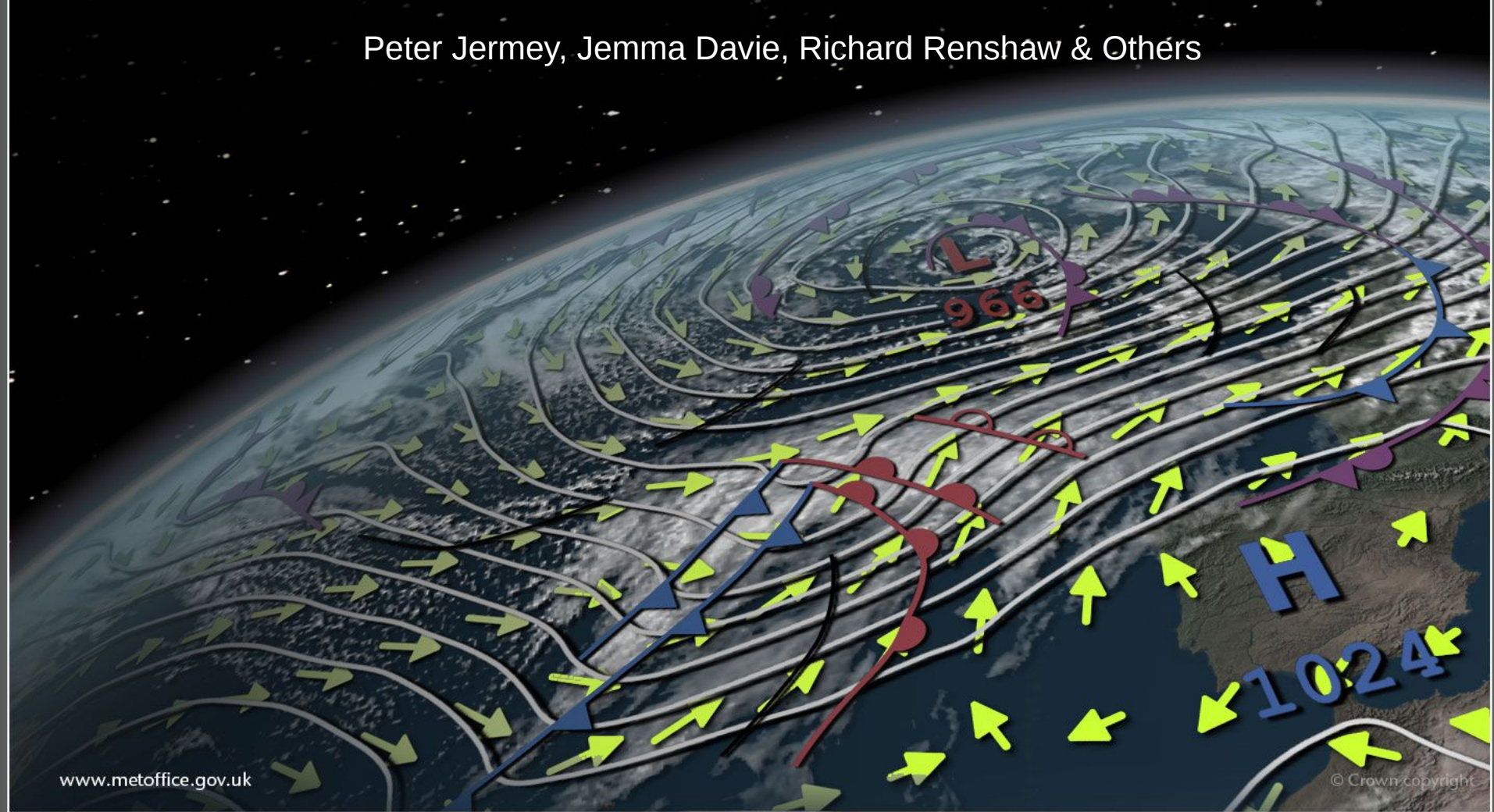


Met Office Reanalysis: Plans & Progress (& Results)

