



# Recent activities related to EPS (operational aspects)

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WGNE-29

# Operational global (weather) EPS

| Center                    | Resolutions                         | FC Range   | Members   | Initial perturbation  | Model Uncertainty  | B.C.  |
|---------------------------|-------------------------------------|------------|-----------|---|--|---|
| <b>ECMWF<br/>(Europe)</b> | TL639L62<br>TL319L62                | 10d<br>+5d | 51        | SV(Total energy norm) +<br>EnDA   | SKEB and Stochastic physics  | <b>coupling to ocean<br/>model, EDA-based<br/>land-surface pert</b> |
| Met Office<br>(UK)        | ~60kmL70<br>~22kmL70                | 15d<br>3d  | 24<br>12  | ETKF  | Random Parameters (RP2) and<br>SKEB2.  | N   |
| Meteo France<br>(France)  | TL538(C2.4)<br>L65                  | 4d         | 35        | SV (Total Energy Norm)+<br>EnDA   | different packages, randomly<br>used   | N   |
| HMC<br>(Russia)           | T85L31<br>+T169L31,<br>+0.72x0.9L28 | 10d        | 13+1+1    | breeding  | N  | ?   |
| NCEP<br>(USA)             | T254L42<br>T190L42                  | 8d<br>+8d  | 45        | Ensemble Transform with<br>Rescaling  | stochastic perturbation to<br>account for random model errors                                      | N   |
| Navy/FNMOC/N<br>RL(USA)   | T159L42                             | 16d        | 20        | local ensemble transform<br>with transform performed in<br>9 latitude bands | N  | N   |
| <b>CMC<br/>(Canada)</b>   | <b>0.6° L74</b>                     | 16d        | 20        | Ensemble Kalman Filter  | stochastic Perturbation of<br>Physical Tendencies and<br>stochastic Kinetic Energy<br>Backscatter. | N   |
| CPTEC/INPE<br>(Brazil)    | T126 L28                            | 15d        | 15        | EOF-based perturbation  | N  | N   |
| <b>JMA<br/>(Japan)</b>    | <b>TL479 L60</b>                    | <b>11d</b> | <b>27</b> | SV(Total energy norm)   | Stochastic perturbation of<br>physics tendency   | N   |
| CMA (China)               | T213 L31                            | 10d        | 15        | bred vector method  | N  | N   |
| KMA<br>(Korea)            | ~40kmL70                            | 10d        | 24        | ETKF  | Random Parameters (RP2) and<br>SKEB2.  | N   |

Japan Meteorological Agency



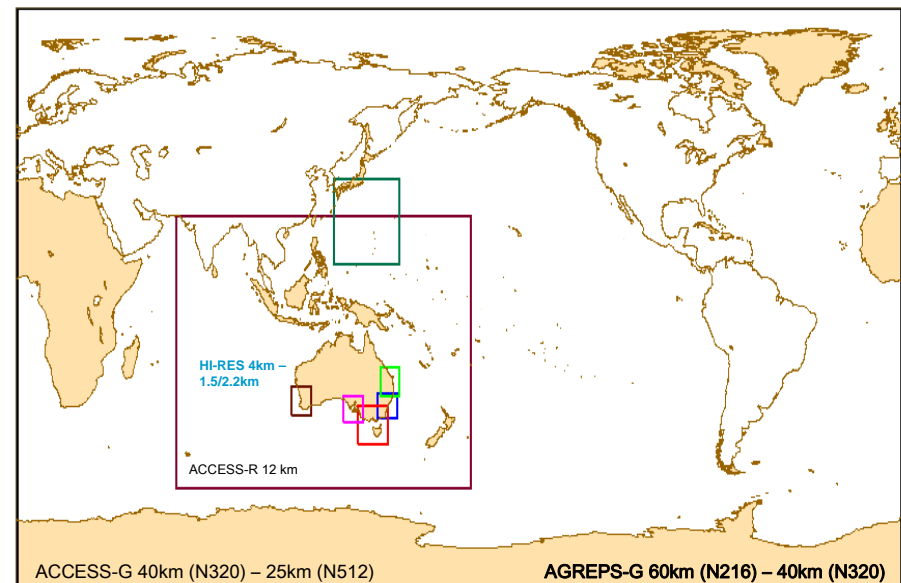
# RECENT ACTIVITIES IN OPERATIONAL CENTERS

# AGREPS – ACCESS medium-range ensemble



## 24-member ensemble designed for medium-range forecasting

- Based on global component of UK Met Office MOGREPS ensemble
- Global ensemble to 10 days
- ETKF for initial condition perts
- Stochastic model perturbations
- Currently running at 60 km (N216) horizontal resolution, 70 vertical levels



