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SRNWP at FMI in 2021

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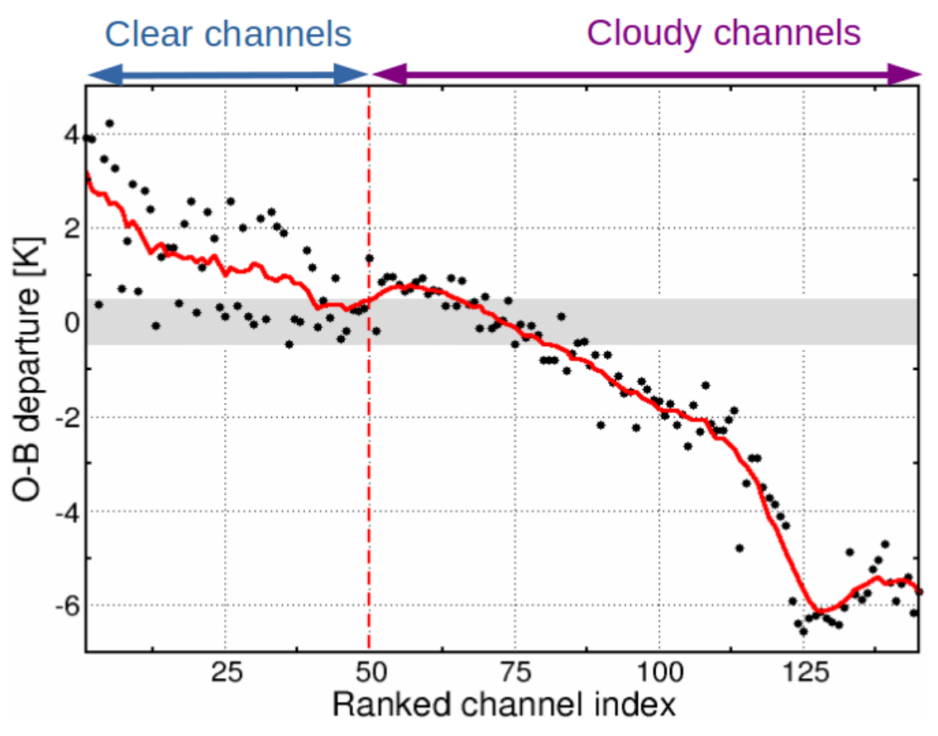
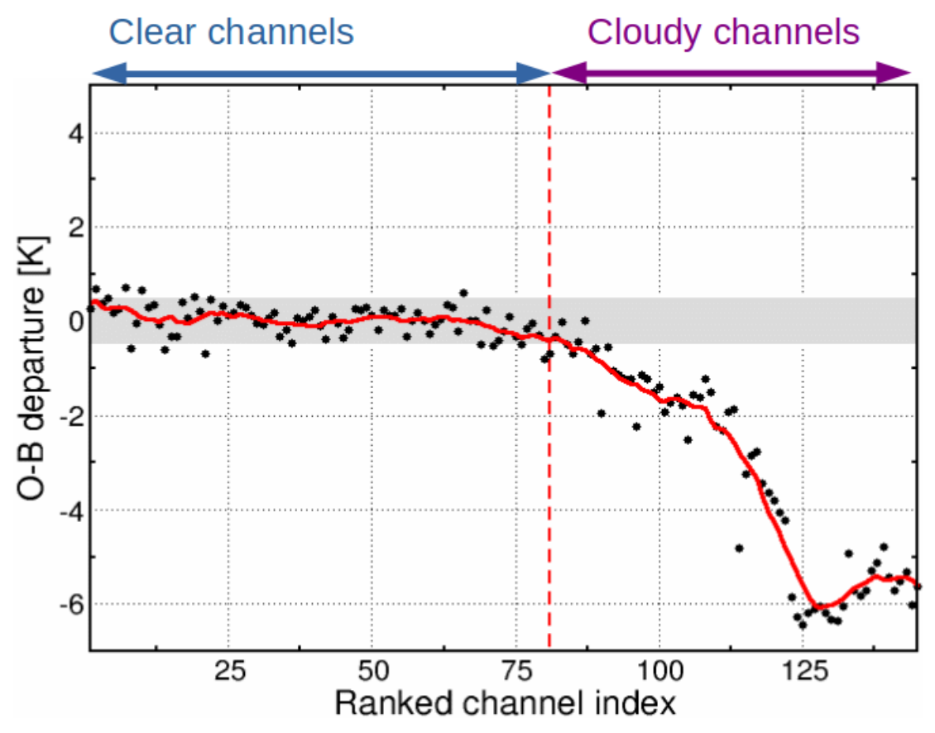
Developments in the use of satellite radiance data in HARMONIE-AROME