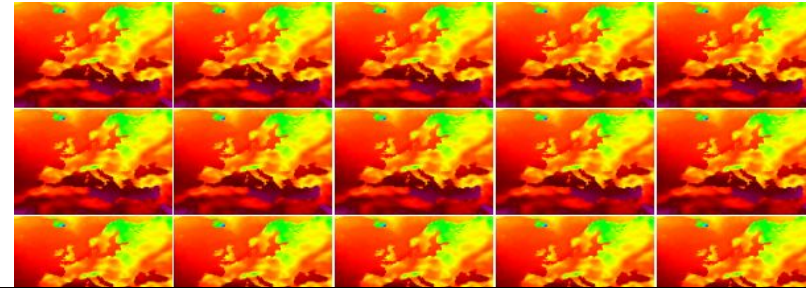
UERRA GA4 November 2016

Peter Jerney, Jemma Davie, Richard Renshaw & Others

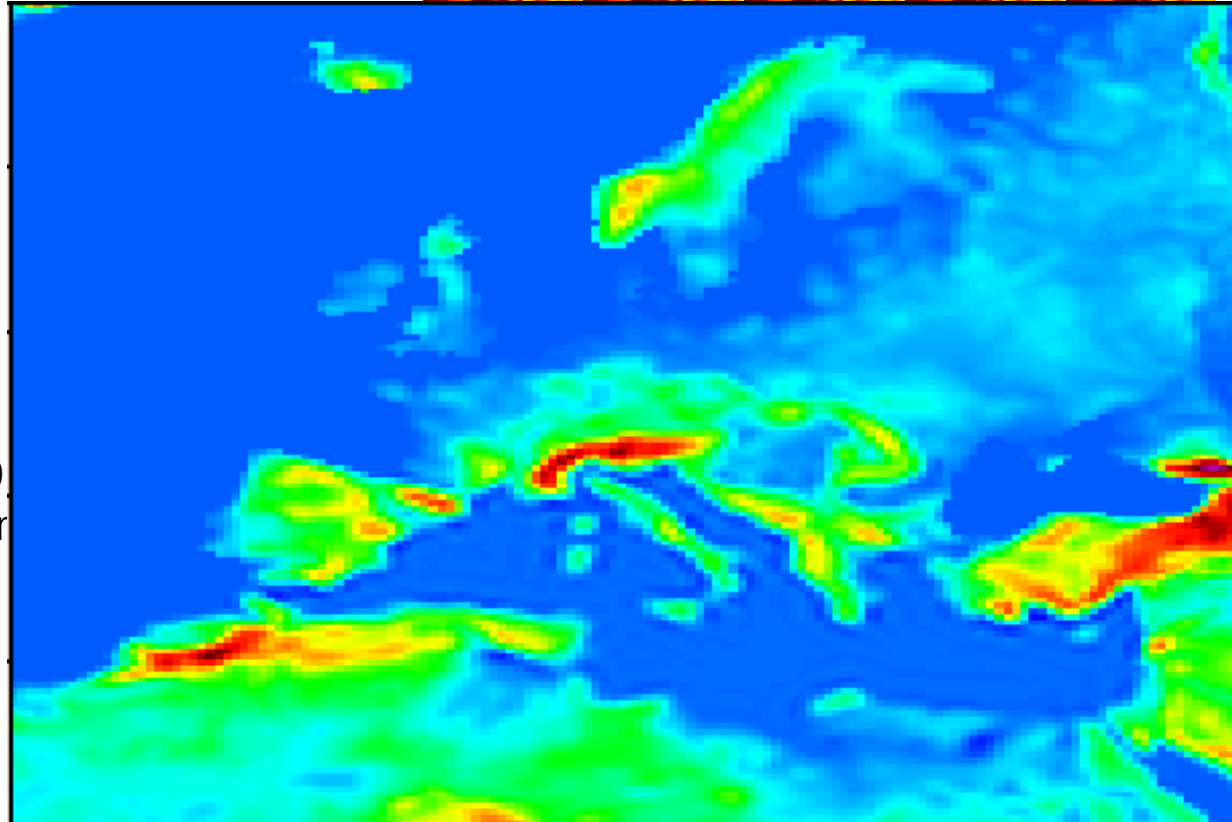


Reminder of MO Reanalysis

- 1979 – pres. 20 member ensemble reanalysis 36km



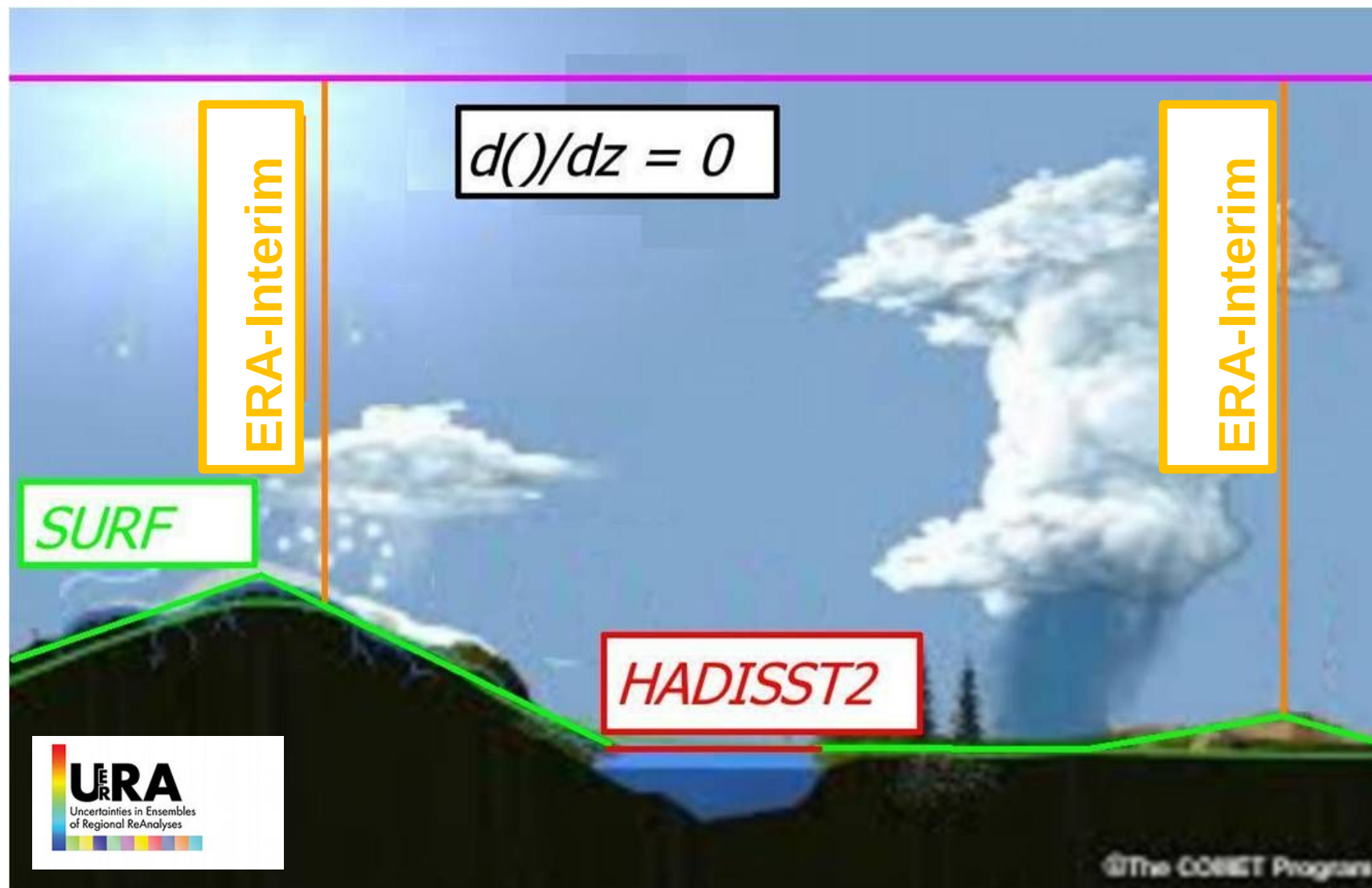
- 1979
determ
12km

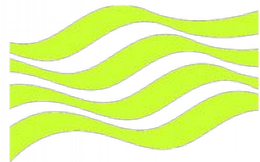


Ensemble System

- Represent every uncertainty in the system via perturbations
- Uncertainty in
 - Observations
 - Model
 - Boundary Conditions*
- Each ensemble member has a different realisation of these
- Set of (input) realisations represent the span of all possible realisations
- Therefore (output) spread should estimate uncertainty in the system

