
Monitoring the observations impact in the short-range forecast

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Many Thanks

Mohamed Dahoui, Anne Fouilloux, Alan Geer,
Fernando Prates

Forecast sensitivity to observation: Equations

J_e is a measure of the forecast error e.g. Energy

$$\frac{\partial J_e}{\partial \mathbf{y}} = \frac{\partial \mathbf{x}_a}{\partial \mathbf{y}} \frac{\partial J_e}{\partial \mathbf{x}_a}$$

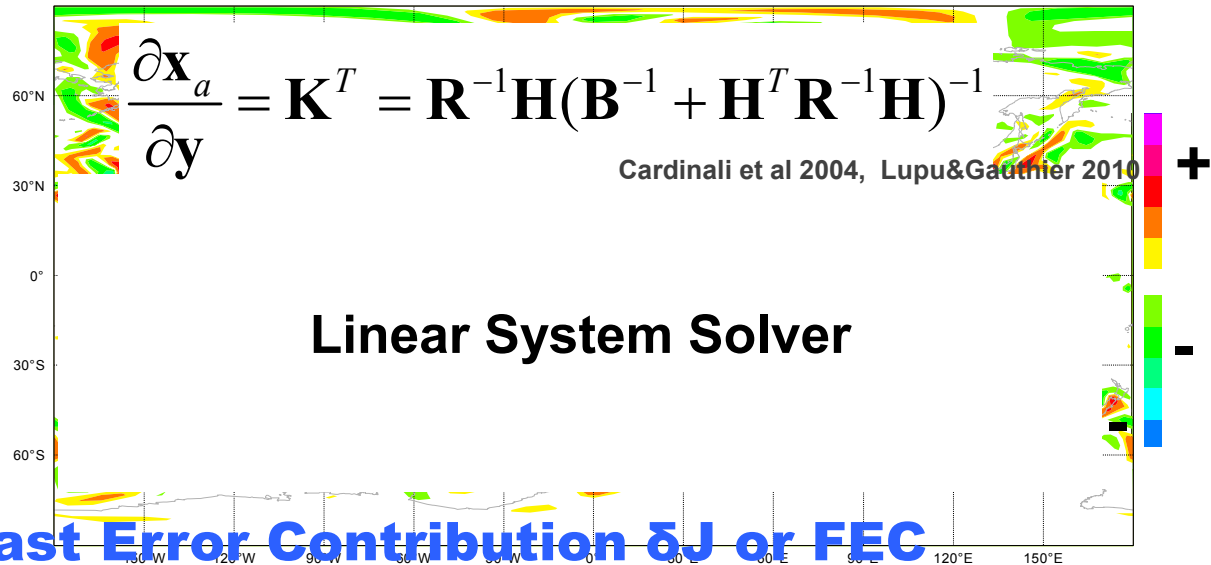
$$\frac{\partial J_e}{\partial \mathbf{x}_a}$$

Forecast error sensitivity to the analysis

Rabier F, *et al.* 1996

2nd order SG

$$\frac{\partial J_e}{\partial \mathbf{y}} = \mathbf{R}^{-1} \mathbf{H} \mathbf{A} \frac{\partial J_e}{\partial \mathbf{x}_a}$$



Computing the Forecast Error Contribution δJ or FEC

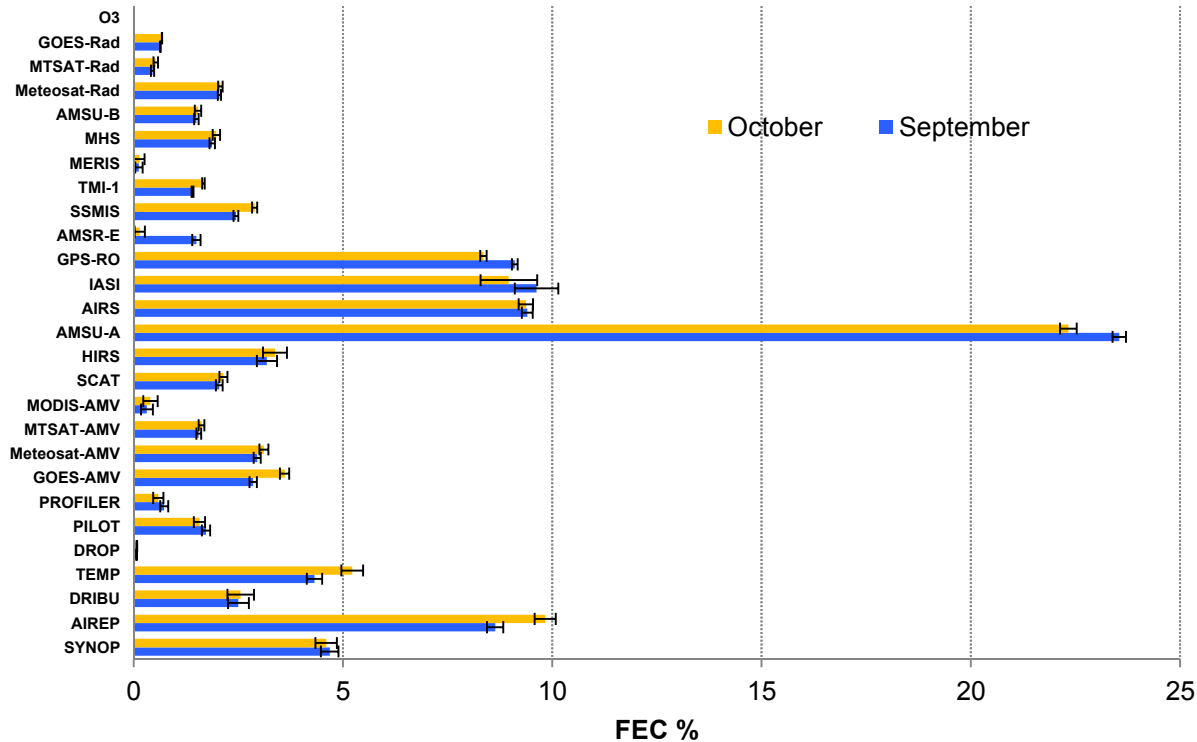
$$\left\langle \frac{\partial J_e}{\partial \mathbf{x}_a}, \delta \mathbf{x}_a \right\rangle = \left\langle \frac{\partial J_e}{\partial \mathbf{x}_a}, \mathbf{x}_a - \mathbf{x}_b \right\rangle = \left\langle \frac{\partial J_e}{\partial \mathbf{x}_a}, \mathbf{K}(\mathbf{y} - \mathbf{H}\mathbf{x}_b) \right\rangle = \left\langle \mathbf{K}^T \frac{\partial J_e}{\partial \mathbf{x}_a}, (\mathbf{y} - \mathbf{H}\mathbf{x}_b) \right\rangle = \left\langle \frac{\partial J_e}{\partial \mathbf{y}}, \delta \mathbf{y} \right\rangle$$

$$\delta J_e = \frac{\partial J_e}{\partial \mathbf{y}} (\mathbf{y} - \mathbf{H}\mathbf{x}_b)$$

Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October

- Forecast sensitivity tool computes the ***variation of forecast error*** due to the assimilated observations
 - ***Positive variation*** means ***forecast error increase***
 - ***Negative variation*** means ***forecast error decrease***
- Forecast error is ***Forecast-Analysis*** → Analysis is a proxy for ***Truth***
- ***Bias*** in the ***Verifying Analysis*** can ***mask*** the observation impact
- ***Linearity assumption*** must be applied therefore only ***24 or 48*** hour forecast can be examined
- ***Interpretation*** of forecast improvement or degradation as depicted by the tool is ***Necessary***

Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October

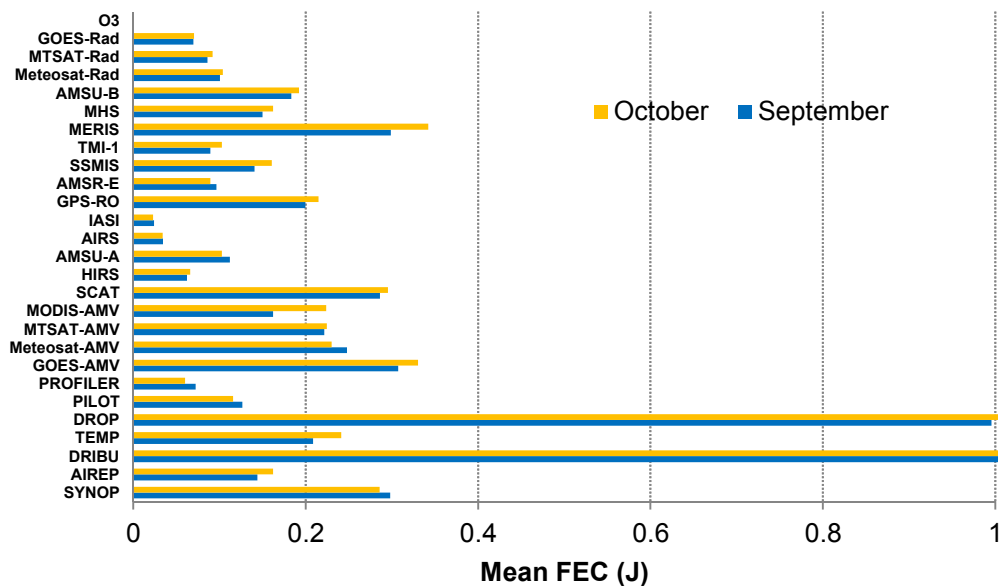
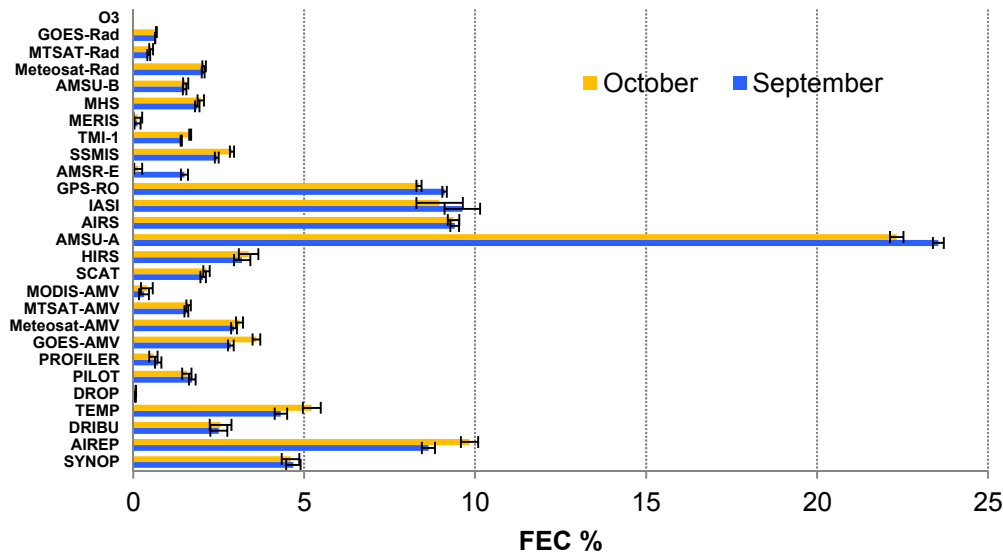


