Cycle 46R1 overview

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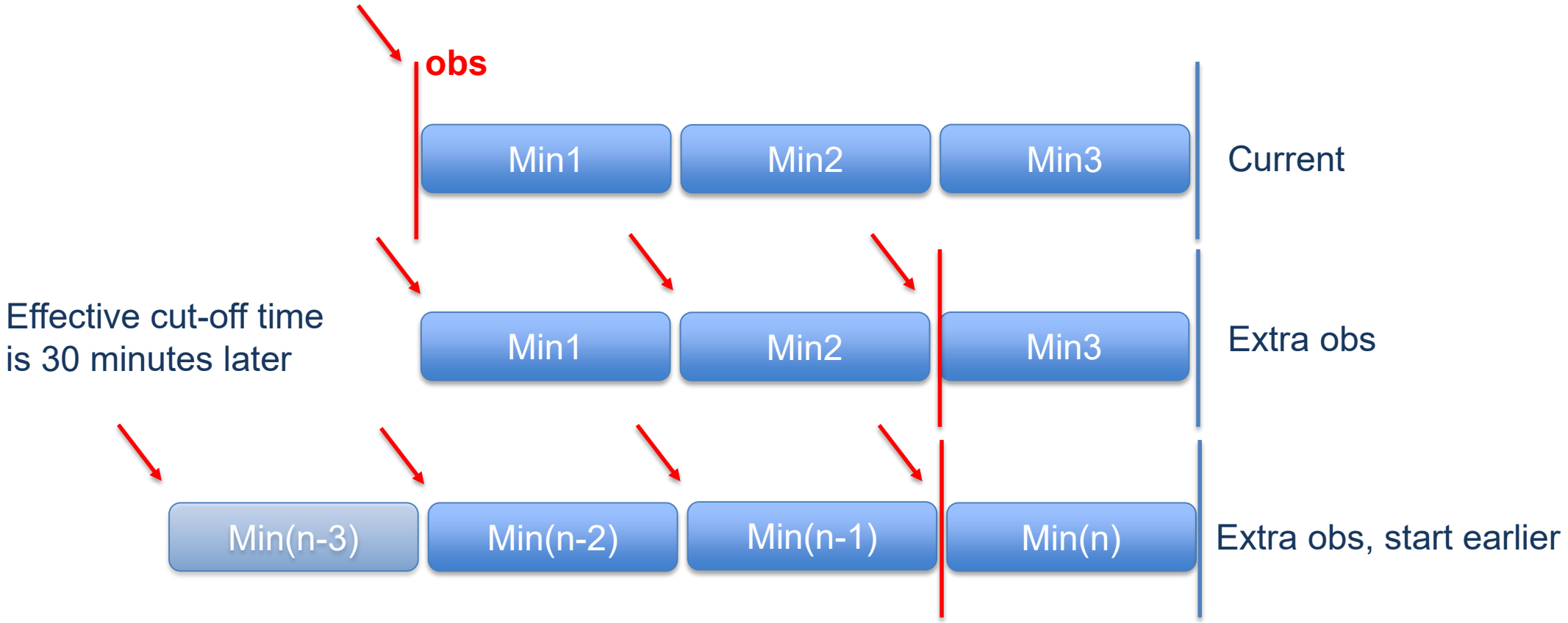
Data assimilation and observation highlights

- Continuous Data Assimilation
- Ensemble of Data Assimilations (EDA) increased from 25 members to 50 members
- New ENS initialization from 50-member EDA – members now exchangeable
- More efficient and more coupled soil moisture analysis
- Assimilation of SMOS neural network soil moisture product
- New microwave channels assimilated (e.g. 150, 166GHz SSMIS F-17) and improved data usage
- Increased and improved use of geostationary radiance data
- RTTOV upgraded from v12.1 to v12.2
- Weakly coupled data assimilation introduced for sea-surface temperature in the tropics
- Consistent spatial interpolation of the model to observation locations in trajectories and minimisations

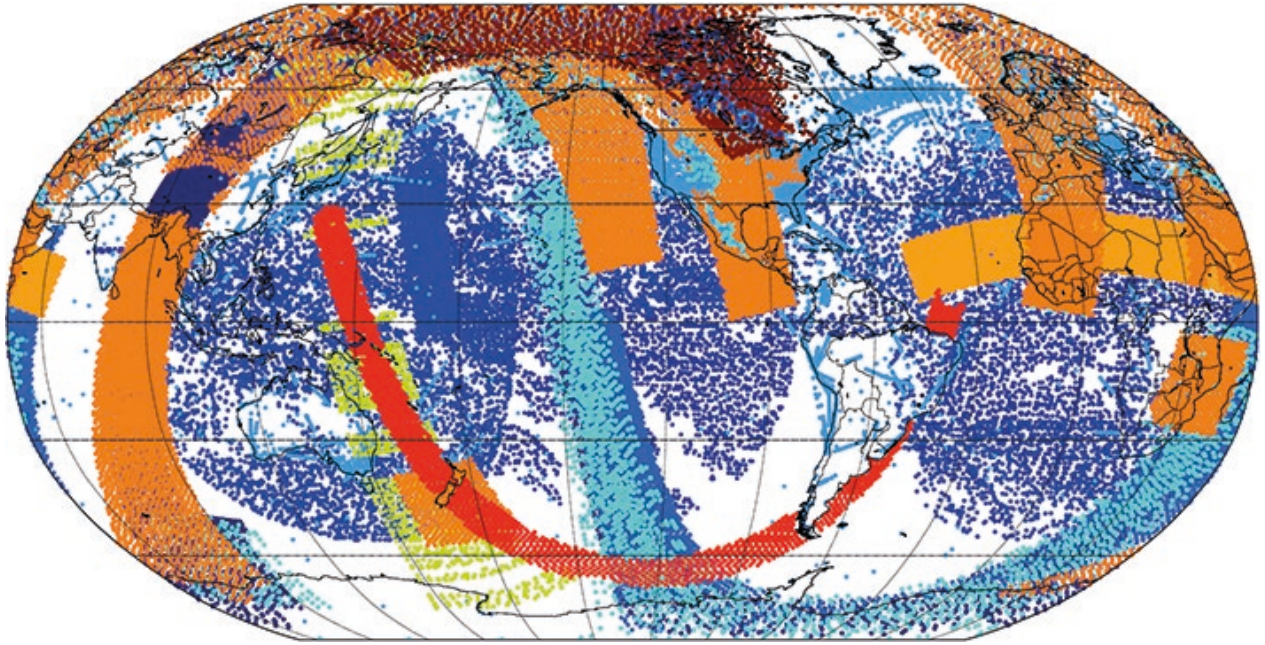
Continuous data assimilation



- Key point: Start running data assimilation **before** all of the observations have arrived:
  1. Most of the assimilation is removed from the time critical path
  2. Configurations which were previously unaffordable can now be considered

Continuous Data Assimilation

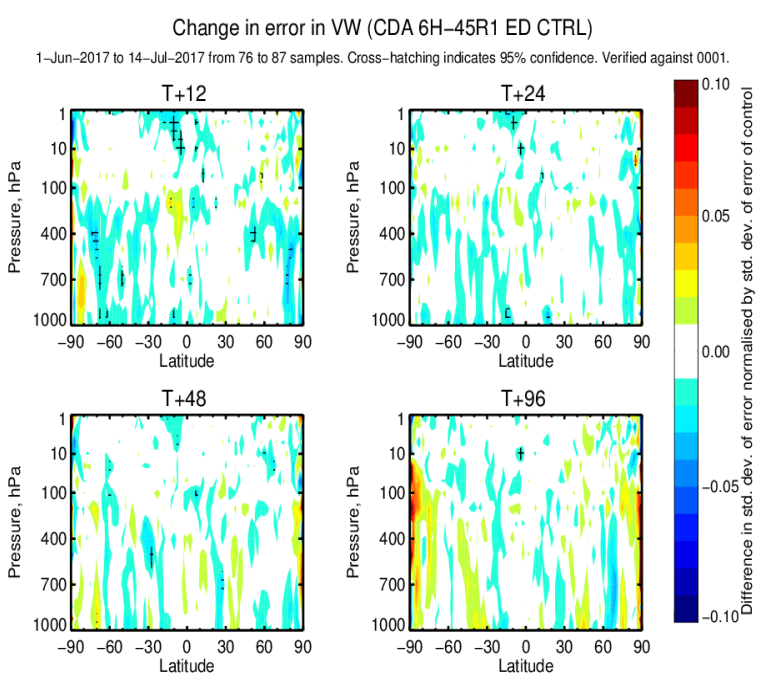
- Decouples observation cut off time from when we can start the assimilation
- Combines 3 main ideas:
  - Later observation cut off
  - Extend assimilation window (6 to 8 hours) to use all available observations
  - Use an extra 4D-Var outer loop

