# Working with single precision

- What is single precision
- Porting the code : targets, who, how
- Methods
- Examples

# Single & double precisions

| | Single | Double |
|---|---|---|
| Bytes per value | 4 | 8 |
| Max value | 3.4028E+38 | 1.7976E+308 |
| Min value | 1.1754E-38 | 2.2250E-308 |
| Significant digits | 6.92 | 15.6 |

# Porting the code

- Only forecast models for now
- No problem with external software (grib_api, netcdf, blas/lapack)
- Porting IOs (encoding & FA files are portable)
- Improvement (?) of some routines of the physics

# Targets

- Long ARPEGE & AROME forecasts
- With/without SURFEX
- Post-processing
- Short ARPEGE & AROME forecast
- ARPEGE & AROME screening

# Who ?

- ECMWF
- GMAP
- ALADIN, ALARO and HIRLAM partners

# How

- Git
- Packs :
  - Beaufix **and** prolix
  - PC
  - debug/optimized
  - single/double
  - modified/not modified
- Web site

# Validation

- Run « mitraillette » in single precision :

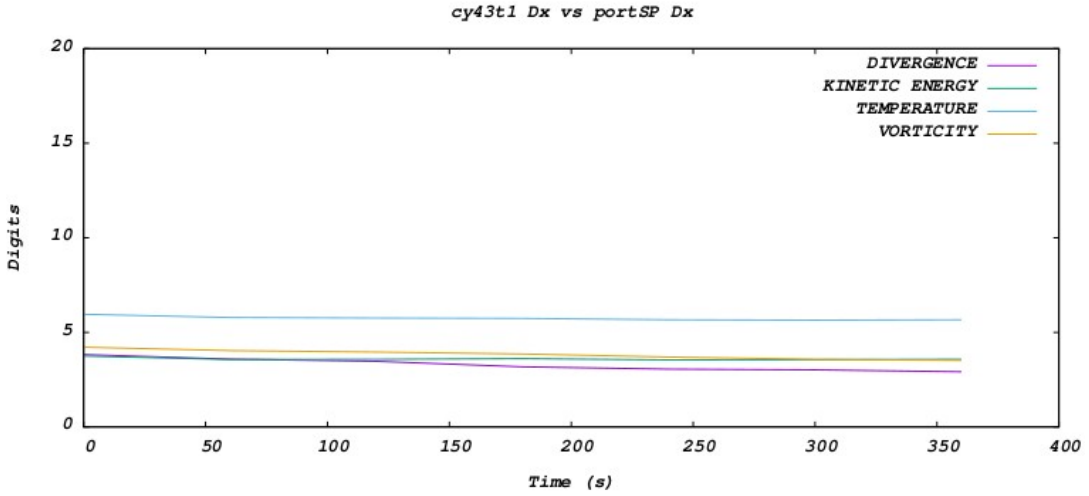
  Everything works on cycle 46t1

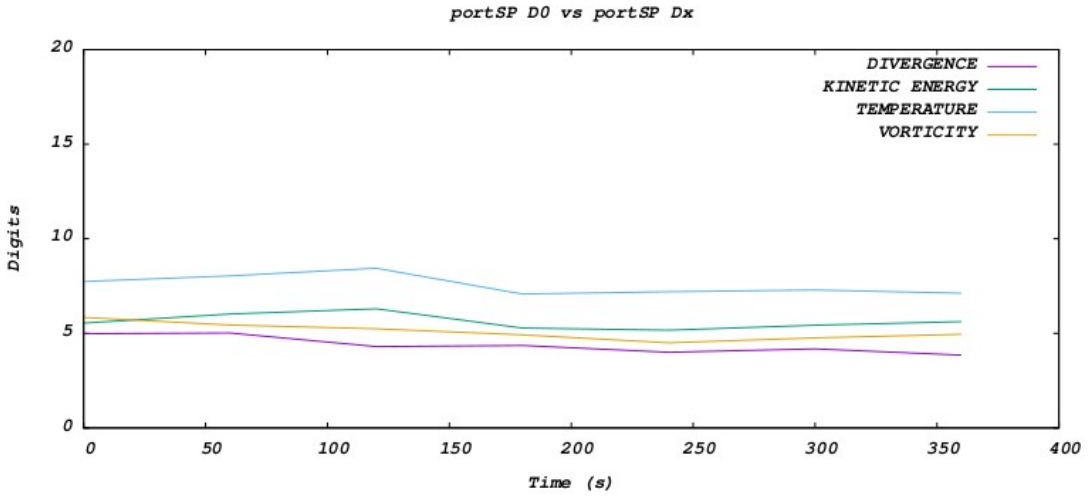
  Differences look acceptable

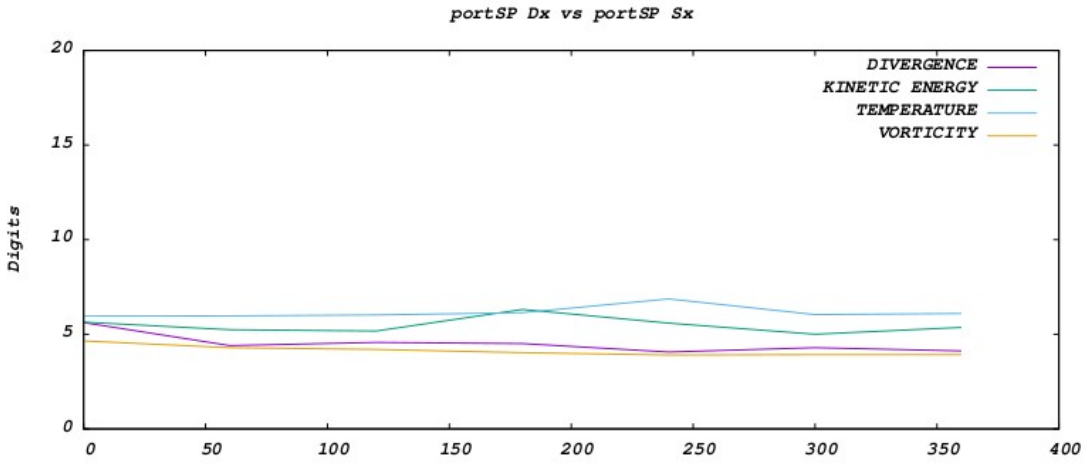
- One month of AROME 1.3km looks OK, some slight degradation of scores to radiosondes

