



Norwegian
Meteorological
Institute

MET Norway use of Aeolus winds and aerosol, contribution to calibration-validation

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ADM-Aeolus cal-val Rehearsal Workshop, Toulouse, 28-30 March 2017

Project goals, frameworks

- *to develop application of Aeolus observations to improve regional weather and aerosol monitoring and forecasting*
- *to contribute to the calibration and validation of the ADM-Aeolus LIDAR*

NWP and weather forecasting:

- Shared NWP code: HARMONIE-AROME NWP model, HIRLAM-ALADIN consortium
- Operational systems: AROME-Arctic and AROME-MetCoOp cooperation with SMHI+FMI (future DMI, IMO)

Aerosols:

- EMEP (European Monitoring and Evaluation Programme) of the Convention on Long-Range Transboundary Air Pollutants (LRTAP) - EMEP chemical transport model
- European CAMS (Copernicus Atmospheric Monitoring Service) programme: regional air quality forecasting, including aerosol
- The institute also contributes to CMIP6 (Coupled Model Intercomparison Project) via coordination of international model intercomparisons (AerChemMIP/AeroCom)

CalVal of ADM-Aeolus aerosol products :

- Performing a NRT quick-check of ADM-Aeolus data using the EMEP MSC-W model in an operational Chemical Weather Prediction (CWP) regime
- Evaluation of ADM-Aeolus performance and consistency with other satellite data for analysis of long-term changes in atmospheric aerosol loads

ADM-Aeolus aerosol backscatter and extinction profiles and AOD are to be compared with

- Calculation results from the EMEP/MSC-W model
- Observations from AERONET and EARLINET networks
- CALIPSO (and other satellites)
- This comparison will be facilitated by the use of the **AeroCom** validation/visualisation tool (Schulz et al., 2009).

Colocations with model simulations will be examined on a global scale focusing on geographic regions influenced with:

- different aerosol types
- different seasons
- facilitated by the additional model information on aerosol physical and chemical characteristics.

NRT data check:

ADM-Aeolus
ALADIN

EMEP model

backscatter/extinction profiles, AOD

NRT observations
AERONET
EARLINET??

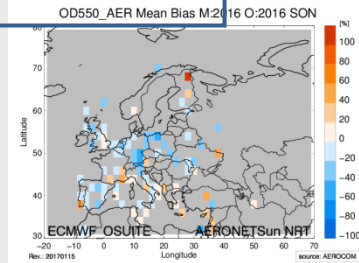
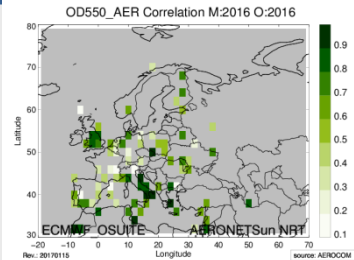
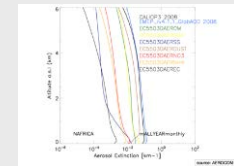
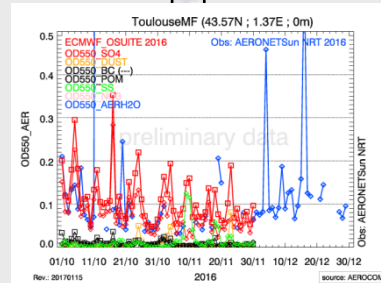
AeroCom
visualisation &
validation tool

- CWP (Chemical Weather Prediction) setup for model runs
- co-location with ADM observations
- Cross-check with available NRT observations

Data exchange with
Andøya Space Centre:

- information about aerosol types from the model for ALOMAR lidar retrievals

- comparison of ALOMAR measured β/σ profiles with model results



First characterization of Aeolus aerosol products

CalVal of ADM Aeolus aerosol products

EMEP model

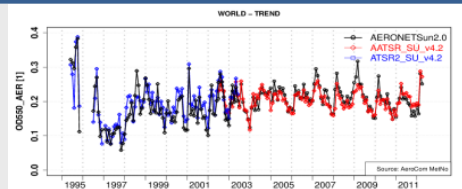
**ADM-Aeolus
ALADIN**

Backscatter/Extinction profiles, AOD
3D aerosols (concentration profiles, types)

