Assessment of the operational potential of assimilating IASI L2 in a regional model

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Eumetsat study EUM/CO/17/4600001975/TA

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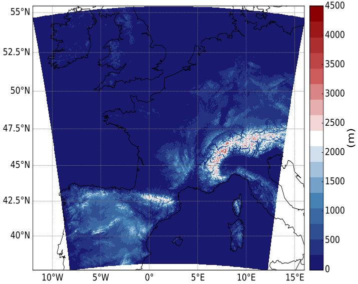
Outline

Applications of Research to Operations at MEsoscale

Characteristics:

- Horizontal Resolution ⇒ 1.3 km;
- Vertical Resolution ⇒ 90 levels (10 hPa top);
- Boundary conditions ⇒ ARPEGE;
- Forecast lead time ⇒ 48 hours

AROME domain and orography



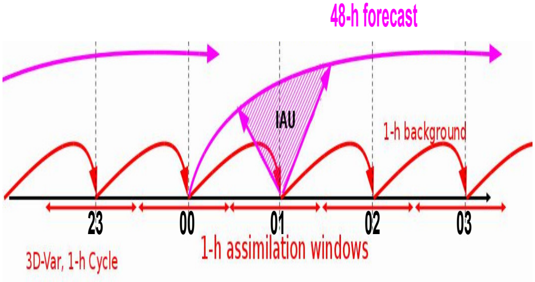
Brousseau et al. (2016) and Seity et al. (2011)

Applications of Research to Operations at MEsoscale

Assimilation System:

- Scheme ⇒ 3D-Var ;
- Assimilation Window ⇒ 1 hour;
- Assimilation cycle ⇒ 1 hour;

Assimilation Scheme

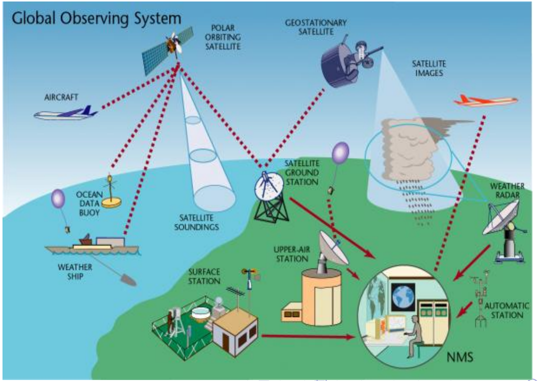


Applications of Research to Operations at MEsoscale

Observations Assimilated:

- Surface stations
- Buoys
- Ship
- Ground GPS
- Aircrafts
- Wind profilers
- Radiosounding
- Radar (RH retrieval and doppler wind)
- Satellite observations - IASI, AMSU-A, MHS, ATMS, SEVIRI, GMI and SSMI .

Global Observing System



WMO

MetOp combined retrieval L2 Products

There are statistical retrieval (piece-wise linear regression) products, which combine products from IASI and microwave sensors (AMSU-A and MHS).

Information Used:

- Temperature profiles;
- Water vapour mixing ratio profiles;
- Pressure levels;
- Surface mean elevation in the pixel;
- Quality control indicator (QCI)

- Only L2 from locally received observations in Lannion.
- No Metop-A in the evening.
- Vertical Resolution: 109 levels below 10 hPa.
- Period v6.3: 07/2017 to 02/2018 Period v6.4: 05/15/2018 to 09/2018.

Objectives

The main objective of this project was to evaluate the potential benefits of assimilating Metop L2 products in replacement of L1 products (radiances) from IASI, AMSU-A and MHS into the AROME-France data assimilation system.

Main Steps:

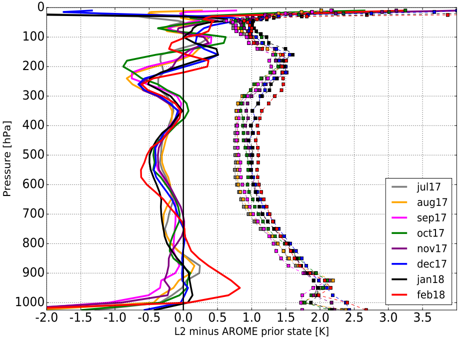
- Evaluation of the MetOp combined retrieval L2 product compared to AROME-France short-range forecast;
- Perform the assimilation experiment with MetOp combined retrieval L2 product (define setups);
- Evaluation of the assimilation experiments using objective scores.

L2 product (v6.3) X AROME - Monthly Variation

Temperature Profiles

Mean Bias and Standard Deviation:

- Agreement below 1 K in mid-troposphere.
- Larger differences near surface and between 200-300 hPa.



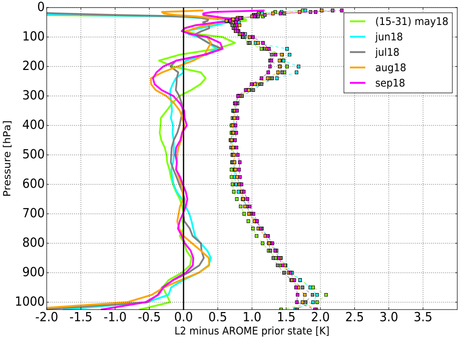
Solid lines - Mean differences
Dashed lines with squares - standard deviations

L2 product (v6.4) X AROME - Monthly Variation

Temperature Profiles

Mean Bias and Standard Deviation:

- Improvement in the bias between 400 and 800 hPa. The standard deviation is smaller near surface, the values are closer 2 K in the v6.4.

