# Aeolus preparations and indications of NWP impact

**by Michael Rennie, Andras Horanyi and Lars Isaksen**

***Twelfth International Winds Workshop***


aeolus
because wind matters

esa

**Acknowledgements:**

**KNMI: Jos de Kloe, Ad Stoffelen, Gert-Jan Marseille; ECMWF: David Tan; DLR: Oliver Reitebuch; DoRIT: Dorit Huber; ESA/ESTEC: Anne Grete Straume, Frank de Bruin; Météo-France: Alain Dabas, Christophe Payan. Plus many other people who have contributed to the L2B/C processing over the years. The activities are supported by ESA contracts: 18555/04/NL/MM and 104080**

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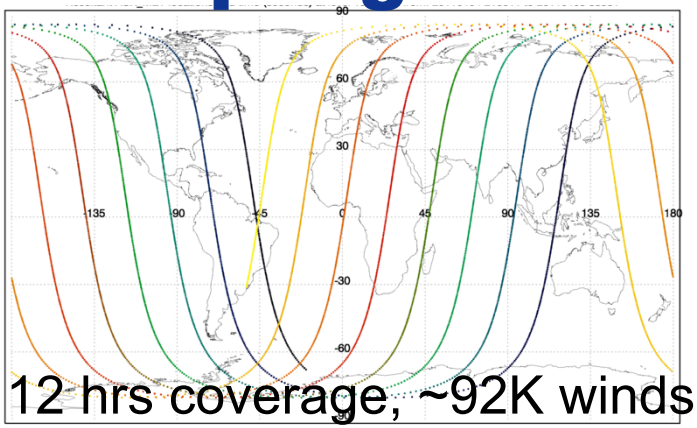
# Outline

1. Aeolus L2B wind product
2. Simulations of Aeolus
3. Impact of HLOS winds at ECMWF

# 1. What is Aeolus measuring?

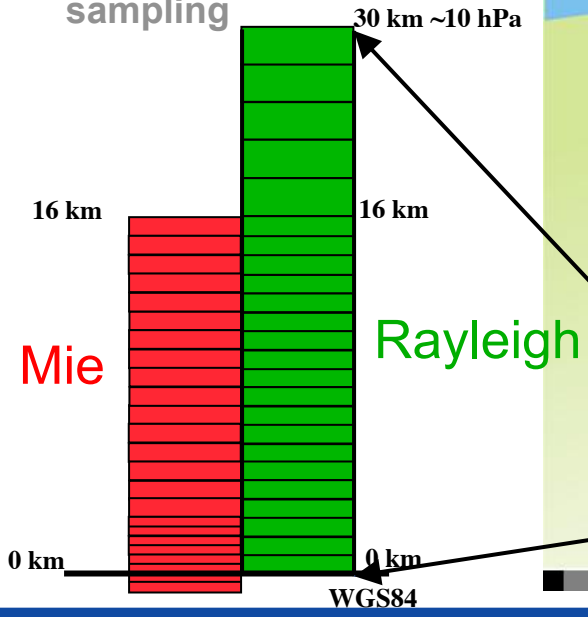
- Counting electrons (photons); output from spectrometers
- Counts calibrated against frequency
  - Frequency shifts (Doppler effect) occur due to relative motion of emitter
  - Atmospheric molecules/particles are the emitter – average motion is the wind
  - At UV:
    - Rayleigh scattering: clear atmosphere
    - Mie scattering: top of dense clouds/aerosols; within/below partially transparent clouds/aerosols
- Still optimistic for good NWP impact
  - Horizontal line-of-sight (HLOS) wind profiles – still lacking in GOS
- Getting ready for a launch in late 2015

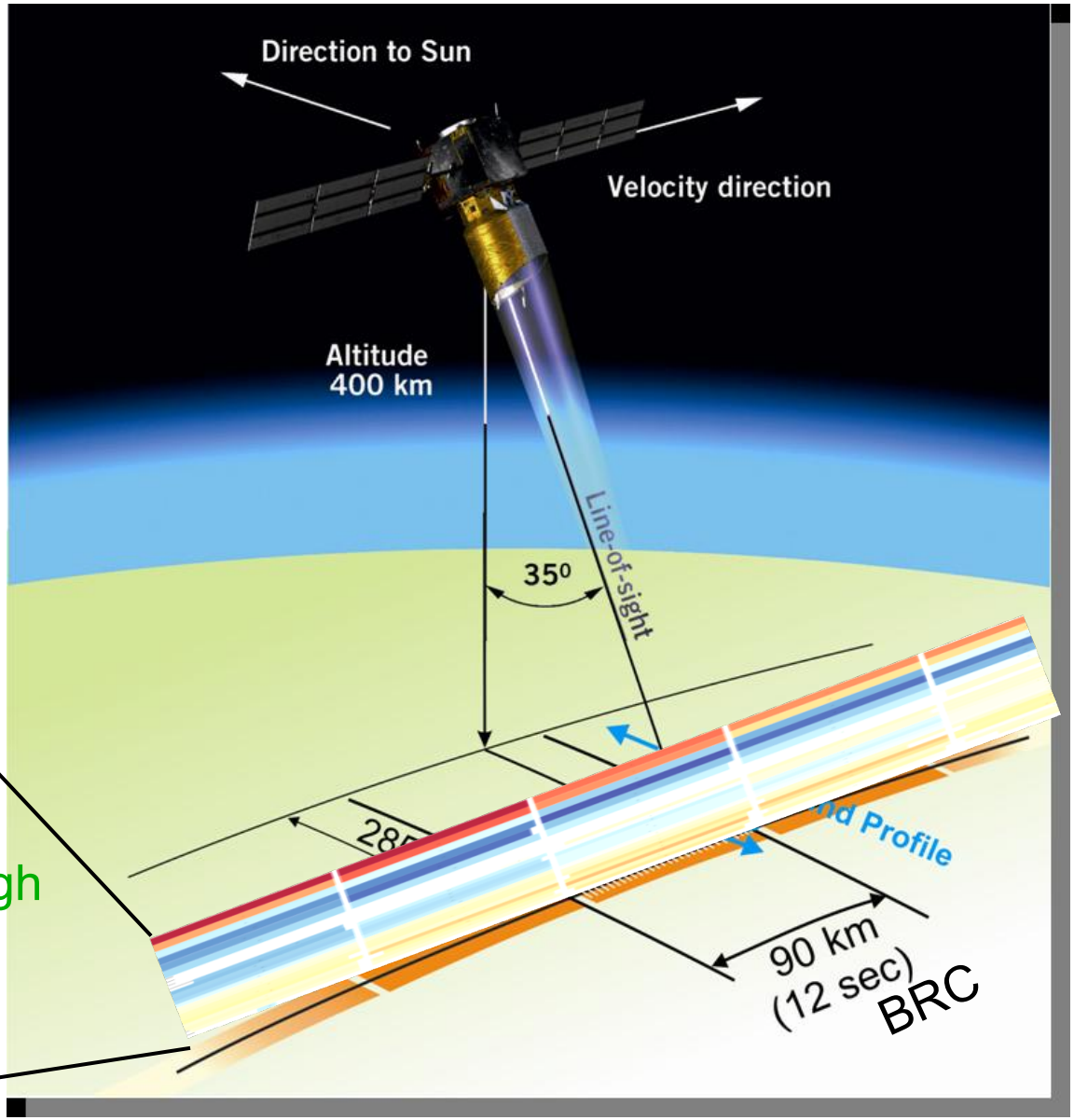
# Sampling




12 hrs coverage, ~92K winds

Example of Aeolus vertical sampling



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# Winds for NWP: Level-2B product

- Level-2B processor provides
  - HLOS winds
    - Geolocated – geometric height, lat, lon, azimuth angle, time
    - Error estimates for each wind, quality flags
  - Flexible classification into wind types – *cloudy or clear (currently)*
  - Flexible horizontal averaging of spectrometer counts
    - Some control of noise and representativity of observations
  - Rayleigh winds corrected for temperature, pressure and Mie cross-talk
  - In future: estimates of optical properties (KNMI)
  - Many processing options controllable from settings file
- Research mission; encourage users to play with L2B processor

- **L2B processor software package:**
  - **Available to download (e.g. for use by NWP centres):**
    - **http://www.ecmwf.int/en/research/projects/aeolus**