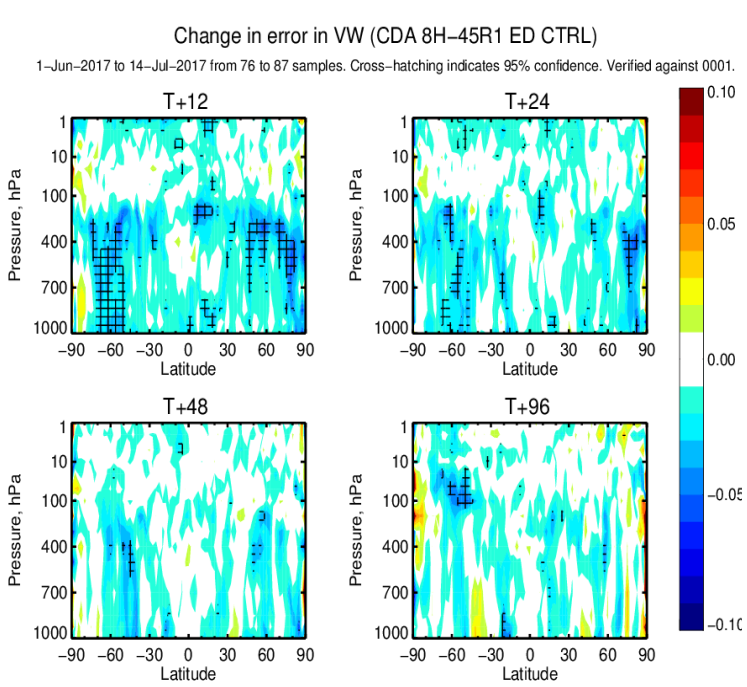


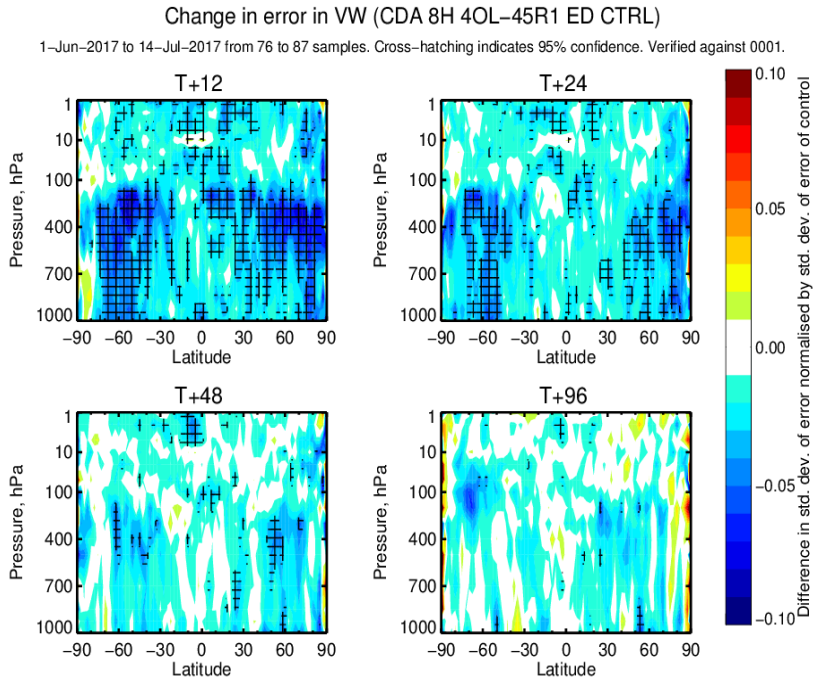
Example of extra observations assimilated in a single continuous DA cycle compared to the current operational setup. They include satellite observations from a large number of instruments as well as in situ measurements.

Continuous DA

- **Preliminary results (Wind Vector error stdev, 1/6/17 – 14/7/17)**







A: Late obs – 6h window

B: Late obs – 8h window

C: B + 4 outer loops

50 Member EDA

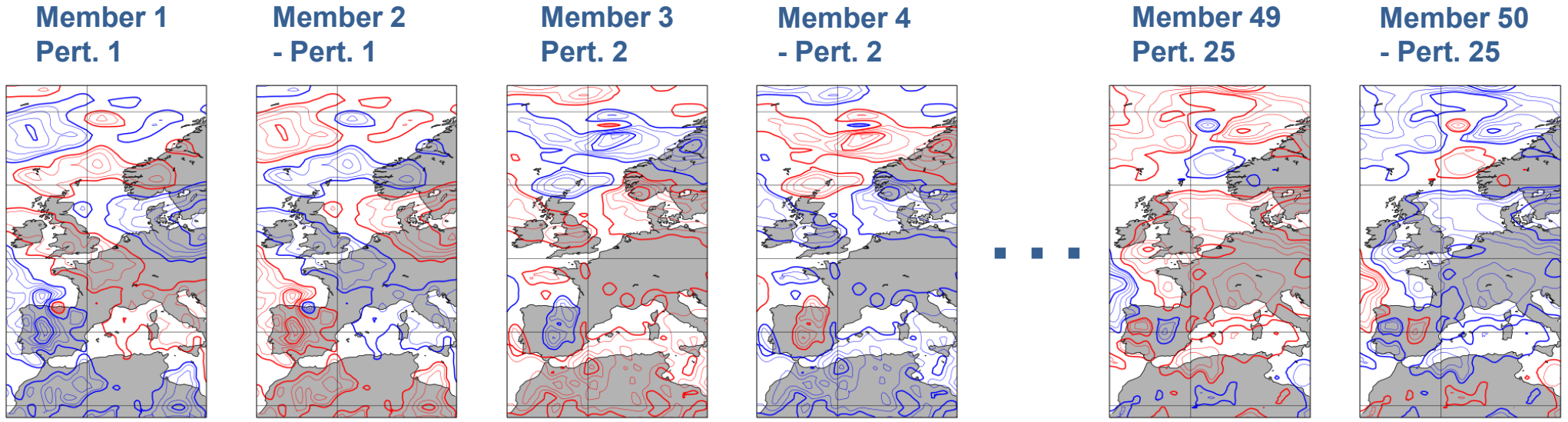
Made possible through a large number of optimizations:

- Minimisations for EDA members are preconditioned by the control (20% fewer iterations)
- Inactive observations have been removed
- Optimizations found in observation operator interpolations
- Observation space spread monitoring has been moved outside of the critical path
- Surface soil moisture analysis using 1D-OI instead of SEKF

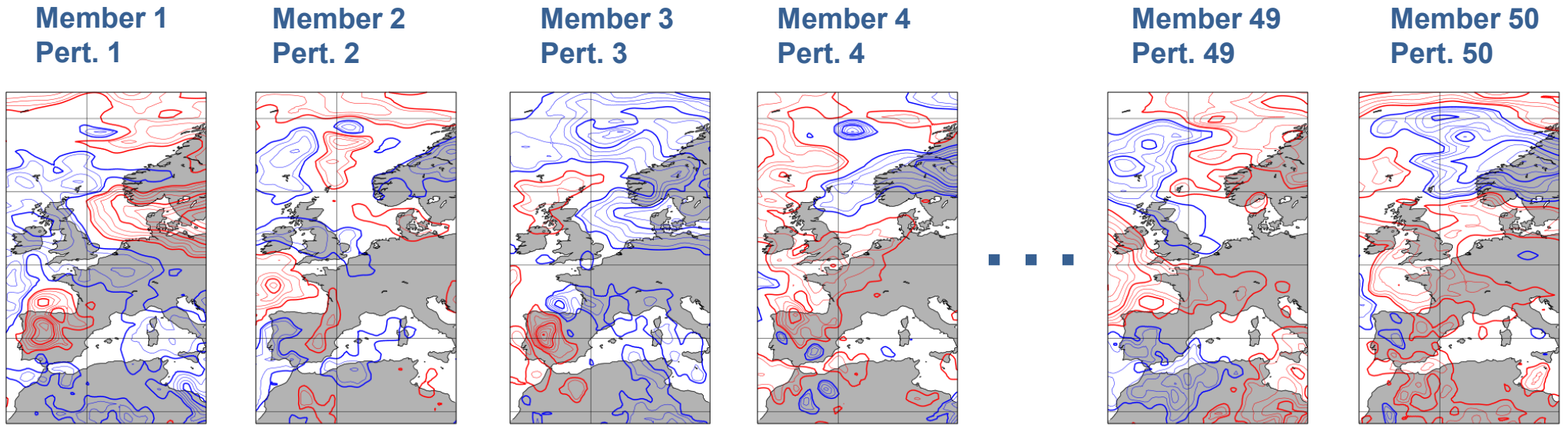
New way to perturb the ensemble initial conditions for 50 Ensemble Members

