OVERVIEW OF INFRARED RADIANCE ASSIMILATION IN METEO-FRANCE MODELS

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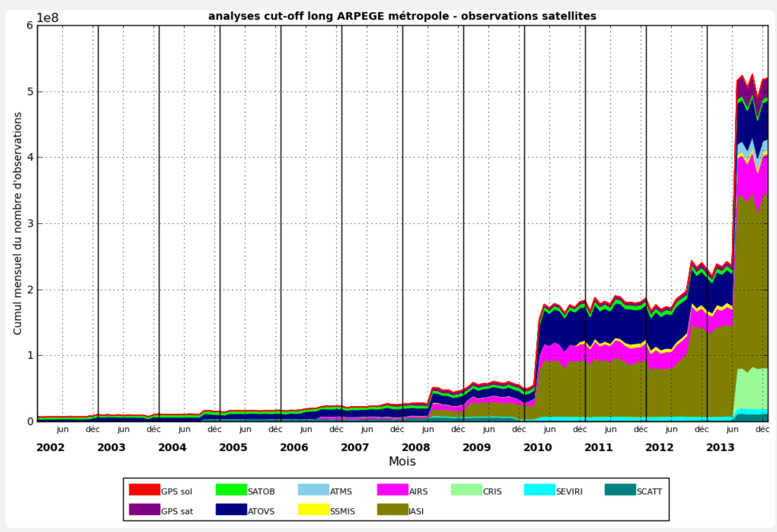
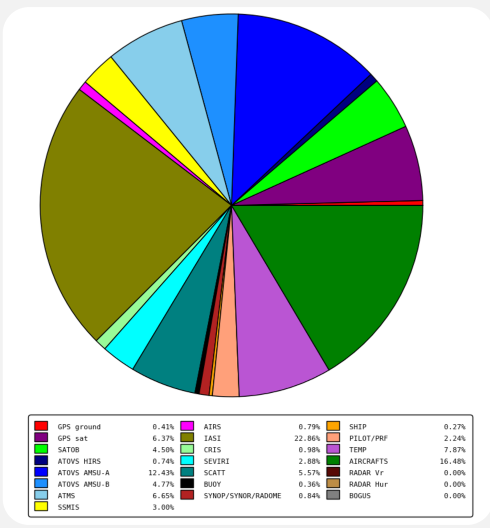
Global model ARPEGE

The 4D-VAR over a 6-hour window processes a huge amount of data, which come from satellite (more than 90%). A large part of assimilated observations in the models of Météo-France comes from infrared radiances. Since last change of the operational suite in July 2013, the number of assimilated radiances has been multiplied by a factor 2. The first contributor to the amount of assimilated observations is IASI sounder onboard both Metop satellites.



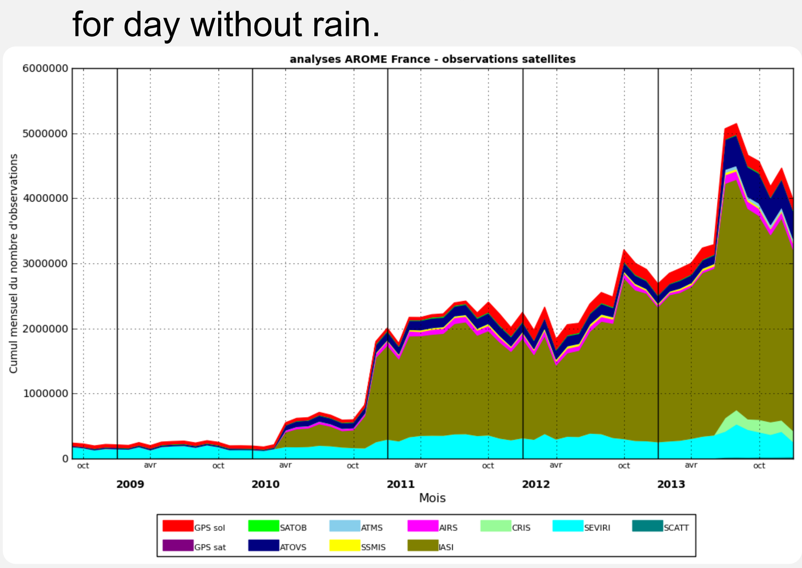
Evolution of the satellite observation number assimilated in the global model ARPEGE since 2002.