Forecast Error

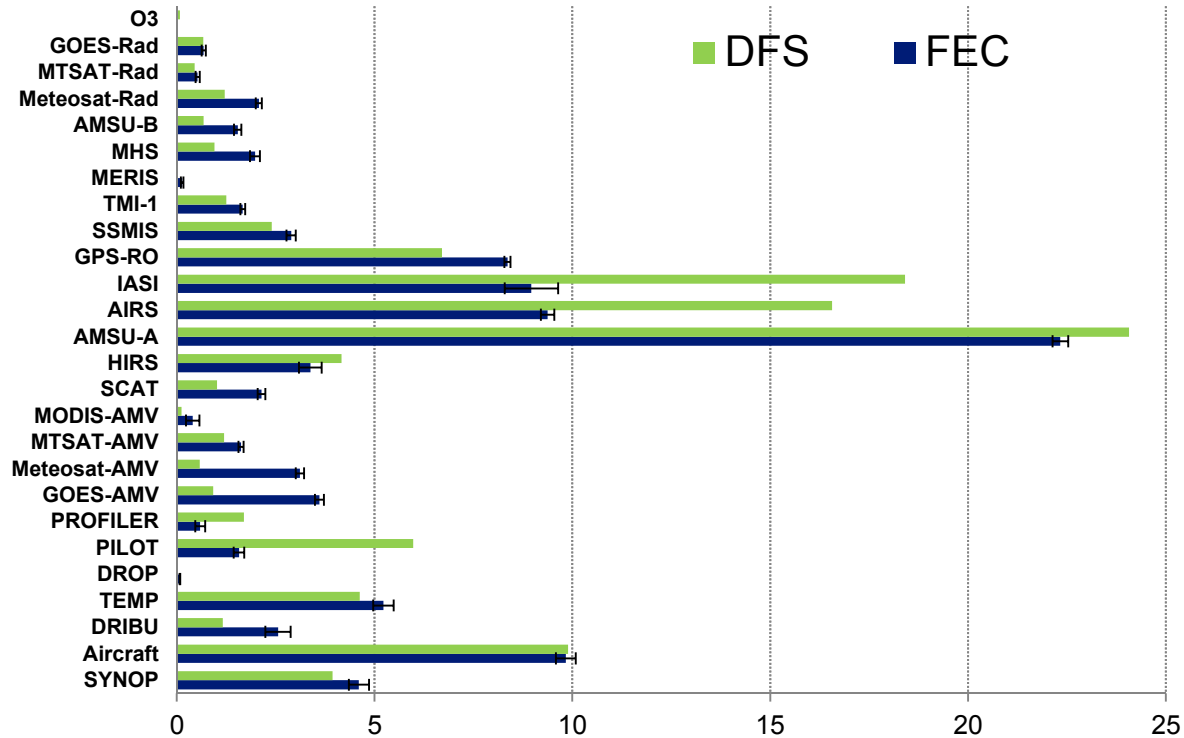
Assimilation System Adjoint

Observation Departure

Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October

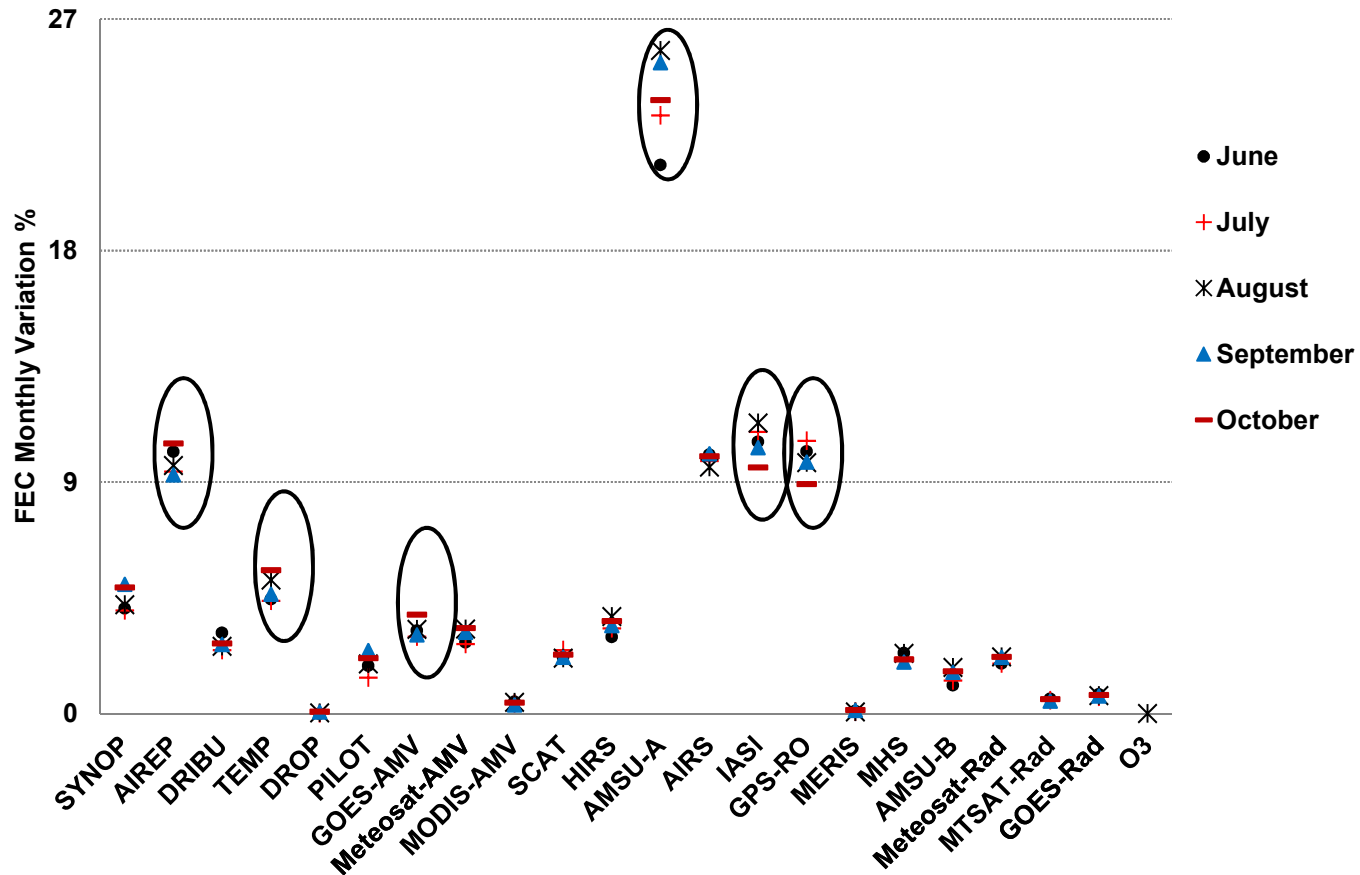


- Forecast sensitivity tool computes the *variation of forecast error* due to the assimilated observations: **Forecast Error Contribution FEC** → K^T, FcE, d

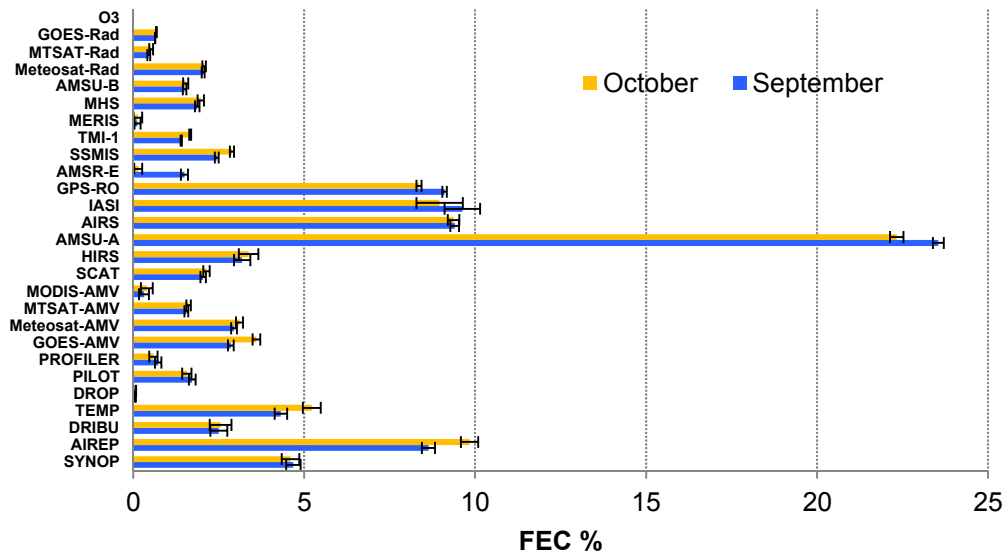


- Degree of Freedom for Signal DFS** quantifies the number of statistically independent directions constrained by each observation. The average can be expressed as **Observation Influence OI** → K^T

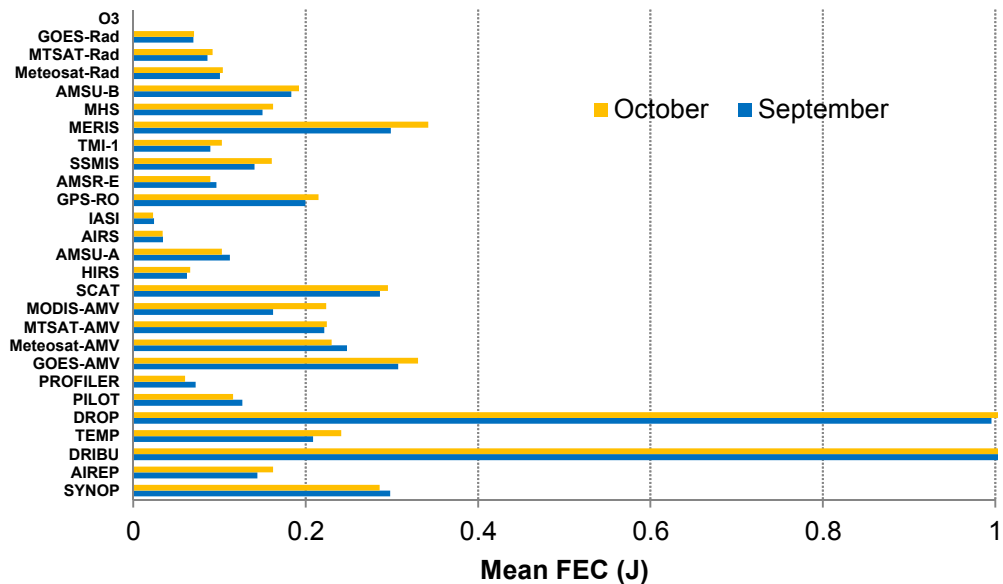
FEC monthly variation



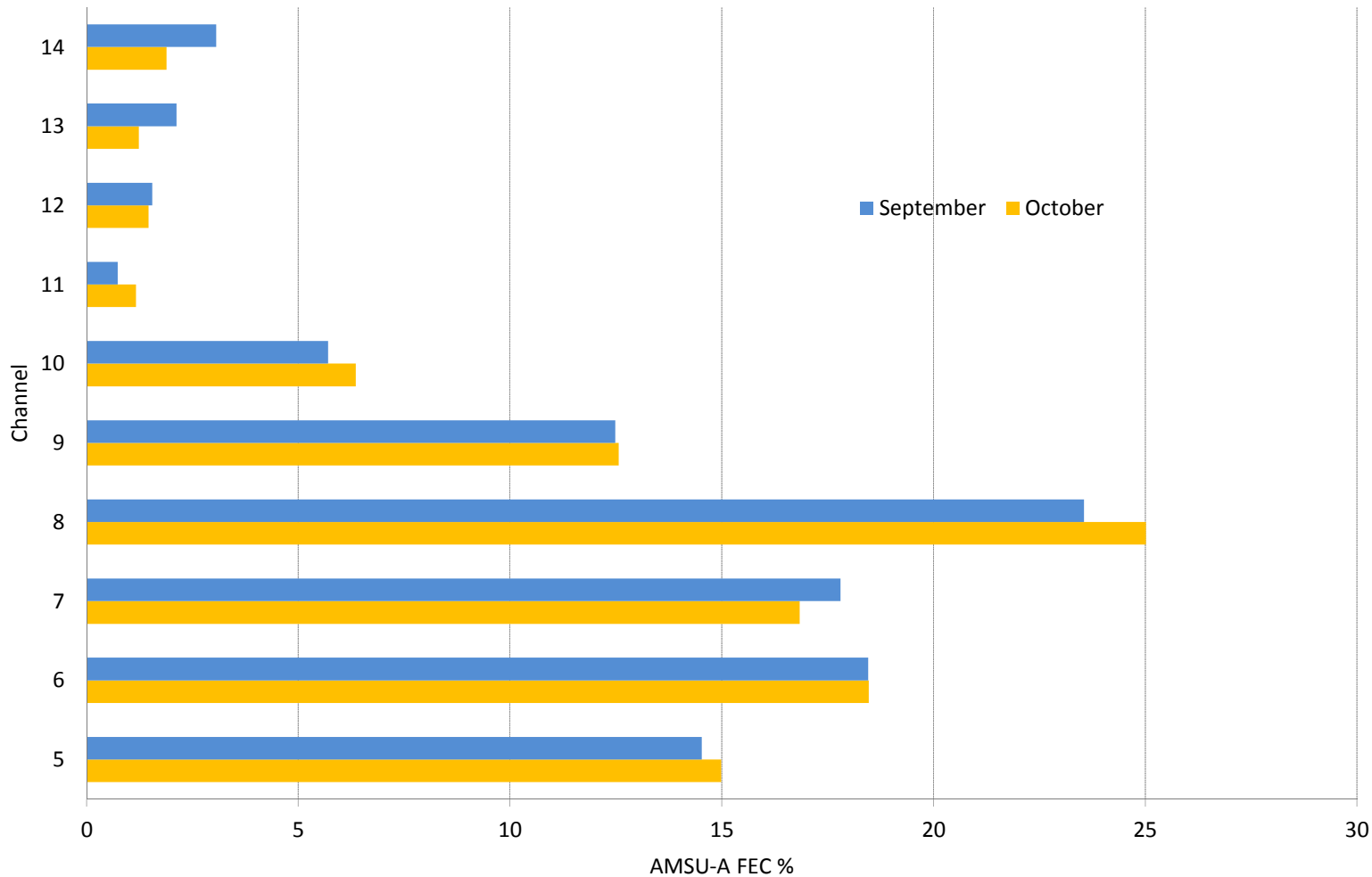
Monitoring the satellite data impact in the 24 h forecast: Global impact of the Observing System September&October