Old:
Plus-Minus
Symmetry with
Perturbations from
25-Member EDA

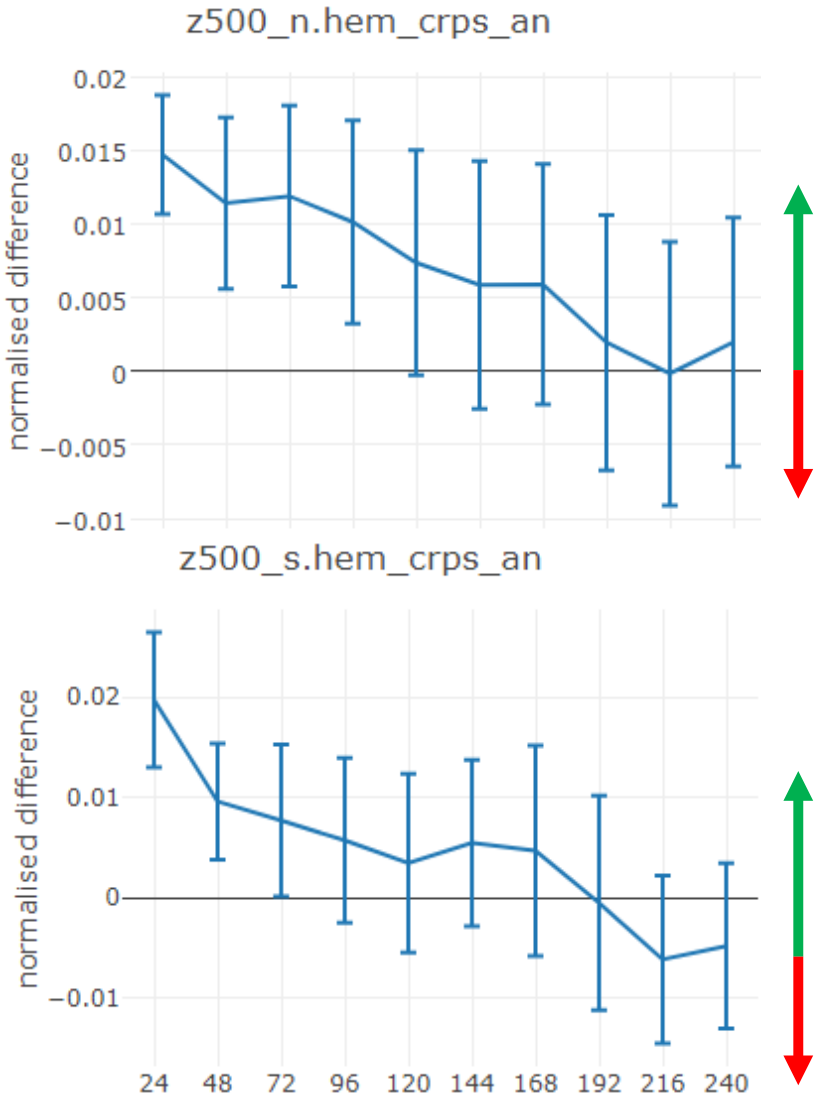
z 500hPa

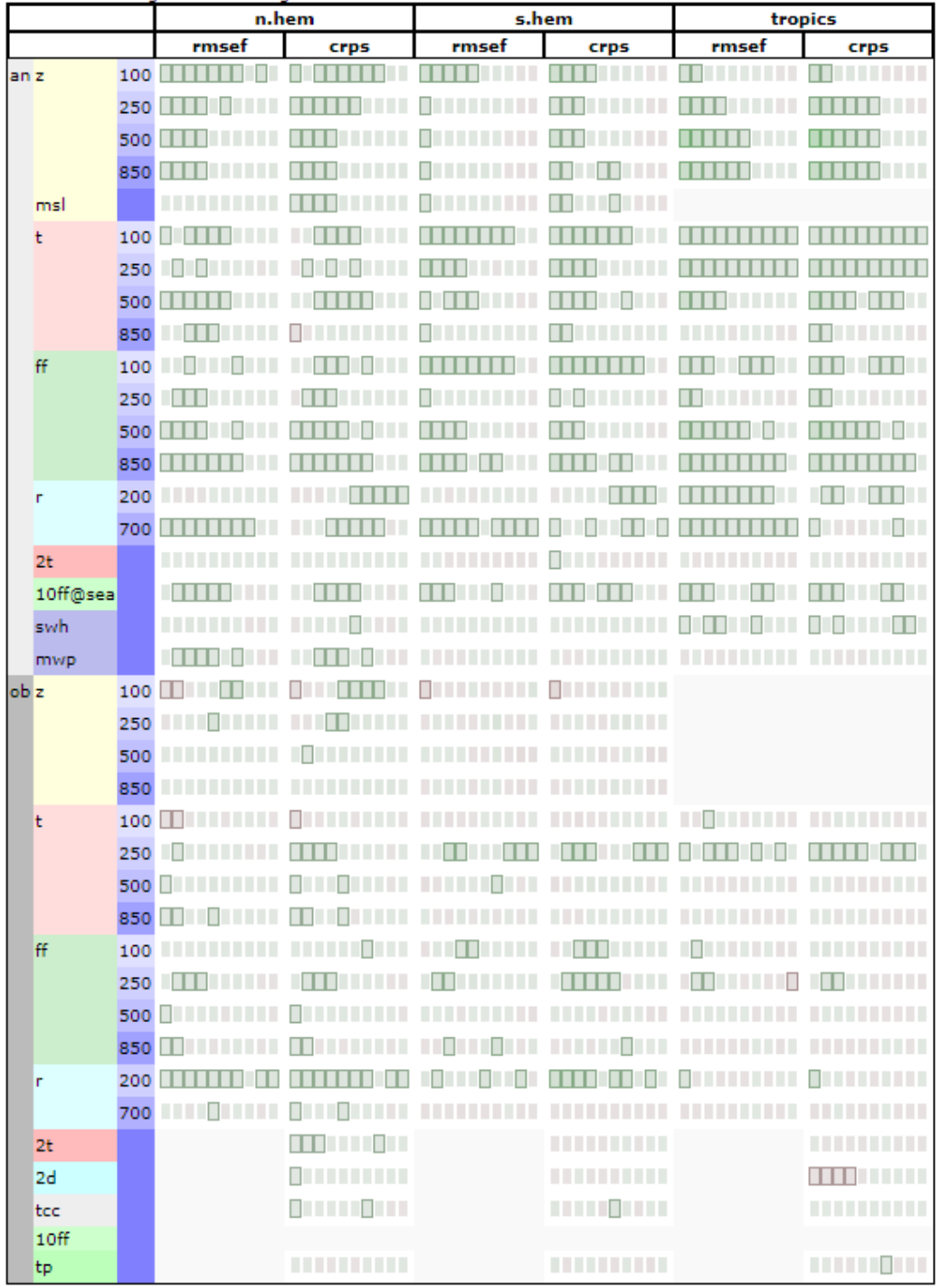


New:
Perturbations
from new
50-Member EDA



Impact of new ENS configuration with 50 EDA members





ENS TCo399, 50 members: started from TCo399 centre analyses, winter and summer

Ref :
Pert : +- symmetry EDA- and SV-pert

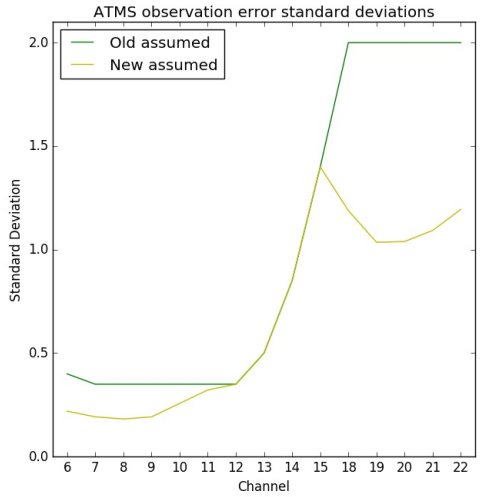
centre analysis : like current HRES, 25 EDA members for B and variances

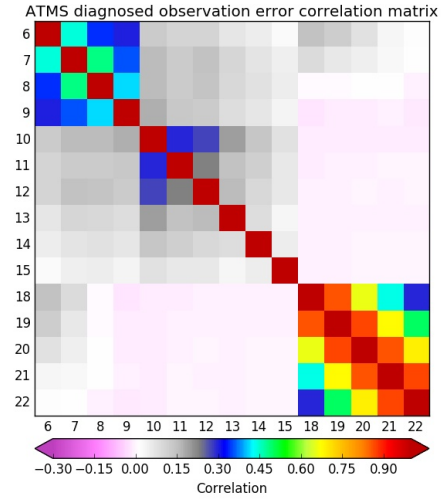
New :
Pert : no +- symmetry EDA- and SV-pert

centre analysis : 50 EDA members for B and variances ; mix of 10% climatological and 90% flow dependent variances

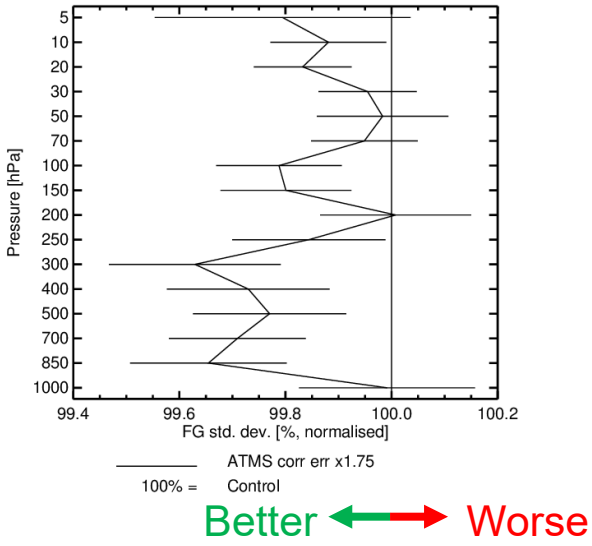
Accounting for Suomi-NPP ATMS inter-channel error correlations

- Smaller diagnosed error standard deviations than those assumed operationally
- Significant correlations between humidity sounding channels and between temperature sounding channels
- Error standard deviations need to be inflated by 1.75 to give optimal results
- Using the new error covariance matrix results in:
  - Improved short-range forecasts of temperature, humidity and wind
  - Improved extra-tropical forecasts of wind, temperature and geopotential height

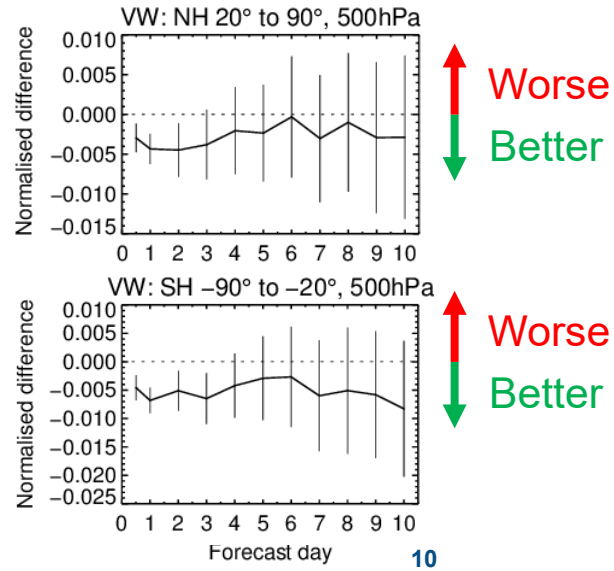




TEMP-T



Change in RMSE of vector wind forecasts

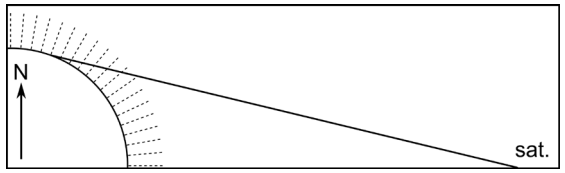


Geostationary radiances

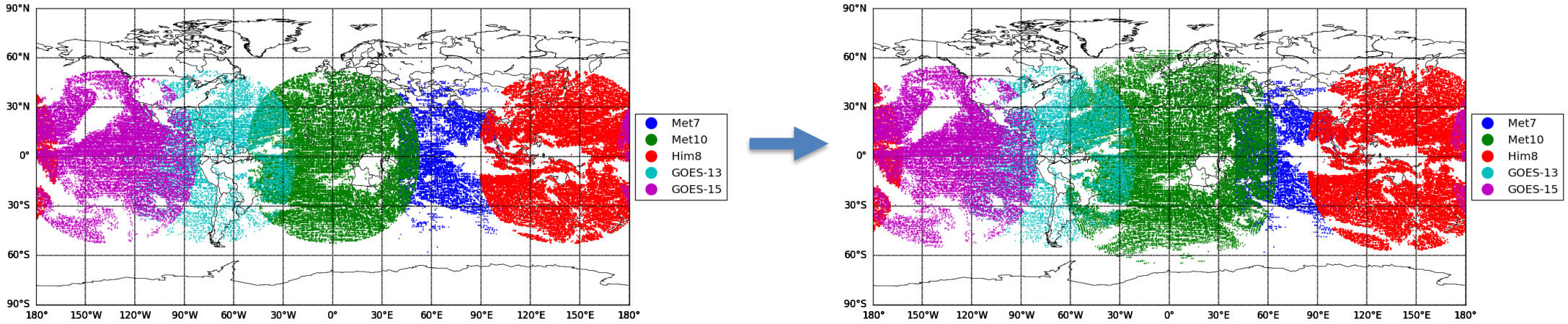
Diagnosed inter-channel error correlations for the water vapour channels on SEVIRI, AHI and ABI. E.g.

