Aeolus Science and CAL/VAL Workshop 10-13 February 2015 Summary

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http://www.aeolus-science-calval-2015.org

The Aeolus Mission Advisory Group

Members:

- Angela Benedetti / ECMWF
- Alain Dabas / MeteoFrance
- Pierre Flamant / IPSL
- Mary Forsythe / MetOffice
- Erland Källén / ECMWF (Chair, preparing Workshop summary)
- Heiner Körnich / MISU
- Harald Schyberg / met.no
- Ad Stoffelen / KNMI
- Oliver Reitebuch / DLR
- Michael Vaughan / Lidar & Optics Associates

Observers:

Regis Borde (EUMETSAT), Mike Hardesty (NOAA/University of Colorado), Ramesh Kakar (NASA), Lars Peter Riishojgaard (WMO)

Outline

1. Aeolus objectives
2. Workshop Session overview
3. Some session highlights
4. CAL/VAL Implementation Plan Session
5. Workshop conclusions

Aeolus objectives

Scientific requirements:

Improve our understanding and predictability of

1. Atmospheric dynamics and global atmospheric transport
2. Global cycling of energy, water, aerosols, chemicals

How:

Improve atmospheric analysis, in particular:

1. Tropics: Wind fields governs dynamics
2. Mid-latitudes: Intense storm developments and mesoscale circulation

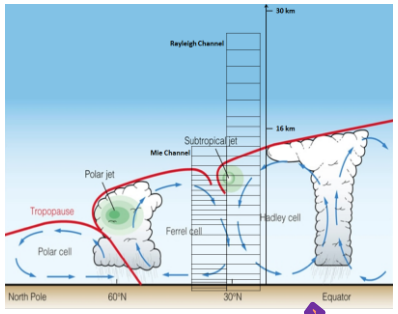
Benefits:

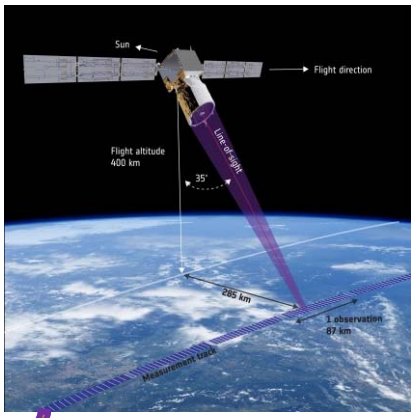
1. Better initial conditions for weather forecasting
2. Improved parameterisation and modelling of atmospheric processes in climate and forecast models

Demonstrate the capabilities of space-based Doppler Wind LIDARs (DWLs) for global wind profiling and its potential for operational use

Aeolus atmospheric products

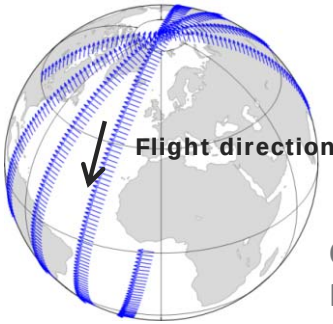
1. **Primary (L2b) product:**
   a. Horizontally projected LOS (HLOS) wind profiles
      - Approximately zonal at dawn/dusk (6 am/pm)
      - 3 km-averaged measurements and ~85 km observation averages – scene classified
      - From surface to ~30 km in 24 vertical layers
      - Random errors: 1-2(PBL), 2(Trop), 3-5 (Strat) m/s
      - Bias requirements: 0.5 m/s





2. **Spin-off (L2a) products:**
   a. Optical properties profiles
      - β, σ, lidar ratio
      - 3 km averaged measurements and <85 km observation averages

      From this one can deduce:
      - Cloud/aerosol cover/stratification
      - Cloud/aerosol top heights
      - Cloud/aerosol base height (optically thin)
      - Aerosol typing (limited)



Courtesy N. Žagar

Dusk/dawn orbit

Aeolus Science and CAL/VAL Workshop - general

1. ESA-ESRIN, 10-13 February 2015, Frascati, Rome, Italy

2. 85 participants - science community, CAL/VAL PIs, industry and ESA
    a. NWP and climate
    b. Wind and aerosol in-situ, remote sensing, modelling groups
    c. Met services, universities, national space research organizations … in Europe, US and Canada, China, Japan
    d. WMO, WCRP

