Ensemble prediction with OpenIFS

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Glenn Carver (ECMWF),
Simon Lang (ECMWF),
Lauri Tuppi (UoH),
Heikki Järvinen (UoH)
Why?
Why?

- Ensemble forecast are useful
Why?

- Ensemble forecast are useful
- They provide...
  - an estimation of the forecast uncertainty
  - efficient means to study impact of initial state
  - a way to gather knowledge about model physics and about closure parameters therein
What?
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    No analytical solution — need to discretize
    Due to limited computing resources, the discretized series cannot be continued into infinity
    Models can’t thus directly describe the smallest scale phenomena — parametrizations
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- Uncertainty in the predicted state of the atmosphere arises from

  - Its current state
    Initial state uncertainty
  - Boundary interactions with the ocean, land surface, etc.
    Boundary uncertainty
  - Governing/primitive equations
    Model uncertainty
What?

- Uncertainty in the predicted state of the atmosphere arises from
  - Initial state uncertainty
    Initialize model from different atmospheric states
  - Boundary uncertainty
    Add (smart) perturbations into boundary interactions, or directly into ocean or land surface models
  - Model uncertainty
    Use different forecast models, physical parametrizations, or add (smart) perturbations into model equations
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COMPLEMENT DETERMINISTIC MODELING!
How?
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- How about initial state perturbations from which ensemble predictions could be started?
Initial state perturbations (for OIFS)

- Replicate what is done operationally at ECMWF
  - IFS CY43R3
  - 50+1 initial states
  - Singular Vectors from the operational ensemble
  - Ensemble of Data Assimilations from the operational ensemble
  - TL159/TL399/TL639 (~120km/~50km/~32km)
  - Dec 2016 – Nov 2017, 00/12UTC
Ensemble workflow manager

- OpenEPS (github.com/pirkkao/OpenEPS)
  - Workflow manager written without any external software (in order to avoid extra hassle)
  - Bash + GNU make
  - Works similarly in HPC, linux cluster and laptop environments
  - NOT the point of this talk, any workflow manager (that gets the job done well) is suitable for using the initial perturbations
Benchmarking the system

- How good is the probabilistic skill of the system
- The experiment design:

<table>
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<th>Reso</th>
<th>Name (ens size)</th>
<th>EDA (N50)</th>
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- Leutbecher (2018) explored the topic of how a small ensemble size is suitable for finding out the probabilistic skill of a system
  - Fair-CRPS (FAIR) is a skill score independent of ensemble size, i.e. it treats different size ensembles the same way
Benchmarking the system

CRPS and different ensemble sizes, TL159. CRPS of temperature at 850hPa in the Northern extra-tropics. Mean over 46 start dates.
Benchmarking the system

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Worse
Better

Forecast length in hours
Benchmarking the system

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- FAIR seems to work as it should!
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FAIR of temperature at 850hPa in the Northern extra-tropics. Mean over 27 start dates.
Benchmarking the system

Quick check against ECMWF operational ensemble. CRPS of T850 over the years.
Benchmarking the system

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ECMWF ens 2017?
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Benchmarking the system

FAIR of temperature at 850hPa in the Northern extra-tropics. Mean over 47 start dates.
EDA+: EDA perturbations inflated by 1.2.
SV+: SV perturbations inflated by 1.2.
Use in case studies: Tropical Cyclone example

- Damrey typhoon
  - Made landfall in Vietnam 00UTC 4th of November 2017

- Lets simulate the case with OIFS
  - CY40R1
  - TL639
  - 20 ensemble members
  - SV and EDA perturbations

- Tracking the cyclone
  - Simply find the MSLP minimum
Let's zoom in here.
Deterministic forecast

2\textsuperscript{nd} of Nov 00UTC

4\textsuperscript{th} of Nov 00UTC
20 ensemble members started from different initial states
Use in case studies: Tropical Cyclone example

- Only using deterministic forecast does not provide enough information (wrong, too southerly track etc.)
- An ensemble started with initial state perturbations starts to find correct solutions of the track
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- Only using deterministic forecast does not provide enough information (wrong, too southerly track etc.)
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- What is more crucial, better representation of the TC initial structure, or better representation of the prevailing flow situation?
- Is it enough to get some aspects of the initial state better represented (e.g. winds)?
Discussion

- The dataset of ensemble initial states will be made public once it has been documented
  - FTP server
  - 22TB of data in tarz-format
- I’ve only discussed initial state perturbations here
  - CY40R1 includes a model uncertainty representation as well (SPPT)
  - CY43R3 includes an alternative model uncertainty representation currently under development at ECMWF (SPP)
Summary

• Why?
  – Ensembles open up a lot of new ways to tackle scientific problems

• How?
  – Get a workflow manager
  – Download OIFS ensemble initial states once available
  – Include a model uncertainty representation
Acknowledgements

ECMWF Special Project: “Parameter estimation (EPPES) in HarmonEPS “

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1st of Nov, 00UTC. +72h
2nd of Nov, 00UTC. +48h

Halved deep entrainment rate

Doubled deep entrainment rate

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