GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE
AEMet Agencia Estatal de Meteorología
EUMETSAT
Monitoring weather and climate from space
Surveiller le temps et le climat depuis l'espace

NWC SAF
Support to Nowcasting and Very Short Range Forecasting

NWC SAF/High Resolution Winds AMV Software Version 2016

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Thirteenth International Winds Workshop

Monterey, United States

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NWC SAF/GEO & High Resolution Winds v2016

Eumetsat's Satellite Application Facility on Support to Nowcasting (NWC SAF) develops and distributes to Meteorological Services and Researchers NWC SAF/GEO Software Package.

It permits NWC SAF users (among other options) to calculate locally and in near real time High Resolution Winds (HRW):

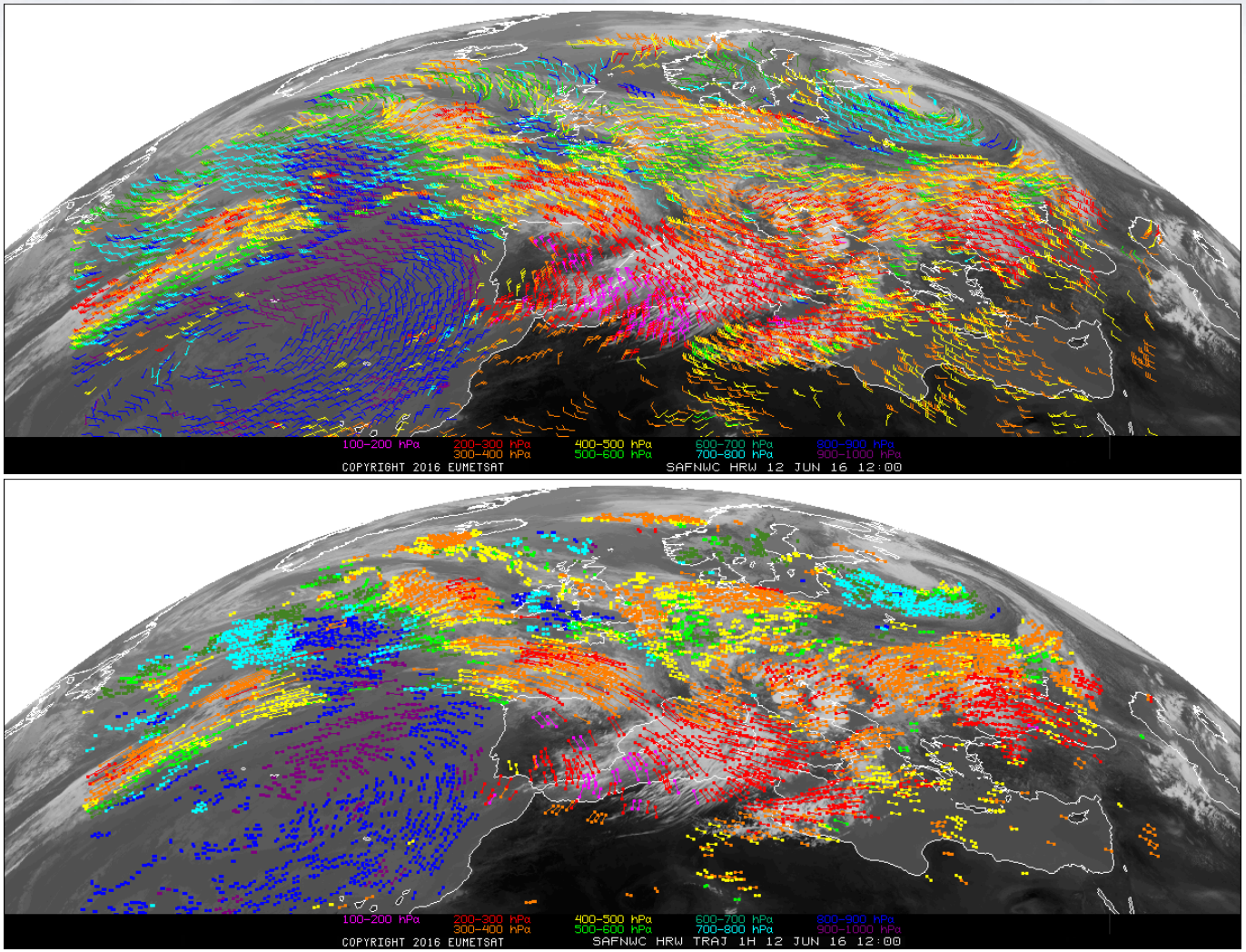
> High density sets of Atmospheric Motion Vectors (AMVs) and Trajectories for near real time applications.