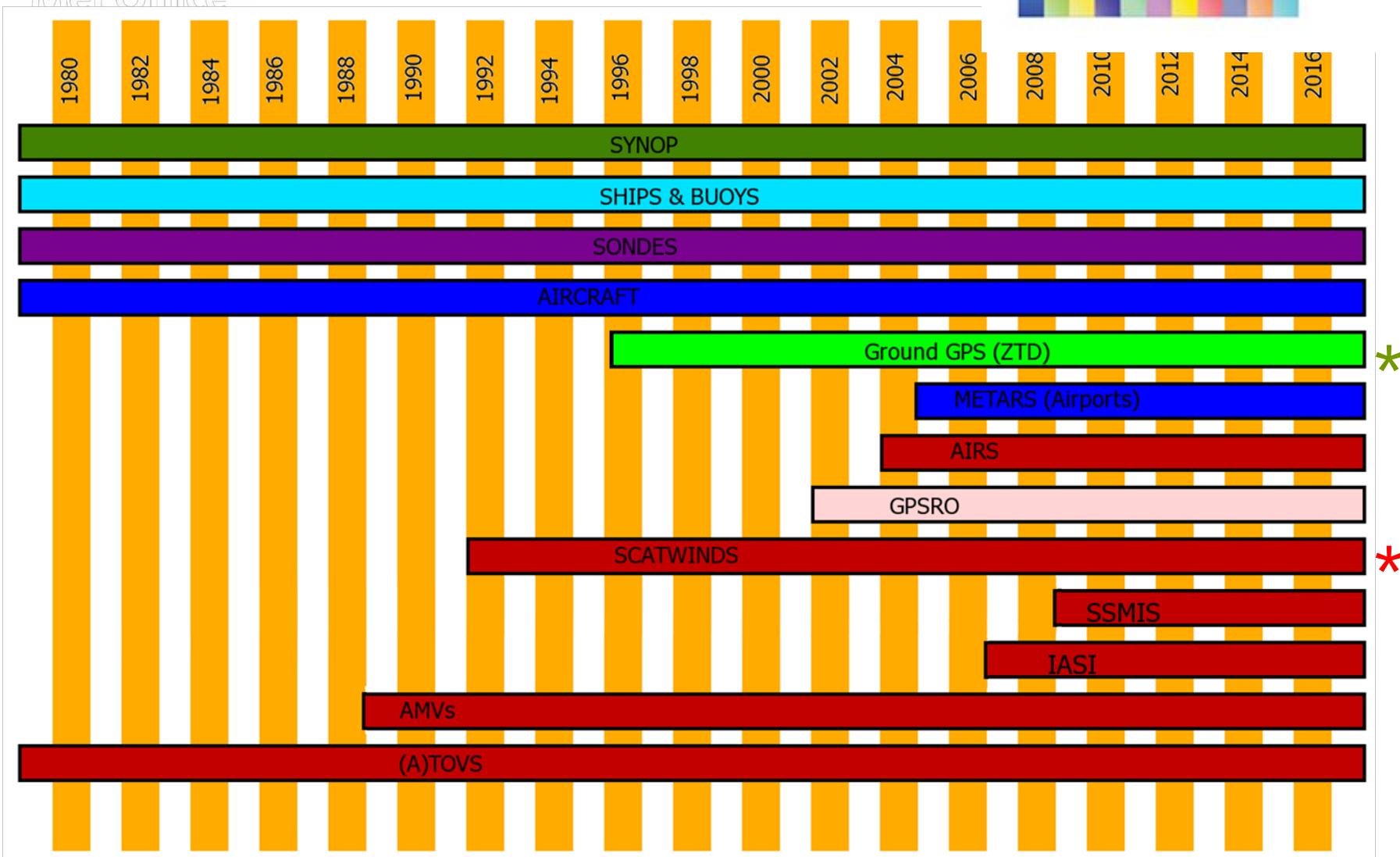
Boundary Conditions





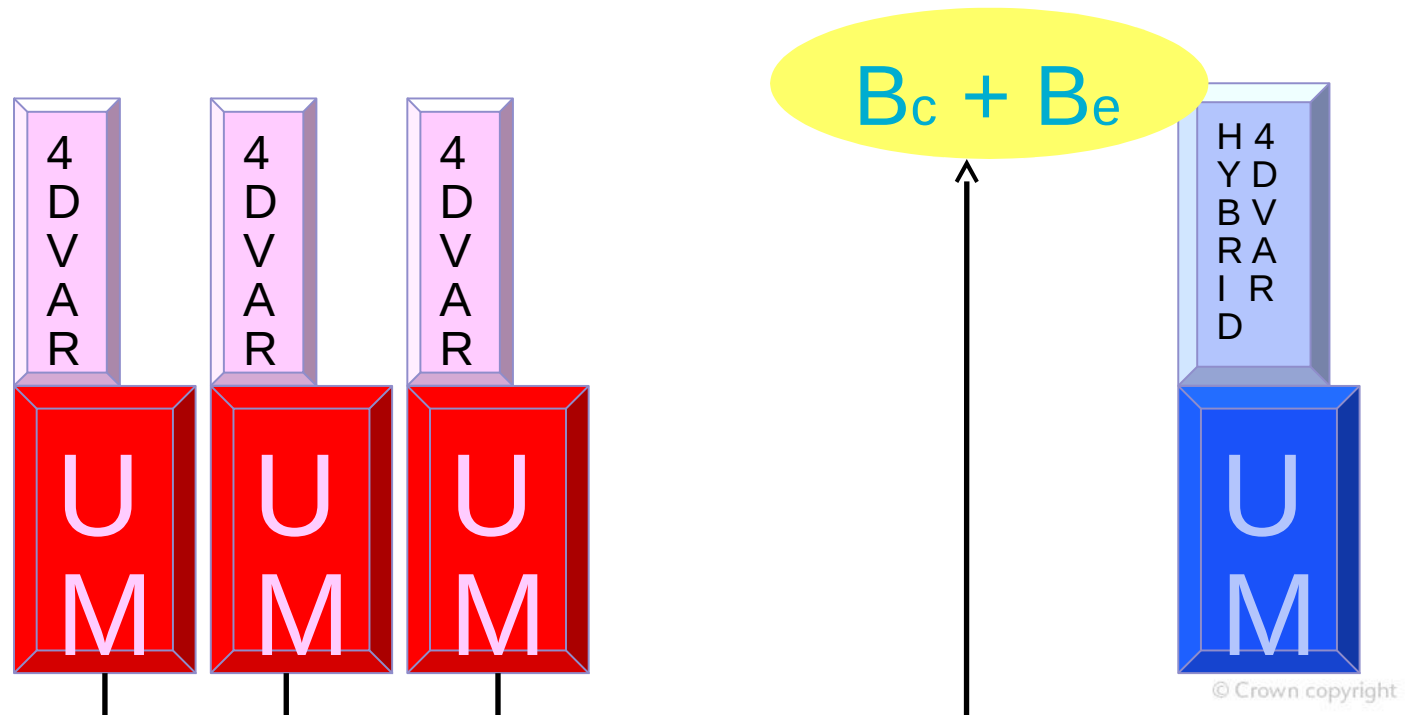
Met Office

Observations



Hybrid System

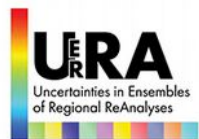
- Ensemble & Deterministic systems coupled
- 4DVAR minimises weighted sum of differences with background & obs
- Weights are dependent on background error covariance matrix (B)
- Ensemble uses fixed bg error cov ($B=B_c$)
- Ensemble provides EOTD to ensemble
- EDA - "hybrid" 4DVAR - weighted sum of bg error covs ($B=b_c B_c + b_e B_e$)





Met Office

Progress



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Progress

- Production system developed
- Boundary data files created
- EC BUFR decoded for conventional obs
- (Re) Developed ability to assimilate TOVS
- Post processing tools
- Conversion to grib2/MARS (thanks to RM)
- Obs & Assimilation Monitoring Tools
- Ensemble production 1979-1980
- Regional SURF
- Regional VarBC



Met Office

Production System

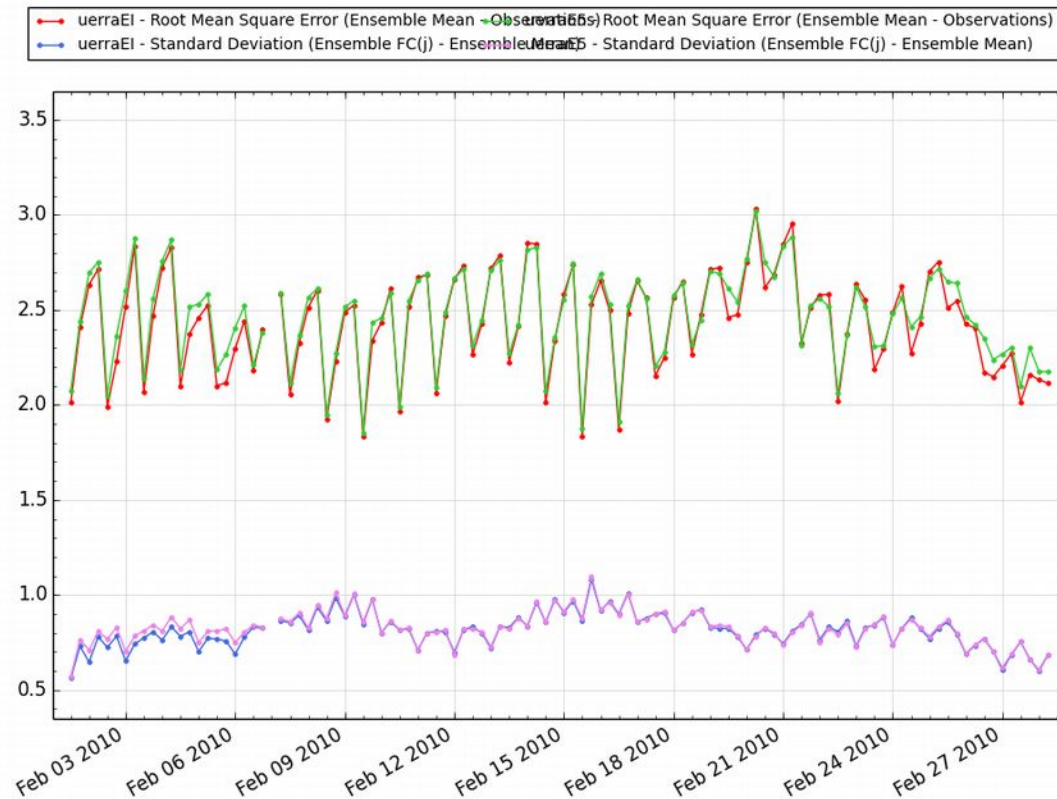
- Uses Rose – a suite cycling tool built onto NIWA's cylc
- Main script has 16k lines!
- ~450 Tasks per cycle, four cycles per day
- Currently takes about 3 days to produce a month (EC machine)
- Allows easy(ish) switching between site, domain etc
- Interest from BOM and KMA

MEMBER_1	held
ra_archive_1	held * * * * * PT12S *
SURF_1	succeeded
ra_surf_um2jules_1	succeeded * * * * 14:57:26Z 14:57:38Z PT11S succeeded