**ADM-Aeolus Level-2B Processor Package**

| **Version 2.00** (2012-12-17) | |
|---|---|
| Downloads | size |
| Release note | 832 KB |
| Source code | 2.3 MB |
| Data pack | 137 MB |
| Install test | 21 MB |
| Documentation | 5.0 MB |
| SAF documents | 1.3 MB |
| Extra data sets | 11 MB |

  - **Code, documentation, test data**
  - **Highly portable (mostly Fortran)**
  - **New version (2.10) available soon with:**
    - **L2B EE-to-BUFR converter**
    - **Much improved speed; bug fixes**

# Aeolus at ECMWF

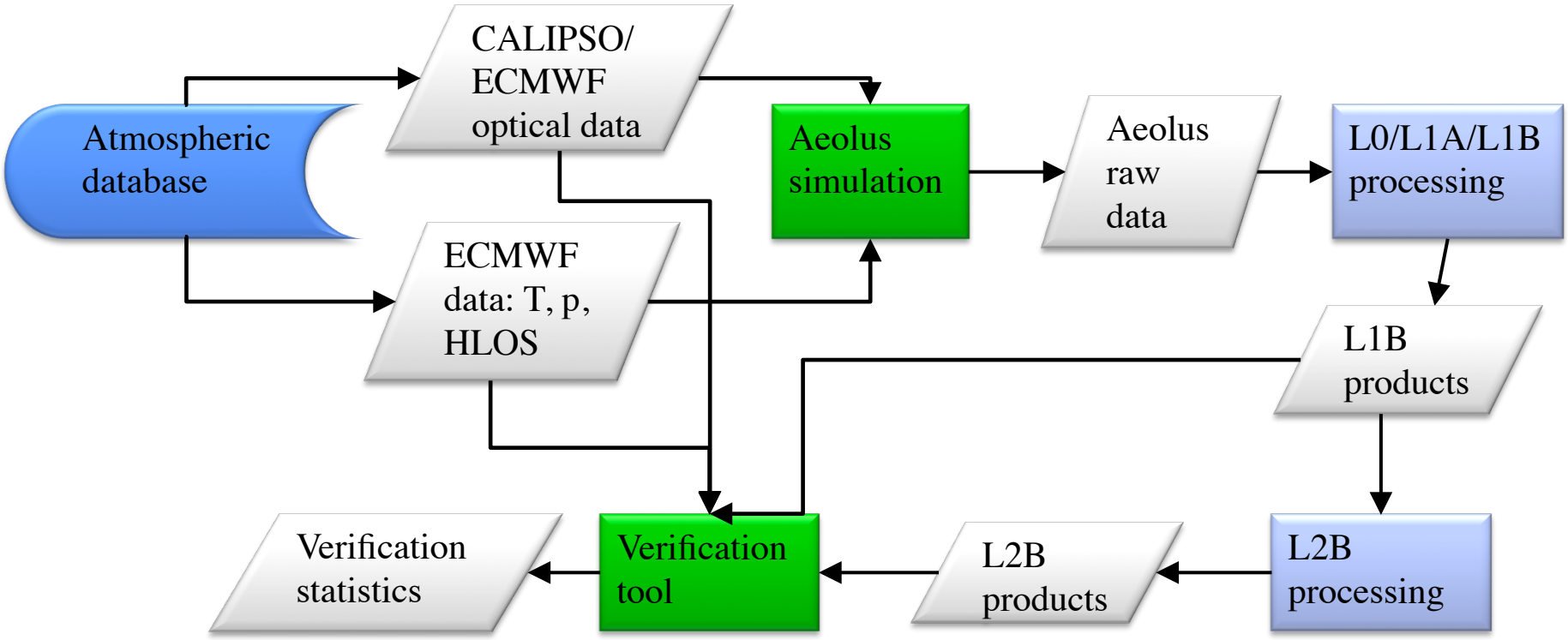
http://www.ecmwf.int/en/research/projects/aeolus

- Develop L2B processor (with KNMI)
- Operational L2B processing:
  - During mission lifetime;
    - products sent to ESA
  - Linked to data assimilation cycles for *a priori* T, p
- Advanced monitoring of Aeolus data
- Involved in CAL/VAL during Commissioning Phase
- Assimilate if proven positive impact

