OpenIFS exercises

Introduction to experiments

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Exp 0 (fw10): High resolution run

Reference experiment (fw13) is T511 ($\approx$ 40 km) is to be compared with operational IFS resolution T1279 ($\approx$ 15 km).

Expected feedback:

- Better positioning of cyclone.
- More accurate wind field description.
- More details in precipitation patterns.

Exp 0 (fw10): High resolution run

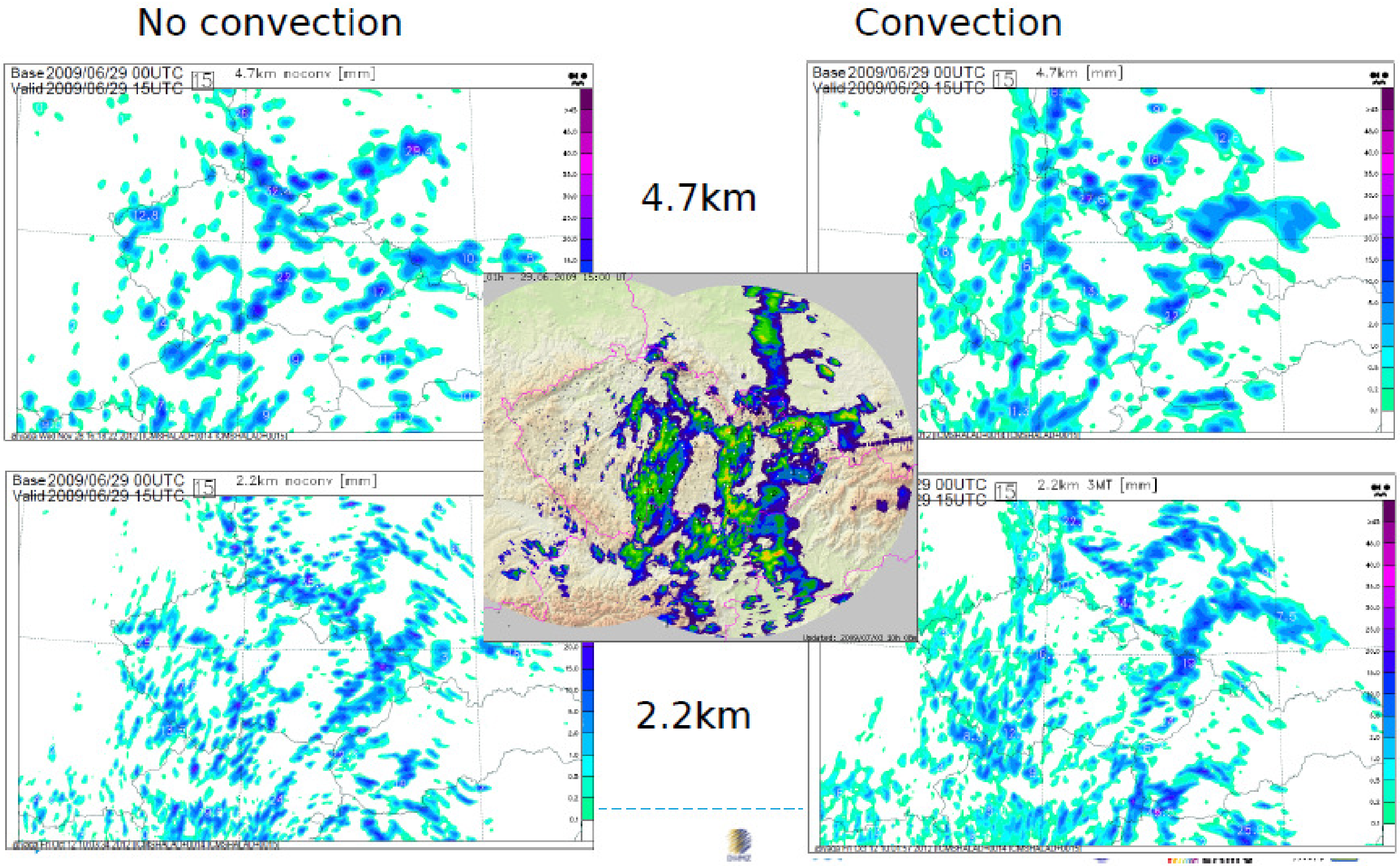
Reference experiment (fw13) is T511 ($\approx$ 40 km) is to be compared with operational IFS resolution T1279 ($\approx$ 15 km).