ra_surf_ekf_1	succeeded * * * * 14:57:44Z 14:57:47Z PT7S succeeded
ra_surf_jules_bunch_1	succeeded * * * * 14:57:40Z 14:57:43Z PT9S succeeded
RA_OPS_1	succeeded
OBS_PROCESS_1	succeeded
RA_OPS_PROCESS_1	succeeded
ra_ops_process_aircraftsonde_1	succeeded * * * * 14:56:32Z 14:56:43Z PT11S succeeded
ra_ops_process_airs_1	succeeded * * * * 14:56:10Z 14:56:16Z PT11S succeeded
ra_ops_process_atovs_1	succeeded * * * * 14:56:46Z 14:56:52Z PT5S succeeded
ra_ops_process_iasi_1	succeeded * * * * 14:56:30Z 14:56:46Z PT9S succeeded
ra_ops_process_satwind_1	succeeded * * * * 14:56:02Z 14:56:10Z PT6S succeeded
ra_ops_process_scatwind_1	succeeded * * * * 14:56:56Z 14:57:07Z PT12S succeeded
ra_ops_process_surface_1	succeeded * * * * 14:56:19Z 14:56:30Z PT9S succeeded
ra_ops_process_screen_1	succeeded * * * * 14:56:54Z 14:57:09Z PT10S succeeded
perturb_varobs_1	succeeded * * * * 14:57:10Z 14:57:16Z PT7S succeeded
perturb_varobs_screen_1	succeeded * * * * 14:57:10Z 14:57:18Z PT10S succeeded
UM_1	succeeded
ra_um_fcst_1	succeeded * * * * 14:57:48Z 14:57:56Z PT9S succeeded
perturbation_selector_1	succeeded * * * * 14:57:27Z 14:57:42Z PT9S succeeded
ra_um_recon_ls_1	succeeded * * * * 14:57:57Z 14:58:07Z PT12S succeeded
ra_um_recon_ls_screen_1	succeeded * * * * 14:57:57Z 14:58:04Z PT4S succeeded
VAR_1	succeeded
ra_var_anal_1	succeeded * * * * 14:57:17Z 14:57:26Z PT12S succeeded
ra_var_anal_screen_1	succeeded * * * * 14:57:19Z 14:57:25Z PT7S succeeded

