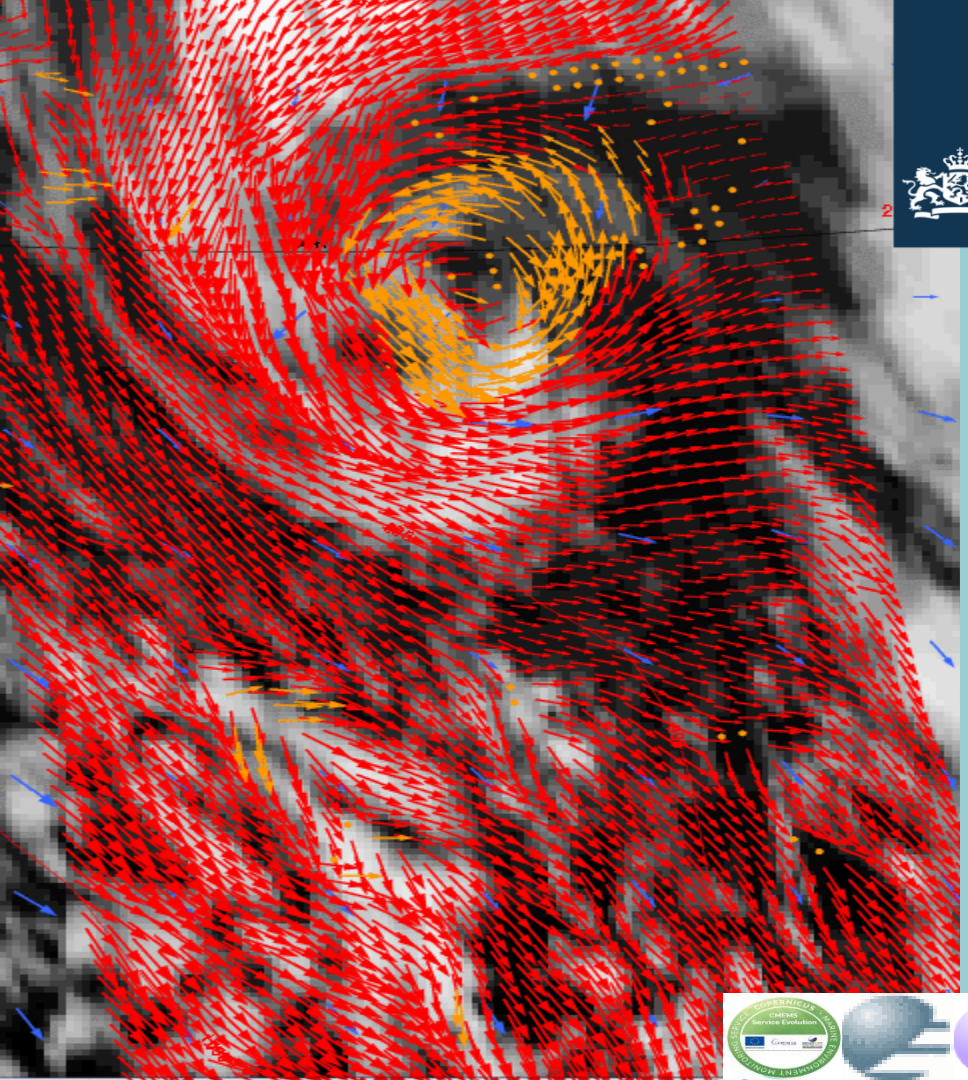

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Ministry of Infrastructure and the Environment

Mesoscale Wind Data Assimilation

Ad.Stoffelen@knmi.nl

Leader Active Remote Sensing Group
Satellite Observations, KNMI

EUMETSAT OSI SAF
EU Copernicus Marine Core Services
ESA Aeolus L2 product development
EUMETSAT NWP SAF