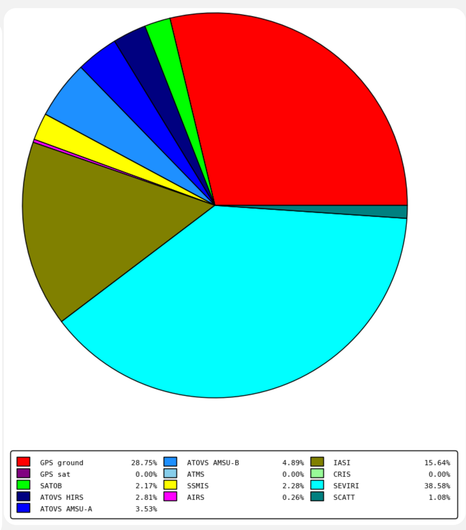
Degrees of Freedom for Signal computed for 27 December 2013 for all observations used in ARPEGE.

Mesoscale model AROME

The analysis is performed with a 3D-VAR every 3 hours at a 2.5 km horizontal resolution. Satellite observations represent between 5% (rainy period) and 50% (clear period) of the total observation amount assimilated in the mesoscale AROME model. Even though IASI provide the largest number of data in AROME but only for 2 analysis times per day, SEVIRI, which is present at every analysis time, contributes the most to the DFS for day without rain.



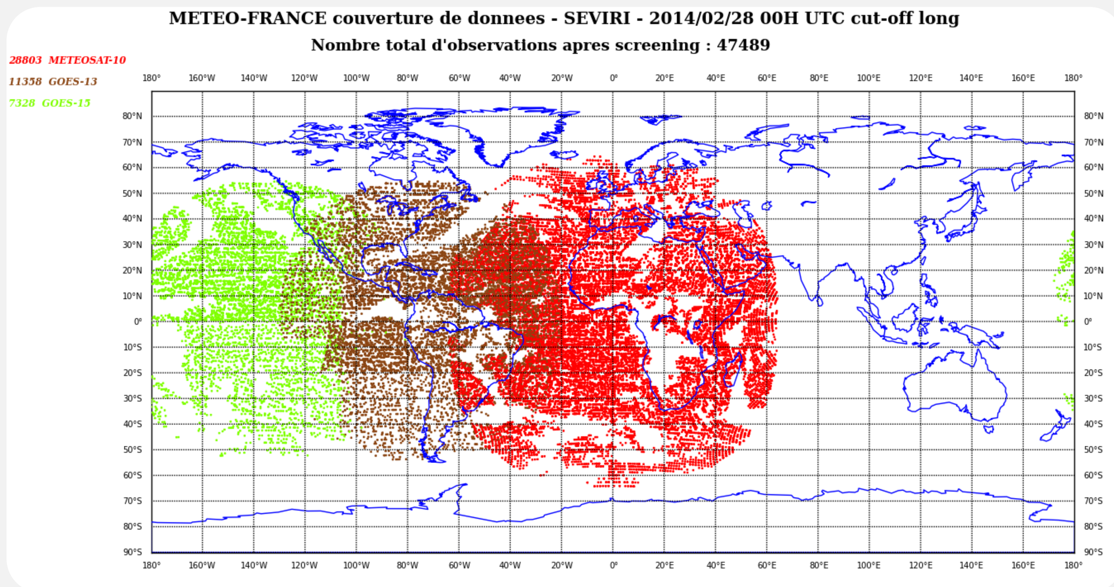
Evolution of the assimilated satellite observation number in the mesoscale model AROME since 2008.



Degrees of Freedom for Signal computed for 3 December 2013 in AROME (non rainy day) and for satellite observations

I. GEOSTATIONNARY CLEAR SKY RADIANCES

Data from 3 satellites are now assimilated: METEOSAT 10, GOES 13 and 15.
The channels assimilated are the 6.2µm channel for GOES13 and GOES 15, the 6.2 and 7.3µm channels for METEOSAT 10.