Lateral Boundary Conditions

- Originally planned to use ERA5's ensemble
- Reverted to ERA-Interim due to delay in production
- Deterministic LBCs do not seem to have degraded the spread

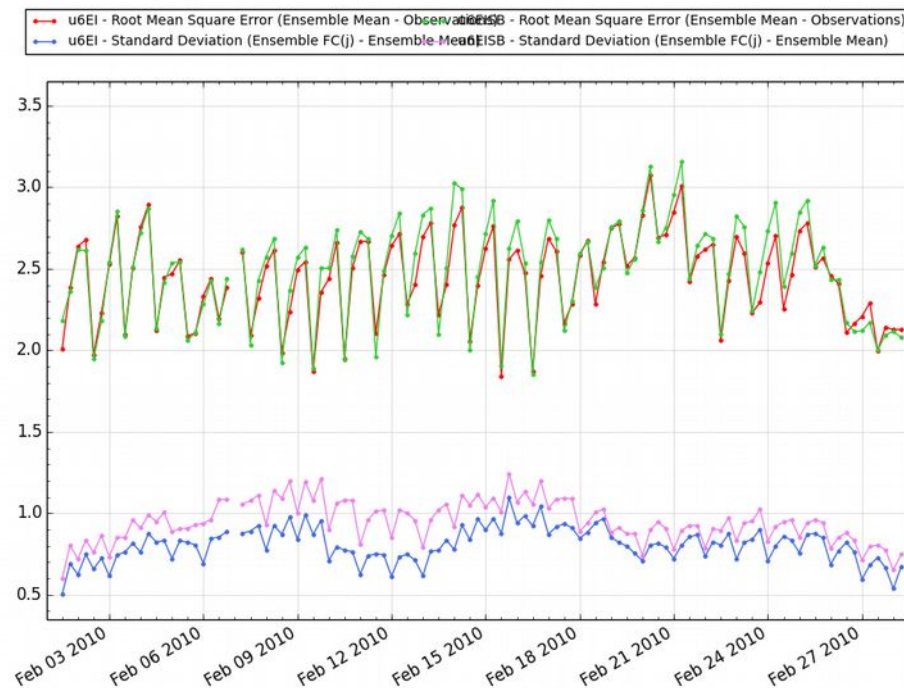
Surface (1.5m) Temperature (deg K), Area 581, T+6, Surface Obs



Regional SURF & VarBC

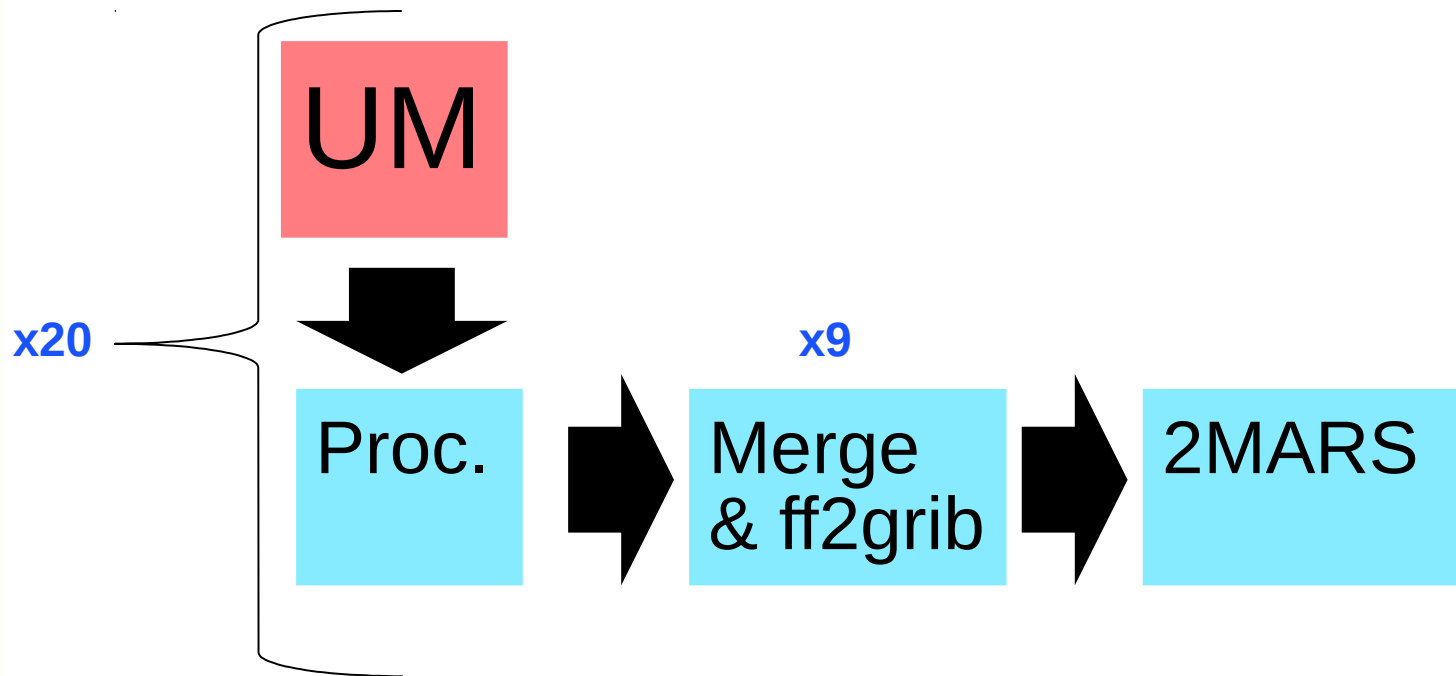
- Previously MO regional systems reconfigured global surface fields
- Reanalysis has regional EKF for land boundary conditions
- Previously MO regional systems used static sat bias correction
- Reanalysis has variational bias correction (developed for global)