$$\mathbf{R}_{SEVIRI} = \begin{pmatrix} 0.46 & 0.20 \\ 0.20 & 0.30 \end{pmatrix} \qquad \mathbf{R}_{AHI} = \begin{pmatrix} 0.55 & 0.43 & 0.22 \\ 0.43 & 0.46 & 0.31 \\ 0.22 & 0.31 & 0.35 \end{pmatrix}$$

Slant path radiative transfer – this improves forward-modelling at high zenith angles:

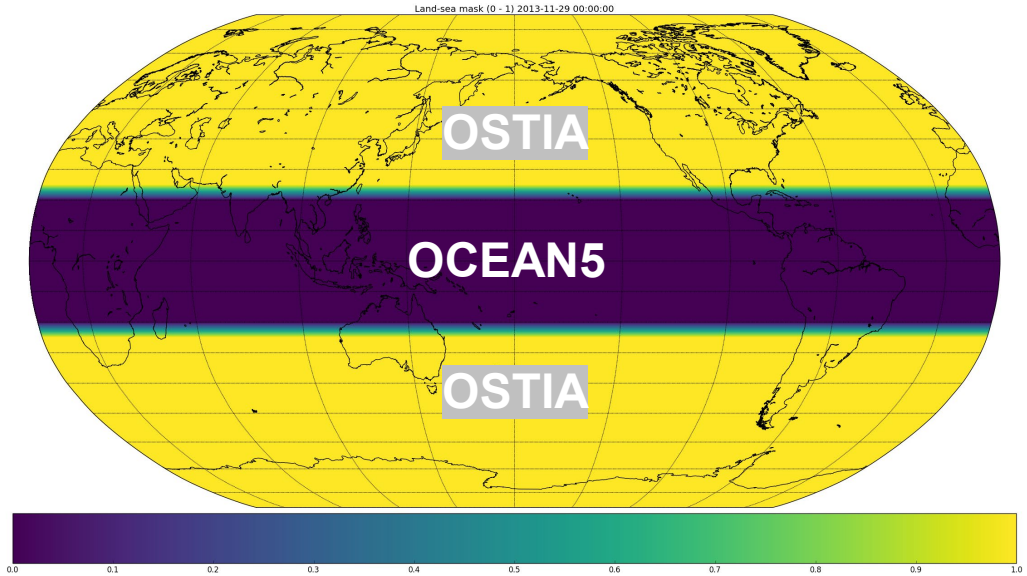


Increased use of data at high zenith angles beyond 60° (assisted by the slant path processing):

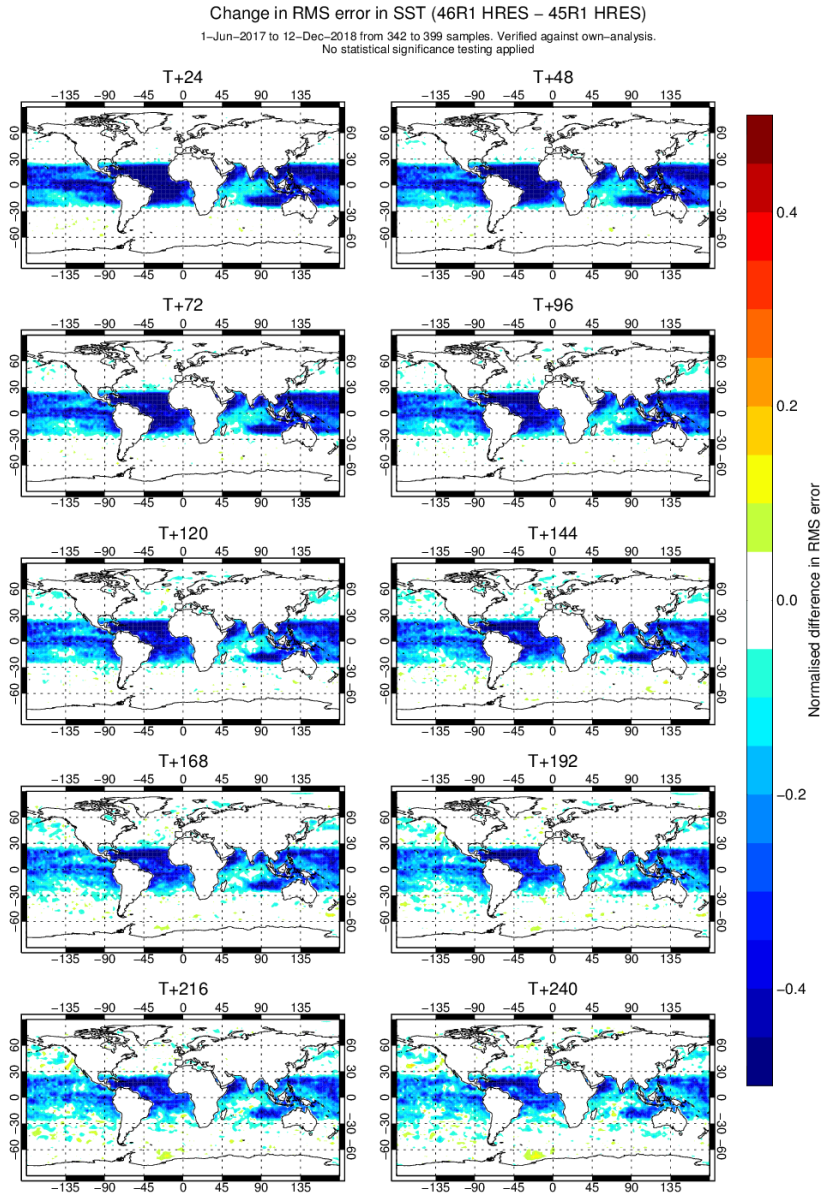


Weakly coupled SST assimilation

- At 45R1: $SST_{\mathrm{AN}} \neq SST_{\mathrm{step\ 0}}$
- From 46R1: $SST_{\mathrm{AN}} = SST_{\mathrm{step\ 0}}$



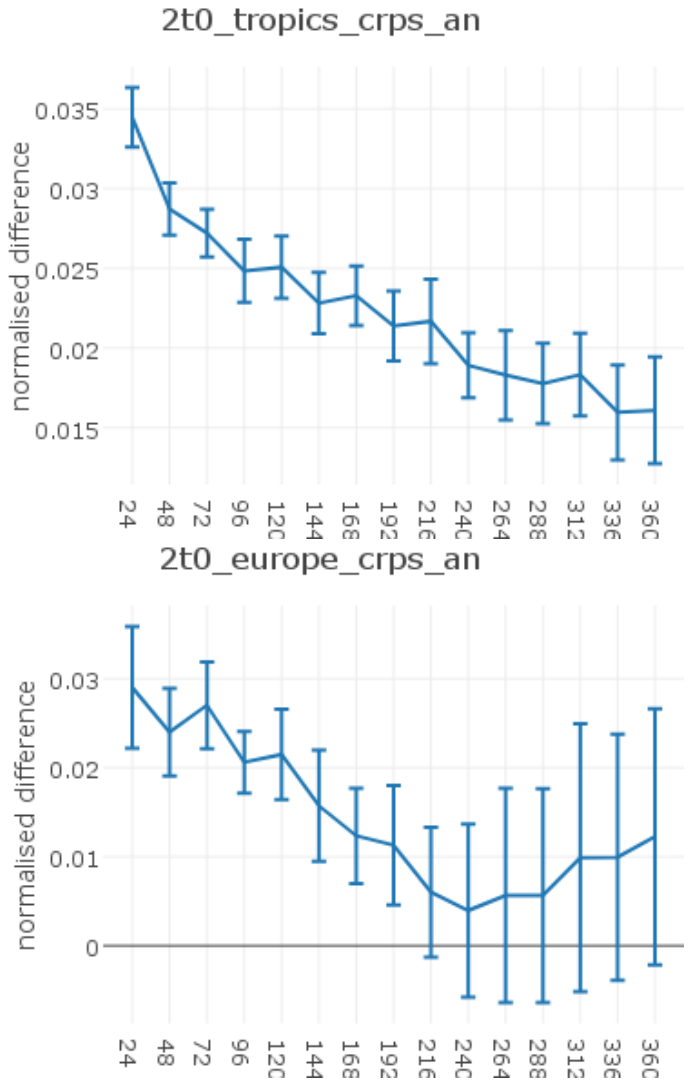
Atmospheric analysis now 'sees' ECMWF OCEAN5-NRT SST in the tropics