NWC SAF/GEO v2016 (latest version of the software package) is ready for release in late Summer 2016

> Initially defined as NWC SAF/GEO v2015, but to be released now due to several delays.

> Already running at NWC SAF Helpdesk, only pending on a final review/authorization by Eumetsat for distribution to users.

NWC SAF/GEO & High Resolution Winds v2016



Example of NWC SAF/HRW v2016 AMVs (up) and 1 hour Trajectories (down)
12 June 2016, 12:00Z, Meteosat 10, European & North Atlantic region

Main changes in NWC SAF/GEO v2016 Software package:

1. A major redefinition of:
   - The general library used by all NWC SAF/GEO Products for:
     - Reading/Processing of Satellite, NWP, Auxiliary data, Input/Ouput data.
     - Processing of Mathematical/Meteorological operations.
   - Auxiliary common data used by all NWC SAF/GEO Products
     - Topographies, emissivities,…

➔ Consequence of this:
- A better homogenization of common processing tasks.
- A simplification of the processing of any additional geostationary satellite series (processed through a common NetCDF data format, with software support by Météo France).

2. Official release of several new NWC SAF/GEO products (causing the largest extension of NWC SAF/GEO software since its start):

➔ **Cloud Microphysics product (CMIC)**, providing:

- Cloud phase
- Cloud optical thickness
- Effective particle radius
- Liquid water path
- Ice water path

➔ **Extrapolated Imagery product (EXIM)**, extrapolating Satellite/NWC SAF product images up to one hour into the future.

➔ **Automatic Satellite Image Interpretation - Next Generation (ASII-NG)**, identifying specific meteorological phenomena.

➔ **Convection Initiation (CI)**, showing the probability of cloudy pixels to become a thunderstorm.

NWC SAF/HRW v2016: Main improvements

Main improvements in NWC SAF/High Resolution Winds v2016:

1. Recoding and verification of all HRW code considering:
   - > the new NWC SAF/GEO common library (NWCLIB) and
   - > the new NWC SAF/GEO Cloud product outputs (CT, CTTH, CMIC).

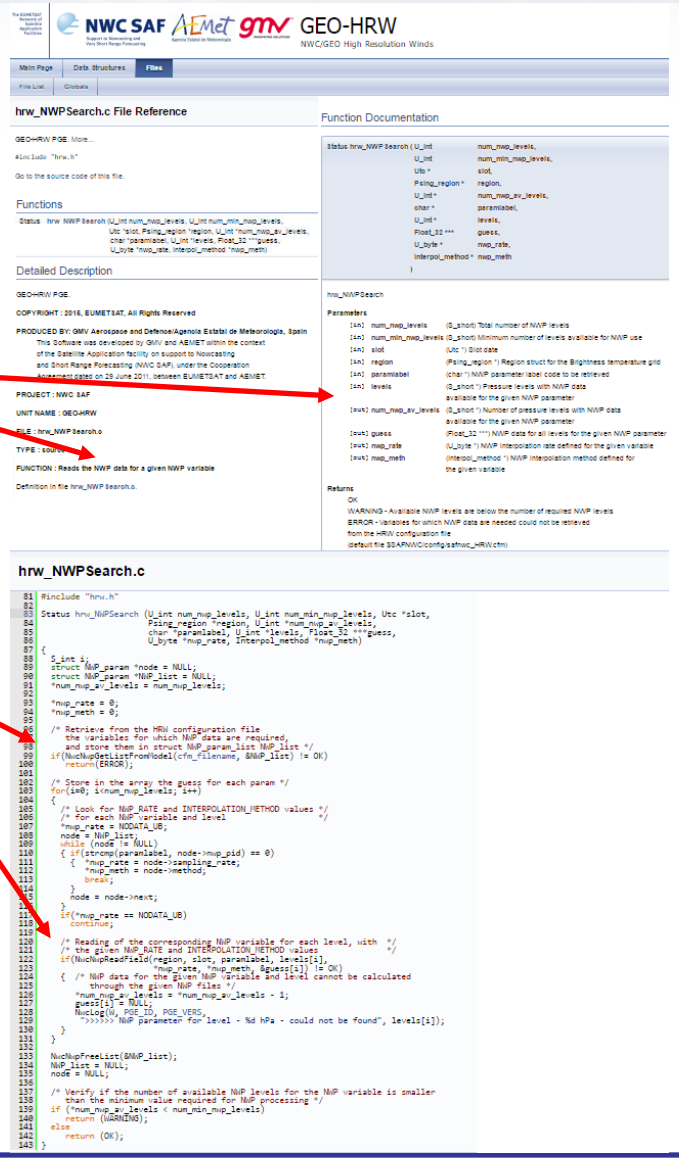
2. Provision of a detailed documentation of all HRW code
   - > through a "html handbook"
     with the support of Doxygen tool.
   - > through comments explaining every single step
     of the C/Fortran code.