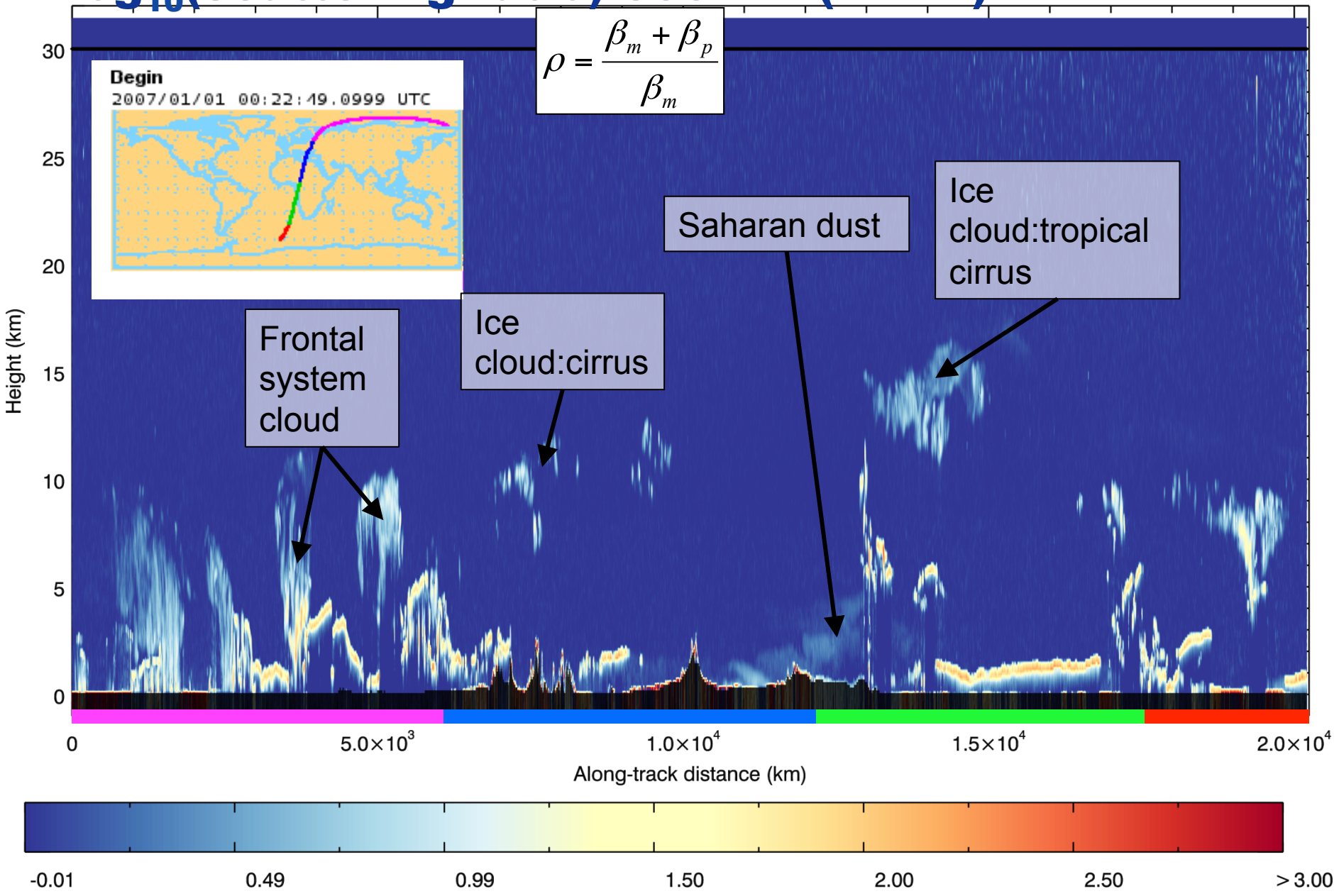
# 2. Simulating Aeolus winds

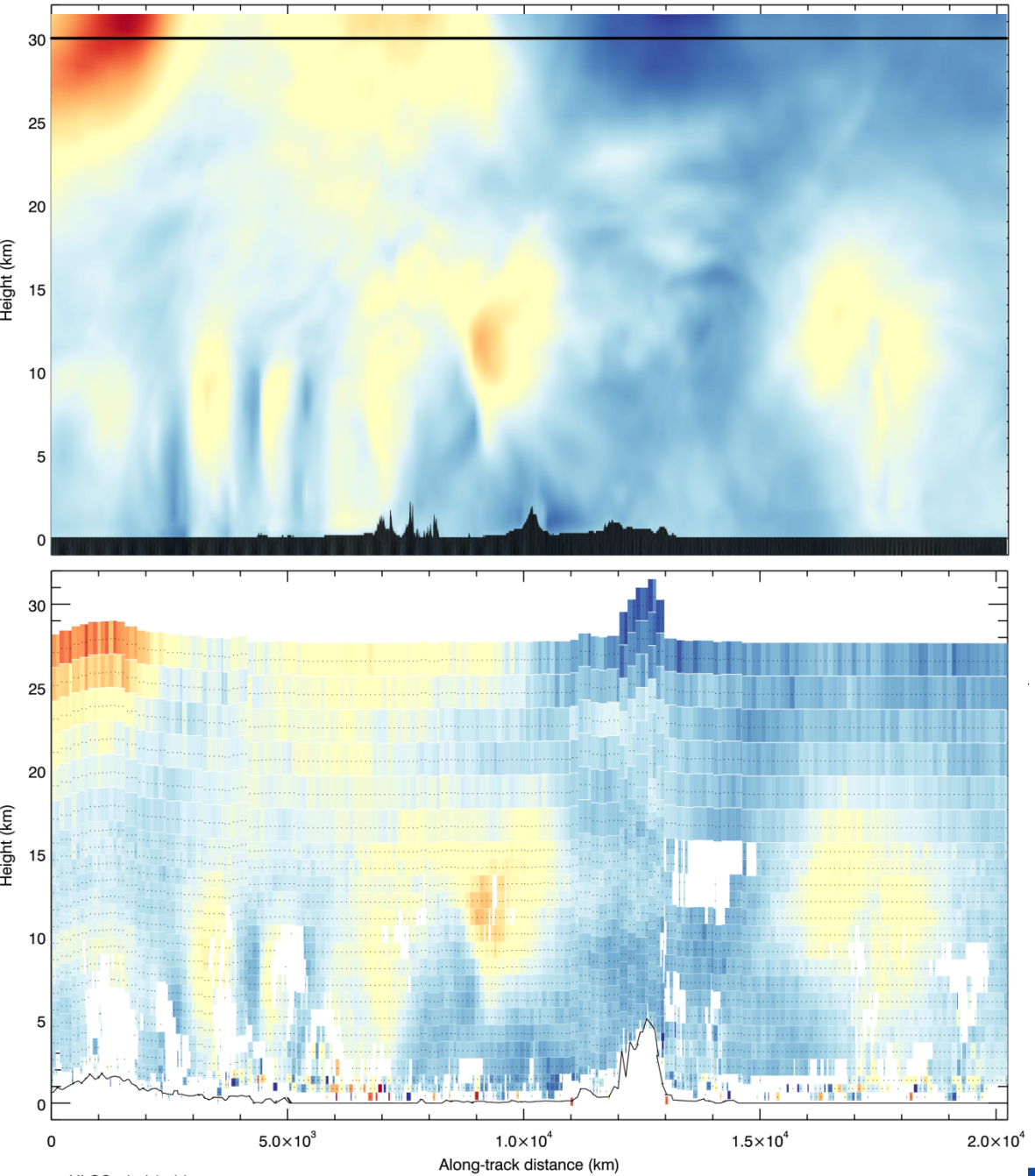
## Preparing processors with simulations:

- **Indications of Aeolus observation quality**



# Example simulator input Derived CALIPSO $\log_{10}$(scattering ratio) 355 nm (KNMI)



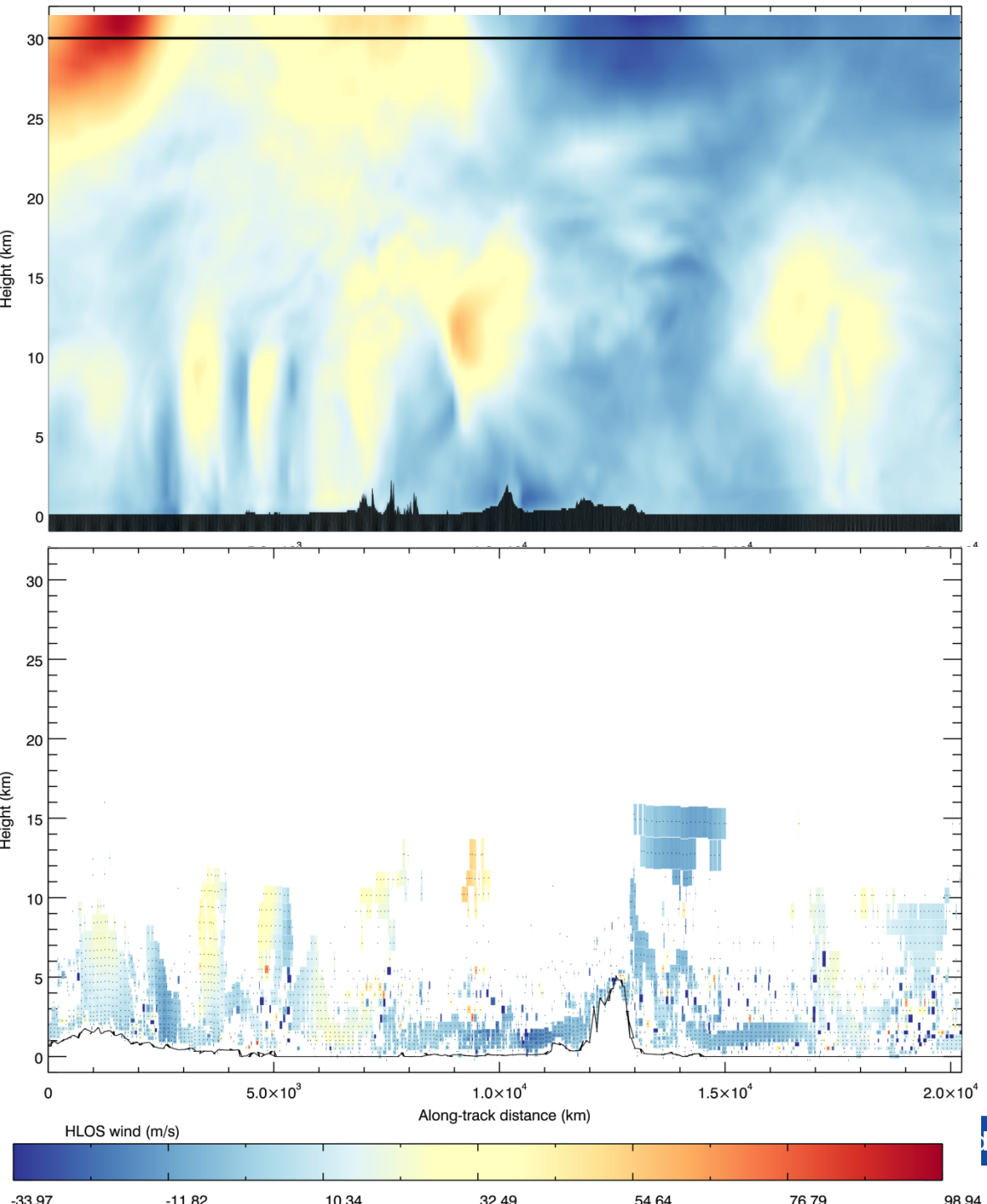



Simulator input: "True" HLOS wind (ECMWF)

Output: L2B "**clear-Rayleigh**" HLOS wind



ECMWF




Simulator input: "True" HLOS wind (ECMWF)

