Expectations from ADM-Aeolus
ESA's Doppler lidar wind-profile mission

DGH Tan
ECMWF

Acknowledgments:

ESA (Mission Experts Division & Aeolus project team)

Aeolus Mission Advisory Group

Level-1B/2A/2B Development Teams

Overview – why expectations are so high

- ADM-Aeolus addresses key observational needs
  - Objectives, wind observation requirements, DWL instrument, viewing geometry
- Implementation well-advanced for launch in 2009
  - Space and ground segments
  - HLOS wind product (L2B data, algorithm, portable s-ware)
  - Cloud and aerosol products (L2A data)
  - Experimental campaigns and calibration/validation
- Studies with wind lidar data support theoretical expectations
  - Data simulations, NWP data impact studies (assimilation ensembles as alternative to OSSEs, + information content)
  - Airborne DWL (Weissman). Tropical assimilation (Zagar).

Key references

- Baker et al 1995, BAMS
- ESA 1999 Report for Assessment (Stoffelen et al 2005, BAMS) and 2007/8 Science Report
- Weissman and Cardinali 2006, QJRMS
- N. Zagar & co-authors, QJRMS & Tellus A

- Tan & Andersson 2005, QJRMS
- Tan et al 2007, QJRMS
- Tan et al 2008, Tellus A (Special Issue on ADM-Aeolus)

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Background for ADM-Aeolus
What is the ADM-Aeolus Mission ?

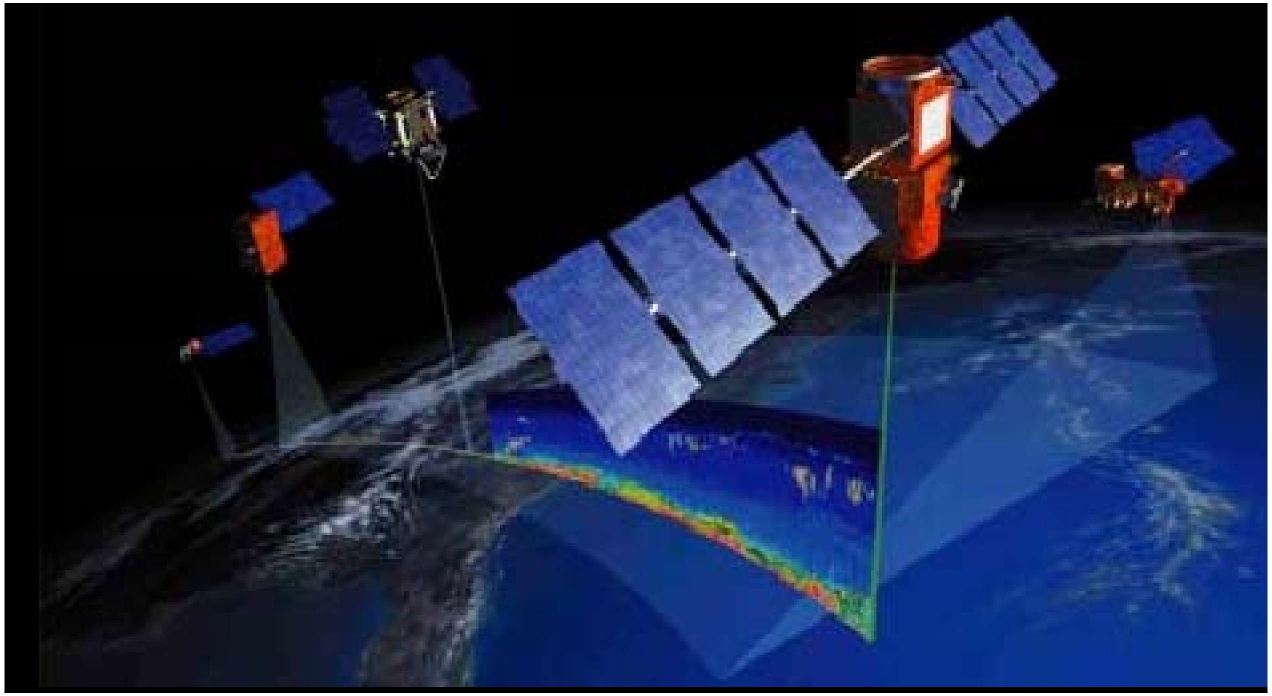
- Aeolus objectives
  - improve understanding of atmospheric dynamics & climate processes (global atmospheric transport, global cycling of energy, water, aerosols, chemicals), and
  - improve the quality of weather forecasts (via better initial conditions – analyses from data assimilation), by
  - providing global observations of wind profiles from space
- Selected in 1999 as the 2nd Earth Explorer Core mission in ESA's Living Planet Programme for Earth Observation
  - Launch 2009 (provisional), duration 3 years
  - Currently in Phase C (manufacturing & testing)
  - R&D, pre-operational for future meteorological satellites

Background for ADM-Aeolus
Observational Requirements

		PBL	Troposph.	Stratosph.
Vertical Domain	[km]	0-2	2-16	16-20
Vertical Resolution	[km]	0.5	1.0	2.0
Horizontal Domain			global	
Number of Profiles	[$hour^{-1}$]		> 100	
Profile Separation	[km]		> 200	
Horizontal Integration Length	[km]		50	
Accuracy (HLOS Component)	[m/s]	1	2	3
Data Availability	[hour]		3	
Length of Observational Data Set	[yr]		3	

➔ **Most important requirements - accuracy & vertical resolution**

Background for ADM-Aeolus
Measurement Concept



CALIPSO lidar – vertical cross sections of backscatter

- Backscatter signal
- Aeolus winds are derived from Doppler shift of aerosols **and** molecules along lidar line-of-sight
- Error estimates, cloud & aerosol properties derived from signal strength

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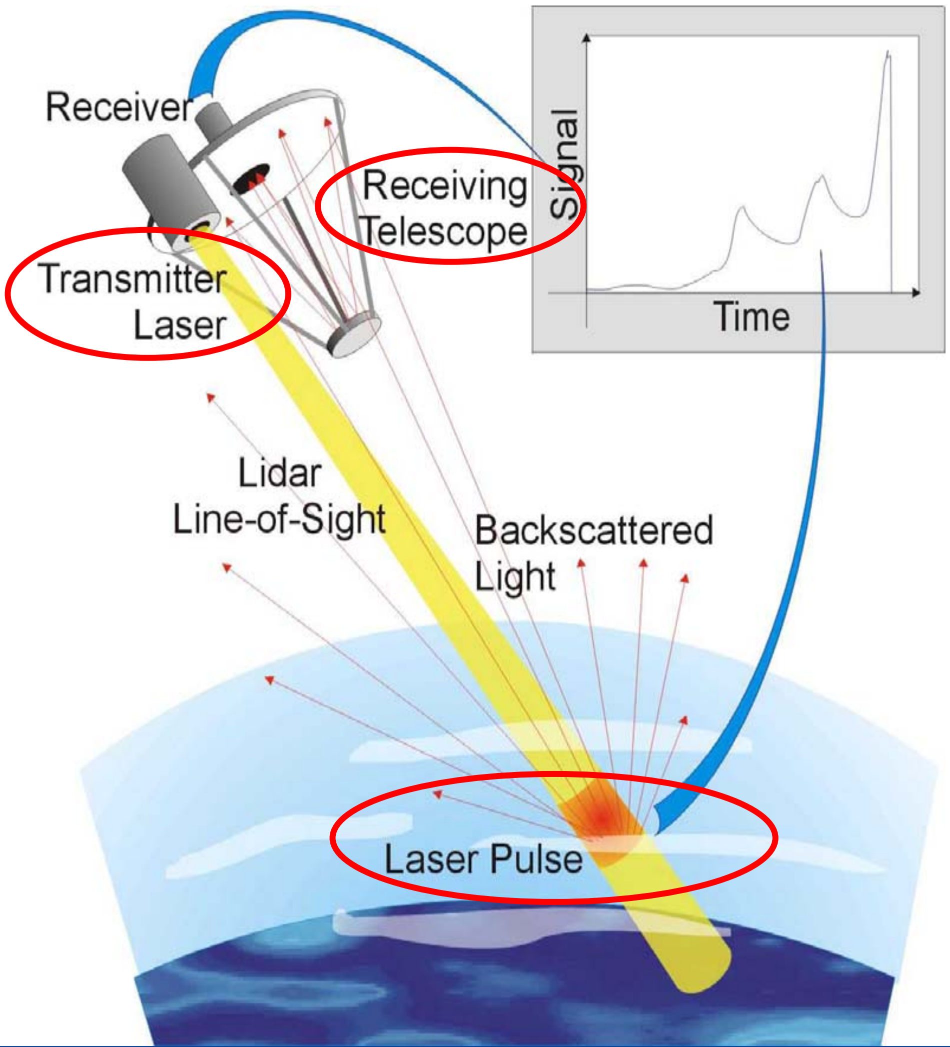
Background for ADM-Aeolus
Measurement Concept



- Backscatter signal
- Winds are derived from Doppler shift of aerosols **and** molecules along lidar line-of-sight
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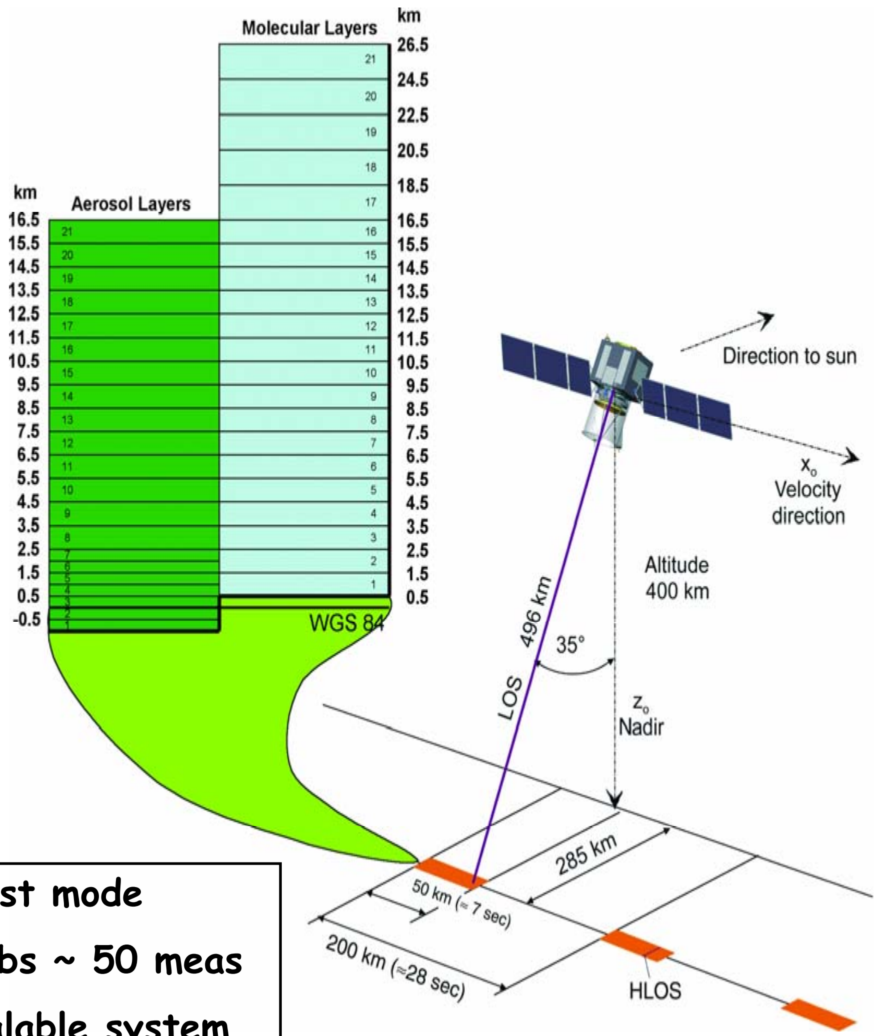
Background for ADM-Aeolus

ADM-Aeolus Baseline

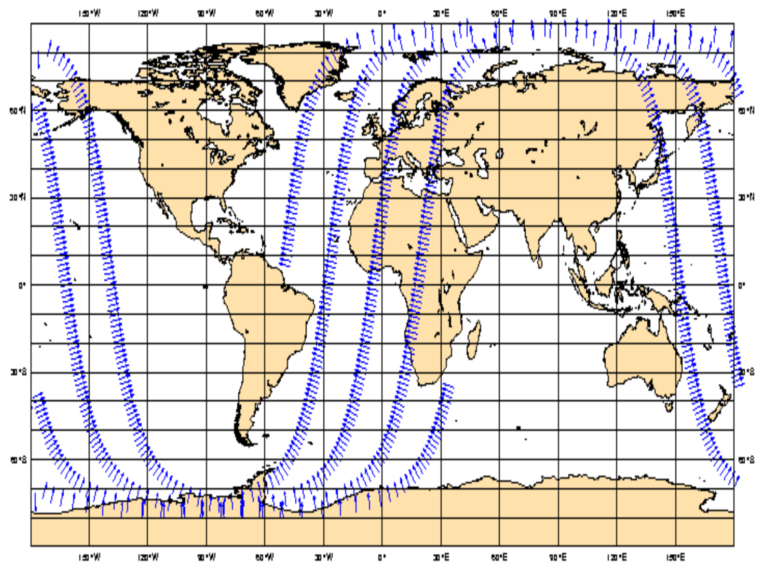


UV lidar (355 nm) with two receivers

- Mie (aerosol), Rayleigh (molecules)
- both use direct detection

Wind profiles from surface to 30 km with resolution varying from 0.5 to 2 km

- vertical bins configurable in flight
- HLOS component only
- direction 7° from zonal at equator
- 6 hour coverage shown



Burst mode

1 obs ~ 50 meas

Scalable system

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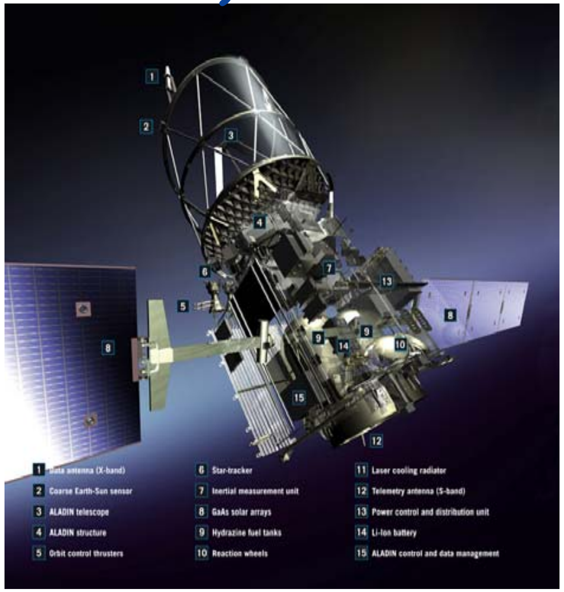
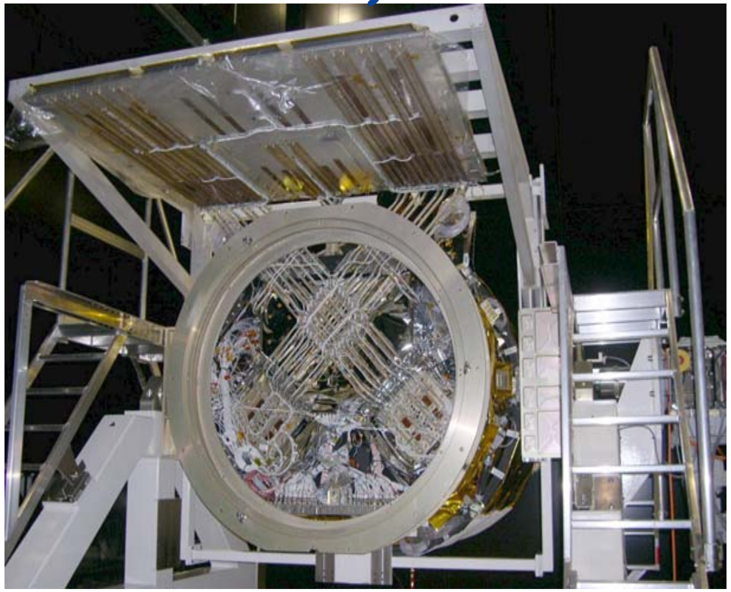
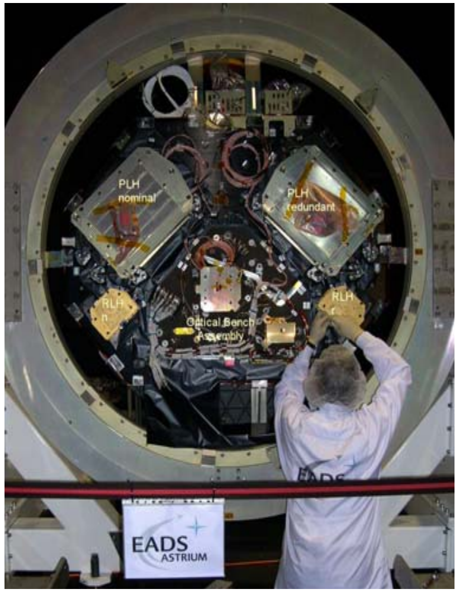
ADM-Aeolus Space Segment – preparation/testing of

1) structural-thermal model   2) lidar transmitter/receiver

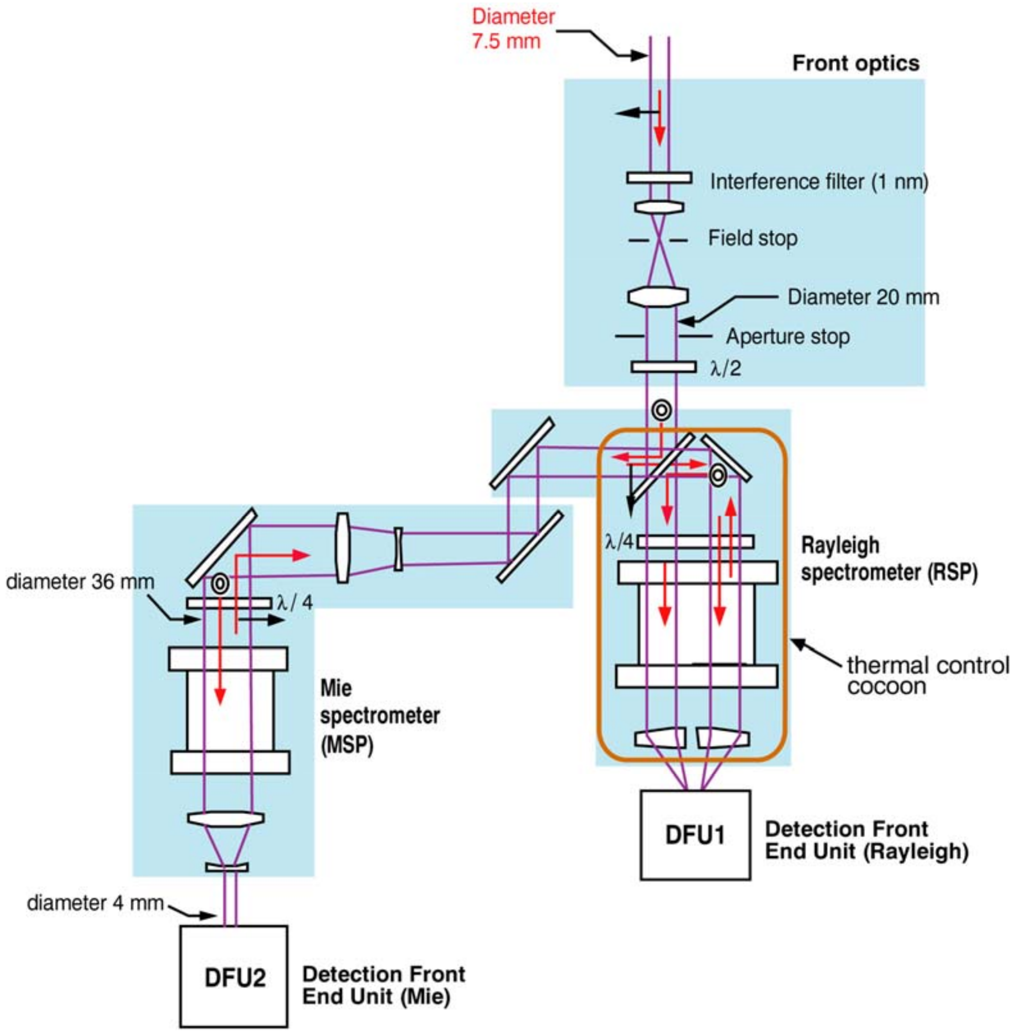






Background for ADM-Aeolus

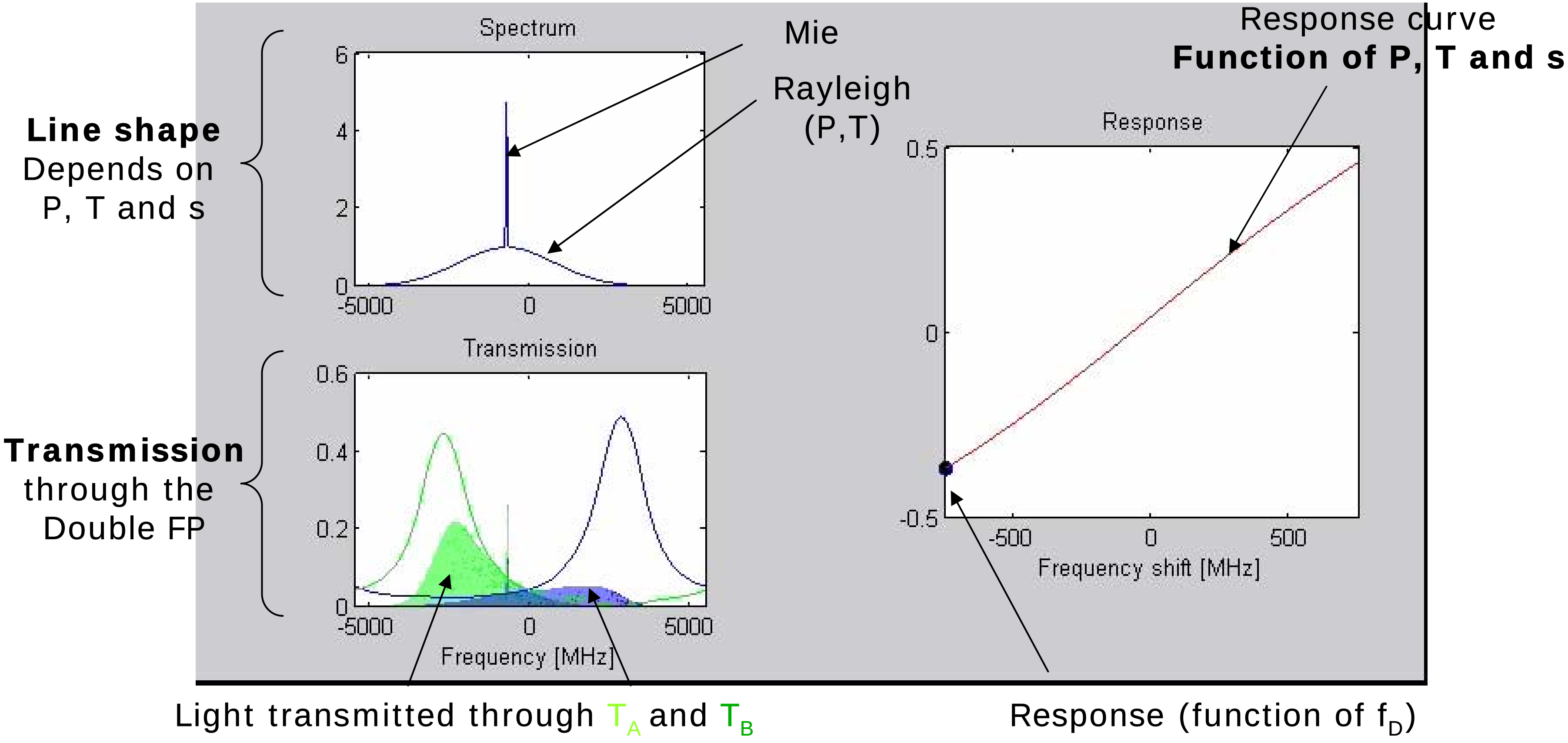
ADM-Aeolus Optical Receiver



Astrium Satellites

- Mie light reflected into Rayleigh channel
- Rayleigh wind algorithm includes correction term involving scattering ratio (s)