Summary 2006 Aeolus workshop

1. 76 participants (similar community representation as in 2015)
2. Science Workshop:
    a. Focussed on the potential and exploitation of the Aeolus products
3. Areas of research focussed on:
    a. NWP
    b. Climate
    c. Tropics, Southern Hemisphere, Polar areas
    d. Stratosphere (less represented in 2015 workshop)
        – Parameterization of gravity wave drag need better vertical resolution
4. Recommendations:
    a. Consolidate expected impact in state-of-the-art assimilation systems
    b. Expand contact to relevant international expert bodies and user communities outside Europe
    c. Airborne campaigns with ALADIN Airborne Demonstrator
    d. Learn from LITE and CALIPSO validation efforts
    e. Promote / prepare follow-on mission

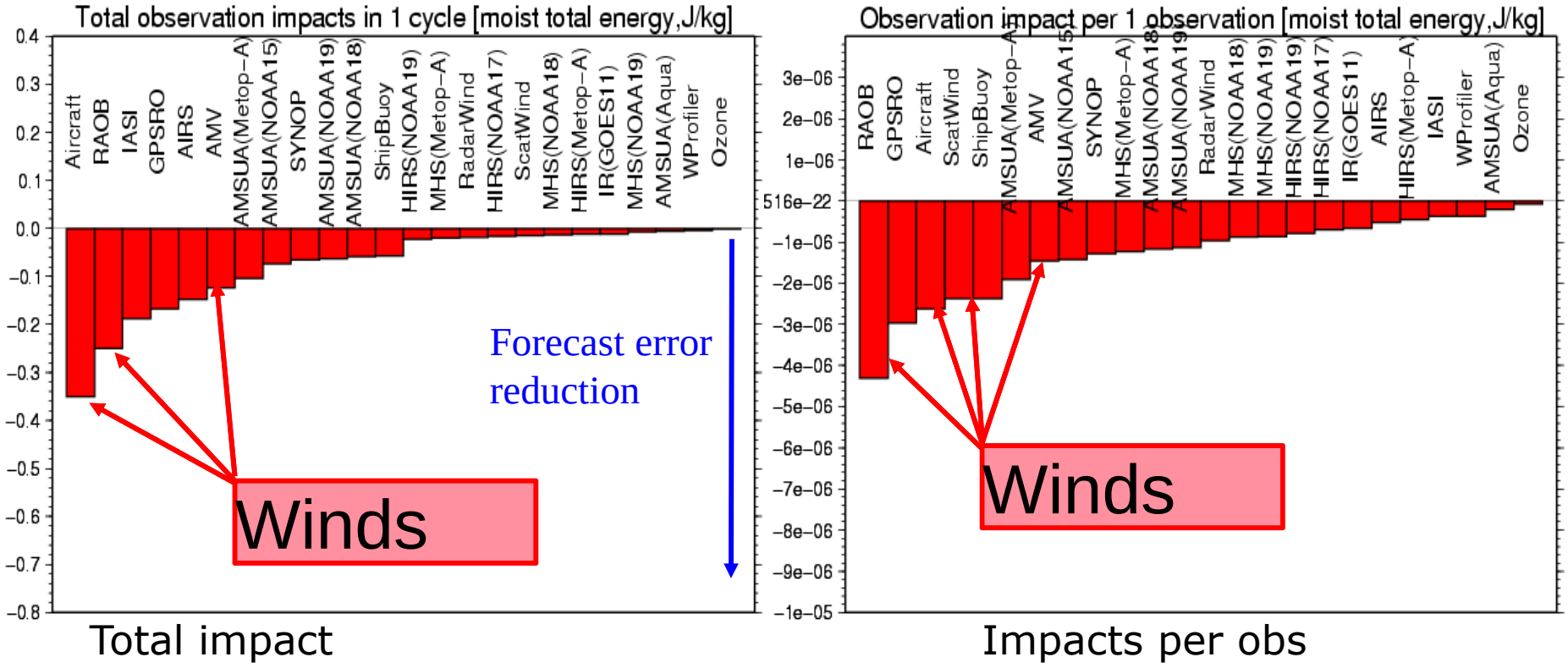
Workshop agenda

1. Welcome (ESA EO programmes, WHO and WCRP wind observation needs, Aeolus Science Motivation)
2. Aeolus Mission, status, products, … (ESA and industry presentations)
3. L1 product and instrument calibration (Aeolus L1b team, industry)
4. Wind session
    a. Products, sampling, expected data quality, …
    b. Scientific exploitation
5. Aerosol session
    a. Products, calibration, information content, quality
    b. User needs, lessons learnt CALIPSO, HSRL observations
6. CAL/VAL Sessions
    a. ESA and industry activities, commissioning and operational phase
    b. CAL/VAL PI projects
7. CAL/VAL Implementation Plan session
8. Workshop wrap-up