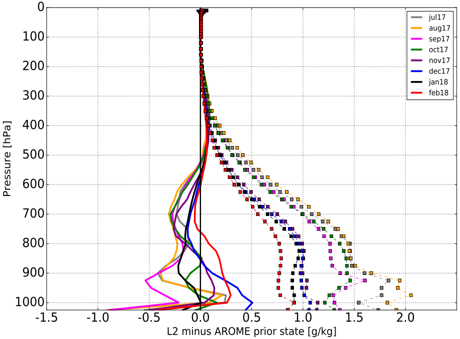


Solid lines - Mean differences
Dashed lines with squares - standard deviations

L2 product (v6.3) X AROME - Monthly Variation

Specific Humidity Profiles

- **Mean Bias:**
  - It is negative near surface in most cases (except in December).
- **Standard Deviation:**
  - Absolute differences varying with seasons (actual moisture content)

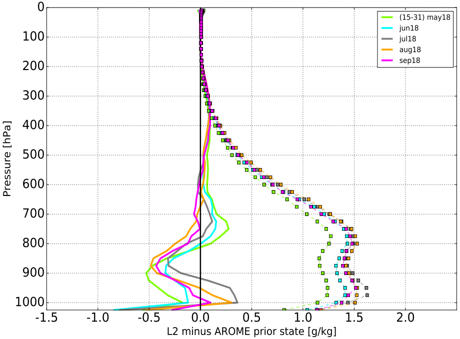


Solid lines - Mean differences
Dashed lines with squares - standard deviations

L2 product (v6.4) X AROME - Monthly Variation

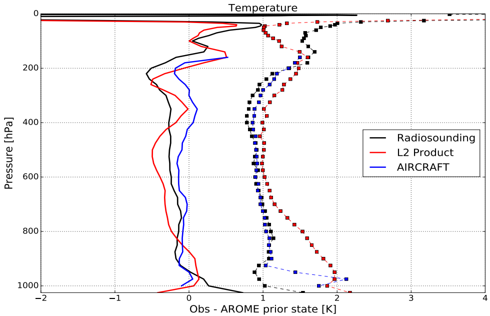
Specific Humidity Profiles

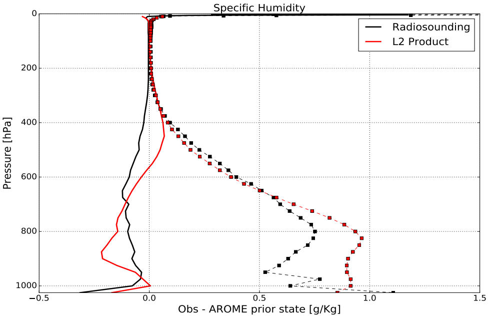
- Improvement in the bias between 600 and 800hPa, below in the atmosphere there is a degradation, near 900hPa the bias has a negative peak in all evaluated months. The standard deviation has a small spread in the v6.4 when compared against v6.3. It is really evident near surface.



Solid lines - Mean differences
Dashed lines with squares - standard deviations

L2, radiosonde and aircraft X AROME (January/2018)





Solid lines - Mean differences
Dashed lines with squares - standard deviations

Evaluation of the L2 product

Conclusion:
The L2 product statistics against AROME model have behavior similar to L2 product evaluated against radiosondes in the IASI L2 PPF v6.4.
The evaluation against radiosounding and aircraft first guess departure (OMF) showed that the L2 products profiles present a good quality in terms of OMF.

Outline

1. Introduction
2. Evaluation of the MetOp combined retrieval L2 product
3. Assimilation experiments
    - Experiments setups
        - L1 assimilation details
        - L2 assimilation details
    - Impact on the statistics of the other assimilated observations
    - Forecast verification
        - Upper-Air verification
        - Verification at 2 meters
        - Precipitation verification
4. Closing Remarks

Experiments Configuration

Period 1 (Summer): Jul 15th, 2017 to Sep 15th, 2017 (63 days)
Period 2 (Winter): January, 2018 and February, 2018 (59 days)
Period 3 (Spring): May 15th, 2018 and Jun 26th, 2018 (43 days)
Two study cases: The results will not be shown

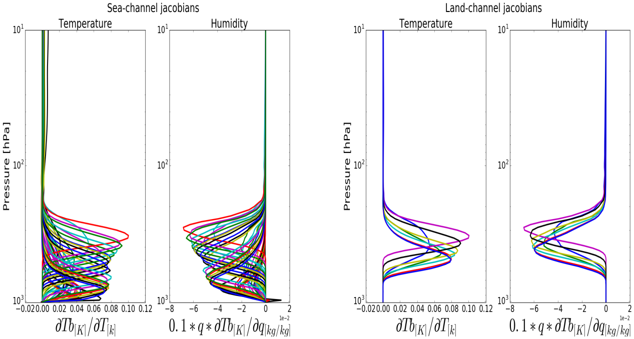
Experiment	**Configuration**
Baseline	No IASI, AMSU-A and MHS data
Control	Baseline + IASI, AMSU-A and MHS L1 product
L2 Experiment	Baseline + L2 product

