Recent activities related to EPS (operational aspects)

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With contributions from WGNE members

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GLOBAL
# Operational global (weather) EPS

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<tr>
<th>Center</th>
<th>Resolutions</th>
<th>FC Range</th>
<th>Members</th>
<th>Initial perturbation, DA</th>
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<th>B.C.</th>
<th>Note</th>
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</thead>
<tbody>
<tr>
<td>ECMWF (Europe)</td>
<td>TCo639L91 TCo319L91 18/32km</td>
<td>15d 46d</td>
<td>51</td>
<td>SV(Total energy norm) + EnDA</td>
<td>SKEB and Stochastic physics update of backscatter scheme</td>
<td>coupling to ocean model, EDA-based land-surface pert. in ENS ICs</td>
<td>Hindcast dataset increased</td>
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<tr>
<td>Met Office (UK)</td>
<td>33kmL70 21km</td>
<td>7d</td>
<td>11+1 44</td>
<td>ETKF En-4D-EnVar</td>
<td>Random Parameters (RP2) and SKEB2.</td>
<td>N</td>
<td>Coupling to ocean</td>
</tr>
<tr>
<td>Meteo France (France)</td>
<td>T798(C2.4) L90</td>
<td>4d</td>
<td>35</td>
<td>SV (Total Energy Norm)+ EnDA</td>
<td>A new set of 10 physical packages, new model pert.</td>
<td>N</td>
<td>SURFEX and pert.</td>
</tr>
<tr>
<td>HMC (Russia)</td>
<td>T169L31 25-30km</td>
<td>10d</td>
<td>12+1+1</td>
<td>Breeding Hybrid (3D-Var with ensemble based “B”)</td>
<td>N SPPT</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>NCEP (USA)</td>
<td>TL574L64 TL382L64</td>
<td>8d +8d 35d</td>
<td>41</td>
<td>Ensemble Kalman Filter + Tropical storm relocation</td>
<td>stochastic pert. to account for random model errors SKEB, SPPT, SHUM</td>
<td>N</td>
<td>Stochastic pert. of land, couple with ocean</td>
</tr>
<tr>
<td>NRL/FNMOC (USA)</td>
<td>T159L42 T359L60</td>
<td>16d</td>
<td>20</td>
<td>local ET Hybrid 4D-Var</td>
<td>SKEB-mc</td>
<td>N</td>
<td>SST initial pert. ocean, ice, wave coupling</td>
</tr>
<tr>
<td>CMC (Canada)</td>
<td>0.6° L40</td>
<td>16d</td>
<td>20</td>
<td>Ensemble KF</td>
<td>stochastic pert. of physical tendencies and SKEB, further pert. to the physics</td>
<td>new method to evolve SST and sea-ice</td>
<td></td>
</tr>
<tr>
<td>DWD (German)</td>
<td>40km</td>
<td>180h</td>
<td>40</td>
<td>LETKF</td>
<td>?</td>
<td>SST random pert.</td>
<td>Pre-operational</td>
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</tbody>
</table>

Black: current, Red: recent upgrade, green: planned or research
## Operational global (weather) EPS

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<tr>
<td>CPTEC/INPE (Brazil)</td>
<td>T126 L28</td>
<td>15d</td>
<td>15</td>
<td>EOF-based perturbation EnKF</td>
<td>N</td>
<td>N</td>
<td>Couple with earth system model</td>
</tr>
<tr>
<td>BoM (Australia)</td>
<td>~60kmL70</td>
<td>10d</td>
<td>24</td>
<td>ETKF</td>
<td>Random Parameters (RP2) and SKEB2.</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>JMA (Japan)</td>
<td>TL479 L60 TL479L100 TL319L100</td>
<td>11d 18d 1month</td>
<td>27</td>
<td>SV(Total energy norm) SV+LETKF Reduce tropical initial pert.</td>
<td>Stochastic perturbation of physics tendency</td>
<td>N</td>
<td>Rev, SST and sea ice</td>
</tr>
<tr>
<td>CMA (China)</td>
<td>T213 L31</td>
<td>10d</td>
<td>15</td>
<td>SV</td>
<td>SPPT</td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>KMA (Korea)</td>
<td>~40kmL70 32km (p)</td>
<td>12d</td>
<td>24 44</td>
<td>ETKF Hybrid Ensemble 4D-Var</td>
<td>Random Parameters (RP2) and SKEB2.</td>
<td>N</td>
<td></td>
</tr>
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Model resolution upgraded / plan