Improvements in the detection of cloud in IASI data

Previous setup



New setup



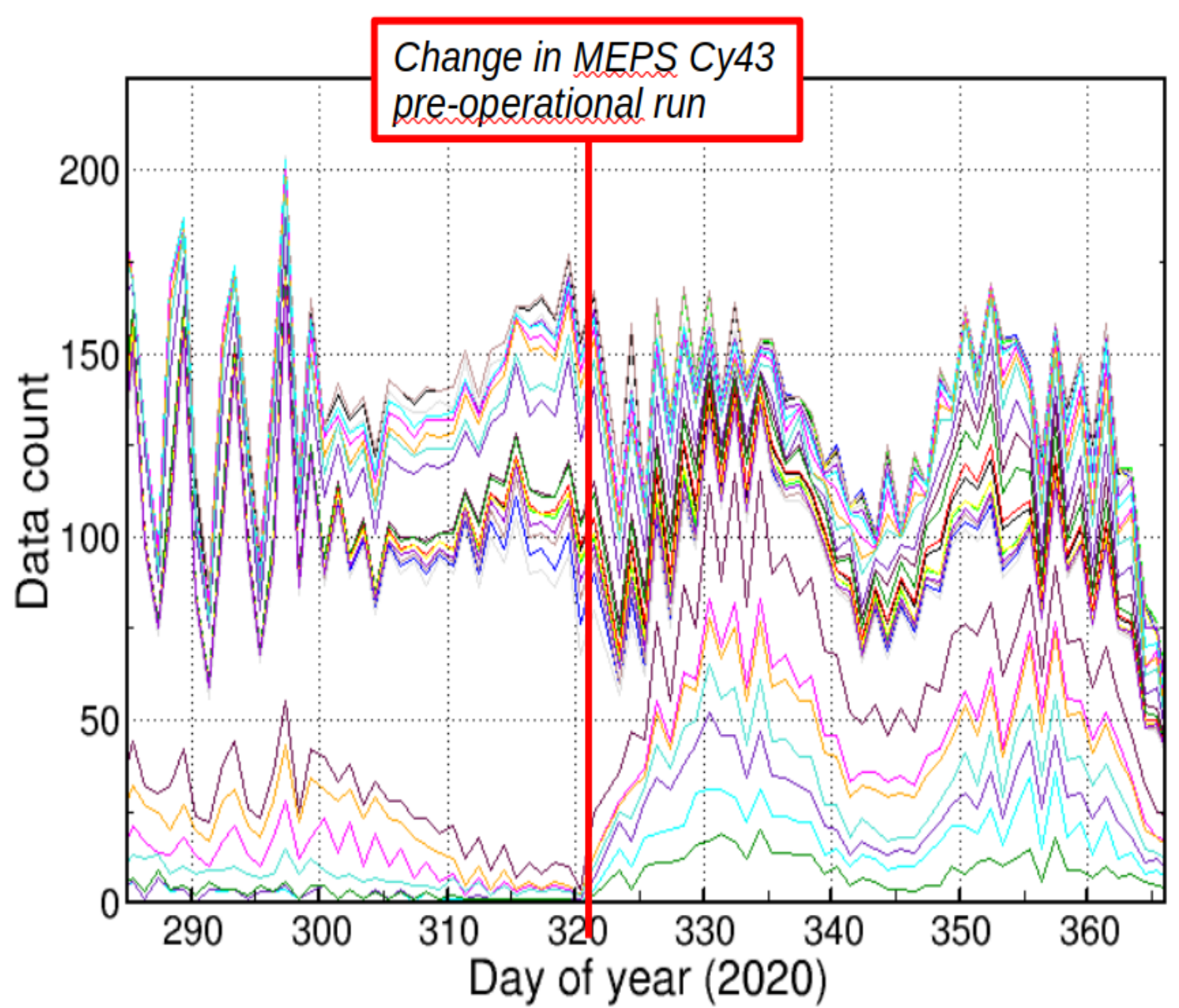
McNally & Watts cloud detection (2003):