II. ASSIMILATION OF SEVIRI OVER LAND (AROME)

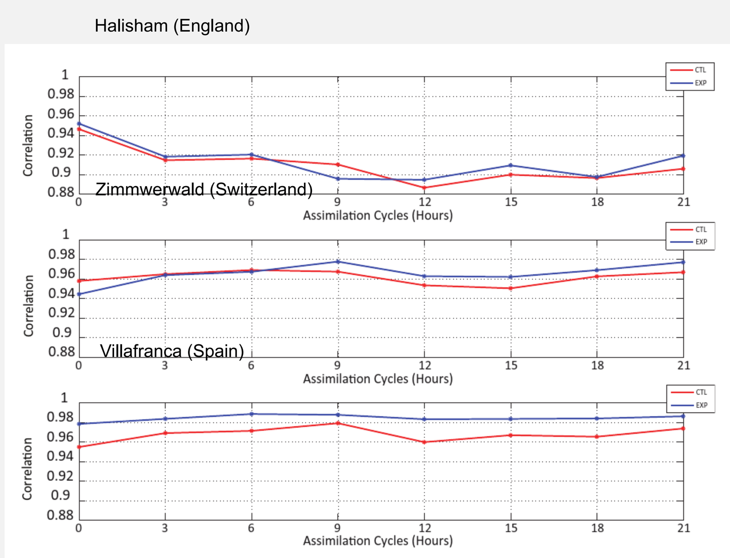
The assimilation of surface sensitive SEVIRI radiances are in operations since July 2013 in AROME

Methodology (Guedj et al, 2011):
Step 1 :Retrievals of Land Surface Temperature (LST) using SEVIRI window channel IR10.8 and land surface emissivity atlases from Land-SAF.
⇒ Single-Channel method (inversion of the radiative transfer equation)

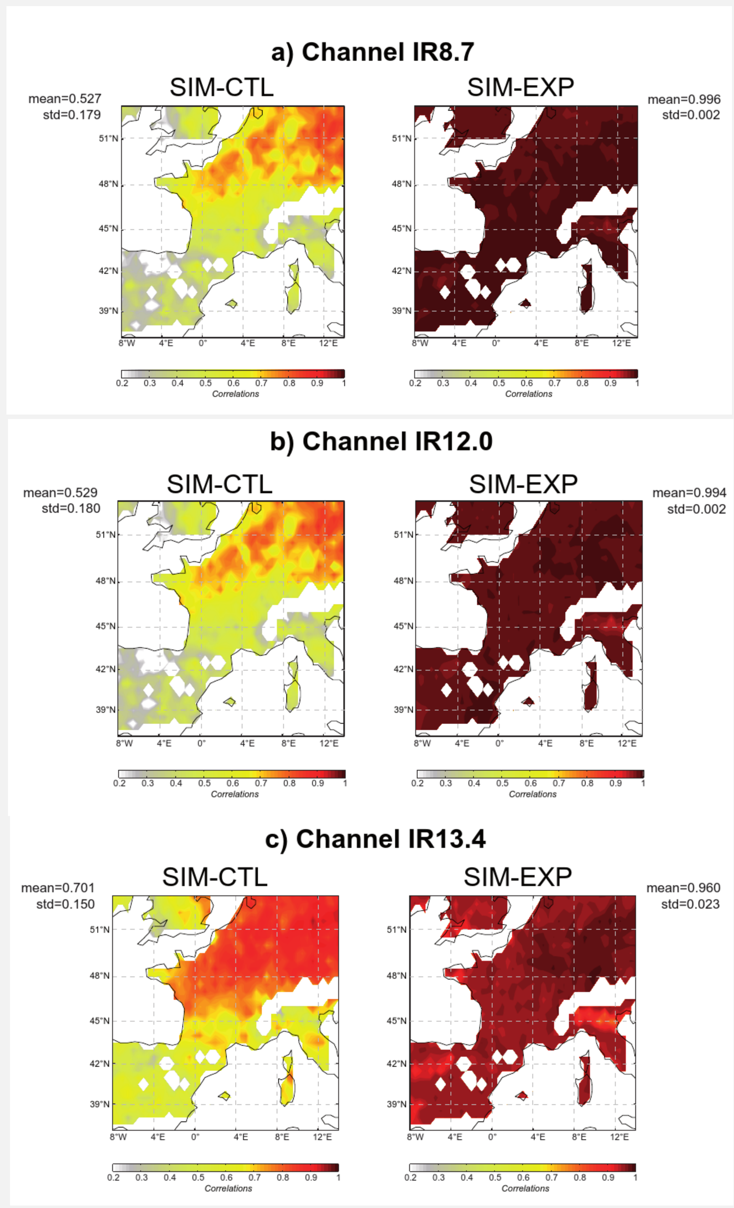
Step 2 : Allocate retrievals of LST to other SEVIRI Bt simulations ⇒ Evaluation of Observations departures to Simulations (right panels)