# AGREPS current status



- Research versions of AGREPS have been running since 2009
- Current 60km APS1 AGREPS has been running since 2012
- Verifications have shown AGREPS ensemble has comparable skill and spread to operational EPS systems at other major weather centres
- Operational implementation is planned for APS2 operational ACCESS NWP suite; date is yet to be set
  
- Upgrade to N320 is planned, possibly in time to be included in the APS2 operational system (2015)
- 2.2 km resolution city/state scale limited area ensemble is planned for 2016 (APS3), based on 2.2 km UK ensemble
- We aim to incorporate Met Office hybrid DA approach using flow-dependent error covariances in APS3 ACCESS-G global NWP system

# Plans for Regional and Global EPS

## For the Canadian REPS

### •Assimilation component

- Regional ensemble Kalman filter and variational method
- A major milestone for the regional EPS
- Background at 15 km grid spacing

### •Forecast component

- Lead time at 4-5 days
- 4x per day
- Stochastic convection
- Increasing the horizontal resolution to 10 km
- Better surface and near-surface model error representation by perturbing uncertain parameters and fields related to the surface scheme

### •Others

- NAEFS-LAM (exchange of REPS and SREF data)
- Better soil properties via assimilation with CALDAS and stochastic perturbations

## General

Ensemble approach will become mainstream:

- Next-gen SCRIBE will incorporate the ensemble paradigm
- Model resolution will become very attractive to forecasters
  - Regional EPS at 10 km grid spacing with dedicated data assimilation
  - Global EPS at ~20-25 km grid spacing
  - Research on ensemble forecasting will be performed at 1-3 km grid spacing, but no operational kilometer-scale EPS within 3-5 years

## For the Canadian GEPS

### •2014

- Ensemble layer in NinJo
- Horizontal resolution of 50 km for the GEPS
- Provide trial fields error statistics for EnVAR

### •2015-2016

- Better soil properties via assimilation with CALDAS and stochastic perturbations
- New Yin-Yang model grid
- Model top at 0.1 hPa (80 km)
- Increase horizontal resolution as a function of available computer power
- Stochastic convection

## COSMO-DE-EPS

### Latest developments

- Target: improve the representation of forecast uncertainty in general and for specific applications leading to better probabilistic forecasts
- Perturbed coefficient for minimum diffusion of heat and momentum,  $tk_{hmin}$  and  $tk_{mmin}$ , range: [0.2, 0.4, 0.7]  
⇒ improvement in 2m temperature
- Perturbed soil moisture  
based on difference between C-EU and C-DE soil moisture  
⇒ improvement in 2m temperature
- Research: increase to 40 members by including COSMO-LEPS forecasts as BC conditions