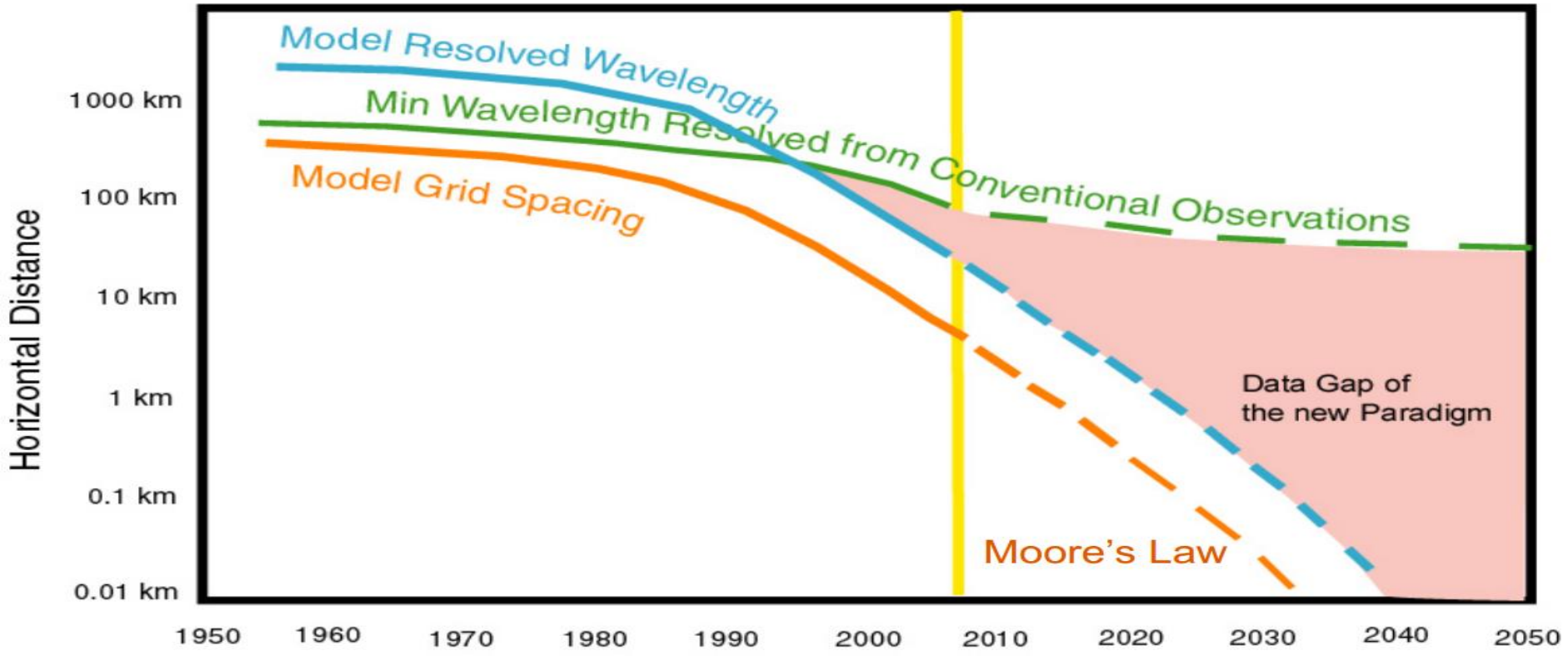
Mesoscale Wind Data Assimilation

- What do we need ?
- Wind observations
- How well do we model ?
- How to assimilate observations ?

NWP SAF workshop
18 Sep 2018 10:00-13:30

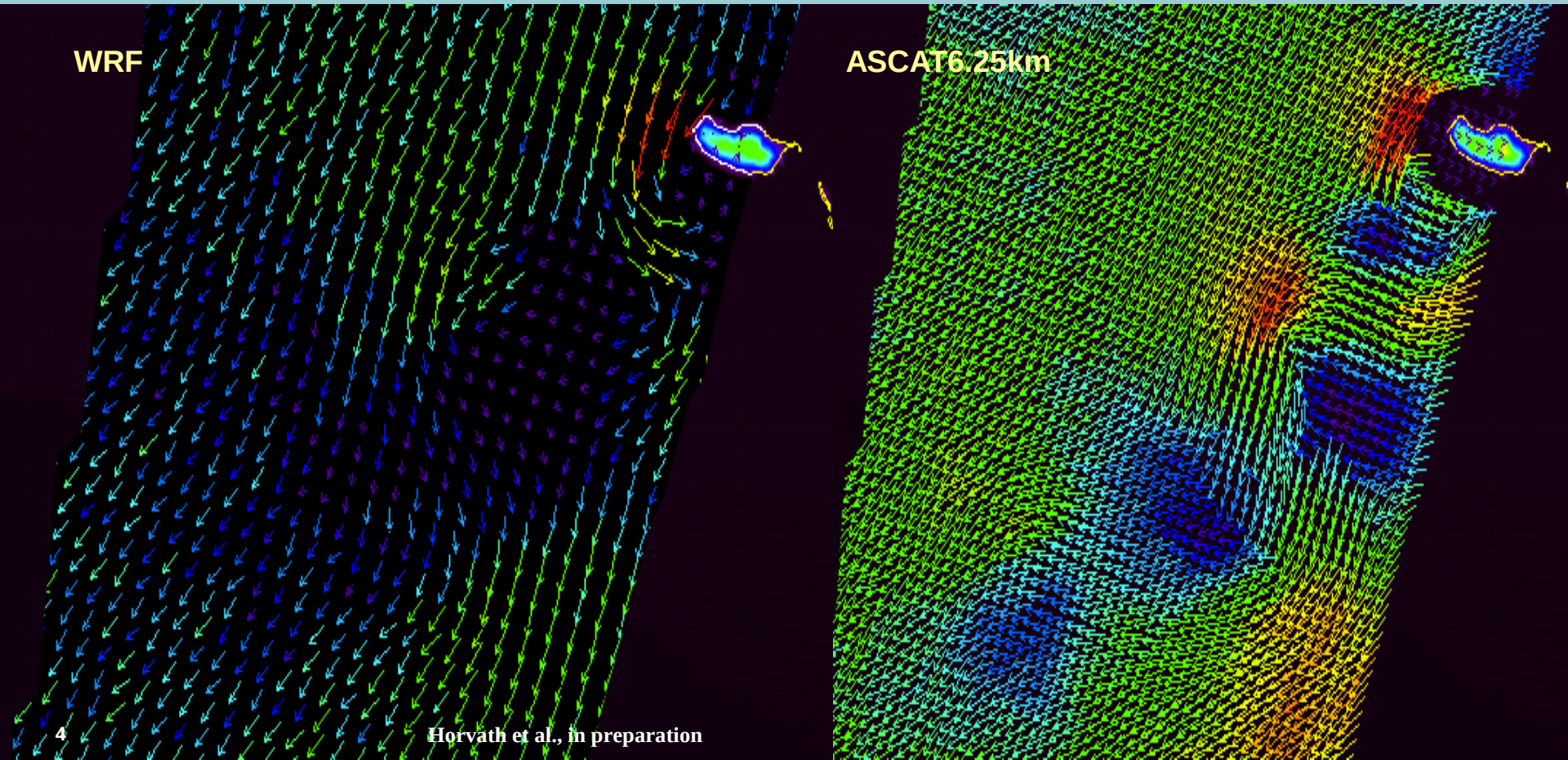
NWP SAF
- Bias correction guide
- Data assimilation guide