Surface (1.5m) Temperature (deg K), Area 581, T+6, Surface Obs



Processing & Archiving

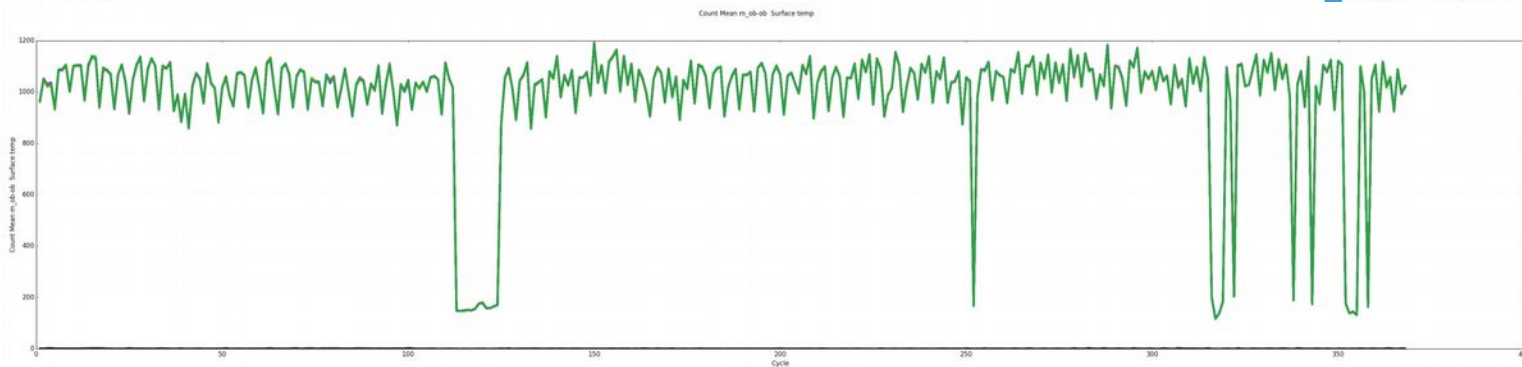
- Most required variables are available direct from the UM
- Some need to be derived using a processing step
- ML 2 PL • ML 2 HL • Derived Variables e.g. TCWV, wind dir.