NWC SAF/HRW v2016: Main improvements

The "Doxygen html handbook" permits simply with a web browser:

- To know the tasks and relationships of all functions inside HRW code.

- To identify all processes included inside HRW code.



This way, the algorithm is very easy for understanding and further development by all NWC SAF users.

3. Modification of AMV height assignment with the Cloud Microphysics:

Several studies suggested to consider AMVs at a level lower than the cloud top (P.Lean et al., Á.Hernández-Carrascal, K.Salonen & N.Bormann, 2014)

A relationship is found to exist between the "AMV best fit pressure level" and the "Cloud depth", considering next steps:

➔ **"AMV Cloud phase" (CPh_{AMV})**

"AMV Liquid water path" (LWP_{AMV}) for liquid AMVs

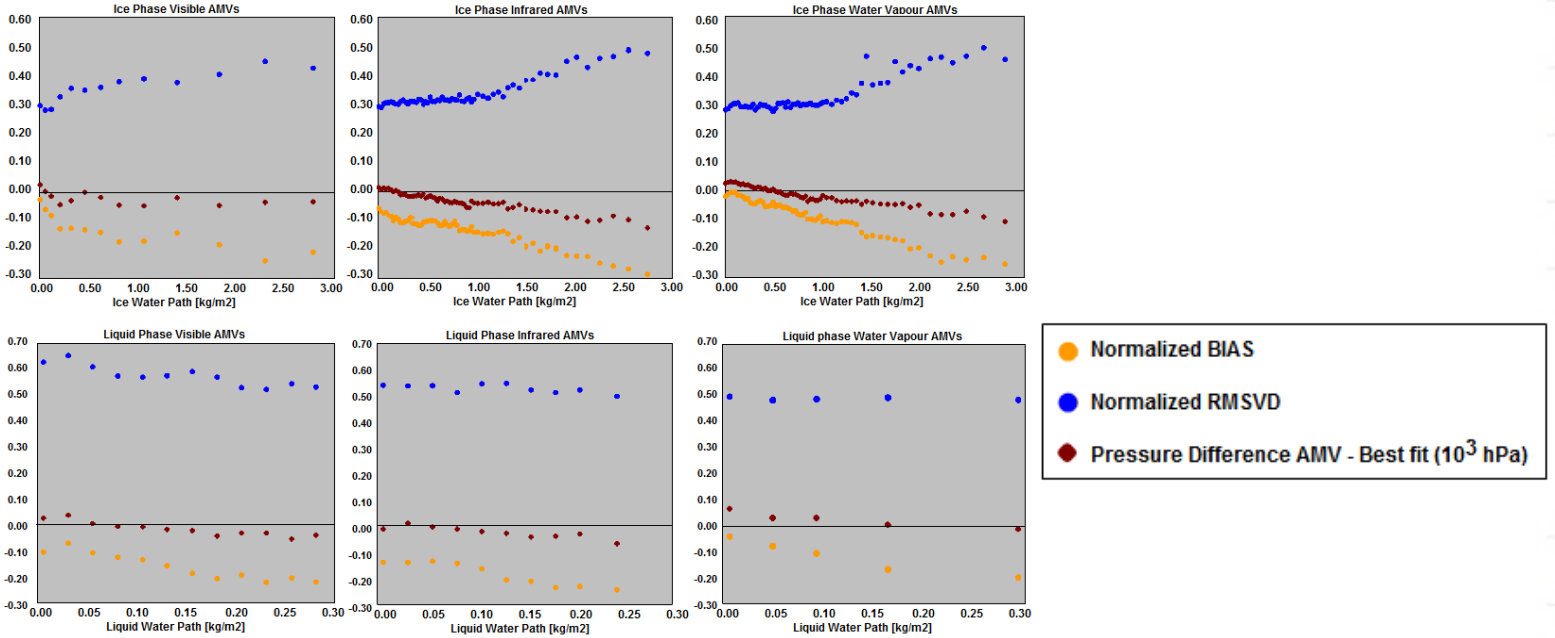
"AMV Ice water path" (IWP_{AMV}) for ice AMVs