Can we still improve forecasts?



Greg.J. Tripoli, Un. Wisconsin

Observations and Models



Horvath et al., in preparation

What do we need ?

- Winds for mesoscale dynamics, shear, convergence, . . .
- At high accuracy
- High spatial and temporal density
- Everywhere, not only in dynamic weather
- Fill gaps over the oceans, tropics and southern hemisphere, particularly UTLS
- Fast timeliness
- Well calibrated winds (no bias; BLUE)

Wind Observations

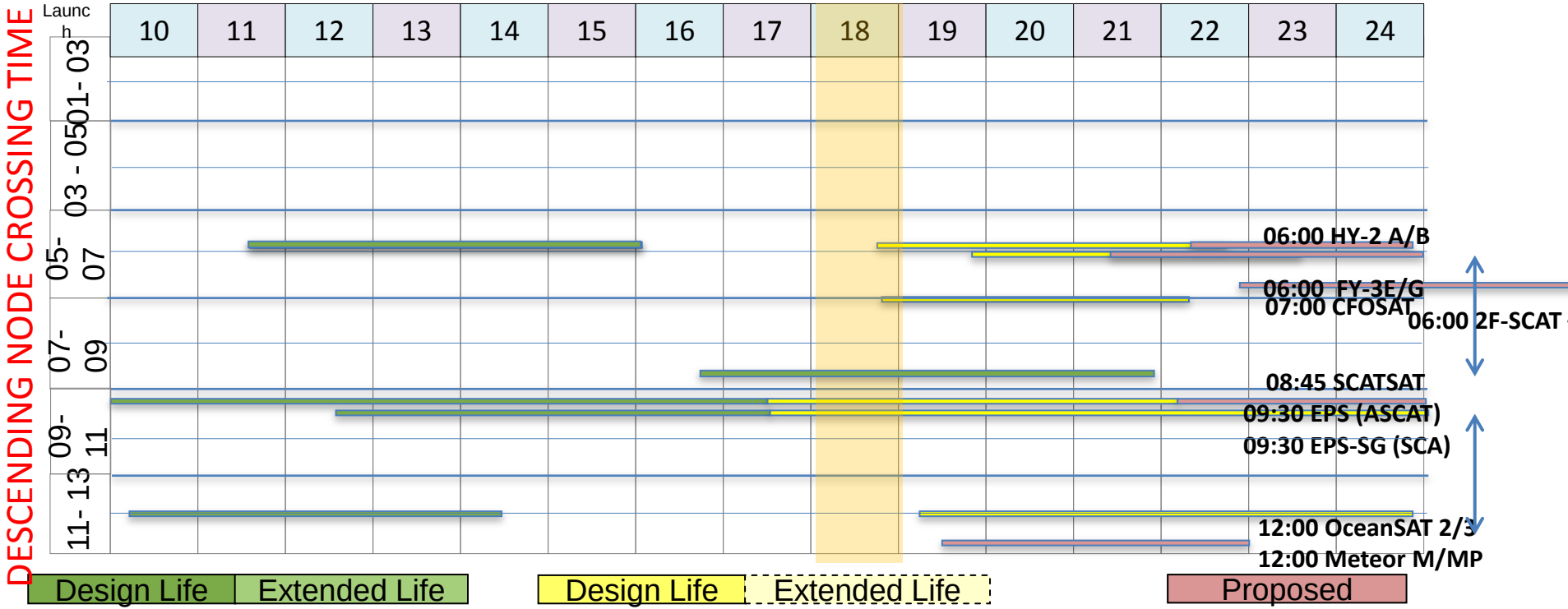
- Will much increase over the sea surface
- Many upper air aircraft winds over land (if made available)
- Aeolus to provide wind profiles in the coming three years
- Many upper clair cloud winds, but less accurate at mesoscale
- Geometric cloud winds appear better (MISR)