IASI, MHS and AMSU-A L1 Product assimilation details

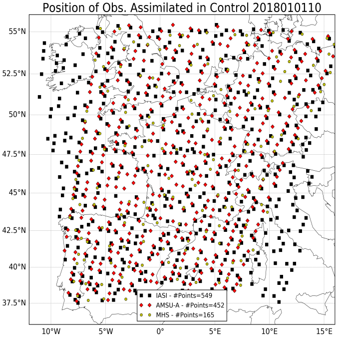
IASI assimilated by AROME-France (Control)

20 temperature channels, 20 water vapour channels and 4 surface channels

Vertical Resolution



Horizontal Resolution

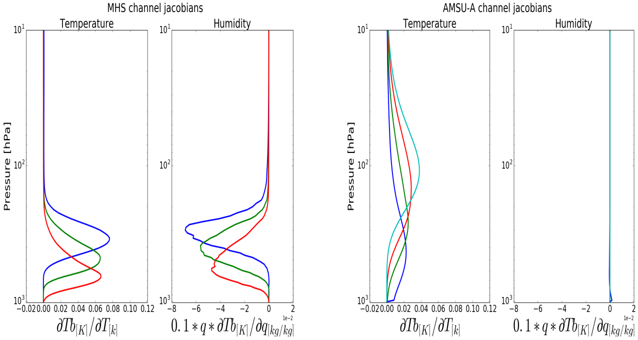


IASI thinning ⇒ 80 km

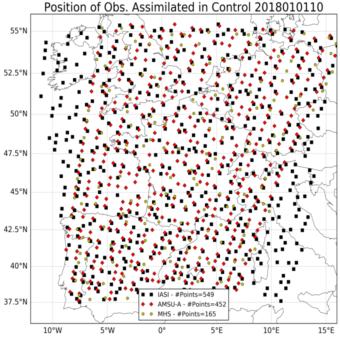
MHS and AMSU-A assimilated by AROME-France (Control)

3 MHS channels (3, 4, 5) and 4 AMSU-A channels (5, 6, 7 and 8)

Vertical Resolution



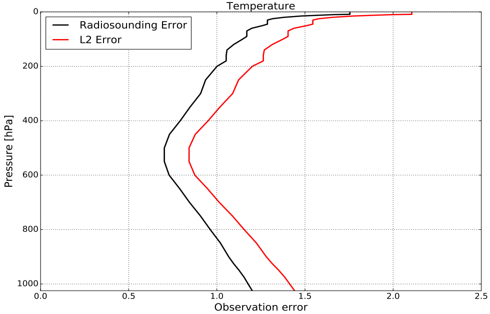
Horizontal Resolution

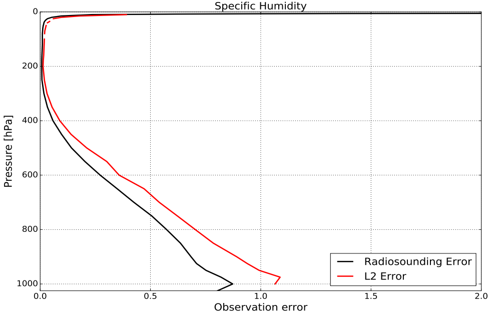


AMSU-A thinning ⇒ 100 km
MHS thinning ⇒ 80 km

L2 Product (temperature and specific humidity profiles) assimilation details

Define the observation error: L2 and radiosounding error profiles





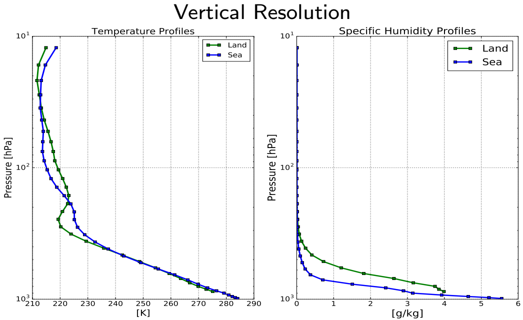
L2 observation error

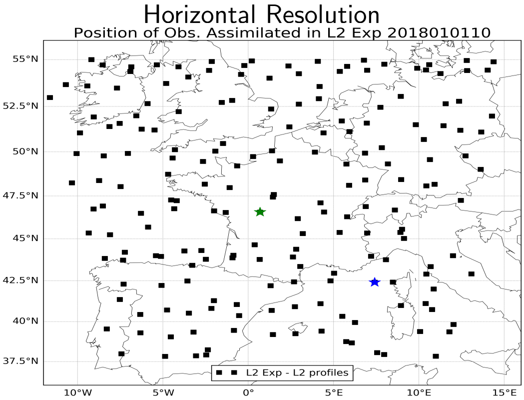
Temperature (L2) observation error ⇒ 1.2 * radiosonde observation error
Humidity (L2) observation error ⇒ 1.25 * radiosonde observation error

L2 data setup

Thinning:

- Horizontal: select one profile over a 160 x 160 km ("best" QCI)
- Vertical: 1 level every 3 levels





★ L2 example profile over sea
★ L2 example profile over land

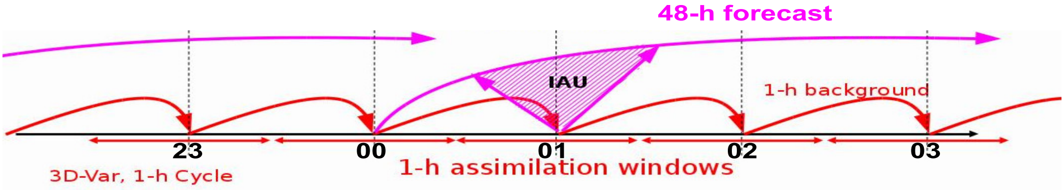
L2 data setup

Filters Applied:

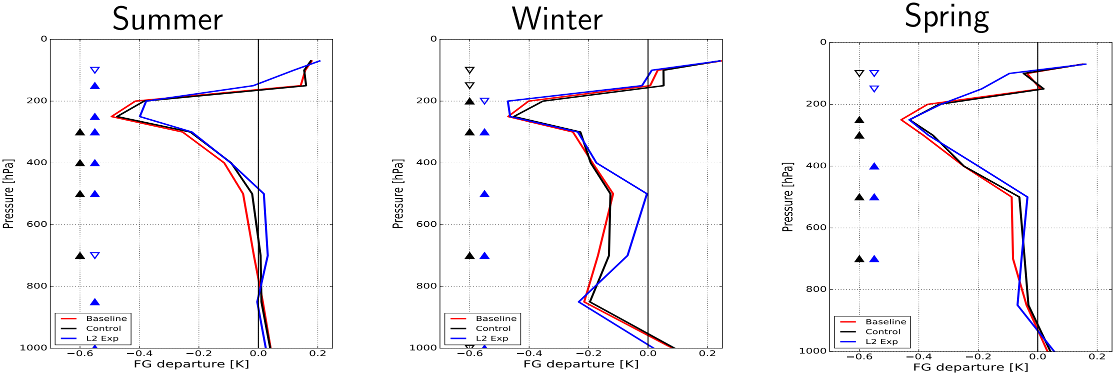
Region	**Filter**
Sea	Use data only above level 1000 hPa
Land, orography below 1 km	Use data only above level 900 hPa
Land, orography above 1 km	Use data only above level 700 hPa

Outline

Observation minus first guess (OMF) and standard deviation of OMF
Red arrows' evaluation



Observation Minus First Guess (OMF) - Radiosonde (Temp)



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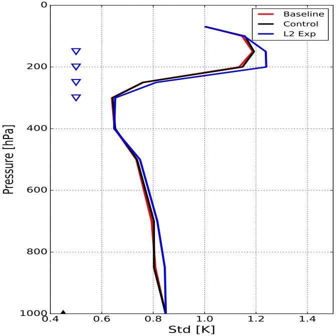
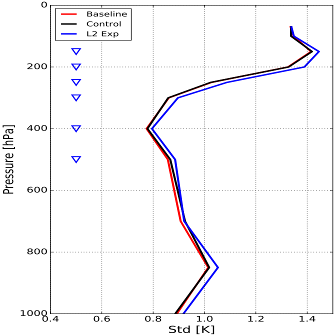
Standard Deviation of OMF - Radiosonde (Temp)

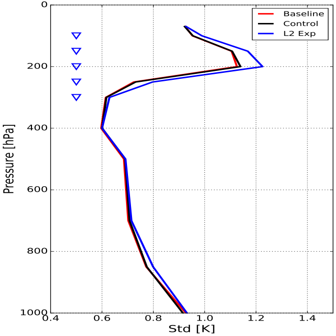
Summer



Winter



Spring



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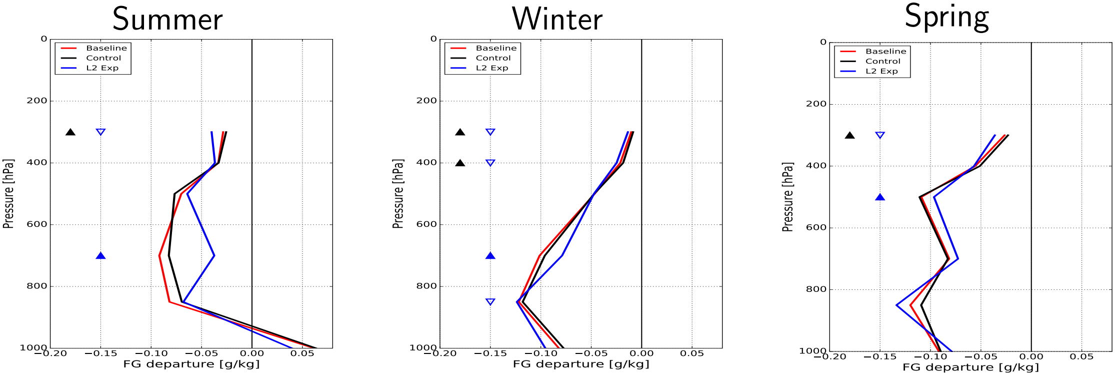
Observation Minus First Guess (OMF) - Radiosonde (Q)



