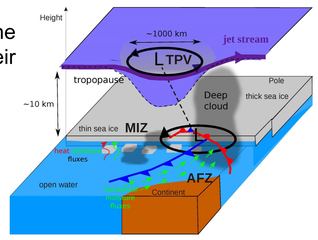
THINICE Overview

Overarching Objectives

- New understanding of the key processes governing the development and evolution of Arctic cyclones, and their influence on coupled air-sea-ice processes.



Targeted phenomena and processes

- Summertime Arctic cyclones dynamics
- Tropopause polar vortices
- Arctic moist intrusion events
- Cloud microphysics
- Interactions with surface hetereogeneities & sea ice

Multi-Agency International Program

- Office of Naval Research Department Research Initiative Supporting a U.S. and French collaborative team
- British Antarctic Survey (BAS) THINICE UK Program (U. Reading, U. East Anglia)

Objectives for ONR-French Program

RALI-THINICE

Processes in the formation/maintenance of mixed-phase clouds

- How are the ice and liquid phases mixed and spatially distributed within the cloud?
- How do the radiative, dynamical, microphysical processes interact and control mixed-phase clouds life cycle?

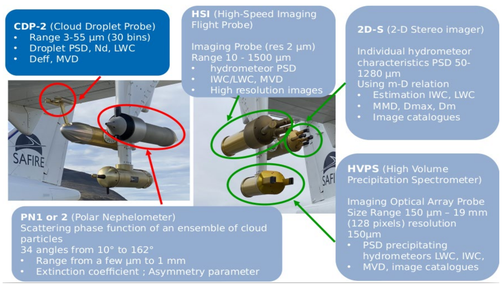
Interactions between microphysics and Arctic cyclones circulations

- How does cloud microphysics representation impact Arctic cyclones dynamics?

Evaluation of NWP and climate models skill in representing Arctic Cyclones, embedded fronts and clouds

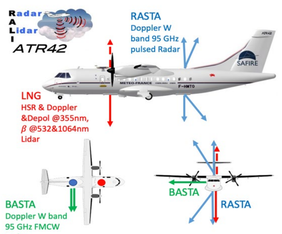
- Focus on low-level jets, fronts and mixed-phase clouds above open water / sea ice

ATR42 payload



+Nevzorov (Bulk TWC) + Licor/KH20 (turbulence) + UHSAS (aerosols)

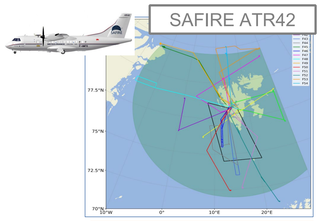
Remote-sensing



CLIMAT (Infrared radiometer)

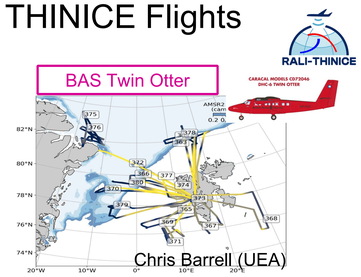
British Antarctic Survey – MASIN Twin Otter

Overview of the THINICE Flights



16 flights, 62 flight hours
(5 Aug – 26 Aug 2022)

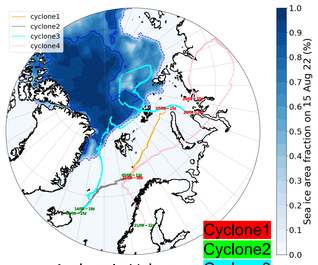
Arctic cyclones development.
Mixed phase clouds within Arctic cyclones.
Improve clouds representation in models.



18 flights, 80 flight hours
(29 July – 20 Aug 2022)

Boundary-layer interaction with cyclones.
Turbulent & heat fluxes, sea ice surface.
Improve drag parametrization over sea ice.

Four Cyclones Observed and Relation to Flights



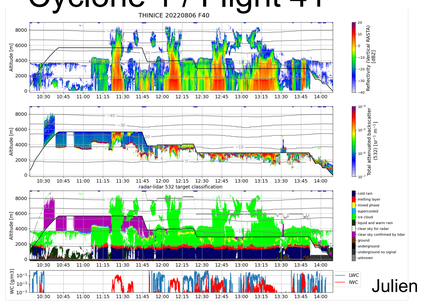
ATR 42

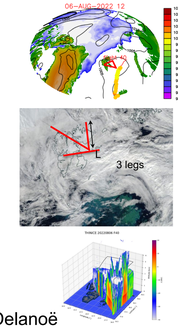
Flight	Date	Take-off	Landing
39	5 Aug	13:29	16:58
40	6 Aug	10:18	14:09
41	8 Aug	10:00	13:49
42	9 Aug	12:57	16:29
43	10 Aug	13:25	17:03
44	11 Aug	06:55	10:57
45	12 Aug	11:54	15:46
46	16 Aug	12:30	16:48
47	17 Aug	12:01	15:28
48	18 Aug	09:01	12:53
49	19 Aug	12:00	16:22
50	22 Aug	10:04	14:45
51	22 Aug	15:47	19:27
52	23 Aug	07:34	11:39
53	25 Aug	10:51	14:34
54	25 Aug	15:44	19:39