are calculated considering pixel information provided by NWC SAF/Cloud Microphysics product (during daytime only!) and the formulas provided by "CCC height assignment method".

NWC SAF/HRW v2016: Main improvements

➔ Displaying for "Ice phase AMVs" (up) / "Liquid phase AMVs" (down)

NBIAS NRMSVD Pressure difference with best fit level against IWP_{AMV}/LWP_{AMV}



NBIAS more negative for larger IWP_{AMV}/LWP_{AMV} values

NRMSVD larger for larger IWP_{AMV} values

≈ Linear relationship of Press.Diff.with best fit level against IWP_{AMV}/LWP_{AMV}

Best fit at lower levels of atmosphere except for small values of IWP_{AMV}/LWP_{AMV}

NWC SAF/HRW v2016: Main improvements

➔ Defining a linear correction of the AMV pressure level with this relationship

Pressure difference with the best fit level(IWP_{AMV}/LWP_{AMV}), and

comparing AMV statistics (Europe & Mediterranean region, Jul 09-Jun 10)

HRW v2013:

HRW v2013 (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV062	Cloudy WV073	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	47280	100836	91677	189804	262992	251524	252375	43004	1239492
SPD [m/s]	16.14	11.04	11.04	23.51	21.28	19.58	19.74	16.52	19.01
NBIAS	-0.10	-0.18	-0.18	-0.06	-0.08	-0.12	-0.11	-0.00	-0.10
NMVD	0.31	0.42	0.42	0.26	0.28	0.30	0.29	0.33	0.31
NRMSVD	0.38	0.50	0.50	0.32	0.35	0.37	0.36	0.40	0.38

HRW v2016:

HRW v2016 with Microph. (Jul 2009-Jun 2010)	Cloudy HRVIS	Cloudy VIS06	Cloudy VIS08	Cloudy WV62	Cloudy WV73	Cloudy IR108	Cloudy IR120	Clear Air	All AMVs
NC	31630	97221	87177	256951	331831	313072	317120	48509	1483511
SPD [m/s]	16.64	10.51	10.48	22.78	20.80	18.53	18.67	16.64	18.70
NBIAS	-0.04	-0.14	-0.15	-0.04	-0.07	-0.09	-0.08	-0.00	-0.08
NMVD	0.29	0.41	0.42	0.26	0.28	0.29	0.29	0.32	0.30
NRMSVD	0.35	0.49	0.49	0.32	0.35	0.35	0.35	0.39	0.36

> All parameters improve, although some of them in a limited way.

> The method can imply a retuning with Cloud type (cirrus ↔ cumulus/stratus)

