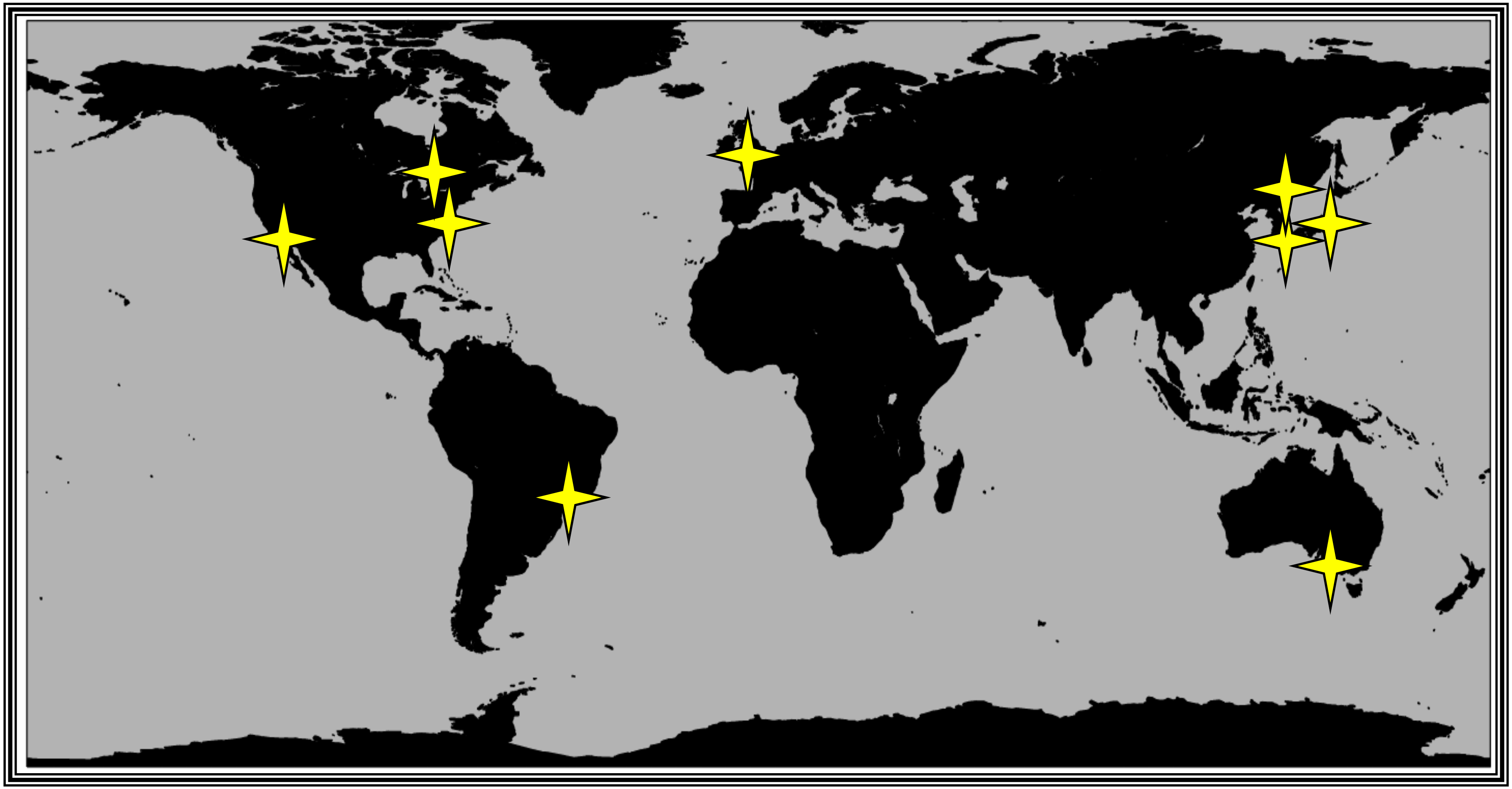
Operational Global Ensemble Prediction



Contributors

This work is the result of a collaboration between:

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The key messages of this talk

- Ensemble forecasts are valuable because they provide an estimate of the whole probability distribution function of forecast states and not only the most likely scenario.

- There are currently 9 Operational Global EPSs, based on 351 ensemble members run with horizontal resolution ranging from T62 to T_L255 (~80km), and with forecast length ranging from 8 to 16 days. A comparison of ensemble forecasts for one case indicate strong similarity in certain products but differences in others.

- TIGGE can help addressing key scientific issues such as whether *"model and data-assimilation quality matters more than perturbation method" ([1],[3]),* and whether a multi-model, multi-analysis, 'sample-all' approach should be followed in the future.

- TIGGE could lead to a Multi-Model, Multi-Analysis Global Ensemble Prediction System (MUMMA-GEPS), which could foster the development of new applications, and better ensemble combination methods.

Outline

- The value of ensemble prediction
- The design of an ensemble prediction system
- Similarities/differences of ensemble prediction systems
- TIGGE and the future of ensemble prediction

The value of ensemble prediction

Three key reasons why ensemble predictions are valuable:

- Ensemble prediction systems can be use to estimate the whole probability distribution function of forecast states. These distributions can be used not only to identify the most likely outcome, but also to assess the probability of occurrence of maximum acceptable losses.

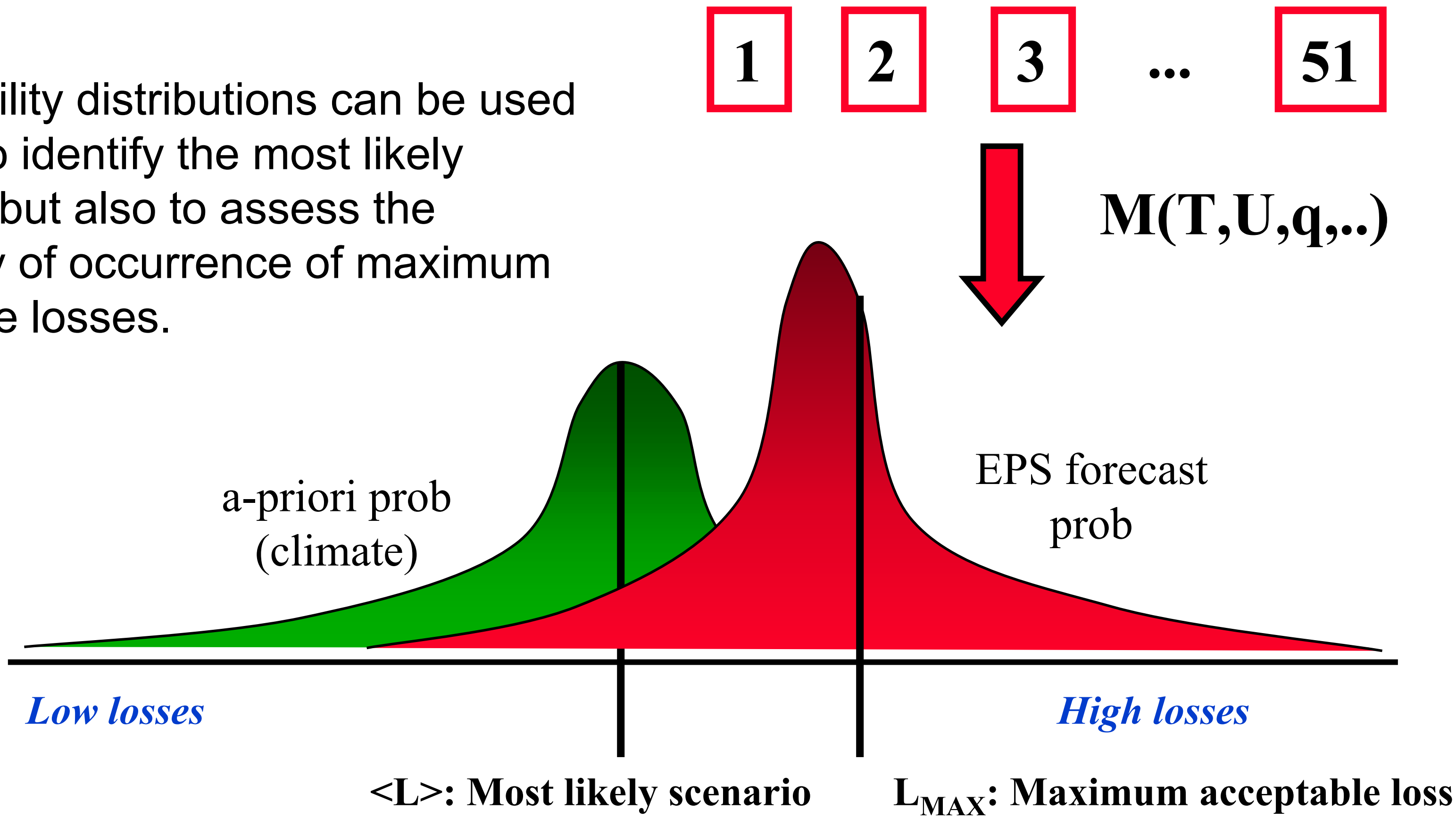
- Ensemble-based deterministic (e.g. the ensemble-mean) and probabilistic forecasts are more accurate than single deterministic forecasts.

- Ensemble forecasts can be used not only to estimate the most likely scenario, but also to estimate the probability of occurrence of extreme, rare events.

The value of ensemble prediction: scenario analysis

- Ensemble forecasts can be ***transformed*** into forecast probability distribution of gains/losses.

- Probability distributions can be used not only to identify the most likely outcome, but also to assess the probability of occurrence of maximum acceptable losses.



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Which are the sources of forecast error?

Initial and model uncertainties contribute to the growth of forecast errors. These sources of forecast error can be classified in four key categories:

- **Observation errors** (observations have a finite precision, point observations may not be very representative of what happens inside a model grid box).
- **Model errors** (e.g. due to a lack of resolution, simplified parameterization of physical processes, arbitrariness of closure assumptions, the effect of unresolved processes).
- **Errors in the boundary conditions** (e.g. roughness length, soil moisture, snow cover, vegetation properties, sea surface temperature).
- **Data assimilation assumptions** (e.g. relative weights given to observations, statistics).

How can an ensemble prediction system simulate these sources?

Two school of thoughts have been followed in the construction of EPSs:

❖ **The *selective sampling* approach –** Identify the leading sources of forecast error, and focus on them: rank sources, prioritize, optimize sampling: growing components will dominate forecast error growth*. Rationale: due to the complexity and high dimensionality of the system, properly sampling the leading sources of errors is crucial.*

❖ **The *sample-all approach* -** Sample all sources of forecast error: perturb any input variable (observations, boundary fields, …) and any parameter that is not perfectly known. *Rationale: all known sources can play a role, and they should all be simulated.*

The ECMWF/NCEP-inspired *"selective sampling"* approaches

ECMWF and NCEP were the first centres to implement operational EPSs in 1992.

❖ The ECMWF *([2],[5])* and NCEP *([8],[9])* EPSs are based on the assumption that initial uncertainties are the leading sources of forecasts errors, and until 1999 their EPSs included only a simulation of initial uncertainties. Since 1999, the ECMWF system simulates also the effect of random model errors due to parameterized physical processes.

❖ ECMWF and NCEP initial perturbations are also designed to span only a subspace of the phase space of the system. These 'selective' initial perturbations are added to the unperturbed analysis to generate the initial conditions.

❖ Selective sampling is now the most common approach used to generate the ensemble initial perturbations.

The MSC-inspired *"sample-all"* approach: an all-inclusive design

The MSC EPS *([6],[7])*, implemented in 1995, has been designed to simulate:

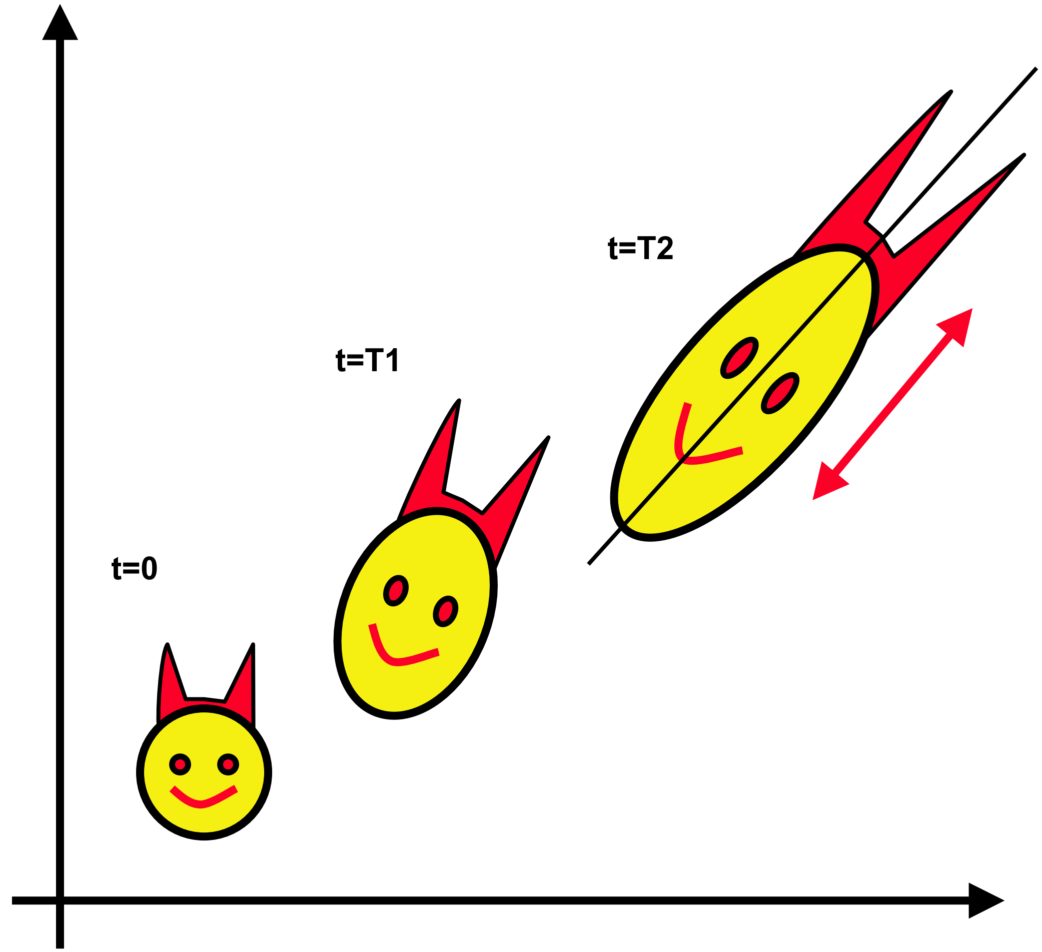
- Observation errors (random perturbations)
- Uncertainties if the boundary conditions
- Uncertainties in the model formulation (2 models and different parameterisations)

On January 12, 2005, MSC implemented a major change to the data assimilation of the Ensemble Prediction System, when the Optimal Interpolation technique was replaced by an analysis cycle based on an Ensemble Kalman Filter method. The first EPS forecasts using the new assimilation technique were produced in the 00Z run of 13 January 2005. (*[7]*).

The rationale behind *selective sampling*

Perturbations pointing along different axes in the phase-space of the system are characterized by different amplification rates. As a consequence, the initial probability density function is stretched principally along directions of maximum growth.

The component of an initial perturbation pointing along a direction of maximum growth amplifies more than components pointing along other directions.



Selective sampling **at ECMWF using singular vectors**

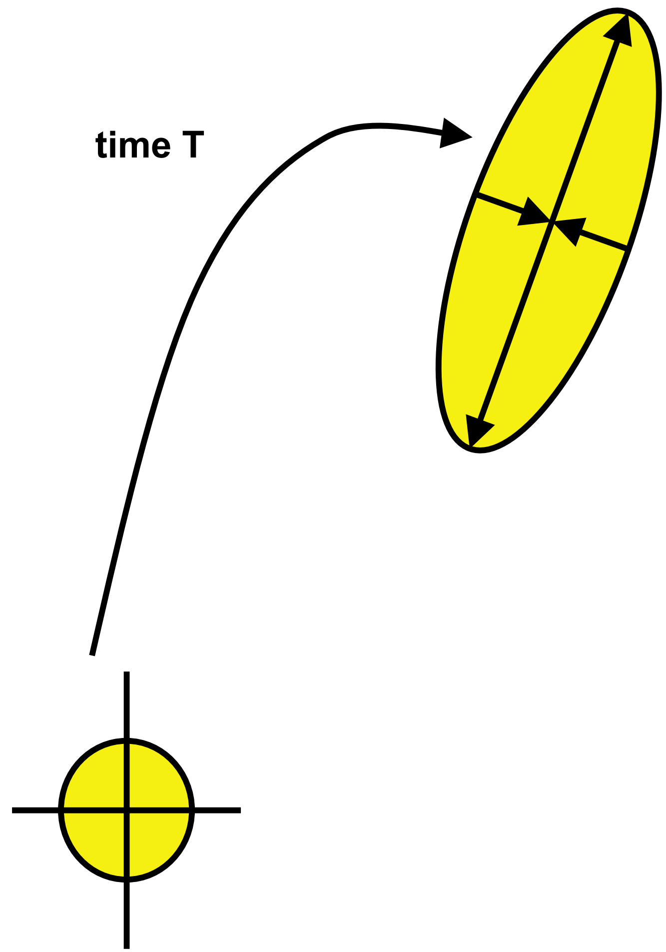
At ECMWF, maximum growth is measured in terms of total energy. A perturbation time evolution is linearly approximated:

$$z'(t) = L(t,0)z'_0$$

The adjoint of the tangent forward propagator with respect to the total-energy norm is defined, and the singular vectors (SVs), i.e. the fastest growing perturbations, are computed by solving an eigenvalue problem:

$$\|z'(t)\|^2 = < z'(t); Ez'(t) > = < L(t,0)z'_0; EL(t,0)z'_0 >$$

$$E^{-1/2}L^* ELE^{-1/2}v_j = \sigma_j^2 v_j$$

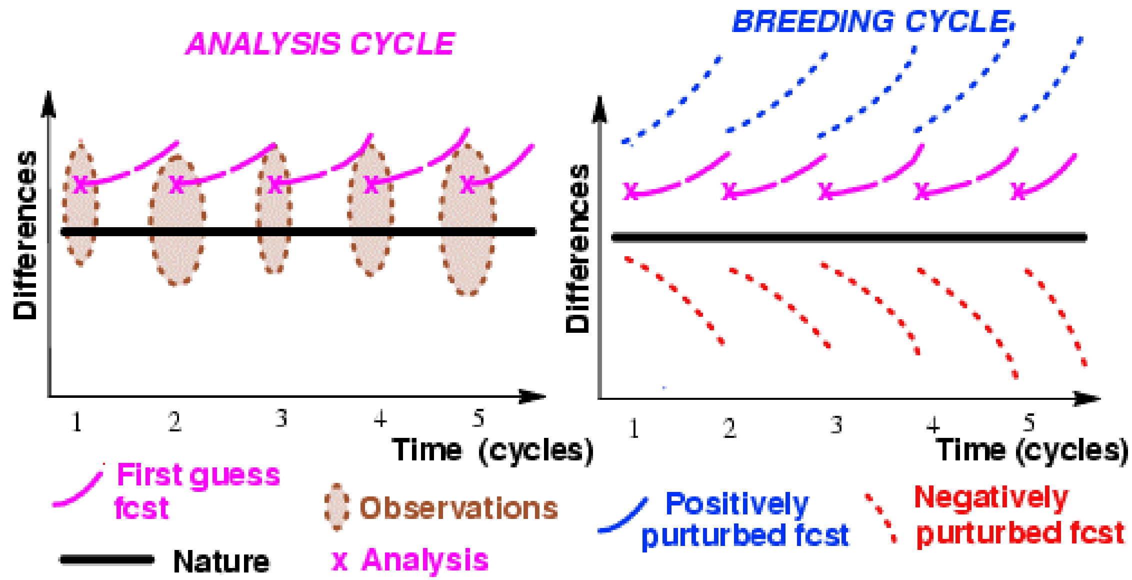


***Selective sampling* at NCEP using breed vectors (BVs)**

At NCEP a different strategy based on perturbations growing fastest in the analysis cycles (bred vectors, BVs) is followed. The breeding cycle is designed to mimic the analysis cycle.

