Initialisation and model error simulatio
in the ECMWF coupled ensemble

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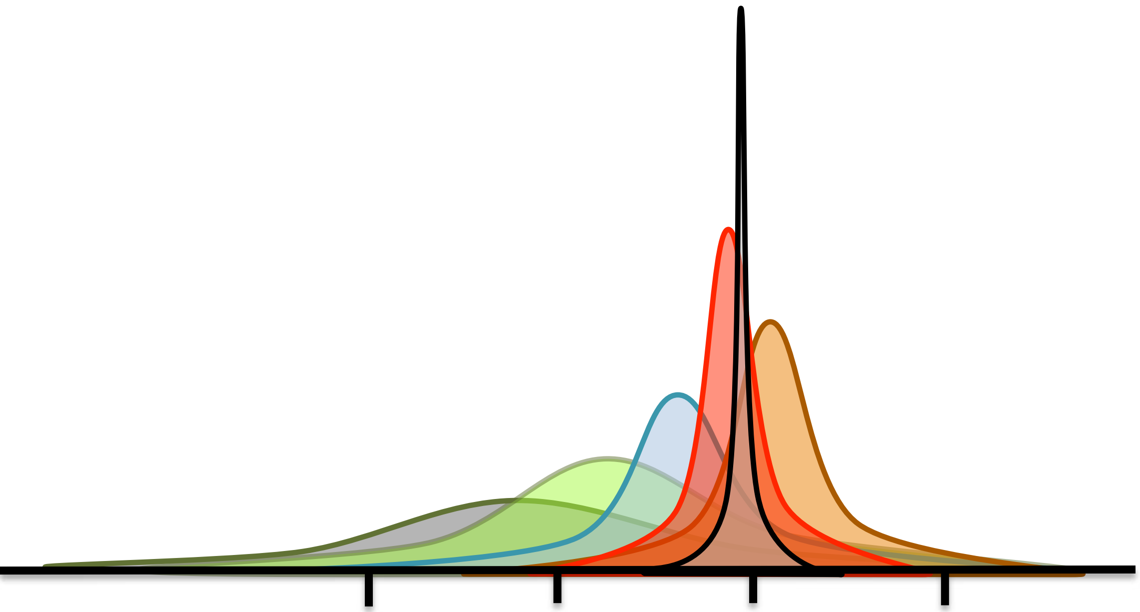

The NWP process: from obs to forecasts

The ECMWF ensembles aim to simulate all sources of errors.