• Upgraded
  – ECMWF
    • use cubic-octahedral instead of linear grid
      – Ensemble of data assimilations 50 km $\rightarrow$ 18 km (TL399 $\rightarrow$ TCo639)
      – Medium-range ensemble 32 km $\rightarrow$ 18 km (TL639 $\rightarrow$ TCo639) with resolution change moved from Day 10 to Day 15
      – Extended-range 64 km $\rightarrow$ 32 km (TL319 $\rightarrow$ TCo319)
      – Analysis and High-resolution forecast: (TL1279 $\rightarrow$ TCo1279)
  – NCEP
    • Resolution 0-192h; T254L42 $\rightarrow$ TL574L64
    • Resolution 192-384h; T190L42 $\rightarrow$ TL382L64

• Plan
  – Met Office
    • Upgrade horizontal resolution 33km $\rightarrow$ 21km
  – JMA
    • Resolution 11-18days; TL319 to TL479
Benefit of higher resolution

Black line : HRES
Whisker Plot : ENS
Red dots : observations

Figures from ECMWF
Cost and benefit of Dec. 2nd 2015 upgrade

• Implementation cycling – 2 years (actually 3+ years now from last implementation)

• Computation cost (example)
  – GEFSv10 – ~105 nodes for 1 hour (one cycle) - 52km (day 1-8)
  – GEFSv11 - ~150-300 nodes for 1 hour (one cycle) – 34km (day 1-8)
  – Nearly 2-3 times resource increasing for upgrade (higher resolution)

• Benefit and improvement (based on 2-year + retrospective runs)
  – Approximate 8-hr useful forecast skill (60%) improvement based on NH 500hPa height AC score
  – Approximate 10% error reduction over all for 72 hours Tropical Storm track forecast from last 4 summer season statistics
  – Approximate 12% error reduction for NA 24 hours surface temperature forecast after bias correction (final products)
  – Approximate 8% BS skill improvement for CONUS PQPF 36-72 hours forecast great than 5mm/24 hours
  – Approximate 8% increasing “hits” for extreme cold weather events for 96 hours forecast with the same “false alarms”
  – Benefit – social and economic impact?
Planned new global EPS in DWD

ICON Ensemble

Pre-operational suite (start October 2015)
- 40 Member
- Global, 40 km (-> +180h)
- ICON-EU Nest, 20 km (-> +120h)
- 00 und 12 UTC
- Ensemble Data Assimilation
- Boundary Conditions for COSMO-DE-EPS

Andreas Rhodin, Harald Anlauf, Alexander Cress, Thomas Hanisch, Michael Buchhold, Michael Denhard
Other topics

- Hindcast (reforecast)
  - ECMWF
    - 5 members once weekly to 11 members twice weekly for past 20 years
  - Met Office Seasonal EPS (GloSea)
    - 4 start dates per month, 3 members per start date, each run to 7 months from 1993 to 2015
  - Met Office Decadal ensemble (DePreSys)
    - 10 members out to 5 years, from 1960 to present days
  - NCEP
    - From ESRL offline with 25 years to EMC offline with 20 years

- Verification
  - DWD
    - Experiment Verification against Analysis (EVA)
  - CPTEC
    - Assessing improved CPTEC probabilistic forecast on medium-range timescale
  - JMA
    - Reports to the Lead Centre on Verification of EPS under WMO/CBS
Verification

Figures from CPTEC and JMA

Original source: WMO/CBS Lead Centre on Verification of EPS
Verification

Feedback File Based Verification at DWD

by Felix Fundel

Feedback file

namelist

Score by Date

- 1x per day
- SYNOP or TEMP
- ICON, ICON-EU, COSMO-EU, IFS
- Deterministic and Ensemble
- Scores: continuous and categorical, probabilistic
- Conditional on: model, lead-time, valid-time, level, etc.
- uses R

namelist

Aggregation

- 1x per day
- Pool scores over period, levels, lead-time etc.
- Score files transferred to visualization server
- uses R