ILIAD - Impact of P, T and backscatter ratio on Rayleigh Responses



Dabas Meteo-France

ADM-Aeolus pre-launch campaigns
with development/pre-flight instrument (A2D)

Ack: Oliver Reitebuch

DLR

Campaign	Location	Time	Instruments
ADM-Aeolus Ground Campaign	Lindenberg DWD-MOL	4 weeks Jul 2007	A2D within container (DLR) 2μm lidar within container (DLR) 482 MHz windprofiler radar (DWD) 35.5 GHz cloud radar (DWD) laser ceilometer (DWD) sun-photometer (DWD) 4 operational RASO/day + 10 additional (DWD) aerosol lidar 355 nm (MIM) *Rayleigh Doppler lidar?*
ADM- Aeolus Airborne Campaign 1	DLR-Oberpfaffenhofen over-flights Lindenberg and other sites	15 days Oct 2007	A2D and 2μm in DLR Falcon DWD-MOL instruments as in AGC
ADM- Aeolus Airborne Campaign 2	TBD	17 days 2008/9	A2D and 2μm in DLR Falcon additional instruments, if linked to other campaign

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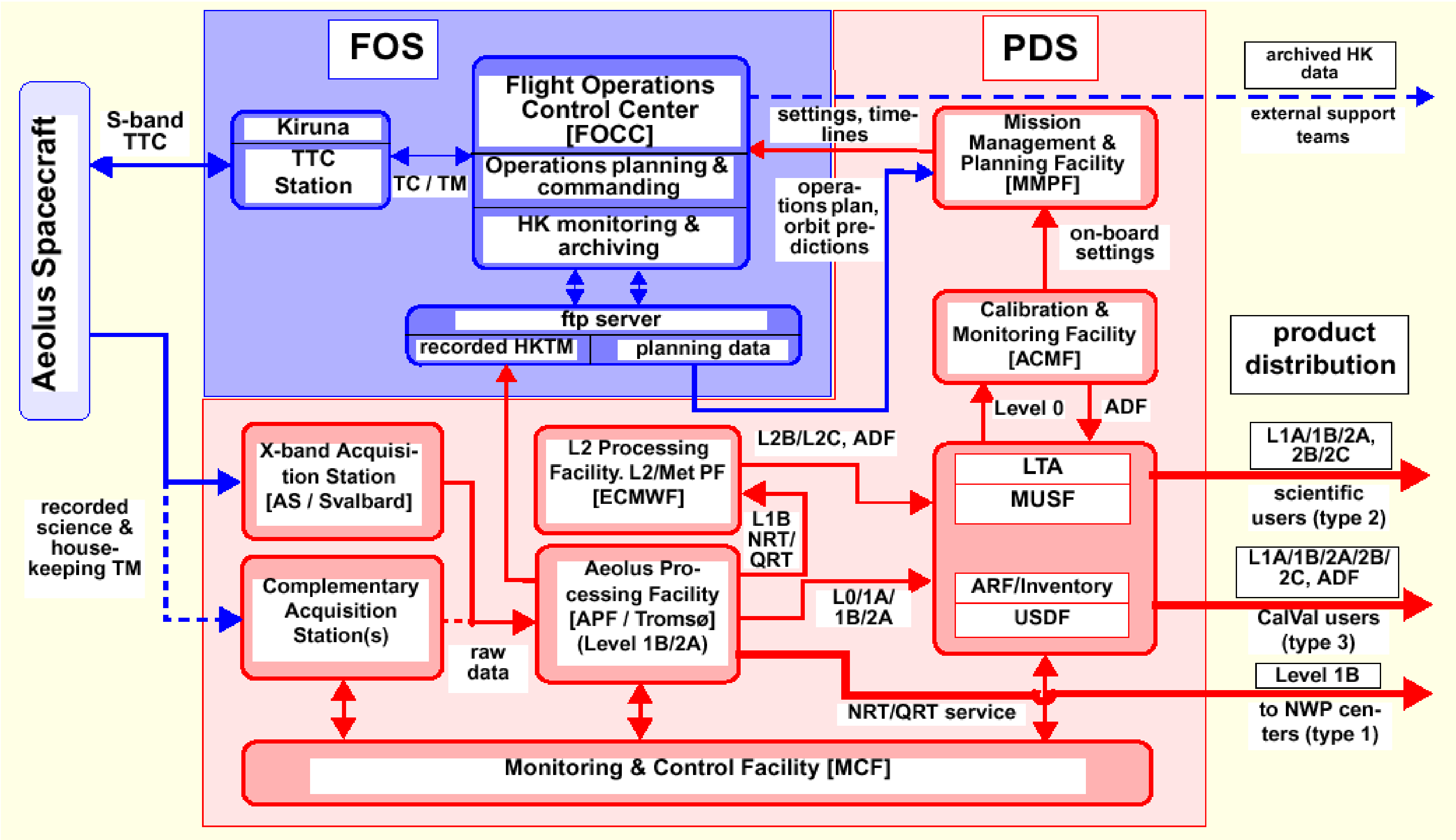
ADM-Aeolus Ground Segment

Aeolus Ground Segment & Data Flows (schematic view)



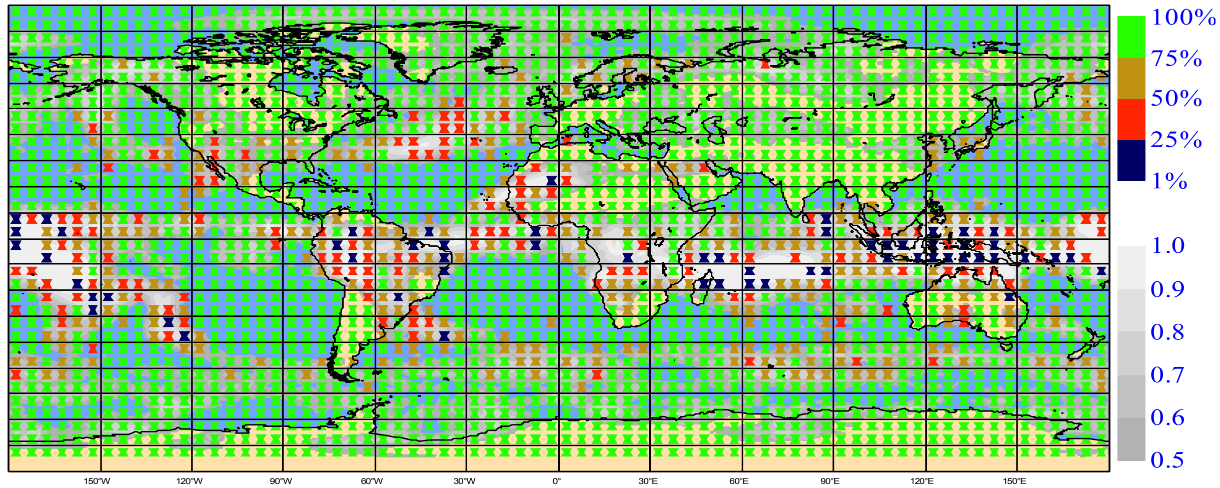
On-going preparations for ADM-Aeolus

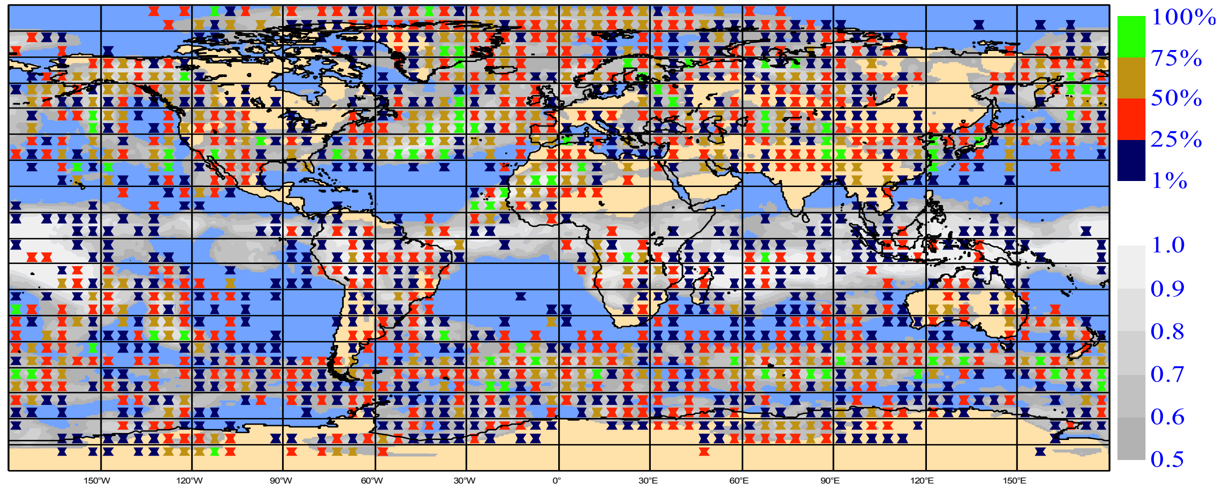
- Level-0 to Level-2B processing
  - Rayleigh HLOS retrieval requires auxiliary meteorological data (T & p profiles) from NWP models
  - Flexible & portable L2B processor being developed
    - ➔ prototype available to the nwp/scientific community
  - Error estimates, quality indicators, weighted averaging of the measurement scale (< 3.5 km) to produce the observation scale (50 km), signal classification
- Potential cloud & aerosol products (+ algs / code for L2Bp)
- Concepts for follow-on & future missions
  - Scanning vs multiple orbits non-scanning
  - Programmatics, data continuity

Previous data simulations for ADM-Aeolus

Yield (data meeting mission requirements in % terms) at 10 km

- 90% of Rayleigh data have accuracy better than 2 m/s
- In priority areas (filling data gaps in tropics & over oceans)
- Complemented by good Mie data from cloud-tops/cirrus (5 to 10%)
- Tan & Andersson QJRMS 2005





Simulator LIPAS ported from MeteoFrance via KNMI

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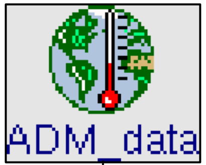
Assimilation of prototype ADM-Aeolus data

New observed quantity introduced into 4d-Var



Prototype Level-2B (LIPAS simulation, includes representativeness error)

Observation Processing

Data Flow at ECMWF

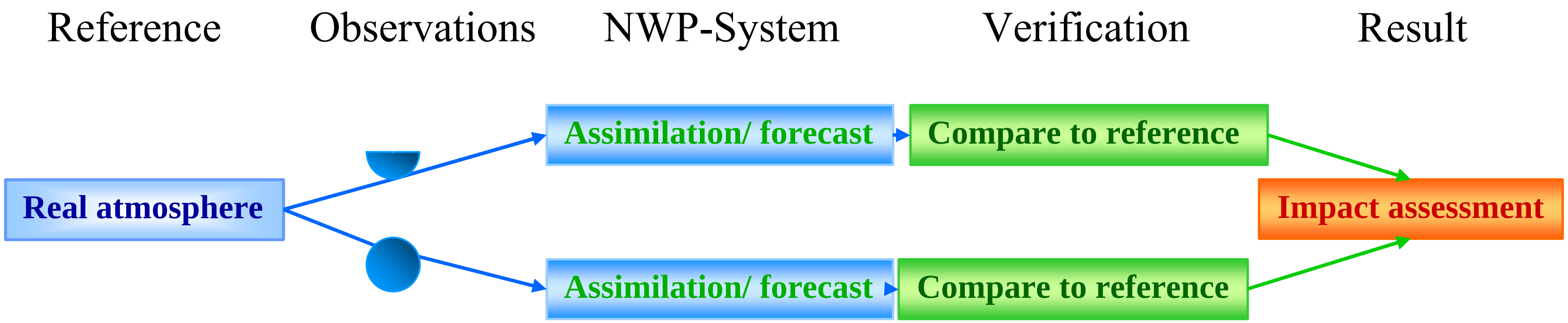
Non-IFS processing	"Bufr2ODB" Convert BUFR to ODB format Recognize HLOS as new known observable
Observation Screening	IFS "Screening Job" Check completeness of report, blacklisting Background Quality Control
Assimilation Algorithm	IFS "4D-VAR" Implement HLOS in FWD, TL & ADJ Codes Variational Quality Control
Diagnostic post-processing	"Obstat" etc (Lars Isaksen) Recognize HLOS for statistics Rms, bias, histograms

Analysis

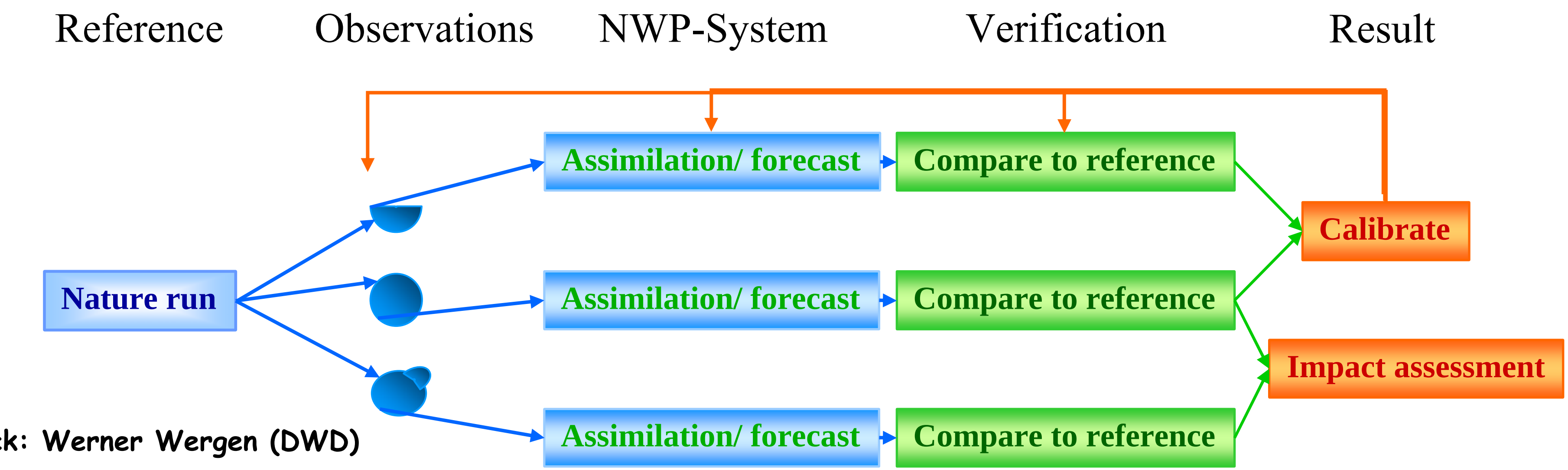
Assimilation studies for ADM-Aeolus

- Tan et al., QJRMS 133:381-390 (2007)
- Assimilation ensembles for data impact assessment
  - Original motivation: use ensemble spread as proxy for short-range forecast errors (background errors)
  - By extension, good data reduce ensemble spread
  - DWL impact
  - Radiosonde/profiler impact - provides calibration
- Additional diagnostics related to information content
  - Entropy reduction
  - Degrees of freedom for signal

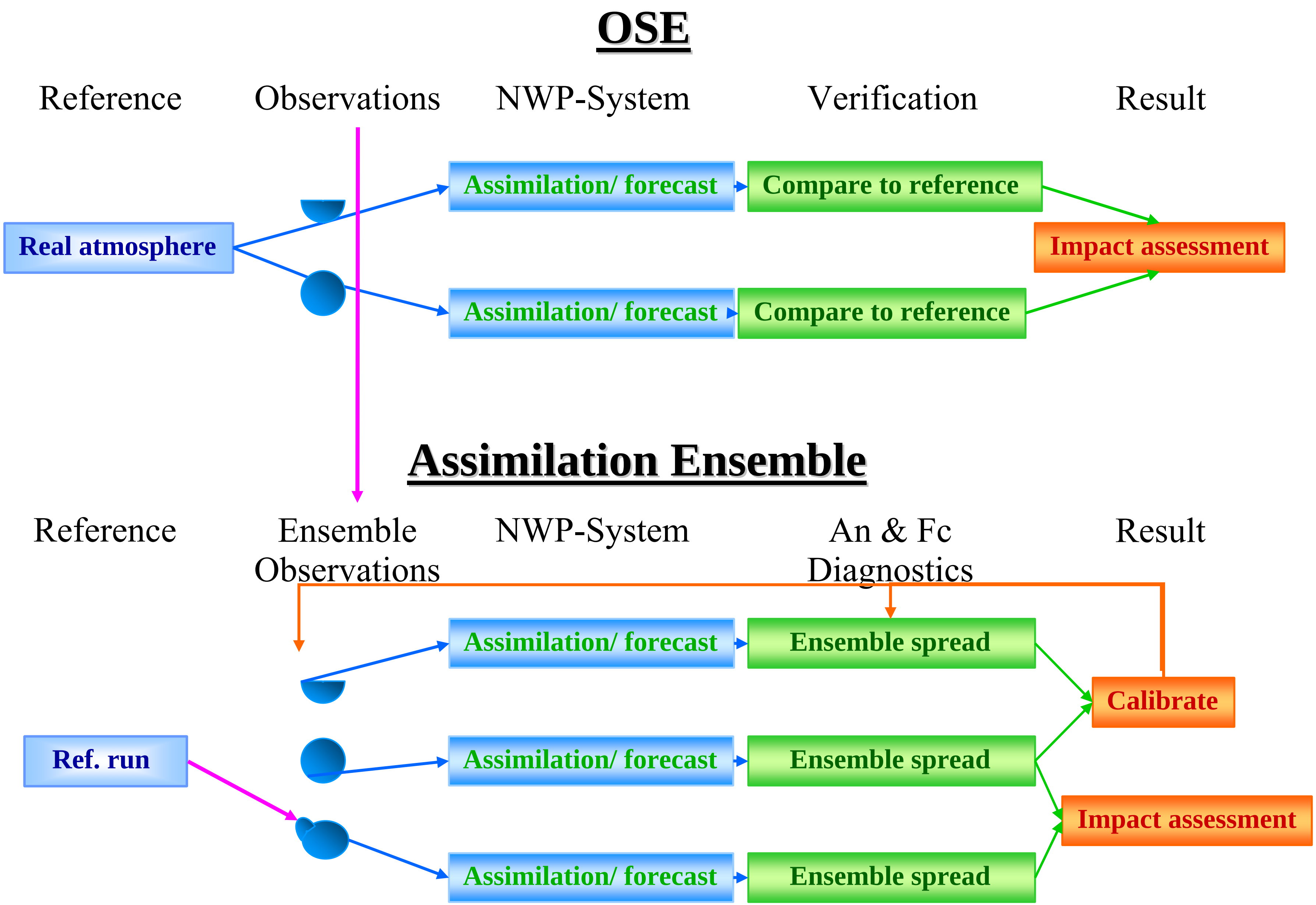
OSE



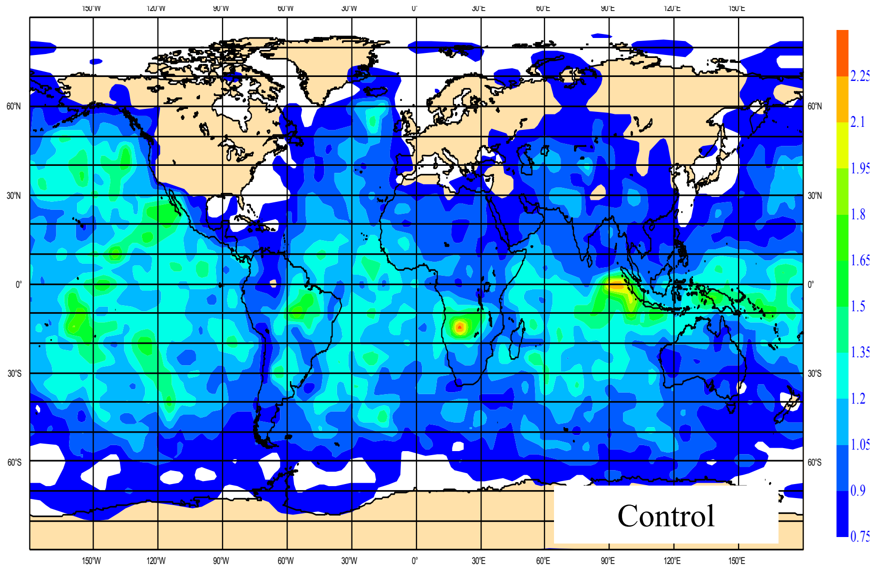
OSSE

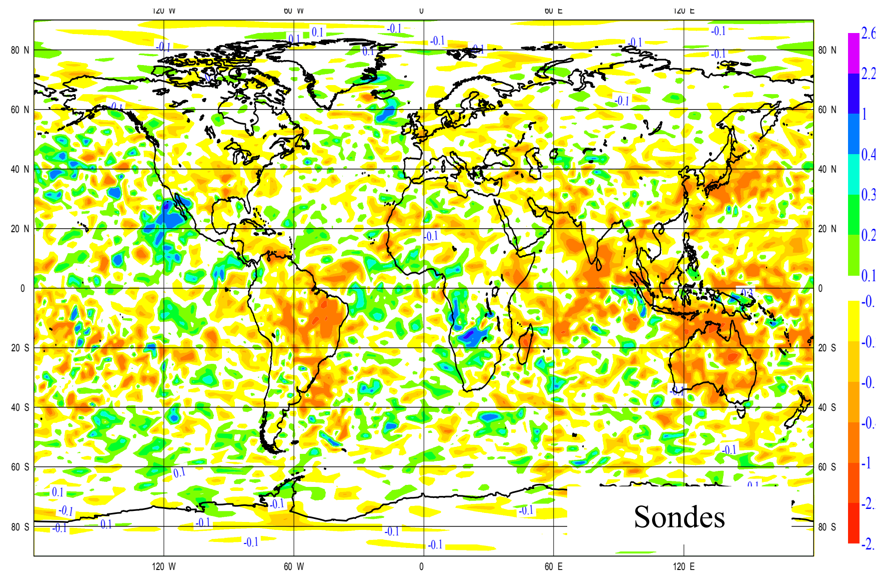


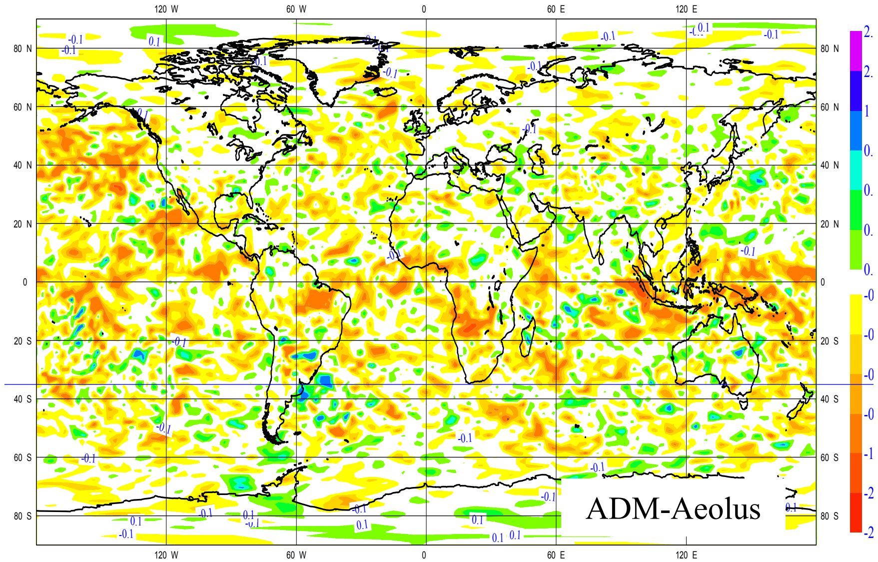
Ack: Werner Wergen (DWD)