Step 3 : Assimilation experiments of 3 surface-sensitive IR SEVIRI observations (see table below) over land
⇒ Impacts on analyses and forecasts skills for many periods. The impact is maximal in areas with clear sky conditions. The main change in the analysis is found for moisture, primarily in Southern Europe (middle panels). It has been evaluated near the surface with independent GPS ground station measurements. A similar approach has been developped for IASI (Vincensini, 2013)

	CTL		EXP	
Channels	SEA	LAND	SEA	LAND
IR3.9				
WV6.2	✓	✓	✓	✓
WV7.3	✓	✓	✓	✓
IR8.7	✓		✓	✓
IR10.8	✓		✓	$LST_{IR10.8}$
IR12.0	✓		✓	✓
IR13.4				✓



correlation between TCWV GPS measurements and 3-h forecasts at 3 stations a) Halisham ENG, b) Zimmerwald SWI, c) Villafranca ESP and analysed TCWV values in EXP (blue line) and CTL (red line) according to the assimilation cycle (0h-3h-6h-9h-12h-15h-18h-21h). TCWV values concern a period of 3 months (1 May - 31 July 2011).

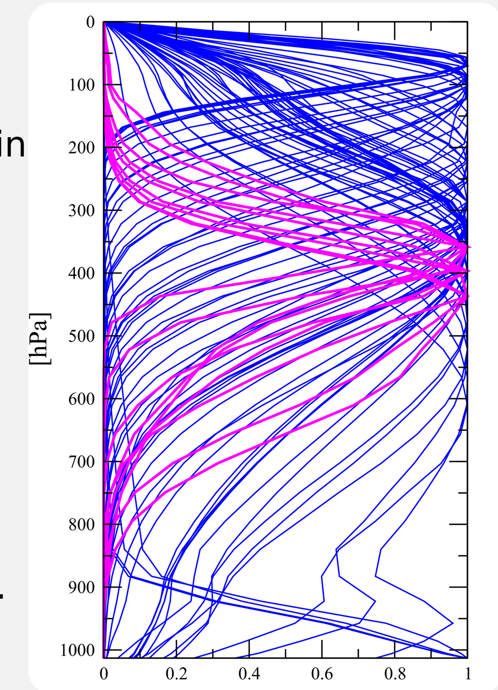


Maps of correlations between observed Bt and simulated Bt of SEVIRI a) channel IR8.7, b) channel IR12.0 and d) channel IR13.4. The correlations have been computed using data falling within a grid cell of 0.5ox 0.5o for the period of 1-20 January 2011. Different configurations have been used to simulate Bt : EXP – CTL (left), EXP – LST (right). Red (grey) color refers to high (low) correlations between observations

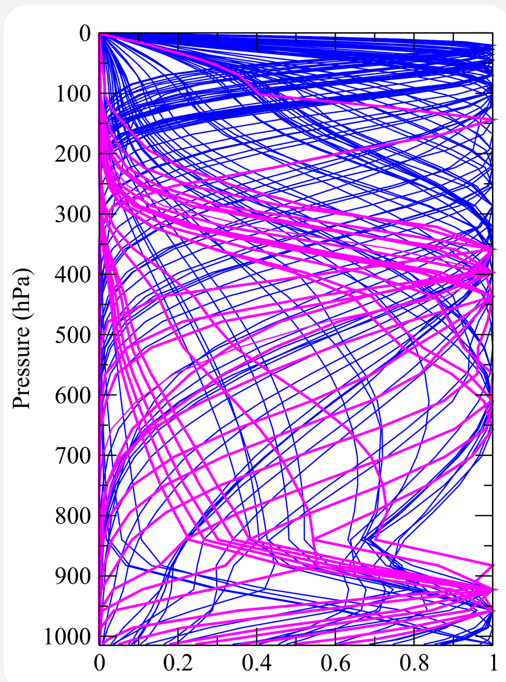
III. IASI

IASI channels from Metop-A and Metop-B are currently assimilated in both models. Assimilation of 24 additional tropospheric channels and 12 water vapour channels sounding in the high troposphere and in the lower troposphere is now in operations since March 2012. The number of assimilated channels increases from 72 T channels to 101 T channels and from 9 to 21 water vapour channels.
Few cloudy IASI channels are also assimilated with adequate cloud top pressure and effective cloud fraction.