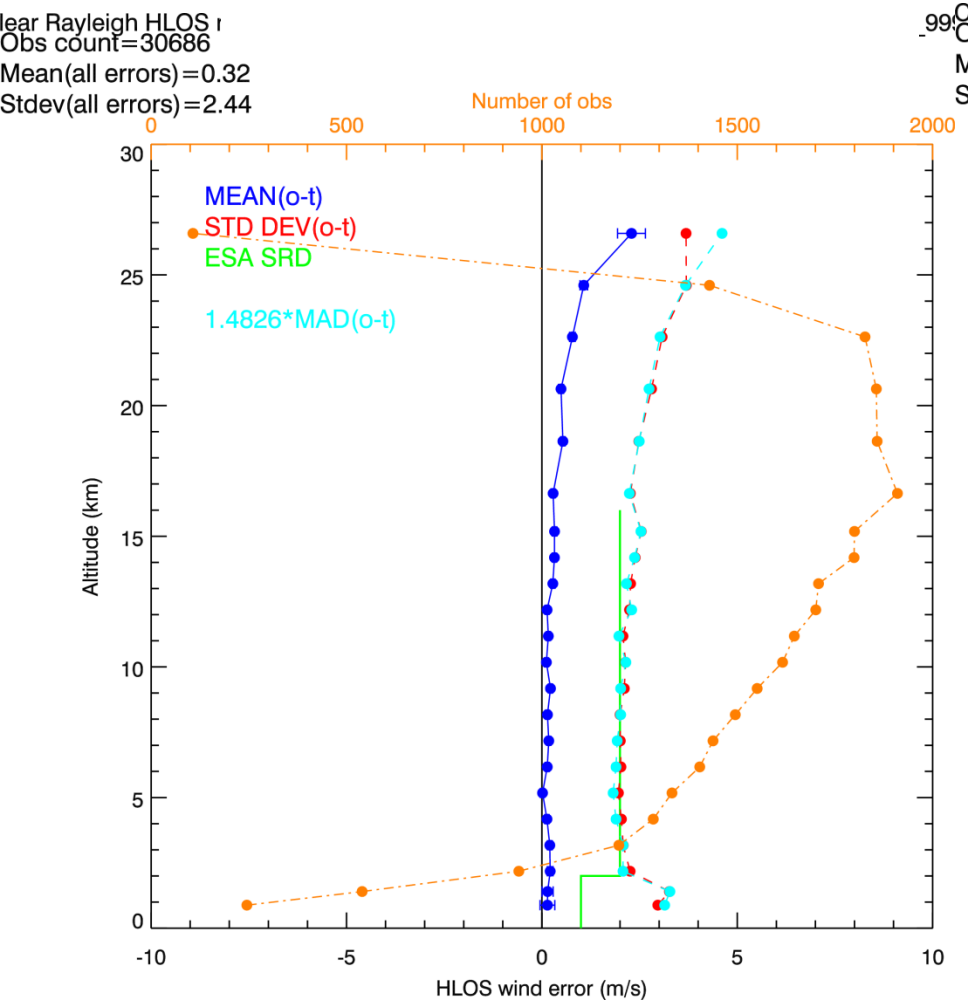
Output: L2B "**cloudy-Mie**" HLOS wind



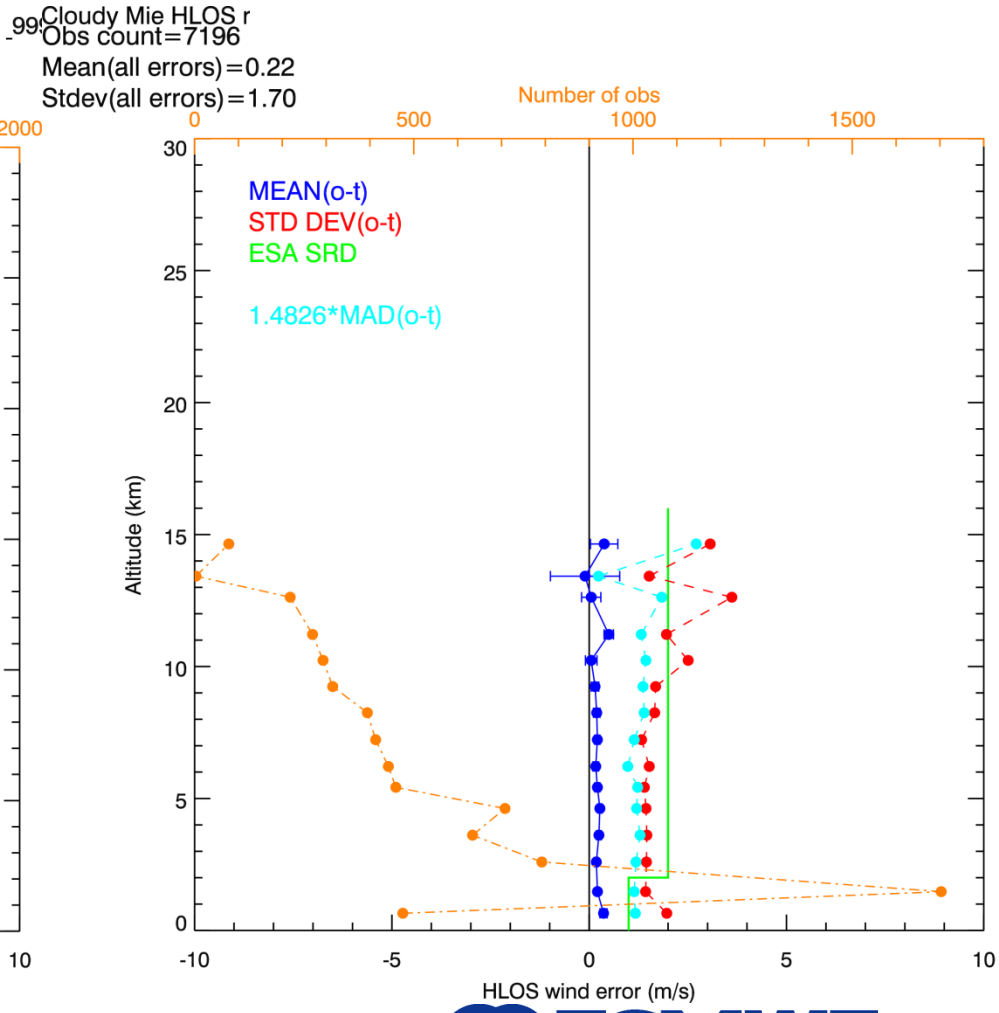
ECMWF

# Example L2B HLOS error statistics

Rayleigh-clear




Mie-cloudy



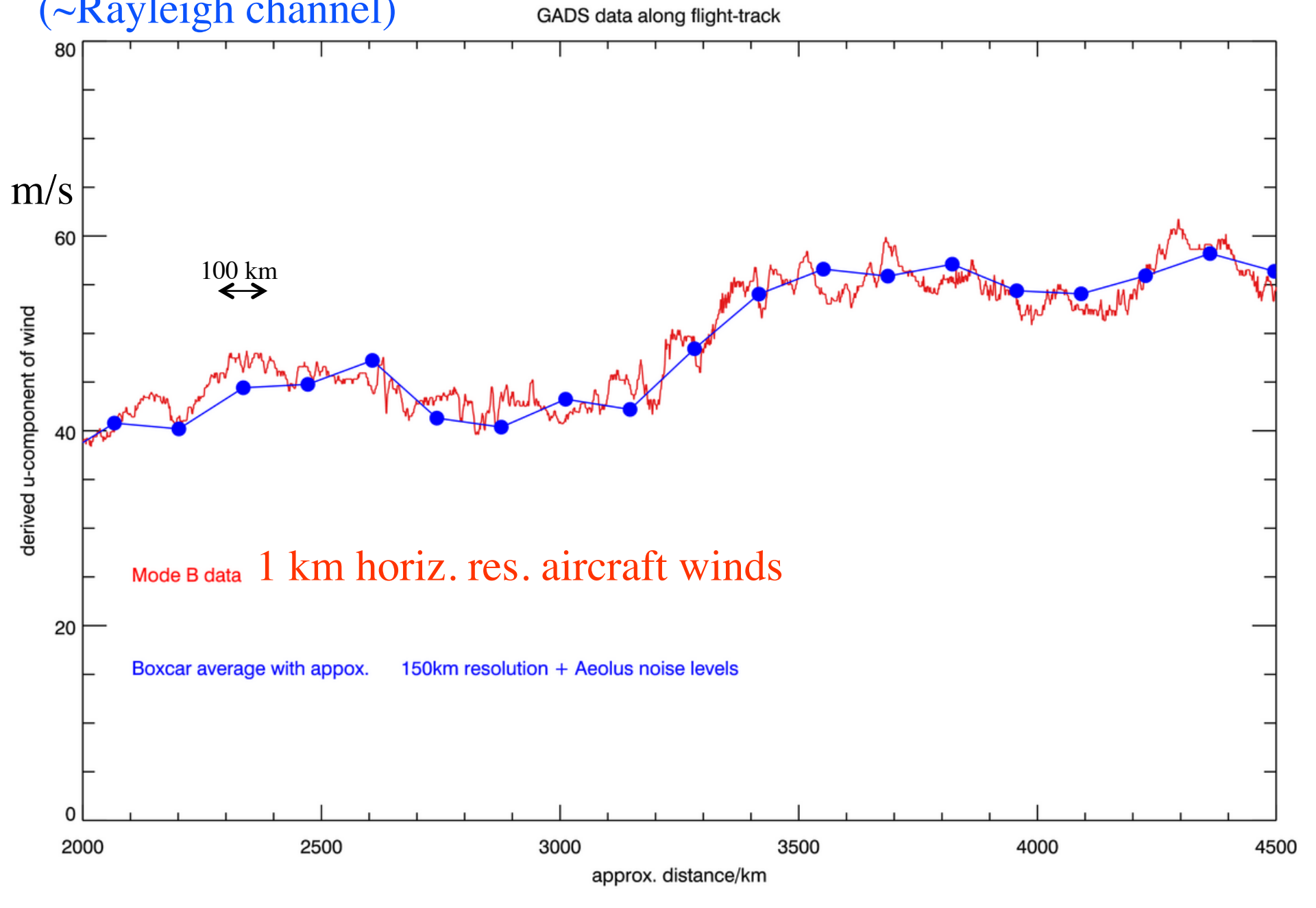



ECMWF

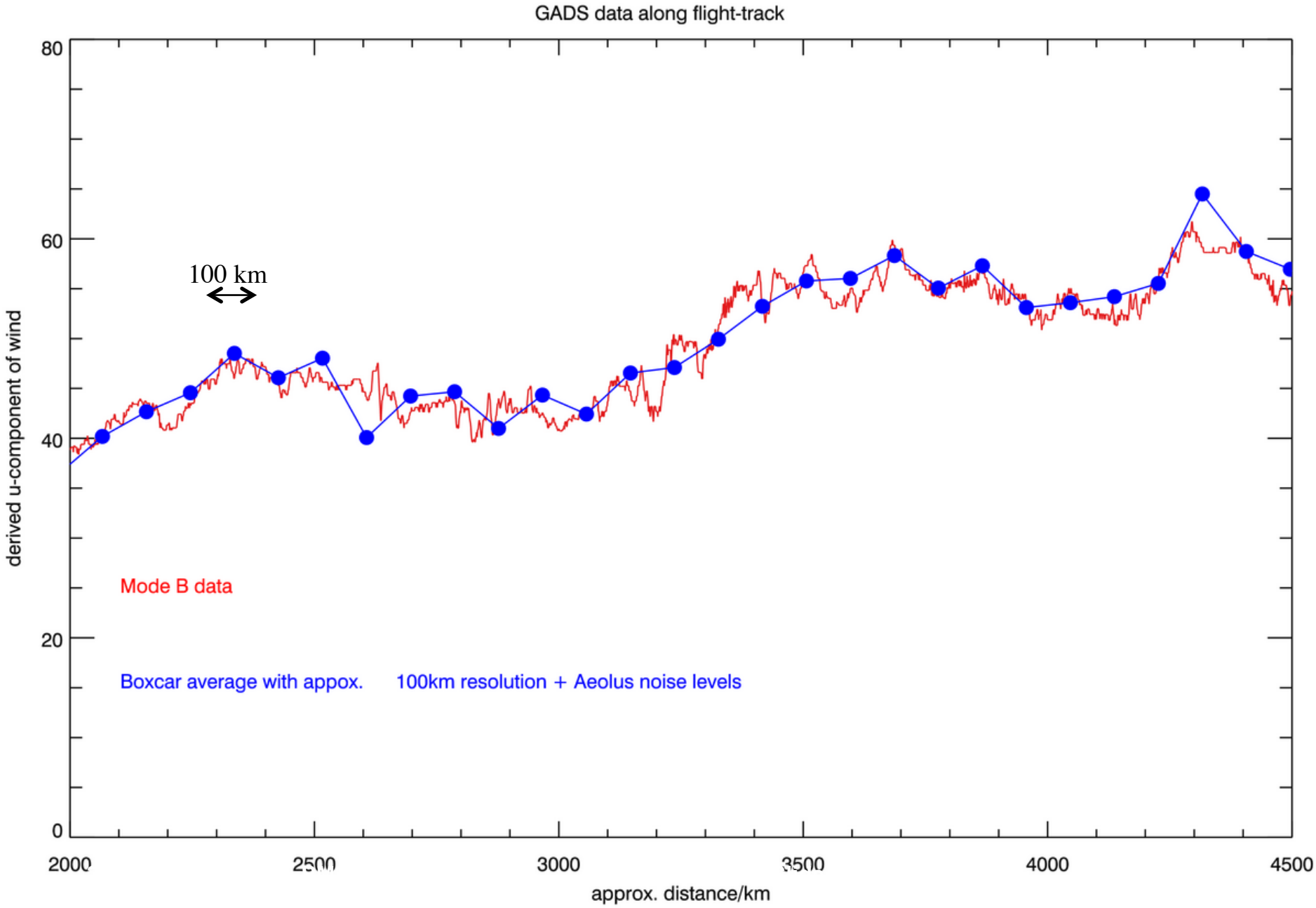
# Simulated Aeolus L2B wind quality

- Random errors:
  - 1.5-3 m/s standard deviation
- Systematic errors:
  - Some surprises; larger than hoped for
  - One source of Rayleigh bias will be corrected soon
  - Mie biases: wind shear/thick range bins/thin particle layers
- Caveat:
  - Simulations!
  - Real data will probably be different
- Worth it?
  - Have fixed many bugs with this process

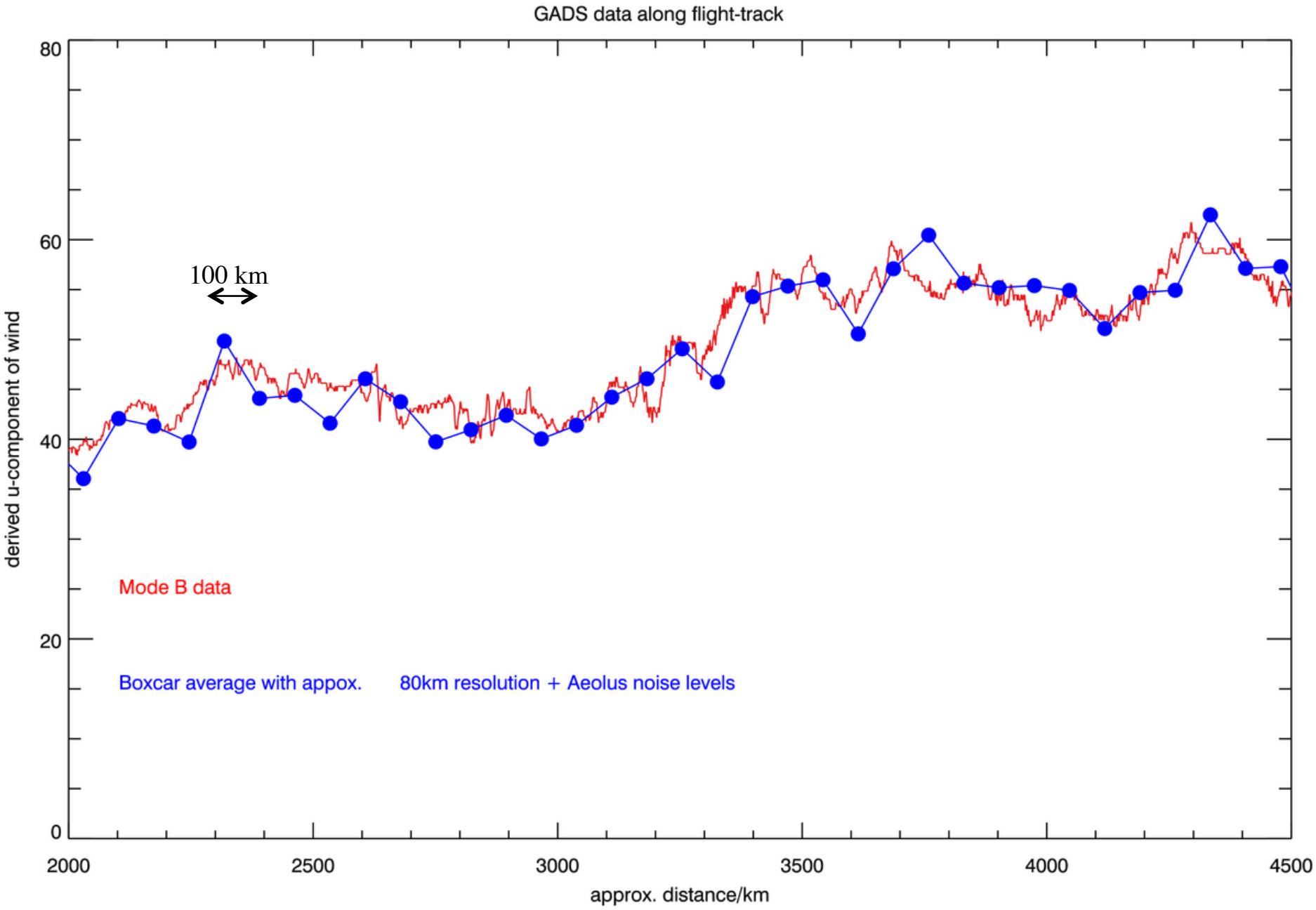
u-component of wind; Aeolus-like averaging (150 km) + 1.6 m/s noise (~Rayleigh channel)