Research:

- Proposed cloud radar mission
- IASI winds/radiances

➢ Brightness temperatures not good for height knowledge

Ocean Vector Surface Winds Constellation
Local time coverage assessment (ground track) - NRT data access



Source: WMO OSCAR database and direct interactions with agencies

Committee on Earth Observation Satellites

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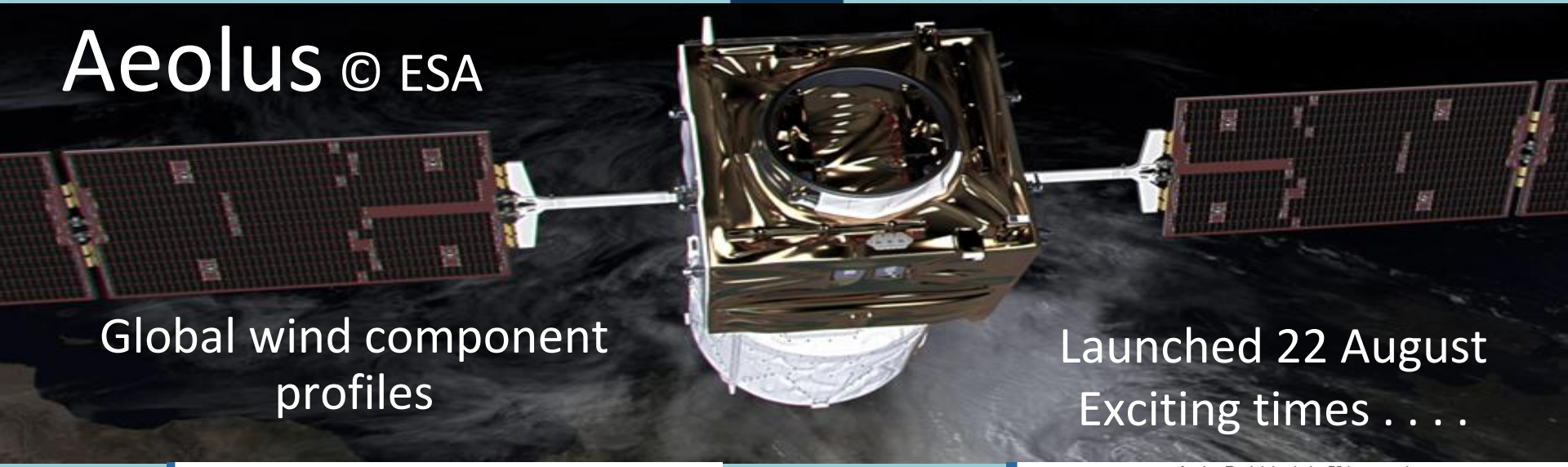
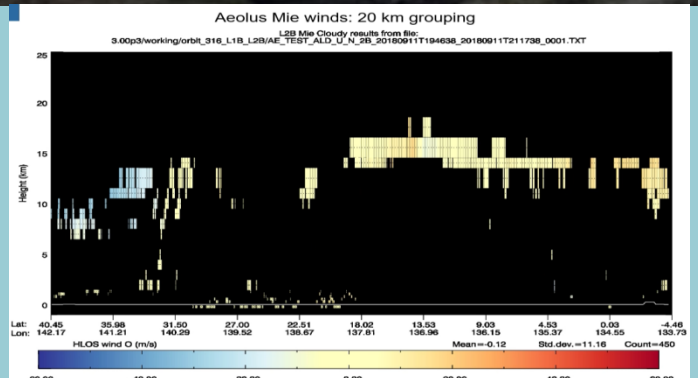
Aeolus © ESA



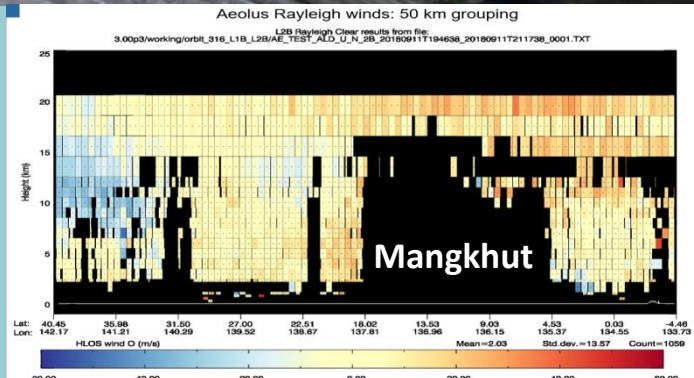
Global wind component profiles

Launched 22 August
Exciting times . . . .