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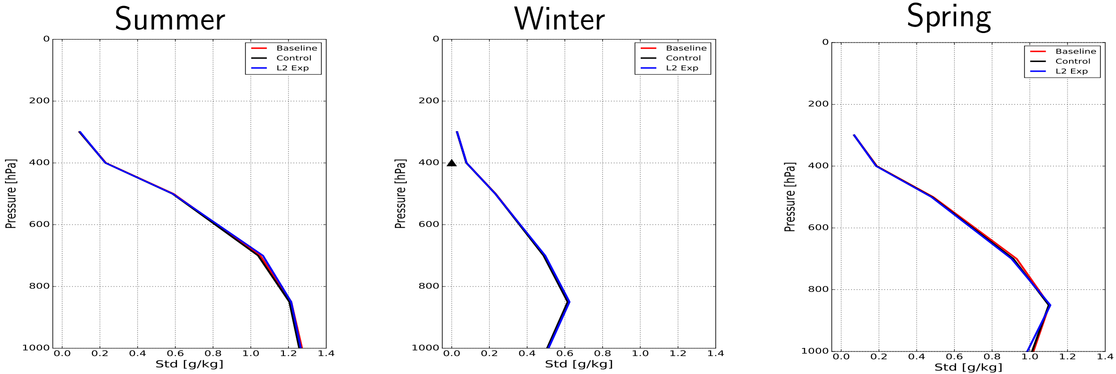
Standard Deviation of OMF - Radiosonde (Q)



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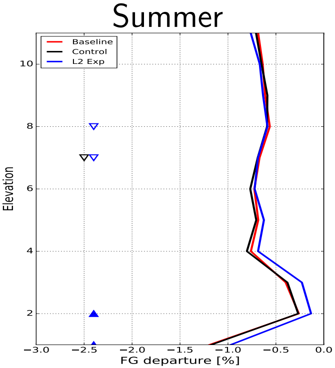
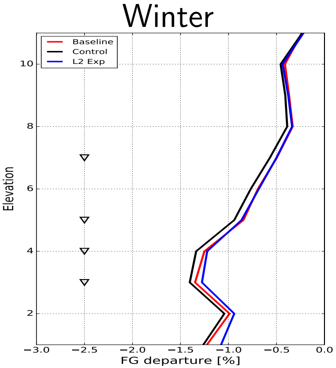
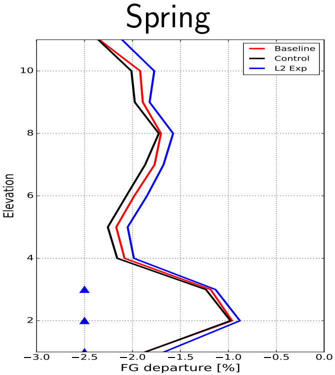
Observation Minus First Guess - Radar (RH)







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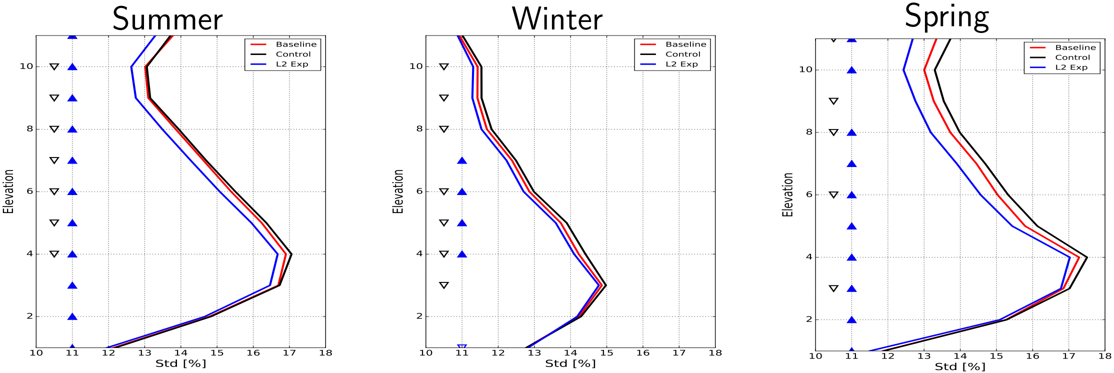
Standard Deviation of OMF - Radar (RH)



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Conclusion:

Temperature Observations:

- L2 Experiment: It helped to decrease the first guess departure (OMF) of temperature observations in the middle atmosphere. These behavior are not observed in the standard deviation profiles where there is a degradation (top of profiles).
- L1 Experiment:It also helped to decrease the first guess departure in the middle atmosphere and up to 300 hPa (almost all periods). As in L2 experiment this characteristic are not observed in the standard deviation profiles.