Model highlights

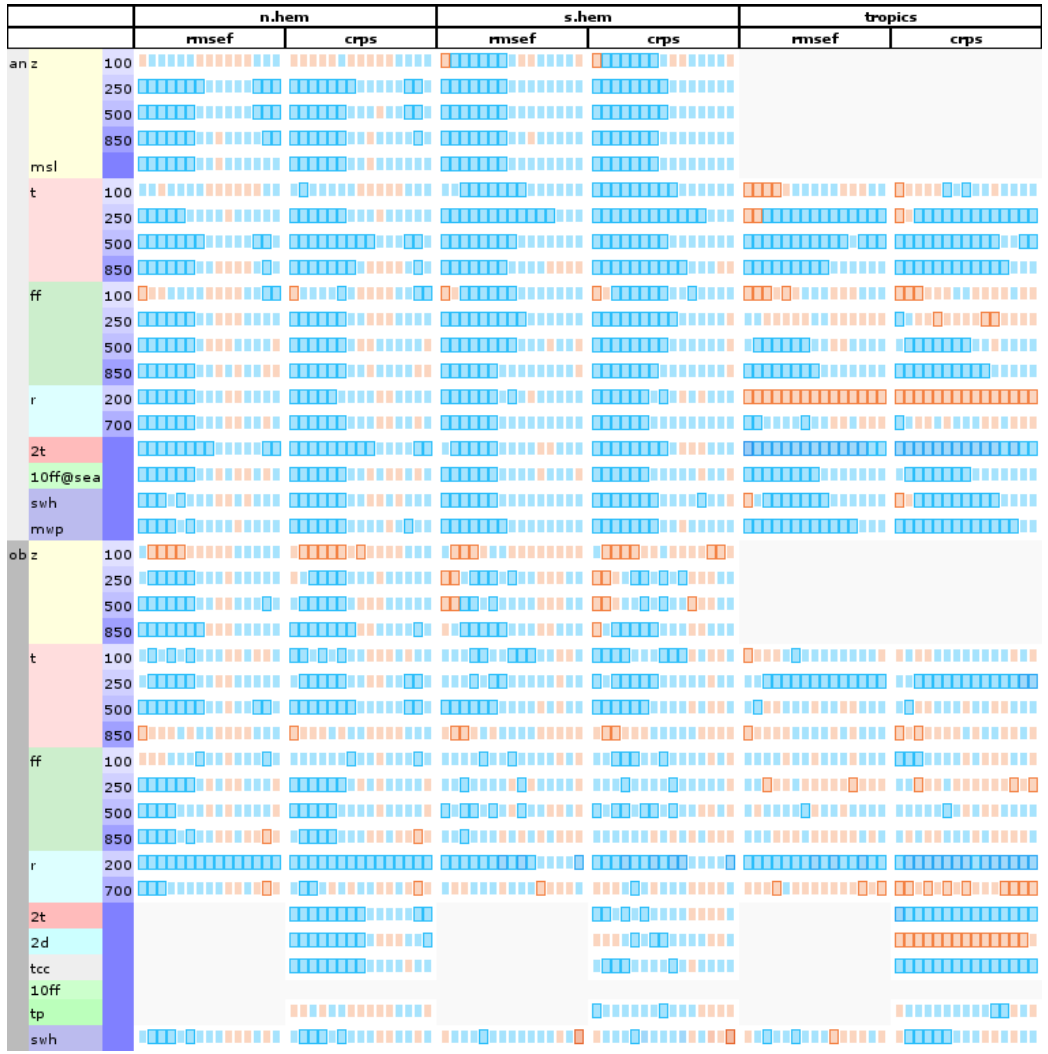
- 1-hour radiation update frequency (timestep) in the ENS (same as in the HRES)
- LW radiation scattering by clouds is turned on
- 2D CAMS aerosol climatology has been replaced by a new 3D climatology
- Convection scheme:
  - Increase in the entrainment of the test parcel
  - A RH dependent area fraction for evaporation replaces a constant value in the shallow convection scheme
- TL/AD improvements (convection; semi-Lagrangian departure point scheme near the poles)
- Adjustment of wet skin tile conductivity
- Improvement in the snow scheme by correctly computing the rain amount that can refreeze
- New version on wave physics based on Ardhuin et al 2010
- New calculation of wave fluxes for NEMO + use of surface currents when coupled to NEMO
- Limit on wave spectrum for very shallow water and minimum depth set to 3m

Impact of 1 hourly radiation on ENS



1 hourly radiation is better

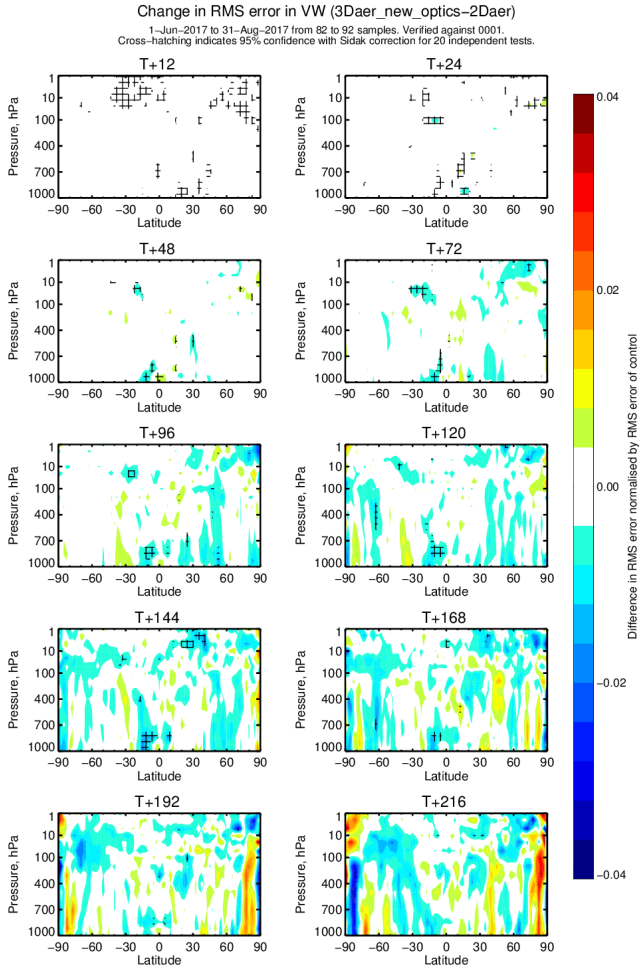
1 hourly radiation is worse

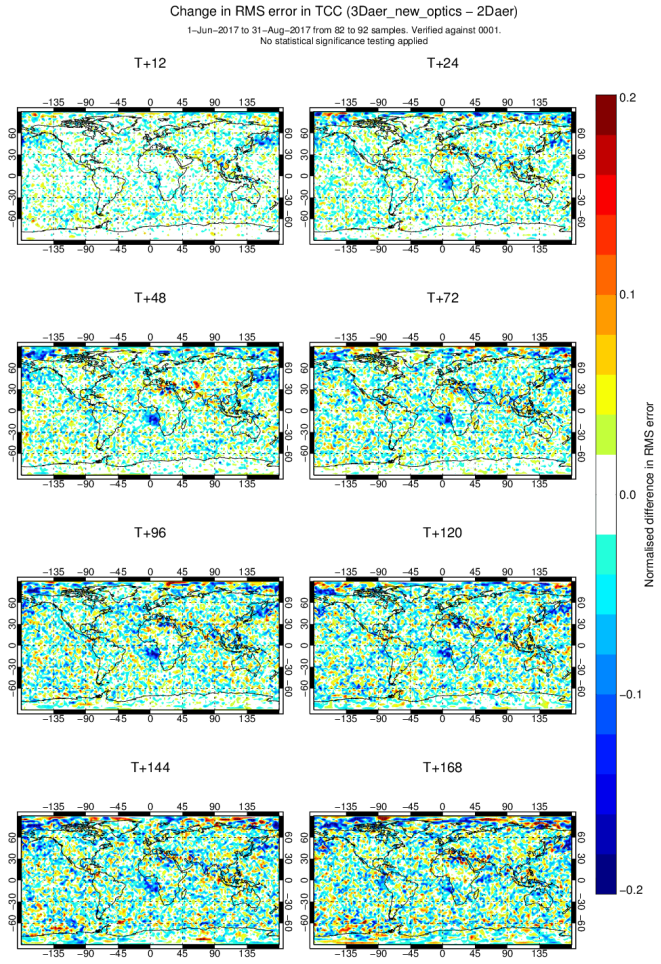


Upgrade to 3D aerosol climatology

- last step in aerosol climatology revision: 3D climatology
  - Reduced number of parameters needed to describe aerosol distribution
  - Easier to compare to full prognostic fields
  - Limited impact, some interesting local effects (e.g. mid Atlantic clouds and winds)

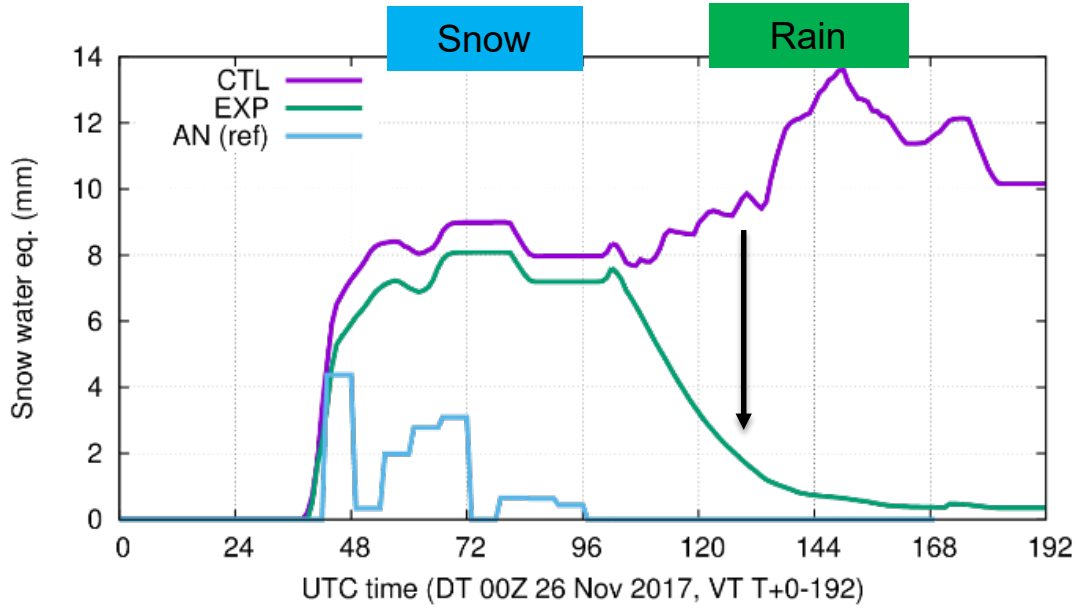
- update aerosol climatology to CAMS reanalysis , harmonized aerosol optics RD-CAMS, working towards flexible prognostic aerosols for use in IFS