Visualization

- On demand interactive plot
- web browser application
- Plot and arrange scores, summaries, browse data
- Separate web based apps for observation and verification types
- uses the R shiny web server

Slide from DWD
REGIONAL
### Operational regional EPS

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<td>Met Office (UK)</td>
<td>2.2kmL70, 1.5kmL70-120</td>
<td>36h, 54h</td>
<td>11+1, 18/24</td>
<td>High Resolution Analysis + global EPS Convective ensemble DA</td>
<td>Stochastic physics using random parameter</td>
<td>Perturbing parameters in JULES</td>
<td>UM Hourly operation</td>
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<tr>
<td>Meteo France (France)</td>
<td>2.5km</td>
<td>42h</td>
<td>11+1</td>
<td>Rescaled and centered from global EPS EDA or B-based random noise</td>
<td>SPPT</td>
<td>perturbations of surface</td>
<td>AROME Pre-operation</td>
</tr>
<tr>
<td>DWD (German)</td>
<td>2.8km</td>
<td>27h, 45h</td>
<td>20, 40</td>
<td>IFS, GMS, GME, GSM Ensemble DA based on LETKF</td>
<td>Pert. Parameters SPPT</td>
<td>IFS, GMS, GME, GSM Global ICON EPS</td>
<td>COSMO For renewable energy</td>
</tr>
<tr>
<td>HMC (Russia)</td>
<td>2.2km</td>
<td>48h</td>
<td>10</td>
<td>COSMO-S14-EPS</td>
<td>N</td>
<td>SPPT</td>
<td>COSMO-S14-EPS</td>
</tr>
<tr>
<td>JMA (Japan)</td>
<td>5kmL48</td>
<td>39h</td>
<td>10+1, 20+1</td>
<td>SV(Total energy norm) Hybrid DA</td>
<td>N</td>
<td>JMA global EPS Perturbed SST</td>
<td>JMA-NHM Test-operation</td>
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<tr>
<td>NRL/FNMOC (US)</td>
<td>27/9/3km</td>
<td>120h</td>
<td>10+1</td>
<td>Perturbed synoptic scales Perturbed Rankine Vortex</td>
<td>N</td>
<td>GEFS/NAVGEM with synoptic perturbations</td>
<td>COAMPS-TC</td>
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<tr>
<td>NRL/FNMOC (US)</td>
<td>45/15/5km</td>
<td>72h</td>
<td>20+1</td>
<td>ETKF</td>
<td>Parameter variations</td>
<td>NAVGEM ensembles</td>
<td>COAMPS</td>
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<td>CMC (Canada)</td>
<td>15km</td>
<td>72h</td>
<td>20+1</td>
<td>Interpolated from global EPS Improved by global EPS</td>
<td>Stochastic pert. of physics</td>
<td>Global EPS Improved by global EPS</td>
<td>GEM</td>
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<td>CMA (China)</td>
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<td>Multi Scale Blending (GEPS and LETKF)</td>
<td>RP</td>
<td>Global EPS</td>
<td>um</td>
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<td>KMA (Korea)</td>
<td>3kmL70</td>
<td>45h</td>
<td>23+1</td>
<td>Downscale from Global EPS LETKF</td>
<td>RP</td>
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JMA: Japan Meteorological Agency
Extension of system configuration

• Upgraded
  – DWD
    • Extension of Lead time from 27h to 45h

• Plan
  – Met Office
    • Extended horizontal domain, following UKV model
    • Extended forecast range (to T+54h)
    • Hourly UK ensemble; combine several runs to make larger lagged ensemble
    • Higher resolution (vertical 70L to ~120L and perhaps horizontal 2.2km to 1.5km)
  – JMA
    • Number of members; from 11 to 21
Other topics

• Various objectives
  – DWD
    • Weather warnings and renewable energy applications
  – Meteo France
    • help human forecasters, (later) automated weather forecast products, flood prediction, air quality, customers (energy, wind farms...)
  – JMA
    • Disaster prevention
  – NRL
    • Tropical cyclone forecast using COAMPC-TC and HWRF multi model ensemble
  – CMA
    • 1-hour EPS products for landfall typhoon forecast