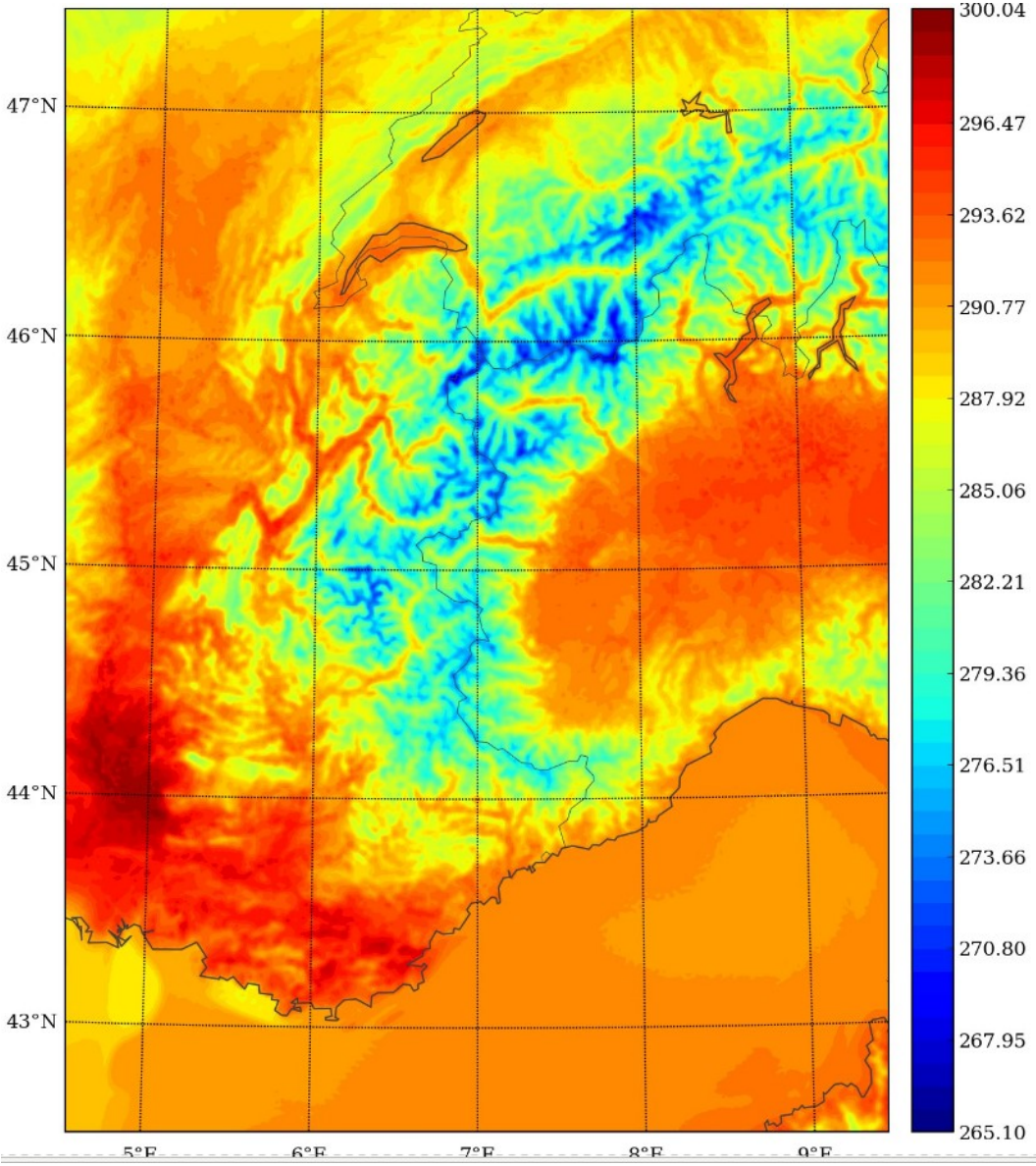
# Mitraillette