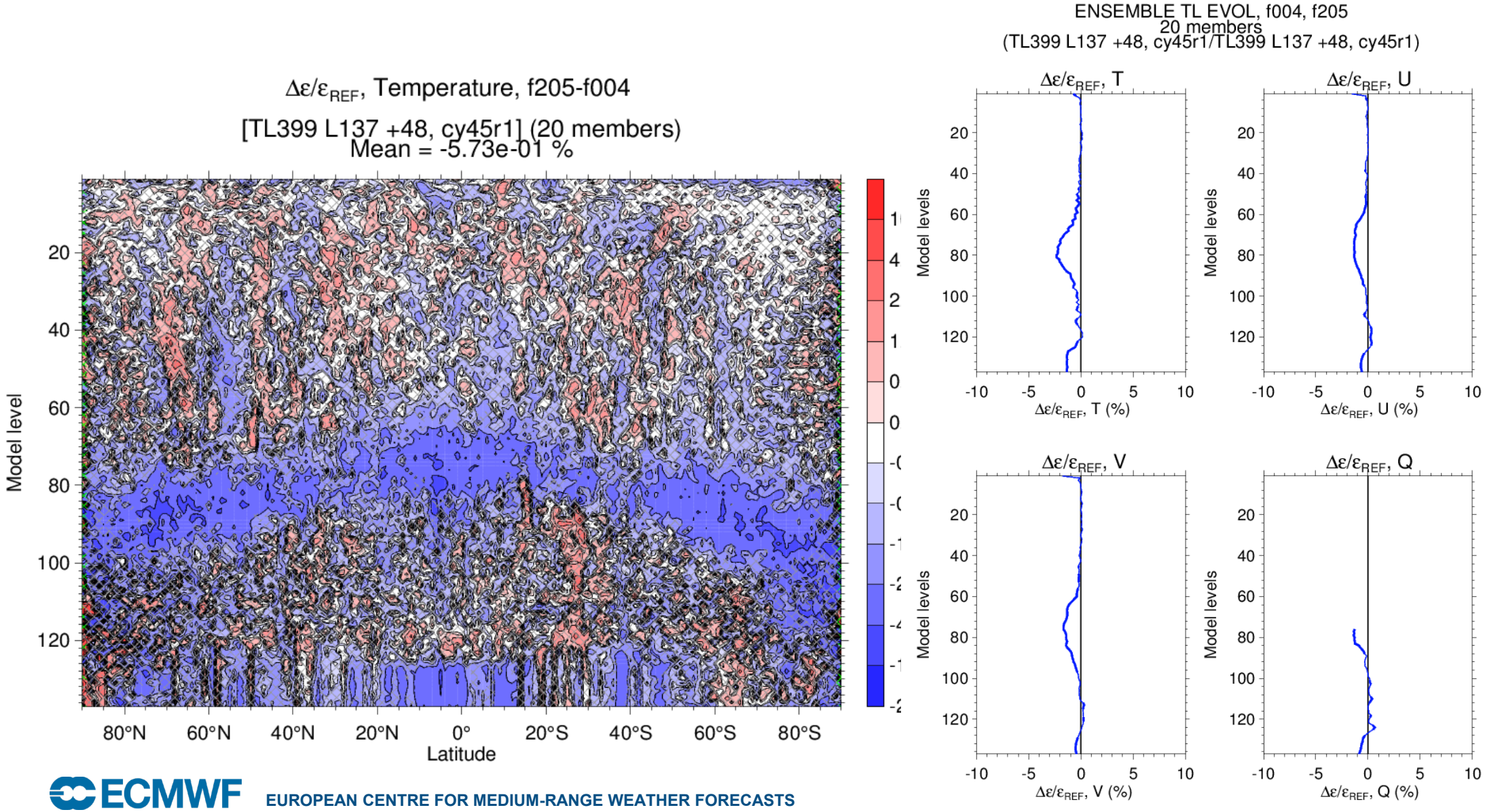
Snow scheme improvements

- Before 46R1 unphysical accumulation of snow in rainy conditions were occasionally observed
- In 46R1 the amount of rain that can refreeze when intercepted by the snowpack is improved
- This results to improved handling of “episodically occurring” snow events



Left: forecast time series from 26 November 2017 at 00UTC of snow water equivalent for a site in Bulgaria (41.44N,24.6E). CTL: operational. EXP: 46r1 scheme. AN: operational analysis (AN).

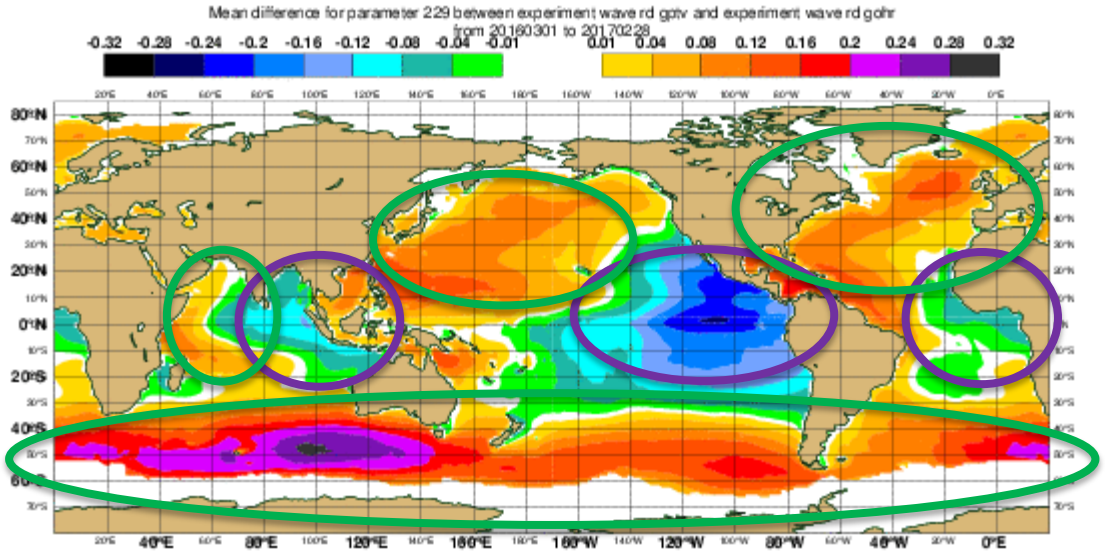
TL approximation improvement: 46R1 physics changes vs CTL (blue is good)



Modified wave physics

The wave model has the tendency to produce
- too much swell in the deep **Tropics**
- too little waves in the **stormy/windy areas**.

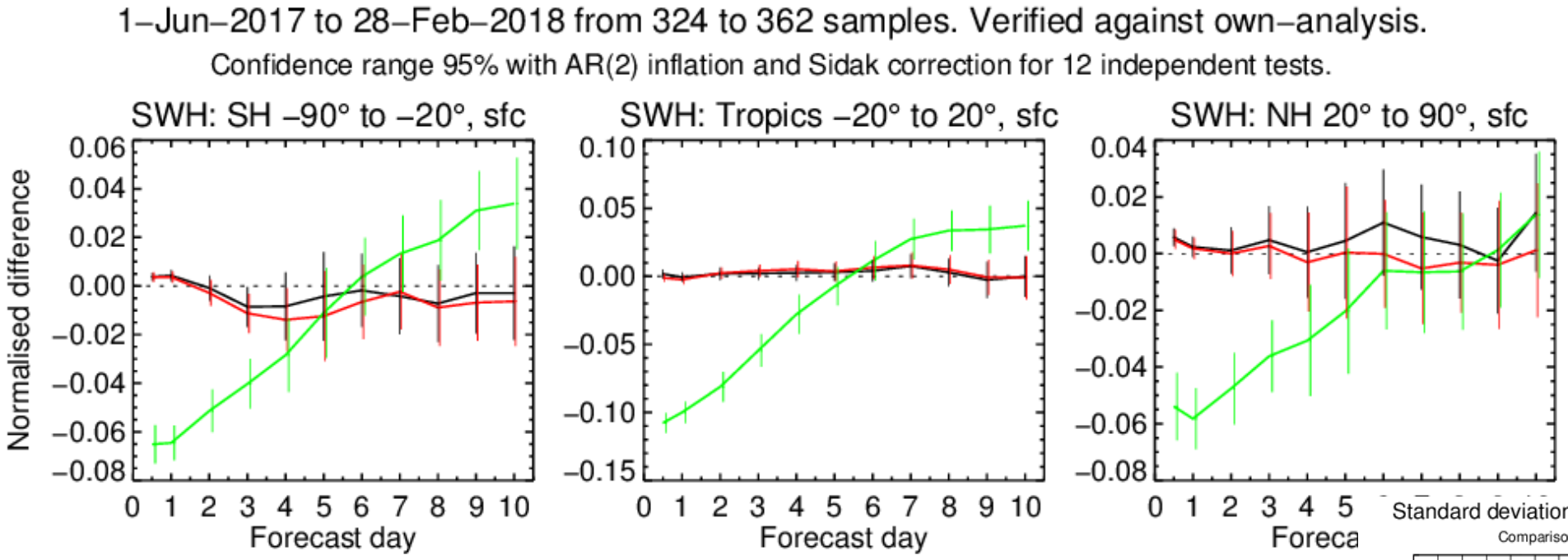
The modified wave physics, based on the work of Ardhuin et al. 2010 generally addresses this issue:



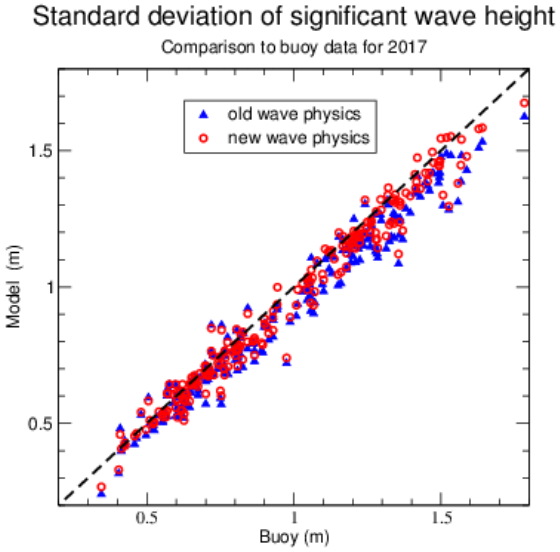
new – default

Stand alone hindcast for 1 year, forced by ECMWF analysis winds:
Mean Significant wave height difference (m)

Wave model improvements: impact on “significant wave height” (SWH)