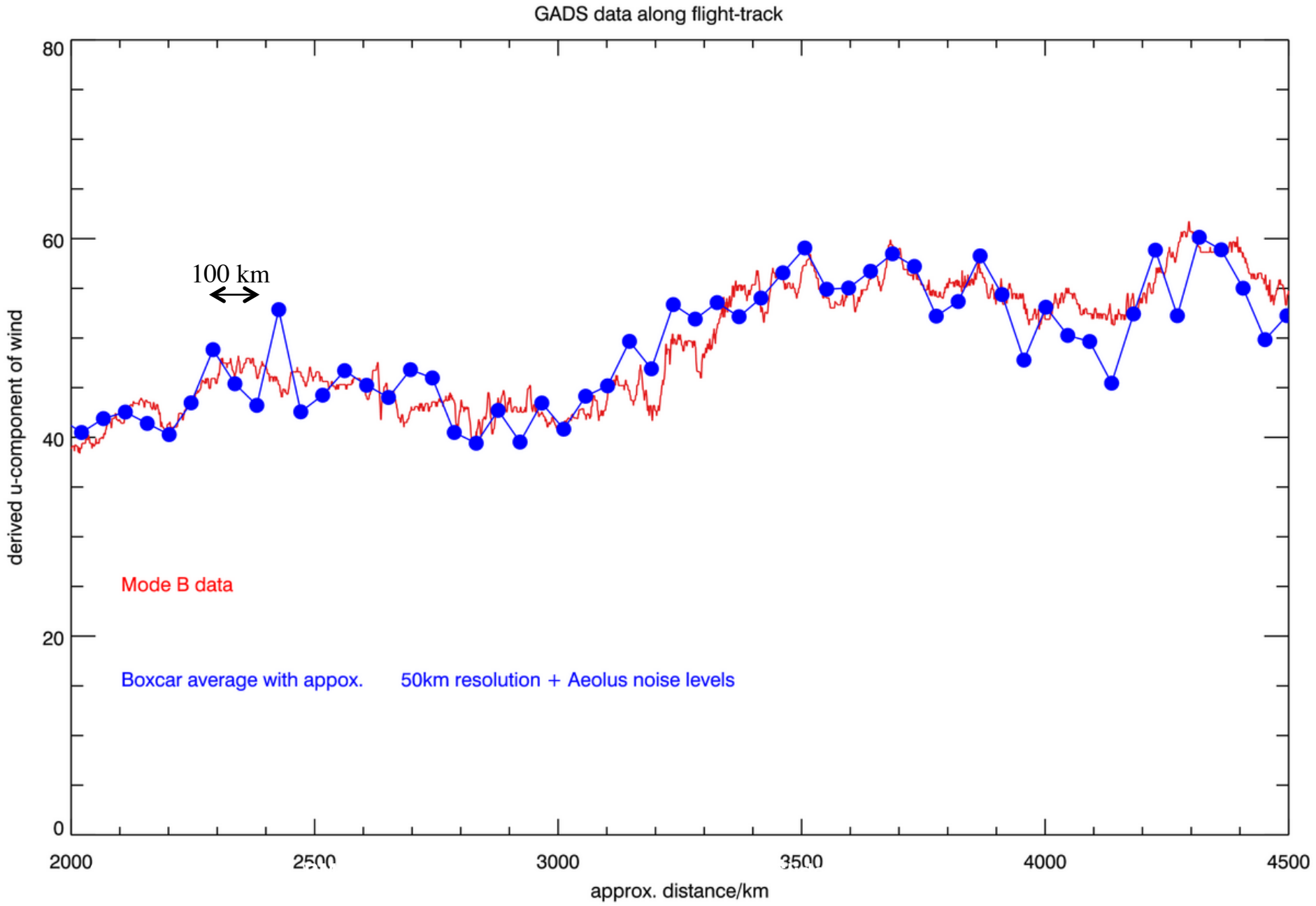
# 100 km averaging + appropriate noise (2 m/s)



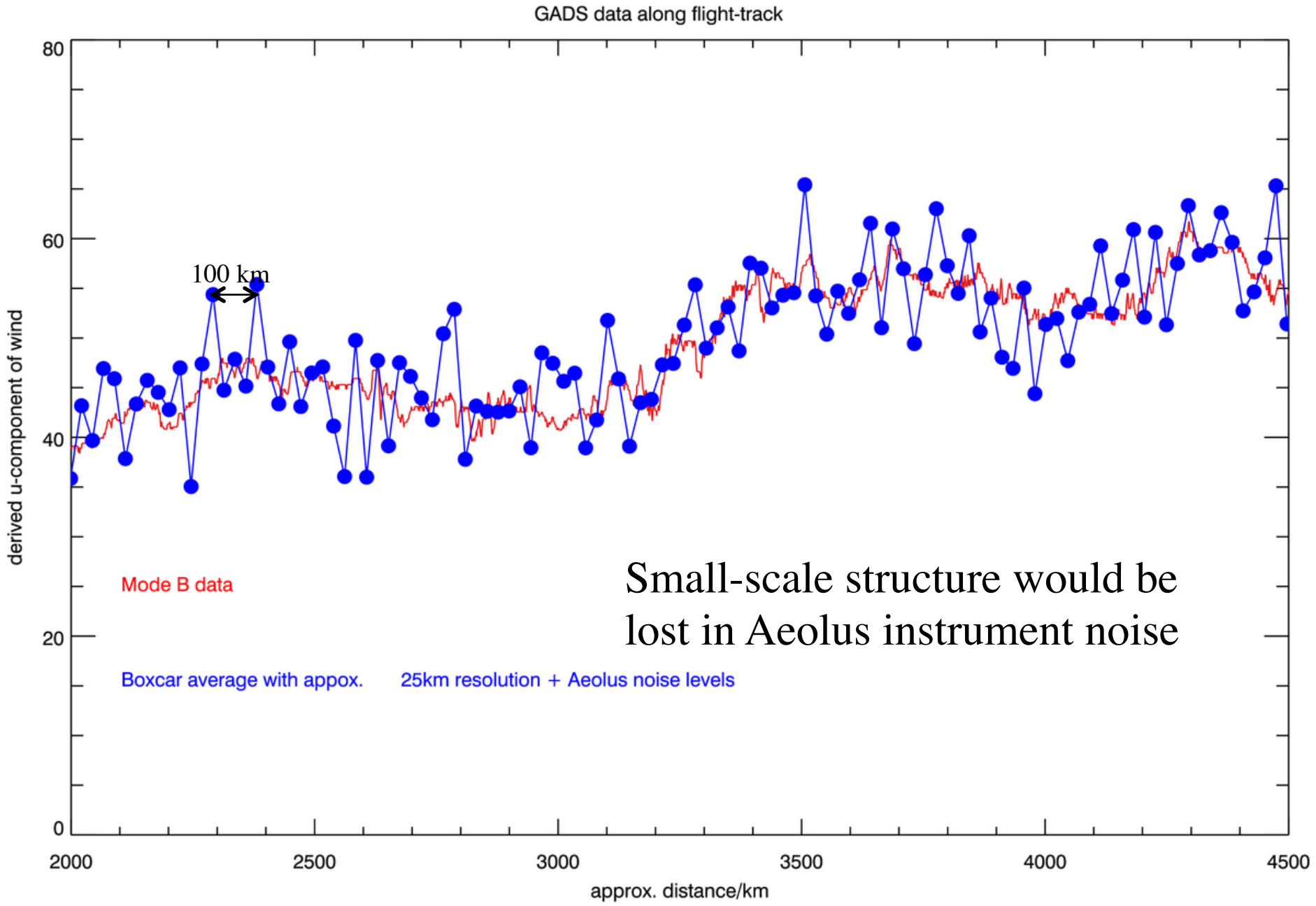
# 80 km averaging + appropriate noise (2.2 m/s)