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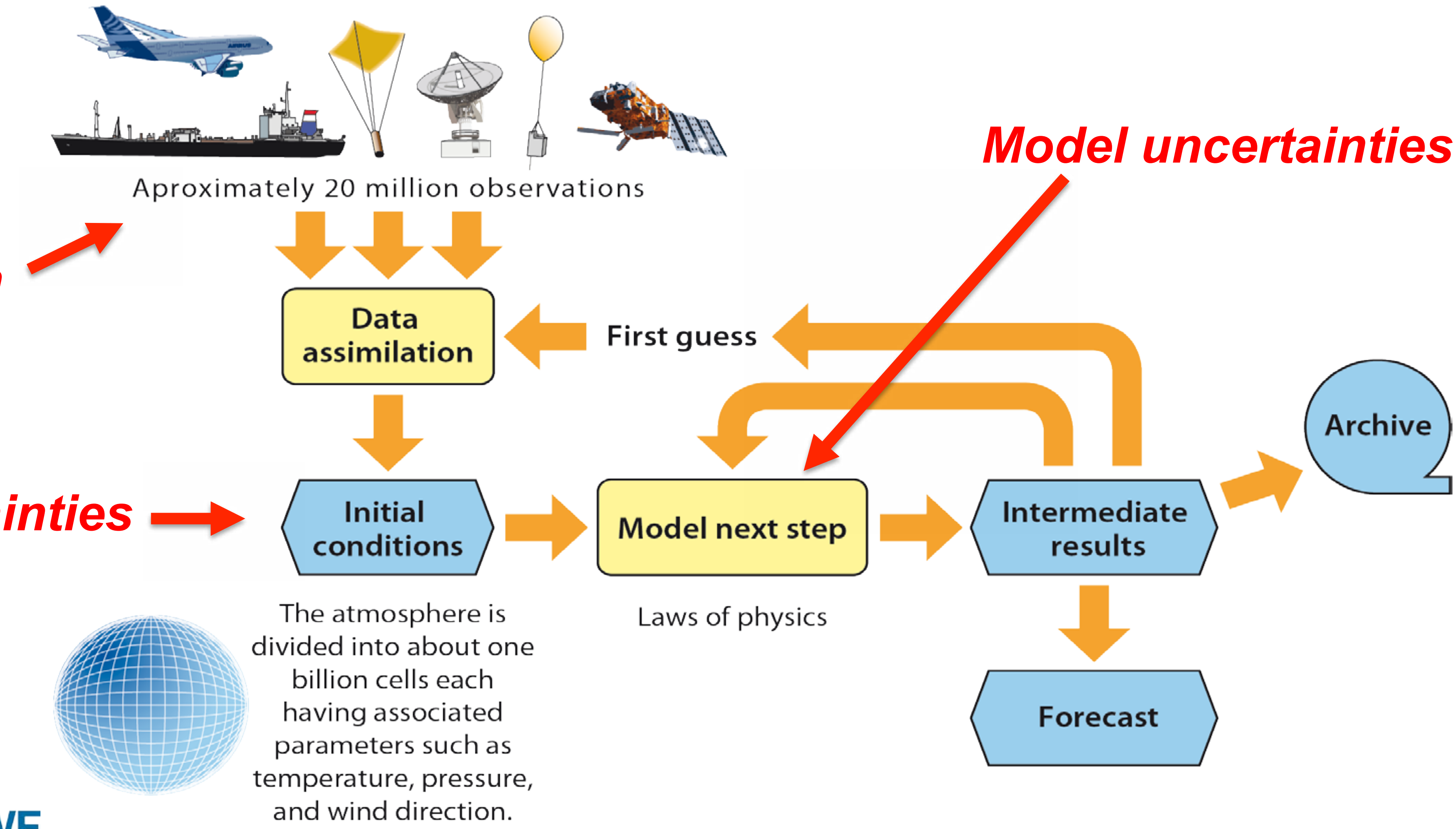
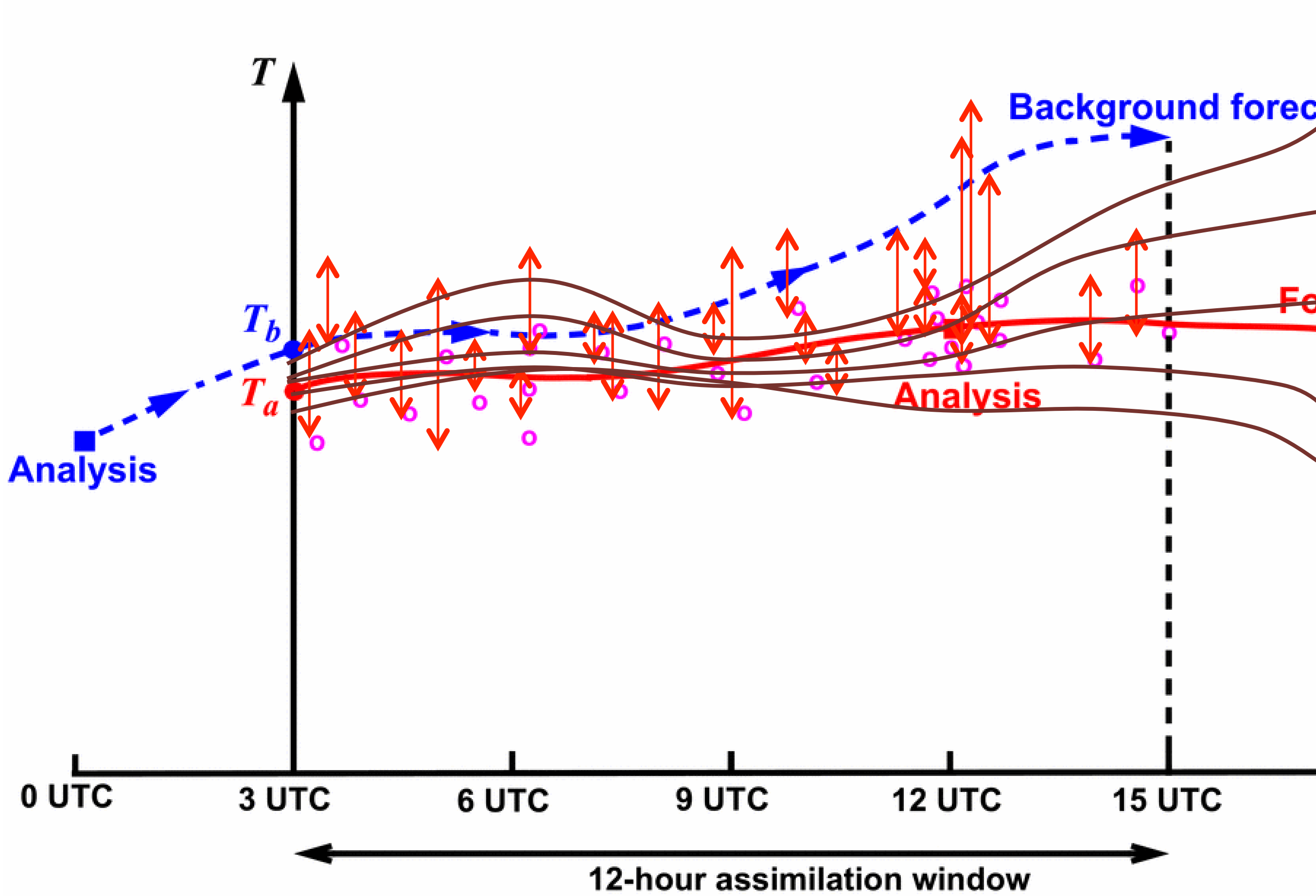
s' uncertainties



The 4 ECMWF ensembles

Since 2008, ECMWF has been running 4 ensembles:

- **The 25-member Ensemble of Data Assimilation (EDA)**

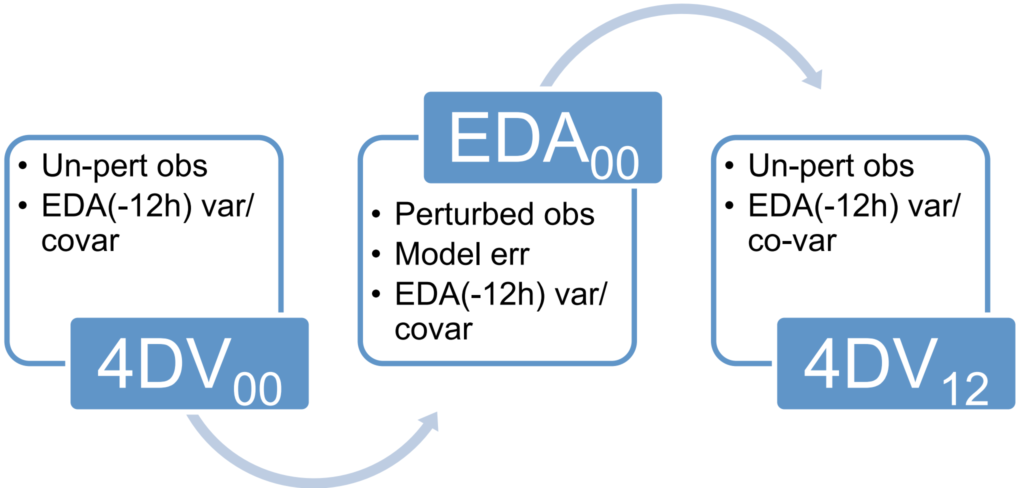


EDA simulates obs errors (perturbed obs in each member) and model error [using SPPT(3L) scheme]

