A short history of the assimilation of AEOLUS HLOS winds in the Météo-France global NWP model with the latest results.

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Outline

- A short history of the assimilation of AEOLUS HLOS winds in the Météo France global NWP model
- Current global NWP system and observation usage
- Overview of AEOLUS HLOS wind assimilation in operations
- Two OSEs to assess AEOLUS current and next months impacts
- Conclusion / future activities
Archeology (NWP purpose only)

2004-2007 (Paul Poli, Alain Dabas):
- Development of L2Bp
- Interfacing L2B with IFS code and ODB database

2008-2016 (Christophe Payan):
- Porting to NEC vectorial architecture
- Interfacing L2B with IFS code
History of AEOLUS winds assimilation in ARPEGE

- **2017** (Vivien Pourret, Christophe Payan):
  - First installation of the stand-alone L2B processor for Bufr production
  - Preparation of the assimilation in the ARPEGE code
  - Use of Aeolus simulated test data got on the ESA Aeolus data Online Dissemination System to make Bufrs with L2Bp and test assimilation in ARPEGE

- **2018 (launch)** (Vivien Pourret, Matic Savli):
  - First monitoring XP, systematic and random errors chasing
  - First Assimilation XP and encouraging impact studies

- **2019** (Vivien Pourret, Matic Savli):
  - ECMWF dissemination of Bufrs on Eumetcast entering in the MF operational observation database in RT.
  - OSE with first very positive impact (with effective bias correction methods developed at MF and at ECMWF): first WAHOO effect!

- **2020** (Vivien Pourret, Matic Savli):
  - January: operational monitoring
  - OSE with very positive impacts (with M1 bias correction method): second WAHOO effect!
  - June: operational assimilation in ARPEGE (and EDA)
  - Sensitivity study of Aeolus HLOS winds to temperature and pressure specification in the L2B processor

- **2021** (Vivien Pourret, Ibrahim Seck):
  - Study of the distinct contributions of Rayleigh and Mie channels of the first reprocessed dataset in NWP impacts of 3 OSEs
  - Case studies of North Atlantic tropical cyclones for season 2019.
Global model ARPEGE (high resolution)

Incremental 4D-Var assimilation (6-h window and 30 min time-slots):

- 2 loops of minimization: $T_L^{224}c1L105$ (40 iterations) + $T_L^{499}c1L105$ (40 iterations)
- Background error variances and correlation lengths from an EDA system (4D-Var at lower resolution: $T_L^{499}/T_L^{224}$) with 50 members (AEARP)

Forecasts (cut-off and ranges):
- 00 UTC (1h10/54h), 00 UTC (2h15/102h), 06 UTC (3h/72h), 12 UTC (1h50/114h), 18 UTC (3h/60h)

Spectral model with variable resolution:
$T_L^{1798}c2.2L105$

# resolution from 5 to 25 km
# 105 vertical levels from 10 m to 0.1 hPa

Since 07/2019
Observation evolution in ARPEGE

Evolution des cumuls mensuels de nombre d'observations utilisées par type d'observation

analyses cut-off long ARPEGE métropole - observations conventionnelles et satellites

Monitoring of Aeolus
January 2020

Assimilation of Aeolus
June 2020
FSOi : February 2022

Slow decrease of the relative positive impact especially for Rayleigh (5% to 3.3% of the total FSOi from 06/2020 to 02/2022, not shown). Aeolus still have one of the best positive impact in terms of FSOi per datum (February 2022).
Assessing AEOLUS impacts for the end of the mission with two OSEs.

Slow increase of SD(OmB) from ~6.5 m/s to ~7.5 m/s till November 2021. Best results with new N/P settings since December 2021, but with a slow increase from ~6.6 m/s since December 2021 to ~6.9 m/s now. It will probably reach ~7.5 m/s in June/July 2022, e.g. same level as in September 2021.

→ comparing results of two one-month OSEs:
OSE1: September 2021 (what we could expect 06-07/2022)
OSE2: December 2021- January 2022 (current state)

TOY ARPEGE:

Spectral model with variable resolution:
T:798c2.2 L105
# Dx from 10 to 50 km
# 105 vertical levels from 10 m to 0.1 hPa

Incremental 4D-Var assimilation (6-h window and 30 min time-slots):
• 2 loops of minimization: T,224c1L105 (40 iterations)
• Background error variances and correlation lengths from an EDA system (4D-Var at lower resolution: T,224) with 50 members (AEARP)

α0 scaled as a function of prescribed HLOS L2B errors (based on one year of operational assimilation dataset)

Quality controls:
HLOS winds restricted to Rayleigh/clear and Mie/cloudy
• Rayleigh/clear above 850 hPa
• Rayleigh winds kept when 2 m/s < α0 < 8 m/s
• Mie winds kept when 0.5 m/s < α0 < 3 m/s
• Background check to reject winds too far from model (5α)
RS u wind (OmB) statistics for OSE1 and OSE2

OSE1 (R+M) 09/21 (B12)
Rayleigh SD(OmB)=7.3 m/s

OSE2 (R+M) 12/21-01/22 (B13)
Rayleigh SD(OmB)=6.6 m/s

As expected, impacts in OSE1 and OSE2 are smaller than in the OSE with early reprocessed FM-B data.

