FORECaster's Forum

An Example of the Importance of Ship Observations

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(Manuscript received 9 August 1990, in final form 9 August 1990)

Abstract

The impact of one ship observation on the National Meteorological Center's (NMC) North Atlantic surface pressure analysis, forecast models, and various forecasts is discussed. In addition, the resources available to surface pressure analysts at NMC in determining the validity of ship observations are described.

Based, primarily, on one ship observation, the analyzed central pressure of a low pressure system was deepened by 39 mb in 6 h. This dramatic change in central pressure impacted the NMC's North Atlantic High Seas forecasts, High-Level Aviation turbulence forecasts and the validity of the results of the NMC Medium Range Forecast (MRF) Model.

It is suggested that the dramatic 6-h change in the analyzed central pressure of the low pressure system was most likely due to an initial underestimate of the depth of the low prior to the receipt of the specific ship observation and an overestimation of the central pressure as a result of the ship observation.

1. Introduction

The case of 3 July 1989 is an example of the impact that one ship observation can have on the National Meteorological Center's (NMC) North Atlantic surface pressure analysis. The purposes of this article are to: 1) illustrate the effect of one report on the NMC surface analysis and various forecasts and forecast models used by NMC and 2) describe the resources available to the surface analyst to determine whether a ship report is correct.

2. Weather situation

The 0000 UTC 3 July 1989 NMC North Atlantic surface analysis indicated a 1009-mb low centered at 40.2N 53.2W (shown in Fig. 1a). This low pressure system developed east of northern Florida on 30 June 1989 in a large area of subtropical moisture. Over the next two days the low moved northeastward gradually increasing in speed to approximately 12 m s⁻¹.

Infrared satellite imagery at 0000 UTC 3 July 1989 of the low pressure system (shown in Fig. 2a) was impressive with a large comma-shaped mass of high cloud extending about 650 km north and east of the low center. Enhanced infrared imagery indicated significant cold top (< −60°C) convection in the vicinity of the comma head. At this time the closest ship observations to the analyzed position of the low were clustered approximately 330 km to the east in the warm sector. The lowest pressure reading was from ship LALZ2 with 1010.2 mb. Observed southerly winds in this region ranged from 8–15 m s⁻¹. Approximately 450 km northeast of the low center the motor ship (M/S) Atlantic Compass (radio call sign SKUN) observed moderate rain with an eastnortheast wind at 15 m s⁻¹, a pressure of 1014 mb with a pressure fall of 5.0 mb in the last 3 h.

The 0600 UTC surface observational plots indicated an alarming observation from the Atlantic Compass (SKUN) located at 42.0N 51.5W with winds from the northnorthwest at 35 m s⁻¹ and a pressure of 979.0 mb. Although no pressure tendency was plotted for the Atlantic Compass, the 979.0-mb pressure reading indicated a 6-h fall of 35 mb. Ship UYBB, 170 km to the north of the Atlantic Compass, reported 12 m s⁻¹ from the north with heavy rain, a pressure of 1003.9 mb, and a 3-h pressure fall of 5.0 mb. Ship KNBD reported a 25 m s⁻¹ wind from the northnorthwest approximately 550 km southwest of the Atlantic Compass.

These reports suggest that the low pressure system had become extremely intense with a central pressure lower than 979 mb, more than 30 mb deeper than analyzed at 0000 UTC. Certainly, the UYBB report helped to substantiate the Atlantic Compass observation. Some doubt, however, was raised by the surface analysts at NMC as to the extreme nature of the Atlantic Compass report (the North Atlantic analyst is the Atlantic High Seas Marine Forecaster). This doubt was
observations globally four times a day using the VAX-based Quality Improvement Performance System (QUIPS) (Richardson and Reilly 1989). The purpose of the quality control effort is to provide an optimum ship observation data base for the computer forecast model runs. The QUIPS compares surface pressure observations from ships with the 6-h forecast from the NMC Aviation Model at 0600 and 1800 UTC and from the 6-h Global Data Assimilation System (GDAS) (McPherson et al. 1979) at 0000 and 1200 UTC. Observations with pressure differences of greater than 4 mb from the model forecast are flagged for investigation. A week's worth of observed pressures and pressure differences from the model guess fields along with other parameters from specific vessels are stored by QUIPS. Recalling this information aids in determining the validity of a vessel's reported pressure and position. A check of the Atlantic Compass history found that she was right on track and her previous observed pressures were comparable to those from the forecast model. The 979.0 mb reading was 31 mb lower than the model guess field: the 6-h surface pressure forecast from the AVN model.

4. Impact on NMC surface analyses

After a review of the latest satellite imagery (shown in Fig. 2b) and further consultation with forecasters of NMC's Forecast Branch and the Senior Duty Meteorologist, the 0600 UTC Atlantic Compass report was drawn for with the placement of a 970-mb low at 42.2 N 49.8 W as shown in Fig. 1b. In addition, a "keep" flag was placed on the Atlantic Compass observation by the NOS meteorologist so it would not be discarded. This ensured that the Atlantic Compass observation would be used in the analysis for the 6-h GDAS forecast. The 6-h GDAS forecast is the first guess for the next cycle of forecast model runs at 1200 UTC. The 0600 UTC 3 July observation of the Atlantic Compass was further substantiated at 1200 UTC with several ships reporting winds of 25-30 m s⁻¹ in the vicinity of the low pressure system. The lowest observed pressure at 1200 UTC was 989.0 mb from ship PEWC, located approximately 180 km to the south of the low center.