Each BV is computed by (a) adding a random perturbation to the starting analysis, (b) evolving it for 24-hours (soon to 6), (c) rescaling it, and then repeat steps (b-c).

BVs are grown non-linearly at full model resolution.



***Selective sampling* at CPTEC using EOF-based vectors**

At CPTEC the EOF-based perturbation method *([10])* is used to generate the initial perturbations:

- First, random perturbations are added to the analysis and non-linearly evolved
- Then, an EOF analysis is performed on the difference fields of the perturbed and unperturbed forecasts
- The ‘modes’ with the fastest growing EOF coefficients are used to define the initial perturbations

This can be considered as a modified breeding method.

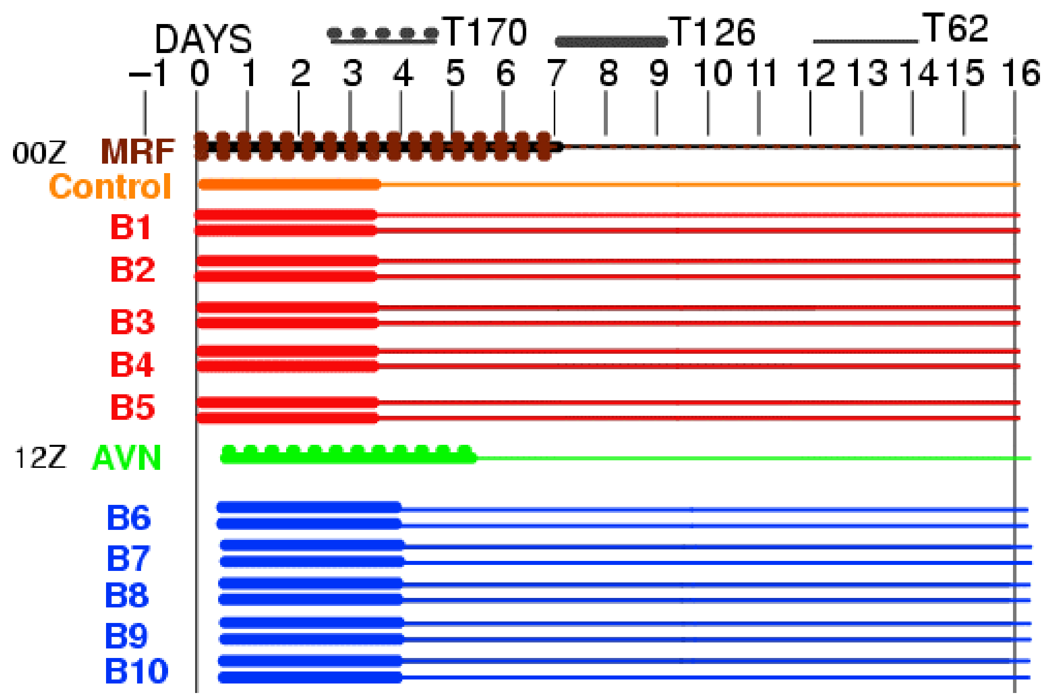
Key characteristics of the 9 Operational Global EPSs

Updated 2 March 2005	BMRC Australia	CMA China	CPTEC Brazil	ECMWF Europe	FNMOC US	JMA Japan	KMA Korea	MSC Canada	NCEP US
simul model syst uncert	NO	NO	NO	NO	NO	NO	NO	YES (16 models)	NO
simul model random uncert	NO	NO	NO	YES (stoch ph)	NO	NO	NO	YES (16 models)	NO
simul observation error	NO	NO	NO	NO	NO	NO	NO	YES (rand pert)	NO
initial pert strategy	SVs	SVs & BVs	EOF-based	SVs	BVs	BVs	BVs	analyses cycl	BVs
hor-resol init pert	TL42	?	T126	TL42	T119	T106	T106	TL149	T126
Initial perturbed area	ExTR (<20S, >20N)	?	TR (45S:30N)	ExTR (<30S, >30N) + upto 6 TR-area	Globe	?	NH+TR (>20S)	Globe	Globe
hor-resol forecasts	TL119	T106	T126	TL255	T119	T106	T106	TL149	T126(d0-7.5) >T62(d7.5-16)
top of the model (hPa)	10	?	3	10	1	0.4	10	10	3
forecast length (days)	10	10	15	10	10	9	8	10	16
# runs per day (UTC)	2 (00,12)	1 (12)	2 (00,12)	2 (00,12)	1 (00)	1 (12)	1 (12)	1 (00)	4 (00,06,12,18)
# pert mem per run	32	32	14	50	16	24	16	16	10
# ens mem per day	66	33	30	102	17	25	17	17	44

A key element of the NCEP EPS: a variable resolution approach

In the operational ensemble system, 5 BVs are grown every 24 hours. They are then used to define 5 perturbations that are added and subtracted to the analysis.

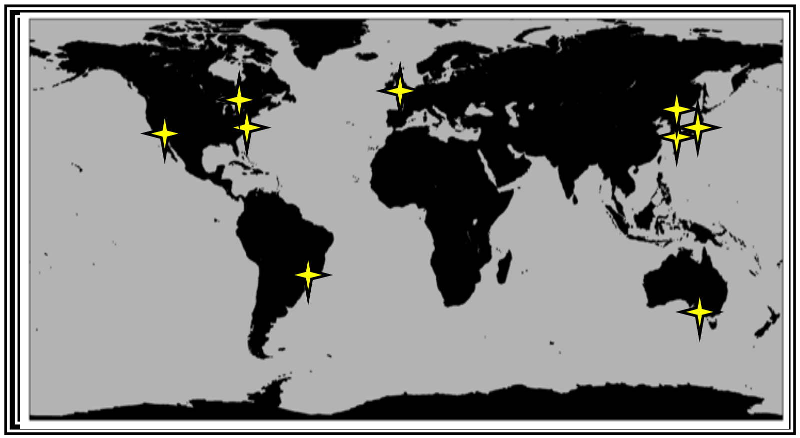
The NCEP ensemble is run with variable resolution: the smaller scales that become unpredictable earlier are not carried through the time evolution.

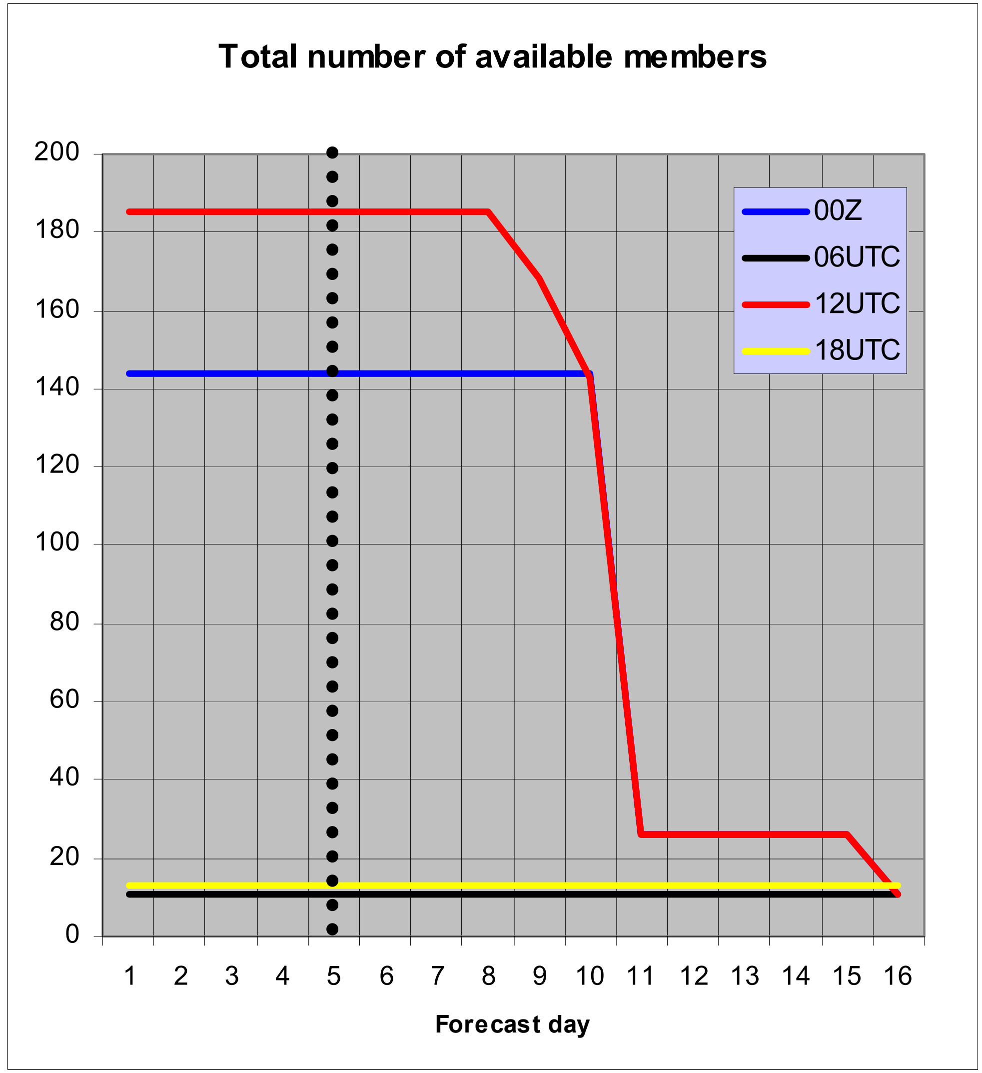


What is the total number of available ensemble members?

Due to differences in the ensemble configurations, the number of available ensemble members varies with the initial time. At forecast day 5, e.g., the number of available ensemble members is:

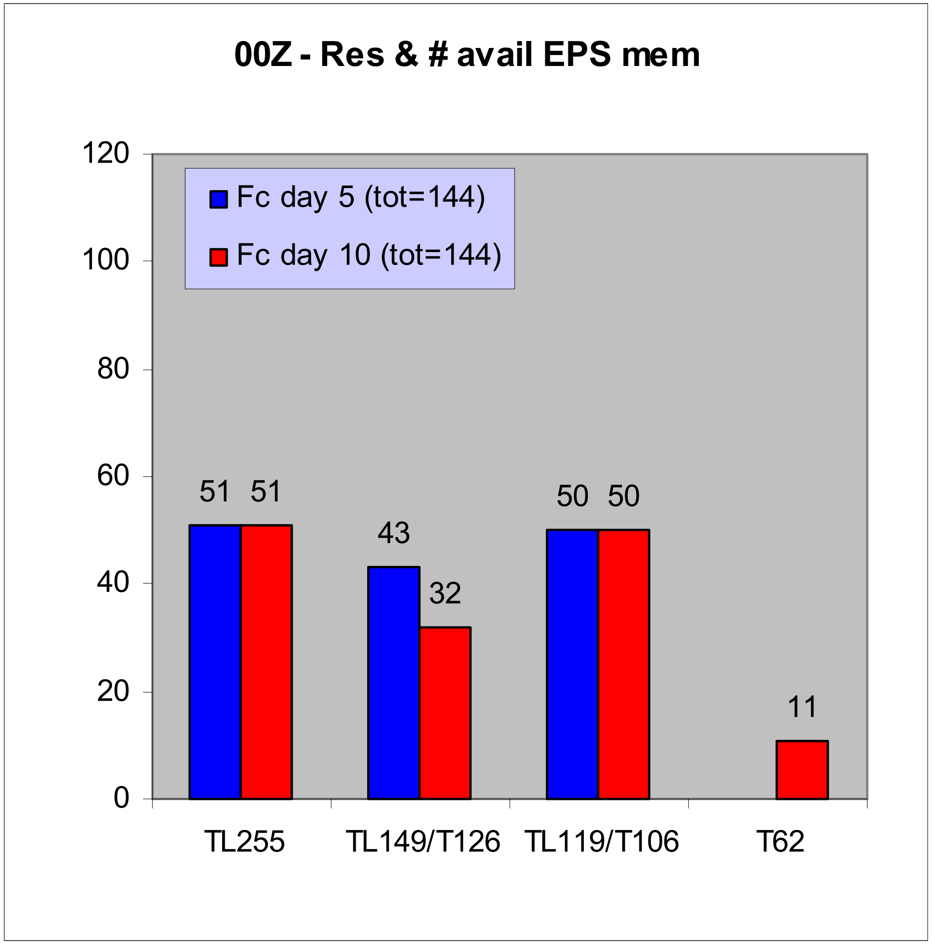
- at 00UTC, 144 members
- at 06UTC: 11 members
- at 12UTC: 185 members
- at 12UTC: 11 members

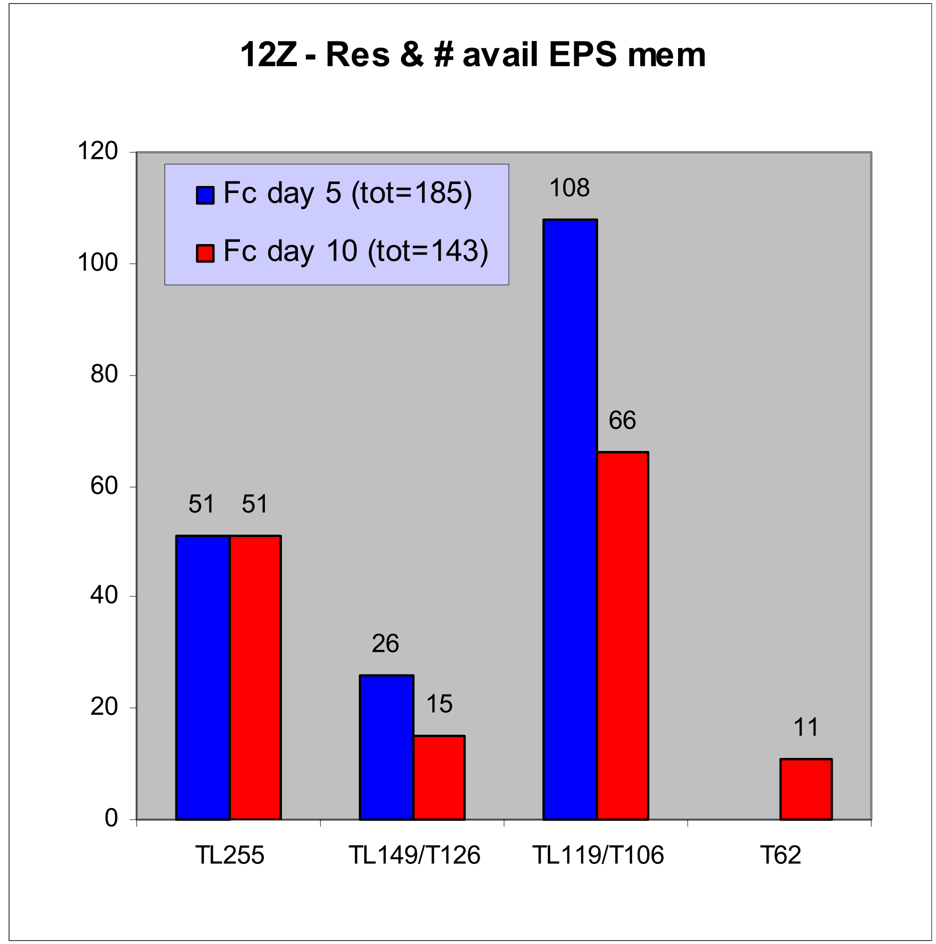




What is the available resolution of the ensemble members?

The ensemble resolution varies substantially, ranging from T62 to T_L255.





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Similarities/differences of ensemble predictions systems

What is the impact of the ensemble design (size, resolution, perturbation method, simulation of model uncertainty) on ensemble characteristics such as the ensemble spread (measure by the standard deviation), the ensemble-mean, and probability forecasts?

Attention will be focused on ensembles started at 00 and 12 UTC of 15 January 2005. Data from 8 centers have been compared (CMA data were not available).