Mie:



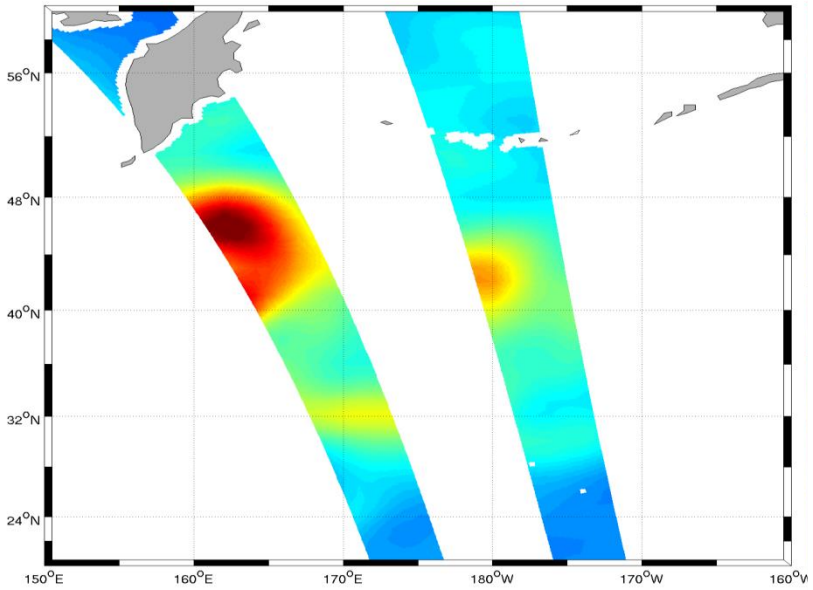
Rayleigh:



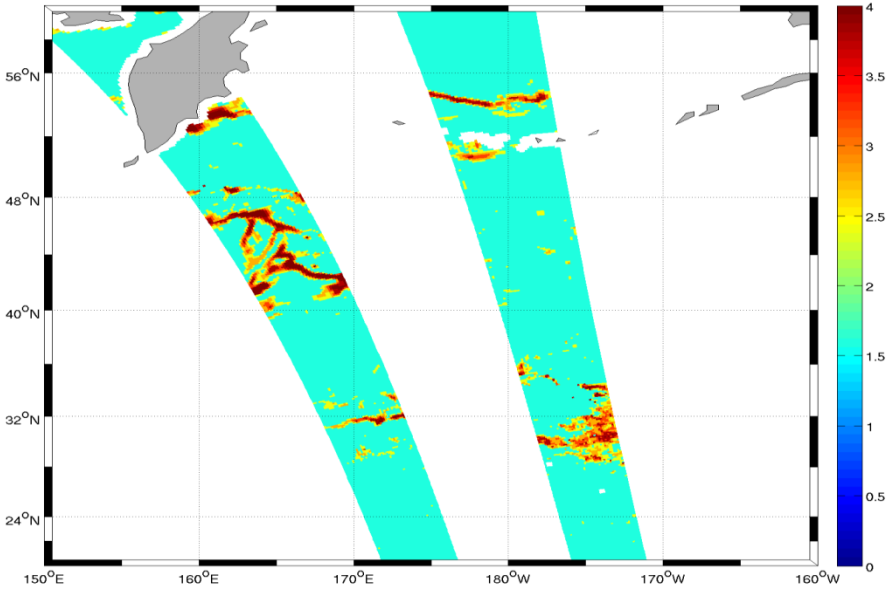
NWP model Winds

- Are initialized from observations in a DAS
- Are continually improving and the forecasters' reference
- Actual background error covariances are poorly known
- Global NWP models lack mesoscale variability
- Regional models lack true mesoscale variability over sea and in the upper air
- Regional models are seriously affected by lateral boundaries http://meteo.fmf.uni-lj.si/sites/default/files/MesoWindsWorkshopLjubljana2016_Summary.pdf
- Are not so good in the tropics or elsewhere near convection (e.g., polar lows)
- Have large systematic wind biases (in stable air, ocean currents, drag, diurnal cycle, ..)