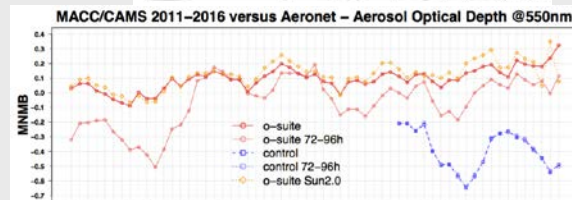
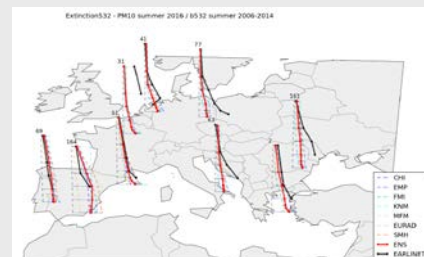
Independent observations:

**AERONET
EARLINET
Satellites**

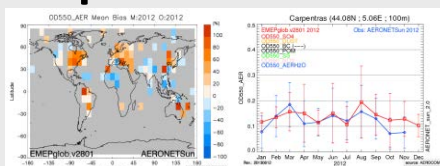
**AeroCom
validation tool &
database**



Checking ADM Aeolus data consistency with other observations (essential for constructing long-term time-series)



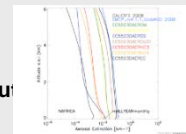
Comparison statistics



CALIOP3 2007 Obs: AERONETSun 2007
only Stations WORLDm
of valid observations: 1150
OBS mean 0.234
MODEL mean 0.222
Spearman Rank Correlation 0.563
Pearson Correlation Coefficient 0.611
Spatial yearly mean Corr Coeff 0.800
Seasonal Anomaly Corr Coeff 0.804
RMS error 0.206
Slope fit forced through zero 0.785
Regression coefficient, Slope 0.558
Regression Constant, Offset: 0.111
STDDEV(Model)/STDDEV(Data): 1.096
Score (mean relative bias) 58%
Taylor Score 0.841

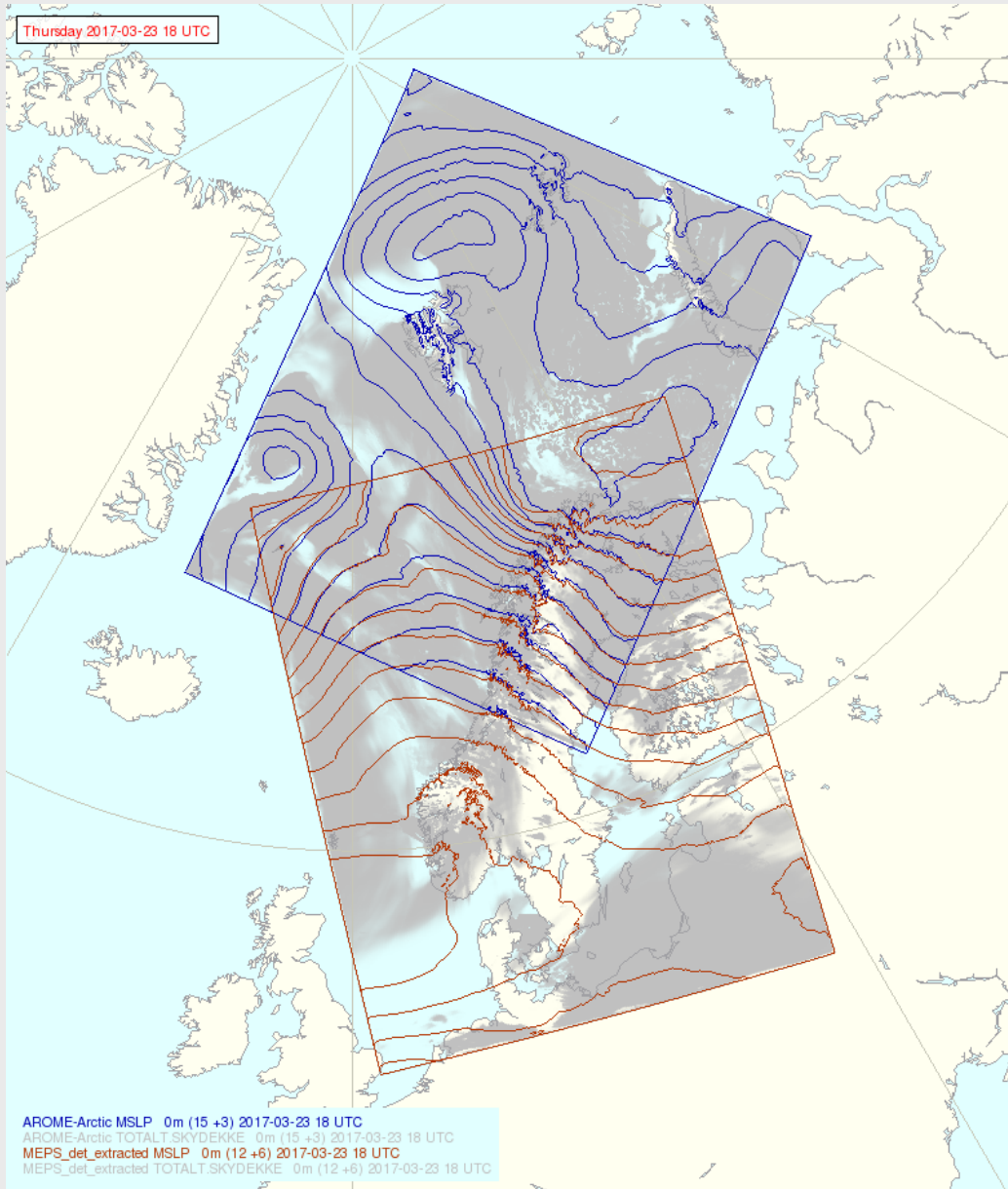
Analysis of geographical differences due to dominating aerosol types