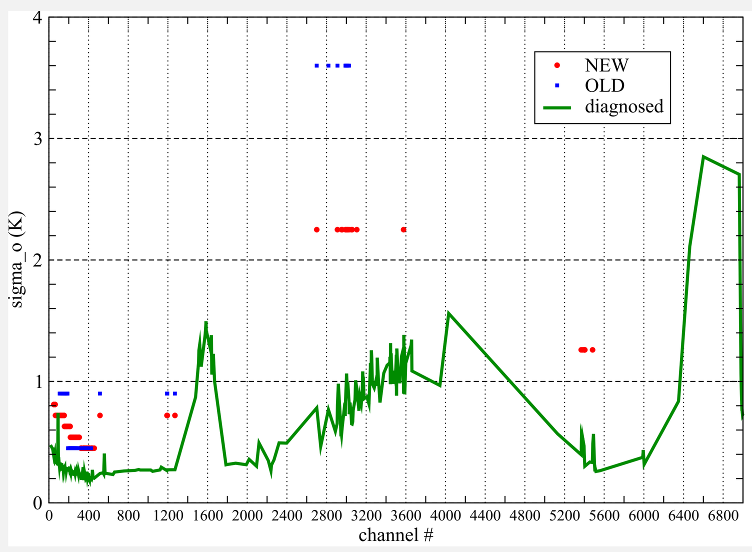
The IASI observation errors have also been decreased (right panel).



68+4+9 IASI channels in early 2012



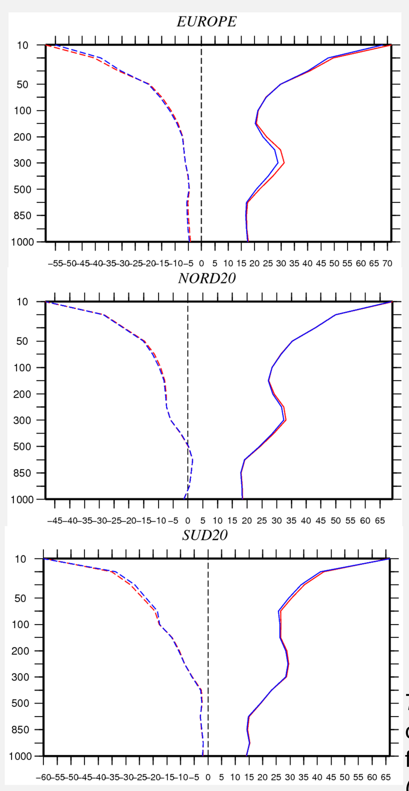
101+21 IASI channels in 2014



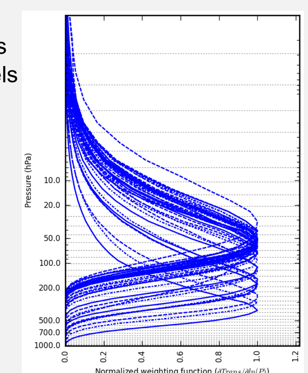
IASI observation errors in the operations (NEW) compared with the oldest ones (OLD). The green line represents the diagnosed observation errors

IV. CRIS

The assimilation of CrIS is operational since July 2013 in ARPEGE and AROME.
41 CRIS temperature channels sounding the stratosphere and the upper-troposphere are assimilated over sea, 37 over land
A positive impact on the forecast is found in the upper-troposphere in both hemispheres and over the Europe area.



72-h forecast errors in geopotential computed with respect to radiosondes for REF (in red) without CrIS and EXP (in blue) with CrIS assimilation.