OSE
Reference
Observations
NWP-System
Verification
Result
Real atmosphere
Assimilation/ forecast
Compare to reference
Assimilation/ forecast
Compare to reference
Impact assessment
Assimilation Ensemble
Reference
Ensemble Observations
NWP-System
An & Fc Diagnostics
Result
Assimilation/ forecast
Ensemble spread
Calibrate
Ref. run
Assimilation/ forecast
Ensemble spread
Impact assessment
Assimilation/ forecast
Ensemble spread

Data impact on ensemble forecasts - zonal wind spread at 500 hPa







- Radiosondes and wind profilers over Japan, Australia, N.Amer, Europe
- DWL over oceans & tropics
- Some features more obvious at 200 hPa …

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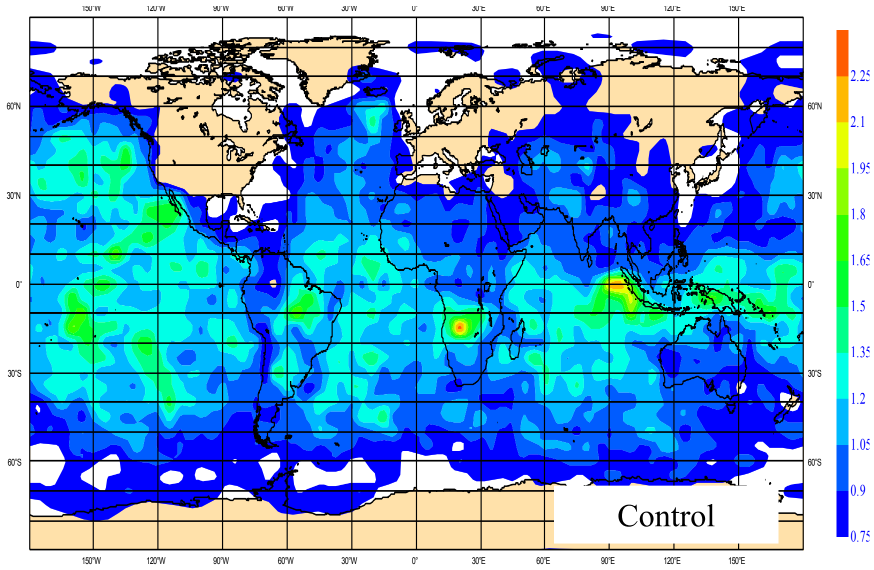
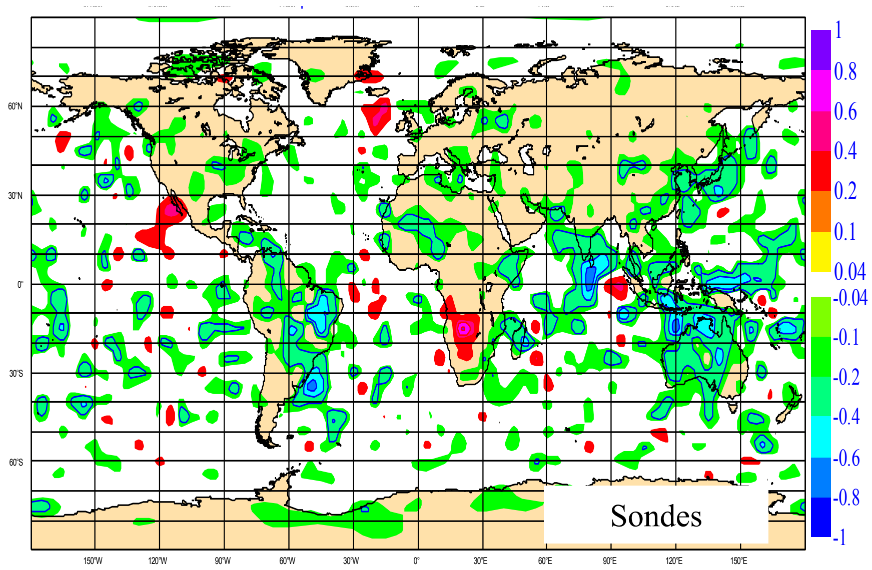
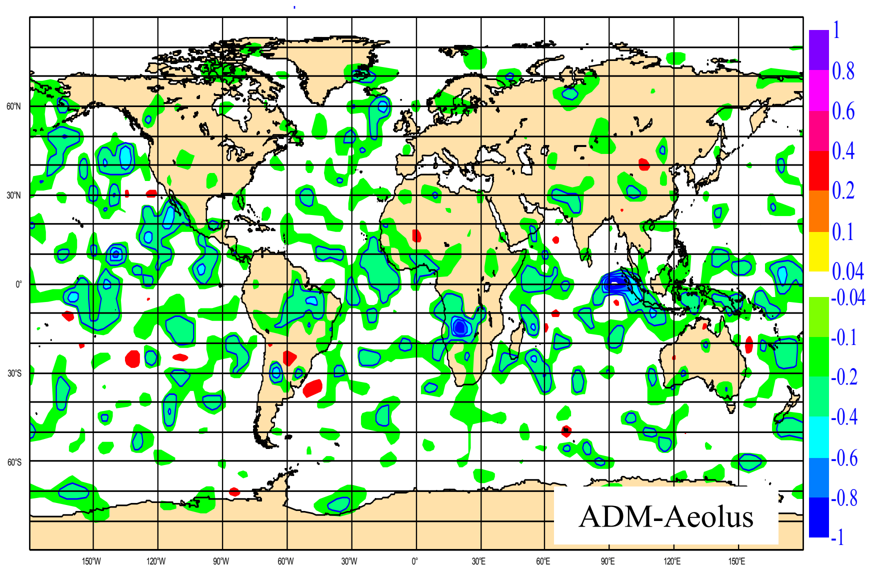
OLD Data impact on ensemble forecasts - zonal wind spread at 500 hPa







- Radiosondes and wind profilers over Japan, Australia, N.Amer, Europe
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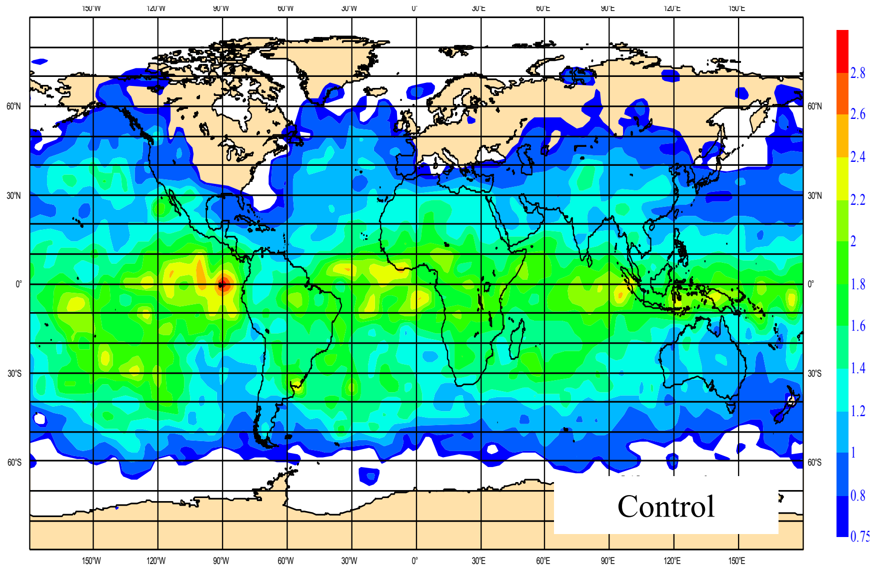
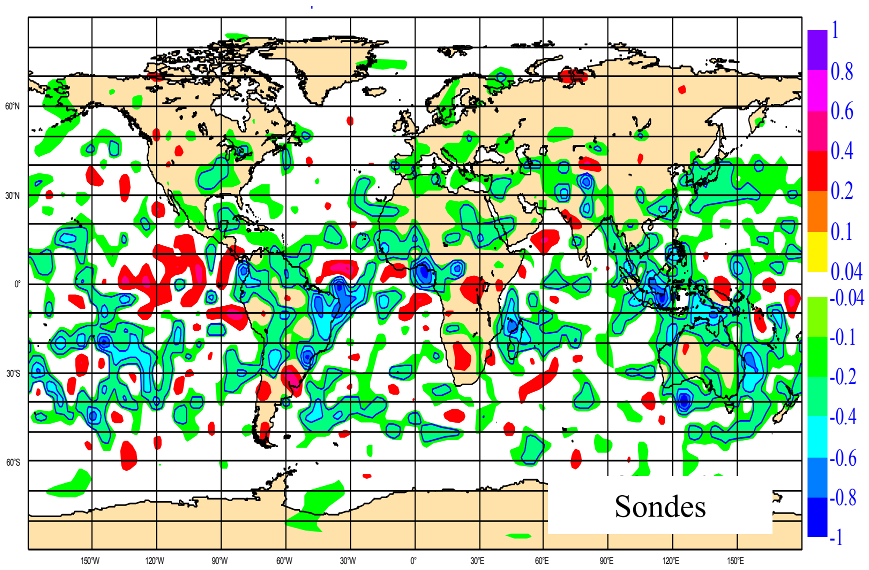
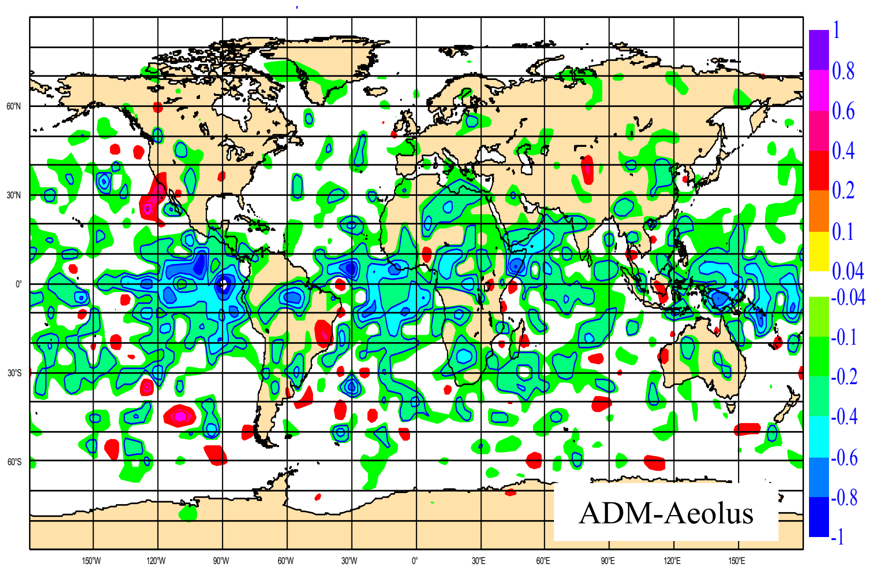
Data impact on ensemble forecasts - zonal wind spread at 200 hPa







- **Radiosondes and wind profilers over Japan, Australia, N.Amer, Europe**
- **DWL over oceans and tropics**

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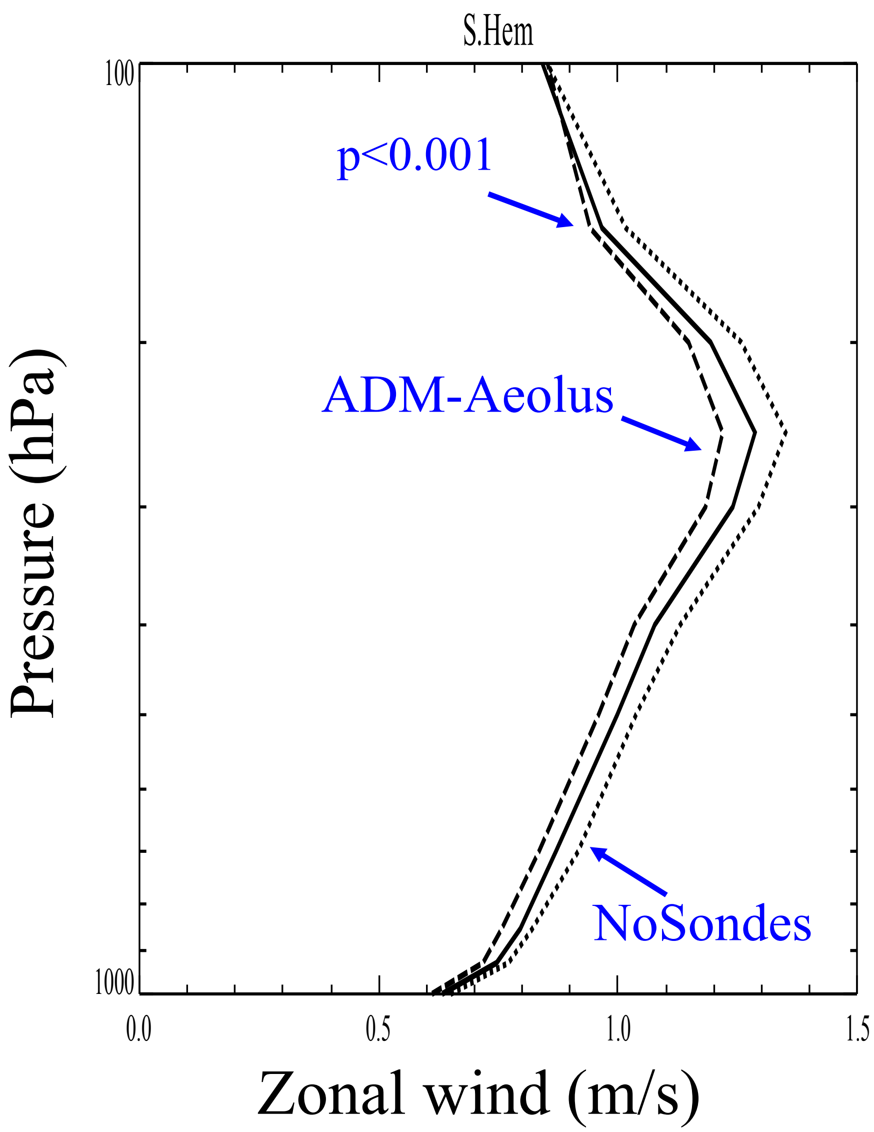
Profiles of 12-hr Fc impact, Southern Hemisphere



Spread in zonal wind (U, m/s)

Scaling factor ~ 2 for wind error

Tropics, N. & S. Hem all similar

Simulated DWL adds value at all altitudes and in longer-range forecasts (T+48,T+120)

Differences significant (T-test)

Supported by information content diagnostics

Information content – global diagnostics

- Mike Fisher for Entropy Reduction & DFS
  - $S \sim \log(\det(P^A))$
  - $\sim tr(\log(J''^{-1}))$
  - J'' = 4d-var Hessian
  - P^A = analysis error covar.
- DWL data are accurate and fill data gaps
  - subject to usual caveats about simulated data

	TEMP/PILOT	Simulated DWL
Data considered	u,v to 55 hPa	HLOS
Entropy_Reduction ("Info bits")	4830	3123
Deg_Free_Sig	3707	2743
N_Obs	90688	50278
Info bits per obs	0.053	0.062
N_Obs/Deg_Free_Sig	24.5	18.3
Redundancy		2 — 3 %

Information content – global diagnostics

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  $S \sim \log(\det(P^A))$

  $\sim \mathrm{tr}(\log(J''^{-1}))$

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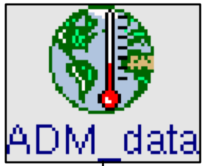
	TEMP/PILOT	Simulated DWL
Data considered	u,v to 55 hPa	HLOS
Entropy_Reduction ("Info bits")	4203	2787
Deg_Free_Sig	3153	2454
N_Obs	74682	28979
Info bits per obs	0.056	0.096
N_Obs/Deg_Free_Sig	23.7	11.8
Redundancy		2 — 3 %

Assimilation of prototype ADM-Aeolus data

Reception of L1B data and L2B processing at NWP centres

Observation Processing

Data Flow at ECMWF



Level-1B data

(67 1-km measurements)

Non-IFS processing — "Bufr2ODB"
Convert BUFR to ODB format
Recognize HLOS as new known observable

L2BP (1 50-km observation)
Observation Screening — IFS "Screening Job"
Check completeness of report, blacklisting
Background Quality Control

Assimilation Algorithm — IFS "4D-VAR"
Implement HLOS in FWD, TL & ADJ Codes
Variational Quality Control
→ *Analysis*

Diagnostic post-processing — "Obstat" etc (Lars Isaksen)
Recognize HLOS for statistics
Rms, bias, histograms

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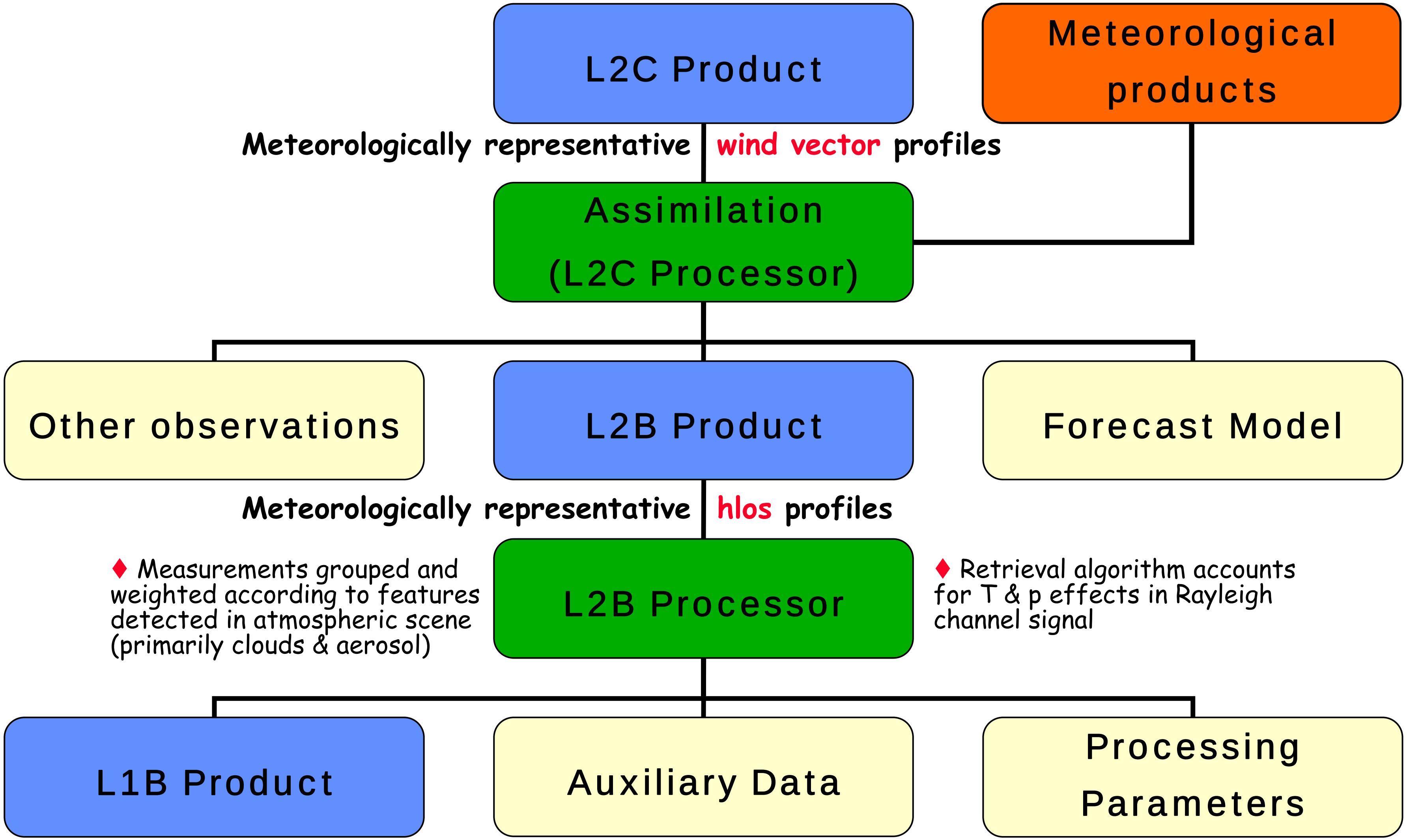
The Level-2B Processor

1. Introduction
    a. What are the Level-2B/2C Wind Products?
    b. How do they differ from Level-1B Products?
2. Strategy and implementation
    a. Who will make them?
    b. Why distribute source code for the L2BP?
3. Does it work?
    a. Main algorithm components
    b. Retrieval examples, future work
4. How will L2BP source code be distributed?

1a/b. What are Level-2B/2C Products?