- Take a large number of channels from the 15 μm long-wave infrared sounding band
- We use 148 channels to detect cloud in IASI (Infrared Atmospheric Sounding Interferometer) data
- Many of the cloud-detection channels are not used in the assimilation
- Rank observation minus background (O-B) departures in vertical and apply a smoothing filter
- Find the “breaking point” that marks the distinction between clear and cloud-affected channels

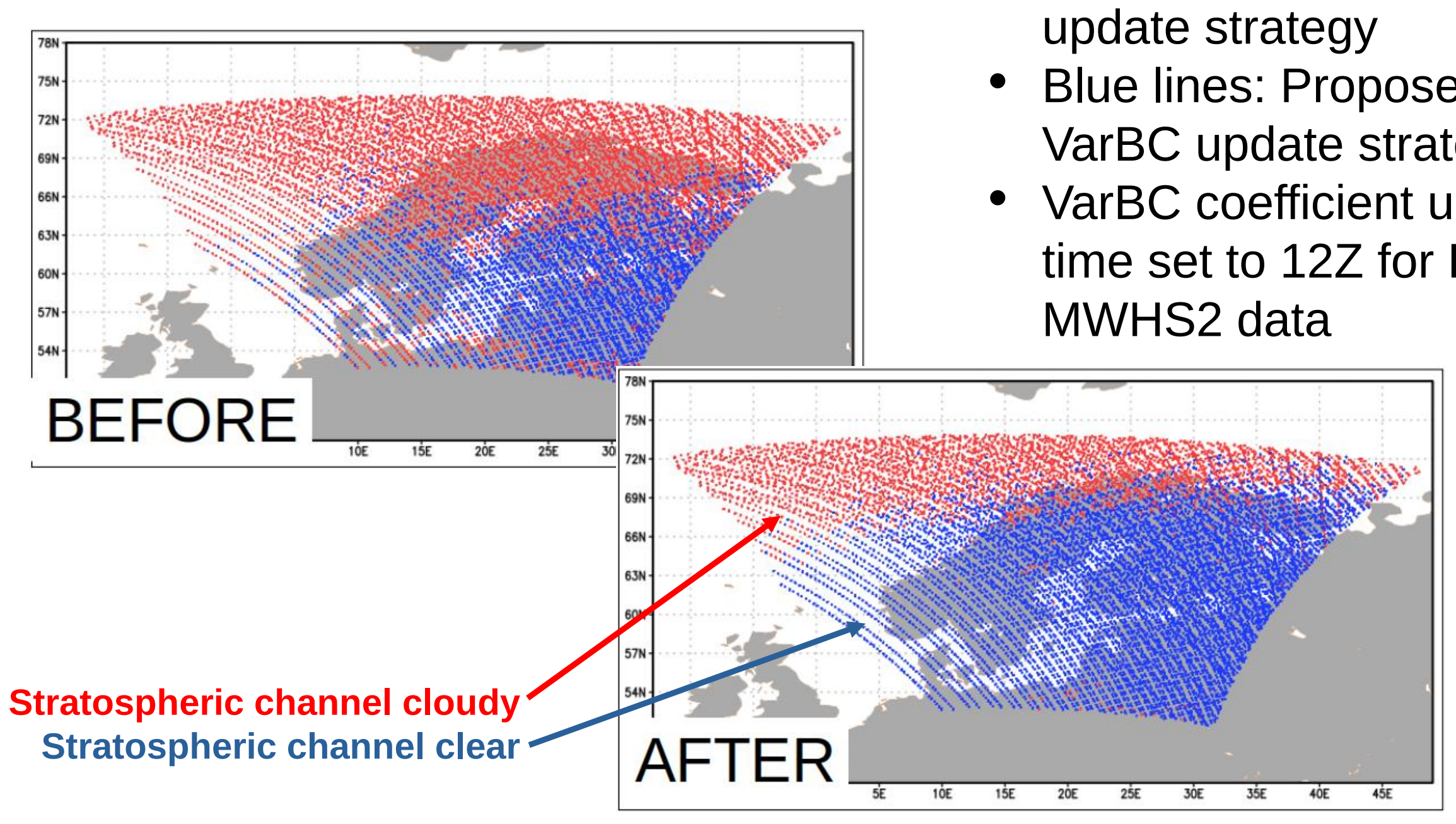
- **Previously we applied bias correction only to the subset of actively-assimilated channels**
- **Improved performance through bias-correcting the cloud-detection channels too**

