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PROPHECY – Implementation of SPPT

A status report

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Implementation Strategy – Joint proposal

Implementation of Model Error
Perturbation Generators in ICON

Joint proposal

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1 Introduction

Model-error perturbations are generated by a Model Error Perturbation Generator (Perturbator) at each model time step during time integration of an ensemble member in order to account for errors and uncertainties in the tendencies of a deterministic model.

2 Three Model Error Perturbators

The three schemes for ICON are being proposed here:

SMME

1. SMME (Stochastic Model of the Model Error).
   SMME aims at modeling the model error by integrating a stochastic partial differential equation at different heights levels for u, v, and T. The solution of the SPDE has spatial and temporal correlations corresponding to the model error in the training data set. These solutions of the SPDE (of course different in each member of the ensemble) are added to the tendencies in the slow physics scheme.

AMPT

2. AMPT (Additive Model-error perturbations scaled by Physical Tendency).
   AMPT relies on the Stochastic Pattern Generator (SPG, **?**) initially developed for and implemented in the limited area COSMO model.

SPG integrates an evolutionary stochastic partial differential equation on the 3D unit torus (the triply periodic unit cube). SPG employs a spectral approach in space and a finite differencing scheme in time. SPG computes Gaussian pseudo-random fields with tunable variance and spatial/temporal scales.

AMPT produces model-error perturbation fields by scaling the unit-variance SPG fields with an area averaged physical tendency.

SPPT

3. SPPT (Stochastic pertubation of physics tendencies)
   For SPPT random pattern field are calculated on a coarser grid with a typical mesh-size of about 50 km and are interpolated to the native model grid to provide correlation in space. We thus suggest to calculate the random number field on a coarser triangular grid (provided by a new namelist switch) every x time step (typically every 6h) interpolate it in time in between and interpolate the resulting field to the native model grid in every time step.

   In a first step we aim on using the same stochastics for all physical parameterisations as compared to an iSPPT implementation where tendencies from each physical parameterisation are perturbed individually. Note that an iSPPT implementation is still possible and the current implementation strategy can be adapted accordingly.

3 Places in the ICON code where perturbations are computed

At this stage of development, both SMME and AMPT will perturb T, u, v fields (perturbing humidity and hydrometeors will be considered within AMPT at a later stage).

Any of the three Model Error Perturbators will be called from `mo_nh_interface_nwp.f90` mimicking - at least in case of SMME and AMPT - an additional slow physics process at the following places.

1. SMME:

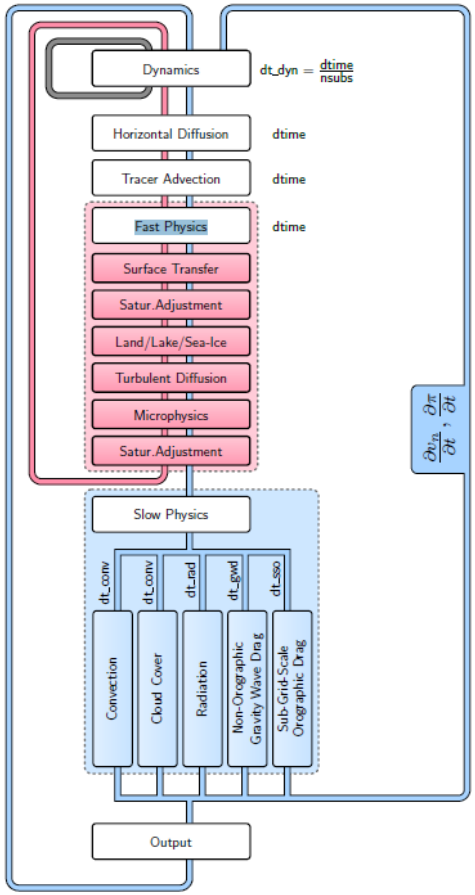
   Place

   ```
   CALL integrate_stoch_model_model_error
   ```

   just before the line

   ```
   ! Anurag Dipankar MPIM (2013-May-29)
   ```

Implementation Strategy – Proof of concept



- **S**tochastic **P**erturbation of **P**hysics **T**endencies Temperature (T), Wind (U,V) as well as water tracers (QV, QC, QI, QS, QR, QG*)
- Separate increments/tendencies for fast & slow physics
- Saving diagnostic parameters before and calculate increments after corresponding schemes.
- Random Number Generator (RNG, normal distributed)*
- Adding of perturbed tendencies to prognostic parameters.

