Forecast verification against Observation: Forecast Sensitivity Observation Impact with an Observation-Based Objective function

Carla Cardinali
## Forecast Skill Score

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Courtesy of Irina Sandu ECMWF
Introduction

- FSOI measures the increase or decrease of the forecast error \( (e_{t=24}) \) due to the assimilation of the observations.

- Model based \( e_{t=24} \) has been expressed in term of global energy scalar product
  \[
  J^f = J_E^f = \langle e_t, Ce_t \rangle
  \]

- Observations based scalar product can be used to compute \( e_{t=24} \)
  \[
  J_O^f = \langle e_t^o, R^{-1}e_t^o \rangle
  \]

- The two observation impact measures are compared in terms of Impact distribution, Total impact, Observation Type Impact and Impact Variability.
Forecast Sensitivity Observation Impact FSOI
Observation-based objective function

\[ J^f = J_{E}^f = \langle e_t, Ce_t \rangle \quad \rightarrow \quad J_o^f = \langle e_t^0, R^{-1} e_t^0 \rangle \]

Forecast Error = Forecast-Observation

\[ J_o^f = \frac{1}{2} \frac{(y - H x_f)^2}{\sigma_o^2} \]
Forecast Sensitivity Observation Impact : Distribution Impact

AMSU-A Channel 8

Mean=-0.22 Std=1.6

CV=7
Z-score 56% <0

Mean=-0.07 Std=1.18 [E kg\(^{-1}\)]

CV=16.
Z-score 52% <0
Forecast Sensitivity Observation Impact : Standard Error

Variability

FSOI-Je

FSOI-Jof

AMSU-A
Aircraft
ALLSKY
IASI
ATMS
Geo-Rad
SYNOP
AIRS
GPS-RO
TEMP
Geo-AMV
PROFILER
SCAT
DRIBU
PILOT
HIRS
O3
DROP
GBRAD

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
GPS-RO Observation Impact

The graph illustrates the observation impact of GPS-RO, comparing FSOI-Je and FSOI-Jo. The vertical axis represents the distance (km), and the horizontal axis shows the percentage impact. The two bars, DFS-FSOI-Jo and DFS-FSOI-Je, are plotted against each other, highlighting the differences in observation impact across various distances.
AMSU-A Observation Impact

DFS-FSOI-Jo  DFS-FSOI-Je

Channel

0  5  10  15  20  25

-20 -15 -10 -5 0 5 10 15 20

DFS-FSOI-Jo  DFS-FSOI-Je
AMSU-A Channel 14

$0 \leq \text{Observation Influence} \leq 1$

- **FSOI-Je**
  - $+ \text{FcE increase}$
  - $- \text{FcE decrease}$

**DA Diagnostic**
AMSU-A Channel 5

+ FcE increase
- FcE decrease

FSOI-Je

FSOI-Jo
Number of observations that decreases the forecast error

- AMSU-A
- Aircraft
- ALLSKY
- IASI
- ATMS
- Geo-Rad
- SYNOP
- AIRS
- GPS-RO
- TEMP
- Geo-AMV
- PROFILER
- SCAT
- DRIBU
- PILOT
- HIRS
- O3
- DROP
- GBRAD

Negative Observation Impact Number %
The new objective function provides a verification field independent from the model

- disentangle degradation due to model bias with degradation due to observation quality

The objective function weights are the observations accuracies which are different from the energy weights:

- Larger in the stratosphere
- Smaller in the troposphere

FSOI-J$_f^o$ shows larger observation impact than FSOI-J$_f^E$ impact in the stratosphere and smaller in the troposphere

FSOI-J$_f^o$ (10%) better correlates than FSOI-J$_f^E$ with DFS

~53% of the observations contribute to decrease the forecast error to be compared with 51% for FSOI-J$_f^E$