Workshop Introductory session

1. Aeolus is an ESA Earth Explorer.
    a. The explorers are technology demonstration missions.
    b. Operational missions programmes are Meteorological missions and Copernicus (Sentinel) missions
2. Uniformly distributed wind profiles still lacking in Global Observing System
3. Wind (profile) observations have large NWP impact
    a. Tropical dynamics impact predictive skills in mid-latitudes on medium range
4. Wind information essential for climate predictions
    a. Grand Challenges of WCRP underline role of cloud circulation interactions for climate sensitivity
5. Reanalysis need more wind observations

Ensemble-based FSO diagnostics, NCEP GFS, Ota et al., WMO, Sedona, May 2012



Total impact

Impacts per obs

All observation types have positive forecast impact on average.

For the total impact, 1: aircraft, 2: AMSU-A, 3: radiosonde, 4: IASI, 5: GPSRO
For impact per 1 obs., 1: radiosonde, 2: GPSRO, 3: aircraft, 4: Scatterometer wind, 5: marine surface observation

Courtesy: L.P. Riishojgaard

Aeolus Mission session

1. Aeolus mission on-track
2. AIT phase started (2nd laser accepted, www.esa.int)
3. Instrument Functional Performance Test (IFP) – August 2015
4. Satellite Thermal Vacuum Test (Tvac) including Instrument Performance Test in Vacuum – 2016
5. Aeolus follow-on would take 10 years to realize after mission selection
    a. Data gap not to be avoided
6. Mission lifetime is limited by availability of oxygen for in-situ cleaning (3 years and a few months)
    a. Hence prolonged mission duration (like CALIPSO) limited
7. Lessons learnt from A2D have been crucial for mission preparation
    a. Instrument testing
    b. Calibration and algorithm development
    c. CAL/VAL satellite under-flights

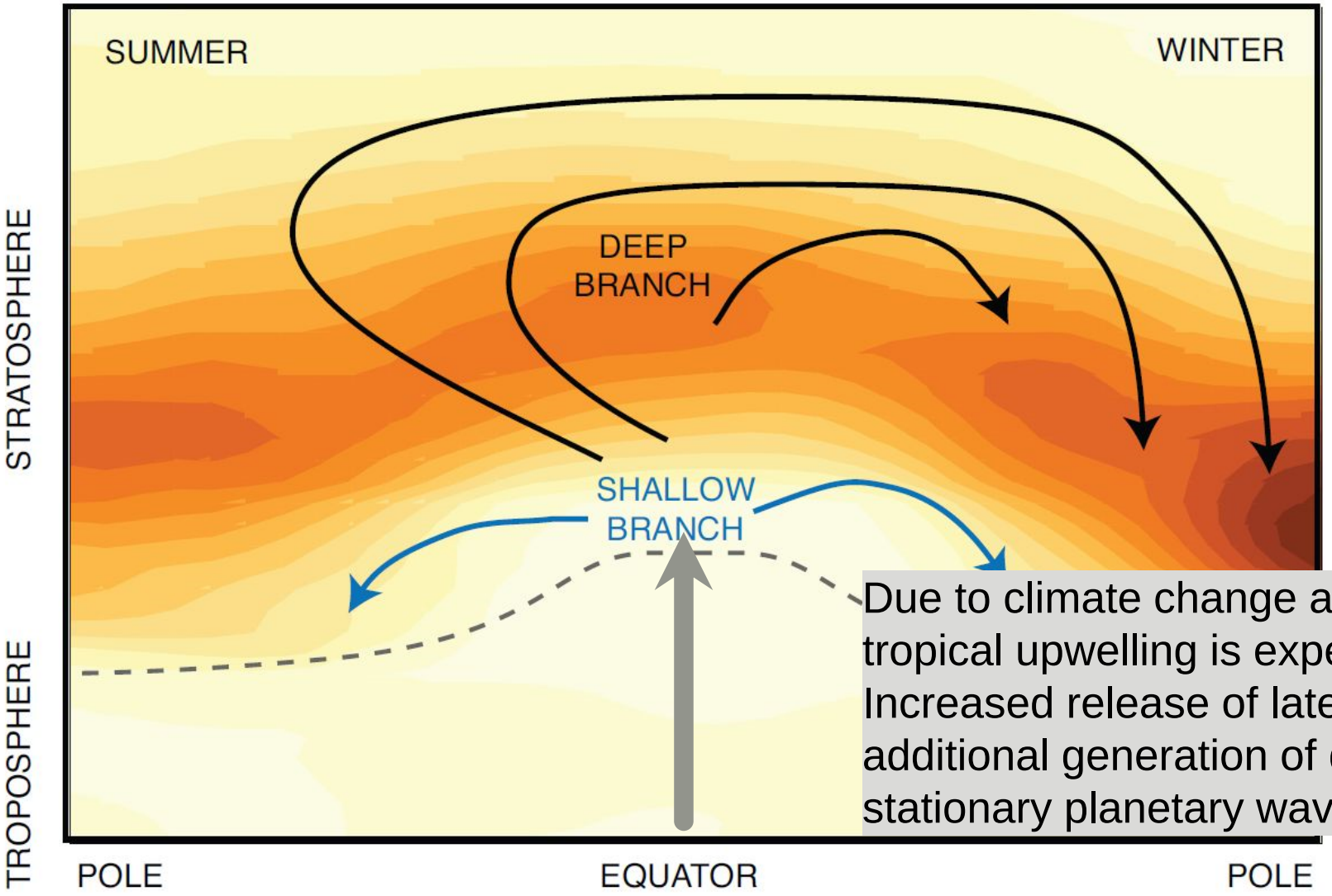
L1 product and instrument calibration session