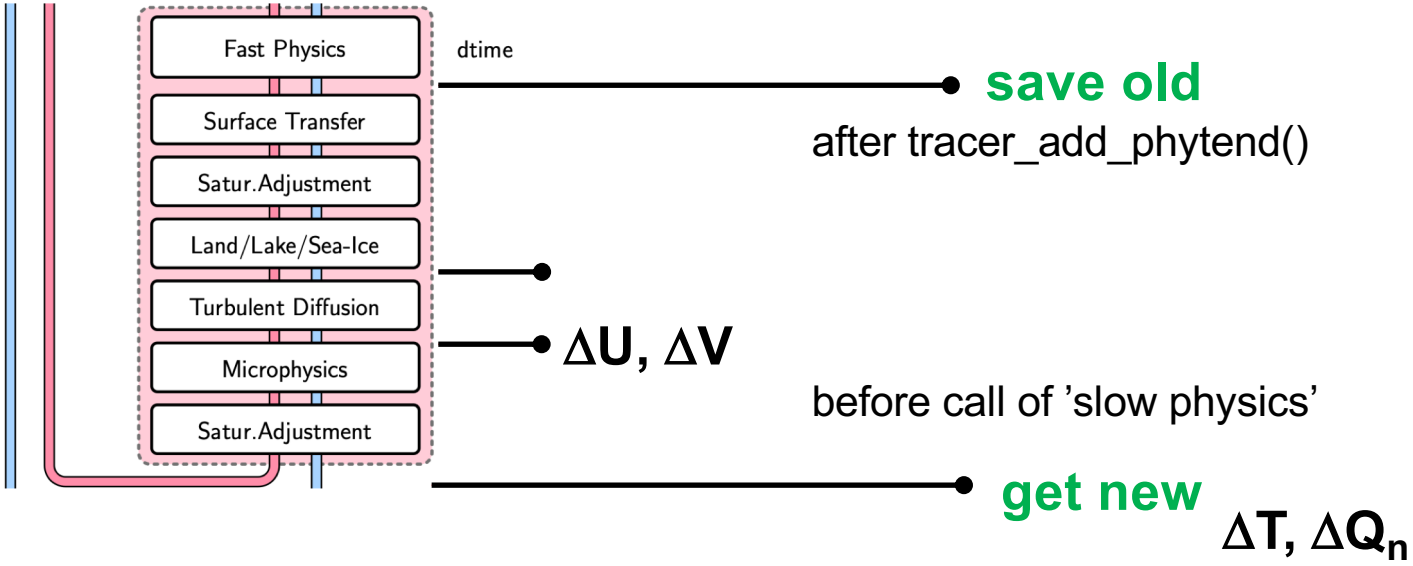
Source: ICON-Tutorial

*not implemented yet

Implementation Strategy – Proof of concept

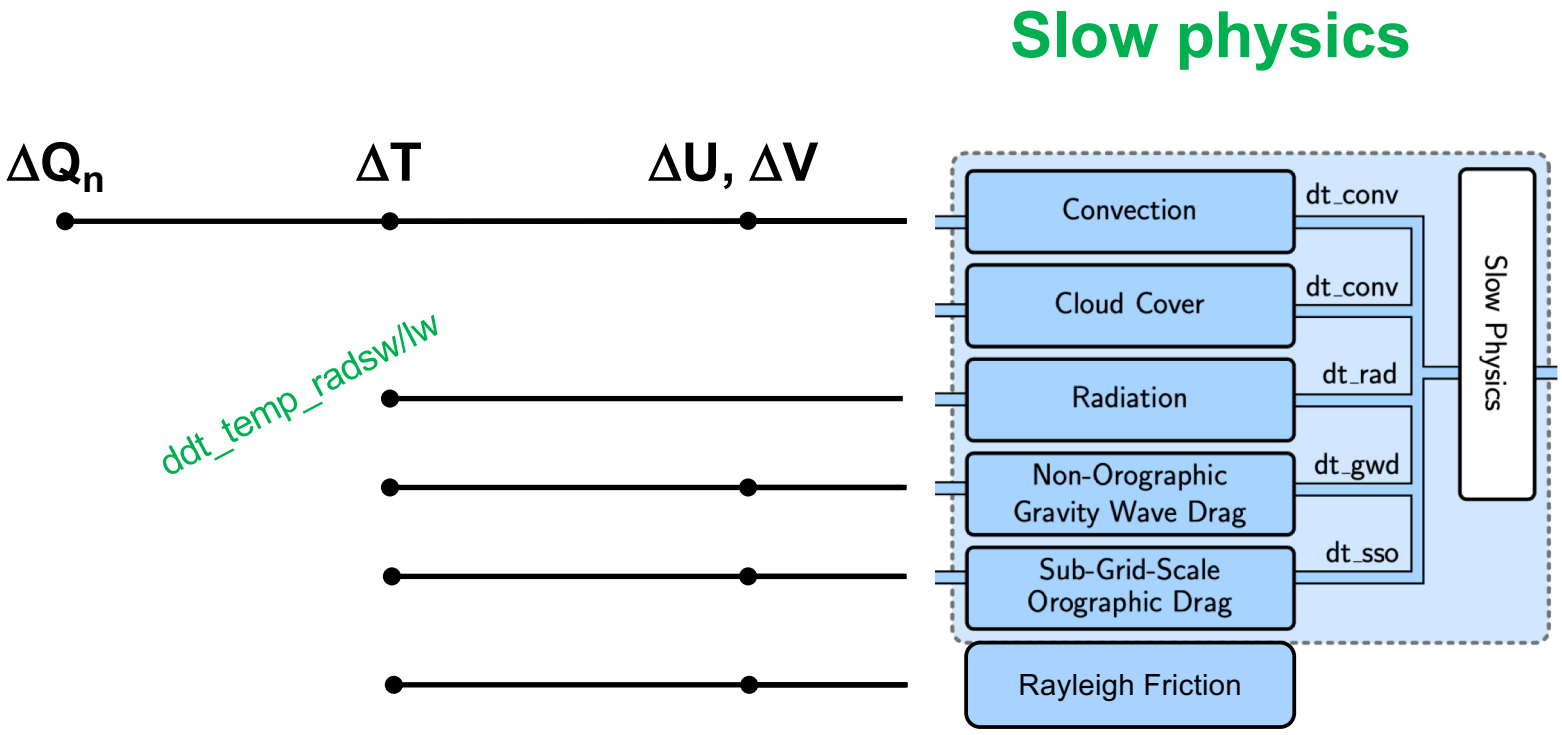
Fast physics

e.g. $\Delta T = T_{new} - T_{old}$

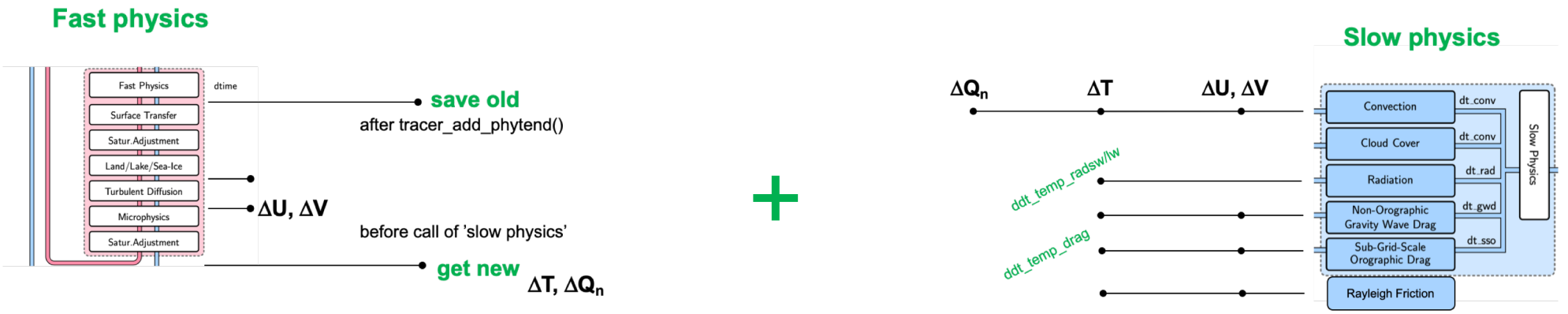


Currently calculations after saturation adjustments!!!

Implementation Strategy – Proof of concept