Conclusion:

Humidity Observations:

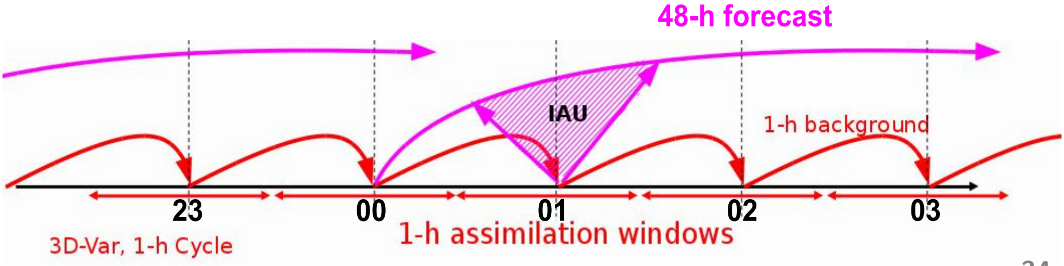
- L2 Experiment: this experiment helped to decrease the first guess departure (OMF) between 800 and 700 hPa (radiosounding), however at 300 hPa there is a degradation. In the relative humidity, retrieved from radar observations, the OMF present an improvement up to elevation 6. The standard deviation of OMF of radar observations shows an improvement in almost all elevations.
- Control Experiment: it helped to decrease the OMF of radiosounding between 800 and 600 hPa (except Spring period) and up to 300 hPa. However, this experiment contributed to increase the OMF of radar (RH), more evident during the Winter and Spring period. The standard deviation of radar observations is increased in this experiment and it is more evident during Winter and Spring periods.

Outline

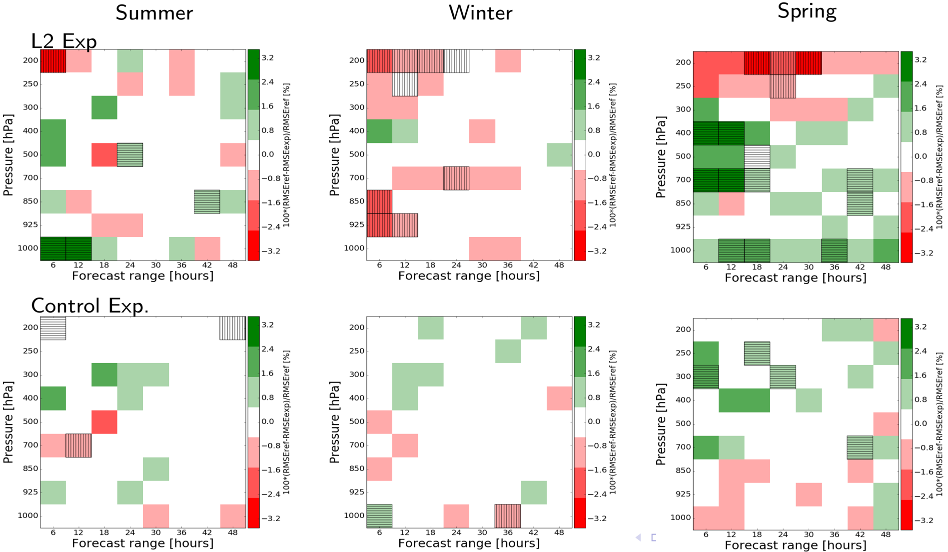
Forecast Verification

- Upper-Air verification - Evaluation against an independent analysis (ECMWF)
- Verification at 2 meters - Evaluation against surface stations over France (nearly 600 stations)
- Precipitation verification - Evaluation against rain gauges.

Magenta arrows' evaluation.