McNally & Watts (2003): *A cloud detection algorithm for high-spectral-resolution infrared sounders.* https://doi.org/10.1256/qj.02.208

Improved cloud detection → more homogeneous sampling of tropospheric sounding channels

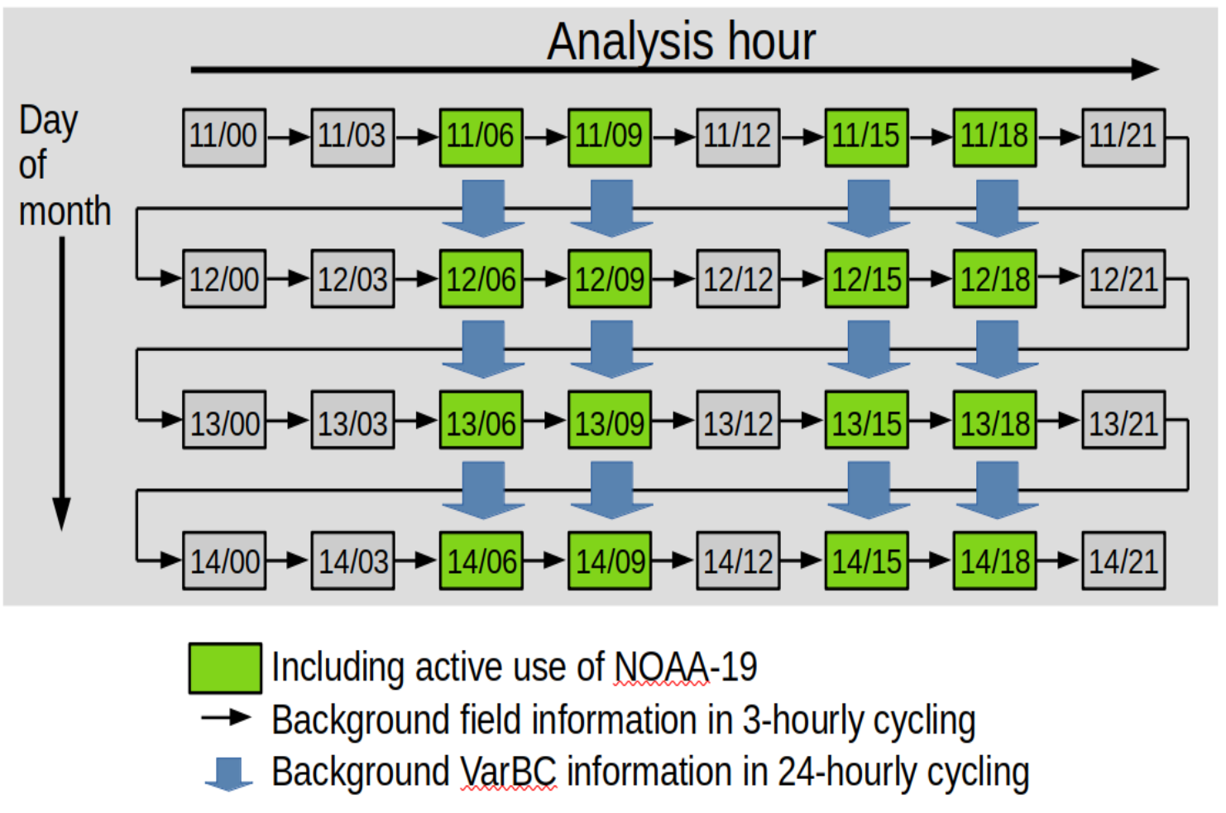


Improved cloud detection → more complete sampling of stratospheric sounding channels