Implementation Strategy – Proof of concept



ΔT

```
! Add tendencies from the fast physics to the once derived from the
! slow pysics as well as pertubations

  DO jk = 1, nlev
    DO jc = i_startidx, i_endidx

      ! air temperature
      z_ddt_temp(jc,jk)     = z_ddt_temp(jc,jk)      + z_ddt_temp(jc,jk)               * pt_diag%rn_gau(jc,jk,jb)   &
                                                     + z_ddt_temp_fast(jc,jk,jb)/dt_loc * pt_diag%rn_gau(jc,jk,jb)
```

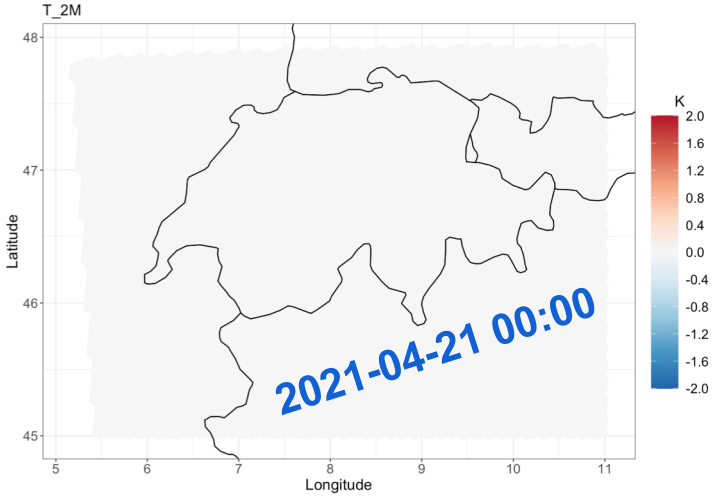
ΔQ_v

```
      ! water vapor
      z_ddt_qv(jc,jk,jb)       =    prm_nwp_tend%ddt_tracer_pconv(jc,jk,jb,iqv)            * pt_diag%rn_gau(jc,jk,jb)    &
                                                  + z_ddt_qv_fast(jc,jk,jb)/dt_loc   * pt_diag%rn_gau(jc,jk,jb)
```