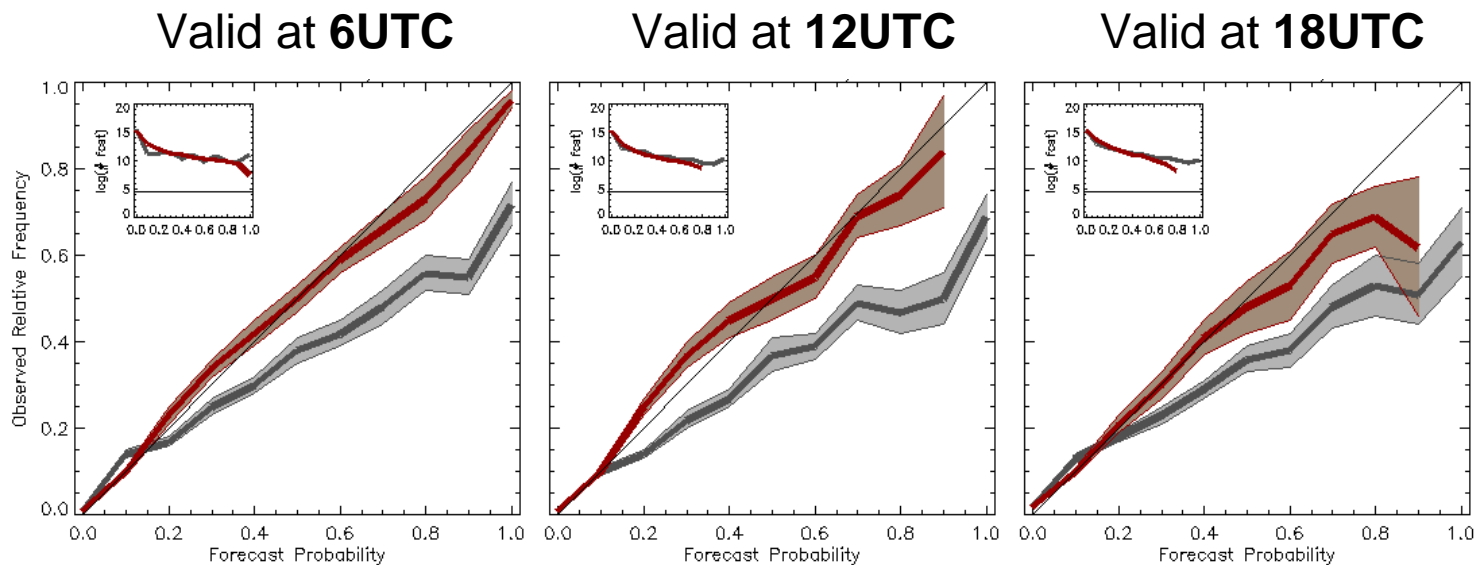


## Statistical Postprocessing based on C-DE-EPS

Methods:

- Precipitation:** ELR with interaction terms (Ben Bouallègue, 2013)
- 10m Wind Speed and Direction:** Bivariate EMOS (Schuhen et al., 2012)
- 2m Temperature:** to be tested (Scheuerer and Büermann, 2013)

Example: precipitation probabilities, summer 2011, threshold **5.mm/6h**





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## Future plans and options

- COSMO-DE-EPS 40 member ensemble in operational mode
- calibration in operational mode (Ben Bouallegue et al., 2013)  
(needs evaluation by forecasters)
- add new physics perturbations or alternative perturbation methods  
(e.g. stochastic physics)
- LETKF for IC perturbations (KENDA)
- global ICON-EPS for BC perturbations (in 201?)
- use time-lagged ensemble approach in product generation

# Current Status (since Feb 2012)

- Model
  - GFS V9.01 (Spectrum, Euler model) – implemented by May 2011
- Horizontal resolution
  - T254 (52-55km for 0-192 hours), T190 (70-74km for 192-384 hours)
- Vertical resolution
  - 42 hybrid levels
  - Model top: 2hPa
- Initialization
  - Breeding-Vector (BV) and Ensemble Transform with Rescaling (ETR) cycling every 6 hours (80 vectors in cycling)
  - Tropical Storm Relocation (TSR) since 2005
- Stochastic perturbation
  - Stochastic Total Tendency Perturbation (STTP) since 2010
- Ensemble size and forecast length
  - 20 perturbations plus control
  - 4 cycles per day
  - Out to 16 days
- Output
  - Every 6-hr for 1\*1 degree pressure GRIB format files
  - Full variables for TIGGE data exchange

# Next Implementation (Q1FY15)

- Model
  - GFS V10.0 (Spectrum, [Semi-Lagrangian model](#)) – Plan for Q4FY14
- Horizontal resolution
  - [T574](#) (T382 physics: 33-35km for 0-168 hours),
  - [T382](#) (T254 physics: 52-55km for 168-384 hours)
- Vertical resolution
  - [64 hybrid levels](#) to match GSI/EnKF hybrid analysis system
  - Model top: 0.2hPa
- Initialization
  - [Hybrid EnKF f06 and Ensemble Transform with Rescaling](#) (ETR – 3 dimension)
  - Improved Tropical Storm Relocation (TSR) scheme
- Stochastic perturbation
  - Stochastic Total Tendency Perturbation (STTP)
- Ensemble size and forecast length
  - 20 perturbations plus control
  - 4 cycles per day
  - Out to 16 days
- Output and data exchange
  - [Every 3-hr for 0.5\\*0.5 degree pressure GRIB format files](#)
  - Full variables for TIGGE data exchange (1\*1 degree, every 6-hr)



# AROME Ensemble Prediction System

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AROME EPS is under development (to be operational in 2015)

AROME-France members running every 6 hours to ~40-h range

~10 members at 2.5km resolution (vs 1.3km for deterministic AROME-France beginning 2015)

Perturbations:

- initial upper-air: rescaled & centered perturbations from global PEARP ensemble (with 8km local resolution)
- initial surface: correlated random perturbations of SST, soil moisture/humidity, snow, physiographies
- lateral boundary conditions: 10 members selected from the 35-member PEARP ensemble (by clustering)
- model error: SPPT (stochastic perturbation of physics tendencies), similar to ECMWF EPS

Current research:

- calibration, verification of radar reflectivities, validation in context of hydrology & air traffic management
- study of forecast error correlations & coupling with EDA