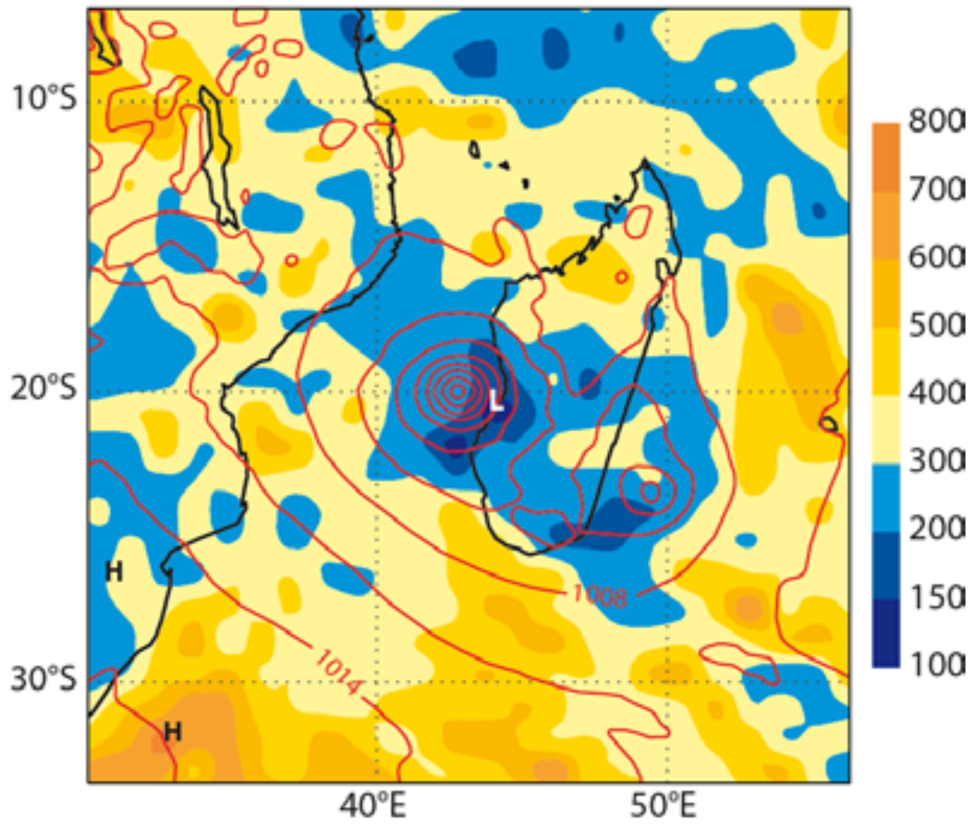
ECMWF

The 4 ECMWF ensembles

The EDA 25 members provide all next cycle's analyses (HRES and EDA) with flow dependent background error statistics. They are also used to simulate initial uncertainties in the forecast ensembles.



Background error correlation length scale for long(p_{msl}) and p_{msl}



The 4 ECMWF ensembles

Since 2008, ECMWF has been running 4 ensembles:

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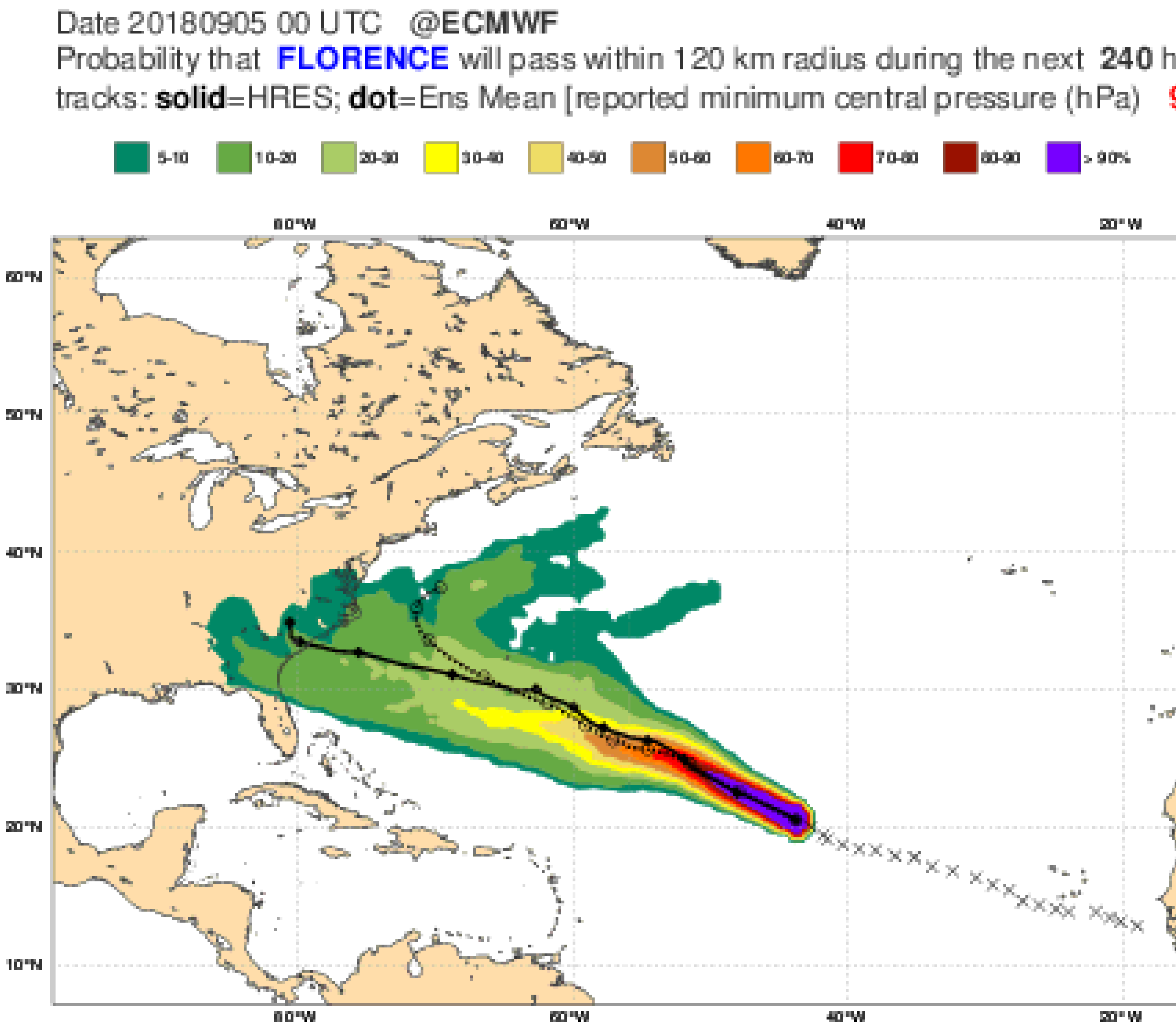
- **The 51-member medium-range/monthly ensemble (ENS)**