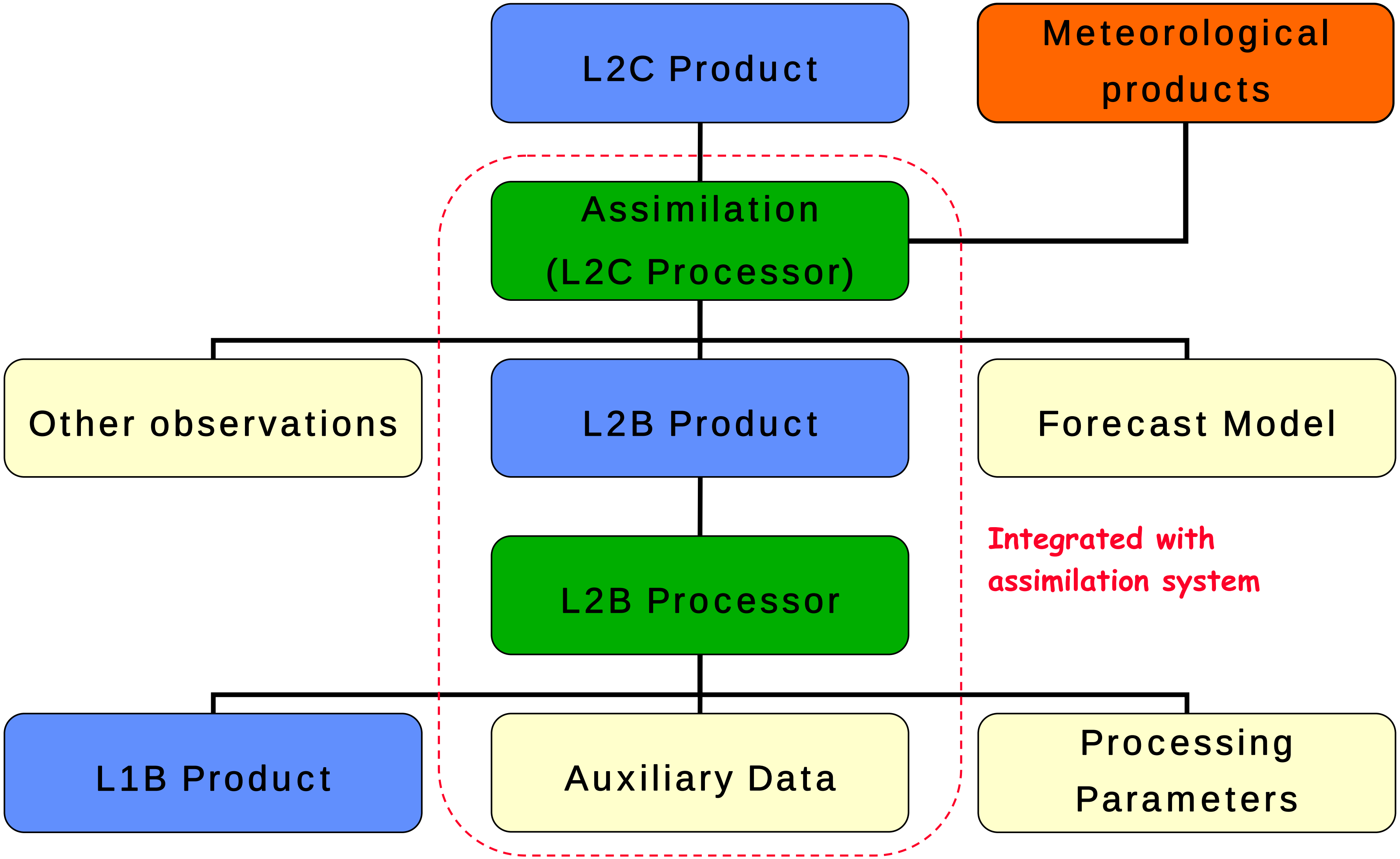
1a/b. What are Level-2B/2C Products?

- **2B: Meteorologically representative HLOS profiles**
  - **retrieval algs applied to Level-1B data, 2B-output suitable as input to data assimilation**
    - auxiliary input data: T & p, Rayleigh-Brillouin response data, etc
- **2C: Meteorologically representative wind vector profiles**
  - **result of a data assimilation algorithm, combining Level-2B with other data/weather forecast model**
- **How do they differ from Level-1B Products?**
  - **Rayleigh channel retrieval accounts for T & p effects**
  - **measurements grouped/weighted by features detected in the atmospheric scene (primarily clouds & aerosol)**

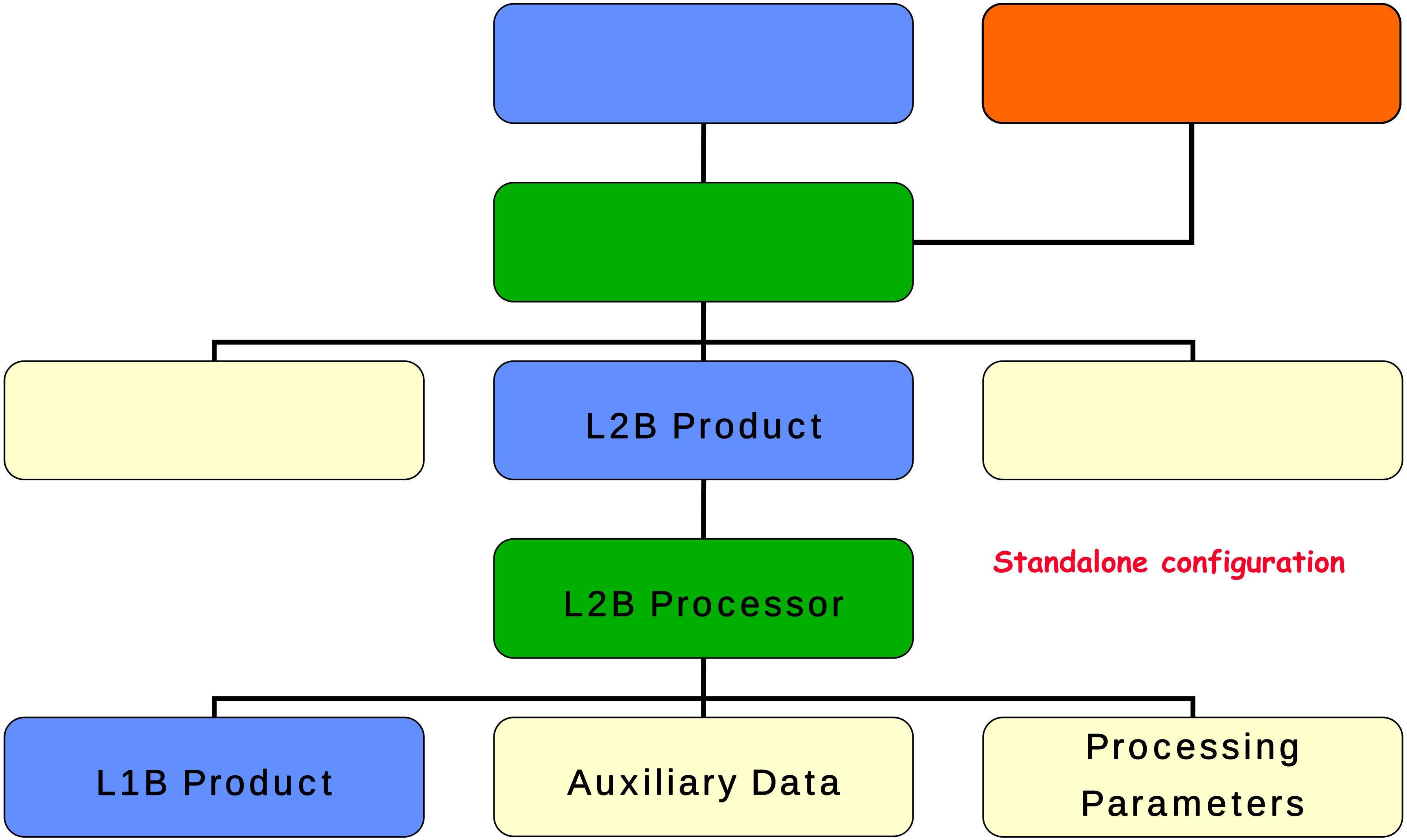
2a. Who will make Level-2B/2C Products?

- ECMWF for "operational" Level-2B/2C products
  - Processing integrated with data assimilation system
  - Products in ESA's Earth Explorer file format available from ESA (Long-Term Archive)
- ESA LTA for Level-2B late- & re-processing
  - Level-1B missing ECMWF's operational schedule
  - New processing parameters/auxiliary inputs
- Other Numerical Weather Prediction centres
  - Different operational schedule/assimilation strategy
  - Different processing params/aux inputs/algorithms
- Research institutes & general scientific users
  - Different processing params/aux inputs/algorithms

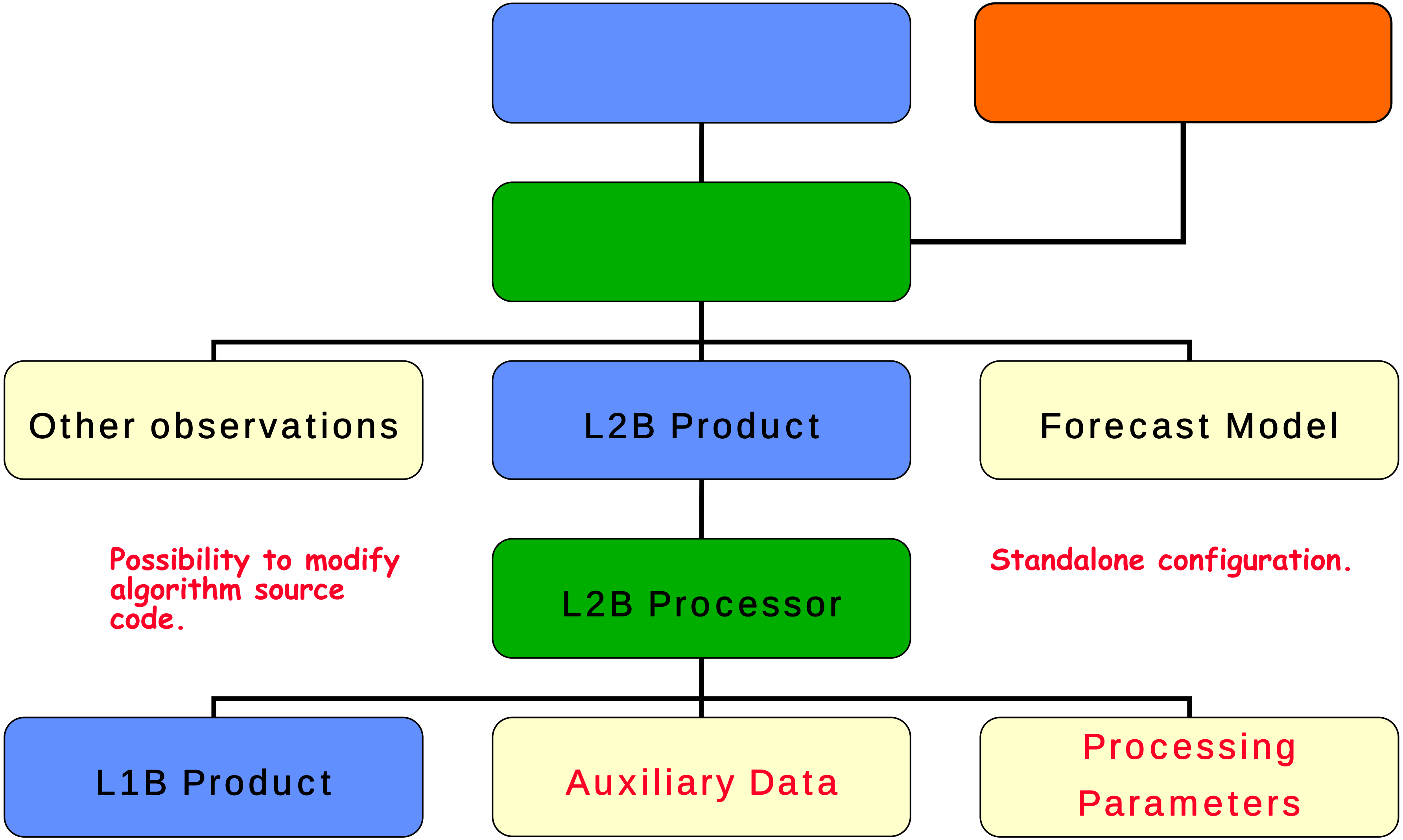
2a-1. ECMWF “operational” configuration



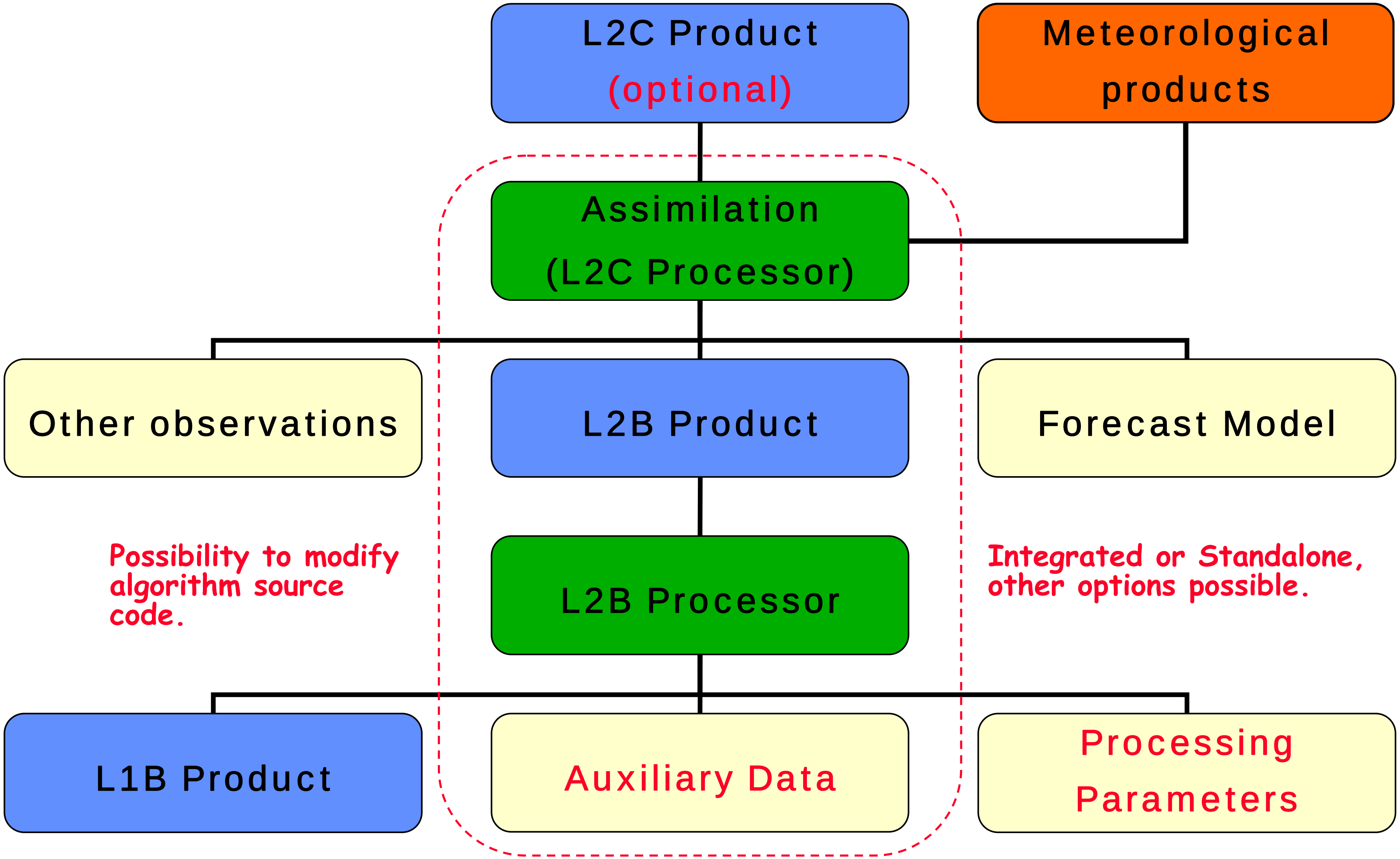
2a-2. ESA-LTA late- and re-processing



2a-4. Research/general scientific use



2a-3. Other NWP configurations



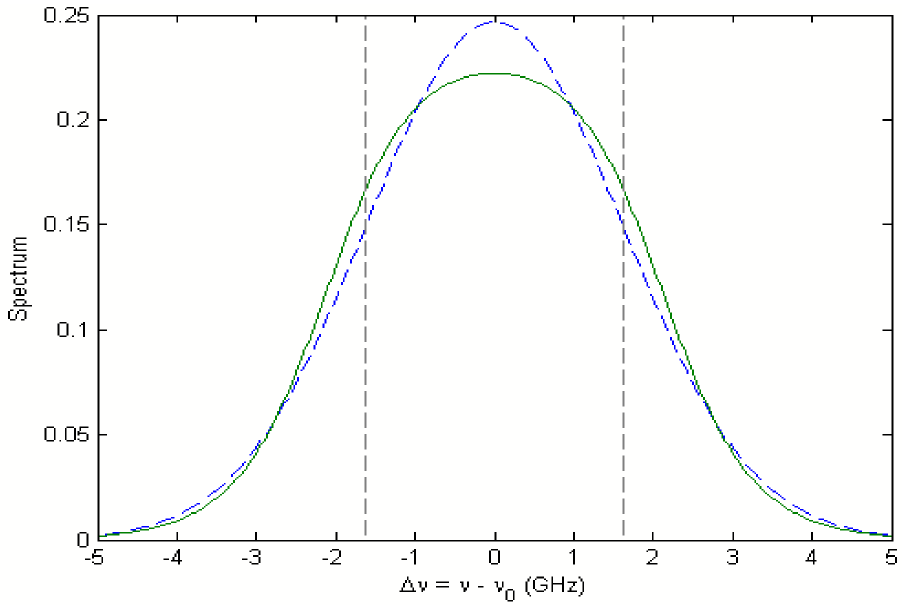
2b. Why distribute L2BP Source Code?

- **Distribution of executable binaries only permits**
  - **limited number of computing platforms**
  - **different settings in processing parameters input file**
    - thresholds for QC, cloud detection
  - **different auxiliary inputs**
    - option to use own meteorological data (T & p) in place of ECMWF aux met data (available from LTA)
- **Provide maximum flexibility for other centres/institutes to generate their own products**
  - **different operational schedule/assimilation strategy**
  - **scope to improve algorithms**
    - feed into new releases of the operational processor

3a. How it works – Tan et al *Tellus A* in press

- Rayleigh channel HLOS retrieval – Dabas et al, Tellus A
  - $R = (A-B) / (A+B)$ and $HLOS = F^{-1} (R;T,p,s)$
  - T and p are auxiliary inputs
  - correction for Mie contamination, using estimate of scattering ratio s
- Mie channel HLOS retrieval
  - peak-finding algorithm (4-parameter fit as per L1B)
- Retrieval inputs are scene-weighted
  - $ACCD = \Sigma\, ACCD_m W_m$, W_m between 0 and 1
- Error estimate provided for every Rayleigh & Mie hlos
  - dominant contributions are SNR in each channel

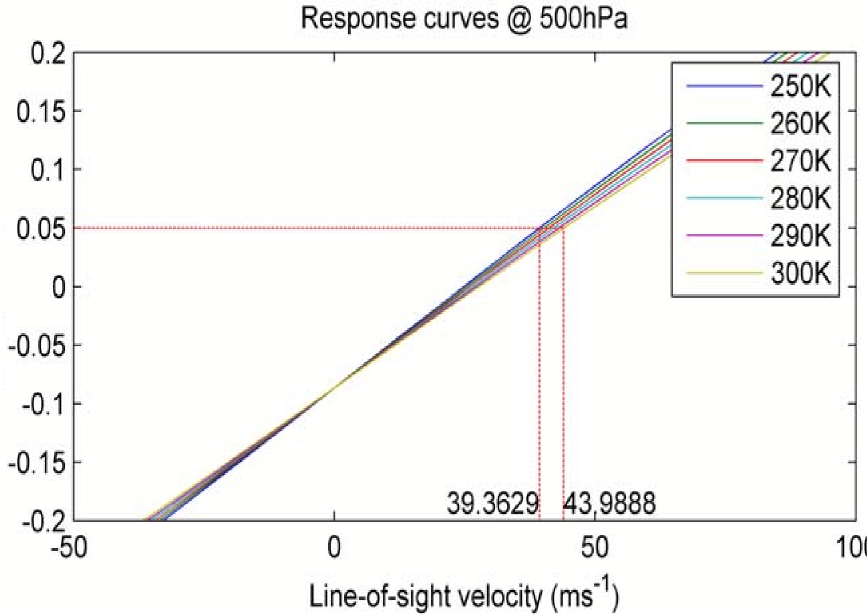
Rayleigh-Brillouin spectrum and Aeolus response curves