using auxiliary
Norwegian Meteorological Institut
model information



Reporting on validation results, analysis and interpretation, recommendations for data use

Assimilation and cal/val in HARMONIE-AROME system



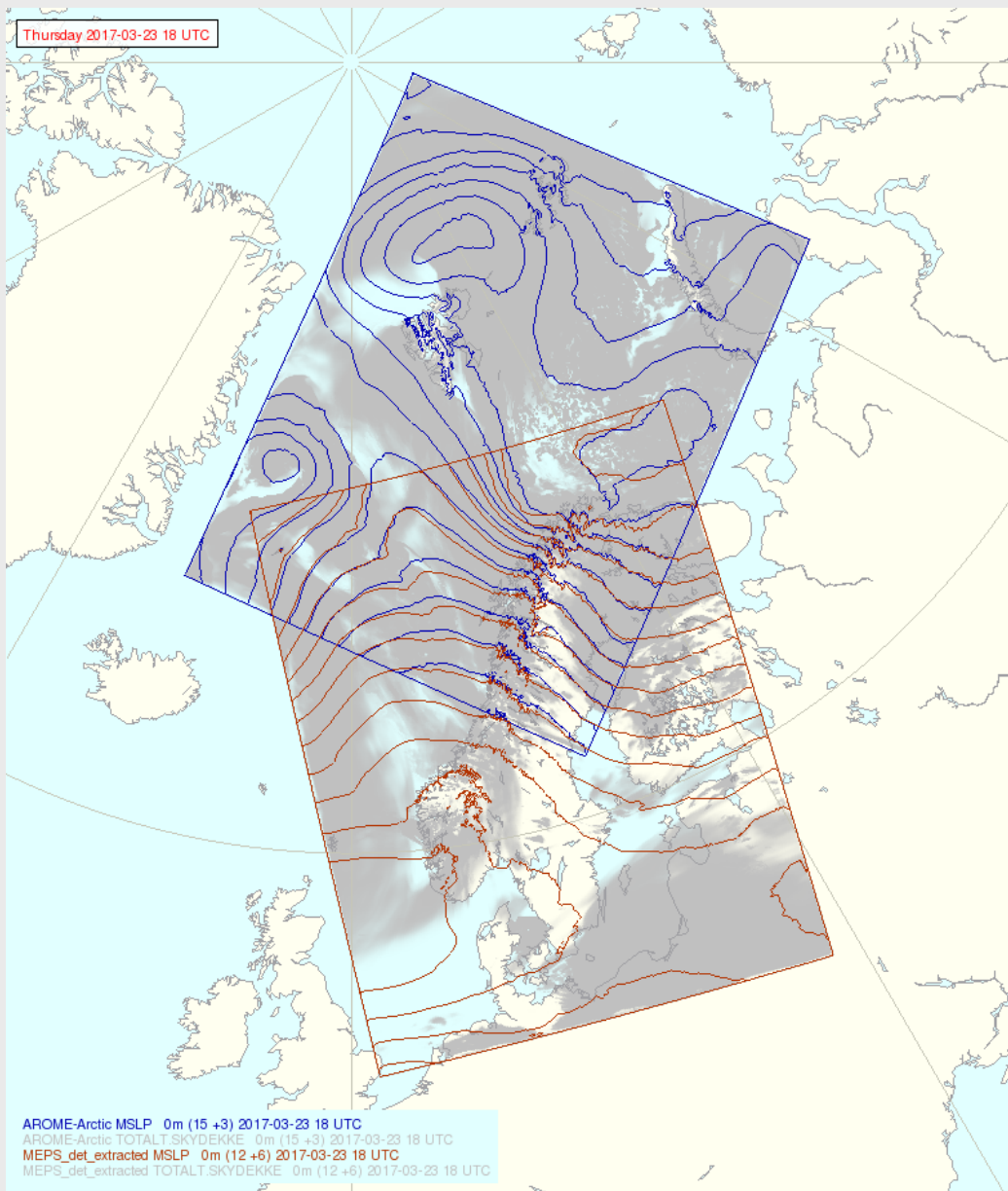
AROME-MetCoOp:

- Operational cooperation between SMHI, MET Norway, and soon FMI
- Using Norwegian and Swedish HPC facilities
- Base for official forecast on yr.no
- Ensemble forecasts with 10 members.

AROME-Arctic:

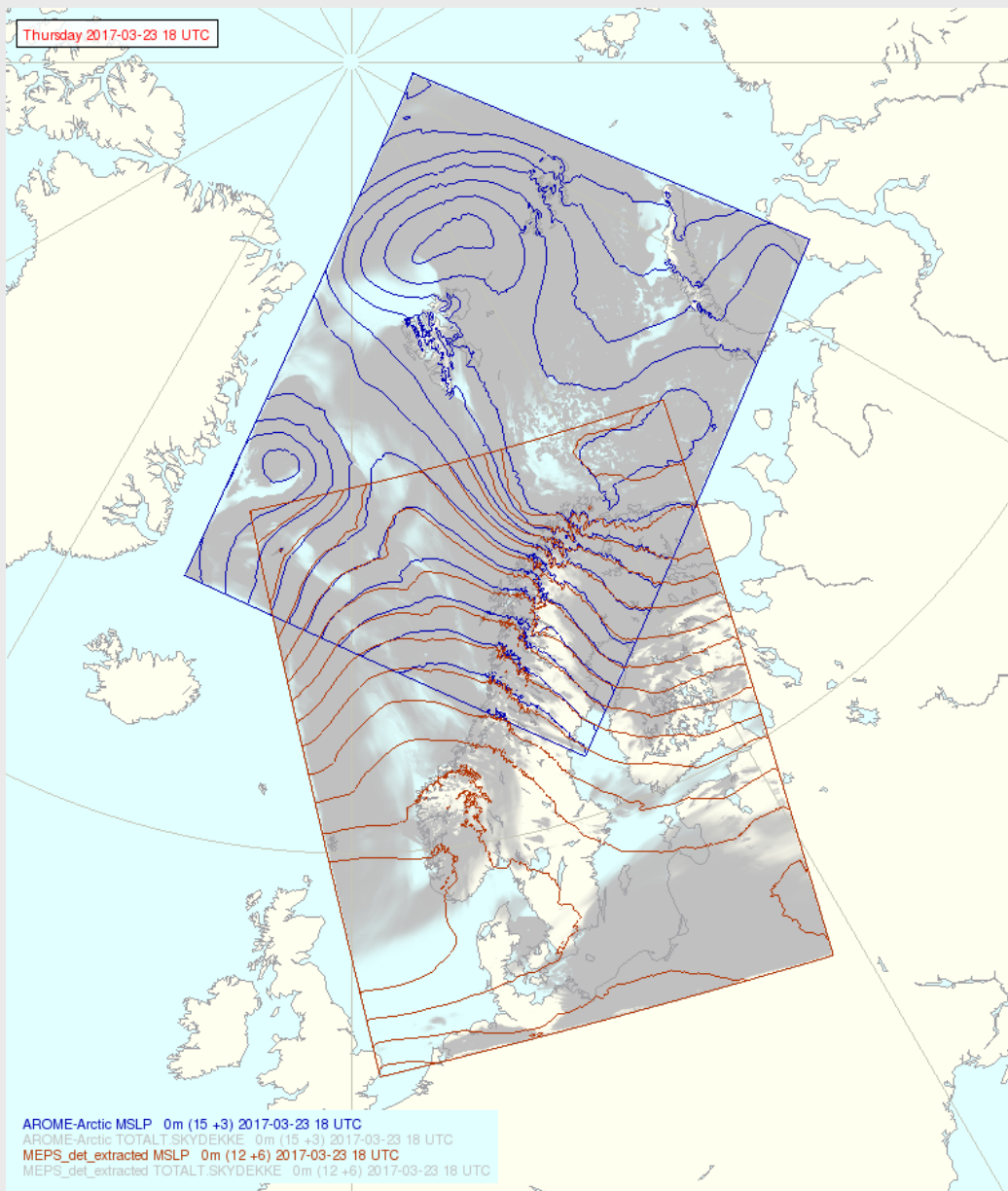
- Operational at MET Norway
- Using Norwegian HPC facilities
- Domain covering Norwegian sea and partly arctic
- No radar reflectivity assimilation
- Deterministic forecasts (no ensemble system)