ECMWF

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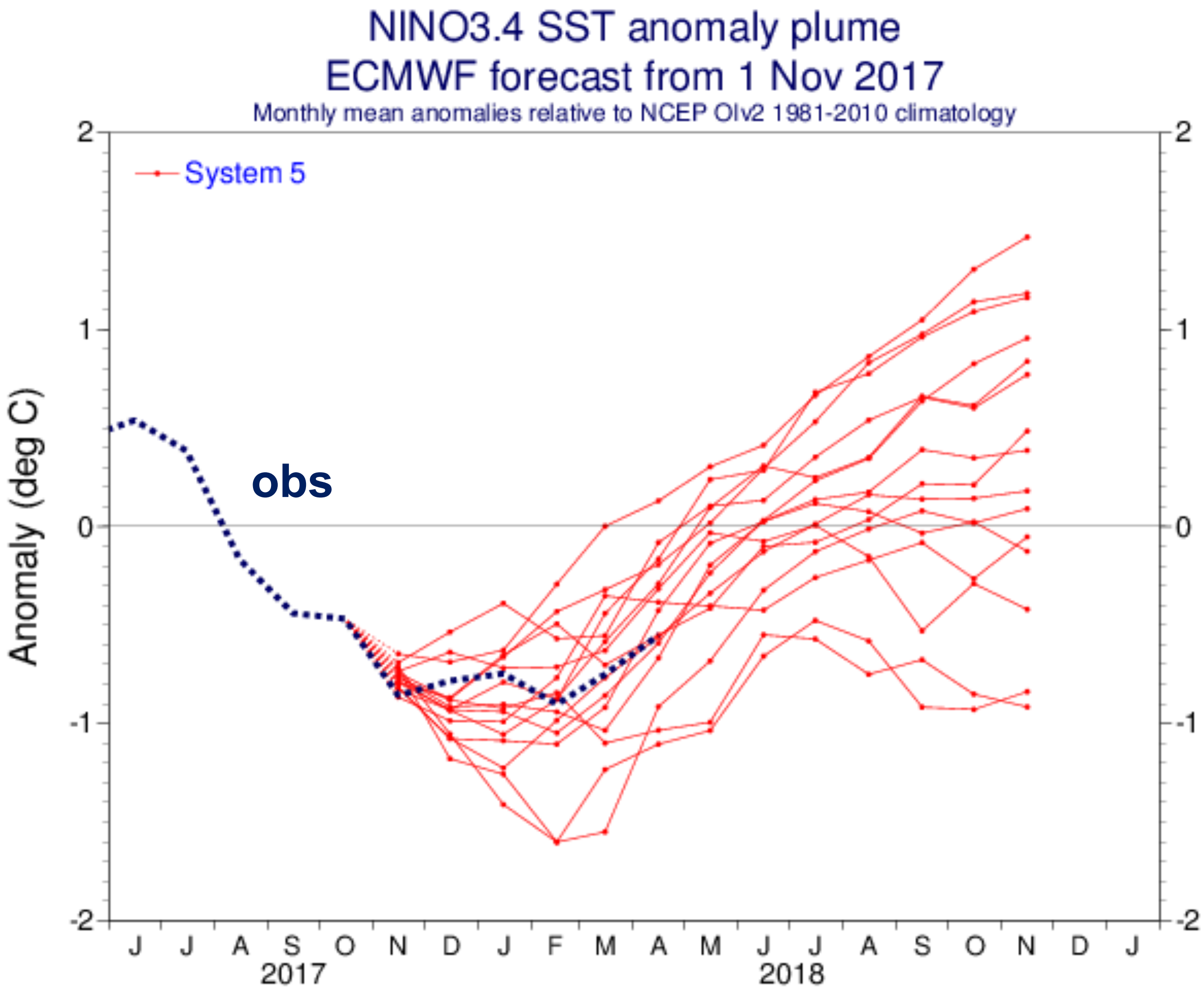
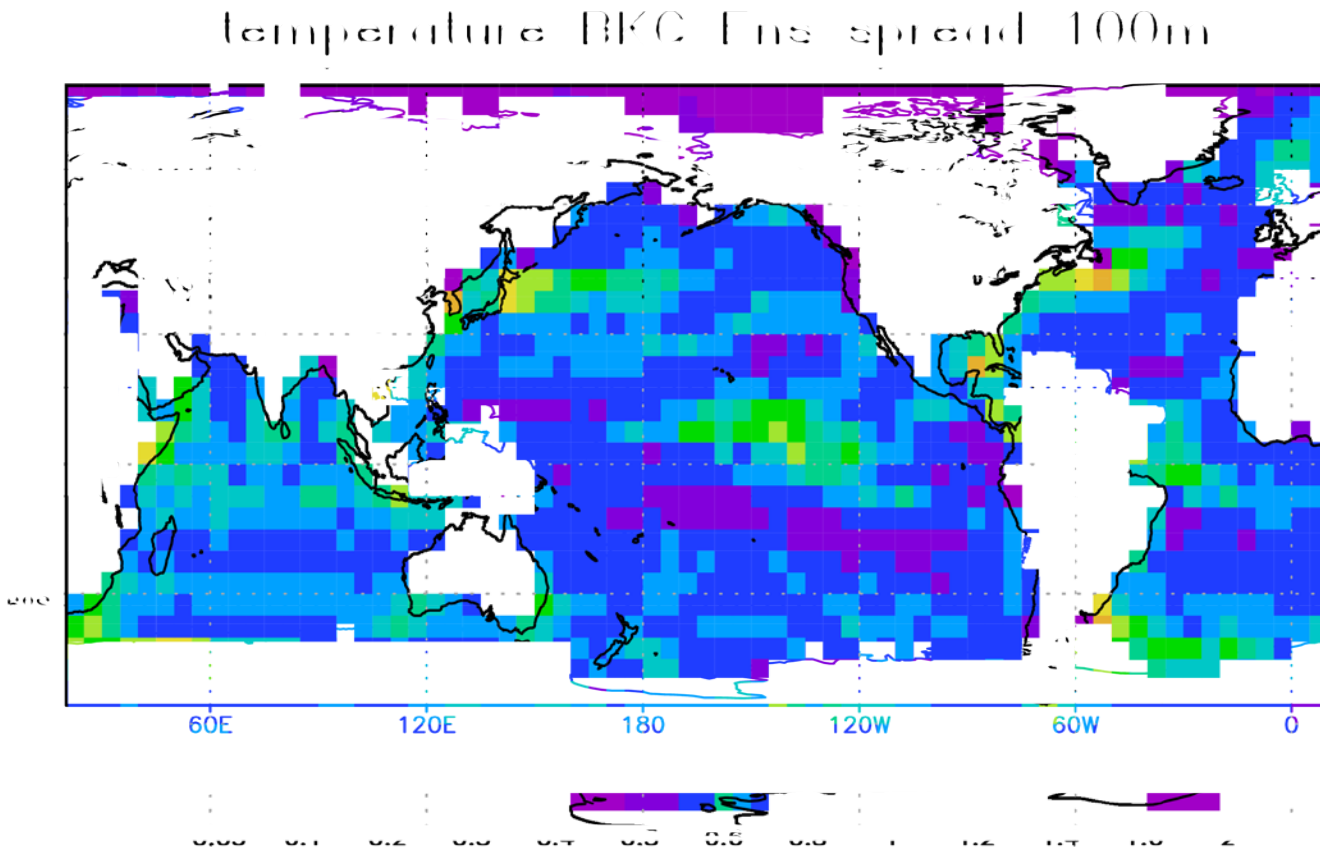
- **The 51-member seasonal ensemble (SEAS5)**