NWC SAF/HRW v2016: Main improvements

4. Adaptation of HRW algorithm to GOES-N satellite series (GOES 13, 14, 15):

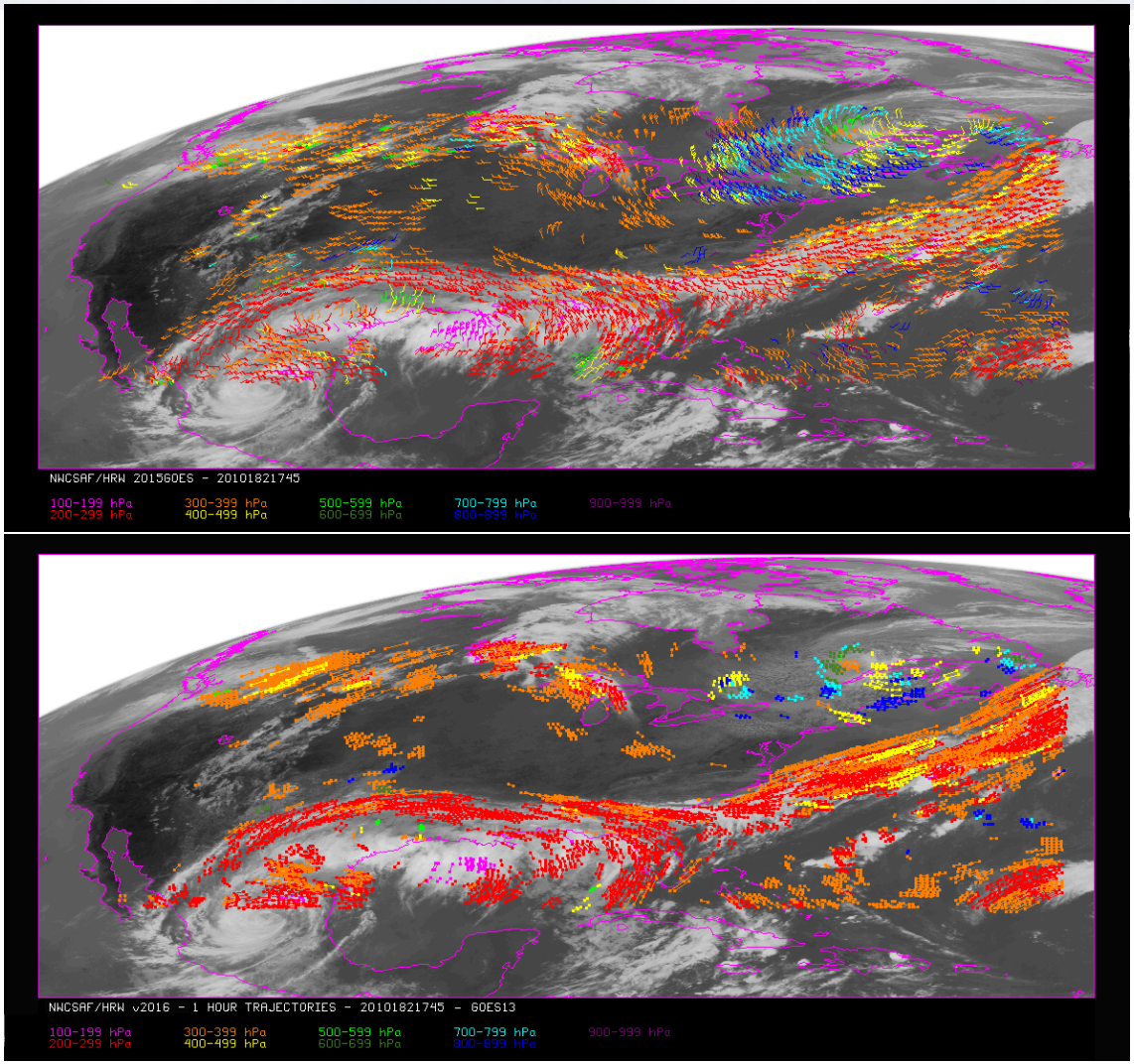
> First geostationary satellite series apart from MSG,
with which NWC SAF/High Resolution Winds can be used
(initial step for the adaptation to other Geostationary series later on).

> This process proves that NWC SAF/GEO software,
and specifically HRW product,
can work very well with other Geostationary satellites.

> AMVs extracted from:

- 0.6 µm Visible channel (1 km resolution).
- 10.7 µm Infrared channel (4 km resolution).
- 6.5 µm Water vapour channel (4 km resolution).

NWC SAF/HRW v2016: Main improvements



Example of NWC SAF/HRW v2016 AMVs (up) and 1 hour Trajectories (down) for 1 July 2010, 17:45Z, GOES 13, United States region

NWC SAF/HRW v2016: Main improvements

> All processes similar for GOES-N series AMVs except Microphysics correction:

- Smaller number of satellite channels permit the calculation of all NWC SAF/Cloud products except Cloud microphysics.

> Two default configurations for AMVs/Trajectories with GOES-N series:

- Every 15 minutes in the United States region.
- Every 30 minutes in the North America region.