Temperature

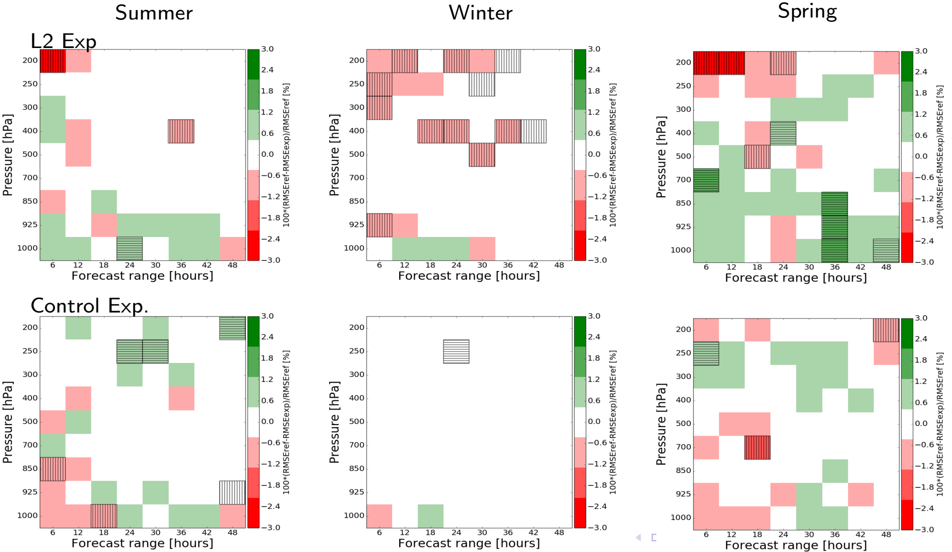


Relative Difference of RMSE (%) against ECMWF analysis

≡ Improvement with 95 % of confidence

|| Degradation with 95 % of confidence

Wind Intensity



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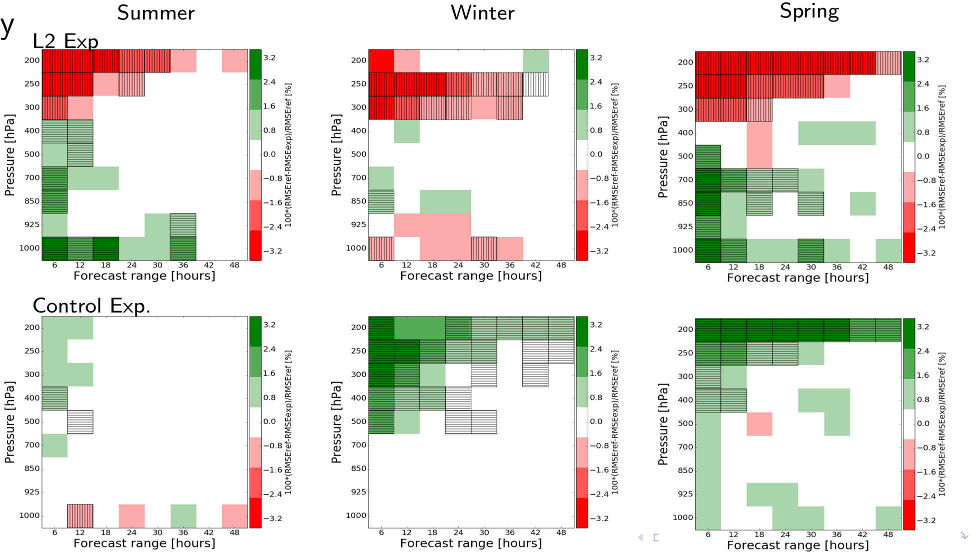
Relative Humidity



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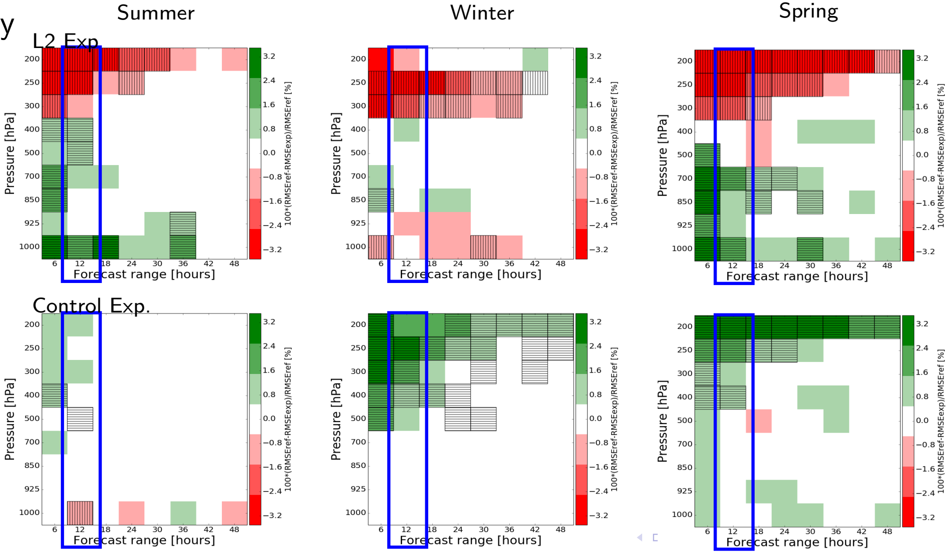
Relative Humidity



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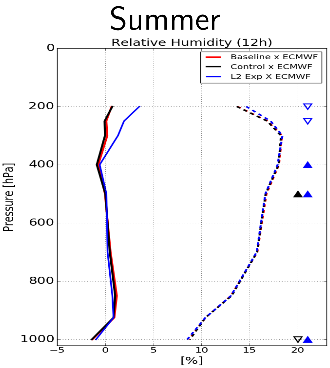
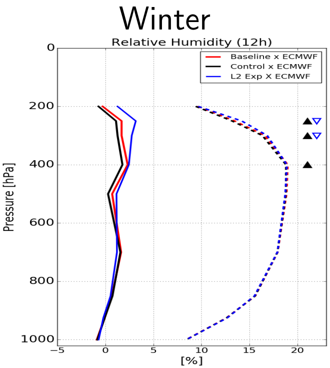
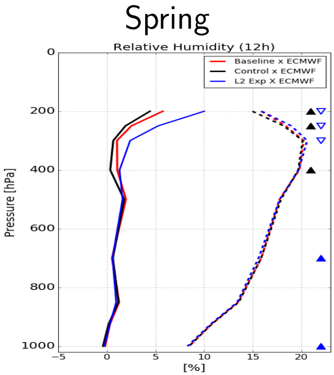