Discussion:

- How the high resolution contributes to the forecast quality?
- Was the T1279 resolution really crucial to have correct forecast of the Sandy event?
- Where would you expect to see an added value from increased resolution (land/sea, tropics/mid-latitudes,...)?

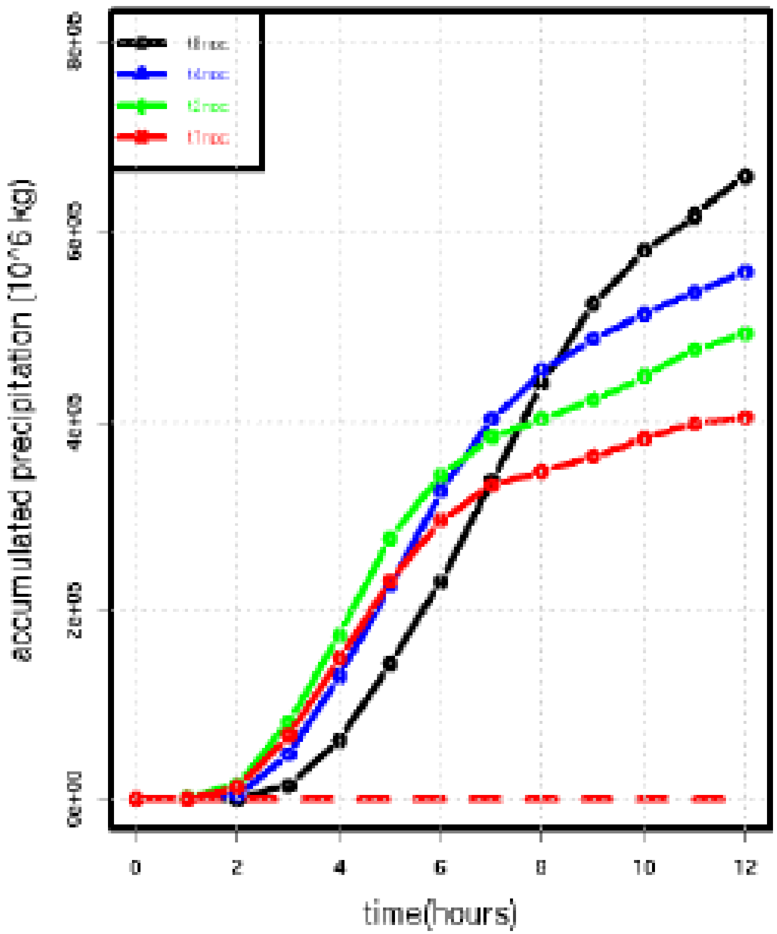
Exp 1 (fw4n): No parametrized convection

Setup IFS to be a convection permitting model:



Exp 1 (fw4n): No parametrized convection

Setup IFS to be a convection permitting model:



8 km
4 km
2 km
1km

Exp 1 (fw4n): No parametrized convection

Namelist change:

```
&NAEPHY
    LECUMF=.FALSE.
```

Expected feedback:

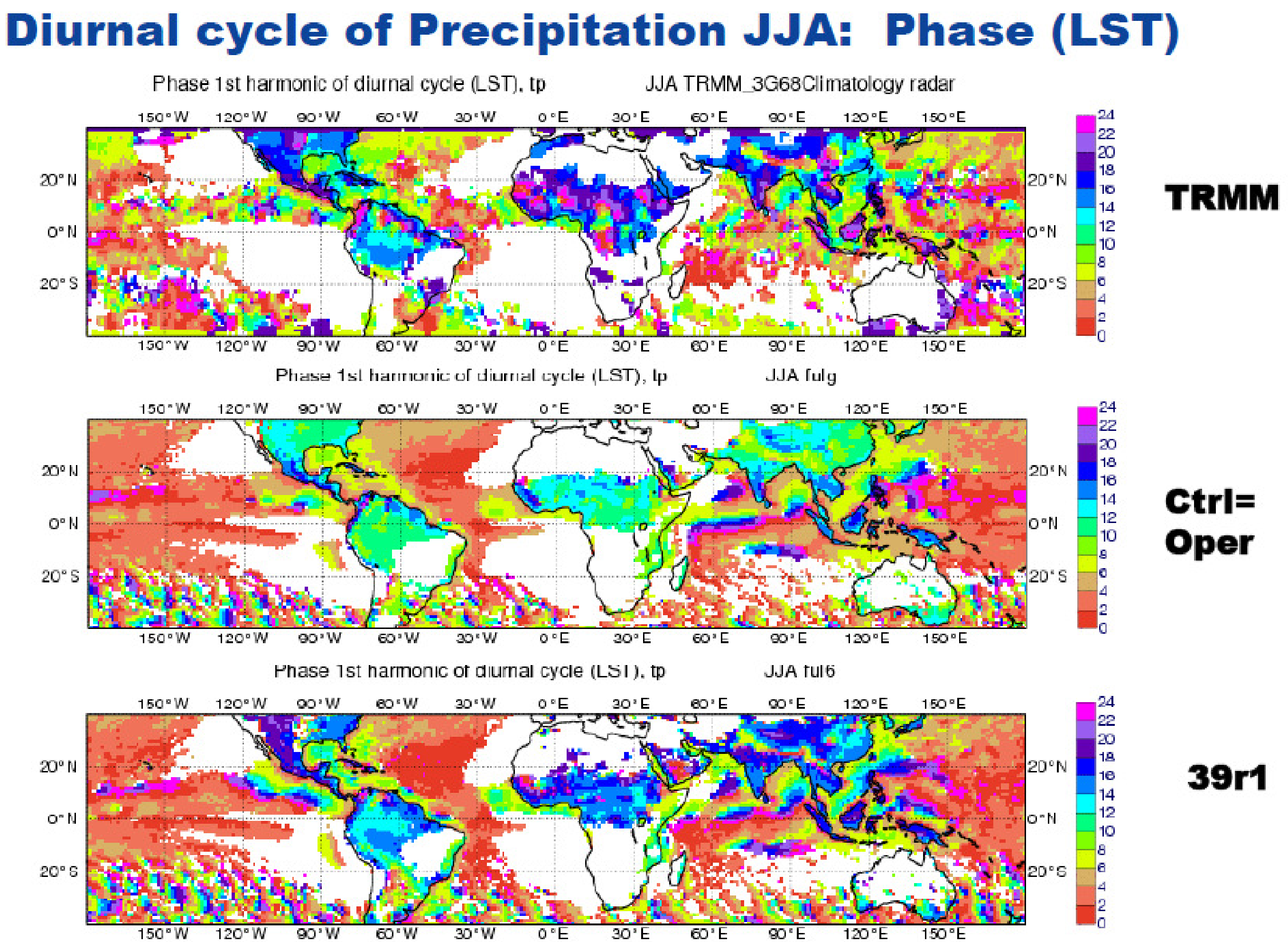
- More intense development.
- Precipitation directly related to the LS forcing.
- Grid-point storms, localised strong precipitation.
- Missing weak precipitation areas.
- Outflow from precip. areas in 200 hPa.