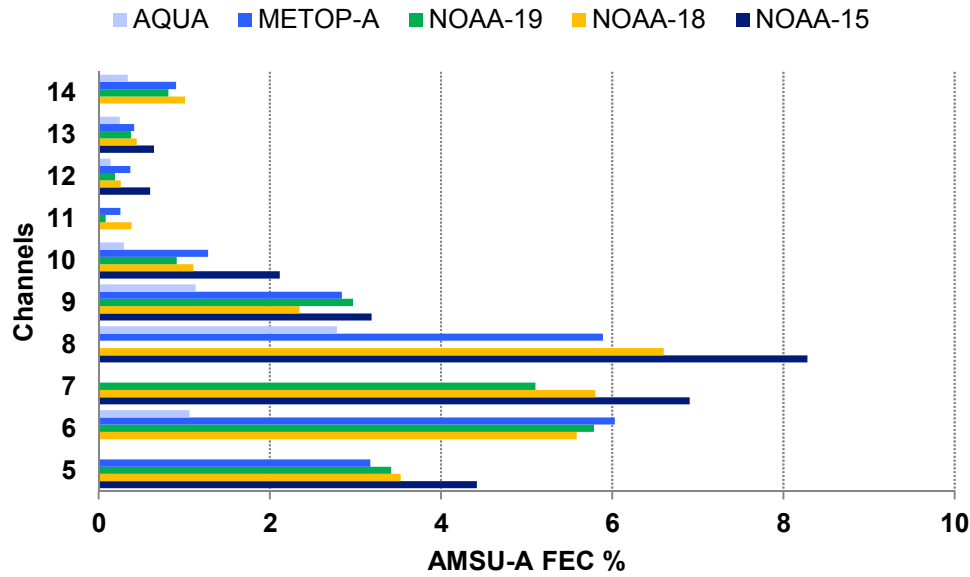
AMSU-A



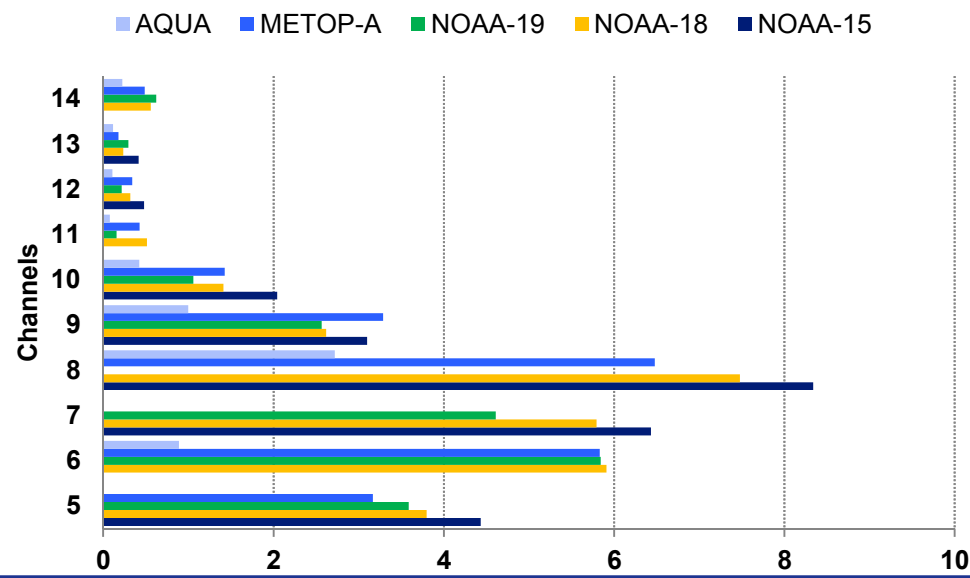
Global AMSU-A forecast impact by Channel



Global AMSU-A forecast impact by Satellite and Channel

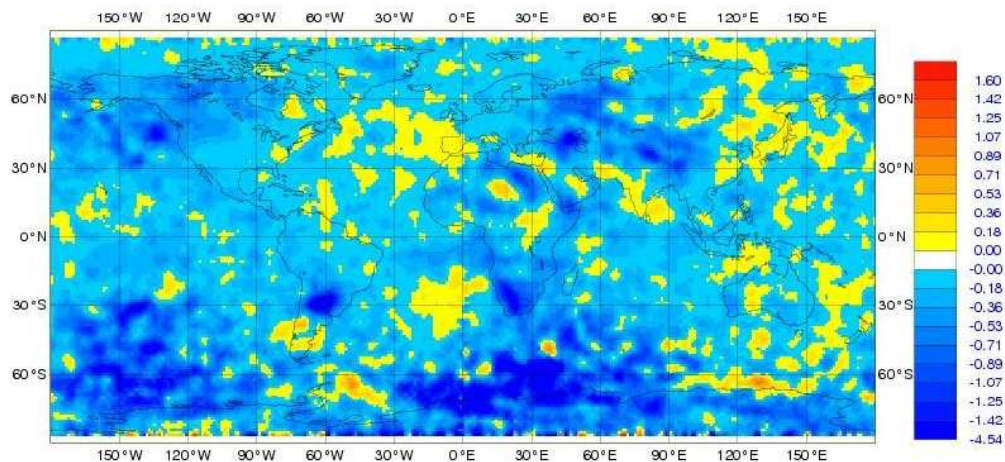


September

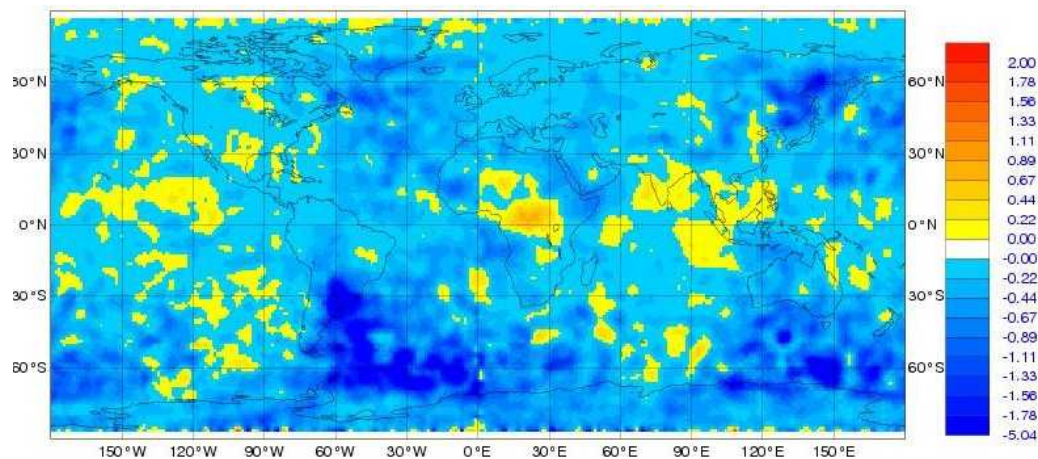


October

AMSU-A Ch8 forecast impact September&October 2011: Geographical mean forecast impact pattern (J)



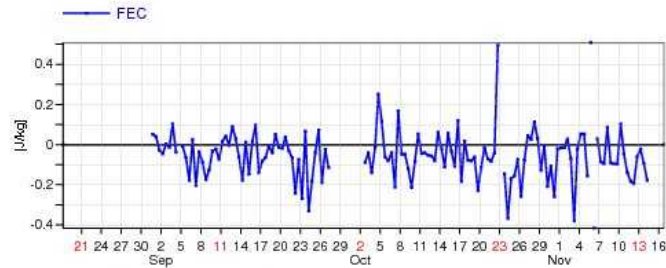
METOP-A
Min=-4.5, Max=2.3, Mean=-0.3



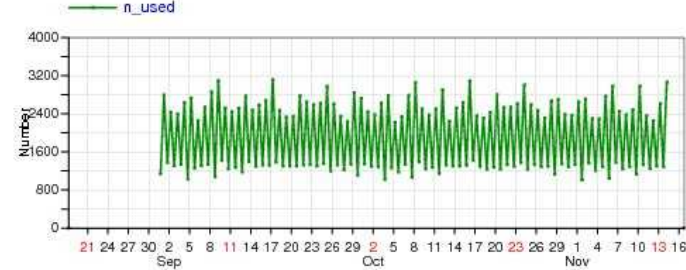
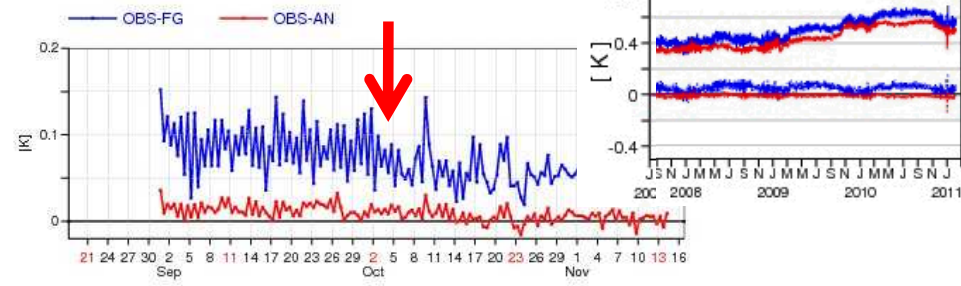
NOAA 15
Min=-5.0, Max=2.0, Mean=-0.3

AMSU-A ch8 Time Series forecast impact over N. Atlantic

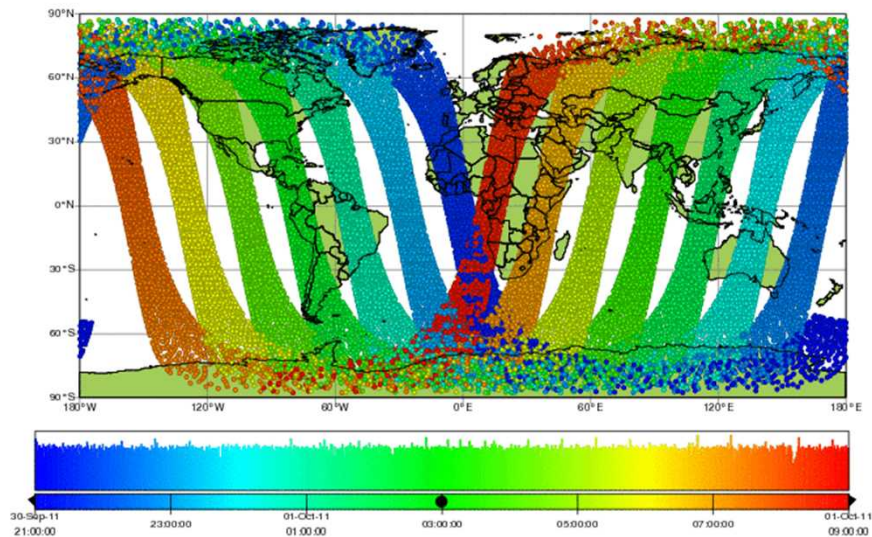
Statistics for RADIANCES from METOP-A/AMSUA
 Channel =8, Used data [time step = 12 hours]
 Area: lon_w= 285.0, lon_e= 355.0, lat_s= 20.0, lat_n= 75.0 (over All_surfaces)
 EXP = 0054



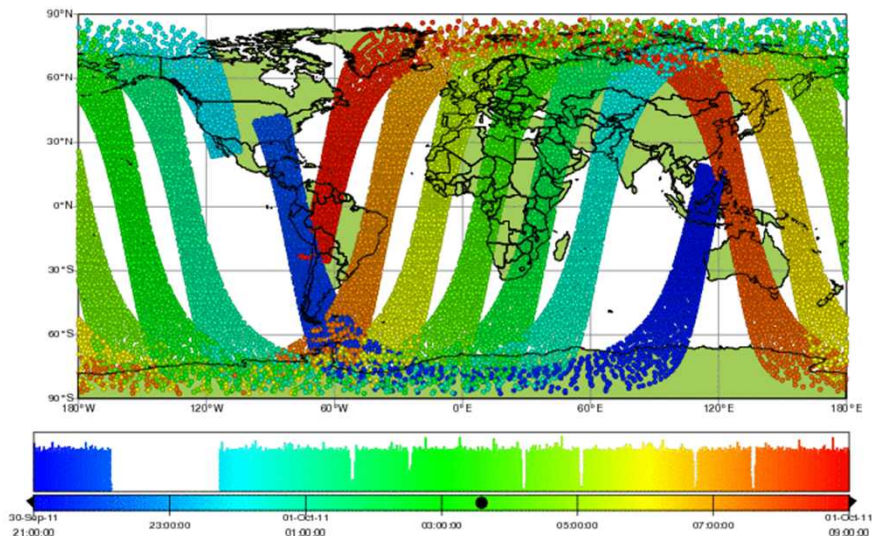
Statistics for RADIANCES from NOAA-15/AMSUA
 Channel =8, Used data [time step = 12 hours]
 Area: lon_w= 285.0, lon_e= 355.0, lat_s= 20.0, lat_n= 75.0 (over All_surfaces)
 EXP = 0054



