FINAL REPORT PROGRAM LEFE

Program LEFE/ IMAGO	ADELISE	Years 2018 – 2020

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Contribution to

Other funding sources :
ANR ASUMA
IPEV/ADELISE
Own resources from LSCE group

Context

A precise understanding and estimation of the surface mass balance in Antarctica is difficult, though of utmost importance to predict future evolution and implication for sea-level. In particular, coastal regions like Adelie Land are highly affected by katabatic winds inducing surface snow remobilization, and blowing snow also induces large uncertainties in surface sublimation estimation.

Objectives / scientific questions

The main objectives of the project were 1/ a better understanding the atmospheric water cycle in Adelie Land by documenting water isotopes both in water vapor, precipitation and surface samples 2/ a reconstruction of the regional variability in Adelie Land over the last 50yrs thanks to bunches of neighbor cores allowing to disentangle signal from noise.

Main results

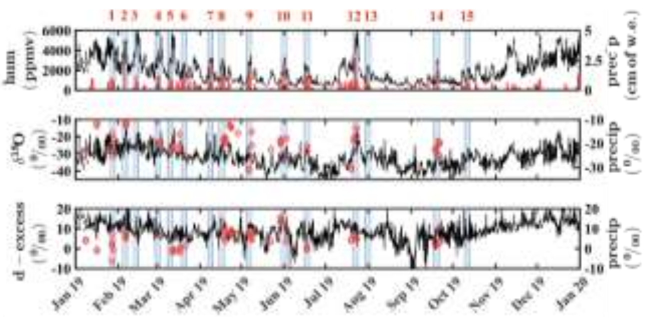

Figure 1: First year-long water vapor isotopic composition recorded at Dumont d’Urville station (Leroy-Dos Santos, 2021).
First panel: humidity and precipitation amount. Second and third panels: δ^{18}O and *d − excess* of atmospheric water vapor (black line) and of precipitation samples (red diamonds). Light blue bars indicate the fifteen biggest precipitation events.

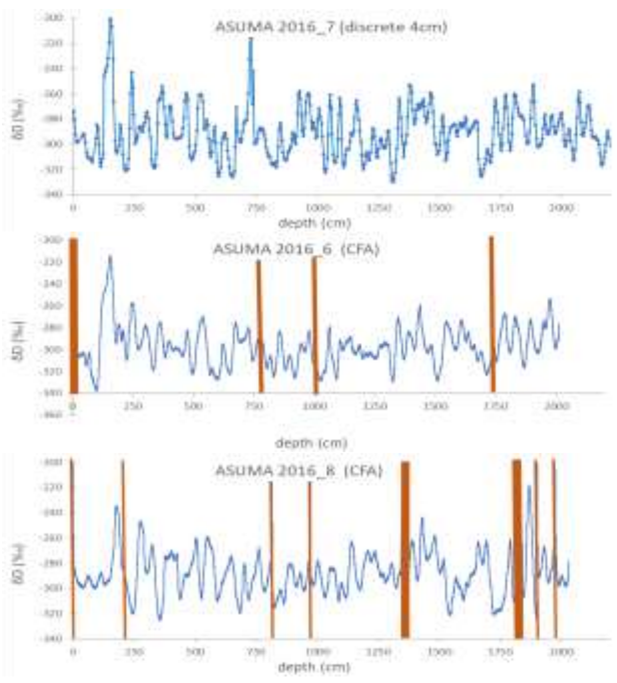

Figure 2: Isotopic record (δD) of three shallow cores (20m) drilled at Stop 0 during the ASUMA field campaign (69.6359°S – 135.2796°E). Discrete samples for core #7 with a resolution of 4 cm (Leroy-Dos Santos, 2021); Continuous Flow Analysis for core #6 (unpublished) and core #8 (Tcheng, 2021)

During his PhD, C. Leroy-Dos Santos compared the isotopic measurements on core ASUMA 2017_7 with a reconstructed core based on temperature and precipitation from ERA5 reanalysis and assuming a linear relationship between temperature and isotopic signature. This clearly demonstrated that in Adelie Land, the isotopic records cannot be directly interpreted as a temperature proxy, as already suggested by S. Goursaud *et al.*(2017, 2019) using a coarser approach on two other shallow cores closer to the coast. Indeed, on top of the condensation temperature, isotopic composition is also very sensitive to the origin of moisture and trajectory between the evaporation source and the site of precipitation.