MASIN

Flight	Date	Take-off	Landing
363	29 Jul	11:25	16:55
364	30 Jul	10:54	16:14
366	2 Aug	07:15	10:55
367	2 Aug	12:48	17:18
368	6 Aug	10:04	15:24
369	8 Aug	09:25	15:05
370	9 Aug	07:00	11:45
371	11 Aug	07:10	12:50
372	12 Aug	07:00	11:35
375	15 Aug	15:33	18:58
376	16 Aug	09:39	12:49
377	16 Aug	13:22	16:47
378	17 Aug	08:00	12:40
379	19 Aug	07:10	12:25
380	20 Aug	10:00	14:30

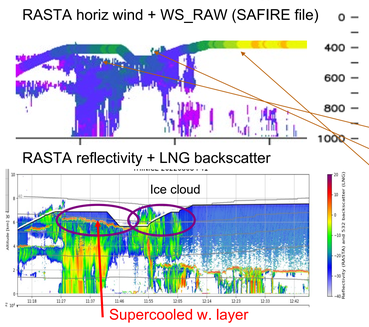
Mixed-Phase Clouds Cyclone 1 / Flight 41

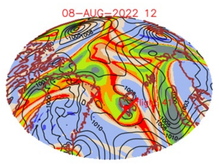




Julien Delanoë

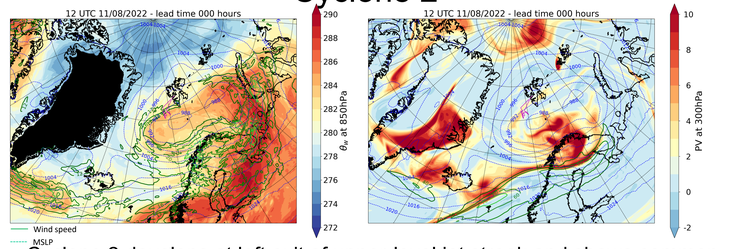
Tropopause Polar Vortex Flight 41





Below the TPV, there are three types of environment
(i) to the NE, cloud top near -30°C formed of supercooled water
(ii) NE-middle, cloud top near -40°C, likely made of ice crystals
(iii) SW : clear sky and low-level clouds where the strong jet is

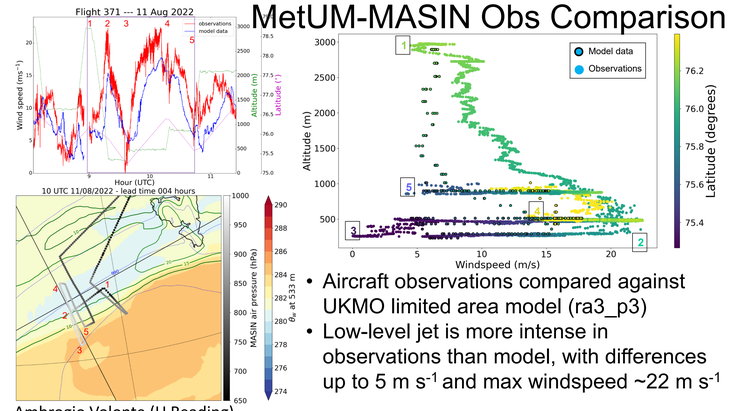
Cyclone 2



- Cyclone 2 develops at left exit of upper-level jet streak and shows common mid-latitude features, such as clear cold and warm fronts.
- At the time of Flight 371 Cyclone 2 is in its mature stage, stretched zonally. It transits S of Svalbard moving E

Ambrogio Volonte (U Reading)

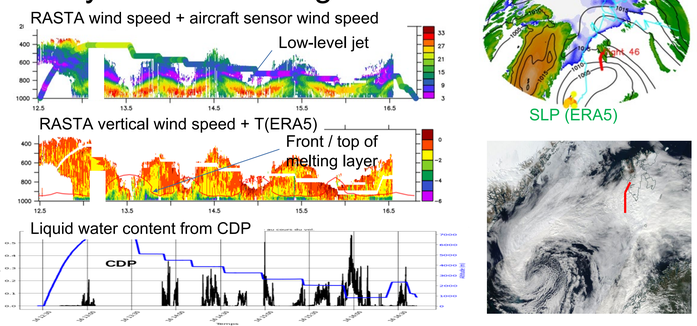
MetUM-MASIN Obs Comparison



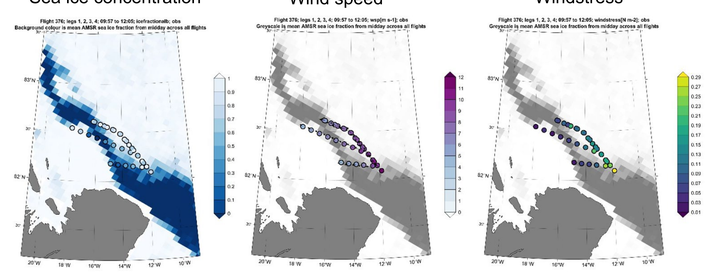
- Aircraft observations compared against UKMO limited area model (ra3_p3)
- Low-level jet is more intense in observations than model, with differences up to 5 m s^{-1} and max windspeed ~22 m s^{-1}

Ambrogio Volonte (U Reading)

Cyclone 3 and Flight 46



Turbulent Momentum Flux (Example from MASIN)



Chris Barrell (UEA)

Summary

Four Arctic cyclones were intensively observed during the THINICE using the French ATR-42 and BAS MASIN Twin Otter during August 2023.

- Observational dataset will be used for process-based studies of clouds, microphysics, boundary layer and air-sea ice processes, cyclone dynamics
- Predictability studies will make use of the Windborne Systems balloon obs.

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