AMSU-A METOP-A versus NOAA-15 orbit over the Atlantic

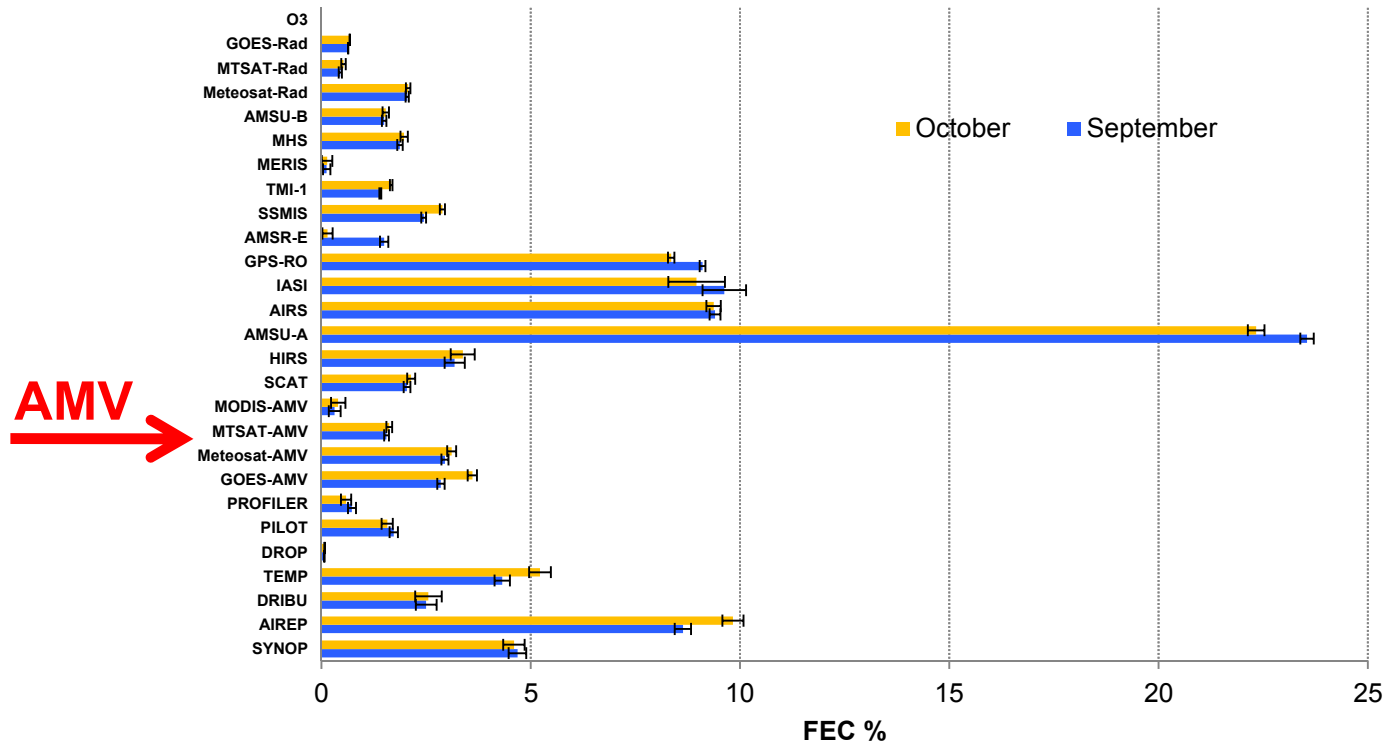


METOP-A
Observing the Atlantic
at the **begin** of 4D-Var Window

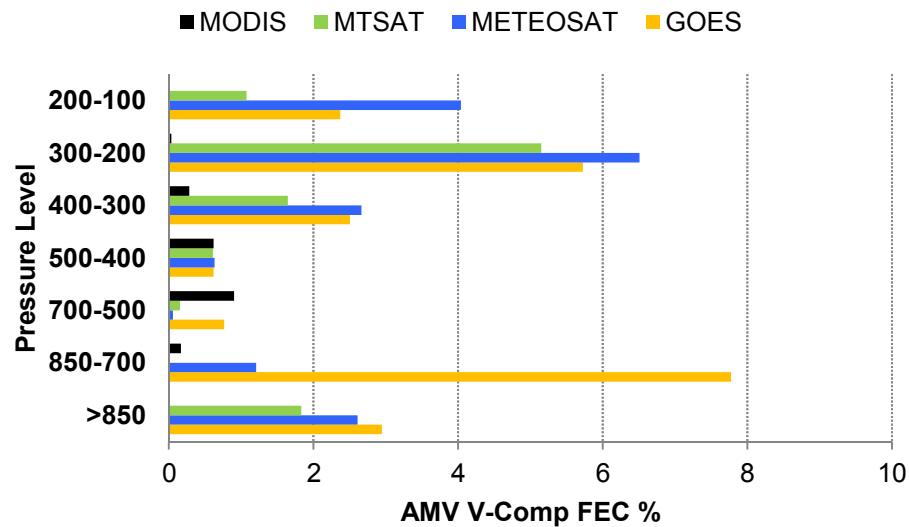
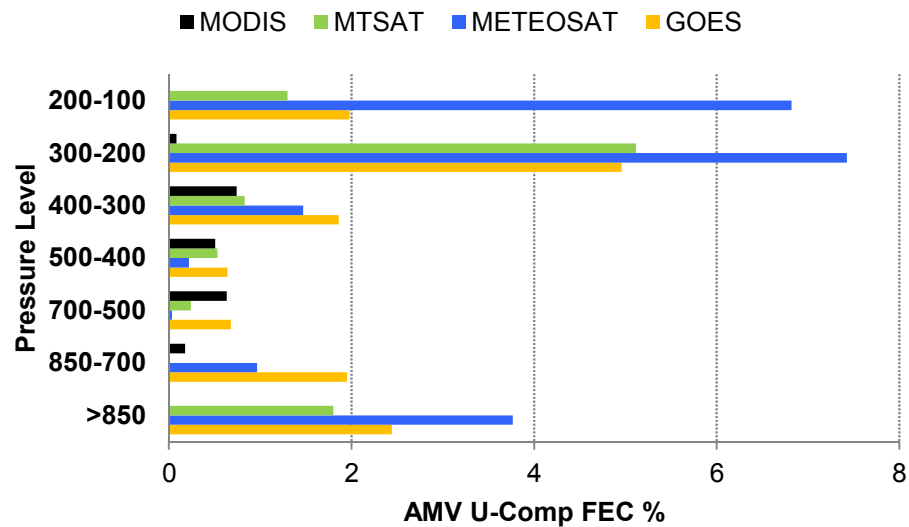


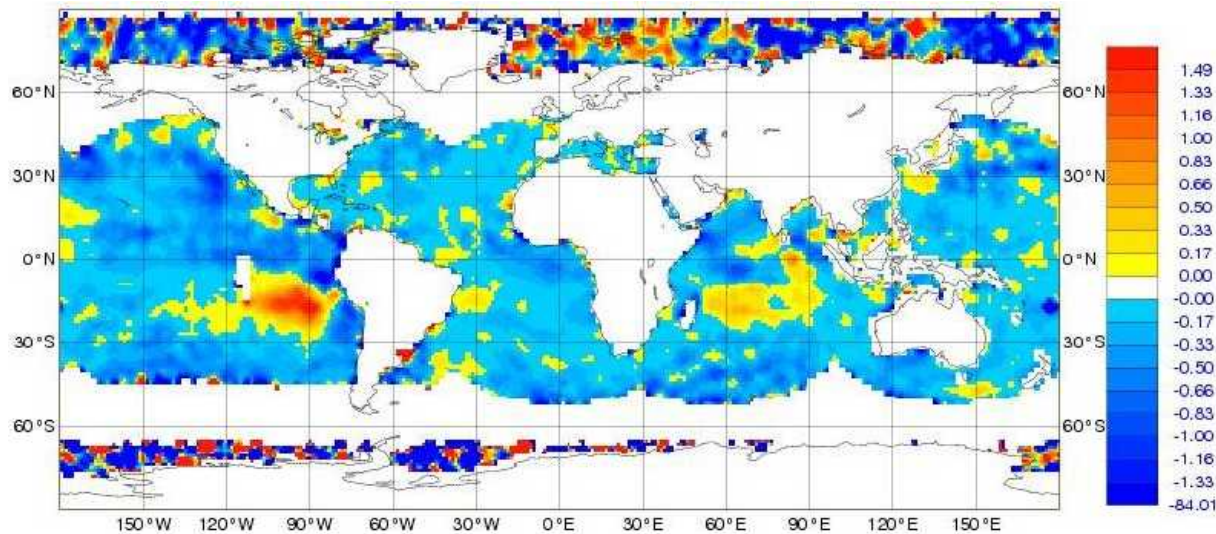
NOAA-15
Observing the Atlantic
at the **end** of 4D-Var Window

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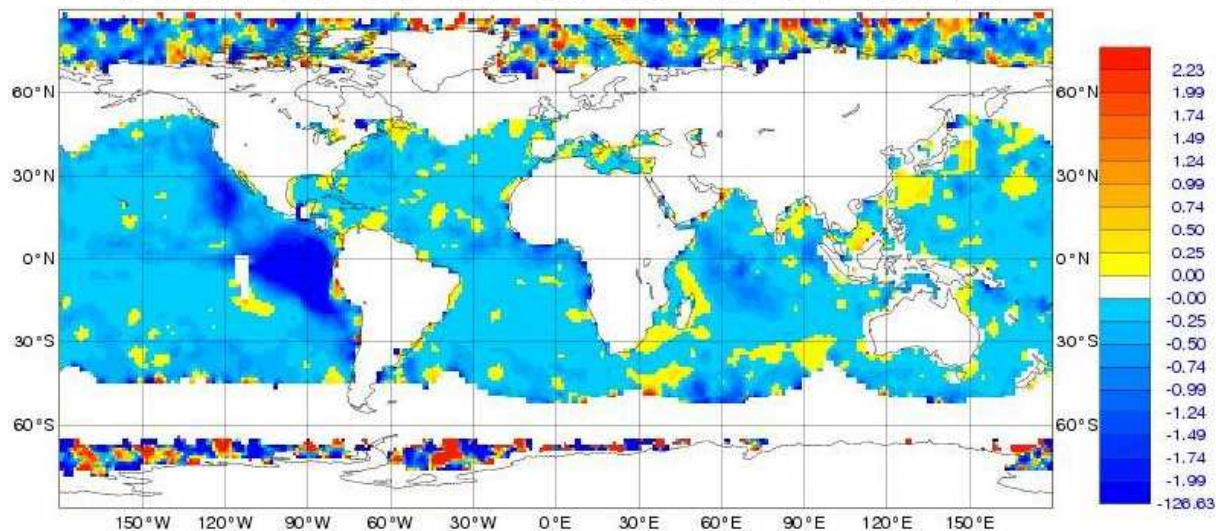