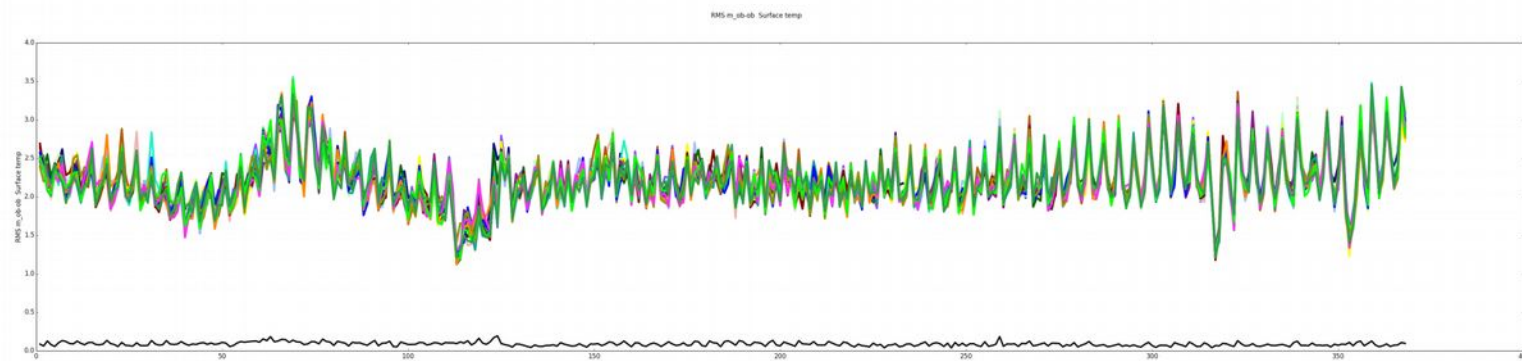
Assimilation Monitoring

Surf T March, April and May 1979

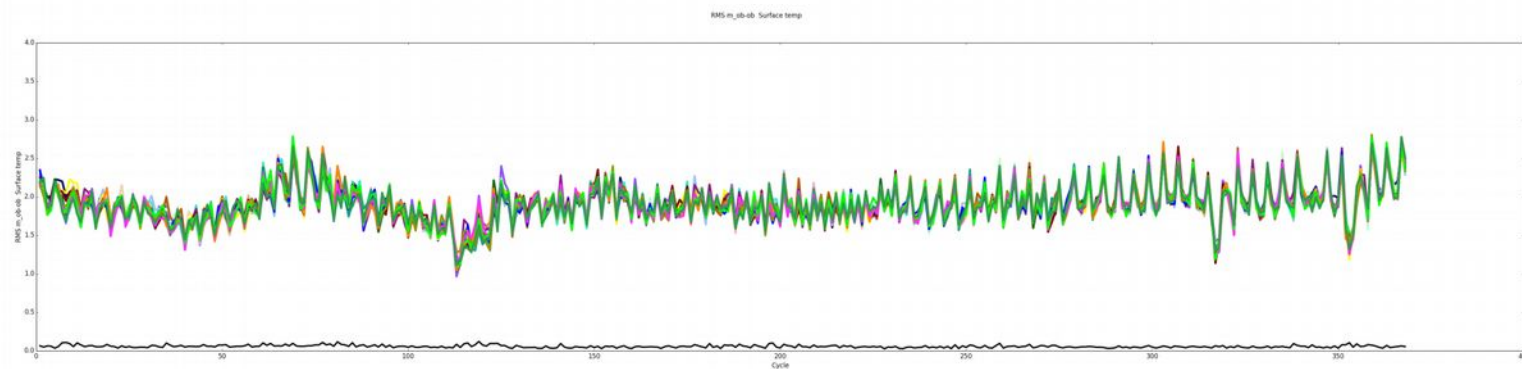
Obs Count



Obs - Bg



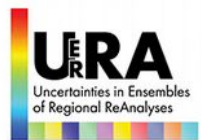
Obs - Anal





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Ensemble Reanalysis Results



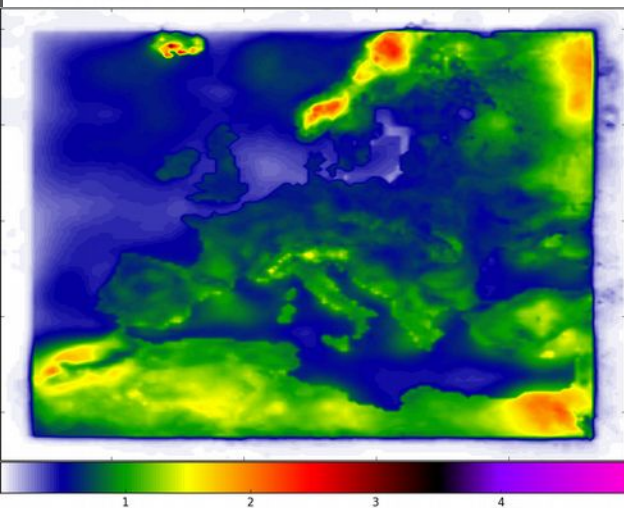
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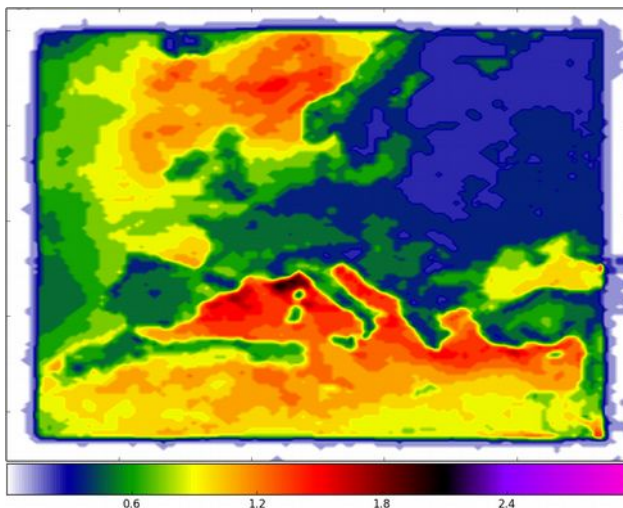
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Ensemble Spread

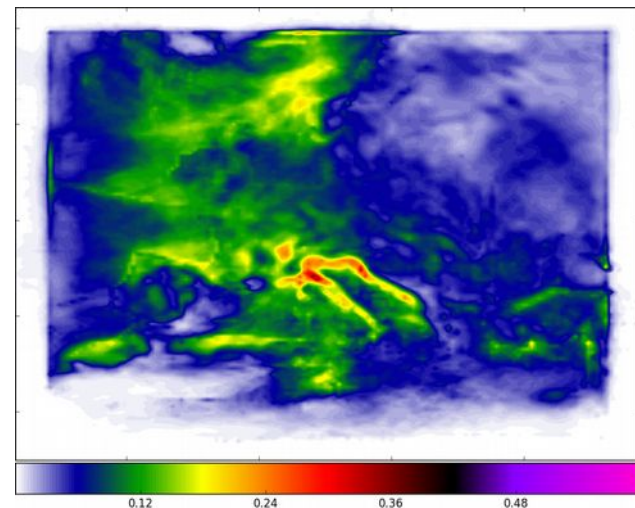
Mean Spread March 1979



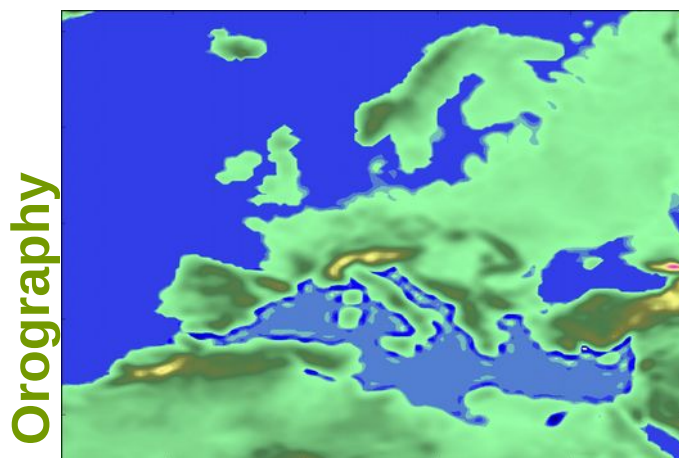
2m Temperature/K



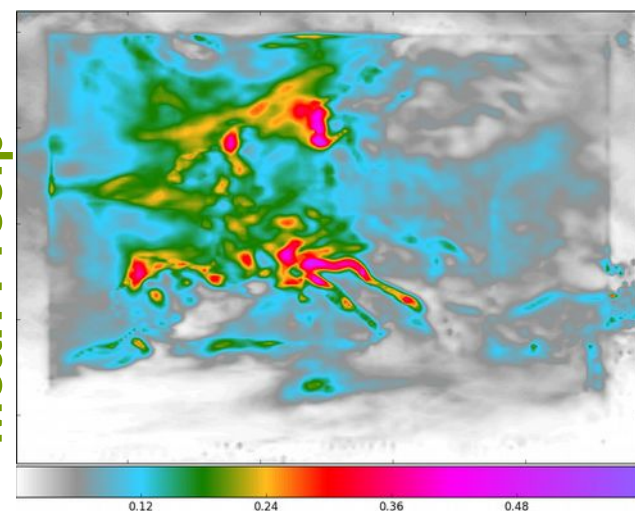
10m Wind Speed/ms-1



6h Precip/mm



Orography



Mean Precip

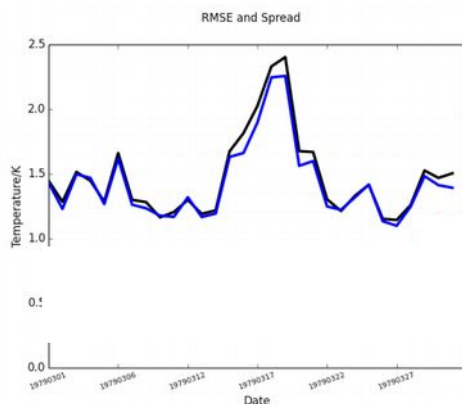
What does a good ensemble look like..?

1. Each member is equally likely
2. Mean error < Control error
3. Ensemble spread = **Mean** error
4. Modelled freq. = Observed freq.