## **NRL Global Ensemble Forecast System**

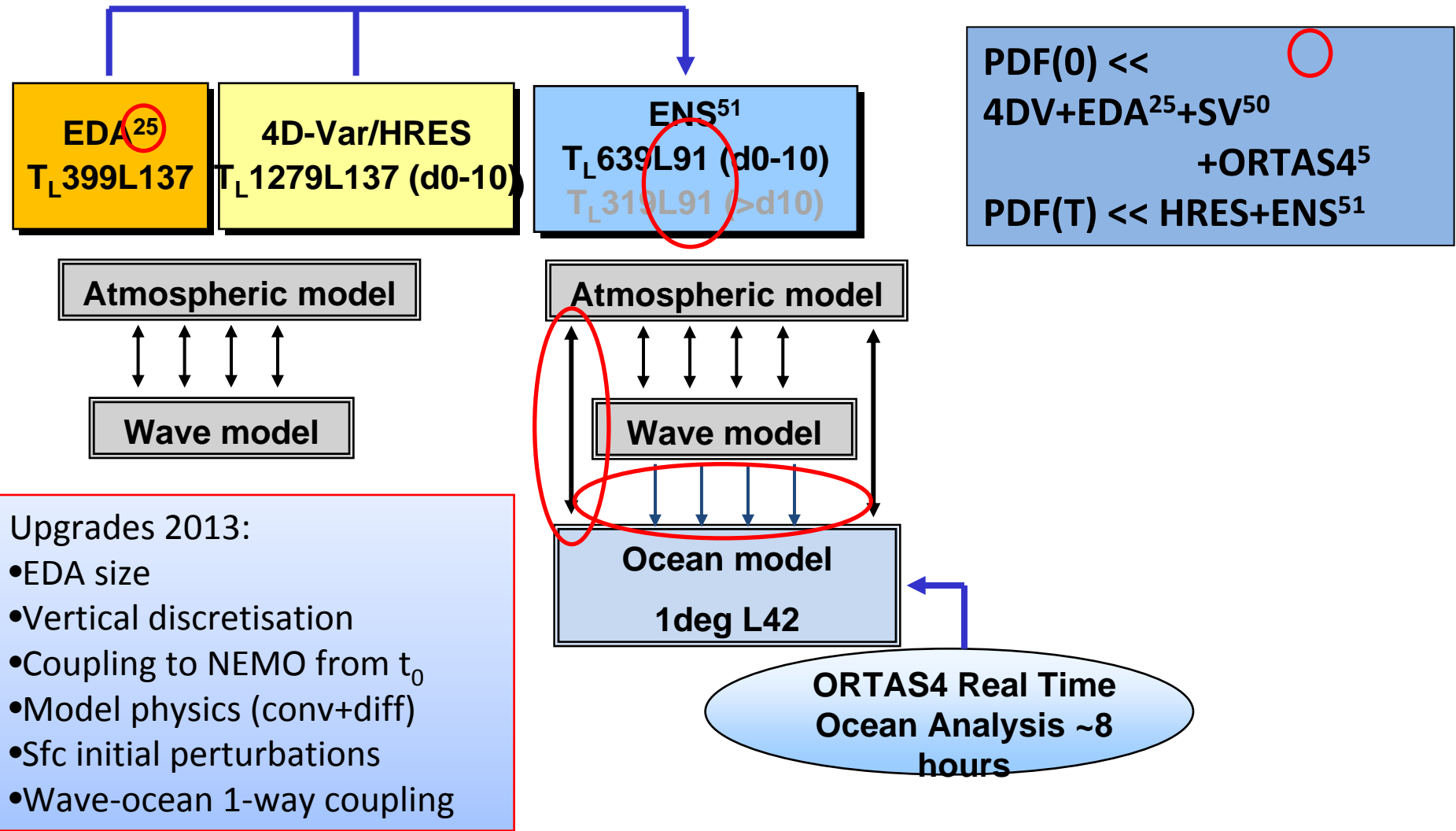
- Current system: NOGAPS T159L42, 20-mem, 2xday to 16 days. ET initial perturbations, no model uncertainty. Used to force surface wave ensemble.
- 2014 Upgrade: NAVGEM T239L50, 20-mem, 2xday to 16 days. ET initial perturbation method with improved analysis error variance estimates.
- Upgrades for 2014-2015: Incorporation of model uncertainty.
  - SST initial perturbations, diurnal cycle, persistent anomaly capability
  - Stochastic forcing (SKEB)
  - T359L50 quasi-real-time run in support of the NOAA HIWPP program

## **NRL COAMPS Ensemble Forecast Systems**

- Ensemble Transform with perturbed physics parameters
- EnKF within DART for COAMPS-TC (27, 9, 3 km, 80-mem DA, 10-mem long forecasts)
- EnKF for RADAR data assimilation
- Applications:
  - Coupled dispersion modeling (Fukushima)
  - Coupled atmosphere-ocean ensembles (Hydrological cyclone in the Mediterranean Experiment)
  - Tropical Cyclone applications (HOAA HFIP, ONR)
  - DoD tactical applications (refractivity)