(Other options possible, configurable by the user)

> Calculating AMV statistics (United States region, Jul 10-Jun 11):

HRW v2016 without Microph. (Jul 2010-Jun 2011)	Cloudy VIS07	Cloudy WV65	Cloudy IR107	Clear Air	All AMVs
NC	5849	205757	208726	47253	467585
SPD [m/s]	22.34	24.46	22.98	15.31	23.00
NBIAS	+0.00	-0.03	-0.08	-0.00	-0.05
NMVD	0.25	0.27	0.29	0.35	0.28
NRMSVD	0.31	0.33	0.36	0.48	0.36

Validation statistics similar to those of MSG satellites

5. Option of additional AMV/Trajectory output using NetCDF format:

➔ A discussion was started in Autumn 2014 in the IWWG mailing list about a possible common NetCDF format for all AMV producers

- Currently only NOAA seems to be providing it.
- EUMETSAT plans about this AMV NetCDF output still not clear (Simon Elliott suggested IWWG defines first the corresponding format).
- HRW will for the moment provide its specific NetCDF AMV outputs.

Suggestion: Discussion at this Winds Workshop about a common NetCDF AMV format?

NWC SAF/HRW in 2017-2022: Next phase

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NWC SAF Support to Nowcasting and Very Short Range Forecasting

NWC SAF proposal for next phase (CDOP3, 2017-2022)

is approved by the Eumetsat Council this month of June.

Evolution for "NWC SAF/High Resolution Winds":

1. Adaptation to additional geostationary series:

- **> Himawari 8/9 (v2018, next release).**
- **> GOES R/S (later on).**
- **> MTG-Imager (version for "day 1", when it becomes operational, ≥ 2020).**

➔ **Due to the similarities in the "Next generation geostationary imagers", once the adaptation to the first one of them is made (Himawari 8/9), the adaptation to the rest of them will be very straightforward (including other possible satellite series).**

➔ **Processing based on the conversion (with tools provided by Météo France) of satellite data to a common NetCDF input, able to process all satellites.**

NWC SAF/HRW in 2017-2022: Next phase

Agencia Estatal de Meteorologia

NWC SAF
Support to Nowcasting and Very Short Range Forecasting

Evolution for "NWC/GEO High Resolution Winds" software:

2. Increase of temporal/spatial density of AMVs, specially at low levels (v2018).

- ➔ More evaluation of smaller tracer sizes/temporal gaps.
- ➔ Option for "Mixed method considering Nominal and Rapid scan", with AMVs calculated in Nominal scan cycles, with Tracking verification considering Rapid scan cycles.

3. Inclusion of additional techniques in the AMV calculation process.

- ➔ Option for "NOAA/NESDIS Nested tracking technique".

4. Research on additional AMV Quality estimates

- ➔ Option for "Mesoscale Quality indicator".
- ➔ Option for "New Speed/Level error estimates".

NWC SAF/GEO-Sounder New software package

NWC SAF will also develop a specific NWC SAF/GEO-S software package for "IRS – Infrared Sounder Instrument" on board MTG-Sounder satellites (≥ 2022).

NWC SAF/GEO-Sounder will include AMV retrieval in a version for "day 2":

1. Considering MTG-S/IRS Level 1 Images
2. Considering MTG-S/IRS Level 2 Vertical profiles

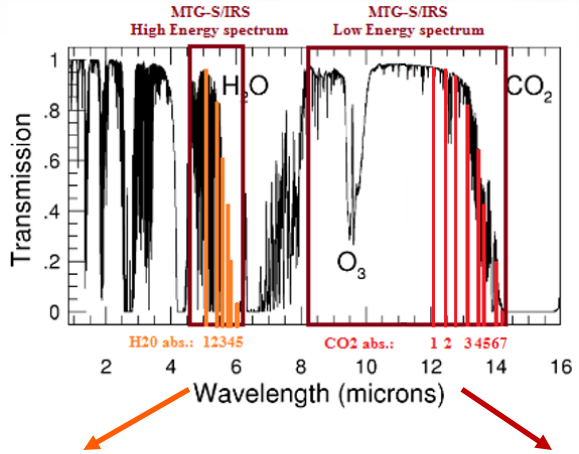
➔ Contributions by M.Á.Martínez, X.Calbet & J.García-Pereda.

➔ Collocated MTG-I/FCI AMVs and MTG-S/IRS winds
can be used together to overcome difficulties,
due to the lower resolution of MTG-S/IRS images (4 km)
and the issue of navigation of MTG-S/IRS data.

➔ Work on AMV retrieval starts in the second half of 2016.