1. Aeolus wind measurements need extensive in-flight calibration
2. L1b product (calibrated wind profiles, but no Rayleigh-Brillouin correction nor scene classification)
3. L1b data will be available NRT (< 3 hours from ESA)
    a. 1-4 blind orbits (affecting US users)
    b. Additional down-link stations can be added
4. ECMWF provides stand-alone L2b processor and documentation
    a. https://software.ecmwf.int/wiki/display/AEOL/ADM-Aeolus+Level-2B+Processor+Package
5. Measurement size: 3 km, observation size: 87 km
6. Vertical range 0-30 km
7. Separate Mie and Rayleigh wind profile products
8. Calibration processors:
    a. Rayleigh-Brillouin correction of Rayleigh winds -> L2b
    b. Instrument calibration coefficients -> L2a
    c. Harmonic bias correction and correction of range dependence

Wind session

1. Absolute calibration of Aeolus wind product important
    a. Zero-wind calibration from ground returns
    b. Wind shear assimilation less effective
2. Largest impact expected
    a. Upper troposphere / lower stratosphere
    b. Tropics
    c. Southern hemispehere and polar areas
3. Vertical sampling should be optimized
    a. Best possible measurement coverage
    b. Tropical cirrus
    c. Tropical ozone strongly impacted by UTLS dynamics (next slide)
    d. Aeolus can help cloud height determination for AMVs
4. Wind structure of jetstream determine propagation characteristics of weather systems (e.g. 2016 NAWDEX campaign)
5. Aeolus expected to provide mesoscale information for LAMs
6. Stratospheric balloon campaigns important for CAL/VAL