Estimated B error variances



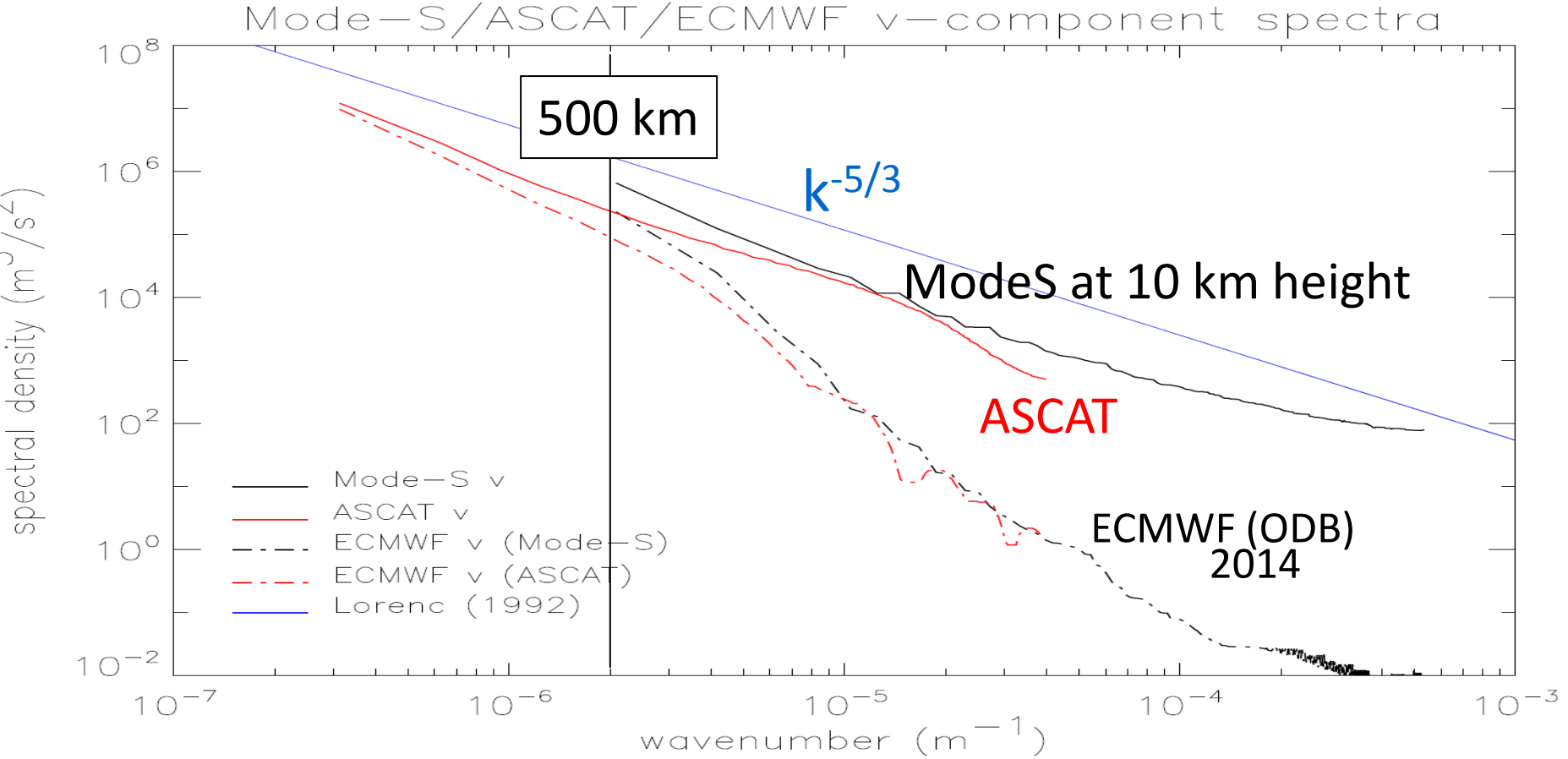
ECMWF Ensemble Data Assimilation (EDA background error)



ASCAT-derived ECMWF background error by triple collocation in QC classes

- The structure and location of ECMWF errors is not well resolved in EDA

NWP gap for small scales upper air



Does Dynamical Downscaling With Regional Climate Models add Value to Surface Marine Wind Speed From Reanalyses?

Jörg Winterfeldt[1*], Ralf Weisse[1], Matthias Zahn[1]
[1]Institute of Coastal Research, GKSS Research Centre, Geesthacht, Germany
*joerg.winterfeldt@gkss.de