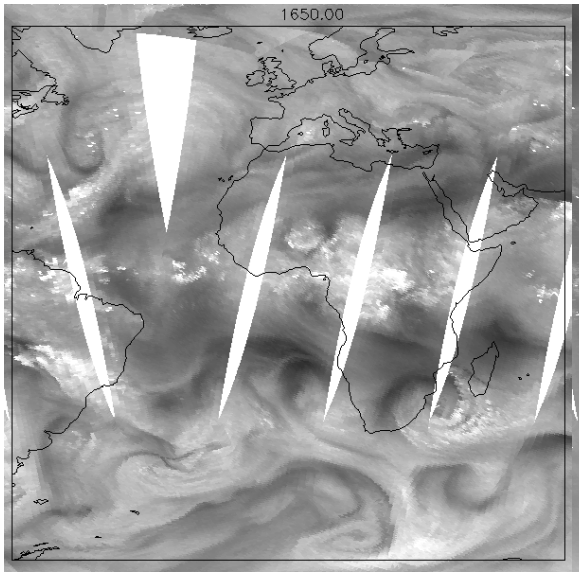
Interaction with other institutions suggested for needs/development.

1. AMV retrieval considering MTG-S/IRS Level 1 Images

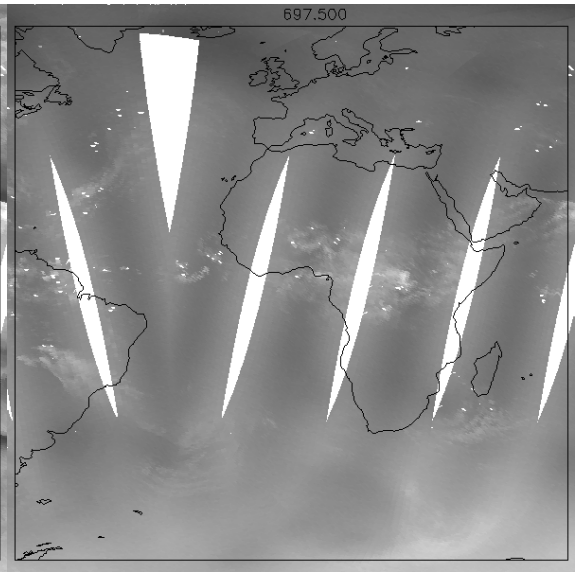


Procedure based on using parts of MTG-S/IRS spectr. with higher to lower absorption by H_2O/CO_2.

H_2O Abs. w. IASI (4.7–6.1µm/1650–2143 cm^{-1})



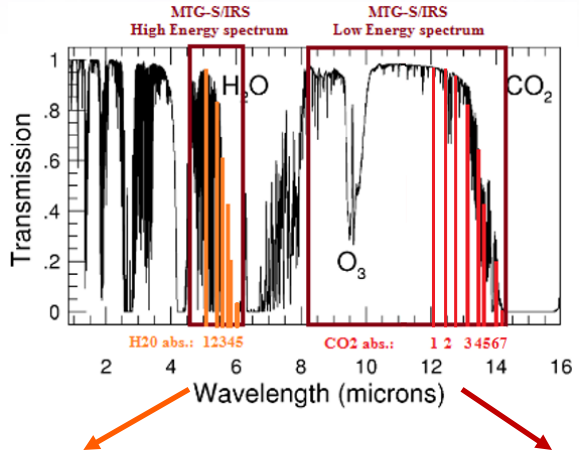
CO_2 Abs. w. IASI (12.1-14-3 µm // 697-824 cm^{-1})



Progressive scan of atmosphere detecting first high levels of clouds/humidity only, and lower levels later on.

➔ Useful for the AMV height assignment.

1. AMV retrieval considering MTG-S/IRS Level 1 Images



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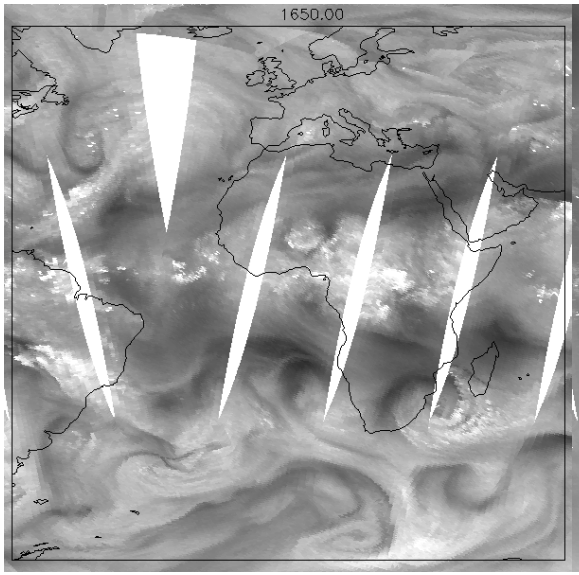