The Brewer-Dobson circulation



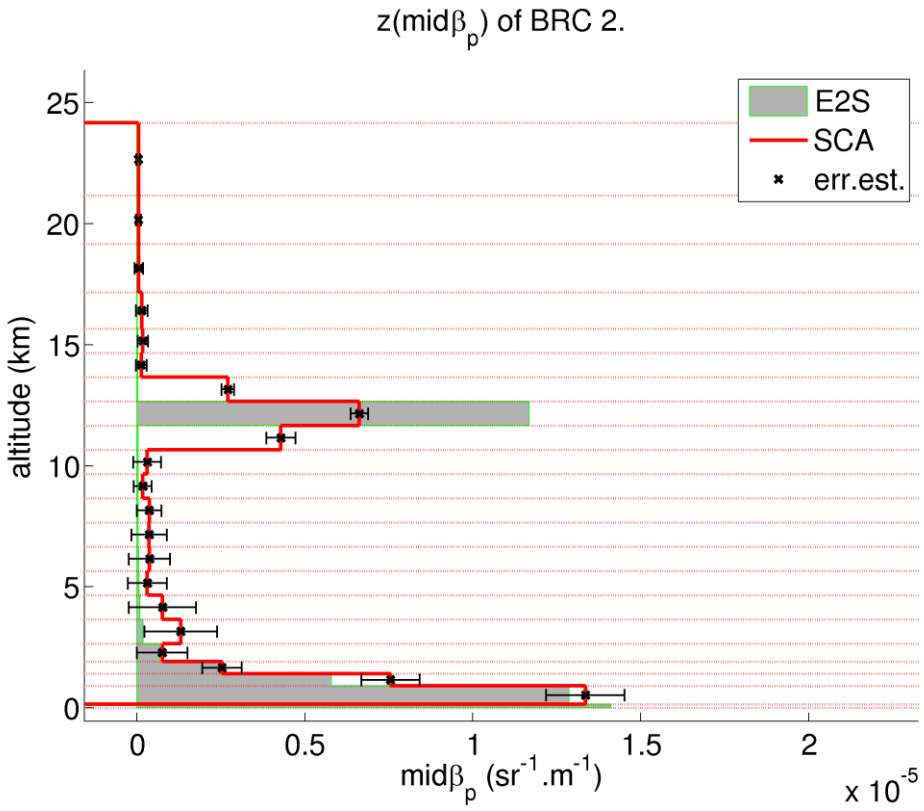
Due to climate change an intensified tropical upwelling is expected!
Increased release of latent heat -> additional generation of quasi-stationary planetary waves

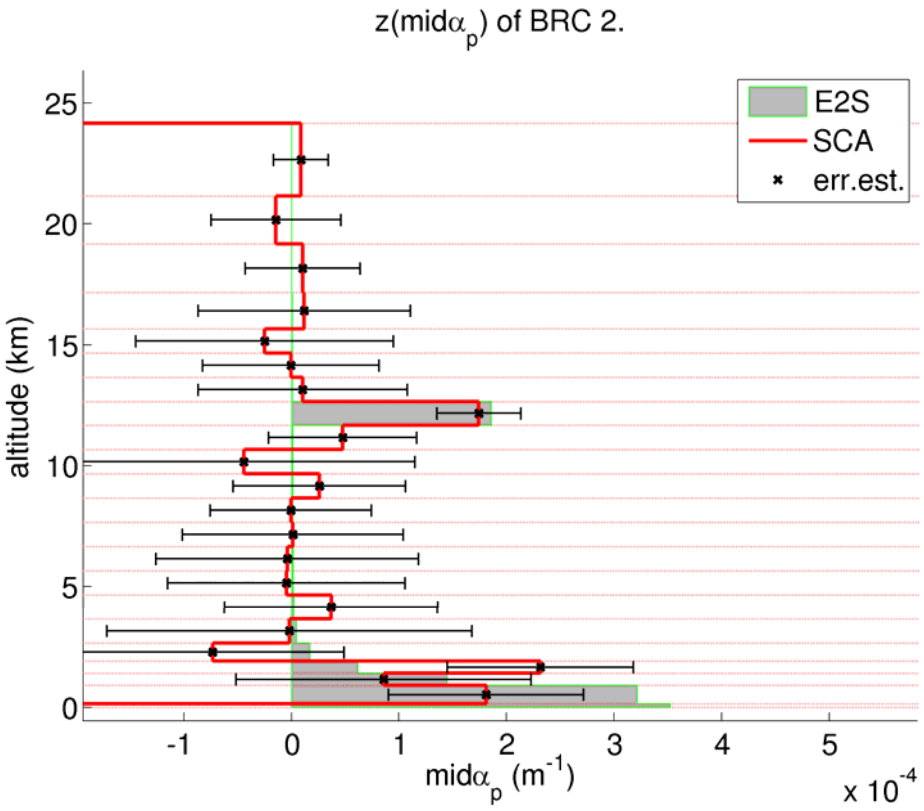
Courtesy: M. Dameris, DLR

Aerosol session

1. Assimilation of aerosol information is still challenging
    a. Available data are sparse and biases are large
    b. Lidars such as CALIPSO provide much needed vertical information
2. Aeolus L2a algorithm developed and being tested
    a. Co-polar β, σ, lidar ratio, potentially also NRT
3. Lack of polarization information in the Aeolus measurements introduce substantial uncertainties
    a. Methods to handle and/or correct for this is being developed
4. Lessons learnt from CALIPSO
    a. Learning of instrument operation during on-ground campaign
    b. Be prepared for surprizes
    c. Work on product quality control and minimizing instrument / random noise pays off (performance beyond specs achieved)
    d. In orbit environment is much more stable than on Earth
    e. CAL/VAL satellite underflights essential
    f. Development of new spin-off products during mission lifetime and beyond