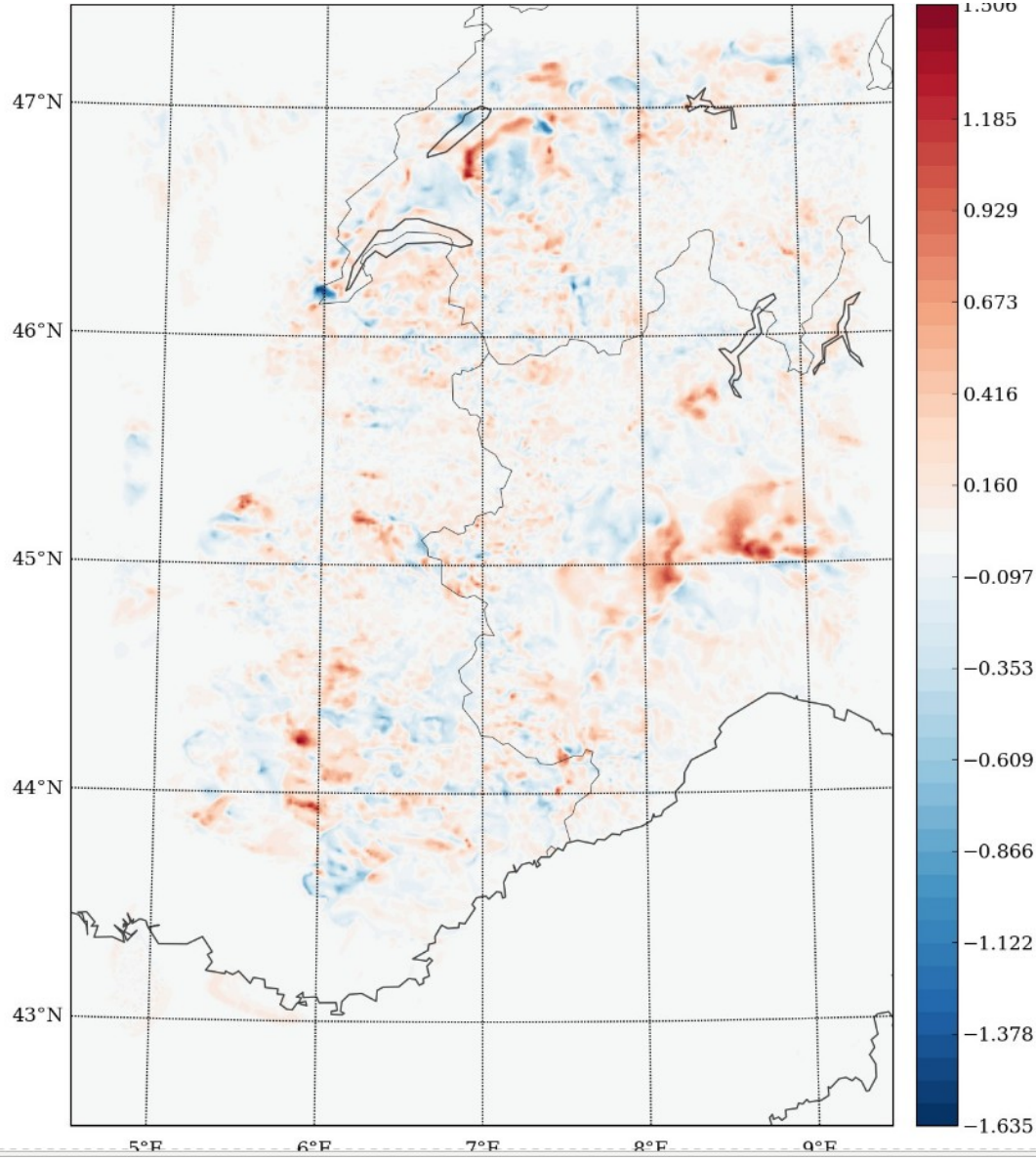
(common significant digits of spectral norms)