5. Verification of M/S Atlantic Compass observation

Indeed, the Swedish registered M/S Atlantic Compass en route from Rotterdam to Halifax on 3 July 1989 did encounter a severe low pressure system as evidenced by the vessel's barograph trace shown in Fig. 3. The following is an excerpt from a letter received from Captain Robert Kiel, Master of the M/S Atlantic Compass (wind strength is given in terms of the Beaufort scale):

"The vessel must have passed right through the centre of the low, as the wind direction changed instantly about 180 degrees at 0600 UTC. The wind force might have been higher than the 70 knots reported, as
the ship's wind-speed meter for a time showed up to 85 knots. The following entries were made in the ship's logbook during the day:

3/7 0200 UTC: wind ENE 7-8 B, pressure 1007 mb, air +17°C, sea +20°C, overcast, rain, high ENE sea.
3/7 0600 UTC: wind NNW 11 B, pressure 979 mb, air +14°C, sea +15°C, overcast, rain, high NNW sea.
3/7 1000 UTC: wind NNW 7-8 B, pressure 1010 mb, air +17°C, sea +22°C, overcast, very high to violent NNW sea.
3/7 1400 UTC: wind N 7-4B, pressure 1015 mb, air +18°C, sea +22°C, var clouds, high NNE swell."

The barograph trace and logbook entries are quite impressive. Certainly, the low had an extremely tight center with a very strong gradient to the southwest as indicated by the sharp pressure rise after 0600 UTC.

Included with the letter from Captain Kiel were copies of the coded 3-h meteorological observations in telex form from the Atlantic Compass for 3 July 1989. Included in these was a confirmation of the 0600 UTC observation sent at 0930 UTC 3 July to the United Kingdom Meteorological Office at Bracknell. This suggests that Bracknell also may have initially questioned the validity of the 979.0-mb pressure reading. It should be mentioned that the group containing the dew point temperature at 0600 UTC was in fact coded as 21040, indicating a $T_d/T_f/T_s$ of $-4.0^\circ$C. This most likely should have been coded as 20140. The pressure tendency and change group (which was not plotted on the NMC map) was reported as 58250. This would indicate a 3-h fall of 25.0 mb.

6. Impact on NMC forecasts

The Atlantic High Seas forecaster posted a storm warning (winds in excess of 24 m s$^{-1}$) for the area surrounding the low based on the Atlantic Compass observation and the analyzed 970-mb central pressure. Prior to 0600 UTC, no warnings were posted in association with this low pressure system.

The Atlantic High Seas forecasters primarily use surface pressure forecasts from the NMC Aviation (AVN) Forecast Model to determine wind strength. The NMC AVN Model is run at both the 0000 and 1200 UTC cycles and forecasts to 72 h (Petersen and Stackpole 1989). To illustrate the difficulty the AVN had in forecasting this low pressure system, three Atlantic High Seas forecasts of this low are listed below.

(i) "Forecast made 2200 UTC 1 July 1989; valid 0600 UTC 3 July 1989.* SYNOPSIS—LOW 33 N 66
W 1011 MBS AT 1800 UTC 1 JUL. FORECAST—
LOW 35 N 62 W 1015 MBS. WITHIN 300 NM IN
N SEMICIRCLE WINDS 15 TO 25 KTS SEAS 8 TO
12 FT. *This forecast was made from the 1200 UTC
1 July 1989 run of the AVN."

(ii) Forecast made 2200 UTC 2 July 1989; valid
0600 UTC 4 July 1989.* SYNOPSIS—LOW 38 N 56
W 1011 MBS AT 1800 UTC 2 JUL. FORECAST—
LOW 44 N 44 W 1013 MBS. WITHIN 250 NM IN
N QUADRANT WINDS 20-TO-30 KTS SEAS 8 TO
12 FT." *This forecast was made from the 1200 UTC
2 July 1989 run of the AVN.

(iii) Forecast made 1000 UTC 3 July 1989; valid
1800 UTC 4 July 1989.* WARNINGS—STORM 42
N 50 W 970 MBS AT 0600 UTC 3 JUL MOVING
NE 20-KTS WINDS 40 TO 65 KTS AND SEAS 15
TO 25 FT WITHIN 250 NM OF CENTER ELSE-
WHERE WITHIN 400 NM OF CENTER WINDS 25
TO 40 KTS AND SEAS 10 TO 18 FT. FORECAST—
GALE 51 N 38 W 1000-MB WINDS AND SEAS DE-
CREASING TO 25 TO 40 KTS AND 10 TO 18 FT
WITHIN 400 NM OF CENTER SE SEMICIRCLE."
*The STORM WARNING was based on the Atlantic
Compass observation and the analyzed 970 mb center.