As OSE1 and OSE2 are short, significativity of results is not very clear.

In NH and SH, impacts are slightly better in OSE2 than in OSE1. In NH results are mitigated for OSE1.

Unexpectedly, in tropics, impacts on short terms forecasts are better in OSE1 than in OSE2. In tropics, OSE1 is still good compared to OSE with early FM-B data.
Forecast scores (winds)

OSE1 (R+M) 09/21 (B12)
Rayleigh SD(OmB)=7.3 m/s

OSE2 (R+M) 12/21-01/22 (B13)
Rayleigh SD(OmB)=6.6 m/s

First reprocessed FM-B (B10)
OSE (R+M) 07-10 /19
Rayleigh SD(OmB)=5 m/s

As expected, impacts in OSE1 and OSE2 are smaller than in the OSE with early reprocessed FM-B data especially in the UTLS, tropics and SH. Forecast range of impacts are decreasing.

Results for both OSEs are very close, except in NH.

Except in NH, impacts on forecast scores do not seem to be too much affected by the 0.7m/s difference of quality of Rayleigh/clear data samples used in OSE1 and OSE2.

In NH, OSE1 has a slight marginal positive impact.

NH

Tropics

SH
Forecast scores (winds) over poles

As expected, impacts in OSE1 and OSE2 are smaller than in the OSE with early reprocessed FM-B data. Impacts in OSE2 are still positive over North and South Pole but smaller than in OSE with early FM-B data. Impacts are weaker and more mitigated in OSE1 especially over North Pole.

OSE1 (R+M) 09/21 (B12)
Rayleigh SD(\sigma_B)=7.3 m/s

OSE2 (R+M) 12/21-01/22 (B13)
Rayleigh SD(\sigma_B)=6.6 m/s

First reprocessed FMB (B10)
OSE (R+M) 07-10 /19
Rayleigh SD(\sigma_B)=5 m/s

Normalized differences of RMS(REF-FCST) between CTRL and EXP
CTRL : ARPEGE (no AEOLUS)
REF : ECMWF analyses

REMINDER

As expected, impacts in OSE1 and OSE2 are smaller than in the OSE with early reprocessed FM-B data. Impacts in OSE2 are still positive over North and South Pole but smaller than in OSE with early FM-B data. Impacts are weaker and more mitigated in OSE1 especially over North Pole.
Case studies of North Atlantic tropical cyclones of season 2019

Aeolus improves NWP forecasts scores, especially in the tropics

How Aeolus HLOS winds impact our ability to describe and predict synoptic phenomena such as cyclones?

To find out, we use results of early FM-B OSE (7-10 2019) to assess the impact on track, maximum speed and minimum pressure of a dozen of NA tropical cyclones during their tropical storm/hurricane phase. Results are compared against BEST TRACK data provided by NHC.

Evolution of maximum speed of DORIAN (10 m asl), Lead 24h

Evolution of pressure at the center of DORIAN, Lead 24h

Evolution of position O-F for DORIAN, Lead 24h

Early results show a marginal modification in the prediction of cyclone dynamics, more work is needed to understand Aeolus wind data impact, and the separate contribution of the Mie and Rayleigh channels.
Conclusions and future activities

- A long story at Météo-France which was worth it!
- We have operationally monitored AEOLUS data in ARPEGE since January 2020, and have operationally assimilated them since June 2020 with very positive impacts.
- Operational FSOi shows that Aeolus still provides positive impact until February this year (even with the slow increase of Rayleigh winds observation error).
- OSEs to assess the impact of AEOLUS winds now and in the next months (09/21 and 12/21-01/22).
- We will probably reach next month (06-07/22) the 09/21 Rayleigh/clear error levels where we could expect:
  - Impacts still be positive over tropics (for shorter ranges)
  - Weaker and mitigated impacts over poles

- Planned activities: consolidate statistics over the period of the whole first reprocessed dataset, statistical and case studies (tropical storms).
- Ready to assimilate until the end!
Thank you for your attention!
Monitoring: June 2020 - March 2022
HLOS winds bias corrected from M1 temperature gradient

Slow increase of SD(OmB) from ~6.5 m/s to ~7.5 m/s till November 2021.
Best results with new N/P settings since December 2021, but increasing.

Stable signals for Mie.
Slight negative bias.
Decreasing data counts.

Blue : SD(OmB)
Red : SD(OmA)
Green : mean(OmB)
Pink : mean(OmA)
Orange : obs number