Assimilation and cal/val in HARMONIE-AROME system



- Domains:** 750x960 grid points
- Horizontal resolution:** 2.5 km
- Model level definition:** 65 level
- Non-hydrostatic dynamic**
- Physical parametrisation:**
HARMONIE-AROME
- Assimilation strategy:** 3-hourly cycling
- Surface modeling:** SURFEX
- Lateral boundary conditions:**
hourly ECMWF
- Surface data assimilation:**
Optimum interpolation
- Upper-air data assimilation:** 3D-VAR
- Observations:** Surface (SYNOP, DRIBU), Radiosondes, Aircraft, ATOVS (AMSU-A, AMSU-B/MHS), IASI, Radar reflectivity, GNSS ZTD

Assimilation and cal/val in HARMONIE-AROME system



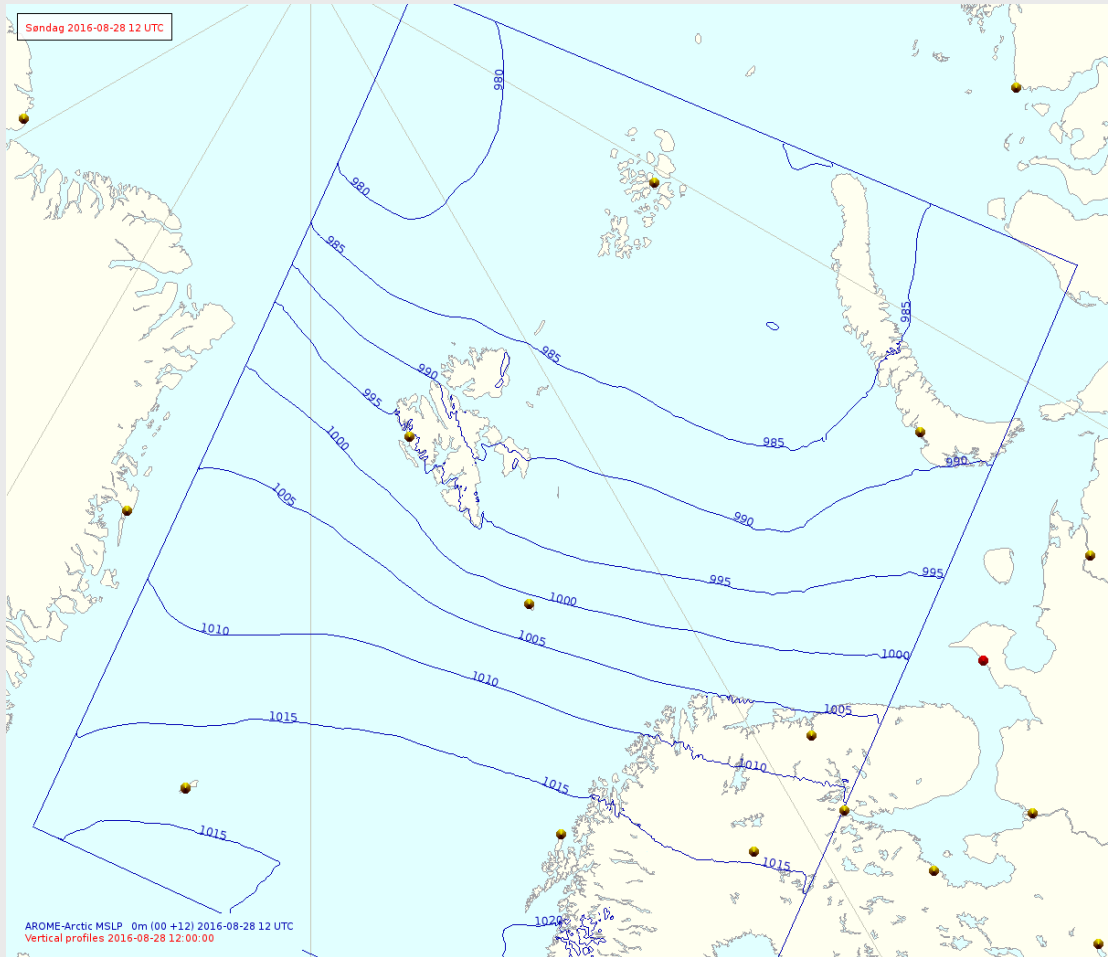
Cal/val:

- Code for collocation of Aeolus HLOS with AROME-MetCoOp og AROME-Arctic. Statistics and analysis.

Assimilation:

- Handling: obs. operator, quality control etc. (IFS implementation is starting point)
- Processing for shorter HLOS averaging lengths than standard desirable, but plans TBD
- With real ADM data: “data denial” experiments
- (Hopefully) operational assimilation

Additional collocations for cal/val: radiosondes and AMVs



Sondes: yellow dots

- Develop collocation tools for radiosonde winds and AMVs from polar orbiting satellites with ADM-Aeolus
- Focus on high-latitude sondes within the two model domains
- Year of Polar Prediction (YOPP, mid 2017- mid 2019) campaign periods of interest

Manpower, tools and funding

- Aerosol data: Svetlana Tsyro, Jan Griesfeller, Michael Schulz
- Wind/NWP data: Roohollah Azad, Roger Randriamampianina, Harald Schyberg

- Tools for assimilation, colocation with independent data and analysis to be built
- Funding through ESA PRODEX programme (return of national fees). Relatively tight budget

MET Norway plans for contribution to calibration-validation and use of Aeolus winds and aerosol

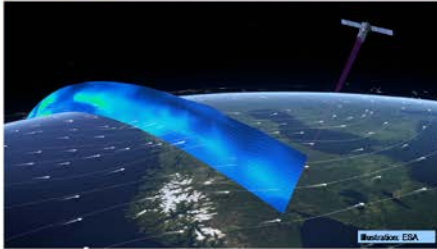


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Collocation of Aeolus winds with HARMONIE-AROME operational NWP-data:

The Aeolus winds will be investigated by using outputs of high resolution limited area numerical weather prediction (NWP) models. Through the data assimilation cycling the model locality adaptation information from other available observation data. Also, the NWP model error statistics are usually well characterized. The focus is on utilization of model and observation data on high latitudes, in particular in the North-East Atlantic and part of the Arctic. Since Aeolus is a polar orbiter, the orbit pattern gives increasing Aeolus observation density with increasing latitude, up to the maximum latitude near the North Pole.

We plan to produce collocations of Aeolus with NWP data from versions of the HARMONIE-AROME (Stangsoen et al., 2017) convection permitting model with 2.5 km horizontal resolution, for two different domains, one covering Scandinavia and adjacent ocean areas, and one covering an Arctic domain. In the framework will also development and test assimilation of Aeolus winds.