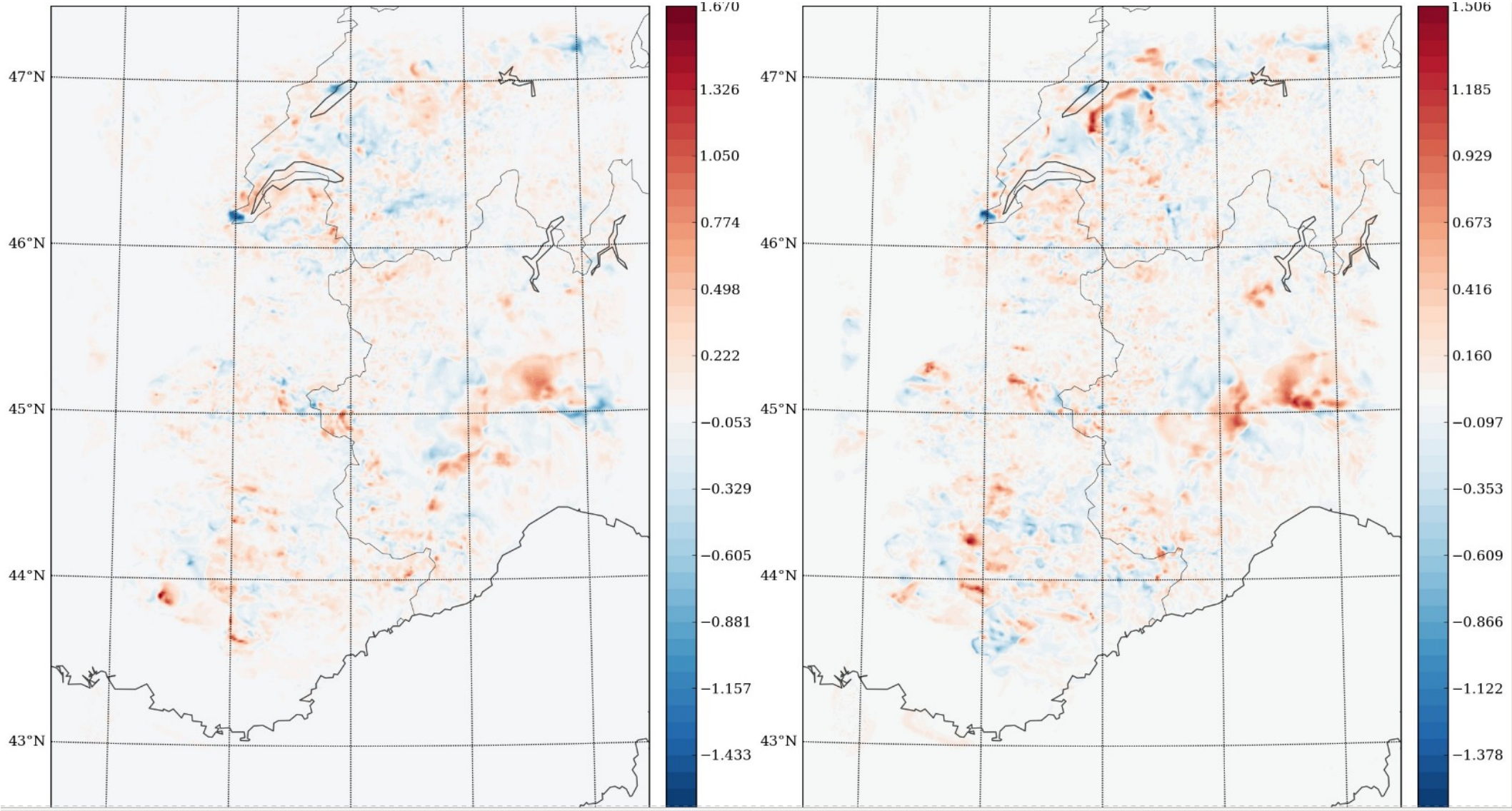



47°N
46°N
45°N
44°N
43°N
5°E
6°E
7°E
8°E
9°E
300.04
296.47
293.62
290.77
287.92
285.06
282.21
279.36
276.51
273.66
270.80
267.95
265.10


47°N
46°N
45°N
44°N
43°N
5°E
6°E
7°E
8°E
9°E
1.506
1.185
0.929
0.673
0.416
0.160
−0.097
−0.353
−0.609
−0.866
−1.122
−1.378
−1.635