Simulations with RCMs REMO and CLM: *(available from* coastDat *Database)*

by GKSS Forschungszentrum Geesthacht

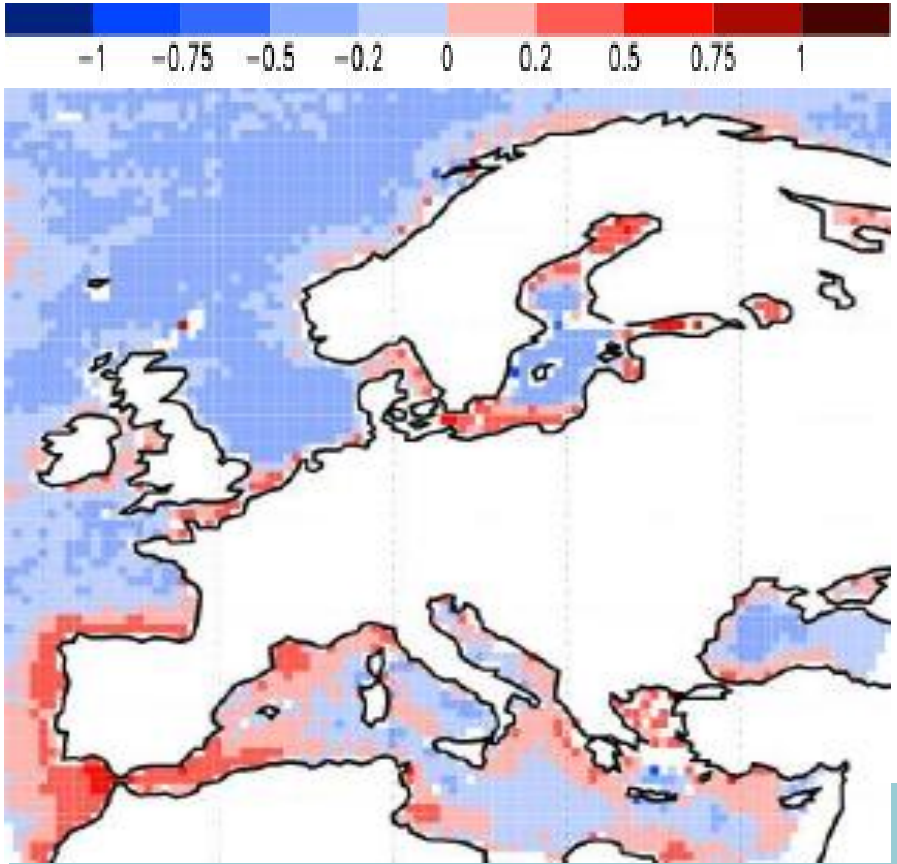
- Three hindcasts with RCMs REMO (Jakob and Podzun, 1997) and CLM (Böhm et al. 2006)
- Initialization and forcing at lateral boundaries: NCEP/NCAR-Reanalysis (NRA), ~1.875° resolution,
- SN-REMO & CLM hindcasts are additionally forced by spectral nudging (von Storch et al., 2000)

Hindcast	*STD-REMO (Standard)*	*SN-REMO*	*CLM*
Based on:	EM	EM	LM
	Hydrostatic	Hydrostatic	Non-hydrostatic
Forcing:	NRA	NRA	NRA
Spectral Nudging:	No	Yes	Yes
Resolution:	0.5°	0.5°	0.44°

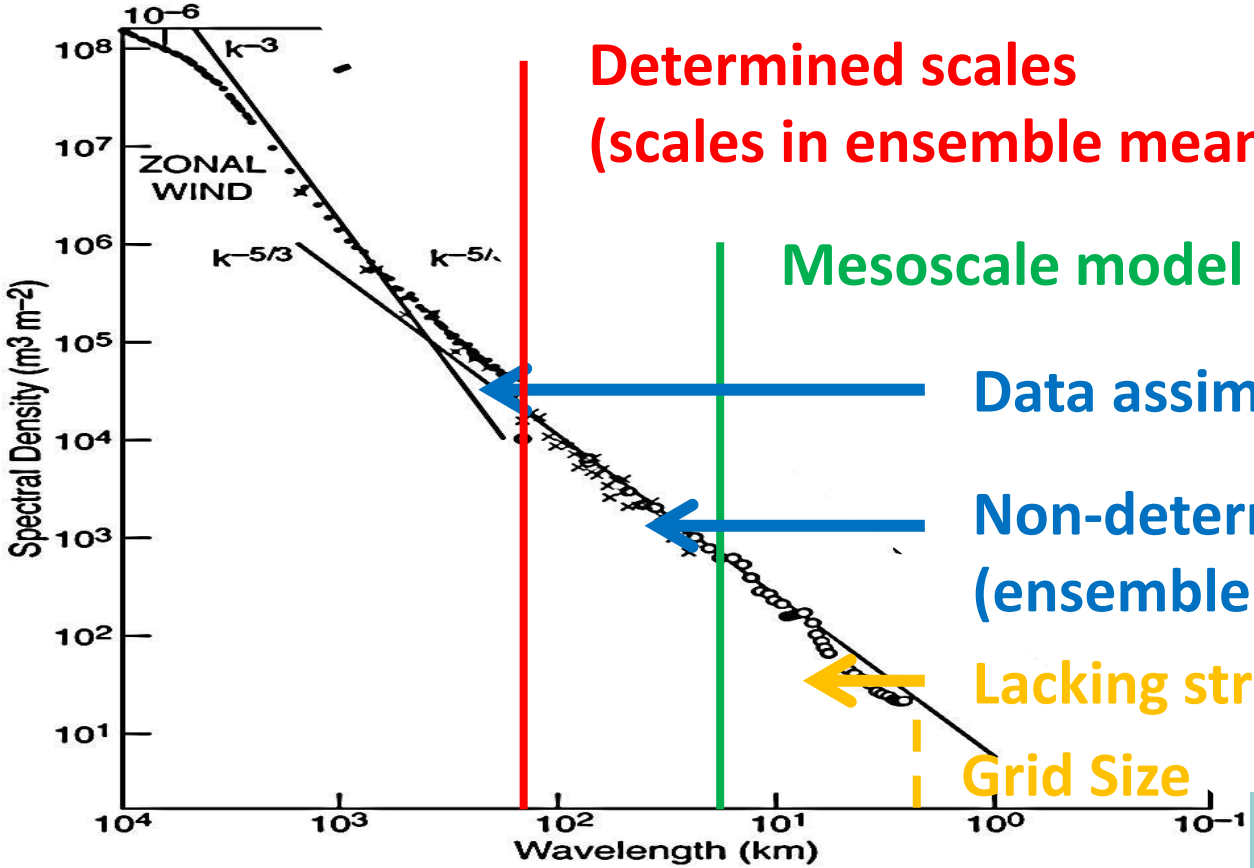
- For that purpose a gridded QuikSCAT Level 2B 12.5 km swath (L2B12) data set is produced on SN-REMO grid (rain flagged L2B12 data discarded)
  co-location with SN-REMO: QuikSCAT wind speed retrieval max. 12.5 km and +/- 10 min from SN-REMO grid point / time step