Example Aeolus L2a retrieval: standard aerosol profile + cirrus cloud (OD 0.2)





CAL / VAL session

1. Aeolus commissioning phase outline presented
    a. Industry (instrument commissioning)
    b. ESA (ground segment commissioning)
    c. CAL/VAL teams (product calibration and validation) under ESA coordination
2. Aeolus instrument performance verification:
    a. Aeolus L1b measurements in nadir and with commanded miss-pointing 0, …, +-100 m/s (forwards/backwards flight direction)
    b. Ground returns (nadir, wind mode) and atmospheric returns 6-16 km (nadir)
    c. Product quality monitoring (wind mode): ECMWF
3. CAL/VAL proposals (17 in total, whereof 2 joint national proposals and one international) were presented (next slide)

CAL / VAL session

1. Wide geographical coverage of planned CAL/VAL including:
    a. Arctic/Antarctic (Canada, Andoya, Kiruna, South Pole)
    b. Mid-latitudes Europe, US, China and Japan
    c. Tropics (Reunion, Okinawa, stratospheric balloons)
2. A large variety of wind and aerosol instrumentation:
    a. Direct and coherent wind lidars (airborne and ground-based)
    b. Radar wind profilers, ground-based aerosol lidar network
    c. Radiosondes
    d. Stratospheric balloons
    e. UAV
3. Trade-off representativeness errors (length scale) versus sampling errors (time scale)
4. Common CAL/VAL protocol to be elaborated to harmonize results
5. Model product quality monitoring and impact assessment to be coordinated

CAL/VAL Implementation Plan Plenary session

1. Calibration & Validation plan as an instrument to coordinate different activities throughout the mission
    a. CAL/VAL project coordination (ground-based, airborne, routine observations, NWP product monitoring and impact, retrieval), list of covered areas, gaps, mission phase
    b. Data needs, protocols, exchange of results, tools, etc.
    c. Links to other missions/campaigns
    d. Funding opportunities

2. Very good CAL/VAL call response, the plan **is a dossier of the CAL/VAL activities** that is used for planning
    a. Great joint response from the US with wide variety of methods and instrumentation!

3. Plan to be presented to member states / national funding agencies

CAL/VAL Implementation Plan Plenary session

1. A number of issues for inclusion in the CAL/VAL implementation plan were discussed:
    a. The importance of instrument calibration and performance calibration (e.g. radiometric performance, noise, zero-wind calibration, …) and the detailed planning for use of reference measurements
    b. Establishing fundamental reference measurements/sites for commissioning phase and long-term monitoring
    c. Portal for sharing of product quality information
    d. CAL/VAL protocols and activity coordination
    e. Overpass tables / sampling and campaign coordination
    f. Planning of sampling strategy and science campaigns
    g. Coupling of wind and aerosol validation
    h. Coordination of NWP / modelling efforts
    i. Coordination of polar activities (IPY 2017)
    j. …

Workshop conclusions

1. The Aeolus community is still very much alive and eagerly awaiting launch
2. The instrument is now entering the more regular AIT phase, which means that the CAL/VAL and user community should start their pre-launch preparations
3. Science community preparation - ESA
4. Further mission promotion needed involving further NWP and research groups e.g. in Latin America, Alaska, Asia, Australia, Africa, … and international bodies such as WIGOS, GCOS, GRUAN, WCRP, SPARC, CLIVAR, …
5. Aeolus Science Workshop in 2015 - ECMWF
6. Start prepare the ground for a follow-on mission

Draft Schedule

1. 1st Cal/Val workshop 13/02/2015
2. Distribution of IP: 30/05/2015
3. Input from Teams: 30/06/2015
4. First version ready for distribution: 01/08/2015
5. Identification of Cal/Val Core Activities: July 2015 onwards
6. Cal/Val Team organization: December 2015 onwards
7. CAL/VAL preparations for launch: Spring 2016
8. CAL/VAL rehearsals: Summer 2016
9. 2nd Cal/VAL Workshop: Autumn 2016
10. Mission launch readiness: 4th quarter 2016
11. Launch: **earliest** 6 weeks later

http://www.esa.int/esaLP/LPadmaeolus.html