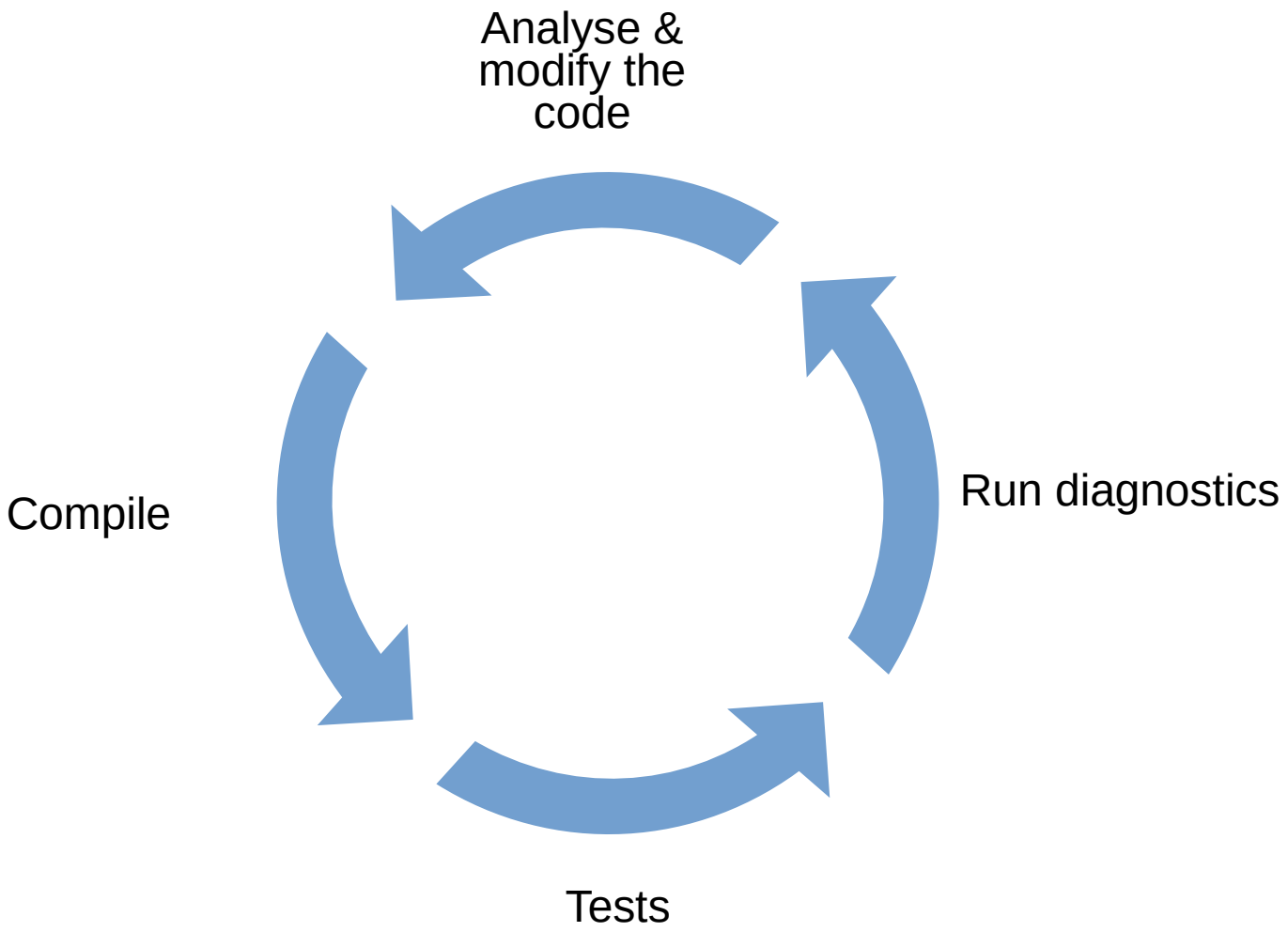

47°N
46°N
45°N
44°N
43°N
1.670
1.326
1.050
0.774
0.498
0.222
−0.053
−0.329
−0.605
−0.881
−1.157
−1.433
47°N
46°N
45°N
44°N
43°N
1.506
1.185
0.929
0.673
0.416
0.160
−0.097
−0.353
−0.609
−0.866
−1.122
−1.378