# The ECMWF Integrated Forecasting System (IFS): Medium-range/monthly components

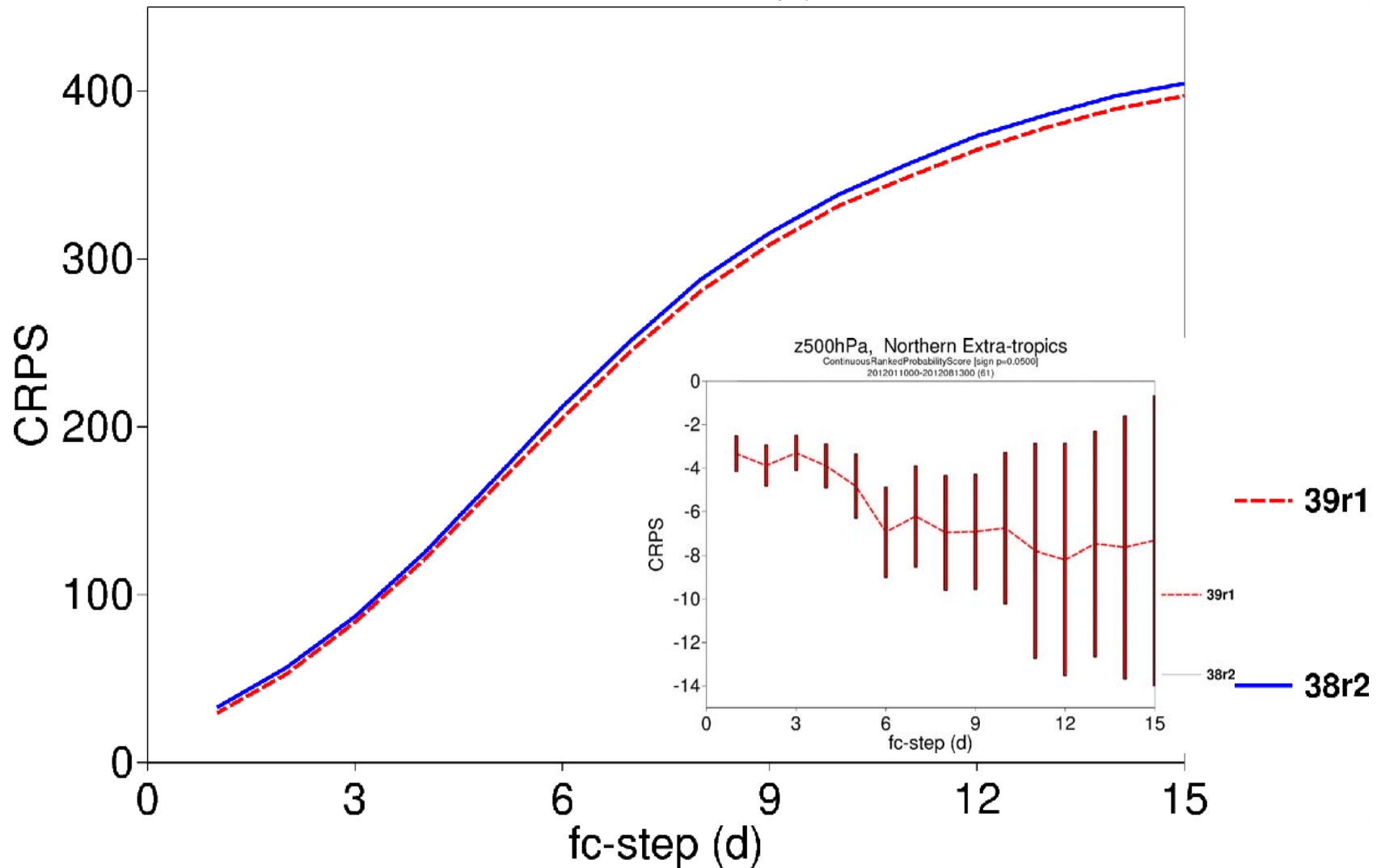




# CY39R1/Cy40r1: ENS coupling d0, L62>L91, new physics+SKEB

## z500hPa, Northern Extra-tropics

ContinuousRankedProbabilityScore  
2012011000-2012081300 (61)





# Ensemble prediction at RHMC

## Global:

**Operational trials:** 14 members (12 perturbed forecasts with T169L31, 2 control forecasts with T169L31 and SL-AV), ~70 km, breeding, no model perturbations, 240h forecast at 12 UTC, verification scores presented at <http://epsv.kishou.go.jp/EPsv/>

**Research&Plans:** bias correction (in progress), SPPT, usage of RHMC EnVar DA results as initial conditions (next year)