Daily Mean T2

Comparison with ECA&D Obs
March 1979

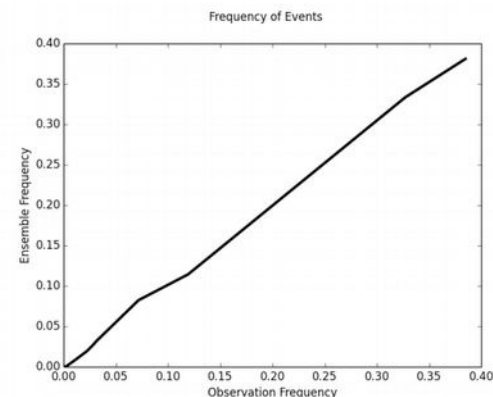
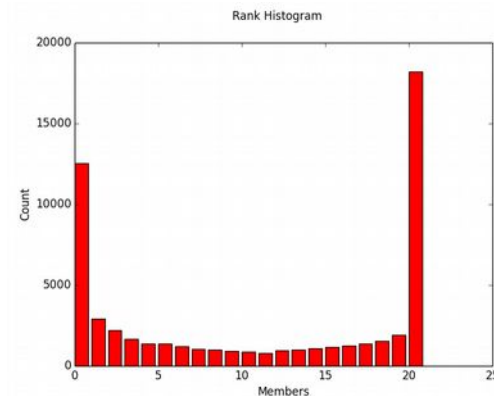
1. Each member is equally likely



2. Mean error < Control error

3. Ensemble spread = Mean error

4. Modelled freq. = Observed freq.



Plans

- Hybrid Production System
- Hybrid Tuning and Testing
- EC BUFR decode for sat obs (nearly there)
- Ensemble production 1981 – pres.
- Deterministic production
- Validation & Verification
- Unknown unknowns

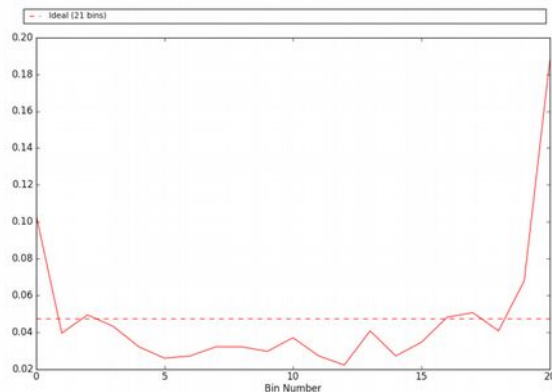
Summary

- Production system developed
- Ensemble working with production started (1979 complete)
- Hybrid system in development
- Archiving in MARS almost there!
- Spatial variation in spread seems realistic
- Ensemble scores reasonably against the four tests

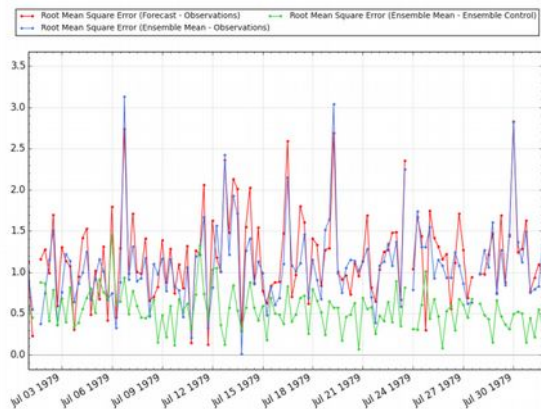
Verification of T+6

Comparison with Obs for next cycle
July 1979 (NB not rm flagged obs)

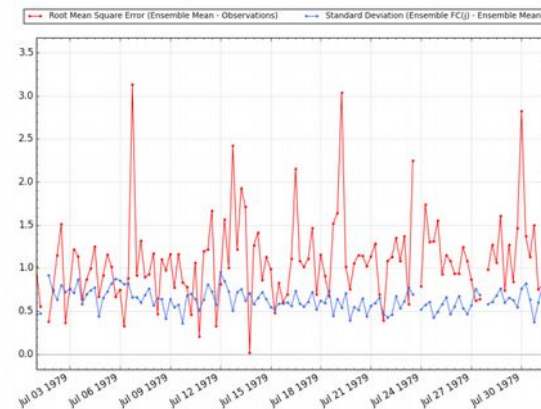
Temperature @ 850hPa, Rank Histogram (Ensemble FC(I) (Excluding Control)), Area 585, T+6, 19790701 00:00 to 19790731 18:00, Sondes, EUENS1979



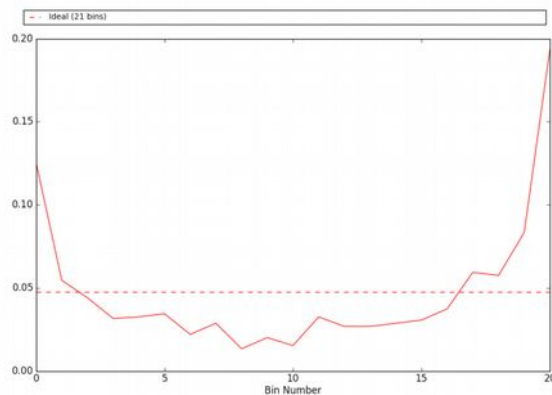
Temperature (deg K) @ 850hPa, Area 585, T+6, Sondes, EUENS1979



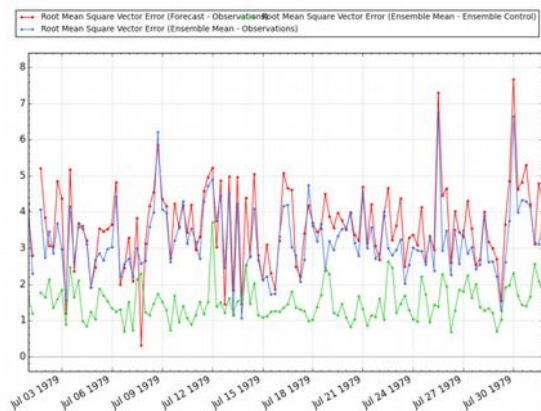
Temperature (deg K) @ 850hPa, Area 585, T+6, Sondes, EUENS1979



Wind @ 500hPa, Rank Histogram (Ensemble FC(I) (Excluding Control)), Area 585, T+6, 19790701 00:00 to 19790731 18:00, Sondes, EUENS1979



Wind (m/s) @ 500hPa, Area 585, T+6, Sondes, EUENS1979



Wind (m/s) @ 500hPa, Area 585, T+6, Sondes, EUENS1979