AMV FEC September by Satellite and Pressure Level





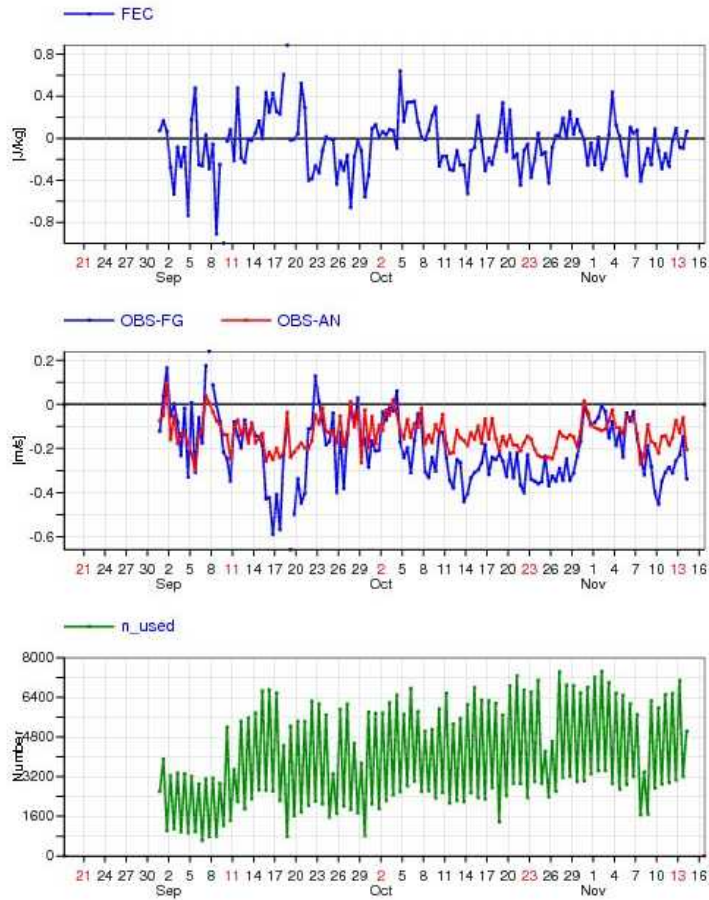
U-Comp
Min=-84, Max=65, Mean=-0.15



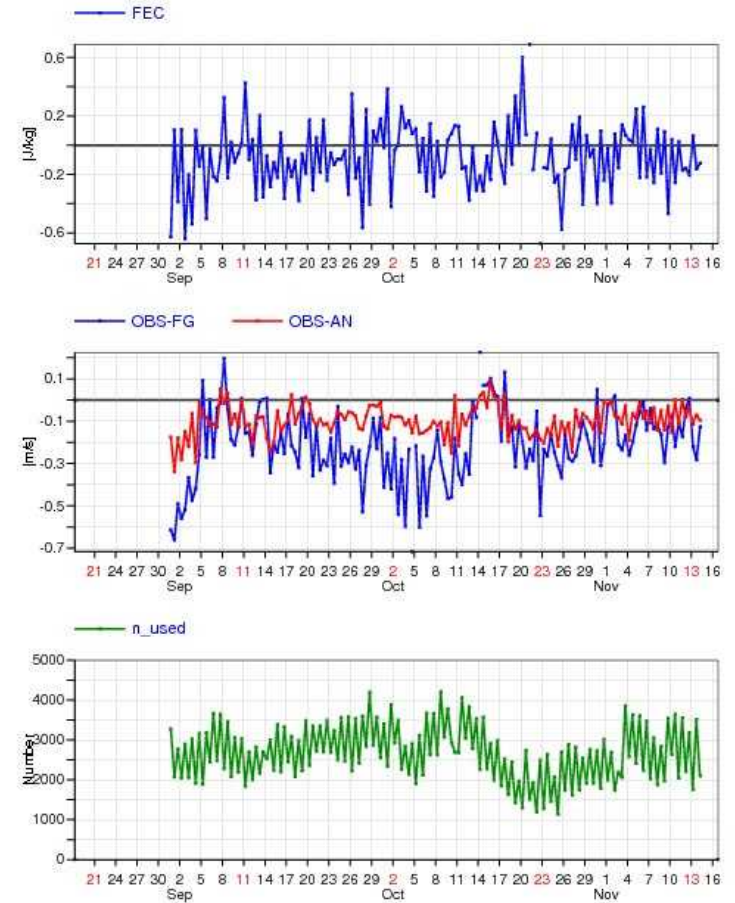
V-Comp
Min=-127, Max=59, Mean=-0.24

AMV FEC Time Series 700-1100 hPa

GOES-13

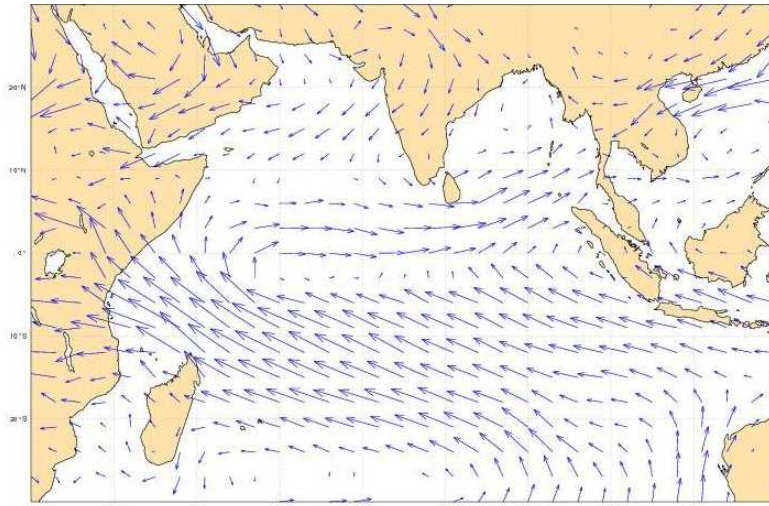


Meteosat-7



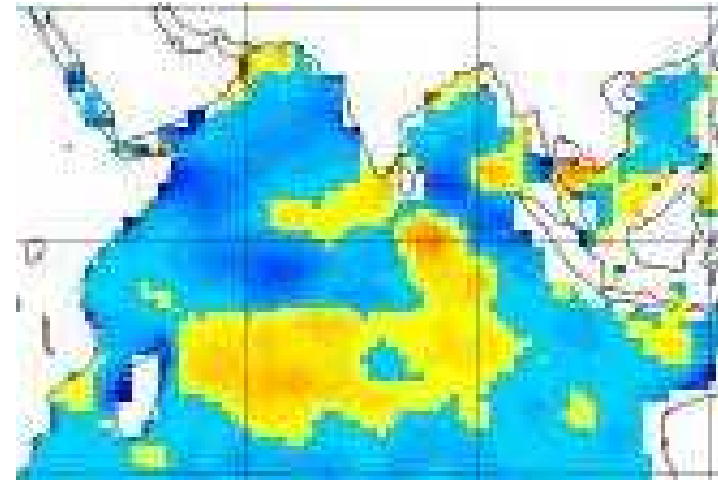
AMV METEOSAT 7 Degradation investigation: September-October OSE NOAMV-CNTR 700-1000hPa

Mean Wind field

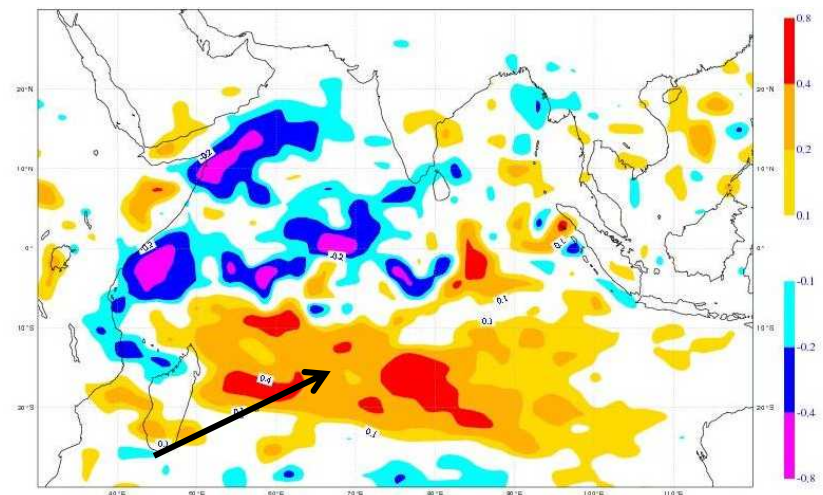


AMV observations reinforce
the zonal circulation

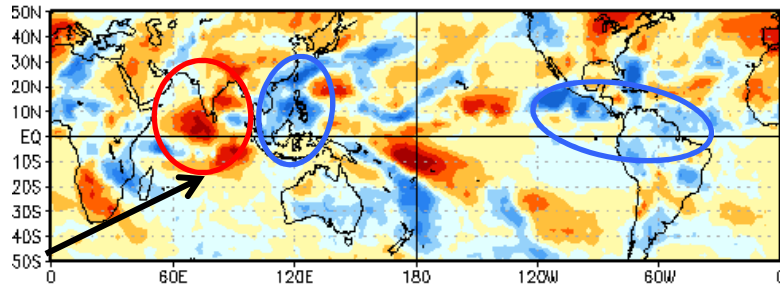
FEC METEOSAT Degradation



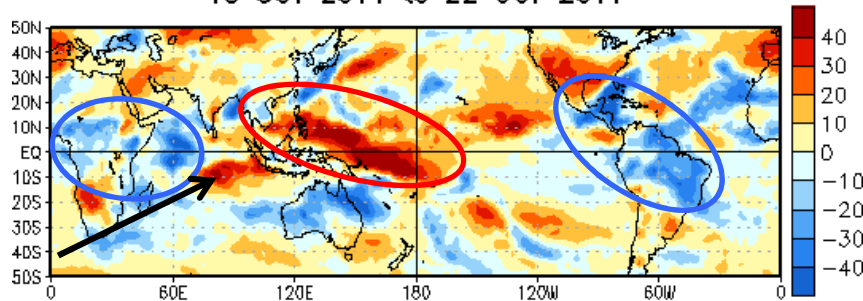
NOAMV-CNTR mean analysis difference



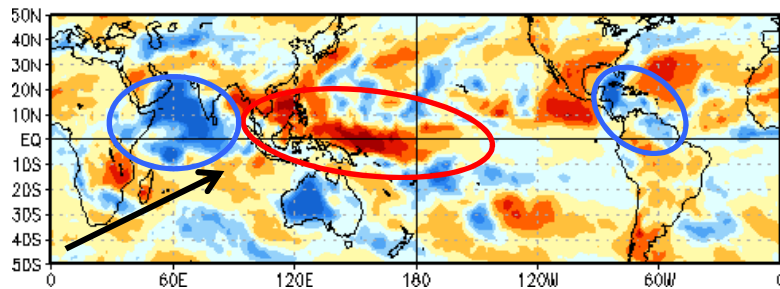
OLR Anomalies
3 OCT 2011 to 12 OCT 2011



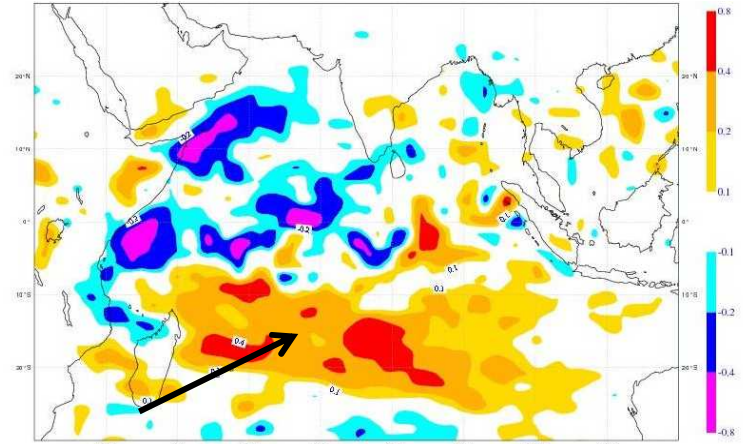
13 OCT 2011 to 22 OCT 2011



23 OCT 2011 to 1 NOV 2011



AMV-CNTR mean analysis difference

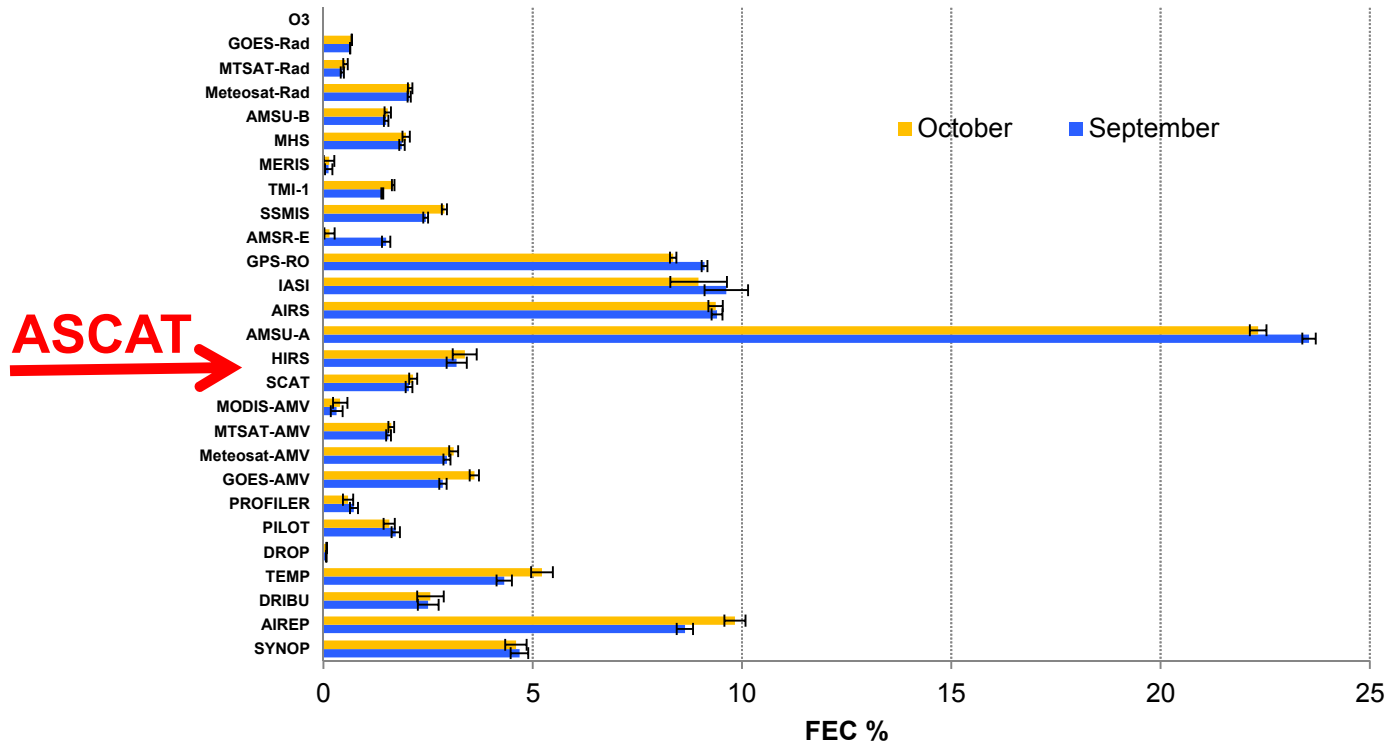


Red Circle: suppressed convection
Blue Circle: Enhanced convection

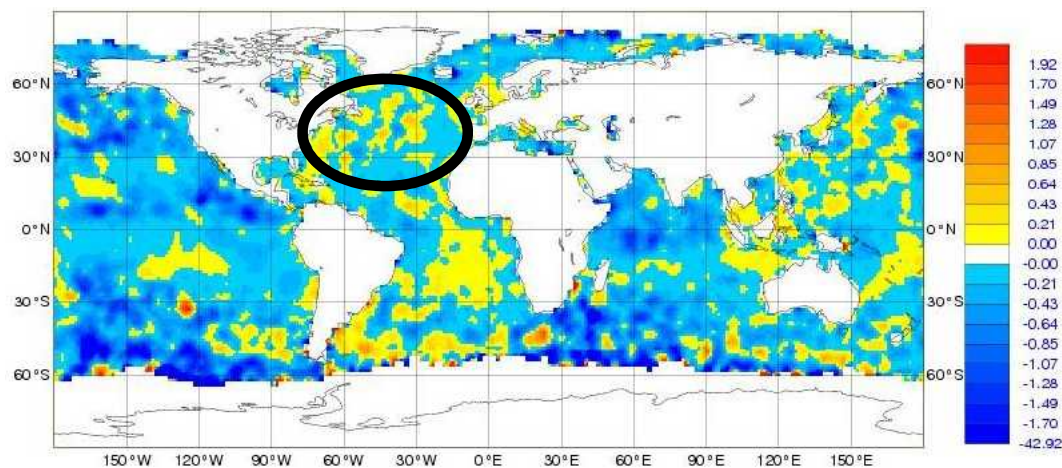
MJO pattern over Indian ocean justifies a reinforcement of the zonal circulation