Initial condition 00UTC of 15 Jan 2005	BMRC	CMA	CPTEC	ECMWF	FNMOC	JMA	KMA	MSC	NCEP		% rec/avaiv
EM, STD Z500 & T850, PR(T850)	33		15	51	17			17	11		100%
Total number of members available	144										
Initial condition 12UTC of 15 Jan 2005	**BMRC**	**CMA**	**CPTEC**	**ECMWF**	**FNMOC**	**JMA**	**KMA**	**MSC**	**NCEP**		**% rec/avaiv**
EM, STD Z500 & T850, PR(T850)	33			51		25	17		11		74%
Total number of members available	185										

Available and received

Not produced

Produced but not available

Similarities/differences of ensemble prediction systems

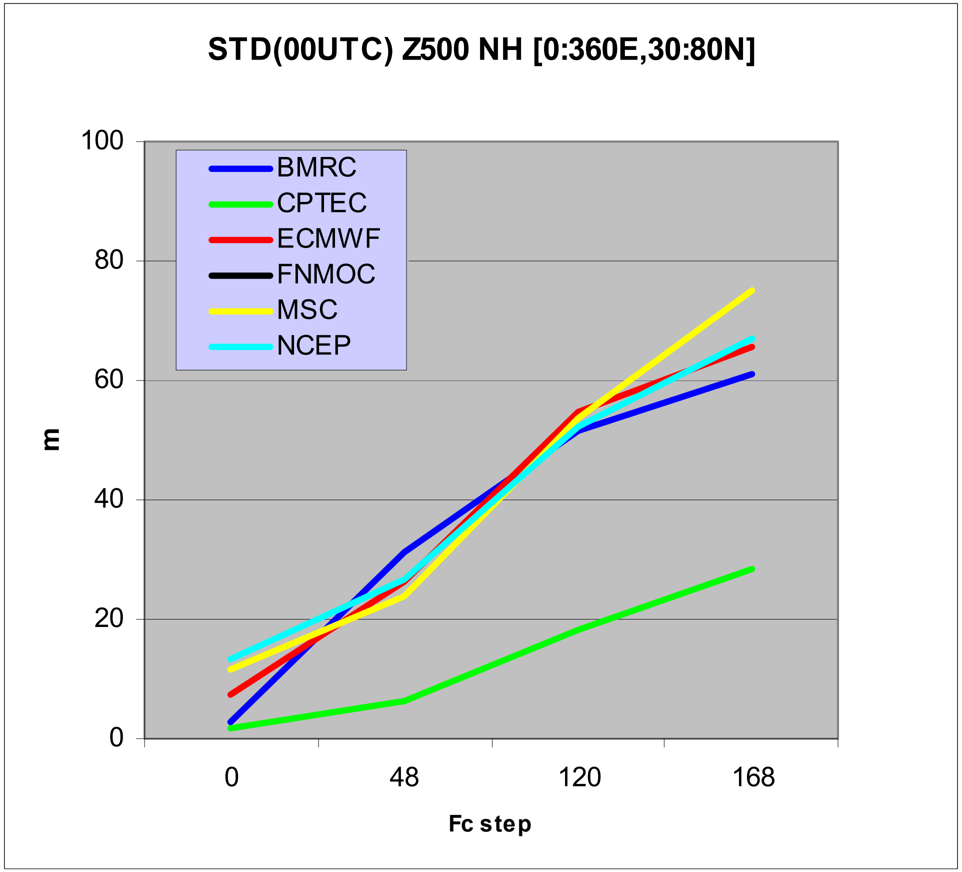
- Ensemble spread (measured by the ensemble standard deviation):
  - **SV-based initial perturbations grow fastest, and SV-based EPS (BMRC, ECMWF) have smallest initial perturbations**
  - **EOF-based perturbations (CPTEC) grow very slowly**
  - **Perturbation methods matter during the first hours, but in the medium range the ensemble spread of the different systems tend to be rather similar**

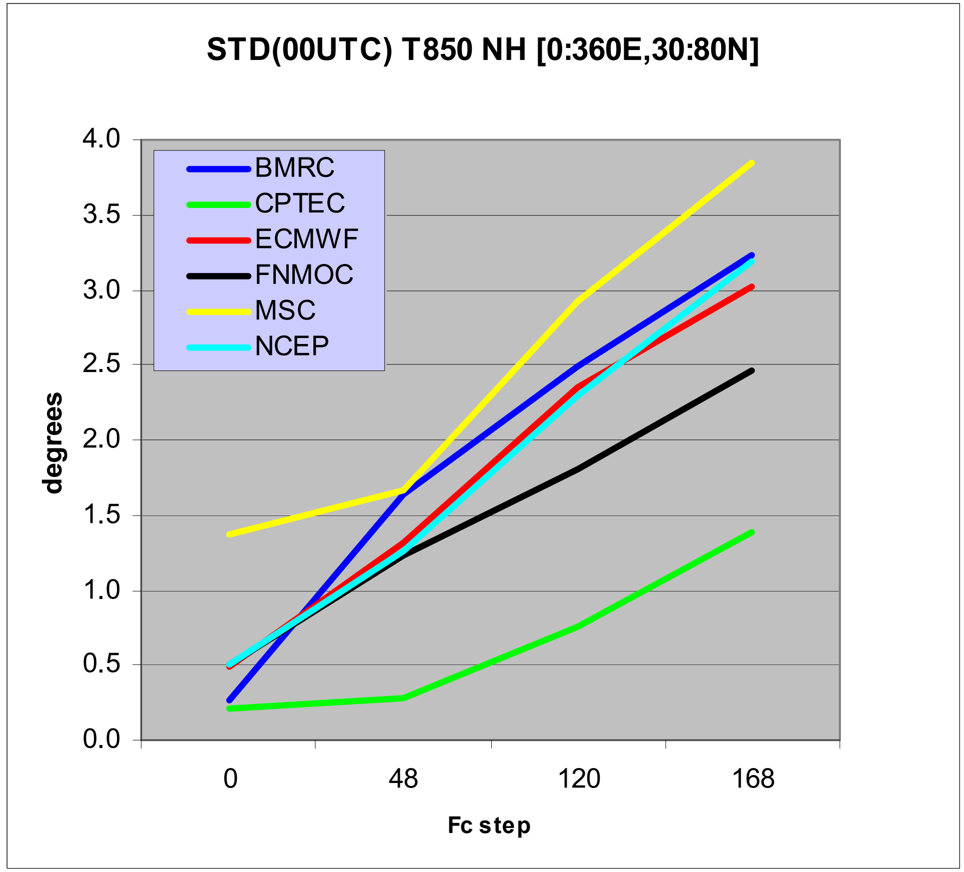
- Ensemble mean:
  - **Filtering of unpredictable scales using all available ensemble systems could lead to a more skillful ensemble-mean forecast.**
  - **Less skillful systems are the ones that could benefit most from a combination of all EPSs**

- Probability forecasts:
  - **Probabilities generated by different EPSs differ, especially at the local level**
  - **Probabilistic products of variables such as weather parameters are probably the ones that could benefit most from a combination of all EPSs**

$\sigma_{Z500,T850}$(00Z,t): BMRC, CPTEC, ECMWF, MSC, NCEP (NH)

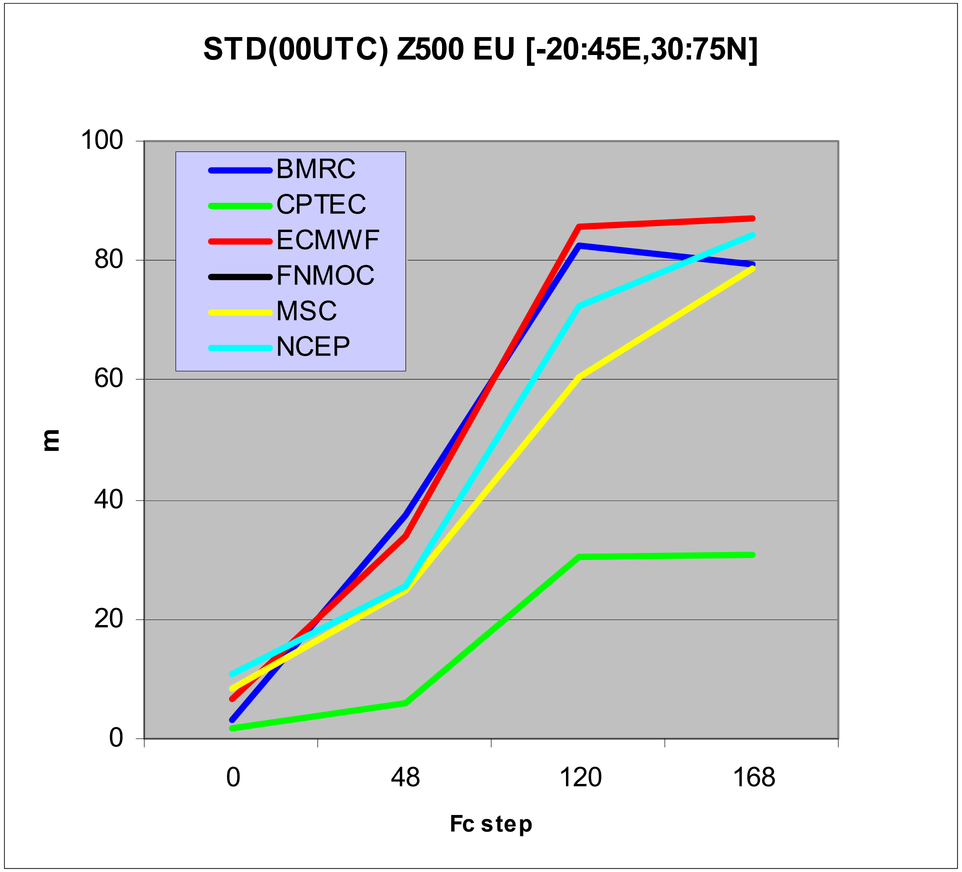
NH: No CPTEC perturbations, BMRC has smallest, fastest growing perturbations (only initial SVs), MSC and NCEP have largest initial perturbations, MSC has largest σ(168h).

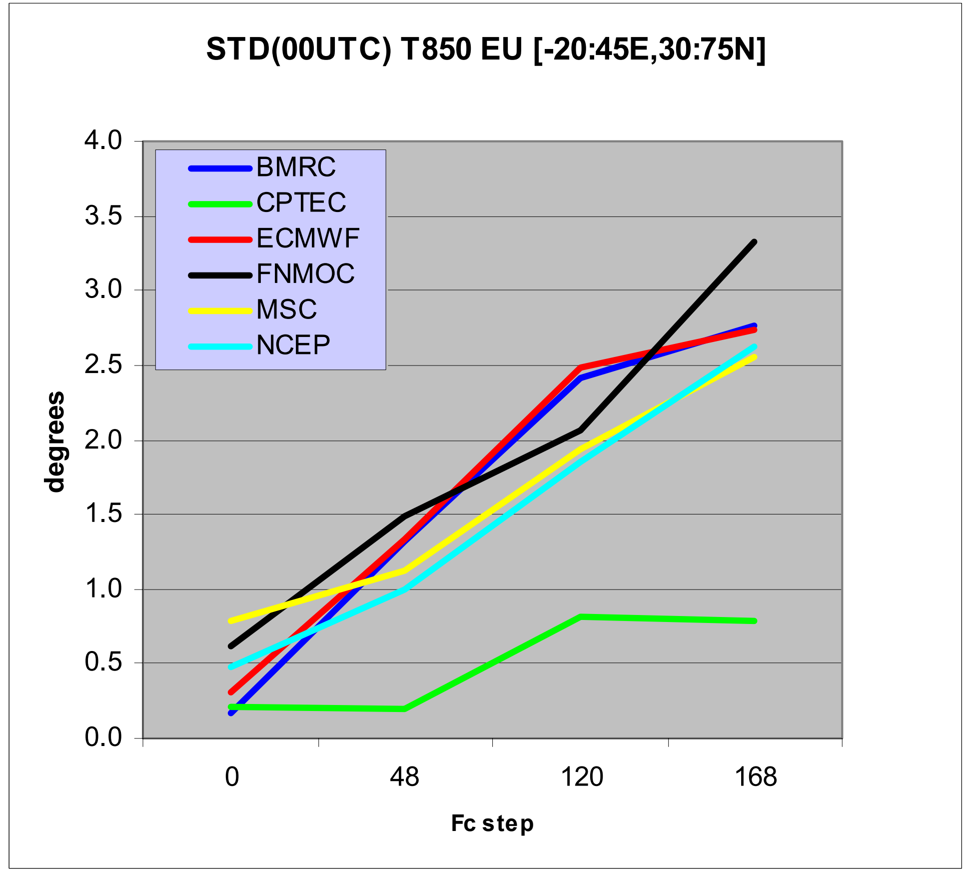




$\sigma_{Z500,T850}$(00Z,t): BMRC, CPTEC, ECMWF, MSC, NCEP (EU)

Europe: No CPTEC perturbations, BMRC has smallest, fastest growing perturbations (only initial SVs), MSC and NCEP have largest initial perturbations.

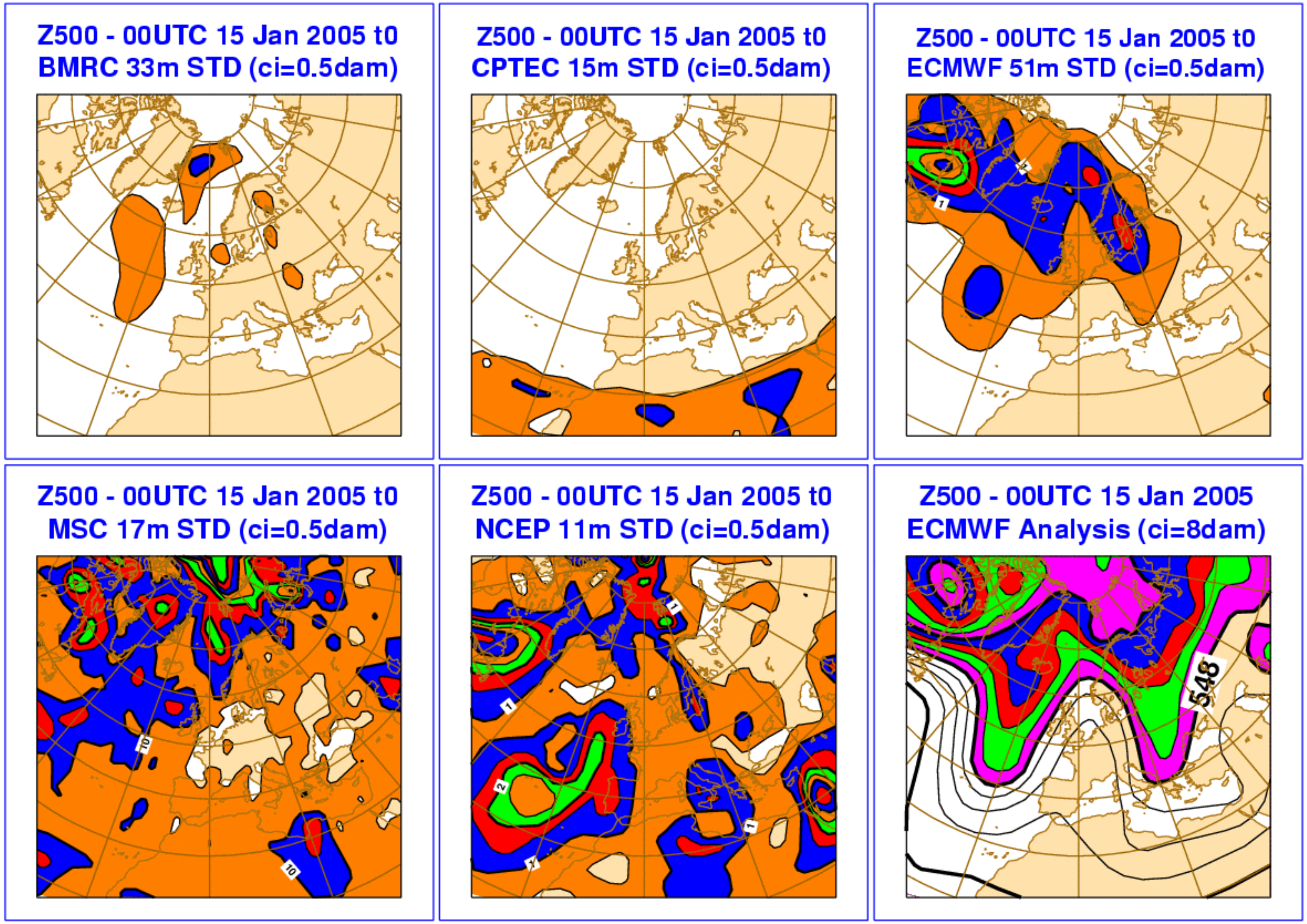




σ_{Z500}(00,t0): BMRC, CPTEC, ECMWF, MSC, NCEP (EU)

Initial Z500 standard deviation. Note that:

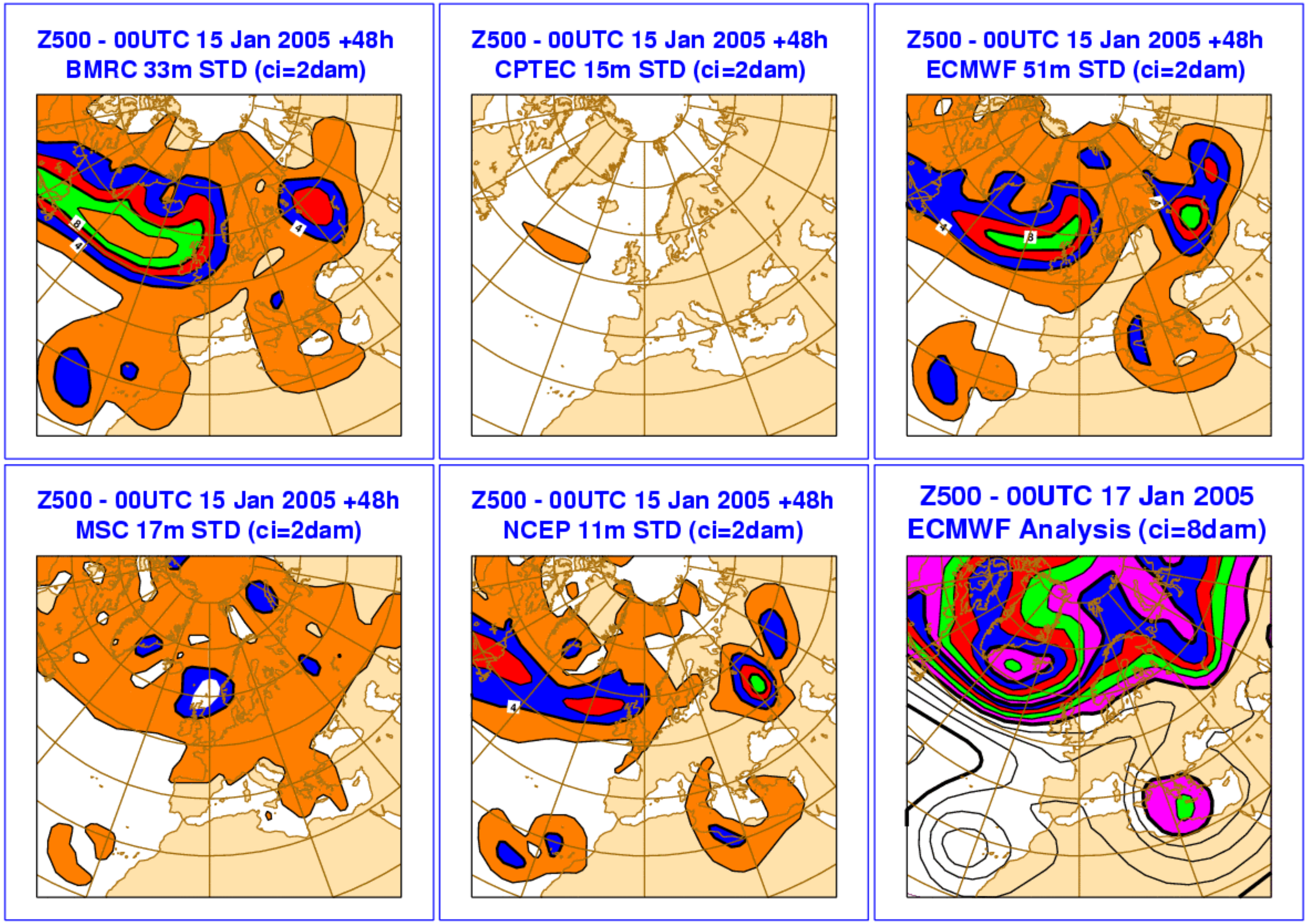
- STD fields are very different
- BMRC has very small values (BMRC uses only initial SVs while ECMWF uses also evolved SVs)
- CPTEC does NOT perturb ExTR
- NCEP has largest values



σ_{Z500}(00,48h): BMRC, CPTEC, ECMWF, MSC, NCEP (EU)

48h forecast Z500 standard deviation. Note that:

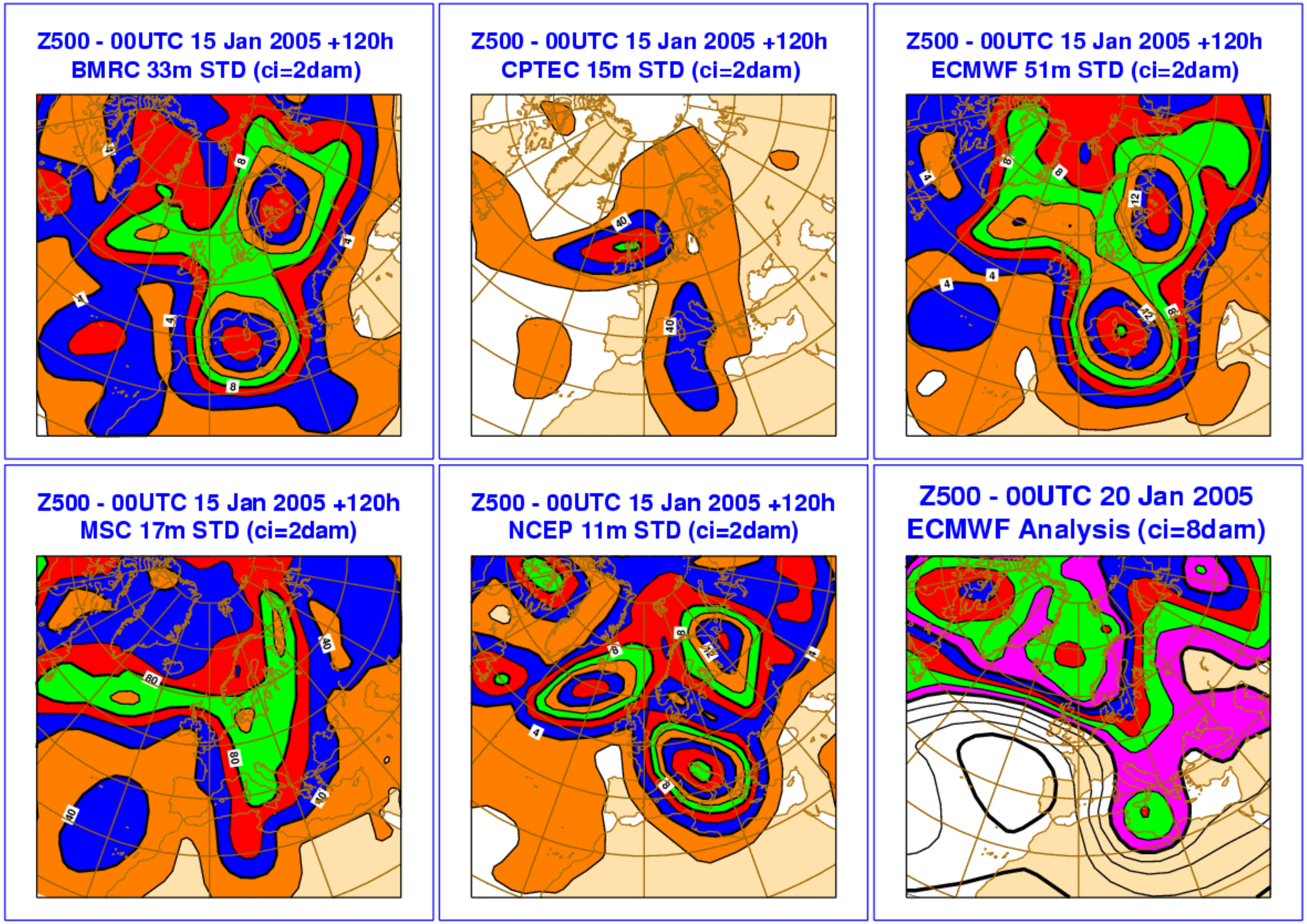
- STDs are rather similar!
- BMRC and ECMWF (both SV-based) show strong similarity
- CPTEC does NOT perturb ExTR
- NCEP shows smaller values than BMRC and ECMWF



σ_{Z500}(00,120h): BMRC, CPTEC, ECMWF, MSC, NCEP (EU)

120h forecast Z500 standard deviation. Note that:

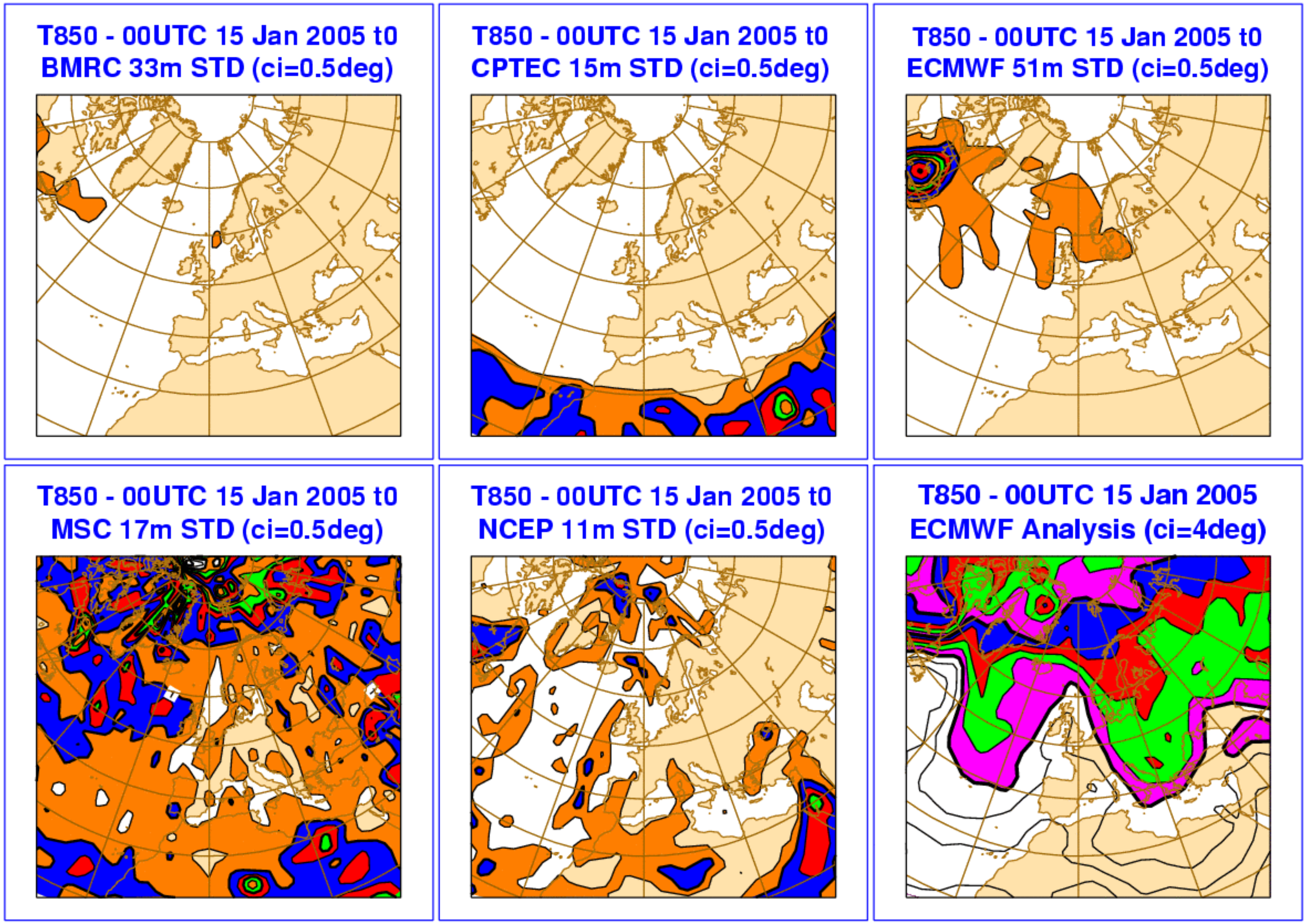
- Very strong similarity of BMRC, ECMWF, MSSC and NCEP STDs
- NCEP showing largest local maxima
- CPTEC has a similar but smaller STD values



σ_{T850}(00,t0): BMRC, CPTEC, ECMWF, MSC, NCEP (EU)

Initial T850 standard deviation. Note that:

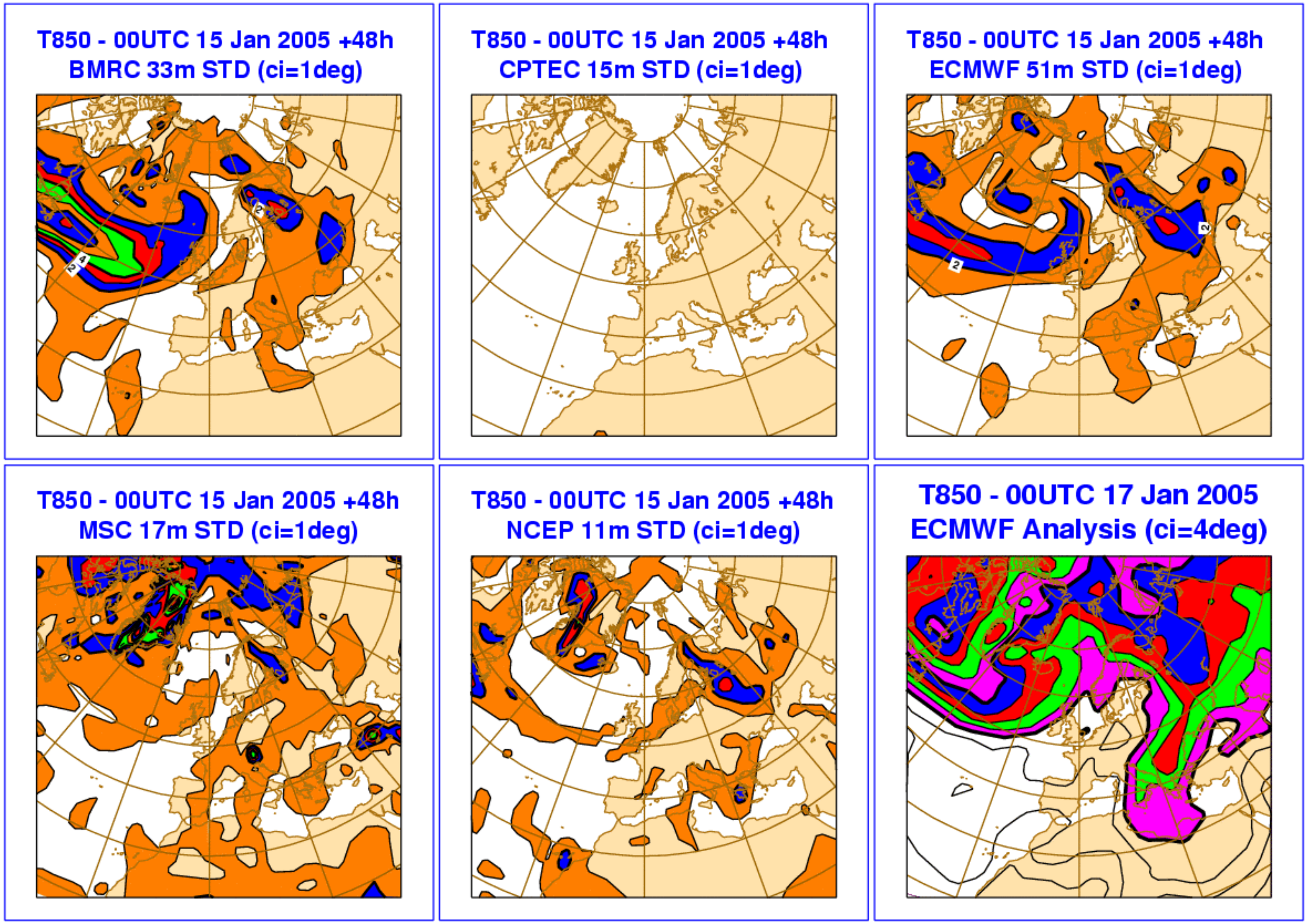
- STDs are very different
- BMRC has very small pert
- CPTEC does NOT perturb ExTR
- ECMWF and MSC have largest local maxima
- MSC has on average largest pert



σ_{T850}(00,48h): BMRC, CPTEC, ECMWF, MSC, NCEP (EU)

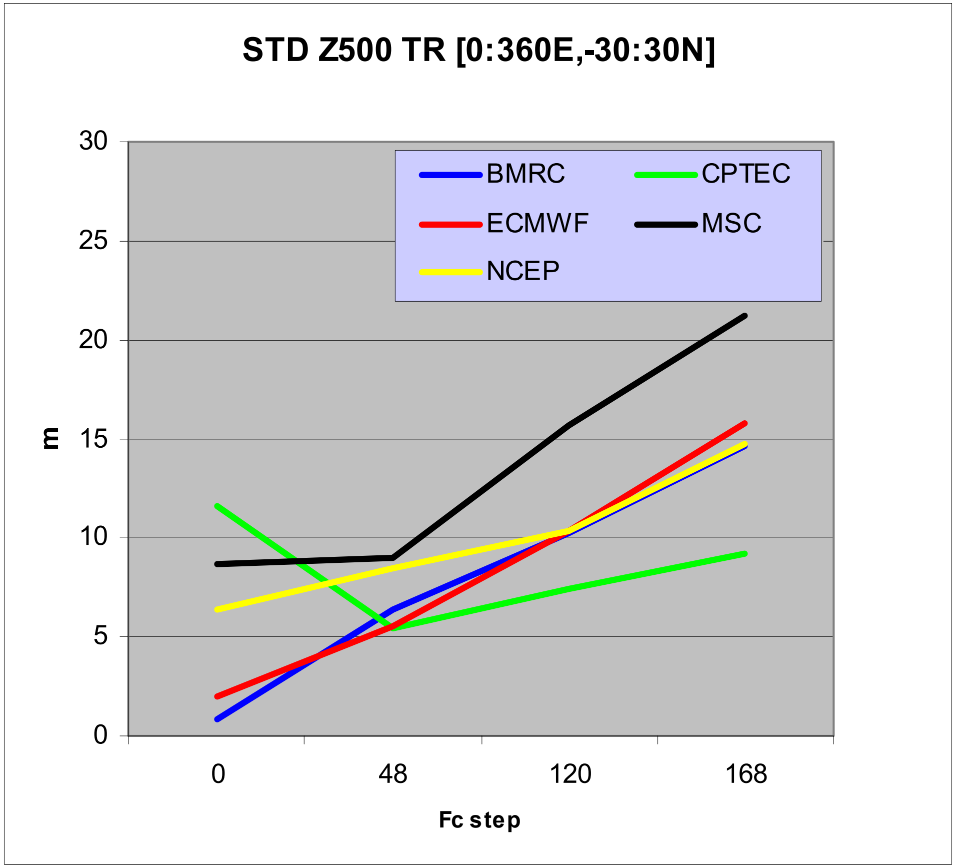
48h forecast T850 standard deviation. Note that:

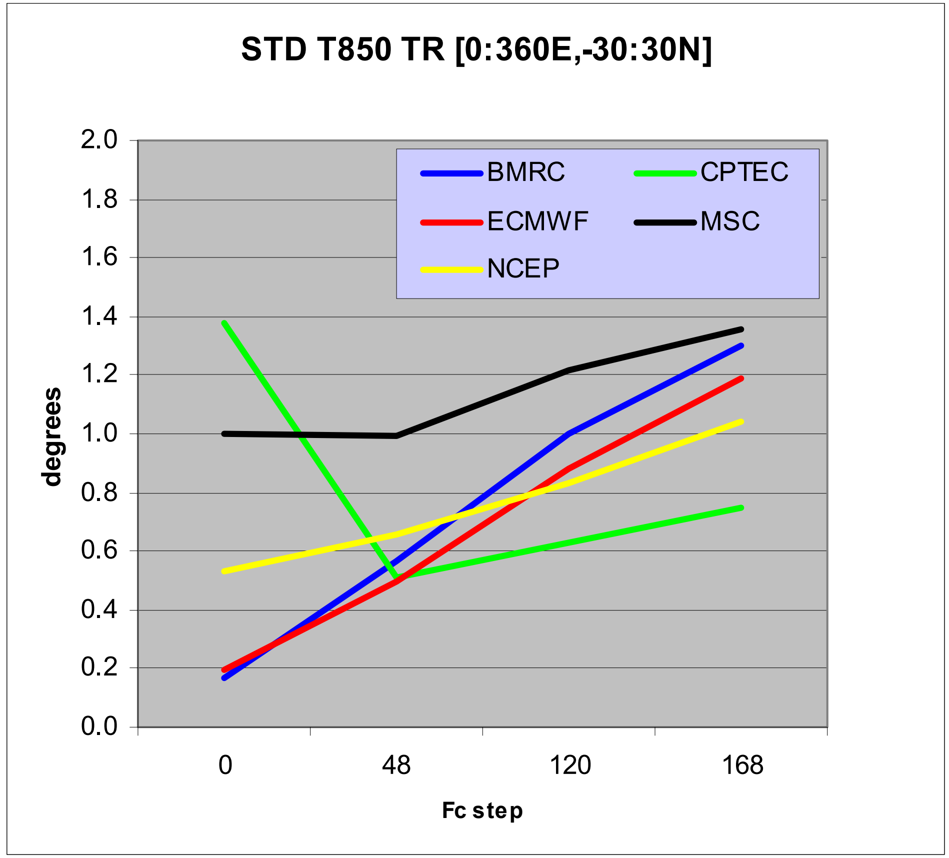
- BMRC and ECMWF show strong similarity
- CPTEC does NOT perturb ExTR
- NCEP also show similarity with BMRC and ECMWF in location (but smaller in size)



$\sigma_{Z500,T850}$(00Z,t): BMRC, CPTEC, ECMWF, MSC, NCEP (TR)

Tropics: CPTEC has largest initial, slowest-growing perturbations, BMRC and ECMWF have similar, fastest growing perturbations, MSC has 2nd largest initial perturbations.