## Regional:

**Operational in winter 2013-2014 (for the Olympics):**

COSMO-Ru-EPS for the Sochi region: 10 members, horizontal resolution 2.2 km, 50 levels, COSMO model, IC&BC from COSMO-S14-EPS (ARPA-SIMC, A. Montani et al, horizontal resolution 7 km), 48h forecasts at 00 and 12 UTC

**Research&Plans:** SPPT, soil perturbations

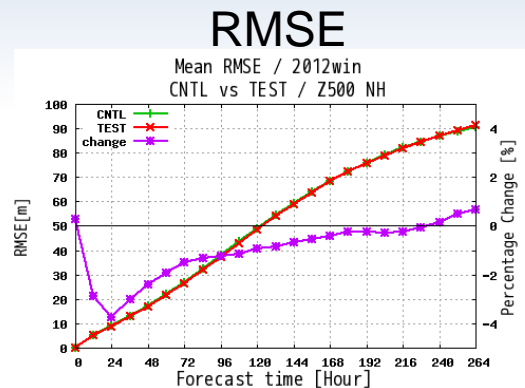
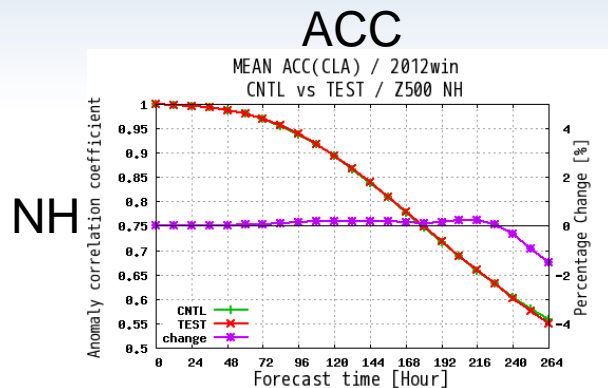
Authors: E.Astakhova, D. Alferov



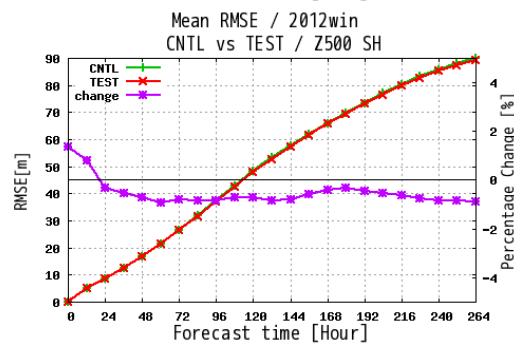
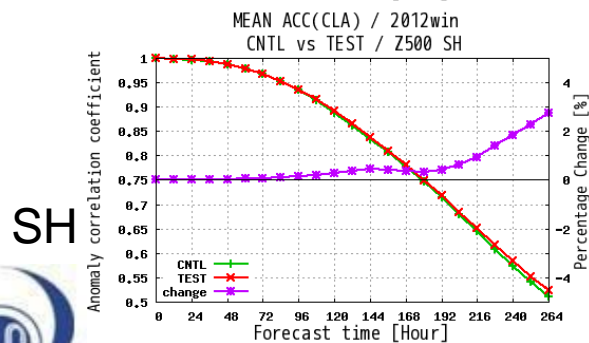
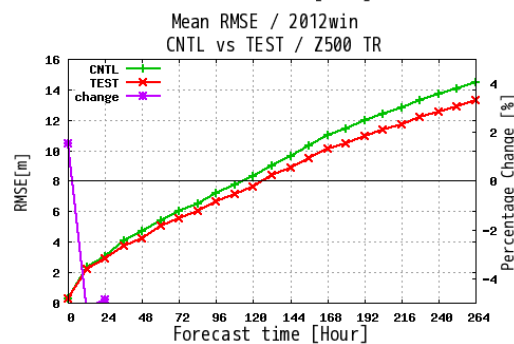
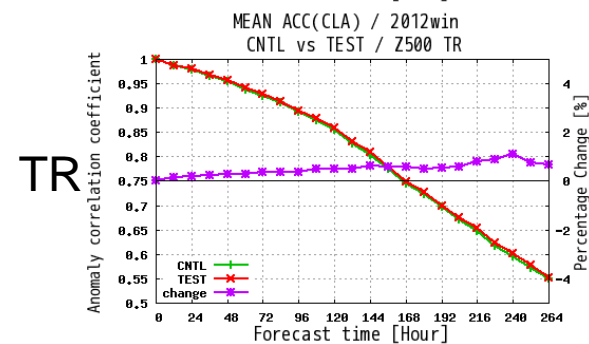
# Upgrade of JMA global EPSs (Feb and Mar 2014)