Rayleigh

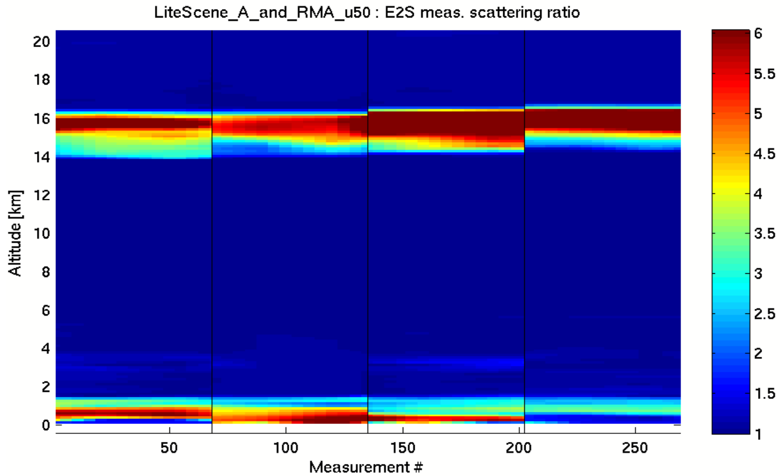
Rayleigh-Brillouin

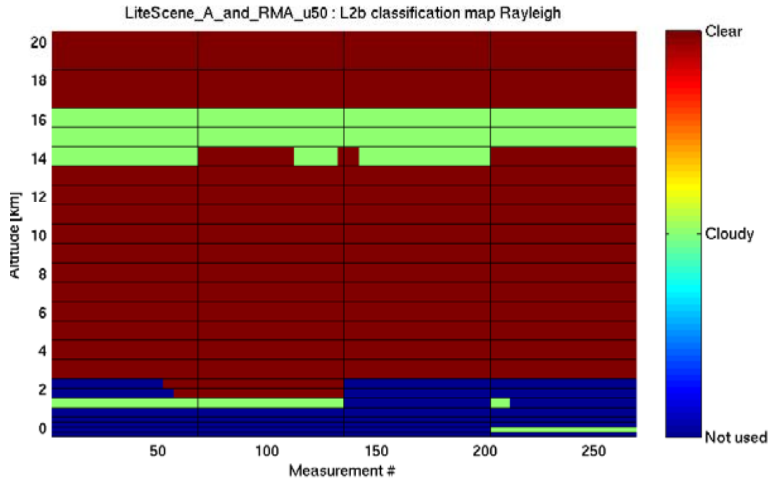
$$R = (A-B)/(A+B)$$

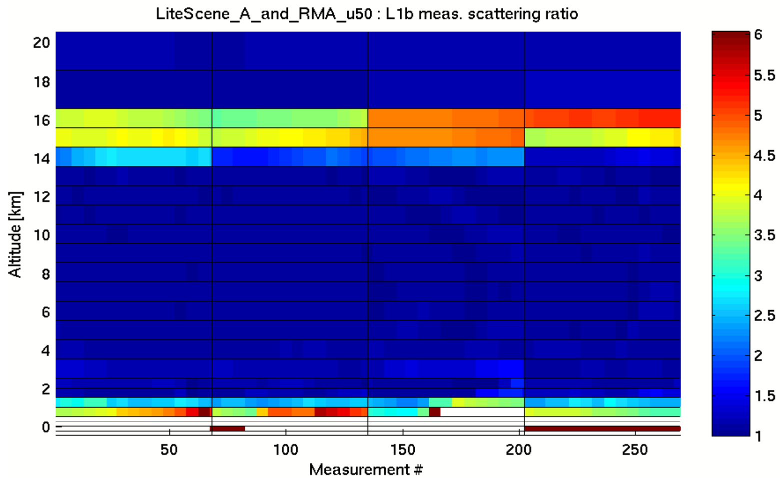


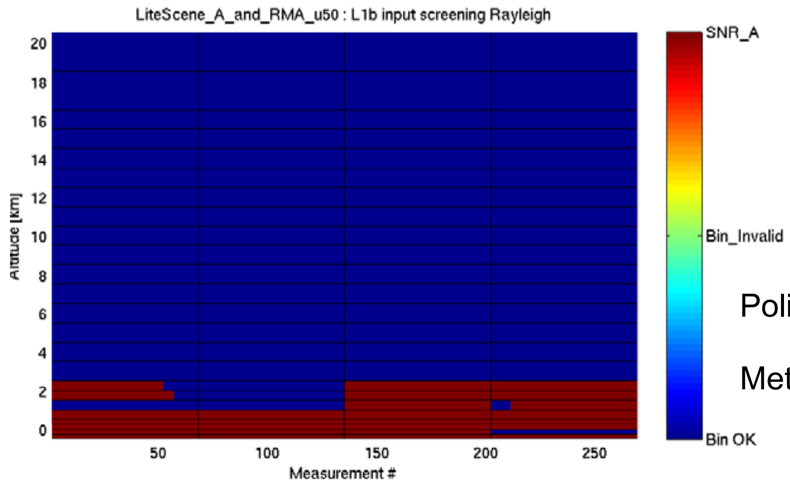
Dabas et al., Tellus accepted

3b. Level-2B input screening & feature finding







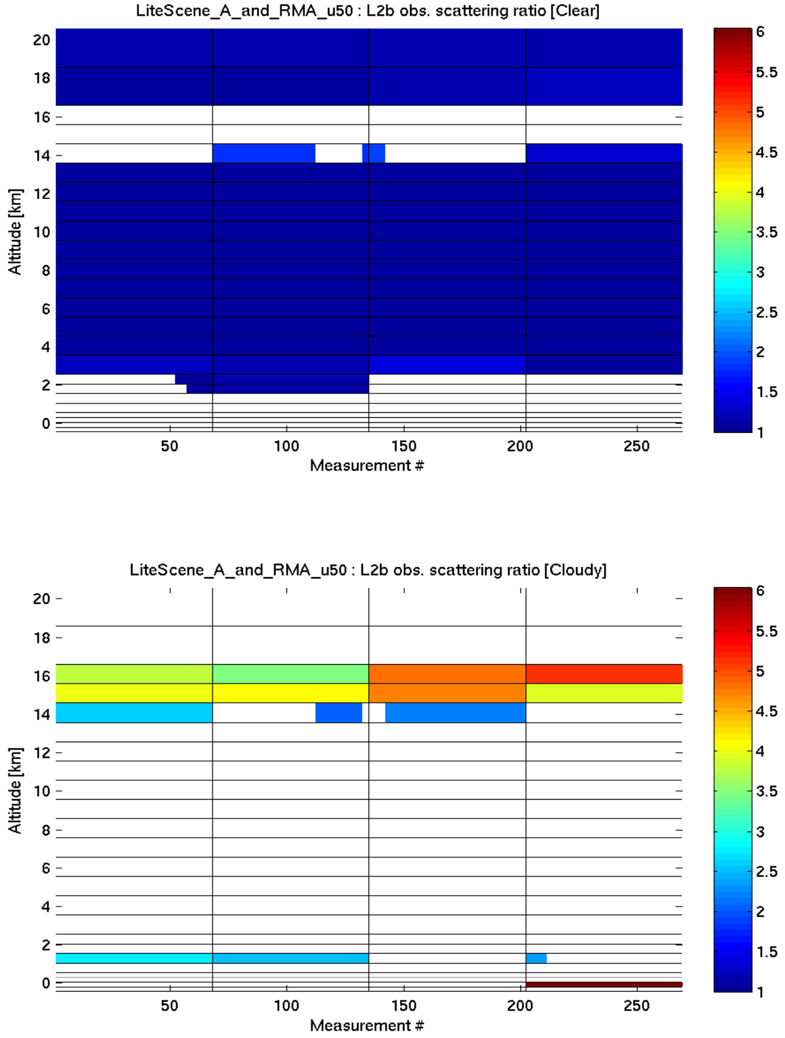


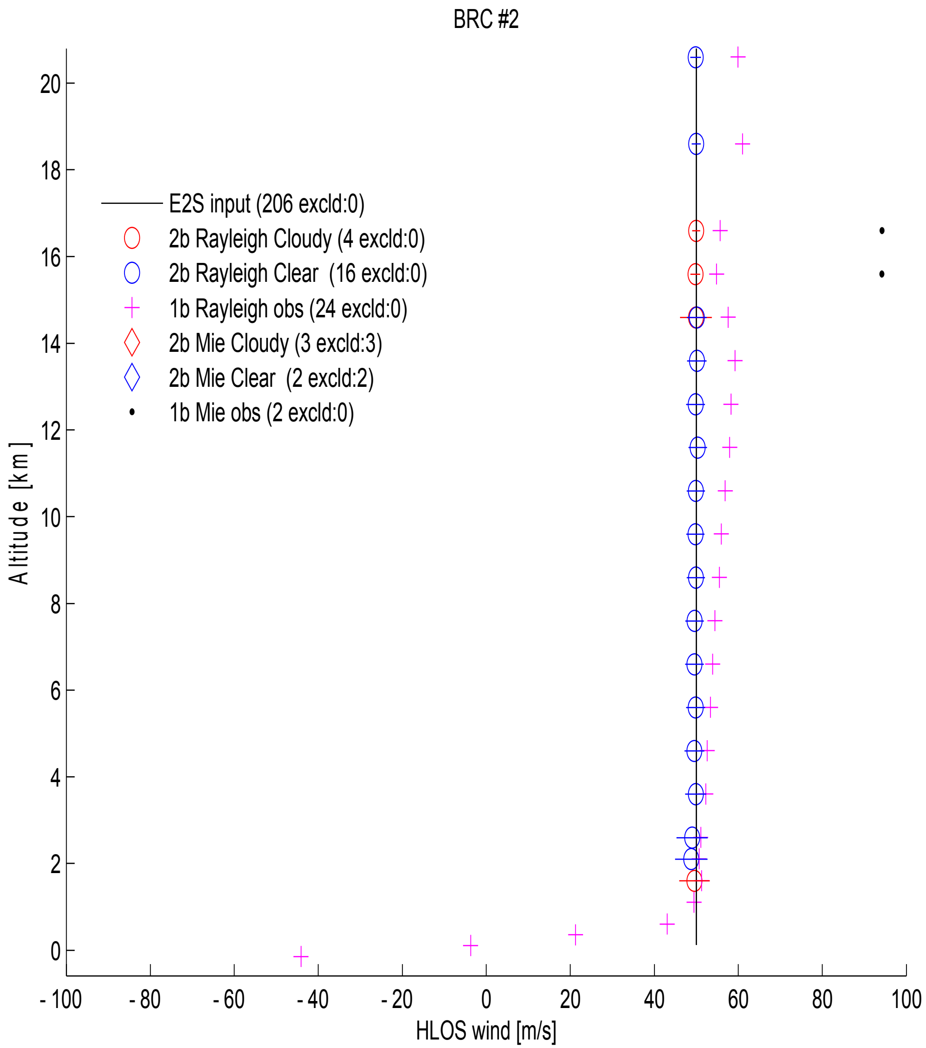
Poli/Dabas

Meteo-France

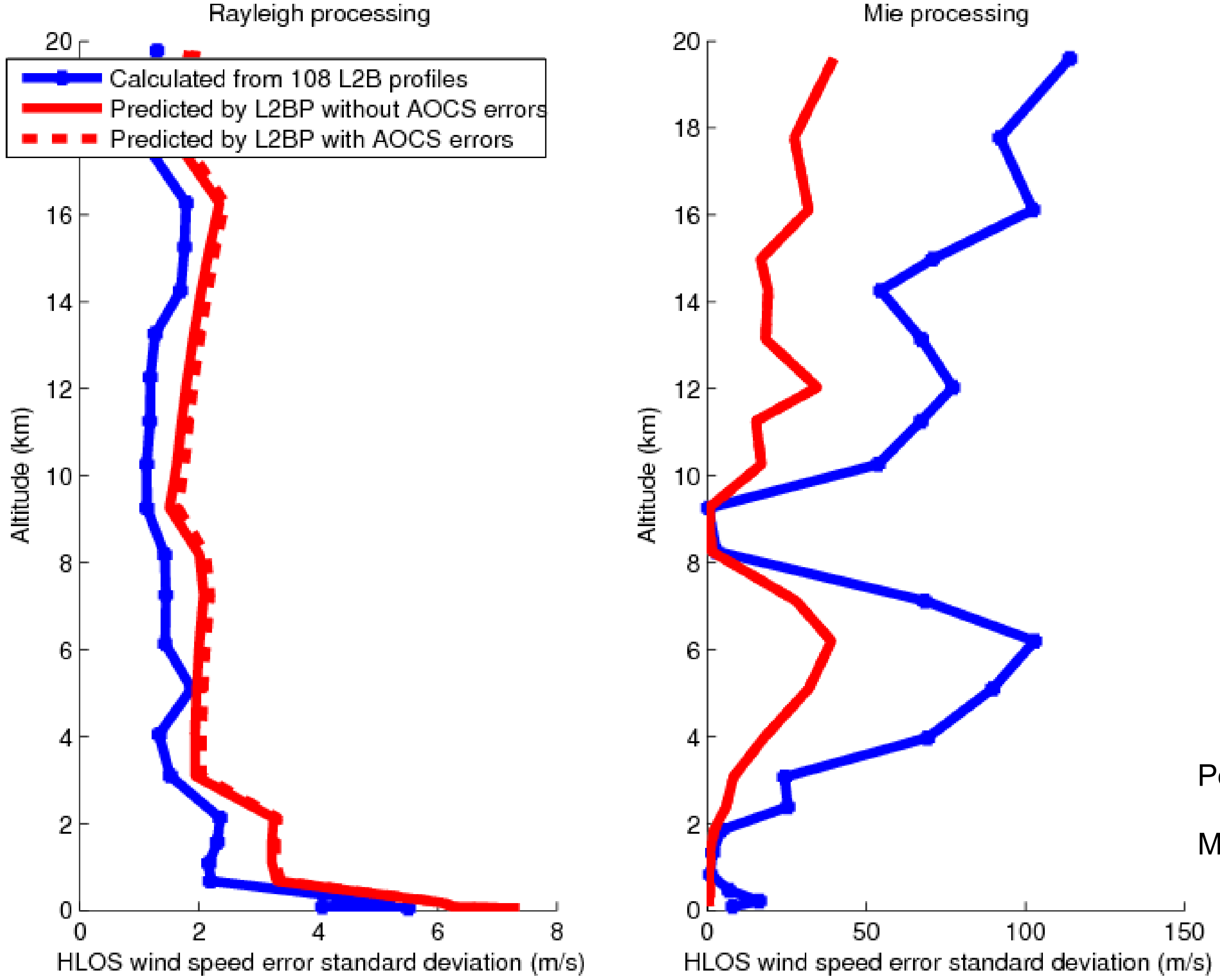
ECMWF

3b. Level-2B hlos wind retrievals





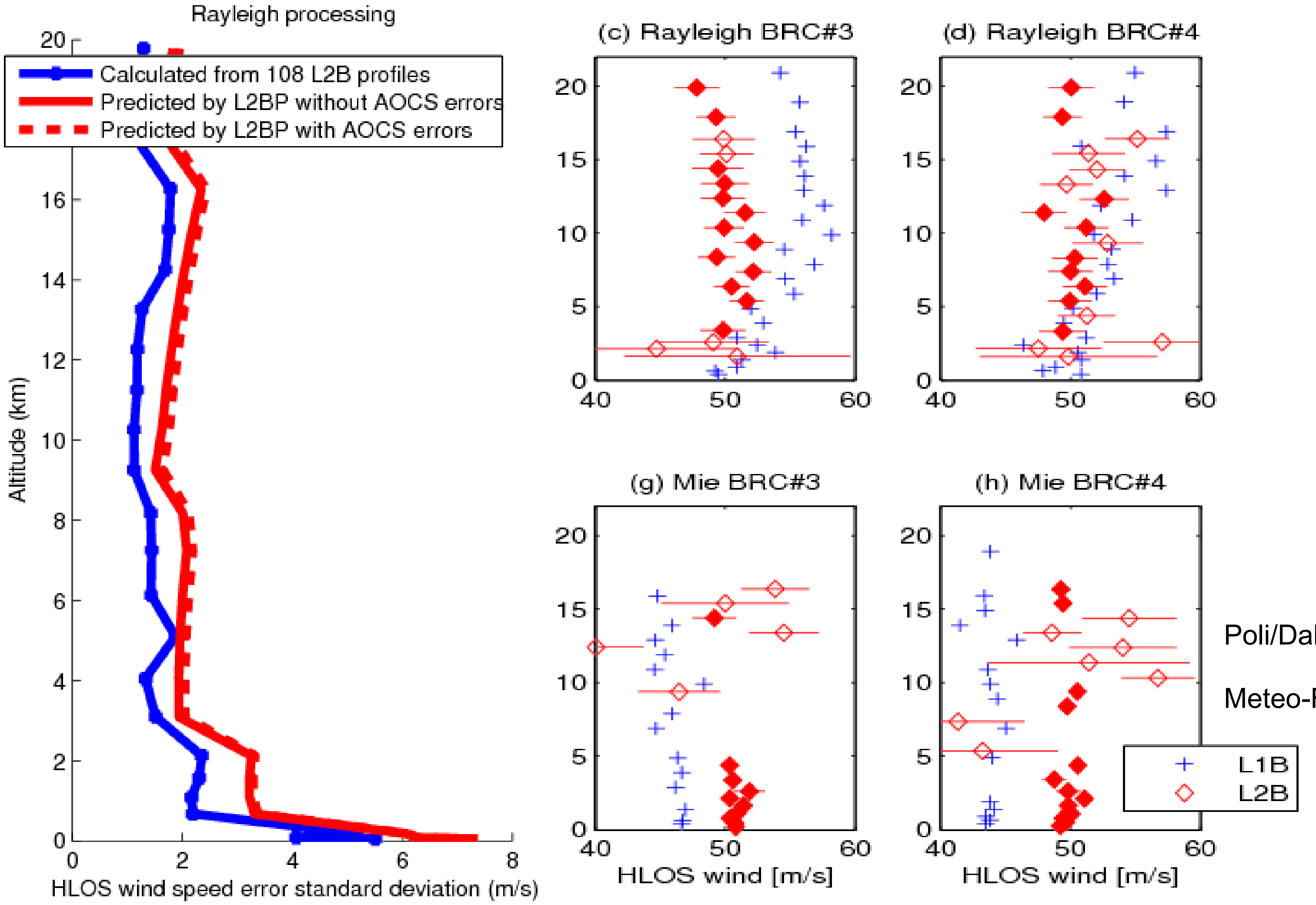
3b. Level-2B hlos retrieval - error estimates



Poli/Dabas

Meteo-France

3b. Level-2B hlos retrieval - error estimates



Poli/Dabas

Meteo-France

3c. Future work

- **Quality Indicators**
  - Highlighting doubtful L2B retrievals
    - More complicated atmospheric scenes from simulations + Airborne Demonstrator
- **Advanced feature-finding/optical retrievals**
  - Methods based on NWP T & p introduce error correlations
- **Modified measurement weights**
  - More weight to measurements with high SNR?
- **Height assignment**
  - In situations with aerosol and vertical shear

4. Distribution of L2BP software

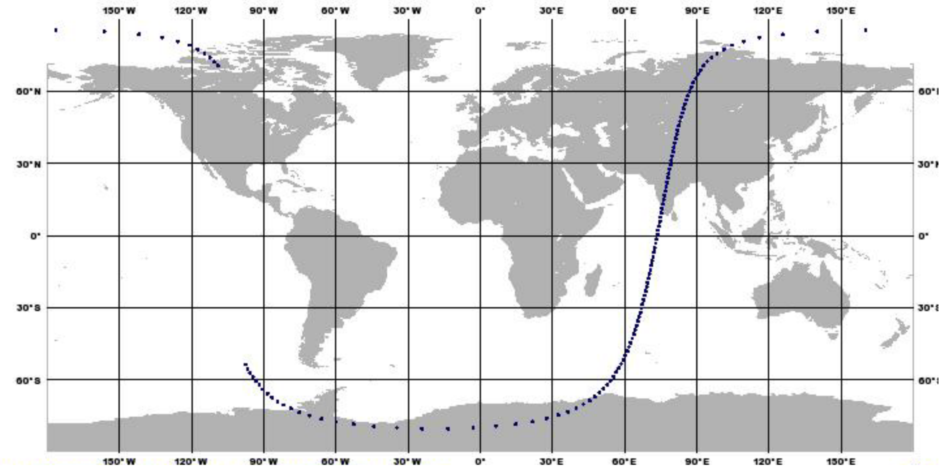
- **Software releases issued by ECMWF/ESA**
  - **Details & timings to be determined**
  - **Probably via registration with ECMWF and/or ESA**
  - **Source code and scripts for installation**
    - Fortran90, some C support
    - Developed/tested under several compilers
  - **Suite of unit tests with expected test output**
  - **Documentation**
    - Software Release Note
    - Software Users' Manual
    - Definitions of file formats (IODD), ATBD, etc.

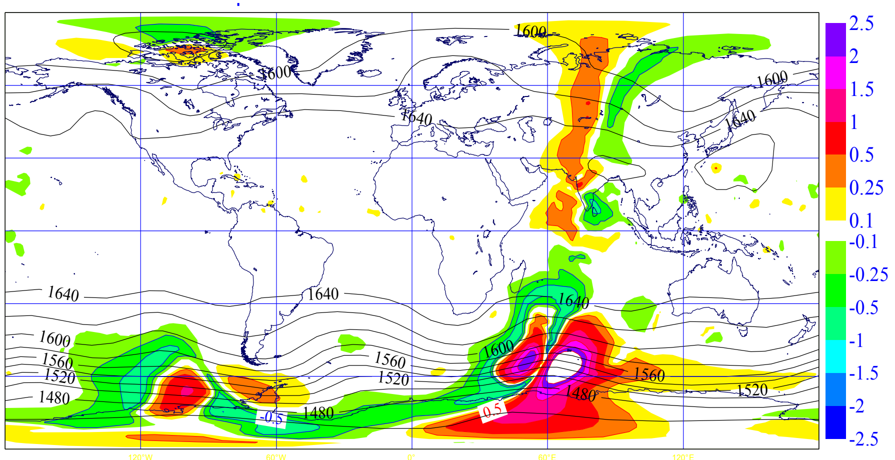
Conclusions

- **Expectations for ADM-Aeolus are high**
  - **On track for producing major benefits in NWP**
    - Meeting the mission requirements for vertical resolution & accuracy
    - Extending to stratosphere, re-analysis
    - Our software available to NWP/science community
  - **Combine with other observations**
    - Height assignment for AMVs
    - Complement other cloud/aerosol missions
  - **Related research**
    - Background error specification

5.1 Prototype Level-2C Processing

- ✓ Ingestion of L1B.bufr into the assimilation system
  - ♦ L1B obs locations within ODB (internal Observation DataBase)
- ✓ Assimilation of HLOS observations (from L1B)
  - ♦ Corresponding analysis increments (Z100)



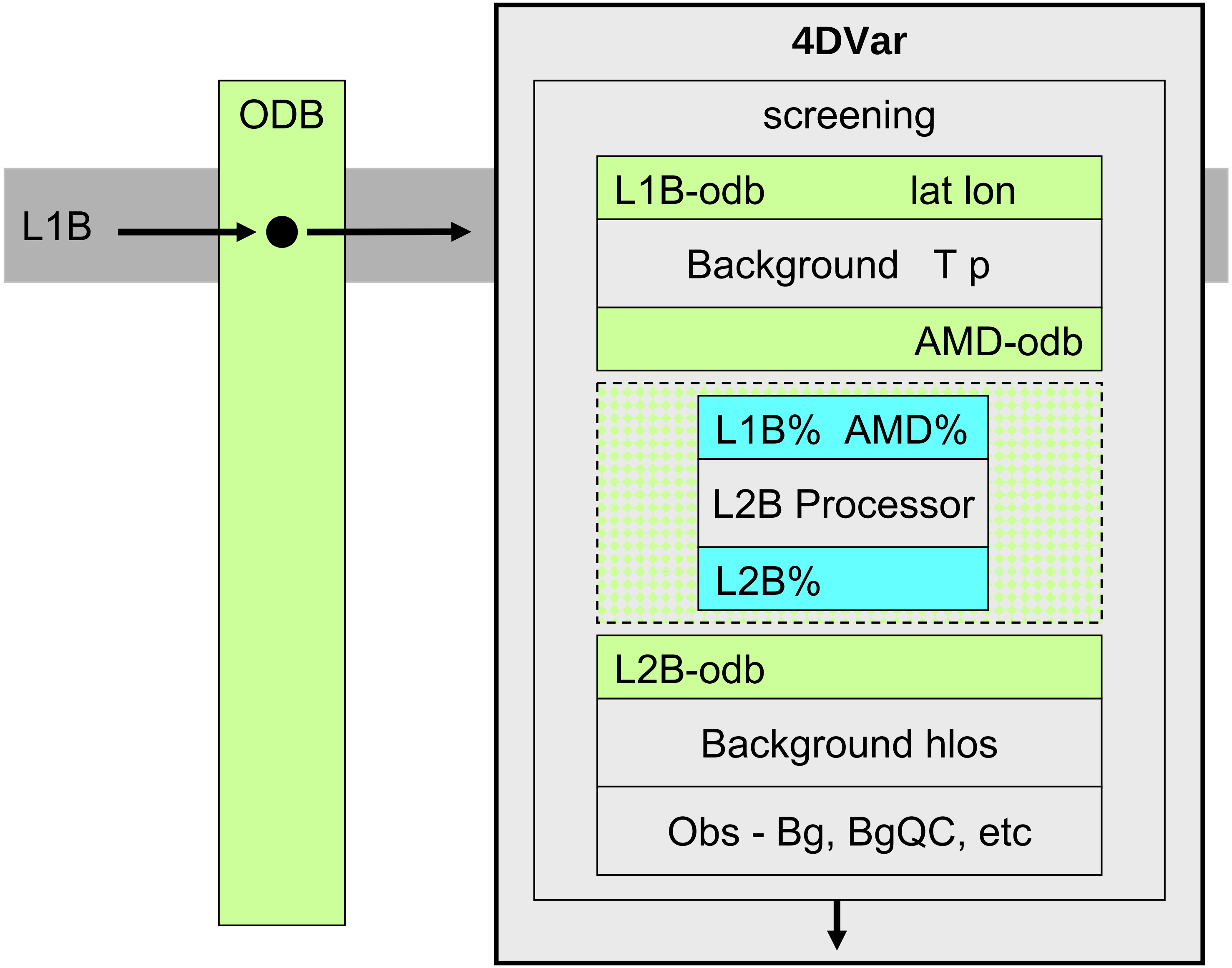


ECMWF

5.2 Key assimilation operators

- HLOS, TL and AD
  - $H = - u \sin \varphi - v \cos \varphi$
  - $dH = - du \sin \varphi - dv \cos \varphi$
  - $dH^* = (- dy \sin \varphi, - dy \cos \varphi)^T$
  - Generalize to layer averages later
- Background error
  - Same as for u and v (assuming isotropy)
- Persistence or representativeness error
  - 10 to 20 m/s for technical development
- Prototype quality control
  - Adapt local practice for u and v