The 4 ECMWF ensembles

Since 2008, ECMWF has been running 4 ensembles:

- The 25-member Ensemble of Data Assimilation (EDA)
- The 51-member medium-range/monthly ensemble (ENS)
- The 51-member seasonal ensemble (SEAS5)
- **The 5-member ocean ensemble (OCEAN5)**



OCEAN5 simulates only obs errors (perturbed obs in each member)

(H Zuo, K Moge

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Key characteristics of the 4 ECMWF ensembles

Ensemble	#	Atmosphere Resolution	Ocean Resolution	Sea-ice	OBS and IC unc	Model unc	Frequency
4DVAR HRES(d0-10)	1	Tco1279L137 (9km)	FC ONLY 0.25deg-z75 (25km)	LIM2	--	--	4/day
EDA	25	Tco639L137 (18km)	--	--	OBS	SPPT(3L)	2/day
ENS (d0-15)	51	Tco639L91 (18km)	0.25deg-z75 (25km)	LIM2	IC	SPPT(3L)	2/day (4/day to d6.5
ENS (d15-46)	51	Tco319L91 (36km)	0.25deg-z75 (25km)	LIM2	IC	SPPT(3L)	2/week
SEAS5 (m0-7/13)	51	Tco319L91 (36km)	0.25deg-z75 (25km)	LIM2	IC	SPPT(3L) & SKEB	1/month
OCEAN5	5	--	0.25deg-z75 (25km)	LIM2	OBS	N	1/day