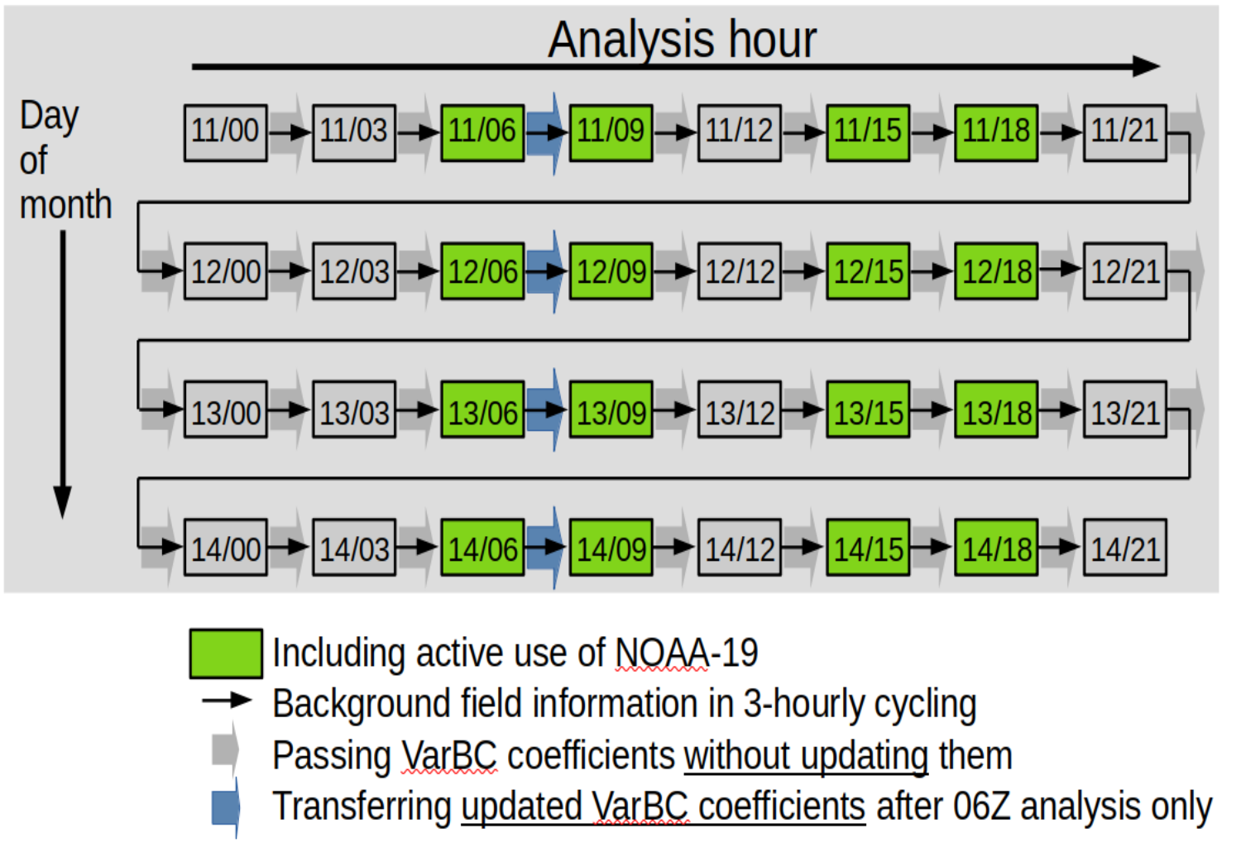


Testing an alternative strategy to update VarBC coefficients in LAM

Update strategy as it stands (for NOAA-19)