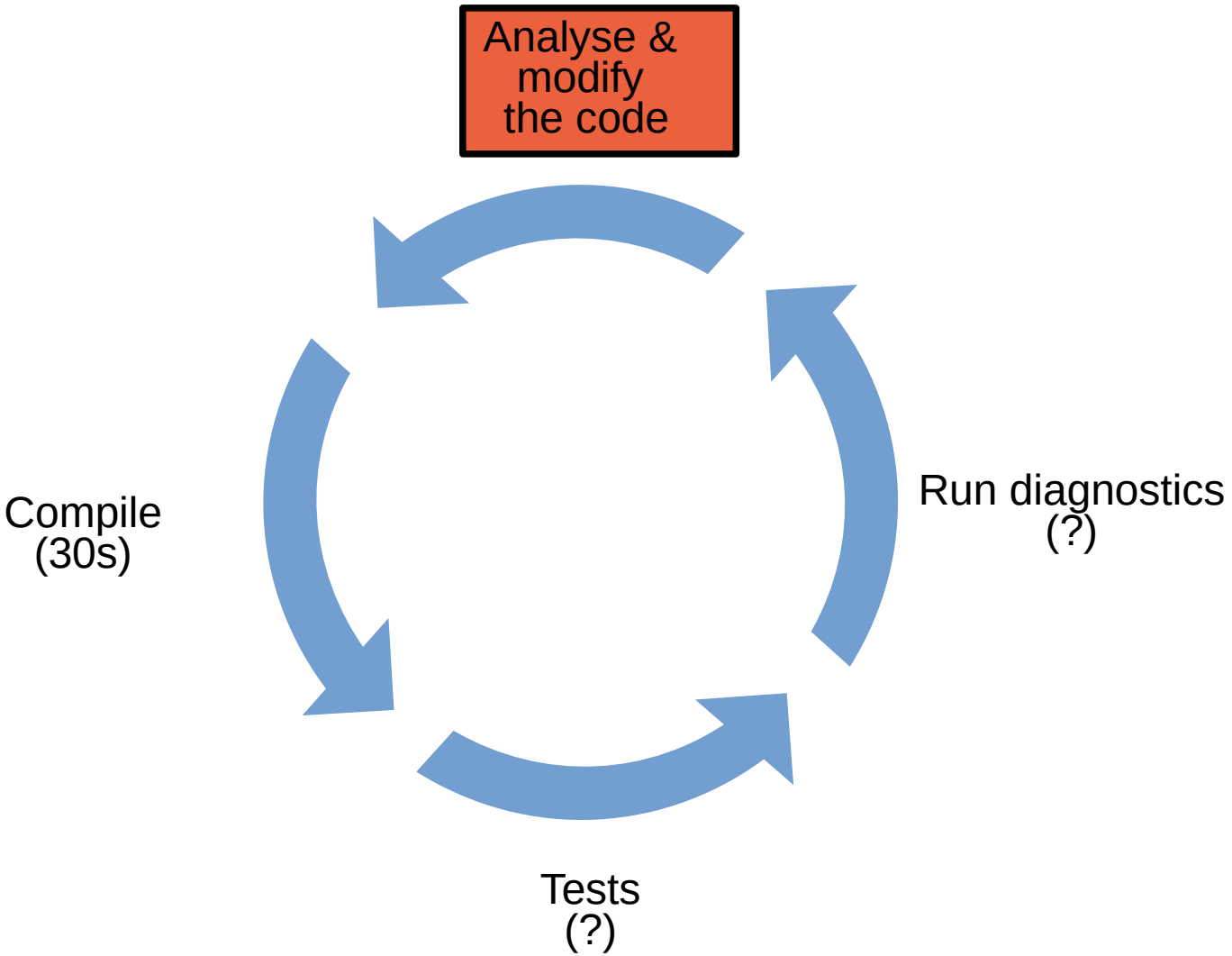
# Performance

ARPEGE, t1198, 48h

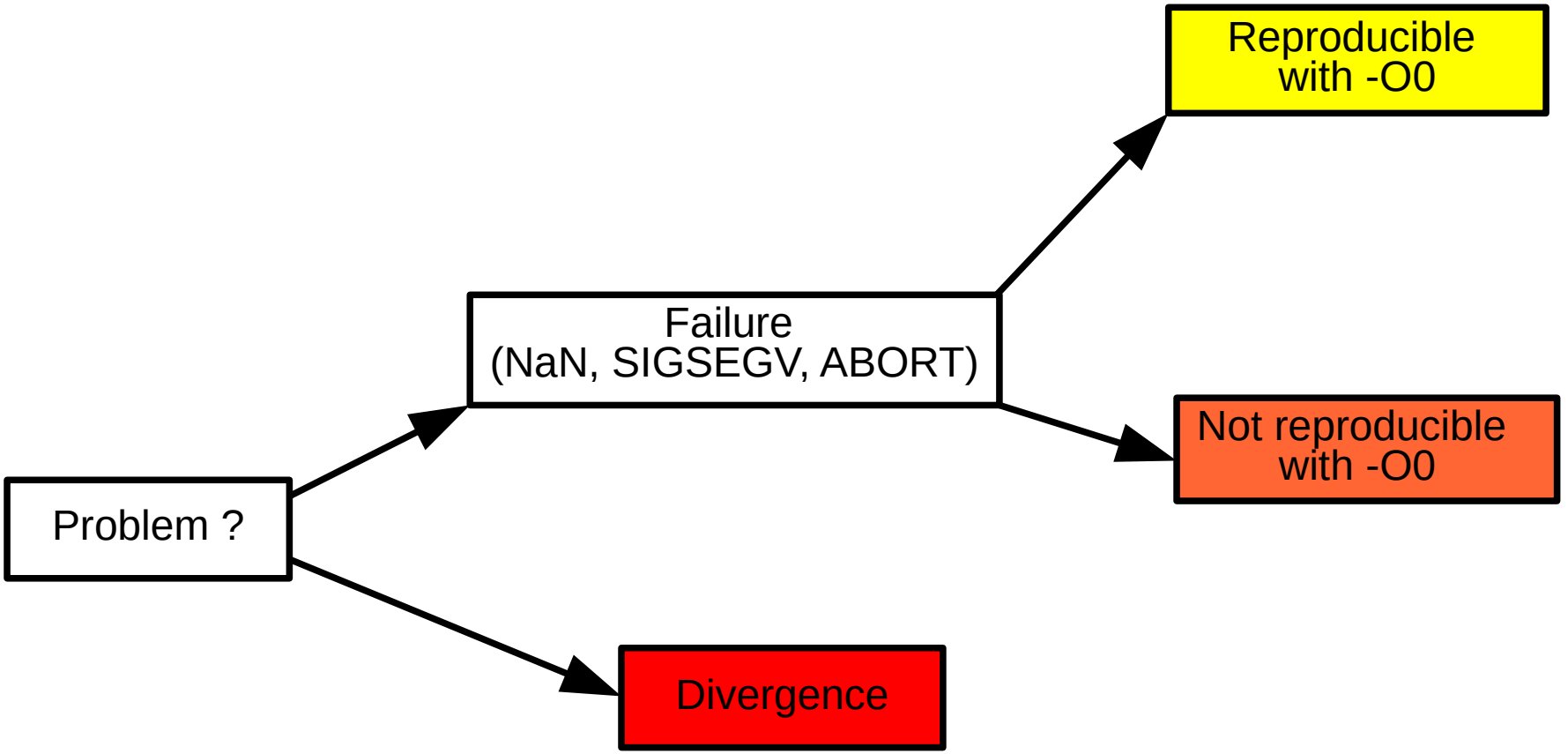
~ 40 % on speed; + a few % with NPROMA tuning

| Broadwell nodes | Double precision | Single precision |
|---|---|---|
| 8 | 2260 | 1352 |
| 16 | 1182 | 697 |
| 32 | 621 | 367 |
| 64 | 332 | 198 |