AMVs increase the zonal circulation

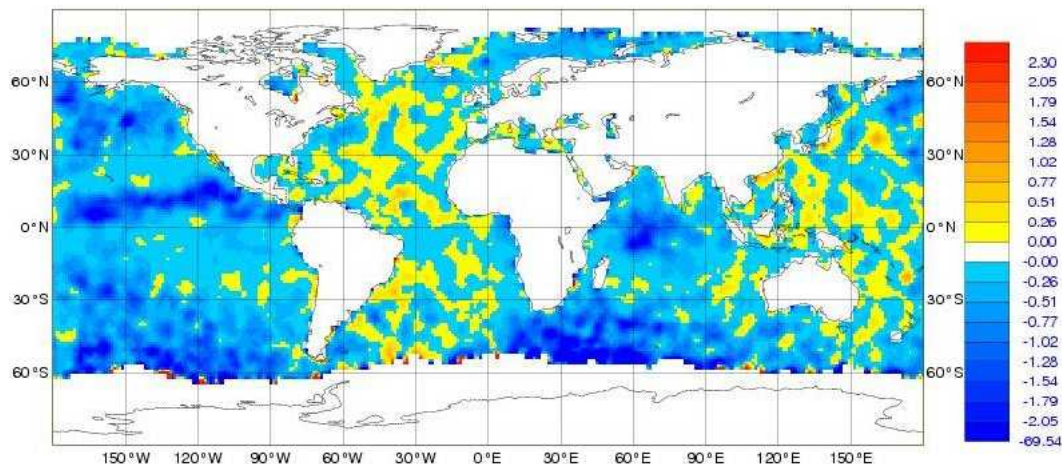
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ASCAT Mean FEC September & October



ASCAT U-Comp
Min=-43, Max=34, Mean=-0.3

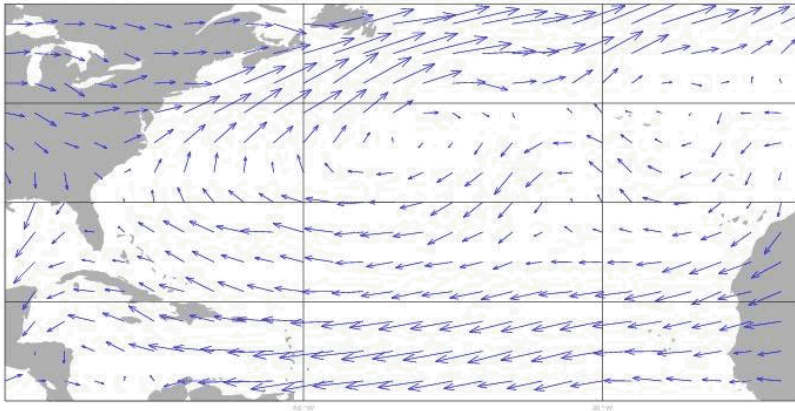


ASCAT V-Comp
Min=-70, Max=55, Mean=-0.4

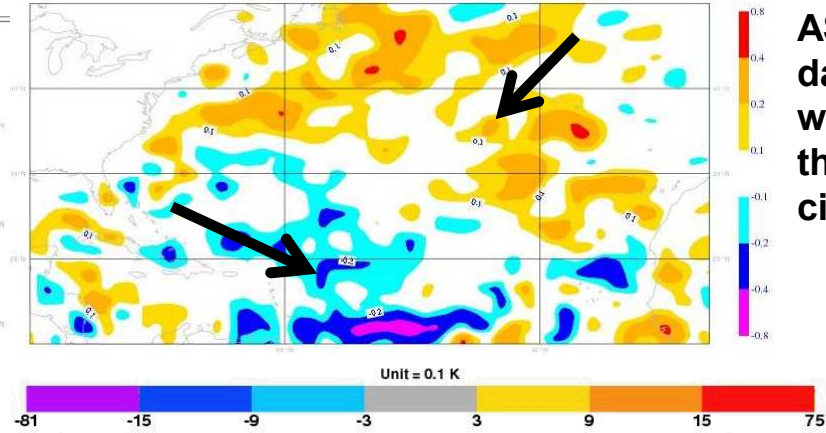
ASCAT September&October Degradation over N. Atlantic

OSE NOSCAT-CNTRL 850-1000hPa

Mean Wind field

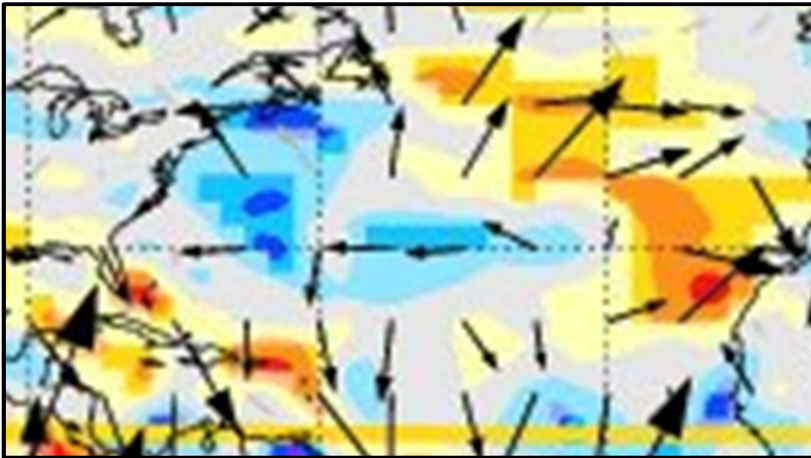


NOSCAT-CNTRL Mean Analysis Differences

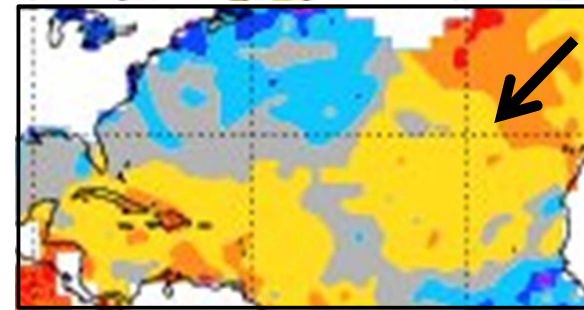


ASCAT data weaken the circulation

Mean Analysis Increments

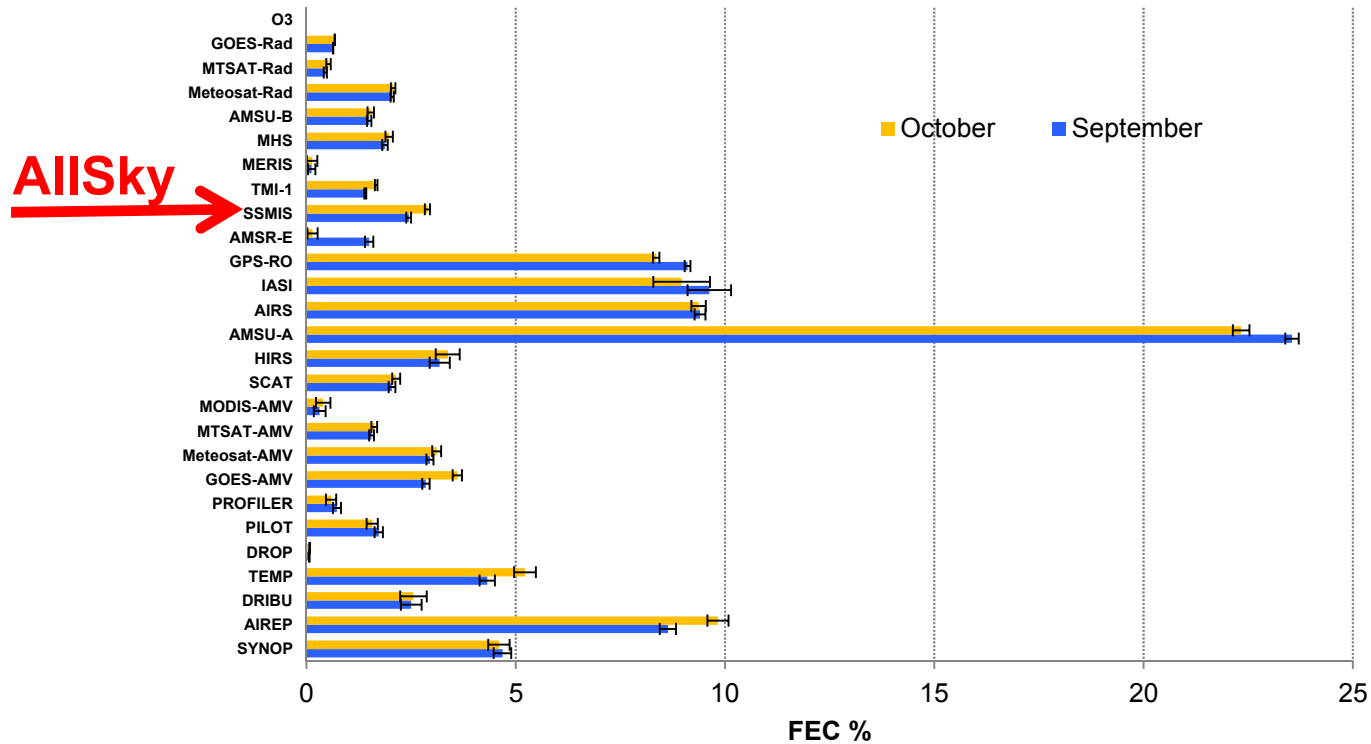


TEMP
U-Comp
FG-dep
reinforce the circulation

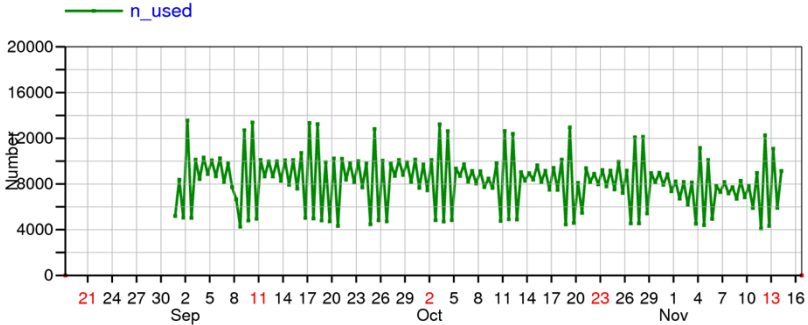
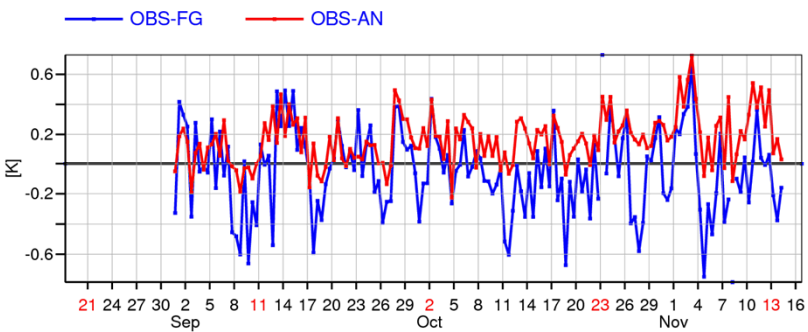
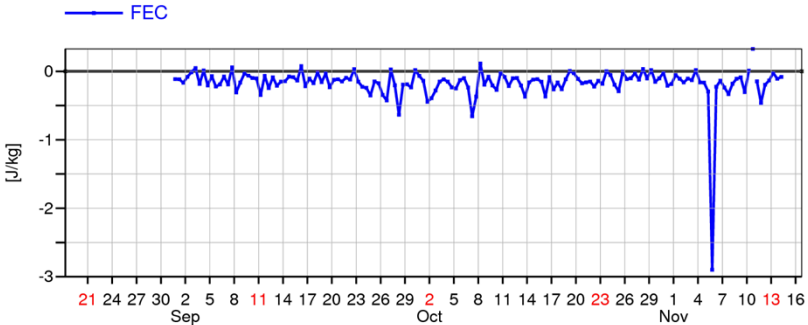
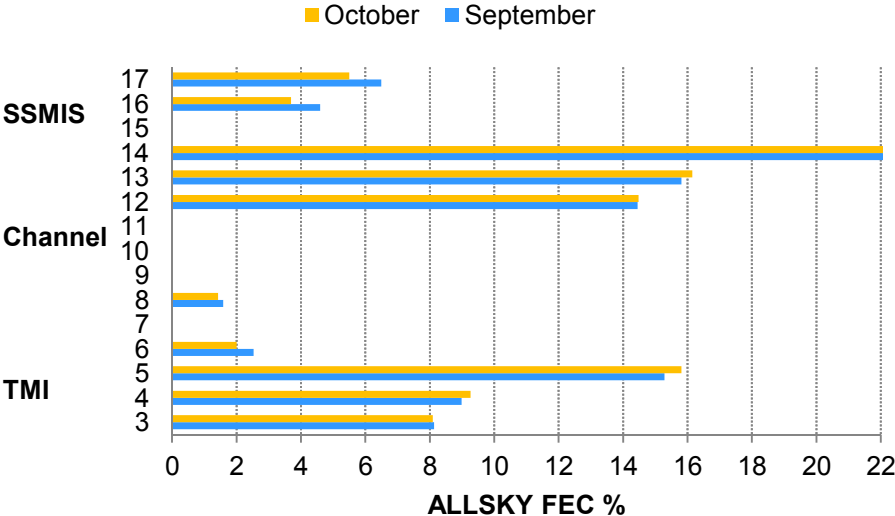