|                               |                       | One-week EPS  | Typhoon EPS  |
|-------------------------------|-----------------------|---|--|
| Objectives                    |                       | One-week Forecasts                                  | TC Information   |
| EPS model and its integration | Model type            | GSM (an atmospheric general circulation model)      |  |
|                               | Horizontal resolution | TL319 (~55km) → <b>TL479 (~40km)</b>                |  |
|                               | Vertical levels       | 60 levels, up to 0.1 hPa                            |  |
|                               | Forecast range        | 264 hours (12UTC)<br>→ <b>264 hours (00, 12UTC)</b> | 132 hours(00,06,12,18UTC)<br>only when Tropical Cyclones of TS/STS/TY intensity are present or are expected to appear in the RSMC Tokyo –Typhoon Centre's area of responsibility |
| Ensemble settings             | Member (per day)      | 51 → <b>27</b> (51/day → <b>54/day</b> )            | 11 → <b>25</b> (44/day → <b>100/day</b> )  |
|                               | Initial perturbation  | SV method,<br>Three target areas (NH,TR,SH)         | SV method, One fixed target area (the Northwestern Pacific) and up to 3 movable target areas (vicinities of up to 3 TCs)   |
|                               | Model ensemble        | Stochastic physics                                  |  |

# Ensemble mean Z500



Red: TEST  
Green: Control  
Purple: improvement ratio



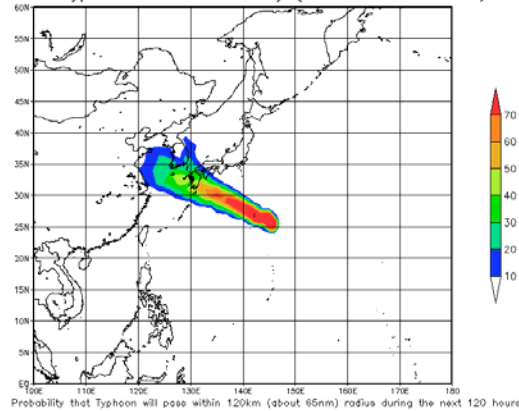
# Probability of Typhoon approaching

Probability of typhoon approaching within 120km from center of TC (FT0~FT120)

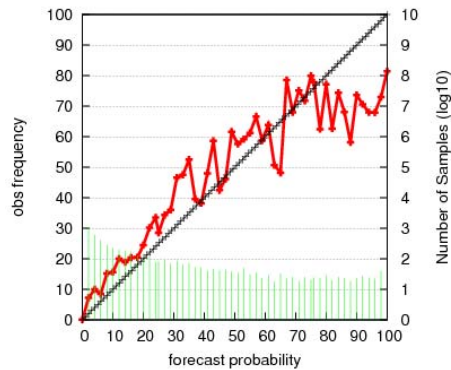
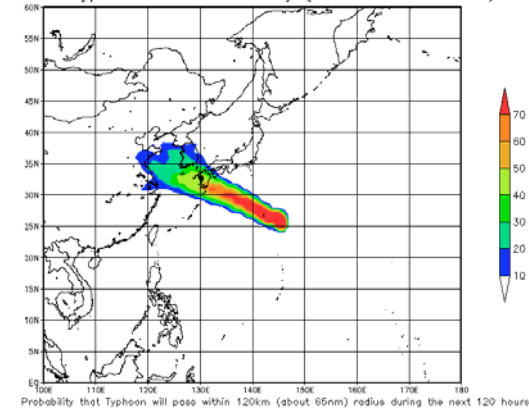
CNTL(TL319 51members)

TEST(TL479 27members)

D0011 Typhoon Strike Probability (2012.07.29.1200UTC)

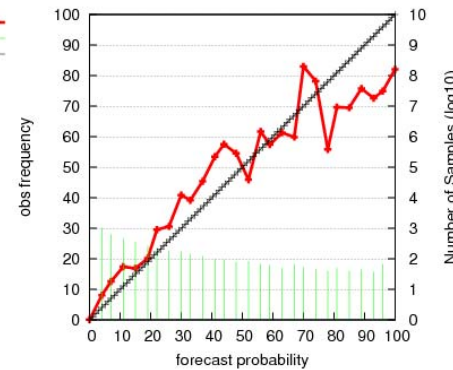


D0011 Typhoon Strike Probability (2012.07.29.1200UTC)