Analyse & modify the code
Run diagnostics
Tests
Compile


Analyse &
modify
the code
Run diagnostics
(?)
Tests
(?)
Compile
(30s)

# Solve a problem



# Solve a problem

Two steps :

- Locate the issue
- Analyze

# Reduce time

Automate :

- Code replication (double/single)
- Compiling
- Tests & diagnostics
- Visualisation

Use restart files (available in cy46t1 both for ARPEGE and AROME)

# Reproducible with -O0

→ Intercept exceptions : break point in a SIGFPE handler, use ddt

# NaN in the physics

Usually a single column is affected

Look at array « PB1 » (contains tendencies)

→ Find MPI task, block and column

→ Dichotomy in physics code

Possibly create an external test case for quick debugging

# Example : acfluso.F90

```
DO JLON=KIDIA,KFDIA
  PCD(JLON)=ZLSM(JLON)*PCD(JLON)&
   & +(1.0_JPRB-ZLSM(JLON))*(ZUSR(JLON)/ZDU(JLON))**2
  PCH(JLON)=ZLSM(JLON)*PCH(JLON)&
   & +(1.0_JPRB-ZLSM(JLON))* ZUSR(JLON)*ZTSR(JLON)/(ZDU(JLON)*ZDTH(JLON))
  PCE(JLON)=ZLSM(JLON)*PCH(JLON)&
   & +(1.0_JPRB-ZLSM(JLON))*(ZUSR(JLON)*ZQSR(JLON)/(ZDU(JLON)*ZDQ(JLON))  &
   & *(1.0_JPRB-ZICHCE)+PCH(JLON)*ZICHCE)
```

# Example : acfluso.F90

```
  DO JLON=KIDIA,KFDIA
...
    ZDELTAU10N(JLON) = ZDU (JLON)
    ZDELTAT10N(JLON) = ZDTH(JLON)
    ZDELTAQ10N(JLON) = ZDQ (JLON)
  ENDDO
...
  DO JJ=1,NITERFL
    DO JLON=KIDIA,KFDIA
...
    ZUSR2=SQRT(PCDN(JLON))*ZDELTAU10N(JLON)
      ZTSR2= ZCHN(JLON)/SQRT(PCDN(JLON))*ZDELTAT10N(JLON)
      ZQSR2=(ZCEFAC*ZCEN(JLON)*(1.0_JPRB-ZICHCE)+ZCHN(JLON)*ZICHCE)&
...
      ZDELTAU10N(JLON)=ZDU (JLON)-ZUSR2*(ZLOGHS10-ZPSI_U)/VKARMN
      ZDELTAT10N(JLON)=ZDTH(JLON)-ZTSR2*(ZLOGHS10-ZPSI_T)/VKARMN
      ZDELTAQ10N(JLON)=ZDQ (JLON)-ZQSR2*(ZLOGHS10-ZPSI_T)/VKARMN
      ZUSR(JLON)=ZUSR2
      ZTSR(JLON)=ZTSR2
      ZQSR(JLON)=ZQSR2
    ENDDO
  ENDDO
```

# Example : ecume_flux.F90

```
DO JLON=1,SIZE(PTA)
    ZZDTH = 0.5* &
             ((1.0+SIGN(1.0,ZDTH(JLON)))*MAX(ZDTH(JLON),ZEPS)  &
             +(1.0-SIGN(1.0,ZDTH(JLON)))*MIN(ZDTH(JLON),-ZEPS))
    ZZDQ  = 0.5* &
             ((1.0+SIGN(1.0,ZDQ(JLON)))*MAX(ZDQ(JLON),ZEPS)    &
             +(1.0-SIGN(1.0,ZDQ(JLON)))*MIN(ZDQ(JLON),-ZEPS))
    PCD(JLON)  =  (ZUSR(JLON)/ZDUWG(JLON))**2
    PCH(JLON)  =  ZUSR(JLON)*ZTSR(JLON)/(ZDUWG(JLON)*ZZDTH)
    PCE(JLON)  =  ZUSR(JLON)*ZQSR(JLON)/(ZDUWG(JLON)*ZZDQ)
```

# Current topics

- Reproducibility of ARPEGE (SGEMM)
- Inline post-processing of ARPEGE
- Mass fixer in AROME
- Validation of SURFEX in single precision
- Running SURFEX using NetCDF in single precision