AMV
U-Comp
FG-dep

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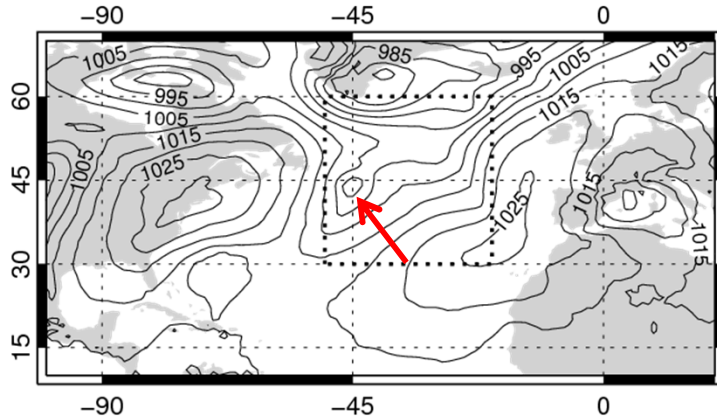
SSMIS FEC North Atlantic November 2011 Case Study



6th November: Case of a rapidly developing cyclogenesis

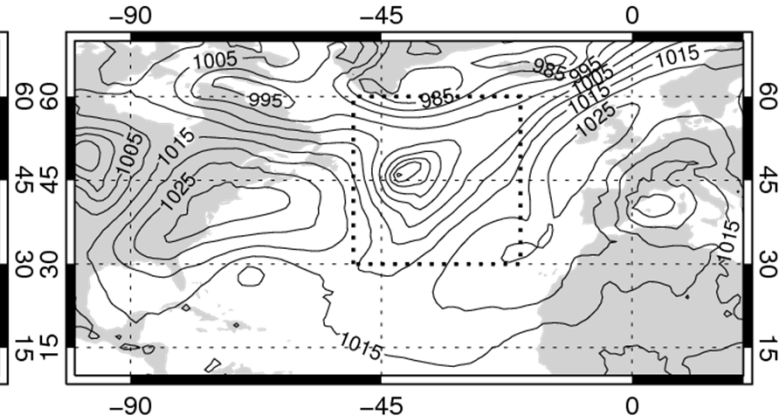
Analysis

00Z 6-Nov-2011



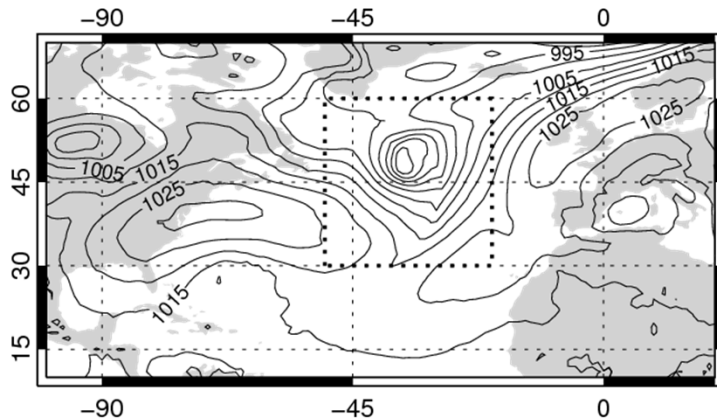
12Z 6-Nov-2011

12h Forecast



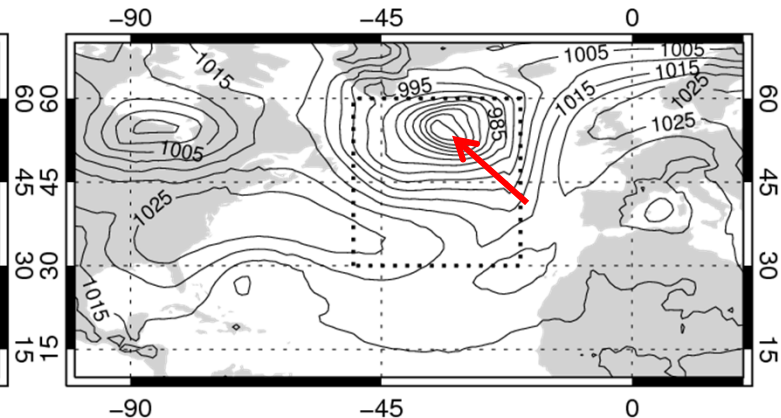
24h Forecast

00Z 7-Nov-2011



12Z 7-Nov-2011

36h Forecast

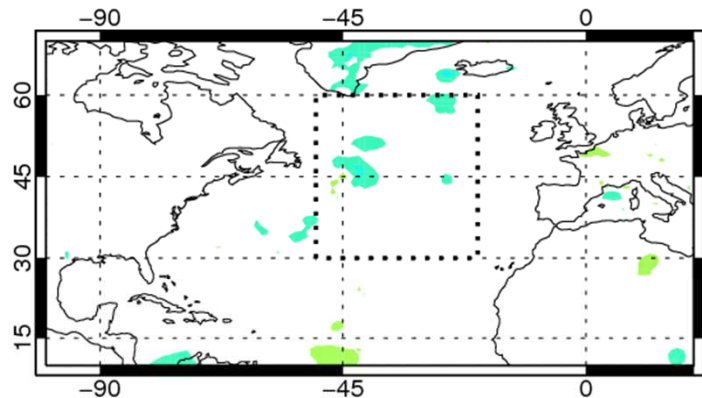


Minimum pressure from **990** to **950** hPa between 00Z 6/11 and 18Z 7/11

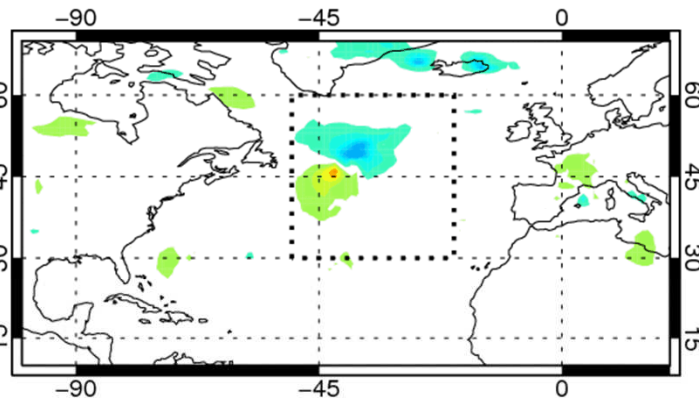
Mean sea level pressure: Evolved increments

Forecast valid at the same time and initiate from subsequent analyses

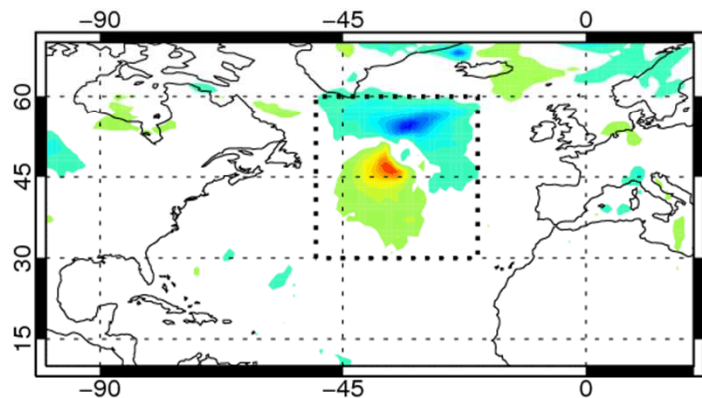
Increments 00Z 6-Nov-2011



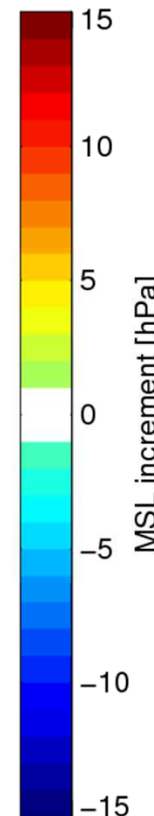
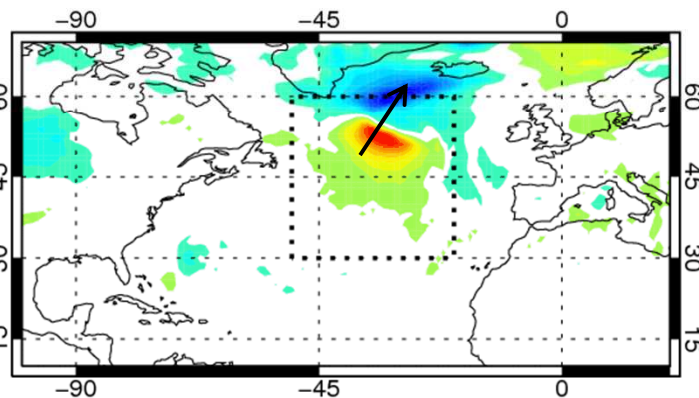
12-24h Forecast 12Z 6-Nov-2011



24-36h Forecast 00Z 7-Nov-2011



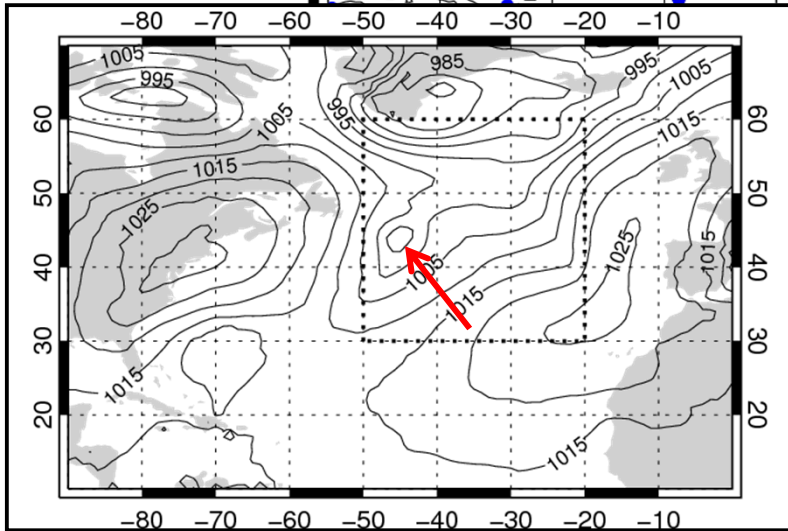
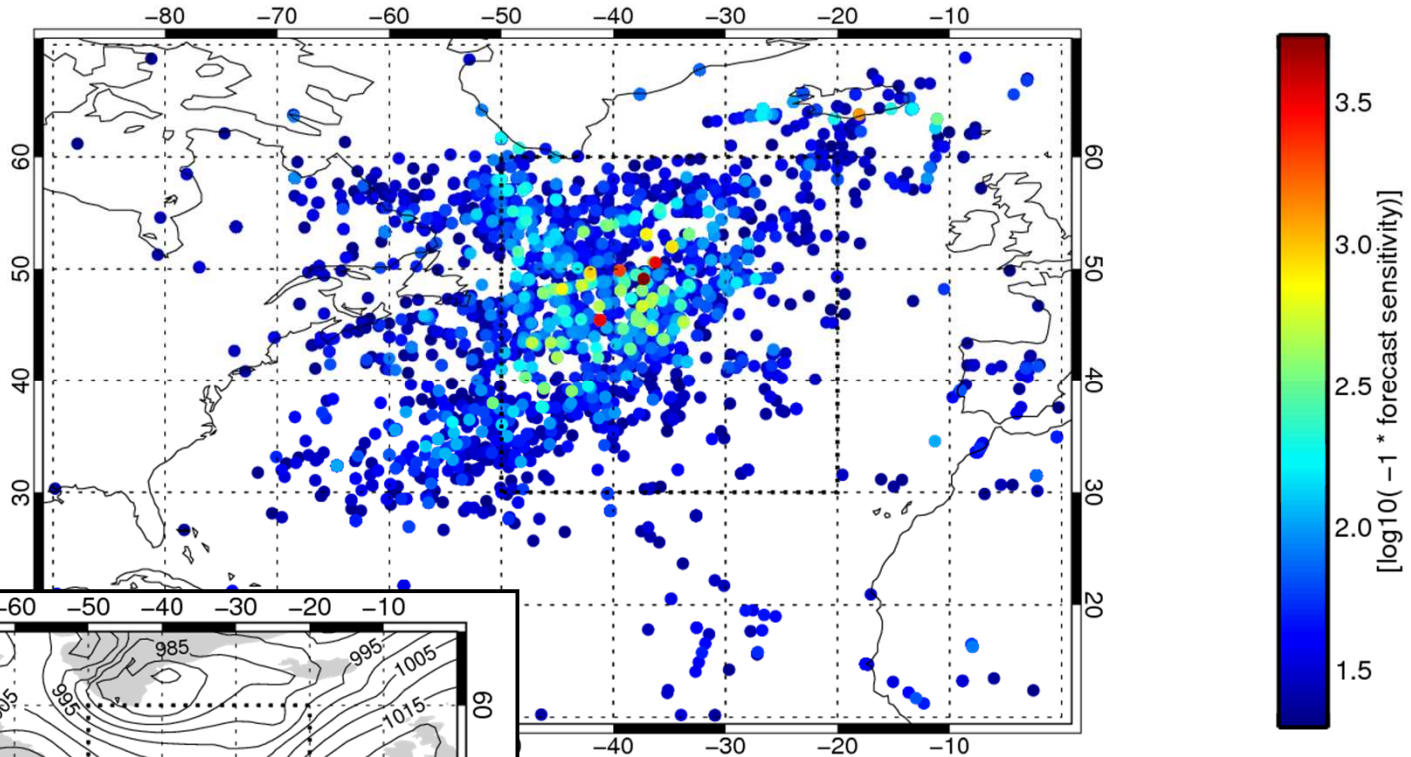
36-48h Forecast 12Z 7-Nov-2011