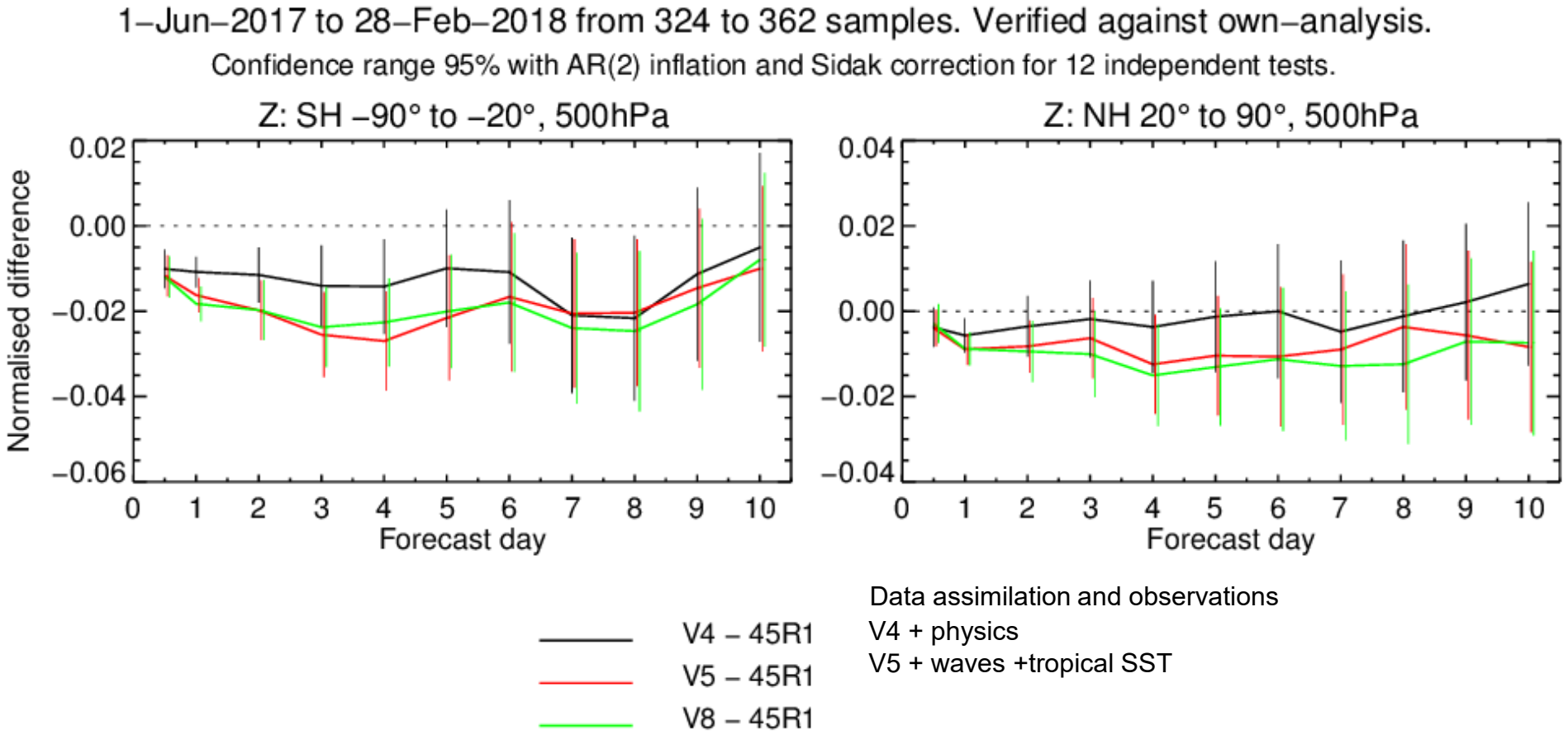
- Green line shows the positive impact of wave model changes in SWH
- Increased RMSE error at +6d and beyond is due to increased model activity. However, ACC remains positive (not shown here)



Incremental testing of contributions to 46r1

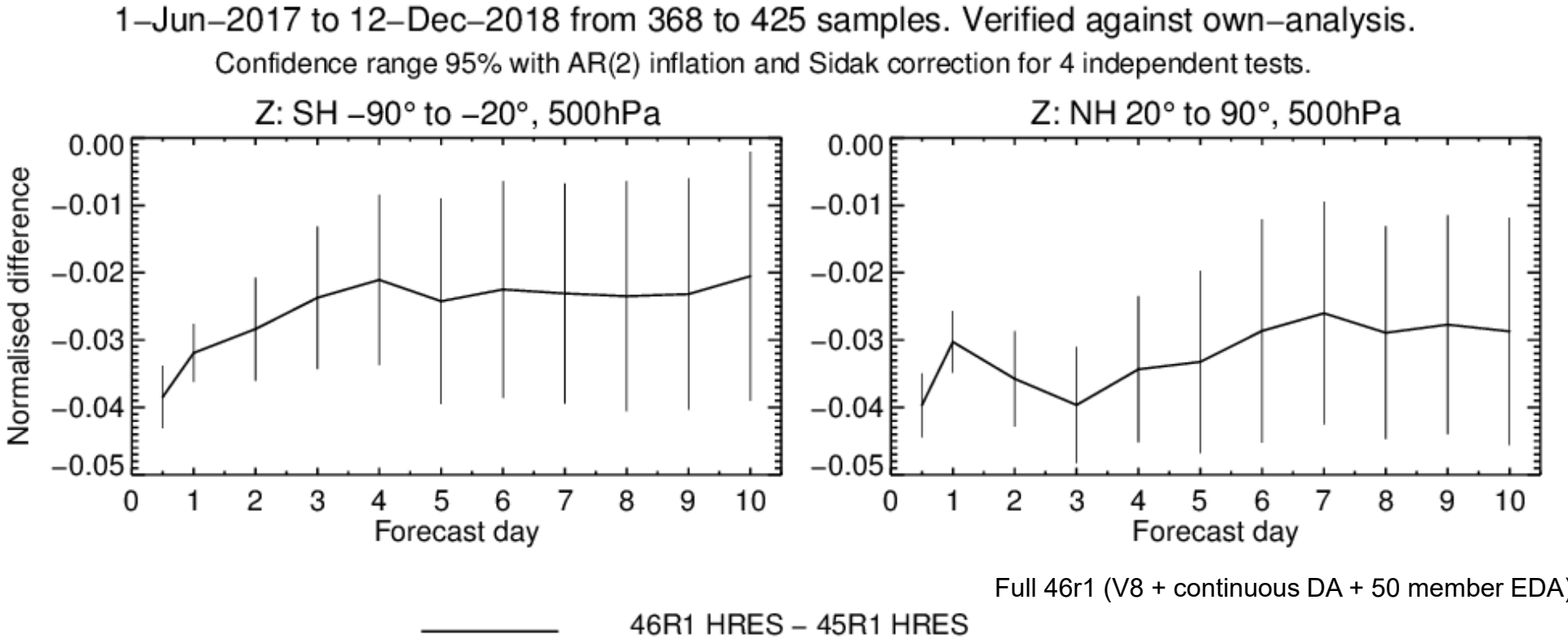
- Performed at TCo399 (~25km)
- Long window data assimilation only
- No new EDA or continuous data assimilation changes at this stage

Headline scores – 500hPa Geopotential height



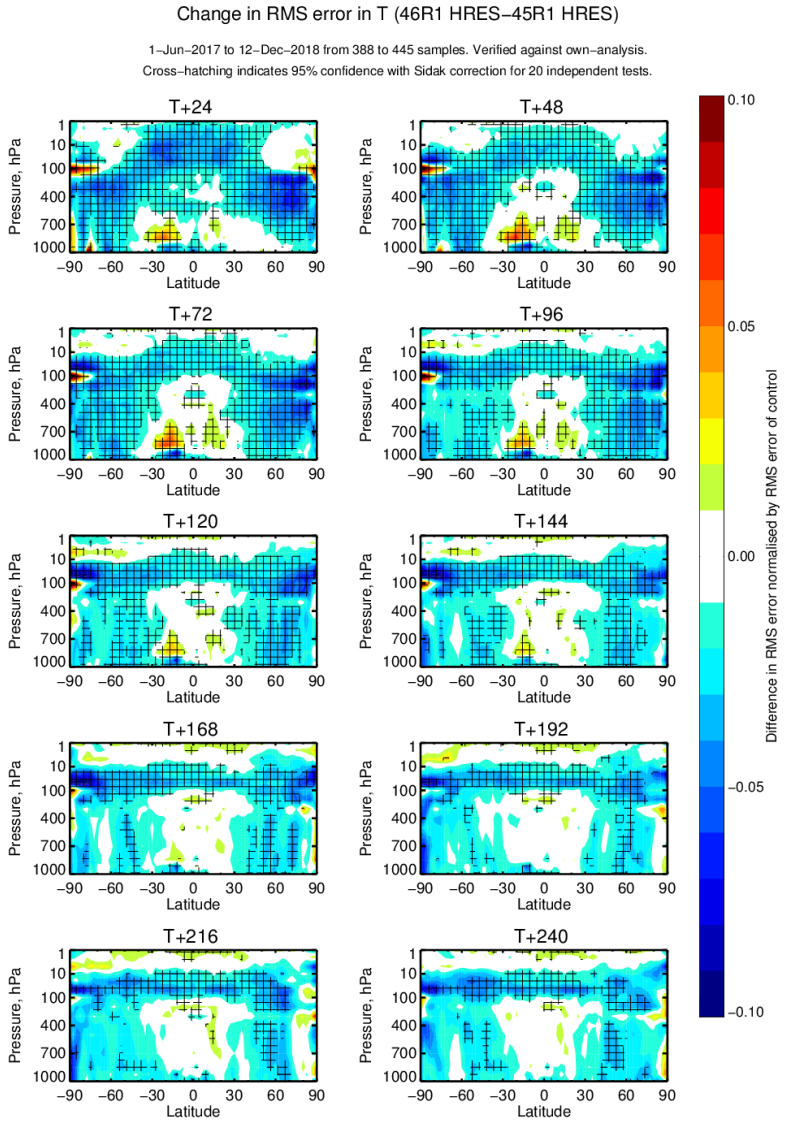
Data assimilation and observations
V4 + physics
V5 + waves +tropical SST