Exp 1 (fw4n): No parametrized convection

Discussion:

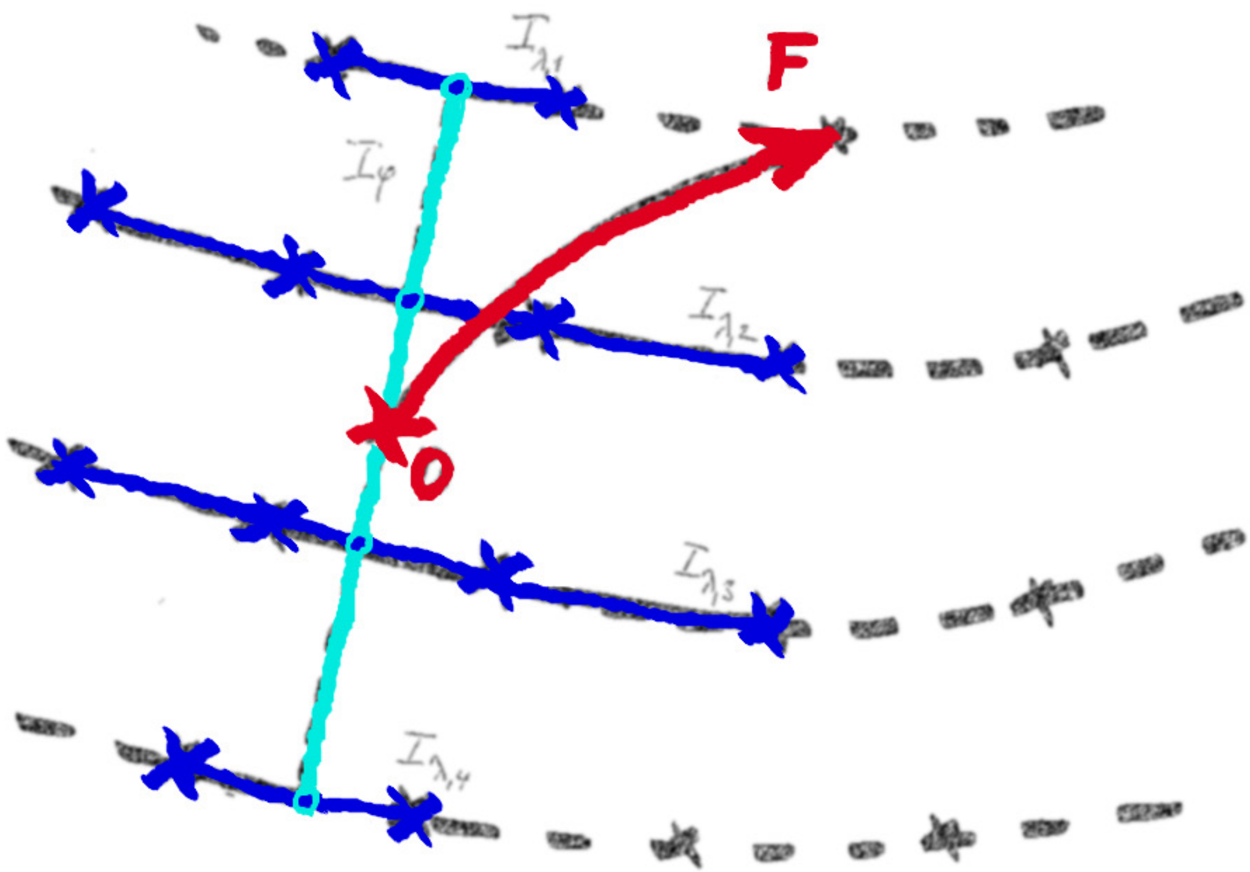
- Resolution (in)dependency.
- Timing and amount of precipitation.
- Resolved versus parameterized effects.