- Modified BSS = $\begin{cases} 1 - \sigma_F^2 \sigma_R^{-2} & \text{if } \sigma_F^2 \le \sigma_R^2 \\ \sigma_R^2 \sigma_F^{-2} - 1 & \text{if } \sigma_F^2 > \sigma_R^2 \end{cases}$

- "Forecast" F: SNREMO, reference "forecast" R: NRA, predictand/observation: gridded QuikSCAT L2B12 data



Nastrom & Gage Observed Spectrum



Determined scales
(scales in ensemble mean)

Mesoscale model resolution

Data assimilation (B)

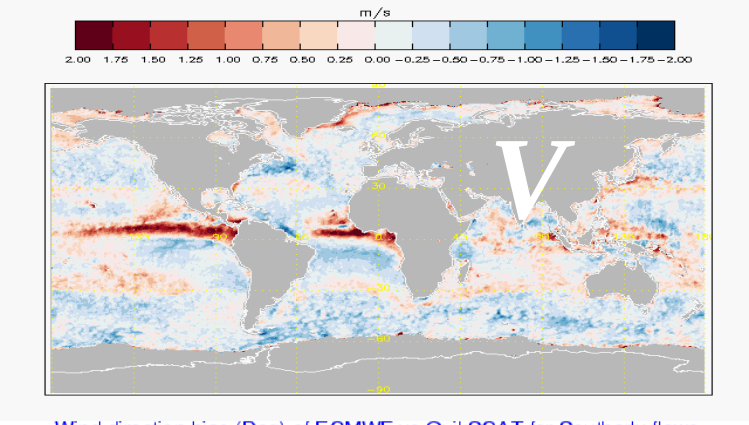
Non-determined scales
(ensemble spread)

Lacking structure (model closure)

Grid Size

Best Linear Unbiased Estimate

- Common assumption in data assimilation
- NWP model biases exist due to drag, ocean currents, stable PBL, moist convection, diurnal cycle, . . .
- Biases are not only speed dependent, but also air mass dependent
- Correcting parameterizations may detriment forecasts (Sandu, 2013)
- Correct model in $\mathbf{H}$ operator to follow BLUE ?
- Local bias contributions are not negligible in o-b, but of the order of the innovations !
- Biases probably severely detriment scatterometer impact in NWP
- Most biases are stable in time -> apply VarBC



Conclusions

- Mesoscale data assimilation is a new paradigm
- Many accurate 4D wind observations are needed to initialize 3D turbulence and convection in the atmosphere
- NWP models are locally substatially biased over long periods -> VarBC needed
- Undetermined scales cause headaches and destroy the analysis of the larger scales potentially
- It is possible to determine small observed scales in the analysis, even if they did not exist yet (2DVAR)
- Weather models return to their dynamical balance very quickly though
- Seek ways to avoid analyzing non-deterministic scales and to avoid their detriment as model noise:
  - Ensemble mean ?
  - Broad B (low pass filter) ?
  - Supermod and superob up to deterministic scales ?