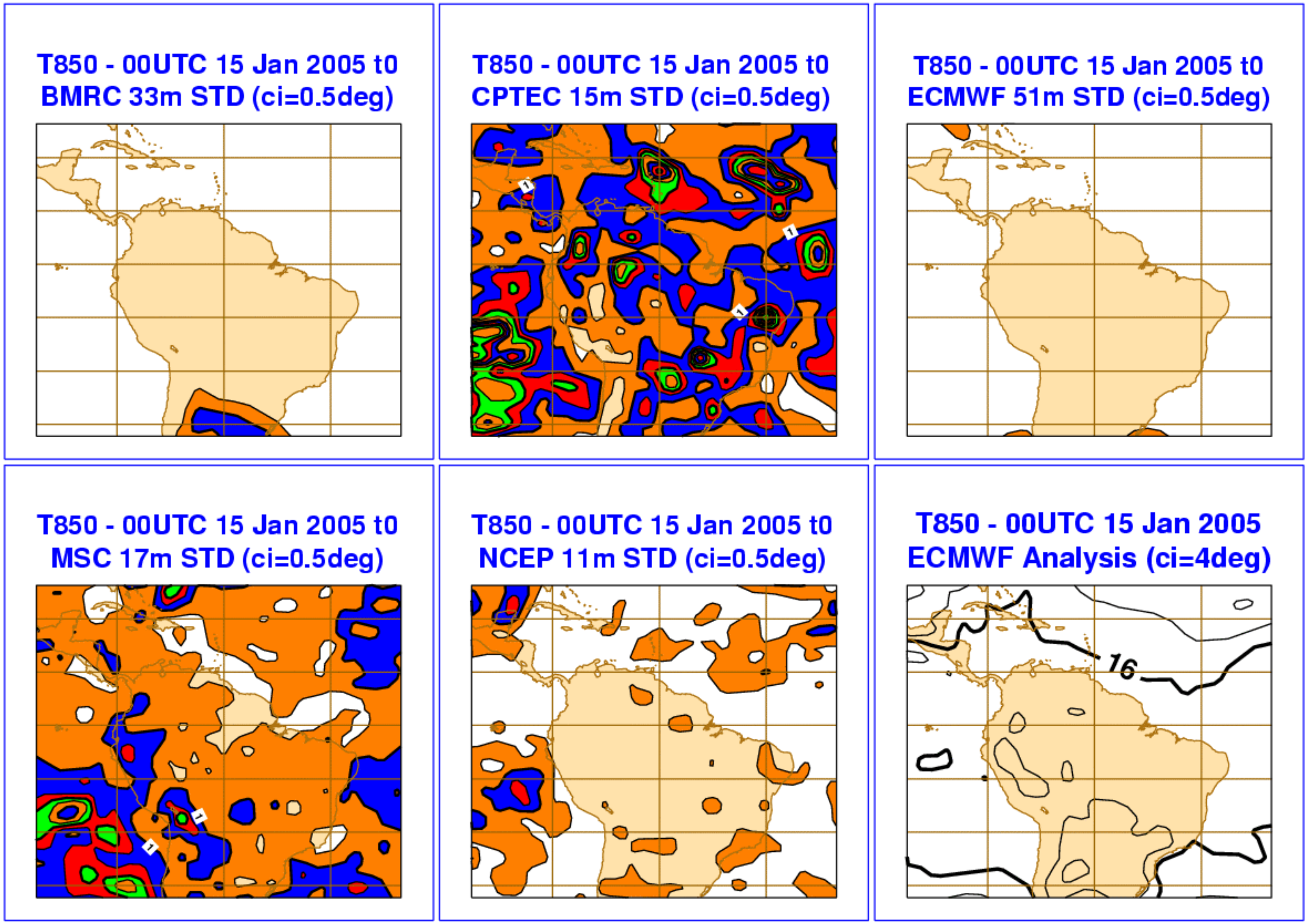




σ_{T850}(00,t0): BMRC, CPTEC, ECMWF, MSC, NCEP (BR)

Initial T850 standard deviation. Note that:

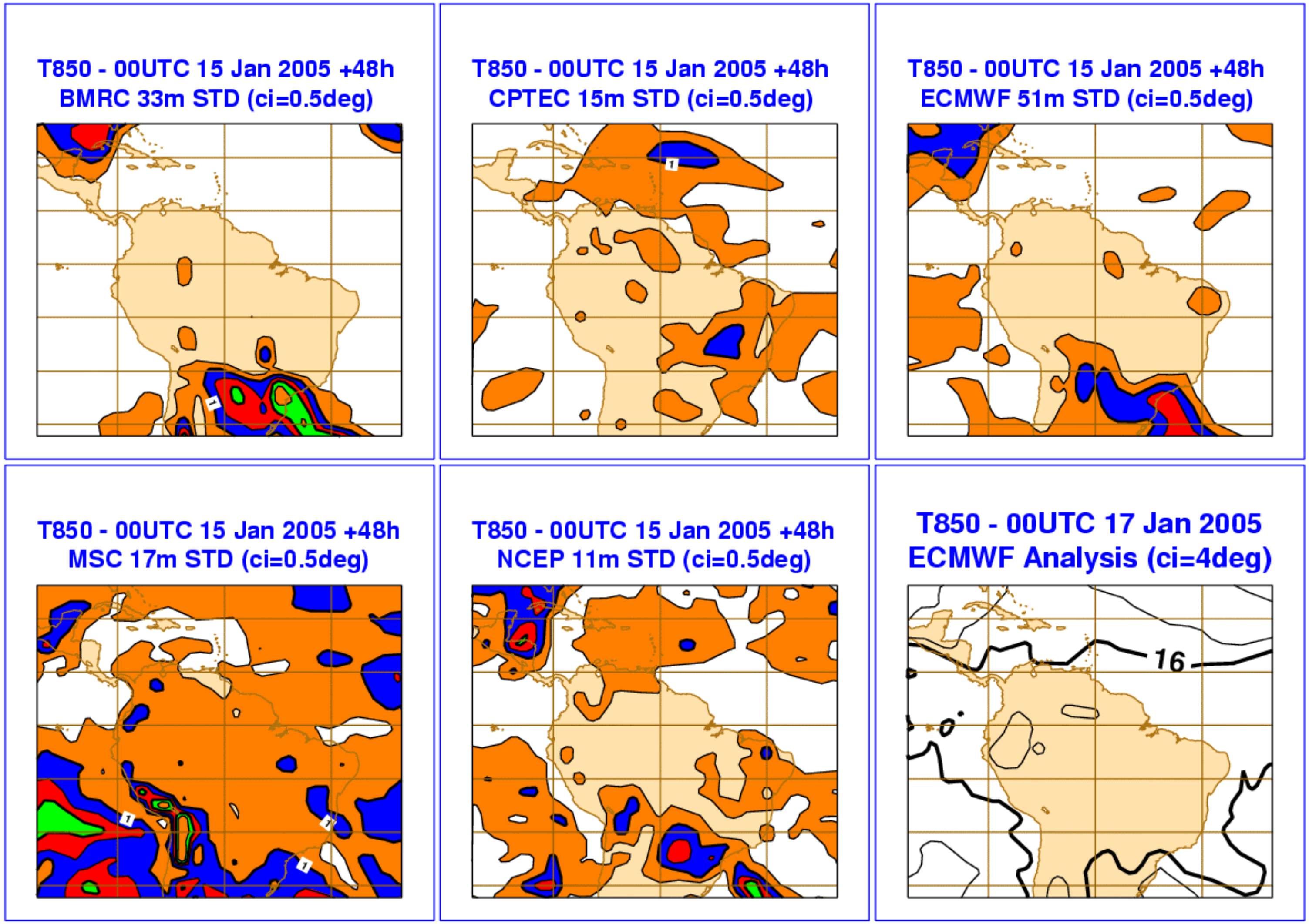
- BMRC does NOT pert TR
- CPTEC and MSC have comparable local maxima
- ECMWF and NCEP have very small pert in this region



σ_{T850}(00,48h): BMRC, CPTEC, ECMWF, MSC, NCEP (BR)

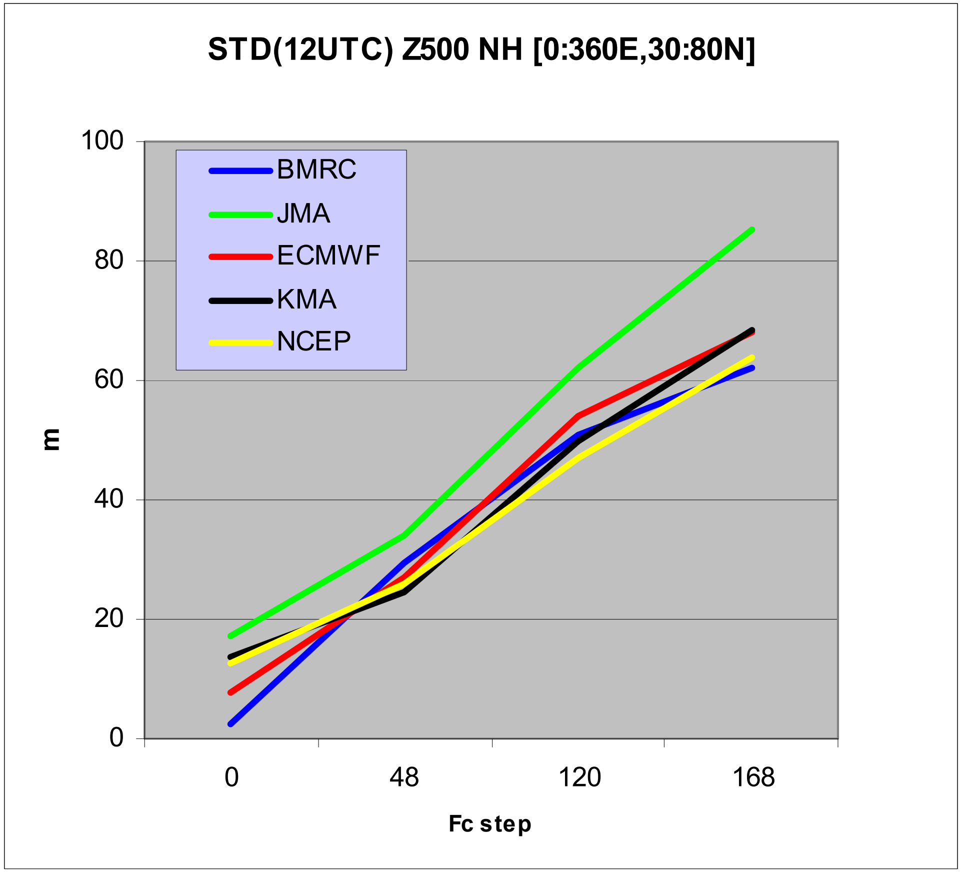
48h forecast T850 standard deviation. Note that:

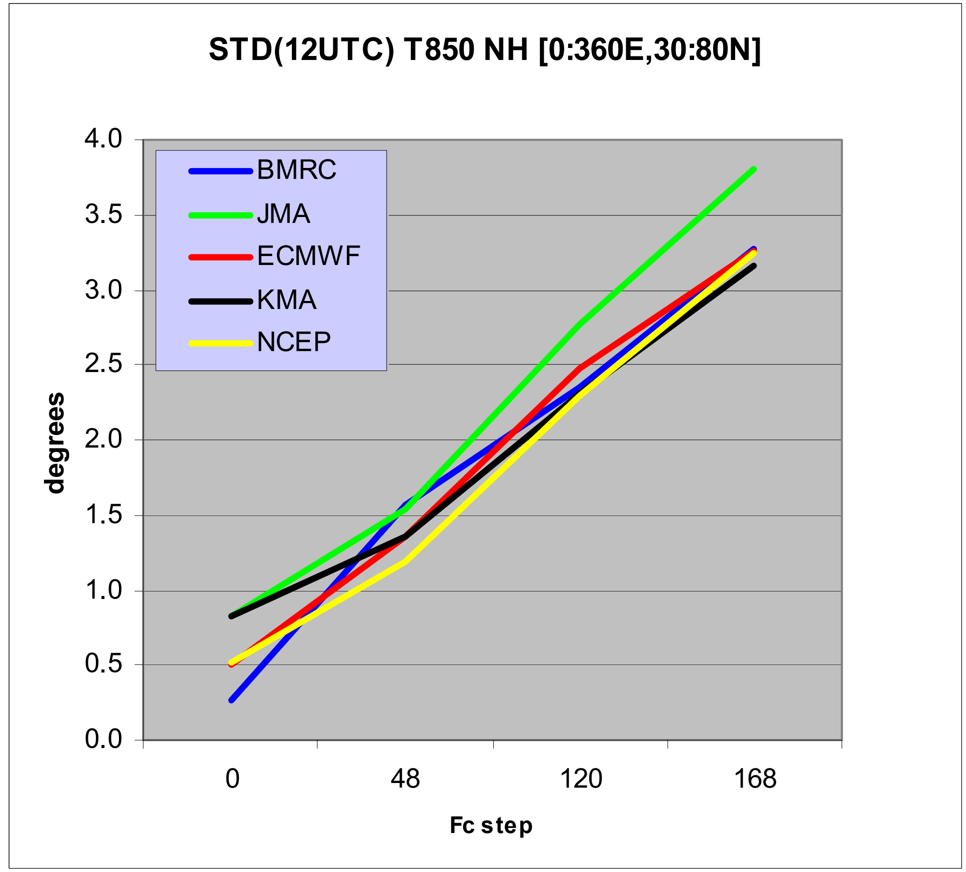
- BMRC and ECMWF are similar
- CPTEC has smallest local values
- MSC has big values over Andes (linked to the use of different algorithms for T-extrapolation)
- NCEP shows pattern similar to BMRC/ECMWF



$\sigma_{Z500,T850}$(12Z,t): BMRC, ECMWF, JMA, KMA, NCEP (NH)

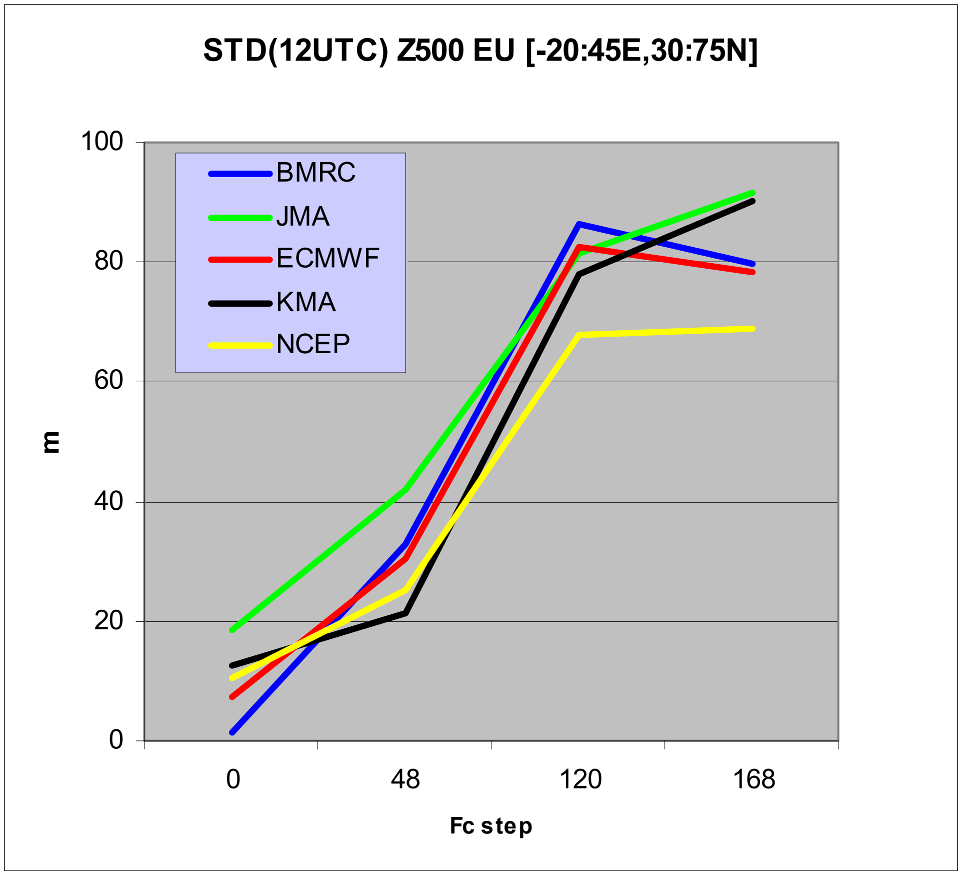
NH: JMA and KMA have largest initial perturbations and largest spread, BMRC has smallest, fastest growing perturbations (only initial SVs).