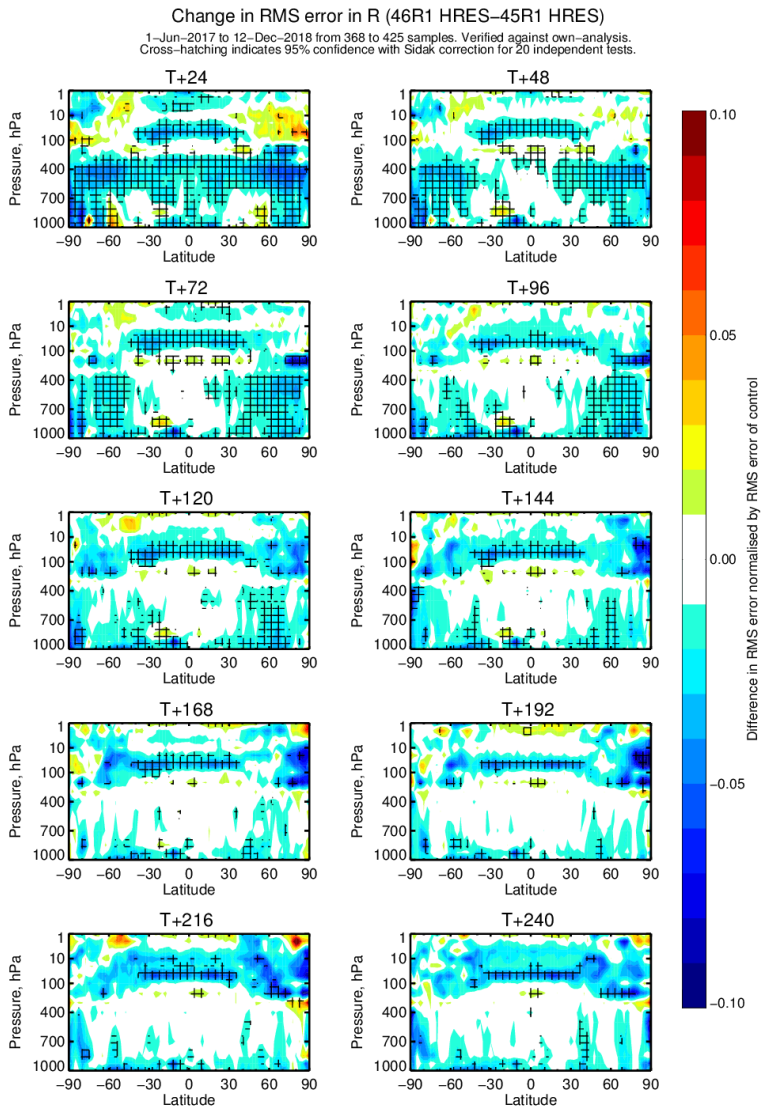
Headline scores – 500hPa Geopotential height



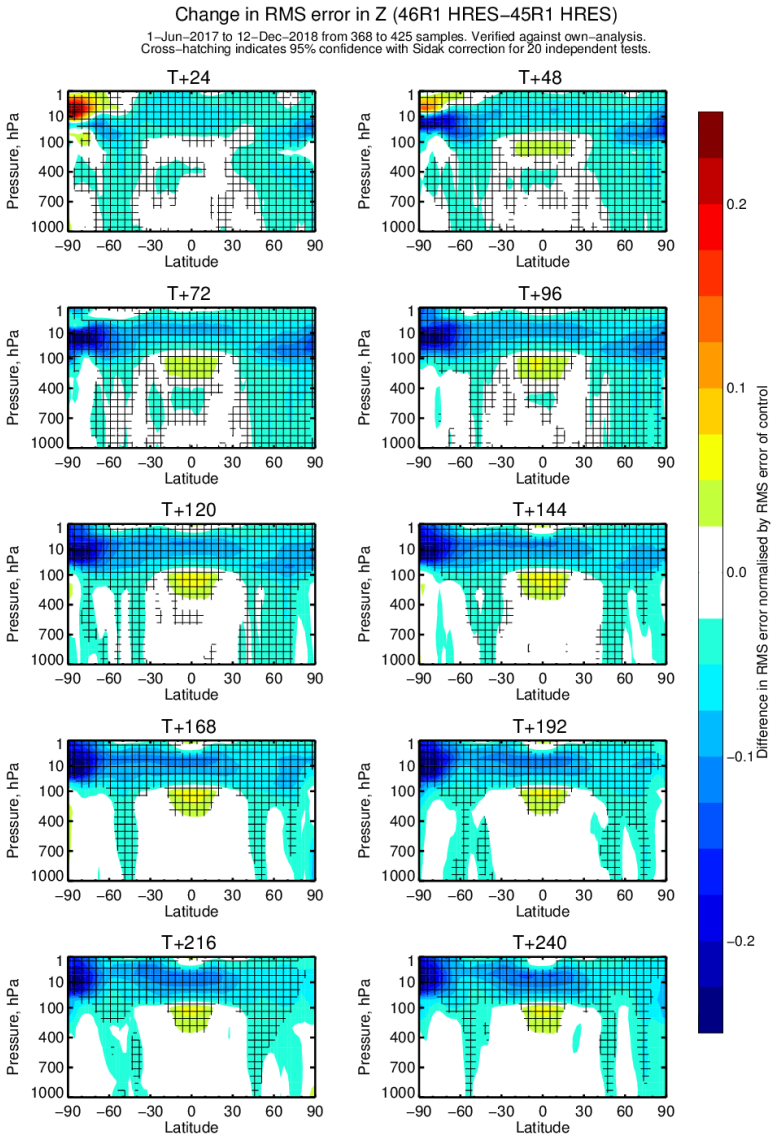
RD esuite ENS scorecard (full 46r1)

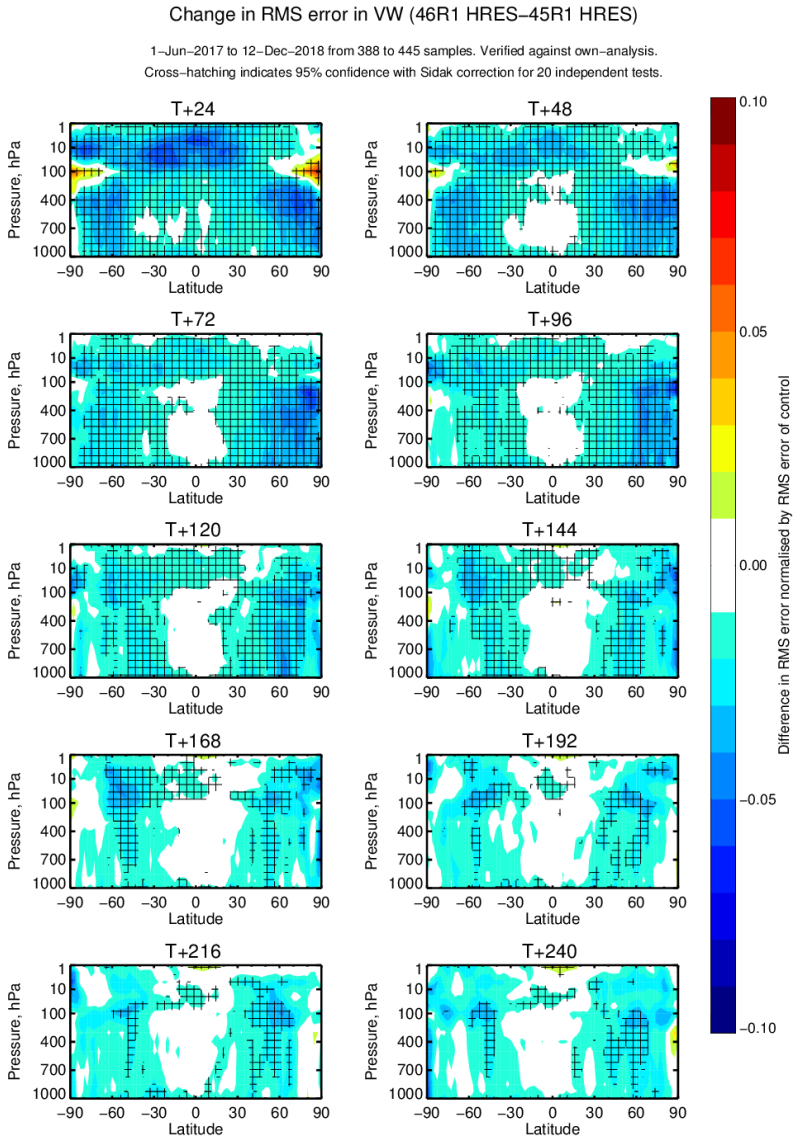
RD esuite zonally averaged forecast errors T and R





RD esuite zonally averaged forecast errors Z and VW





Changes in Reforecast

Reforecasts are used operationally

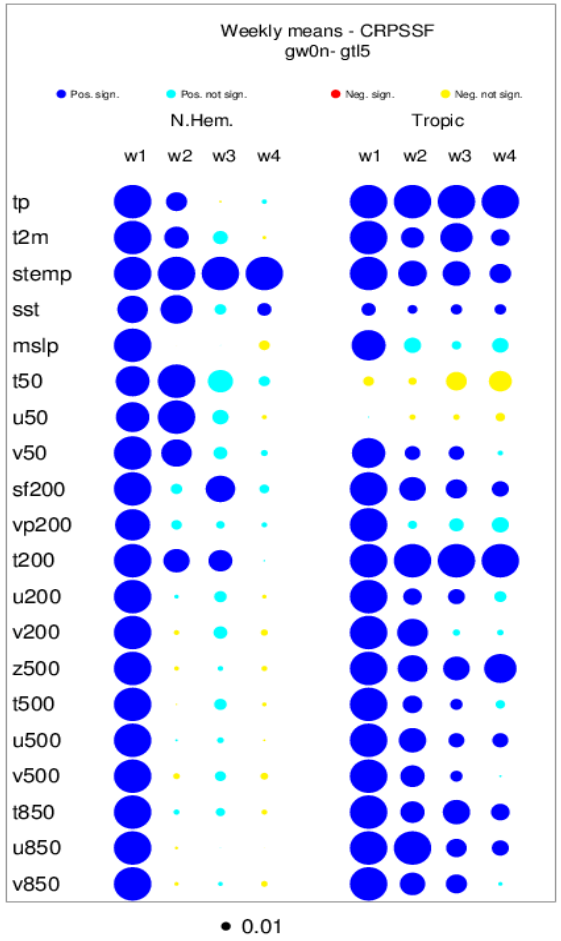
- To calibrate the extended range forecast products
- For skill assessment of the extended range
- To produce the EFI

Reforecast are a set of hindcast covering the past 20 years. They need initial conditions compatible with the operational cycle.

	Current	46r1
Atmospheric I.C	Era-Interim (EI)	ERA5
EDA and SV	Pert from EDA oper	EDA from ERA5+Re-scaled SV
Land I.C	Offline EI driven land simulation	Land from ERA5
Wave I.C	EI	ERA5 (TBD)
Ocean/Seaice IC	ORAS5	ORAS5

Impact of ERA5 on extended range

ERA5 v ERAI initialization of reforecast



The improvements in ERA5 atmospheric IC are noted in the extended range

The possibility of using directly the land from ERA5 simplifies the operational suite (no longer need for offline land initialization).

Next steps

- Implementation planned for June
- Further webinars planned for May with a focus on verification, technical access to the 46r1 test data and new parameters and products
- First test runs of 46r1 in operations, including HRES and ENS expected soon. Once done and checked, initial 46r1 test data will become available in MARS, purely to be used for technical tests.
- Please do 'watch' the cycle 46r1 implementation wiki page to keep in touch with the latest news
  - https://confluence.ecmwf.int/display/FCST/Implementation+of+IFS+cycle+46R1