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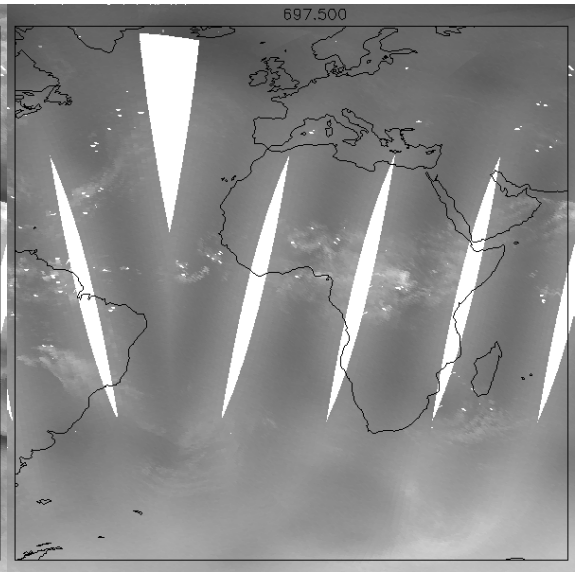

It is important to define very well the used wavelenghts, so that they strictly have a progressively lower degree of H_2O/CO_2 absorption.

2. AMV retrieval considering MTG-S/IRS Level 2 Vertical profiles

NWC SAF will be able to:

1. Use the Eumetsat MTG-S/IRS Level 2 Vertical profiles

➔ Based on Physical retrieval and ECMWF model.

2. Generate its own MTG-S/IRS Level 2 Vertical profiles

➔ Based on a Statistical estimation and any model provided by the user, for all MTG-S/IRS regions, with much less use of CPU.

➔ Possibly based on linear regression using collocated NWP Temperature/Humidity & MTG-S/IRS Level 1 data.

for the extraction of Winds and Wind profiles.

2. AMV retrieval considering MTG-S/IRS Level 2 Vertical profiles

At this moment (initial step):

Work based on tuning the calculation of Winds and Wind profiles considering equivalent High Resolution NWP Model profiles.

➔ **Using NWP resolution as near as possible to the 4 km/30 min. MTG-S/IRS resolution.**

Interactions of NWC SAF with other institutions

Some interactions are possible between NWC SAF and other AMV producers:

1. Extension of HRW algorithm to other options:

- Extension to other GEO satellites,…
- Integration of methods developed by other AMV algorithms,...
- Collaborations to compare methods/algorithms,…

Financiation of tasks possible through Visiting Scientist activities.

2. Implication in the next AMV Intercomparison study:

- NWC SAF could participate again in the coordination and financing of the next AMV Intercomparison Study.
- Economic resources for this limited up to February 2017, but wider later on in NWC SAF CDOP-3 phase.

Interactions of NWC SAF with other institutions

3. Opportunity to use the displacement of Meteosat 8 to 41.5ºE in late 2016 (depending on Eumetsat Council decission this week) for AMV studies

➔ Use of all capabilities of MSG satellites at two locations 40º apart (although a verification is needed on the usability and stability of this old satellite at this location).

➔ Option to compare for HRW AMVs:

- AMV height calculated with the purely geometric stereo method
- AMV height calculated with CCC method + NWC SAF/CTTH outputs
- Best fit height against NWP model winds/Radiosounding winds

(All of them could be different!)

A Visiting Scientist Activity can be defined to finance this study.
We are looking for a specific candidate, with experience in this field.

HRW as "Stand alone AMV calculation software"

Due to its characteristics and its ease to be obtained/understood/run locally, NWC SAF/HRW was proposed at previous "International Winds Workshops" as "Stand alone AMV calculation software" available for all AMV researchers and users.

Its good validation results by independent studies (MetOffice AMV Monitoring, 2014 AMV intercomparison study) and the additional improvements in validation shown by NWC SAF/HRW v2016 should be enough to convince any researchers about the use of HRW algorithm.

For any questions/suggestions please contact me here at any moment or at:

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