Research reproducibility and workflows with the Integrated Forecasting System

(Featuring Belle the cat and friends)

Andrew Bennett
ECMWF
andrew.bennett@ecmwf.int
Belle
Integrated Forecasting System

- Non-linear feedbacks between components
- 6 million lines of code
- Future changes will increase complexity
Handling data

- Outputs: results
- Inputs:
  - invariant (static/ancillary) data
  - Initial data
  - Driving data/observations

Central filesystem

Other experiment

MARS or ECFS archive

My experiment

Operational IFS

• Outputs: results
• Inputs:
  - invariant (static/ancillary) data
  - Initial data
  - Driving data/observations

• Inputs:
  - Initial data
  - Driving data/observations

• Outputs: results
Code dependencies

- IFS code
  - ifs-source: Fortran source code
  - ifs-scripts: Korn shell scripts
  - Ifs-defaults: templates for configuration of experiments
  - ifs-suites: definition of experiment pipeline / ecFlow suite

- Supporting libraries: ifs-bundle
  - Build machinery: ecbuild
  - In-house developed: eccodes, MIR, fckit, eckit, MARS client, …
Branching models
Belle’s new IFS feature

Problem: everyone needs to run a control experiment

Problem: possible bugs or interactions between features
Belle fixes a bug

Problem: how do we merge the hotfix into an old release?
A better workflow for the IFS

Controls made available

Undesirable interactions caught early

Incremental merging
Long live the release branch!

Hotfixes merged into relevant release branch(es)

Tag and new controls if results change

Tag CY47R1.2

ci-hotfix-
CY47R1.2

hotfix-
CY47R1.1

EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS
It’s complicated!
Continuous integration

- Scientific evaluation needs humans!
- Bit-identical changes only

If tests successful, merge into master

master frequently merged into release branch

Overnight integration tests

release CY47R1

CY47R1 v2
## Workstation build and test system

```shell
Test project /tmp/tmpdir/diab/git/ifs-builds/CY46R1/build
Start 898: ifs_t21_test_fc
1/18 Test #898: ifs_t21_test_fc ............... Passed 44.06 sec
Start 899: ifs_t21_test_fc_tegen
2/18 Test #899: ifs_t21_test_fc_tegen ........ Passed 4.77 sec
Start 900: ifs_t21_test_adj
3/18 Test #900: ifs_t21_test_adj ............... Passed 9.20 sec
Start 901: ifs_t21_test_tl_taylor
4/18 Test #901: ifs_t21_test_tl_taylor ........ Passed 4.75 sec
Start 902: ifs_t21_test_np2
5/18 Test #902: ifs_t21_test_np2 ............... Passed 6.12 sec
Start 903: ifs_t21_test_nt2
6/18 Test #903: ifs_t21_test_nt2 ............... Passed 5.91 sec
Start 904: ifs_t21_test_sv
7/18 Test #904: ifs_t21_test_sv ............... Passed 16.50 sec
Start 905: ifs_t21_test_sppt
8/18 Test #905: ifs_t21_test_sppt ............... Passed 4.79 sec
Start 906: ifs_t21_test_hybrid
9/18 Test #906: ifs_t21_test_hybrid ............... Passed 3.98 sec
Start 907: ifs_t21_test_updclie
10/18 Test #907: ifs_t21_test_updclie ............ Passed 12.77 sec
Start 908: ifs_t21_test_updclie2
11/18 Test #908: ifs_t21_test_updclie2 ............ Passed 12.87 sec
Start 909: ifs_t21_test_compo_fc
12/18 Test #909: ifs_t21_test_compo_fc ............ Passed 16.80 sec
Start 910: ifs_t21_test_compo_fc_climrad
```
Pre-built module
Possible future improvements

- Version control of invariant data files
- Run experiments inside a container
Summary

IFS tools and workflow adapted for:

• Ensuring reproducibility
• Long-running experiments for statistical significance
• Enabling scientific evaluation

But we’re taking ideas from non-scientific workflow!
Thanks for listening!
Extra slides
Themed merging

Feature branches

- Optimization of EDA post-processing
- archiving refactor
- Update on IASI and CrIS observation errors
- Slant path radiative transfer
- IR aerosol detection
- Strat-only model error forcing
- bias correction of aircraft T
- Vertical correlation for SYNOP analysis
- use Sonntag formula for background humidity

Pre-merge branches

- ODB improvements
- All-sky MW upgrades
- IR land surface emissivity atlas
- Technical & passive theme
- Satellite & assimilation theme
- Bit-reproducible theme
- Technical & passive theme

::
Themed merging (2)

Pre-merge branches

- Bit-reproducible theme
- Technical & passive theme
- Satellite & assimilation theme

Prototype release branches

- v0
- v1
- v2
- v3
- v4
- v5
- v6

...