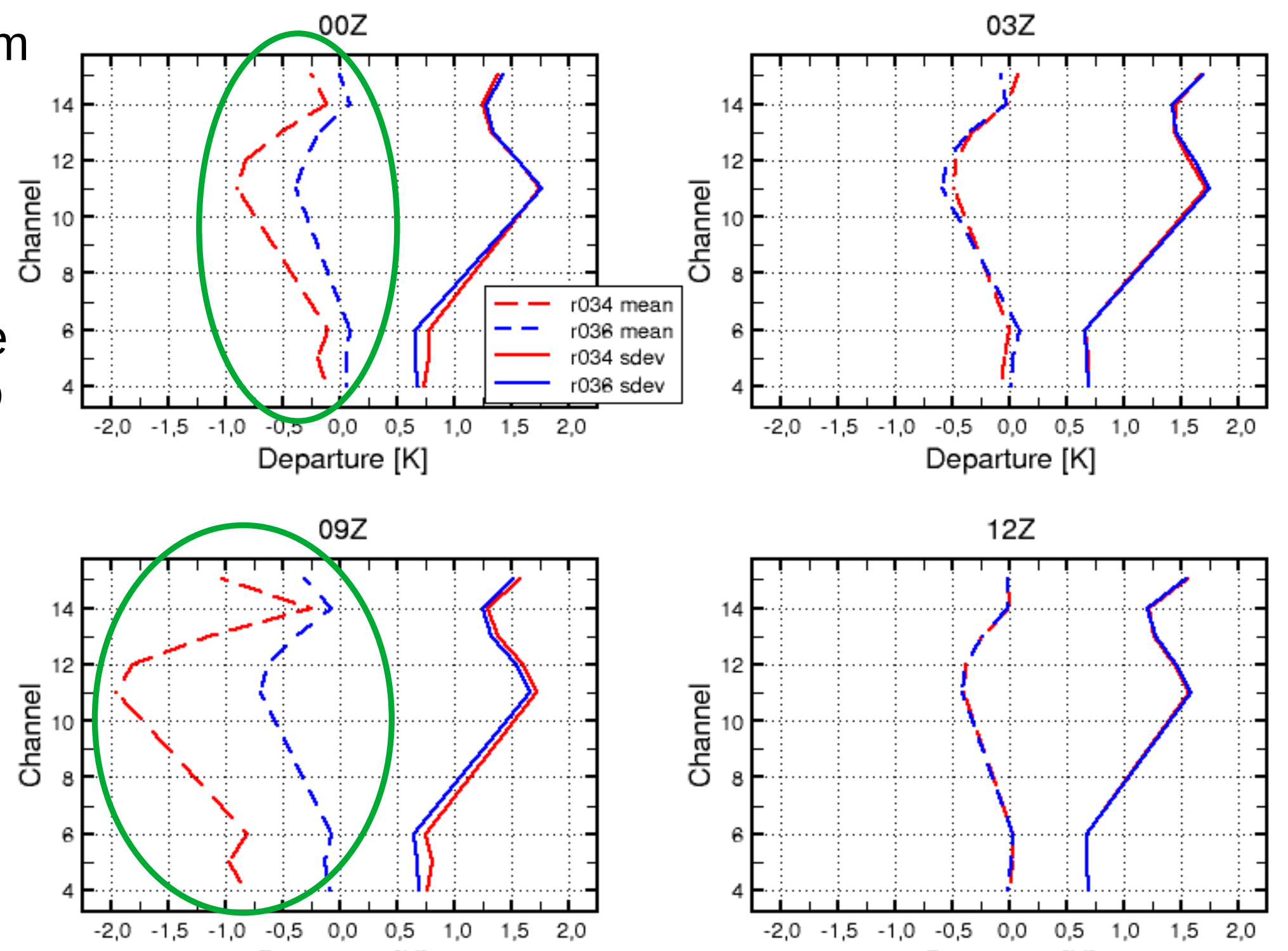
Proposed update strategy (for NOAA-19)