About AROME-MetCoop and AROME-Arctic

Domains: 750000 grid points; Horizontal resolution: 2.5 km; Model level definition: 65 level; Non-hydrostatic dynamical; Physical parameterization: HARMONIE-AROME; Assimilation strategy: 3-hourly cycling; Surface modeling: SURFEX; Lateral boundary conditions: hourly ECMWF; Surface data assimilation: Cyclone assimilation; Upper-air data assimilation: 3D-VAR; Observations: Surface (SYNOP, DROG), Radiosoundings, Aircraft, ATOS (AMSU-A, AMSU-B/HS), IASI, Radar reflectivity, CNES ZTD.

AROME-MetCoop:
 -Operational cooperation between SMH, MET Norway, and soon FMJ
 -Using Norwegian and Swedish IFC facilities
 -Base for official forecast on yr.00
 -Resolvable forecasts with 10 members
 -For details, see Mikki et al., 2017.

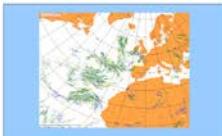
AROME-Arctic:
 -Operational at MET Norway
 -Using Norwegian IFC facilities
 -Domains covering Norwegian sea and partly arctic
 -No radar reflectivity assimilation
 -Deterministic forecasts (no ensemble system)



Plans for development of assimilation of ADM-Aeolus in HARMONIE-AROME

The implementation will include:
 -Handling in HARMONIE-AROME, including observation operator, quality control, tuning of error statistics etc.
 -Implementation will take already existing code from ECMWF in the FS system as a starting point.
 -After launch: Data check, data experiments in HARMONIE-AROME 3D-VAR, possibly also in 4D-Var or other more advanced schemes.

A goal is to have assimilation of Aeolus running in the operational system after demonstration of positive impact



Typical coverage of geostationary AAVs from polar orbiting satellites are also available

Collocation with radiosonde wind observations and Atmospheric Motion Vectors (AMVs)

As a contribution to col-val we will, in addition to cooperate with HARMONIE-AROME, develop collocation tools for radiosonde winds and AMVs from polar orbiting satellites with ADM-Aeolus. This will help assess errors and accuracies in ADM-Aeolus, and we will analyse the comparison results.



Typical radiosonde coverage in the AROME-Arctic domain (sondes marked with yellow dots)

Cal-val of ADM-Aeolus aerosol products is planned to include:

> Performing a near real time quick check of ADM Aeolus data using the EMEP MSC-W model in an operational Chemical Weather Prediction (CWP) system

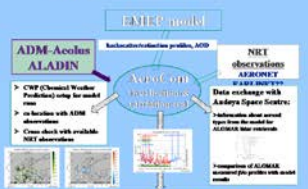
The regional EMEP MSC-W model (Simpson et al., 2012), which is run operationally as part of the Copernicus Atmosphere Monitoring Service (CAMS), will provide near real time data for co-location and evaluation with the satellite products

> Evaluation of ADM-Aeolus performance and consistency with other satellite data for analysis of long term changes in atmospheric aerosol loads

ADM Aeolus aerosol backscatter and extinction profiles and AOD are to be compared with calculation results from the EMEP MSC-W model as well as with observations from AERONET and EARLINET stations, and also from CALIPSO (and other satellites). This comparison will be facilitated by the use of the AeroCov validation/visualization tool (Schutz et al., 2009).

The discrepancies between ADM-Aeolus data with other observations and model simulations will be examined on a global scale, focusing on geographic regions influenced with different aerosol types and different seasons facilitated by the additional model information on aerosol physical and chemical characteristics.

NRT aerosol data check:



First characterization of Aeolus aerosol products

Cal-val of ADM Aeolus aerosol products



REFERENCES:

Stangsoen, L. et al (2017): The HARMONIE-AROME model configuration in the ALADIN-HIRLAM NWP system. Mon. Wea. Rev., in press, doi: 10.1175/MWR-D-16-0147.1.
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 Schyberg, M., Chm, M., Kinnø S (2009): The Aerosol Model Comparison Project, AeroCom, Phase II: Creating Up Diversity. WAC Newsletter, No. 41, May 2009.
 Simpson, J. et al (2012): The EMEP MSC-W chemical transport model – technical description. Atmos. Chem. Phys., 12, 7853-7865, 2012.

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