To better understand how these these effects are recorded in ice cores, it is first necessary to document the links between the isotopic composition of water vapor (and snow) and the different synoptic and meteorological conditions; after a first pilot season limited to the summer season showing strong diurnal cycles associated to clear-sky conditions (Bréant et al., 2019), we successfully installed during this project a year-long monitoring of the isotopic composition of water vapor and precipitation at Dumont D'Urville station (**Figure 1**, monitoring still on-going). This was possible thanks to the development of a low humidity level generator (Leroy-Dos Santos *et al.*,2021), necessary to calibrate our laser spectroscopy instrument during winter time. Large precipitation and atmospheric rivers events (identified by the numbers above the upper panel in Fig 1) have been explored using Flexpart back-trajectories to identify low-latitude origin of moisture. This record is also key for ongoing model evaluation (LMDZ whose resolution appeared too coarse to resolve the local weather at the station, MAR and ECHAMwiso which shows very good agreement with the data).

In parallel to the studies on water vapor, we started measuring the shallow ice cores drilled during the 2016-2017 ASUMA campaign. The three cores displayed in **Figure 2** were all drilled within meters and highlight why multiple cores are necessary in this Antarctic region to properly infer the signal to noise ratio of the isotopic profiles and to extract the most meaningful regional climatic signal. The differences between the three records can be attributed to local post-deposition effects, like wind remobilization, blowing snow, local densification effects… From a technical point of view, this project was the opportunity to run the Continuous Flow Analysis facility developed at LSCE for the first time with firn cores and to validate the whole set-up. The expected schedule for core measurements was delayed due first to cold room failures and then to the Covid situation which prevented us from working together in the cold room. More work is on-going, as well as statistical studies of the signal (master study in 2022 and hopefully a PhD starting in fall).

Future of the project:

A manuscript (Leroy-Dos Santos *et al.*) will be submitted in the following months to publish the vapor isotopic record at DDU and model validation study. The monitoring of the water vapor isotopic composition at Dumont d'Urville is going on, especially to explore the effect of sea-ice extent from one year to another. It will be included in wider projects of monitoring: ANR ARCA with a similar set-up to be installed in 2022 at coastal Davis station (Australian) and ERC AWACA with autonomous containers to be installed in 2024-2025 along a transect from DDU to Concordia Dome C where a laser instrument is already running. The results from this project were decisive to join the consortia of these successful proposals.

The results on ice core analysis will be presented at IPICS conference in Oct 2022. The ARCA project also builds on the ASUMA core analysis to explore the possibility to trace atmospheric river frequency in Adelie Land ice cores. A 2nd year master thesis is beginning the study of the cores from a mid-slope point between Stop 0 and DDU. Titouan Tcheng is applying for an ENS doctoral scholarship to continue his 1st year master thesis in 2021.

Nombre de publications, de communications et de thèses

Publications :

- C. Bréant *et al*. Coastal water vapor isotopic composition driven by katabatic wind variability in summer at Dumont d'Urville, coastal East Antarctica. EPSL, 514, 37-47, 2019 https://doi.org/10.1016/j.epsl.2019.03.004
- C. Leroy-Dos Santos *et al*. A dedicated robust instrument for water vapor generation at low humidity for use with a laser water isotope analyzer in cold and dry polar regions. Atmos. Meas. Tech., 14, 2907–2918, 2021 https://doi.org/10.5194/amt-14-2907-2021

Communications :

1 en 2018 : Journées scientifiques du CNFRA (Comité national français des recherches arctiques et antarctiques)
2 en 2019 : Atelier Hautes Latitudes de Paris Saclay and IUGG (International Union of Geodesy and Geophysics)
2 en 2020 : EGU and Virtual Be-OI isotope workshop
2 en 2021: EGU and Water cycle and water isotopes international meeting

Thèses incluant des chapitres concernant ce projet:

Sentia Goursaud (2018), Christophe Leroy-Dos Santos (2021)
1st year master student : Titouan Tcheng (2021)