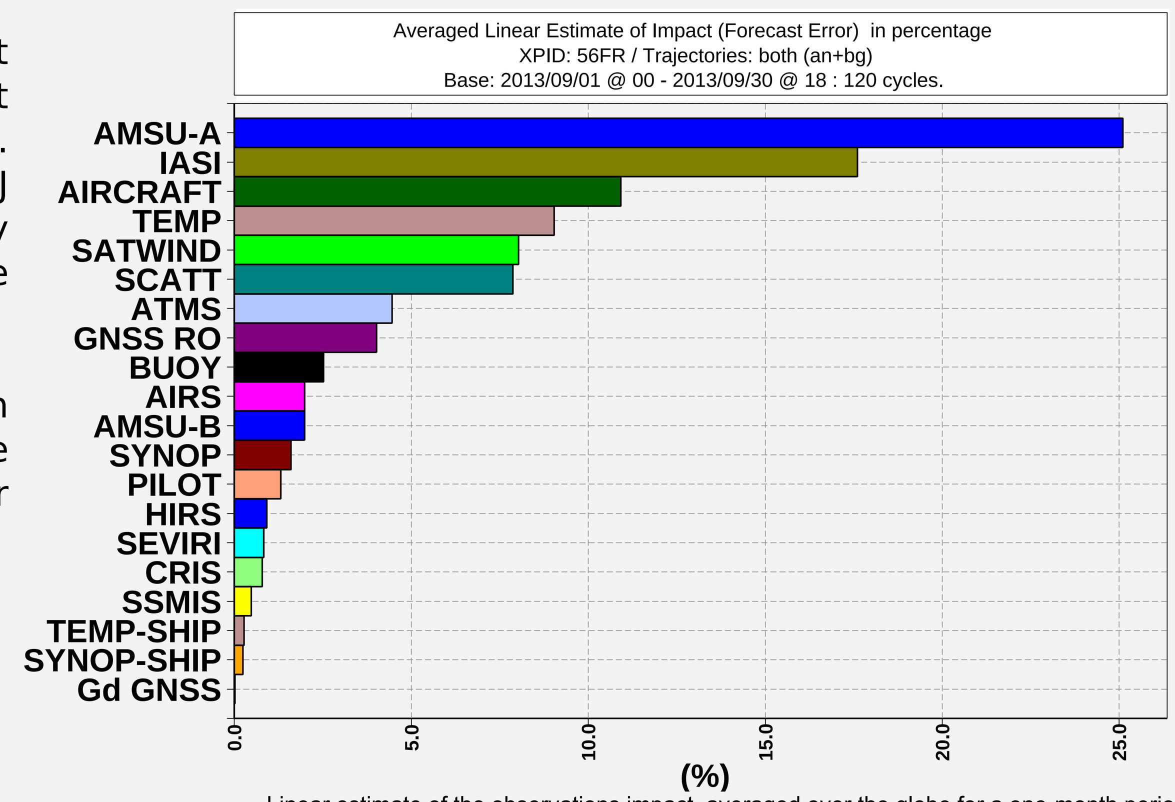


Normalized weighting functions of the assimilated CrIS channels over sea

V. FORECAST SENSITIVITY TO OBSERVATIONS

An adjoint diagnostics, implemented by C. Cardinali at ECMWF, is used at METEO-FRANCE (Boullot, et al. 2014). It allows to evaluate the observation impact on forecast skill. To compute this observation impact, a cost function J representing the forecast error (i.e. total dry energy difference between the 24h forecast and the reference analysis) is used.

The forecast sensitivity to observations has been computed over 1-month period (September 2013) for the operational suite. First contributors to the forecast error reduction are the 7 AMSU-A sounders followed by 2 IASI.



Linear estimate of the observations impact, averaged over the globe for a one-month period (September 2013) separated by observation group

REFERENCES
• Guedj S., F. Karbou and F. Rabier (2011): Land surface temperature estimation to improve the assimilation of SEVIRI radiances over land, J. Geophys. Res., 116, D14107, doi:10.1029/2011JD015776.
• Boullot N., F. Rabier, R. Langland, R. Gelaro, C. Cardinali, V. Guidard, P. Bauer, A. Doerenbecher (2014): Observation impact over the Antarctic during the Concordiasi field campaign. Quart. J. R. Met. Soc., in revision.
• Vincensini, A. (2013): "Contribution du sondeur IASI à l'estimation des paramètres des surfaces continentales pour la prévision numérique du temps". PhD of the Univesity of Toulouse.

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