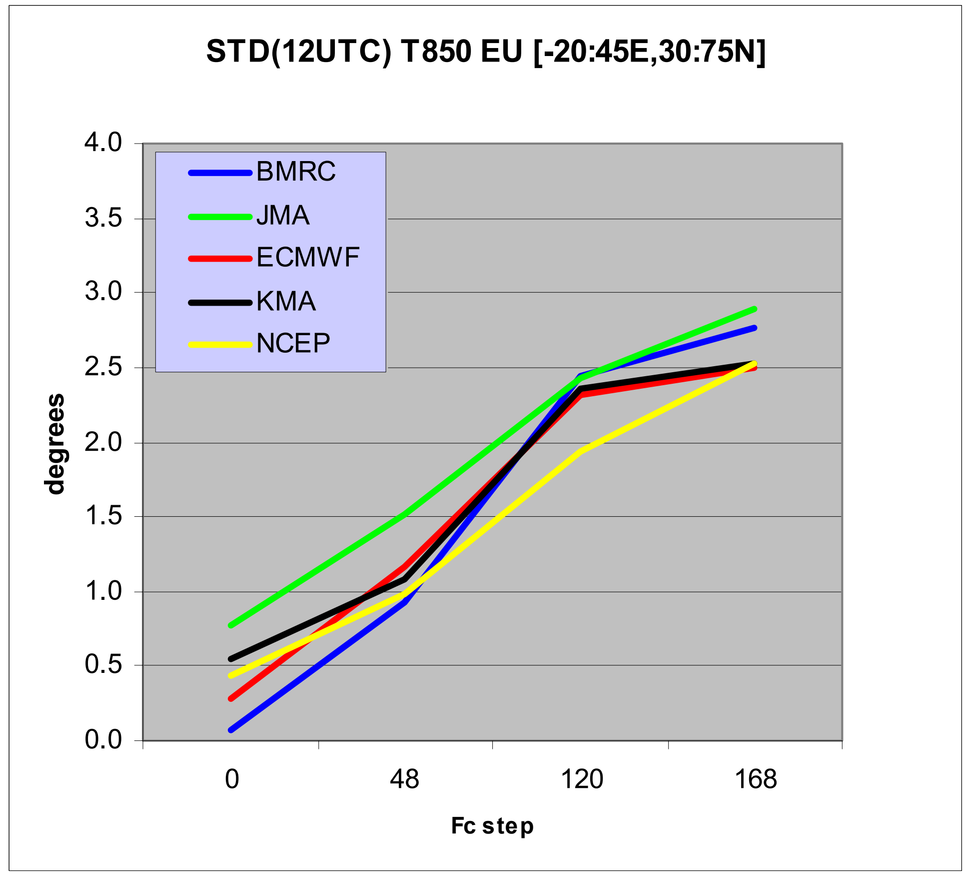




$\sigma_{Z500,T850}$(12Z,t): BMRC, ECMWF, JMA, KMA, NCEP (EU)

Europe: JMA has largest initial perturbations, BMRC has smallest, fastest growing perturbations (only initial SVs).

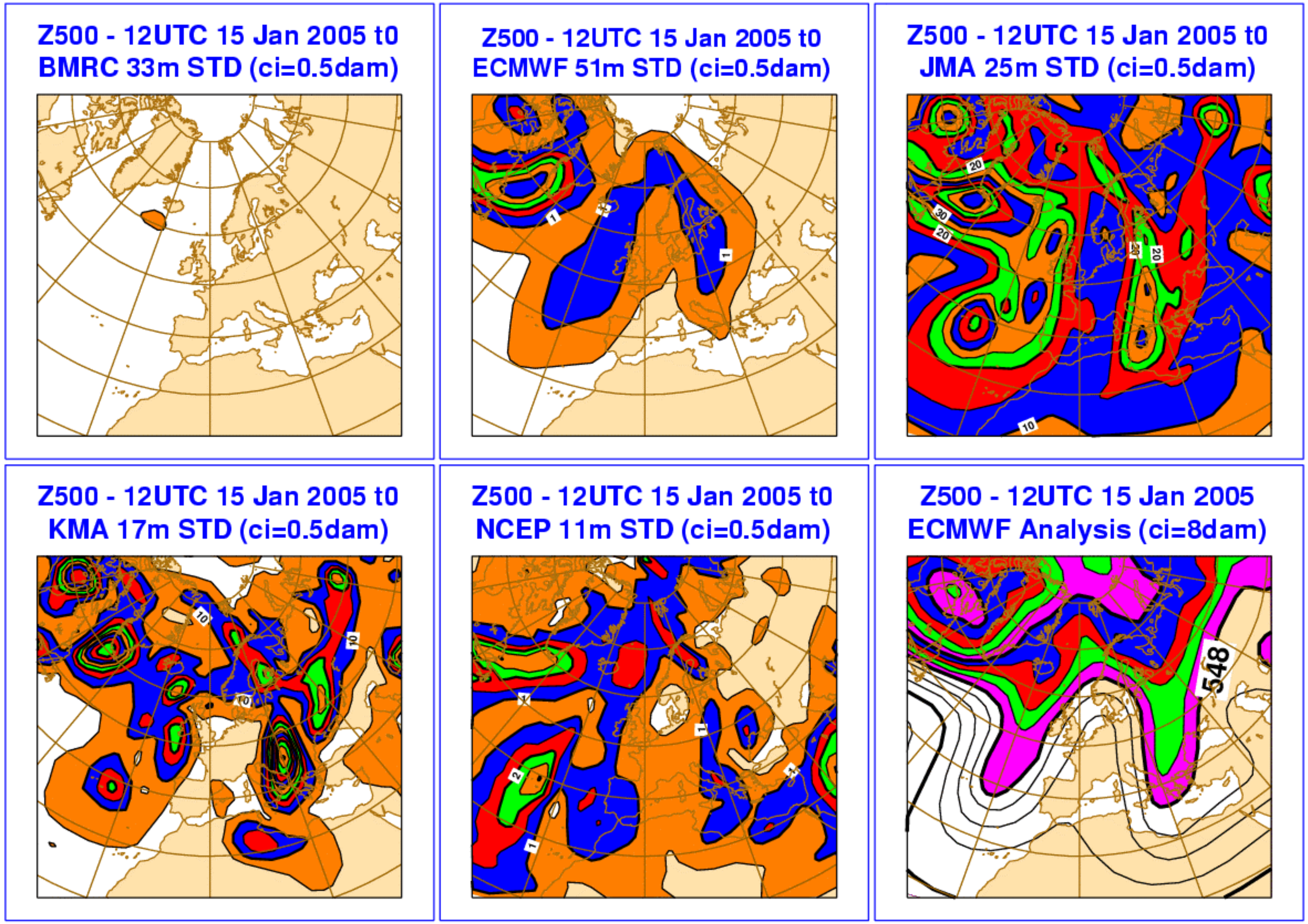




σ_{Z500}(12,t0): BMRC, ECMWF, JMA, KMA, NCEP (EU)

Initial Z500 standard deviation. Note that:

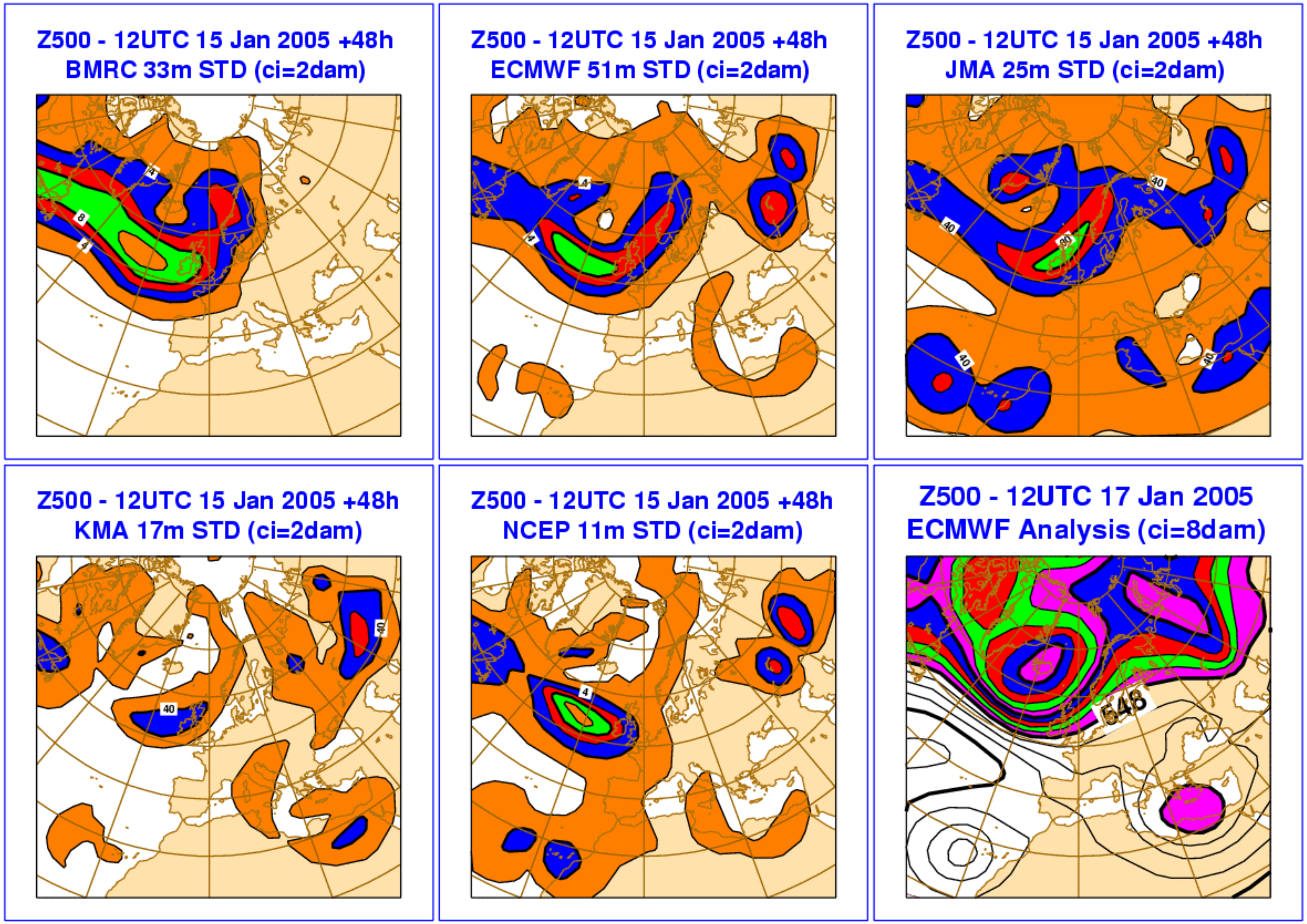
- BMRC has very small perturbations (BMRC uses only initial SVs while ECMWF uses also evolved SVs)
- ECMWF, JMA, KMA and NCEP identify similar large-scale regions
- JMA and KMA have largest perturbations



σ_{Z500}(12,48h): BMRC, ECMWF, JMA, NCEP (EU)

48h forecast Z500 standard deviation. Note that:

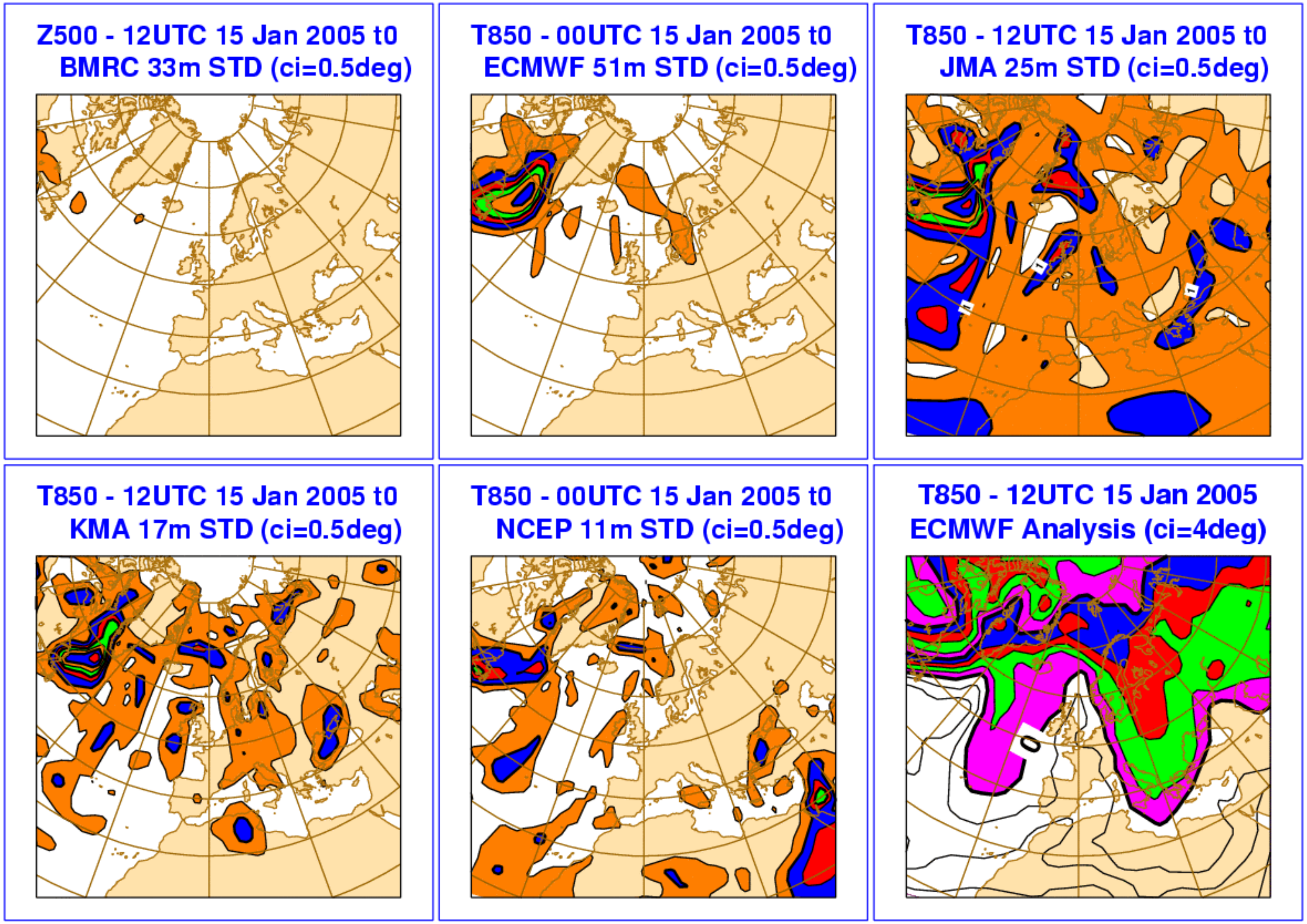
- STDs are rather similar
- BMRC shows fastest growth
- BMRC and NCEP show largest local maxima



σ_{T850}(12,t0): BMRC, ECMWF, JMA, KMA, NCEP (EU)

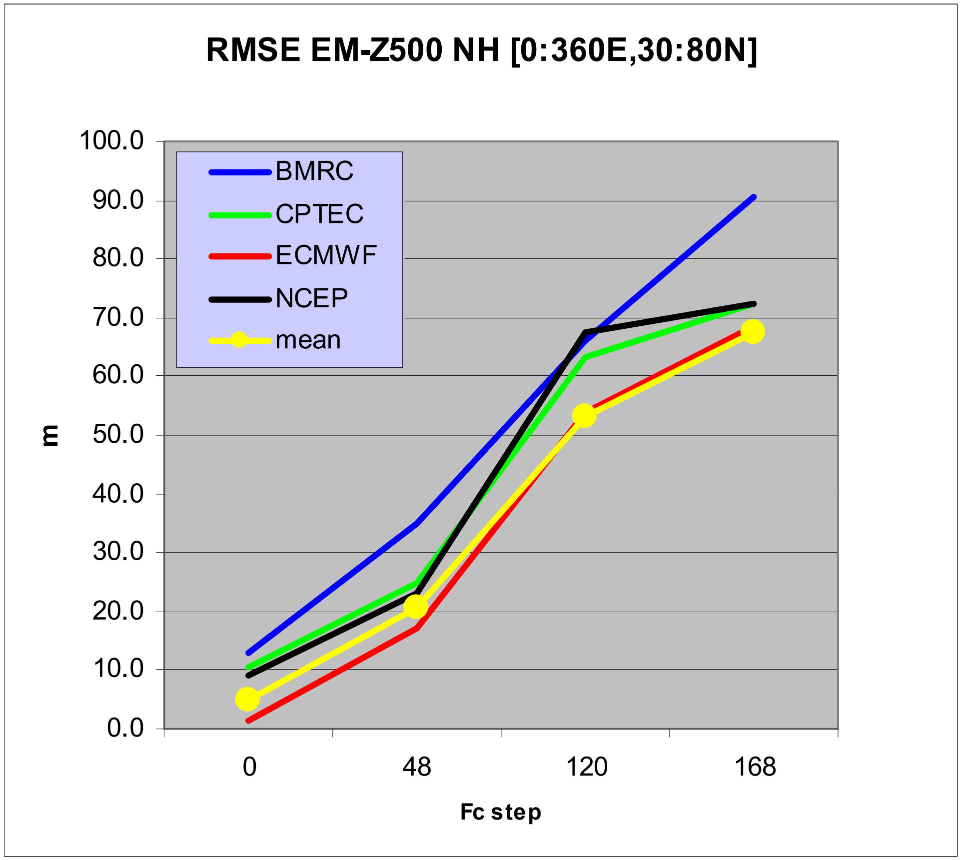
Initial T850 standard deviation. Note that:

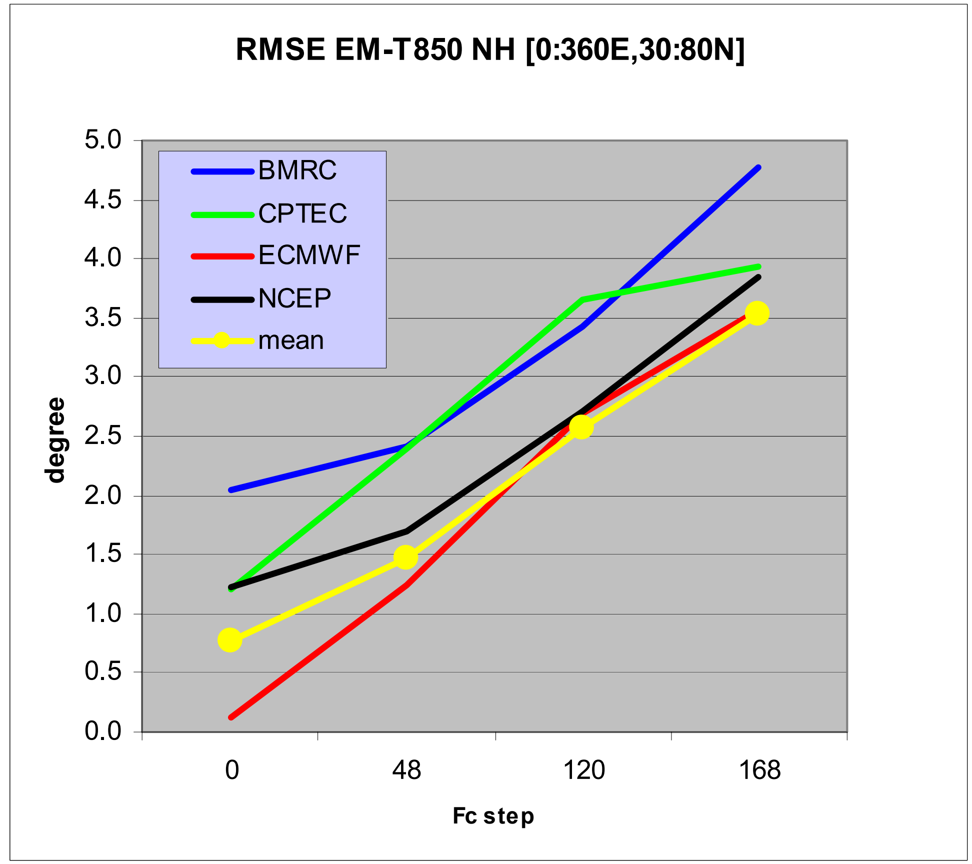
- STDs identify similar regions
- BMRC has very small pert
- JMA and KMA have largest perturbations



$\mu_{Z500,T850}$(00Z,t): BMRC, CPTEC, ECMWF, NCEP (NH)

NH: filtering of unpredictable small-scale features maybe more efficient with a multi-model, multi-analysis ensemble system. Poorer EPSs benefit most (NB: ver=EC).





$\mu_{Z500,T850}$(12Z,t): BMRC, ECMWF, JMA, NCEP (NH)

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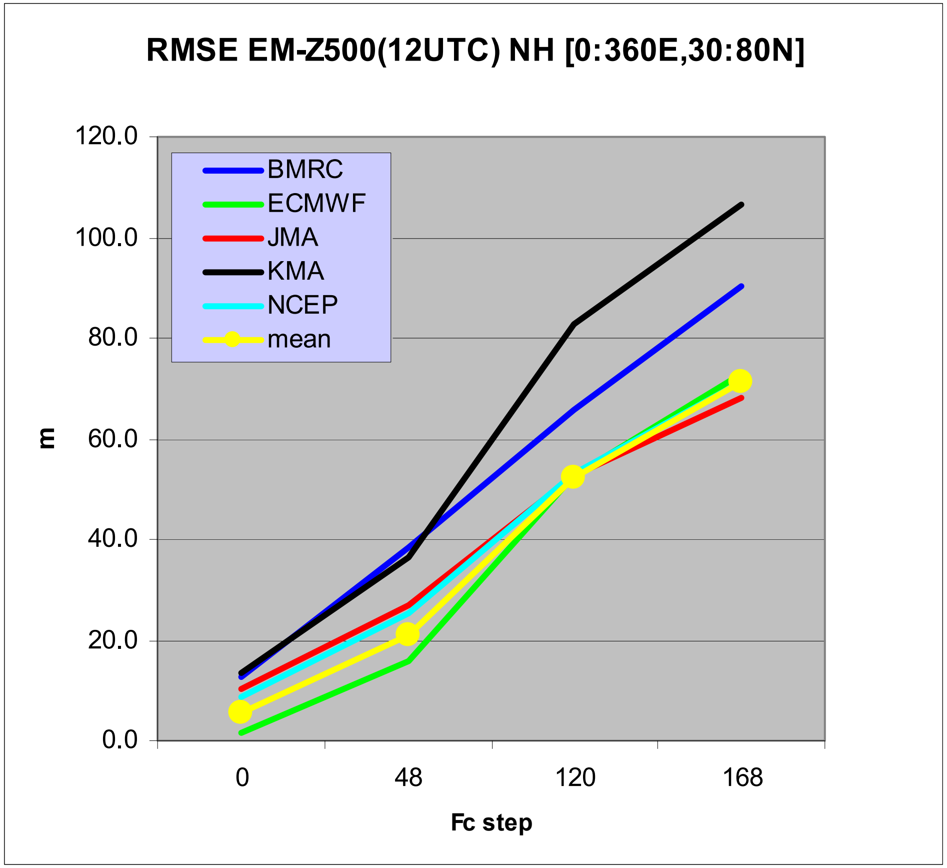
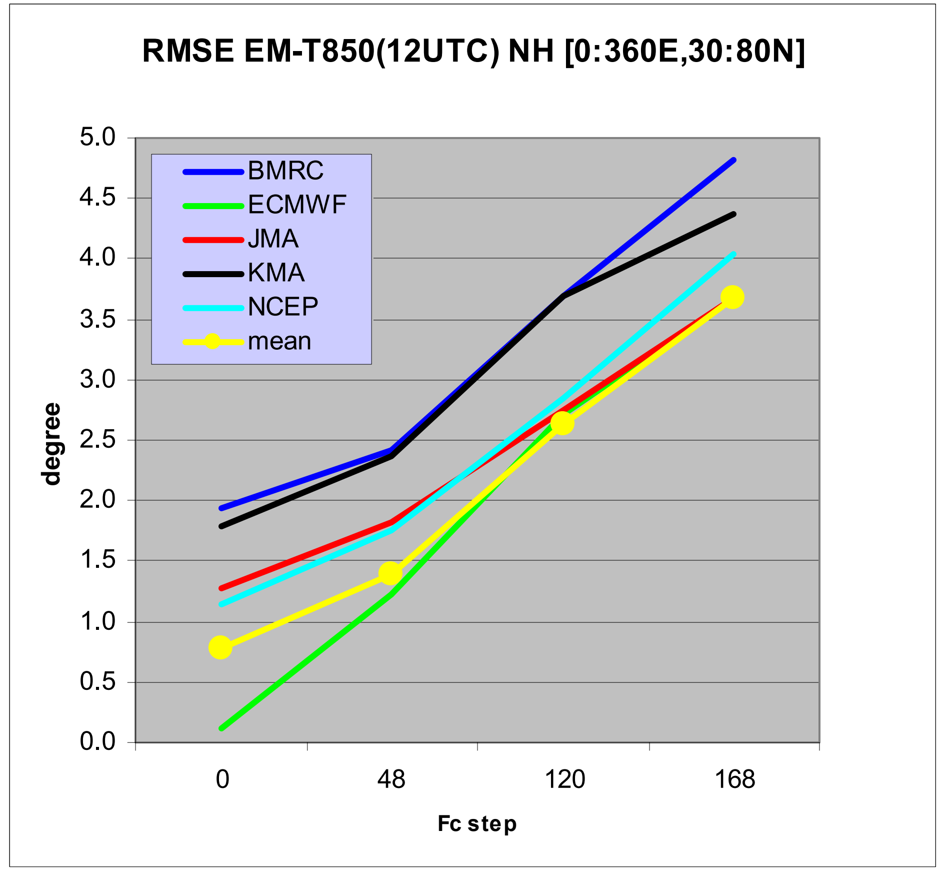




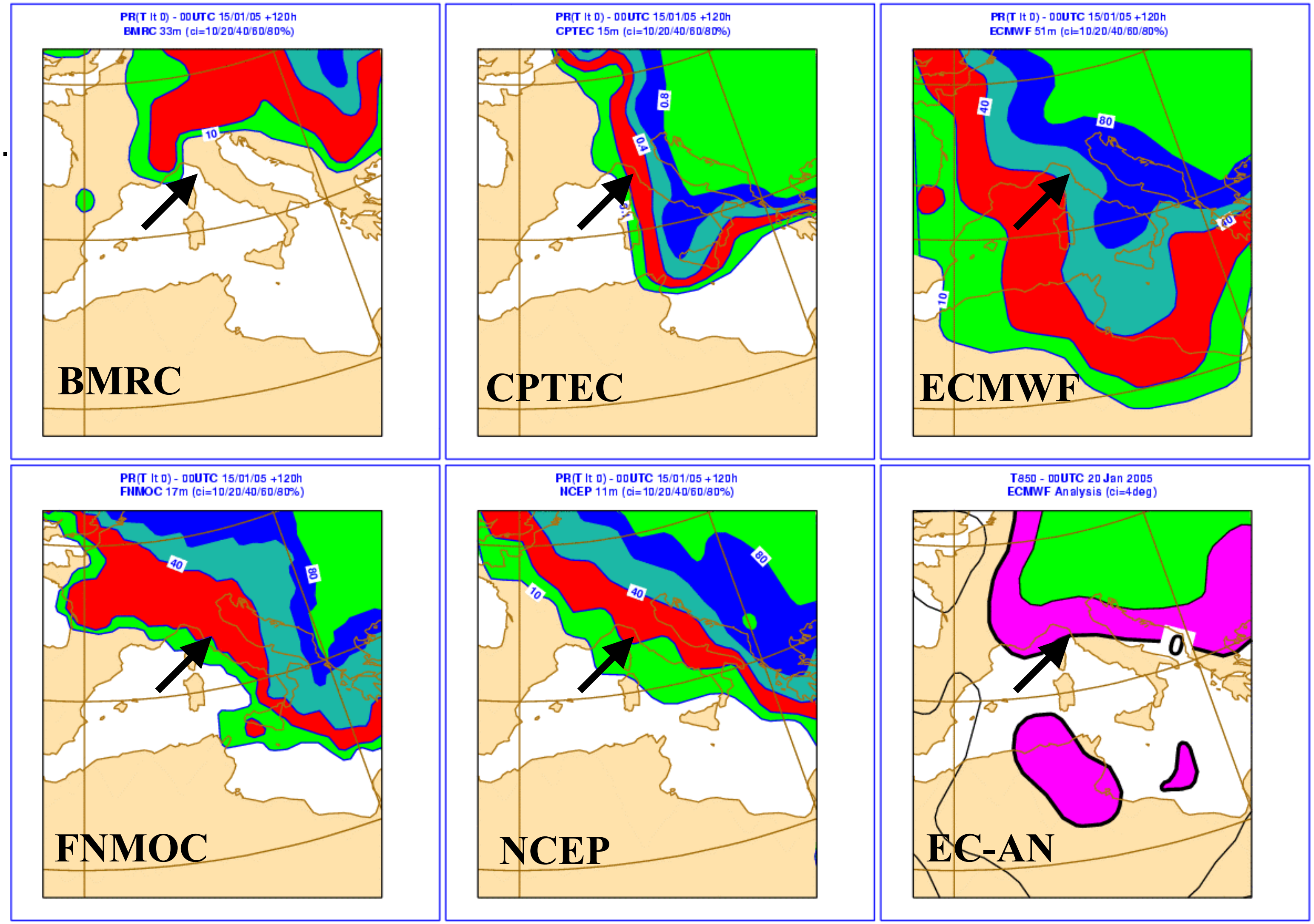
π_{Z500}(00,120h): BMRC, CPTEC, ECMWF, FNMOC, NCEP (IT)

Europe: 120h forecast probability of T850<0 degrees.

What is the PR(T850<0) in Firenze?

BMRC gives 0%, the others more than 20% probability.*

** This is just one case: probability forecasts should be verified on a large dataset.*



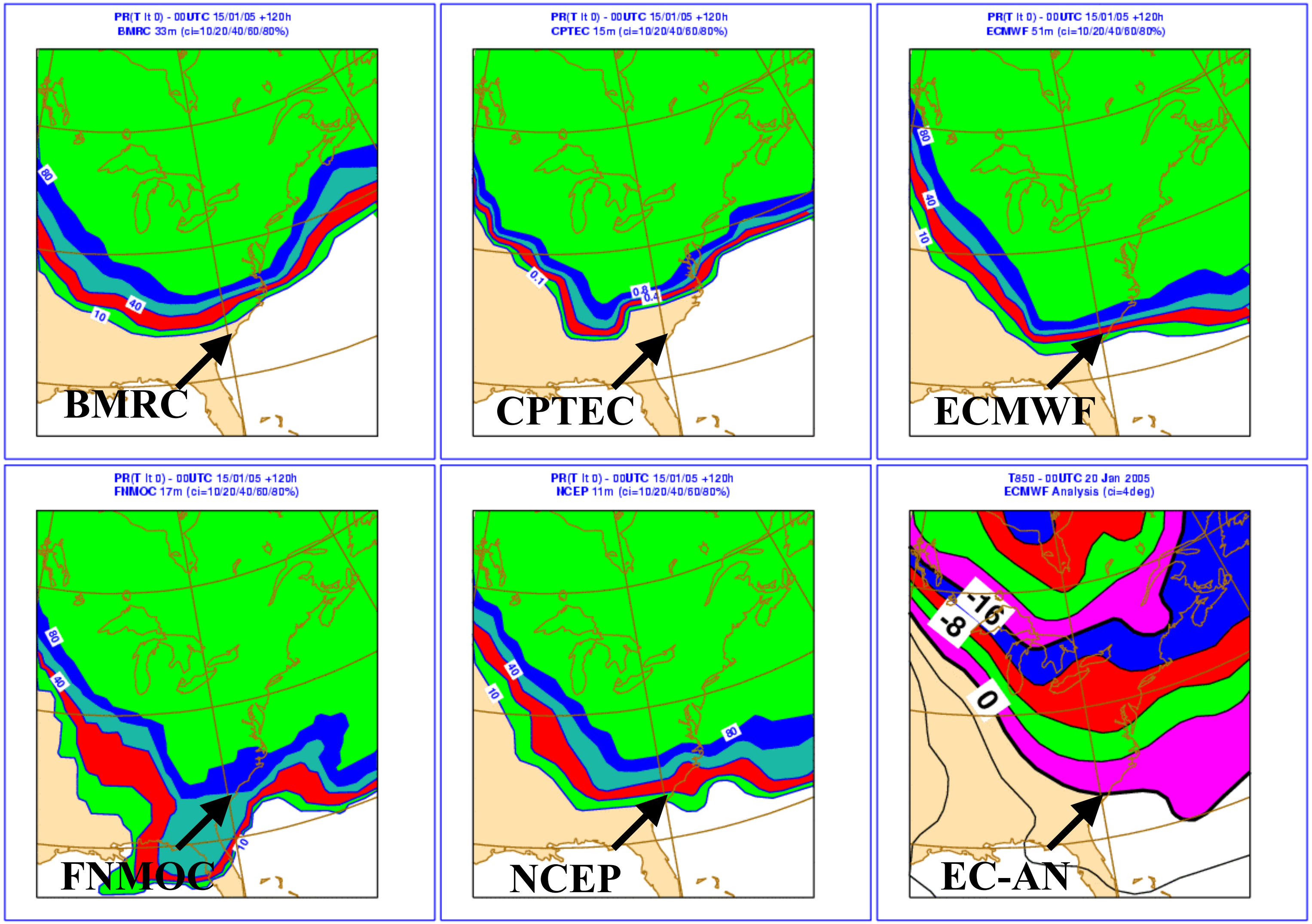
π_{Z500}(00,120h): BMRC, CPTEC, ECMWF, FNMOC, NCEP (US)

US: 120h forecast probability of T850<0 degrees.

What is the PR(T850<0) at ~33°N?