Forecast (i) was valid at the time of the Atlantic
Compass observation (0600 UTC 3 July). This forecast
was based on the 36-h and 48-h forecasts from the
1200 UTC 1 July run of the AVN. The forecast position
of 35N 65W was nearly 1300 km SW of the observed
position and was 41 mb too high with the forecast cen-
tral pressure. Forecast (ii) was made just 8 h prior to
the Atlantic Compass observation and was based on
the 1200 UTC 2 July AVN Model run and 1800 UTC
2 July surface analysis. There was no indication at that
time in the forecast or synopsis of the development of a
“STORM” or even a “GALE.” Forecast (iii) was
made immediately after the Atlantic High Seas fore-
caster finished the 0600 UTC 3 July surface analysis.

Fortunately, it is quite unusual for a 36-h or 48-h
forecast (Forecast (i)) to be that much in error in po-
sition and strength of a low pressure system.

The 00 h 500-mb height field and vorticity analysis
from the NMC AVN Forecast Model for 0000 UTC 3
July 1989 and the analyzed position of the surface low
and associated fronts are shown in Fig. 4. According
to the 0000 UTC 500-mb AVN analysis the surface
low was about to come under the influence of a strong
upper-level short wave trough. Due to this strong upper-
level trough, considerable deepening of the low may
have occurred between 0000 UTC and 0600 UTC 3
July 1989. However, the 39-mb deepening in 6 h of
the central pressure (as indicated by the NMC analyses
shown in Fig. 1b) was most likely excessive. If, indeed,
the Atlantic Compass did pass under the low center
at 0600 UTC (as suggested by Captain Kiel) then the
NMC 0600 UTC analyzed central pressure of 970 mb
was 9 mb too low. Secondly, due, primarily, to a lack

of ship observations near the low center prior to 0600
UTC 3 July 1989, the strength of the low was probably
underestimated by the NMC surface analysts.

At NMC, the effects of having a confirmed strong
low pressure system in the North Atlantic did not end
with the surface analysis and High Seas forecast. An
area of moderate turbulence was forecast by the At-
antic High-Level Aviation forecaster in association
with the storm. Several commercial aircraft reported
experiencing moderate turbulence in the vicinity of this
storm system on 3 July 1989.

The 0600 UTC Atlantic Compass report along with
those reports of all the other ships received at 0600
UTC became part of the global data set of surface ob-
servations and were used in the initialization process
of the forecast models for the 1200 UTC 3 July 1989
forecast cycle. Also, the Northern Hemisphere surface
pressure analysis over oceanic regions is routinely in-
serted, called bogusing, (Corfidi and Comba 1989) into
the Global Data Assimilation System (GDAS). The
GDAS 6-h 0600 UTC forecast is then used as the first-
guess field for the 1200 UTC analysis and forecast cycle.
Without the 0600 UTC Atlantic Compass observed
pressure and wind, the intensity of this low pressure
system would in all likelihood have been missed in the
model quess field for the 1200 UTC forecast cycle.

As a result of the change in intensity of this low
pressure system from 0000 UTC to 0600 UTC 3 July,
some consideration had to be given by the NMC Me-
dium Range forecaster to the validity of the results of the NMC Medium Range Forecast Model (MRF) (which forecasts out to 240 h (Petersen and Stackpole 1989)), in particular, over the Eastern Atlantic and Western Europe. The MRF is run once a day as part of the 0000 UTC cycle and would not have had either the 0600 UTC Atlantic Compass report or the analyzed 970-mb central pressure of the low as input data.

7. Summary

Several factors make this case unusual. Prior to the 0600 UTC 3 July 1989 observation of the Atlantic Compass, the strength of this low was most likely underestimated by the NMC analysts, primarily, due to a lack of observations in the vicinity of the low center. Secondly, the resulting dramatic change from 0000 UTC to 0600 UTC in the analyzed central pressure of this low was due to the fact that the Atlantic Compass passed directly under the center of the low at a synoptic observing time. This was indicated in the letter from Captain Kiel and was not known by the NMC analysts. The NMC analyst placed the low center east of the Atlantic Compass with a central pressure 9 mb deeper than the observed 979 mb. Lastly, the existence of a 979-mb low in the North Atlantic is not typical for the first week of July.

The Atlantic Compass observation and resulting surface pressure analysis impacted the NMC High Seas forecasts, High-level Aviation turbulence forecasts, Medium Range Forecasts, and was used in determining initial conditions for the 1200 UTC 3 July 1989 NMC computer forecast cycle.

Although information from various sources is available to the NMC surface pressure analysts, including satellite data, ship observations are the primary source of data used to determine the surface pressure patterns over the oceans. This case stresses the importance of accurate merchant ship weather observations and the need for timely transmissions of those observations to the National Meteorological Center for purposes of analysis, model initializations, and subsequent forecasts.

Acknowledgments. I would like to thank my colleagues at NMC for their comments in helping to prepare this article and also Captain Robert Kiel and the crew of the M/S Atlantic Compass for providing the necessary information needed for this article and for their diligence in providing timely weather observations.

REFERENCES