* rn_gau(jc,jk,jb) = 0.8

Results – Difference T_2M; **lsppt = .FALSE. – .TRUE.**

Lead +0



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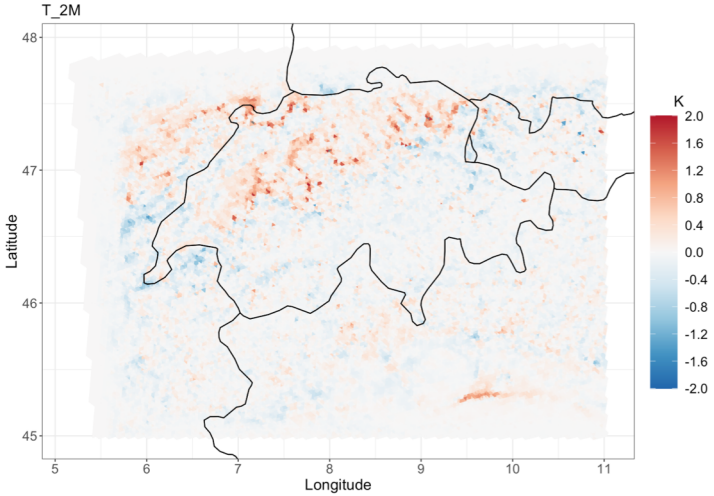
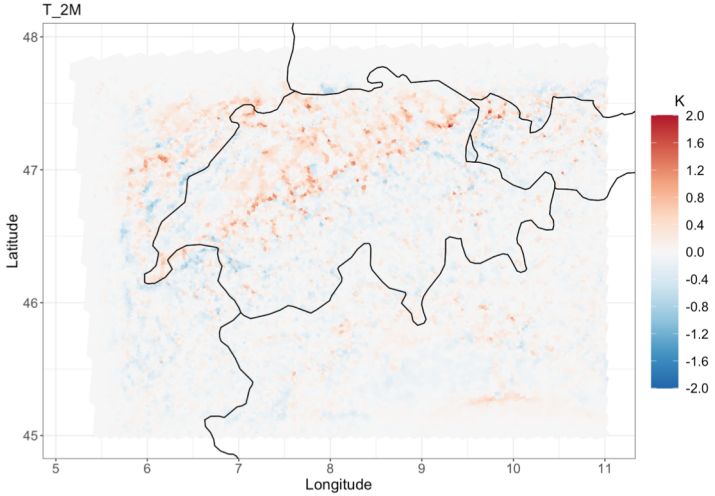
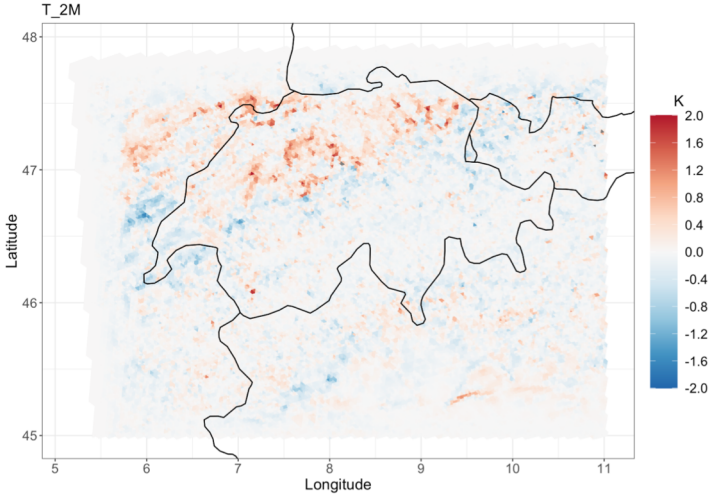


Lead +1



Lead +3



Wrap up!!!

- First very *'basic'* implementation of **S**tochastic **P**erturbation of Physics Tendencies (SPPT) – Proof of concept!!!
- Next steps:
  - Consolidate code, activate and implement additional namelist switches and features.
  - Generate random numbers correlated in space on 'coarse' grid.
  - GPU support.
  - Simulations on full ICON-1E and ICON-2E domain.
  - Probabilistic verification
- Implementation of Random Number Generator (RNG) pending:
  - A 'zoo' of RNG's exist in ICON including 'legacy' code.
  - Inquire needs of different groups and implement one, which serves all needs and architectures (NEC, GPU etc.)

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Thanks!
Comments or Questions?

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