Summer


Winter


Spring

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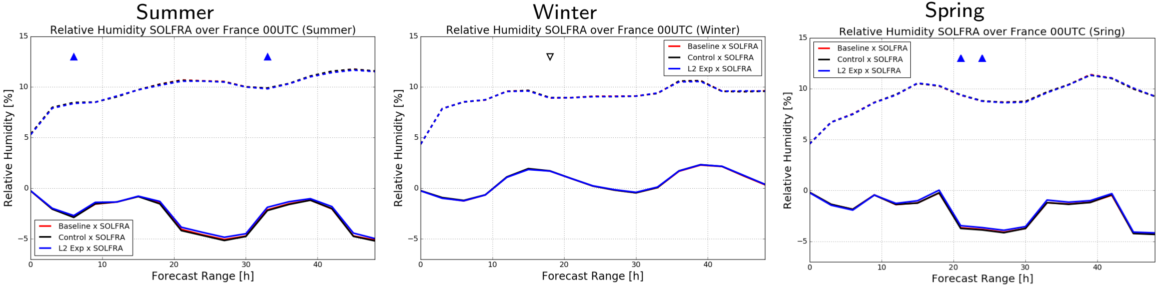
Solid lines are bias and dashed lines are standard deviation of bias.

Verification at 2 meters

Relative Humidity over France


Summer
Winter
Spring

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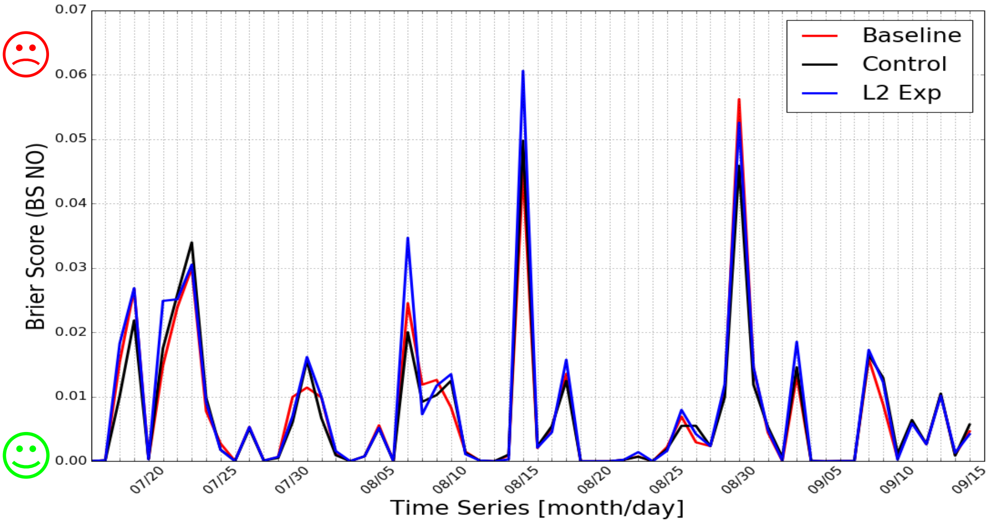
Solid lines are bias and dashed lines are standard deviation of bias.

Upper-air and surface verification

Conclusion:
For temperature and wind intensity the scores are almost neutral in all experiments. The relative humidity forecast present improvement in the control experiment and improvement/degradation in the L2 experiment. However, when a specific profile (12 h) is analyzed the standard deviation lines are similar and the differences in the RMS come from the bias values.
We can not draw any conclusion for the two extreme events.

Precipitation Verification:
Variable: Precipitation accumulated in 6 hours
Scores: Frequency bias, Detection Rate, False Alarm Rate, Heidke Skill Score (HSS), Brier Skill Score (BSS NO), **Brier Score (BS NO)**, precipitation maps.
Precipitation Thresholds: 0.5 mm, 2 mm, **5 mm** and 10 mm
Neighborhood: 1.3 km, 20.6 km, **52.8 km** and 120.2 km
Forecast range: 6 h, 12 h, 18 h, **24 h**, 30 h, 36 h, 42 h and 48 h
Period: **Summer**, Winter and Spring.


Summer Period - Precipitation accumulated 6 hours - 5 mm - 52.8 km - 24 hours forecast

Conclusion

It seems that the differences between the baseline and the experiments (control and L2 experiments) are neutral, but here neutral does not mean same forecast.

Main Conclusions:

- The L2 product is suitable to assimilate in the NWP models.
- The L2 experiment helped to decrease the first guess and the analysis departure of the other observations (during the assimilation cycle).
- Forecast Scores:
  - The Control experiment improves the upper-troposphere forecast skill for humidity.
  - The L2 experiment helped to improve the humidity skill scores in the middle-lower troposphere and it also helped to degradate the scores above 300 hPa for the temperature (not all periods) and humidity.

Way forward:

- About horizontal data selection:
  Evaluate the horizontal error correlation to define the optimal horizontal thinning.
- About vertical data selection:
  Evaluate the vertical error correlation and use it in the assimilation process (also cross-variable ?).
  Implement an adaptive vertical selection to have only one L2 level per model level.

Way forward:

- Possible additional information from Eumetsat
  Provide some information on the vertical (cloud top? profiles of QC?) to help assimilate partial L2 profiles.
  Could some kind of averaging kernels be available? They could be used in the assimilation process.
- In case MW sensors are not available
  Evaluate the potential of IR only L2 (detailed cloud information needed).
  Preparation of IRS?

Thank you!!!

Questions??