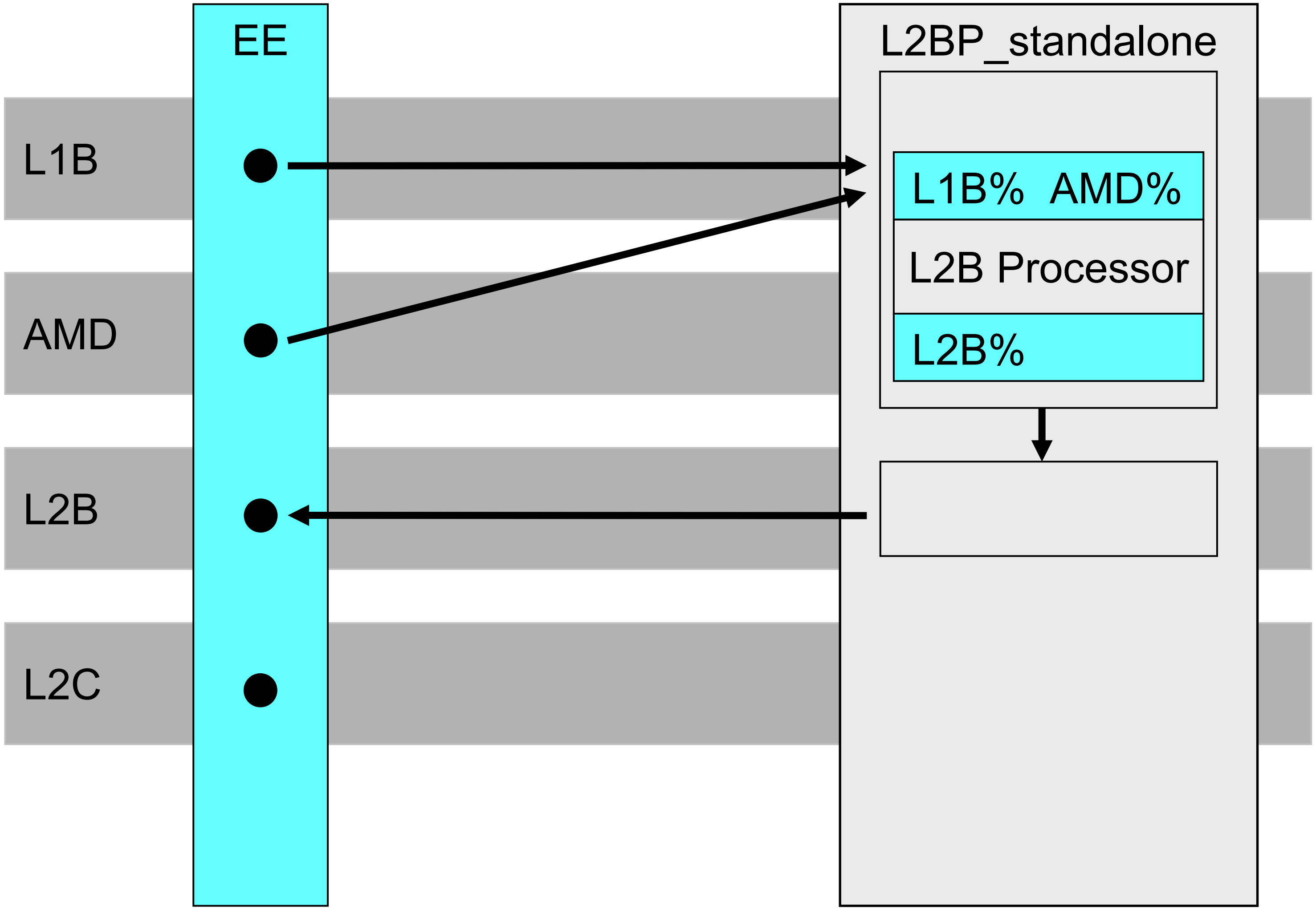
5.3 L2BP integration within an assimilation system



Wrapper module copies "odb" variables to & from % data structures (hidden from screening)

C.f. RTTOV + SSMI TCWV

5.4 Overview data flow – standalone mode



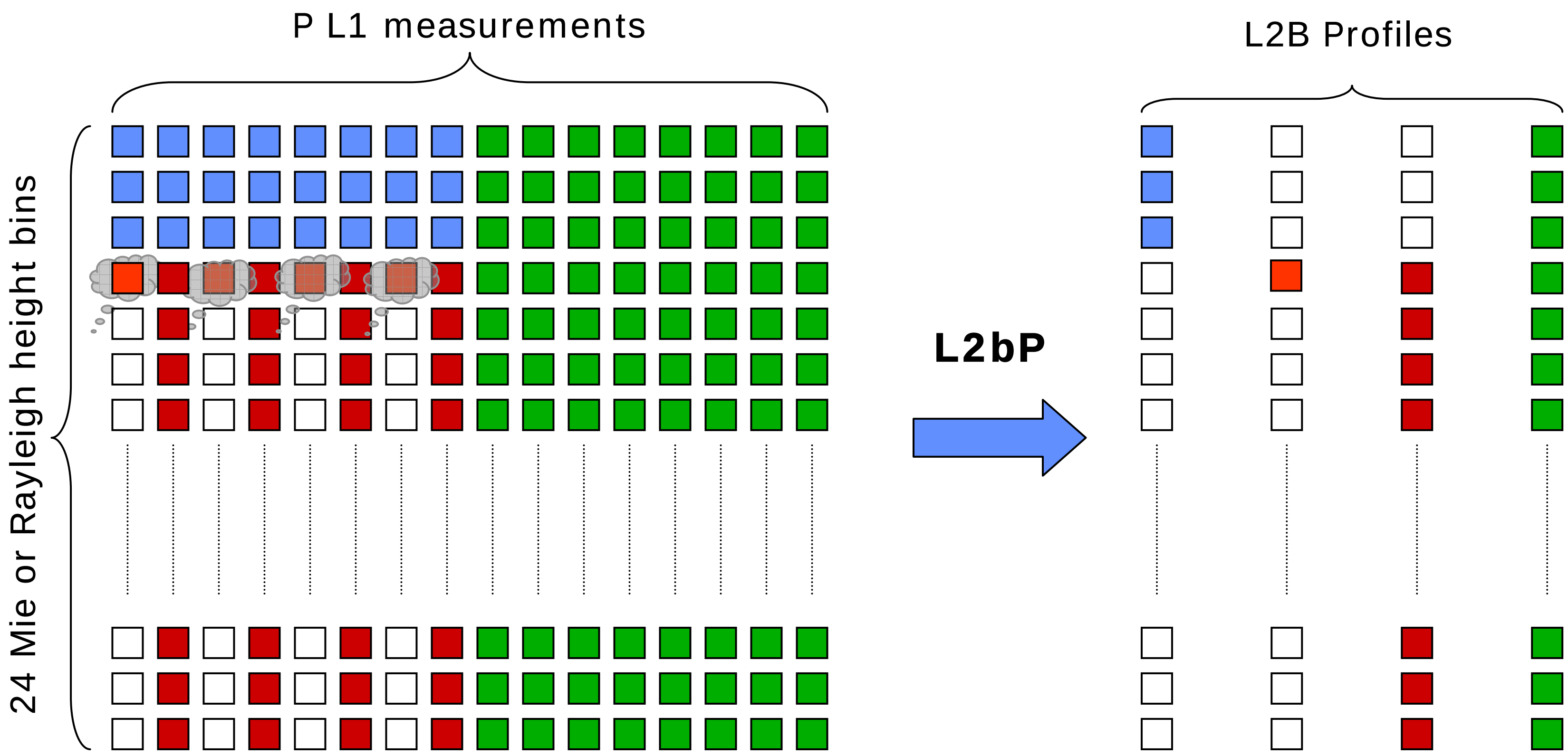
5.5 Principal Guidance to Met Centres

1. How to install and test the standalone version
   - Source code, documentation, unix scripts and test data (EE format) supplied
   - Useful tool for inter-comparison purposes
2. Interface requirements for integrated-assimilation mode
   - Generation of auxiliary meteorological data
   - Wrapper module between "odb" and L2B processor used as a callable subroutine within assimilation.x
   - Both to occur during Screening
   - Facilitates assimilation of Aeolus data
   - Assimilation outputs at discretion of each met centre

1 Baseline L2BP Algorithm

- **Purpose of L2BP**
  - Produce L2B data from L1B data and aux met data
    - **50 km observations from ~ 1 km measurements**
    - **Error estimates and quality indicators**
  - Temperature and pressure corrections via met data
  - Scene classification and selective averaging
- **Design a portable source code for three processing modes**
  - Integration at many met centres
  - Reprocessing @ ESA (ECMWF-supplied met data)
  - Testing in a range of environments
  - Simple to use, yet flexible to permit extensions
- **Auxiliary processing – prepares met data as L2BP input**

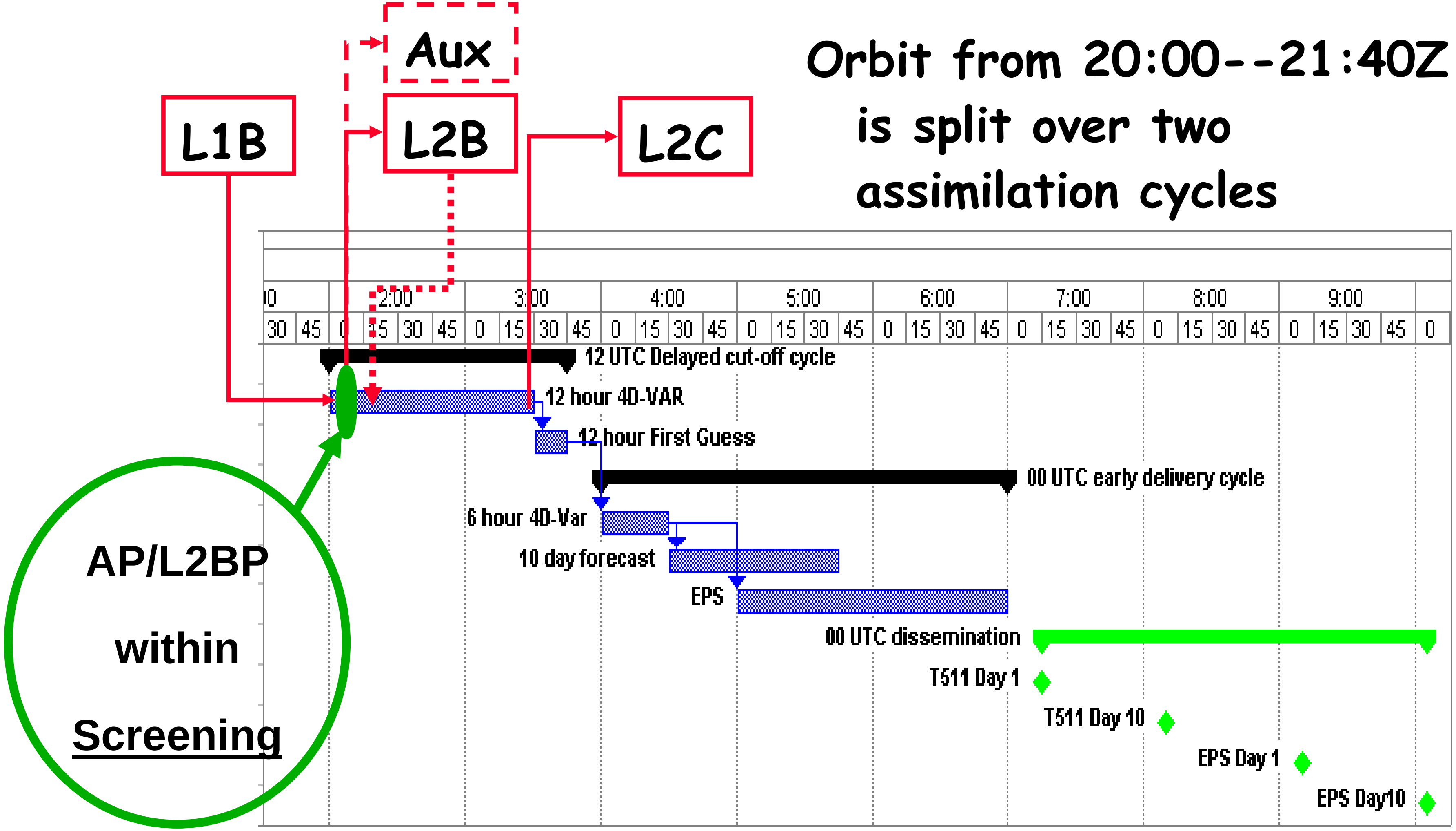
Scene classification influences L2B output



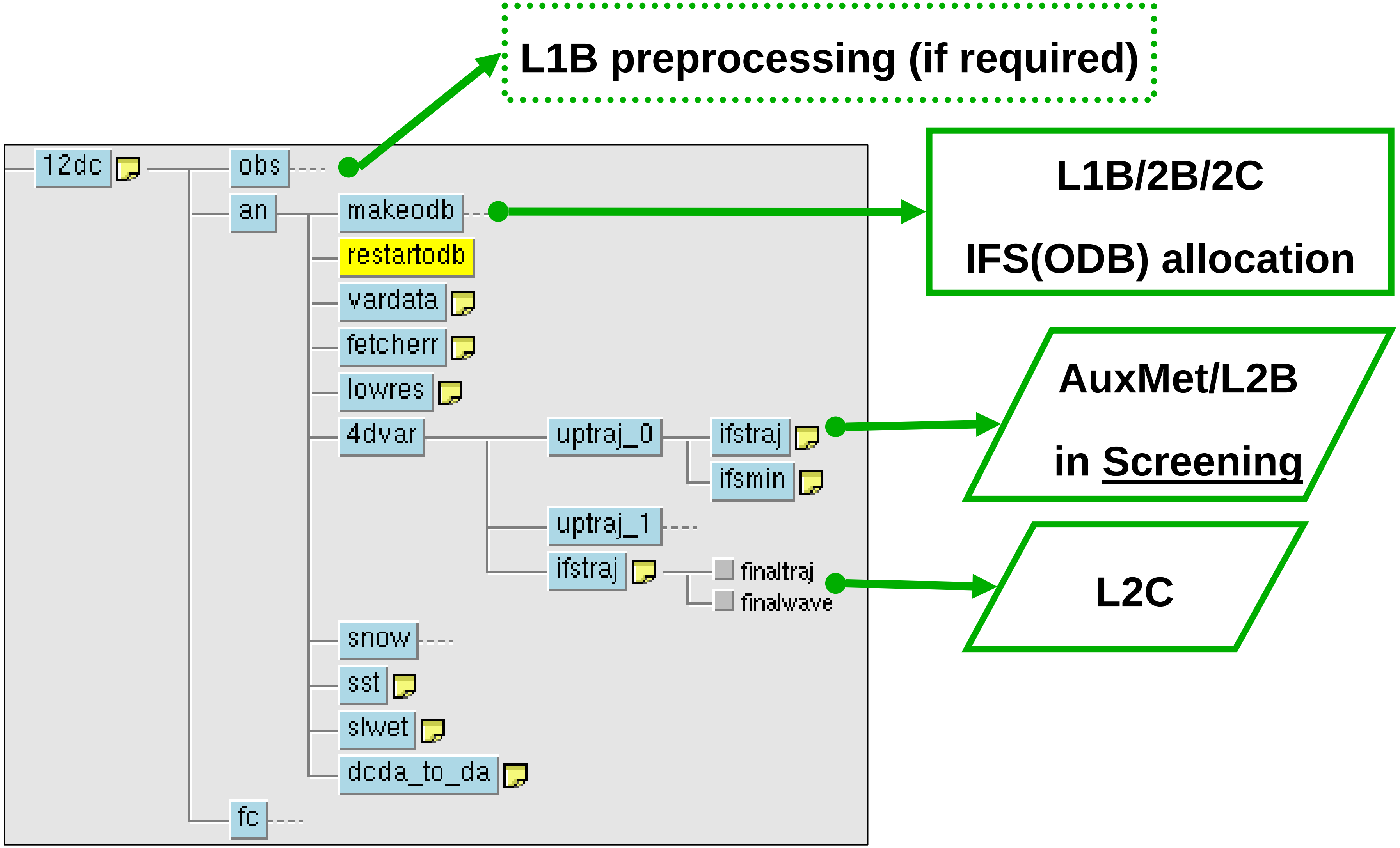
1.3 ECMWF operational schedule

Processing of L1B 09-21Z starts at 02Z (D+1) "dcda-12utc"

Orbit from 20:00--21:40Z is split over two assimilation cycles



1.3 Integration of Aeolus L2BP at ECMWF

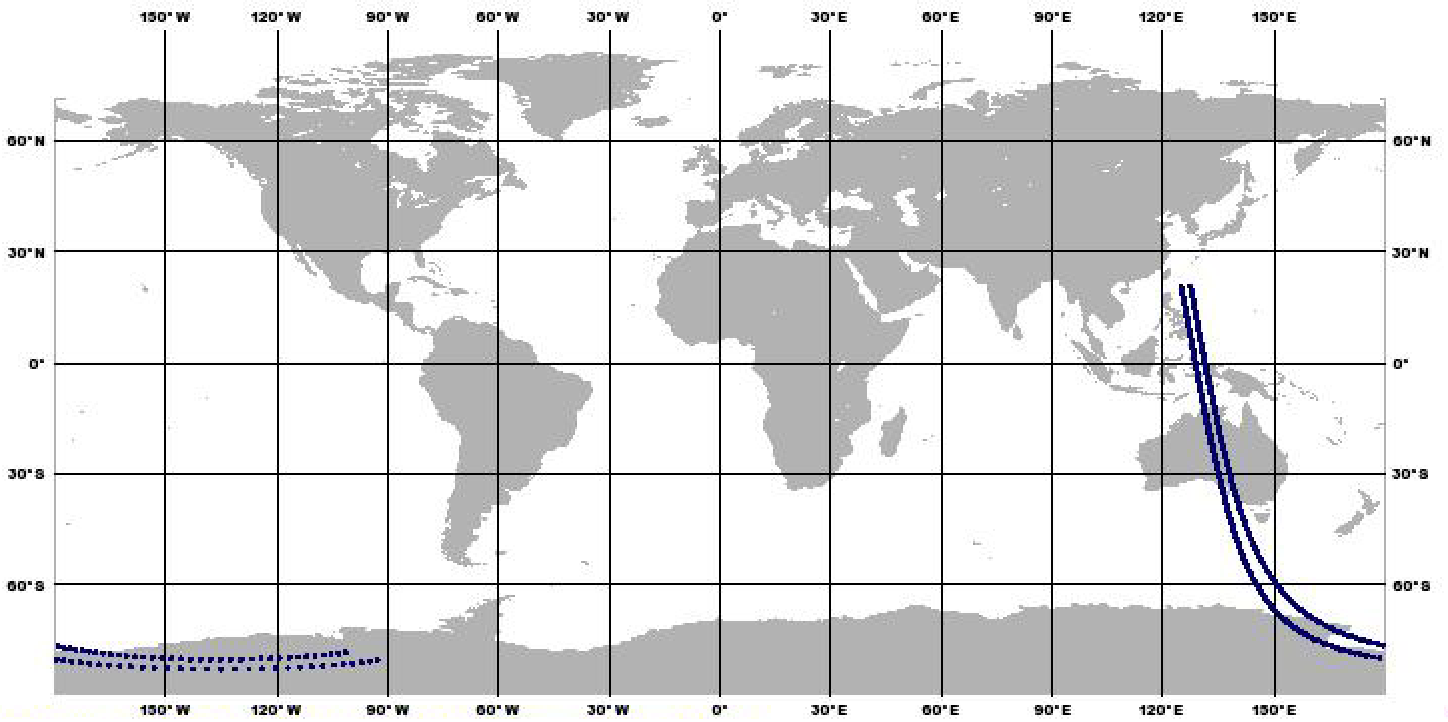


1.4 Baseline architecture – L2BP

- **Auxiliary L2B processing (centre-dependent)**
  - **Profiles of temperature and pressure vs height**
    - ➔ At requested locations, full model vertical resolution
    - ➔ L2BP will perform conversion to WGS84 coords
  - **Extract from "first-guess fields" during "screening"**
    - ➔ Nearest time (within 15 mins at ECMWF)
    - ➔ At ECMWF, vertical profiles and not slanted
    - ➔ Currently one profile per observation
  - **Pre-processing step**
    - ➔ Standardize input for primary L2B processing
    - ➔ Align met data with L1B measurements in horizontal
    - ➔ Could be achieved via extrapolation or interpolation

1.5 Locations for computing aux met data

- Obtain from geolocation information in real L1B data
- Offset from the sub-satellite track
  - Example shows 30 mins x 50 km spacing along-track