*BMRC/CPTEC gives 0%, ECMWF/NCEP 10% and FNMOC 50%.**

** This is just one case: probability forecasts should be verified on a large dataset.*



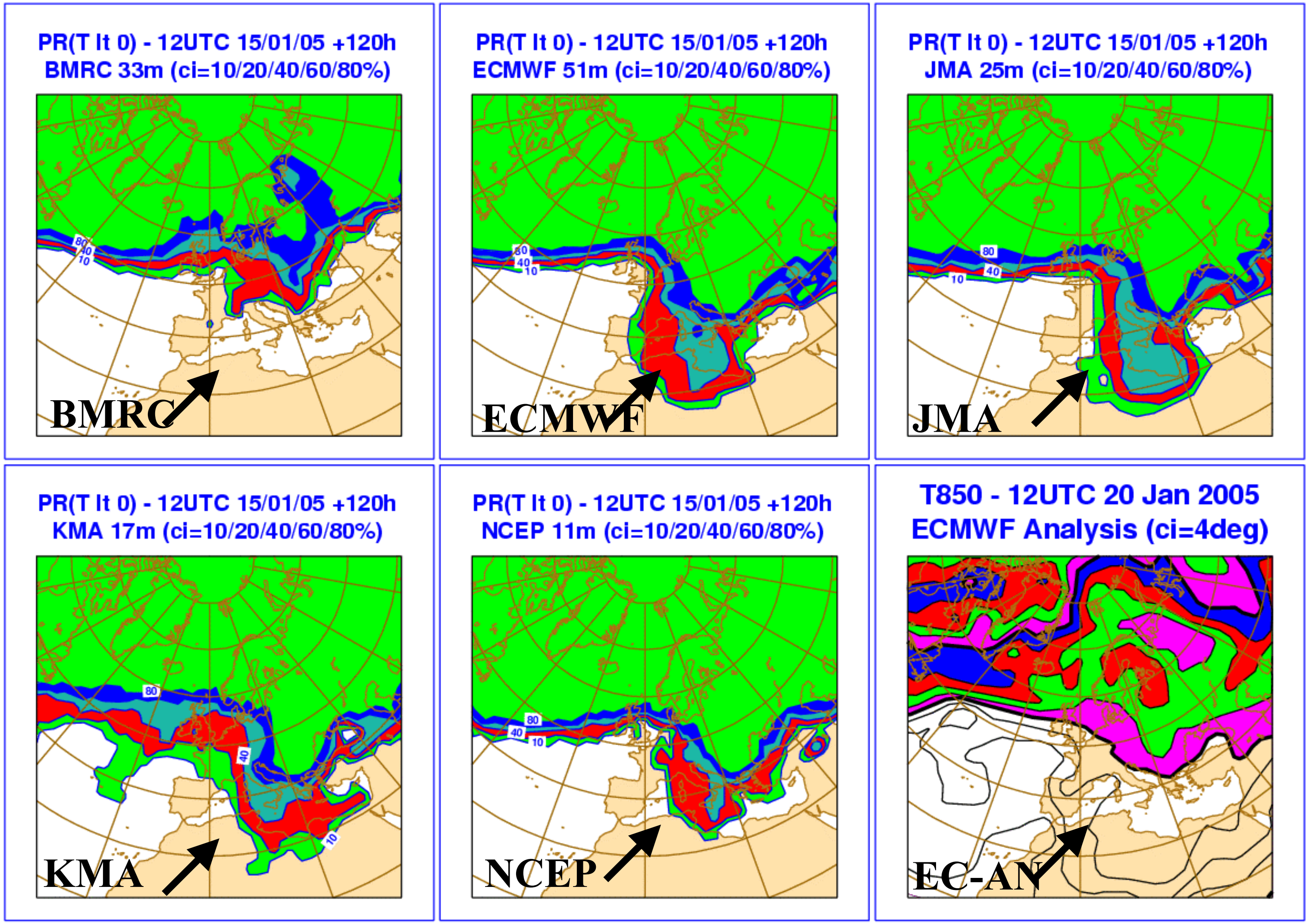
π_{Z500}(12,120h): BMRC, ECMWF, JMA, KMA, NCEP (EU)

Europe: 120h forecast probability of T850<0 degrees.

What is the PR(T850<0) in Tunisia?

*BMRC gives a zero probability.**

** This is just one case: probability forecasts should be verified on a large dataset.*

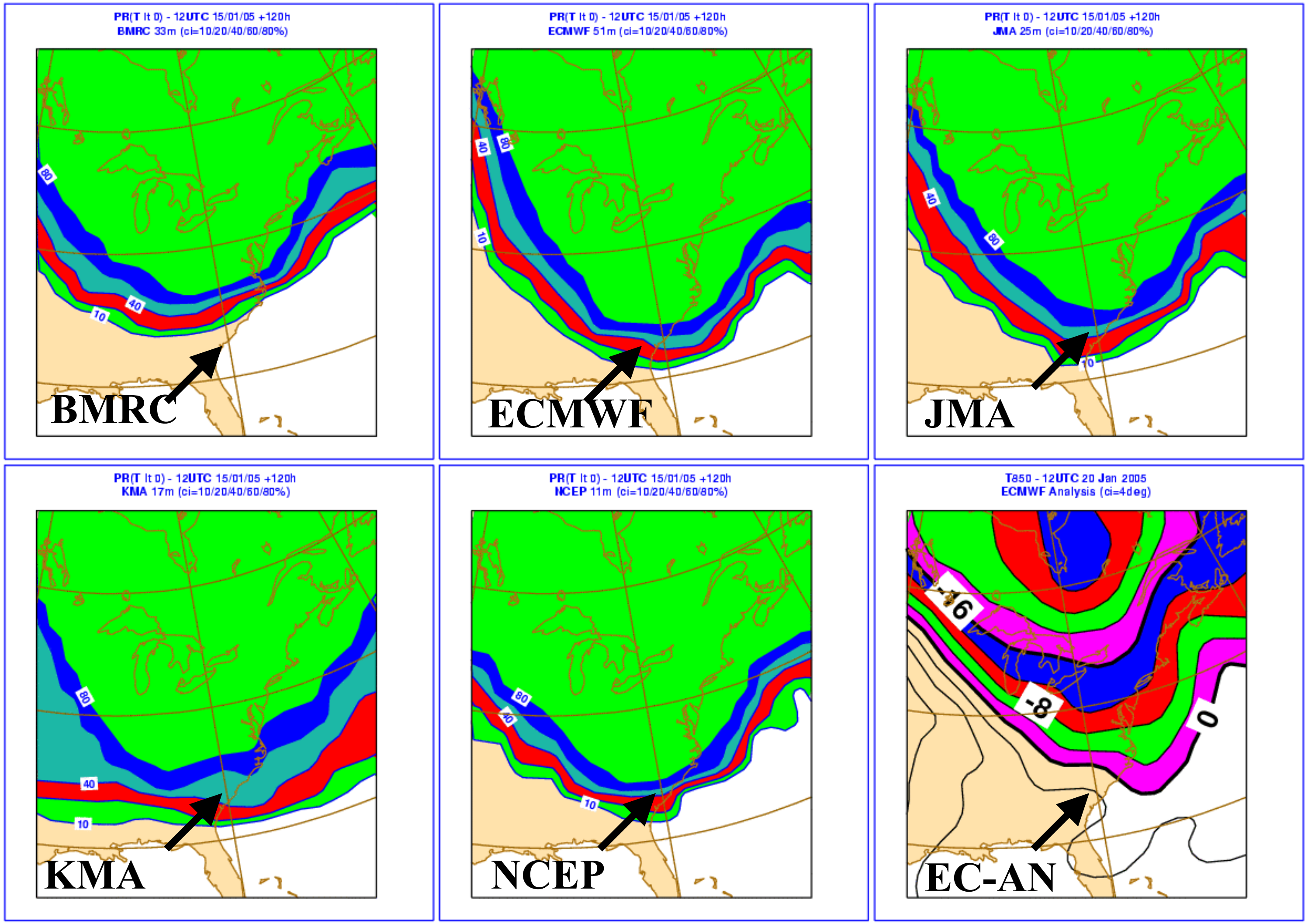


π_{Z500}(12,120h): BMRC, ECMWF, JMA, KMA, NCEP (US)

US: 120h forecast probability of T850<0 degrees.

What is the probability of below freezing temperatures at ~33°N?

*BMRC gives zero probability, the others ~50%.**



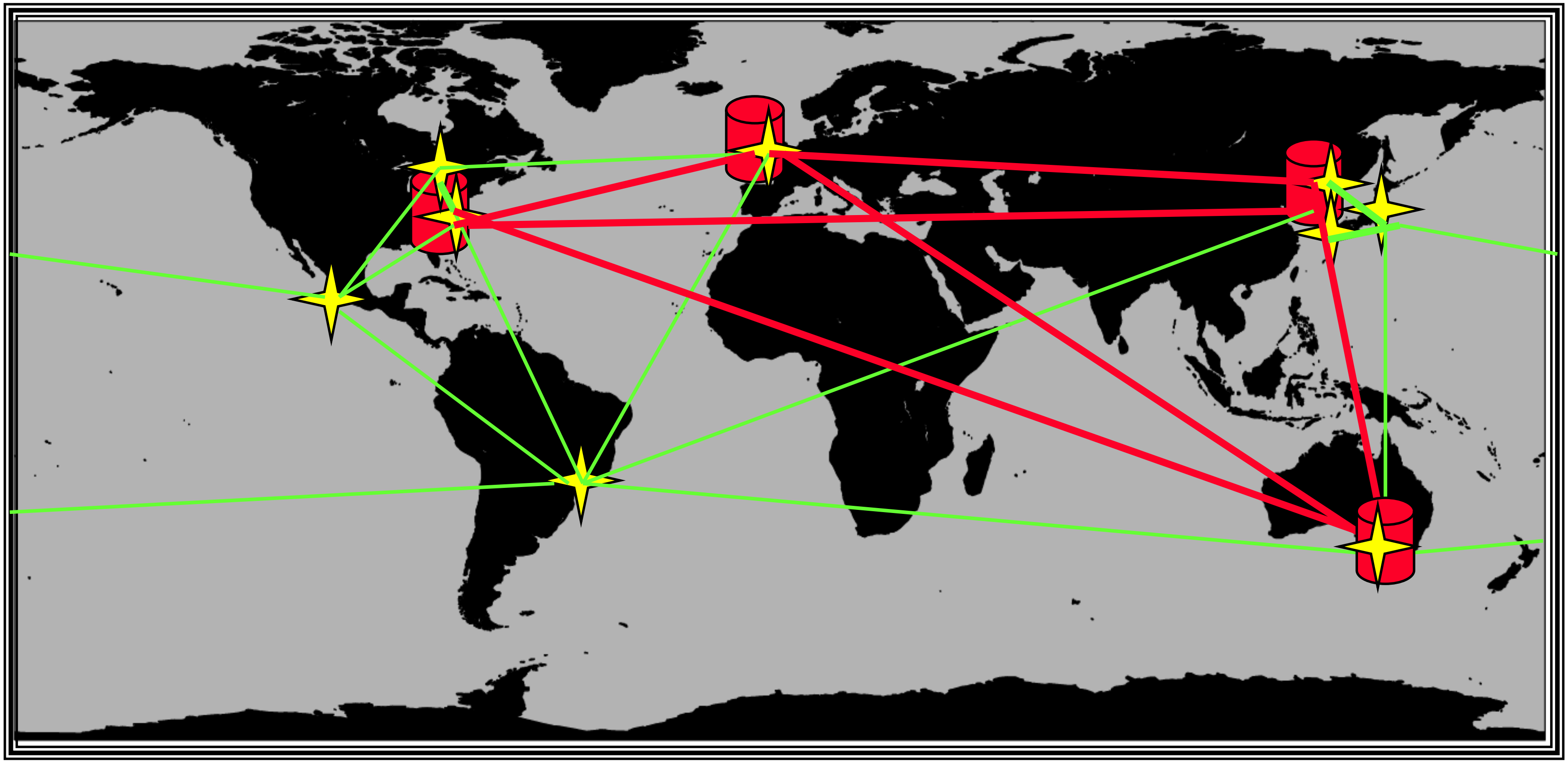
** This is just one case: probability forecasts should be verified on a large dataset.*

Outline

- The value of ensemble prediction
- The design of an ensemble prediction system
- Similarities/differences of ensemble prediction systems
- TIGGE and the future of ensemble prediction

TIGGE could lead to a MUMMA-GEPS

TIGGE could lead to a **Multi-Model, Multi-Analysis Global Ensemble Prediction System (MUMMA-GEPS)**, with N production centers (yellow stars) and few data-hubs (red) connected by high-speed, high-capacity communication lines.



Flood applications can help to value a MUMMA-GEPS

The value of the **MUMMA-GEPS** could be assessed by linking TIGGE with the European Flood Alert System (EFAS) and the Hydrological Ensemble Prediction Experiment (HEPEX).

Observations	Data assimilation	Global M~al modelling	Local M~al modelling	Local H~al modelling	Quality control
•Weather data •Hydrological data •Observation perturbation methods • …	•3/4D-Var Data Assimilation Systems •Ensemble Data Assimilation • …	•Global perturbation methods •Model design •Model resolution •Ensemble Size	•Nested Limited Area Models •Local perturbation methods • …	•Post-processing methods •Combination methods •Rainfall, runoff models •…	•Verification methods •Users' value •Verification data • …

TIGGE could address open issues in ensemble forecasting

TIGGE could confirm whether conclusions drawn by recent works (*[1]*, *[3]*) are valid:

- **Model and data-assimilation quality matters more than perturbation method**
  - *"The performance of EPSs strongly depends on the quality of the data assimilation system used to create the unperturbed initial conditions, and the numerical model used to generate the forecasts" [3]*
  - *"The superior quality of the ECMWF-EPS with respect to the BMRC-EPS is attributed primarily to the superior quality of the ECMWF analysis rather than model differences or model resolution" [1]*

- **Ensemble design**
  - What is the importance of the initial perturbation method?
  - What is the importance of the method used to simulate model uncertainty?

TIGGE could address open issues in ensemble forecasting

- **A ‘sample-all’ approach should be followed**
  - *“A successful ensemble prediction system should simulate the effect of both initial and model related uncertainties on forecast errors” [3]*

- **A multi-model multi-analysis system is necessary**
  - *“In the ECMWF, MSC and NCEP EPSs, the spread is still insufficient to systematically capture reality, suggesting that none of them is capable alone to simulate all sources of forecast uncertainties” [3]*

- **Increasing ensemble size beyond 50 matters less than increasing resolution**
  - A distributed, MUMMA-GEPS which involves several production centres can lead to a higher-resolution ensemble prediction system
  - Now, 351 members are run daily with resolution from T_L119 to T_L255
  - By sharing production costs, ~50 members could be run at T_L399 (~40km)

The key messages of this talk

- Ensemble forecasts are valuable because they provide an estimate of the whole probability distribution function of forecast states and not only the most likely scenario.

- There are currently 9 Operational Global EPSs, based on 351 ensemble members run with horizontal resolution ranging from T62 to T_L255 (~80km), and with forecast length ranging from 8 to 16 days. A comparison of ensemble forecasts for one case indicate strong similarity in certain products but differences in others.

- TIGGE can help addressing key scientific issues such as whether *"model and data-assimilation quality matters more than perturbation method" ([1],[3]),* and whether a multi-model, multi-analysis, 'sample-all' approach should be followed in the future.

- TIGGE could lead to a Multi-Model, Multi-Analysis Global Ensemble Prediction System (MUMMA-GEPS), which could foster the development of new applications, and better ensemble combination methods.

Few selected references

- [1] Bourke, W., Buizza, R., & Naughton, M., 2004: **Performance of the ECMWF and the BoM Ensemble Ensemble Systems in the Southern Hemisphere**. *Mon. Wea. Rev.*, in press.
- [2] Buizza, R., Richardson, D. S., & Palmer, T. N., 2003: **Benefits of increased resolution in the ECMWF ECMWF ensemble system and comparison with poor-man's ensembles**. *Q. J. R. Meteorol. Soc.,*129, *Soc.,*129, 1269-1288.
- [3] Buizza, R., Houtekamer, P. L., Toth, Z., Pellerin, G., Wei, M., & Zhu, Y., 2004: **A comparison of the the ECMWF, MSC and NCEP Global Ensemble Prediction Systems**. *Mon. Wea. Rev.*, in press.
- [4] Jones, D, Sestak, M, & Rennick, M A, 1999: **Operational Ensemble Forecast Products and Verification at FNMOC**. 13th Conference on Numerical Weather Prediction, AMS, Boston, 250-253.
- [5] Molteni, F., Buizza, R., Palmer, T. N., & Petroliagis, T., 1996: **The new ECMWF ensemble prediction prediction system: methodology and validation**. *Q. J. R. Meteorol. Soc.*, 122, 73-119.
- [6] Houtekamer, P L, Lafaivre, L, Derome, J, Ritchie, H & Mitchell, H L, 1996: **A system simulation approach to Ensemble Prediction**. *Mon. Wea. Rev*, 124, 1225-1242.
- [7] Houtekamer, P L, Herschel, L M, Pellerin, G, Buehner, M, Charron, M, Spacek, L, & Hansen, B, 2005: 2005: **Atmospheric Data Assimilation with an Ensemble Kalman Filter: results with real observations**. **observations**. *Mon. Wea. Rev.*, 133, 604-620.
- [8] Tracton, M S, & Kalnay, E, 1993: **Operational ensemble prediction at the National Meteorological Meteorological Center**. *Weather & Forecasting*, 8, 379-398
- [9] Toth, Z, & Kalnay, E., 1997: **Ensemble Forecasting at NMC and the Breeding Method.** *Mon. Wea. Wea. Rev.*, 125, 3297-3319.
- [10] Zhang, Z, Krishnamurti, T N, 1999: **A perturbation method for hurricane ensemble prediction**. **prediction**. *Mon. Wea. Rev.*, 127, 447-469.

Web sites of the 9 Operational Global EPSs

- BMRC Australia (www.bom.gov.au)
- CMA China (www.cma.gov.cn)
- CPTEC Brazil (www.cptec.inpe.br)
- ECMWF Europe (www.ecmwf.int)
- FNMOC US (www.fnmoc.navy.mil)
- JMA Japan (www.jma.go.jp)
- KMA Korea (www.kma.go.kr)
- MSC Canada (www.msc.ec.gc.ca)
- NCEP Washington (www.ncep.noaa.gov)

List of acronyms

- BMRC: Bureau of Meteorology Research Center
- BV: Breeding Vector
- CMA: China Meteorological Administration
- CPTEC: Centro de Previsao de Tempo e Estudos Climaticos
- ECMWF: European Center for Medium-Range Weather Forecasts
- EFAS: European Flood Alert System
- EM: ensemble-mean
- EOF: empirical orthogonal function
- EPS: Ensemble Prediction System
- FNMOC: Fleet Numerical Meteorology and Oceanography Center
- GEPS: Global EPS
- HEPEX: Hydrological Ensemble Prediction EXperiment
- JMA: Japan Meteorological Agency
- KMA: Korea Meteorological Administration
- MSC: Meteorological Service of Canada
- MUMMA: MUlti-Model Multi-Analysis
- NCEP: National Centers for Environmental Prediction
- STD: Standard Deviation
- SV: Singular Vector
- THORPEX: The Observing system Research and Predictability EXperiment
- TIGGE: THORPEX Interactive Grand Global Ensemble
- UTC: Coordinated Universal Time