Exp 1 (fw4n): No parametrized convection



Exp 2 (fw4i): Reduced diffusivity of SL interpolation

Semi-Lagrangian advection scheme

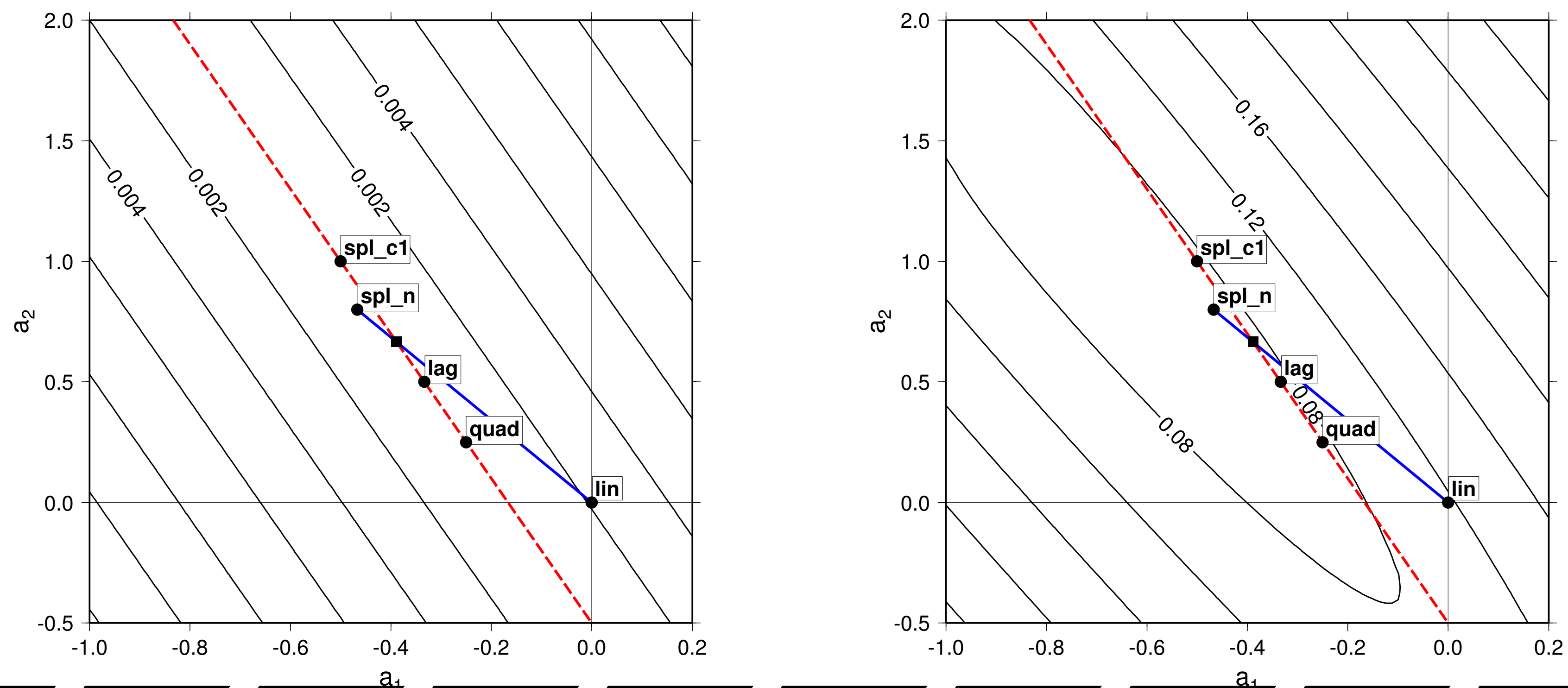


Exp 2 (fw4i): Reduced diffusivity of SL interpolation

Weight-driven interpolation:

accuracy measured by weighted MAE

weight: $\exp(-25m/M)$ weight: $\exp(-m/M)$

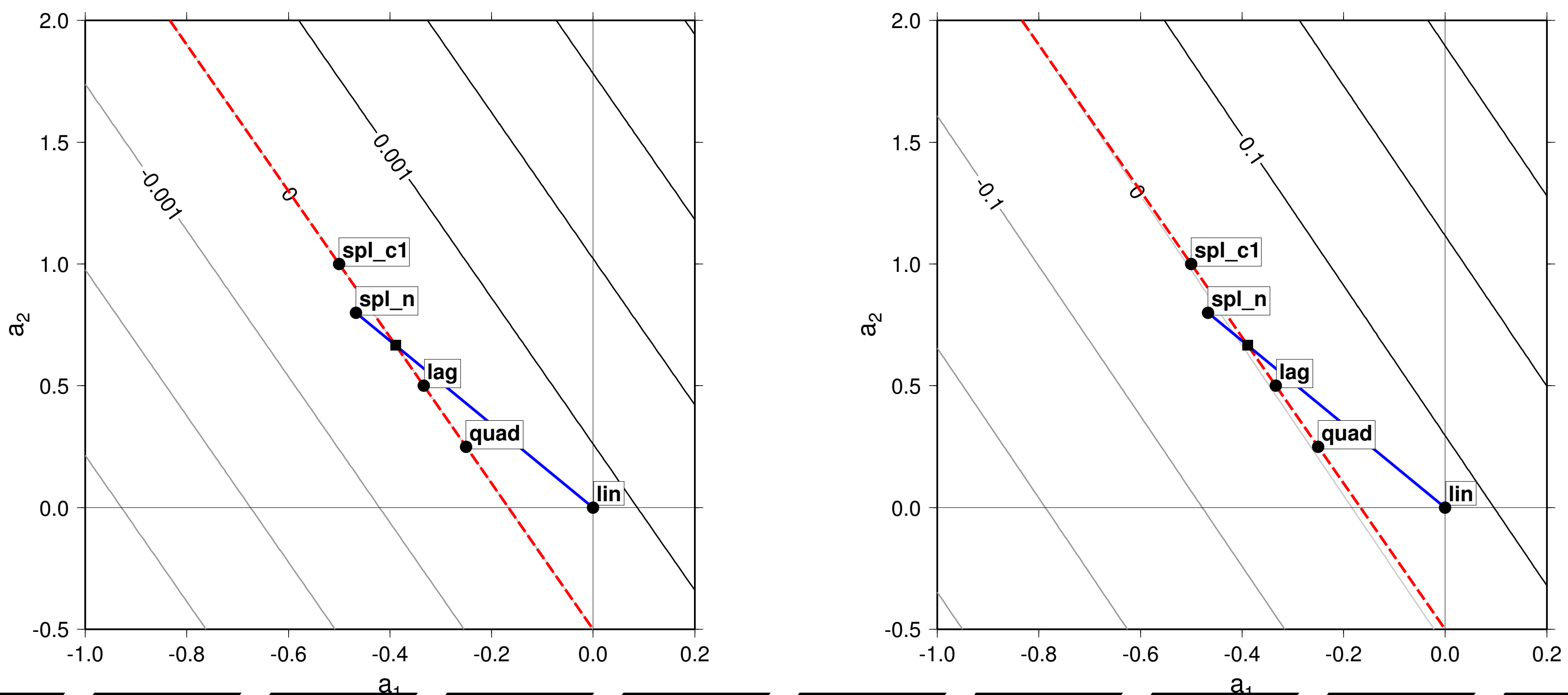


Exp 2 (fw4i): Reduced diffusivity of SL interpolation

Weight-driven interpolation:

dimensionless damping rate

$\lambda = 100\Delta x$ $\lambda = 10\Delta x$

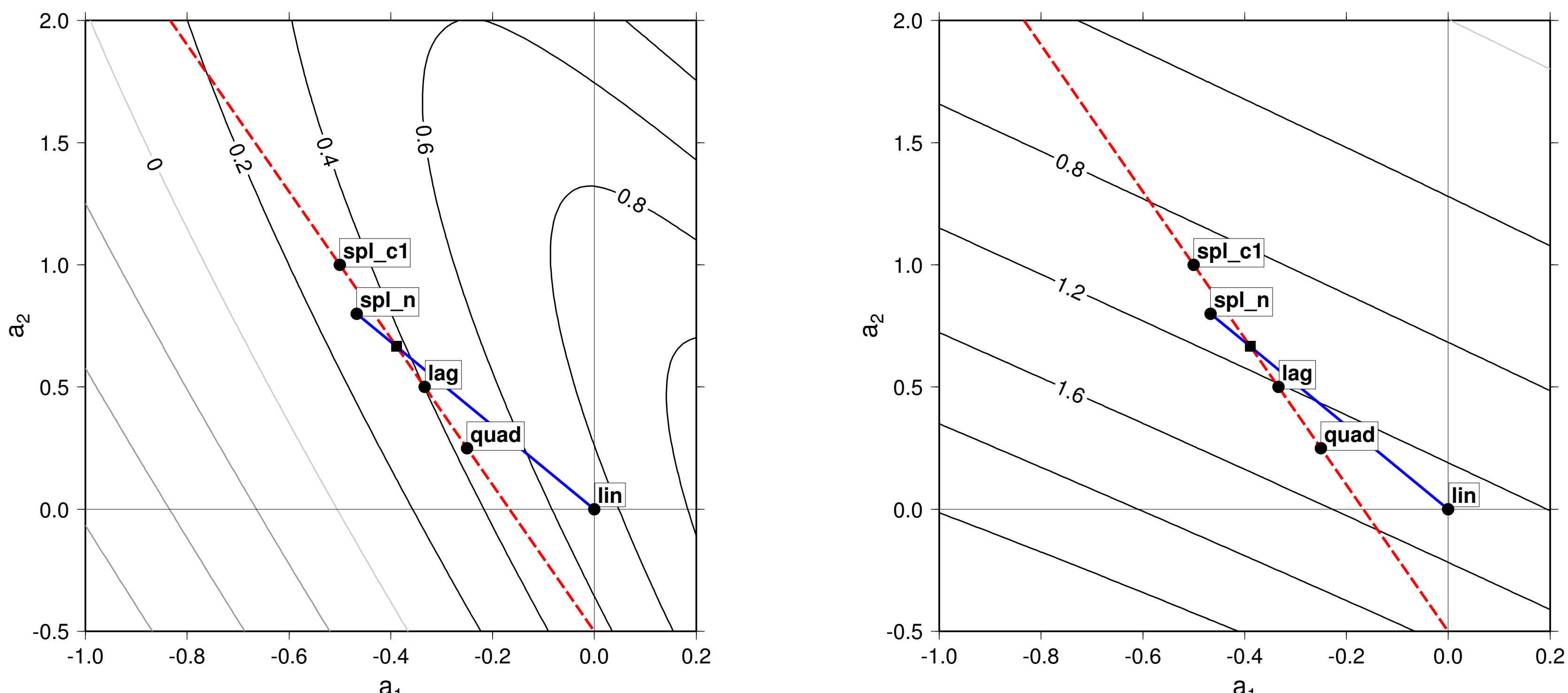


Exp 2 (fw4i): Reduced diffusivity of SL interpolation

Weight-driven interpolation:

dimensionless damping rate

$\lambda = 3.0\Delta x$ $\qquad\qquad$ $\lambda = 2.0\Delta x$



Exp 2 (fw4i): Reduced diffusivity of SL interpolation

The default Lagrangian cubic interpolation (SLHDKMIN=0.) is replaced by less damping interpolation with SLHDKMIN=-0.6 .

Namelist changes:

```
&NAMDYNA
    LSLHD_OLD=.FALSE.,
    SLHDKMIN=-0.6,
```

Expected feedback:

- Similar to resolution increase.
- Non-linear feedback through (moist) physics...

Exp 2 (fw4i): Reduced diffusivity of SL interpolation

Discussion:

- Is less diffusive scheme always profitable in terms of forecast quality?
- How the stability is generally affected when a scheme diffusivity is reduced?
- What is the model effective resolution?