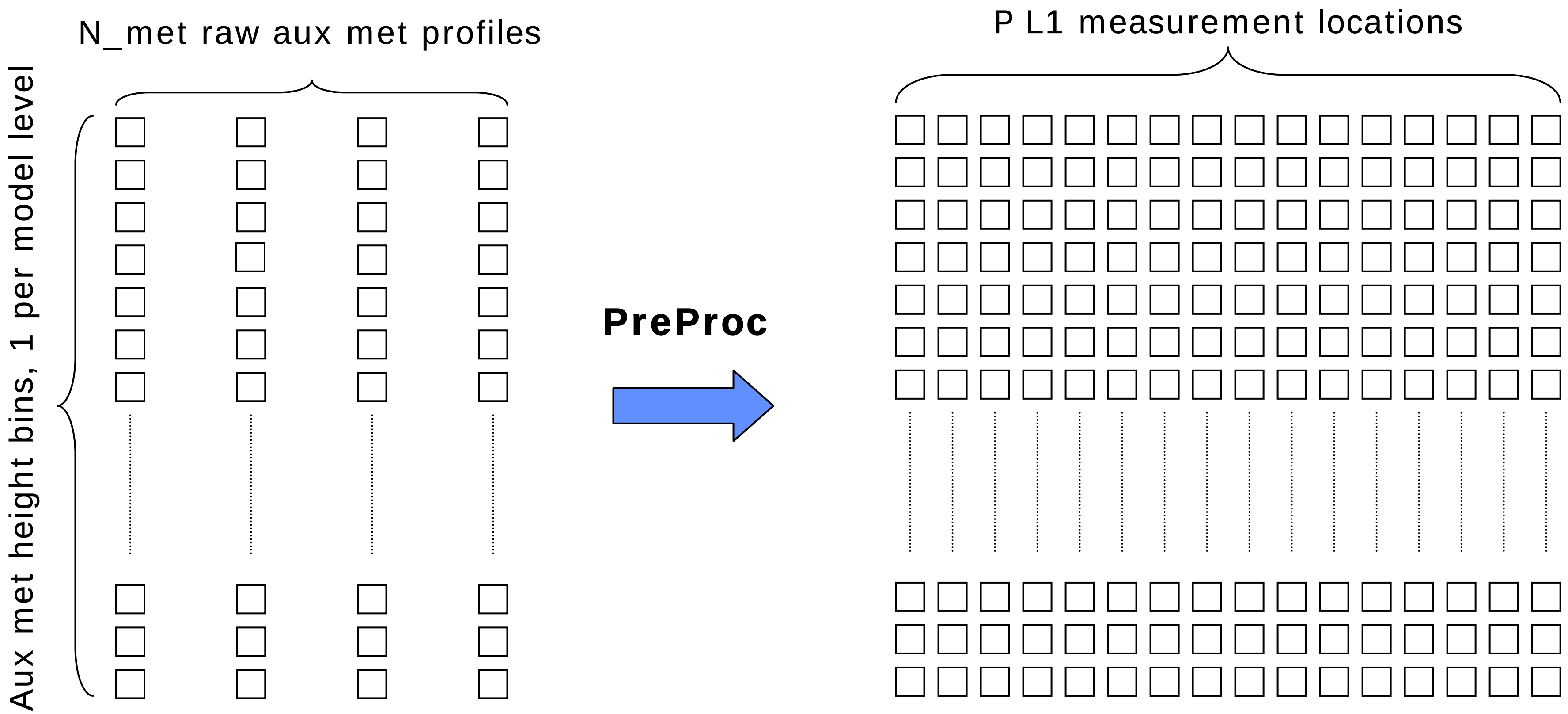


ECMWF

1.4 L2BP - auxiliary pre-processing

✓ Collocation implemented, suitable for 1 met locn per BRC

❑ Sensitivity study to guide extensions, eg interpolation code



1.5 L2BP - primary processing

- Primary processing (HLOS retrieval)
  - ❑ L1B product validation (mainly in Consolidation Phase)
  - ✓ Signal classification (+ further code from L2A study)
  - ✓ Assign weights to signals (+ further development)
  - ❑ Apply weights to a general parameter
    - ✓ lat & lon = L2B centre-of-gravity
    - ❑ temperature & pressure = Tref & Pref
  - ❑ HLOS temperature & pressure corrections
  - ❑ Error estimates, quality indices
  - ❑ Output in EE format

2 Future work

- **Key inputs from other activities**
  - **L1B test datasets**
  - **Cloud detection and scene classification**
    - ➔ algorithms/codes based on L2AP
  - **Details of temperature & pressure correction scheme**
    - ➔ ILIAD results & implementation (e.g. lookup table)
  - **Algorithms for**
    - ➔ HLOS error estimates & Quality indicators
- **Check suitability of interfaces for many met centres**
  - **Basic concept ~ screening of radiosonde observations**

Facts and figures for ADM-Aeolus

- **ESA point of contact – Dr Paul Ingmann**
  - Mission Experts Division, ESA/ESTEC, The Netherlands

Orbit	Sun-synchronous	Dawn-dusk
- inclination & altitude	97 °	408 km
Mass - total & "ALADIN" lidar component	1100 kg	450 kg
Transmitter - laser type & pulse energy	Nd:YAG, frequency tripled to 355 nm	150 mJ
- pulse repetition freq. & duty cycle	100 Hz	10 s every 28 s
Receiver - telescope diameter		1.5 m
- spectrometers	Fizeau (Mie)	Dual edge etalon (Rayleigh)
Average power demand	1400 W	
Launch date & mission lifetime	2008	3 years

1 Baseline L2BP Algorithm

- Baseline architecture
  - HLOS retrieval - TN2.2, Fig 2
  - Generation of aux met data – TN2.2, Fig 1
- L1B BRCs processed independently (& possibly in parallel)
  - No communication of intermediate L2BP results
- L1B data arriving within met centre operational schedule
  - Met centre produces aux met data, L2B (and L2C)
- L1B data missing the ECMWF schedule
  - ECMWF produces aux met data
    - ➔ at locations inferred from predicted flight tracks
  - L2B possible via re-processing

1.1 L2BP – Portability considerations

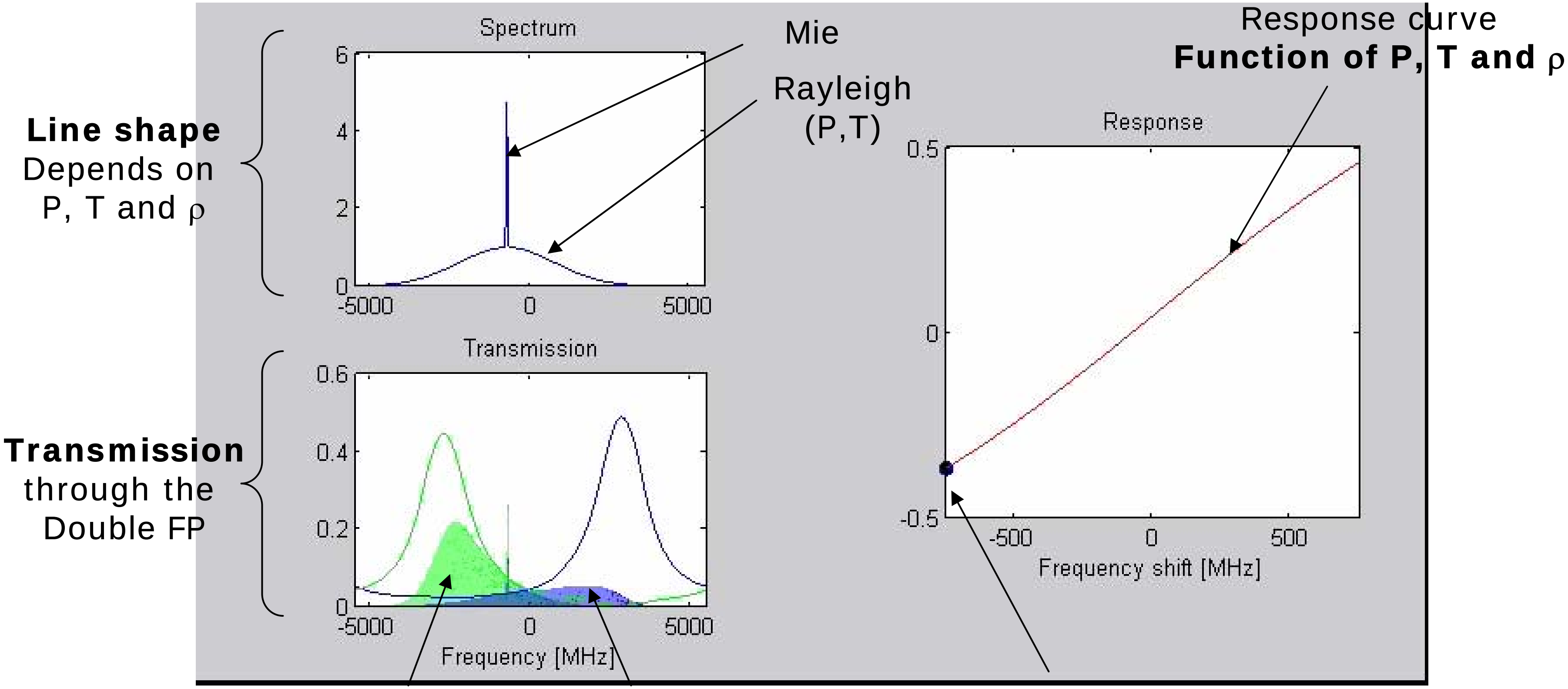
- Common design accommodating three processing modes

	Met Centres	Operational (ECMWF)	Re-proc (ESRIN)
L1B data (input) in EE format (or predicted orbit locations)	Received in Q/NRT (30m-3h)	Received in NRT (~5h)	LTA/reprocessing
Auxiliary meteorological input (T & p profiles, EE/BUFR)	Self-generated	Self-generated & sent to LTA	Oper available (via LTA)
Primary L2BP code	Oper available	Oper	Oper available
Auxiliary parameter input files	Oper available	Oper	Oper available
L2B data output in EE format	Yes	Yes	Yes
L1B/L2B data in BUFR format (for assimilation purposes)	EE2BUFR	EE2BUFR	Not required

The ILIAD Study

- Why the ILIAD study ?
  - The L1 processing scheme proposed by the industry for Rayleigh winds does not take into account the impact of the pressure and the potential presence of Mie scattering.
  - Preliminary studies conducted by DLR (O. Reitebuch) and ESA (M. Endemann) suggested the impact of both exceed requirements on data quality.
- Objectives
  - Find a correction scheme.
- Study Team.
  - IPSL/LMD (P. Flamant, C. Loth), IPSL/SA (A. Garnier), ONERA/DOTA (A. Dolfi-Bouteyre), HOVEMERE (D. Rees), MF/CNRM (A. Dabas, M. L. Denneulin)

ILIAD - Impact of P, T and backscatter ratio on Rayleigh Responses

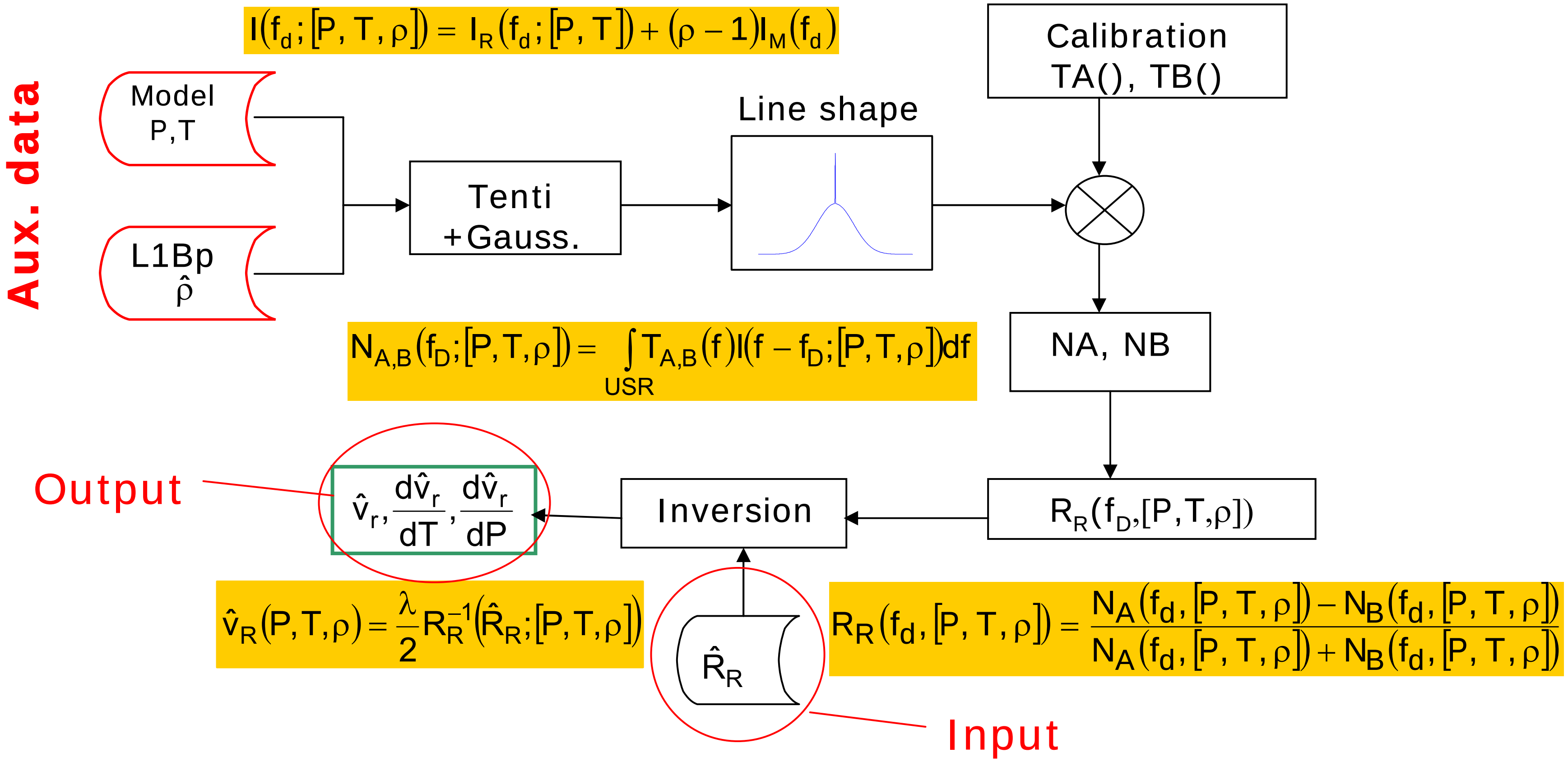


Light transmitted through T_A and T_B

Response (function of f_D)

ECMWF

ILIAD - Baseline Inversion Scheme



ECMWF

ILIAD - Simplified correction scheme

Based on a simplification of baseline inversion.

Two-step appraoch:

1. Inverse response R_R as if there were no Mie.

   - **Method**: Look-up in the 3D matrix $\mathcal{F}_d$(i,j,k) giving the inverse frequency (or velocity) for pressures $P_i=P_0+i\Delta P$, $Tj=T_0+j\Delta T$ and $R_k=R_0+k\Delta R$

   - **Output parameters**:

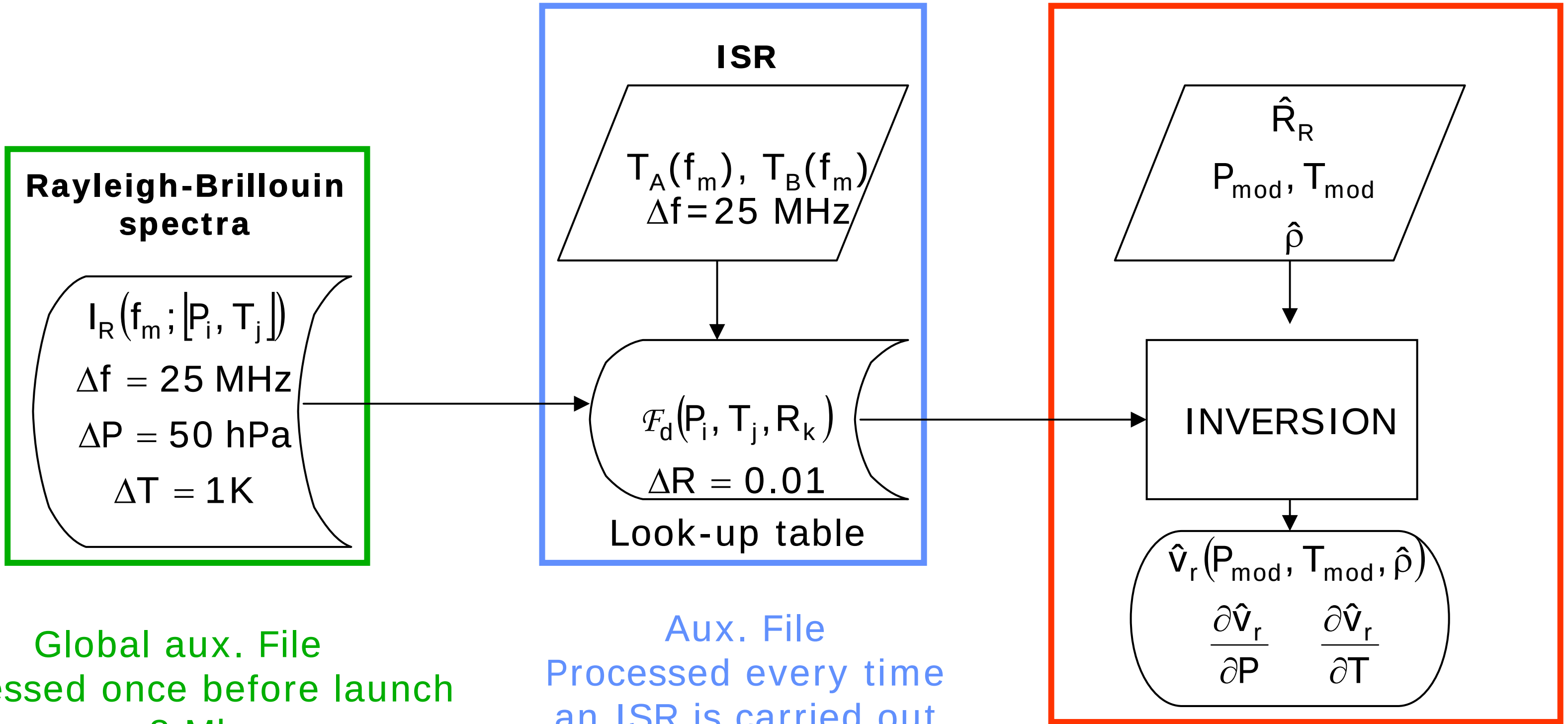
     → $V_r(P_{mod},T_{mod},\rho=1)$ where P_{mod} and T_{mod} are the pressure and temperature inside the sensing volume as predicted by the NWP model.

     → dv_r/dP, dv_r/dT and dv_r/dR, that is, the first order derivative of v_r with respect to P, T and the response R_R.

2. Correct from Mie contamination.

   - **Method**: First order, linear correction based on the estimation of $dv_r/d\rho$