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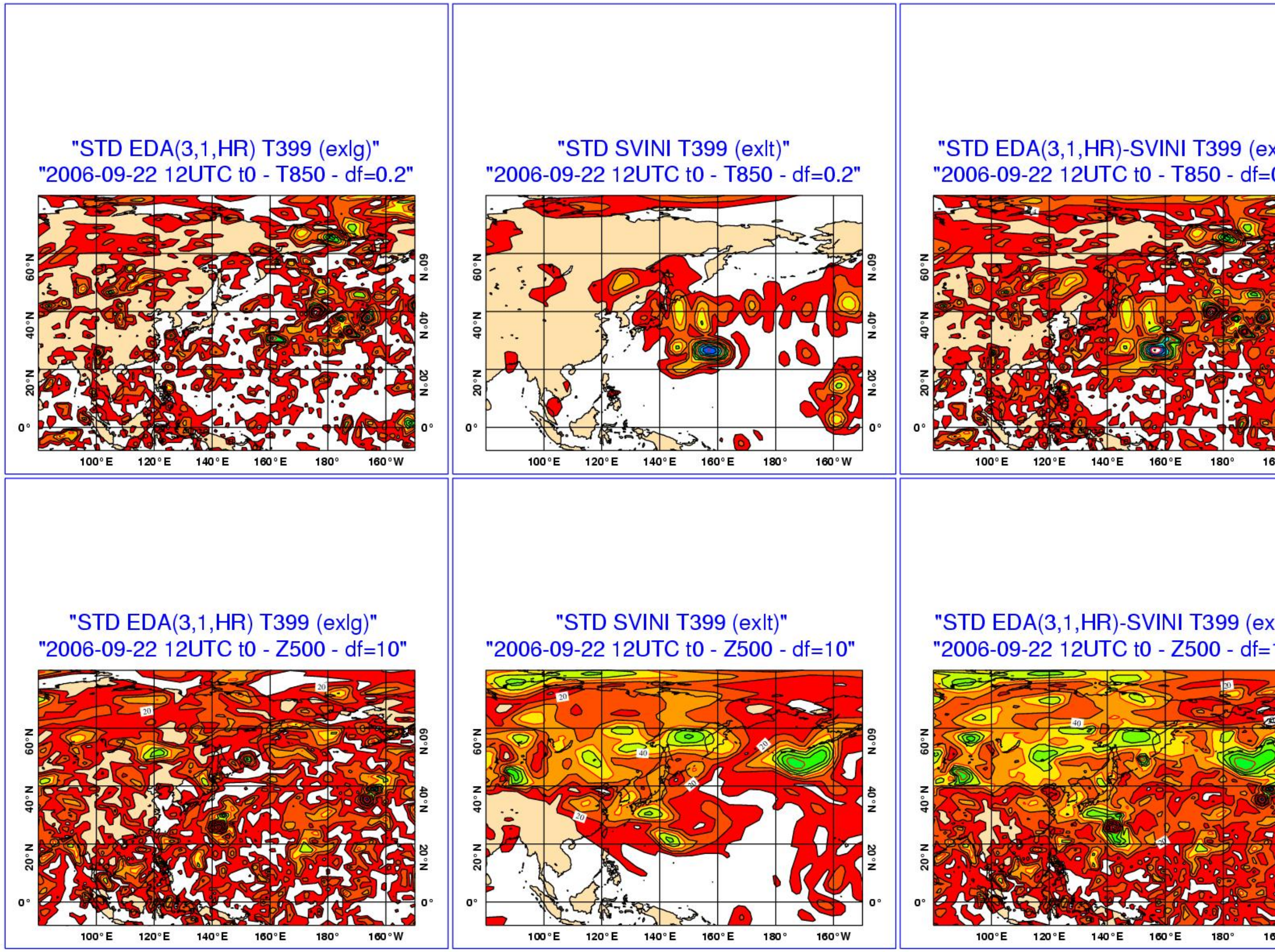
ENS initial uncertainties use SVs & EDA

- EDA-based perturbations simulate the effect of obs errors
- Singular vectors capture the initial error components that could lead to the fastest error growth:

$$E_0^{-1/2} L^* E L E_0^{-1/2} \nu = \sigma^2 \upsilon$$

EDA **SVs** **EDA+SVs**



Stochastic model uncertainties

Each ensemble forecast is given by the time integration of perturbed equatior

$$e_j(d,T) = e_j(d,0) + \int_0^T [A(e_j,t) + P(e_j,t) + \delta P_j(e_j,t)]dt$$

$$\delta P_j(\lambda,\varphi,p) = r_j(\lambda,\varphi)P_j(\lambda,\varphi,p) + F_\Psi(\lambda,\varphi,p)$$

SPPT: Stochastically Perturbed Parameterized Tendencies
(to represent uncertainty associated with parameterisations)

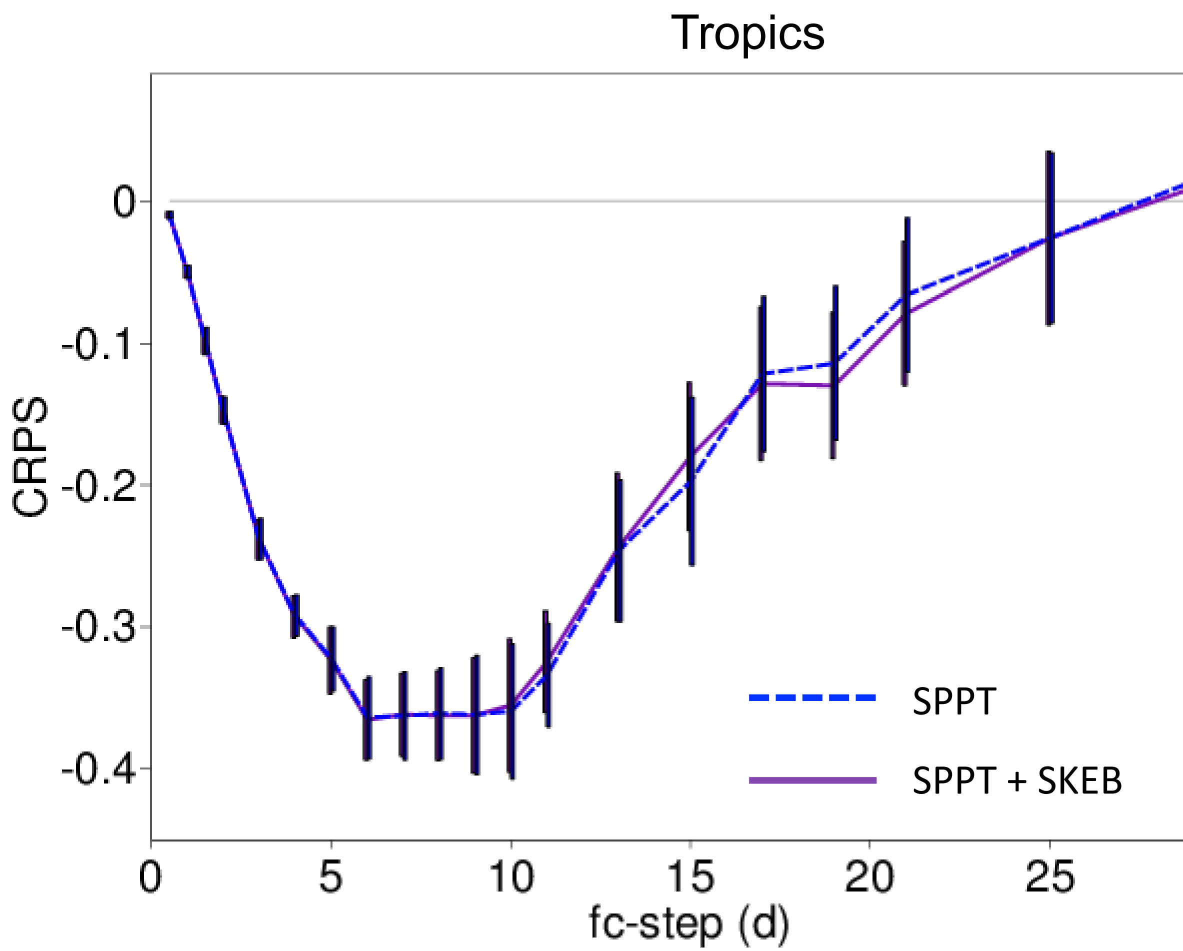
SKEB (used only in SEAS5): Stochastic Kinetic Energy Backsca
(to represent unresolved upscale energy transfer)

Stochastic model uncertainties [SPPT(3L)]

The simulation of model uncertainties improves the ENS reliability and accuracy.