Exp 3 (fw4g): Non-linear diffusion

Numerical spectral linear diffusion (X = VOR, DIV, $f(T)$)

$$\left(\frac{\partial X}{\partial t}\right)_{\text{hd}} = -K_X \nabla^r X$$

is replaced by a non-linear flow dependent alternative triggered by horizontal flow deformation field d and acting through the SL interpolation (applied to u, v, $f(T)$ and q_v):

$$\left(\frac{\partial X}{\partial t}\right)_{\text{hd}} = -\mathcal{D}\left[d, X_F^+ - \frac{1}{2}\mathcal{N}_F^{\frac{1}{2}}\right] - K'_X \nabla^{r'} X$$

$K'_{vor,div} < K_{vor,div}$, $K'_{f(T),q_v} = 0$ and $r' = 6$ ($r = 4$).

Exp 3 (fw4g): Non-linear diffusion

Code + namelist changes:

```
&NAMDYNA
    SLHDKMIN=-0.6, SLHDKMAX=.6,
    SLHDEPSH=0.016, SLHDEPSV=0.010,
    LSLHD_T=.true. LSLHD_W=.true.
    (...)
&NAMGFL
    YQ_NL%LSLHD=.true.
```

Expected feedback:

- Different storm evolution (diffusion no longer sees the storm as a symmetric feature) - look at the pressure field and 500 hPa geopotential.
- Atmosphere gets more active, sharper gradients...
- Moist field homogenised - see precipitation.

Exp 3 (fw4g): Non-linear diffusion

Discussion:

- Which scheme was the better performer?
- What is the role of numerical diffusion?
- Linear versus non-linear diffusion scheme.

Exp 4 (fw2s): Modified vertical diffusion

Exchange coefficients in the mixed layer:

$$K_{M,H} = K_{M,H}^{sfc} + K_{M,H}^{top}$$

$$K_{M,H}^{sfc} = \kappa u_* \Phi_{M,H0}^{-1} \left(1 - \frac{z}{h}\right)^2$$

Exp 4 (fw2s): Modified vertical diffusion

Exchange coefficients in the mixed layer:

$$K_{M,H} = K_{M,H}^{sfc} + K_{M,H}^{top}$$

$$K_{M,H}^{sfc} = \kappa u_* \Phi_{M,H0}^{-1} \left(1 - \tfrac{z}{h}\right)^2$$

$$\Rightarrow K_{M,H}^{sfc} = \kappa u_* \Phi_{M,H0}^{-1} \left(1 - \frac{z}{h}\right)^{3}$$

Surface driven diffusion damps more rapidly toward the BL top h.

Exp 4 (fw2s): Modified vertical diffusion

Code change only:

ifs/phys_ec/vdfexcu.F90

Expected feedback:

- Different storm evolution (turbulence differs near the ground) - see surface pressure fields; if possible compare it with the Exp 3 (fw4g) results.
- Strong effect to 10m wind, precipitation.
- Impact seen up to stratosphere.

Exp 4 (fw2s): Modified vertical diffusion

Discussion:

- Why this small change in the code has such a dramatic impact?
- Why the impacted areas on surface pressure are having similar location with those from Exp 3 (fw4g)?

Exp 5 (fw2n): Modified albedo

Model albedo increased by 10% everywhere.

Discussion:

- Most impact to be seen above continent (T2m).
- Impact mainly in temperature (global average) and radiation fluxes.
- The position of cyclone is also affected (see pressure field). What does it mean?

Exp 6 (fw2q): Modified roughness length

Momentum roughness length for ocean open water set to double value.

Discussion:

- Impact seen in position of cyclone (moves faster now) - see surface pressure.
- Wind field affected above sea, T2m affected everywhere (secondary feedbacks above land - gets more structured there...).
- Not much impact higher up.

Exp 7 (fw2u): Modified asymptotic mixing length

Tropospheric asymptotic mixing length set to 50% of its original value.

Discussion:

- Weak effect mainly above sea (T2m, w10m), cooling in areas of stable stratification.
- Trajectory of cyclone is affected (surface pressure).
- Not much impact higher up.

Exp 8 (fw5a): Numerical diffusion on moist quantities

As Exp 2 with non-linear diffusion affecting q_v, q_l and q_i.

Discussion:

- Affecting position and shape of the cyclone (surface pressure, geopotential)
- Affecting precipitation.
- Not much of impact otherwise.