# 50 km averaging + appropriate noise (2.8 m/s)



# 25 km averaging + appropriate noise (4 m/s)



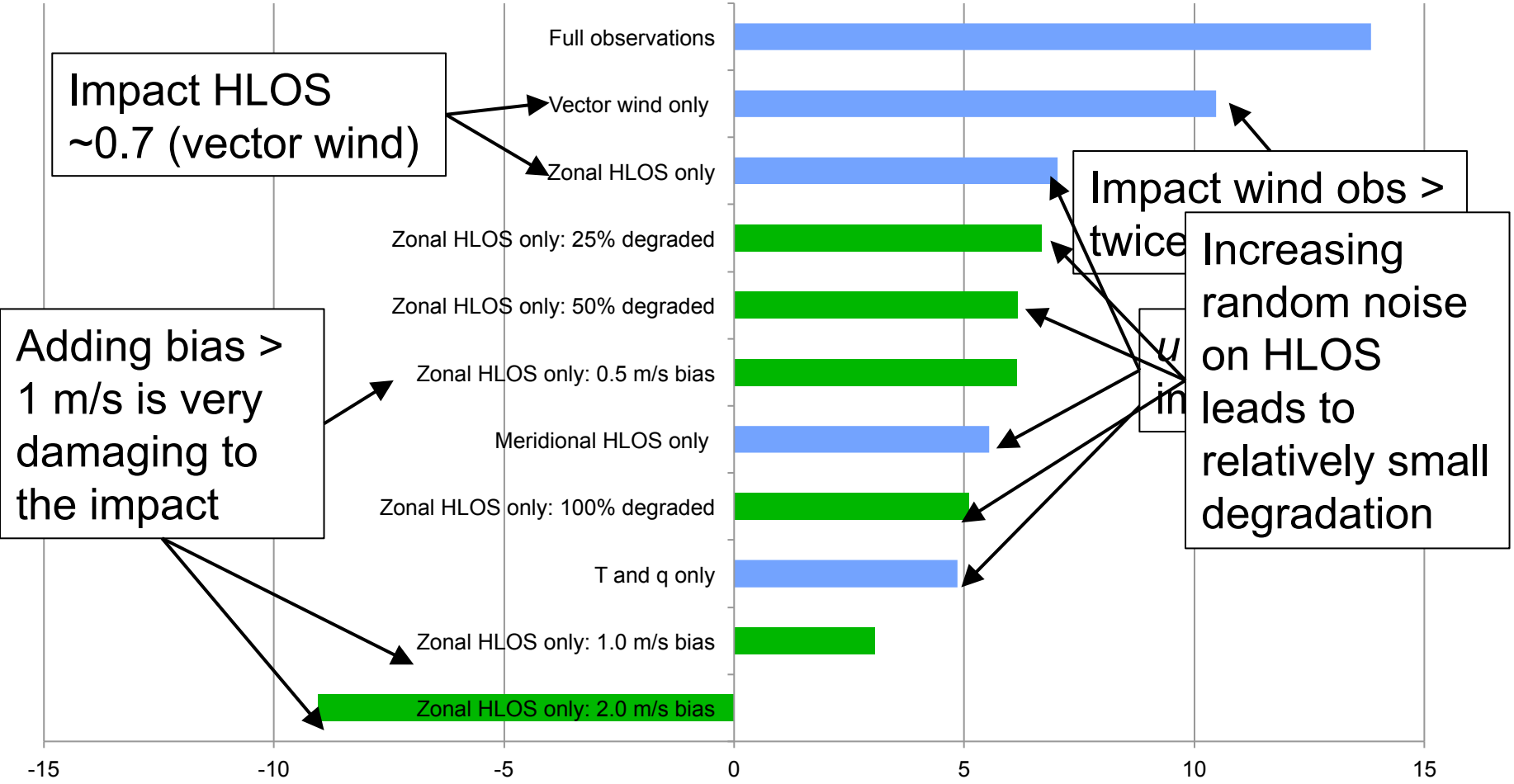
# 3. Wind impact investigation at ECMWF

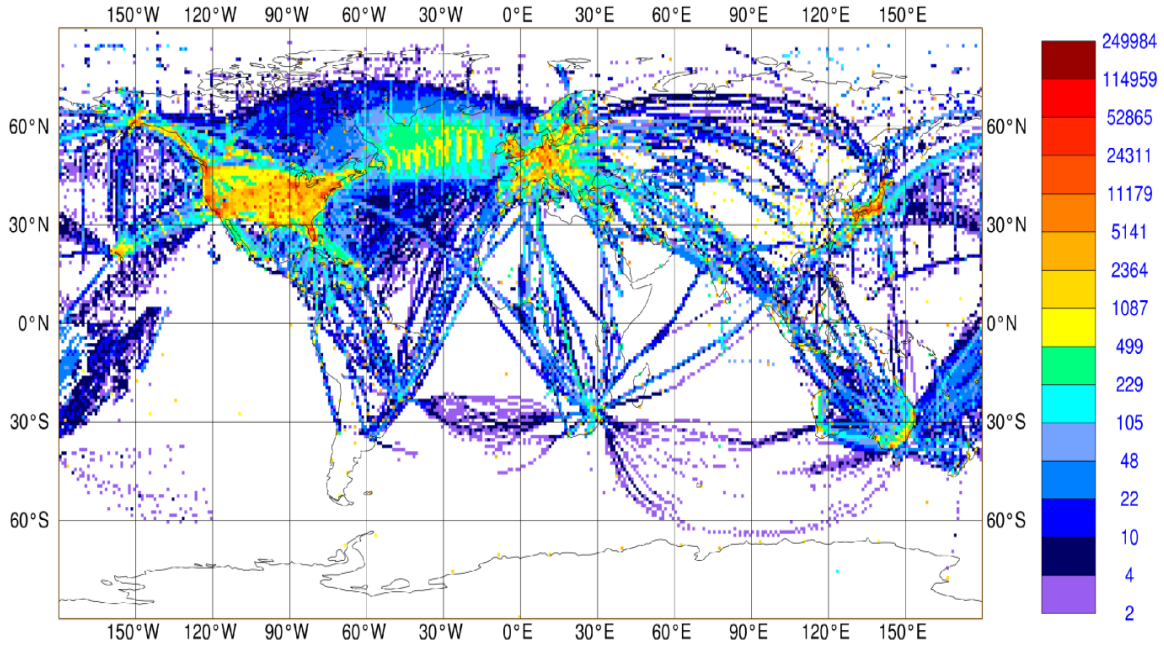
work by A. Horanyi , C. Cardinali, M. Rennie and L. Isaksen