Since June 2018 (cycle 45r1) the same stochastic physics' scheme SPPT(3L) is used in the EDA and ENS.

SEAS5 includes also the SKEB scheme.



[Results based on U200; ENS run with TCo255/TCo159, dates (2013-2014), with 20 members]

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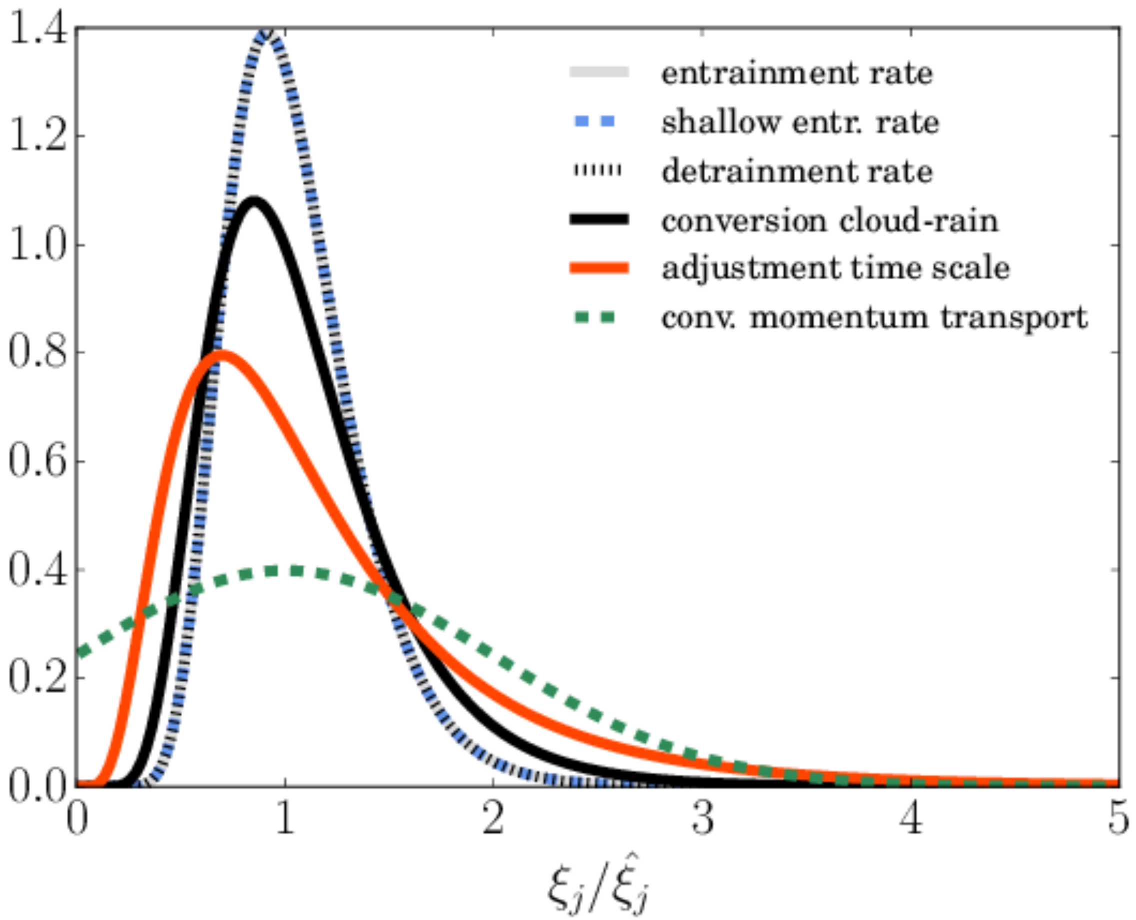
Stochastically Perturbed Parameterisation [SPP



Stochastically Perturbed Parametrisations (S
(Ollinaho et al., 2017, QJRMS):

Parameters/variables within parametrisation schemes are multiplied with noise from a 2D random pattern: $\xi = r\hat{\xi}$

correlated in space (2000 km) and time (72 h).

e.g. convection scheme parameters are perturb with numbers drawn from distributions shown.

Under development and testing, with 20 independent perturbations in parametrisations o sub-grid orography and vertical mixing, radiatio cloud and large-scale precipitation and convect