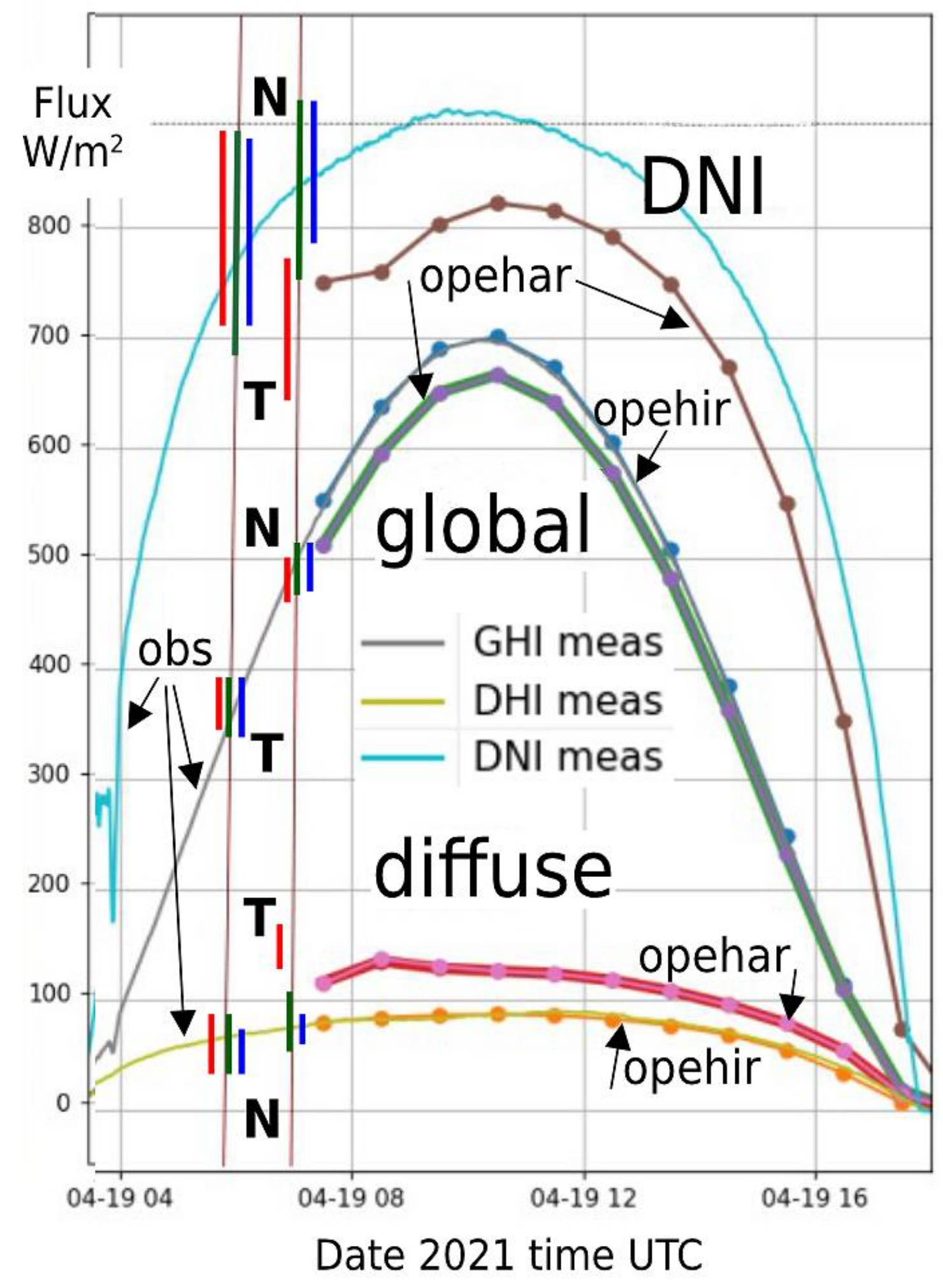
- Currently we apply 24-hour cycling for variational bias correction (VarBC) coefficients to avoid problems due to large variations in observation coverage
- We are considering to switch to 3-hour cycling in VarBC
- However limiting the updating of VarBC coefficients once per day
- The satellite-specific VarBC update times will be chosen such that observation coverage is “as complete as possible”, but potentially also taking into account the availability of radiosonde data to provide anchoring

Example: Improved monitoring statistics in MicroWave Humidity Sounder 2 of Fengyun 3D satellite (FY3D MWHS2)

- Showing mean and standard deviation in O-B departure in a 34-day sample over the MetCoOp LAM domain
- Red lines: Control system with the current VarBC update strategy
- Blue lines: Proposed VarBC update strategy
- VarBC coefficient update time set to 12Z for FY3D MWHS2 data



Testing and development of radiation and aerosol parameterizations in HARMONIE-AROME



Impact of aerosols on NWP is often studied during wildfire, dust intrusion, volcanic eruption episodes. From the point of view of everyday forecast, that may include a forecast of the direct solar radiation for energy producers, it would be interesting to evaluate model performance - the range of uncertainty, possible bias, related to aerosols in clean-air conditions.

As an example, the figure shows radiation in Helsinki on the 19th of April 2021. Shown are direct normal irradiance (***DNI***), global (GHI, ***global***) and diffuse (DHI, ***diffuse***) short-wave radiation fluxes at the surface. Thin solid curves show observed every-minute values, thick and thin curves with dots show operational HARMONIE-AROME (***opehar***) and HIRLAM (***opehir***) hourly-averaged results. Two vertical lines denote 6 UTC and 7 UTC, when single-column model (MUSC) diagnostic experiments were run. At 7 UTC, a thin ice cloud appeared around the pressure level of 200 hPa, with a very small vertically integrated specific ice content of 1 g/m^2.

In the operational HARMONIE-AROME forecast, the Tegen aerosol optical depth and the IFS radiation scheme are applied by default. In the operational HIRLAM forecast, simple prescribed coefficients account for aerosol scattering and absorption. In this clean-air case, opehir performed well for the global and diffuse radiation[1]; opehar underestimated the direct and overestimated diffuse radiation flux, also the global radiation was somewhat underestimated.