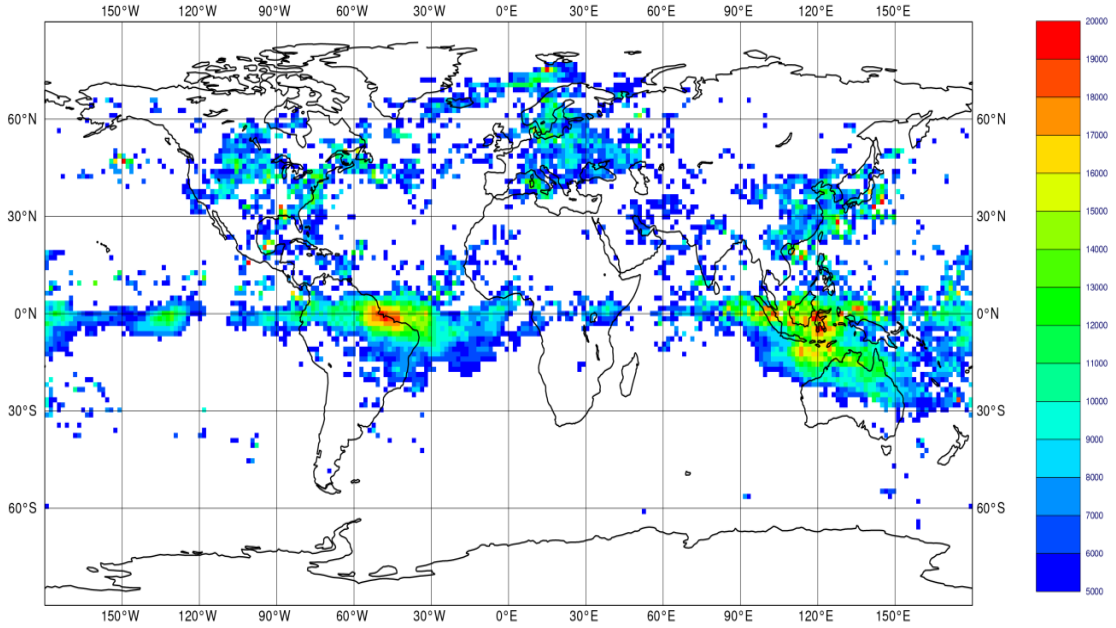
- 1 month OSEs using *in situ* observations:
  - aircraft; radiosondes; PILOT and wind profilers
- Assessed impact of:
  - Different combinations of wind and mass obs (*u*, *v*, *T* and *q)*
    - which gives most impact relative to current OS?
  - Assimilation of HLOS winds
    - convert (u, v) → HLOS
    - can real single-component wind give useful impact?
  - Increasing HLOS random and systematic error
    - what reduction in accuracy can we tolerate?
    - indications for Aeolus

# OSE results: comparison of different experiments

Reference = no upper-air *in situ* obs






## Distribution of observations

- mostly aircraft at 100-400 hPa

## OSE results: Impact of zonal HLOS

- largest in tropical regions
- Impact also larger in data-rich areas

**Metric:** reduction of vertically integrated total energy error for 24 hr FC

# Summary of impact experiments

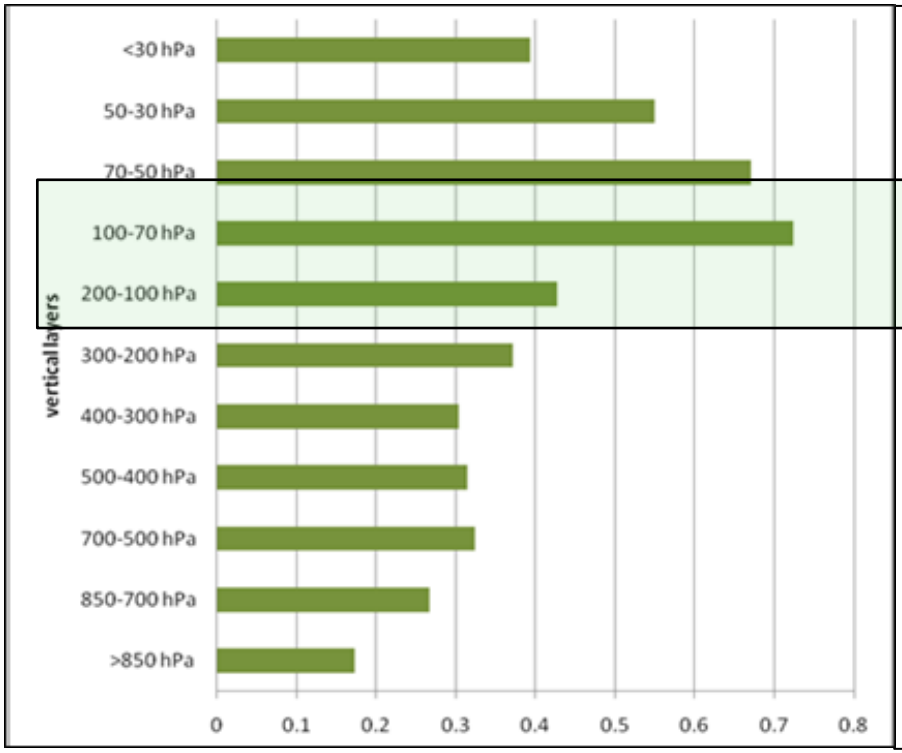
- **Wind and mass comparison:**
  - wind more beneficial than mass when added on top of the full satellite observing system
    - particularly in Tropics
- **HLOS assimilation:**
  - HLOS gives large fraction of vector wind impact – promising for Aeolus
  - Zonal component impact a bit larger than meridional
  - Larger random errors not too damaging
  - 2 m/s bias: large negative impact – therefore critical to minimise Aeolus "unknown" biases
  - study has limitations for assessing Aeolus potential impact
- Paper submitted to QJRMS

# Thanks for listening.
# Any questions?

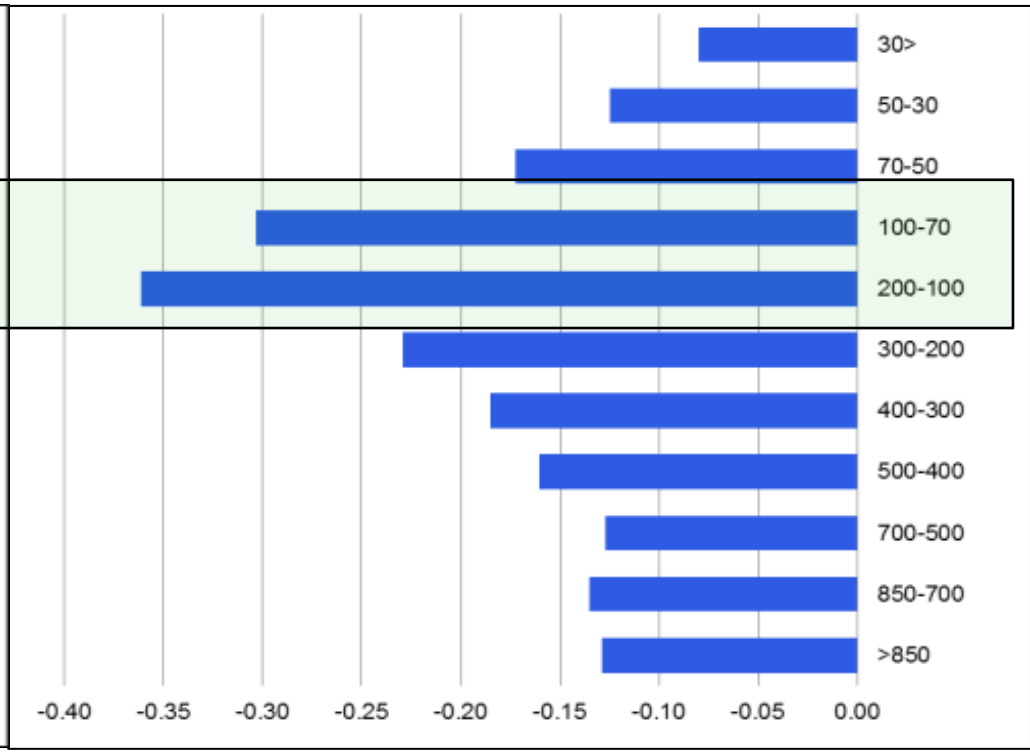
Aeolus L2B processing software available to download:
http://www.ecmwf.int/en/research/projects/aeolus

# Wind vector impact per ob; dependence on height

DFS per ob




Forecast error contribution per ob




70-200 hPa winds provide most impact per ob. Therefore can expect new obs to be most beneficial here – Aeolus should provides lot of Rayleigh and Mie winds here



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# L2Bp inputs

- ESA provide:
  - L1B data (typically 1 file per orbit)
    - Measurement level spectrometer counts
    - Geolcation information
    - Uncorrected Rayleigh winds
    - Mie calibration information
    - Zero wind correction
  - AUX_RBC_L2: Rayleigh calibration taking account of T and p dependence (uncertain, but perhaps once per week)
- Users provide:
  - AUX_MET; profiles of T, p along Aeolus orbit
  - AUX_PAR_2B; processor settings file