So far results indicate SPP not as effective as S

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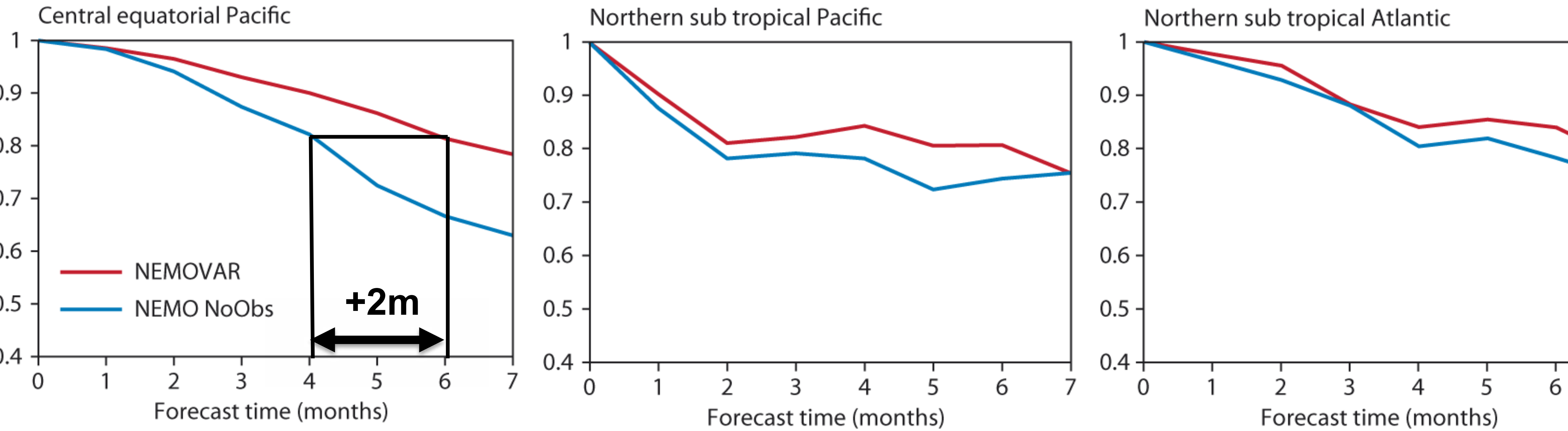
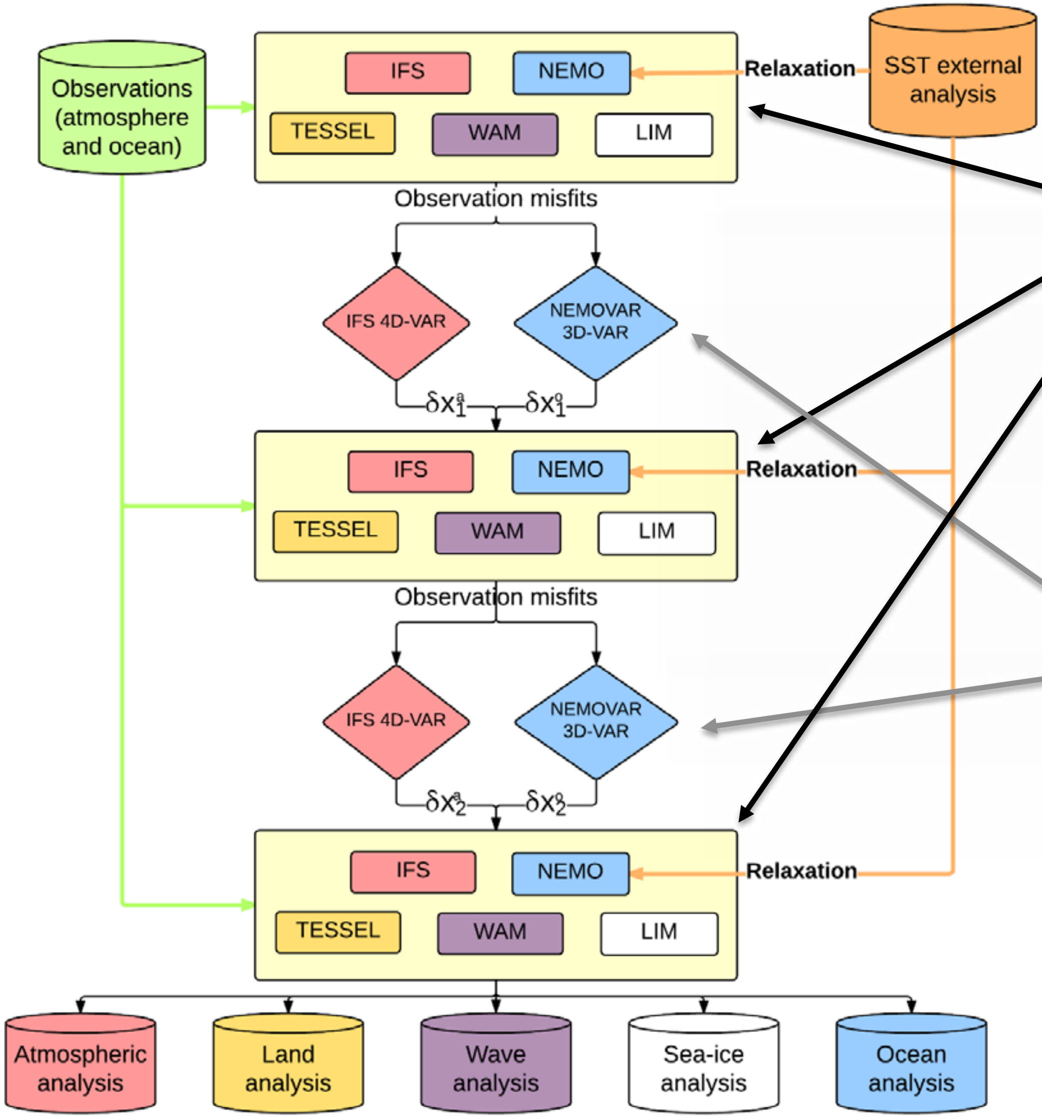
The role of proper ocean initial conditions

- Without observations we cannot initialize the ocean properly
- Without proper initial conditions ocean and atmospheric forecasts are wors

Sea Surface Temperature (SST)



CERA: the ECMWF weakly-coupled DA



The coupled model computes observation misfits in each outer iteration

The SST is computed in NEMO and constrained by relaxation

The atmospheric and ocean increments are computed in parallel to correct the initial sta

The analysis is dynamically consistent with the coupled mo

2016-2025: ECMWF five key focus areas

ECMWF

STRATEGY 2016–2025

THE STRENGTH OF A COMMON GOAL

ECMWF aims to improve its forecasts by:

1. Improving the model (processes, uncertainty est) and assimilation system
2. Assimilating more observations
3. Building more consistent Earth-system ensembles of analyses and forecasts
4. Increasing the ensembles’ resolution
5. Understanding predictability