Single-column (MUSC) experiments were run in order to understand the uncertainties and sensitivities of the radiation fluxes to the aerosol treatment and radiation parametrizations. The short vertical bars show the range of values suggested by three different radiation schemes, available for HARMONIE-AROME experiments: the default IFS cycle25 scheme (*red*), acraneb (*green*), hlradia (*blue*). ***N*** in the end of the bars denotes the results obtained when no aerosol was assumed in the calculations, ***T*** denotes results due to the use of default Tegen aerosol and related optical properties. MUSC output represent instant (one-minute) values. Details of the MUSC results - the numbers inside the vertical bars - are given in the table. Preliminary conclusions based on the MUSC experiments are given here.

In all cases, the lowest global and direct and the highest diffuse SW fluxes were due to the use of default Tegen AOD at 550nm of 6 aerosol species[2]. As expected, the highest global and direct, lowest diffuse fluxes were obtained when no aerosols were assumed. In-between and closer to the observations are the values from experiments, where aerosol input was derived from the mass mixing ratio (MMR) of 11 aerosol species using the new aerosol inherent properties from ECMWF. Either two-dimensional total climatological or three-dimensional near-real-time MMR values were obtained from Copernicus Atmosphere Monitoring Service data via three-dimensional HARMONIE-AROME experiments.

The range of differences/uncertainty was tens of W/m^2 for global (340-382/458-504), diffuse (44-86/61-156) and direct solar radiation at the surface. Direct normal irradiance (682-893/626-915) appeared the most sensitive to aerosol and clouds variable. This is because of its large range of values that depend on the solar elevation. The magnitude of aerosol impact was comparable to the impact of a thin (cirrus) cloud. The IFS radiation parametrizations reacted strongly to the cloud, independently of the aerosol impact. The total aerosol optical depth at 550 nm was well correlated with the radiative impact, although it is not directly applied in the model's parametrizations.

Downwelling SW radiation at the surface [W/m^2] and aerosol optical depth at 550 nm [unitless]

	DNI 6 / 7 UTC	Global 6 / 7 UTC	Diffuse 6 / 7 UTC	Total AOD550
Observed	769 / 835	367 / 494	63 / 76	0.07
Zero aerosol				0.00
IFS	887 / 760	382 / 492	45 / 122	
hlradia	881 / 912	380 / 504	47 / 61	
acraneb	893 / 915	384 / 504	44 / 58	
Tegen 2D AOD550				0.21
IFS	697 / 626	350 / 461	86 / 156	
hlradia[1]	701 / 782	340 / 458	74 / 78	
acraneb	682 / 742	345 / 465	86 / 104	
CAMS 2D AOD550				0.17
IFS	738 / 656	359 / 471	78 / 152	
hlradia[1]	751 / 818	352 / 473	68 / 76	
acraneb	734 / 785	365 / 476	78 / 94	
CAMS 2D MMR				0.06
IFS-sul[2]	829 / 720	374 / 485	59 / 135	
hlradia[1]	751 / 818	363 / 492	55 / 66	
hlradia-all[3]	847 / 888	372 / 495	52 / 64	
acraneb	831 / 866	372 / 493	57 / 71	
CAMS 3D n.r.t.				0.12
IFS	784 / 689	369 / 485	72 / 147	
hlradia[1]	831 / 852	363 / 486	62 / 72	
hlradia-all[3]	810 / 861	362 / 484	56 / 66	
acraneb	787 / 830	368 / 489	69 / 85	

[1] hlradia aerosol inherent optical properties derived from GADS/OPAC aerosols for 6 IFS species (Baklanov et al. 2017, https://doi.org/10.5194/gmd-10-2971-2017)

[2] indirect effect of sulfate aerosols parametrized

[3] aerosol inherent optical properties from ECMWF/CAMS (Bozzo et al. 2020, https://doi.org/10.5194/gmd-13-1007-2020)

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[1] *DNI is not shown for HIRLAM. It would be obtained from the difference global-diffuse divided by cosine solar zenith angle.*

[2] *The monthly climatological values, given in a coarse latitude-longitude grid of 2.5 degrees, are interpolated horizontally to the model's 2.5 km grid and distributed to the model levels according to predefined exponential profiles, then combined with hardcoded inherent optical properties for different SW and LW wavelengths.*