00Z 6th Nov analysis shifts the storm North West

00Z 6th November FEC

All observations with $FEC < -20$ J

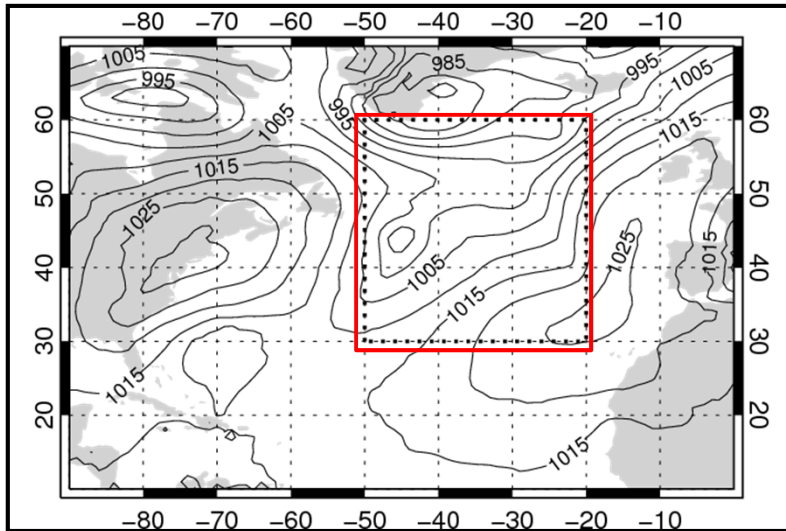
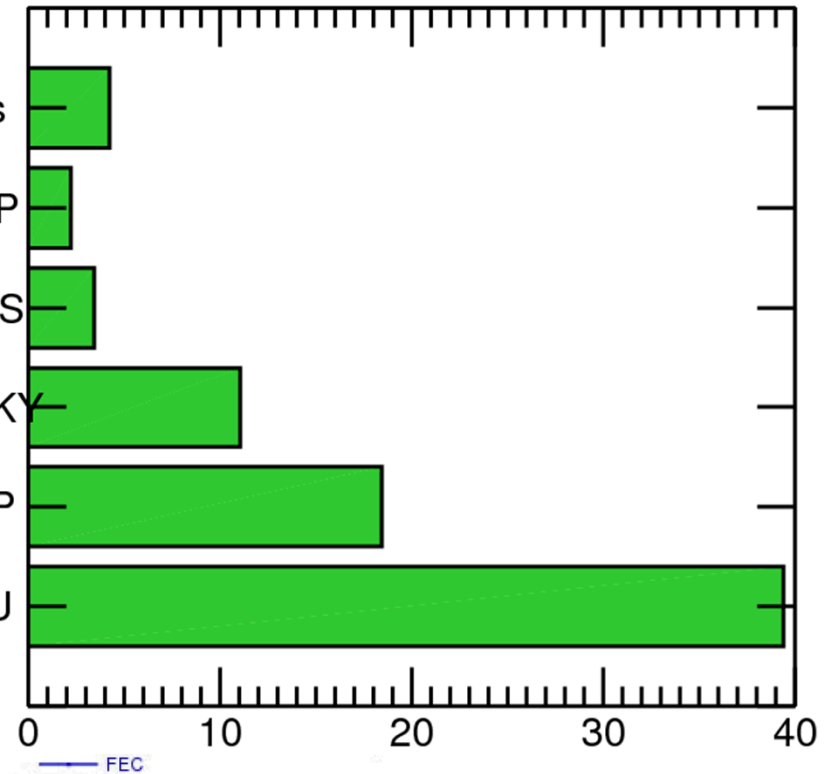


MSL pressure

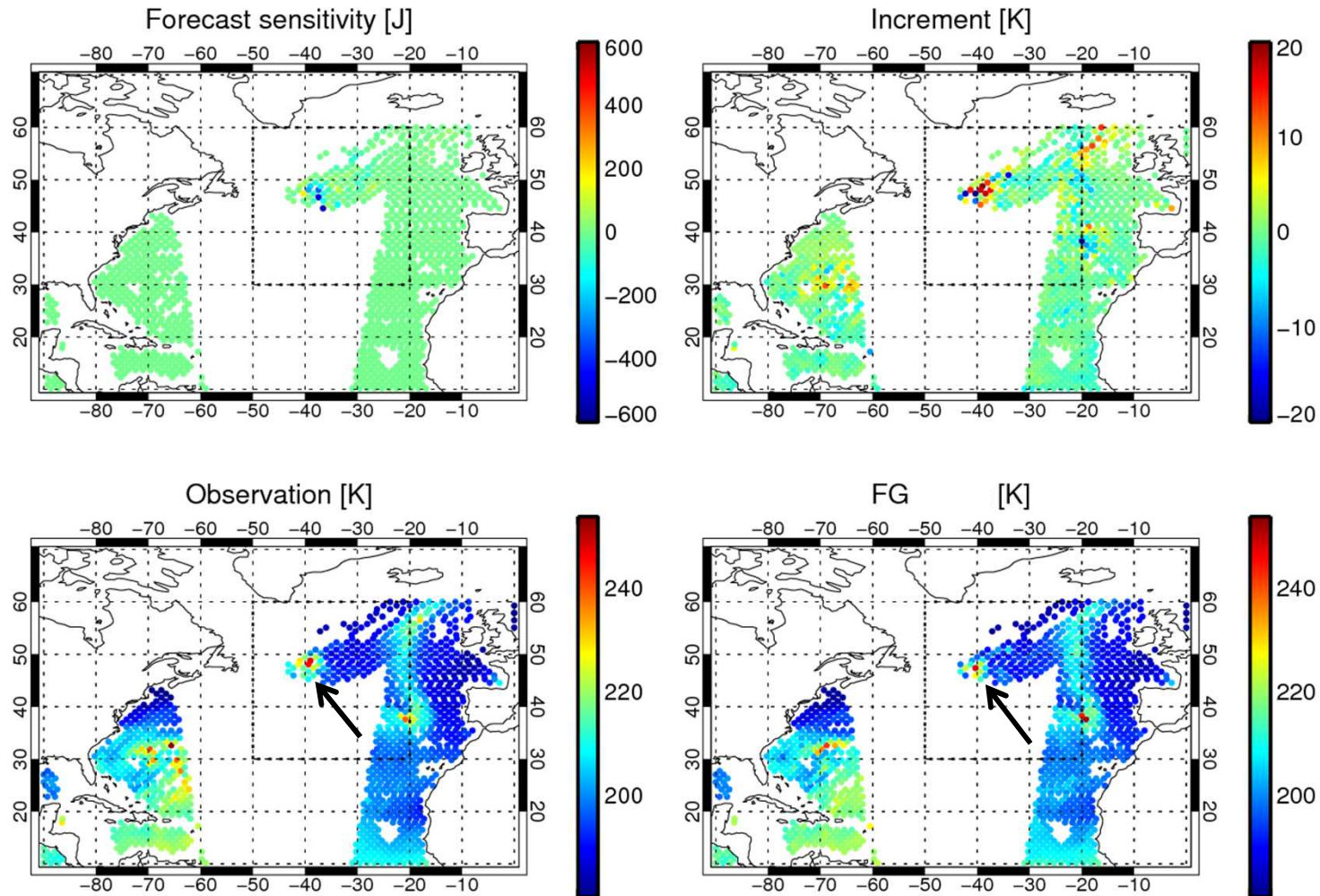
00Z 6th November FEC in the 30° x30°

All other observations
AUTOMATIC SHIP
NOAA 18 AMSUA RADIANCES
DMSP 17 SSMIS RADIANCES ALL-SKY

AIREP
DRIBU



All-sky SSMIS: channel 19v

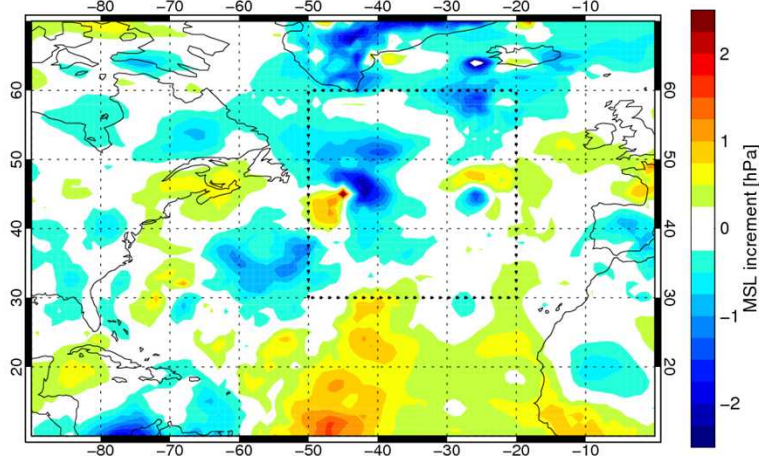


Cloud and precip shifted ~250km to the NW in accordance with obs

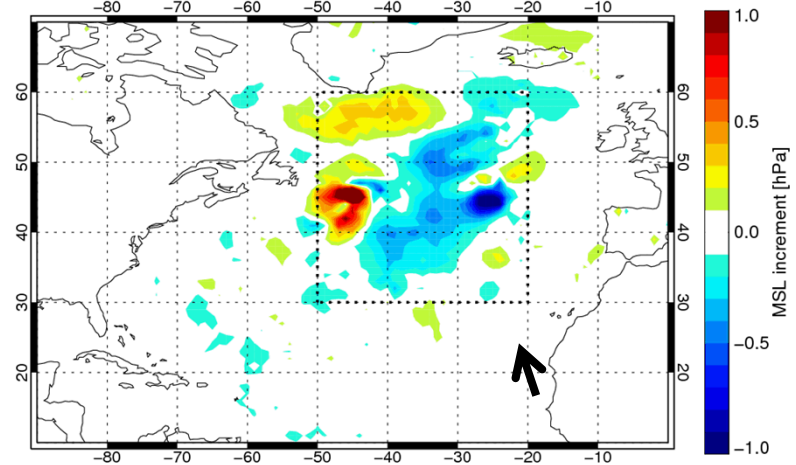
Denial OSEs vs. Operations

Mean sea-level pressure increment at 00Z, 6th November

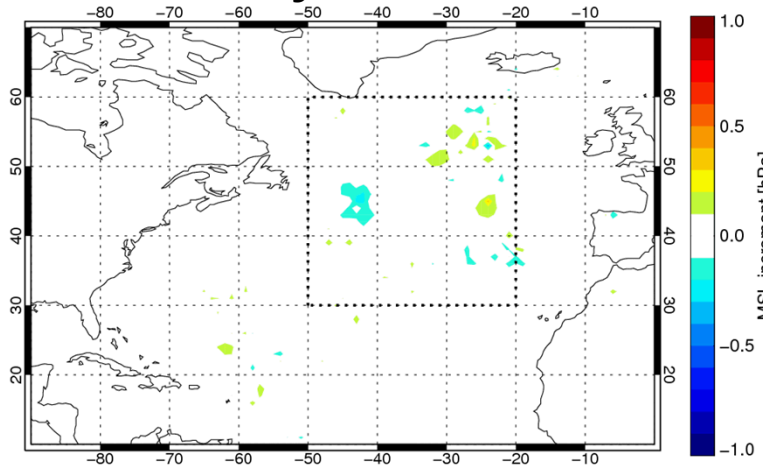
Operations: total increment



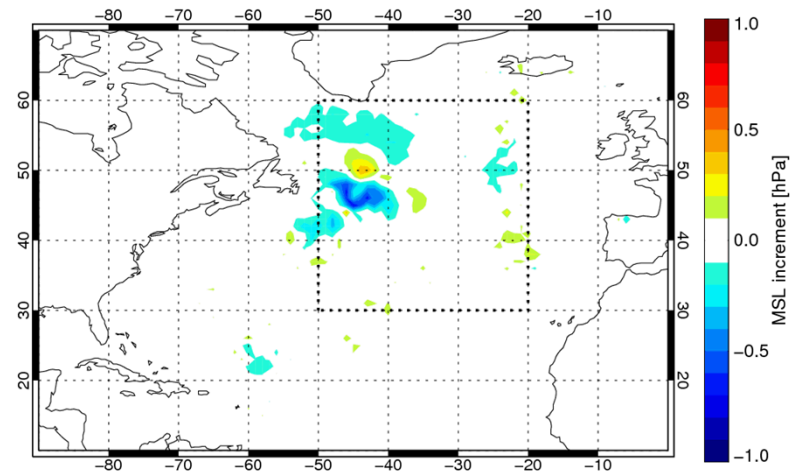
Ship and DRIBU



All-sky SSMIS F-17



AIREP



Conclusions

- Use of Forecast Error Contribution of the Observing system components at ECMWF has been demonstrated
- The observation impact is daily monitored
- Illustrative examples include:
 - Impact of AMSU-A
 - NOAA and METOP-A
 - Impact of AMV
 - METEOSAT-7 over Indian Ocean: Degradation related to model bias
 - Impact of ASCAT
 - North Atlantic Degradation related to underestimation of observed wind speed
 - Allsky Forecast Improvement Case study
- Potential and Limitation of the diagnostic tool have been shown