Strike Probability Reliability  
Number of Samples  
Perfect Reliability

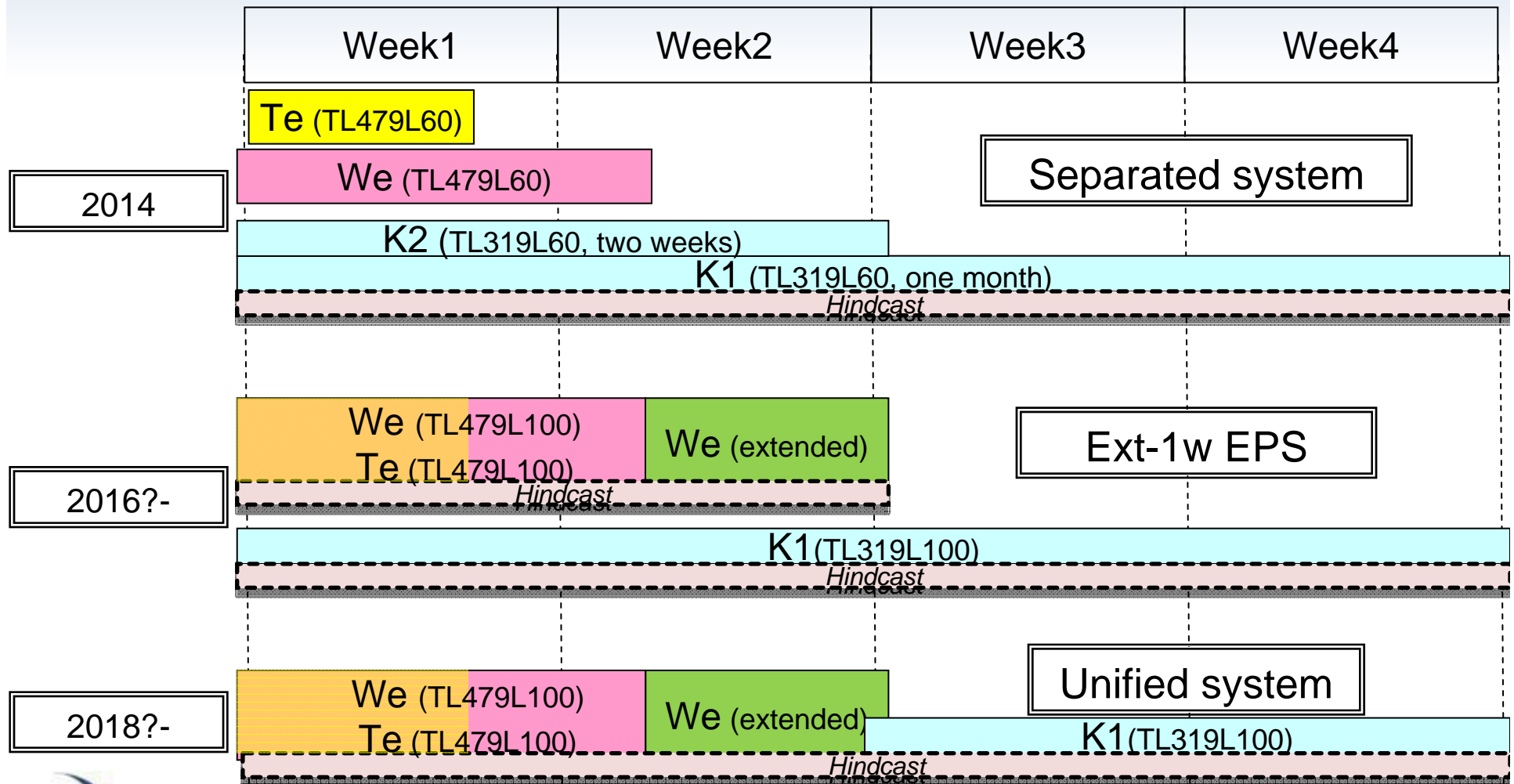
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br\_rel = 0.0002  
br\_res = 0.0038  
br\_unc = 0.0091  
bss = 0.3857  
N = 186564.5  
M = 1722.037  
M / N = 9.2302505E-03



Strike Probability Reliability  
Number of Samples  
Perfect Reliability

br = 0.0054  
br\_rel = 0.0002  
br\_res = 0.0039  
br\_unc = 0.0091  
bss = 0.4112  
N = 186564.5  
M = 1722.030  
M / N = 9.2302123E-03

# Future plan of medium range and one month ensemble prediction system



A dramatic photograph of a stormy sky at dusk or dawn. The sky is filled with dark, heavy clouds, with a bright orange and yellow glow from the sun low on the horizon. A single, bright white lightning bolt strikes down from the clouds on the right side of the frame. The foreground is a dark silhouette of a dense forest or trees.

# **SUMMARY OF EPS ACTIVITIES (OPERATIONAL ASPECTS)**

# Summary of Operational EPS

- Ensemble approach is now **mainstream in operational NWP**
  - Almost all centers
- Consideration of **near-surface model error representation**
  - ECMWF, CMC, DWD, NRL, RHMC
- Increased development of **cloud-permitting regional ensembles**
  - BOM, CMC
- High-resolution fine dataset
  - NCEP