ILIAD - Practical implementation

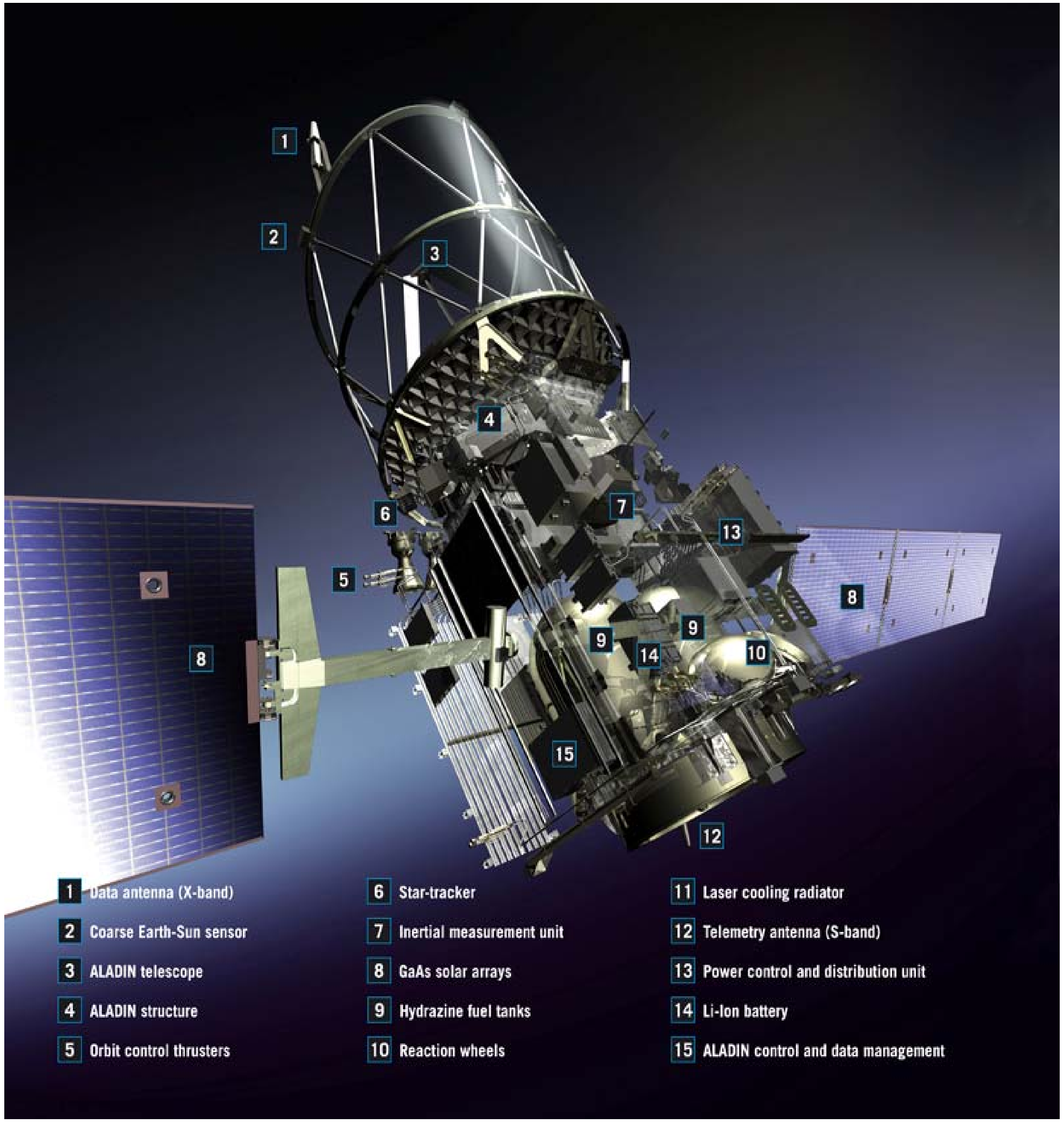


Global aux. File
Processed once before launch
~8 Mb

Aux. File
Processed every time an ISR is carried out
~2 Mb

Part of L2Bp
Applied to all Rayleigh responses

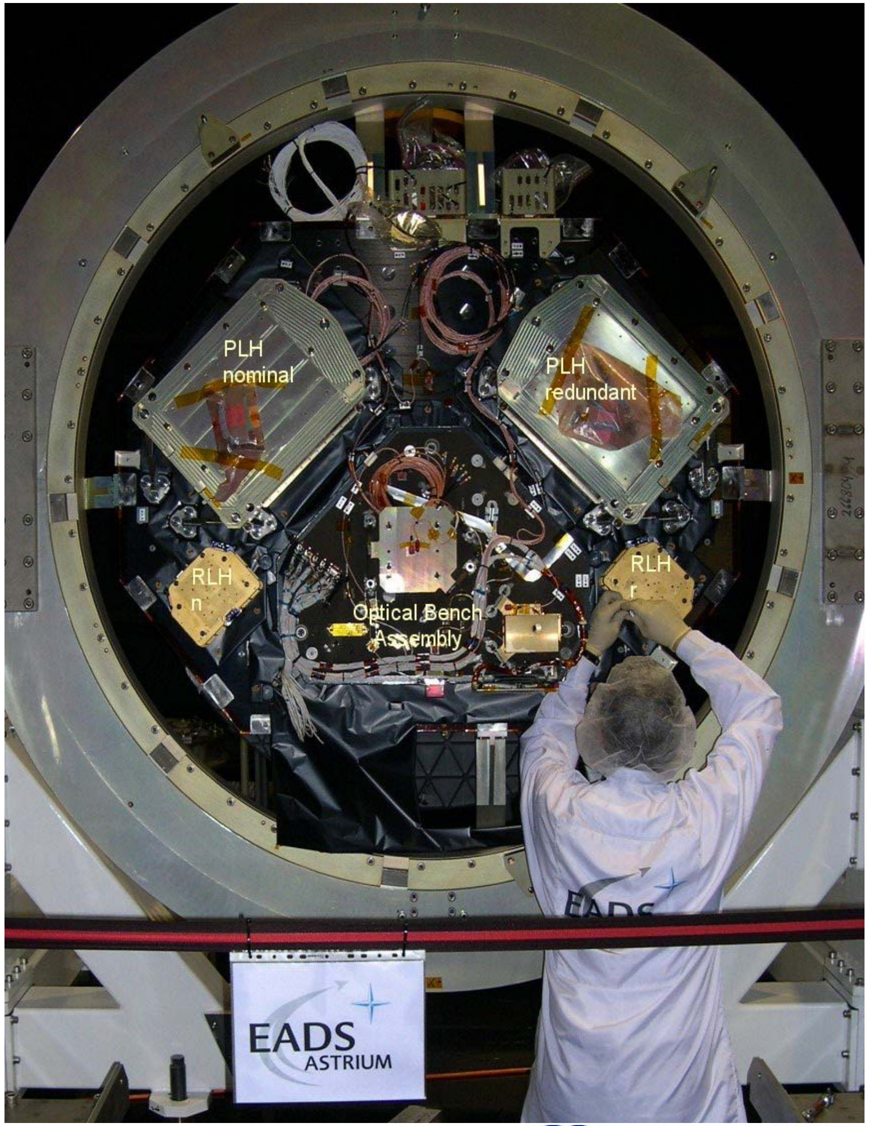
Aeolus satellite layout



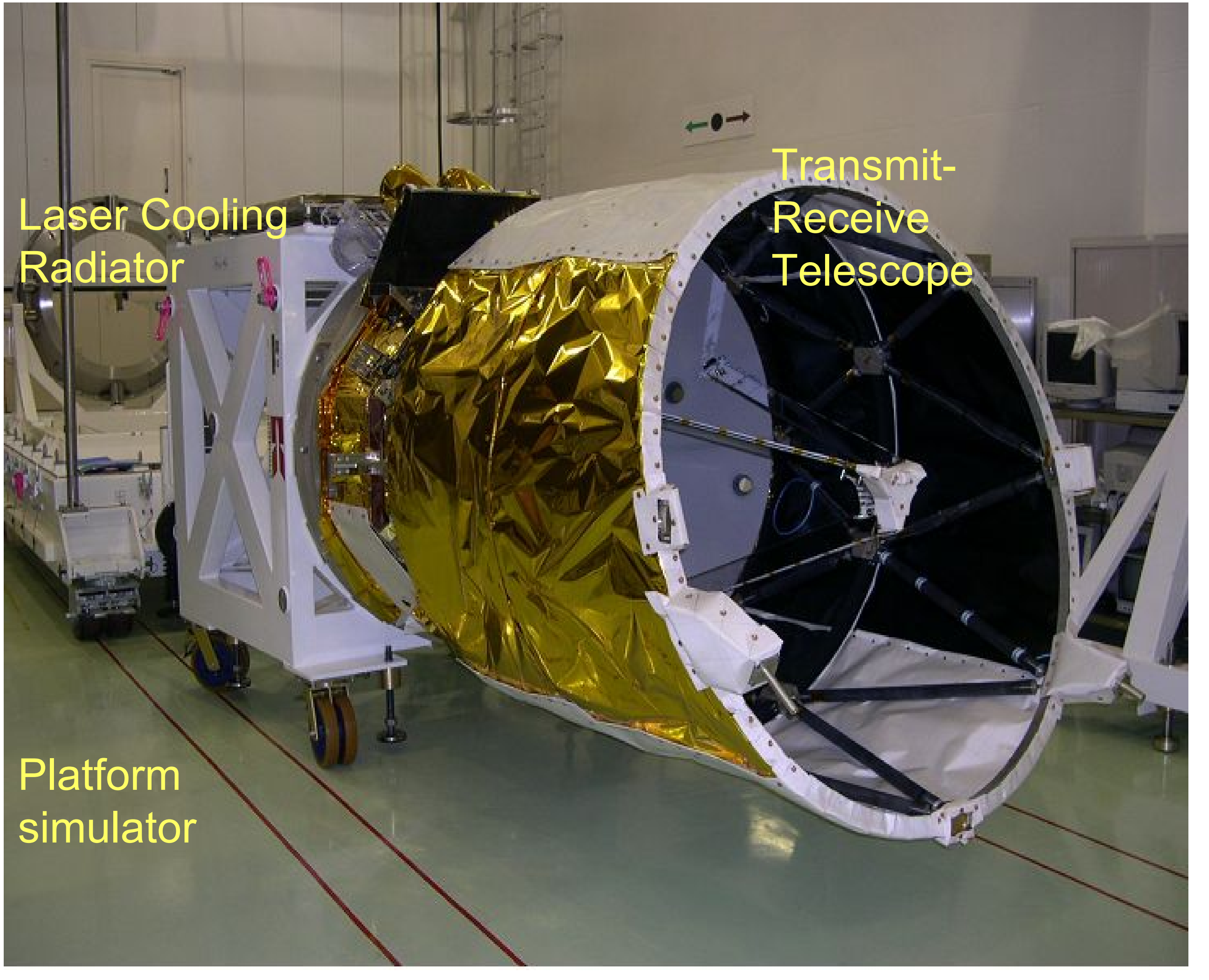
ALADIN Structure and Optical Structural Thermal Model

ALADIN structure has been completed for OSTM and tested.

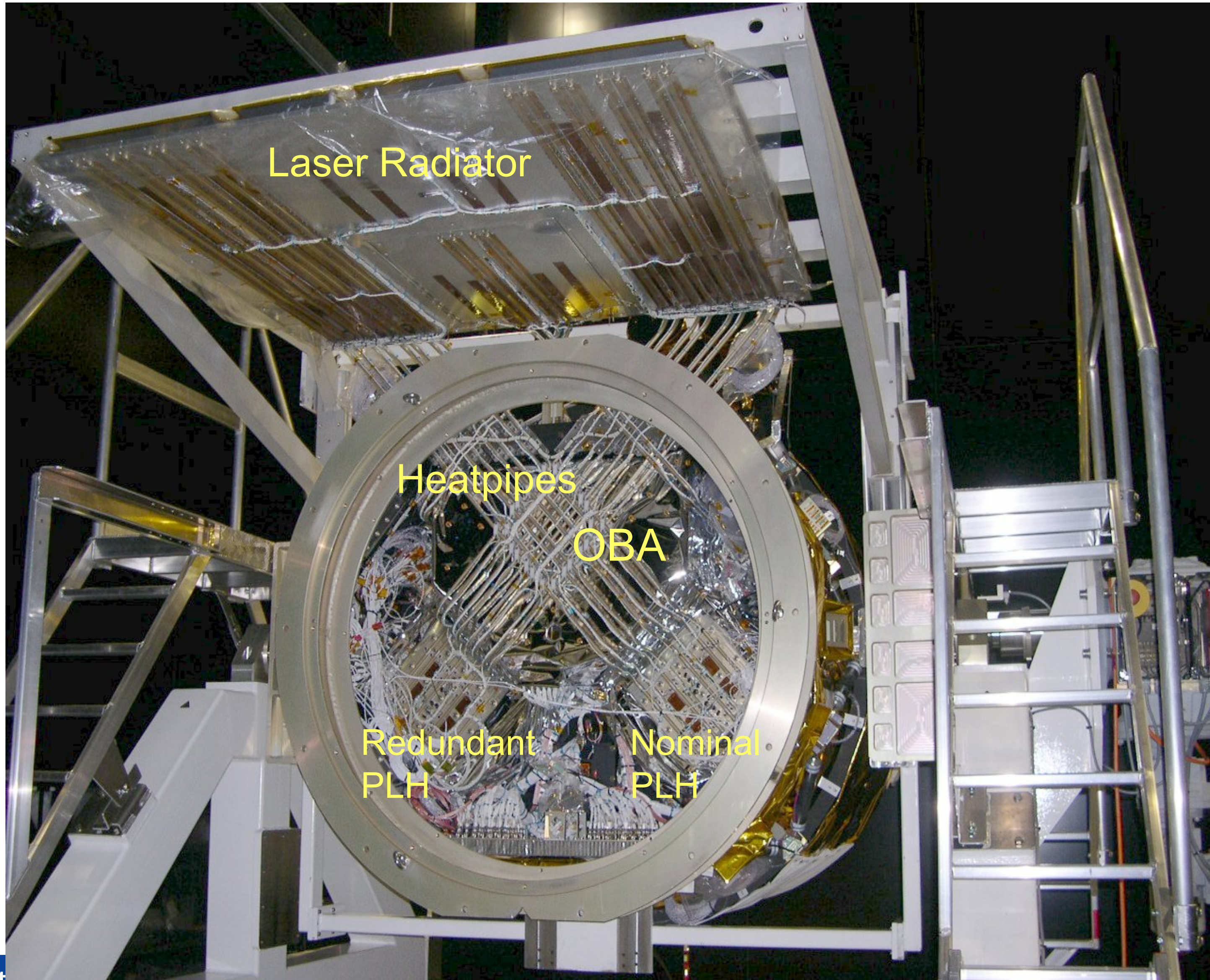
Mass-dummies have been integrated for OSTM:
  Power Laser Heads (PLH),
  Reference Laser Heads (RLH),
and
  Optical Bench Assembly (OBA)



ALADIN OSTM


Laser Cooling
Radiator
Transmit-
Receive
Telescope
Platform
simulator

ALADIN Laser Cooling System



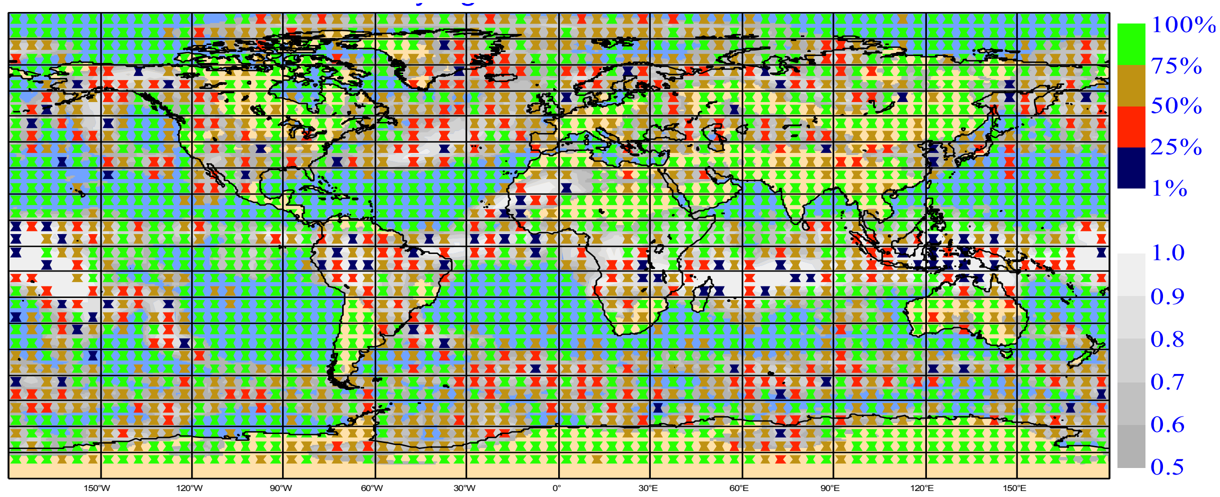
ALADIN
OSTM

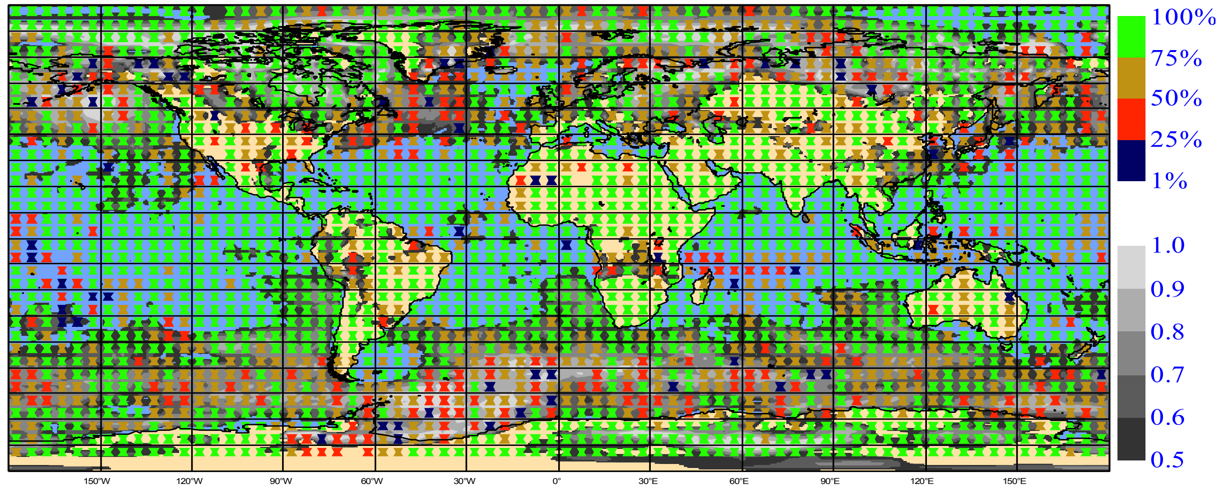
Before shipment to CSL (Liege) for installation in vacuum chamber and full thermal vacuum testing

Data simulations for ADM-Aeolus

Yield (%age of data meeting mission requirements) at 5 & 1 km

- 5 km: 75% of Rayleigh have accuracy < 2 m/s (also 15% Mie not shown)
- 1 km: 66% of Mie have accuracy < 1 m/s (aerosol & cloud returns)
- Adequate transmission through overlying cloud



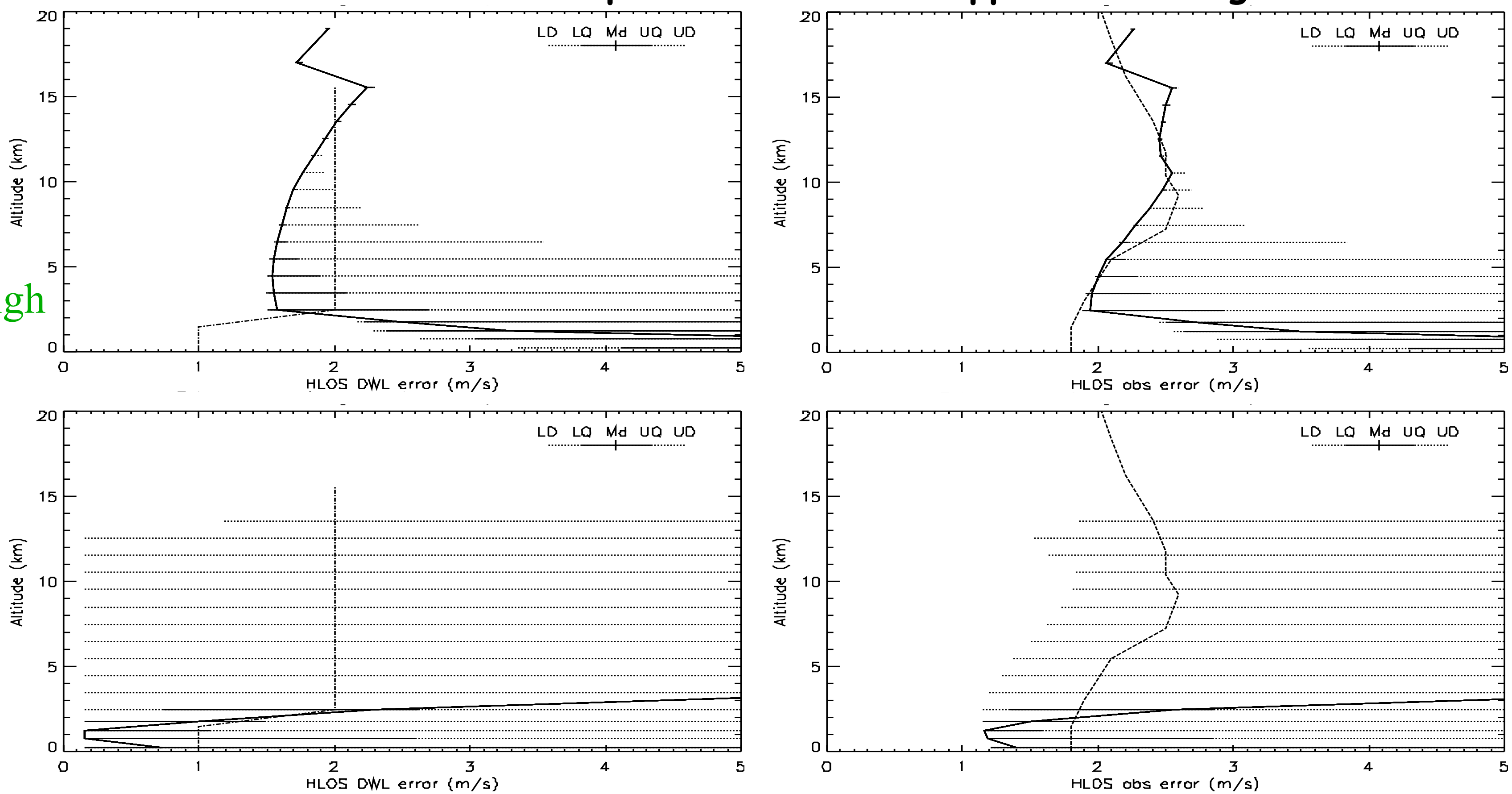


ADM-Aeolus data simulations - comparison with radiosondes/mission spec

- Aeolus median like obs error assigned operationally to radiosondes
- Aeolus HLOS observations expected to receive appreciable weight

Rayleigh

Mie



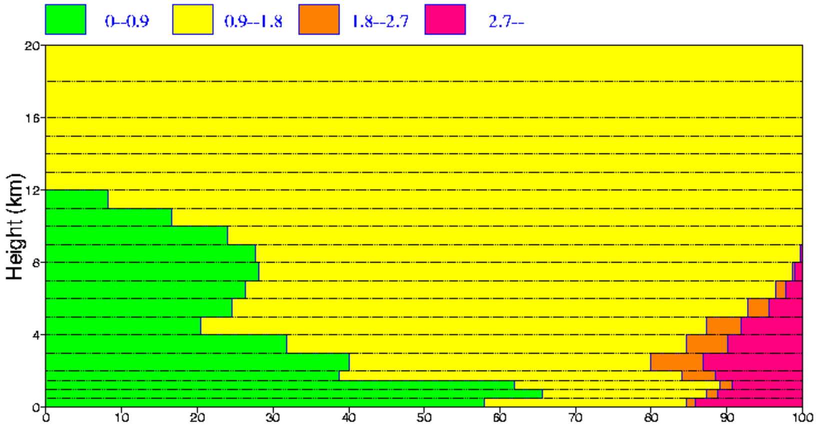
Without representativity
(cf mission spec – dash-dot)

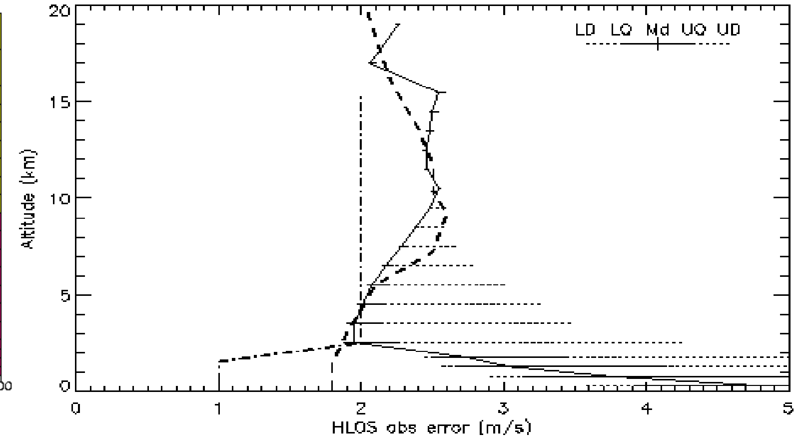
With cross-track representativity
(cf radiosonde – dashed)

ADM-Aeolus data simulations – Effects of model cloud cover (2)

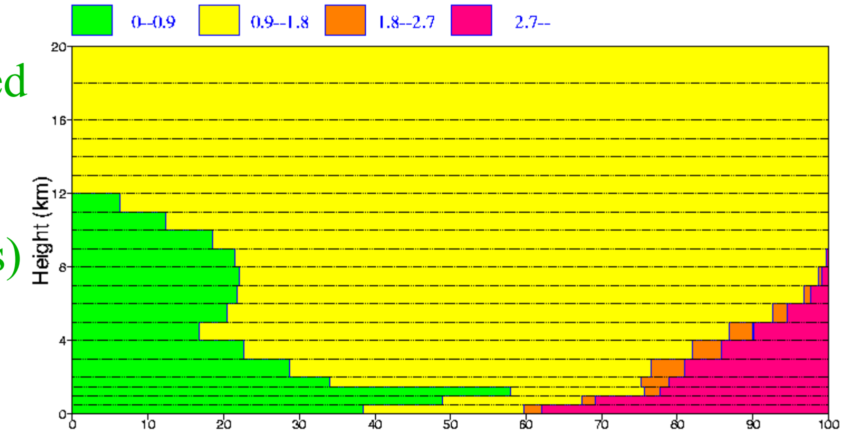
- **Mid-latitude example**
- **QC implications, Task 2**
- **Tails of Rayleigh error distributions underestimated, median barely changed**

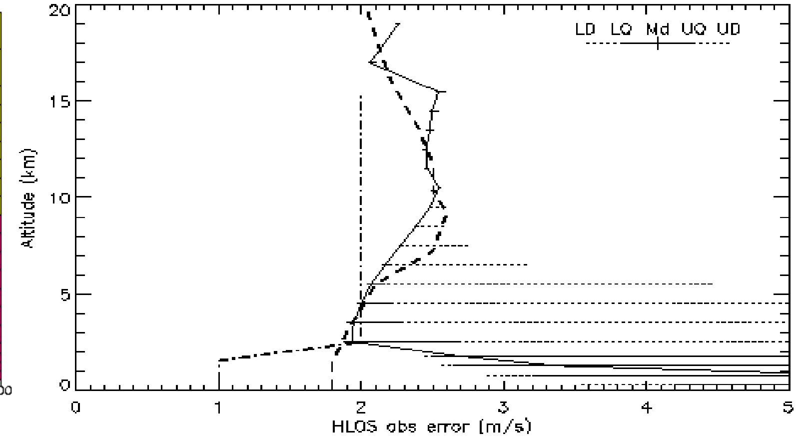
Model





Observed cloud cover (midlats)





ECMWF

Assimilation of prototype ADM-Aeolus data

Quality Control for Aeolus data

- **Most QC parameters taken from conventional wind obs**
  - Background errors & quality control thresholds (BgQC+VarQC)
- **Aeolus-specific Background Quality Control (recommended option)**
  - Capping of observation error in bg departure classification

Set B = (obs-bg) / ES(obs-bg), accept obs iff abs(B) < 4.

In standard BgQC for Aeolus, $ES = (\sigma_o^2 + \sigma_b^2)^{1/2}$.

Aeolus option: $ES = (s_o^2 + \sigma_b^2)^{1/2}$, where $s_o = \min(\sigma_o, 2.5\ \mathrm{ms}^{-1})$

- **Testing with LITE period, LIPAS-simulated Level-2B data**
  - Gaussian + non-Gaussian errors (instrument bias, input wind bias)
  - Operational model (Cy26r1) at full/reduced resolution, ERA40/NoSSMI

Quality Control Examples: Std + Aeolus-optional QC for DWL -- *active*

Radiosonde U-wind

Option improves departure statistics